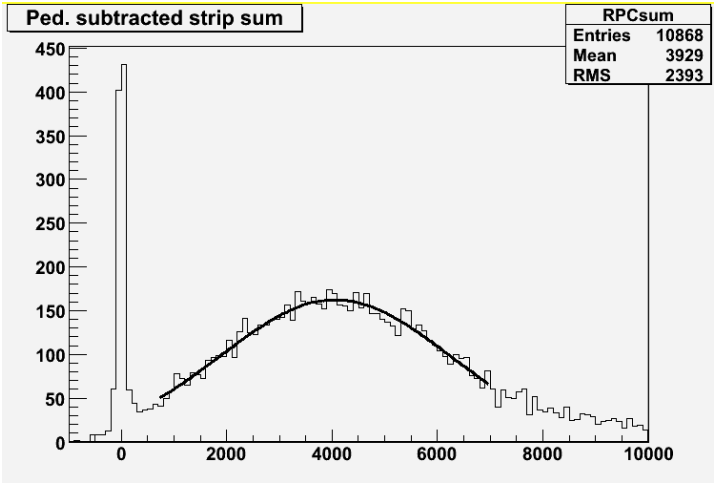
RPC/KPIX Studies

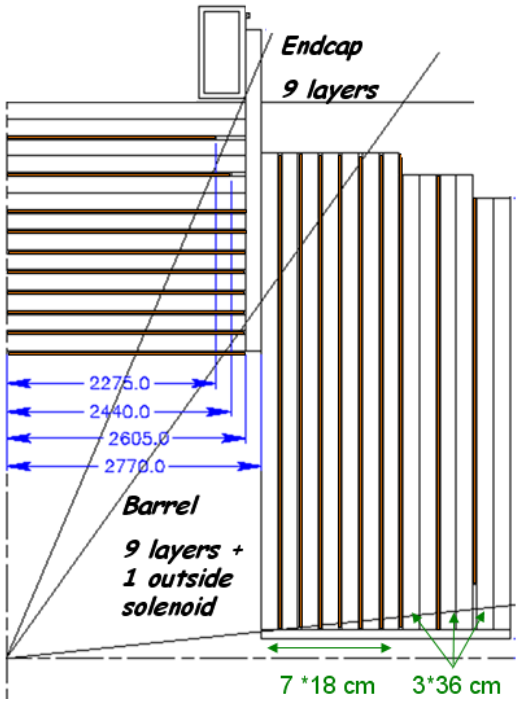
Henry Band
U. Of Wisconsin

Outline

- RPCs are the baseline muon and calorimeter detectors for SiD
- KPIX readout - Ryan Herbst - Tues. 9:10 DAQ
- This talk
  - SiD Muon system
  - RPCs & teststand
  - KPIX tests
  - Future plans

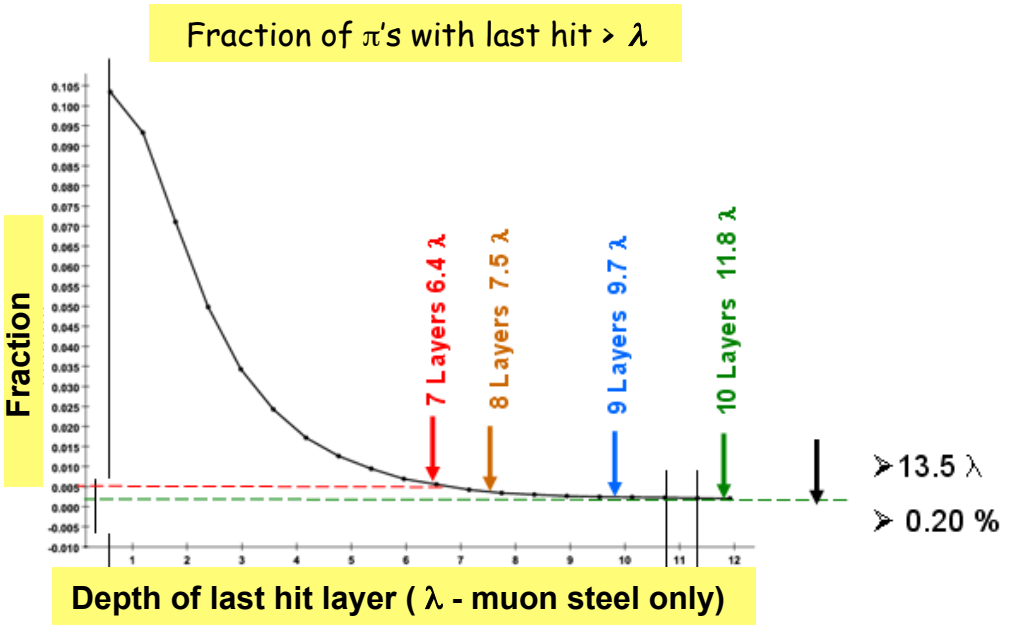


Muon /Flux Return



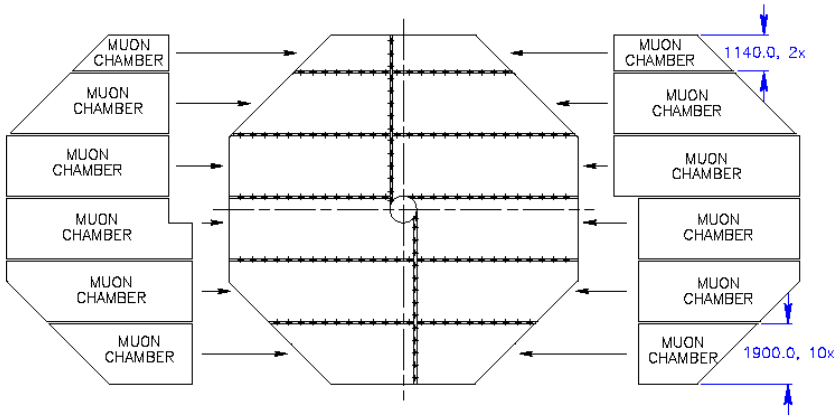
- *9-10 layers*
- *ECAL + HCAL + Solenoid = 6 λ*
- *Muon = 14 λ*
- *Study of pion misidentification vs cut on penetration depth in steel flux return, 10<p<50 GeV/c - flat distribution*

- *Steel thickness determined by flux return requirements*
- *Modest detector resolution needs can be meet by scintillator strips or RPCs*



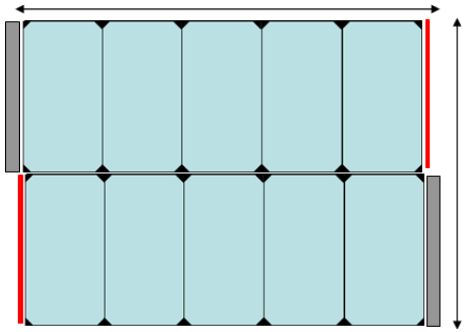
RPC Baseline

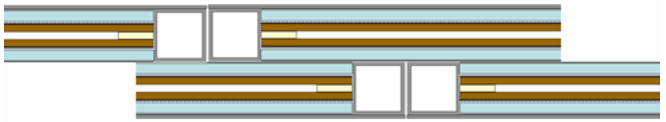
- Double gap RPCs operated in avalanche mode
- RPC and steel boundaries staggered to minimize geometric inefficiencies
- > 93% eff. per layer
- Digitized by KPIX64

