Hinode/EIS

EIS capability and opportunities for collaboration

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EIS features

- Two wavelength bands: 170-212 Å and 246-292 Å
  - dominated by iron: Fe VII-XVII, XXIII and XXIV
- Four slits: 1", 2", 40" and ~~266"~~
- 1" pixels (spatial resolution: 3-4" ?)
- FOV: up to 806" x 1024"
- Velocity measurement precision: 1-2 km/s
- Line width precision: 1-2 mÅ

- *Data issues*
  - Calibration seems to be very stable
  - Thermal effects: lines move on detector
  - S-band: leading to reduced observing runs, smaller line lists
  - Warm pixels: increasing with time (currently 12 %), but limited effect on science

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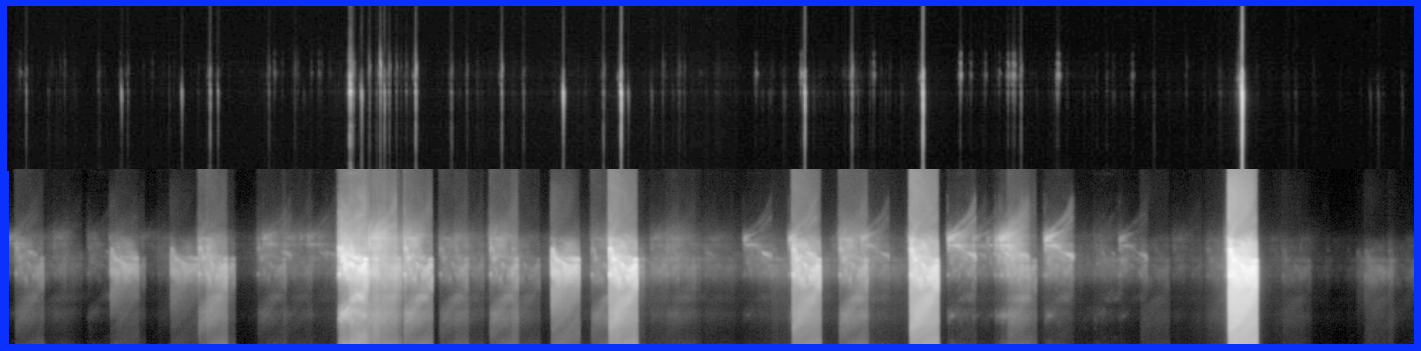
Observing modes

1. Rasters
   - use 1” or 2” slit to generate raster images
   - complete spectroscopy (velocity, widths, diagnostics)
   - (generally) low cadence
2. Spectroheliograms
   - use the 40” slit to generate monochromatic images in several lines
   - high cadence and large spatial coverage



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Getting started with EIS

- Check out the EIS wiki:

  http://msslxr.mssl.ucl.ac.uk:8080/eiswiki/

- The 'Data processing and analysis' link has a lot of information
- The EIS data analysis tutorial (top link) from the Paris meeting (Nov 2007) is probably the best place to start

- Young et al. (2007, PASJ, 59, S857) has an overview of emission lines in the EIS spectrum

Publications

- A full list of EIS-related publications is available from the EIS wiki under the 'Publications' link.
- Currently 145 papers (90 refereed)

