Status of GEM DHCAL

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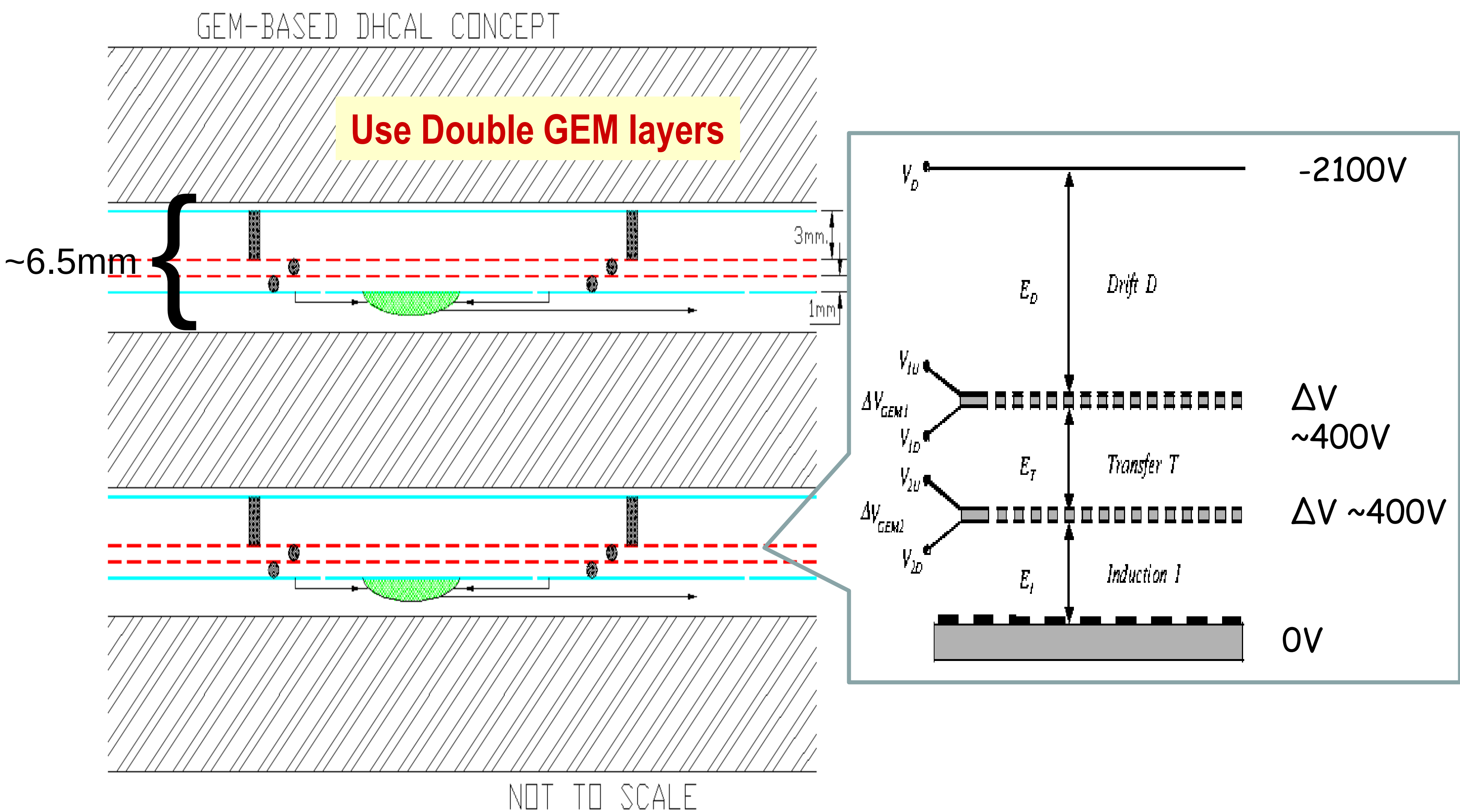
CALICE Collaboration Meeting
Univ. Hassan II, Casablanca

- Introduction
- What has been done?
- 2D readout with KPiX chip
- TGEM Beam Test at CERN
- Large GEM Foil Certification
- Large Chamber Mechanics Design
- 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

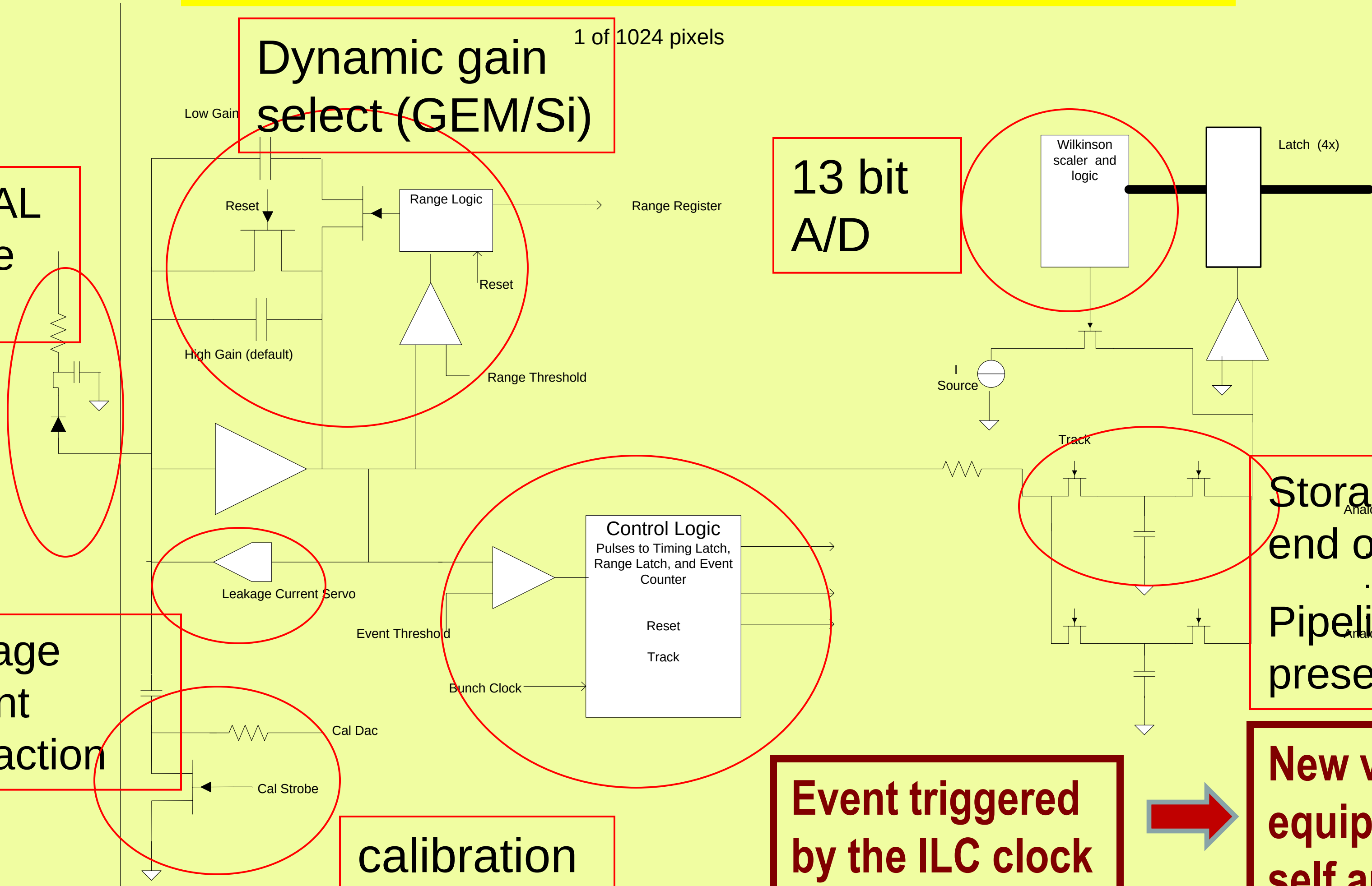
GEM-based Digital Calorimeter Concept



What have been done so far?

- Bench tested with various source and cosmic ray
  - Used QPA02 chip based preamp
  - Verified the signal shape, responses and gain
- Took a beam test at a high flux electron beam
  - Prototype chamber built with 3M's 30cmx30cm GEM
  - Used QPA02 chip based preamp
  - Verified that the chamber can survive
- Took two beam tests at FNAL's MTBF
  - Used QPA02 chip based preamp
  - 8 GeV pion beams and 120GeV proton beams
  - Measured chamber responses, efficiencies and gain

KPiX Analog Readout for GEM DHCAL



Dynamic gain select (GEM/Si)

DHCAL anode pad

13 bit A/D

Storage until end of train.

Pipeline depth presently is 4

Leakage current subtraction

calibration

Event triggered by the ILC clock

New version equipped with self and ext. trigger

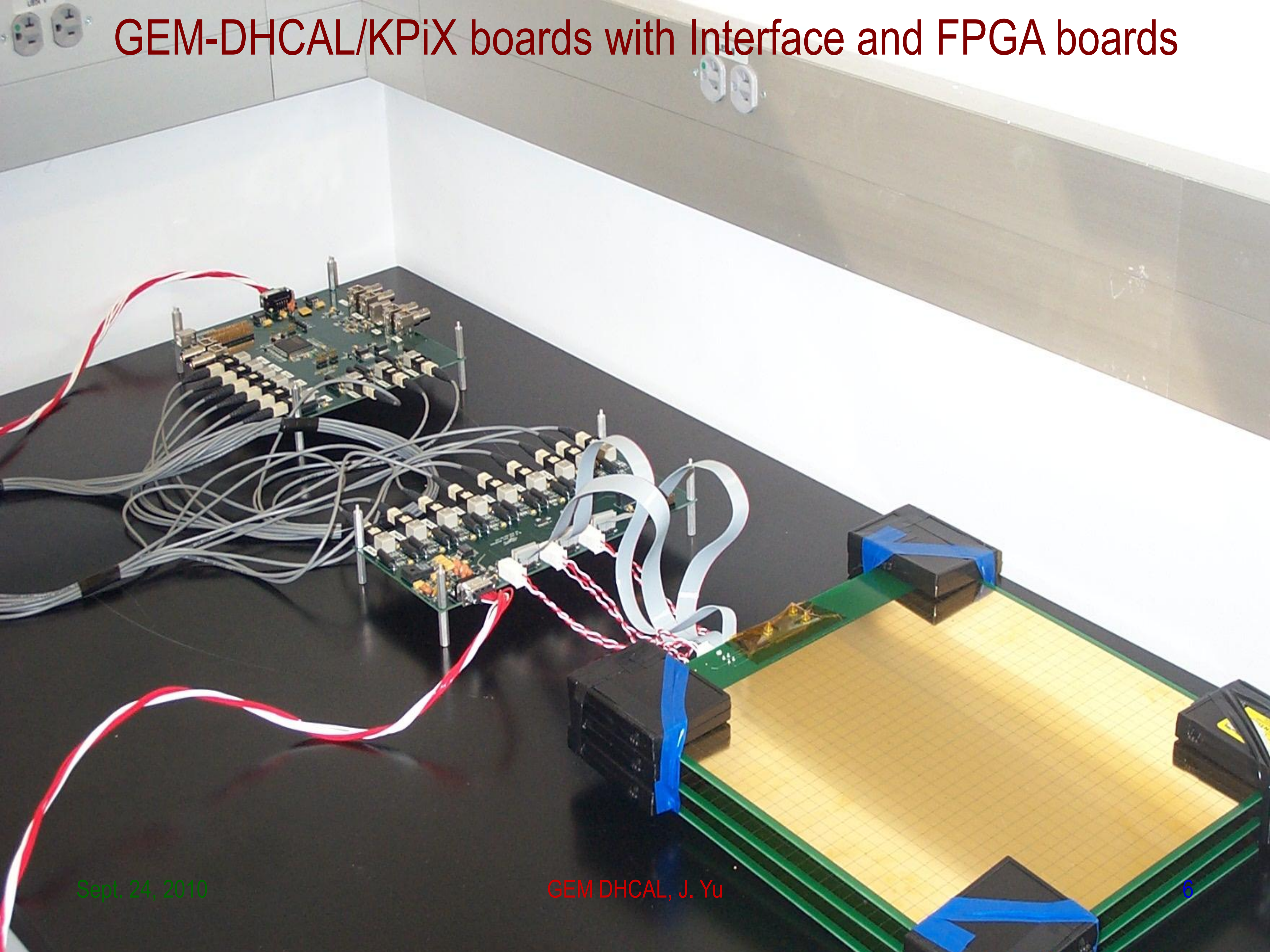
Simplified Timing:

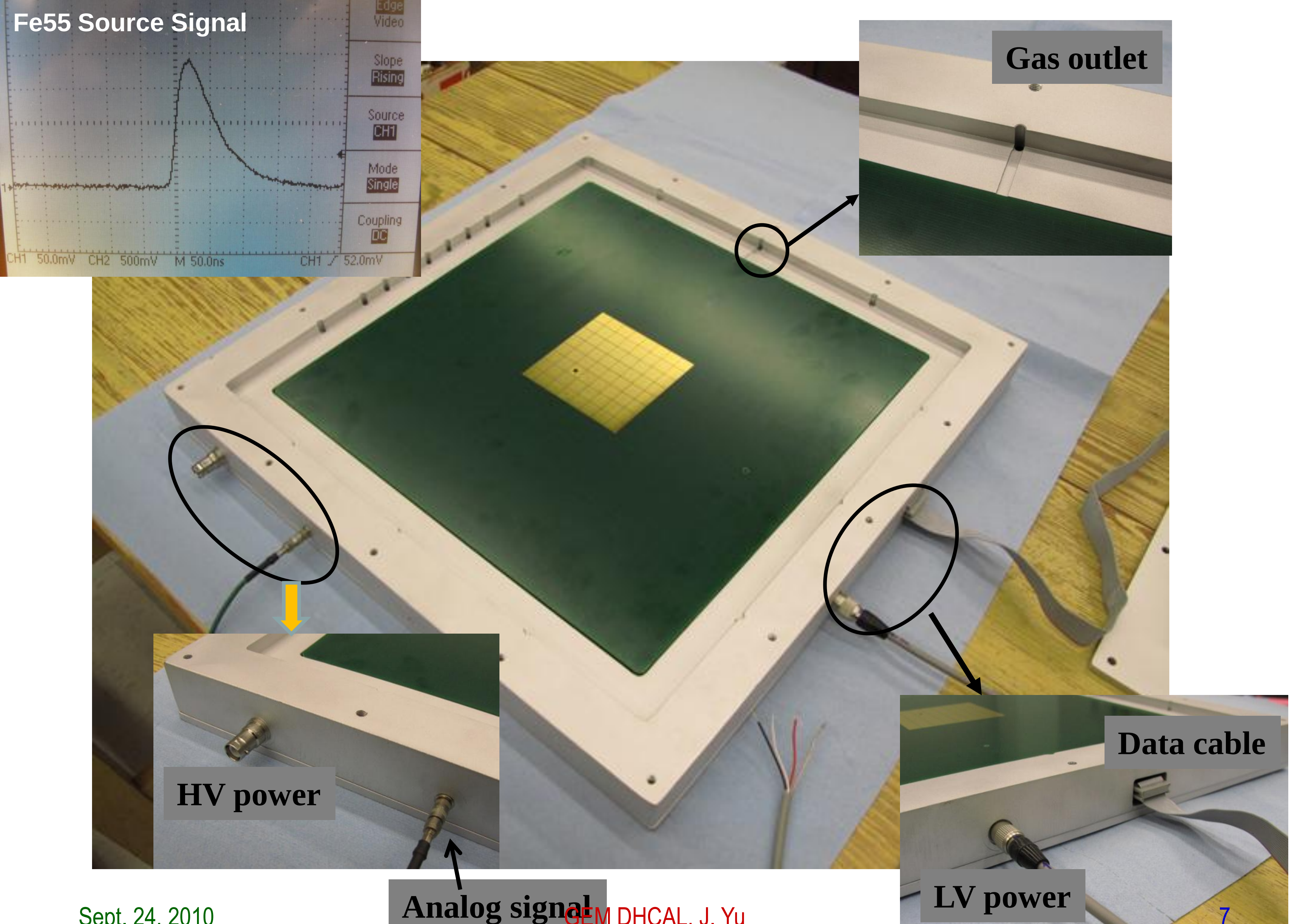
There are ~ 3000 bunches separated by ~300 ns in a train, and trains are separated by ~200 ms.

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
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 outp
The Track signal opens the switch isolating the sample capacitor at T0 + 1 micro s. At this time, the amplitude of the si
Reset is asserted (synched to the bunch clock) . Note that the second capacitor is reset at startup and following an eve
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.

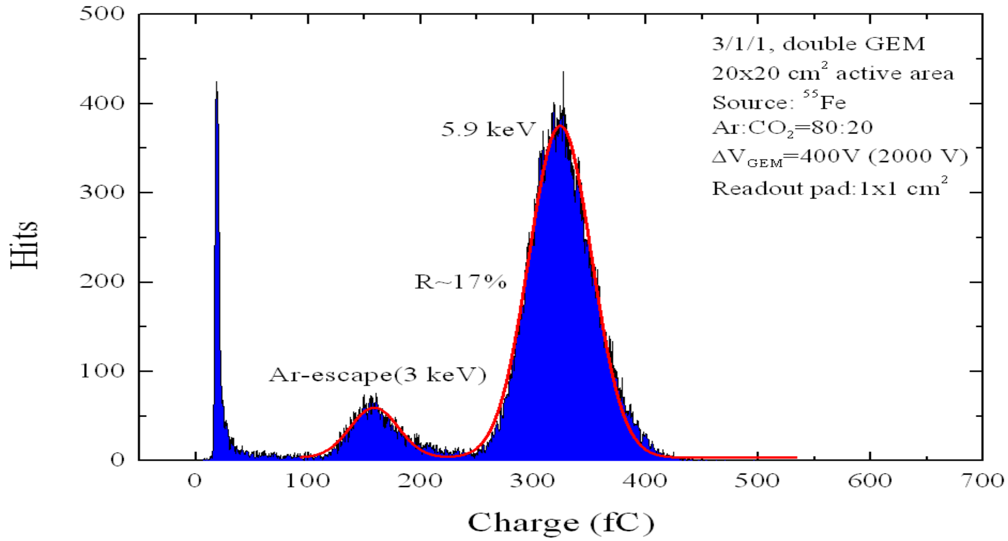
- 1024 channel 13 bit ADC chip
- Developed for Si/W ECAL@ SLAC

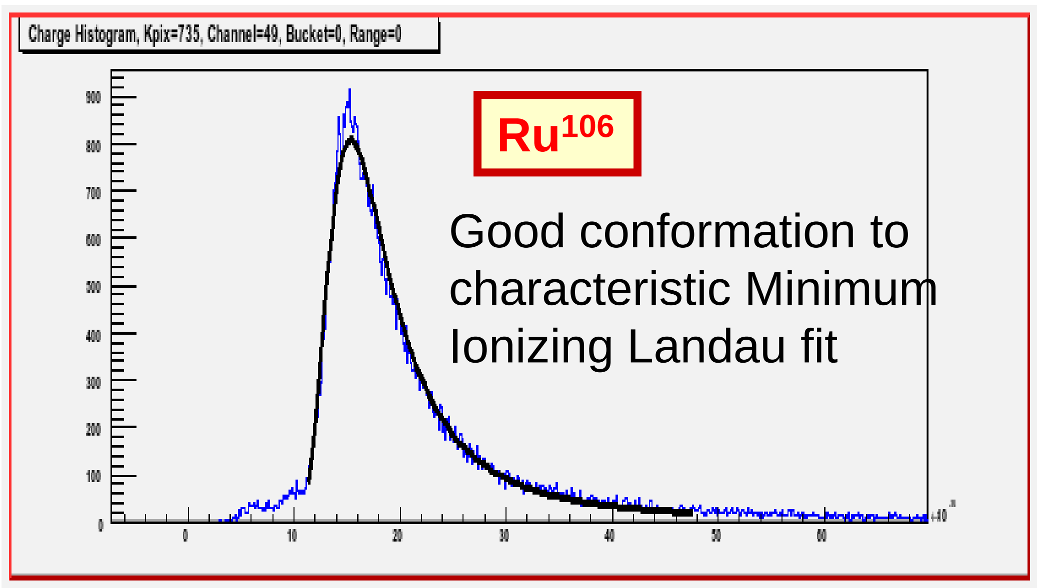
GEM-DHCAL/KPiX boards with Interface and FPGA boards



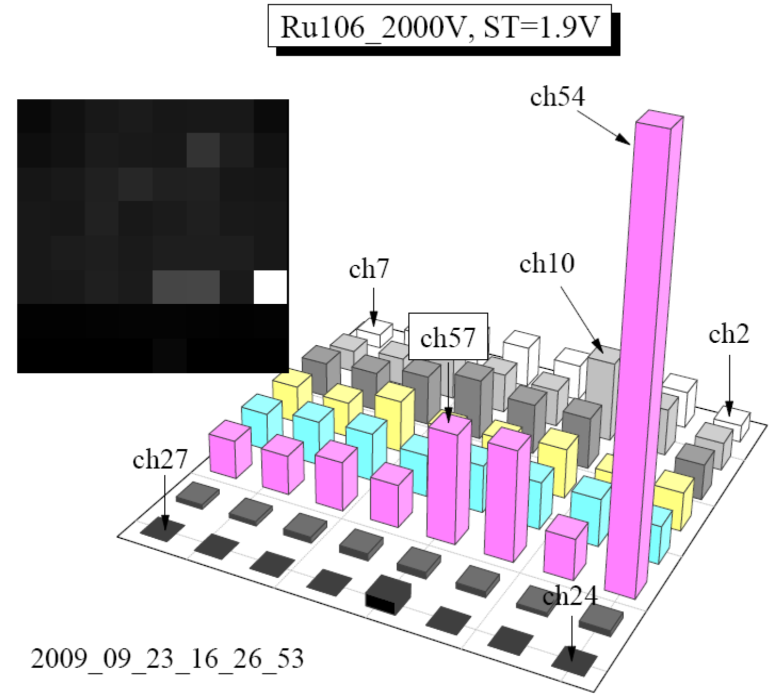

Fe55 Source Signal
Edge
Video
Slope
Rising
Source
CH1
Mode
Single
Coupling
DC
CH1 50.0mV CH2 500mV M 50.0ns CH1 ∕ 52.0mV
Gas outlet
HV power
Analog signal
Data cable
LV power

