BELLE

RESISTIVE

PLATE

CHAMBERS

DAVID KOLTICK

FOR L. PIILONEN

LINEAR Collider

μ- System Goals.

1. UNAMBIGUOUS ASSOCIATION of μ with TRACK IN TRACKING System without NEED FOR μ-system $\vec{p}$ MEASUREMENT.

IF $\sigma_\mu \sim 1$ cm

$\Rightarrow r\delta\phi \cdot r\delta\theta \simeq 0.5\ \text{cm}^2$

@ OUTER TRACKER.

II. Provide a Trigger For High P_T μ.

A.: No $\vec{P}$ Measurement

$\Rightarrow \frac{dE}{dx}$ only Selection

$\sim P_T > 5$ GeV/c

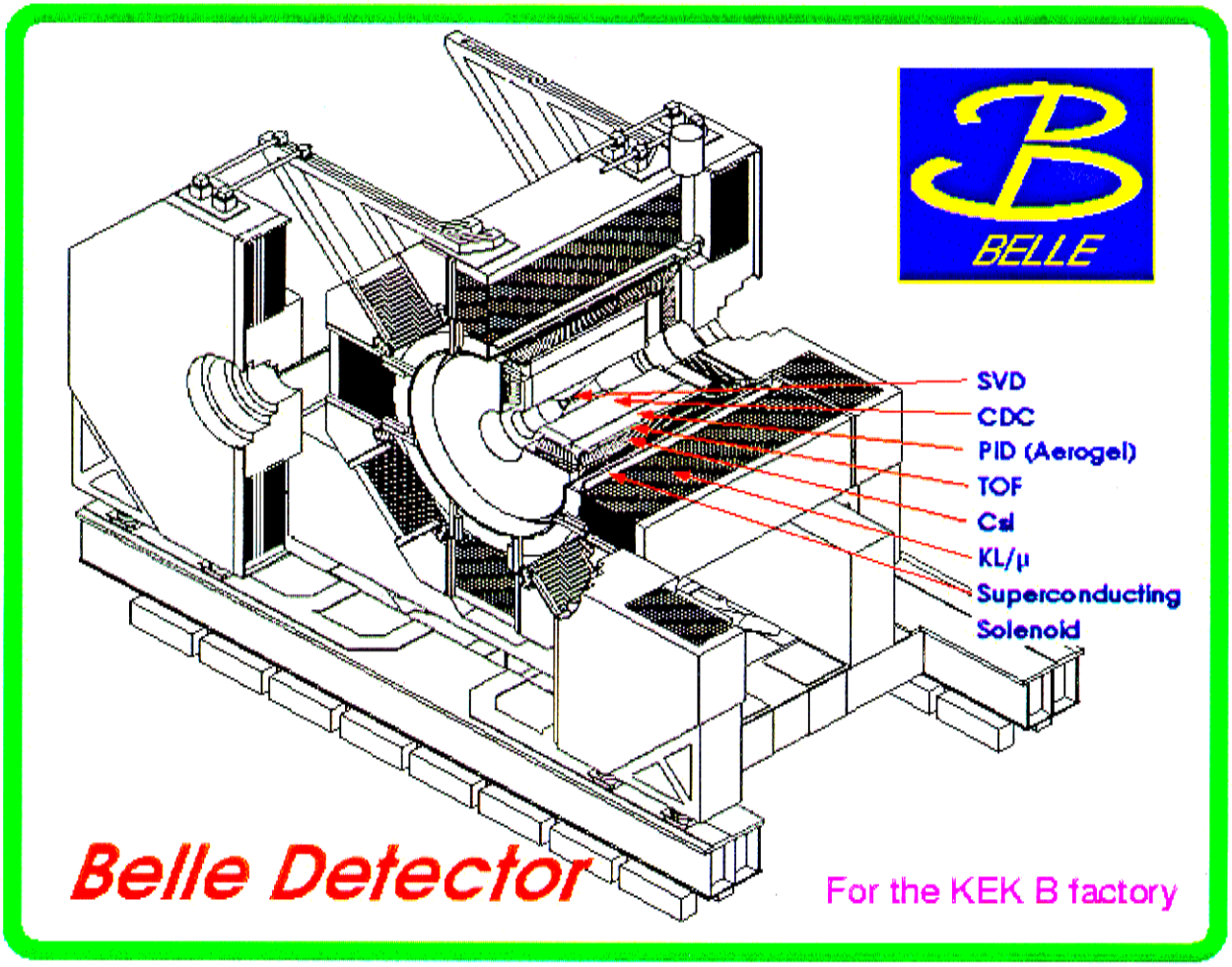
B. Bucket Spacing

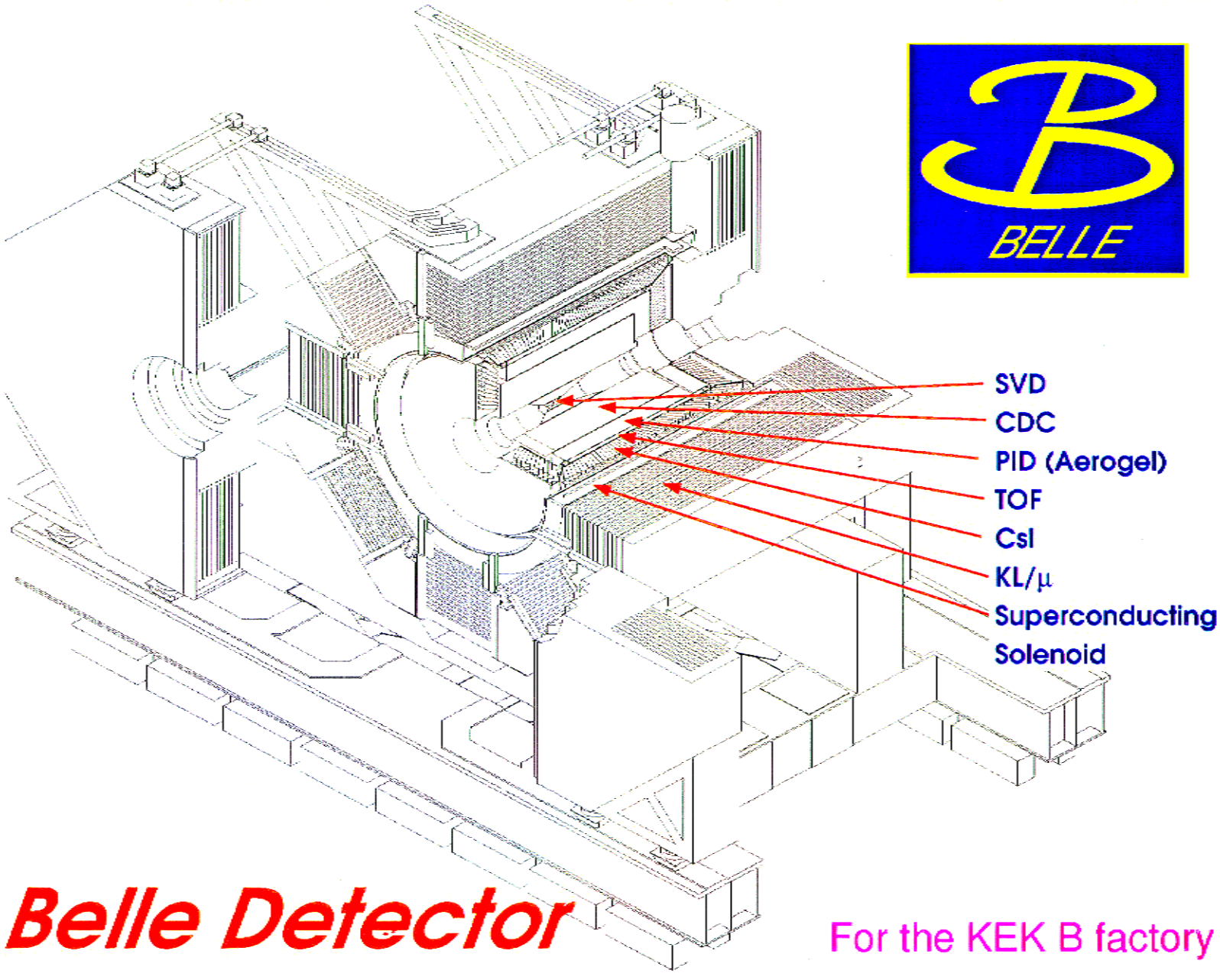
$\sim$ 2 nsec

$\Rightarrow \delta t \approx 1$ nsec

III Provide a Cosmic Ray Trigger to facilitate Calibration & testing of the Complete Detector

⇒ Pointing to I.P.


