GEM DHCAL Status

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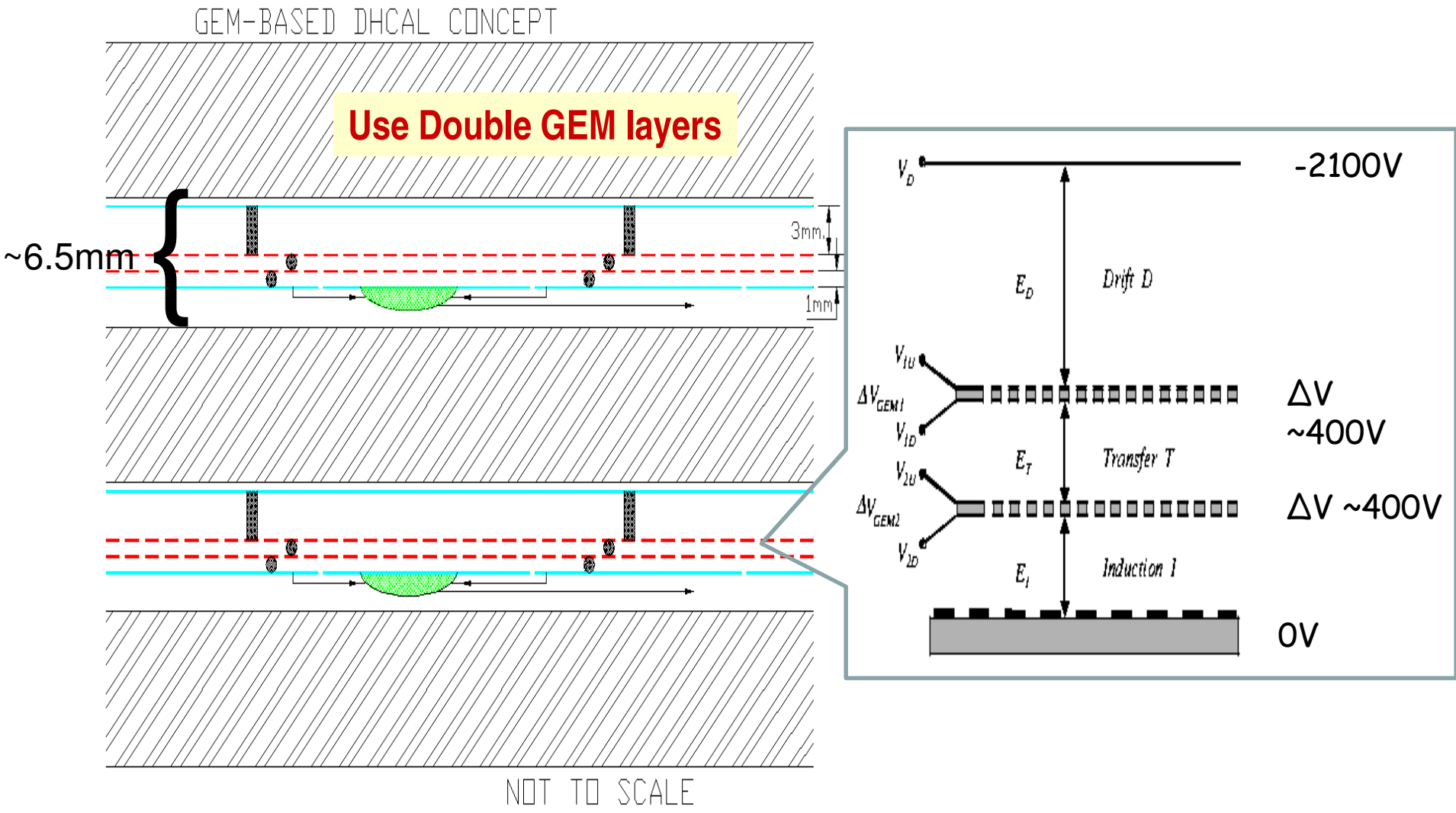
For GEM/DHCAL Group
Oct. 2, 2009
ALCPG2009, UNM

- Introduction
- What has been done?
- Multi-channel readout with Kip
- Large GEM chamber
- Plans
- Summary

Why GEM?

- 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 (Ar/CO_2) – no long-term issues
- Runs at relatively low HV (~400V across a foil)
- Stable and robust operations

