



Muon (RPC) Detector Studies for SiD

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U. Of Wisconsin*



Outline

- *RPC Performance & Aging*
 - *BaBar experience*
 - *Low rate streamer mode*
 - *Humidity requirements*
 - *Fluorine*
- *HF sensitivity*
- *Test stand*
 - *IHEP RPCs*
 - *KPIX*
- *Plans*



Goals

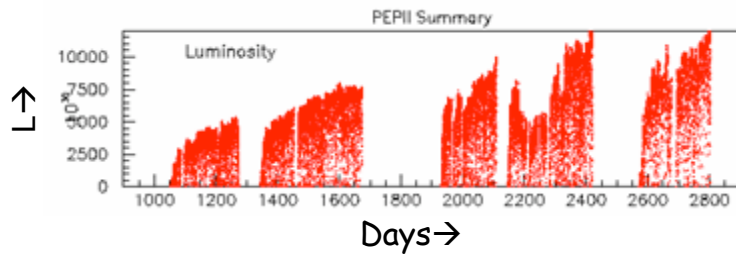
- Expected backgrounds for an ILC muon system remain low $\sim .01$ hit/cm² per train (change from $\sim 2 \cdot 10^{-4}$)
N. Mokhov
- Will impact strip size depending on electronics (KPIX < 5 hits/train)
- Position resolution modest (~ 1 cm)
- RPCs can meet these requirements @ low cost
- Primary concern is reliability
- Many large systems coming inline will test RPCs further
 - CMS, ATLAS (avalanche)
 - BESIII
 - Opera, Daya Bay
- Ongoing results from BaBar & BELLE



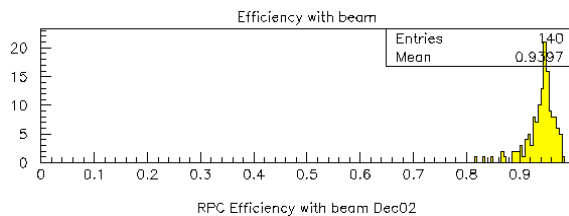
BaBar Forward Endcap RPCs



- Over 200 2nd generation RPCs installed in O2 forward upgrade
- Data from Nov.02 - Sep. 07

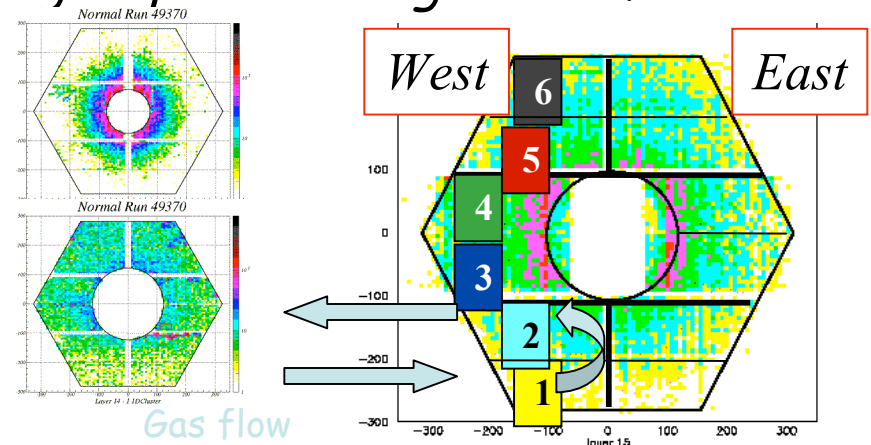


- Efficiency still high (94%→92%) but adjustments to gas flow, gas humidity, & HV cabling were required. Many chambers show an increase in current & rates
- Small number of RPCs have gas or HV problems (8%)

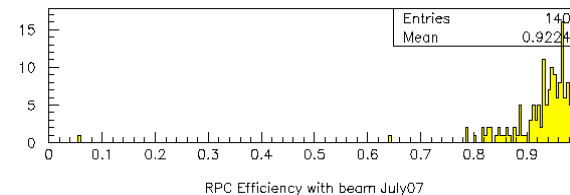


10/26/07

- 12 RPC HV modules per layer, grouped into 6 gas volumes



- Signal and background rates vary widely with position
 - Highest rate RPCs switched to avalanche mode
- Most relevant to ILC are the RPCs in the low rate positions



RPC Efficiency with beam July07

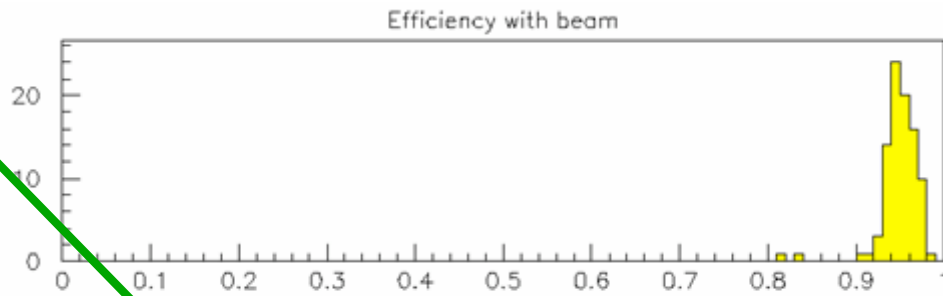
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BaBar Efficiency with μ pairs



