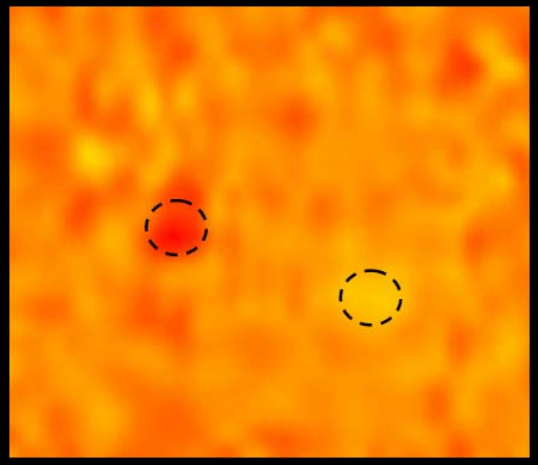
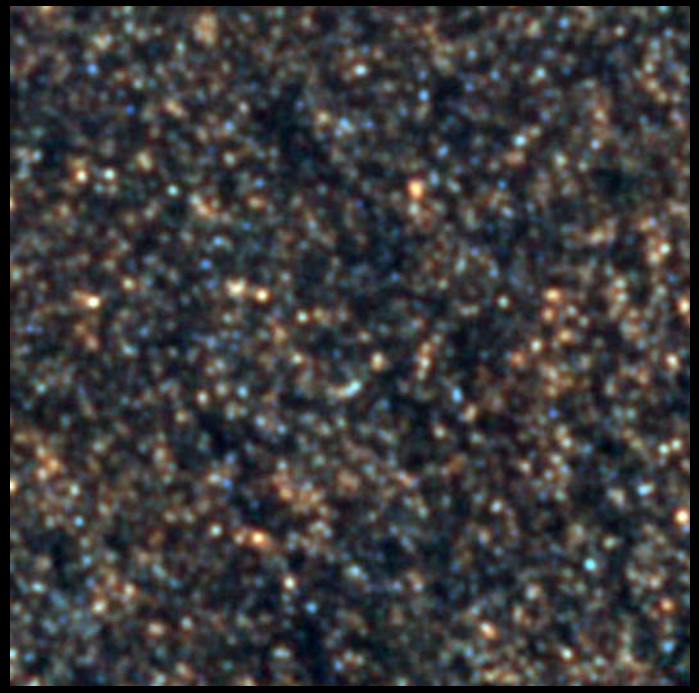
SPIRE

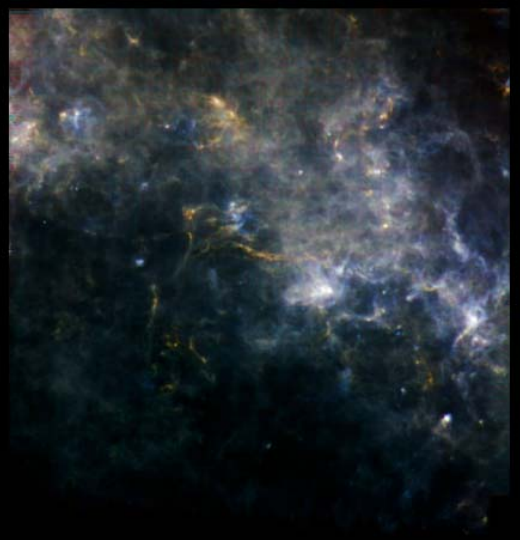
In-flight Performance, Status and Plans

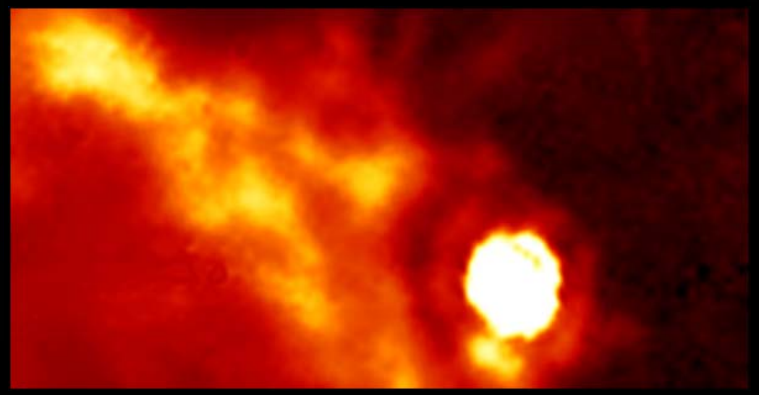
Matt Griffin
on behalf of the SPIRE Consortium

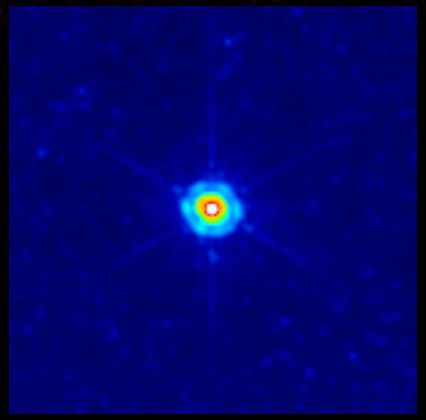
Photometer











AOT Status: Photometer

- **Scan Map and Parallel Mode**
  - **Released for nominal source brightness settings**
  - **Bright source settings now defined: release imminent**
  - **Active thermal control of 300-mK stage: to be evaluated**
- **Small Map**
  - **Decision to change mode from 64-point jiggle to small scan map**
  - **AOT to be available ASAP in 2010**
- **Point Source**
  - **On hold due to issues Beam Steering Mechanism and nodding stability**
  - **Planned to be available early in the new year**
  - **Comparison to be made with small map**

Scan-Map Sensitivity

Pre-launch (HSpot) estimates (instrument noise)

- One repeat = two cross-linked scans
- Numbers referred to point source detection in a map in the absence of confusion noise
- For (250, 350, 500 μm)
  - 1-σ sensitivity for one repeat: (10, 13, 11) mJy/beam
  - No. of repeats to achieve 3 mJy rms: (10, 19, 14)

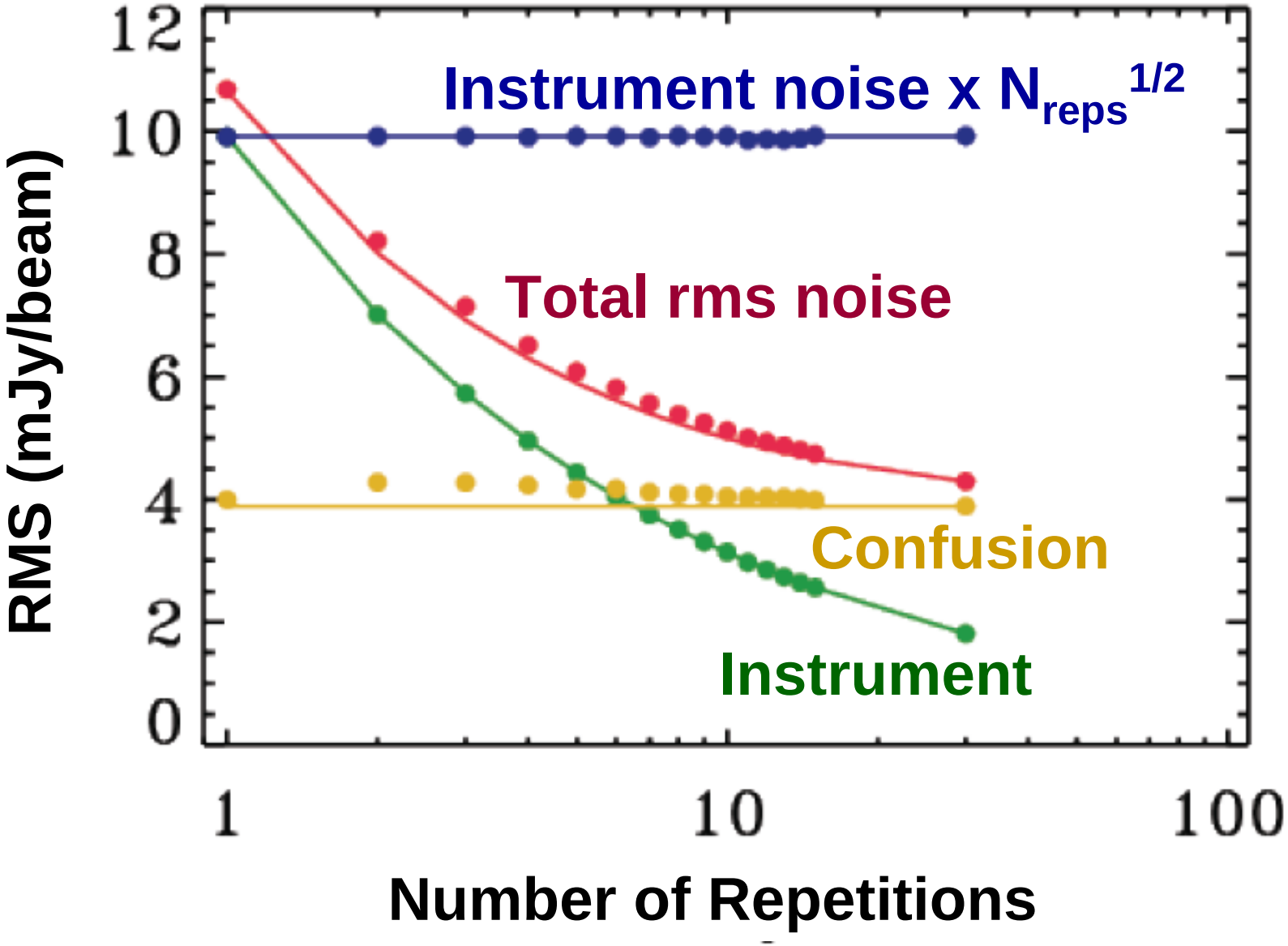
Achieved instrument noise

- Standard map pixel sizes (6, 10, 14)”
  - 1-σ sensitivity for one repeat: (12, 8, 12) mJy/beam

