CTA 報告47:
CTA 大口径望遠鏡用分割鏡の開発:
LST Mirror System

手嶋政廣[A, B], R.Krobot[C], 中嶋大輔[A], 馬場浩則[D], 加賀谷美佳[D], 片桐秀明[D], 峪中良介[E], 周小溪[E], 千川道幸[E], 野里明香[E], 柳田昭平[D], 山本常夏[F], 吉田龍生[D], 他CTA-Japan Consortium

東大宇宙線研[A], Max-Planck-Inst. fuer Phys.[B],
Univ. of Erlangen[C], 茨城大理[D], 近畿大理[E], 甲南大理工[F]

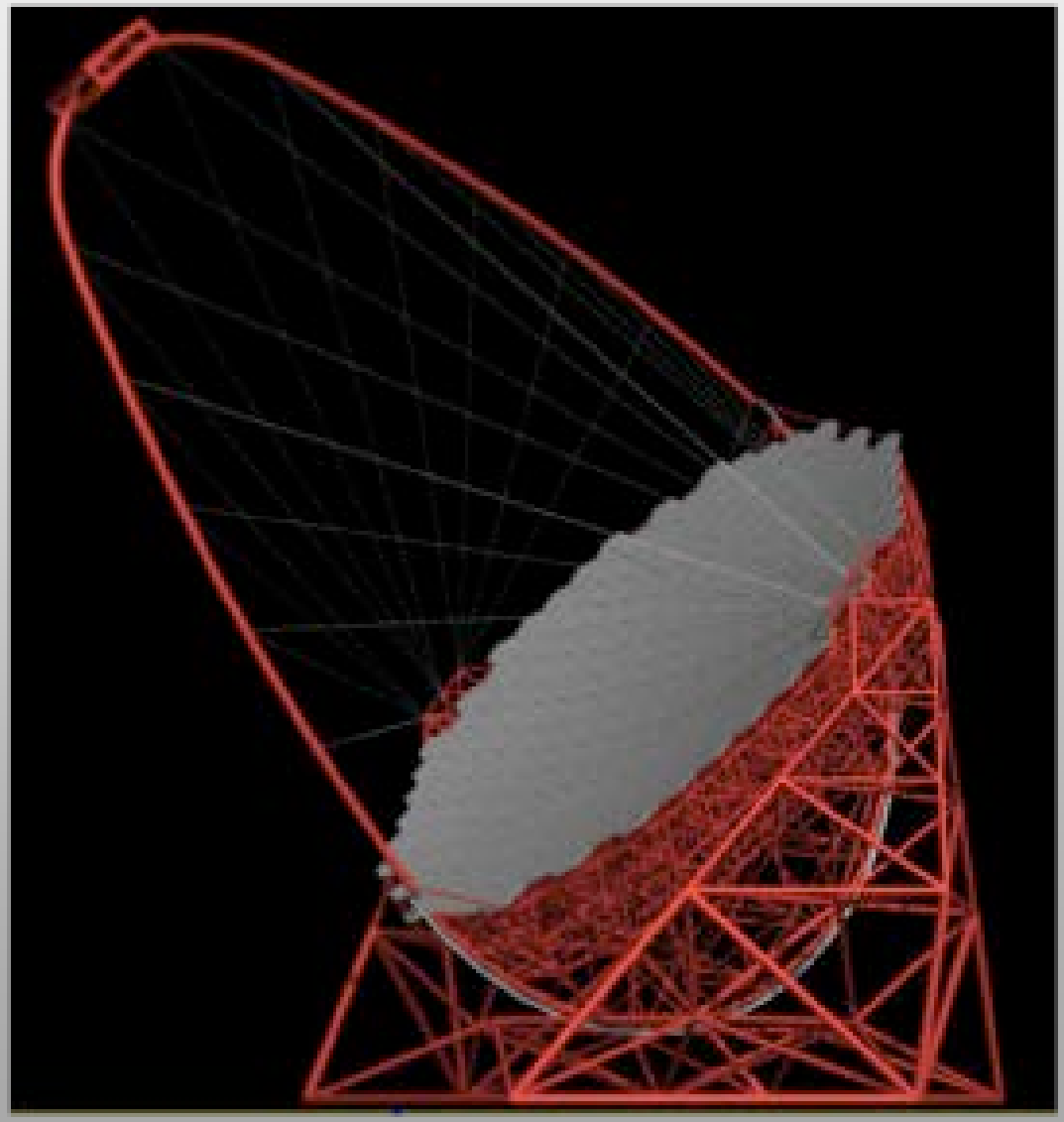
Specifications/Requirements of LST

- Diameter: 23m
- Dish area: 407 m^2
- F/D = 1.2, F=28m
- Dish profile: Parabolic
- Permanent Active Mirror Control

- FOV = 4.5 degrees, Pixel size = 0.1 degrees (1855ch camera)

