Status of DHCAL Slice Test Data Analysis

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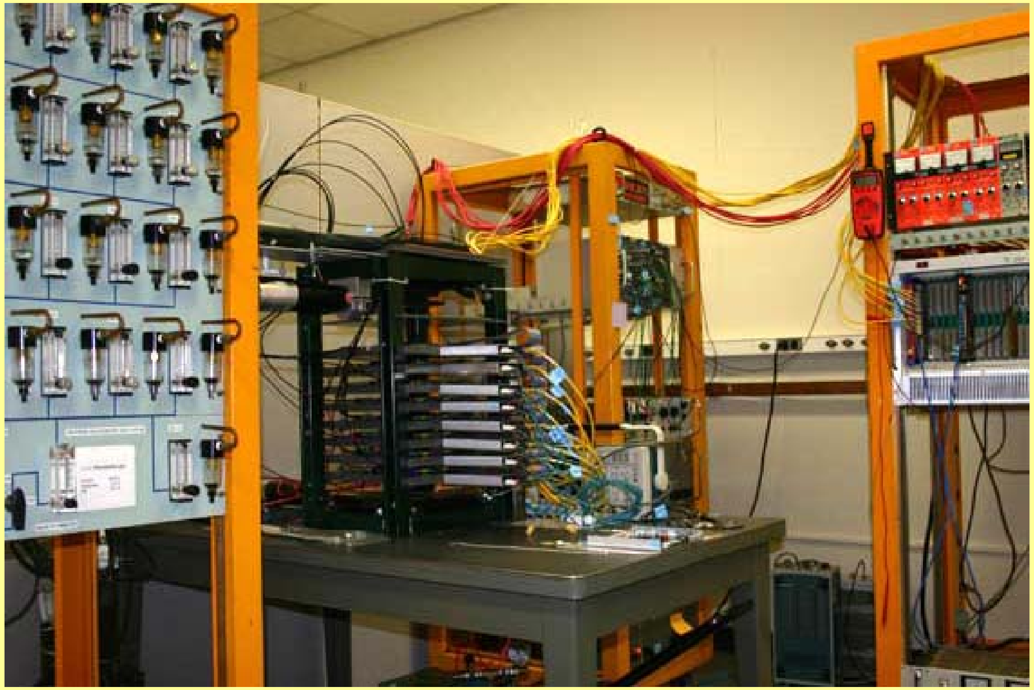
All results preliminary

RPC DHCAL Slice Test: T970
MTBF - FNAL

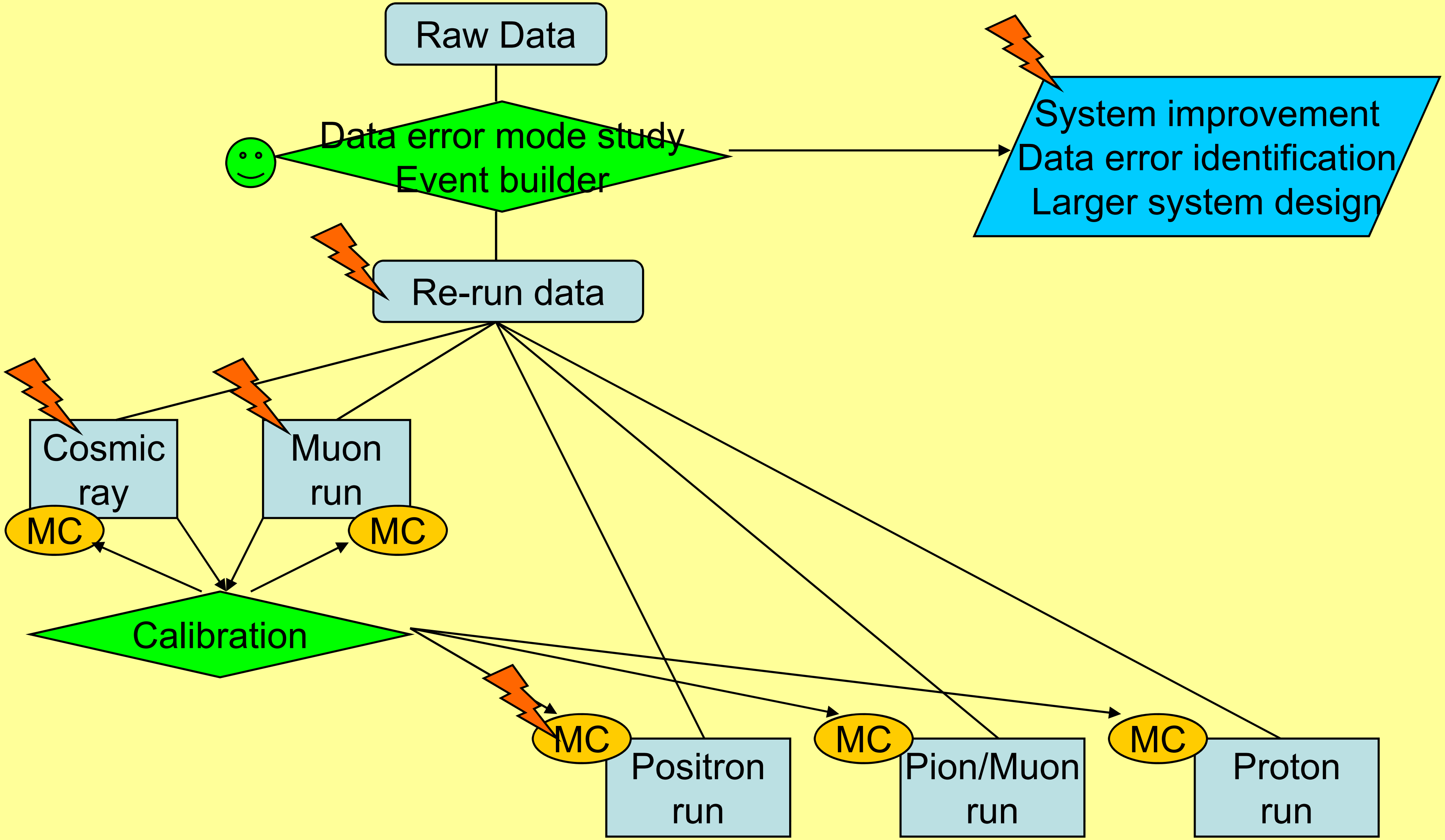
Back to ANL, continue running…



Data set

- Beam data
  - Muon runs (‘calibration run’, RPC eff/pad multiplicity vs HV/Thr)
    - 120 GeV proton beam hitting beam stop
    - Steel (16mm) + copper (4mm) absorber
  - Positron runs (‘EM shower’)
    - 1,2,4,8,16 GeV/c secondary beam (Čerenkov trigger)
    - Steel (16mm) + copper (4mm) absorber
  - Pion/muon runs (‘hadronic shower/MIP track’)
    - 1,2,4,8,16 GeV/c secondary beam (veto on Čerenkov trigger)
    - With/without additional Fe absorber in front of stack
    - Steel (16mm) + copper (4mm) absorber
  - Proton runs (‘rate measurement’)
    - 120 GeV primary beam
    - Scan beam rate (from lowest possible rate to ~30k/spill)
    - PVC ‘absorber’ plate (17x17cm^2 hole at center == no absorber)
- Cosmic ray data (‘calibration’)
  - Before beam test (ANL lab)
  - Right after beam test (FNAL MTBF + ANL lab)
- Charge Injection data (‘FE diagnostics’)
  - After beam test

