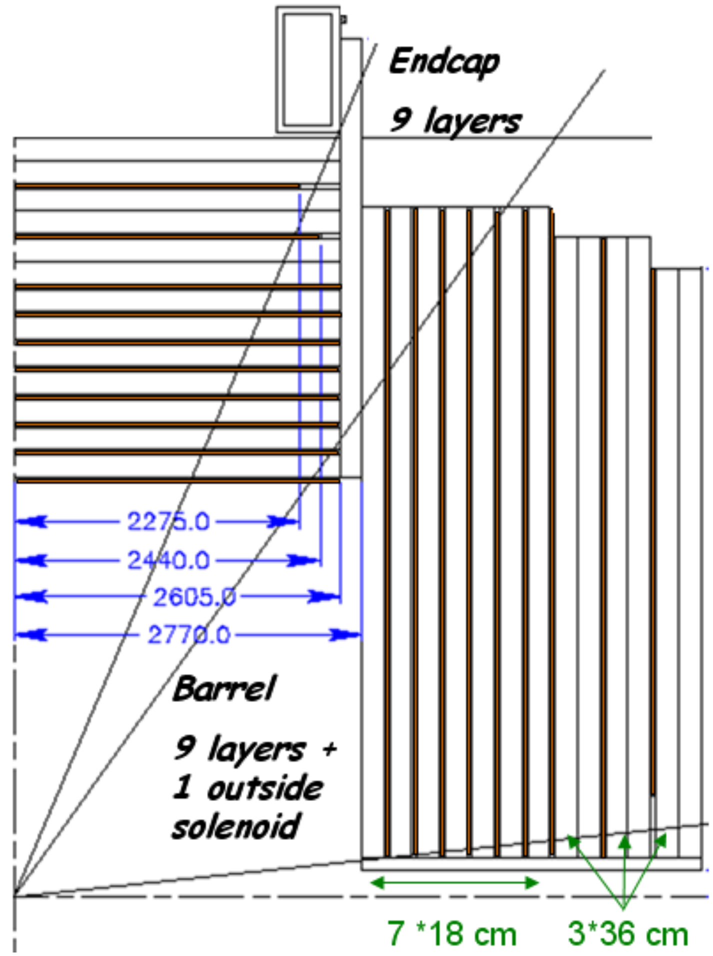
SiD Muon R&D
SiPM Studies, RPC Aging Studies

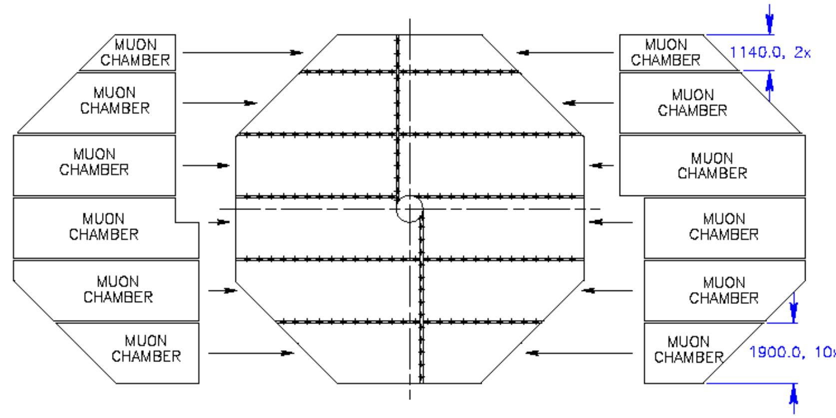
H. Band
University of Wisconsin

SiD Muon

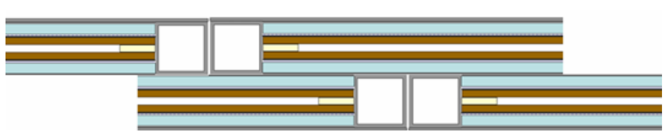


- *Expected Backgrounds*
  - *Barrel -Beam halo induced muons*
    - *3 10^{-3}/cm^2- pulse train*
  - *Endcap -2 γ hadrons & μ*
    - *4 10^{-2} /cm^2- pulse train*
- *Detector design*
  - *Modest resolution ~ cm*
  - *9-10 layers interspersed in steel flux return (8 λ)*
  - *X and Y coordinate readout ~ 3-4 cm pitch*

SiD Muon Detector



- *Baseline choice*
  - *Double gap RPCs operating in avalanche mode are expected to have lowest cost and have adequate reliability*
  - *RPC and steel boundaries staggered to minimize geometric inefficiencies*
  - *> 93% eff. per layer*
  - *Digitized by KPIX(64or128)*



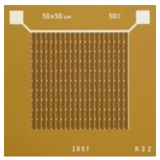
- *Detector Option*
  - *MINOS style scintillating strips with SiPM readout being pursued to understand cost and performance of SiPM readout – reliable backup*

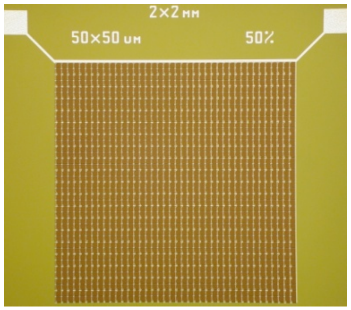
T-995
Scintillator Strips
with
SiPM Readout

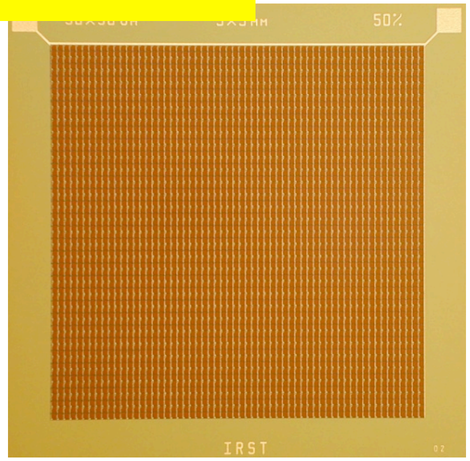
H.E. Fisk, A. Meyhoefer, A. Para, E. Ramberg, P. M. Rubinov
Fermilab
M. Wayne, M. McKenna
University of Notre Dame
D. Cauz, M Ouri, G. Pauletta,
INFN: Roma I and Trieste/Udine
J. Blazey, S. Cole, I. Viti, D. Hedin, R. Shea,
Northern Illinois University,
P. Karchin, A. Gutierrez
Wayne State University

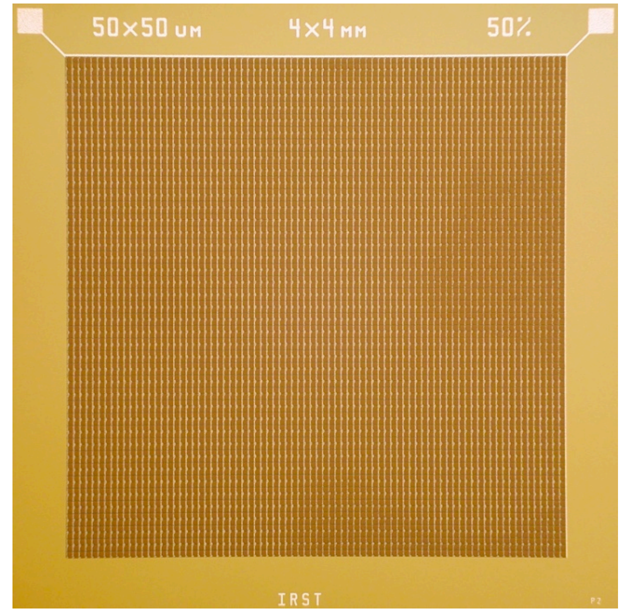
INFN/IRST C. Piemonte
G. Pauletta INFN/Udine

June 13th, 2007, Perugia

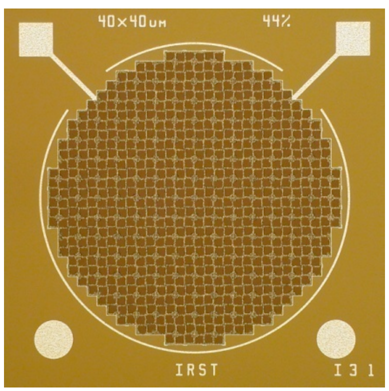








1x1mm 2x2mm 3x3mm (3600 cells) 4x4mm (6400 cells)

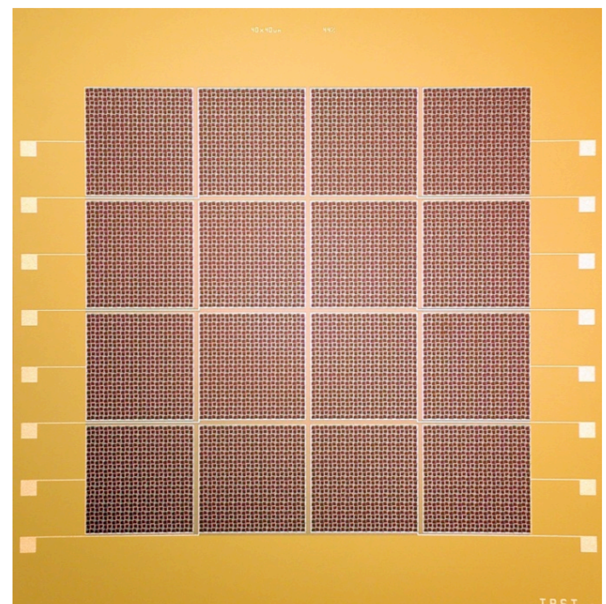


Circular Array 1.2mm dia.
~ 650 pixels 40 x 40 μ^2

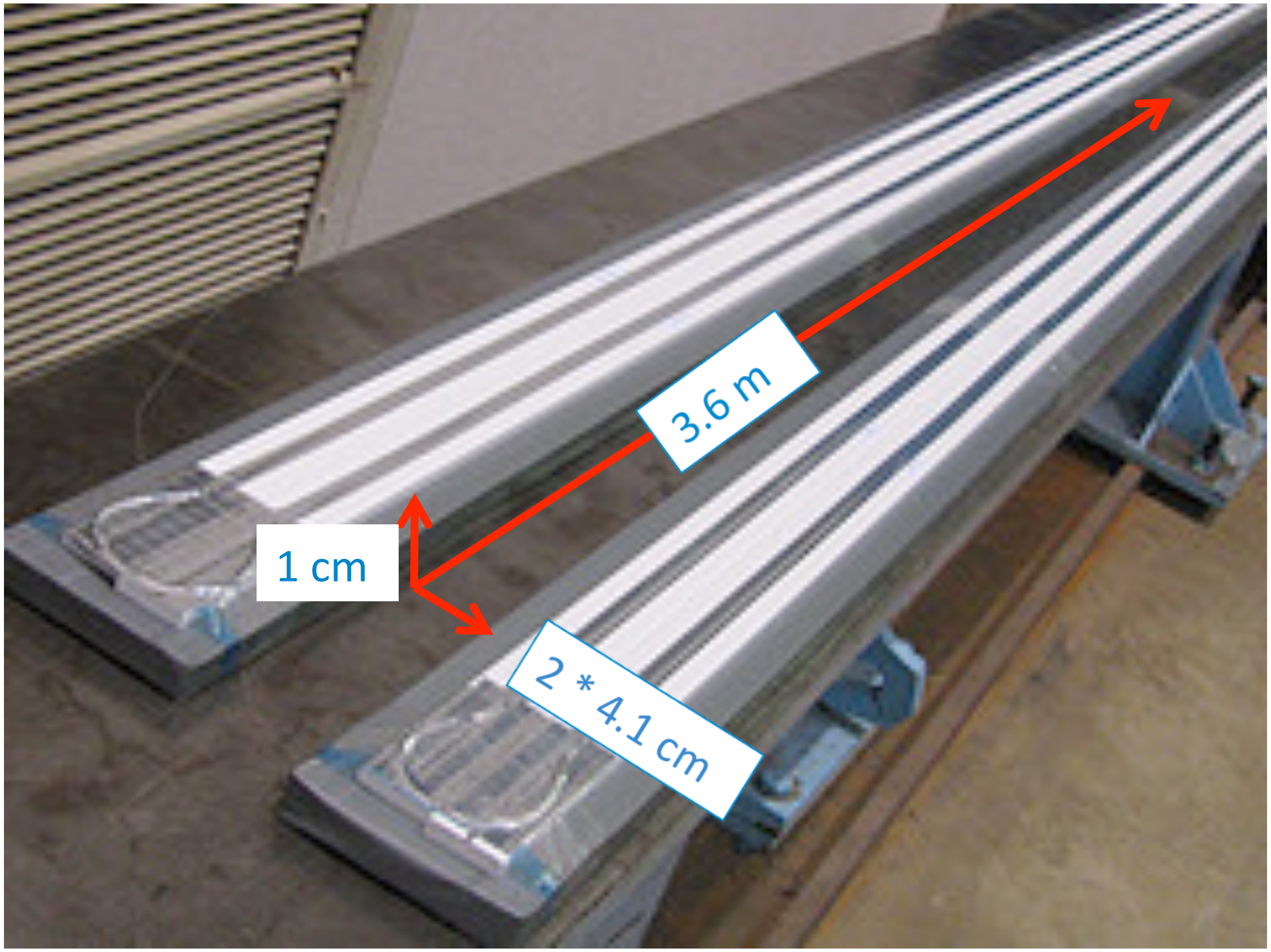
increased fill factor:

40µx40µ => 44%
50µx50µ => 50%
100µx100µ => 76%;

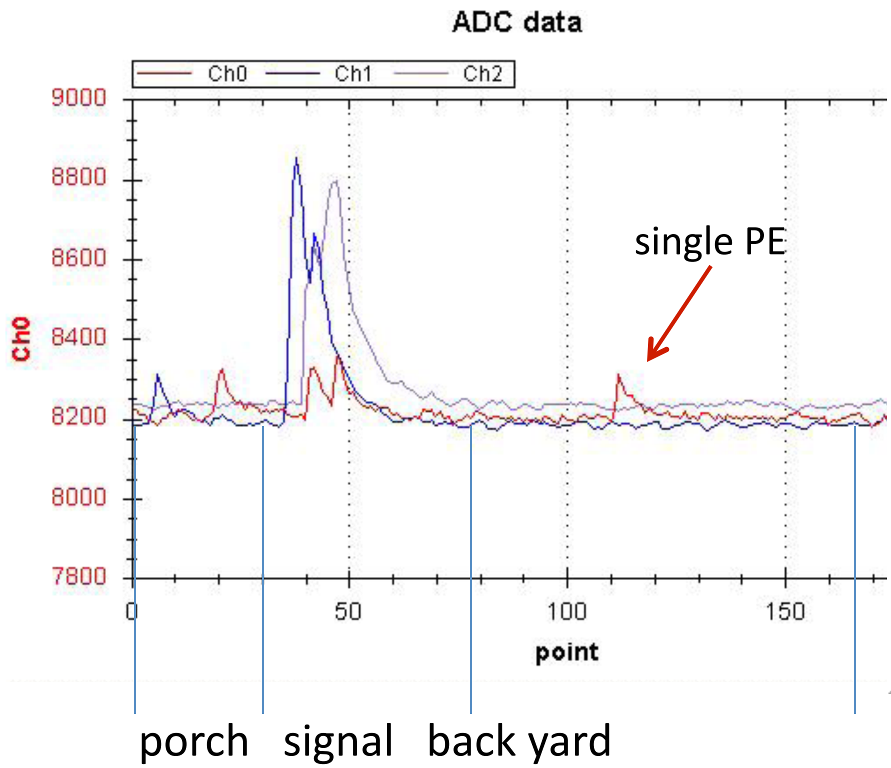
Giovanni Pauletta

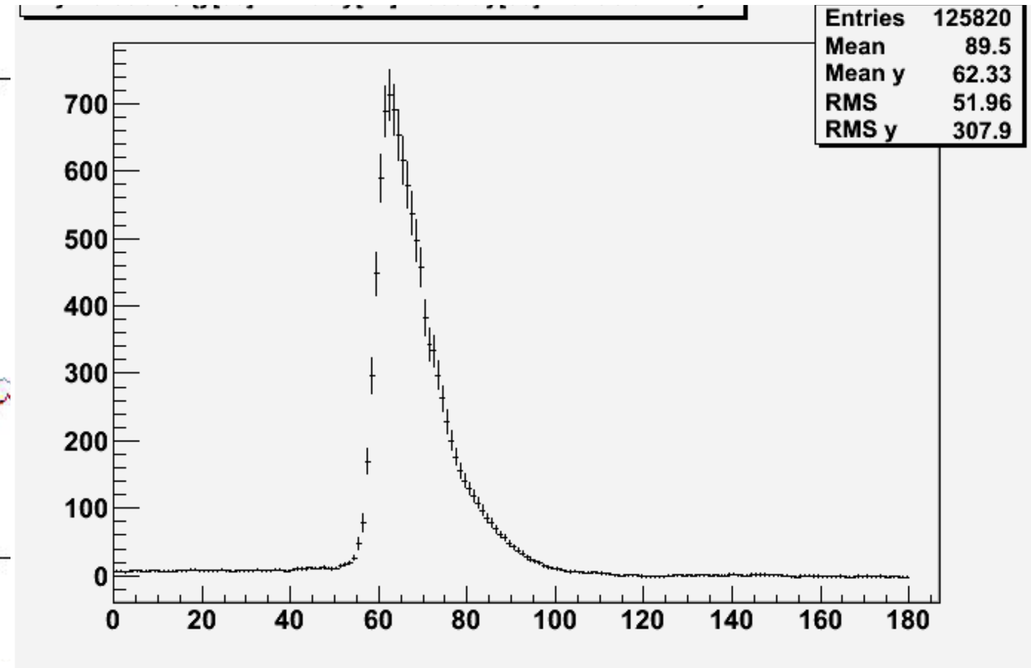


Scintillator Strips mounted side-by-side with 1.2mm dia. WLS fiber U-turn



TB4 Set-up at D0 ; Cosmic Rays



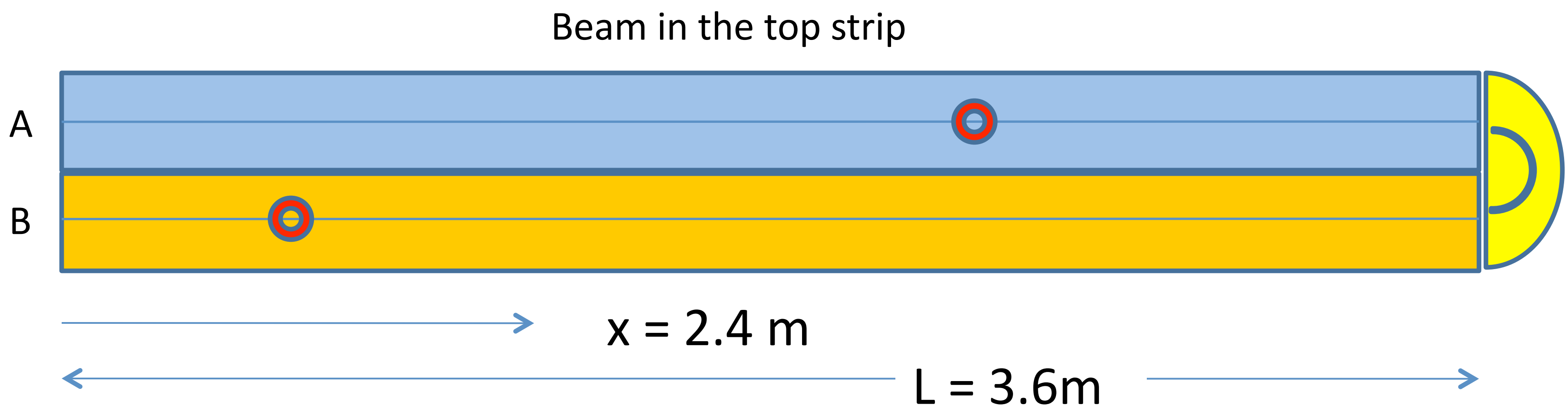


Single trace

Average pulse shape

180 digitizations * 4.708ns = 847ns . **Small pulses and Large pulses!**

Dual Strip Readout



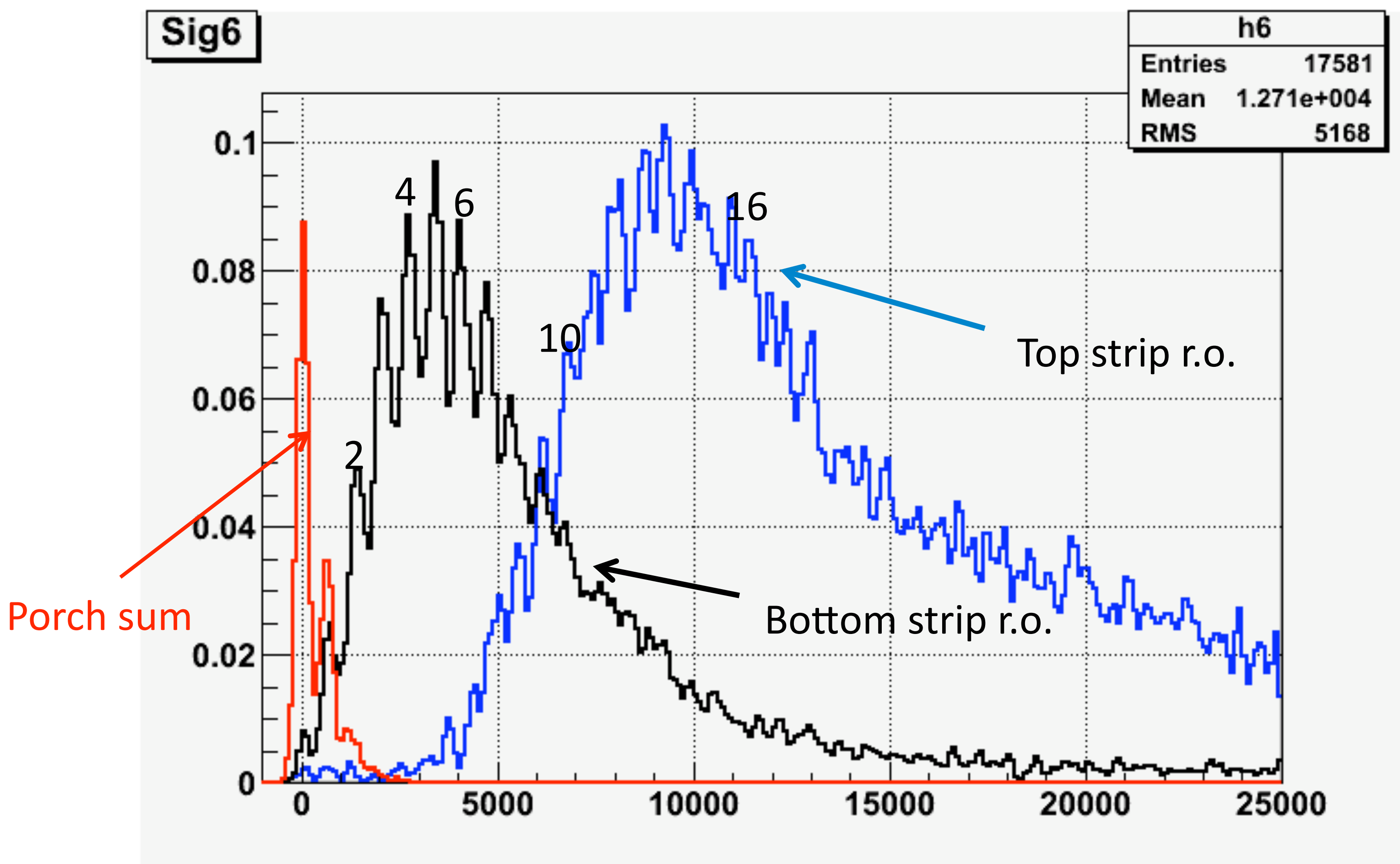
For beam in the top strip the top distance is 2.4 m. For beam in the top strip, the bottom readout distance is 3.6m + 0.25m + 1.2m = 5.05m.

