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SIXTH FRAMEWORK PROGRAMME  
Research Infrastructures Action



**Report of the 2005 CERN contributions  
to the EU co-funded Activities in FP6**

by

**B.Boutboul, R.Forrest, G.Guignard (editor), H.Haseroth, M.Lindroos, A.Lombardi,  
R.Losito, L.Oberli, U.Raich, K.Riisager, C.Rossi, F.Ruggiero, C.Saitta,  
W.Scandale, D.Schulte, G.Suberlucq, M.Vretenar, C.Wyss**

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# 1. CARE Integrated Infrastructure Initiative

## 1.1 CARE ELAN Network Activities

### 1/ INTRODUCTION

The European Linear Accelerator Network (ELAN) aims at fostering linear accelerator R&D in Europe by organising meetings and by supporting attendance of meetings. Two main linear collider studies are currently carried out on the ILC and on CLIC. ELAN also supports a repository for beam dynamics codes and some databases. CERN is mainly involved in the Work Packages (WP) 1 (normal conducting technology) and 3 (beam dynamics) and leading them.

For WP 3, the planning was significantly affected by the technology choice for the ILC. Since an organisation has been formed to perform R&D for the ILC (the GDE), the related European effort needed to be integrated into this international framework. The originally planned workshop in the middle of 2005 has thus been replaced by a combination of a European workshop in London (with open attendance) and the second ILC workshop in Snowmass.

During 2005, CERN was participating in

- specialized workshops dealing with matters related to the preparation of the future ILC
- the mid-year ELAN workshop embedded in the European meeting on ILC in London
- specialized workshops related to Normal Conducting Linear Collider and Beam Dynamics.
- discussion on future initiatives for R&D on linacs

### 2/ MEETINGS

#### **GDE meeting in Frascati (December 7-9, 2005)**

In this meeting the base line configuration document for the ILC should be finalized and together with a definition of the required R&D. ELAN supports the CERN participants.

#### **Meeting of the European members of the GDE in Oxford (October 25, 2005)**

The main aim of the meeting was to agree on the organisation of the ILC in Europe and to identify the potential funding for ILC research after the completion of the current projects, which are supported by the different laboratories, the UK and the Europe Commission. The attendance of two CERN personnel has been supported.

#### **SPIE<sup>1</sup> Conference in Warsaw (28 August–2 September 2005)**

One CERN staff has been supported to present the photo injector work.

#### **Second ILC workshop in Snowmass, Colorado (August 2005)**

The aim of the workshop was to collect the input for the reference base line document that should be available at the end of the year and to define the further R&D needed. Also the GDE was formed, which will coordinate the worldwide ILC effort; the role of ELAN will be to ensure the participation of Europe. ELAN supported three CERN staff who acted as co-conveners in the working groups on beam dynamics, instrumentation and civil engineering.

#### **The ELAN/ILC workshop in London (June 19-23, 2005)**

The London meeting supported in parallel the following international workshops:

- ILC-BDIR (Beam Delivery and Interaction Region) Interim Workshop
- Annual EUROTeV Workshop
- CARE/ELAN Workshop

The workshop was a milestone towards the second ILC Accelerator Workshop at [Snowmass 2005](#).

Contribution to ELAN parallel sessions:

Beam dynamics session to understand how the European beam dynamics effort could be integrated with the effort in Asia and the Americas.

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<sup>1</sup> SPIE: Society of Photo-Optical Instrumentation Engineering

WP3+4: Beam dynamics-Instrumentation common session  
 Session on interfaces for beam dynamics simulation codes

### **Workshop of the ANAD<sup>2</sup> work package in Paris (HEEAUP<sup>3</sup> , June 8-10, 2005)**

The plasma acceleration experts invited a CERN expert to inform them about the systematic method in which the CLIC parameters have been determined, in order to be able to develop a reasonable parameter set for a plasma accelerator.

### **Workshop on Positron Sources for ILC at Daresbury (April 11-13, 2005)**

This workshop discussed all possible positron source options for the ILC that are presently being considered, assessed the outstanding R & D issues that will need to be addressed for each of them to become viable and considered how best these issues should be addressed.

### **The Workshop on Metrology and Stabilization for Linear Colliders in Annecy (March 10-11, 2005)**

The workshop was a kick off meeting on this topic with the participation of the LTECNC package from ELAN (2 CERN participants). This meeting has been able to define the major activities to pursue in the area of theory and numerical simulations, specific component development in collaboration with industry, defining which tests can be done and where, and of alignment system comparison with common set-up.

### **The WIGGLE 2005 Mini-Workshop at Frascati (February 21-22, 2005)**

The workshop has been held at the Frascati National Laboratories with the participation of the beam dynamics experts package from ELAN (4 CERN participants, 2 visitors). The aim of the Workshop was to study wiggler optimization for emittance control and low emittance tuning strategies.

#### **List of CERN contributions (talks) in the meetings**

| <b>Workshop</b> | <b>Title of the talk</b>                                      | <b>Speaker</b>  |
|-----------------|---|-----------------|
| GDE Oxford      | The CERN contribution to ILC                                  | J. -P. Delahaye |
| SPIE            | CARE JRA2 activities  | R. Rinolfi      |
| ILC Snowmass    | Main Linac Steering and tuning Studies                        | D. Schulte      |
| ILC Snowmass    | Integrated Simulations  | D. Schulte      |
| ILC Snowmass    | Work plan for WG 1  | D. Schulte      |
| ILC Snowmass    | Recommendation of WG 1 concerning T. Himmels List             | D. Schulte      |
| ILC Snowmass    | Summary of Working Group 1                                    | D. Schulte      |
| ILC Snowmass    | Recommendation on Ground motion                               | D. Schulte      |
| ELAN/ILC London | Issues related to normal conducting linear colliders          | G. Guignard     |
| ELAN/ILC London | Introduction to LET beam dynamics                             | D. Schulte      |
| ELAN/ILC London | LET Beam Dynamics Summary                                     | D. Schulte      |
| ELAN/ILC London | Benchmarking of MAD, SAD and PLACET                           | T. Asaka        |
| ELAN/ILC London | Halo and tail generation studies                              | D. Schulte      |
| ELAN/ILC London | Introduction to Joint Beam Dynamics / Instrumentation Session | D. Schulte      |
| ELAN/ILC London | Simulations of Emittance and Luminosity Tuning Bumps          | P. Eliasson     |
| ELAN/ILC London | Beam Dynamics Studies in Europe                               | D. Schulte      |
| ELAN/ILC London | ATF2 Commissioning Strategy                                   | F. Zimmermann   |
| ELAN/ILC London | E-Cloud Code Benchmarking and Simulations                     | F. Zimmermann   |
| ELAN/ILC London | CERN contribution to ATF2                                     | D. Schulte      |
| HEEAUP Paris    | Requirements of a multi-TeV Collider                          | D. Schulte      |
| WIGGLE 2005     | Requirements & Studies for CLIC                               | M. Korostelev   |
| WIGGLE 2005     | Wigglers versus Undulators                                    | H. Braun        |
| WIGGLE 2005     | Electron Cloud Simulations for Wigglers                       | F. Zimmermann   |

<sup>2</sup> ANAD: Advanced Novel Accelerator Development

<sup>3</sup> HEEAUP: High Energy Electron Acceleration Using Plasmas

### 3/ PUBLICATIONS

The ELAN-Documents are kept in :

<http://esgard.lal.in2p3.fr/Project/Activities/Current/Networking/N2/ELAN/index.php>

#### List of reports with CERN authors in CARE/ELAN

| <b>ELAN documents</b>  | <b>Title</b>   | <b>Authors</b>                      |
|------------------------|--|-------------------------------------|
| 2005-003               | Summary of the 2004 CTF3 Steering Workshop   | R. Lifshitz, D. Schulte             |
| 2005-011               | Characterization and Performance of the CLIC Beam Delivery System with SAD, MAD and PLACET | T. Asaka, J. Resta Lopez            |
| 2005-013               | Conceptual design of a Polarised Source Based on Laser Compton                             | S.Araki, et al.                     |
| 2005-014               | Progress on Issues of LC Normal Conducting Technology                                      | G.Guignard                          |
| 2005-016               | Snowmass Summary on WG1  | D.Schulte, K. Kubo, P. Tenenbaum    |
| 2005-017               | Report on the Workshop on positron sources for the ILC.                                    | L. Rinolfi                          |
| <b>CARE Notes</b>      | <b>Title</b>   | <b>Authors</b>                      |
| Note-05-005-ELAN       | Workshop Report on Metrology and Stabilization for LCs.                                    | G.Guignard, A.Jeremie, Y.Karyotakis |
| Note-05-008-ELAN       | The automatic steering system in CTF3  | R. Lifshitz, D. Schulte             |
| <b>CARE Reports</b>    |  |                                     |
| Report-05-006-ELAN     | Annual report of the ELAN Collaboration  | F.Richard, D.Schulte                |
| Report-05-013-ELAN     | First intermediate report of the ELAN Collaboration  | F.Richard, D.Schulte                |
| Report-05-020-ELAN     | Intermediate report of the ELAN Collaboration  | F.Richard, D.Schulte                |
| <b>CARE Conference</b> |  | <b>Authors</b>                      |
| Conf-05-035-ELAN       | Considerations on the Design of the Decelerator of the CLIC Test Facility (CTF3)           | D. Schulte, I. Syratchev            |
| Conf-05-036-ELAN       | Automatic Steering for the CTF3 Linear Accelerator   | R. Lifshitz, D. Schulte             |

### 4/ ACTIVITIES

The main activities of ELAN are to provide support for meetings. They are thus covered by the commented list of meetings above. These activities often include direct contributions from the CERN participants. An important part of these contributions originates from the work around CTF3 and on high-gradient cavities. The CTF3 collaboration meeting 2005 took place in November and included about 20 to 30 talks/discussions on various subjects such as: commissioning results, photo-injector, diagnostics, linac, delay loop, combiner ring, 30 GHz power production and experimental area.

### 5/ ACHIEVEMENTS

The main objectives of the Working Groups (WP) 1 and 3 have been fulfilled, see the table below. WP1 delivered a work-plan. It also supported the CTF3 collaboration meeting.

The original intention for WP3 was to provide a prioritized list of R&D topics. After the technology decision, it became clear already at the end of last year that this cannot be done on a European basis only but in a global framework. The London meeting and the ELAN participation to Snowmass provided the European input into the process; the European contributions are well integrated into the global effort.

An agreement for the standard interface for the different tracking codes has been reached in London and in Snowmass. The existing format (termed XSIF) will be used to describe lattices. In the future a more powerful interface (based on the so-called XML) will be adopted and is currently under development.

A complete conceptual layout of the ILC from the damping ring to the interaction point has been derived; the detailed designs need to be developed. This layout also specifies which beam parameters need to be measured in the different measurement stations.

**List of deliverables achieved in 2005 with CERN participation.**

| <b>(Intermediate) Deliverable</b> | <b>Intermediate Deliverable and Deliverable Name</b>  | <b>Work-package No</b> | <b>Planned (months)</b> | <b>Achieved (months)</b> |
|-----------------------------------|---|------------------------|-------------------------|--------------------------|
| ID                                | Reports on topical NC LC issues   | 1                      | 18                      | 17-22                    |
| D                                 | Work-plan and documentation data base   | 1                      | 24                      | 22                       |
| ID                                | Report on status of sources   | 1                      | 18                      | 22                       |
| ID                                | Proceedings of CTF3 collaboration   | 1                      | 24                      | to come                  |
| ID                                | Prioritized list of work items  | 3                      | 18                      | 24 (by GDE)              |
| ID                                | Workshop concerning interfaces, interaction with the instrumentation and prioritized R&D list | 3                      | 18                      | 18/20                    |

For the coming year it is planned to support the workshops for the global effort on the ILC, but the schedule of the GDE is not yet clear. A beam dynamics workshop on the synergy between CLIC and the ILC and the special requirements for CLIC is also planned. It remains to be decided if it will be attached to an ILC workshop or be held independently. The meeting of the CTF3 collaboration is planned for Autumn 2006.

## 1.2 CARE BENE Network Activities

### 1/ INTRODUCTION

The BENE network aims at co-ordinating and integrating the activities of the accelerator and particle physics communities that are giving or promise contributions to the realization of upgraded and/or new European neutrino facilities of unprecedented performance. The final objectives are 1) recommend the optimal road map from the present infrastructure to the most rewarding future facilities, including conventional neutrino Superbeams, Neutrino Factories and Betabeams 2) assemble a coherent community capable to sustain the long term program of R&D, technical realization and scientific exploitation.

During 2005, CERN was participating in

- NUFACT05 which is the main workshop for beam based neutrino workshop world wide
- workshops dealing with matters related to the preparation of a future beta-beam facility
- workshop related to the preparation of a future neutrino factory design study
- specialized workshops related to targets for high power facilities

### 2/ MEETINGS

#### **JOINT UK-BENE Nuclear and Particle Physics meeting on the beta-beam, Rutherford Laboratory, January 2005**

Contributions:

- The beta-beam baseline, S.Hancock,
- The EURISOL design study, P. Butler,
- The beta-beam task, M. Benedikt
- Synergies with other tasks, M. Lindroos
- FFAG options, S.Koscielniak (invited from TRIUMF, Canada, 50% BENE),
- Tracking studies to reduce losses and activation, F. Jones (invited from TRIUMF, Canada, 50% BENE)

#### **MICE collaboration meeting and the American Muon Collaboration meeting, 10-12 February 2005, LBNL USA**

Contribution: Synergies of Targetry Experiment with Other Programs – nTOF-11, H.Haseroth.

#### **MERIT (nTOF-11) collaboration meeting at MIT, 15-17 March 2005**

#### **NNN05, 7-9 April 2005, Frejus, France**

Presentation: The beta-beam baseline, M. Lindroos

#### **Meeting on the future physics program at ZARAF, April, Israel, 2005**

Contribution: Beta-beam and ISOL techniques, M. Lindroos

#### **Seminar at Louvain-La-Neuve, May, 2005**

Presentation: The beta-beam, A. Fabich and M. Lindroos

#### **NUFACT05, Frascati, 21-26 June 2005**

Contributions:

- Working group on Machines were lead by H. Haseroth
- The moderator of the working group on targets was P. Sievers.

Presentations:

- The technical challenges of Superbeams and Neutrino Physics, H. Haseroth
- Targets WG plan and summary, P. Sievers
- An isochronous 10-20 GeV Muon Ring with constant Tunes operating above transitions, H. Schoenauer
- Questions and challenges for the driver WG, R. Garoby

- Beam dynamics in an isochronous FFAG ring, F. Lemuet
- Technical challenges for the beta-beam, M. Lindroos
- How to optimize the beta-beam, M. Lindroos
- 

**MERIT (nTOF-11) collaboration meeting at MIT, 27-28 June 2005**

**HEP2005 Europhysics Conference. 21-27 July, Lisboa, Portugal**

Presentation: A monochromatic beta-beam, M. Lindroos

**2nd High Power Targetry Workshop at ORNL, 10-14 October 2005**

Presentation: High Temperature Targets, J.Letry

**MERIT (nTOF-11) collaboration meeting at MIT, 17-19 October 2005**

**General BENE and ENG (European Neutrino Group) meetings at CERN, 16-18 March and 22-24 November 2005.**

Travel (1) to **Paris (Orsay)** for informal meetings: M. Lindroos and M. Benedikt for the beta-beam post accelerator

Travel to **Grenoble** for informal meeting and supervision at LPSC<sup>4</sup> for F. Lemuet

### 3/ PUBLICATIONS

List of reports with CERN authors in CARE/BENE

| Conference  | Title  | Authors                        |
|---|--|--------------------------------|
| NUFACT05  | Targets WG summary   | P.Sievers                      |
| NUFACT05  | Technical challenges for the beta-beam   | M. Lindroos                    |
| NUFACT05  | Optimization of the beta-beam  | M. Lindroos                    |
| <b>Paper</b>  |  |                                |
| Nuclear Instruments and Methods in Physics Research A 547 (2005) 638–651. | Developments in the ray-tracing code Zgoubi for 6-D multiturn tracking in FFAG rings | F. Lemuet, F. Méot             |
| Nuclear Physics B (Proc. Suppl.) 149 (2005) 313–315                       | Numerical methods for 6-D dynamics simulations in FFAG rings                         | F. Lemuet, F. Méot, A. Verdier |
|   | 6-D Beam dynamics in an isochronous FFAG ring  | F. Lemuet, F. Méot, G. Rees    |
|   | 6-D beam dynamics in an electron model lattice of an isochronous FFAG                | F. Lemuet, F. Méot, G. Rees    |

### 4/ ACTIVITIES

The BENE network organised the NUFAC05 meeting in Italy and participated in the NUFAC School preceding the workshop. The network is at present putting the final touch to the interim report.