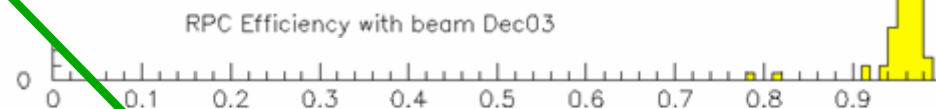
Top + bottom sections
Rate $< 2 \text{ Hz/cm}^2$
Nearly 5 years of data



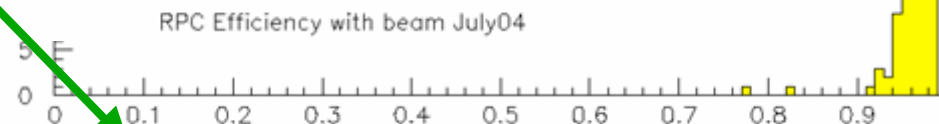
$\langle e \rangle = 0.950$



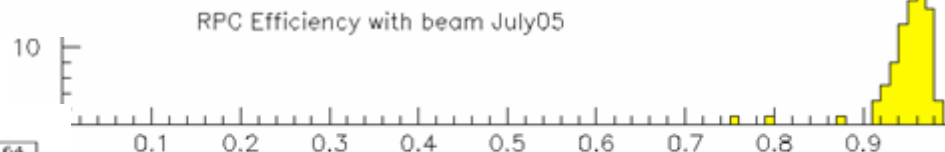
$\langle e \rangle = 0.955$



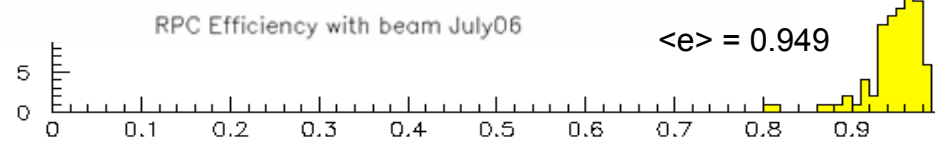
$\langle e \rangle = 0.959$



$\langle e \rangle = 0.960$



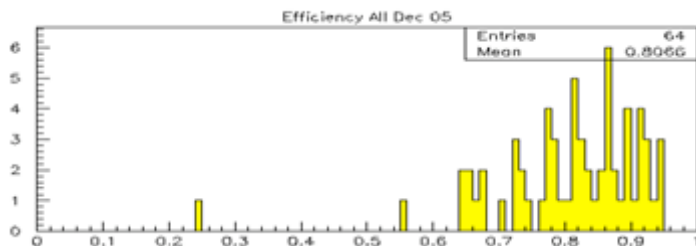
$\langle e \rangle = 0.951$



$\langle e \rangle = 0.949$

RPC Efficiency with beam July07

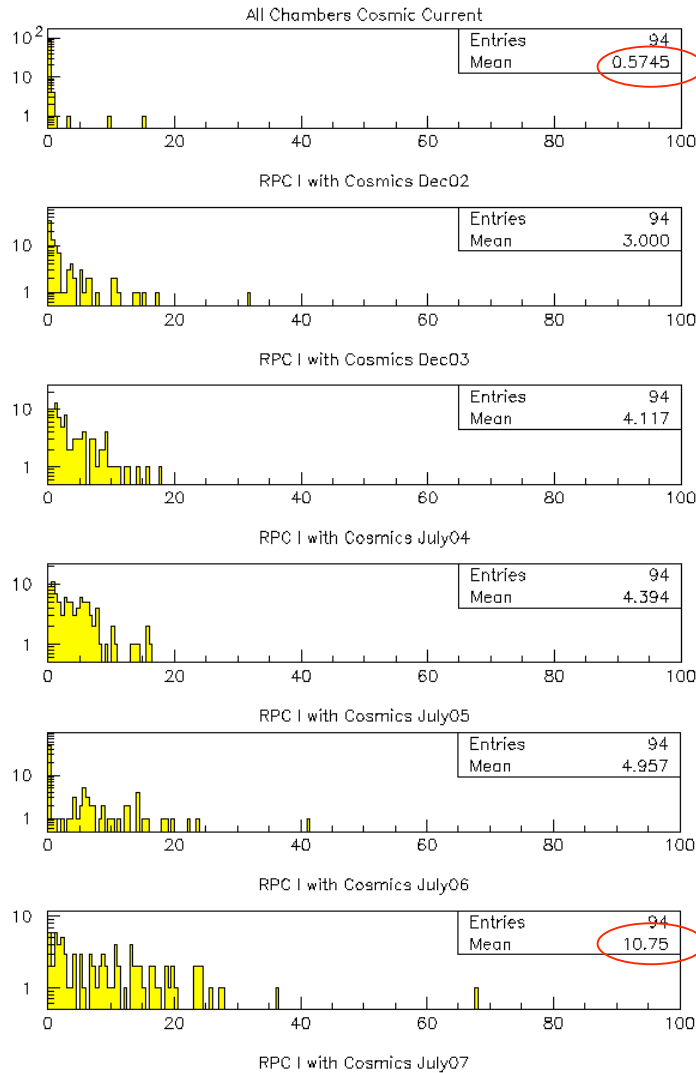
Middle sections
Peak Rate $> 20 \text{ Hz/cm}^2$



