Lyman-α data from LYRA and GOES for use in flare studies

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Lyman-α from PROBA2 LYRA

PROBA2 – compact, sun-synchronous orbit, 720 km, launched 2009

LYRA – radiometers, 3 quasi-redundant instruments
4 channels of different wavelength bands, 100 Hz

LYRA Lyman-α channel

benefits: radiation hardened diamond detector
cut-off 300 nm

issues: degradation (70% in 1st month)
broadband detection (115-300 nm)
slow recovery (hours)

Challenge: Extract Lyman-α signal at 121 nm.

Lyman-α measurements for flares

We want continuous measurements with both high cadence and high wavelength resolution. No instrument has both.

PROBA2 LYRA and GOES EUVS

high cadence, continuous

but are broadband and have degradation.

Need other measurements to calibrate the Lyman-α line.

SORCE SOLSTICE

has better than 1 nm resolution

but is in LEO orbit and provides single orbit or daily measurements

1 orbit per day has high resolution scans across Lyman-α

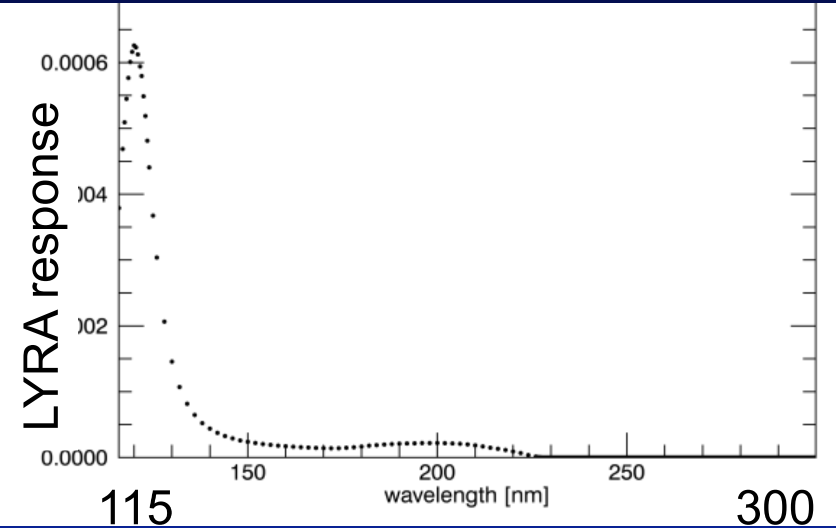
So...use SOLSTICE to scale and validate the high cadence instruments!

The Quest

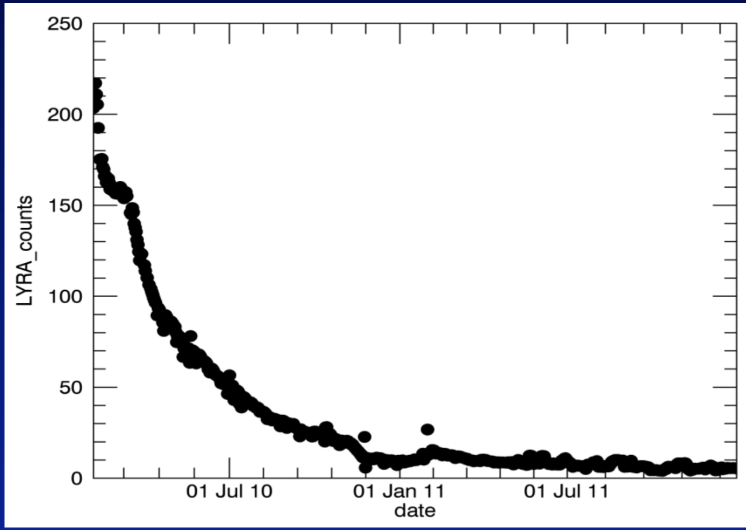
Goal: Extract 121-123 nm irradiance from LYRA data.

Challenges:

detector response 115-300 nm

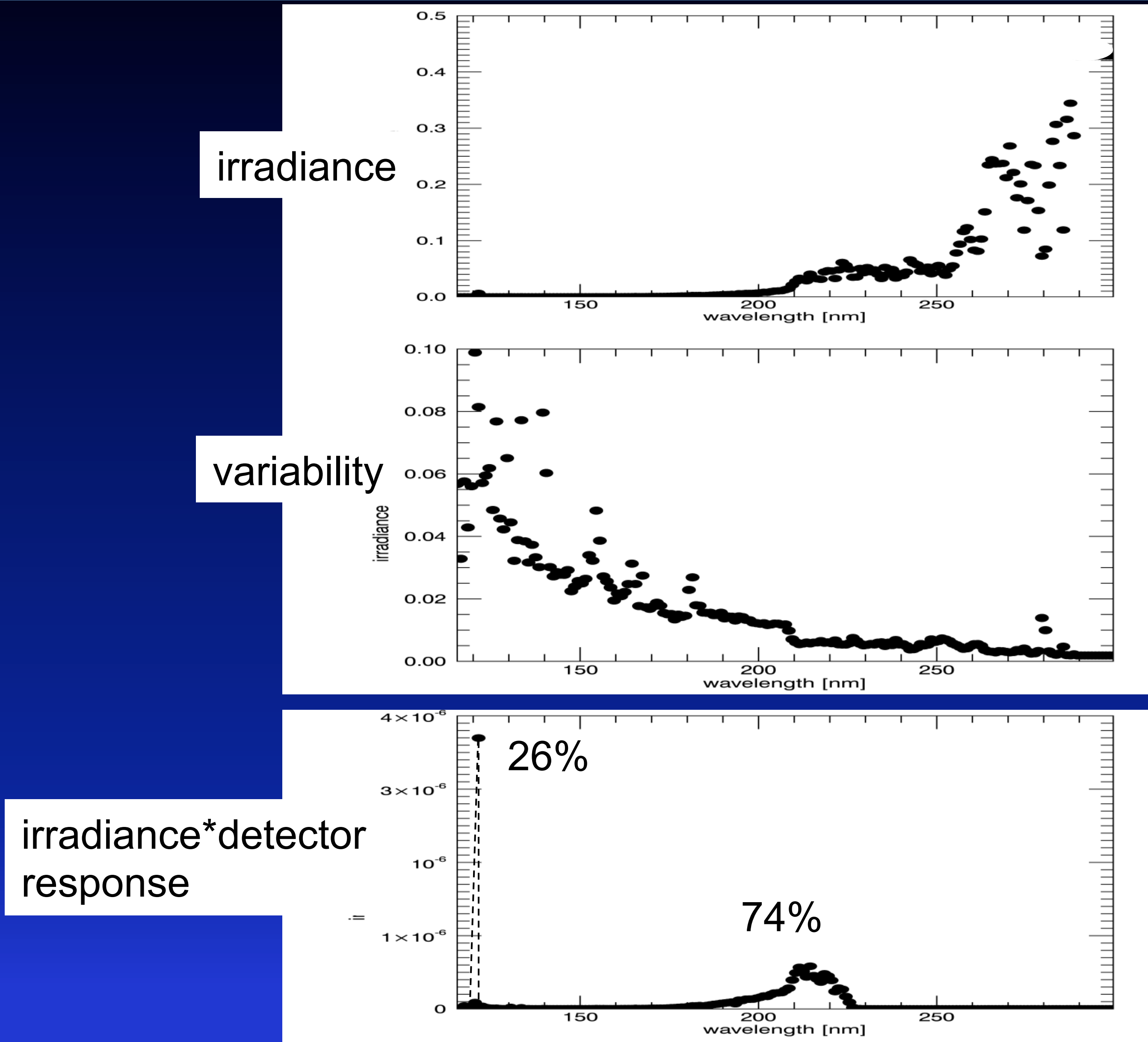


degradation, slow recovery times

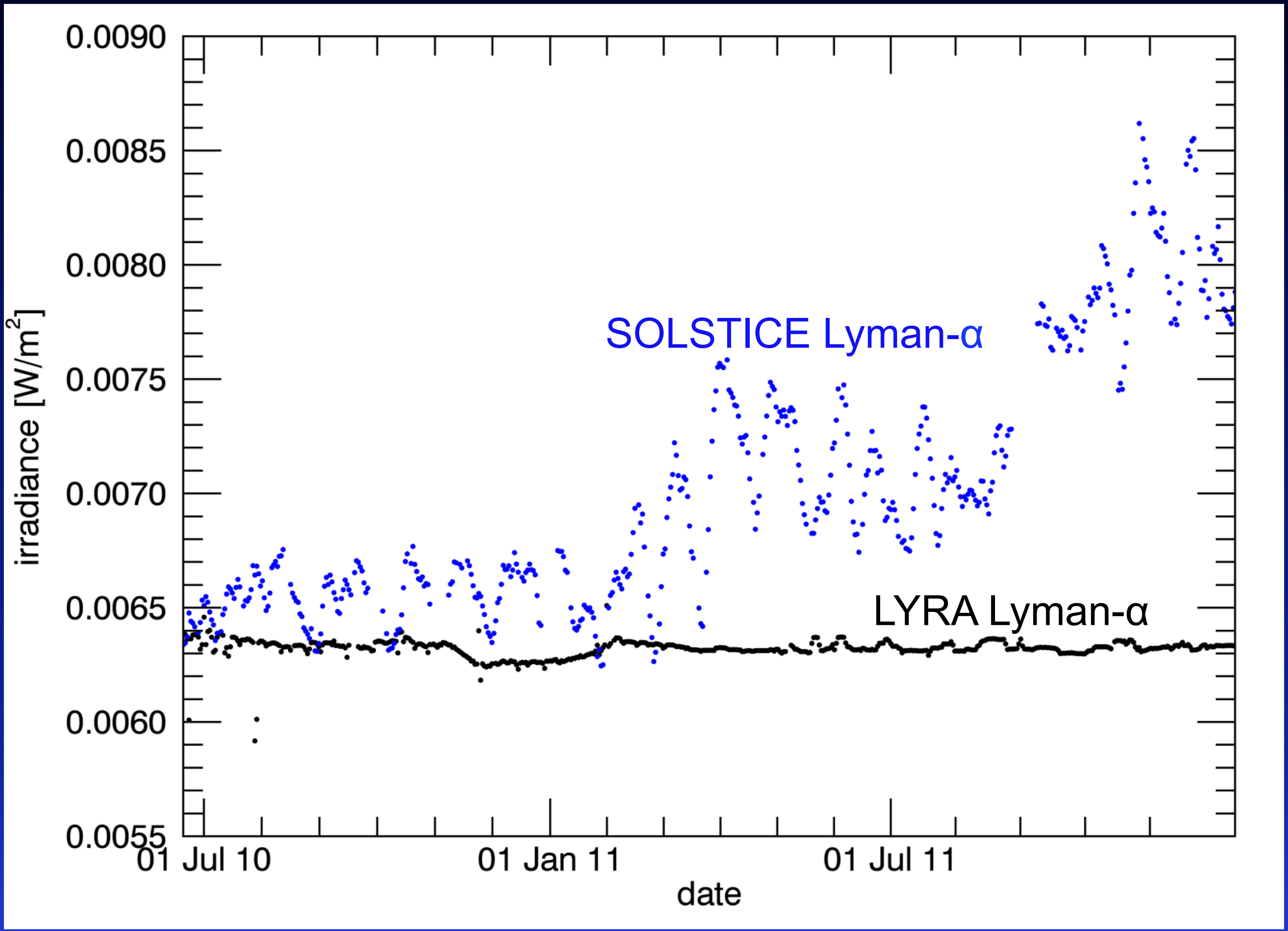


Plan: Divide full range into bands. Use SOLSTICE irradiance data to simulate measurements and do a fit to counts. Estimate degradation.

