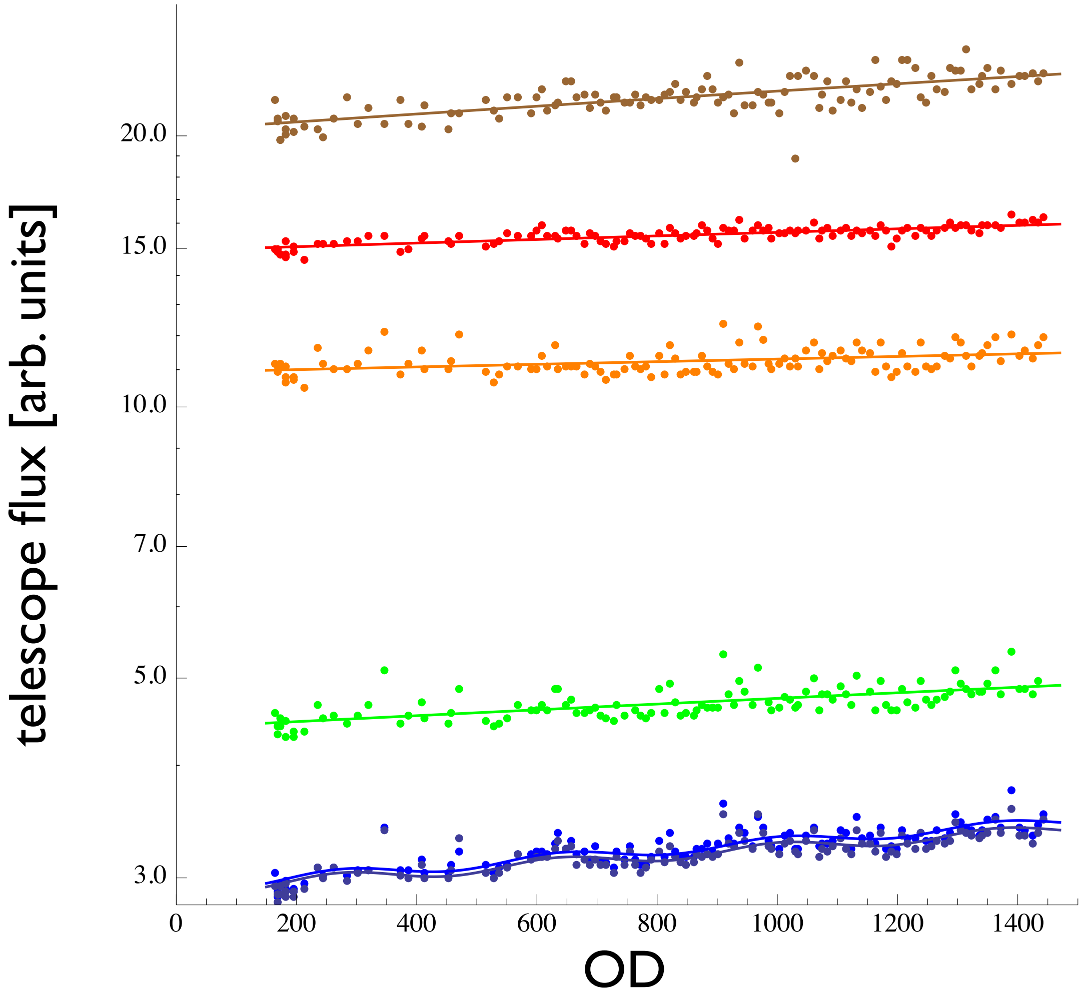
Description of Telescope Background (OD, λ)

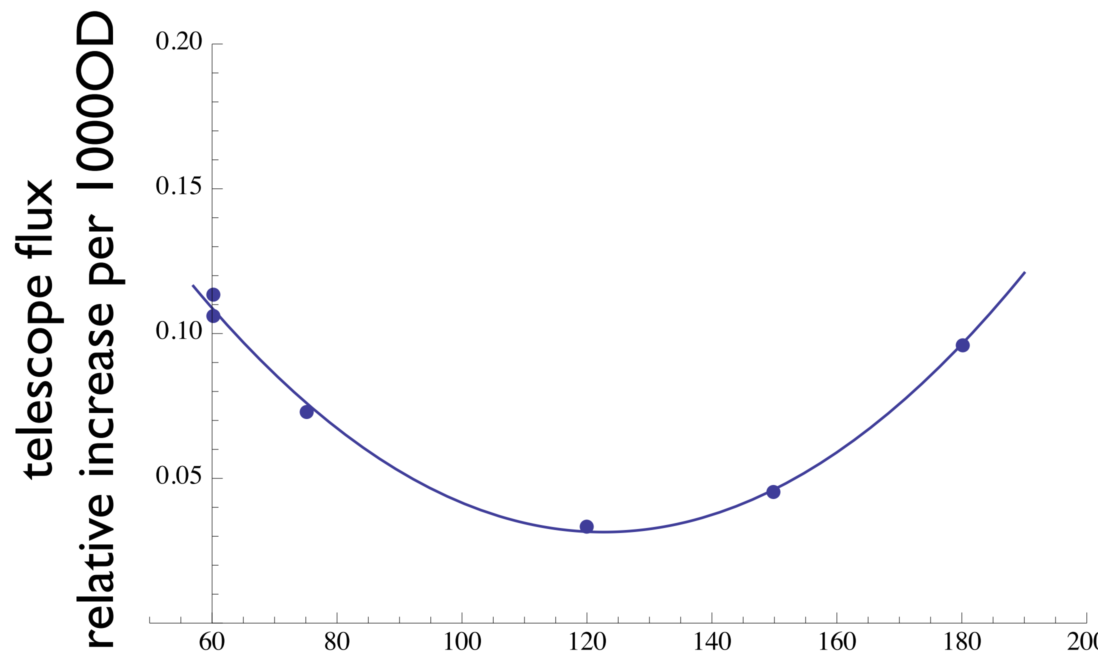
- Express telescope in units of source (3x3 co-added, no pointing correction; 3x3→1x1 + canonical point source correction for absolute fluxes)
- Best sampling with HD161796, no absolute flux
- Second-best sampling with Ceres, variable flux, best absolute standard (model T.M.), but non-linearity (?)
- Pallas good absolute standard (model T.M.) without non-linearity issues, but lower S/N
- Express evolution as linear growth (change per 1000 ODs as fraction of mean flux over mission) + seasonal variation, as function of wavelength, fitted to (60, 75, 120, 150, 180μm) points of HD161796

Description of Telescope Background (OD, λ)

- a) "Map" Ceres-derived mean (over mission) telescope SED onto Pallas-derived mean SED with simple, smooth, fitted correction function, to get absolute fluxes right while maintaining S/N and "features" of Ceres-derived SED
  b) Use Ceres-derived mean (over mission) telescope SED directly
- The resulting mean telescope SED is in the form of 2 tables (for blue and red) of {wavelength[μm], flux[Jy]} with 0.1μm wavelength increment
- For a given OD, the "catch of the day" is obtained by multiplying the tabulated fluxes with the time evolution function (OD, λ)

Time Evolution of Telescope SED



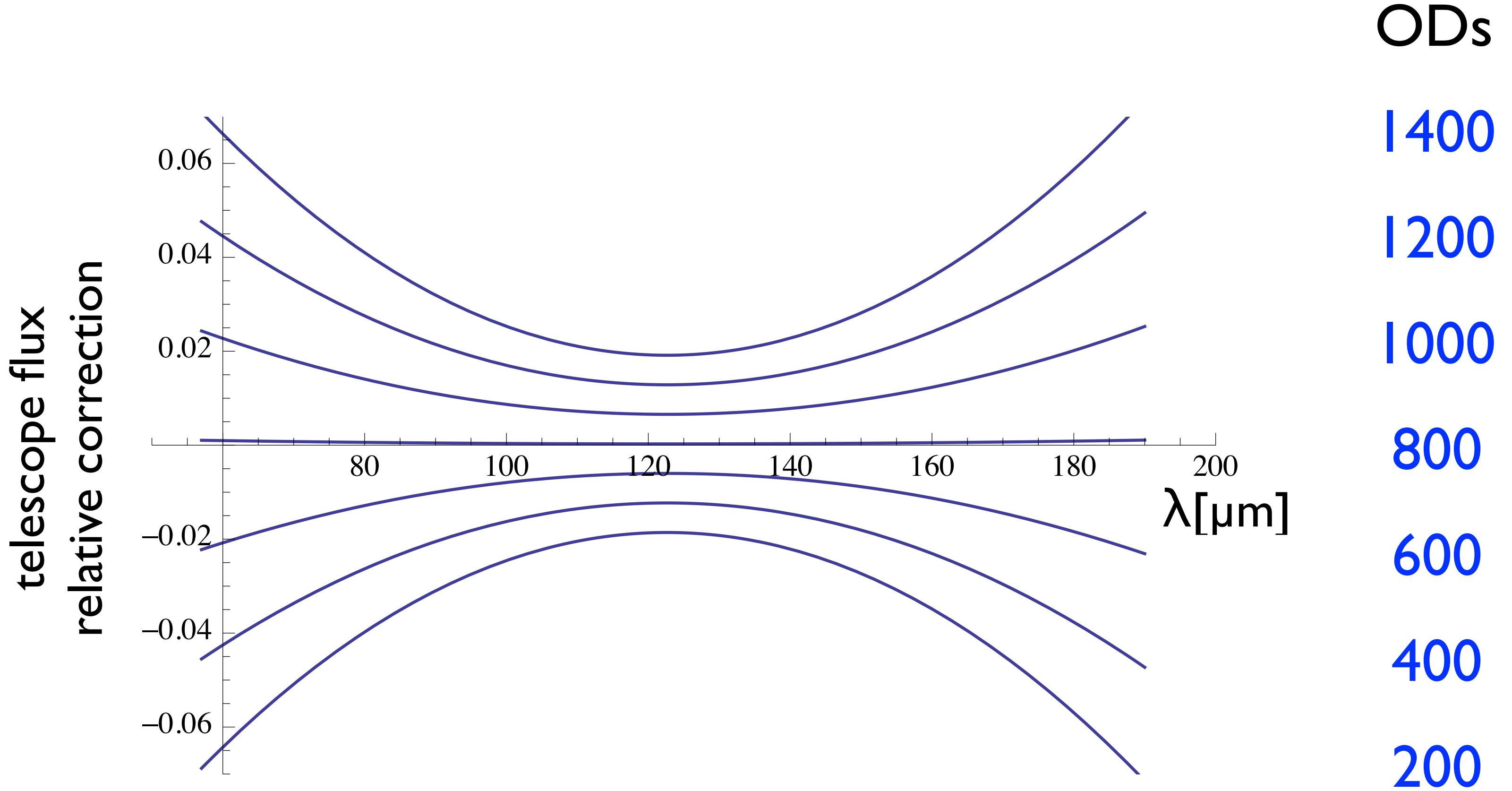



```
bowl = a * x^2 + b * x + c;

evo = FindFit[degradm, bowl, {a, b, c}, x]

{a → 0.000019719214, b → -0.0048365646, c → 0.32801474}
```

```
smodel = a * x + b + b * c * Sin[2 π / 365 * x + d];

fit60o2s = FindFit[tel60o2, smodel, {a, b, c, d}, x]

{a → 0.00033636616, b → 2.9038983, c → -0.014973405, d → 0.015114584}
```

- The seasonal variation is fitted to 60μm points, where the effect is strongest, and "phased out" at the transition from blue to red

Time Evolution of Telescope SED (Linear Growth)




```
bowlf =
Function[{x}, 0.32801474 - 0.0048365646 x + 0.000019719214 x^2]
day0 = 791;
evof[x_, od_] := (od - day0) / 1000 * bowlf[x]
```

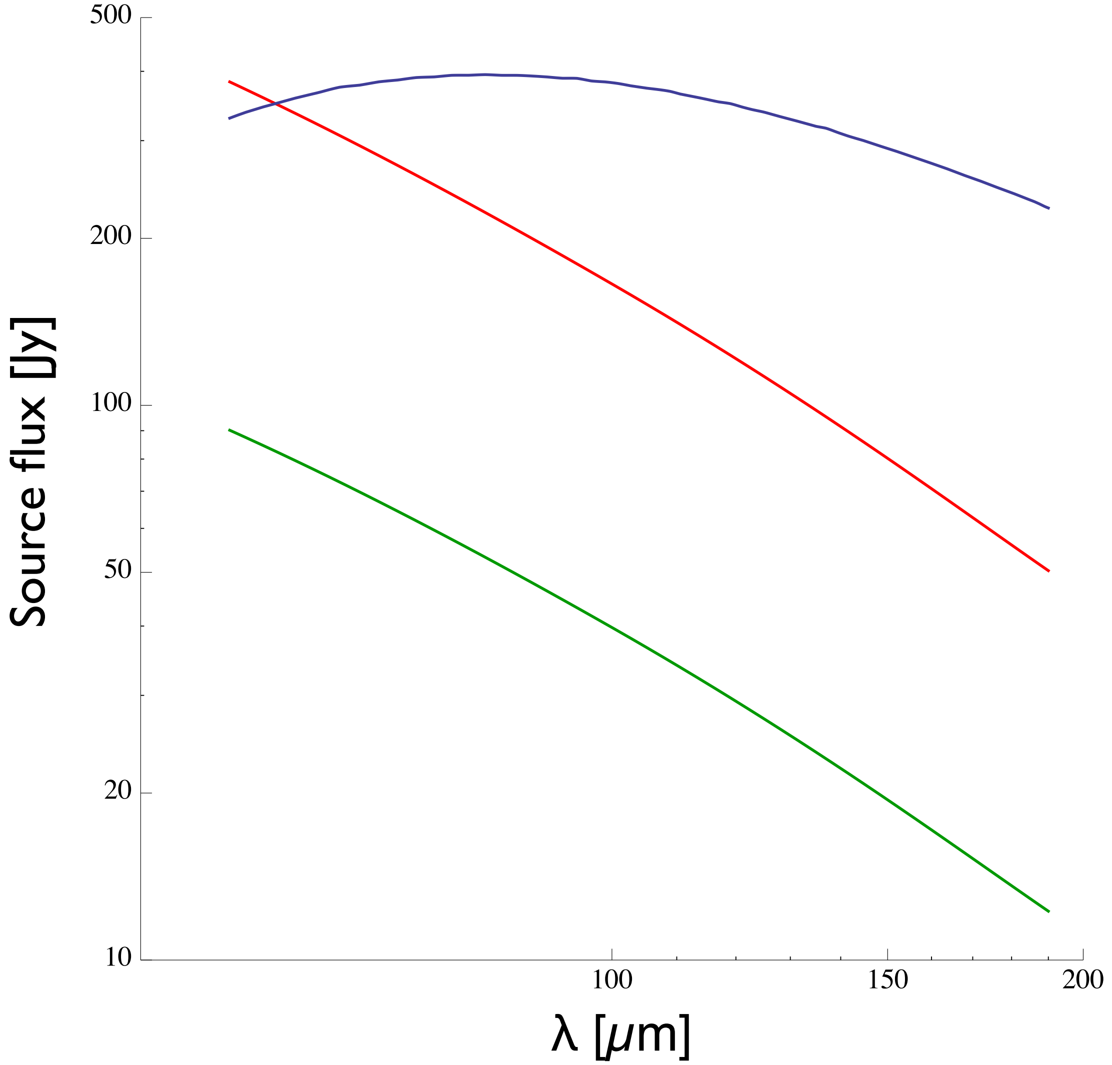
- The evolution at each wavelength is linear with OD, but the slope varies with wavelength

