SMM BCS revitalized: Evolution of High resolution spectra for a number of impulsive flares

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Why returning to 30+ old measurements

- „Golden age" for solar X-ray spectroscopy
- VERY HIGH spectral resolution (instrumental width<<thermal or turbulent width)
- High-Z spectra Ca (XIX) & Fe(XXV)
  - →strong satellite lines present
  - → DE satellites provide "plasma temperature"- but this might be just "equivalent" of the temperature (population of the resonance to tail)
  - Innershel excitation/ionisation transitions
  - Ka lines seen (impact excitations? & fluorescence 99% of the photosphere from overlying strong coronal source)

Bent-Crystal Spectrometer
Solar Maximum Mission
1980-1989

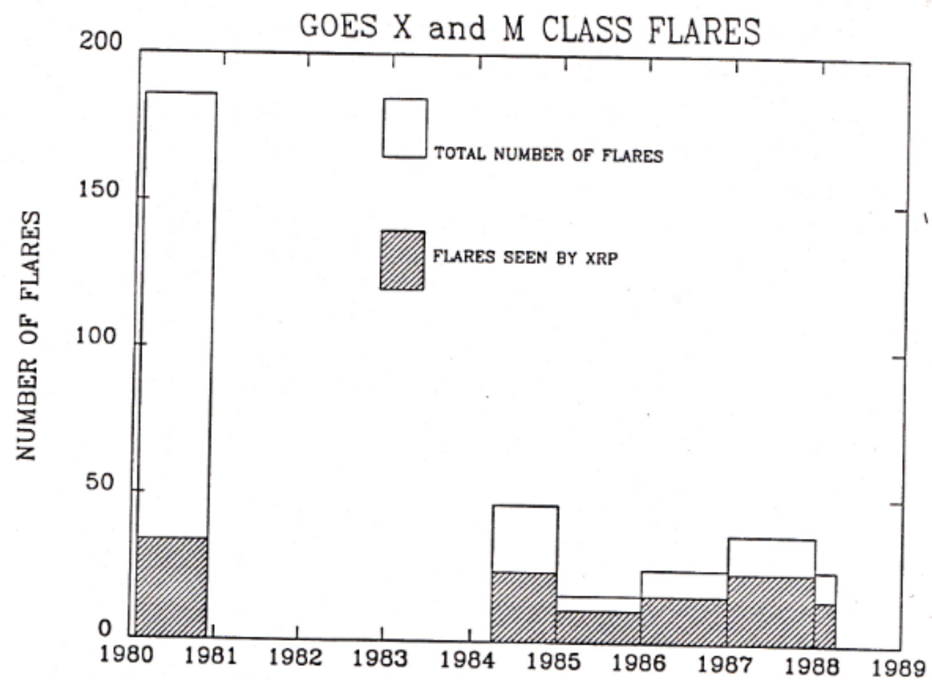


Figure 1-5. M- and X-level Flares observed by *SMM*.

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 paer 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.

WHY to go back & investigate

- Unprecedent spectral resolution, time resolution & sensitivity (to be presented)
- Many lines due to different types of transitions observed “instantanousely” for heavy ions. Time to ionise these ions is expected to be comparable to DGI
- Continuum is “present” and not “contaminated” strongly by fluorescence in most of channels except the Fe XXVI

OUR ISSI –based project

- 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
- 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

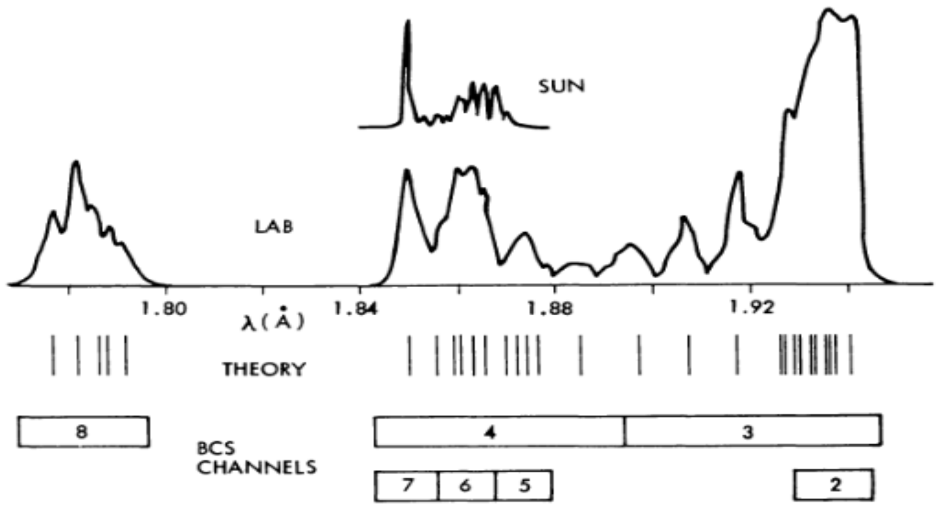


Fig. 7 Spectral coverage of the 7 short wavelength BCS channels. Actual spectra and theoretical line positions are shown schematically for comparison.

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

In-flight calibration of detectors

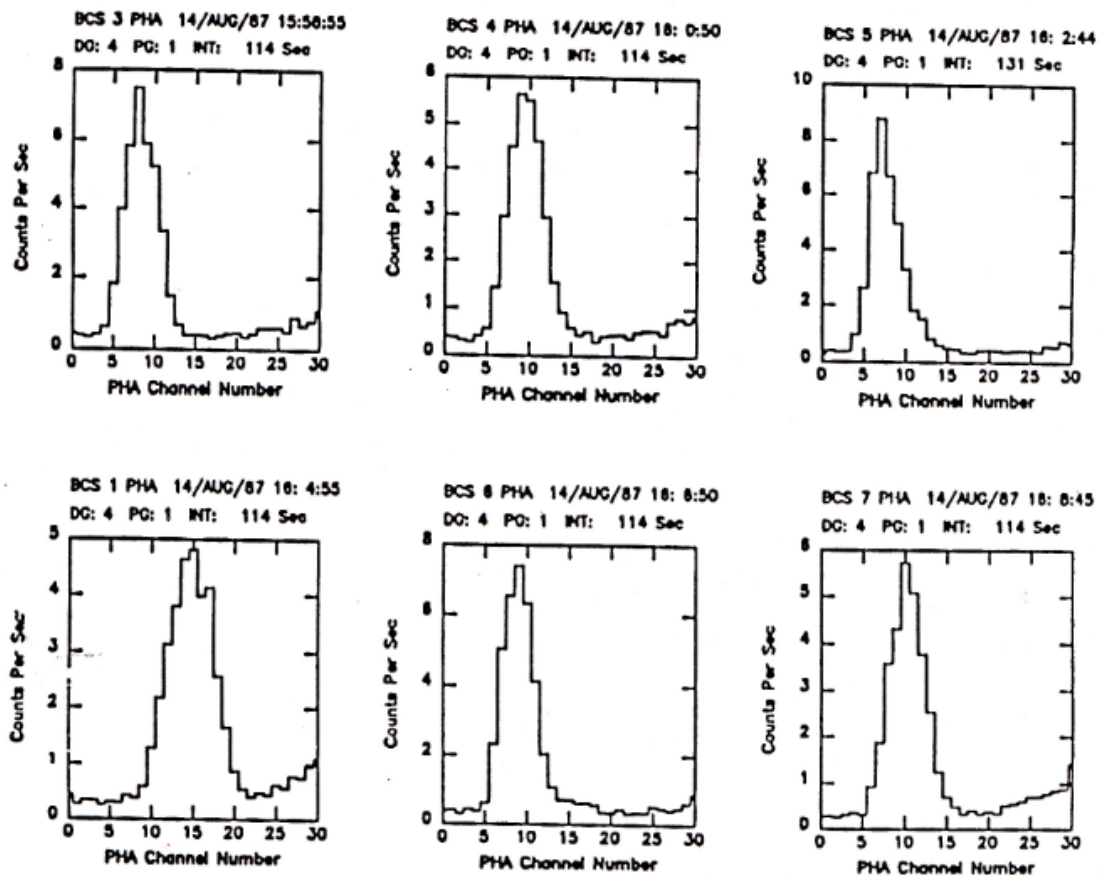


Figure 2-16. Sample BCS PHA calibration data obtained in channels 1 and 3 to 7 using a $^{+55}$Fe radioactive source.

Time degradation

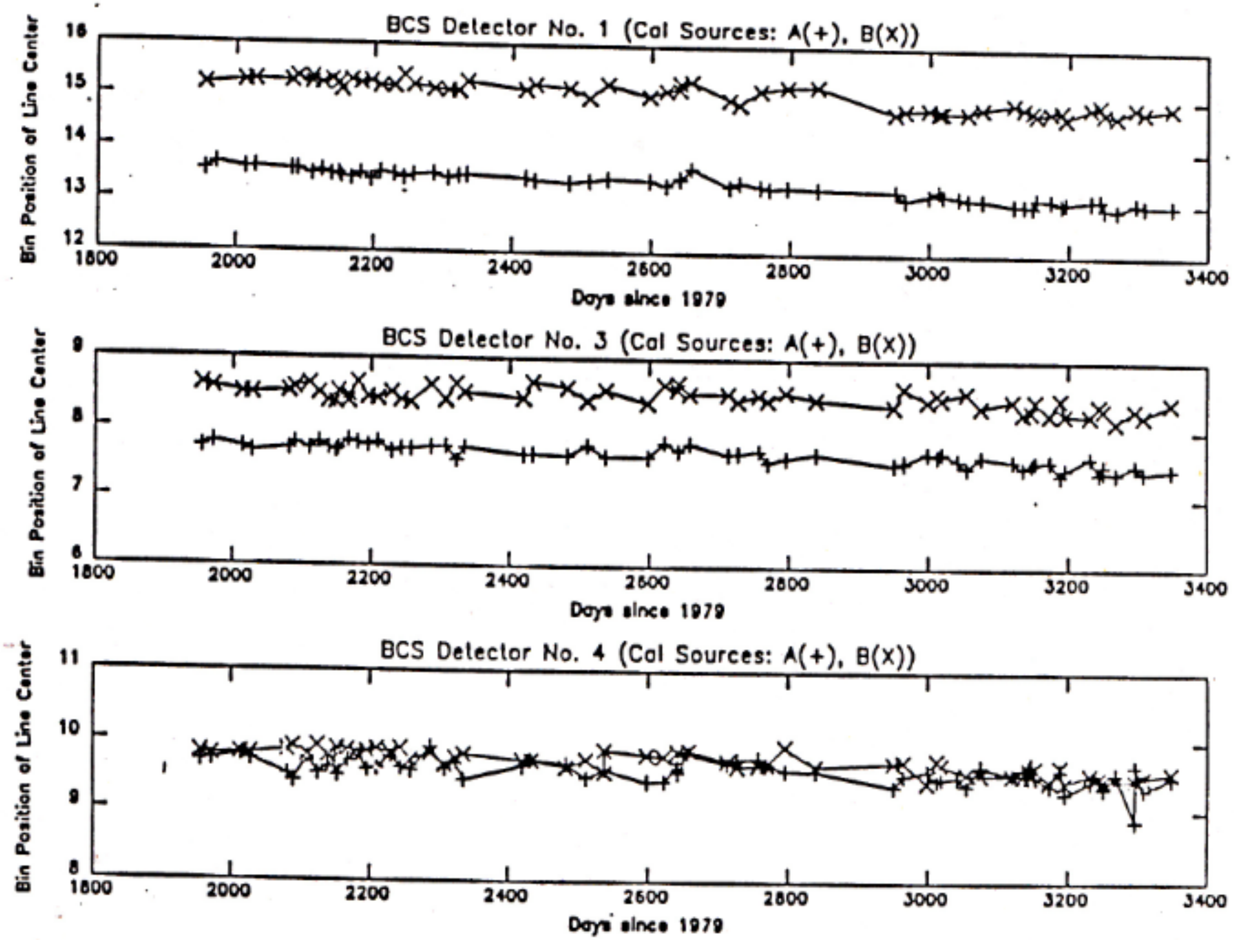


Figure 2-17. Time history of the BCS PHA calibration data. Channels 1, 3 and 4 are displayed. These data indicate the stability of the detector gains as a function of time.