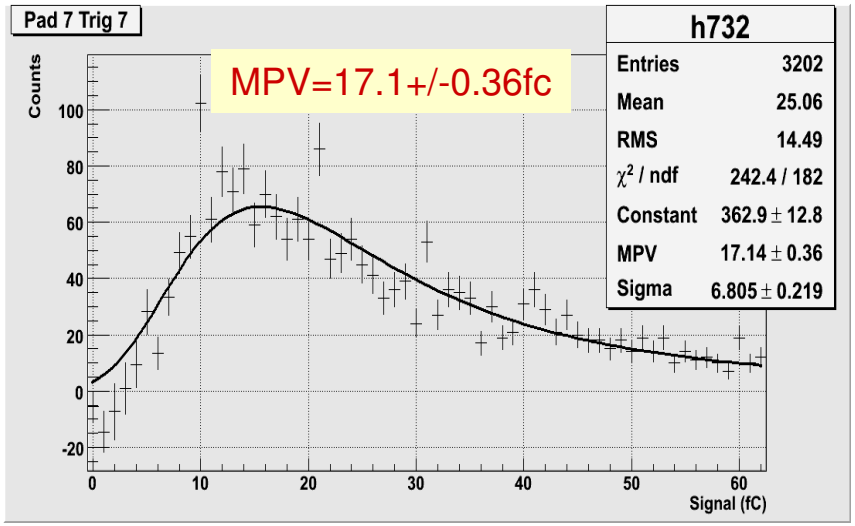
GEM-based Digital Calorimeter Concept

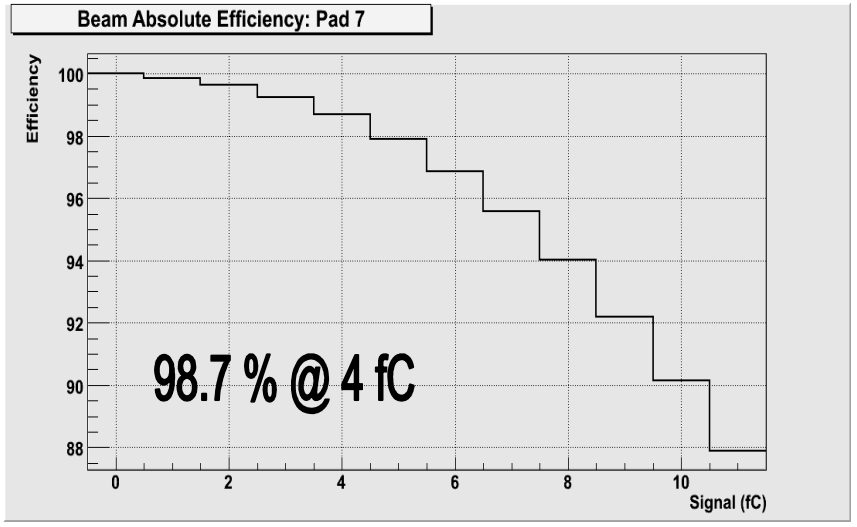


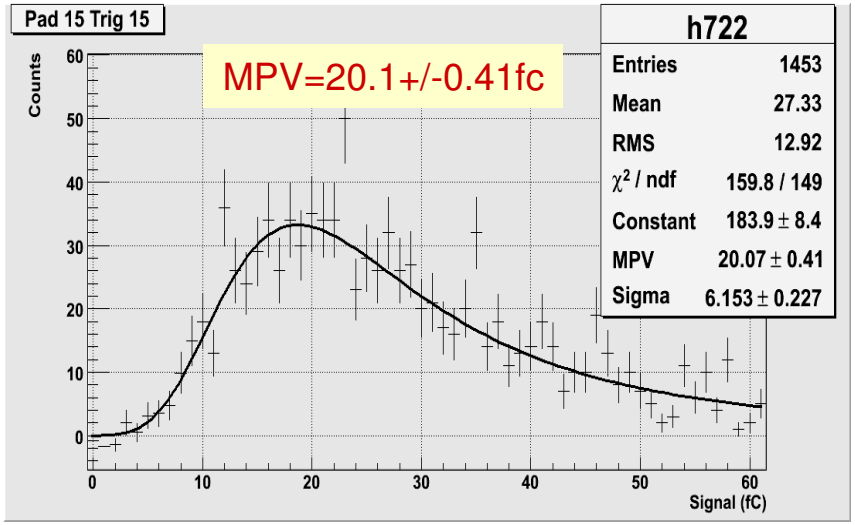
What have been done so far?

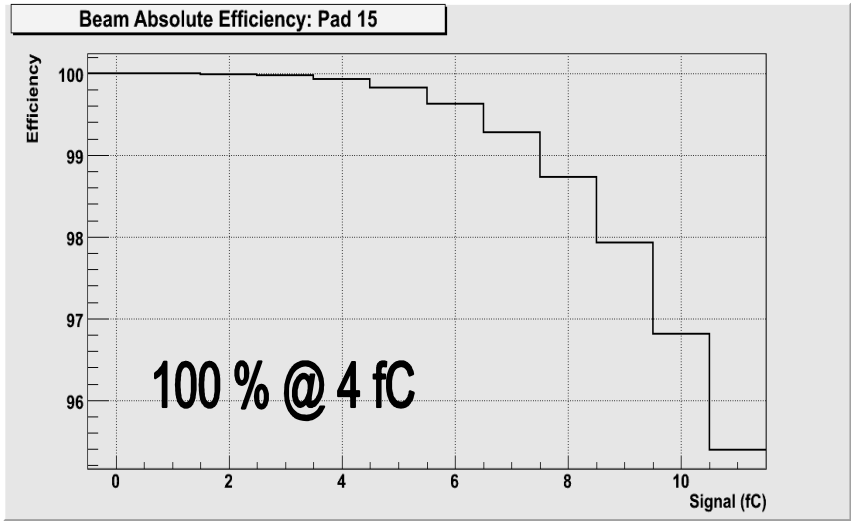
- Bench tested with various source and cosmic ray
  - Used QPA02 chip based preamp
  - Verified the signal shape, responses and gain
- Took a beam test at a high flux electron beam
  - First chamber built with 3M's 30cmx30cm GEM
  - Used QPA02 chip based preamp
  - Verified that the chamber can survive
- 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