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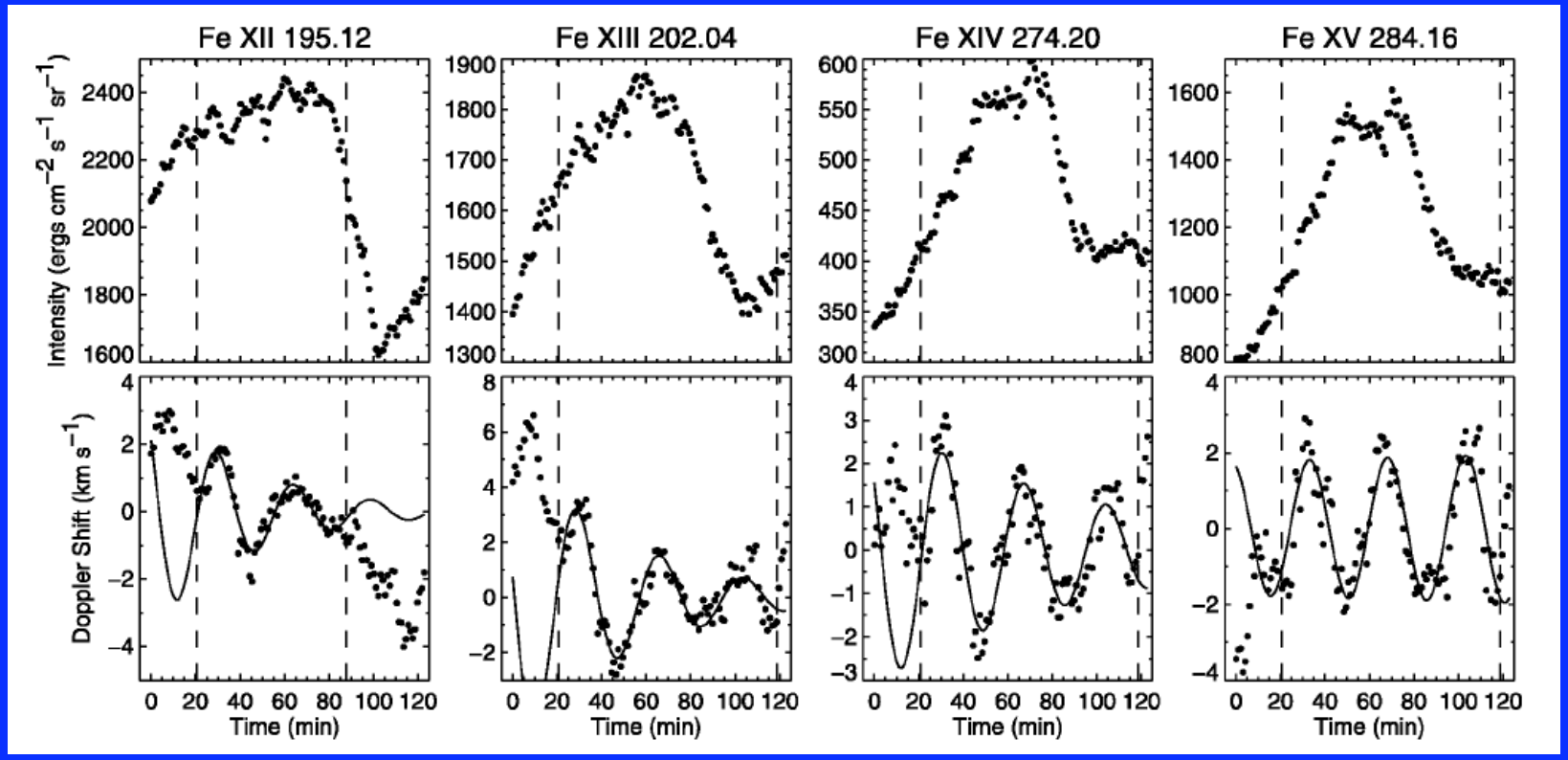
EIS capabilities: velocity



