Production of Silica Aerogel Radiator Tiles for the HELIX RICH Detector

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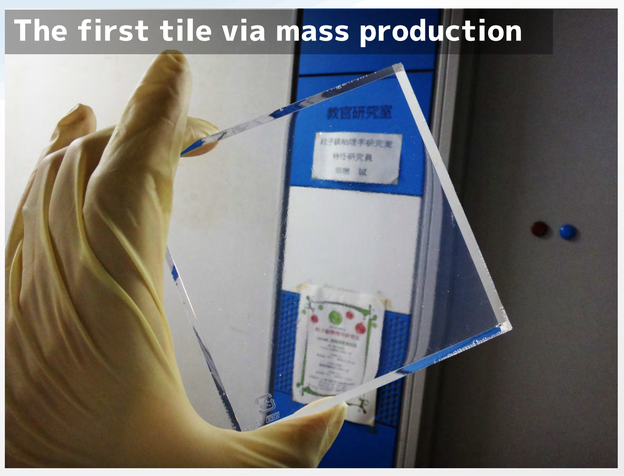
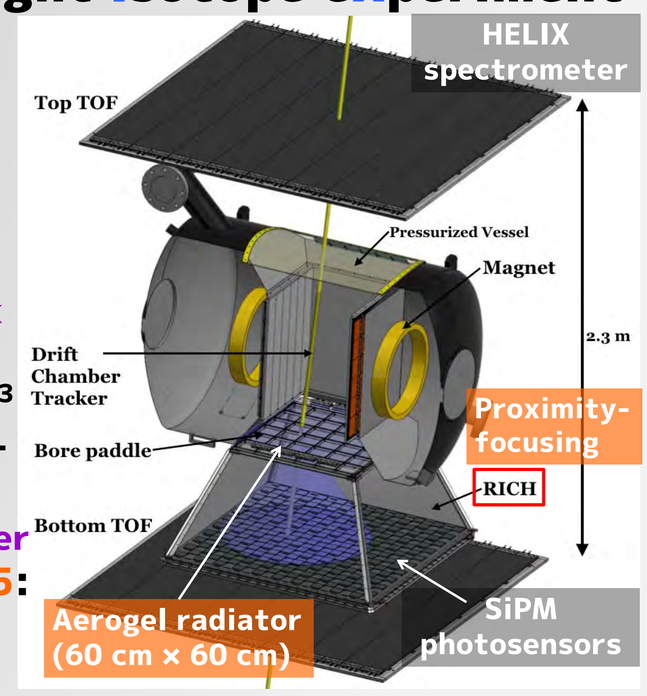
Highlights

- Mass production of hydrophobic silica aerogel tiles as RICH radiators with $n \sim 1.15$ was completed.
- Aerogel cutting and gluing tests were successful.
- Integration procedure for the flight tiles is ready.



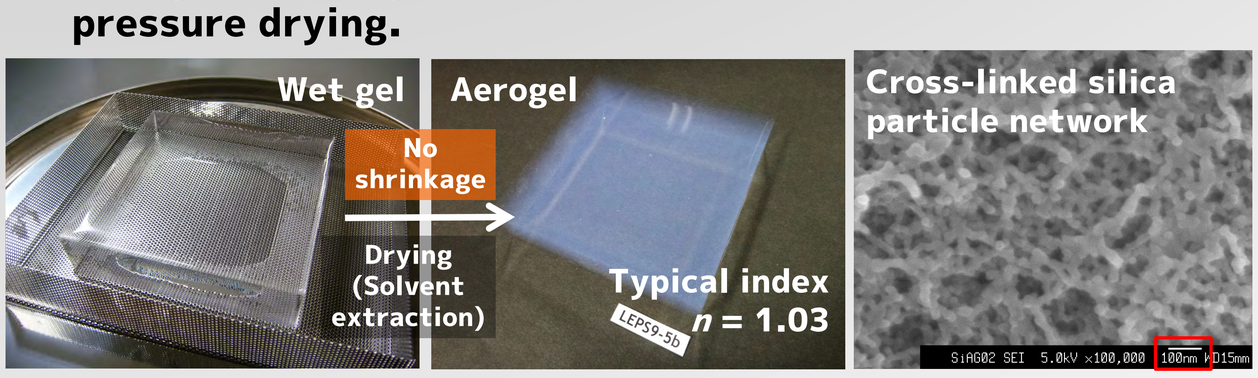
HELIX—High Energy Light Isotope eXperiment

- Magnet spectrometer to measure $^{10}Be/^{9}Be$ isotope ratio up to 10 GeV/n (Stage1: Up to 3 GeV/n, flight in Antarctica with a long duration balloon in 2020/21) → CRD6h by N. Park
- Velocity measurement w/ resolution of $\Delta\beta/\beta \sim 1 \times 10^{-3}$ for $Z > 3$, $E > 1$ GeV/n: ring-imaging Cherenkov (RICH) detector → PS1-39 by I. Wisher
- Aerogel radiator w/ $n \sim 1.15$: 36 tiles × (□100 mm × 10-mm thick).