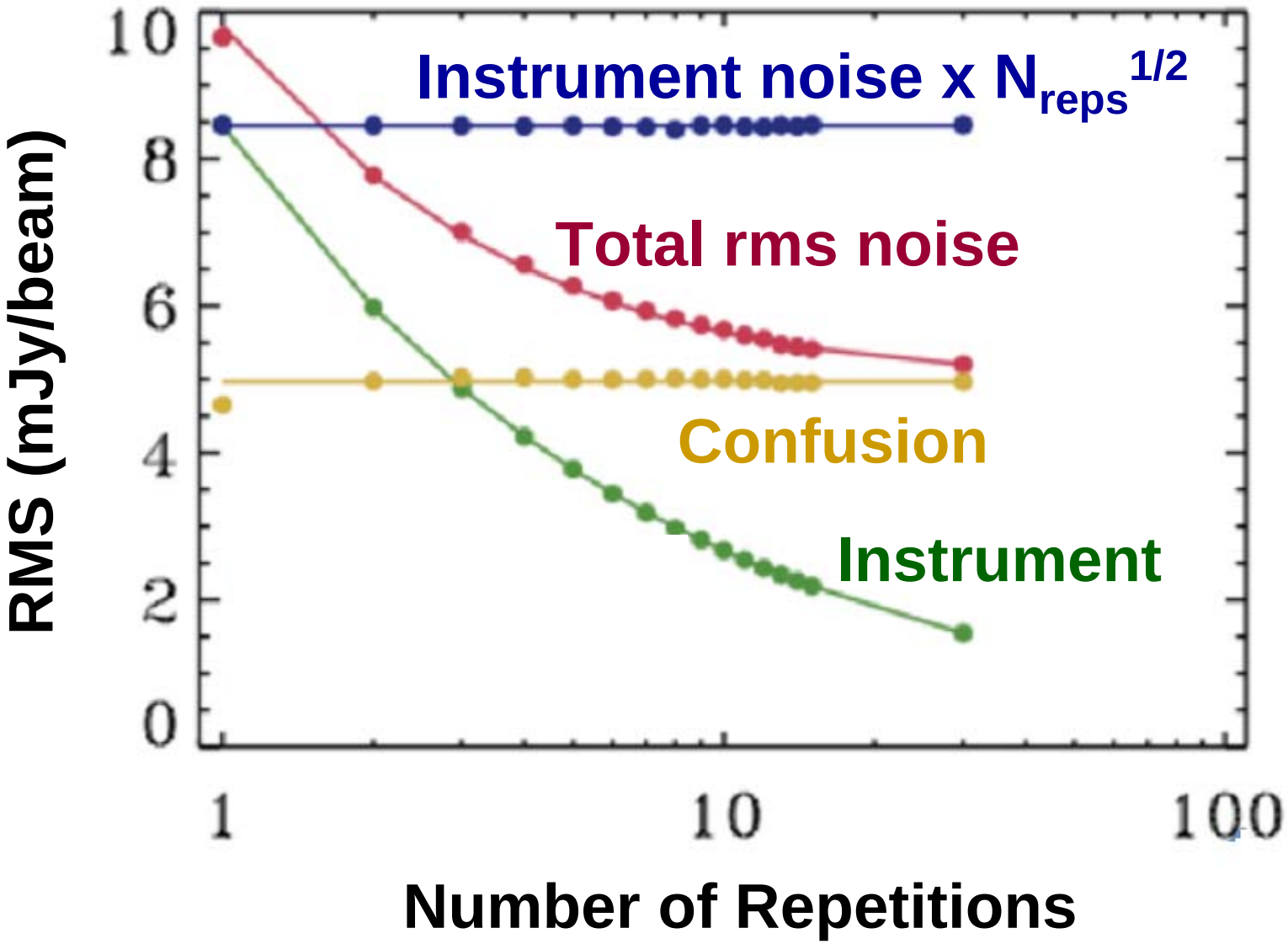
Extragalactic confusion levels

- Measured 1-σ confusion noise for (250, 350, 500 μm): (4, 5, 6) mJy/beam for (6, 10, 14)” map pixels

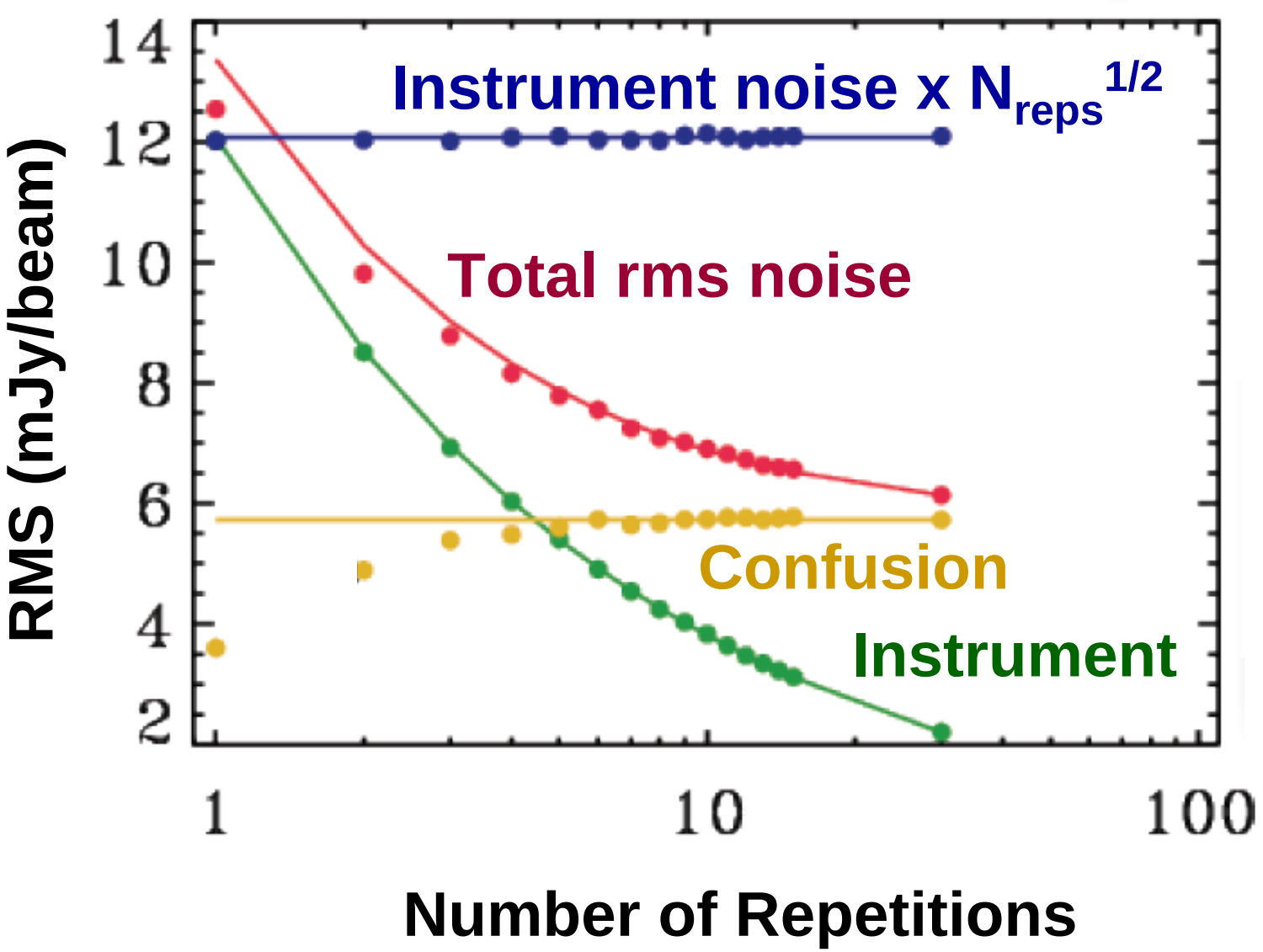
PSW (250 μm)


Instrument noise x N_reps^1/2
Total rms noise
Confusion
Instrument
RMS (mJy/beam)
Number of Repetitions
0
2
4
6
8
10
12
1
10
100

PMW (350 μm)


Instrument noise x N_reps^1/2
Total rms noise
Confusion
Instrument
RMS (mJy/beam)
Number of Repetitions
0
2
4
6
8
10
1
10
100

PLW (500 μm)

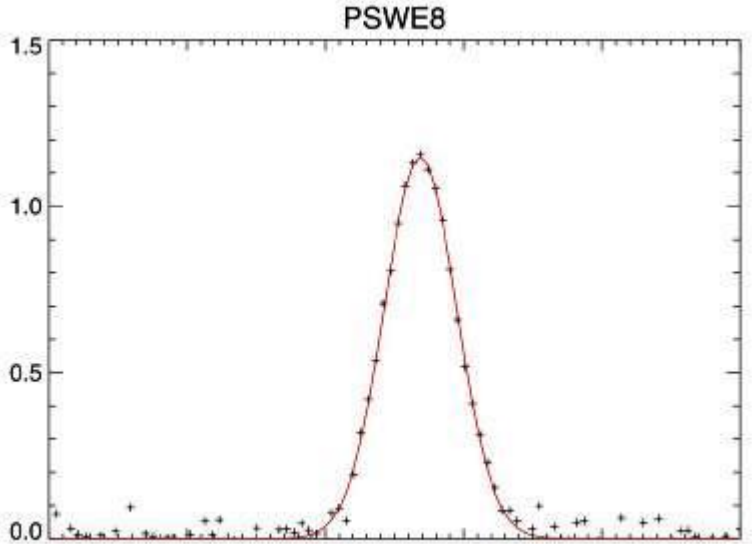

Instrument noise x N_reps^1/2
Total rms noise
Confusion
Instrument
RMS (mJy/beam)
14
12
10
8
6
4
2
1
10
100
Number of Repetitions

Photometer Beams

(as given in Scan-Map Release Note)

