Development of Focusing Aerogel RICH detectors in Novosibirsk

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Abstract

*Latest steps in the development of the **F**ocusing **A**erogel **RICH** (**FARICH**) in Novosibirsk are presented. FARICH is studied using a Geant4 simulation code. A project of the Forward RICH for the SuperB experiment is presented. It features a dual aerogel-water radiator and Photonis MCP PMTs. The detector will be able to perform π/K separation at 3 sigma level from 0.2 to 7 GeV/c, μ/π separation — from 0.13 to 1.4 GeV/c. A prototype of the FARICH is being built at BINP. It will be tested with a dedicated electron beam line. At the first stage MRS APDs produced by CPTA, Moscow will be used as photon detectors. Noise rate, gain and photon detection efficiency were measured for several APDs. An aerogel RICH for the PANDA detector is proposed. It is shown that the detector will separate pions and kaons up to 10 GeV/c momentum. Also μ/π separation up to 2 GeV/c momentum will be possible.*

1. FARICH concept

FOCUSING AEROGEL was suggested in 2004 [1, 2] to improve the Cherenkov angle resolution in a proximity focusing RICH. The radiator in FARICH is composed of several aerogel layers with different refractive indices. Single ring and multiple rings options are possible.

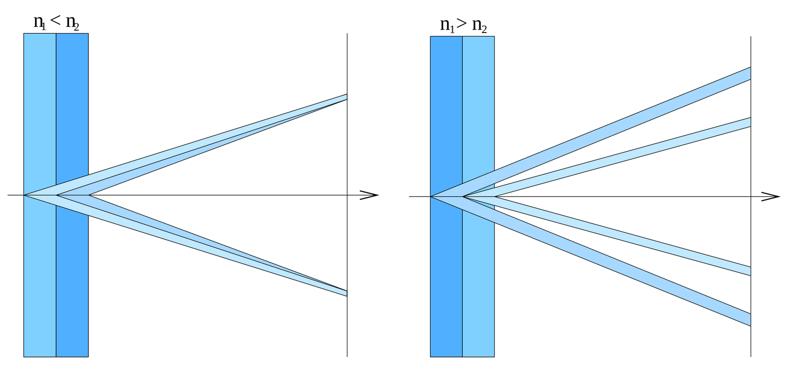


Figure 1: *Focusing aerogel RICH concept with single ring (left) and multiple rings (right).*

Both schemes allow one to increase the total thickness of radiator and hence the number of detected photoelectrons while keeping the emission point uncertainty constant.

2. Aerogel

THE WORKS with silica aerogel were started in Novosibirsk in 1986 by the collaboration of BINP and BIC. Since that time a great progress has been made in improving transparency of aerogel [3].

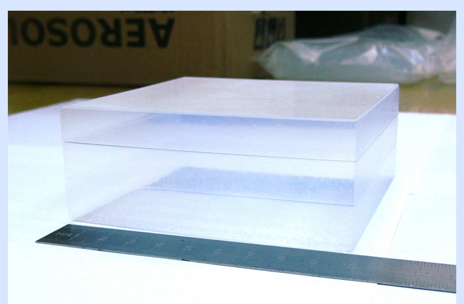
Parameters of aerogel made in Novosibirsk

Refractive index	1.006–1.13[a]
Light scattering length @400nm	4–5 cm
Light absorption length @400nm	5–7 m
Maximum tile dimension (n=1.03)	200x200x50 mm

[a] Aerogel with an index higher than 1.07 can be sintered from lower index aerogel.

'Focusing aerogel'

Several multilayer aerogel samples were produced. One of them is shown: 3-layer, 100x100 mm transverse dimension, $L_{sc} = 44$ mm.