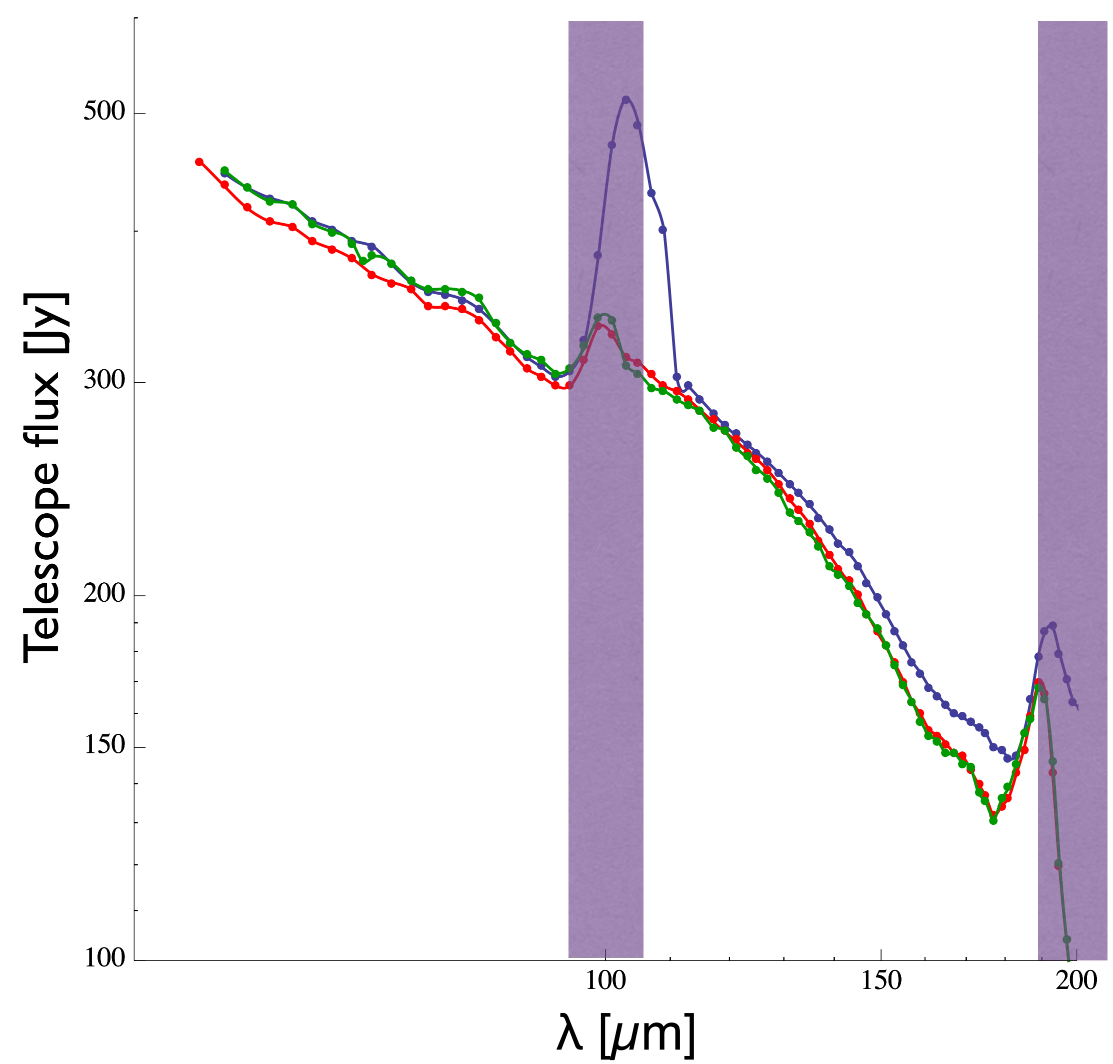
Time Evolution of Telescope SED: Linear + Seasonal

```
telsedblue[x_, od_] :=
 (1 - (100 - x) / (100 - 60) *
      (0.01497 * Sin[2 π / 365 * od + 0.01511] - 0.01497 * Sin[2 π / 365 * day0 + 0.01511]) +
    evof[x, od]) * meantelsedblue[x]

telsedred[x_, od_] := (1 + evof[x, od]) * meantelsedred[x]
```

- The amplitude of the seasonal variation, originally fitted in the arbitrary units of the HD161796 60μm observations, has been converted to fraction of the mean flux
- The seasonal variation fades out at 100μm
- No seasonal variation in the red band

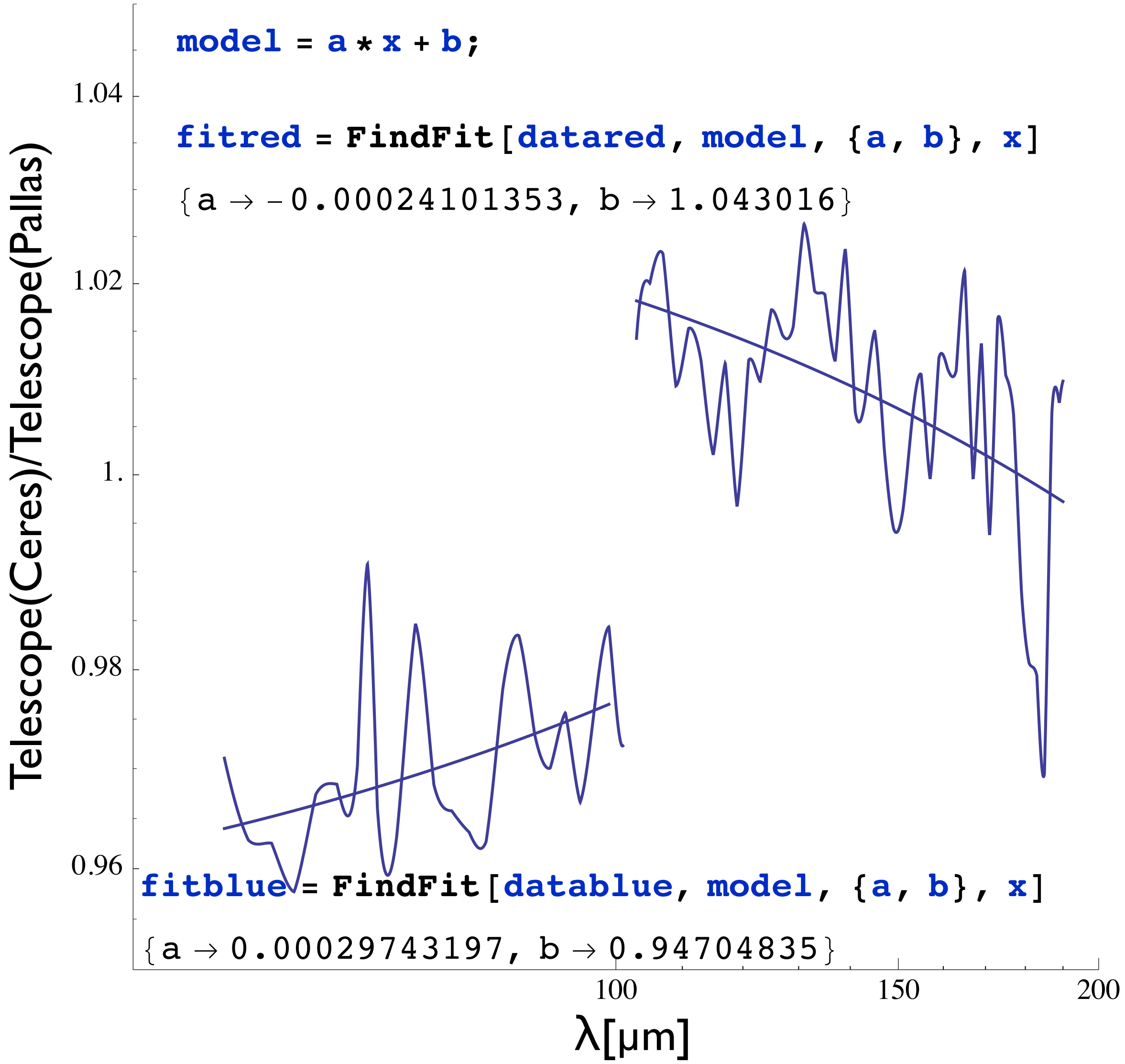
Comparison of SEDs of Neptune, Ceres, Pallas and Telescope

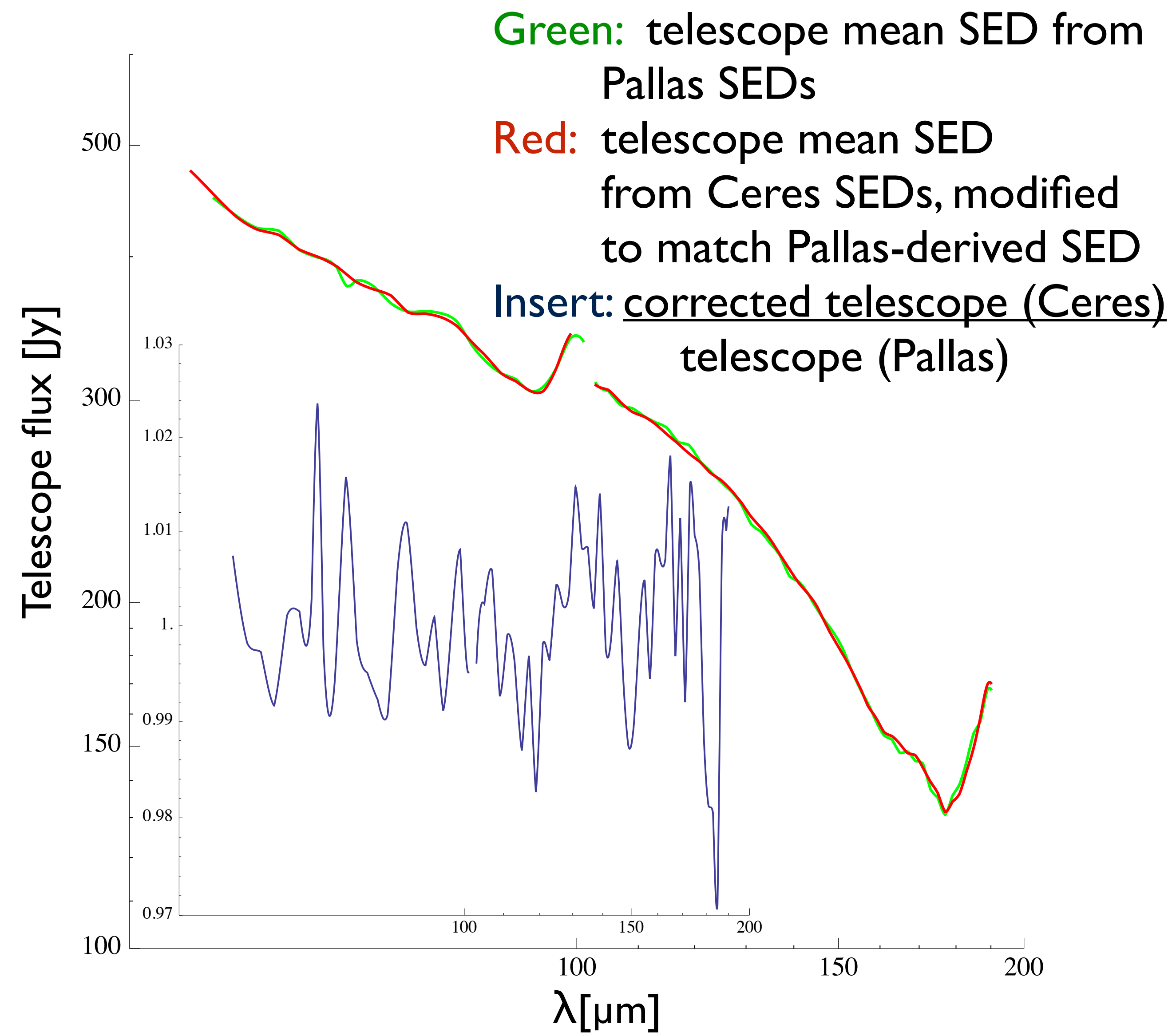




- Left: "Typical" SEDs of Neptune (blue), Ceres (red), and Pallas (green) [they vary with time]
- Right: Telescope mean SEDs derived from Neptune (blue), Ceres (red), and Pallas (green)
  - At the red end, the difference between Neptune-based and asteroid-based telescope SEDs look systematic - could be non-linearity, but could also be color effect via "ghost" wavelength contamination

