Detector Simulation

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Overview:

- *Overview of available simulation tools*
- *Status of Geant3 BRAHMS*
- *Tracking results with BRAHMS (K.Mönig)*
- *Occupancy studies (M.Battaglia)*
- *Other studies planned or in progress*
- *Fast simulator tools: SIMDET,SGV*
- *Event Output*
- *Code Management*
- *Agenda for Parallel Session.*
- *Summary.*

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Overview of Simulation tools:

A variety of complementary simulation tools are available. Detailed detector and physics studies are already underway using these tools. Links to the code and documentation can be found at:

`http://rsl3eth2.cern.ch/~pohl/sim_home.html`

- SIMDET v2 authors S Schreiber, M Pohl et al. is a FAST simulation for general physics studies. It applies an energy flow algorithm obtained using the full simulation BRAHMS. This program is an updated version of the one used in the previous ECFA/DESY study.
- SGL author M Berggren is an alternative FAST simulation for general physics studies. It is based on code developed originally for the DELPHI experiment.
- P.Steffen has been modifying SIMDET to produce a a MEDIUM speed program using the GFLASH parametrisation developed originally for the H1 experiment; effectively a fast version of GEANT3. Aimed towards detailed studies of granularity, jet mass studies etc.
- BRAHMS authors T.Behnke,G.Blair,K.Mönig,M.Pohl et al. is a FULL simulation using GEANT3. Ideal for detailed calorimeter and tracking studies. Track reconstruction and (rudimentary) clustering are present. No detailed pattern recognition.

Fast Simulation:

SIMDET:

SIMDET v2.0 is now available on the Web. It contains Gaussian smearing for resolution effects, energy flow and will be matched to BRAHMS for more detailed calorimeter effects. A common output format is planned. You can find the code at:

`http://www.ifh.de/~pohl/sim_guide.html`

SIMDET v3 is almost ready for release. It will include:

- Shower shape of CDR detector, as determined from BRAHMS.
- Parametrisation and implementation in fast monte-carlo.
- Cluster finder (from L3)
- Commonly-agreed output structure
- Energy Flow

The Energy Flow alogorithm will be of use in any monte-carlo. Plans exist to incorporate it into BRAHMS.

SGV: This is an alternative fast simulator which can be used as a cross-check on the SIMDET output, as well as in its own right. See talk by Andre Sopczak for examples of its use. M.B. has generated background events of WW,ZZ, $q\bar{q}$, Weν, Zee and $t\bar{t}$ with PYTHIA (in total 16 000 000 events corresponding to 500 pb^{-1}, without any problems). These events are being used in physics studies. You can find the code at:

