GEM-based Digital Hadron Calorimetry for SiD

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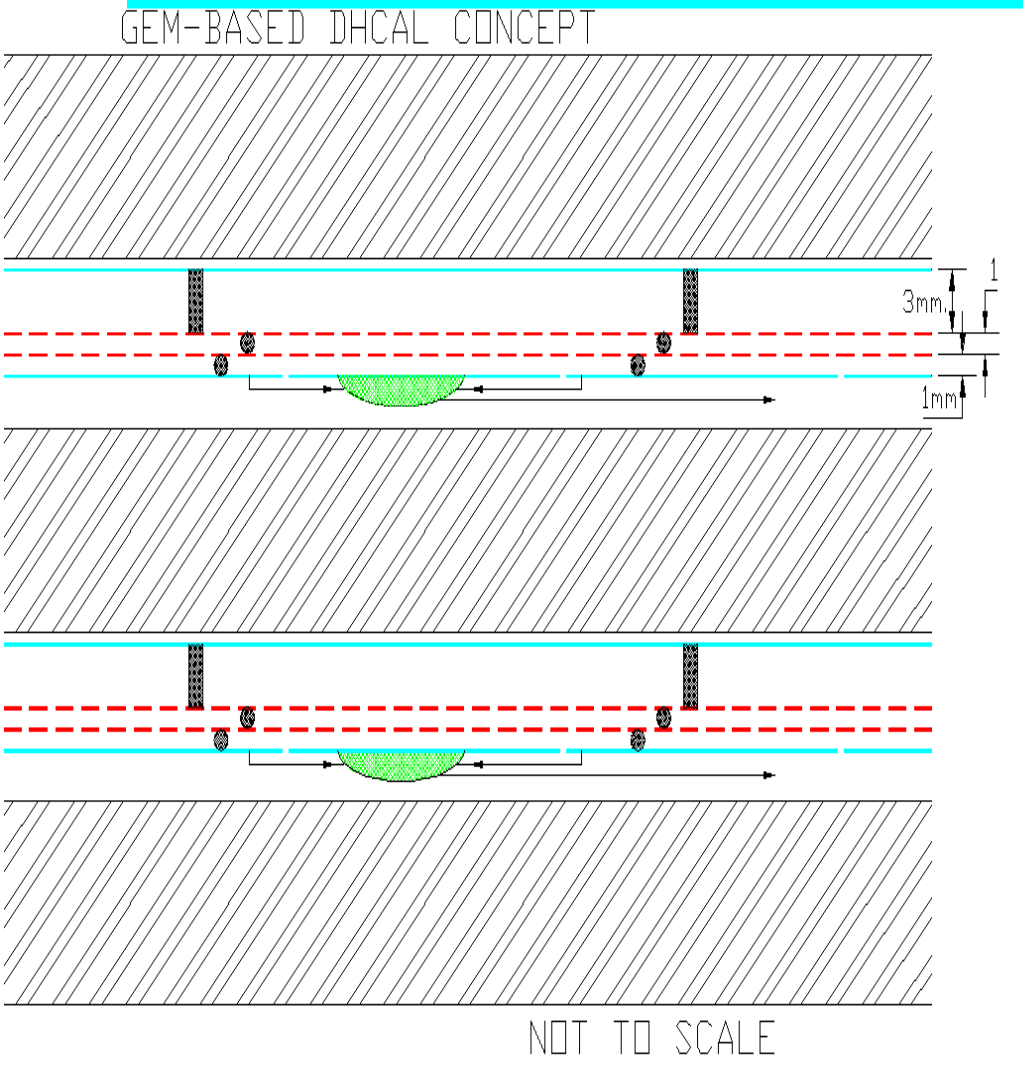
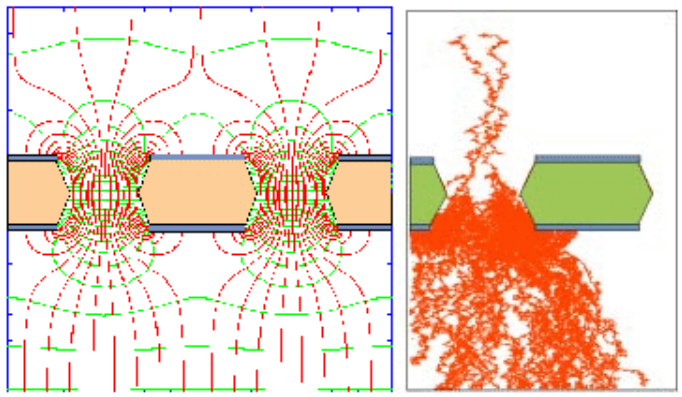
GEM/DHCAL active layer concept





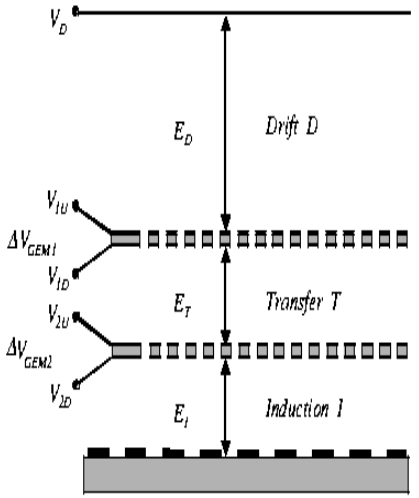


Fig. 1: Schematics of a double-GEM detector.

-2100V

ΔV ~400V

ΔV ~400V

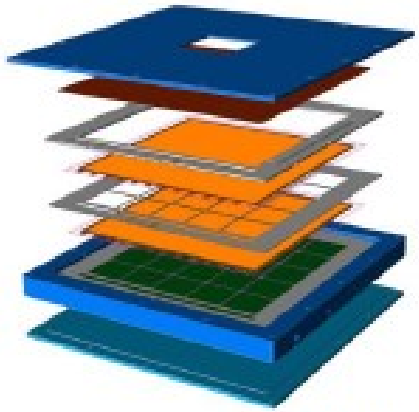
0 V

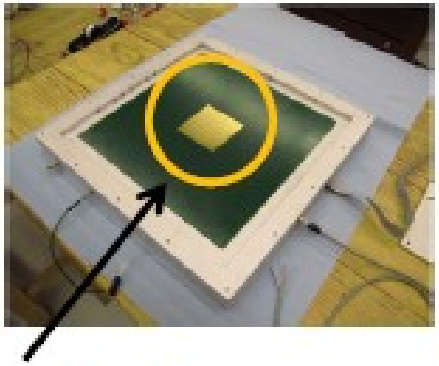
GEM DHCAL Developments

- GEM detector with an optimal gas flow spacer design constructed and integrated with SLAC KPiX V7 (64-channel) readout.
- Two dimensional readout of 30cm x 30cm chamber using KPiX successful.
  - Benchmark Fe^{55} from single channel analog electronics
- Three additional 30cm x 30cm chambers constructed.
  - One at ANL for DCAL chip readout testing (for 40-layer stack)
  - Two at UTA for continued chamber characterization
- Completed the design of 30cm x 100cm GEM foil.
  - Construction of first five 30cm x 100cm foils has begun at CERN GDD workshop, Feb. 2010
- Mechanical design considerations for large chamber construction in progress.