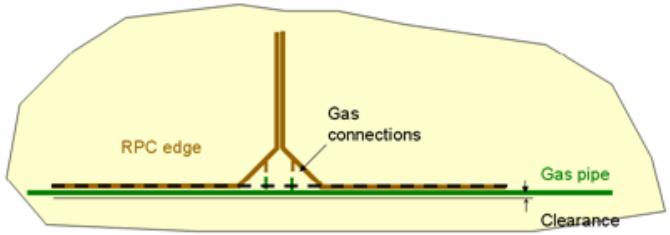


Endcap

Barrel

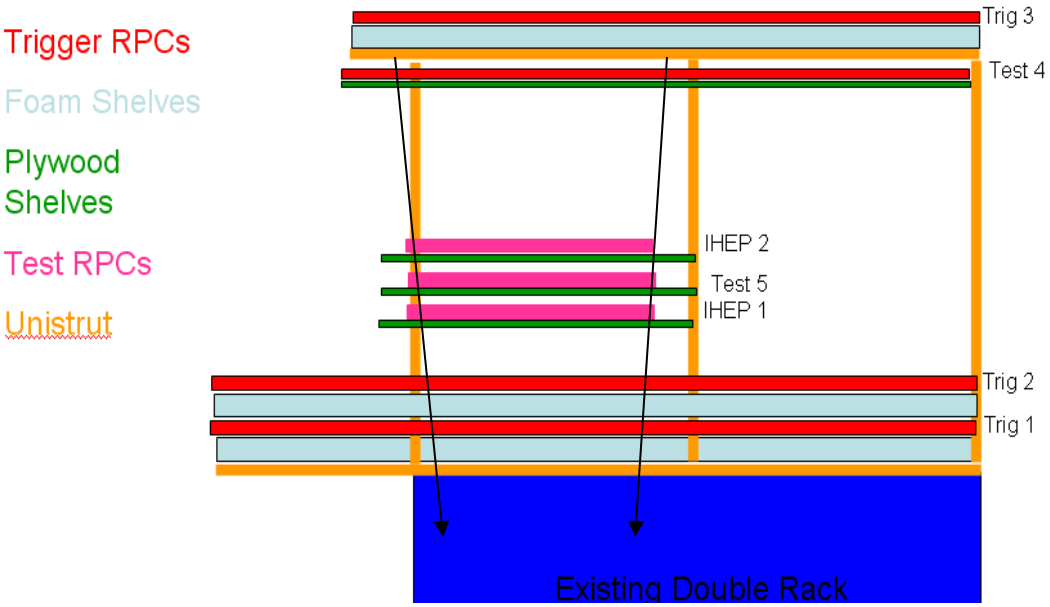






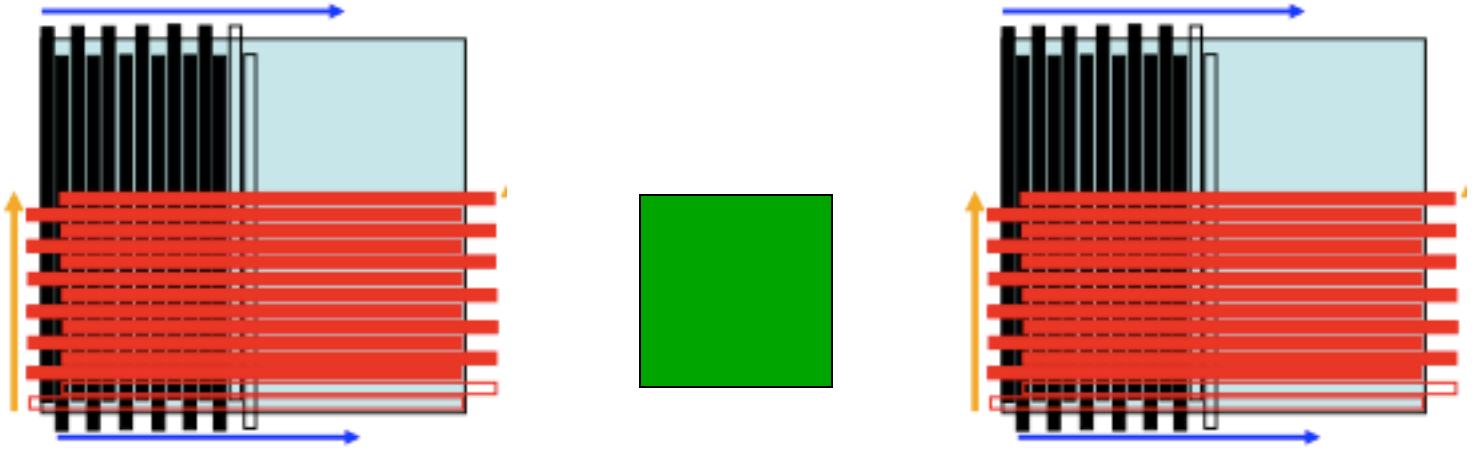
RPC Teststand

- RPC test stand with BaBar spares
- **Available Gases**
  - **BaBar streamer gas - 34.9% Freon 134a, 60.6% Argon, 4.5% isobutane**
  - **BaBar avalanche gas - 75.5% Freon 134a, 19.4% Argon, 4.5% isobutane, 0.6% CF6**
  - **Argon**
  - **Ordered CERN/ANL**
  - **94.5% Freon 134a, 5.0% isobutane, 0.5% CF6**
- Trigger ~ 10 Hz
  - **3-fold coincidence Trig1*Trig3*IHEP 2**



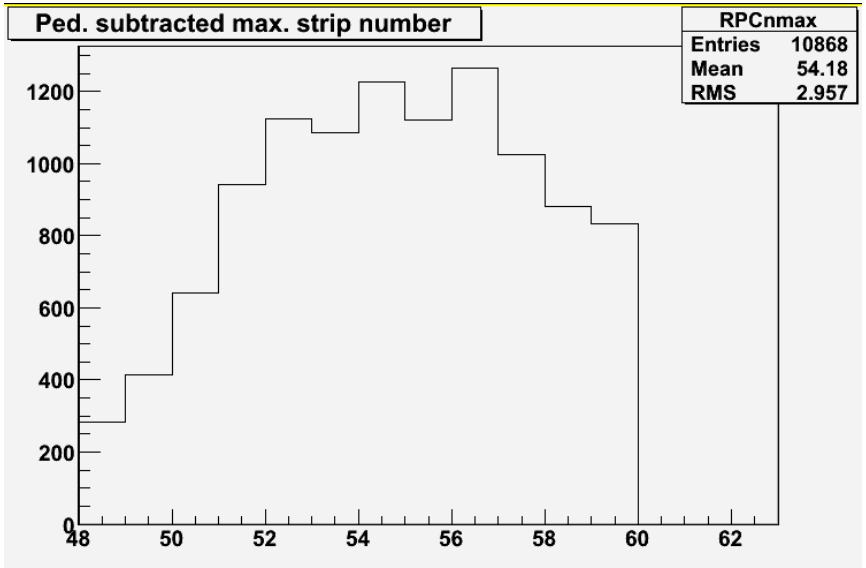
- Available RPCs
- IHEP 0.5 by 0.5 m (4 + 6)
- Italian Bakelite 0.5 by 0.5 m
- BaBar spares 1.1 by 1.3-1.6 m

Teststand

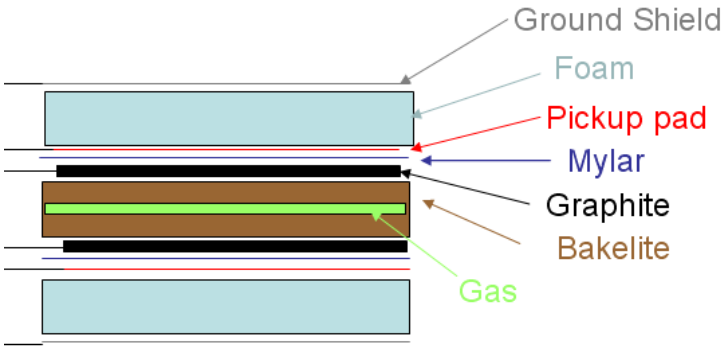


Trigger made from subset of x and y strips to match IHEP chamber size

For these initial tests
Trigger coverage non-uniform
Biased efficiency measurement

