Overall Status of the Herschel Spacecraft: Lessons Learned from Commissioning and Performance Verification

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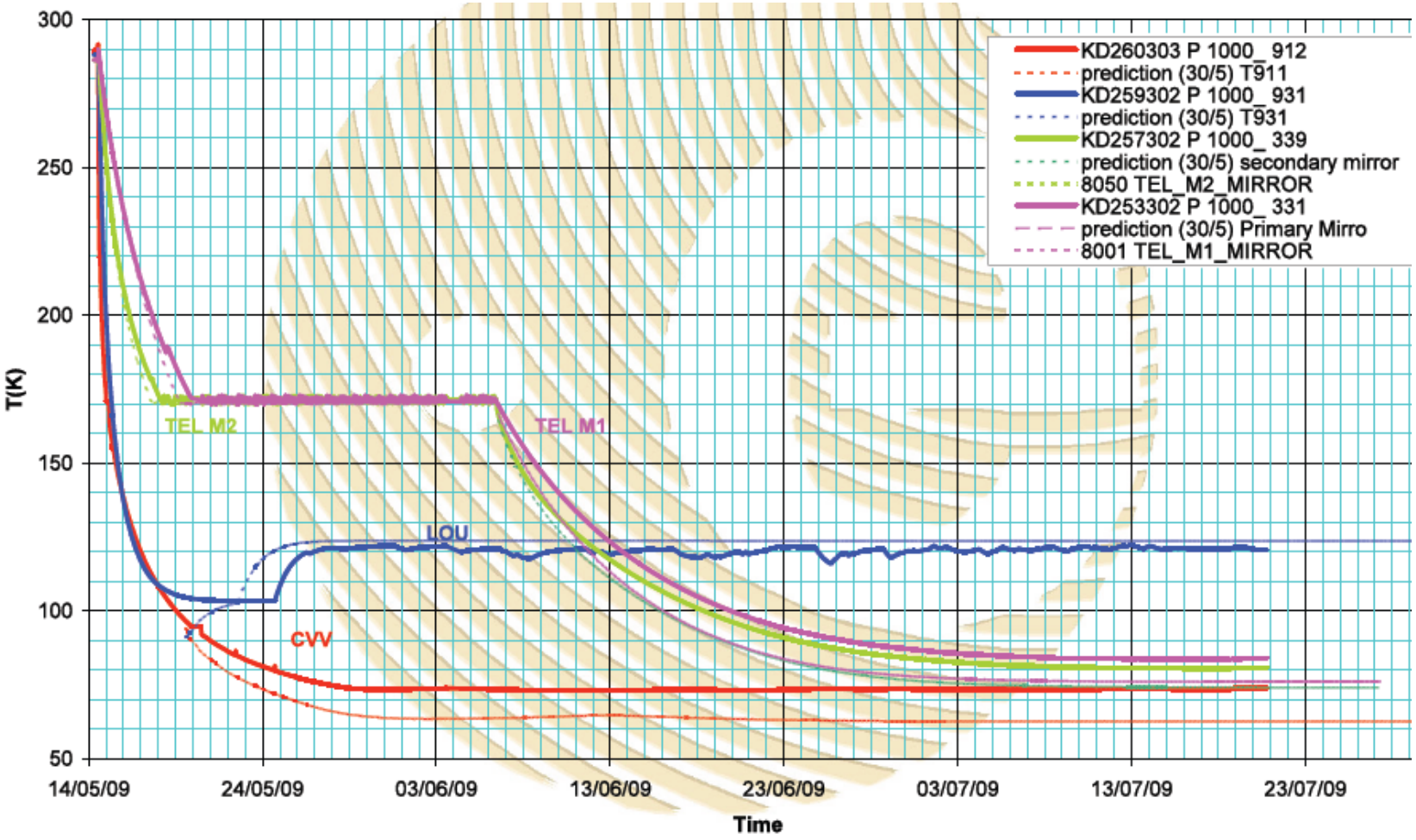
Outline

- Overall Scheme for COP
- Telescope status after COP and “sneak preview”
- Mirror emissivity and temperature
- Pointing performance
  - Accuracy
  - Tracking
  - Scanning
- Observing modes status at the end of PV
  - SPIRE
  - PACS
  - HIFI
- Conclusions

