Neptune Rasters, Coarse & Fine

• Coarse rasters (25x25x2.5") executed between ODs 174 and 751

• Fine rasters (4x[5x5x2'']) executed on ODs 1311/1312

• Pointing reconstruction with STR sub-pixel correction and GYR filter (Méthode Hêlmutoise)

• Mean-averaged signals after masking of “unstable” pointings and signal outliers

• Normalized fluxes with “f-factor” method for asymmetric chopping
Neptune Coarse Rasters

• Inspection of flux “timelines” with progressing raster step

• Cancellation of chopping asymmetry to sub-percent level of peak flux (baseline off-source)

Spaxel 12, detector 8
\( \lambda = 94 \mu m \)
Neptune Coarse Rasters
Coordinates


ΔR.A., ΔDec.

Rotation (position angle)

Proper motion compensation
Neptune Fine Rasters
Coordinates

4 5x5x2.5" rasters, offset by 1",
proper motion compensated

Combined raster positions
(in spacecraft coordinates)
Measured fluxes in coarse (red) and fine (blue) Neptune rasters @ 94µm

Plotted without any correction

Coordinates and gain corrected (least-square) by (0.8", 0.7", 1.02)
Synthetic beam from coarse raster outside of area covered by fine raster and from matched fine raster inside.

coarse raster only

combined raster
At least at shorter wavelengths, flatter top / steeper slope than Gaussian beam.

How to construct “simple” beam model for distribution?

\[ \sigma = 1.5\% \times \text{peak} \]
3x3 “Super-Spaxel” Response Map @ 94µm

- **Blue dots**: reconstructed raster pointing positions
- **Contours**: $\sum_{3\times3} \text{Neptune/telescope}$ as function of reconstructed raster pointing position
- **Green dots**: raster points of maximum signal for respective spaxels
- **Red dots**: fitted Gaussian peak positions for respective spaxels
110µm
136µm
145µm
150µm
168µm
187µm
(Central Spaxel) / (3x3 “Super-Spaxel”)

\[\sum_{3x3} \text{Neptune/telescope}\]

at nearest raster position from fitted peak position of central spaxel

Fitted peak (Neptune/telescope) for central spaxel

(Rationale: central spaxel alone should be more sensitive to mispointing than 3x3)
(Central Spaxel) / (3x3 “Super-Spaxel”)

- Measured (coarse raster)
- Measured (fine raster)
- CalFile (P.R.)
- Polynomial fits to all points

0.77966142 + 0.0004646496268 x - 5.7386242 \times 10^{-6} x^2 - 2.1809111 \times 10^{-8} x^3

0.75821147 + 0.0013108039 x - 0.000017520145 x^2 + 4.7028507 \times 10^{-8} x^3 - 1.4318894 \times 10^{-10} x^4
Calibration of Telescope (Central Spaxel only)

- Measured
  
  $\text{telescope} = \text{neptune} \times \text{pointcorrfactor} / \text{neptel}$

- Telescope model
  with T-dependance
  and surface degradation

$\sigma(\Delta F/F) = 1.6\%$

Code:

```math
\text{modelcdegrad} = \\
\left( (a \ast (0.0336 \ast x^{-0.5} + 0.273 \ast x^{-1}) \ast 2 \ast h \ast c \ast (x \ast 10^{-6})^3 \ast A \ast \Omega \ast \text{bose}[c / (x \ast 10^{-6}), tt] + \\
  aa \ast 2 \ast h \ast c \ast (x \ast 10^{-6})^3 \ast A \ast \Omega \ast \text{bose}[c / (x \ast 10^{-6}), te] \right) \ast 10^{26} + \\
\text{If}[\text{odt} > 200, \text{rayleigh}[\text{ar} (\text{odt} - 200) / (1000 - 200), x], 0] \ast \text{If}[x > 105, b, 1];
```

```math
\text{bose}[\nu, T] = \text{If}[ (h \ast \nu) / (k \ast T) < 50, 1 / \left( e^{(h \ast \nu) / (k \ast T)} - 1 \right), e^{-(h \ast \nu) / (k \ast T)} ]
```

```math
\text{rayleigh}[a, x] := 10^5 \ast a / (x \ast 10^{-6})^4 \ast 2 \ast h \ast c \ast (x \ast 10^{-6})^3 \ast A \ast \Omega \ast \text{bose}[c / (x \ast 10^{-6}), 88.5]
```
Calibration of Telescope (Central Spaxel only)

