# Absolute calibration of spectral fluxes registered by the SPIRIT spectroheliograph using the data of EIT/SOHO wide-band telescope

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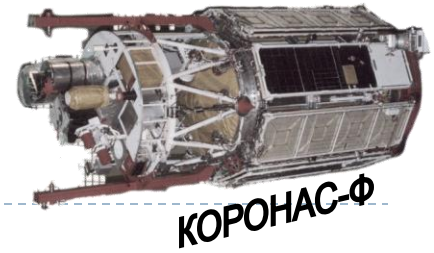
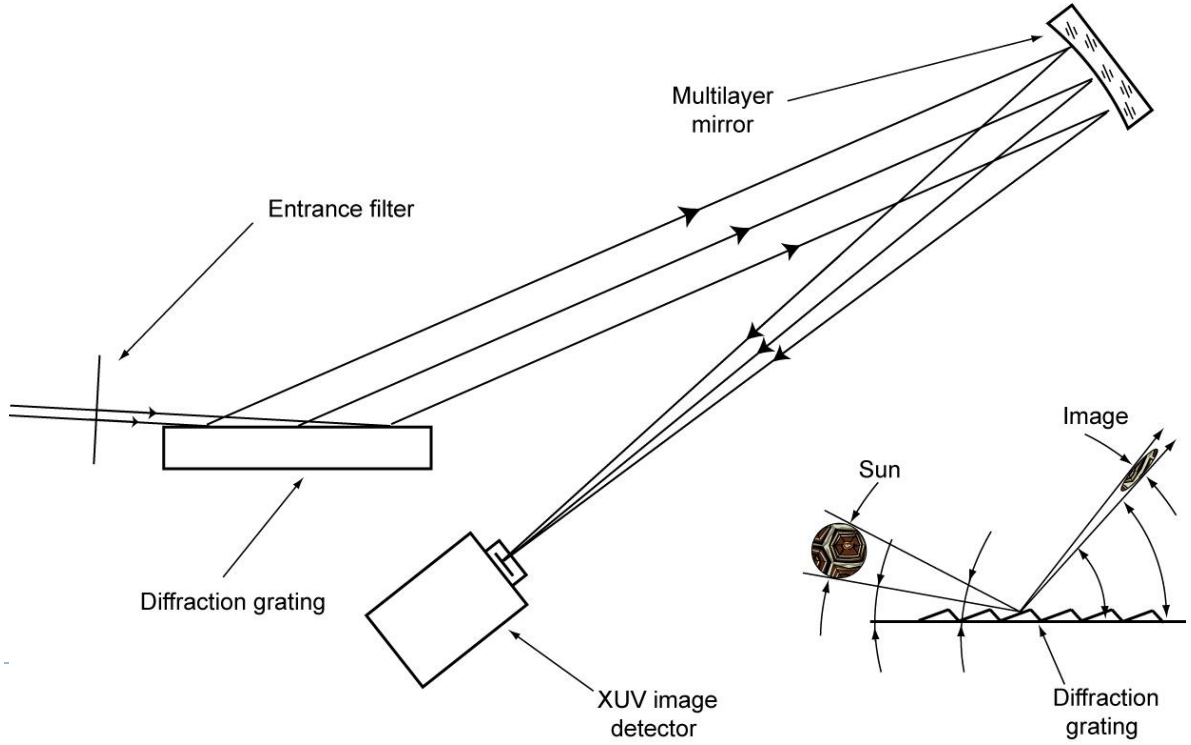
# SPIRIT EUV spectroheliograph

(CORONAS-F 2001-2005)




- EUV slitless spectroheliographs:
  - 2 channels: 176-207 Å and 280-330 Å
- Grazing incidence (~ 1.5˚) diffraction grating
- Multilayer Mo-Si mirror
- Detector – Image Intensifier+CCD

- Pros: Full-Sun FOV
- Cons: low spectral resolution



# Calibration

- Importance of both
  - Relative intensities of different spectral lines
  - Absolute fluxes
- EIT – in units dn [digital numbers]. To convert to erg/s/cm2 – it is required it's spectral sensitivity (bandpass) and real spectral composition
- SPIRIT – in units DN. Relative intensities of different spectral lines

# Calibration

- Flux in EIT is given in [dn]. It is related to physical units by eq.

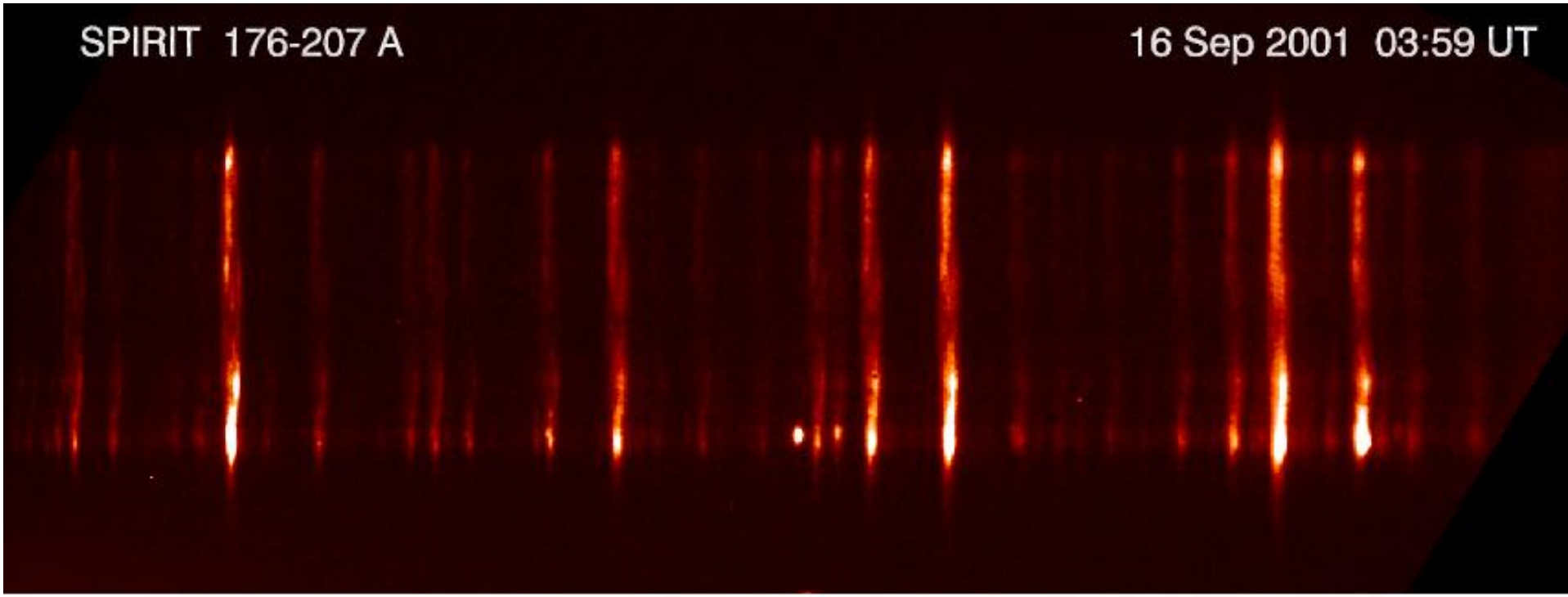
$$F = \int s(\lambda) b(\lambda) d\lambda$$

