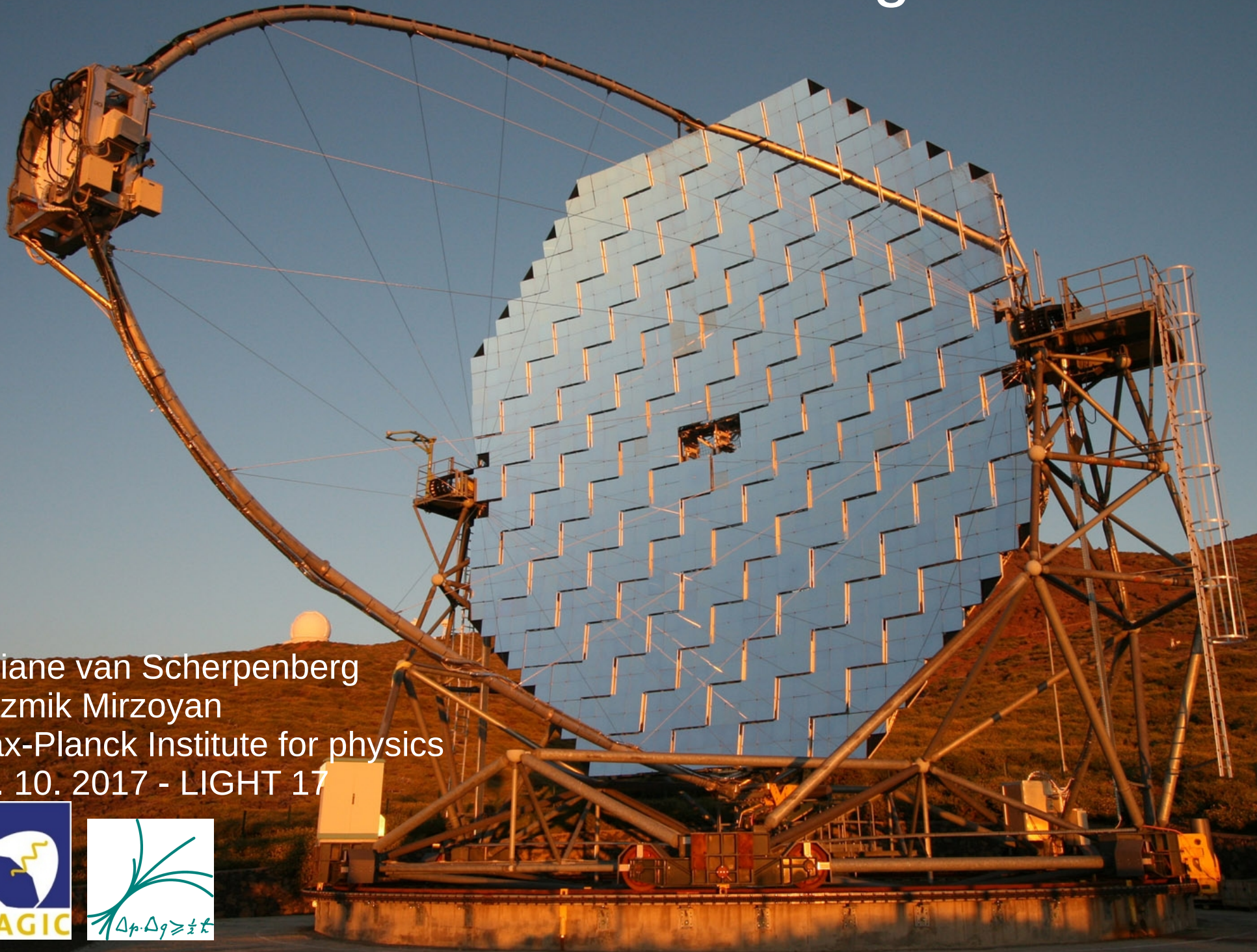
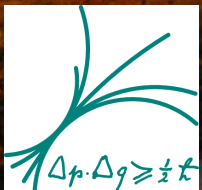