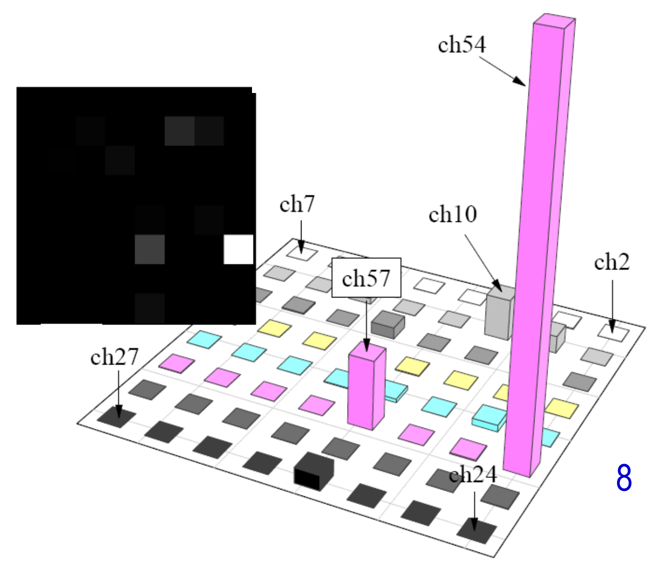
GEM+kPiX Fe^{55} and Ru^{106} Spectra



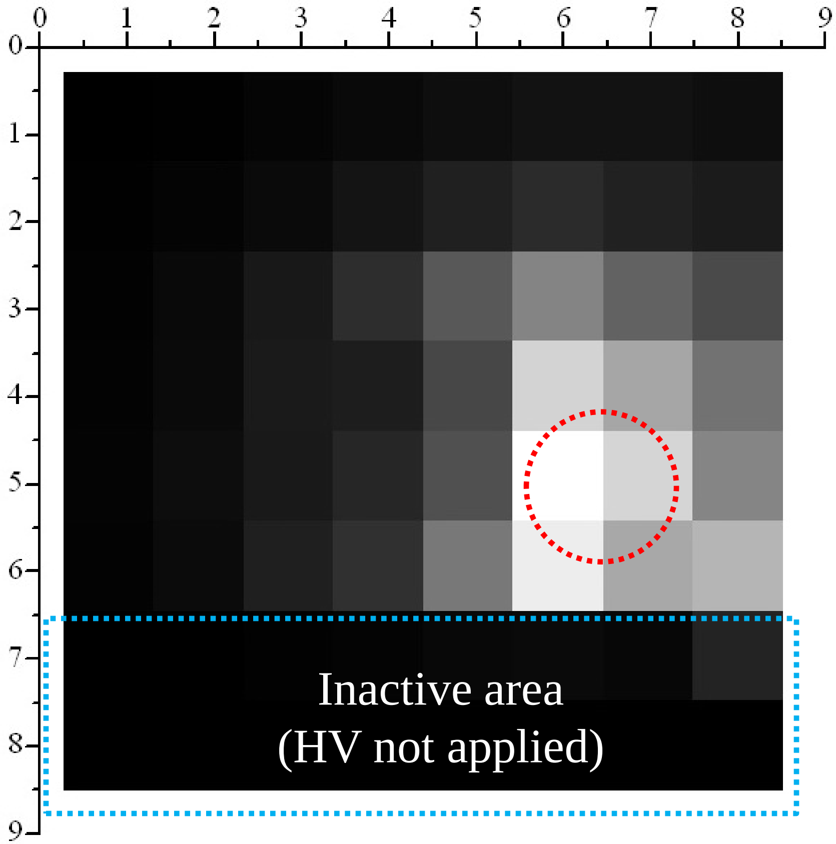


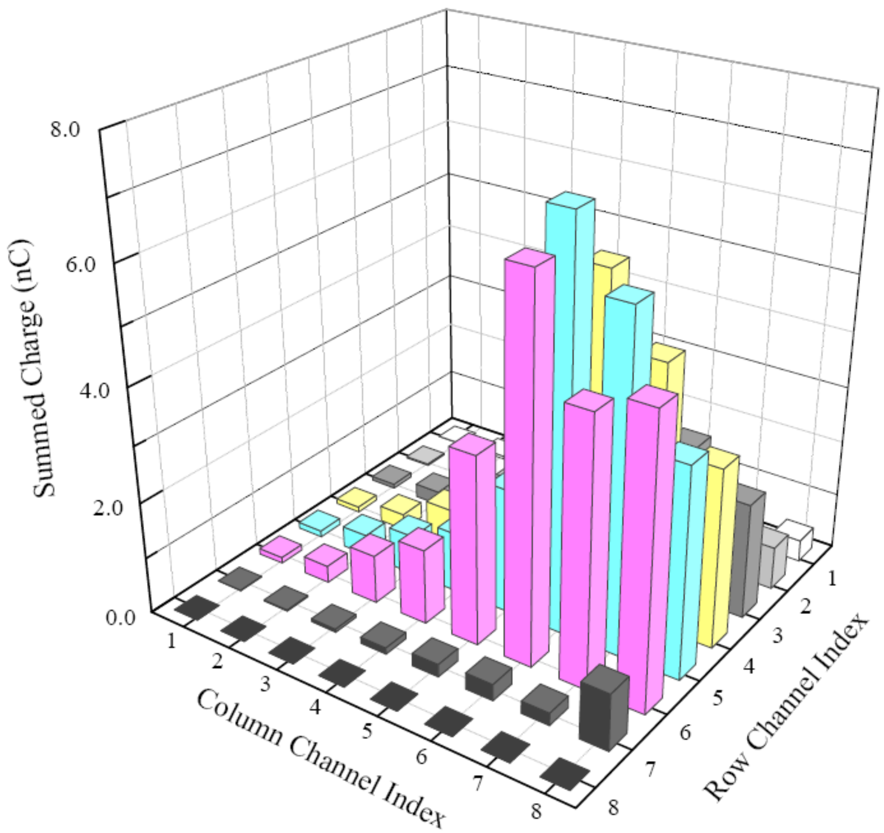
Good conformation to characteristic Minimum Ionizing Landau fit





