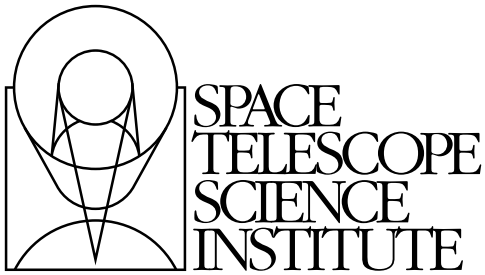

Technical Software Report 2011-4

TSR 2011-4: Comparison of Synphot and Pysynphot Bandpar Functionality

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CHAPTER

ONE

COMPARISON OF SYNPHOT AND PYSYNPHOT BANDPAR FUNCTIONALITY

Abstract

Pysynphot attempts to replicate much of the functionality of the Synphot bandpar utility but sometimes uses different formulae and algorithms. This TSR collects the calculations used in Pysynphot, Synphot, the formulae described in the Synphot Manual in Section 5.1 on page 42, and the formulae in the Synphot help files.

CHAPTER

TWO

RMS WIDTH - BANDW - PHOTBW

2.1 Summary

RMS width is added to image headers in the PHOTBW keyword.

Pysynphot

- *Function name*: SpectralElement.rmswidth
- *Source code*: spectrum.py
- *References*: *3: page 836*

Synphot

- *Bandpar name*: BANDW
- *Function name*: rmslam called by comppar called by bandpar.
- *Source code*: rmslam.x
- *References*: *1: sections 5.1,7.1*, *2*, *4: page 46*

2.2 Synphot Equations

The Synphot Manual section 5.1 gives the equation for RMS bandwidth as

$$\lambda_{rms}^2 = \bar{\lambda}^2 \frac{\int P_\lambda \ln(\lambda/\bar{\lambda})^2 \, d\lambda/\lambda}{\int P_\lambda \, d\lambda/\lambda}$$

where

$$\bar{\lambda} = \exp\left[\frac{\int P_\lambda \ln(\lambda) \, d\lambda/\lambda}{\int P_\lambda \, d\lambda/\lambda}\right].$$

The Synphot function rmslam does appear to implement this procedure for calculating the RMS width of the bandpass. The source code references the WF/PC-1 Instrument Handbook as the source of the equation for RMS width and references Schneider, Gunn and Hoessel (1983 ApJ 264,337) as the source for the equation for mean wavelength.

The bandpar help file gives the same equations as above for the RMS width but the Synphot Manual in section 7.1 gives different equations when describing bandpar. The equations in section 7.1 are the same as used by Pysynphot, shown below.

2.3 Pysynphot Equations

The Pysynphot rmswidth source code references Koornneef et al 1987, page 836 as the source for its RMS width calculation, which is

$$\lambda_{rms}^2 = \frac{\int P_\lambda (\lambda - \bar{\lambda})^2 \, d\lambda}{\int P_\lambda \, d\lambda}$$

where

$$\bar{\lambda} = \frac{\int \lambda P_\lambda \, d\lambda}{\int P_\lambda \, d\lambda}.$$

CHAPTER

THREE

FULL WIDTH HALF-MAX - FWHM

3.1 Summary

Pysynphot

- *Function name*: SpectralElement.fwhm
- *Source code*: spectrum.py
- *References*:

Synphot

- *Bandpar name*: FWHM
- *Function name*: fwhmlam called by comppar called by bandpar.
- *Source code*: fwhmlam.x
- *References*: *1: section 5.1*

3.2 Synphot Equations

The FWHM is simply defined relative to the RMS width above:

$$fwhm = \sqrt{8 \ln 2} \cdot rmswidth$$

3.3 Pysynphot Equations

Pysynphot does not currently implement a FWHM calculation. See https://trac.assembla.com/astrolib/ticket/139.