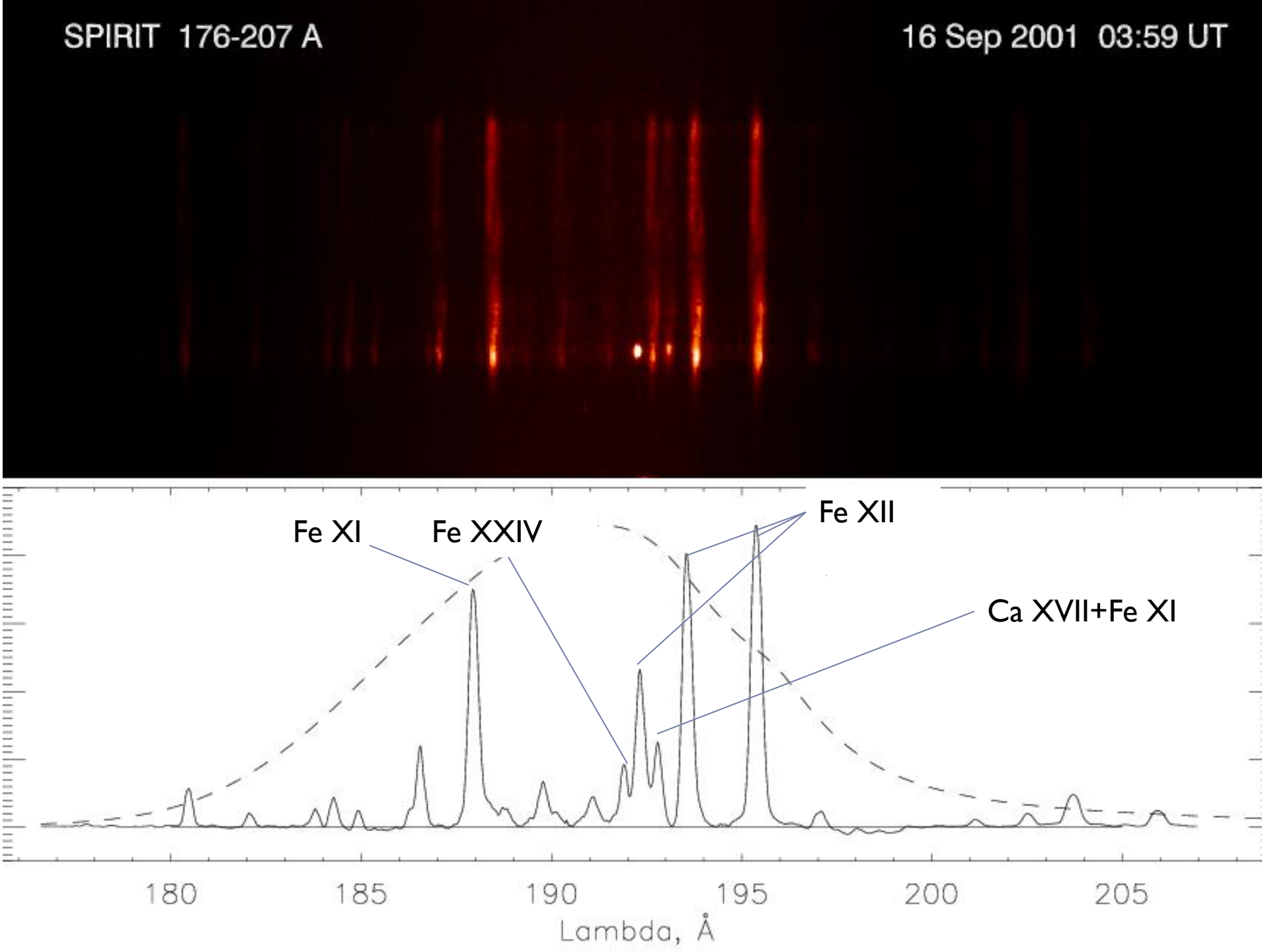
  - s(λ) – real incident flux
  - b(λ) – EIT bandpass (`eit_parms` from SSW)

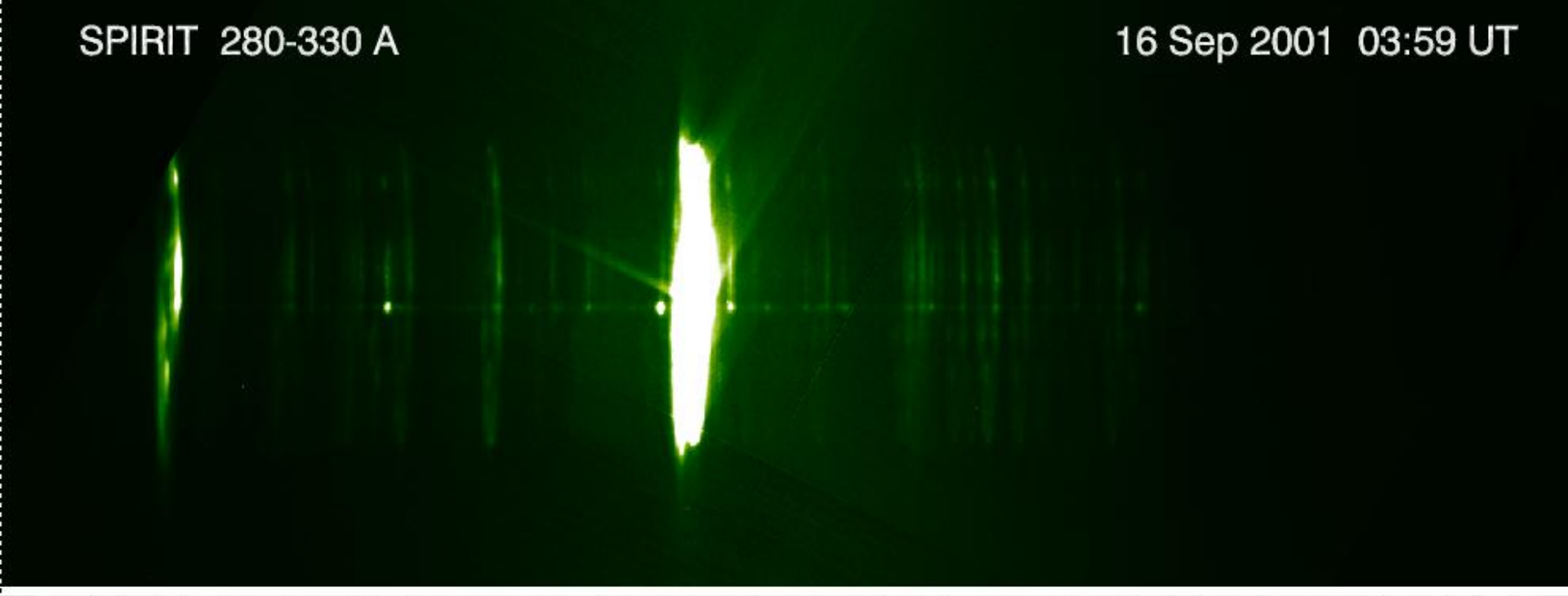
and

- s(λ)=i(λ)*k
  - i(λ) – relative flux measured by SPIRIT
  - k – calibration coefficient

$$k = \frac{F}{\int i(\lambda) \cdot b(\lambda) d\lambda}$$


SPIRIT 176-207 A
16 Sep 2001 03:59 UT


SPIRIT 176-207 A
16 Sep 2001 03:59 UT
Fe XI
Fe XXIV
Fe XII
Ca XVII+Fe XI
180
185
190
195
200
205
Lambda, Å