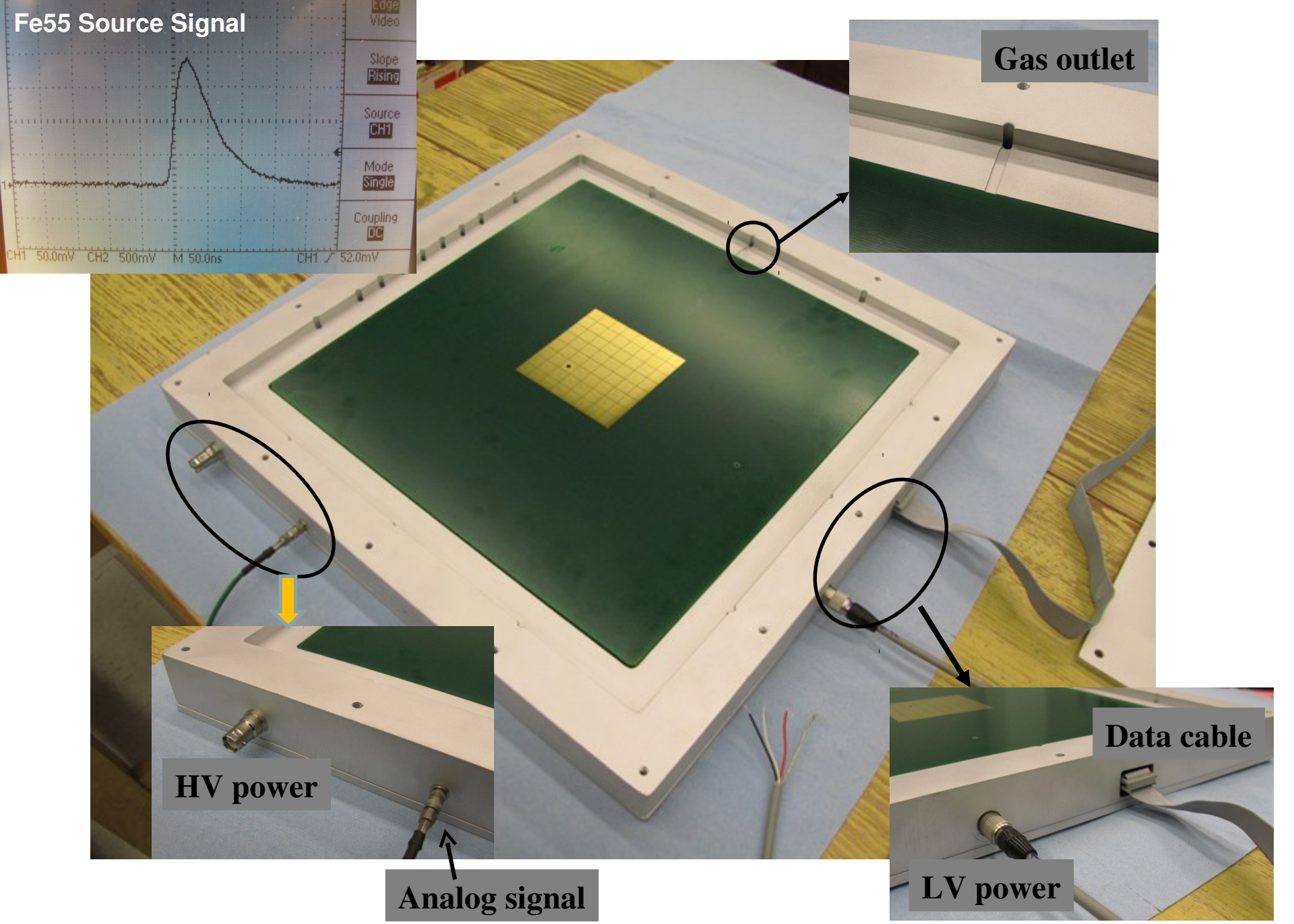
30cm x 30cm GEM with 8x8 pads

- GEM Foils(3M) **Chamber**
  - 310x310 mm^2
  - Active area : 280x280 mm^2
- Active gas room
  - 350x350x6 mm^3 → For 3/1/1 gaps(d/t/i
- 64 readout channels(1x1 cm^2)

