Status of GEM DHCAL

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ALCPG11 Workshop

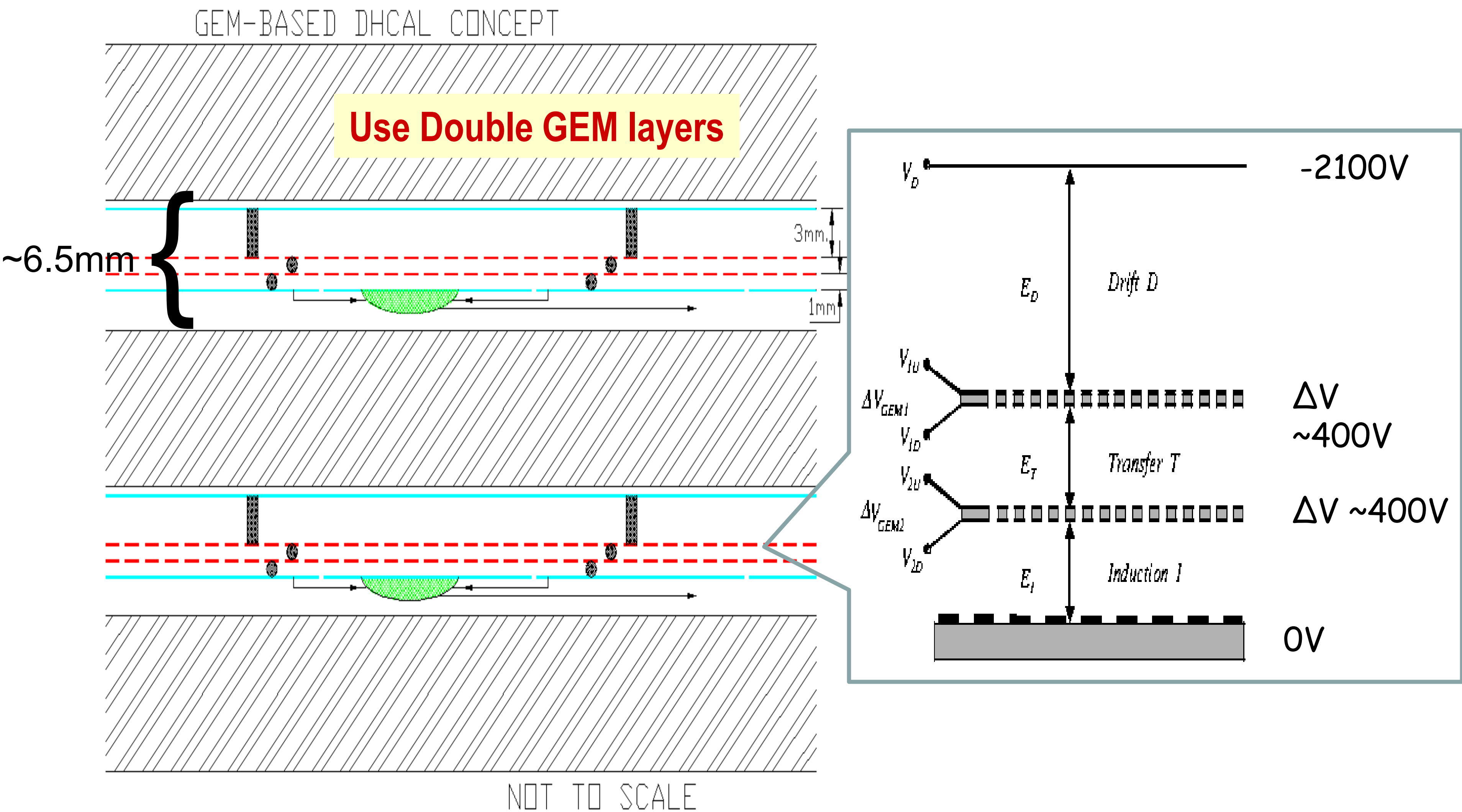
Univ. of Oregon

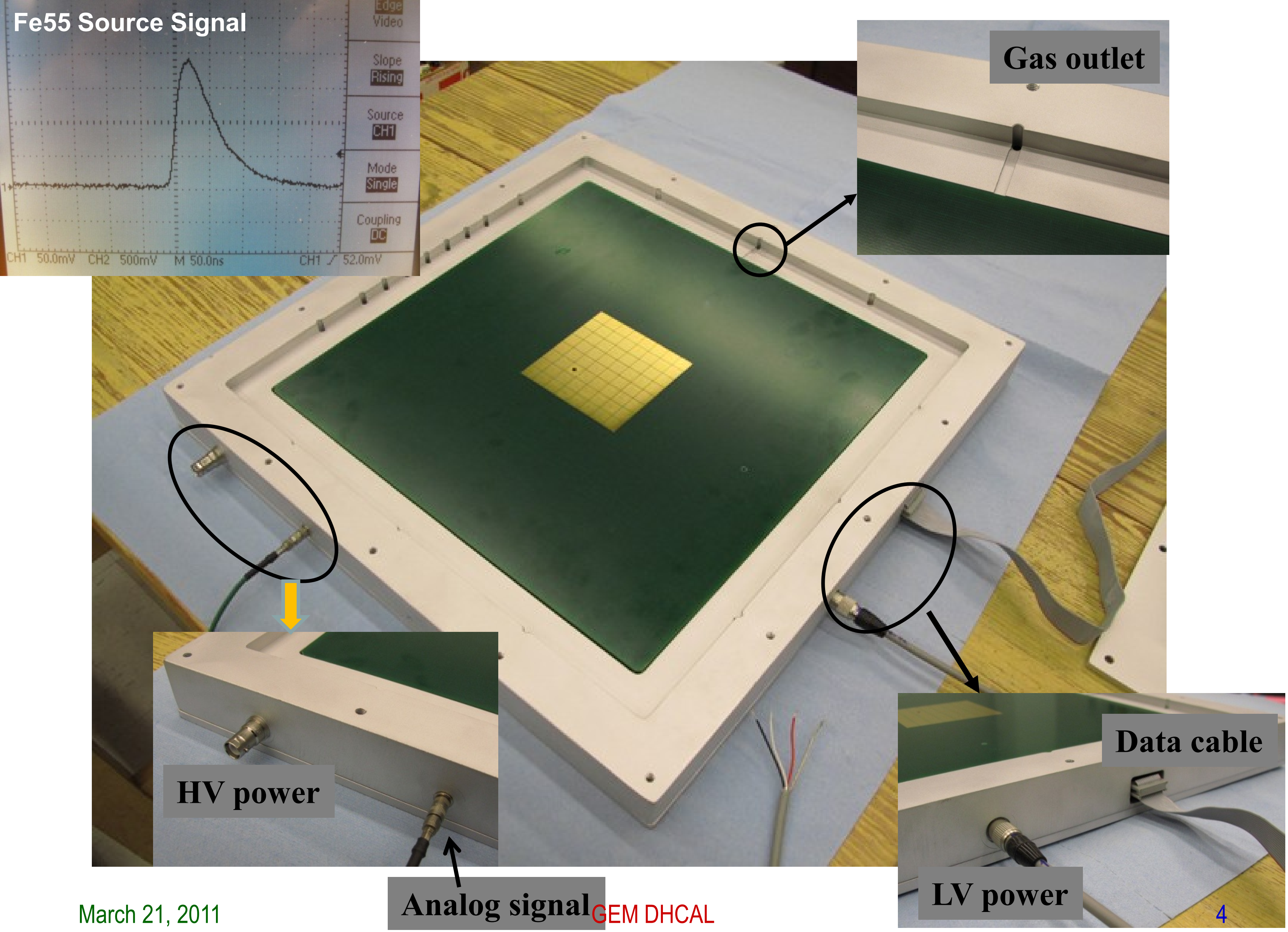
- Introduction
- 30cmx30cm 2D readout with KPiX chip
- GEM-DCAL Integration
- TGEM Progress
- Large GEM Foil Certification
- Large Chamber Mechanical Design
- GEM DHCAL Plans
- Summary

Why GEM?

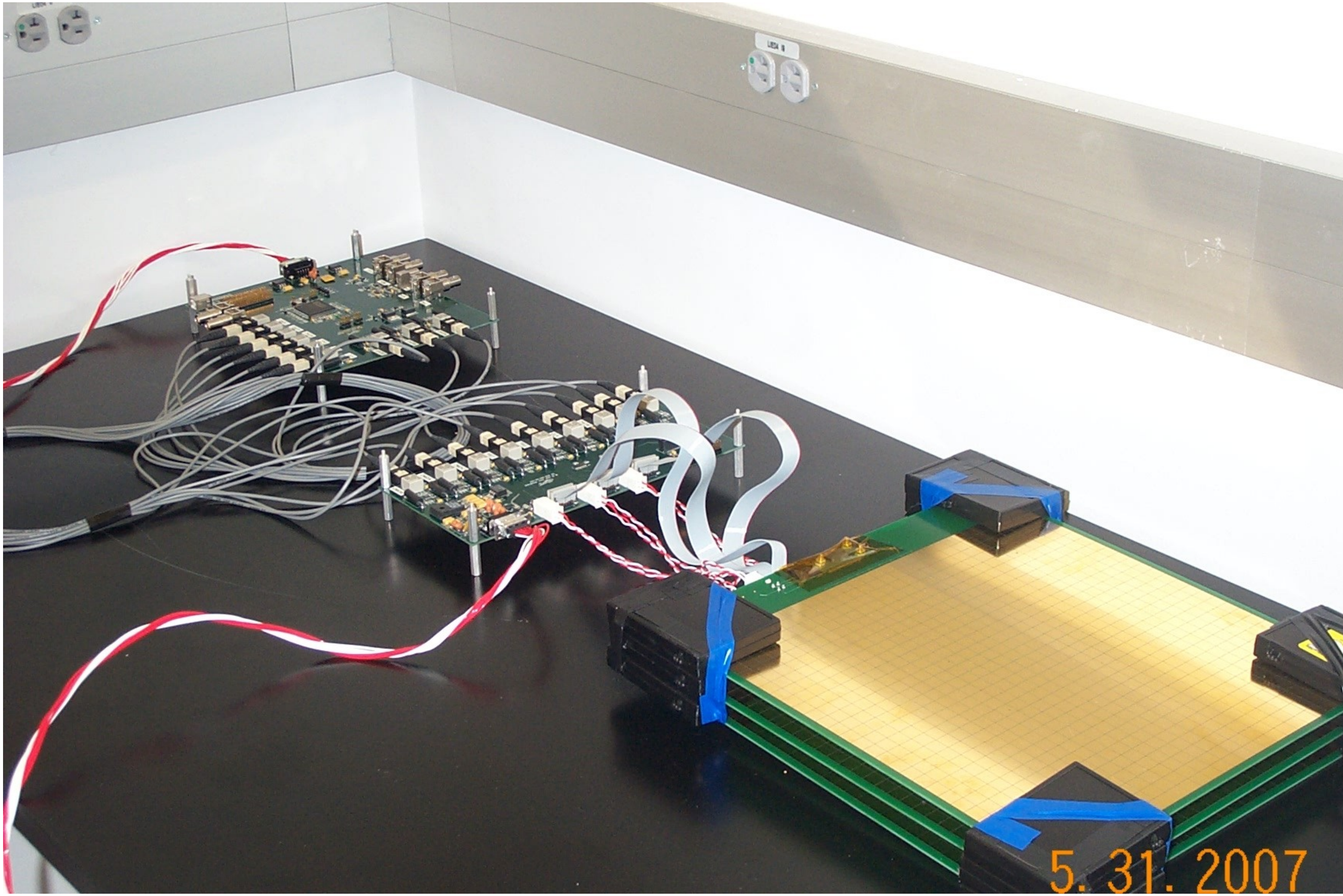
- Flexible configurations: allows small anode pads for high granularity
- Robust: survives ~10^{12} particles/mm^2 with no performance degradations
- Based on electron collection, ~few ns rise time
- Short recovery time ➔ can handle high rates
- Uses simple gas (Ar/CO_2) – no long-term issues
- Runs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