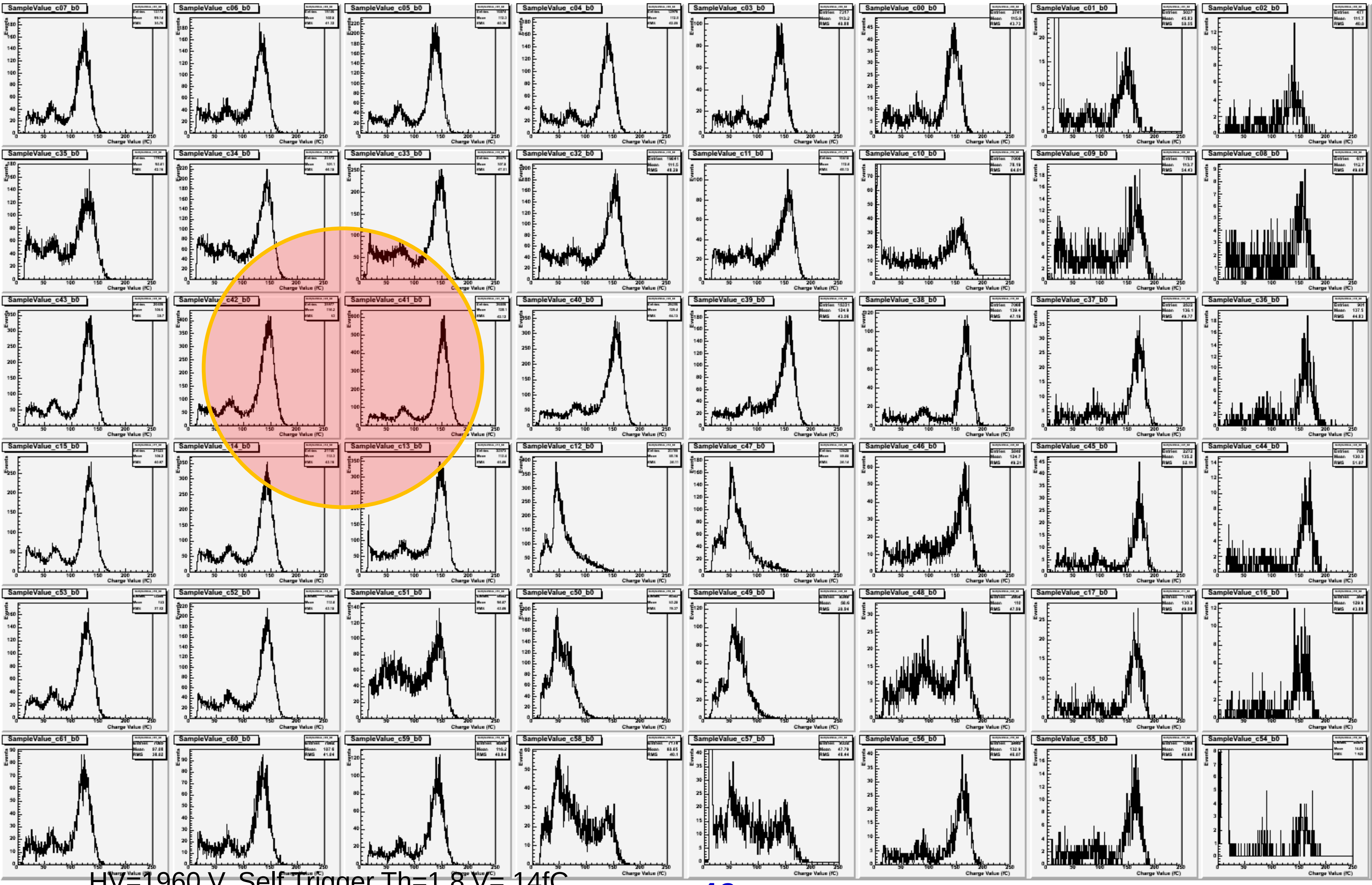
Charge Weighted Lego for Fe55





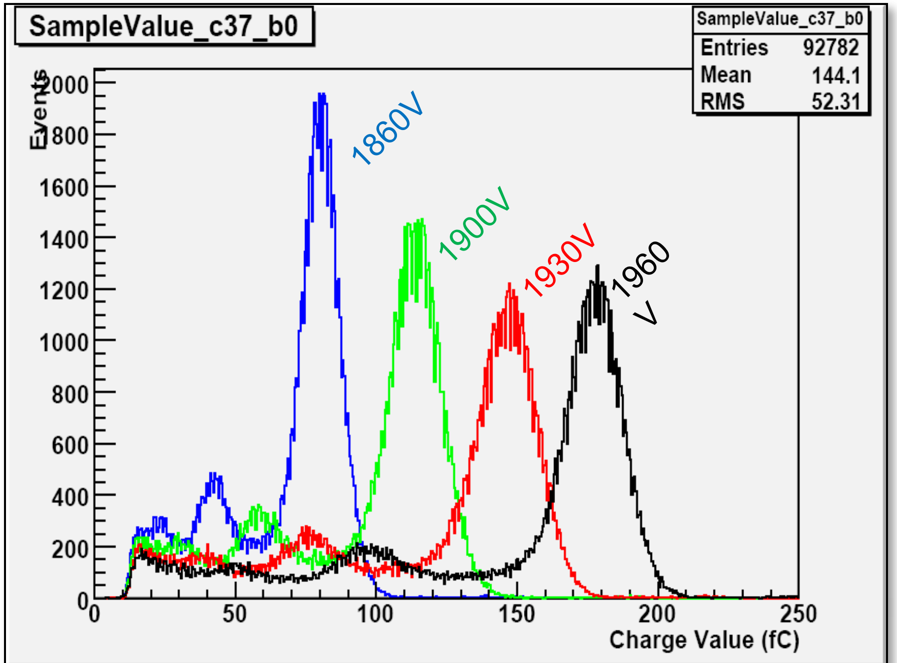
HV=1960 V, Self Trigger Th=1.8 V= 14fC

Histogram Map for Fe55

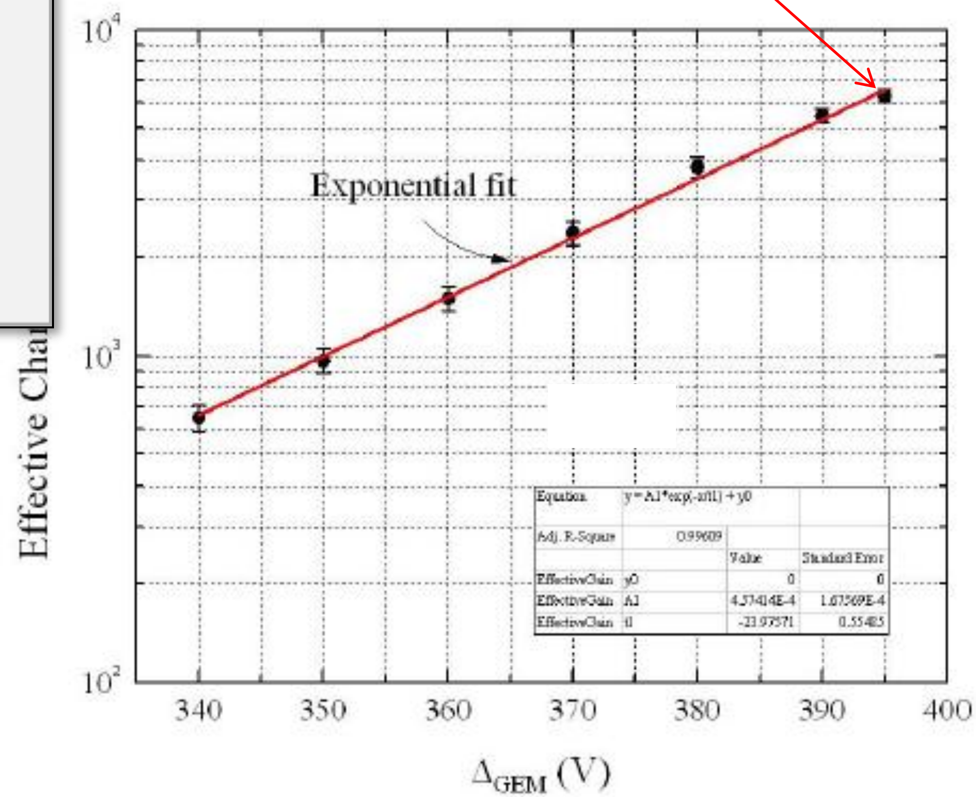


HV=1960 V, Self Trigger Th=1.8 V= 14fC

Gain vs HV

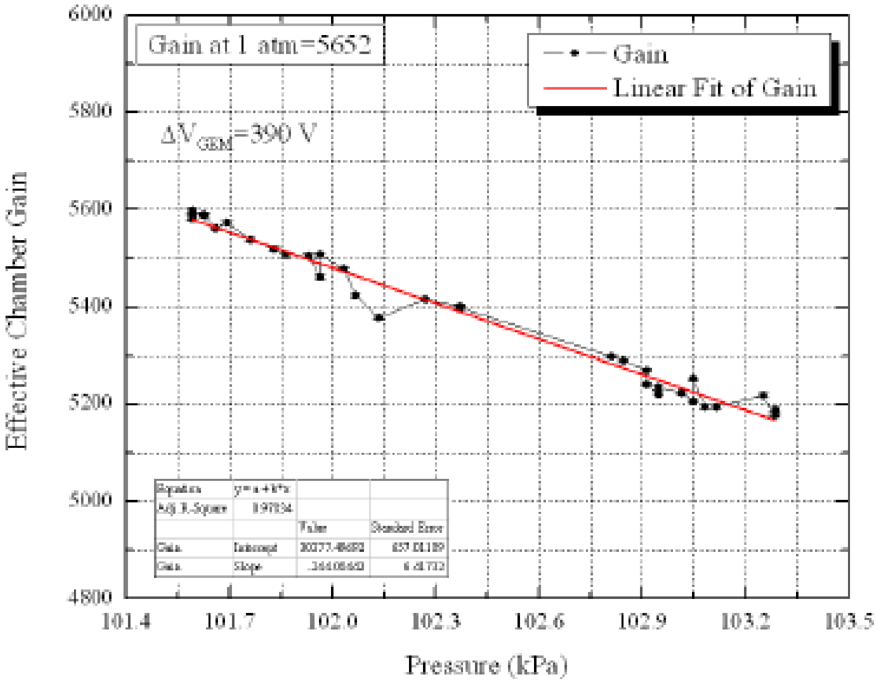


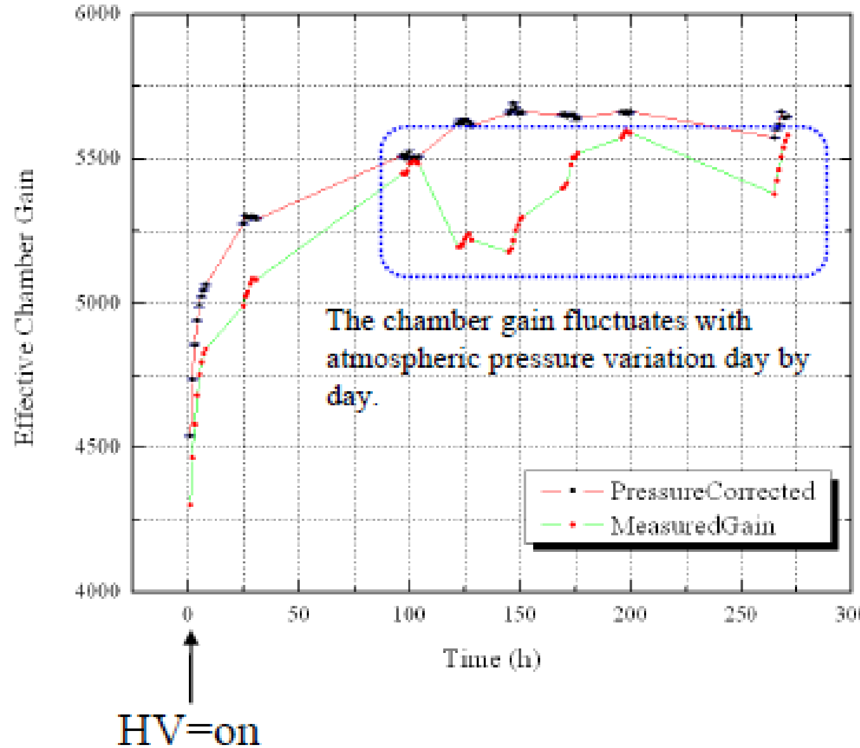
Typical operating point:
Gain ~6000



Pressure Dependence of Gain

HV =1950V (ΔV_{GEM}=390 V)





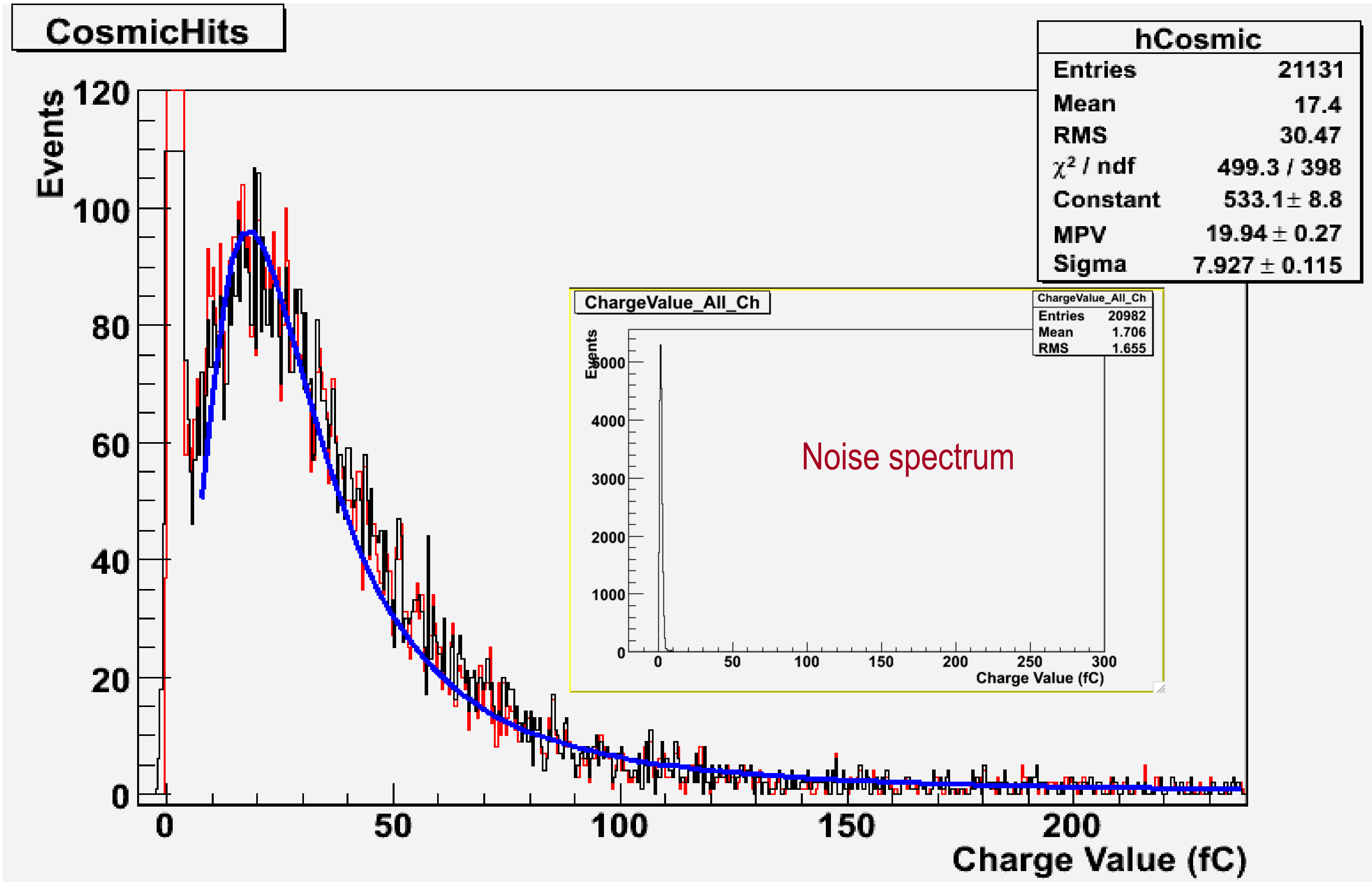
We use an open gas system (gas flows at atmospheric pressure).

