GEM DHCAL Update

Jae Yu

For GEM/DHCAL Group

Mar. 18, 2008

CALICE Meeting @ ANL

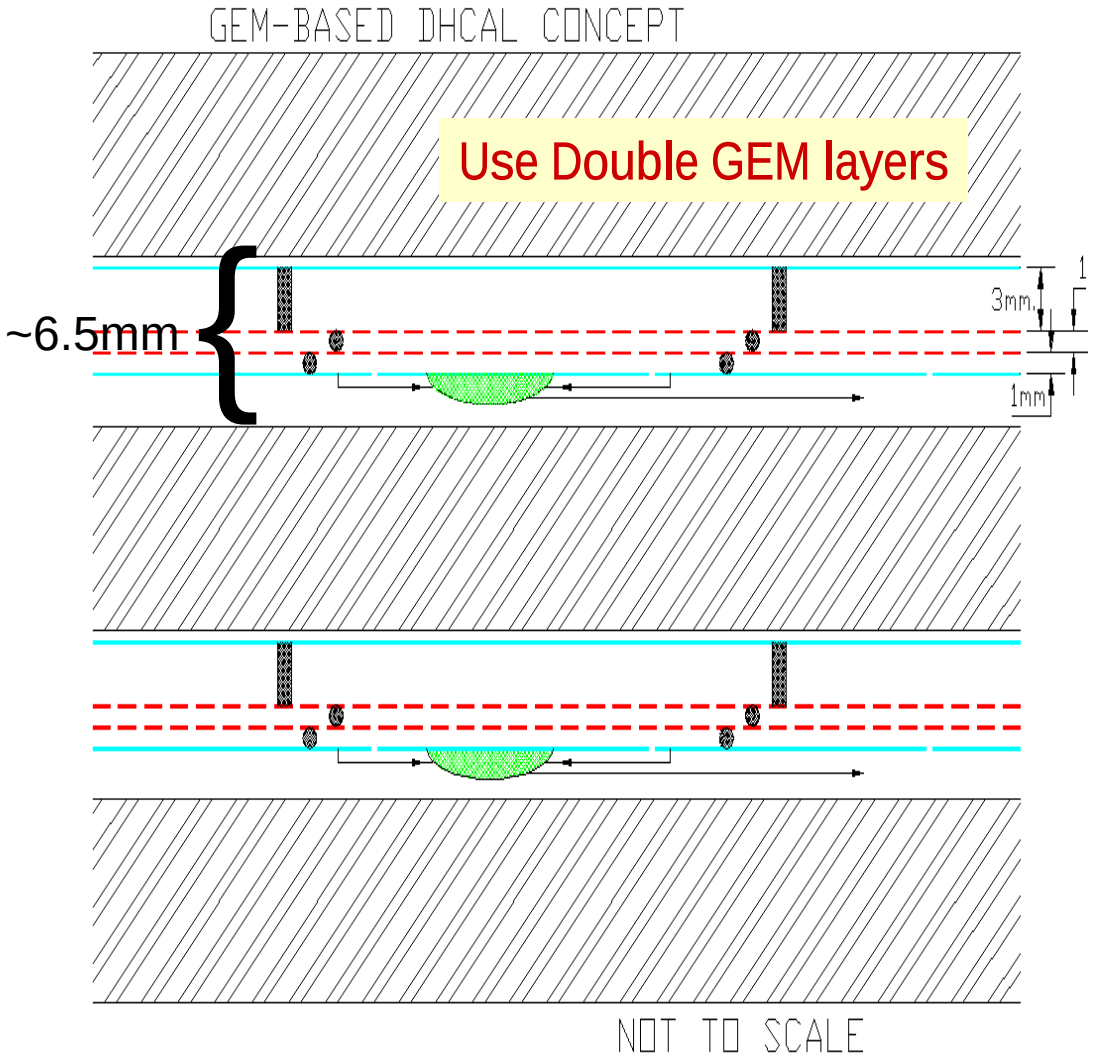
- Introduction
- Some previous measurements
- MTBF beam test data analysis
- Summary of the results so far
- New chamber design and kPix readout
- TGEM and RETGEM Development
- Conclusions

* UTA, U.Washington, Changwon Nat.U., Tsinghua U.

Why GEM's?

- Flexible configurations: allows small anode pads for high granularity
- Robust: survives ~10^{12} particles/mm^2 with no performance degradations
- Fast: based on electron collection, ~few ns rise time
- Short recovery time ➔ can handle high rates
- Uses simple gas (Argon/CO_2) – no long-term issues
- Runs at low HV (~400V across a foil)
- Stable and robust operations

GEM-based Digital Calorimeter Concept



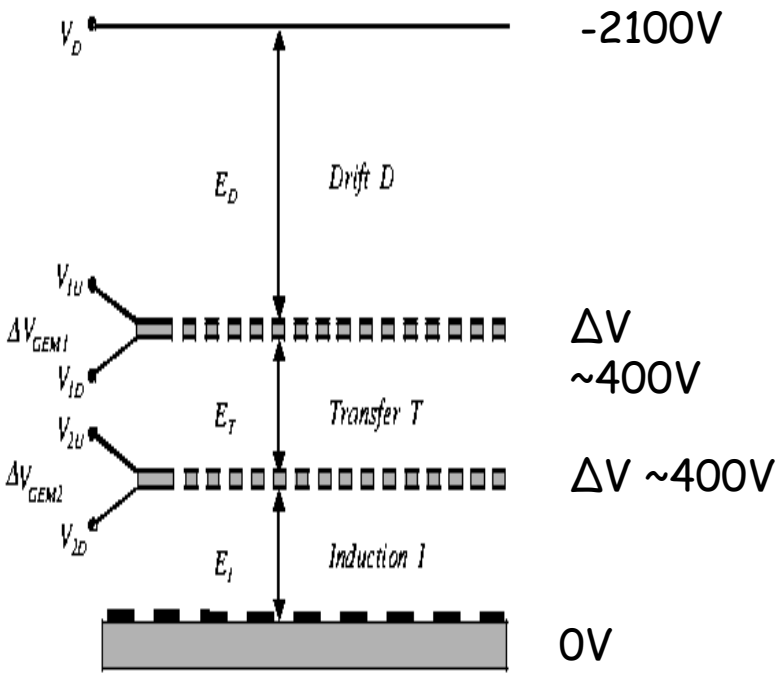
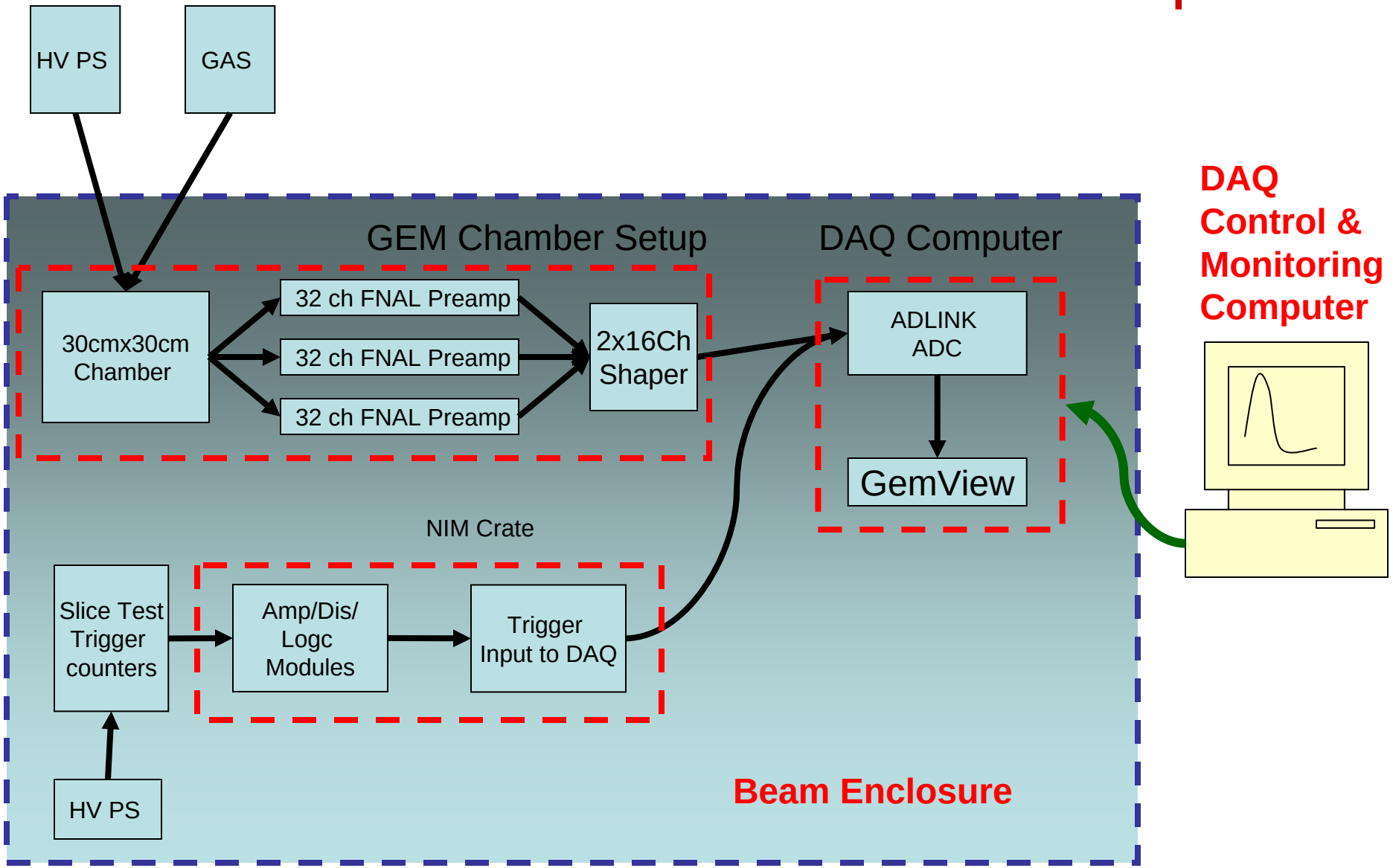


Fig. 1: Schematics of a double-GEM detector.

