Particle beam test for the GLAST-LAT Calibration

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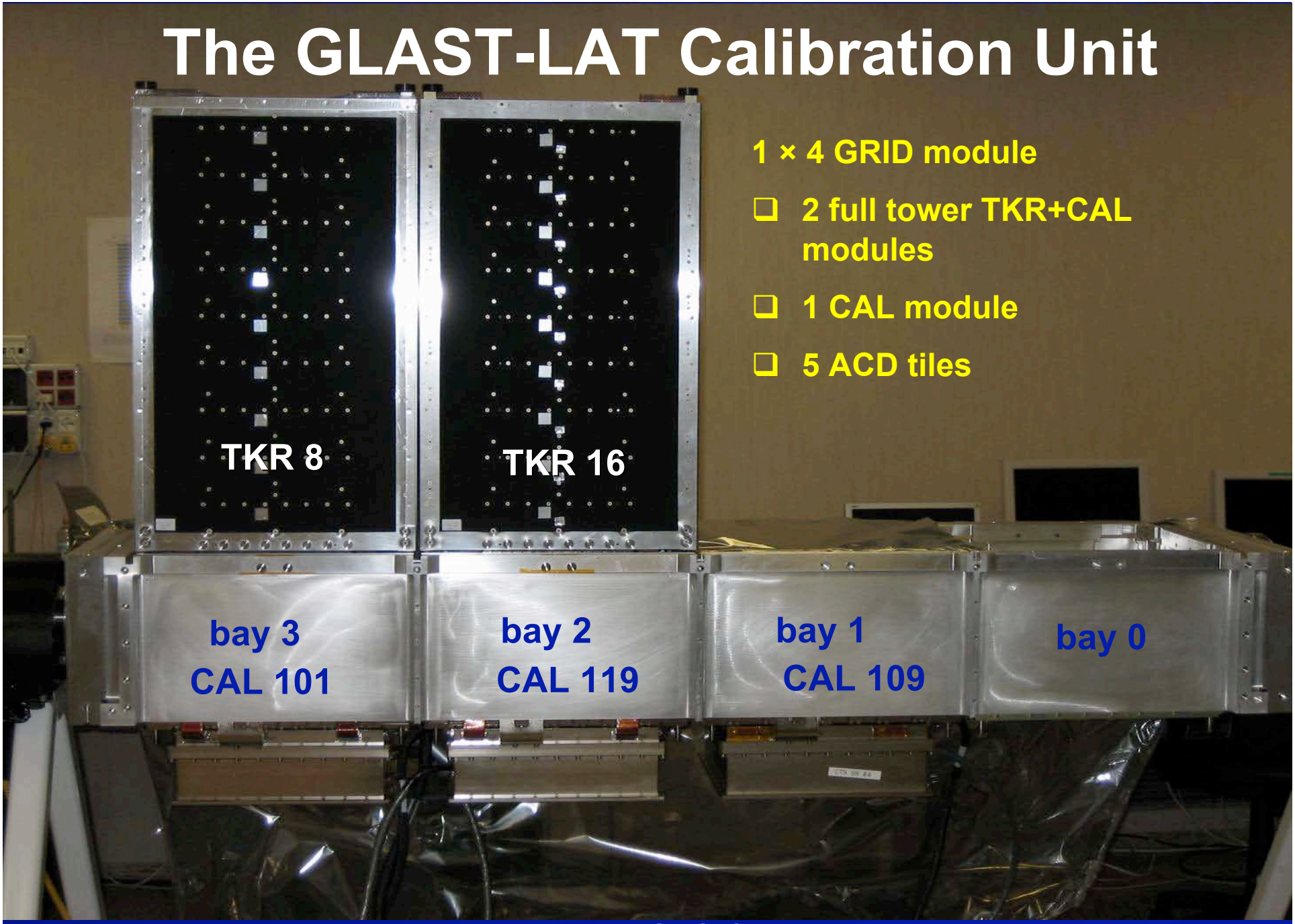
The GLAST-LAT Calibration Program

Calibration of any astronomical instrument is essential to the interpretation of its results, in particular the pre-launch calibration is crucial for a complex detector such as GLAST-LAT.

- LAT Calibration Strategy
  - Analysis by Monte Carlo Simulations
  - Test
    - Charged Cosmic rays (pre-launch and on-orbit)
    - Particle Beam test
- Calibration Unit Beam Test
  - Direct LAT calibration on a beam is too demanding
  - Most events on orbit contained in 2 towers
- Calibration Unit (CU) Beam Test Plan
  - build a fraction of the LAT using available flight spare modules
  - expose CU to variety of beams (at CERN and GSI)
    - photons, electrons, protons, positrons, heavy ions
    - energies from 100MeV to 300GeV
    - many different configurations (angle, impact point)
  - directly measure CU performance
  - validate full LAT Monte-Carlo simulation