Analysis plan

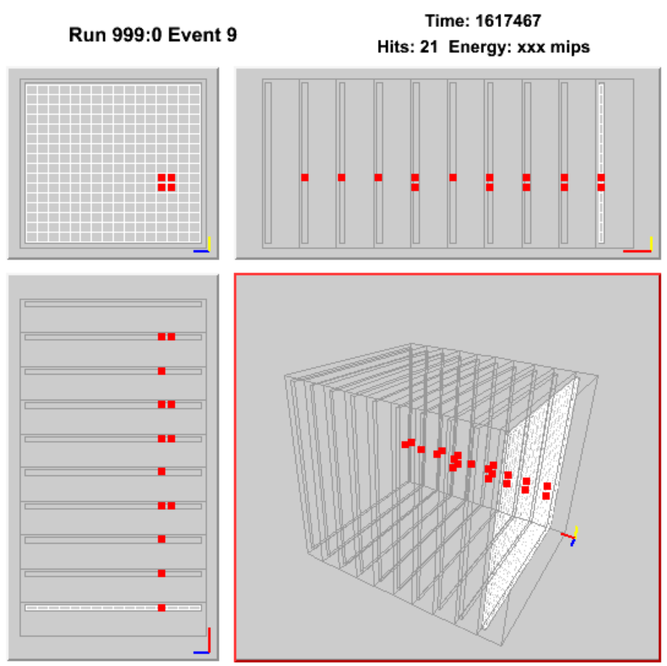


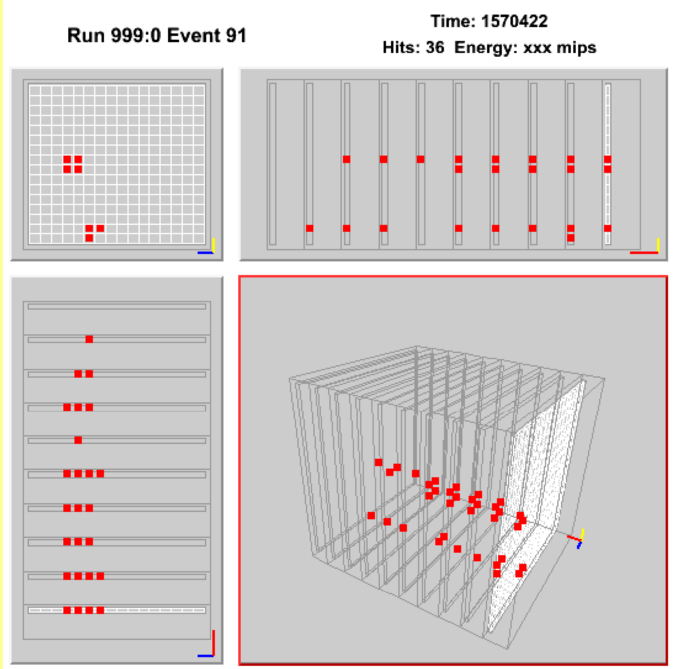
With limited manpower, a lot of analyses are not covered at the moment…

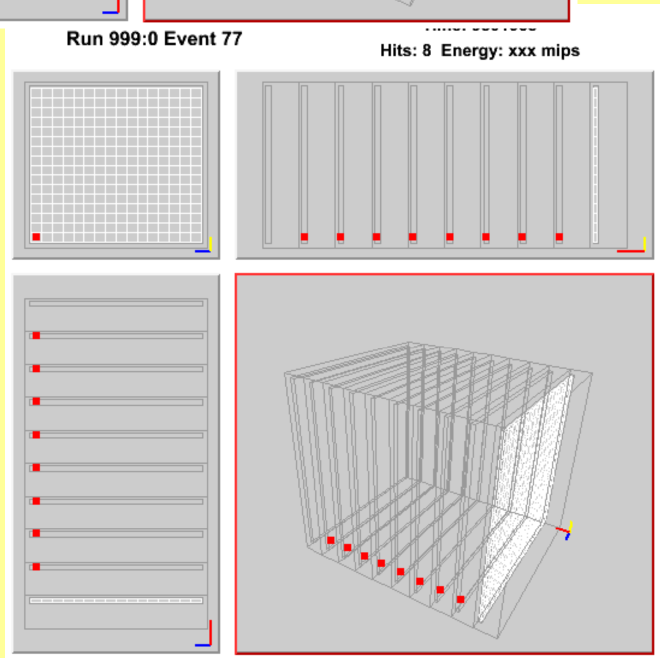
Data error modes

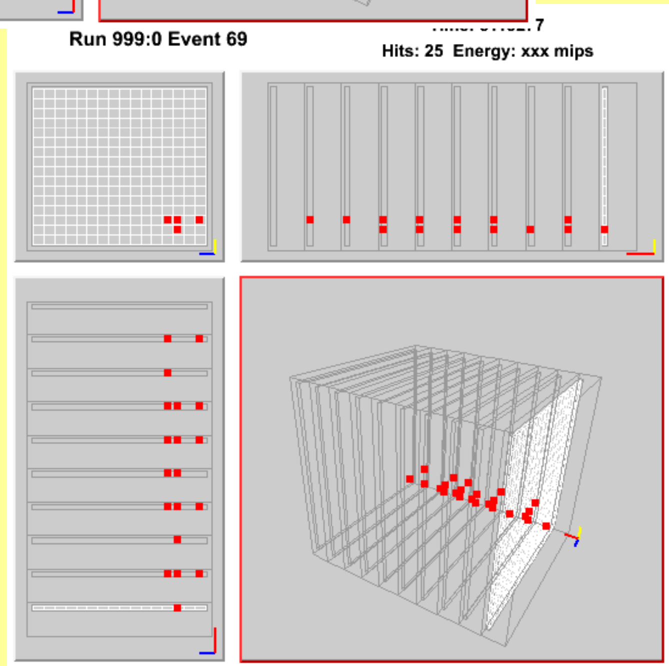
- Slice test data errors
  - Rate of data error is very low, ~0.x% (error package/total package)
  - Need to understand the source, mechanism and scaling properties of these errors
    - Critical for event building and data analysis
    - Helps to find ways to eliminate/identify errors
    - Critical for designing a larger system (1m^3 physics prototype)
- Current status
  - Identified 14 error modes (not all independent)
    - 9 ‘fatal error’ modes: data can NOT be recovered
    - 5 ‘non-fatal error’ modes: data can still be recovered
  - 7 error modes have been eliminated after slice test
  - 4 major errors (2 ‘fatal’+2 ‘non-fatal’) still exist
    - 2 ‘fatal’ + 1 ‘non-fatal’ errors correlated with noise issues
    - 1 ‘non-fatal’ error likely to be a firmware issue
    - ‘Solution(s)’ still need to be studied
  - Data re-run just started

