ISSI team:

The Role of Spectroscopy and Imaging Data in Understanding Coronal Heating

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www.issibern.ch/teams/Spectdata/

Topics:

Modeling:

- ✓ Nanoflares with 0D and 1D models (Klimchuk, Cargill, Patsourakos, Parenti, Spadaro)
- ✓ MHD turbulence (Buchlin)
- ✓ Thermal nonequilibrium (Klimchuk)

Observations:

- ✓ Nanoflares in AR observed in the EUV (Mason, Parenti, Klimchuk, Landi) and hard X-ray (Benz)
- ✓ Thermal analysis in AR (Reale, Parenti, Mason, Landi, Benz) and quiet full Sun (Sylwester)
- ✓ Flows in loops (Patsourakos, Parenti, Mason, Klimchuk)

Enthalpy Based Thermal Evolution of Loops (EBTEL)

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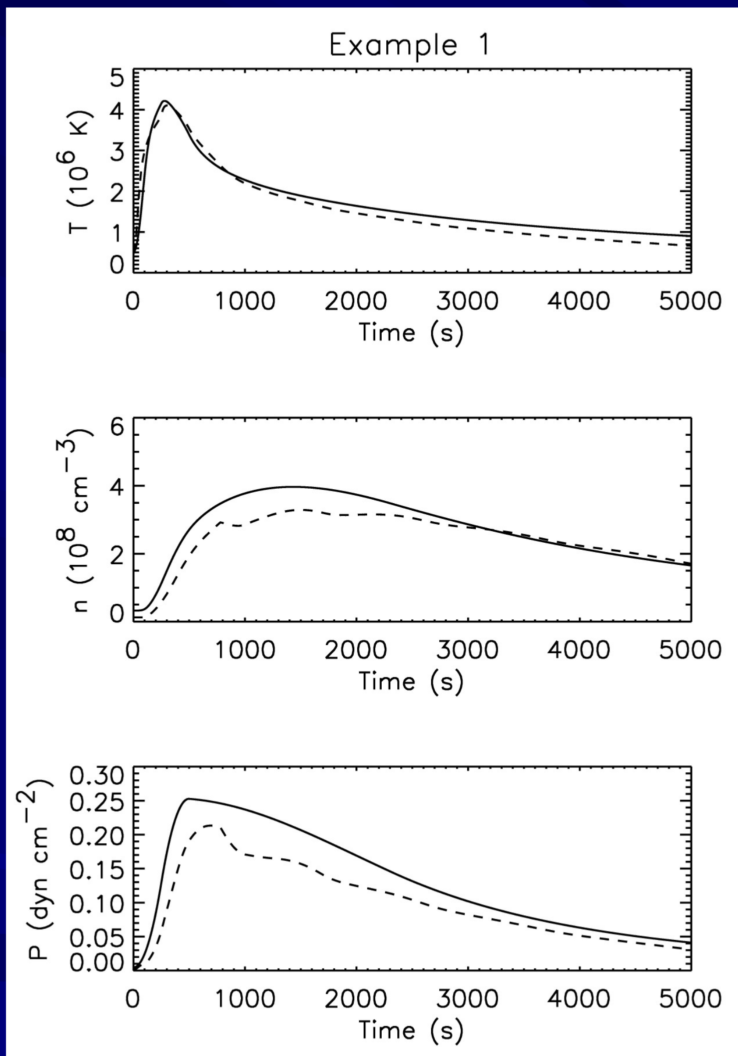
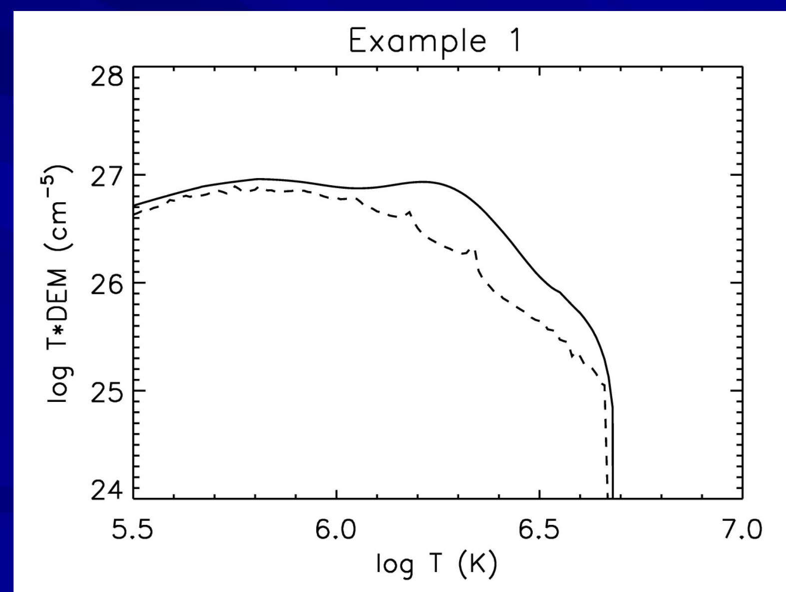
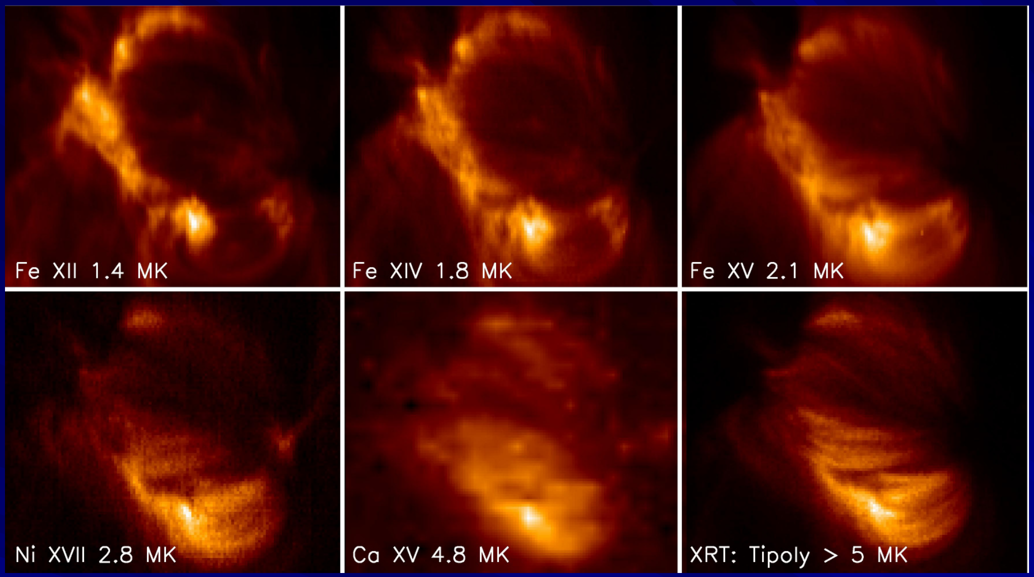