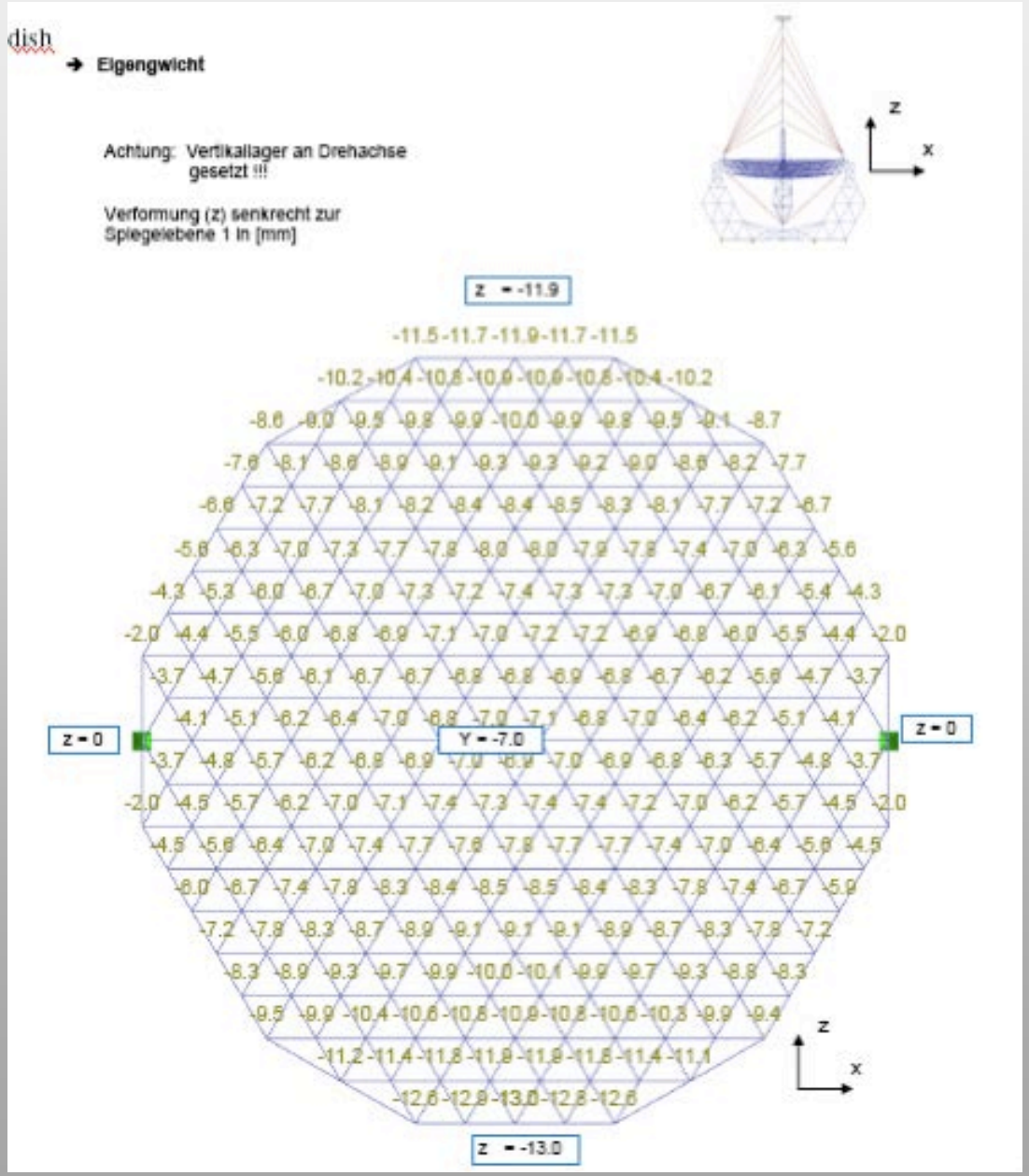
- Fast rotation: <180 deg/20 sec

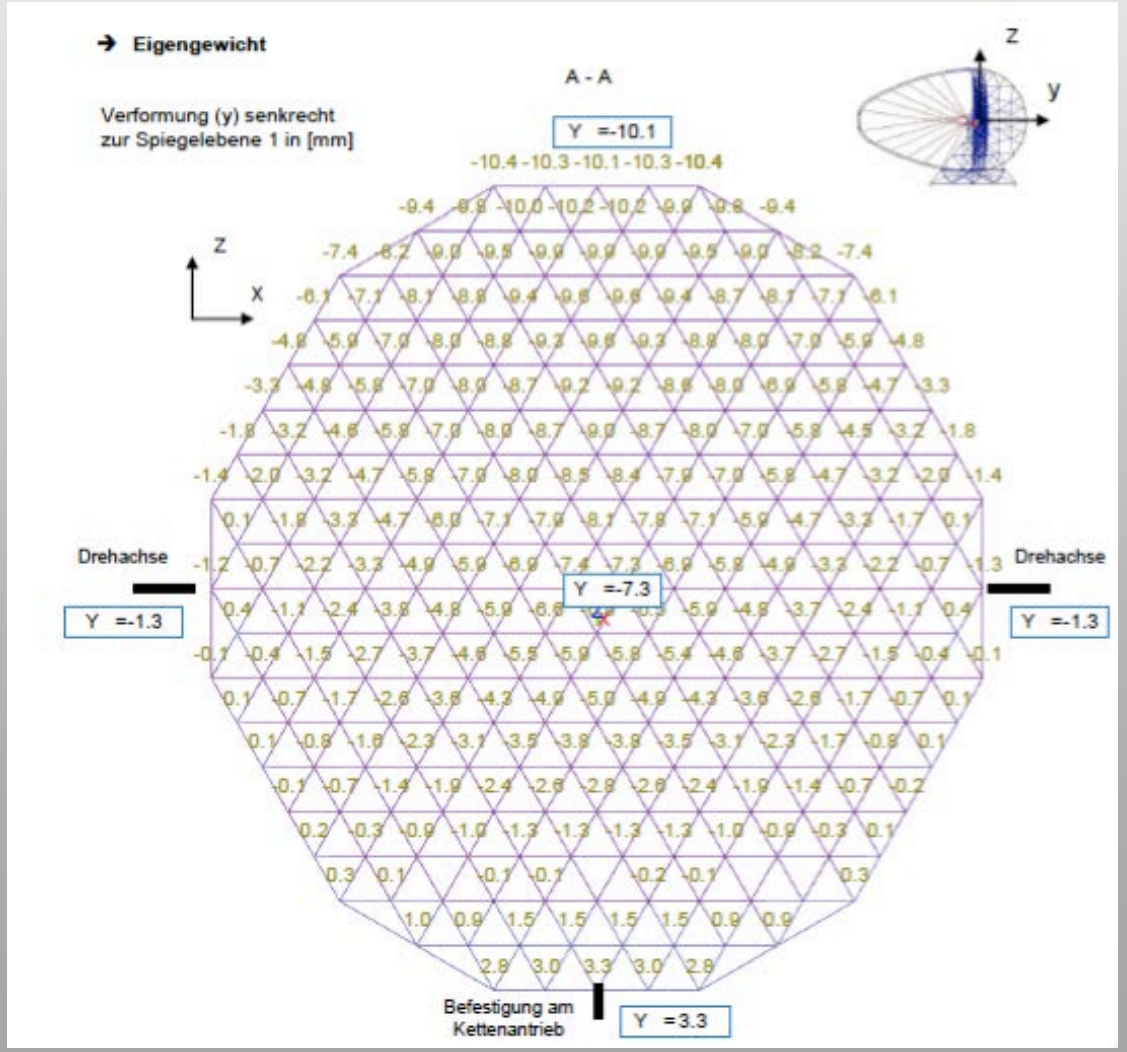
- Dish profile: parabolic ➔ isochronicity: <0.6 ns RMS
- Camera sagging: < 1-2 pixels
- Camera oscillation in wind gust: <8mm
  - ➔ Active oscillation damping by LAPP IN2P3



Designed by MPI Munich and MERO

Deformation of mirror dish





Optical axis and permanent AMC (Active Mirror Control)

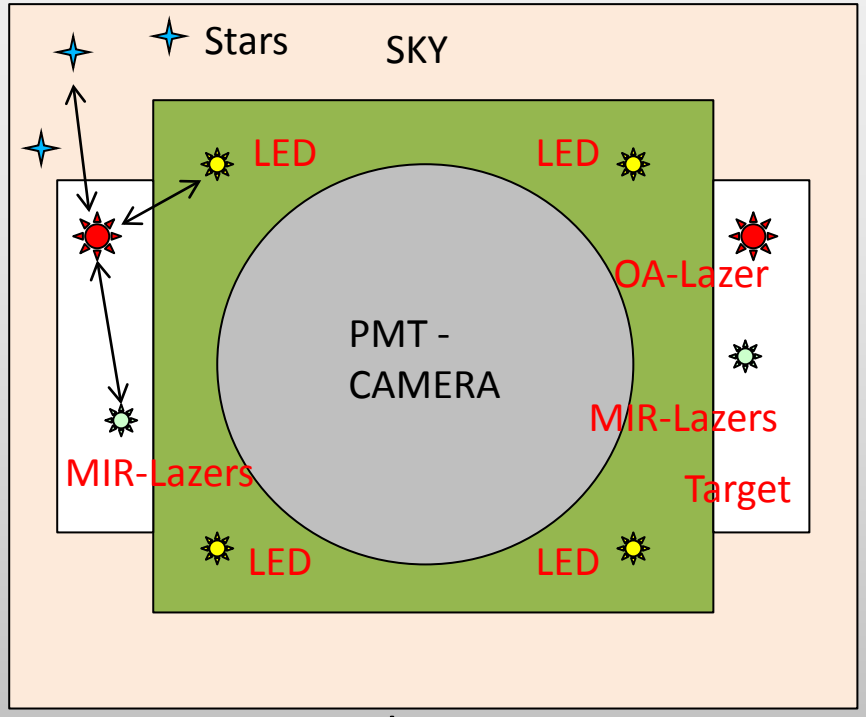
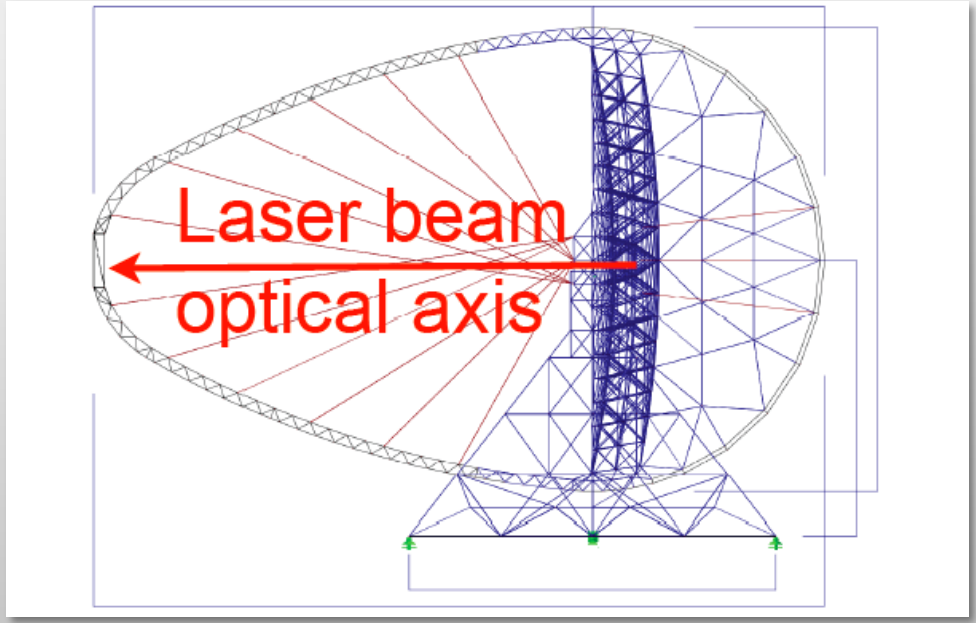