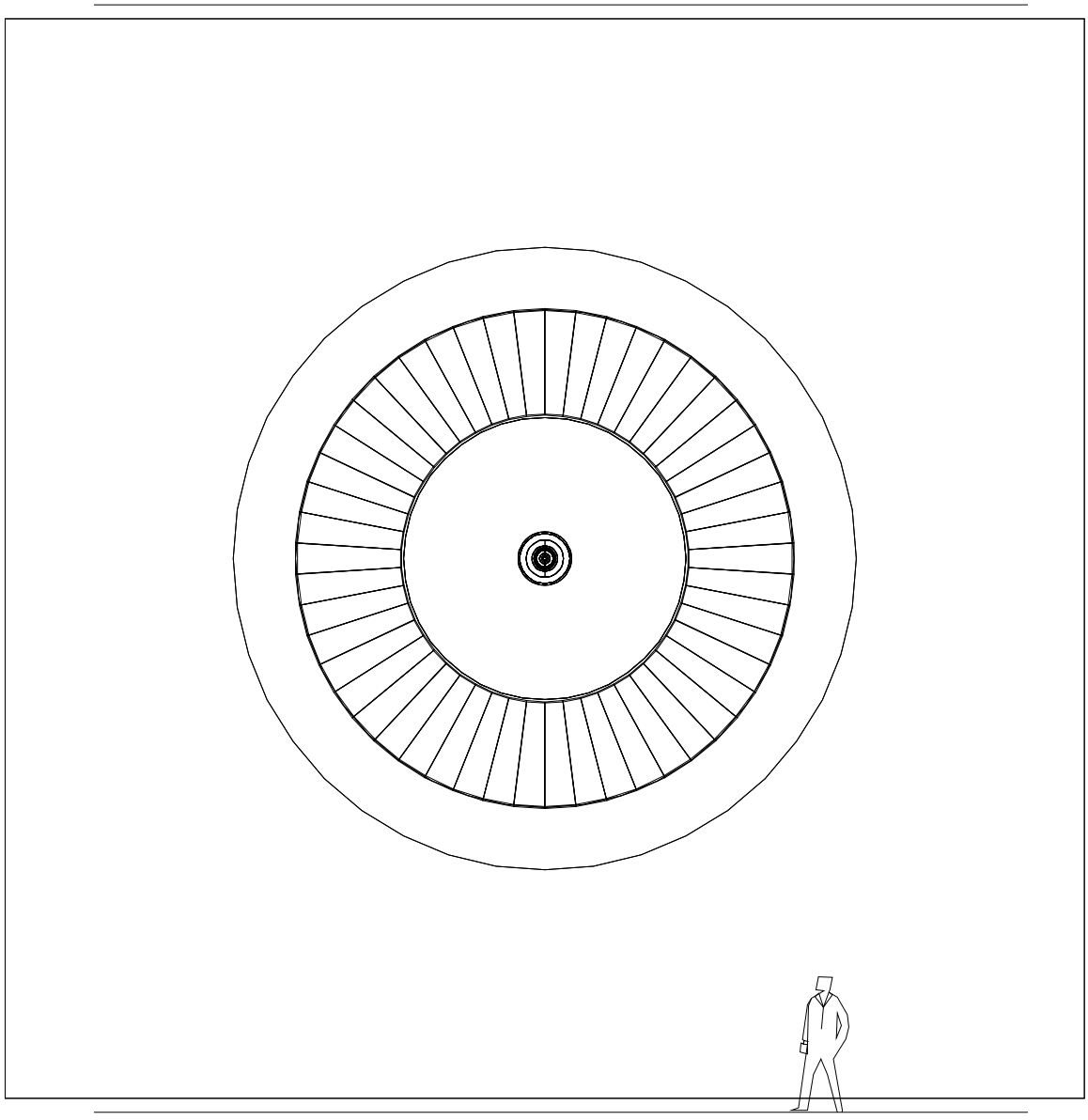
`http://home.cern.ch/~berggren/lc/sgv_lc.html`

The CDR Detector as coded in BRAHMS:

- Beampipe (Depends on Vertex Detector Option)
- Vertex Detector (CCD or APS) geometries plus basic hits
- Intermediate Tracker material only
- Silicon Intermediate Tracker not yet included
- Main tracker (TPC) material, with basic hits
- Presampler material plus basic hits
- E-M Calorimeter (Lead-Scintillator Shashlik), material plus hits
- Hadron Calorimeter (Copper-Scintillator Shashlik), material plus hits
- Tail Catcher, muon id material plus very basic hits
- Luminosity Calorimeter material plus basic hits
- Instrumented Mask material only
- Forward Tracker material plus hits
- Forward Muon Tracker not yet included
- Muon Trackers not yet included