The distance difference is: 5.05 – 2.4 = 2.65 m.

c(effective) = 265cm / 14.8 ns = 18 cm/ns

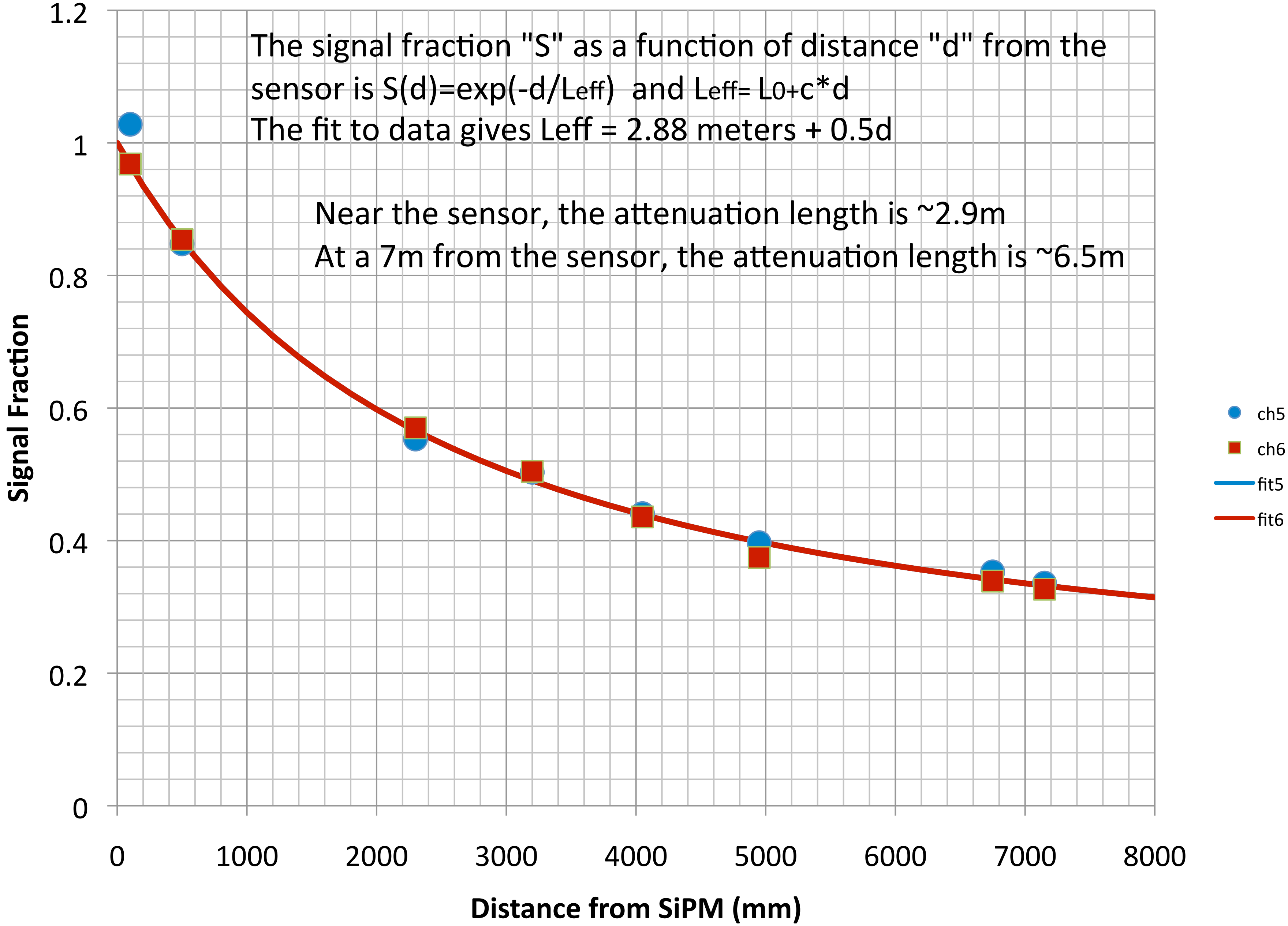
For D0's fiber tracker: c(eff.) ~ 17 cm/ns

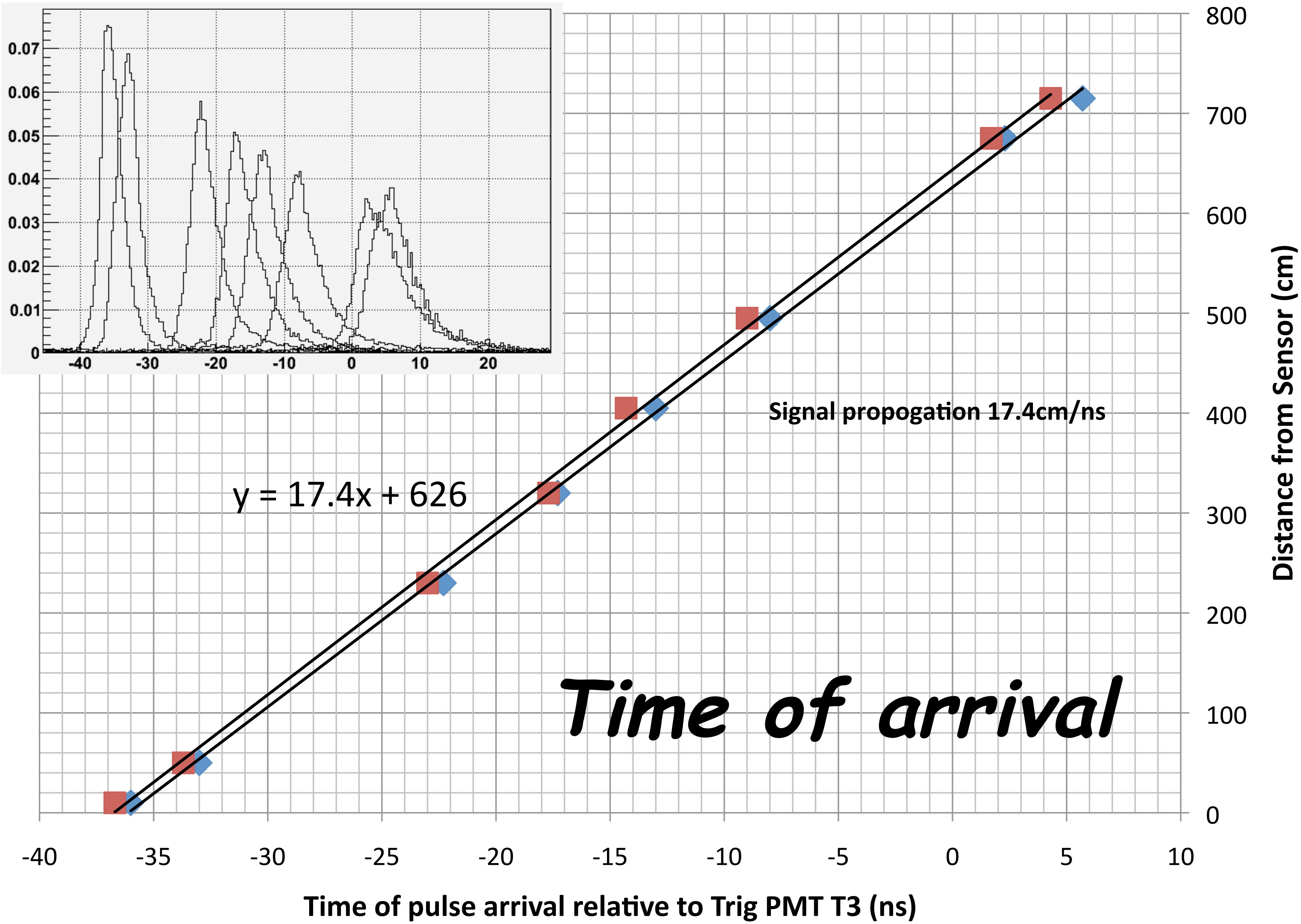
Beam in the top strip 10 cm from readout end.



Runs 5045 and 5046 2/20/2010

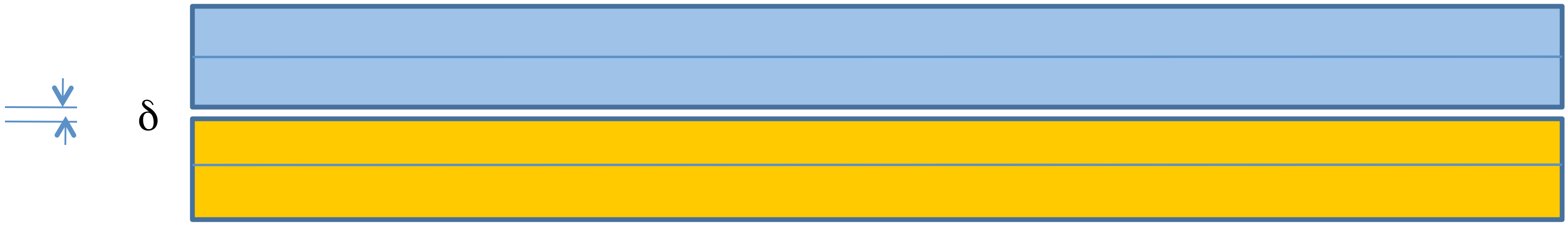
attenuation length



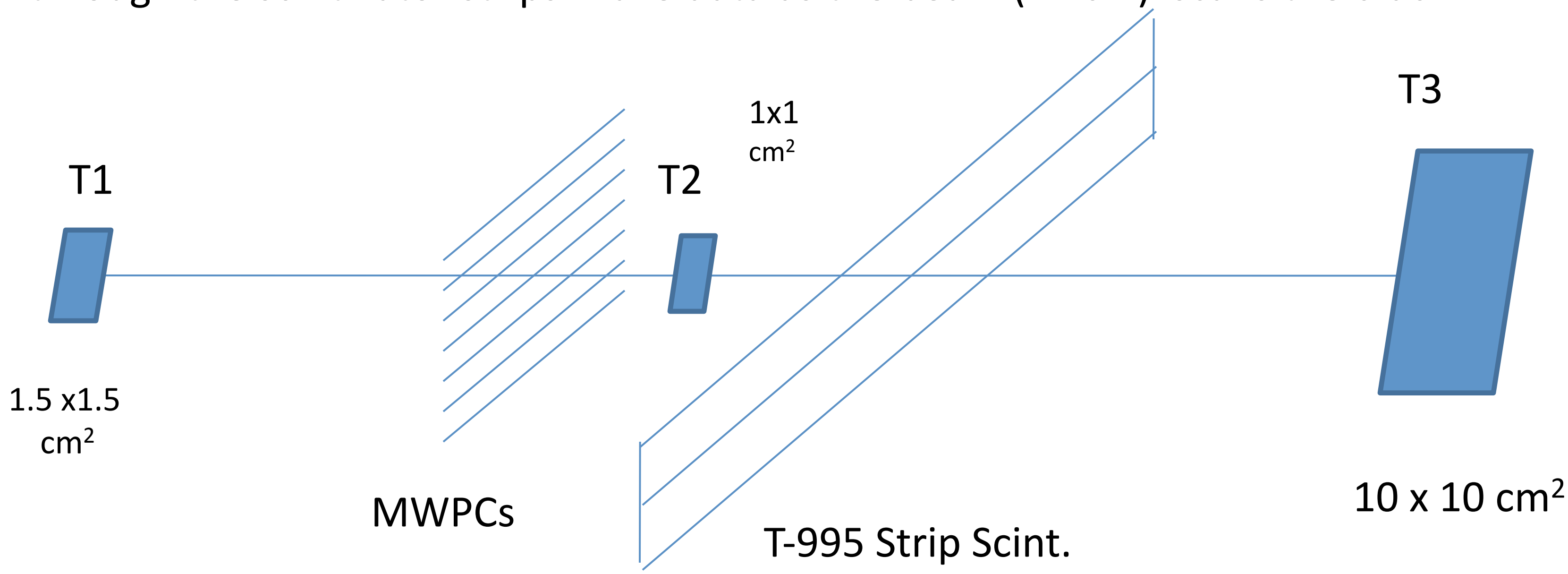


0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-40
-30
-20
-10
0
10
20
Signal propogation 17.4cm/ns
y = 17.4x + 626
Time of arrival
800
700
600
500
400
300
200
100
0
Distance from Sensor (cm)
-40
-35
-30
-25
-20
-15
-10
-5
0
5
10
Time of pulse arrival relative to Trig PMT T3 (ns)