Problems

- Dispersion never account for non-linearity of crystal reflections
- CHIANTI DW not of “sufficient accuracy” to accommodate theory spectra- not all lines present etc. Old spectral data files still present

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

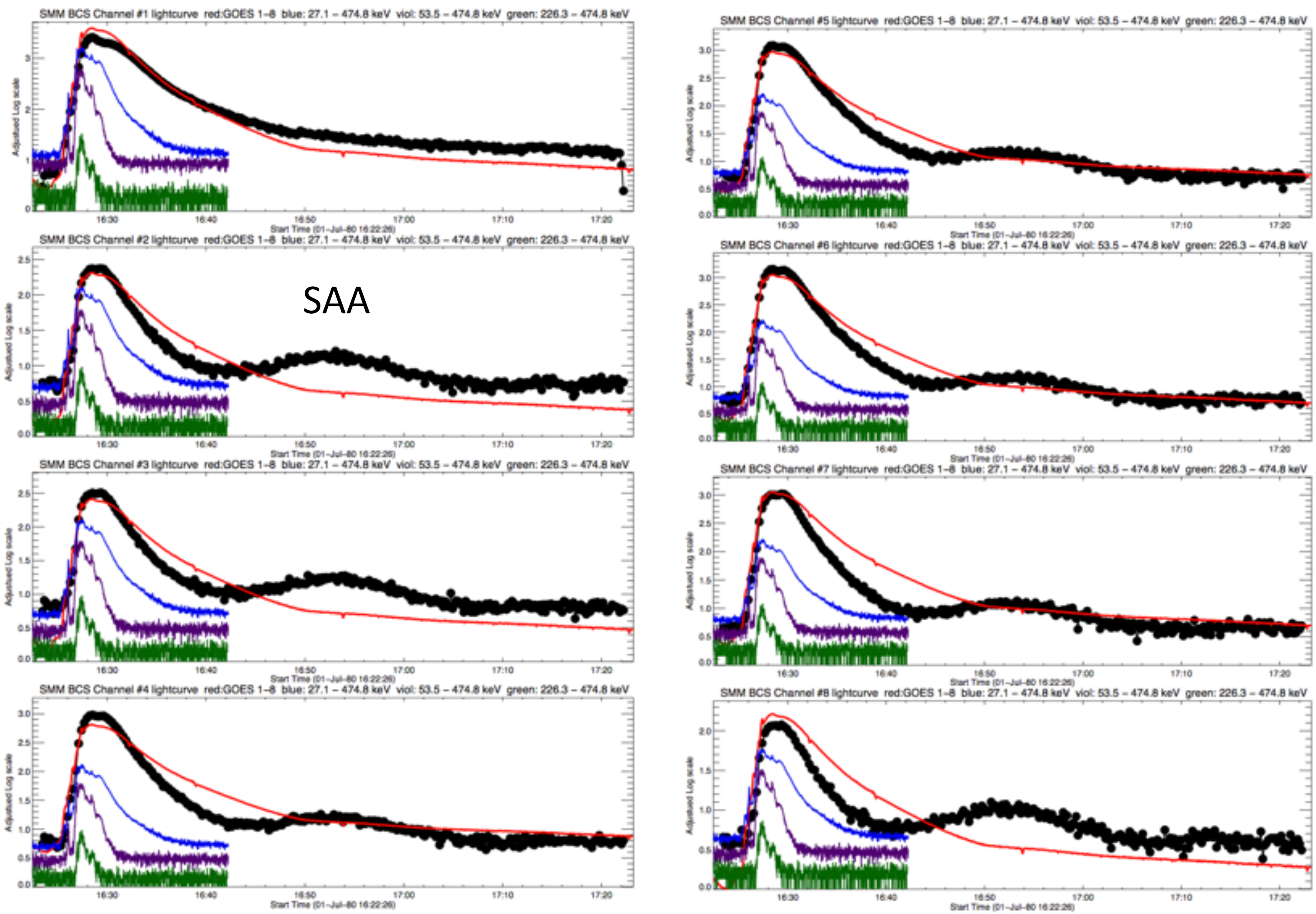
Problems II

- Hand-written unchecked effective areas
- Peak Collimator transmission known from one remark 33%
- No data for flare sources moving transversally across the FOV of the collimator (no RHESSI)- availability of HXIS data were not checked yet
- Missing documentation!!!

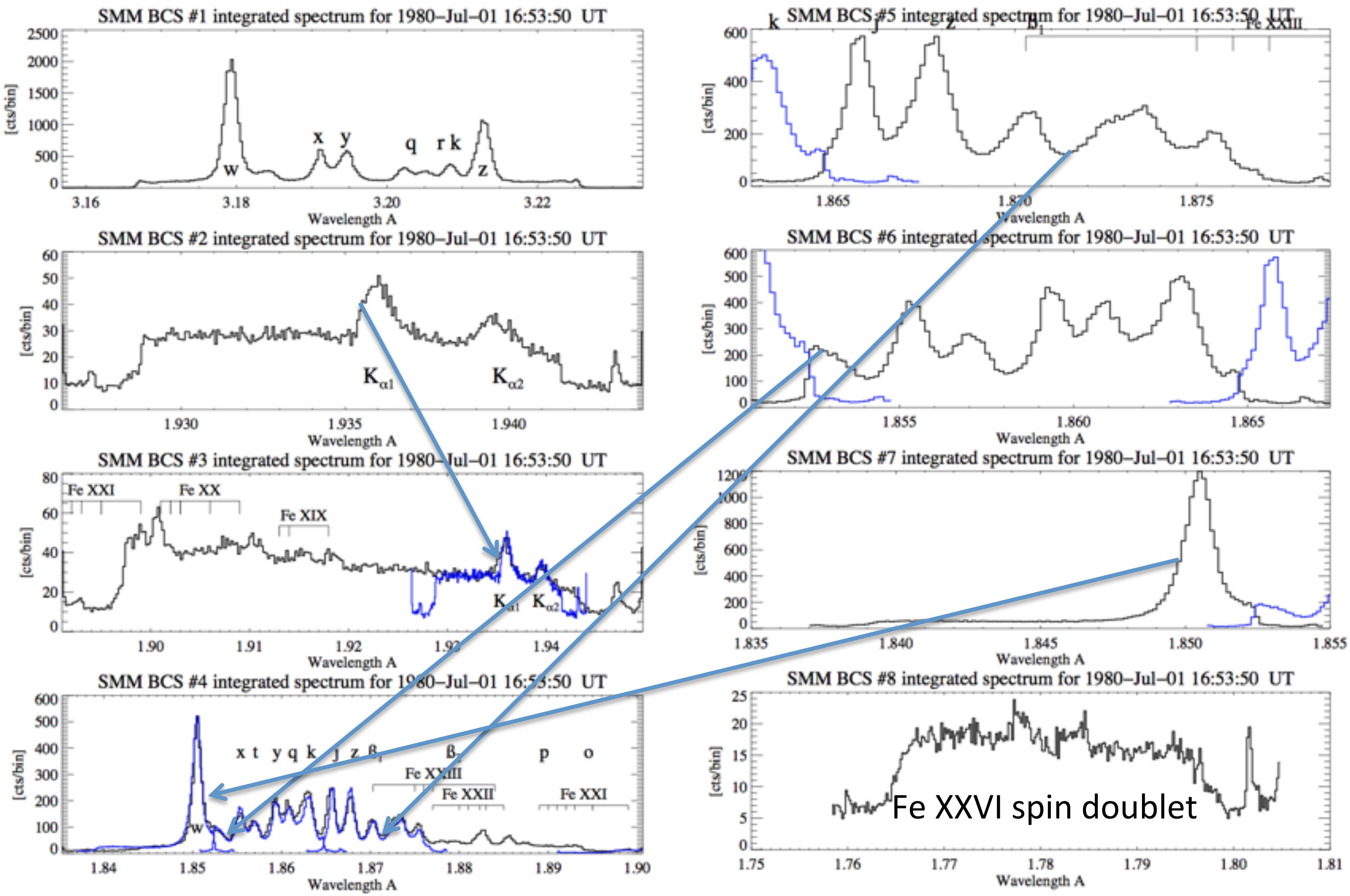
However the data are "fantastic"

- We will soon see them
- We have the team of experts who learnt the BCS (RESIK and Yohkoh BCS)
- There are new Crystal codes available to re-calculate the Rc and effective areas
- New atomic data are present (f.i. Kanti Aggarwal for He-like ions)
- The team is enthusiastic to work on this "reincarnation" project:
  - Anna Kepa & Zaneta Szaforz

