Simulation checks

Ph. Bruel

on behalf of many working groups :

Beam tests, Instrument analysis,
Calibration & analysis

Simulation checks

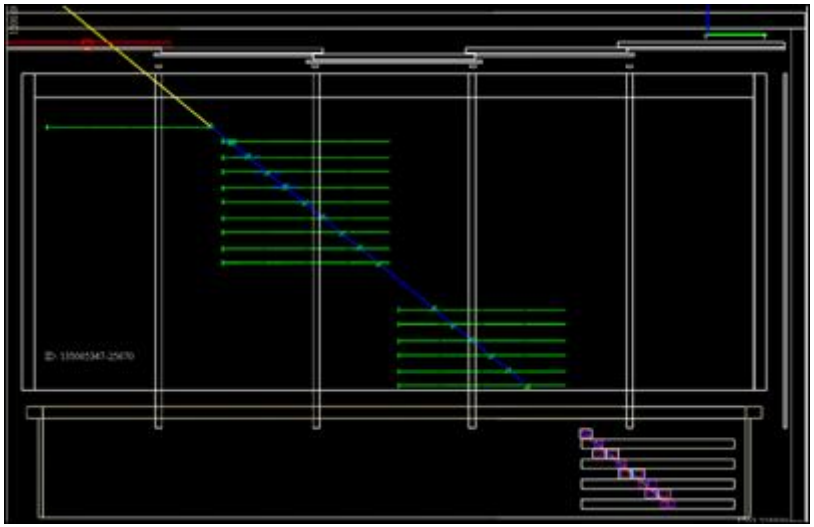
- Data/simulation agreement
- LAT ground muons results
- Beam tests at CERN
  - Tracker
  - Calorimeter
  - ACD
  - Background studies
- Beam test at GSI
- Conclusions

Data/MC agreement : agreements

- Event processing steps :
  - Trigger and On Board Filter
  - Reconstruction algorithms
  - Classification trees

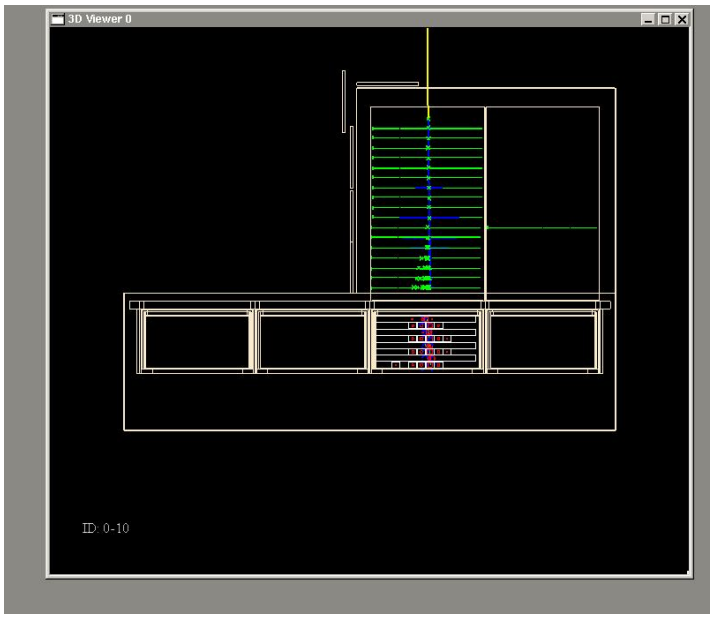
  (-> Instrument Response Functions and Background rejection)
- Different kinds of agreements :
  - For raw signals
    - Local and usually not too complex
  - For reconstruction variables
    - Local or global, can be complex but still a concrete quantity
  - For classification variables
    - Global, very high correlation level
- For the whole phase space and all types of particles…

LAT ground muons and CERN beam tests



- LAT ground muons
  - Testing the real LAT
  - With a lot of muons

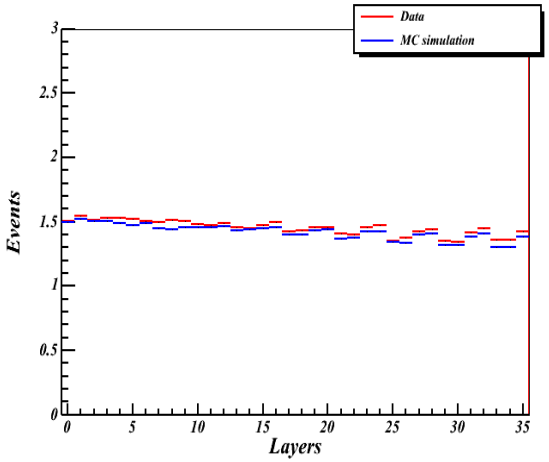
  but no gammas, no protons

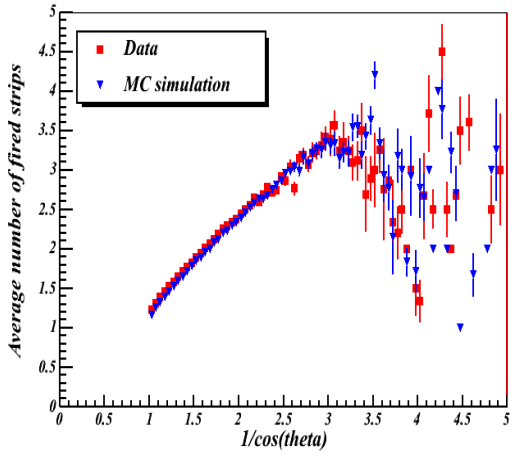


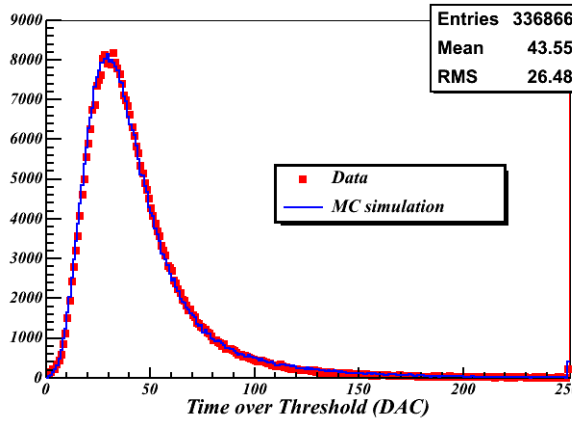
- CERN beam tests
  - Muons, gammas, electrons, positrons,protons, pions
  - From few MeV to 280 GeV
  - Testing the Calibration Unit
  - Most of the events are within two towers