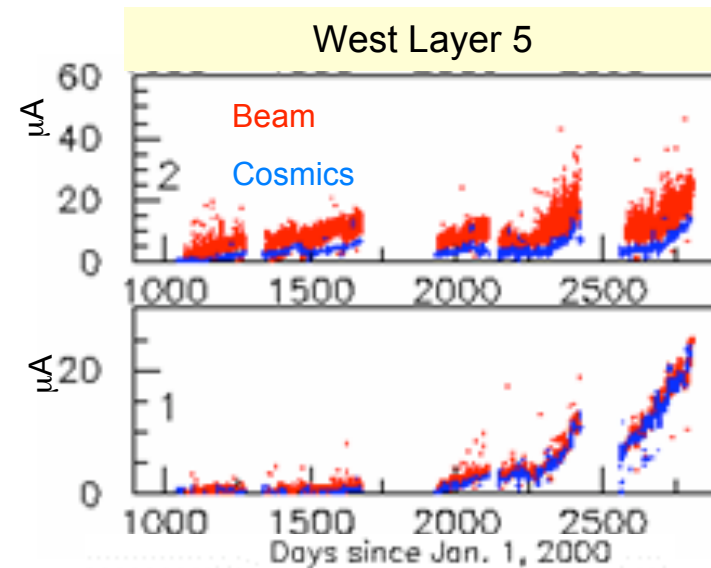


Current with Cosmics Only

Top + bottom sections
Rate < 2 Hz/cm²



- *Efficiencies stable*
- *Increased currents*



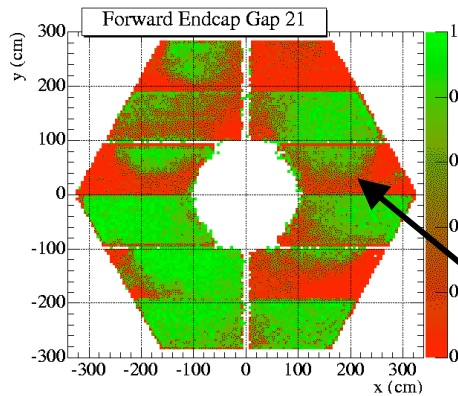
- *Not understood, low Gas Flow? Too humid?*



Gas Humidity

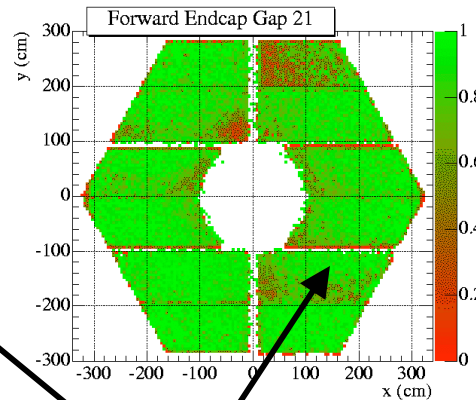
Run 53918

April, 05



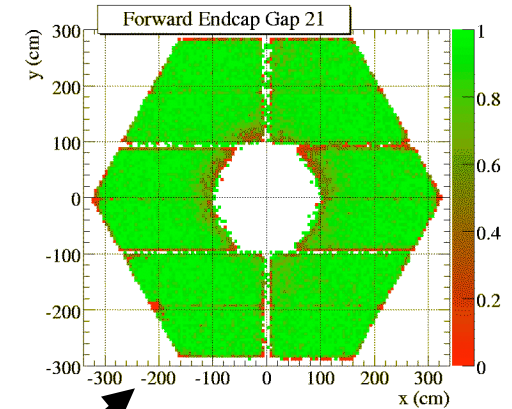
Run 57387

Aug. 23, 05

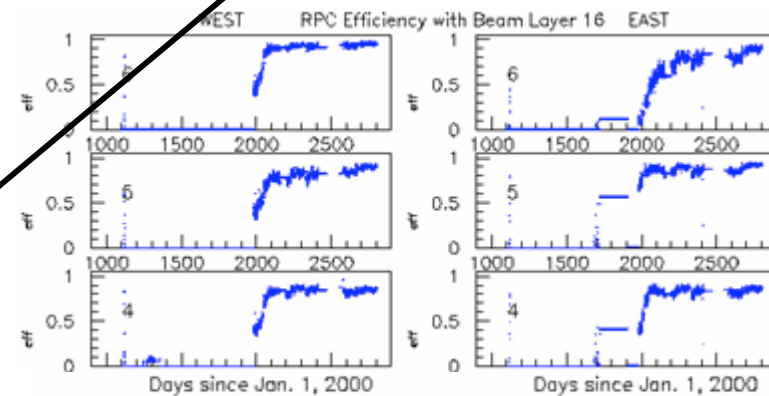


Run 74506

July 07

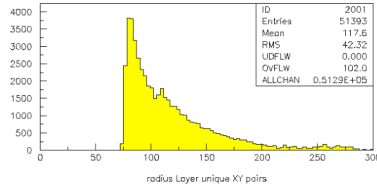


- *Outer layers inefficient in Run 5 even some which had been off*
 - *But OK with cosmics*
 - *Input IFR gas ~0% RH*
 - *RPC exhaust ~30% RH*
- *Humidify input gas to 35% for some and later all in Run 5b*
- *Clear improvements seen*
- *Stable efficiency in Run 6*





