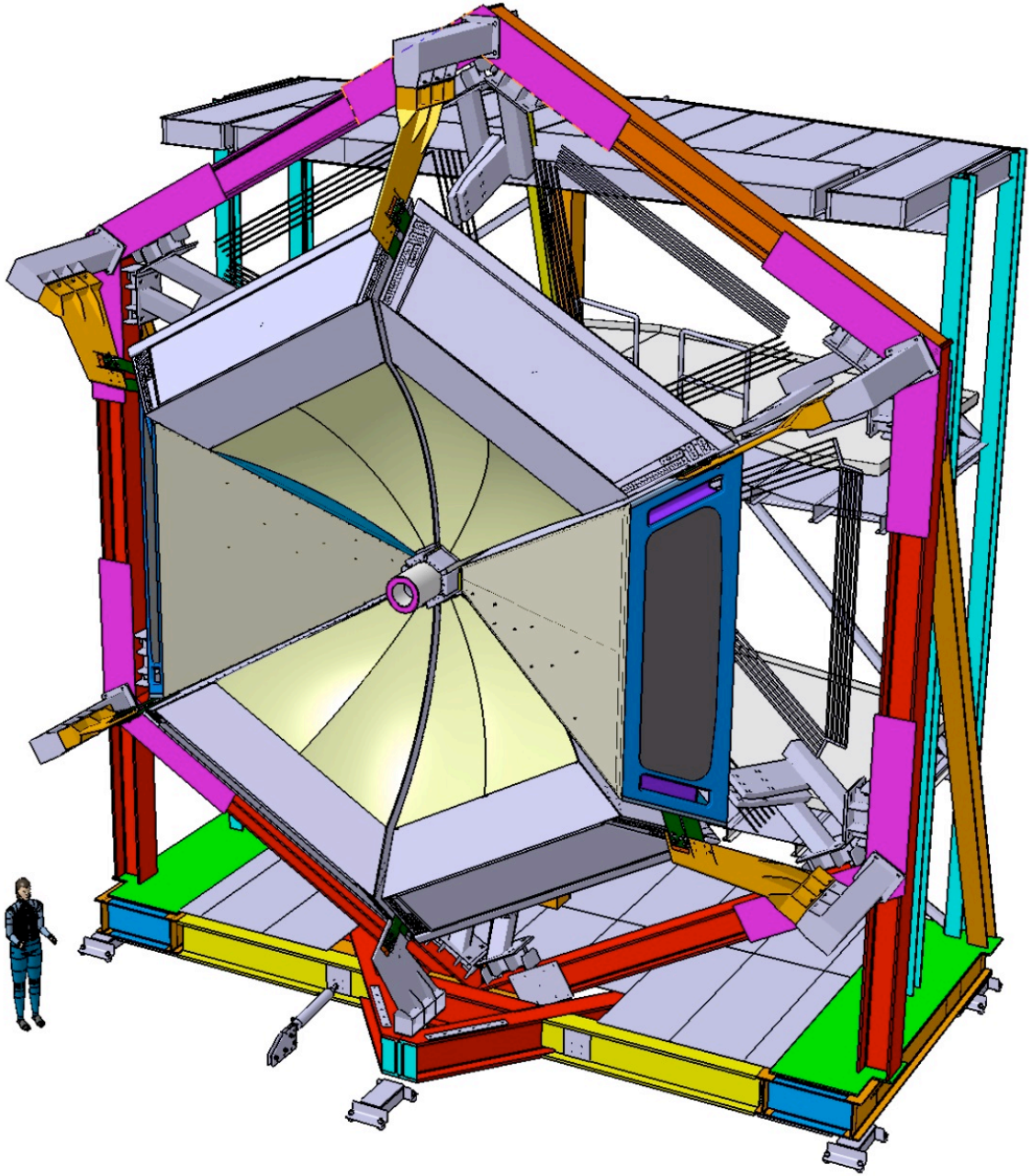


CLAS12-RICH Status-Report

Slides shown at the informal meeting with DOE representative December 11th 2013

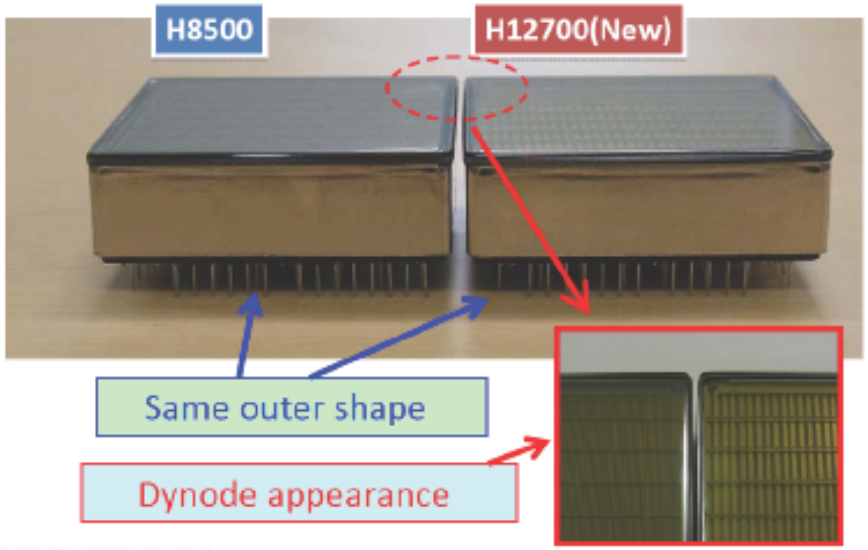
PMTs

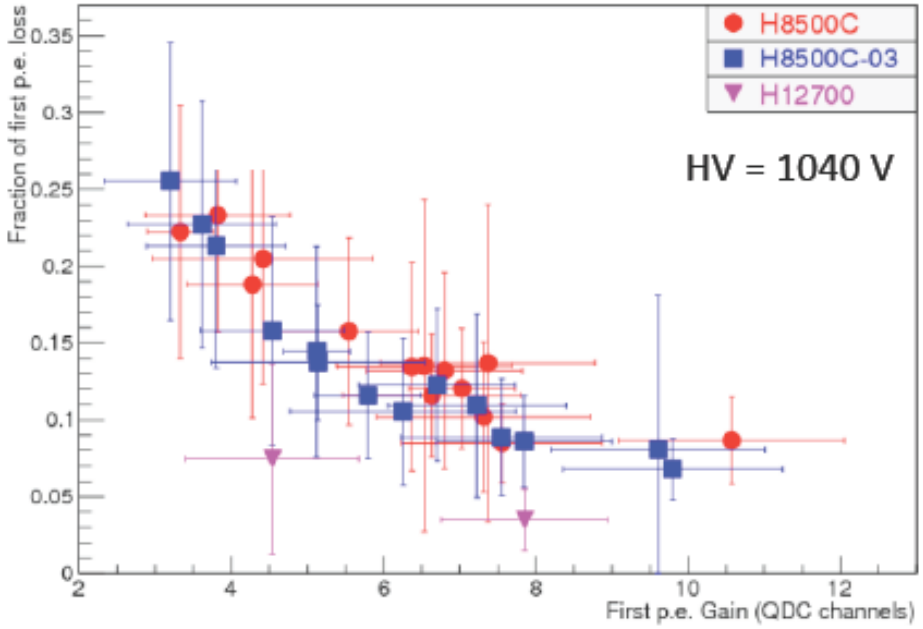
H12700 vs H8500:

