

HMI White-Light Flares

Hints on heights

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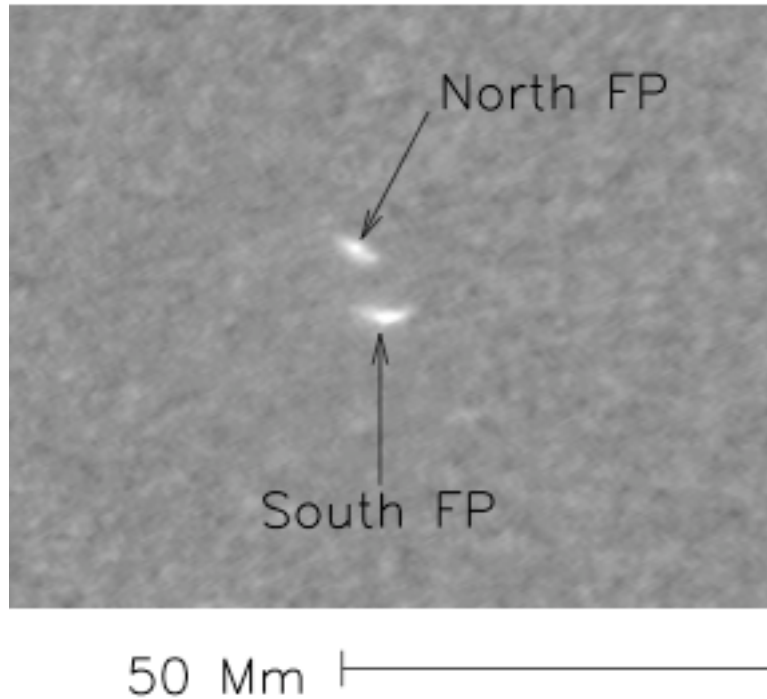
Three clues

- 1) Xu et al. IR observations (1.56 microns)
 - SOL2003-10-29
- 2) Potts et al. optically-thin WLF ribbon source
 - SOL2002-07-15
- 3) Martinez-Oliveros et al (STEREO source location)
 - SOL2011-02-24

Starting with HMI

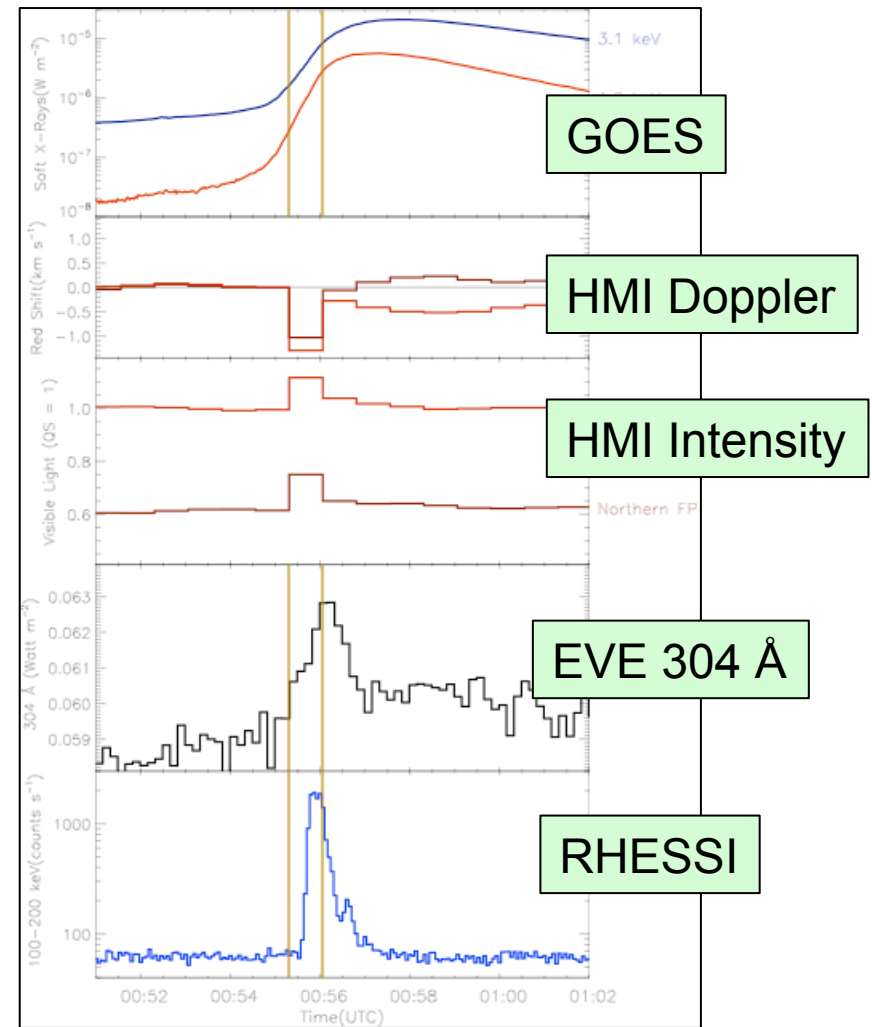
- This instrument, on SDO, obtains 6-point spectroheliograms at high spectral resolution and 45-s sampling
- The data are continuous since launch (Feb. 2010)
- The observations, similar to those of MDI on SOHO, use the line profile to infer continuum intensity as well as Doppler and Zeeman modifications of the specific line: a Fe I line at 6173.34 Å
- This instrument is a wonderful gift to research on white-light flares, because at last we have systematic imaging spectroscopy at high resolution (but, only 45-s cadence)

