

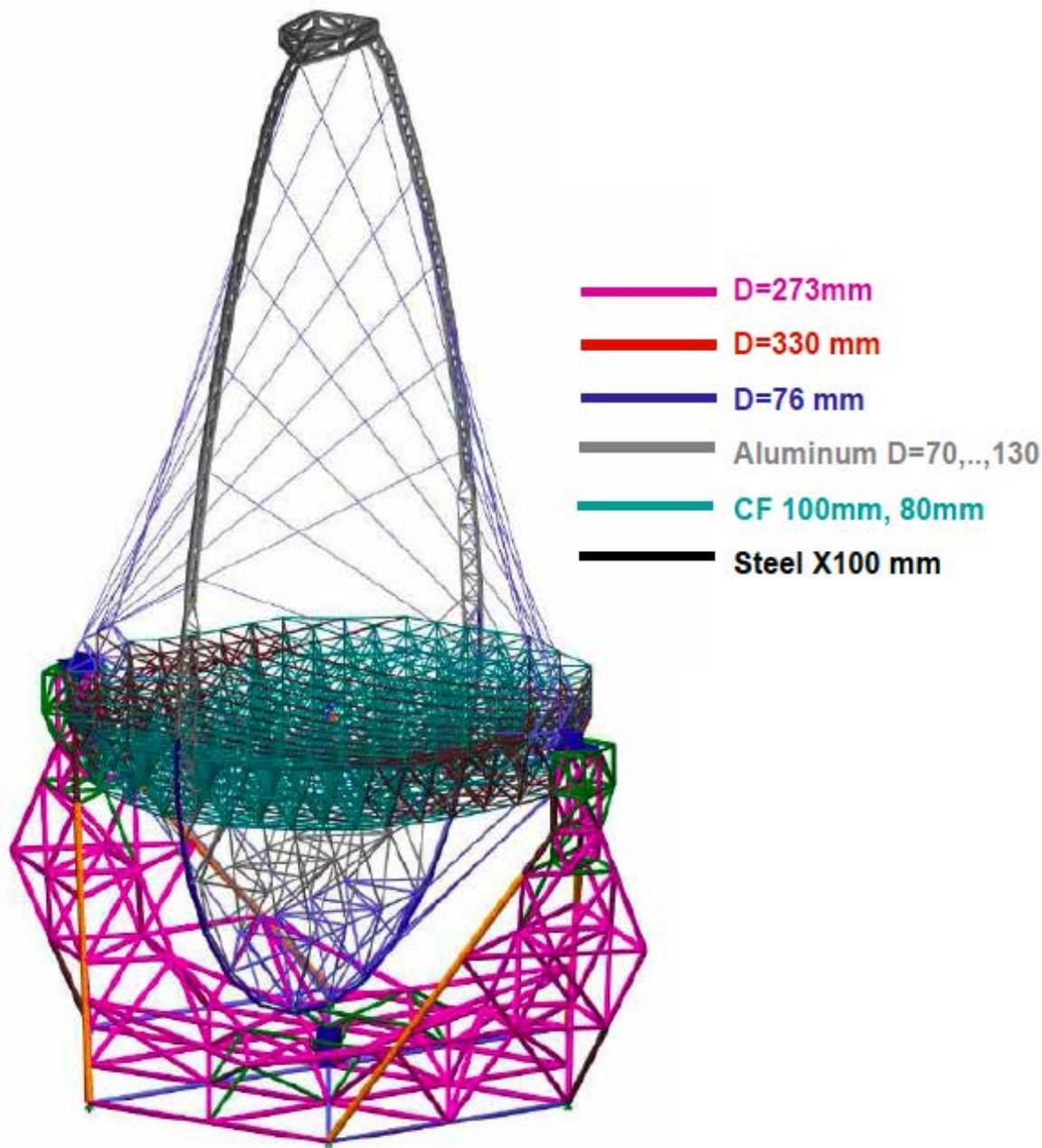
CTA 報告7: CTA-LST MIRROR 開発

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Max-Planck-Institute for Physics