Novel back-coated ultra-thin glass mirrors



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20. 10. 2017 - LIGHT 17



Outline

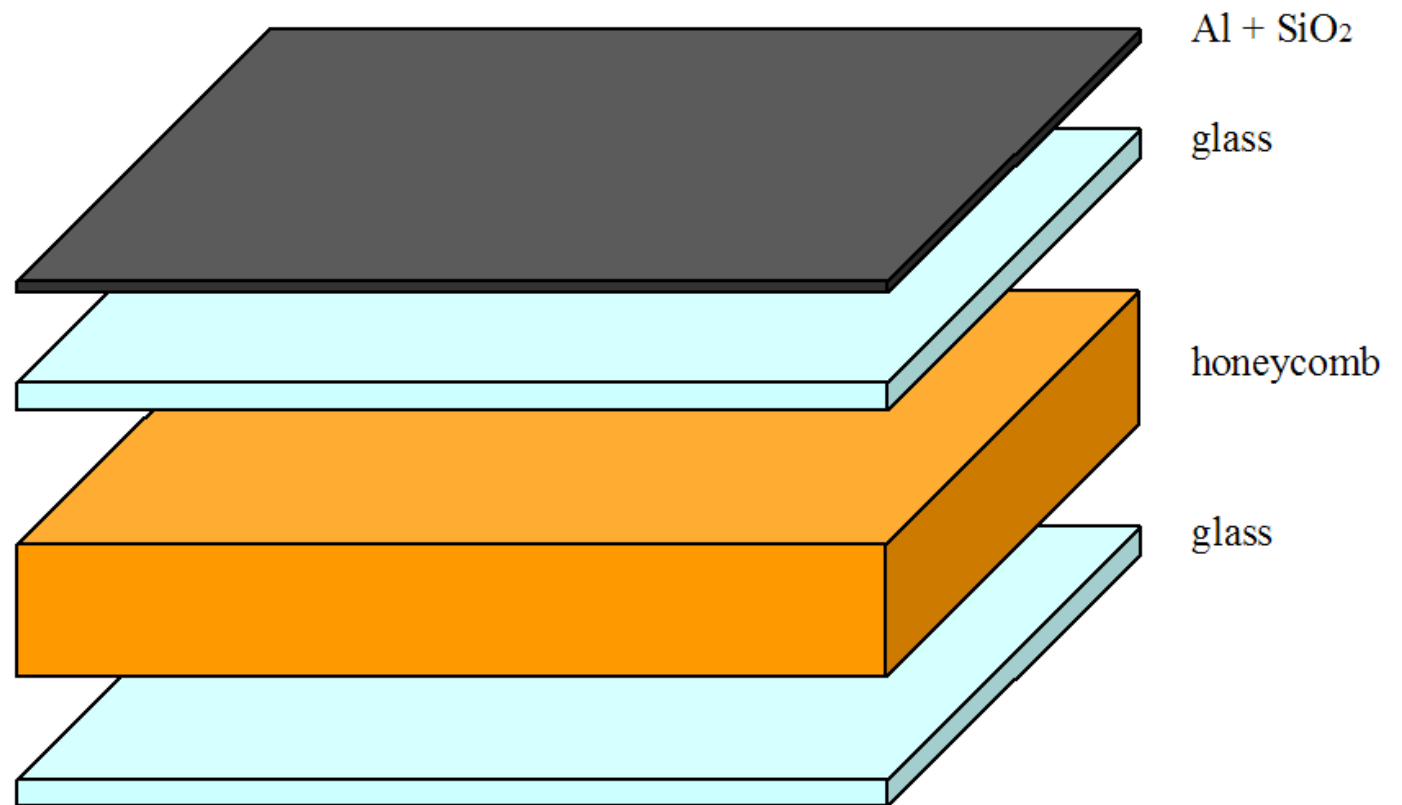
- Motivation for a new glass mirror design
 - Typical design of glass mirrors
 - Problems with the material
 - Problems with maintenance
- Possible Solution: Back-coated ultra-thin-glass mirrors
- State of development
- Outlook