GEM MTBF Runs

- As a secondary: Mar. 21 – Mar. 27, 2007
  - Joint run with ChangWon National University, Korea
  - Run behind a straw tube detector group
  - 8 GeV mixed beams
  - Commissioned the detector and readout system
- As the primary: Apr. 4 – 10, 2007
  - Beam: 120GeV primary proton beam alone
  - Chamber analog signal patched outside the enclosure

UTA MTBF Beam Test Setup



GEM Beam Test Detector Setup

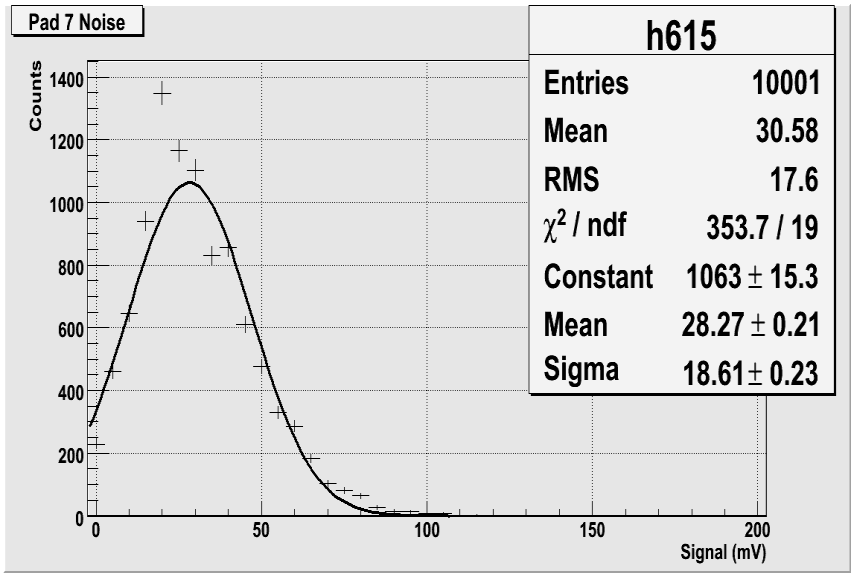
Trigger Types

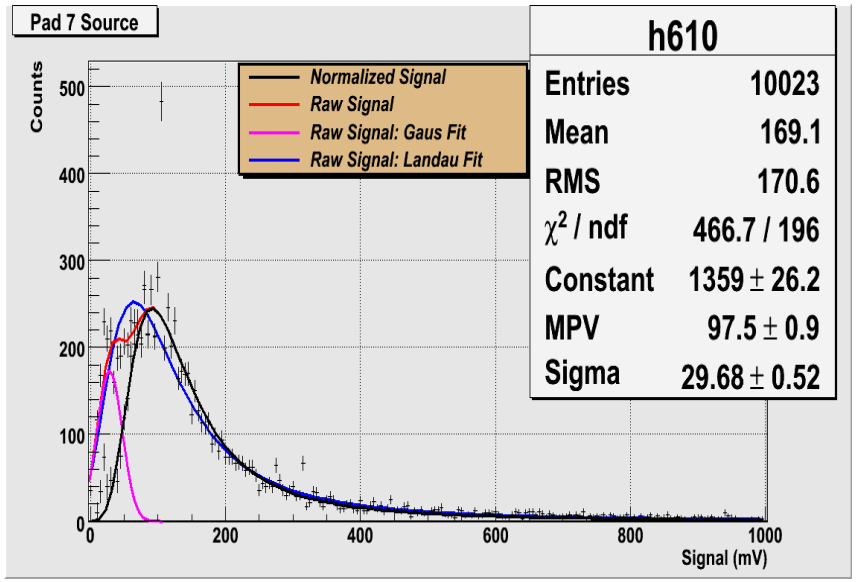
- Beam Trigger – 5Fold scintillation counters
  - Three 1cmx1cm finger counters, 5cm apart, are located in front of the setup
  - Two 19cmx19cm counters envelop the chamber active area, separated by about 3m's
    - One counter located about 40cm upstream of the chamber and the other about 2.5 m downstream of the chamber
  - Coincidence of all 5 counters defines a beam spot less than or equal to 1cmx1cm ➔ Size of one readout pad
- GEM Chamber self trigger
  - Use negative chamber output
  - Threshold set at -30mV
- Beam constrained chamber trigger formed of 5F*GEM: 6Fold
  - Allows to look at data from neighboring pads while triggering on the pad centered at the beam
  - Had to use this since there were no independent means of ensuring the beam containment in one pad

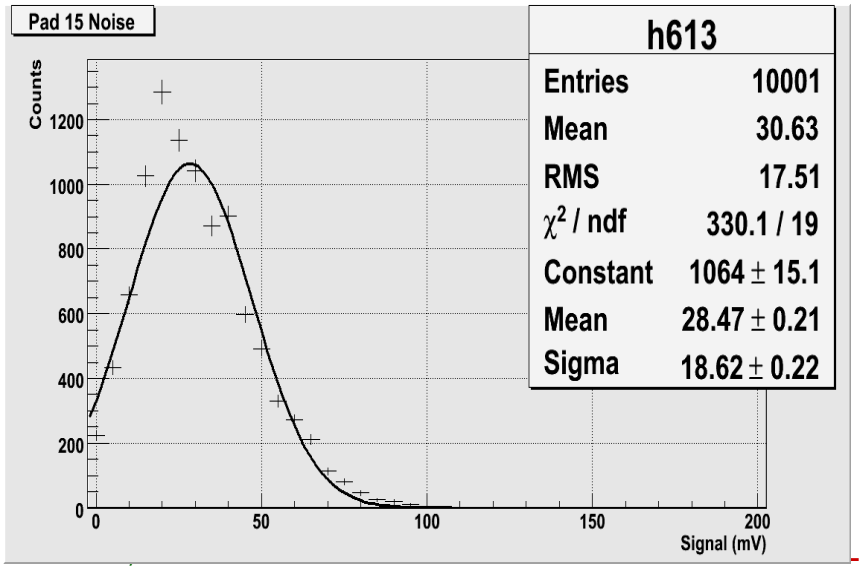
Procedure for Noise Subtraction

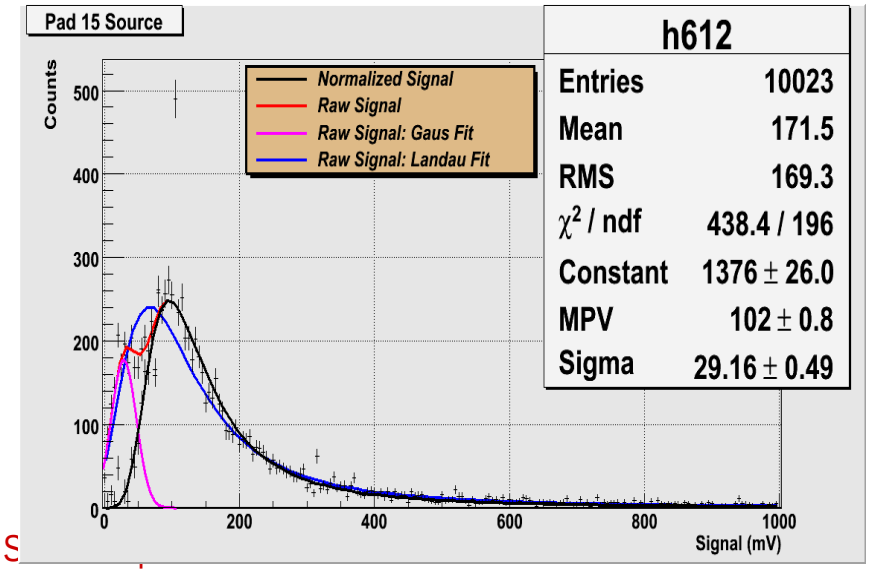
1. Fit Raw Noise Histogram to Gaussian and store shape (width and sigma) parameters
2. Fit Raw Signal with noise Gaussian shape in pulse height range of noise allowing the amplitude to float
3. Use this amplitude as normalization factor to normalize noise to the signal
4. Subtract Normalized Noise histogram from Raw Signal
5. Fit the noise subtracted Signal Histogram with Landau Function