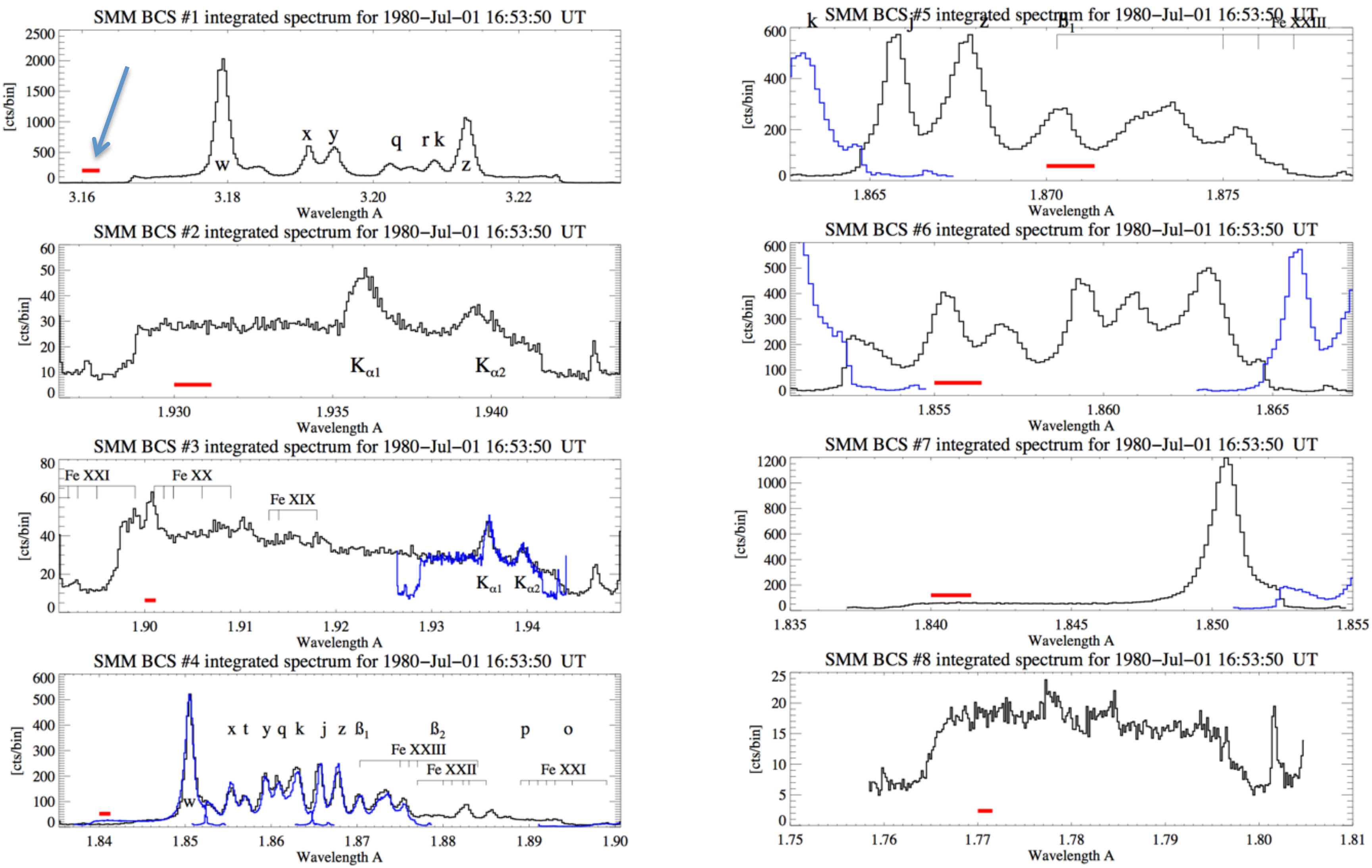
The observations: example flare SOL1980-Jul-01 impulsive event all 8 SBCS channels



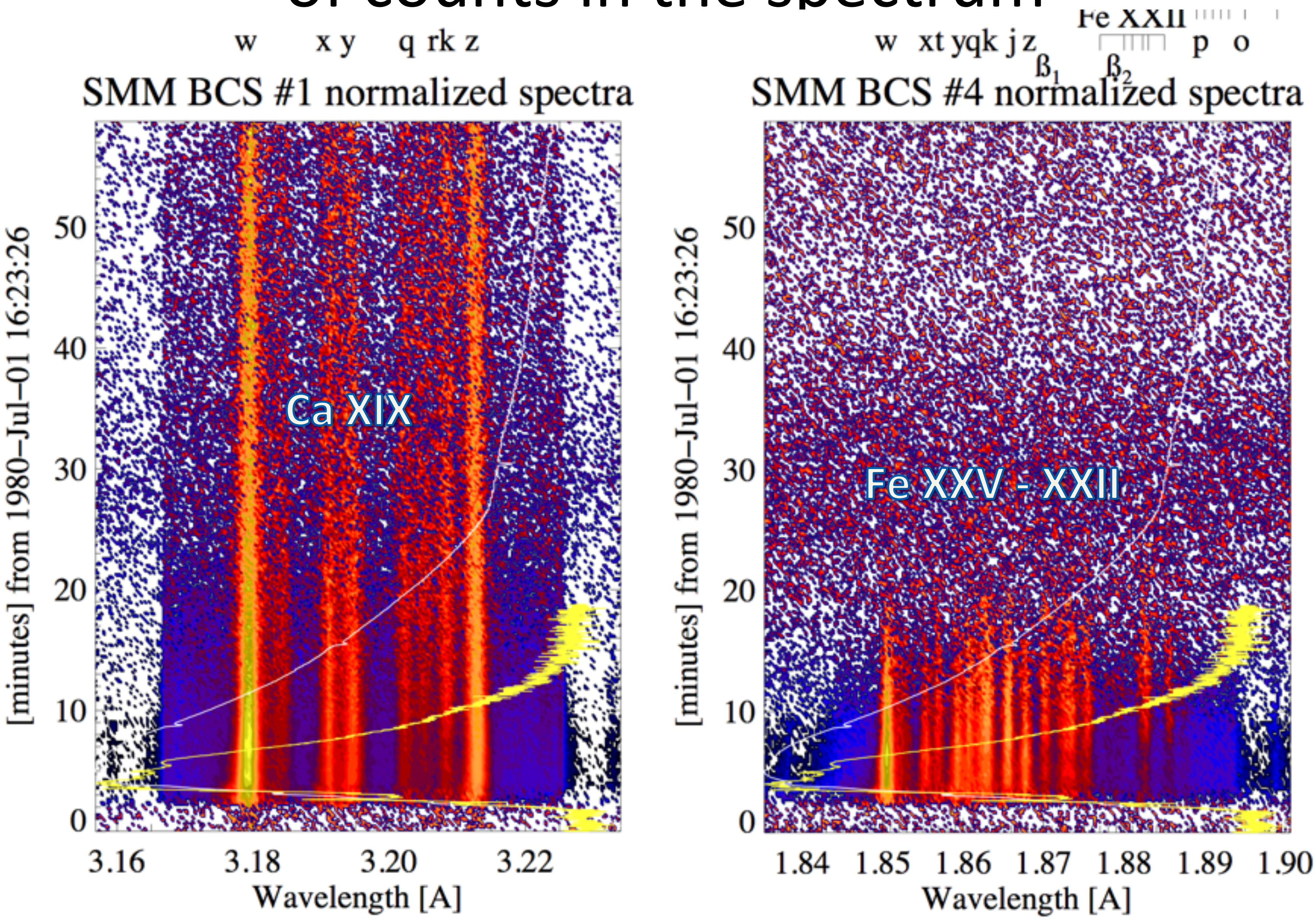
Flare-integrated spectra (adjusted)