LST: 23m Large size telescope design

Space frame with carbon fiber tubes



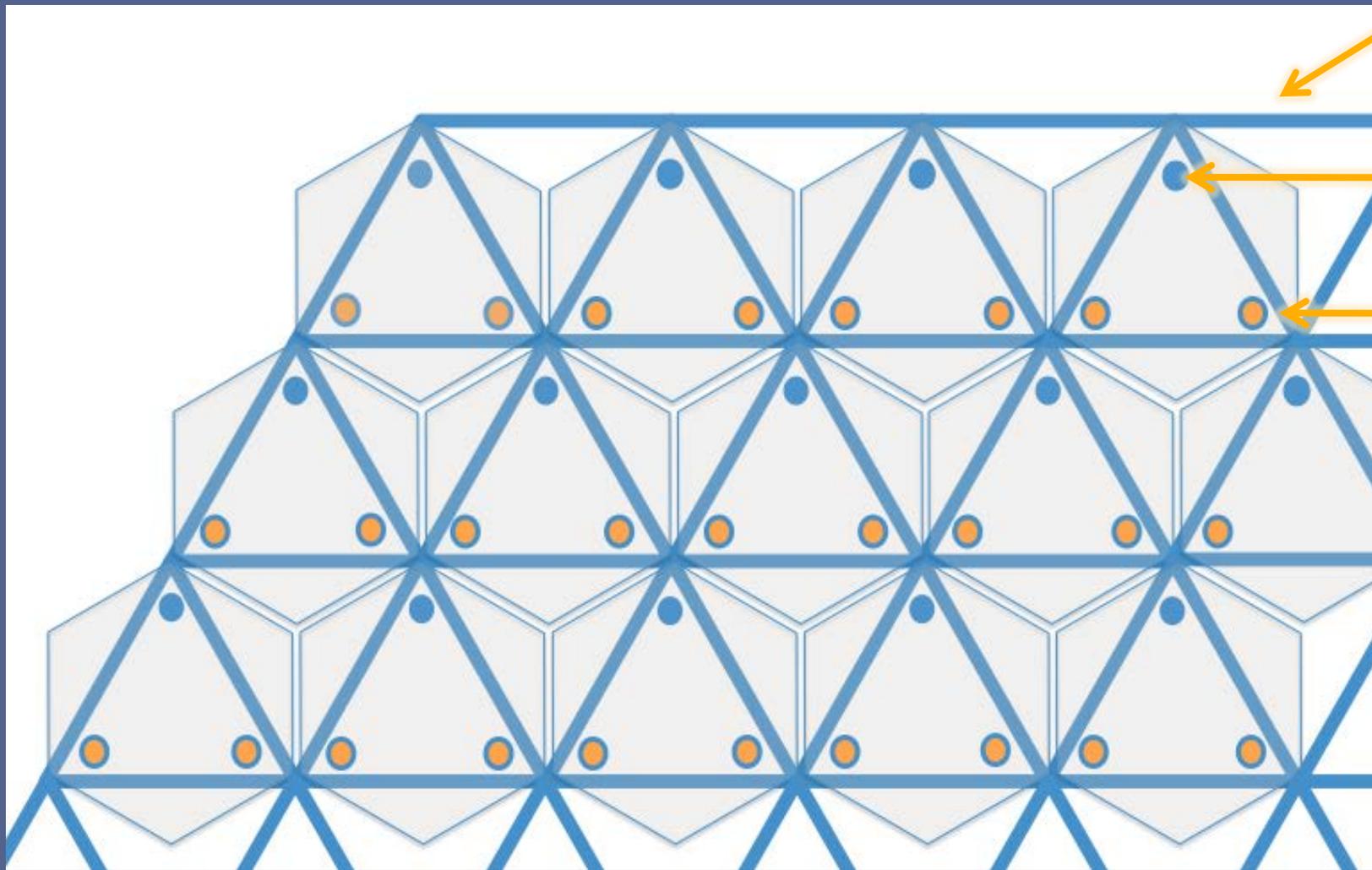
MERO beams connections

We need 200 units of
1.5m Hex mirrors / Telescope

1600 Units in total



Mirrors and Actuators on Triangular space frame



Triangular Space frame

Universal Joints

Actuators

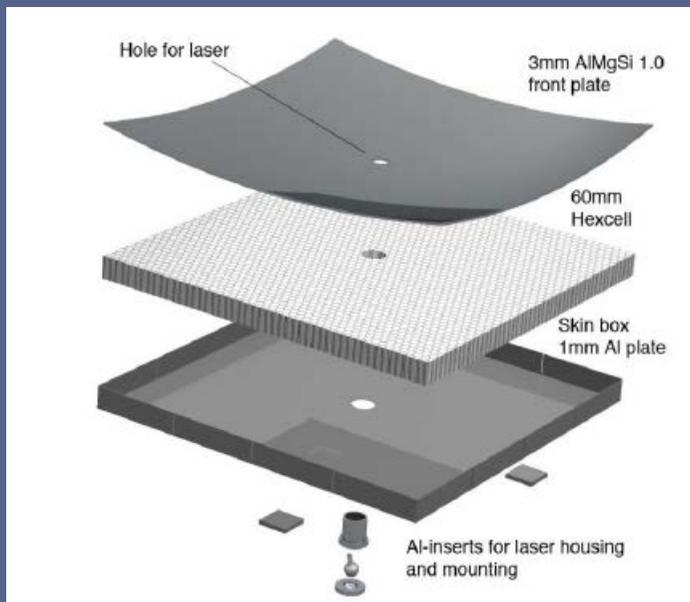
LST-Mirrors:
1.5m (flat-flat)