Adjusting Telescope (Ceres) to Telescope (Pallas)





- Linear fits to ratios of Ceres-telescope to Pallas-telescope in red and blue
- Use fits as "correction function" to make (higher S/N) Ceres-telescope match absolute flux of (non-linearity-free) Pallas-SED

Exported (FITS) Telescope SEDs (Ceres on Pallas)

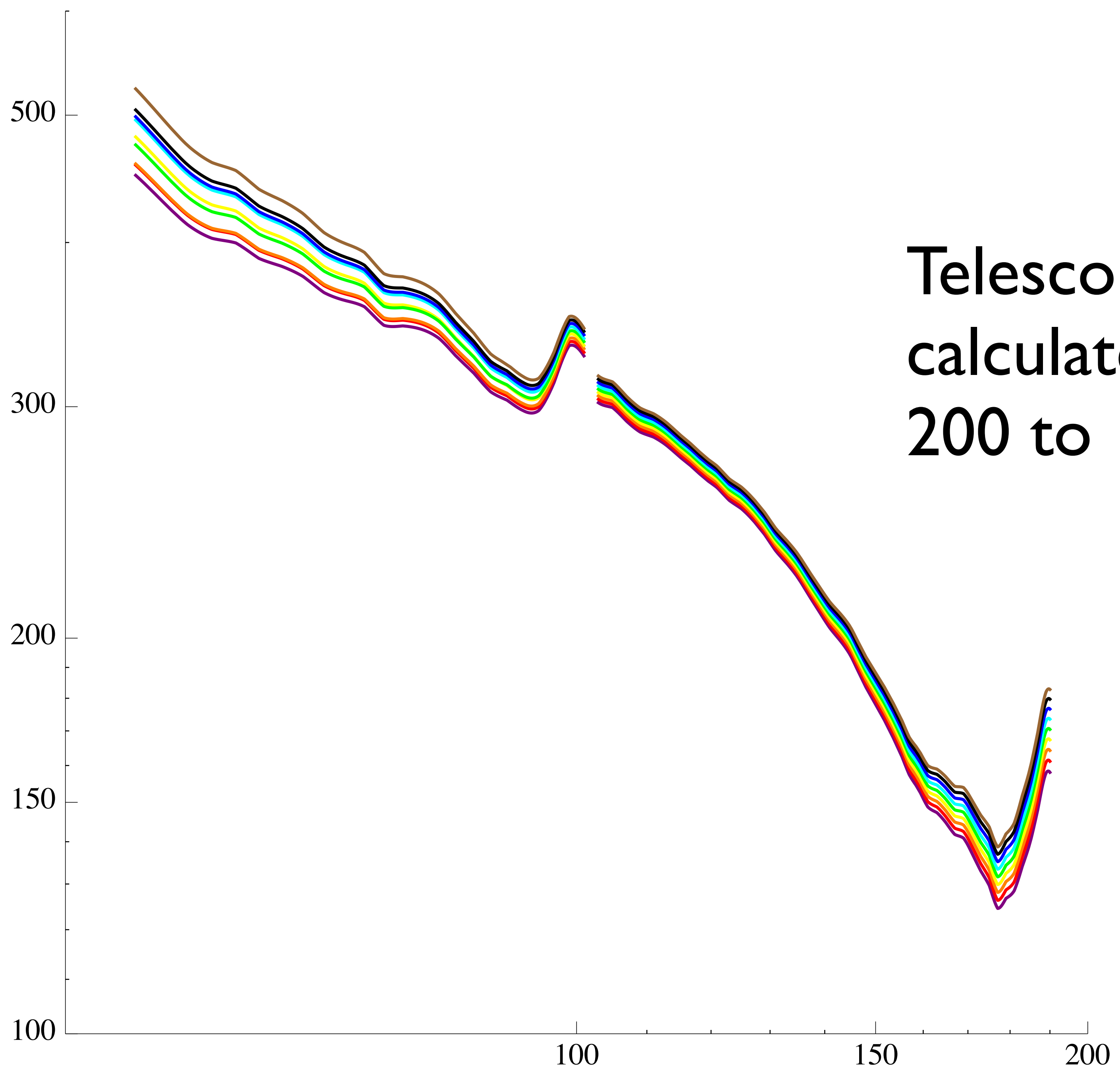
```
bluetelod =
  Table[{meanbluetel[[n, 1]],
    meanbluetel[[n, 2]] *
     (1 - (100 - meanbluetel[[n, 1]]) / (100 - 60) *
        (0.0139 * Sin[2 π / 365 * Max[180, od] + 0.0773] -
          0.0139 * Sin[2 π / 365 * day0 + 0.0773]) +
       evof[meanbluetel[[n, 1]], Max[180, od]])}, {od, 1, 1446},
   {n, Dimensions[meanbluetel][[1]]}];

redtelod =
  Table[{meanredtel[[n, 1]],
    meanredtel[[n, 2]] * (1 + evof[meanredtel[[n, 1]], Max[180, od]])},
   {od, 1, 1446}, {n, Dimensions[meanredtel][[1]]}];
```

- Data structure is 1446 x n x 2:
  - 1446 ODs, starting at 1
  - n wavelengths (in steps of 0.1μm)
  - data: { wavelength[μm], flux[Jy] }
- Evolution is switched off (flat) below OD180

`bluetelod_ext.fits`

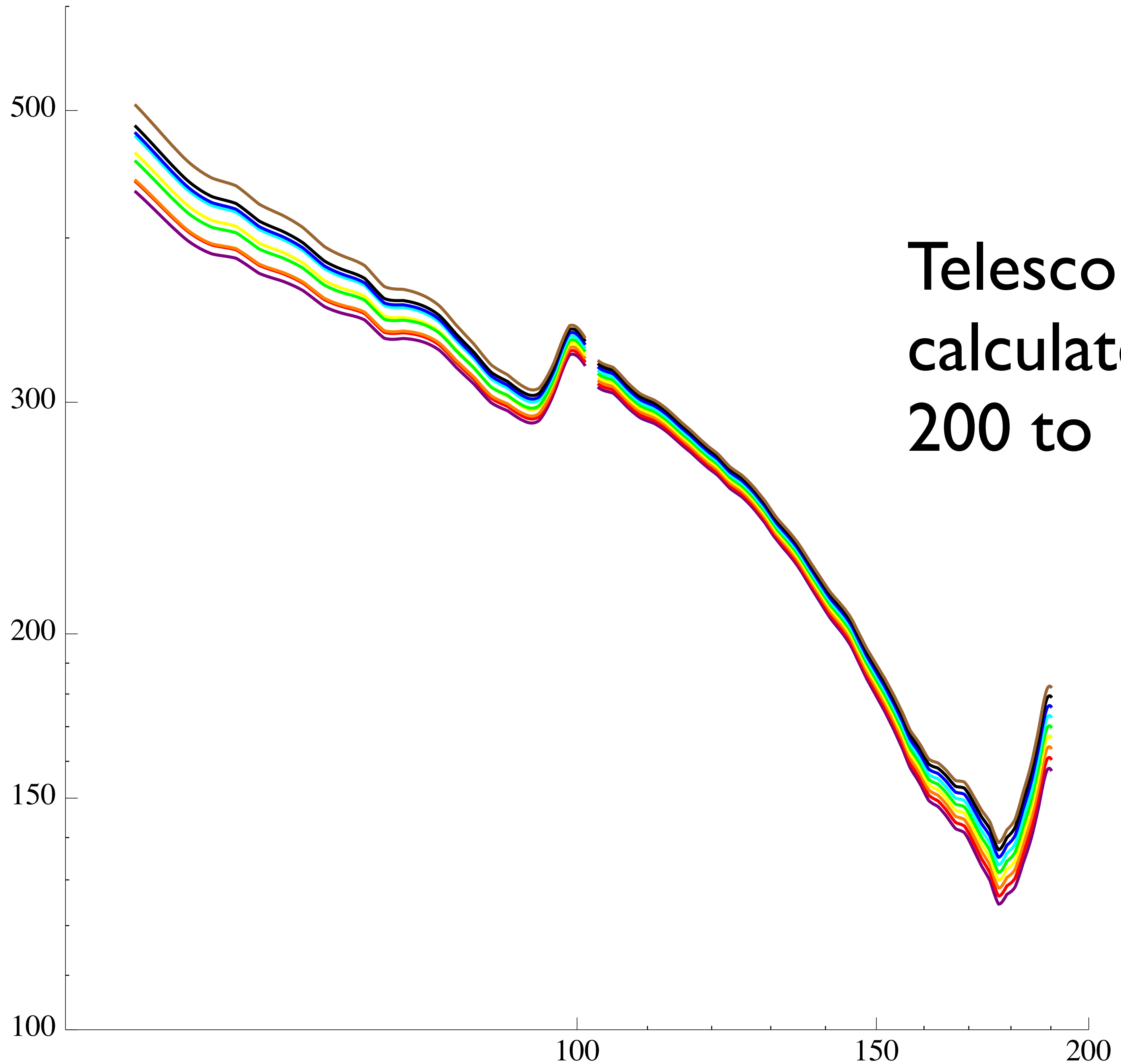
`redtelod_ext.fits`

Telescope SED Model (Ceres on Pallas)



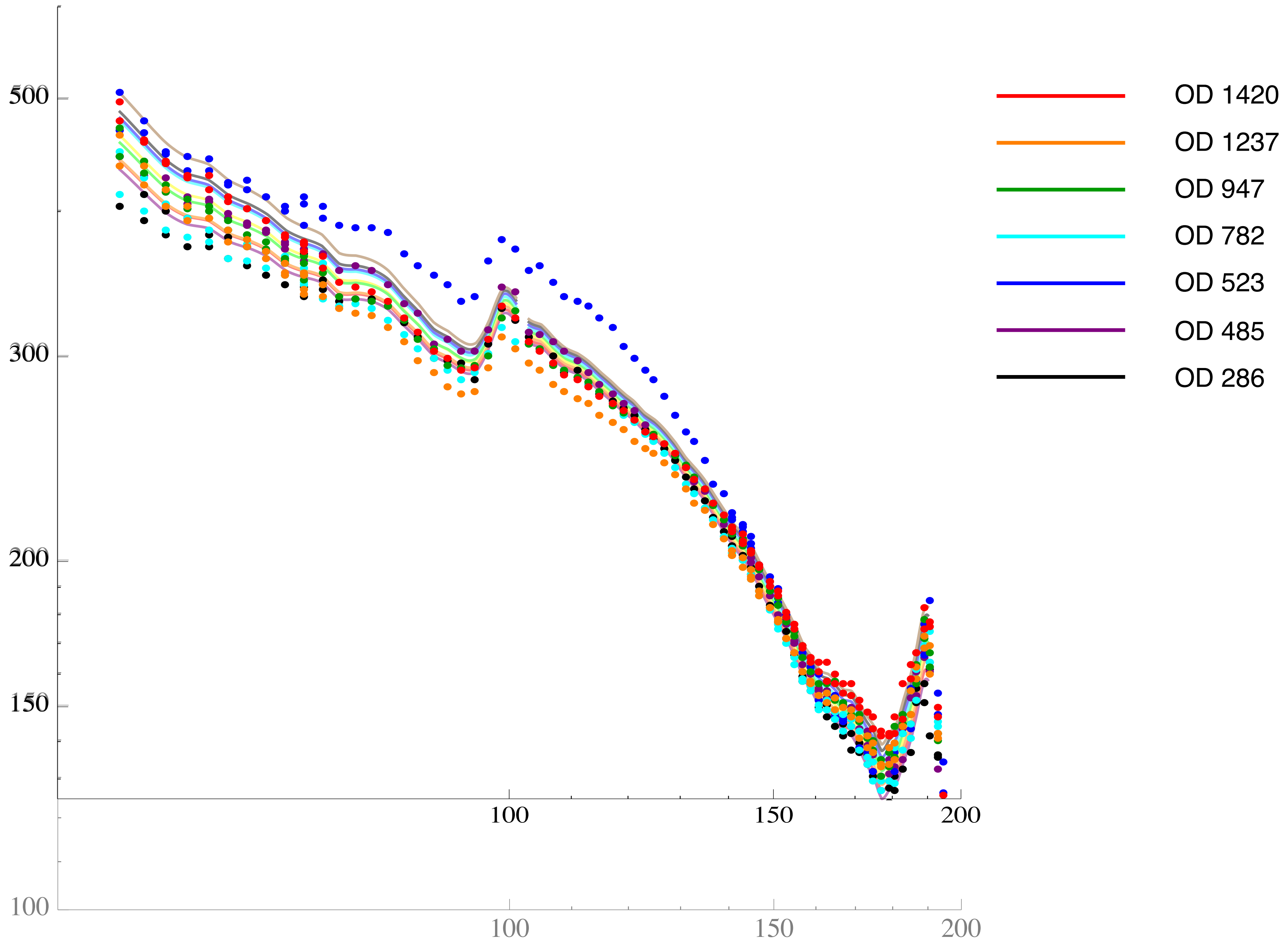
Telescope model fluxes calculated for ODs from 200 to 1400 in steps of 150