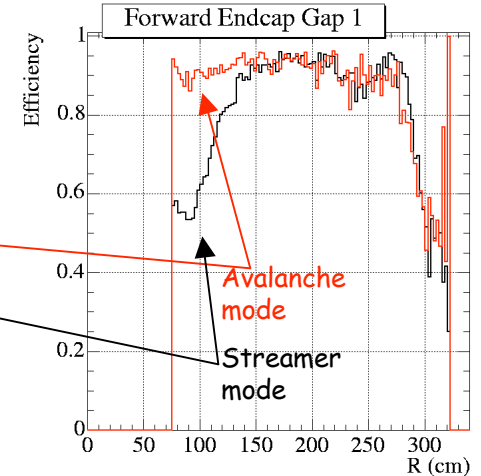
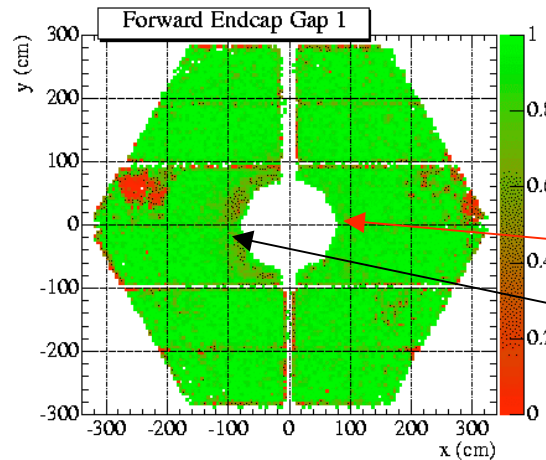
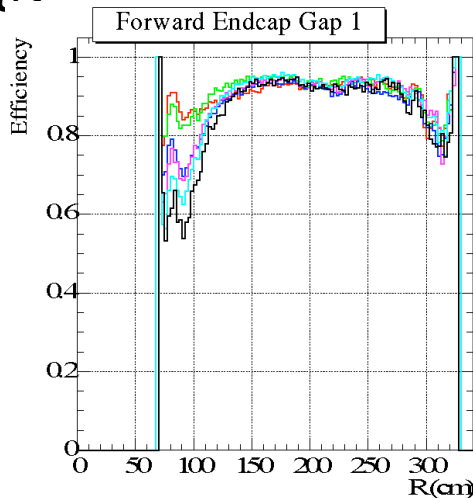
Avalanche Mode



- Declining efficiency observed in high rate ring at small radii
- Most aging processes proportional to integrated charge
- Did not improve with humidified $g\alpha$

- Convert to avalanche mode
 - Lower current, improved efficiency
 - 22% Ar, 72.9% $C_2H_2F_4$, 4.5% C_4H_{10} , 0.6% SF_6
- 12 middle RPCs converted for Run6
- Improved efficiencies, lowered currents, noise rates +20%

Feb. 2003
 Oct. 2003
 Dec. 2003
 Jan. 2004
 Jun. 2004
 Jun. 2005



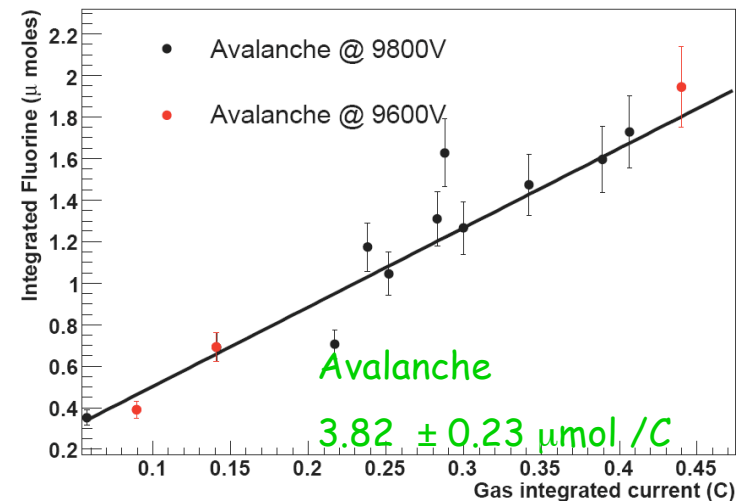
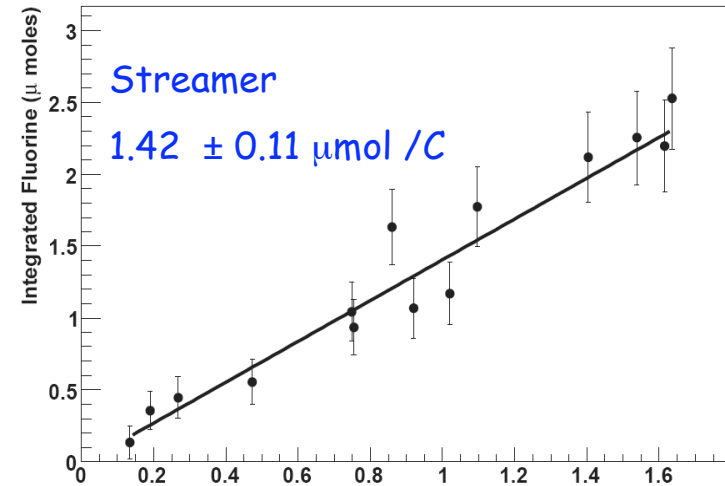
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Fluorine studies

