Swieze spojrzenie na widma SMM BCS

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Bent-Crystal Spectrometer
Solar Maximum Mission
1980-1989

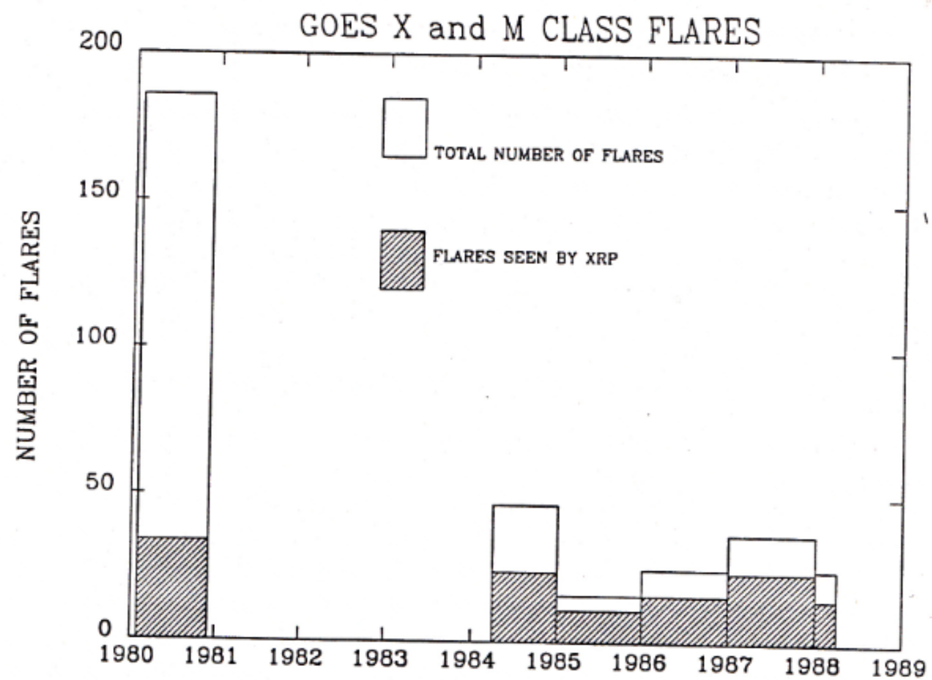


Figure 1-5. M- and X-level Flares observed by *SMM*.

Adventages of SBCS (SMM BCS)

- Extremely high sensitivity (Ca XIX -10 MK+ & Fe XXV 15 MK+ plasmas)
- Overlapping channels: indepednent detectors & electronics→ cross check possible
- The 2D collimator present if front 6 x 6 arcmin
- Sufficient DGI ~30 sec- may allow for non-equilibrium studies
- Preserved data set ~ 1000 flares x 200 spectra

Dis-adventages of SBCS

- Poor/non-existent instrument documentation (instrument paper not written- hand written pages available from Chris Rapley)
- Software missing in IDL to interpret spectra (VMS FORTRAN spectral fitting package SPCFIT rediscovered – Andrzej Fludra)
- Pointing of ROI areas yet un-discovered
- Catalogue of measurements is missing.

OUR revitalization project- subject to grant application?

- Recover the software to read & understand the measurements (based on Dominic Zarro routine to access the “bda” spectral files)
- Recover and use the HXRBS hard X-ray intensity profiles with 0.1s time resolution- not available for RHESSI
- Create a catalogue of ~ 1000 spectral events- all present on NASA SBCS data base (Zaneta & Ania)
- **Create algorithm to „isolate” overlapping lines**
- Provide the community with light-curves of selected line emissions due to resonance, DE, IE, II lines of ions of interest Fe XXVI-XIX-Ka

BCS characteristics

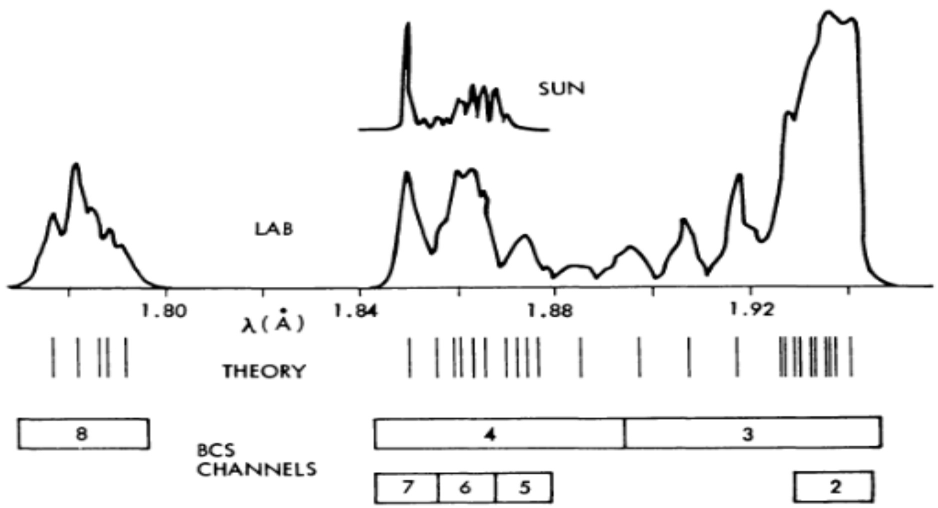


Fig. 7 Spectral coverage of the 7 short wavelength BCS channels. Actual spectra and theoretical line positions are shown schematically for comparison.

Table 1-1. BCS Characteristics

Channel	Ion Stage Number	Wavelength (Å)	Peak T_e (10^6 K)	Resolution $\lambda/\delta\lambda$
1	Ca XIX	3.165 – 3.231	35	3463
2*	Fe^{inner}_{shell}	1.928 – 1.945	2	11206
3	Fe^{inner}_{shell}	1.839 – 1.947	2	4075
4	Fe XXV	1.840 – 1.984	50	3967
5	Fe XXV	1.866 – 1.879	50	8937
6	Fe XXV	1.854 – 1.867	50	8937
7	Fe XXV	1.842 – 1.855	50	8911
8*	Fe XXVI	1.769 – 1.796	60	7005

* Channel has data for 1980 only

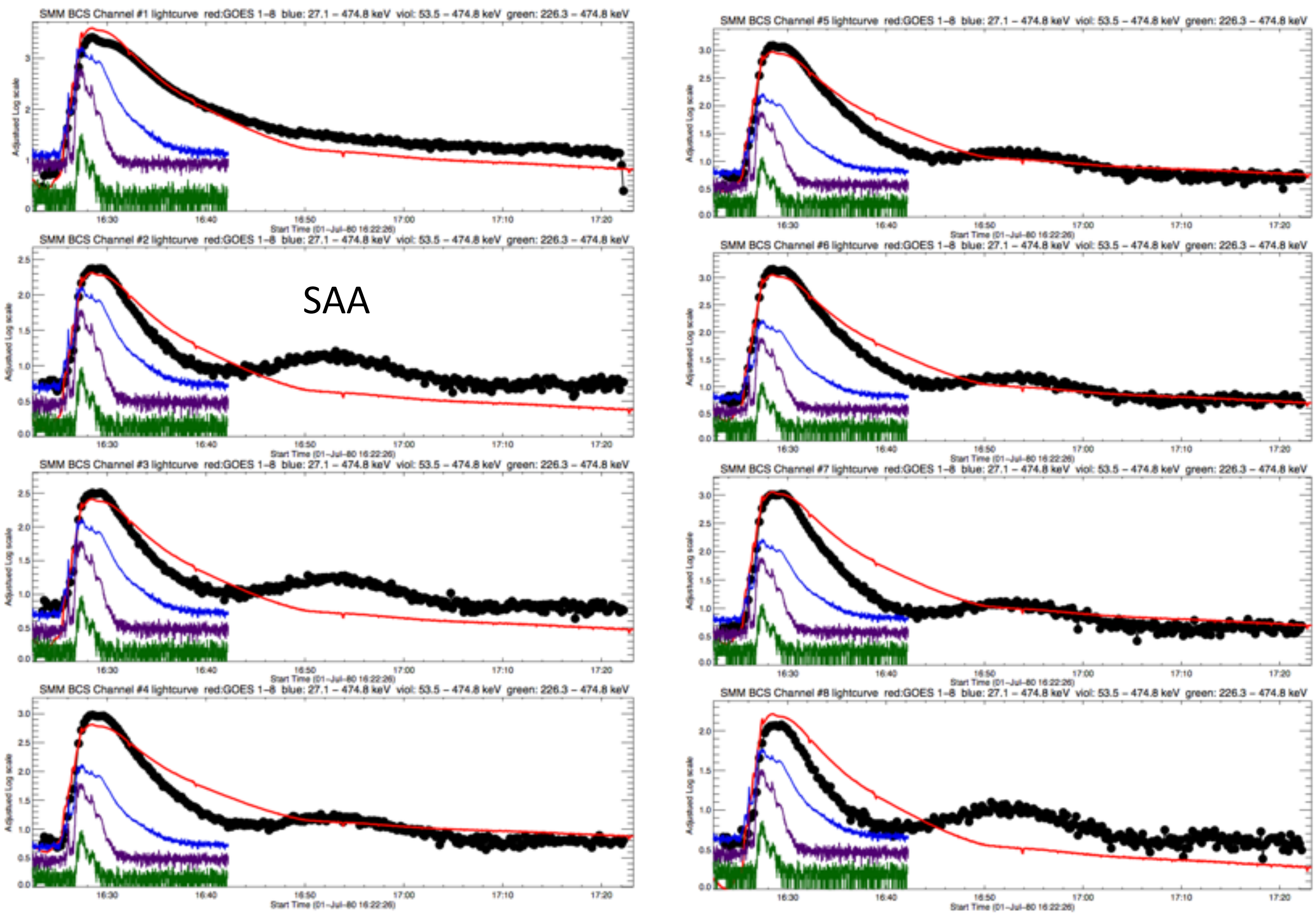
Problems

- Dispersion never accounted for properly (non-linearity of crystal reflections)
- For 1984-1989 period channels are missing
- We expect atomic data (CHIANTI new release) can be used to interpret the observed spectra, also for n or k distributions.
- Previous fitting codes are „uneasy to use”, but available

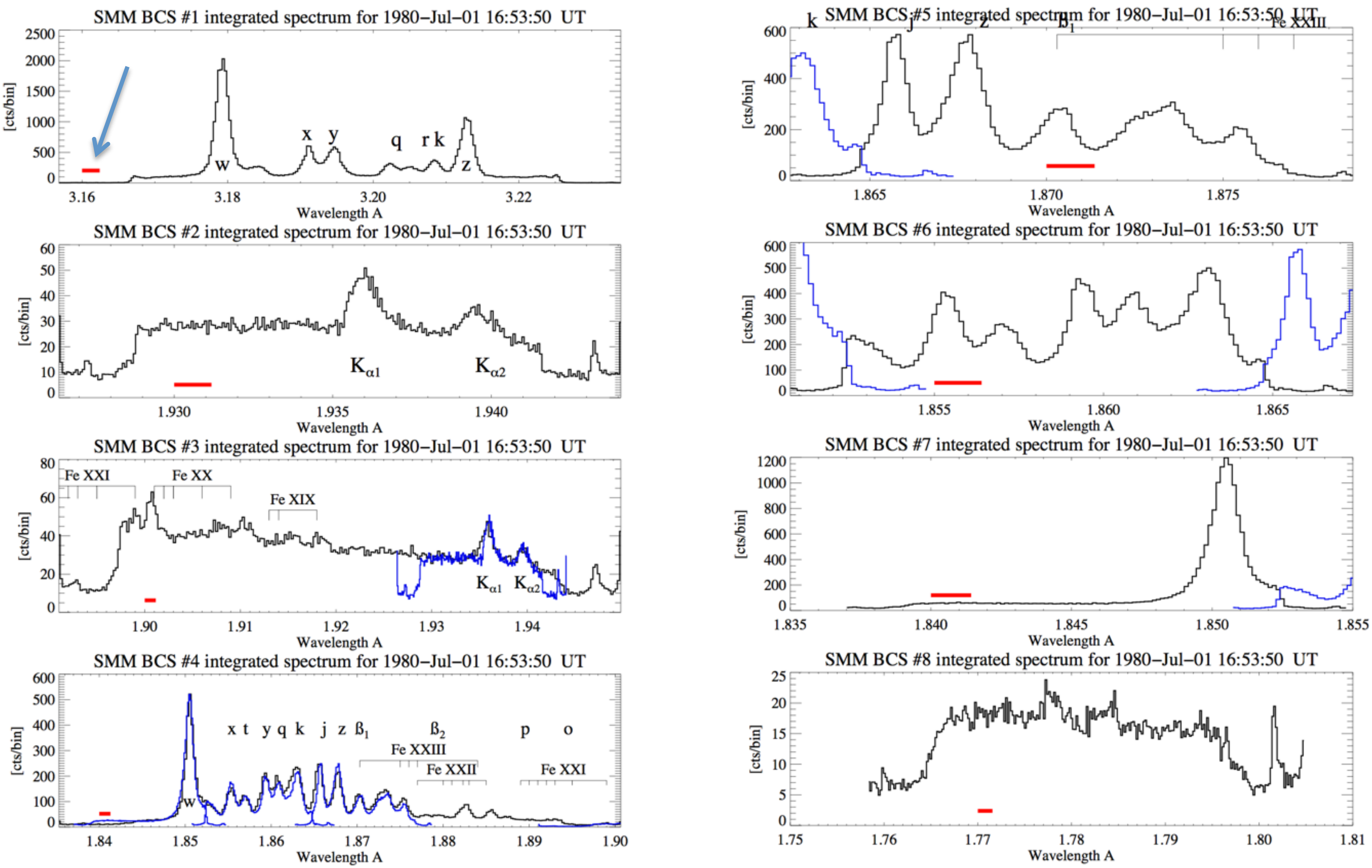
c:\ssw\gen\data\spectra*.*

Nazwa	Roz.	Wielkość	Czas
[..]		<DIR>	2013-03-28 09:26
cabal1	dat	710	1994-10-05 03:00
casec4	dat	11 880	1993-10-05 03:00
f26sec4	dat	6 442	1993-10-07 03:00
febal1	dat	1 591	1993-10-08 04:08
febal2	dat	4 552	1998-01-05 14:20
fesec4	dat	17 784	1993-10-06 03:00
mewe_cosmic	genx	399 472	1993-02-25 01:00
mewe_solar	genx	399 492	1993-02-26 01:00
subal1	dat	1 025	1993-09-01 03:00
susec4	dat	8 798	1994-01-13 01:00
susec5	dat	14 588	1994-03-24 01:00
susec6	dat	24 175	1995-05-02 03:00
uv_xsections	dat	3 362	2000-03-31 11:31