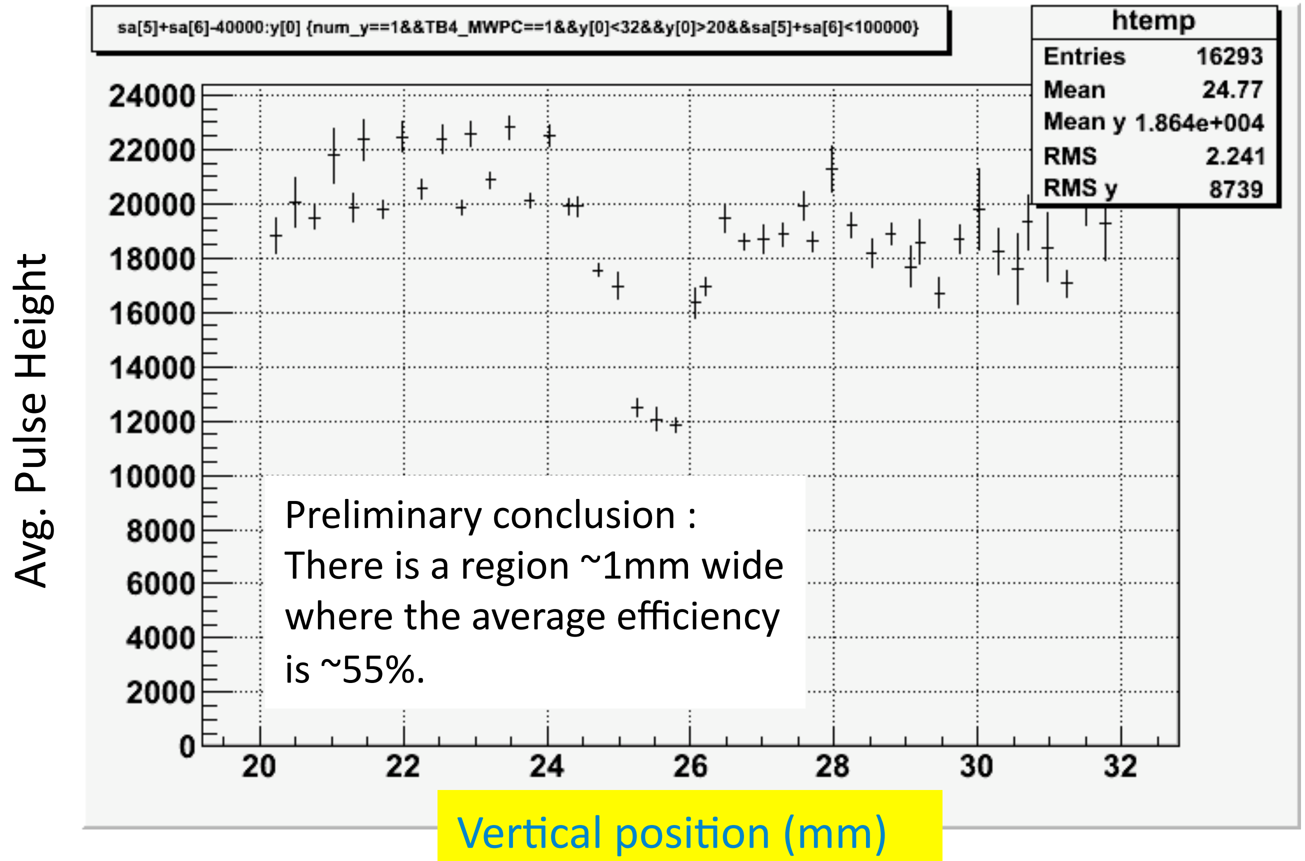
Preliminary meas. of the inter-strip inefficiency



Method: Use two 1 mm spacing MWPC horizontal wire planes upstream of the strip scintillator counters to measure the vertical position of beam tracks that pass through the scintillator strips. Take data as the beam (~ 1cm) scans the crack.



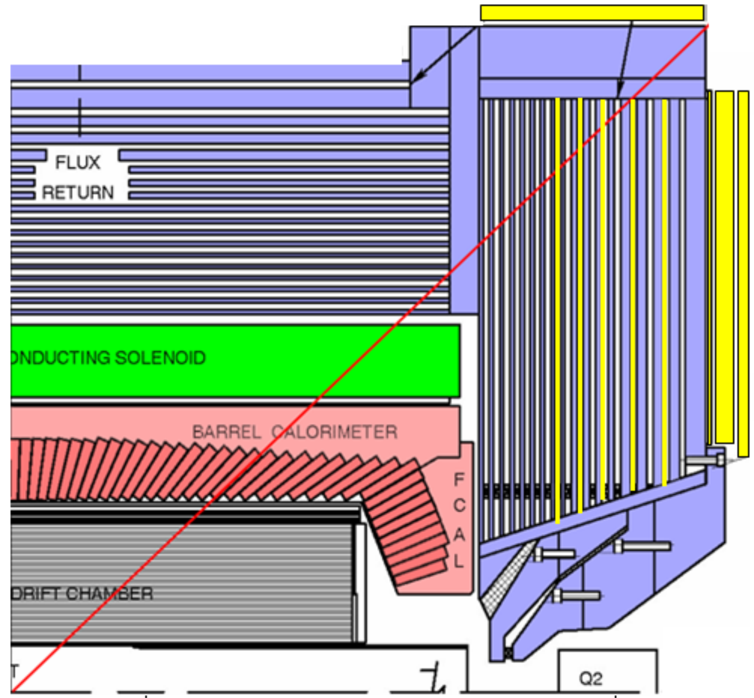
Vertical Scan of Inter-strip Crack

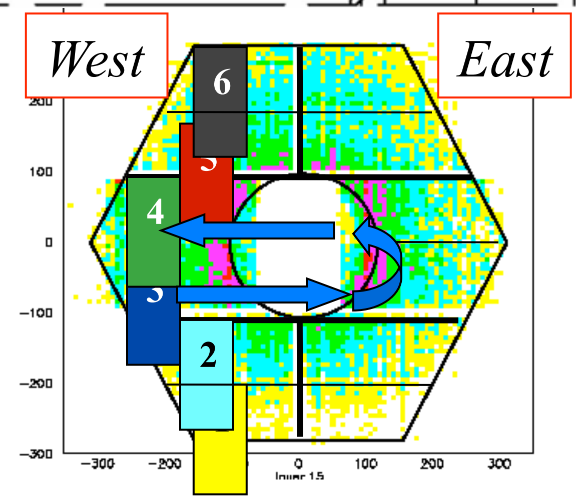


- *Beam test and analysis continuing*

Muon – Bakelite RPC R&D

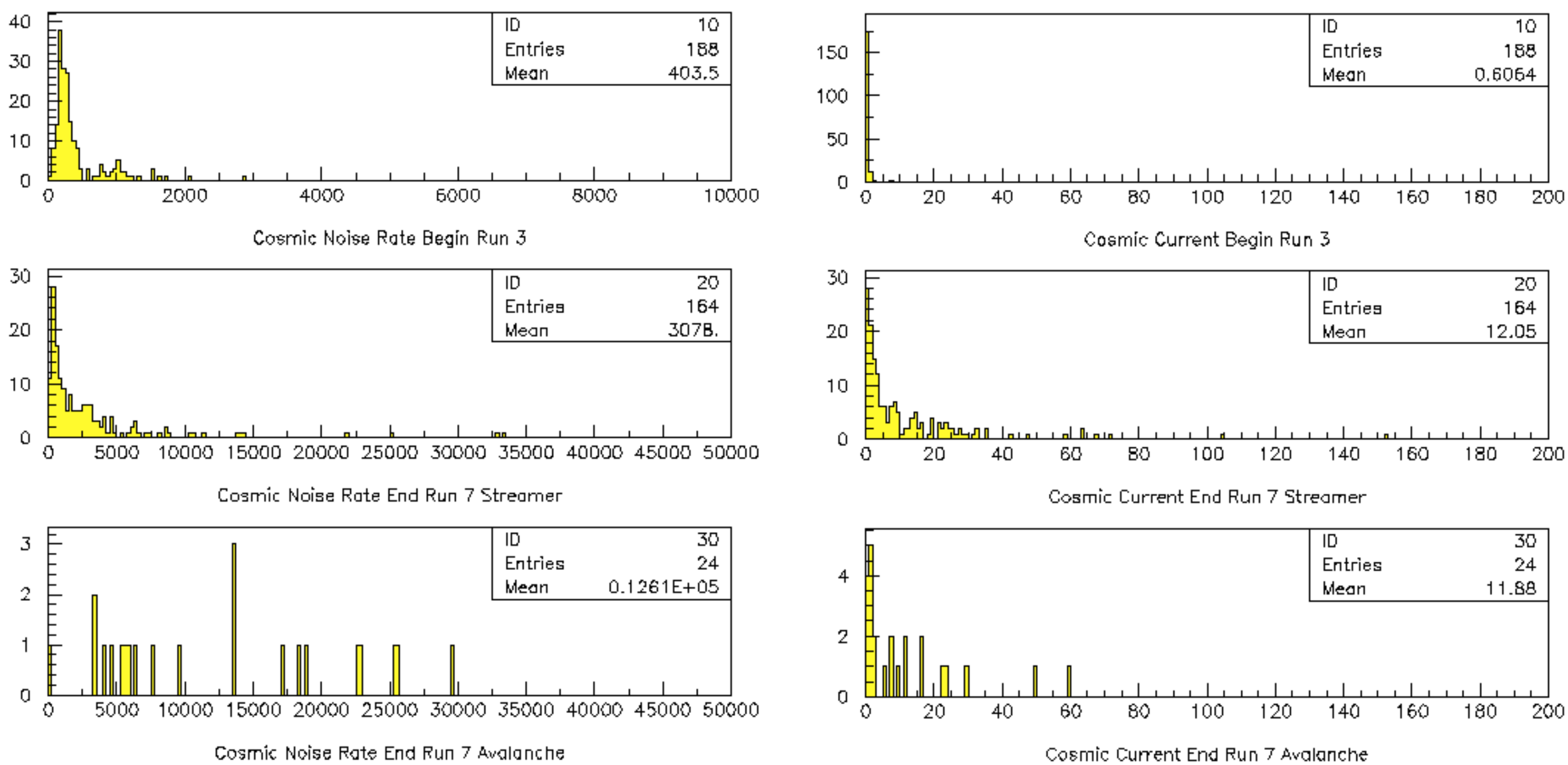
- *RPC readout with KPiX chip previously reported at LCWS08 and LCWA09*
- *Aging Studies*
  - *Babar Forward Endcap RPCs – H. Band, U. Wisconsin*
    - *Run from Nov.02 – Apr. 08*
    - *Similar construction to Atlas/CMS RPCs*
    - *Wide range of rates/ current accumulated over ~ 6 years*
    - *Good overall efficiency but clear signs of aging*



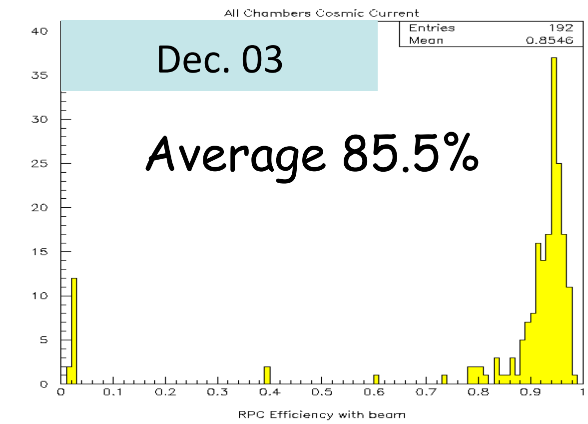


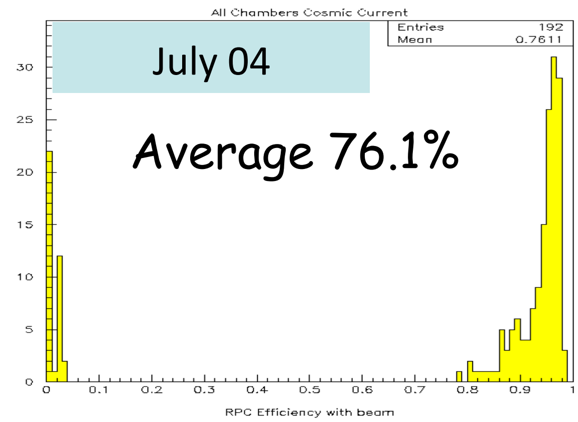
Noise Rate and Currents with Cosmic Rays

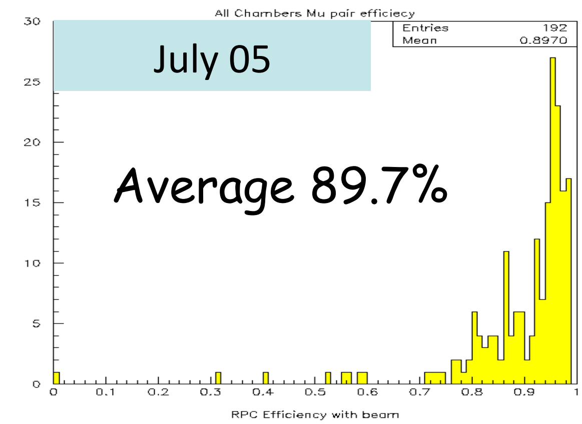
- *Both noise and currents have increased over 5 years*
- *Average noise rate 400 Hz → 3 kHz (area 1.5 – 2 m^2)*
- *Average current < 1 μA → 12 μA*