SPIRIT 280-330 A
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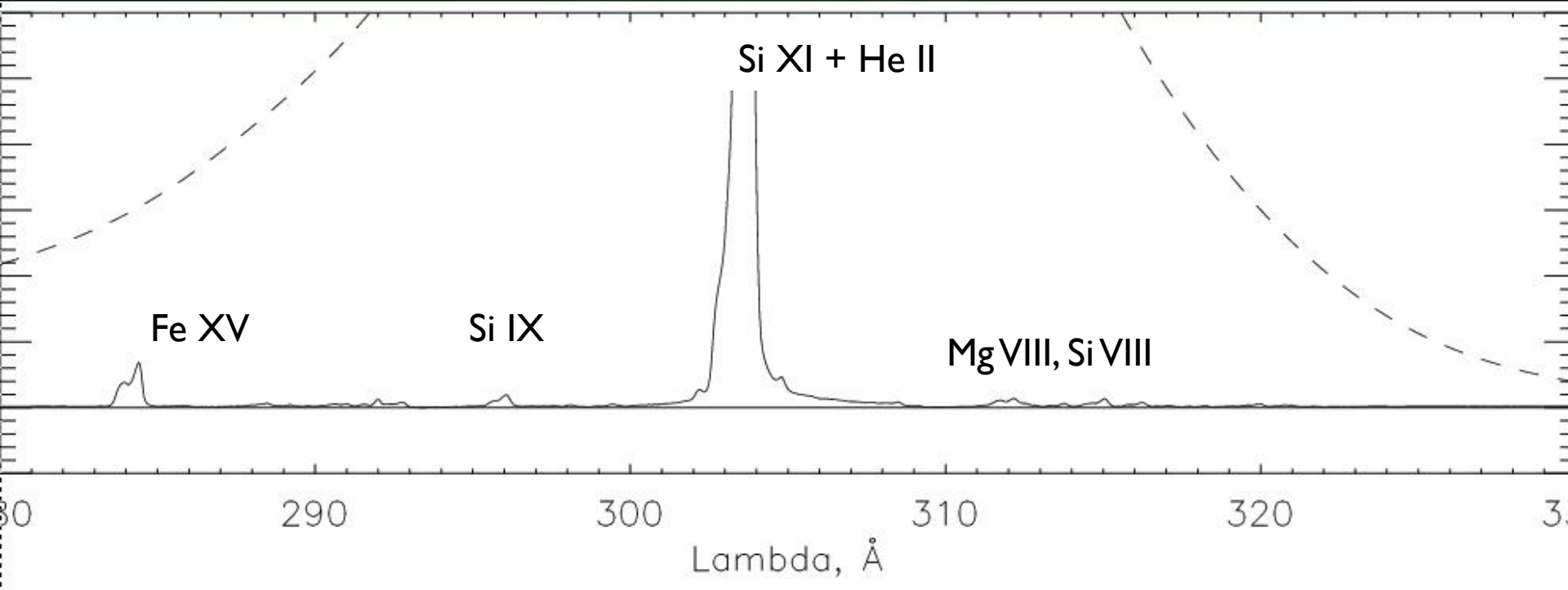

Si XI + He II
Fe XV
Si IX
Mg VIII, Si VIII
290
300
310
320
Lambda, Å

# Calibration coefficients

| | | M5.6 | X1.3 | X17 20:04 | X17 21:35 | X3.4 |
|---|---|---|---|---|---|---|
| V190 | exp. time | t=37sec, 900 V | t=300sec, 900 V | t=300sec, 900 V | t=300sec, 900 V | |
| | k | 1,46E-06 | 1,09E-06 | 1,08E-06 | 1,09E-06 | |
| U304 | exp. time | t=37sec, 800 V | t=150sec,900 V | t=300sec, 900 V | t=300sec, 900 V | |
| | k | 8,54E-07 | 7,70E-07 | 3,30E-07 | 3,26E-07 | 5,70E-07 |
| EIT 195 | | 1,10E+08 | 7,33E+07 | 5,07E+07 | 5,07E+07 | |
| EIT 304 | | 5,70E+07 | 4,40E+07 | 3,52E+07 | 3,52E+07 | 6,90E+07 |
| cross-calibr. | | k=1,0 | k=1,6 | k=0,9 | k=1,0 | |
| flux, erg/s/cm2 | FeXII 195,11 | 1,70E-03 | 7,90E-04 | 8,20E-04 | 9,72E-04 | |
| | Fe XI 180,41 | 1,80E-03 | 8,90E-04 | 8,70E-04 | 9,70E-04 | |
| | Si IX 296,11 | 2,40E-04 | 1,46E-04 | 1,45E-04 | 1,37E-04 | 3,70E-04 |

# Verification

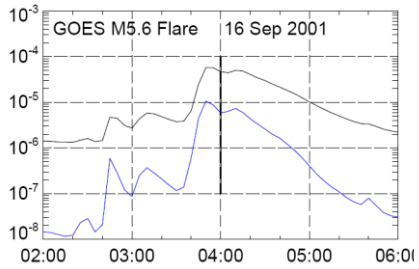
Possible variants of verification:

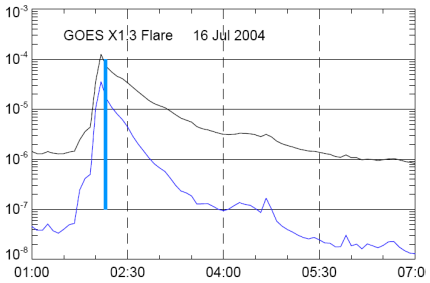
- Calculation of DEM
- DEM -> Comparision vs fluxes measured by different instruments (GOES, RESIK, EIT)

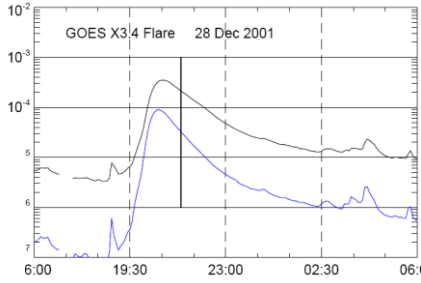
- Interpretation of obtained spectra
  - Identification
  - Blending?
  - Relative sensitivity of SPIRIT?

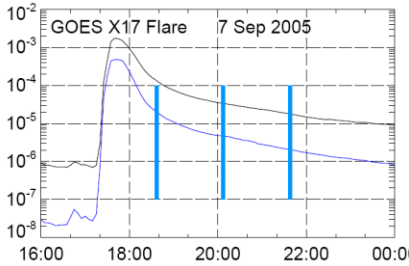
# Observed Flares

- M5.6 on 2001 September 16th
- X3.4 on 2001 December 28th
- X1.3 on 2004 July 16th
- X17 on 2005 September 7th