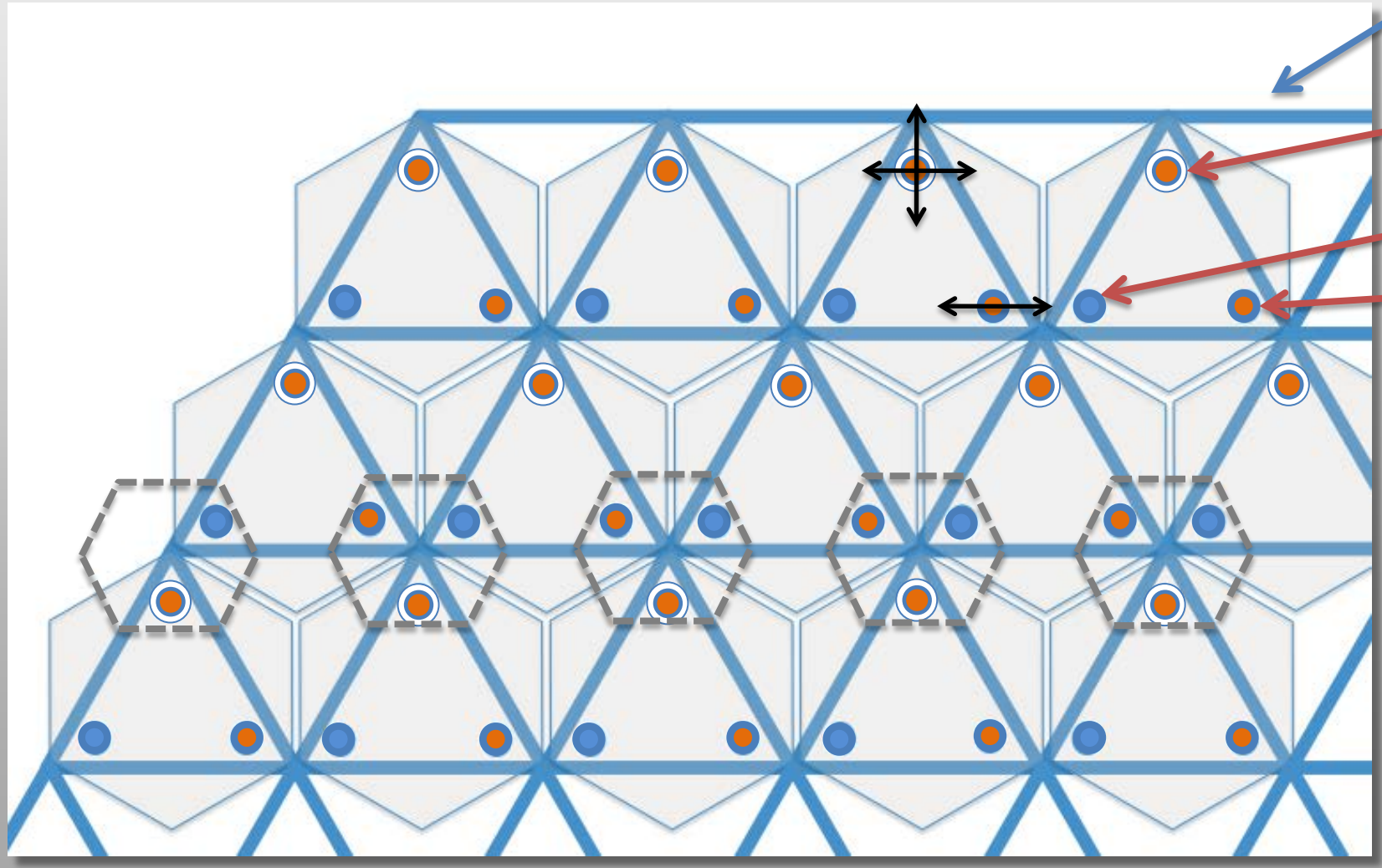
IMAGE with HR CCD Camera



- Define optical axis with the IR Laser beams
- High precision inclinometer (a few arcsec) ➔ zenith angle
- HR CCD camera at the center of dish to monitor the optical axis and star field ➔ pointing direction in sky

- (Camera LED position) – (Optical axis Laser position) ➔ camera sag
- (Mirror Laser positions) – (Optical axis Laser position) ➔ misalignments of mirror directions

Mirrors and Actuators on Triangular space frame



Triangular
Space frame

Actuators (2 axis free)

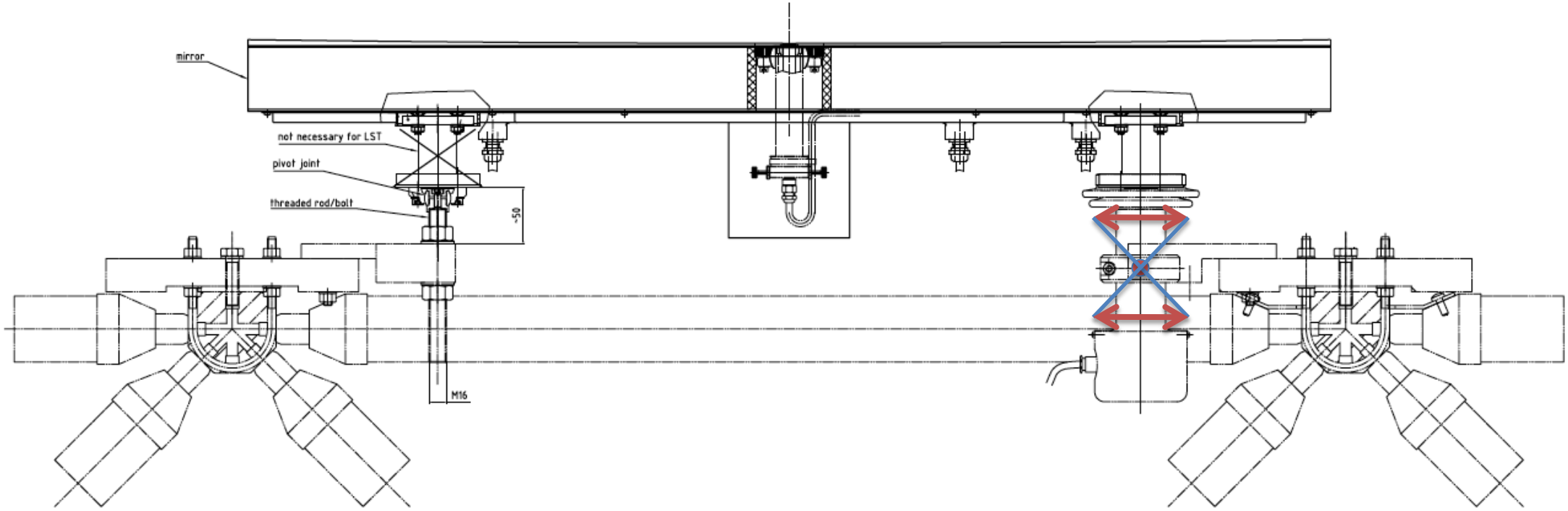
Universal Joints

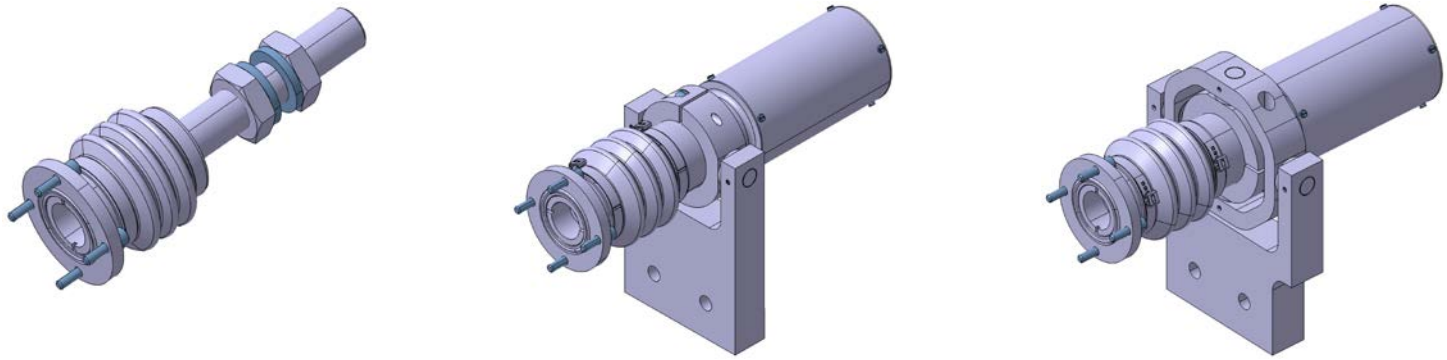
Actuators (1 axis free)

