GEM DHCAL Update: KPiX Electronics

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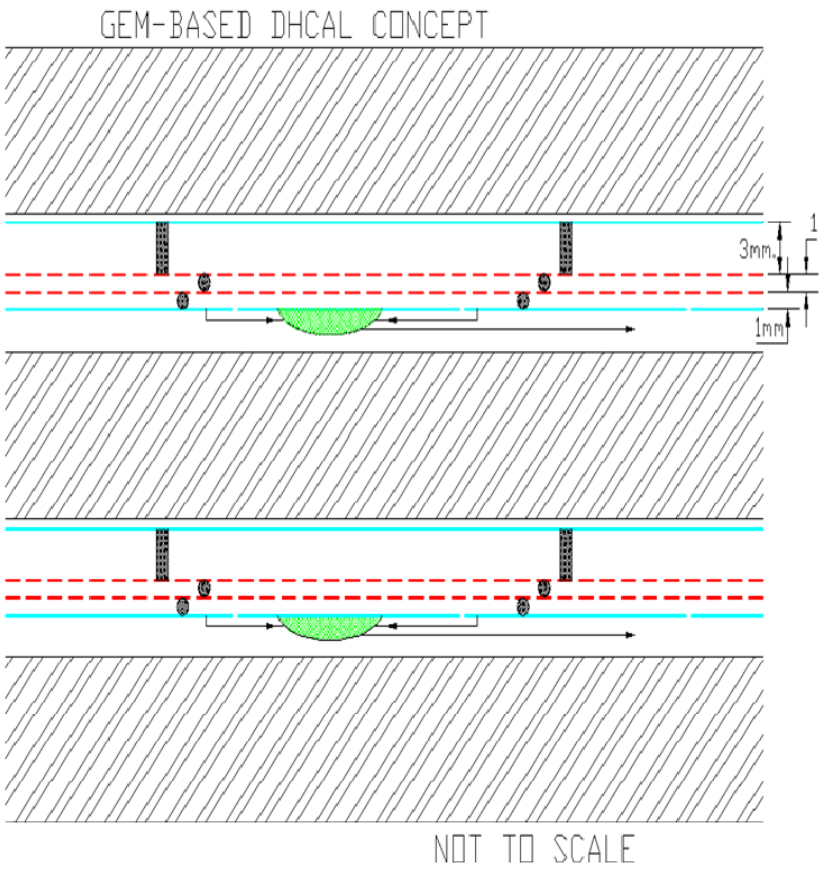
LCWS08

Outline

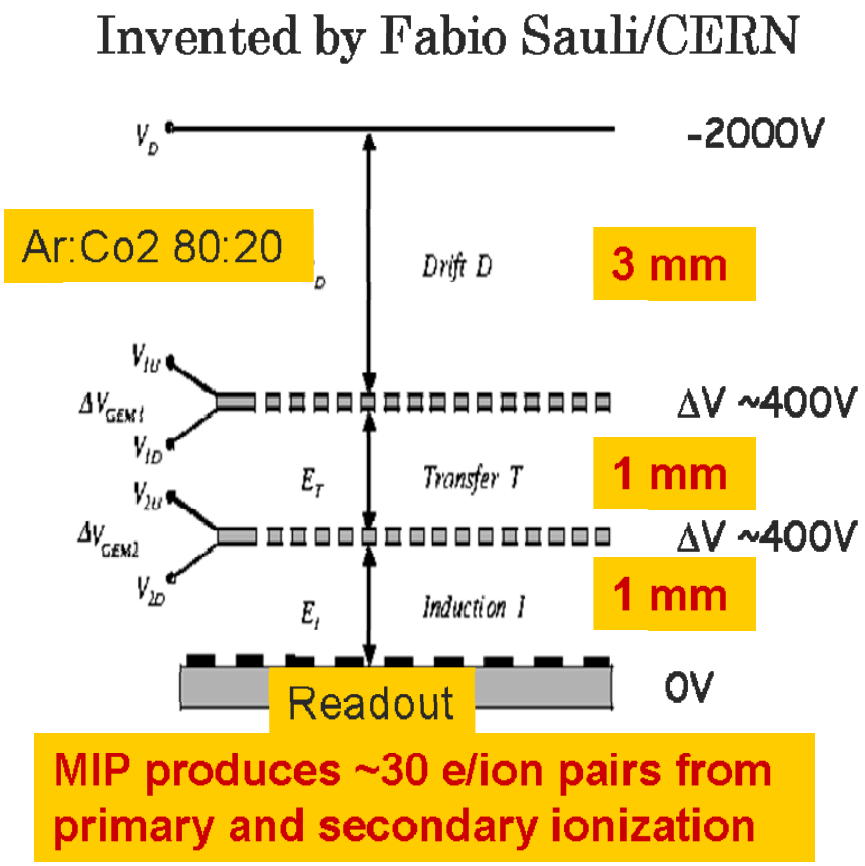
- GEM Background
  - Motivation and Calorimeter Concept
  - Test Beam Results (QPA02 Fermilab Preamp)
- KPiX Version 4
  - Calibration with Chamber
  - Source Data
  - Simulation
- KPiX Version 7
  - Calibration with new Chamber
- Conclusions

GEM-based Digital Calorimeter Concept

- Flexible: configuration allows cells of anode pads on order of cm^2 for high granularity
- Robust: survives ~10^{12} particles/mm^2 with no performance degradations
- Fast: based on electron collection (~few ns rise time)
- Recovery: can handle high rates
- Simple Gas: Ar:Co2
- Reduce nominal operating voltage: 2kV for double GEM
- Utilize Double GEM technology

