Cold-slumped glass mirrors

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Outline

- Description of the Cold-slumped glass technology
- The MAGIC glass panels
- The Middle Size Telescope mirror prototypes for CTA
- Future goals

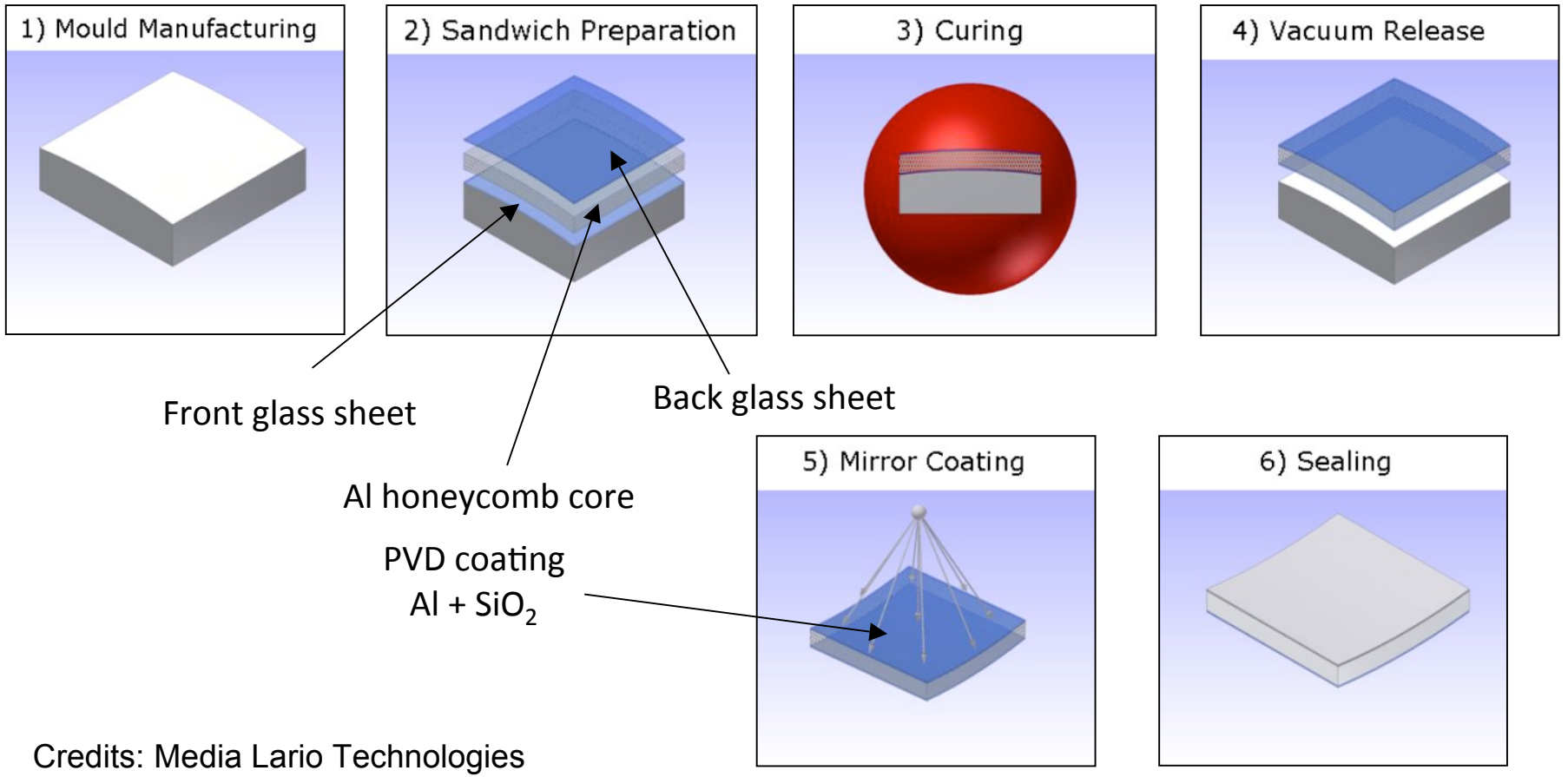
Cold glass slumping technology

- It is based on the concept of bending a thin glass sheet onto a precise machined mould.
- The bending is done through a vacuum suction.
- Finally, on this glass is glued a stiffening structure – Al honeycomb – and a second glass sheet.
- After the polymerization of the glue this “blank mirror” is coated with Al+SiO_2.

This technology is a spin-off on an INAF idea and developed by the Media Lario Technologies company.

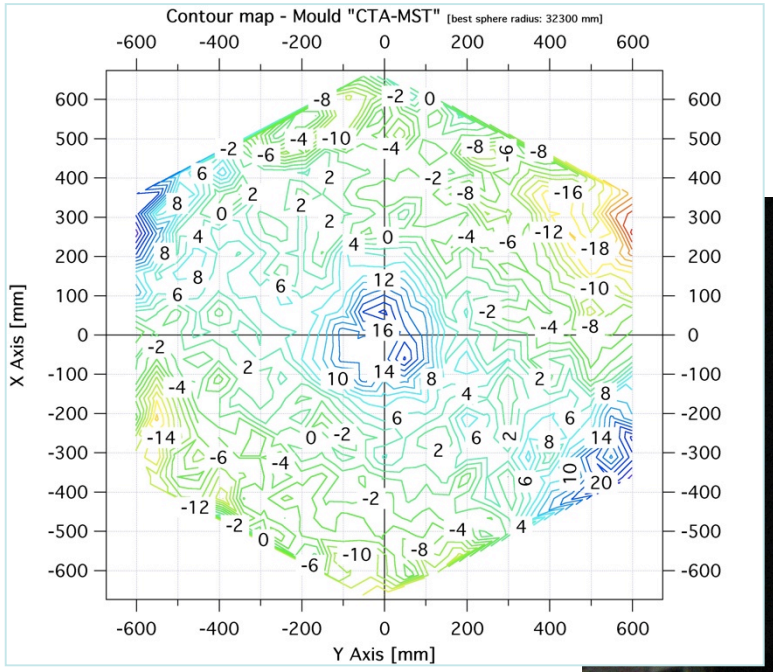
References: Pareschi, Giro et al. – SPIE Proc. 7018-0W, 2009

