GEM DHCAL Status and Plans

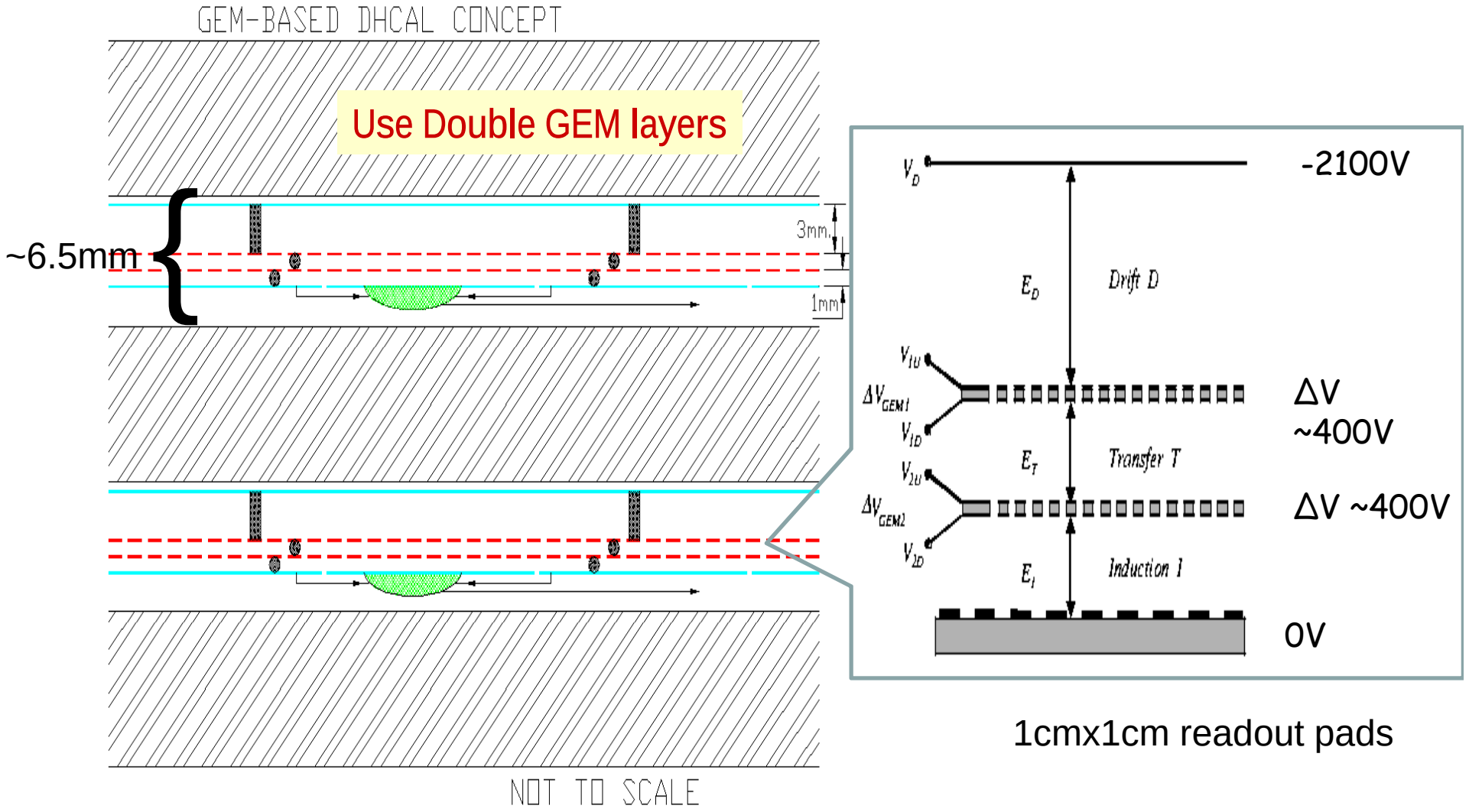
Jae Yu
For GEM/DHCAL Group
Feb. 20, 2009
CALICE Collaboration Meeting

- Introduction
- Status of GEM DHCAL Development
- GEM readout via KPiX Analog Chip
- GEM DHCAL Plans
- Conclusions

Why GEM's for DHCAL?

- 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



1cmx1cm readout pads

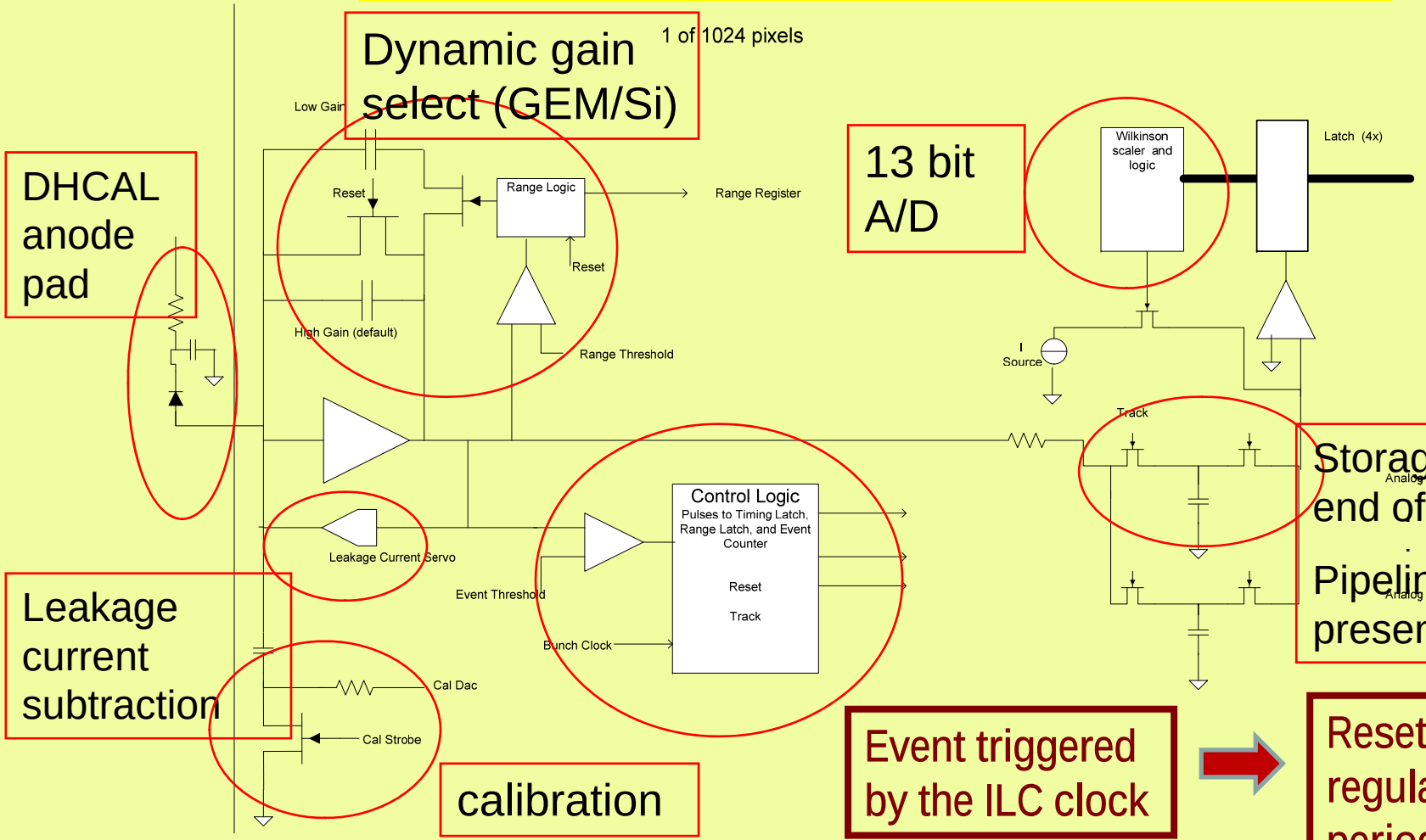
What have been done so far?