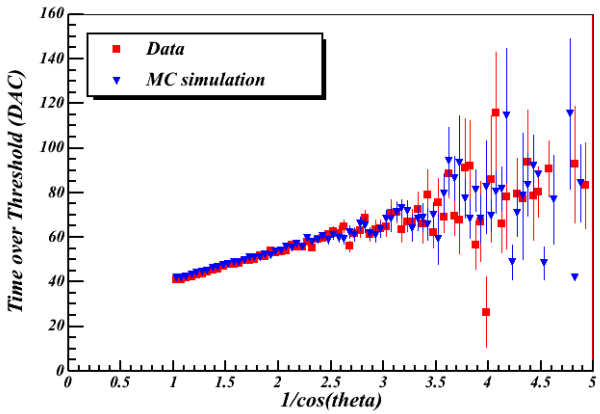
  but the CU is not the real LAT

The tracker and muons





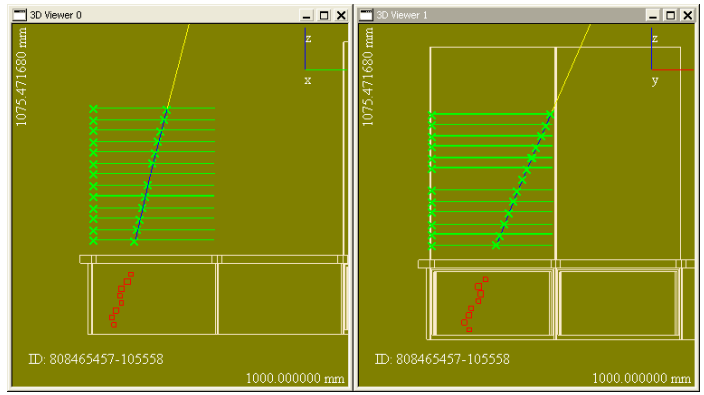




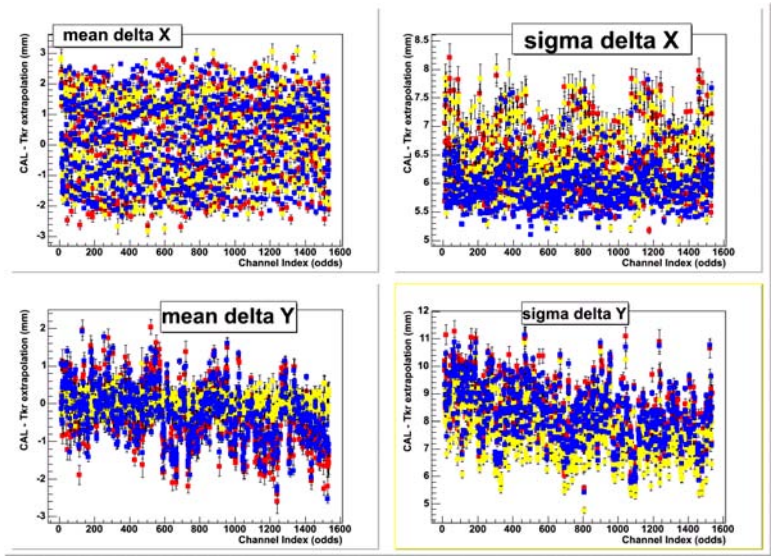
- Within muon selection, the agreement between data and MC is very good, both for
  - hit multiplicity
  - ToT
- Ground muons were used to perform the tower alignment

The calorimeter and muons

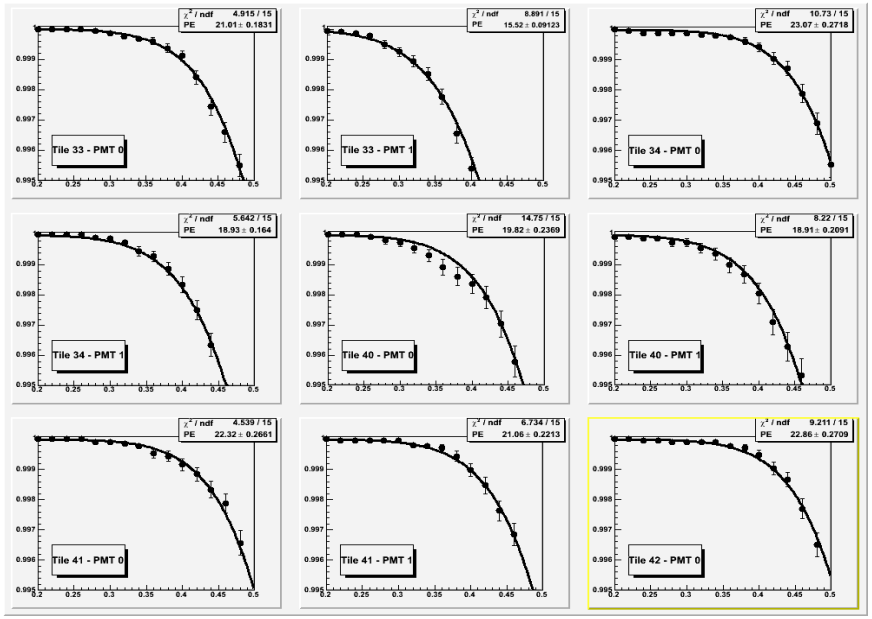
- Muon calibration
  - The energy distribution is a little broader in the data than in MC
  - Likely explained by intrisic light emission in CsI
  - Only at very low energy
- Position measurement
  - Comparing calorimeter measurement along the crystal to the tracker extrapolated position
  - Very sensitive to intercalibration (~1% calibration error can lead to a 5mm position error)



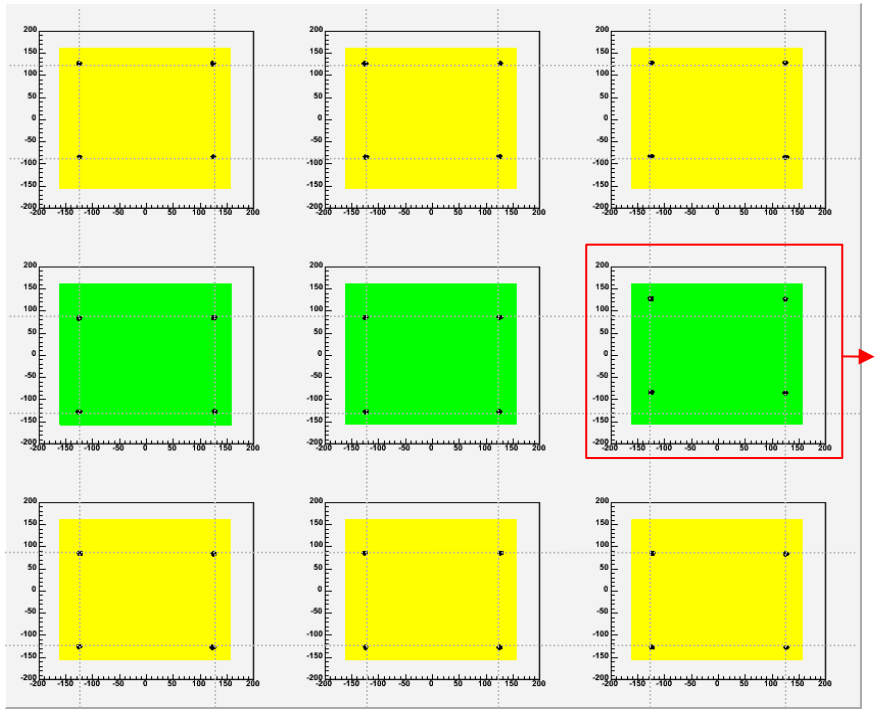
Data (red,blue) MC (yellow)