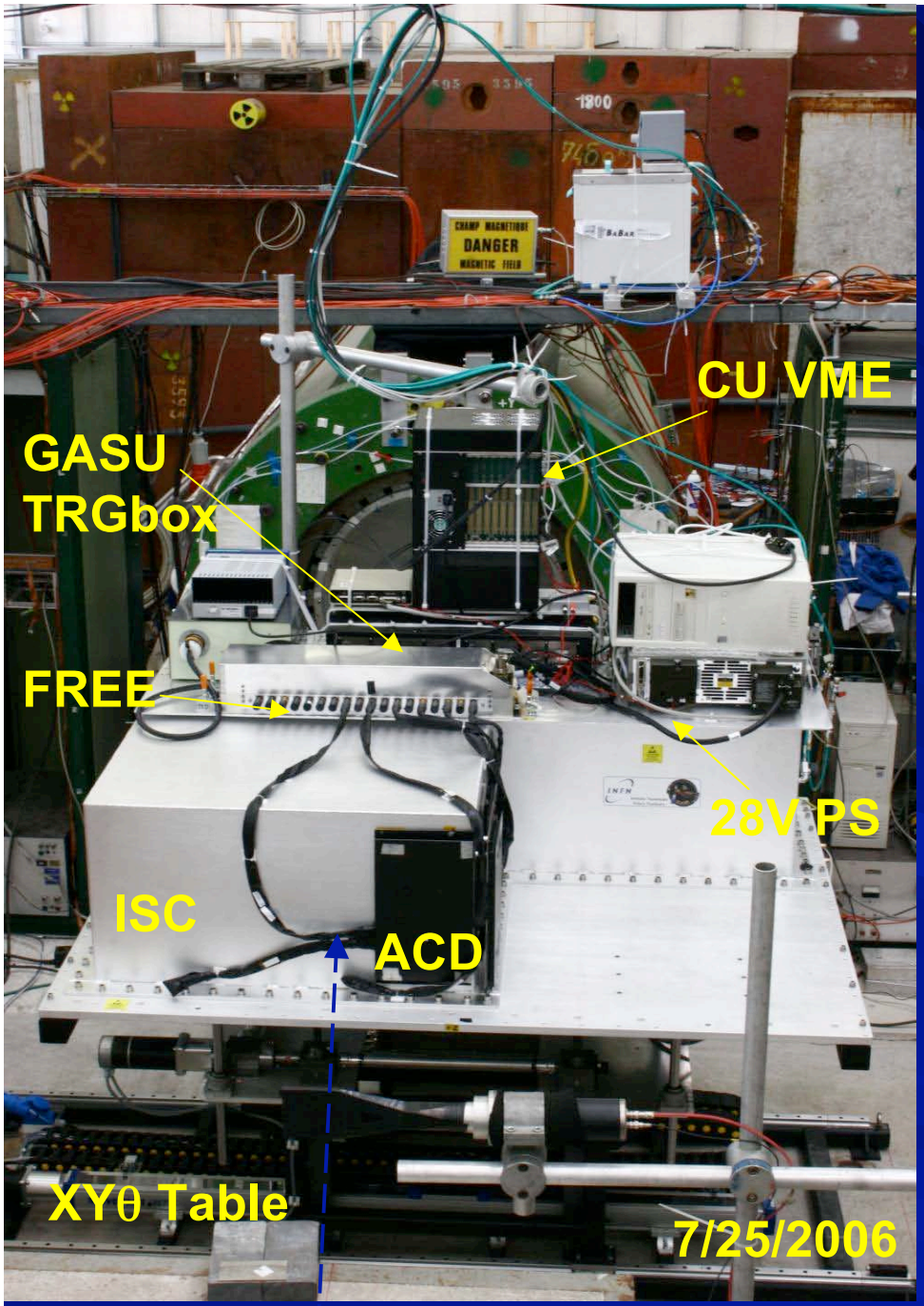
The GLAST-LAT Calibration Unit



- 1 × 4 GRID module
- ❑ 2 full tower TKR+CAL modules
- ❑ 1 CAL module
- ❑ 5 ACD tiles

Accelerator facilities

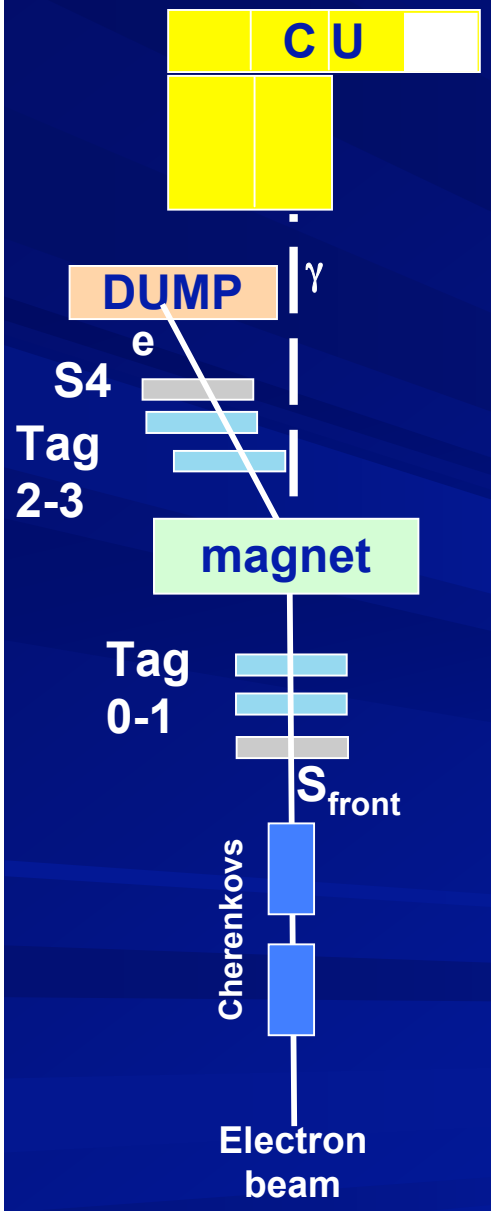
- CERN – Geneva
  - T9 beam line at PS
    - Beam extracted from PS (24 GeV/c primary proton)
    - Secondary beam (e±, π±, K±, p, …) 0.5-15 GeV/c
  - H4 beam line at SPS
    - Beam extracted from SPS (400 GeV/c primary proton)
    - Secondary beam (e±, π±, K±, p, …) 10 – 300 GeV/c
    - Tertiary "Clean" beam (e±, π±, p) 10 – 300 GeV/c
- GSI – Darmstadt
  - Relativistic heavy ions (Carbon and Xe) 1.5 GeV/n
    - More details on the poster session (P.19.43)



The CERN campaign

- 4 weeks at PS/T9 area, 26/7-23/8
  - γ @ 0-2.5 GeV
  - e @ 0.5 - 5 GeV
  - e+ @ 1 GeV (through MMS target)
  - p @ 6, 10GeV (also through MMS)
- 11 days at SPS/H4 area, 4-15/9
  - e @ 10, 20, 50, 100, 200, 280 GeV
  - p @ 20,100 GeV
  - π @ 20GeV
- Data
  - 1700 runs
  - 330 different configurations (particle, energy, angle, impact point)
  - 94M events processed
  - Mass MC simulation in place
- A very dedicated team
  - 60 people worked at CERN
  - all collaboration represented (IT, FR, US, SW, JP)