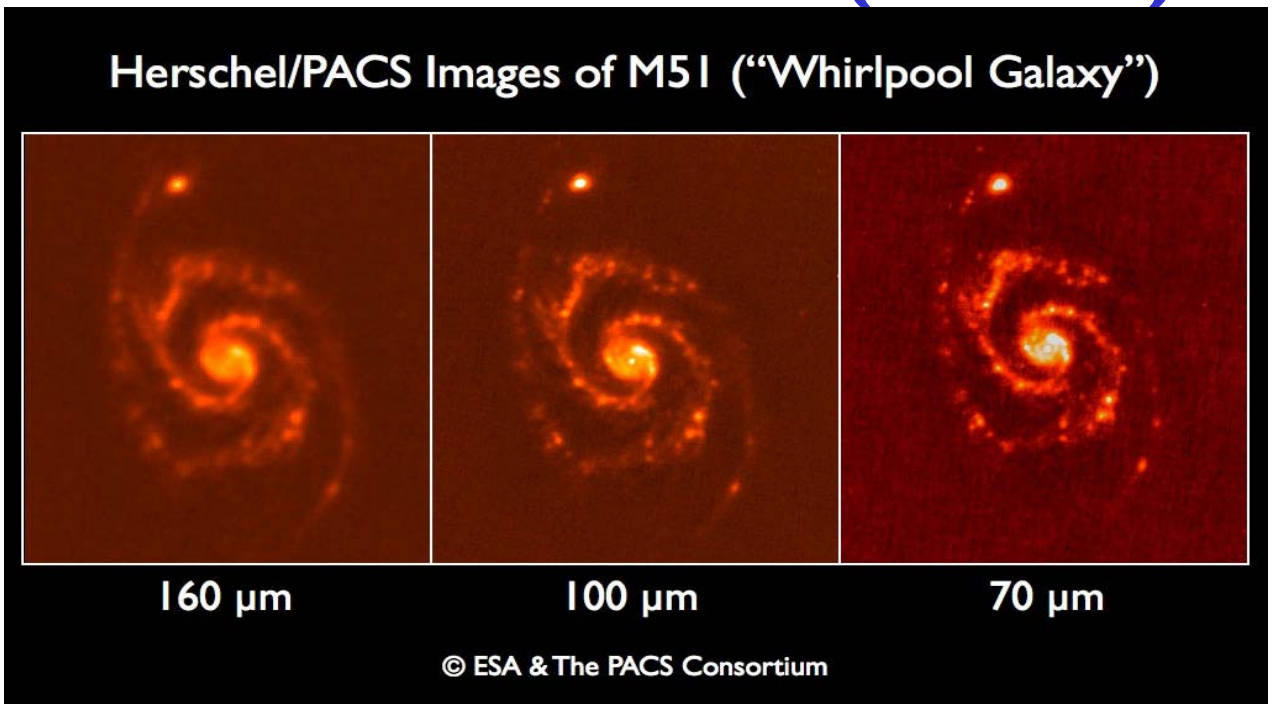
Overall Scheme for COP

- Intention:
  - To functionally test all instruments.
  - To assess initial calibrations prior to and just after cryo-cover opening (e.g., check against internal calibrators, assess stability, adjust satellite heaters).
  - Checkout pointing/ACMS system (STRs point opposite direction to instruments, check misalignment between STRs).
  - Heat system to ensure contaminant removal.
  - Cryocover opening on OD32.
  - Assess straylight and telescope background.

Cooling System During COP



"Sneak Preview (OD32)"