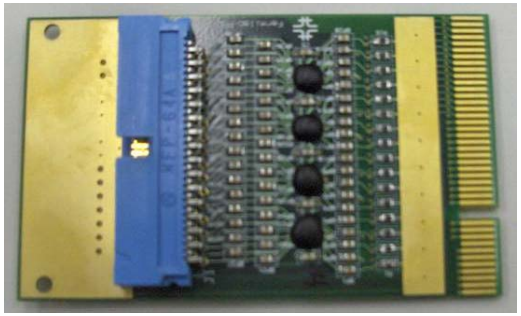


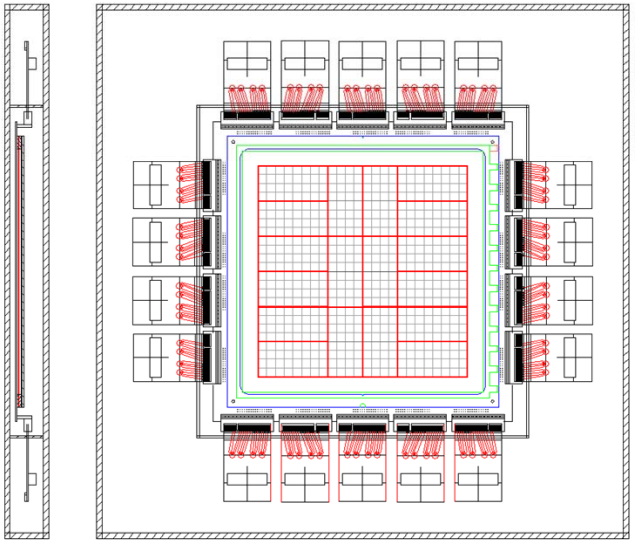
GEM Technology



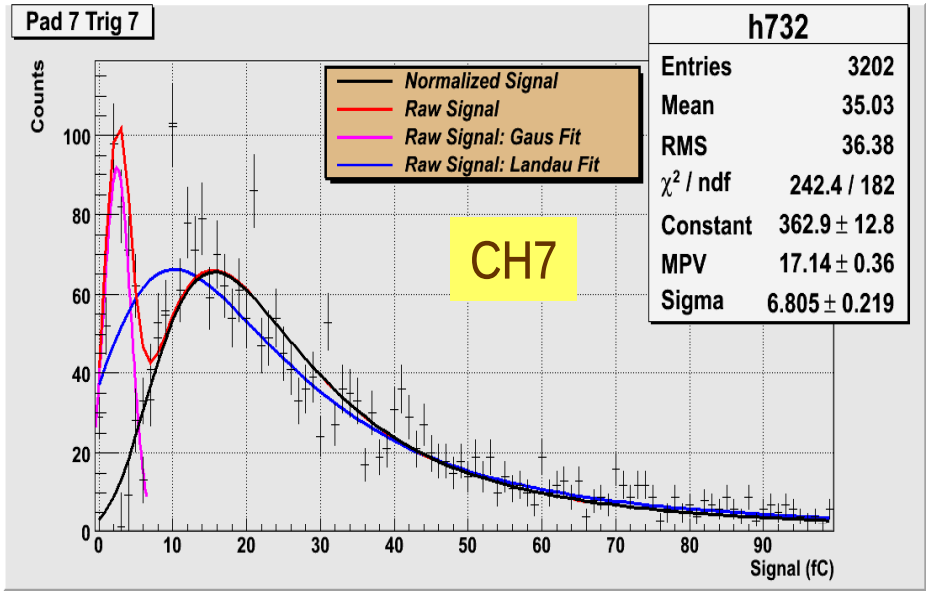
- Gas Electron Multiplier - gaseous ionizing detector
- Charge multiplication occurs in avalanches through foils – apply 400V over 65μm foil
- Minimum Ionizing Particles produce # of electron/ion pairs dependent on size of drift gap