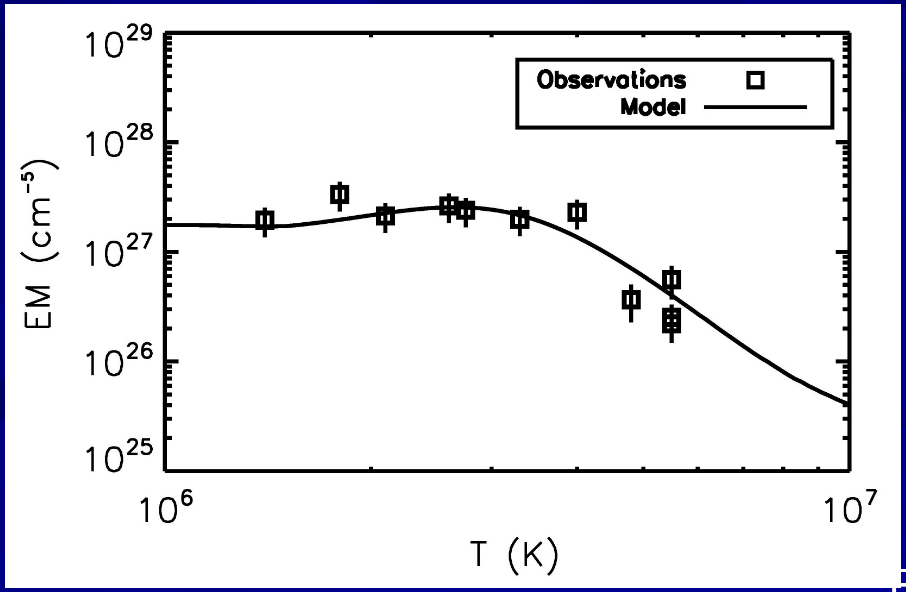
500 s nanoflare

"0D" hydro code
Easy to use, runs in IDL
Any heating function, H(t)
DEM(T,t) in transition region
Heat flux saturation
Non-thermal electron beam
10^4 time faster than 1D codes



Klimchuk, Patsourakos, & Cargill (2008)





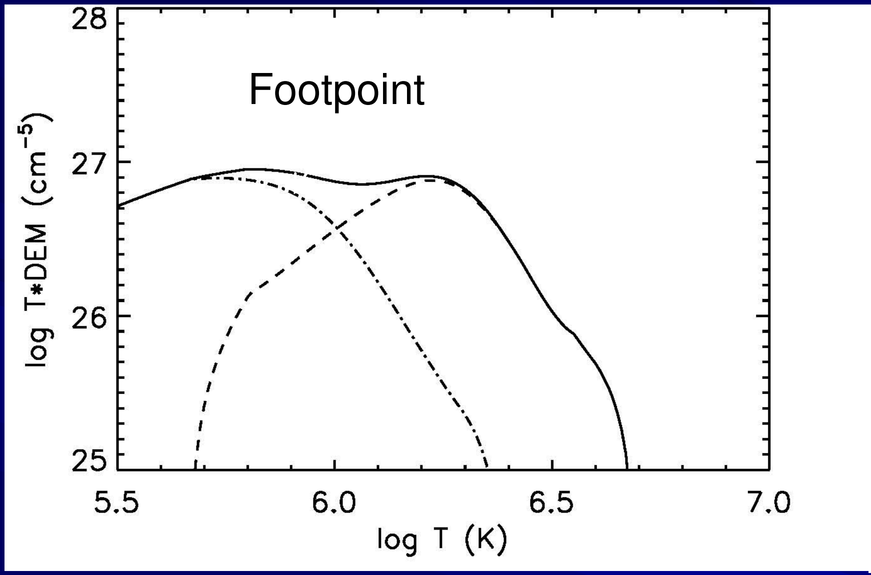
Hinode/EIS:

Fe XII – XVII
Ca IV – VI
Ni XVII

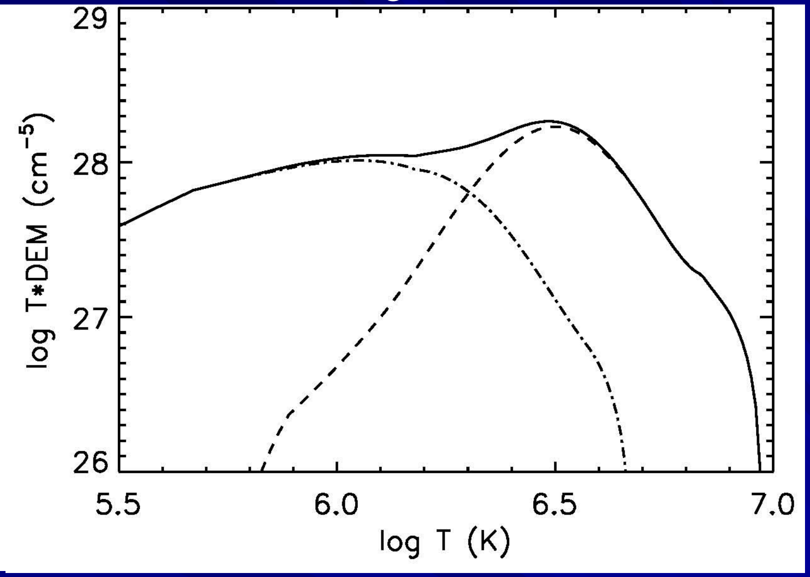
Patsourakos & Klimchuk (2008)