Mariska et al., 2008, ApJ, 681, L41

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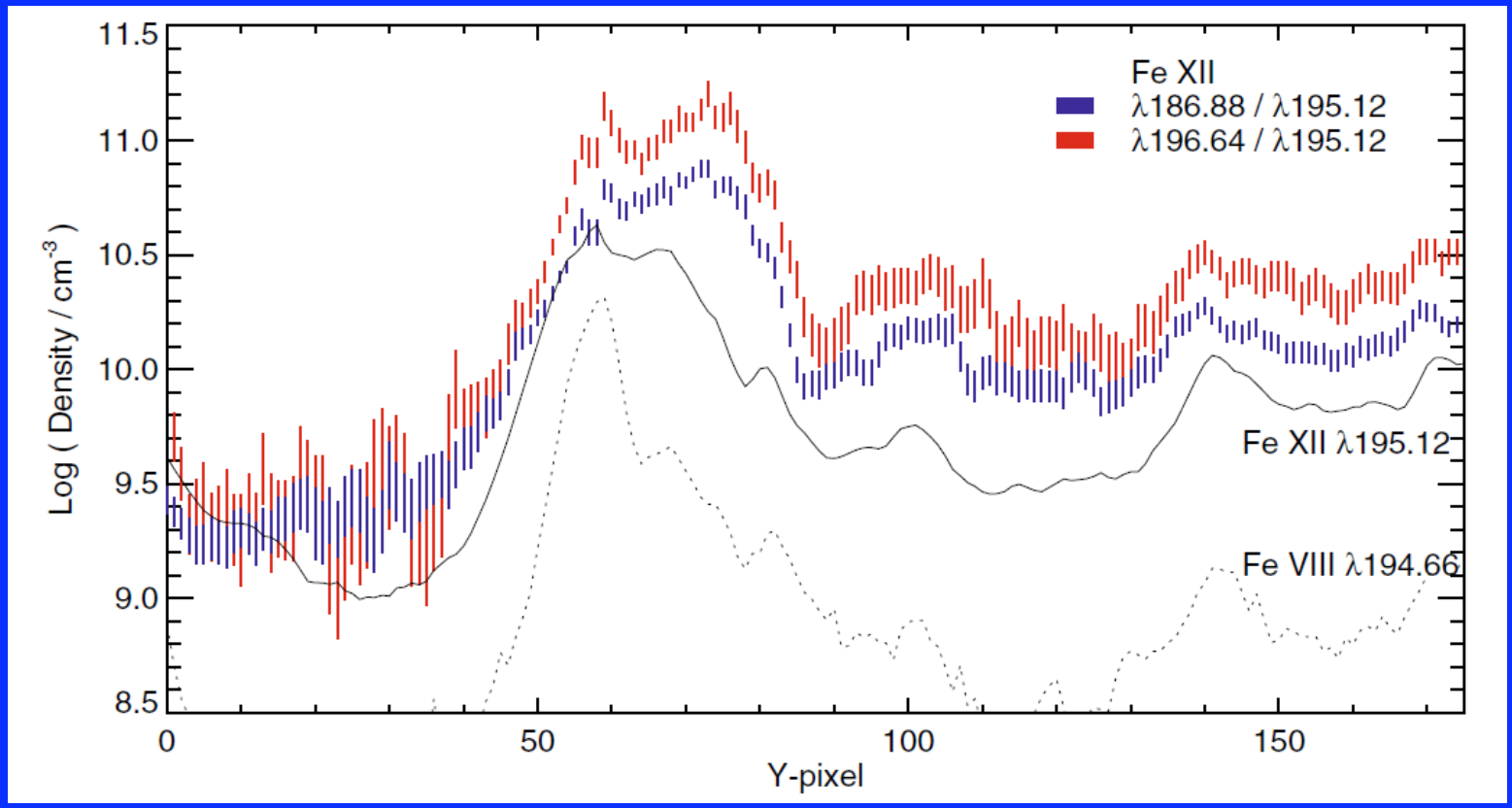
EIS capabilities: density