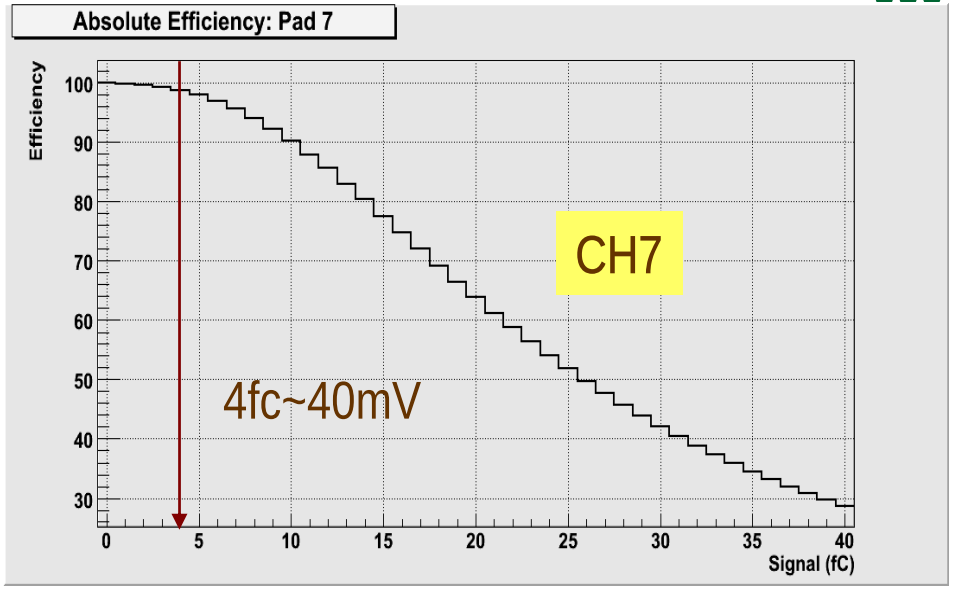
GEM at the FNAL Test Beam – 120 GeV

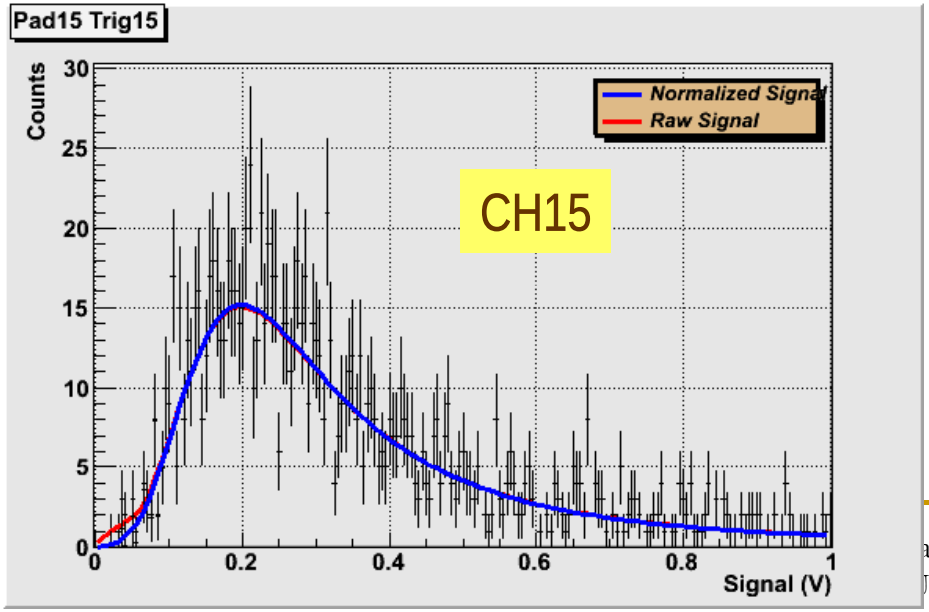


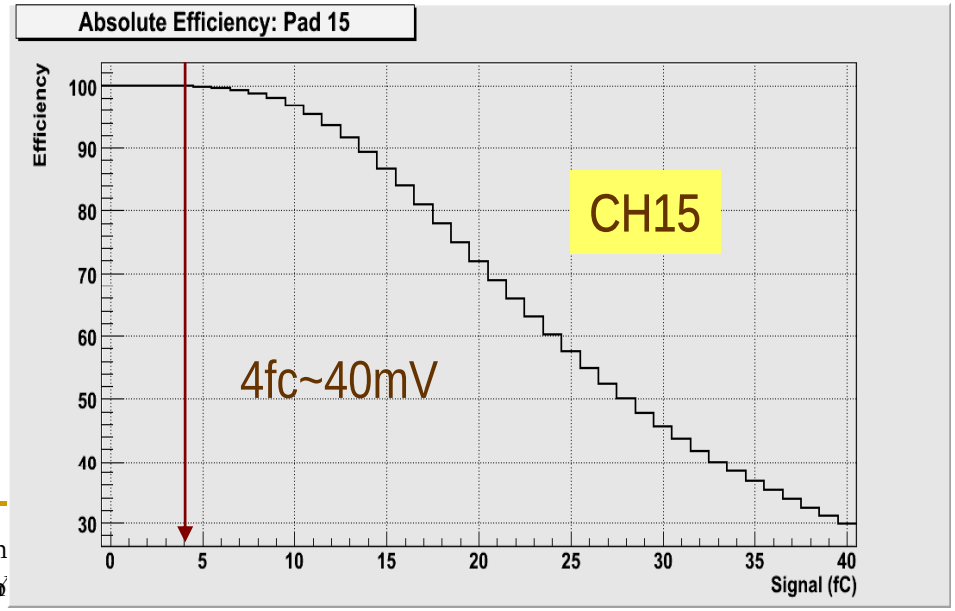


GEM Chamber Responses and Absolute Efficiency

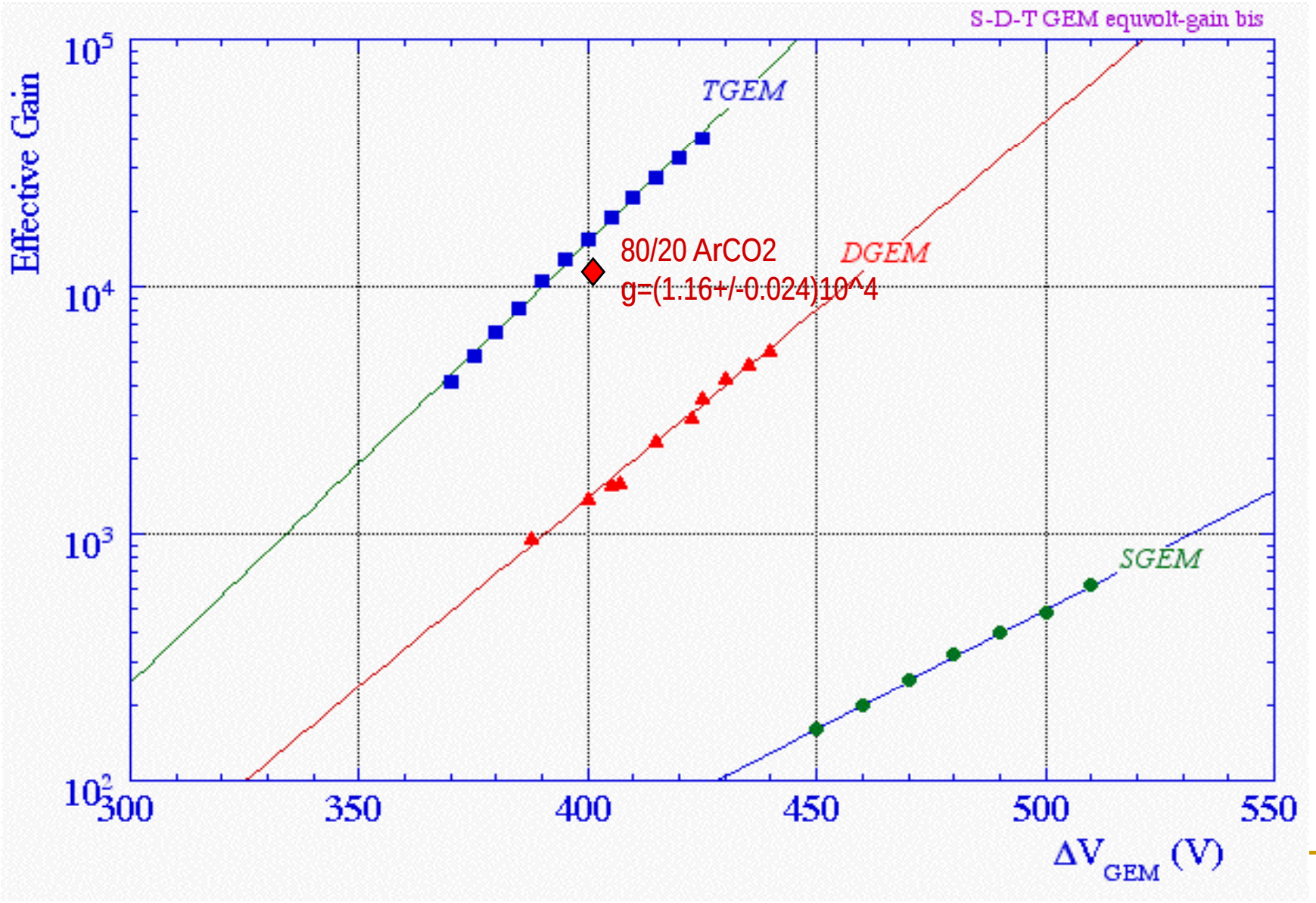








UTA GEM Chamber Gain



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  - Calibration with Chamber
  - Source Data
  - Simulation
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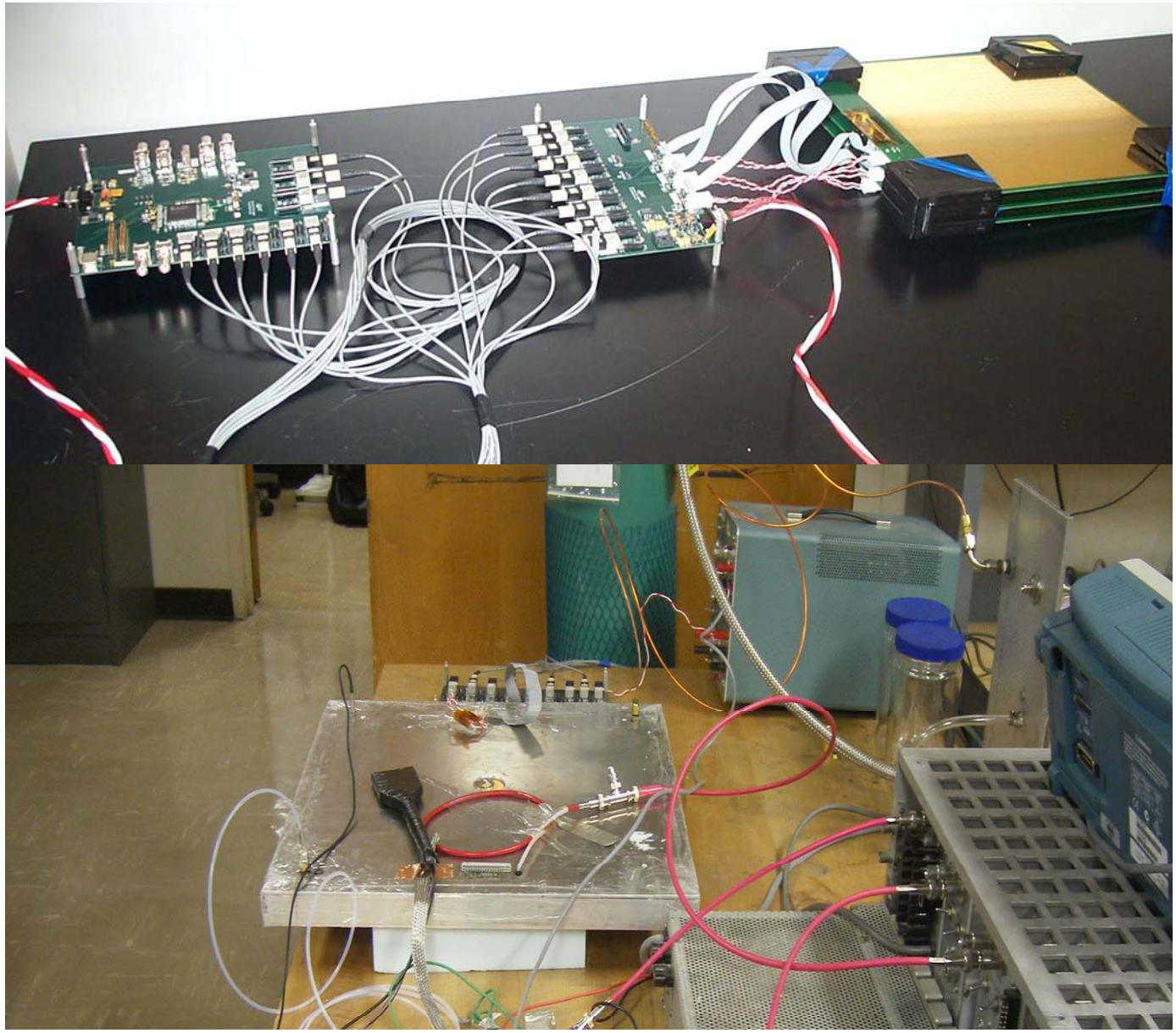
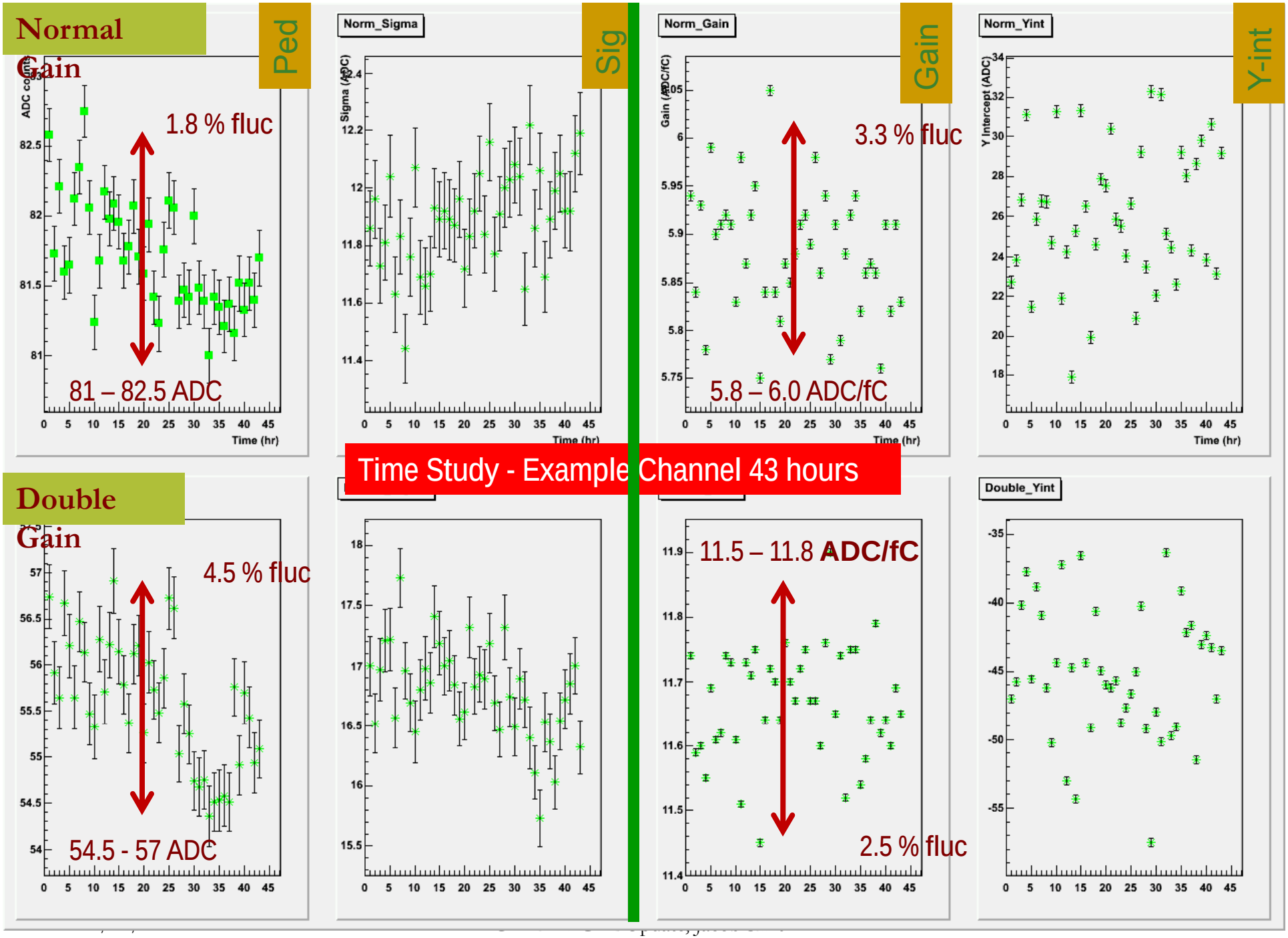


