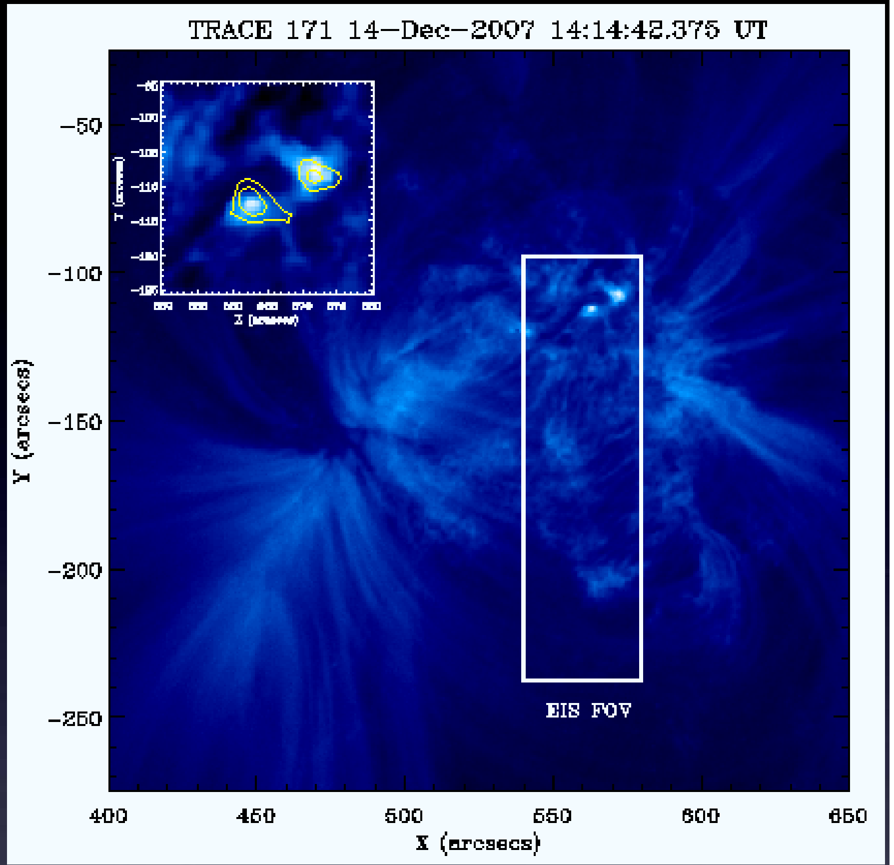
Impact of Electron Beams on the Ambient Material in the Chromosphere and Corona

Ryan Milligan & Brian Dennis (NASA-GSFC)