Photon configuration set-up

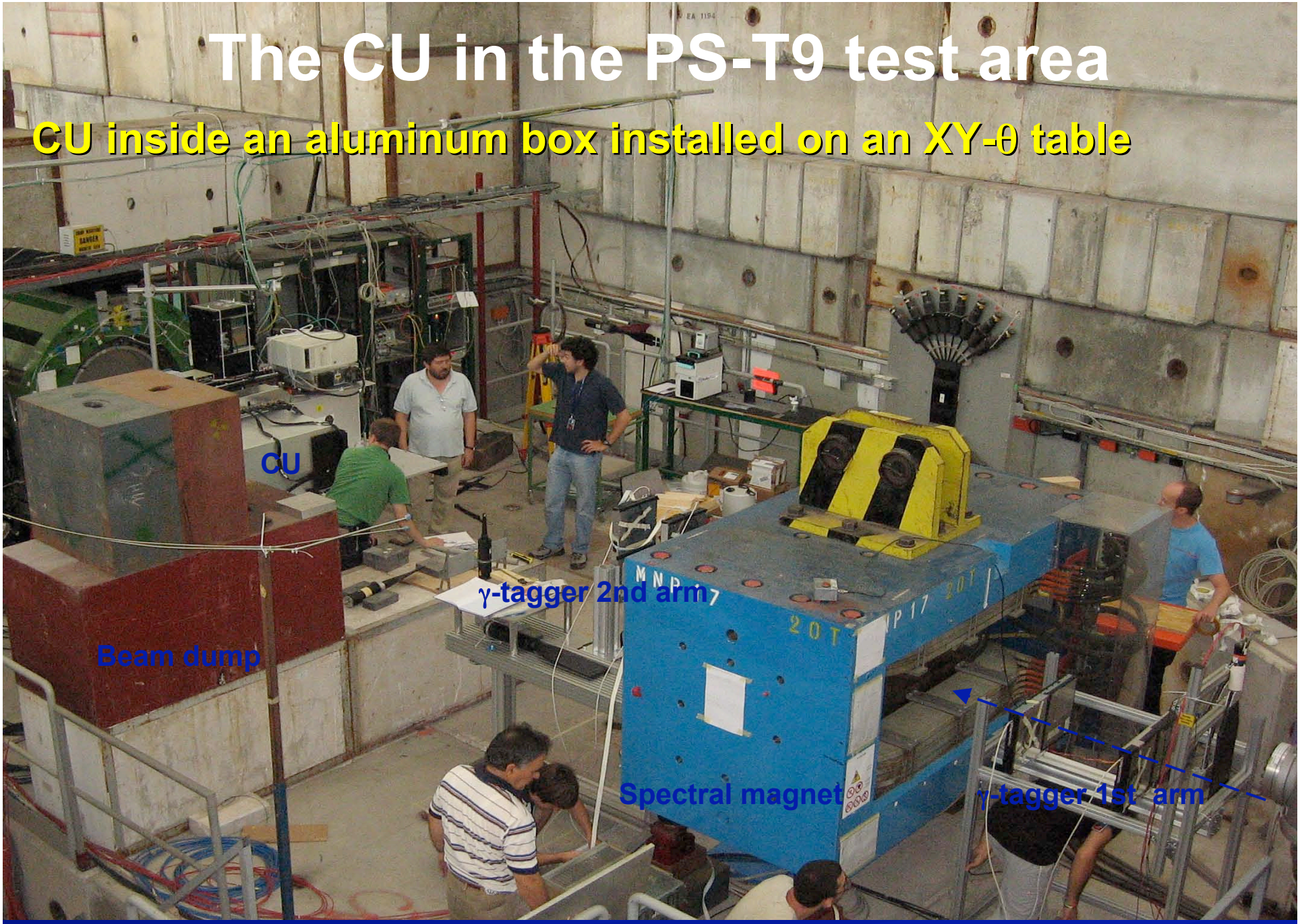


The gamma ray beam at the CERN PS T9 line was produced by bremsstrahlung between electrons and the upstream materials. A magnet has been used to well separate electrons from photons. Finally a beam dump has been used to stop electrons.

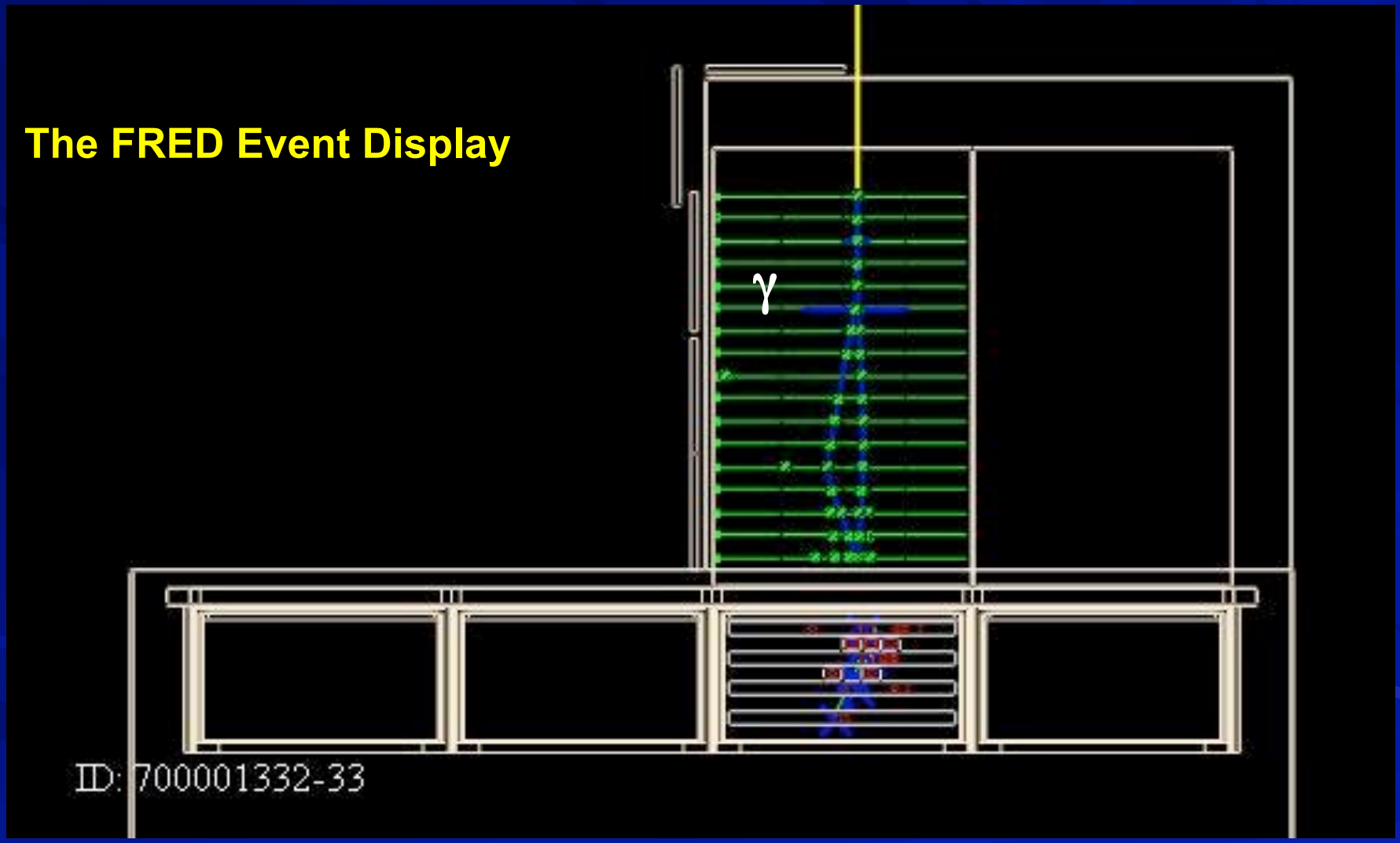
- Tagged photon beam
  - An external tracker (4 x-y view silicon strip detector) was used to track electrons upstream and downstream the magnet, read-out by means of an external DAQ
  - Trigger on S4&S_{front} & Cherenkovs
  - External DAQ was synchronized with the CU one, then the data have been merged with the CU one
  - Different electron beam energy in the range 0.5-2.5 GeV and magnetic field intensity have been used to provide a gamma spectrum to the CU below 2 GeV
- Not tagged photon beam
  - Trigger on S_{front} & Cherenkov
  - Full bremsstrahlung spectrum from 2.5GeV/c electron beam