Muon data

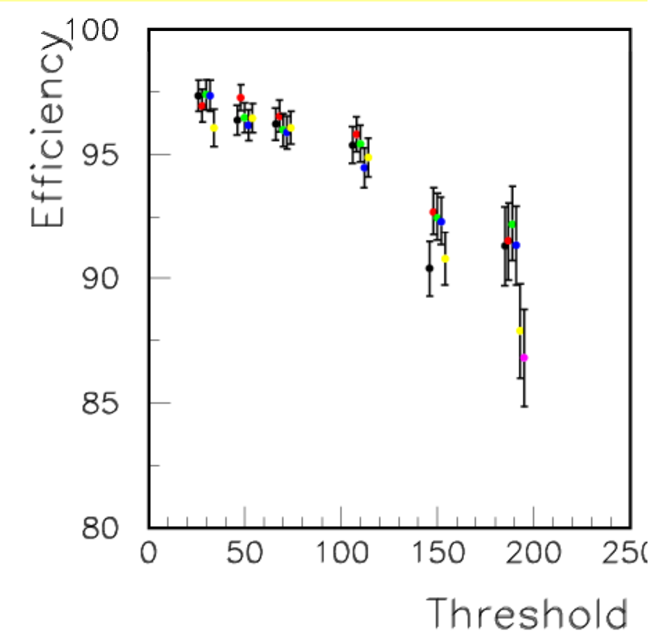

Run 999:0 Event 9
Time: 1617467
Hits: 21 Energy: xxx mips

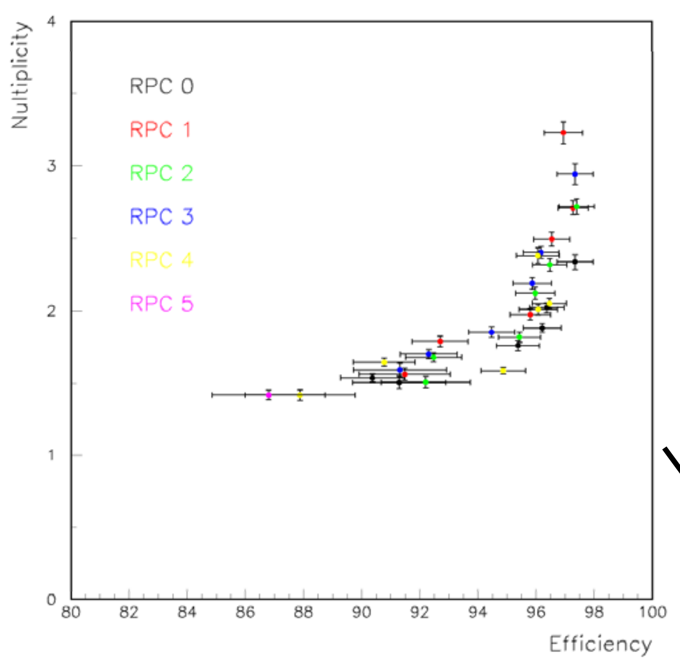

Run 999:0 Event 91
Time: 1570422
Hits: 36 Energy: xxx mips

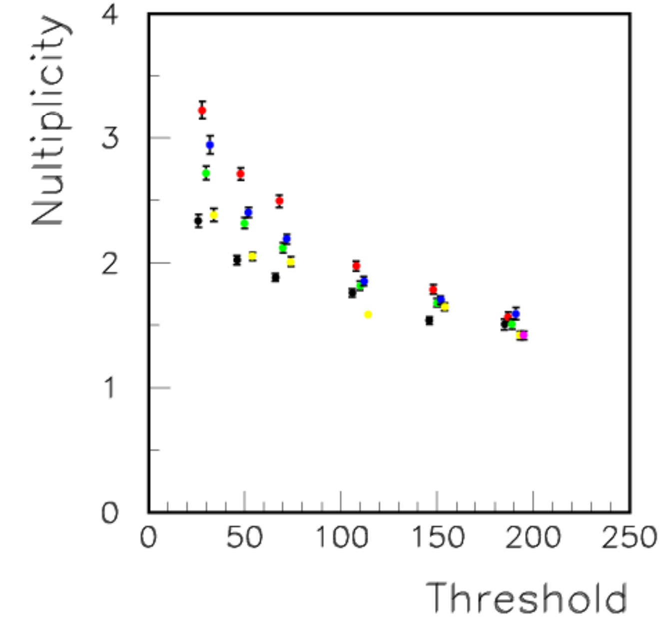

Run 999:0 Event 77
Hits: 8 Energy: xxx mips


Run 999:0 Event 69
Hits: 25 Energy: xxx mips

Muon data: calibration of all runs



