ACHIEVING HIGHER SPECTRAL RESOLUTION DATA AND DETERMINING DOPPLER VELOCITIES DURING FLARES USING SDO/EVE LEVEL 0B DATA

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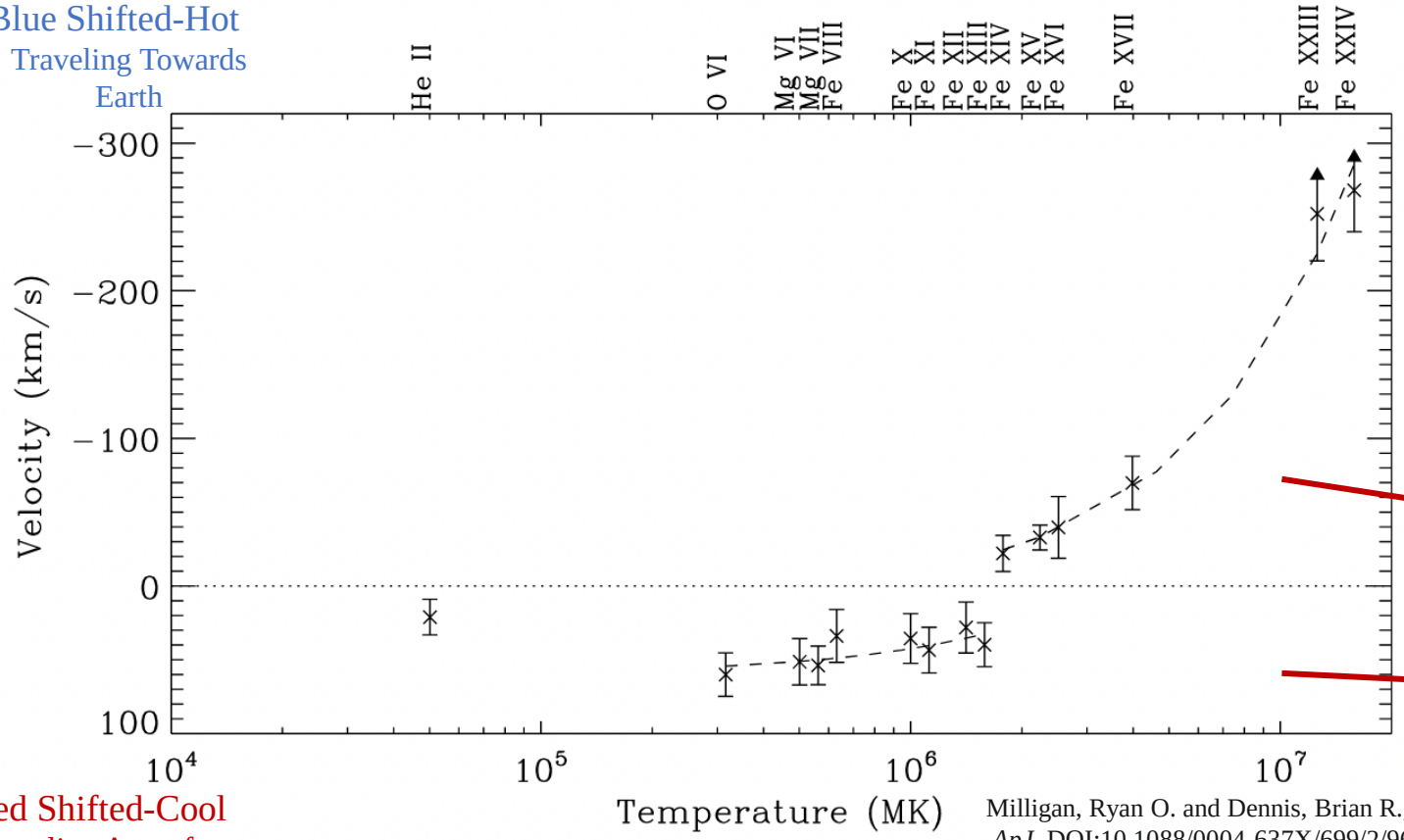
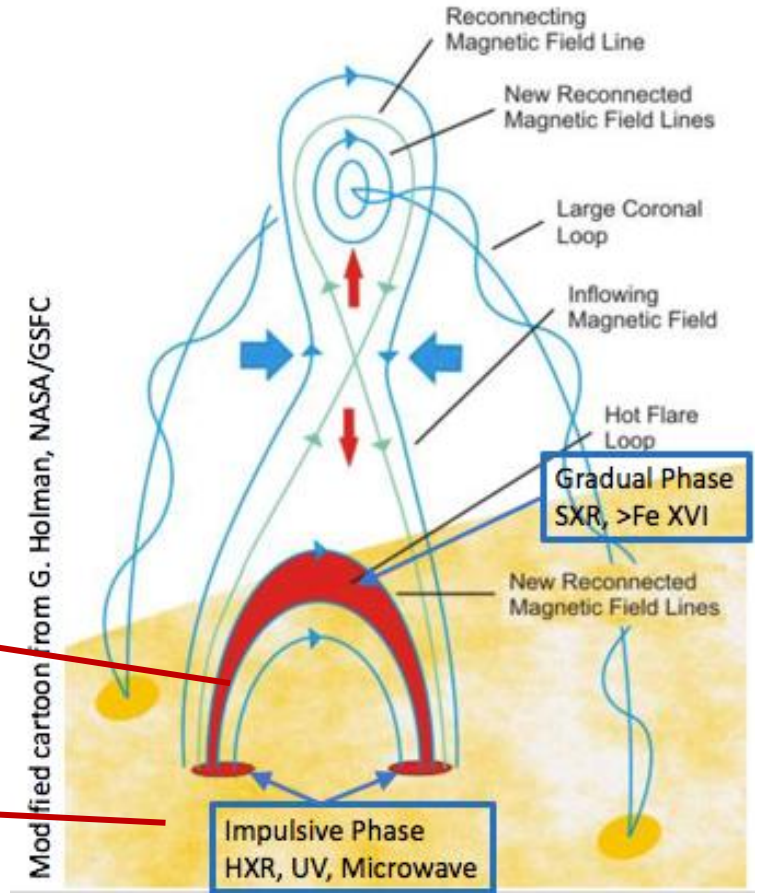
Science Motivation

Blue Shifted-Hot
Traveling Towards Earth



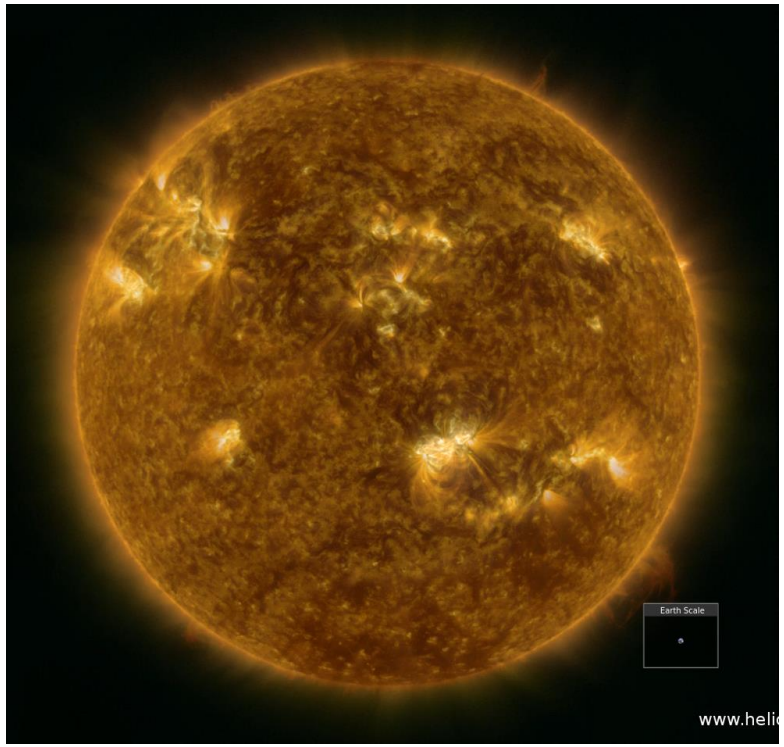
Red Shifted-Cool
Traveling Away from Earth

Milligan, Ryan O. and Dennis, Brian R., 2009, *ApJ*, DOI:10.1088/0004-637X/699/2/968

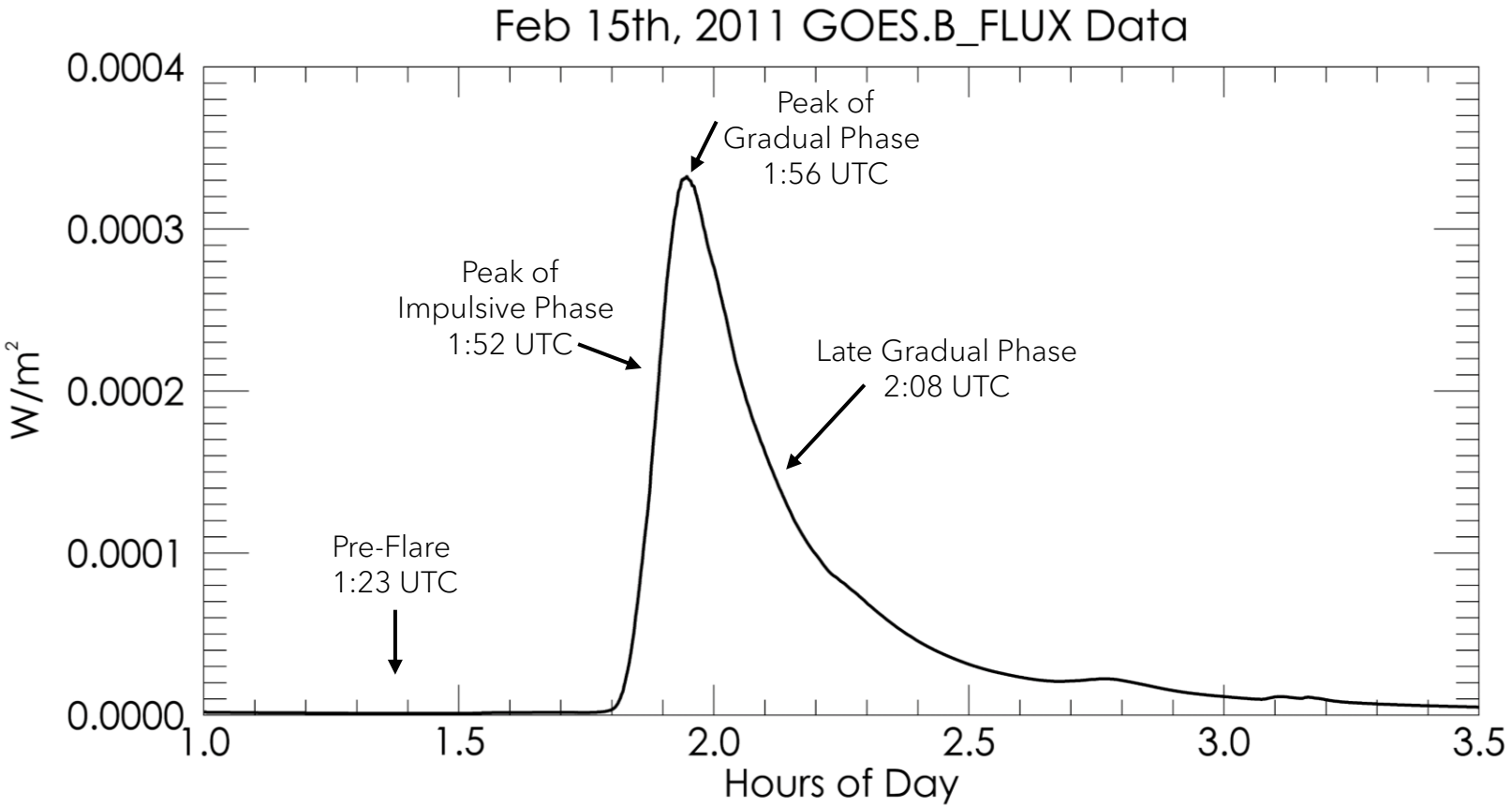


This plot was made for the analysis of a GOES C1.1 class flare that occurred on December 14th , 2007
Doppler shift measurements were made using data from the EIS onboard Hinode.