The CU in the PS-T9 test area

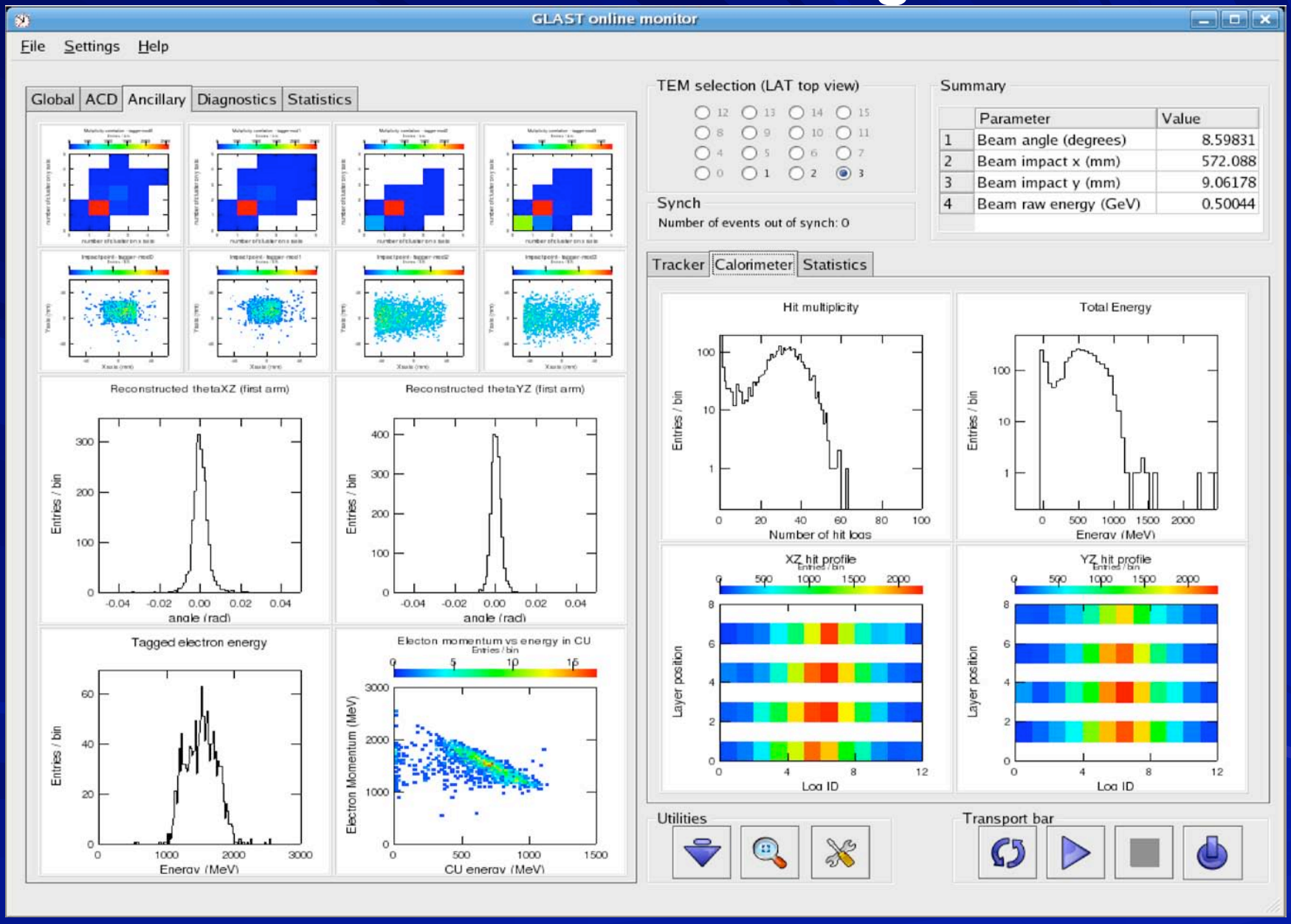
CU inside an aluminum box installed on an XY-θ table