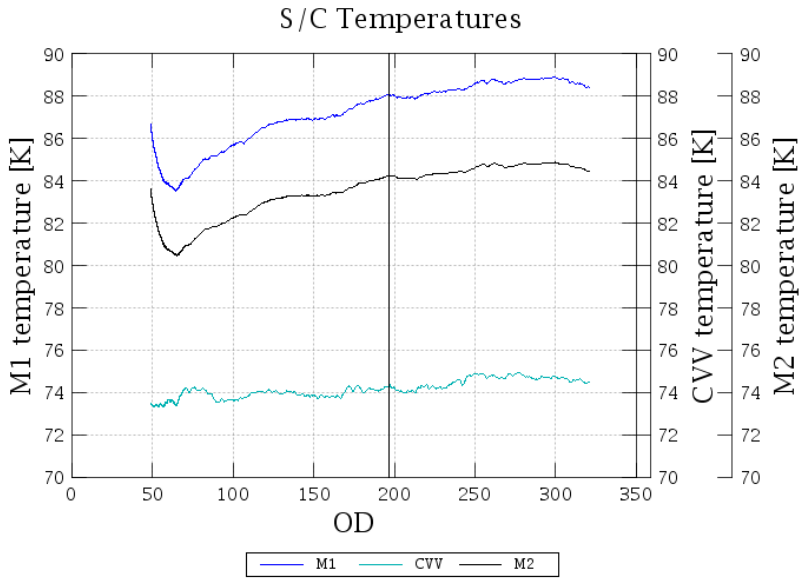


But – very inefficient and observatory was far from ready.

Very useful for early understanding of focal plane geometry for all instruments.

Mirror Emissivity and Temperature

- Basically – low emissivity → higher temperature for mirror. Overall, lower background with lower emissivity. We are towards the low end of expected.
- Temperature of primary/secondary will change over the mission. This is seasonal and has a deviation of as much as 6 degrees (peak in January).

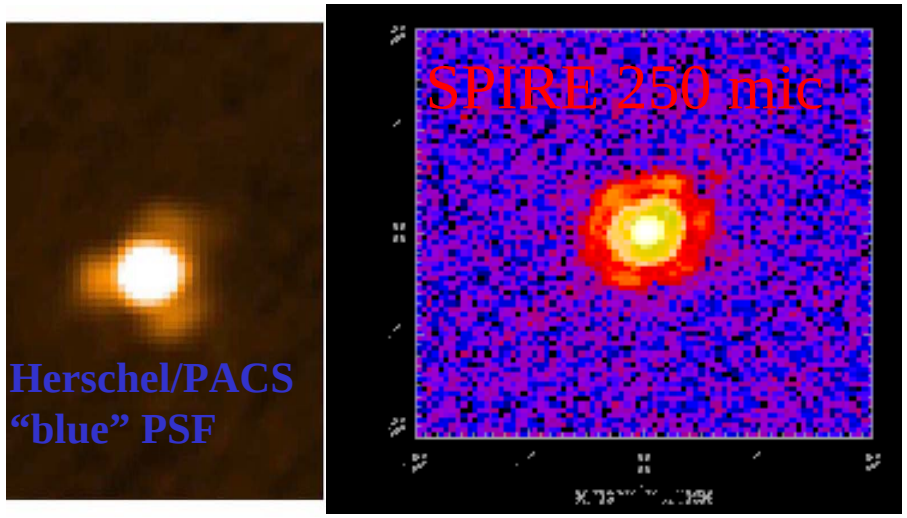


Telescope Status After COP

- Telescope allowed to passively cool down to 170K (M1 and M2 cooled at slightly different rates). Held at 170K for decontamination purposes, then allowed to cool from day 27 so that at 120K around opening on day 32.
  - **No hint of contamination**
  - Local oscillator windows of HIFI show no evidence for contaminants/ice at all.

- **Focus very good** – measurements with PACS indicate diffraction-limited PSFs down to the shortest wavelengths of Herschel.

- PSFs – these show the **diffraction-limited core**, but wings at lower levels giving a triangular shape (diffraction from the hexapod holding the secondary mirror)