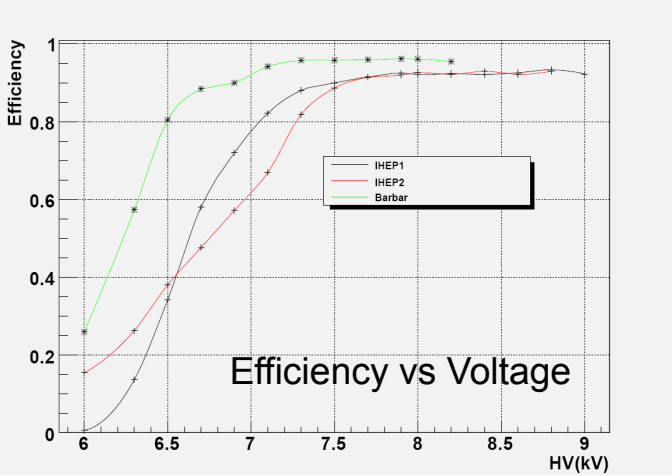


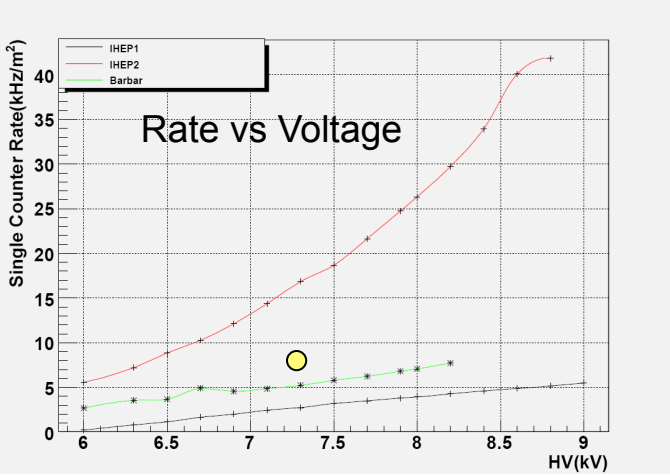
RPC details



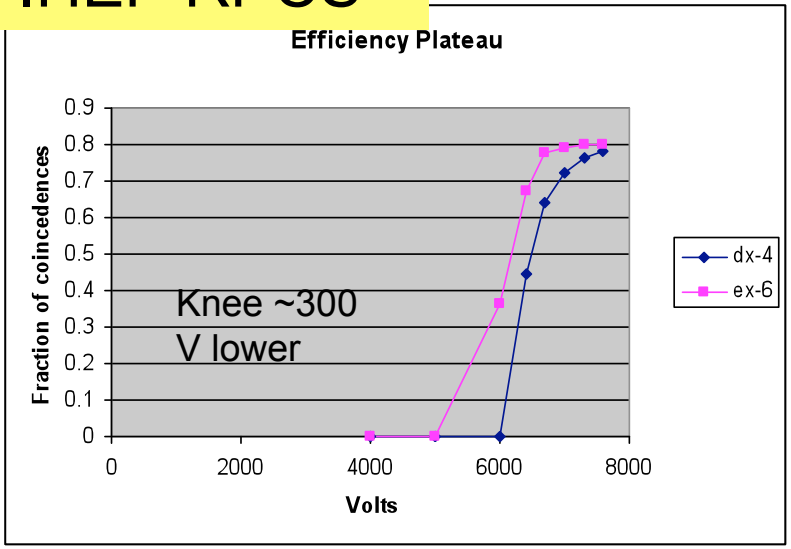
- *IHEP and Italian RPC have 2mm gas gap & 2 mm Bakelite anode & cathode*
- *Pickup strips 22-38 mm pitch, capacitance to gnd . 3-.6 nF*
- *IHEP RPCs have no linseed oil coating*
  - *IHEPs 1-4 damaged in shipping*

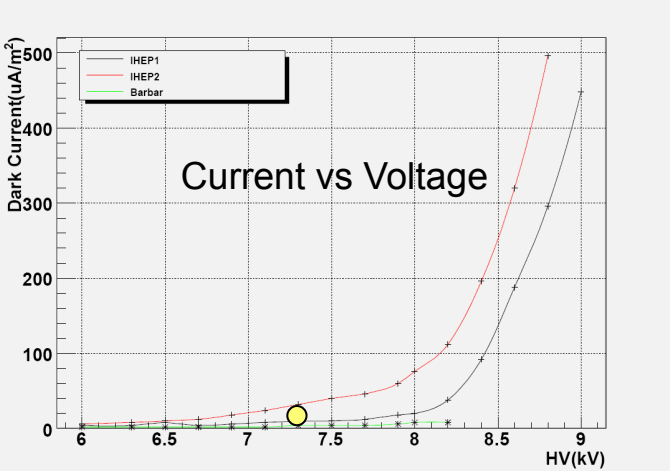
Streamer Mode





New IHEP RPCS





Preliminary RPC/KPIX Data

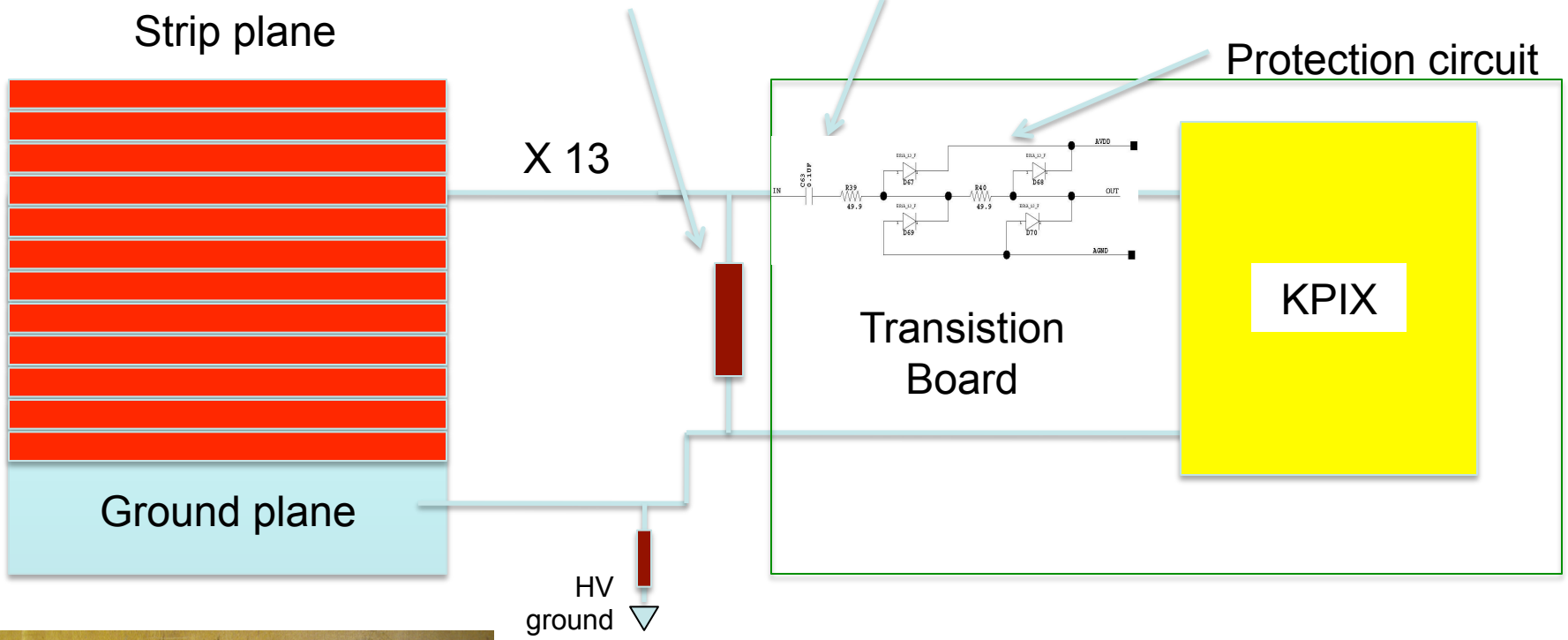
- "Proof of Concept"
- RPC interface board 64 channels
- First tests -AC coupling
  1. Optimize resistor/ capacitor values
  2. Protection circuits
  3. KPIX readout modes

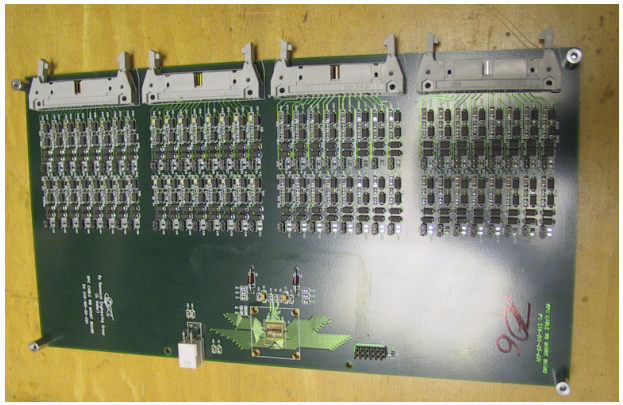
Ryan Herbst,
Dieter Freytag
SLAC

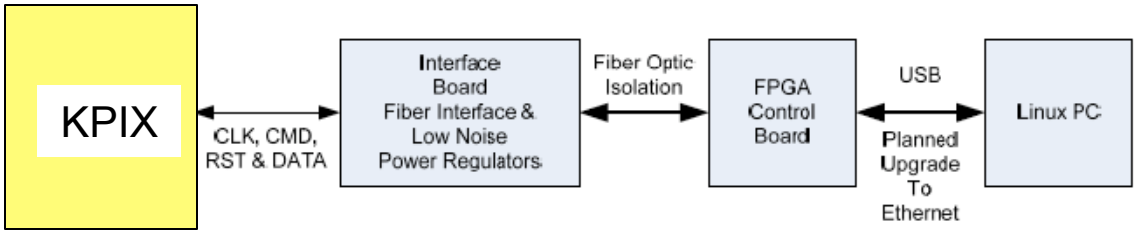
- Vary
- Strip Termination 5-100 kΩ
- Blocking Capacitor 0.1 – 5 nF
- KPIX int. time 1.4 – 4 μs
- Asynch. or triggered readout
- Periodic or DC resets