GEM-based Digital Calorimeter Concept




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

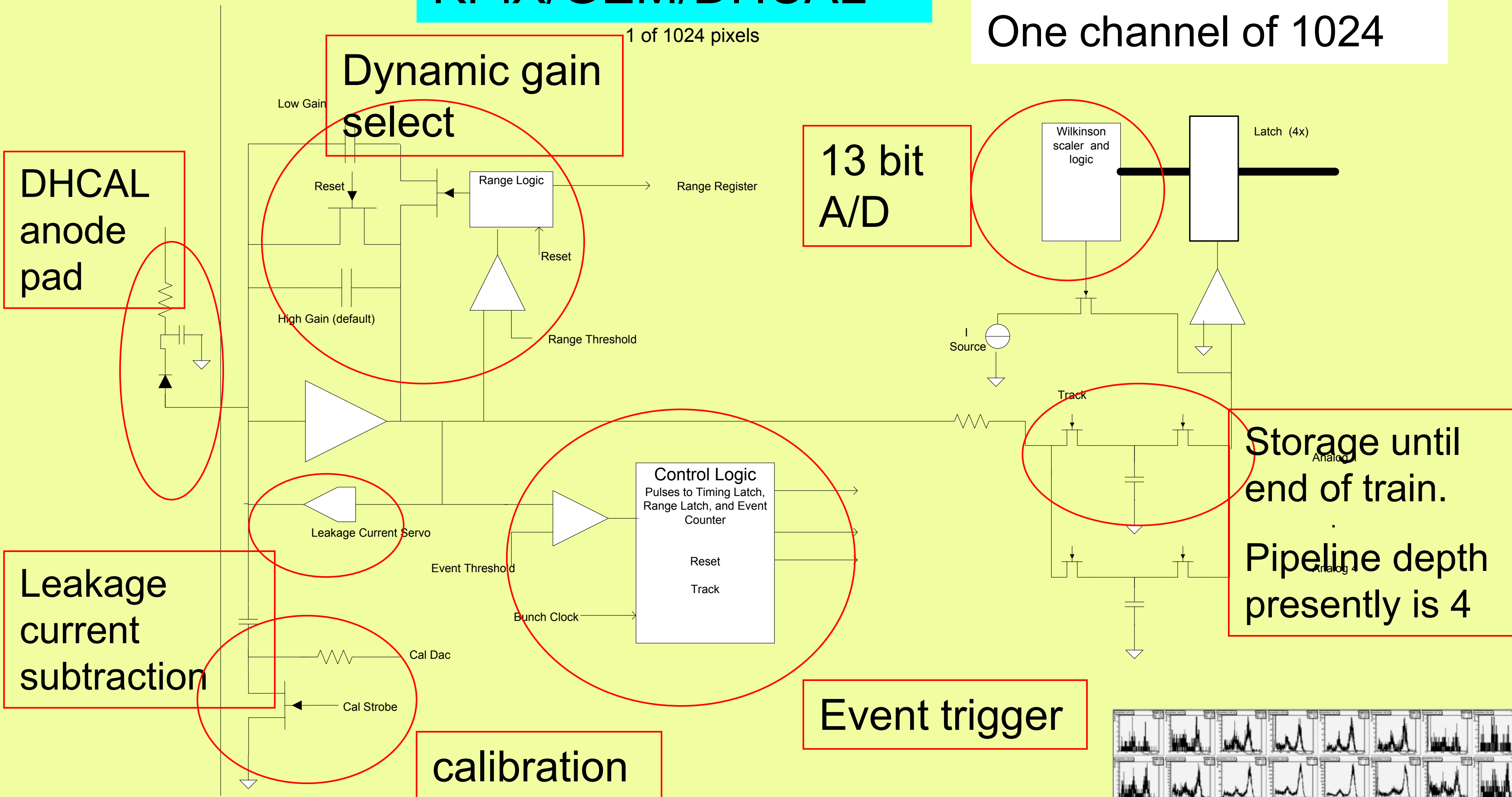
GEM-DHCAL/KPiX boards with Interface and FPGA boards

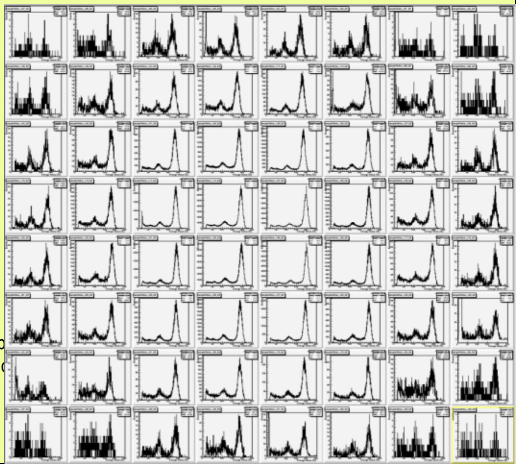


KPiX/GEM/DHCAL

KPiX chip

One channel of 1024





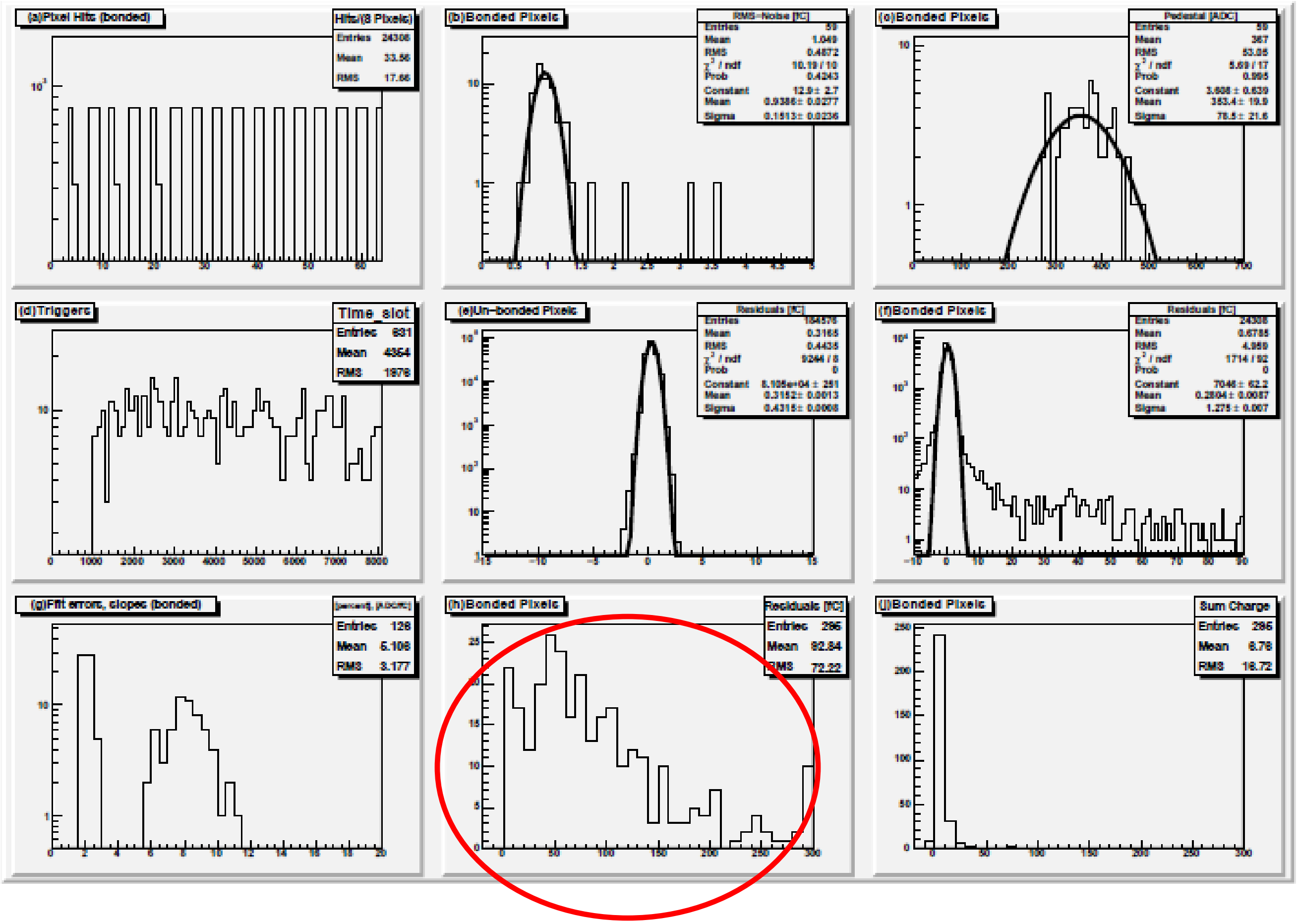
Simplified Timing:

There are ~ 3000 bunches separated by ~300 ns in a train, and trains are separated by ~200 ms.

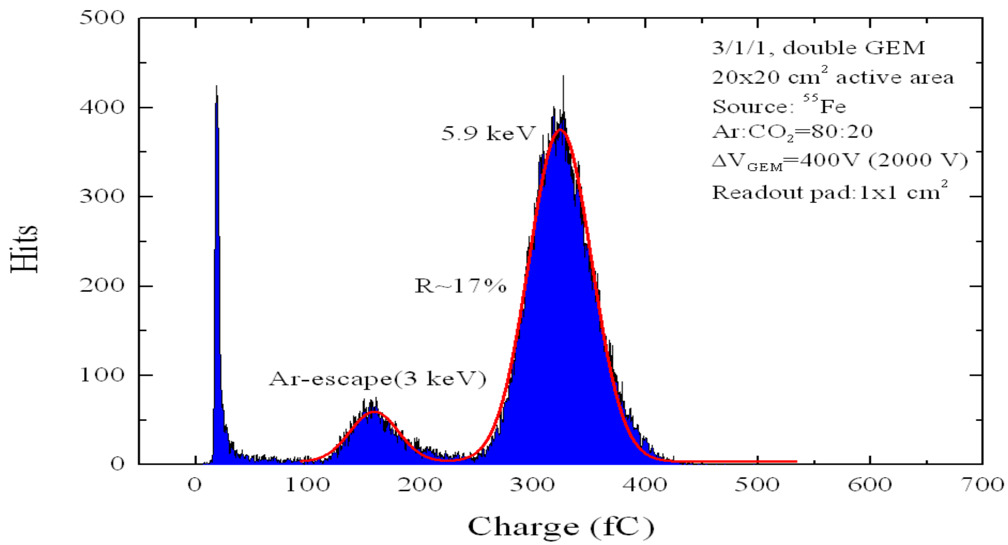
Say a signal above event threshold happens at bunch n and time T0.
The Event discriminator triggers in ~100 ns and removes resets and strobes the Timing Latch (12 bit), range latch (1 bit) and Event Counter (5 bits).
The Range discriminator triggers in ~100 ns if the signal exceeds the Range Threshold.
When the glitch from the Range switch has had time to settle, Track connects the sample capacitor to the amplifier output. (~150 ns)
The Track signal opens the switch isolating the sample capacitor at T0 + 1 micro s. At this time, the amplitude of the signal at T0 is held on the Samp
Reset is asserted (synched to the bunch clock) . Note that the second capacitor is reset at startup and following an event, while the high gain (small) c
while processing an event)
The system is ready for another signal in ~1.2 microsec.
After the bunch train, the capacitor charge is measured by a Wilkinson converter.

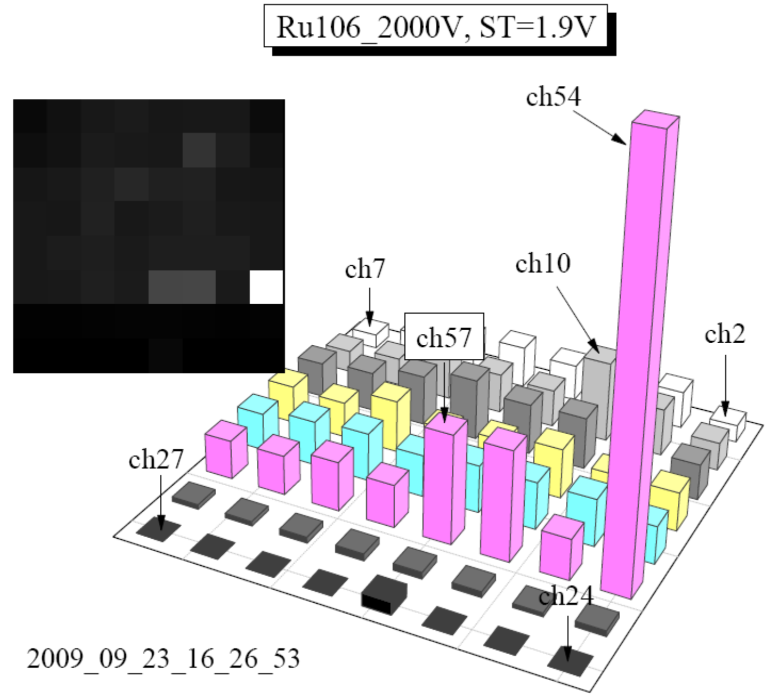
KPiX/GEM/DHCAL

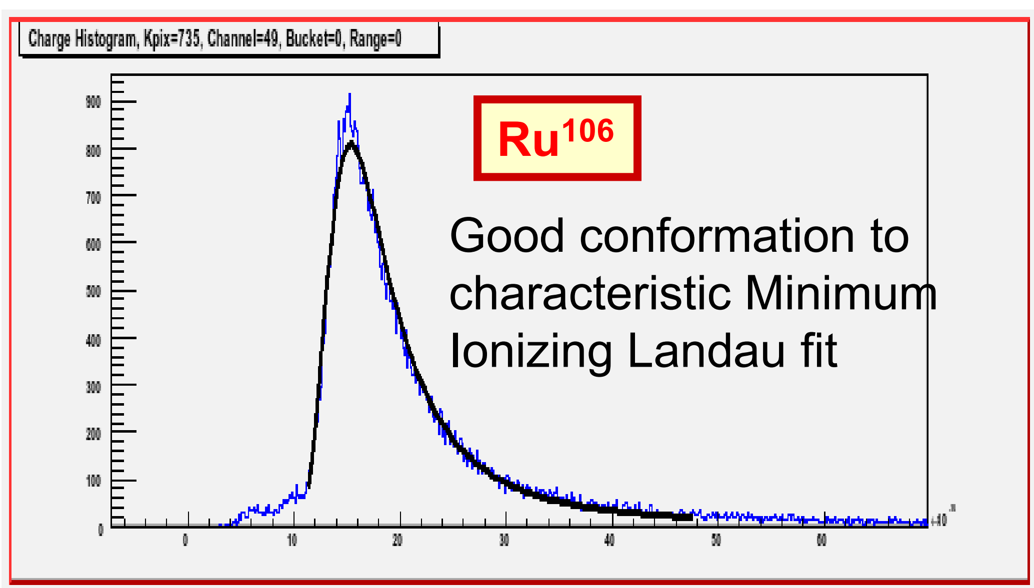
Work with SLAC colleagues on KPiX7,9 debugging/operation
* Many thanks to M. Breidenbach, D. Freytag, R. Herbst