BELLE
SVD
CDC
PID (Aerogel)
TOF
CsI
KL/μ
Superconducting
Solenoid
Belle Detector
For the KEK B factory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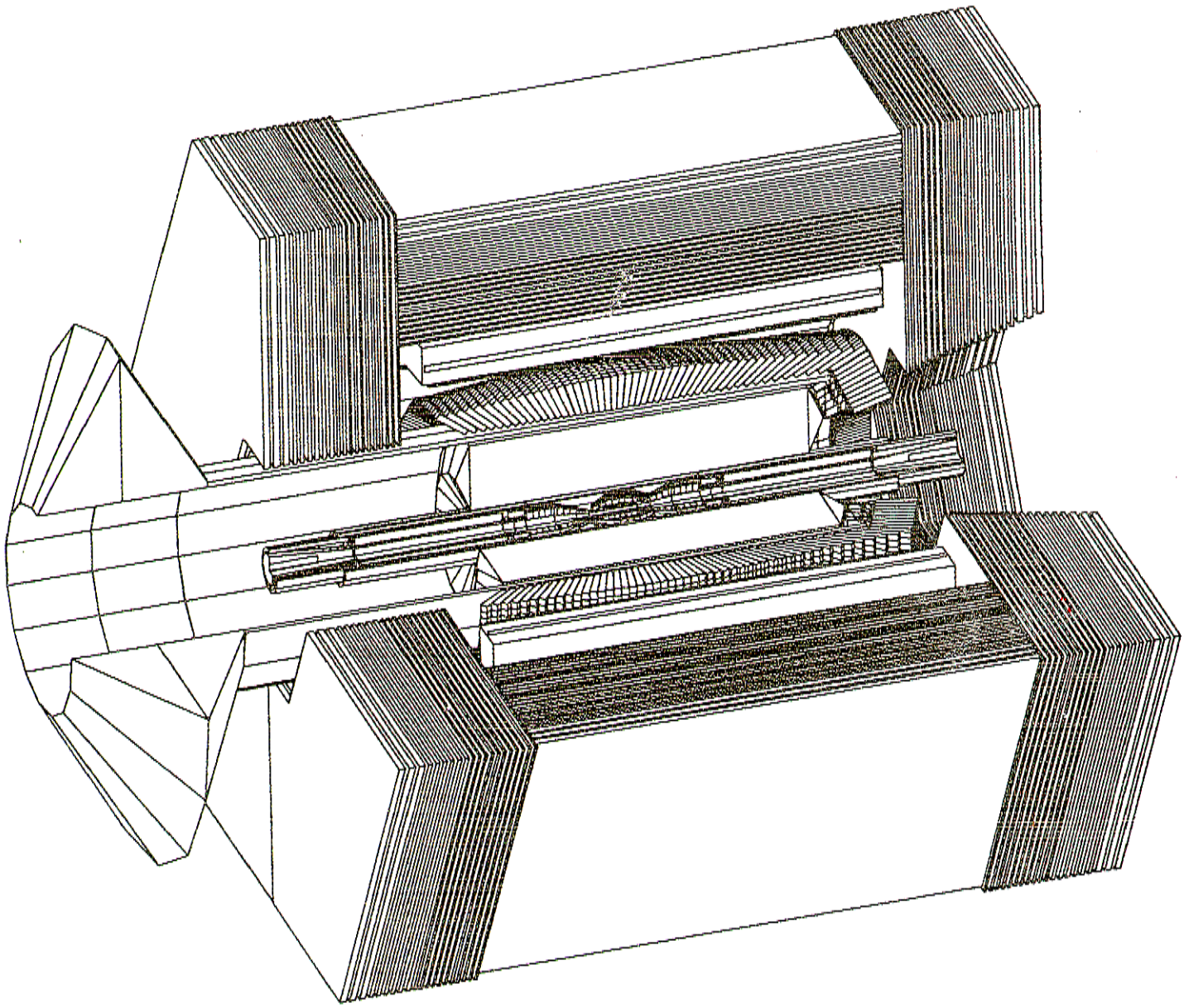
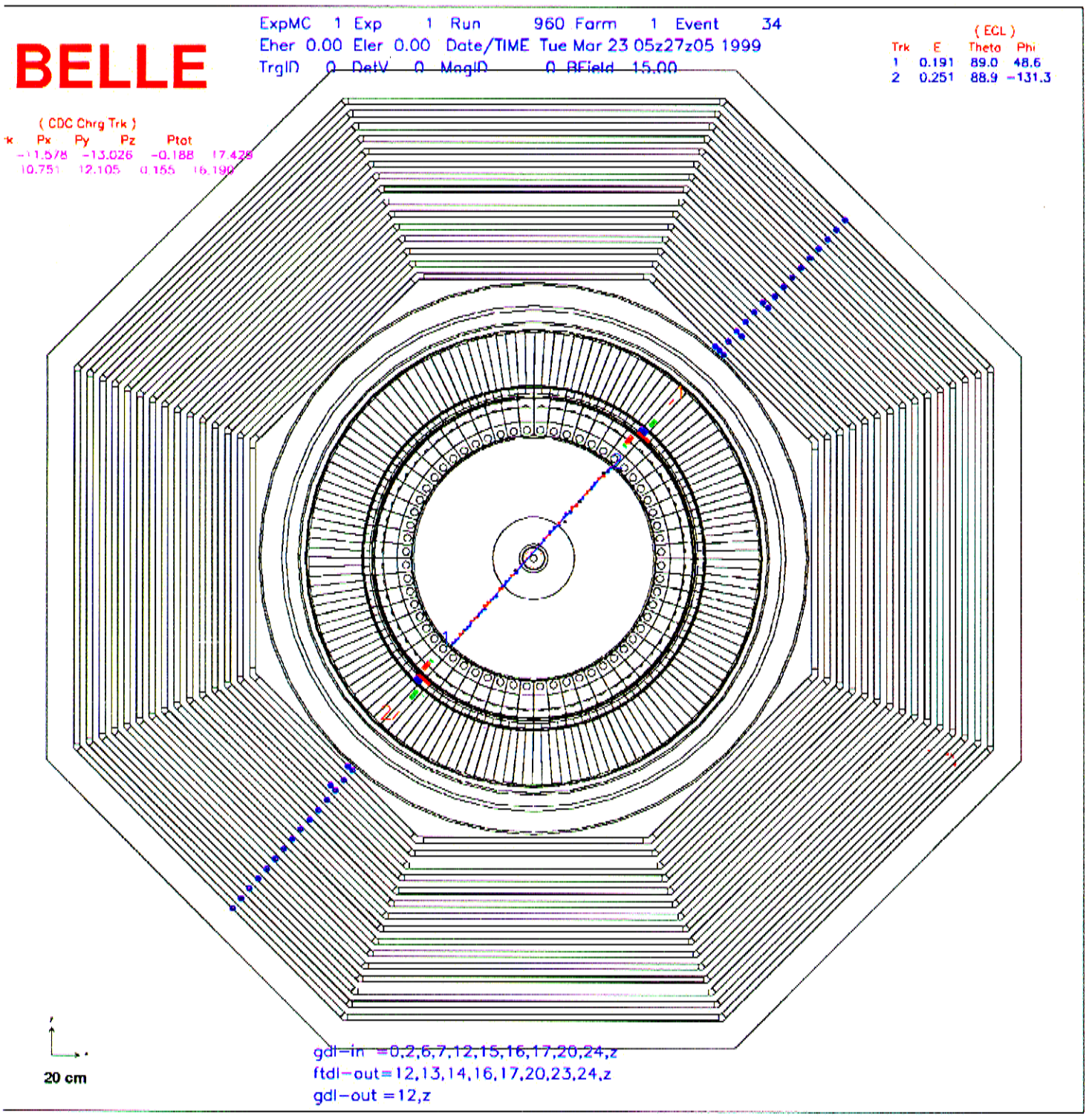
BaBar cutout




