GEANT4 simulation efforts at NIU/NICADD

Robert C. McIntosh
rmcintos@nicadd.niu.edu
Mike Arov
arov@nicadd.niu.edu

What is Geant4?

- From the Geant4 website (http://geant4.web.cern.ch/geant4/):
  - "Geant4 is a (programming) toolkit for the simulation of the passage of particles through matter"
  - AND
  - "Geant4 provides a complete set of tools for all the domains of detector simulation: Geometry, Tracking, Detector Response, Run, Event, and Track Management, Visualisation and User Interface"

LCDRoot

- Authored by T. Abe and M. Iwasaki (University of Colorado)
- What is LCDRoot?
  - Group of tools for LCD studies, that covers two areas:
    - Simulation engine using Geant4 and ROOT system
    - Analysis is based based on the ROOT system
    - Output as ROOT ntuples

Lcdg4 – Our program

- Is a port of the simulation engine (G4FullSim) in LCDRoot
  - The LCDRoot G4FullSim classes decoupled from ROOT
  - Decoupling achieved by making appropriate substitutions using C++ STL and CLHEP libraries instead of ROOT internal classes
  - This port is work in progress…
- The result:
  - A standalone geant4 simulation program
  - XML description of detector geometry
  - SIO output functionality

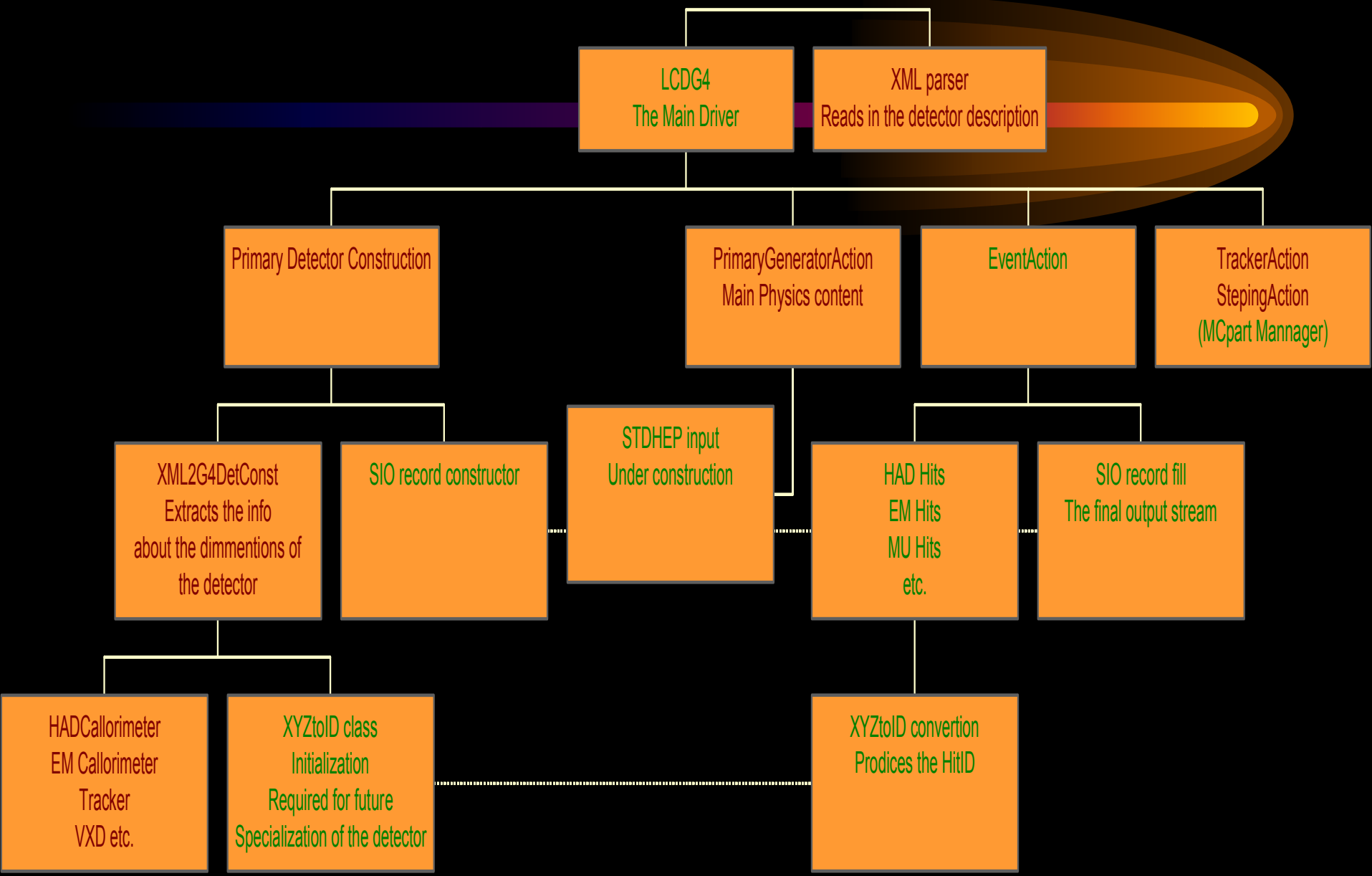
Why decouple from ROOT

- Decoupling allows us to have a "standalone" simulation program
- Standalone simulation program, not bound to a particular analysis environment
- I/O compatible with the SLAC/HEP.LCD library and JAS
- Preservation of the ROOT compatibility. Ntuple output is still an option