<sup>4</sup> LPSC: Laboratoire de Physique Subatomique et Cosmologie



CERN participates in the following work packages:

### **WP TARGET**

MERIT (nTOF-11) as a proof-of-principle target test for a multi-MW proton beam is carried out by the USA - Neutrino Factory and Muon Collider Collaboration. CERN collaborates for hosting this experiment, which will run in 2007. Contributions concern mainly the installation of power (5MW) and cryogenics, logistics and safety (people involved: I.Efthymiopoulos, A.Fabich, H.Haseroth, J.Letry). Beyond being a contact link to the externally located community, physicists are providing expertise on the layout of the mercury jet target and loop, and study the particle production of the liquid target concept.

### **WP NOVEL NEUTRINO BEAMS**

CERN has participated in the neutrino factory study with a contribution in machine physics to the EMMA (electron model FFAG) proposal and participation in NUFACT and the International Scoping Study.

The beta-beam part of the work package is the information backbone of the beta-beam design study within the EURISOL DS and serves as forum for neutrino physicists to meet the machine physicists working within the DS. Note that there is no work package neutrino physics within the design study and that the BENE meetings are the only forum for these two communities to meet. A new idea to produce monochromatic neutrino beams through nuclei decaying through electron capture was the direct result of discussion in these meetings. Furthermore, the meetings have been crucial to establish target values for the annual rate of neutrinos for the design study.

## **5/ ACHIEVEMENTS**

All deliverables have been achieved as planned (see the Table below). Among the main achievements in 2005, there were the organization of NUFACT05 in Italy at Frascati and the editing of the interim report for the BENE network (in its last phase at present).

### **List of deliverables achieved in 2005 with CERN participation.**

| <b>Deliverable/<br/>Milestone</b> | <b>Deliverable/Milestone Name</b>                               | <b>Work-package</b>  | <b>Planned<br/>(in<br/>months)</b> | <b>Achieved<br/>(in<br/>months)</b> |
|-----------------------------------|---|----------------------|------------------------------------|-------------------------------------|
| D                                 | Organization of NuFact05 International Workshop and Proceedings | All                  | 18                                 | 18                                  |
| D                                 | BENE Meeting  | All                  | 16                                 | 16                                  |
| D                                 | Interim Report (IR)   | All                  | 24                                 | In progress                         |
| D                                 | Proceedings of Workshop Target Section of IR                    | TARGET               | 20                                 | 20                                  |
| D                                 | Beta-beam Workshop  | NOVEL NEUTRINO BEAMS | 13                                 | 13                                  |
| D                                 | Novel Beam Section of IR and Beta-beam Workshop Summary         | NOVEL NEUTRINO BEAMS | 20                                 | 20                                  |

## 1.3 CARE HHH Network Activities

### 1/ INTRODUCTION

In 2005 the networking activity of CARE-HHH was essentially focused on the upgrade of the FAIR project at GSI and of the LHC accelerator complex at CERN.

The HHH networking activities comprise 3 work packages (WP):

WP1: Advancements in Accelerator Magnet Technologies (AMT)

WP2: Novel Methods for Accelerator Beam Instrumentation (ABI)

WP3: Accelerator Physics and synchrotron Design (APD)

Two specific working groups were created: the first addressing issues such as accelerator physics and machine-detector interface aspects related to the upgrade of the LHC Interaction Regions, the second investigating an appropriate R&D programme for AC superconducting magnets in view of the upgrade of the LHC injector complex and of FAIR at GSI.

### 2/ MEETINGS

- **14 January 2005 (APD):** Meeting at CERN between Accelerator Experts and representatives of ATLAS and CMS Physicists to discuss LHC Luminosity Upgrade issues, with 7 participants.  
To deal with the follow up of the treated items a stable a working group and forum of discussion, called LUMIUP, with periodic meeting, was created.
- **03 February 2005 (dissemination):** A seminar summarising the outcomes of the HHH-2004 workshop was organised at CERN, in the frame of the regular AB department seminars. The talk, with the title *LHC Upgraded Taking Shape - Highlights of HHH-2004: "Beam Dynamics in Future Hadron Colliders and Rapidly Cycling Synchrotrons"*, was jointly presented by W. Scandale and F. Zimmermann to an audience of more than 50 experts.
- **17-18 February 2005 (AMT):** A meeting held at CERN on the design and the prototyping of a fast-ramping superconducting pulsed dipole. The attendance was of 20 experts from CERN, INFN, GSI and CEA. For the follow up of the future R & D, a working group, named PMWG has been created. <http://pmwg.web.cern.ch/PMWG/>.
- **02 March 2005 (coordination):** CARE-HHH coordination meeting at CERN to review the HHH Network strategy, the sequence of future HHH events and the distribution of the P&M resources between the HHH working packages.

One of the outcomes of the meeting was the identification of a few tentative milestones for future LHC machine studies, listed here:

- 2005/2006: installation and test of a beam-beam long range compensation system at RHIC to be validated with colliding beams;
  - 2006/2007 new experiment for crystal collimation at the CERN-SPS;
  - 2006: installation and test of Crab cavities at KEKB to validate higher beam-beam limit and higher luminosity with large crossing angles;
  - 2007: if KEKB test successful, installation and test of Crab cavities in a hadron machine to validate low RF noise and emittance preservation.
- **3-4 March 2005 (AMT):** a CARE-HHH-AMT workshop was organized at CERN on *Beam-Generated Heat Deposition and Quench Levels*. 80 specialists from CERN, INFN, CEA, IFJ-Krakow, GSI, DESY, FNAL, University of Geneva and from SIEMENS attended it.
  - **7-8 March 2005 (APD):** CARE-HHH-APD mini-workshop 'CC-2005' on *Crystal Collimation in Hadron Colliders* held at CERN. About 80 specialists from CERN, INFN, PNPI, IHEP, FNAL, LBNL, University of Aarhus, Helsinki Institute of Physics and University of Texas attended it.

- **March-April 2005 (AMT):** visit of Peter McIntyre (University of Huston, Texas, USA) to CERN as HHH-AMT consultant for about four weeks.
- **18 March 2005:** seminar at CERN ‘Super Dipoles for Super Colliders’, to an audience of 35 specialists.
- **21 & 30 March 2005:** discussions at CERN on (i) advanced SC magnet technology and design, (ii) radiation resistant dipole to be used in dipole-first IR design; (iii) chromaticity correction for quadrupole-first IR design; (iv) LHC energy tripler using hybrid SC magnets; (v) possible counter-measures against electron cloud.
- **22-23 March 2005 (AMT):** CARE-HHH-AMT Topical Meeting at CERN on *Insulation and Impregnation Techniques*. About 30 specialists from CERN, LBLN, INFN, University of Twente, GSI, University of Texas, KEK, CEA, CIEMAT, MIT, NSCL and CCLRC, were present.
- **30 March – 2 April 2005 (dissemination):** invited talk of W. Scandale at the workshop IFAE-05 in Catania (Italy) ‘LHC Status and Possible Upgrade’. The meeting was organized by the INFN and attended by about 100 physicists.
- **04 April 2005** seminar at CERN ‘Optimizing IR design for LHC luminosity upgrade’;
- **05-06 April 2005 (coordination):** CARE steering committee held at CERN: F. Ruggiero presented the status of CARE-HHH.
- **06-08 April 2005 (coordination):** US-LARP Collaboration Meeting in Port Jefferson, USA. The main item of discussion was the ‘technical and resource loaded plans for FY06 and FY07’.
- **07-08 April 2004 (dissemination):** invited talk of F. Ruggiero on ‘LHC Upgrade, R&D and Impact on LHC detectors’ at the mini-workshop on Future High Energy Accelerators, CPPM, Marseille, France.
- **April 2005 (APD):** Preliminary discussions of F. Zimmermann with M. Klein (DESY) and J. Dainton (Un. Liverpool) about "QCD-explorer": colliding  $\sim 1$  TeV proton (or ion) beam from Tevatron or Super-SPS with 20-75 GeV electron beam from ILC or CLIC (first stage).
- **April 2005 (AMT):** submission of the following NEST proposals:
  - ‘ECOMAG’ for the Fast SC pulsed magnet for GSI and LHC injector upgrade: CERN (Scandale), GSI (Moritz), INFN (Volpini, Fabbricatore), CEA/Saclay (Rifflet);
  - ‘Electron model of FFAG’, CERN (marginally) involved for LHC accelerator complex upgrade: UK (CCLRC-Lancaster-Liverpool-Oxford)-CERN-CEA/Saclay
  - ‘Eurodip’, a possible extension of NED: CERN-CEA/Saclay-CIEM.
- **13 April 2005 (APD):** second meeting ‘LUMIUP’ on LHC luminosity upgrade with ATLAS and CMS physicists (8 participants).
- **14 April 2005** seminar at CERN ‘LHC Energy Tripler’;
- **15 April 2005** seminar at CERN ‘Novel Method to Avoid e-cloud Limitation in the LHC’;
- **18 & 20 April 2005 (dissemination):** seminars in CEA-Saclay and Dipartimento di Fisica, Milano on ‘LHC Energy Tripler’;
- **19-20 May 2005 (AMT):** second meeting ‘PMWG’ of the Pulsed Magnet Working Group, 19 participants.
- **18-25 May 2005 (dissemination):** contribution of 4 papers to PAC 2005 (USA). See Chapter 3.

- **28 May – 1 June 2005 (dissemination):** invited contribution (W. Scandale, ‘High Intensity Injector Chain for the LHC’) to the HIF<sup>5</sup> 2005 workshop organized by the INFN.
- **June 2005 (AMT):** A. Devred took part to the DOE review of LARP at FNAL.
- **8 July 2005 (APD):** contribution the 61st meeting of the LHC collimation working group W. Scandale presented a possible scenario to investigate crystal collimation in the SPS in view of the LHC intensity upgrade.
- **18-20 July 2005 (dissemination):** contribution to Atlas Tracker Upgrade Workshop in Genova with more than 100 participants. Presentation by F.Ruggiero of the plans for the Super LHC.
- **July 2005 (APD):** completion of the proceedings of the workshop on Crystal Collimation CC-2005.
- **July 2005 (dissemination):** written contribution to the HIF 05 proceeding. Author W. Scandale, title: ‘Possible scenarios for the LHC upgrade’.
- **31 August – 3 September (APD):** CARE-HHH-APD Workshop ‘LUMI 05’ on ‘Scenarios for the LHC luminosity upgrade’, Arcidosso (Italy). About 40 participants attended the meeting.
- **28 September – 14 October 2005 (AMT):** visit of H. Piekarcz (Fermilab, Illinois, USA) to CERN as HHH-AMT consultant for about two weeks.
- **28 September – 01 October 2005 (dissemination):** contribution to the [8th ICFA Seminar on ‘Future Perspectives in High Energy Physics’](#), Kyungpook National University, Daegu, Korea, with about 170 participants. F. Ruggiero presented the plans for the LHC Luminosity Upgrade.
- **3-4 October 2005 (APD):** US-LARP mini-Workshop on ‘LHC IR upgrade’, FNAL, attended by 3 CERN scientists associated to CARE.
- **5-6 October 2005 (coordination):** US-LARP coordination meeting, FNAL, attended by F. Ruggiero. About 35 participants.
- **24 October 2005 (coordination):** HHH coordination meeting at CERN in view of CARE05.
- **26-28 October 2005 (AMT):** CARE-HHH-AMT Workshop ‘ECOMAG05’ on SC Pulsed Magnets for Accelerators, Frascati, 70 participants from CERN, INFN ENEA, GSI, CEA, EPFL, JINR, MIT, CIEMAT, KEK, IHEP, EFDA, Bochvan Institute of Inorganic Materials, University of Twente, Ohio State University and from 6 European Industries acting on SC magnets or SC materials (Alstom, Accel, NBB, Bruker BioSpin, Outokumpu, Ansaldo).
- **10 November 2005 (APD):** LHC Seminar given at CERN by F. Ruggiero and W. Scandale on “Scenarios for the LHC Luminosity Upgrade”, in the presence of some 120 scientists.
- **11 November 2005 (AMT):** Debriefing of the outcome of the workshop ECOMAG0. (30 participants)
- **6-7 December 2005 (ABI):** CARE-HHH-ABI Workshop on “Remote diagnostics and maintenance of beam instrumentation devices”, Hirschberg (close to Heidelberg, Germany), to be attended by about 20 invited contributors associated to CARE.

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<sup>5</sup> HIF: High Energy Frontier

### 3/ PUBLICATIONS

| CARE document type and number | Title  | Authors   | Date       |
|-------------------------------|--|---|------------|
| <b>CARE Reports</b>           |  |   |            |
| Report-05-08-HHH              | Annual report on the HHH collaboration   | F. Ruggiero, W. Scandale  | Jan 2005   |
| Report-05-15-HHH              | First 2005 intermediate report on the HHH collaboration                            | F. Ruggiero, W. Scandale  | April 2005 |
| Report-05-22-HHH              | Second 2005 intermediate report on the HHH collaboration                           | F. Ruggiero, W. Scandale  | Sep 2005   |
| <b>CARE Conference</b>        |  |   |            |
| Conf-04-24-HHH                | Proceedings of the 1st CARE-N3-ABI networking meeting                              |   | April 2005 |
| Conf-04-23-HHH                | Proceedings of the 2nd CARE-N3-ABI networking meeting                              |   | April 2005 |
| Conf-05-01-HHH                | Proceedings of the E-CLOUD'04 Workshop   | Editor F. Zimmermann  |            |
| Conf-05-02-HHH                | Proceedings of the HHH 2004 Workshop   | Editor F. Zimmermann  |            |
| Conf-05-04-HHH<br>PAC 2005    | On the feasibility of a tripler upgrade for LHC                                    | P. McIntyre, A. Sattarov  | May 2005   |
| Conf-05-05-HHH<br>PAC 2005    | Low- $\beta$ quadrupole design for the LHC luminosity upgrade                      | R. Ostojic et al.   | May 2005   |
| Conf-05-06-HHH<br>PAC 2005    | Towards an optimization of the LHC intersection region using new magnet technology | P. McIntyre, A. Sattarov, J.P. Koutchouk                                    | May 2005   |
| Conf-05-07-HHH<br>PAC 2005    | Killing the electron cloud effect in the LHC arcs                                  | P. McIntyre, A. Sattarov  | May 2005   |
| Conf-05-21-HHH                | Electron cloud measurements in the SPS in 2004                                     | G. Arduini, V. Baglin, J.M. Jimenez, F. Ruggiero. D. Schulte, F. Zimmermann | May 2005   |

### 4/ ACTIVITIES

**Deliverables:** A preliminary version of the web repository for accelerator physics codes was made available in the frame of WP3 (APD). The work on the database for superconducting cable and magnets in the frame of WG1 (AMT) has been further delayed owing to serious difficulties in recruiting an appropriate fellow (two potential candidates have found a better position and withdrawn their application). A Doctoral Student has been finally selected and will start working on the AMT database in January 2006.