- Measured
  \[
  \text{telescope} = \frac{\text{neptune} \times \text{pointcorrfactor}}{\text{neptel}}
  \]

- Telescope model with T-dependance and surface degradation

\[
\sigma(\Delta F/F) = 1.6\%
\]

\[
\text{modelcdegrad} = \left( a \times (0.0336 \times x^{-0.5} + 0.273 \times x^{-1}) \times 2 \times h \times c / (x \times 10^{-6}) \right) \times A \times \Omega \times \text{bose}[c / (x \times 10^{-6}), tt] + aa \times 2 \times h \times c / (x \times 10^{-6}) \times A \times \Omega \times \text{bose}[c / (x \times 10^{-6}), te] \right) \times 10^{26} + \]

If[odt > 200, rayleigh[ar (odt - 200) / (1000 - 200), x], 0] \times \text{If}[x > 105, b, 1];

\[
\text{bose}[\gamma, T] = \text{If}[(h \times \gamma) / (k \times T) < 50, 1/(e^{(h \times \gamma) / (k \times T)} - 1), e^{-(h \times \gamma) / (k \times T)}]
\]

\[
\text{rayleigh}[a, x] := 10^5 \times a / (x \times 10^{-6})^4 \times 2 \times h \times c / (x \times 10^{-6})^3 \times A \times \Omega \times \text{bose}[c / (x \times 10^{-6}), 88.5]
\]

ar = 3.1;

\{ a \rightarrow 0.15343895, b \rightarrow 1.1373601, 
\}

aa \rightarrow 0.0030538508, te \rightarrow 50.169052\}
Calibration of Telescope (Central Spaxel only)

- Measured
  \[ \text{telescope} = \text{neptune} \times \text{pointcorrfactor} / \text{neptel} \]

- Telescope model with T-dependance and surface degradation

\[ \sigma(\Delta F/F) = 1.6\% \]

Point source correction factor has influence on "shape" of telescope SED!
Calibration of Telescope (Central Spaxel only)

- Measured
  \[
  \text{telescope} = \text{neptune} \times \text{pointcorrfactor} / \text{neptel}
  \]
- Telescope model with T-dependance and surface degradation

\[\sigma(\Delta F/F) = 1.6\%\]

Point source correction factor has influence on “shape” of telescope SED!
Calibration of Telescope (Central Spaxel only)

- Measured (coarse raster)
- Measured (fine raster)
- Telescope model with T-dependance and surface degradation

```
modelcdegrad = 
  ((a * (0.0336 * x^-0.5 + 0.273 * x^-1)) * 2 * h * c / (x * 10^-6)^3 * A * \Omega * \text{bose} [c / (x * 10^-6), tt]) + 
  aa * 2 * h * c / (x * 10^-6)^3 * A * \Omega * \text{bose} [c / (x * 10^-6), te]) * 10^{26} + 
  \text{If}[odt > 200, \text{rayleigh}[ar (odt - 200) / (1000 - 200), x], 0]) * \text{If}[x > 105, b, 1];

bose[y_, T_] = \text{If}[(h * y) / (k * T) < 50, 1 / (e^{(h * y) / (k * T)} - 1), e^{-(h * y) / (k * T)}]

rayleigh[a_, x_] := 10^5 a / (x * 10^-6)^4 * 2 * h * c / (x * 10^-6)^3 * A * \Omega * \text{bose} [c / (x * 10^-6), 88.5]
```

ar = 2.7;
\{a -> 0.16334946, b -> 1.1271673, aa -> 0.0037199115, te -> 46.159126\}

```
Calibration of Telescope (Central Spaxel only)

- Measured (coarse raster)
- Measured (fine raster)

Telescope model with T-dependance and surface degradation

Model does not describe increase of "telescope emission" at long λ!