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

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

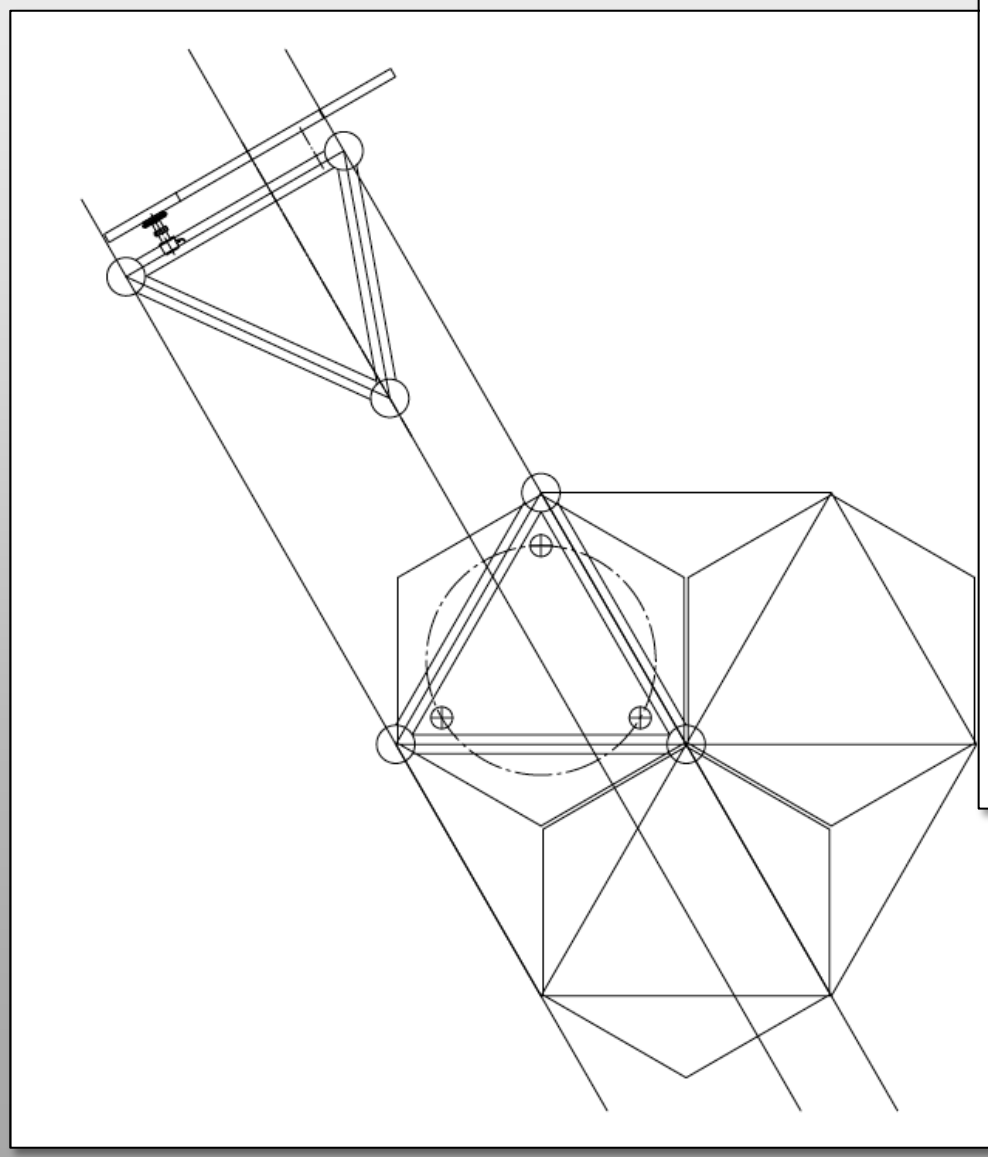
Mirror mounting scheme

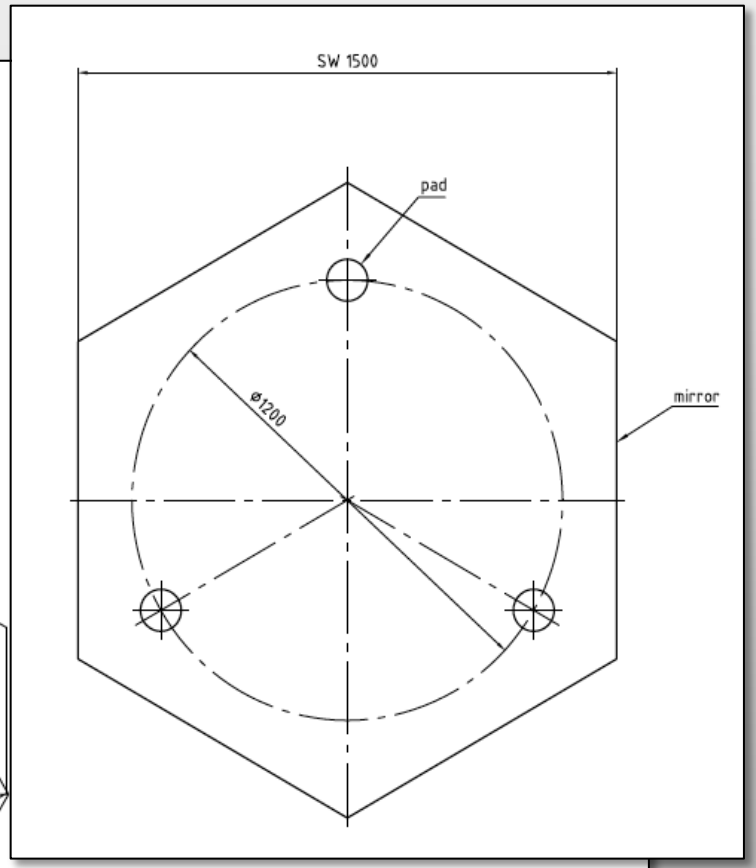




MAX-PLANCK-INSTITUT FÜR PHYSIK
Werner-Heisenberg-Institut
Föhringer Ring 6
80805 München
M 1:5
Datum: 01.12.2010
Projekt: CTA
Zeichnungsnr: Mirror support M-II
Sachbearbeiter: H. Wetteskind
MPP MÜNCHEN

Pads rear side of mirrors
Interface with AMC





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MÜNCHEN
Datum: 01.12.2010
Projekt: CTA
Zeichnungsnr: Mirror arrangement
Sachbearbeiter: H. Wetteskind

