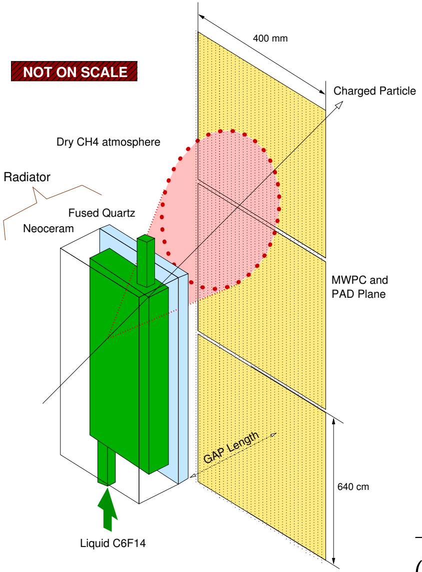
Progress on RICH detector

Performance Estimation and Technical Issues

Rome/Sanità Group

11 April 2006 / 2nd Transversity Meeting

RICH schematic view

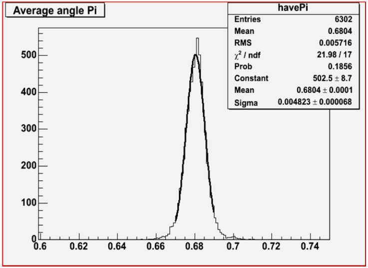


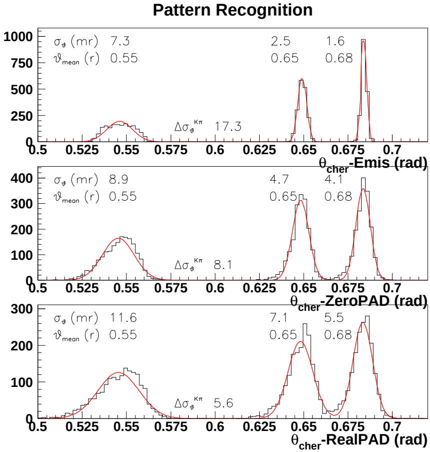
- Radiator: Liquid Freon (15 mm) at Room temperature
- Radiator Vessel: $1.9 \times 0.31 \times$ Neoceram (4 mm) / Quartz (5 mm)
- Proximity Gap: 10 cm
- Photon Detector: MWPC + 3 PAD PLANES ($\sim$ 11000 pads)
- Dry Methane at STP

+ the evaporation facility (now at Stony Brook University)

Current RICH performance at $2.0 \pm 5\%$ GeV/c $\Rightarrow$ **π/K rejection 1:1000**

- Mean Number of Firing Pads (for π) : $N_{PAD,\pi} = 13$
- Cherenkov Angle resolution (sigma) : $\sigma_{\theta_\pi} = 5$ mrad $\rightarrow \Delta\theta_{\pi,K} = 6\sigma_{\theta_\pi}$





Pretty good agreement between experimental data and MC:

$\sigma^{EX}_{\theta_\pi} \sigma^{MC}_{\theta_\pi} \sim 0.9$ $\quad N^{EX}_{PAD,\pi}/N^{MC}_{PAD,\pi} \sim 0.9$ $\quad \Delta\theta^{EX}_{\pi,K}/\Delta\theta^{MC}_{\pi,K} \sim 1.07$

2.4 GeV/c Upgrade

Requirement (?)

Rule of thumb: π/K rejection factor at the level of 1:1000

$(\Rightarrow \Delta\theta_{\pi,K} \geq 5.5 \cdot \sigma_\theta)$

Criteria

- Re-use existing (spare) parts as much as possible
- Minimize costs and resources
- Guarantee the existing performance (switching back to the pre-upgrade conditions in few hours)

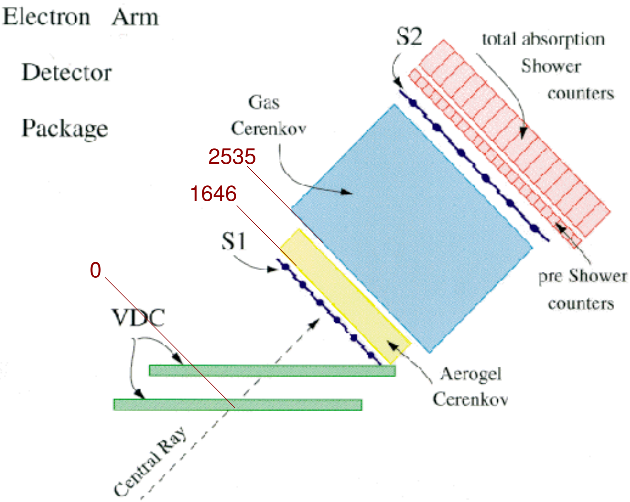
Constraints

- Maximum available electronics channels: 2×11520
- Maximum pad plane size: 65×45 cm^2 (evaporation chamber)
- Maximum size along particle trajectory ~ 1 m
- ???

