

# *A HCAL for SiD*

Vishnu Zutshi  
Northern Illinois University



# General HCAL Parameters

## Barrel

Inner Radius: 1420 mm

Outer Radius: 2370 mm

Length in Z:  $\pm 2780$  mm

Absorber Thickness: 20 mm

Gap Thickness:  $<8$  mm

## EndCap

Inner Radius: 200 mm

Outer Radius: 1410 mm

Length in Z:  $\pm 1820$  mm to 2780mm

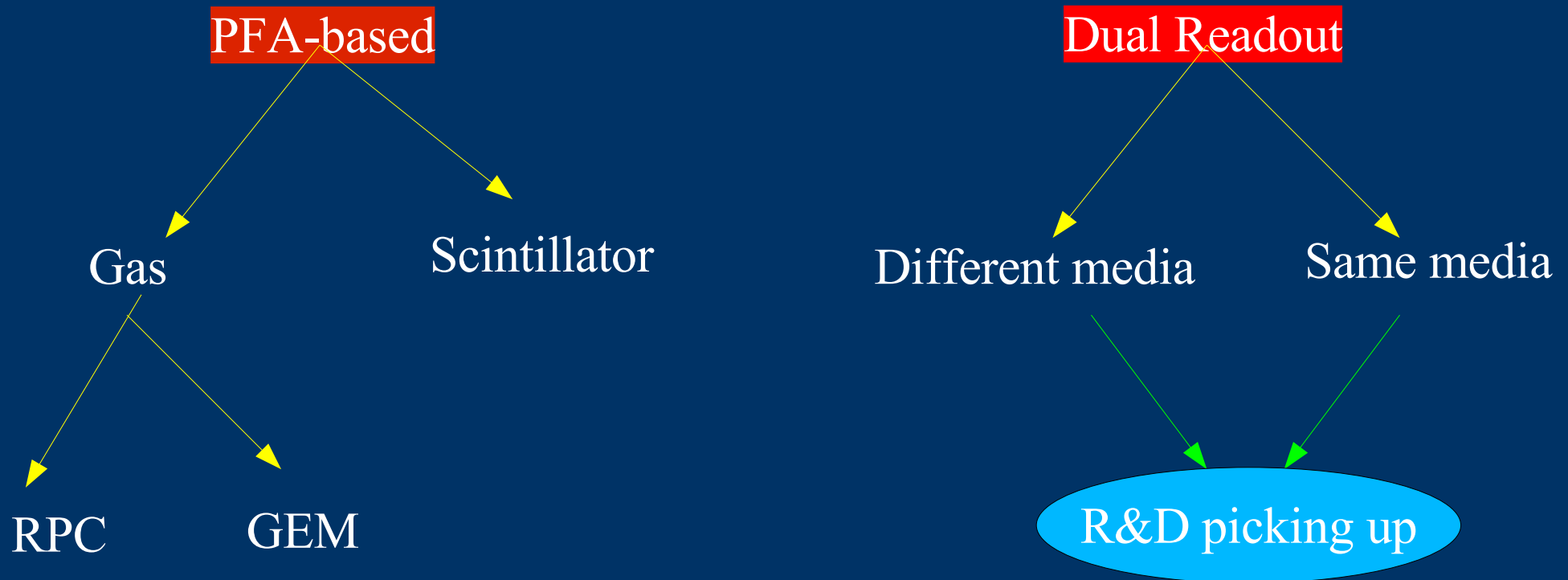
Absorber Thickness: 20 mm

Gap thickness:  $<8$  mm

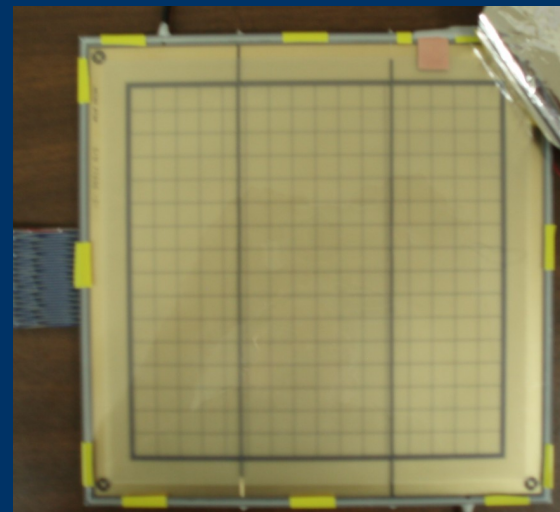
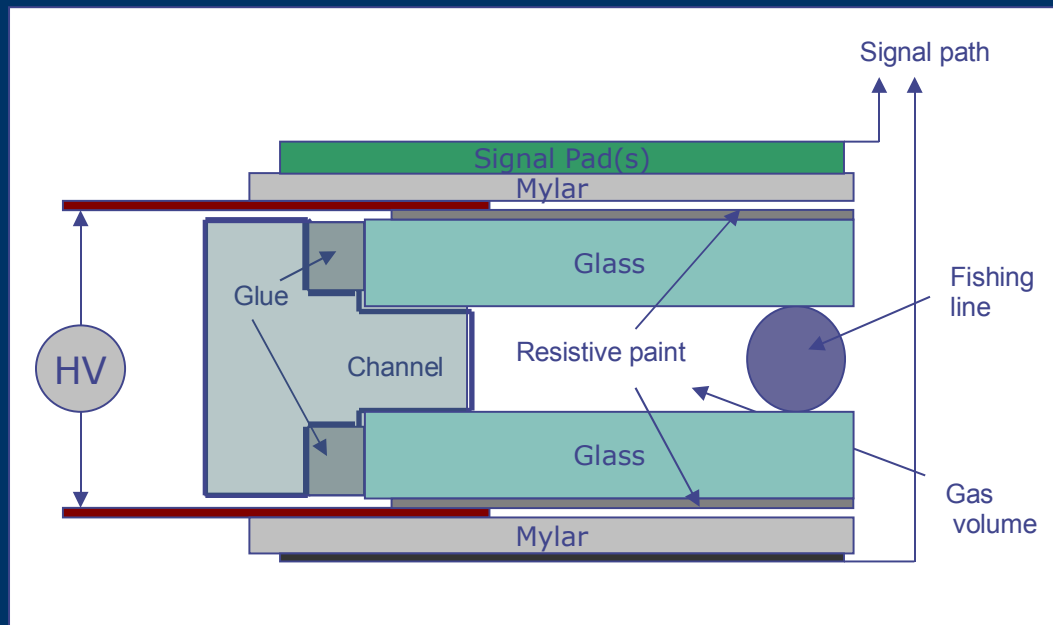
---

---

# SiD HCAL Tree



# RPC HCAL



ANL, Boston, Chicago, FNAL, Iowa

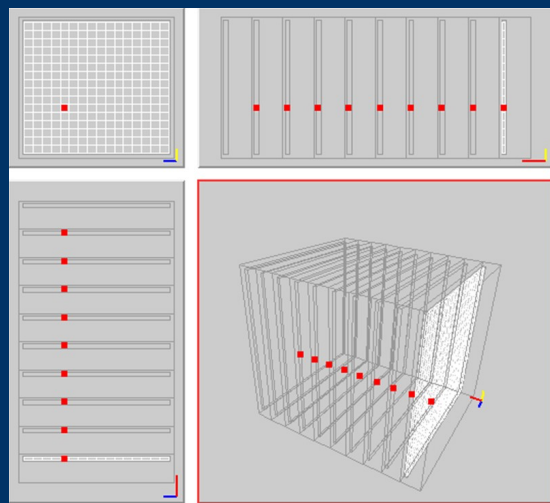
# *RPC Slice Test @ MTBF*

July 2007 at MTBF  
9 chambers (20cm x 20cm)  
256 channels/chamber  
Steel-Cu absorber  
PVC plates for rate studies

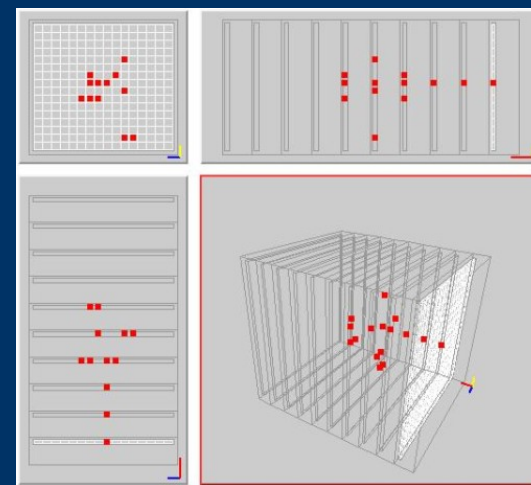
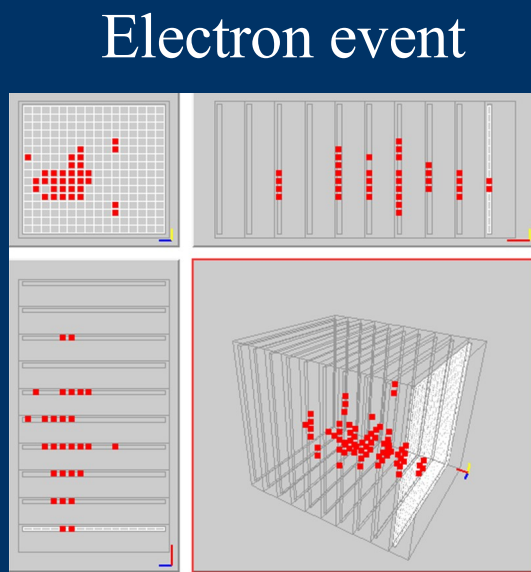
Beam-dump muons  
Positrons (1-16 GeV)  
Pions (1-16 GeV)  
120 GeV Protons



