DEVELOPMENT AND PERFORMANCES
3.5M SIC TELESCOPE FOR THE HERSCHEL MISSION

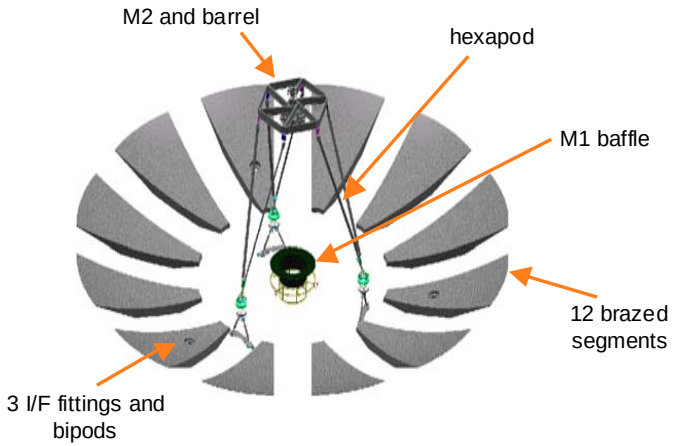
Dominique Piérot

Optical Engineer, Instruments department , ASTRIUM EADS – Toulouse

All the space you need

EADS astrium

TELESCOPE DESIGN



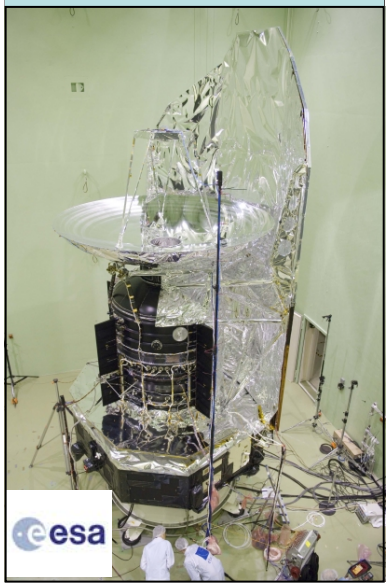
Telescope	
focal length	28,5m
F/number	8.68
Field of view	0,25
secondary magnification	16.29
Mass	315kg
Primary reflector (M1)	
Radius of curvature	3490 mm
Conic constant	-1
Distance to M2	1583,6 mm

- **Cassegrain – 260x axial magnification**
- **WFE 5.3µm rms (FOV0.Ø25° or 250mm)**
- **[80;670 µm] – 70K**
- **Focus located inside 5mm^3**
- **All SiC-100 conception**
- **No refocalization mechanism**
- **12 petals sintered to approximated shape,ground machining of brazed mirror, polishing by diamond tooling**
- **Al protected coating**
- **Sic thermal hardware wrapping**