- better SPE resolution at similar gain
- reduced cross-talk (shown at RICH2013)

H12700 not on marked because:

- x10 dark count on the corner pixels (not an issue for us)
- leakage current between case and base (to be solved)





H12700 – a new MAPMT from Hamamatsu

- Recently, Hamamatsu announced **a new MAPMT: H12700**
- Combining geometrical **benefits of large H8500** with single-photon optimized **dynode structure of R11265**
- **2x2" MAPMT, optimized for single photon detection**

- Sounds like perfect match - we tested a first sample:
  - ADC spectra
  - single photon scans

2 * H8500

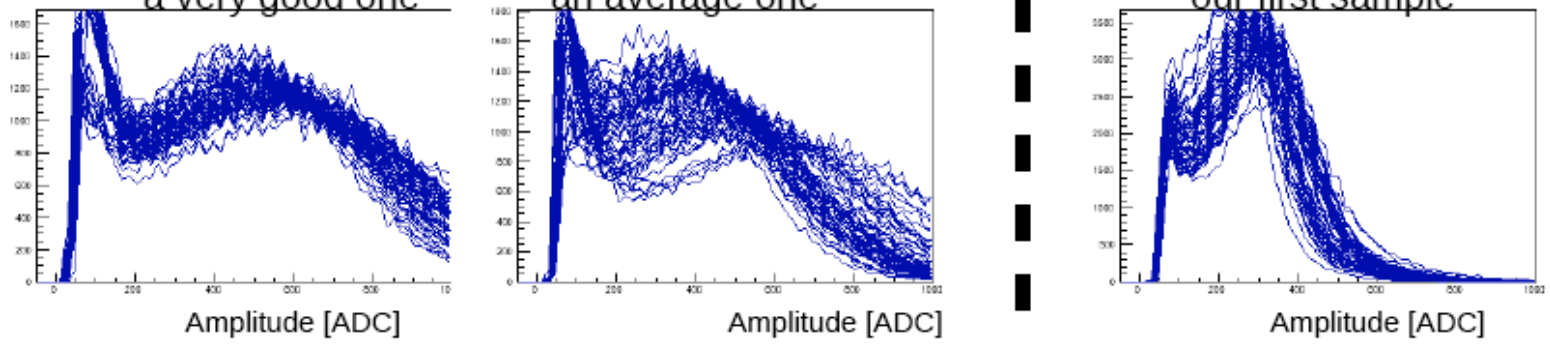
a very good one

an average one

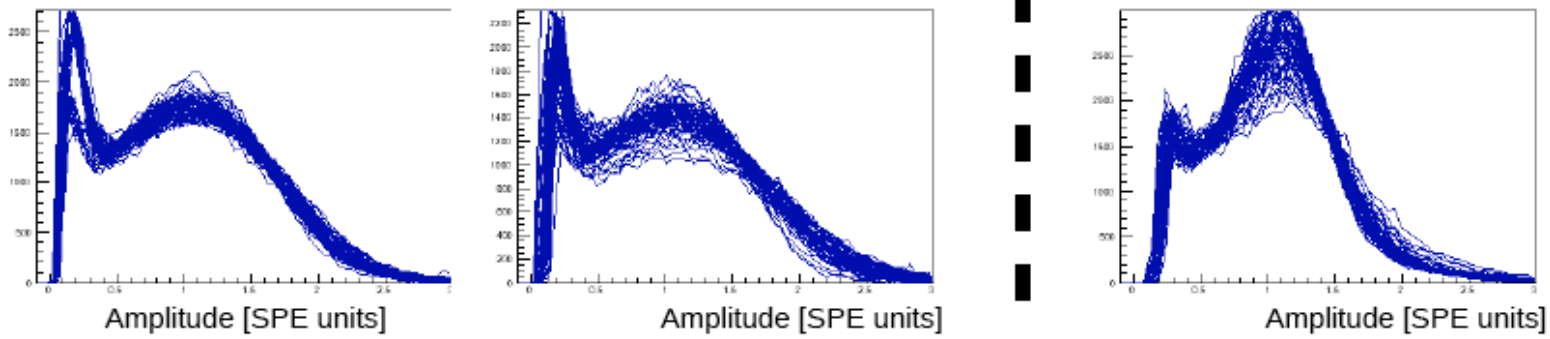
H12700

our first sample

Raw spectra:
Overlay of all 64 channels
(in ADC counts)



Gain normalized:
(in SPE units)



BERGISCHE UNIVERSITÄT WUPPERTAL

Single photon scans: H8500 vs R11265 vs R12700

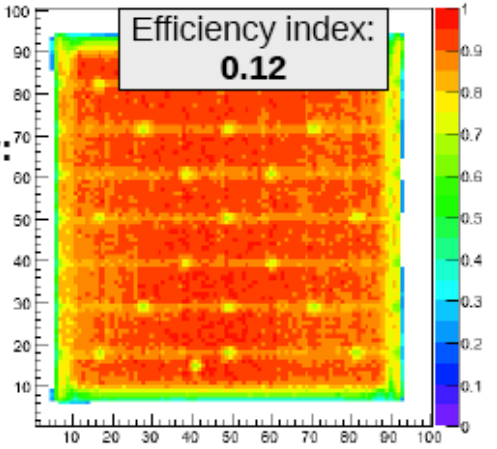
CBM

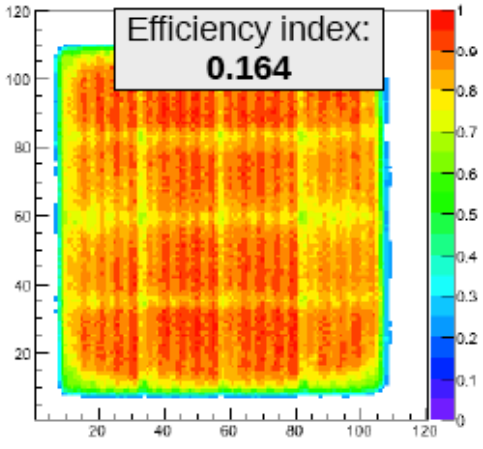
H8500 (2x2 inch”)
one of our best

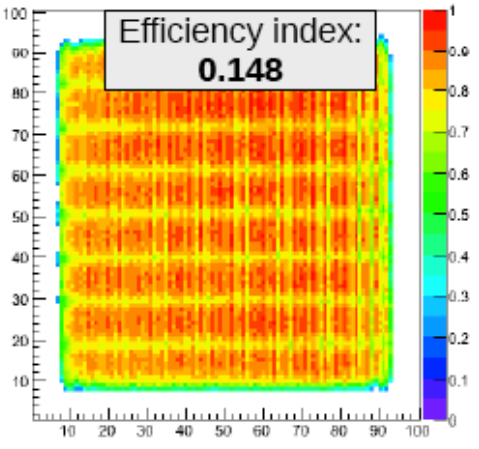
R11265 (1x1 inch²)

