SCHEDULE AND PRIORITIES FOR 2000

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Abstract

The reduction of the time dedicated to machine development in 2000, as compared to 1999, and the increasing demand for beam time impose a prioritisation of the subjects and a careful planning. After a review of the machine development requests and of the available time a possible programme for 2000 and its implications for the injectors and for LEP physics will be presented.

1 MACHINE SCHEDULE

The SPS is one of the major PS users in terms of beams with a maximum of 6 basic periods (each 1.2 s long) during fixed target proton run and 8 during the fixed-target lead ion run. Two of them, initially dedicated to lepton acceleration for LEP, are no more used since 1995 thanks to the implementation of the double-batch injection scheme in the SPS. Since then these two basic periods have been dedicated to machine development sessions in the SPS during working hours and have been granted for physics in the PS during the rest of the time. Since the beginning of 1999, due to the increasing number of PS users, these two basic periods have been shared with the PS colleagues to permit them performing the studies required for the preparation of the LHC beam and of new beams for physics (AD, nTOF). In 2000 concurrent users of the beams provided by the PS complex will be East Hall users, ISOLDE, AD and CERN TOF facility. It is therefore evident that the planning of the machine development sessions (in particular of those performed in parallel to physics) is strongly dependent on the PS and SPS machine schedules [1][2]. The features of the 2000 run which might be relevant for the scheduling of the machine development sessions in the SPS are listed below:

- The SPS start-up with protons to verify the alignment of the machine elements will take place at the end of week 12. Afterwards the SPS will be set-up for lepton acceleration and in weeks 14 to 16 will have to provide lepton beams only. During this time protons will be available from the PS but acceleration to 450 GeV/c will not be possible for budgetary constraints.
- The SPS fixed target physics is due to start by 2nd May 2000.
- In the period 11th May - 23rd May a slow-extracted 450 GeV/c proton beam with 25 ns bunch spacing will be provided for LHC detector tests.
- Very likely in the middle of the run the extraction energy of the fixed target proton beam will be lowered from 450 to 400 GeV/c as the request for the highest energy will fail very likely for the second half of the run. The end of the fixed-target proton physics run is scheduled for 9th September 2000.
- Week 37 and 38 will be devoted to set-up the SPS for lead ion fixed target physics that is due to start on 25th September 2000 and stop on 2nd November 2000.
- East Hall physics in the PS complex will start at the beginning of week 15. Stops are foreseen in weeks 23, 24, 37 and 38.
- ISOLDE physics will start at the beginning of week 17.
- AD will be started-up in week 14 and physics is scheduled by the beginning of week 21. During physics AD will not be running over weekends over nights (24:00-08:00). During stable running AD is supposed to require an antiproton production cycle (2.4 s long) once every four PS supercycles.
- Neutron time of flight experiments are supposed to start in 2000. At least initially they will run parasitically to East Hall physics and therefore will not require any additional cycle in the PS supercycle.

2 POSSIBLE SUPERCYCLES IN THE SPS

Due to the different modes of operation foreseen for the SPS in 2000 several supercycles might be considered in order to optimise time and conditions for performing machine development studies in parallel with physics.

2.1 During weeks 14 to 16

During this time only leptons will have to be provided, nevertheless the supercycle cannot be shortened because of the physics cycles in the PS complex. The available time in the cycle could be therefore used to extend by about 5 s (from 600 ms to 5.5 s) the plateau (14 or 26 GeV/c) devoted to machine development studies in parallel with physics. This would leave the time for a demagnetisation peak at 450 GeV/c making the magnetic conditions during the lepton cycles insensitive to the magnetic history in the other cycles and therefore minimising the perturbations to LEP physics during the setting-up of the SPS for fixed-target physics.

Up to 3 batch, spaced by 2.4. s, of an LHC-like beam (TSTLHC) could be injected in the MD segment in week 14 (No East Hall Physics). This could also be possible in weeks 15 and 16 but only when there is no lepton request or when a PS physics cycle is made available (AD or East Hall). Coasts at the proton injection energy could be also foreseen when no lepton request is present (e.g. during LEP Z^0 coasts).