**Events:** A total of 6 workshops were organized: three in the frame of WP1 (AMT), one in the frame of WP2 (ABI), and two in the frame of WP3 (APD). The ABI workshop and an additional APD mini-workshop are planned in December 2005. The participation was in general large and extended to several Institutions contributing to HHH. In two cases the participation was extended to representatives of the European Industry.

**Dissemination and outreach:** An intense effort was made for dissemination of information: several talks were given mostly by the HHH coordinators to illustrate the HHH activity in European laboratories and Universities or in workshops organized by other Institutions. Eleven new publications were issued and most of them are stored in the CARE database. Finally, the HHH web site was finalized and contains pages specific to each work-package and links to the HHH events and activities.

**Exchanges and educational aspects:** Two US accelerator specialists were hosted by CERN with the support of HHH in the frame of WP1 (AMT). Two junior scientists active in HHH issues were hosted and supported, one

by CERN in the frame of WP1 (AMT), the other by the University of Sannio, Benevento, Italy in the frame of WP3 (APD). A master degree student was active at CERN on issues covered by WP1 (AMT). A master degree and a doctoral student just hired at CERN will investigate issues related to WP1 and WP3 respectively. A doctoral student has been working at CERN in 2005 on LHC IR design aspects (dipole-first).

## 5/ ACHIEVEMENTS

The following table gives the status with respect to the interim reports and the deliverables to be done in 2005 according to the project breakdown in Mile-Stones (MS) and Intermediate Deliverables (ID).

| WBS #   | Title  | Due date in Annex 1 | Status | Revised delivery date |
|---------|--|---------------------|--------|-----------------------|
| WP1-AMT |  |                     |        |                       |
| 15      | MS: AMT topical meeting on Insulation                                | T1-2005             | 100 %  | T1-2005               |
| 16      | ID: proceedings if the first AMT topical workshop on superconductors | T1-2005             | 100 %  | T1-2005               |
| 17      | ID: report on AMT organization and conductor development             | T4-2004             | 80 %   | T2-2005               |
| 19      | MS: AMT topical meeting on Beam loss induced thermal effects         | T1-2005             | 100 %  | T1-2005               |
| WP2-ABI |  |                     |        |                       |
| W3-APD  |  |                     |        |                       |
| 48      | MS: proceedings of the first topical APD workshop                    | T1-2005             | 100 %  | T1-2005               |
| 49      | ID: meeting on simulation code bench marks                           | T1-2005             | 0 %    | T3-2005               |

The development of the web-based database for SC cables and magnets has been slowed down. The main reasons of the delay are that the budget to hire a dedicated fellow was not yet available in T2-2005; later on, it turned out to be non-trivial to recruit an adequate candidate.

# 1.4 CARE PHIN Joint Research Activities

## 1/ INTRODUCTION

During 2005, CERN was participating in:

- Design of the RF Gun (responsibility of LAL-Orsay)
- Design of the Laser (responsibility of CCLRC-RAL) and purchasing of components of the laser (shared responsibility between CERN and CCLRC-RAL)
- Refurbishing of the CERN photocathode lab and upgrade of diagnostics for the monitoring of the deposition of photo emissive films.
- CARE Steering Committee activities (R. Losito, deputy coordinator of PHIN)

## 2/ MEETINGS

### CERN – CCLRC/RAL

Several videoconferences and visits were organized to follow-up the design and procurement of the laser system and of the different components.

- 3 – 2 – 2005: selection of diodes for the first amplifier following bids at Invitation to Tender
- 14 – 4 – 2005: acceptance tests of the laser oscillator from HighQLaser.
- 10 – 7 – 2005: Visit of G. Suberlucq at RAL to participate in acceptance tests of the laser oscillator
- 11 – 8 – 2005: Update on progress, and finalization of the laser parameters
- 20 – 9 – 2005: Visit of CCLRC – RAL representatives at CERN. Update timing issues, phase coding, interlocks and controls.

### CERN – LAL

Several videoconferences were organized to follow-up the design and procurement of the RF Gun and of the different components.

- 12 – 7 – 2005: Visit of LAL representatives at CERN. Clarification of dimensions needed to fit CERN installations.
- 6 – 10 – 2005: Videoconference. Clarification of dimensions needed to fit CERN installations.

## 3/ PUBLICATIONS

The PHIN-Documents are kept in:

<http://www.infn.it/phn/docs.html>

| <b>CARE Reports</b>    |   | <b>Authors</b>                  |
|------------------------|---|---------------------------------|
| Report-05-003-PHIN     | Annual Report of the PHIN Collaboration                               | A. Ghigo, R. Losito, L. Rinolfi |
| Report-05-010-PHIN     | First 2005 intermediate report of the PHIN Collaboration              | A. Ghigo, R. Losito, L. Rinolfi |
| Report-05-017-PHIN     | Second 2005 Intermediate report of the PHIN Collaboration             | A. Ghigo, R. Losito, L. Rinolfi |
| <b>CARE Conference</b> |   |                                 |
| Conf-05-016-PHIN       | CARE-JRA2 activities on photo-injectors and CLIC test facility (CTF3) | L.Rinolfi                       |



## 4/ ACTIVITIES

### WP2: Photocathodes

CERN is preparing the photocathode lab for detailed investigations on the co-evaporation method to deposit  $\text{CsTe}_2$  on copper substrates. The co-evaporation process has given very good results in CTF2 but its reproducibility is not yet satisfactory.

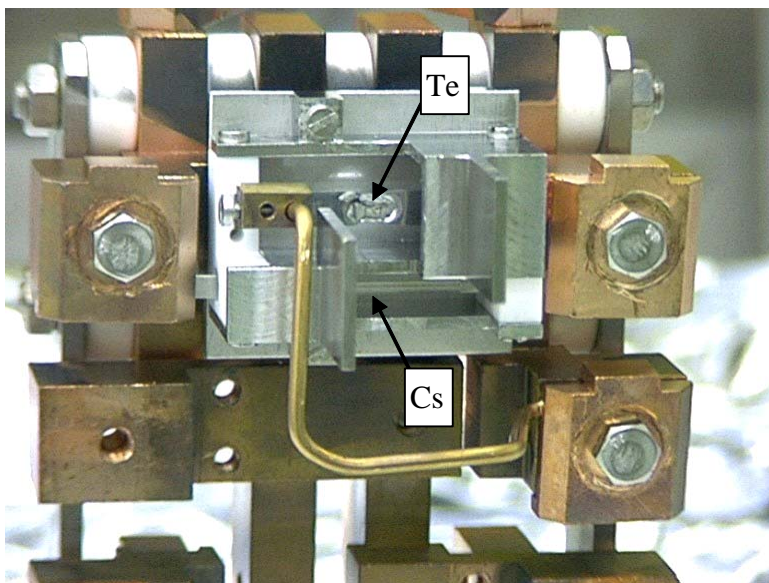
One of the main issues of the co-evaporation process is the management of the stoichiometric ratio between caesium and tellurium during the evaporation phase. This implies to control accurately the evaporation rate of both products.

Two different methods are under development at the CERN photoemission lab:

- Separate thickness measurement with quartz microbalance;
- Vacuum species analysis.

### Separate thickness measurement

Two quartz microbalances situated on both side of the photocathode allow measuring the tellurium and caesium thicknesses. In the case of the co-evaporation (two products are evaporated simultaneously) it is mandatory that each microbalance measures only a single product, while the cathode receives the 2 in a homogeneous way. Such masks are under development, and the first tests of thickness calibrations are foreseen during autumn, 2005.



### Vacuum species analysis

During the evaporation process, it is possible to observe a dependence of the residual gas composition inside the cathode preparation chamber with the evaporated products<sup>6</sup>. With a mass spectrometer (here a QMG 112 from Balzers), tuned to the products to be evaporated, we hope to be able to follow the evaporation rate of each product. For this purpose, a dedicated software was developed<sup>7</sup> to allow on one hand, the acquisition of the partial pressure of the residual gases before evaporation, detection of contaminants produced by the evaporators, and, on the other hand, acquisition of ionic currents produced by the evaporated products.

To be able to define partial pressures and to follow various species, it is necessary to determine the various cracking pattern and to calibrate the corresponding coefficients.

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<sup>6</sup> "Closed loop multi source evaporation rate control with a quadrupole mass spectrometer in an ultra high vacuum system", K. Wellerdieck *et al* Proc. 8<sup>th</sup> International Vacuum Congress, 22-26 September 1980, special issue of "Le vide les couches minces" No 201, Vol. II Vacuum Technology and Vacuum Metallurgy, p. 542.

<sup>7</sup> "Instrumentation d'un spectromètre de masse sous Labview", J. Sanchez, CERN CTF3 Note, to be published.



For instance, in the table below, one can see the difference between the tabulated values and the measured values in a specific environment (after background subtraction) for methane at a pressure of  $2 \times 10^{-7}$  mbar equivalent nitrogen.

|  |      |     |      |      |      |     |     |
|--|------|-----|------|------|------|-----|-----|
| Nb of mass for CH <sub>4</sub>         | 1    | 12  | 13   | 14   | 15   | 16  | 17  |
| Fraction (%) from Balzers <sup>8</sup> | 16.5 | 3   | 7.8  | 16   | 85   | 100 | 1.2 |
| Fraction (%) measured                  | 24.9 | 5.1 | 10.8 | 19.4 | 85.7 | 100 | 1.1 |

By doing that at different pressures and for different species, it is possible to compute the different coefficients linking the sensitivity of the spectrometer to the different species.

With our new software up to twenty species can be followed and recorded in real-time.

### **WP 3: Laser.**

CERN participated actively to the design and procurement of all the components for the laser of CTF3. The entire EU budget for this laser is managed by CERN, while CCRLC-RAL, responsible for design and set-up of the laser, received funding for the qualified manpower. In particular CERN has carried on some tests to measure the efficiency of frequency multiplication through non-linear crystals and has found an alternative solution to realize the pulse coding essential for the synchronization of the beams within the delay loop of CTF3.

### **WP 4: RF Gun.**

CERN has followed closely the design of the RF Gun for CTF3 through regular meetings and videoconferences. The challenges of this gun are the low emittance at the output, reached through a special design of the iris (racetrack shape) and focusing magnets around the gun, and the low pressure and high dynamic recovery of vacuum pressure reached through a special chamber coated with a NEG film, in order to preserve the lifetime of the photocathode even in presence of vacuum breakdown due to RF conditioning. The design, procurement and manufacturing of the RF Gun are under the full responsibility of the Laboratoire de l'Accélérateur Linéaire.

## **5/ ACHIEVEMENTS**

The CERN Photocathode laboratory, in use since 1989, has been completely refurbished in order to ensure a reliable exploitation in the next years. Several actions had to be taken to repair vacuum flanges and leaks. Some diagnostics has been added with the aim of improving the understanding of the co-evaporation process, in order to achieve a better reproducibility of the film quality. The first coatings are restarting now after nearly one and a half years of stoppage for the upgrade.

The main components of the laser have been procured; nearly 60% of the EU budget is already committed. Assembly and tests are ongoing at CCLRC-RAL. The main achievement has been the delivery and successful test of the 1.5 GHz laser oscillator, which demonstrated the requirements on amplitude stability (0.25%) and timing jitter (<1 ps).

The RF Gun procurement and construction is suffering several months of delay and the gun is now announced for August 2006 (instead of November 2005). This is due to the complex mechanical design and some technological challenges to include the NEG coating into the Vacuum chamber. Part of the delay is also due to a shortage of manpower at LAL, in particular in the mechanical design office.

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<sup>8</sup> "Mesure de pressions partielles dans la technique du vide", Balzers, BG 800 169PF (8310)

## 1.5 CARE HIPPI Joint Research Activities

### 1/ INTRODUCTION

During 2005, CERN was participating in

- Management of the Activity (WP1).
- Development of Normal-Conducting linac design, prototype construction and testing (WP2).
- Construction of beam chopping line components and chopping line analysis (WP4).
- Beam dynamics and diagnostics for high intensity linacs (WP5).

### 2/ MEETINGS

#### Work Package Meetings:

- **WP2 (Normal Conducting RF) Meeting (CERN, 2-3 June 2005)**

The meeting allowed to summarise the progress on DTL design for Linac4 (CERN, LPSC-Grenoble, CEA), to coordinate the Side Coupled Linac (SCL) design between CERN and LPSC, and to have reports on the progress of the CH (nick-name) structure design for the FAIR linac and of the Drift Tube Linac (DTL) design for the RAL linac upgrade.

- **WP4 and WP5 (Chopping & Beam Dynamics) Joint Meeting (RAL, 13-15 May 2005)**

The joint meeting of WP4 and WP5 was extremely beneficial: it gave the occasion to chopper hardware experts and beam dynamics experts to exchange ideas and concerns. In particular the beam dynamics in the chopper line was analysed in the wider context of the whole acceleration system till 200 MeV, as recommended by the External Scientific Advisory Committee (ESAC).

#### ISTC Collaboration Meetings

These meetings are intended to coordinate the construction in Russia of the three prototype structures for Linac4 funded by ISTC. These structures are not part of HIPPI (different funding) but their specifications result from the HIPPI work. Their status and performance are then analyzed in HIPPI.

- March 1-4, CERN: DTL mechanics.
- March 21-24, CERN: CCDTL design.
- April 13-14, Snezhinsk (Russia): CCDTL mechanics.
- April 18-20, Sarov (Russia): DTL and RFQ-DTL projects.
- August 17-19, CERN: DTL and RFQ-DTL projects.
- October 10-13, CERN: CCDTL project.

#### HIPPI Annual Meeting (RAL, Abingdon, 29-30 September 2005)

The complete activity of HIPPI was reviewed (31 presentations and 44 participants, 5 from CERN). A summary of the meeting has been published and is available on the HIPPI web site, as well as all the presentations ([http://mgt-hippi.web.cern.ch/mgt-hippi/programme\\_HIPPI05.html](http://mgt-hippi.web.cern.ch/mgt-hippi/programme_HIPPI05.html)). CERN contributed with 7 technical presentations plus the organizational and introductory talks. Two members of the External Scientific Advisory Committee (ESAC) were present (A. Pisent and J. Stovall) and expressed their appreciation for the quality and amount of work. The final ESAC report is available on the HIPPI web site and will be attached to the HIPPI Annual Report.

### 3/ PUBLICATIONS

The list of HIPPI Documents and Notes is available on the HIPPI web site:

[http://mgt-hippi.web.cern.ch/mgt-hippi/publications/HIPPI\\_PAPERS.doc](http://mgt-hippi.web.cern.ch/mgt-hippi/publications/HIPPI_PAPERS.doc)

## List of reports with CERN authors in CARE/HIPPI

| HIPPI Documents                        | Title  | Authors and Labs  |
|--|--|---|
| HIPPI Document-05-001                  | An investigation of different methods to simulate the cavity-to-waveguide coupling | R. Wegner, M. Vretenar  |
| HIPPI Document-05-006                  | Phase and Amplitude error study for the Linac4 RF system                           | M. Pasini   |
| HIPPI Document-05-007                  | Energy distribution for 3 coupled resonating cavities                              | M. Pasini   |
| CARE Notes                             | Title  | Authors and Labs  |
| Note-2005-011-HIPPI                    | Status of CERN chopper driver and the solid state alternative                      | M. Paoluzzi   |
| Note-2005-013-HIPPI                    | Design and Construction of a Beam Shape and Halo Monitor for the CERN SPL          | M. Hori, K. Hanke   |
| Note-2005-014-HIPPI                    | CCDTL design update for Linac4   | M. Pasini   |
| Note-2005-015-HIPPI                    | Design of a Side-Coupled Linear Accelerator Structure for Linac4                   | E. Benedico Mora, M. Vretenar   |
| CARE Conference                        | Title  | Authors and Labs  |
| Conf-05-017-HIPPI (HPSL05, Naperville) | Progress In The Design Of Linac4, the SPL Normal-Conducting Front-End              | F. Gerigk, R. Garoby, K. Hanke, A.M. Lombardi, M. Pasini, C.Rossi, E.Sargsyan, T. Sieber, M. Vretenar |

## 4/ ACTIVITIES

For WP1 (Management and communication), CERN has provided the Coordination of the Activity (R. Garoby, from 1<sup>st</sup> July M. Vretenar) and the Deputy Coordination (M. Vretenar, from 1<sup>st</sup> July A. Lombardi). The Coordinators have prepared 2 Quarterly Reports and are preparing the Annual Report, have discussed and updated the planning, are keeping the database of HIPPI publications, have prepared the HIPPI Annual Meeting at Abingdon and have organized a contribution from INFN-Naples to the WP2 programme in 2006.