Young et al., 2009, A&A, 495, 587

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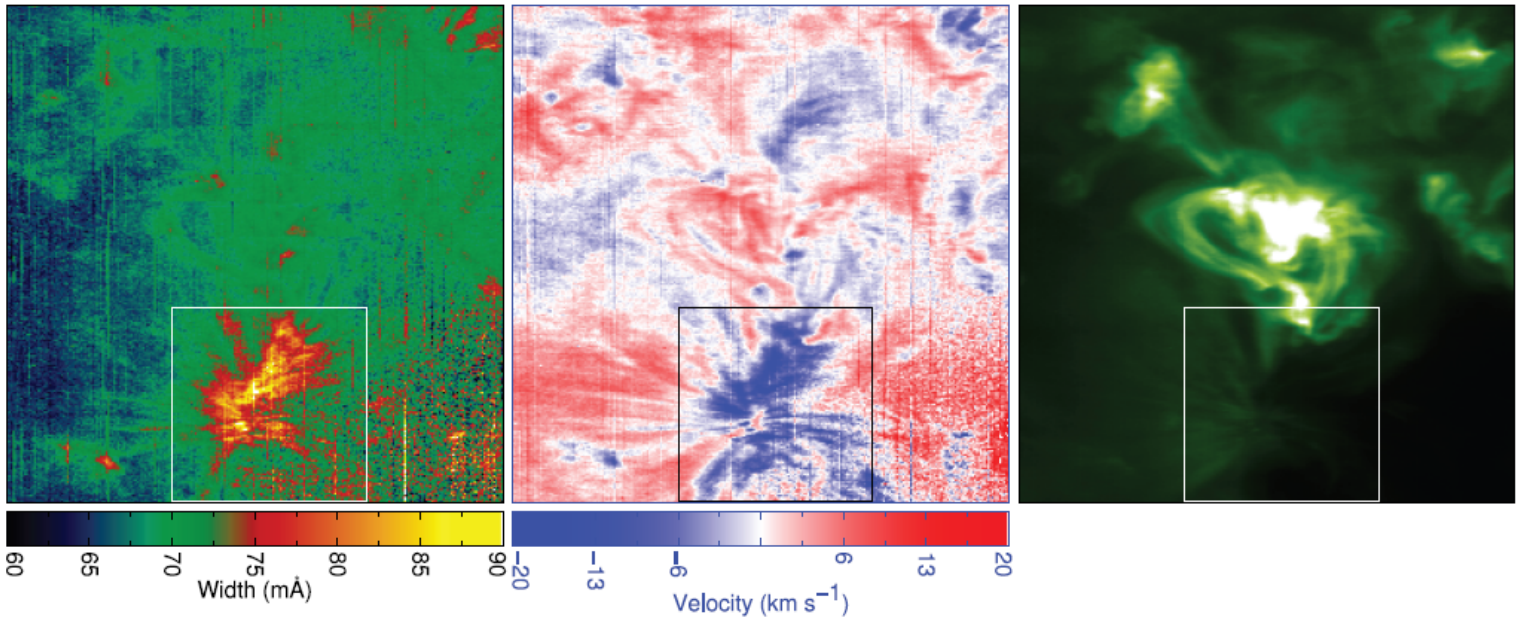
EIS capability: line widths



Doschek et al., 2008, ApJ, 686, 1382

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Collaboration – technical issues

- Cross-calibration
- Pointing & co-alignment
- Software

Cross-calibration

- No attempt has yet been made to compare the EIS and XRT calibrations
- Many co-spatial observations are available
  - regular synoptics at Sun center
  - a number of EIS spectral atlases of active regions have been coordinated with XRT multi-filter observations
- *Should specific individuals be identified to work on calibration?*
- *Topics*
  - use EIS quiet Sun DEM to predict XRT counts
  - what is the predicted EIS spectrum for recent XRT active region DEMs? (Schmelz et al., Reale et al. 2009)

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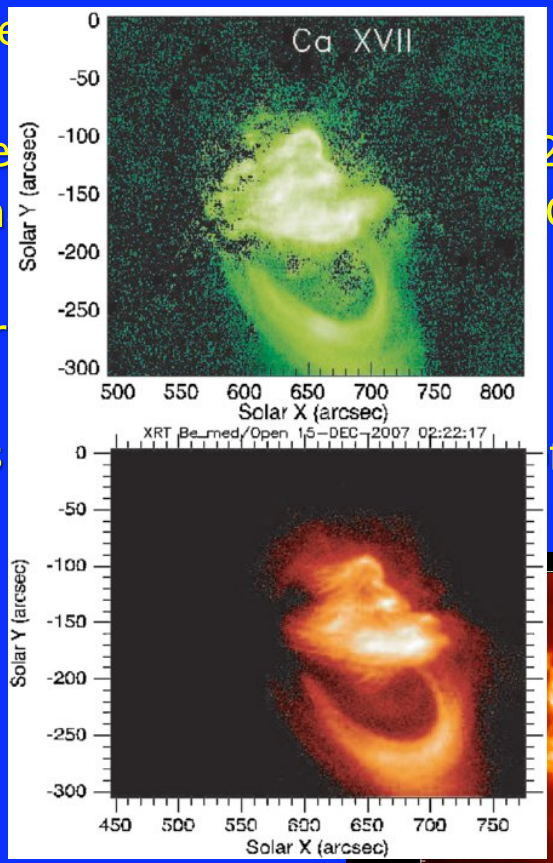
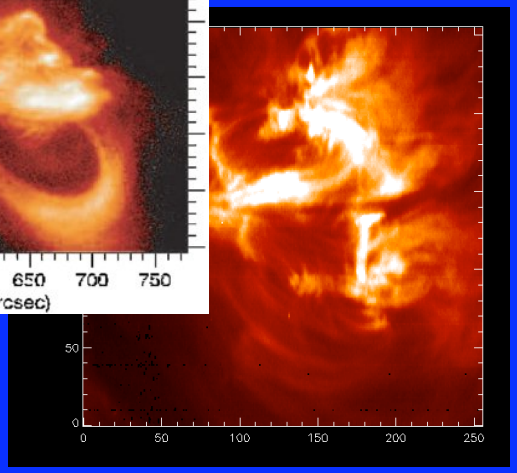
Pointing & co-alignment