2.2 During the '25 ns test'

The supercycle foreseen for this kind of physics includes a slow ramp (pbar type) a plateau at 450 GeV/c 2 s long and 2 lepton cycles. All that can be fitted in 14.4 s. A machine development segment can be added only in a 16.8 s long supercyle. During the Wednesday MD in week 20 LHC studies (injection and acceleration to 450 GeV/c) could be performed without the need of changing supercycle. The acceleration of high intensity beams will be subordinated to the absence of lepton request or to the possibility of injecting leptons at lower energy (20 GeV/c) in LEP [3][4].

2.3 During the fixed-target proton run

The supercycle during this period will look like the 1999 one. It will consist of a proton fixed target cycle with injection at 14 GeV/c and extraction at 450 GeV/c, 2 lepton cycles and a machine development segment at 14 or 26 GeV/c. Also a 20 GeV/c plateau might be needed for machine studies. This is nevertheless incompatible with lepton acceleration (there is not enough time to move the SWC200 damping loop in between electron extraction and 20 GeV/c proton injection). As previously mentioned the extraction energy of the fixed-target proton beam might be reduced from 450 to 400 GeV/c during the run. Ramps from 14 to 28-29 GeV/c and from 26 to 29-30 GeV/c can be also fitted in the machine development segment in order to study acceleration and transition crossing for the high intensity CNGS beam and the acceleration of the LHC beam, respectively. Timing driven coasts at 14 GeV/c or 26 GeV/c can be also performed during Wednesday MD when no lepton request is present.

2.4 During the fixed-target lead ion run

The supercycle will include a fixed target lead ion cycle with injection at 5.11 GeV/c/u and extraction at 158 GeV/c/u, two lepton cycles and a machine development plateau at 14, 20 or 26 GeV/c. Injection of 20 GeV/c protons will be possible after LEP stop. Ramps are also conceivable during the machine development segment (from 20 GeV/c to 30 GeV/c). During that time the preference should be given to the 20 GeV studies.

2.5 During dedicated MD sessions

In the occasion of Wednesday MDs efficiency reasons prevent to foresee supercycle changes (except for the parallel machine development session) due to the significant amount of time required by this operation and by the corresponding beam setting-up [5]. Therefore operational supercycles must be considered for these 8-hour long sessions.

During Long machine development sessions (24 hours long) any super-cycle can be in principle installed. The possibility to inject up to 3 batches of the nominal LHC beam should be foreseen. Supercycles of variable length (16.8 s, 18 s, 20.4 s) might be therefore required.

3 MD REQUESTS

The subjects of the requests for machine development sessions can be classified in six groups:

- "Operation" studies directed to solve possible problems encountered during fixed target physics or to enhance the performances of the machine in this mode of operation.
- "SPS as a multi-cycling machine" studies. In the LHC era the SPS will have to provide different beams for a variety of physics users (LHC, CNGS, test areas and other fixed-target experiments). This request is even more compelling due to the variety of studies that will be needed before that time. This requires the possibility of rapidly switching between the different combinations of cycles. At the present time this cannot be done and new software might be available only in a few years. Therefore possible enhancements of the present system are considered while waiting for a more elegant and complete solution.
- "SPS as LHC Injector" studies include all the subject related to the preparation of the SPS as LHC injector and to the understanding of the problems related to injection, capture, acceleration, extraction and transfer of the LHC beam within the stringent constraints Imposed on emittance conservation.
- "SPS for CNGS" studies are devoted to understand and find solutions to the problems encountered in handling the high intensity beams foreseen for CNGS (beam instabilities, hardware limitations, radiation, etc.).
- "SPS as LHC testbed" studies are devoted to the tests of instruments and analysis techniques to be implemented in the LHC as well as to the exploration of phenomena that might possibly affect LHC performances.
- "Others". This class includes all those studies that might have interest for future accelerator developments at CERN beyond the LHC.