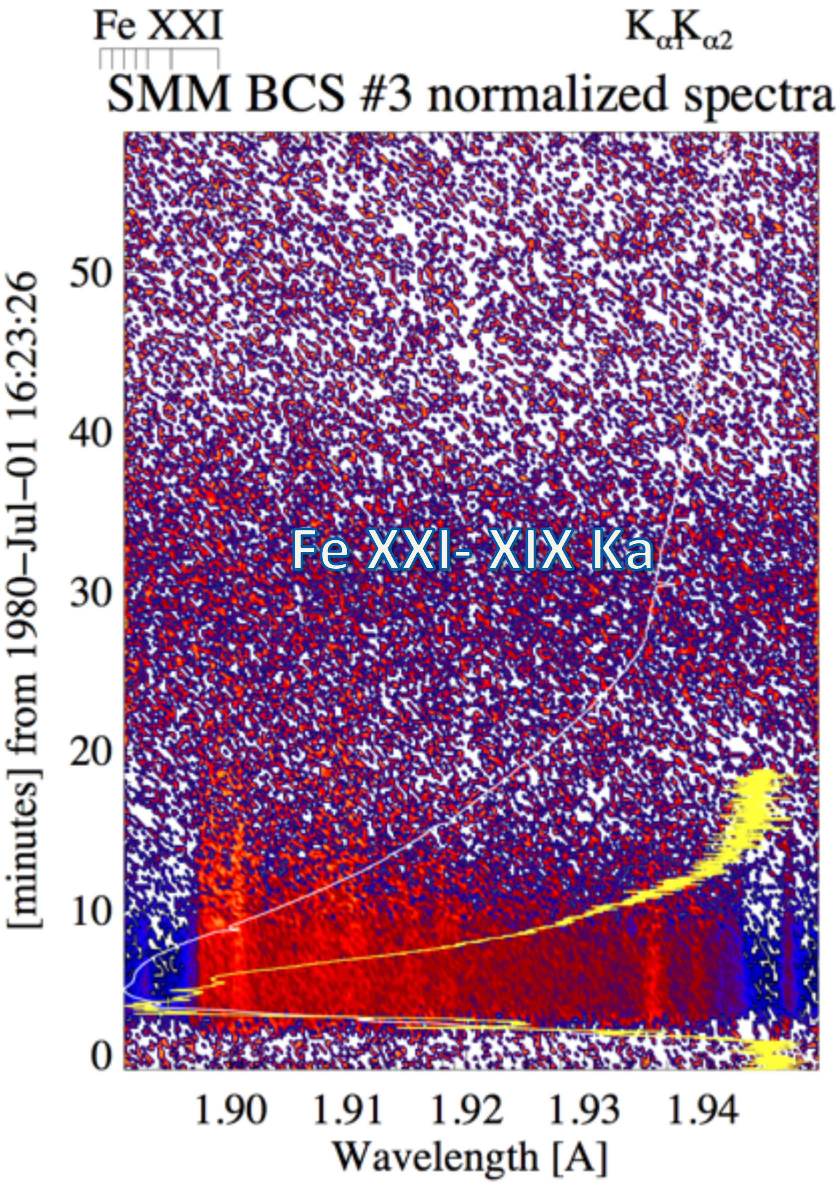
Projected width of collimator FWHM

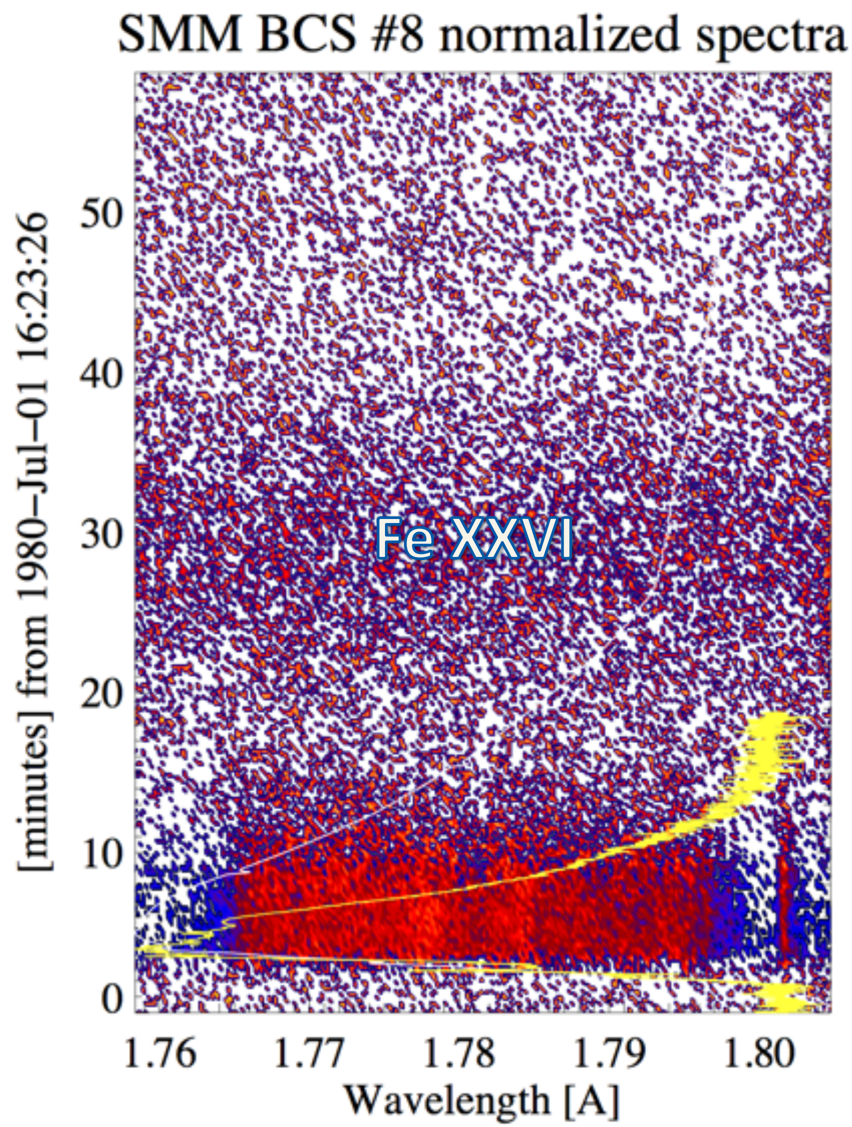


Spectra evolution: normalized to total No. of counts in the spectrum

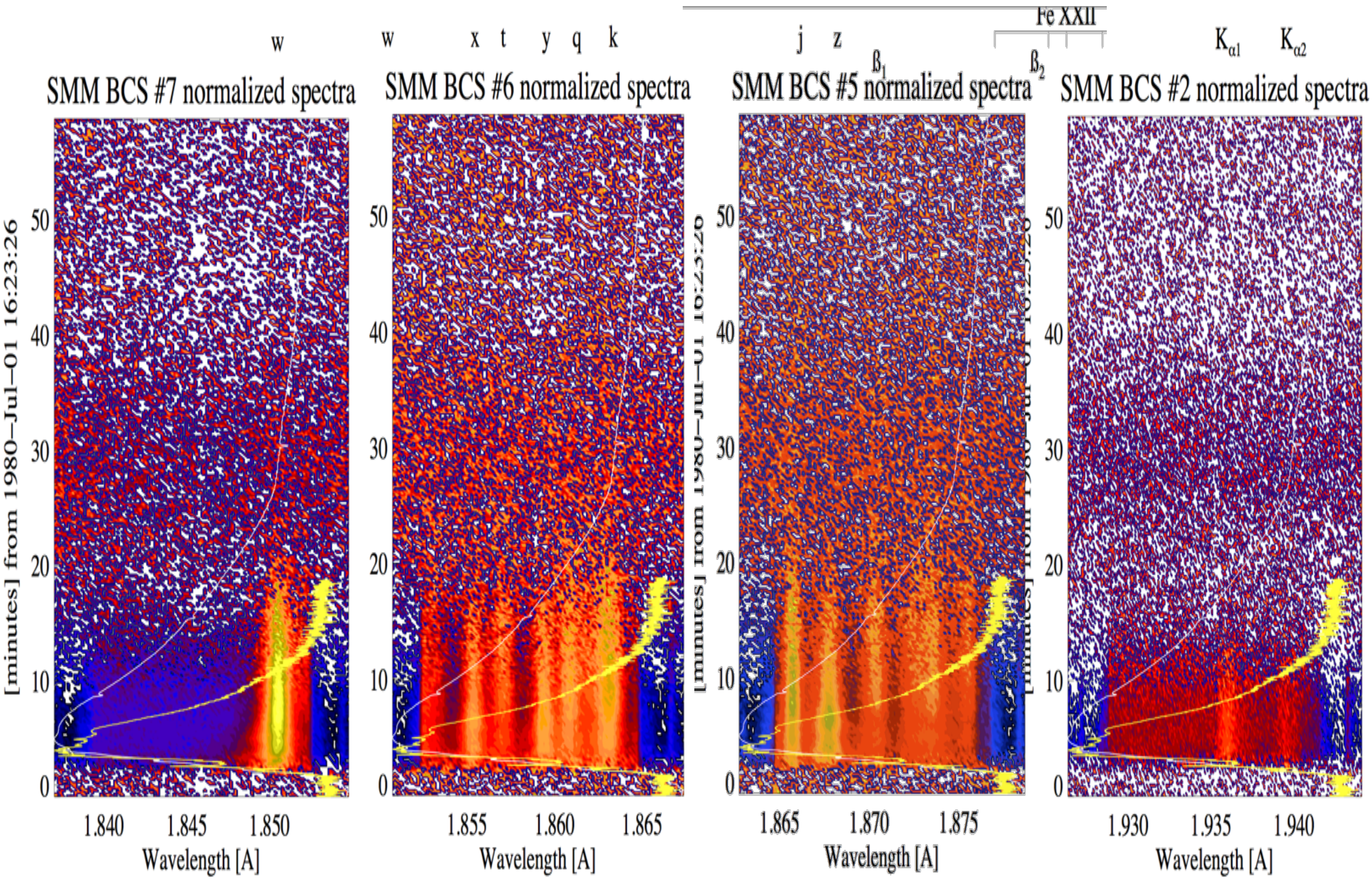


Spectra evolution: normalized to total No. of counts in the spectrum