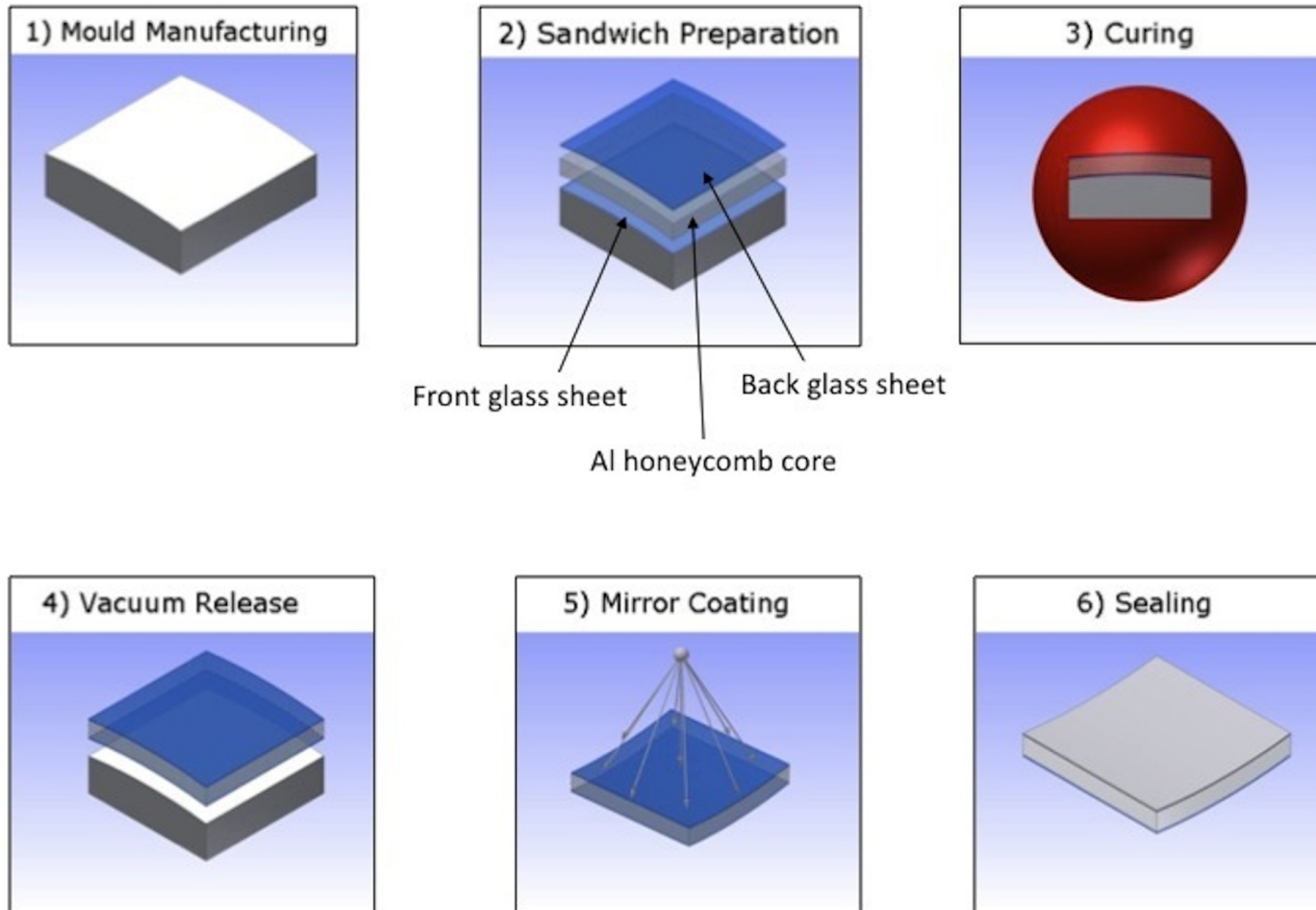
Motivation for a new glass mirror design

Typical design of MAGIC glass mirrors

Produced by *Cold Slumping* Technology developed by G. Pareschi (INAF-OAB) and Media Lario (*arXiv:1211.3577*)



Cold Slumping



Motivation for a new glass mirror design

Problems with the material

- Acid enters with rain water through micro cracks in SiO₂-layer
- Chemical reactions with aluminum lead to degradation of reflectivity
- After ~3 years clear spots are visible on mirrors