The machine development requests, grouped according to the above classification, are listed in the tables below. The subject, the required amount of time, type of session (L=Long MD session, W=Wednesday MD session, P = parallel MD session), and beams are presented. The minimum unit for parallel MD time request is one day. References are given for papers describing the aim of the studies and the preliminary results. A short description of the required beams is given in Table 12.

3.1 Operation

Table 1: MD requests for operation studies

Subject	Time	Beam
Matching verification [6]	8h W	SFTPRO 1 turn CT
Physical aperture measurements	1d P	TSTLHC or SFTPRO

Additional subjects might be added during the run as a function of the problems encountered in operation.

3.2 SPS as a multicycling machine

Table 2: MD requests for "SPS as a multicycling" machine studies

Subject	Time	Beam
Poor man multicycling [7]	3 x 4h W	SFTPRO / TSTLHC / leptons
Beam parameters measurements vs. magnetic history [7]	3 x 4h W	SFTPRO / leptons

3.3 SPS as LHC Injector (SLI)

Due to the large number of requests these have been classified according to the group demanding for machine development time.

Table 3: MD requests for SLI studies (AP et al.)

Subject	Time	Beam
Beam induced electron cloud investigations [8]	4 d P 8h W/L 6h L	TSTLHC / LHC with different bunch spacing
Control of impedance changes (transverse measurements) [9]	5d P 8h L	MESPS Short
Emittance blow-up and lifetime due to IBS and RF noise [10]	8h L	SFTION

Table 4: MD requests for SLI studies (BI)

Subject	Time	Beam
Halo scraping [11]	2d P 2 x 4h W	TSTLHC / MESPS Short SFTPRO /
Matching monitor [12]	1 x 6h W	MESPS Long
Profile monitors [11][13][14]	4d P 2 x 4h W 43h L	MESPS Short / TSTLHC / LHC

Table 5: MD requests for SLI studies (BT)

Subject	Time	Beam
Performances of the new beam dump (TIDVG)	5h L	TSTLHC / SFTPRO max. intensity

Table 6: MD requests for SLI studies (HRF)

Subject	Time	Beam
Damper hardware tests [15]	8d P 3 x 4h L	TSTLHC / MESPS Short SFTPRO /
Injection damping and transverse (in)stability [15]	> 4d P	TSTLHC / LHC
Satellite bunch creation	3d P	TSTLHC
LHC beam acceleration (transv. and long. stability, emittance blow-up, hardware tests) [16]	5x24h L	TSTLHC / LHC
Control of impedance changes (longitudinal measurements) [17]	4d P	MESPS Short/ Long
Beam Transfer Function for 200/800 MHz RF	3x4h W	SFTPRO

Table 7: MD requests for SLI studies (MS)

Subject	Time	Beam
Protection of the ES septa	> 2d P	MESPS Short

Table 8: MD requests for SLI studies (OP)

Subject	Time	Beam
Injection matching: measurements and correction [18]	3d P	MESPS Long
Low-tune optics	2d P	TSTLHC / MESPS Short
Continuous β beating and dispersion measurement	2d P	TSTLHC / SFTPRO / MDPRO
Minimisation of the emittance blow-up at the stripper)	4 d P	SFTION

3.4 SPS for CNGS

Table 9: MD requests for "SPS for CNGS" studies

Subject	Time	Beam
Beam stability at injection and transition [19]	>5d P	MDPRO
Barrier bucket experiments	3d P	SFTPRO
Microwave instability below transition	2d P	TSTSPS (single bunch)

3.5 SPS as LHC Testbed

Table 10: MD requests for "SPS as LHC Testbed" studies

Subject	Time	Beam
Beam induced ion desorption (LHC/VAC)	8h W	TSTLHC
LHC-AP studies (linear and non-linear optics measurements, threader, injection into low aperture) [20]	14d P 8h W 2 x 8h L	MESPS Short

3.6 Others

Table 11: Other MD requests

Subject	Time	Beam
Suppression of synchrotron radiation by a conducting vacuum chamber [21]	2 x 12h L	SFTPRO