- 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
- Multiple channel readout w/ Analog KPiX chips

GEM + KPiX Readout

- Have been working on getting the SLAC-Oregon KPiX analog chip working with GEM
  - KPiX modified to accommodate smaller GEM signals
- Signal from source extracted using 64 channel KPiX v4
  - No external trigger acceptance
  - Basically a random trigger with respect to signal arrival

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.

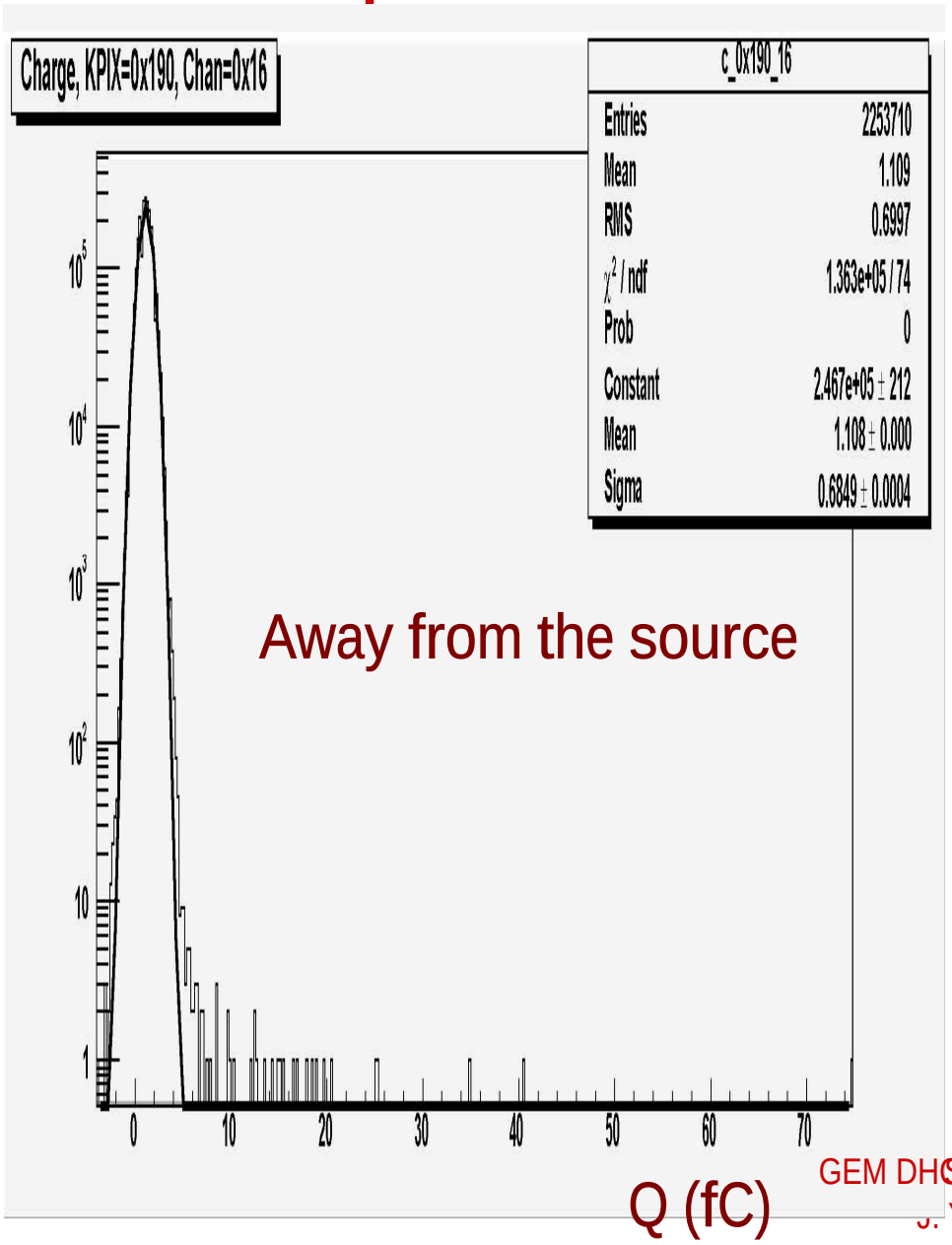
Say a signal above event threshold happens at bunch n and time T0.
The Event discriminator triggers in ~100 ns and removes resets and strobes the Timing Latch (12 bit), range latch (1 bit) and Eve
The Range discriminator triggers in ~100 ns if the signal exceeds the Range Threshold.
When the glitch from the Range switch has had time to settle, Track connects the sample capacitor to the amplifier output. (~150
The Track signal opens the switch isolating the sample capacitor at T0 + 1 micro s. At this time, the amplitude of the signal at T(
Reset is asserted (synched to the bunch clock) . Note that the second capacitor is reset at startup and following an event, while t
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.