RPC/KPIX

RPC


Strip termination
Blocking Capacitor
Strip plane
Protection circuit
X 13
Transistion Board
KPIX
Ground plane
HV ground



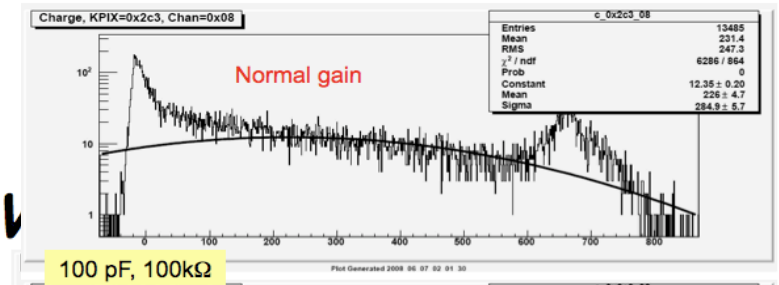

KPIX
CLK, CMD, RST & DATA
Interface Board Fiber Interface & Low Noise Power Regulators
Fiber Optic Isolation
FPGA Control Board
USB
Planned Upgrade To Ethernet
Linux PC

Steps along the way

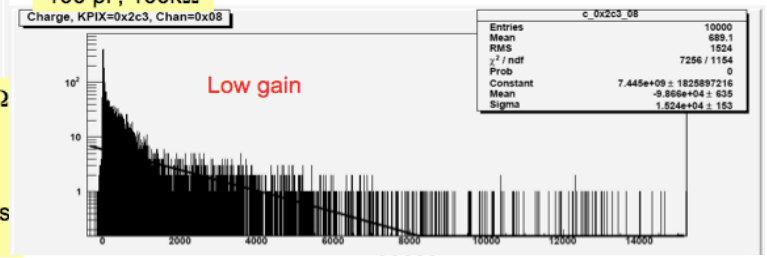
Normal gain saturates - use low gain
Strip multiplicity high – make blocking cap. large
KPIX inputs unstable – power chip earlier, reduce RC time, reduce R

Pedestal wider than expected
Isolate HV

Normal gain vs low gain



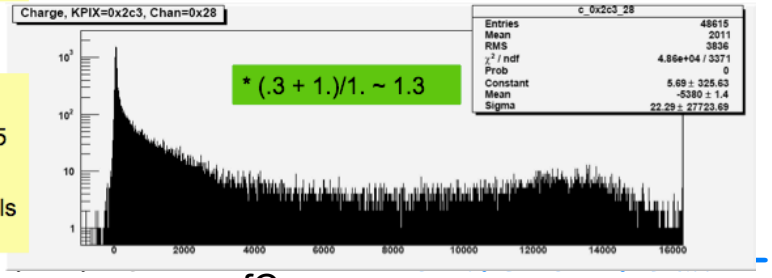
100 pF, 100kΩ



100 pF, 100kΩ

Int time ~ 4 microsec

KPIC channels 0 -15



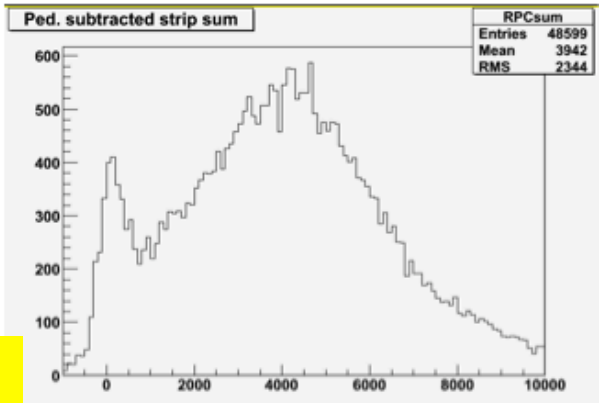
1 nF, 10kΩ

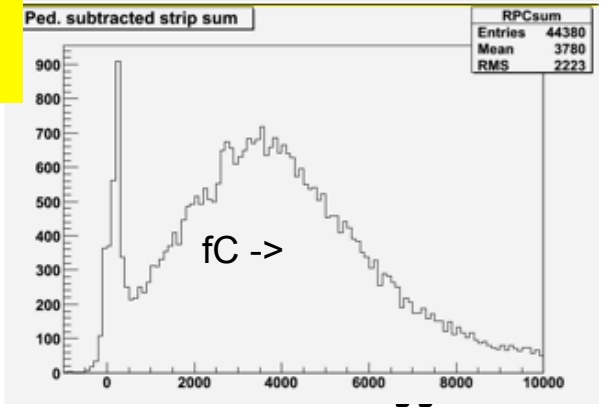
Int time ~ 1.5 microsec

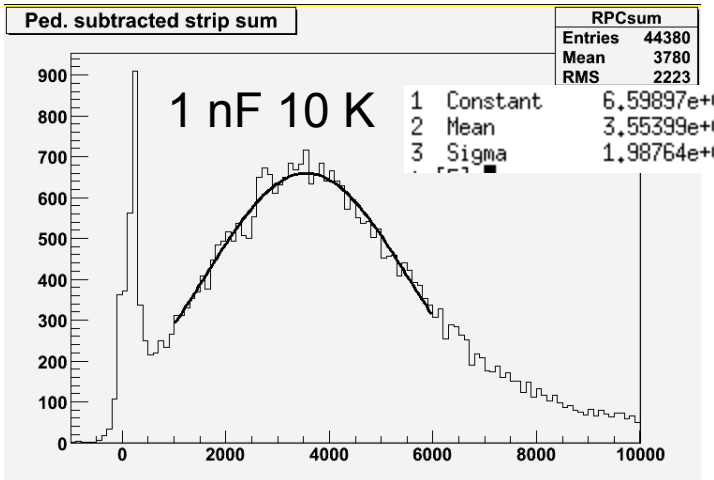
KPIC channels 32-47

fC ->

Noise Reduction
Add 1 MΩ to HV leads

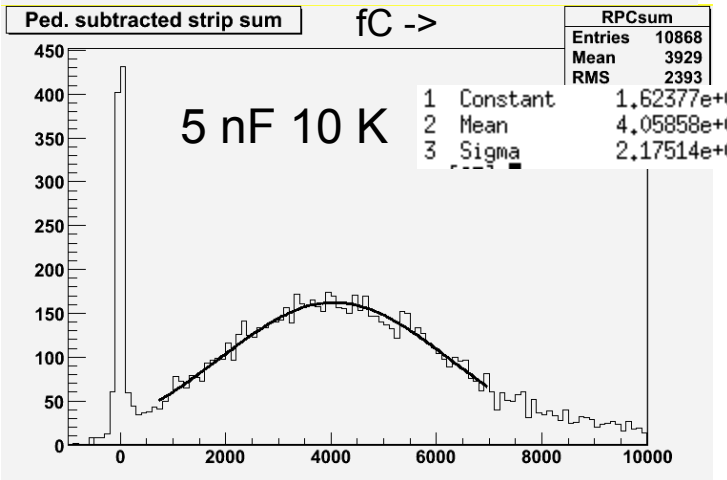




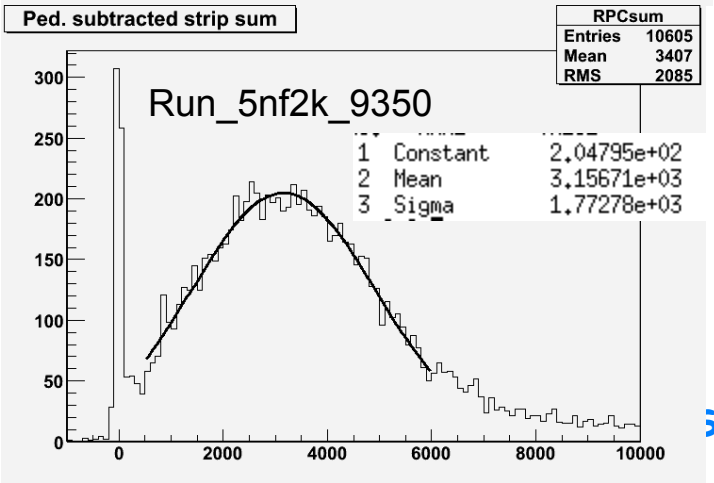


9350 V

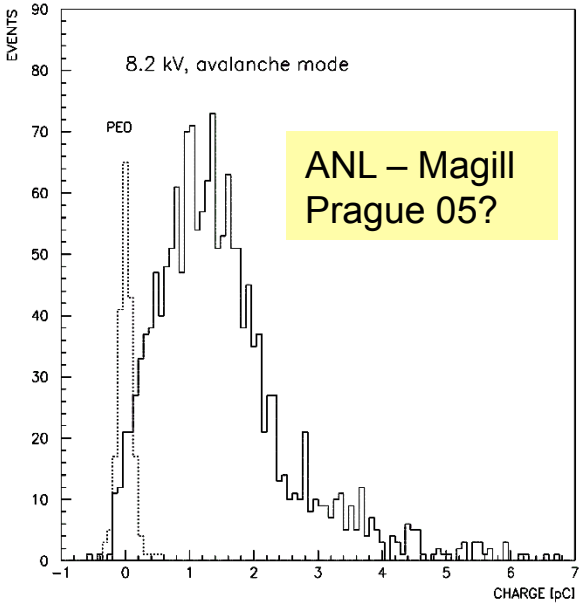
Compare transition board components
~20% variation