Production method

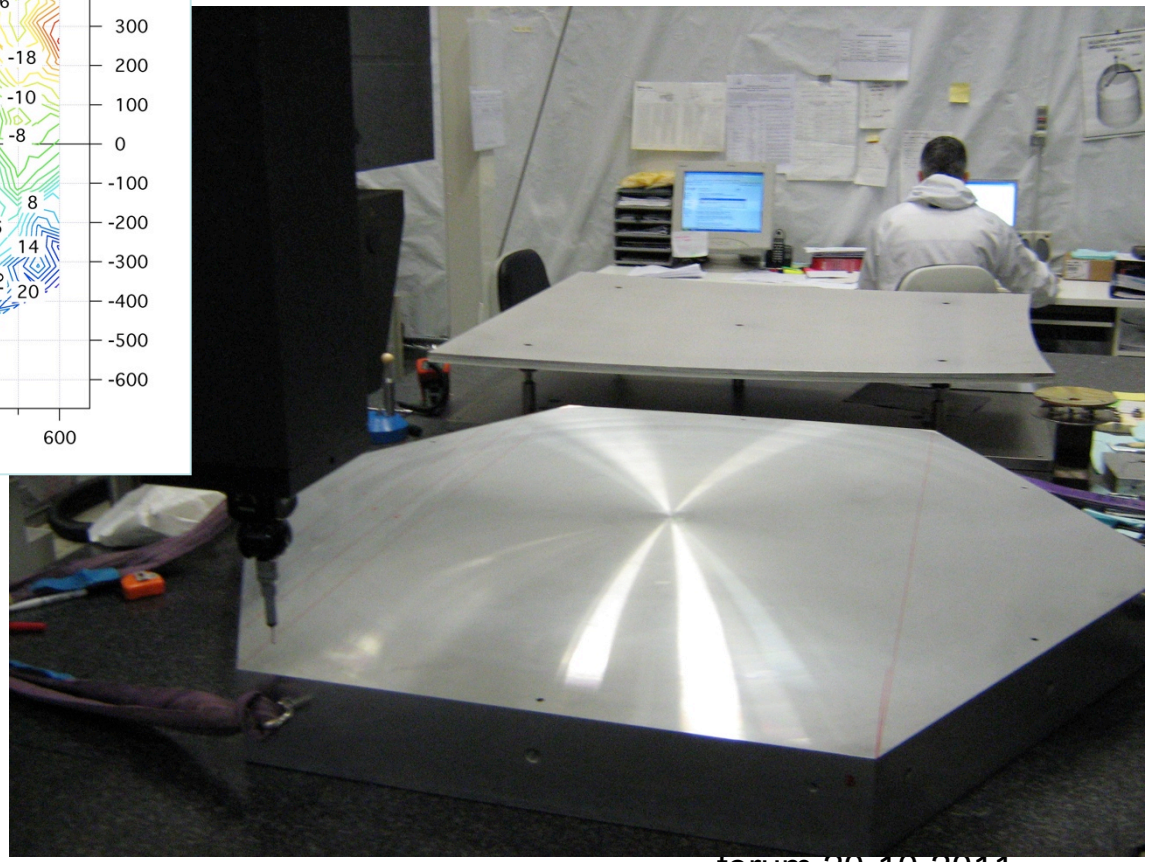


Credits: Media Lario Technologies

Mould manufacturing



Mould obtained by diamond milling technology. Errors in surface and shape must be of the order of the target results



sphere radius ~ 30000 mm
Typical PV error ~50 μm
Typical rms ~ 8 μm

Results in replicating the mould

- The shape of the master is replicated by the reflecting glass sheet.
- with large curvature radii the glass sheet can be elastically deformed and pressed against the master using vacuum suction.
- A backing glass sheet is assembled with an interposed aluminum honeycomb core element giving the proper rigidity.
- A careful control of the spring-back effect during the gluing process, permits to obtain several mirrors with curvature different than the mould

Gluing process

The gluing process is one of the most critical phases of the procedure.

Keypoints to get a good replica of the master shape are:

- Choice of the glue type
- capability to apply a uniform bonding layer

Main characteristics of the glue must be:

- Low percentage shrinkage, in the order of 0.1 % or less
- UV resistant
- wide range of operational temperature