In WP2 (Normal Conducting Structures), CERN participates to the DTL (Drift Tube Linac) design activity, to CCDTL (Cell-Coupled Drift Tube Linac) design and prototyping and to the SCL (Side Coupled Linac) design and modelling. All these structures are used for Linac4.

A "DTL Task Force" has been set up at CERN and met five times in 2005, with participants from CERN, LPSC Grenoble and CEA. It consists of experts in RF, beam dynamics, magnets and mechanics, in order to a) define an optimised design for the Linac4 DTL, b) provide a stronger coordination of activities and c) give a closer guidance to the construction of the DTL Tank1 prototype in Russia. A new beam dynamics design has been defined, with higher accelerating gradient, FFDD focusing and no field ramp in the first tank. The RF design has been recalculated, keeping the klystron peak power below 750kW. The resulting layout has been sent to ITEP (Moscow), and has been followed for the mechanical design of the Tank1 prototype. Two meetings with the VNIIEF Sarov team, in charge of the mechanical construction of the prototype, have defined the construction technologies. A separated alignment of drift tubes with respect to a supporting girder has been retained, as well as laser welding of drift tubes containing Permanent Magnet Quadrupoles (PMQ) outside of the vacuum. Different PMQ designs have been compared. CERN has given to LPSC Grenoble and CEA the specifications for the RF coupler to build for the ISTC prototype.

The CCDTL design has been improved, establishing a new layout for Linac4 with 3 tanks per module all along the structure, with an increased gradient adjusted to require the same amount of RF power from all the klystrons. The CCDTL prototype to be built at CERN has been delivered by the CERN workshops at end of January 2005, with a delay of about 9 months from the original schedule. This delay was due to some mechanical problems and to the low priority given to this activity by the CERN workshops. After a careful assembling and alignment of the prototype, the first RF measuring campaign in June allowed easy tuning and RF adjustment, with an excellent agreement between

computations and measurements. The continuation of the RF tests was then halted by the delayed copper plating of a component, finally delivered at the beginning of November. Due to these delays, the RF power tests foreseen in 2005 will have to be rescheduled to the first months of 2006. The mechanical design and the technologies for the next, more complete, prototype to be built in Russia (BINP and VNIIEF Snezhinsk) have been defined during three meetings with the Russian partners. Construction has started and the project is on schedule.

A new generation code for SCL structures has allowed the optimisation of the SCL section. A complete SCL module has been analysed, indicating that the choice of 3% coupling is compatible with the overall number of cells foreseen and the expected residual frequency errors. The SCL design for Linac4 has been communicated to LPSC Grenoble for a thermal analysis and to INFN-Naples for a more detailed error study.

In WP4 (Chopping), to cope with the delays generated by the overload of the CERN mechanical workshop, it has been decided to skip the assembly of a pre-prototype and directly assemble the full-scale prototype. This does not jeopardize the validation of the chopper, as the difference between pre-prototype and prototype was only in the mechanical configuration of the chopper and not in its core constituents. The consequence is that an intermediate milestone originally foreseen will be delayed by about one year, whilst the final deliverable will be provided on time.

Chopper structure: all the components have been delivered by the CERN workshop, however with about 6 months delay from the original planning. They have been cleaned and then assembled inside the quadrupole. Mounting should finish by mid-November, and will be followed by vacuum tests before the electrical tests in 2006.

Chopper driver: in 2005, a new system based on solid-state MOSFET has been defined and a first prototype has been built giving promising results. This solution is now the mainline. By the end of the year a base module giving 500 V should be fully tested and more information will be available on a possible driver proposed by a Russian firm. At this point, a decision will be taken whether to proceed with the construction at CERN of three more identical modules or to go towards a commercial device.

Dump: the special copper alloy for the dump core has arrived at the CERN workshop. Machining will start as soon as the brazing team will give approve to the drawings.

Beam dynamics studies, including matching to the subsequent possible accelerator have continued and the interface between the chopper line and the Drift Tube Linac is defined.

In WP5 (Beam Dynamics), CERN is participating with the code PATH to the benchmarking of codes being done at GSI. The work on the codes for the 3 MeV test stand preparation is steadily progressing. The prototype of the Beam Shape and Halo Monitor detector has been finished in September and tested with a laser beam. The first tests showed that the time resolution (3 ns instead of 2 ns) has to be improved by optimising the electron beam transport.

## 5/ ACHIEVEMENTS

The 2005 planning had only one deliverable, the final report on the Halo measurements device, which has been finished in September. This promising diagnostics device is one of the main highlights of 2005. All milestones concerning testing of hardware components made by the CERN workshops are late by about 6 months. However, CCDTL and chopper prototypes are in the process of being assembled for tests. To gain time, the intermediate test of the chopper has been suppressed; the corresponding milestone will be merged with the final tests in 2006, which constitute a deliverable. Main deliverables in 2006 are the results of CCDTL and chopper testing.

### List of deliverables achieved in 2005 with CERN participation.

| Deliverable/<br>Milestone | Deliverable/Milestone Name               | Work-<br>package No | Planned    | Achieved             |
|---------------------------|--|---------------------|------------|----------------------|
| M                         | CCDTL pre-prototype: intermediate report | 2                   | June 2005  | <i>December 2005</i> |
| M                         | Chopper design report                    | 4                   | June 2005  | <i>December 2005</i> |
| M                         | Chopper intermediate test report         | 4                   | March 2005 | <i>March 2006</i>    |
| M                         | Dump design report                       | 4                   | June 2005  | <i>December 2005</i> |
| M                         | Halo measurement device prototype ready  | 5                   | June 2005  | September 2005       |
| D                         | Final report on halo measurement device  | 5                   | June 2005  | September 2005       |

## 1.6 CARE NED Joint Research Activities

### 1/ INTRODUCTION

In the frame of the NED Joint Research Activities, CERN is in charge of the conductor development to produce high performance Nb<sub>3</sub>Sn wires and cables in collaboration with EU industry. Following the write-up of wire and cable specifications, CERN issued a call for tender in June 2004 and in November 2004, selected two firms Alstom-MSA in France and Shape Metal Innovation (SMI) in the Netherlands to develop a strand of 1.25 mm in diameter to reach a high critical current of 1636 A at 12 T and 4.2 K (corresponding to a non-copper critical current density of 3000 A/mm<sup>2</sup> at 12 T and 4.2 K). After discussion with CERN, the two firms have started a development program made up of two R&D steps (referred as Step 1 and Step 2) followed by final production. The current year was devoted to follow the manufacture of the billets for Step 1, to follow the cross calibration of the critical current test facilities of three institutes and to launch a dedicated program to assess the sensitivity of the NED strands to cabling.

### 2/ MEETINGS

#### Follow-up meetings of the conductor development:

- 17 May 2005: visit of T. Boutboul, D. Leroy, L. Oberli to Alstom/MSA
- 28 June 2005: visit of T. Boutboul, D. Leroy, L. Oberli to SMI
- 14 September 2005: visit of T. Boutboul, L. Oberli to Alstom/MSA
- 21 October 2005: visit of T. Boutboul, L. Oberli to Alstom/MSA

#### NED steering committee meetings:

- 20 January 2005: steering meeting at CERN. CERN participants: T. Boutboul, D. Leroy, L. Oberli, D. Richter, S. Sgobba, C. Scheuerlein
- 14 April 2005: steering meeting at CERN. CERN participants: T. Boutboul, L. Oberli, C. Scheuerlein
- 7 July 2005: steering meeting at TUW. CERN participants: T. Boutboul, D. Leroy, L. Oberli, S. Sgobba

#### Meetings on mechanical studies:

- 15 February 2005: meeting at CERN to update table of material properties to be used in FE model. Participants: A. Devred (CEA&CERN), T. Boutboul, D. Leroy, C. Scheuerlein, S. Sgobba
- 11 October 2005: meeting at CERN to discuss results of tensile tests performed at BAM (Bundes Anstalt fur Materialforschung) and at EIAJ and to review the table of material properties. Participants: L. Oberli, C. Scheuerlein, S. Sgobba

#### Meetings of the working group on Conductor Characterization:

- 22 February 2005: third Working Group meeting at INFN-Milan  
CERN participants: A. Devred (CEA&CERN), T. Boutboul and V. Previtali
- 3 May 2005: fourth Working Group Meeting at CERN  
CERN participants: T. Boutboul, D. Leroy, L. Oberli

### 3/ PUBLICATIONS

#### List of reports with CERN authors in CARE/NED

| CARE/NED document                             | Title  | Authors                                     |
|---|--|---|
| EDMS-567297                                   | Hardness of the different phase in a non-reacted internal Sn, Nb <sub>3</sub> Sn strand (Alstom 0.825 mm, B15/3762)                                    | C. Scheuerlein                              |
| EDMS-567365                                   | RRR evaluation of copper for MSA/CEA Nb <sub>3</sub> Sn strand before heat treatment   | T. Boutboul                                 |
| EDMS-567375                                   | Best guess on material properties of un-annealed and un-reacted Alstom/MSA-CEA internal-Tin wire (B15/3762)  | S. Sgobba and C. Scheuerlein                |
| EDMS-592009                                   | Ultimate tensile strength (UTS) and E-modulus of the Nb <sub>3</sub> Sn composite wire (Alstom B15/3762) calculated according to the rule of mixtures. | C. Scheuerlein                              |
| NED report                                    | Title  | Authors                                     |
| CERN/AT-MAS 2004-01<br>CARE-Report-04-008-NED | Technical Specification for the Dipole Superconducting Cable of NED Project  | D. Leroy                                    |
| CERN/AT-MAS 2004-22<br>CARE-Report-05-023-NED | Preliminary magnetic designs for large bore and high field dipole magnets  | D. Leroy and O. Vincent-Viry                |
| CARE-Report-05                                | Status of the Next European (NED) activity of the Coordinated Accelerator Research in Europe (CARE) project  | A. Devred, T. Boutboul, D. Leroy, L. Oberli |

Other NED-Documents are kept in :

<http://lt.tnw.utwente.nl/project.php?projectid=9>

### 4/ ACTIVITIES

#### Conductor development

Both firms have started the manufacturing of the billets for Step 1.

During Step 1, SMI has tried to increase the non-copper critical current density of the 192 filament Powder In Tube strand to a value above 2500 A/mm<sup>2</sup> at 12 T. SMI has produced 2 billets using a tantalum barrier around the niobium tube of each filament and 2 billets (called B201 and B205) with a modified powder composition without using a tantalum barrier. The drawing to a diameter of 1 mm of the 2 billets using a Ta barrier was not successful due to a large number of breakages attributed to a poor quality of the Ta barrier. The 2 other billets B201 and B205 were drawn without breakage to a diameter of 1 mm and two unit lengths of 327 m and 320 m were delivered to CERN. A critical current density around 2350 A/mm<sup>2</sup> at 12 T was measured on the billet B201, substantially lower than expected due to Sn leakage occurring at the melting point of Sn. A piece length of 20 m of another billet called B179 was delivered to CERN. On a sample of the billet B179, a critical current density of 2584 A/mm<sup>2</sup> at 12 T was obtained by SMI.

CERN has carried out an extensive program to characterize the strands. A RRR value of 220 was measured on a sample of the billet B179 above the specified NED value. RRR measurements performed on samples of the billet B201 have confirmed the Sn leakage in the copper matrix. The Sn leakage is a consequence of the rupture of the Nb tube. Metallographic strand cross-sections of the reacted strand have permitted to observe a burst Nb tube by optical microscopy, which explains the relatively low critical current density. Same test will be performed on the billet B205 as Sn leakage was also reported by SMI, even if the free Sn content in the powder was decreased compared to the Sn content used in the powder of the billet B201. CERN has also investigated the strand behaviour under heavy deformation to evaluate if the strands are indeed capable to sustain the cabling. Samples of the 2 billets B179 and B201 were rolled down at CERN to flatten the strand from 1 mm to 0.85, 0.75, 0.70

and 0.65 mm. The filament layout was observed by optical metallography of the cross-section of the samples. Whereas the filament layout of the billet B179 rolled to 0.75 mm was severely deformed showing shear fracture planes crossing the filaments, the filament layout of the billet B201 was able to sustain the high unidirectional deformation. More extensive investigations will be launched on samples from billets B179 and B205 to understand how the internal filament layout sustains the deformation by rolling. For the next period, the effort will be focused on the qualification of the final design by using filaments identical to the billet B179 with equal powder composition and with more copper around the filaments as for the billet B201.

For step 1, Alstom has launched 5 types of strand in fabrication following an internal tin process. The different layouts were discussed with CERN with the aim to determine the optimum design to get a good workability and a high critical current. Alstom has encountered few problems in the preparation of the Sn rods used in billet assembly and in the extrusion of the monofilament billets. Solutions have been found and CERN has contributed by performing quality assurance tests on the Sn rods to verify the suitability of the process and acid cleaning of the Nb bars. All intermediate billets have been assembled and drawn. Only one type of intermediate billets with a central Sn core was successfully drawn without breakages to restacked dimension. Alstom has investigated the possible reasons and has decided in agreement with CERN to produce two additional intermediate billets with a modified process. A revised plan for Step 2 is in discussion with CERN to improve the manufacturing process followed for Step 1 and to develop alternative manufacturing process for intermediate billets. The first results of Step 1 are expected for the end of 2005, while those of Step 2 are expected in the summer of 2006.

#### Working Group on Conductor Characterization

CERN has also been involved in the cross-calibration program for  $I_c$  measurements launched by the Working Group on Conductor Characterization made up of representative from CEA, CERN, INFN-Milan, INFN-Genova and Twente University. CERN has followed the cross-calibration of the various test facilities taking into account all the variables and has a major contribution for the data analysis. In order to evaluate the effect of Nb<sub>3</sub>Sn strand deformation during cabling, the different institutes performed a series of critical current measurements on virgin and deformed strands rolled by CERN. A paper reporting on the status of the cross-calibration program was presented at the Magnet Technology Conference in 2005.

#### Finite Element wire model to simulate cabling effects

To simulate the effect of cabling and derive optimum billet layout, an effort has been launched by INFN-Genova to build a Finite Element mechanical model of un-reacted strands. For sake of accuracy, the model requires a detailed knowledge of the properties of the materials that make up strand in their cold work state. CERN has undertaken a literature survey of these properties and has launched a series of nano and micro-hardness measurements on crosscuts of internal tin strand manufactured by Alstom and tensile tests on strands and single Nb-Ta filaments. The data from the various tests has been analysed and crosschecked with available literature data, yielding a summary table of relevant material properties in the cold work state of the strand at the end of drawing. These material properties will be used in the FE model to study the behaviour of the NED strand

## **5/ ACHIEVEMENTS**

The two firms Shape Metal Innovation and Alstom-MSA have started the manufacturing of the strands for the first step of the development programme. Encouraging results have been obtained. Although Alstom-MSA has encountered workability problems during the manufacturing of intermediate billets, the work is progressing well. The first results for Alstom-MSA are expected before the end of 2005. Shape Metal Innovation has achieved a critical current density above 2500 A/mm<sup>2</sup> at 12 T and 4.2 K fixed as a target for step 1 and has started the step 2 of the development of the NED strand.