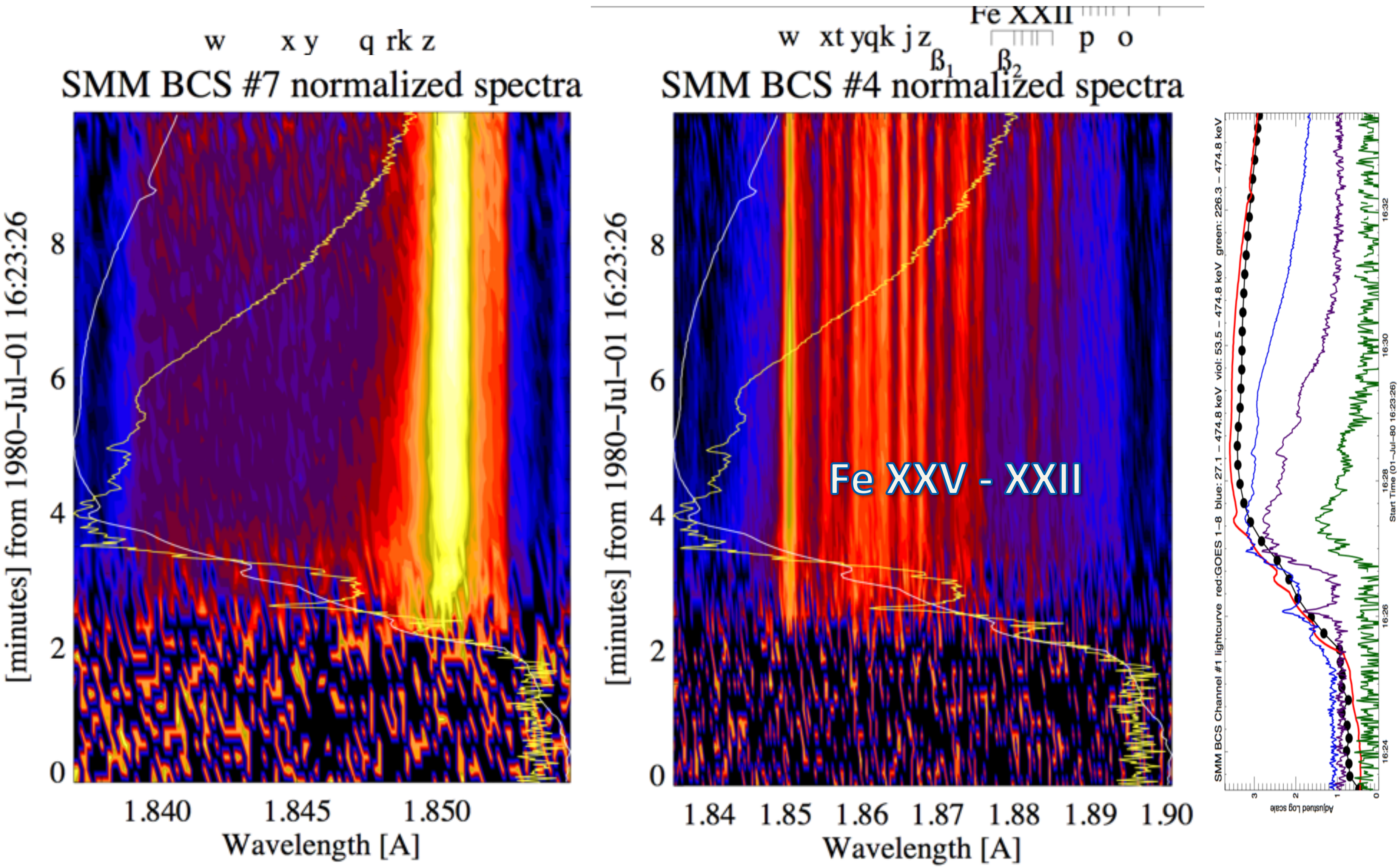




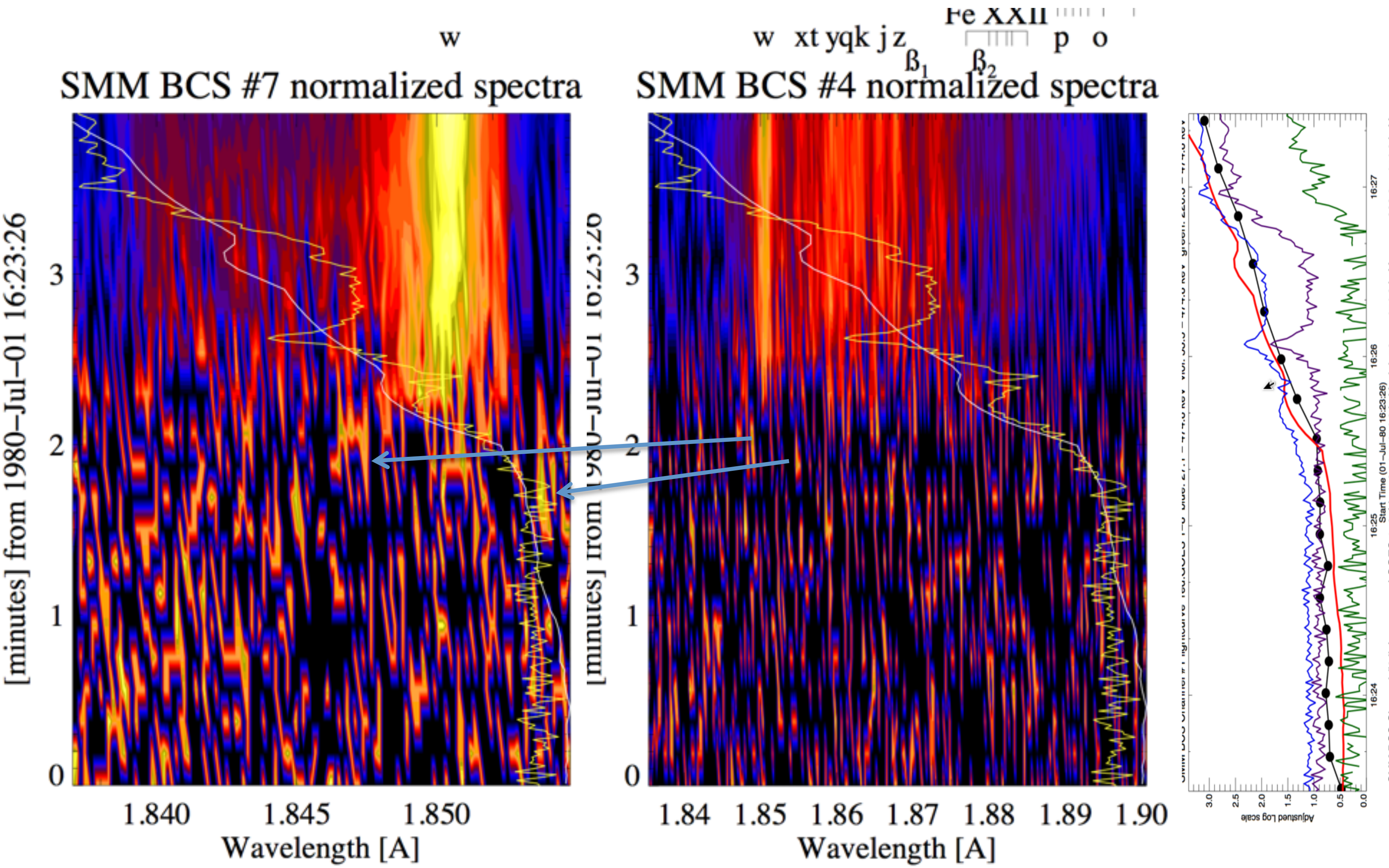
evolution in high-spectral resolution



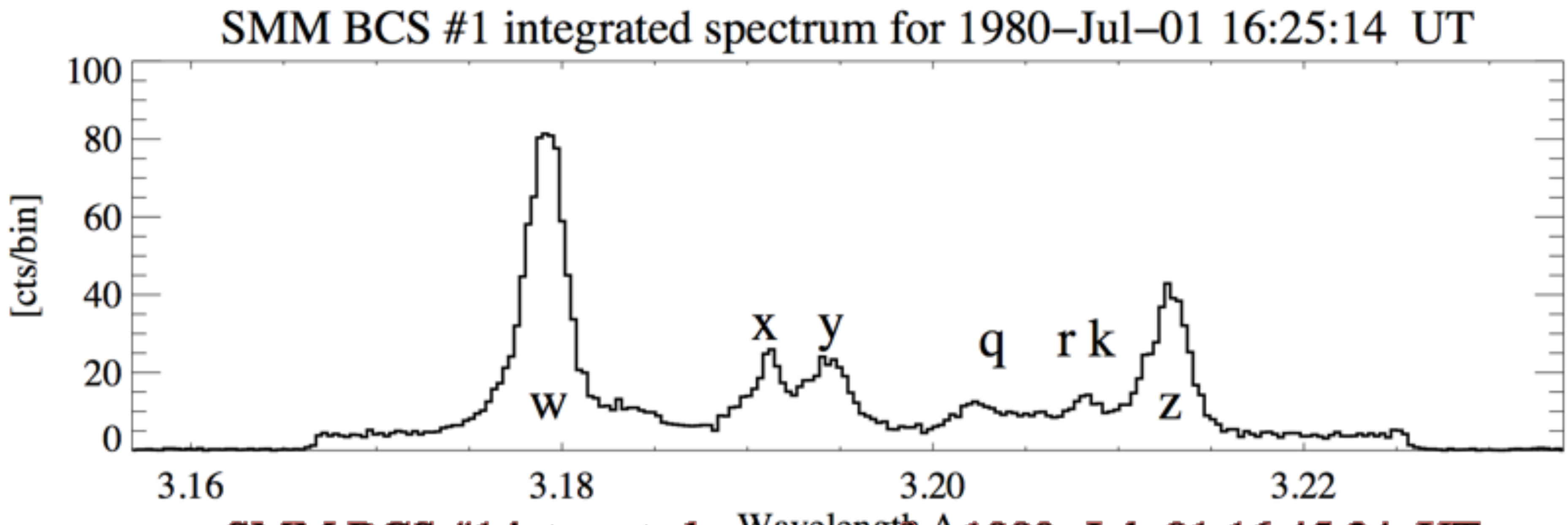
Spectra evolution: early few min

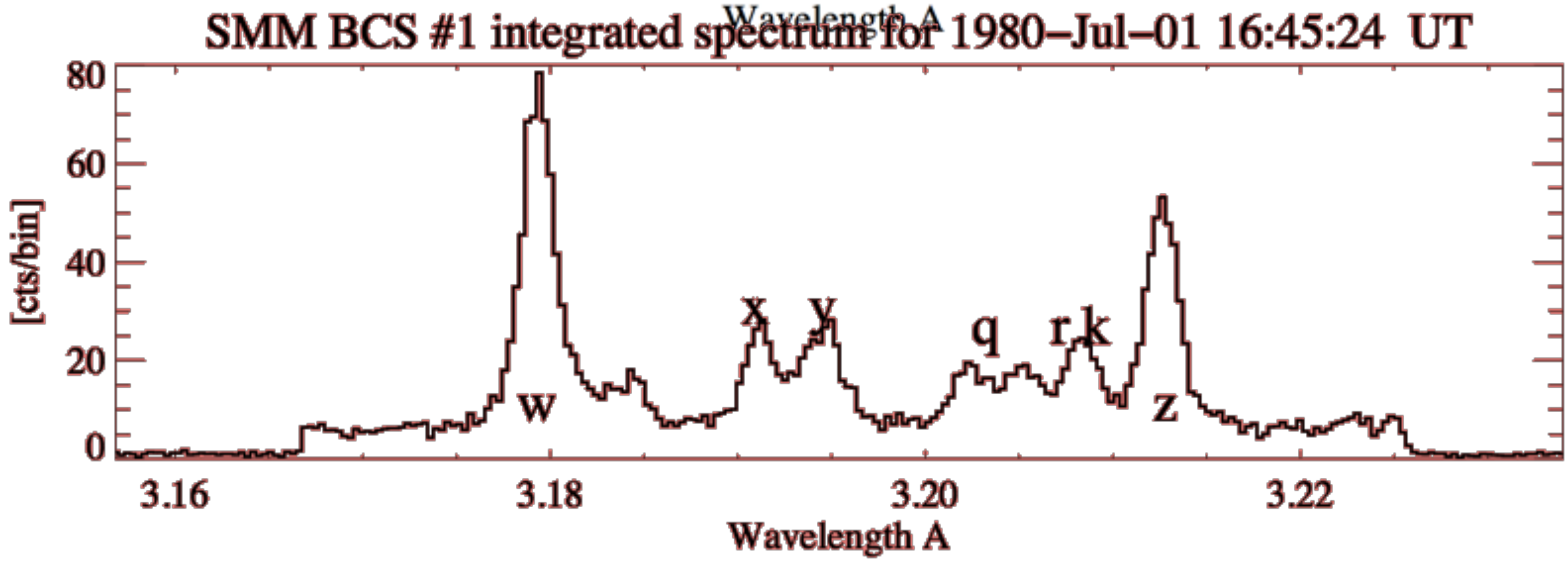