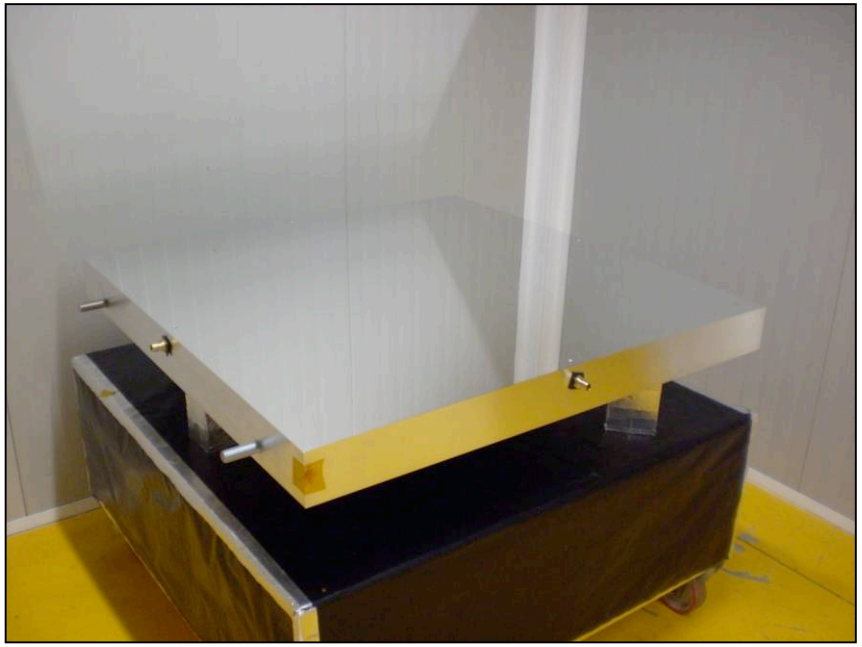
the typical gluing is performed with epoxy resin structural adhesive bonding with curing under elevated temperature while maintaining the vacuum suction.

Coating

- After the polymerization of the glue a coating can be applied to make the glass surface reflecting and hard to environmental conditions.
- Typical coating applied is Al+SiO_2
- Cleaness of the glass is important to have a good adesion of the coating on the surface.
- Thickness of the quartz permits fine tuning of the peak of reflectivity
- Homogeneity in quartz coating is needed to obtain an uniform bandpass on the full surface of the mirror.
- Sealing of the mirror is performed only after coating

The “MAGIC” experience

Panels produced for Magic II

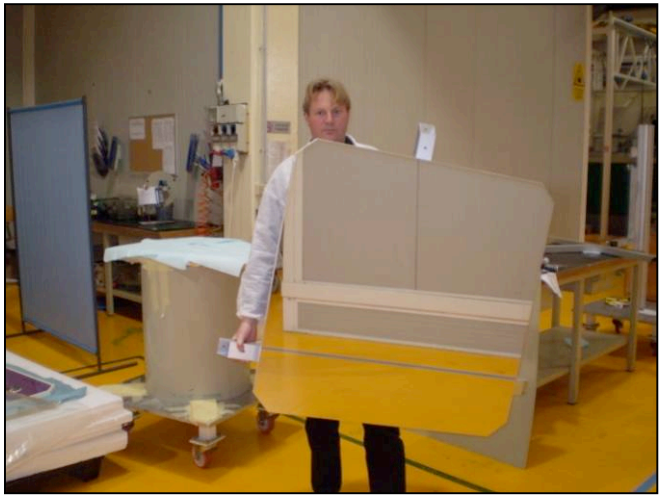


Aluminum master 1040 x 1040 mm

Front and rear of a produced segment

Size = 985 x 985 mm Weight = 9.5 Kg.