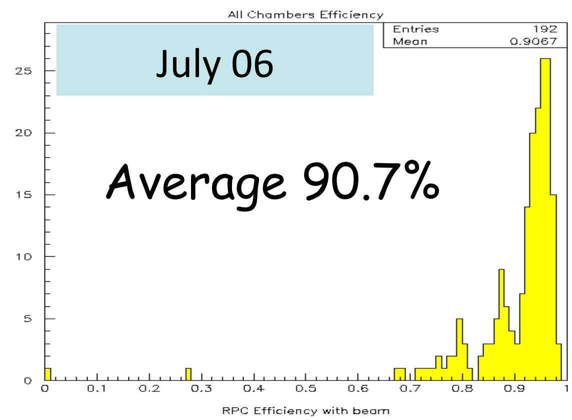


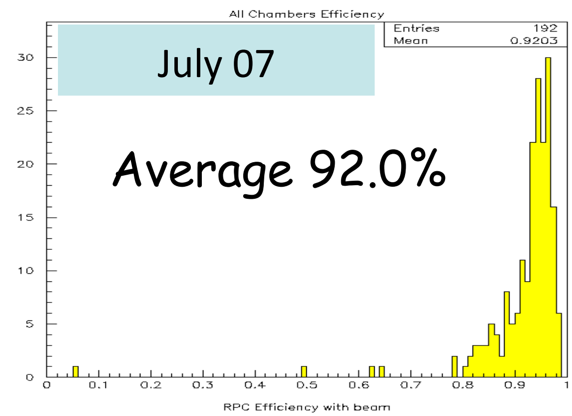
Endcap efficiency

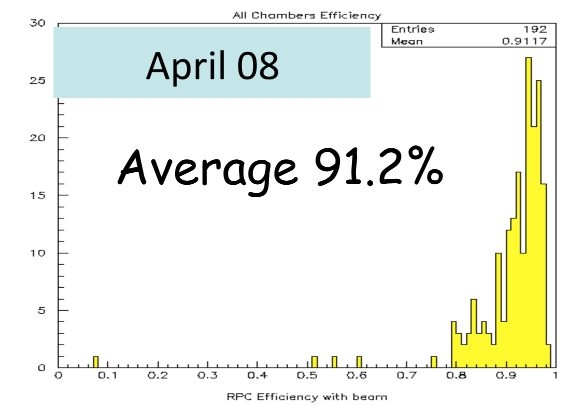






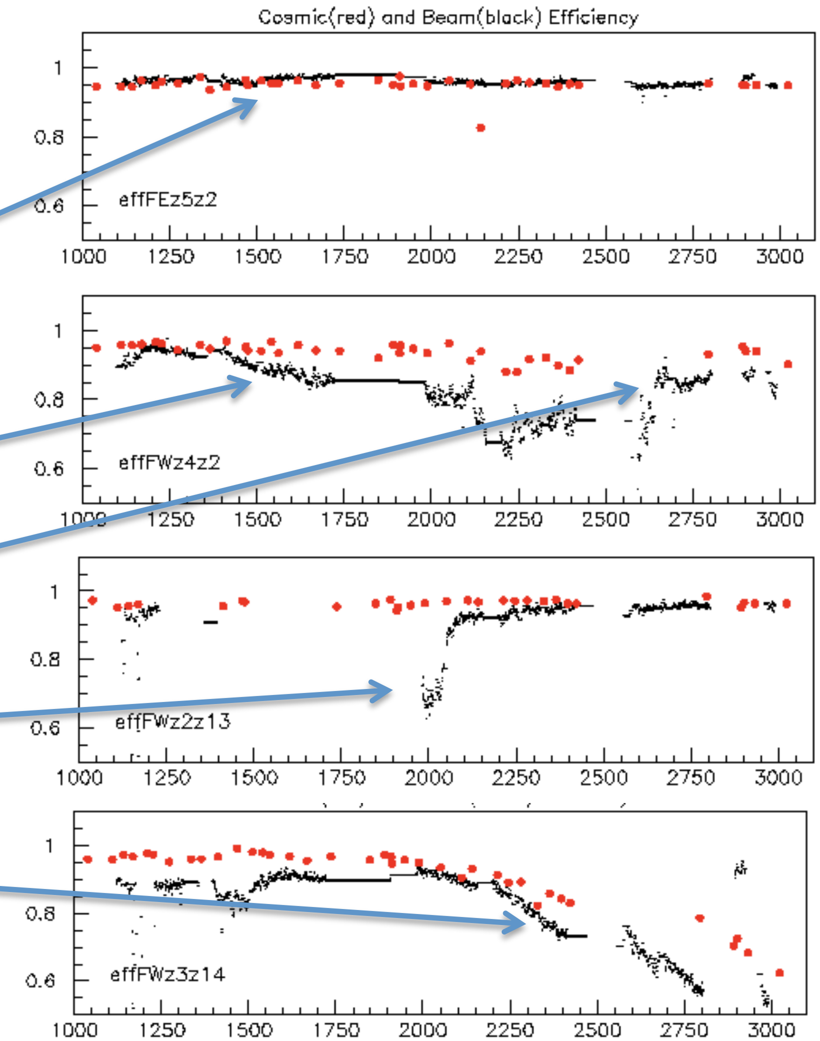






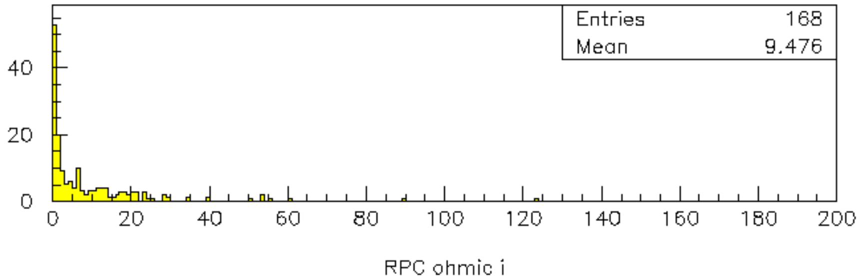
Beam/Cosmic Histories

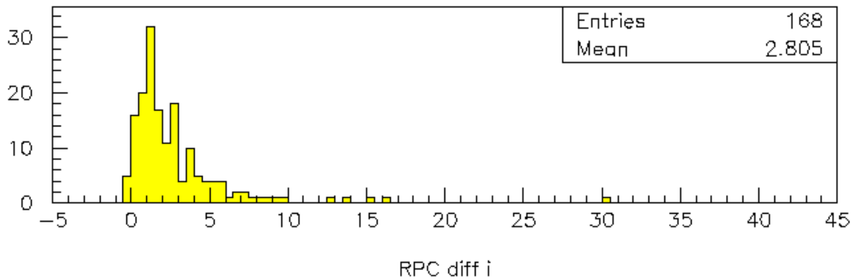
- Difference between beam and cosmic ray determined efficiencies highlight rate induced inefficiencies
- Many RPCs have stable efficiency
- Near the beamline a rate dependent inefficiency
- Conversion to avalanche mode restored efficiency
- Rate dependent inefficiency due to dry Bakelite restored by humidifying input gas
- Inefficiency due to poor gas flow similar in both

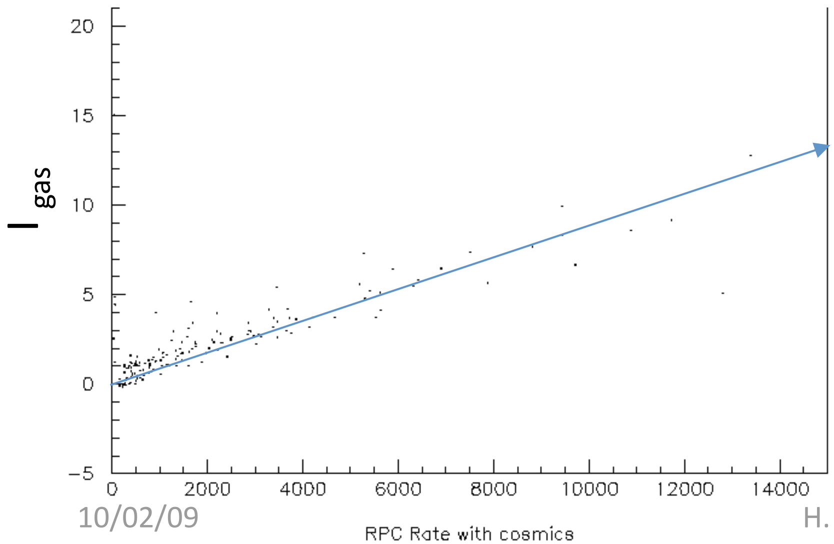


Noise Rate and Currents with Cosmic Rays

- *About ¾ of current increase due to rise in ohmic current (Estimated by extrapolating the I vs V curve below the gas gain turnon)*
- *Remaining ¼ strongly correlated with increased noise rate*



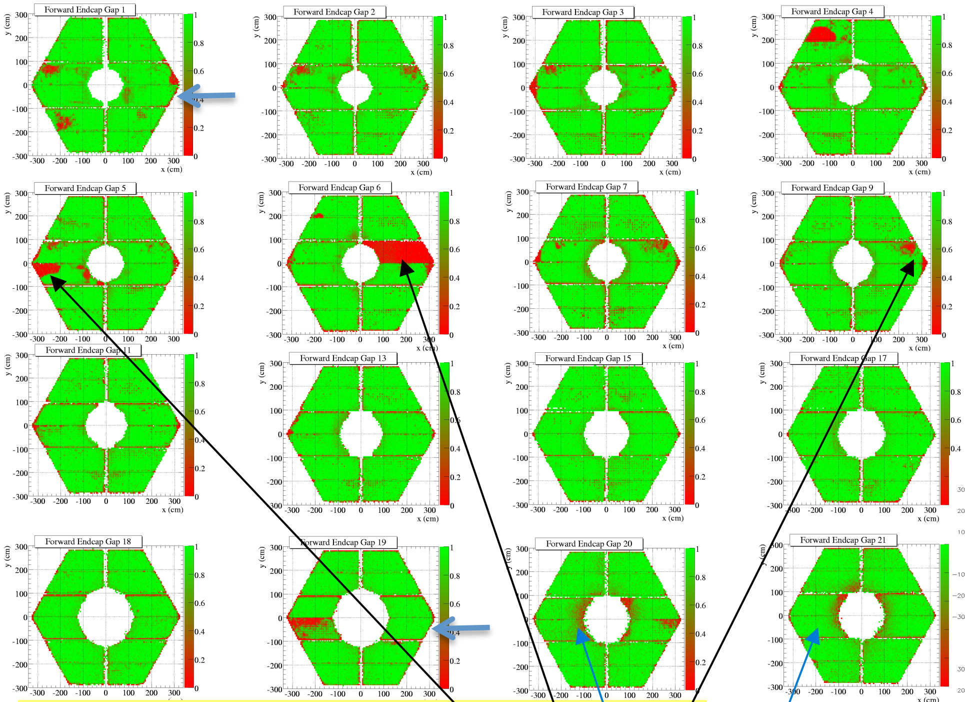




- *Trying to understand causes of:*
  - *Ohmic current*
    - *No correlation with integrated current seen*
  - *Increased noise*

Cosmic vs Collisions

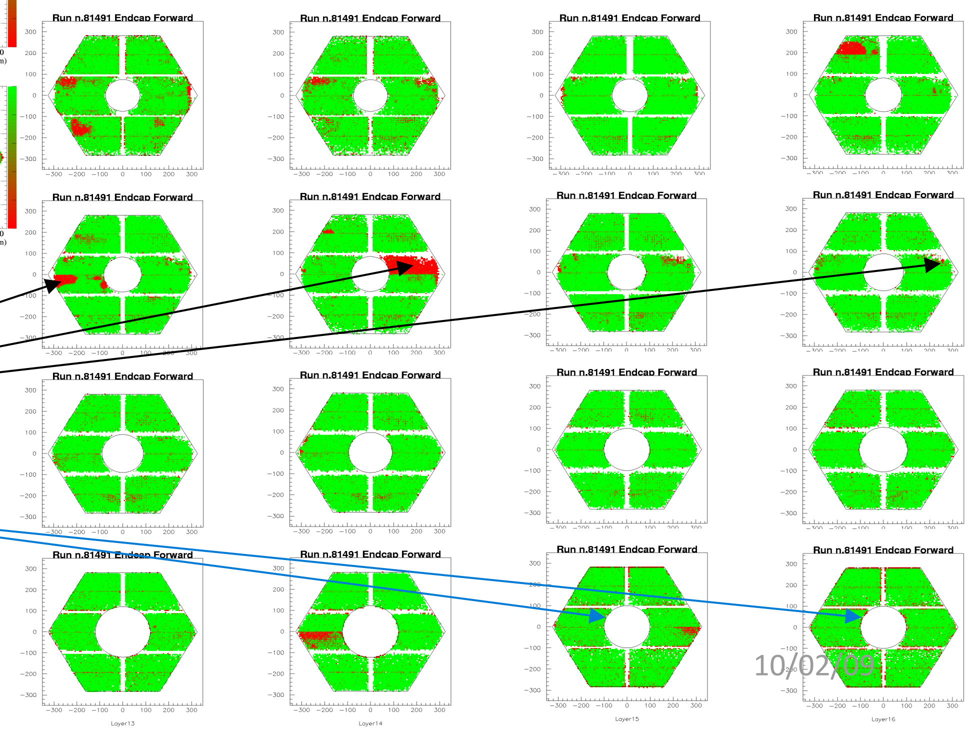
μ pairs with beam



2-D Efficiency map

Overall - efficiency at the end of running remains high

Cosmic rays



Need to decouple the aging effects from other failures ~ 8%:

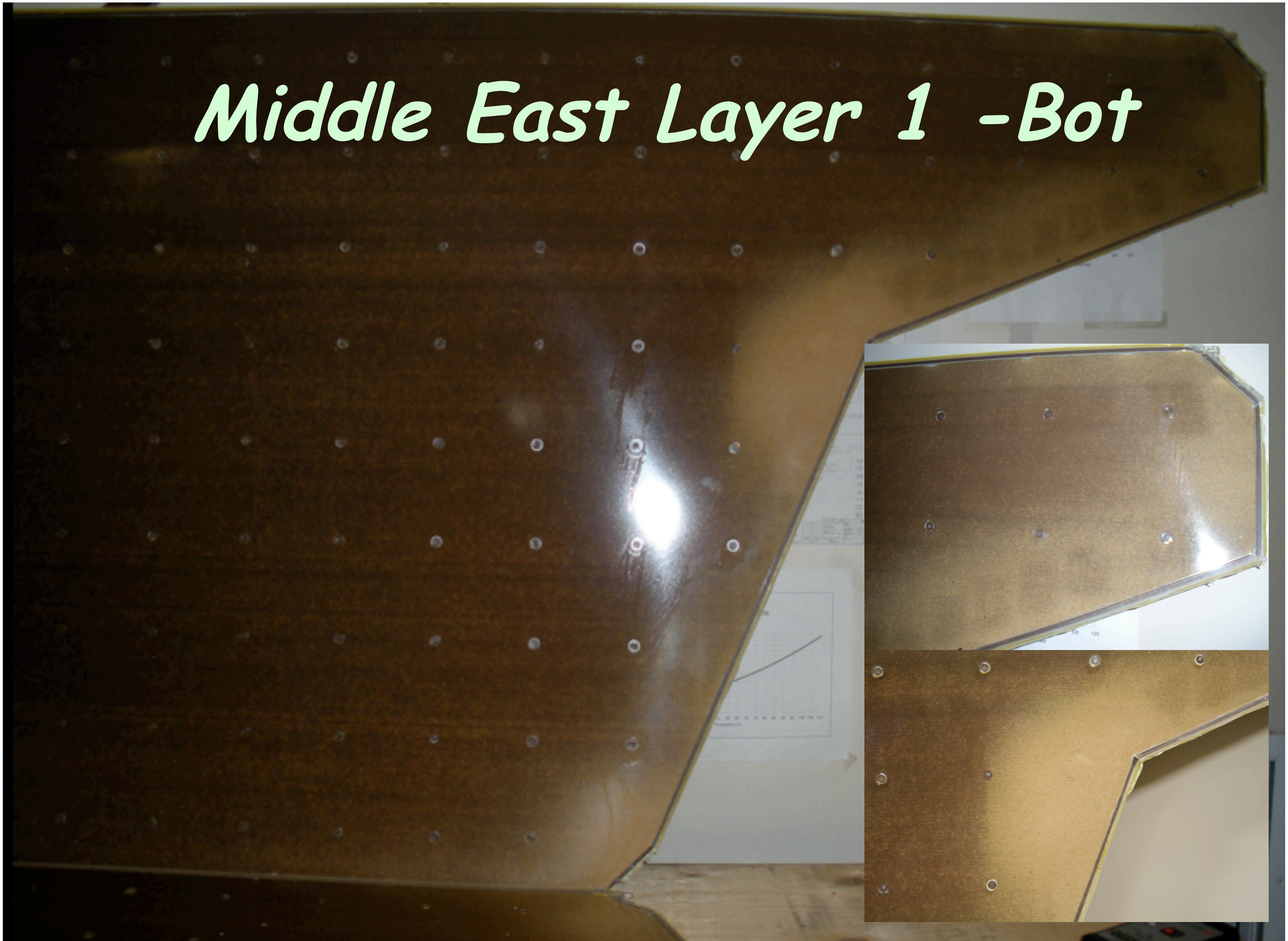
- ***gas problems***
- ***HV problems***

Low efficiency ring around beam-line only seen at high rates with beam

Final Tests

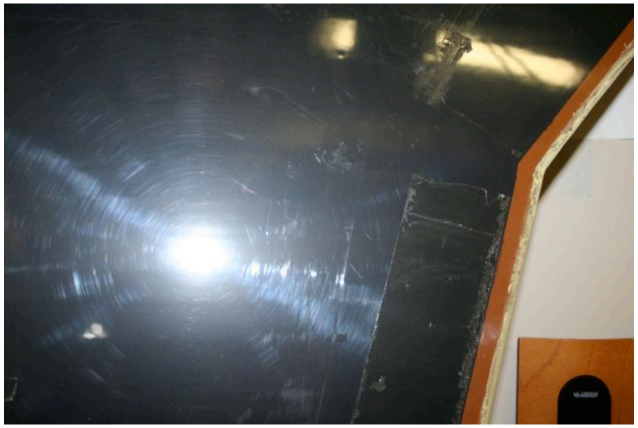
- 10 RPCs were selected for further tests
  - No HV or gas problems over 6 years
  - Finally removed from BaBar steel Mar. 2010
- 2 failure modes of most interest
  - Rate inefficiency around beamline
  - Noisy, inefficient regions near gas inlets
  - Correlate problem areas with changes in Bakelite or graphite resistivity or HV surface finish
- Quick first look at 2 RPCs reported
- Long term plan is to verify RPC Performance before autopsy