(Super) Hot Plasma

Weak Nanoflare



Strong Nanoflare

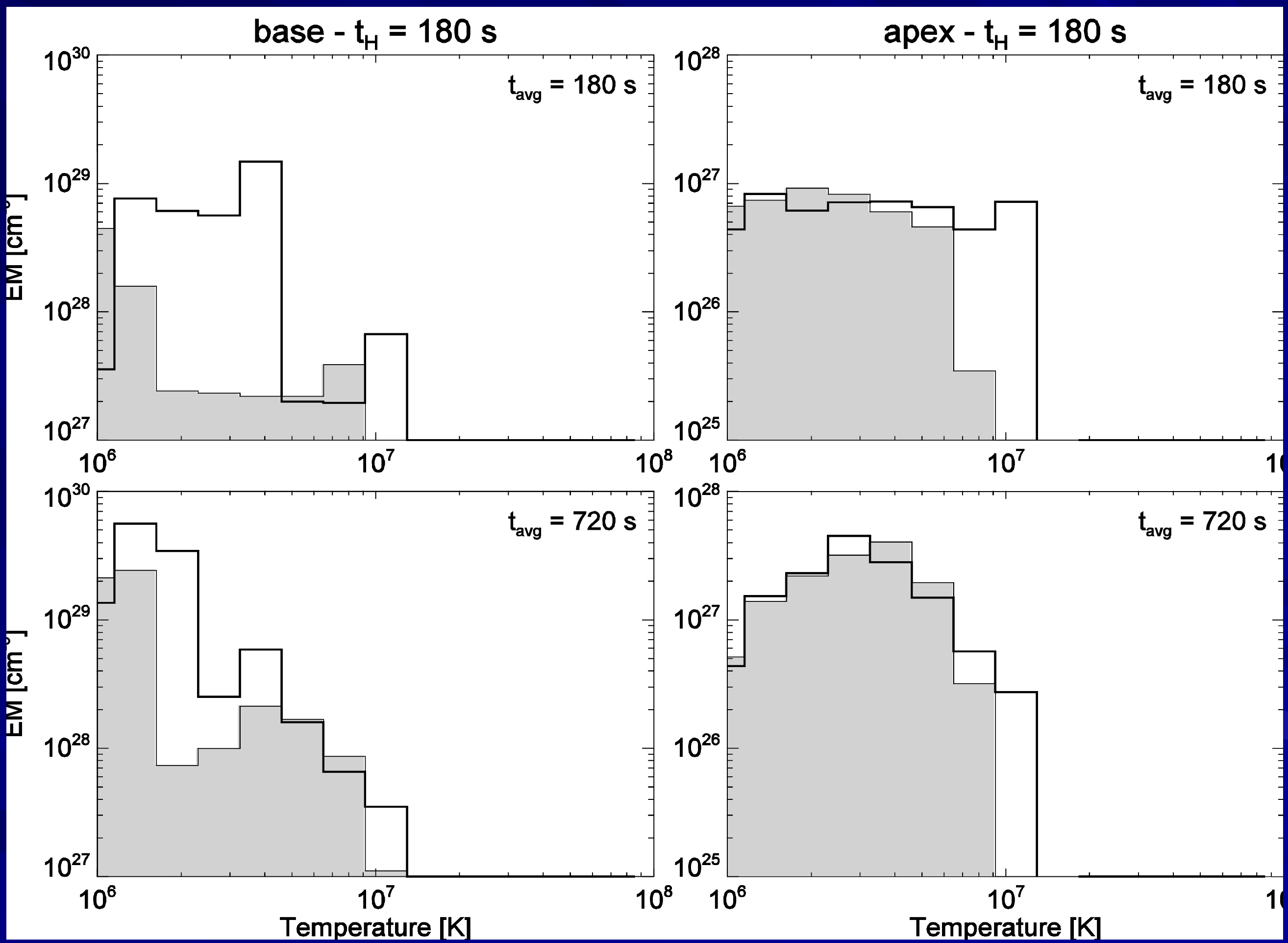


Hot plasma predicted to be **very faint**:

EM (cm^{-5}) = T x DEM reduced by **1-1.5 orders** magnitude
DEM (cm^{-5} K^{-1}) reduced by **1.5-2 orders** magnitude

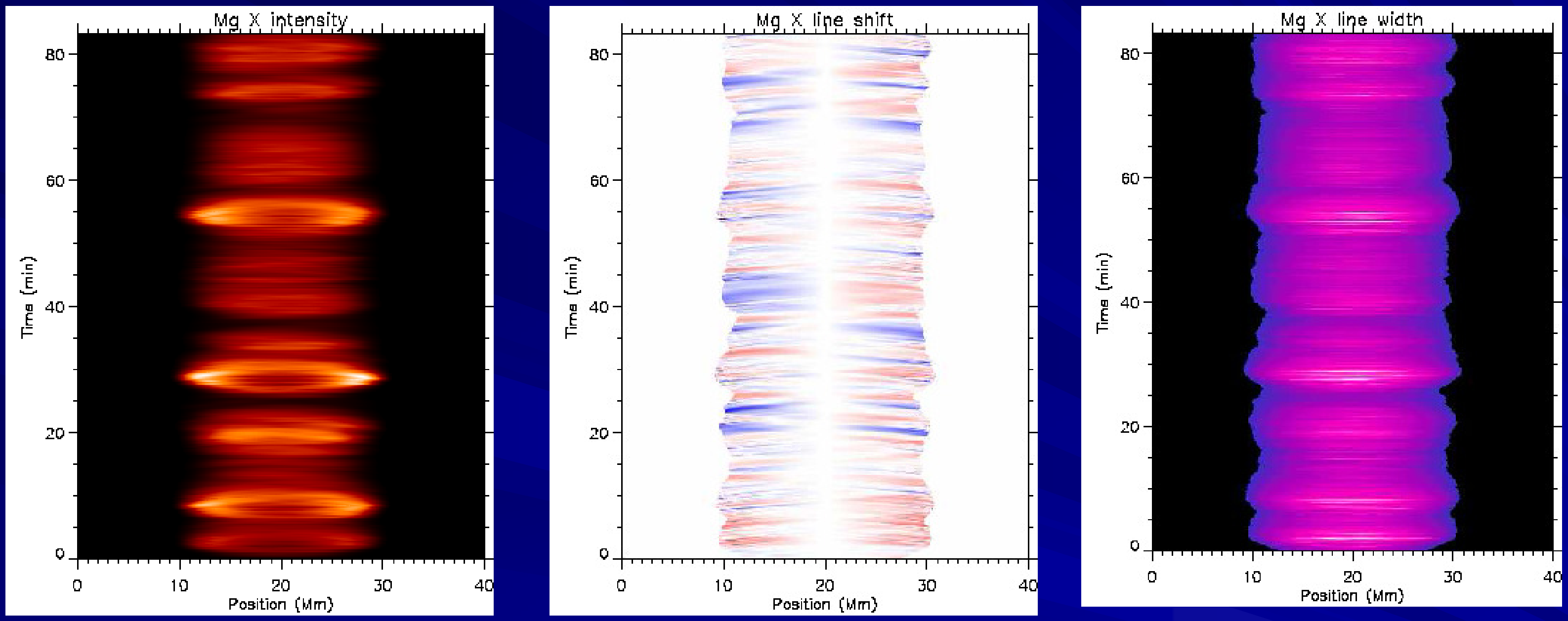
Seen by CORONAS-F (Zhitnik et al. 2006), RHESSI (McTiernan 2008), XRT (Siarkowski et al. 2008; Reale et al. 2008; Schmelz et al. 2008); EIS (Patsourakos & K 2008; Ko et al. 2008)