Improvement: Multilayer coating

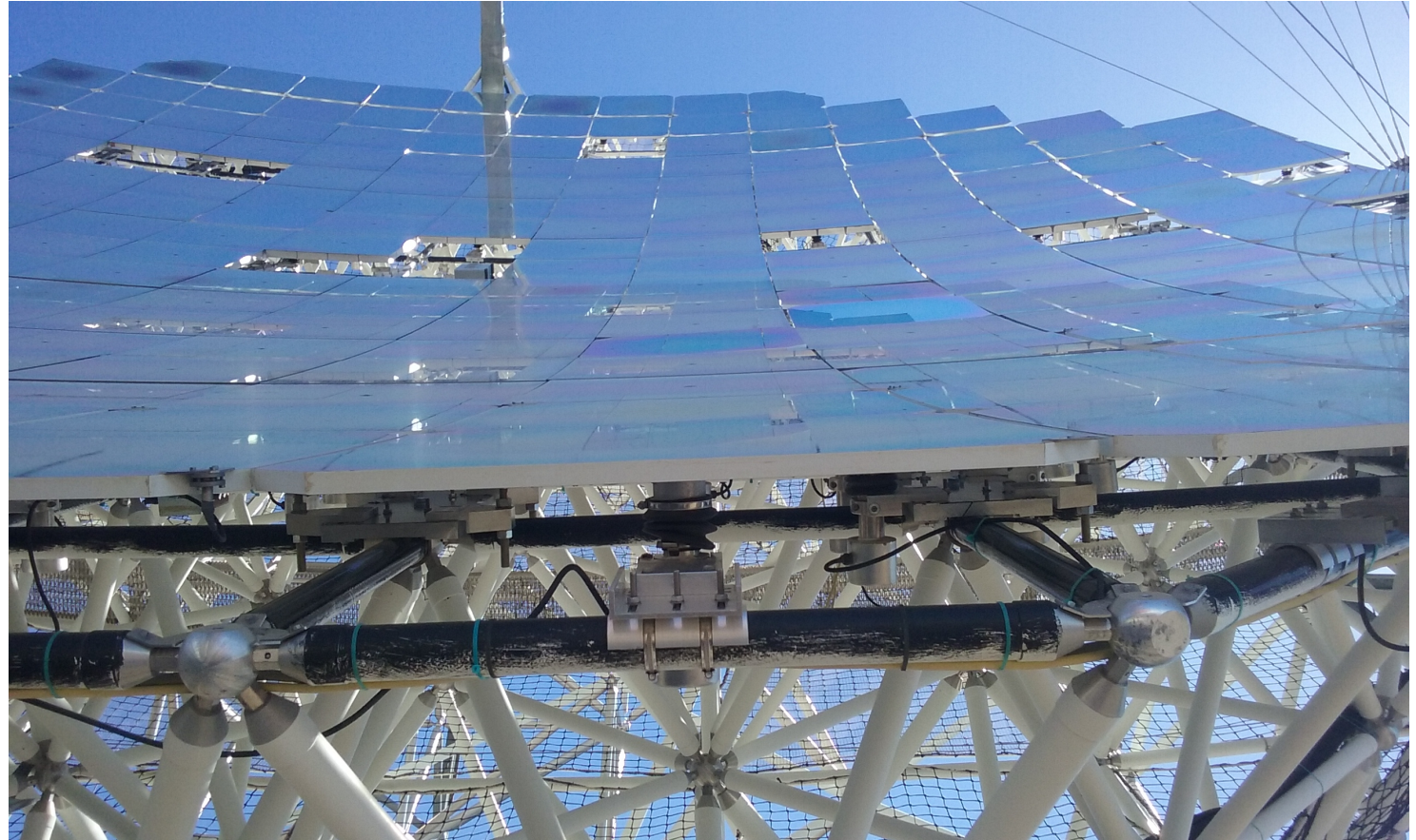
- Mirrors developed for CTA LST produced by Sanko
- Multilayer-coating: Cr-Al-SiO₂-HfO₂-SiO₂
- Applied with sputtering technique
- Reflectivity of $\geq 93\%$ at 400nm through optimal thickness of respective layers
- Very stable under temperature and humidity variations
- Exposed to environment at rooftop of Tokyo University → About 1% loss of reflectivity per year
- Possible lifetime of 10 years

But one problem remains...