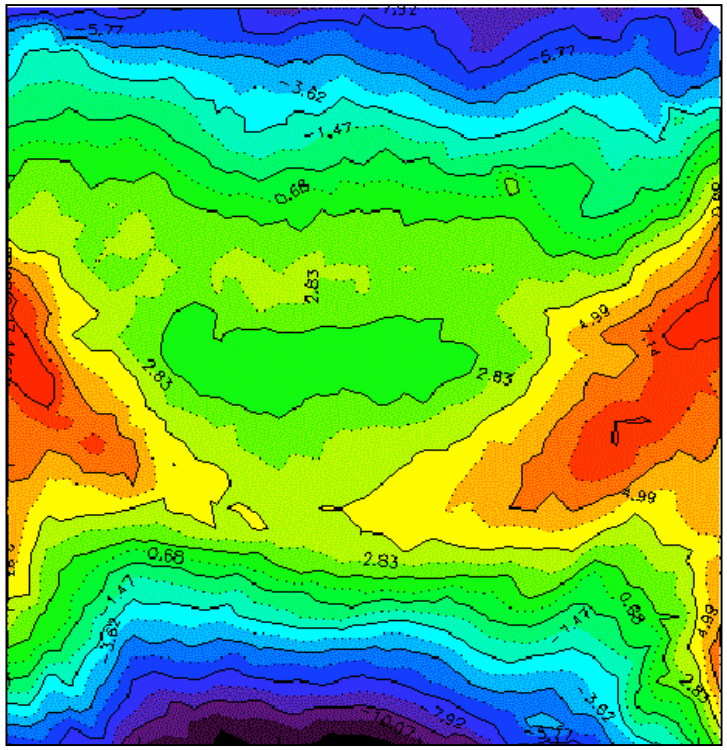
Nominal radius= 35 m



Credits: Media Lario Technologies

Surface mapping with 3D machine

Aluminum master



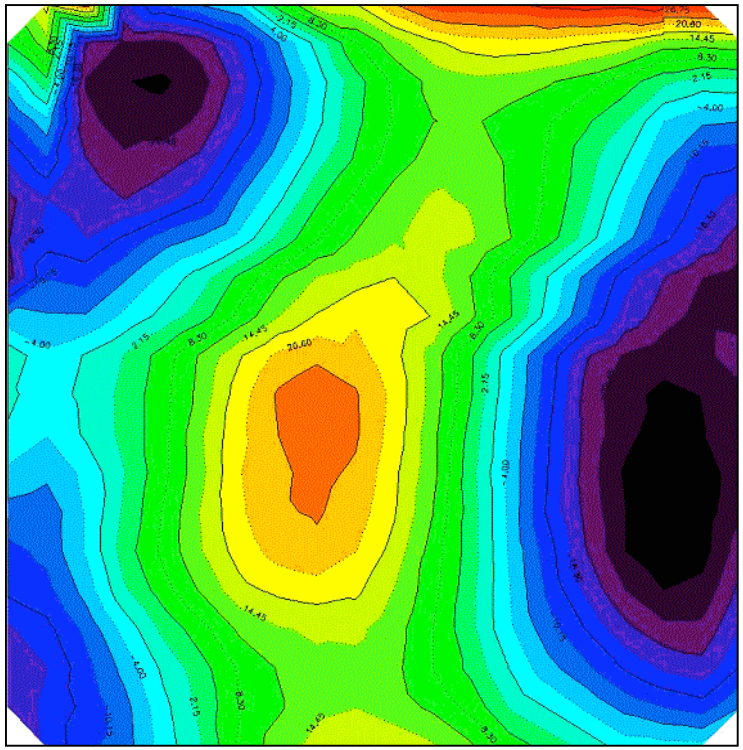
(The color palette is inverted on this surface)