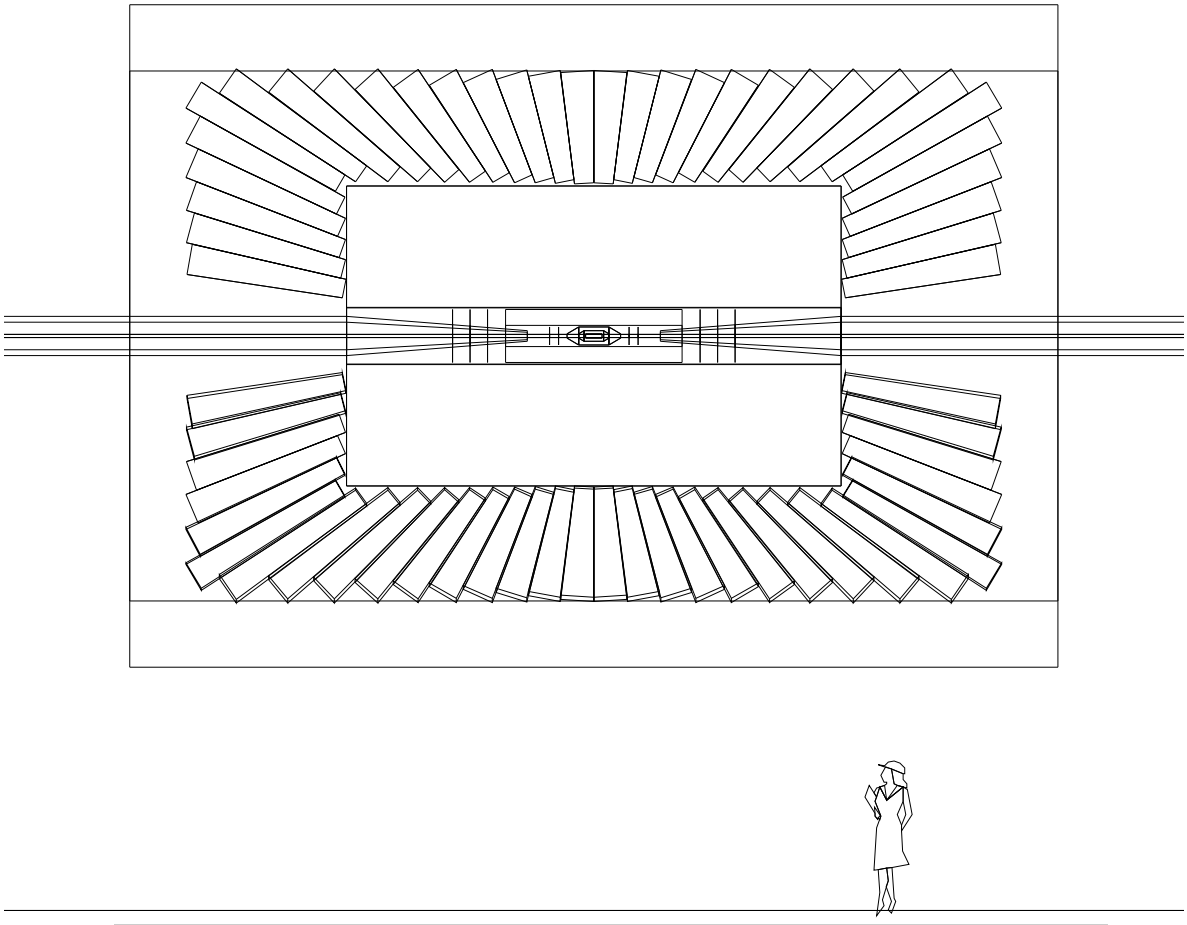
End View of the Detector as coded in BRAHMS:

- 3T Magnetic Field
- 50 Calorimeter towers around phi in barrel region.