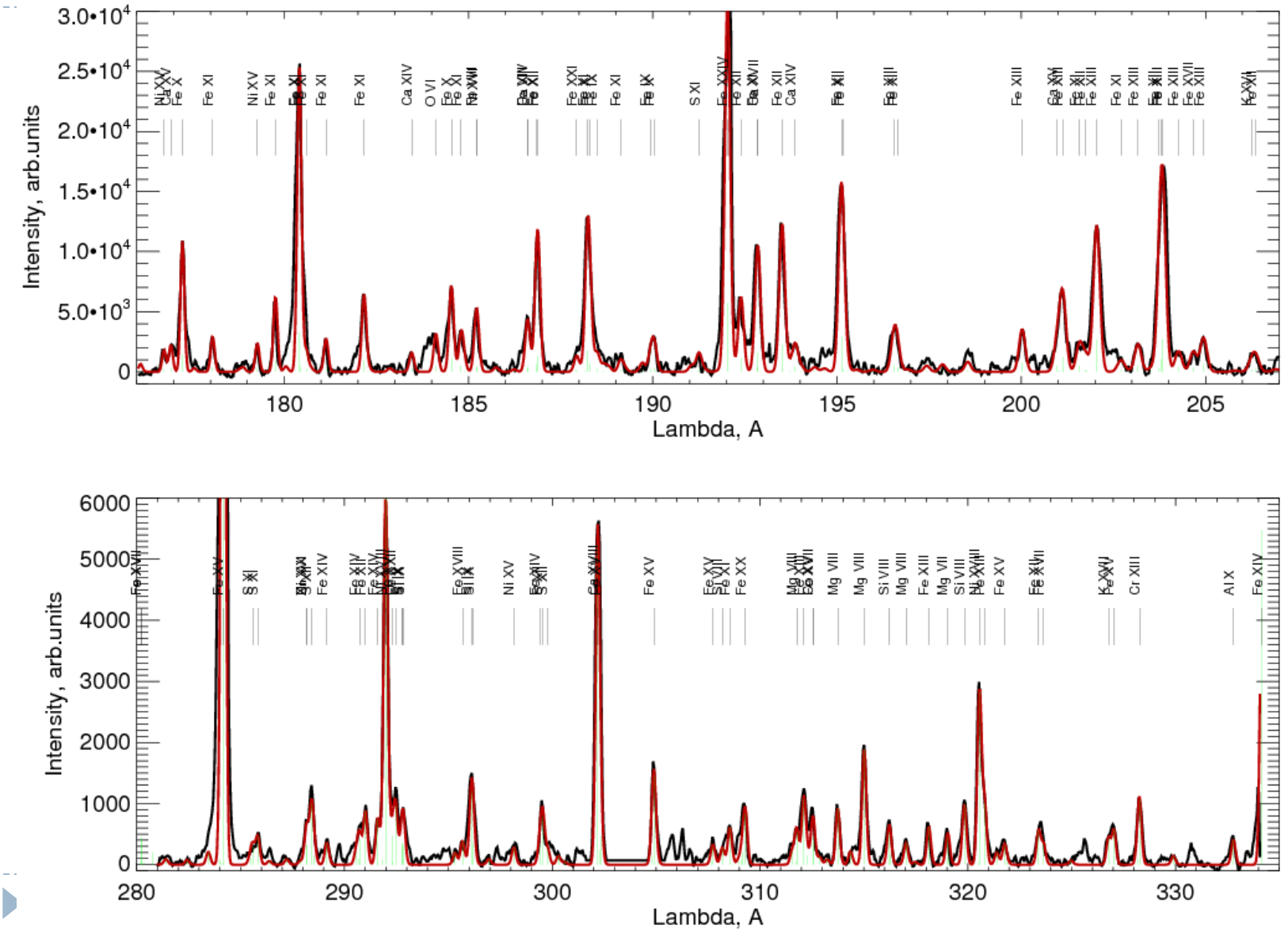


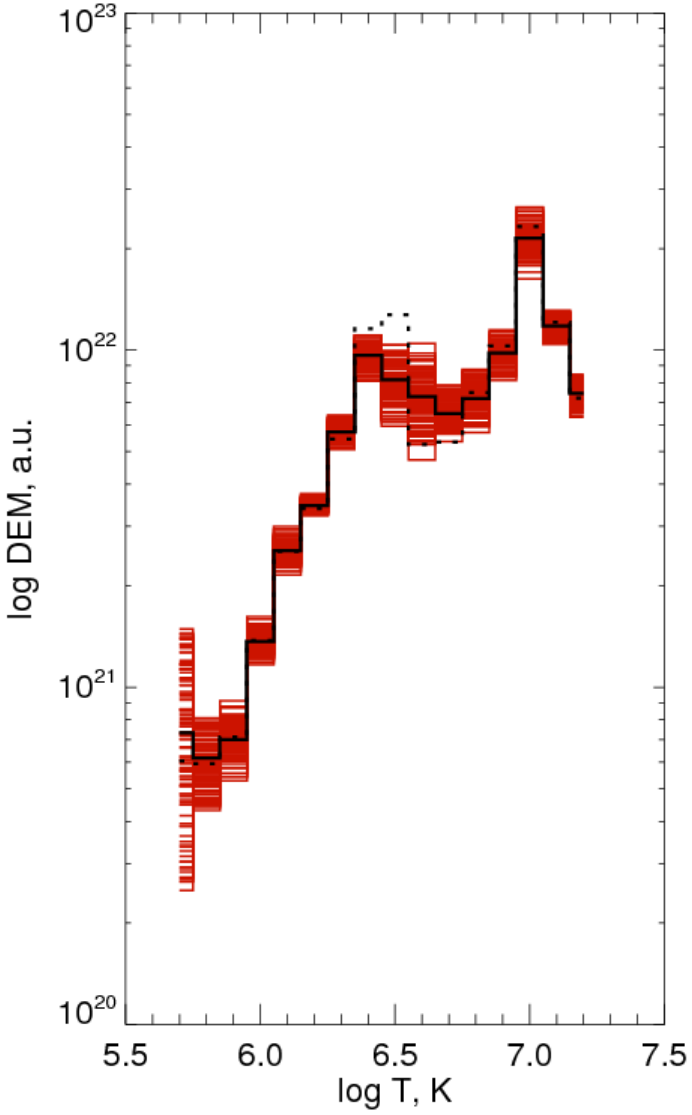



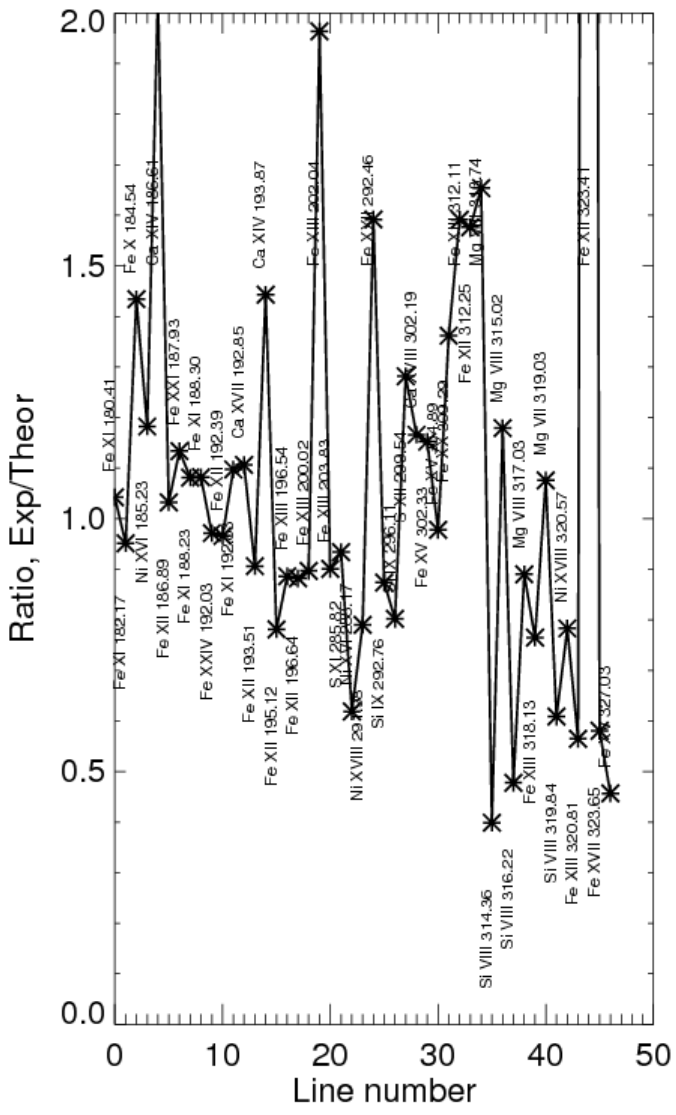



# X1.3 Flare 2004 July 16th

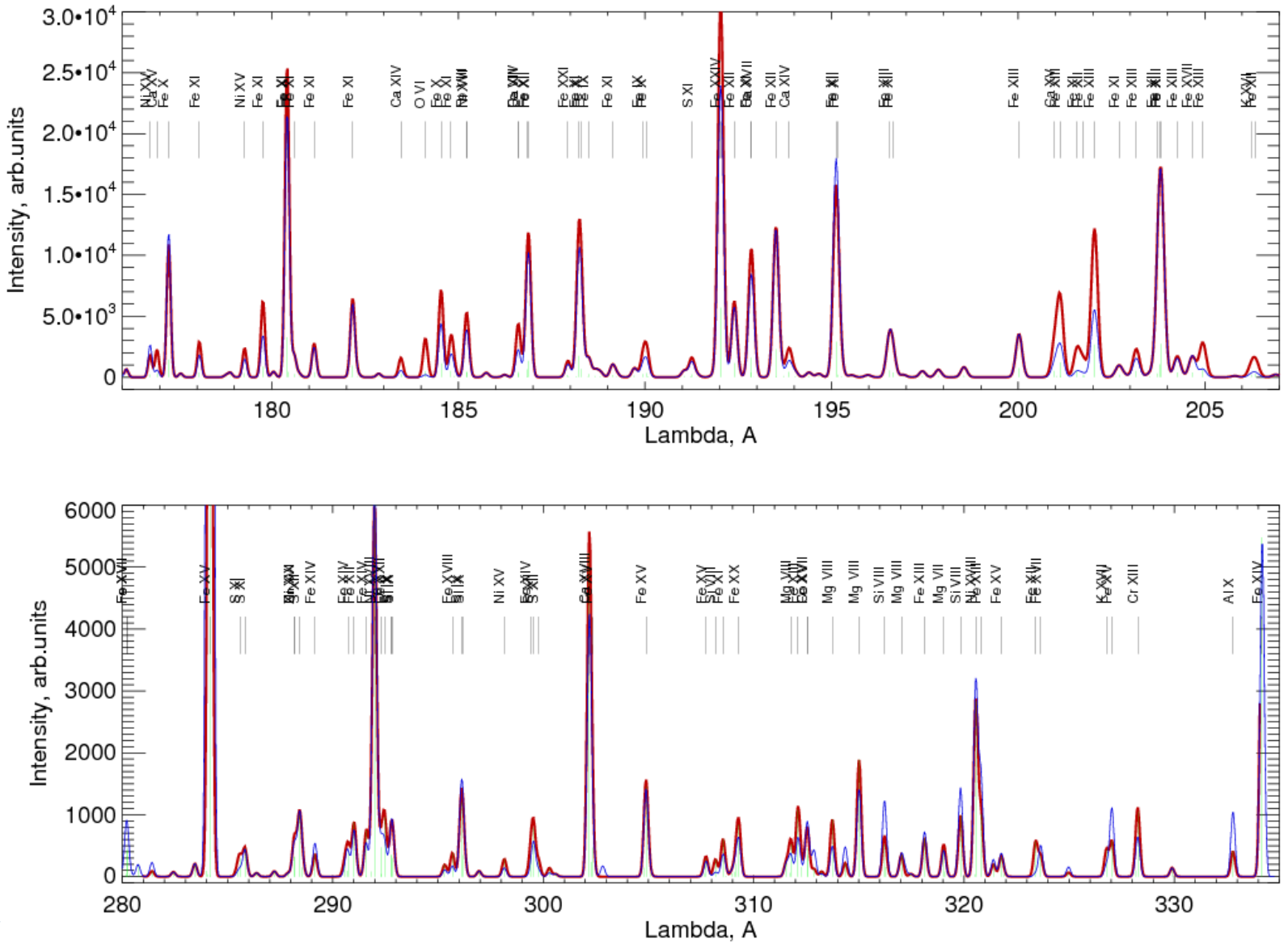


# X1.3 Flare on 2004 July 16th

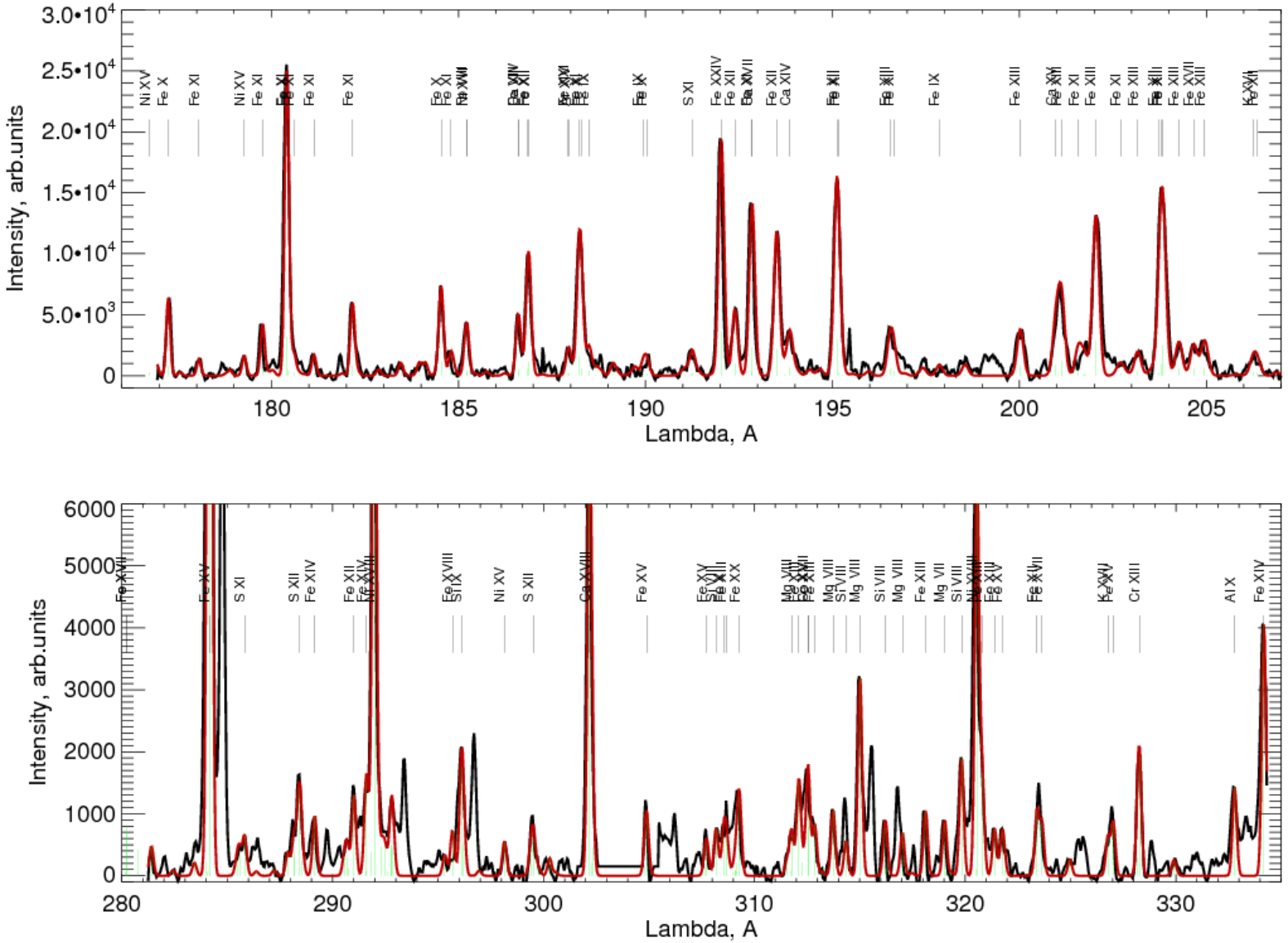


