2nd Update on SPIRE Photometer Beam Profiles

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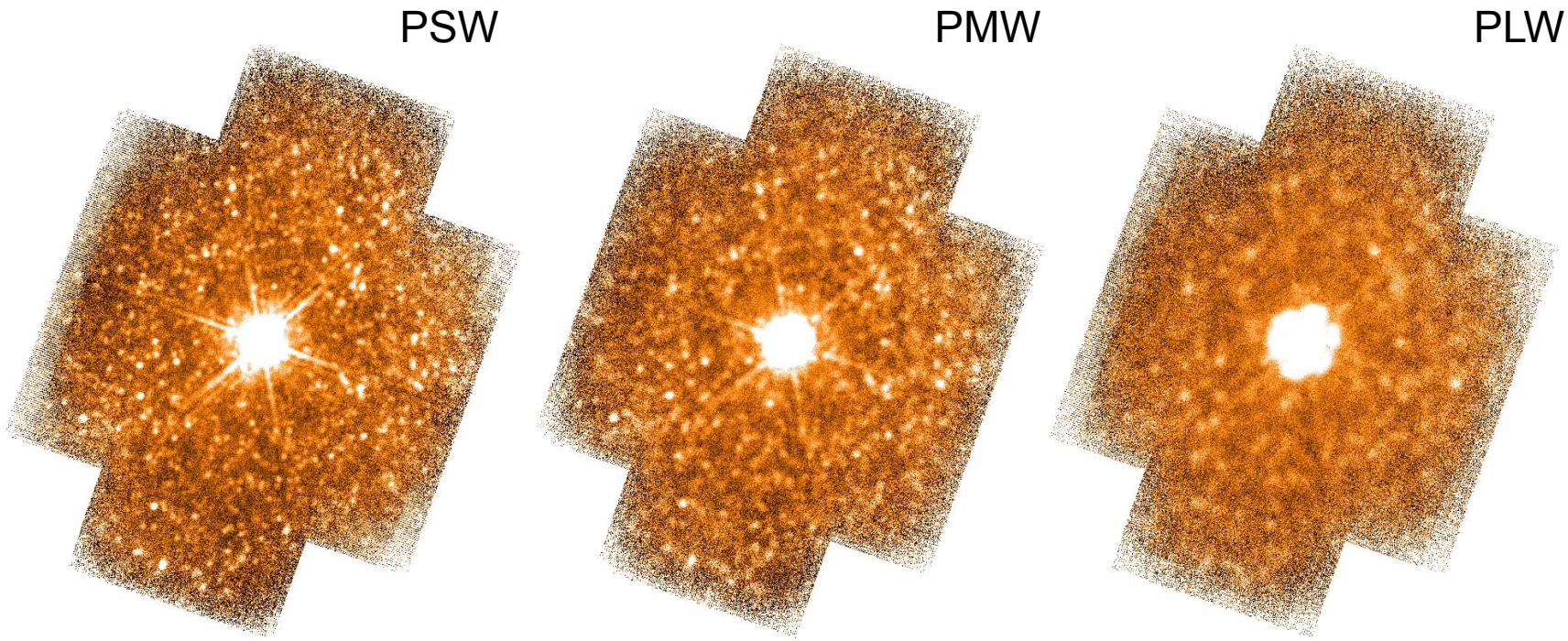
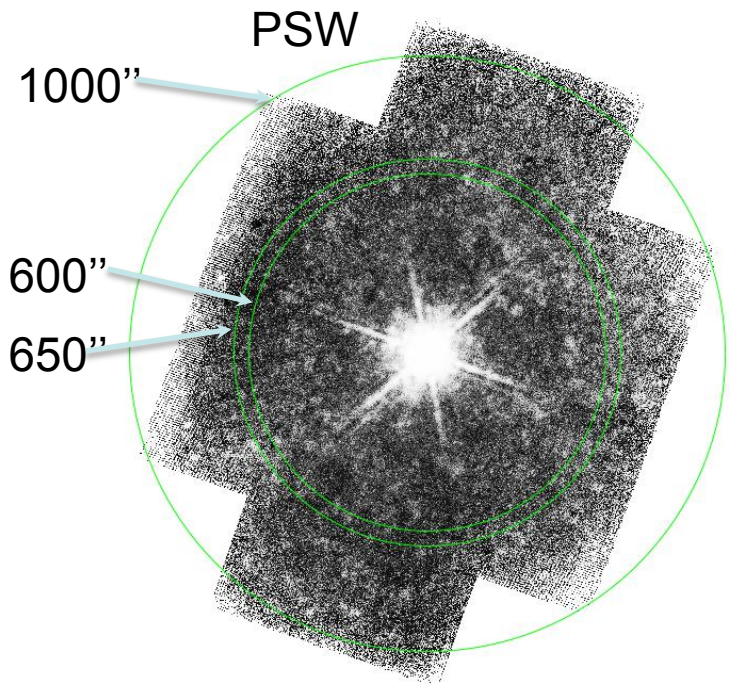
Neptune Fine Scan Maps



Background Estimate



- Background estimates at 1000'' suffer from low coverage.
- Map reliability beyond 600-700'' questionable.