CHAPTER

FOUR

EQUIVALENT WIDTH - EQUVW

4.1 Summary

Pysynphot

- *Function name*: SpectralElement.equvwidth
- *Source code*: spectrum.py
- *References*:

Synphot

- *Bandpar name*: EQUVW
- *Function name*: widthlam called by comppar called by bandpar.
- *Source code*: widthlam.x
- *References*: *1: section 5.1*

4.2 Synphot Equations

The equivalent width is simply the integral of the throughput:

$$equvw = \int P_\lambda \, d\lambda$$

4.3 Pysynphot Equations

Pysynphot calculates the equivalent width in the same manner as Synphot.

CHAPTER

FIVE

RECTANGULAR WIDTH - RECTW

5.1 Summary

Pysynphot

- *Function name*: SpectralElement.rectwidth
- *Source code*: spectrum.py
- *References*:

Synphot

- *Bandpar name*: RECTW
- *Function name*: widthlam called by comppar called by bandpar.
- *Source code*: widthlam.x
- *References*: *1: section 5.1*

5.2 Synphot Equations

Synphot calculates the rectangular width at the same time it calculates the equivalent width by simply dividing the equivalent width by the maximum throughput of the passband:

$$rectw = \frac{equvw}{\max(P_\lambda)}$$

This is equivalent to the formula given in section 5.1 of the Synphot Manual:

$$rectw = \frac{\int P_\lambda \, d\lambda}{\max(P_\lambda)}$$

5.3 Pysynphot Equations

Pysynphot calculates the rectangular width in functionally the same way as Synphot but does not defer any calculation to the equivalent width method. Instead, Pysynphot directly calculates the integral of the throughput and divides by the maximum within the rectwidth method.

CHAPTER

SIX

UNIT RESPONSE - URESP - PHOTFLAM

6.1 Summary

Unit response is added to image headers in the PHOTFLAM keyword.

Pysynphot

- *Function name*: SpectralElement.unit_response
- *Source code*: spectrum.py
- *References*:

Synphot

- *Bandpar name*: URESP
- *Function name*: funit called by comppar called by bandpar.
- *Source code*: funit.x
- *References*: *1: sections 5.1, 7.1*

6.2 Synphot Equations

$$U_\lambda = \frac{hc/A}{\int \lambda P_\lambda \, d\lambda}$$

where h and c are the usual fundamental constants and A is the area of the telescope primary mirror.

6.3 Pysynphot Equations

Pysynphot calculates the unit response in the same way as Synphot.

CHAPTER

SEVEN

PIVOT WAVELENGTH - PIVWV - PHOTPLAM

7.1 Summary

Pivot wavelength is added to image headers in the PHOTPLAM keyword.

Pysynphot

- *Function name*: SpectralElement.pivot
- *Source code*: spectrum.py
- *References*:

Synphot

- *Bandpar name*: PIVWV
- *Function name*: pivlam called by comppar called by bandpar.
- *Source code*: pivlam.x
- *References*: *1: sections 5.1, 7.1*

7.2 Synphot Equations

The pivot wavelength equation is recorded in sections 5.1 and 7.1 of the Synphot Manual and matches in both places.

$$\lambda_p = \sqrt{\frac{\int \lambda P_\lambda \, d\lambda}{\int P_\lambda \, d\lambda / \lambda}}$$

7.3 Pysynphot Equations

Pysynphot calculates the pivot wavelength in the same way as Synphot.

CHAPTER

EIGHT

WAVELENGTH AT PEAK THROUGHPUT - WPEAK

8.1 Summary

Pysynphot

- *Function name*:
- *Source code*:
- *References*:

Synphot

- *Bandpar name*: WPEAK
- *Function name*: peaklam2 called by comppar called by bandpar.
- *Source code*: peaklam.x
- *References*: *1: sections 5.1*

8.2 Synphot Equations

Like the name implies, this is simply the wavelength at the point of peak throughput. Synphot finds it by looping over the throughput.

8.3 Pysynphot Equations

Pysynphot does not currently implement a peak wavelength calculation. See https://trac.assembla.com/astrolib/ticket/139.