Spectra evolution: very early min

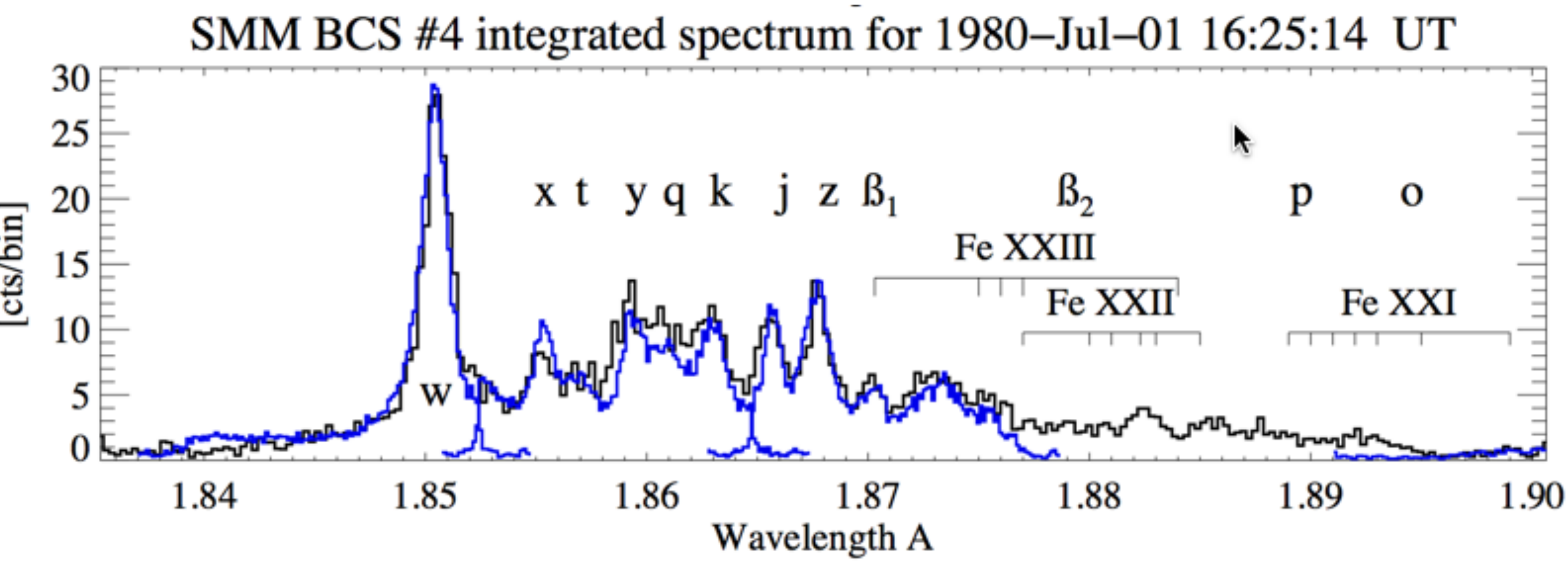


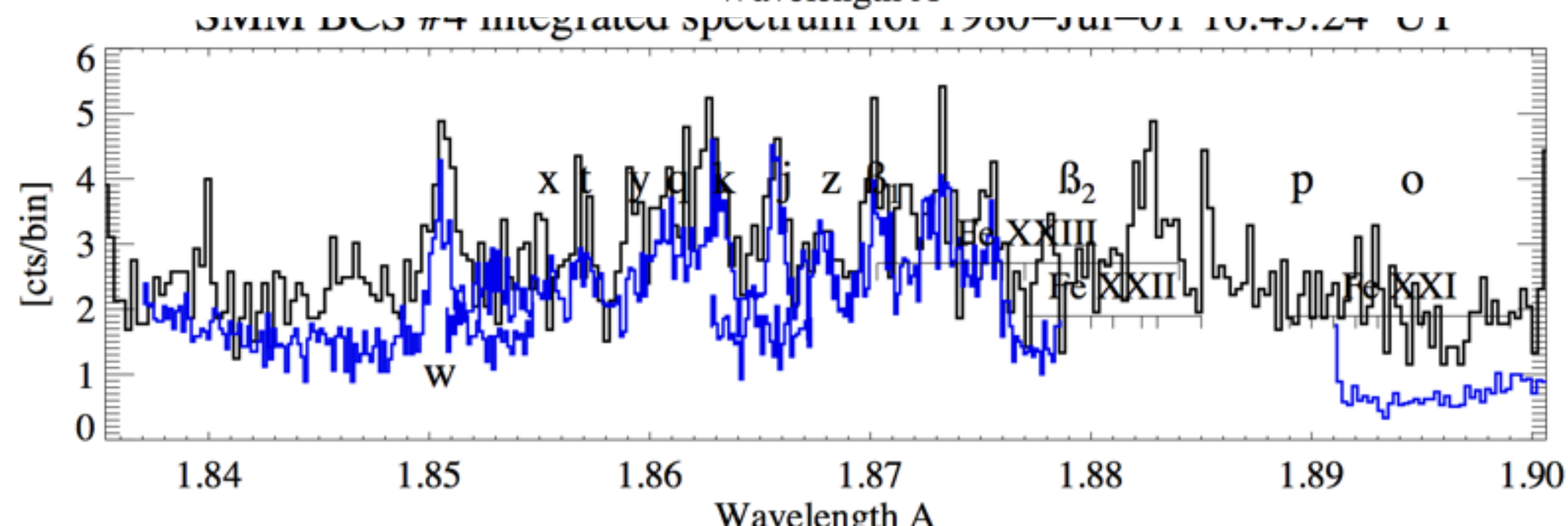
Impulsive vs decay phase spectra Ca



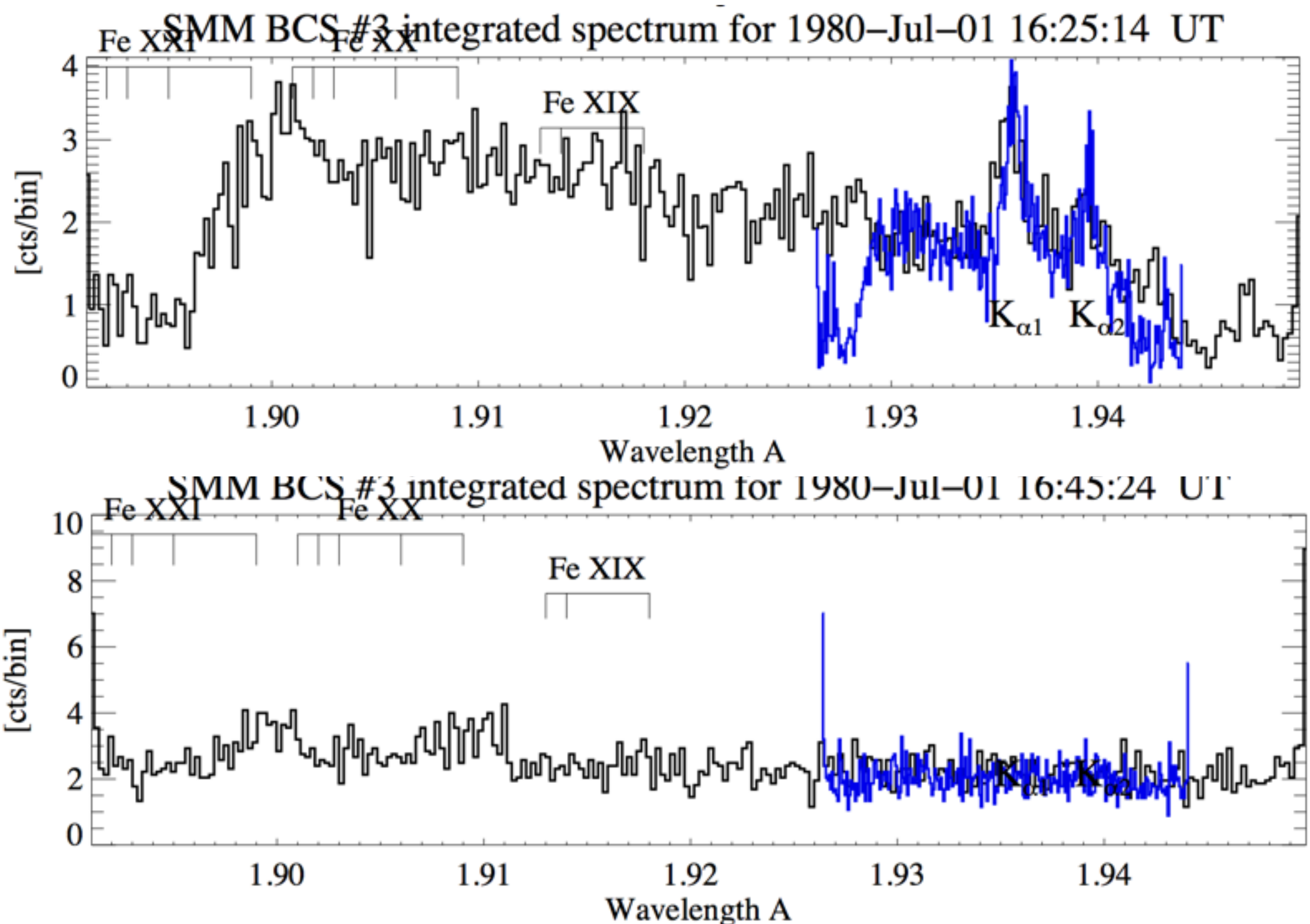


Impulsive vs decay phase spectra Fe

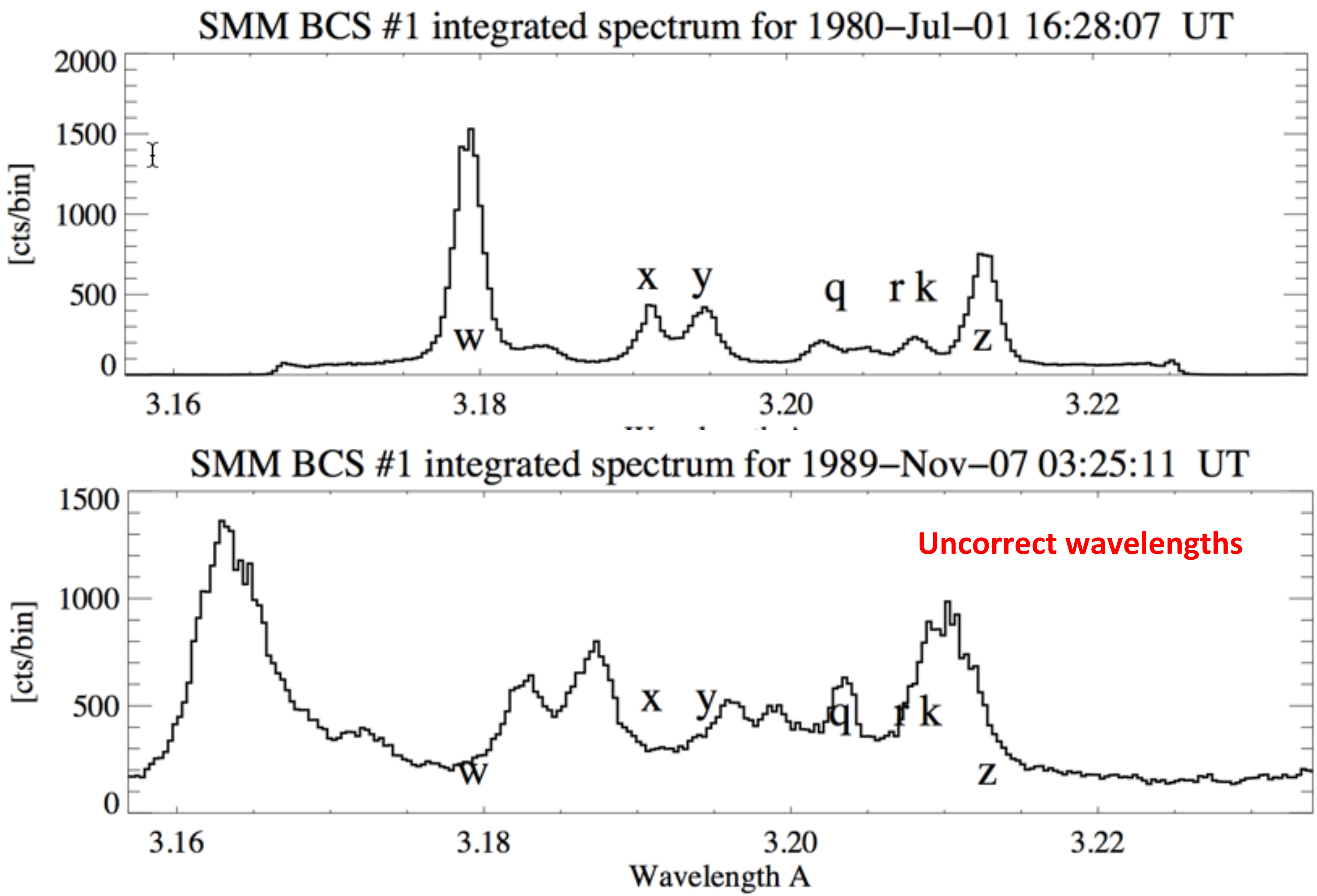