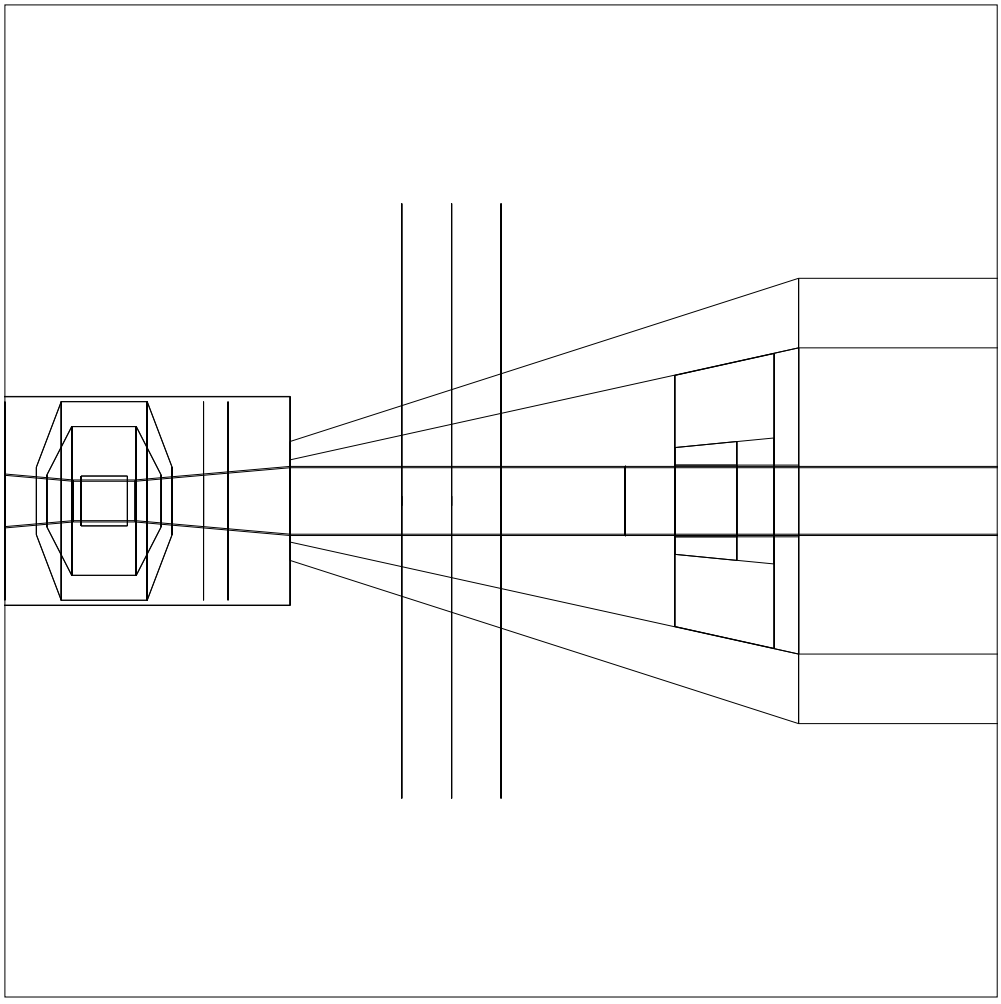
Side View of the Detector as coded in BRAHMS:

- Projective Calorimeter towers
- Calorimeter within coil.



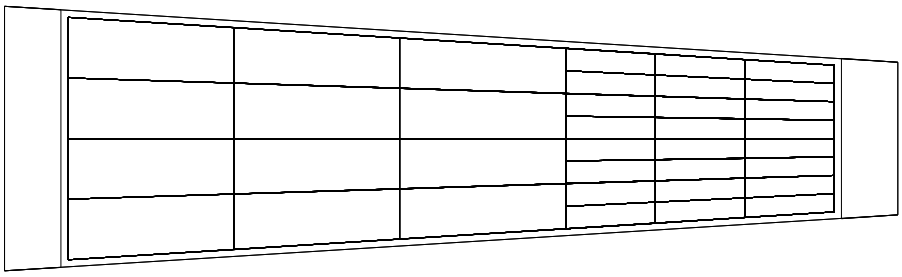
Inner Detector as coded in BRAHMS:

- Vertical scale enlarged 4 times
- APS VXD option shown
- Side view - FTD disks appear as lines.
- LCAL visible within mask.