## 2. DIRAC Secondary-Beams Design Study

### 1/ INTRODUCTION

For the EU design study “DIRAC Secondary-Beams for the FAIR project” CERN is involved in 3 distinct sub-projects briefly described below:

**Task 18 SIS100\_2** regards the study of a Longitudinal Feedback System for the FAIR injector with possible hardware tests to be performed on the CERN PS ring. Task 19 SIS100\_3 is focused on the design and prototyping of a fast semi-conductor RF gap switch. The deliverables of the two tasks are represented by a series of documents reporting about the work of analysis that is being performed and defining a specification for the final system. In the case of Task SIS100\_3 (Fast High-power Switches for RF Gaps) the tests on the prototype will also be documented.

No deliverables are foreseen in year 2005.

**Task 19 SIS100\_3** deals with the prototyping of a fast semi-conductor RF gap switch with low resistance for high voltage RF gaps and high image currents of the beam.

**Task 21 SIS100\_5** addresses the Digital Signal-Analysis Electronics for Beam Position Monitors (BPMs). For the SIS100 at GSI a new type of digital Trajectory and Orbit system is foreseen. This system will consist of

- Fast sampling ADCs (~ 120 MHz sampling rate) directly converting signals coming for beam position monitors (BPMs) around the ring
- Big Field Programmable Gate Arrays (FPGAs) for “on the fly” signal treatment
- Big memories for storage of the beam position values
- Network interface to read out the measure data and digitally treat them further

The PS trajectory and orbit system needs replacement and will be used as a test-bed for the SIS100 installation. Already in 2004 a system similar to the one described above has been used to take test measurements on many different acceleration cycle types on the PS. This system did not perform any online digital signal treatment but simply transferred the converted data into its RAM memory for readout. The measured data have been saved on disk files and were used in 2005 to test signal treatment algorithms off-line.

The signals from the BPMs are converted with a sampling clock asynchronous with respect to the bunch frequency. Within a constant stream of converted signals, the bunches must be found and the sum and difference signals must be integrated over the bunch length and the beam position calculated. This necessitates a digital synchronisation algorithm defining the integration gates. Due to variable revolution frequency and changes in harmonic number, these integration gates must be adjusted on the fly.

### 2/ MEETINGS

#### Project Kick-off Meeting GSI Darmstadt

The project kick-off meeting for the FAIR project was held at GSI Darmstadt 14-15 April.

The work packages related to the tasks 18 and 19 have been defined and their sharing between CERN and GSI decided. The Task Leader (GSI) has presented two documents on that occasion:

<http://www.gsi.de/documents/DOC-2005-Apr-66-1.ppt>

<http://www.gsi.de/documents/DOC-2005-Apr-67-1.ppt>.

GSI takes care of the theoretical investigation that is preliminary to the design study on Task 18 SIS100\_2 and will be responsible for the work of development on the signal processors for the longitudinal feedback, while CERN makes its experience available to the study group and will perform specific studies in the PS aimed to possibly realize a prototype system to be operated there.

For Task 21 SIS100\_5 U. Raich presented the results from preparatory work already done in 2004 and beginning 2005 and gave a tentative schedule for the project.

<http://www.gsi.de/documents/DOC-2005-apr-69-1.ppt>



For Task 21 SIS100\_5 two additional meetings have taken place:

- **Collaboration Meeting at Solkan, Slovenia on May 10-11 May**

J. Belleman presented a progress report describing signal treatment algorithms developed by him at CERN and results on the application of these algorithms on data measured in 2004 on the CERN PS and at GSI.

- **Collaboration Meeting at CERN on 17/18 November**

At this meeting progress reports are expected as well as planning activities. At the beginning of next year we hope to be ready with the first implementations of our signal treatment algorithms such that they can be tested during a machine development session once the PS is restarted.

### 3/ PUBLICATIONS

For Task 21 SIS100\_5 preliminary results have given rise to two publications at the European conference on beam instrumentation, DIPAC June 6-8 2005 in Lyon. The first one was a poster while the second one was a contributed talk.

| Notes                       | Title  | Authors   |
|-----------------------------|--|---|
| AB-Note-2004-050 BDI        | Using a Libera signal processor for acquiring position data from the PS orbit Pick-Ups | J.Belleman  |
| AB-Note-2005-015 BDI        | The Libera as a PS orbit measurement system building block                             | J.Belleman  |
| <b>Conferences</b>          |  |   |
| To be published<br>DIPAC05  | Digital Beam Position Measurement at GSI-SIS and CERN-PS                               | A.Galatis, A. Peters (GSI, Darmstadt), J. Belleman, U.Raich (CERN), A. M. Zoubir (TU Darmstadt) |
| CERN-AB-2005-059<br>DIPAC05 | A New Trajectory Measurement System for the CERN Proton Synchrotron                    | J.Belleman  |

### 4/ ACTIVITIES

#### ***Task 18 SIS100\_2***

The task 18 SIS100\_2 in 2005 the activity dealt with the preparation work. Among the essential steps one was the recruitment by GSI of personnel to drive the studies.

#### ***Task 19 SIS100\_3***

As for Task 19 SIS100\_3 GSI is in charge of the specification work and will perform one part of the tests on the prototype, while CERN will complete the tests on the prototype for the complementary frequency range and perform radiation hardness studies during PS runs.

During the month of October Monika Mehler, a GSI staff member expressly recruited to work on both tasks 18 and 19 by GSI, has visited CERN. A series of meetings has been organized with the participation of CERN experts to introduce her to the fundamentals of the multibunch instability and to discuss the relevant issues related to the operation of RF gap switches. During the conclusive meeting, a strategy on a 12-month basis has been defined for both Tasks.

#### ***Task 21 SIS100\_5***

During 2005 first versions of the digital synchronization algorithms have been developed and tested on the data measured in 2004. First attempts of implementing parts of these algorithms in VHDL for simulation on the target FPGA have also been made. During 6 months we employed a technical

student in mathematics and electronics (M. Stuckert) to test these algorithms, find their strength and weaknesses and propose new solutions.

In addition new front-end electronics for the PS beam position monitors have been developed and tested. This will allow extending the orbit measurements to ion beams. We intend to install these front ends during the shutdown 2005/2006.

For the purchase of the digital signal electronics we proceeded along normal CERN purchase rules. In collaboration with the purchase office a market survey has been prepared in order to find companies capable of delivering the needed electronics as well as having the competence to implement the needed algorithms. Then the “call for tender” documents have been written and controlled by the specification committee. This procedure is unfortunately still not entirely completed and it took much longer than we initially expected.

## **5/ ACHIEVEMENTS**

The first deliverable for Task 18 SIS100\_2 is foreseen within 31 August 2008, while the first deliverable for Task 19 SIS100\_3 is foreseen on 1<sup>st</sup> February 2007.

For Task 21 SIS100\_5 experimental data have been taken during runs at the CERN PS and GSI SIS18 already in 2004. Synchronisation and signal treatment algorithms have been developed and tested offline on these data. It could be shown that a digital phase locked loop was capable to lock onto the bunch frequency. Baseline correction and signal integration was also demonstrated even though several problems remain. We started to implement these algorithms in VHDL such that they can be programmed in the FPGA but found problems due to the very high speed required. Work on improving the quality of the algorithms as well as ease of implementation is ongoing.

# 3. EURISOL Design Study Activities

## 1/ INTRODUCTION

The EURISOL DS is aimed at producing feasibility studies and performing technical preparatory work of the most critical parts of the future EURISOL facility. The main technical challenges and the necessary prototyping were identified during the EURISOL RTD in the 5th framework (FP5). This design study is part of the roadmap towards the EURISOL facility and cross-fertilization is expected between the design study and the design and construction of the so-called "mid-term" facilities. A conceptual design study for an associated beta-beam facility, which can benefit from the prototyping work concerning the RIB (Radioactive Ion Beam) facility, is an integral part of the DS proposal.

During 2005, the CERN contribution can be summarized as

- Leading three of the EURISOL tasks (Multi MW target station, direct targets and beta-beam)
- Organization, hiring and management of three task teams with in total 5 FTE/year paid by EU working at CERN
- Organization of 9 task meeting at CERN
- Work with seven of twelve EURISOL tasks with published (internal and external) results
- Contributions to the management of EURISOL
- Contributions to management boards, steering committee meeting and coordination board meetings
- Contributions to task meetings

## 2/ MEETINGS

**Coordination board meeting, Steering committee meeting and Management Board Meeting, 3-4 February 2005, Orsay**

**Management Board Meeting, 18-19 April 2005, Montagnana, Italy**

**Coordination board meeting and Management Board Meeting, 17-18 July 2005, Liverpool, UK**

**Management Board Meeting, 3 October 2005, CERN**

**Topical restricted MB meeting with target tasks, 10 November 2005, CERN**

**Task 2, 3 and 4 Kick-off meeting, 10-11 March 2005, CERN**

Presentations:

- General Introduction, J. Lettry, CERN
- Introduction for the 100kW direct targetry meeting, J. Lettry, CERN
- Visualization of complex irradiation schemes, M. Eller, CERN
- General introduction task 2, Y. Kadi
- Preliminary Calculation from CEA-Saclay, Y. Kadi on behalf of D. Ridikas, CEA
- Preliminary Study of the MMW Hg Target, A. Herrera-Martínez, CERN

**Task 2, 3, 4 and 5 meeting, CEA Saclay, France**

Presentations:

- Task 2: General Info, *Y.Kadi* CERN
- Task 2: Multi-MW Target Design, *A. Herrera-Martínez*, CERN
- Task 3: direct target, *J.Lettry*, CERN
- Task 5: Preliminary results of the validation of Monte-Carlo code FLUKA for activation calculations, M. Felcini, UCLA and CERN
- Task 3: Overview on Task #3, T. Stora

**Task 5 Kick-off meeting, 28-29 January 2005, CERN**

Presentations:

- Introduction to Subtask 1 (Radiation, activation, shielding) Th. Otto, CERN

**Task 5 “Monte-Carlo” Meeting, 7-10 June 2005, CEA Saclay**

- Discussion and determination of reference parameters for the validation study of Monte-Carlo codes for activation and shielding calculations

**Task 7- Proton Accel.-Task meeting n. 1, 30 March 2005, Laboratori Nazionali di Legnaro**

**Task 2 and 3 meeting, PSI, Switzerland**

Presentations:

- Joint EURISOLDS T2-T3 meeting for the EURISOLDS T3 CERN workgroup, T. Stora
- Direct Target Irradiation, T. Stora, CERN
- T2 General Information, Y. Kadi, CERN
- Results of the Baseline Multi-MW Hg Target A. Herrera-Martínez, CERN
- T2 Discussion, Y. Kadi, CERN

**Task 9 kick-off meeting, 18 February 2005, CERN**

Presentations:

- General presentation of the task by Ari Jokinen
- Different presentations of the subtasks by the participants
- EURISOL High Resolution Separator
- Ion cooling and bunching
- Charge breeding
- The 60 GHz ion source for the beta-beam project

**Task 9 and 11, 6 July 2005, CERN**

Presentations:

- Project overview, P. Butler, CERN
- Presentation of the Task 11 deliverables, P. Delahaye, CERN
- The ISOLDE yield database completion, U. Koester, CERN
- Presentation of the Task 9 deliverables, P. Delahaye
- The ion cooler ISCOOL, Ivan Podadera, CERN
- The EURISOL High Resolution Separator, Tim Giles, CERN
- The Phoenix ECR charge breeder, P. Delahaye
- The 60 GHz ion source for the beta-beam project, M. Lindroos, CERN

**Task 9 RFQ cooler meeting at ISOLDE, 21 September 2005, CERN**

Organization of the ISCOOL ion cooler project at ISOLDE

**Task 12 Meeting on RCS parameters and FFAG options for low energy stage, 10 February 2005, Orsay**

**Task 12 Meeting with Task 9 on the use of the EURISOL post accelerator for the beta-beam, 7 March 2005, Orsay**

**Task 12 Meeting on post accelerator issues and decay ring optical design, 6 April 2005, Orsay**

**Task 12 1st Beta-beam task meeting, 14 April 2005, CERN**

Presentations:

- Introduction, M. Benedikt
- Ion intensities along the complete chain, M. Lindroos
- Preliminary parameters (RCS to decay ring), S. Hancock
- Targets, parameters, status, planning, J. Lettry

**Task 12 2nd Beta-beam task meeting, 17 October 2005, SACLAY**

Presentations:

- Introduction and status, M. Benedikt

- Parameter list, A. Fabich
- Decay losses in RCS, PS and SPS, A. Fabich
- Intensity limitations for the base line design, S. Hancock

### 3/ PUBLICATIONS

#### List of reports with CERN authors in EURISOL DS

| EURISOL DS NOTE                      | Title  | Authors and Labs  |
|--------------------------------------|--|---|
| EURISOL DS/TASK2/TN-05-01            | EURISOL Multi-MW Target: Preliminary Study of the Liquid Metal Proton-to-Neutron Converter                 | A.Herrera-Martinez, Y.Kadi (CERN)   |
| EURISOL DS/TASK2/TN-05-02            | EURISOL Multi-MW Target: Baseline Parameters   | A.Herrera-Martinez, Y.Kadi (CERN)   |
| EURISOL DS/TASK2/TN-05-03            | EURISOL Multi-MW Target: Neutronic Calculations for the Baseline Design of the Proton-to-Neutron Converter | A.Herrera-Martinez, Y.Kadi (CERN)   |
| EURISOL DS/TASK2/TN-05-04            | Baseline Design of a Solid Neutron Converter Driven by 160 MeV Protons                                     | A.Herrera-Martinez, Y.Kadi (CERN)   |
| TASK3 - (not numbered yet)           | Irradiation of prototype target samples at PSI   | T. Stora, E. Noah, E. Bouquerel, M. Eller, S. Marzari, S. da Visitacao Fernandes (CERN)               |
| TASK9 - Rev. Sci. Instrum., in print | Recent results with the Phoenix Booster at ISOLDE  | P. Delahaye et al., CERN and institutes from the IS397 collaboration                                  |
| TASK9 - Rev. Sci. Instrum., in print | The REXEBIS charge breeder as an operational machine   | F. Wenander et al., CERN  |
| EURISOL DS/TASK12/TN-05-04           | Accumulation in a ring at low energy for the Beta beam   | A. Källberg (MSL, Stockholm) and M. Lindroos (CERN)   |
| EURISOL DS/TASK12/TN-05-01           | Parameter and Intensity Values, Version 1, April 2005  | M. Benedikt, A. Fabich, S. Hancock, M. Lindroos (CERN)  |
| EURISOL DS/TASK12/TN-05-03           | Parameter and Intensity Values, Version 2, July 2005   | M. Benedikt, A. Fabich, S. Hancock, M. Lindroos (CERN)  |
| EURISOL DS/TASK12/TN-05-02           | Possible ways of increasing the number of (anti-) neutrinos from the EURISOL Beta-beam facility            | M. Lindroos (CERN)  |
| TASK12                               | A Novel Scheme for Injection and Stacking of Radioactive Ions at High Energy                               | M. Benedikt, S. Hancock (CERN) Nuclear Instruments and Methods in Physics Research A 550, 1-5 (2005). |
| TASK12                               | Beta-Beam Research and Development in Europe.  | M. Benedikt (CERN) Nuclear Physics B 149, 54-59 (2005).   |

### 4/ ACTIVITIES

The EURISOL DS started 1 February 2005. The first half of the year was mainly spent on organizational matters such as adapting work objectives for CERN staff, advertising and hiring of new staff paid by the EU, local administrative matters and training of the new staff members and fellows. In one case, for the multi-MW target station task, the task leader retired during the contract negotiation phase and his replacement was only appointed after the official start date of the contract. The new leader, Y. Kadi, is a well recognized expert in the field of high power targets for neutron physics but had in a short time to not only learn all about EURISOL but also to plan and organize the work of one of the key EURISOL tasks.

The second half of the year has been very productive with many inventive and explorative notes published. The preparation for planned prototyping and material testing is well under way and first results will be available in 2006. First results from simulations runs in programs like FLUKA are already available and many more are coming.

