FARICH detector beam test results

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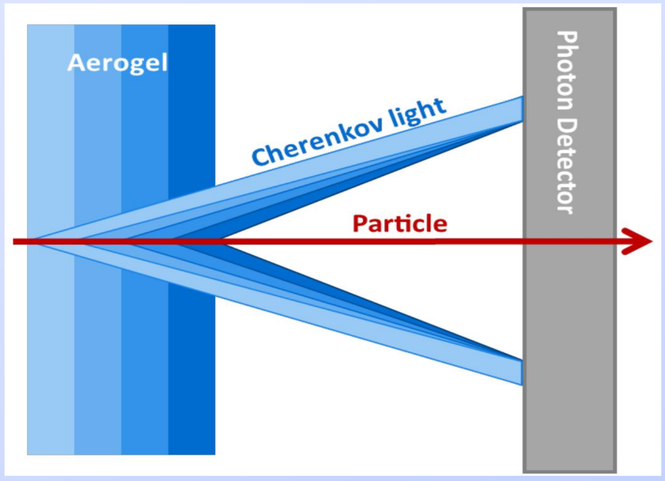
A high-performance particle identification (PID) system is essential for the successful realization of the broad physics program at the future Super C-τ Factory in Novosibirsk. The main requirements for the PID system are as follows: good π/K-separation in the entire operational momentum range and good μ/π-separation in the momentum range from 0.3 to 1.2 GeV/c. The RICH detector based on focusing aerogel radiator (FARICH) meets all these requirements.

FARICH method

Focusing aerogel improves proximity focusing design by reducing the contribution of radiator thickness into the Cherenkov angle resolution

Aerogel has much larger Cherenkov angle difference and less chromatic dispersion than Fused silica which means Higher momentum PID coverage

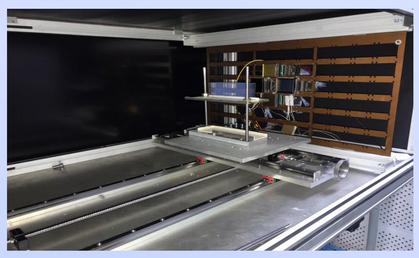


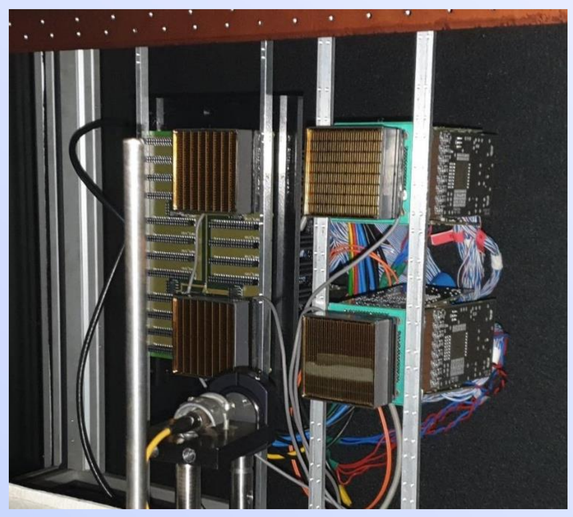
Aerogel development

To expand the lower boundary of the momentum range for particle identification below ~400 MeV, the need for manufacturing a four-layer focusing aerogel with a refractive index of 1.07. Aerogel produced according to the methodology with the introduction of additives of ZrO_2 *[see poster A.Shalygin]* could meet the above requirements. The first samples of such an aerogel have been produced. Beam test results are also presented.

