Measuring the PSF and the energy resolution with the GLAST-LAT Calibration Unit

Ph. Brue

on behalf of the beam test working group
Measuring the PSF and the energy resolution

• Data/Simulation agreement and the LAT analysis
• Beam tests at CERN (PS and SPS)
  - Tracker and PSF
  - Calorimeter and energy resolution
• Conclusions
Data/simulation agreement and analysis

- Event processing steps:
  - Trigger and On Board Filter
  - Reconstruction algorithms
  - Classification trees (-> IRFs and Background rejection)

- Example 1: PSF
  - Tracks, vertices are reconstructed
  - Using not only tkr variables, the classification tree gives:
    - The best estimate of the incoming direction of the gamma
    - A quality variable used to select the best measured gammas

- Example 2: Energy resolution
  - 3 energy reconstruction algorithms -> 3 estimates
  - Using not only cal variables, the classification tree gives:
    - The best estimate of the energy of the gamma
    - A quality variable used to select the best measured gammas

- The calibration unit is different from the LAT
  - We can not apply directly and simply the classification tree analysis
  - But we can compare between data and MC
    - the PSF of each direction estimate
    - The energy resolution of each energy estimate
Dealing with a huge phase space…

1700 runs, 94M events, 330 configurations (particle, energy, angle, impact position)

For PSF and energy resolution analysis: gammas (\( \rightarrow 2.5 \text{ GeV} \)), electrons (5–\( \rightarrow \text{280 GeV} \))
Mass simulation

<table>
<thead>
<tr>
<th>Site</th>
<th>Particle</th>
<th>Energy</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS</td>
<td>Full-brem</td>
<td>2.5</td>
<td>0,30,50,-215</td>
</tr>
<tr>
<td>PS</td>
<td>Tagged g</td>
<td>0.5,1,1.5</td>
<td>0,10,20,30,50</td>
</tr>
<tr>
<td>PS</td>
<td>e+, e-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>e- scan</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>p</td>
<td>6,10</td>
<td>0,30,60,90</td>
</tr>
<tr>
<td>SPS</td>
<td>e-</td>
<td>10,20,50,100,200,280</td>
<td>10,20,30,45,60 degree</td>
</tr>
<tr>
<td>SPS</td>
<td>p</td>
<td>20,100</td>
<td>0</td>
</tr>
</tbody>
</table>

- 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
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

Ele 20 GeV 0°

Ele 10 GeV 30°

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Tracker (work in progress...)

- 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
  - 2 diodes x 2 gains : 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…)

- 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
Conclusions

• A huge amount of good quality data to ensure that our simulation well reproduces the data through the LAT very large phase space
• Data reprocessing and mass simulation are fast and easy
• Ongoing tests to understand the current low-level disagreements
• The preliminary results show that PSF and energy resolution are well reproduced by the simulation