Calorimeter Towers as coded in BRAHMS:

- Projective Cells
- ECAL: 8×8 cells in transverse segmentation
- HCAL: 4×4 cells in transverse segmentation
- ECAL,HCAL each have 3 longitudinal segments.
- ECAL: Lead-Scintillator
- HCAL: Copper-Scintillator
- Electronics: included as material at both ends of tower.



A tracking study using BRAHMS:

Klaus Mönig has been using his code within BRAHMS to study the tracking performance as specified in the CDR.

1. hits as supplied by BRAHMS
2. no allowances for multiple scattering
3. no pattern recognition.

400 GeV single Muons

$7^o < \theta < 173^o$

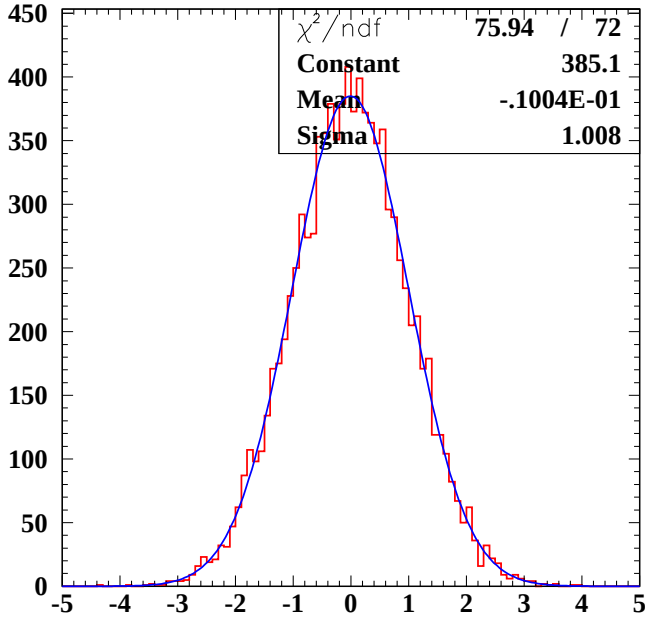


Figure 1: pull distribution for $\frac{1}{p}$

Plotting the relative momentum error as a function of polar angle for 400 GeV muons:

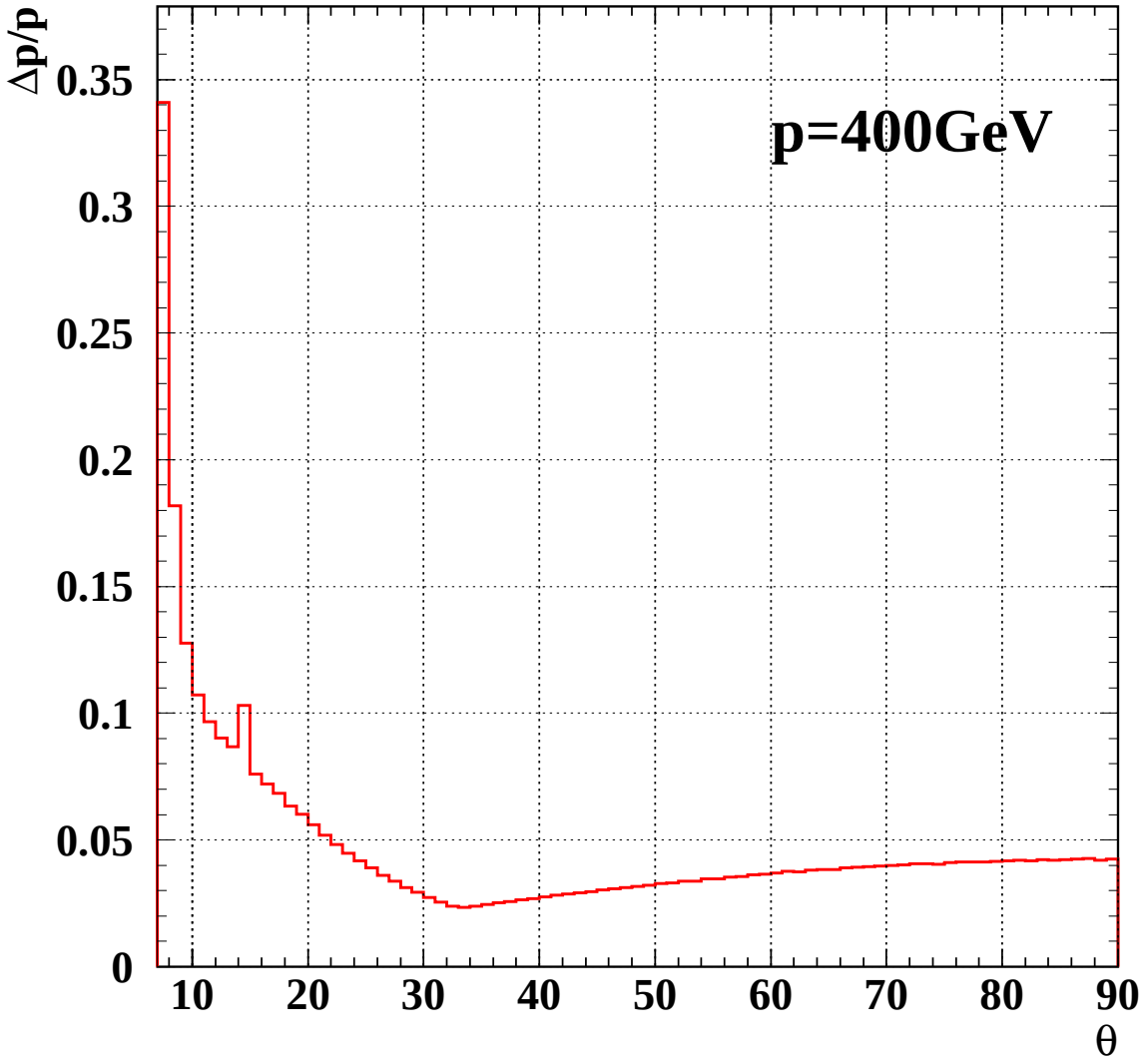


Figure 2: Relative momentum error vs angle (CDR Detector)

and the resolution (μm) on $r\phi$ and z impact parameter:

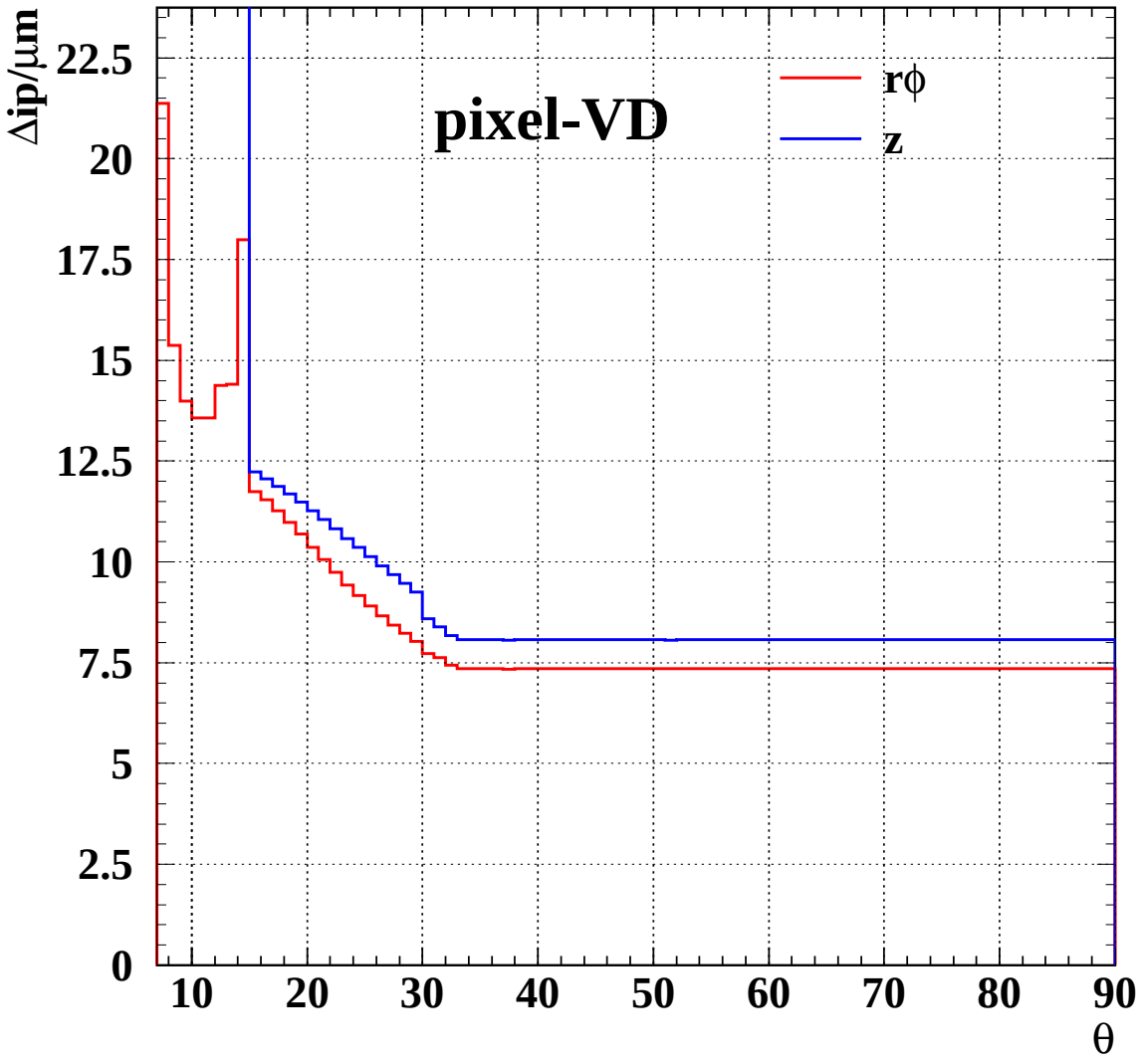


Figure 3: resolution on $r\phi$ and z impact parameter(CDR Detector)

In summary: a very useful tracking study is in progress using the full simulation. See KM's talk for further details.

Occupancy Studies and other studies:

Marco Battaglia and Kenneth Osterberg have been using GEANT to study:

1. The occupancies in the vtx tracker for the 1 cm beam-pipe radius
2. The occupancies in the ITC.
3. Some proposals of geometry

They have implemented their code in BRAHMS and this will be included in the next release. For details, see the talk by M.B in the detector parallel sessions.

Calorimetry: Volker Korbel and Sergey Kotelnikov are using BRAHMS to investigate calorimeter performance in the full detector. One aim is to study how resolution and tails are affected by the amount of calorimetry inside the coil.

Study outline:

- Simulating single pions at normal incidence.
- full geant calorimeter simulation using 'porridge' scintillator/absorber material.

In addition they intend to:

- measure visible energy in ECAL and HCAL , all cells.
- measure visible energy in coil.
- measure visible energy in tail catcher (not fully reconstructed but smeared with resolution $\frac{130\%}{\sqrt{E}}$).
- Calculate resolution and tails from 10,20,50,100,200,400 GeV particles or jets.
- Study effect of reducing number of λ inside coil.

Requirement: Needs many events (pions) of fixed energy. Such an event sample could be of use to many studies; so : we should think of coordinating this centrally.

