EIC AEROGEL Requirements

Dual Radiator RICH

- Proposed dimension in the baseline design:
  - 200 mm x 200 mm x 20 mm in size
  - Expect to have a minimum of 300 tiles (assuming 2 layers and shaping as BELLE2).

Note: so far the only manufacturer that achieved thickness larger than 2 cm was Russian.

- Proposed mechanical specifications of the baseline design:
  - No cracks or bubbles inside the block. Spalling chips which decrease useful area no more than 1% are acceptable;

    OK. identical with Belle II.

  - Block shape defined by the customer (to best cover the dRICH circular ring area) starting from a maximum area of 200 x 200 mm^2;

    It will be OK with R&D.

  - Tolerance of +/- 0.25 mm in the block shape;

    OK, if water-jet cutting is allowed.

  - Thickness of 20 mm with a maximum tile to tile variation of 1 mm;

    OK.

  - Planarity of the block surface, defined as the maximum peak to valley variation, as low as possible and in any case not exceeding 1% of the lateral dimension.

    It needs R&D.

Note: these numbers are driven by the Russian mass production for CLAS12. Other requests and numbers may be necessary with different manufacturers or production methods, and should be defined during R&D.

- Proposed optical specifications of the baseline design:
  - Refractive index, to be chosen by the customer in the range from 1.015 to 1.025, with a maximum tile to tile variation of +/- 0.002; OK.
  - Absorption coefficient, defined as the constant term of the Hunt parameterization of the aerogel transmission, greater than 0.95;
  - Scattering length at 400 nm wavelength larger than 45 mm;
    It will be OK with R&D except for n=1.015. 30–35 mm is expected for n=1.015.

Note: refractive index match is crucial between tiles in the same stack. Adjacent tiles could have different refractive indexes.

- Dimension for prototyping studies
  - 5 cm x 5 cm x 2 cm (> 20 tiles)
  - 20 cm x 20 cm x 2 cm (> 10 tiles)

Note: he dRICH prototype works (at the moment) with 5x5 cm^2 tiles, but can be modified to house larger tiles. Several samples are required to test reproducibility and capability to stay within specifications. Large samples are required to test the maximum area achievable with quality within specifications.

Proposed questions:

Can the lateral faces have optical quality ?

Yes, aerogels as-is fabricated have optical quality. However, it is lost by water-jet cutting.

Which is the maximal area achievable for a block (with R&D) ?

hich is the maximum thickness achievable (with R&D) ?

For n=1.02, 20 x 20 x 2 cm will be possible with a reasonable crack-free yield (say 70%). 3 cm thick will also be possible. Constraint due to drying equipment is 30 x 30 cm. This size may be possible with a

reduced crack-free yield. In general, lower-index aerogels have an advantage in terms of crack-free yield.

Which is the method and precision of the block shaping ?

The aerogel size is determined by mold size and volume shrinkage during production. To minimize shrinkage, temperature control during wet-gel aging and drying is essential. For example, the precision is 150 ± 1 mm for n=1.03 as-is fabricated. As for block shaping, water-jet cutting is available after production, with an accuracy of ±0.25mm.

Are there information on the uniformity of the refractive index within the block volume ?

A study reported a tile-transverse uniformity of ±1% by measuring density with X-ray (https://dx.doi.org/10.1016/j.nima.2012.09.001). No more comprehensive analysis is unknown.

Is there a known relationship of refractive index and density ?

$n = 1+k\rho$ (or $n^2 = 1+\alpha\rho$). Russian reports k=0.21. Japanese aerogels have k=0.25-0.3 due to hydrophobic properties and depending on the nanostructure of silica particles and pores, which relates to transparency.

Modular RICH (edited by Xiaochun He on Nov 10, 2022)

- Index of refraction: n ~ 1.03
  OK.

- Dimension for prototyping studies
  - 10 cm x 10 cm x 3 cm (3 tiles)
    OK.

  - 10 cm x 10 cm x 4 cm (3 tiles)
  - 10 cm x 10 cm x 5 cm (3 tiles)
    Will try.

- Proposed dimension of the baseline design
  - 10 cm x 10 cm x 4 cm in size
  - Expect to have a minimum of 100 tiles (including spares)
    OK.

Note: For mRICH, because of its modular nature, one can tolerant slight variations in n (not sure about the typical uncertainty in n) as long as its optical quality is good and surfaces are flat.

Proximity focusing RICH

- Proposed dimension and refractive index in the baseline design:
  - ~ 200 mm x 200 mm max linear dimension, in three different form-factors (curved trapezoids a la Belle II), matching three radial bands between R_{min} ~ 70mm and R_{max} ~ 630mm
  - Geometry: 8+14+20 = 42 **spots** maximum
  - Refractive indices: either a single layer with a refractive index of ~1.040+/-0.010, or a dual layer setup (in a less demanding defocusing configuration) with n1 ~ 1.050 and n2 ~ 1.020
  - Thickness: 3cm total for aerogel with n ~ 1.020 and 2cm total for n ~ 1.030 ..1.050. Prefer single blocks with the same refractive index rather than stacks
  - Quantity: assuming 2cm and 3cm thickness can be available, will obviously need either 42 or 84 tiles total + spares

    OK.

- Options:
  - Can consider ~ 150 mm x ~150 mm size (four radial bands)

    OK.

- Quality (in addition to what Marco formulated already):
  - Forward scattering (caused by a bulk refractive index variation) and surface non-flatness should not contribute more than ~0.3 mrad smearing into the overall Cherenkov angle determination
- Prototyping:
  - 50 mm x 50 mm or 100 mm x 100 mm size with thickness between 10 mm and 30 mm, <10 tiles total

    OK.

Proposed questions:

Can one have optical quality sides, if max size requirement is lifted (say, would a ~4x4x2 cm^3 size with five optical quality sides be

possible)?

Yes, possible.

Can one produce a "honeycomb" structure with transparent (glass, acrylic, etc.) thin walls, lateral cell size <5cm, filled with aerogel (each cell with optical quality sides, either with or without optical contact with the walls)?