```plaintext
In[48]:=

modelcdegrad =

\[
\left( a \left( 0.0336 \times x^{-0.5} + 0.273 \times x^{-1} \right) \times 2 \times h \times c / (x \times 10^{-6})^3 \times A \times \Omega \times \text{bose}[c / (x \times 10^{-6}), tt] + aa \times 2 \times h \times c / (x \times 10^{-6})^3 \times A \times \Omega \times \text{bose}[c / (x \times 10^{-6}), te] \right) \times 10^{26} + \\
\text{If}[odt > 200, \text{rayleigh}[ar \left( odt - 200 \right) / (1000 - 200), x], 0] \times \text{If}[x > 105, b, 1];
\]

bose[\_ \_ , T_] = \text{If}\left[ (h \times \nu) / (k \times T) < 50, 1 / \left( e^{(h \times \nu) / (k \times T)} - 1 \right), e^{-(h \times \nu) / (k \times T)} \right] 

rayleigh[a\_\_ , x\_] := 10^5 a / (x \times 10^{-6})^4 \times 2 \times h \times c / (x \times 10^{-6})^3 \times A \times \Omega \times \text{bose}[c / (x \times 10^{-6}), 88.5]
```

```plaintext
ar = 2.7;
{a \rightarrow 0.16334946, b \rightarrow 1.1271673, 
aa \rightarrow 0.0037199115, te \rightarrow 46.159126}
```
Calibration of Telescope (Central Spaxel only)

- Measured (coarse raster)
- Measured (fine raster)

\[
\text{telescope} = \frac{\text{neptune} \times \text{pointcorrfactor}}{\text{neptel}}
\]

- Telescope model with T-dependance and surface degradation

Model does not describe increase of “telescope emission” at long \( \lambda \! \)

- Could it be some straylight/dark current, independent of grating position, which - relatively - adds more to the telescope proper at long wavelengths?

- Should we use interpolation scheme rather than model?
Calibration of Telescope (Central Spaxel only)

- Measured (coarse raster)
- Measured (fine raster)

\[
\text{telescope} = \frac{\text{neptune} \times \text{pointcorrfactor}}{\text{neptel}}
\]

- Telescope model with T-dependance and surface degradation

Model does not describe increase of “telescope emission” at long \( \lambda \)!

Suggestions?

- Could it be some straylight/dark current, independent of grating position, which - relatively - adds more to the telescope proper at long wavelengths?

- Should we use interpolation scheme rather than model?
Could it be some straylight/dark current, independent of grating position, which - relatively - adds more to the telescope proper at long wavelengths?

Should we use interpolation scheme rather than model?
Comparison with Photometer Background?

- Calculated background in center of photometer bands
- Can “load” on bolometers (absolute power) be assessed?
Comparison with Photometer Background?

- Calculated background in center of photometer bands
- Can “load” on bolometers (absolute power) be assessed?
Open Issues

• How do we generate user-friendly beam maps for the central spaxel from (irregular) coarse & fine raster observations?
  - Interpolation scheme?
  - Model?

• How can we arrive at meaningful model?
  - Some convolution of spaxel response and diffraction beam?

• Should we get fine rasters on other spaxel(s)?
Spaxel 12

94µm Neptune (coarse + fine)

fine raster
+ coarse raster

fitted Gaussian center
+ coarse raster

coarse raster
1342268650 Calibration_RPSpecFlux_2-RPSpecFlux_4310D_nStd_5x5R_M4XY_00_w69B2A_RDor_04 0 0
1342268651 Calibration_RPSpecFlux_2-RPSpecFlux_4310D_nStd_5x5R_M4XY_01_w69B2A_RDor_04 +1 0
1342268652 Calibration_RPSpecFlux_2-RPSpecFlux_4310D_nStd_5x5R_M4XY_11_w69B2A_RDor_04 +1 +1
1342268653 Calibration_RPSpecFlux_2-RPSpecFlux_4310D_nStd_5x5R_M4XY_10_w69B2A_RDor_04 0 +1
Spaxel 4
68µm Neptune (coarse)
+ 69µm RDor (fine)

course raster

fine raster
+ coarse raster

fitted Gaussian center
+ coarse raster
Spaxel 4
94µm Neptune (coarse) + 89µm RDor (fine)

coarse raster

fine raster + coarse raster

fitted Gaussian center + coarse raster
Spaxel 4
136\,\mu m Neptune (coarse)
+ 138\,\mu m RDor (fine)

coarse raster

fine raster
+ coarse raster

fitted Gaussian center
+ coarse raster