GOES X1.1 Class Flare
Feb 15th, 2011

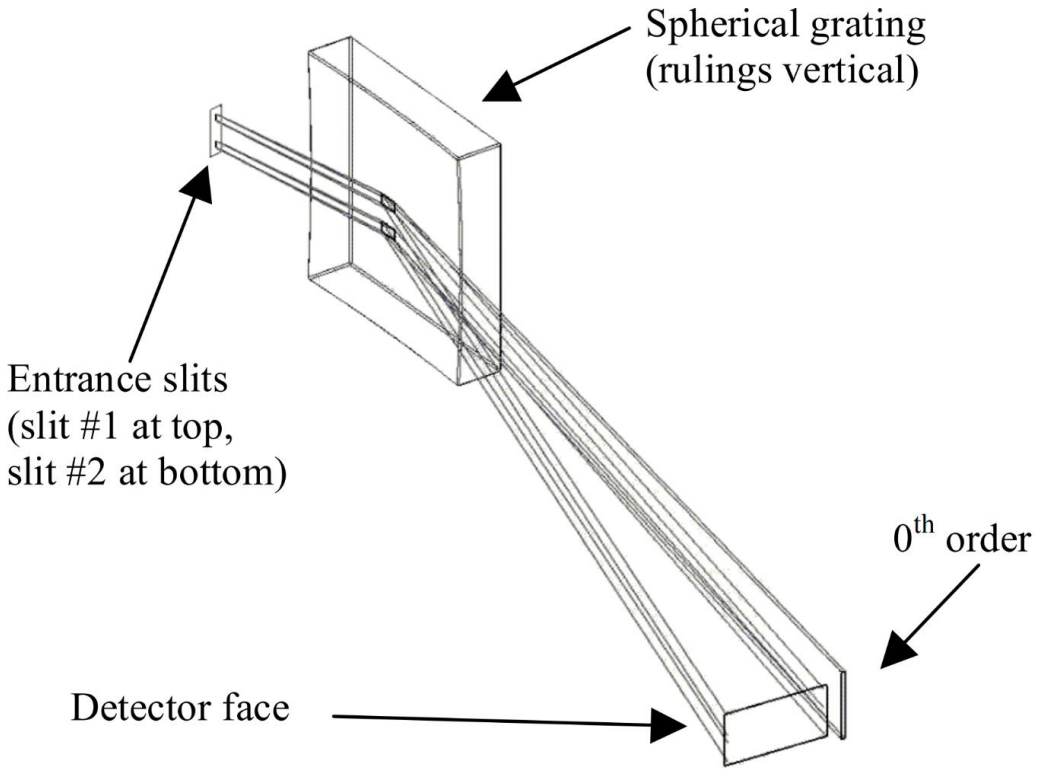


Movie made using Helioviewer.org



SDO/EVE MEGS-A

(Multiple EUV Grating Spectrograph)

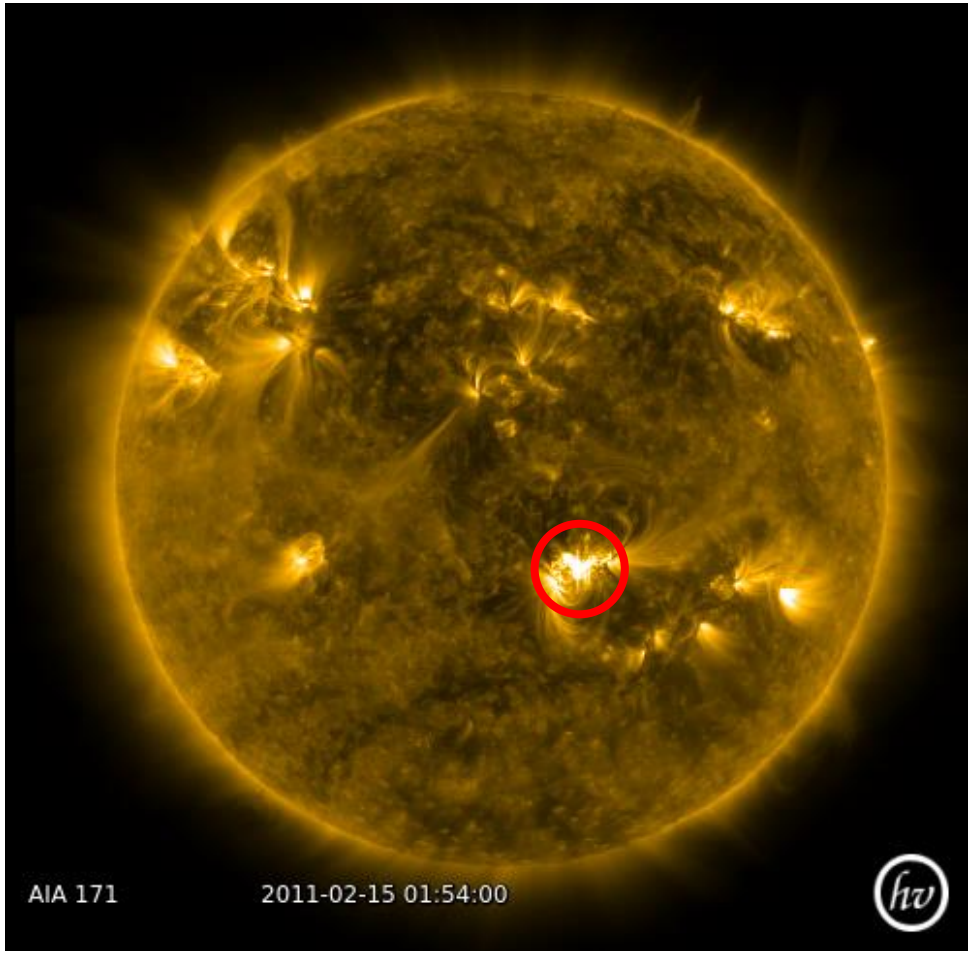


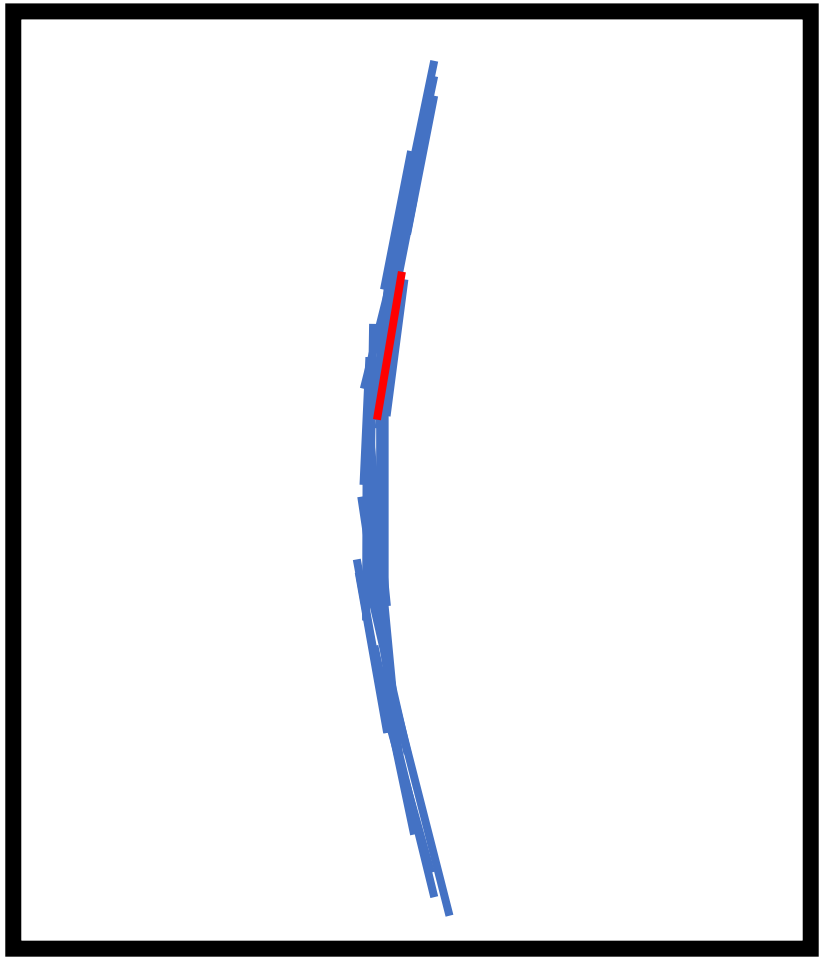
David A. Crotser, Thomas N. Woods, Francis G. Eparvier, Matthew A. Triplett, Donald L. Woodraska, SPIE, 2007; DOI: 10.1117/12.732592

- Has a special grazing incidence, off-Rowland circle design
  - Minimal photon absorption at grating
  - Increased photon absorption at detector due to it being at near-normal incidence
  - More spectral resolution with the sacrifice of spatial resolution
- Two slits together measure wavelengths between 5-37nm
  - Each slit has its own filter to measure different wavelengths of light and block higher orders

SDO/EVE MEGS-A

Spectral Line Geometry



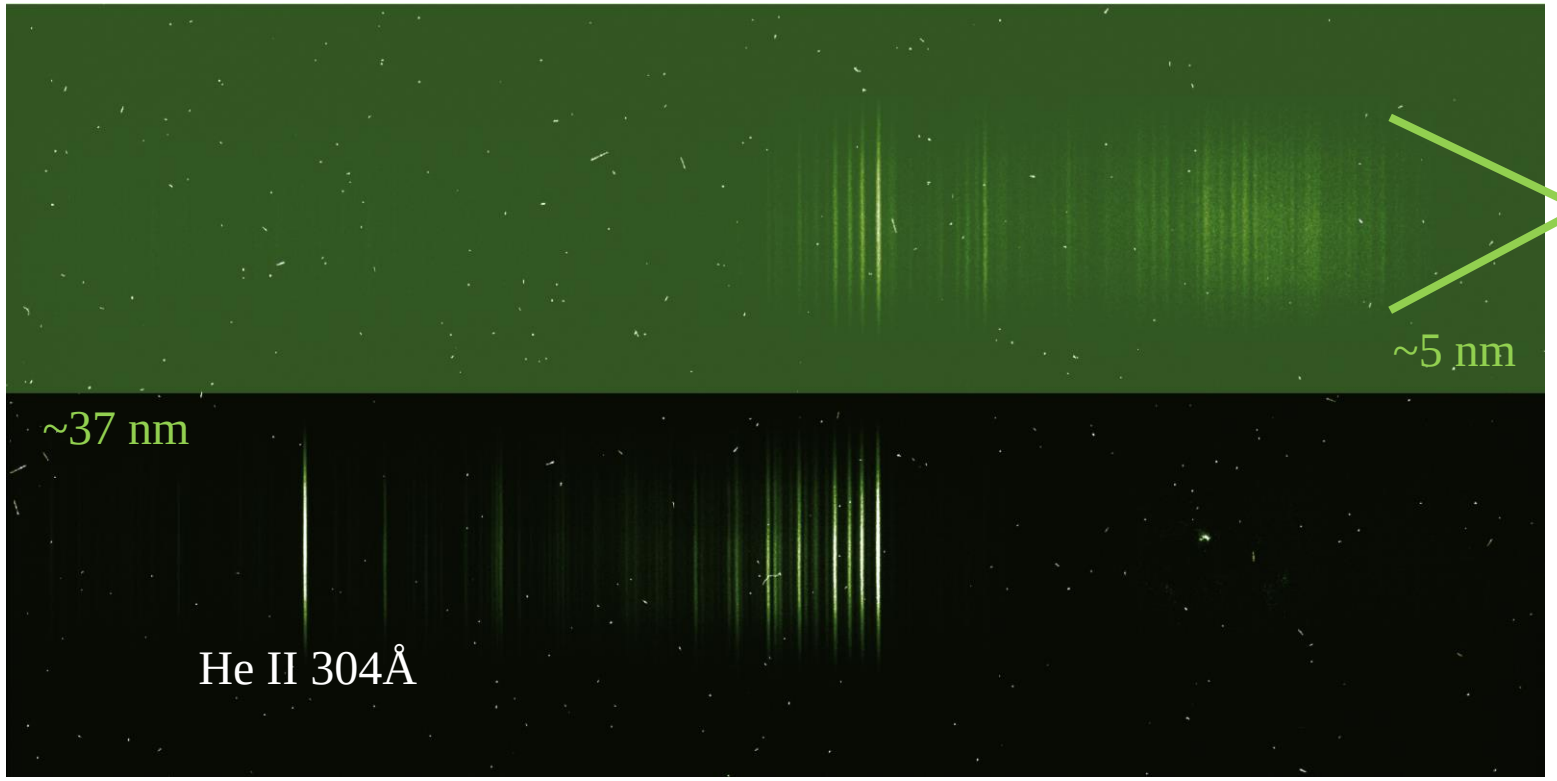


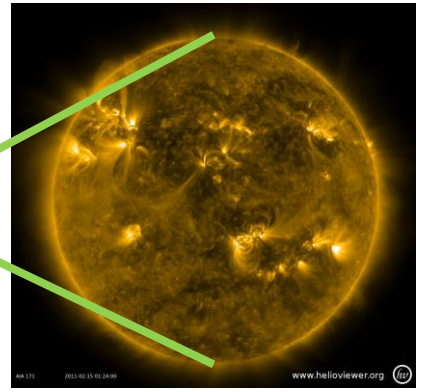
MEGS-A “Quiet Sun” Spectral Image

(1024 x 2048 pixels)

MEGS-A1
(~5-18nm)

MEGS-A2
(~17-37nm)