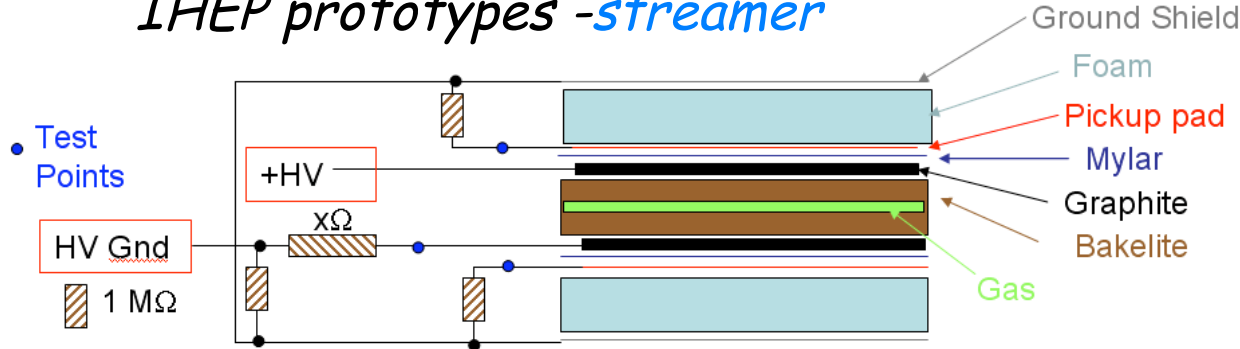
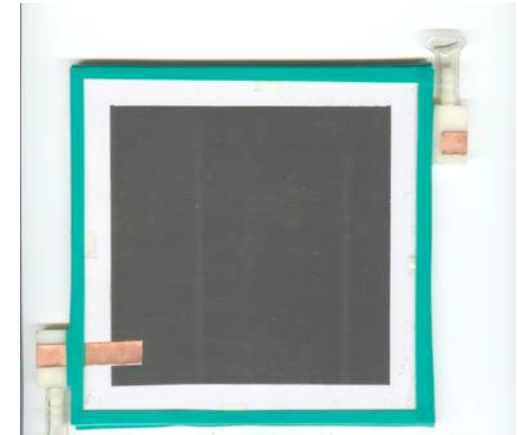
- Several studies have shown correlation between the production of F^- and increased currents and surface damage
- F^- in the exhaust gas measured by bubbling gas through a H_2O & TISAB solution and measured with a Fluorine specific probe
- Comparison of avalanche mode and streamer mode RPCs shows comparable F^- production
 - Avalanche Current is $\sim \frac{1}{4}$ streamer mode
 - Avalanche produces more F^- per unit charge





IHEP RPC & KPIX Studies

- Cosmic test stand built with BaBar spares and gas
- Initial tests of small 15 *15 cm IHEP prototypes -*streamer*

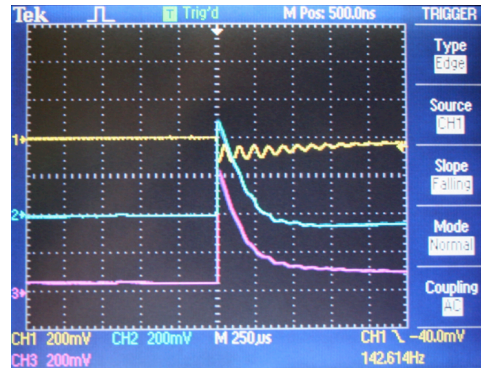


- KPIX is DC coupled $\sim 2\ \mu\text{sec}$ integration time
- RPC strips(pads) are AC coupled and see fast signals $\sim 300\ \text{nsec}$ decay time depending on termination of pad and HV ground



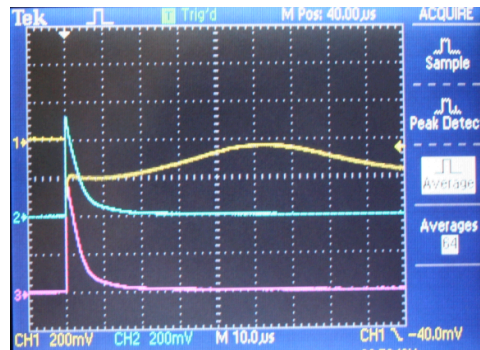
IHEP RPC & KPIX Studies(2)