Review of Current Material

- Erratum: The y-axis units in the plots are not Jy/beam but fractions of the peak of the beam profile! This didn't change the results.
- To get a handle on applicable uncertainties several small effects were investigated
  - Influence of Integration radius
  - Numeric errors
  - Difference between simple map integral and integral over the radially symmetric beam
  - Influence of the extended nature of the source (2.3" Neptune)
  - Influence of beam map filtering
  - Effect of current uncertainty in the background level

Integration Radius

- The Fine Scan Maps are reconstructed with 1” pixels which makes the solid angle Omega in [“^{2}] simply the sum of all pixels within a radius R, assuming that the peak of the solid angle was normalized to one.
- So far Omega was calculated as the average of all Omega(R) within radii of R= 600” to 650”.
- Calculating Omega(R) just at radius 600” is practically the same.
- Extending the radius to 700” makes only up to 0.42% difference.

	PSW	PMW	PLW
Average R=600"-650"	449.5	794.8	1665.4
Omega (600")	449.4	794.6	1665.6
Effect in %	0.02%	0.03%	-0.01%
Omega (700")	450.6	798.1	1668.4
Effect in %	-0.24%	-0.42%	-0.18%

How To Integrate

- The solid angle was integrated in two different ways:
  - select all 1”^{2} pixels within integration radius and sum them up (this method was used to derive the quoted numbers)
  - Determine the average of rings $PSF_{rad}(R)$ of pixels within R and R+1” for all radii within the map and calculate Omega as

$$\Omega(R) = \int_0^R PSF_{rad}(r) \cdot 2 \cdot \pi \cdot R \cdot dr$$

- The difference between simply summing up or numerically integrating is negligible.
- The difference between the sum of the 2 dimensional map and the radialized PSF is not negligible if we aspire to accuracies in the per-cent range.

	PSW	PMW	PLW
Sum within R in 2-dim. map	449.5	794.8	1665.4
Numeric Integral over PSF(R)*2*PI*R	437.3	771.0	1638.2
Effect in %	2.7%	3.0%	1.6%
Simple sum over PSF(R)*2*PI*R	437.4	770.7	1638.8
Effect in %	2.7%	3.0%	1.6%

Neptune: A slightly extended source

- Neptune has a 2.3” diameter in our observation which we have neglected so far.
- As a shortcut, to avoid having to perform a deconvolution, two approaches were tried:
  - Increase the resolution of the measured map to 0.2” per pixel and convolve it with a 2-dim. 2.3” top hat kernel.
  - Increase the resolution of the radial PSF to 0.011” per bin and convolve it with a one-dim. 2.3” top-hat kernel.
  - Perform Omega calculation as before
- The changes range between 0.7% and 1.9% and depend strongly on the integration method.
- If we want to take account for this effect and stay with the 2 dimensional integration method, the Omegas have to be divided by 1.0075, 1.0076, 1.0069 respectively.

	PSW	PMW	PLW
2-dim to 600"	449.4	794.5	1665.6
2-dim. convolution	452.8	800.6	1677.2
Effect in %	0.75%	0.76%	0.69%
1-dim. to 600"	437.40	770.70	1638.20
1-dim. to 600" with convol.	445.7	780.3	1665.3
Effect in %	1.86%	1.23%	1.63%