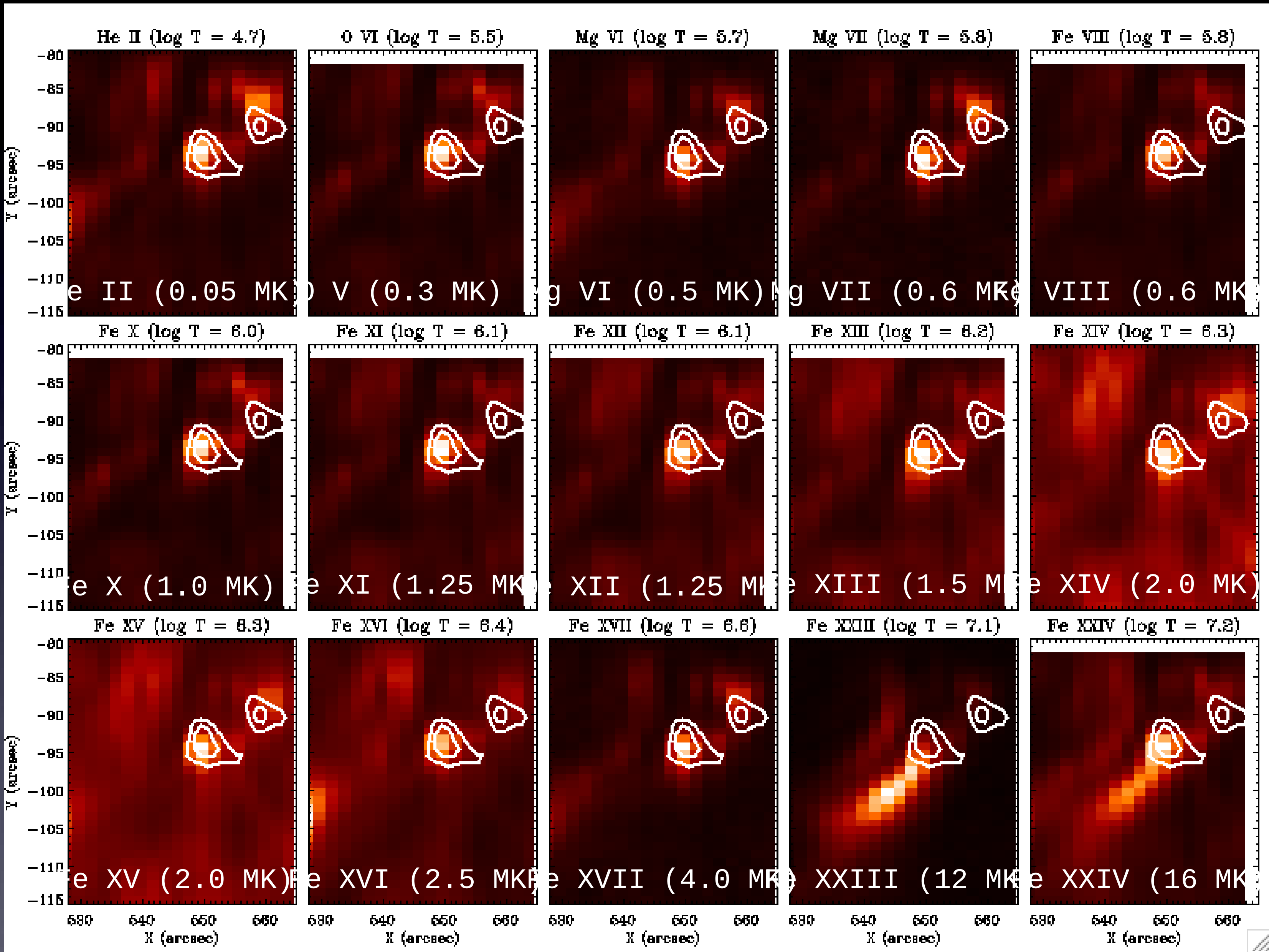
- 14 December 2007
  - Before Hinode X-band problem
  - After RHESSI's detectors were annealed
  - RHESSI HXR footpoints align with TRACE EUV emission during impulsive phase
- EIS study: CAM_ARTB_RHESSI_b_2
  - -40"x143" FOV using 2" slit
  - -3.5 minute raster cadence
  - -22 spectral windows, including:

    He II, O IV, O V, O VI, Mg V, Mg VI, Mg VII, Si X, Ca XVII, Fe VIII, Fe X, Fe XI, Fe XII, Fe XIII, Fe XIV, Fe XV, Fe XVI, Fe XVII, Fe XXIII, Fe XXIV