Three pads of 150mm Φ at 1200mm diameter Circle

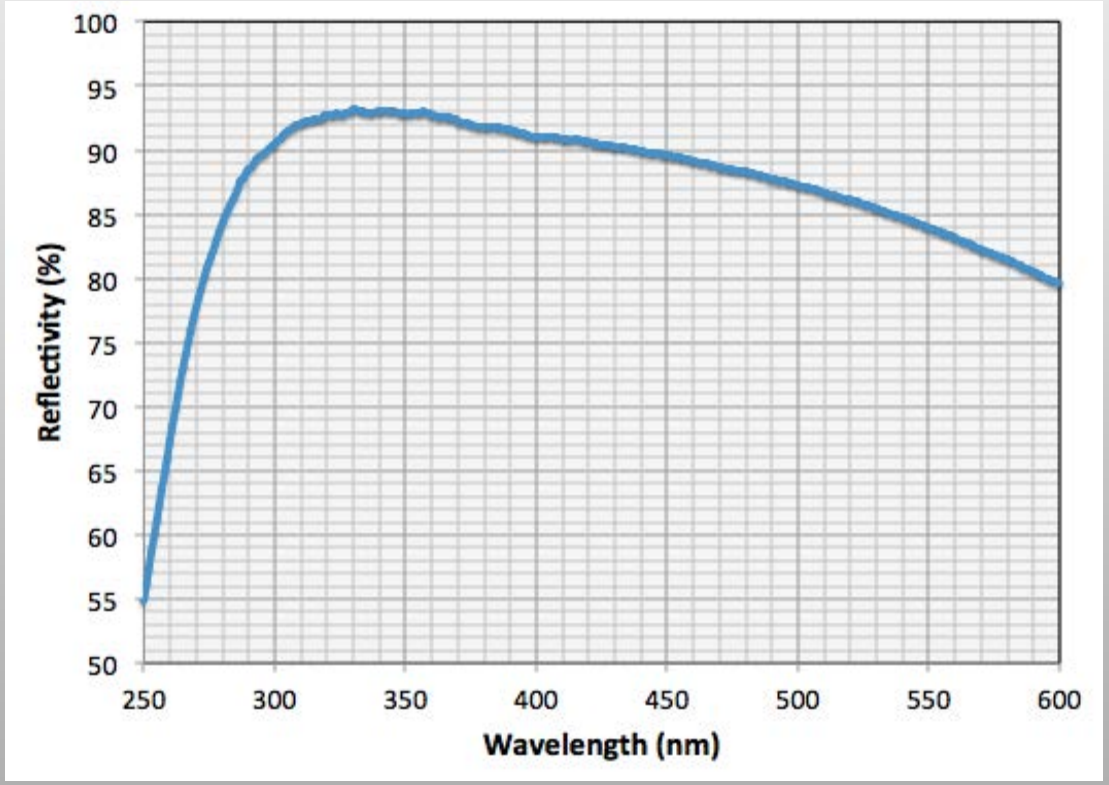
4 holes of 5mm Φ on each pad

Specifications for LST Mirrors

Telescope Parameters	Values	Comments
Layout	Parabolic	Intermediate solution between Parabolic and DC may be better
Diameter of dish	23m	Consists of 198 segmented mirrors
Focal Length	28.0 m	
Pixel size of camera	50.0 mm	Corresponding 0.1 degrees
Total reflectance	> 85% btw. 300-600nm	
PSF	R80 = 1/3 pixel (17mm)	Radius contains 80% of light
Segmented mirror parameters	**Values**	**Comments**
Shape	1.51m flat to flat hex.	Pitch of space frame knots is 1.54m
Area	1.98m^2	
Weight	< 40kg	Corresponding to 20kg/m^2
Surface shape	Spherical	
Thickness	< 80mm	
Focal length	28.0 – 28.4m	Optimized with ray trace
Reflectance	>85% btw. 300-600nm	
PSF	R80 = 1/5 pixel (10mm)	Radius contains 80% of light
Survival temp.	-25℃ ~ +60℃	
Operational temp.	-10℃ ~ +30℃	
Rear surface	Flat preferred	
Flanges (interface to actuators)	Three flanges at 600mm from the center	Drawing is shown in Fig 5.1.4
Life time	> 10 years	Annual degradation of the reflectance should be < 2 %/yr

Upgrade of Sputtering Chamber of 2.8mΦ x 9 m at Sanko

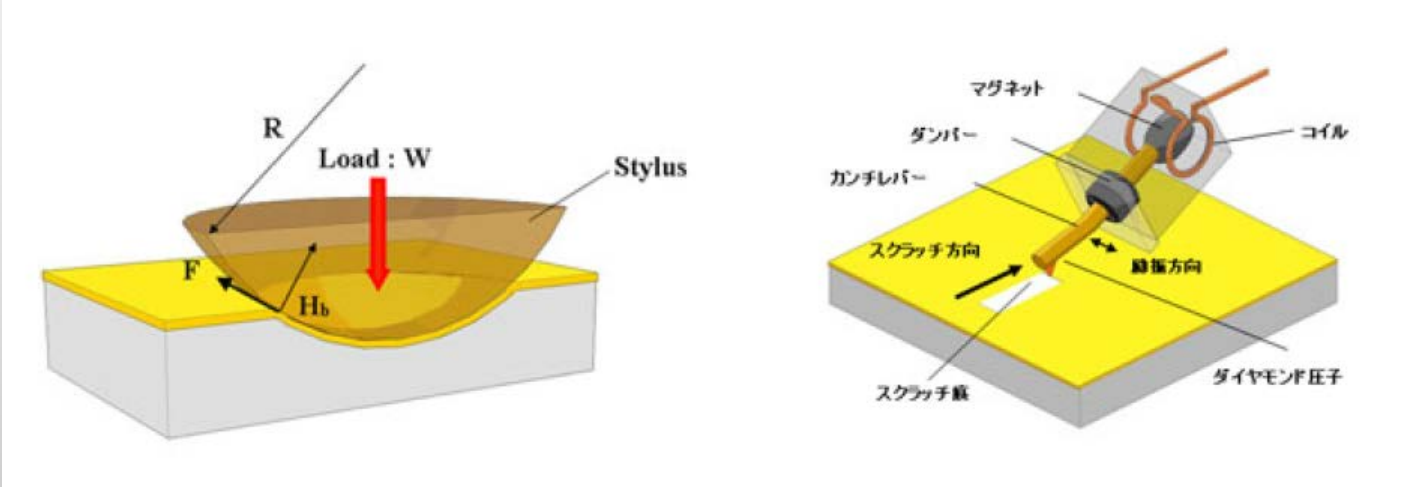
92% of reflectivity

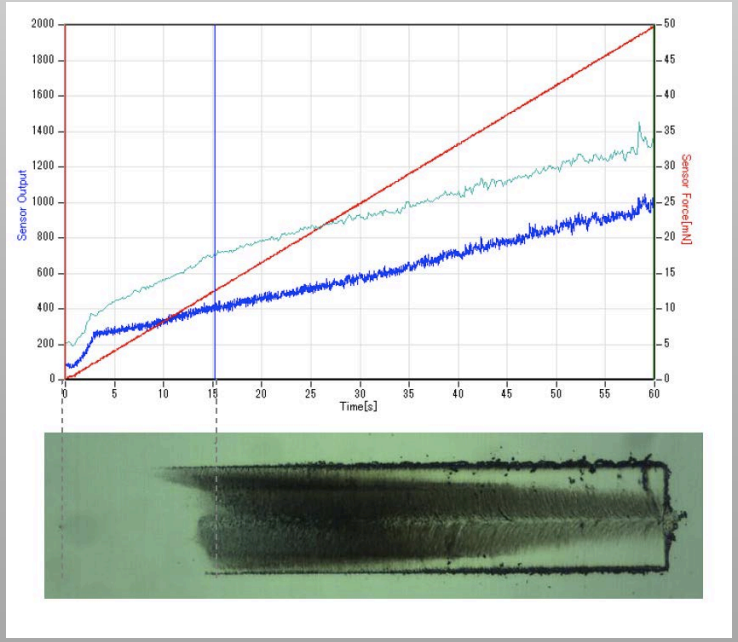


Multi (5 or 7) layer coating: Cr + Al + SiO2 + HfO2 + SiO2 (+HfO2 + SiO2)

