Non-Gaussian coronal spectral line profiles in active region cores

(preliminary results)

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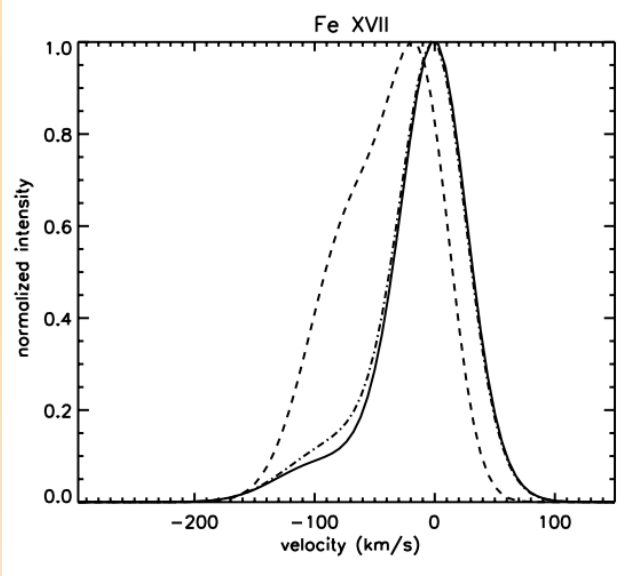
Introduction

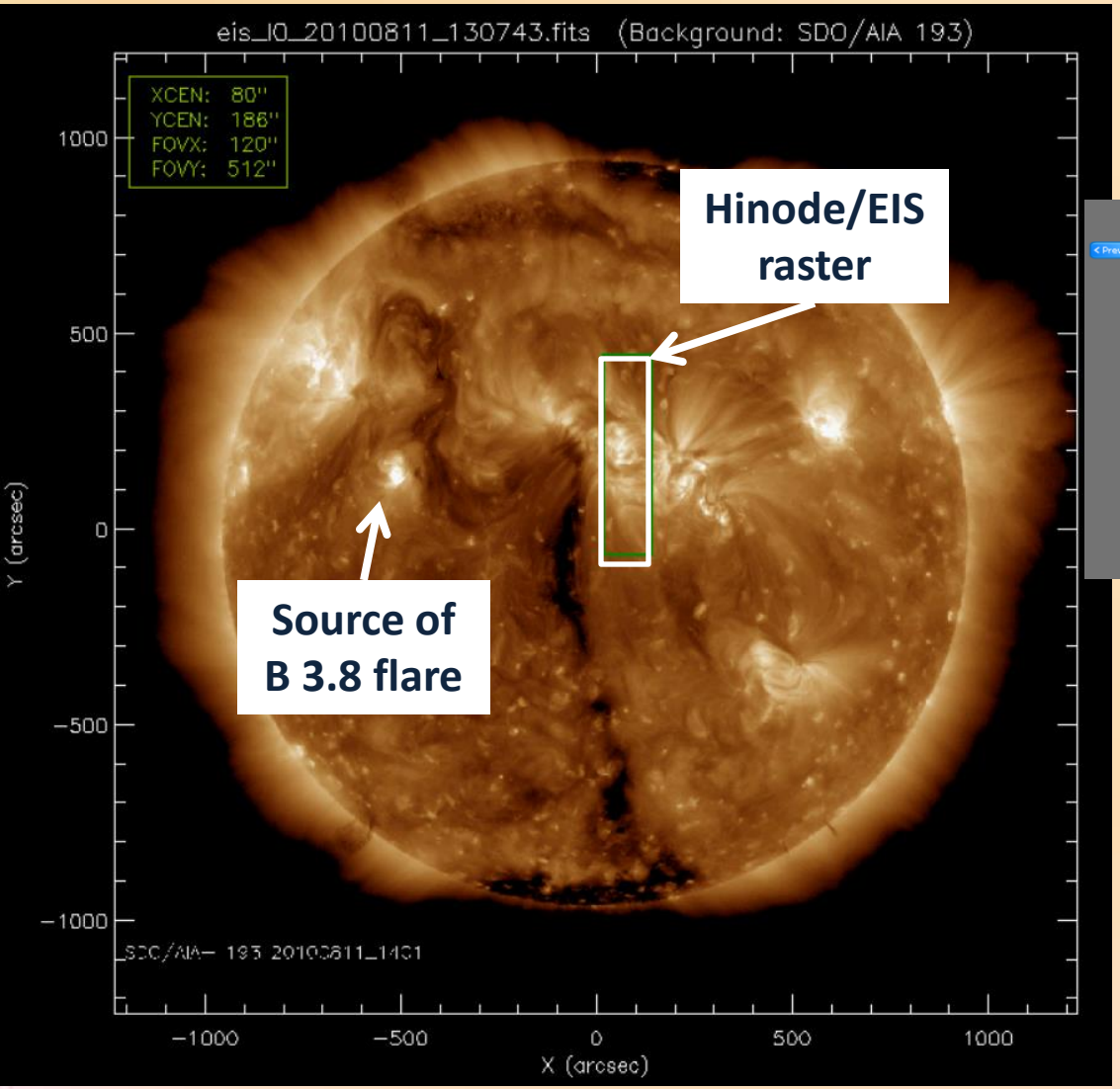
- Multi-component spectral line profiles already observed:
  - Peter (2001): in the transition region
  - Imada et al. (2008): flare arcade, Fe XIV
  - Bryans et al. (2010): large outflows at the edge of AR, Fe XII and Fe XIII
  - Peter (2010): Fe XIV, especially near footpoints of loops
  - McIntosh et al. (2010): coronal dimmings
  - Dolla and Zhukov (2011): coronal dimmings and post-flare AR for Fe XII, Fe XIII, Fe XIV…