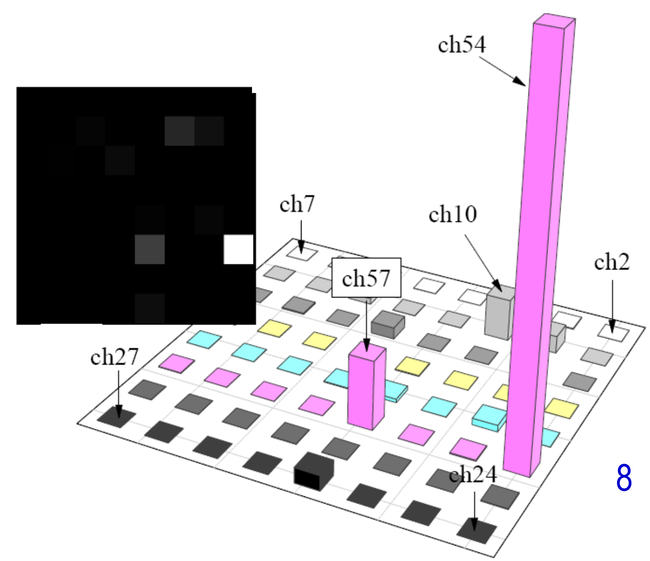


GEM+kPiX7 Fe^{55} and Ru^{106} Spectra

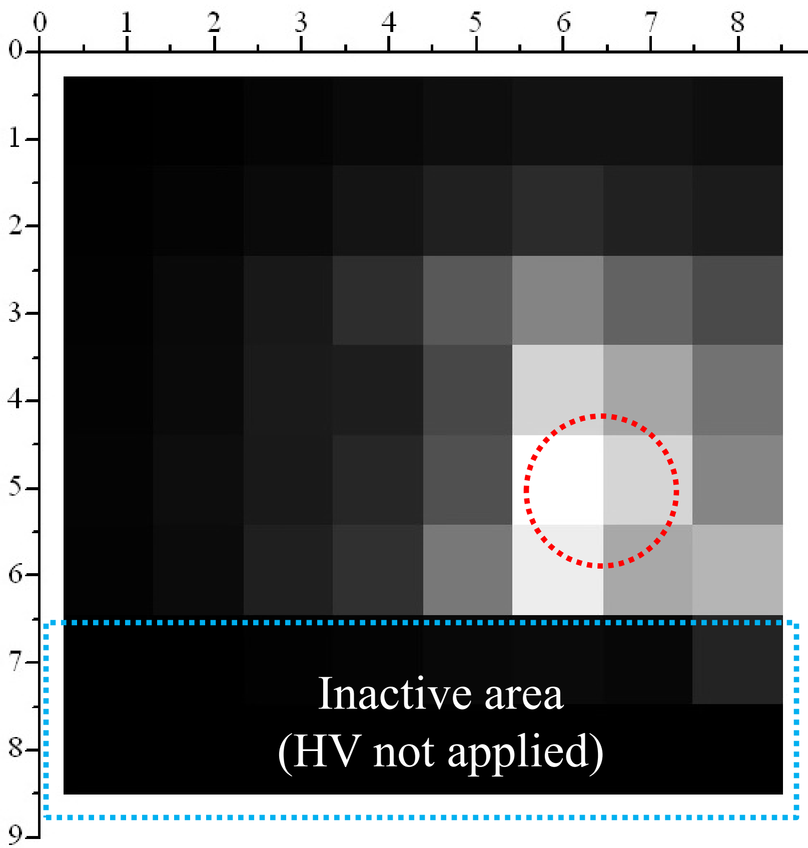


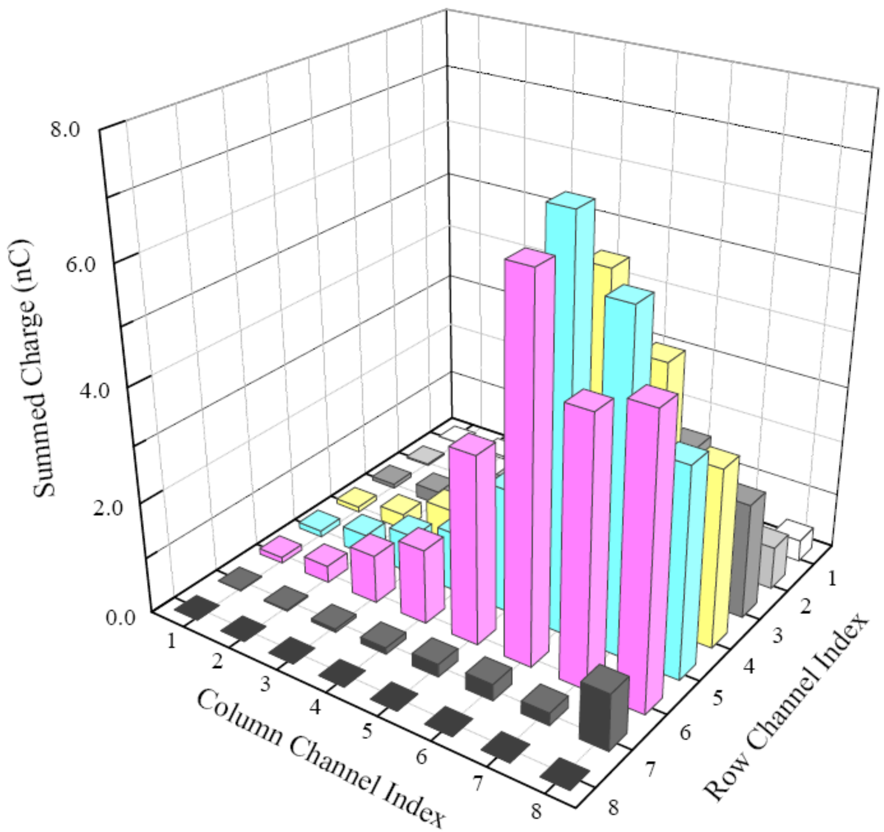






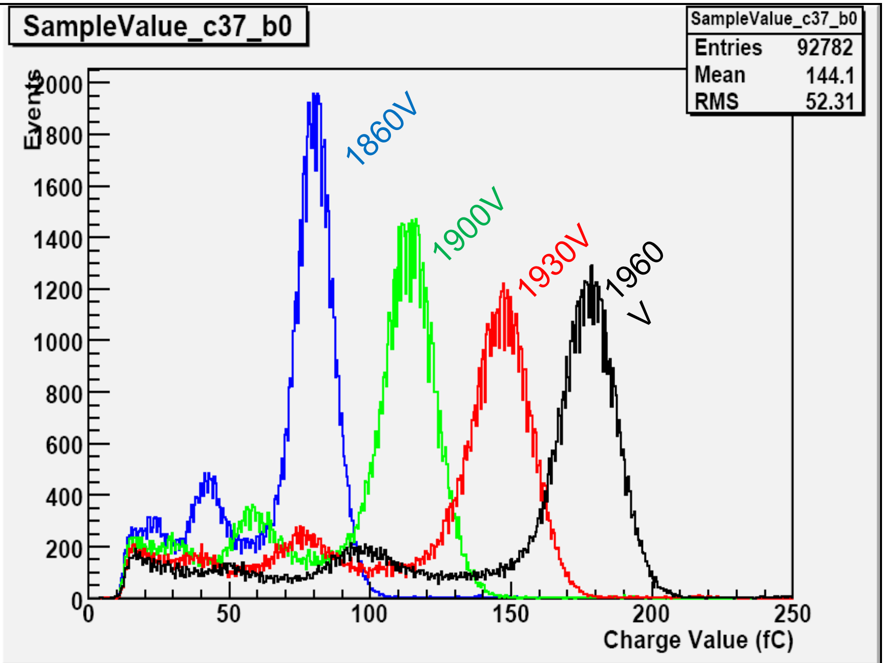
Charge Weighted Lego for Fe55



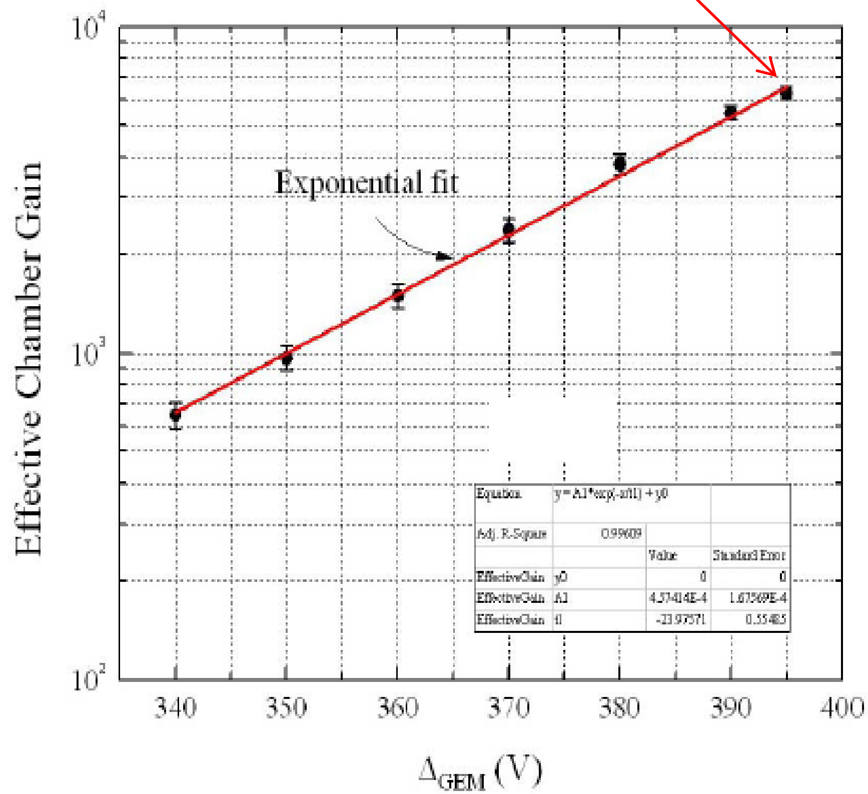


HV=1960 V, Self Trigger Th=1.8 V= 14fC

Gain vs HV

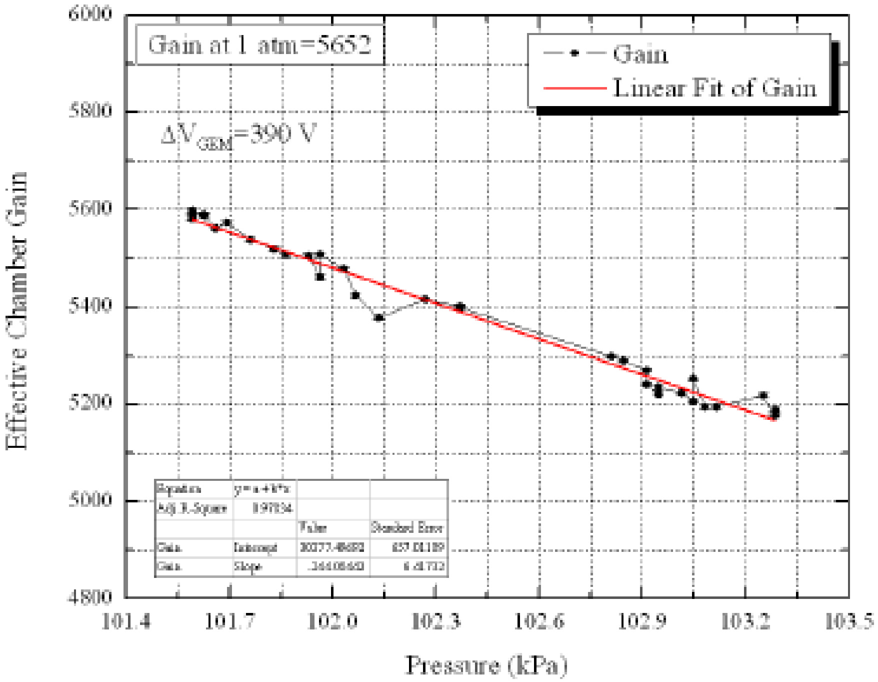


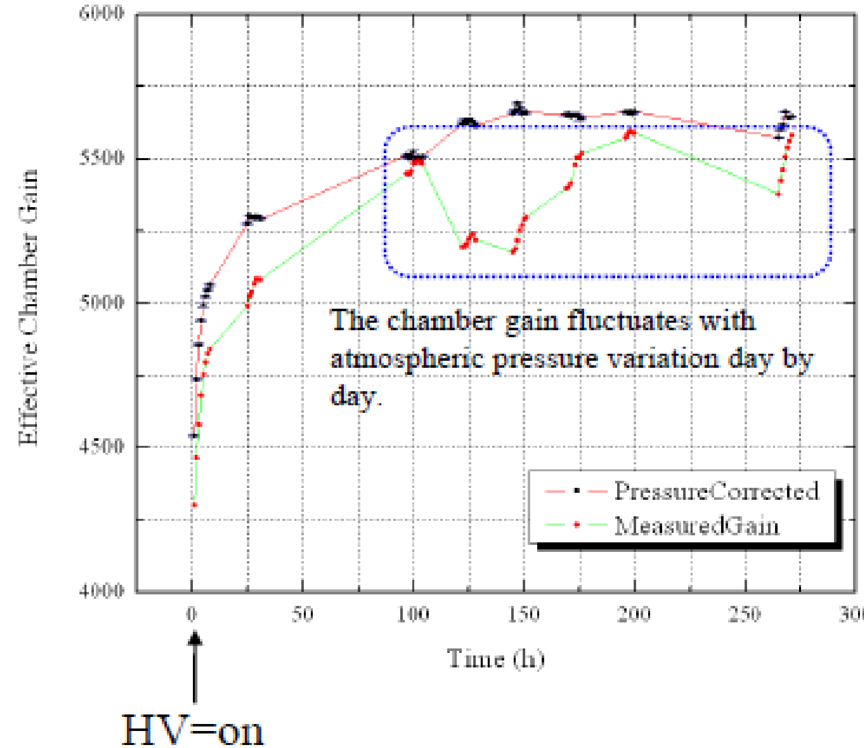
Typical operating point:
Gain ~6000