Structure of package

- All lcdg4 user action classes are nearly identical to their G4FullSim counterparts (appropriate modifications made…)
- EventAction class has been modified to output in SIO format
- The rough graph class structure of the package is shown on the next slide

Organization of LCDG4 package
Classes marked in green are new or rewritten

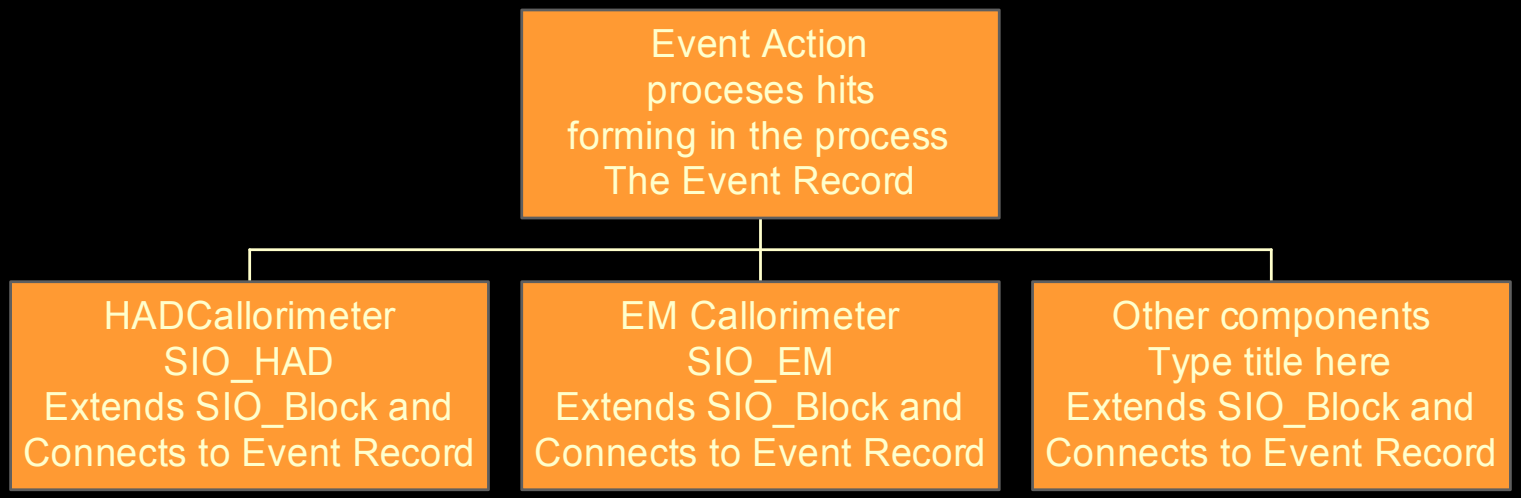


Some of the advantages of the Serial Input Output format

- Is the preferred data format for Java Analysis Studio, the main analysis framework for NICADD
- Allows read access to huge files in sequential/selective manner, using records and blocks without overburdening the memory
- Allows writing onto several streams simultaneously
- Has built-in support for file compression, which is important, since uncompressed events can take well over 1 GB of space

Writing SIO output

Organization of SIO Record



XYZ to ID conversion

- The output of GEANT4 provides the Cartesian coordinates of the hits, without regard for the actual geometry:

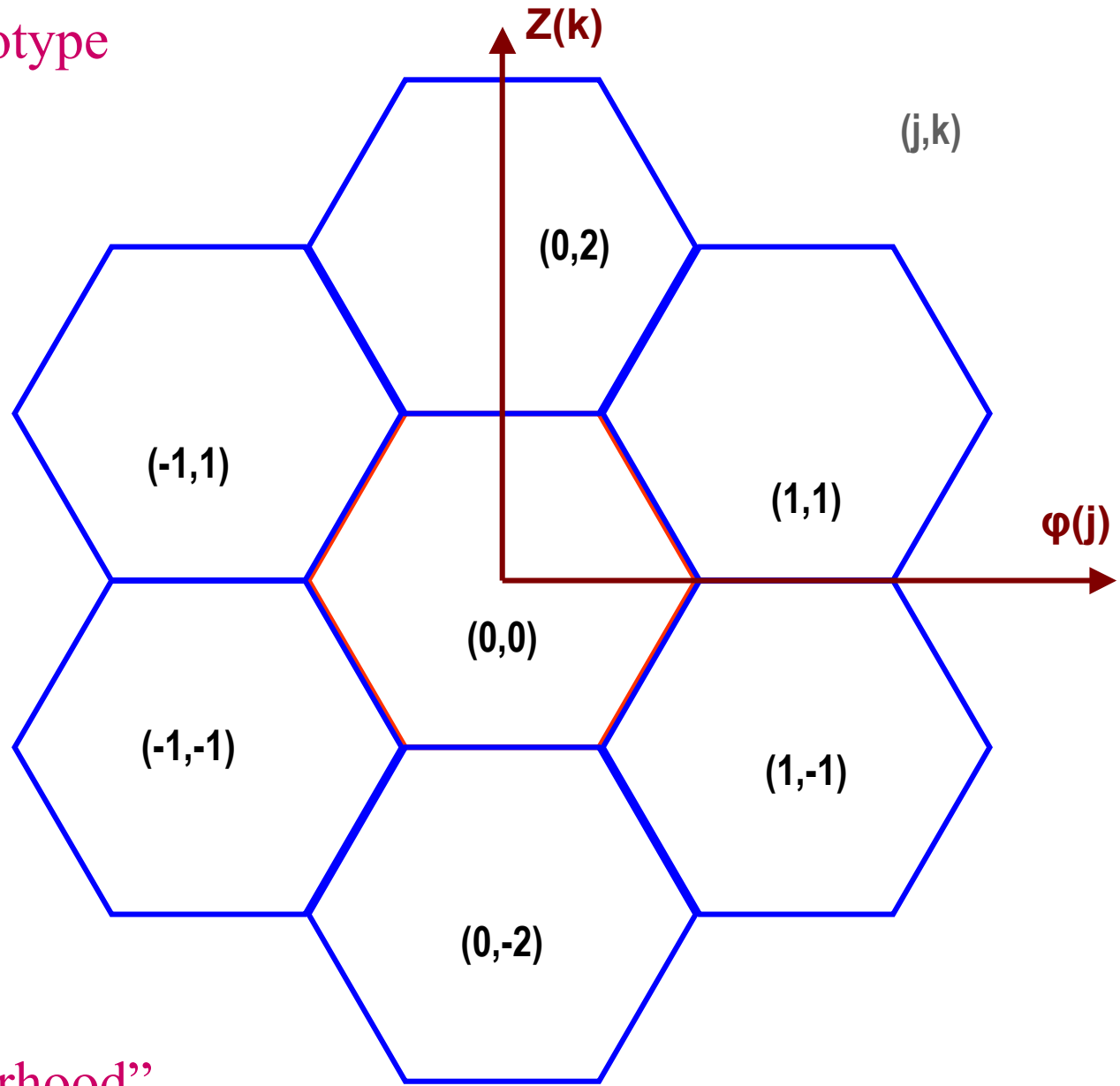
  a) number, shape and spacing of the cells

  b) projective or non-projective towers
- Specific detector geometry is handled by a separate class, initialized at the construction of the detector and invoked on each event
- Important for the hexagonal geometry of the cell

NIU Prototype

Layer (i)

Cell (j, k)



The Cell
"neighborhood"

- Using the geometry described above one can determined which Cell the coordinates of the hit correspond to and associate the ID of the Cell with the hit
- The ID formed contains 3 fields :

  a) R_ID (the radial component

  b) Phi_ID (the azimuthal angle component)

  c) Theta_ID (or Z_ID) (the transverse angle component)

Test Results

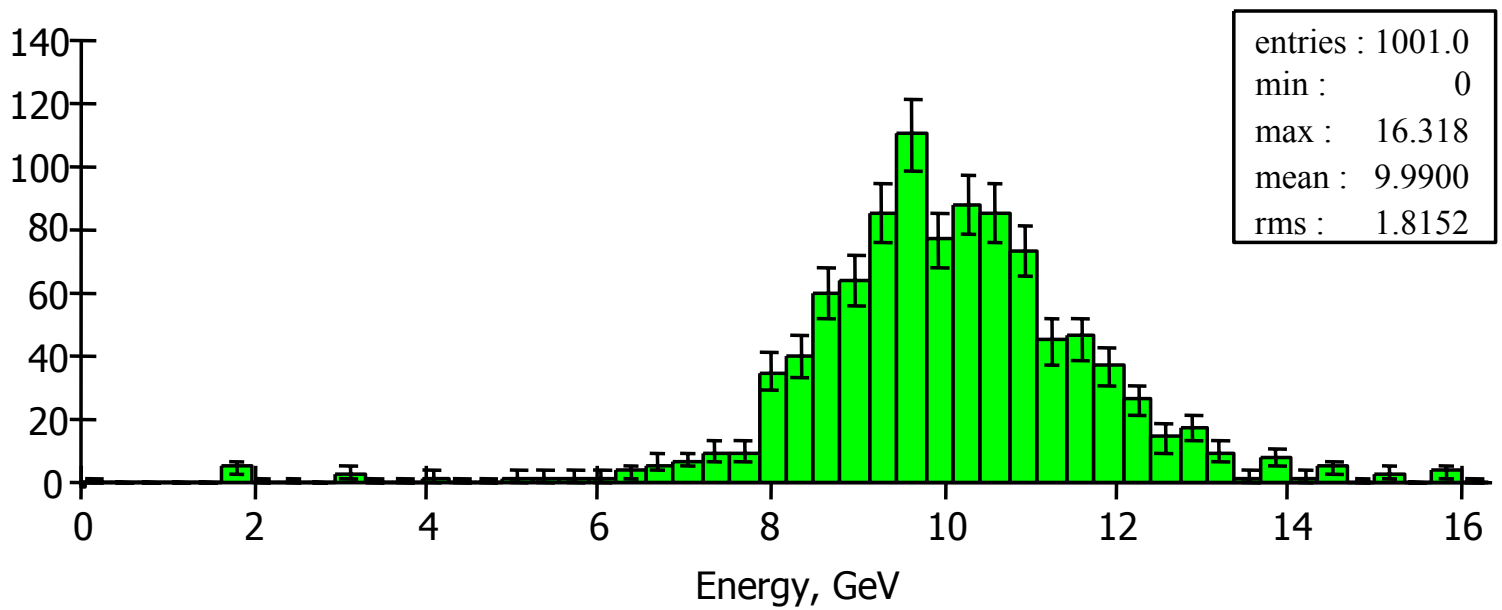
- The Sampling Fractions for the EM and Hadronic Callorimeters