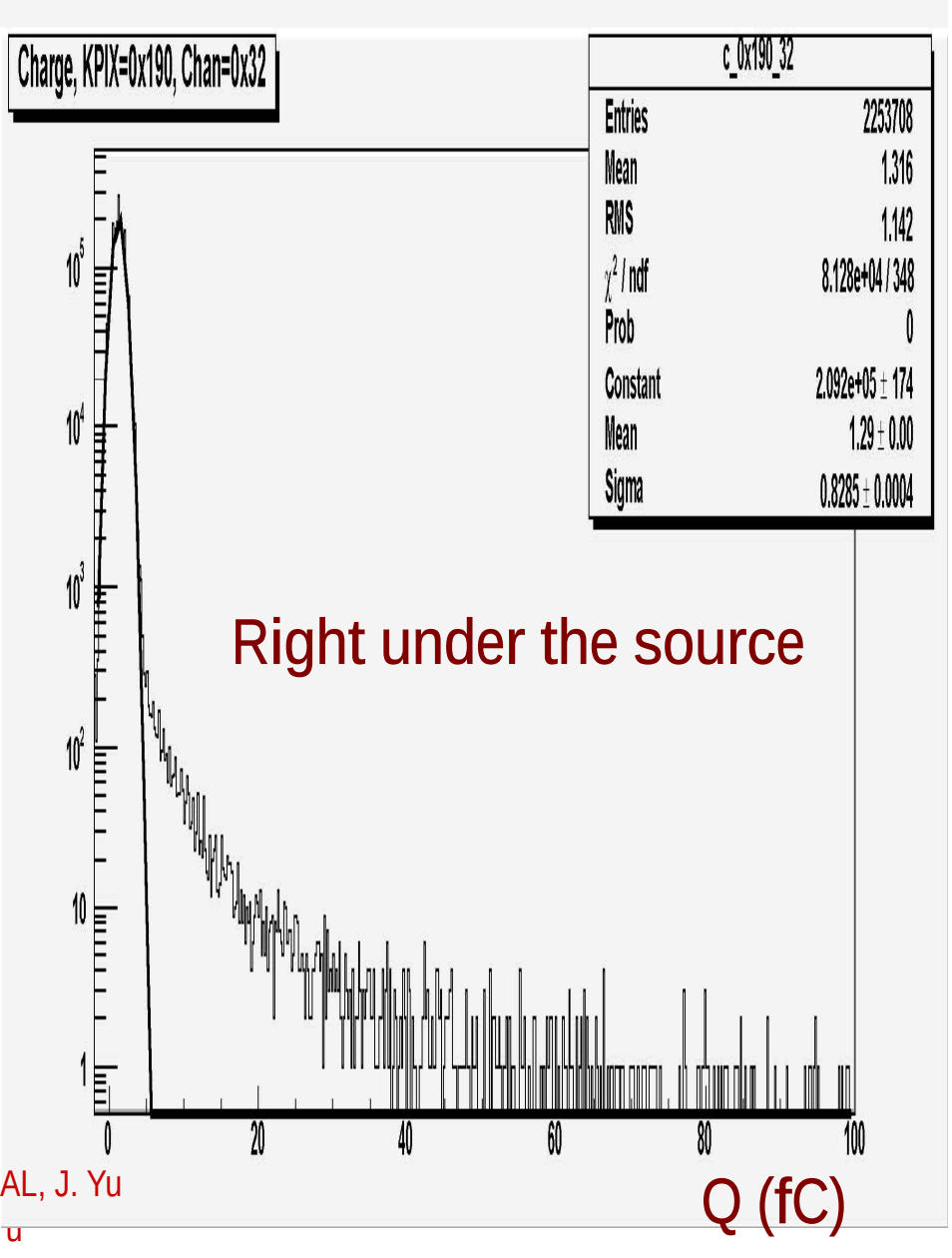
- 1024 channel SLAC's KPiX chip
- Developed for Si/W ECAL

Study of KPiX Behaviors with GEM

- Analysis of KPiX data complicated due to
  - Its triggering scheme using accelerator clock
  - Thus, no external triggering scheme
  - How do you trigger weak radioactive source signal?
  - Use a simulation based inference method to extract the signal

Reponses to Source – GEM-KPiX





Study of KPiX Behaviors with GEM

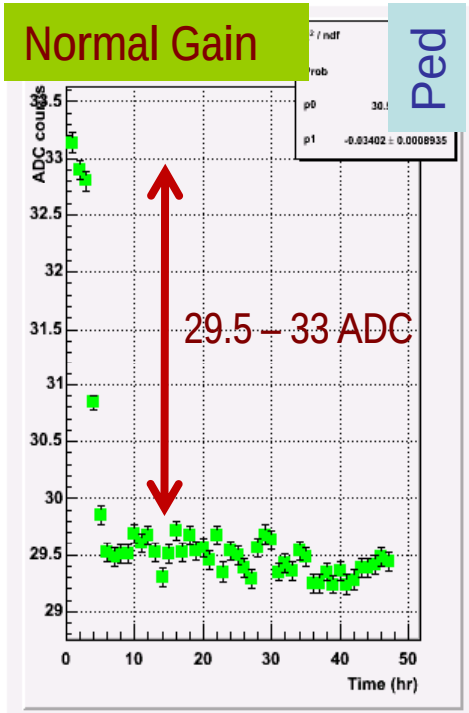
- Analysis of KPiX data complicated due to
  - Its triggering scheme using accelerator clock
  - Thus, no external triggering scheme
  - How do you trigger weak radioactive source signal?
  - Interesting inconsistencies in calibration observed
- Understand the chip's behavior using calibration data
  - Data taken hourly for two separate days + three months
  - Each Channel's Pedestal Mean, Sigma; Gain, and Y-Intercept verses Run# (on order of an hour) is graphed for each channel and for two gain modes

Study of KPiX Behaviors with GEM

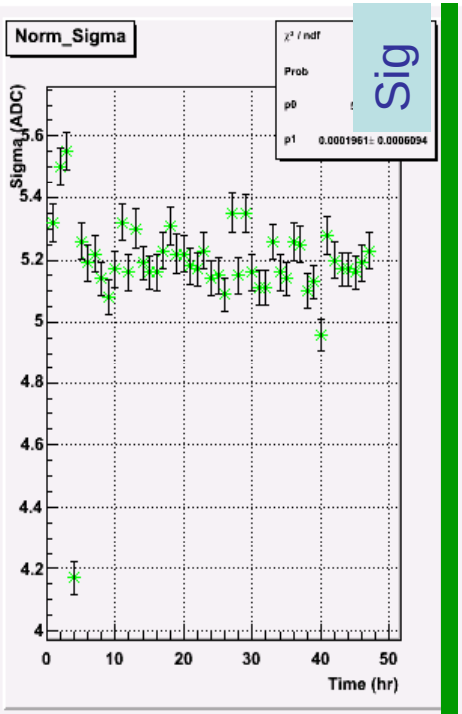
- Analysis of KPiX data complicated due to
  - Its triggering scheme using accelerator clock
  - Thus, no external triggering scheme
  - How do you trigger weak radioactive source signal?
  - Use a simulation based inference method to extract the signal
- Understand the chip's behavior using calibration data
  - Data taken hourly for two separate days + three months
  - Each Channel's Pedestal Mean, Sigma; Gain, and Y-Intercept verses Run# (on order of an hour) is graphed for each channel and for two gain modes