RPC probably poorly aligned resulting in more events without signal

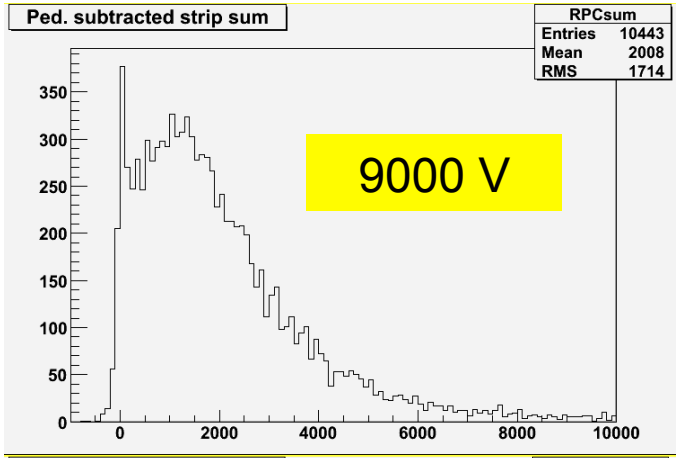


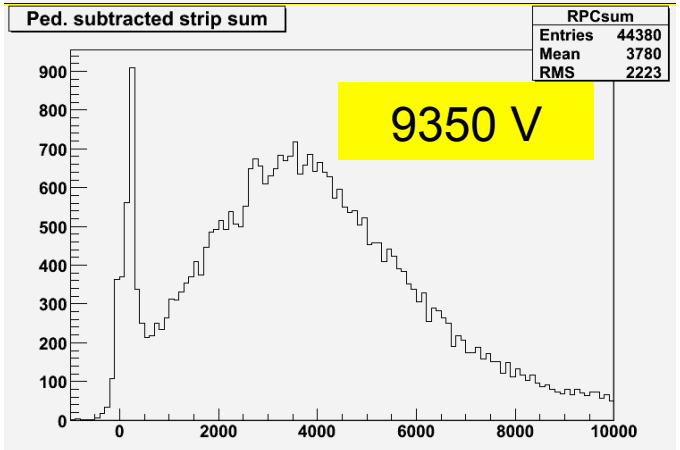
Total charge 3-4 pC,
larger, as expected, than ANL RPCs. Need absolute calibration.

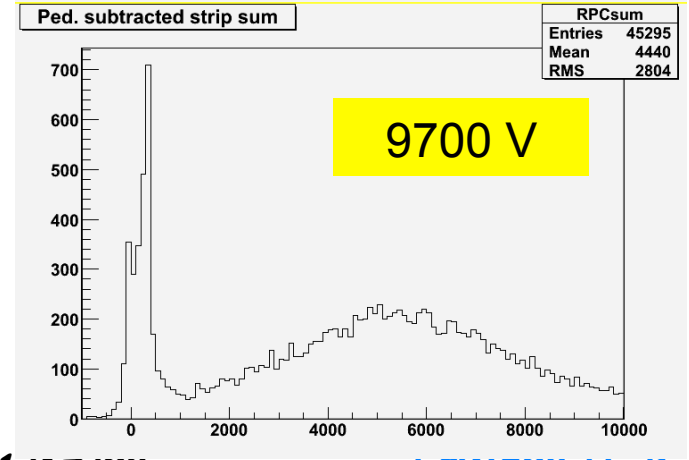


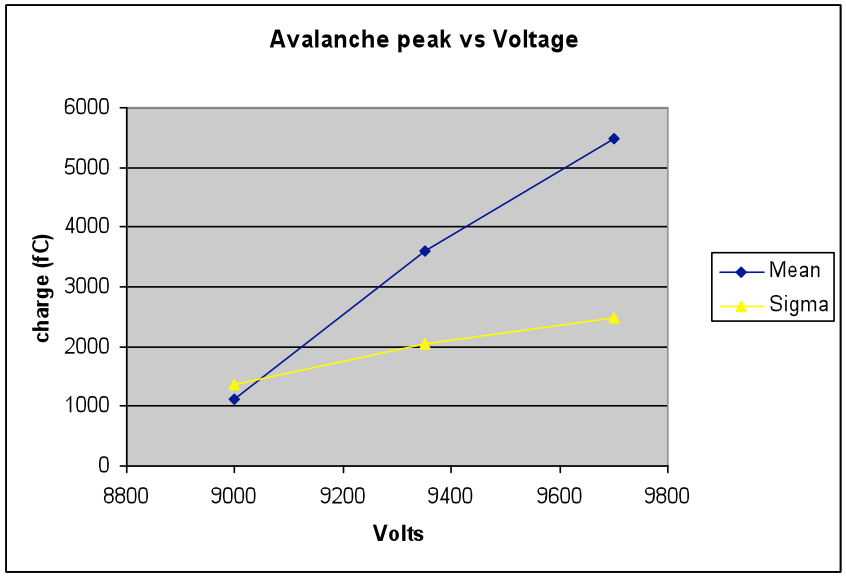
ANL – Magill Prague 05?

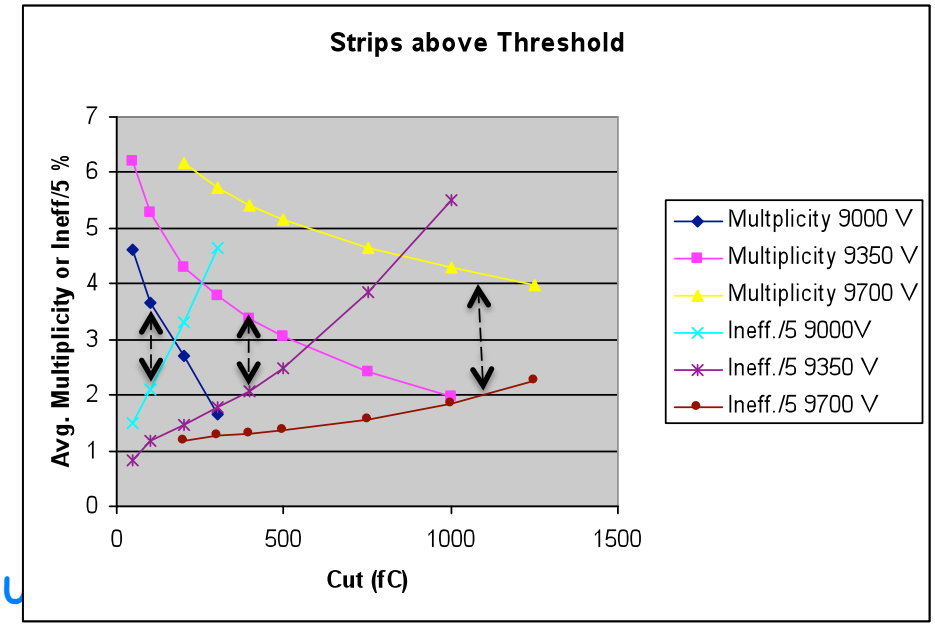
HV Scan


Ped. subtracted strip sum
RPCsum
Entries 10443
Mean 2008
RMS 1714
9000 V


Ped. subtracted strip sum
RPCsum
Entries 44380
Mean 3780
RMS 2223
9350 V


Ped. subtracted strip sum
RPCsum
Entries 45295
Mean 4440
RMS 2804
9700 V


Avalanche peak vs Voltage
charge (fC)
Volts
Mean
Sigma

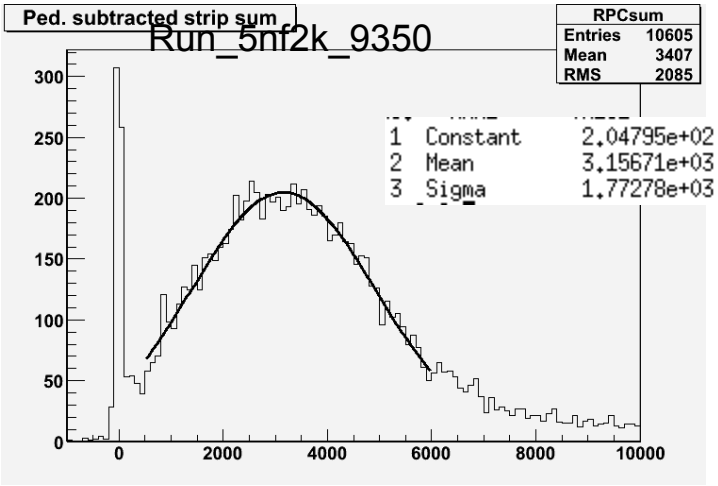

Strips above Threshold
Avg. Multiplicity or Ineff/5 %
Cut (fC)
Multplicity 9000 V
Multiplicity 9350 V
Multiplicity 9700 V
Ineff./5 9000V
Ineff./5 9350 V
Ineff./5 9700 V