H12700 (2x2 inch²)
very first sampe

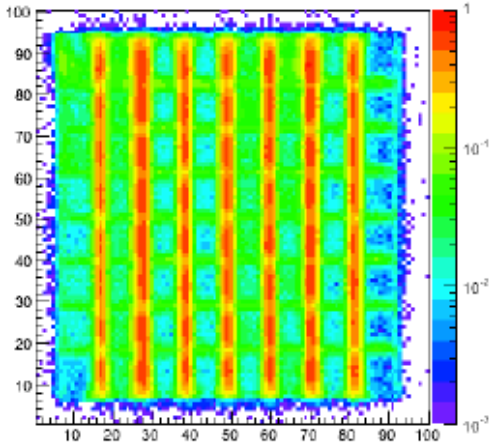
Detection efficiency:
>=1 hit
per detected photon

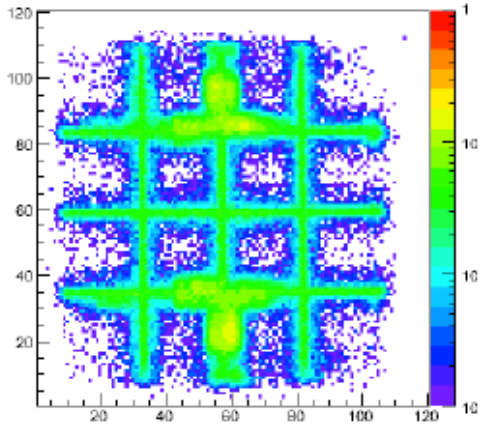


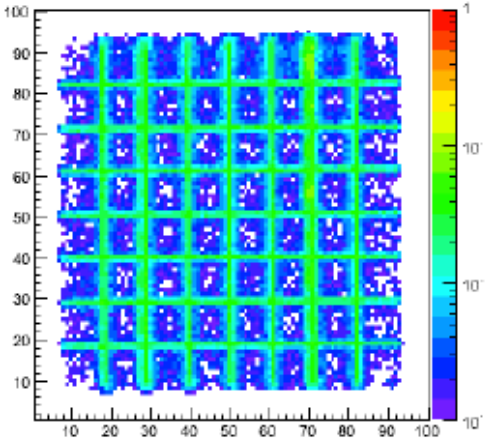




Cross talk:
>=2 hits
per detected photon

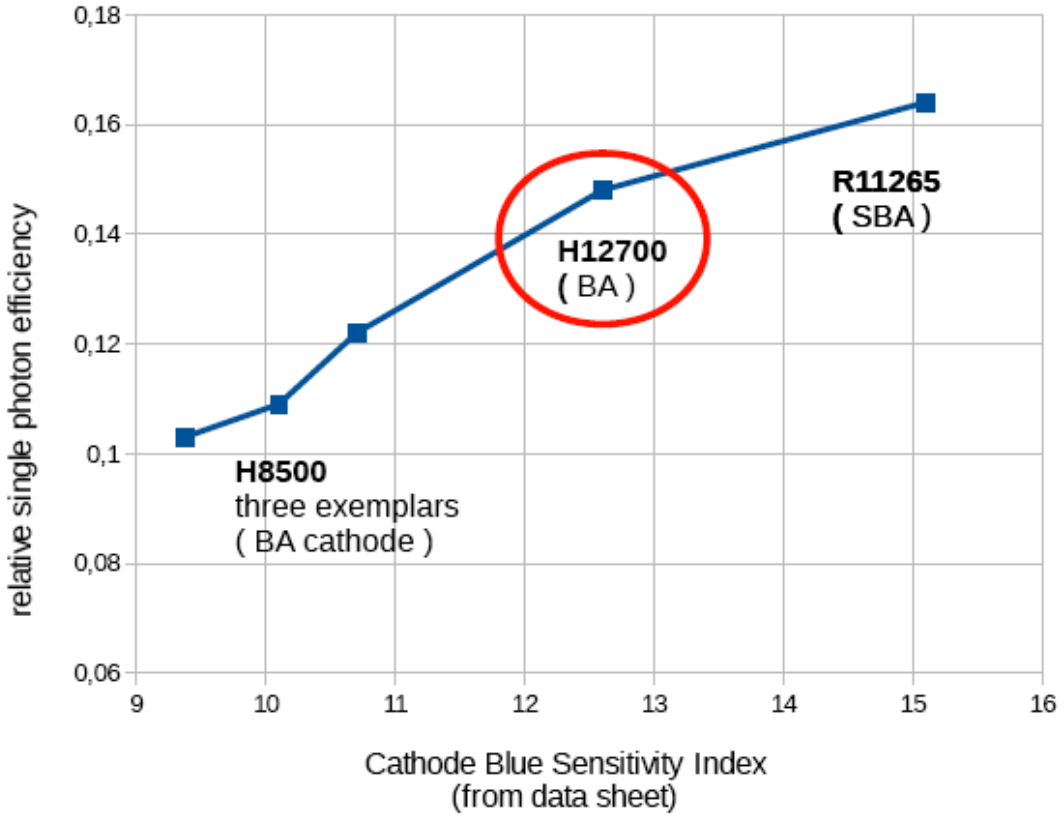






New H12700 MAPMT

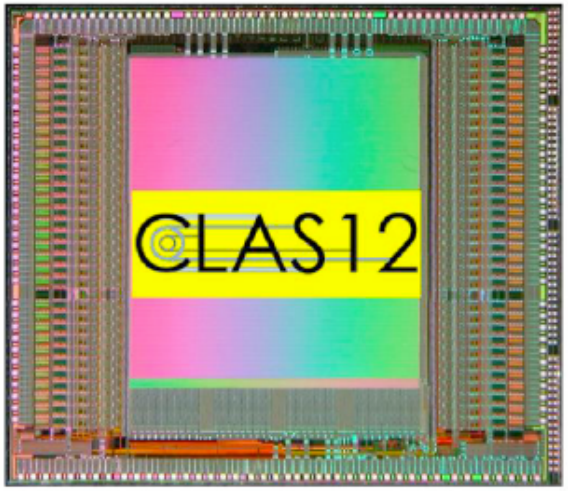
- First test of very first sample H12700 look very promising
- Significant better Single photon peak distribution (similar R11265)
- Much better channel separation (similar R11265)
- First sampe: very high overall efficiecy, half-way to SBA cathodes



Electronics

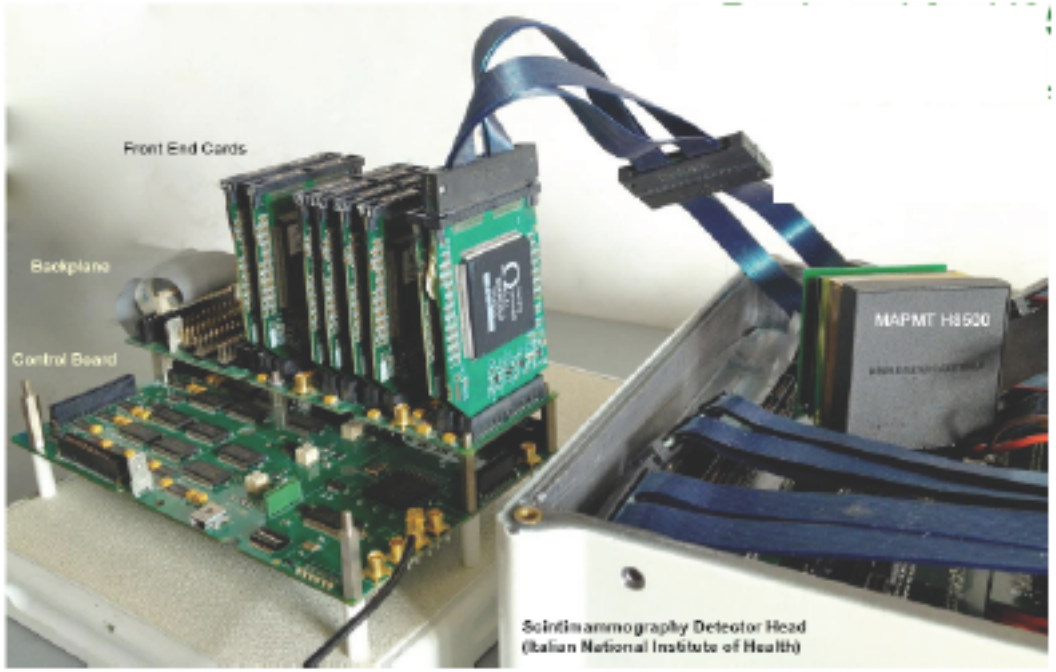
DREAM chip:

- successfully tested with H8500 (laser test)
- ~2 ns time resolution
- available only in limited number, no new production foreseen



MAROC3 chip:

- less than 100 ps intrinsic time resolution of the digital output



Aerogel

Manufacture Engineering Phase ongoing with Novosibirsk to improve and stabilize large tiles production yield and transmission length

- 1st batch with 20x20 cm^2 mold (17x17 cm2 tiles): no cracks on the 6 trial samples

Milestone: Start Aerogel procurement 12/31/13

- pro-forma quotation for 1st square meter in line with cost evaluation
- 80 keuro reserved from INFN FY2013

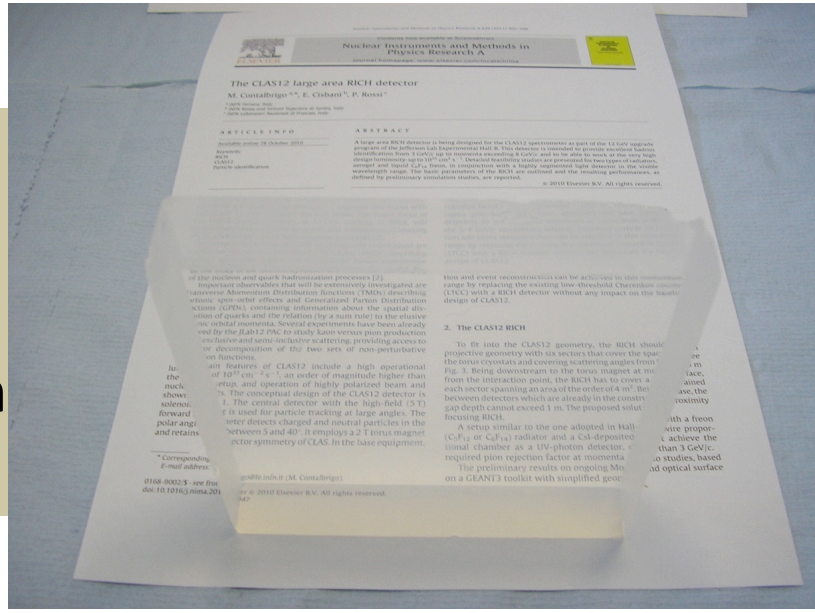
Aerogel Radiator

Rafractive index: 1.05

Area: 20x20 cm^2

Thickness: 3 cm

Scattering Length: greater than 50 mm



Conventional Method

- **Sol–gel synthesis** of wet gel (Hydrolysis, condensation, and polymerization):

$$CH_3O[Si(OCH_3)_2O]_nCH_3 + (n+1)H_2O \rightarrow (SiO_2)_n + (2n+2)CH_3OH$$

Polymethoxysiloxane — Water — Silica — Methanol

Wet-gel processing
- Wet-gel synthesis
- Hydrophobic treatment

⇨ **Supercritical drying**

- **Refractive index control in the wet-gel synthesis process** (by recipe)
- First developed using methanol as solvent at KEK in the early 1990s, and modernized using *N*,*N*-dimethylformamide at Chiba Univ. in the mid 2000s
- Well-established method → **Outsourcing**

  Wet-gel processing: Panasonic Corp. → Japan Fine Ceramics Center (JFCC)

  Supercritical drying: Mohri Oil Mill Co., Ltd.

Pin-drying Method

- Fine-structure modification and bulk density increment by **shrinking wet gel**

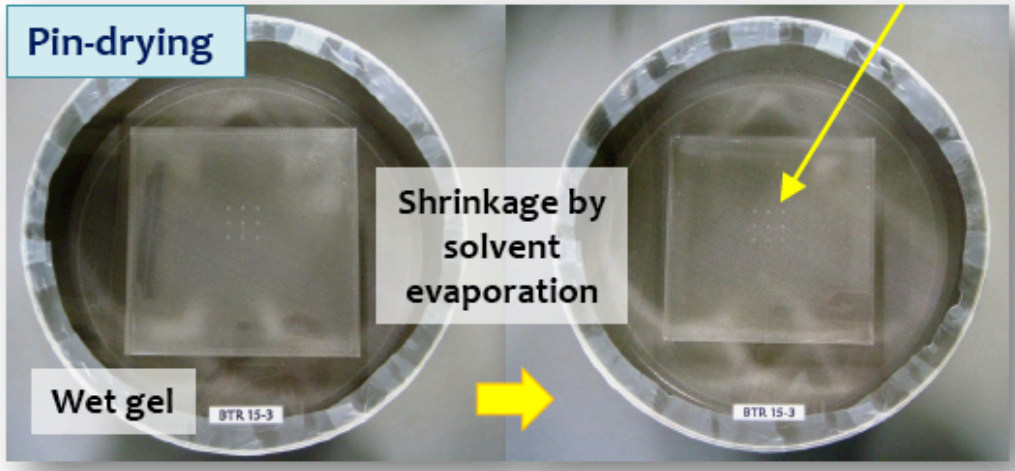
Wet-gel processing
- Wet-gel synthesis
- Pin-drying
- Hydrophobic treatment

⇨ **Supercritical drying**

→ **Improving transparency**

→ **Increasing refractive index**
e.g., n = 1.05 → 1.06
n_{max} = 1.26 !