LYRA 115-300 nm



Original correction for degradation

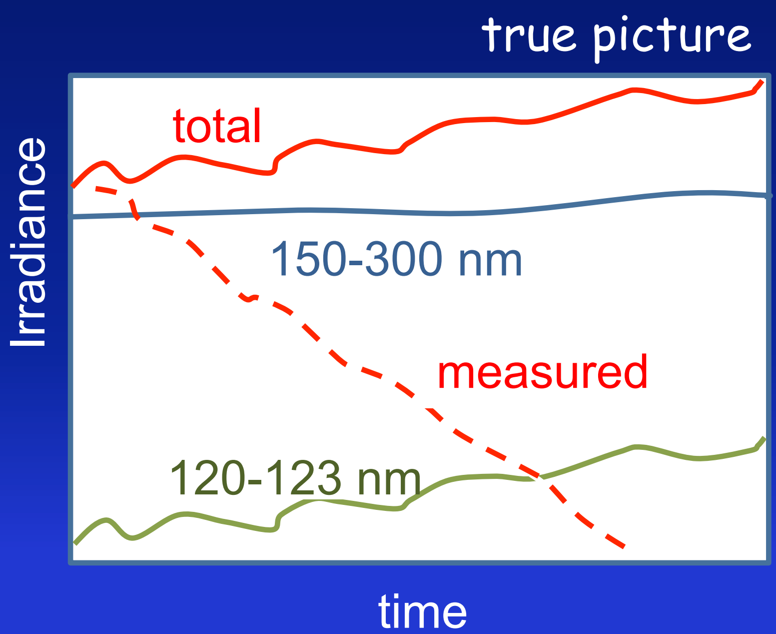


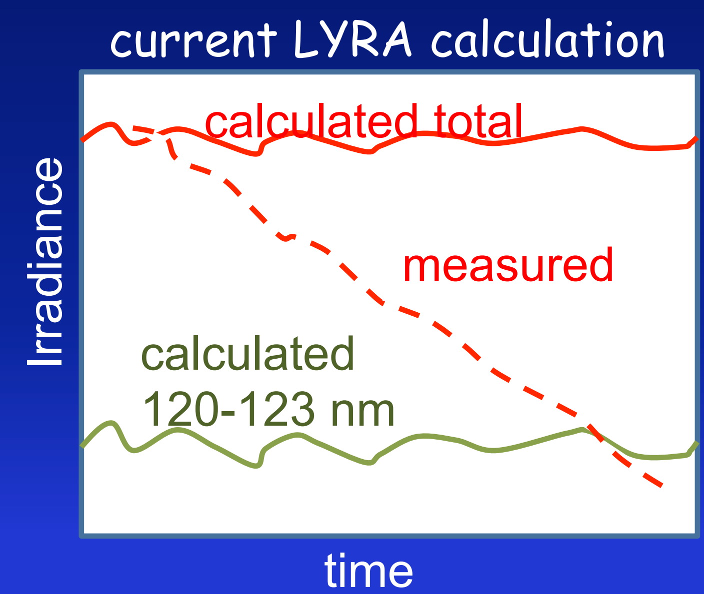
Original correction for degradation

Additive technique -purpose is to retain variability at 121 nm (Ingolf)

1. Determine counts and Ly-α irradiance at launch, C_0 and I_0
2. At all later times, add ΔC: $C_0 = C(t) + \Delta C$
3. Use I_0 / C_0 conversion to determine Ly-α irradiance.

Result: approximately flat irradiance with time, variability is not exaggerated.
M. Kretzschmar, Dominique, Dammasch, 2012, LYRA flare study





Try another method for correction

Extract Lyman-α signal at 121 nm from LYRA data.

- Divide 115-300 nm into several wavelength bands (use SOLSTICE)

  $I_i(t)=\int_i I \, d\lambda$ ***true** integrated irradiance over ranges*

  $M_i(t)=\int_i I \cdot R \, d\lambda$ ***non-degraded measured** integrated irradiance over ranges*