Charge Sum of all strips

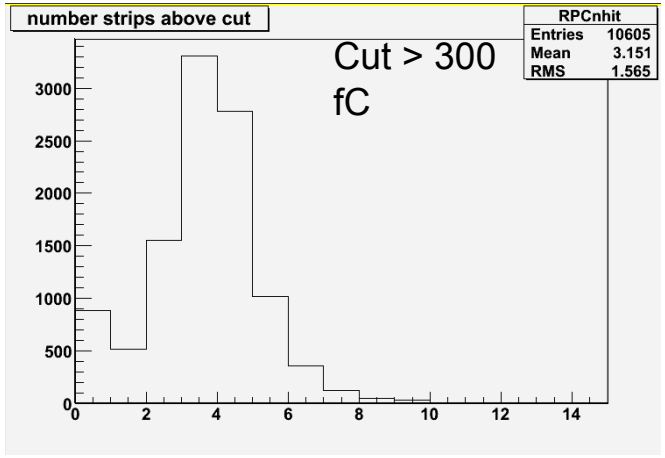
Charge of Max. strip

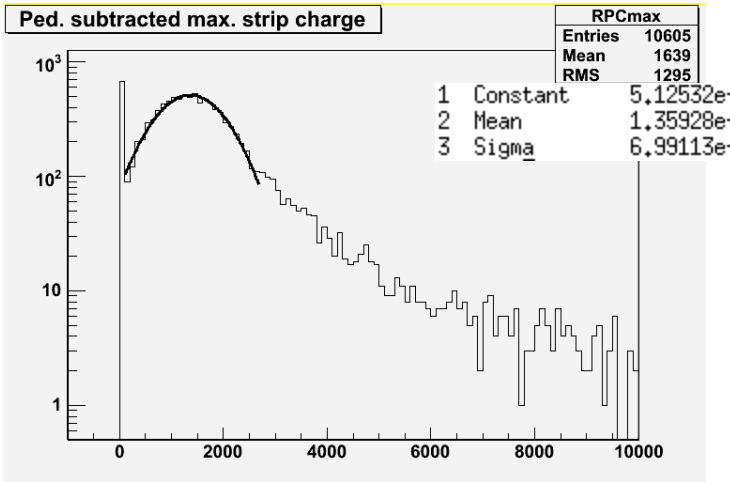
Charge Sum of strips above cut

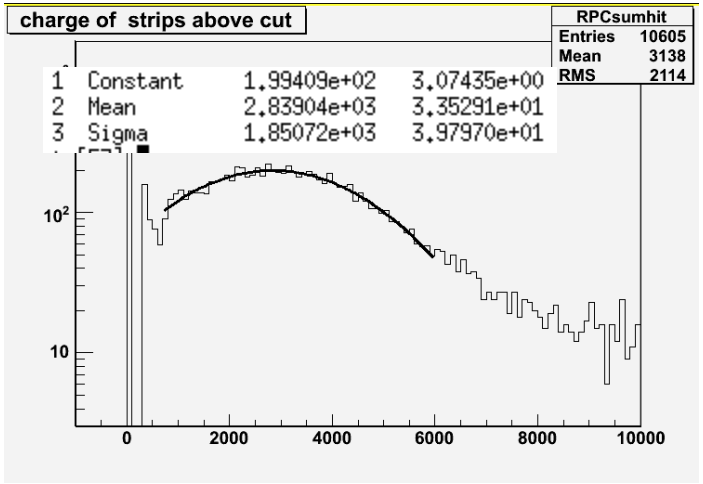
Strips 3.8 cm wide



Less than half of the charge is in the max. strip

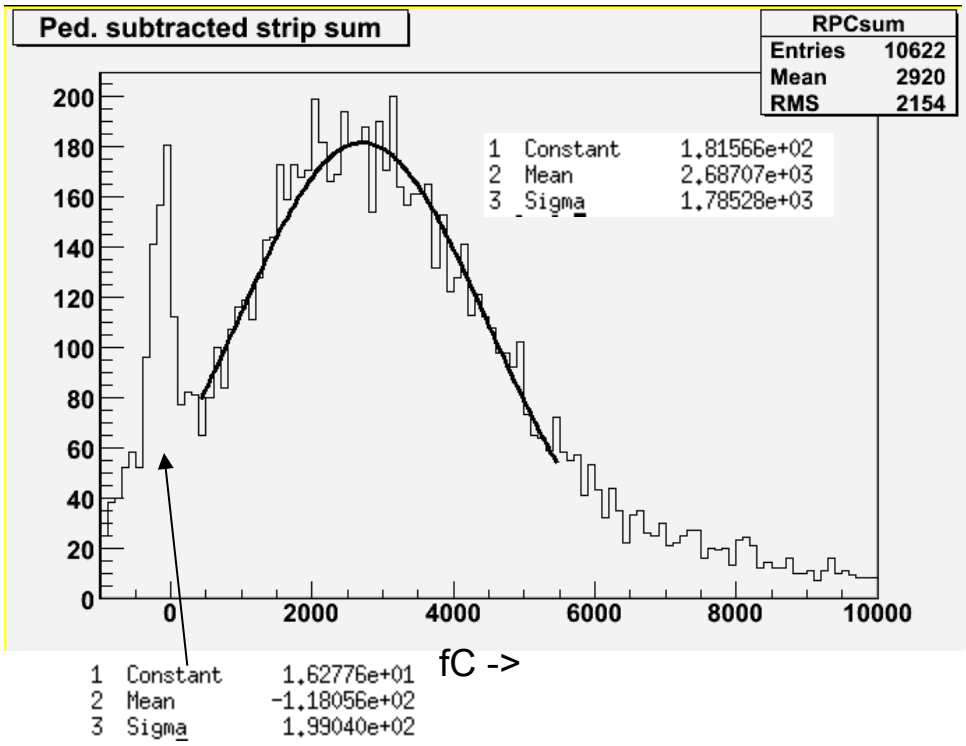




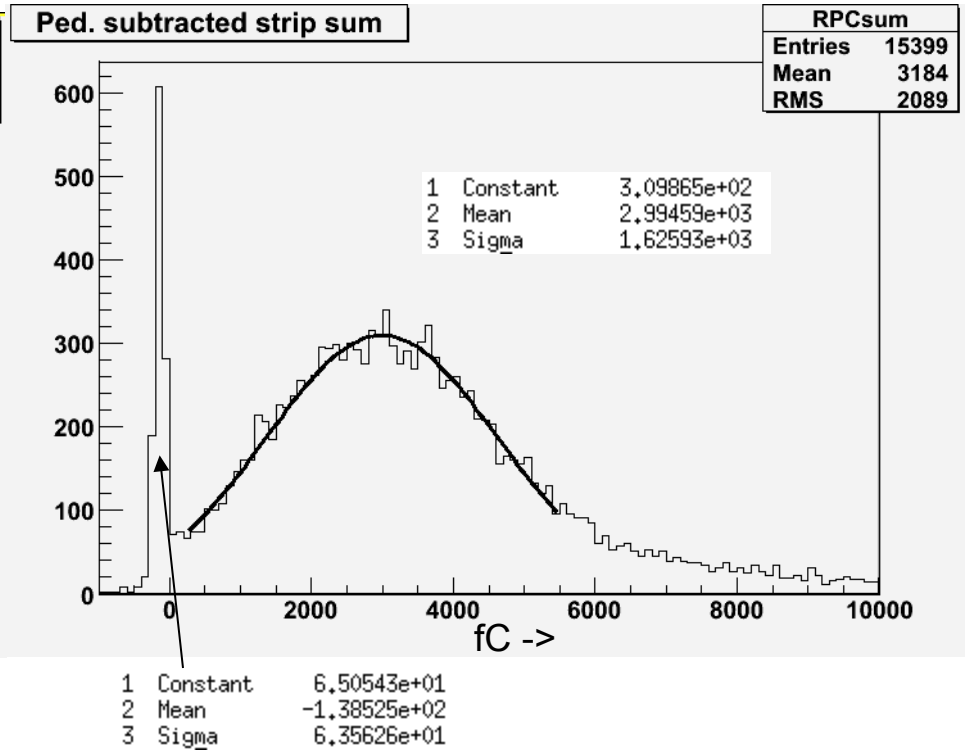


KPIX Reset Mode Study