The ACD and muons

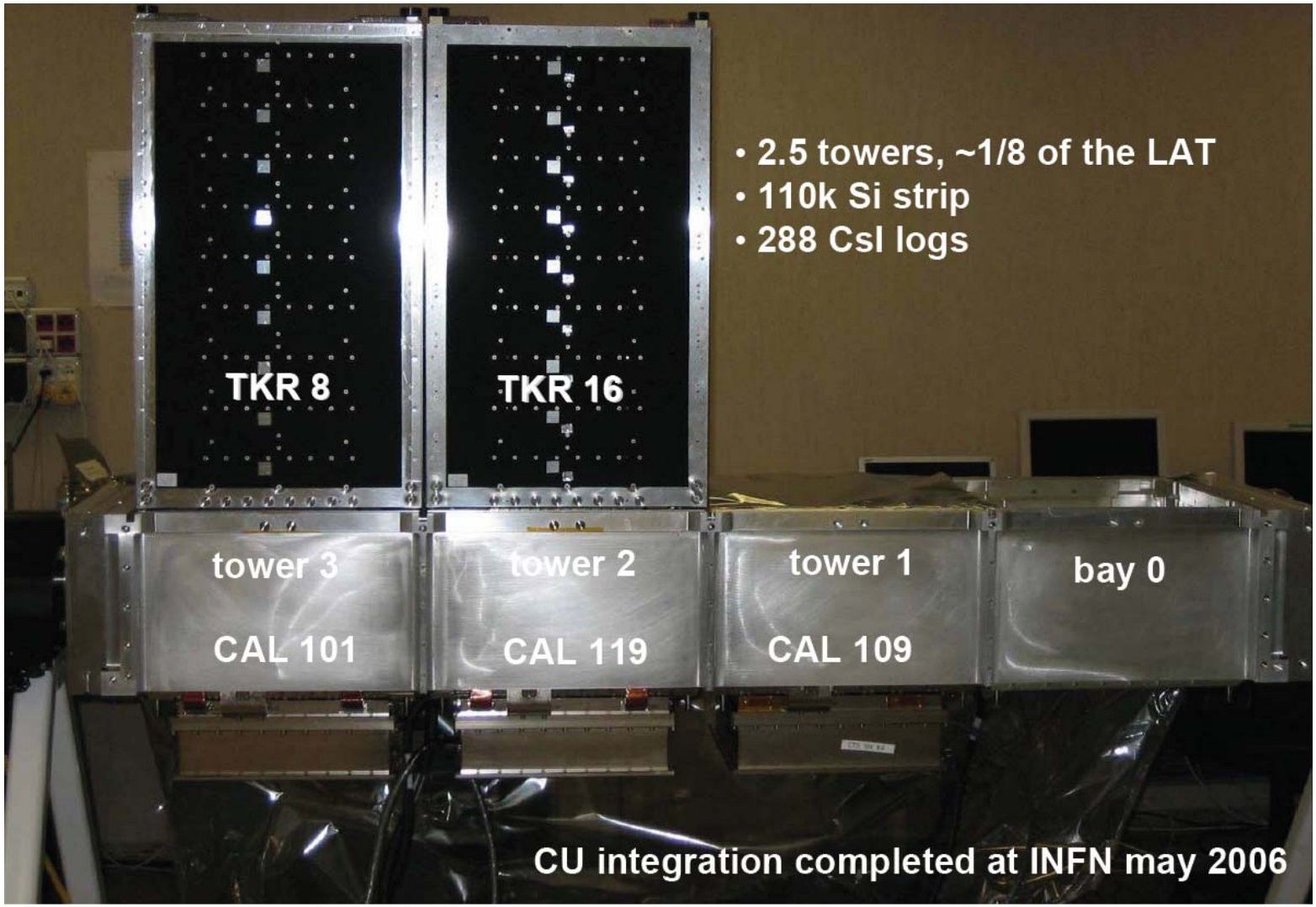


ACD efficiency as function of threshold -> implemented in the simulation

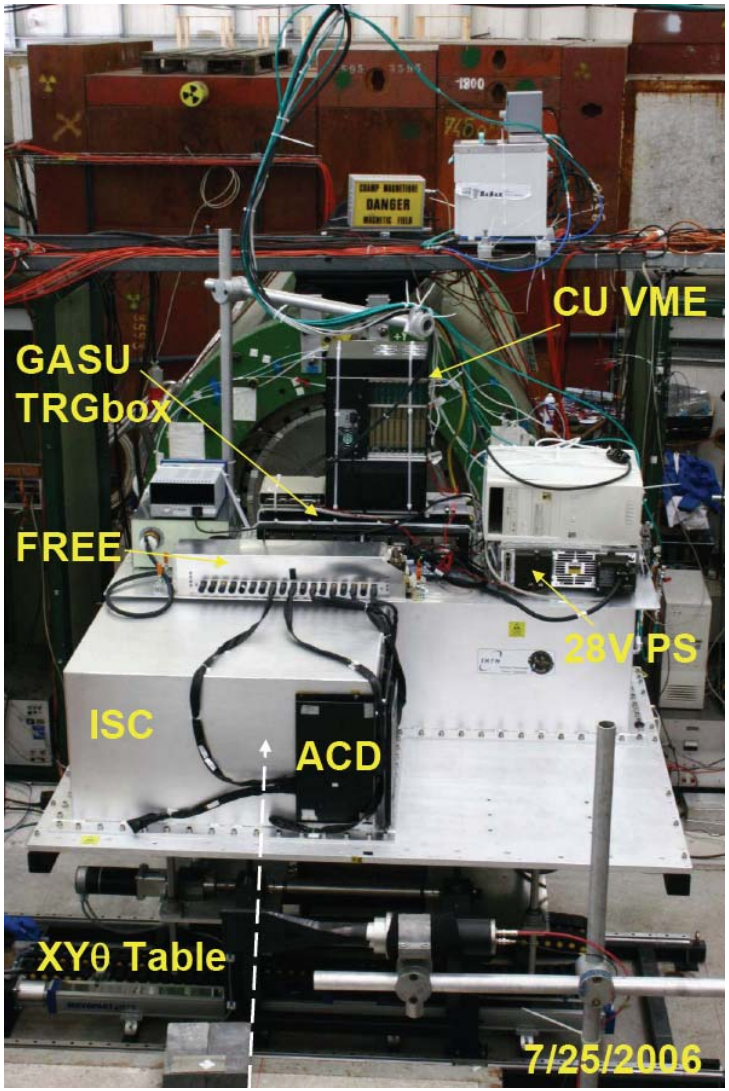


Ground muons allow an accurate implementation of the ACD geometry of the ACD in the simulation (holes, ribbons,…)