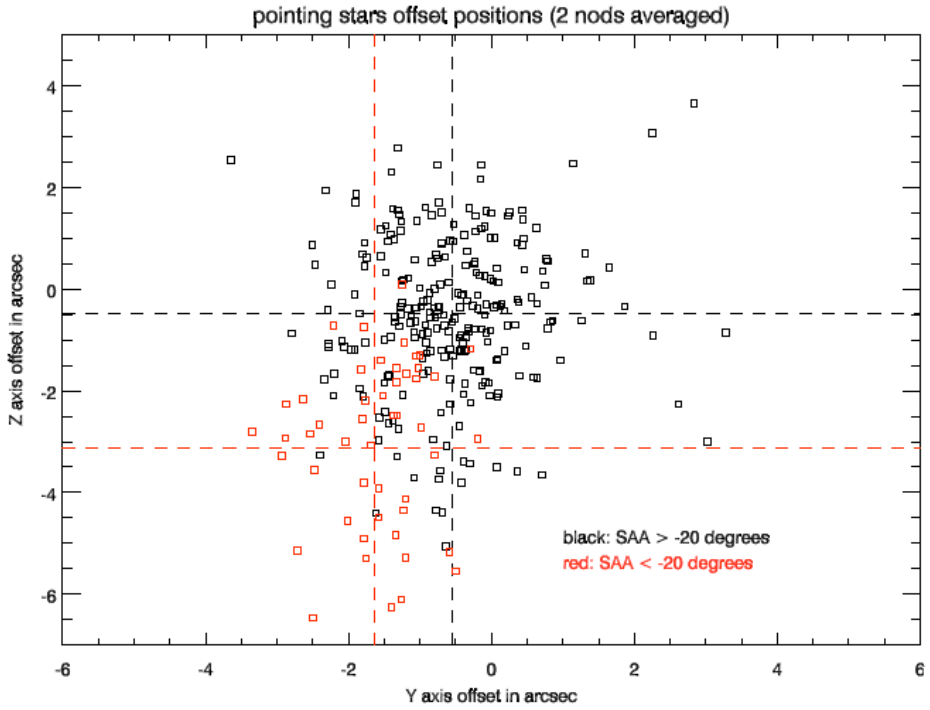


Overall Scheme for PV

- Based on the instrument PV plans that were reviewed well before launch.
- Intention: to verify observing modes and optimize sufficiently that close to / at / above sensitivity expectations.
- Typically worked in 12 day cycles (to start) which allowed time for analysis, commanding updates (CUS), and planning cycles.
- Literally dozens of changes made to instrument commanding. Typically 5000 to 10000 telecommands uplinked daily. Very few commanding problems.
- When ready, each AOT went through a release review, included uplink and downlink (pipeline) concerns and issues to inform users about.
- SDP observations started with release of associated AOT mode.
- Assessed performance of the observatory.

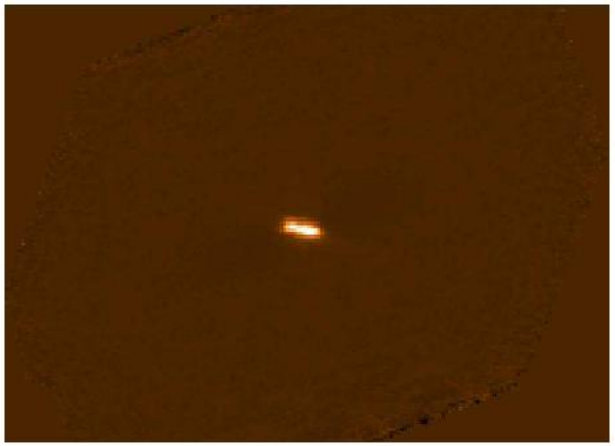
Pointing Performance

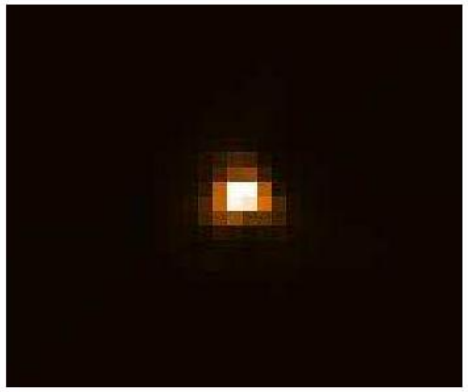
- Generally speaking we are where we expected to be, which is better than requirements on direct staring (absolute pointing – 1.9 arcsecs, relative pointing improved with interlacing).



Tracking

- Tracking has been shown to be excellent. Solar system targets have been shown to easily stay within a single PACS blue frame pixel for observations of 1 hour+.
- E.g., 18 Melpomene (67”/hour).