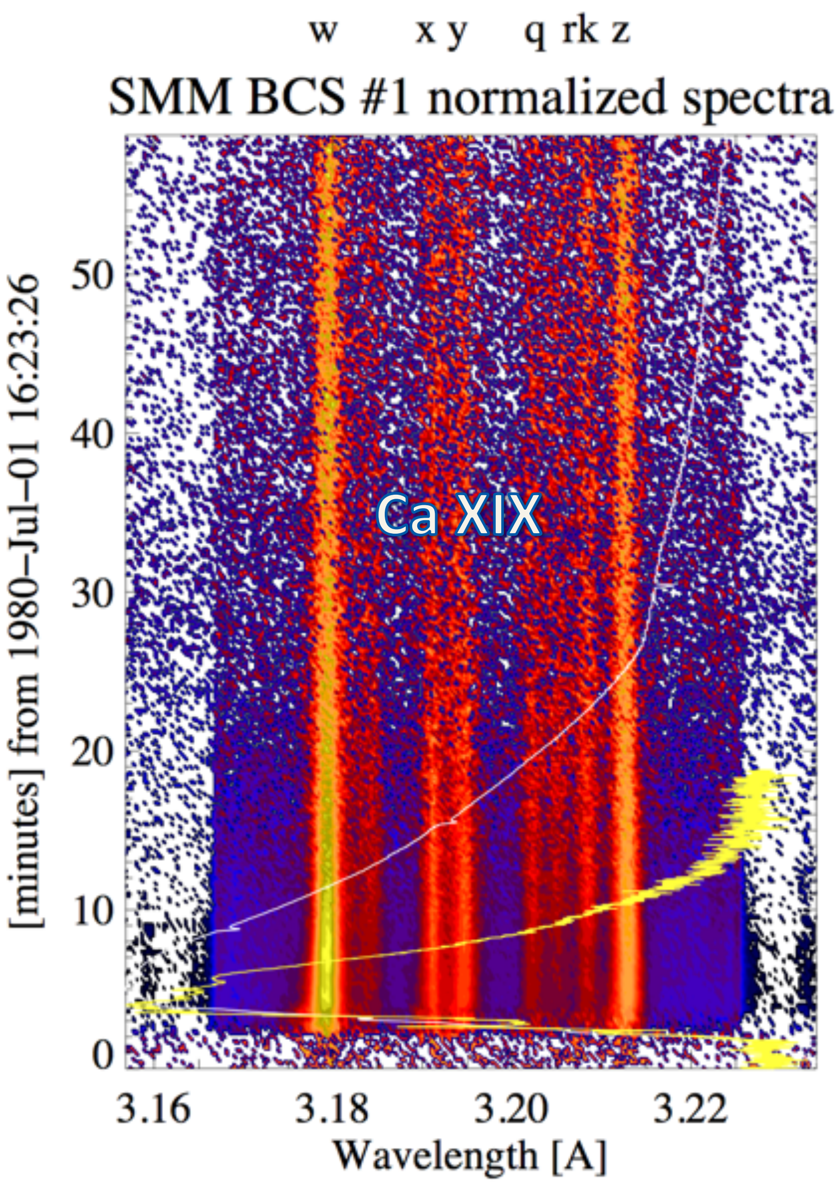
The observations: example flare SOL1980-Jul-01 impulsive 3B white light & gamma event, all 8 SBCS channels

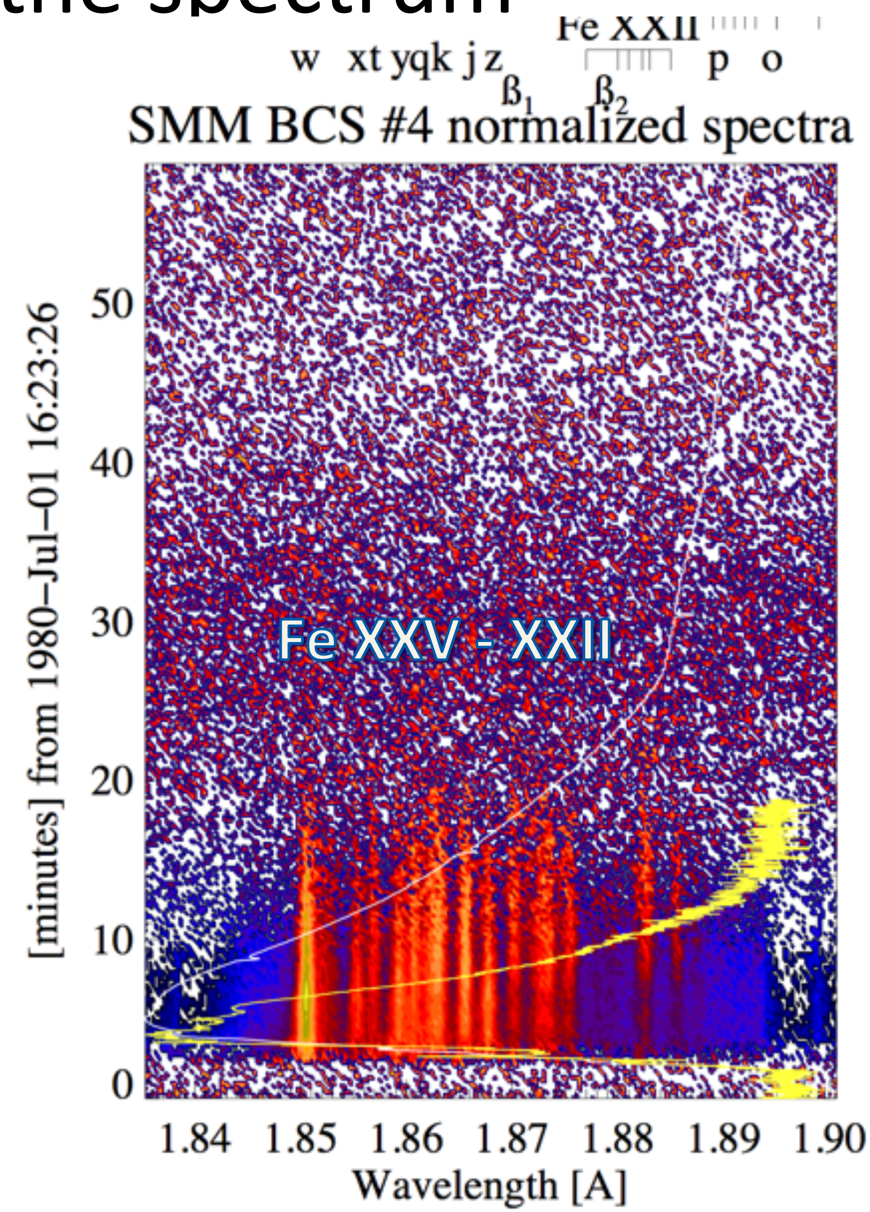


Projected width of collimator FWHM

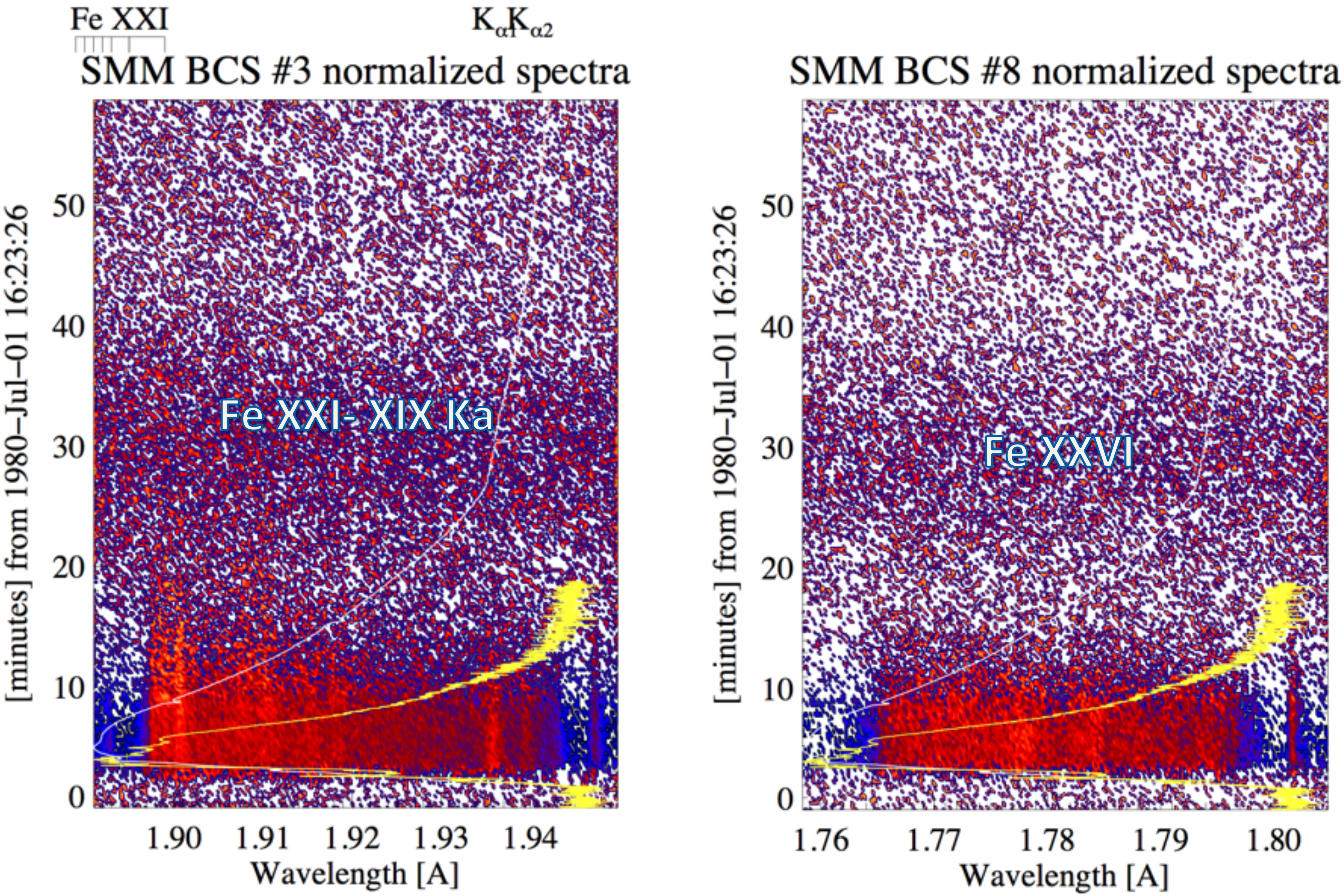


Spectra evolution: normalized to total No. of counts in the spectrum

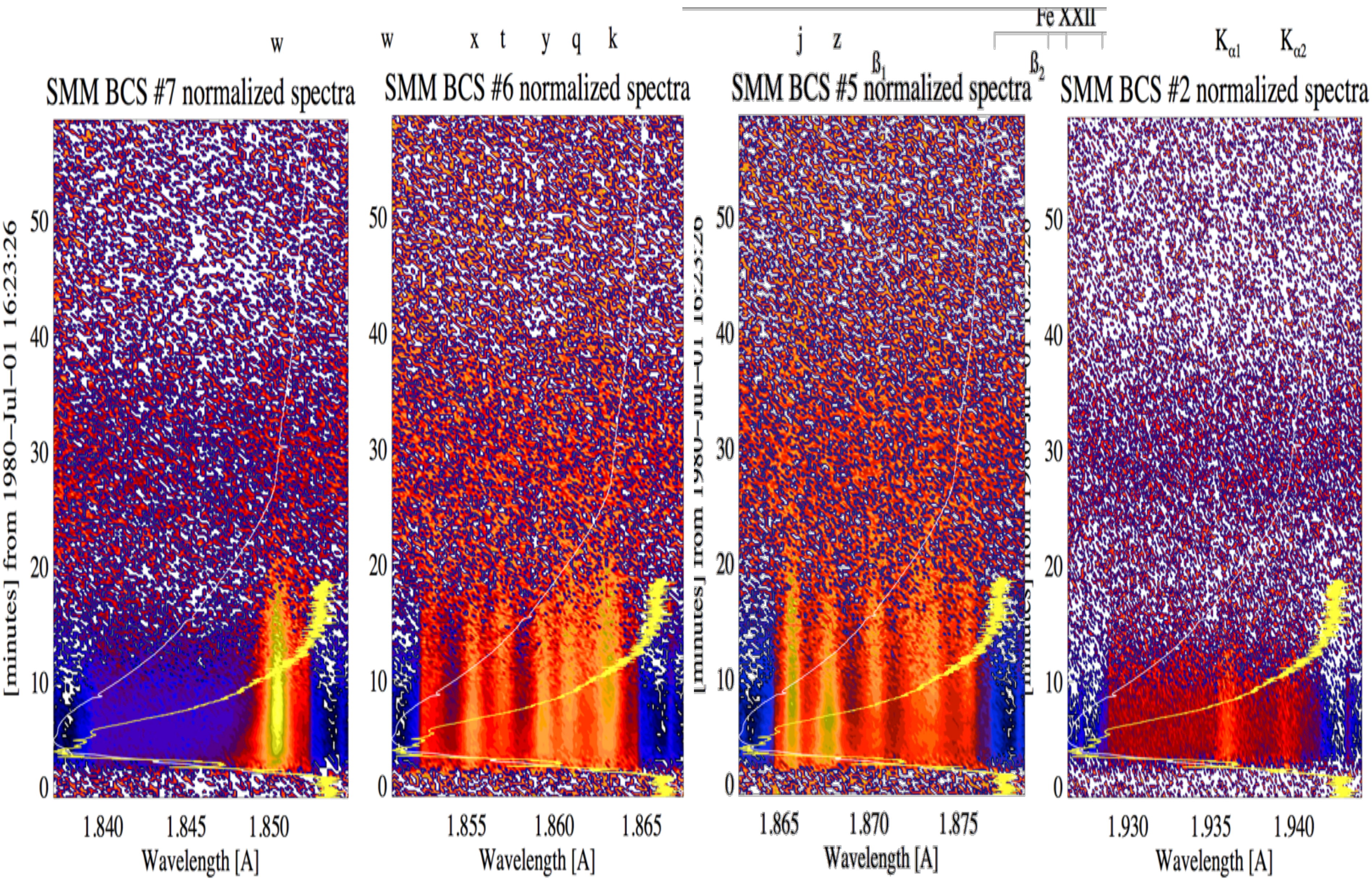




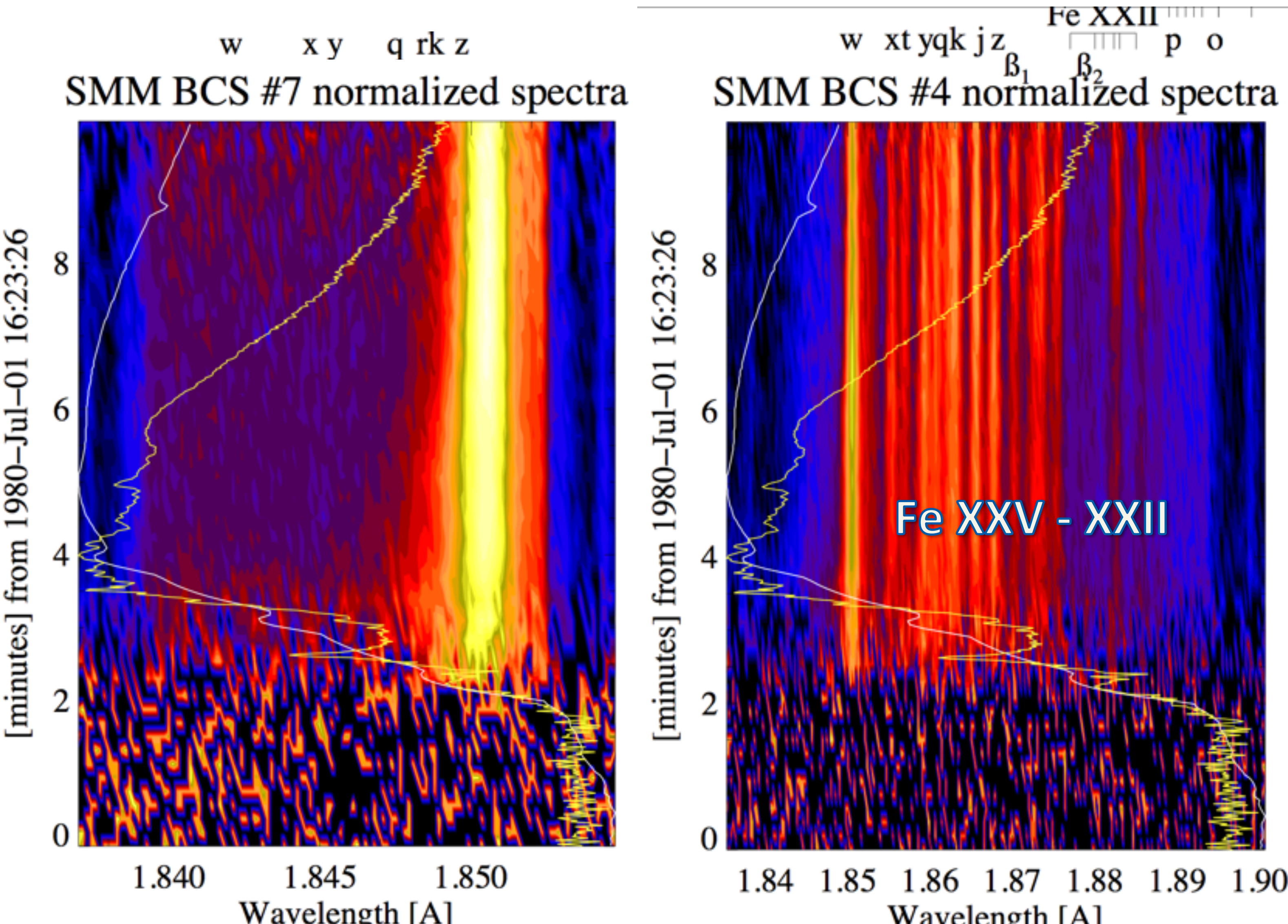
Spectra evolution: normalized to total No. of counts in the spectrum