  EMfr = 0.05935

  HADfr = 0.07421

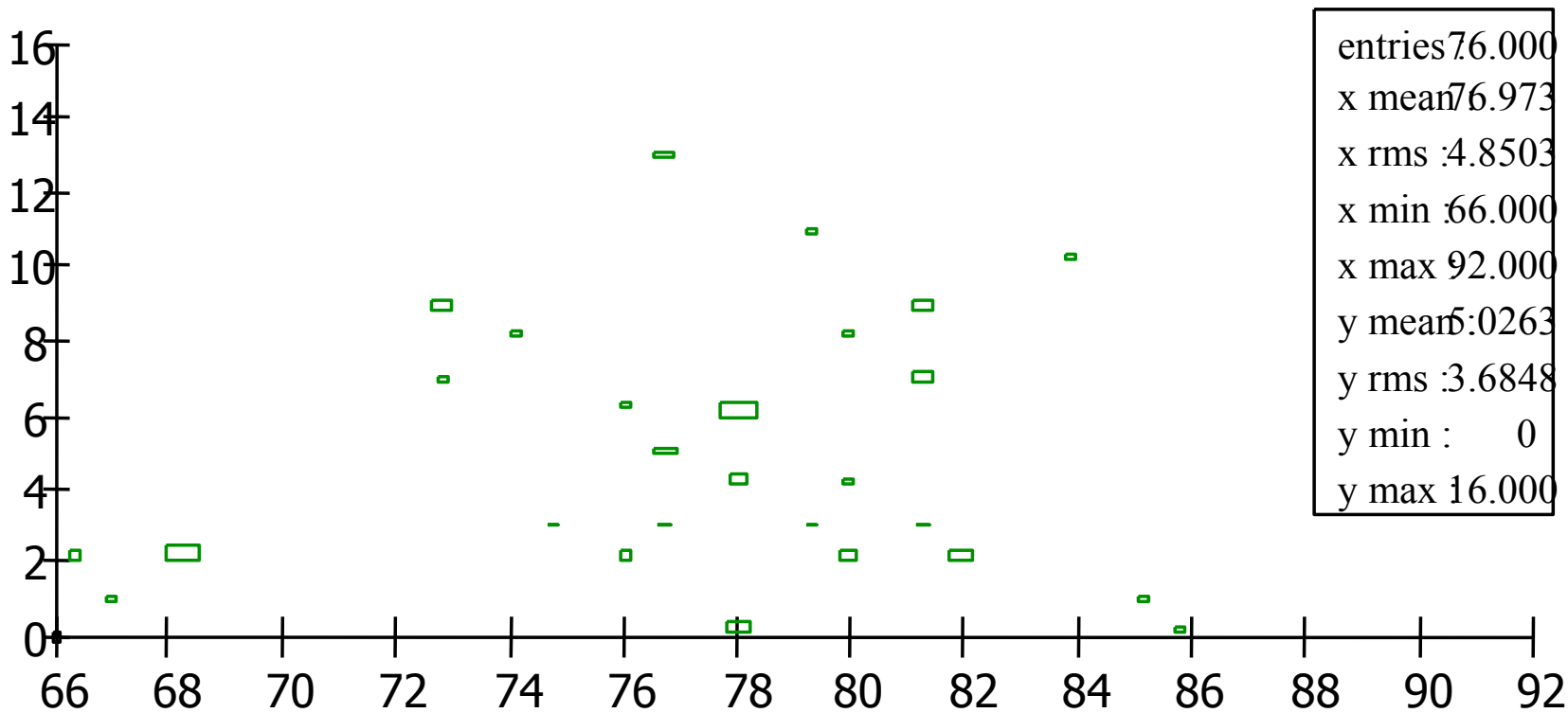
- The old values are 0.02187 and 0.06338 correspondingly