... HRS Electron Detectors Layout

RICH installed at 2.6 m (from Bottom VDC) in HRS-Hadron

... HRS Electron Detectors Layout



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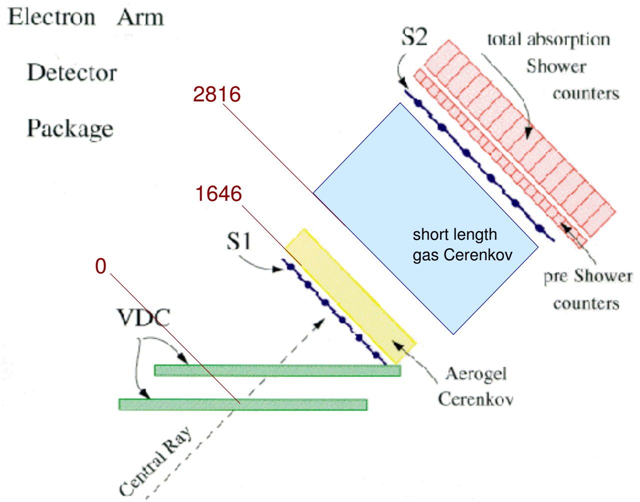

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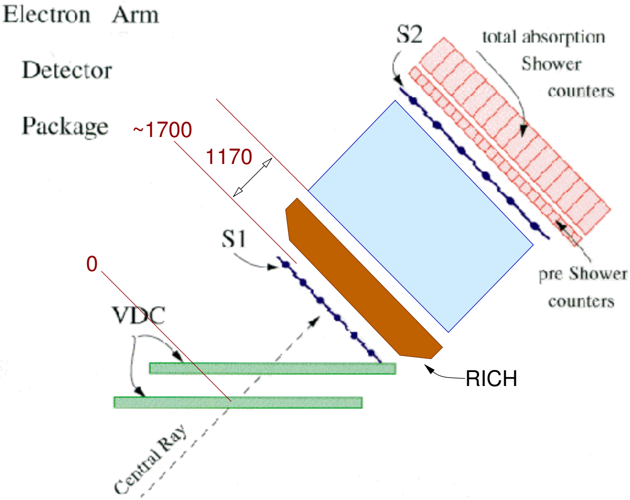

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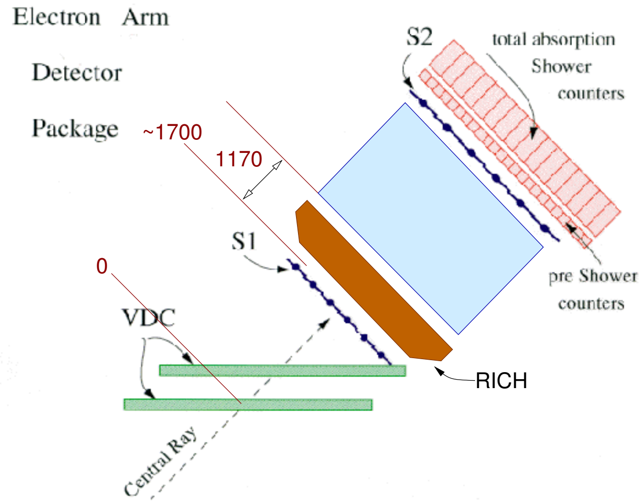

can be moved to $\sim$ 1.7 m in HRS-Left

2.4 GeV/c Upgrade Options

Optimize the **gap length** and ...