Non-equilibrium of ionization and the detection of hot plasma in nanoflare-heated coronal loops



Reale & Orlando 2008

UV observables in a loop submitted to MHD turbulent heating



Buchlin, Bradshaw and Cargill, 2008

Hinode/XRT multi-filter analysis

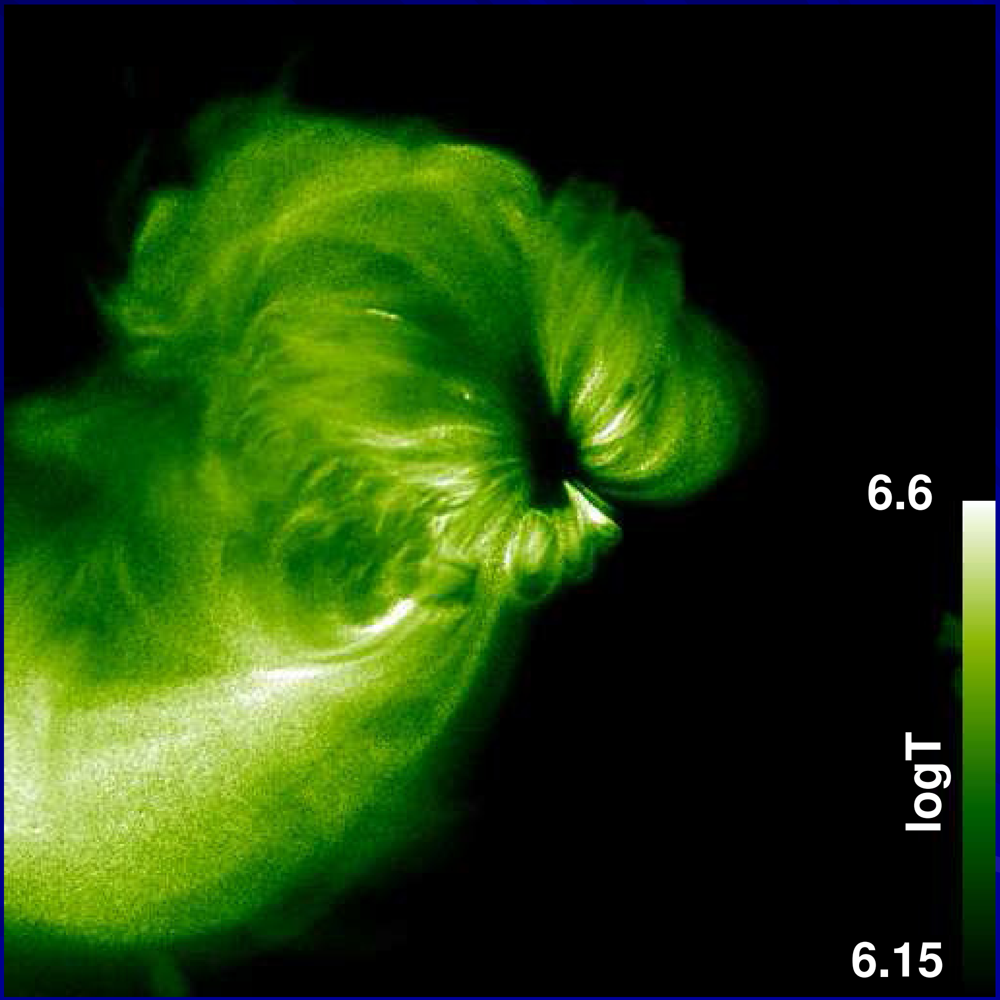
Combined Improved Filter Ratio
(Reale et al. 2007)

✓ Fine scale thermal structure of X-ray loops

✓ Indications of non-flaring plasma in a wide T-range compatible with nano-flare (*Reale et al, Hinode meeting 2008*)

$$CIFR(T) = \frac{(\prod_i I_i)^{1/n}}{I_j} \frac{(\prod_i I_i)^{1/n}}{I_k}$$

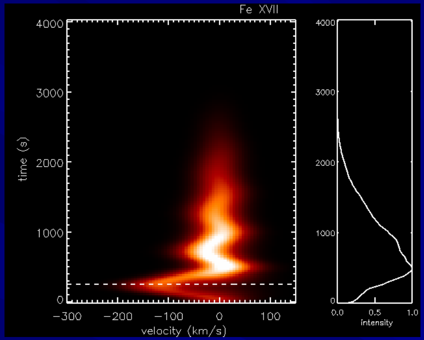
$$= \frac{(\prod_i G_i(T))^{1/n}}{G(T)_j} \frac{(\prod_i G_i(T))^{1/n}}{G(T)_k}$$