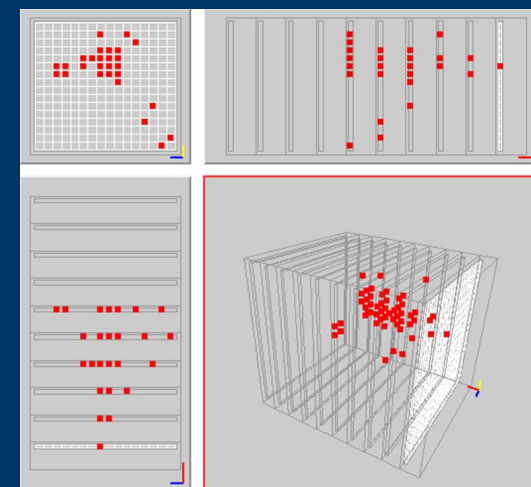
# Beam Events



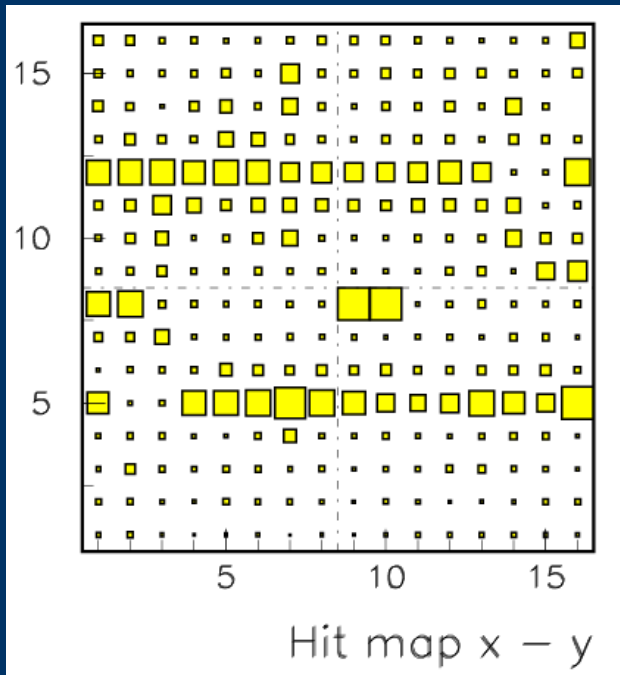
Muon event



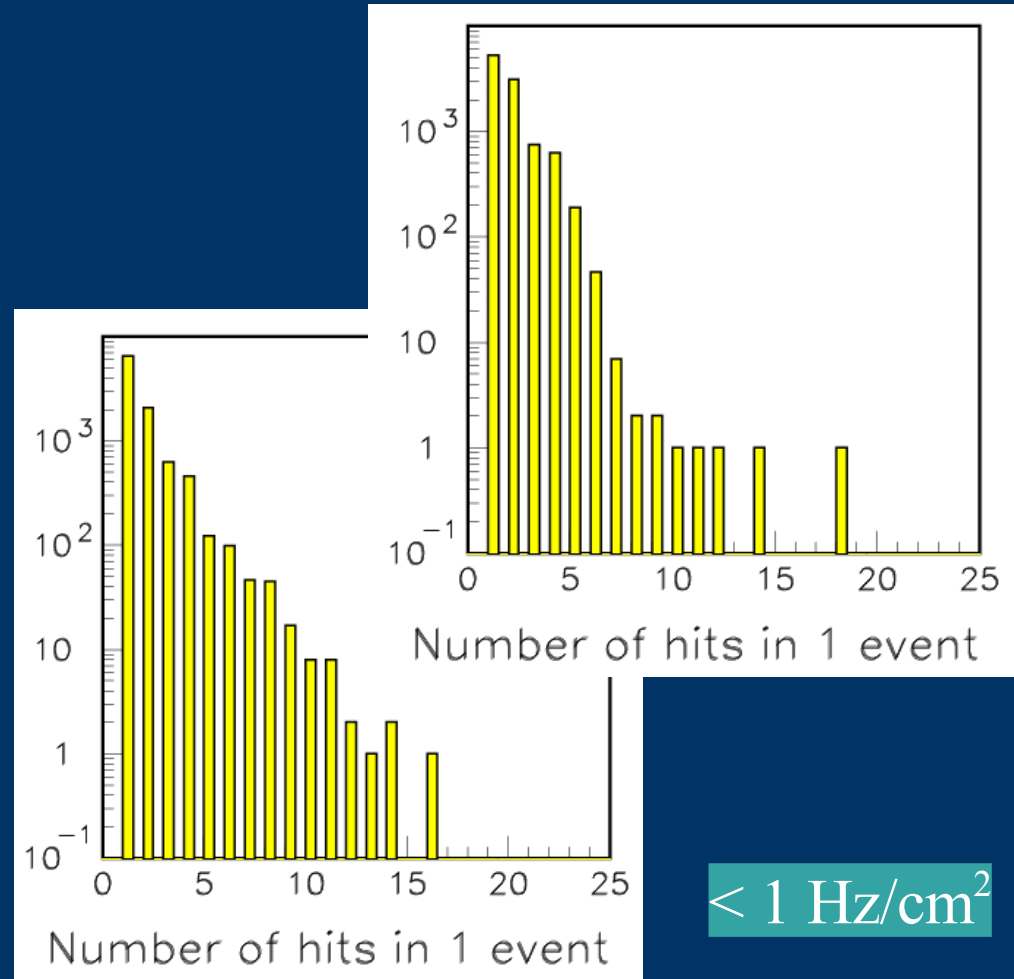
Pion events



# Noise

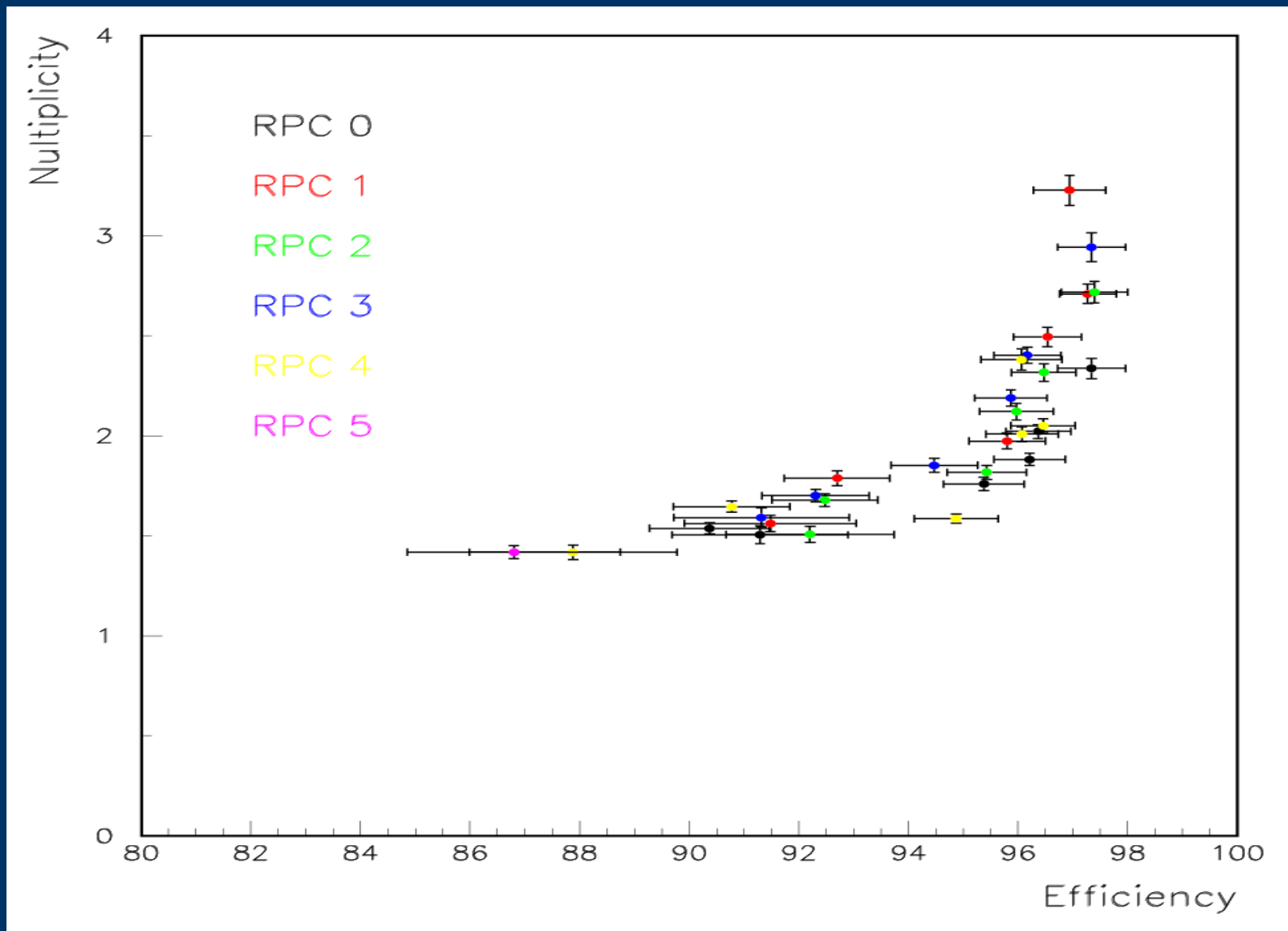


Hits along fishing lines



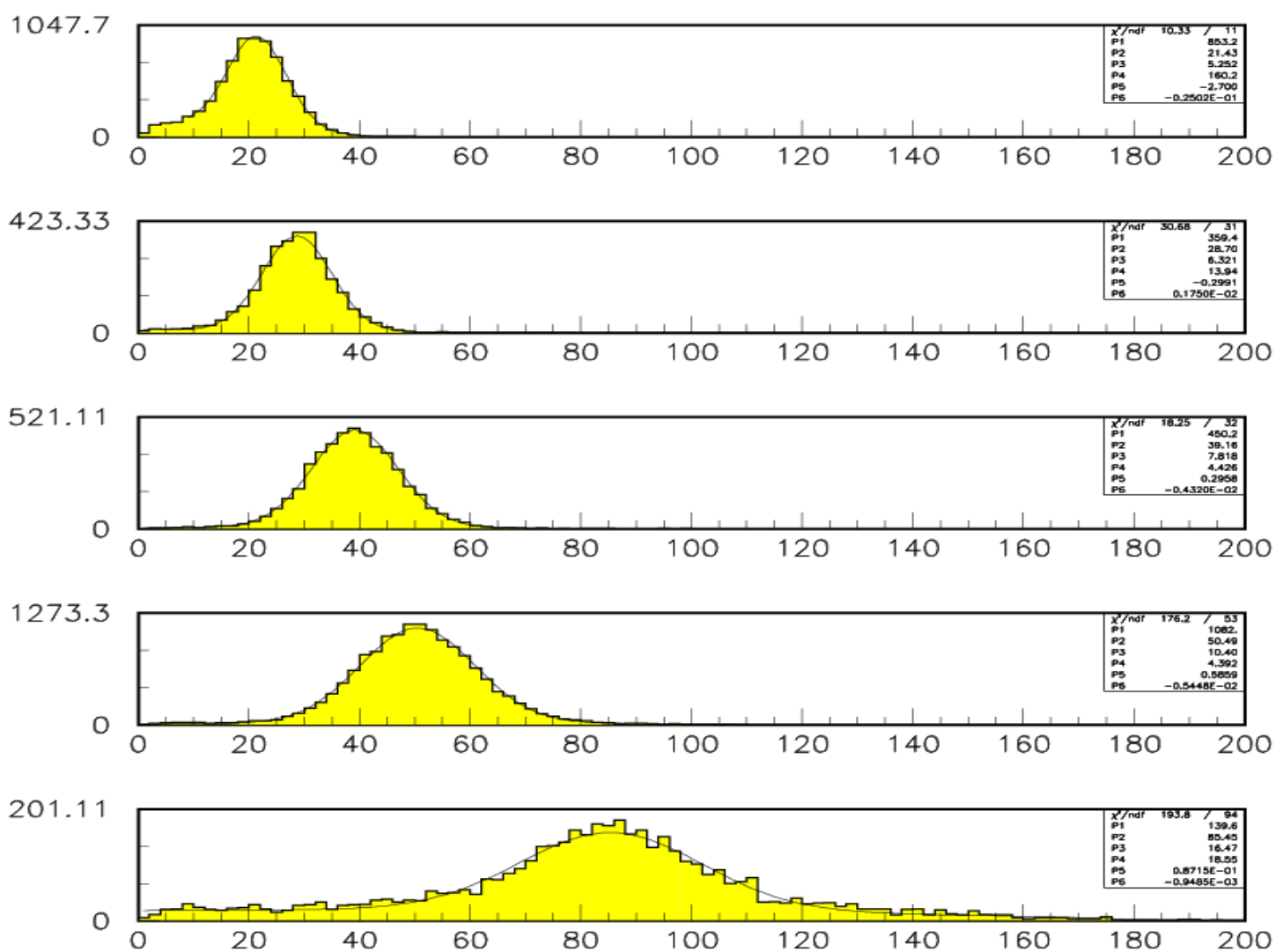
$< 1 \text{ Hz/cm}^2$

# Performance

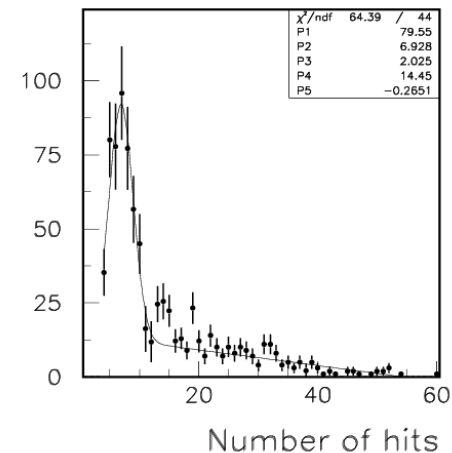
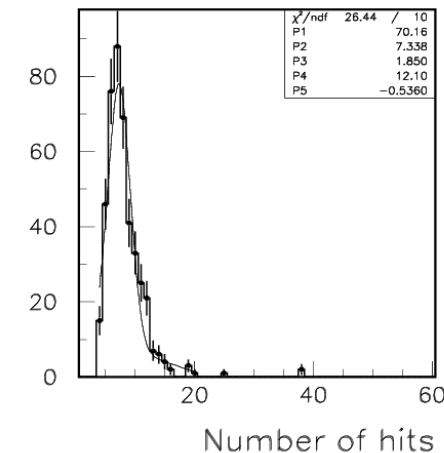
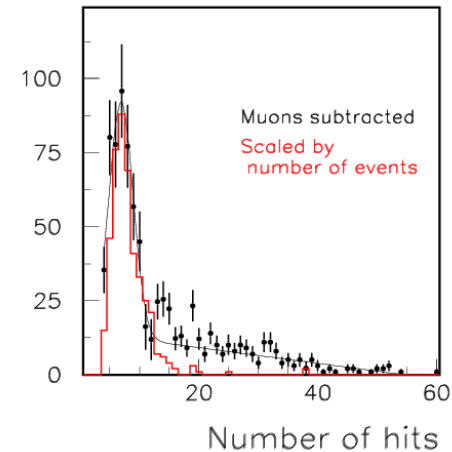