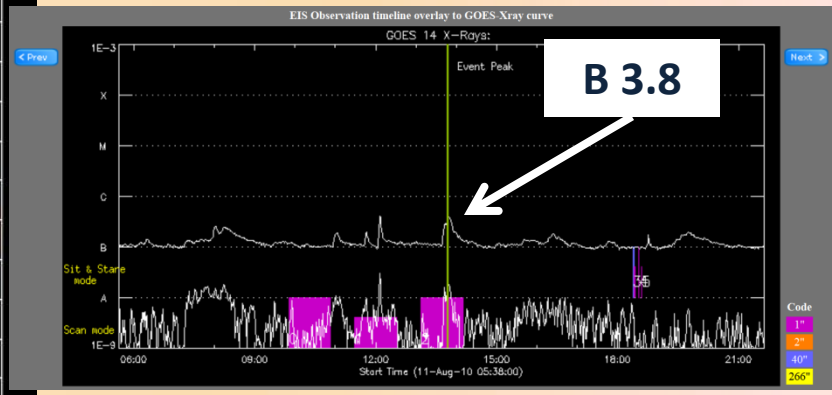
⇒ Is their a systematic presence of multi-component coronal lines in quiet Active Regions? (cf nanoflare models)
⇒ What is the behaviour as a function of formation temperature?



Patsourakos & Klimchuk (2006)