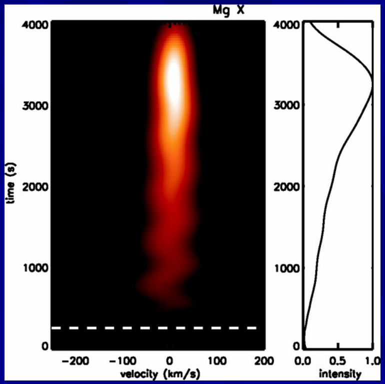


Reale et al 2007

Flow in loops

- ✓ Modeling: upflow at high T

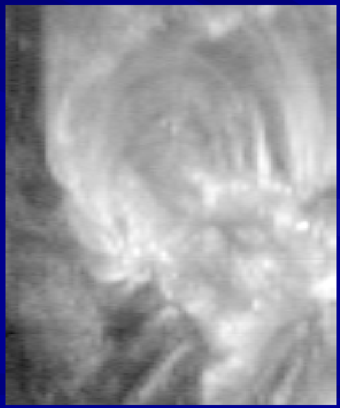




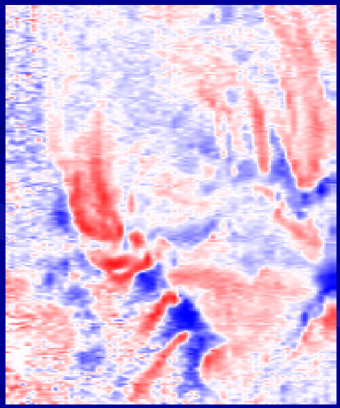
Patsourakos & klimchuck 2006

- ✓ Observations: downflow at TR T

Dammasch et. 2008

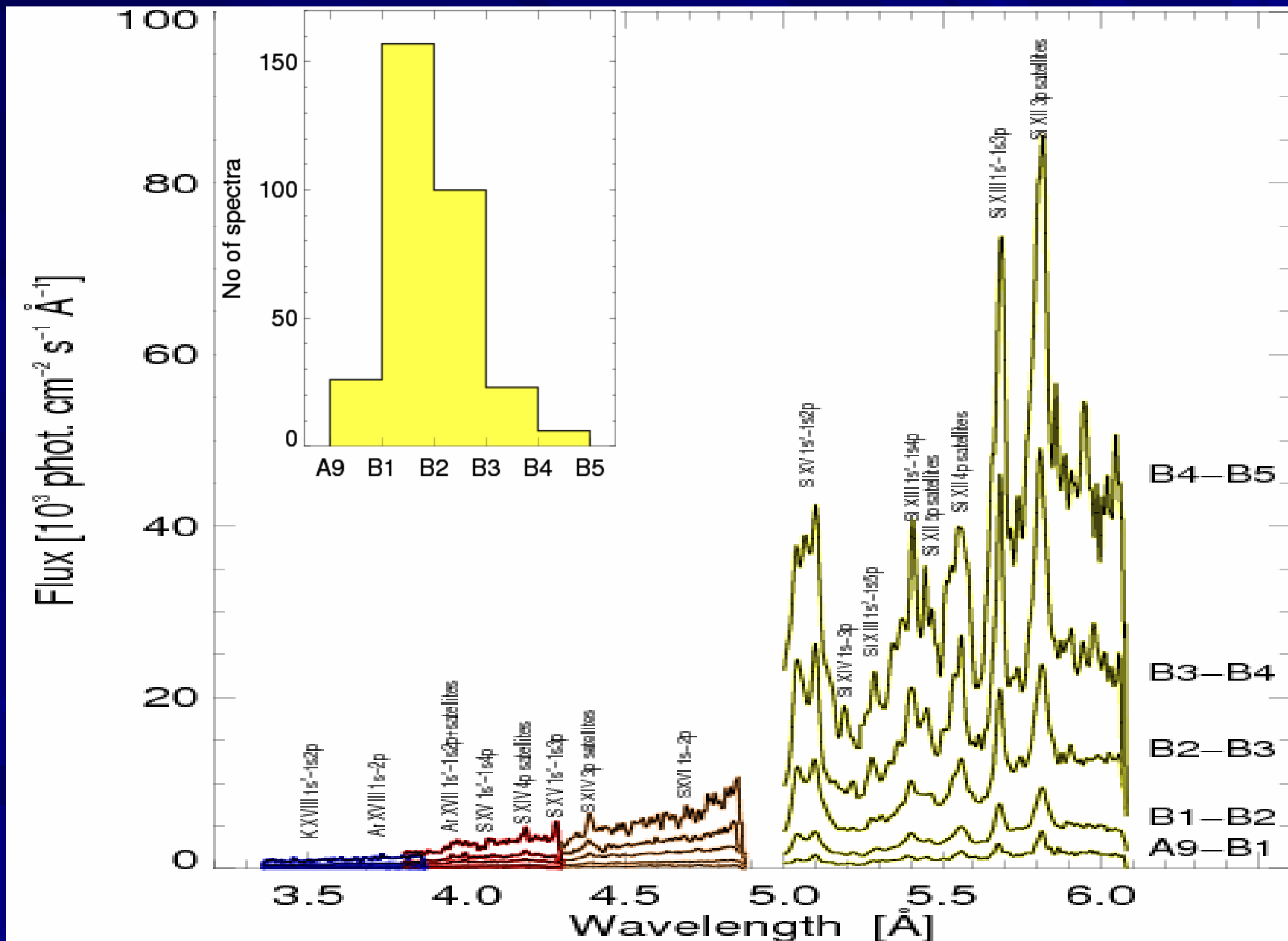


Ne VIII



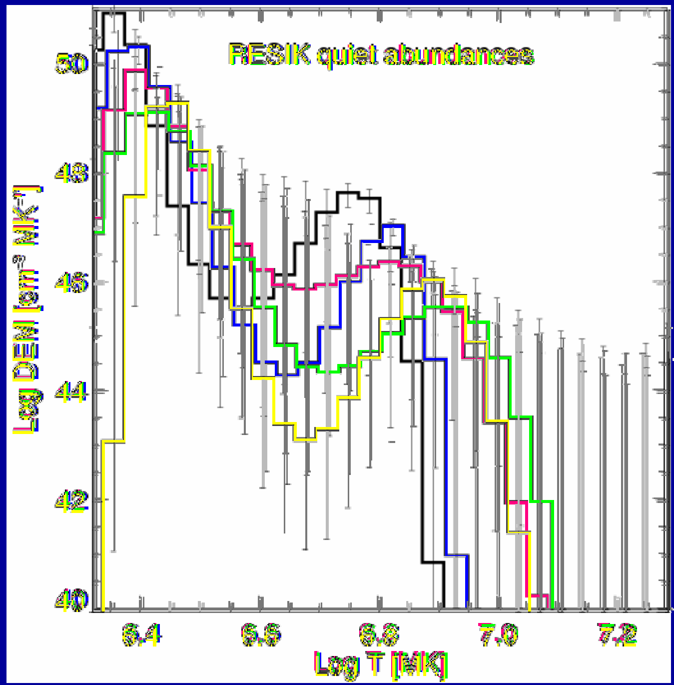
$V_{Ne\ VIII}$

Characteristic spectra of corona for indicated activity intervals as observed by RESIK



Sylwester et al. 2008