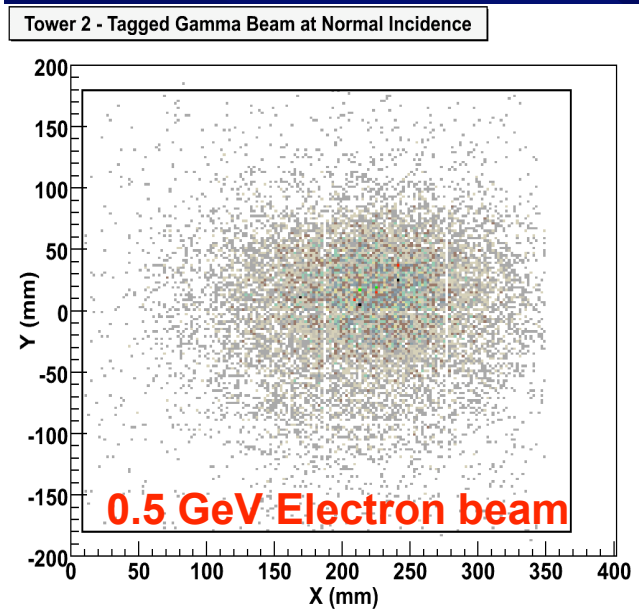
Display of a candidate photon event

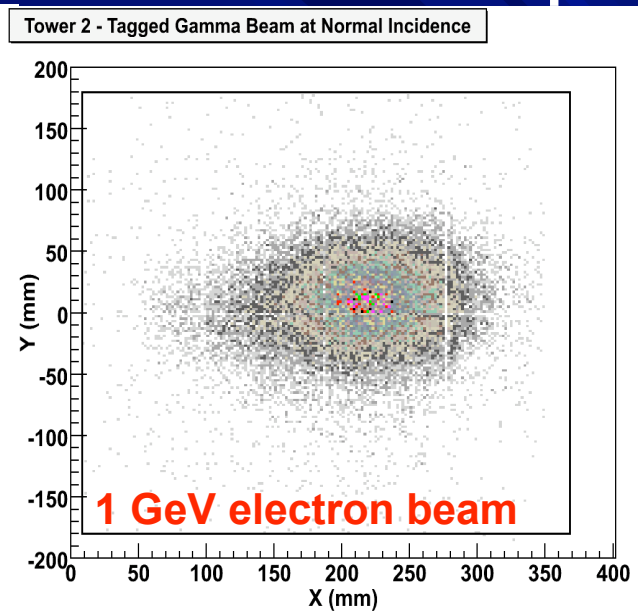


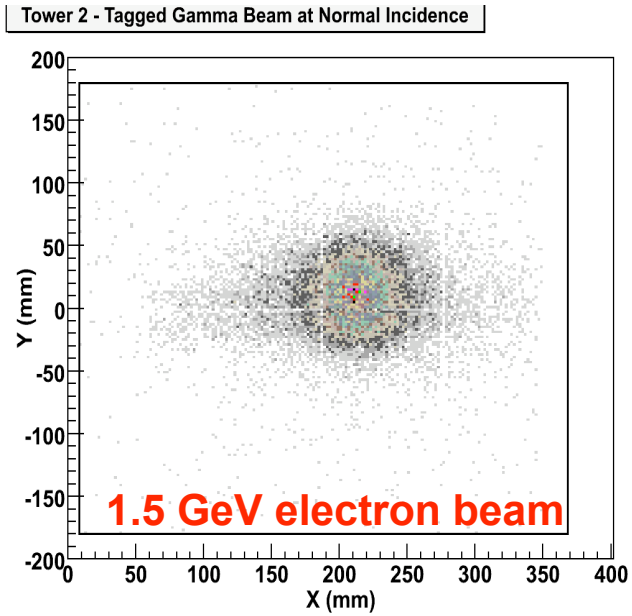
Online monitoring

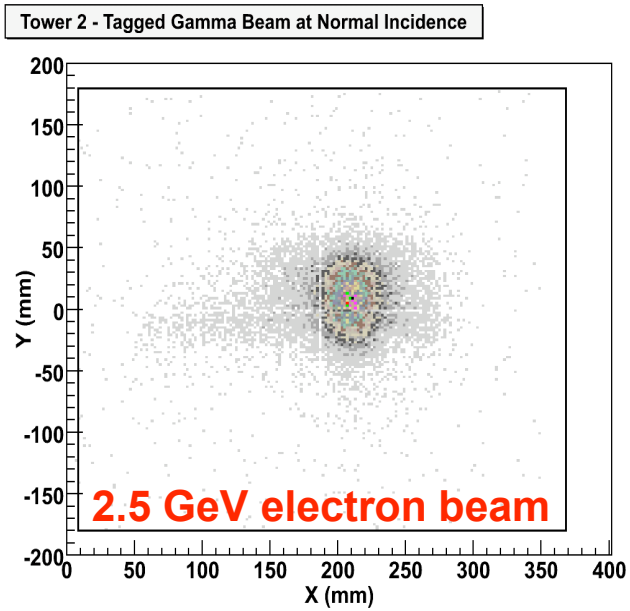


Photon beam spot



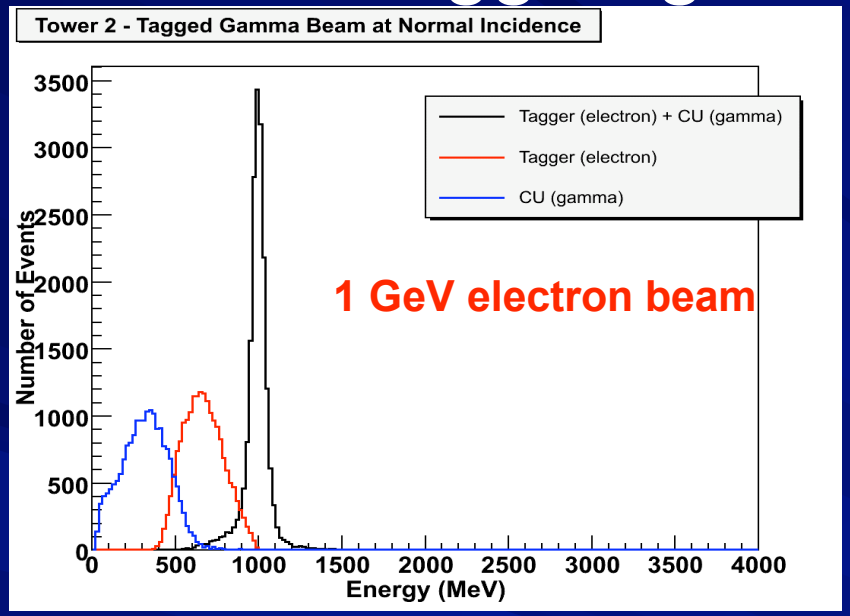


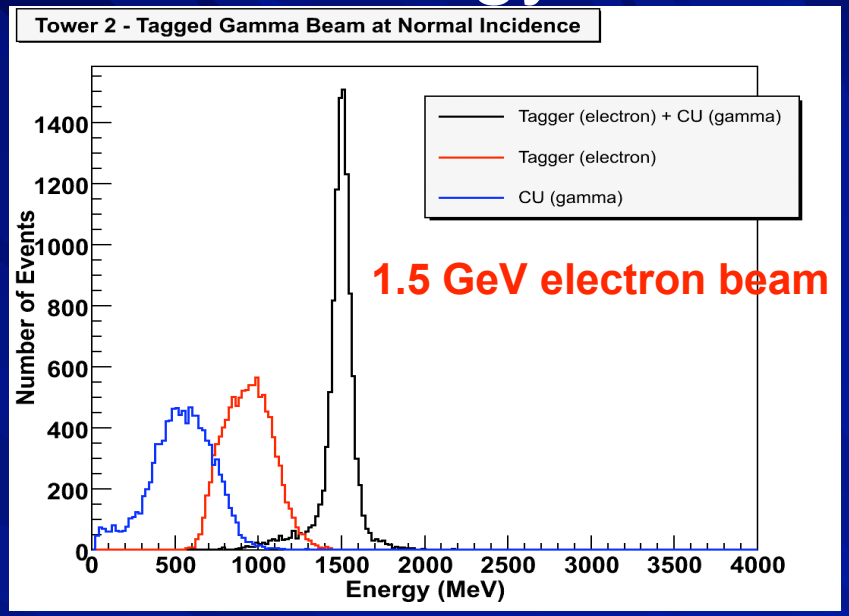