The GLAST-LAT Calibration Unit



The CERN campaign



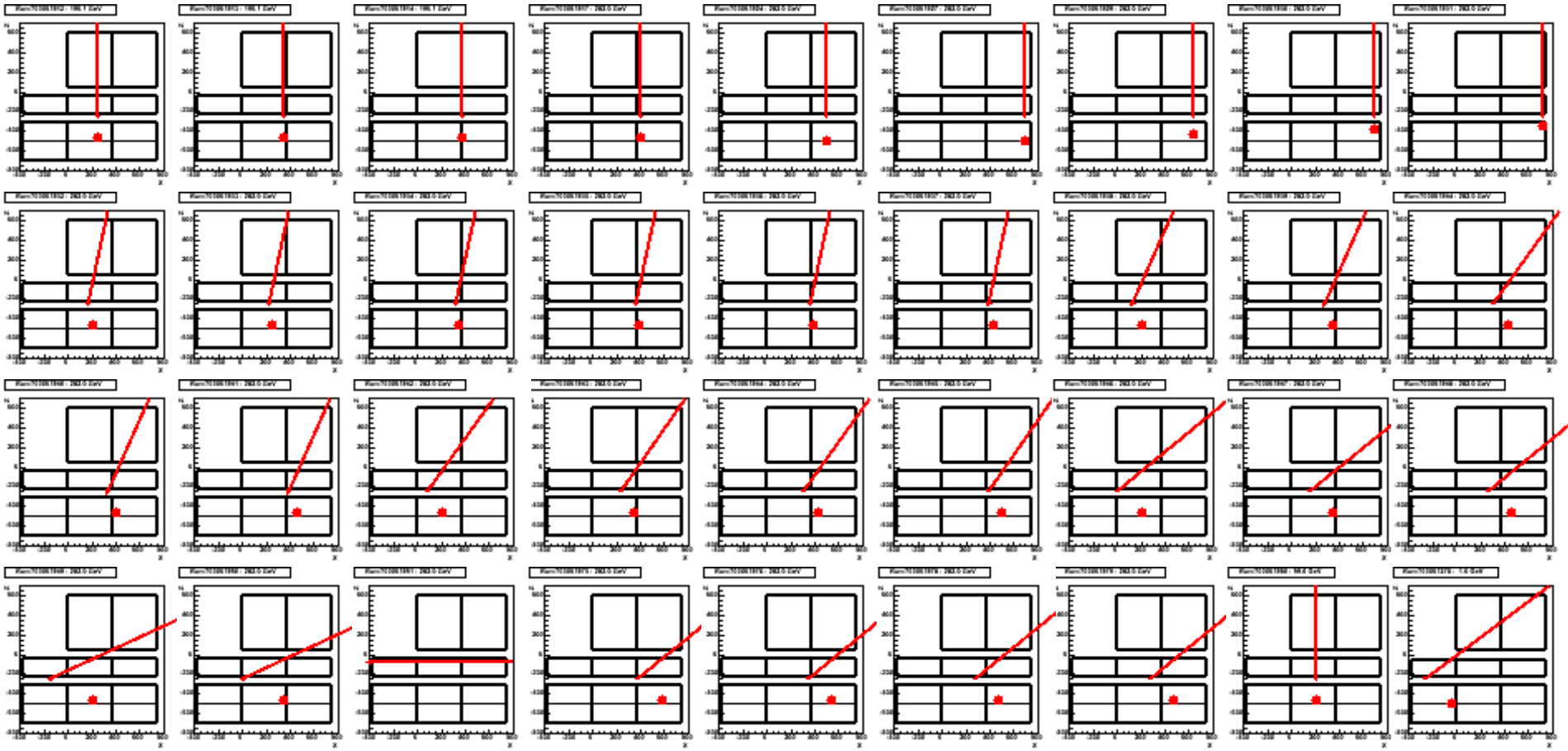
- 4 weeks at PS/T9 area (26/7-23/8)
  - Gammas @ 0-2.5 GeV
  - Electrons @ 1,5 GeV
  - Positrons @ 1 GeV (through MMS)
  - Protons @ 6,10 GeV (w/ & w/o MMS)
- 11 days at SPS/H4 area (4/9-15/9)
  - Electrons @ 10,20,50,100,200,280 GeV
  - Protons @ 20,100 GeV
  - Pions @ 20 GeV
- Data, data, data…
  - 1700 runs, 94M processed events
  - 330 configurations (particle, energy, angle, impact position)
  - Mass simulation
- A very dedicated team
  - 60 people worked at CERN
  - Whole collaboration represented

Mass simulation

Site	Particle	Energy	Angle
PS	Full-brem	2.5	0,30,50,-215
PS	Tagged g	0.5,1,1.5 ,2.5	0,10,20,30,50
PS	e+, e-	1	
PS	e- scan	5	
PS	p	6,10	0,30,60,90
SPS	e-	10,20,50 ,100,200 ,280	10,20,30,45,60 degree
SPS	p	20,100	0

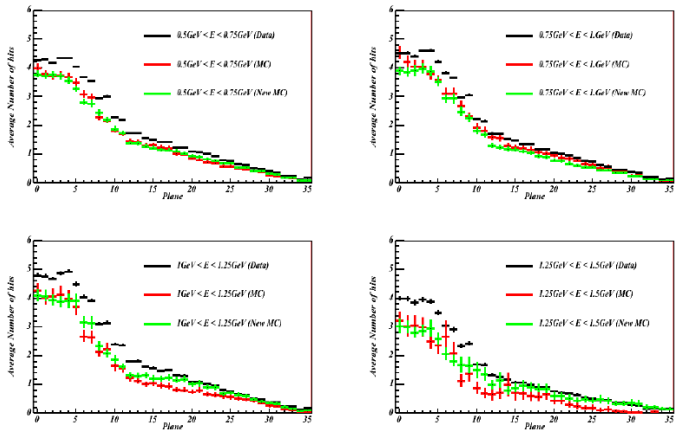
- Simulation of the beam upstream the CU (Geant4)
  - Trigger/veto scintillators & cerenkov
  - Electron tagger at PS
- LAT simulation (GLEAM-Geant4)
- Automatic generation of the run configuration
  - Allowing the best comparison
- Efficient processing through the pipeline at SLAC
- Geant4 optimization
  - Simulation parameters
  - Physics lists
- Also a very dedicated team !