Hex shape
2m² area

MST-Mirrors:
1.2m (flat-flat)
Hex shape



Mirror Production Technique

1.5m, 1.2m size mirrors for LST, MST



Experience in M-I, M-II
Long lifetime
Expensive ~3KEuro/m²

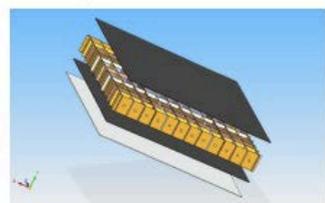
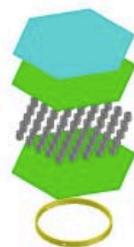
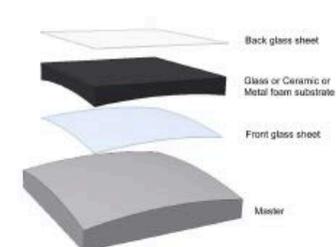
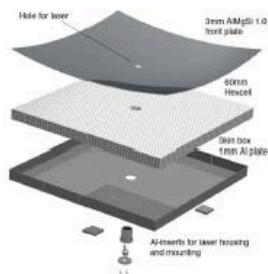
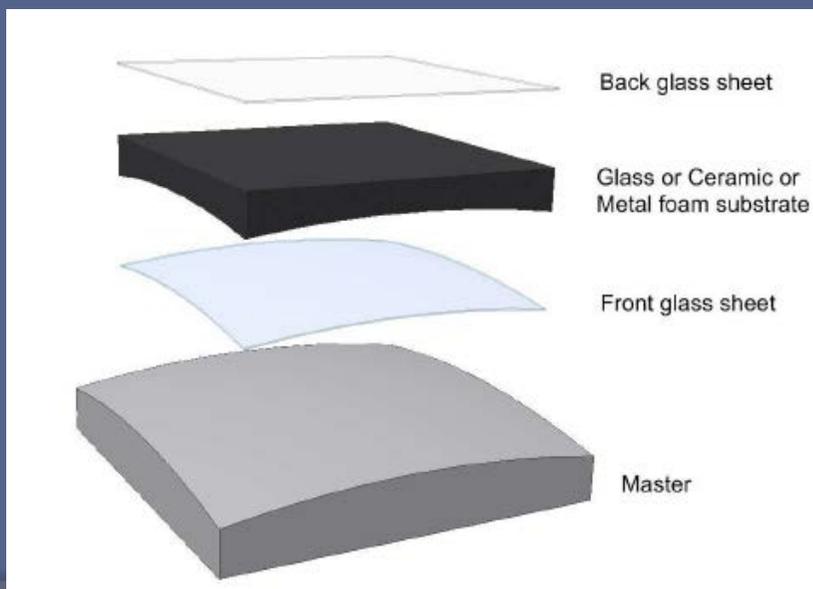