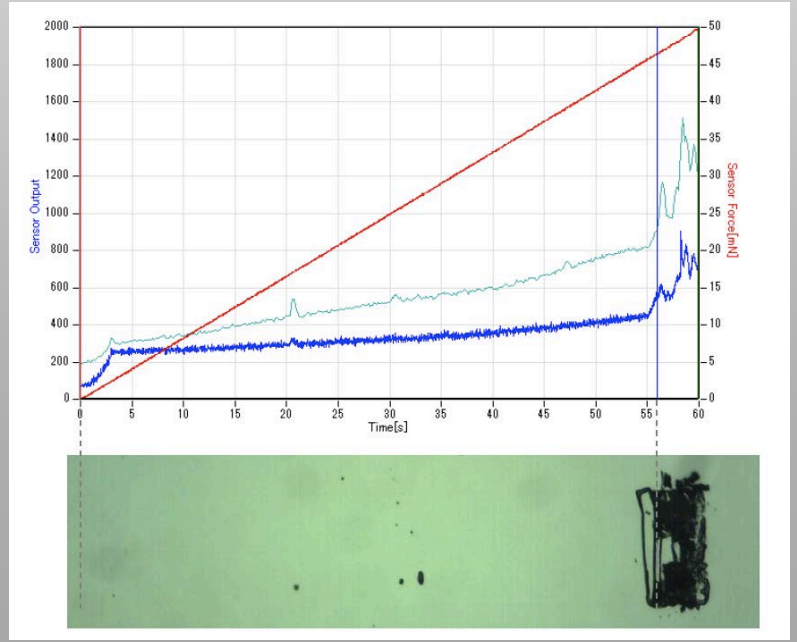
In total it takes < 3hrs of process

Scratching tests for vapor and sputtering coats





Al+MgF2 coat

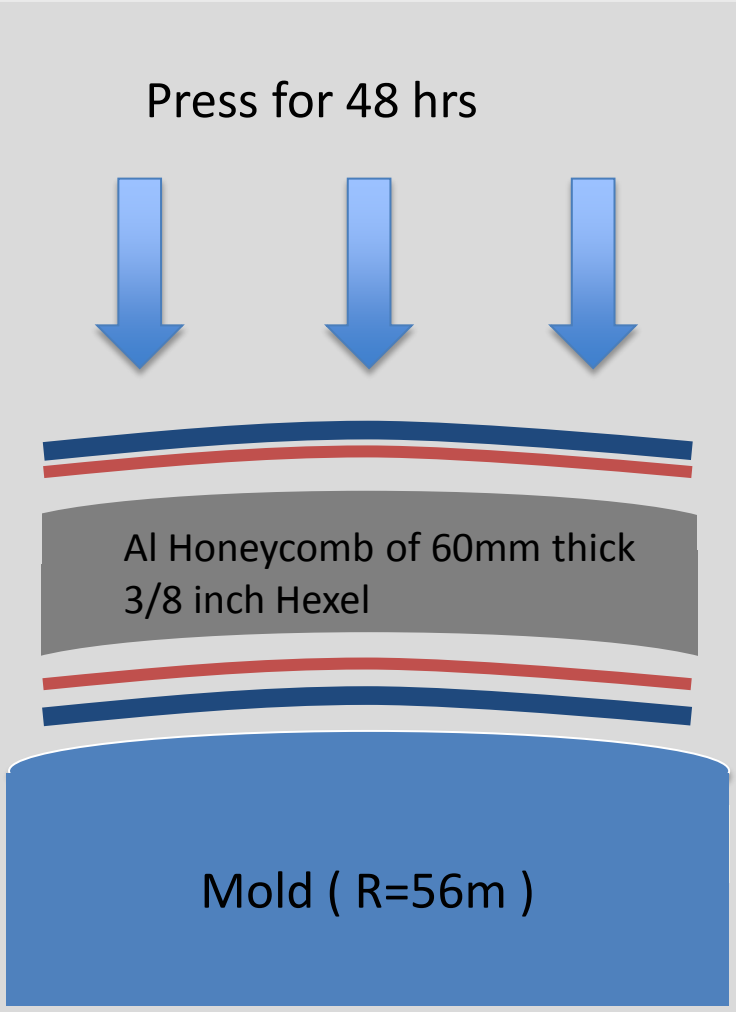


Sputtering CR+Al+SiO2+HfO2+SiO2

Stylus R = 25 µm
Amp. of Osc. = 100µm
Scratch speed 10µm
Acc. of Force 50mN/60sec

Conclusion:
Sputtering coat is about 3-4 times stronger than vapor coat

Cold slump for LST mirrors
Hot slump for MST mirrors



Glass sheet 2.7mm
Glue Konishi-E

Glue Konishi-E
Glass sheet 2.7mm
(surface)

Milling of Al-Honeycomb surface

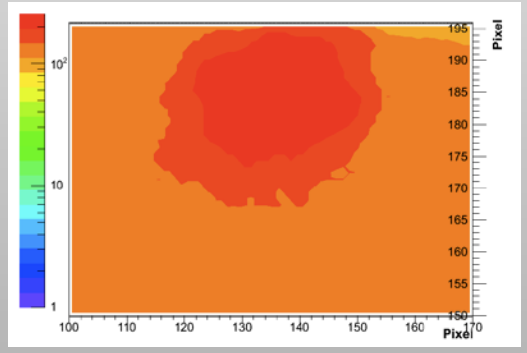
Mold R=56.0m after machining

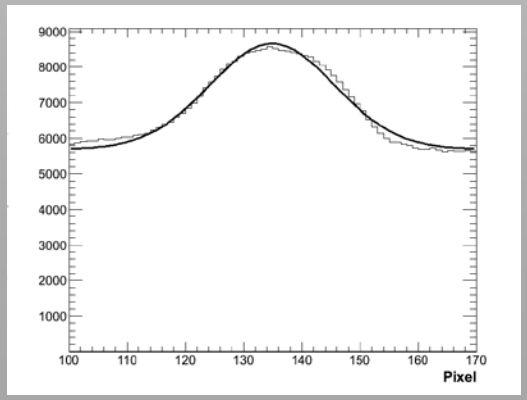
1510mm LST mirror Prototypes

2.7mm glass＋60mm AL.Honeycomb＋2.7mm Glass

D80 ~ 24mm at 2f

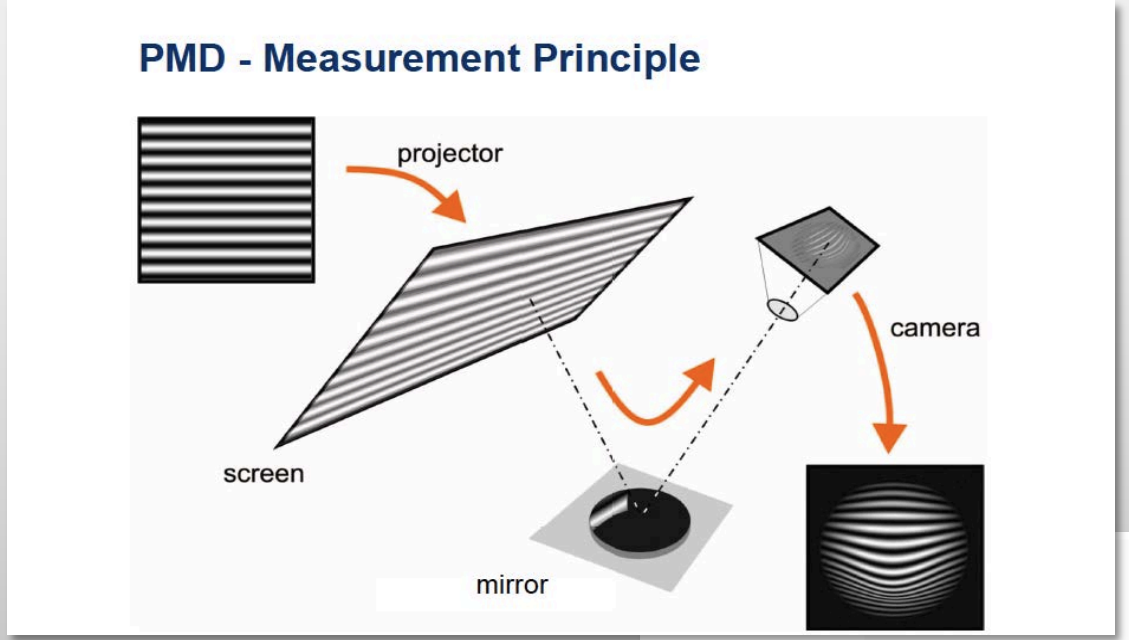
F2F : 1.51m
Area : 2m²
R of Curvature: 57m
PSF : <0.02°
Weight : 45kg