The administrative overhead is heavy but difficult to avoid as the study has 21 participating institutes spread all over Europe. The support offered by the CERN EU office is highly appreciated.

CERN participates in the following tasks:

### **Task 1, Management**

The ISOLDE project leader and is based in Legnaro in Italy and has an administrative support team locally to manage the daily administrative work within the study. The technical coordinator is based in Caen in France, as GANIL is the coordinating institute of the design study. The management team has with the project leader four members based at CERN, Orsay and University of Liverpool with the responsibility for the detailed follow up of tasks geographically close to them. The management board meets four times a year to discuss the work progress based on "simple one page" work progress reports from the task leaders. The coordination board brings task leaders and management board together three times a year with the BENE and HIPPI coordinators participating if they find the topics on the agenda of interest. Restricted topical meeting between task leaders and management is organized on a need basis, one such meeting was recently held at CERN to strengthen the coordination between the target tasks and agree on priorities for the shared work between task 2 and 4 on the multi-MW target (neutron converter and Uranium Carbide target design). The EURISOL DS web site is finally coming into operation, <http://eurisol.org>.

### **Task 2, Multi MW target station**

A sensitivity study has been performed with respect to the particle type (proton vs. deuteron), beam energy (1, 2 and 3 GeV) and beam profile (parabolic vs. Gaussian vs.  $\sigma$ ). This has led to the establishment of a **reference parameters list**. As a result of this a preliminary conceptual design of the MMW Hg converter and nearby structures (target vessel, fission target, BeO target, reflector) has been proposed. First estimates of the energy deposition, n-flux distribution and spallation product yields in the Hg target have been obtained together with an evaluation of the radiation damage to the target vessel. Fission product yields have been calculated for several UC target composition at different locations around the Hg converter, and corresponding  $^6\text{He}$  production from a dummy BeO target. In parallel a detailed characterisation of an Hg jet configuration has been performed and compared in terms of performance with the baseline design proposed initially. Consequently, and taking into account the results of the preliminary integration study performed by **Task#4**, CERN proposes an intermediate solution (similar to the baseline design but with a reduced radius of 8 cm) which exhibits the same performances as the jet and can still be cooled in a "conventional way" (to be confirmed). This solution enables an easier integration of the fission target the volume of which might be reduced by an order of magnitude (to be confirmed). It was decided to propose a more conventional target design similar to those proposed for ESS and SNS spallation neutron sources. The idea of a windowless, small-diameter proton-to-neutron converter (Hg jet) similar to the one planned for the neutrino factories is considered to be very challenging from the engineering point of view and is set aside for the moment (backup solution). Such a deviation from the original plan is the only possibility for the participants to make progress with the engineering design of the Multi-MW target assembly of which a prototype should be constructed and extensively tested off-line.

Studies are being carried out in collaboration with **Task#5** to define the requirements for radiation protection of the multi-MW power target station and to propose options for the minimization of dose rates, activation, material handling and interventions, during and after operation.

### **Task 3, Direct Target**

Task 3 is addressing in this first part of the project specific key elements contributing to the design and feasibility of the 100kW direct target stations. It is also integrating the necessary skills and tools, which will be used for the rest of the project. This includes the definition of yearly revised baseline parameters, R&D development on ion sources, on effusion properties, and on innovative target materials. For this last point, collaboration with St-Gobain European R&D centre has been established. Finally aspects on operation and waste disposal, direct target aspects for the beta beam are under consideration.

Eurisol operations will be extremely demanding for target materials and their lifetime is a critical issue to address. Irradiation at PSI-LISOR and analysis will be undertaken, starting mid 2006. Its preparation is well advanced with the design of the test jig by numerical simulations tools.

### **Task 5, Safety and Radioprotection**

At CERN, calculations have been performed to validate the FLUKA Monte-Carlo code for calculations of radioactive inventories.

Published experiments for the determination of production cross sections of isotopes in spallation reactions with protons of energies between 300 MeV and 1.8 GeV were reproduced in Monte-Carlo calculations. The calculated cross sections thus obtained were compared to the published data.

For light targets, the agreement between published experimental data and Monte Carlo simulations is satisfactory. For heavy target materials, such as Au, Pb or U, some areas of improvement of the code were identified. Parameters in the Monte Carlo code will be adjusted to obtain a more satisfactory agreement.

Estimates for activation and shielding of the target stations have begun after a preliminary layout became available from task 2 (Multi-MW target station). Tasks 3 and 4 are supposed to submit preliminary layouts of their proposed target stations by end of 2005.

### **Task 9, Beam Preparation**

CERN-ISOLDE occupies a central place in the projects associated to task 9. It concerns the study and development of charge breeding techniques, of ion cooling techniques, of a high-resolution separator, and the 60 GHz ion source project needed for the beta-beam project. Here is a short summary of the last period achievements:

- The ion cooler ISCOOL is being assembled and will be soon ready for the first off-line tests.
- The ECR charge breeder tests have been continued this year and the first tests with the pulsed mode (“afterglow” mode) have been started.
- Advanced techniques of charge breeding with the REXEBIS, continuous injection and shell closure effects, have been tested.
- The High Resolution Separator primary design has been defined and will be refined in the next two years by detailed beam calculations.

In general the different projects associated with task 9 are progressing according to the schedule. The deliverables, which concern the refinement and comparison of different beam preparation techniques, will be most likely reached in time.

### **Task 11, Beam Intensity Calculations**

Even the contribution of CERN-ISOLDE is not central in this task, it is however of primary interest for its contributors. The ISOLDE yield database provides the other contributors with results that they can compare to their calculations. This task is progressing according to the schedule so that the ISOLDE yield database will be extended before the end of January 2006. The second and last deliverable concerning CERN-ISOLDE is the extrapolation of the measured release efficiency data to the EURISOL-type targets. It will be undertaken during the coming months. Up to now it is expected that this deliverable will be reached in time.

### **Task 12, Beta Beam Aspect**

CERN has provided the task leader and has coordinated the activities of all six institutes participating to the Beta-beam task. This included the scientific coordination as well as the organization of two general task meetings (04/2005 and 10/2005) and the organizational link to the EURISOL Design Study.

Major scientific contributions from CERN to the Beta-beam task were:

- The development and optimization of the base-line design for the beta-beam accelerator chain and the establishment of the corresponding parameter list.
- An estimation of beam losses and their impact for the PS and SPS machines with a comparison to CNGS operation.
- The development of a new technique for stacking of ions in a high-energy storage ring.

- An analysis of the potential performance improvement by adding a low-energy accumulation and cooling ring to the accelerator chain.

## 5/ ACHIEVEMENTS

The deliverables and milestones are listed in the following Table. The time of their achievement is given in months after the beginning of the project (01.02.2005). Two milestones for task 2 have not yet been achieved due to a change in the task organization and planning. The hiring of staff paid by the EU suffered delays because of the late availability of the funds. The work is now making very good progress and the task leaders estimate to achieve the missing milestones before the end of the year.

### List of deliverables achieved in 2005 with CERN participation.

| <b>Deliverable/<br/>Milestone</b> | <b>Deliverable/Milestone Name</b>   | <b>Work-<br/>package</b> | <b>Planned<br/>(in months)</b> | <b>Achieved<br/>(in months)</b> |
|-----------------------------------|---|--------------------------|--------------------------------|---------------------------------|
| D1/M0                             | Determination of neutron flux angular and energy distributions, radiation damage, heat deposition and spallation product distributions for different configurations | T2                       | 4                              | 9                               |
| D1/M1                             | Determination of the Hg flow rates, pumping power, heat exchanger size and cavitation limits.   | T2                       | 7                              |                                 |
| D1/M2                             | Report on the evaluation of the feasibility of a windowless configuration   | T2                       | 9                              |                                 |
| M1.1                              | Validation of Codes   | T5                       | 6                              | 12                              |
| M1.2                              | Radiation & activation estimates  | T5                       | 12                             | 18 (est.)                       |
| M1.1                              | Parameter list for beta-beam baseline design.   | T12                      | 4                              | 8                               |
| M3.1                              | Freeze input parameters input parameters ion acceleration in PS and SPS   | T12                      | 9                              | 9                               |



## 4. EURONS Joint Research and Transnational Access Activities (I3)

### 1/ INTRODUCTION

Since January 1st 2005 CERN-PH-ISOLDE is via the EURONS activity engaged in the transnational access program as well as in several Joint Research Activities (JRAs) within the sixth framework of the European Union. The JRAs with CERN-ISOLDE participation within EURONS are the following:

Charge breeding (J03): The project aims at narrowing charge state distributions from charge breeders, to optimize beam purification, to compare breeding measurements from both ECR and EBIS sources and to optimize the transverse and longitudinal emittance of the extracted beams.

Intag (J06): The goal of Intag (Instrumentation for Tagging) is the study of exotic nuclei, including heavy nuclei, which are identified by electromagnetic separation and/or by observing the characteristics of their radioactive decays in the focal plane of separators.

Laser (J08): The objective is to develop tools and perform R&D for the Resonance Ionization Laser Ion Source (RILIS) in order to produce pure ground-state and isomeric beams of exotic nuclei, to develop in-source laser spectroscopy of short-lived nuclei and to accumulate, cool, bunch and polarize radioactive ion beams.

Saferib (J11): Addresses safety aspects of RIB production targets.

Trapspec (J13): To design multi-purpose set-ups for precision experiments in decay spectroscopy which combine ion traps and detectors as well as the development of retardation spectrometers for high-resolution and precision recoil ion spectroscopy.

The transnational access program gives financial support for the participation of users in experiments at ISOLDE and has since July 1, 2005, provided user support in the form of physics expertise for users of the facility (in particular REX-ISOLDE) as well. In respect to the JRAs CERN has organized and participated in meetings as well as actively performed R&D according to the milestones defined in the projects. The project started in 2005 and many milestones are thus scheduled to be met in 2006 or later.

### 2/ MEETINGS

#### 2.1 General

##### **EURONS, First PCC meeting, Funchal, 8-9 February 2005**

The project coordination committee (PCC) is constituted of all activity coordinators and the EURONS coordinator/managing team and supports the EURONS coordinator in all management issues. It meets twice per year.

##### **EURONS, First GA and second PCC meeting, Bordeaux, 29-30 September 2005**

The general assembly (GA) is constituted by one representative of each participating laboratory (1 CERN participant). The GA ensures the feedback to the community at large and monitors the progress of EURONS. It approves the annual working plan, budget relevant matters, changes in the structure (including the involvement of new partners or the withdrawal of participants) and in the consortium agreement.

## 2. 2 Transnational access related

### **NUPAC: Nuclear Physics and Astrophysics at CERN, CERN, Oct. 10-12, 2005.**

The meeting was organized by the ISOLDE and NTOF physics and technical teams in order to give external scientists the opportunity to present their research activities and discuss plans for future initiatives to the INTC. Possible upgrades of the ISOLDE and NTOF facilities as well as the CERN proton injectors were also discussed. Based on the meeting INTC will present a report to the CERN research board on the direction of the future experimental program at ISOLDE.

### **ISOLDE workshop and Users Meeting, CERN, Feb. 6-8, 2006**

The meeting provides the opportunity for a yearly follow up of the physics results from ISOLDE in the form of presentations given by external physicists as pertains to their results. Local physicists provide information on current status of the machines and future plans are discussed. The meeting is organized by the ISOLDE physics group. The local EURONS project coordinator (J. Cederkall) is scientific secretary for the meeting.

### **Nuclei in the Cosmos IX Summer School, CERN, June 20-25, 2006**

The ISOLDE and NTOF teams at CERN will organize in 2006 the Nuclei in the Cosmos IX conference. A summer school for young physicists is planned to take place at CERN prior to the meeting. This activity is partly intended to provide training for potential new users of the facility in accordance with the long term planning for the physics program. The local EURONS project coordinator will chair the organizing committee of the school.

## 2.3 JRA related

### Charge breeding

#### **EURONS, EURISOL-DS combined meeting, 14, September 2005, GANIL, Caen**

Status reports on different tasks from involved institutes. 2 CERN participants, 1 of those related to EURONS (1 related to EURISOL-DS), Presentation by F. Wenander on REXEBIS status, in particular accu-mode measurements.

### Intag

#### **Recoil separator subtask meeting, 21-22 November 2005, CERN,**

The meeting draws together experts in recoil separator design and related experiments to establish the design criteria for a recoil separator after REX-ISOLDE. The meeting is co- organized by Liverpool University, the Weizmann Institute and the CERN-ISOLDE physics group.

### Laser

#### **First Annual Workshop, 17-18 March 2005, Leuven, Belgium (1 CERN participant)**

The meeting was of 'kick-off' type and brought together experts from different laboratories to discuss current status of laser ionization equipment and methods. The task and deliverables as well as the milestones were discussed during the second day of the meeting.

#### **Poznan workshop, May 29- June 01, 2006, Poland**

Agenda not yet prepared.

### Saferib

#### **SAFERIB, Kick-off meeting (combined with EURISOL-DS), 28-29 January 2005, CERN**

Introduction to subtask 1, radiation, activation and shielding. Contribution by Th. Otto

#### **SAFERIB "Monte-Carlo" meeting (with EURISOL-DS), 28-29 June 2005, CEA, Saclay**

Discussion and determination of reference parameters for the validation study of Monte-Carlo codes for activation and shielding calculations. Th. Otto, CERN participant.

#### **SAFERIB Progress meeting (with EURISOL-DS), 27-28 October 2005, CEA, Saclay**

Characterization of ISOLDE targets as radioactive waste, Th. Otto, CERN

Trapspec: only local working group meetings at CERN during 2005.

## 3/ PUBLICATIONS

### 3.1 General

The EURONS documents are available under the following URL:

<http://www.gsi.de/informationen/jofu/EURONS/>

### 3.1 Transnational access related

<http://isolde.web.cern.ch/ISOLDE/> Follow link to EC support.

The REX-ISOLDE facility. Design and Commissioning Report. Two CERN affiliated editors and contributors. J. Cederkall and F. Wenander. CERN-2005-009.

Publications of this years physics results are on the way.

### 3.2 JRA related

Charge breeding:

<http://www.ha.physik.uni-muenchen.de/jra03cb/>

Recent results with the Phoenix Booster at ISOLDE, P. Delahaye et al.  
Rev. Sci. Instrum., in print.

The REXEBIS charge breeder as an operational machine, F. Wenander et al.,  
Rev. Sci. Instrum., in print.

Intag:

<http://www.lnl.infn.it/~intag/>

Saferib:

<http://www.ha.physik.uni-muenchen.de/saferib/>

<http://proj-saferib.web.cern.ch/proj-saferib/>

Radiation Protection Issues for a Beam Power upgrade of the ISOLDE facility, A. Dorsival,  
Th. Otto. CERN-SC-2005-029-RP-IR

Radionuclide characterization studies of radioactive waste produced at high-energy  
accelerators. L. Ulrici, M. Brugger, Th. Otto, S. Roesler, Proceedings, AccApp'05, Venice,  
Italy

Trapspec:

ISOLTRAP pins down masses of exotic nuclides. Authors including: A. Herlert, P. Delahaye,  
A. Kellerbauer J. Phys. G: Nucl. Part. Phys. 31, S1775-S1778 (2005)

Mass spectrometry of atomic ions produced by in-trap decay of short-lived nuclides.  
Authors including: A. Herlert, P. Delahaye, A. Kellerbauer, New J. Phys. 7, 44 (2005)

## 4/ ACTIVITIES

### 4.1 Transnational access related

The activity has so far included providing expert advice for physics users of the REX ISOLDE post-accelerator and associated equipment. A user reference group has been set up and a local working group has been created in order to process the feedback from the reference group. The aim is to facilitate coherence in the expansion of the REX physics program in line with user requirements as the facility is upgraded. The local working group has had two meetings during 2005. A third meeting is planned for the end of the year. The reference group is foreseen to meet in connection to the ISOLDE users workshop in February 2006. The transnational access program has also provided local expert supervision for infrastructure improvements. The task includes data acquisition system renovation and related user support as well as work on improvement of beam properties as requested by users. Experiments financially supported by the transnational access program during 2005 were as follows:

IS360, IS367, IS368, IS378, IS390, IS401, IS405, IS407, IS411, IS412, IS413, IS414, IS415, IS423, IS426, IS427, IS428, IS429, IS430, IS432, IS434, IS435.