3.7 Beam requests

Table 12: Beam requests in 2000

Beam	Description
LHC	Nominal beam, double batch injection in the PS, multi-splitting. Different spacings or bunch patterns will be required.
MDPRO	Fast extracted fixed-target proton beam (2 μs batch), I_{batch}=0.4 - 3 x 10^{13} p
MESPS Long	Single bunch at 26 GeV/c, ε =0.2 eVs, $\tau_b(4\sigma)$ < 22 ns, I_{bunch}~ 0.1 - 1 x 10^{11} p
MESPS Short	Single bunch at 26 GeV/c, ε =0.2 - 0.5 eVs, τ (4σ) < 5 ns, I ~ 0.1 - 1 x 10^{11} p, possibility to vary I without affecting ε_L by vertical scraping.
SFTION	Fixed target lead ion beam, τ (4σ) ~ 5 - 20 ns
SFTPRO	Fixed target proton beam, I ~ 0.4 - 3 x 10^{13} p
SFTPRO 1-turn CT	16 bunches at 14 GeV/c in a 2 μs batch, (Δp/p) ~ 2 x 10^{-4}, τ (4σ) < 5-7 ns, I ~ 3 x 10^{10} p
TSTLHC	Quasi-nominal, 1-batch injection in PS, debunching and recapture at h=84, bunch rotation at h=84/128, 1-3 batches, variable I_{batch}
TSTSPS	Single bunch at 20 GeV/c. Not RF synchronised. ε_L= 0.2 eVs, $\tau_b(4\sigma)$ ~ 25 ns, I_{bunch}~ 1 - 5 x 10^{10} p.

4 DEMANDED VS. SCHEDULED TIME

The total requested time for machine studies in 2000 is shown in Table 13 for the dedicated and parallel MD sessions. The scheduled time in 2000 and a comparison with the scheduled time in 1999 are also presented.

Table 13: Demanded vs. scheduled time in 2000 and comparison with 1999.

	Requests	Scheduled 2000	Scheduled 1999
Long [h]	242	144	156
Wednesday [h]	90	56	64
Parallel [d]	> 72	71	56

The following assumption have been considered in the estimation of the scheduled MD time in 2000:

- Availability of at least two beams, among those listed in Table 12, by the beginning of week 14.
- At least two days per week (08:00 - 18:00) should be allocated to SPS parallel machine development sessions when the East Hall experiments are running. Thursdays and Fridays would be preferred by the users of the parallel machine development time.
- When East Hall experiments are not running or after the LEP stop the space available in the PS supercycle should allow running machine studies in the PS and in the SPS in parallel to physics during working days (08:00 - 18:00) at least. This is not the case during dedicated machine development sessions in the PS complex when PS has priority.
- No study in parallel with physics will be performed during the '25 ns test'.

The requests of machine time for studies in 2000 overwhelm the allocated time, in particular for dedicated machine time that has been reduced as compared to 1999. The above assumptions bring to a minimal solution that cannot be further squeezed. It must be remembered that setting-up time is not included in most of the requests. Furthermore during the last long MD (24 hours in week 44) only low intensity and/or low energy beams can circulate in the SPS in order to profit of the decay of the remanent radiation during the lead ion run. Lepton request for LEP physics during Wednesday MD adds an additional constraint to machine development planning. It must be stressed that requests of dedicated machine time have been diverted to parallel machine development sessions wherever possible already in the compilation of the list of MD studies presented in the previous Section.

An efficient use of the scheduled MD time can be achieved only by setting the guidelines for a strict (and necessarily painful) prioritisation of the subjects.

5 PROPOSED GUIDELINES FOR THE ALLOCATION OF MD TIME

Multicycling facilities, beam instrumentation and other pieces of hardware like the beam dump and the damper must be operational for all the beams required for machine studies, in order to get an efficient use of the available time. For that reason priority should be given to setting-up and tests of these components.