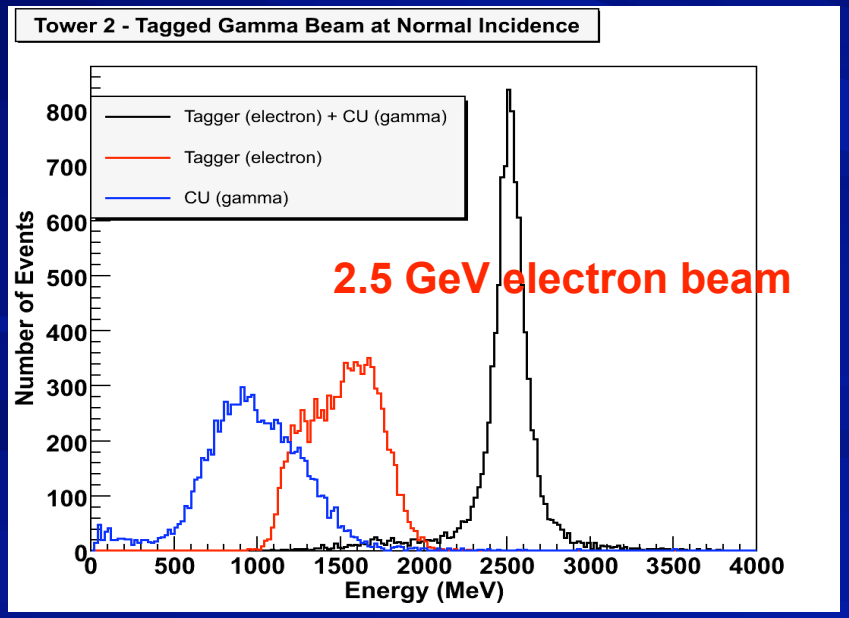


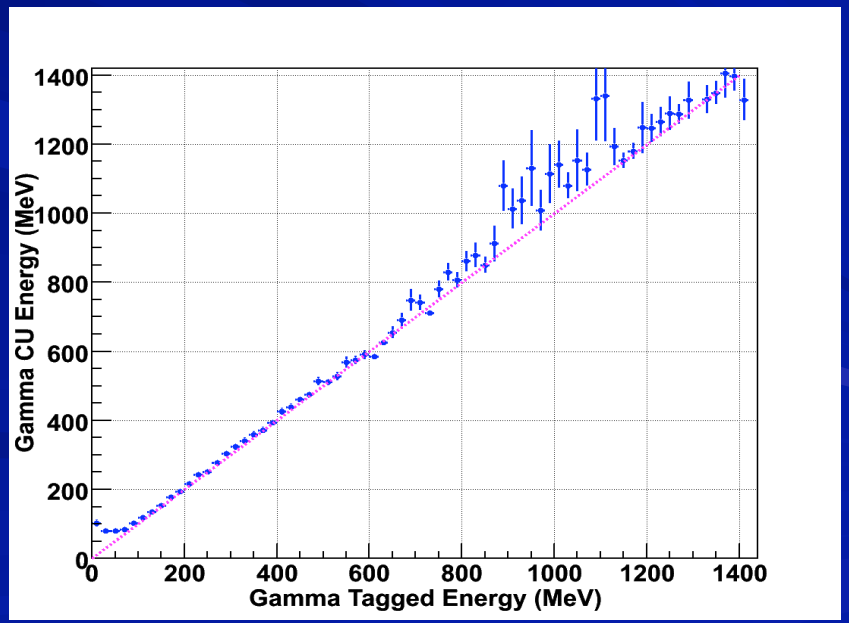
- Data points are gamma vertex positions
- Beam dispersion and electron-gamma angle have to be taken into account in analysis and MC
- Beam dispersion from electron data
  - 0.5 GeV: 14 mrad
  - 1.0 GeV: 9 mrad
  - 1.5 GeV: 7 mrad
  - 2.5 GeV: 4 mrad