For a description of the experiments under respective heading refer to the ISOLDE webpage and links thereon (given above).

### 4.2 JRA related

Charge breeding: The tasks include modifications of charge state distributions and electron beam adjustment, exploration of di-electronic recombination, cooling of highly charged ions and emittance improvements. For these tasks the first tests of charge breeding at atomic shell closures have been started as well as the generation of isobaric pure beams using molecule break up. In addition, the continuous mode injection into the REXEBIS, the so-called accu-mode operation has been tried, with surprisingly high efficiency of 2% in one charge state. Here the beam has been shot through the Penning trap without any cooling. In comparison to tests with Dione at Saclay, this test is a real step forward in efficiency of the accu-mode. Thus at high ion beam intensities, the Penning trap bottleneck could be overcome. However the small transverse acceptance of the EBIS requires that the beam is prepared in a single pass cooler, which will be installed at ISOLDE. The work has during 2005 been carried by CERN personnel with 1-2 persons active within the project over the year.

Intag: The tasks include the design of emittance meters and upgrade of the ISOLDE HRS, use of beam cooling and providing of accelerated radioactive ion beams e.g. for experiments using recoil separation techniques after post-acceleration in REX-ISOLDE. The design of a new offline separator is underway. The work is carried by CERN personnel (1 person). Plans exist to hire one person within the project budget for the main activity directed towards improving the mass resolution of the HRS but no personnel have yet been hired for the task. Plans for 2006 include continuation of the design of the offline separator as preparatory work for the HRS design. The RFQ cooler will be mounted in a test bench, at the CERN site, where all parts of the system as well as beam injection will be tested.

Laser: The tasks are the establishing of new laser ionization schemes for new beams, including the preparation of a new laser spectroscopy laboratory. This work is ongoing. The second task is the improvement of the selectivity of the RILIS. This includes the reduction of surface ionized components of the beam. Off-line tests are planned for 2006 in collaboration with Mainz University for this task.

Saferib: CERN SC-RP was in 2005 engaged in the work addressing the migration of radio-activity and the deliverables; reliability of codes for production cross sections of isotopes and monitoring of contamination from an ISOL RIB targets. Reports are planned for 2006.

Trapspec: The first task to install the new CDEM detector within the trapping system has been completed during the year. After a successful test, the new Channeltron detector has been applied at CERN-ISOLDE. The first results show a single-ion detection efficiency of nearly 100%. This allows true single-ion sensitivity. Secondly the production of radionuclides by in-trap decay of short-lived nuclides has been demonstrated successfully. The demonstration of the decay method for refractory elements is planned for 2006.

## **5/ ACHIEVEMENTS**

### **5.1 Transnational access related**

Milestones and deliverables achieved during 2005 (corresponding set in 2006):

M-TA08-1.1 Web site operating – 02/05 achieved

M-TA08-1.2 Call for users – 04/05 achieved

M-TA08-1.3 Meeting of user selection panel – 05/05 achieved

D-TA08 -1.1 Access report 2005 – to be delivered 01/06

Experiments carried out by supported groups according to list above. The establishing of the physics program for REX-ISOLDE at the upgraded energy (~3 MeV/u) and of a local working group and a physics reference group for definition of program requirements for further upgrades to 5 and 10 MeV/u.

### **5.2 JRA related**

Milestones achieved or to be achieved until end 2006

Charge breeding:

M-J03-1.4 Exploration of enhancement of efficiency in one charge state – planned for 11/06

M-J03-1.6 New gun design and tests at REXEBIS – planned for 8/06

M-J03-3.4 Emittance measurements at REXEBIS for different charge states- planned for 6/06

M-J03-5.3 Measurements of beam purification with radioactive beams - planned for 12/06

Intag:

M-J06-2.1 Design of upgrade of HRS - 6/06

Laser:

M-J08-2.1 - New laser ionization schemes tested with stable isotopes - planned for 01/06.

M-J08-4.1 - Off-line test with different cavity materials – planned for 06/06.

Saferib:

M-J11-2.1 Identification of radiologically important isotopes – 6/05 achieved

M-J11-2.2 Calculations of cross sections and production rates – 9/05 achieved

M-J11-2.3 Comparison of calculated and measured production rates – 11/05 achieved

M-J11-2.4 Isotope-specific analysis of contamination – 5/05 achieved

M-J11-2.5 Developments for sampling – planned for 6/06 - achieved

Trapspec: Milestones achieved or to be achieved

M-J13-2.1 Test of electronics and vacuum system – 8/05 achieved

M-J13-2.2 Test of software – planned for 5/06 - achieved

M-J13-2.3 Test and specification of CDEM detector – planned for 8/06 - achieved

M-J13-2.4 Publication of results – planned for 2/07 - achieved

M-J15-2.5 Specification of the in-trap decay method – planned for 8/07 - partly achieved

# 5. EUROTeV Design Study Activities

## 1/ INTRODUCTION

The design study EUROTeV addresses R&D issues common to the ILC and CLIC. It started 1st January 2005 and will end 31st December 2007. The first main milestone has been to develop a detailed work plan in the middle of 2005. The next main milestone is to have completed a first round of studies in the middle of 2006, which will lead to an updated work plan. The final results are expected for middle of 2007 and a summary document will be delivered by the end of 2007. For more information see <http://www.eurotev.org>.

Within EUROTeV, CERN is participating in the work packages addressing the damping ring, the beam delivery system, the instrumentation and the luminosity performance; CERN also contributes to the management; in the form of one of the two scientific coordinators and the leader of the beam dynamics work package (ILPS).

While strong synergy exists between ILC and CLIC oriented work in EUROTeV, it is often necessary to make an additional effort to improve the solutions for ILC to be also sufficient for CLIC. In most cases this needs to be done by the CERN team. The ILC oriented work needs to be integrated into the framework set by the GDE, which does not cover the more CLIC oriented studies.

## 2/ MEETINGS

Two main meetings were of highest importance for EUROTeV. A number of smaller meetings, on the level of the tasks or work packages have also been taking place.

**The ELAN/EUROTeV/BDIR workshop in London (4-6 May 2005)** The workshop aimed to finalize the EUROTeV work plan and was a preparation for the second ILC Accelerator Workshop at [Snowmass 2005](#). Results of CERN studies for CLIC and ILC have been shown and the work plan of all tasks has been presented.

**Second ILC workshop in Snowmass, Colorado (August 2005)** The aim of the workshop was to collect the input for the reference base line document that should be available at the end of the year and to define the further R&D needed. Also the GDE was formed, which will coordinate the worldwide ILC effort to which EUROTeV is a very significant European contribution. First results of CERN contributions to the ILC have been shown.

## 3/ PUBLICATIONS

The work for EUROTeV has been documented in a number of publications. The EUROTeV reports and memos are listed below.

| Reports        | Title   | Authors                         |
|----------------|---|---------------------------------|
| 2005-001-1     | Multi-bunch Simulations of the ILC for Luminosity Performance Studies | G. White, D. Schulte, N. Walker |
| 2005-004-1     | Different Options for Dispersion Free Steering in the CLIC Main Linac | D. Schulte                      |
| 2005-006-1     | Luminosity Tuning Bumps in the CLIC Main Linac                        | P. Eliasson, D. Schulte         |
| 2005-012-1     | Electron Cloud Build-up Study for DAFNE                               | C. Vaccarezza et al.            |
| 2005-016-1     | Study of Incoherent Pair Generation in GUINEA-PIG                     | C. Rimbault et al.              |
| 2005-021-1     | Dispersion Free Steering and Tuning Bumps in the ILC Main Linac       | P. Eliasson, D. Schulte         |
| In preparation | Aims and Initial Progress of TPMON Task                               | A. Anersson, J. Sladen          |
| In preparation | Electron Cloud in Wigglers  | F. Zimmermann et. al            |
| Memos          | Title   | Authors                         |
| 2005-004-1     | Beam-beam Simulations of the Proposed ILC Parameters                  | D. Schulte                      |
| In preparation | Status of the Halo and Tail Generation Task                           | H. Burkhardt                    |

A work plan has been written for each task in which CERN is involved. This remains to be published by the EUROTeV management as a single integrated report; the ILPS part of the work plan can be found at [http://www.eurotev.org/workpackages/wp6ilps/workplandrafts/index\\_eng.html](http://www.eurotev.org/workpackages/wp6ilps/workplandrafts/index_eng.html)

Contributions to the BCD (the base-line configuration document for ILC) have been made. In particular a white paper reviewing the ILC tunnel configuration. The GDE will decide about the format of publication

## **4/ ACTIVITIES**

A list of the EUROTev tasks in which CERN is involved, is given in the table in appendix A.

### ***Resources***

The main aim until July 2005 was to develop a detailed work plan and to hire additional personnel. Five EU-funded fellowships and one additional associate funded by CERN, as well as two (part time) staff that would compensate the EU effort.

All the five EU-funded fellowships could be filled, the first contract starting in May, the last in November. The required personnel from CERN have been made available in the AB department in the groups ABP, RF, and OP; also the resources from the DSU were confirmed. An associate and the two staff have been hired. The original estimate assumed 45 fellow-months paid by the EU in 2005, 60 in 2006 and 45 in 2007. This is modified to 26 in 2005, 60 in 2006 and 60 in 2007. It is also foreseen to use part of the available money to buy a small computer cluster to improve the simulation efficiency.

A problem arose for the AB-BDI group, which after a re-evaluation of the overall resources found that it could not provide the required personnel. The group is responsible for two prototype development tasks, a precision beam position monitor (PTBPM) and a current monitor (WBCM). After discussion with the group leader concerned (H. Schmickler) and the AB deputy department leader (J-P. Delahaye) the resources for one of the two tasks (PTBPM) were made available to start the task in 2006, a delay of one year. A new work plan has been devised that should allow to still finish this task before the end of 2007.

Concerning the second BDI task, it was agreed to try to fill the CERN missing resources with an associate. During summer, it has not been possible to find a suitable candidate. Hence it has been agreed with the new BDI group leader (R. Garoby) and the AB deputy department leader to make a further attempt to find an associate in Russia or India. Indeed a good candidate could be found but after the last associate committee for 2005. It will be very important to hire an experienced person, to avoid further delays, which would put the fulfilment of this part of the EU contract at stake.

Three of the tasks also need resources for hardware development. Due to the developments in the BDI group, no resources were spent on their two tasks. The task supported by the RF group (TPMON) spent as planned. It was agreed with Ian Wilson, that the CERN contribution to the hardware foreseen for 2005 will be delayed to 2006.

### ***Beam Delivery System***

#### ***BDSLD (Beam Delivery System Design)***

CERN goal is to explore the feasibility of a non-linear collimation system and to understand whether it helps to ease the challenging collimation task. Two different system designs have been investigated. The first was found not to function for CLIC; however, a design based on the same strategy seems to perform well for the LHC, the studies are ongoing. The second design currently achieves a luminosity performance that is too low by a small factor. The possibilities to improve the second design are being investigated; it is not yet clear whether the non-linear system can outperform a linear one.

To study the reliability of the tracking codes used for collimation studies three codes (MAD8, SAD and PLACET) were benchmarked against each other. This revealed significant shortcomings in MAD8 for this type of study.

#### ***SWMD (Mechanical Spoiler System)***

The task aims at designing the collimators for a linear collider. CERN is contributing to the wake-field calculations by providing expertise for analytical calculations and numerical simulations. The CERN tracking code PLACET has been extended to be able to simulate the effect of collimator wake-fields. A module that implements the different analytical wake-field calculations into the code is under development.

## ***Damping Rings***

### *ECLLOUD (Electron Cloud and Fast Beam Ion Instability)*

In the electron cloud task CERN focuses on developing a new code for the simulation of the build-up of electrons cloud during the passage of a beam. The development of the program has been started in July and until now a module to simulate the collective forces of the beam and the cloud has been developed; it is able simulate arbitrary beam pipe shapes. Also the tracking of the particles has been implemented, which can move electrons and ions. The production of secondaries when electrons hit the surface will be implemented next.

Ion effects were estimated analytically for three different ILC damping rings, namely OTW, OCS and TESLA. In particular, we computed the trapping condition, the exponential rise time of the fast ion instability, and the incoherent tune shift at the end of the train, for arcs, wigglers, and straight sections. The ion effects are significant even for an extremely low CO pressure of 0.01 nTorr. If the vacuum is assumed to be uniform around the ring, a smaller circumference is slightly preferable.

In order to benchmark the code that simulates the instability of the beam due to electron cloud (HEADTAIL) machine experiments have been performed in the SPS in 2004. The data has been analysed and compared to simulations in 2005, the work is continuing. More realistic models of the electron cloud distribution and the machine have been introduced in the code. The simulations show a slow growth of the emittance below the threshold of instability; the origin of this effect is being investigated

## ***Diagnostics***

### *TPMON (Precision Phase Reference)*

The objective of the task will be to build the electronics for a high precision RF-based bunch timing measurement system. The phase of a bunch train will be measured at 30GHz with the aim to approach an accuracy of 10fs for a single-shot wideband measurement. An essential part of the work will consist of testing in an accelerator and it is envisaged to do this in CTF3.

Phase detection will be done at an intermediate frequency (IF) somewhere in the range of several hundred MHz. The choice of an optimum (or even acceptable) IF phase detector is not evident. Firstly available devices have to be carefully characterized and effort is at present concentrating on this.

The figures of merit of a phase measurement devices at the intermediary frequency are the bandwidth, the input amplitude dependence, and the noise floor of the devices. A consideration of the possible IF frequencies is also important for the overall phase measurement system, where higher IF frequencies should in general lead to simpler requirements for the down conversion from 30GHz. A test setup for determining these four factors has been built. The devices to be tested are both phase detectors and power detectors as all phase detectors have some dependence on the input amplitude which must be corrected. To date, all physical devices have been built and tested to satisfaction and support software has been written. Specific test runs remain to be written. The first tests should be written and run within a month and data on the first power and phase detector should be evaluated as well.

### *WBCM (Wide Band Current Monitor)*

The aim of the task is to provide a high bandwidth monitor that allows measuring the beam current, it has been delayed for the reasons detailed above. It is hoped that by hiring an associate the resources can be made available next year. The design will be based on an existing prototype, which needs to be improved in bandwidth. In the prototype the signal shows some ringing which needs to be avoided. As a first step, it is planned to study the current design using sophisticated RF simulation codes in order to identify potential sources of the ringing. The task coordinator and the fellow will participate in some course on such a code. It has also been agreed that the RF group will support the activity with their expertise, by helping to set up the simulations and by follow them.

A mini workshop will be held end of November to identify the best approach to the problem.

### *PTBPM (Precision Beam Position Monitor)*

The aim of this task is to provide a very precise beam position monitor with a very good time resolution. Also this task has been delayed for the reasons detailed above. The necessary resources will be made available next year. The design will be based on a prototype aiming to improve the



performance. Potentially beam tests of this monitor will be possible at ATF2, the beam delivery system test facility planned at KEK. A contact has been established with KEK, and the monitor parameters have been redefined such that they can be incorporated into the ATF2 beam line.

### ***Integrated Luminosity Performance Studies***

The work package delivered the work plan in due time and held a number of phone meetings to ensure the progress of the work.

#### *COLSIM (Collimation Simulations)*

The task is studying the post-linac halo collimation. CERN will contribute to the simulation of the impact of luminosity tuning on the collimation, once the procedures have been defined in LAST. It will also provide the study of the efficiency of a CLIC collimation system.