Telescope SED Model - Directly from Ceres as Absolute Flux Standard

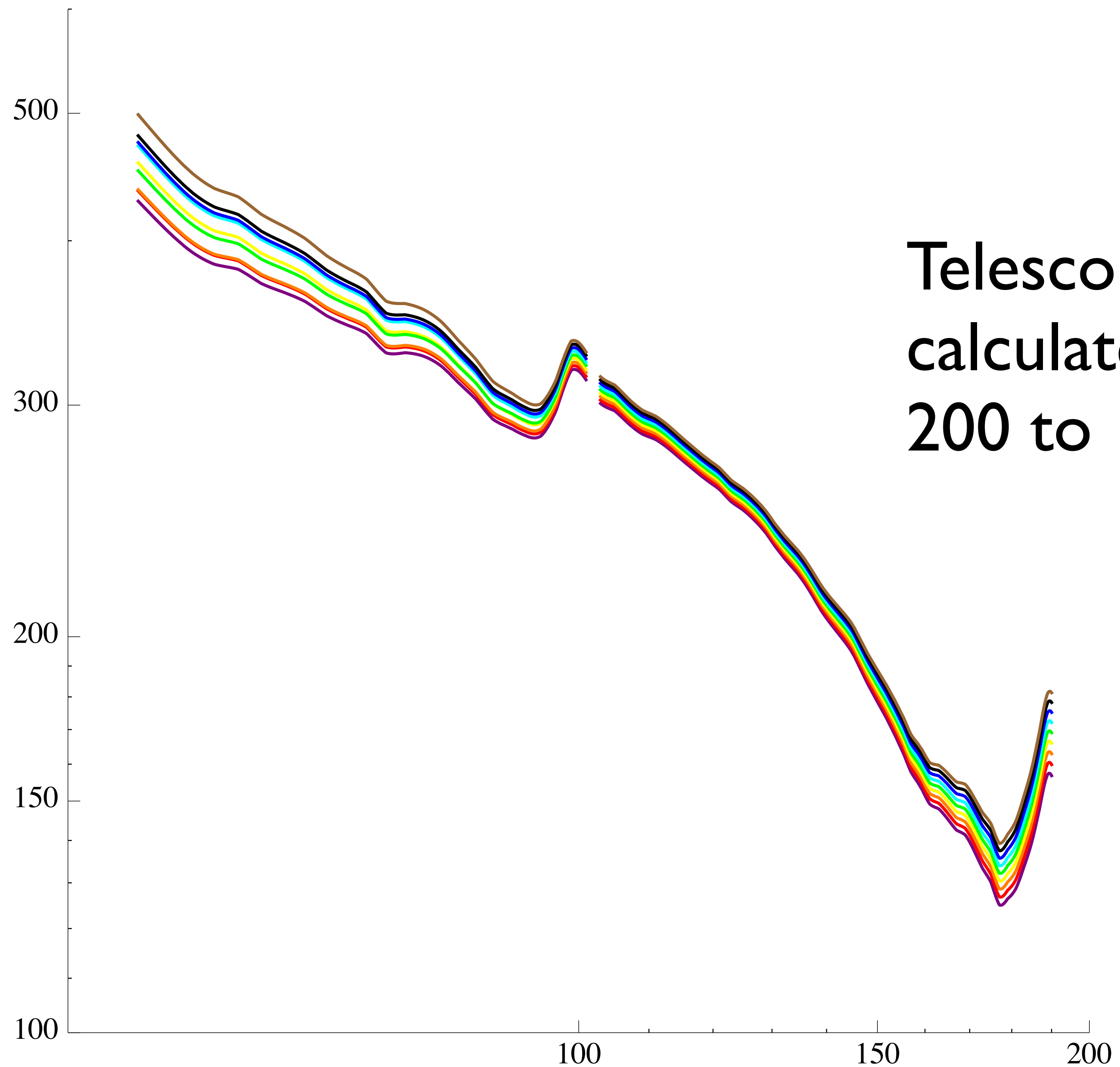


Telescope model fluxes calculated for ODs from 200 to 1400 in steps of 150

Telescope SEDs as Measured - Directly from Ceres as Absolute Flux Standard

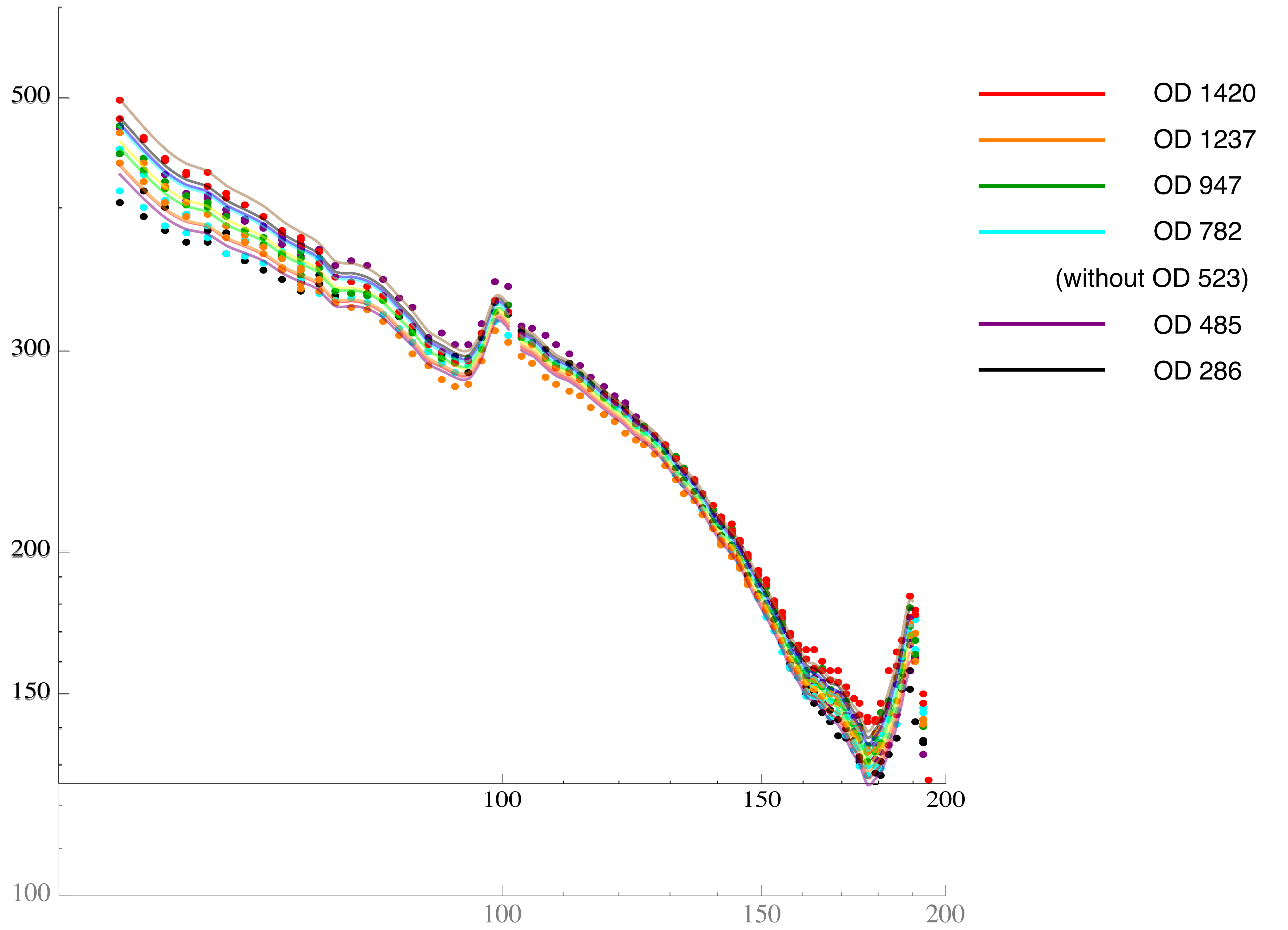


Telescope SED Model (without OD 523) - Directly from Ceres as Absolute Flux Standard

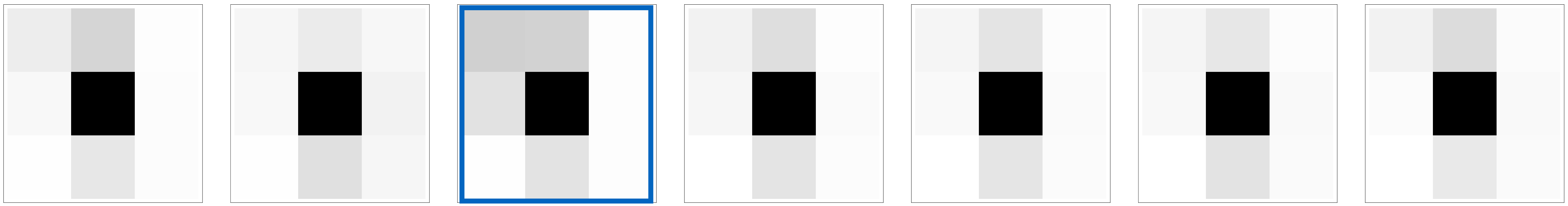


Telescope model fluxes calculated for ODs from 200 to 1400 in steps of 150

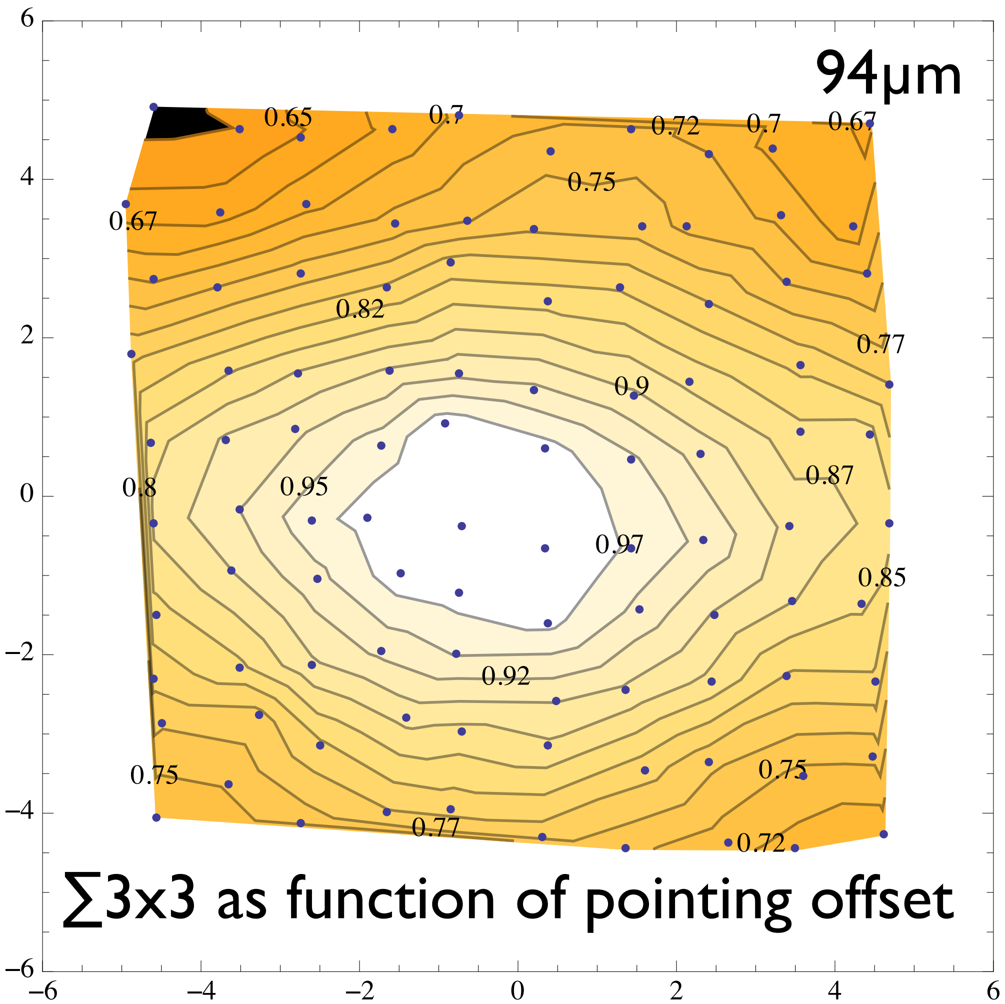
Telescope SEDs as Measured (without OD 523) - Directly from Ceres as Absolute Flux Standard



Pointing Effects on Flux in 3x3?