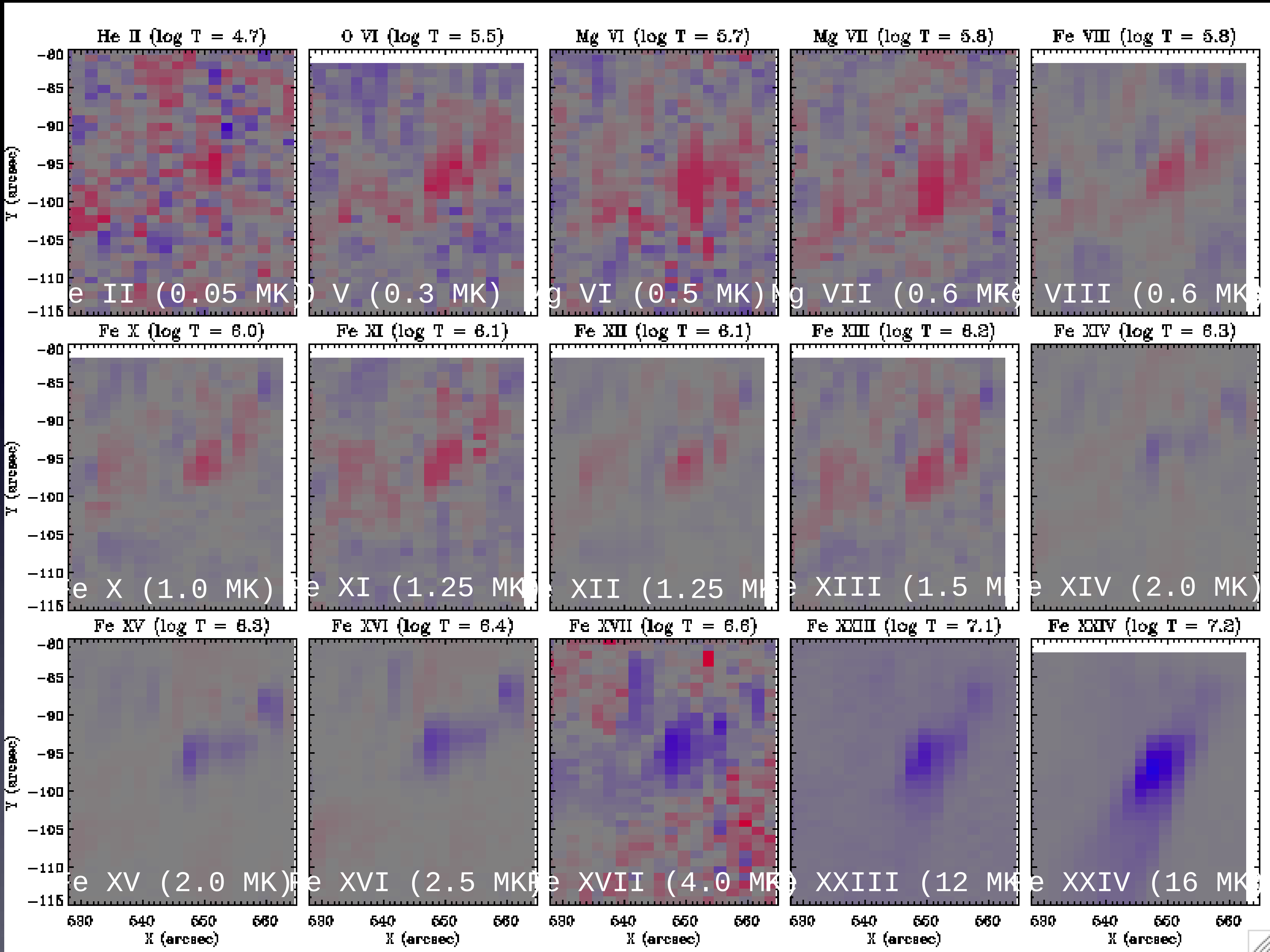
RHESSI 20-25 ke

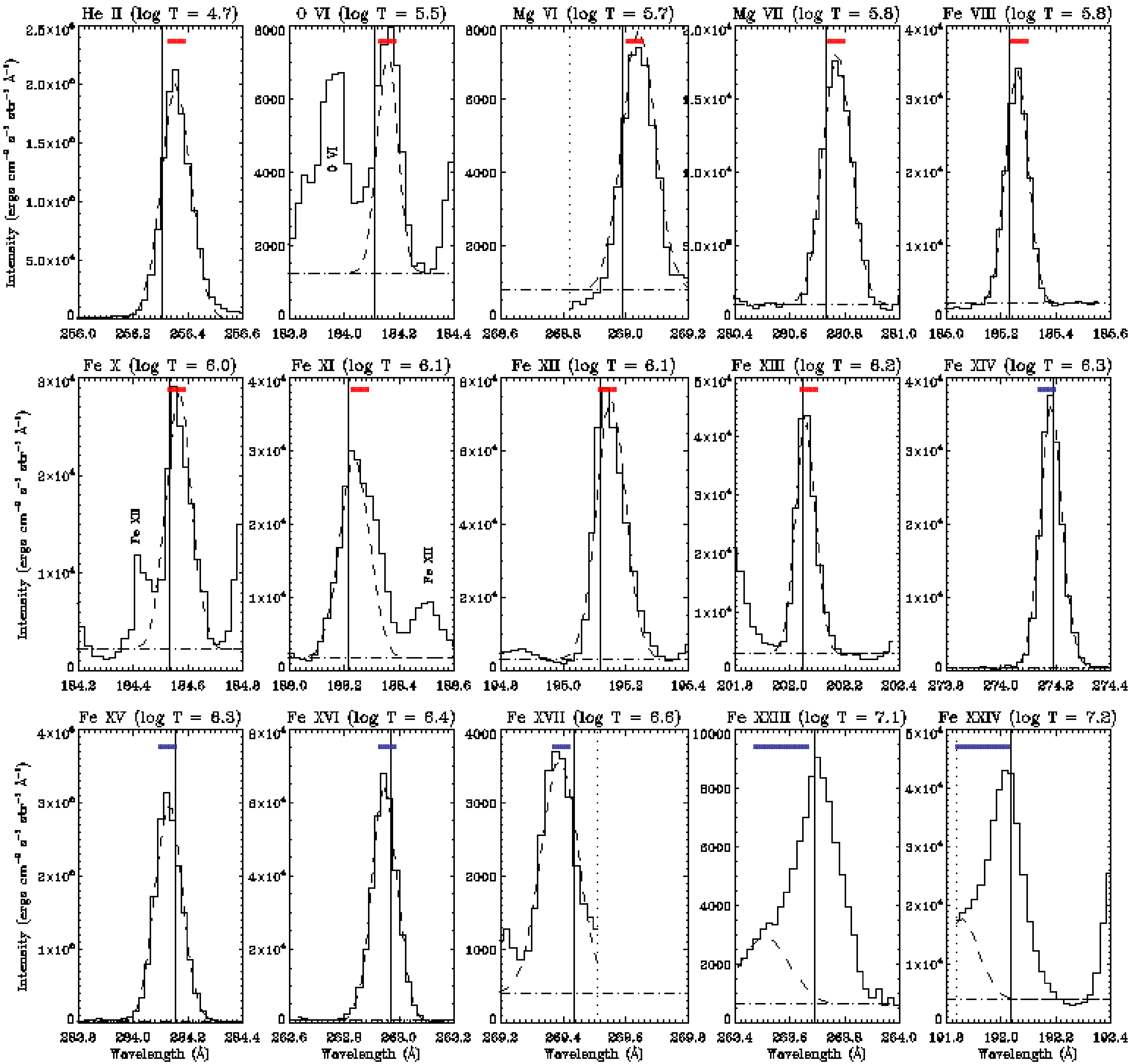
Intensity Maps



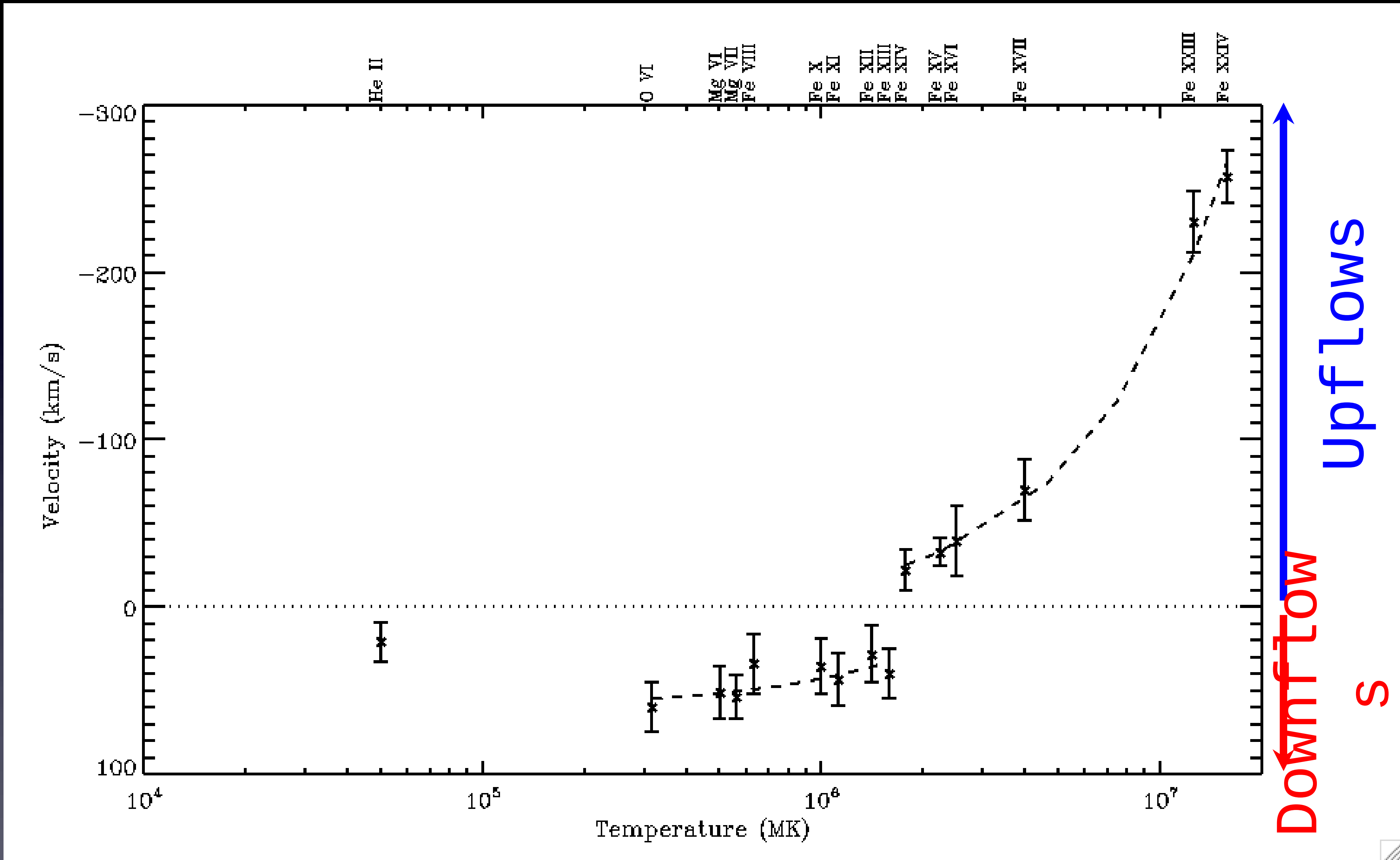
RHESSI 20-25 keV

Velocity Maps