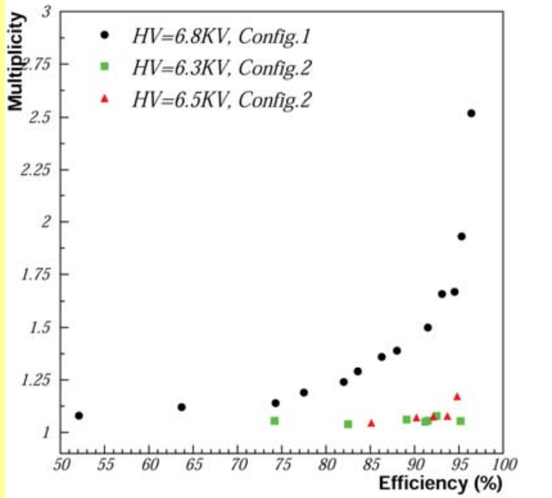




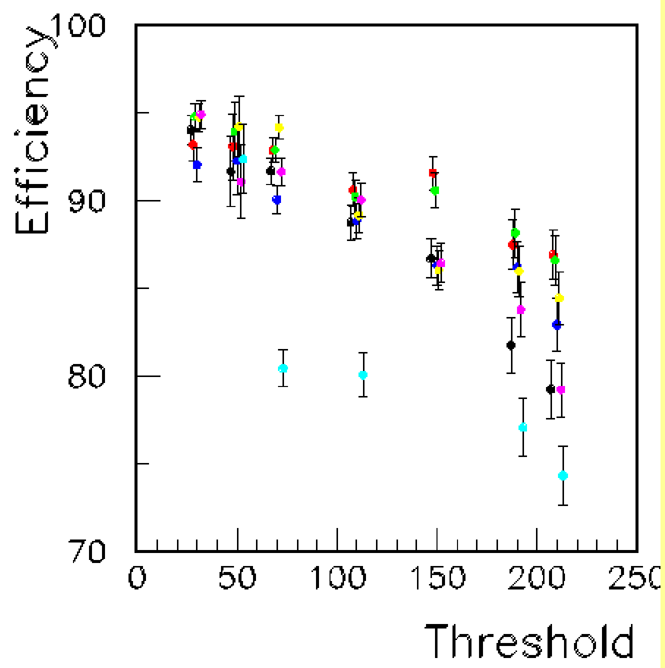
RPC 0
RPC 1
RPC 2
RPC 3
RPC 4
RPC 5

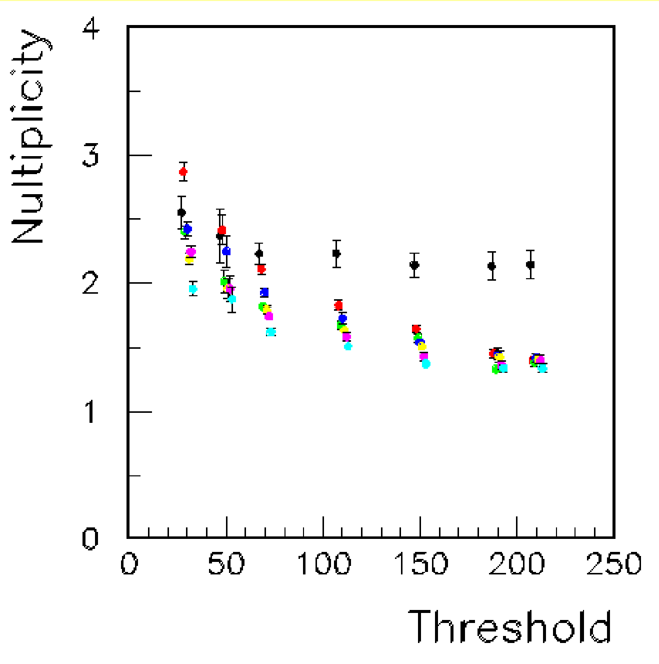
From: Cosmic Ray Runs

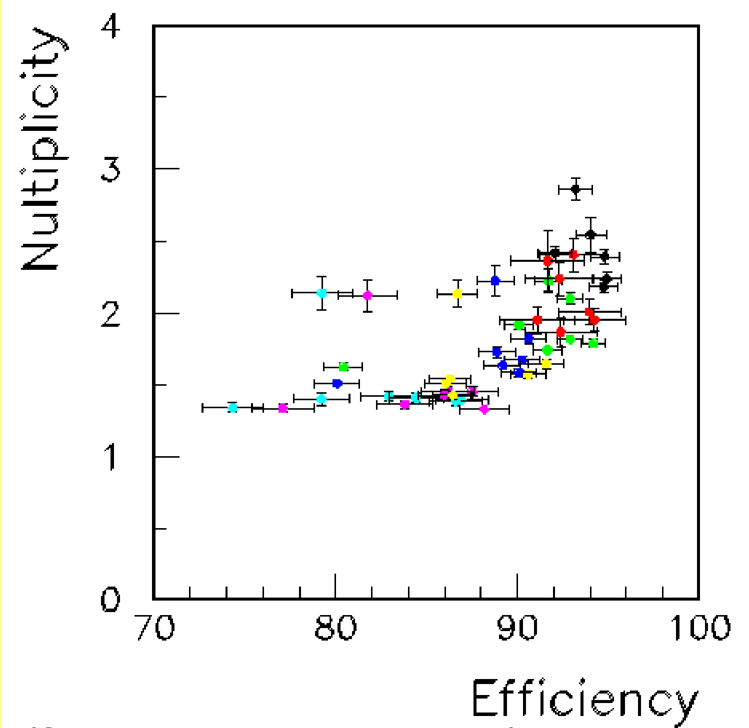
Very similar to results with 'old' VME digital readout



Muon data: ‘online results’







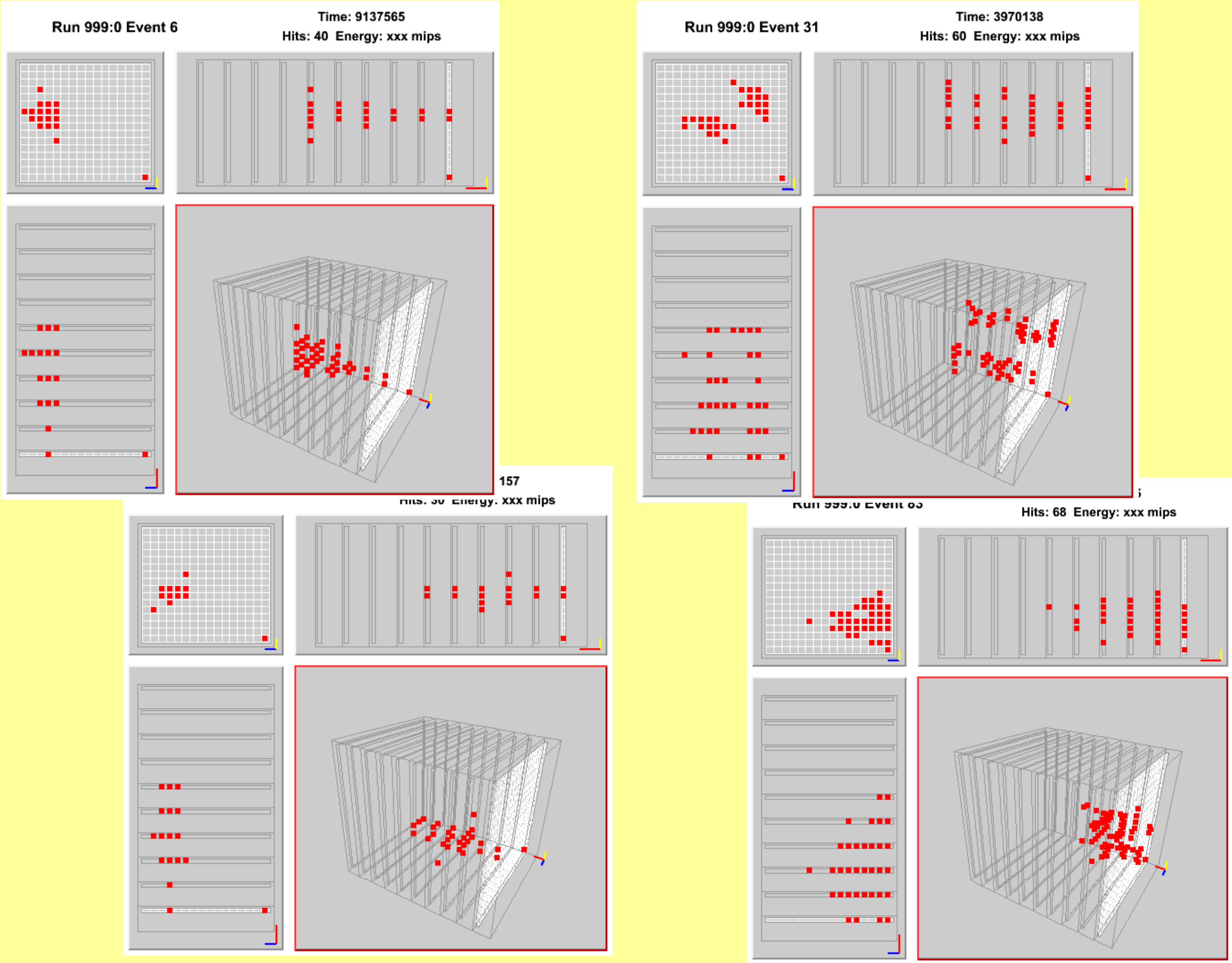
(from muon beam runs)