1. NO CHANGES: leave as it is
2. NEW FREON: use radiator with lower refractive index (C_5F_{12} instead of C_6F_{14})
3. 2×PLANE: double the photon detection surface (double the pad planes)
4. PAD/2: halve the pad size (double the pad numbers) on the same pad plane
5. MIXED: quite a few combinations of the above; e.g.:
   - NEW RADIATOR and 2×PLANE
   - Reduce the pad size and increase the detection surface appropriately (up to the maximum available channels)

Options 3 and 4 are exclusive (max. electronics channel)

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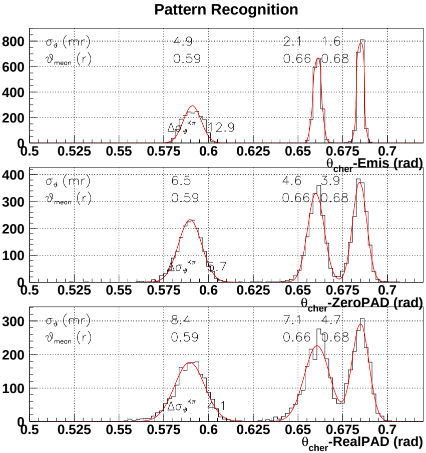
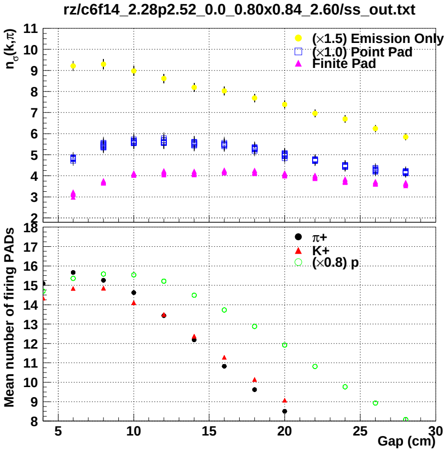
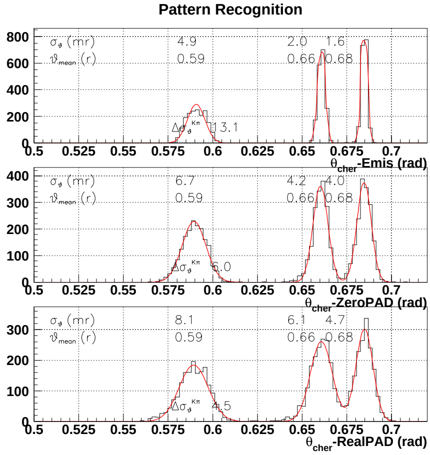
Option 1 : NO CHANGES (Detector at 2.6 m from VDC)

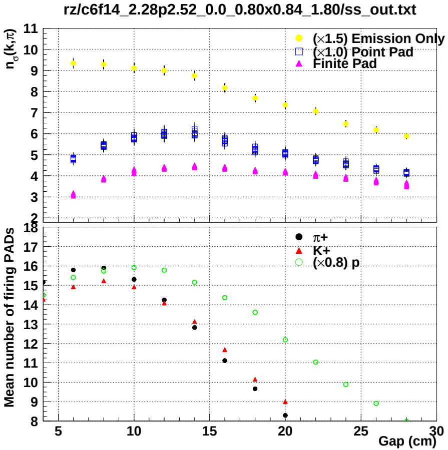




$$\Delta\theta^{MC}_{\pi,K} \sim 4.1 \cdot \sigma_\theta \Rightarrow \pi : K \sim 1 : 140$$ **(95% efficiency)**

Option 1 : NO CHANGES (Detector at 1.8 m from VDC)

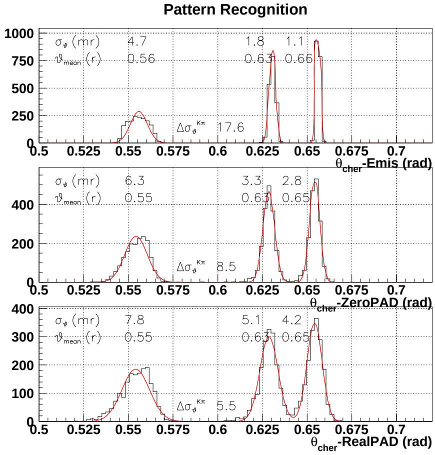


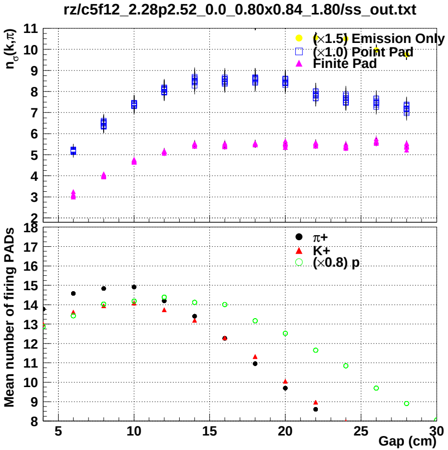


$$\Delta\theta^{MC}_{\pi,K} \sim 4.4 \cdot \sigma_\theta \Rightarrow \pi : K \sim 1 : 500$$ **(95% efficiency)**