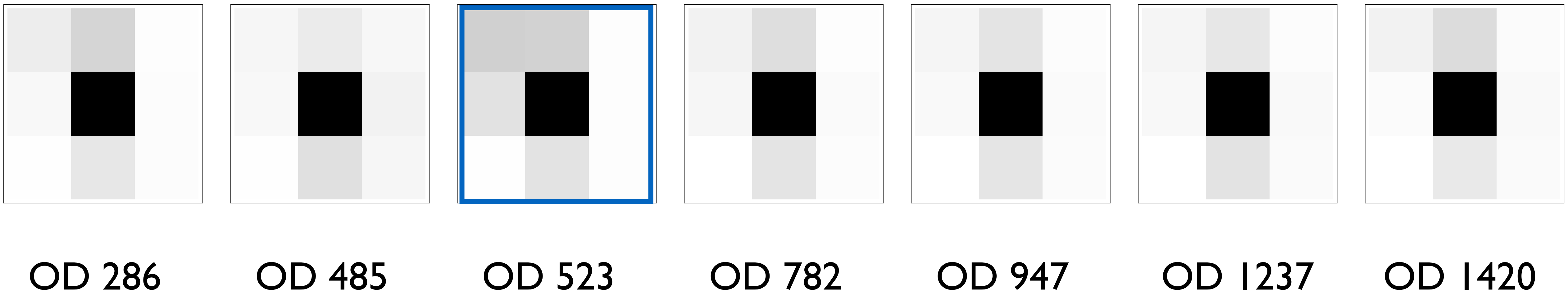


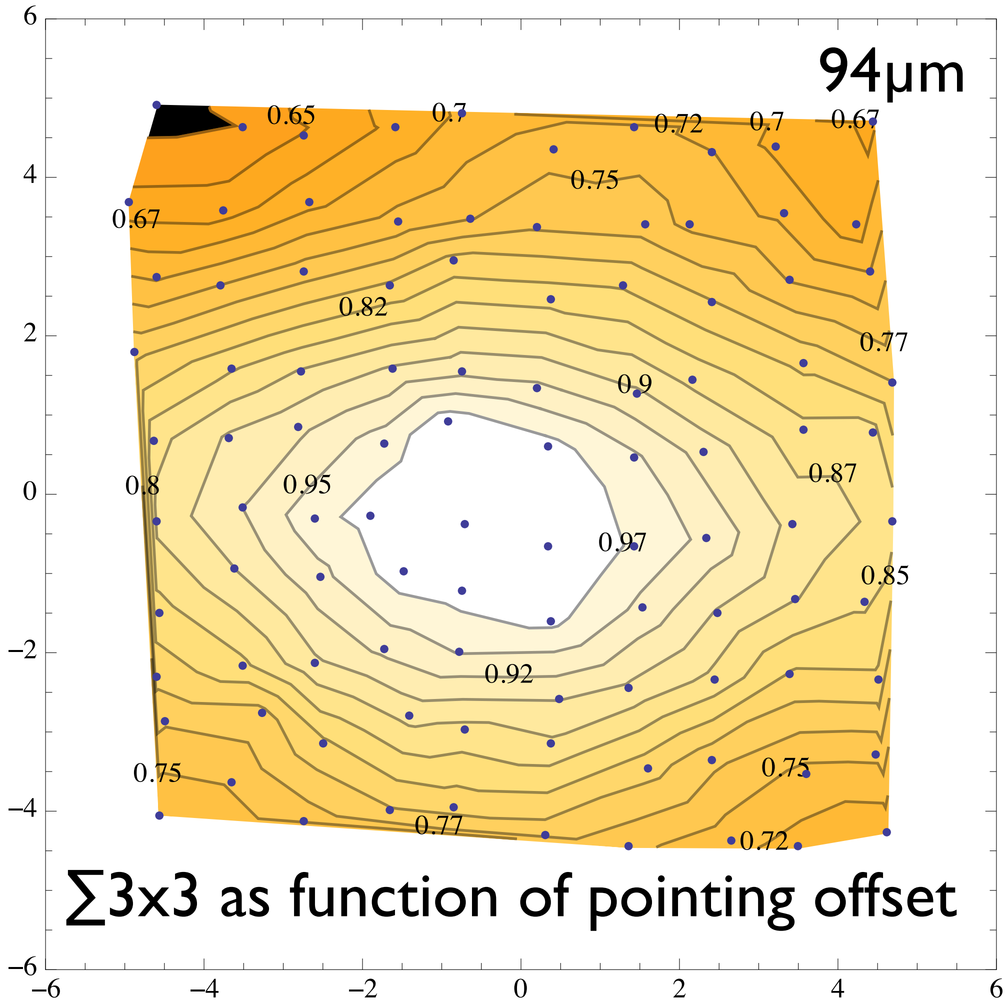
OD 286 | OD 485 | OD 523 | OD 782 | OD 947 | OD 1237 | OD 1420



- The absolute pointing was quite similar for most ODs
- OD 523 is clearly different, but could it explain the outlier in derived telescope SED?
- The fine raster map of ∑3x3 suggests 10% effect for offset of >1" in most sensitive direction

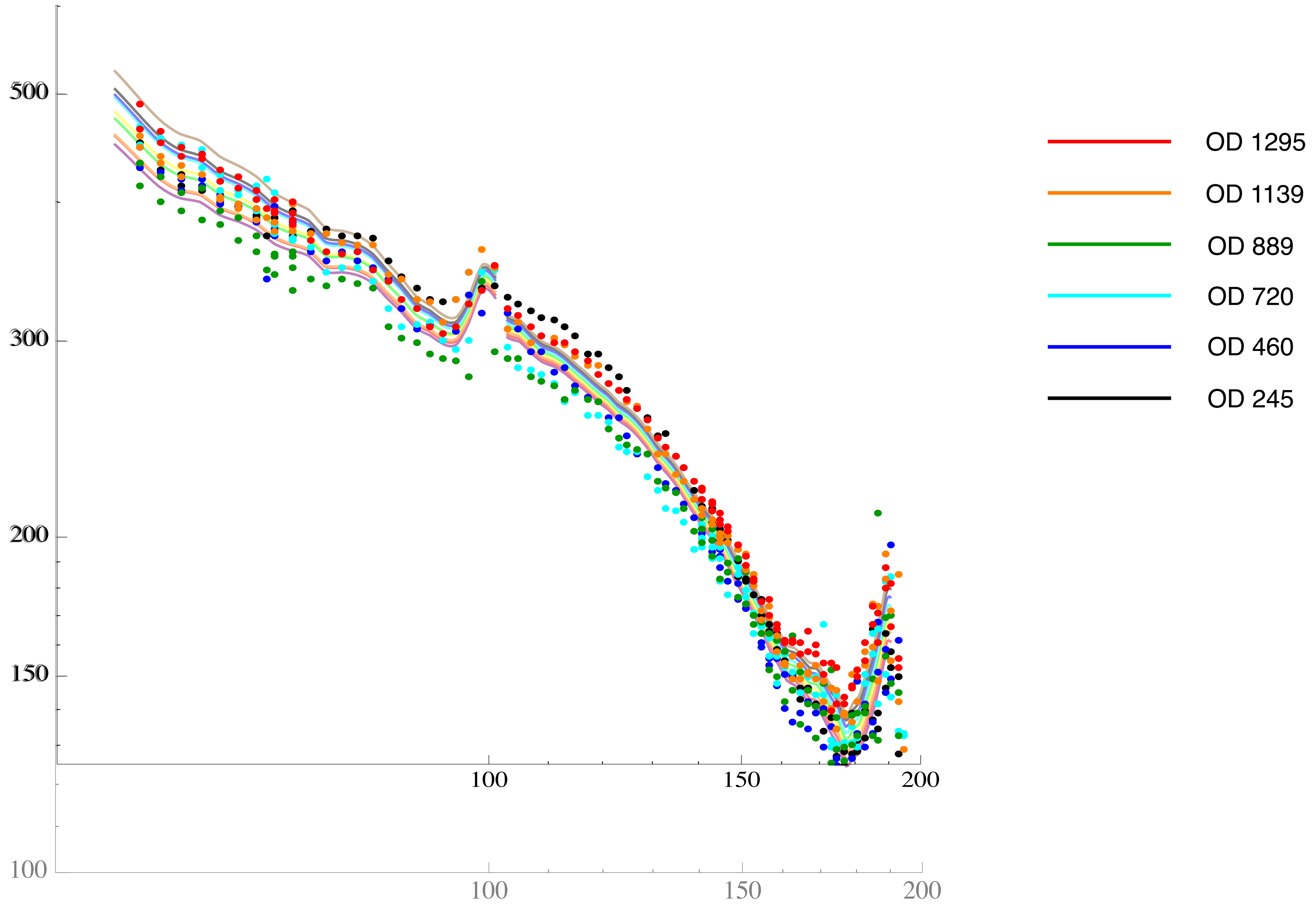
Pointing Correction of Flux in 3x3?





- Heidelberg recipe for pointing determination based on signal
- With known pointing offset, correction of ∑3x3 should be possible fairly accurately
- Could/should offset be determined per OD/OBSID/ wavelength bin? S/N?

Telescope SED as Measured - Directly from Pallas as Absolute Flux Standard



Exported (FITS) Telescope SEDs - Absolute Ceres

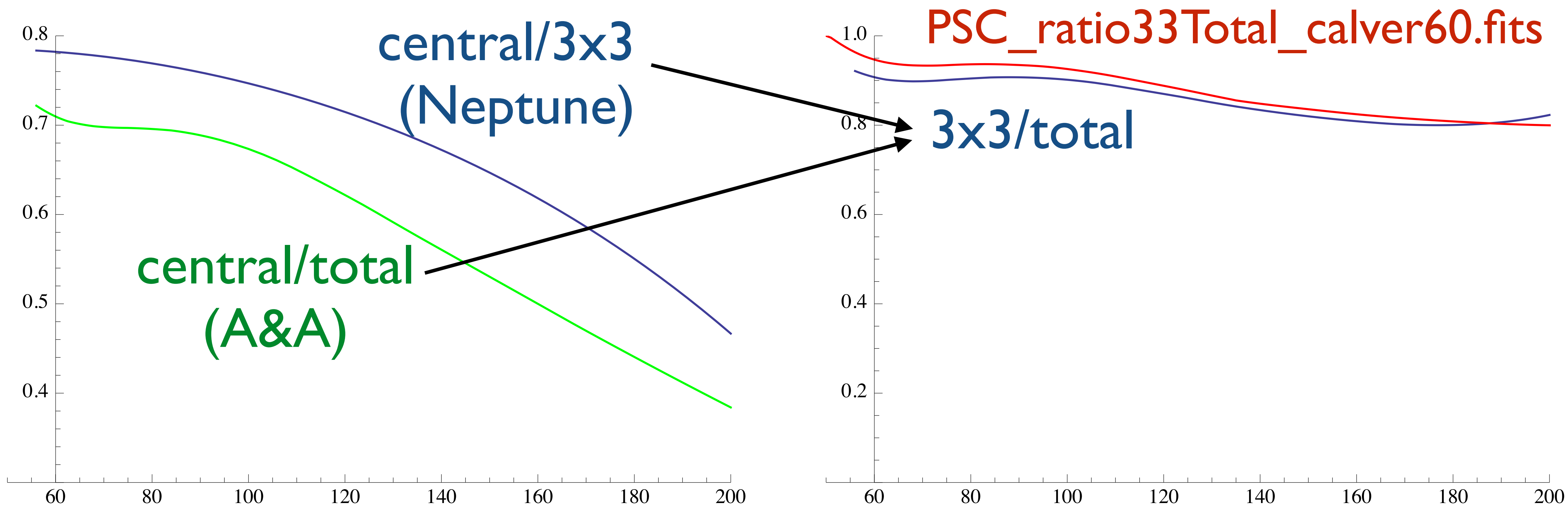
```
bluetelodcer =
  Table[{meanbluetelcer[[n, 1]],
    meanbluetelcer[[n, 2]] *
     (1 - (100 - meanbluetelcer[[n, 1]]) / (100 - 60) *
         (0.01497 * Sin[2 π / 365 * Max[180, od] + 0.01511] -
           0.01497 * Sin[2 π / 365 * day0 + 0.01511]) +
        evof[meanbluetelcer[[n, 1]], Max[180, od]])}, {od, 1, 1446},
   {n, Dimensions[meanbluetelcer][[1]]}];

redtelodcer =
  Table[{meanredtelcer[[n, 1]],
    meanredtelcer[[n, 2]] * (1 + evof[meanredtelcer[[n, 1]], Max[180, od]])},
   {od, 1, 1446}, {n, Dimensions[meanredtelcer][[1]]}];
```

- Data structure is 1446 x n x 2:
  - 1446 ODs, starting at 1
  - n wavelengths (in steps of 0.1μm)
  - data: { wavelength[μm], flux[Jy] }
- Evolution is switched off (flat) below OD180