BELLE
ExpMC 1 Exp 1 Run 960 Farm 1 Event 34
Eher 0.00 Eler 0.00 Date/TIME Tue Mar 23 05z27z05 1999
TrgID 0 DetV 0 MagID 0 BField 15.00
(ECL)
Trk E Theta Phi
1 0.191 89.0 48.6
2 0.251 88.9 -131.3
(CDC Chrg Trk)
Px Py Pz Ptot
-11.578 -13.026 -0.188 17.428
10.751 12.105 0.155 16.190
20 cm
gdl-in =0,2,6,7,12,15,16,17,20,24,z
ftdl-out=12,13,14,16,17,20,23,24,z
gdl-out =12,z

K_L Muon System

KEK,Osaka City University,Princeton University

Tohoku University, Tokoku-Gakuin University, and

Virginia Polytechnic Institute and State University

- 352 Superlayer Modules with Glass Electrode Resistive Plate Counters

  Largest module 2.7 m x 2.2 m

  ~2200 m^2 total area

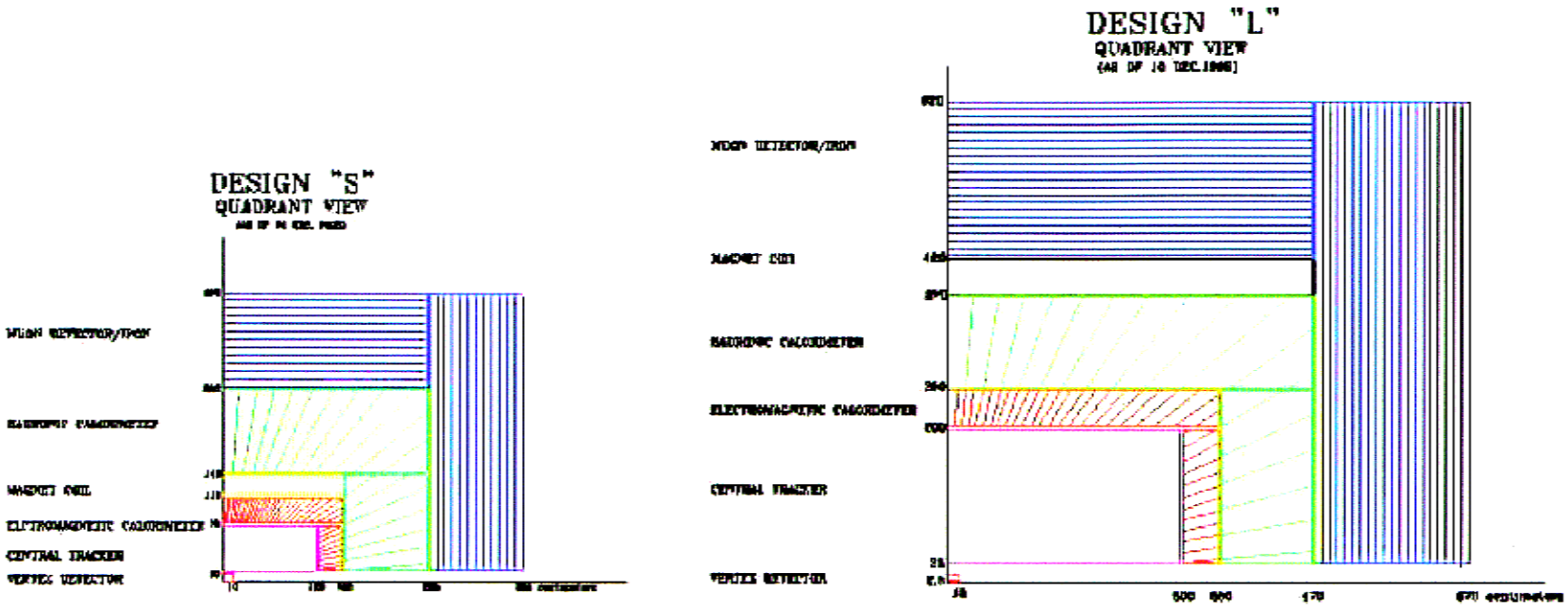
  62% R134a 30% argon 8% isobutane gas mixture

- 38016 signal readout strips

  30 mV Threshold

  12x Time multiplexing to 3168 TDC channels

  Spatial Resolution of ~1.5 cm



Quadrant Views of Designs S and L on same scale

For a postscript version, please click here.

Home

BELLE

CHAMBER Philosophy:

USE of Rib's

(a) STRUCTURAL "STRONG"