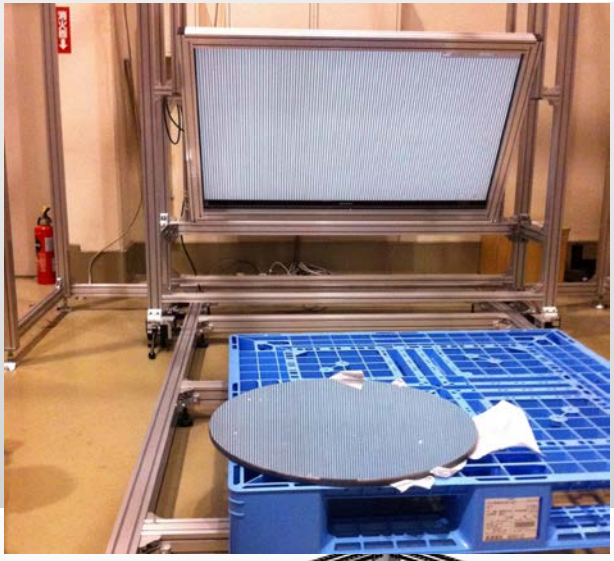




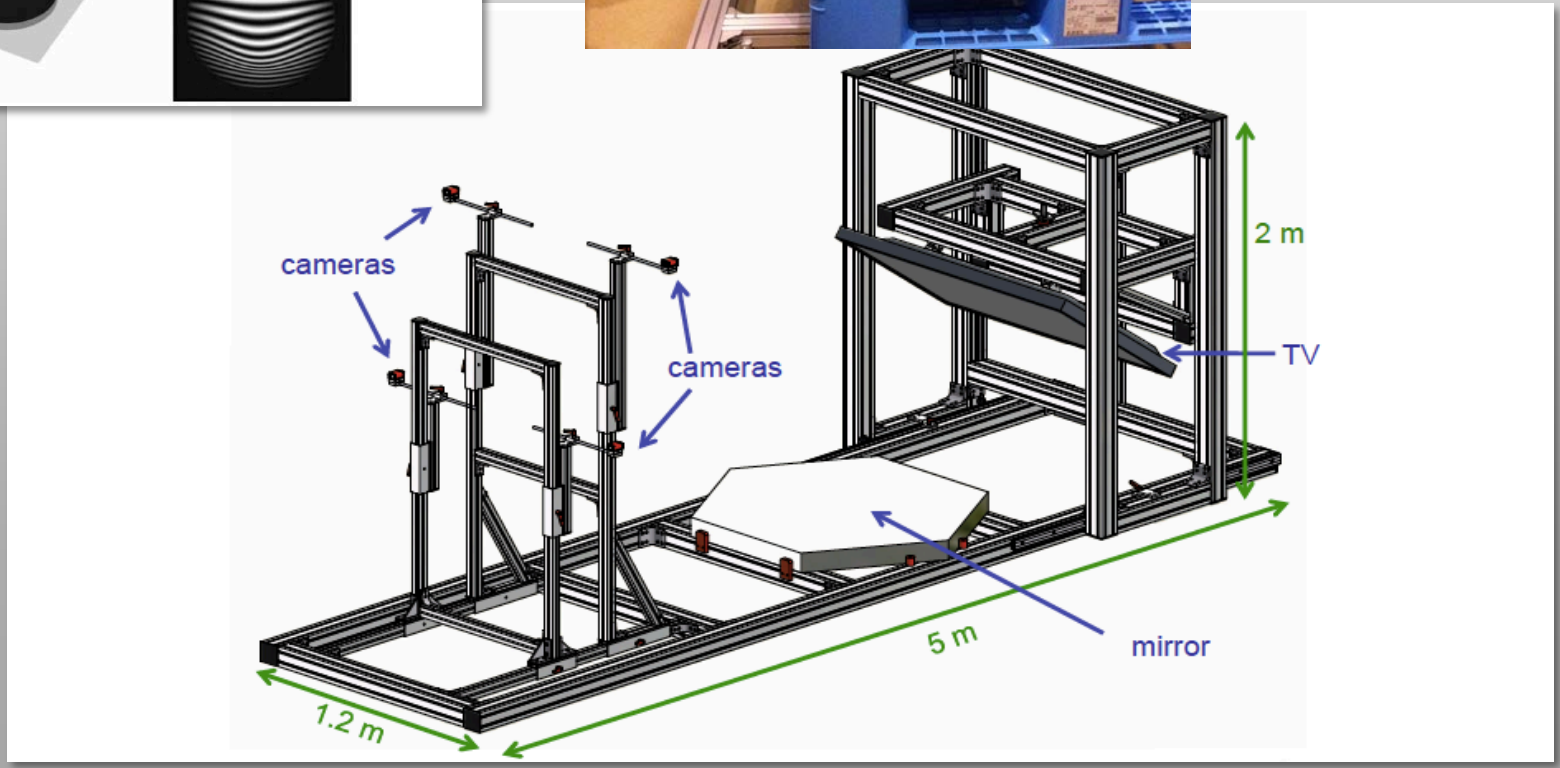
D80 = 24mm at 2f
(by Hironori Baba)

PMD system is installed at ICRR, U-Tokyo
(developed by experts of Erlangen optic group)