Total (EM+HAD) energy for the 10 GeV pions

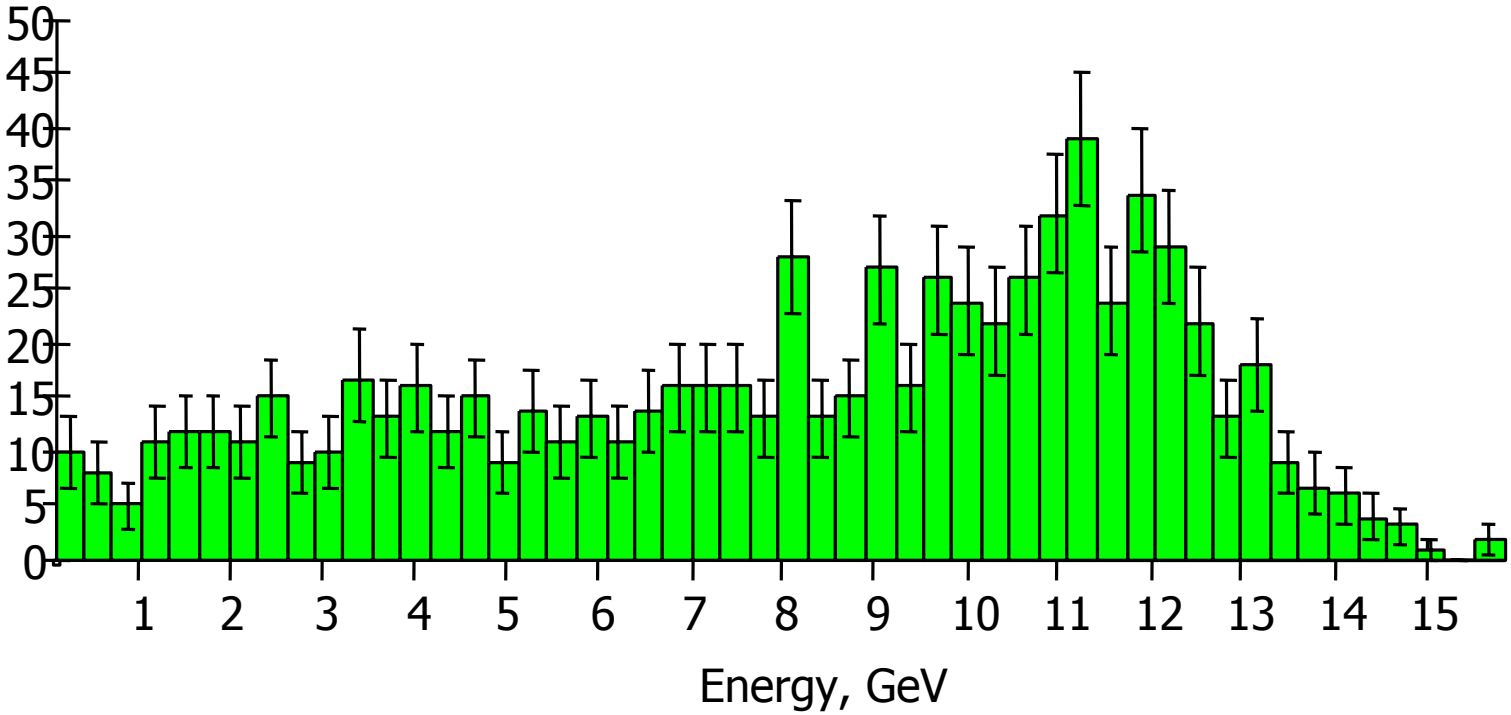


Using LCDG4 with NICADD proposed detector

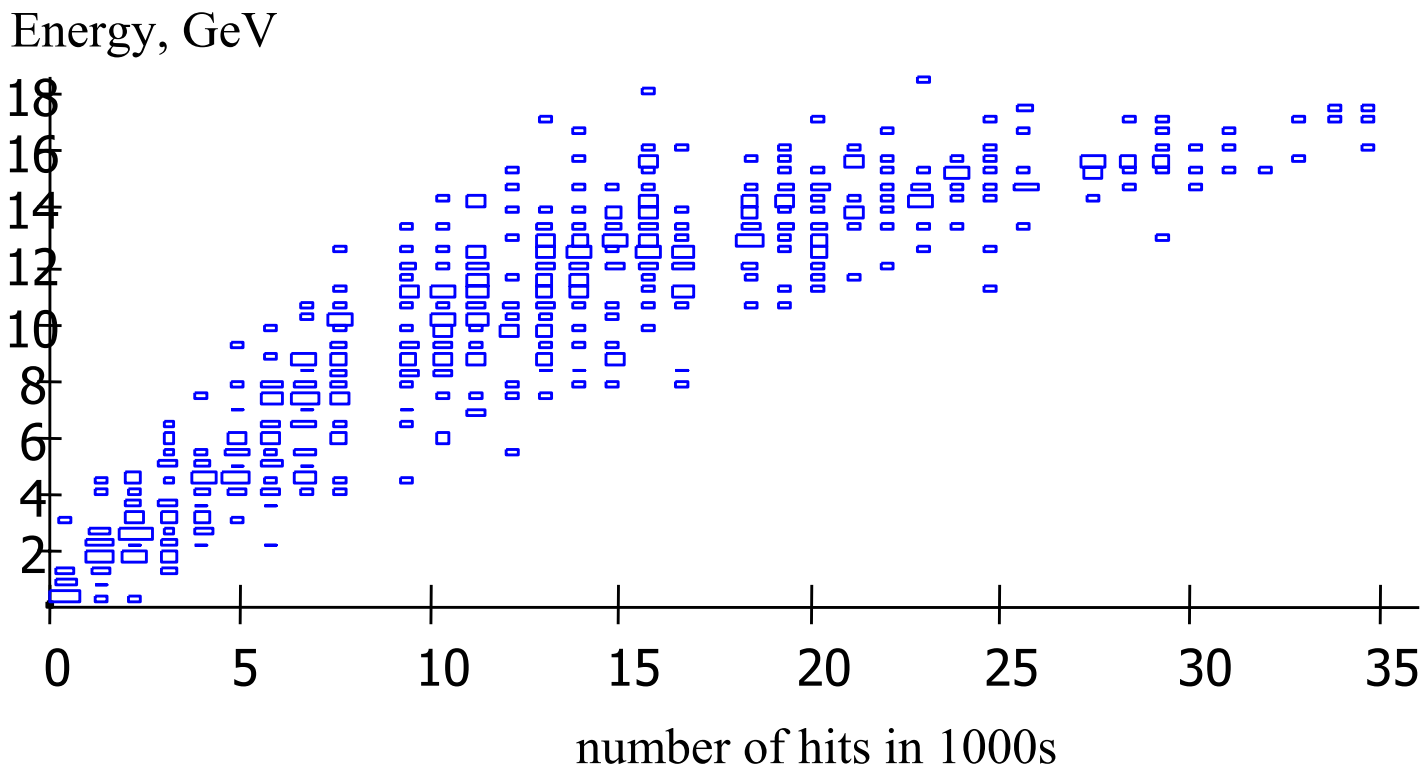