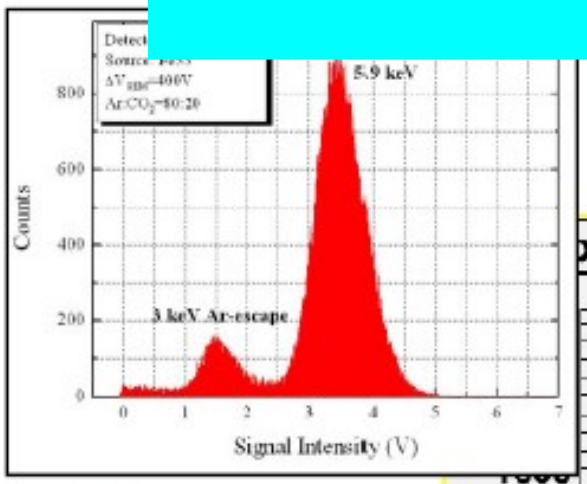




64-readout pads

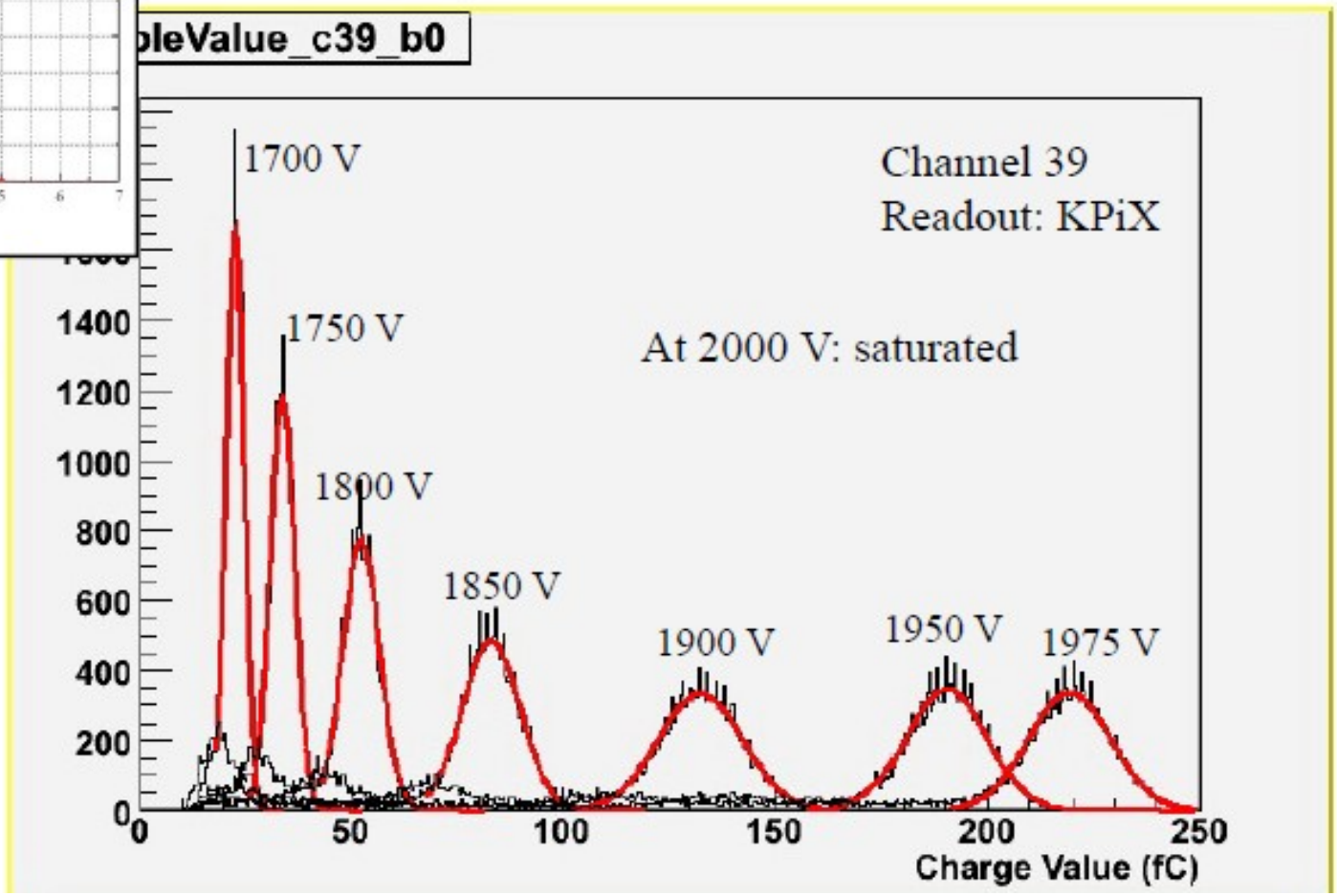

Fe55 Source Signal
Edge
Video
Slope
Rising
Source
CH1
Mode
Single
Coupling
DC
CH1 50.0mV CH2 500mV M 50.0ns CH1 52.0mV
Gas outlet
HV power
Analog signal
Data cable
LV power

30cm x 30cm GEM with 8x8 pads



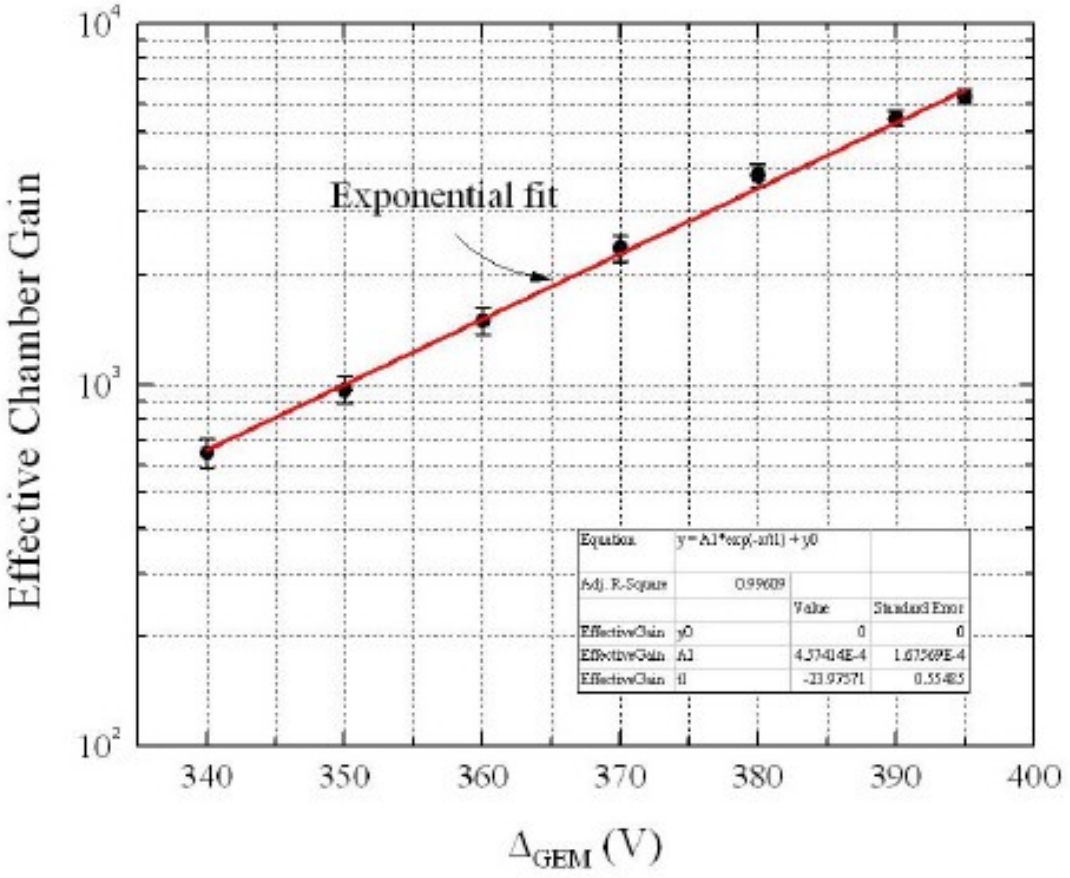
Typical Fe55 spectrum from an Ar-based gas detector

Readout:
A225+A206(AmpTek)