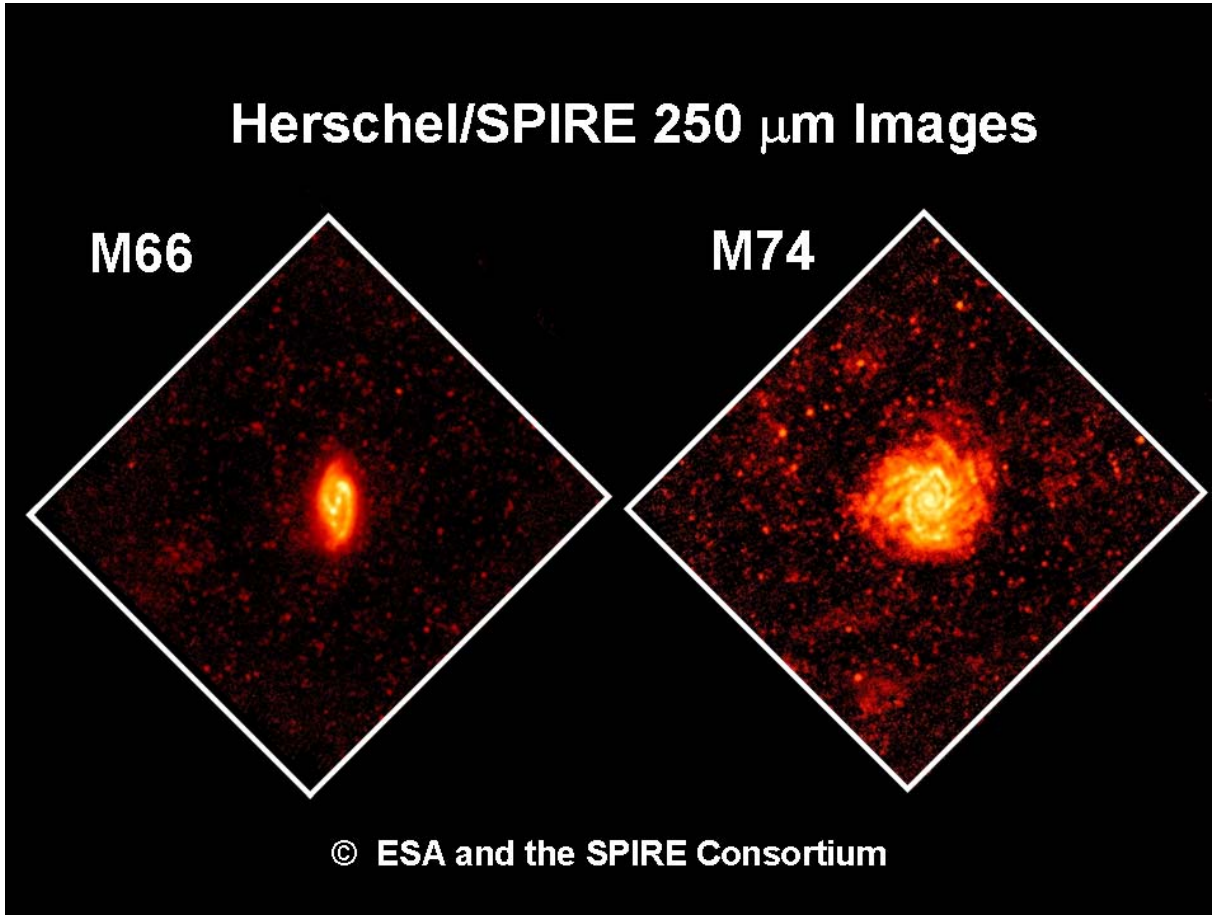




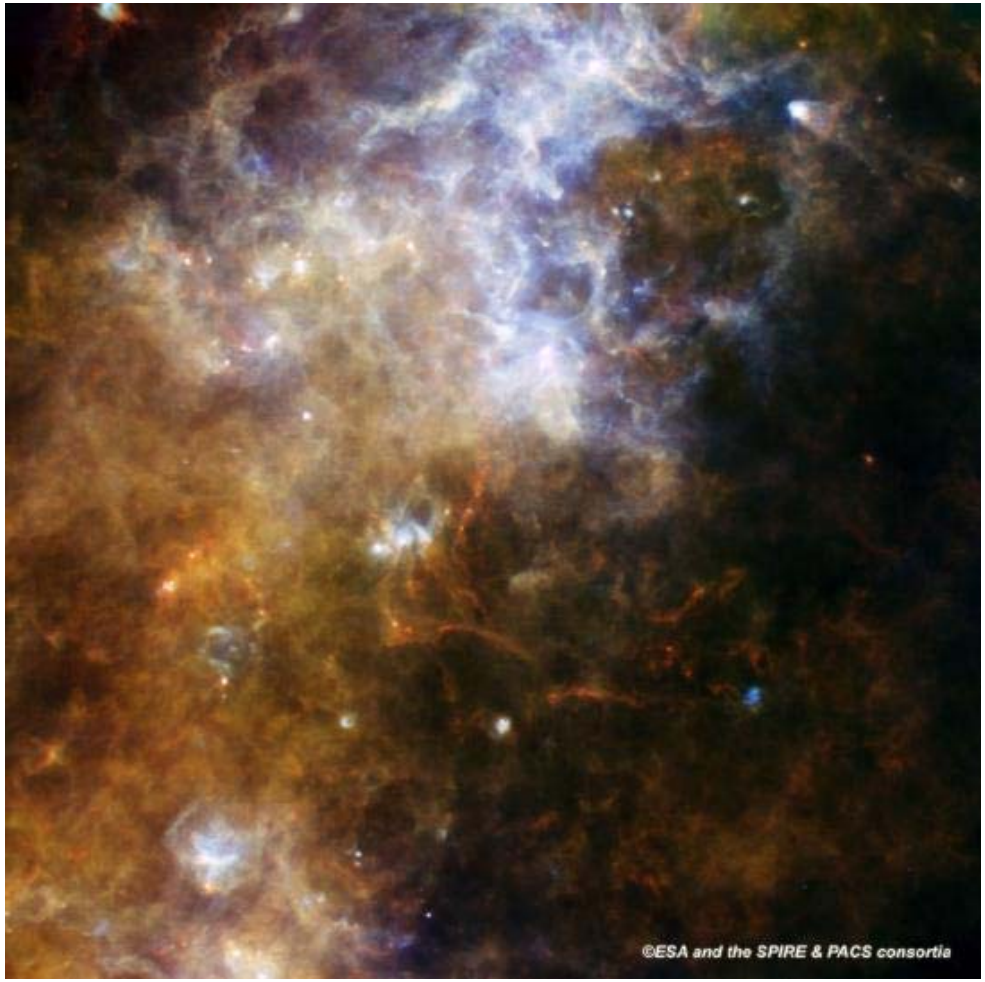
Scanning

- Scan maps work well for both PACS and SPIRE. **But** we did notice some jumps in scanning speed/reported direction for portions of some scans. Believed solved for future observations.
- Delays noted at the beginning of scan legs have been reduced. More efficient for PACS scans.
- Scan leg offsets provide improved/even coverage for PACS & SPIRE scan maps.
- SPIRE scan map go to confusion limit after only 2-3 scans.

SPIRE Scan Maps



Parallel Mode Scan Maps



Observing Mode Status: SPIRE

SPIRE Modes	Sensitivity	Released	Comments
Phot - point	Yes	Yes	7-pt jiggle.
Phot – small map	Yes	Yes	Not 64-pt jiggle. Will use orthogonal scan maps instead.
Phot – scan map	Yes (~same as HSpot, 2 or 3 scans → confusion limit)	Yes	Bright source mode released. Use for sources >200Jy. Approx. 10-20% accuracy in photometry.
Parallel mode SPIRE/PACS	Yes (as for scan map)	Yes	Colour corrections and high flux linearities understood.
Spec - point	Yes (~2x better than HSpot)	Yes	High and low resolutions only.
Spec - mapping	Yes	Yes	Intermediate and large map.