$X = 10^6 \Omega$

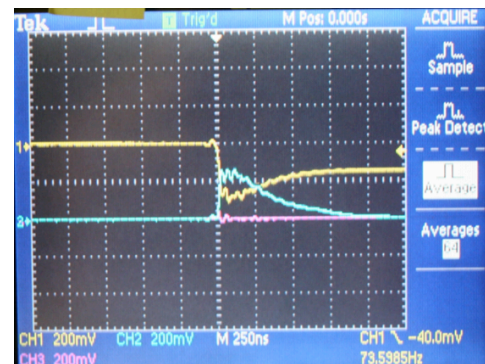


#1 HV side pad
#2 Gnd side pad
#3 HV ground return

$X = 10^4 \Omega$



$X = 0 \Omega$

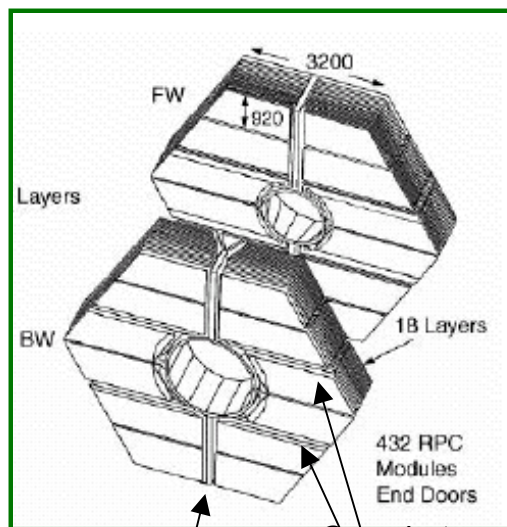


- 2 possible solutions
- Revise KPIX with $\sim .2 \mu$ sec integration time
- Replace Pickups by DC connections to segmented graphite layer
- Will build interface board to test alternatives