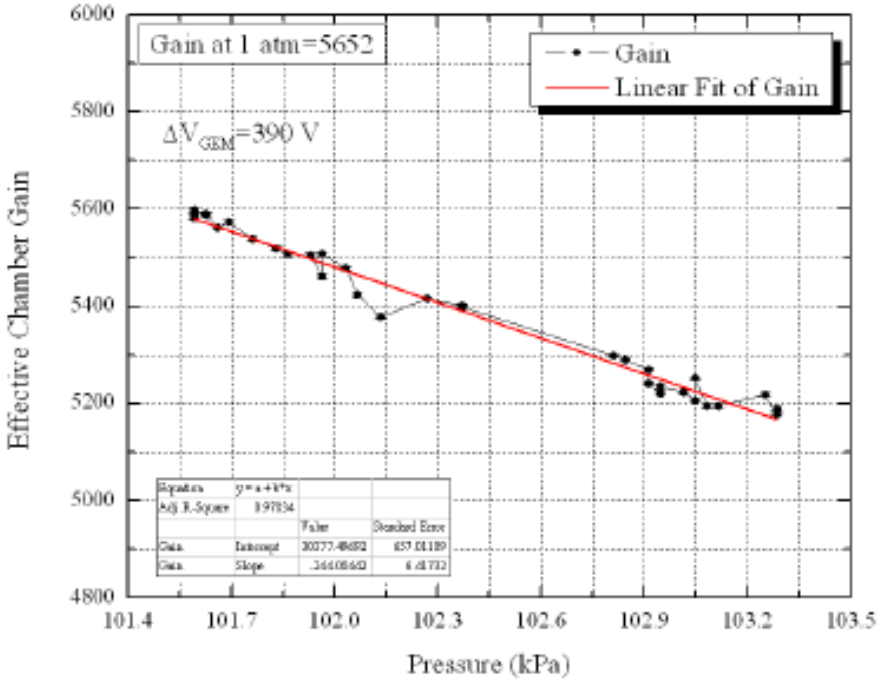


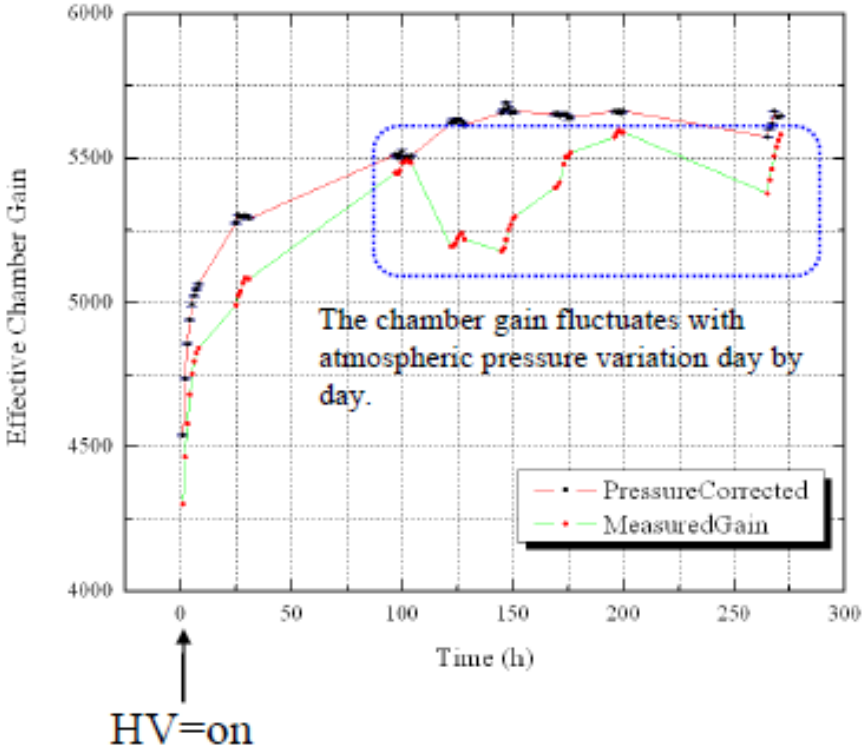
30cm x 30cm GEM with 8x8 pads

Chamber gain increases nonlinearly with high voltage



30cm x 30cm GEM with 8x8 pads





We use an open gas system (gas flows at atmospheric pressure).

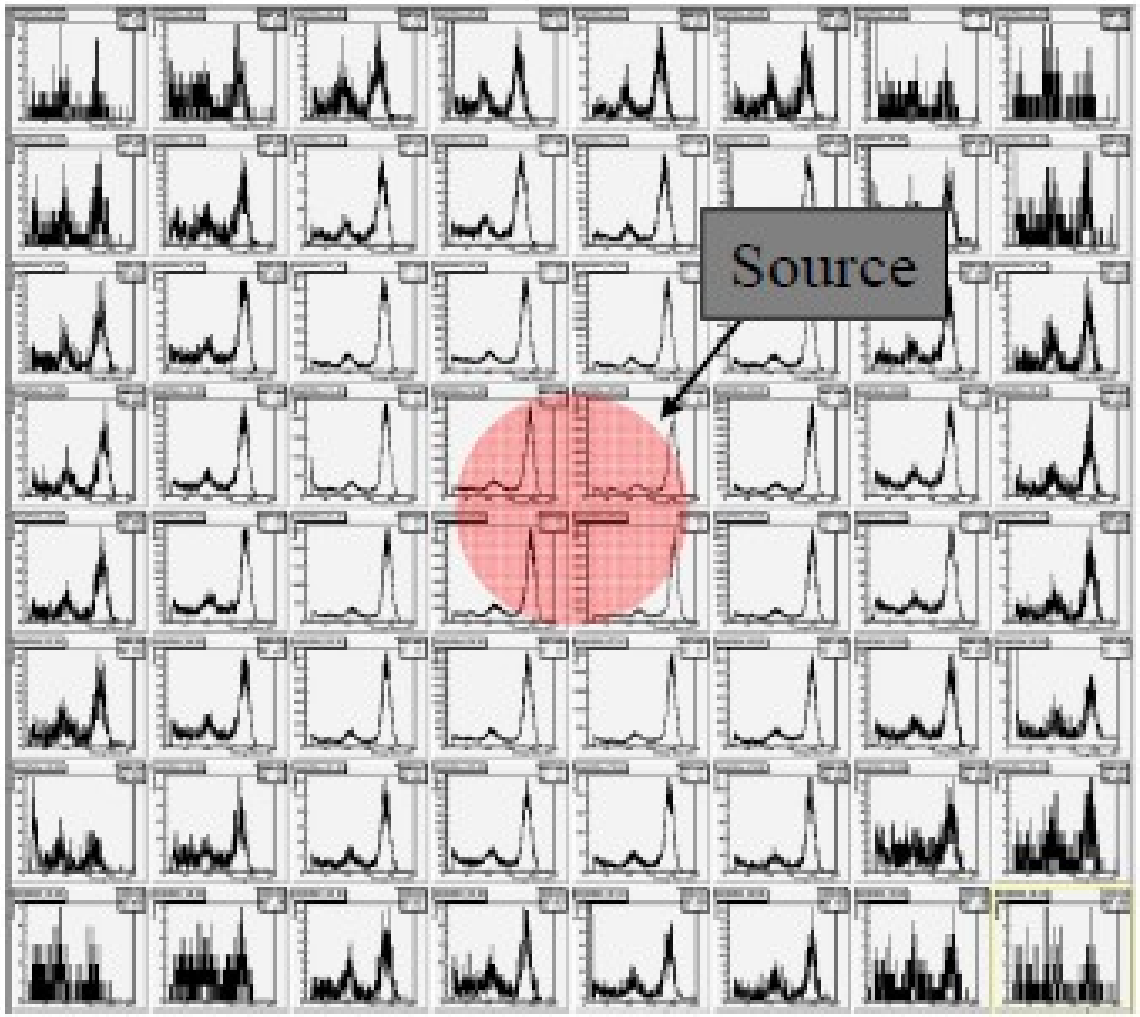
Thus, pressure inside chamber is affected by the atmospheric pressure directly.

This pressure change affects the chamber gain.

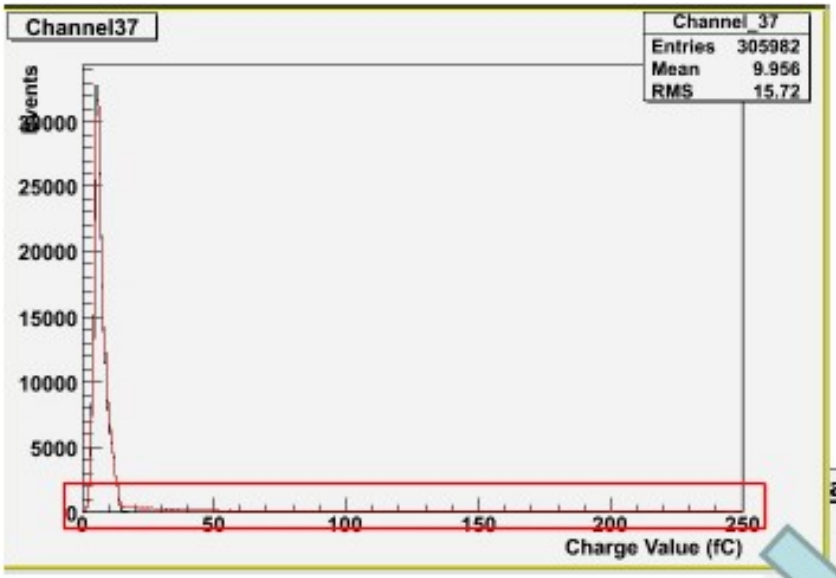
The chamber gains were recalculated to the values at 1 atm.

