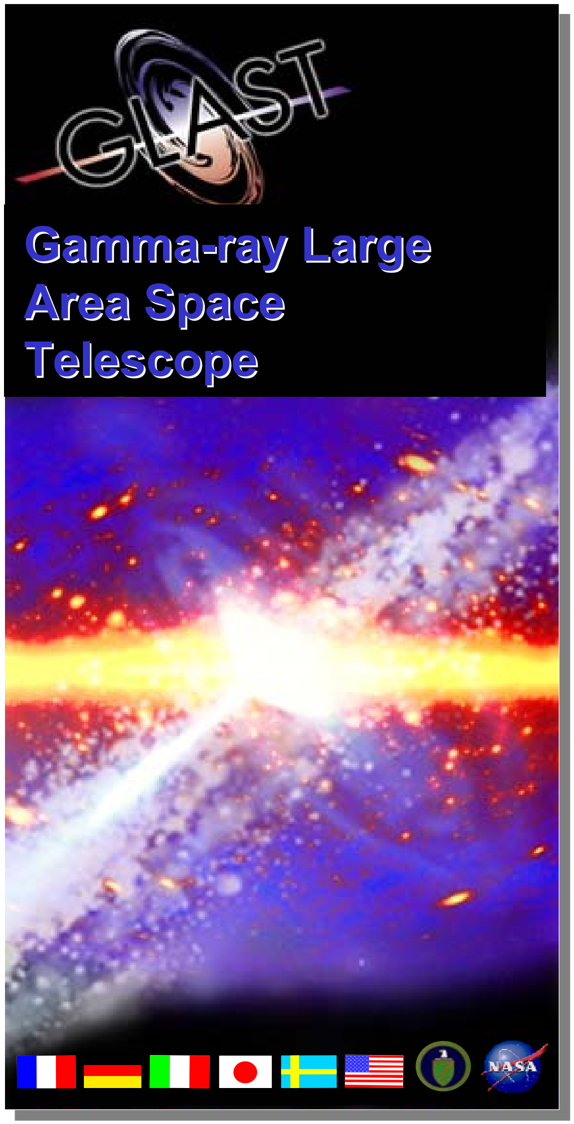

CAL on-orbit calibration with protons.

Alexandre Chekhtman
NRL/GMU

Why do we need alternative calibration method ?

- We always considered galactic cosmic rays (with 26≥Z≥6) as the only source of calibration signal for CAL on orbit
  - Advantages:
    - GCR events are collected in parallel with science operation
    - GCR provide several peaks with known energies covering all energy ranges (energy deposition ~500 MeV for C, ~7 GeV for Fe)
  - Problems:
    - Statistics is limited: according to recent simulation, to get 1000 hits per crystal we have to wait ~3 days for Carbon and ~200 days for Iron
      - This estimation doesn't include onboard filter efficiency and any angular or position selections – could easily get additional factor of 2
    - There is no way to debug GCR calibration software with real data before launch
      - one could expect difficulties and delays to get CAL calibrated on orbit for the first time
    - We expect the change of CAL calibration constants due to launch vibrations – and at the same moment we switch from one calibration method (cosmic muons on ground) to completely new (GCR) and not well tested
      - It will be difficult to decide, if the visible change of calibration constants is real or due to different calibration procedure
- Proposed solution:
  - Calibrate calorimeter right after launch using protons
  - Calibration procedure should be very similar to muon calibration on the ground
  - It will be dedicated data taking mode, but the procedure could be done within few hours

Calibration procedure

- collect proton data to calibrate LEX8 range
  - Tracker trigger && ACD in the region of interest
  - 1 range readout zero-suppressed data
  - 2 kHz of protons hitting the CAL (compare to 0.5 kHz of muons on the ground)
    - We'll be mainly limited by the downlink bandwidth
  - Special onboard filter required to make the event rate acceptable
    - Select only clean proton events, without nuclear interactions
      - Ratio of signals from different layers should be close to 1
      - Factor ~ 2
    - Select protons close to vertical direction in one plane
      - requiring the signals above threshold 4 crystals in one column, signals below thresholds in all other columns
      - Factor ~15 (from muon calibration on the ground)
    - If rate is still too high – we can prescale proton events

Calibration procedure (cont.)

- Ratio LEX8/LEX1 and HEX8/HEX1 could be calibrated by charge injection (calibGen)
- To calibrate ratio HEX8/LEX1 we need to collect 4 range readout zero-suppressed data with energy depositions 100 MeV – 800 MeV in one crystal
  - Any background events with CAL_LO trigger could be used:
    - Nuclear interactions of protons
    - albedo
    - …
  - Should not be close to the crystal end – direct light affects the ratio
    - Need some selection based on longitudinal position (light asymmetry)
  - Statistics is not so critical
    - The spread of the HEX8/LEX1 ratio is defined by HEX8 noise (~1-2%) , so even 100 events per crystal give reasonable calibration precision

Conclusion

- To provide quick initial CAL calibration after launch we propose additional calibration procedure using protons
- The procedure is very similar to actual muon calibration used on the ground
- It requires dedicated data taking
- Special onboard filter is needed to make the rate of proton events acceptable
  - Eric Grove started to discuss this possibility with flight software group