#### *FMSIM (Failure Mode Simulations)*

The aim of the task is to identify potential failure modes, their impact on the machine and potential ways of mitigating their effects. The task collected potential failure modes. It is now prioritizing the list and determining how the key processes can be simulated. The actual work is going to start when the beam-based alignment procedures have been defined.

#### *LAST (Luminosity and Alignment Study Task)*

The main aim of LAST is to contribute to the studies of the expected luminosity performance of CLIC and ILC, including static and dynamic imperfections, as well as to participate to the proposal of the correction, feedback and tuning strategy. For ILC the task has to integrate into the international context, hence it has been agreed to focus on the main linac and beam delivery system and to currently leave the bunch compressor and damping ring to main linac transport to the American and Asian groups. CERN is contributing to all areas of the European studies, in order to allow benchmarking and to extend the solutions to the more demanding case of CLIC. In 2005, the following CERN contributions were made.

Systematic studies of the performance of an advanced beam-based alignment procedure, the dispersion free steering, have been carried out for CLIC and ILC; they allow to choose the optimum gain factors for these correction techniques and to understand which imperfections are most relevant. In both machines, the performance of these alignment procedures has been shown not to be sufficient to alone ensure the preservation of the beam quality.

The effect of main linac emittance tuning bumps has been studied for CLIC and ILC, mainly assuming static machines. A novel, faster method has been proposed to perform the beam size measurements necessary for these bumps; studies showed that it seems to be a viable option. For CLIC, a new system of five bumps yields better performance than the previous system did with ten; the achieved performance is significantly better than required. Also for ILC, the use of the bumps improved the performance to be better than specified.

Studies of luminosity tuning have been started. These procedures will allow optimizing the luminosity directly. Currently, due to limitations in the computing power, simplifications need to be made for the simulation of beam delivery system. The results for static machines show excellent performance, more complete studies need to be performed in 2006.

In CLIC, no fast signal is present that is directly proportional to luminosity. Therefore a different strategy needs to be adopted. A number of beam parameters will be varied one after the other. For each these scans a fast signal needs to be identified that allows an optimum choice. A very promising signal is the beamstrahlung of each beam, the use of which has been studied for a number of different optimization knobs. So far, the signal has been shown to be usable in all cases.

A new method to simulate the feedback system in the main linac has been developed for CLIC; it will allow to simulate the impact of the feedback on the beam based alignment and tuning. In 2006, the different components of the alignment, tuning and feedback will be merged into a coherent simulation. PLACET has been improved by adding the potential to simulate collimators, a feedback using Kalman filters, the possibility to simulate a linac that follows the curvature of the earth and more. Planned extensions are to include the possibility to simulate bunch compressors and to use parallel computer systems.

## ***HTGEN (Halo and Tail Generation)***

A list of the different halo and tail generation processes has been devised and currently it is inquired for which of them existing programs can be used as a basis for implementation. Also an assessment has started concerning which process can be benchmarked.

A new precise and very fast synchrotron radiation spectrum generator has been developed, based on direct spectrum inversion and Chebyshev polynomials. Modules to simulate beam-gas scattering and bremsstrahlung have been developed and an interface to the beam dynamics tracking code PLACET has been defined. The implementation of the interface is ongoing.

## ***BBSIM (Beam-Beam Simulations)***

The aim of BBSIM is to verify the beam-beam simulation code GUINEA-PIG by benchmarking with sophisticated physics generators and in 2006 to implement the possibility to simulate polarization; the work is mainly performed by LAL with some help from the author who is at CERN. The code has been sent to LAL and the necessary support has been given, answering a number of questions on details of the code and its usage and explaining the ways to extend it. The benchmarking at LAL showed that GUINEA-PIG and the other beam-beam simulation code CAIN predict different background levels for the detector at a linear collider. They also showed that GUINEA-PIG is in the excellent agreement with the physics generators.

## **5/ ACHIEVEMENTS**

The planned EUROTeV milestone for mid 2005 was the delivery of a detailed work plan. CERN contributed its share in all the tasks in which it is involved. All the required resources were made available at CERN, with the one exception mentioned above. All EU funded fellow positions have been filled. Except for the two tasks concerned by the personnel difficulty, the work is progressing well.

Some specific contributions were

- The benchmarking of the electron cloud code has made considerable progress. The related effects have a very significant impact on the design of linear colliders, in particular in the damping rings.
- A strategy has been devised how to provide the required precise phase signal. A test setup has been constructed which allows testing the necessary phase detector.
- The benchmarking of GUINEA-PIG showed excellent agreement with a sophisticated physics generator, but the other beam-beam simulation program used for linear colliders was found to predict too small background levels.
- Studies of the ILC main linac showed that the dispersion free steering algorithm used cannot ensure sufficient emittance preservation but that emittance-tuning bumps can improve this well beyond the target.
- For CLIC, new tuning bumps have been developed that are based on luminosity rather than emittance measurements. With only five bumps the performance is better than for the old design with ten, this will reduce the complexity of the operation significantly.
- A white paper reviewing the ILC tunnel configuration has been written lead by a CERN staff.

The main aim for 2006 is to provide the first results at the mid-year workshop. Based on these results, the work plan for the second part of the project will be revised. The final results are expected in mid 2007.

## APPENDIX A

EUROTeV tasks in which CERN is involved. CERN task coordinator names are given, bold font indicates that the CERN contact person is leading the whole task, underlined names indicate that CERN is the only contributing institute. The person years are shown, integrated over the three years, for CERN provided staff (S), associates (A), and PhD students (PhD) as well as EU- paid fellows (EU-F). Bold parts of the task description indicate CERN involvement.

| TASK   | Short description of the task  | Involvement  |
|--------|--|--|
| Mngmnt | <b>Set up of a management structure that reviews the financial data of the Consortium and reports the auditing information to the European Commission</b>  | G. Guignard<br><b>S: 1.35</b>  |
| BDSL   | Design/optimization of final focus systems • design/optimization of collimation systems • <b>feasibility studies of non-linear collimation schemes</b> • maintenance of BDS lattice files • component specification  | F. Zimmermann<br><b>S: 0.26</b><br><b>PhD: 1.0</b><br><b>EU-F: 1.0</b> |
| SWMD   | Design/optimization of mechanical spoiler systems • <b>2/3D modelling of single and multi-bunch wake fields</b> • benchmarking of wakefield calculations against experiments • studies of spoiler damage scenarios • material tests with high powered beams  | F. Zimmermann<br><b>S: 0.14</b><br><b>EU-F: 0.5</b>                    |
| ECLD   | <b>Development of simulation codes for electron cloud build up • benchmark and tuning of simulations against experimental data</b> • application of codes to DR lattices • R&D on DR vacuum systems • R&D on low secondary electron yield vacuum coatings • <b>studies of fast ion instabilities</b>   | <b>F. Zimmermann</b><br><b>S: 1.5</b><br><b>A: 2.0</b>                 |
| PTBPM  | <b>BPM with &lt;100nm resolution, &lt;10µm precision, &lt;15ns rise-time • design and fabrication of prototype • beam tests in CTF3</b>  | <u>L. Soby</u><br><b>S: 1.5</b><br><b>EU-F: 2.5</b>                    |
| TPMON  | <b>Develop phase reference system with stability better than 15 fs rms over long distances (km) suitable for ILC applications • conceptual design of system • design and construction of system test in CTF3</b>   | <u>J. Sladen</u><br><b>S: 2.0</b><br><b>EU-F: 2.5</b>                  |
| WBCM   | <b>Development of a 20 GHz bandwidth bunch charge monitor capable of accurately resolving single bunches in a bunch train • design and construction of prototype monitor for tests in CTF3</b>   | <u>L. Soby</u><br><b>S: 1.0</b>  |
| CFBPM  | <b>Validation of BPM performance with beam tests in CTF3 (2007)</b>  | <u>H. Braun</u><br><b>S: 0.3</b>                                       |
| COLSIM | <b>Simulation of post-linac beam-halo collimation • estimation of collimator efficiency</b> • optimization of collimator systems • simulations of muon and neutron production in collimator sections • estimates of impact of physics detector performance • studies of muon and neutron production • impact of luminosity tuning on halo collimation efficiency   | D. Schulte<br><b>S: 0.1</b><br><b>EU-F: 0.5</b>                        |
| FWSIM  | <b>Determination of set of key failure modes (FM) • simulation of FMs using sophisticated ILC modelling codes • evaluation of impact of FMs on accelerator performance/design • specific attention to BDS spoiler protection</b>   | D. Schulte<br><b>S: 0.1</b><br><b>EU-F: 0.5</b>                        |
| LAST   | <b>Development of sophisticated models of the ILC from DR to IP • further development of beam based alignment algorithms • simulations of algorithms with relevant machine imperfections • impact of upstream on downstream tuning • identify/specify diagnostics requirements • understand tuning time-scales • simulations of beam base feedback systems in the presence of time-dependent environmental effects (e.g. ground motion) • studies of intra-train and repetition rate based feedback • beam-beam feedback • fast luminosity feedback • interaction of feedback systems • optimization of stabilization algorithms and number of feedback stations</b> | D. Schulte<br><b>S: 0.5</b><br><b>PhD: 2.25</b><br><b>EU-F: 2.5</b>    |
| HTGEN  | <b>Study of potential sources of halo and tail generation • development of analytical models of halo • estimates of halo population • development of computer models for halo/tail generation • simulation studies of hail/tail generation • explore possibilities for benchmarking</b>  | <u>H. Burkhardt</u><br><b>S: 1.5</b><br><b>EU-F: 2.5</b>               |
| BBSIM  | <b>Benchmarking of physics processes in GUINEA-PIG against known and trusted physics generators • implementation of spin transport into GUINEA-PIG</b>   | D. Schulte<br><b>S: 0.1</b>  |

## 6. Financial Report

### CARE EU PROJECT - BUDGET OVERVIEW

|   |                  |
|---|------------------|
|   | <b>EUR</b>       |
| <b>EU Maximum contribution for CERN</b> | <b>2,756,000</b> |
| <b>CERN, received Payment 1</b>         | 1,069,328        |
| <b>CERN, received Payment 2</b>         | 1,117,320        |
| <b>Total received</b>                   | <b>2,186,648</b> |
| <b>CERN, to be received</b>             | <b>569,352</b>   |

| <b>EU Budget (in kCHF)</b> |                                |   |               |
|----------------------------|--------------------------------|---|---------------|
| <b>Project activities</b>  | <b>Total budget allocation</b> | <b>Budget used up to Oct. 2005 <sup>(1)</sup></b> | <b>% used</b> |
| ELAN                       | 158                            | 57  | 36%           |
| BENE                       | 89                             | 32  | 36%           |
| HHH                        | 282                            | 82  | 29%           |
| PHIN                       | 1,812                          | 747   | 41%           |
| HIPPI                      | 997                            | 897   | 90%           |
| NED                        | 926                            | 138   | 15%           |
|                            | <b>4,264</b>                   | <b>1,953</b>                                      | <b>46%</b>    |

| <b>CERN Budget (in kCHF)</b> |                                |   |               |
|------------------------------|--------------------------------|---|---------------|
| <b>Project activities</b>    | <b>Total budget allocation</b> | <b>Budget used up to Oct. 2005 <sup>(1)</sup></b> | <b>% used</b> |
| ELAN                         | 633                            | 244   | 39%           |
| BENE                         | 660                            | 183   | 28%           |
| HHH                          | 2,745                          | 1,447   | 53%           |
| PHIN                         | 2,081                          | 898   | 43%           |
| HIPPI                        | 9,132                          | 2,418   | 26%           |
| NED                          | 316                            | 150   | 47%           |
|                              | <b>15,567</b>                  | <b>5,340</b>                                      | <b>34%</b>    |

|                              |               |              |            |
|------------------------------|---------------|--------------|------------|
| <b>TOTAL EU +CERN Budget</b> | <b>19,831</b> | <b>7,293</b> | <b>37%</b> |
|------------------------------|---------------|--------------|------------|

*(1) Including expenditure (G. Guignard estimates) not charged to the CARE project's specific budget codes (mainly personnel costs for CERN Part)*

## DIRAC PROJECT - BUDGET OVERVIEW

|   |                |
|---|----------------|
|   | <b>EUR</b>     |
| <b>EU Maximum contribution for CERN</b> | <b>181,900</b> |

|                                 |               |
|---------------------------------|---------------|
| <b>CERN, received Payment 1</b> | 82,659        |
| <b>Total received</b>           | <b>82,659</b> |

|                             |               |
|-----------------------------|---------------|
| <b>CERN, to be received</b> | <b>99,241</b> |
|-----------------------------|---------------|

| EU Budget (in kCHF) | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used     |
|---------------------|-------------------------|---|------------|
|                     | <b>281</b>              | <b>48</b>                                     | <b>17%</b> |

| CERN Budget (in kCHF) | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used     |
|-----------------------|-------------------------|---|------------|
|                       | <b>2,041</b>            | <b>621</b>                                    | <b>30%</b> |

| Total EU + CERN Budget | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used     |
|------------------------|-------------------------|---|------------|
|                        | <b>2,322</b>            | <b>669</b>                                    | <b>29%</b> |

*(1) Including expenditure (G. Guignard estimates) not charged to the project's specific budget codes (material and personnel)*

## EURISOL PROJECT - BUDGET OVERVIEW

|   |                  |
|---|------------------|
|   | <b>EUR</b>       |
| <b>EU Maximum contribution for CERN</b> | <b>1,827,000</b> |

|                                 |                |
|---------------------------------|----------------|
| <b>CERN, received Payment 1</b> | 548,100        |
| <b>Total received</b>           | <b>548,100</b> |

|                             |                  |
|-----------------------------|------------------|
| <b>CERN, to be received</b> | <b>1,278,900</b> |
|-----------------------------|------------------|

| EU Budget (in kCHF) | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used |
|---------------------|-------------------------|---|--------|
|                     | 2,750                   | 382   | 14%    |

| CERN Budget (in kCHF) | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used |
|-----------------------|-------------------------|---|--------|
|                       | 4,159                   | 651   | 16%    |

| Total EU + CERN Budget | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used |
|------------------------|-------------------------|---|--------|
|                        | 6,909                   | 1,033   | 15%    |

*(1) Including expenditure (G. Guignard estimates) not charged to the project's specific budget codes (material and personnel)*

## EURONS PROJECT - BUDGET OVERVIEW

|   | EUR              |
|---|------------------|
| <b>EU Maximum contribution for CERN</b> | <b>1,346,480</b> |
| <b>CERN, received Payment 1</b>         | 335,707          |
| <b>Total received</b>                   | <b>335,707</b>   |
| <b>CERN, to be received</b>             | <b>1,010,773</b> |

| EU Budget (in kCHF)    | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used |
|------------------------|-------------------------|---|--------|
|                        |                         | 2,080   | 546    |
| CERN Budget (in kCHF)  | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used |
|                        |                         | 2,685   | 370    |
| Total EU + CERN Budget | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used |
|                        |                         | 4,765   | 916    |

*(1) Including expenditure (G. Guignard and K. Riisager estimates) not charged to the project's specific budget codes (material and personnel)*

## EUROTeV PROJECT - BUDGET OVERVIEW

|   | EUR              |
|---|------------------|
| <b>EU Maximum contribution for CERN</b> | <b>1,482,000</b> |
| <b>CERN, received Payment 1</b>         | 604,000          |
| <b>Total received</b>                   | <b>604,000</b>   |
| <b>CERN, to be received</b>             | <b>878,000</b>   |

| EU Budget (in kCHF)    | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used |
|------------------------|-------------------------|---|--------|
|                        |                         | 2,260   | 470    |
| CERN Budget (in kCHF)  | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used |
|                        |                         | 2,941   | 900    |
| Total EU + CERN Budget | Total budget allocation | Estimated budget used for 2005 <sup>(1)</sup> | % used |
|                        |                         | 5,201   | 1,370  |

*(1) Including expenditure (G. Guignard estimates) not charged to the project's specific budget codes (material and personnel)*