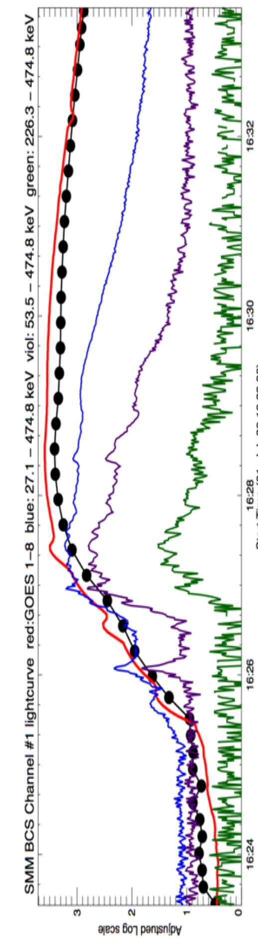


evolution in high-spectral resolution

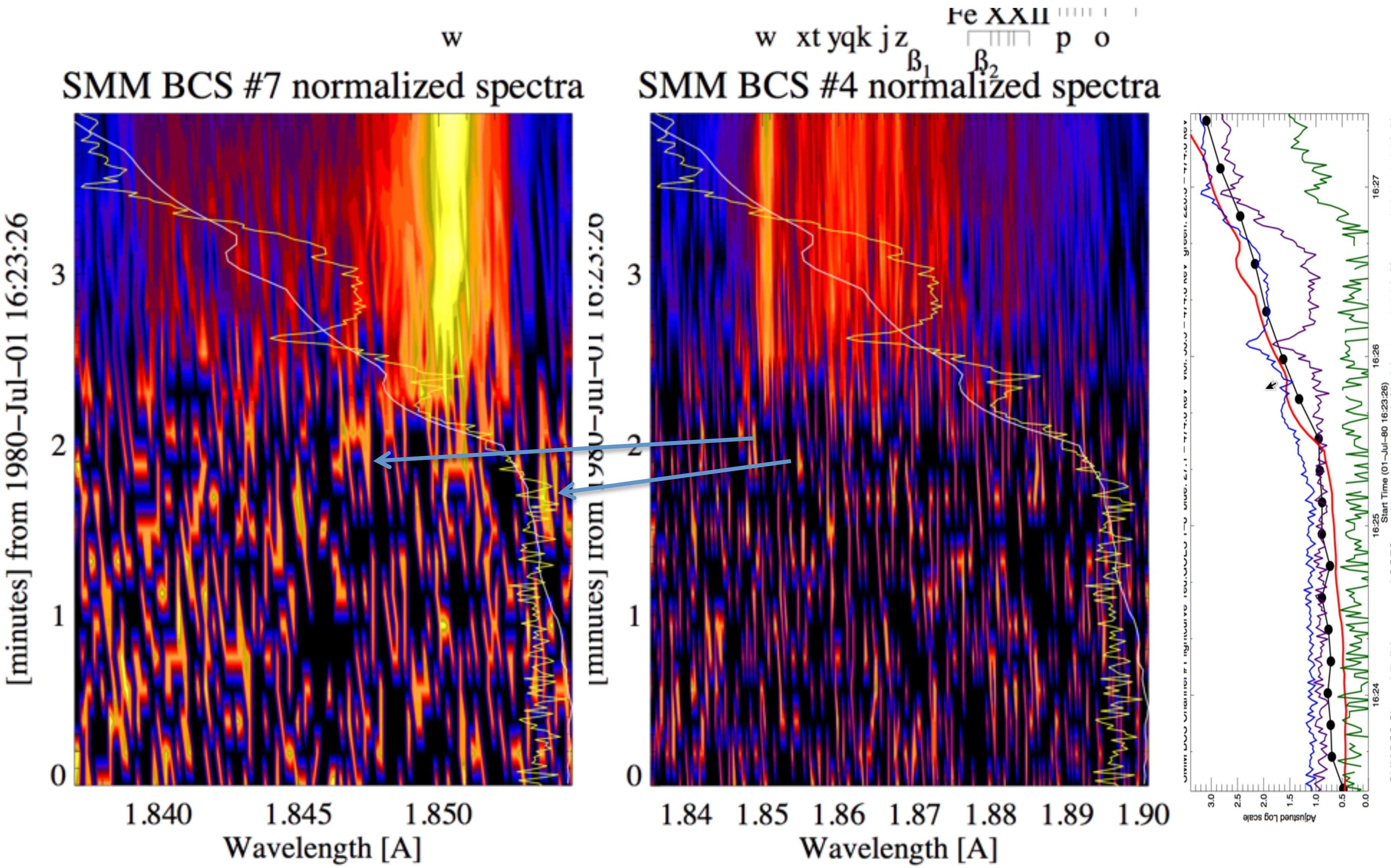


Spectra evolution: early few min

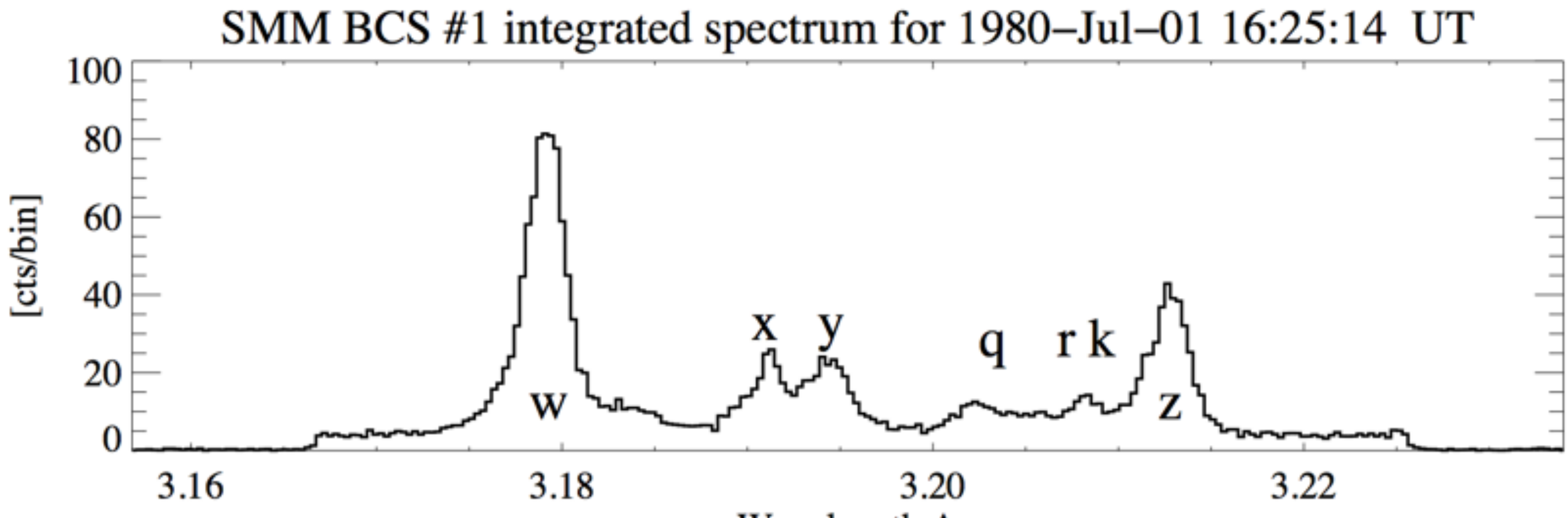


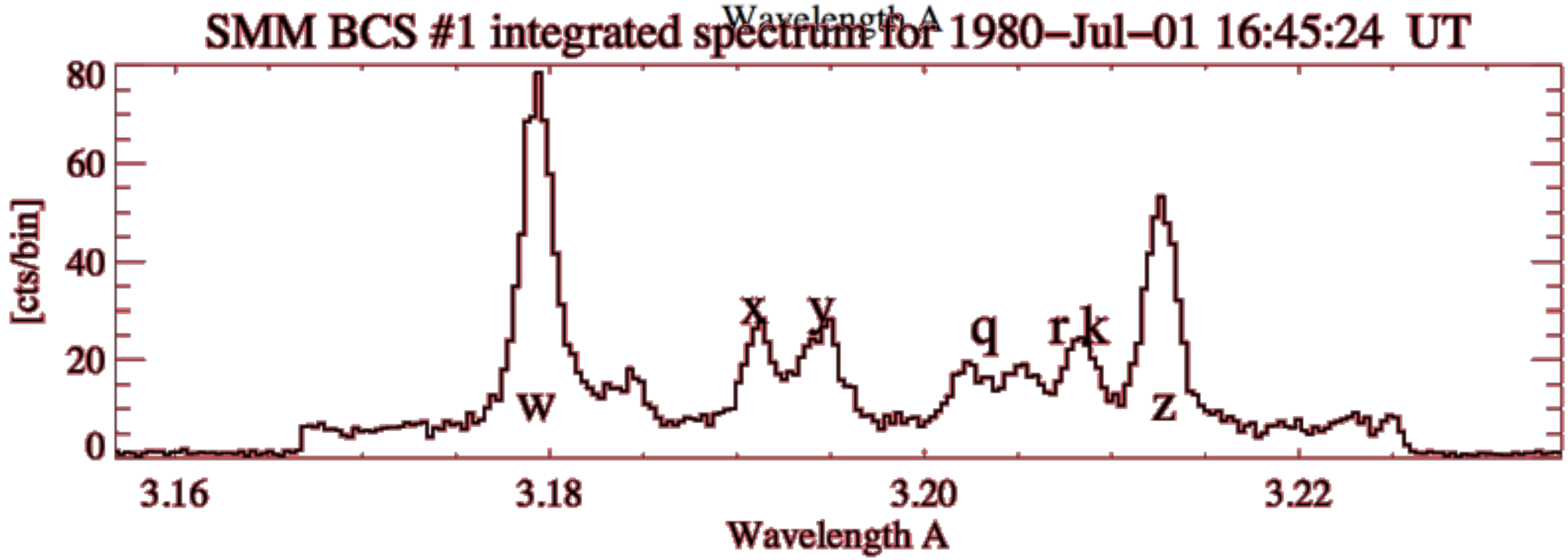


Spectra evolution: very early min

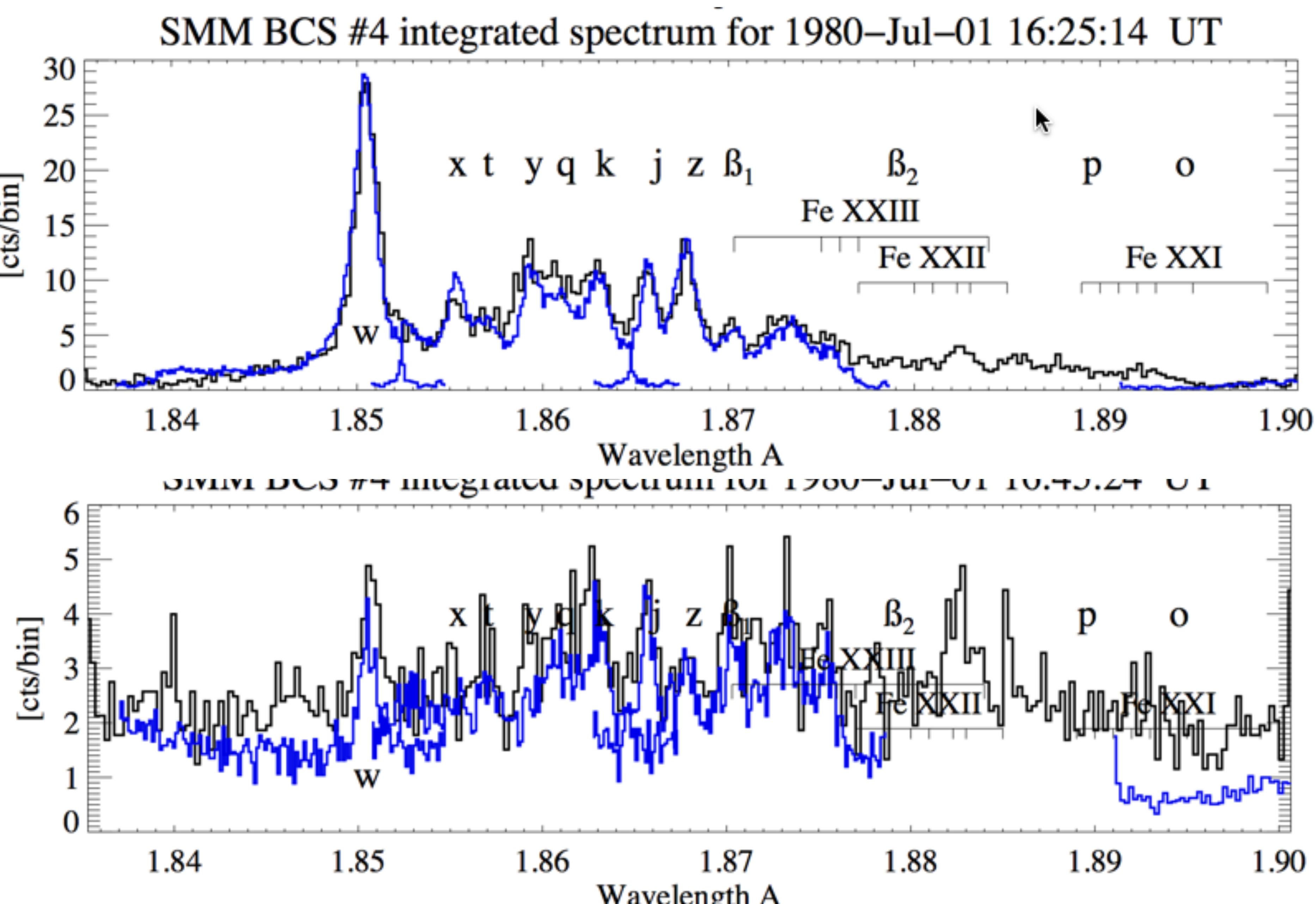


Impulsive vs decay phase spectra Ca

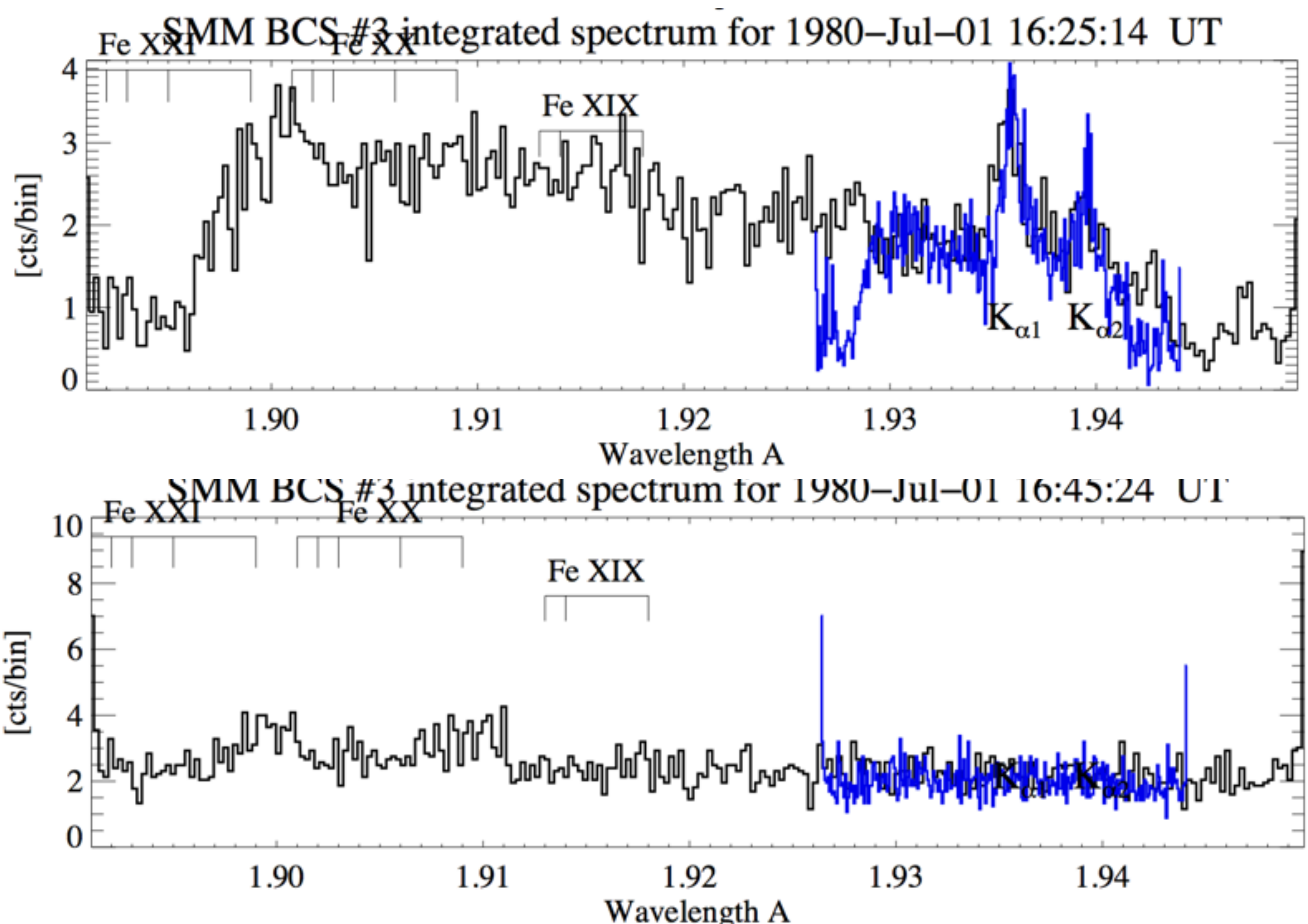




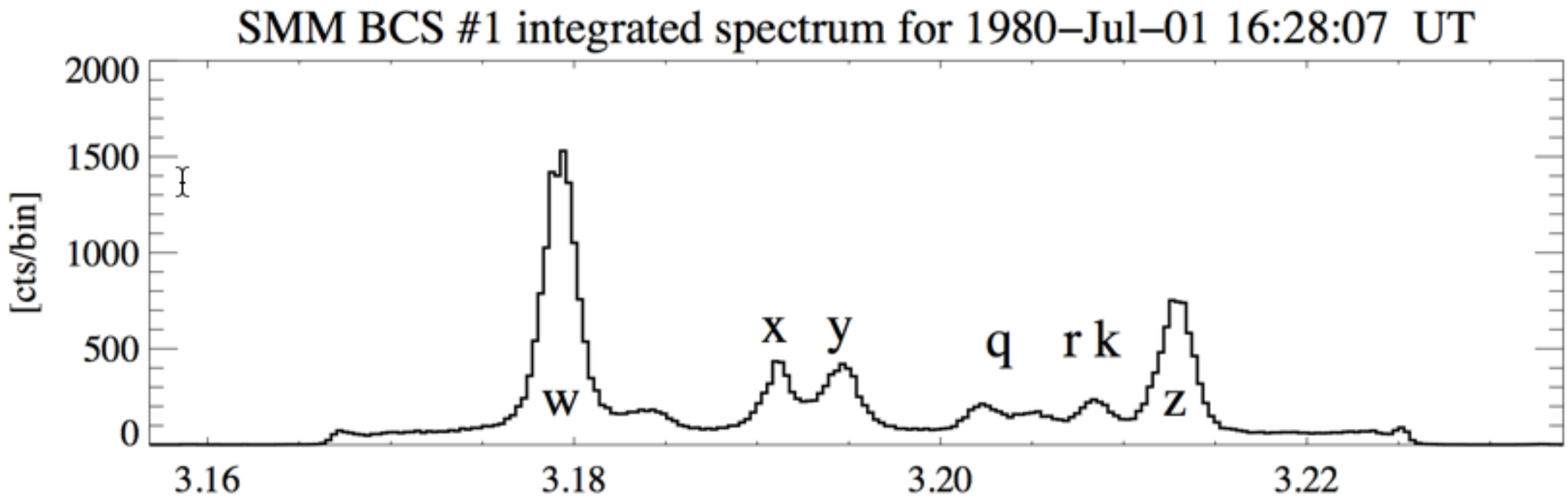
Impulsive vs decay phase spectra Fe

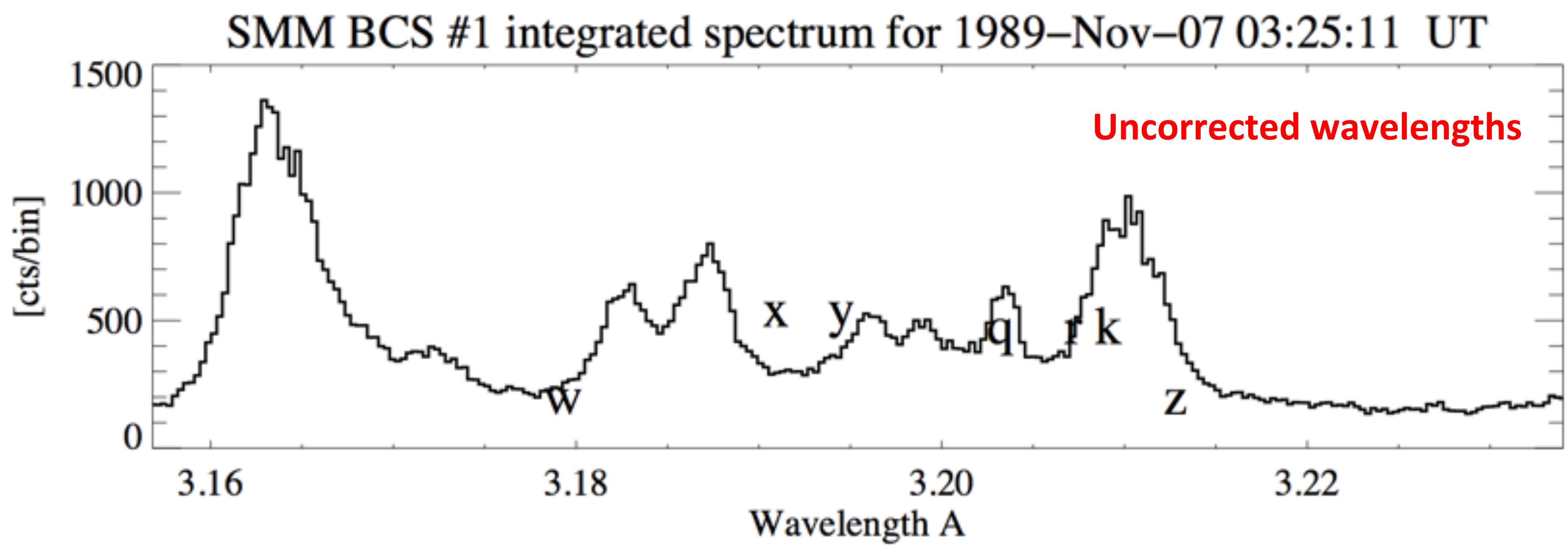


Impulsive vs decay phase spectra Fe Ka

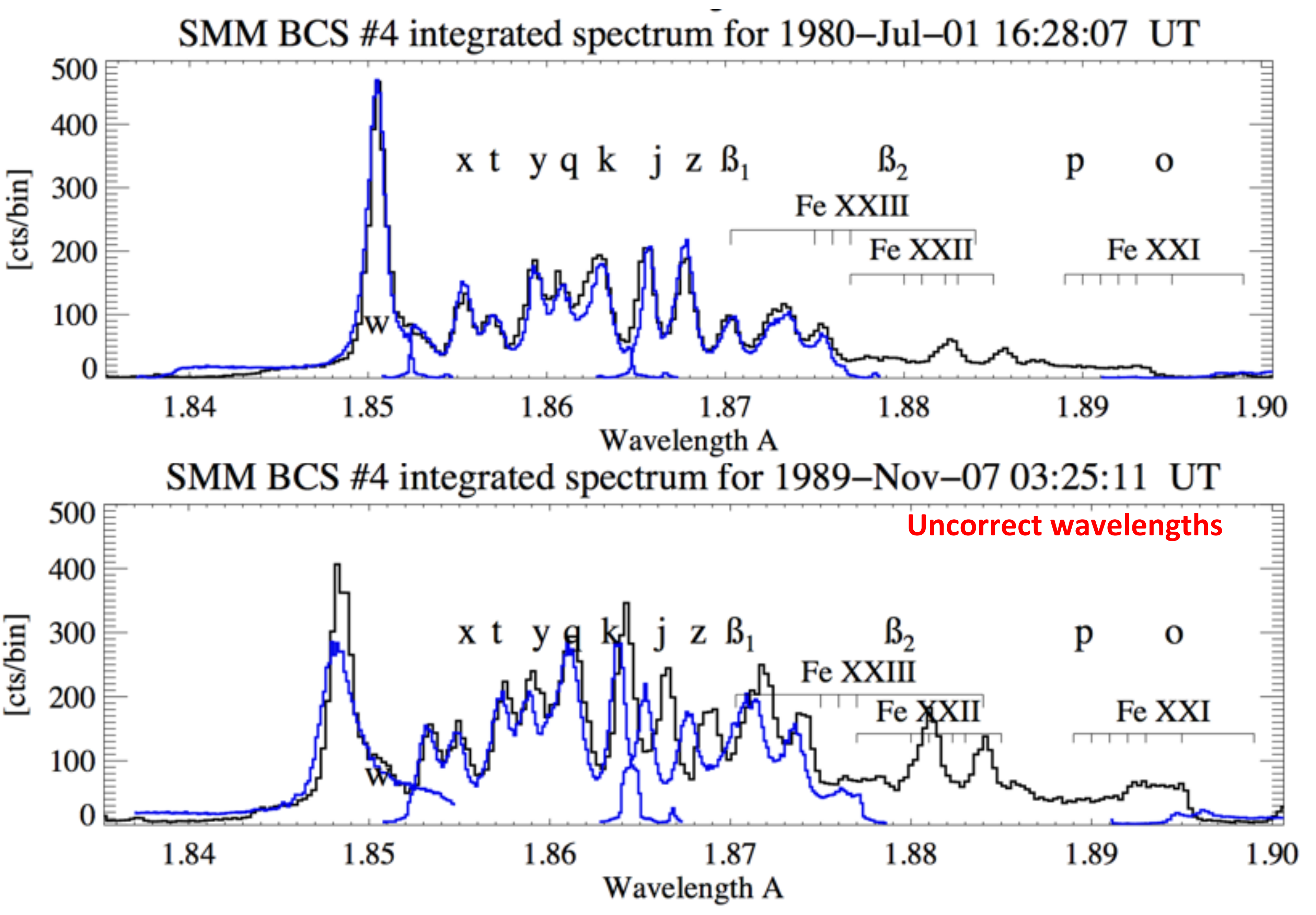


Early (1980) and late (1989) observations

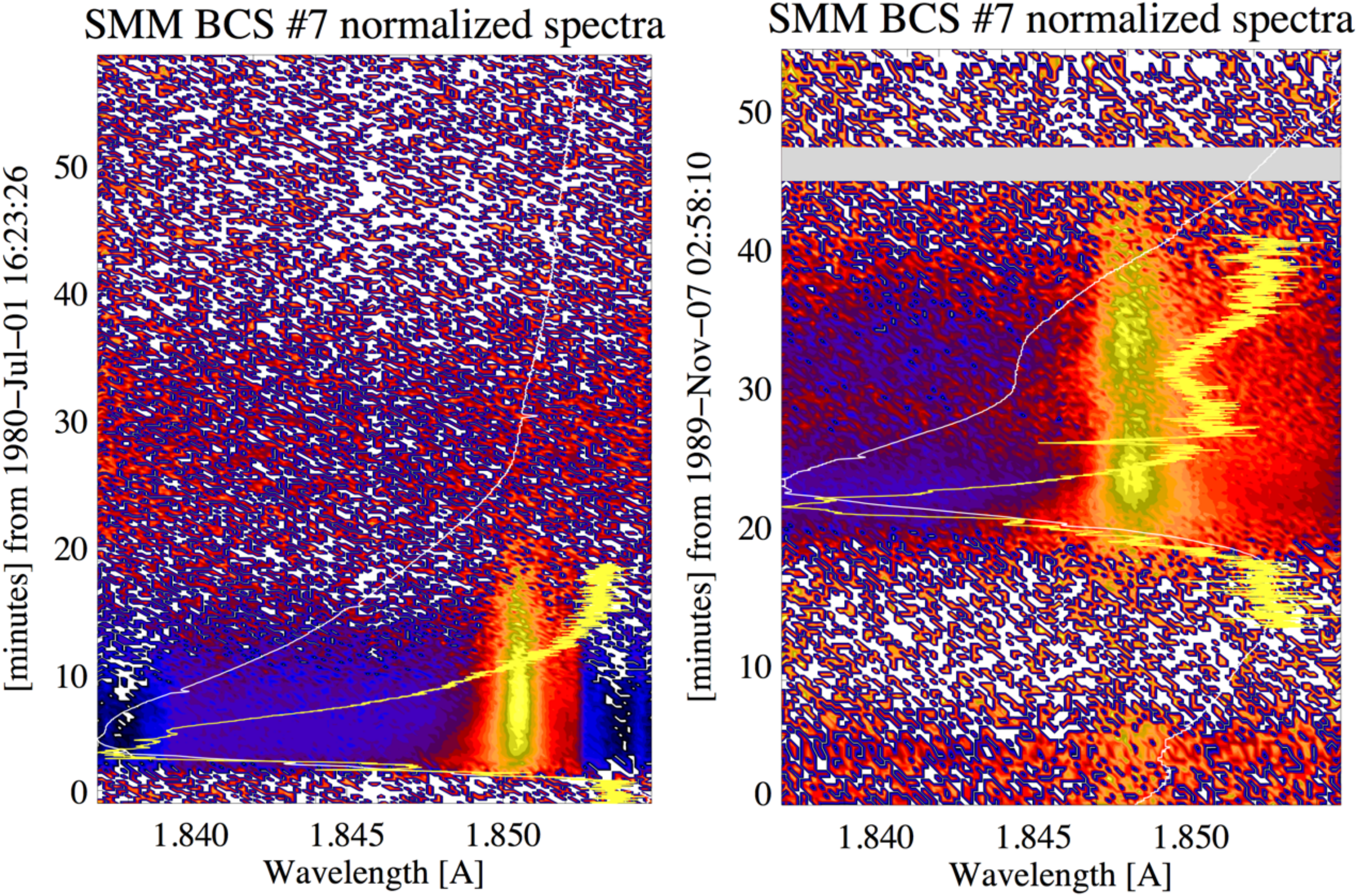




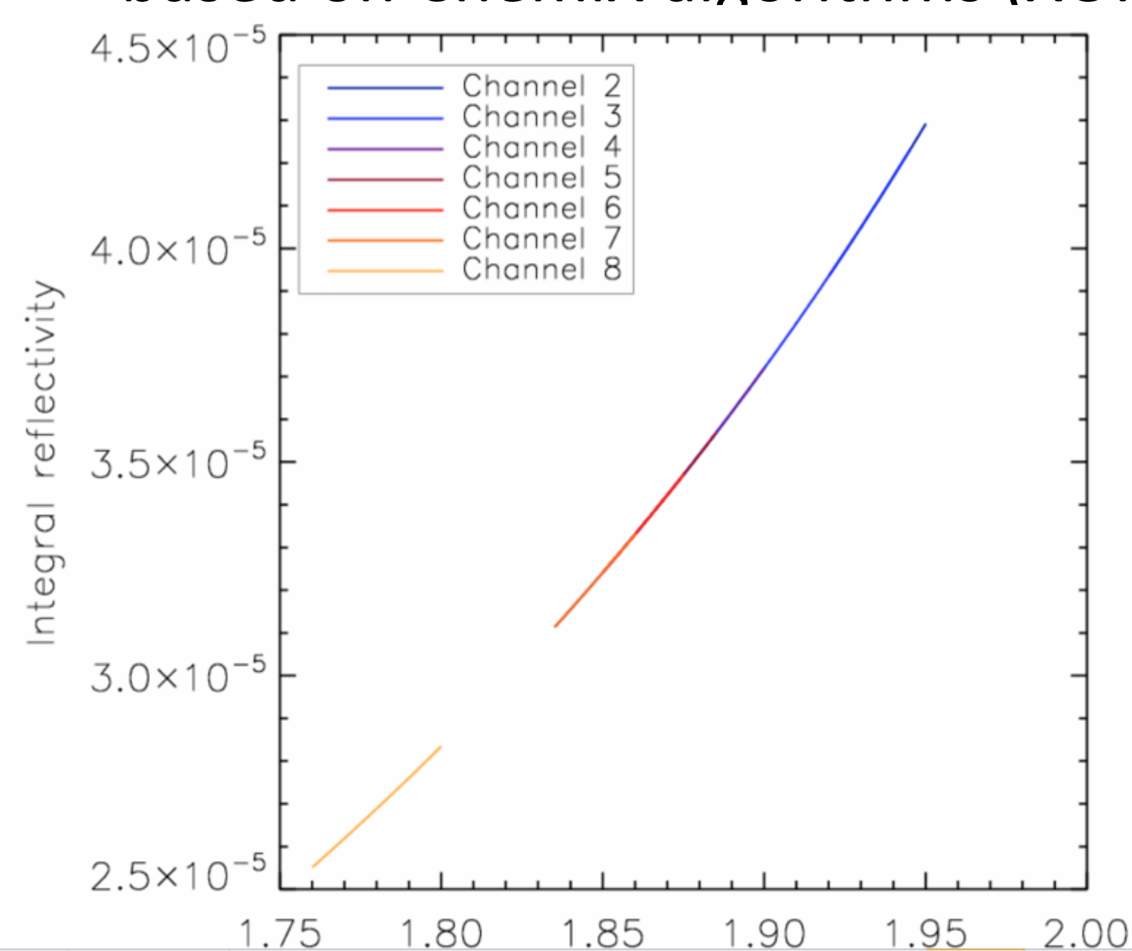
Early (1980) and late (1989) observations



Interesting Channel #7: Fe XXV w



New crystal & SBCS eff. Areas (Zaneta) based on ChemiX algorithms (XOP)



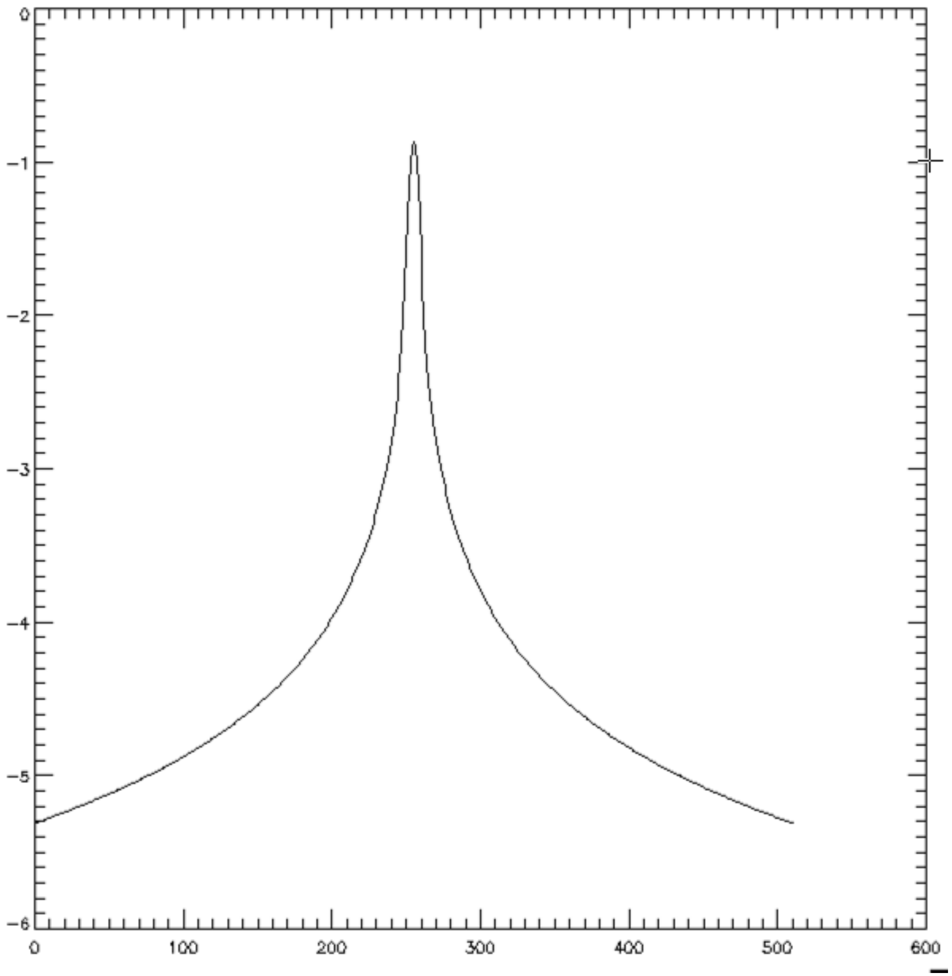
				Rapley 1976					XOP 2.3			