Pulse Heights w/ Source

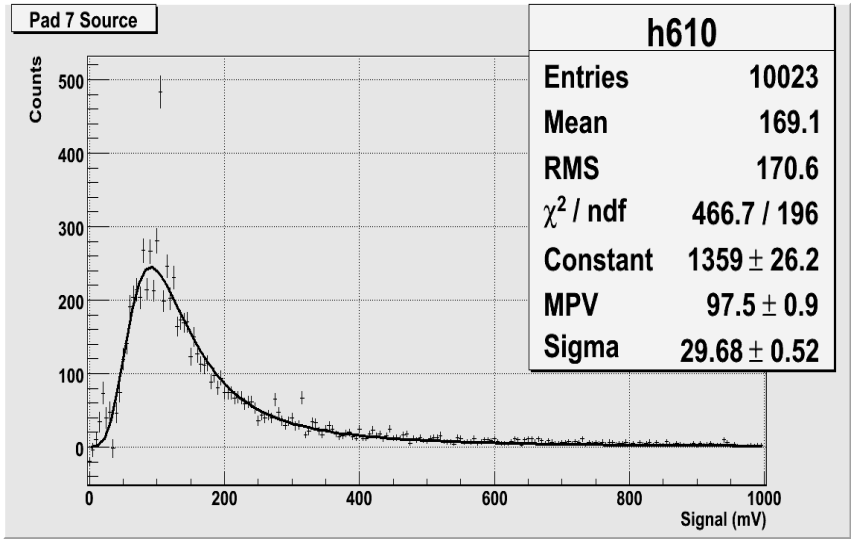


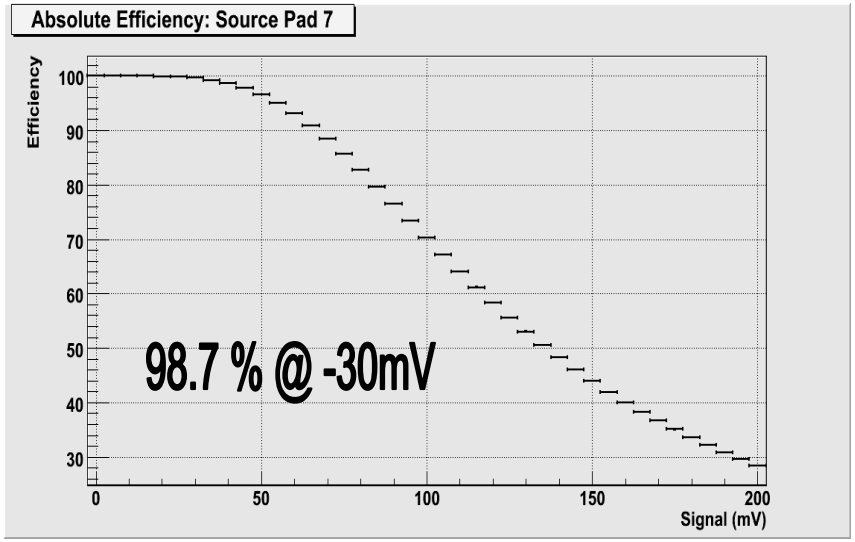


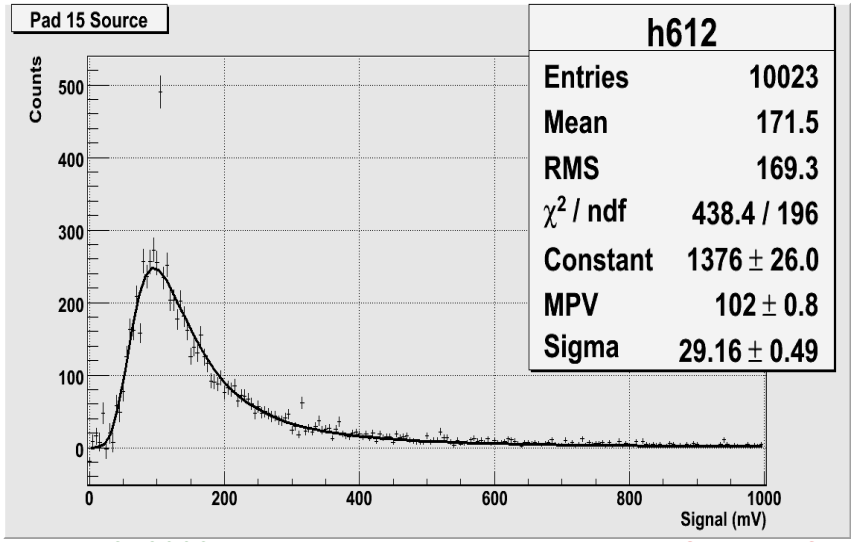


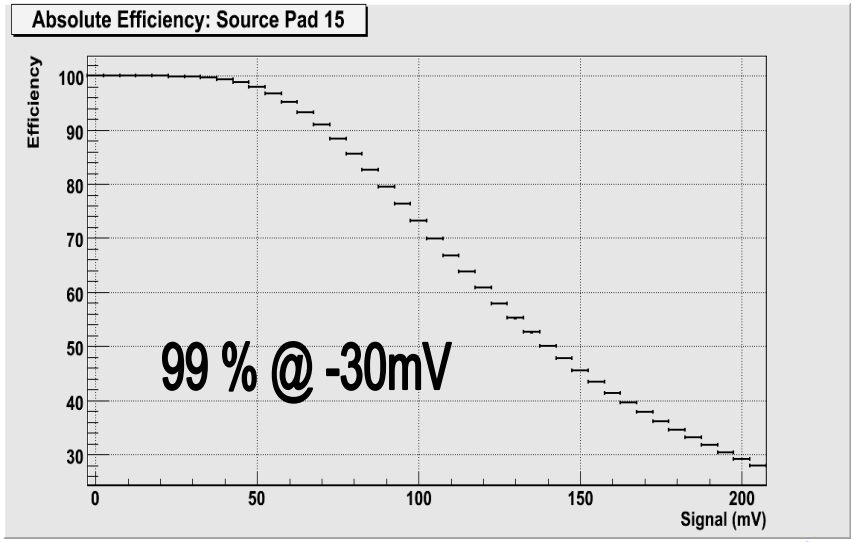


Absolute Efficiency vs Threshold - Source

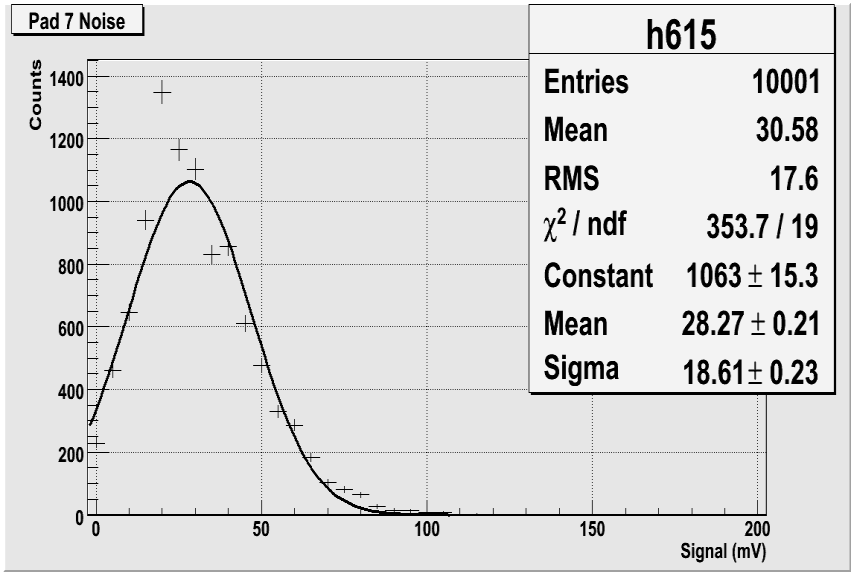


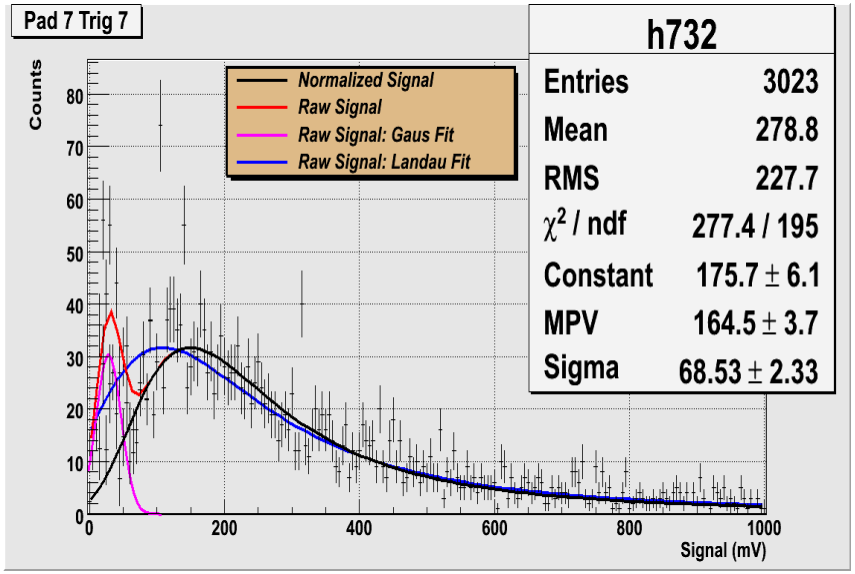


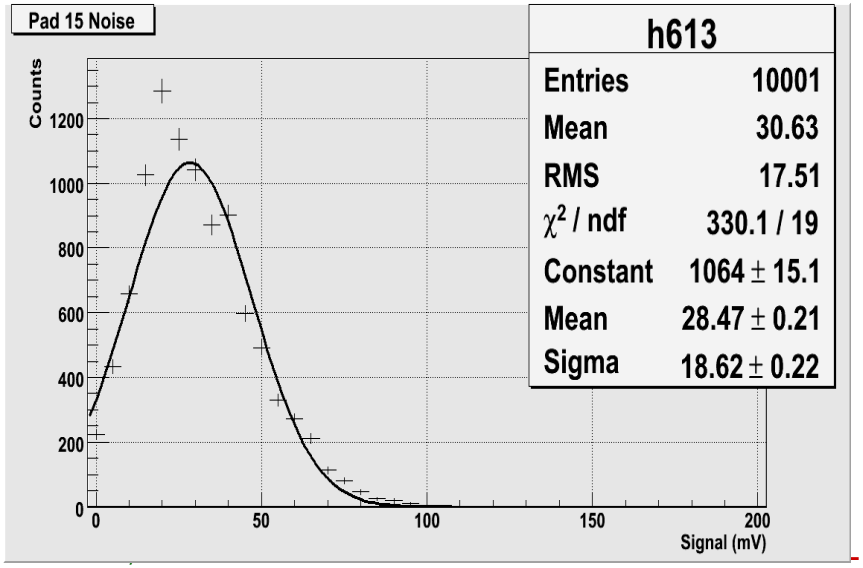


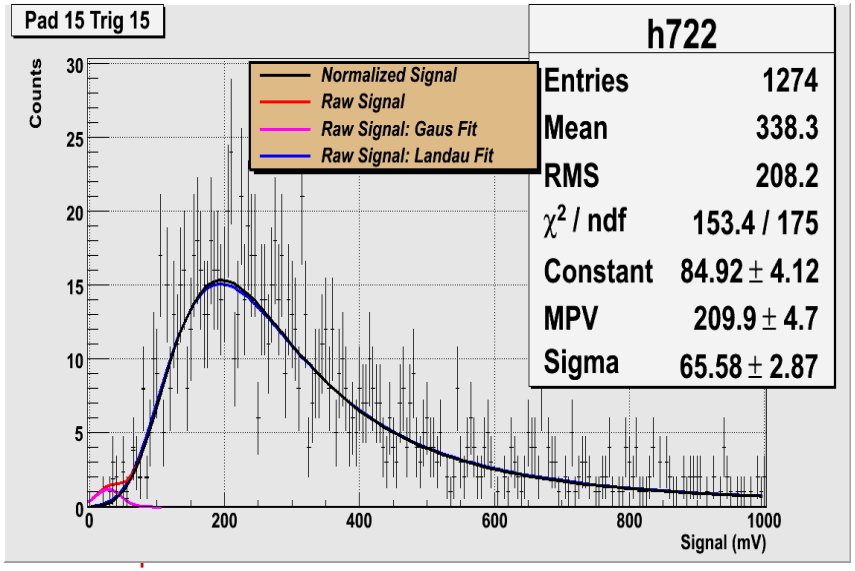


Pulse Height w/ Beam









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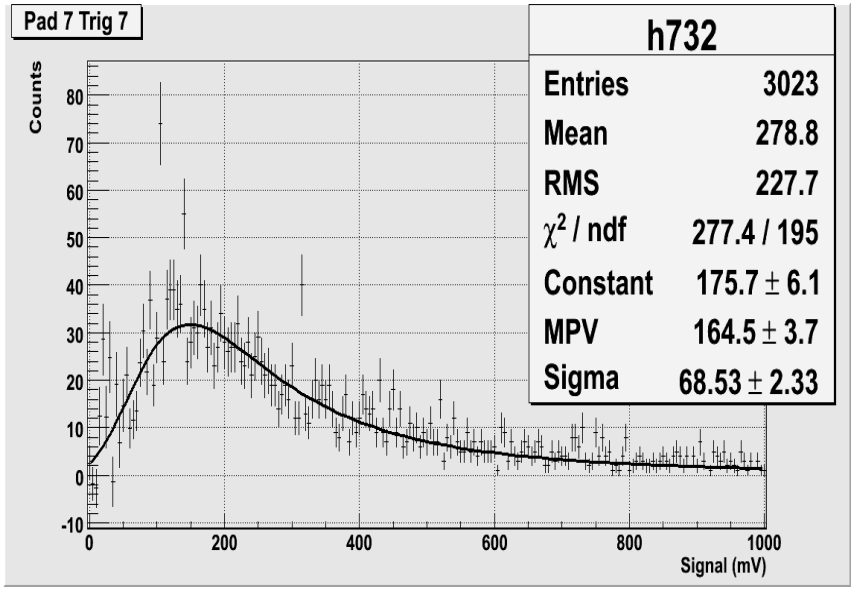
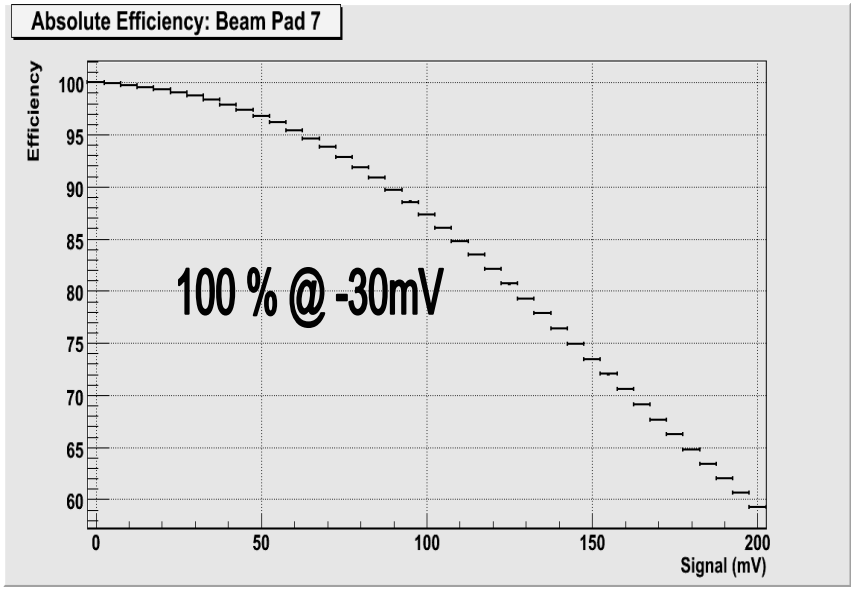