CHAPTER

NINE

PEAK THROUGHPUT - TPEAK

9.1 Summary

Pysynphot

- *Function name*:
- *Source code*:
- *References*:

Synphot

- *Bandpar name*: TPEAK
- *Function name*: peaklam2 called by comppar called by bandpar.
- *Source code*: peaklam.x
- *References*: *1: sections 5.1*

9.2 Synphot Equations

This is simply the maximum throughput of the passband. Synphot finds it by looping over the throughput.

9.3 Pysynphot Equations

Pysynphot does not currently implement a peak throughput calculation. See https://trac.assembla.com/astrolib/ticket/139.

CHAPTER

TEN

AVERAGE WAVELENGTH - AVGWV

10.1 Summary

Pysynphot

- *Function name*: SpectralElement.avgwave
- *Source code*: spectrum.py
- *References*: *3: page 836*

Synphot

- *Bandpar name*: AVGWV
- *Function name*: avglam called by comppar called by bandpar.
- *Source code*: avglam.x
- *References*: *1: sections 5.1, 7.1*

10.2 Synphot Equations

$$\lambda_0 = \frac{\int \lambda P_\lambda \, d\lambda}{\int P_\lambda \, d\lambda}$$

10.3 Pysynphot Equations

Pysynphot calculates the average wavelength in the same way as Synphot.

CHAPTER

ELEVEN

DIMENSIONLESS EFFICIENCY - QTLAM

11.1 Summary

Pysynphot

- *Function name*: SpectralElement.efficiency
- *Source code*: spectrum.py
- *References*:

Synphot

- *Bandpar name*: QTLAM
- *Function name*: qtlam called by comppar called by bandpar.
- *Source code*: qtlam.x
- *References*: *1: section 5.1*, *5: page 152*

11.2 Synphot Equations

$$qtlam = \int P_\lambda \, d\lambda/\lambda$$

11.3 Pysynphot Equations

Pysynphot calculates the efficiency in the same way as Synphot.

CHAPTER

TWELVE

THROUGHPUT AT REFERENCE WAVELENGTH - TLAMBDA

12.1 Summary

Pysynphot

- *Function name*:
- *Source code*:
- *References*:

Synphot

- *Bandpar name*: TLAMBDA
- *Function name*: monolam called by comppar called by bandpar.
- *Source code*: monolam.x
- *References*: *1: sections 5.1*

12.2 Synphot Equations

This is simply the bandpass throughput at a reference wavelength. By default the reference wavelength is the average wavelength as defined above.

12.3 Pysynphot Equations

The throughput of a Pysynphot SpectralElement object can be sampled at any wavelength using the sample() method. There is no function specifically for retrieving the throughput at the average wavelength.

CHAPTER

THIRTEEN

EQUIVALENT MONOCHROMATIC FLUX - EMFLX

13.1 Summary

Pysynphot

- *Function name*:
- *Source code*:
- *References*:

Synphot

- *Bandpar name*: EMFLX
- *Function name*: monolam called by comppar called by bandpar.
- *Source code*: monolam.x
- *References*: *1: sections 5.1*

13.2 Synphot Equations

The equivalent monochromatic flux is a combination of unit response, rectangular width, peak throughput and throughput at the average wavelength:

$$emflx = uresp \cdot rectw \cdot \frac{tpeak}{tlambda}$$

13.3 Pysynphot Equations

Pysynphot does not currently implement an equivalent monochromatic flux calculation. See https://trac.assembla.com/astrolib/ticket/139.

CHAPTER

FOURTEEN

REFERENCE WAVELENGTH - REFWAVE

See the section on average wavelength above.

CHAPTER

FIFTEEN

REFERENCES

1. Synphot Manual: http://stsdas.stsci.edu/stsci_python_epydoc/SynphotManual.pdf
2. Schneider, Gunn and Hoessel (1983 ApJ 264,337)
3. Koornneef et al., 1987
4. WFPC1 Instrument Handbook: http://www.stsci.edu/hst/wfpc/documents/HST_WFPC_Instrument_Handbook.pdf
5. WFPC2 Instrument Handbook: http://www.stsci.edu/instruments/wfpc2/Wfpc2_hand_current/wfpc2_ihb.pdf