No	Crystal	Crystal dimensions [r	Bent radius [m]	2d spacing [A]	Crystal rocking curve FW	Integral reflectivity [rad]	Integral reflec	Peak reflec	2d spacing	Crystal rockii	Integral reflectivity	Peak reflectivity
1	Ge 220	160 x 30 x 1	5.642	4,00066	0,000145444	3,00E-05	1,03E-04		4,000351	0,00013228	0,00011288	0,724453
2	Ge 422	160 x 30 x 1	11.474	2,30978	4,85E-05	4,00E-05	3,35E-05		2,309603	4,17E-05	4,11E-05	0,853892
3	Ge 422	160 x 30 x 1	3.683	2,30978	4,85E-05	4,00E-05	3,35E-05		2,309603	3,78E-05	3,71E-05	0,848235
4	Ge 422	160 x 30 x 1	3.902	2,30978	4,85E-05	4,00E-05	3,35E-05		2,309603	3,49E-05	3,41E-05	0,843819
5	Ge 422	160 x 30 x 1	16.112	2,30978	4,85E-05	4,00E-05	3,35E-05		2,309603	3,53E-05	3,45E-05	0,844451
6	Ge 422	160 x 30 x 1	16.325	2,30978	4,85E-05	4,00E-05	3,35E-05		2,309603	3,44E-05	3,36E-05	0,843041
7	Ge 422	160 x 30 x 1	16.507	2,30978	4,85E-05	4,00E-05	2,80E-05		2,309603	3,31E-05	3,22E-05	0,841008
8	Ge 422	160 x 30 x 1	8.434	2,30978	4,85E-05	4,00E-05	2,30E-05		2,309603	2,78E-05	2,69E-05	0,832193