Map for Fe^{55} GEM+KPiX7

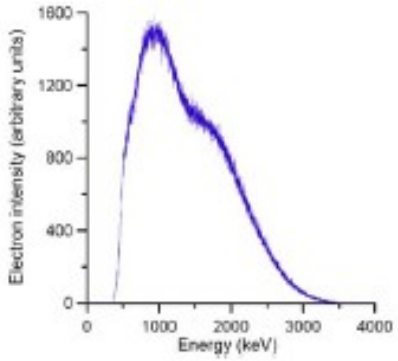
Source (Fe55) was put on the detector window.
Each histogram corresponds to each anode pad on the readout board.



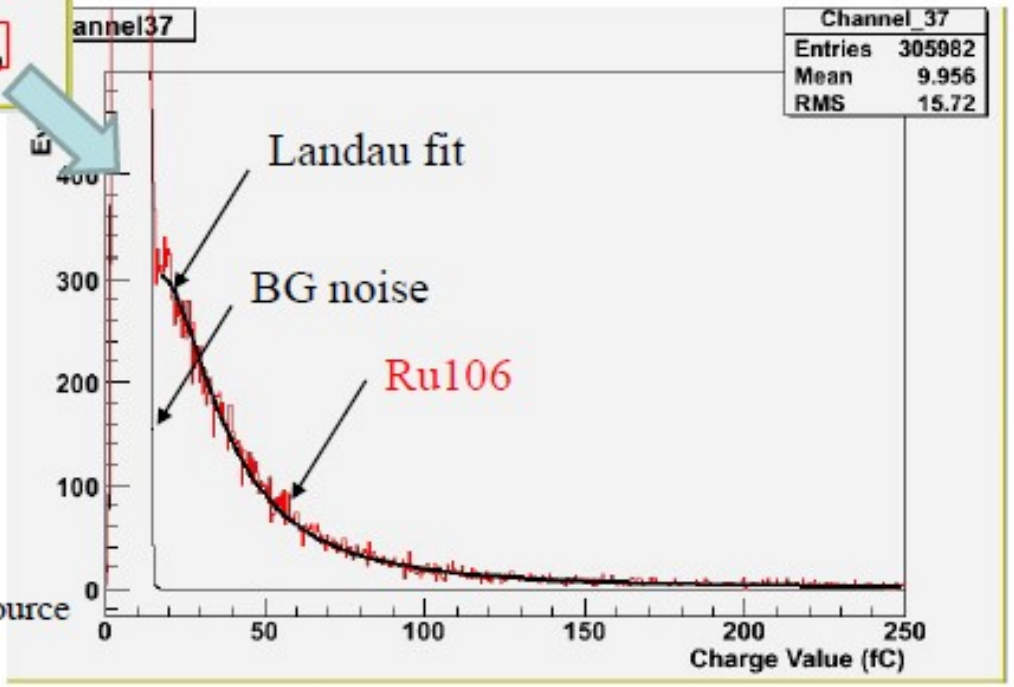
30cm x 30cm GEM with 8x8 pads: ^{106} Ru



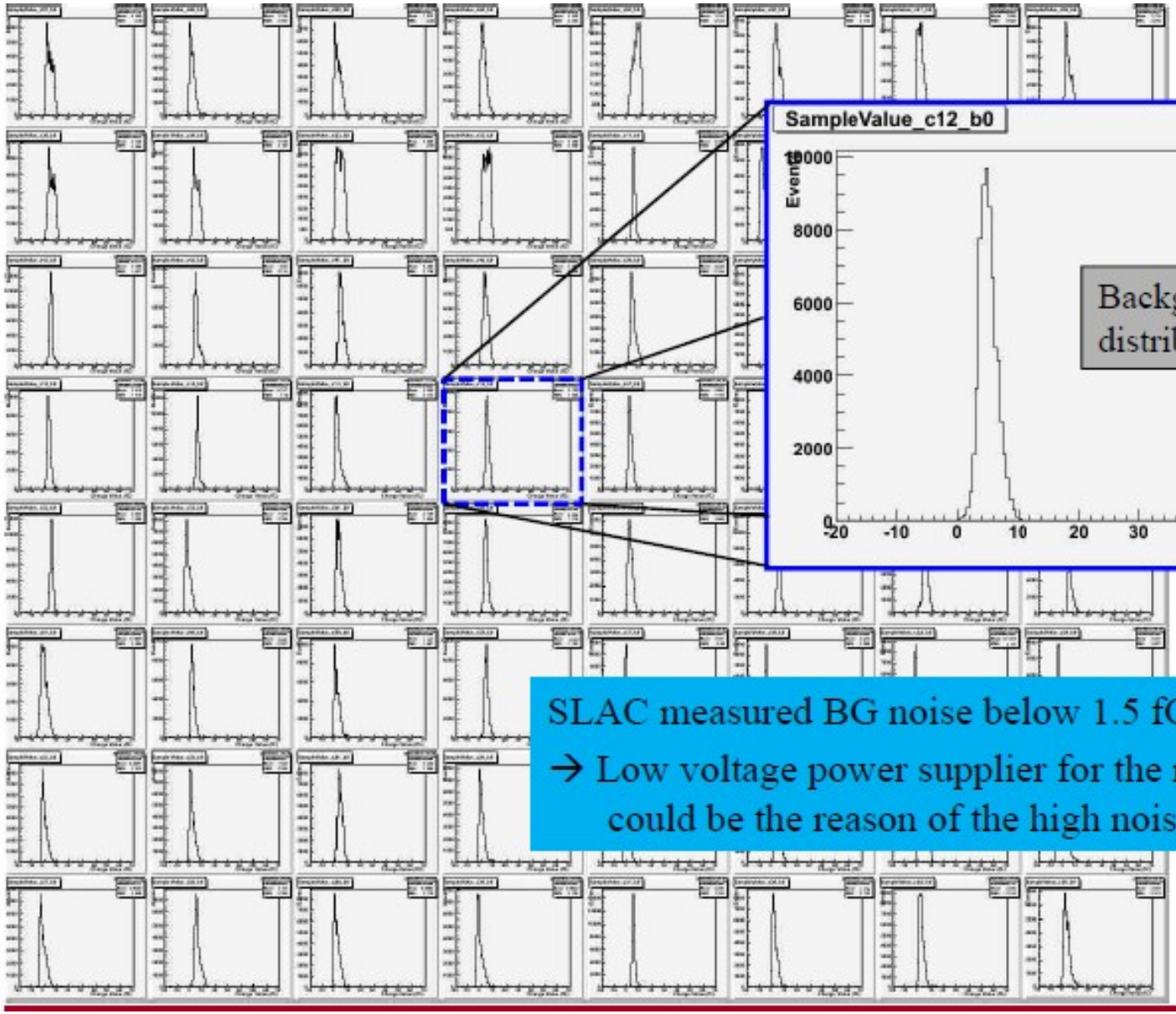
Ru106, 1960V, ST=2.4V=2 fC
Background, 1960V, ST=2.4V=2 fC