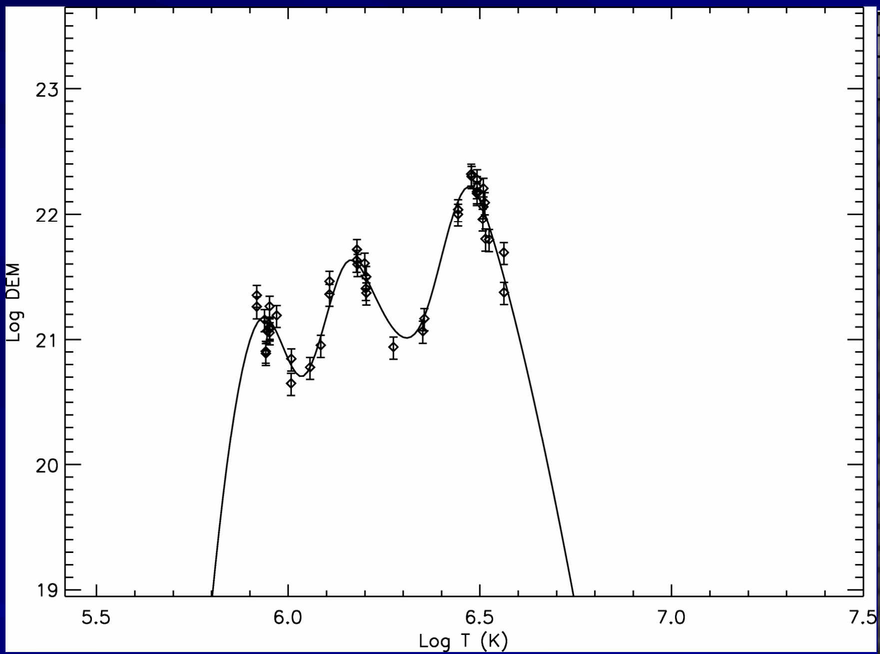
Two plasma components are always present

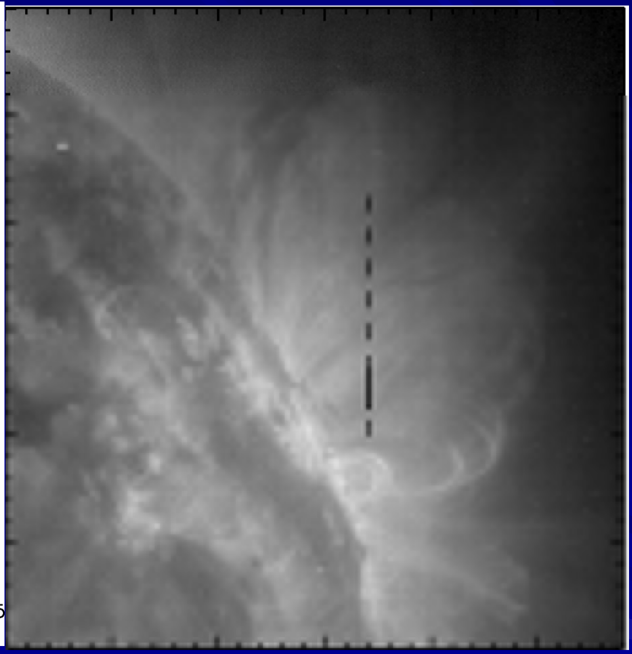


Sylwester et al. 2008

The low temperature component (2.2-2.8 MK) represents possibly a classical corona, the higher T component (5.6-8 MK) is due to active region (6 MK) and the energy release region (10 MK) components. Note that with decrease of the activity level, the temperaure of the hotter component rises, being always within the tail „envelope"