TELESCOPE MAIN INDUSTRIAL TEAM

Telescope Prime

Spacecraft & mission

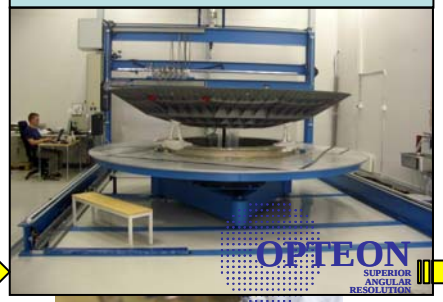


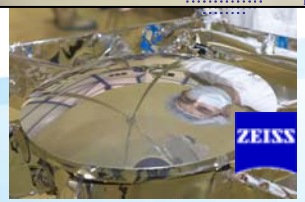
Cryo tests

AIT & qualification tests

SiC blanks&parts

Polishing

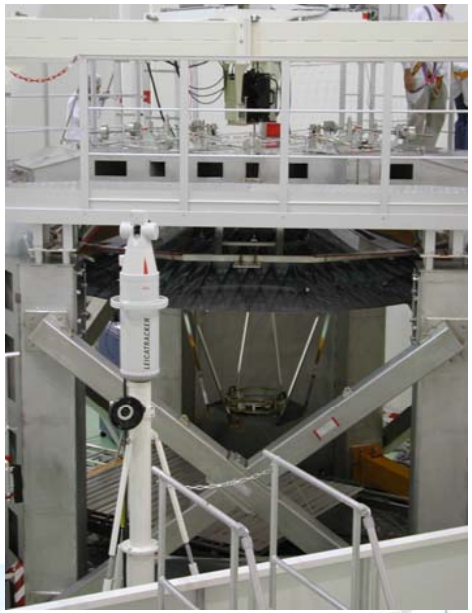




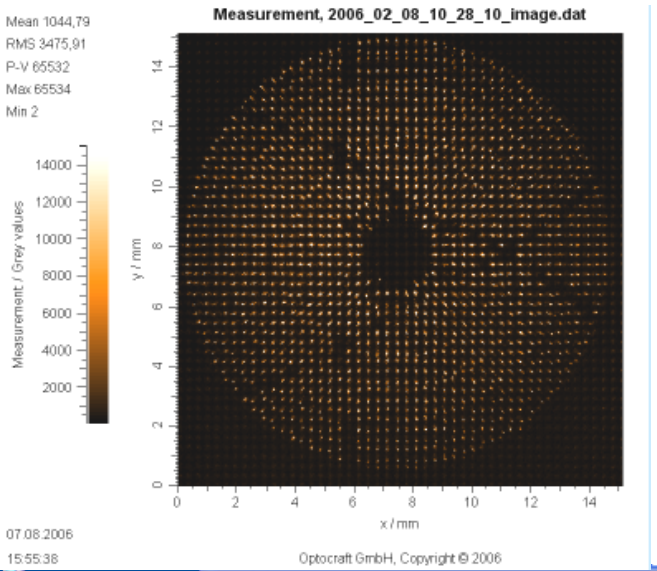
M1&M2 Coating

Optical performances verification

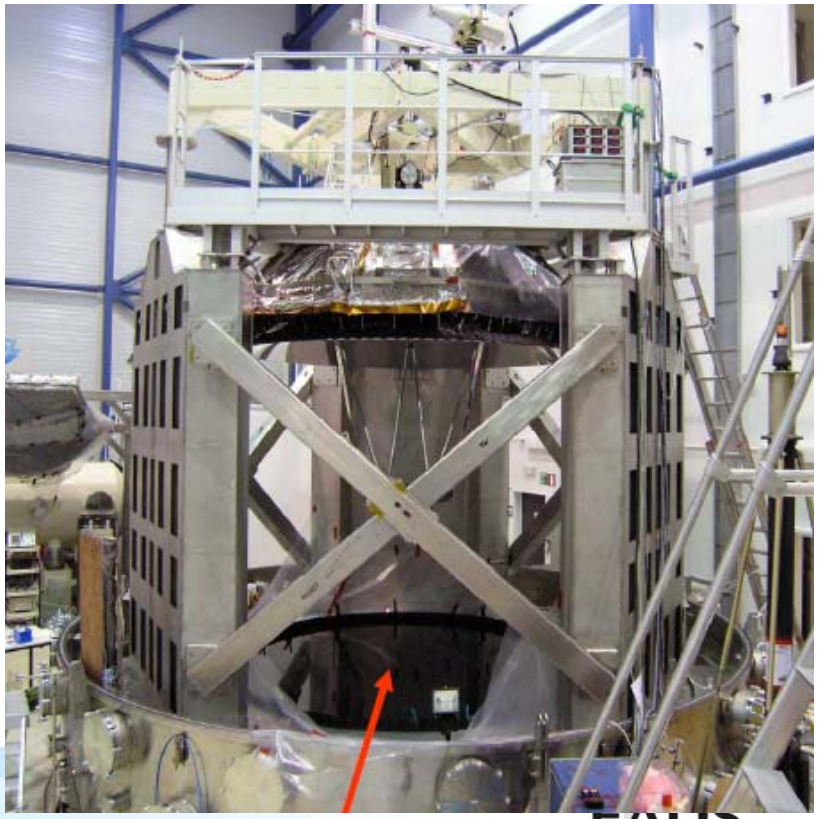
- Gravity compensation during polishing
  - WFE Correlation with FEM predictions
- Alignment and geometrical controls
  - Use of laser tracker
- WFE measurement under ambient conditions
  - Autocollimation on liquid mirror Hartman method, at 0.633 µm 66x66 points
- Focal length measurement ($\pm 2.10^{-4}$)
- Best Surface curvature characterisation
- WFE and best focus cool down variation control
- Monitoring of intermirror distance (±30 µm)
- Coating cleaning