Priority should also be given to those subjects who will allow:

- to take decisions on hardware modifications. This is the case of the study of the beam induced electron cloud, of the impedance control to monitor the effect of the impedance reduction campaign, the study of the impact of a beam loss on the wires of the electrostatic septa.
- to make progress in the understanding of the behaviour of the CNGS and LHC beams. The studies related to the stability of these beams might have in fact unexpected implications on the hardware.

The attribution of time for the repetition of an experiment will be subordinated to the availability of a detailed documentation of the results of previous attempts justifying the need of additional time.

Due to the limited time available for dedicated studies the above criteria should be even more strictly applied for Long and Wednesday sessions. Those newly proposed subjects that do not fulfil these criteria should be postponed if they can be (even partly) treated in parallel sessions.

Use of the SPS setting-up period should be also envisaged wherever possible and efficient.

For sake of efficiency it seems also convenient to foresee breaks (4-6 h long) to the main subject of a long MD for other studies requiring similar beam and hardware conditions. This would allow for some turnover of the investigators.

6 TENTATIVE SCHEDULE FOR 2000

On the basis of the guidelines illustrated above a schedule covering at least the long machine development sessions and the Wednesday and parallel sessions for the first part of the run can be proposed.

6.1 Cold check out

This period could be used to test a large fraction of the supercycles foreseen during the run and to perform tests without beam of the "SuperDuper cycle" [7]. This would require help from SL/CO and should be very likely foreseen for the late afternoon to minimise the interference with the power converter tests.

6.2 Start-up with beam (weeks 12 - 13)

The alignment check that is usually performed every year at the beginning of the run could profit of a finer sampling by using the low tune optics foreseen as a possible candidate for the SPS as LHC injector.

An early evaluation of the performances of the new beam dump absorber (TIDVG) is vital for the operation of the SPS therefore its behaviour (residual pressure evolution, gas analysis) should be monitored already at low intensity from the beginning of the setting-up with beam. The SFTPRO beam is required during this period.

6.3 Weeks 14 to 16

The availability of a long (~ 5.5 s) injection plateau at 14 or 26 GeV could be used for the setting-up of beam instrumentation (wire scanners, LSS5 fast scrapers, fast BCT for bunch-to-bunch intensity measurements, chromaticity measurement) and of the damper. Once this is done electron cloud investigations would take advantage of the larger fraction of the cycle dedicated to machine studies to investigate the 'scrubbing effect' [22] or to determine the effect of different filling patterns. These activities would require the availability of the TSTLHC beam by the beginning of week 14.

6.4 Setting-up for proton fixed target physics (week 17)

The verification of the matching of the injection transfer line for the fixed-target beam should be considered as part of the setting-up procedure. Furthermore the availability of SFTPRO beam of variable (increasing) intensity at 450 GeV could be used for parasitic monitoring of the TIDVG behaviour and for tests of profile monitors such as the Ion Beam Scanner and to continue the setting-up of the LSS5 fast scrapers.

6.5 Before the "25 ns test" (weeks 18 - 19)

The availability of the SFTPRO and TSTLHC beams should allow the completion of damper tests on the parallel MD segment. The damper should be made operational for the LHC tests for the first long MD (week 21). The generation of satellite bunches should be also investigated during weeks 18-19 in order to get it ready for the electron cloud investigations later in the run. The first Wednesday session (week 19) could be dedicated to the tests with beam of the "SuperDuper cycle" and/or to the setting-up of the OTR matching monitor.

6.6 After the start of the "25 ns test" (week 20 and following) - Wednesday and parallel sessions

The machine development time should be distributed according to the following order of decreasing priority and as a function of the beam availability form PS:

1. Operation studies (according to the needs).
2. SPS as a multicycling machine.
3. SLI and SPS for CNGS.
4. SPS as LHC testbed.

The operational supercycle during the "25 ns test" will include an LHC ramp, it is therefore conceivable to foresee the setting-up of the TSTLHC beam acceleration (1 batch) during the Wednesday session in week 20. This would provide also the opportunity to verify the behaviour of the TIDVG for the LHC beam at 450 GeV and with variable (increasing) intensity.