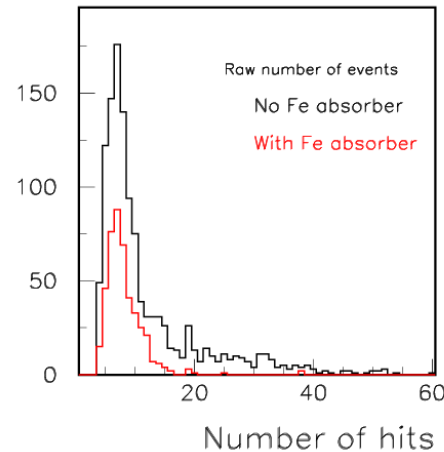
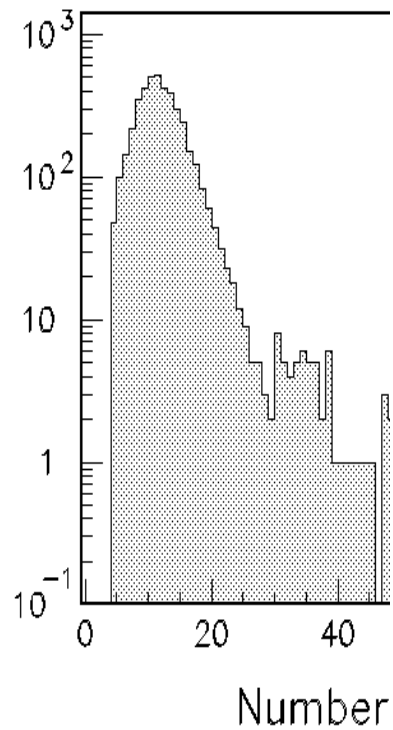
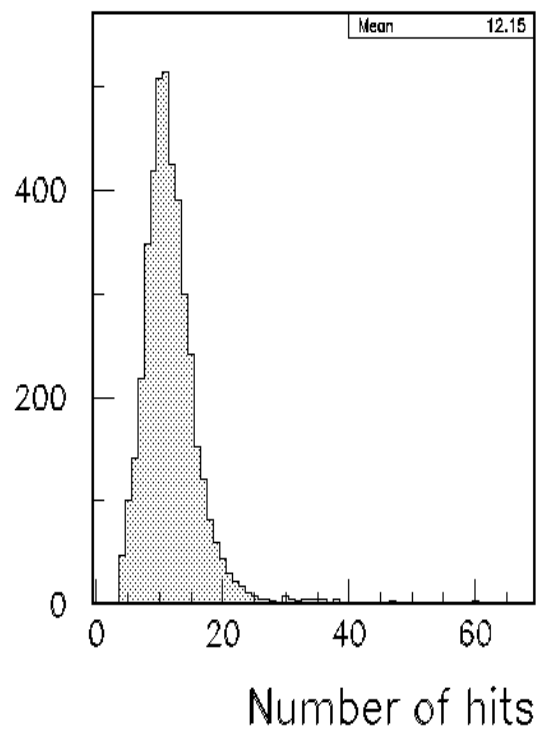




# Positrons



# Muons and Pions



# *RPC Plans*

- Continue analysis of test beam data
- Move towards the 1 m<sup>3</sup> prototype
- This involves amongst other things:

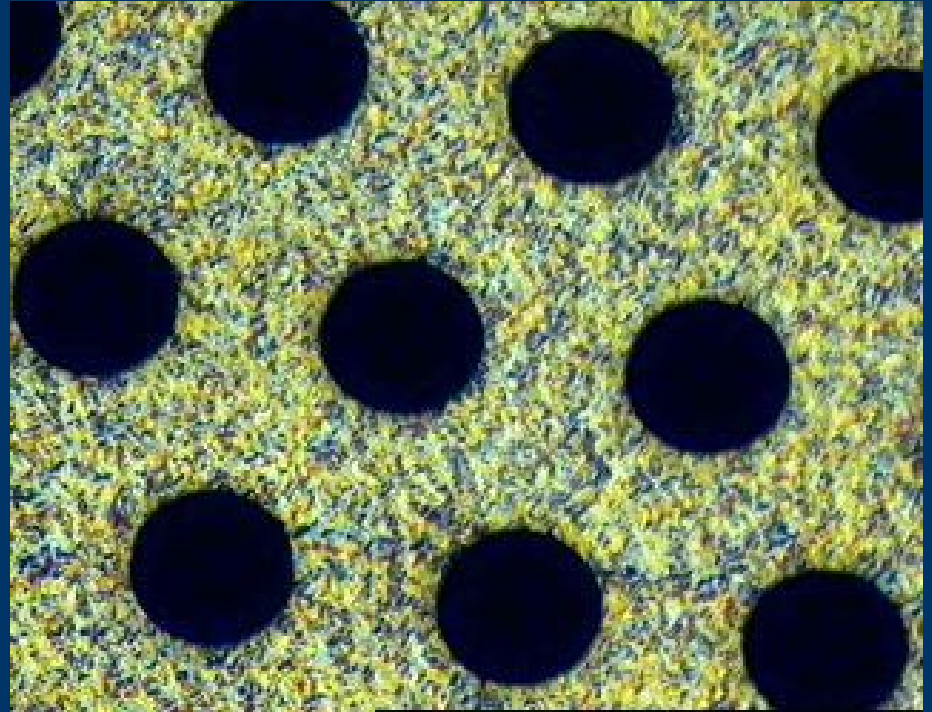
Prototyping larger RPC's  
cheaper front-end and pad boards  
final data concentrator boards