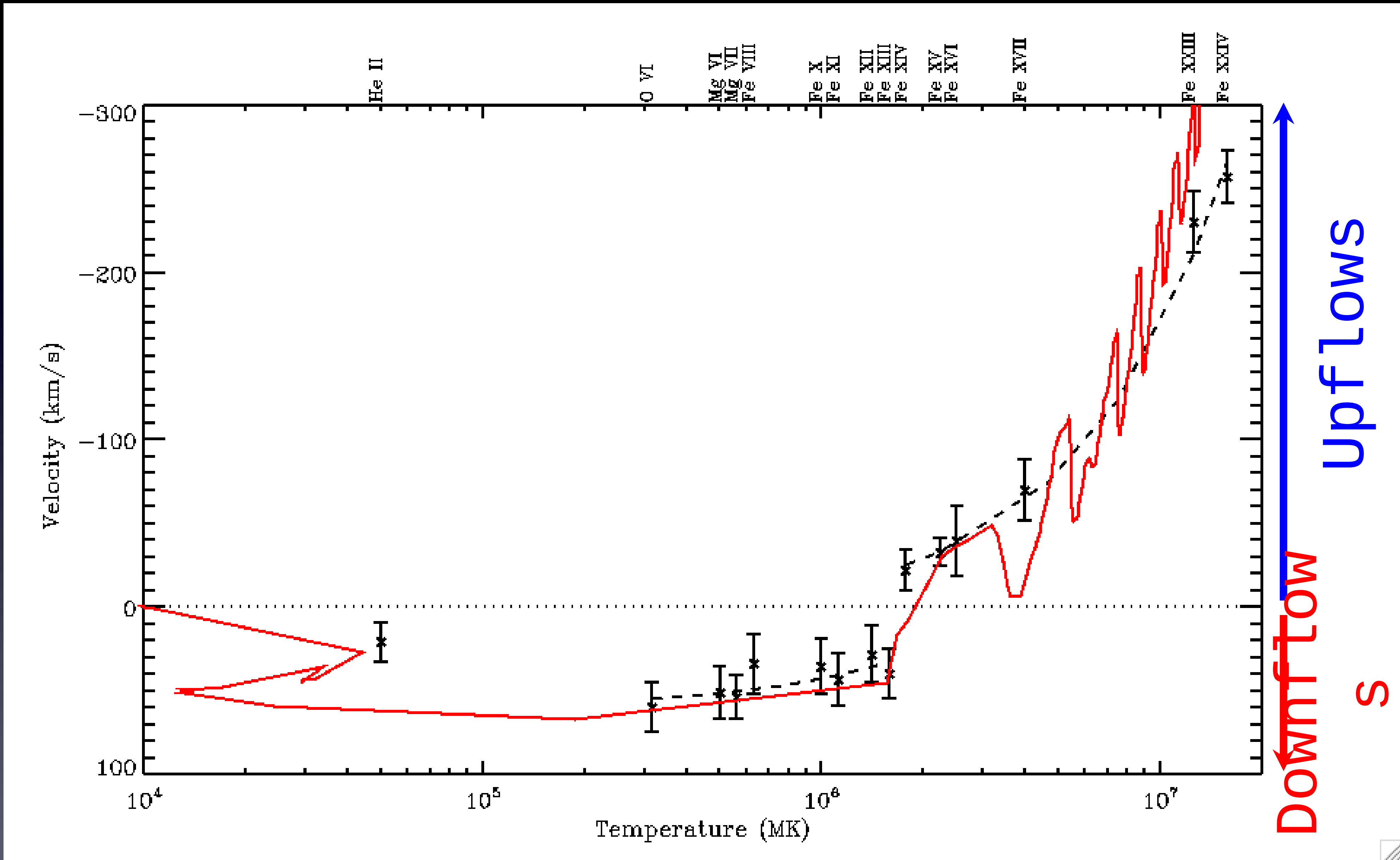


He II (log T = 4.7)
O VI (log T = 5.5)
Mg VI (log T = 5.7)
Mg VII (log T = 5.8)
Fe VIII (log T = 5.8)
Fe X (log T = 6.0)
Fe XI (log T = 6.1)