Phi vs Theta for layer 1



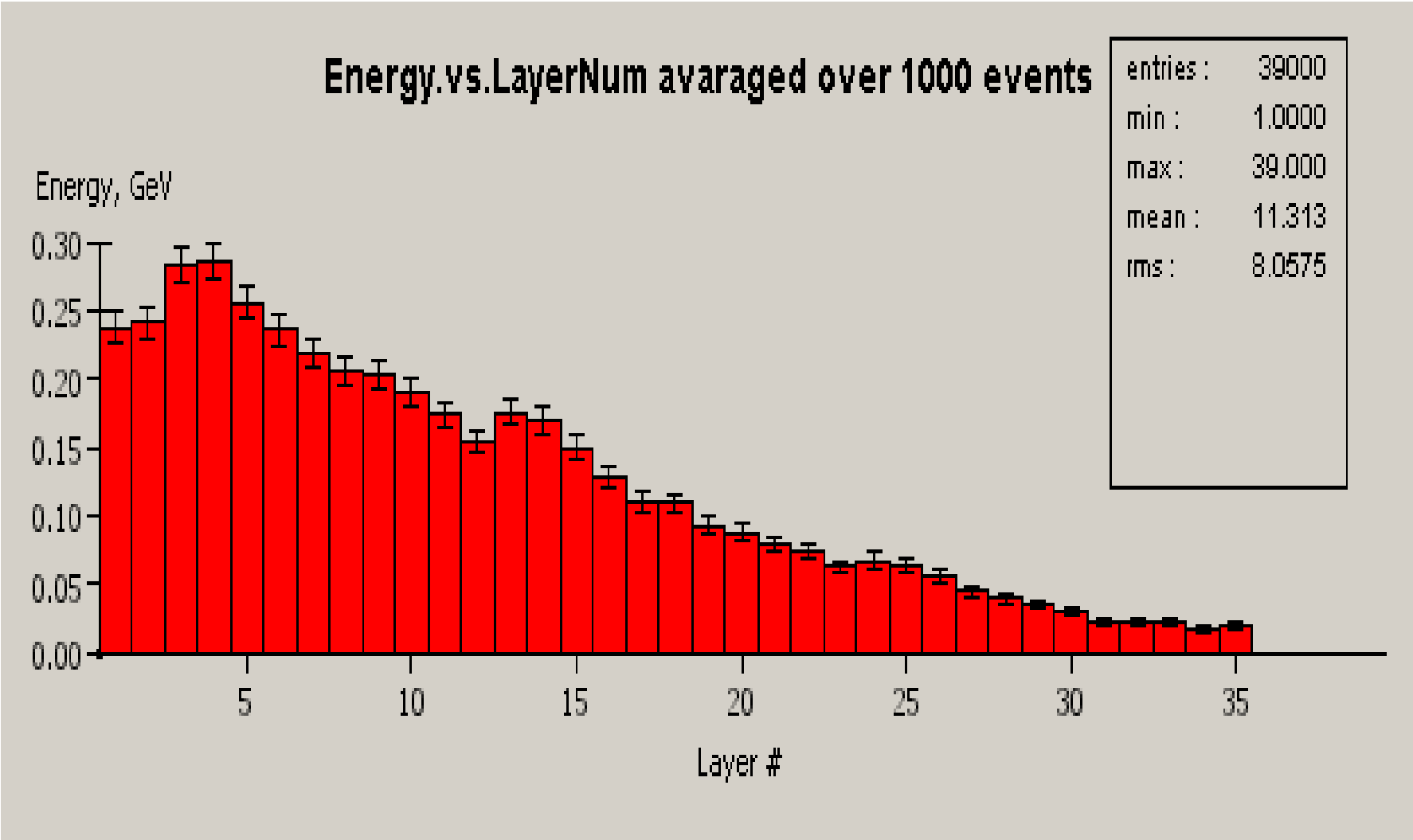
The total energy deposition
for 20 GeV charged pions
in HAD