Forward Region:

- Albert de Roeck and B.Surrow are planning to look into the the simulation program in the vicinity of the beamline: Mask, lumi detector, magnets...
- M.Piccolo is also interested in this region.
- Some of this is already included in Brahms, but *needs to be studied by experts*.

Again, this will need many events which will be of used to the entire workshop. : We should think of coordinating this centrally.

Event Output:

A group of interested people, coordinated by M. Pohl, have discussed a possible event output format for the workshop. This has been written up and put on the web page:

`http://www.ifh.de/~pohl/sim_guide.html`

A summary of the content of this web page follows:

- List of generator particles (straight copy from input):

  Number of particle records

  Particle record:

- status code, particle code, mother(s)

  p_x, p_y, p_z, E, M

  x, y, z, t of origin vertex

- List of reconstructed energy flow objects:

  Number of energy flow records

  Energy flow record:

  status code, object type, mother(s)

- best estimate: p_x, p_y, p_z, E, M

  tracker: p, theta, phi, DCA_{xy}, DCA_z, covariance

  Ecal cluster: E, theta, phi, C_{em}

  Hcal cluster: E, theta, phi, C_{mip}

  Muon system: E, theta, phi, C_{punch}

The intention is to use such a common output format for both SIMDET and BRAHMS, to allow a direct comparison.

Code Management:

This has become a priority.

Harald Vogt is setting up a central afs area for the workshop. It will be in:

`/afs/ifh.de/group/lc`

- Harald will act as code manager
- We will continue to use PATCHY/CMZ.
- Source code will go into a src subdirectory.
- Documentation will go into a doc subdirectory.
- An example directory will be created which contains examples of how to use the programs.

A web-based system TUOVI is also being investigated on a trial basis.

`http://pia.desy.de:8135/TWDM/cgi/twdmproto.pm`

OO Plans and Activities:

This is gaining some momentum

- Harald Vogt and Martin Pohl are collaborating on OO plans to create an interface between Fortran based simulation programs for the LC and OO graphic tools now on the market .
- In their case this is hepvis $\rightarrow$ OpenInventor $\rightarrow$ OpenGL $\rightarrow$ X11
- Ralf Gerhards has been involved with the installing GEANT 4 at DESY. He has been looking at taking the geometry rz file of BRAHMS and employing a conversion to put it into GEANT 4.
- It is becoming time to think about longer-term reconstruction issues in the context of OO.
- There is clearly a good opportunity to collaborate with our US/Japanese colleagues here.
- This is on the Agenda for the parallel session.

Simulation Group Parallel meeting

AGENDA

All talks 20 mins (approx).

1. G.Blair: Status of BRAHMS
2. J.Schreiber: Status of SIMDET
3. M.Berggren: Status of SGV (?)
4. R.Dubois: US simulation
5. H.Vogt: European OO plans and activities
6. R. Gerhards: Geant 4 and trigger issues.
7. M.Battaglia: VXD simulation.
8. V.Korbel: Calorimeter simulation.
9. M.Piccolo: Instrumented mask
10. D.Schulte: Comments on beampipe/forward geometry.
11. Discussion: What changes do we want with respect to what we have, especially: what changes to the baseline CDR detector? What pattern recognition/reconstruction tools do we want to study?

Summary: "what you should use"

- BRAHMS, SIMDET, SGV are up and running for the ECFA/DESY study.
- If you are starting a physics analysis, the recommendation is to start with SIMDET and if you would like a check: use SGV.
- If you are using SGV and you would like a check: use SIMDET.
- If you want to do detailed detector studies including material effects: use BRAHMS.
- Detailed physics studies as well as detector design studies are now possible and some are already started.
- Code management is now being implemented
- Common backround data sets are still on the agenda.
- GEANT4 is being considered for the medium term.
- BRAHMS, SIMDET, SGV are up and running for the ECFA/DESY study.

Final Comment: The simulation tools will not change much on the timescale of Sitges unless there is a significant input of effort from the users (or future users). If you don't like it, change it!