Normal Gain

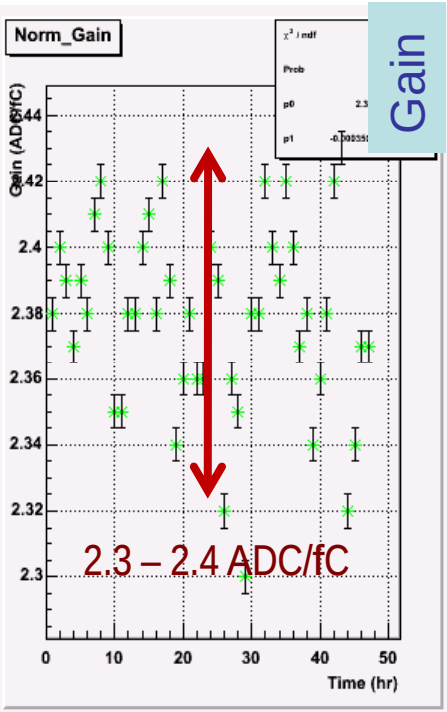
Ped



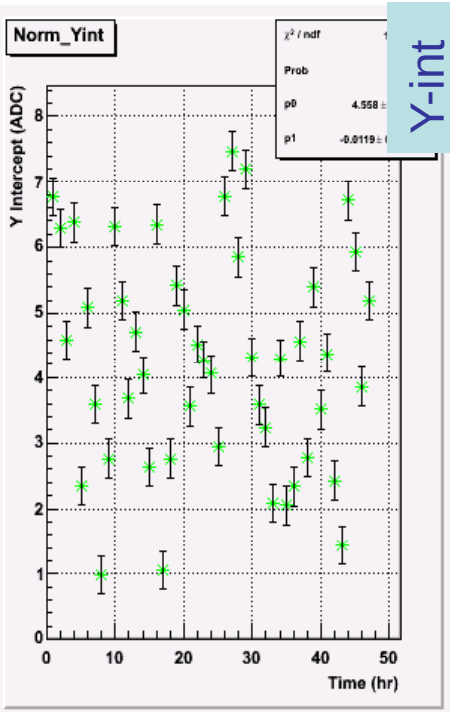
Sig



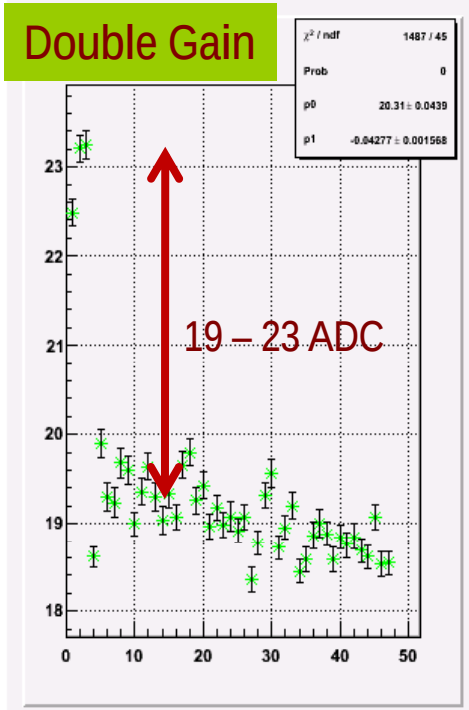
Gain

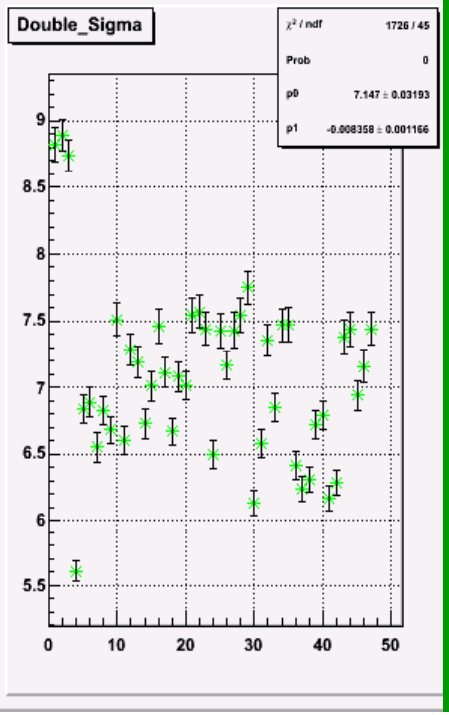


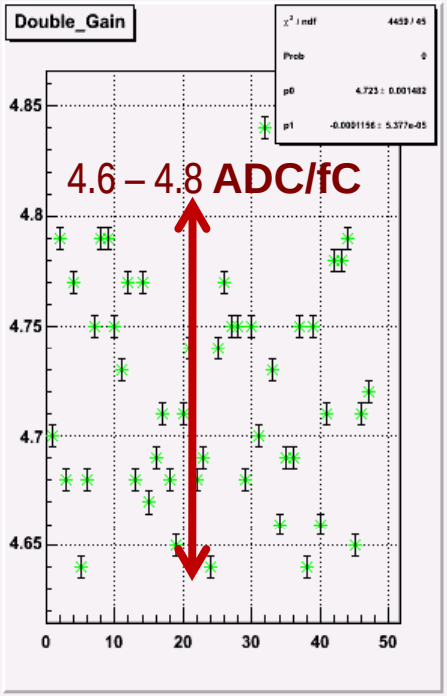
Y-int

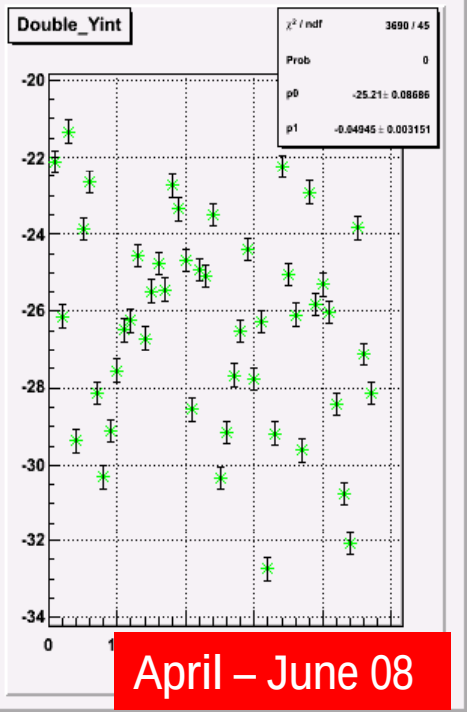


Double Gain



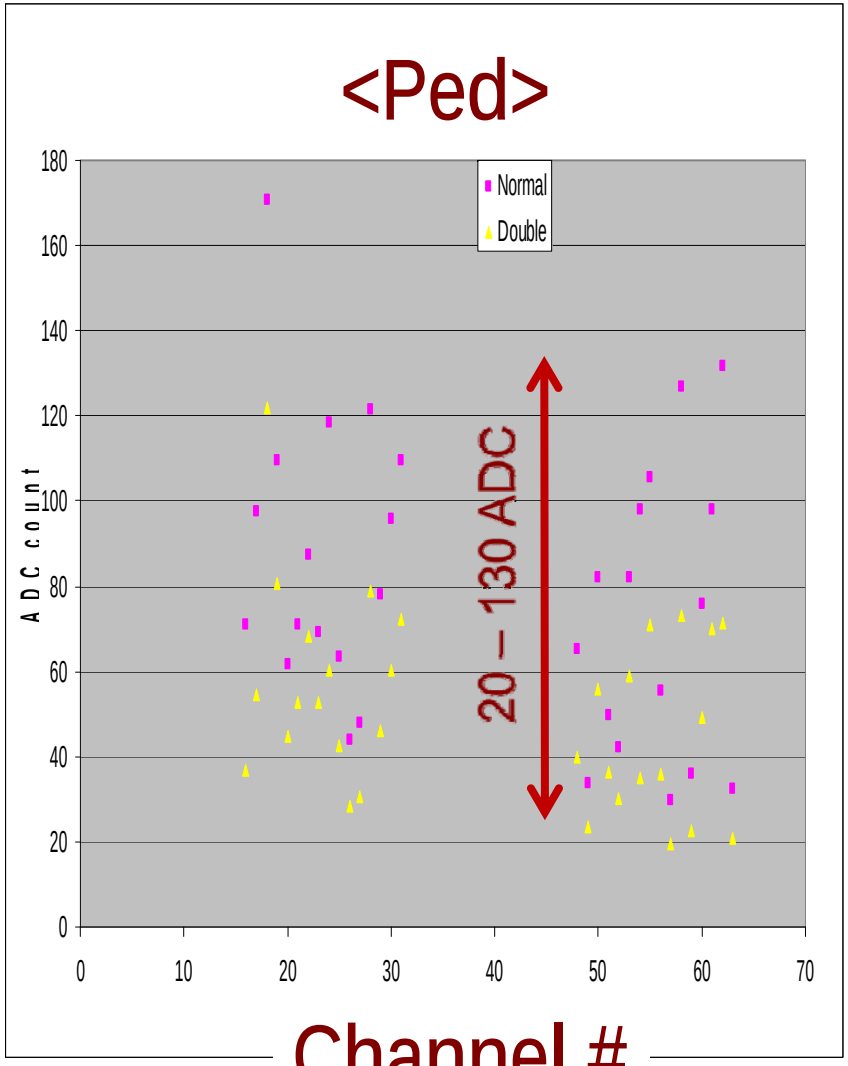


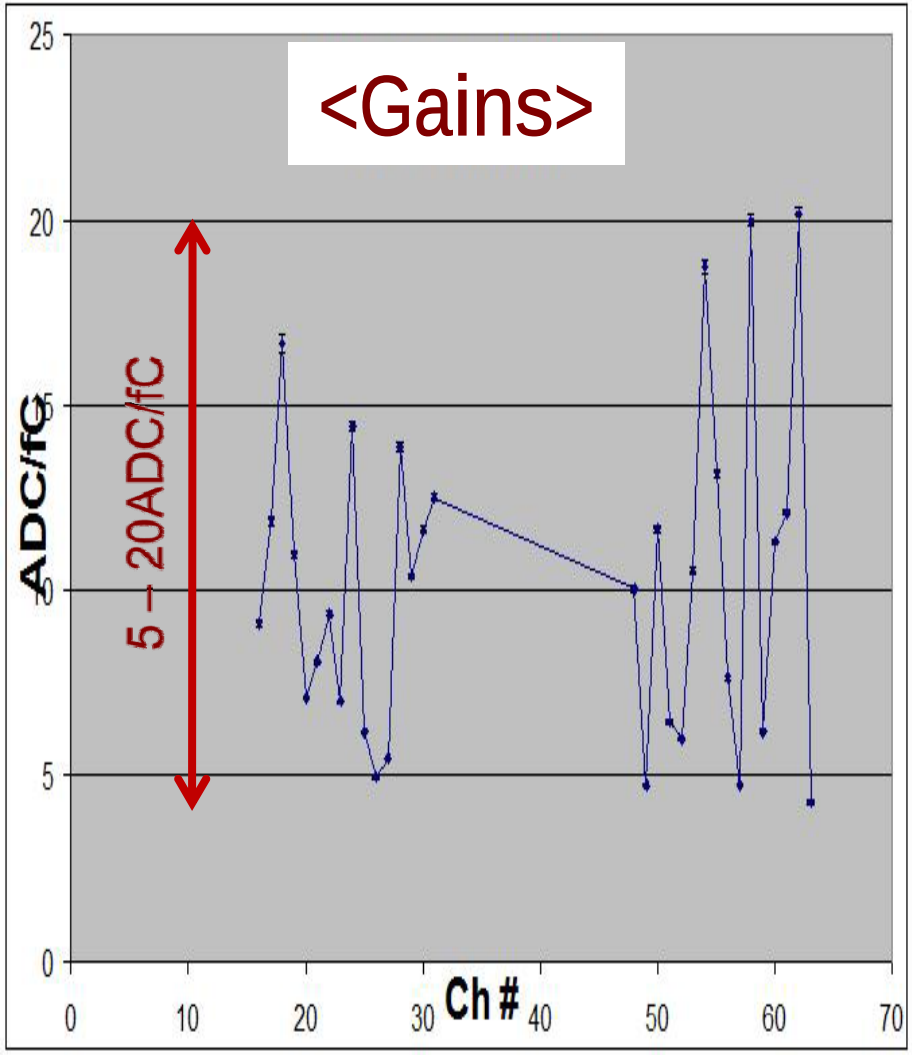




April – June 08

Channel to Channel Variations





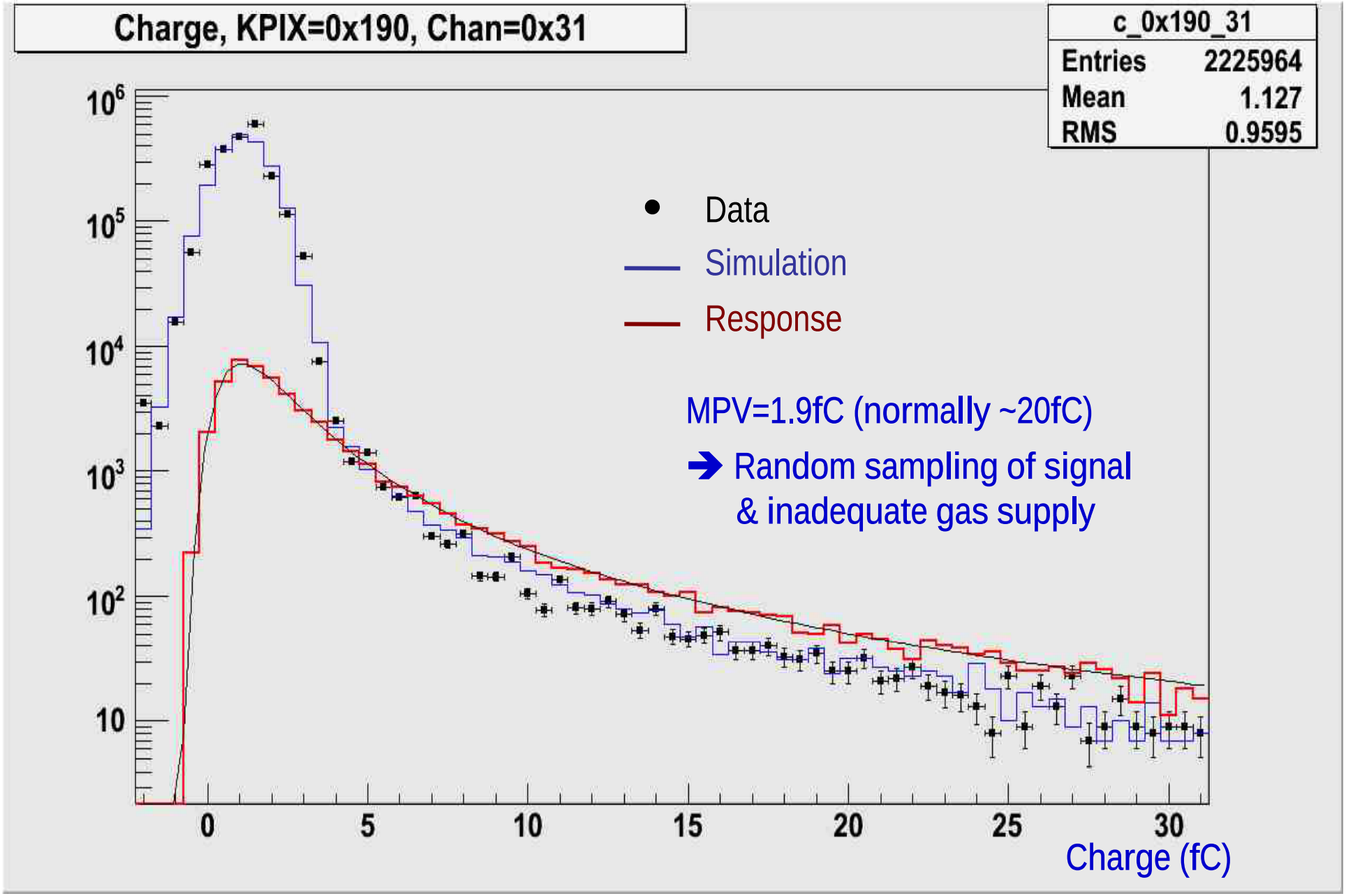
Study of KPiX Behaviors with GEM

- Analysis of KPiX data complicated due to
  - Its triggering scheme using accelerator clock
  - Thus, no external triggering scheme
  - How do you trigger weak radioactive source signal?
  - Interesting inconsistencies in calibration observed
- Understand the chip's behavior using calibration data
