DEVELOPMENT AND PERFORMANCES
3.5M SIC TELESCOPE FOR THE HERSCHEL MISSION

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**TELESCOPE DESIGN**

- **Cassegrain** – 260x axial magnification
- **WFE 5.3µm rms** (FOV0.025° or 250mm)
- **[80;670 µm]** – 70K
- **Focus located inside 5mm³**
- **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**

<table>
<thead>
<tr>
<th>Telescope</th>
<th></th>
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<tbody>
<tr>
<td>focal length</td>
<td>28.5m</td>
</tr>
<tr>
<td>F/number</td>
<td>8.68</td>
</tr>
<tr>
<td>Field of view</td>
<td>0.25</td>
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<tr>
<td>secondary magnification</td>
<td>16.29</td>
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<tr>
<td>Mass</td>
<td>315kg</td>
</tr>
<tr>
<td>Primary reflector (M1)</td>
<td></td>
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<tr>
<td>Radius of curvature</td>
<td>3490 mm</td>
</tr>
<tr>
<td>Conic constant</td>
<td>-1</td>
</tr>
<tr>
<td>Distance to M2</td>
<td>1583.6 mm</td>
</tr>
</tbody>
</table>

- 12 brazed segments
- 3 I/F fittings and bipods
- M1 baffle
- M2 and barrel
- Hexapod
TELESCOPE MAIN INDUSTRIAL TEAM

- Telescope Prime
- Cryo tests
- Spacecraft & mission
- AIT & qualification tests
- Polishing
- M1&M2 Coating
- SiC blanks & parts

Presentation Herschel – OPTRO2010
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 (±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 operational 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 months 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 knowledge of Invar to SiC CTE value
- High axial magnification => Amplification of the few tens of µm variations of the M1M2 cavity and high sensitivity 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
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)