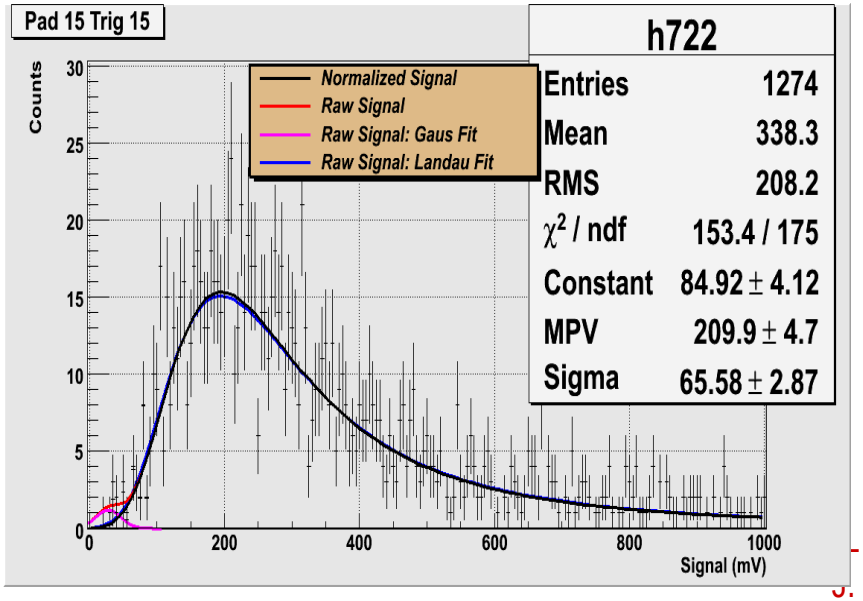
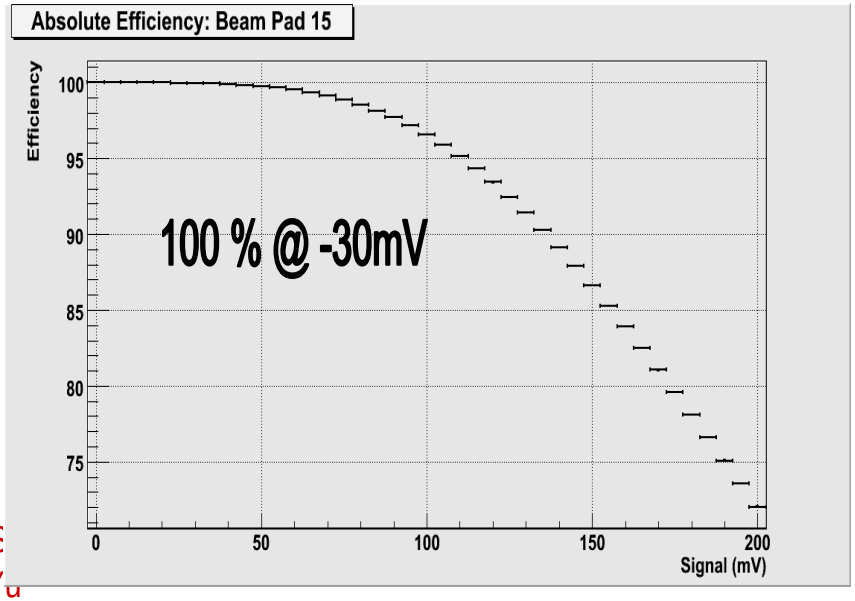
Absolute Efficiency vs Threshold w/ 120GeV P









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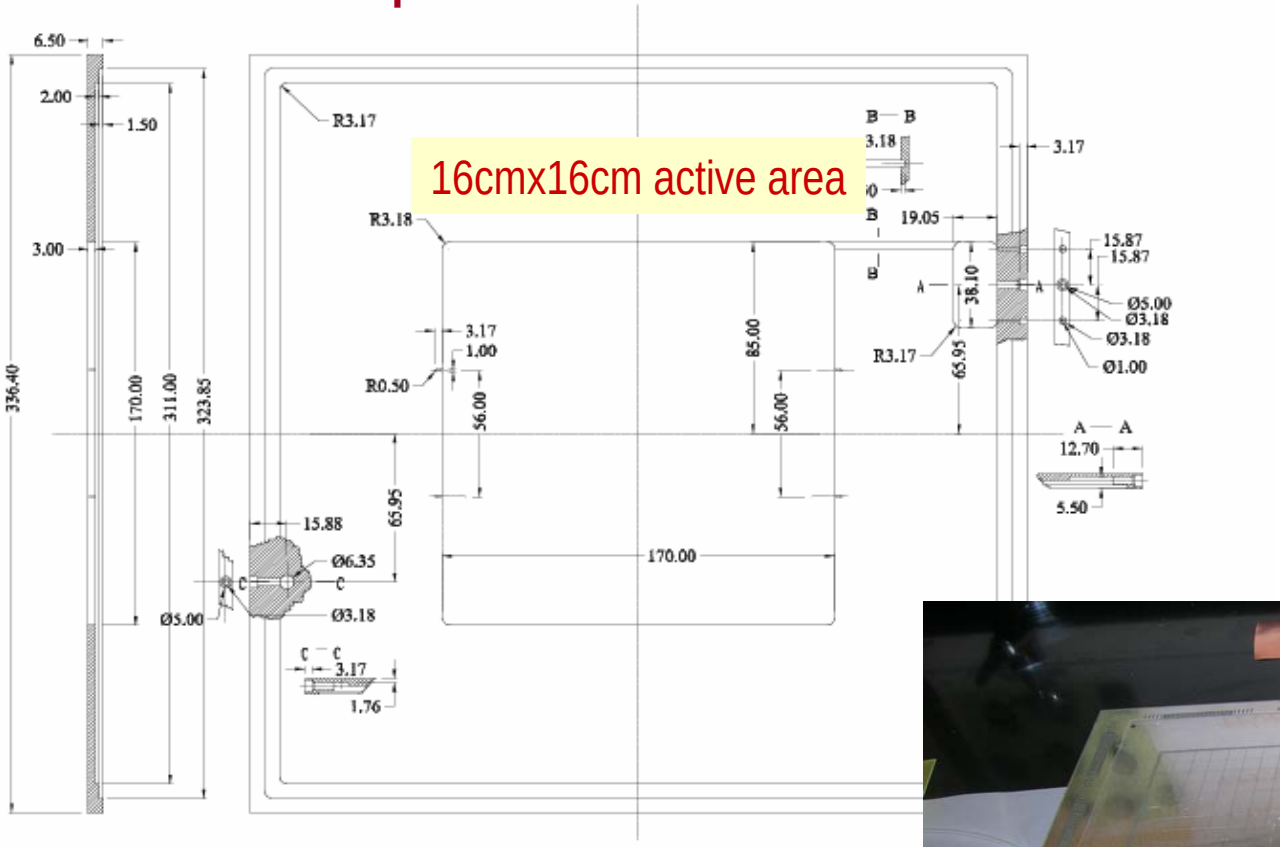
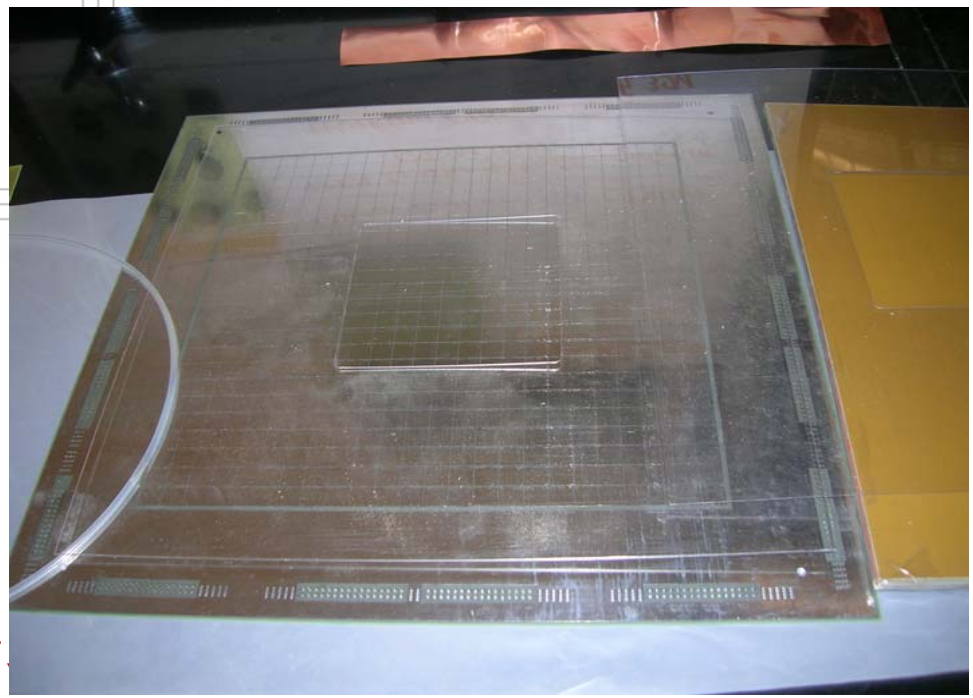
Vertical Slice Test

- Completed two 30x30 cm^2 chambers
  - One 8x8cm^2 active area chamber constructed with kPix
  - One 16x16cm^2 active area chamber constructed with DCAL
  - Use large area Delrin spacers
  - Used interface boards to made 20cmx20cm DCAL FEB+PB to 30cmx30cm chamber
- Both kPix and DCAL chambers did not show credible signal