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

This pressure change affects the chamber gain.

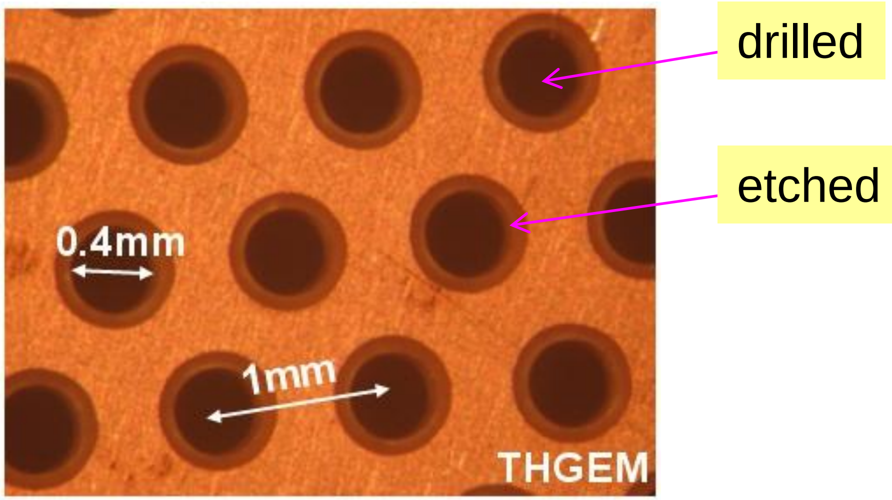
The chamber gains were recalculated to the values at 1 atm.

Cosmic Ray Data with External Trigger – kPiX

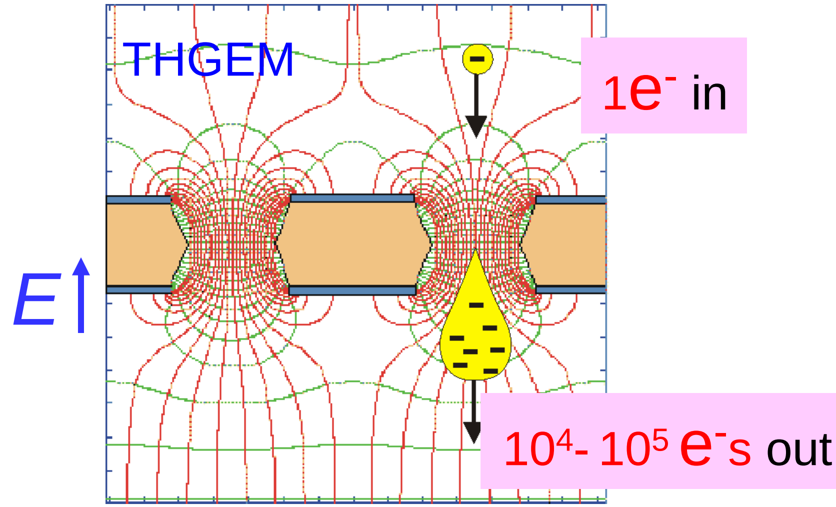


Thick Gas Electron Multiplier (THGEM)

~ 10-fold expanded GEM



Thickness 0.5-1mm



Double-THGEM: 10-100 higher gains

SIMPLE, ROBUST, LARGE-AREA

➔Intensive R&D
➔Many applications

- PCB Based GEM ➔ Cost effective
- 0.5 – 1mm thick PCBs
- Drilled 0.4mm holes with 1mm pitch
- Expected to have higher gain per GEM
- 10cmx10cm tested, up to 30cmx30cm produced

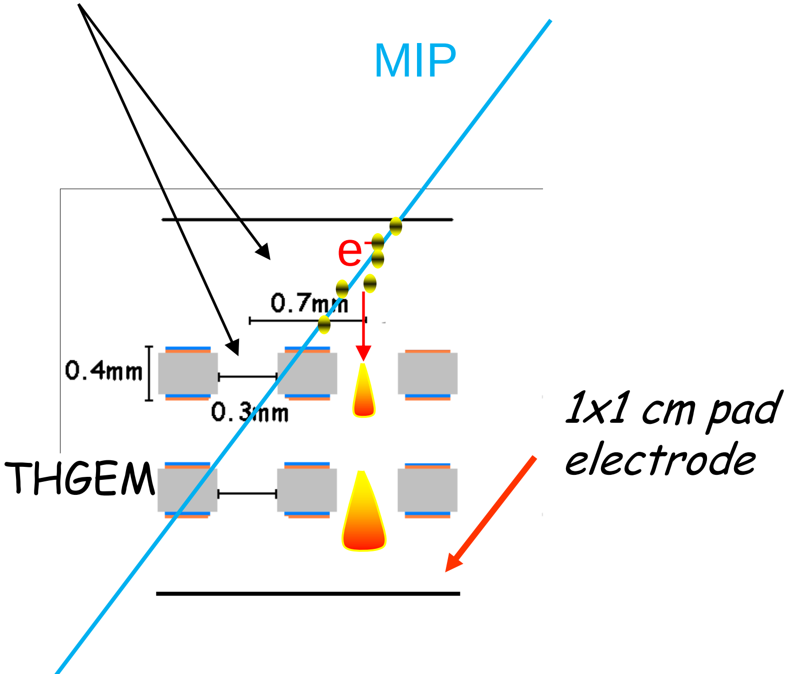
THGEM Recent review
NIM A **598** (2009) 107

Muons w Double-THGEM KPIX or Q-preamp/MCA

August 2010

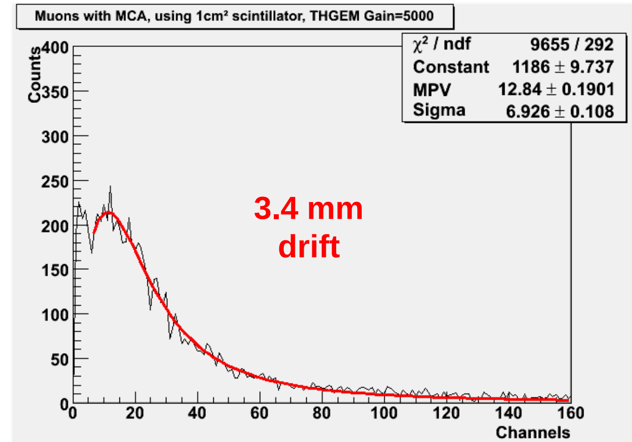
Here we had:

0.5mmholes/1mm space



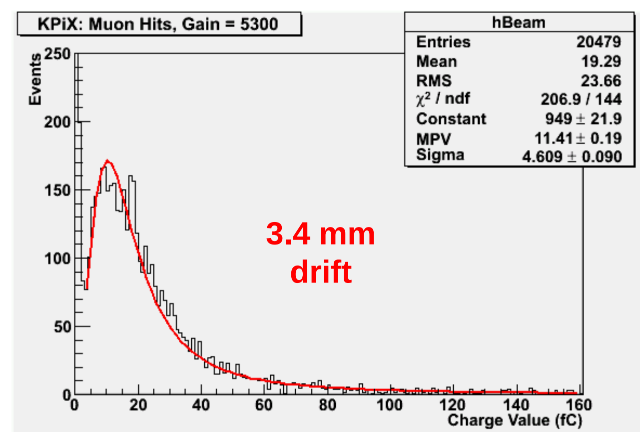
KPIX or Q-preamp/MCA

2-THGEM BEAM TESTS with Q-preamp/MCA



First **Q-preamp** spectrum with muons.
Double-THGEM, Ne/5%CH4; Average gain 5000
Trigger: large scint + ~1cm2 scint