Energy spectrum of Beta emission from a Ru106 source



30cm x 30cm GEM with 8x8 pads: Bkgd

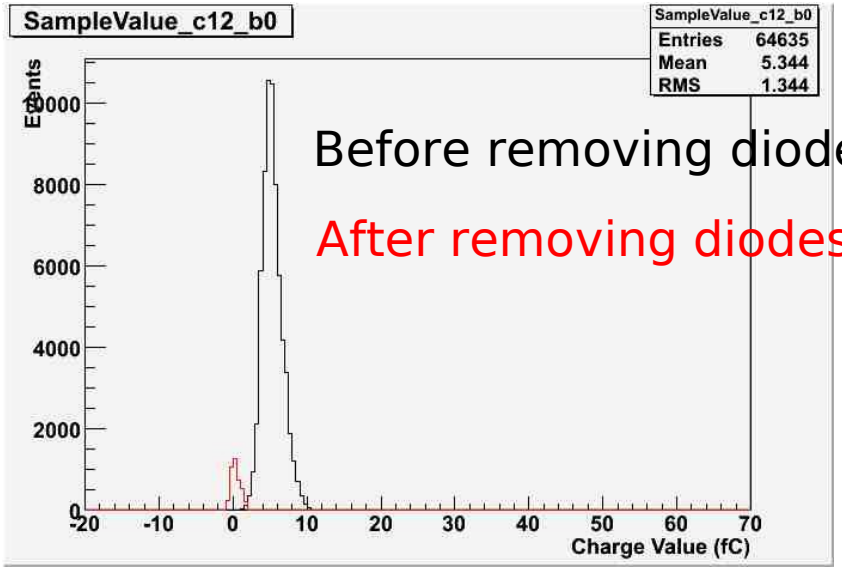


Background noise bands are distributed between 0~15 fC.

SLAC measured BG noise below 1.5 fC

→ Low voltage power supplier for the readout electronics could be the reason of the high noise.

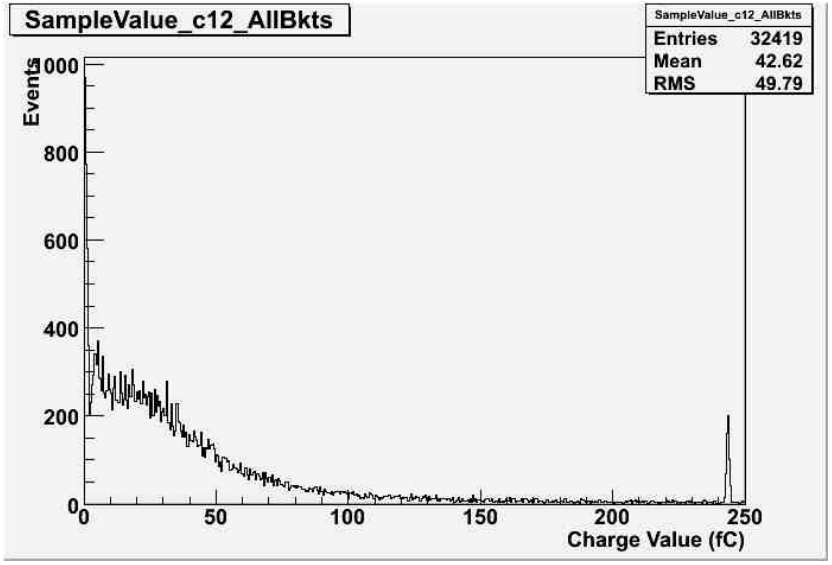
30cm x 30cm GEM with 8x8 pads: ^{106}Ru



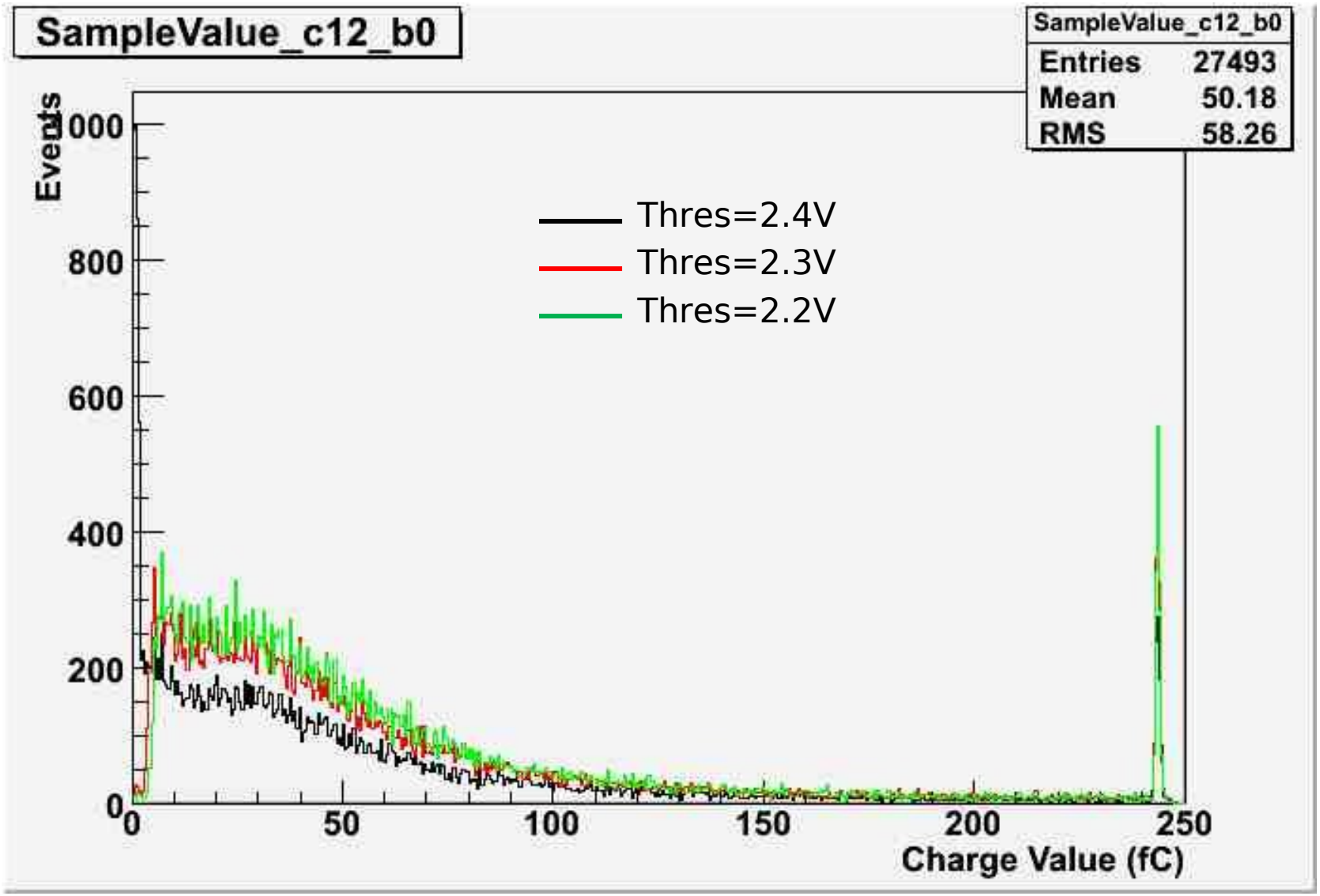
Before removing diodes

After removing diodes

Not all e- are Min-I in chamber (+ range of angles) -> use cosmics/beam for next tests