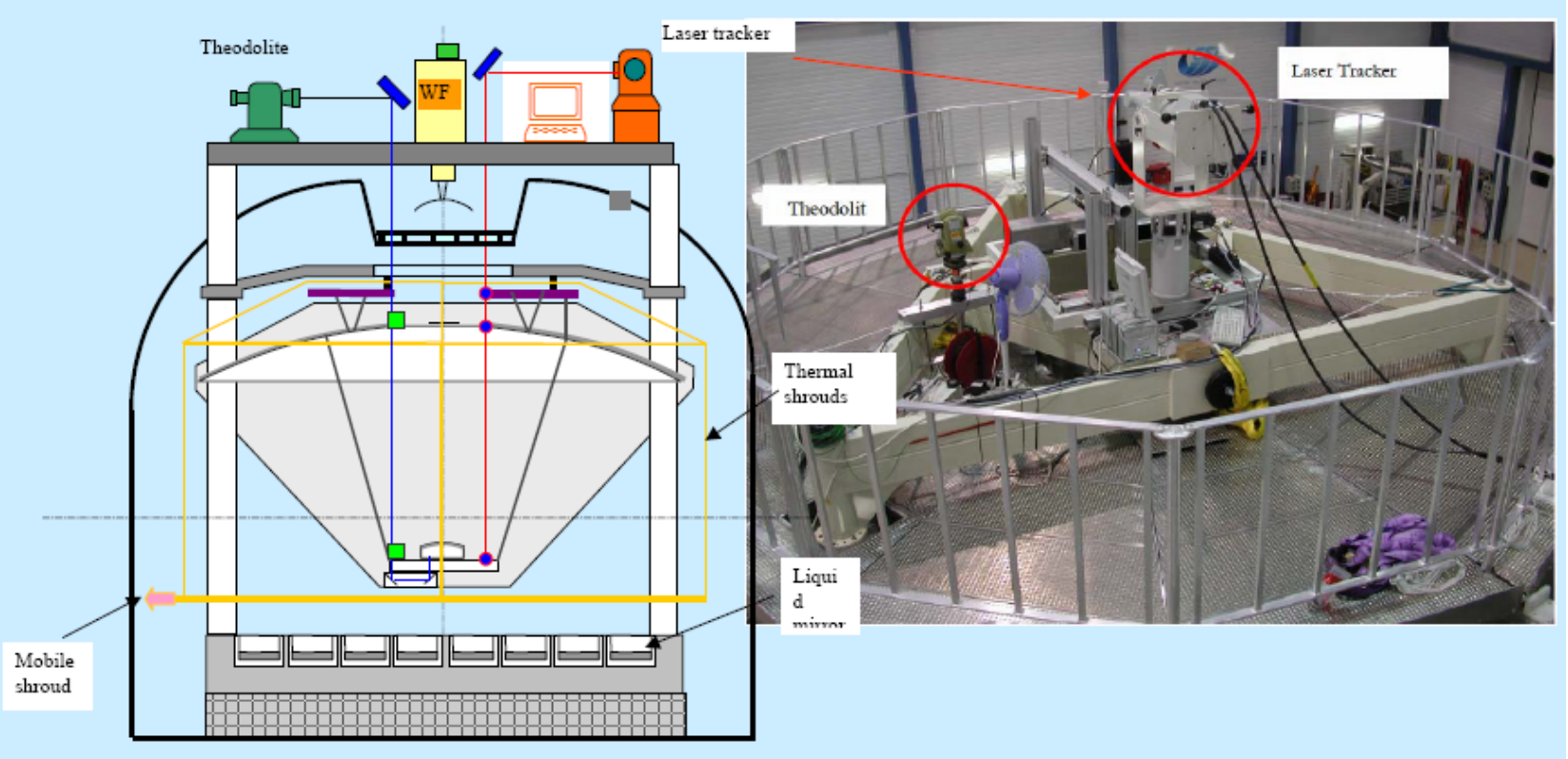
WFE measurement – ambient test set up



- **Ambient measurements in-between thermal tests**
- **33x33 grid (HSM)**
- **Equiv 66x66 grid by interlacing a 33x33 mask**