- Irradiance in each band is a simple function of measured irradiance

  $I_i = f_i \cdot M_i$ f are the **scale factors**

- Clean counts. Consider counts to be a sum of counts from several bands

  $C(t) = \text{background} + \sum_i C_i(t)$

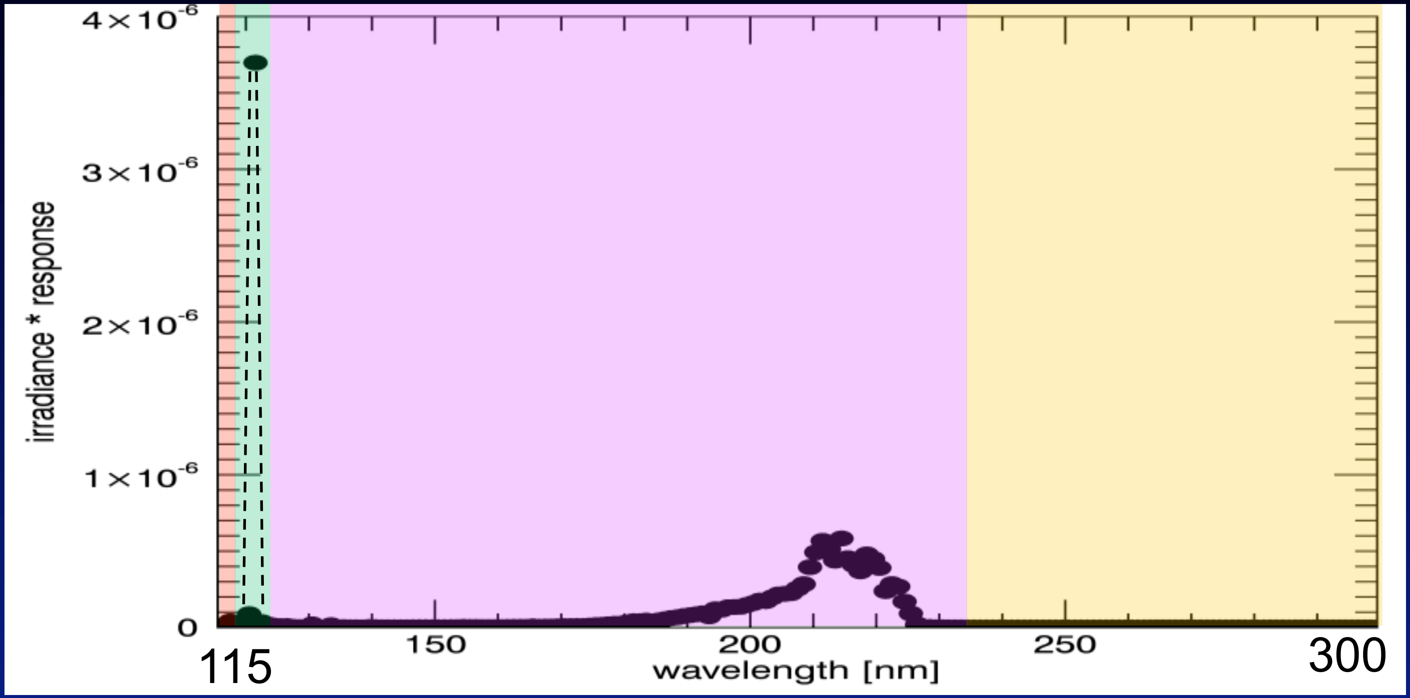
  $= \text{background} + \sum_i (\text{degradation}_i \cdot \text{meas\_irrad}_i) / (\text{conversion factor})$