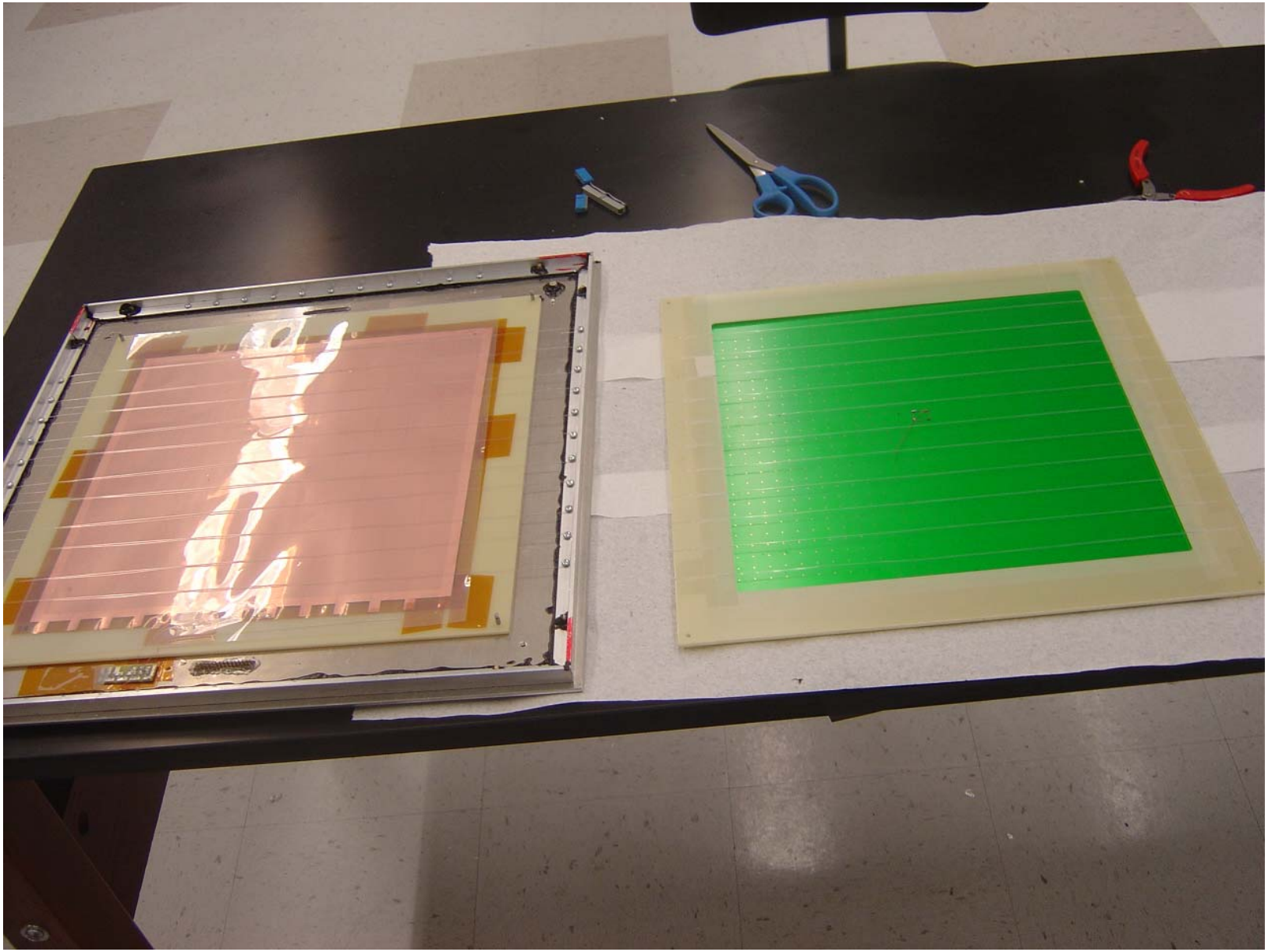
DCAL Chip 16cm x16cm Slice Test Chamber





Progress with the new chamber design

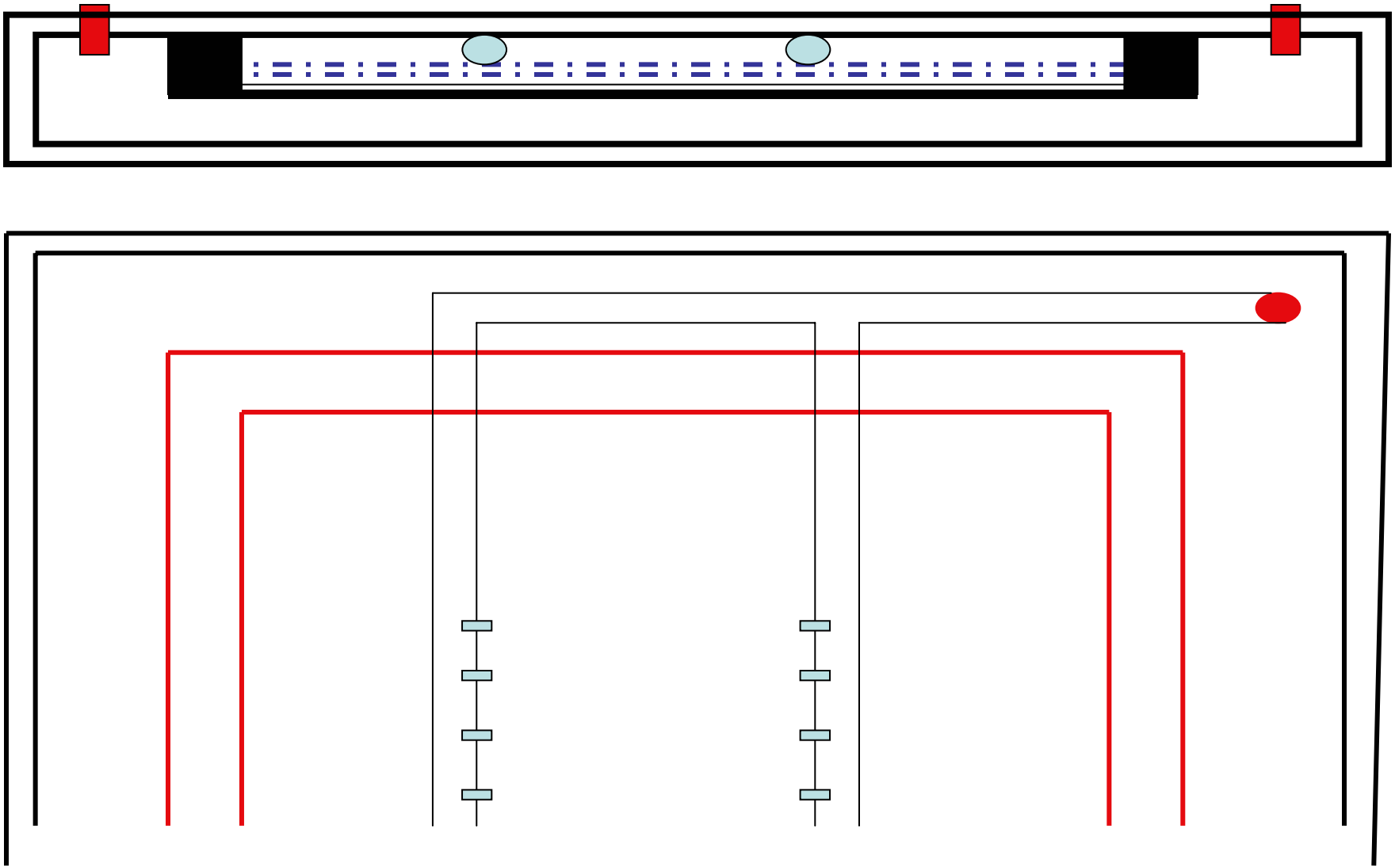
- A double GEM chamber with fishing line spacer instead of large area Delrin spacers
- Tested with single channel readout using source
- kPix board cosmic-ray trigger timing completed



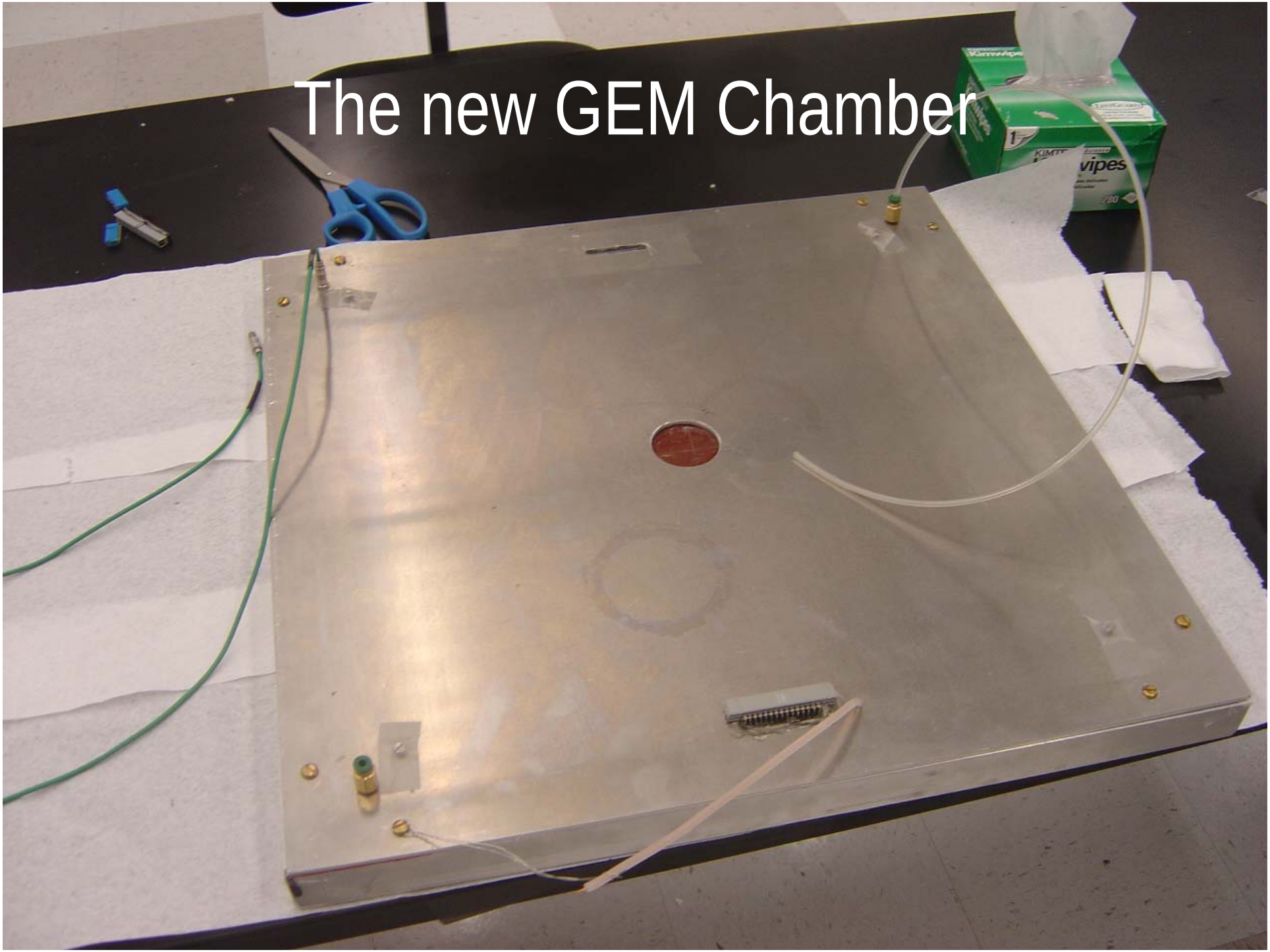
Progress with the new chamber design

- Replaced the single channel anode board with a kPix readout board w/ zap protection
- More direct gas distribution into the ionization gap
- Test on the new chamber in progress
  - Now that the chamber is working w/ kPix readout
    - We will repeat chamber property tests on the bench
    - This will then be followed by beam tests at ESA and MTBF
- We will construct another chamber with the same structure shortly for running with DCAL chip