Pressure Dependence of Gain

HV =1950V (ΔV_{GEM}=390 V)





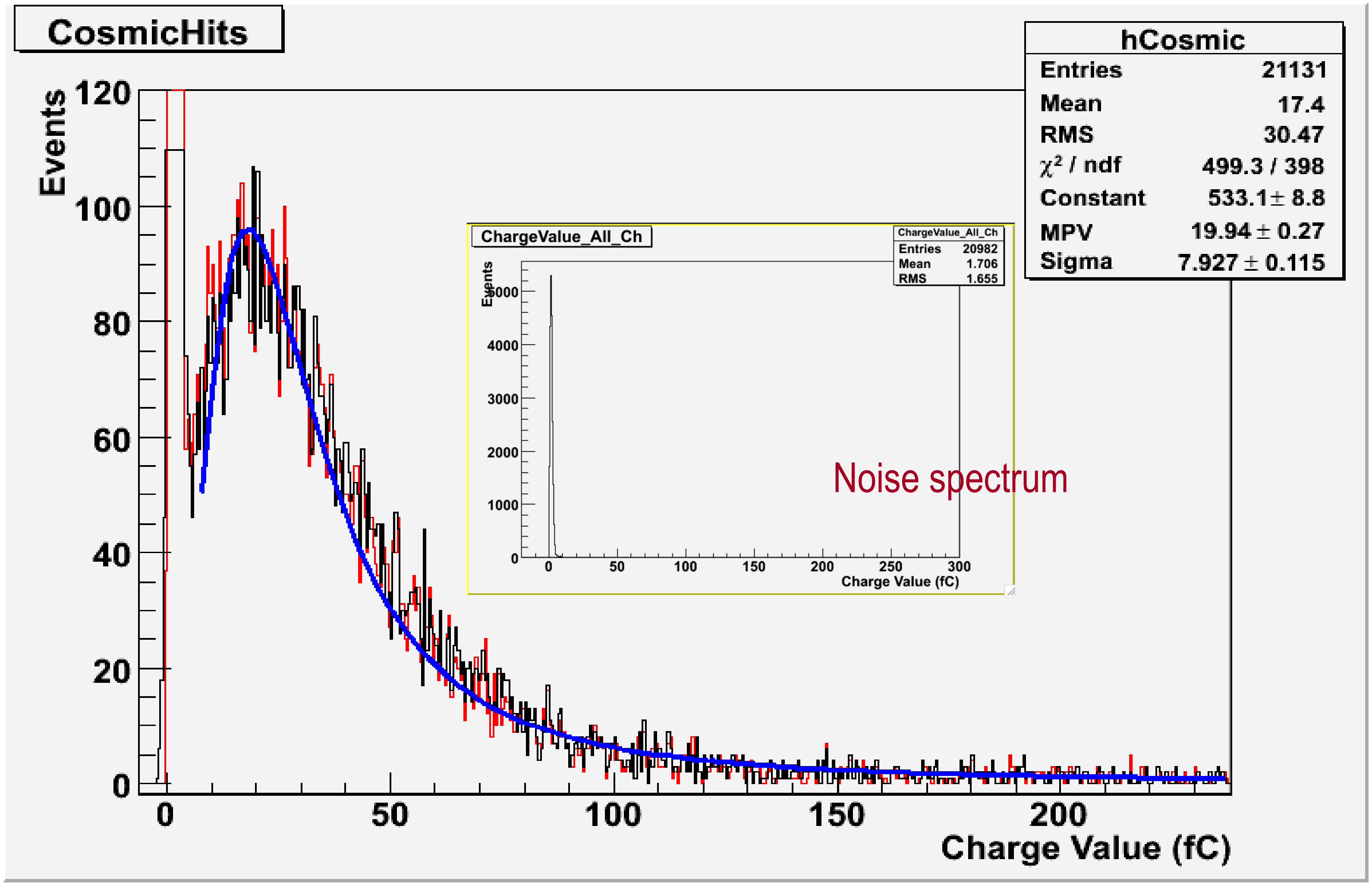
We use an open gas system (gas flows at atmospheric pressure).

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

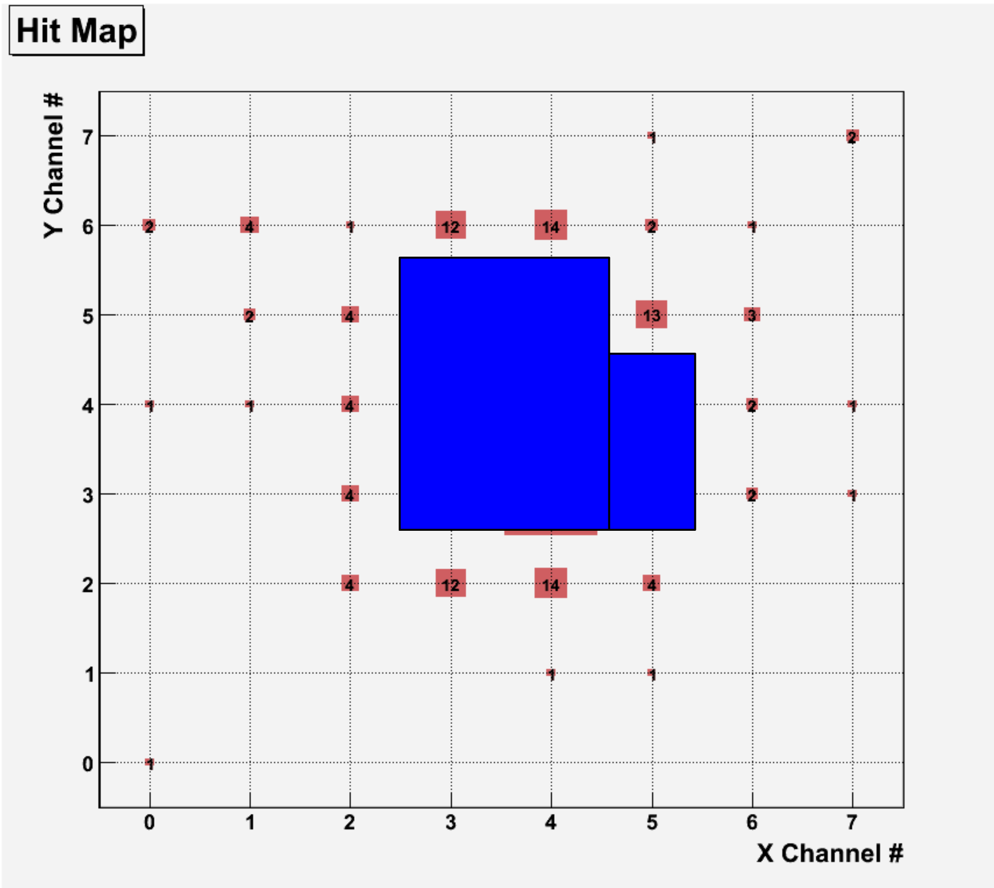
This pressure change affects the chamber gain.

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

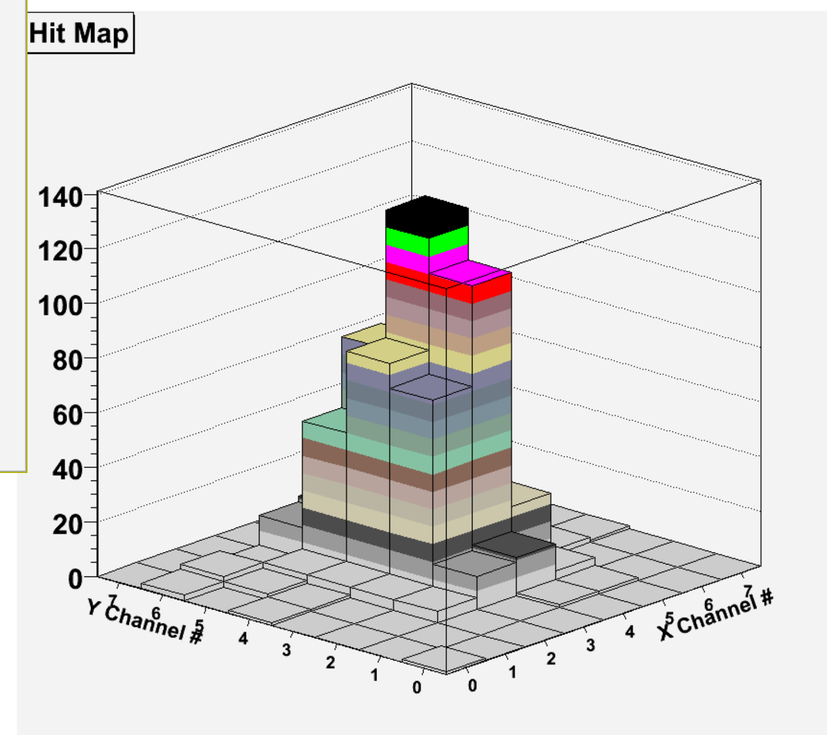
Cosmic Ray Data with External Trigger – kPiX7