Moving at 1.8 improve performance (better light collection)

Option 2 : NEW FREON (Detector at 1.8 m from VDC)





$$\Delta\theta^{MC}_{\pi,K} \sim 5.5 \cdot \sigma_\theta \Rightarrow \pi : K < 1 : 1000$$ **(95% efficiency)**

Option 2 : NEW FREON: Technical/Thermal Issues

!! C5F12 boiling point @ 1atm [C] = 30 ^{o}C !!

Thermal Effects / Good News

- Very low neoceram (and quartz) expansion coefficient
- Epoxy elasticity will absorb dilatation effects (expected small)
- Mechanical stresses under control at $T = 21^{o}$C $\pm 20^{o}$C

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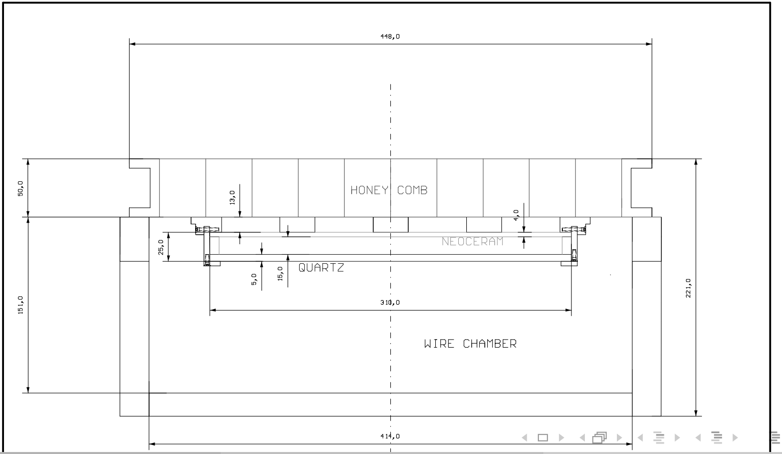
Thermal Effects / Bad News

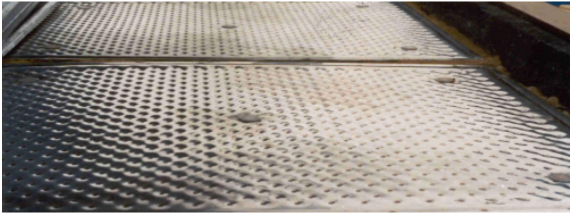
- Cavitation (?): hot spots in the liquid can cause localized high pressure ... but inclination (that is pressure variation) may compensate the decrease of vapor pressure with temperature
- Disandantageous Thermal Conductivity: any cooling system MUST NOT touch the radiator vessel in order to avoid propagation of possible vibrations to the fragile vessel
- Turbolence and Instability: higher freon flux may generate turbolence and mechanical instability of the radiator vessel

NEW FREON: Cooling System

Lateral cooling rods along the vessel long-side is not effective.
$\longrightarrow$ Large cooling plate between the RICH entrance window and the neoceram vessel



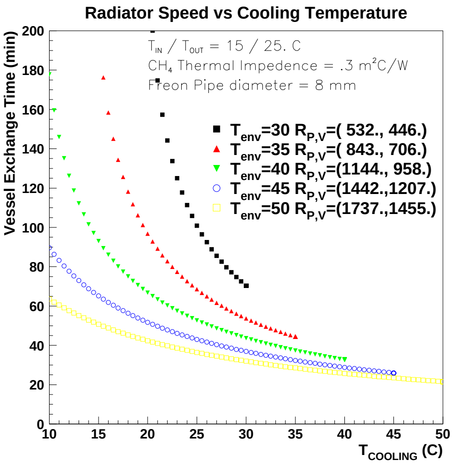
NEW FREON: Cooling Stainless Steel Plate System



- Two foils of stainless steel $0.5 \div 1.0$ mm thick
- Liquid cooler: $5 \div 10$ mm thick
- One plane, size: $\sim 300 \times 1500$ mm^2
- Weight: < 10 Kg

Additional material on particle path: ~ 2 **g/cm^2 (now** 1.3 **g/cm^2)**
Mechanically compatible with the existing structure (planarity to be verified)
French Company DATE (DEVELOPPMENT ET APPLICATION DES TECHNIQUES DE L'ENERGIE)

NEW FREON: Is a cooling system really needed ?