Figure 39: Various mirror types under consideration for CTA: **top:** Diamond-milled aluminium honeycomb mirrors. **middle left:** Cold slumped glass-foam sandwich mirrors. **middle right:** Open fibre-reinforced plastics mirror (carbon fibre or glass fibre). **lower left:** Carbon-fibre composite mirror with CFRP honeycomb. **lower right:** Carbon-fibre composite mirror produced with SMC technology.



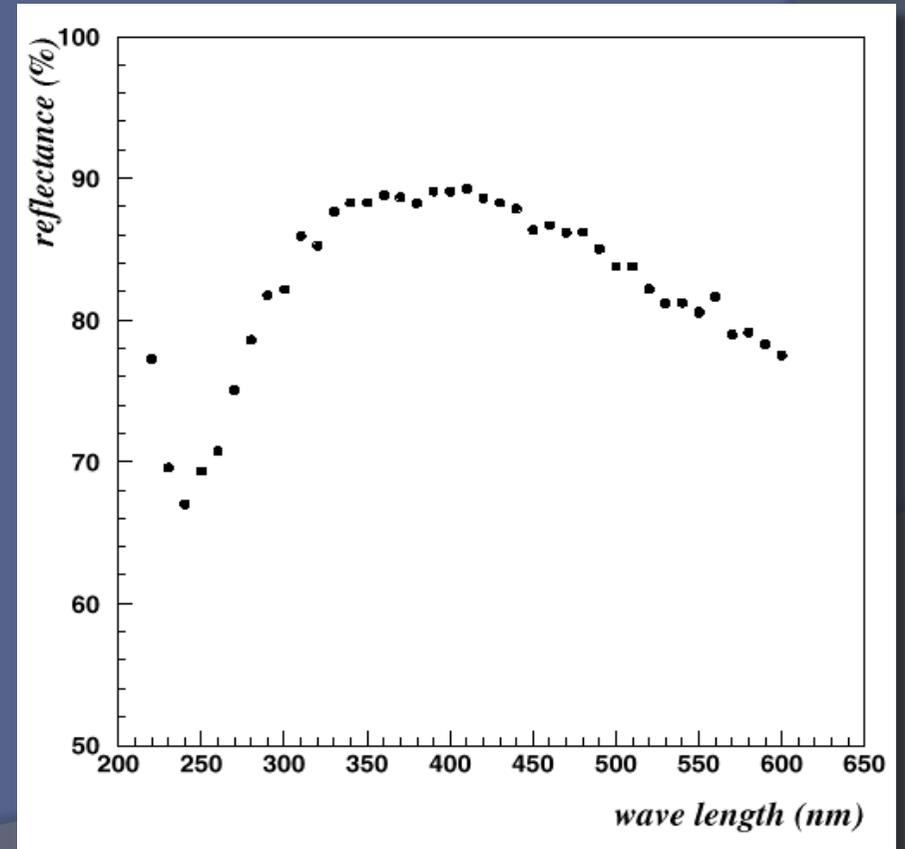
Experience in M-II
Cheap ~1.5KEuro/m²



Sanko - ICRR: Our past cooperation

600mm flat-flat Hex shape mirrors are produced for Utah Seven TA, TA

200 mirrors for Utah seven TA,
500 mirrors for TA (too good for TA)