Fe XII (log T = 6.1)
Fe XIII (log T = 6.2)
Fe XIV (log T = 6.3)
Fe XV (log T = 6.3)
Fe XVI (log T = 6.4)
Fe XVII (log T = 6.6)
Fe XXIII (log T = 7.1)
Fe XXIV (log T = 7.2)
O VI
Fe XII
Fe XII
Intensity (ergs cm^{-2} s^{-1} str^{-1} Å^{-1})
Wavelength (Å)



own (km/s) = 60-17 T (MK)

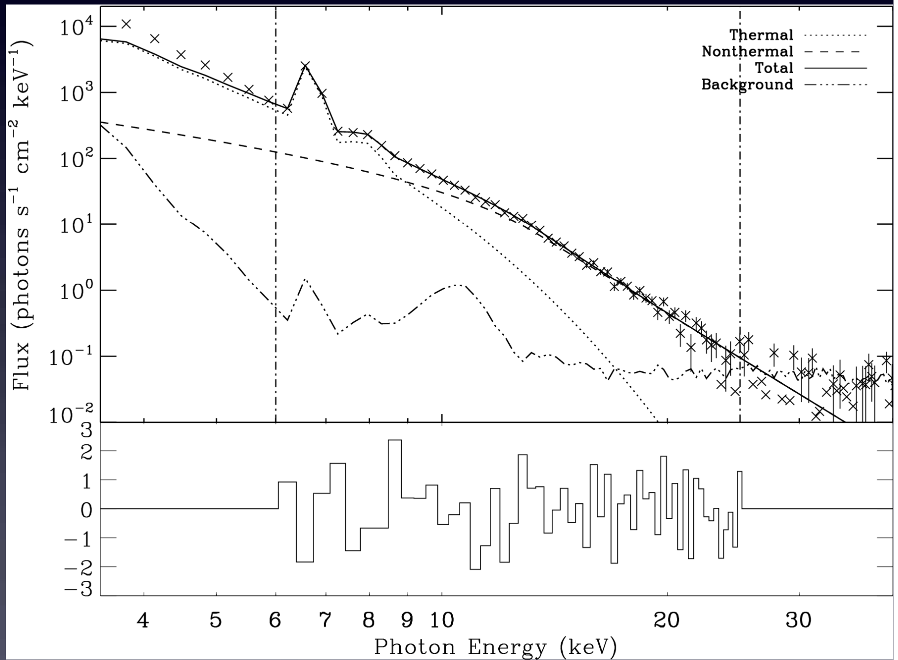
v_{up} (km/s) = 5-17 T (M



1-D hydro-code (Liu et al. 2009)