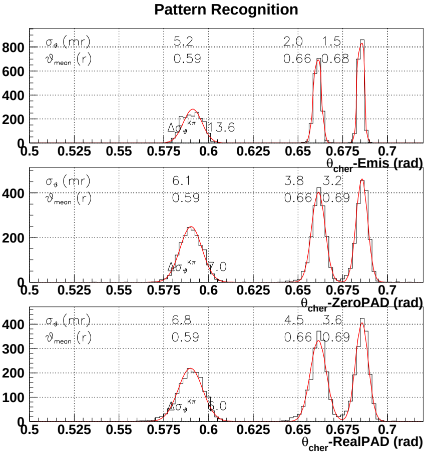


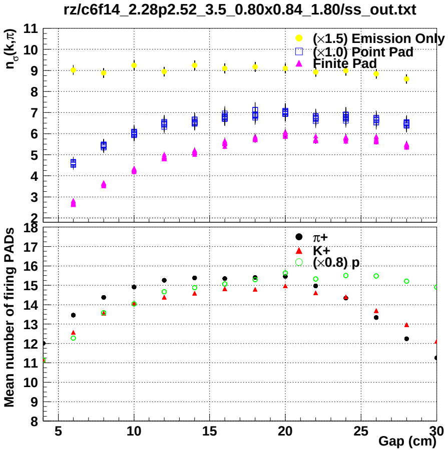
- Max freon speed w/o cooling ($\sim$ 30 min radiator vessel refill time / current system works at $\sim$ 6 h) seems to be compatible with laminar flow in pipe ($R_c \sim 2200$) and vessel ($R_c > 10000$)
- Inlet freon temperature can be reduced to 10 ^{o}C
- *Coarse* cooling (down to 30 ^{0}C) of the external radiator will help)
- Finite element analysis for mechanical stability

Open Problems:

- Hot Spot
- Max Freon Speed

Option 3 : 2×PLANE (Detector at 1.8 m from VDC)



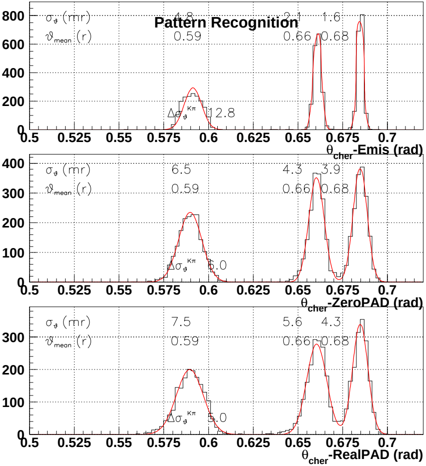


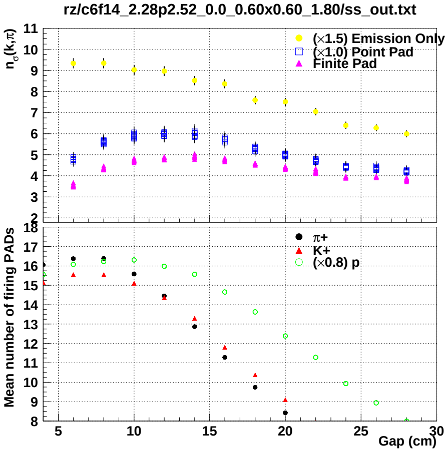
$$\Delta\theta^{MC}_{\pi,K} \sim 6.0 \cdot \sigma_\theta \Rightarrow \pi : K \ll 1 : 1000$$ **(95% efficiency)**

2×PLANE

- NO relevant technical issues
- Design is straightforward
- Re-use existing pad planes
- Use two acquisition systems (old and new one, both available)
- Some more contamination from delta electrons due to the middle break ($\sim$ 3.5 cm). (however electron MIP - kaon trajectory greater than $\sim$ 6 cm!!)
- $\sim$ 15 cm longer detector
- Major Impacts:
  - New MWPC (largest cost)
  - Partially new mechanical supports for the front-end cards
  - Modify (increase) the glove box used in the evaporation of the CsI on the pad planes
  - Longer evaporation procedure
- Costs: quotation requested