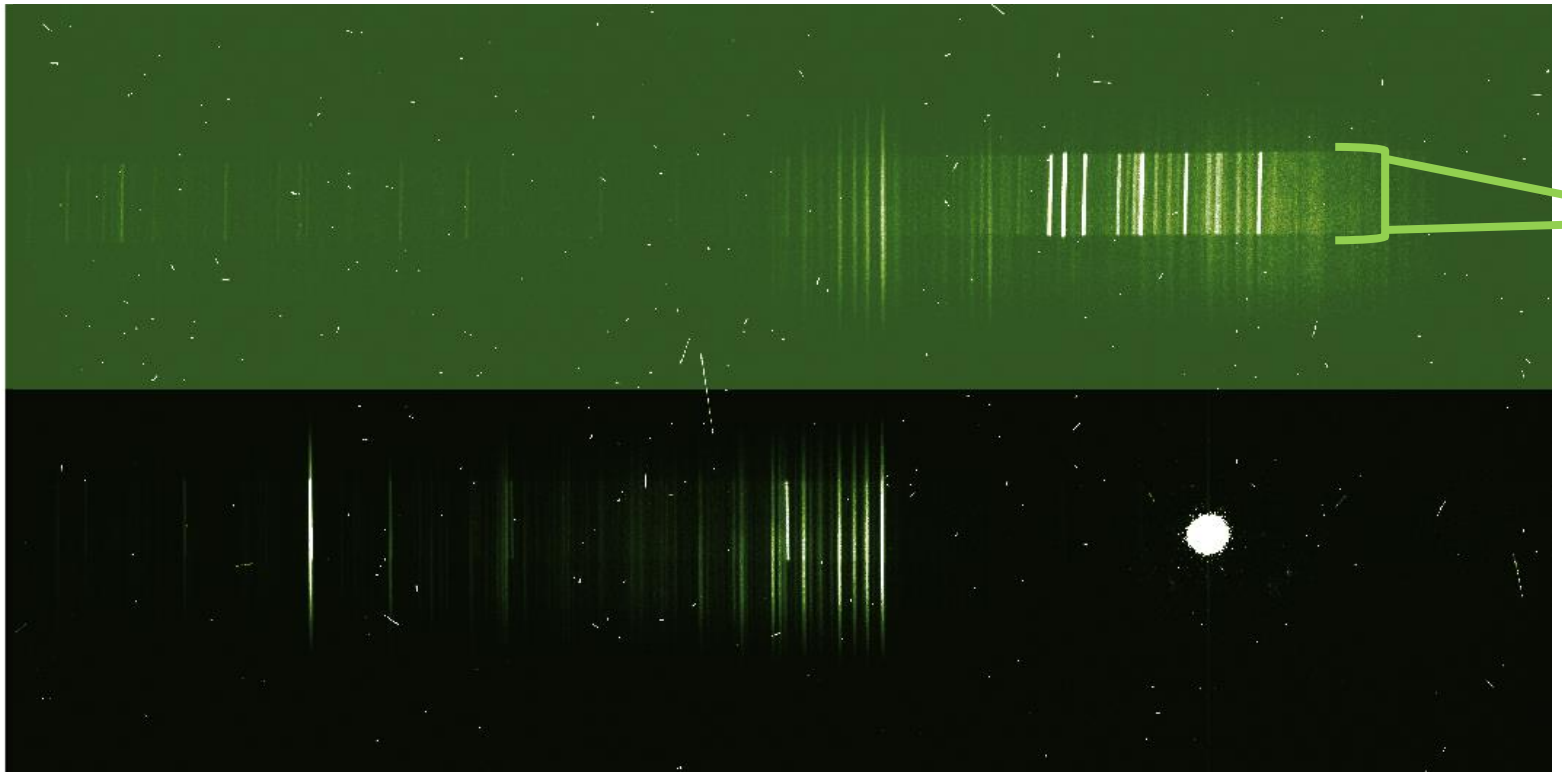


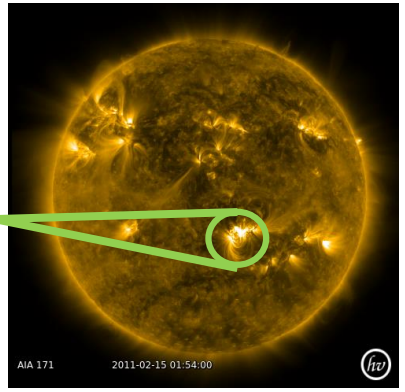
MEGS-A Flare Spectral Image

(1024 x 2048 pixels)

MEGS-A1
(~5-18nm)

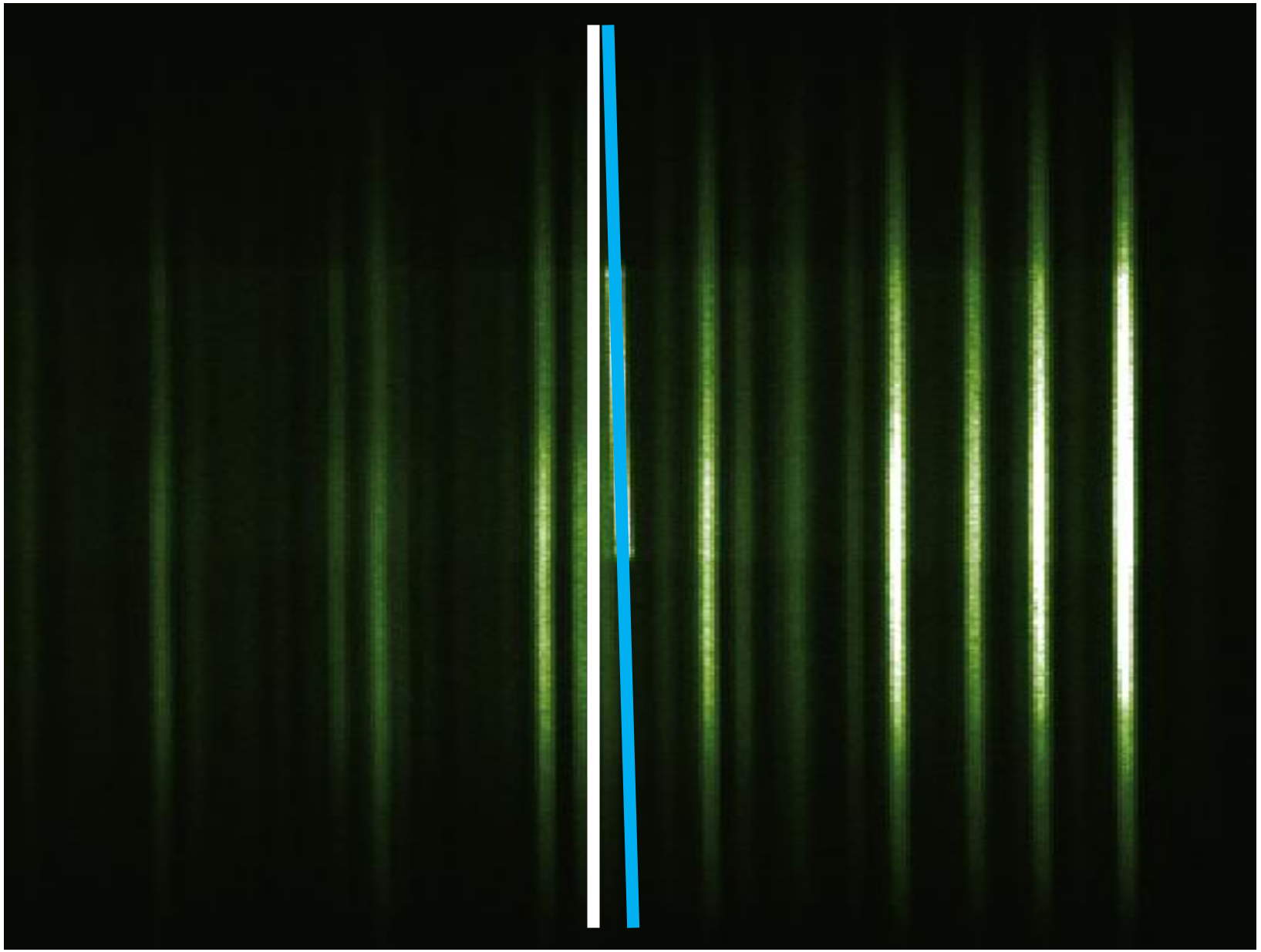
MEGS-A2
(~17-37nm)





Spectral Image of the Gradual Phase of a Flare

You can see that the emission line coming from the flare is at a slant

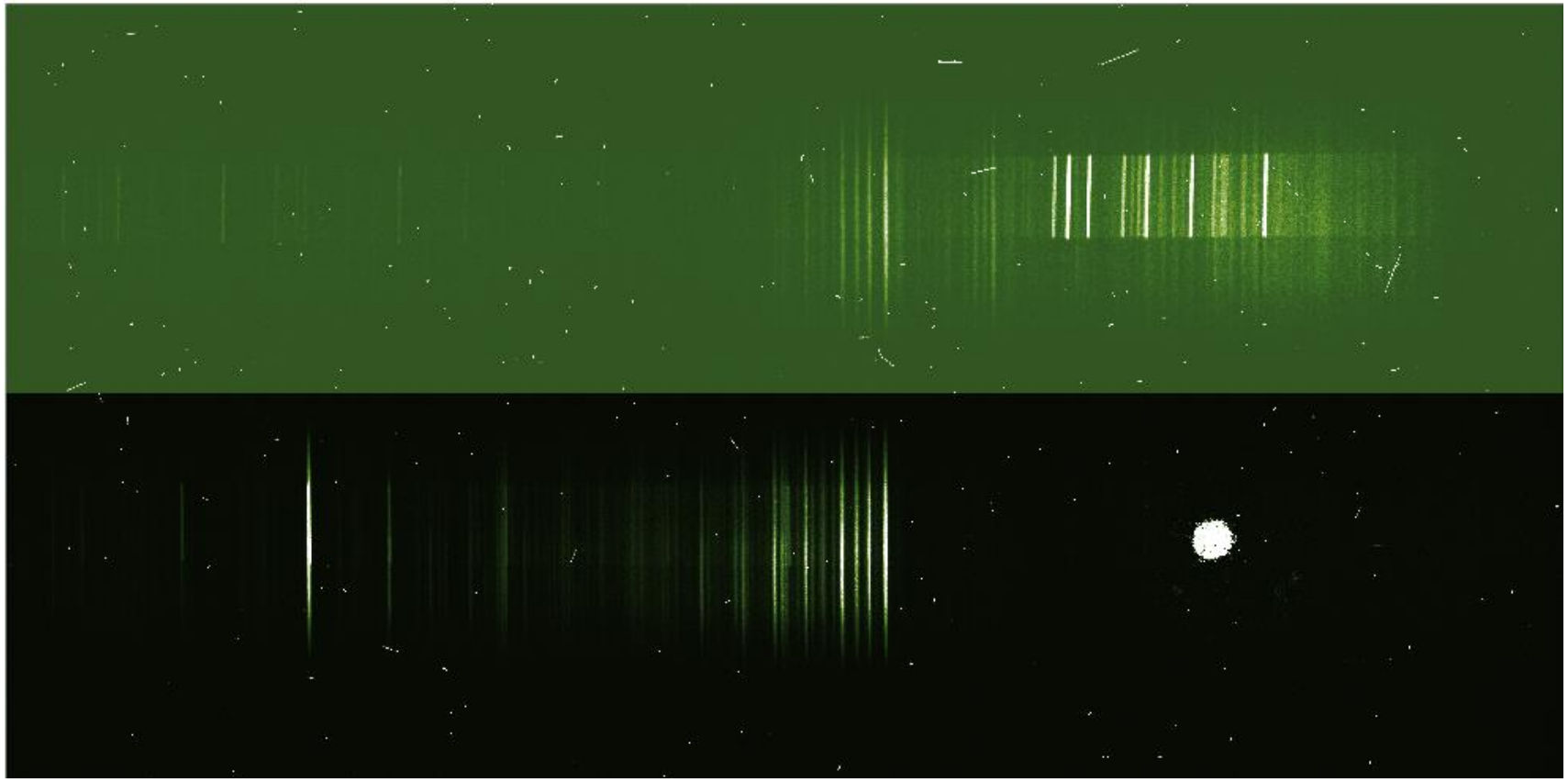


How can we create more accurate wavelength scale, that will inherently have higher spectral resolution, from the EVE Level 0B flare data?

A Late Gradual Phase Spectral Image

MEGS-A1
(~5-18nm)

MEGS-A2
(~17-37nm)