Efficiency vs Threshold w/ 120GeV P

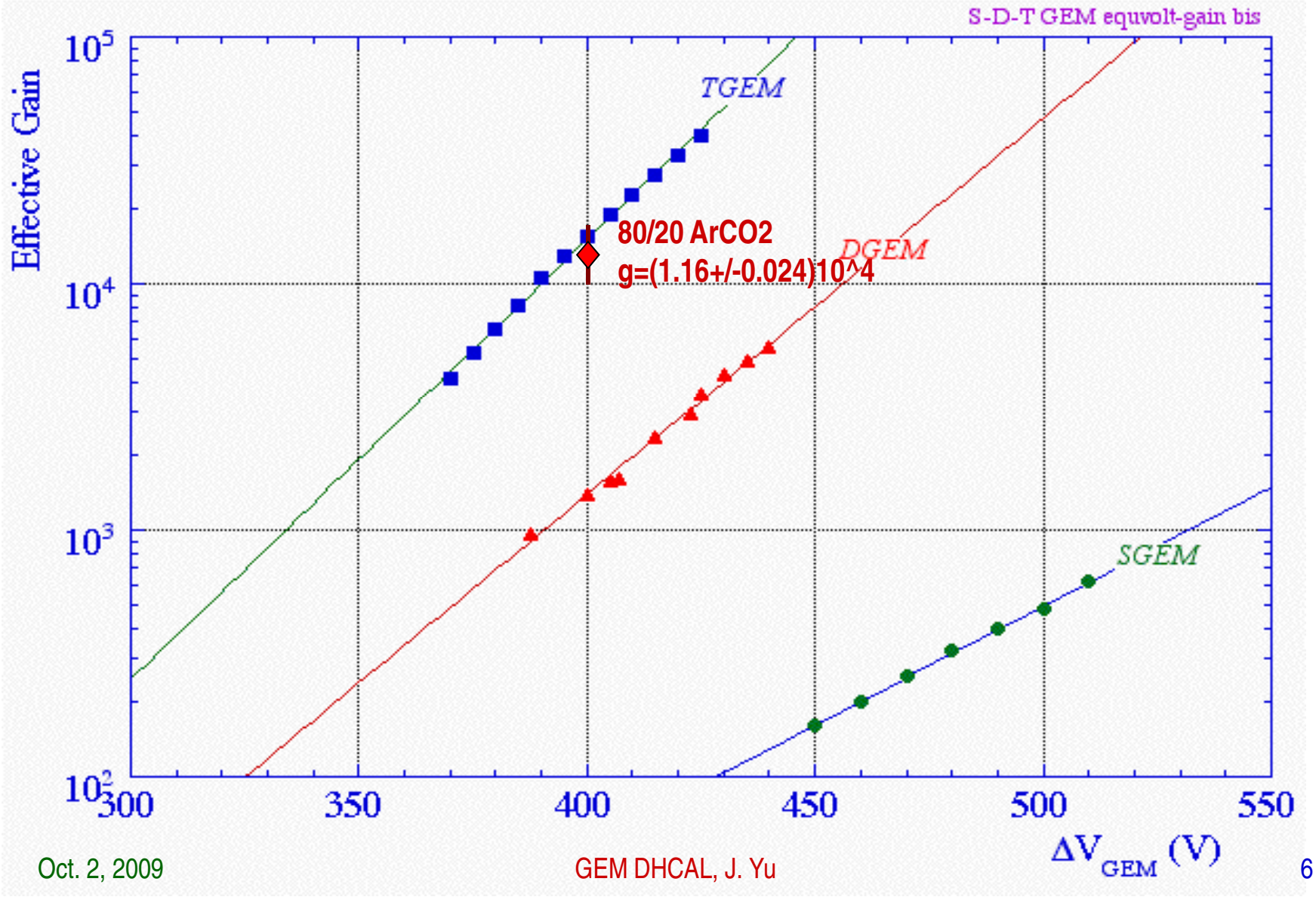




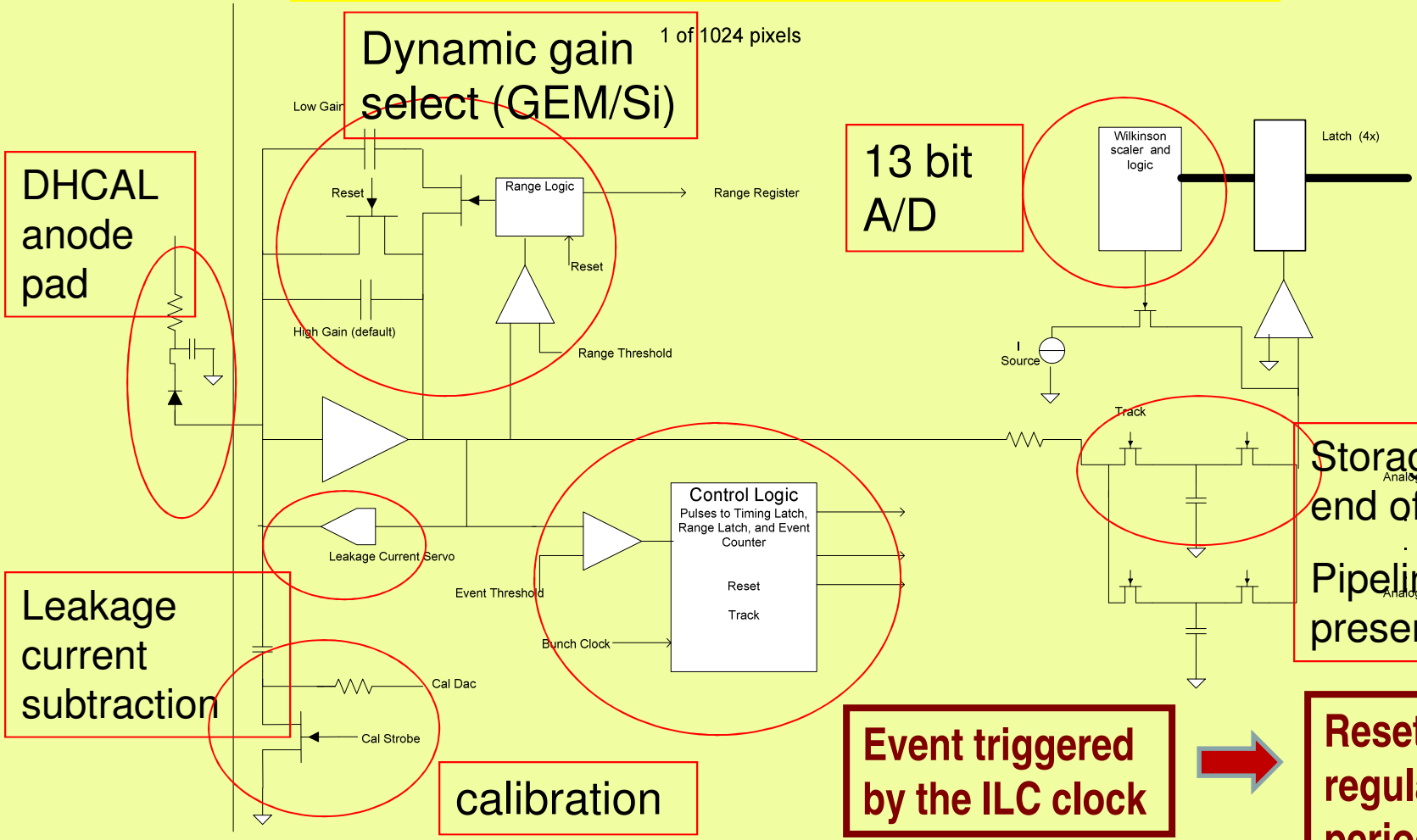




UTA GEM Chamber Gain



KPiX Analog Readout for GEM DHCAL



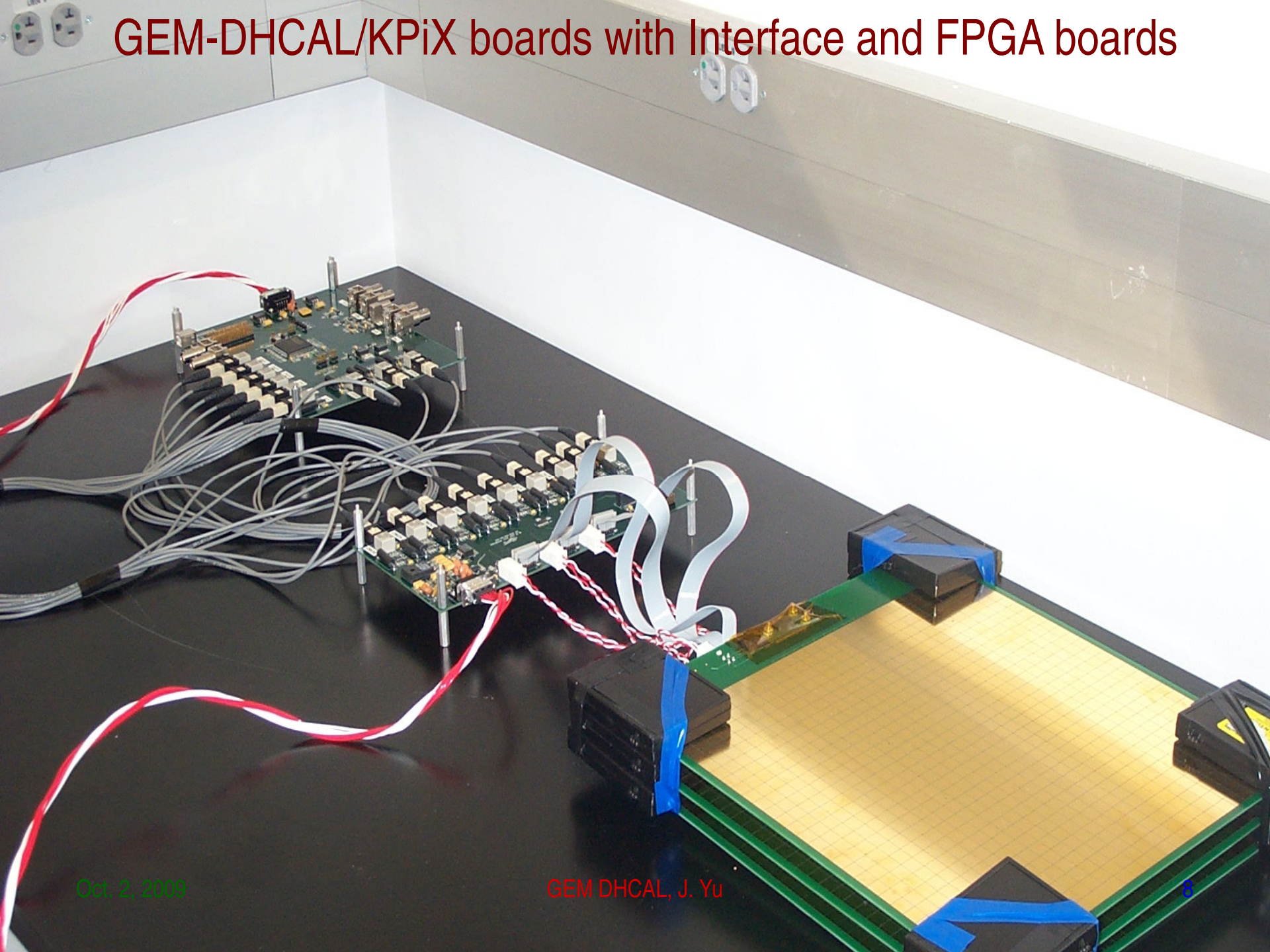
Simplified Timing:

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

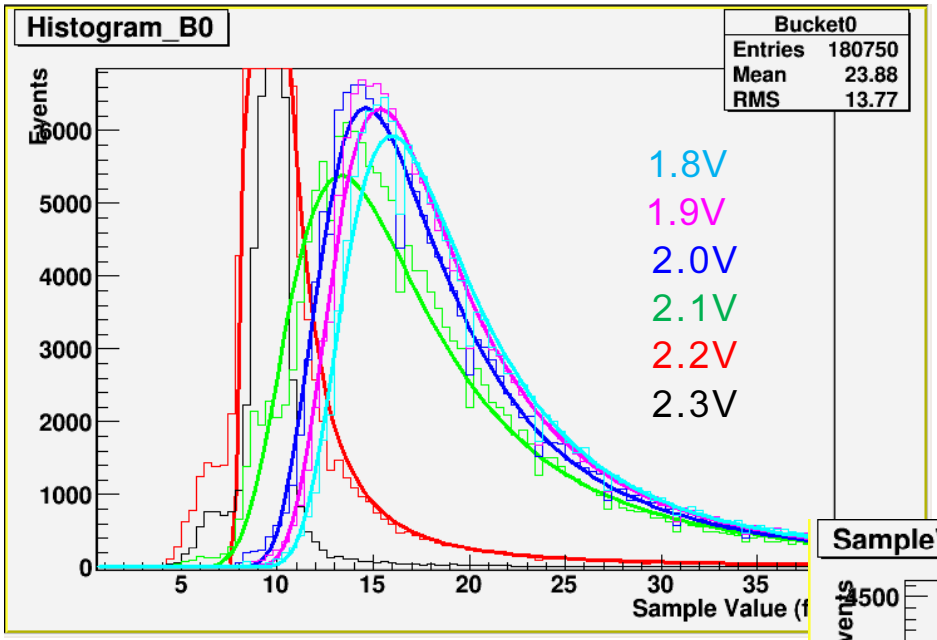
Say a signal above event threshold happens at bunch n and time T0.
The Event discriminator triggers in ~100 ns and removes resets and strobes the Timing Latch (12 bit), range latch (1 bit
The Range discriminator triggers in ~100 ns if the signal exceeds the Range Threshold.
When the glitch from the Range 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

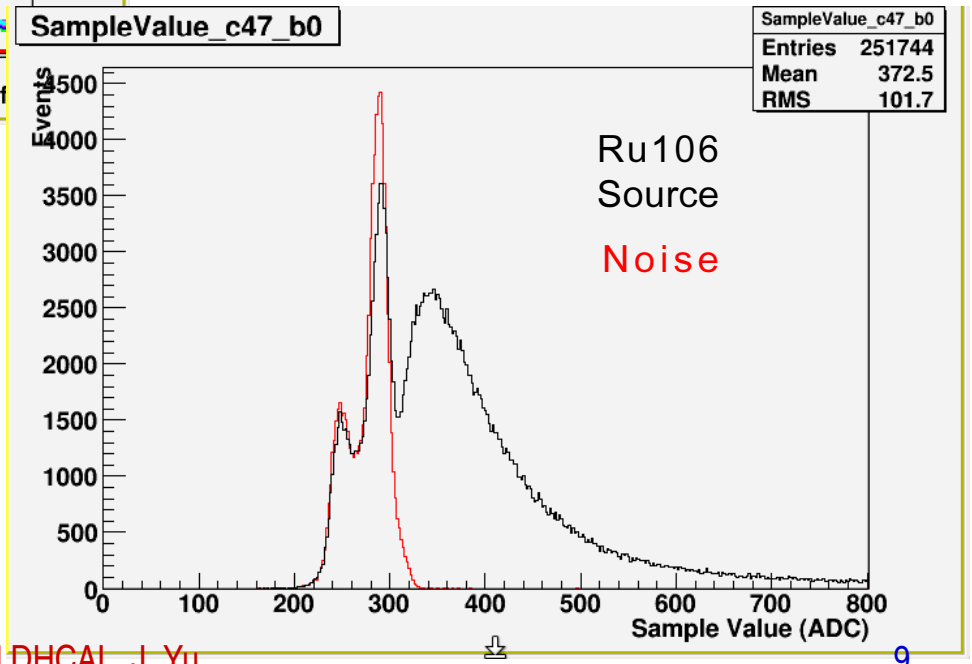
GEM-DHCAL/KPiX boards with Interface and FPGA boards



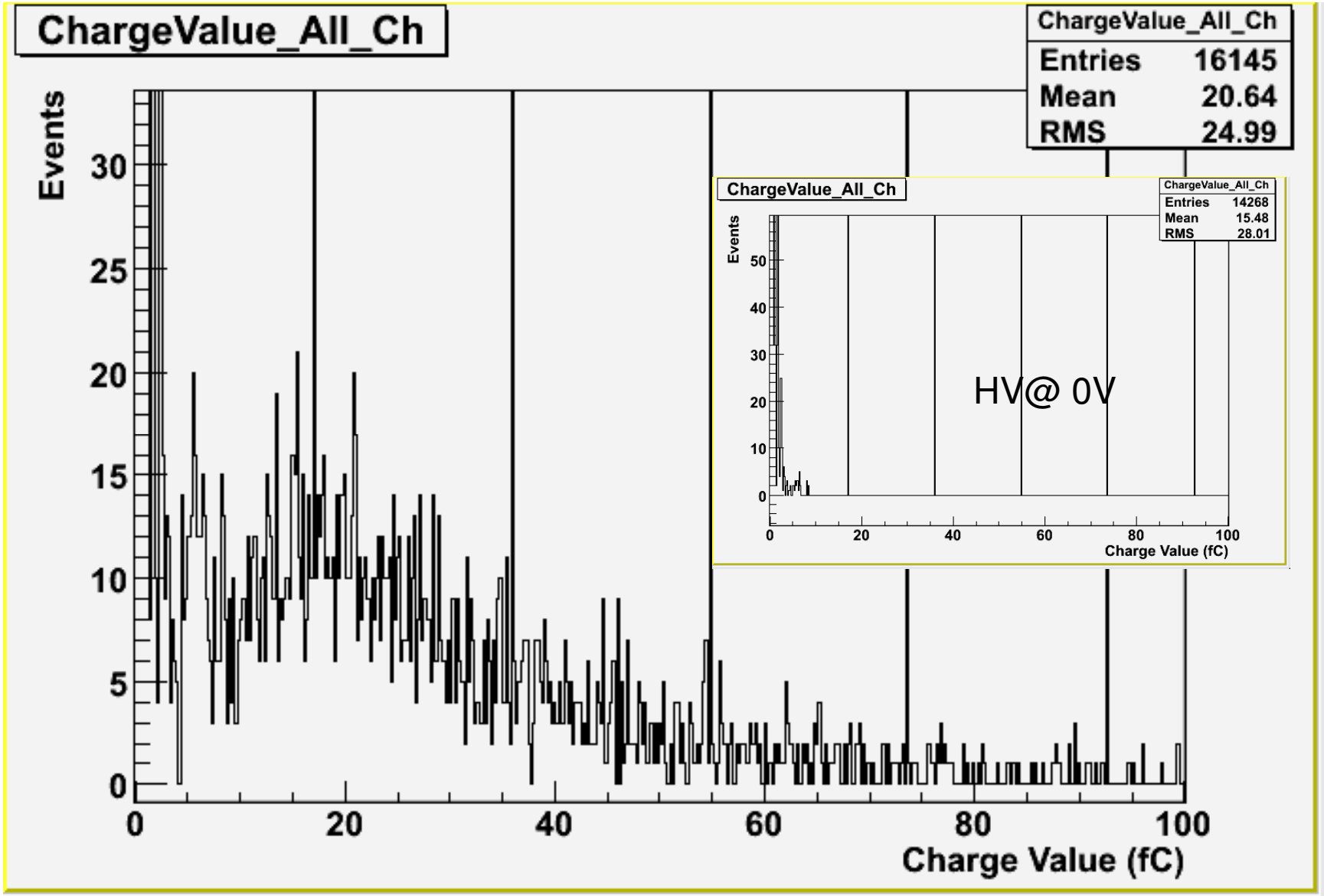
KPiX Self Trigger Threshold and Noise Scan