Points: 392

P-V: 21.5 µm

RMS: 4.6 µm

Typical mirror segment



Points: 392

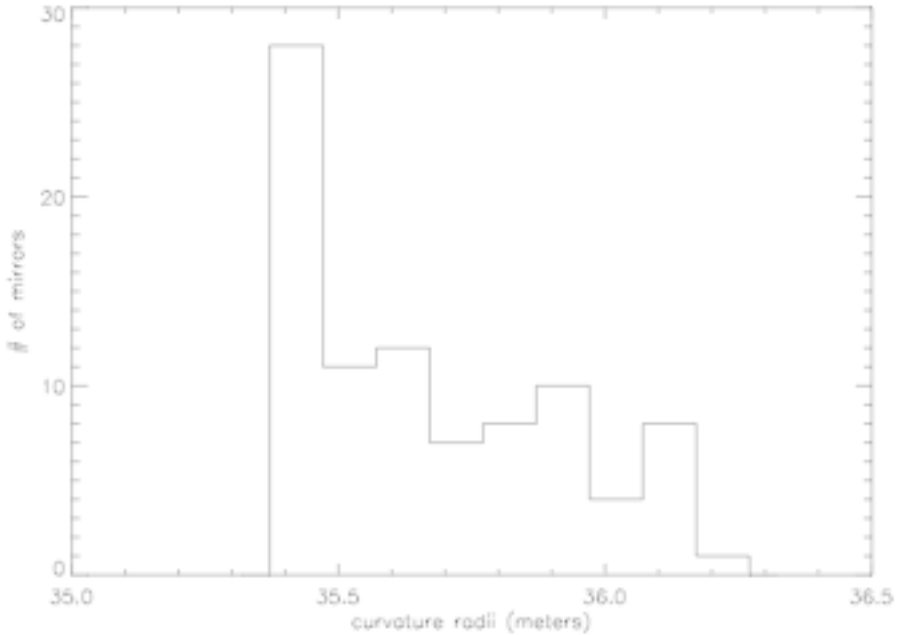
P-V: 62.3 µm

RMS: 15.3 µm

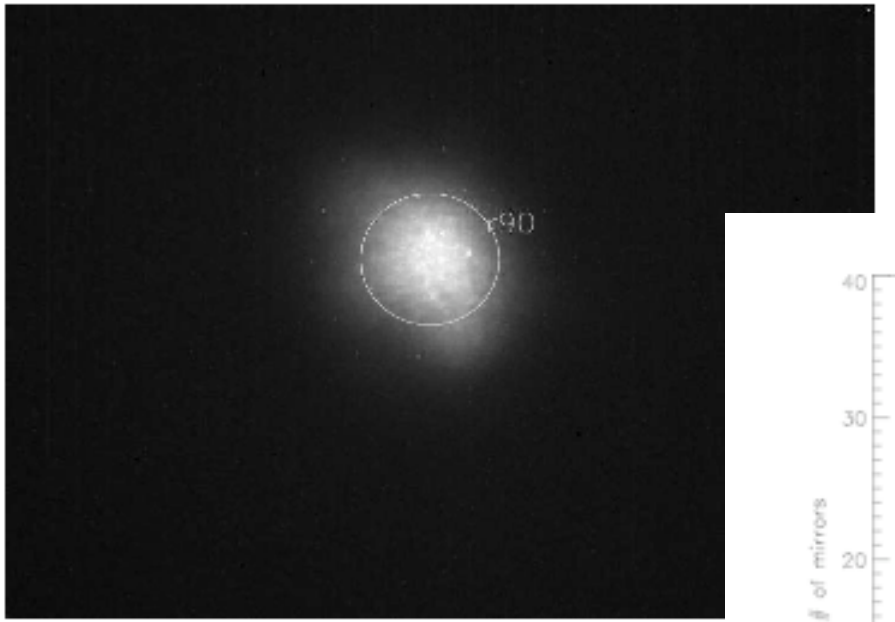
Curvature radii distribution

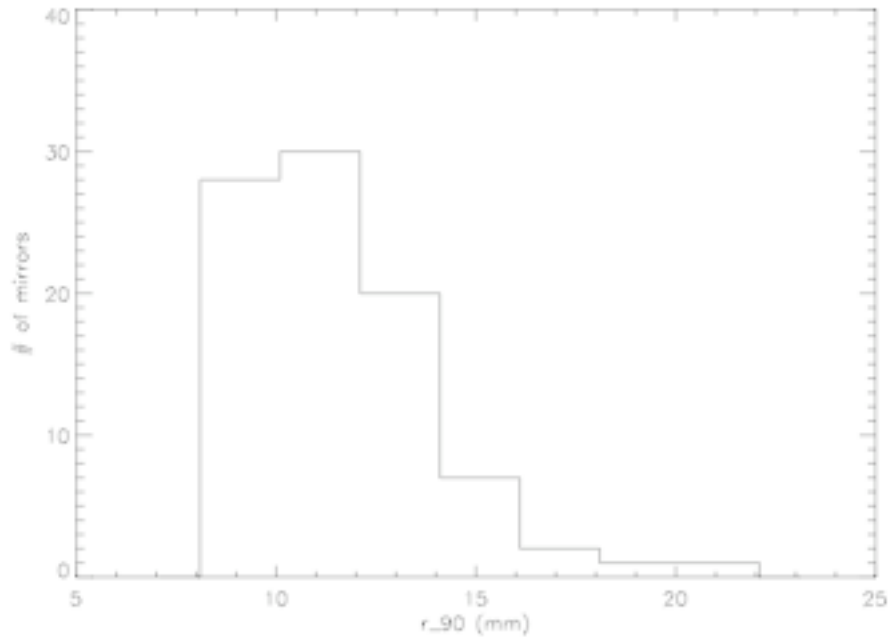
Two moulds (36.3 m and 36.5 m curvature radii) have been used for the production of 112 mirrors.

Using the springback effect the distribution shown in the plot has been obtained

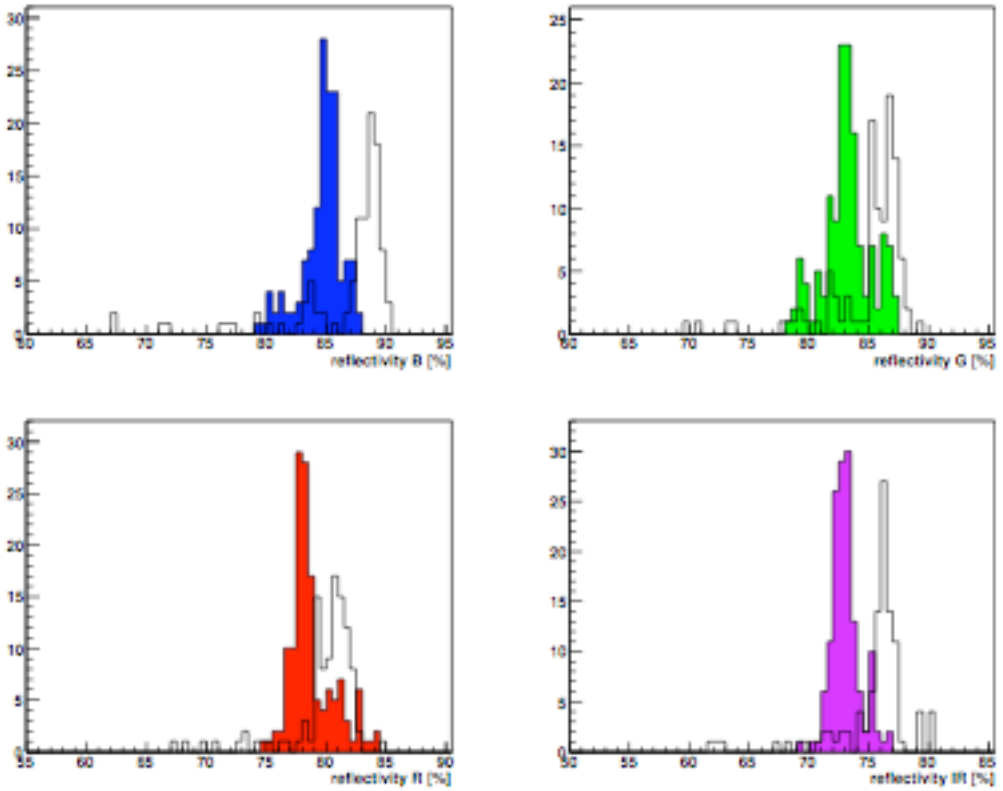


PSF shape and distribution





Reflectivity after three years



Reflectivity @470
(86.6 ± 5.1)%

Difference between
2009 and 2011
measurements
(-0.43 ± 2.49)%

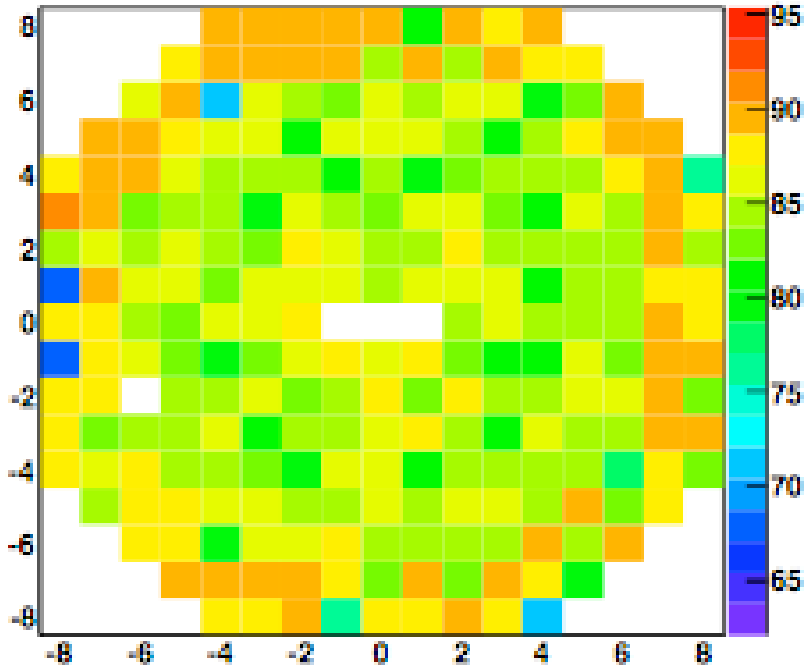
Ref: Reflectivity of the MAGIC-II reflector
Markus Garczarczyk IAC Tenerife
October 2011

Anomalies

A batch of 10 mirrors shown a bad coating application. It has been decided to use it and possibly recoat them.