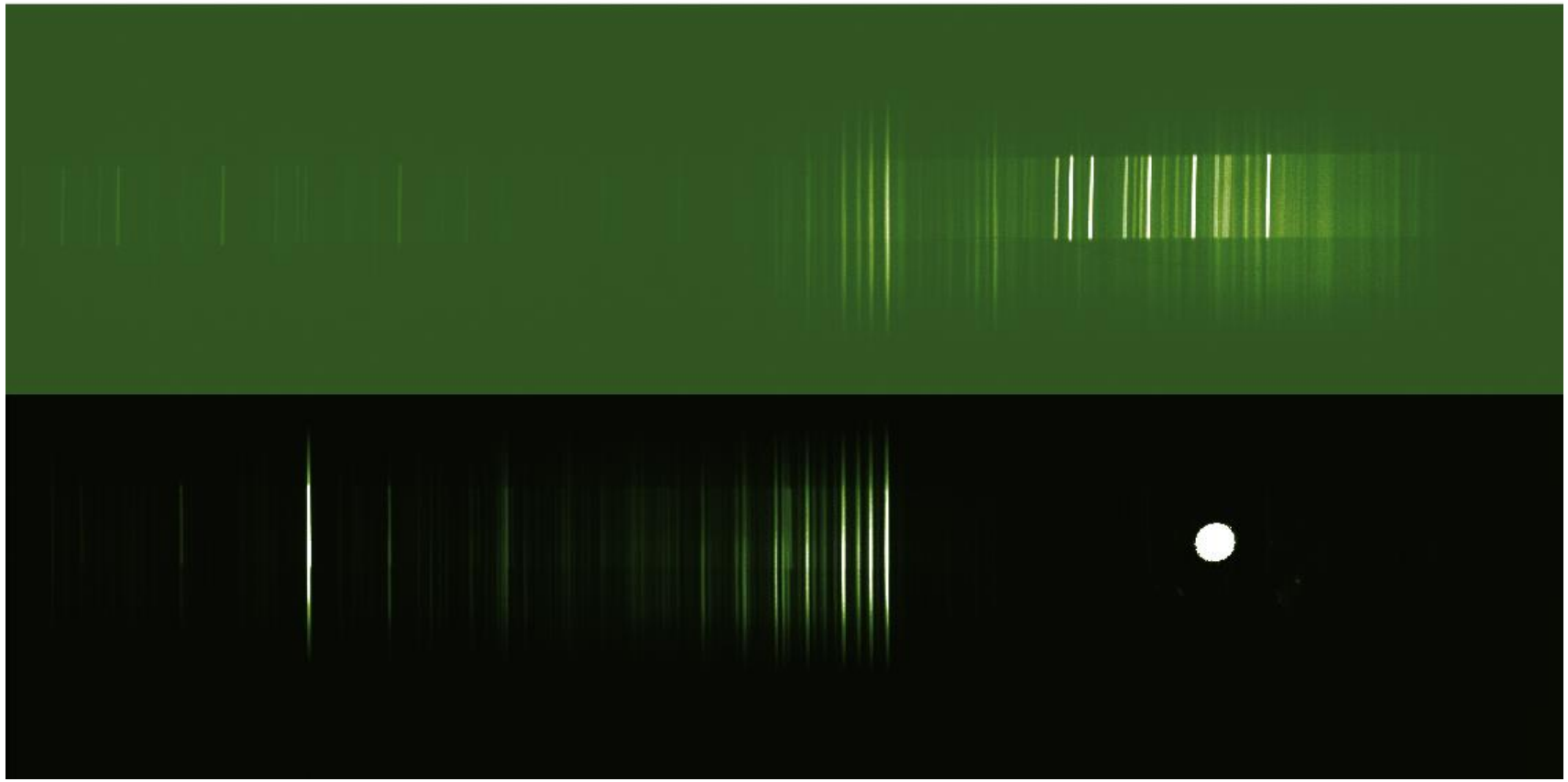


Our Flare: Feb 15th, 2011

Twelve Image Median Spectral Image

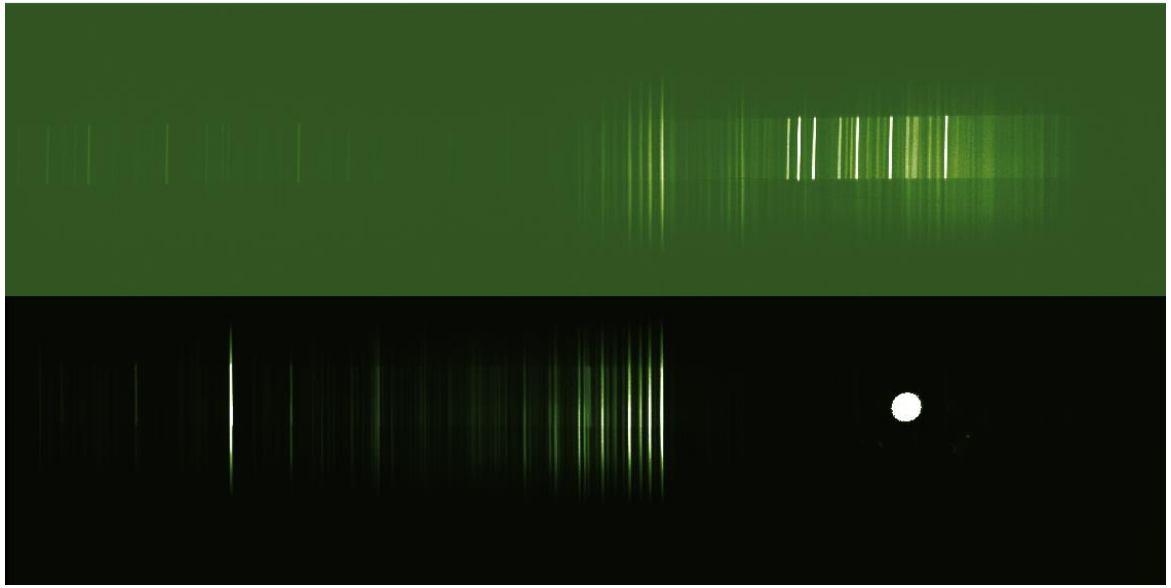
MEGS-A1
(~5-18nm)

MEGS-A2
(~17-37nm)



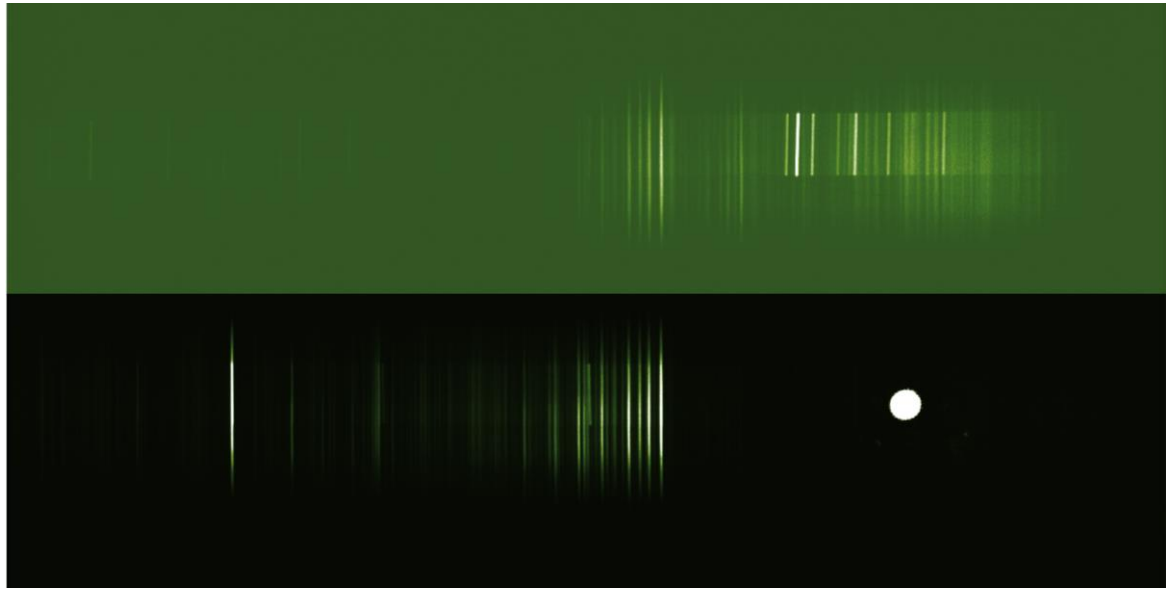
Late Gradual Phase Time Range
Feb 15th, 2011
02:08:07, 02:09:57
Time found using GOES-XRS

Late Gradual Phase Spectral Image

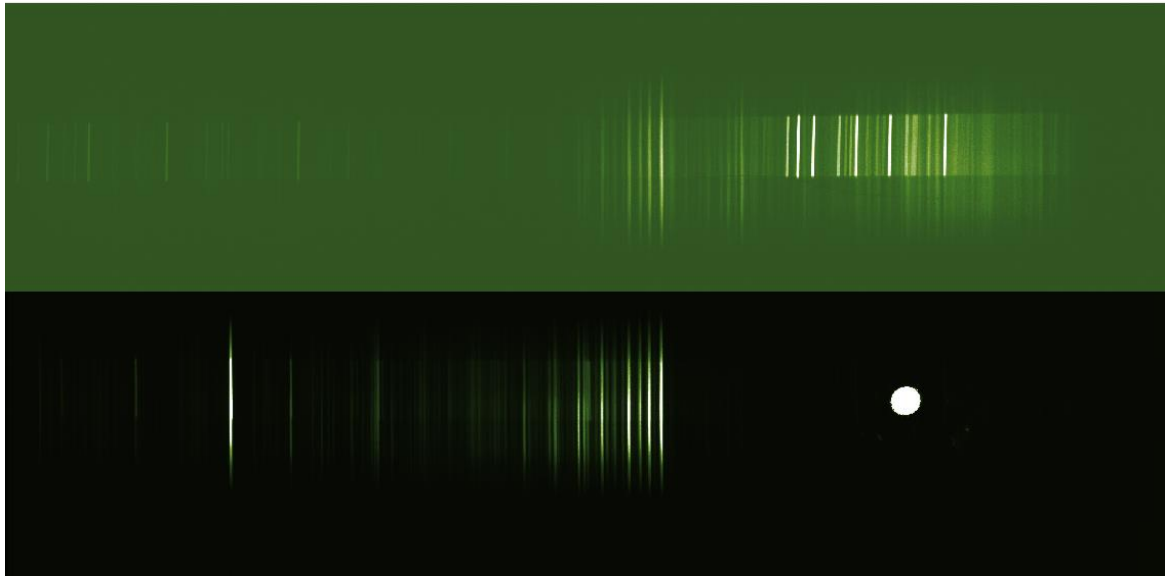


Impulsive Phase Spectral Image

Impulsive Phase Time Range:
Feb 15th, 2011
01:52:17-01:54:37 UTC

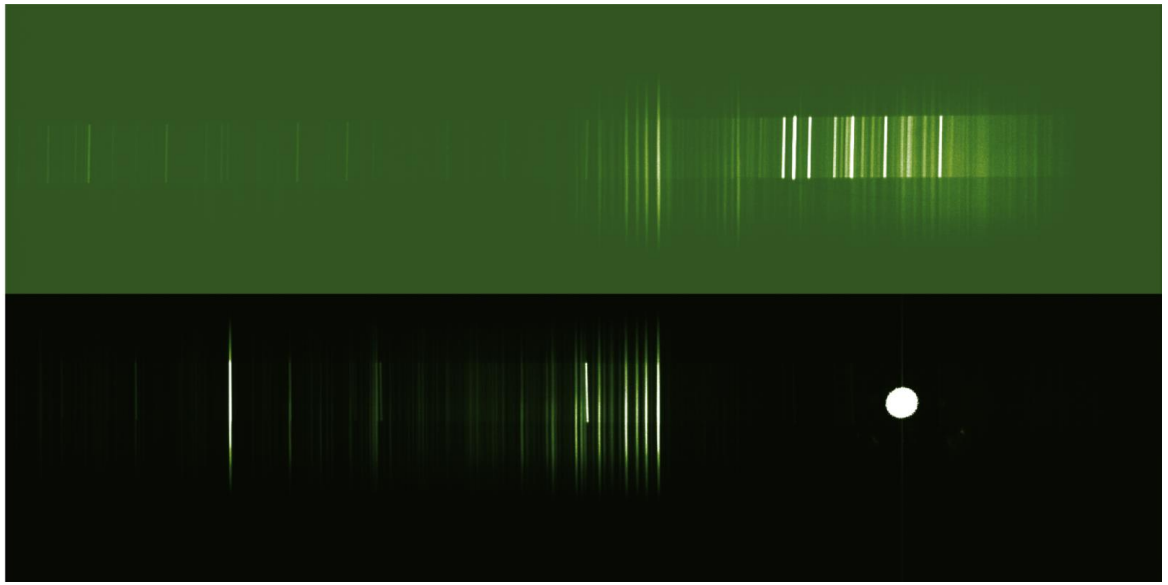


Late Gradual Phase Spectral Image

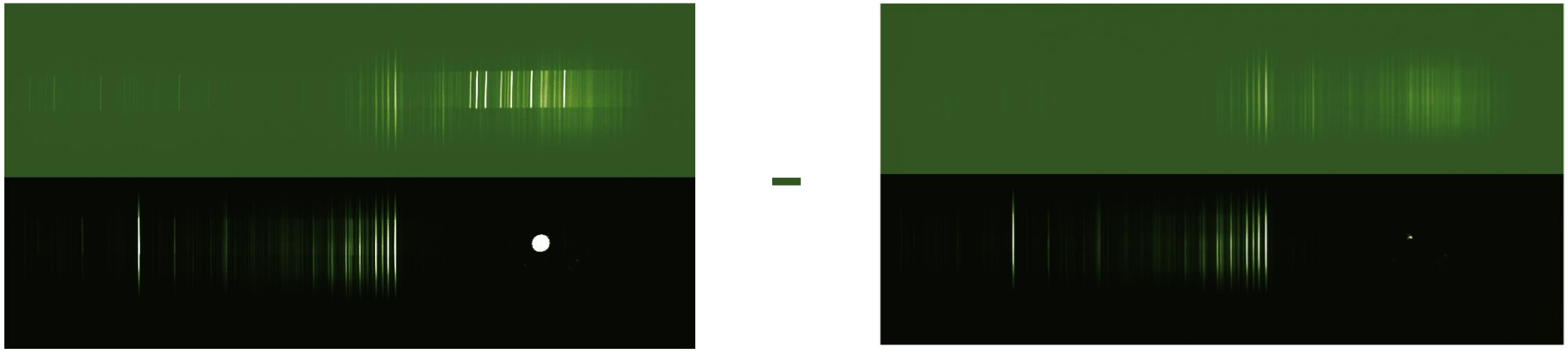


Peak of Gradual Phase Spectral Image

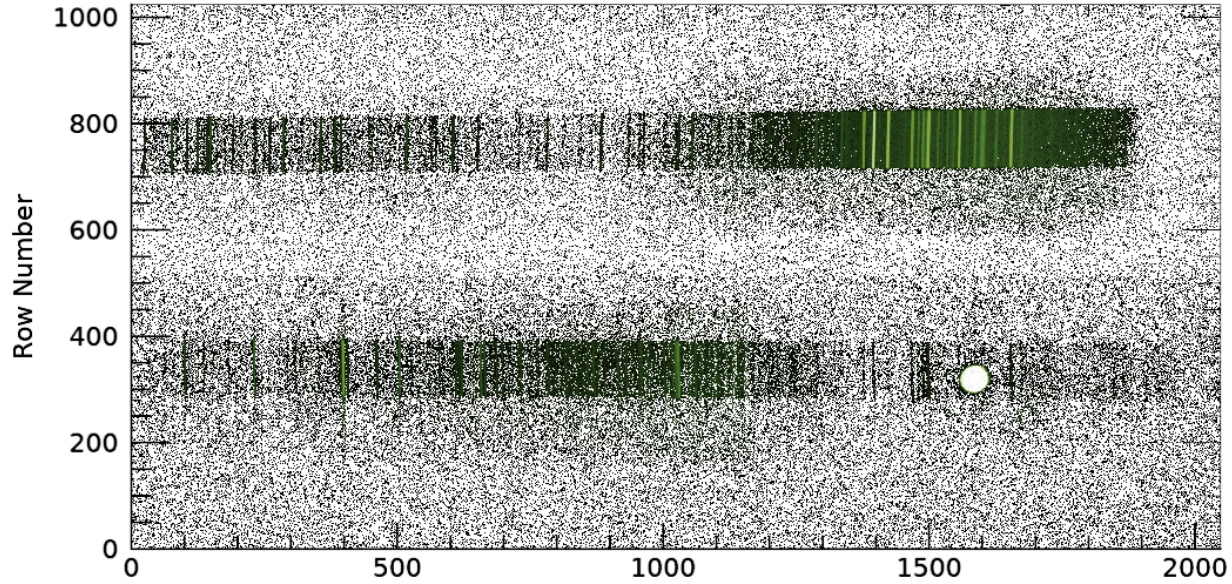
Gradual Phase Time Range:
Feb 15th, 2011
01:56:17-01:57:27 UTC