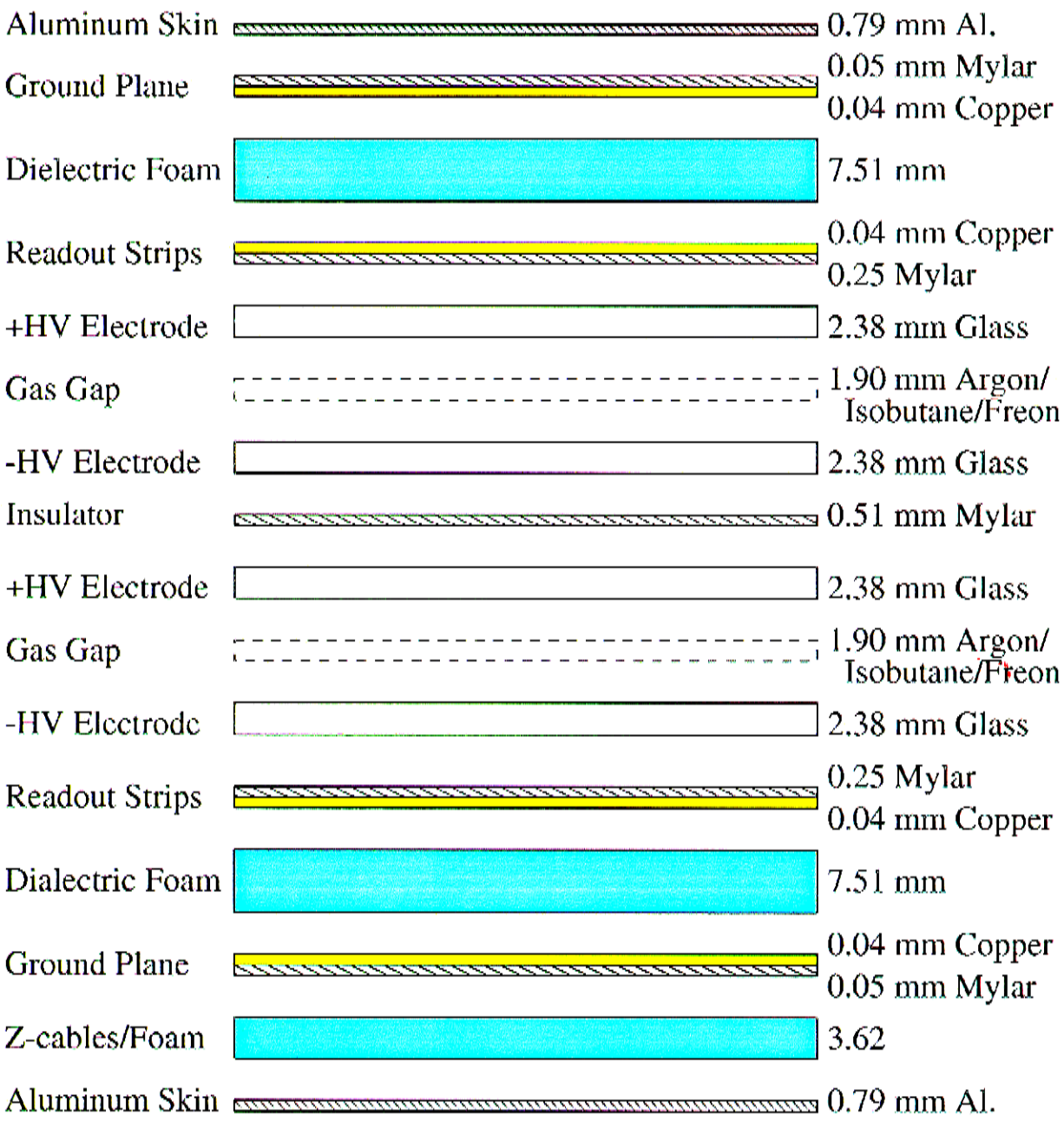
(b) Good GAS flow "long Life"

USE of Double Chamber/LAYER

- BACKUP (LARGE System)

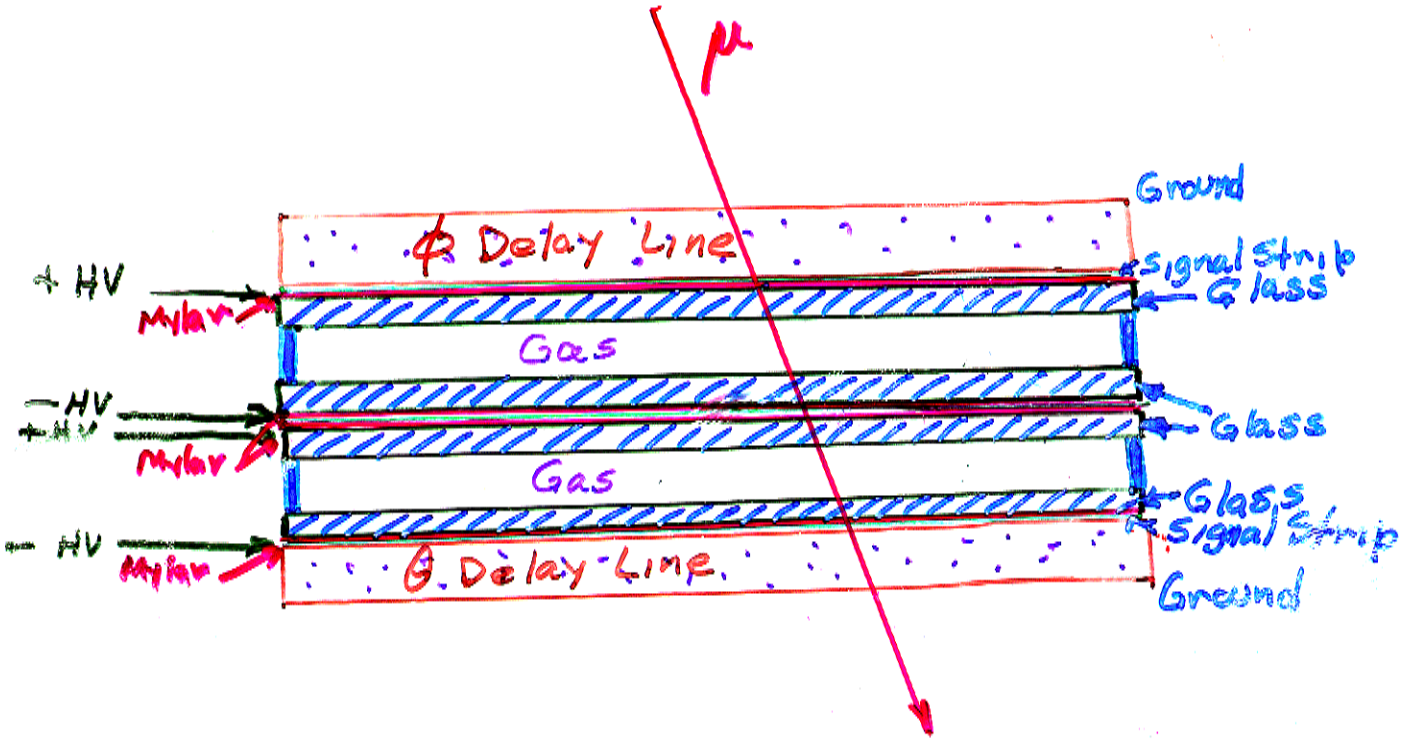
⇒ No loss of LAYER GIVEN A chamber failure.