Option 4 : PAD/2 (Detector at 1.8 m from VDC)

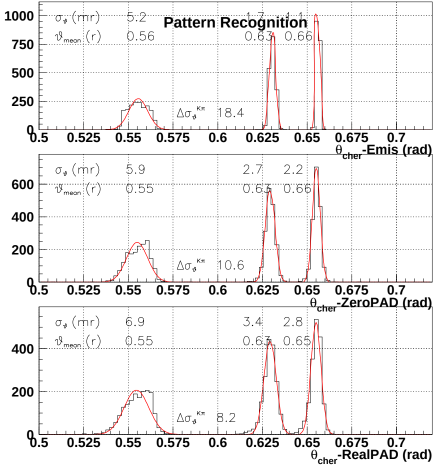


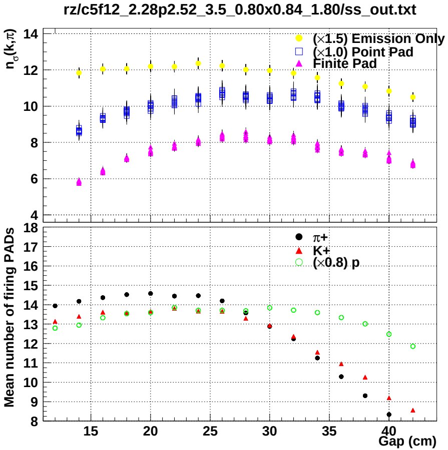


$$\Delta\theta^{MC}_{\pi,K} \sim 5.0 \cdot \sigma_\theta \Rightarrow \pi : K \leq 1 : 1000$$ **(95% efficiency)**

High front-end electronics compacteness is demanding

Option 5 : NEW FREON & 2×PLANE (Detector at 1.8 m from VDC)

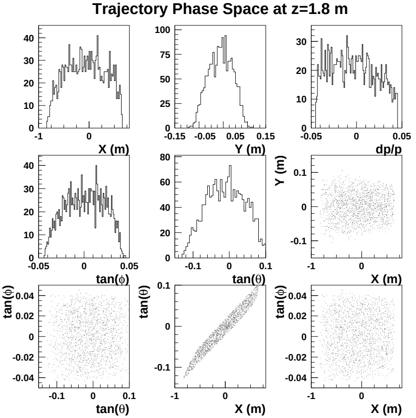




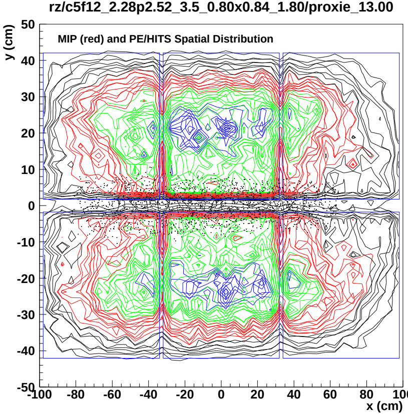
$$\Delta\theta^{MC}_{\pi,K} \sim 8.0 \cdot \sigma_\theta \Rightarrow \pi : K \lll 1 : 1000 \ \textbf{(99\% efficiency)}$$

Phase Space

HRS Phase Space



RICH PE/MIP Distribution



Pro's and Con's

Option	$\Delta\theta$	Pro	Con
1	4.4	Trivial Implementation	Poor performance
		Negligible cost and effort	
2	5.5	Good performance	Open issues
			Involve the fragile vessel
			Slightly complex design
			Add material in path (?)
3	6.0	Very Good performance	More space required
		Straight Design	Two readout systems
			Expensive (?)
4	5.0	Moderate performance	Electronics compactness
			Two readout systems
5	8.0	Superior performance	See 2 and 3

… than ?

- NO CHANGES and detector at 1.8 m: π/K rejection $\sim 1:500$ (not so bad)
- NEW FREON requires more analysis for cooling
- 2$\times$PLANE better solution, but cost may be high (expecting quotation today!)
- PAD/2, complexity/benefit not convenient
- NEW FREON & 2$\times$PLANE: superior performance, but …

coming …

- In the next couple of weeks expected results from the finite element analysis by the Engineer that designed the radiator vessel
- Careful evaluation of the 2$\times$PLANE to reduce costs