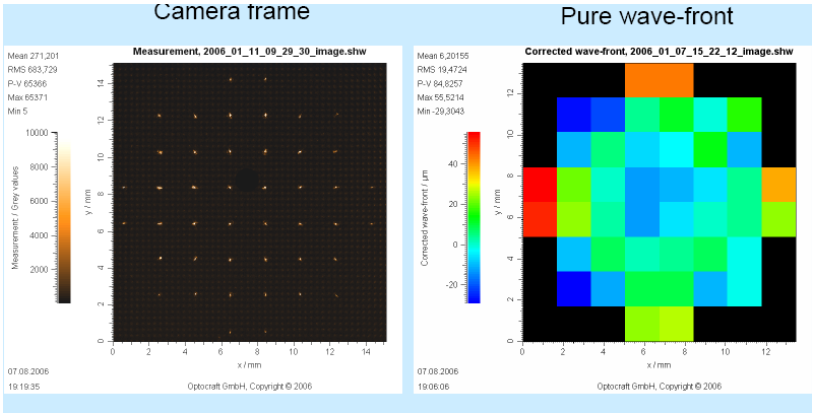


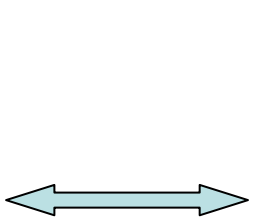
Vacuum thermal test set-up



WFE measurement – LSM mode

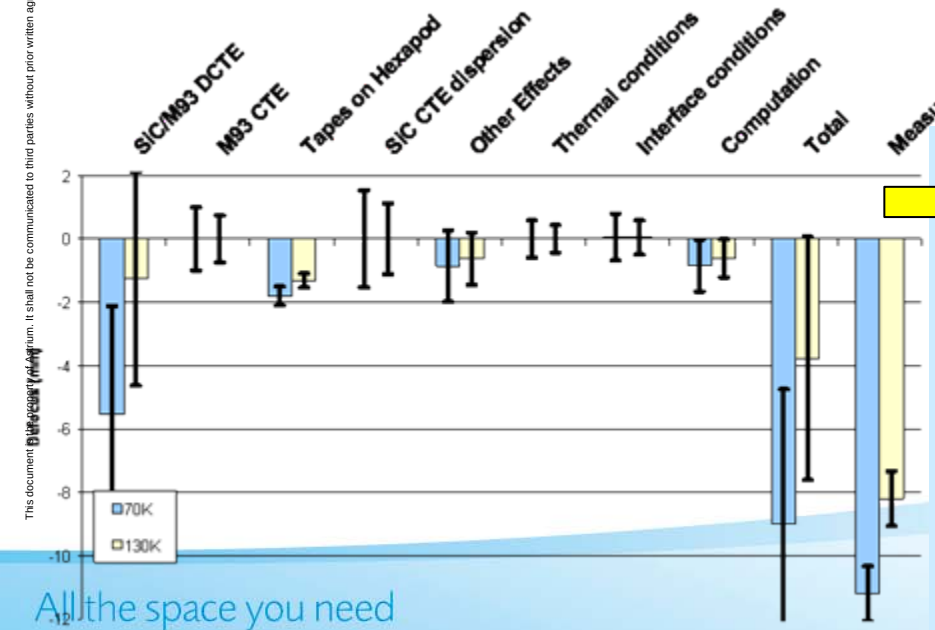
- Thermal tests under vacuum
- 8x8 grid with individual liquid mirrors
- Test of low aberrations evolution : spherical aberration, coma, astigmatism and trefoil
- focus drift monitoring and fit at operationnal temperature
- Cool down deformations signed mainly by defocus and trefoil