Silica Aerogel

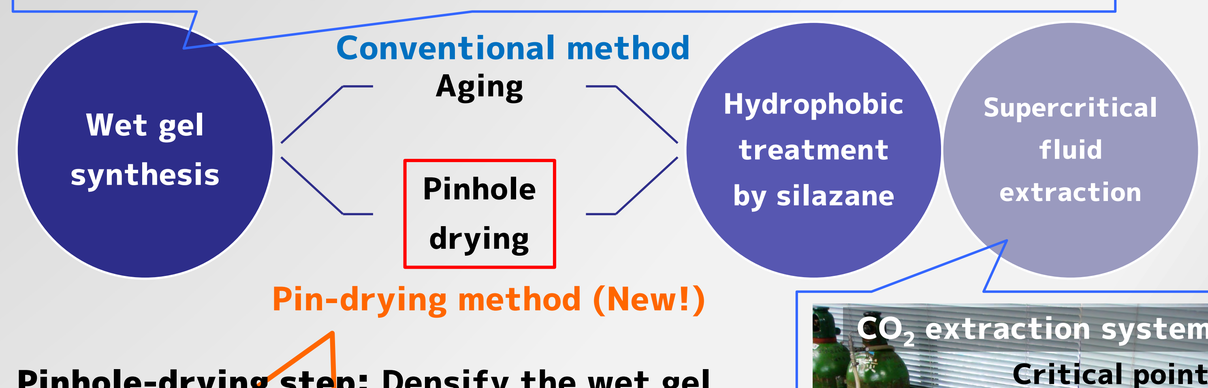
- Created in the 1930s.
- Applied as Cherenkov radiators in the 1970s: cosmic-ray experiments; e.g., ISOMAX, AMS-02 ($n \sim 1.05$).
- Solid-like glass state.
- Transparent at the visible range.
- Refractive index between gases and condensed materials; Density control by varying the volume ratio of silica particles and pores (O(10 nm)),
  n = 1.003–1.10 (Conventional, direct sol–gel synthesis),
  n = 1.10–1.25 (Sintering or pin-drying, densification by shrinkage).
- Wet gel → Aerogel via supercritical extraction or ambient pressure drying.



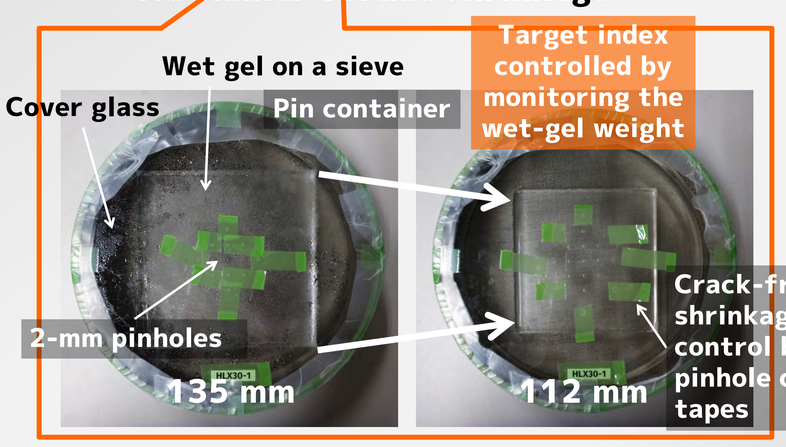
Novel Production Method

M. Tabata *et al.*, NIMA 623 (2010) 339.

Aerogel density (i.e., index) can be controlled by varying the volume ratio of the silica precursor and diluent solvent (n < ~1.14).



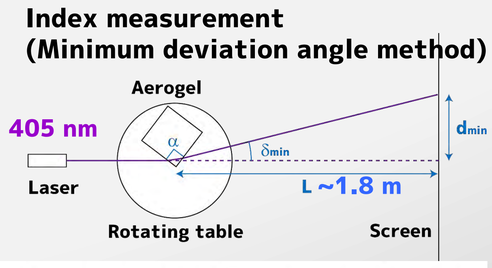
Pinhole-drying step: Densify the wet gel via similar volume shrinkage