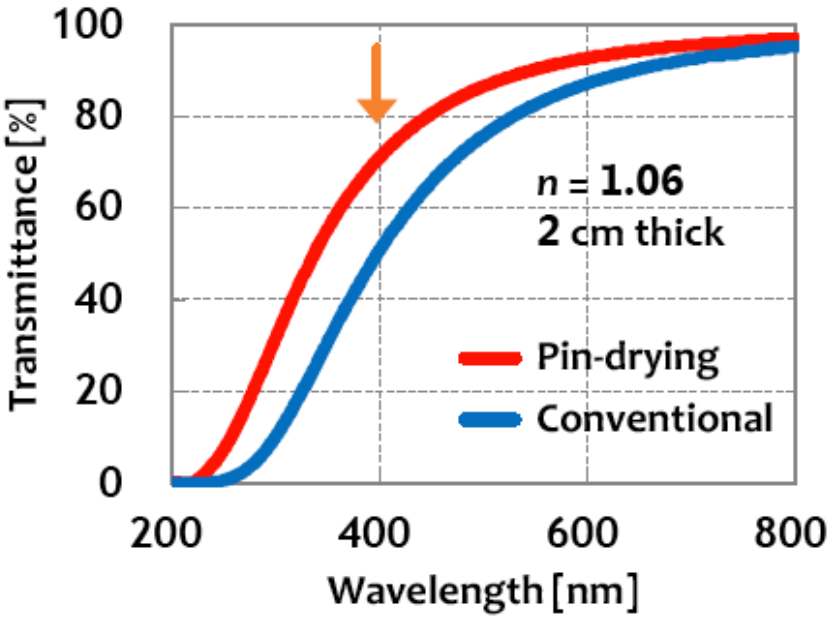
Semi-sealed container with pinholes

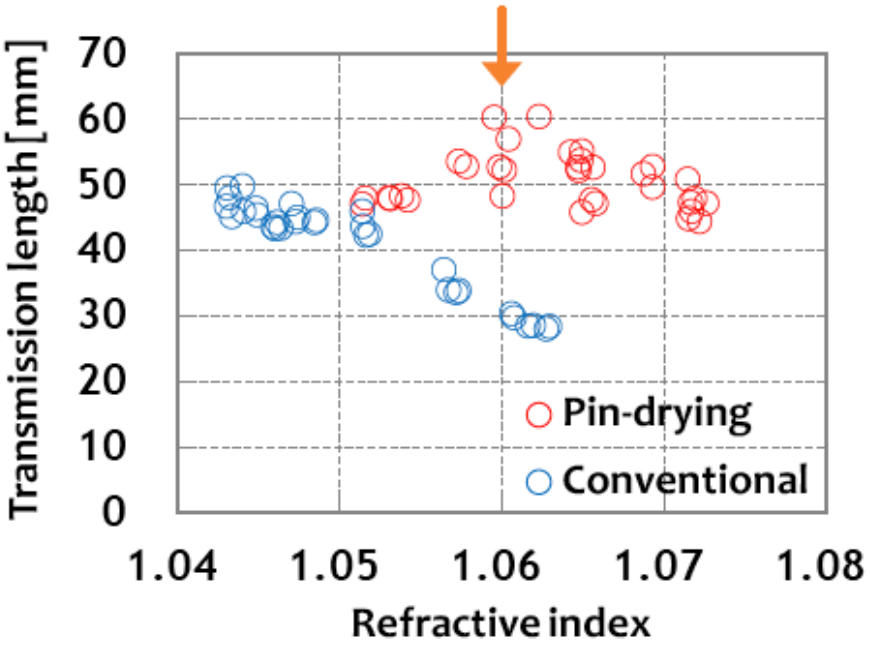


From several weeks to months later

- **Refractive index control in both the wet-gel synthesis and pin-drying processes** (by recipe and shrinkage)
- **In-house development** at Chiba Univ. since the mid 2000s

Optical Performance





- Optical parameters taken from aerogel tiles smaller than 10 cm
  - Refractive index measured using a 405-nm laser
  - Transmission length (Λ_T) at 400 nm calculated from transmittance and aerogel thickness
- **Higher transmittance in a wide range of wavelengths independent of refractive index by the pin-drying method**

Aerogel Tiling

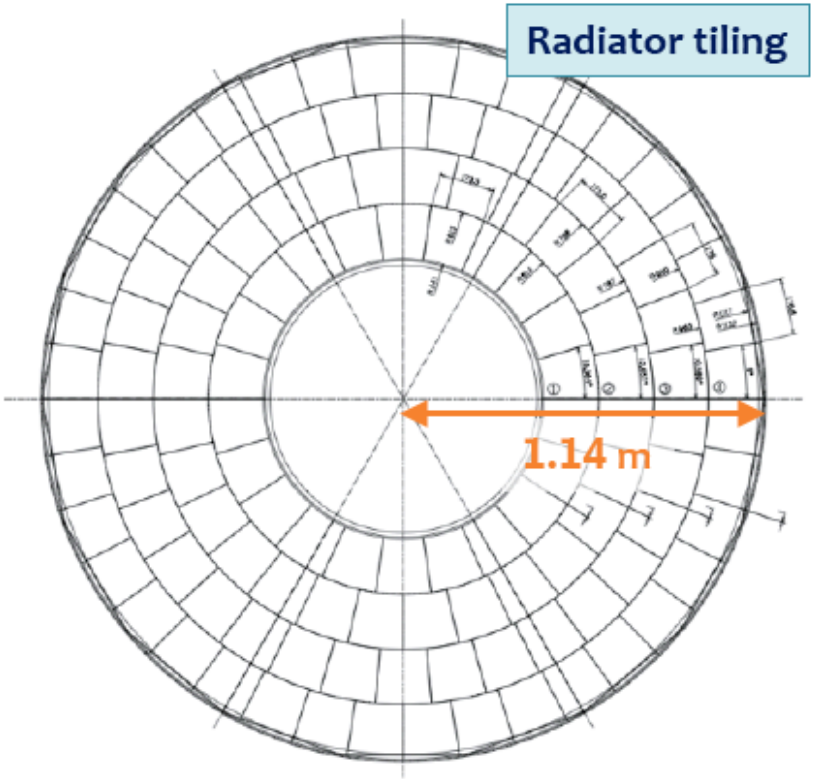
- **3.5 m^2** cylindrical forward end cap of the Belle II detector
- **Reducing adjacent boundaries of aerogel tiles,**
  at which the number of detected photoelectrons decreases
- Minimizing the total number of tiles with realistic dimensions for production
- Simplifying mechanical structure

→ **2 cm × 2 layer-focusing** aerogels

→ **18 × 18 × 2 cm^3** large tiles

→ **248 tiles** in total

→ Cutting aerogels in **fan shapes**



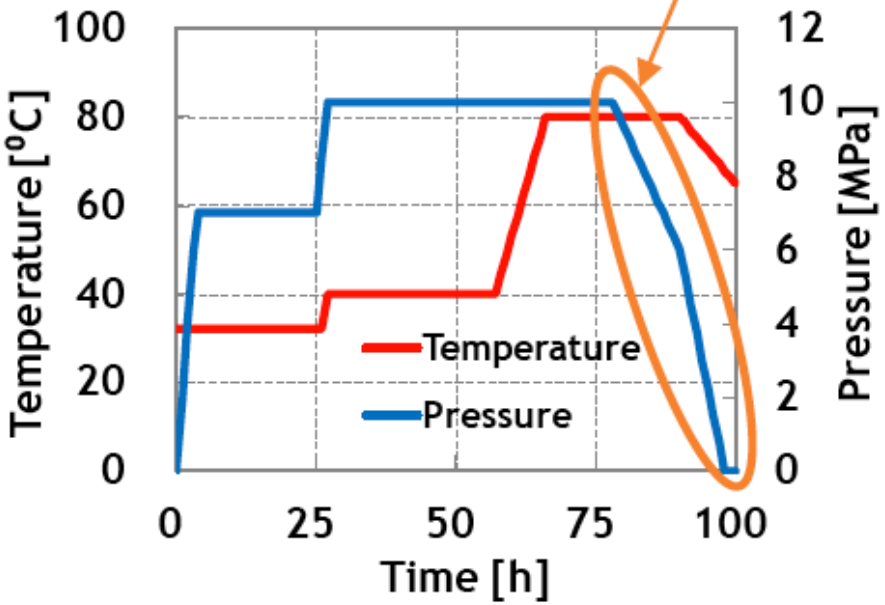
Large Tile Production

- Collaboration with JFCC and Mohri Oil Mill Co., Ltd.
- Large-area aerogels can be **cracked** in the supercritical drying (SCD) process.