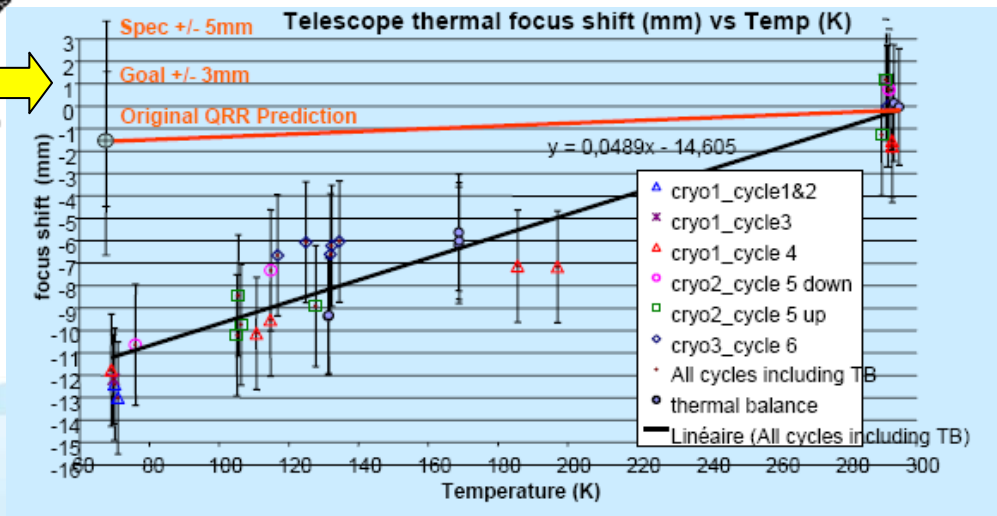




Predictions & measured Focus position

- 2.1µm rms WFE and -11.7 mm defocus measured at 70K against 1.2µm and 0.9 mm predicted during design by FEM
- 6 monthes test campaign 10/2005-04/2006 and parallel analyses until end of summer 2006 have been needed to fix the problem
- Most part of the effect explained by the uncertainty in the knwoledge of Invar to SiC CTE value
- High axial magnification => Amplification of the few tens of µm variations of the M1M2 cavity and high sensivity to small relative differences of CTEs

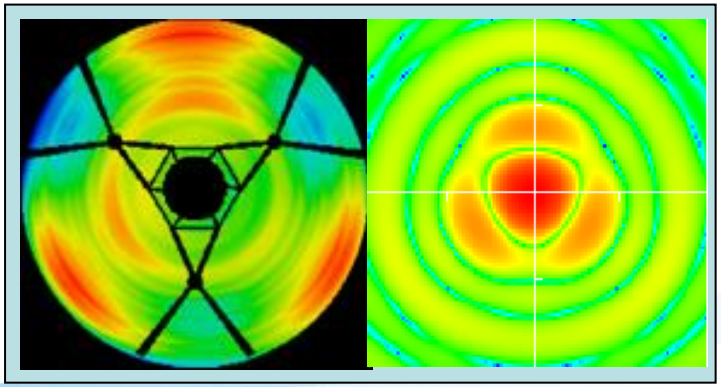




focus investigations & flight predictions

- No doubt was allowed on defocus value
  - the telescope is not equipped with in-flight focalization mechanism
  - No End to End test at satellite level
- Independent team of experts (« Tiger Team ») has been mandated by ESA to investigate the defocus
- CTE causes has been confirmed
- Focus has been compensated by shimming at the telescope to spacecraft interface on order to bring focal surface in the focal depth of tolerance of instruments
- In flight First light on PACS instrument has confirmed success of the operation

Flight predictions
a Tiger team expertize
D.Doyle courtesy



Telescope WFE PACS PSF @55µm

In flight performances

- Herschel is in orbit since 7 months
- General satisfaction of the science community after validations « exam »
- PACS first images (on courtesy of G.Pilbratt –Science team)
  - Comparison to NASA Spitzer Space telescope : Herschel is performing well optically at 100µm
  - remarkable agreement between predicted PSF and observed one at 70µm
  - Signature of the 3 isostatic mounts of the hexapode (trefoil)
- SPIRE first images (on courtesy of G.Pilbratt)
  - Remarkable similarity between Observation (Neptune at 250µm) and simulations;
  - Signature of hexapode geometry (six branch diffraction)