Cleaning the mirrors

After Kalima mirrors are covered with dust



Motivation for a new glass mirror design

Problems with maintenance

- Dust particles stick to mirror surface and need to be removed
- Wiping is impossible – would scratch the surface
- Use water and special detergent
- Still after 3-5 years mirrors has to be properly cleaned:
- Detachment, transport to facility, removing layers, wash & dry (clean room), reapply layers, transport back, reattach and readjust
- Very large effort in time and cost



Possible Solution: Back-coated ultra-thin-glass mirrors

- Take thin layer of glass (100-200 μm)
- Back-coat it with aluminum reflective layer
- Glue to glass at back

Advantages:

- Glass layer protects effectively from entering humidity and acid
- Dust particle can be simply swiped of without scratching the mirror

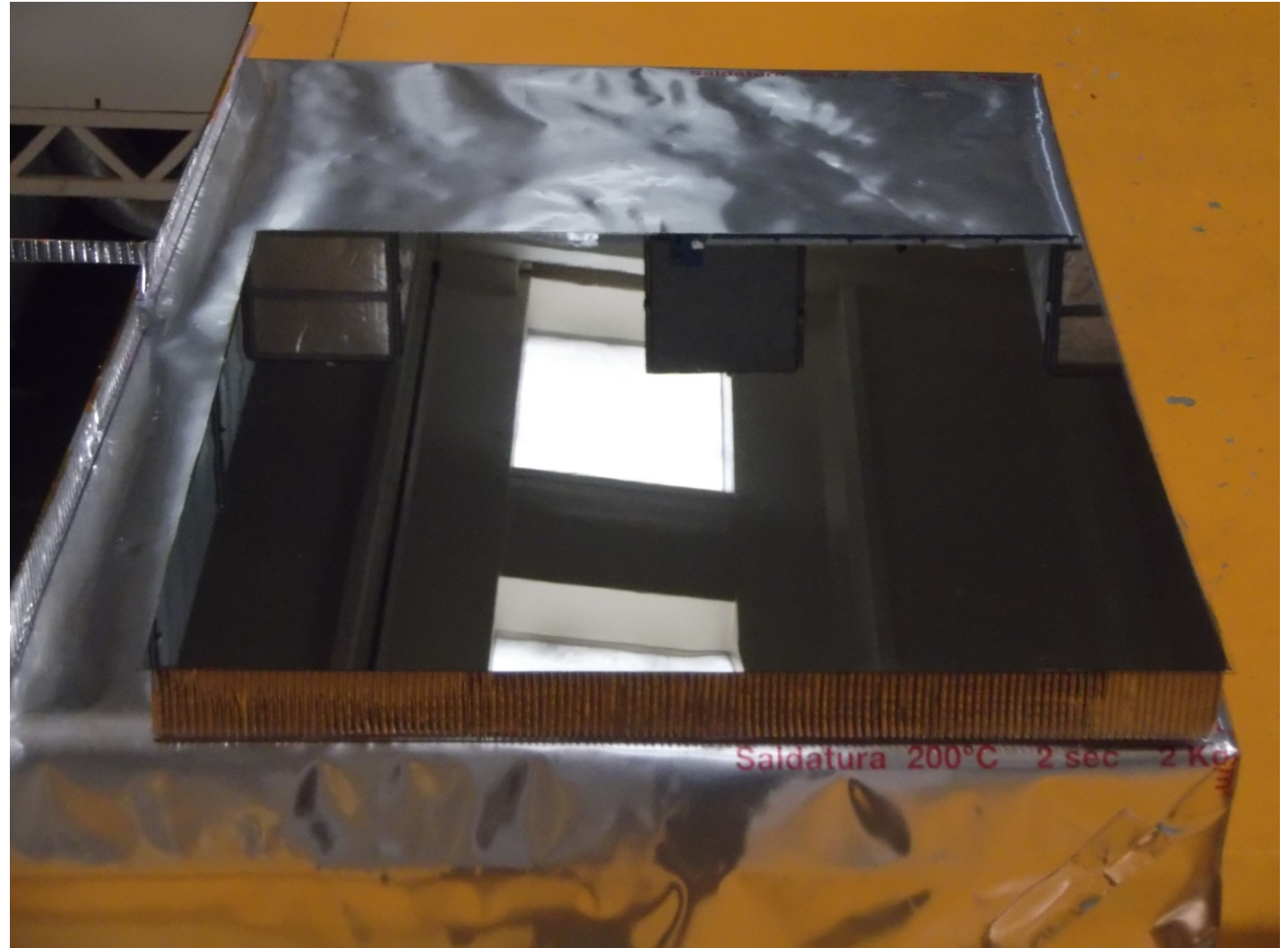
Difficulties:

- Avoid dust and air bubbles when gluing the ultra-thin glass sheet
- Protect edges of the mirror (covering glass layer very delicate – breaks easily, seal sides to prevent humidity from entering)