AR thermal structure in the UV-EUV





(*Landi & Feldman 2008*)

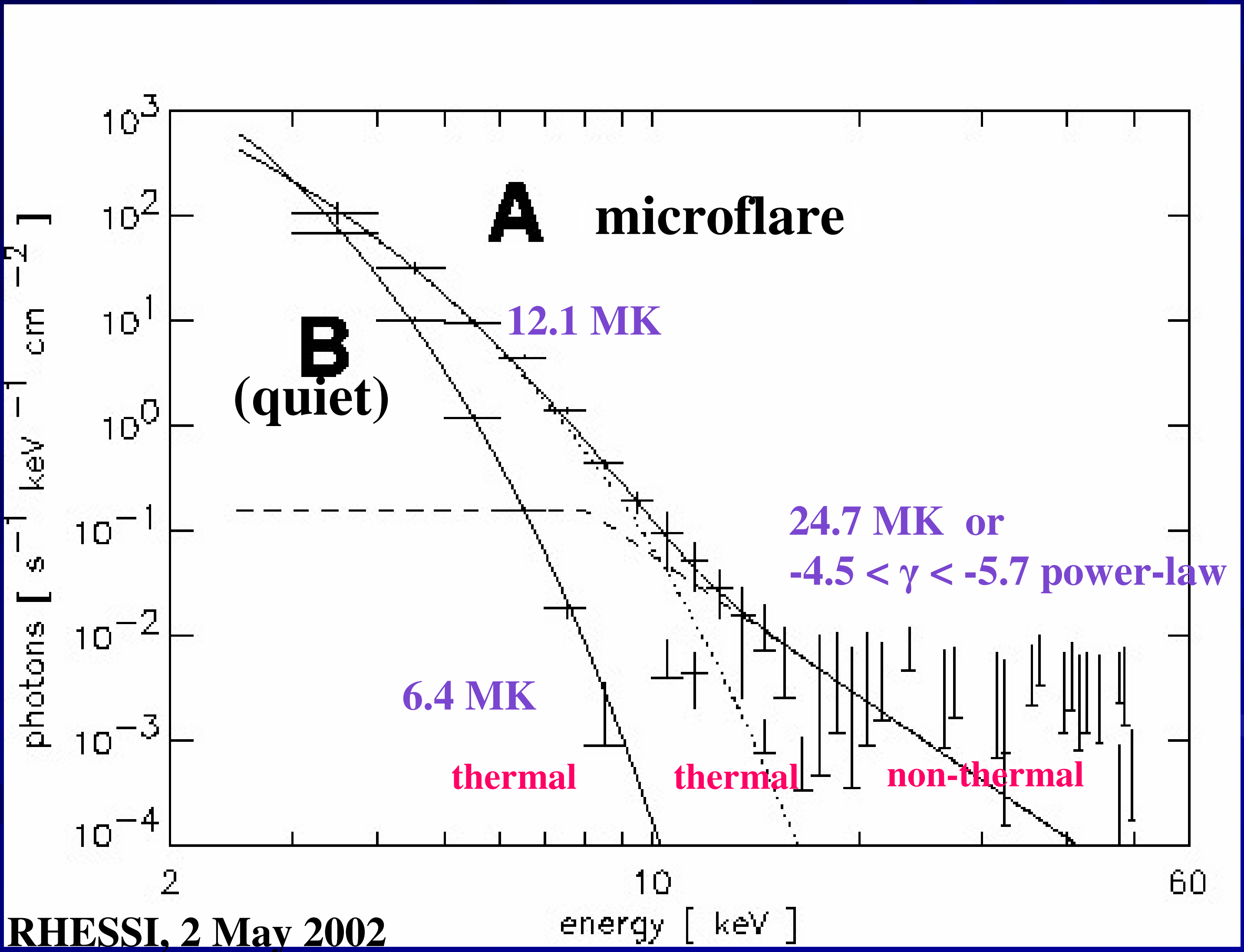
RHESSI Results in QS

Search window	6-12 keV
Number of nanoflares in quiet regions	**0 events**

Some 6 – 12 keV emission of quiet Sun, but not clear from where and possibly from small spots (Krucker & Hannah)

Benz et al.

RHESSI Results in AR



Benz & Grigis, 2002

More work to come….

– http://www.issibern.ch/teams/Spectdata/