A quiet Active Region
2010/08/11 13:07:43

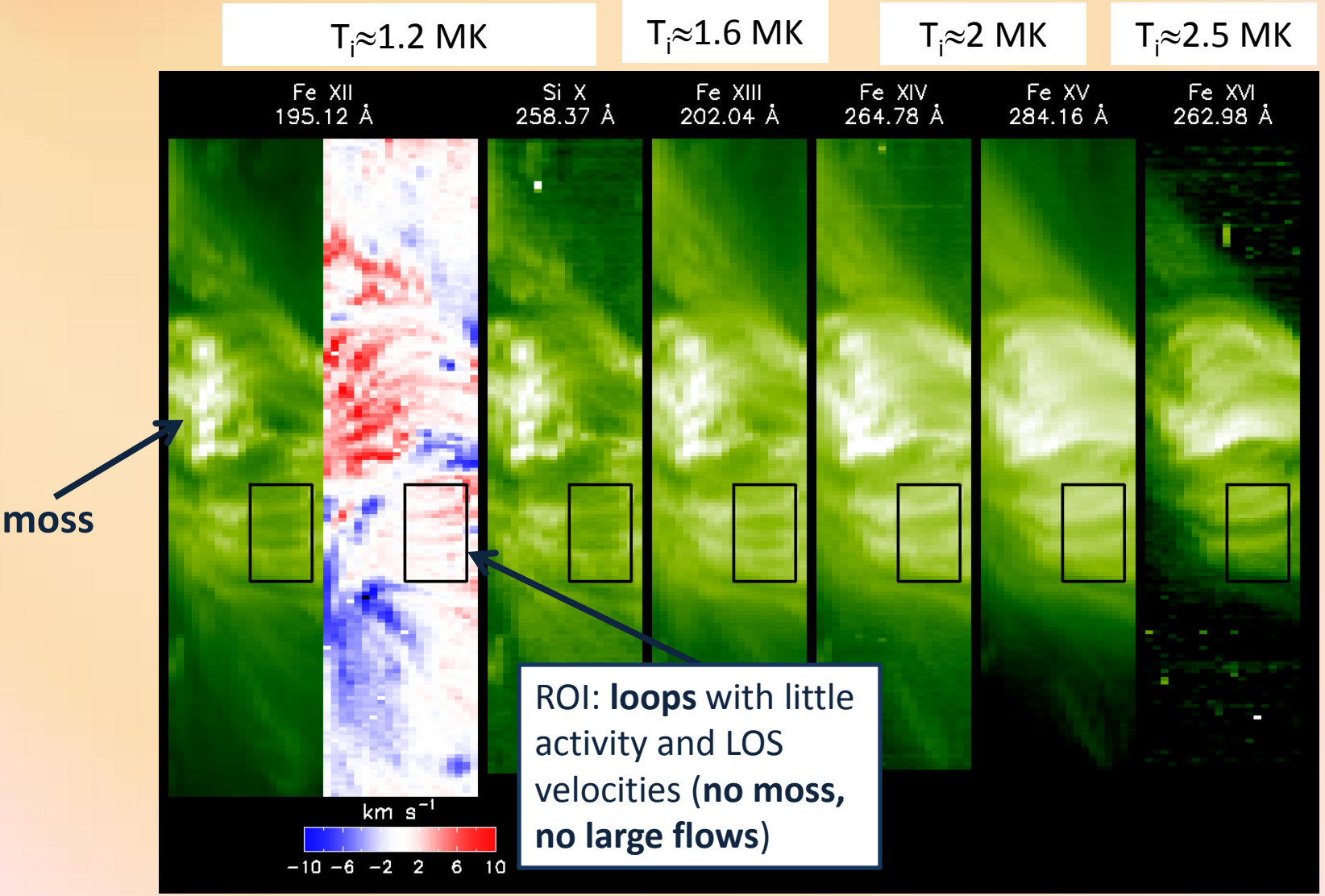




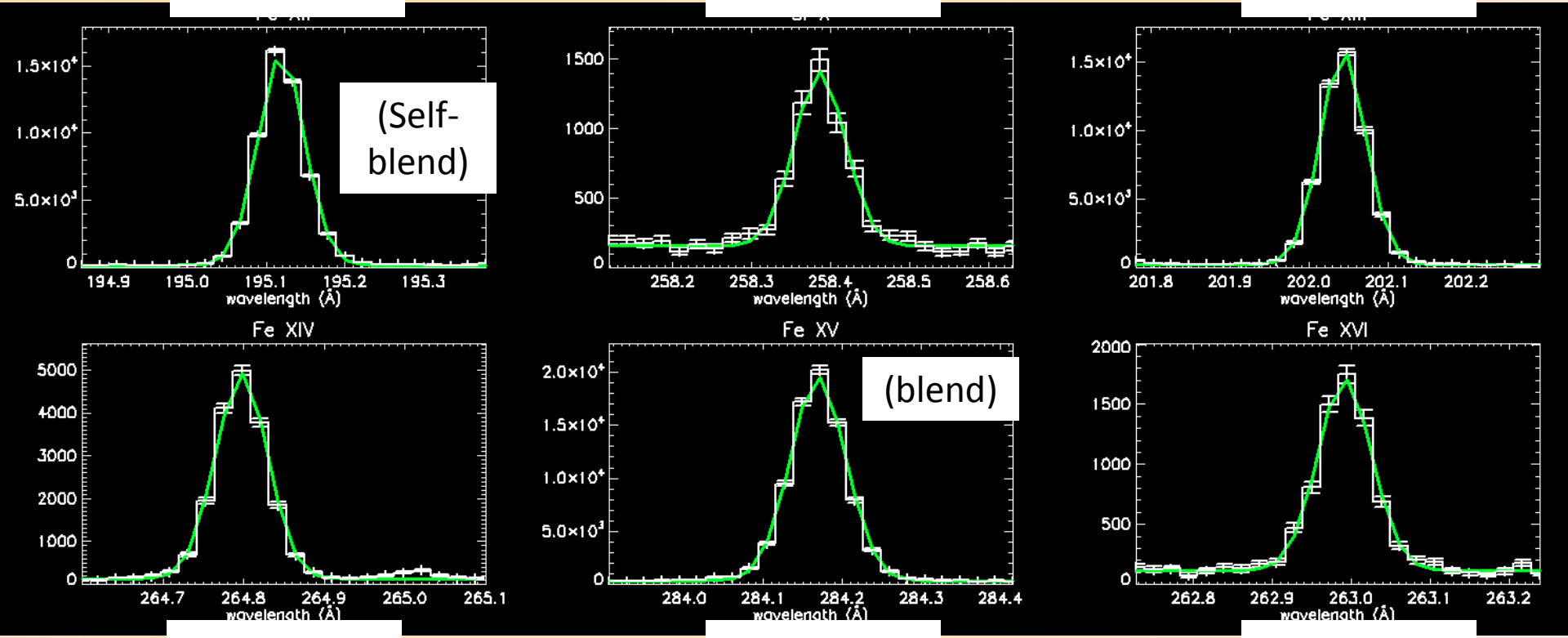
Hinode/EIS raster interval

Source of images:
http://msslxr.mssl.ucl.ac.uk:8080/SolarB/

Hinode/EIS raster



Typical 1-Gaussian fits in the Region of Interest



N.B: following results also found in other data sets, with additional spectral lines (e.g. Fe XII 193.51, without know blend)

An additional component to fit the spectral profiles?

Fe XIII 202 Å

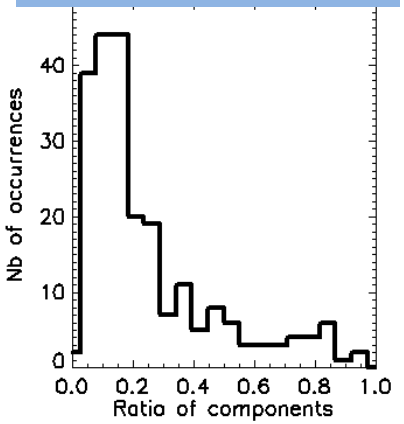
- **Double Gaussian fit** based on random restart hill-climbing:
  - Confidence in finding the best χ^2
  - But: biased by photon statistics, that may lead to a better χ^2 for a (sometimes very) different solution

    $\Rightarrow$ **Necessity to make a statistical study**

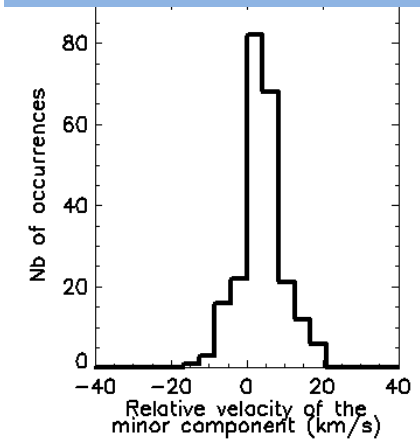
- Example of histograms for Fe XIII 202 Å

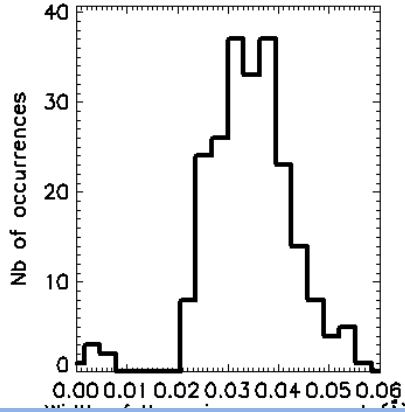
  $\Rightarrow$ **median and standard deviation**