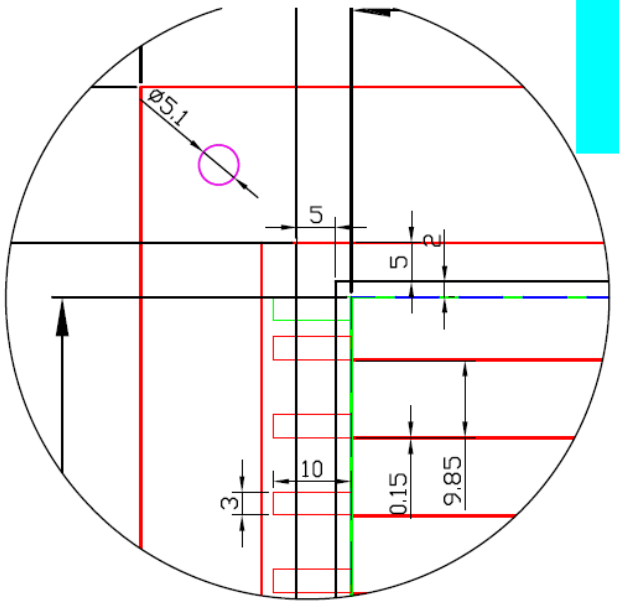
30cm x 30cm GEM with 8x8 pads: ^{106} Ru



GEM DHCAL Plans

- Through mid 2010
  - Complete 30cm x 30cm chamber characterization using radioactive source, cosmic ray and particle beams
    - Need to understand electronic noise affecting MIPs
  - Start producing 33cm x 100cm GEM foils
  - Begin construction of 33cm x 100cm GEM unit chambers and characterize them using source, cosmic ray and particle beams
- Mid 2010 – Late 2011
  - Complete construction of fifteen 33cm x 100cm chambers and construct five 100cm x 100cm GEM DHCAL planes
  - Beam test GEM DHCAL planes in the CALICE beam test stack together with RPC
  - If available construct TGEM chambers (initial test of a 10 x 10 cm2 TGEM board with KPiX-7 readout set for May at the Weizmann Institute)