See talks by J. Repond and L. Xia

---

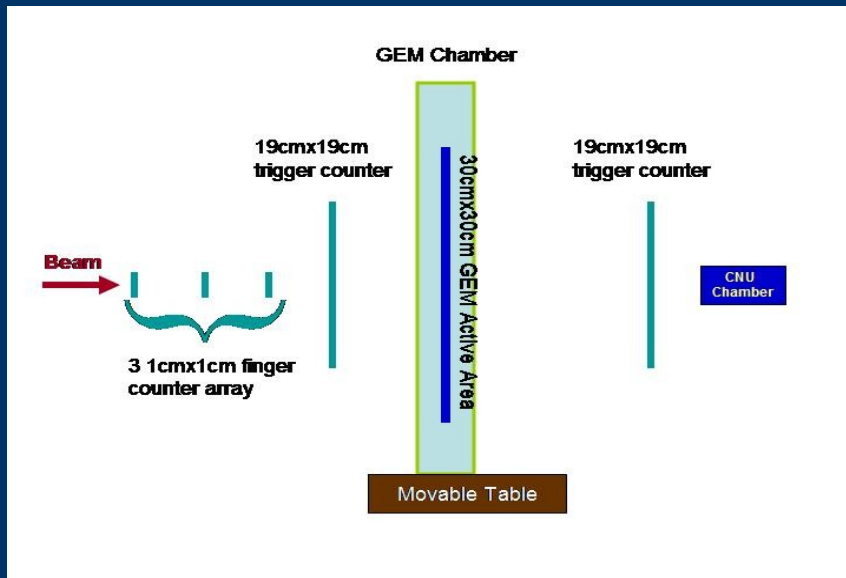
---

# *GEM HCAL*



UTA - UW - CNU

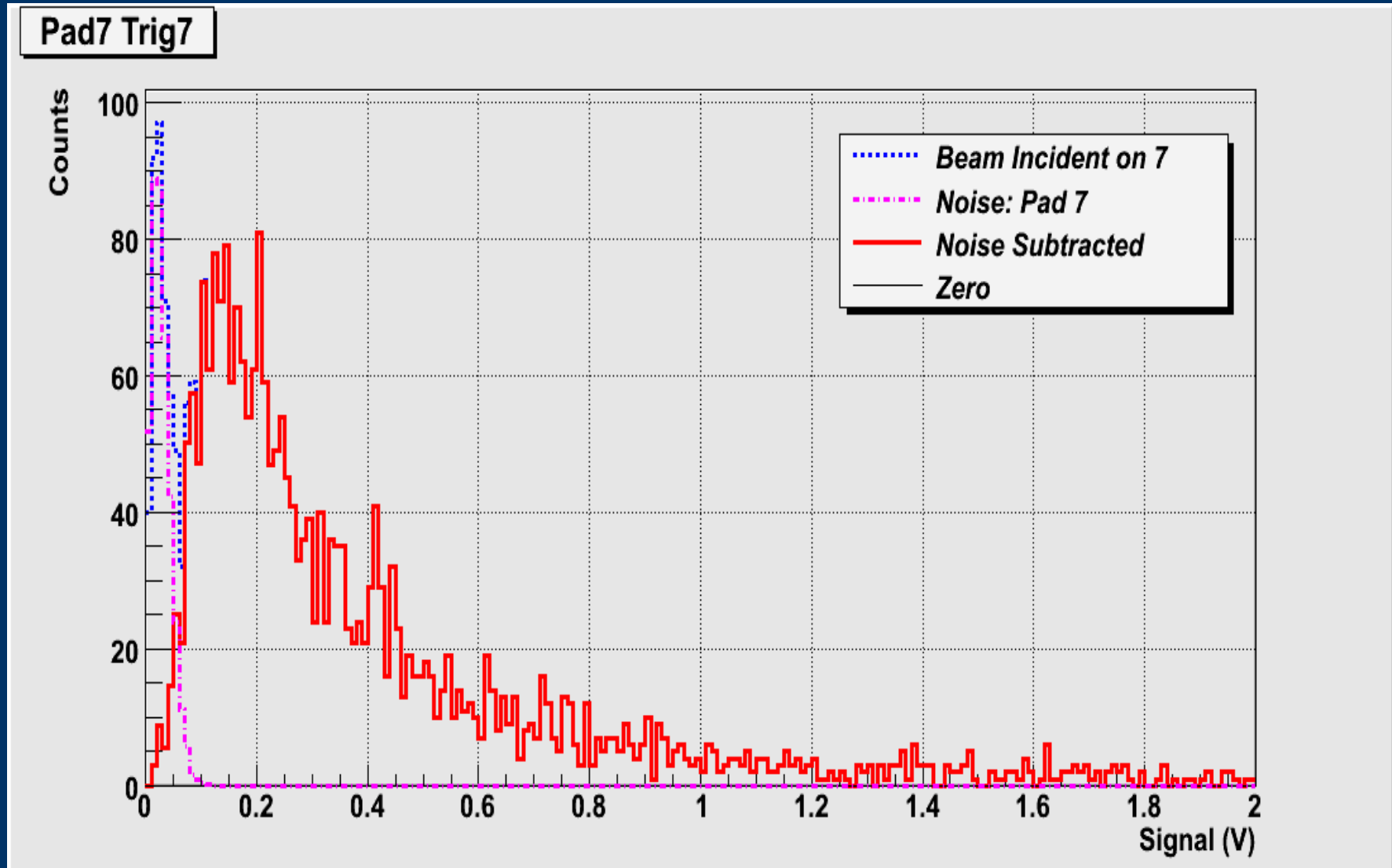
# GEM Test Beam



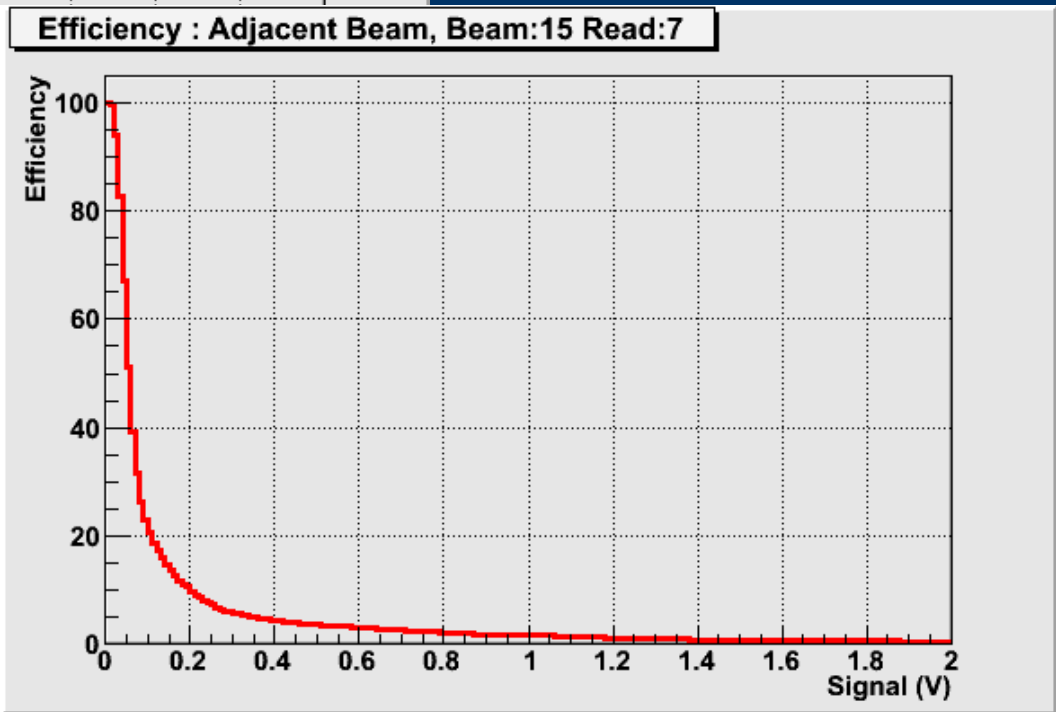
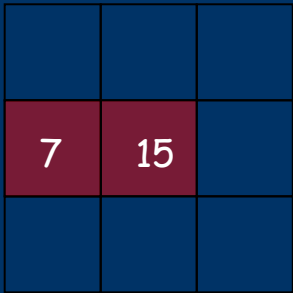
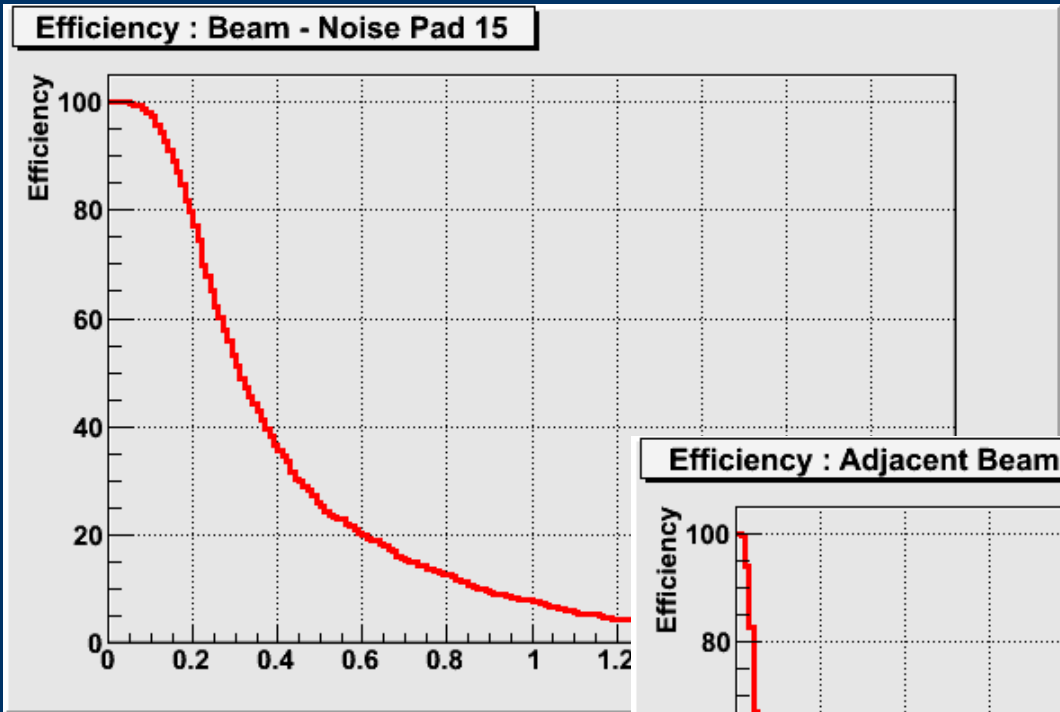
Spring 2007  
120 GeV proton and 8 GeV pion  
efficiency, occupancy, rate.....