KPiX Version 4 Calibration

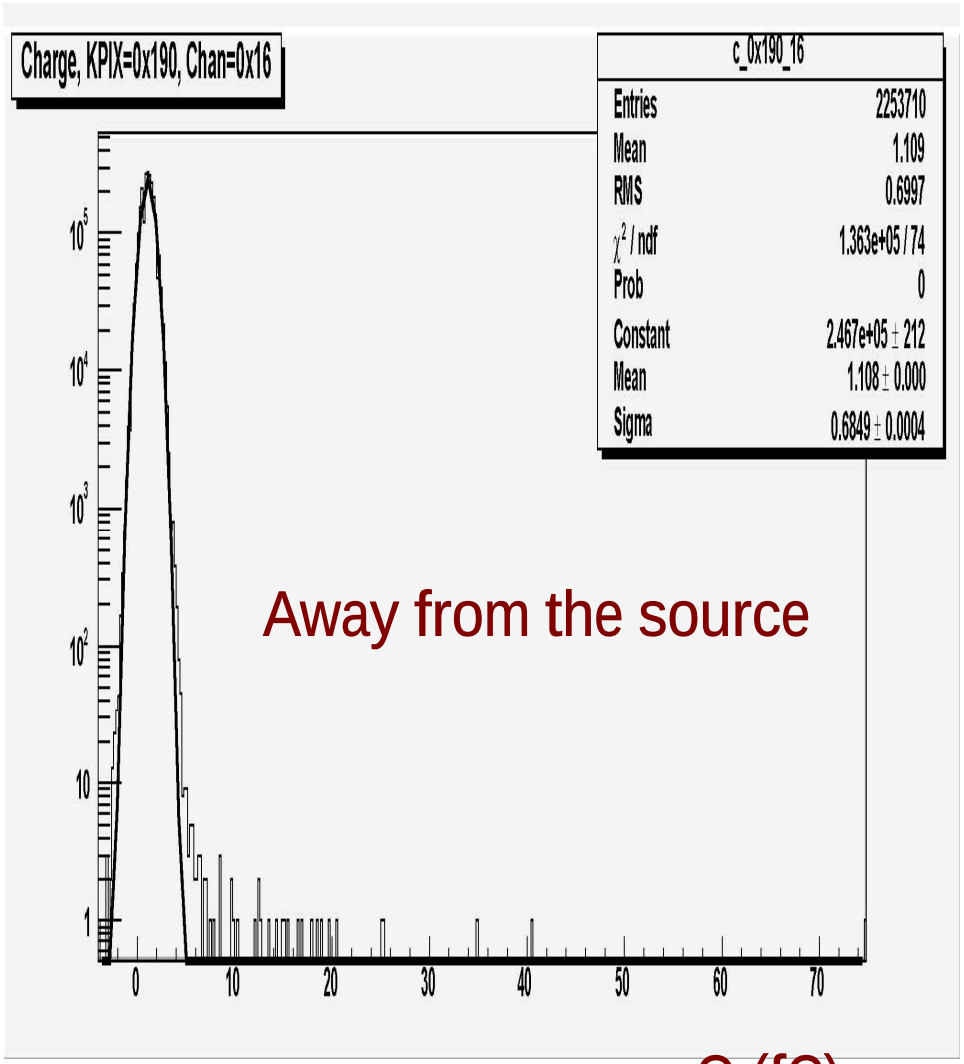
- Unique Capabilities
  - Integrated calibration operation
    - Pedestal distribution (mean, width)
    - Gains calibrations (slope)
      - Onboard DAC injects charge through readout electronics
  - 3 Gain modes available: normal, double, low
- Time Dependence of Calibration Constants
  - Calibration Constants: pedestal, noise (width), gain
  - Performed two sets of calibrations each two days apart for a 19 and 24 hour time in one hour periods
  - Plot the constants