RPC Superlayer

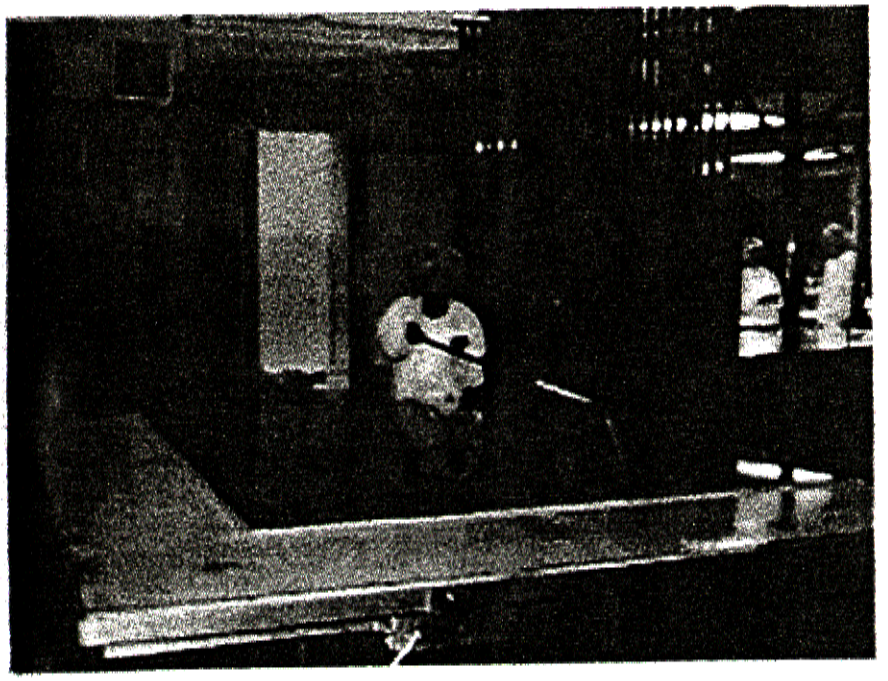


S. Schuenk, 23 May 96

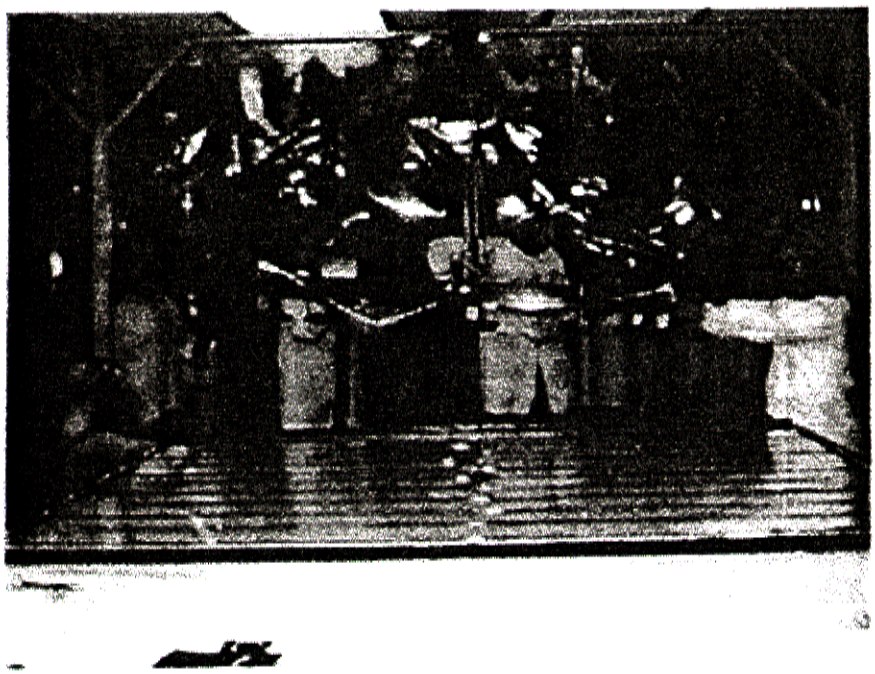
BELLE GLASS RPC CONSTRUCTION



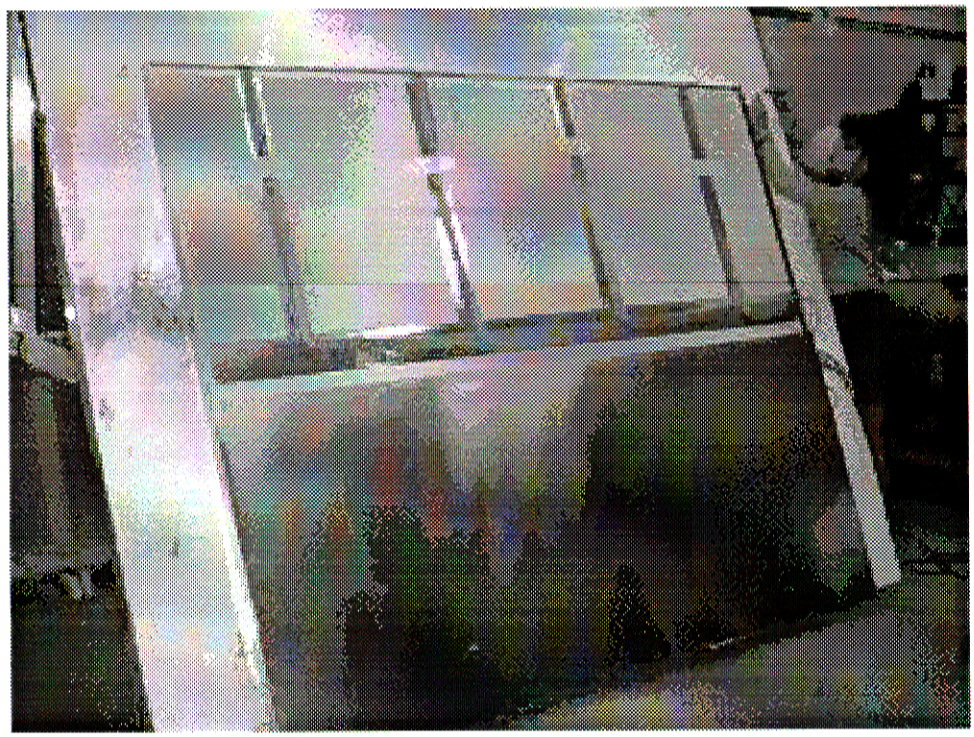
Applying Ink to Outer Surface of Glass Electrode