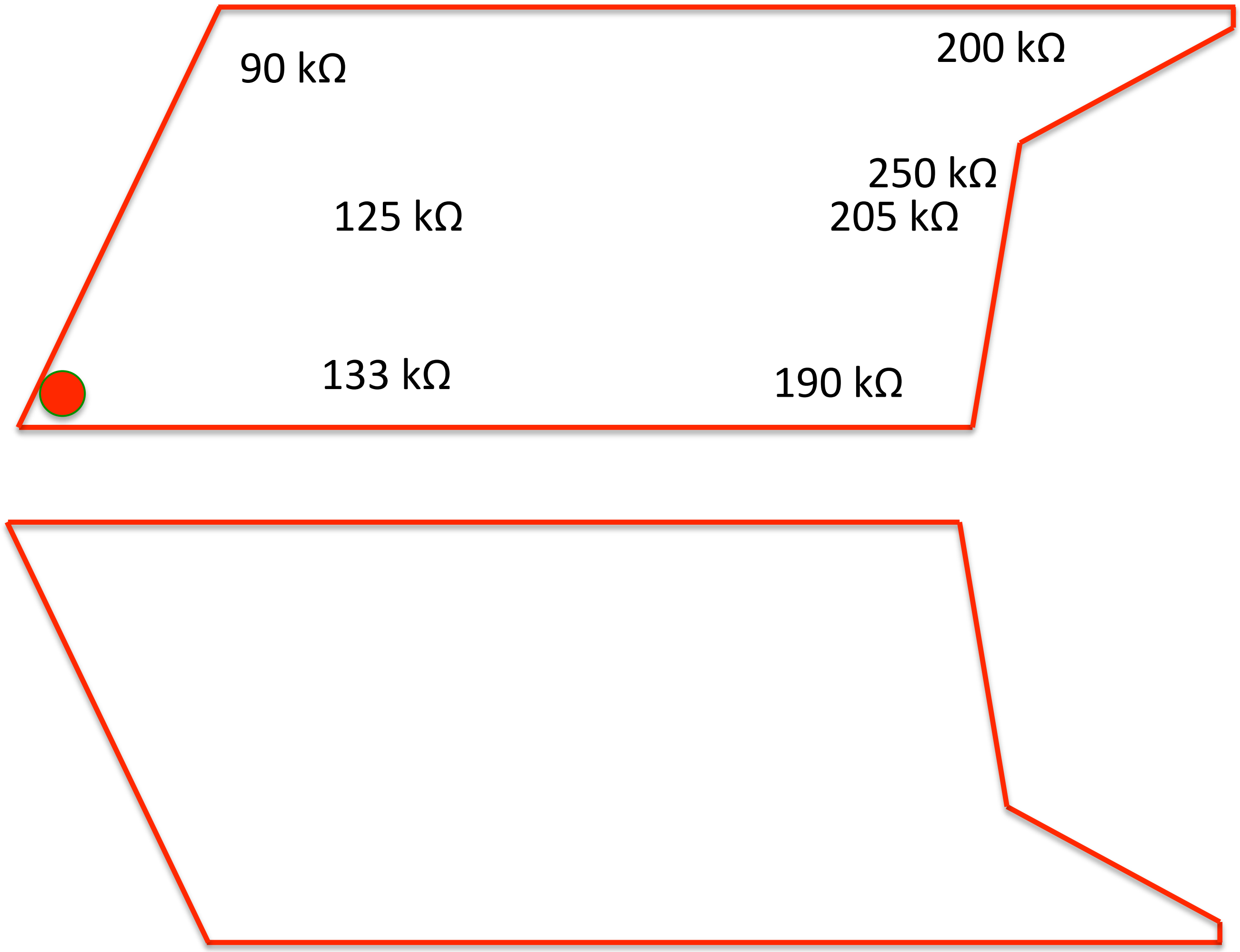
Middle East Layer 1 -Bot



Bakelite Samples
Middle East Layer 1 -Bot

East Layer 14 - Graphite

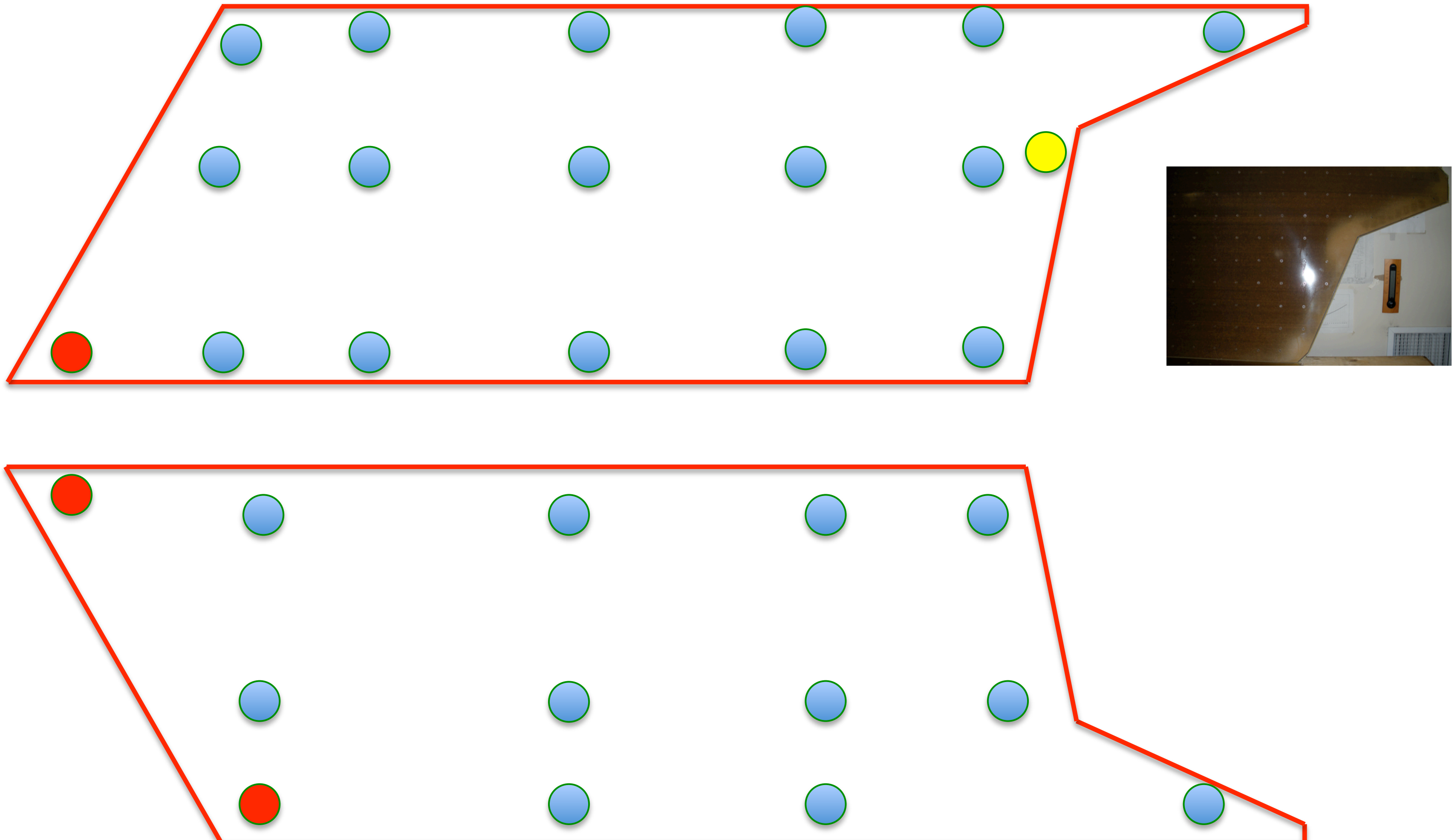




- 10^{11} Ω/□ & 10^{10} Ω
- 10^{10} Ω/□ & 10^{9} Ω
- 10^{11}-10^{12} Ω/□ & 10^{11} Ω

East Layer 1 - Bakelite

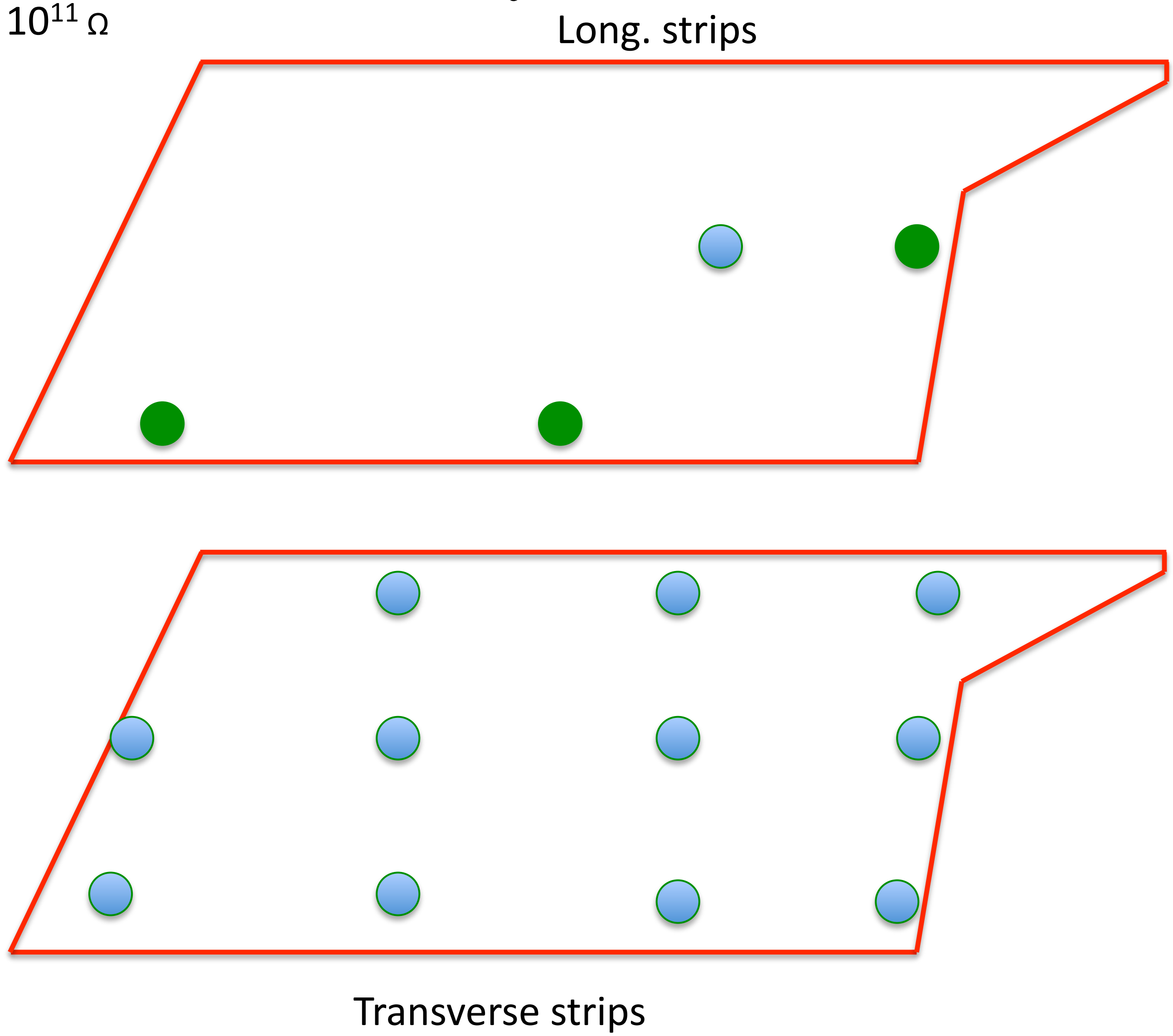
Long. strips



Meter SCC-625
resolution ½ decade

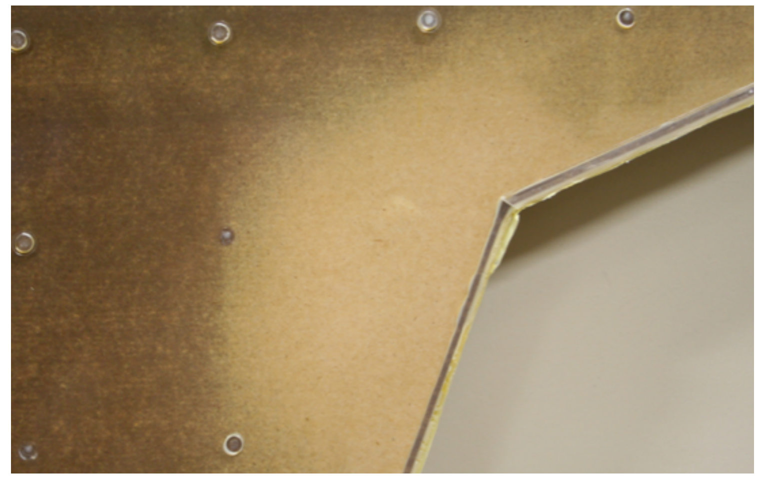
- $10^{11}\ \Omega/\square$ & $10^{10}\ \Omega$
- $10^{11}\ \Omega/\square$ & $10^{9}\ \Omega$
- 10^{11}-$10^{12}\ \Omega/\square$ & $10^{11}\ \Omega$

East Layer 14 Bakelite

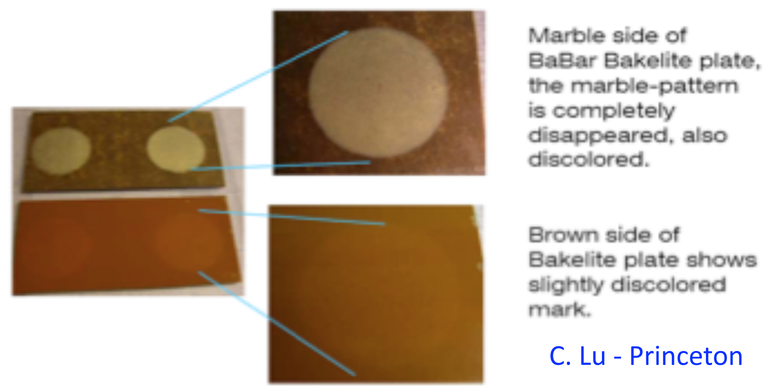


Autopsy Summary

- *No evidence of graphite problems*
- *Linseed oil dry & smooth*
- *Bakelite resistance is fairly uniform*
  - *Lower in "bleached area"*
  - *Needs more precise measurements*
- *"Bleached" surface in areas of rate inefficiency*
- *Not yet clear what causes inefficiency - More detailed studies*



Previous HF studies



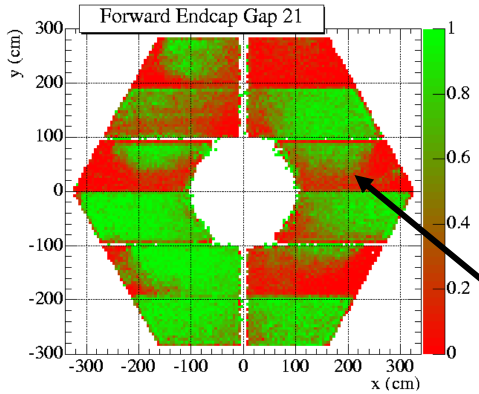
C. Lu - Princeton

Figure4. HF vapor corrosive action on BaBar Bakelite surface.

Gas Humidity

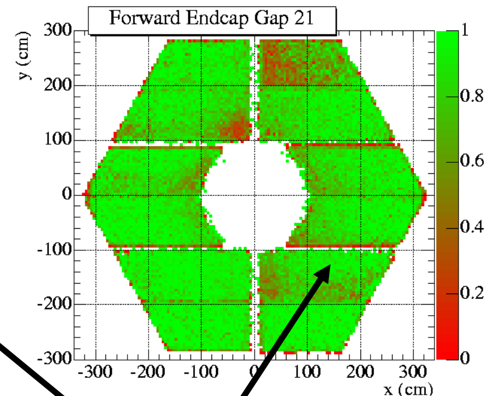
Run 53918

April, 05



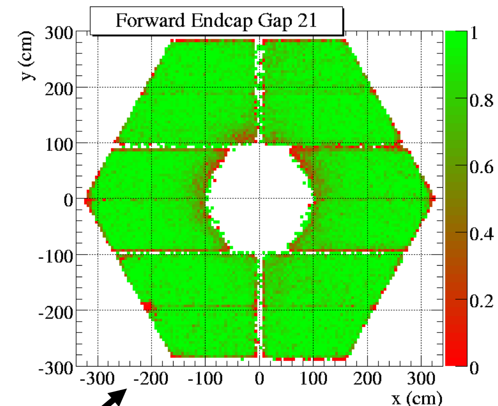
Run 57387

Aug. 23, 05

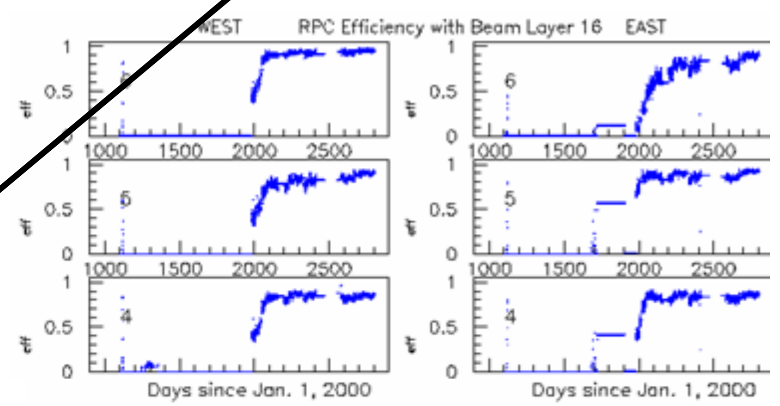


Run 74506

July 07



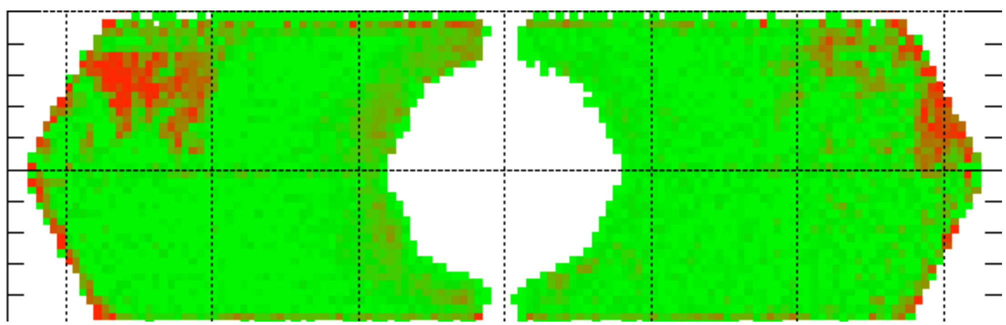
- *Outer layers inefficient in Run 5 even some which had been off*
  - *But OK with cosmics*
  - *Input IFR gas ~0% RH*
  - *RPC exhaust ~30% RH*
- *Humidify input gas to 35% for some and later all in Run 5b*
- *Clear improvements seen*
- *Stable efficiency in Run 6*