  → **Improving SCD operation** [conventional (Panasonic) → Chiba pattern]

Very slow pressure reduction (one day)

SCD operation pattern (Chiba)



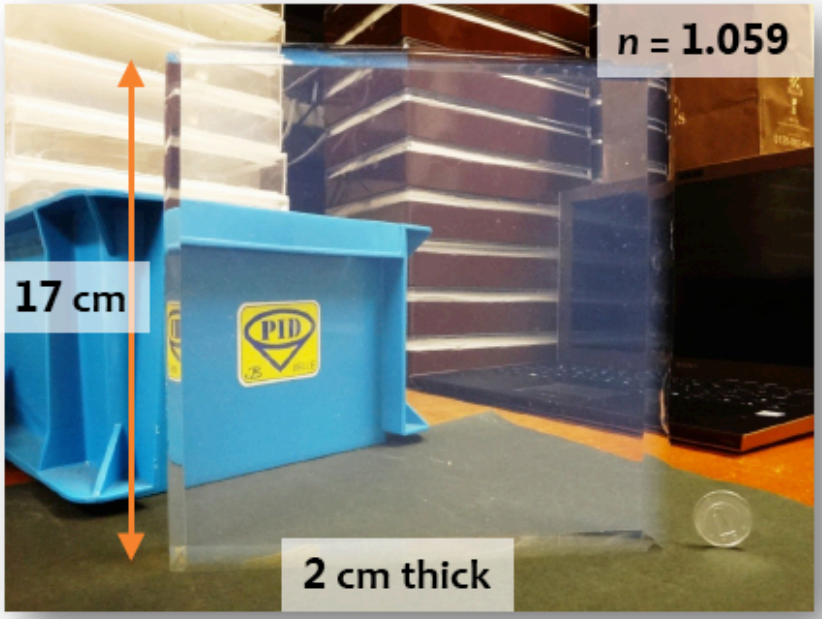
Recent test production results

- Using the **conventional method**
- 18 × 18 × 2 cm^3 tiles
- n = 1.045–1.055
- **28 tiles/batch** (SCD capacity)
- **5 batches** since 2012
- **89% crack-free** tile yield

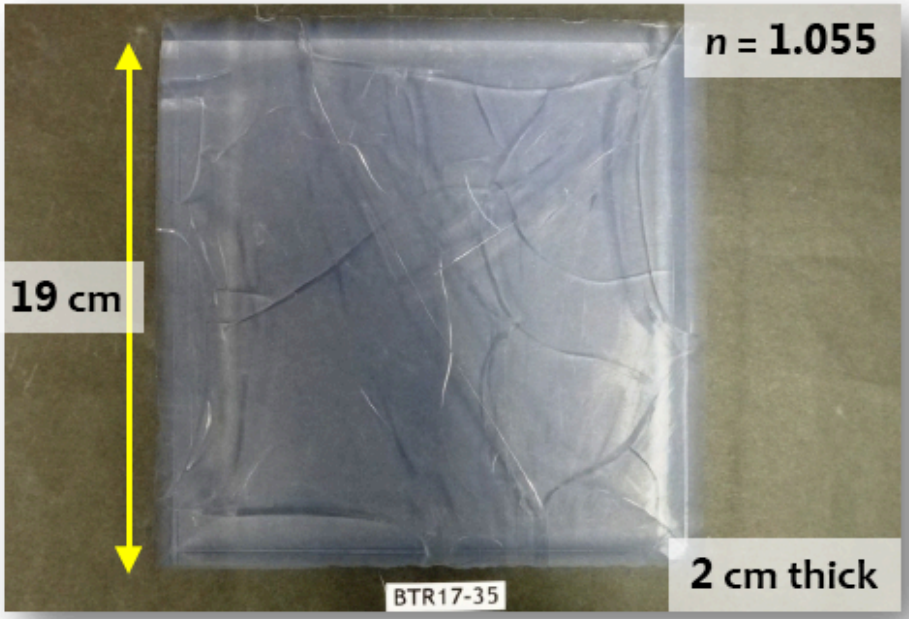
Pin-dried Large Tile Production

- Pin-dried aerogels are easily cracked in the SCD process in even small tiles.
- Large tile production by the pin-drying method is fairly challenging.
- We obtained **several 17 cm samples with no cracking** in trial productions.
- **No crack-free tiles were obtained in the final test production** in 2013.

Pin-dried large aerogel with no cracking



Final test aerogel with cracking



Our Decision

- Upstream aerogel → n = 1.045 or 1.050 using the conventional method
- Downstream aerogel → n = 1.055 or 1.060 using …

  Conventional method or **Pin-drying method**
- The **transparency** of the downstream aerogel is important because all the emitted Cherenkov photons must pass through the downstream layer.
- Another important issue is to use **crack-free** aerogels.
- **Our decision** based on the test productions of large aerogel tiles

  → Using the **conventional method**

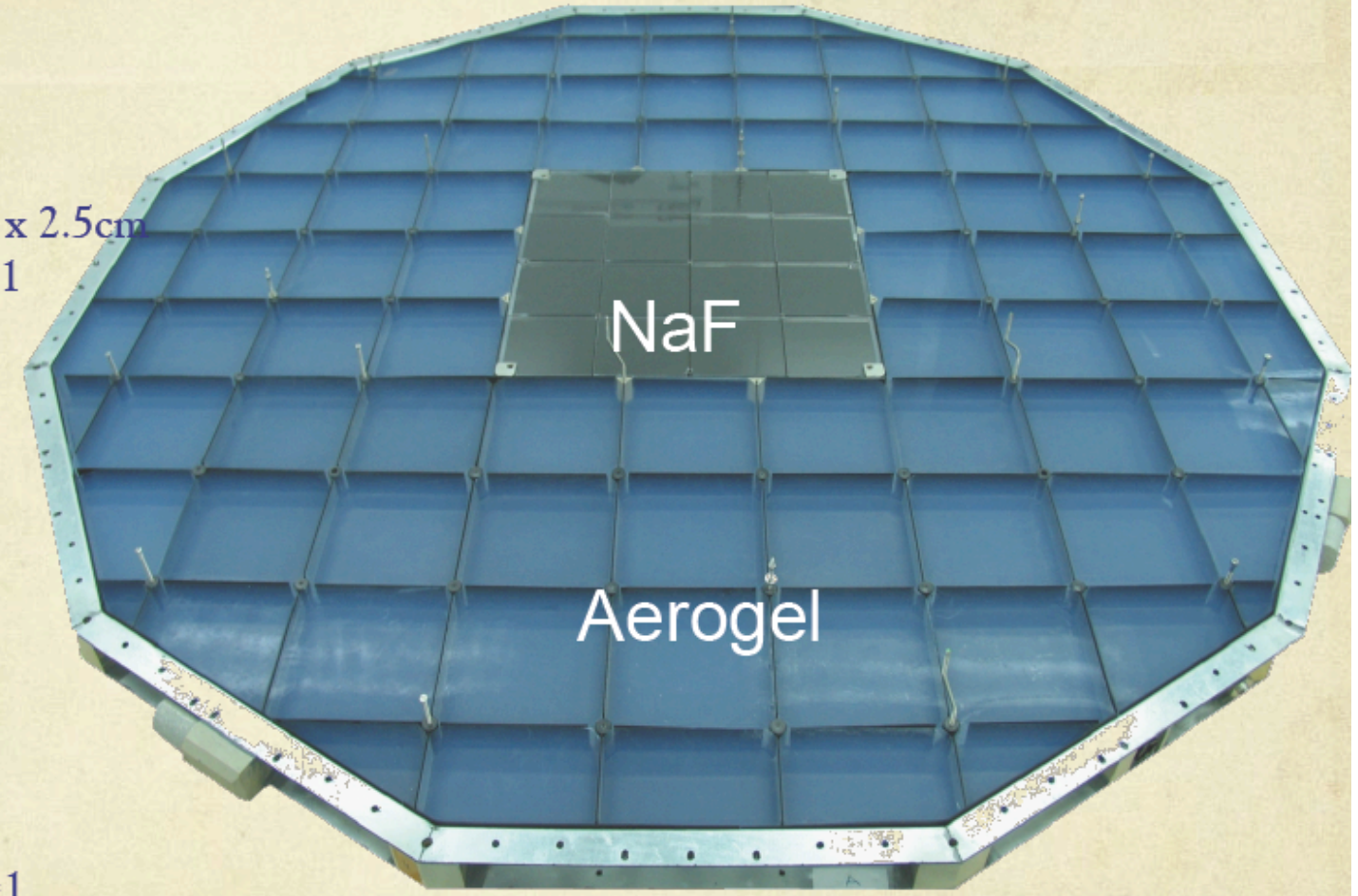
  → n = **1.045 and 1.055** (producing each 2 cm thick tile separately)