FARICH prototype #3

The third generation FARICH detector is being developed. The first detector module was assembled, based on analog Silicon Photomultiplier Sensors (SiPM) with active area dimension 3mm x 3mm





- ***Photon detector***

4 H12700 MaPMT: 8x8 anodes 6x6 mm^2
Optional ø1mm-hole mask on MaPMTs
3 SensL SiPM arrays: 4x4 pixels 3x3 mm^2

- ***Readout electronics***

DiRICH & PADIWA & TRB3 (GSI)

- ***MCP detector*** for the time reference
- ***Radiator***

Several aerogel samples at 200mm distance from PD

- ***Flat mirror*** was optionally used to reflect light on PD and keep sensors from away from the beam line

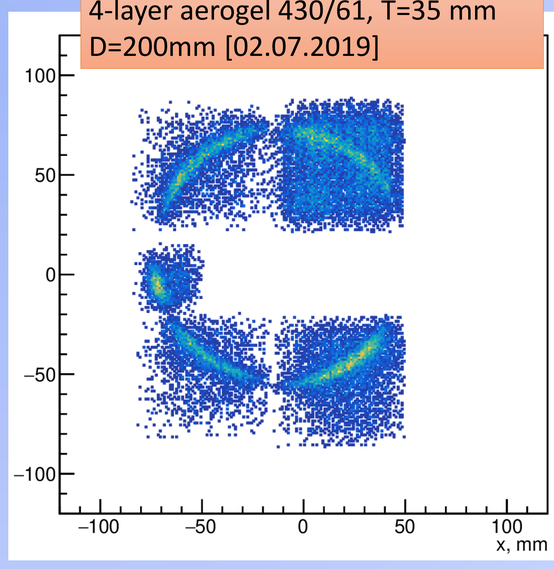
Results

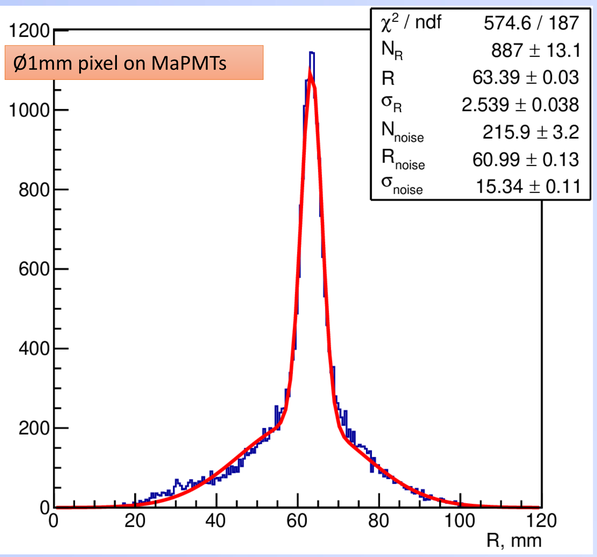
The table shows an example of measurement results (for 2018) and calculations of the Cherenkov radius for 3 different aerogel samples studied with 1mm-hole mask on MaPMTs. In measurements and calculations, the distance between the photon detector and the aerogel was the same and amounted to 200 mm.

	1-ply	3-ply	4-ply
Thickness, mm	20	31	35
Refractive index	1.0513	1.0495 1.0485 1.0462	1.0487 1.0467 1.0455 1.0445
L_{sc} (400nm), mm	41.2 ± 0.5	46.7 ± 0.6	54.4 ± 0.7
calc $\frac{\sigma R}{R}$, mm	$\frac{1.91}{64.8}$	$\frac{2.17}{60.2}$	$\frac{1.96}{58.3}$
exp $\frac{\sigma R}{R}$, mm	$\frac{1.94 \pm 0.17}{66.2}$	$\frac{2.20 \pm 0.15}{62.4}$	$\frac{2.01 \pm 0.18}{61.8}$

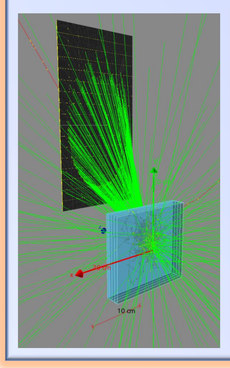
The Super C-Tau factory's identification system should ensure separation of π/K and μ/π at the level of three σ in the momentum range of 0.6–2.5 GeV/c and 0.3–1.2 GeV/c, respectively. According to the FARICH simulation, the detector is able to satisfy these requirements, which was also confirmed by experiments.