Band (μm)	Fitted Gaussian FWHM (arcsec)
250	18.1 ± 0.4
350	25.2 ± 0.5
500	36.9 ± 1.0

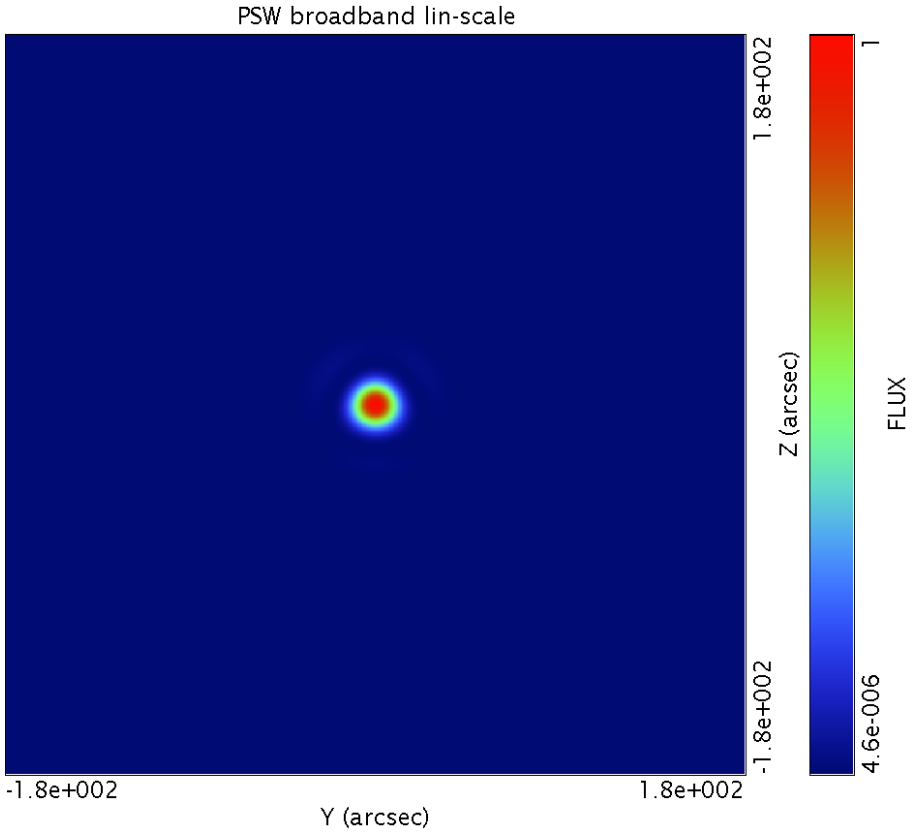
Ellipticity: Y/Z ≈ 1.08 ± 0.05



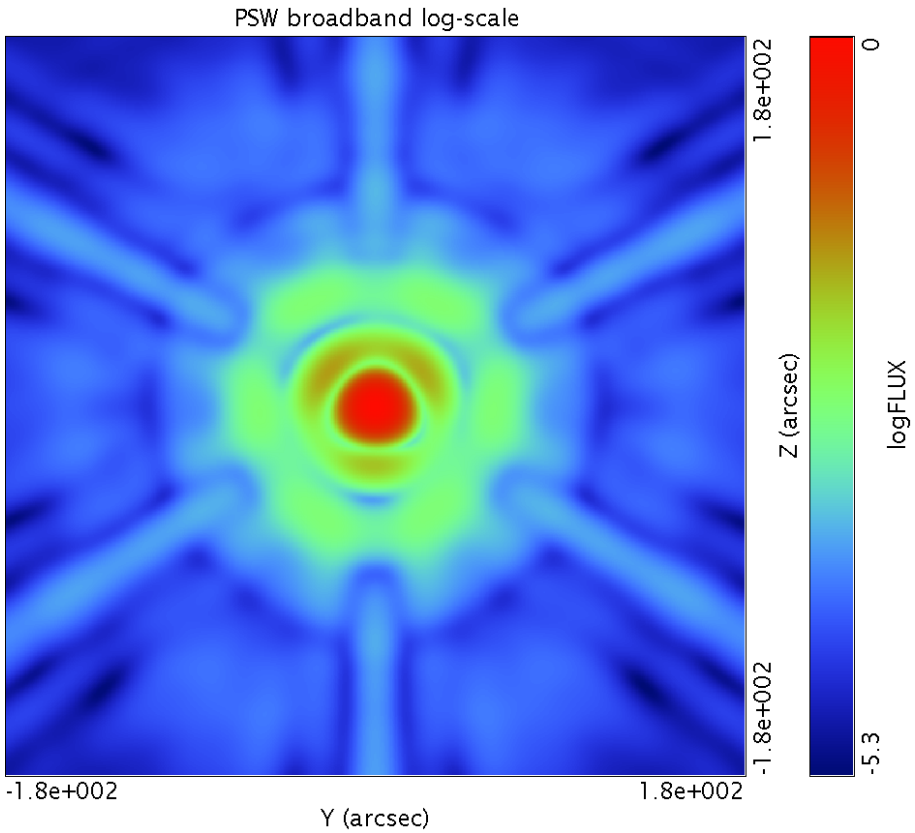
- **Fine-scan observations of Neptune being analysed**
  - **Above numbers will not change much**
- **Main beams very well fitted by Gaussian response**
- **Detailed effective PRF and conversion from Jy/beam to Jy/pixel to be derived**
- **Individual beam profiles for every detector will eventually be made available**

250 μm Model over 6'x6'

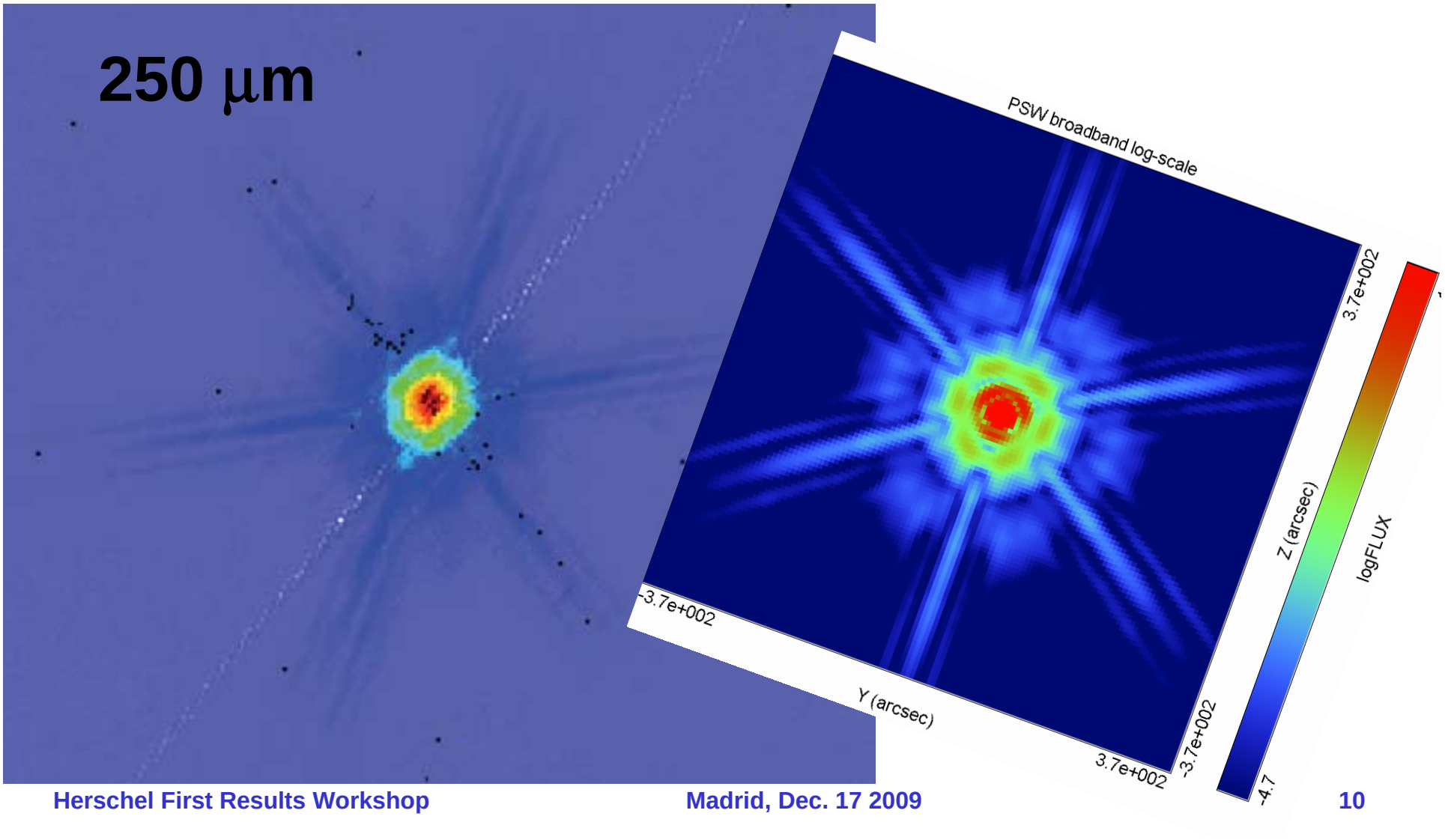
Linear scale



Log scale



Model (at 6” sampling) Compared to Mars Map (Saturated in the Core)