- We will perform **further developments for pin-dried aerogels at Chiba Univ.** independent of the Belle II program.

RICH Detector: Radiator

Silica aerogel:

- 80 tiles
- n=1.05
- 11.3 cm x 11.3 cm x 2.5cm
- ring ≈31cm for β=1
- E_{kin}>2.1 GeV/n



NaF crystals:

- 16 tiles
- n=1.33
- 8.5 x 8.5 x 0.5 cm
- ring ≈85cm for β=1

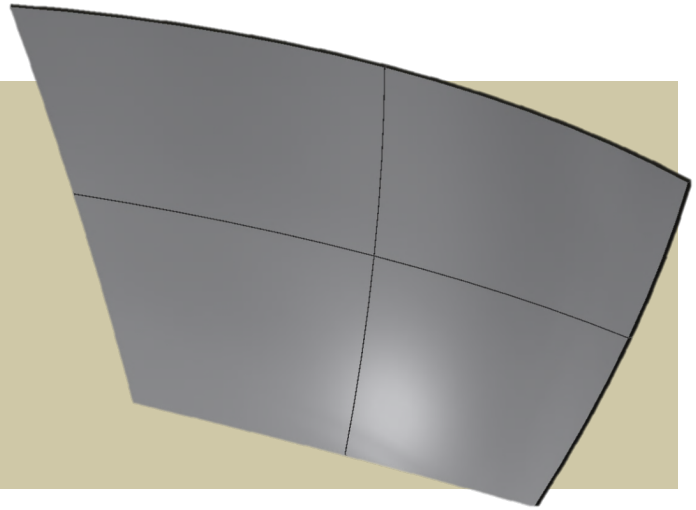
  Larger Cherenkov angle to reduce photon loss in the central hole
- Extend RICH beta range to lower Energies (E_{kin} > 0.5 GeV/n) to match with TOF

Mirrors

Manufacture Engineering Phase ongoing with companies in Italy and USA
In contact with CERN laboratory for mirror characterization

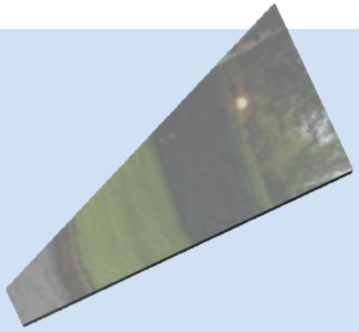
CFRP SPHERICAL Mirror

Radius tolerance <= 1%
Surface accuracy: 5 µm RMS
Surface Quality: 3 nm RMS
D0 < 5 mm
Reflectivity > 90%



Planar Glass Mirror

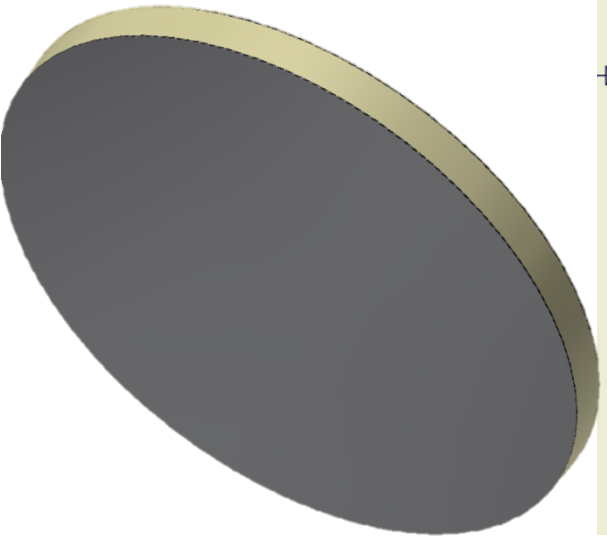
Planarity tolerance <= 0.1 mm
Surface accuracy: 5 µm RMS
Surface Quality: 3 nm RMS
Reflectivity > 90%