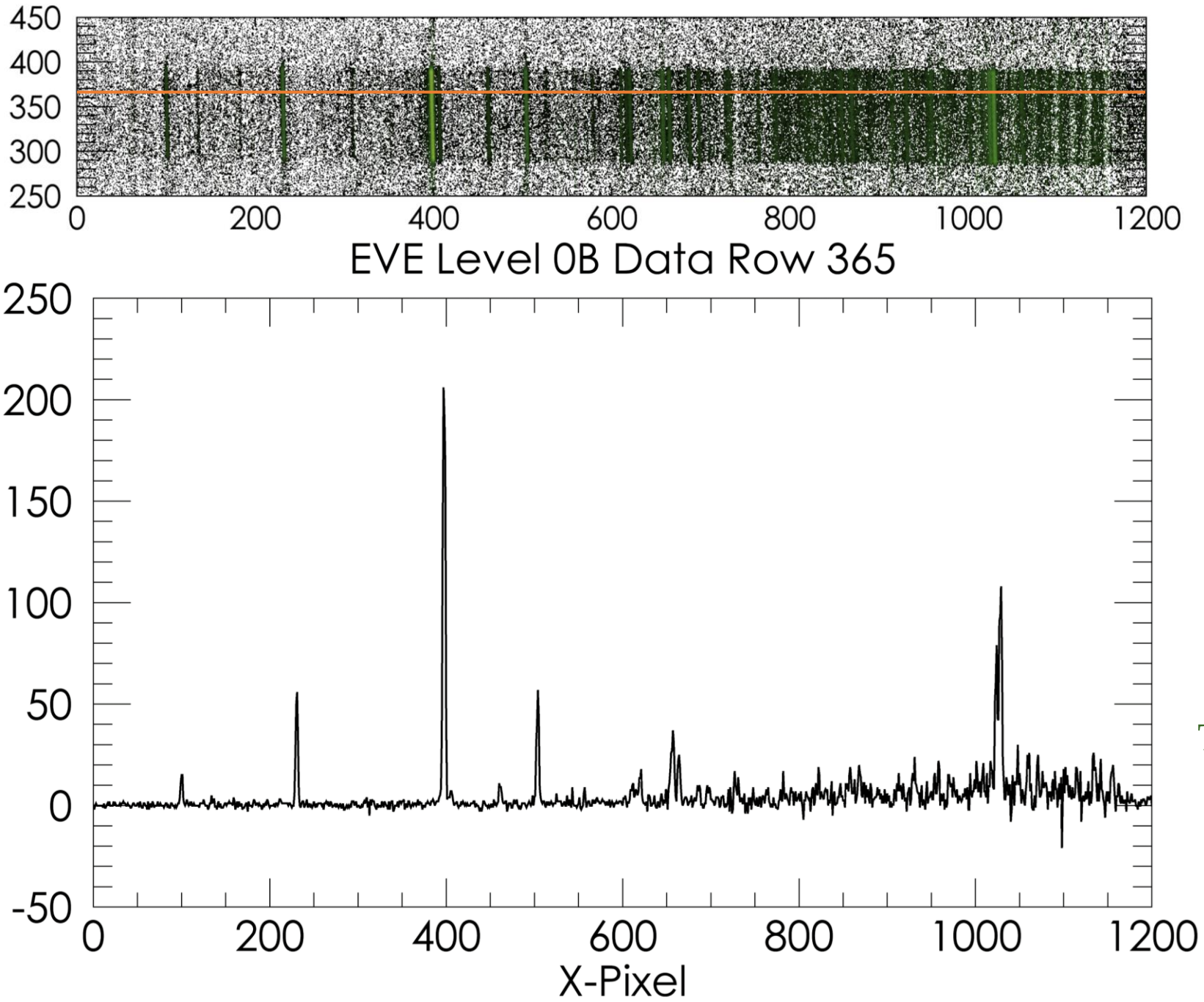
Subtract Late Gradual Phase Spectral Image by Pre-Flare Spectral Image



To See Only Late Gradual Phase Emissions



Pre-Flare Subtracted From Late Gradual Phase

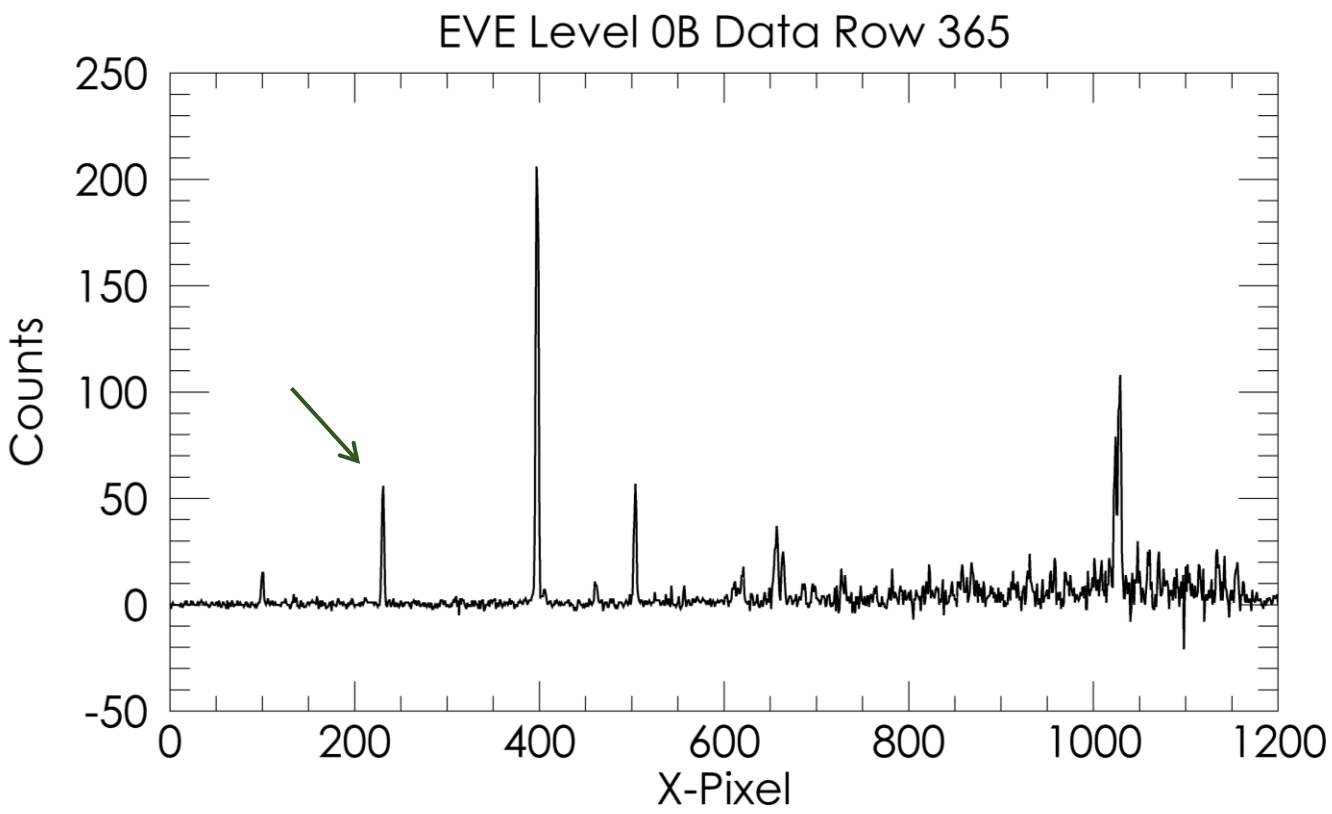


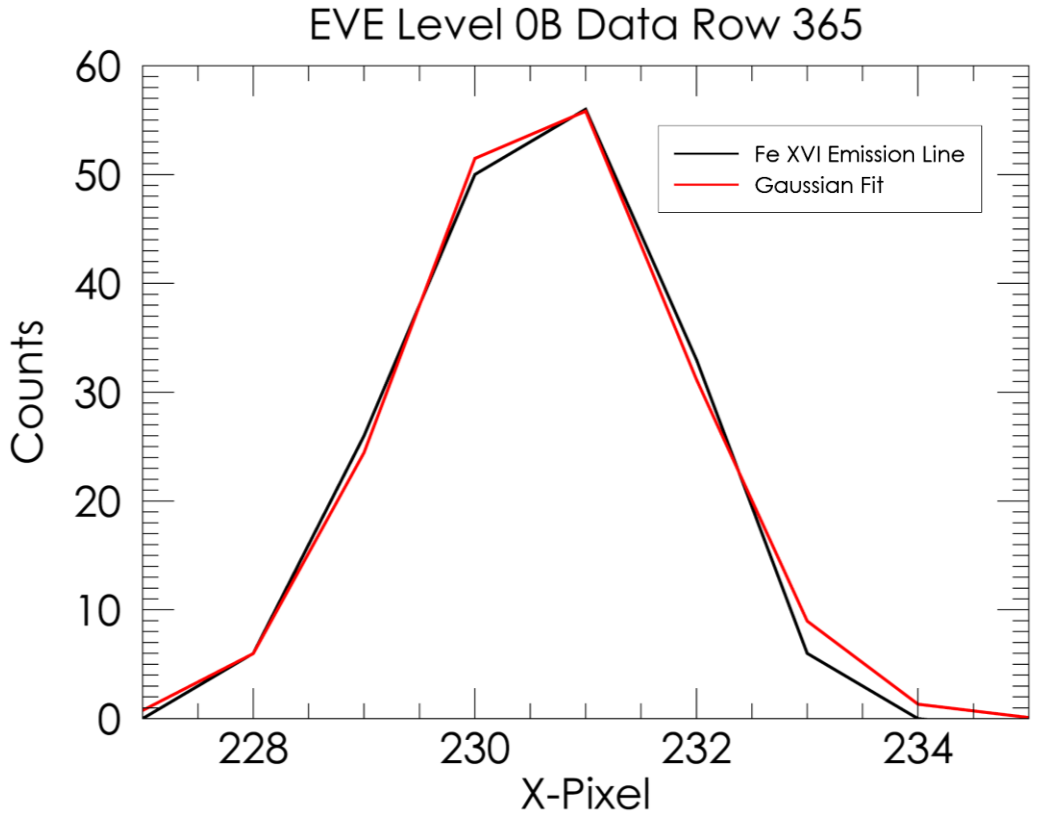
This graphs comes from a single row (row 765) of data from MEGS-A2

Gaussian Fitting Emission Lines to find X-Pixel Peak Locations

Fe XVI 33.54nm Example for a Single Row of Data From MEGS-A2

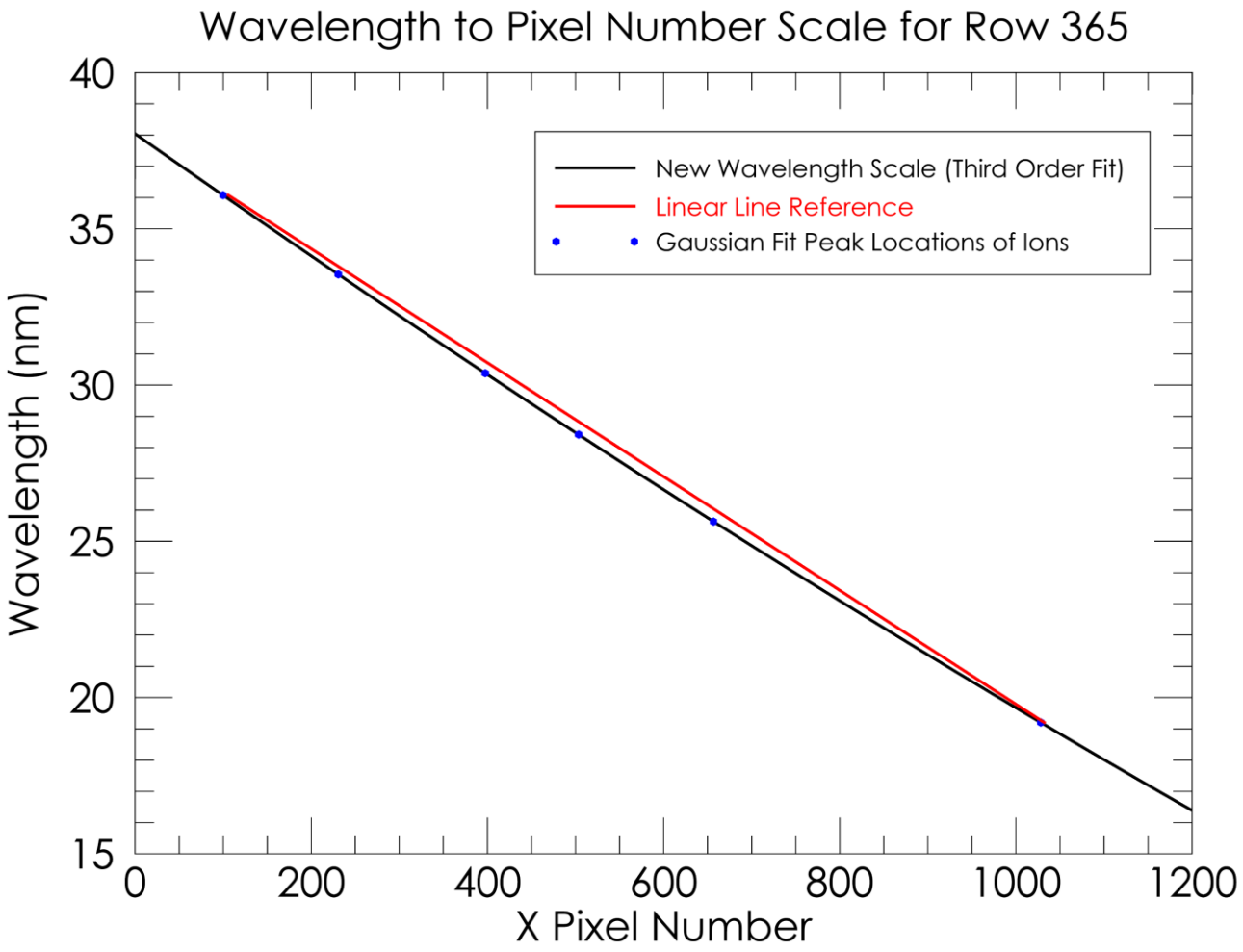
Fe XVI 33.54nm is located between pixels 227 and 235