Placing Top Glass Electrode on Top of Lower Electrode and Spacer Ribs



An Almost Completed Module Showing Z-Cables and Foam, and Aluminum Cover



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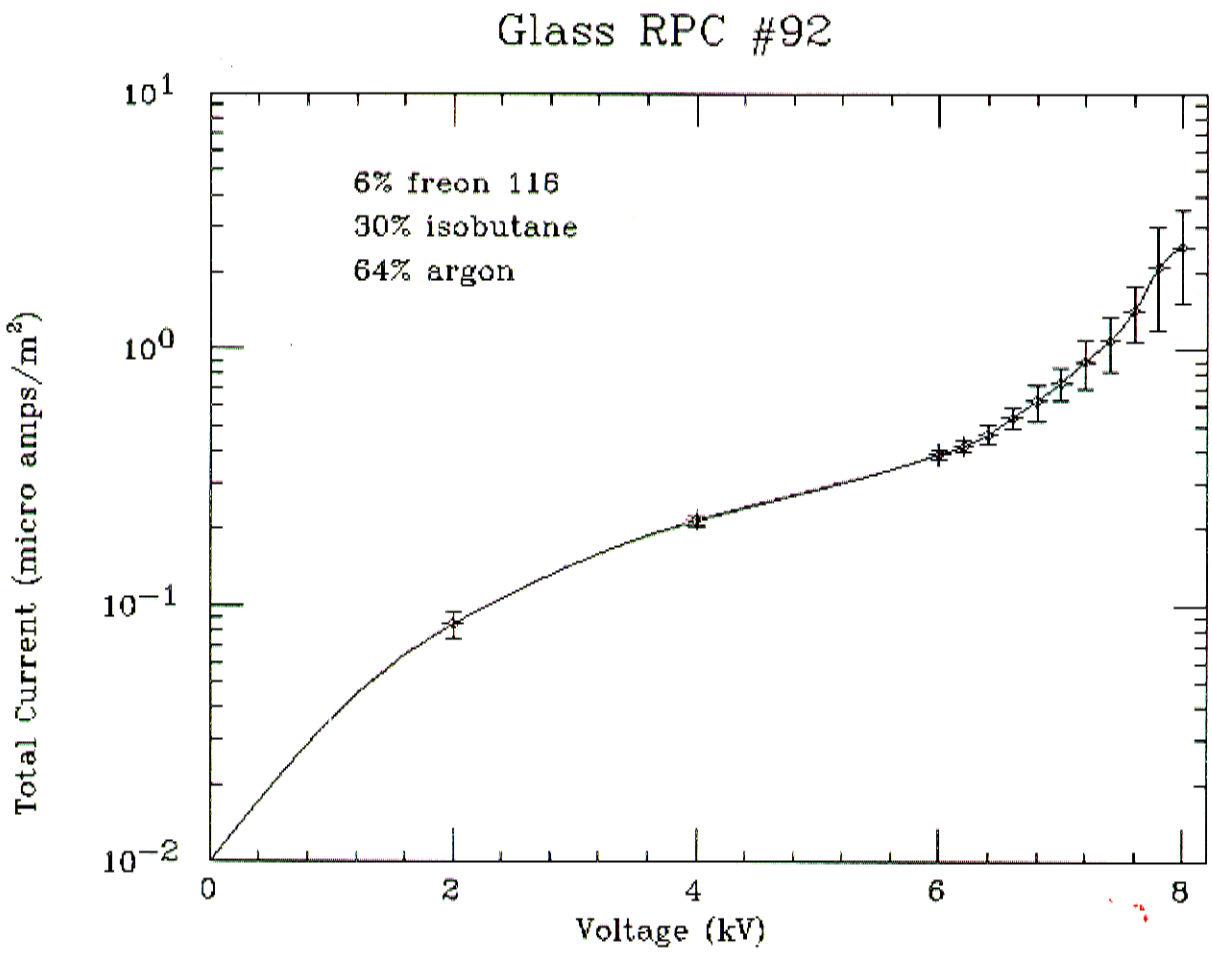
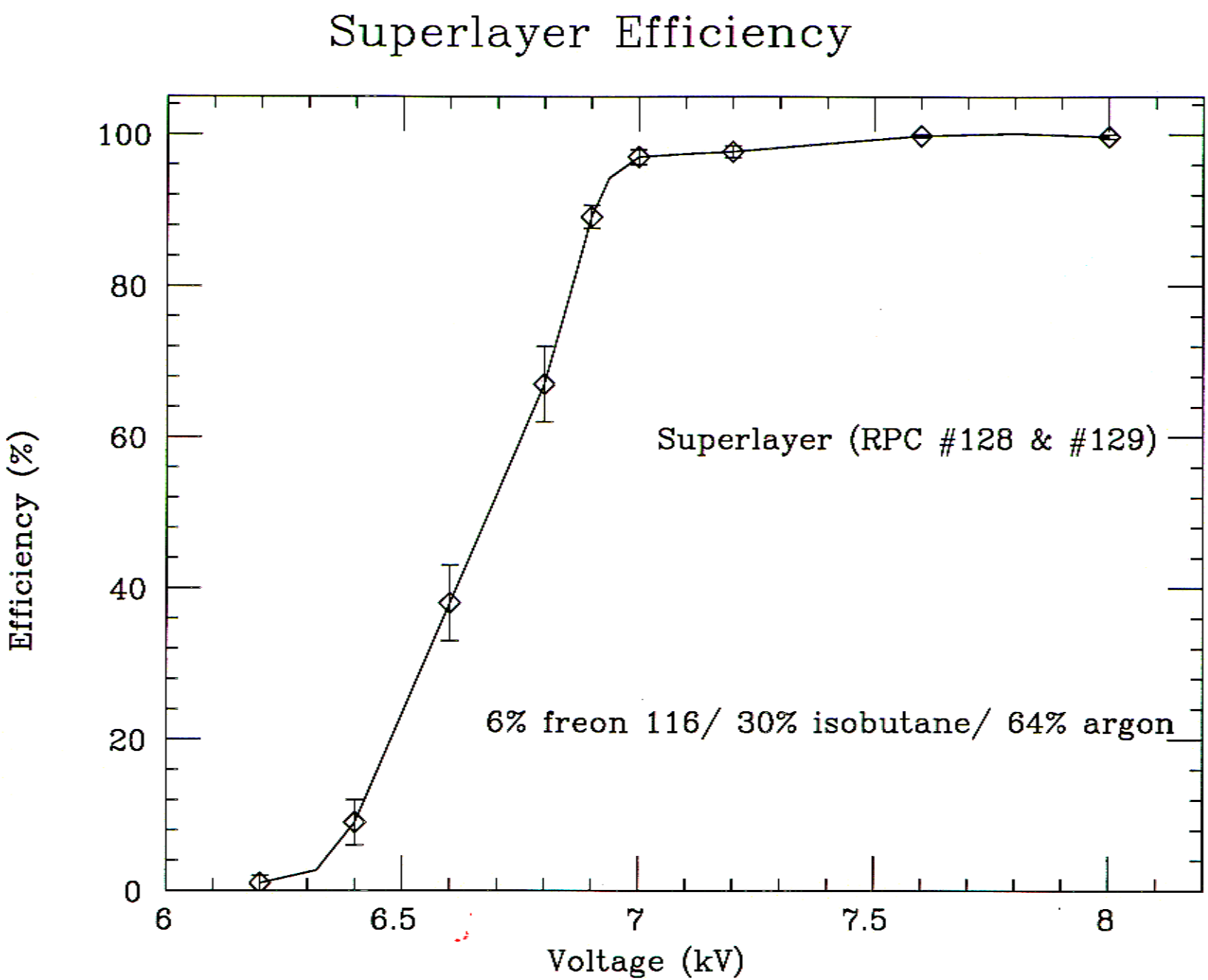
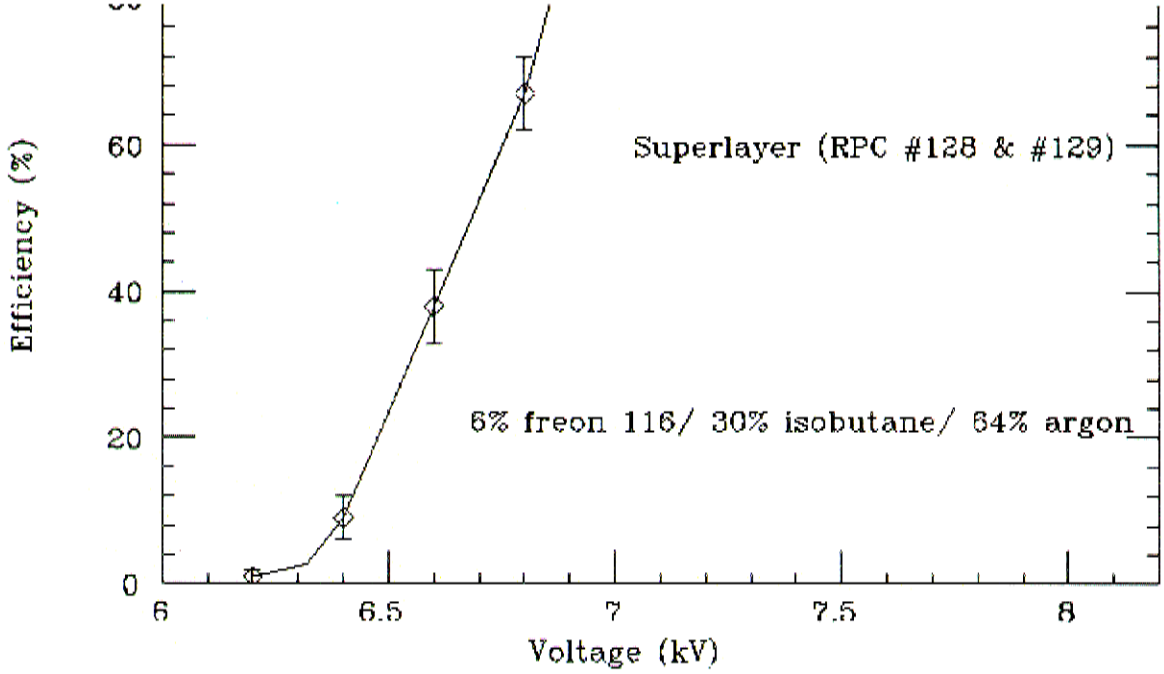
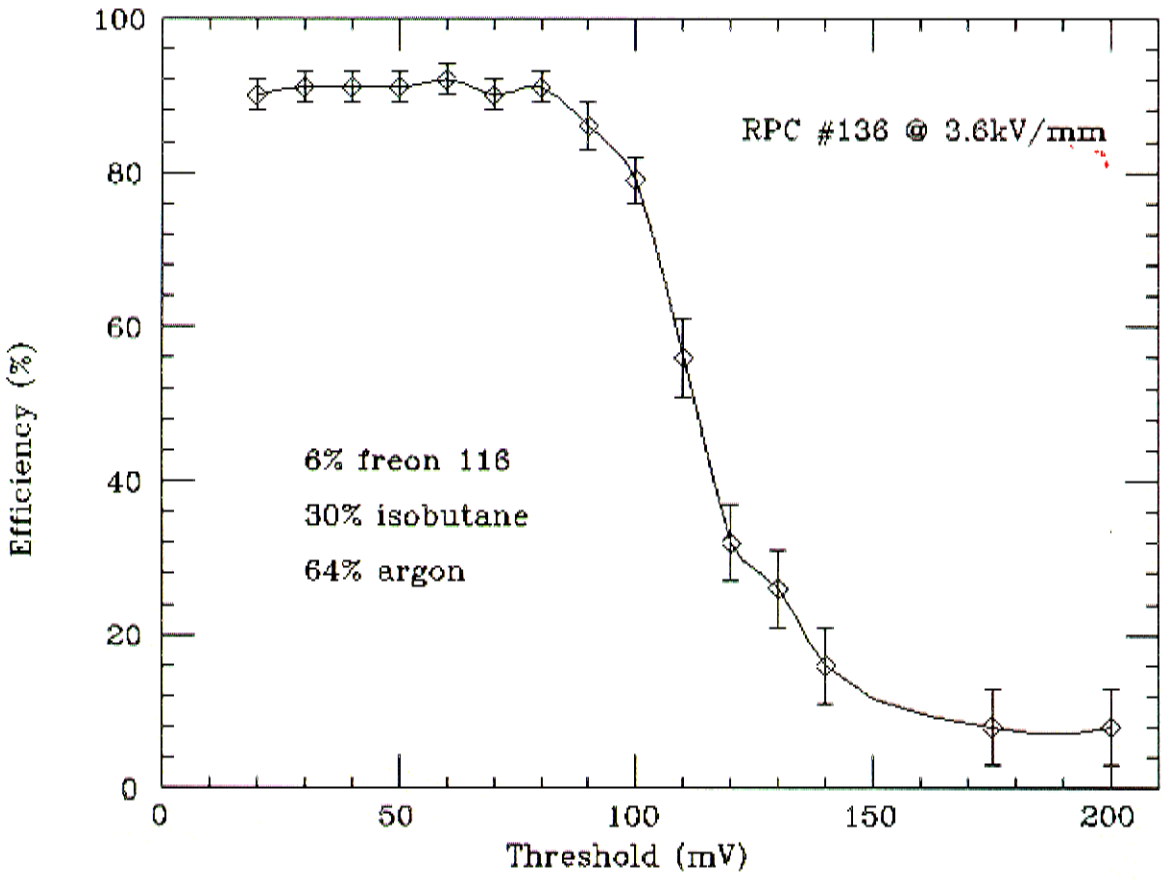
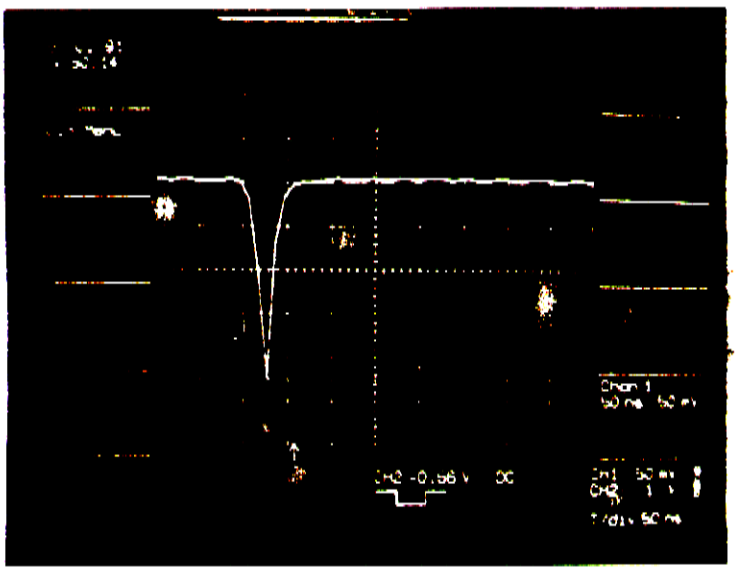