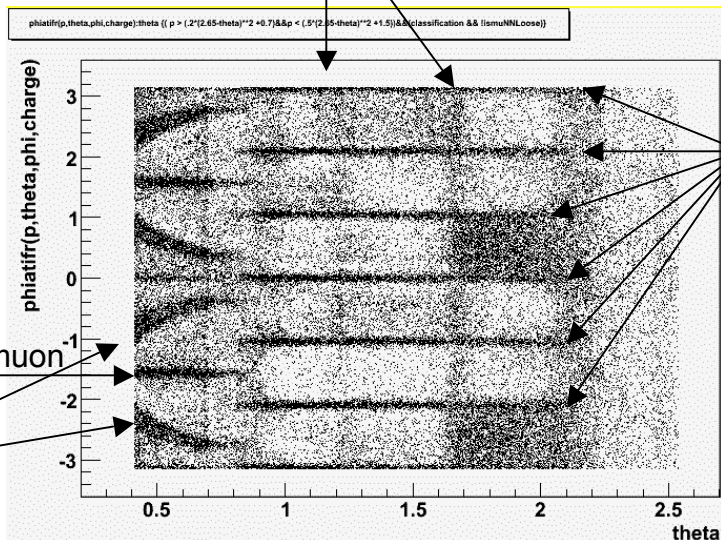


BaBAR IFR Muon Losses

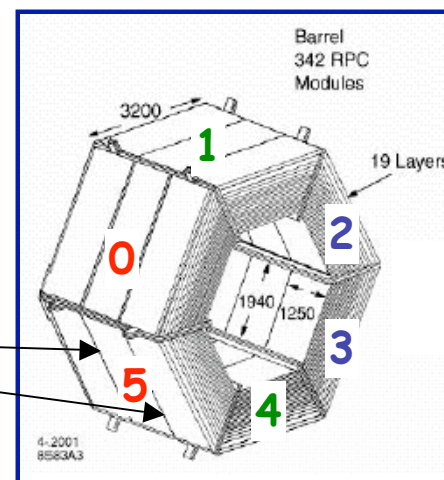
Reminder to avoid projecting cracks



Gaps between muon chambers
Cracks between Endcap doors



Gaps between muon chambers



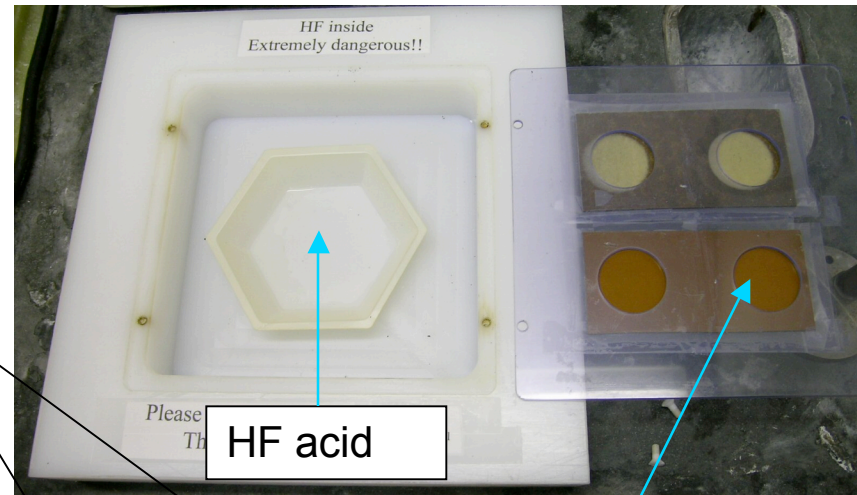
Cracks between barrel sextants

BaBar - muons failing loose NN selector efficiency Runs 1-6

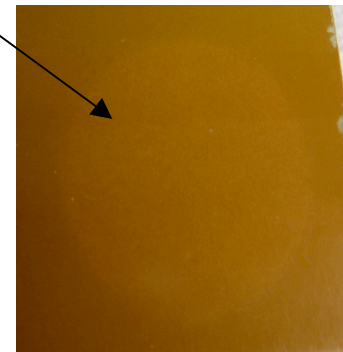
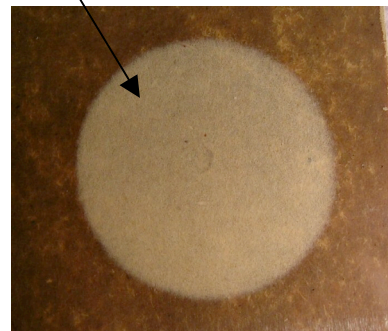
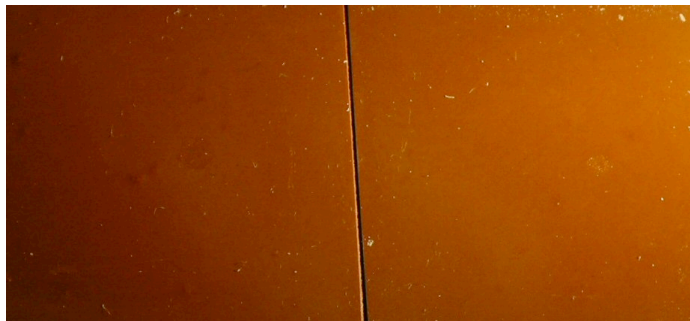


Studies of HF - C. Lu Princeton

- Exposed Bakelite/glass surfaces to HF vapor for 24 hrs
- Bare Bakelite (BaBar) shows clear discoloration
- The Linseed oil coated Bakelite surface is much better protected from HF vapor attack



Cover plate with 4 round windows that let the testing samples exposed to HF vapor.

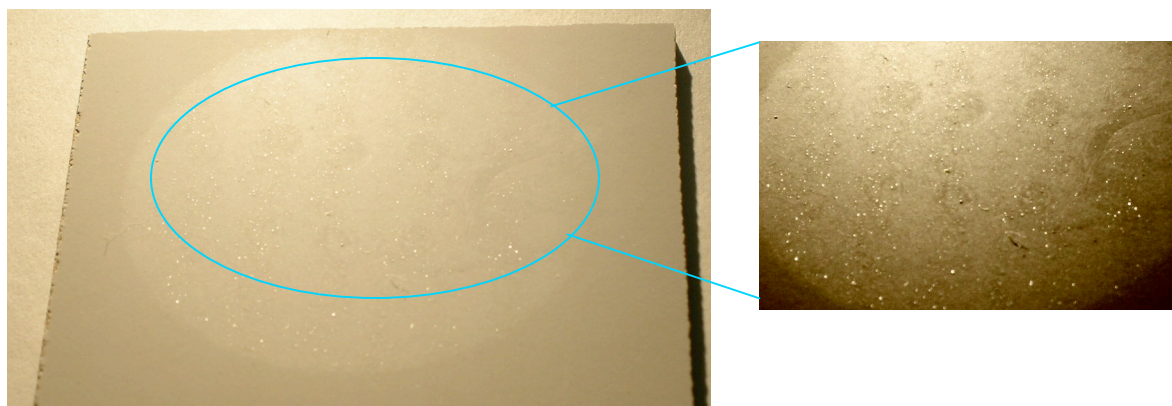




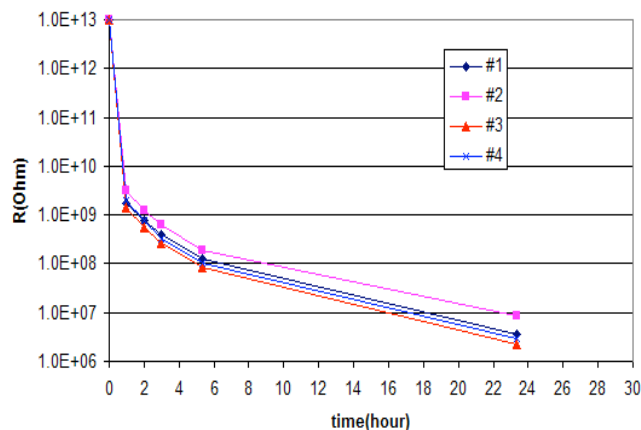
Effect on IHEP Bakelite surface

Surface has been badly attacked by HF vapor.