- When comparing EIS and XRT images, use cross-correlation…
- …don't trust pointings in file
- Best EIS lines to use are Fe 2.98 & Ca XVII λ192.85
  - Ko et al. (2009, ApJ) h Ca XVII image
- Spacecraft jitter can be der
- Be aware that jitter applies f rasters, giving rise to strange movies!





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Software

- The instrument teams have generally developed software specifically for their own instrument
- Do we need tools to help users analyze all data-sets?
- Examples
  1. For a given time period show the timelines and pointings for each instrument
  2. Create a XRT movie to cover an EIS raster's duration
  3. Overplot EIS raster locations on to an XRT synoptic image
- Routines such as these may have been developed by the Hinode community – is there a way to contribute these to the instruments' SSW trees?

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Future observations

- Flare flag
- Default flare study
- Active region observations
- CO communication

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Flare flag

- Internal EIS flare flag not useful following S-band restrictions
  - take 266” slot images in He II at 30 s cadence
  - pre-flare data can not be discarded
- What is status of XRT flare flag observations?
- How quickly will EIS receive pointing coordinates?

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Flare study

- Following EIS meeting (Mar 09) a consensus for a single flare study was obtained

- FLR001_flare_study
  - 80" x 120" field of view (2" slit)
  - 5 min cadence
  - can run continuously for 15-24 hours
  - He II 256.3, Fe XIV 264.8, 274.2 (dens. diag.), S XIII 256.6, Fe XVII 254.8, Fe XXIV 255.1

- This study will be run on the next active region with expected flaring activity (M, X-class)

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Regular EIS active region studies

1. Active region maps at disk center (HPW0017AR_30x400_30s2)
   - take large active region map (e.g., 500" x 400") in many lines
   - good reference data-sets for loops, DEMs, AR velocities

2. CME watch/AR dynamics (PRY_slot_context_v3)
   - slot context rasters (500" x 500") with 3 min cadence
   - can run continuously for 6-18 hours/day

3. Active region jets (IUU_SCAN_STEPS_002)
   - 2" sparse raster, 58" x 368" (4" jumps)
   - 5 min cadence
   - large line list
   - can run continuously for 6 hours/day

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CO communication

- How effective is communication between EIS and XRT COs?

- Are the instruments observing at the same time?
- Are the observing programs compatible?

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Science collaboration topics

- Coronal hole jets
- Active region outflows
- Nanoflares/high temperature AR plasma

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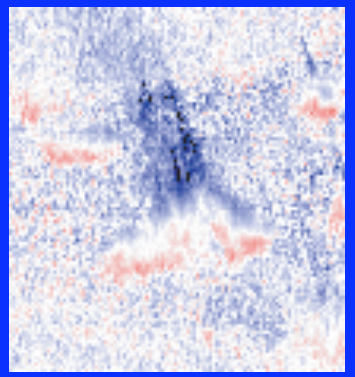
Topic 1: coronal hole jets

- EIS can contribute through
  - line-of-sight velocity measurements
  - DEM
  - density measurements
- Either small narrow-slit rasters, or large slot rasters
- Early EIS work
  - Culhane et al. (2007, PASJ, 59, 751)
  - Kamio et al. (2007, PASJ, 59, 757)
- Are collaborations in place?
- Are more observations needed?