State of development

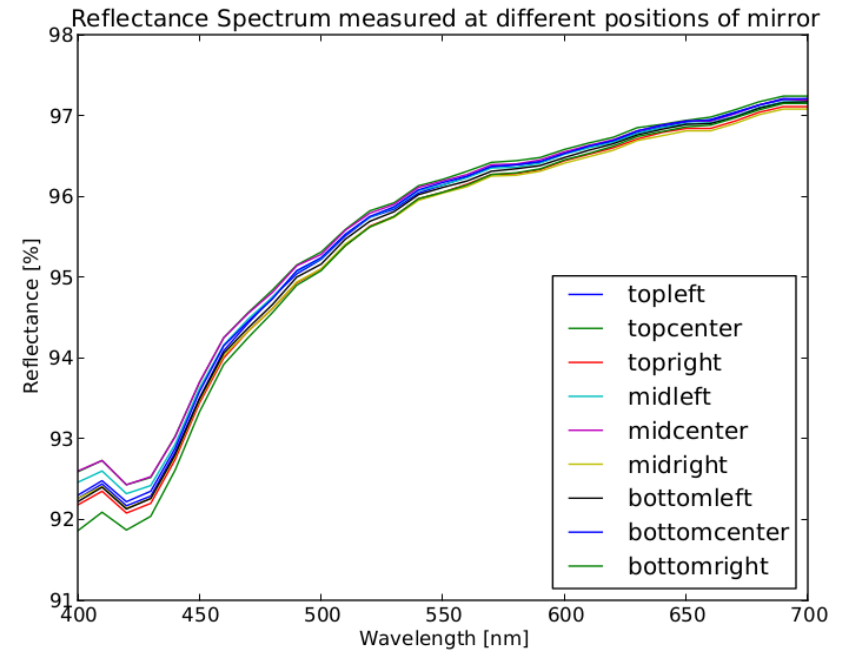
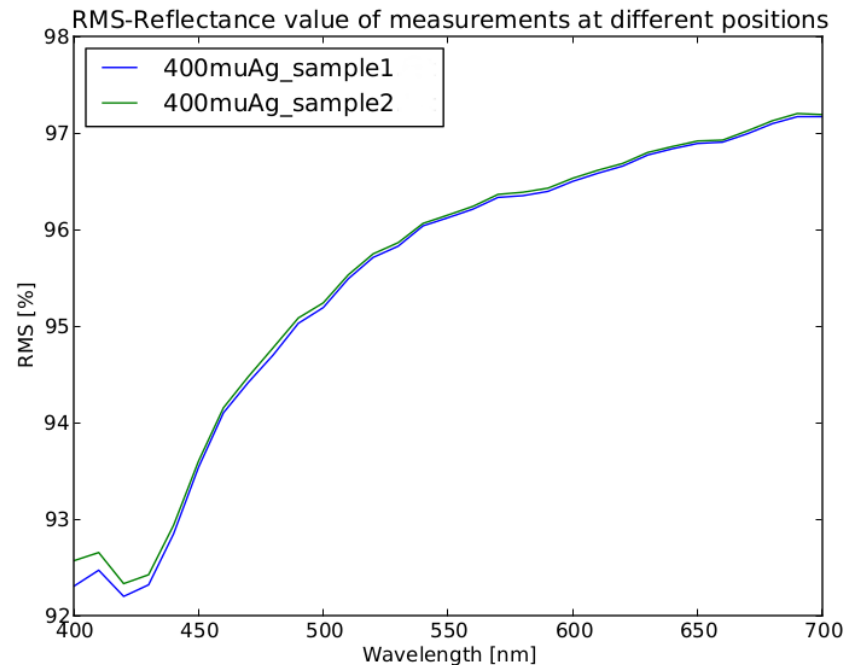
40cm x 40cm
spherical back-
coated mirror
sample
produced by
Media Lario
with the MAGIC
mold form



State of development

Reflectivity measurements of small size samples (20cmx20cm) produced by MediaLario