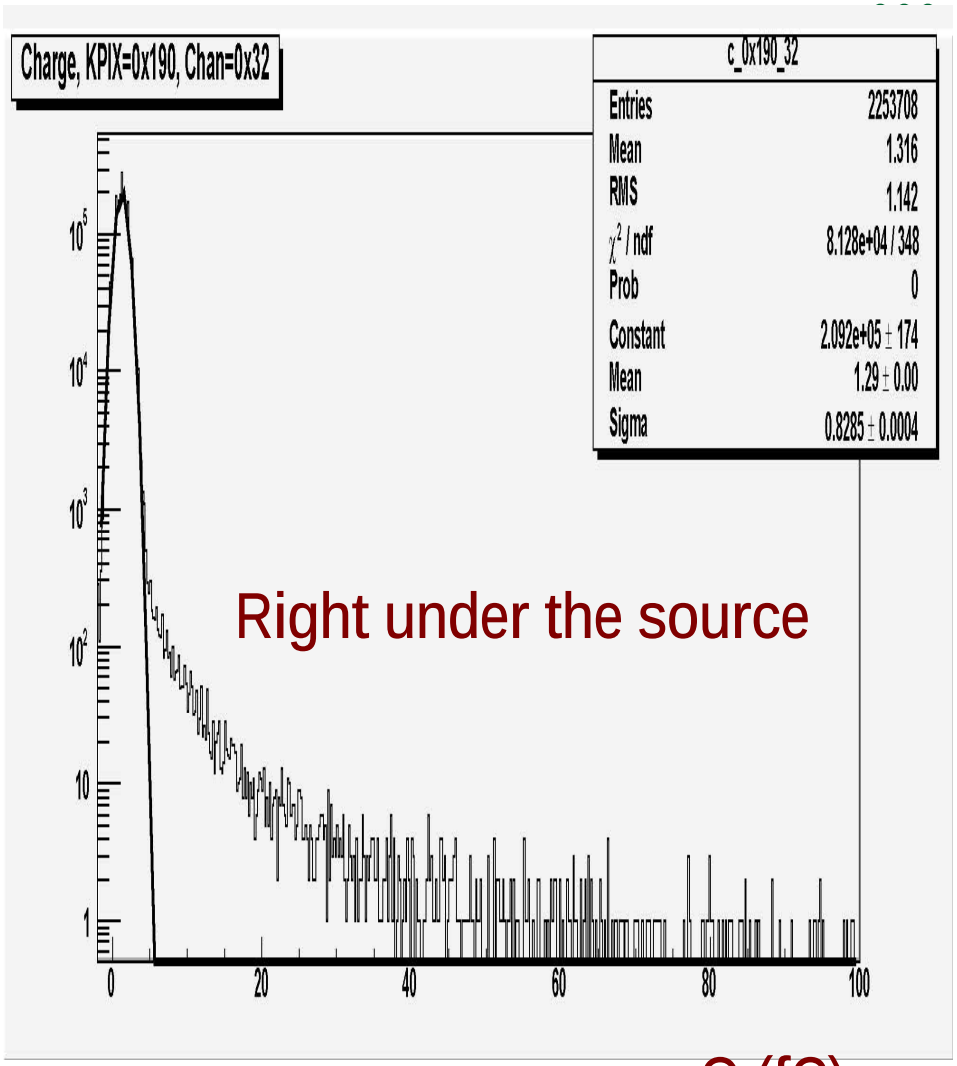

Normal Gain
Ped
Norm_Sigma
Sig
Norm_Gain
Gain
Norm_Yint
Y-int
1.8 % fluc
81 – 82.5 ADC
3.3 % fluc
5.8 – 6.0 ADC/fC
Time Study - Example Channel 43 hours
Double Gain
4.5 % fluc
54.5 - 57 ADC
11.5 – 11.8 ADC/fC
2.5 % fluc
Double_Yint
Time (hr)

KPiX Version 4

- Source Data
  - Strontium 90 (SLAC source)
- Simulation
  - Estimate MIP response in KPiX/GEM

Reponses to Source (SLAC) - KPiX





Study of Source Data Behaviors

- KPiX Version 4 electronics signal trigger
  - Version 4 periodic reset also causes signal integration to stop early
  - Timing designed for ILC accelerator clock
  - No external trigger scheme for Sr-90
- “Random” trigger produces a large noise contribution in signal distribution that overwhelms signal’s MIP response
- Simulate KPiX v4 effects on expected Landau distribution