2D Cosmic Ray Hits – kPiX7



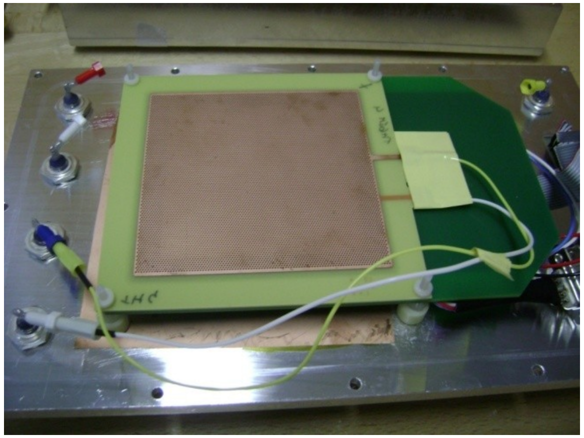
2 x 3 cm^2 trigger counter



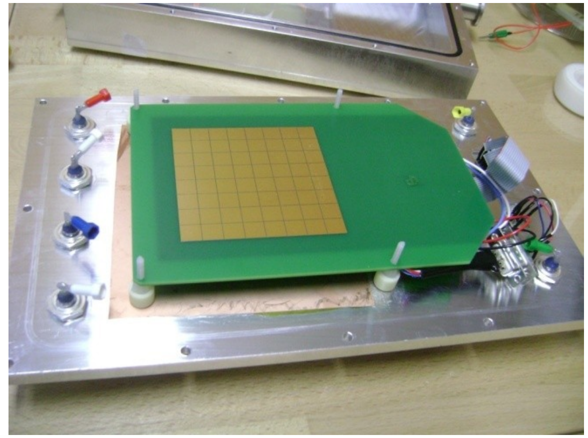
Three noisy channels removed
~4.5% kPiX duty factor

CERN TGEM Test-beam detector

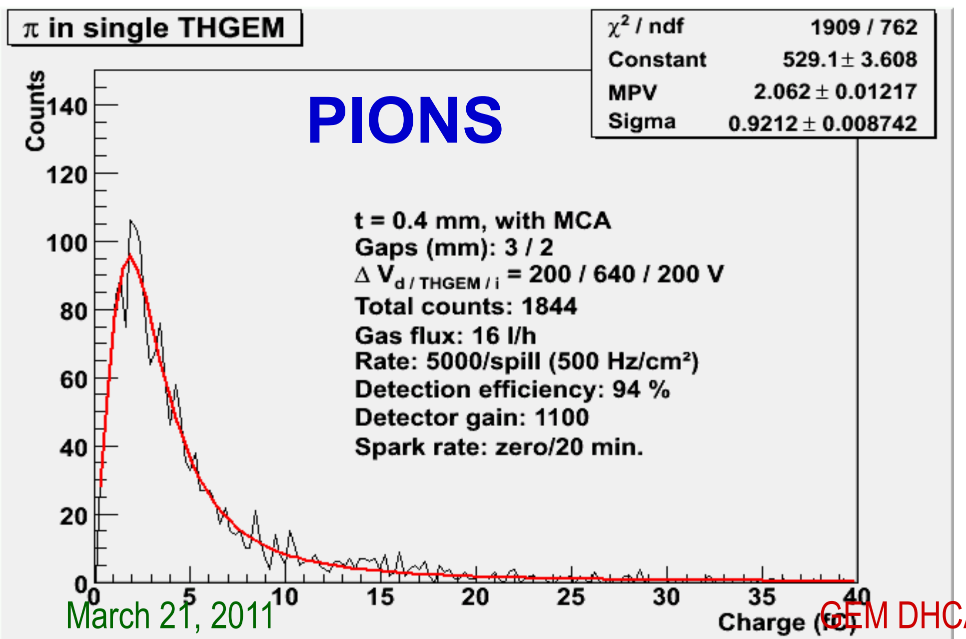
10x10 cm² THGEM

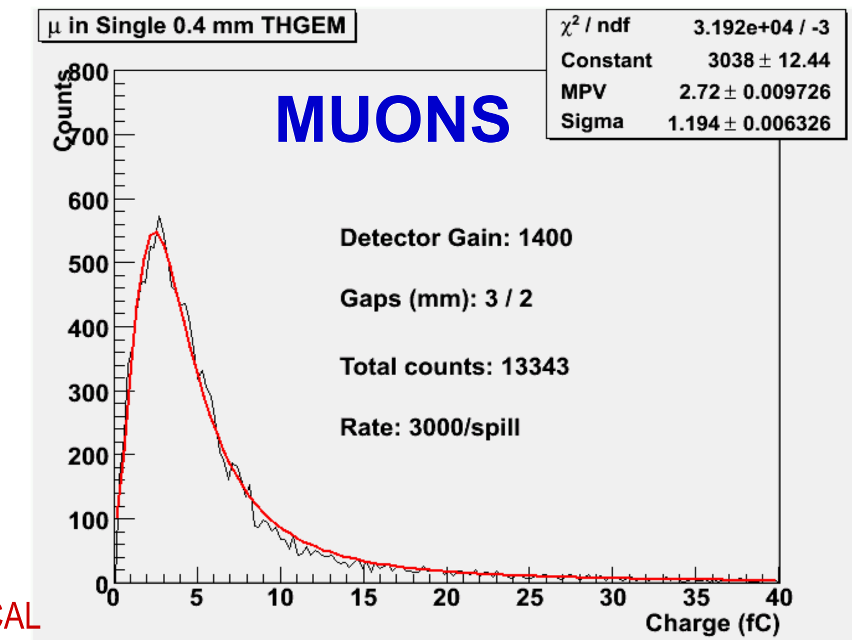


64 pads electrode with KPiX behind



Weizmann - UTA - Aveiro
U.S. Israel Bi-National Science Foundation

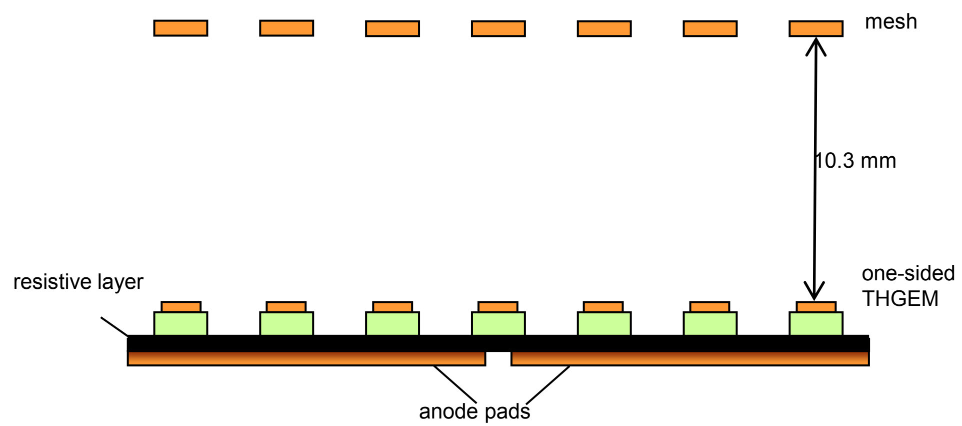


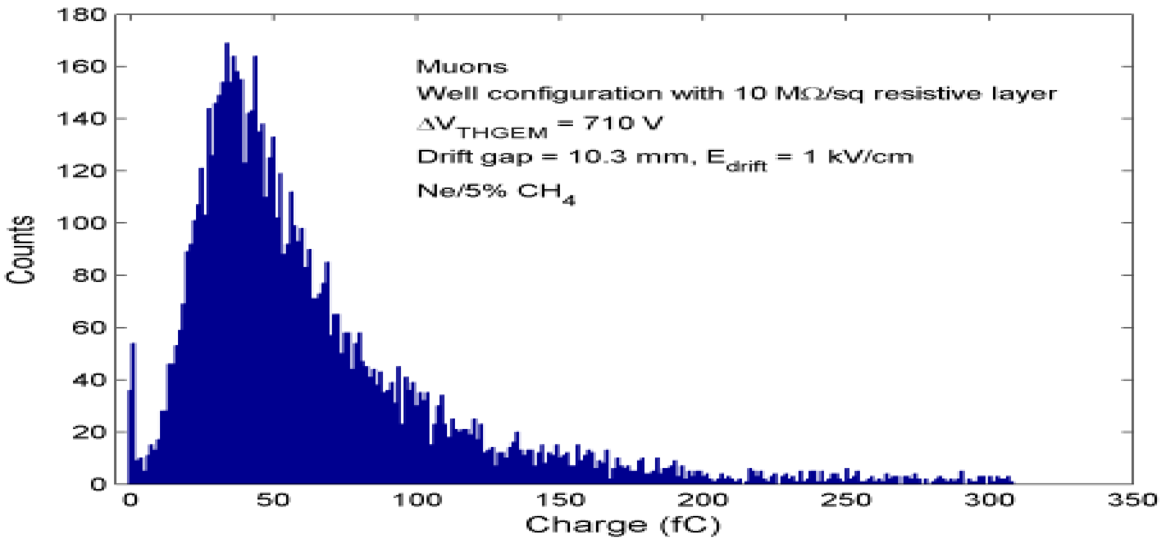


THGEM - A. Breskin et al

CERN TGEM Test-beam detector

"Well" TGEM configuration
- Further tests Summer 2011



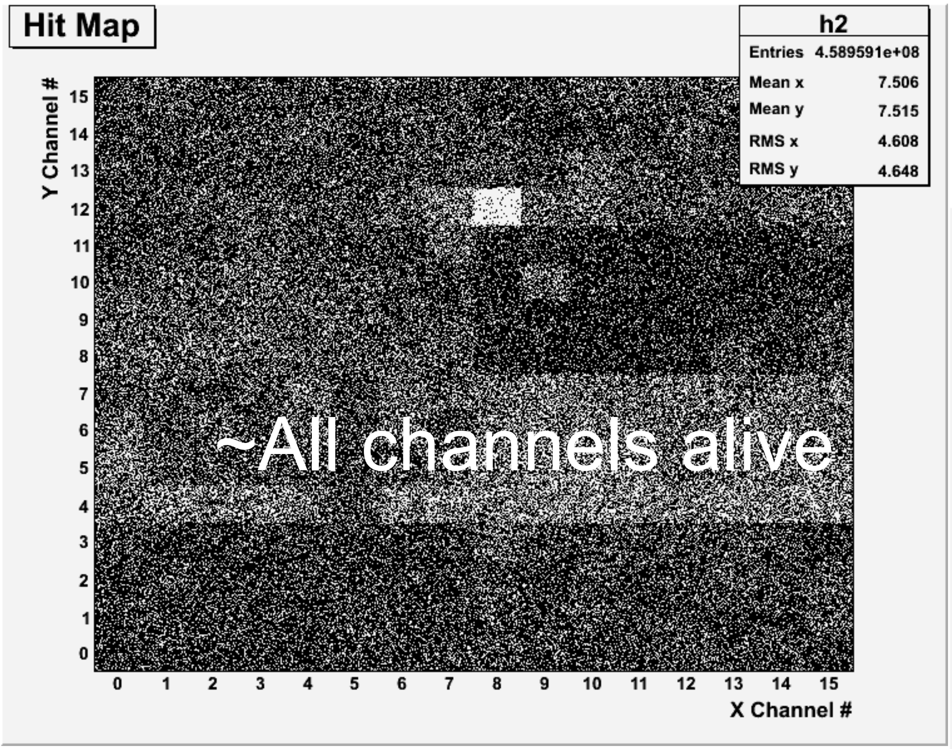


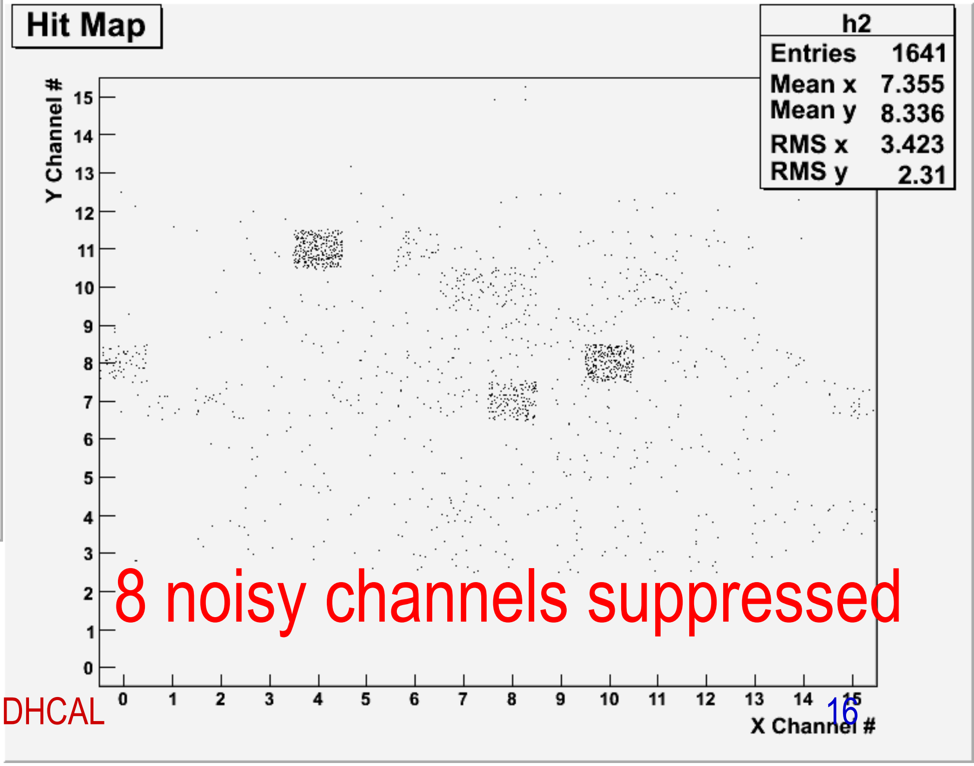
GEM+DCAL

*Many thanks to ANL colleagues! J. Repond, L. Xia, G. Drake, J. Schleroth, J. Smith and H. Weerts.