`bluetelod_ext_cer.fits`

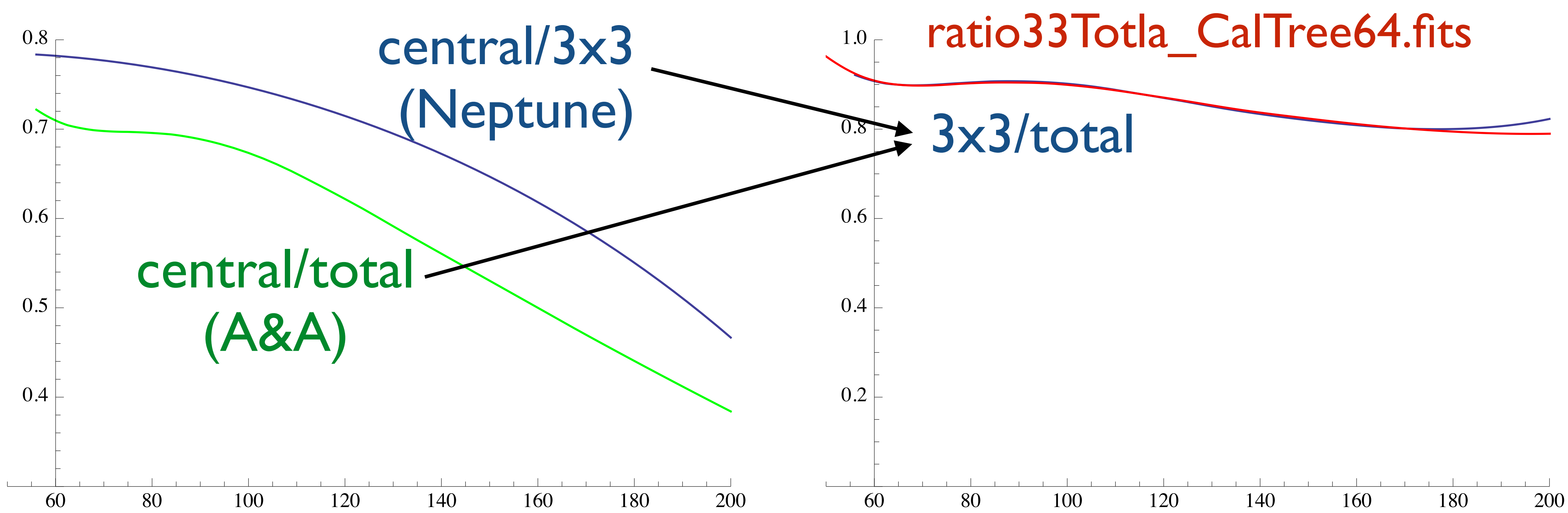
`redtelod_ext_cer.fits`

Comparison of 3x3 to Total Conversions



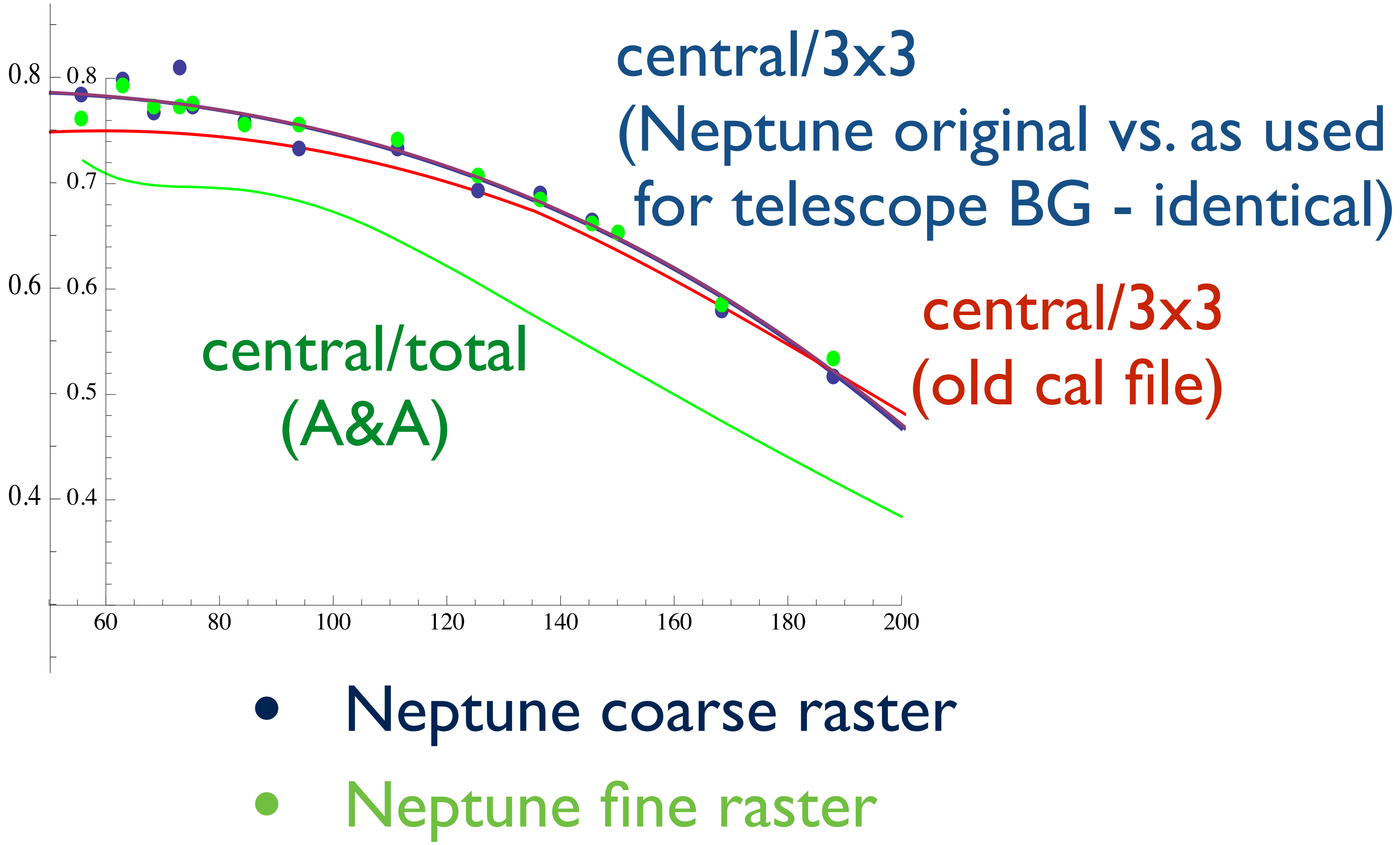
- For the derivation of the "telescope background", the central 3x3 spaxels were added up, the fraction of the central/3x3 fluxes calculated/interpolated with the fitted beams from the Neptune rasters, and the thus *calculated* central flux corrected with the canonical central-to-total conversion law. This corresponds to the 3x3-to-total correction depicted by the blue curve in the right panel.
- The v60 cal file for direct 3x3-to-total conversion is shown as the red curve
- There are discrepancies at the few percent level

Comparison of 3x3 to Total Conversions



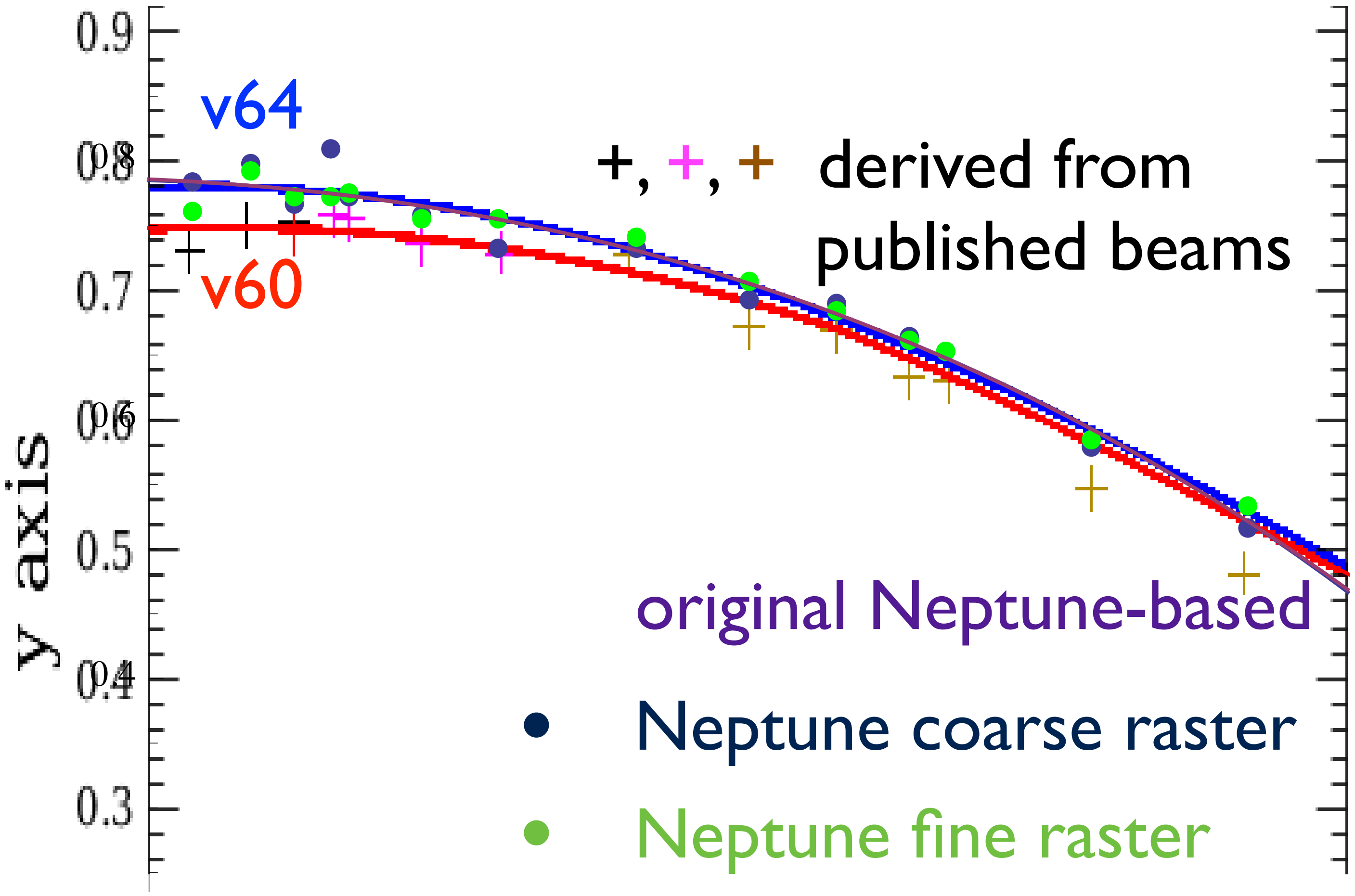
- For the derivation of the "telescope background", the central 3x3 spaxels were added up, the fraction of the central/3x3 fluxes calculated/interpolated with the fitted beams from the Neptune rasters, and the thus *calculated* central flux corrected with the canonical central-to-total conversion law. This corresponds to the 3x3-to-total correction depicted by the blue curve in the right panel.
- The v64 cal file for direct 3x3-to-total conversion is shown as the red curve
- Good agreement, except above 180μm. The cal tree curve looks more "credible".

Comparison of Central/3x3 with Original Derivation from Neptune Beam Rasters



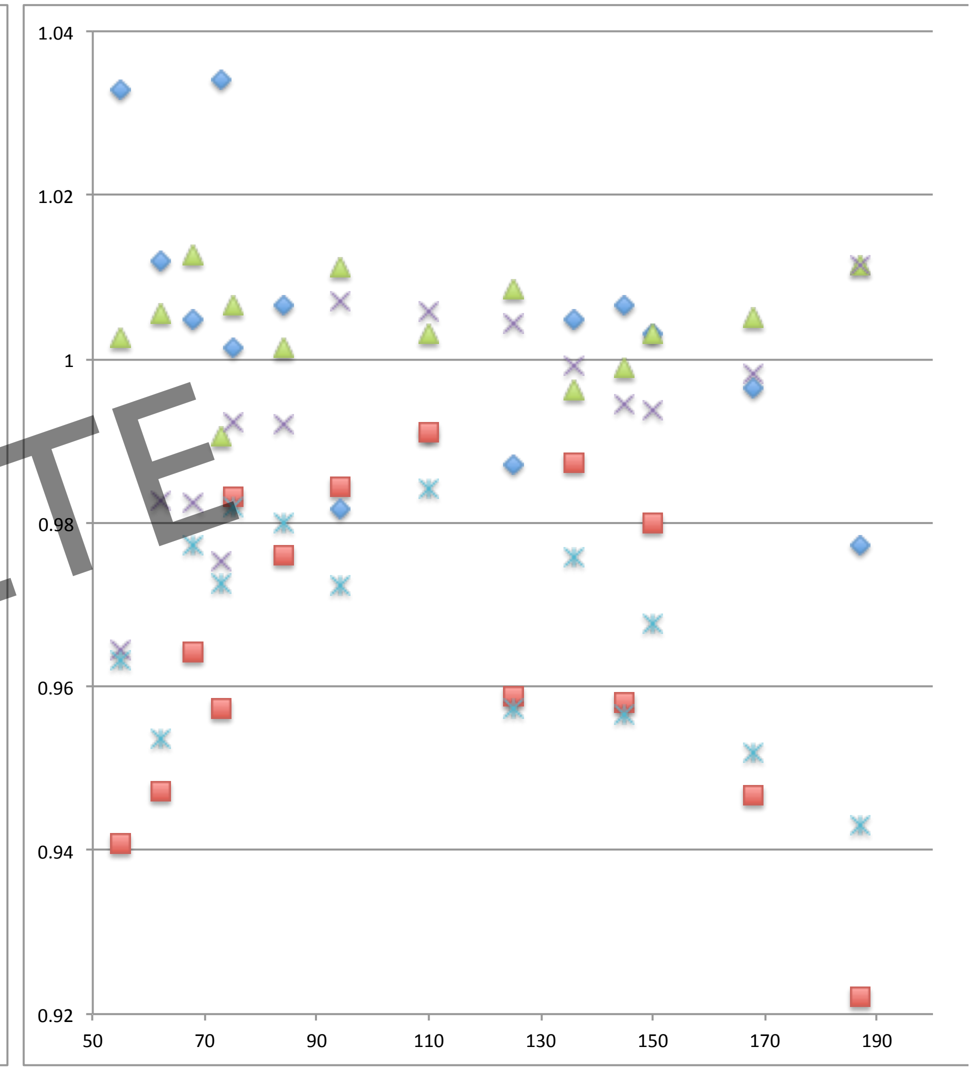
- The conversion 3x3 to 1x1 originally derived from the Neptune beam maps has been transferred correctly for the telescope BG determination

Comparison of Central/3x3 (Original Derivation from Neptune Beam Rasters, CalFiles) with Ratios Derived from Published Beams (by EPu)