HMI, EVE, RHESSI



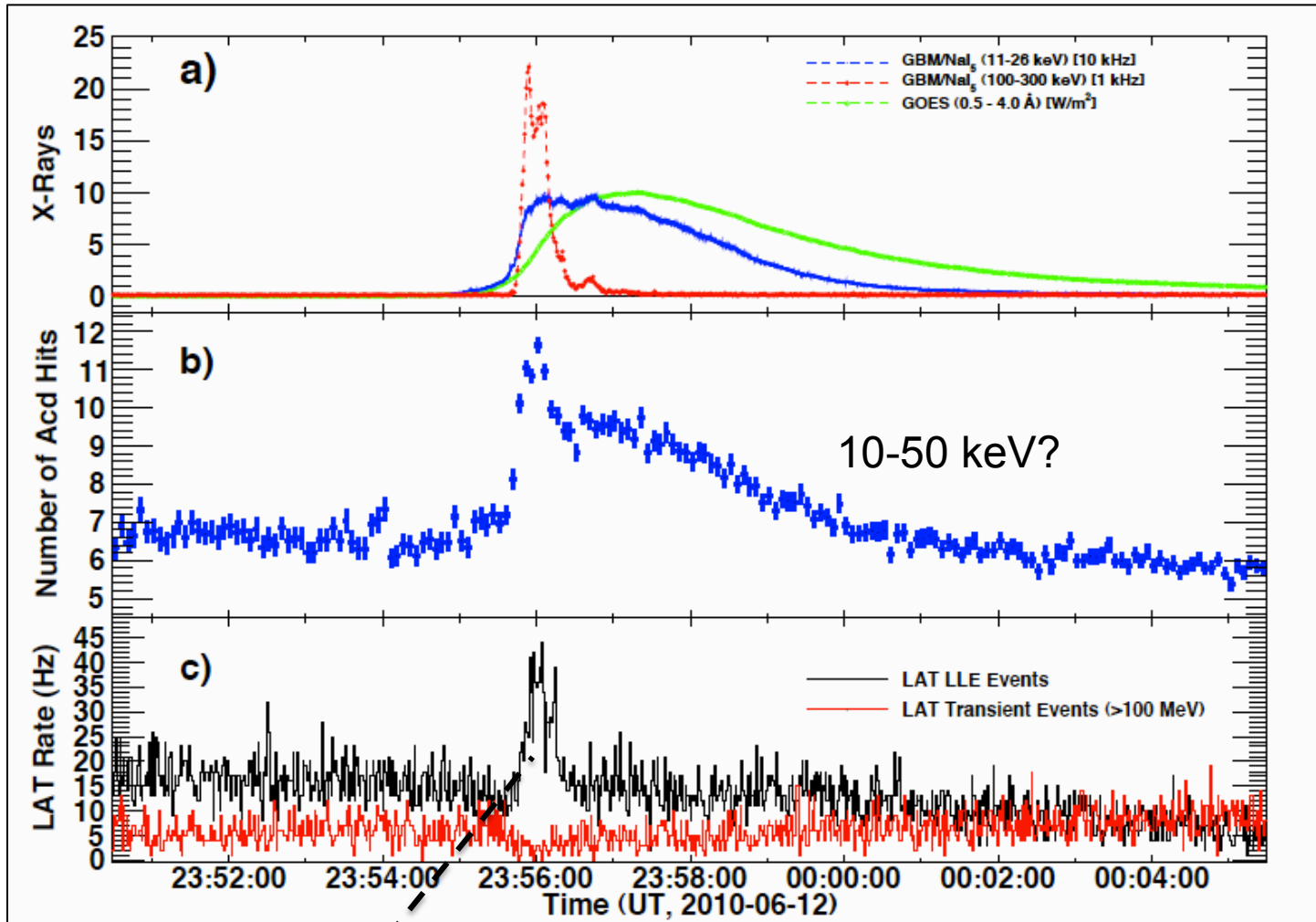
Observations from Martínez-Oliveros et al. 2011.