6.6 After the start of the "25 ns test" (week 20 and following) - Long MD sessions

Four out of the five Long MD sessions scheduled during the proton run should be devoted to the study of injection and acceleration of 1 to 3 batches of the LHC beam. During these sessions parasitic monitoring of the TIDVG could be performed and short breaks (4-6 h) should be allowed in the middle of the session for measurements performed by the operation crew and/or for beam profile monitor tests. Two out of the four LHC sessions should make use of the nominal LHC beam. A possible schedule could be:

- Week 21: Acceleration of 1-3 batches of TSTLHC beam
- Week 25: Study of the blow-up due to damper noise, measurements of the beam transfer function for the 200/800 MHz RF system and AP studies (synchrotron radiation suppression due to a conducting chamber and/or measurements of non linear terms). All these studies require in fact SFTPRO beam at about ~100 GeV in pulsing or coasting mode. Among the AP studies the latter would have lower priority because it can be likely performed also at 26 GeV.
- Week 29: Acceleration of 1-3 batches of TSTLHC beam. In this way the time between the first two LHC sessions could be used for any hardware upgrade needed in consequence of the results of the studies during the first session.
- Week 35 and Week 36. Acceleration of 1-3 batches of LHC beam. By that time the PS will very likely be able to deliver the nominal LHC beam.
- The last Long MD session in week 44 should be devoted to the measurement of the emittance blow-up and lifetime due to Intra Beam Scattering and RF noise and to all these studies requiring acceleration of a single bunch to high energy. These include: impedance determination by measurement of the detuning with intensity, halo scraping and beam profile monitor tests, linear and non-linear optics measurements. These would be compatible with the request of minimising induced radioactivity before the shutdown.

7 IMPLICATIONS

7.1 Implications for the PS and its users

The actual schedule will depend on the availability of the hardware required for the experiment and on the beam availability form the PS. A possible schedule for the beam availability is presented in Table 14:

Table 14: A possible schedule for the MD beams

Beam	Available by…
SFTPRO	week 12
TSTLHC	beginning week 14
SFTPRO CT 1-turn	beginning week 17
MESPS Short	week 19 or earlier
MDPRO	week 21
MESPS Long	week 24
LHC (with different bunch patterns)	week 30
High intensity SFTPRO / MDPRO	week 32
TSTION	week 37
TSTSPS	week 38

The presented schedule will require modifications of the supercycle length and composition during Long MDs. This might have implications for the rate of protons delivered to the experiments during this period and some flexibility from the PS users will be of great help in assuring the feasibility and efficiency of the machine development session. In 1999 thanks to the collaboration of the PS users and of the physics co-ordinator parallel machine development sessions could be often extended outside working hours. The same attitude will be of great help also in 2000. On the other hand additional scheduling effort on the ISOLDE beams would make planning of the machine development sessions easier.

7.2 Implications for LEP

Running high intensity LHC studies during Long machine development session proved to be incompatible with lepton acceleration to 22 GeV/c in 1999. This will be very likely the case also in 2000 [3].

Lepton availability for LEP during Wednesday sessions must be guaranteed in 2000 as it was in 1999 nevertheless any effort aiming at minimising the lepton request during theses dedicated sessions will be very helpful for an efficient running of the study. This could be achieved by programming access and RF or cryogenics maintenance preferentially during Wednesday MD sessions.

8 CONCLUSIONS

The requests of machine studies for the year 2000 is increasing as compared to 1999 as a consequence of the future commitments of the SPS as LHC Injector and as neutrino source for the Gran Sasso Laboratory. The corresponding decrease of available machine time (particularly dedicated time) for studies makes scheduling essential.

A set of guidelines for the attribution of time has been proposed and a possible planning reflecting these guidelines has been presented. This is based on a thorough use of the parallel sessions wherever possible and in a limitation of the dedicated studies to the most urgent ones. The implications in terms of the beam requests for the PS have been analysed and the implications for the PS users and LEP investigated.

Due to the absence of margins, flexibility will be demanded to the injectors and to LEP and their users as well as to the SPS MD users who might see their requests in terms of time not fully satisfied.

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