  - Data taken hourly for two separate days + three months
  - Each Channel's Pedestal Mean, Sigma; Gain, and Y-Intercept verses Run# (on order of an hour) is graphed for each channel and for two gain modes
  - Relatively stable short term time dependence of ped and gains for the given channel but some long term ped change
  - Significant channel-to-channel gain variations (5 – 20 ADC/fC) observed

KPiX4-GEM Source Response Extraction

- A method based on simulation developed to overcome the triggering complication with weak source ➔ Jacob's Method
- Simulate KPiX4 readout of GEM signal using GEM pulse signal, actual pedestal distributions and previously measured Landau response curves
  - Since the source signal is random, KPiX integrates charge partially
- Let the Landau MPV and width as well as the normalization of the ped gaussian float till the source data is well described by the simulation

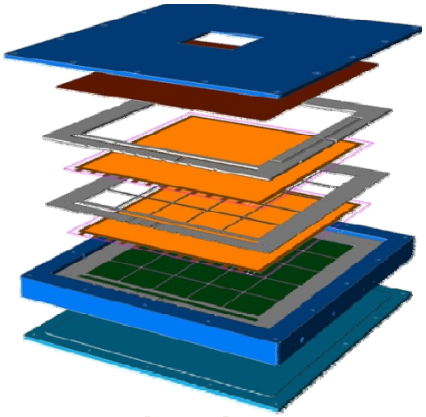
Extracted Response – GEM-KPix



GEM DHCAL Status

- Have been working on getting the SLAC-Oregon KPiX analog chip working with GEM
  - KPiX modified to accommodate smaller GEM signals (>~20fC)
- Signal from source extracted using 64 channel KPiX v4
  - No external trigger acceptance
  - Basically a random trigger with respect to signal arrival
- A chamber with the updated KPiX v7 with external trigger capability working
  - Have been debugging the chip
  - Cosmic and source data taken and being analyzed
    - 7% duty factor a cosmic killer
- 256 channel v8 to be ready for characterization in spring 09
- Much higher hope for funding this year than last several