Observing Mode Status: PACS

PACS Modes (all limited to 9.1h)	Sensitivity	Released	Comments
Phot - point	Yes (approx. 2 times worse than original – as per HSpot 5.0)	Yes	Provides best PSF. Photometer flux cal accuracy ~10%.
Phot – small map	Yes	Yes	**Cover approx. 4' field. Change from original raster.**
Phot – large scan	Yes	Yes	Use 20"/sec scan speed NOT 10"/sec.
Spec – point&raster /range & chop/nod	Yes	Yes	
Spec – SED spectroscopy	Yes	Yes	
Spec – Wavelength switching X	Deprecated	Yes	.Replaced by "unchopped grating line/SED scans"

Observing Mode Status: HIFI Point

Reference scheme	Sensitivity	Release	Comments
DBS	Yes (relatively unchanged)	Yes	Overall calibration dependant on TBC beam efficiencies. **HEB bands now to use Fast DBS only**.
FSW	Yes	Yes	Not recommended for use with bands 6 and 7.
PSW	Yes	Yes	Limited use with bands 6 and 7.
LChop	Yes	Yes	Limited use with bands 6 and 7. **Use reference OFF position.**

Observing Mode Status: HIFI Map

Reference scheme	Sensitivity	Release	Comments
OTF (incl. LChop/PSW/FSW)	Yes	No	Expected to be released shortly.
DBS raster	Yes	Yes	As per point mode.
DBS cross	Yes	Yes (on hold)	As per point mode.

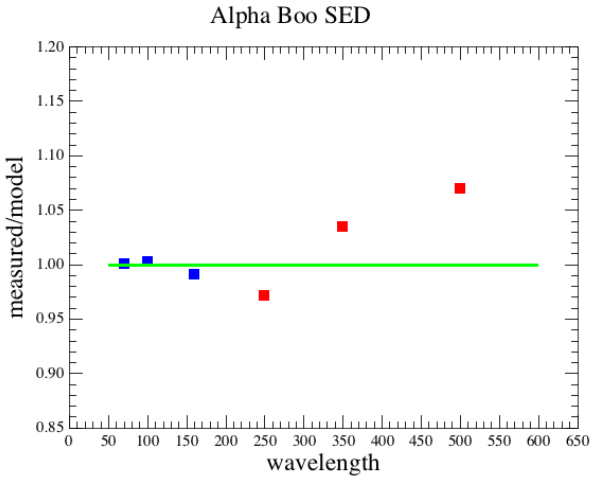
Observing mode status: HIFI Scan

Reference scheme	Sensitivity	Release	Comments
DBS	Yes	Yes	Same as for point DBS mode, use fast chop for bands 6 and 7.
FSW	Yes	Yes (partial)	Limited usage – not for HEBs.

Other Issues

- The SPIRE DCU heat dissipation affects HIFI laser leading to instability in the HIFI V polarization measurements. SPIRE needs to be off for at least 10 hours before HIFI comes on.
  - –Current schedule has SPIRE separated from HIFI by at least one observing day.
- Almost simultaneous measurements have been made by SPIRE and Planck (HFI), covering same wavelength range. Possibilities of later cross-calibration and this is being actively pursued – possibilities of high absolute calibration.

- **Limited cross-calibration so far, but shows excellent agreement (e.g., PACS and SPIRE photometers). Common standards and models being used. Full cross-calibration plan due end of April.**



Conclusions

- Every key project now has data (SDP and/or PSP)!
- Sensitivities are mostly similar to or better than pre-launch predictions (for HIFI also).
- Some modes changed and recommended updates communicated to KP teams.
- There will be further improvements to AOTs in the future.
- Possible problems areas that are not problems:
  - Focus: none (also known that LO windows aligned with waveguides)
  - Contamination: none seen including on LO windows.
  - Straylight: Modeled. As expected.
  - Consistent calibrations: Across the instruments, so far showing very good agreement.
- Still issue of HIFI beams and optimizing the aperture placements (SIAM) for HIFI.
- Pipelines are catching up with all the lessons learned but some work will be needed from astronomers…which is why you are here!!

Additional Slides

Organigram for Operations

Calibration (7.5 fte)

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- **D. Teyssier** **(HIFI Inst. Cal. Sci.)**
- **I. Valtchanov** **(SPIRE Inst. Cal. Sci.)**
- **M. Sanchez** **(Pointing Expert)**
- **R. Vavrek** **(PACS Inst. Cal. Sci.)**
- **L. Conversi** **(SPIRE Inst. Cal. Sci.)**
- **B. Merin** **(DP Astronomer** 0.5fte**)**