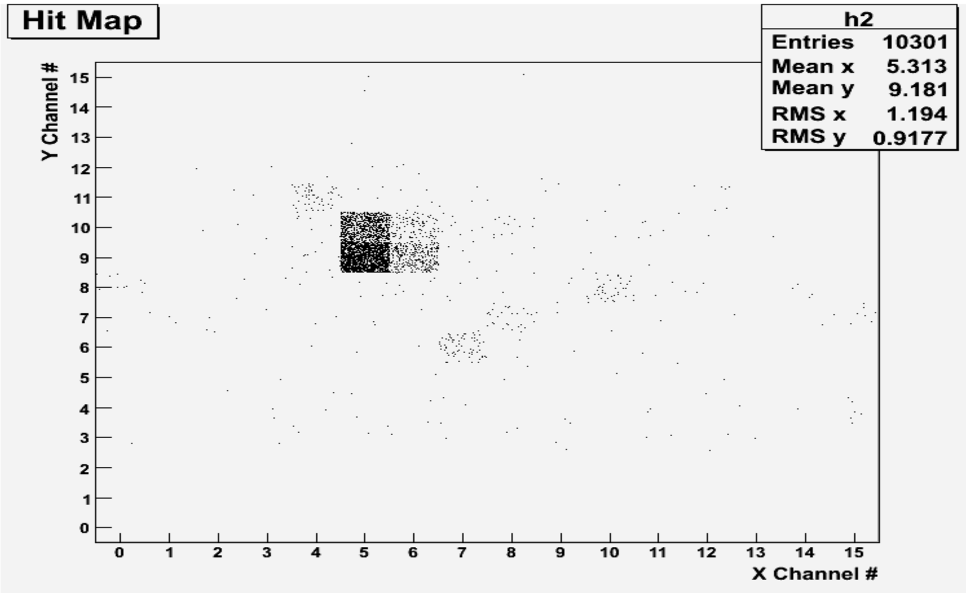
Noise Scan with Threshold at 0 DAC counts

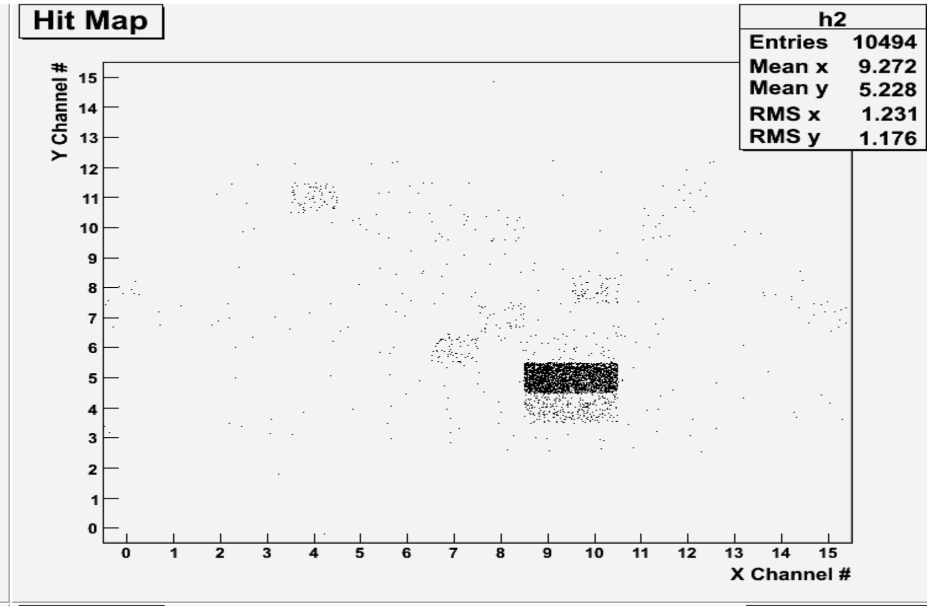
We found that noise rate is very low for the range of threshold 0 – 40ADC, once the 8 noisy channels are suppressed. No significant changes of noise rate increases seen after the suppression.

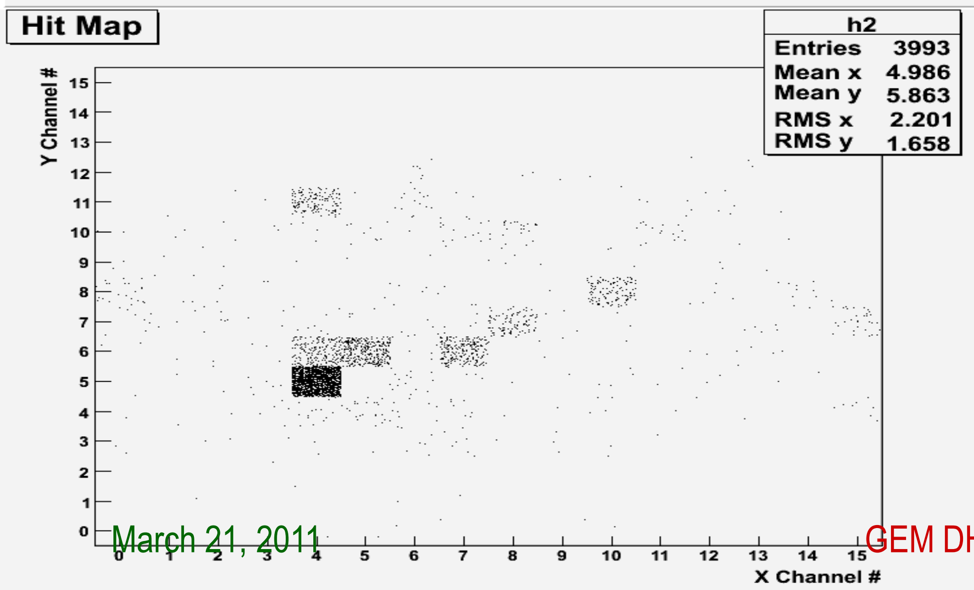


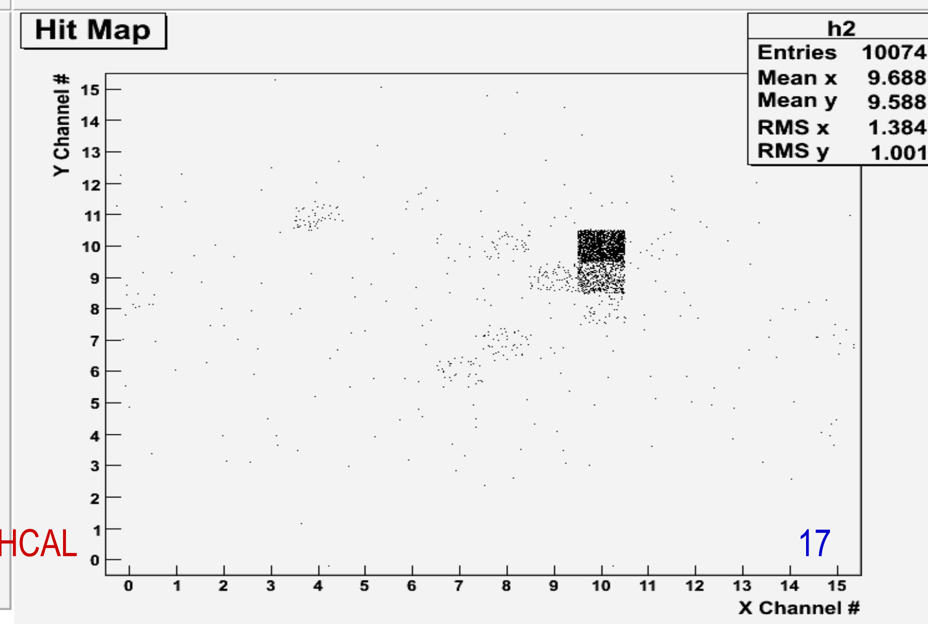


GEM+DCAL, Collimated Fe55 Source in 4 locations
Threshold: 0 DAC, noisy channels suppressed