  $= b + \frac{1}{k} \sum_i e^{a_i \cdot T} \cdot M_i(t)$

- Do fit to find parameters *b, k, a*

- Invert equations to find the Lyman-α irradiance, $I_{120\text{-}123\ nm}$

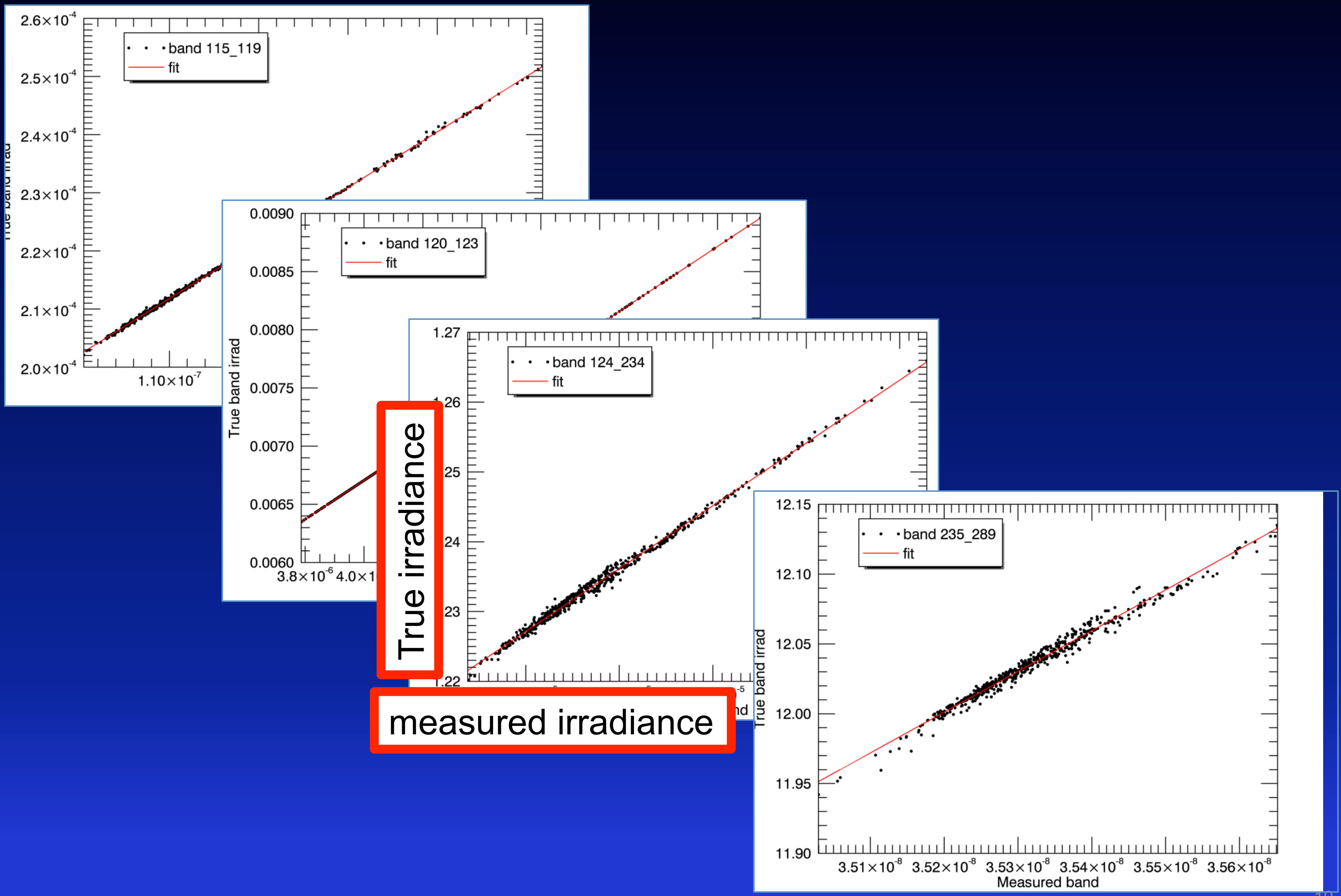
Four wavelength bands



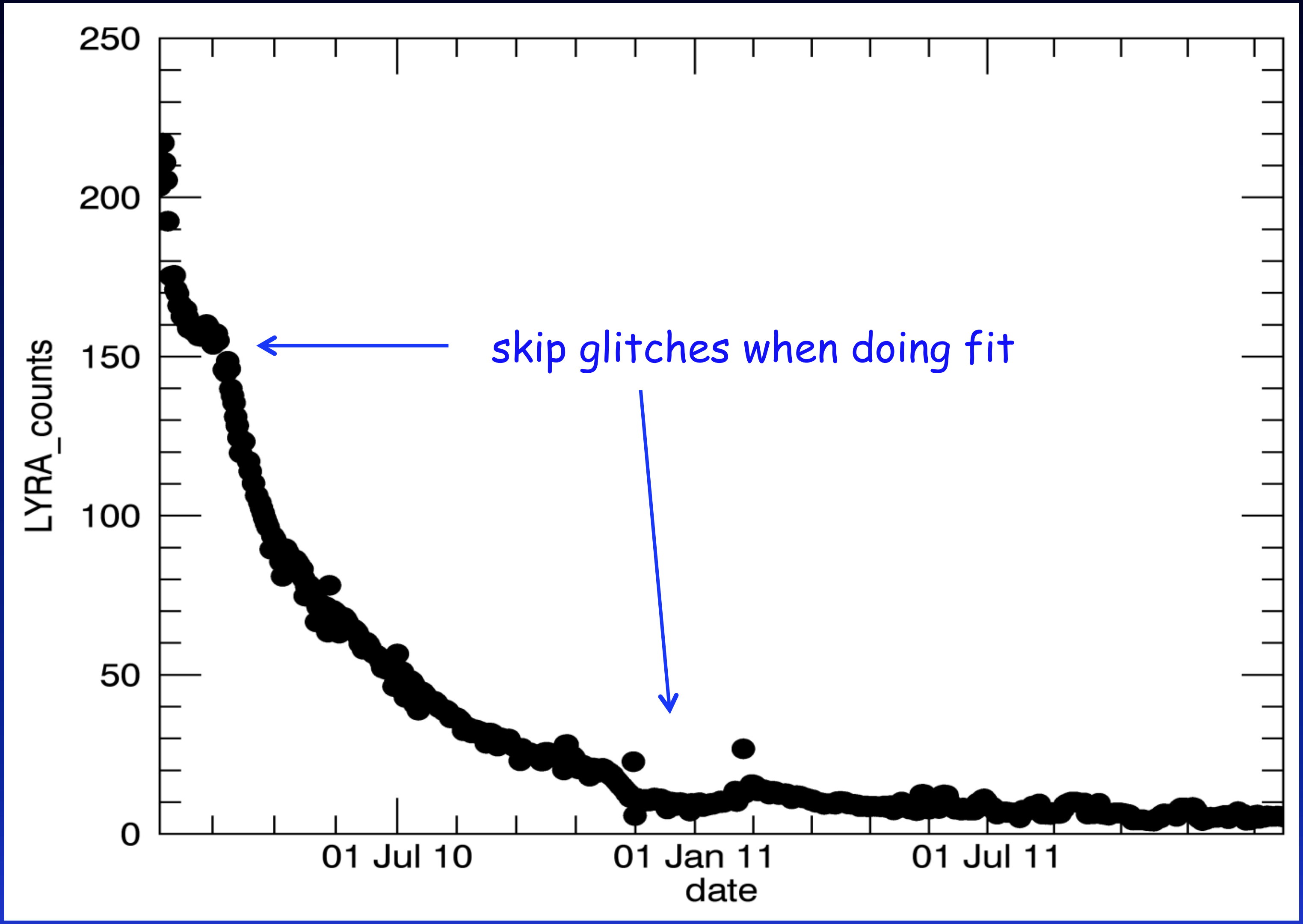
built with SOLSTICE daily data for 2010 and 2011

band	λ	%measured	%irradiance
0	115_119	0.7	0.002
1	**120_123**	**26.5**	**0.05**
2	124_234	72.5	9.3
3	235_289	0.3	90.7