However some lines are blended

we developed DEM- based approach to remove the instrumental broadening

- We use W-S deconvolution
- Emission functions are the instrument Voigt profile
- Input data (observed fluxes) are the fluxes in bins
- We assume constant first approximation for DEM deconvoved spectra

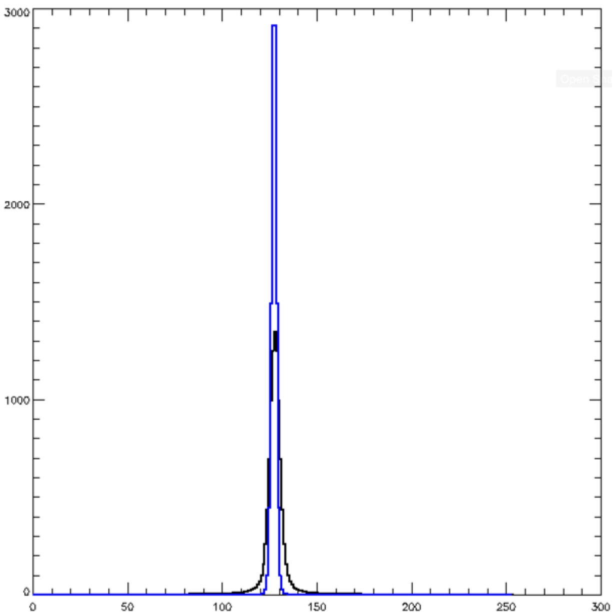
Voigt profile



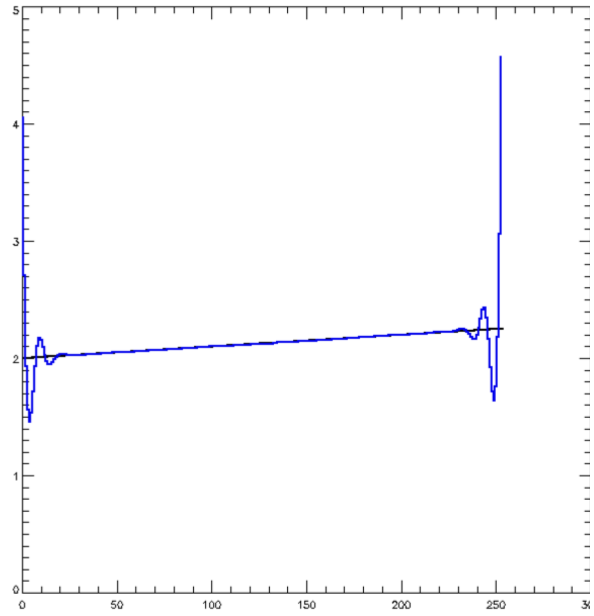
SolarSoft mvoigt(xx,a,pder)

```
• a=replicate(0,7)  ; set-up a-vector
•     ; a[0,1,2]=coefficients of quadratic background, taken zero
•     a[3]=1.e6    ; line intensity
•     a[4]=255     ; line center
•     ; setting defaults
•     a[5]=3.0     ; 1/e Doppler width in units of bin
•     a[6]=1.5     ; rocking width (1/e units)
•     if keyword_set(a5) then a[5]=a5
•     if keyword_set(a6) then a[6]=a6
•     nor_lor=mvoigt(xx,a,pder)   ; calculates profile
•     nor_lor=nor_lor/total(nor_lor)   ; normalize line profile to unit integral
```