Results Fitting a Single Row of MEGS-A2 Data

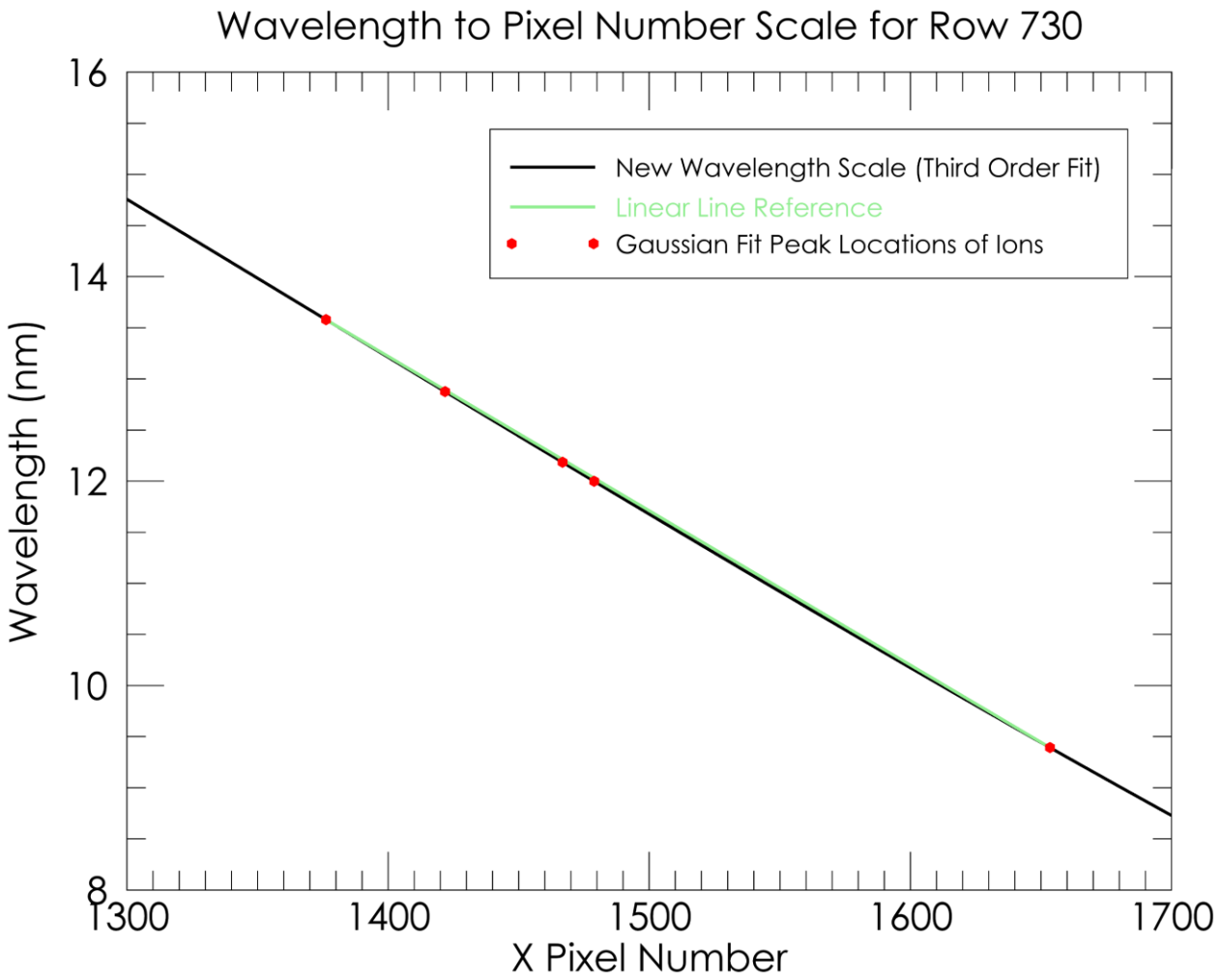
Ion	Peak Location (Pixel)	Wavelengths* (nm)	T_{max} * (10^T)
Fe XXIV	1028.34	19.20285	7.2
He II 25.63	656.564	25.6317	4.9
Fe XV 28.42	503.820	28.4163	6.4
He II 30.38	397.602	30.3781	4.9
Fe XVI 33.54	229.880	33.541	6.8
Fe XVI 36.08	100.133	36.0759	6.8



*From the CHIANTI database
Dere, K.P. et al., *A&A*, 2009, DOI: 10.1051/0004-6361/200911712

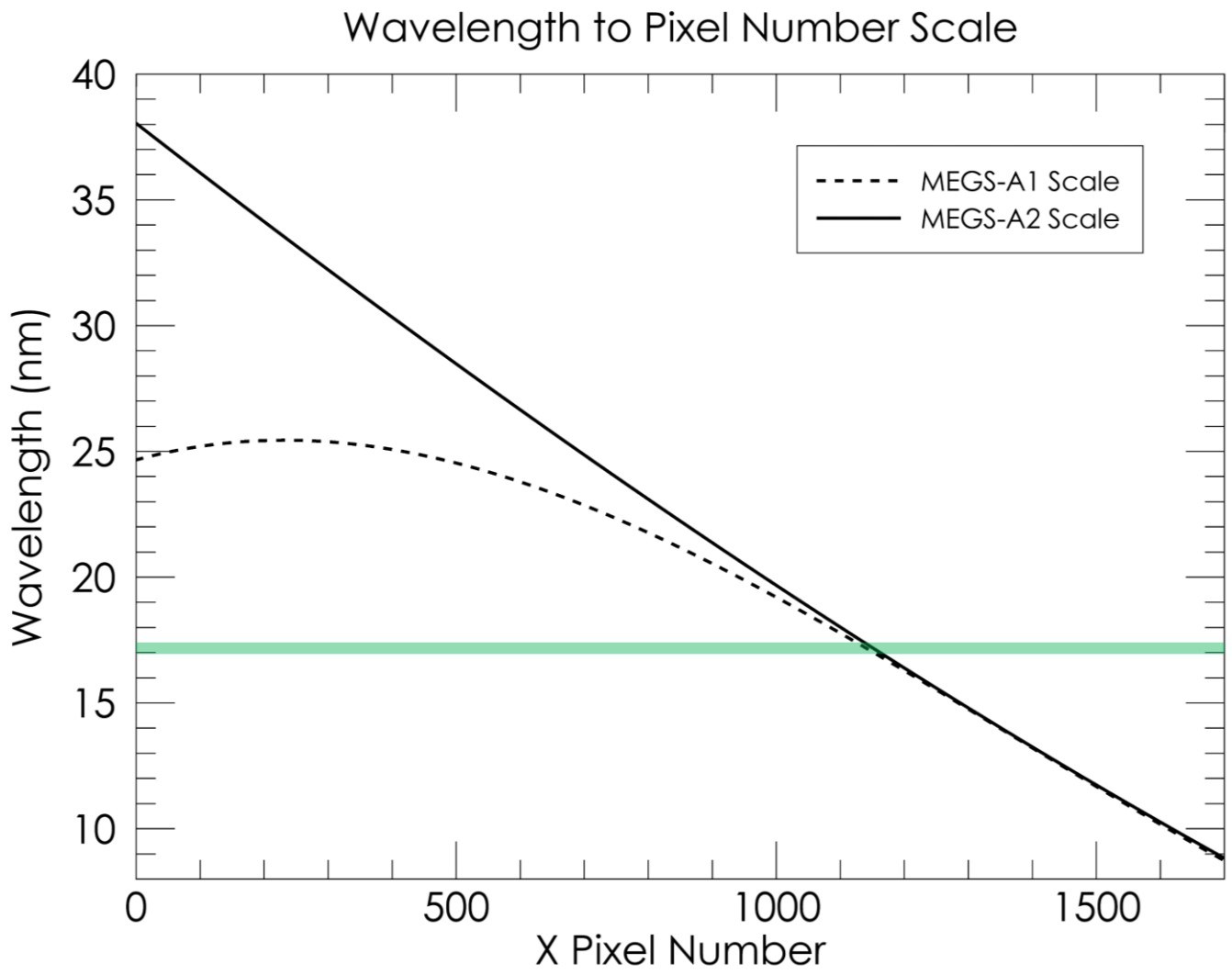
Results Fitting a Single Row of MEGS-A1 Data

Ion	Peak Location (Pixel)	Wavelengths* (nm)	T_{max} (10^T)
Fe XXII	1376.279	13.57912	7.1
Fe XXI	1421.87	12.87526	7.1
Fe XX	1466.794	12.18448	7.1
Fe XIX	1478.847	11.99836	7
Fe XVIII	1653.424	9.39322	6.9

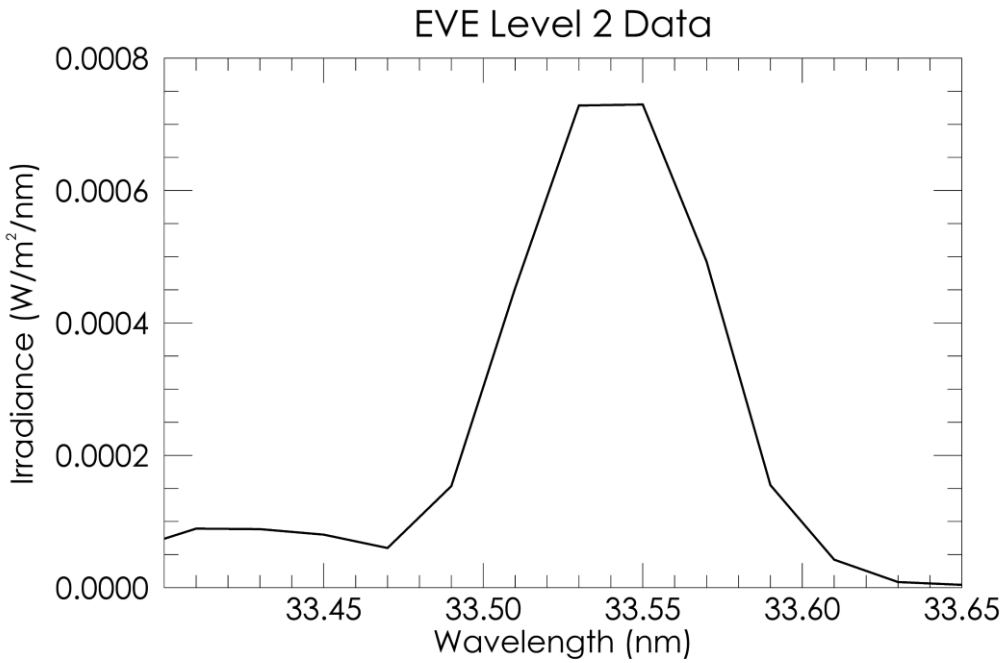


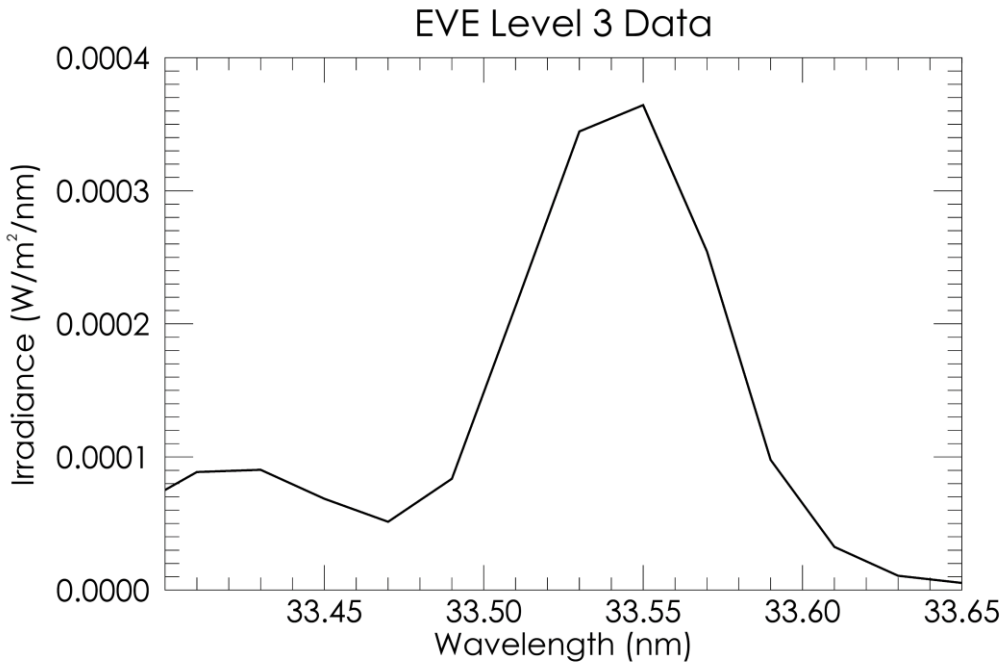
*From the CHIANTI database
Dere, K.P. et al., *A&A*, 2009, DOI: 10.1051/0004-6361/200911712