Ratio of intensities of the components

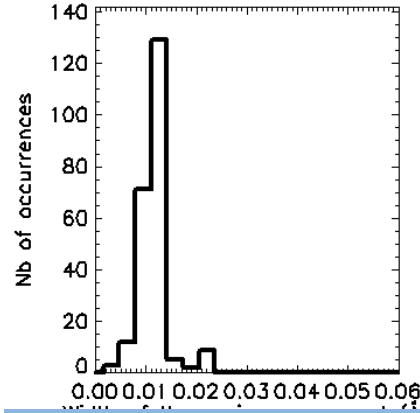


Relative velocity of the minor component





Gaussian width of the minor component



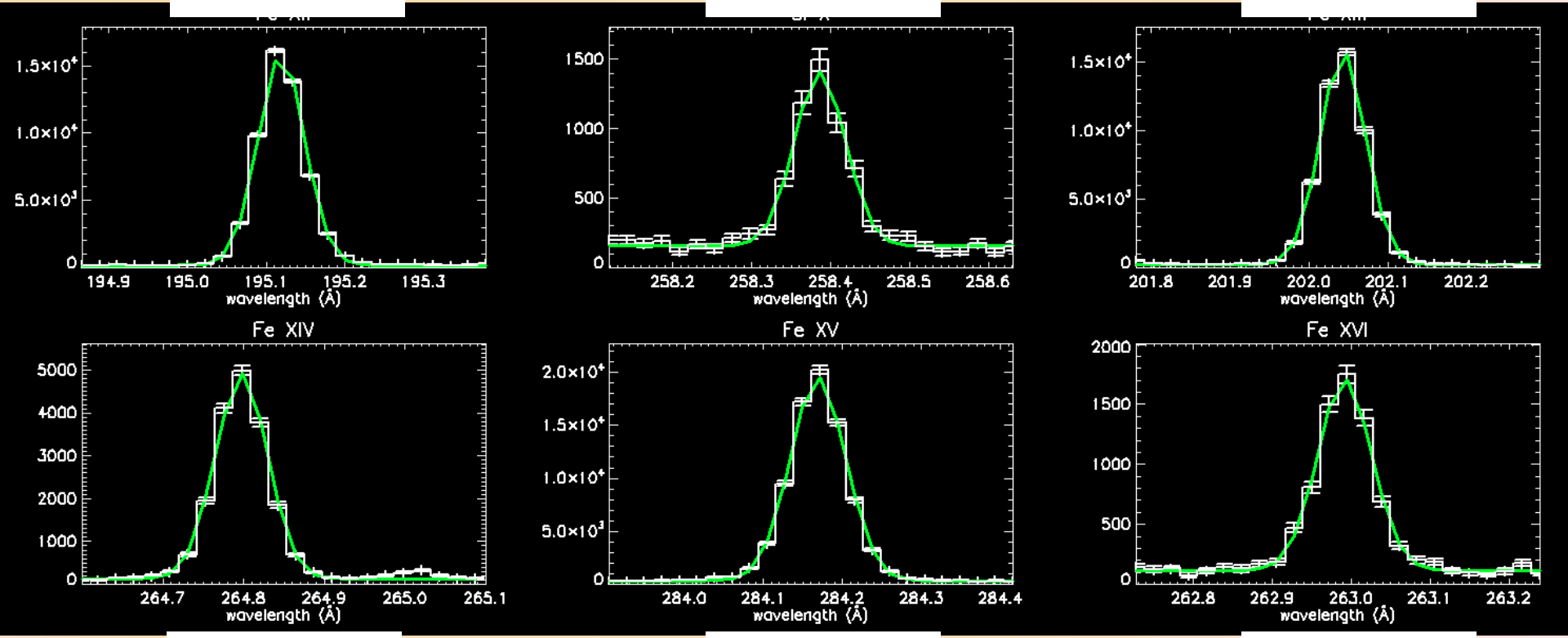
Gaussian width of the major component

Typical 1-Gaussian fits in the Region of Interest (repeat)