3. Project of FARICH for SuperB

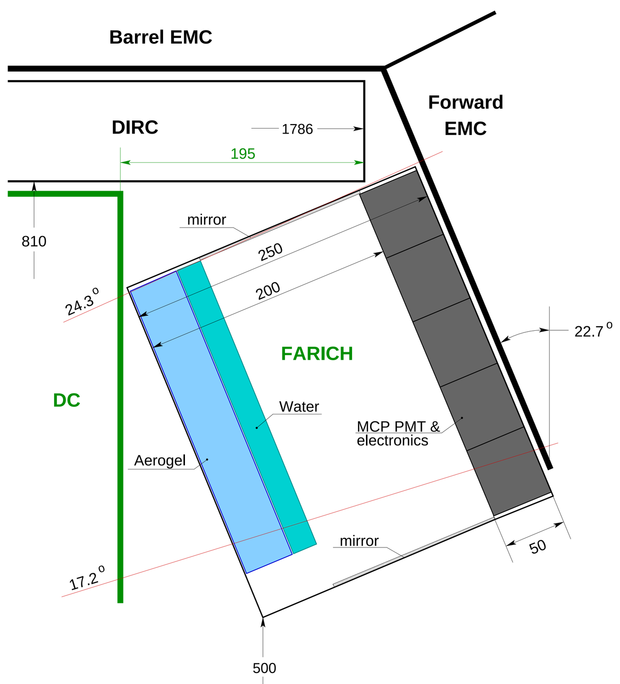


Figure 3: *FARICH is a forward PID option for SuperB.*

Photon detector: Photonis multi-anode MCP PMT

- Bialkali photocathode, $QE_{max} = 29\%$
- Active/total area: **85%**
- Photoelectron collection: **70%**
- $\sim$ 550 PMTs in total

Cherenkov radiator

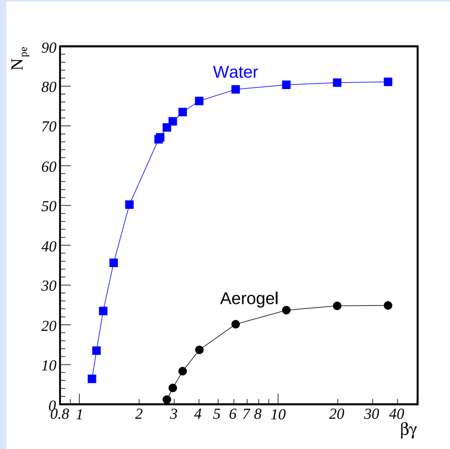


Figure 5: *Number of photoelectrons as function of $\beta\gamma$*

- 4 cm of 4-layer aerogel ($n_{max} = 1.07$)
- 2 cm of water ($n = 1.33$)

Particle ID

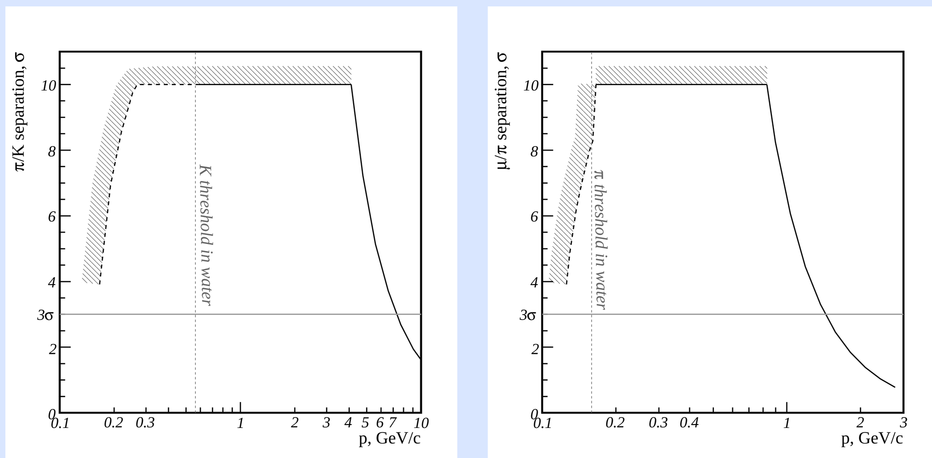
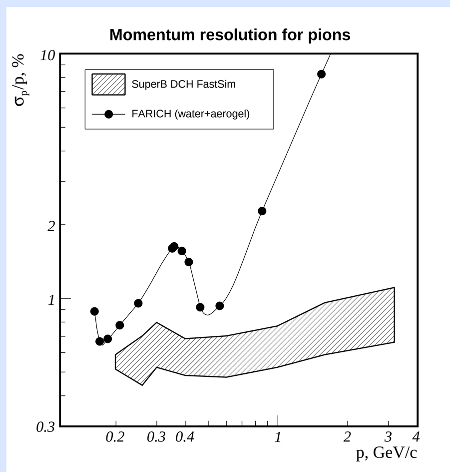


Figure 6: *π/K (left) and μ/π (right) separations versus momentum. A curve to the left of a vertical line shows separation in the threshold regime.*

Momentum measurement



A velocity measured by FARICH can be used to reconstruct particle momentum when particle ID is done.

$$p = \beta\gamma M, \quad \frac{\sigma_p}{p} = \gamma^2 \frac{\sigma_\beta}{\beta}$$