2-THGEM BEAM TESTS with KPIX

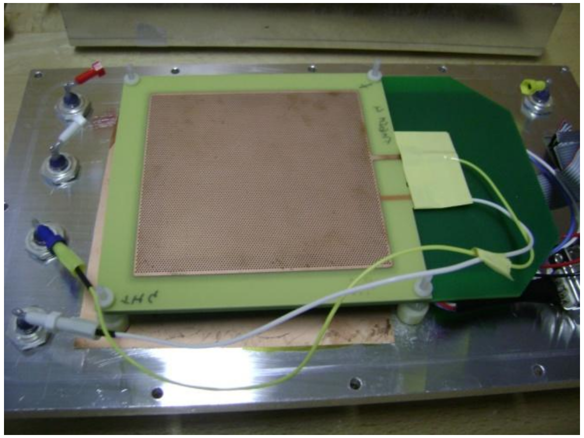


First **kpix** spectrum with muons.
Double-THGEM, Ne/5%CH4; Average gain 5300

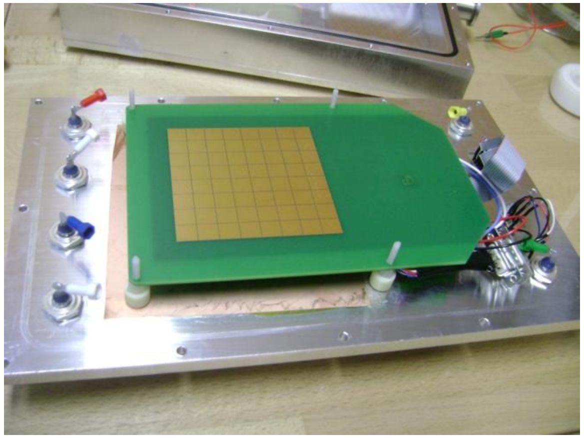
Trigger: large scint + ~1cm2 scint

CERN TGEM test-beam detector

10x10 cm2 THGEM



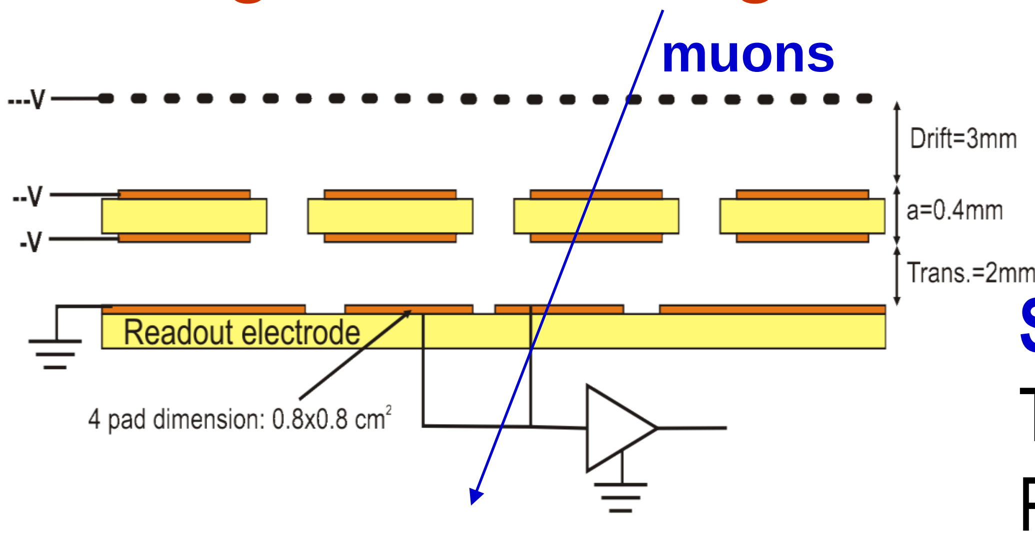
64 pads electrode with KPiX behind

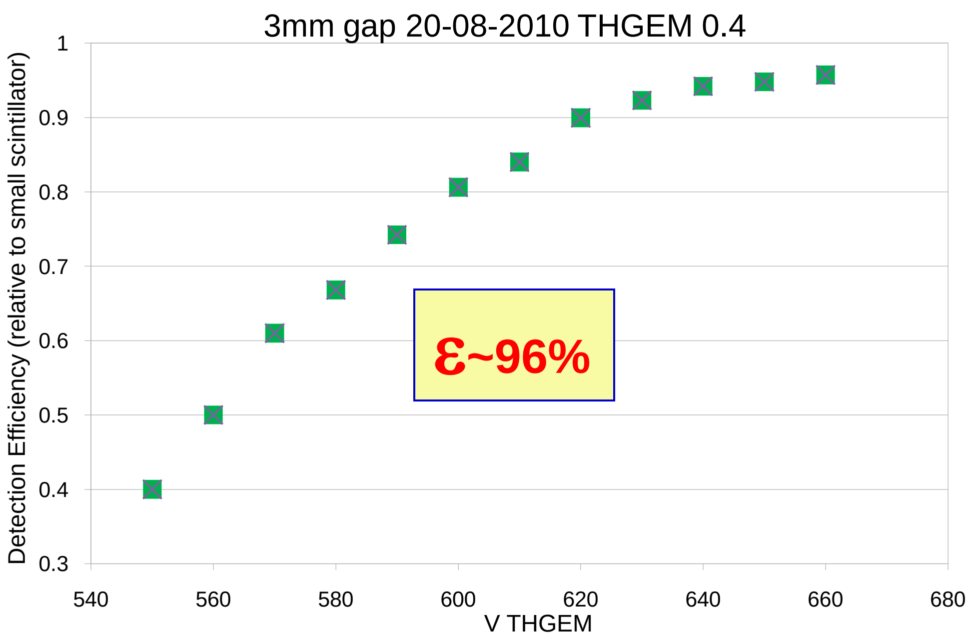


Installation at CERN

20 August 2010: Single-THGEM with muons

August 2010





Single THGEM 10x10cm

Thickness: 0.4 mm

Particles: muons

Gas: Ne/5%CH_4

Drift gap: **3 mm**

Charge preamp/MCA

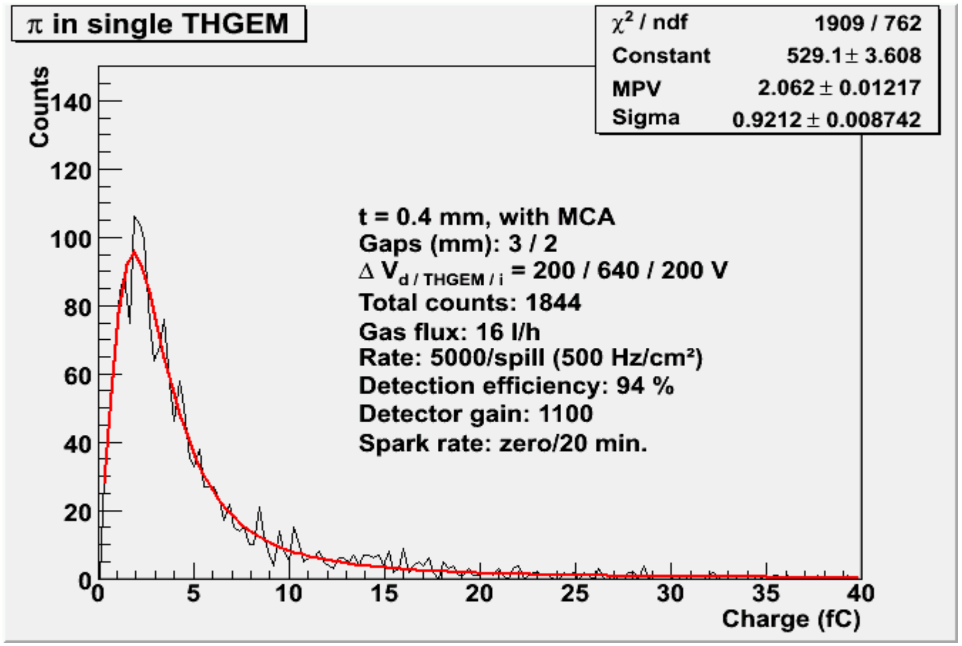
0.5 cm^2 trigger

Efficiency: ~95%

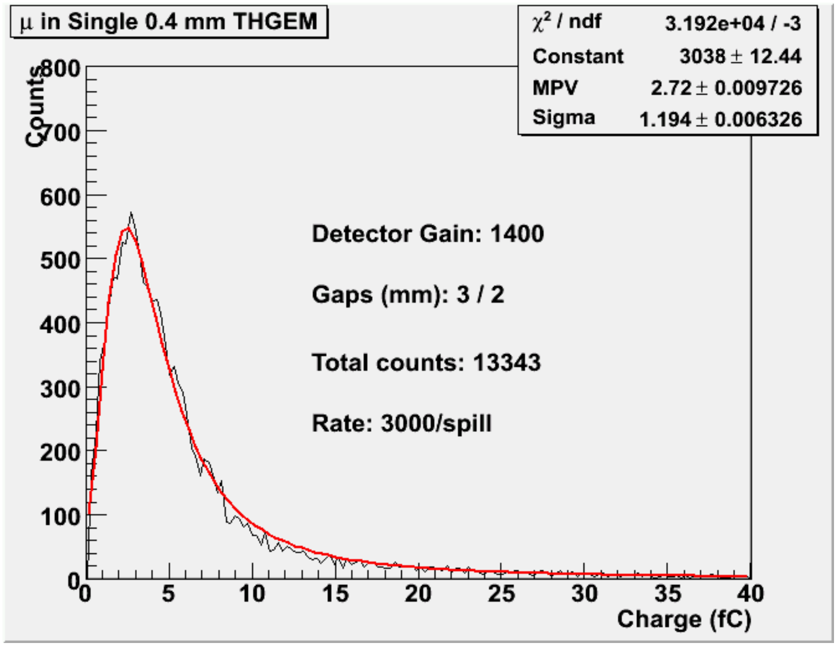
THGEM - A. Breskin et al

Single-THGEM/3mm drift gap

PIONS

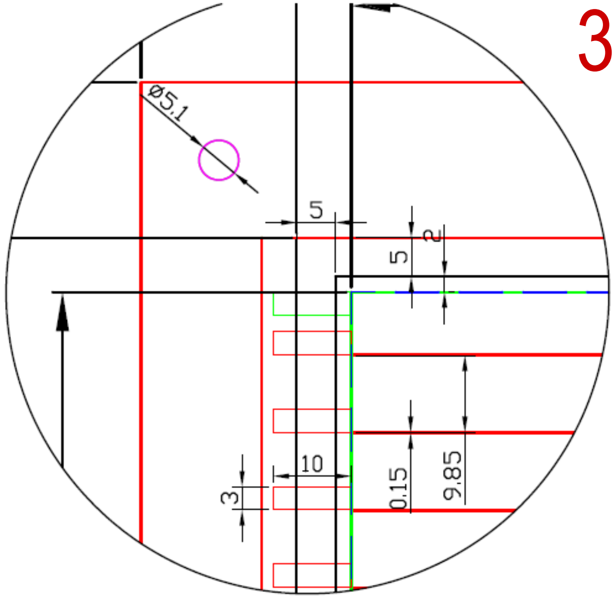


MUONS