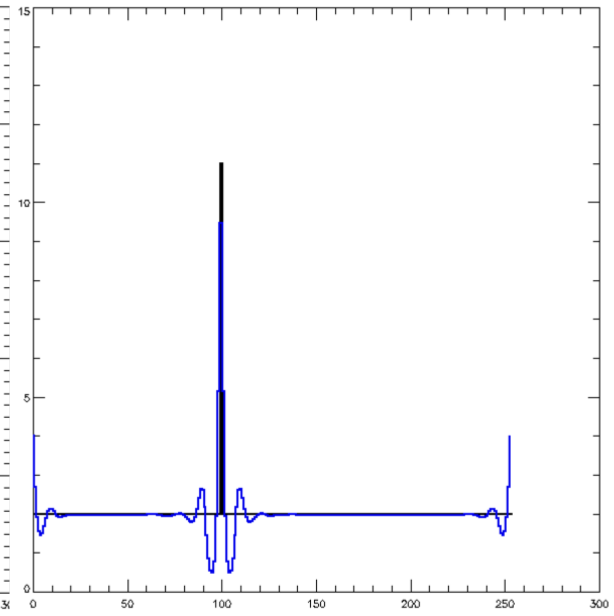
How line deconvolution works



Single bin on input, 1000 iter



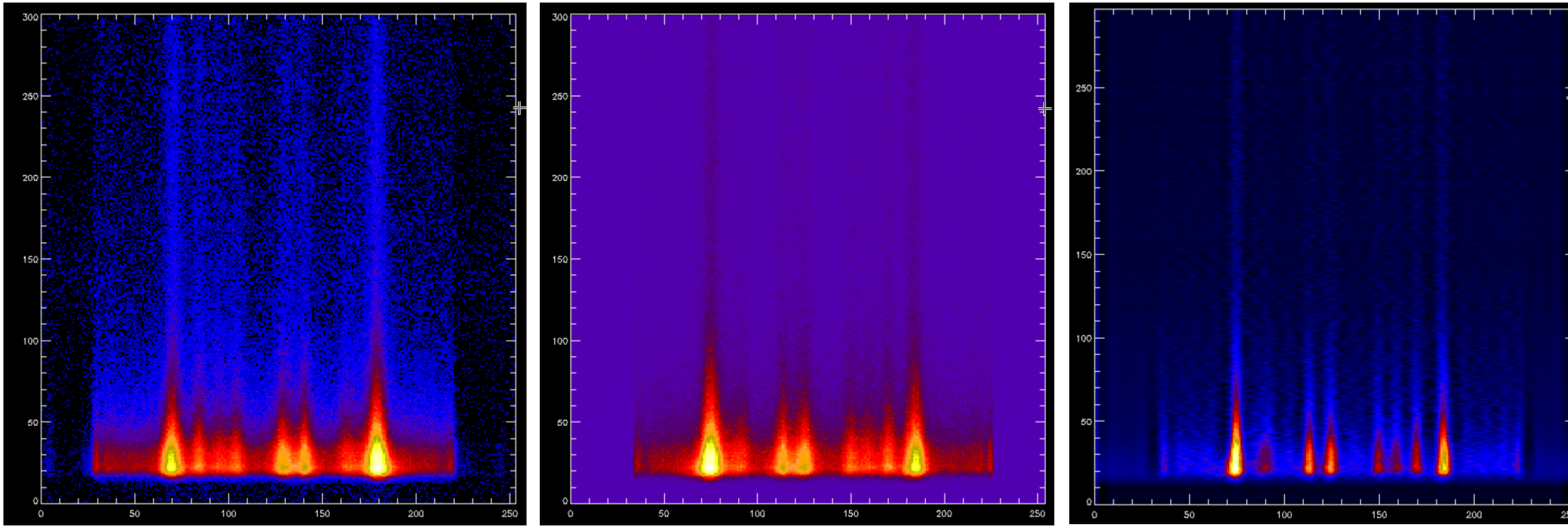
Inclined cont. on input, 1000 iter



Cont+ Single bin on input, 1000 iter

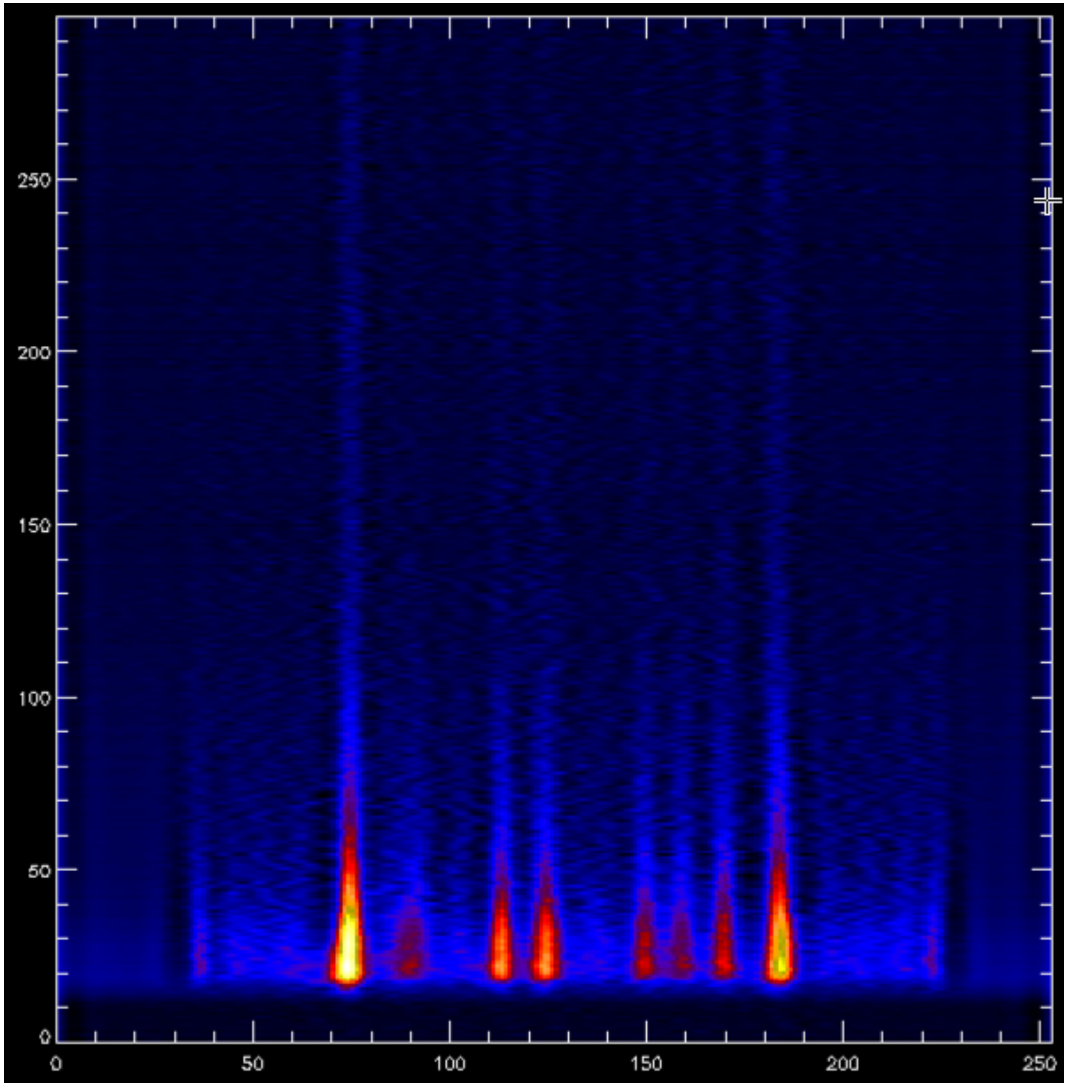
- Solutions always positive, Bayesian→ „detect” lines from spectra, collecting the flux and determining the position.

Comparison of original, cleaned & deconvolved



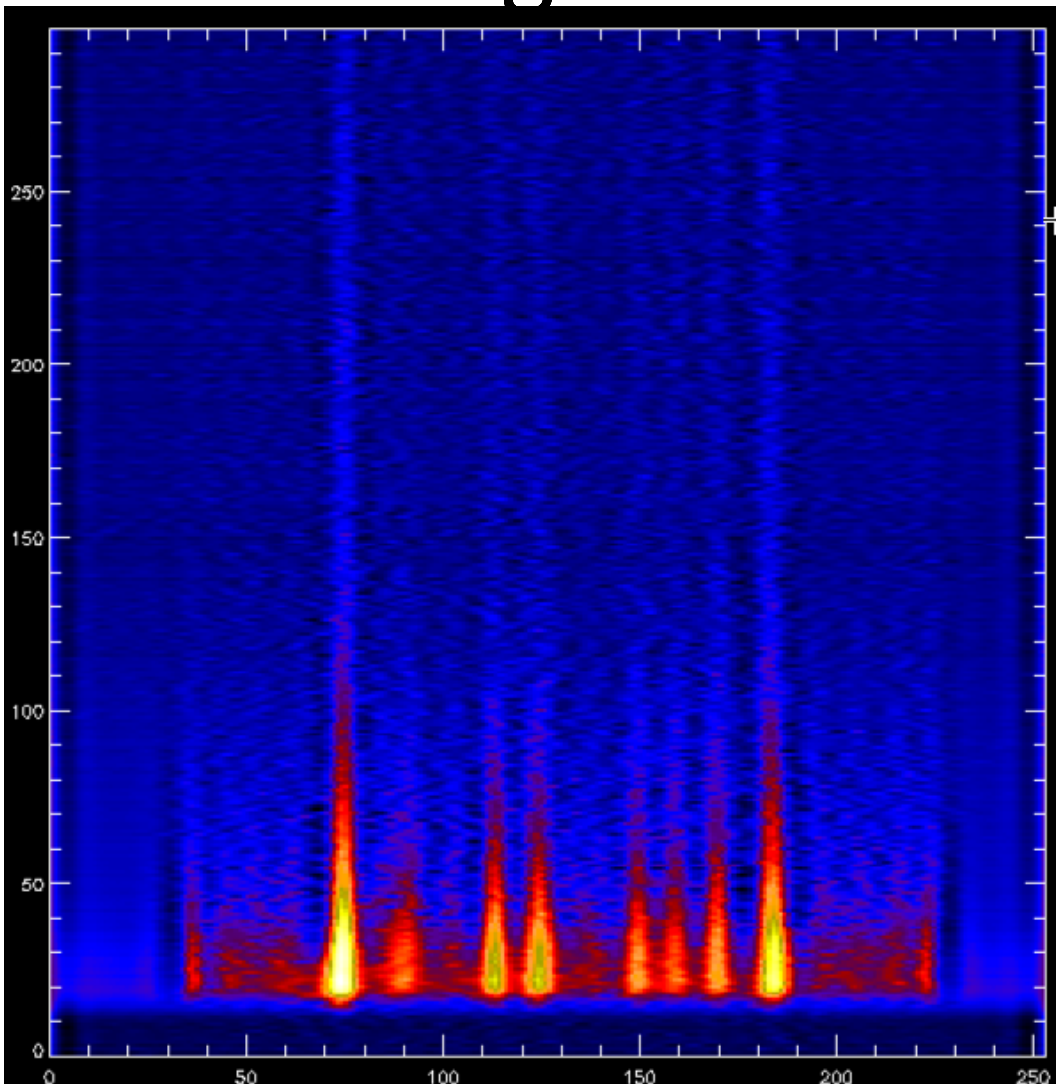
- Effects removed for cleaned spectra:
  - orbital background through analysis of hidden bins, we interpolate background for every bin
  - Continuum established
- On deconvolved:
  - continuum subtracted
  - Add1 for the positive result
  - Start always with „flat spectrum”
- On result: return the continuum, normalize for the total flux

What we see on deconvolved spectra



- **Why it is so consistent?**
- We actually detect presence of spectral features since the W-S deconvolution is always positive and finds optimal solution (Bayesian approach) from existing data, even single counts
- No a priori assumptions on spectral feature location on bin scale

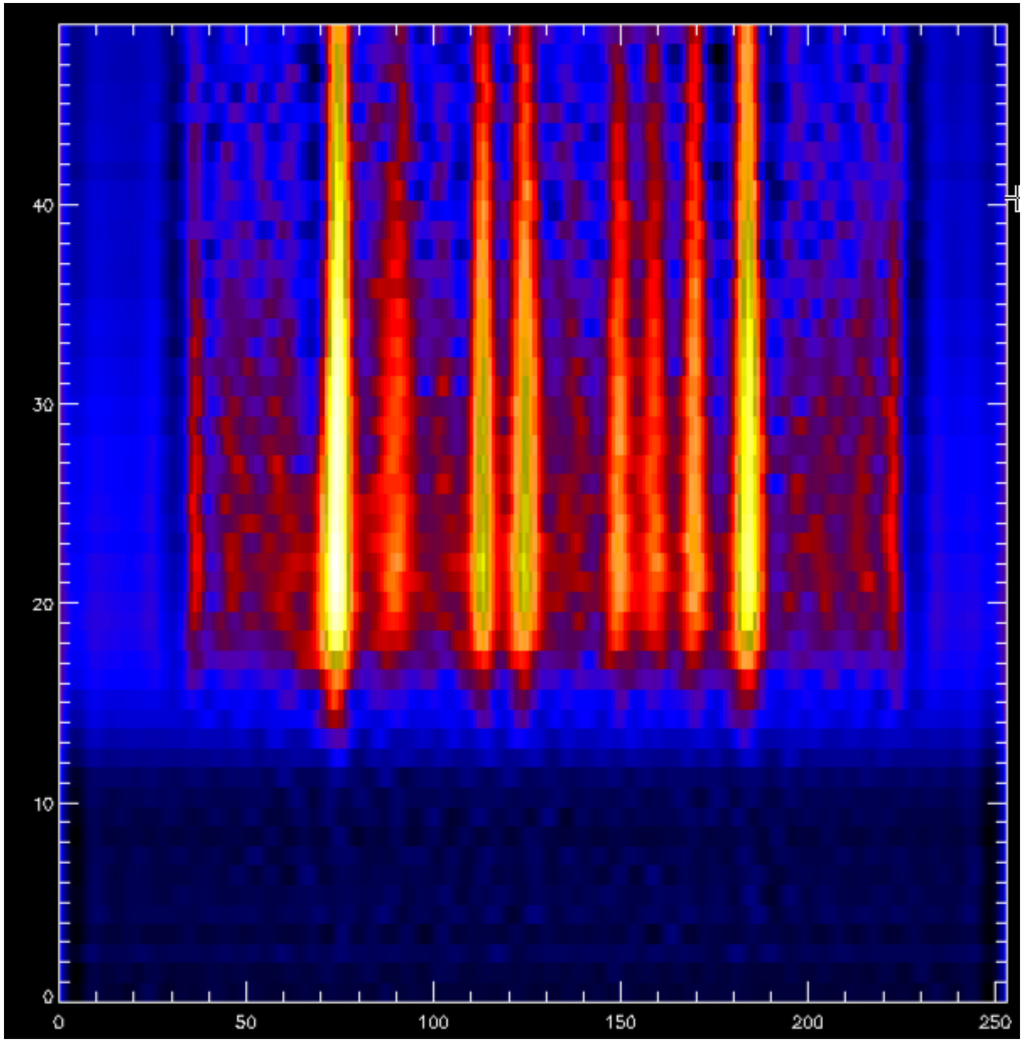
Enlarged deconvolved



image_c,spectrum_lc1[*,3:*]^0.05

- vibrating, but Stable position of lines at low intensities
- If correlated may have some physical meaning

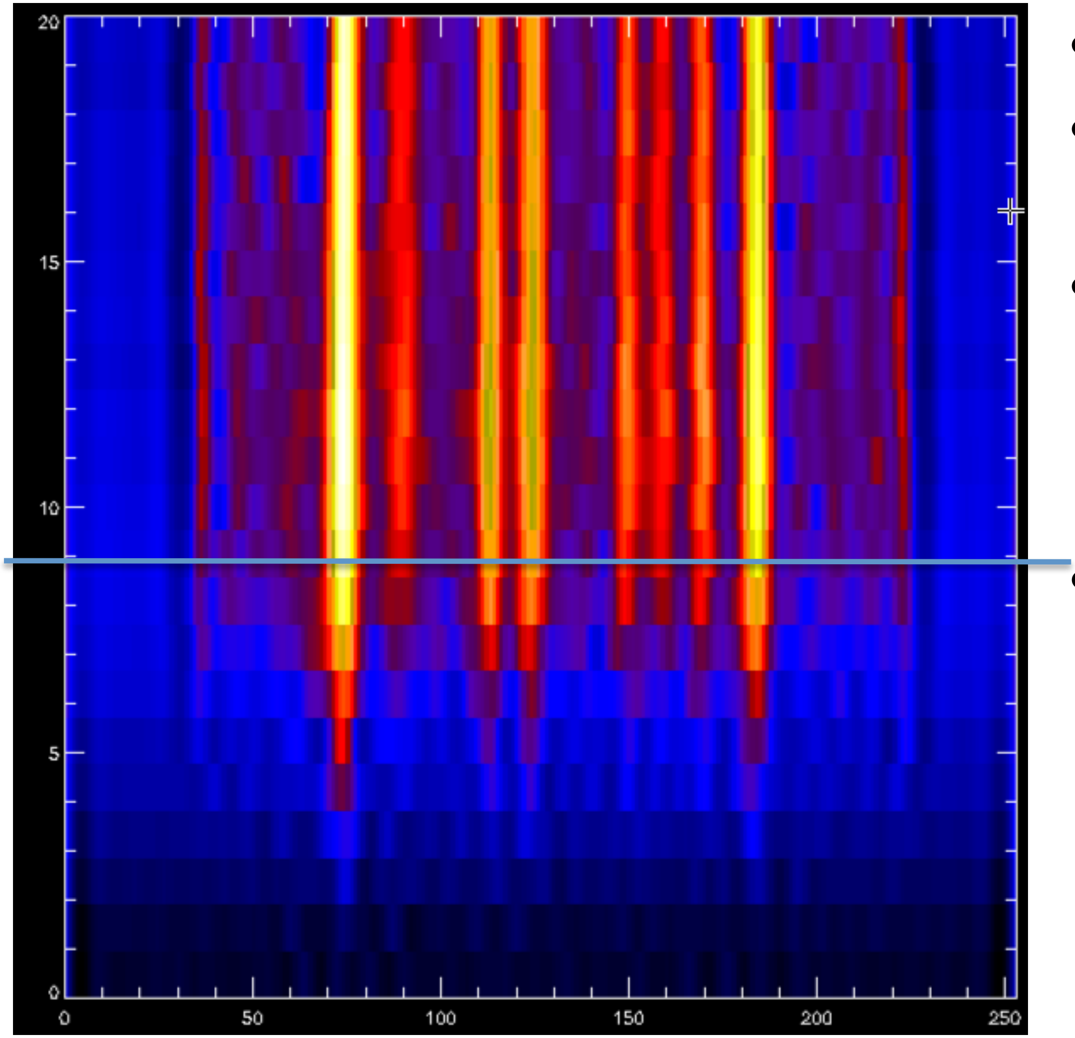
Deconvolved low level „enhanced”



image_c,spectrum_lc1[*,3:3+49]^0.05

- Clearly seen is timing of flare emission arrival
- The spectral image is normalized to the total intensity over the instant spectrum