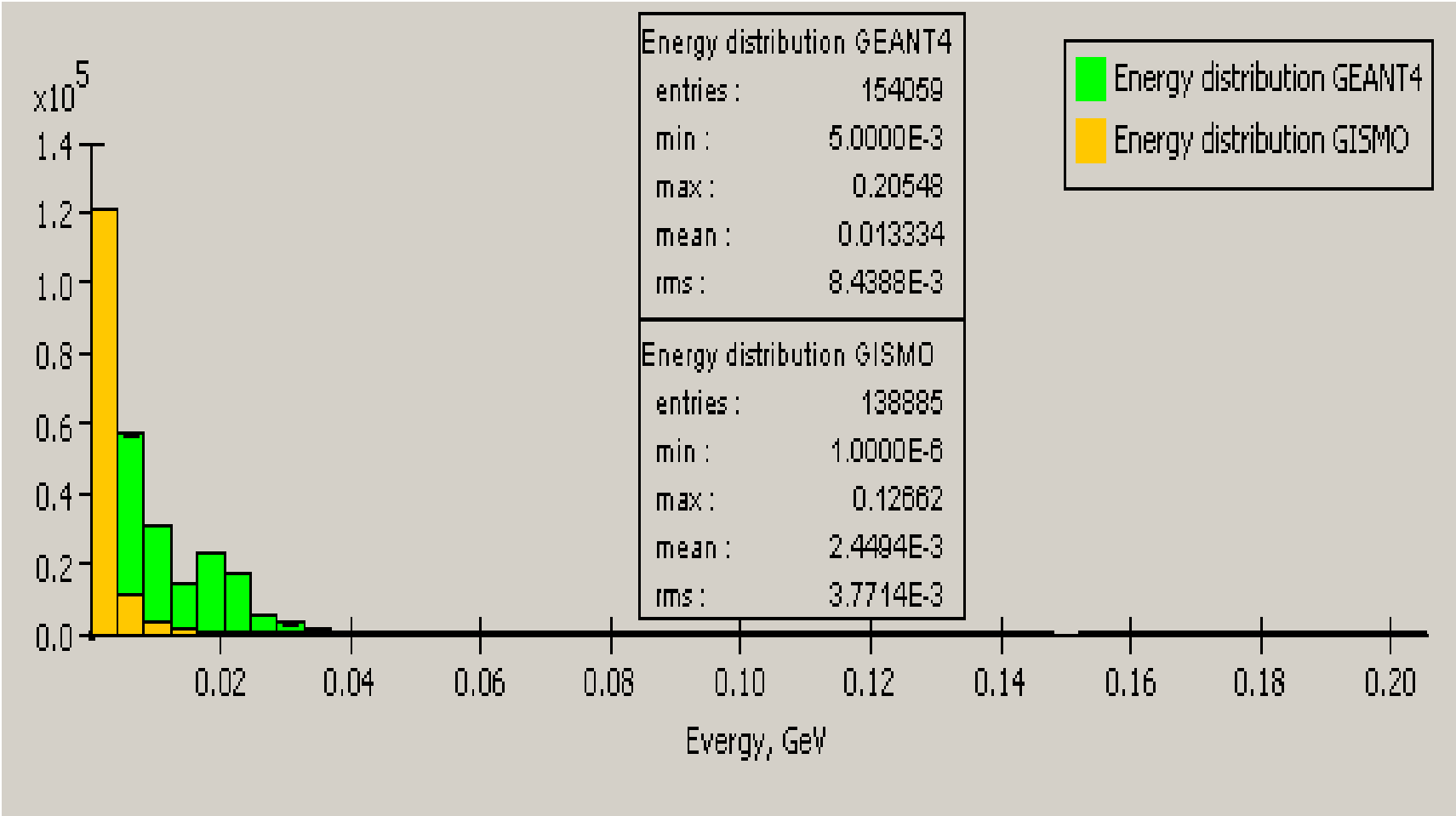
Energy in HAD vs. # of hits (Response plot)