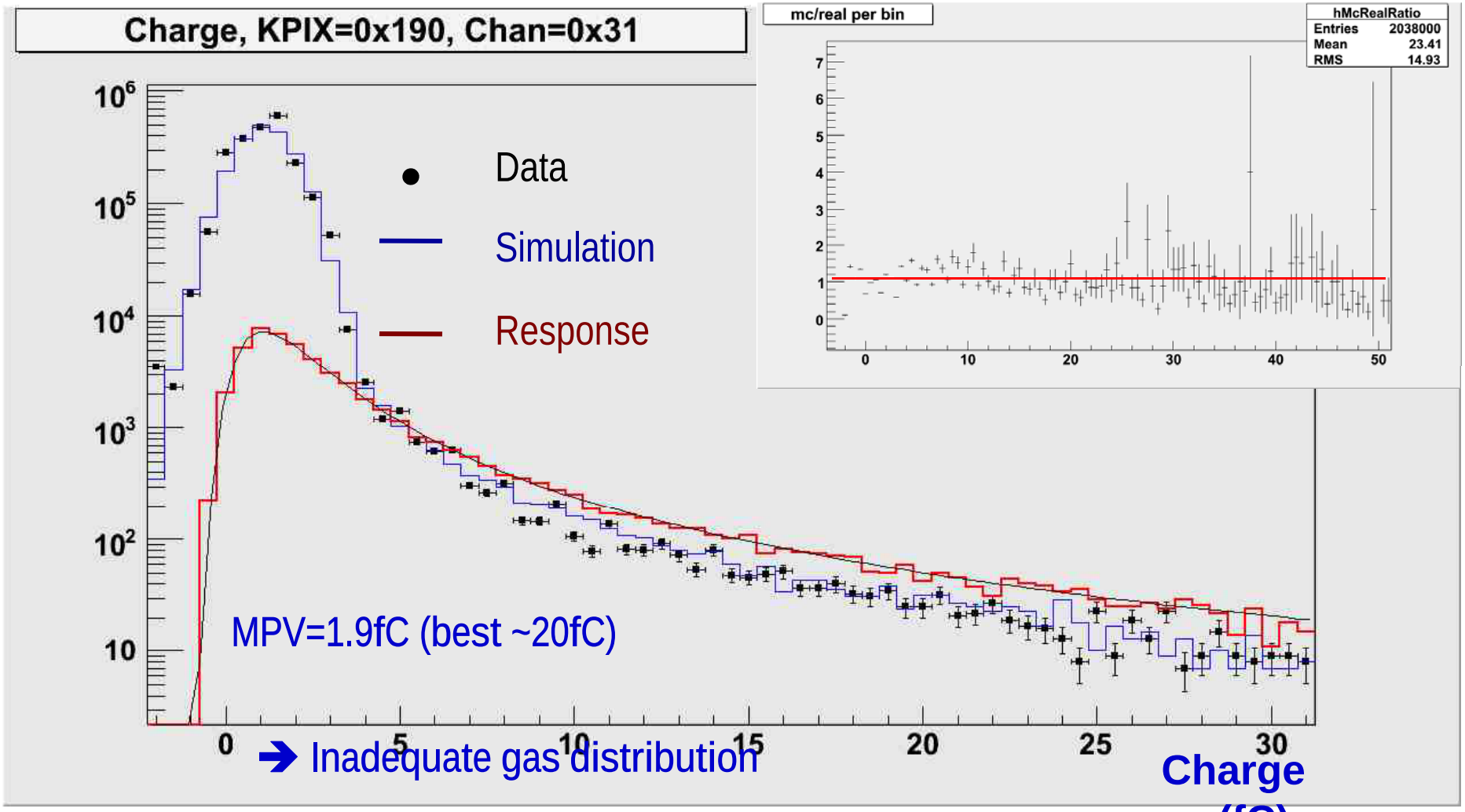
KPiX Monte Carlo Signal

- Need to approximate effect of
  1. Asynchronous running with source
     - Or beam (unless its timed like SLAC's)
  2. Periodic Reset in KPiX
     - Periodic reset replaced with DC Reset that does not interrupt signal integration
- Simulation Procedure
  - Assume GEM ionization charge distribution is Gaussian
  - [Re]Guess initial Landau MIP distribution based on previous GEM chamber MIP responses (beam tests)
  - Simulate periodic reset through random integration of Gaussian
  - Simulate signal's large Gaussian contribution based on real data's noise peak

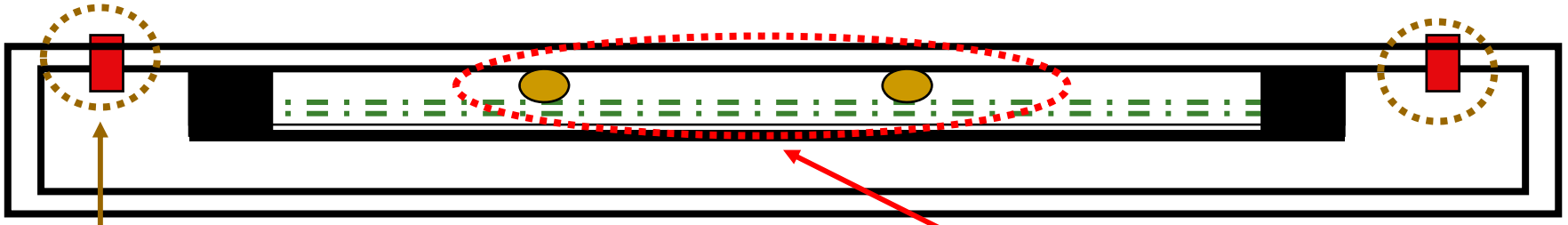
Initial assumed Landau represents chamber MIP response