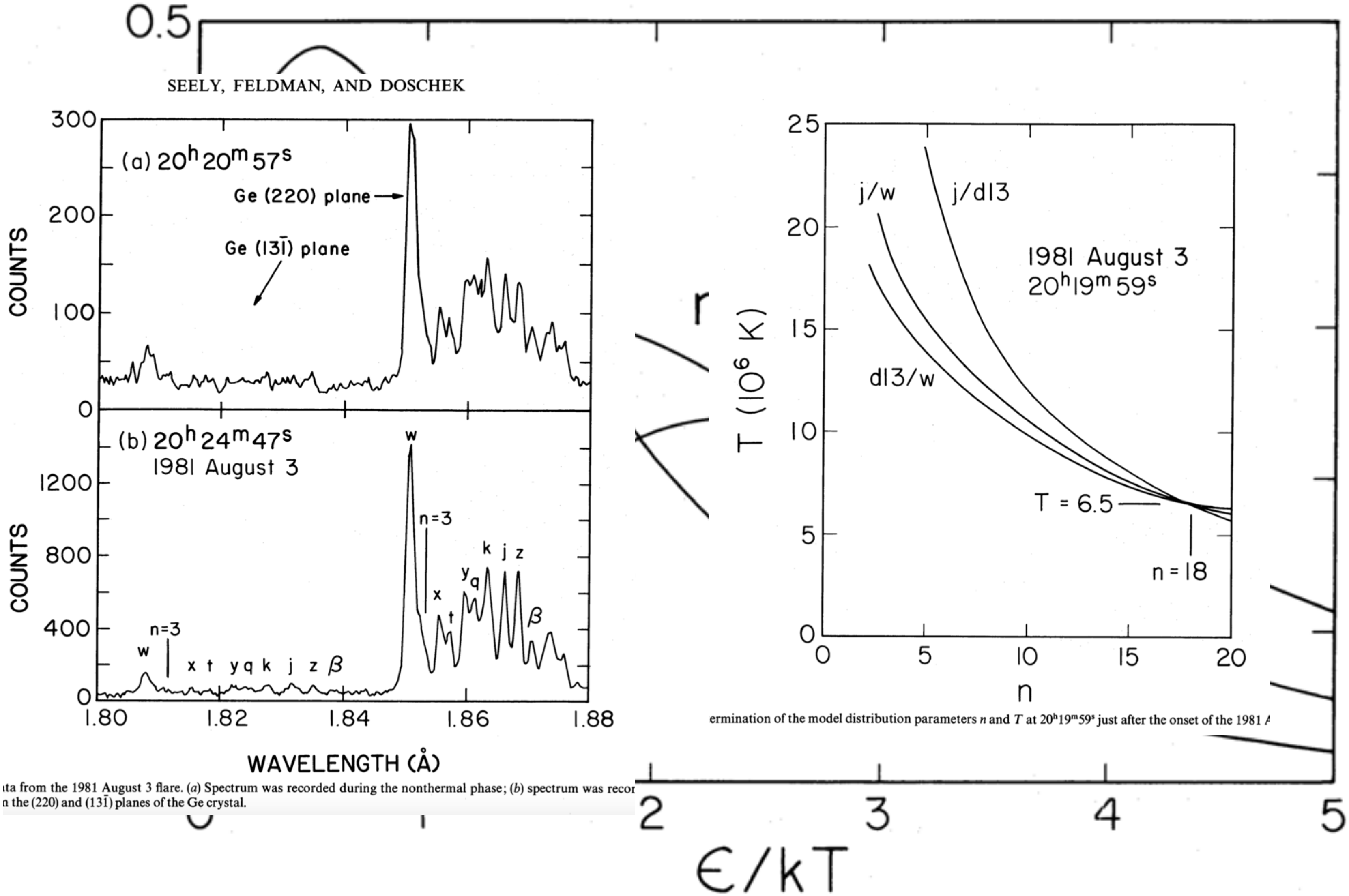
deconvolved very early phase DGI=17s



image_c,spectrum_lc1[*,3:3+49]^0.05

- w, x, y & z first
- q & r somewhat delyed
- Slight bias? of DE against direct excitation and/or innershell exitation
- Electron spectra too hard? Not enough softer electrons at the resonance energies?

THE ASTROPHYSICAL JOURNAL, 319:541–554, 1987 August 1



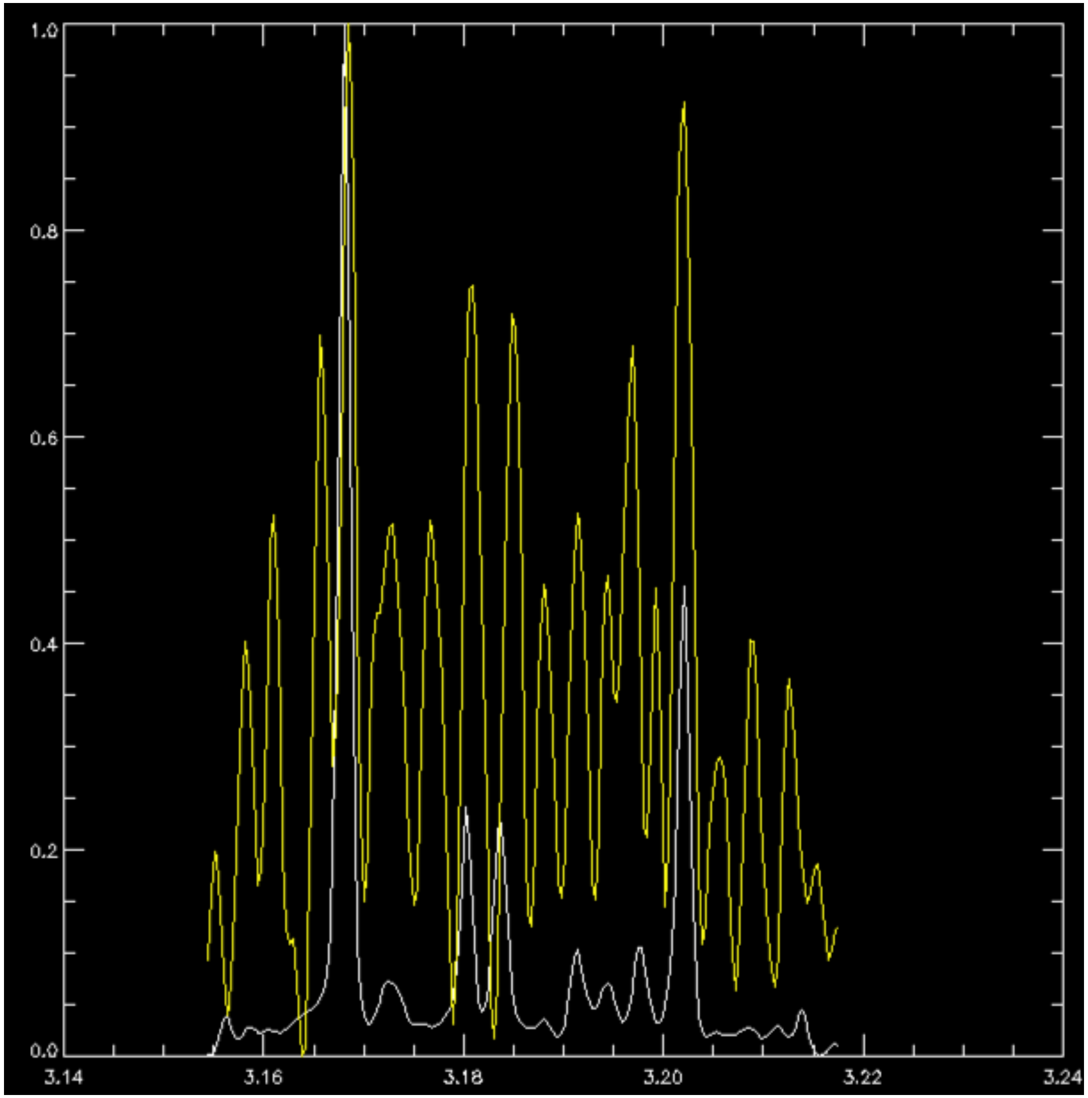
SEELY, FELDMAN, AND DOSCHEK

ıta from the 1981 August 3 flare. (*a*) Spectrum was recorded during the nonthermal phase; (*b*) spectrum was recor
n the (220) and (13$\bar{1}$) planes of the Ge crystal.

ermination of the model distribution parameters *n* and *T* at $20^h19^m59^s$ just after the onset of the 1981 A

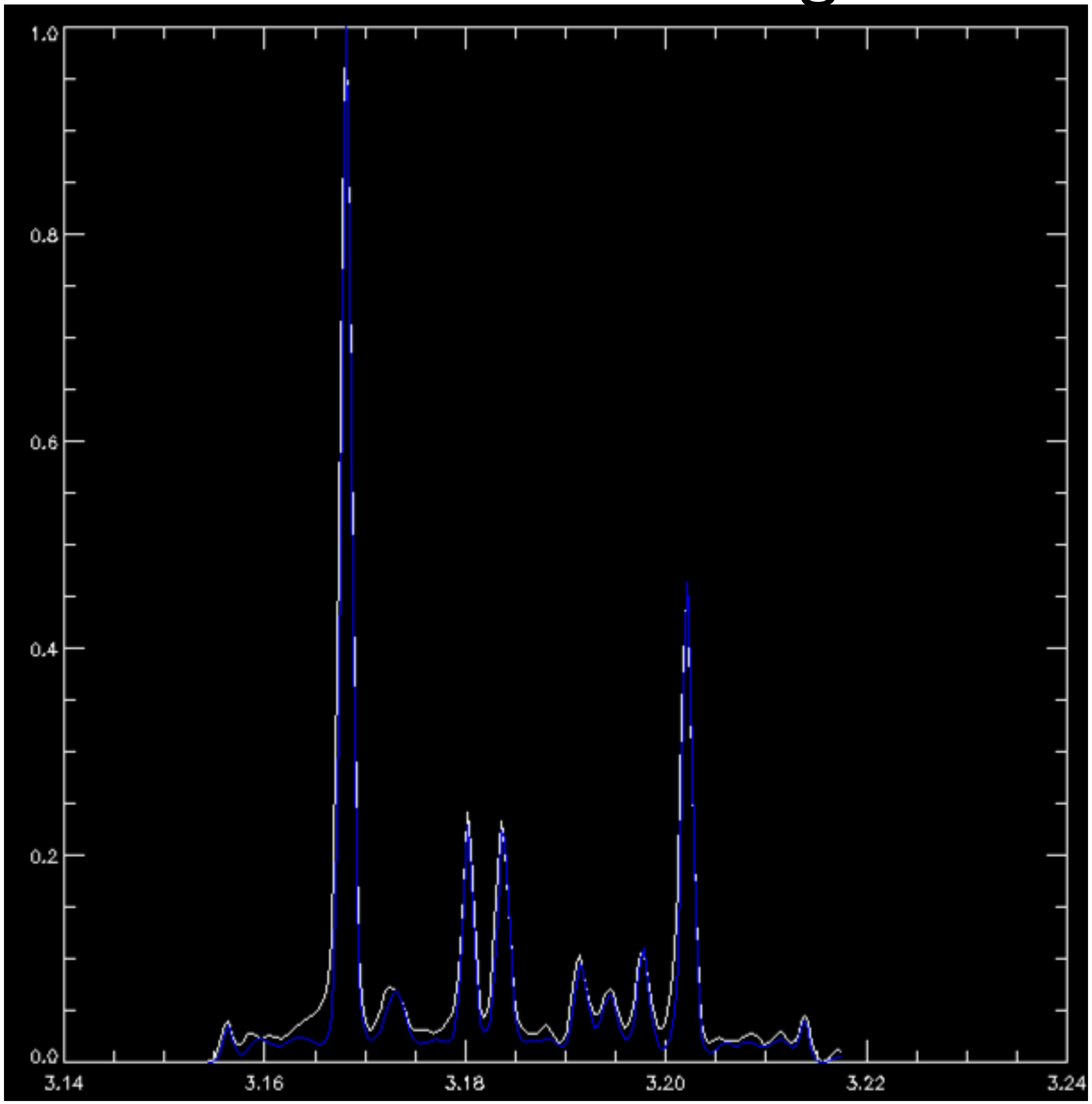
FIG. 3.—Model electron energy distribution for $n = 1$ (Maxwellian) and for $n = 3$ and $n = 5$ (nonthermal)

Deconvolved Spectra at different times during the event



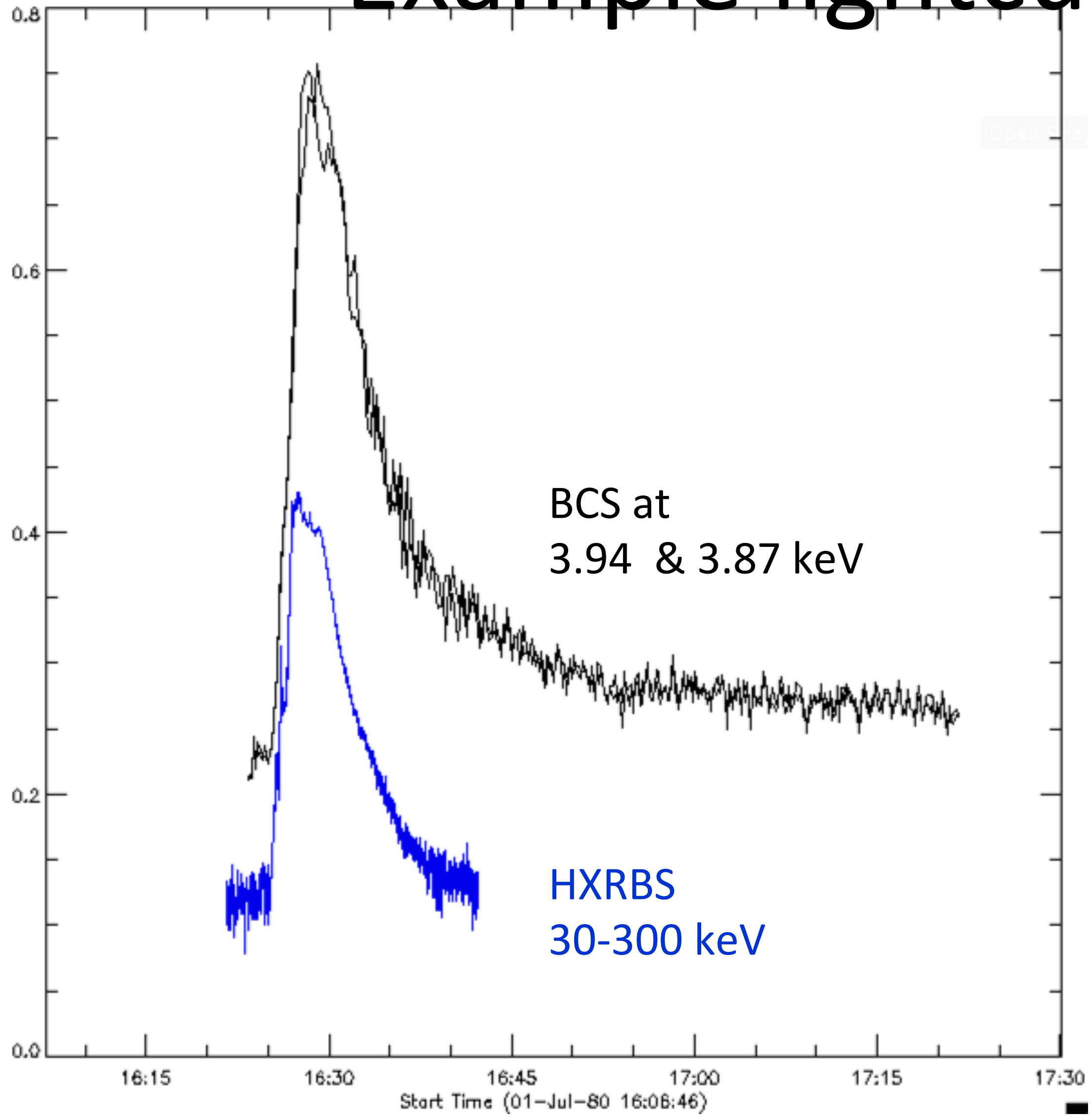
- Yellow: very early rise [0:9]
- White: main phase [10:19]
- Isolated Doppler components seen