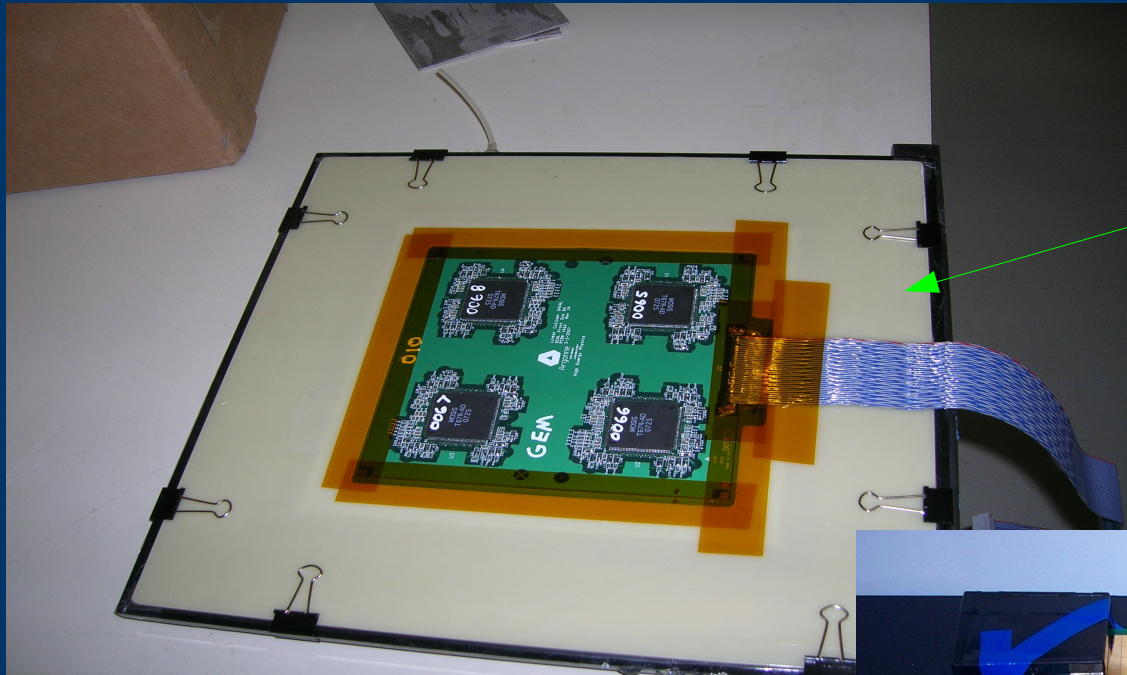
# 120 GeV protons



# Efficiency and Multiplicity

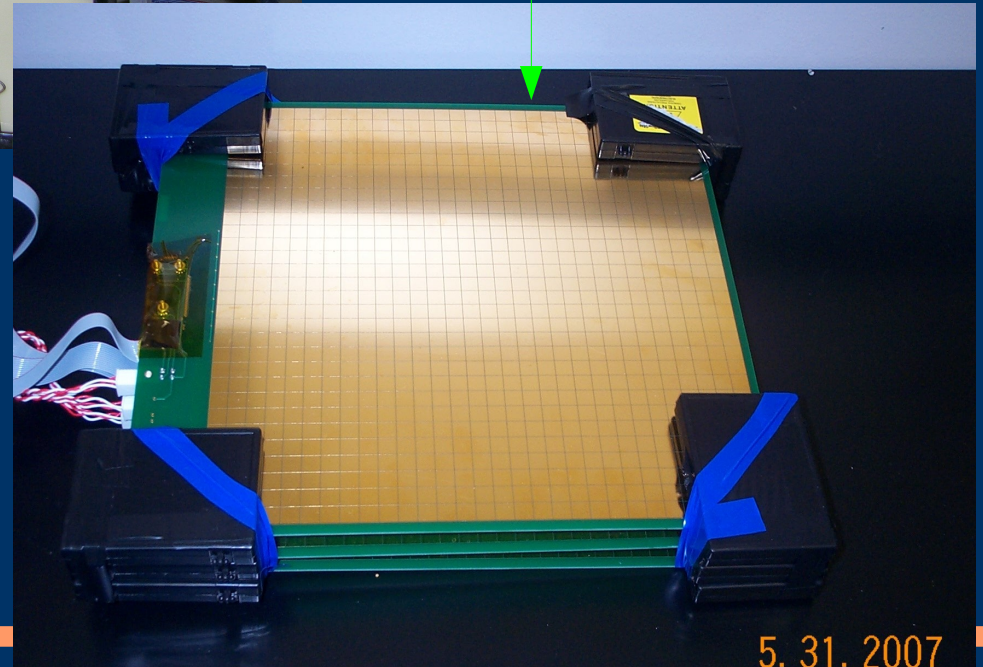


# GEM DHCAL Chamber(s)



GEM-DCAL

GEM-kPix



Both chambers did not see signal  
above noise  
New delrin spacers are suspected

5. 31. 2007



# *GEM Plans*

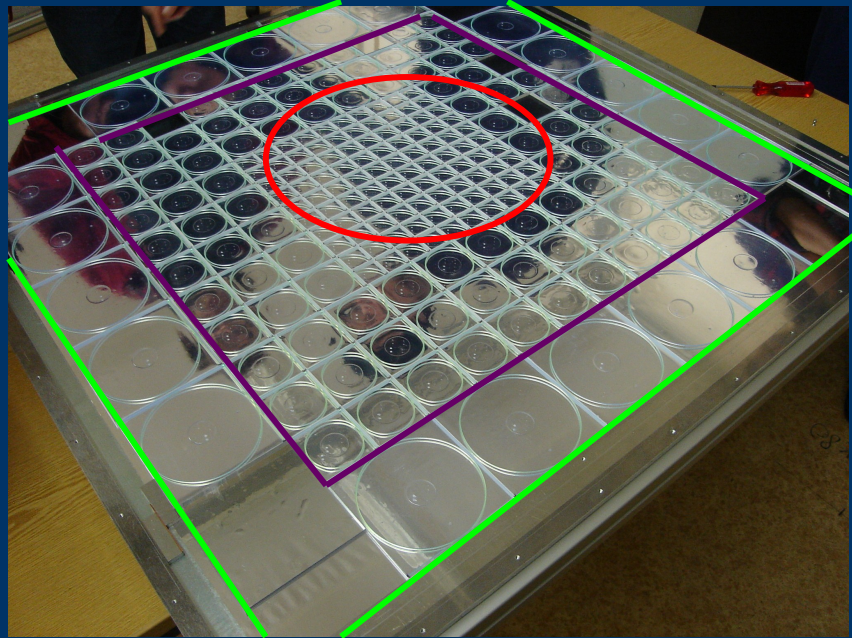
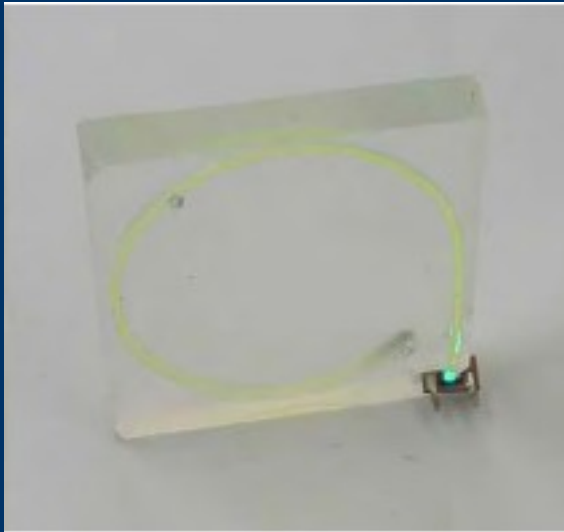
- Complete analysis of collected data
- Resolve GEM-DCAL/kPiX issues
- Beam tests in Nov. at Fermilab
- Study 1m x 30cm GEM chambers to develop designs for 1m x 90cm planes