Fe XII

Si X

Fe XIII



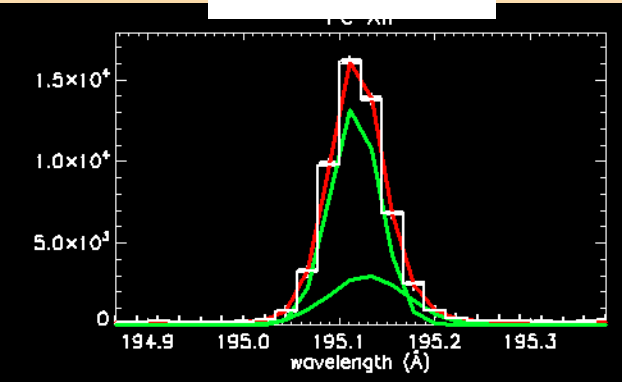
Fe XIV

Fe XV

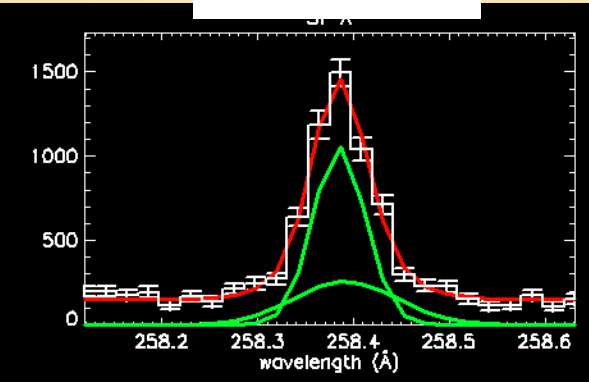
Fe XVI

Typical 2-Gaussian fits in the Region of Interest

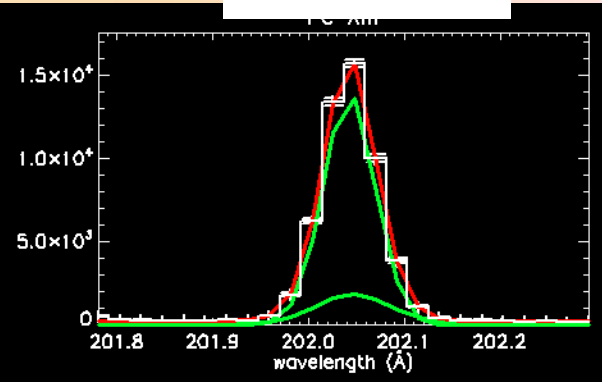
Fe XII

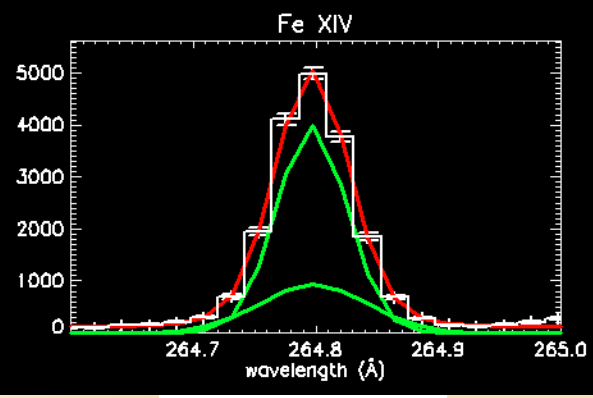


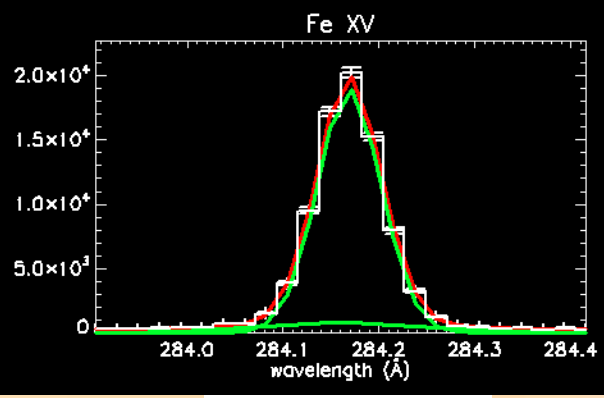
Si X

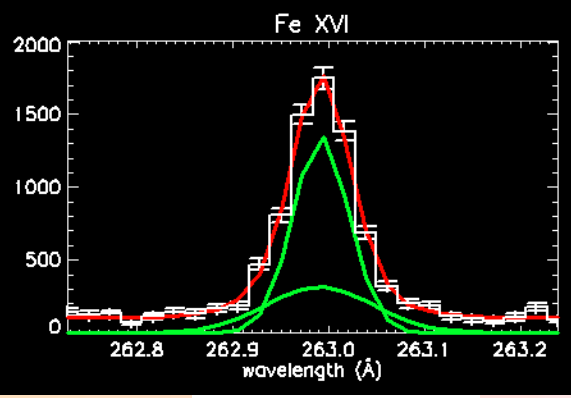


Fe XIII









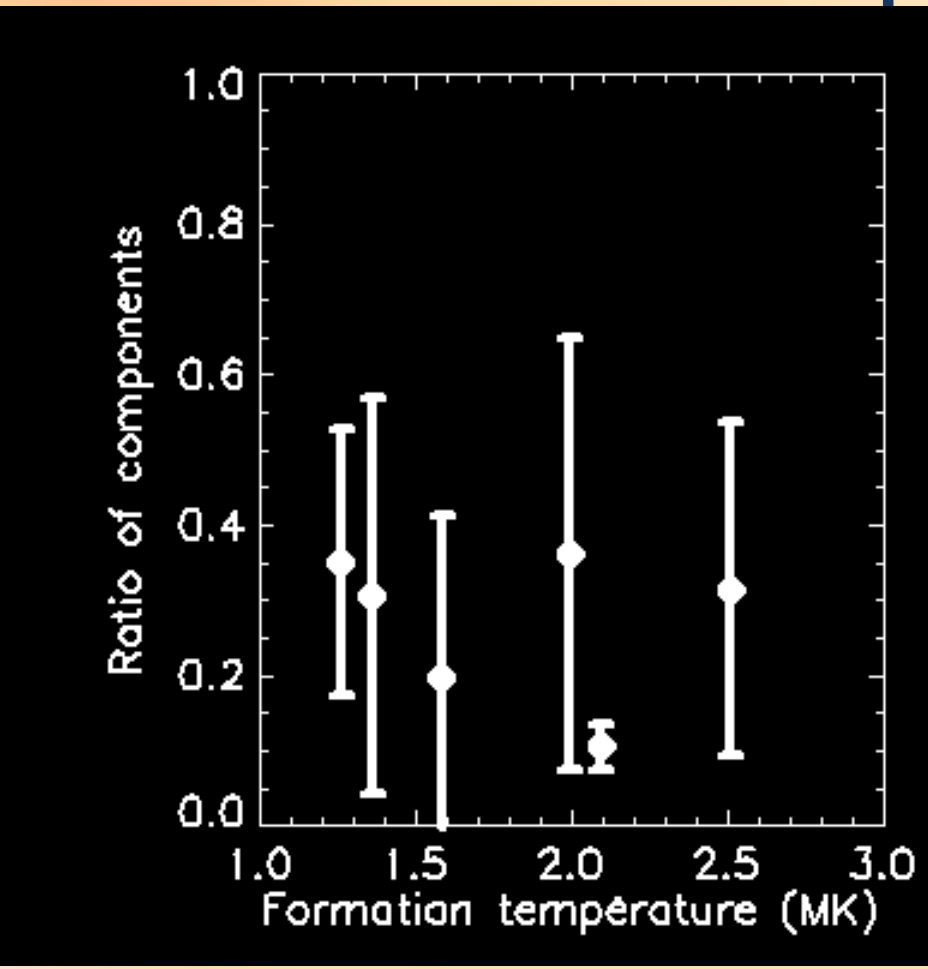
Fe XIV

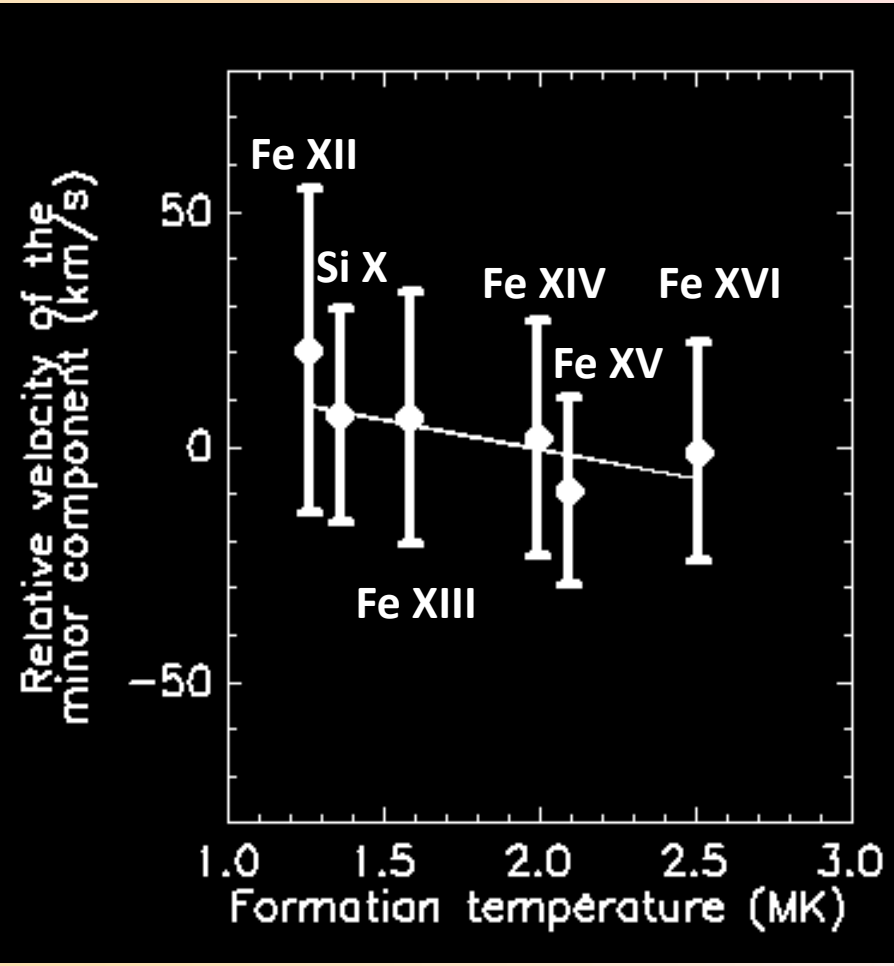
Fe XV

Fe XVI

(Chosen as spectra with fitted parameters as closed as possible to the median values of ratio of intensity, relative difference in velocity and Gaussian withs)

Medians as a function of formation temperature





⇒ **A significant minor component**

⇒ **Red shifts below 2 MK**

⇒ **No strong blue shifts**

(N.B.: formation temperature of Si X and Fe XIV slightly shifted for display only)