RPC avalanche: intro

- *We have been testing 3 RPC modules in avalanche mode since Oct 2005.*
- *The goal was to understand if operating RPC in avalanche can solve the rate capability and efficiency problem at small radii…*

West streamer

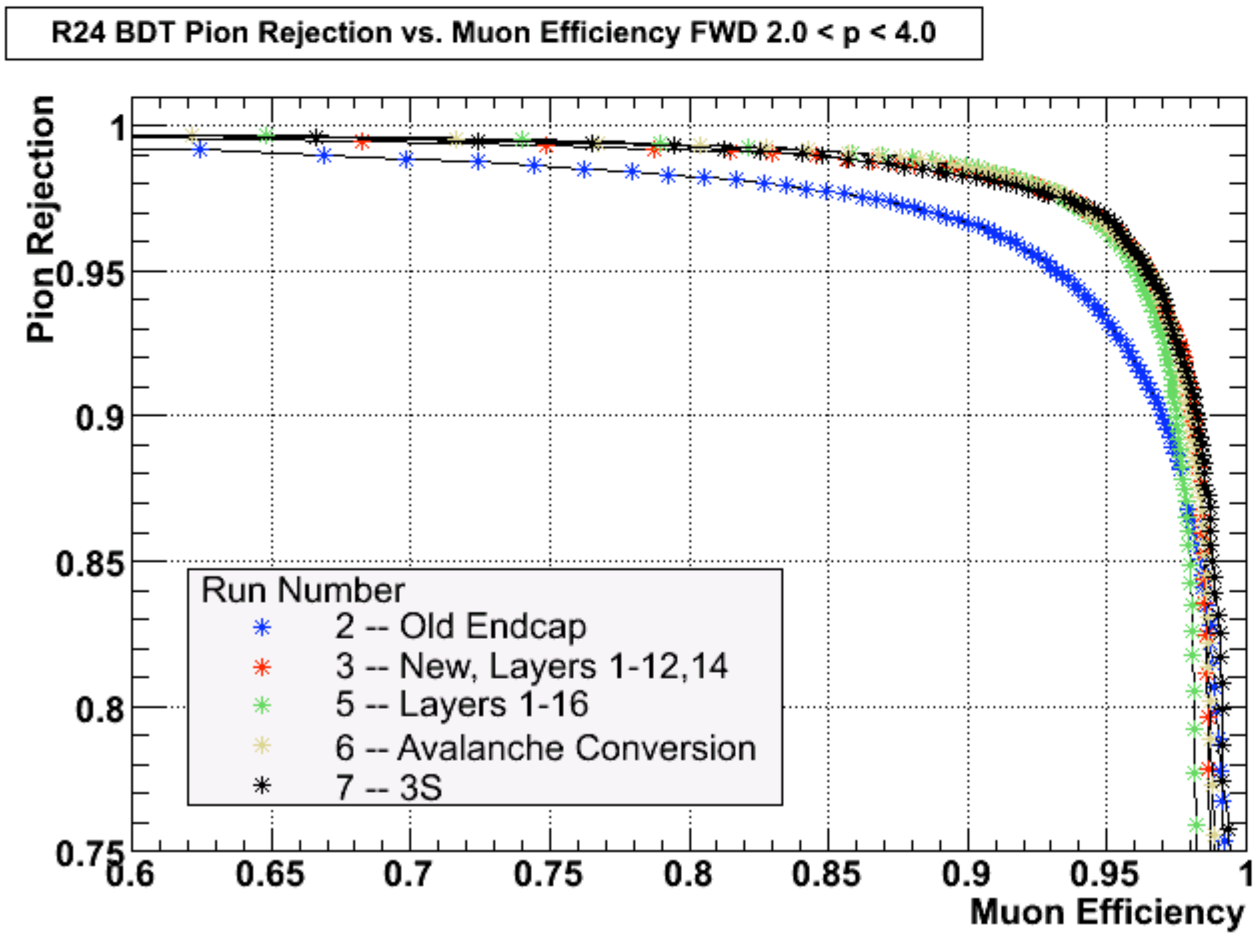


East avalanche

- *…And see if the new configuration is operationally stable and reliable.*

	STREAMER	vs	AVALANCHE
runningHV	6700V		9500V
Gas mixture	57%Ar		22%Ar
	39%Freon		72.9%Freon
	4% Isobutane		4.5% Isobutane
			0.6% SF_6

Muon ID Performance



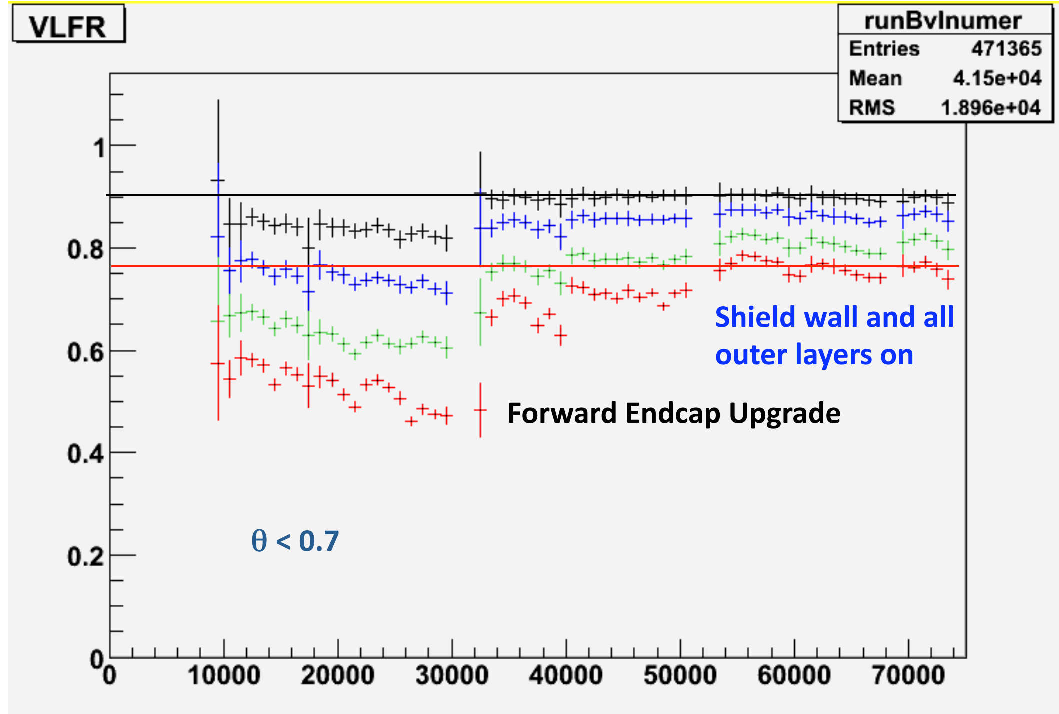
BaBAR Muon PiD

VeryLoose

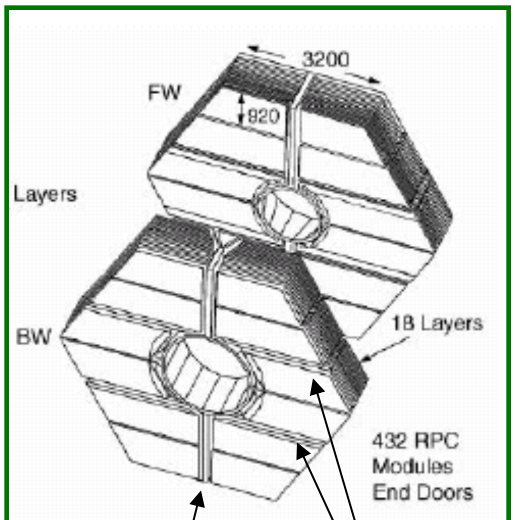
Loose

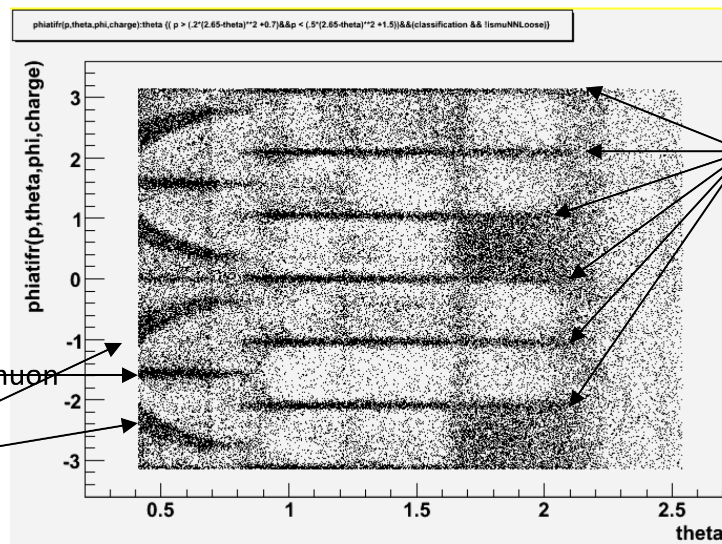
Tight

VeryTight



Run #





Cracks between barrel sextants

Cracks between Endcap doors

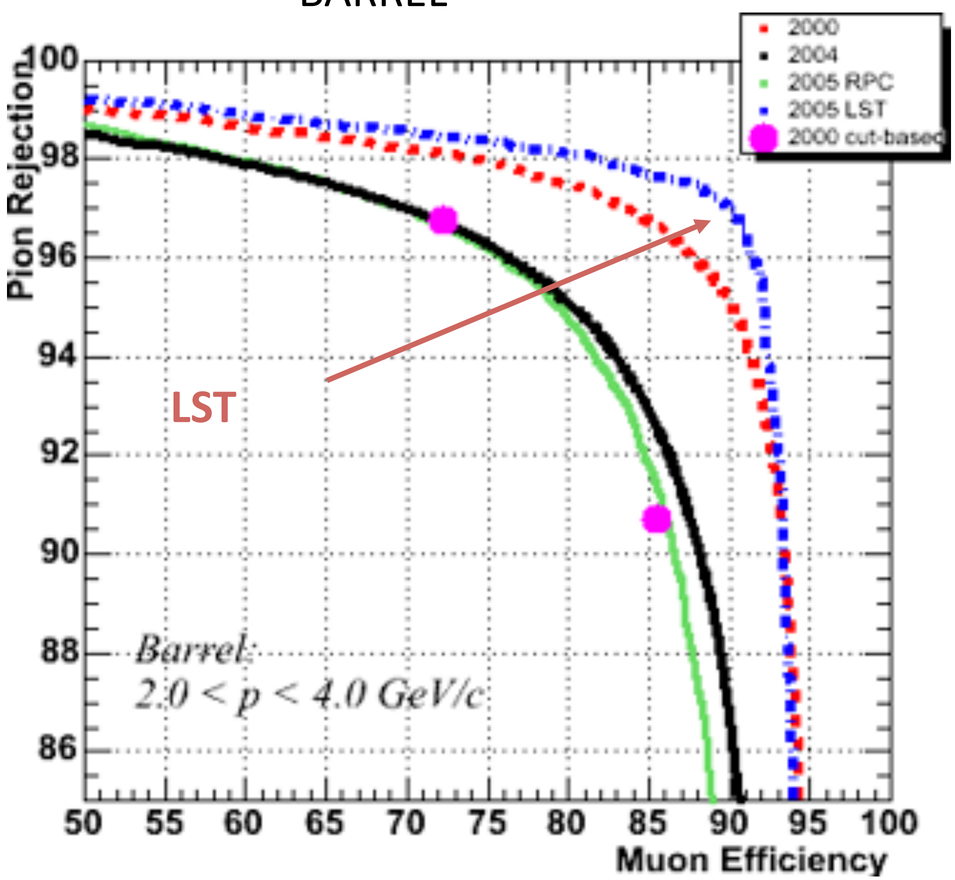
Gaps between muon chambers

BaBaR – muons failing loose NN selector efficiency

Outlook

Muon ID vs pion rejection

BARREL



FORWARD ENDCAP