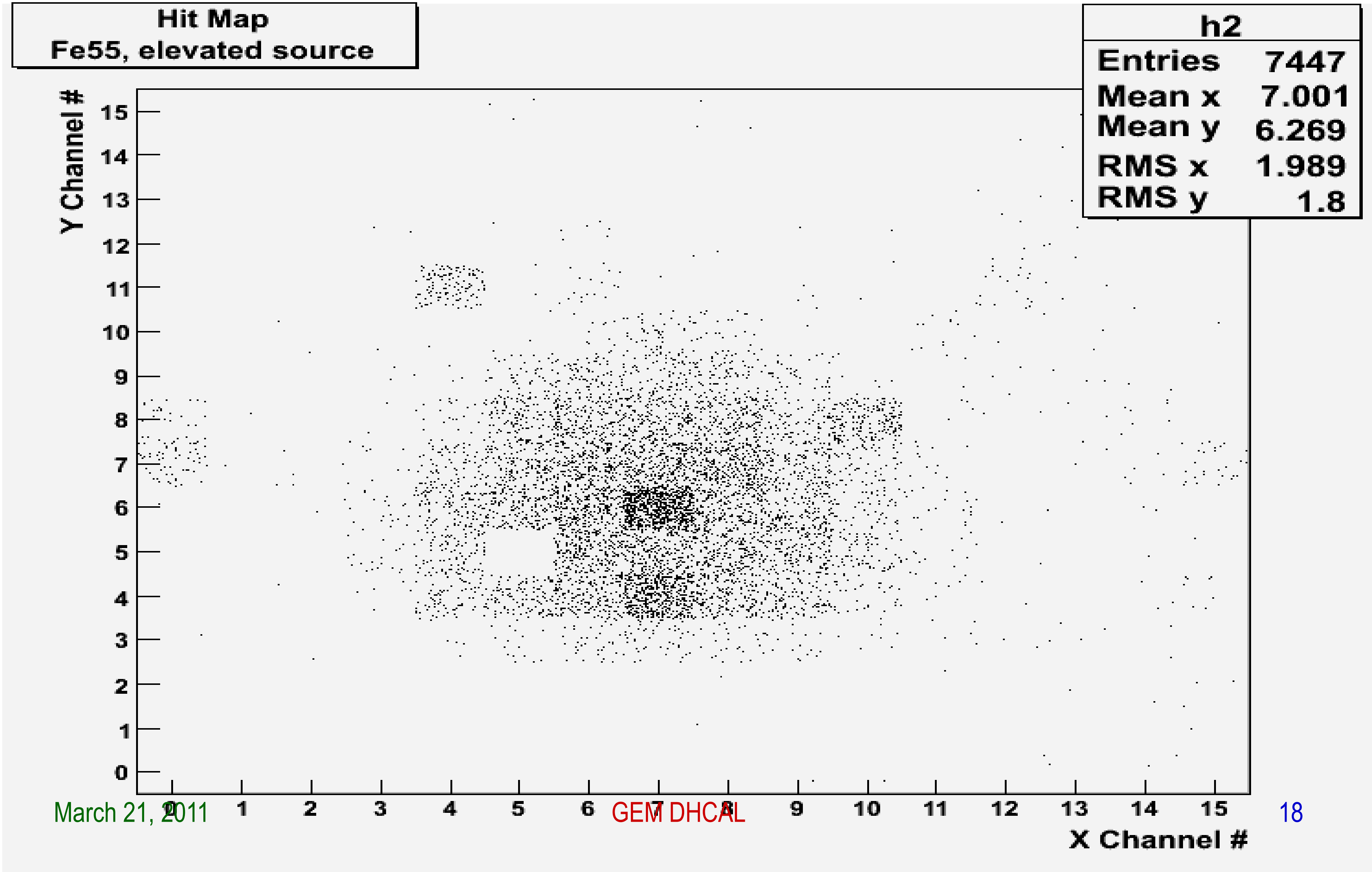




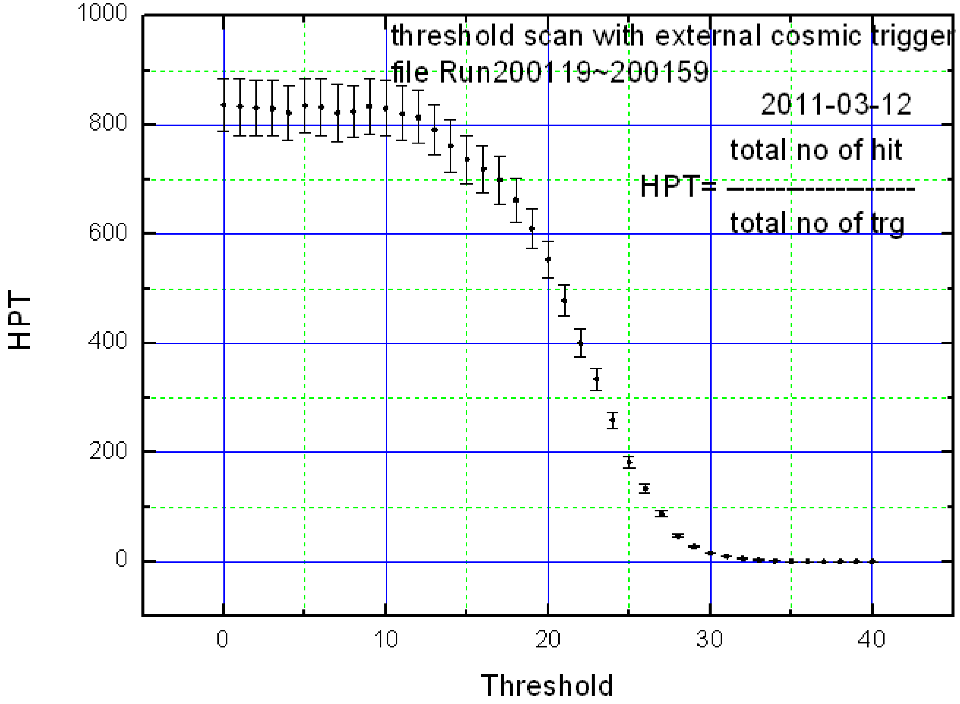


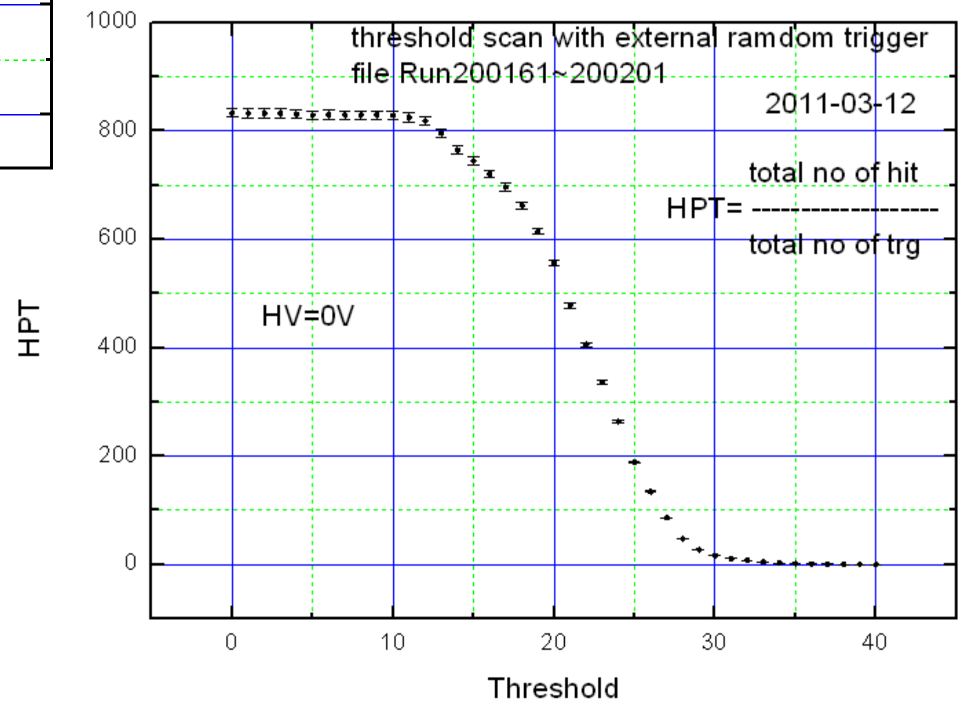


GEM+DCAL, Elevated Fe55 Source
Threshold: 0 DAC, noisy channels suppressed



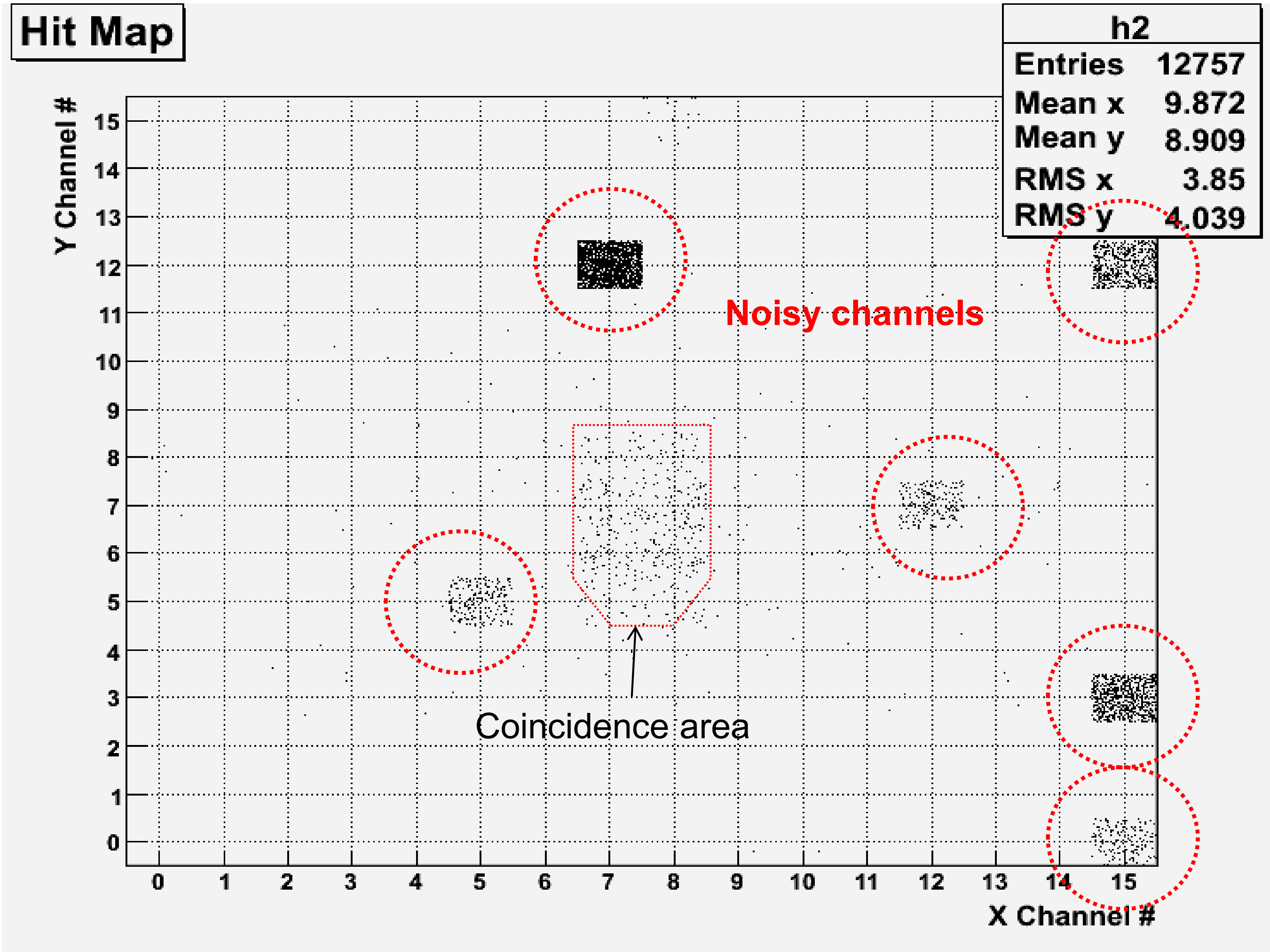
DCAL Threshold Scan, External Trigger



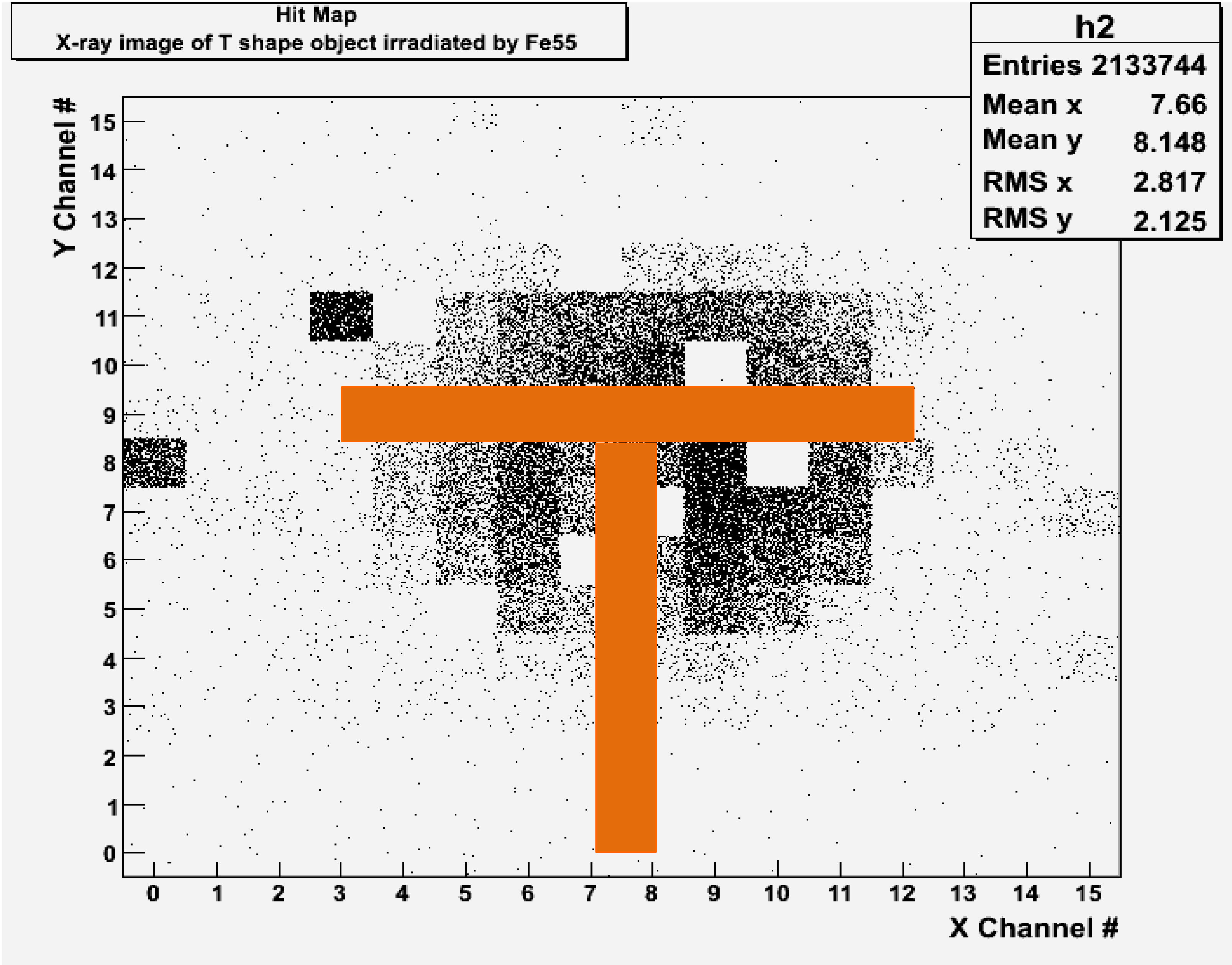


1 DAC count ~ 0.3fC

Cosmic Ray Seen with GEM-DCAL

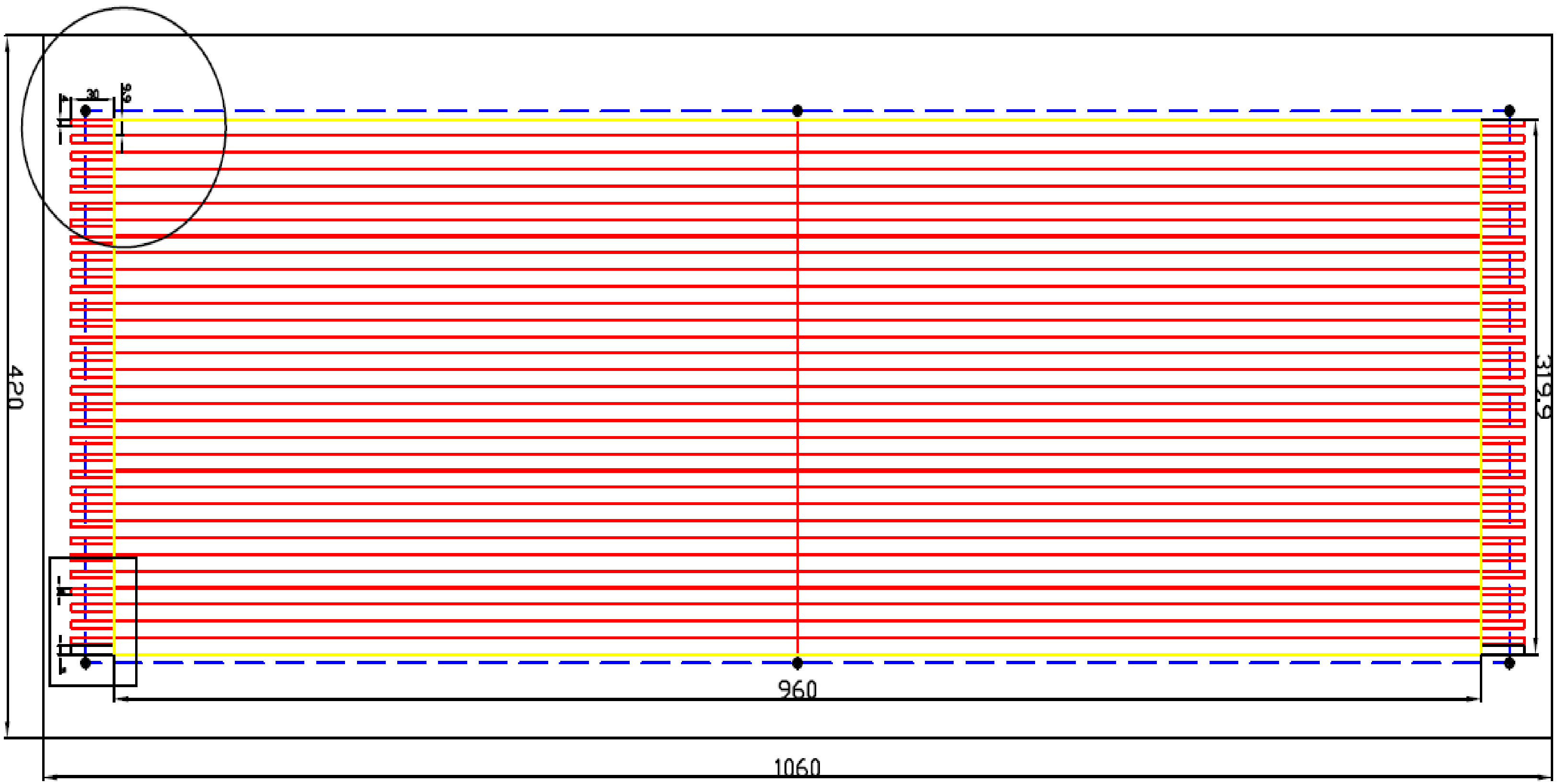


Just for fun, Fe55 Source + X-ray image

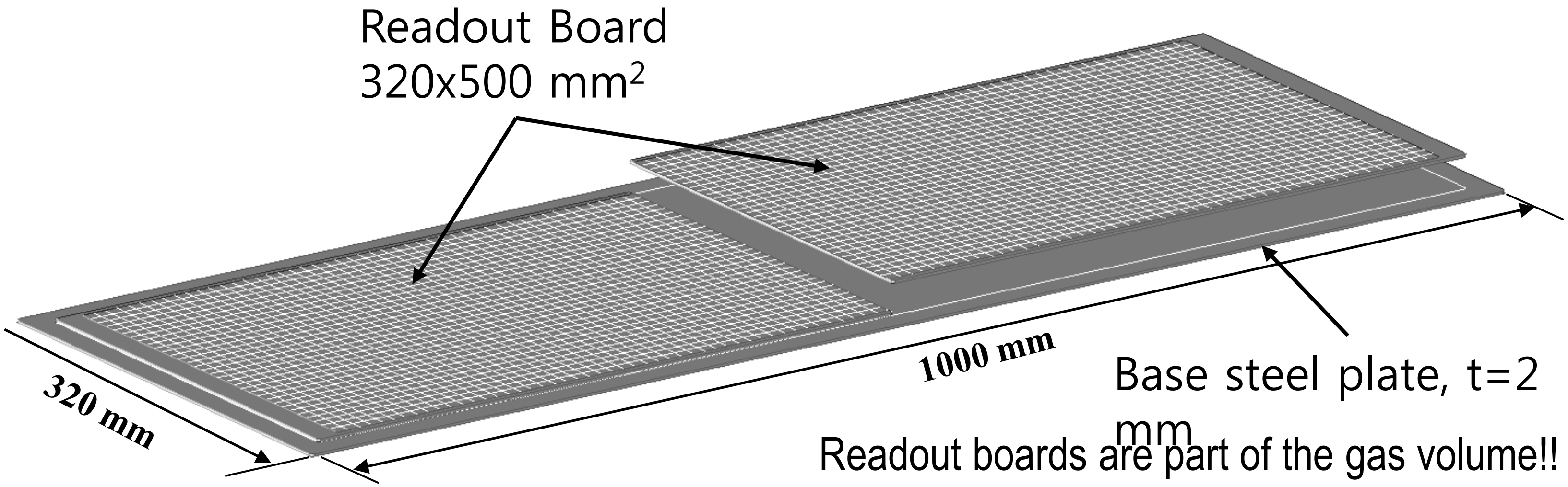


33cmx100cm GEM Foil Design

- Designed to work with DCAL boards
- Active area 940x306 mm^2
- Number of HV sectors = 31 to minimize loss in case of damage
- HV sector dimension= 9.9x950 mm^2



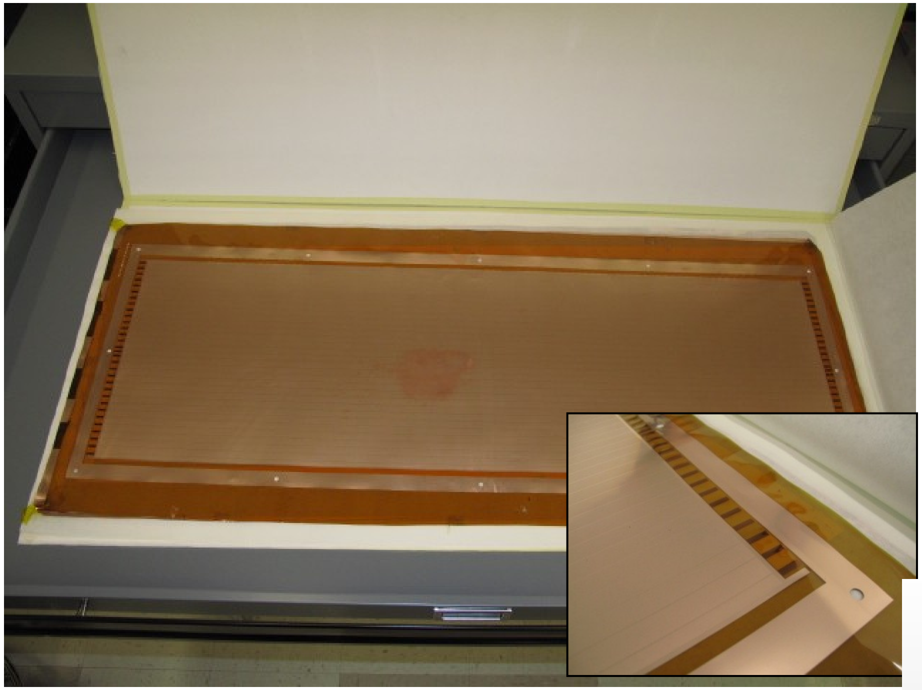
33cmx100cm DHCAL Unit Chamber Construction



Readout boards are part of the gas volume!!
How do we mate these together with minimal dead area?

We might be able to avoid this dead zone by gluing the two boards directly together!!

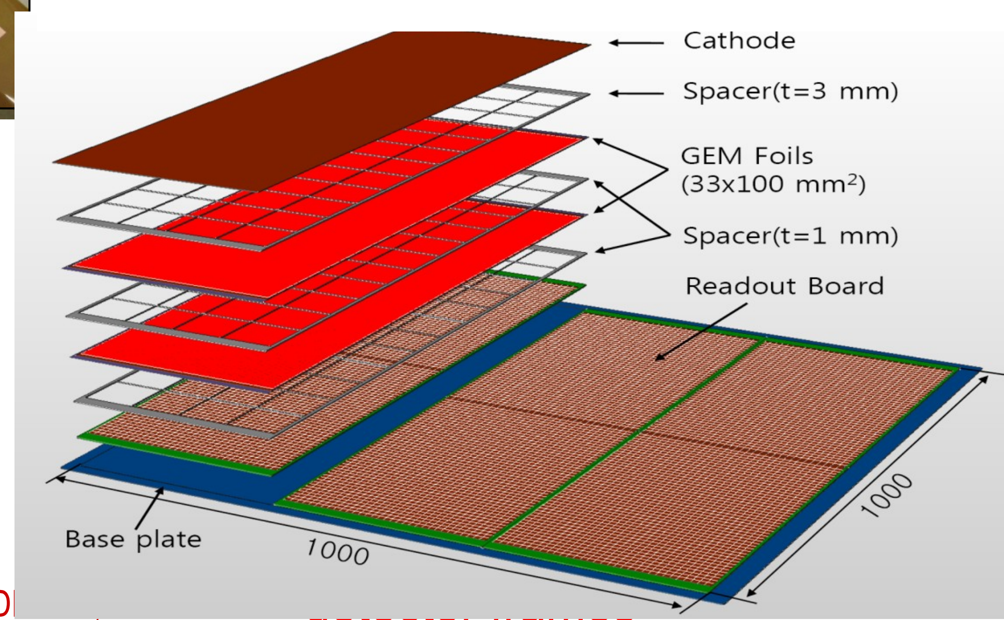
Onward to 100cmx100cm GEM Planes!!



CERN GDD Workshop delivered the first 5 of 33cmx100cm GEM foils in 2010 ➔ Qualification completed!!

Foil Name	$N_{strip-pass}$	$\langle t_{saturation} \rangle$	N_{strip}>2000s	Qualification	Note
LGEM 1	31	1725 s	4	Pass-med	Strips 1, 2, 10 & 23 >2000s
LGEM 2	30	1692 s	3	Pass-med	Strip 22 failed Strips 4, 5 & 29>2000s
LGEM 3	31	1484 s	0	Pass-high	
LGEM 4	31	1491 s	1	Pass-high	Strip 20 >2000 s
LGEM 5	Untested				Free-Delivered broken

Each of the GEM 100cmx100cm planes will consist of three 33cmx100cm unit chambers



GEM DHCAL Plans

- Phase I (Through late 2011) ➔ Completion of 30cm x 30cm characterization and DCAL chip integration