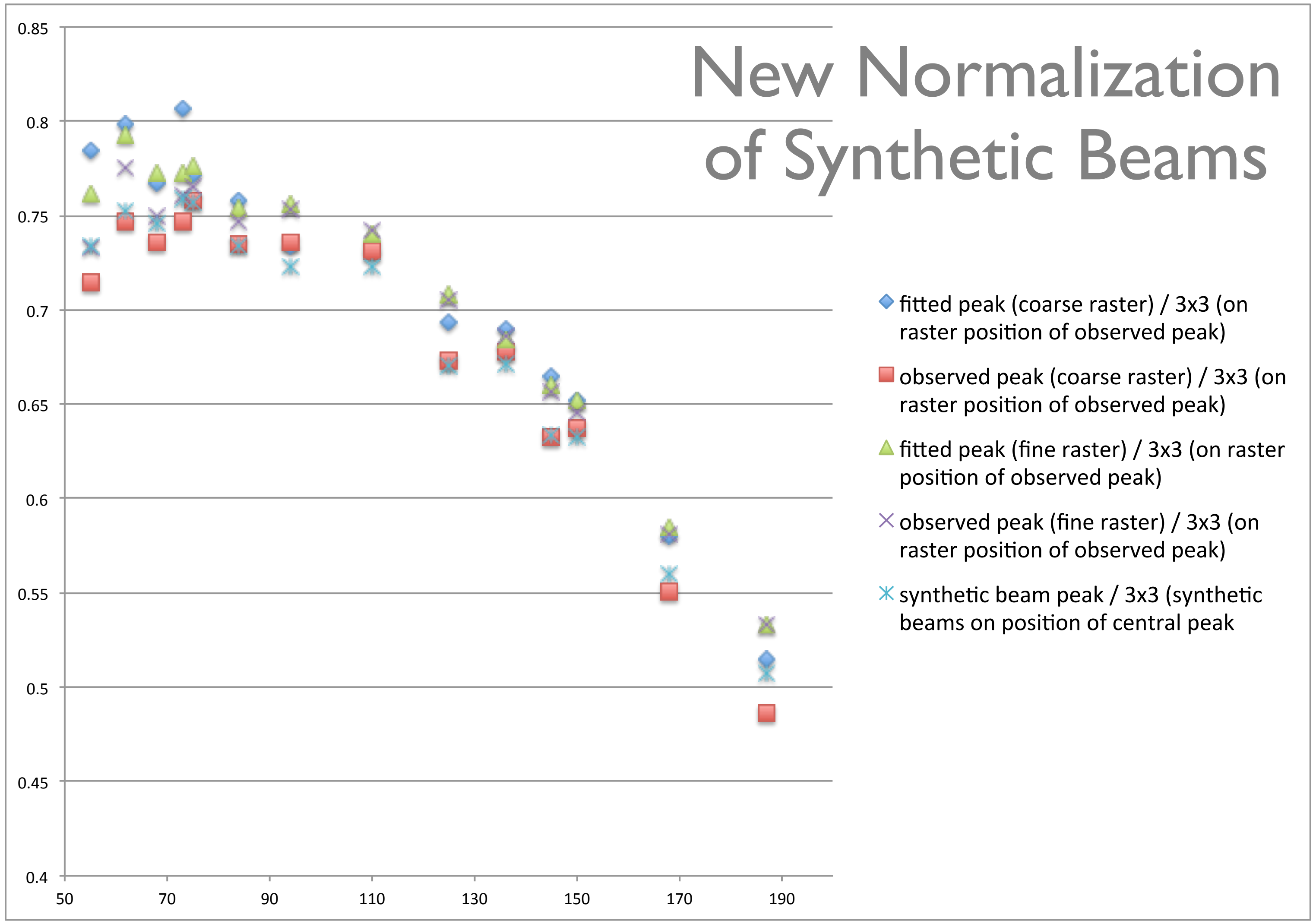
- Original Neptune and v64 agree, again, except for $\lambda>180\mu m$
- Re-derived ratios (from interpolated beam tables as published) are generally lower - even lower than v60 (in R band)!

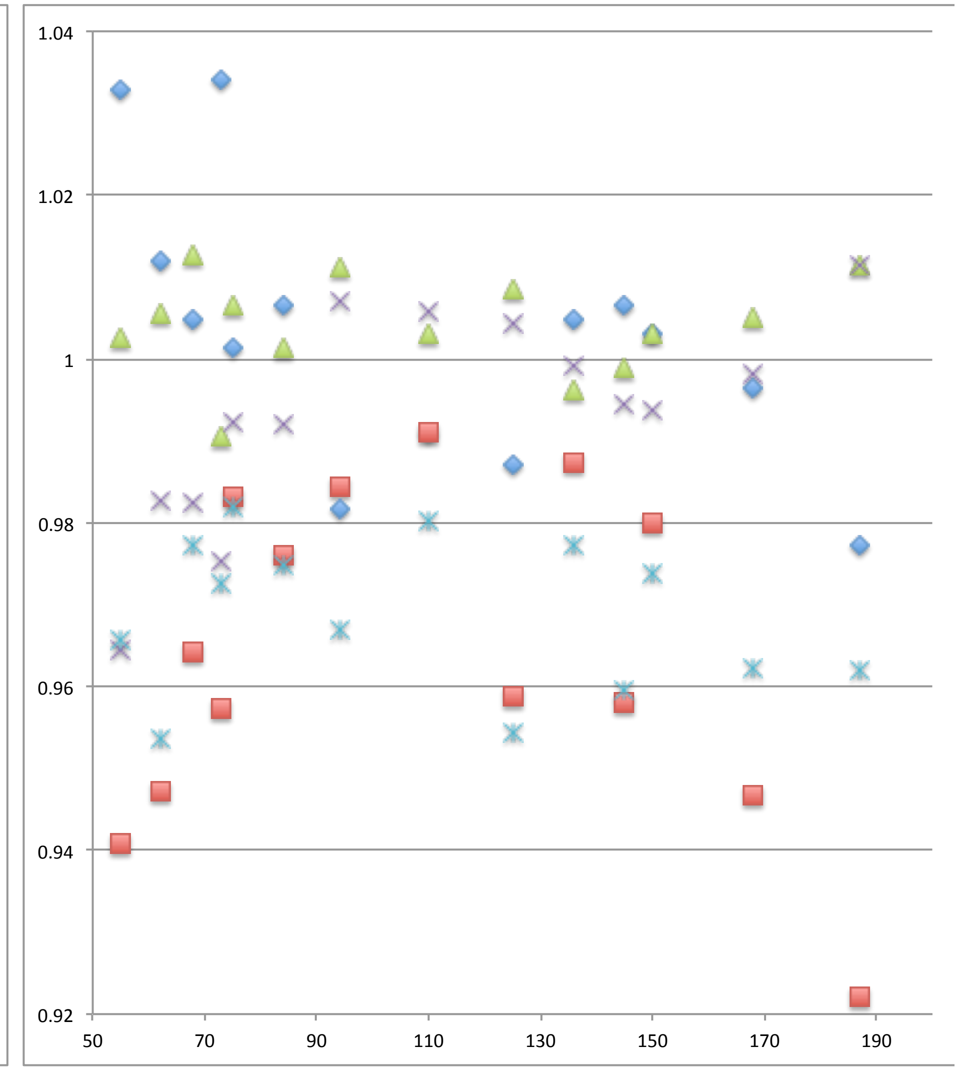
Comparison of Central/3x3 from Neptune Beam Rasters – Coarse/Fine; Fitted/Observed Peak; Synthetic Beams



- Left: 1x1/3x3. Right: 1x1/3x3 normalized to mean of coarse fit, fine fit and fine observed
- For the 3x3 to 1x1conversion in v64, the "fitted" coarse + fine raster values have been used to derive polynomial approximation as function of wavelength

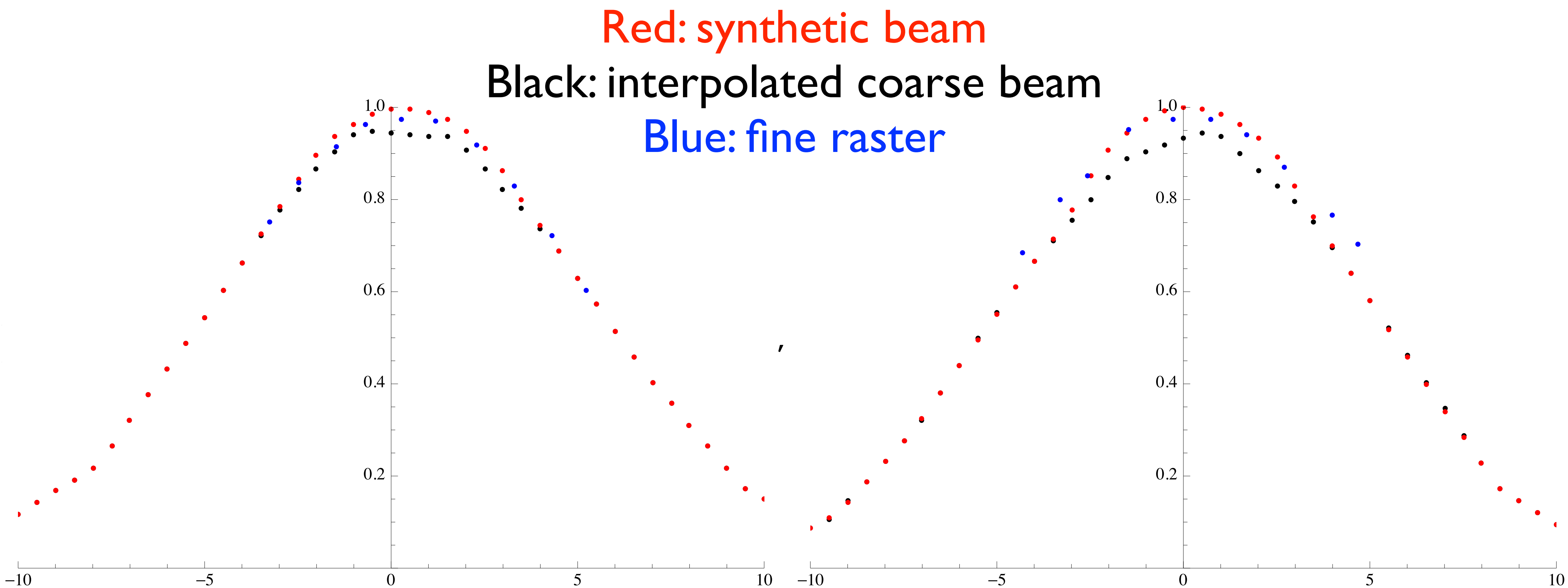
Comparison of Central/3x3 from Neptune Beam Rasters – Coarse/Fine; Fitted/Observed Peak; Synthetic Beams





- Left: 1x1/3x3. Right: 1x1/3x3 normalized to mean of coarse fit, fine fit and fine observed
- For the 3x3 to 1x1conversion in v64, the "fitted" coarse + fine raster values have been used to derive polynomial approximation as function of wavelength

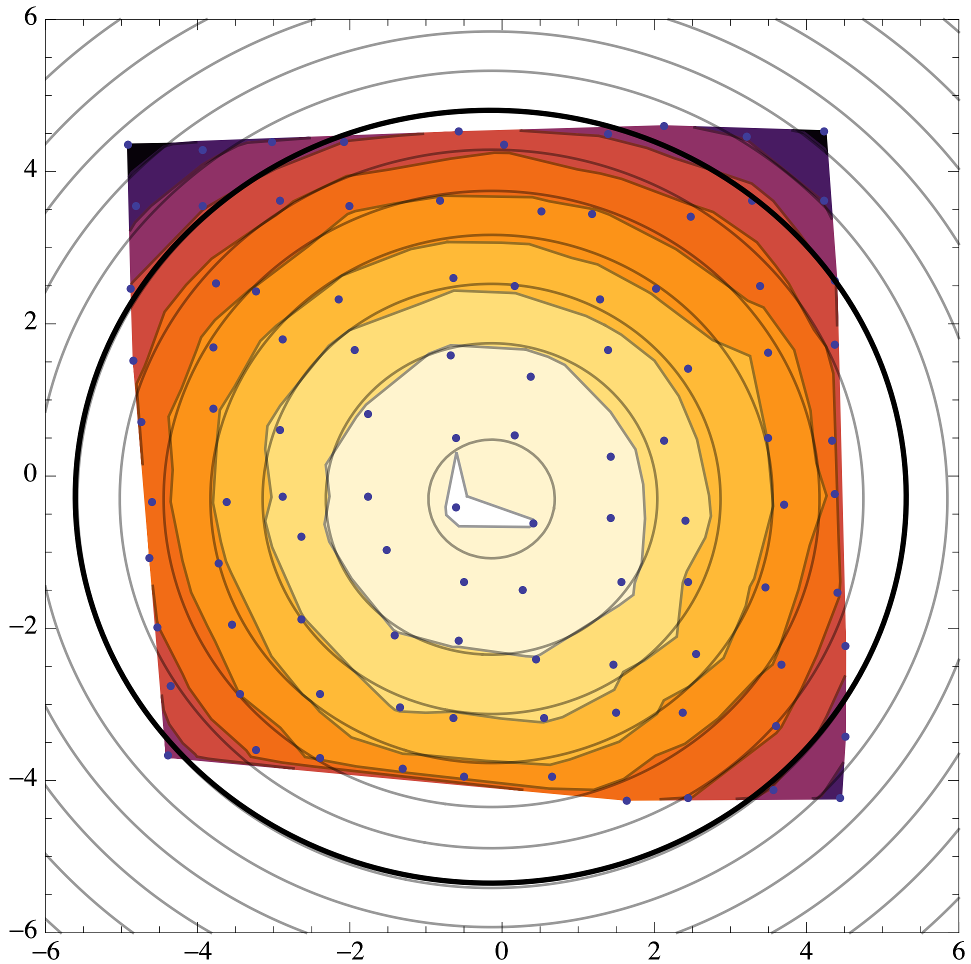
Comparison of Coarse/Synthetic and Fine Beams Y- and Z-Cut (Central Spaxel) @ 168μm