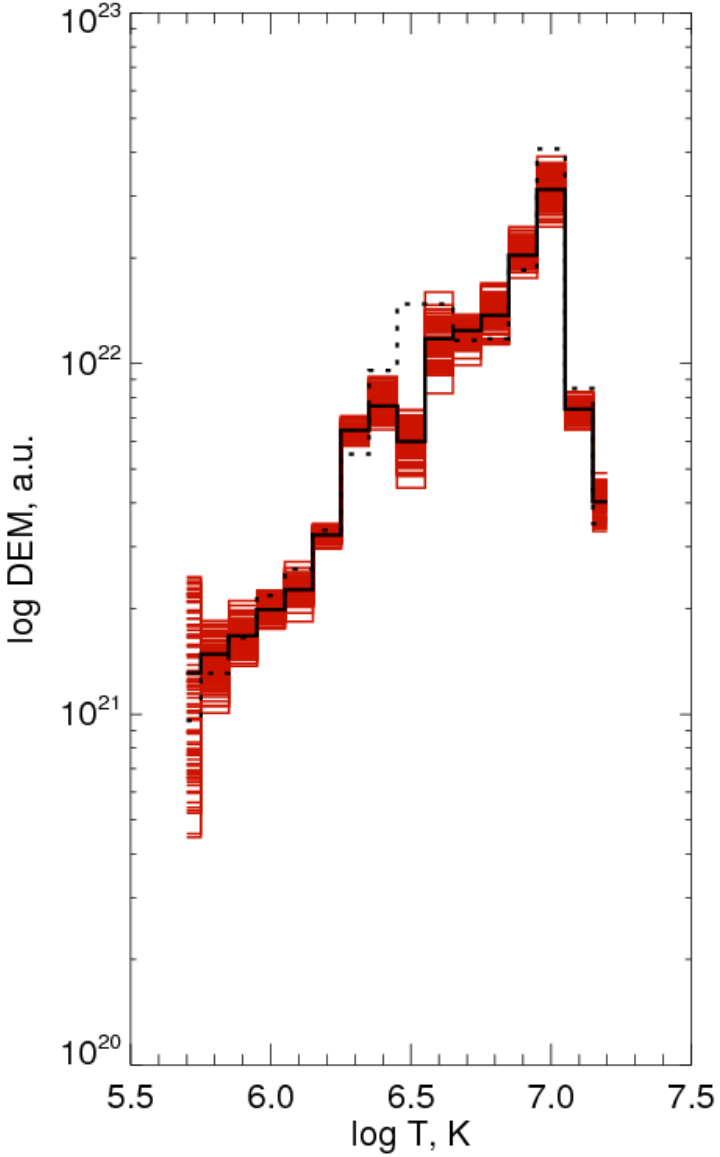
# X1.3 Flare on 2004 July 16th

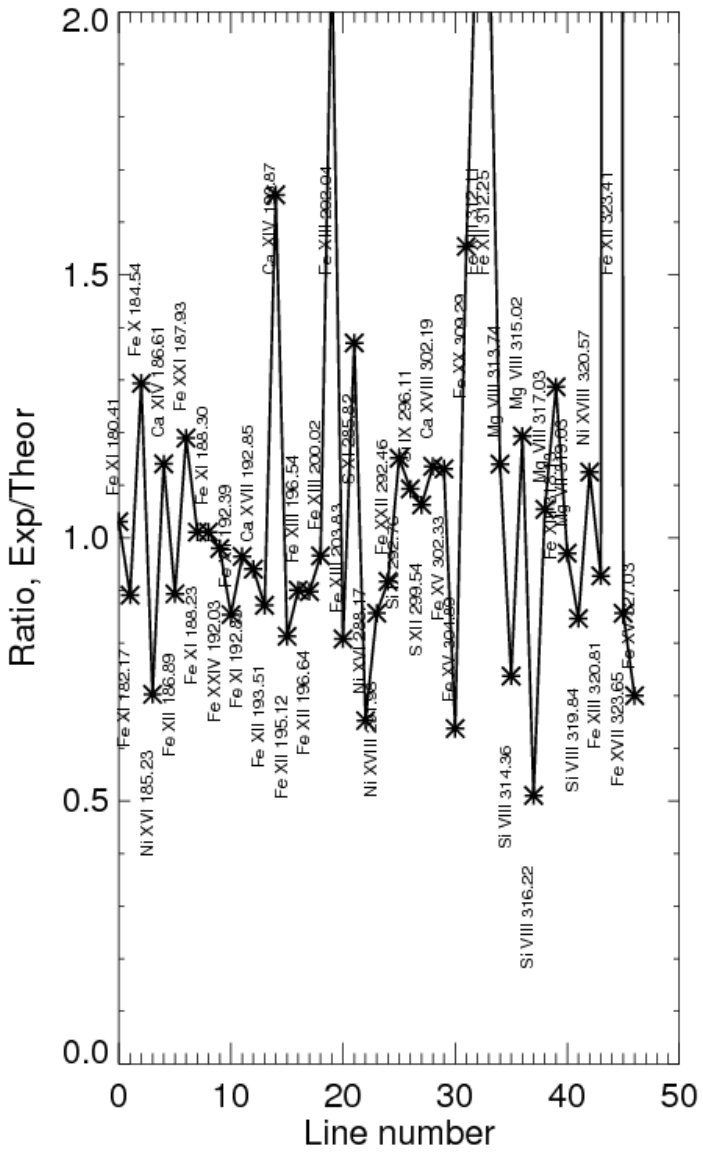


# X17 Flare on 2005 September 9th

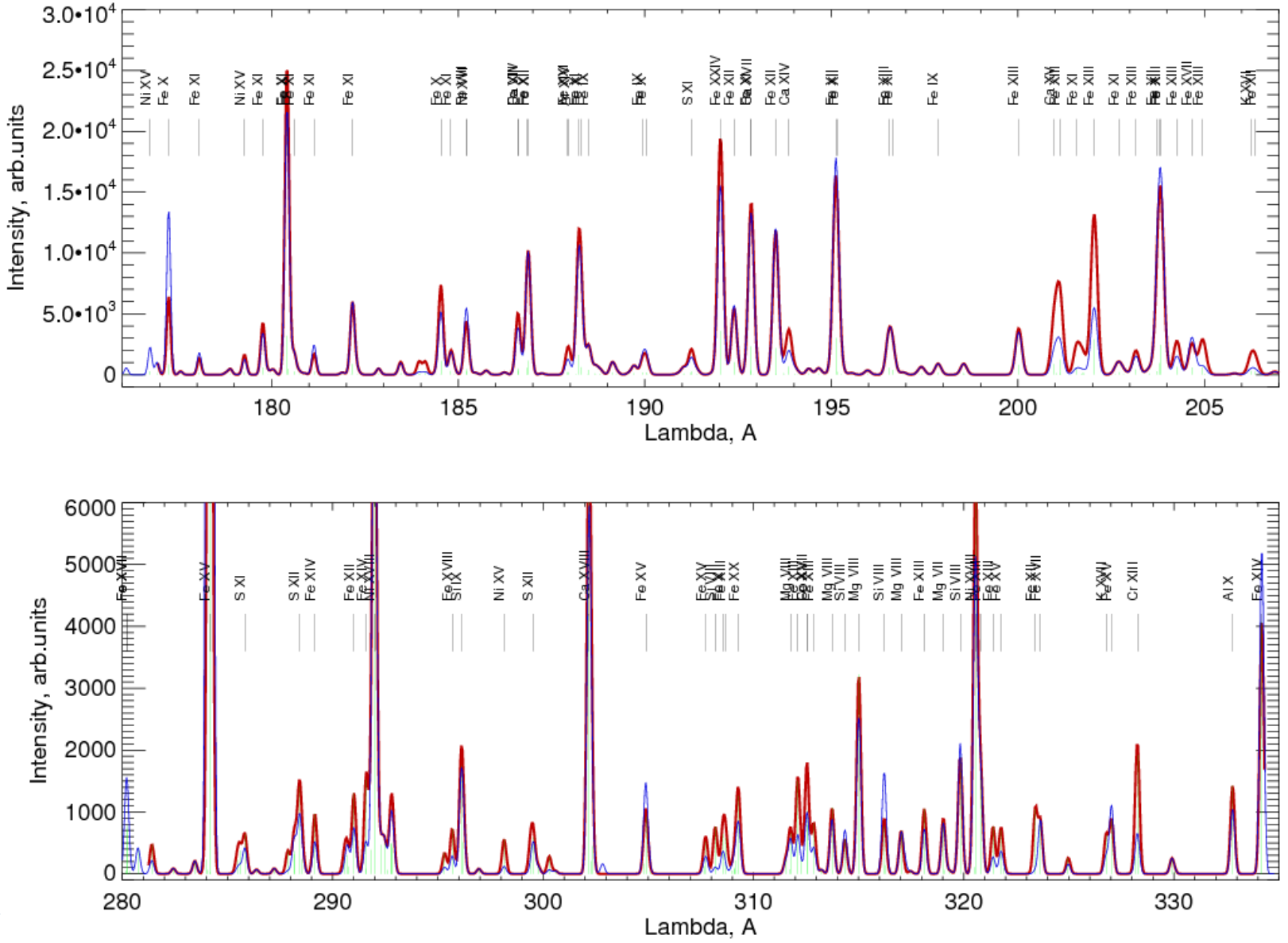


# X17 Flare on 2005 September 9th



# X17 Flare on 2005 September 9th



# Verification

- Relative intensities of spectral lines
- Cross-calibration of **V190** and **U304** SPIRIT channels:
  - $\alpha * i_{304}(\lambda) \leftrightarrow i_{190}(\lambda)$ - obtain $\alpha$ minimazing $\chi^2$ during DEM determination
- Assessment of $n_e$ using Fe XI, XII, XIII lines and others