DC resets

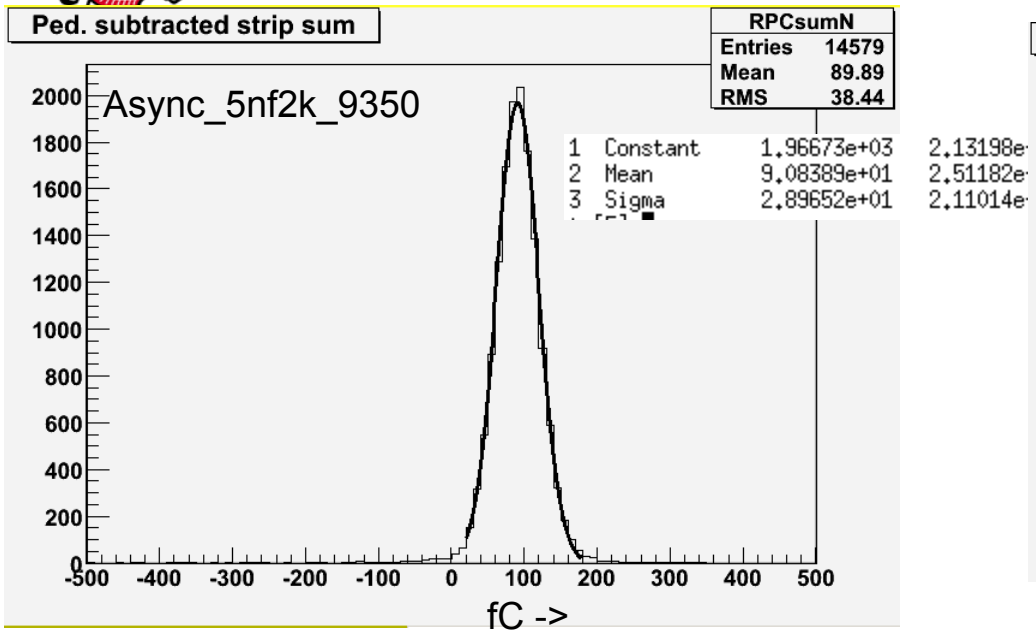


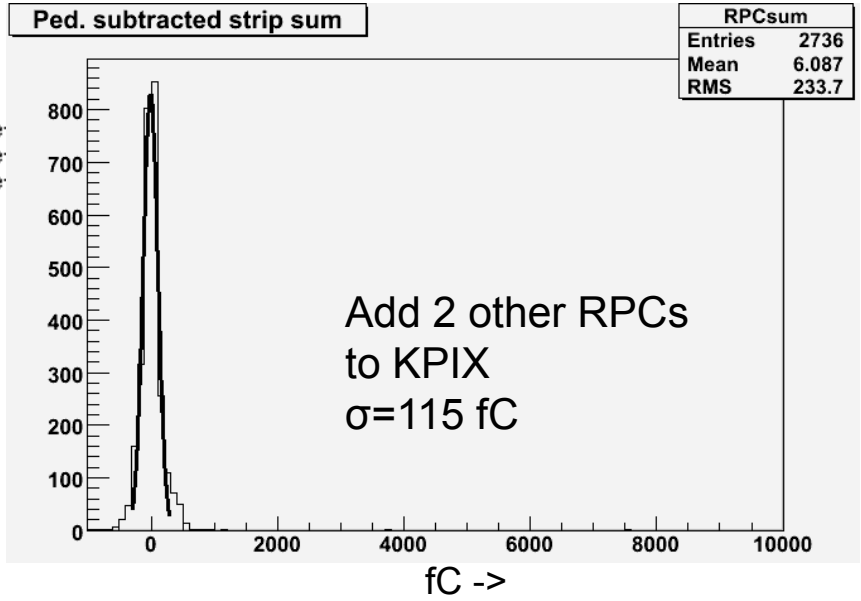
per resets

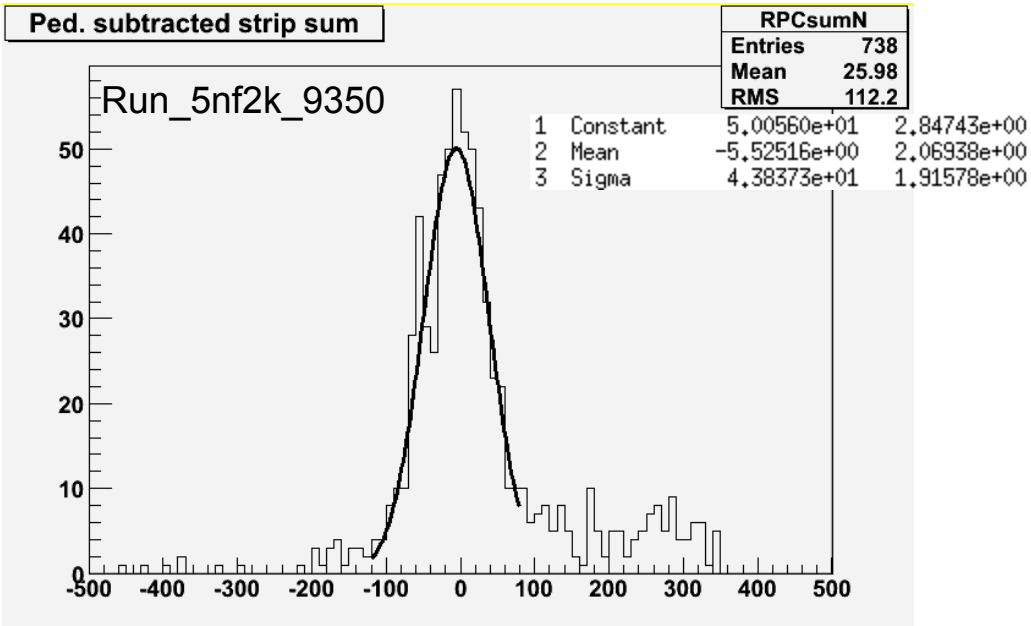


In normal LC operation the KPIX charge amp is reset between beam pulses every 400ns
A continuous DC reset mode was added for cosmic rays tests
However, the noise seems 2-3 times worse in DC mode
Noise 8 times worse with no reset