Data still need clean-up…

Results will be fed into simulation for all run types

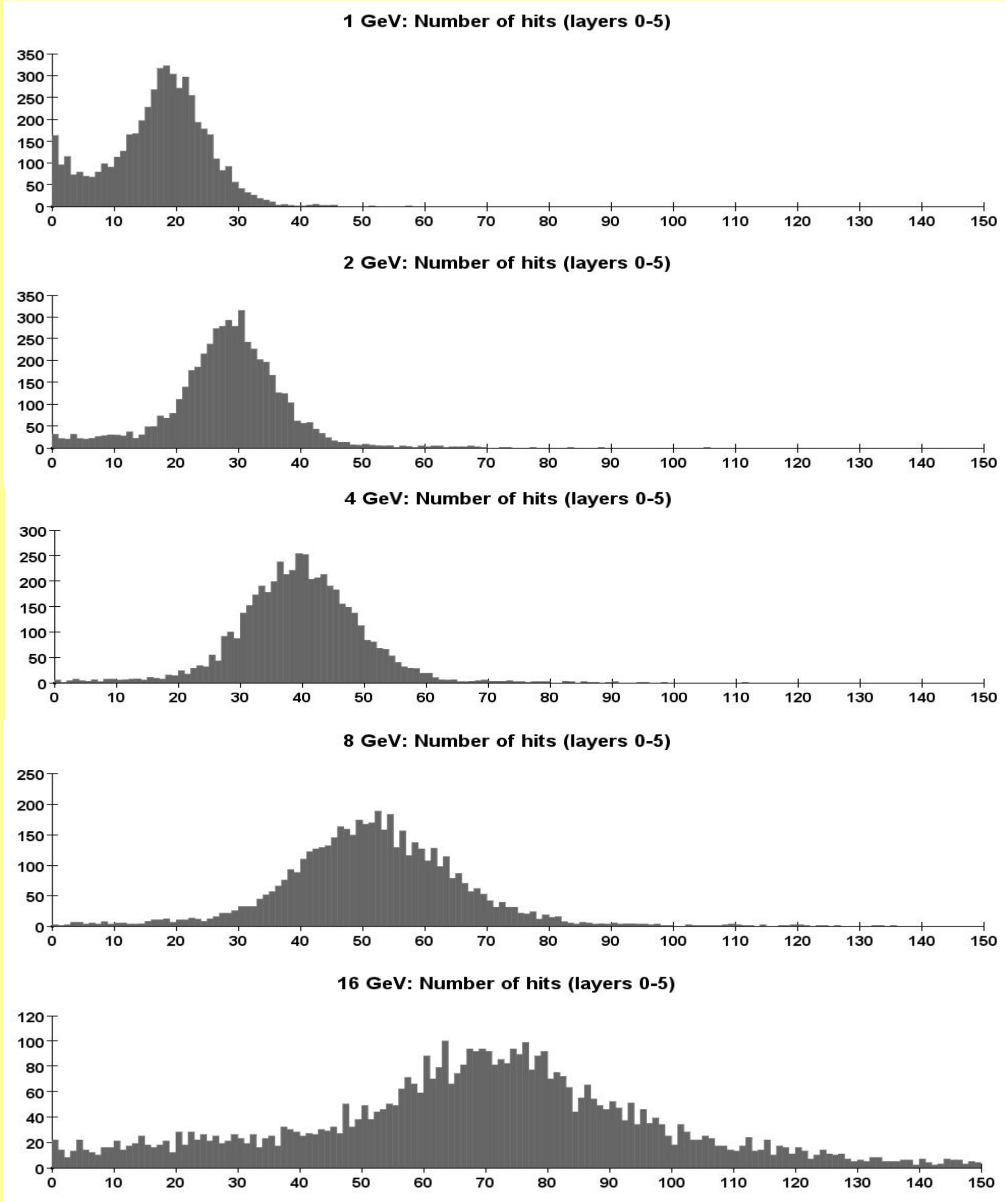
Jose and Lei has been working on it
Burak Bilki (Iowa) started working on it since last week…

Positron data



Positron data: 'online results'

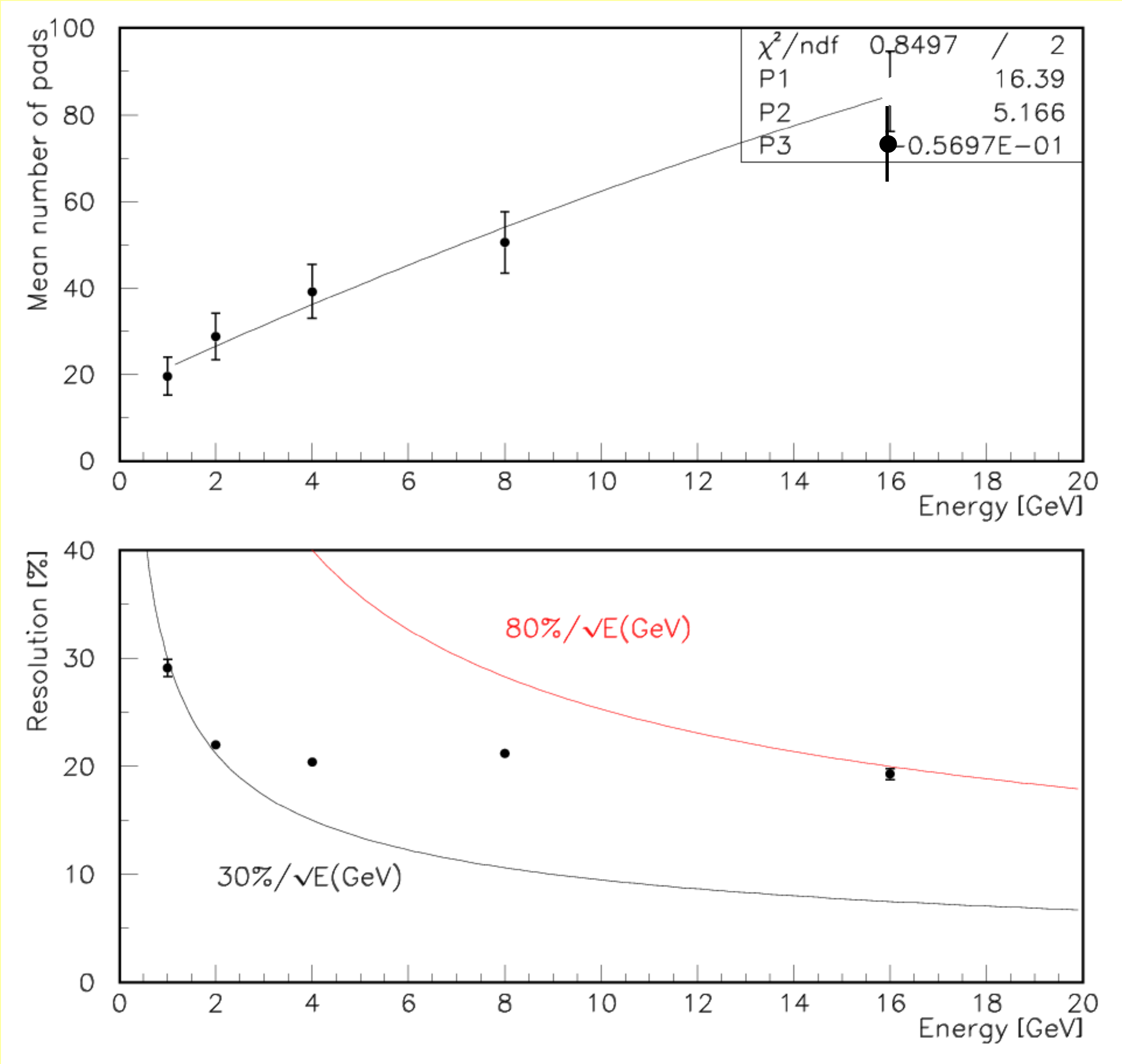
- Number of hits in layer 0-5
  - Positron data @ 1, 2, 4, 8, 16 GeV/c
  - Using Čerenkov signal to selecte positron (very pure)
  - No event selection
    - Particle hitting edge
    - Particle showered upstream
    - Multiple particles
    - …