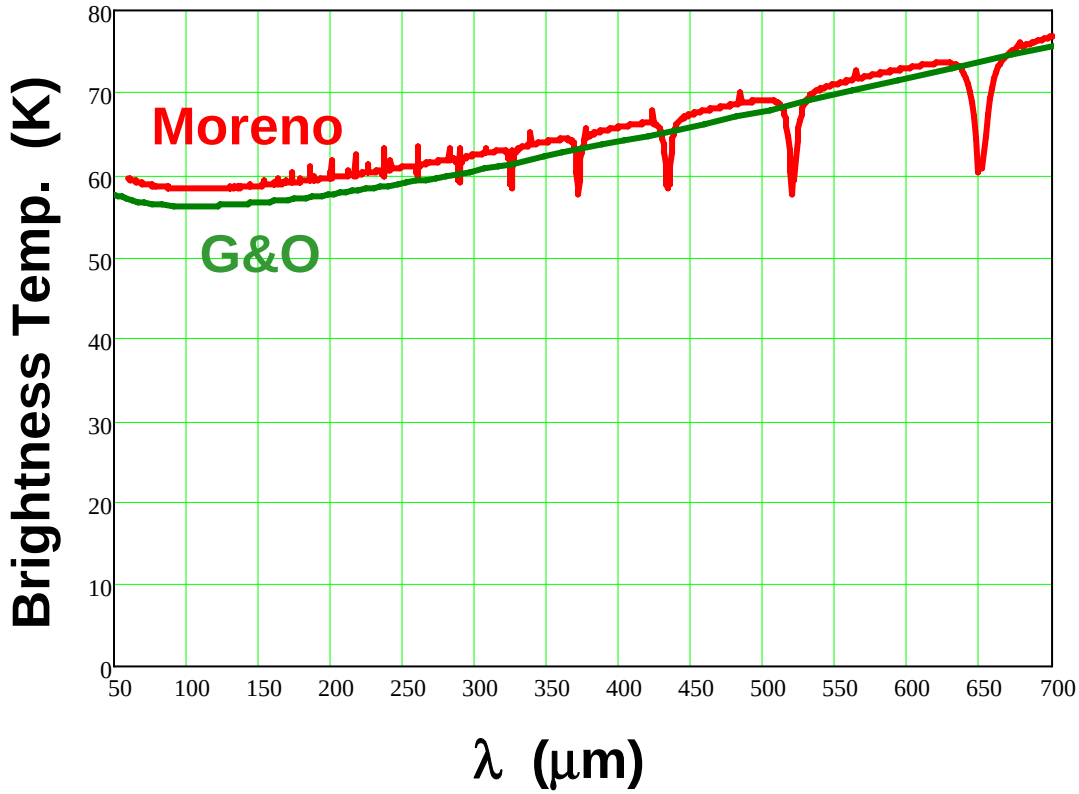


Photometer Flux Calibration

- **Primary calibrator is Neptune (Moreno Model)**

- **Estimated absolute accuracy = ± 5% (correlated over the SPIRE range – i.e., whole spectrum moves up or down)**

- **Note: Moreno model is 2-3% warmer than the Griffin & Orton model often used for ground-based submm calibration**



Photometer Flux Calibration

- Neptune not available for most of PV
- Larger asteroids as secondary/interim calibrators
  - Also not available for most of PV
- Current SPIRE pipeline uses interim calibration based on early observations of Ceres
- Recent Neptune observations and non-linearity characterisation – analysis still to be completed
- Current calibration is very accurate wrt Neptune model
- Interim correction factors can be applied to pipeline flux densities (with statistical uncertainties):
  - 250 μm: 1.02 ± 0.07
  - 350 μm: 1.05 ± 0.12
  - 500 μm: 0.94 ± 0.06

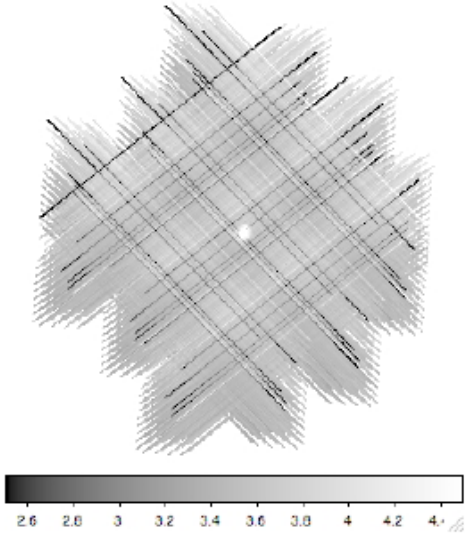
Photometer Scan-Map Pipeline

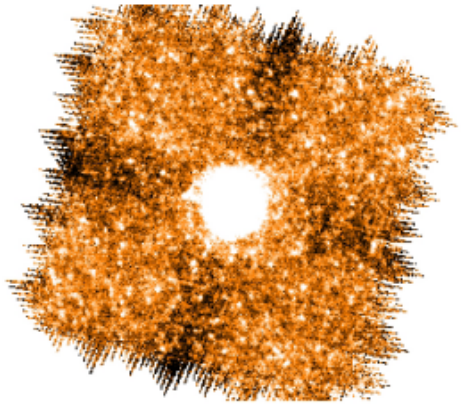
- **Current Level 2 products are naïve maps**
  - **MadMap not yet implemented as standard**

- **Various remaining issues to be addressed**
  - **Pointing:**
    - **Small systematic shifts during long observations**
    - **Fix devised and under test**
  - **Baseline removal**
  - **1/f noise**
  - **Glitch replacement**

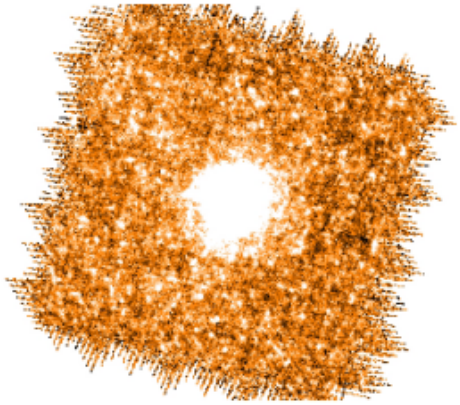
Photometer Scan-Map Pipeline

- **Baseline removal**
  - **Median baseline removal added to L2 processing before the map making stage**
  - **Improved temp-drift calibration will ease but not eliminate the effects**
  - **SPIRE consortium and OT users are investigating improved algorithms**
  - **De-correlation using thermistor signals over an entire observation has been very successful**





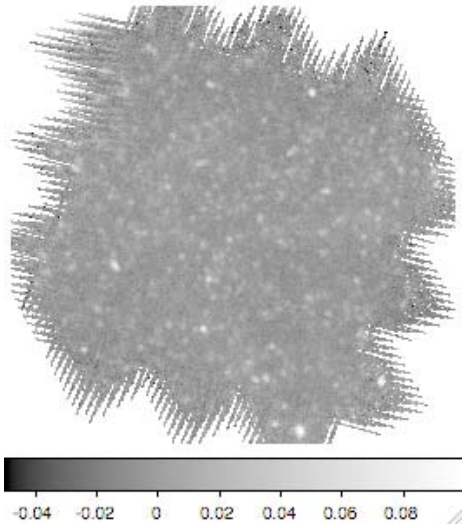
median baseline subtraction

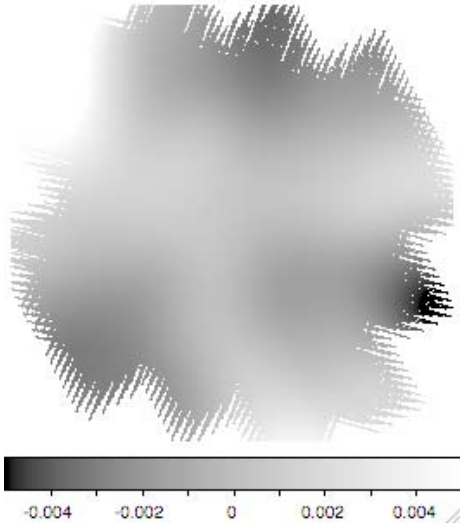


robust linear baseline subtraction per scan

Photometer Scan-Map Pipeline

- **Residual 1/f noise**
  - **Small effect, remaining from temperature drift correction**
  - **Produces low level structures in the background**
  - **Improved operation of 300-mK temperature control will be tested**

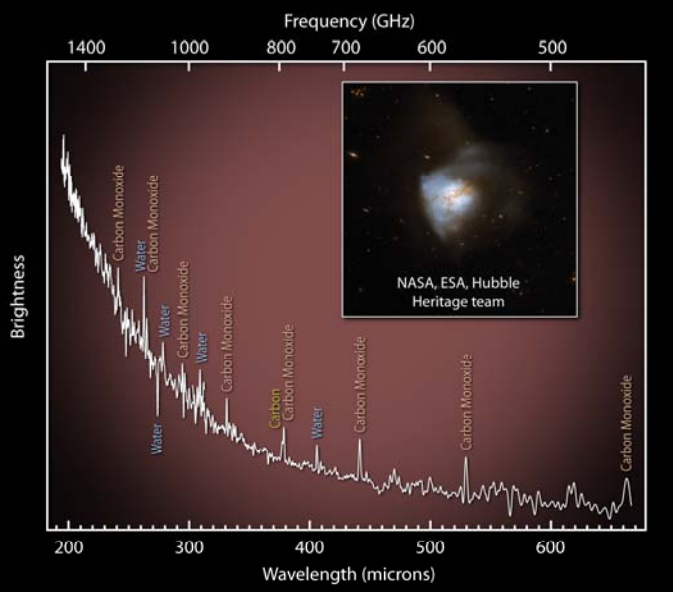




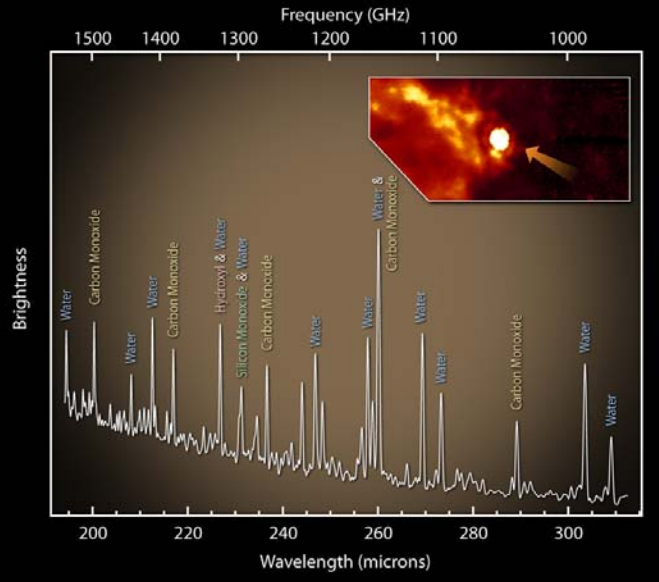
Scan-Map AOT and Pipeline: Future Plans

- AOT implementation: possible updates
  - 300-mK temperature control
  - Less frequent PCal operation
  - Dithering for maximum uniformity of coverage
  - Use of small scan map even for point source AORs
- Pipeline (pre-mapmaking)
  - Correction for pointing shifts
  - Improved baseline removal
  - Improved flux calibration
  - Glitch replacement
- Mapmaking
  - Current baseline plan: implementation of MadMap as standard SPIRE mapmaker
  - Review of mapmaking will be held in January to assess mapmaking options in the light of in-flight characteristics and scientific needs