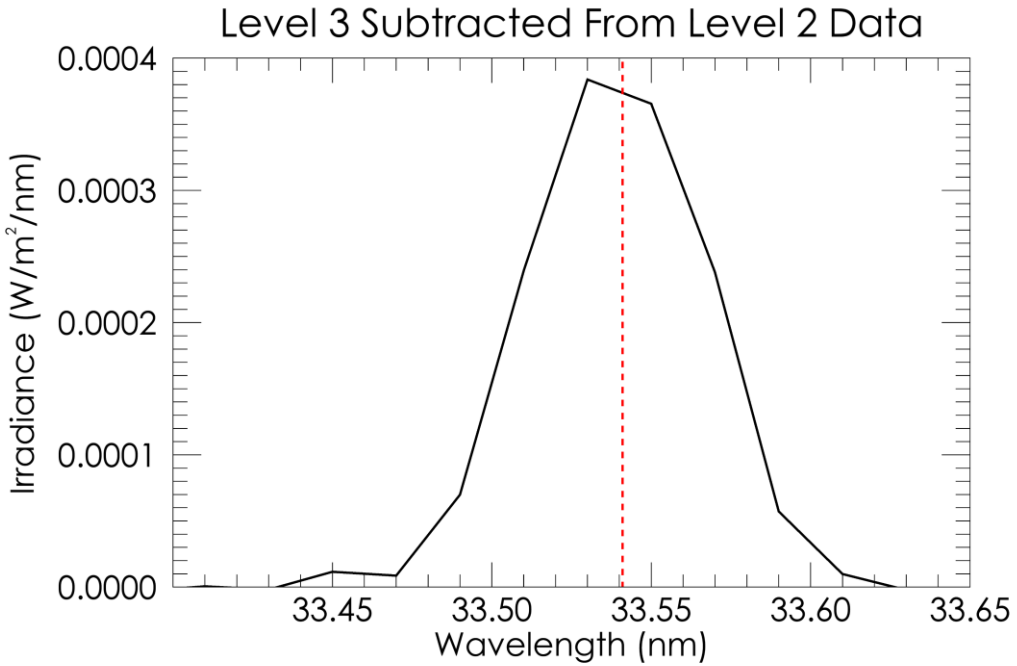
Wavelength Scale



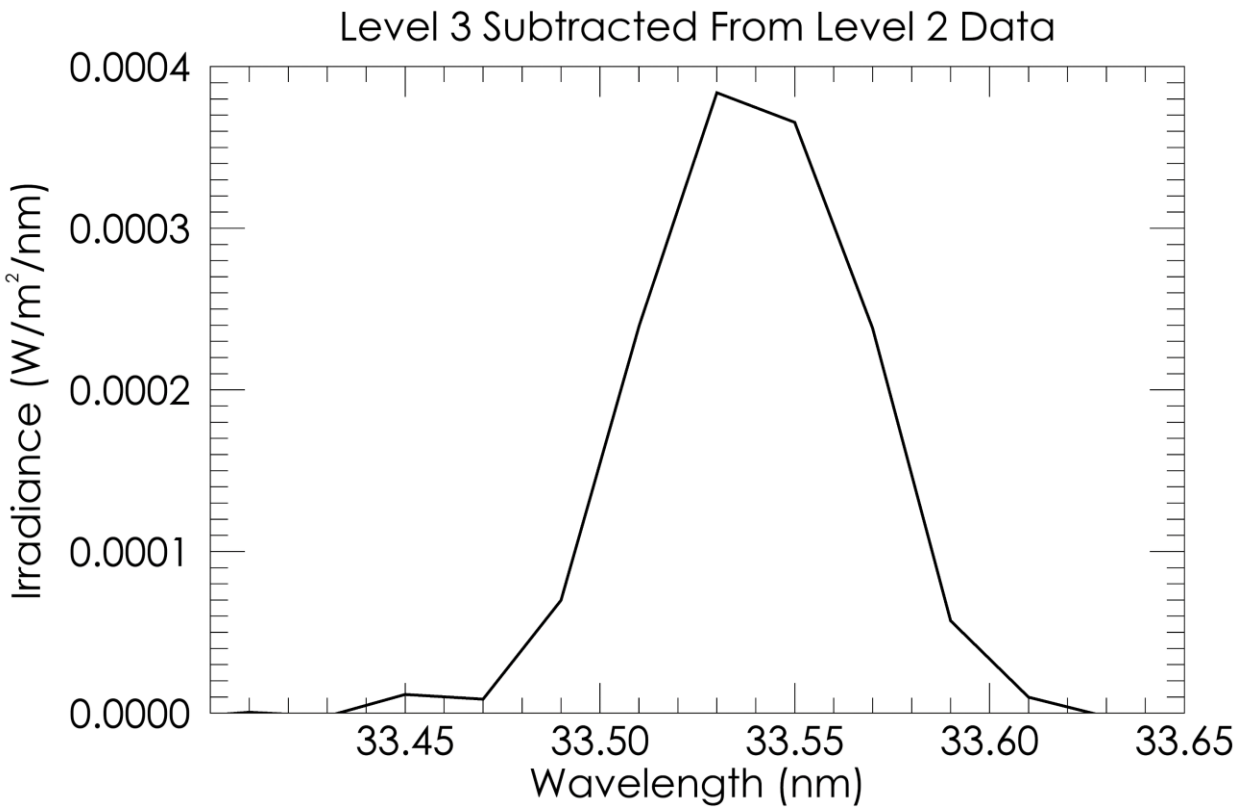
Reminder that MEGS-A1 measures about 5-18nm and MEGS-A2 about 17-37nm

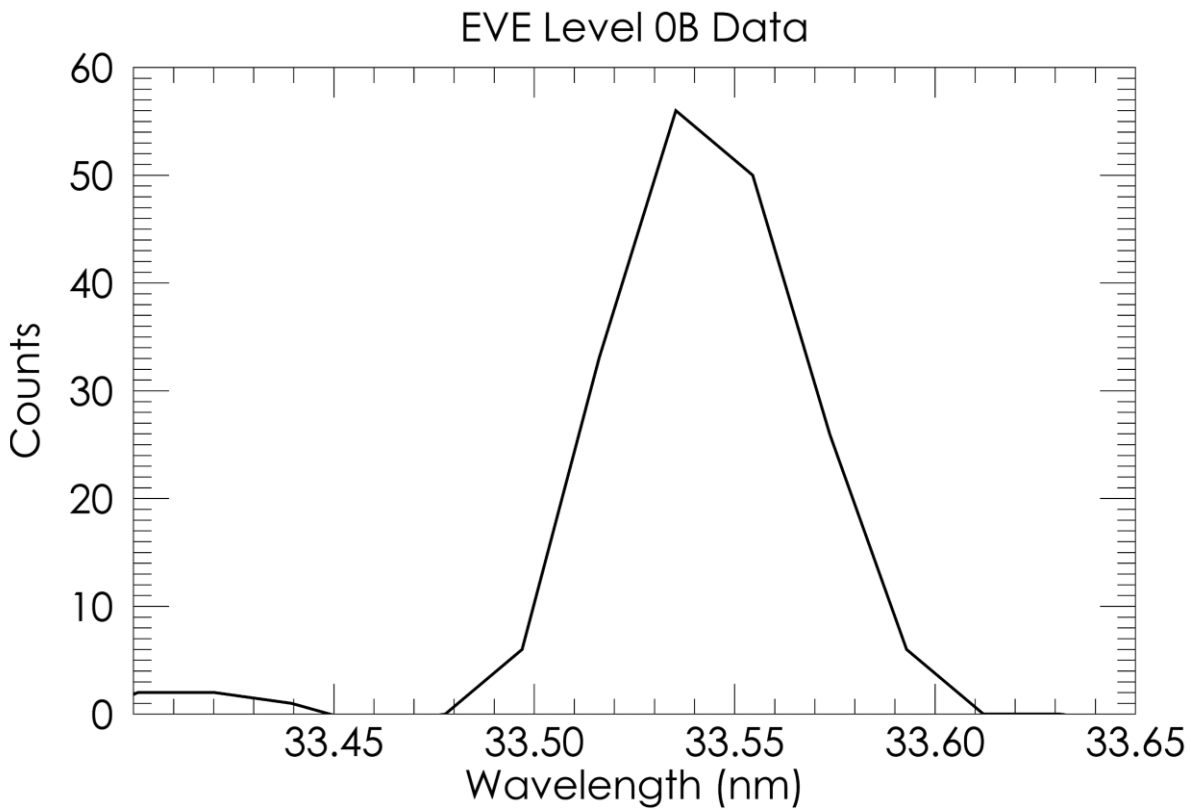

EVE Level 2 Data
Irradiance (W/m²/nm)
0.0008
0.0006
0.0004
0.0002
0.0000
33.45
33.50
33.55
33.60
33.65
Wavelength (nm)


EVE Level 3 Data
Irradiance (W/m²/nm)
0.0004
0.0003
0.0002
0.0001
0.0000
33.45
33.50
33.55
33.60
33.65
Wavelength (nm)

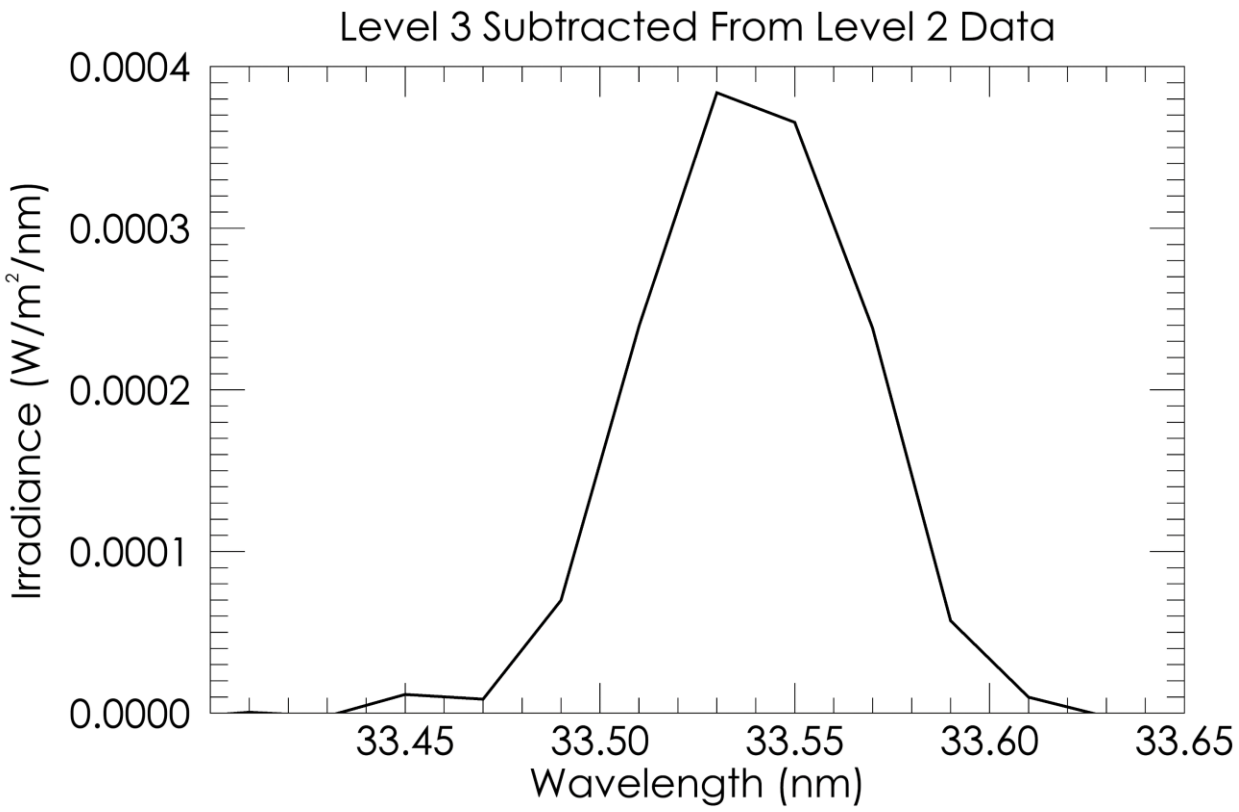

Level 3 Subtracted From Level 2 Data
Irradiance (W/m²/nm)
0.0004
0.0003
0.0002
0.0001
0.0000
33.45
33.50
33.55
33.60
33.65
Wavelength (nm)