Remember:

This is an incomplete Digital Hadron Calorimeter

Positron data: 'online results'



Highly non-linear response

- Largely due to shower leakage
- Also due to digital approach

Surprisingly good energy resolution

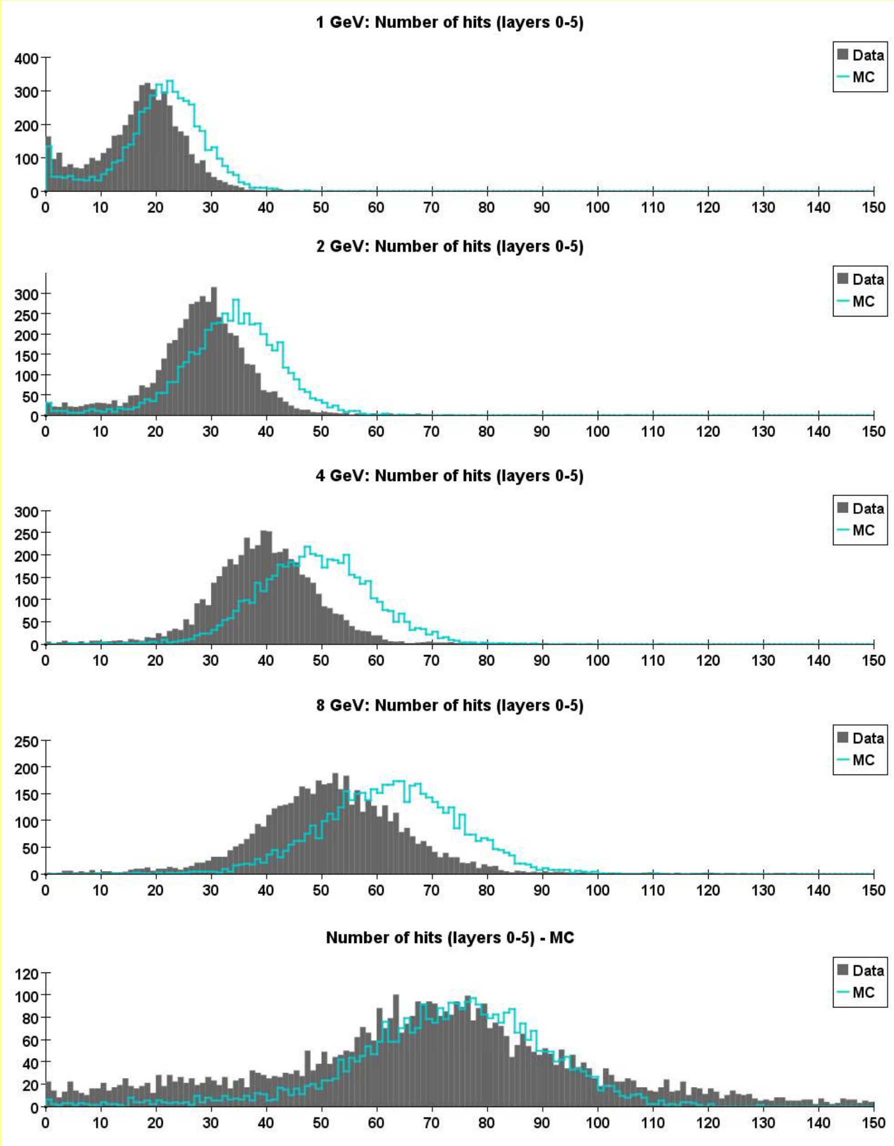
- degrade at high energy due to heavy shower leakage