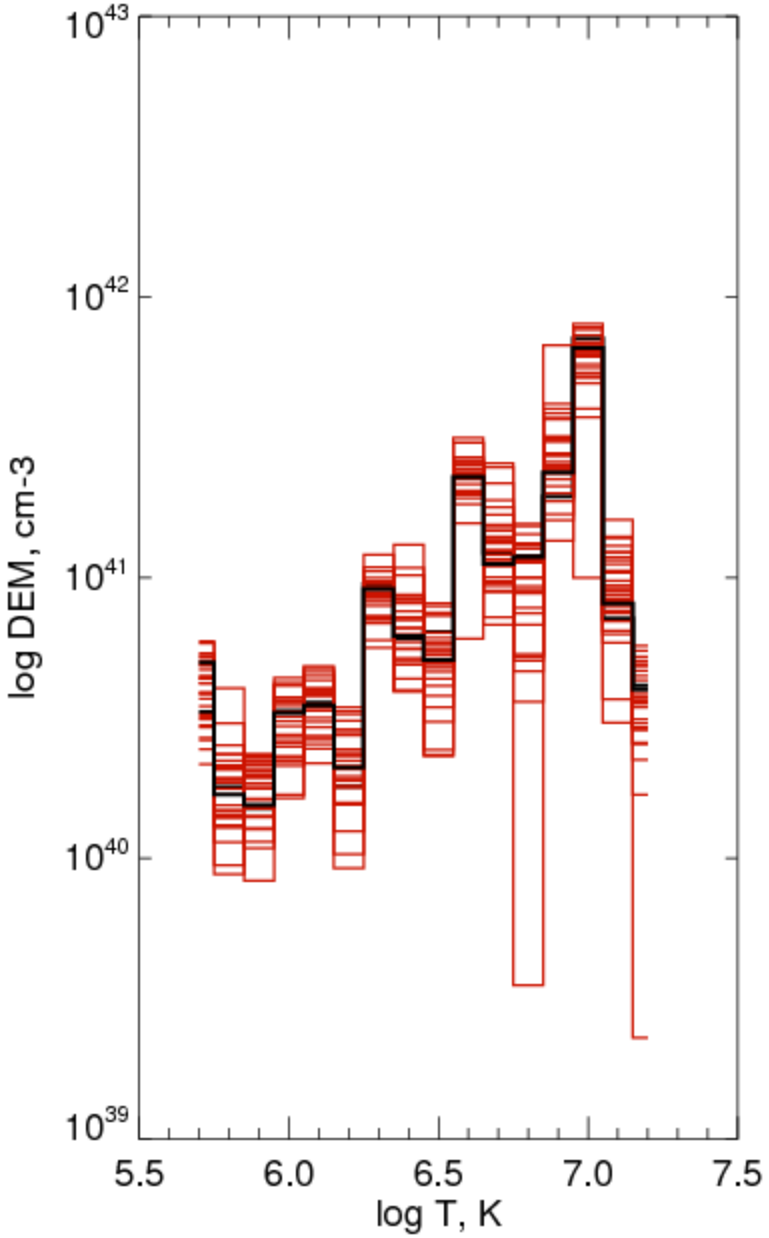
# Verification

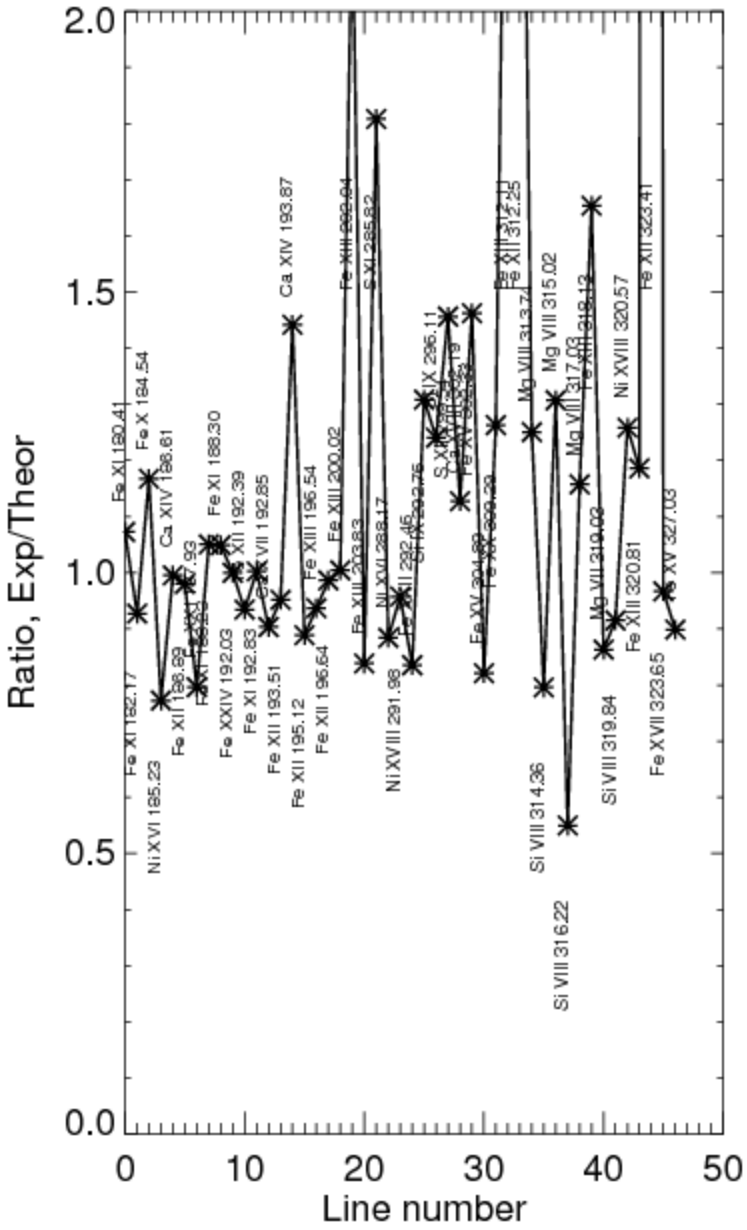
- Comparison with GOES measurements

GOES flux, Watts/m2

| | M5.6 | X1.3 | X3.4 | X17 |
|---|---|---|---|---|
| 1-8 Å | 1.7e-5 | 1.3e-5 | 3.5e-5 | 1.0e-5 |
| 0.5-4 Å | 1.6e-6 | 1.3e-6 | 3.8e-6 | 9.4e-7 |
| R | 11 | 9.2 | 9.9 | 11 |

# X17 Flare on 2005 September 9th



# Conclusions

- Method for interpretation of spectra
- Method for calibration
- Both can be applied to other spectroscopic & imaging instruments