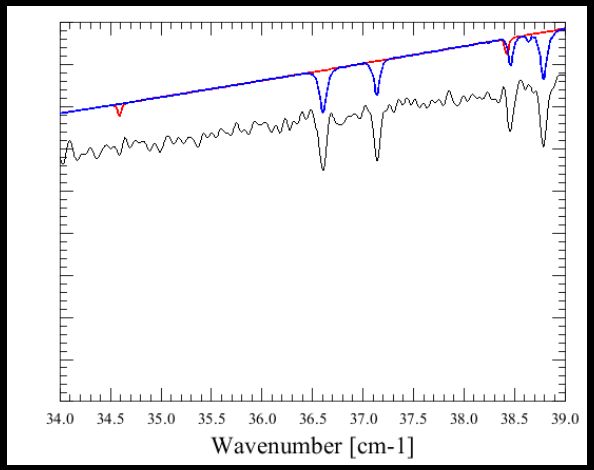
Spectrometer

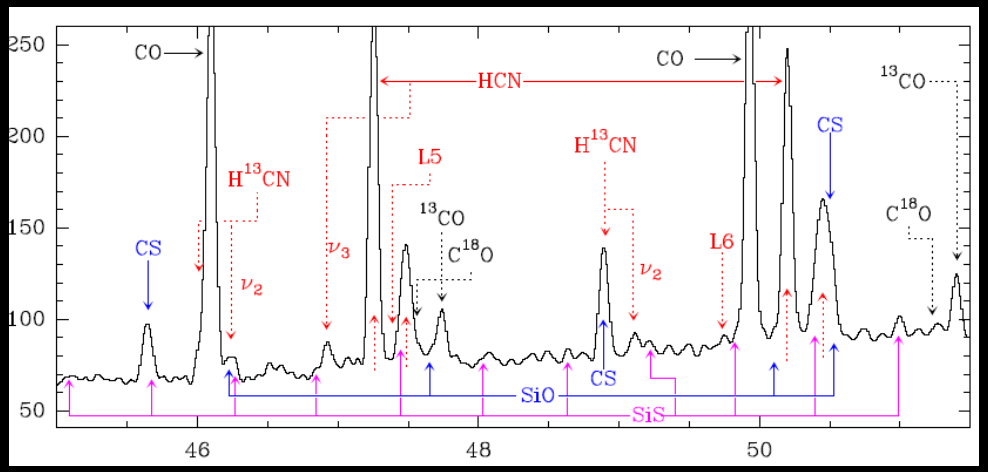


Arp 220



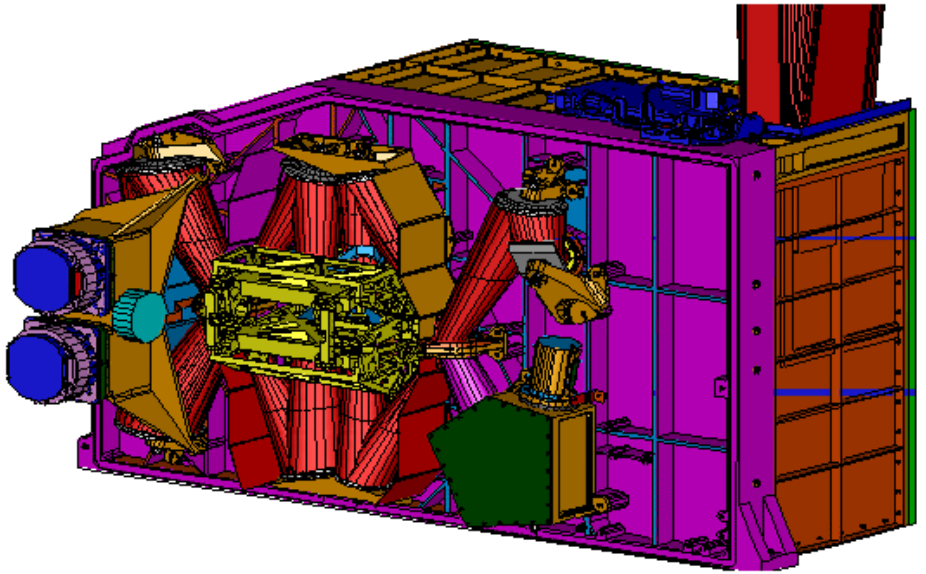
VY Canis Majoris





Reminder of SPIRE FTS Capabilities

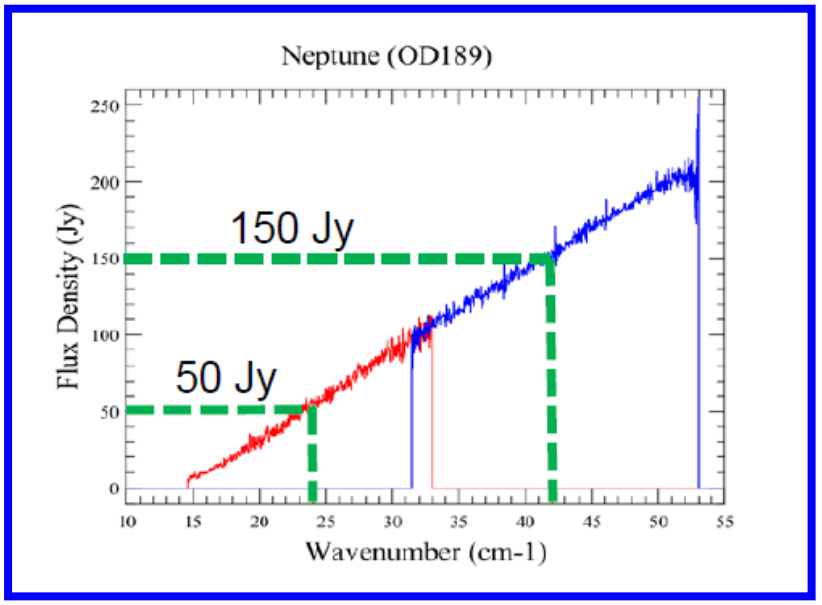
- **Wavelength range: 194 – 671 μm**
- **Entire range covered simultaneously**
- **Continuum measured as well as spectral lines**



- **35 and 19 detectors in SSW and SLW arrays**
  - **Imaging spectroscopy over ~ 2.6 arcmin fov**
- **Spectral resolution (adjustable)**
  - **High: 1.2 GHz**
  - **Medium: 6.7 GHz**
  - **Low: 25 GHz**

Spectrometer Status

- Spectrometer commissioning and PV was delayed due to thermal and OBS issues affecting the mechanism operation
- PV and SD have been successfully hybridised – all SD users of the FTS have some data
- Point source/sparse map spectroscopy AOT now released
  - Caveats
    - Calibration currently only guaranteed for on-axis detector pair
    - Bright source settings not yet available
    - Nominal settings OK for flux densities < 50/150 Jy in SLW/SSW bands)



- FTS mapping
  - Intermediate/full spatial sampling AOT to be released early 2010

Spectrometer Sensitivity

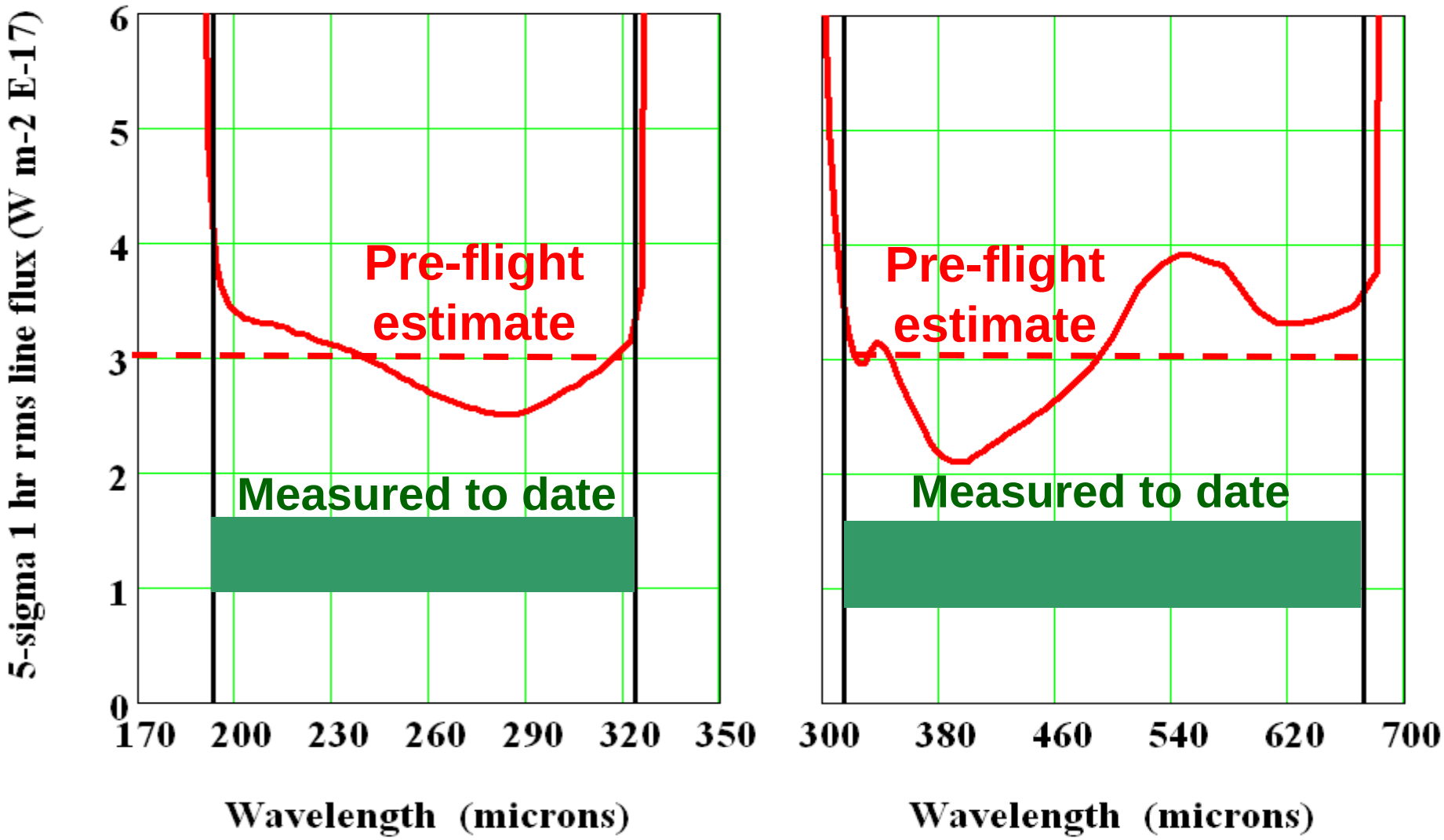
- **In-flight sensitivity is significantly better than pre-launch estimates**