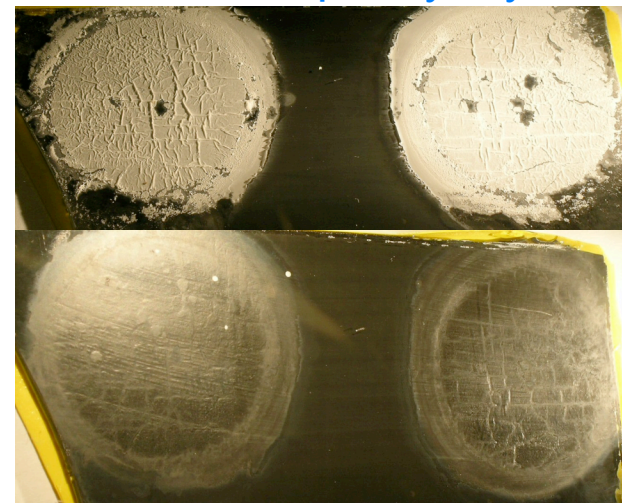
C. Lu
Princeton



Surface resistivity drops very fast in first hour of exposure.



A reminder that glass RPCs have to be kept very dry

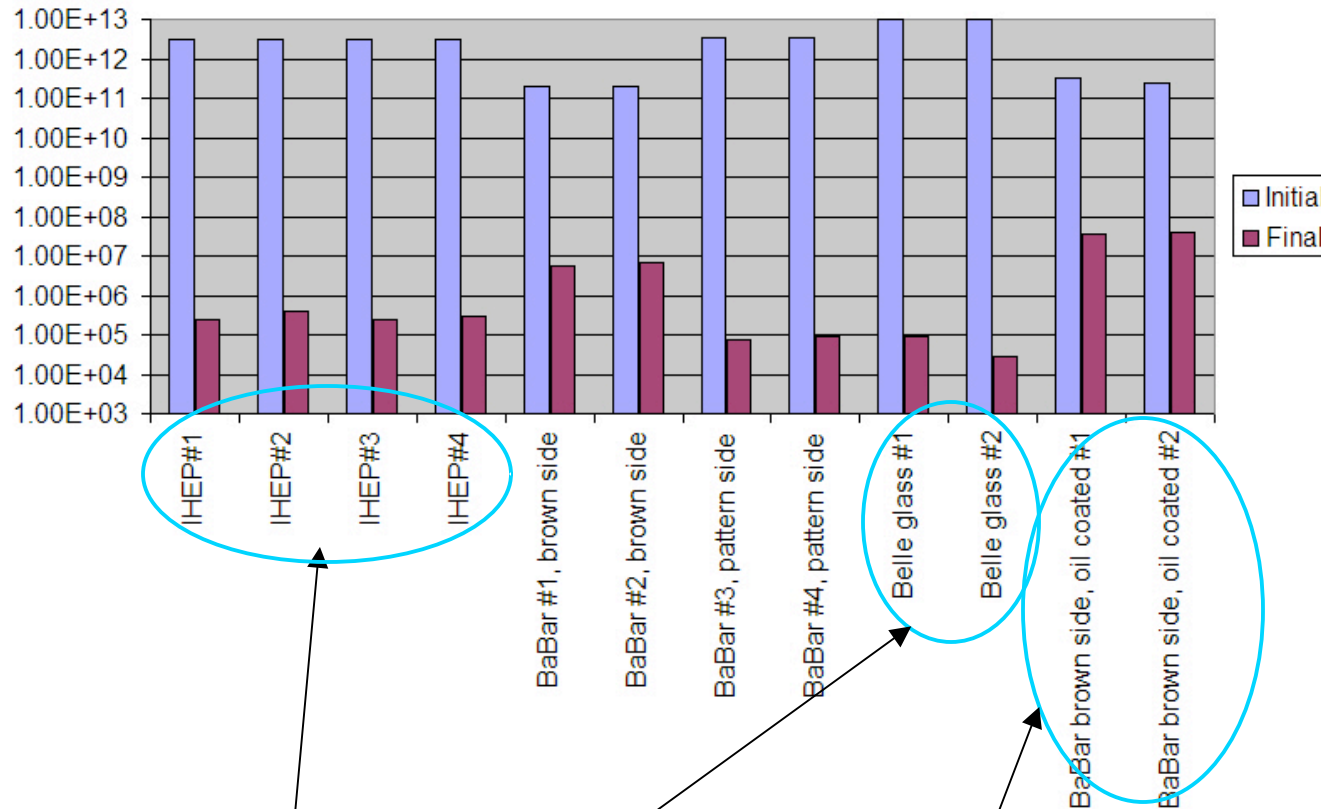




Summary of the HF tests

C. Lu Princeton

Surface resistivity change after exposed to HF vapor



We can see that the surface resistivity reduction for IHEP Bakelite samples is $\sim 10^7$, for Linseed oil coated BaBar Bakelite samples is $\sim 10^4$, the glass surface is worse than IHEP Bakelite.



Plans

- *Obtain larger IHEP RPCs*
- *Design and build KPIX(64 ch) interface board*
 - *Test on spare BaBar and New IHEP RPCs*
- *More F- sensitivity tests*
 - *Last year of BaBar running is good source of F- (and any other pollutants)*
 - *Test IHEP RPCs*
- *Cosmic ray tests (08)*
- *Need beam tests (09-10)?*