See talk by A. White

---

---

# *CALICE Scintillator HCAL*

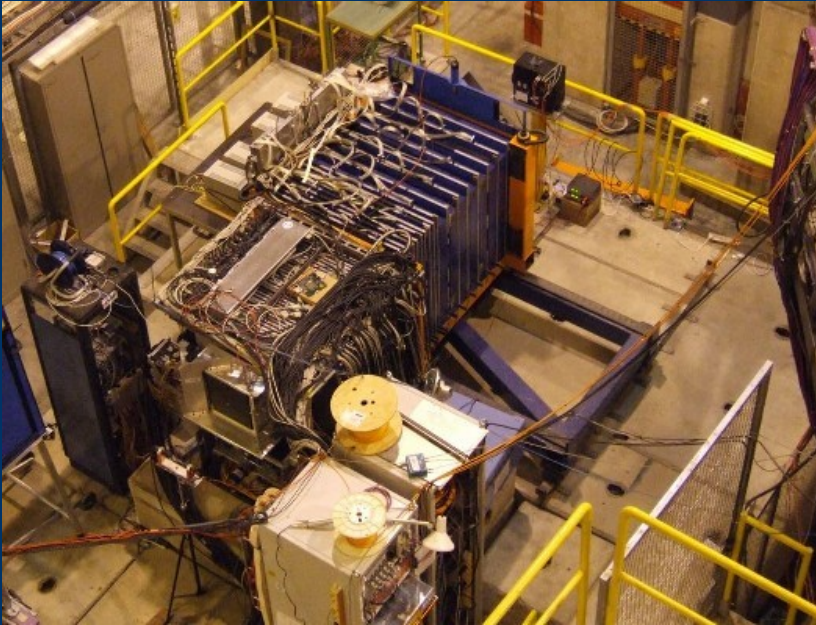


DESY, Hamburg, ITEP, MEPhI, LPI, NIU, Prague, LAL, UK

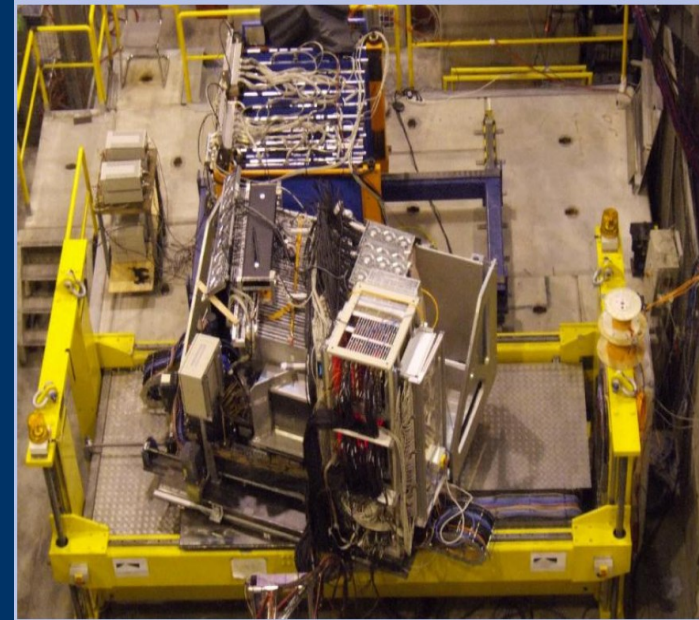
---

---

# *CALICE Testbeam @ CERN*



2006



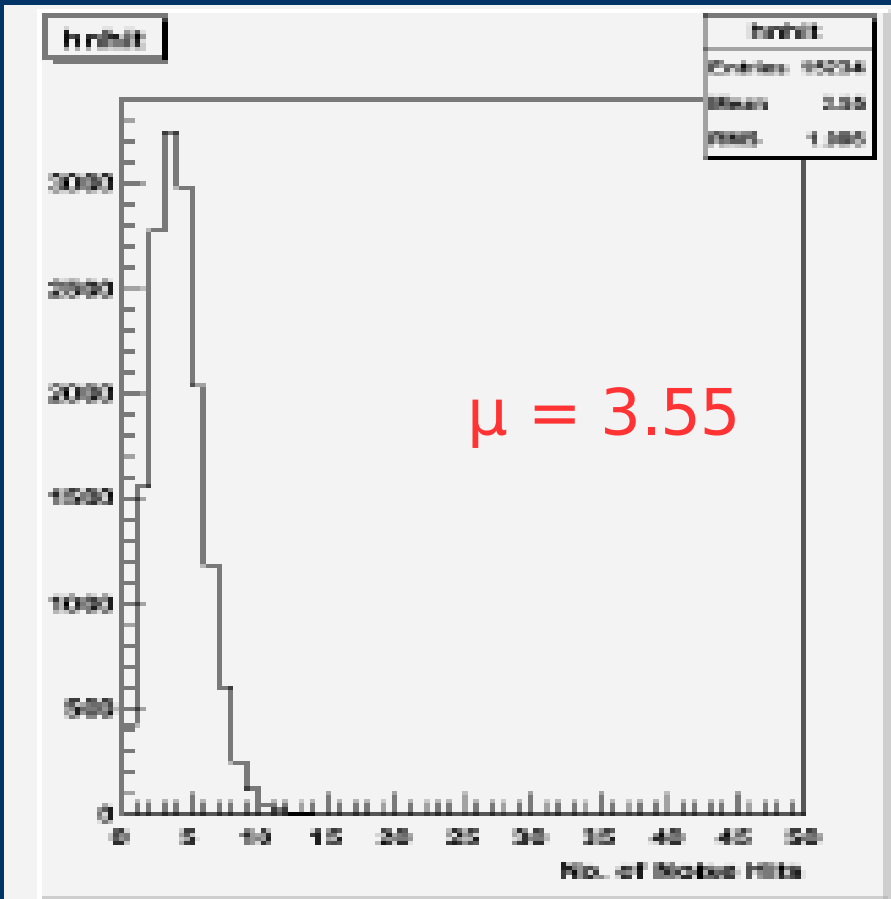
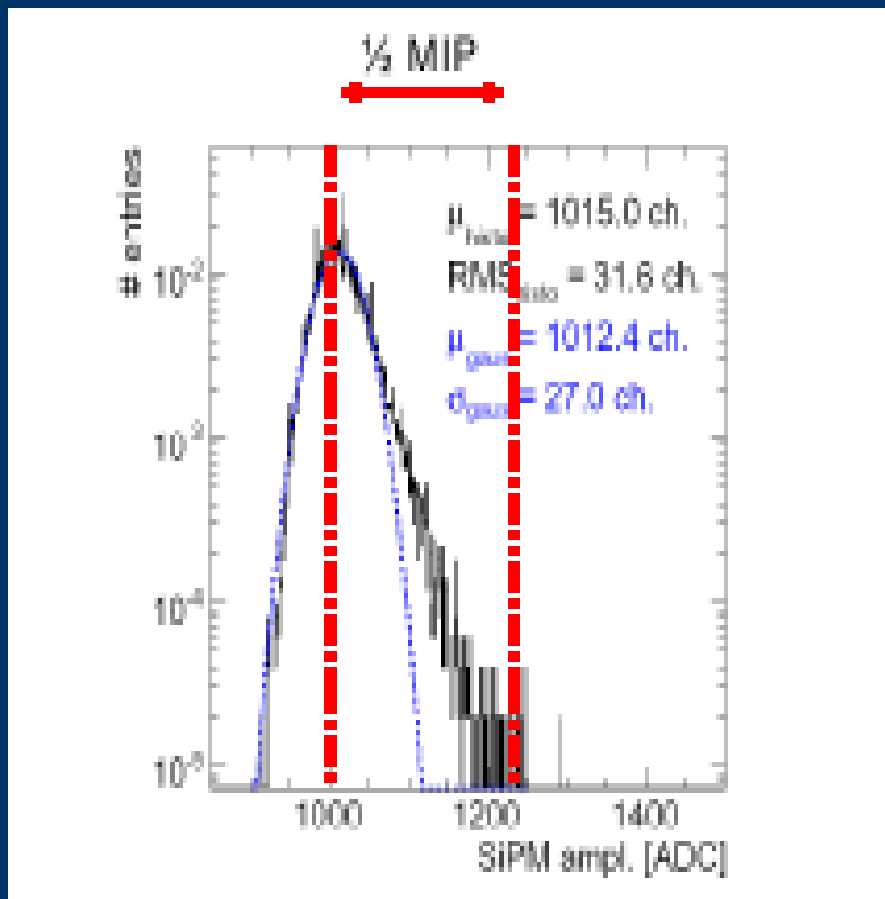
2007

~ 19 Tbyte of data collected, available on the grid now  
electron, pion, proton and beam dump muons  
energies 6-180 GeV available  
angle of incidence in the 0-30<sup>0</sup> range

---

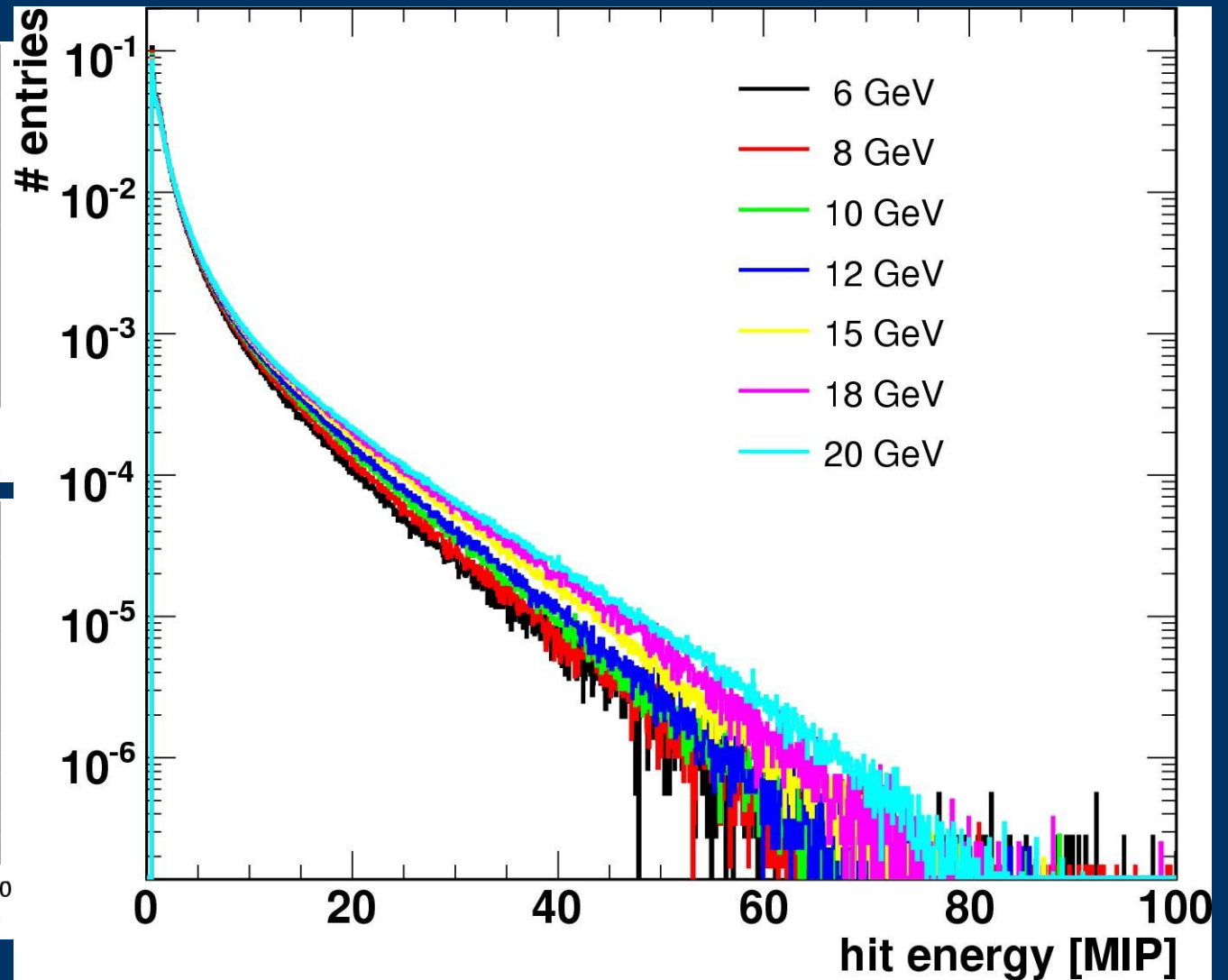
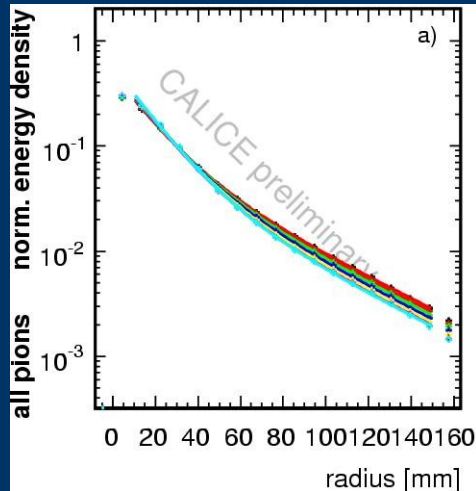
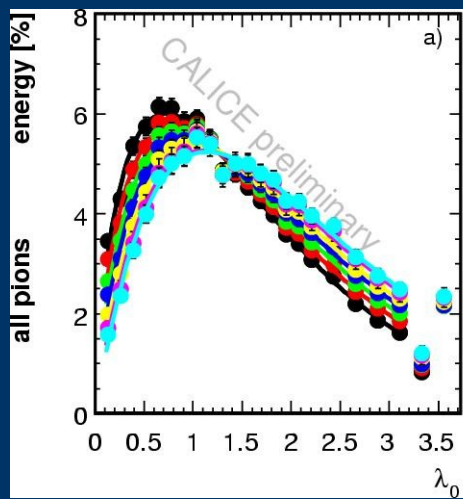
---