Deconvolved normalized spectra at different times during the event

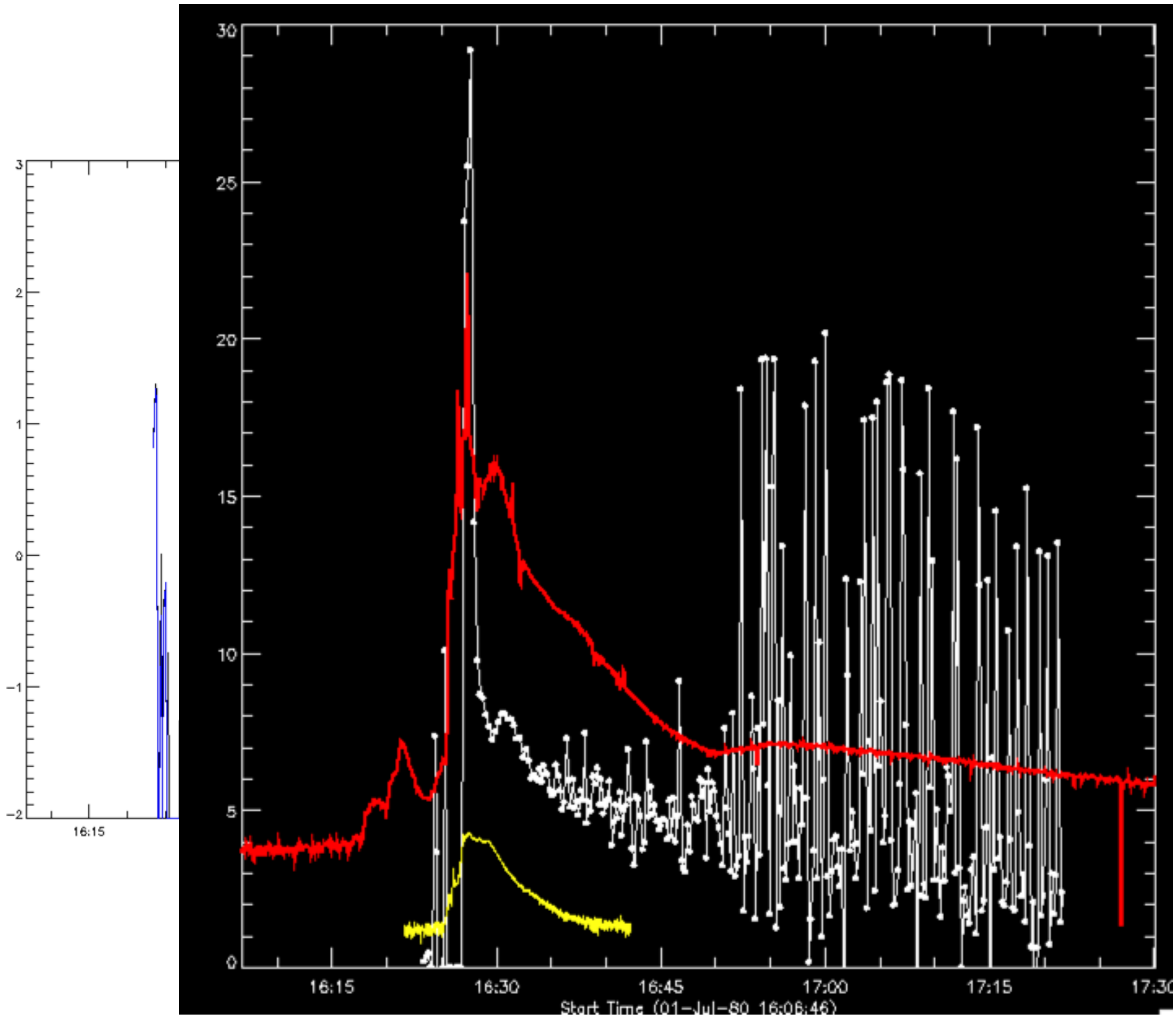


- White: spectra [10:19]
- Blue spectra [20:29]

Example lightcurves

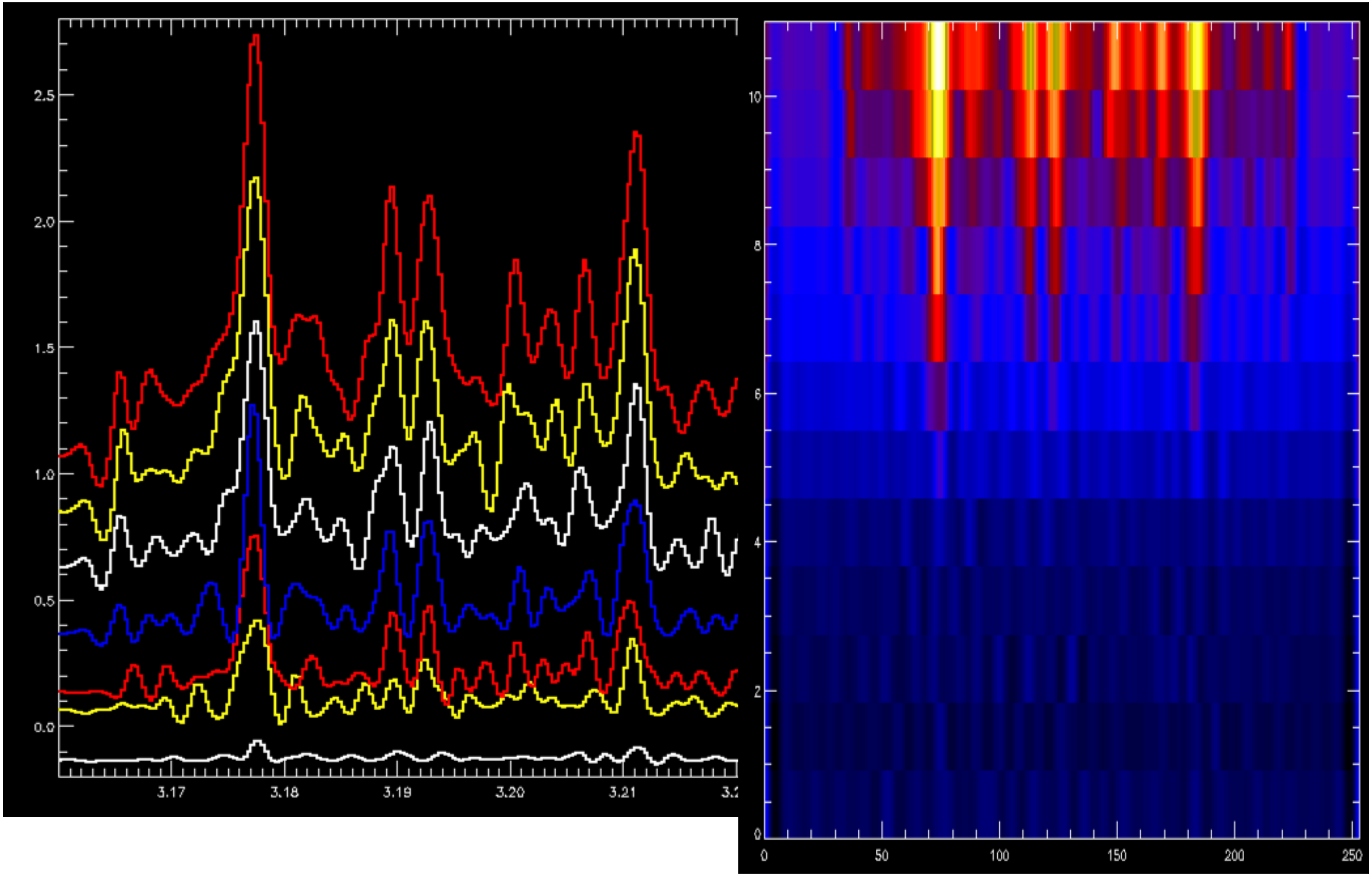


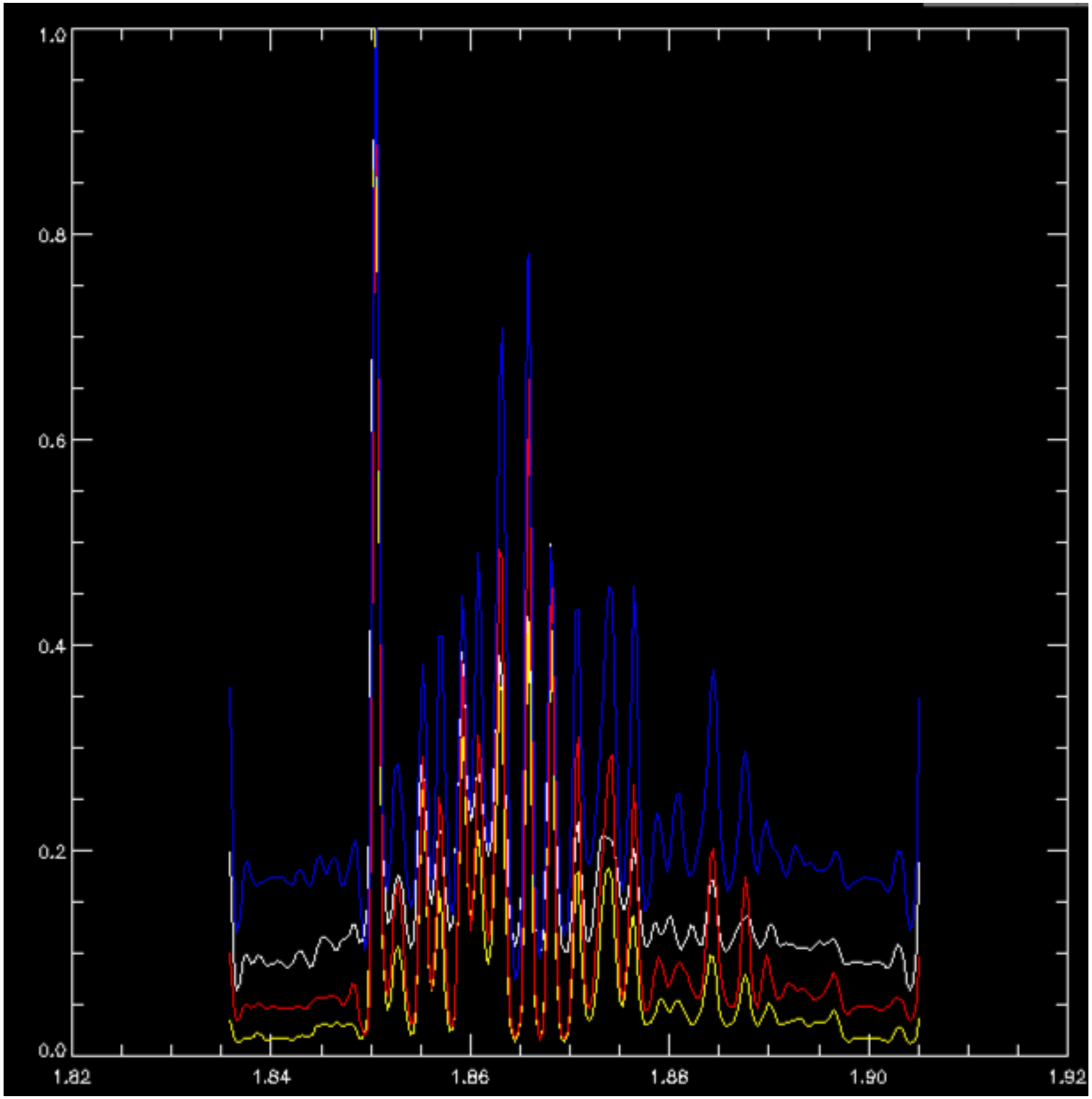
- Excellent coincidence during rise phase
- Left and right BCS chan1 continua overlap but fluctuate!!



30
25
20
15
10
5
0
16:15
16:30
16:45
17:00
17:15
17:30
Start Time (01-Jul-80 16:06:46)
3
2
1
0
−1
−2
16:15

Evolution of deconvolved spectra during the peak

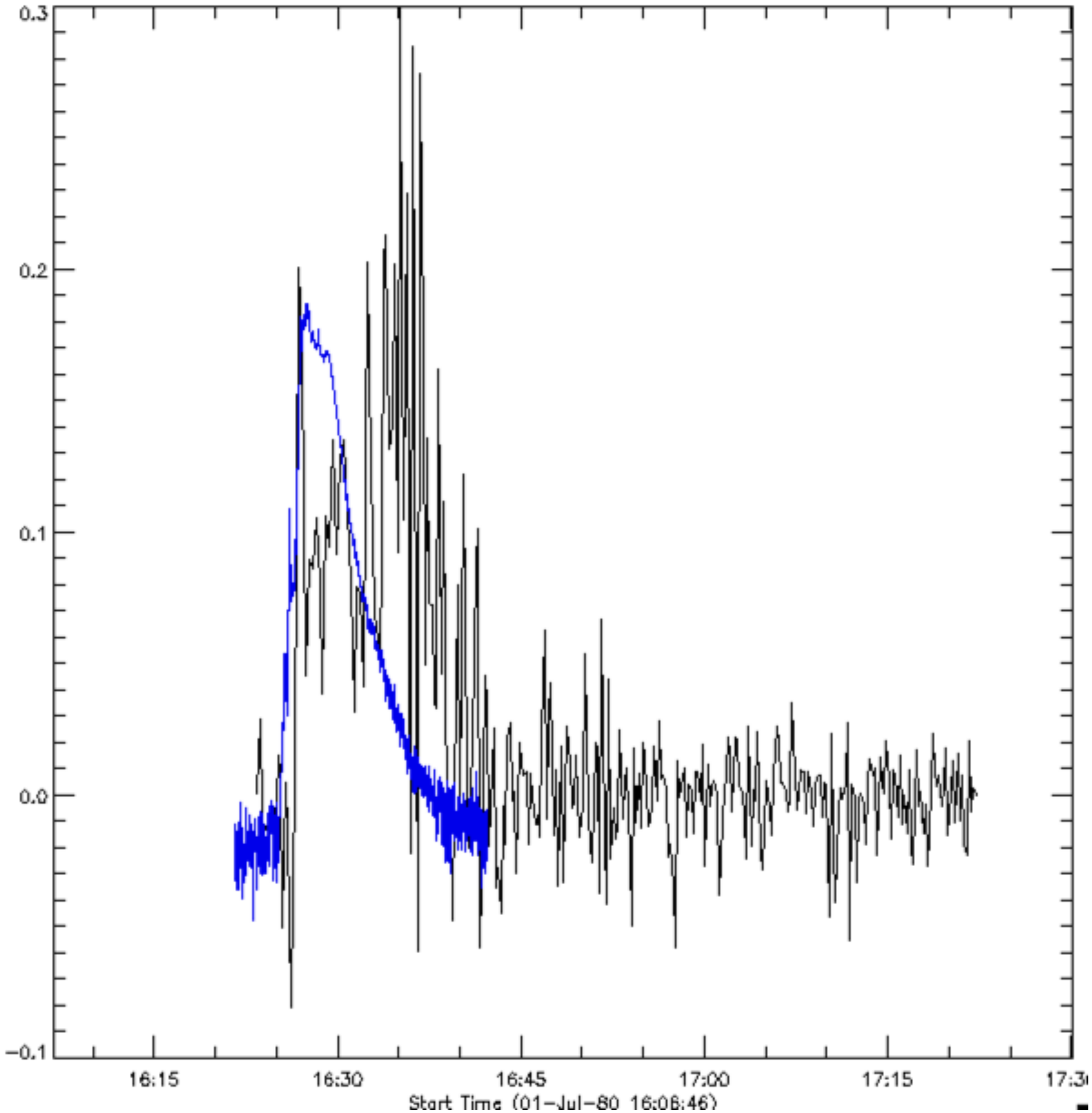




1.0
0.8
0.6
0.4
0.2
0.0
1.82
1.84
1.86
1.88
1.90
1.92

Conclusions

- Our small team is capable & ready to re-establish reduction of SBCS- thanks to ISSI
- We slowly will reduce SBCS entire database starting from the most interesting impulsive flares
- Will produce lightcurves in selected transitions ~30 in Fe and Ca
- We will perform deconvolution of instrumental profile
- By comparing many events we possibly can „place every" flare within the collimator FOV
- Data will be put to public domain



plot_ut,dgi_m
alog10(chan4_
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