- “Perfect” coincidence with GOES

- Spectra and DEMs of large flares M5.6, X1.3, X3.4, X17

- Systematic discrepancies in particular lines (Fe XII 202.04, Fe XIII 323.04, Mg VIII 315.01 vs. Si VIII 319. etc)

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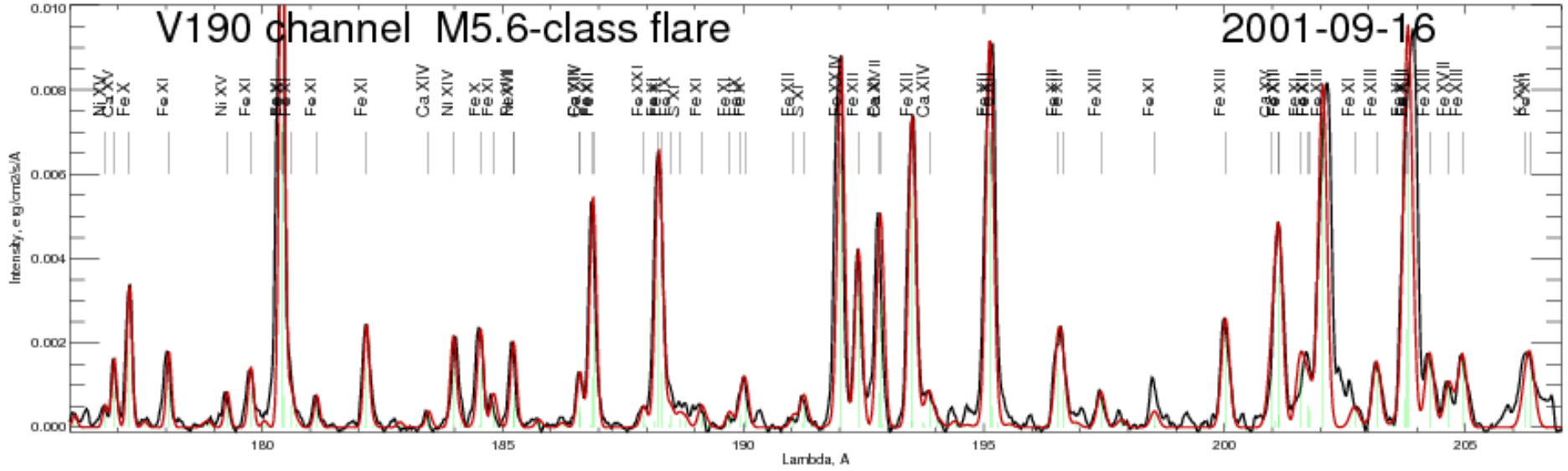
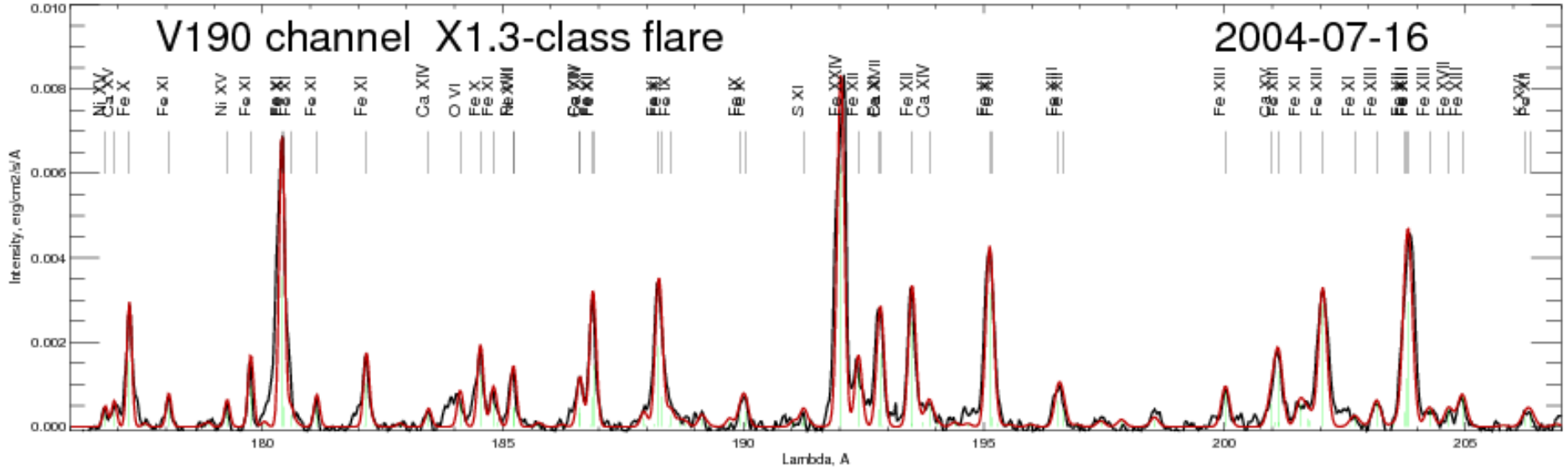

V190 channel M5.6-class flare
2001-09-16
Intensity, erg/cm2/s/A
Lambda, A


V190 channel X1.3-class flare
2004-07-16
Intensity, erg/cm2/s/A
Lambda, A

# Comparison of Bayesian and GA DEM inversions