Glass RPC #92
6% freon 116
30% isobutane
64% argon
Total Current (micro amps/m^2)
10^1
10^0
10^{-1}
10^{-2}
0
2
4
6
8
Voltage (kV)


Superlayer Efficiency
Efficiency (%)
100
80
60
40
20
0
6
6.5
7
7.5
8
Voltage (kV)
Superlayer (RPC #128 & #129)
6% freon 116/ 30% isobutane/ 64% argon


Efficiency (%)
0
20
40
60
6
6.5
7
7.5
8
Voltage (kV)
Superlayer (RPC #128 & #129)
6% freon 116/ 30% isobutane/ 64% argon


Efficiency (%)
0
20
40
60
80
100
0
50
100
150
200
Threshold (mV)
RPC #136 @ 3.6kV/mm
6% freon 116
30% isobutane
64% argon

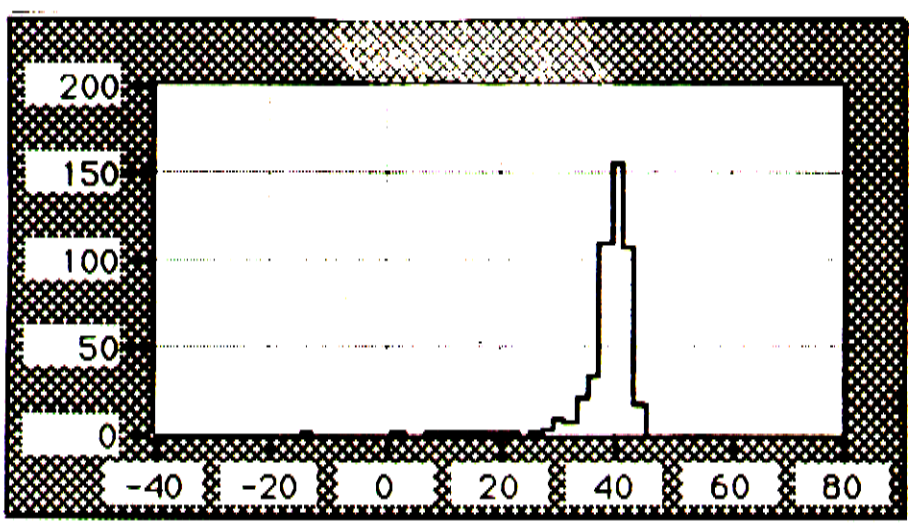
RPC Pulse Shape



225 mV Peak

FWHM < 20 ns

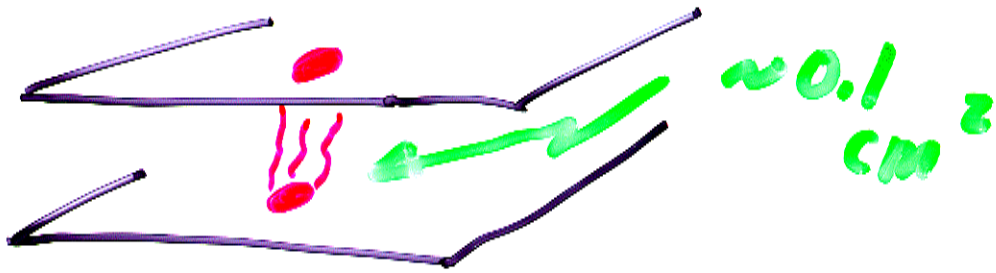
Time Resolution Relative to Scintillators