Recent large size mirror productions by Sanko

2.0m x 1.8 m spherical mirrors



3.15m x 2.83m spherical mirrors



For the process of LCD Panels



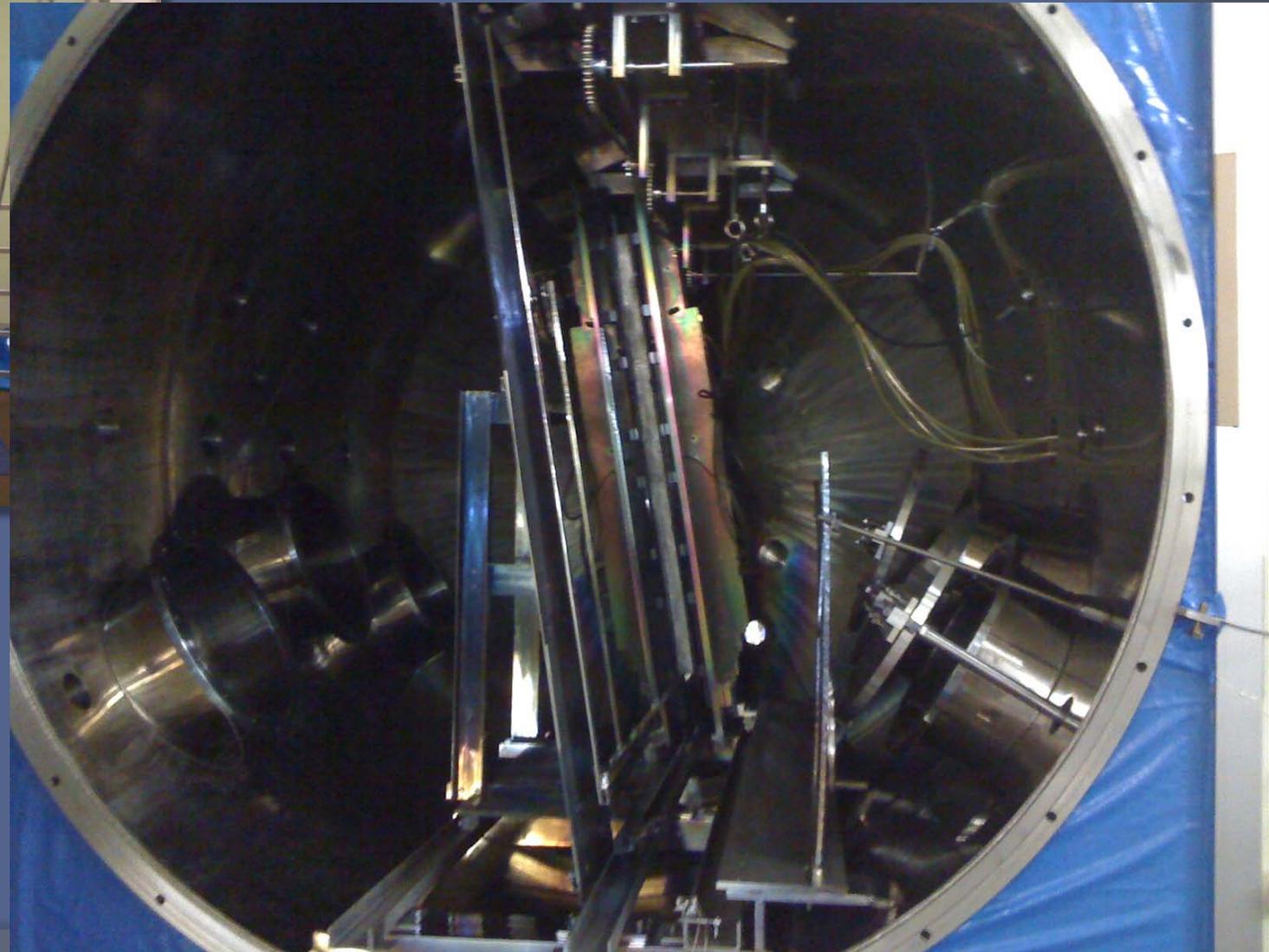
Chamber for spattering coating up to 2.00 x 2.20m mirrors