Dealing with a huge phase space…



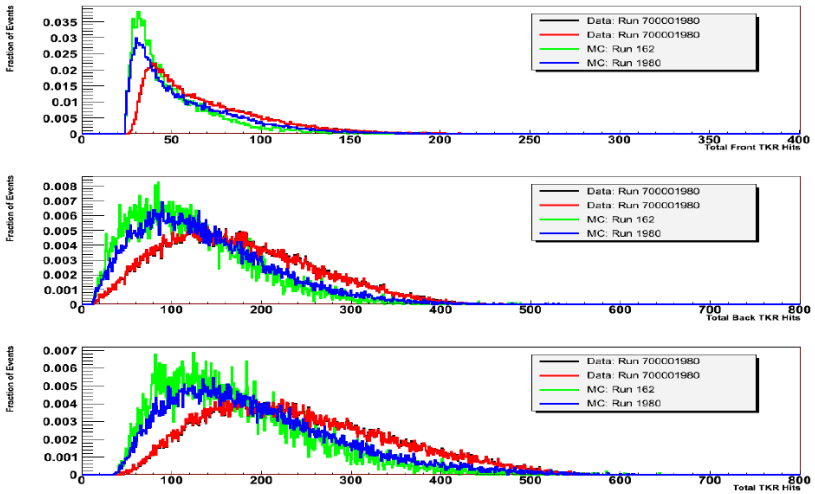
Tracker (work in progress…)

Hit multiplicity for gammas (0.5 to 2.5 GeV)

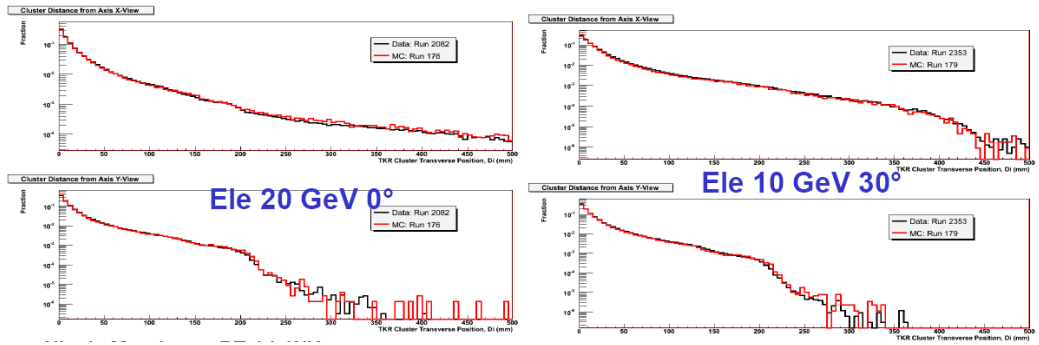


- 10-20% more hits in data than in MC
- Effect almost independent of particle, E
- Clusters are well reproduced by MC
- More secondary particles / preshower ?
  - Lower range cuts in Geant4 : no effect
  - Testing low energy processes
  - The calorimeter should say if there is extra material upstream the CU

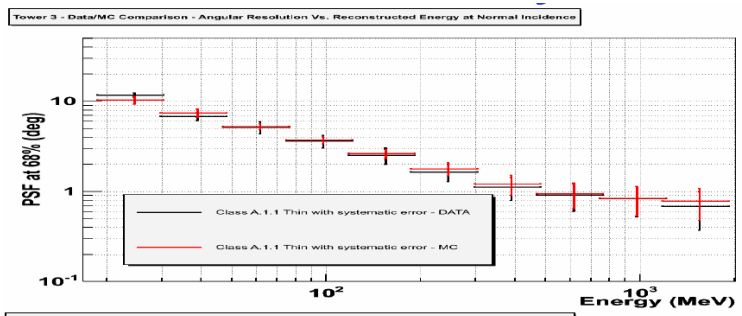
Hit multiplicity for 100 GeV electrons

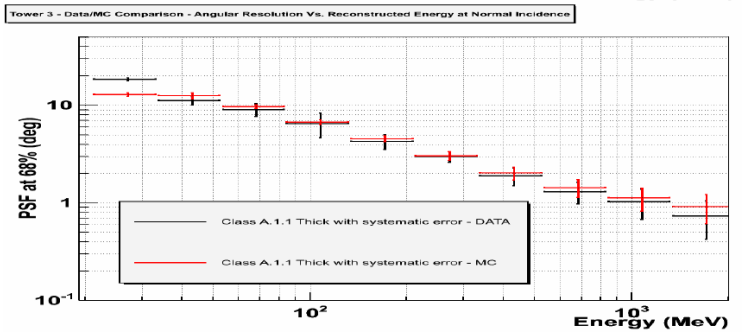


Cluster-axis distance for 20 GeV electrons



Tracker (work in progress…)