- If real data and MC match

MC and Real – Sr90 KPiX v4

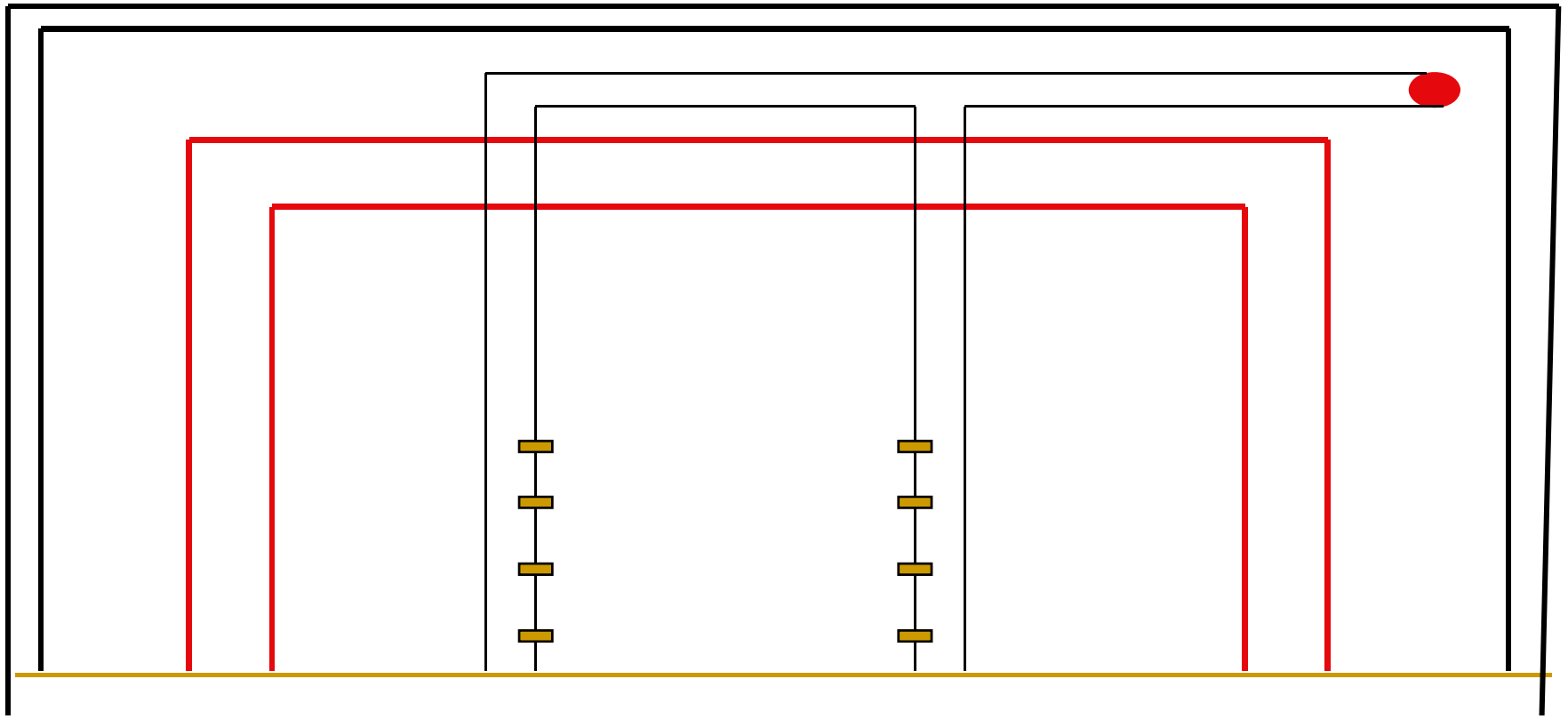


Direct Forced Gas Supply System



Old way gas passes main chamber

New way gas injected in main chamber



Outline

- KPiX Version 7
  - Calibration with new Chamber
    - Compare v4 and v7 calibration constants dependence on ch
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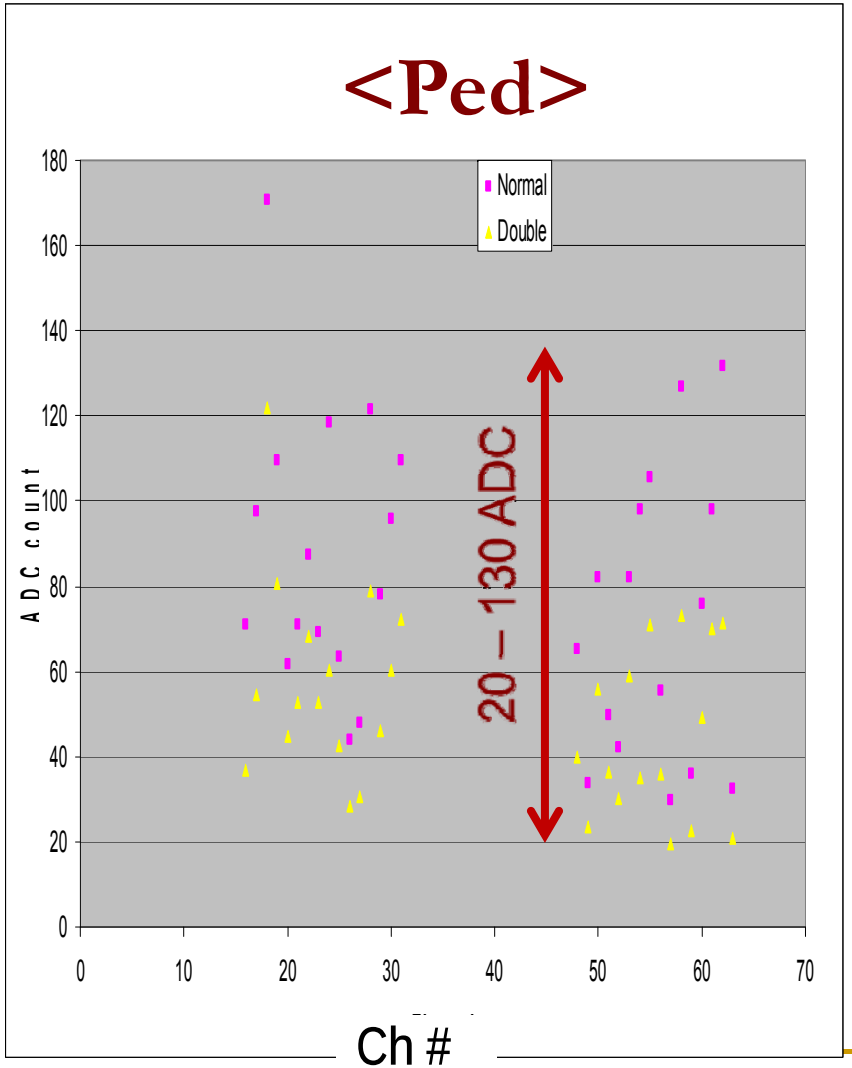
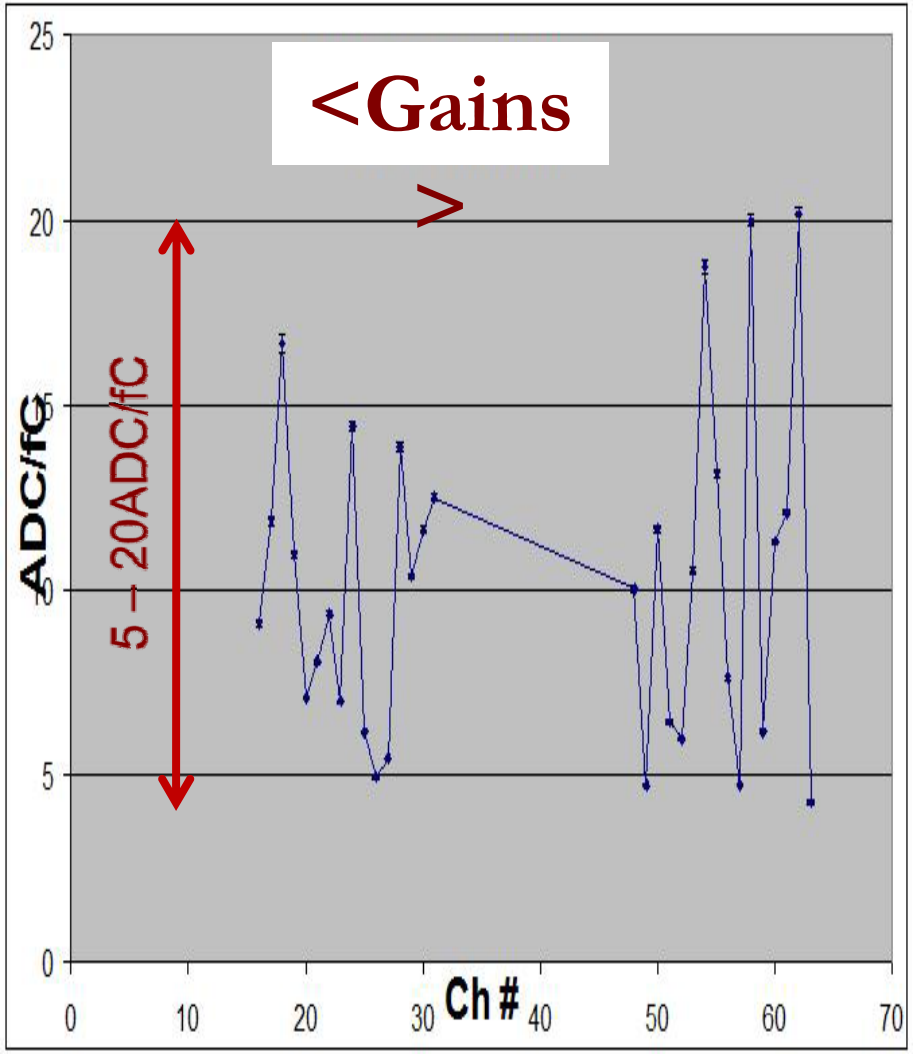
Ch to Ch Variations (KPiX 4)