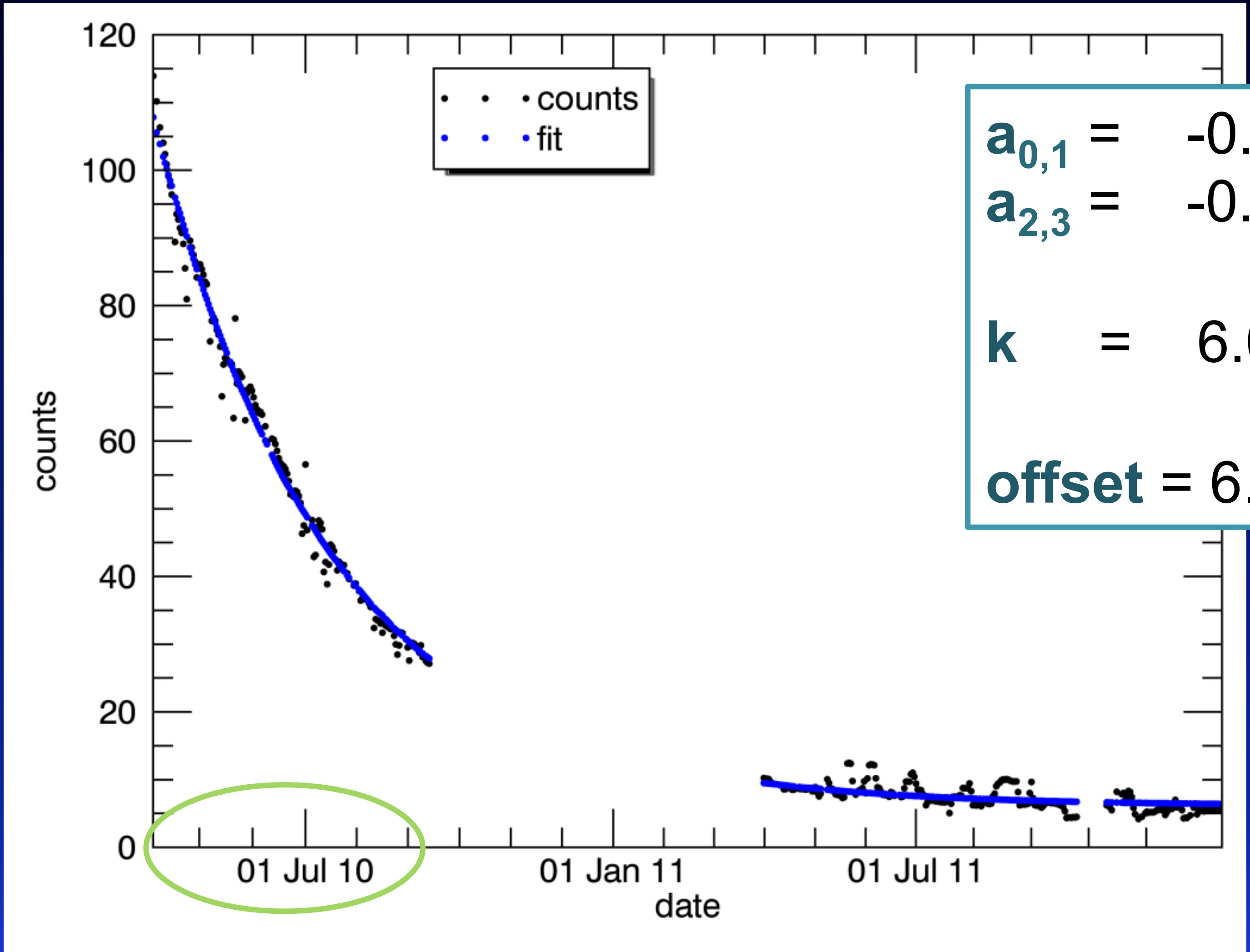
Fits for true vs measured irradiance



Counts for 2010-2011



Fit counts to SOLSTICE data

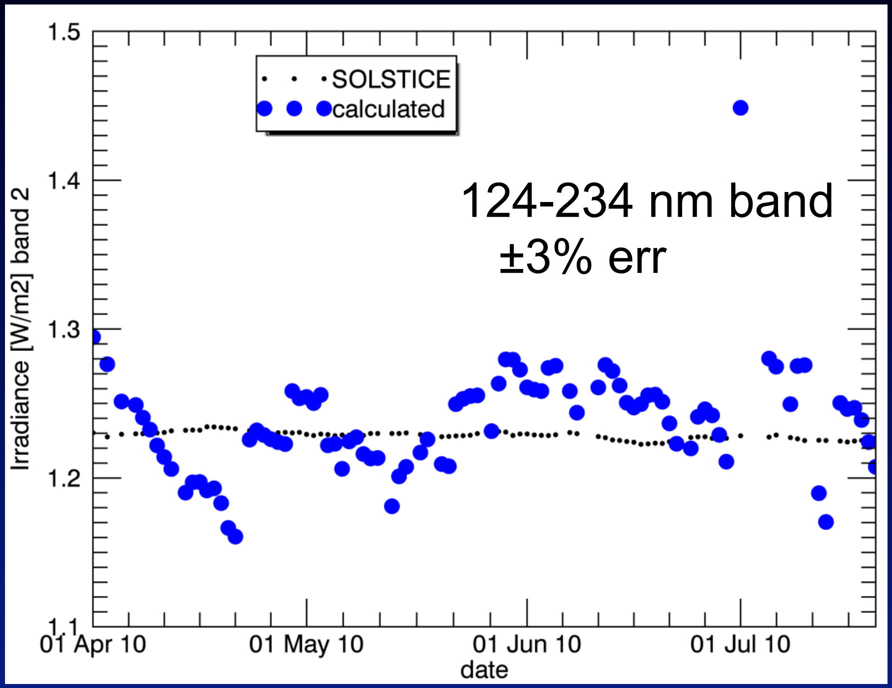


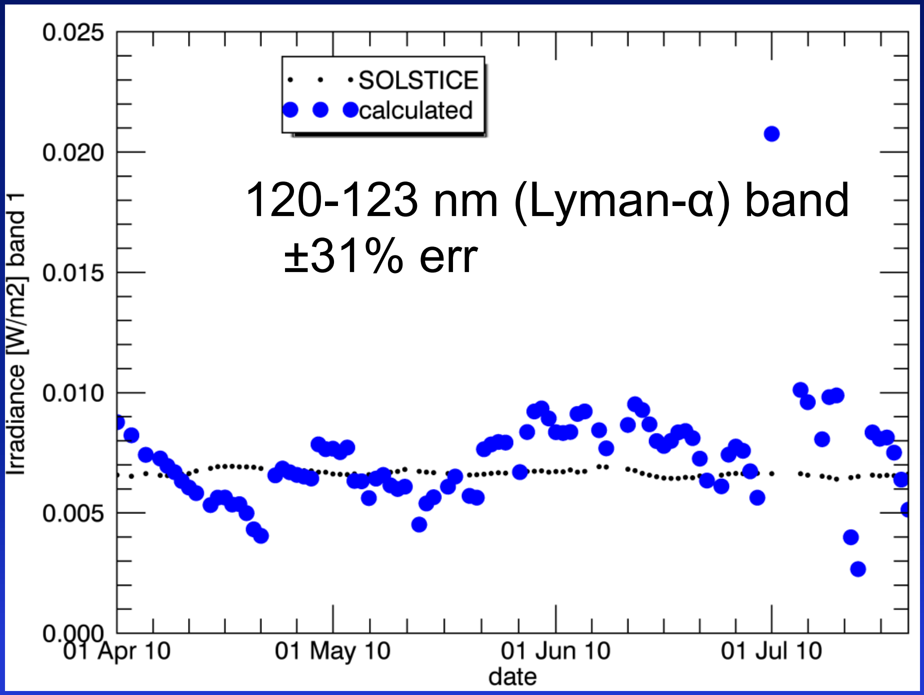
$a_{0,1}$ = -0.015
$a_{2,3}$ = -0.008

k = 6.07E-8

offset = 6.02

Invert and obtain band irradiances



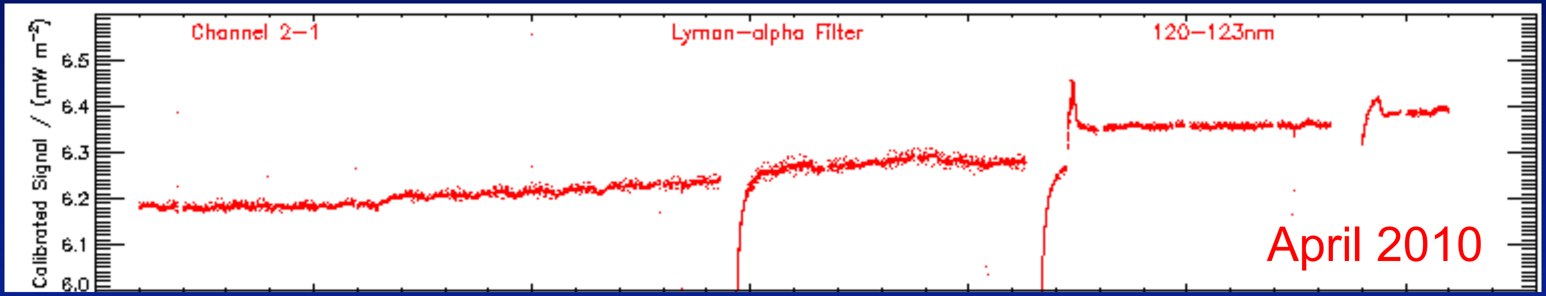


Where are we? Next steps?

- We have a technique that estimates the degradation for the bands.