# Noise



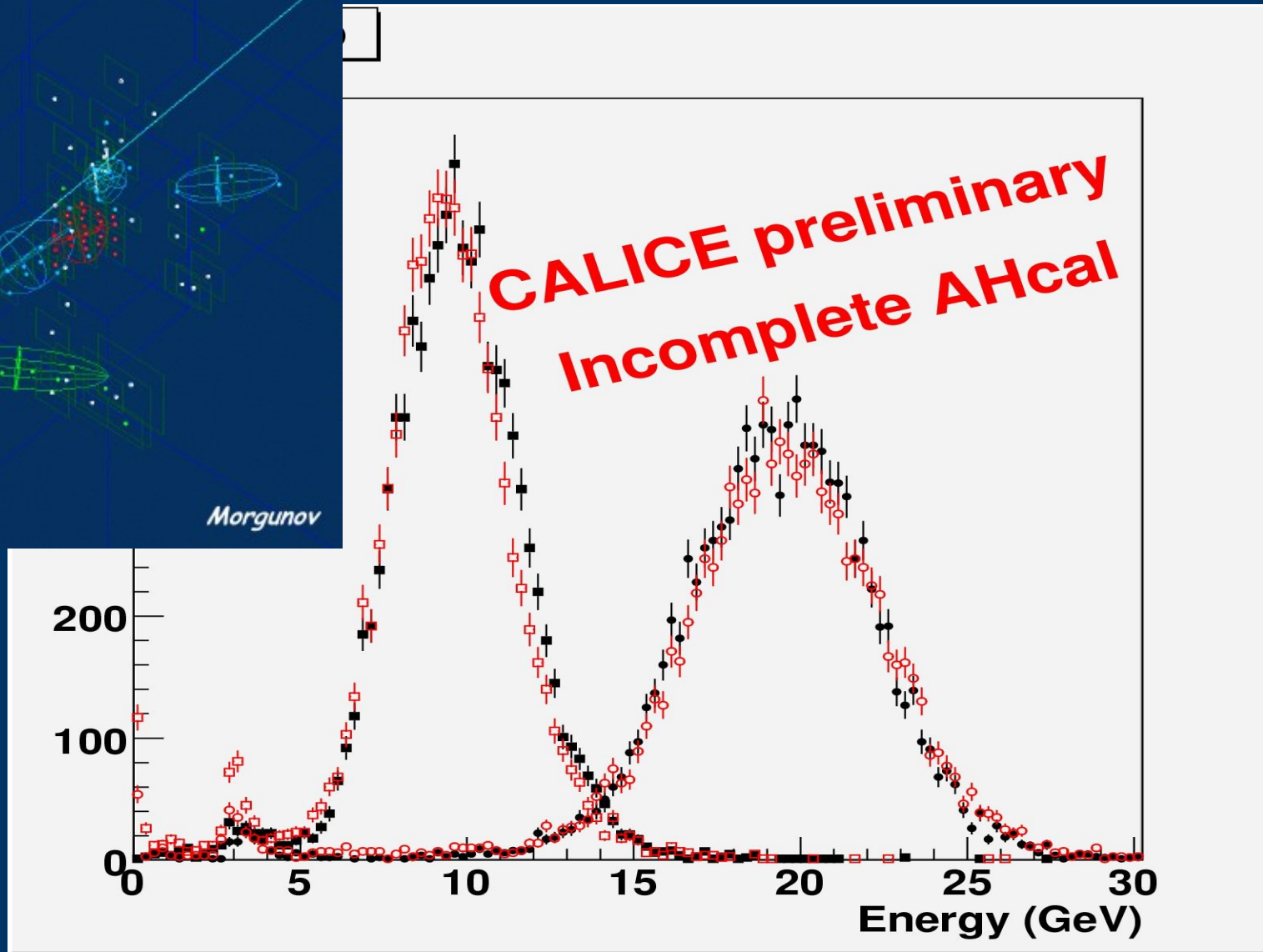
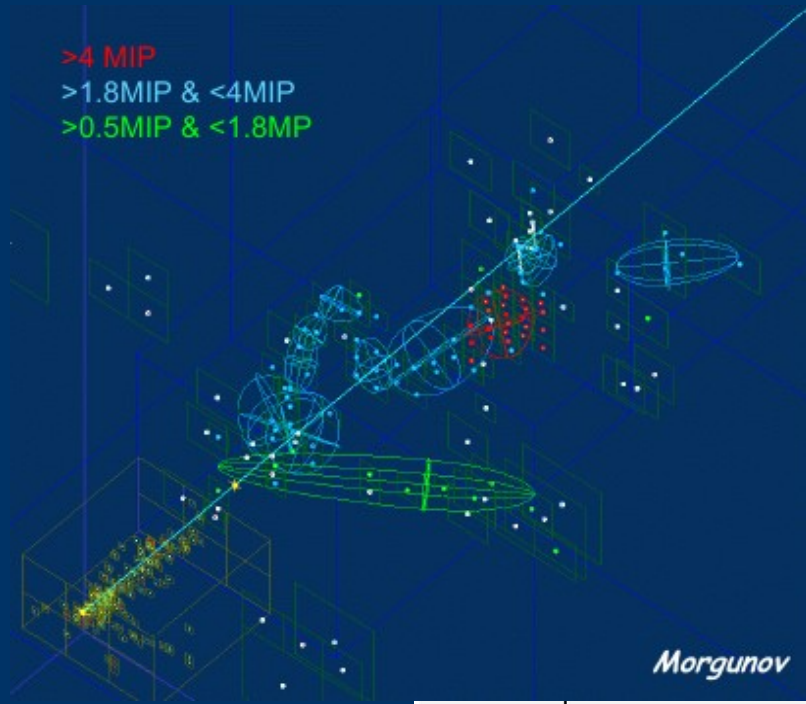
Above threshold of 0.5 MIP, occupancy is  $10^{-3}$

# Hadron Showers

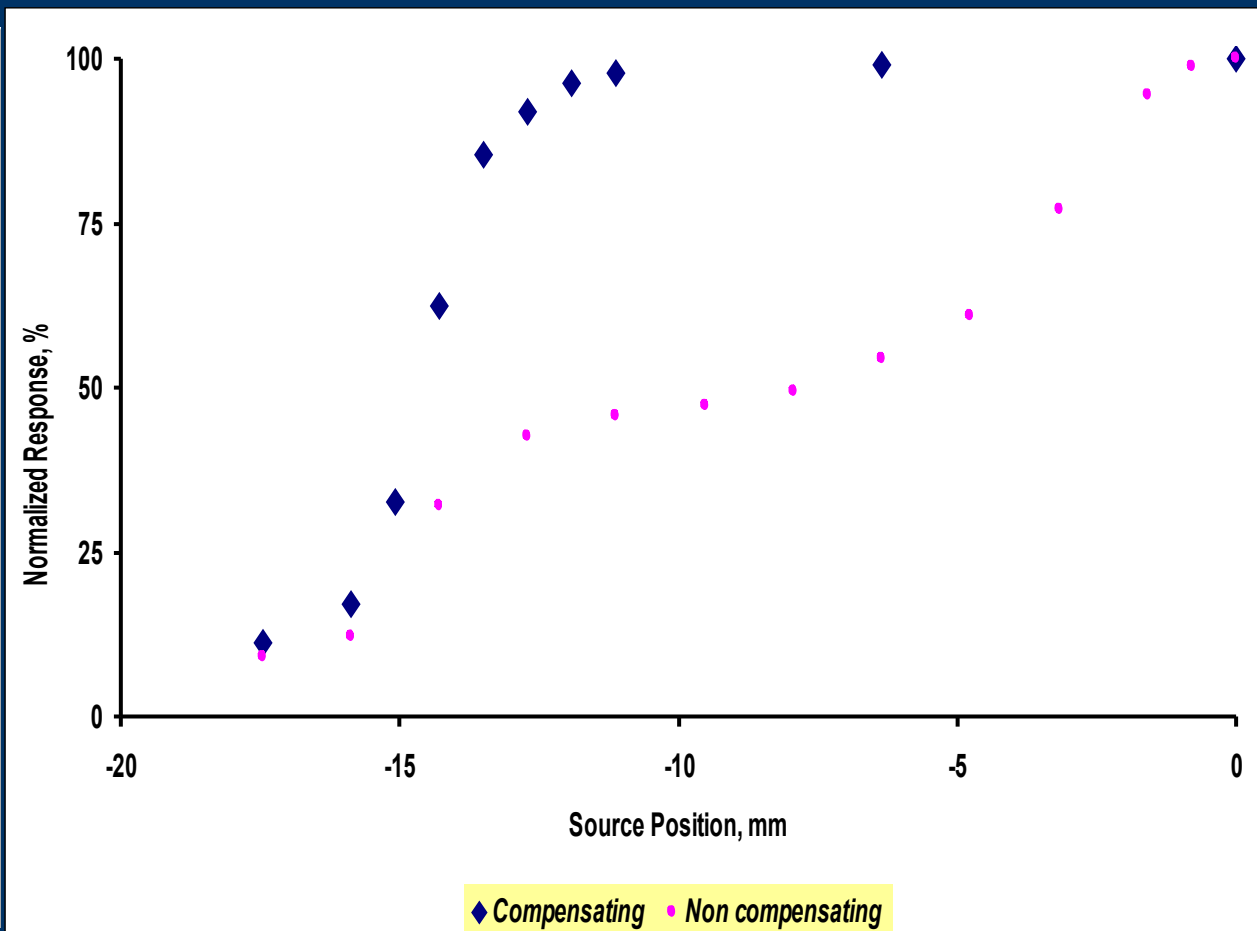
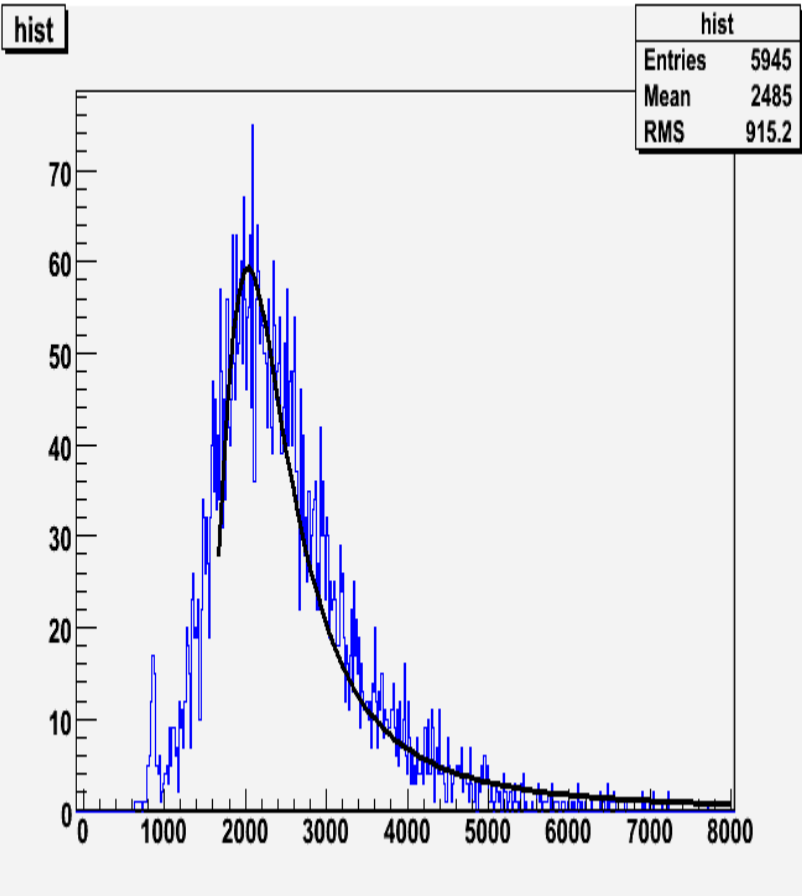