Measured very low discharge rates even with pions

33cmx100cm GEM Foil Design



Designed to work with DCAL boards

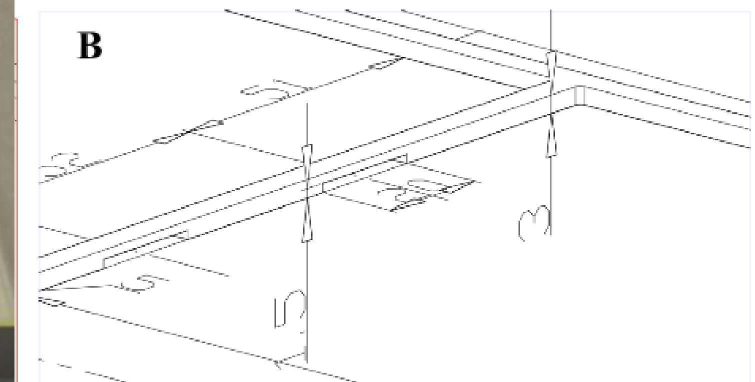
Active area 468x306 mm^2

Number of HV sectors = 32x2=64

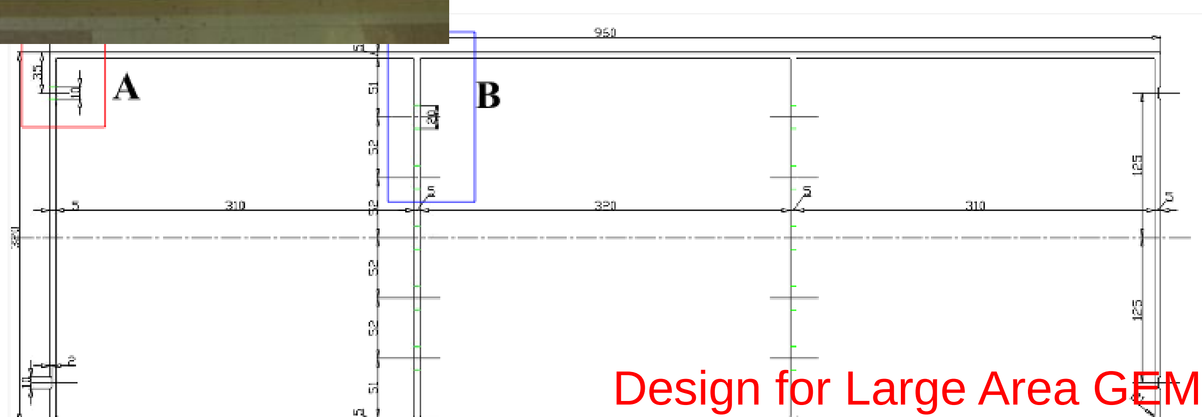
HV sector dimension= 9.9x479.95 mm^2

33cmx100cm Large Area GEM

First 5 of 33cmx100cm GEM foils delivered early July, 2010

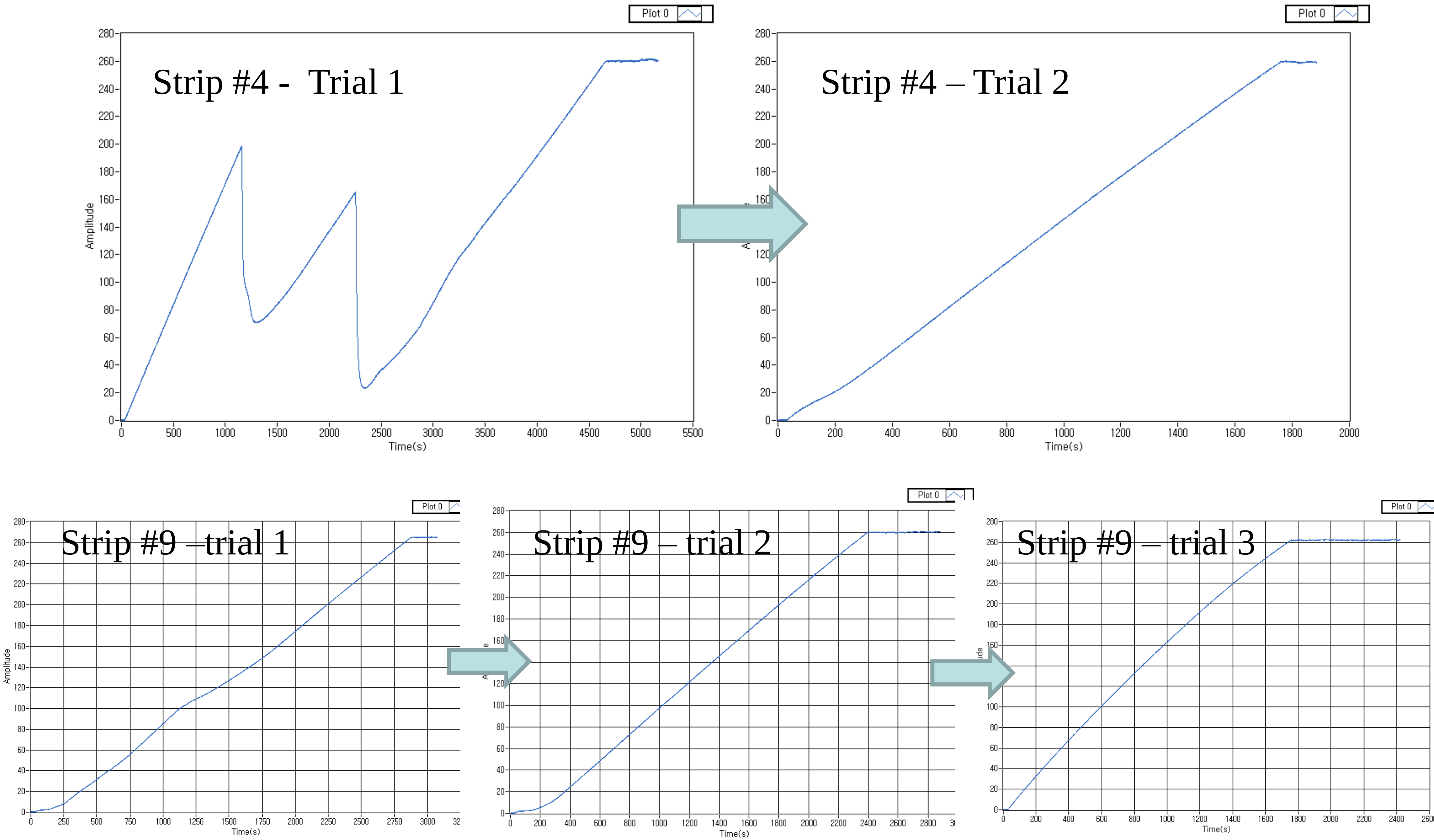


Spacer for drift gap

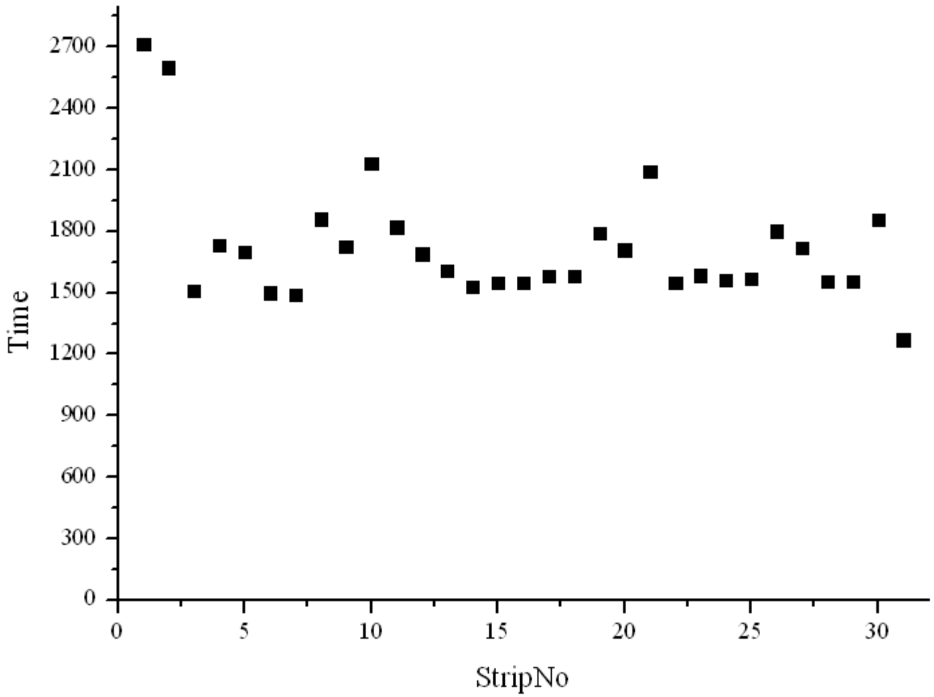


Design for Large Area GEM detector frames

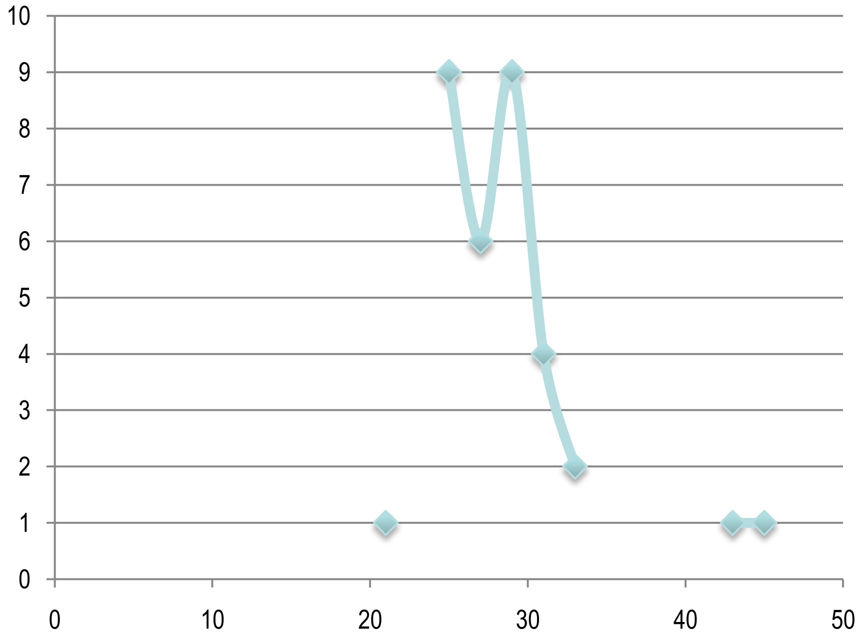
Temporal Behavior of Strips



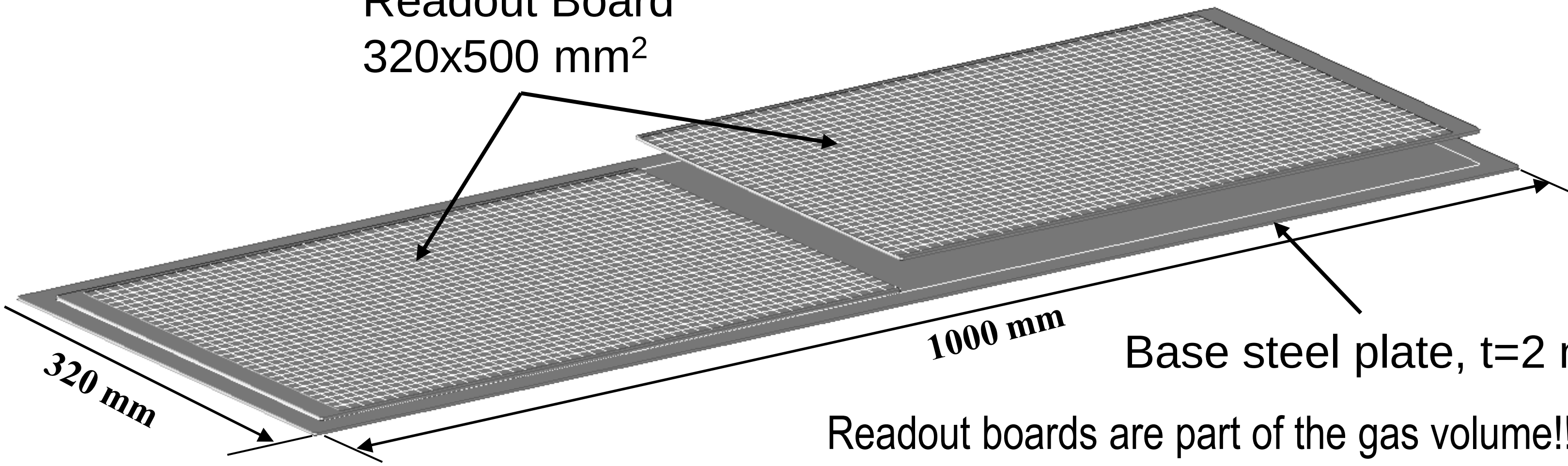
Times to reach full charge saturation



- Indication of general health of each strip
- Most of them reaches full charge up in 30min
- Two strips took 15min longer
- Resistance of each strip is over 260GOhms!!