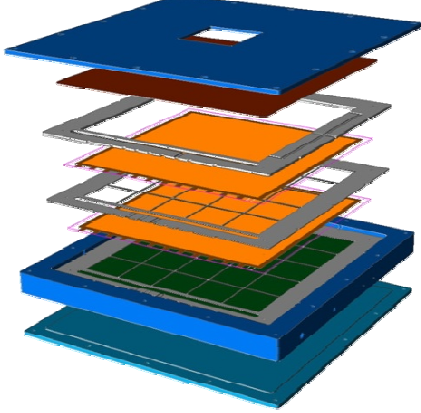
- Threshold at -1.9 to -2.0 V most optimal
- Observe clear Landau distribution of β from Ru^{106}



Cosmic Ray Data with External Trigger

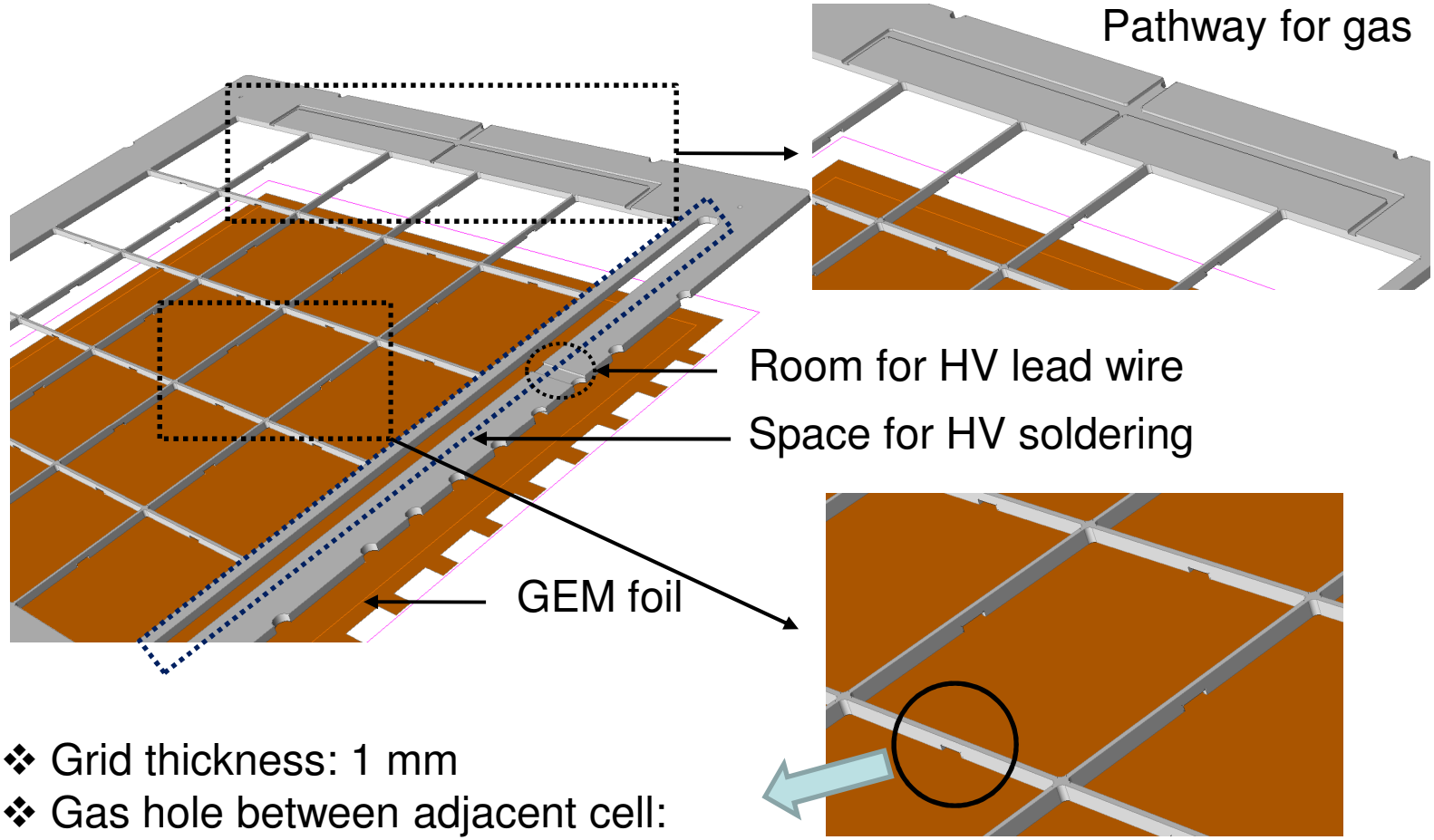


GEM DHCAL Plans - I



- Through late 2009
  - 30cmx30cm chamber
    - Construct a new chamber with optimal gas flow design
    - Complete characterization of the chamber with sources and cosmic rays using 64 channel KPiX v7

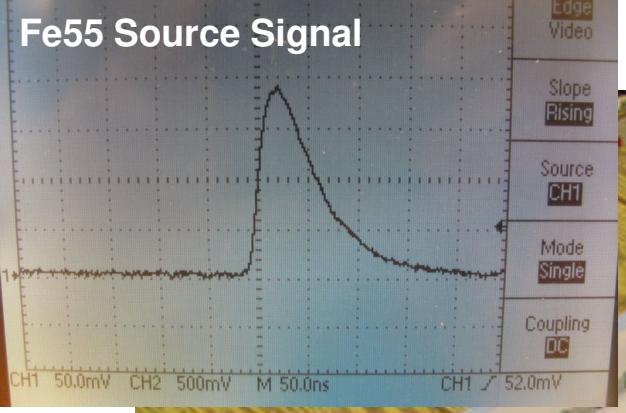
Gas Transparent Spacers



- Grid thickness: 1 mm
- Gas hole between adjacent cell:

→5x1 mm^2 for 3 mm spacer

→5x0.5 mm^2 for 1 mm spacer



Gas outlet

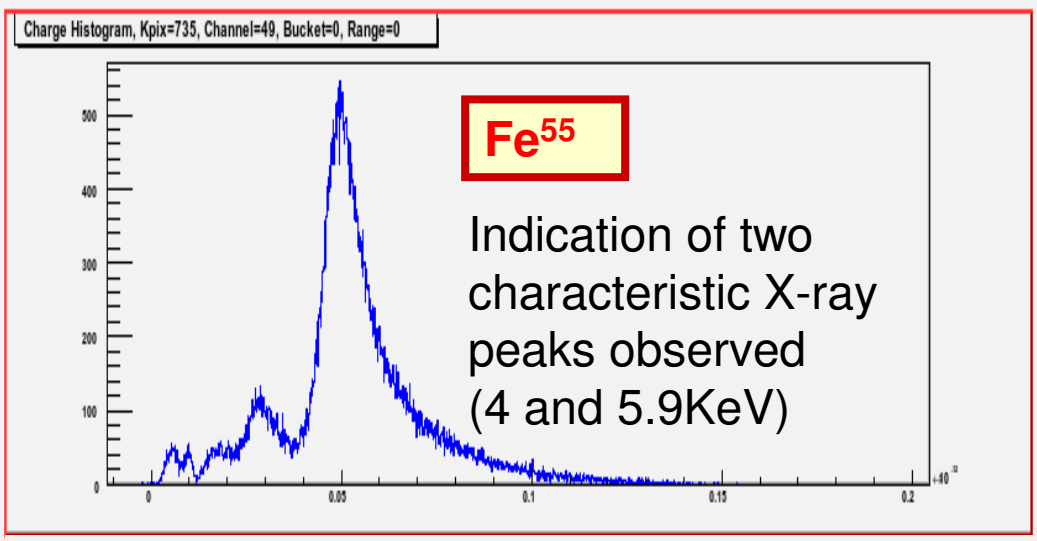
HV power

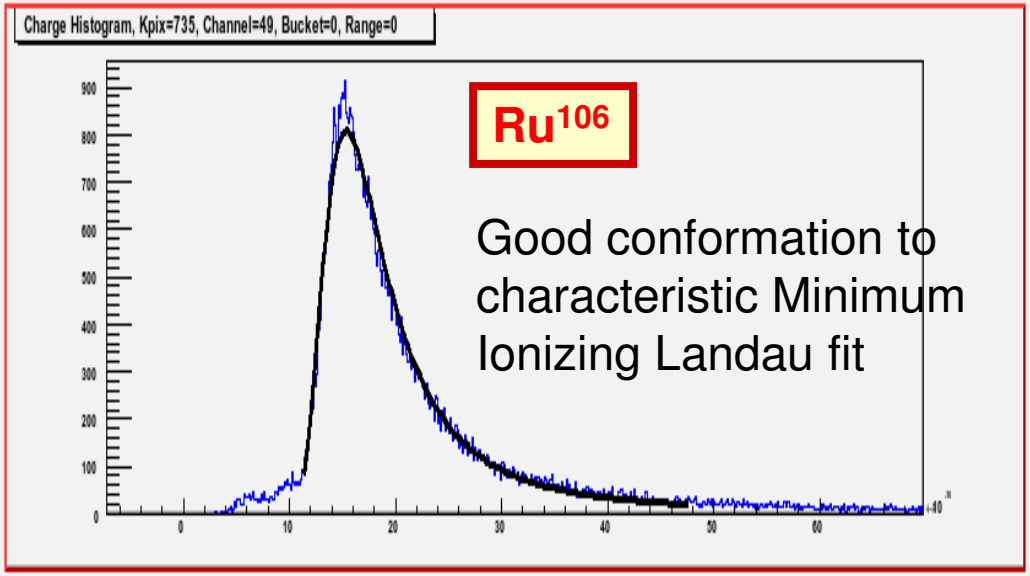
Analog signal

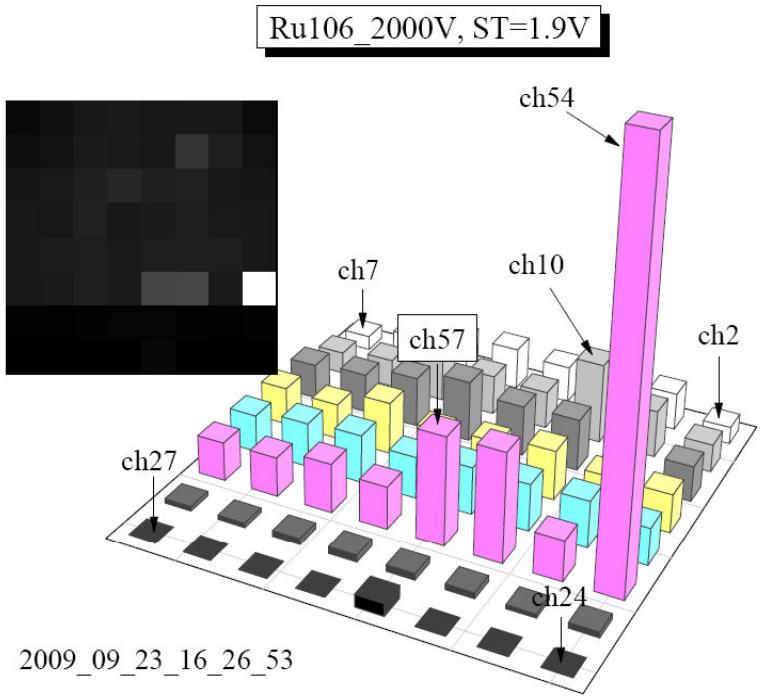
Data cable

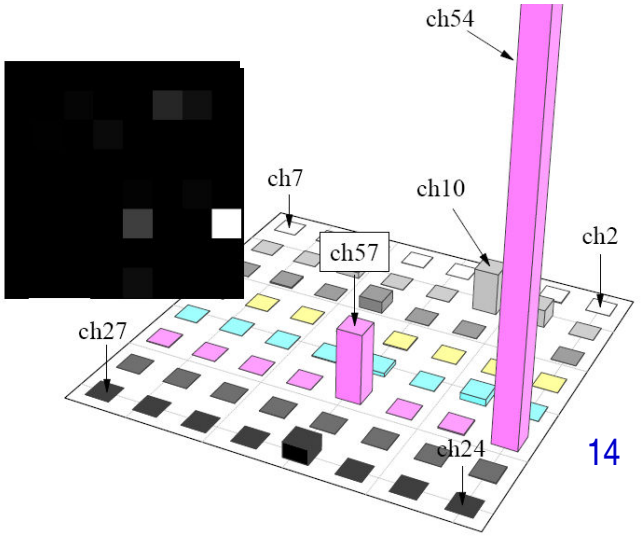
LV power

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

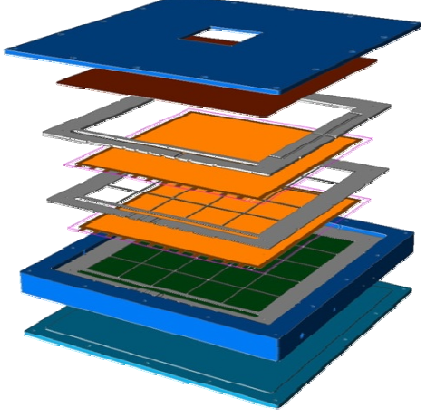








GEM DHCAL Plans - I

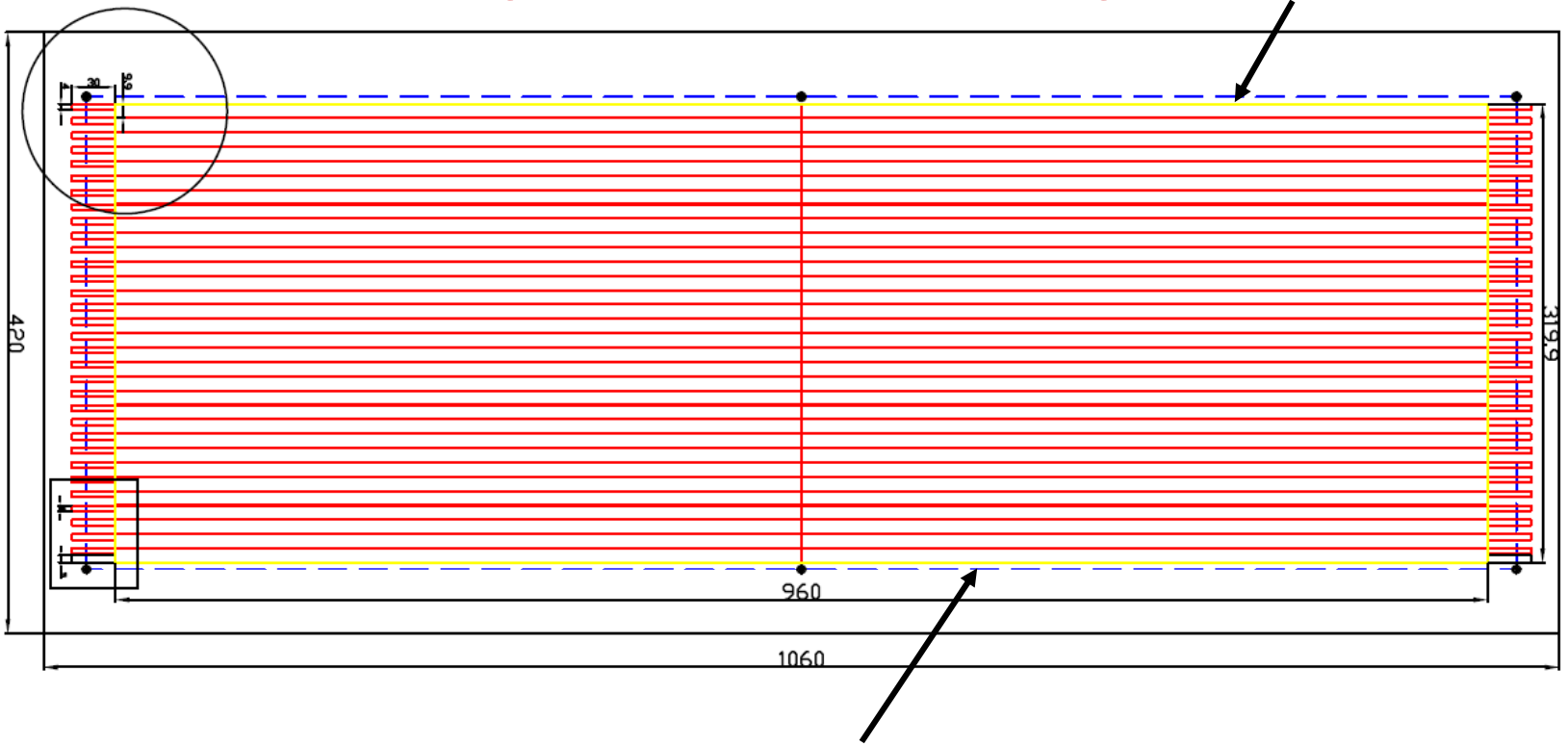


- Through late 2009
  - 30cmx30cm chamber
    - Construct a new chamber with optimal gas flow design
    - Complete characterization of the chamber with sources and cosmic rays using 64 channel KPiX v7
    - Characterize the chamber in particle beams
    - Understand the chamber behaviors with DCAL chips (thru early 2010)
  - 33cmx100cm unit chamber
    - Finalize 33cmx100cm (32cmx96cm active area) large GEM foil silkscreen design and submit to CERN GDD
    - Initial prototype tried in late Aug. 2009

Large GEM Foil Development with CERN

- The size of the foils are 33cmx100cm, the same as the physical size of the unit chamber
  - Active area is 33cmx100cm
  - Is this realistic to think of constructing a chamber with the same physical size foils?
- The design of large GEM foil completed and delivered to CERN GDD Workshop
- One-side etching technique successful
- CERN GDD workshop is working on prototype foil production

Large GEM Foil Design



Active area 319.9x960 mm^2
Chamber size=330x1000 mm^2

Number of sectors = 32x2=64
(bottom layer has only one sector)