Pedestal Studies



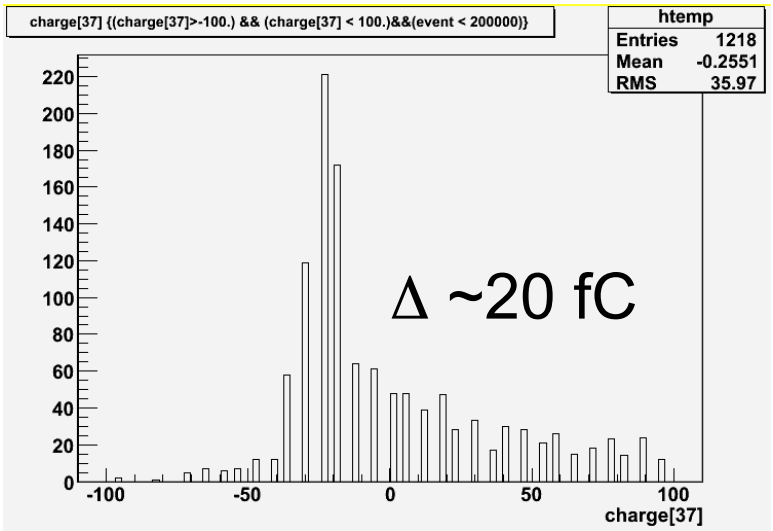


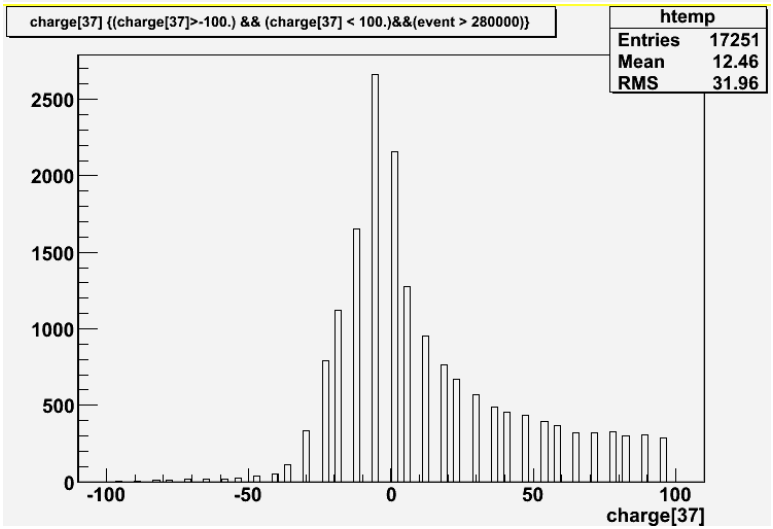


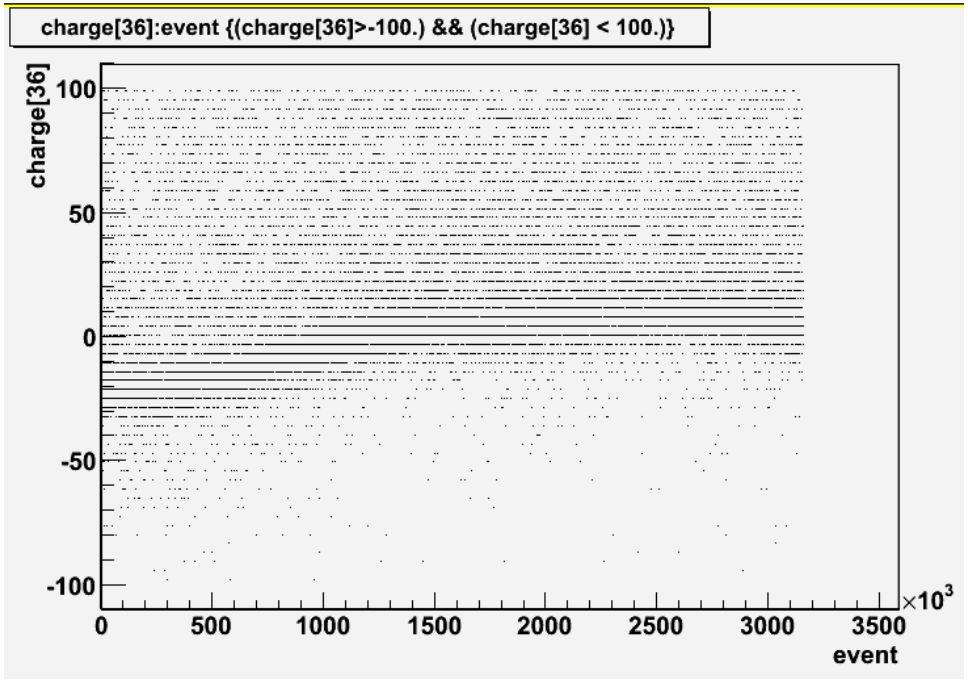
- Pedestal width higher for triggered events even if no track is seen
- Possible correlation between the time of the trigger and the reset
- Adding multiple RPCs increases the overall noise
- Without cables - noise ~ 5 fC/channel
- Need to better understand grounding

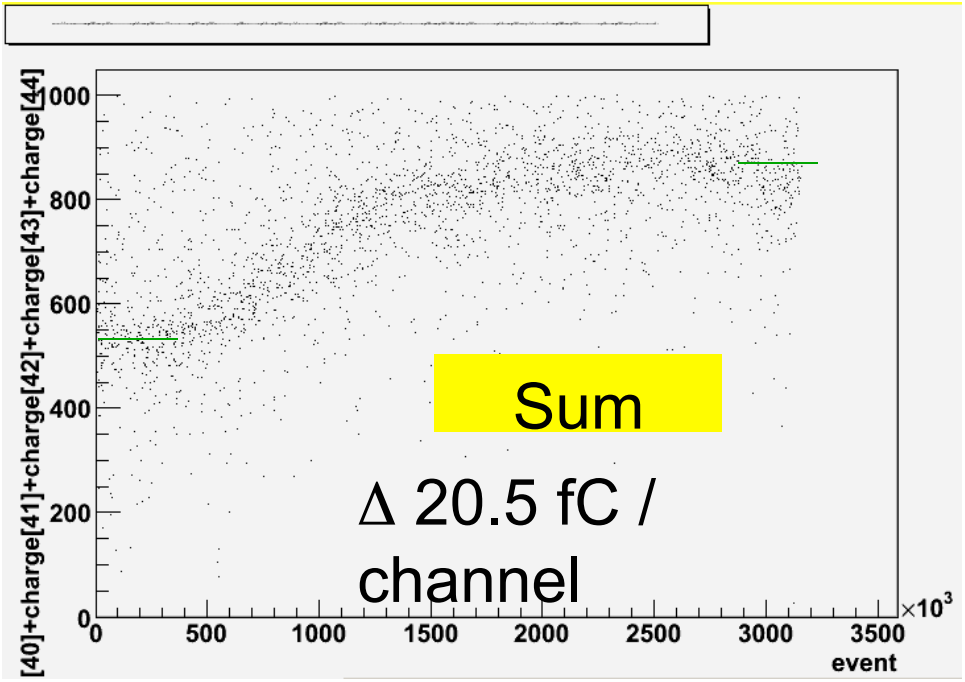
Pedestal Drift

Overnight run shows pedestal drift with time, presumably due to temperature



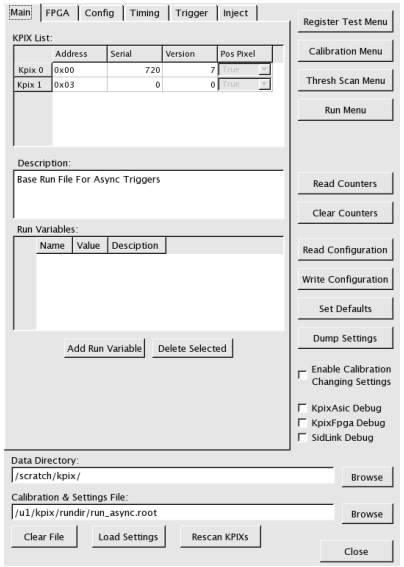


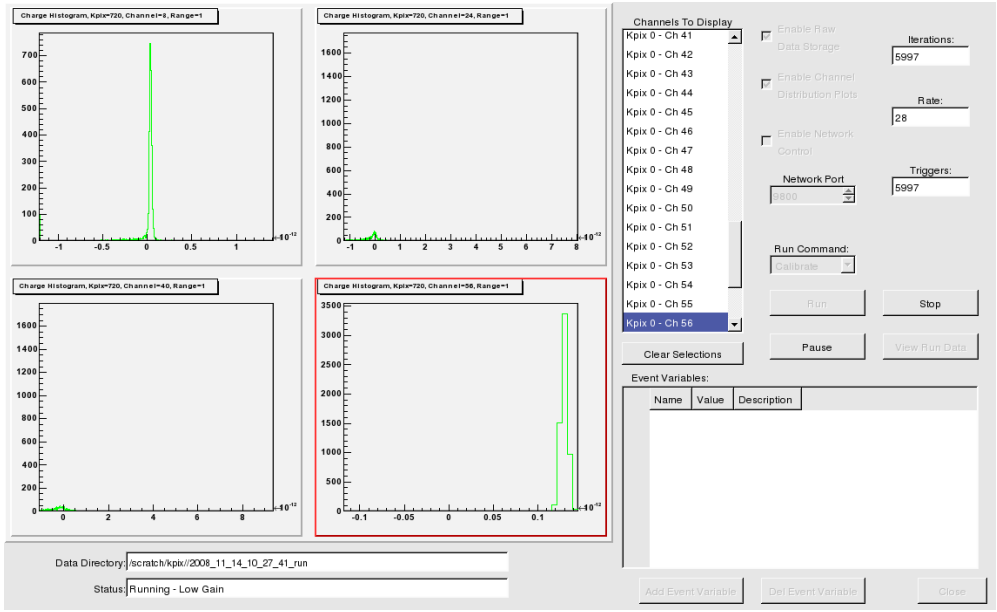




Recent developments

- Use all 64 channels for readout of 4 RPC planes to enable tracking studies
- 7 new IHEP RPCs in hand of varying bulk resistivity 3 10^{11} - 5 10^{12} Ωcm
- Improved software –GUI interface





Plans

- Start of a long program to optimize readout
- Proof of concept done, but still disentangling RPC/ KPIX effects
- We should be able to do better!
  - Lower noise & cross talk
- Next steps
  - Understand strip multiplicity, noise
  - Readout opposite polarity + several RPCS for a stand-alone tracker
  - Test IHEP RPCs
- Longer Term
  - Tracking, position resolution studies
  - Test CERN gas
  - Test GEM pad readout with Bakelite RPC
  - Pad readout of glass RPC