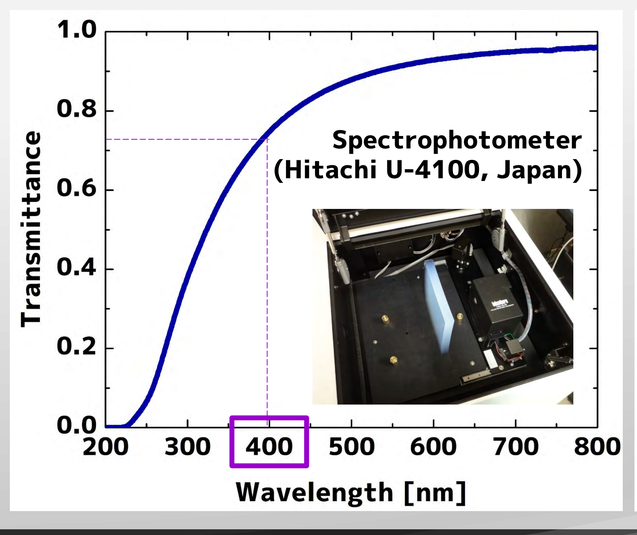


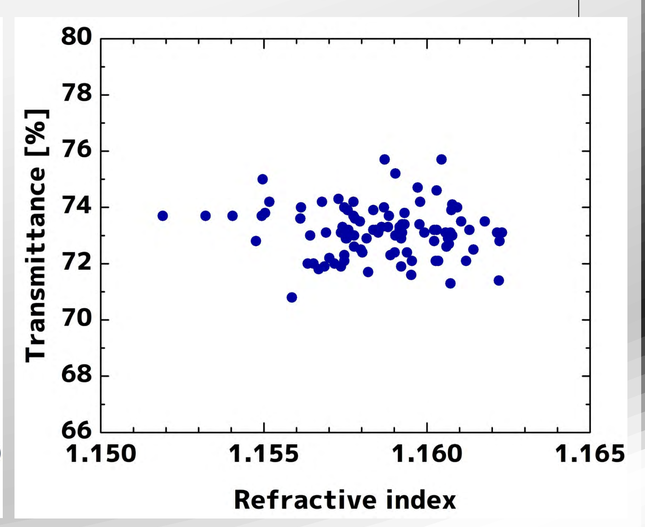
Mass Production Results

- From March to December in 2018.
- 96-tile mass production at Chiba U.
- 74 crack-free tiles (77% yield).
- 112 mm × 112 mm × 10 mm.
- n = 1.152–1.162.
- Transmittance > 70% at 400 nm, 10-mm thickness.
- Precise calibration to be performed → PS1-29 by T. Rosin

Index measurement (Minimum deviation angle method)



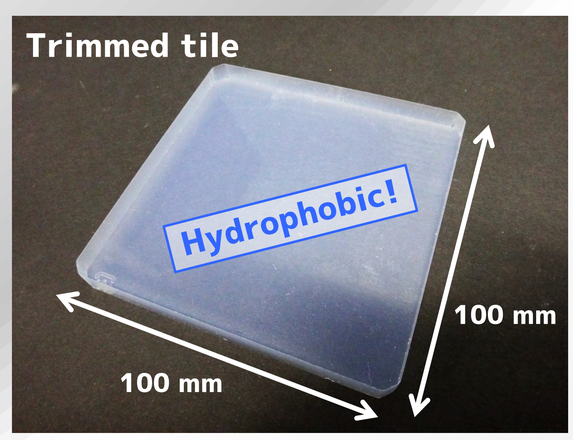


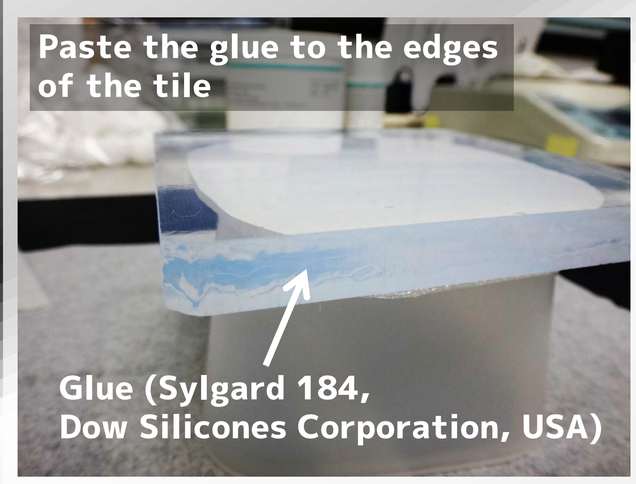


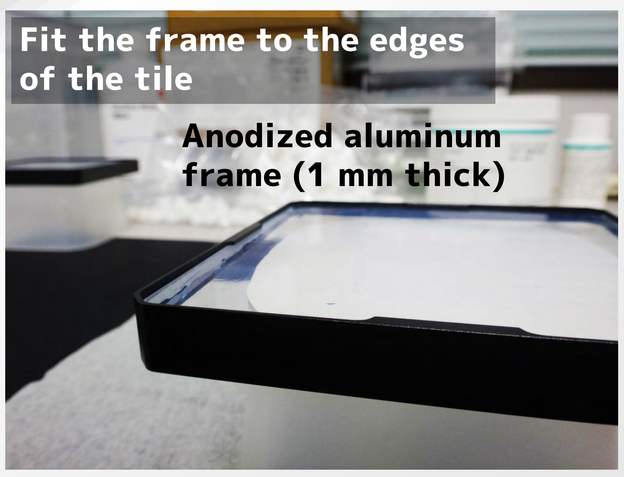
Machining and Gluing Tests

❖ Aerogel cut processing using a water-jet cutting device.
- □112 mm → □100 mm.
- ±0.2 mm precise control.
- No damage to transparency.

❖ Aerogel gluing to the frame.
- Silicone elastomer as a glue.
- Chemical damage to the aero-gel minimized by limiting the amount of glue used.







The HELIX Collaboration

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