Broad width of the minor component: Interpretation in terms of temperature?

$$\sigma^2 = \frac{\lambda^2}{2c^2}\left(\frac{2kT}{M} + \xi^2\right)$$

(squared) Thermal velocity

Non-thermal velocity

- If no nonthermal velocity ξ is assummed: 10-18 MK

  With ξ=30 km s^{-1}: 6-15 MK
- Or: integration of velocity shifts as a function of time and/or space (more than 2 components)

Conclusions

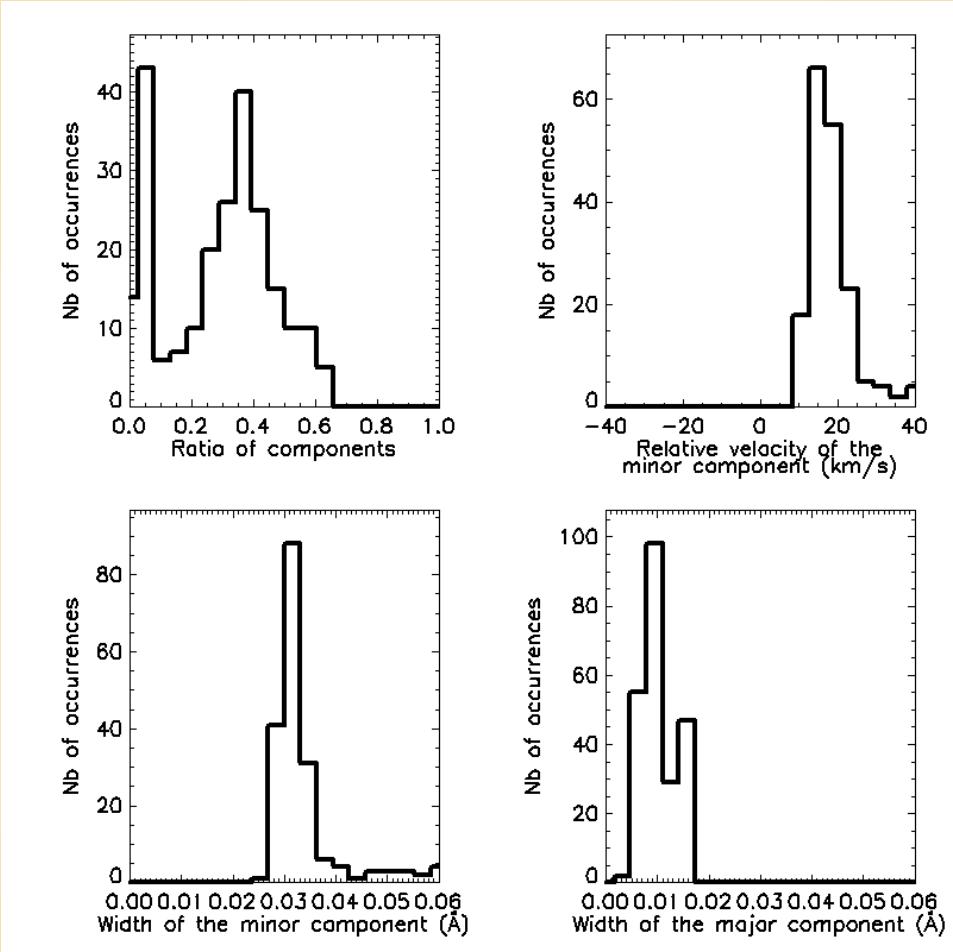
- Spectral line profiles are non-Gaussian in the main part of coronal loops in a quiet AR: presence of a minor, broader (hot?) component (10-60% in intensity)

  (**A result that we found in other active regions with EIS**)
- Distortion is apparently not instrumental in origin (i.e. “asymmetric PSF”), because velocity shifts depend on the formation temperature
- In this data set, we observed no strong Doppler shifts compared to the major component (but probably due to LOS projection)