Tagged gamma beam energy



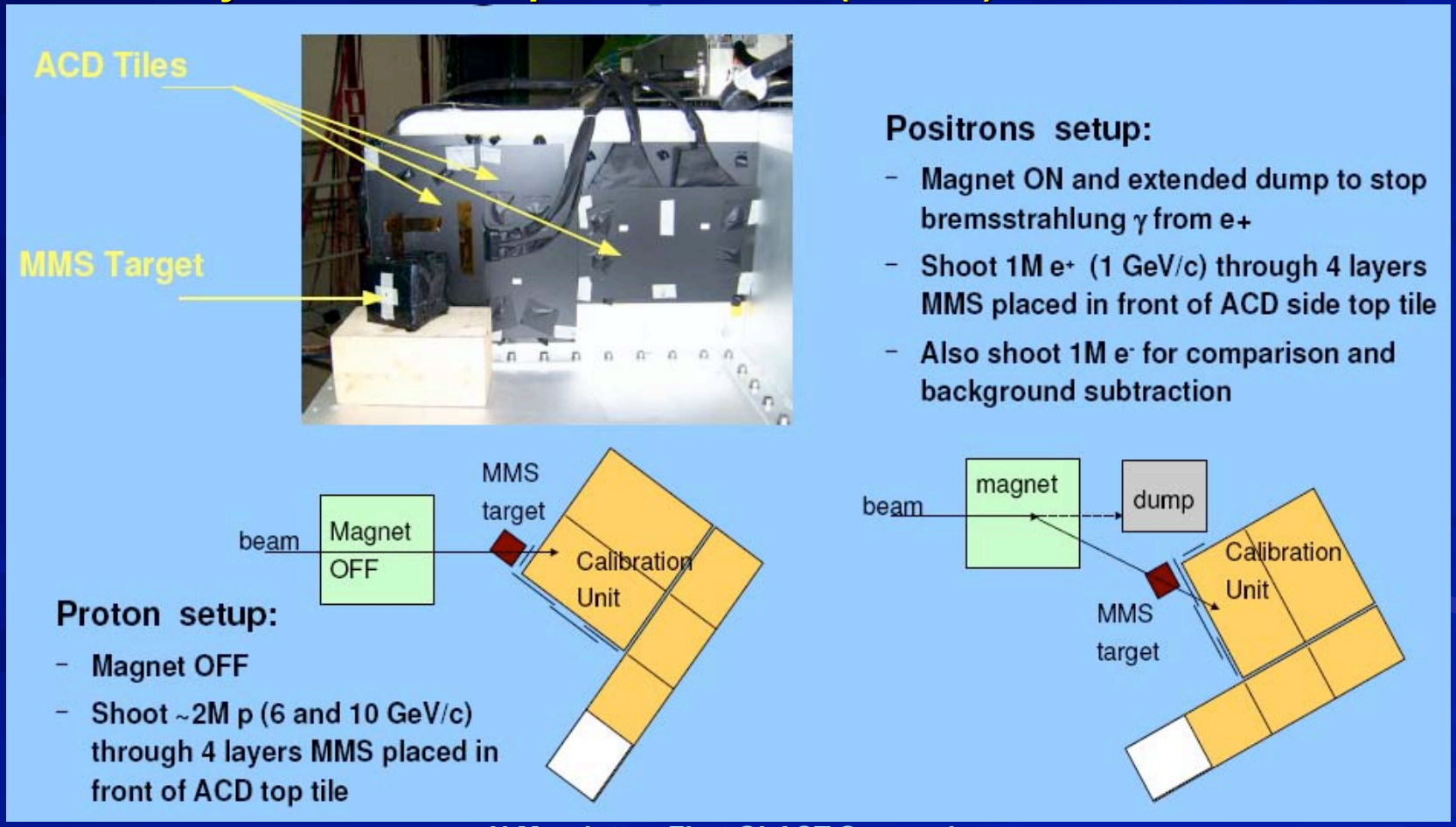




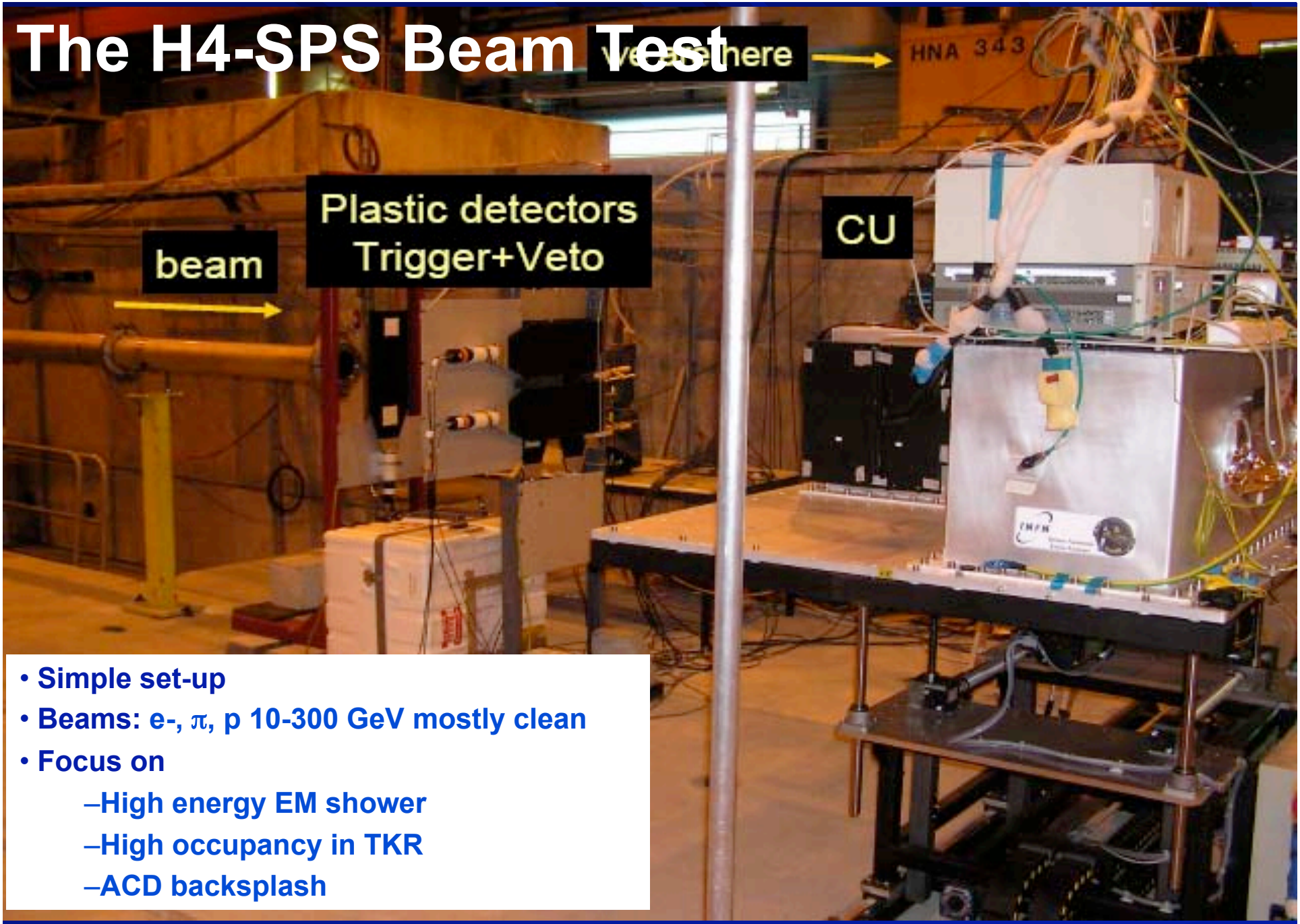


Background studies configuration

- **Charged particle interaction in Micro Meteoroid Shield that produces a gamma like signal in the CU (no ACD signal, good signal in tracker and calorimeter)**
  - **Protons: gamma by neutral pion decay, produced by exchange charge effect**
  - **Positrons: gamma by annihilation, a "clean" positron beam is needed**
- **Preliminary results in the poster session (P19.21)**