- We have 30% error in the Lyman-α band. (due to artifacts in counts?)

Next steps

- Clean counts of artifacts. Ingolf's work to temperature correct dark current.

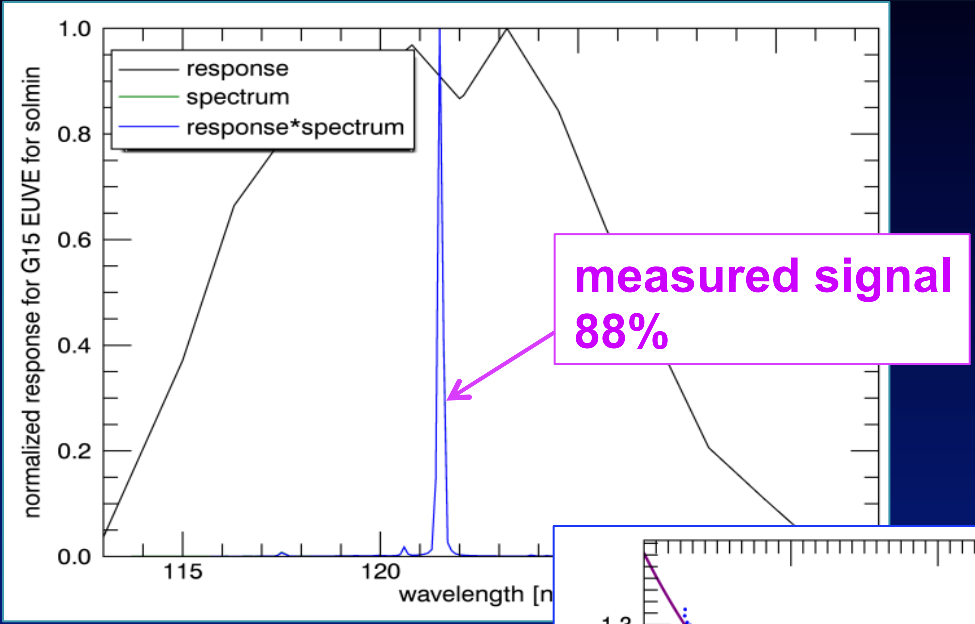


- Try this at a high cadence. Use a proxy in I = f(M) relationship to take into account solar activity for short wavelengths.
- Look at particular flares. Compare to GOES results (2010-2015)....