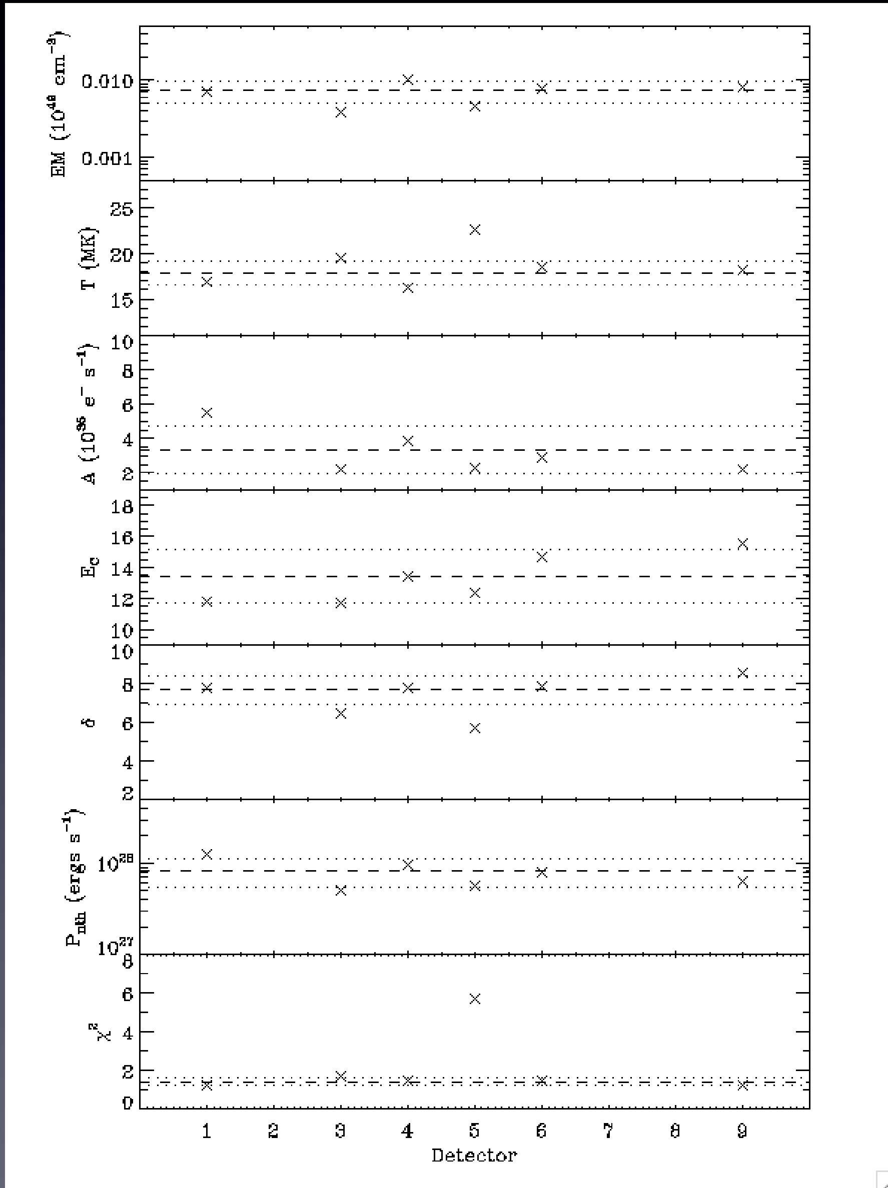
Electron Beam Diagnostics

- The combination of RHESSI imaging and spectroscopy provides a measurement of the energy flux of the electrons responsible for driving evaporation
- Use HSI_SPECTRUM_SEP_DET_FILES to generate spectrum and srm files for each detector individually
- Allows the most up-to-date corrections for pulse pileup and gain offset to be used