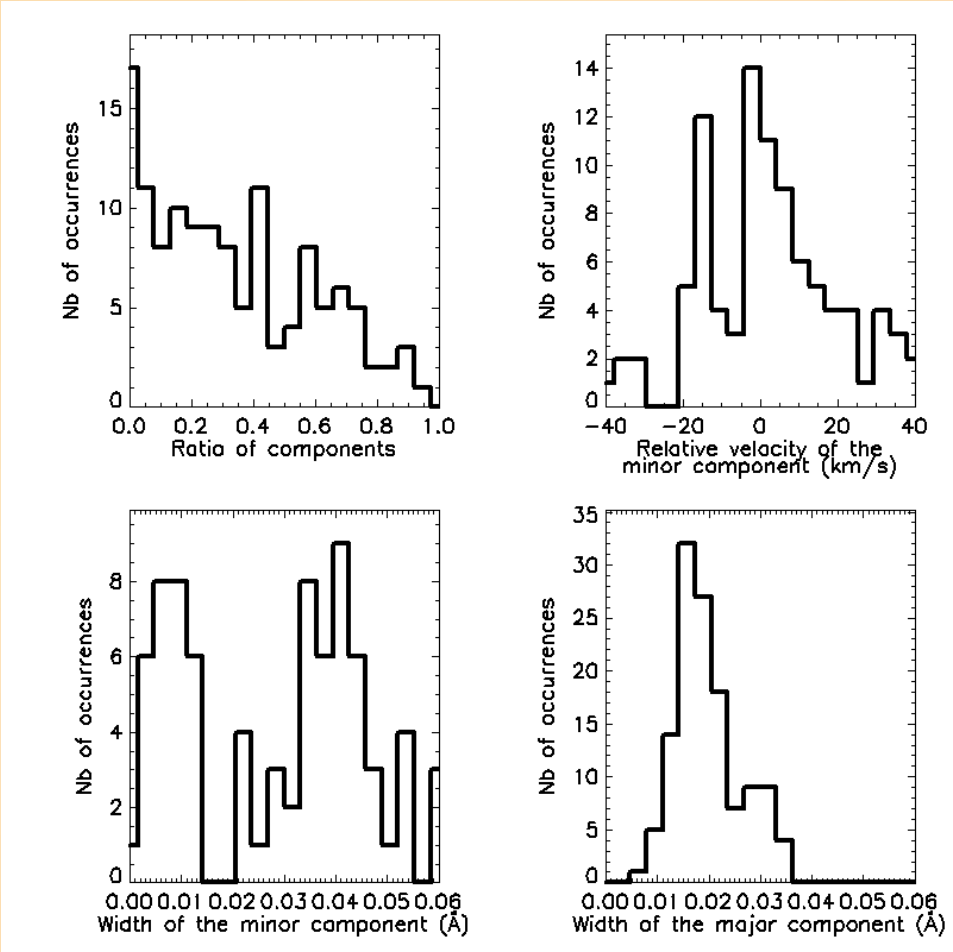
  Mostly: **redshifts, even for hot lines like Fe XVI?**

  $\Rightarrow$ **Strong constraints for models of coronal loop heating**
- **We need more spectral resolution! (besides spatial and temporal resolution)**
- Future work:
  - density and DEM of the minor component
  - Comparison in different structures (moss, loop legs, warm loops, post-flare…)