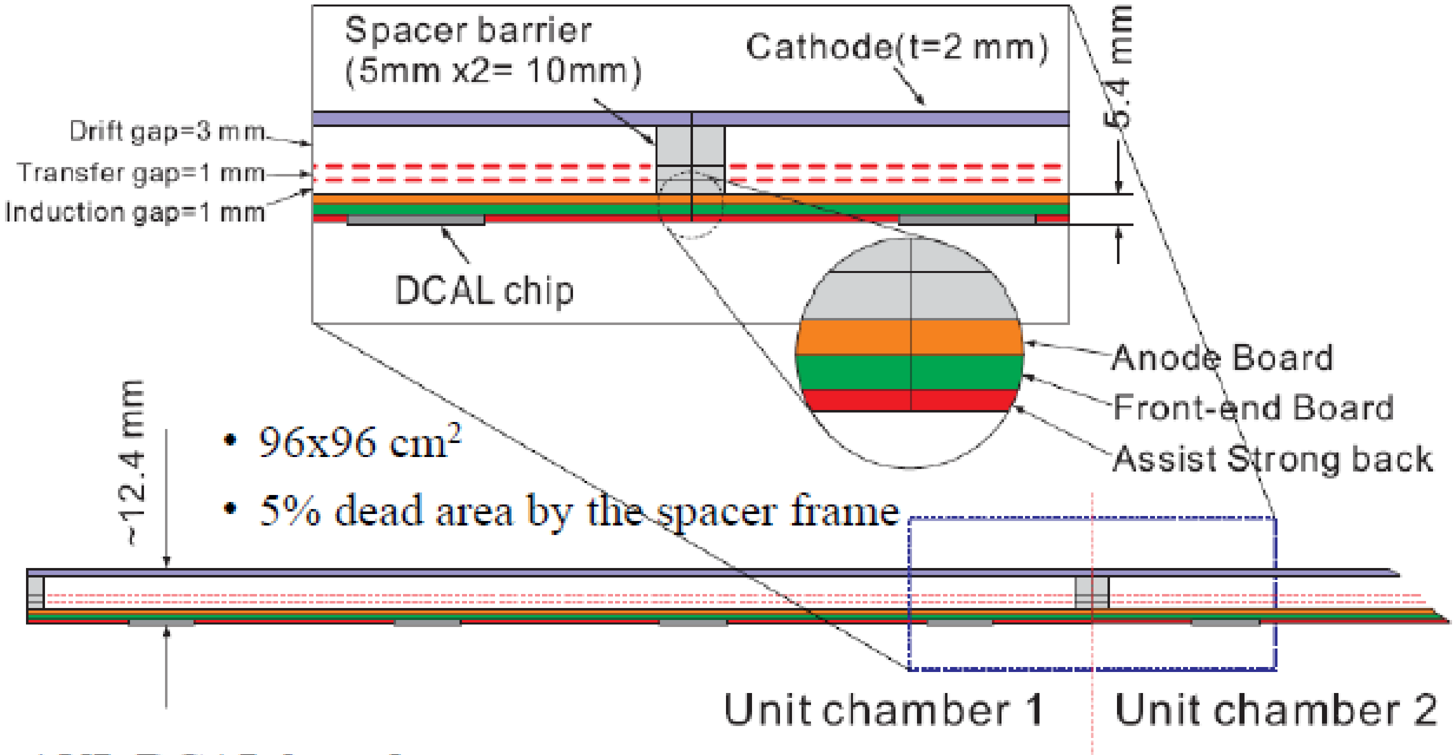
33cmx100cm DHCAL Unit Chamber Construction



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

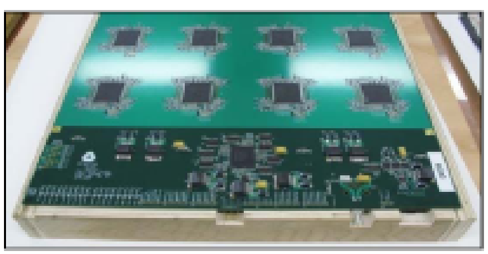
We might be able to avoid this dead zone by gluing the two boards directly together!!

UTA's 33cm x 100cm DHCAL Unit Chamber



- 96x96 cm^2
- 5% dead area by the spacer frame

➢ **ANL DCAL board**

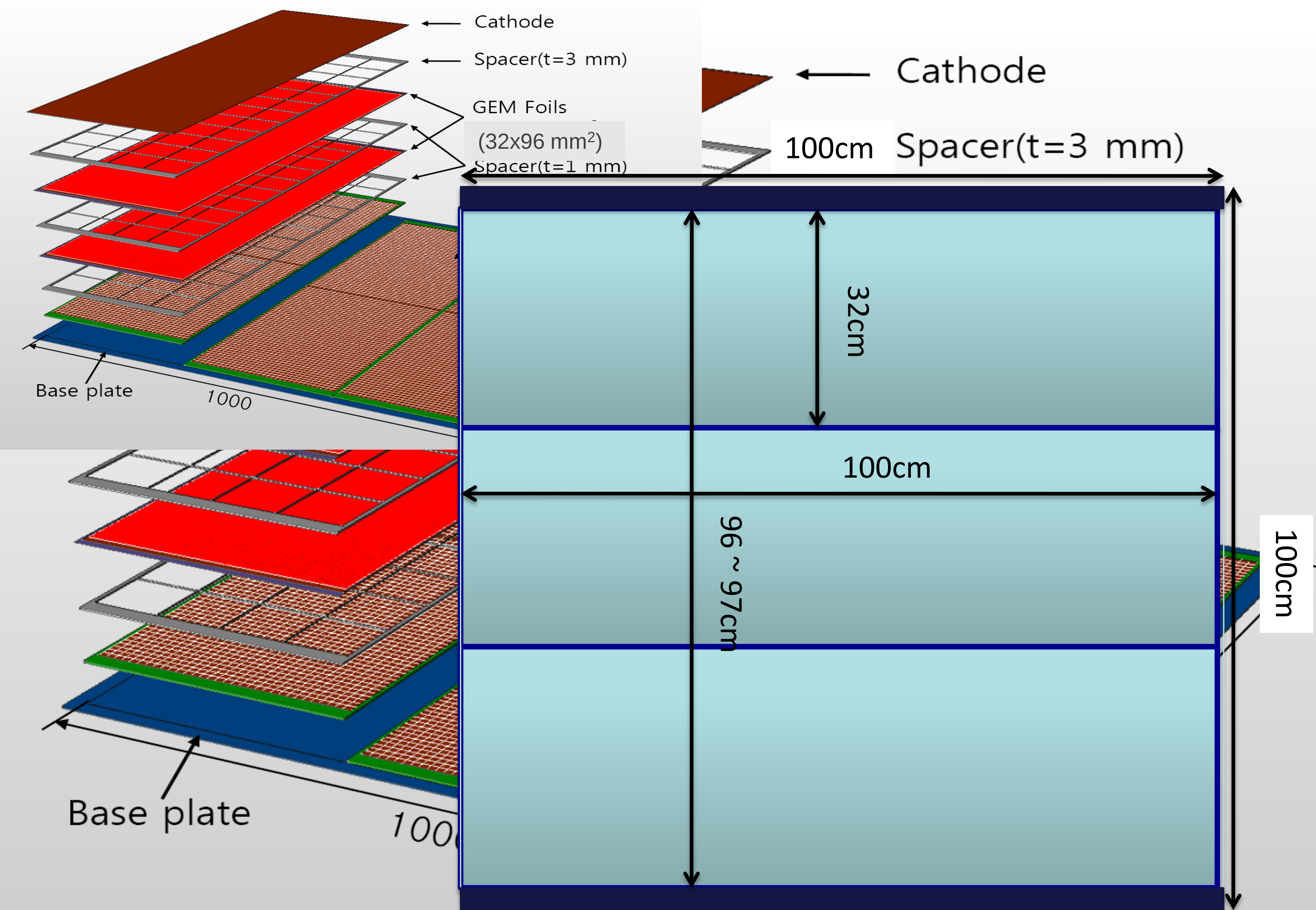


Pad board: 320x480x1.5 mm^3

Front-end board: 320x555x1.5 mm^3

Glue the boards directly on their edges??

UTA's 100cmx100cm Digital Hadron Calorimeter Plane



GEM DHCAL Plans

- Phase I ➔ Completion of 30cm x 30cm characterization
  - Mid 2010 – Early 2011: using one to three planes of 30cm x 30cm double GEM chamber with 64 channel KPiX7 and DCAL chips
  - Oct. 2010: Joint Test with THGEM/KPiX at CERN (Using RD51 setup)
- Phase II ➔ 33cm x 100cm unit chamber construction and characterization
  - Early 2011 – late 2011 at FTBF: Using available KPiX chips (V9?) and DCAL chips
- Phase III ➔ 100cm x 100cm plane GEM DHCAL performances in the CALICE stack
  - Late 2011 – Late 2012 at Fermilab's FTBF *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 or other technology planes in the remaining HCAL

Summary

- Steady progress has been made reading out 30cmx30cm GEM prototype chambers with 64 channel KPiX v7 chips
  - Observed clean characteristic peaks from Fe^{55} and Ru^{106} sources as well as cosmic ray muons
  - Getting ready to beam test these chambers
  - Higher channel count (512 channel) KPiX V9 chips available
  - Pressure dependence measured and data corrected
- TGEM made a quantum jump and had a beam test at CERN
  - Will have another one in Oct. 2010 ➔ RD51 setup
- 33cmx100cm unit chamber construction proceeding
  - First 5 foils of 33cmx100cm delivered and one HV tested
- Mechanical design being worked out for constructing 33cmx100cm unit chambers and 1mx1m planes for DHCAL testing