- **Improvement factor of 2 – 3 at present**
  - **May get better still as data processing and RSRF characterisation are further improved**

- **Reasons for better sensitivity**
  - **Telescope is less emissive**
  - **Lower background allows second-port calibrator to be switched off – further reduction in photon noise**
  - **Detectors are running slightly colder than assumed**
  - **FTS model is complex with a number of uncertainties, so a "pessimism factor" was applied pre-launch**

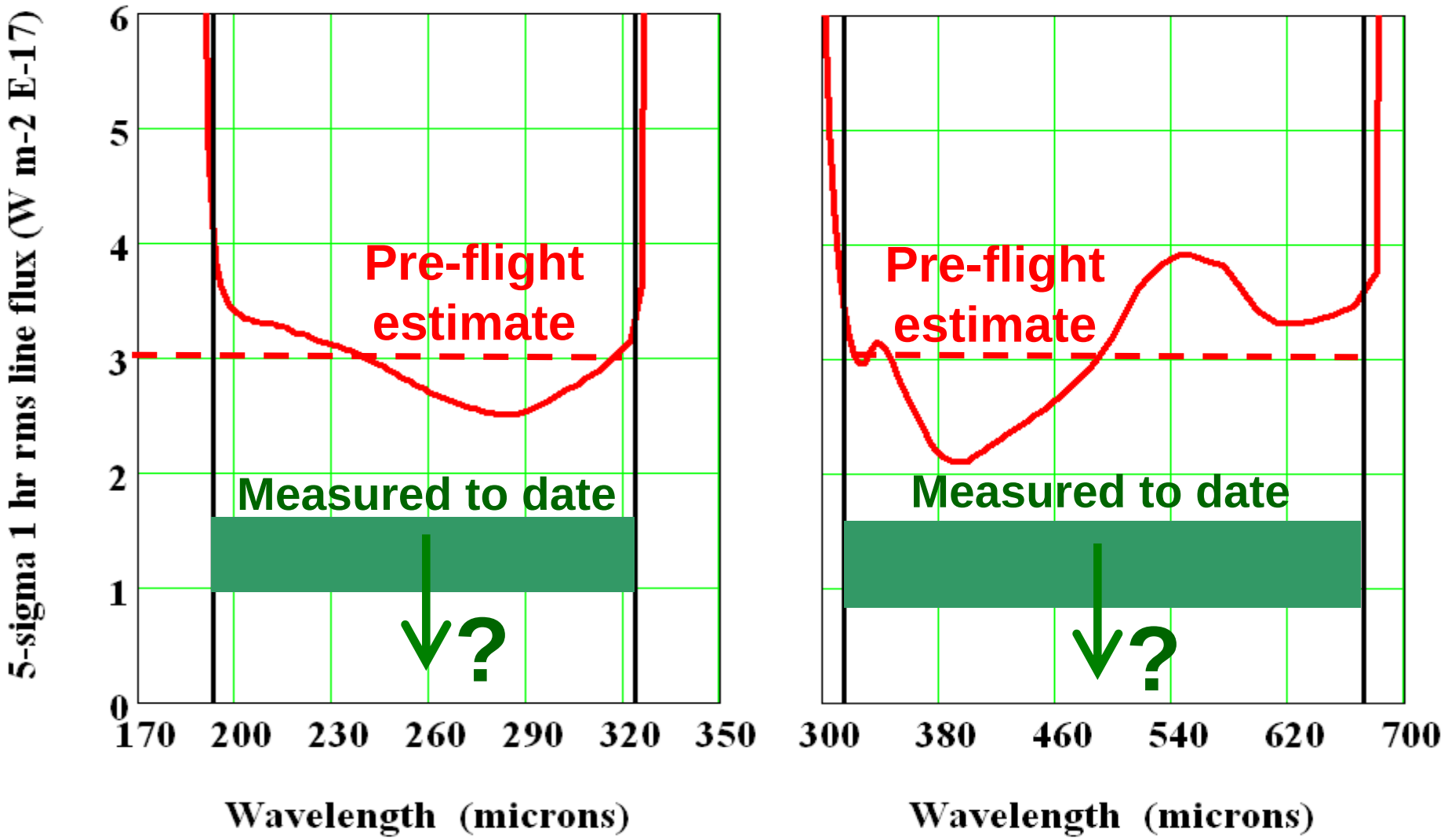
FTS Line Spectroscopy

(0.04 cm^{-1} unapodised; W m^{-2} x 10^{-17} 5-σ 1 hr)



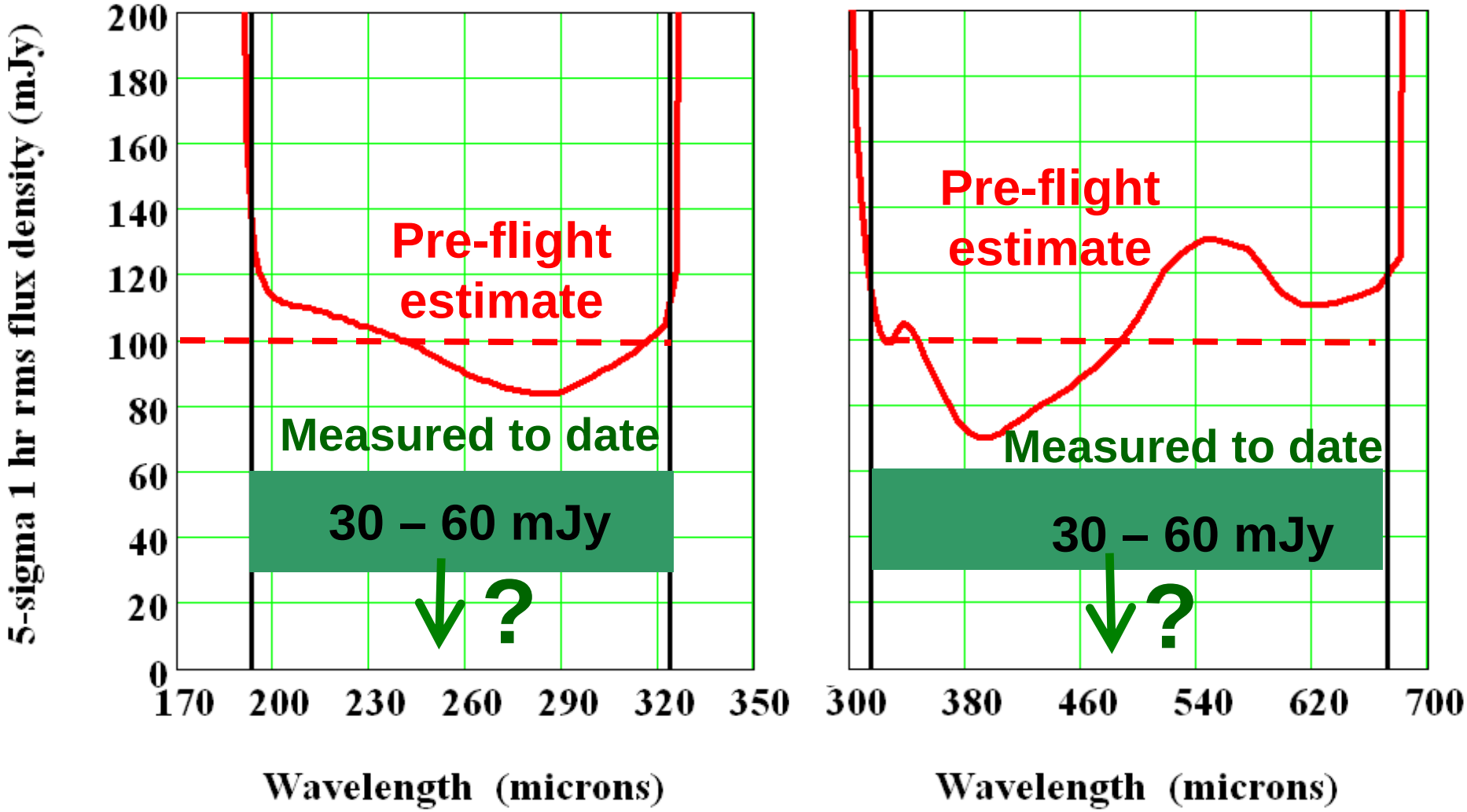
FTS Line Spectroscopy

(0.04 cm^{-1} unapodised; W m^{-2} x 10^{-17} 5-σ 1 hr)