GEM DHCAL Plans - I

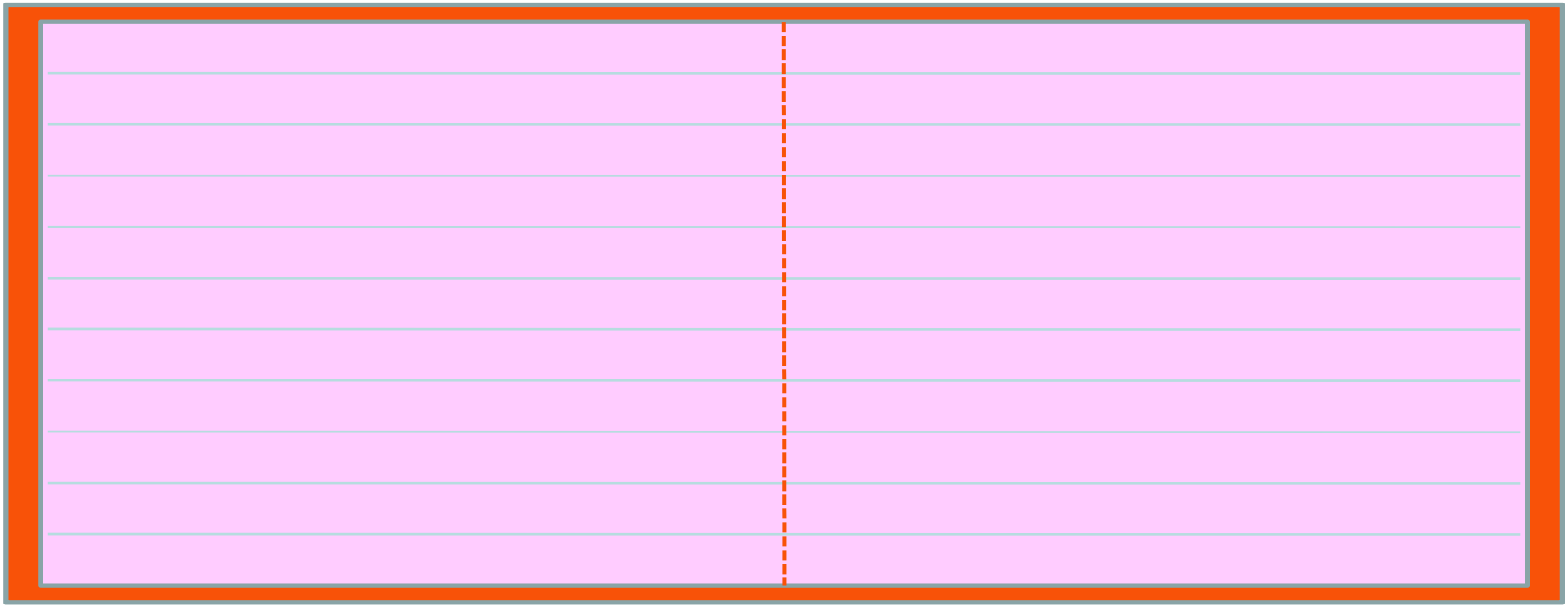


- Through Summer 2009
  - 30cmx30cm chamber
    - Construct a new chamber with optimal gas flow design
    - Characterize the chamber with sources and cosmic rays using 64 channel KPiX v7 at UTA
    - Characterize the chamber in particle beams
      - Responses, noise characteristics, efficiencies, gains, etc
  - 33cmx100cm unit chamber
    - Finalize 33cmx100cm (32cmx96cm active area) large GEM foil silkscreen design
    - First draft became available 1.5 weeks ago…

Large GEM Foil Discussion with CERN-GDD

- The size of the foils are 33cmx100cm, the same as the physical size of the unit chamber
  - Active area is 32cmx96cm
  - Is this realistic to think of constructing a chamber with the same physical size foils?
- Rui says that the foils will be delivered in eight weeks or so once the design is completed and once the hole etching technique is verified
  - One-side hole etching technique is being improved ➔ Since gain shows factor two difference

Large GEM HV Strip Run

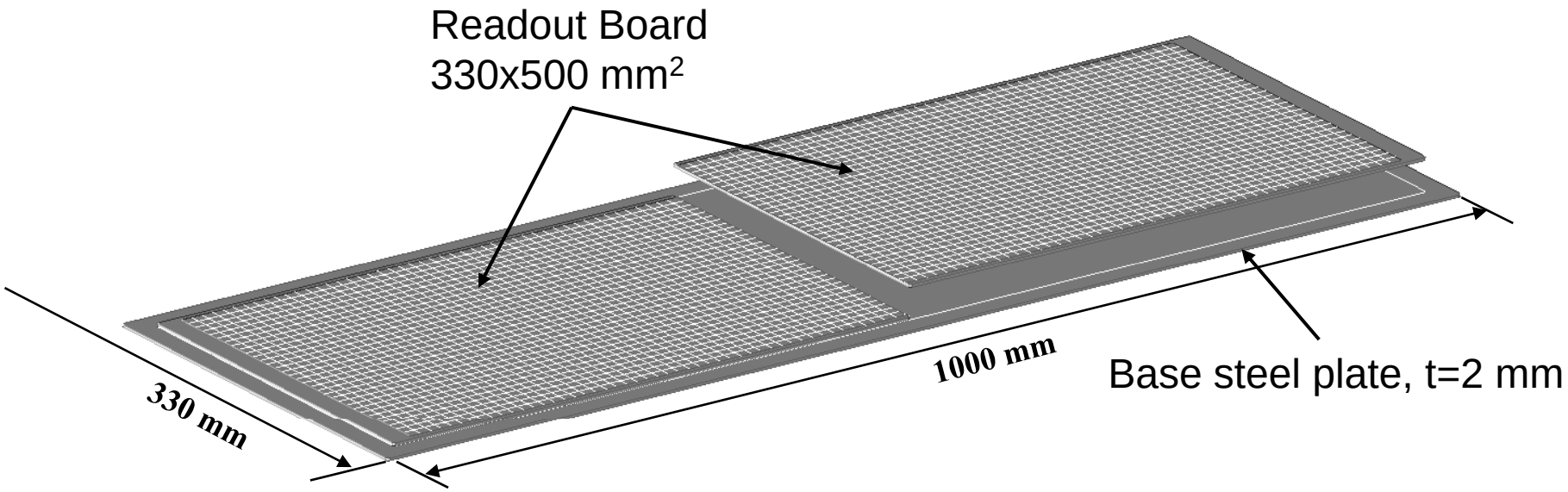


- 10 strips of size 3cmx100cm with HV connection on either side of 2cm edge
  - Mechanically more stable when foils stretched
- 20 strips of size 3cmx50cm with 20 HV connections, 10 each on other side
  - Miminize the lost area of foils under an HV trouble