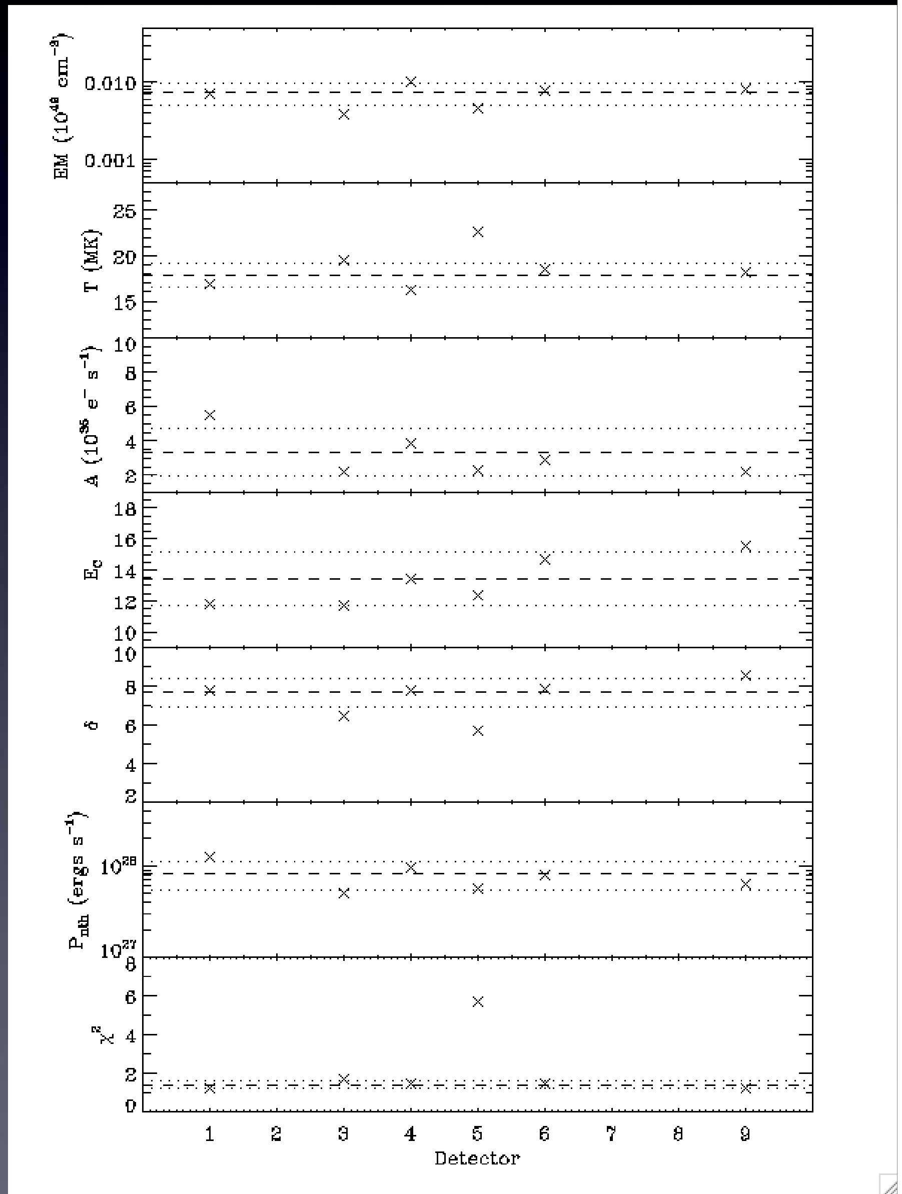
Electron Beam Diagnostics

- The combination of RHESSI imaging and spectroscopy provides a measurement of the energy flux of the electrons responsible for driving evaporation
- Use HSI_SPECTRUM_SEP_DET_FILES to generate spectrum and srm files for each detector individually
- Allows the most up-to-date corrections for pulse pileup and gain offset to be used



Electron Beam Diagnostics

- Total power contained in electron beam:
  - P_{nth} $(E>E_C)$ = $\int E\ F(E)\ dE$ erg/s
  - where $F(E) \sim E^{-\delta}$, is the electron distribution
- Using $E_C = 13 \pm 2$ keV, $\delta = 7.6 \pm 0.7$
- $P_{nth} \geq 8 \pm 3 \times 10^{27}$ erg/s
- Dividing P_{nth} by the footpoint area:
  - $F_{nth} \geq 5 \times 10^{10}$ erg/cm^2/s



Summary

- We present the first detailed study of (explosive) chromospheric evaporation using Hinode/EIS and RHESSI (Milligan & Dennis 2009, ApJ, 699, 968)
- EIS is able to determine evaporation velocities across a broad range of temperatures, while RHESSI can establish the parameters of the driving electron beam
- The key findings are:

- The Fe XXIII and Fe XXIV lines profiles were both dominated by stationary components
- Both upflow and downflow velocities were found to be dependent on temperature
- Downflows due to the overpressure of evaporated material occur at higher temperatures than previously observed or predicted by current models
- Energy flux of electrons is high enough to drive explosive evaporation

Future Work

- Observe a variety of events (or one LDE) with varying electron beam parameters (from RHESSI) and measure the response of the atmosphere with Hinode/EIS.
- Mariska et al. 1989 predicts different velocity responses according to changes in δ, E_C, and flux.
- Also perform accurate density diagnostics