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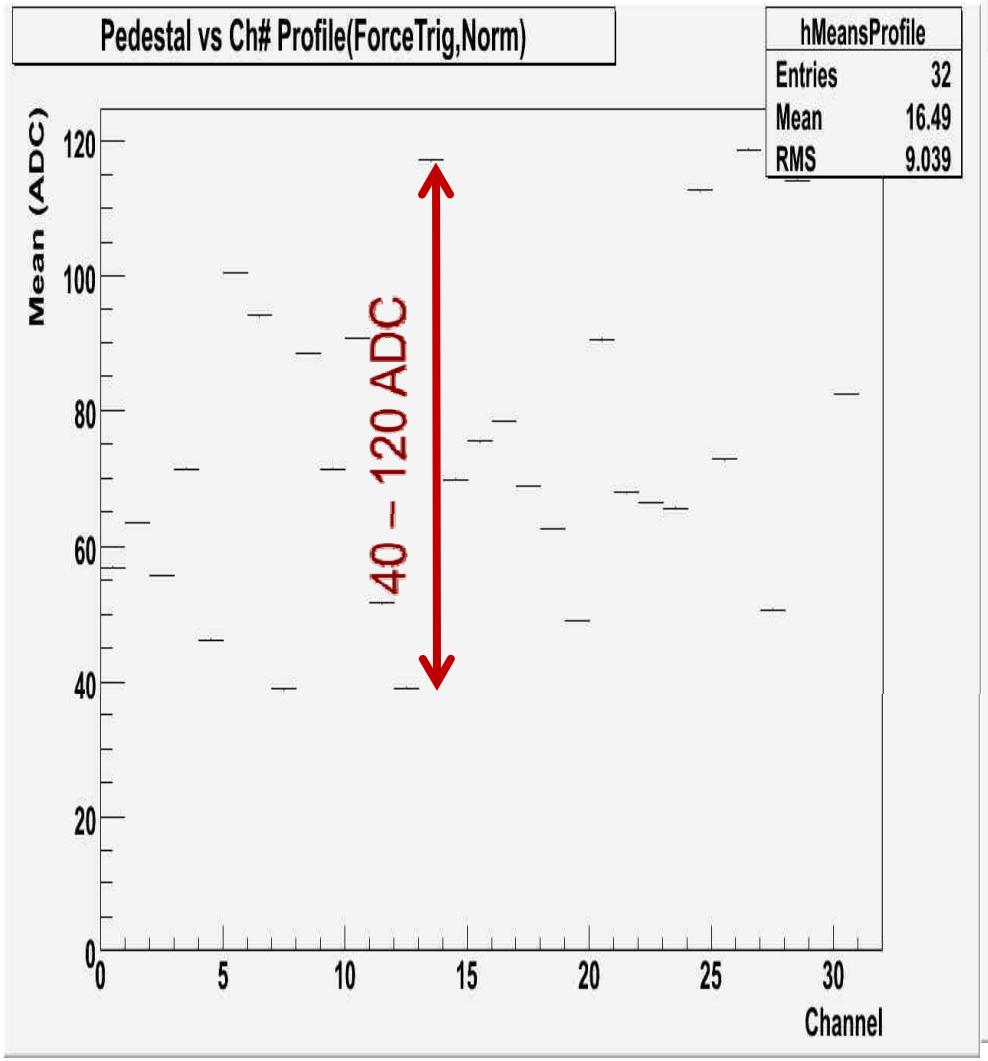

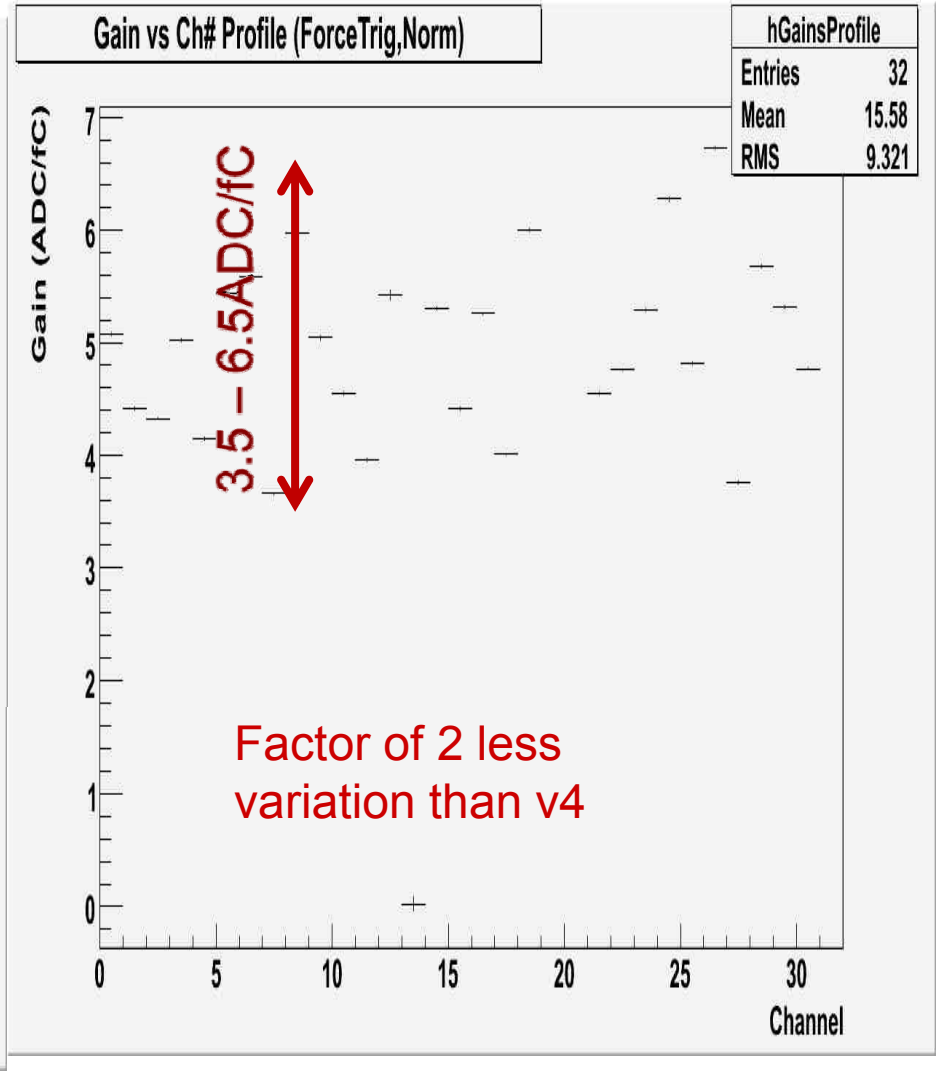

Conclusions

- Much progress made with 30cmx30cm GEM chambers
- Calibration constants are stable in Version 4
  - More detailed calibration studies for KPiX v7 in progress
    - Expect stability improvement
- KPiX Version 7 gain variation by a factor of 2 less than Version 4
- GEM-KPiX readout integration in progress
  - Working with SLAC team for cosmic and source tests with improved Version7 KPiX
  - External triggering scheme implemented on KPiX v7
- 1mx33cm long foil development with CERN for 1mx1m unit chambers for large scale test
  - 3M Inc. punted on flex circuit division
  - Source, cosmic ray and beam test the chamber
- Looking into large area TGEMs and RETGEM s for the future