Some mirror shows damage due to ice and small stones

Mirror reflectivity distribution



Most of the mirrors after three years
Show reflectivity better than 85%
Only mirrors of the “bad” batch
Show degradation in reflectivity

INAF prototypes for MST of CTA

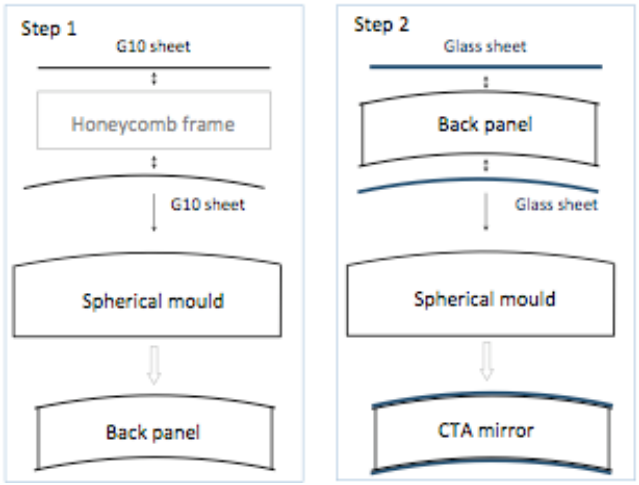
A contract has been signed with Media Lario Technologies for the production of 25 panels for the middle size telescope prototype of CTA.
At the moment the mould has been produced, honeycomb and glass sheets have been delivered and the production of the panels is ready to start.

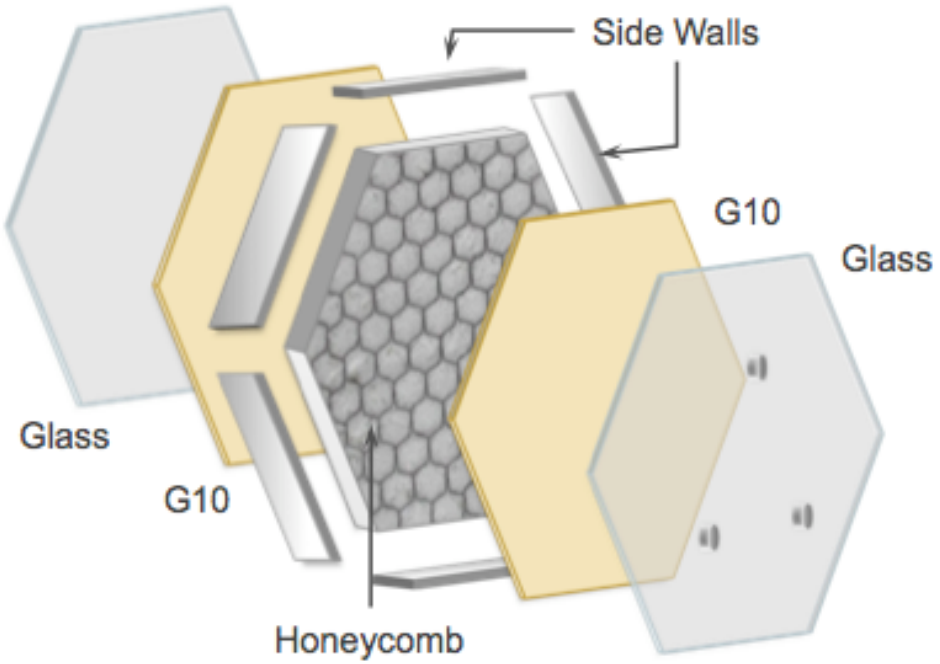
Qualification of the panels

Test Type	Req. #	Test to be performed	Test article
Spot size measurement	100 140	Optical measurement with beam line	mirror
Weighing	330	Weighing of the complete mirror	mirror
Reflectivity tests	700 710 720	Reflectivity of panel	specimens & mirror
Coating resistance tests	770	Peel-off test on mirror	mirror
	780	Coating abrasion on mirror	mirror
	790	Accelerated aging - Damp heat test	coupon
	790	Accelerated aging - Salt spray	coupon
Mirror environmental conformity tests	800	Mechanical Impact	mirror
Mirror environmental conformity tests	510 520	Thermal cycling	mirror
	-	Sealing tightness test	mirror
	-	Water ingression test	mirror
Inspections	760	Visual inspection	mirror