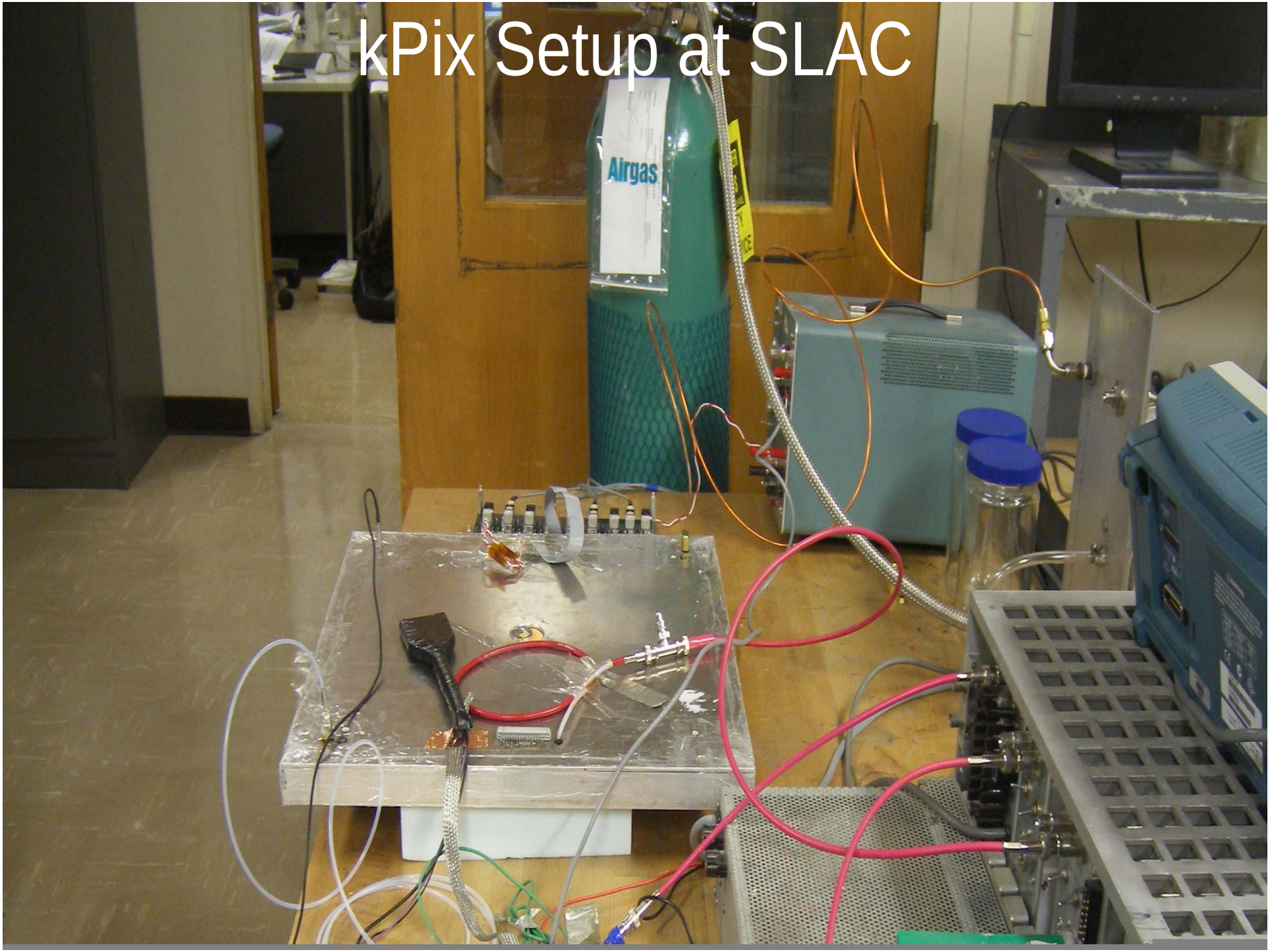
Direct Forced Gas Supply System



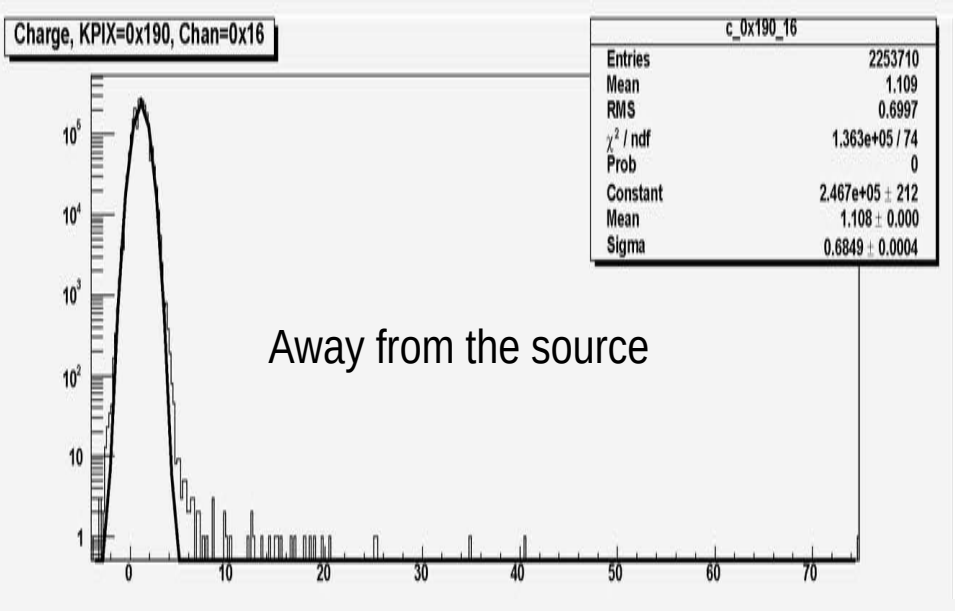
The new GEM Chamber

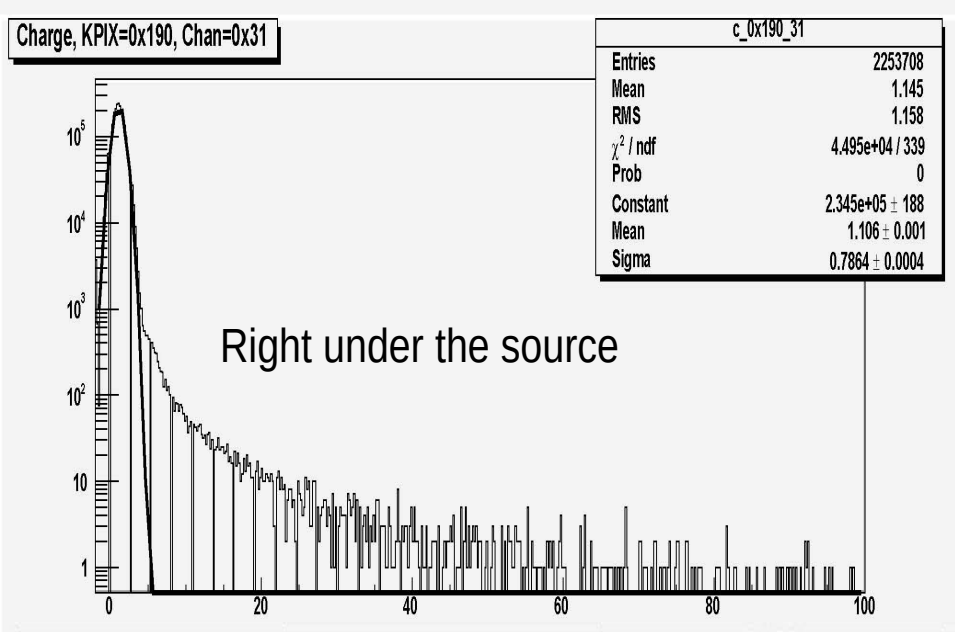


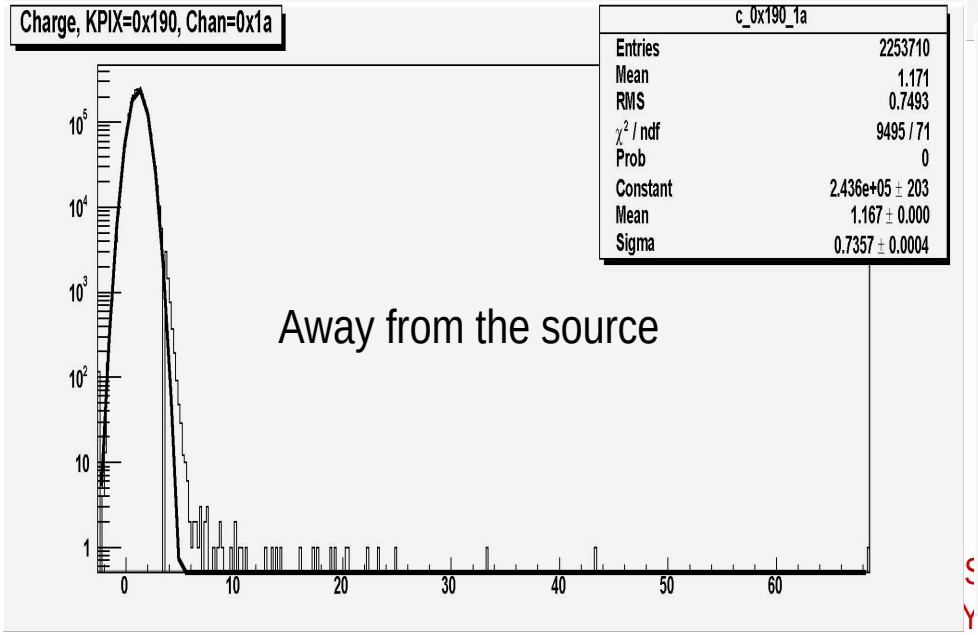
kPix Setup at SLAC

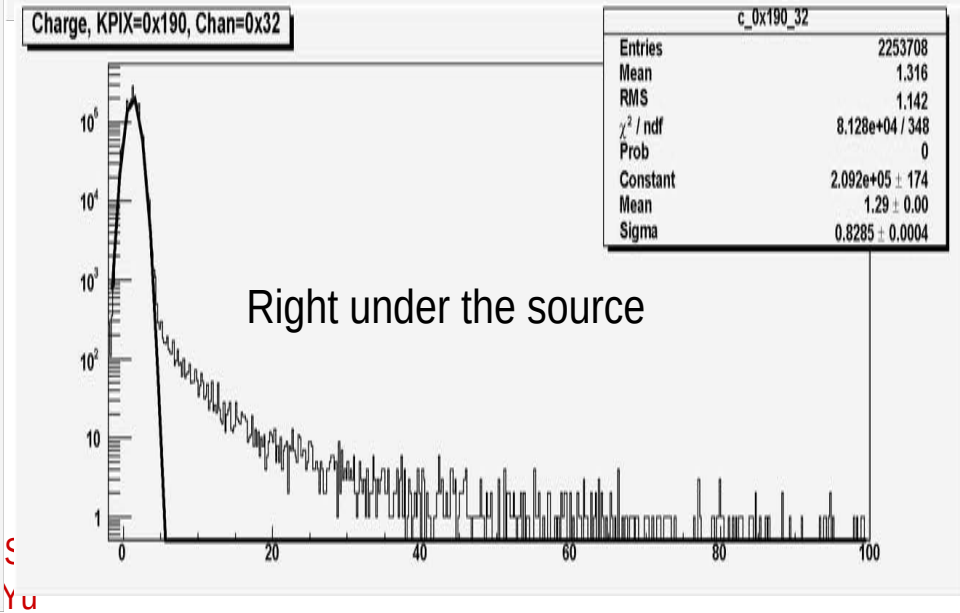


Reponses to Source – GEM-kPix

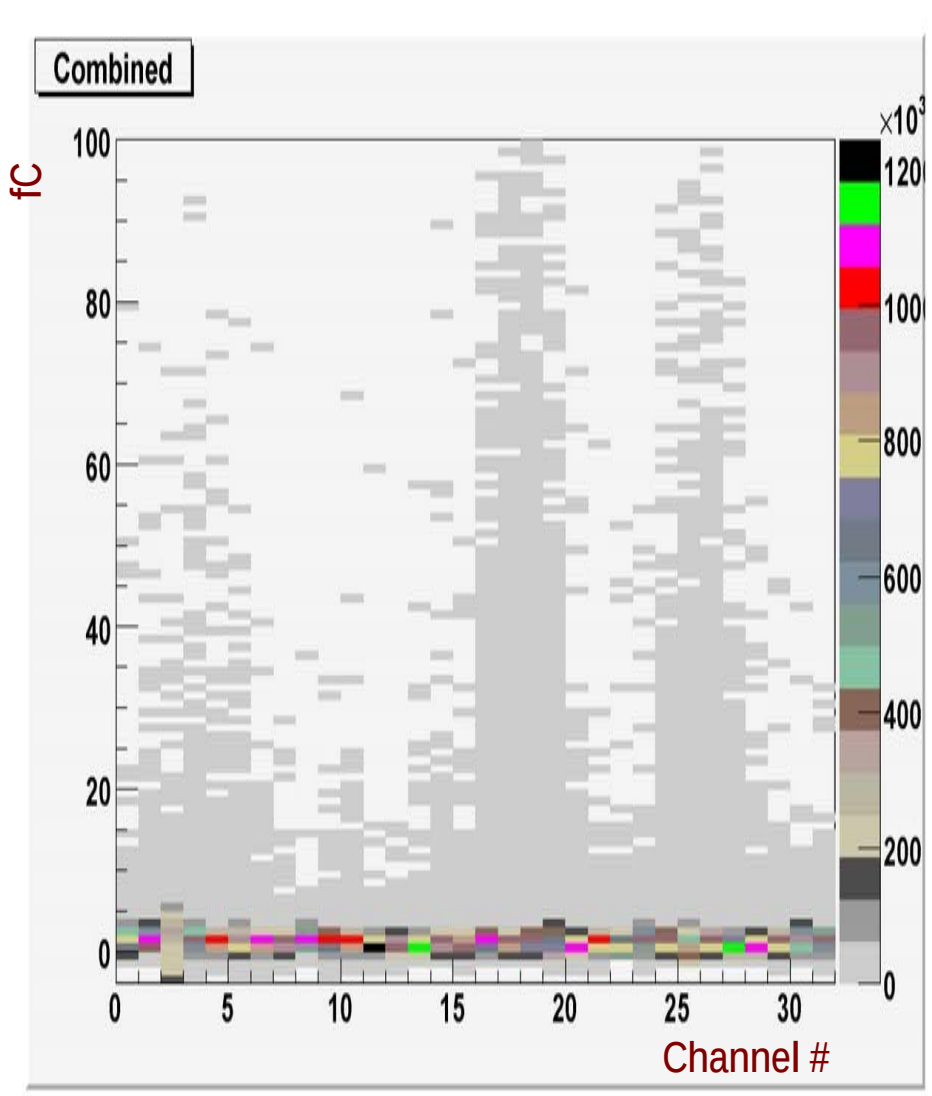


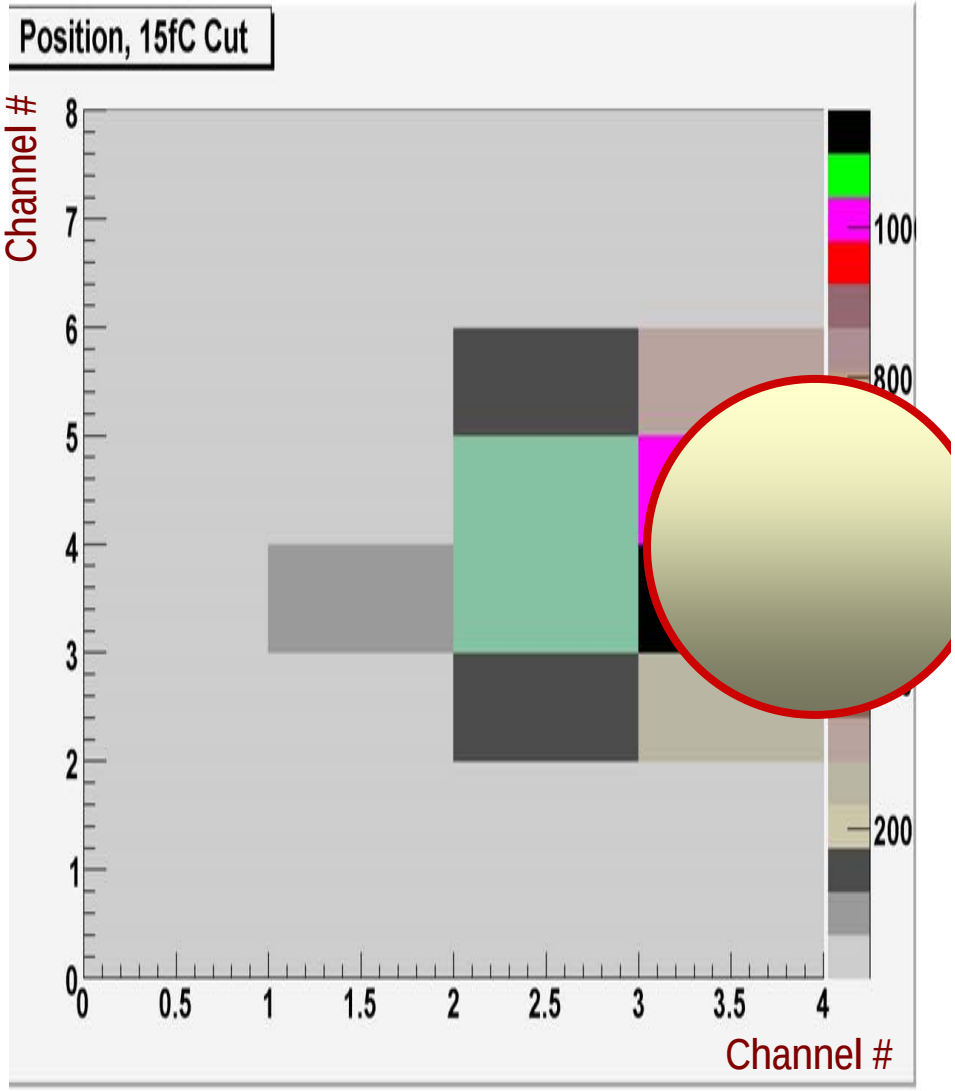






Source Runs with kPix Readout



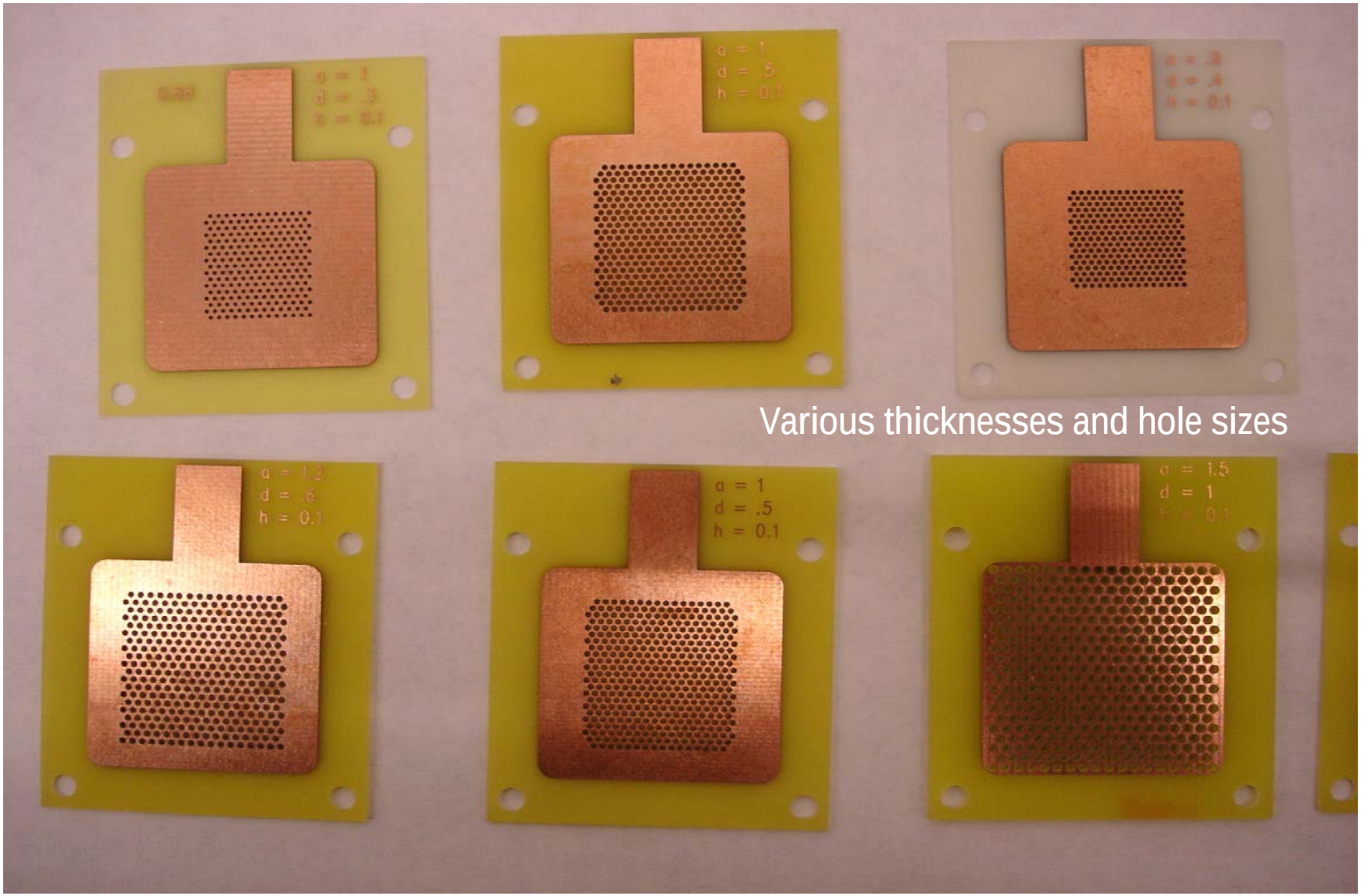


GEM DHCAL Plans

- Late 2007 - mid 2008: Further chamber characterization and combined electronics run at ESA and MTBF
  - Use kPix and DCAL chips for multi-channel readout
  - Finalize uniformity measurements, x-talk and high stat chamber property measurement
- Mid - late 2008: Large unit chamber (1mx33cm) characteristics test
  - Working with CERN for foil production
  - Possible TGEM prototype chamber testing
- Early - mid 2009: Possible run with 1mx1m chamber characteristics testing
- Late 2009 – early 2010: Joint run with CALICE stack as 1mx1m
  - Number of 1mx1m chambers depends heavily on support