Effort to include detector effects in MC underway

# Energy Reconstruction

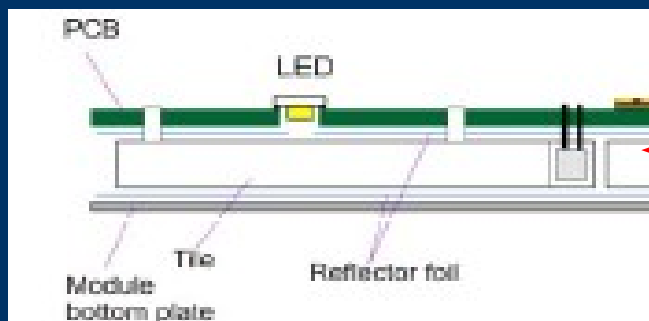


# Direct Coupling



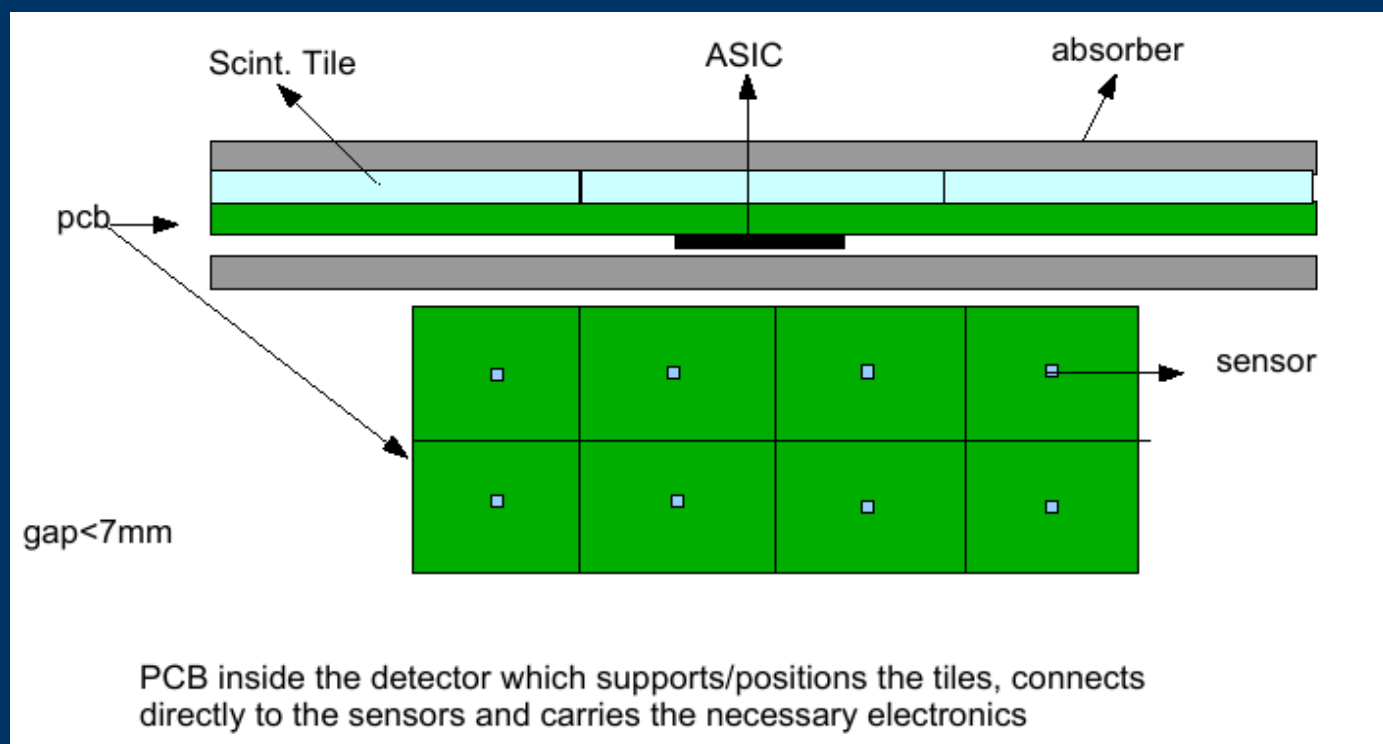
Looks promising with enough light and good uniformity

# Integrated Readout Layer



Sensor in tile

Sensor in PCB  
Direct Coupling  
w/ engineering  
help from Fermilab





# *Scintillator HCAL Plans*

- Continue analysis of copious test beam data
- Continuation of test beam program at Fermilab next year with focus on low energy hadrons
- Prototyping of integrated readout layer and associated electronics

See talks by A. Dyshkant and F. Sefkow

---

---

# *Moving Forward*

**SiD Detector – Hadron Calorimeter Plan for LOI and Beyond**

**Andy White, Vishnu Zutshi**

**Developed from 2006-7 HCal Plan (Jerry Blazey, Andy White)**

# *Towards the LoI*

- Baseline choice with possible alternates
  - The LoI should serve as the mechanism by which SiD arrives at a baseline design
  - Especially relevant for HCAL as multiple technologies are being pursued
  - Series of hardware and software benchmarks that the technologies have to address for inclusion in the LoI
  - Operationally propose a series of reviews...
  - Who reviews ?
- 
-

# *Performance Criteria*

- MIP efficiency/pad
  - Hit multiplicity/MIP
  - Uniformity of response
  - Need for, or ease of calibration
  - Recovery time
  - Discharge rates
  - Magnetic field issues
  - Track-cluster separability
  - PFA jet resolution
- 
-

# *Technology Issues*

- Reliability
  - Availability of components
  - Active layer thickness
  - Segmentation achievable
  - Scalability
  - Aging
  - Cost
- 
-

# *Proposed HCAL Reviews*

January 2008

all available information on potential technologies  
assessed against performance and technological criteria  
preliminary mechanical design for all options  
identify needed information for second review

March 2008

updates from all technology options  
basis for decision on baseline

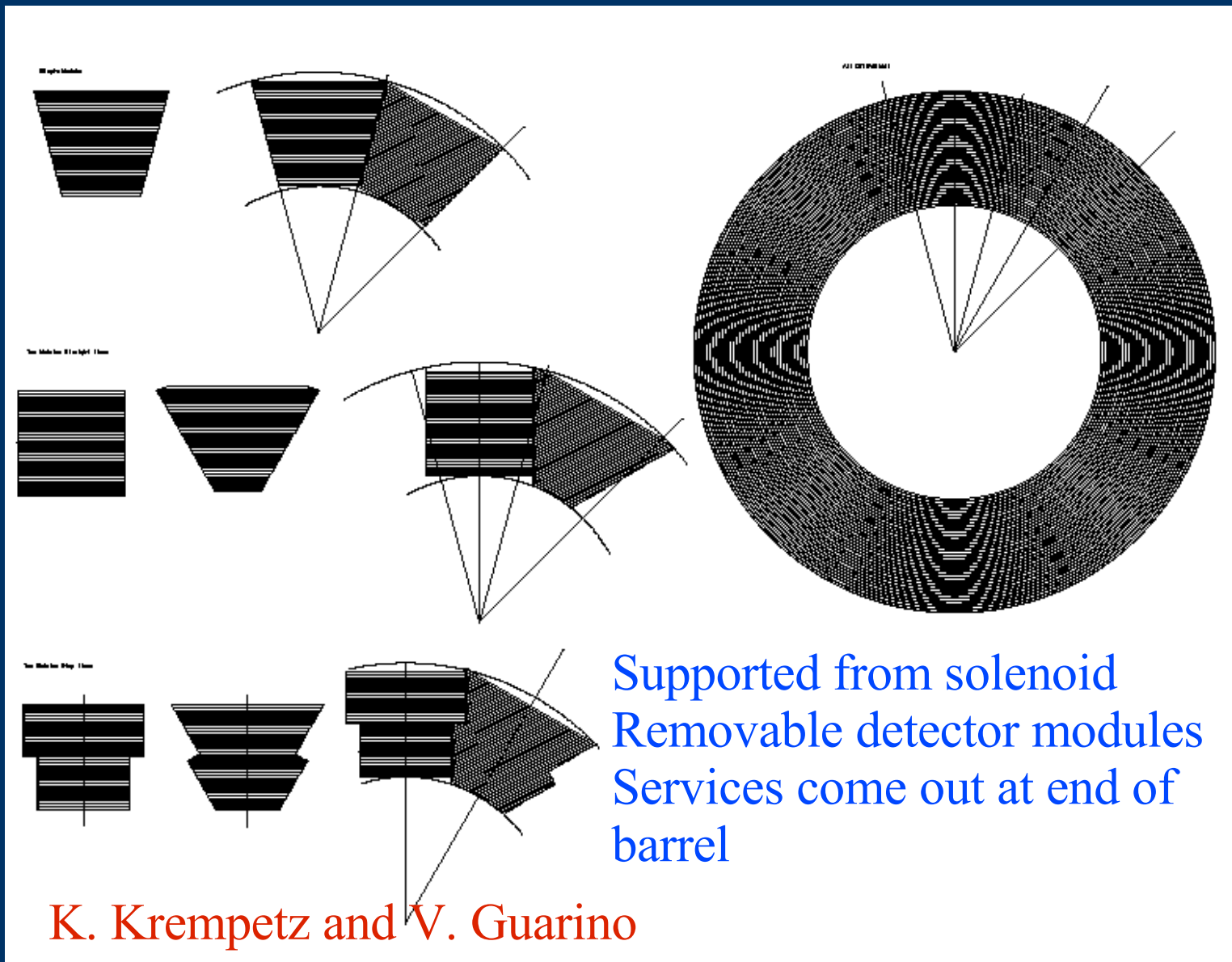
May 2008

presentation of the recommendations of the review  
writing starts

---

---

# HCAL Mechanical



K. Krempetz and V. Guarino

# Summary

- All HCAL technologies have been making good progress
  - Lots of data already on disk
  - Need to organize ourselves for the LoI process
  - Testbeam data analysis combined with PFA studies and prototyping results should provide a sound (though inevitably incomplete) basis for making a baseline choice for the SiD LoI
- 
-