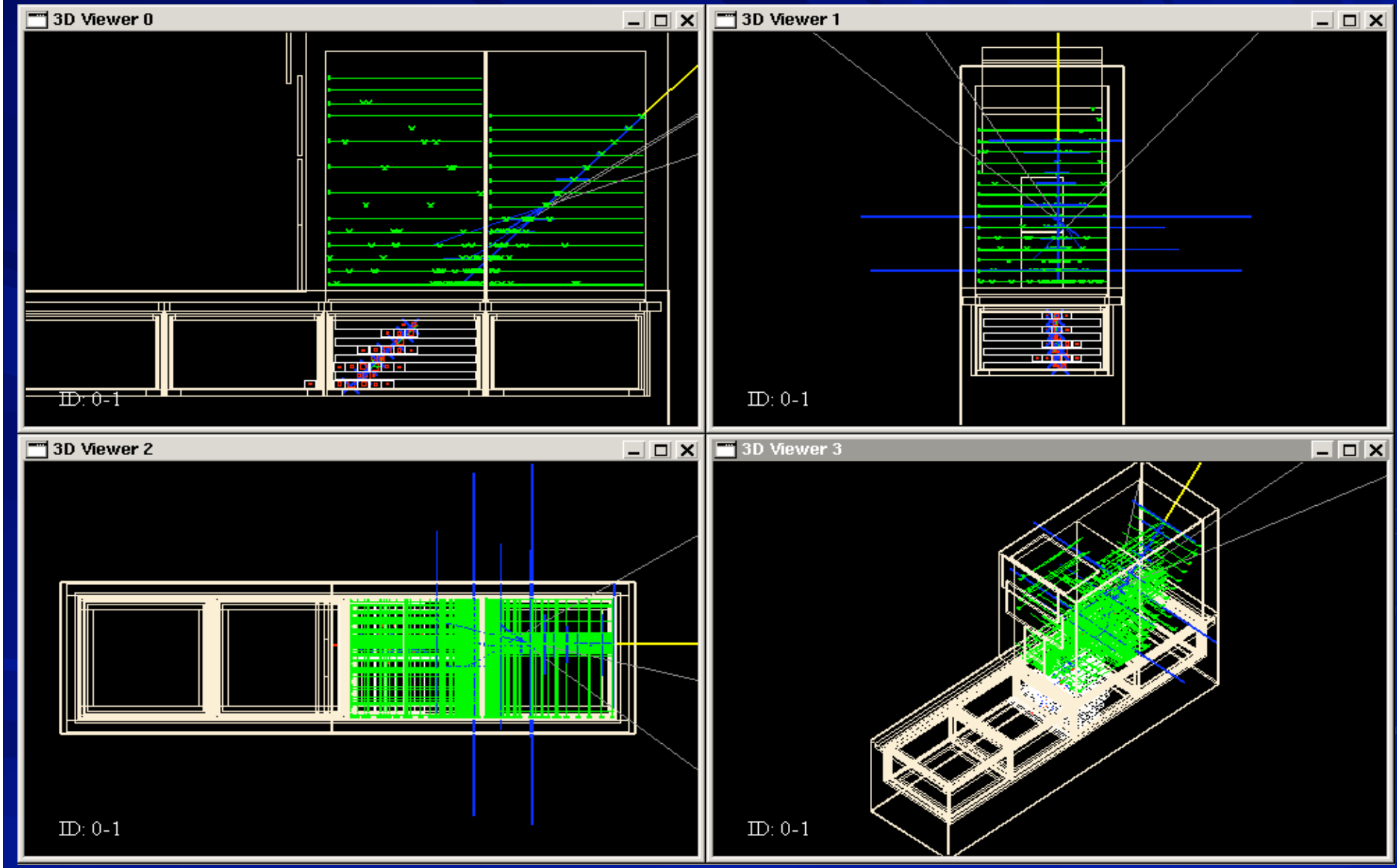


The H4-SPS Beam Test

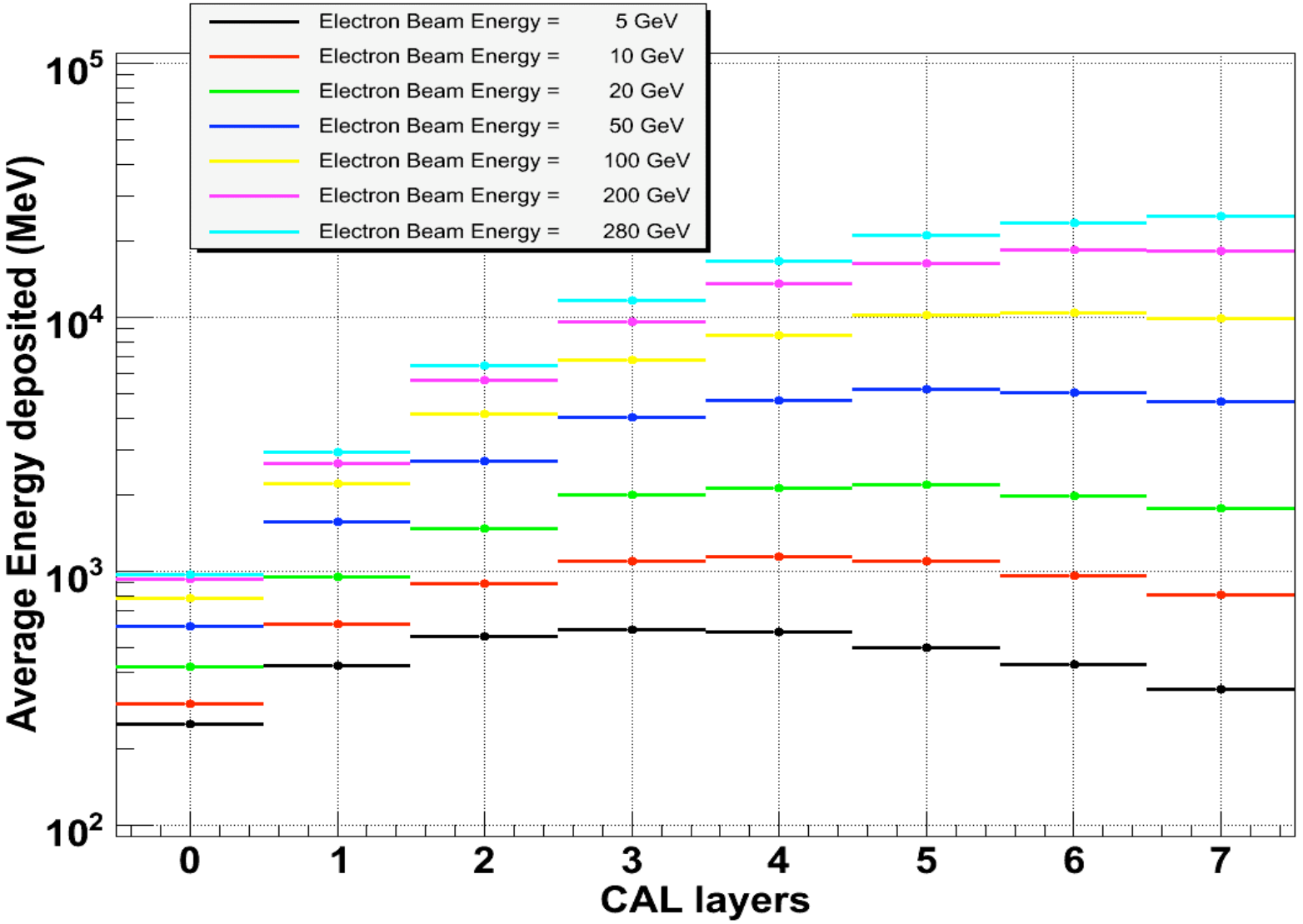


- Simple set-up
- Beams: e-, π, p 10-300 GeV mostly clean
- Focus on
  - –High energy EM shower
  - –High occupancy in TKR
  - –ACD backsplash

280 GeV electron event



Longitudinal CAL energy shower profile at 0 deg



Conclusions

- We have collected a huge amount of data exploring a large set of configurations (particles, energies and angles)
- The data analysis and MC validation is still in progress