30cmx100cm GEM Foil Design

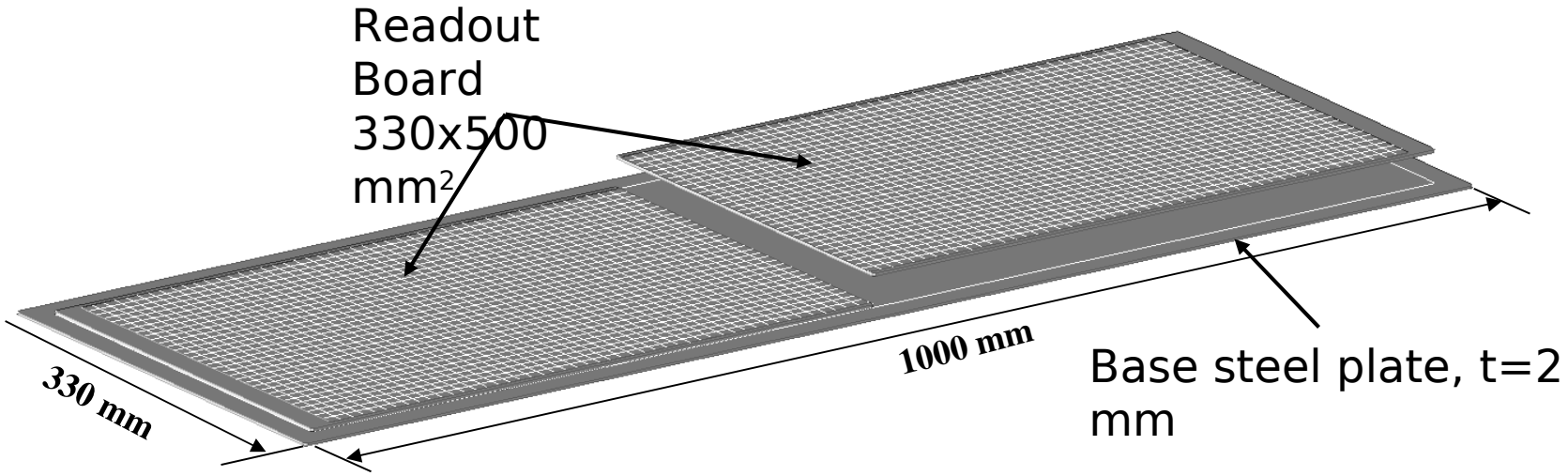


Active area 468x306x2 mm^2

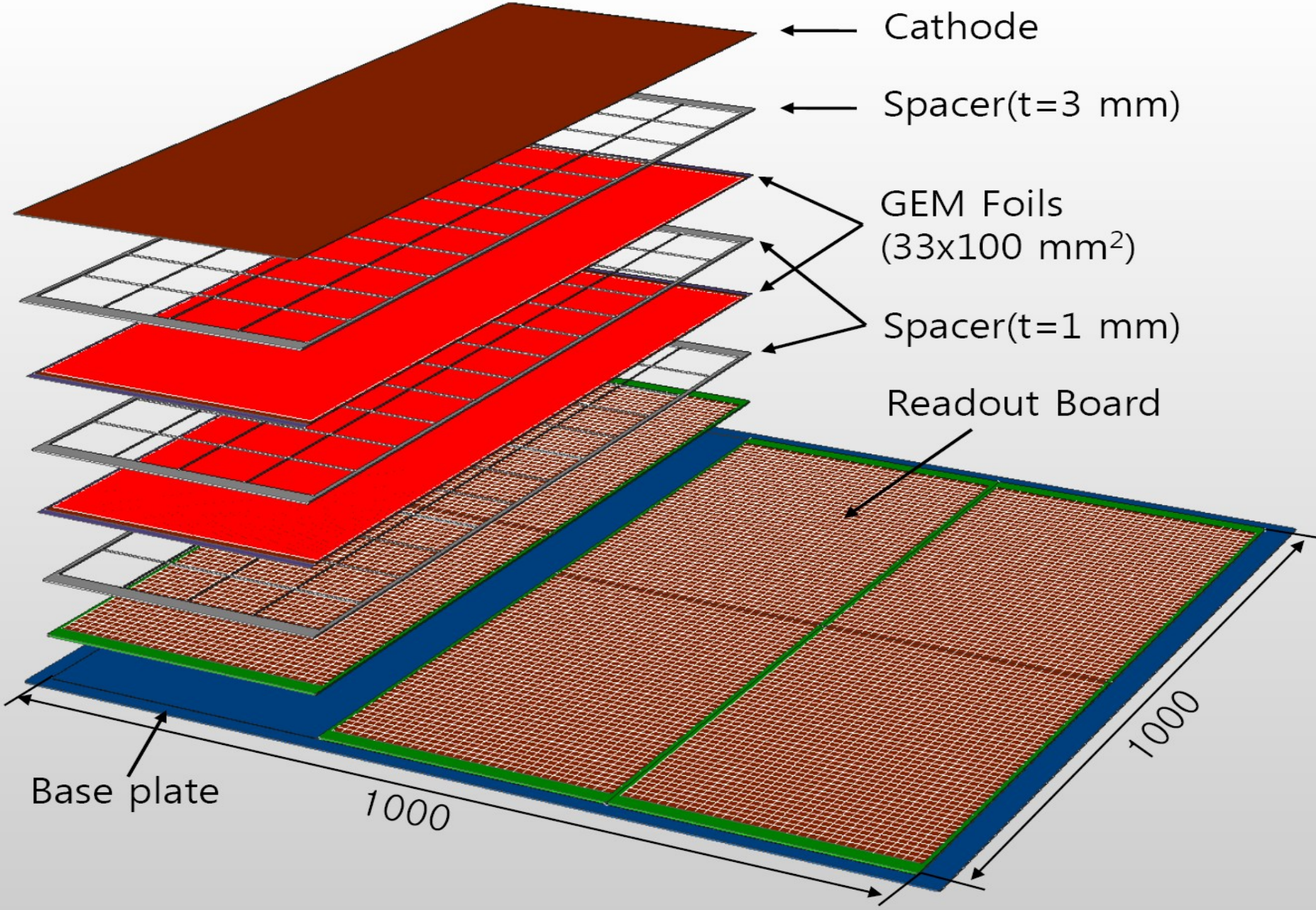
Number of HV sectors = 32x2=64

HV sector dimension= 9.9x479.95 mm^2

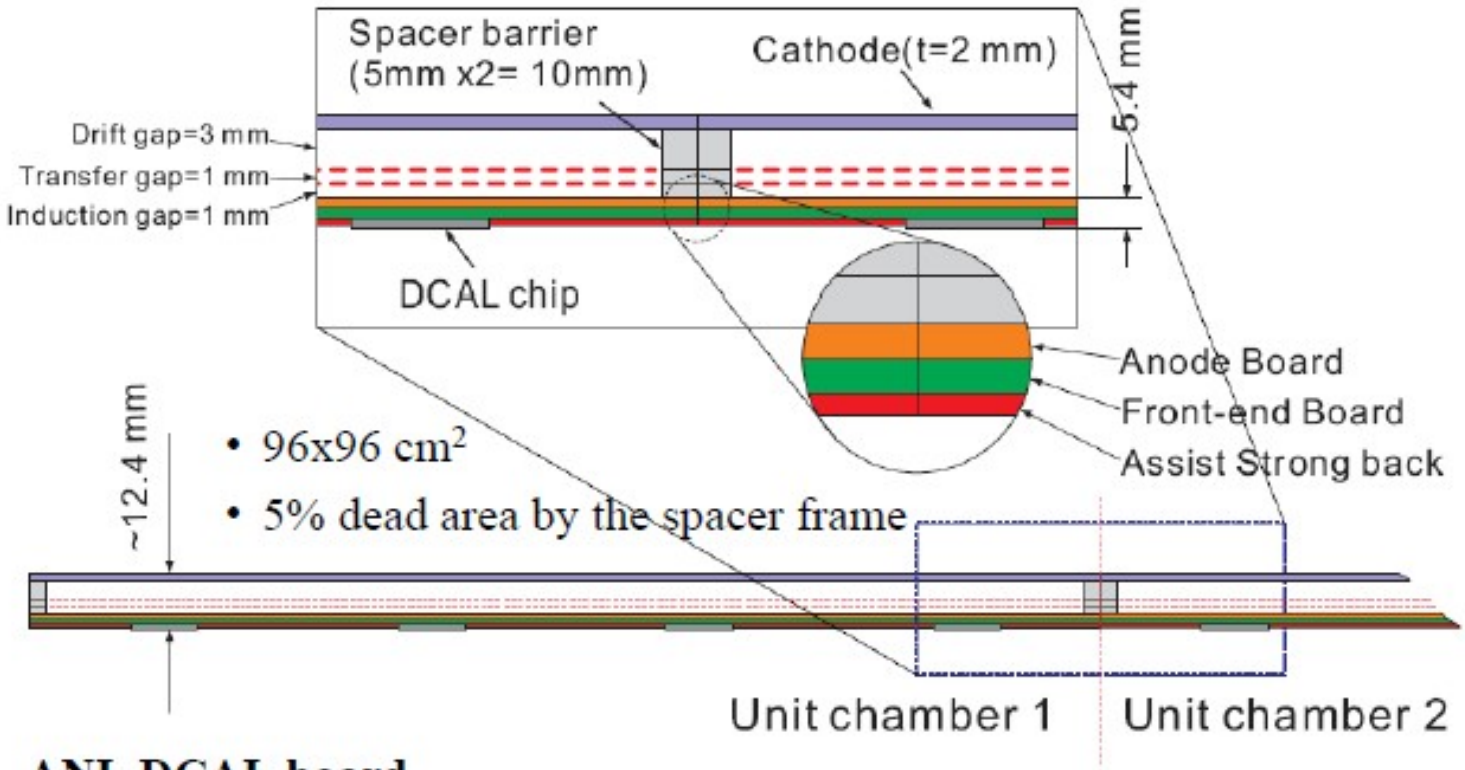
33cmx100cm DHCAL Unit Chamber Constructio



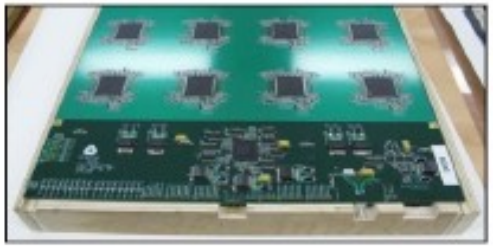
UTA's 100cm x 100cm Digital Hadron Calorimeter Plan



TA's 100cm x 100cm Digital Hadron Calorimeter Plane



- **ANL DCAL board**



Pad board: 320x480x1.5 mm³

Front-end board: 320x555x1.5 mm³

GEM DHCAL Beam Test Plans

- Phase I ➔ Completion of 30cm x 30cm characterization
  - Mid 2010: using one to two planes of 30cm x 30cm double GEM chamber with 64 channel KPiX7
- Phase II ➔ 33cm x 100cm unit chamber characterization
  - Mid 2010 – mid 2011 at MTBF: Using available KPiX chips and DCAL chips
- Phase III ➔ 100cm x 100cm plane GEM DHCAL performances in the CALICE stack
  - Early 2011 – Late 2011 at Fermilab's MTBF *or CERN*
  - Five 100cm x 100cm planes inserted into existing CALICE calorimeter stack and run with either Si/W or Sci/W ECALs, and RPC planes in the remaining HCAL