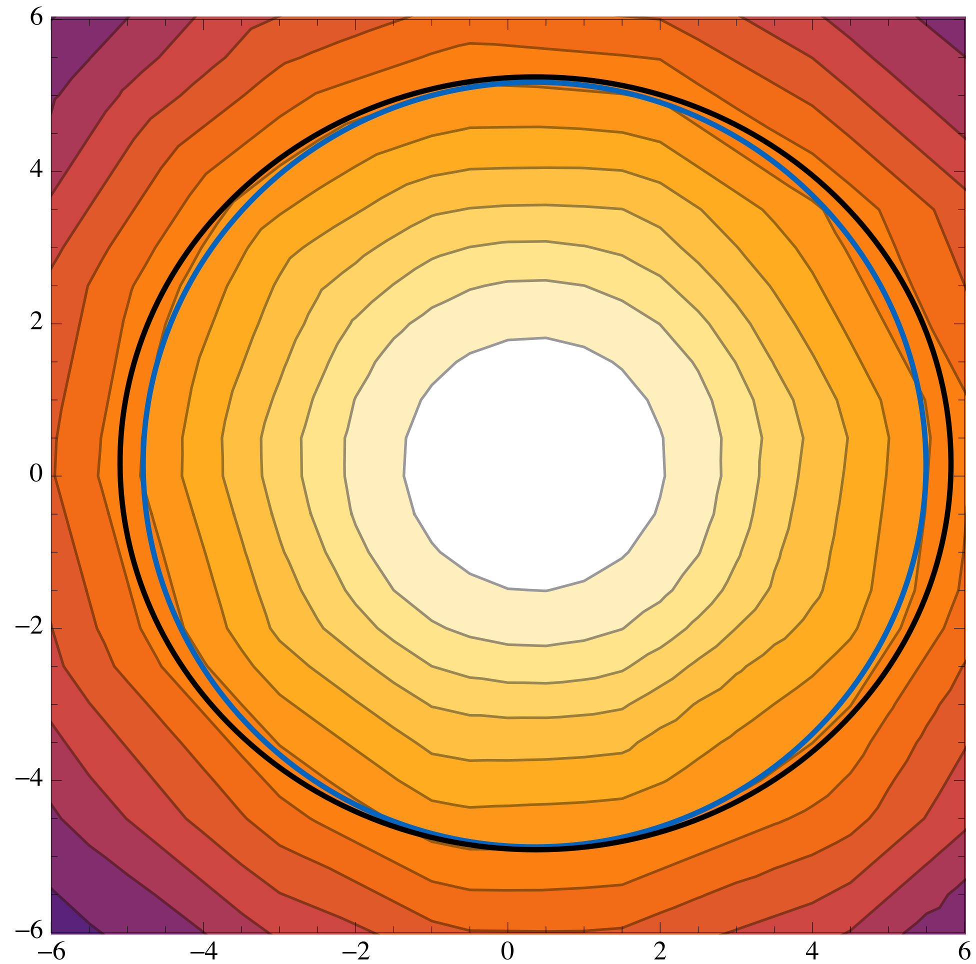


Fine raster and synthetic beams agree well along one axis but differ noticeably along the orthogonal axis!

Comparison of Coarse/Synthetic and Fine Beams (Central Spaxel) @ 168μm

Fine raster and synthetic beams have different ellipticity!

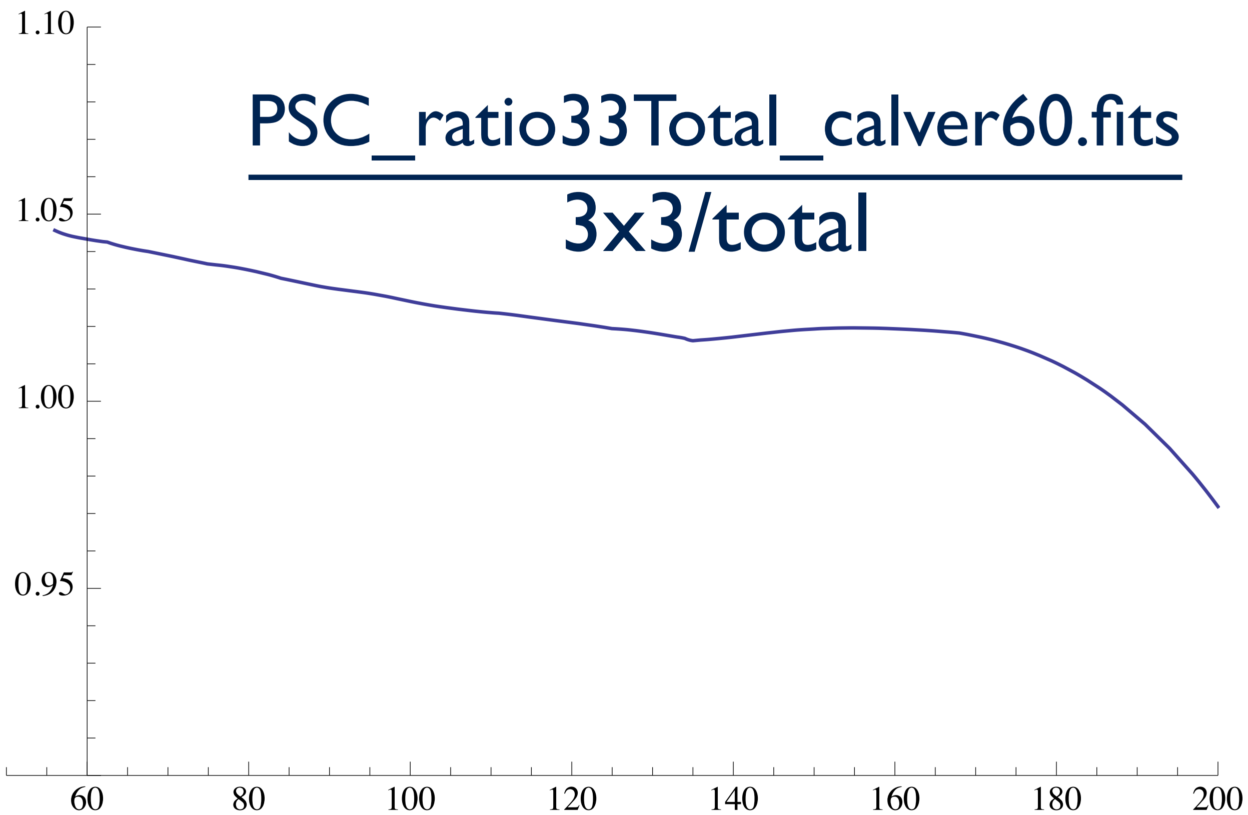


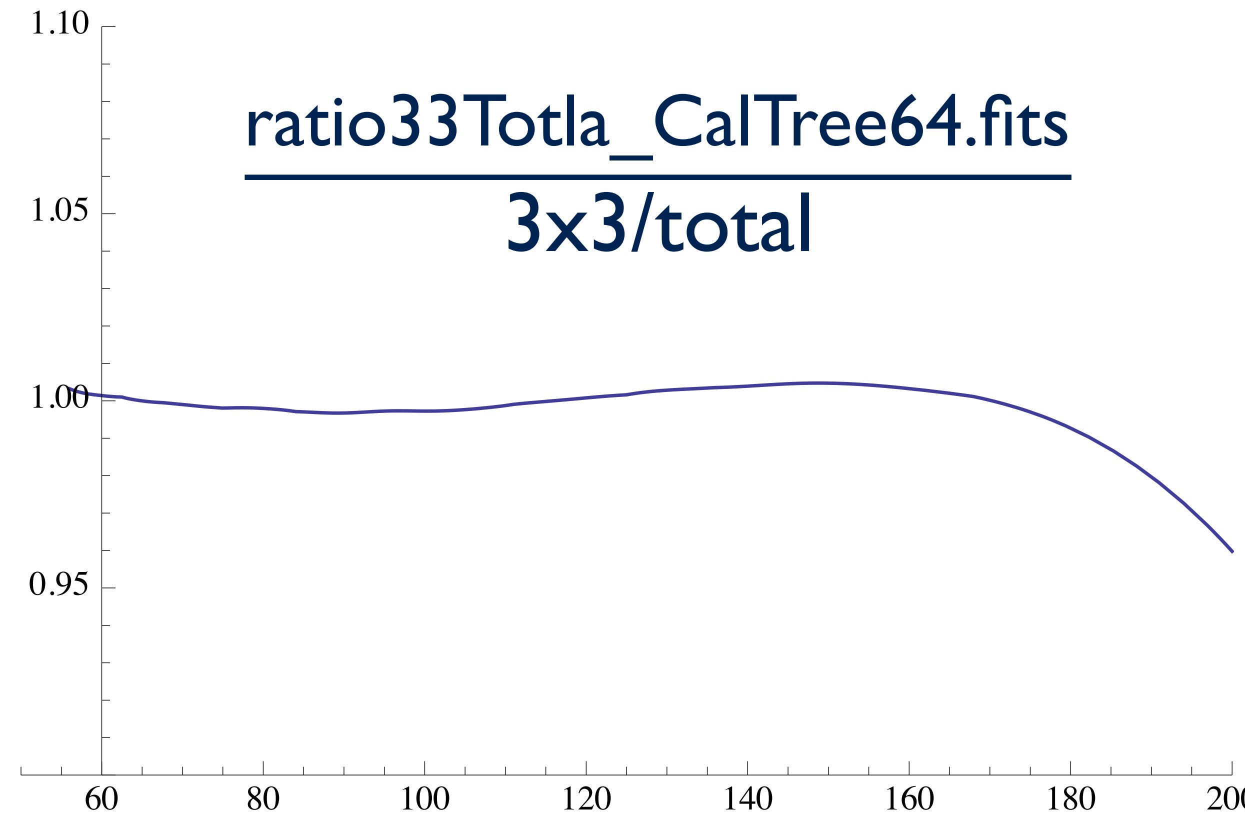


Color: fine raster contour plot
B/W: fitted elliptical Gaussian

Color: synthetic beam contour plot
B/W: fine raster fitted elliptical Gaussian
Black: highlighted fine raster contour
Blue: highlighted synthetic beam contour

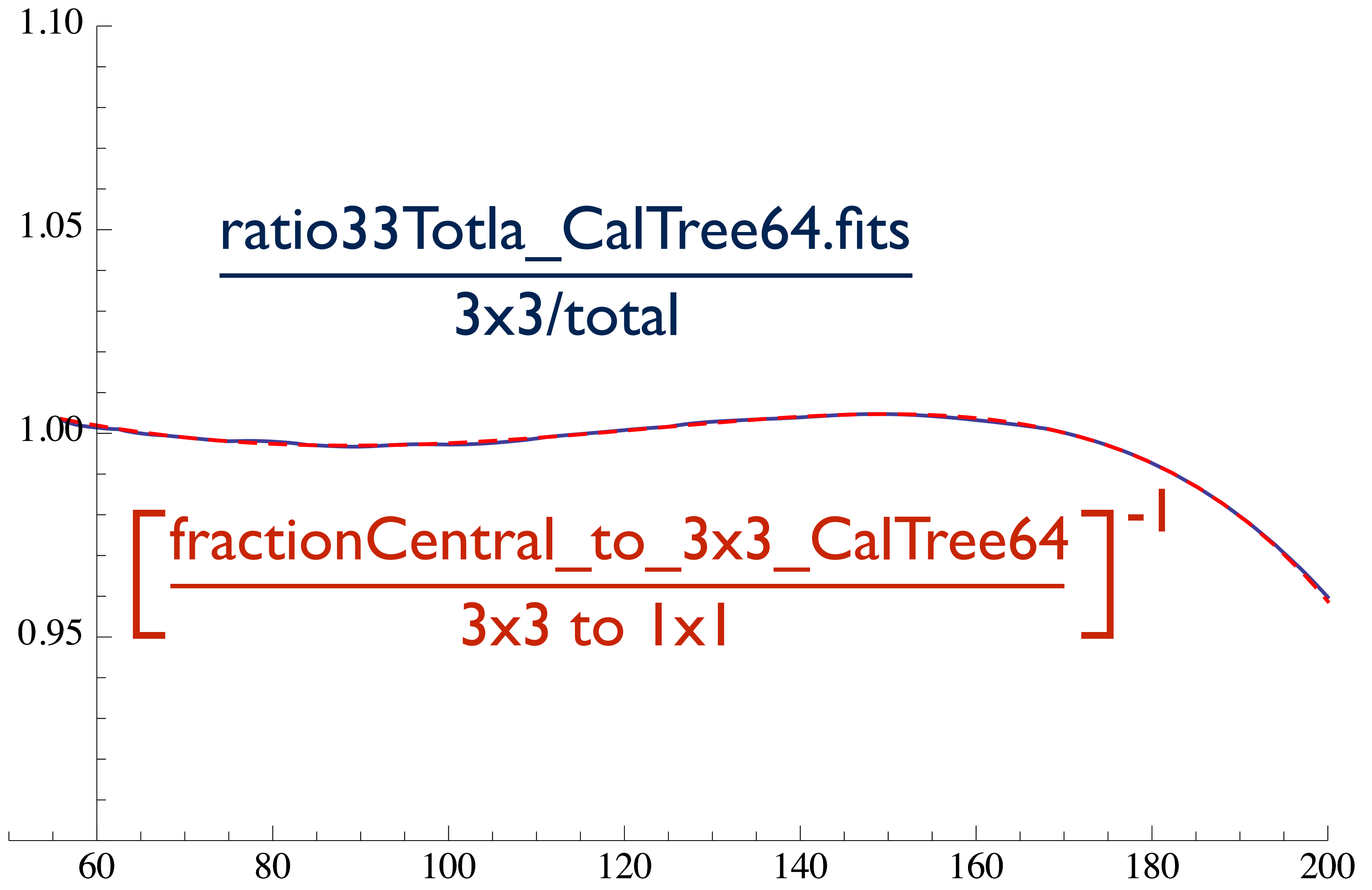
Comparison of 3x3 to Total Conversions





- Ratio of 2 recent cal file values for direct 3x3-to-total conversion over the method used for the telescope background calculation
- <u>v64 should be used to be consistent (for standard processing *and* for derivation of telescope models!)</u>

Comparison of 3x3 to Total Conversions and of 3x3 to Central Conversions in v64



- Deviation between CalTree and AlPog traceable to (small) difference in 3x3 to 1x1 conversion