Chamber and Spattering machine

Considering Al, SiO₂, HfO₂ spatterings in this chamber





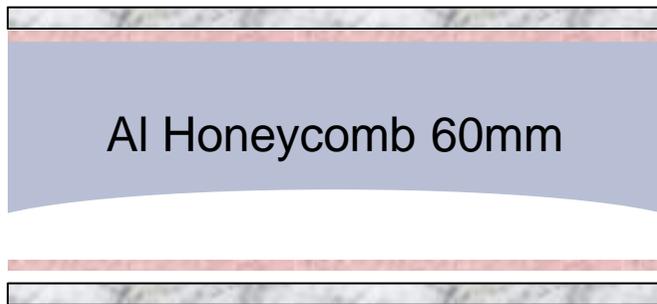
Requirements for LST mirrors

- Hex shape spherical mirror of 2m²
 - Hex shape 1510mm face to face
- Focal Length $\sim (D/23m) \times (F/1.2) = 27.6 (F \times D) \text{ m}$
 - Radius of curvature $\sim 55,200 \text{ mm}$
 - Sag at the center of mirror $\sim 5.16 \pm 0.05 \text{ mm}$
- Spot size $< 0.03 \text{ degrees} \sim 17\text{mm}$
- Aging $\sim 10\text{yrs}$
 - possibly multi-layer coating with sputtering method
 - Possible solution: SiO₂ + HfO₂ coating
- Light Weight
 - $< 20\text{kg/m}^2 \sim 0.3\text{g/cc}$ (float on water !!)
- Target cost $\sim 3000 \text{ Euro} / 2\text{m}^2$
- Possible structure/production solutions
 - Replica method with cold slump technique (glass + Al honeycomb + glass)
 - Diamond milling with all aluminum structure (Al + Al honeycomb + Al)



Sanko tried cold slump technique

Press for 24 hrs



Al Honeycomb 60mm

Glass sheet 3mm
Glue (Hysol)

Glass sheet 3mm
(surface)



Mold (R=55.2m)

Milling of Al-Honeycomb surface



Mold R=55.2m after machining





50cm x 50cm prototype mirror (R = 30m) at Sanko
3mm Glass + 60mm Al-honeycomb + 3mm Glass
Al-Nd, SiO₂ coating