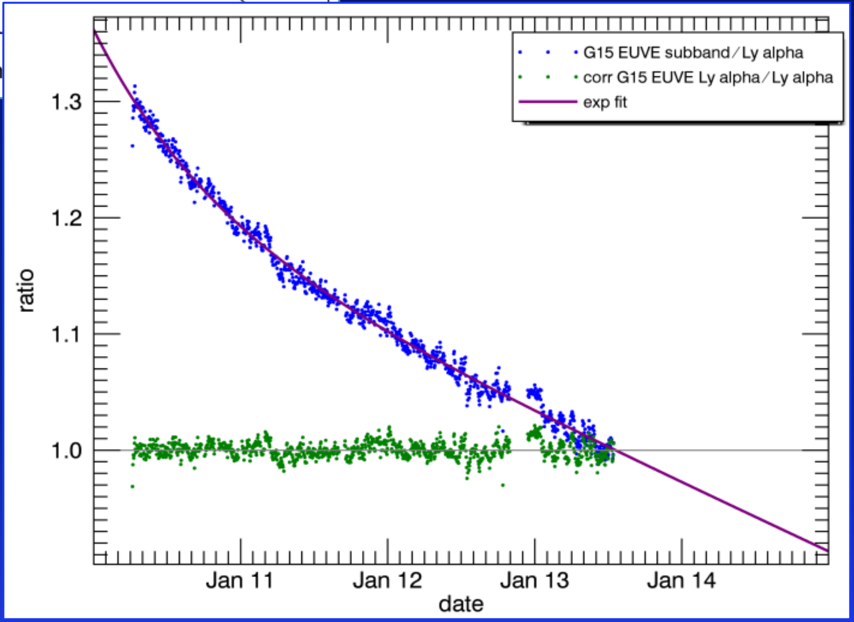
Backup slides

GOES EUVS Lyman-α

GOES EUVS also requires a broadband correction



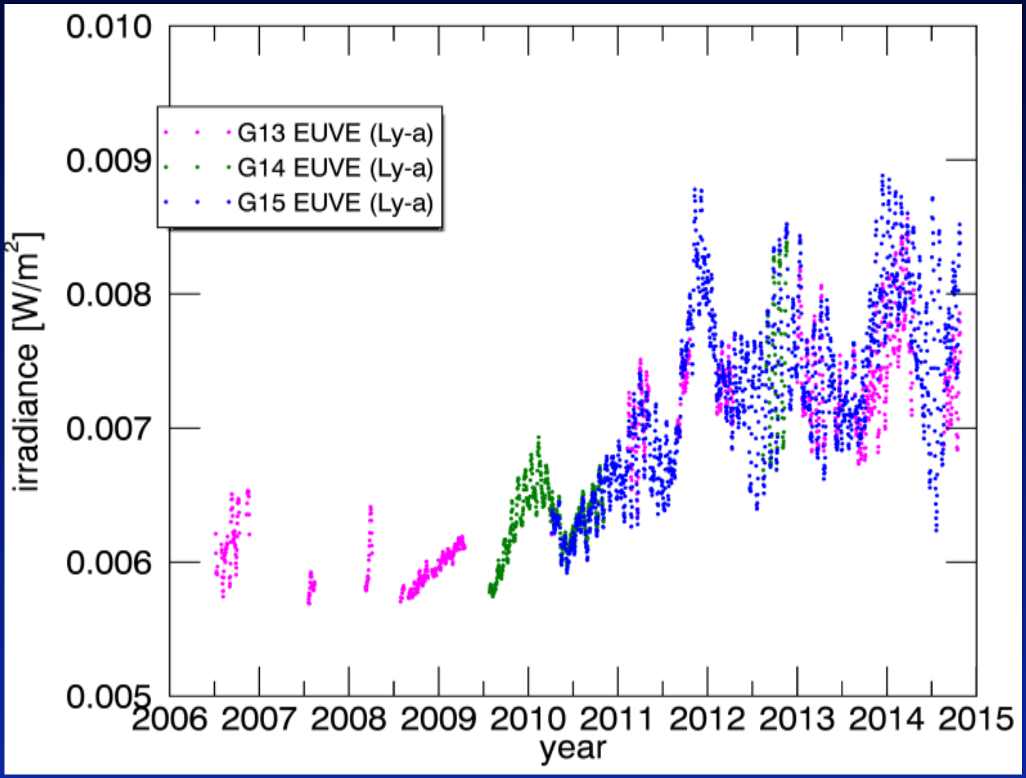
...and a degradation correction (SOLSTICE)



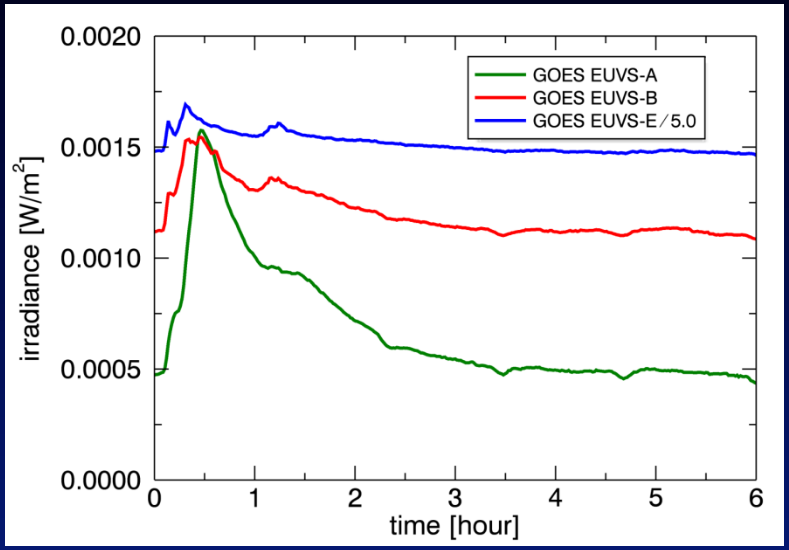
GOES Lyman-α

1 minute and daily data for 2009-15

Needed improvement:
Use a scale factor which is a function of solar activity



Flares with GOES and SOLSTICE



Flare as seen in 3 of the GOES EUV channels.

X17 flare
SORCE SOLSTICE
(Marty Snow, LASP)