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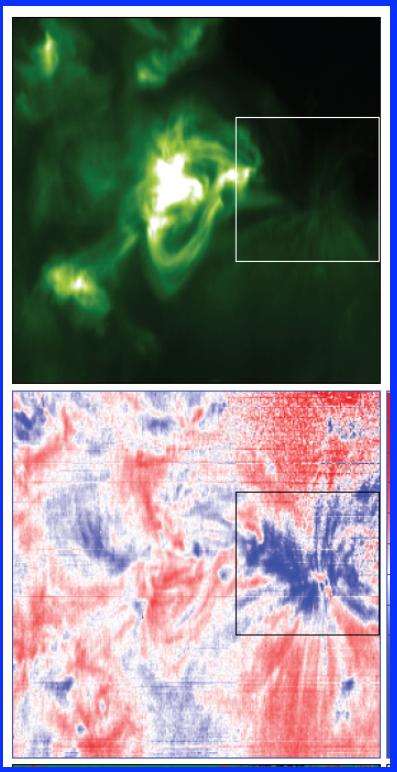
Topic 2: active region outflows

- Outflow regions around active regions are a ubiquitous feature of EIS observations
  - Harra et al. 2008, ApJ, 676, L147
  - Doschek et al. 2008, ApJ, 686, 1362
  - Del Zanna, 2008, A&A, 481, L49
- Outflows also seen by XRT (Sakao et al. Science, 2007)
- Questions
  - are both instruments seeing the same thing?
  - what contribution do the flows make to the solar wind?
- A HOP is in place to make future coordinated measurements (Korreck et al.)



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Topic 3: nanoflares & high-T plasma

- High temperature (log T > 7.0) plasma has been identified in active regions using XRT data (Schmelz et al. 2009, Reale et al. 2009)
- Consistent with nanoflare picture of coronal heating

- Is this high temperature plasma accessible to EIS?

- Ca XVII λ192.85 (log T=6.7) was expected to reveal nanoflare signature
  - line affected by blending

- XRT observations suggest Fe XXIV λ192.0 (log T=7.2) is more useful

- Many coordinated observations already exist

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Topic 3: nanoflares & high-T plasma

- EIS, XRT DEM comparison

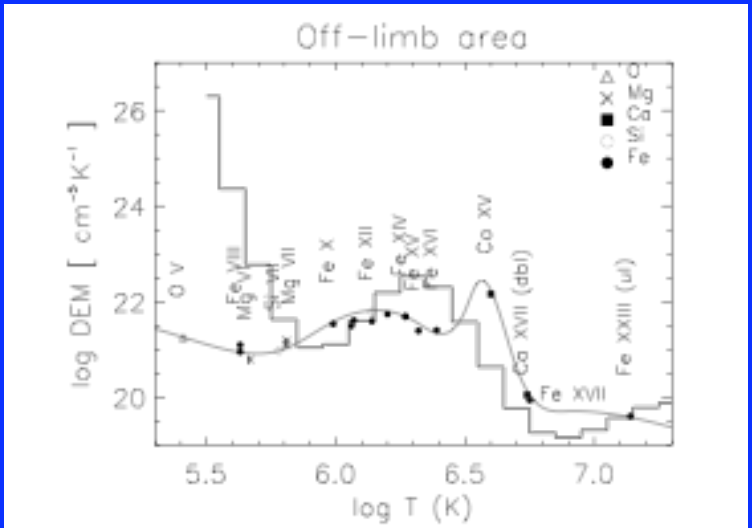

Fig. 17. Plot of the EIS (spline function) and XRT (histogram) DEM curves created in the off-limb area shown in Fig 16. The notation dbl and ul denote deblended and upper limit respectively.

O'Dwyer et al., A&A, submitted

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Summary

- Coordinated EIS and XRT observations have not been fully exploited yet
- Instrument teams should help users with technical issues (calibration, pointing, software)
- COs should ensure coordinated observations are performed, and data-sets complement each other
- Some science topics have good potential for collaboration
  1. coronal hole jets
  2. active region outflows
  3. nanoflare heating

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