Table 2 : Validation tests

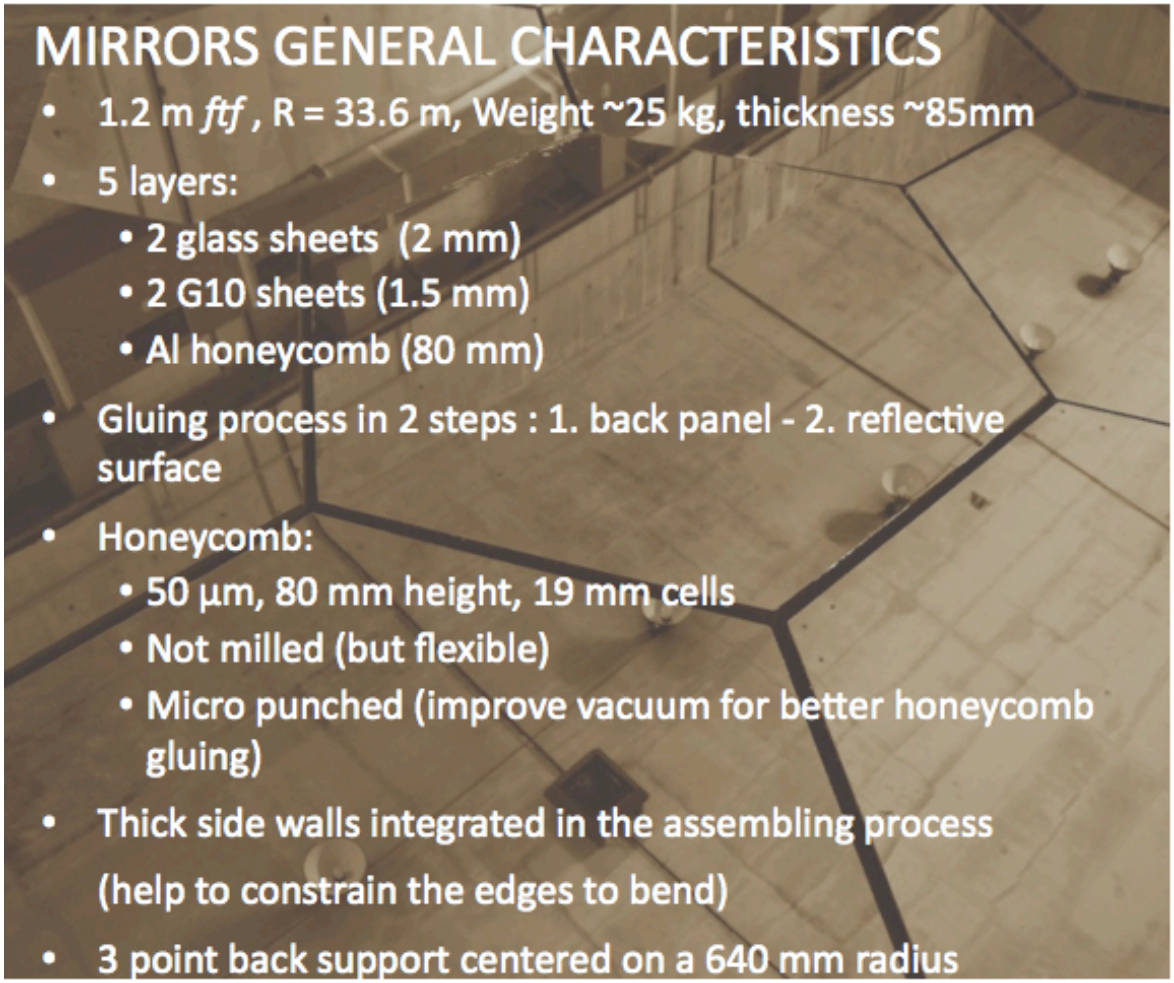
Saclay 1.2 m prototypes for CTA





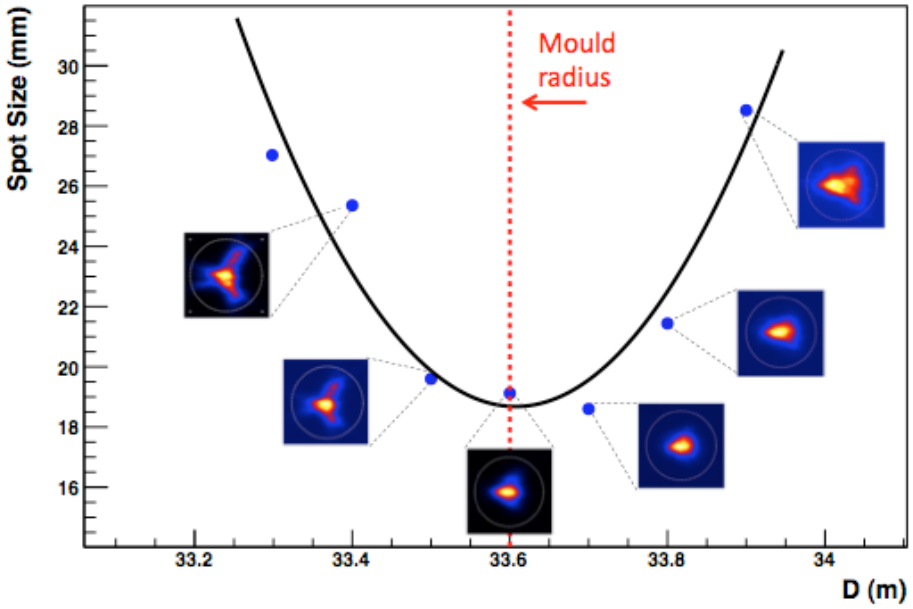
Credits: Clementina Medina (CEA/IRFU)

