FARICH detector beam test results

A high-performance particle identification (PID) system is essential for the successful realization of the broad physics program at the future Super C-t Factory in Novosibirsk. The main requirements for the PID system are as follows: good n/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 ZrO₂ [see paper A.Yu. Barnyakov et al.] could meet the above requirements. The first samples of such an aerogel have been produced. Beam test results are also presented.

**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.

<table>
<thead>
<tr>
<th>Thickness, mm</th>
<th>Refractive index</th>
<th>Lₜ (400nm), mm</th>
<th>calc. 𝑅, mm</th>
<th>exp. 𝑅, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-ply</td>
<td>3-ply</td>
<td>4-ply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>31</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0513</td>
<td>1.0495</td>
<td>1.0497</td>
<td></td>
<td></td>
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<tr>
<td>1.0485</td>
<td>1.0485</td>
<td>1.0485</td>
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<tr>
<td>1.0462</td>
<td>1.0462</td>
<td>1.0462</td>
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<td></td>
</tr>
<tr>
<td>41.2 ± 0.5</td>
<td>46.7 ± 0.6</td>
<td>54.4 ± 0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.91</td>
<td>2.17</td>
<td>1.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>64.8</td>
<td>65.7</td>
<td>65.3</td>
<td></td>
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</tr>
<tr>
<td>1.94 ± 0.17</td>
<td>2.20 ± 0.15</td>
<td>2.01 ± 0.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66.2</td>
<td>62.4</td>
<td>61.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

**Aerogel with the addition of zirconium oxide [06.12.2019]**

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.

**Photon detector**

4 H12700 MaPMTs: 8x8 anodes 6x6 mm²
Optional 0.1mm-hole mask on MaPMTs

3 SensL SiPM arrays: 4x4 pixels 3x3 mm²

**Readout electronics**

DIRICH & PADIVIA & 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.

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.

**Conclusion**

- Resolution of Cherenkov angle σ₉ₜ ≈ 10 mrad for single detected photon was obtained.
- The number of detected photons in full ring $N_{90}$ ≈ 39 are expected.
- Such results could provide the μ/π-separation at the level of more than 3σ at the 1.5 GeV/c.

**References**

A.Yu.Barnyakov et al., NIM A553 (2005) 70
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