Positron data: MC simulation

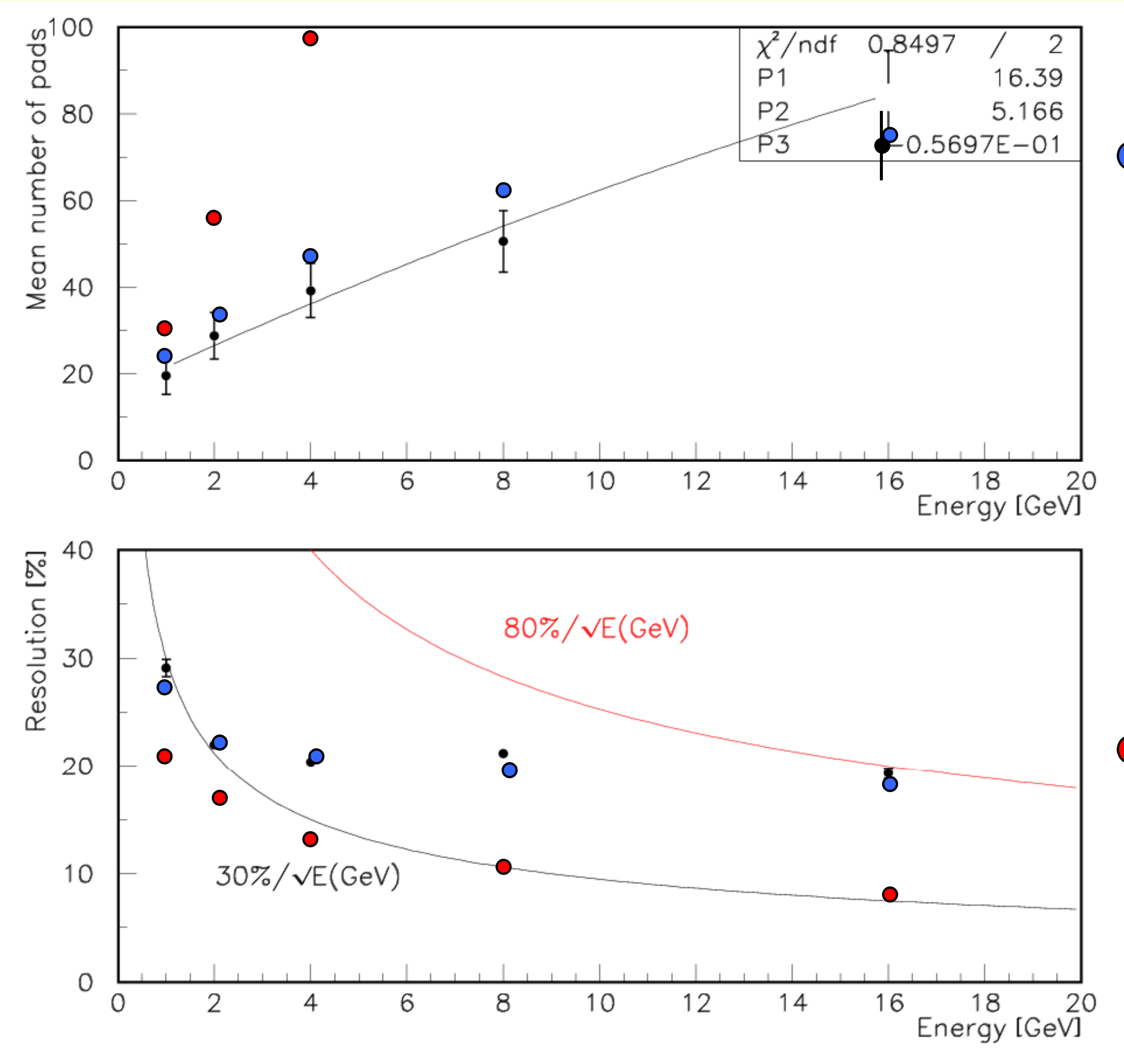
- A crude Geant4 simulation was done, just to have an idea about the detector performance
  - Simulated detector has similar layer structure, but with larger size and much more layers
    - Absorber: 2cm Fe → 1.6cm Fe + 0.4cm Cu
      (beam test: 1.6cm Fe, 0.4cm Cu)
    - Gap size: 13.4mm (== beam test setup)
    - Use fiducial cut to get 'beam test' hits
  - RPC properties
    - MIP efficiency = 0.90 (beam test: still to be determined)
    - Hit multiplicity = 1.65 (beam test: still to be determined)
      - Implementation not optimal
      - Need results from muon runs to get correct implementation
    - Dead channels: not simulated (beam test: exist)
  - Beam properties
    - Pure positron at 1,2,4,8,16 GeV/c, no upstream material, no multiple beam particles, etc. (data: may have junk in it)
    - Assume Gaussian distribution for beam spot (reality: still to be determined)
      - Gaussian central/width from a crude estimate

Positron data: compare data/MC

- Agreement is reasonably good
  - Peak positions are a little bit off
  - Resolution well reproduced
  - Expect significant improvement with careful calibration
- Confirmed that DHCAL works as expected