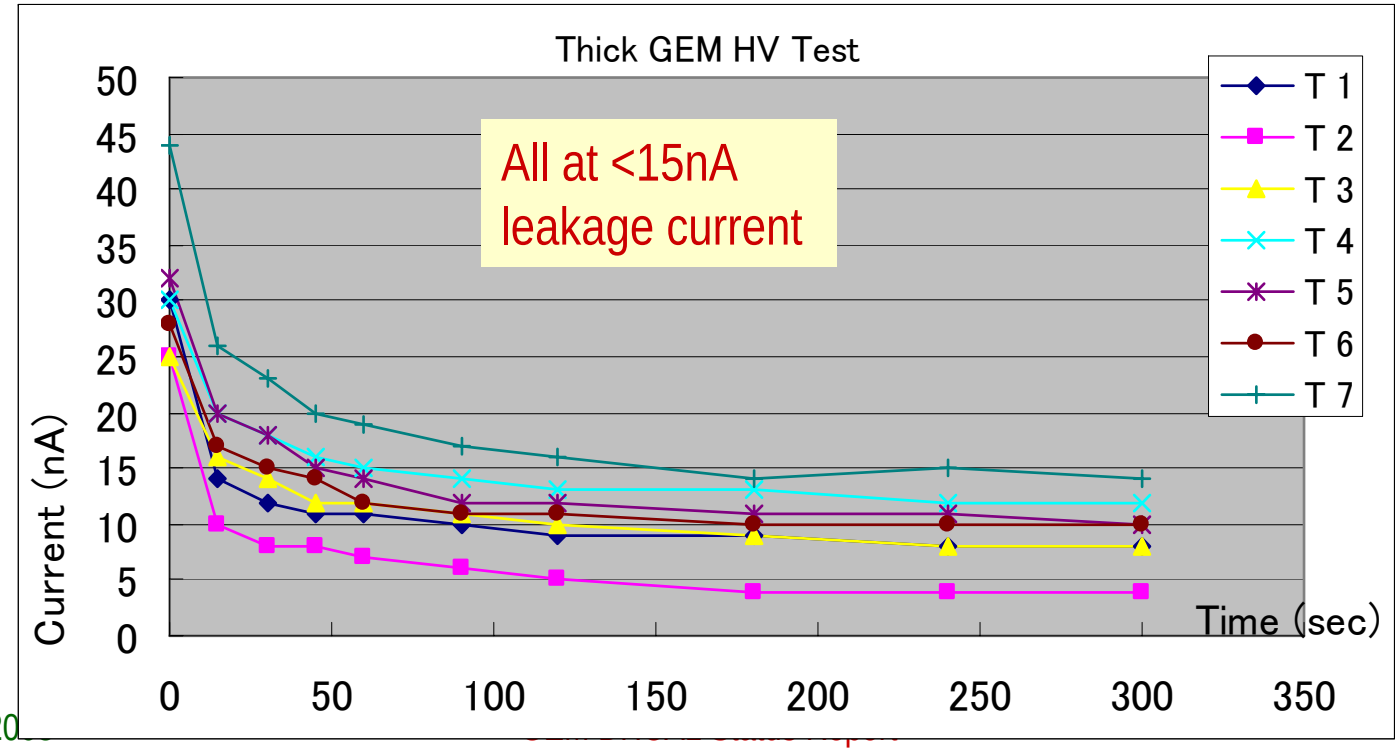
Samples of Thick GEM (TGEM)

Higher gains than thin GEMs and lower production cost ….

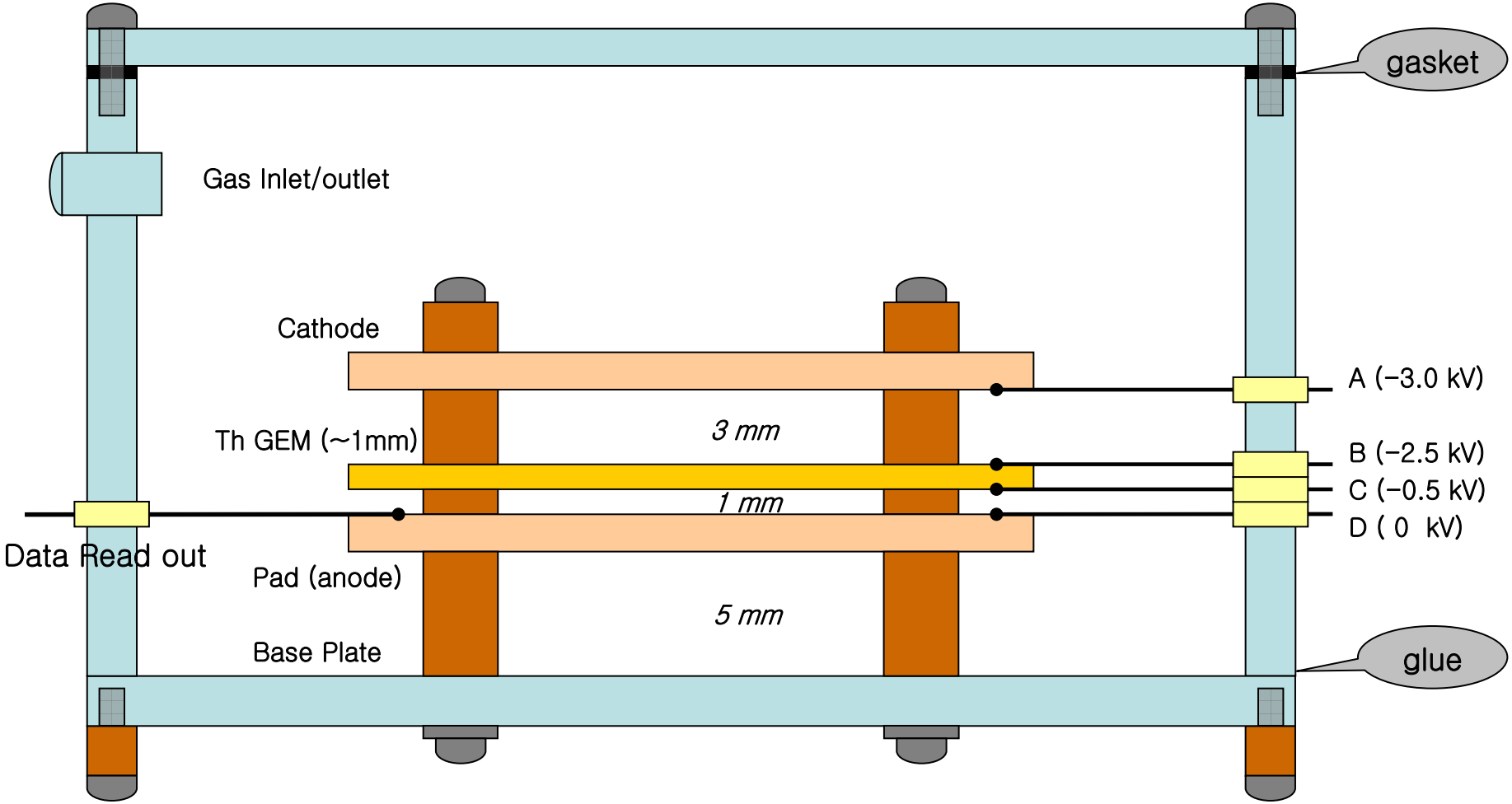


TGEM HV Test Results

Thick GEM ID	0	15	30	45	60	90	120	180	240	300	Voltage (V)
T 1	30	14	12	11	11	10	9	9	8	8	1000
T 2	25	10	8	8	7	6	5	4	4	4	1000
T 3	25	16	14	12	12	11	10	9	8	8	1700
T 4	30	20	18	16	15	14	13	13	12	12	1700
T 5	32	20	18	15	14	12	12	11	11	10	1700
T 6	28	17	15	14	12	11	11	10	10	10	1700
T 7	44	26	23	20	19	17	16	14	15	14	2000



Thick GEM Prototype Chamber Lay-out



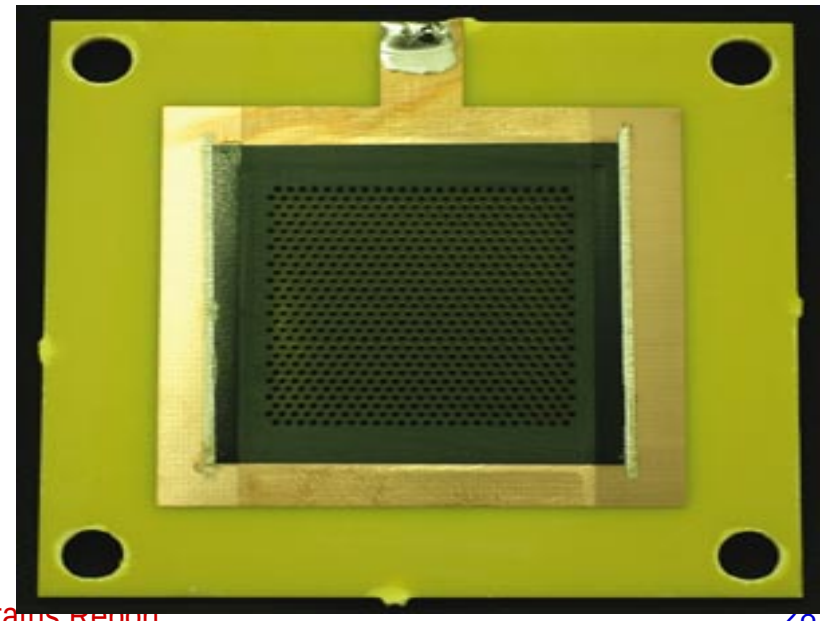
Outer dim. : 15 cm x 15 cm x 10 cm(h)

TGEM Prototype Chamber Progress

- TGEM samples certified for prototype
  - Had to ultrasonic clean and bake
  - Long storage in lab area wasn't so ideal for G10 board
- Prototype chamber built
- Signal has been observed from the prototype chamber
- KAERI will collaborate with us on TGEM chamber development
- Working with our CNU collaborators for large area TGEM production at higher efficiency

RETGEM

- Latest development at CERN in 2007 (Peskov and Oliviera)
  - Better spark resistance and stability, using high resistance Kapton
  - High gain
- Working with the CERN team to produce more samples for our testing
  - Plan to search for US micropattern, printed circuit industry to produce large scale RETGEMs



Conclusions

- Analysis of the 30cmx30cm GEM chamber test beam data in progress
  - Many characteristics parameters are being systematically studied
- Electronics slice test in July 2007 had issues that prevented GEM from running jointly with RPC
  - Issue with chamber design resolved
  - kPix based new chamber constructed and testing in progress
  - Will perform another beam test once we complete another bench tests
- 1mx32cm long foil development with CERN for 1mx1m unit chamber ➔ Heavily dependent on the availability of funds
- Thick GEM Prototype development had a breakthrough and saw signal ➔ collaboration for further development agreed
- Collaborating with CERN GDD for RETGEM