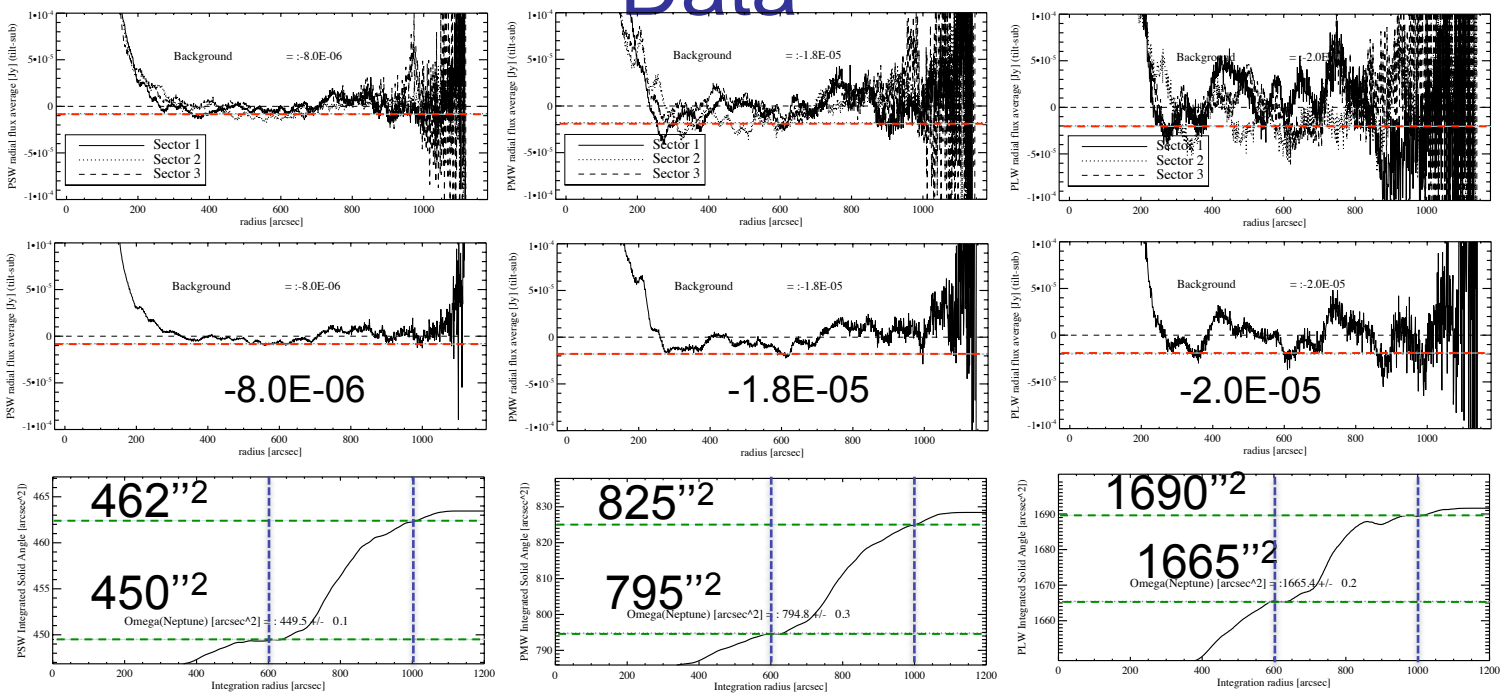
Influence of Filtering

- To remove residual glitches and smooth the resulting PSF maps a 3x3 median filter and a 3x3 boxcar smoothing were used.
- The beam profiles were then re-normalized to the peak.
- The Omegas were re-calculated.

- The median filter introduces changes by 0.14% to 0.76%.
- Additional smoothing changes Omega by 0.88 to 1.54%.
- As a consequence unfiltered beam profile maps were produced that include all background subtracted data within a radius of 700”.

	PSW	PMW	PLW
Omega (600")	449.4	794.6	1665.6
Omega(600") after Median	452.8	800.7	1667.9
Effect in %	0.75%	0.76%	0.14%
Omega(600") after Median and Smooth	456.4	804.8	1680.4
Effect in %	1.54%	1.27%	0.88%