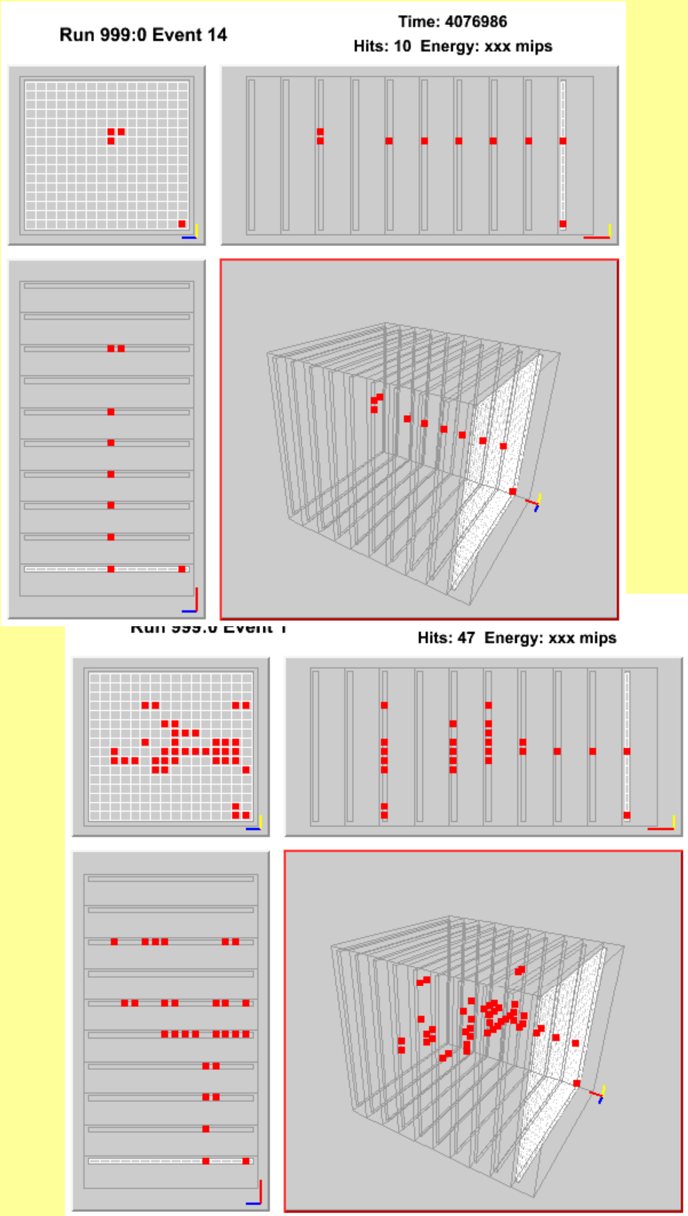
Positron data: compare data/MC

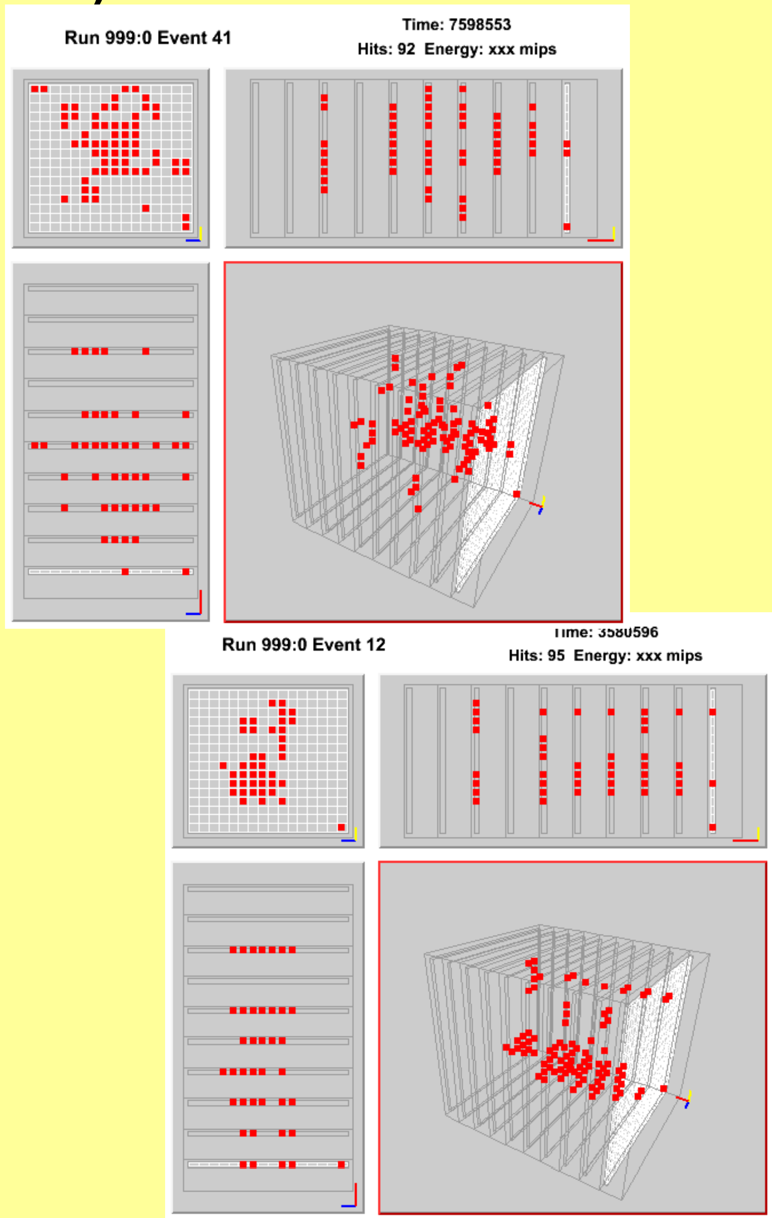


- : simulation: 0-5 layers
  agree reasonably well

- : simulation: no leakage
  linearity: improved
  resolution: even better

Pion(/Muon) data

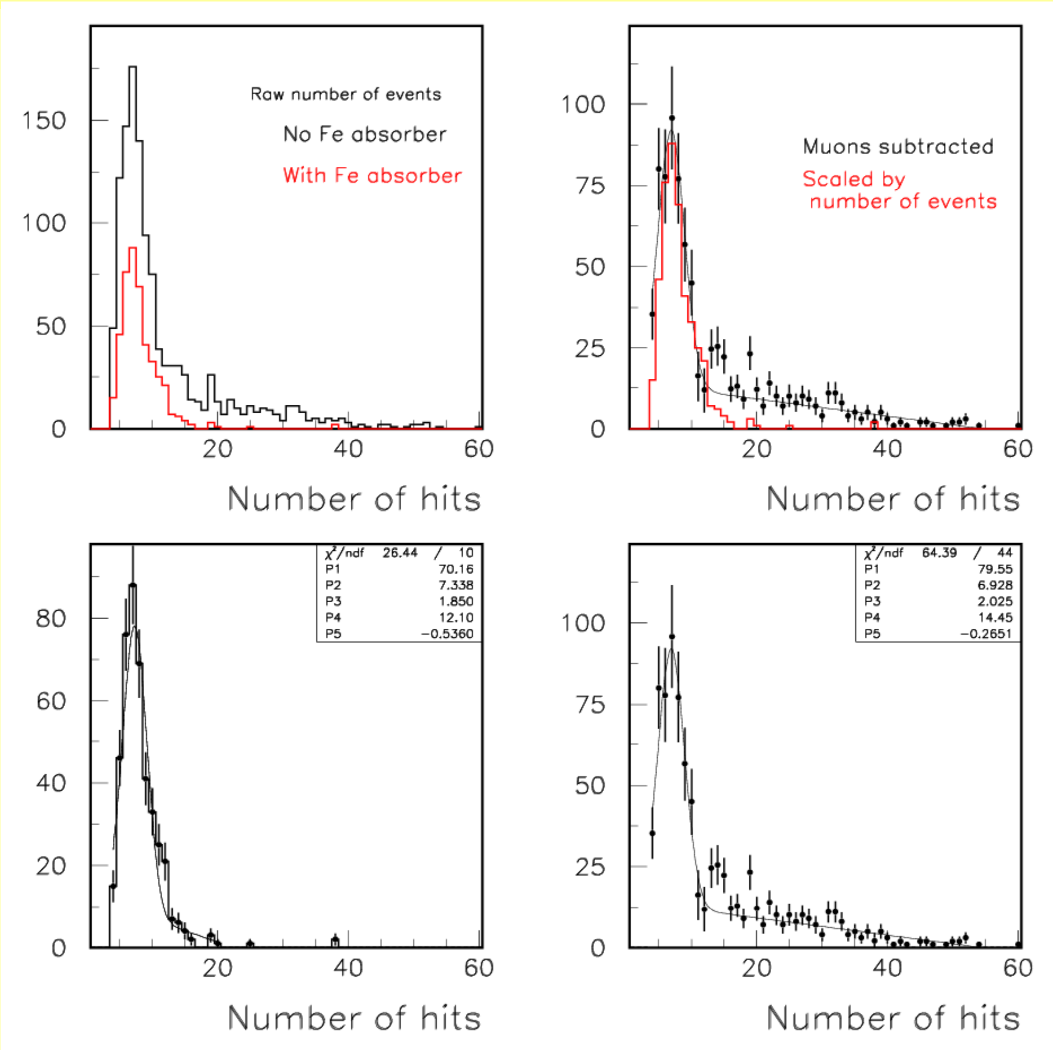




Collected data at (1),2,4,8,16 GeV/c data with Čerenkov veto

Pion(/Muon) data: ‘online results’

Data at 2 GeV taken with/without additional iron absorber



Clear evidence for π^+ at 2 GeV (~ 57% π^+ and ~ 43% μ^+)

Data will be used to compare with Geant4 simulation

Proton data

- No absorber: event looks like MIP tracks
- Data will be used to study RPC rate capability
  - Long time scale effect: decrease of efficiency with overall rate (T ~ sec)
  - Short time scale effect (?): ‘dead time’ after individual event (T ~ ms)

Conclusion

- DHCAL slice test was a great success
- We collected large, high quality data sets
- The analysis has begun, but a lot remains to be done
- We plan on producing 4 – 5 papers
- We are clearly short of manpower – help is very welcomed (Many thanks to U Iowa group for helping our data analysis with a part time graduate student)