FTS Low-Res. Spectrophotometery

(0.83 cm^{-1} unapodised; mJy 5-σ 1 hr)



Spectrometer Sensitivity

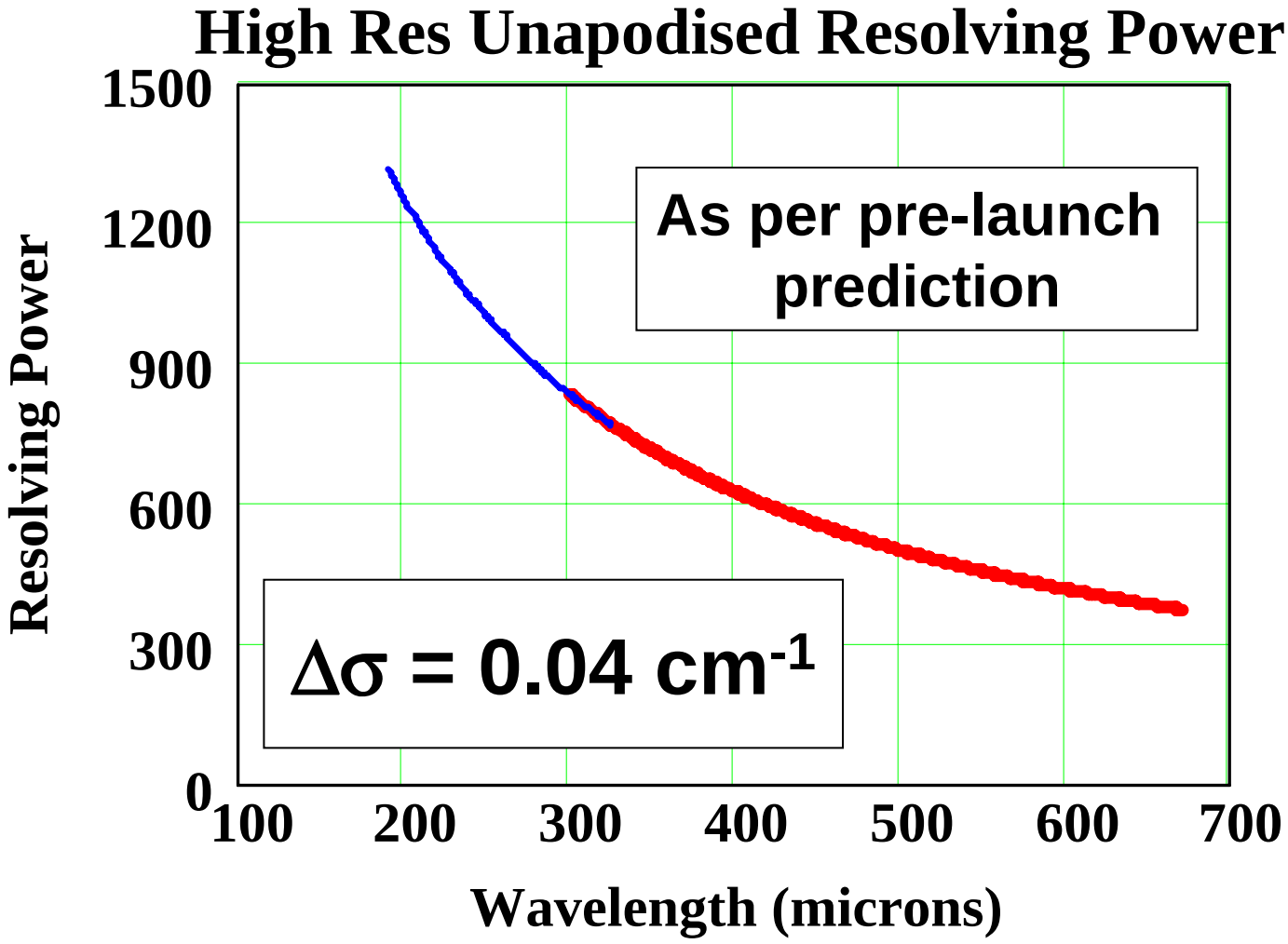
- **Caveats for current data processing**

  - **So far, sensitivities are limited by systematic noise associated with channel fringing and imperfect RSRF removal**
    - **Noise currently integrates down as $N_{Reps}^{1/2}$ for up to ~ 2500 s (~ 20 repeats) in high-res mode, then more slowly**

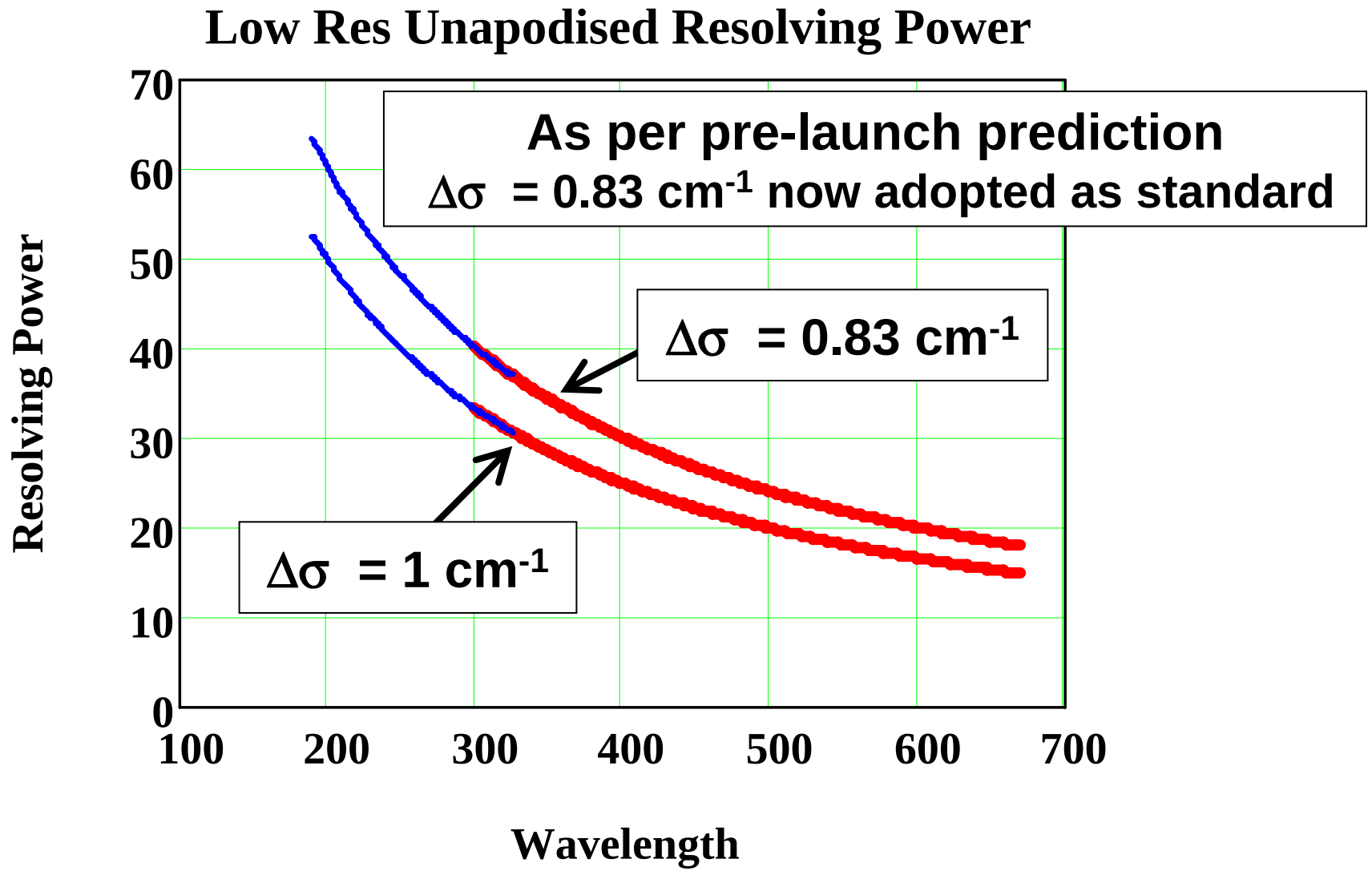
  - **Better data processing will improve basic sensitivity and allow noise to integrate down**

  - **No change to AOT implementation will be needed, so longer integrations can be scheduled now**