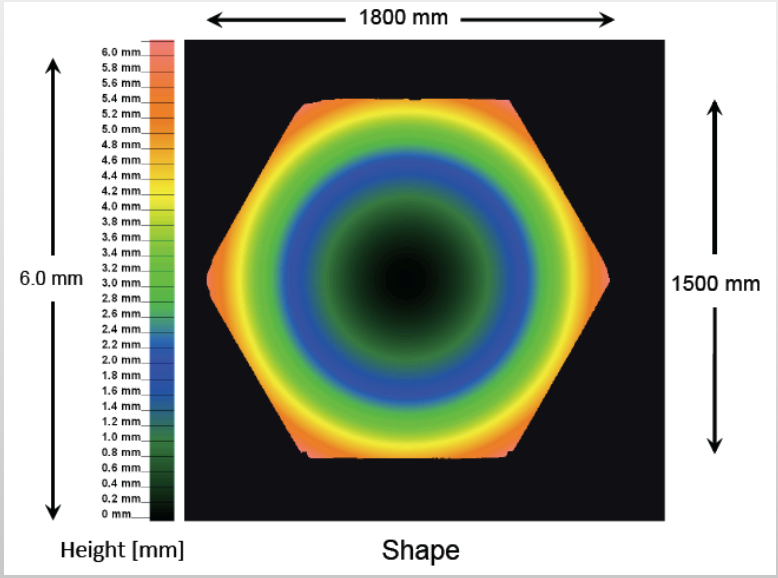


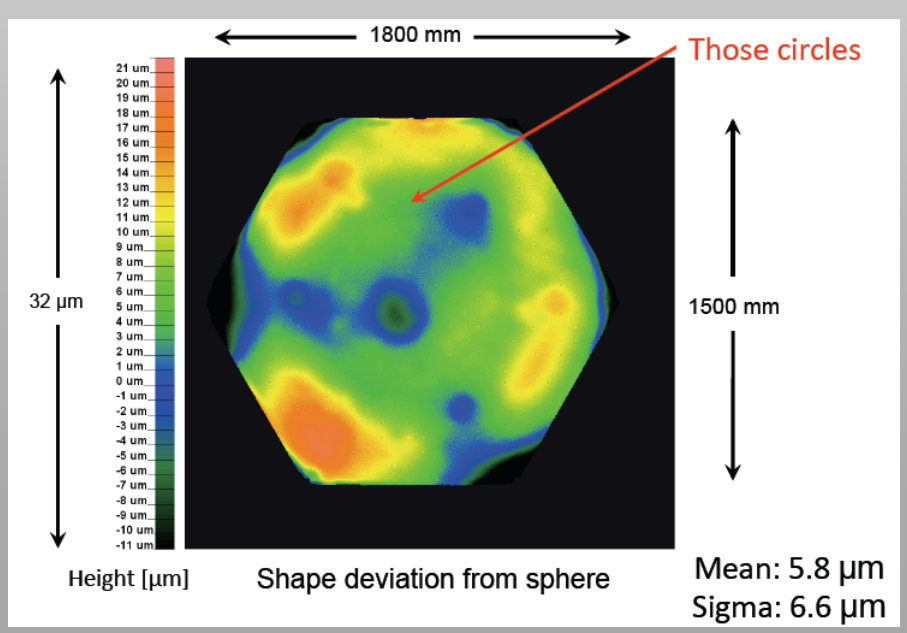
Installed at ICRR



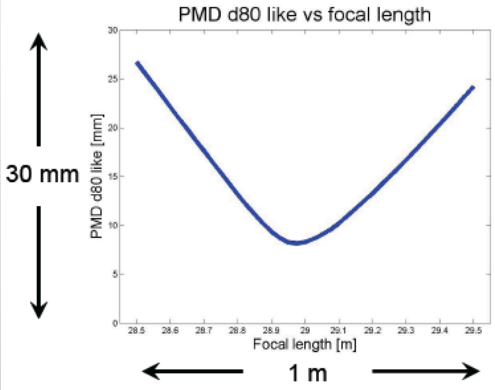
Sanko Mirror #01

measurements at Erlangen





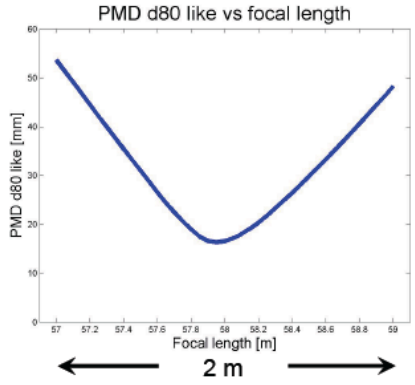
Parallel light from infinity



minimum @ 28.975 m

d80 = 8.15 mm

Point source in 2f distance

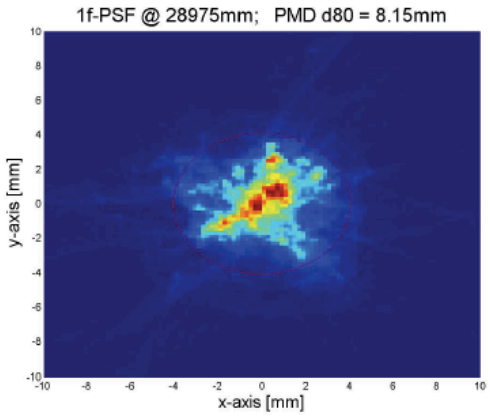


minimum @ 57.950 m

d80 = 16.35 mm

PSF for parallel light

Minimum @ 28.975 m



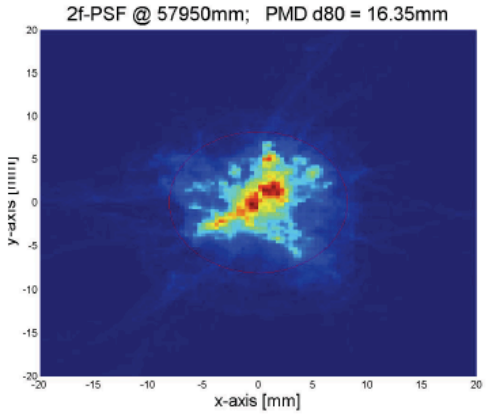
20 mm

d80 = 8.15 mm

Δz = 25 mm; Δd80 = 0.05 mm

PSF for 2f distance

Minimum @ 57.950 m



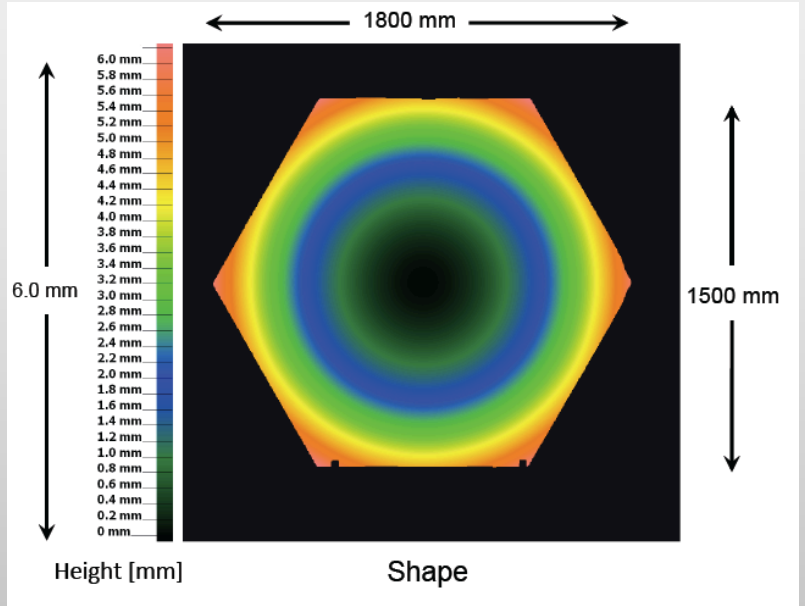
40 mm

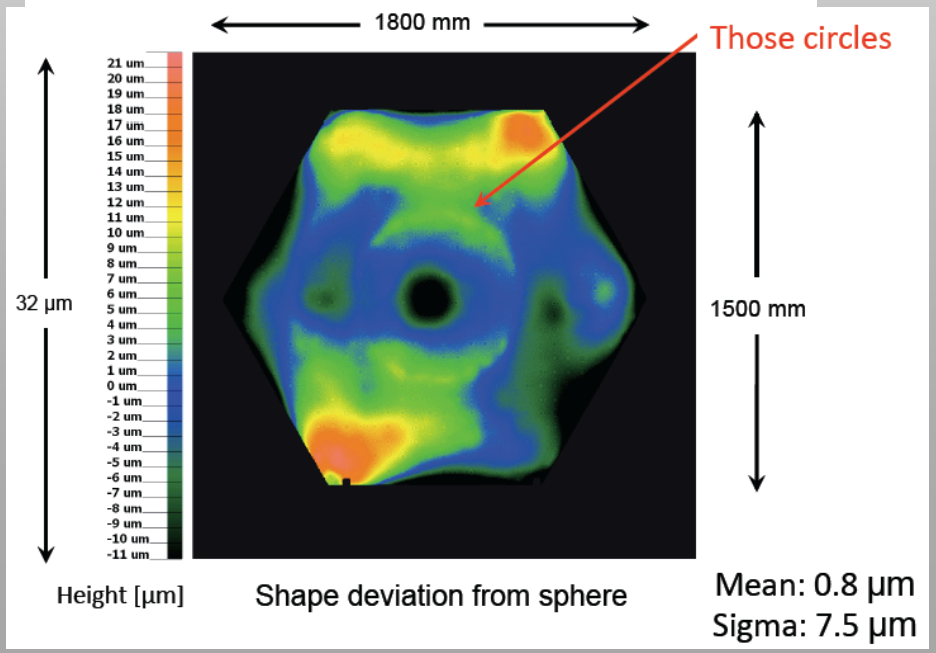
d80 = 16.35 mm

Δz = 50 mm; Δd80 = 0.05 mm

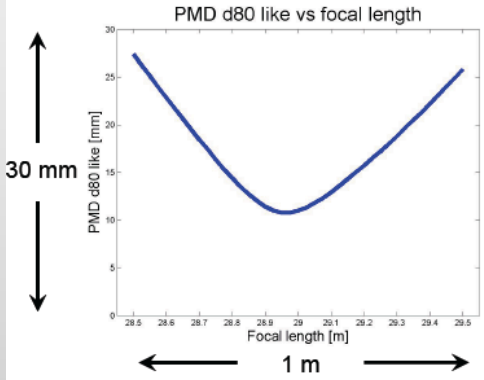
Sanko Mirror #02

measurements at Erlangen





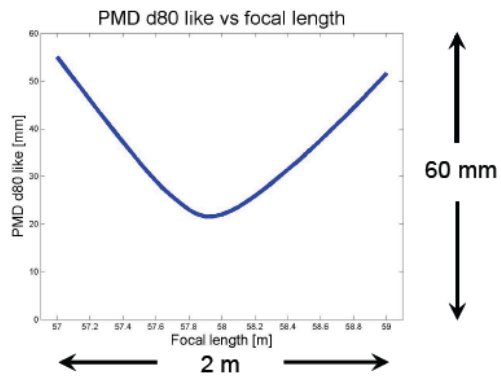
Parallel light from infinity



minimum @ 28.950 m

d80 = 10.80 mm

Point source in 2f distance

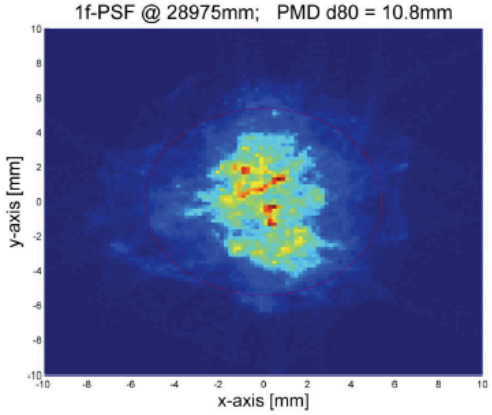


minimum @ 57.900 m

d80 = 21.60 mm

PSF for parallel light

Minimum @ 28.950 m

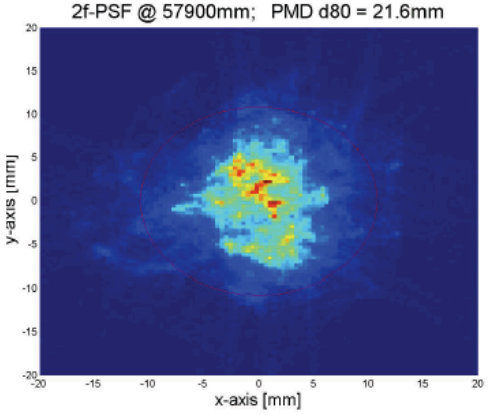


d80 = 10.80 mm

Δz = 25 mm; Δd80 = 0.05 mm

PSF for 2f distance

Minimum @ 57.950 m



d80 = 21.60 mm

Δz = 50 mm; Δd80 = 0.05 mm

Summary

- New prototype mirrors for LST and MST are produced by Sanko
  - New process, and new honeycomb(3/8")
  - The PSF is now enough small
  - The sputtering coat shows >92% reflectivity at 350nm.
  - Scratch test was done for the sputtering coat. It is 3-4 times stronger than the vapor coat of MgF2
- PSF is measured with LWD method by Erlangen group
  - Sanko M#01, D80 = 8.15mm
  - Sanko M#02, D80 = 10.80mm (~12mm by H. Baba)
  - PMD instrument is installed at ICRR, U-Tokyo ➔ Next talk by Mr. Baba
- Development and production of AMCs are expected by CTA-Japan
- We are planning the mass production of 220 LST mirrors in 2012 – 2016 at Sanko.