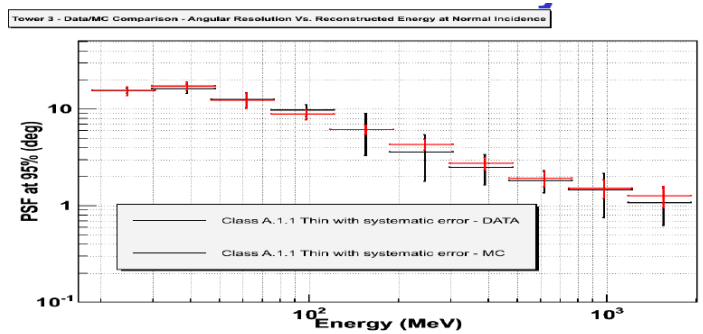


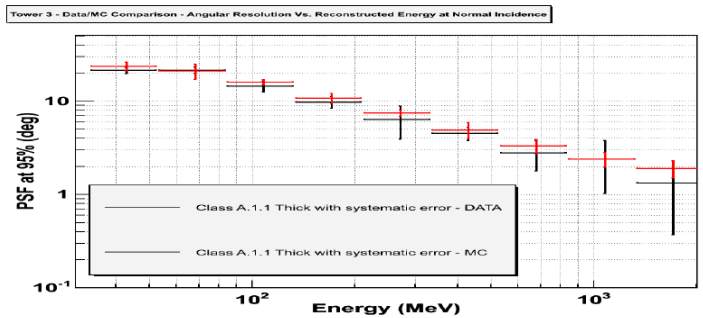


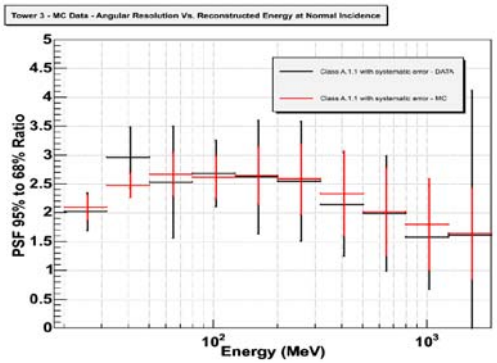
<- 68%

PSF

95% ->

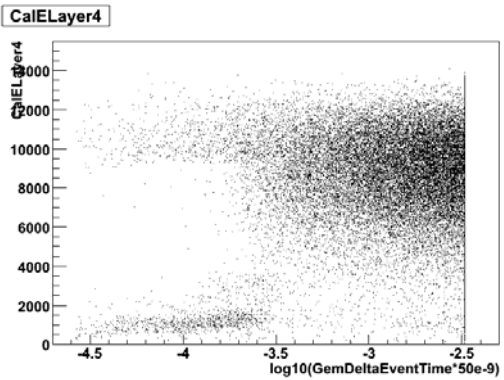


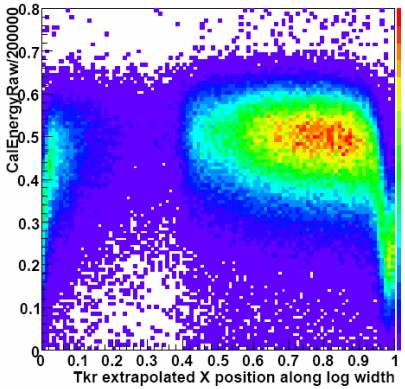


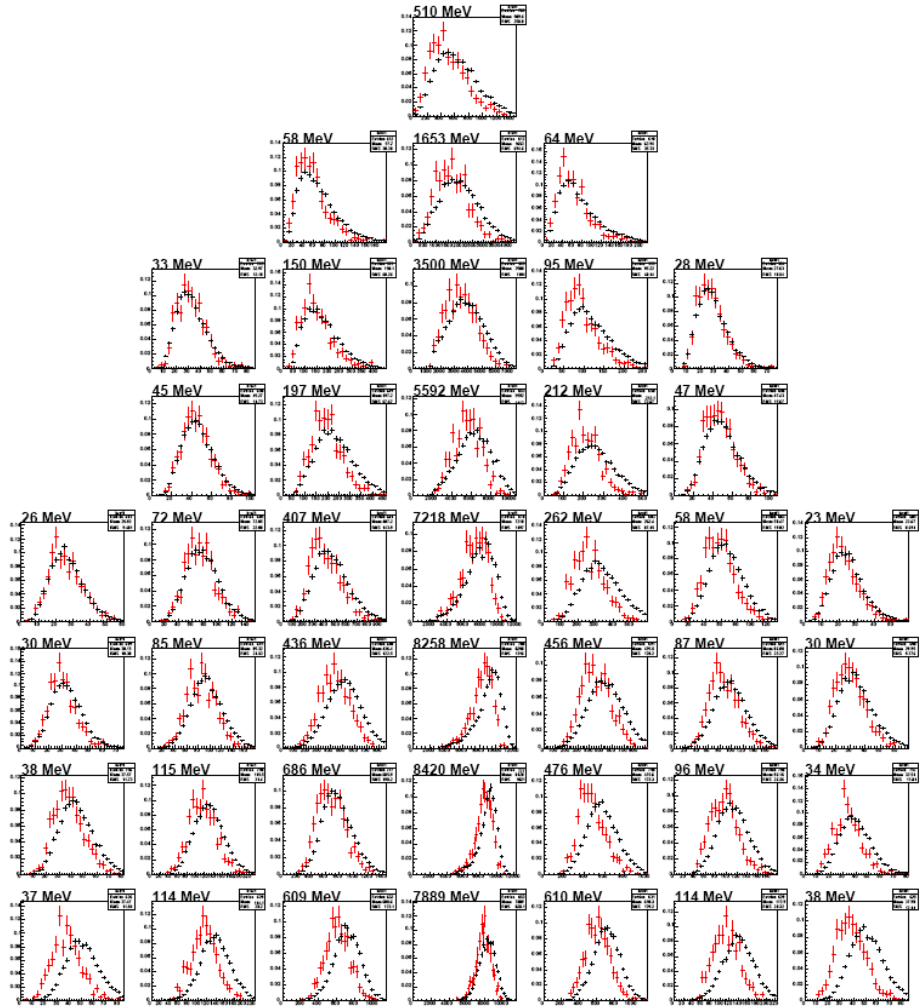


- Preliminary PSF results for events with 1 vertex and 2 tracks shows a good agreement between data and the simulation
- This not yet the PSF from the IRFs (i.e after signal selection and background rejection)

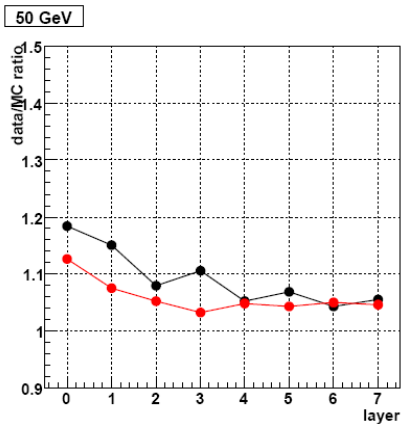
Calorimeter (work in progress…)

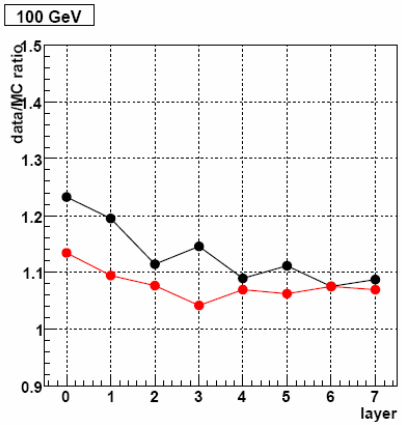




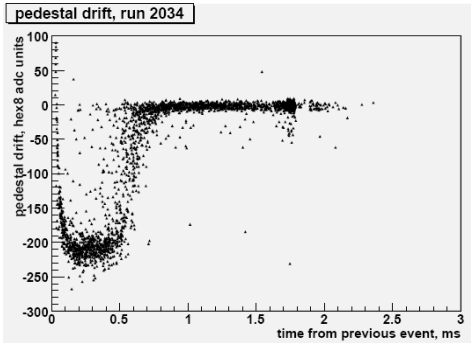


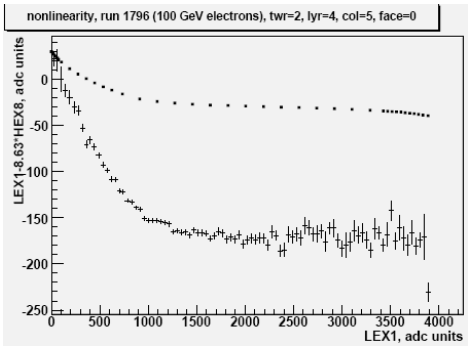
- Importance of quality/fiducial cuts
- Raw energy : 10% more energy in data for electrons at SPS

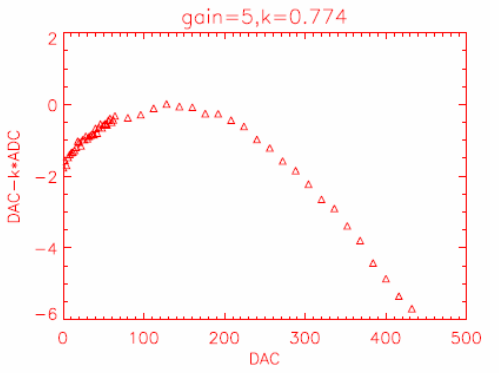




Calorimeter (work in progress…)