4. Proposal of FARICH for PANDA

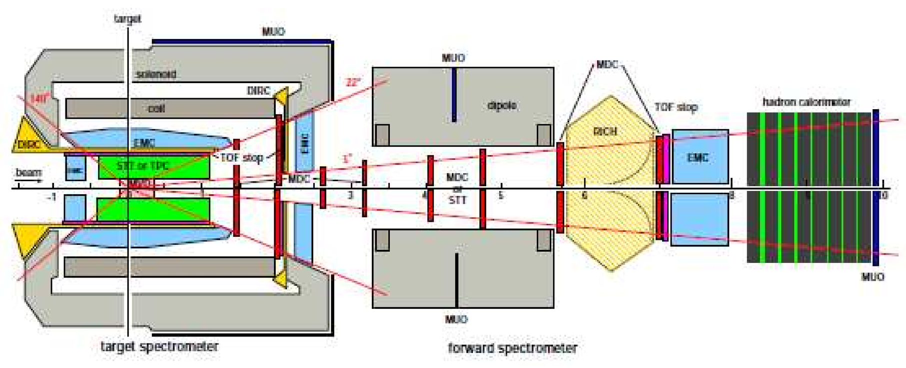


Figure 8: *Side view of the PANDA detector.*

Objective: high momentum particle ID for forward angles: $\theta_x < 10°$, $\theta_y < 5°$.

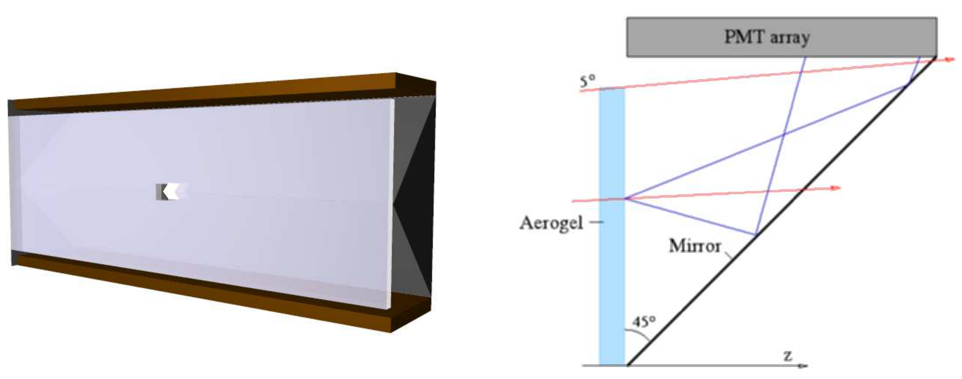


Figure 9: *Project of the PANDA FARICH.*

Parameters of the PANDA FARICH

- Size of aerogel radiator: 300x100x4.5 cm^2
- 2-layer aerogel
- 1200 Hamamatsu H8500 8x8 multi-anode PMTs
- Flat carbon fiber mirror for light collection
- Material budget: 8% X_0

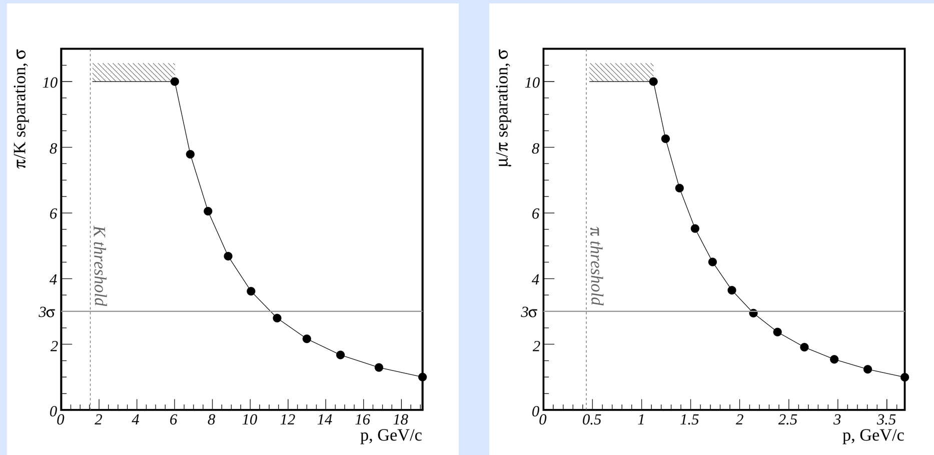


Figure 10: *Simulated π/K (left) and μ/π (right) separations.*

5. FARICH prototype beam test

FARICH prototype is being built at BINP. It will allow us to test the FARICH concept using multilayer aerogel produced in Novosibirsk. The prototype will be tested on a dedicated electron beam line at the VEPP4-M collider.