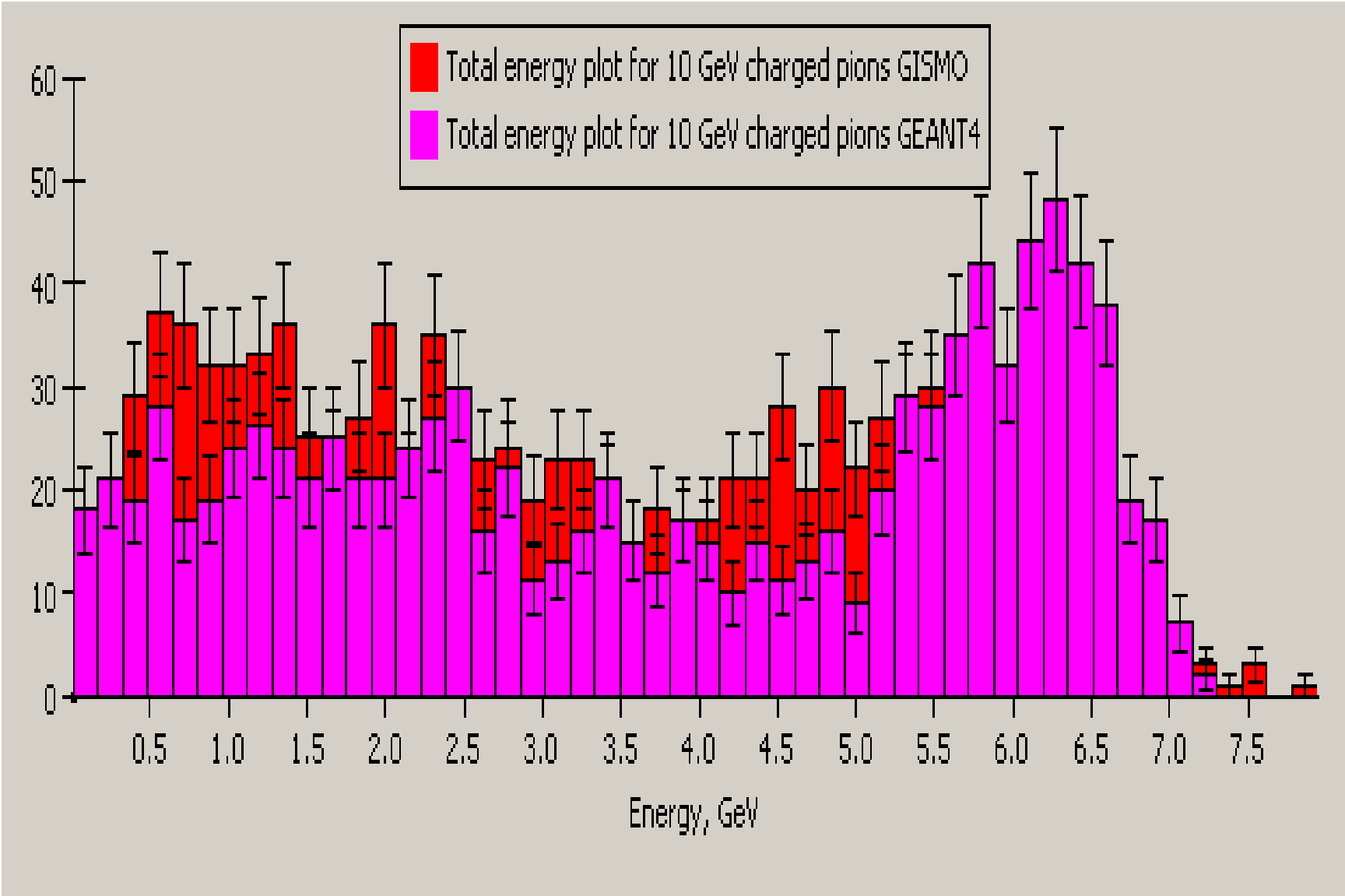
Shower Profile for the10 GeV charged pions



The comparison plot of energy per hit between Gismo and Root for 10 GeV pions, run over 1000 events each



The units are GeV. Green is GEANT4



The total energy in HAD. Also over 1000 events

Conclusions

- The initial release of our complete simulation package is in order
- The preliminary analysis of the test results shows reasonable agreement with expectations
- However, the striking discrepancy between our and an old, GISMO-based package has to be interpreted and understood
- More work is needed to make the package as modular as possible, i.e. extendable to possibly alternative detector design