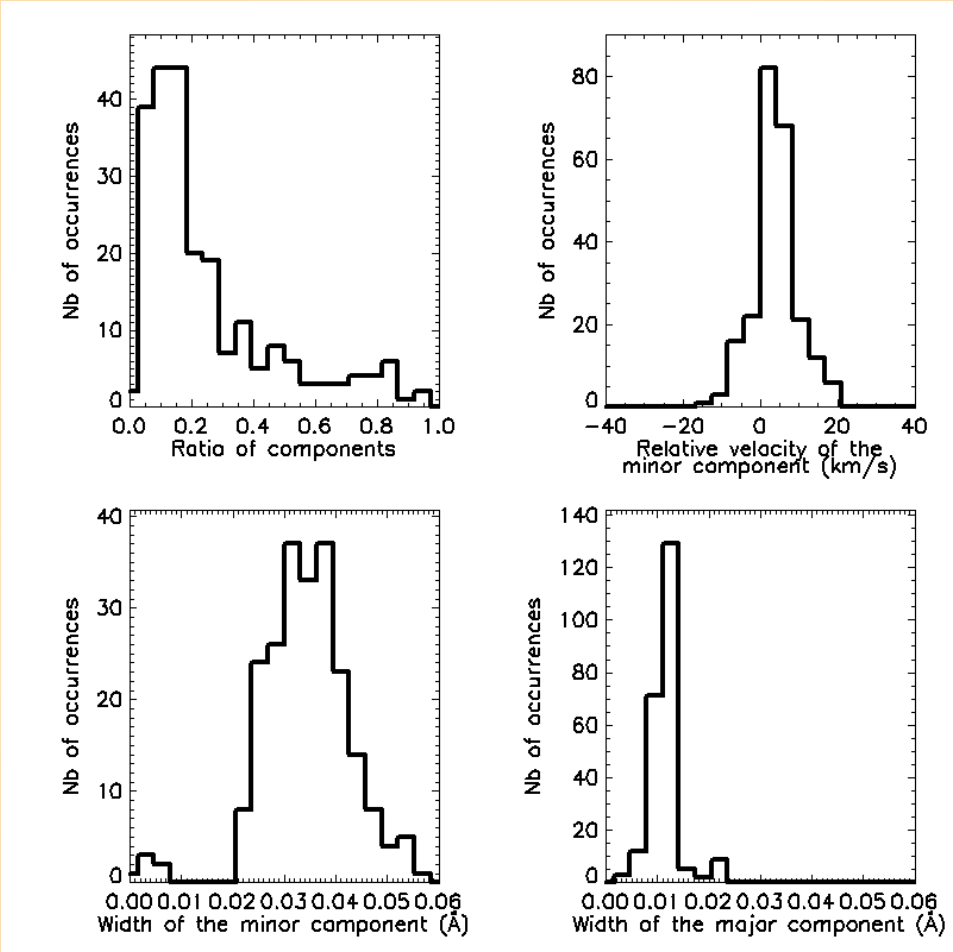
Fe XII 195.12 Å



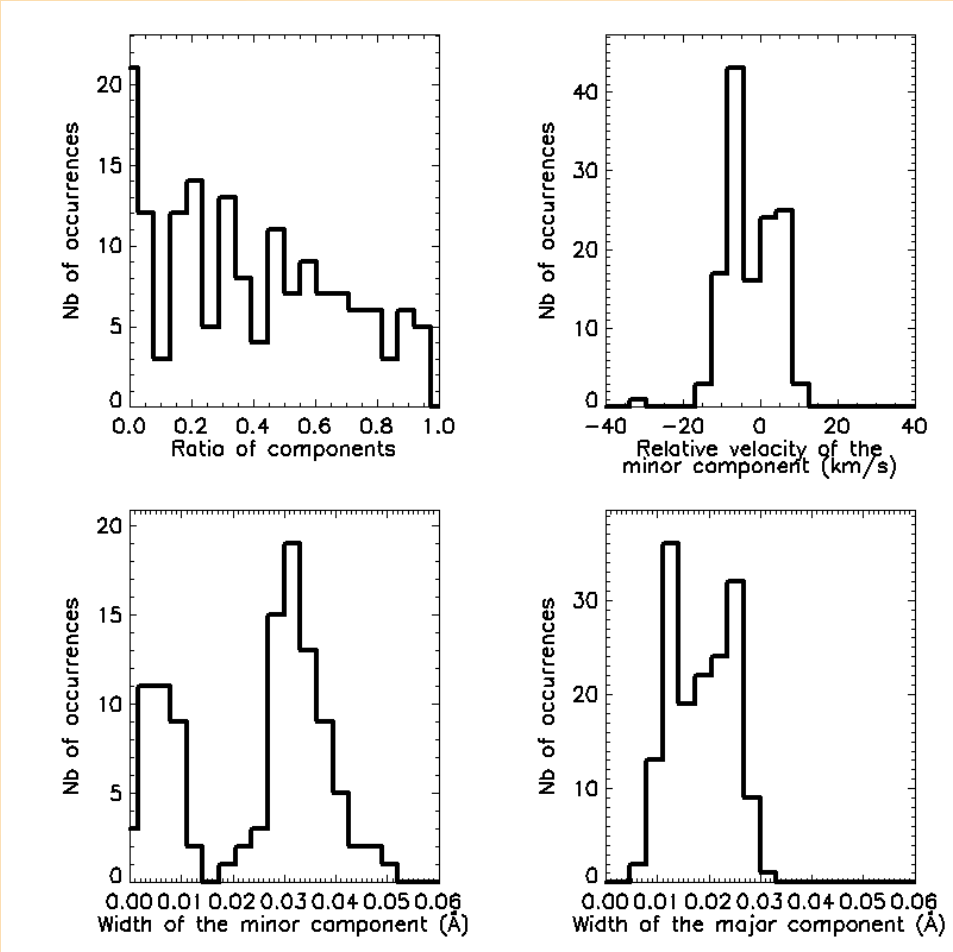
Si X 258.37 Å


Nb of occurrences
Ratio of components
Nb of occurrences
Relative velocity of the minor component (km/s)
Nb of occurrences
Width of the minor component (Å)
Nb of occurrences
Width of the major component (Å)

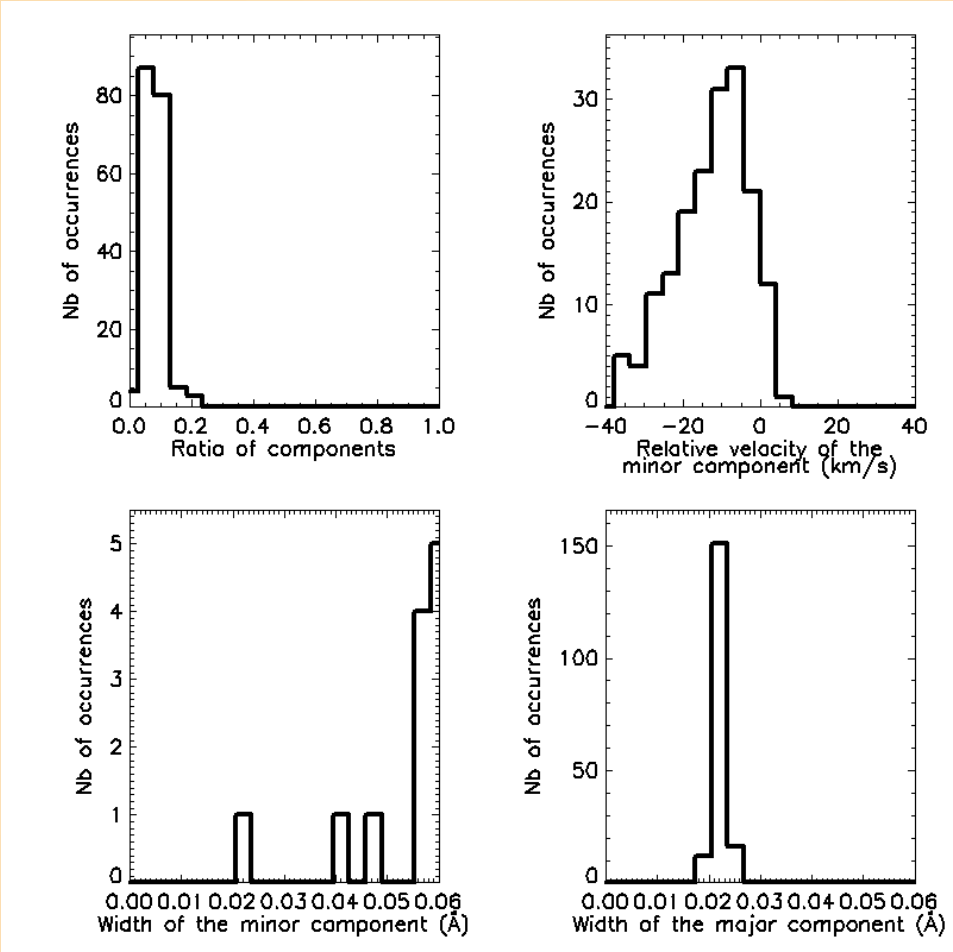
Fe XIII 202.04 Å



Fe XIV 264.78 Å



Fe XV 284.16 Å


Nb of occurrences
Ratio of components
Nb of occurrences
Relative velocity of the minor component (km/s)
Nb of occurrences
Width of the minor component (Å)
Nb of occurrences
Width of the major component (Å)

Fe XVI 262.98 Å