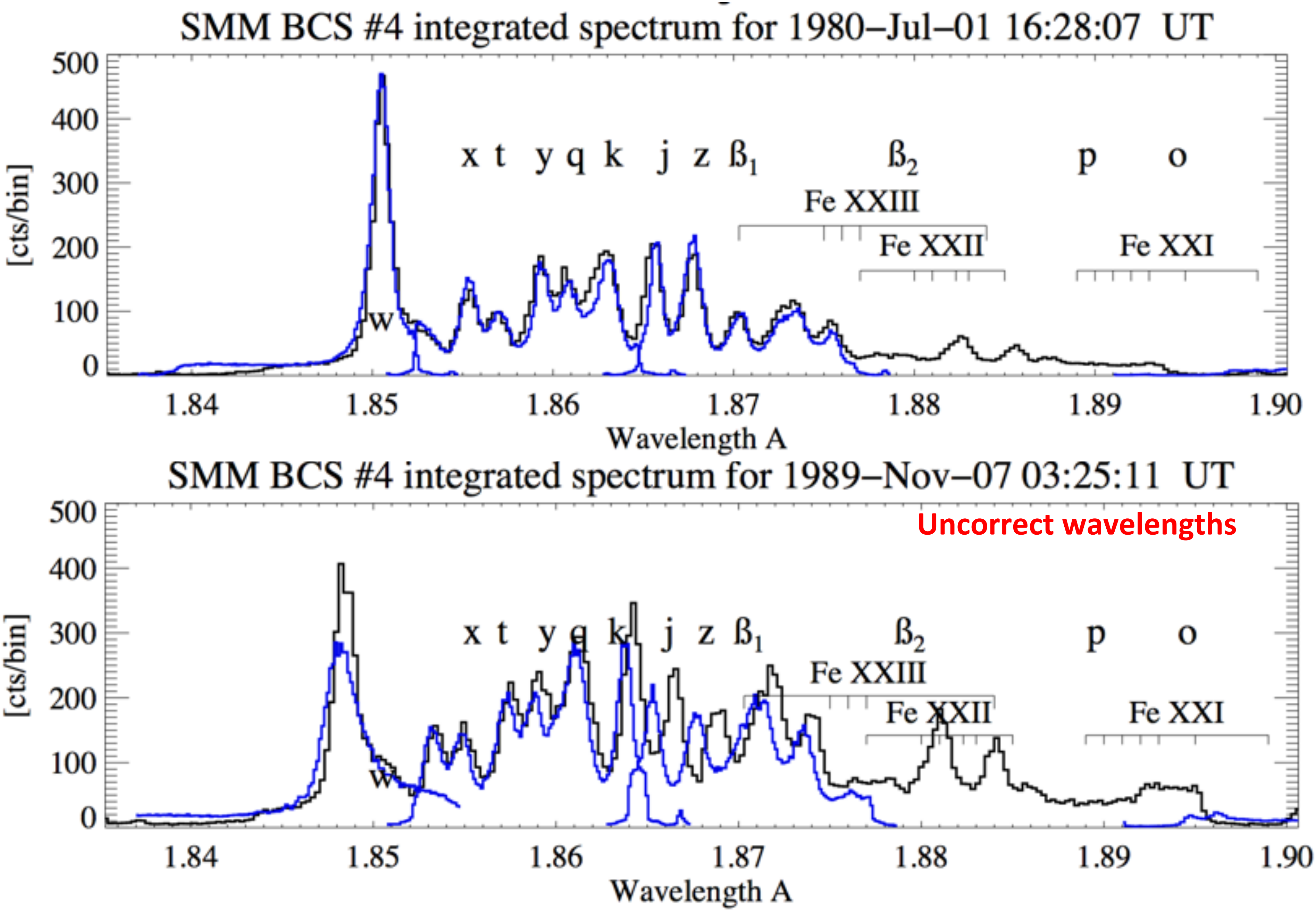
Impulsive vs decay phase spectra Fe Ka



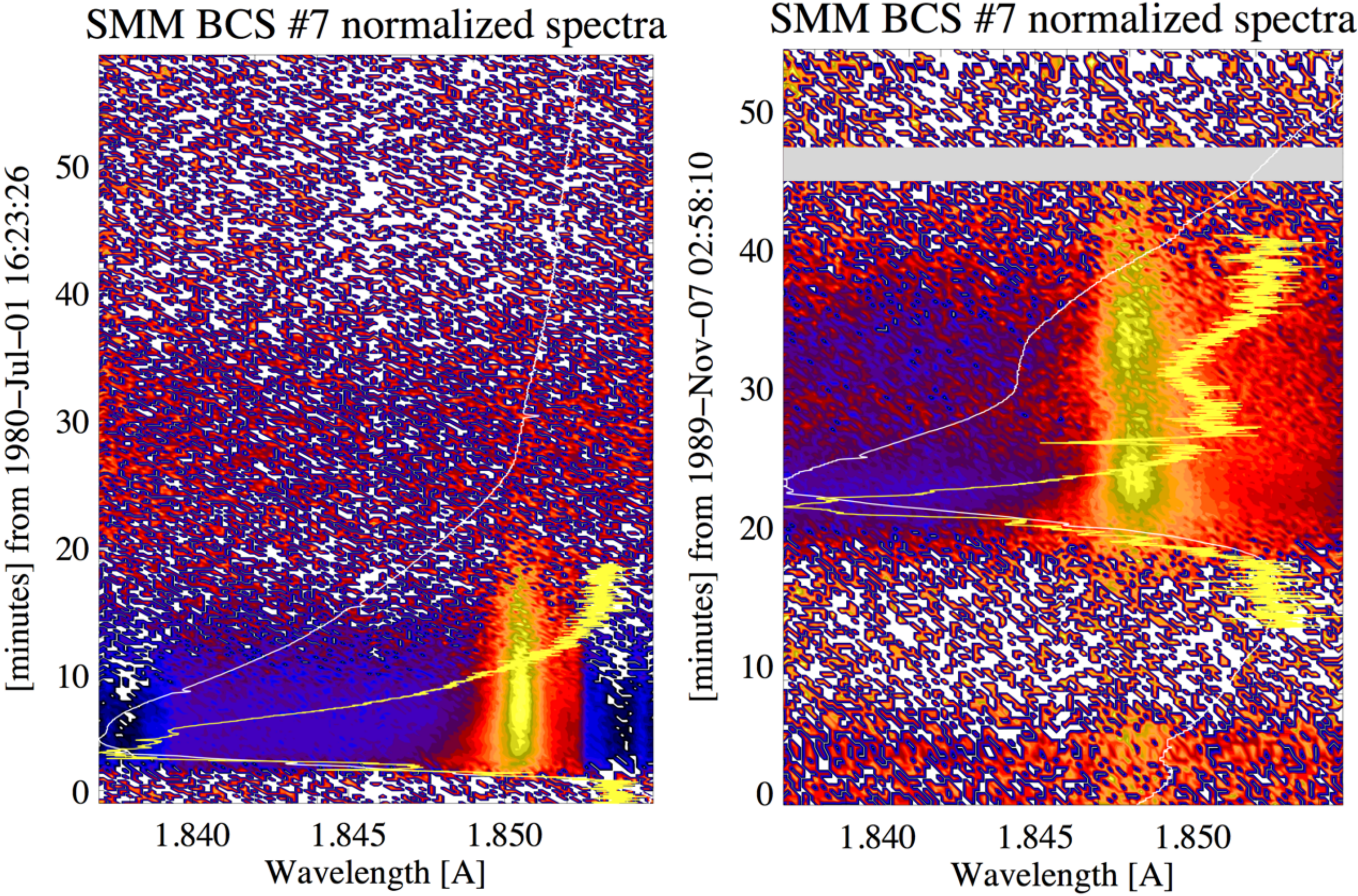
Early (1980) and late (1989) observations



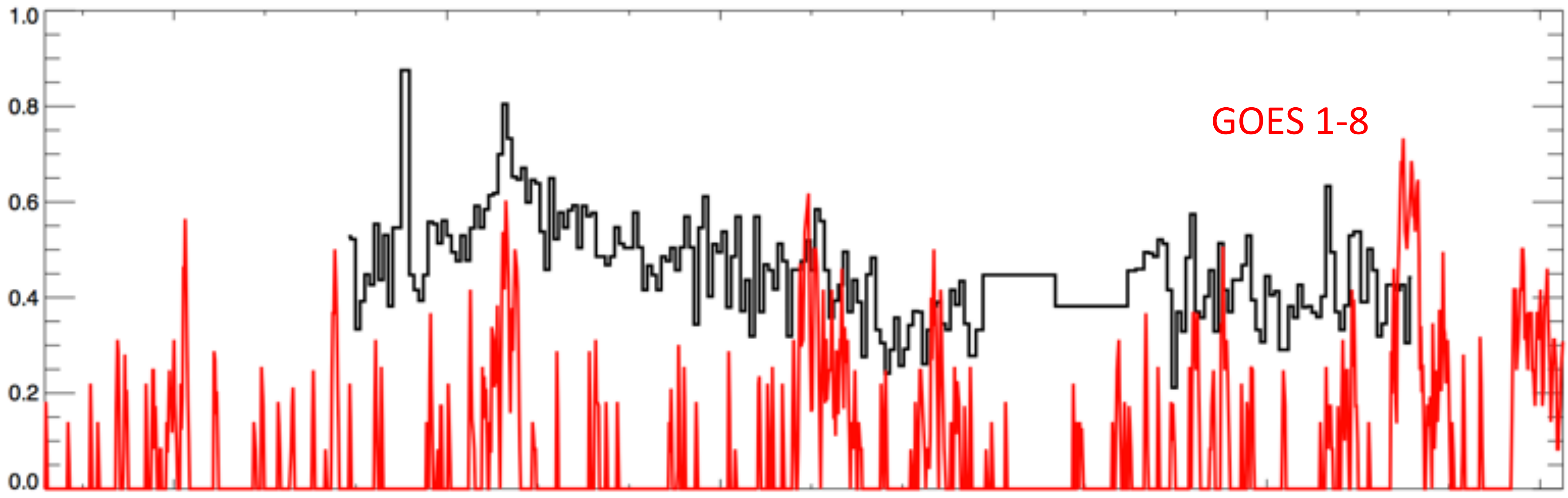
Early (1980) and late (1989) observations