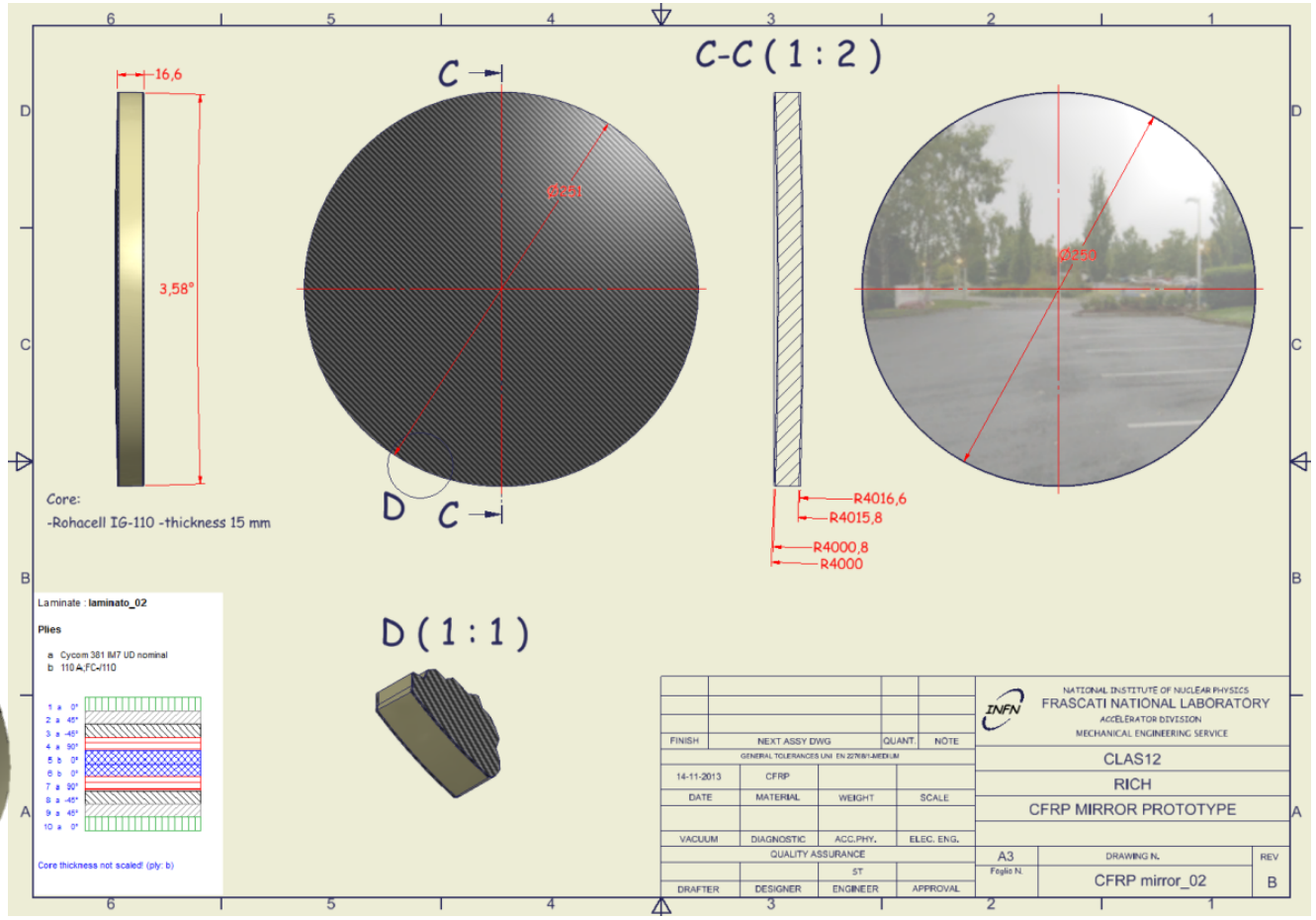


CFRP Spherical Mirror: Mandrel Demo

Mandrel demo in preparation at Marcon (Italy) :

- supremax (borosilicate glass) material
- spherical shape, 4 m radius, 35 cm diameter



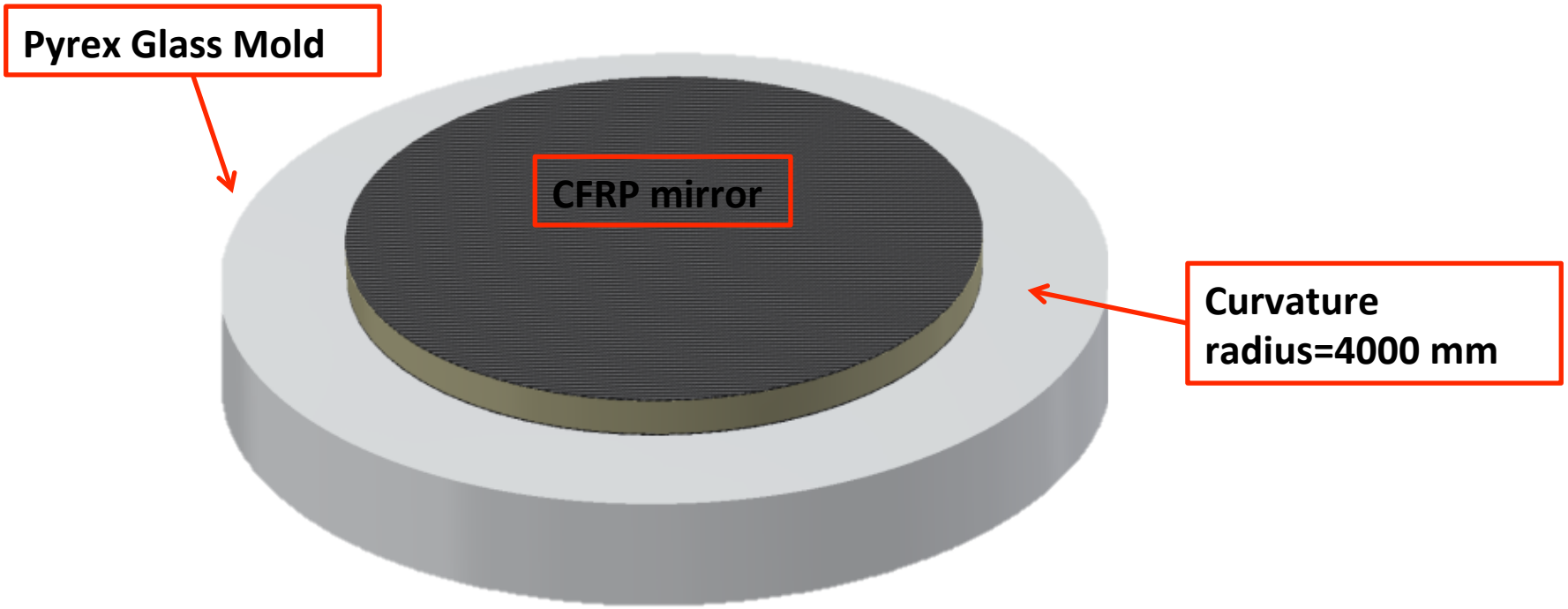


CFRP Spherical Mirror

Two mirrors demo in preparation at CMA (USA) :

- CFRP skin and rohacell core
- spherical shape, 30 cm diameter
- 1st demo: 3.5 m radius, LHCb finish, from a CMA mandrel
- 2nd demo: 4 m radius, CLAS12 finish, from the Marcon mandrel

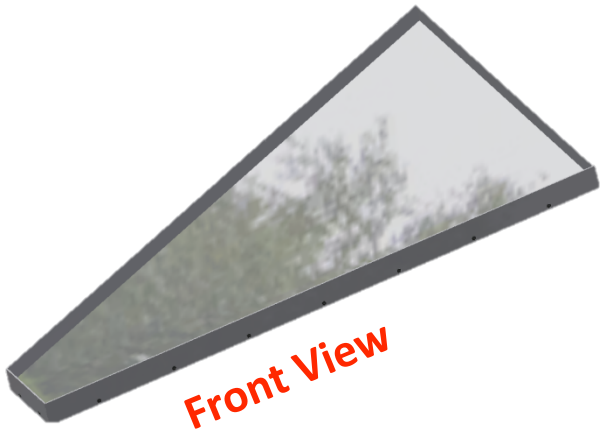
CMA can do mirror and coating up to 1.8 m diameter
prefer to produce the mirror together with support structure



Forward Glass Mirror

Two demos under preparation at Media-Lario (Italy) :

- soda-line mm glass skin and Al honeycomb core
- reinforced frame for aerogel holder
- 1st demo: 1.6 mm (standard) glass skin thicknesses
- 2nd demo: <1 mm (goal) glass skin thicknesses



Front View

Back View