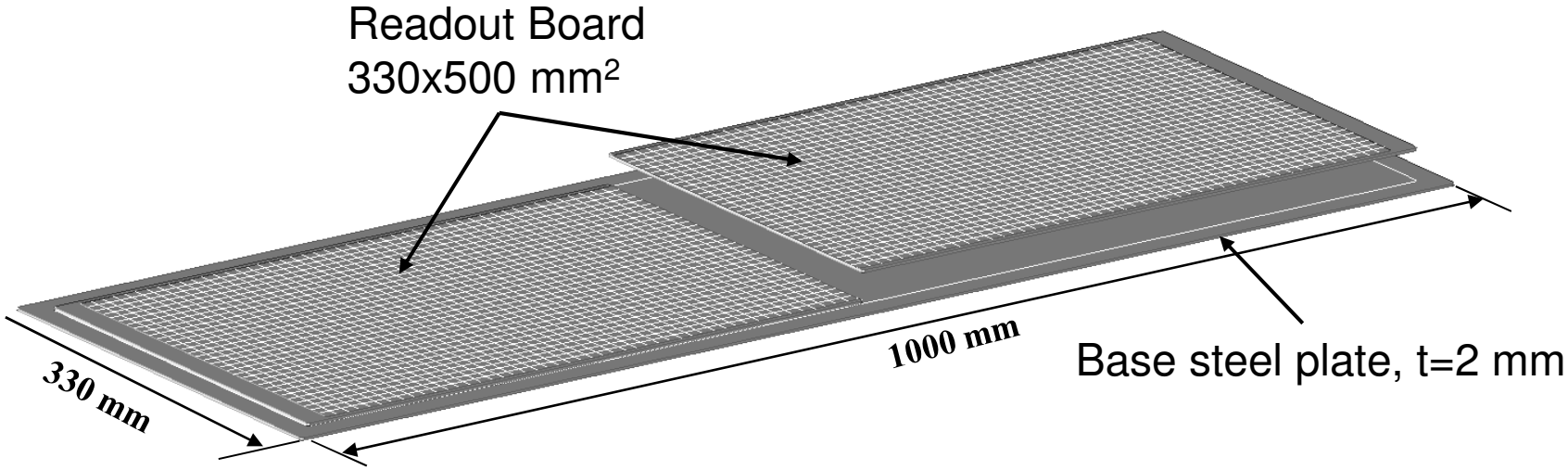
Sector dimension= 9.9x479.95 mm^2

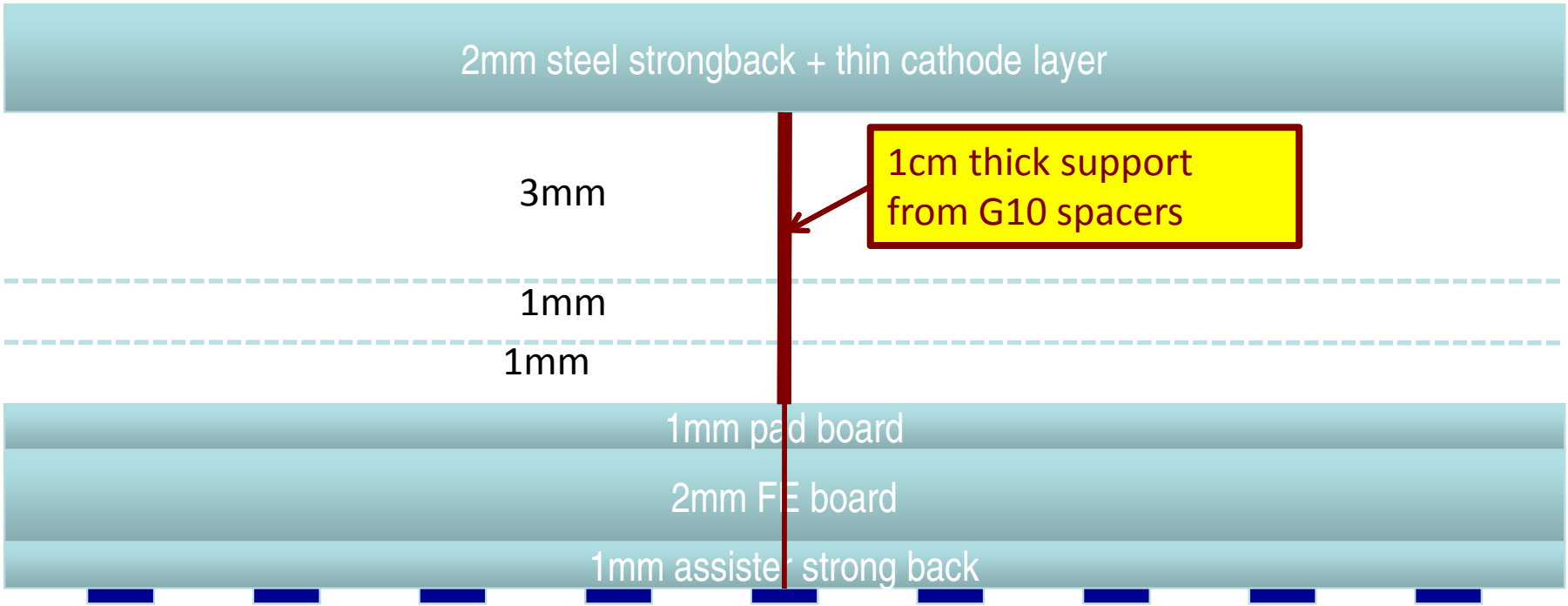
Gap between sectors = 0.1 mm

GEM DHCAL Plans - II

- Late 2009 – Late 2010
  - 33cmx100cm thin GEM unit chambers
    - Production and certification of 33cmx100cm foils
    - Characterization of 1024 KPiX chips
      - To be available in late 2009 to early 2010
      - Use 30cmx30cm the new GEM chamber
    - Understand chamber behaviors with DCAL chips
    - Begin construction and characterization of 33cmx100cm unit chambers
      - One with anode board with available KPiX chips
      - Remainder with DCAL Chips

33cmx100cm DHCAL Unit Chamber

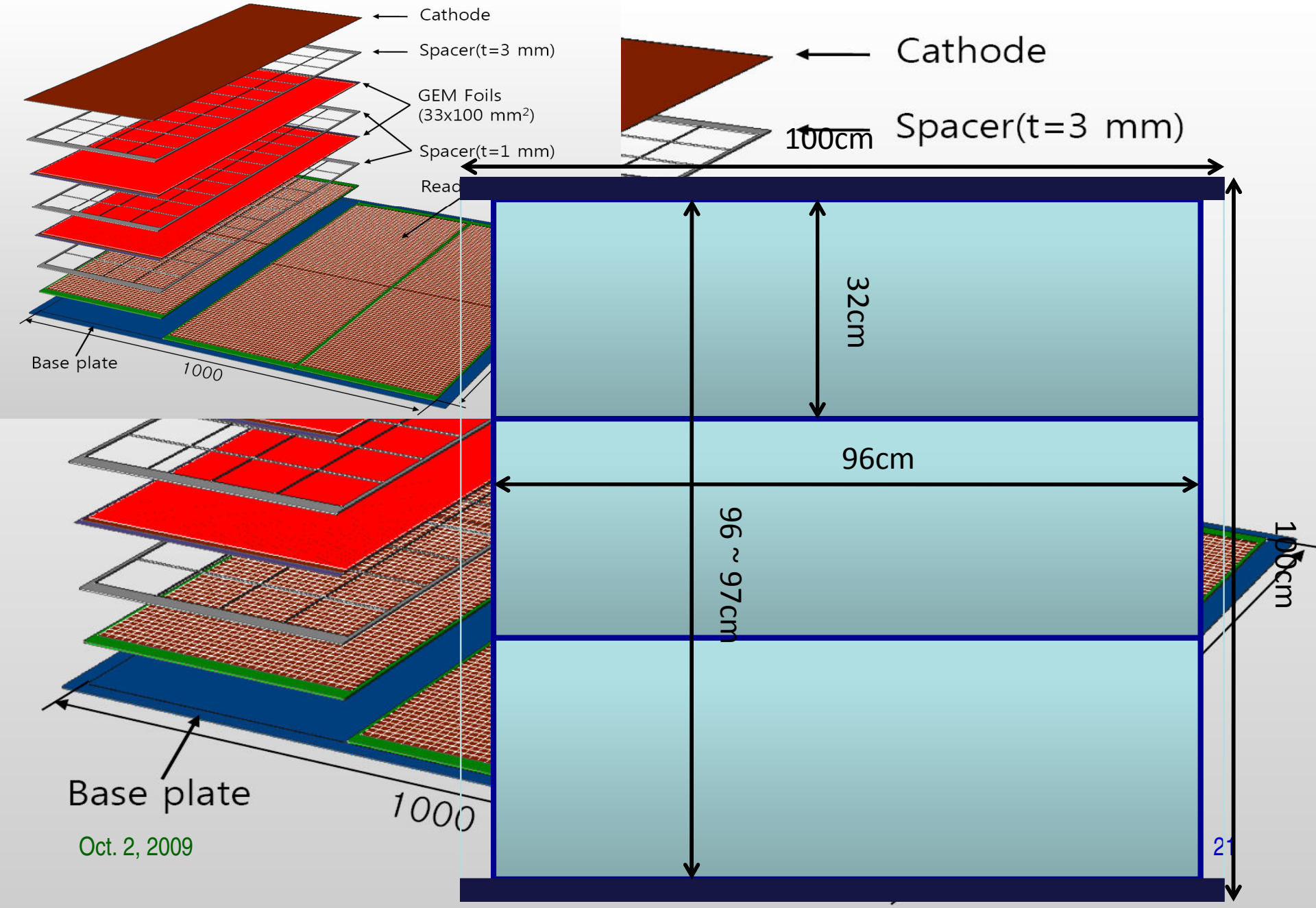




GEM DHCAL Plans - III

- Mid 2010 – Late 2011
  - 33cmx100cm thin GEM unit chambers w/ DCAL chips
    - Characterization with DCAL chip
    - Complete production of fifteen 33cmx100cm unit chambers
  - Construct five 100cmx100cm GEM DHCAL planes
    - Using DCAL readout chips
  - Beam test GEM DHCAL planes in the CALICE beam test stack together with RPC
  - If available: TGEMs and RETGEMs
    - Construction and characterization of a prototype chamber using an analog readout chip
    - Beam test of TGEM prototype chamber

UTA's 100cmx100cm Digital Hadron Calorimeter Plane



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GEM DHCAL Beam Test Plans

- Phase I ➔ Completion of 30cmx30cm characterization
  - Late 2009 – Early 2010: using one to two planes of 30cmx30cm double GEM chamber with 64 channel KPiX7
- Phase II ➔ 33cmx100cm unit chamber characterization
  - Early 2010 – Late 2010 at MTBF: Using available KPiX chips and DCAL chips
- Phase III ➔ 100cmx100cm plane GEM DHCAL performances in the CALICE stack
  - Late 2010 – Mid 2011 at Fermilab's MTBF
  - Five 100cmx100cm planes inserted into existing CALICE calorimeter stack and run with either Si/W or Sci/W ECALs and RPC planes in the remaining HCAL

Summary

- Good progress has been made reading out GEM chamber with 64 channel KPiX v7 chips
  - Observed clean characteristic peaks from Fe^{55} and Ru^{106} sources
- Cosmic ray data taking and analysis in progress
- 30cmx100cm unit chamber construction proceeding
  - GEM foil design completed and delivered to CERN ➔ Prototype foil production in progress
- Mechanical designs being worked out for constructing 1mx1m planes for DHCAL testing