$\sigma_t = 2$ ns

HADRON SHOWER "CATCHER"

- Active Pulse Region

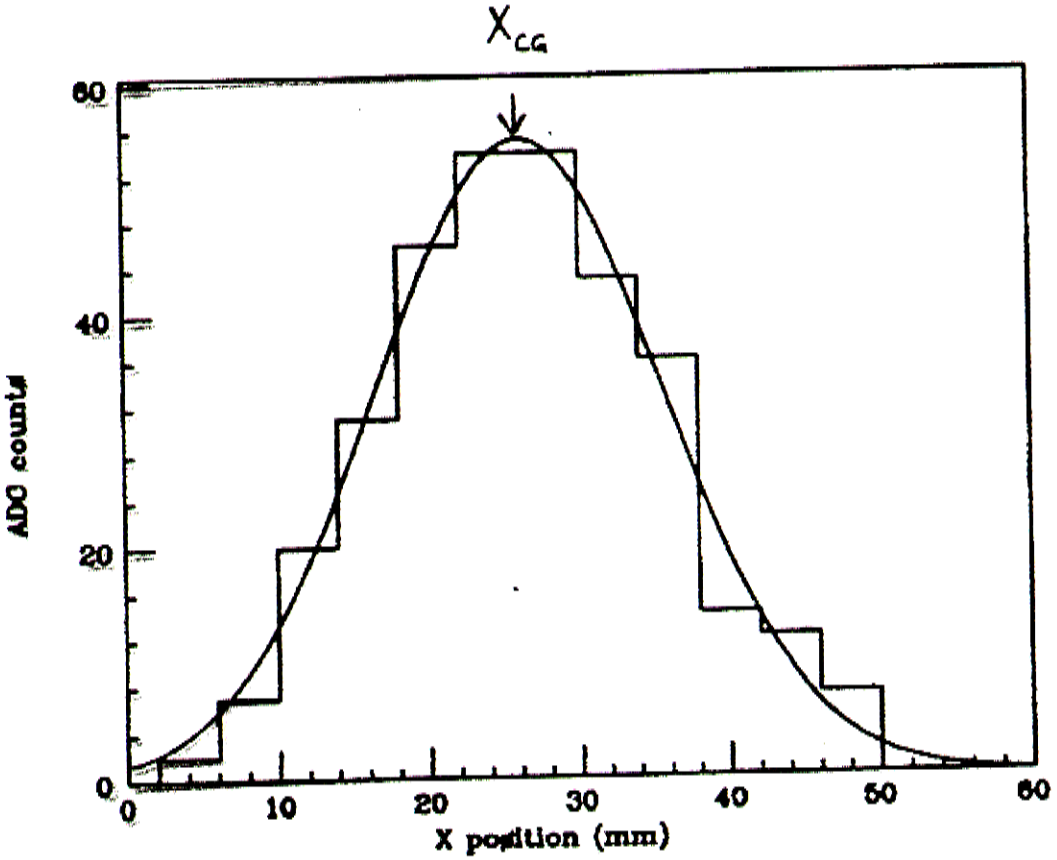


Pulse shape is very uniform

⇒ should be possible to count charged tracks from HADRON LEAKAGE upto ~ 10^5 particles/m²

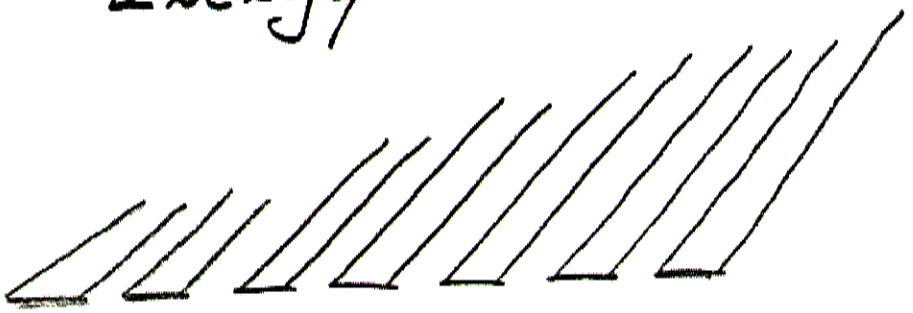
⇒ NEEDS to be checked!

$$X_{CG} = \frac{\sum_{i=1}^{N} Q_i X_i}{\sum_{i=1}^{N} Q_i} \qquad \delta X_{CG} = \frac{\text{strip width}}{2} \frac{\sqrt{\sum_{i=1}^{N} Q_i}}{\sum_{i=1}^{N} Q_i}$$



$$\Delta X_{FIT} = 0.7 \text{ mm}$$

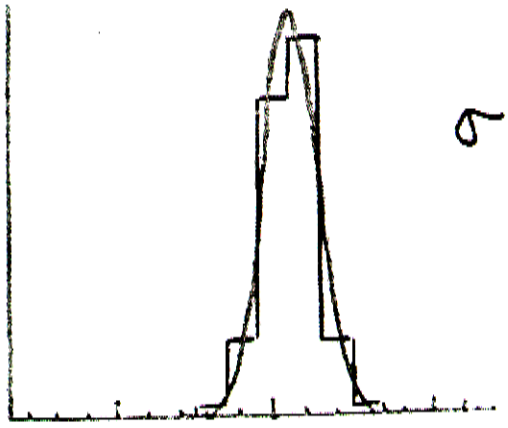
UP GRADE SPACIAL Resolution
to Improve track pointing
AS ENERGY INCREASES.



PHASE I. GANG STRIPES (4mm)
$\Rightarrow \sigma \sim 1\,cm$

PHASE II. 4mm STRIPES
$\Rightarrow \sigma \sim 1\,mm$

Chambers Can Prouide Excellent Timing Resolution



$\sigma = \sqrt{2} \cdot (1.2\, n_{Rec})$

Time Difference

Intrinsic Time Resolution

1 n_{Rec}

$\Rightarrow$ test if bucket pointing is possible.

e+e- Collider Detector - Design P

Component	Radius (cm)		Axial |Z| (cm)		Technology	Performance
	Min	Max	Min	Max		
Vertex Detectors	1	10	0	15	CCD	$3.0\,\mu + 10\mu/p\sin^{3/2}$
Tracker	25	150	0	200	TPC	$dP/P^2 \sim 7 \times 10^{-5}$ high p $dP/P \sim 1.5 \times 10^{-3}$ low p
EM Calorimeter Barrel End Cap	150 25	185 175	0 205	235 240	Pb/scintillator or Liquid Argon	$dE/E \sim 15\%/\sqrt{E} + 1\%$
Magnet Coil	185	215	0	235	SC Solenoid	3.0 Tesla
Had Cal Barrel End Cap	215 25	295 175	0 240	320 320	Pb/scintillator	$dE/E \sim 50\%/\sqrt{E} + 2\%$
Iron/Muon Det/Tailcatcher Barrel End Cap	295 25	425 320	0 425	320 450	Iron Gas Chambers	

Summary

- Resistive Plate Counters with glass electrodes are being used for muon detection at the KEKB b-factory
- The glass is 2.4 mm thick window glass with a bulk resistivity of ~5 x 10^{12} ohm-cm
- The high resistivity of the glass limits the rate capability to <~0.5 Hz/cm^2
- Long-term tests (almost 4 years) show no deterioration
- Spatial resolution determined by pickup pad size
- Nanosecond timing resolution
- Superlayers have 99% efficiency with low noise
- Relatively low cost per unit area (~\$150/m^2 for material)