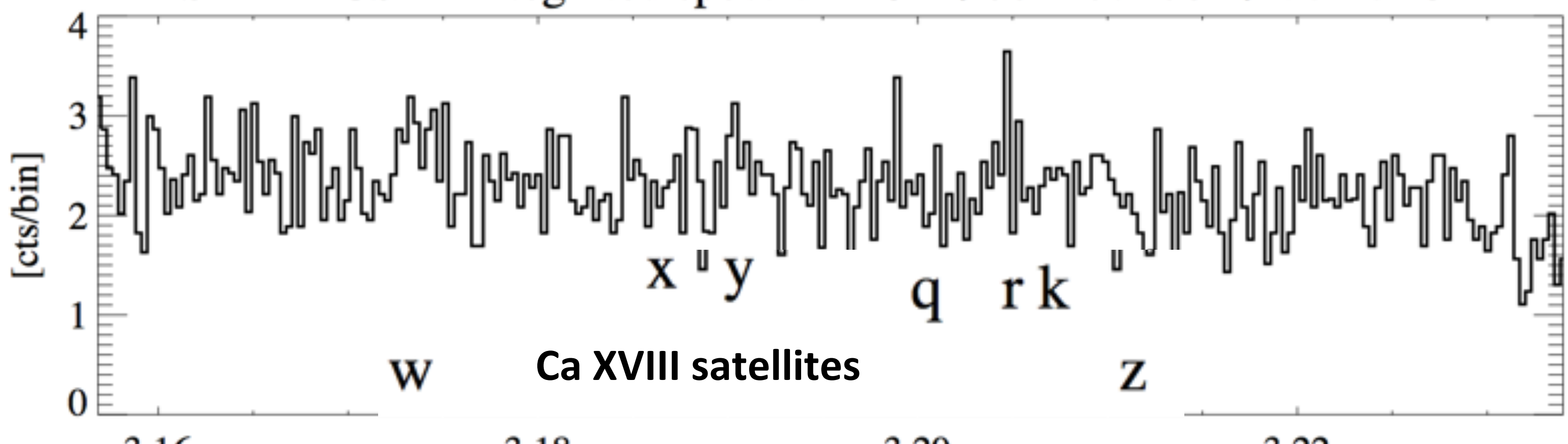
Interesting Channel #7: Fe XXV w



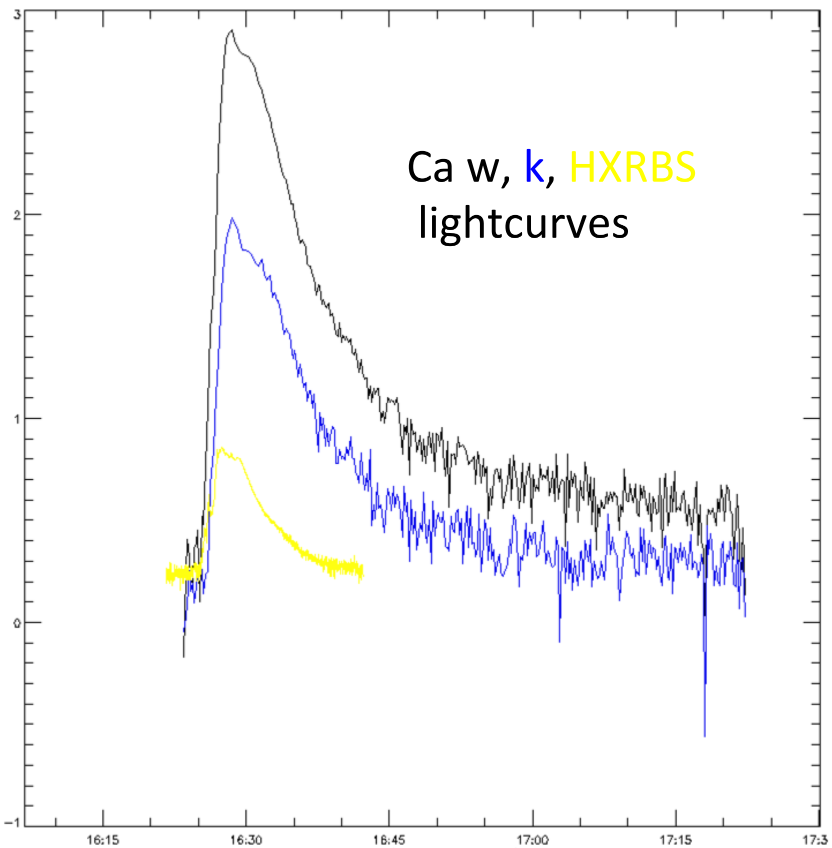
Microflare signatures if within FOV

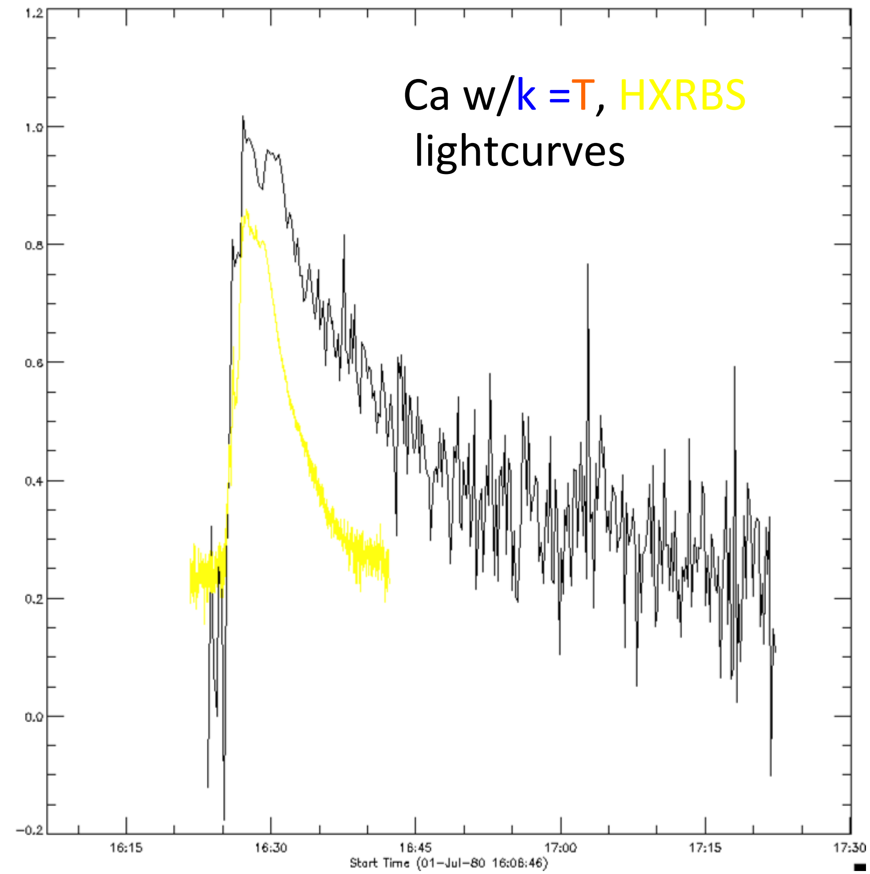


SMM BCS #1 integrated spectrum for 1986–Feb–08 19:37:17 UT

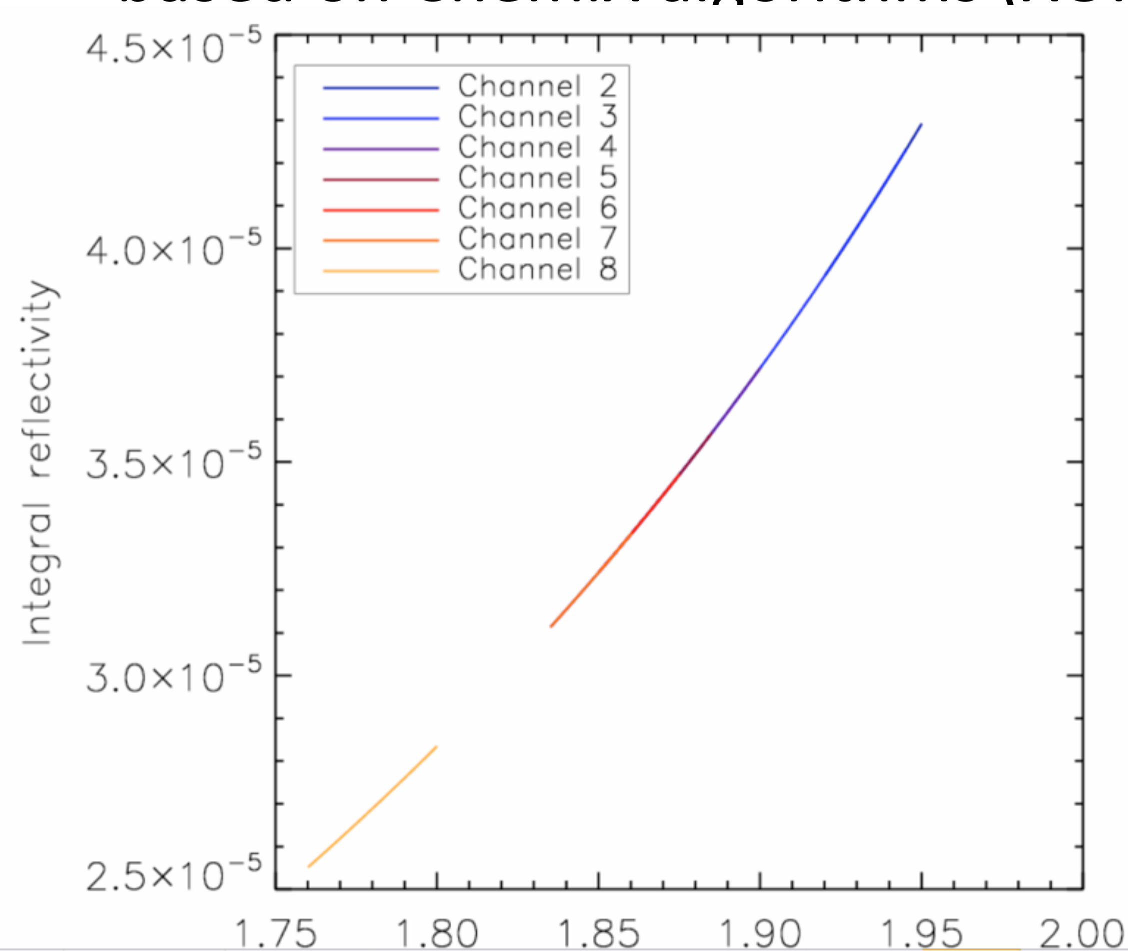


Lightcurves in selected lines





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

Conclusions

- Our small team is capable & ready to re-establish reduction of SBCS
- We will define time&intensity-dependet wavelenght scale for SBCS
- By comparing many events

  Ca XIX vs GOES 1-8 A the collimator transmission function can be estimated

QUESTIONS

- Are the atomic data base (1990) adequate?
- Can CHIANTI be upgraded? (Kanti Aggarwal ascii database fro collision strengths as well as cross-sections 10^5 entries that he can provide)
- Are there people who can help the project.

Hands-on session

- Other flares impulsive ~ 10 different cases
- You suggest what to look for…