Resolving Power



Resolving Power

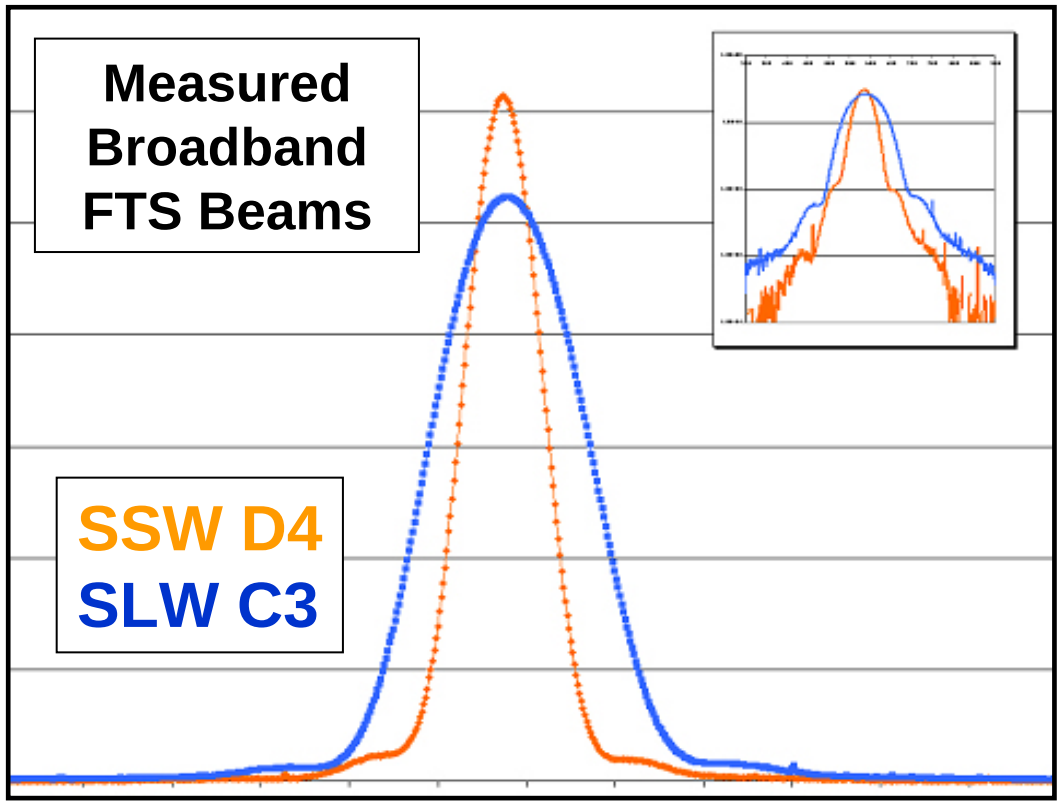


Beams

- **Broad-band FWHM for centre detectors**
  - SSW D4: 19 ± 1” SLW C3: 35 ± 1.5”

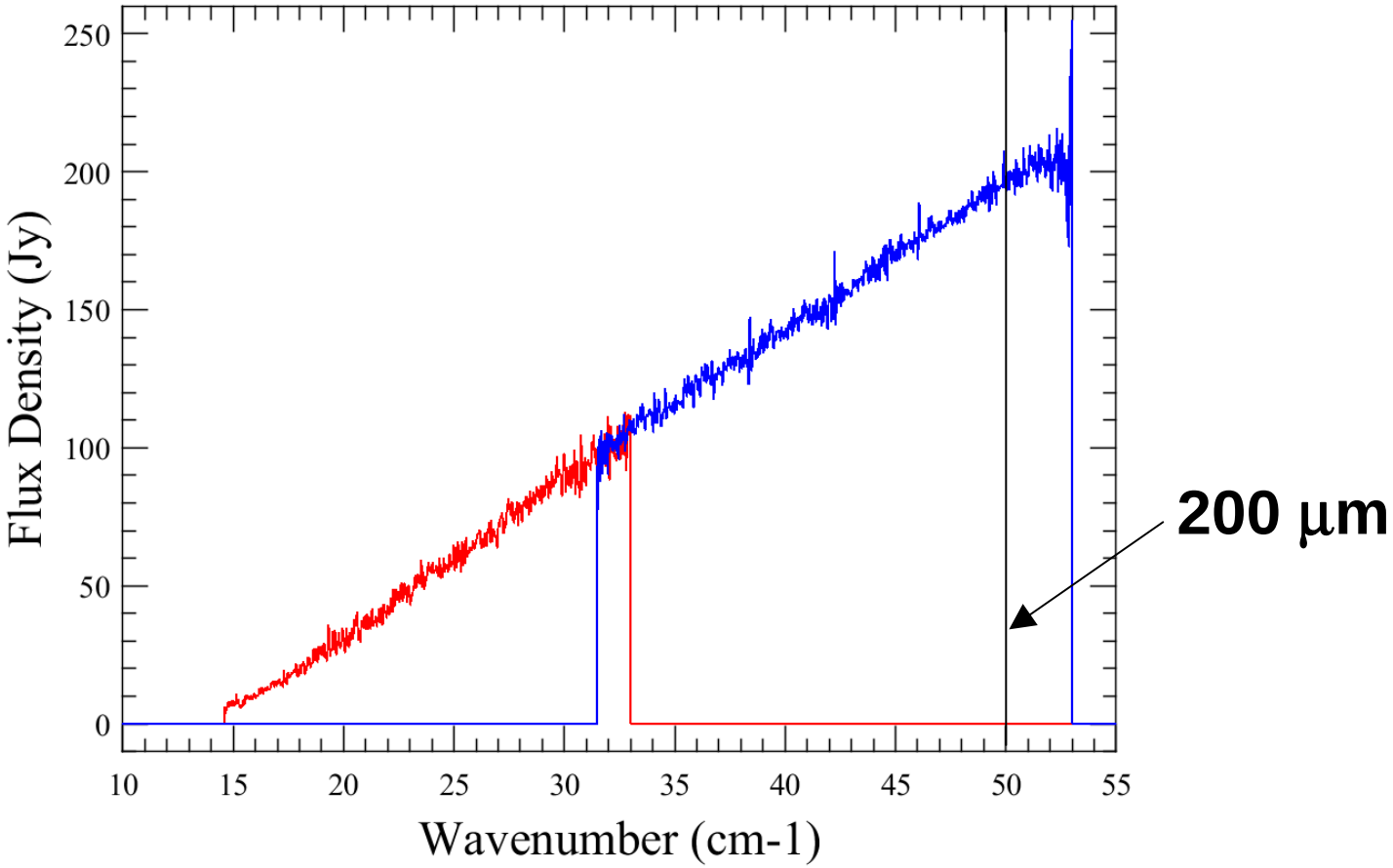
- **Pre-flight estimates: 16” and 34”**

- **Variation across the band:**
  - Measurements made and being analysed



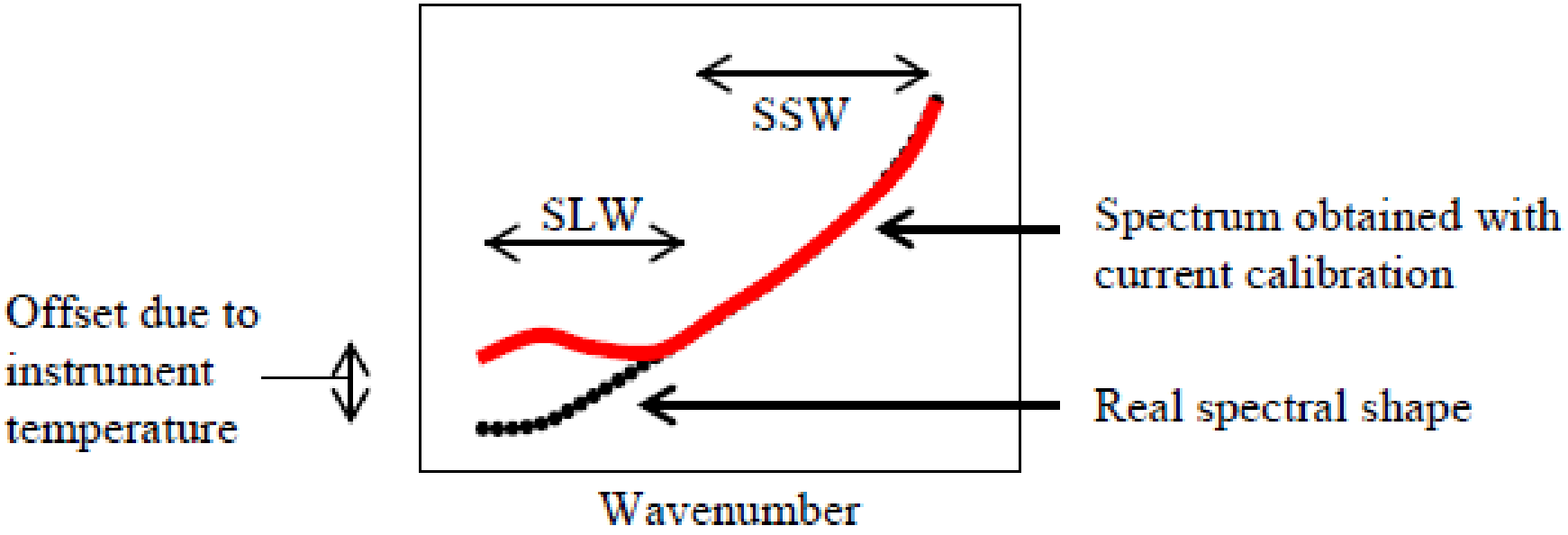
Overlap Between Bands

- **Good agreement in overlap region for point sources**
  - **Beamsize difference will affect extended sources**
- **Short-wavelength overlap for cross calibration with PACS**



Flux Calibration

- **Currently:**
  - **SSW: 10 – 20%**
  - **SLW: ~ 30%**
- **Better for stronger sources**
- **Will improve with better modelling of instrument emission**



Spectral Range and Wavelength Calibration

- **Wavelength coverage:**
  - **As per pre-launch prediction:**
  - **14.9 - 51.5 cm^{-1} ≡ 194 – 671 μm**

- **Wavelength calibration**
  - **Accurate to 1/10 of a spectral resolution element across both bands**
  - **Slight systematic deviation: +30 km s^{-1} offset (1/10 resolution element at shortest wavelength and 1/30th at longest wavelength)**

FTS Data: Issues to be Addressed

- Flux calibration
  - Instrument and telescope temperature variations to be modelled and corrected
- Deep integrations
  - Known issues with standing waves and RSRF definition
  - Characterisation and correction procedures are under development
- De-glitching
  - Glitch shapes are consistent and repeatable
  - Small impact on current sensitivity
  - Deglitching routines are being optimised and tested
- Strong source settings
  - To be verified and released
  - Sources as strong as Mars are observable

Conclusions

- **The SPIRE instrument is fully functional with performance matching or exceeding pre-launch estimates**
- **Current pipelines are already producing very high-quality data, and further improvements are being made**
- **Flux calibration is already very good and will be further improved**
- **Work in early 2010 will concentrate on**
  - **Releasing remaining AOTs**
  - **Enhancing pipeline products and calibration**
  - **Supporting observers**

Simply InSPIRErational

Happy Christmas 2009
From the SPIRE Team