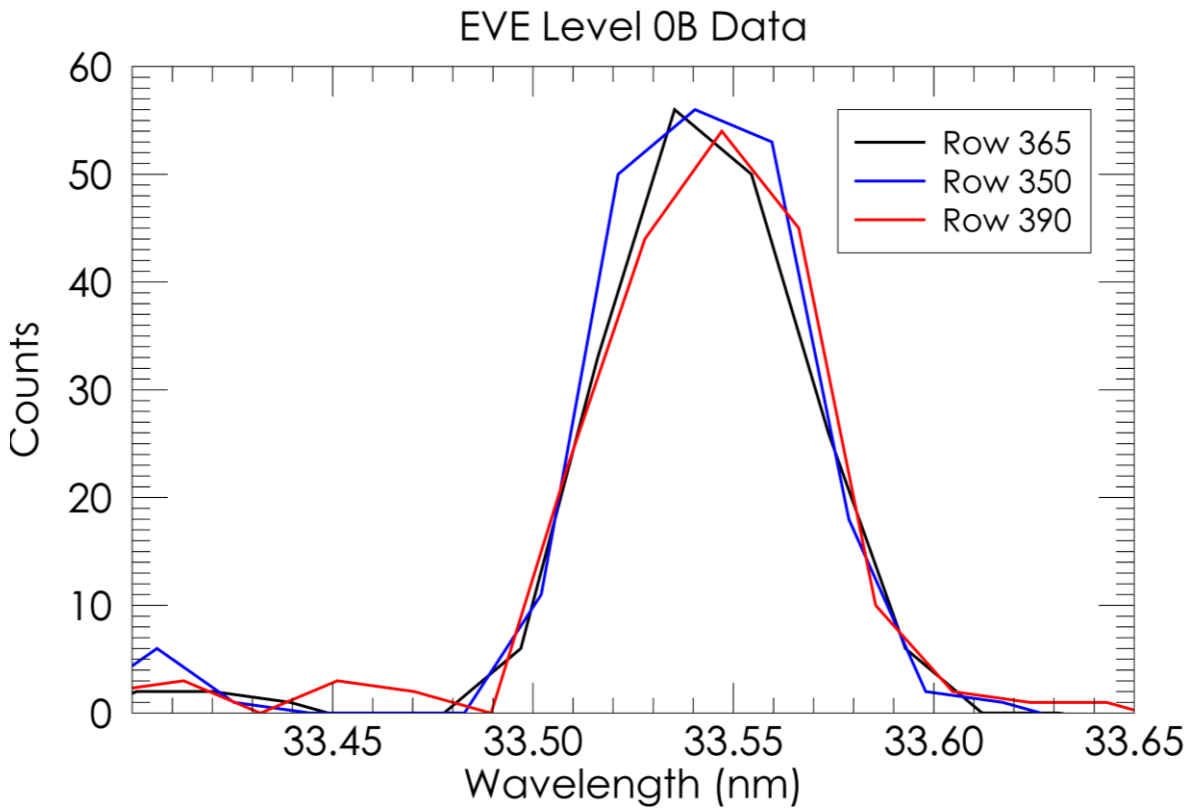
Comparing Level 2 and 3 Data to Level 0B



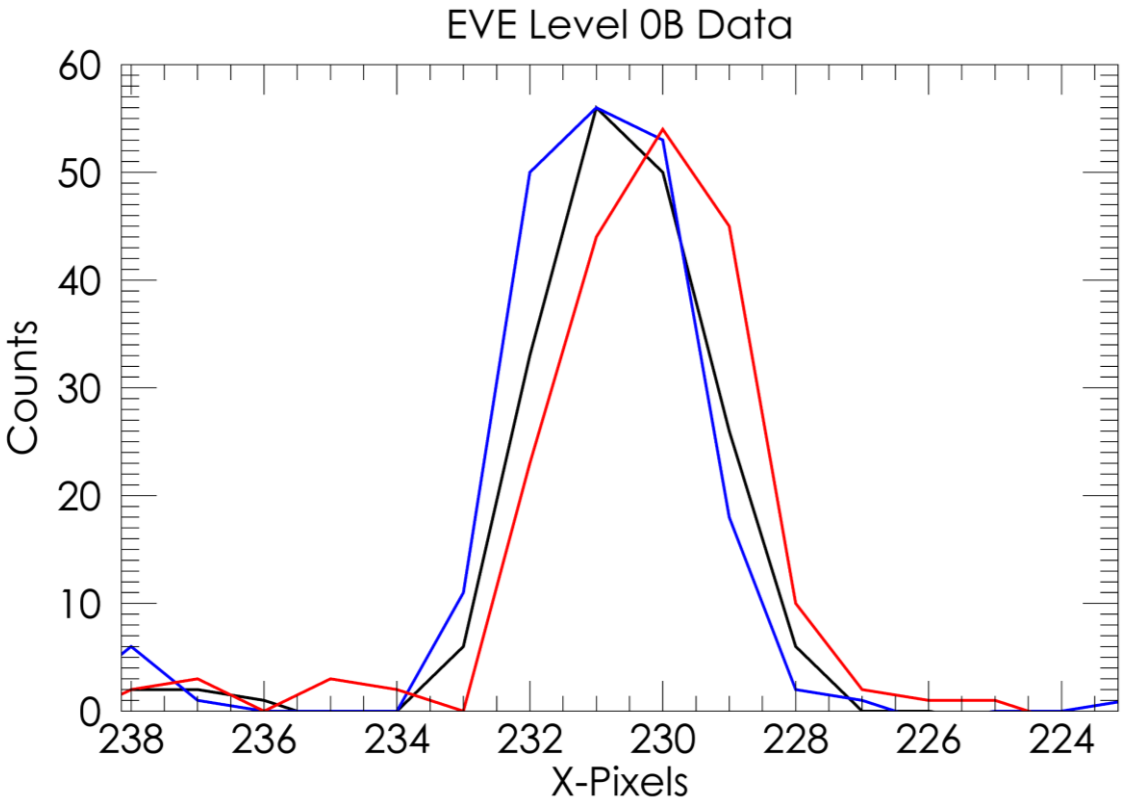


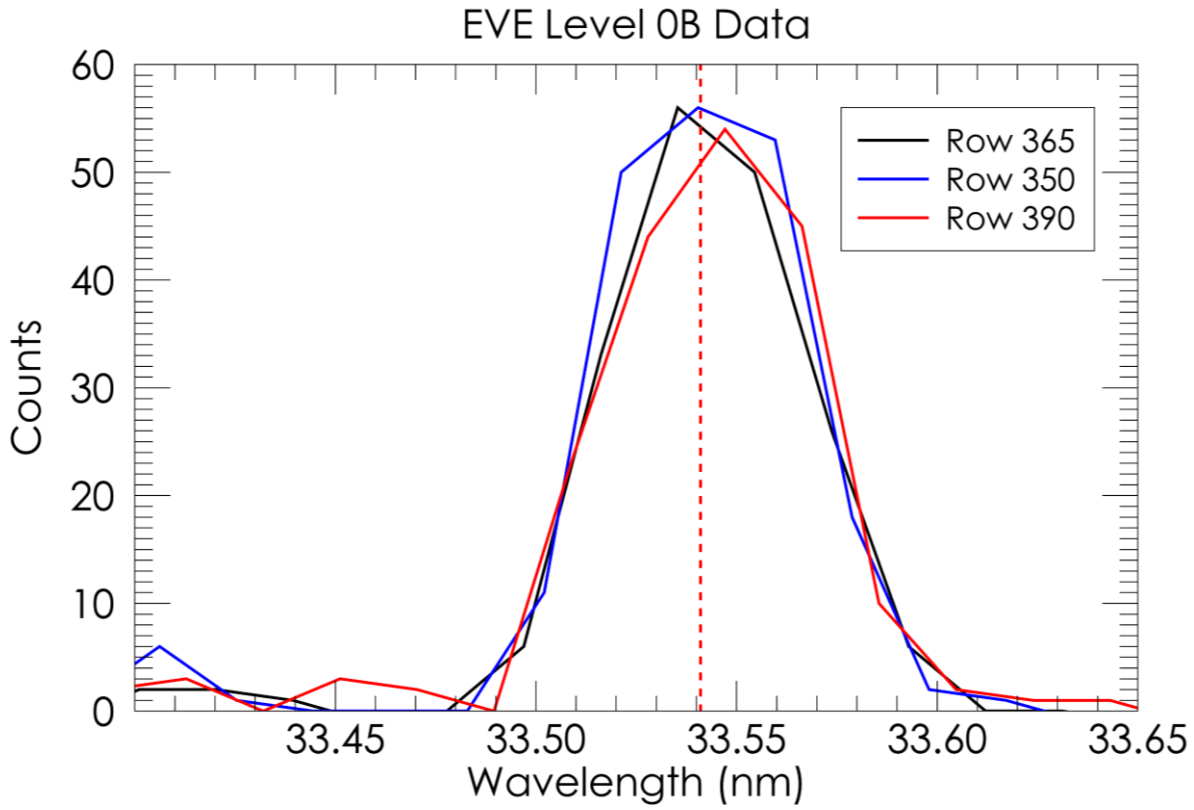
Comparing Level 2 and 3 Data to Level 0B





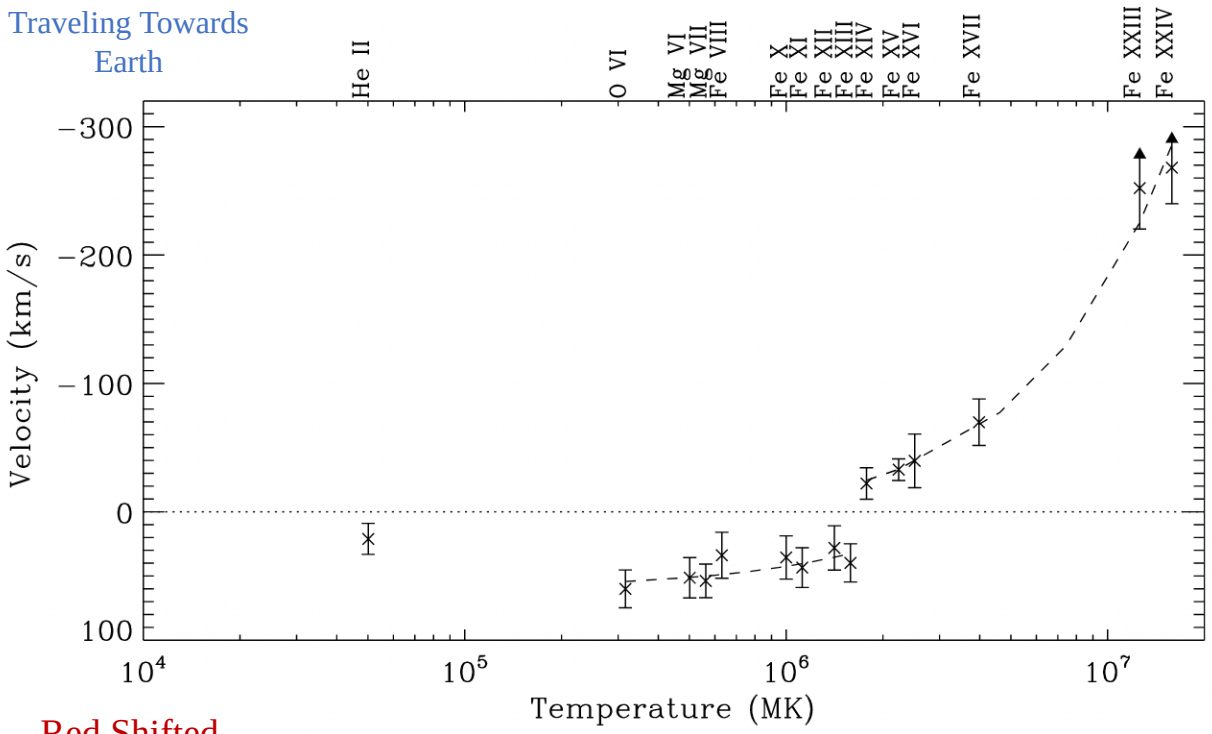
Wavelength Scale Accounts for Slant in Flaring Data





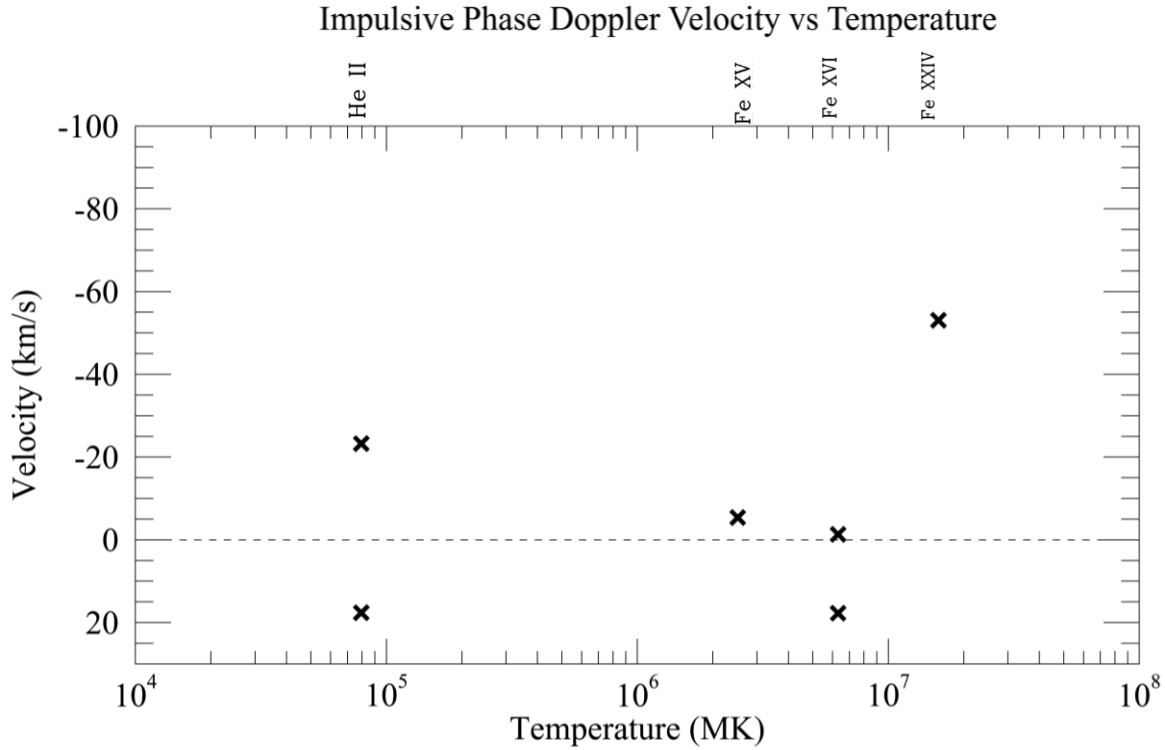
What We Were Hoping to See vs Our Results

Blue Shifted
Traveling Towards Earth



Red Shifted
Traveling Away from Earth

Ryan O. Milligan and Brian R. Dennis, 2009, *ApJ*, DOI:10.1088/0004-637X/699/2/968



Our Results

Future Work

- Calculate doppler velocities for MEGS-A1
- Find more ions to fit and analyze
  - Learn to fit a double-gaussian
- Look at different times of the flare
- Calculate uncertainties