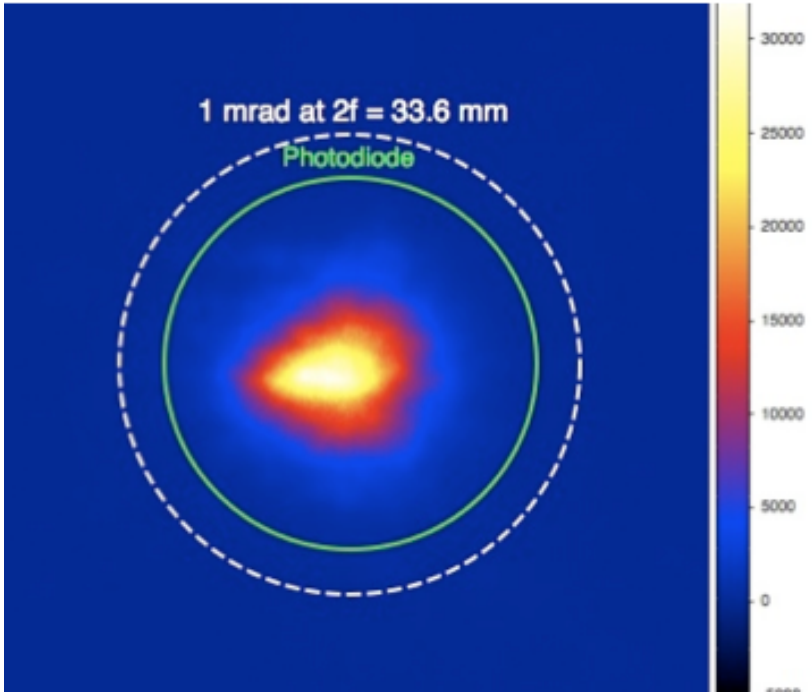
Saclay 1.2 m prototypes for CTA



Credits: Clementina Medina (CEA/IRFU)

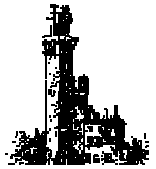
Qualification of the mirrors





Credits: Clementina Medina (CEA/IRFU)

Industrial partnership of CEA/IRFU

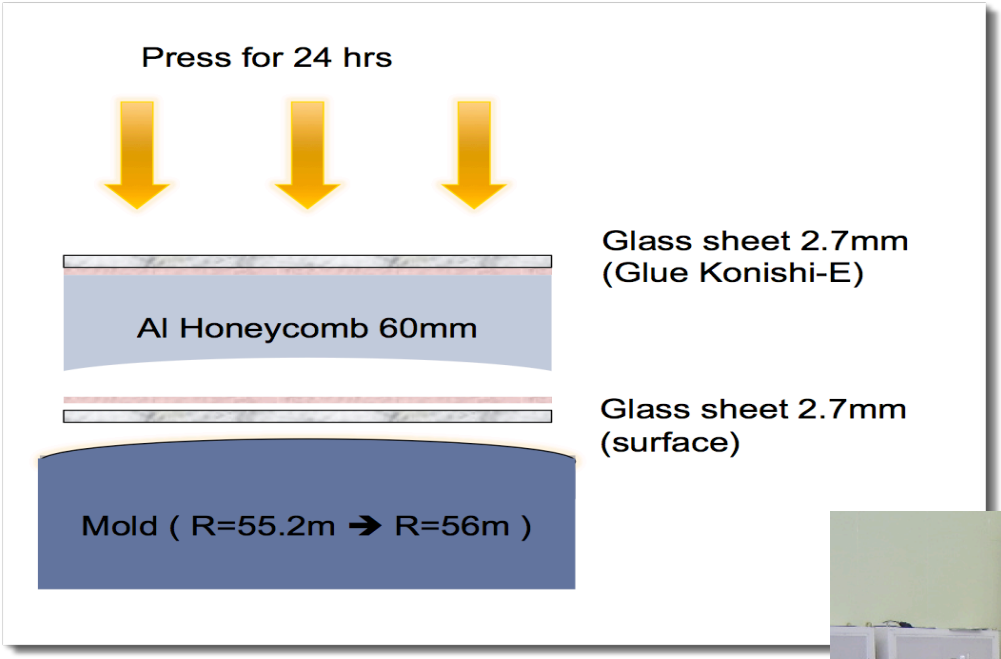


Technology transfer agreement signed (spring 2011) between CEA/IRFU and the Kerdry company.

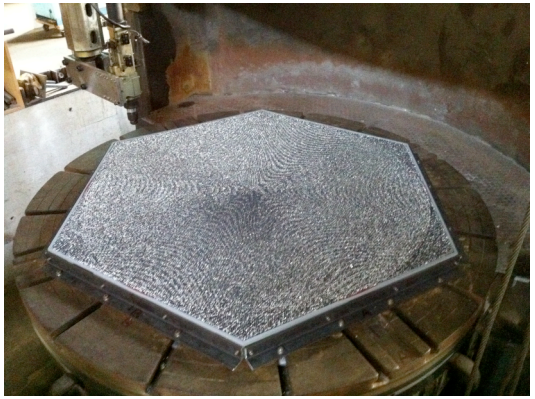
Production of 20 mirrors pre-serie at Kerdry's January-March 2012 (and a fortiori the further productions)

Credits: Clementina Medina (CEA/IRFU)

ICRR University of Tokyo 1.5 m mirror



Milling of Al-Honeycomb surface



Credits: M. Teshima MPI and University of Tokyo

Future goals of the technology

- Use of thinner glass sheets translate in a more flexibility of the front skin. This permits an ease bend of the glass and hence a more detailed copy of the mould,in particular for the medium spatial frequencies band.
- Replacing the honeycomb core with a stiffer structure. This can strongly reduce the spring-back effect to which the panel is subjected, it is especially true if the core part of the panel is pre-processed to accommodate the curvature of the mould.
- Use of cheaper materials, in particular concerning the core part of the panel and the epoxy glue used to assemble together the sandwich.
- Reduce the production's steps where possible, especially if they are critical and/or manpower consuming

Conclusions

- A reliable technology for mirror production for IACTs has been demonstrated with the MAGIC case.
- Further developments shown that Cold-slumped glass technology is ready for a mass mirror production for CTA
- 25 panels will be in short time provided for the prototype of the MST of CTA
- CEA/IRFU is starting with a production of 20 mirror with an industrial partner
- Also University of Tokyo is working on prototypes for the MST
- Technology seems can be improved for better cover CTA requirements