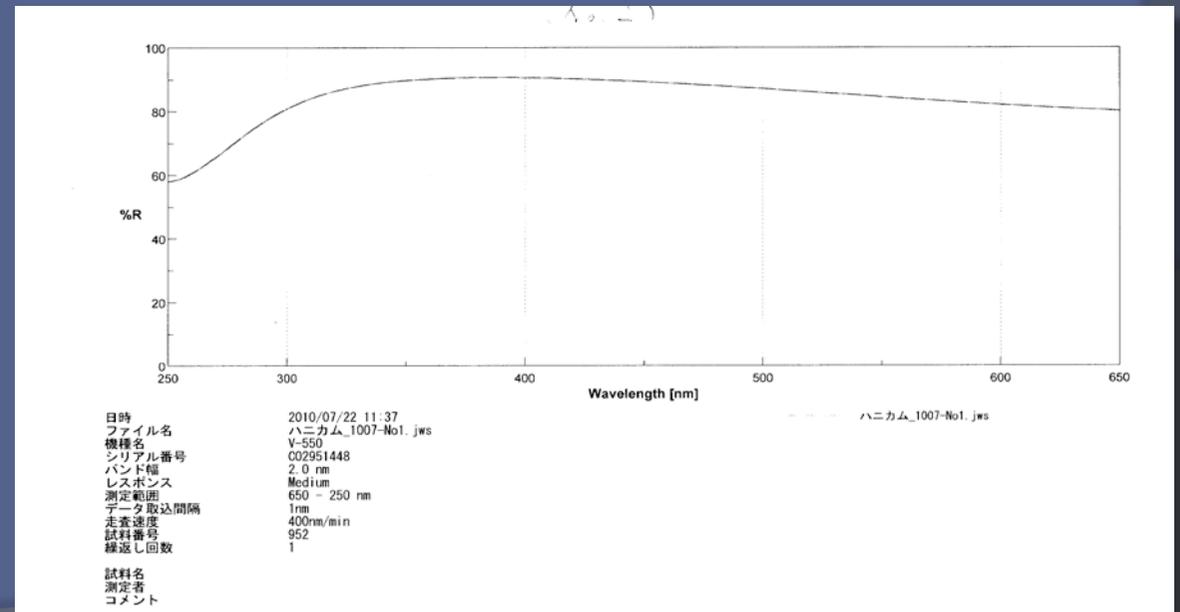
The reflected image near the R





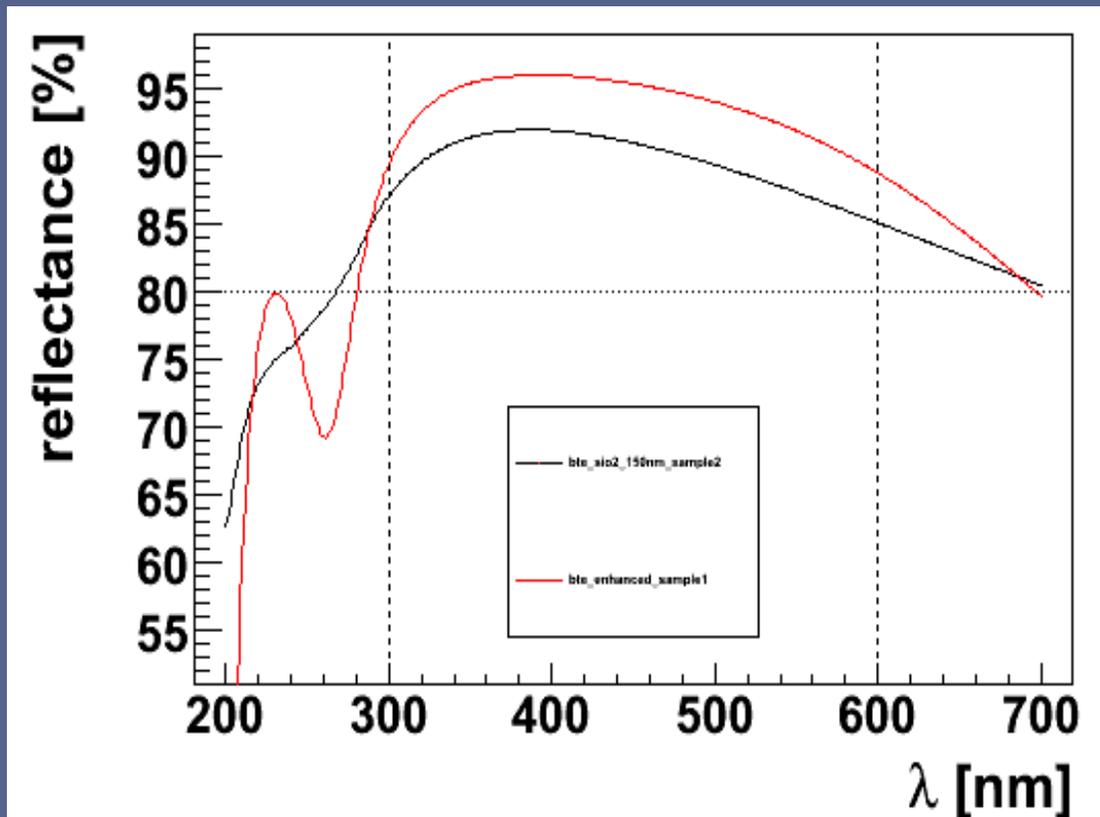
Prototype Mirrors with Cold Slump Technique

- The prototype mirrors of 50x50cm, $R=30m$ were successful made
 - Image of Sun looks nice
 - Reflectivity of 92% is OK
 - Two mirrors were delivered to MPI, ICRR for the optical quality tests (PSF, Temperature cycle, etc.)





SiO₂+HfO₂+SiO₂ multicoat



- New coating developed for HESS re-coating
- Longer life time than simple SiO₂ coating
- High Reflectivity 95%



Critical Paths

- Prototyping LST, MST mirrors
 - Size 1.5m Hex, $R=55.2\text{m}$, $f = 27.6\text{m}$
 - Size 1.2m Hex, $R=32\text{m}$, $f = 16\text{m}$
- Series of Production
 - Check stability and reproducibility (~20 Units)
- Critical tests
 - Test in temperature cycle (acceleration test)
- Coating for long life
 - Spattering Machine for SiO_2 , HfO_2 multi-coat
 - Measure life time at the sites
- Other technical issues
 - Inexpensive Glues
 - Water sealing, Field test