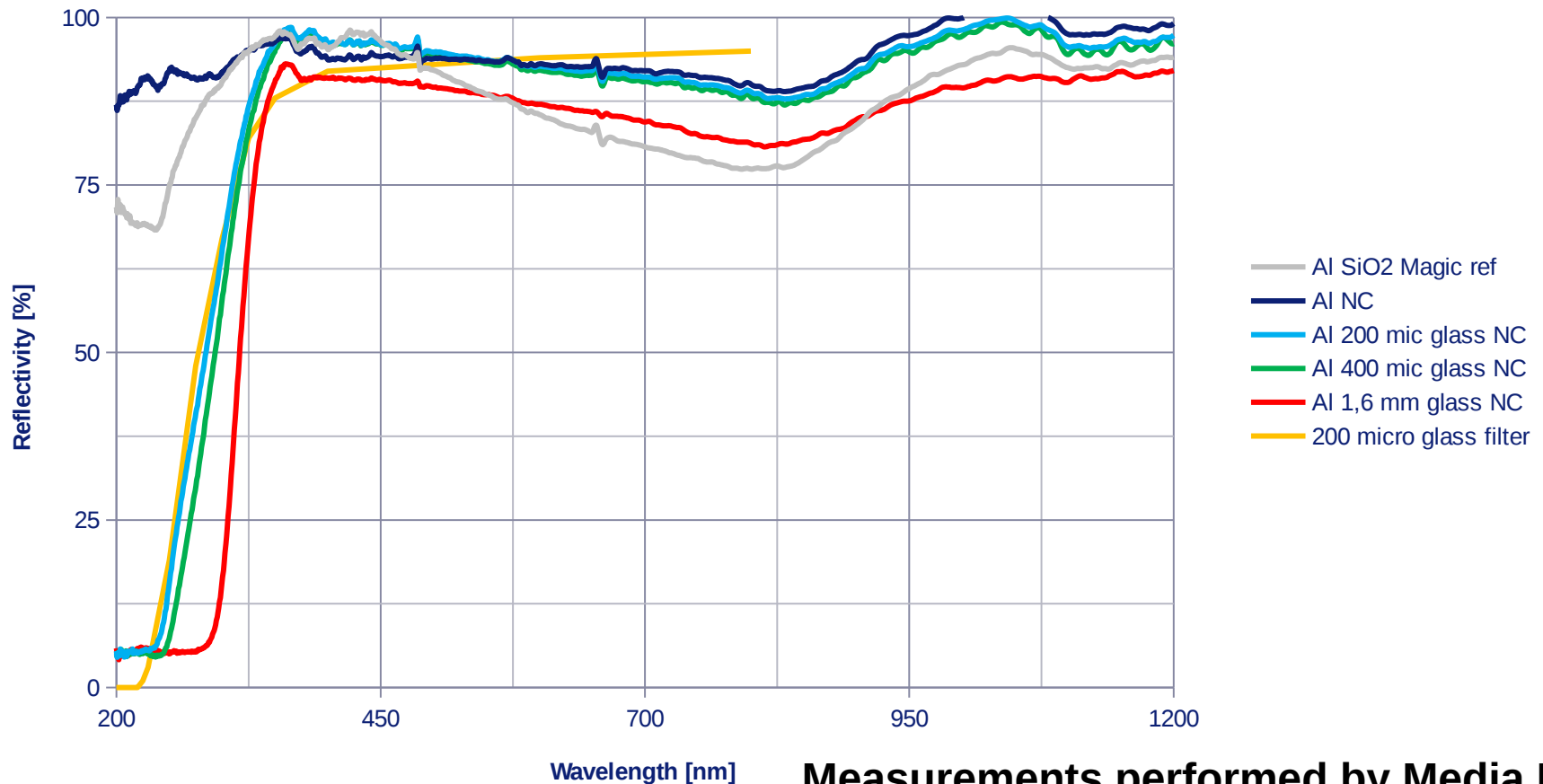
400µm glass sheet back-coated with silver



Reflectivity $\geq 92\%$

State of development

Al coating: Non contact reflectivity measurements



State of development

- Light absorption by glass is minor issue
- Different types of glass exists depending on requirements:
 - Highly scratch resistant (Gorilla glass by Corning)
 - highly flexible (Willow Glass by Corning)
 - highly UV-transmitting (Fused Silica)
 - ...



Outlook

- Up to eight more samples in larger sizes (1sqm) will be produced until the end of this year
- Evaluations will be performed concerning
 - Stability under extreme temperatures
 - Quality of reflectivity and focus
 - Long time weather resistance
 - Ultimate test: install on MAGIC telescopes – evaluate after ~6months

If this technology succeeds a major improvement in the lifetime and maintenance of MAGIC/CTA mirrors can be obtained