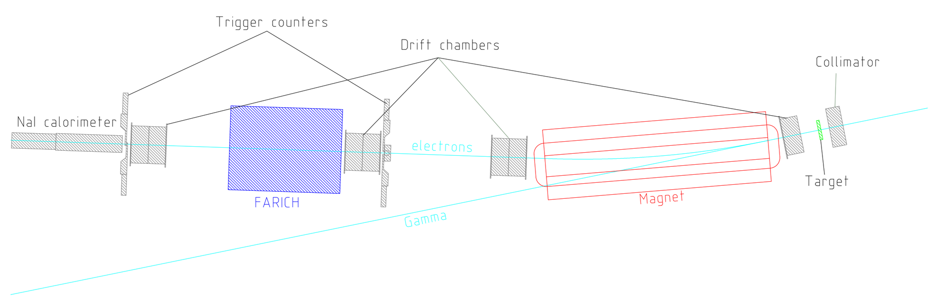
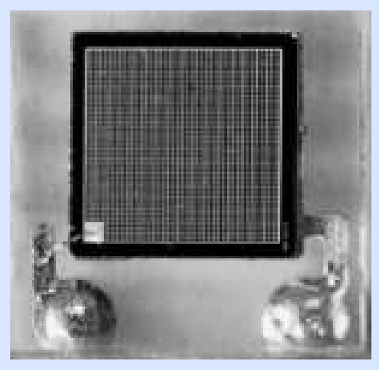


Figure 11: *Schematic layout of the electron beam facility.*

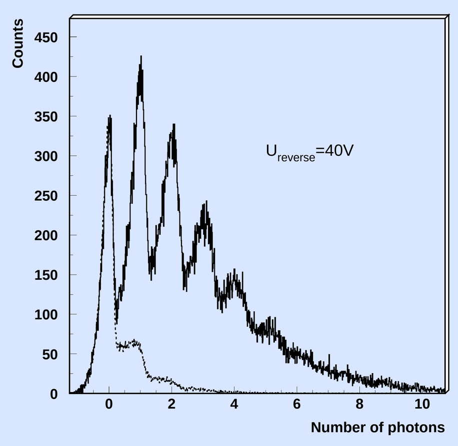
MRS APD (CPTA, Moscow)

Parameters quoted by CPTA

Parameter	Min.	Typ.	Max.
Bias voltage, V	26	35	44
Capacity, pF		150	
Gain, $\times10^5$	2	4	10
Dark current, μA	10	25	50
Maximum PDE @600nm		40	



MRS APD measurements



32 MRS APDs are to be used in the prototype at the first stage as photon detectors. Noise rate, gain and photon detection efficiency (PDE) were measured for all the units.

Typical amplitude spectrum of a MRS APD is shown on the left

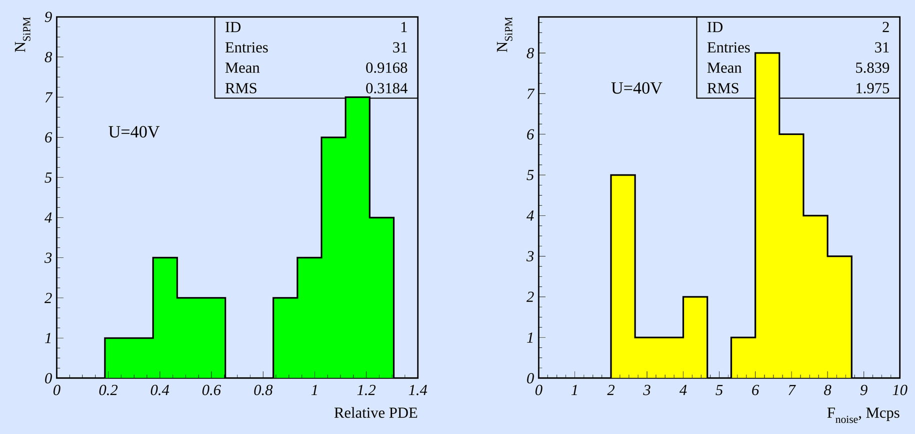


Figure 13: *Distribution of MRS APDs on relative PDE and noise rate at $U_{bias} = 40$V.*

References

[1] T. Iijima *et al.*, Nucl. Instrum. Meth. A **548** (2005) 383.
S. Korpar *et al.*, Nucl. Instrum. Meth. A **553** (2005) 64.

[2] A. Yu. Barnyakov *et al.*, Nucl. Instrum. Meth. A **553** (2005) 70.

[3] A. F. Danilyuk *et al.*, Nucl. Instrum. Meth. A **494** (2002) 491.