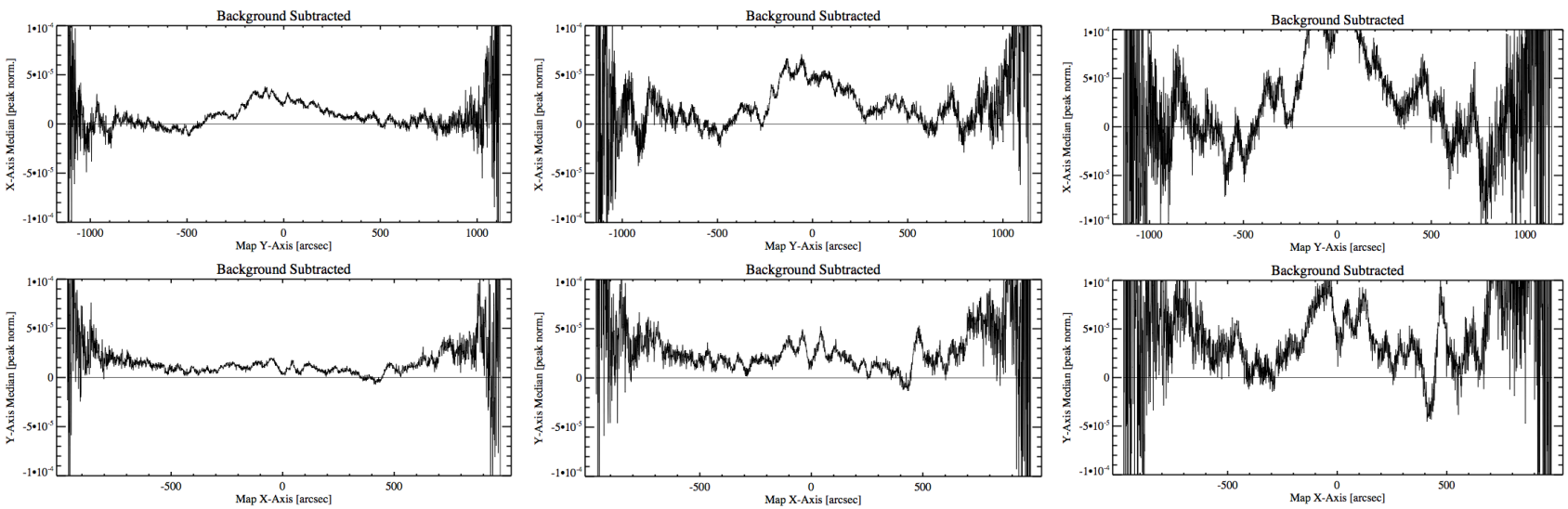
Background Estimate in Radial Beam Data



- Removed sources and warped plane (different one).
- Consistency between beams improved.
- Increased contribution outside 700'' but unclear whether real.
- Background estimates similar to previous estimates before source removal.
- Integration out to 600'' results in 450''^{2}, 795''^{2}, 1665''^{2} respectively for PSW, PMW, PLW.
- Integration out to 1000'' results in 462''^{2}, 825''^{2}, 1690''^{2} respectively for PSW, PMW, PLW.

Background Uncertainty

- Apart from the problem not knowing whether any credible emission lies outside of 700”, the error in the estimated level of the background translates into an error in Omega.
- Plotting the column- or row-median of the beam profile map vs. column or row gives another handle on the uncertainties.
- The y-scale of all diagrams goes from -10^{-4} to 10^{-4}.
- The visually estimated uncertainties of the zero level based on these diagrams are: $1.5*10^{-5}$, $2.0*10^{-5}$, $5*10^{-5}$ for PSW, PMW and PLW respectively.
- This translates into uncertainties for Omega of 17, 23, 56 arcsec^2 respectively, corresponding to per cent errors of +3.6/-3.8%, +2.8/-2.8%, +3.3/-3.4% for PSW, PMW and PLW respectively.



Numeric Summary

	PSW	PMW	PLW	Radius
North & Griffin	433.0	777.0	1632.0	500
after tilt and source removal	462.0	825.0	1690.0	1000
after tilt and source removal (avg 600”-650”)	**450.0**	**795.0**	**1665.0**	**600**
Omega at 600"	449.4	794.6	1665.6	600
Omega at 700"	450.6	798.1	1668.4	700
2-dim map convolved with top-hat	452.8	800.6	1677.2	600
Omega at 600" median filtered	452.8	800.7	1667.9	600
Omega at 600" median f. and smoothed	456.4	804.8	1680.4	600
Integral over 1-dim radial beam	437.3	771.0	1638.2	600
Simple sum over 1-dim radial beam	437.4	770.7	1638.8	600
1-dim radial beam convolved with top-hat	445.7	780.3	1665.3	600
Background Uncertainty	17.0	23.0	56.0	600.0

The largest variations come from the uncertainties in the integration radius and the background level.

	PSW	PMW	PLW	Radius
North & Griffin	-3.8%	-2.3%	-2.0%	500
after tilt and source removal	2.7%	3.8%	1.5%	1000
after tilt and source removal (avg 600”-650”)	0.0%	0.0%	0.0%	600
Omega at 600"	-0.1%	-0.1%	0.0%	600
Omega at 700"	0.1%	0.4%	0.2%	700
2-dim map convolved with top-hat	0.6%	0.7%	0.7%	600
Omega at 600" median filtered	0.6%	0.7%	0.2%	600
Omega at 600" median f. and smoothed	1.4%	1.2%	0.9%	600
Integral over 1-dim radial beam	0.0%	0.0%	0.0%	600
Simple sum over 1-dim radial beam	0.0%	0.0%	0.0%	600
1-dim radial beam convolved with top-hat	1.9%	1.2%	1.7%	600
Background Uncertainty	3.8%	2.9%	3.4%	600

All integrals are over the 2 dimensional map, except where indicated.

Conclusion

- Many small effects exist when aspiring to per-cent level accuracy.
- The largest variations come from the uncertainties in the integration radius and the background level of up to 3.8%.
- Numeric issues seem to be negligible.
- The difference between convolution of a top-hat with the 2 dim. map and the radial beam profile is not understood yet.
- The 2.3” extension of Neptune makes only a small effect of 0.6-0.7%
- Median filtering or box-car filtering the beam profile can change the solid angle at per-cent levels and should be avoided.
- Until the shadow observations allow a better subtraction of the backgrounds we should quote the 600” values 450”^{2}, 795”^{2}, 1665”^{2} with an uncertainty of 4%.