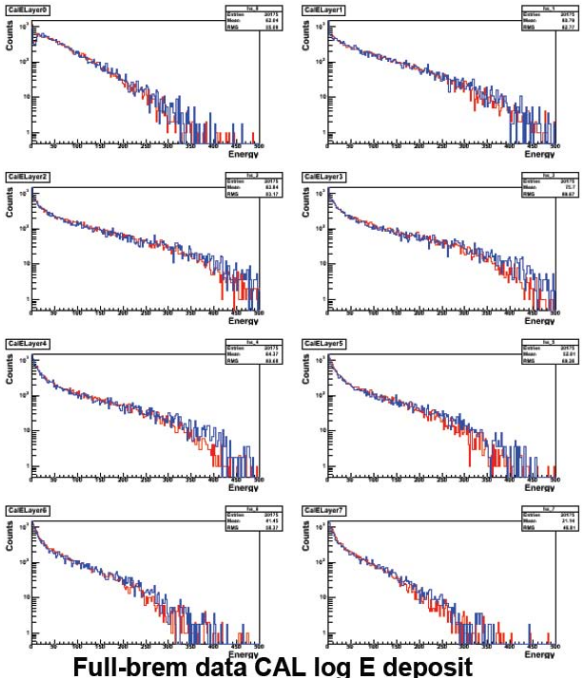






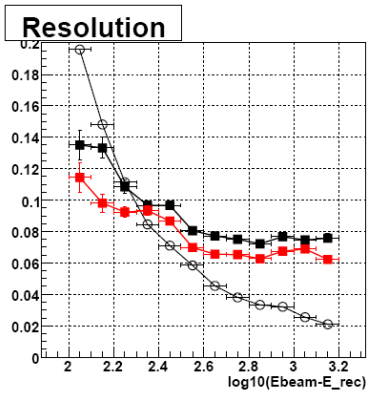
- The beam tests allow us to fully understand the electronics of the calorimeter
  - High rates
  - Cross-talk
  - Non linearity
- The 10% energy excess at high energy is mainly due to calibration issues
  - 2diodes x 2gains : 4 ranges from 1 MeV -> 70 GeV
  - Ground calibration : muon peak at 11 MeV
  - CERN data allow a complete check of our procedure to extrapolate the energy scale from 11 MeV up to 70 GeV

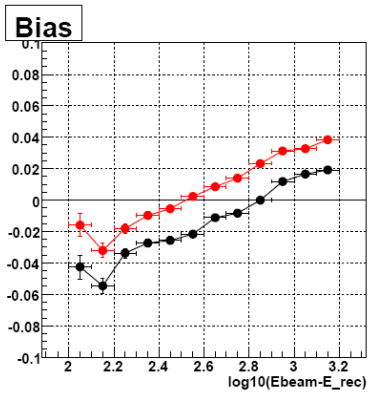
Calorimeter (work in progress…)



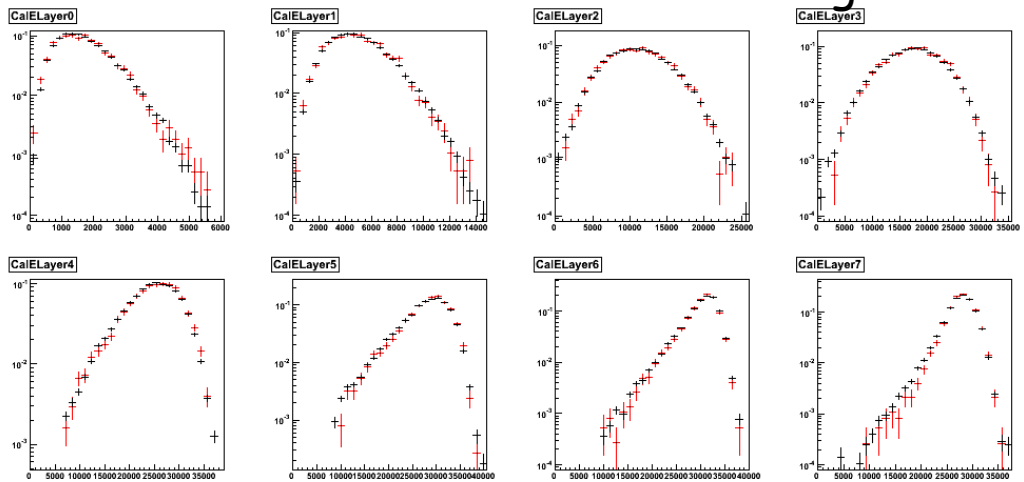
Full-brem data CAL log E deposit

- Very good agreement at PS energies
- Thanks to the electron tagger, we can measure the energy resolution from 50 MeV up to 2.5 GeV
- After naive calibration correction, very good agreement at SPS energies

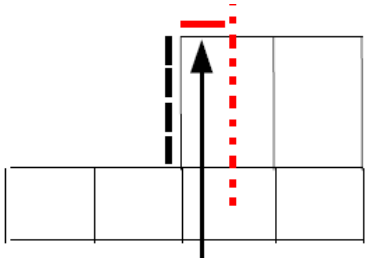


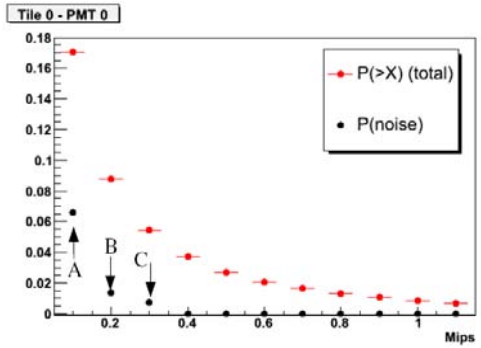


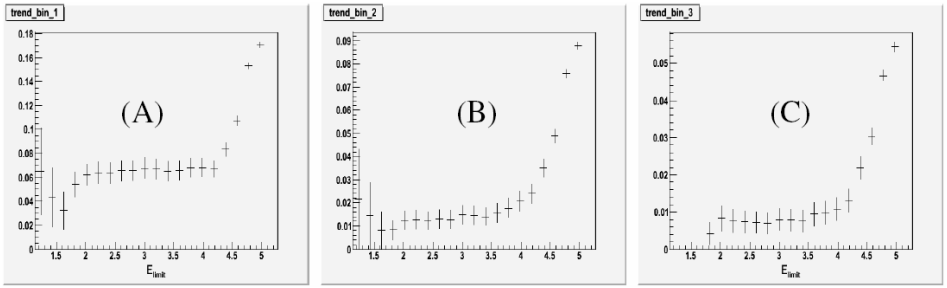
280 GeV electrons at 30 deg

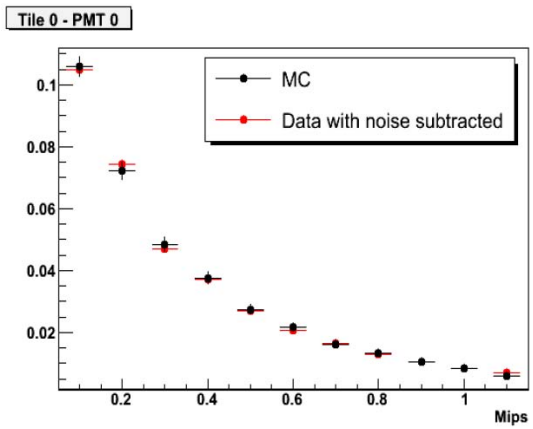


Preliminary backsplah study with ACD







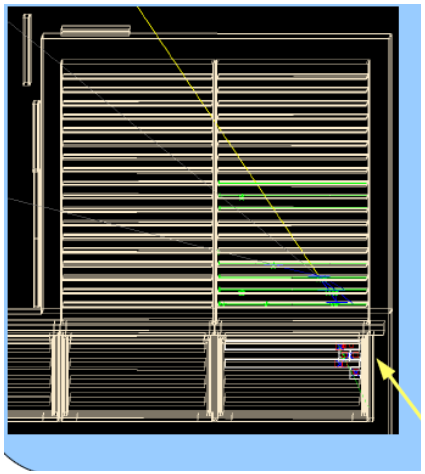


- Many configurations in order to test the backsplah simulation as function of energy, angle, distance to tile
- Use the dependance with the energy in cal to determine the beam noise contribution
- After noise substraction, data is well reproduced by MC