GEM DHCAL Plans - II

- Summer 2009 – Late 2009
  - 33cmx100cm thin GEM unit chambers
    - Production and certification of 33cmx100cm foils
    - Characterization of 256 channel v8 KPiX chips
      - Available in late spring 2009
      - Use 30cmx30cm STP chamber
    - Construction and characterization of 33cmx100cm thin GEM unit chamber
  - Large Thick GEMs
    - Working with Weizman institute on TGEMs
    - Certification of large TGEMs

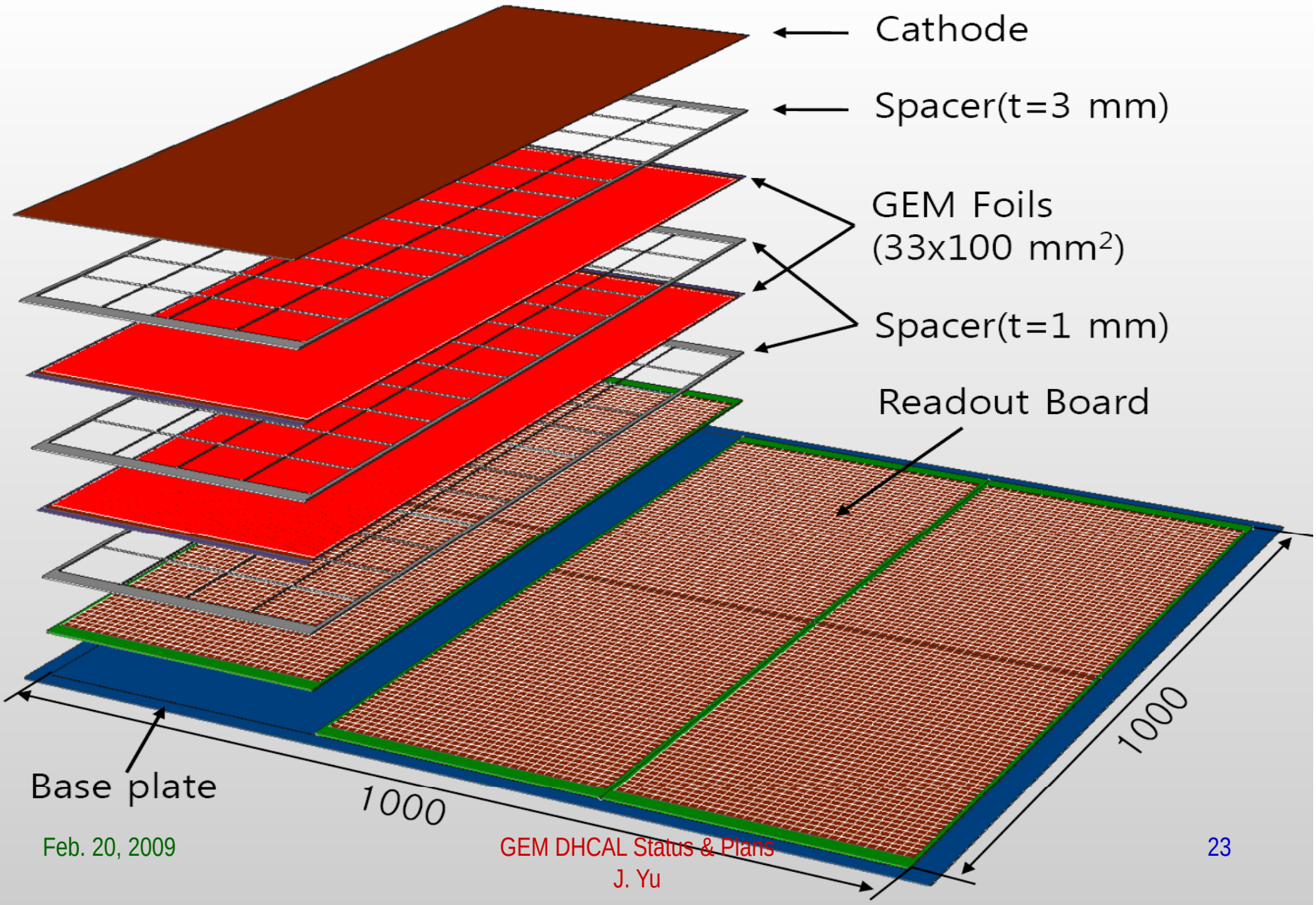
UTA's 33cmx100cm DHCAL Unit Chamber



GEM DHCAL Plans - III

- Late 2009 – Mid 2011
  - 33cmx100cm thin GEM unit chambers
    - Complete production of 15 33cmx100cm unit chambers
  - Construct five 100cmx100cm GEM DHCAL planes
    - Using DCAL or KPiX readout chips
  - Beam test GEM DHCAL planes in the CALICE beam test stack together with RPC
  - 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



GEM DHCAL Beam Test Plans

- Phase I ➔ Completion of 30cmx30cm characterization
  - Early summer 2009 at MTBF: using one plane of 30cmx30cm double GEM chamber with 64 channel KPiX7
- Phase II ➔ 33cmx100cm unit chamber characterization
  - Late 2009 – mid 2010 at MTBF: Using 256 channel v8 KPiX chips
  - Possible beam test and characterization of TGEM prototype using 256 channel v8 KPiX chips
- Phase III ➔ 100cmx100cm plane GEM DHCAL performances in the CALICE stack
  - Late 2010 – Mid 2011 at 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

Conclusions

- Multi-channel GEM readout with KPiX in progress
  - Signal extracted using KPiX4 w/o external trigger
- KPiX 7 became available two months ago
  - Have been working on debugging and cosmic data taking
- Large GEM foil silkscreen design being finalized
- TGEM work continues in collaboration with Weizmann institute
- Full, multi channel characterization to complete this year, followed by large GEM chamber tests
- Positive news on funding gives better prospect on making tangible progress on GEM