4-layer aerogel 430/61, T=35 mm
D=200mm [02.07.2019]



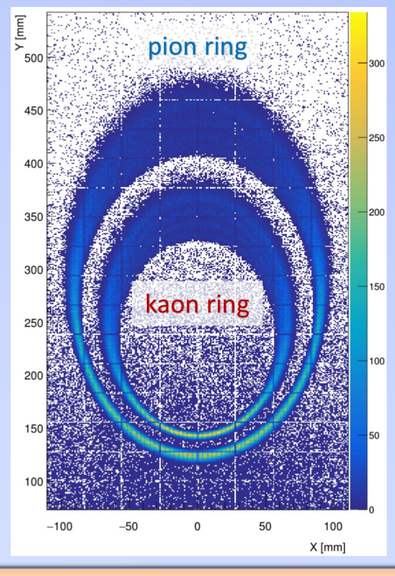


The full FARICH simulation has been developed in Geant4. It was shown that improvement of aerogel refractive index profile could improve the separation by 1.5 times.

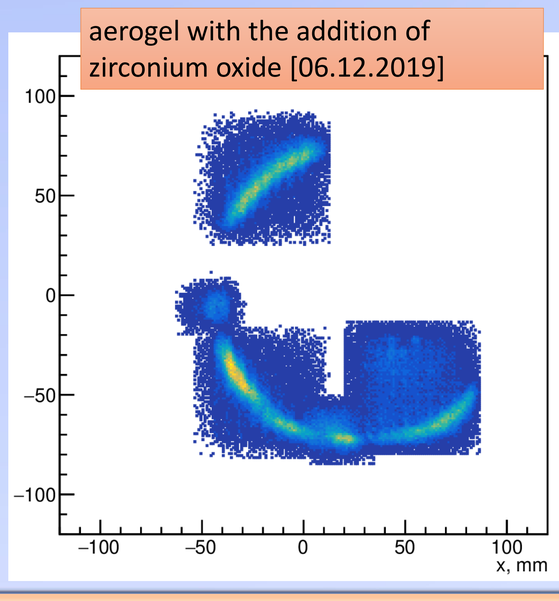


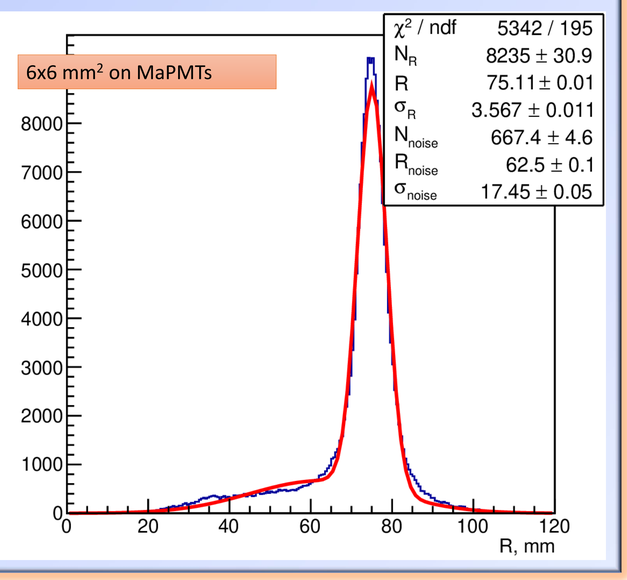
Described effects:

- Multiple Coulomb scattering
- Cherenkov emission
- Aerogel chromatic dispersion
- Rayleigh light scattering in aerogel
- Light absorption in aerogel
- Photon detection efficiency
- PD pixel size (no crosstalks)
- Ideal discriminator efficiency



aerogel with the addition of zirconium oxide [06.12.2019]





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Conclusion

- Resolution of Cherenkov angle $\sigma_{\Theta_c} \approx 10$ mrad for single detected photon was obtained.
- The number of detected photons in full ring $N_{ph} \approx 39$ are expected.
- Such results could provide the μ/π-separation at the level of more than 3σ at the 1.5 GeV/c.