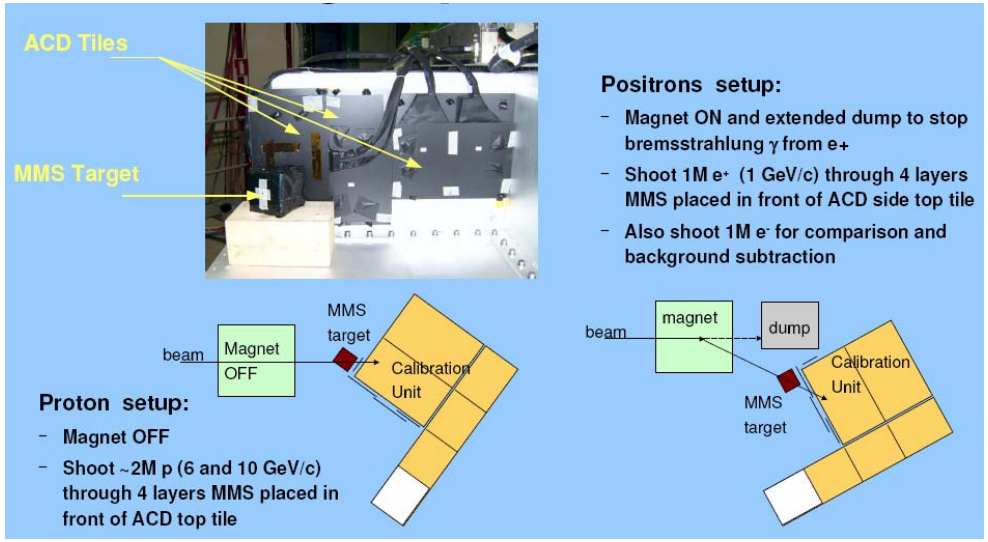
Preliminary background studies

- Simulation of hadronic processes with Geant4
- Albedo gammas
- Charged particle interaction in MicroMeteoroid Shield
  - Measure the probability that the particle creates a gamma like signal in the CU (no ACD signal, good signal in tracker and calorimeter)
  - Protons : preliminary results show a reasonable agreement
  - Positrons : preliminary analysis shows a clear signal due to positron annihilation with the expected probability

Albedo gammas (from 2.5 GeV e^-)

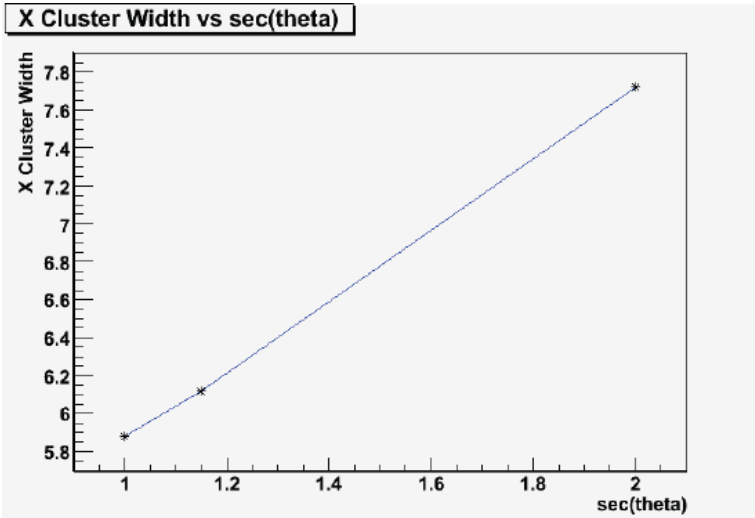


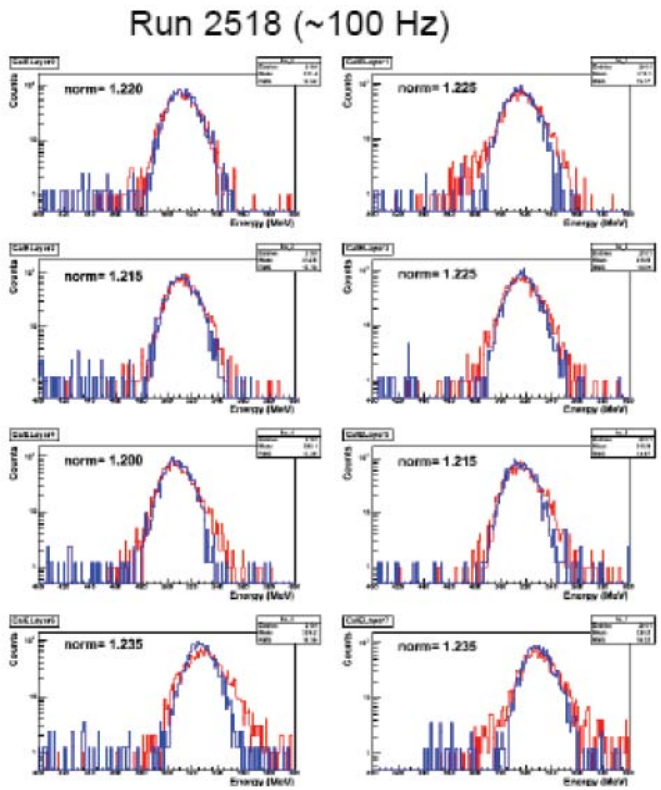
Protons and positrons interaction in MMS



Preliminary GSI results

- 17-19 November
- Beam : C @ 1.5 GeV, Xe @ 1 GeV
- Tracker clusters are x2 wider in data
- Same calorimeter quenching factors as measured in 2003





Analysis status

- Beamtest working group
  - Beamtest preparation workshops
  - Beamtest data taking at CERN, GSI
  - Data analysis coordinated by :
    - Luca Latronico (INFN-Pisa)
    - Philippe Bruel (IN2P3-LLR)
  - Weekly VRVS since September + analysis workshops
- Tracker : hit excess
  - Secondary particle excess
  - Ongoing tests with low energy processes ON in Geant4
  - Tray standalone simulation
- Calorimeter : energy excess
  - Understanding and improving the calibration
- Higher level studies (PSF, energy resolution, background,…)
  - Hampered by tracker hit and cal energy discrepancies
  - But the analysis tools are ready

Conclusions

- Ongoing tests to understand the current disagreements
- Data reprocessing and mass simulation are fast and easy
  - Testing new ideas or implementing a new calibration can be done within 1-2 weeks
- A huge amount of good quality data to ensure that our simulation well reproduces the data through the LAT very large phase space
- This effort must continue
  - Our results have to be implemented in the LAT simulation
  - The whole LAT analysis will then have to be checked before launch