  - Perform beam tests @ FTBF with 30cm x 30cm double GEM chambers, one with KPiX9 and two with DCAL
  - Completion of 33cmx100cm large foil evaluation
  - TGEM chamber beam tests at CERN
- Phase II (late 2011 – early 2013): 33cm x 100cm unit chamber development and characterization
  - Begin construction of 2 unit 100cmx33cm chambers, one with kPiX and one with DCAL
  - Bench test with sources and cosmic rays and beam tests
- Phase III (Early 2013 – mid 2014): 100cmx100cm plane construction
  - Construct 6 unit chambers with DCAL for two 100cmx100cm planes
  - Characterize 100cmx100cm planes with cosmic rays and beams
- Phase IV (Mid 2014 – late 2015): 100cm x 100cm plane GEM DHCAL performances in the CALICE stack
  - Complete construction of five 100cm x 100cm planes inserted into existing CALICE calorimeter stack and run with either Si/W or Sci/W ECALs, and RPC or other technology planes in the remaining HCAL

Summary

- 30cmx30cm GEM prototype chambers
  - kPiX readout: Established good 2D working condition with v7 now working on v9 (512 channel) integration
  - DCAL integration started well ➔ developing understanding ➔ more work!
  - Getting ready for beam test at FTBF in May 2011
- TGEM with KPiX v7 had a beam test at CERN
  - Another with V9 planned this summer at CERN
- 33cmx100cm unit chamber construction proceeding
  - First 5 foils of 33cmx100cm delivered and qualification completed
  - Spacers to be ordered
- Mechanical design being worked out for constructing 33cmx100cm unit chambers and 1mx1m planes for DHCAL testing
- Funding uncertainty makes it difficult to plan for long term