EVE shows impulsive emission in He II 304 Å



SOL2010-06-12 white-light flare

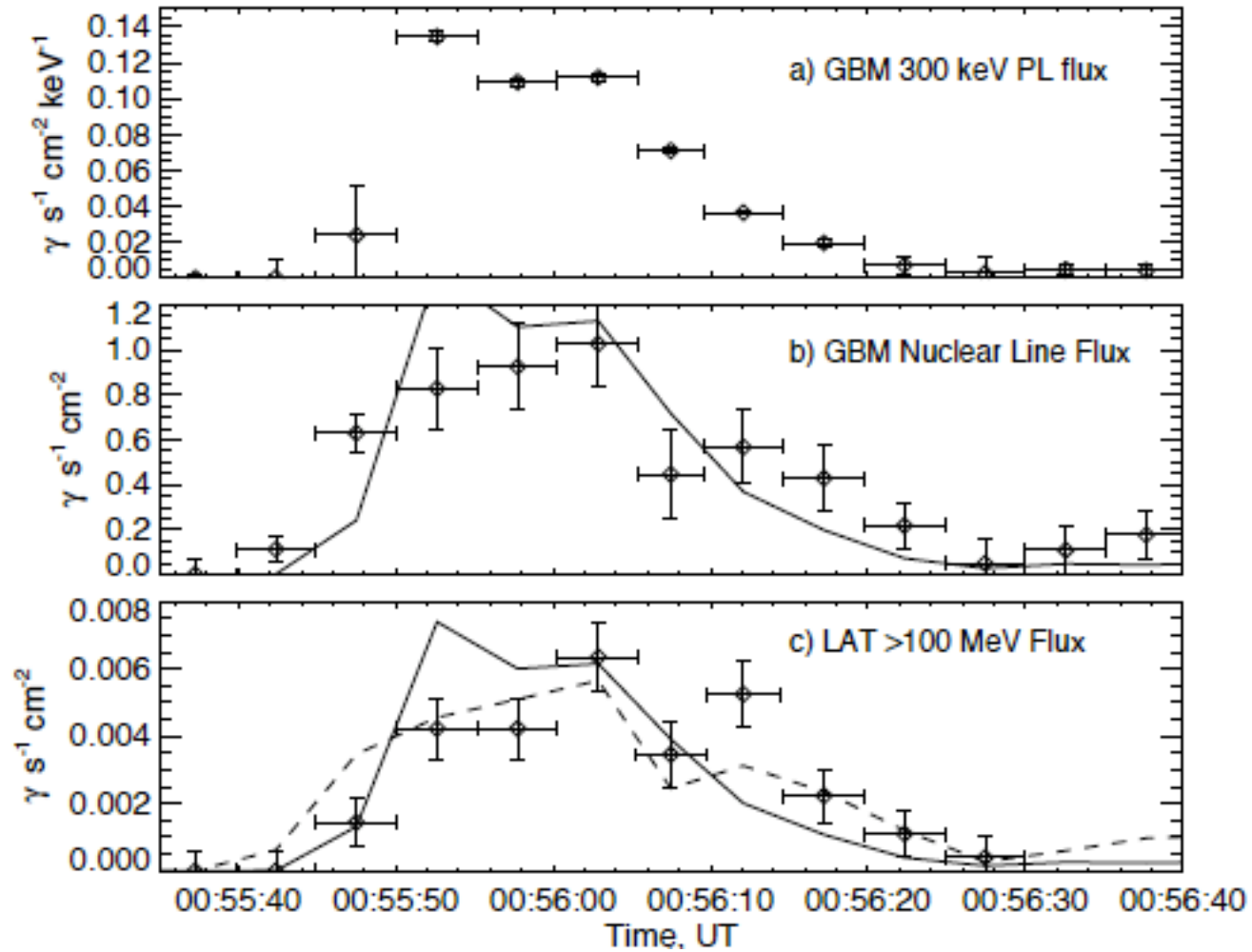
SOL2010-06-12 γ -ray flare



~100 MeV photons!

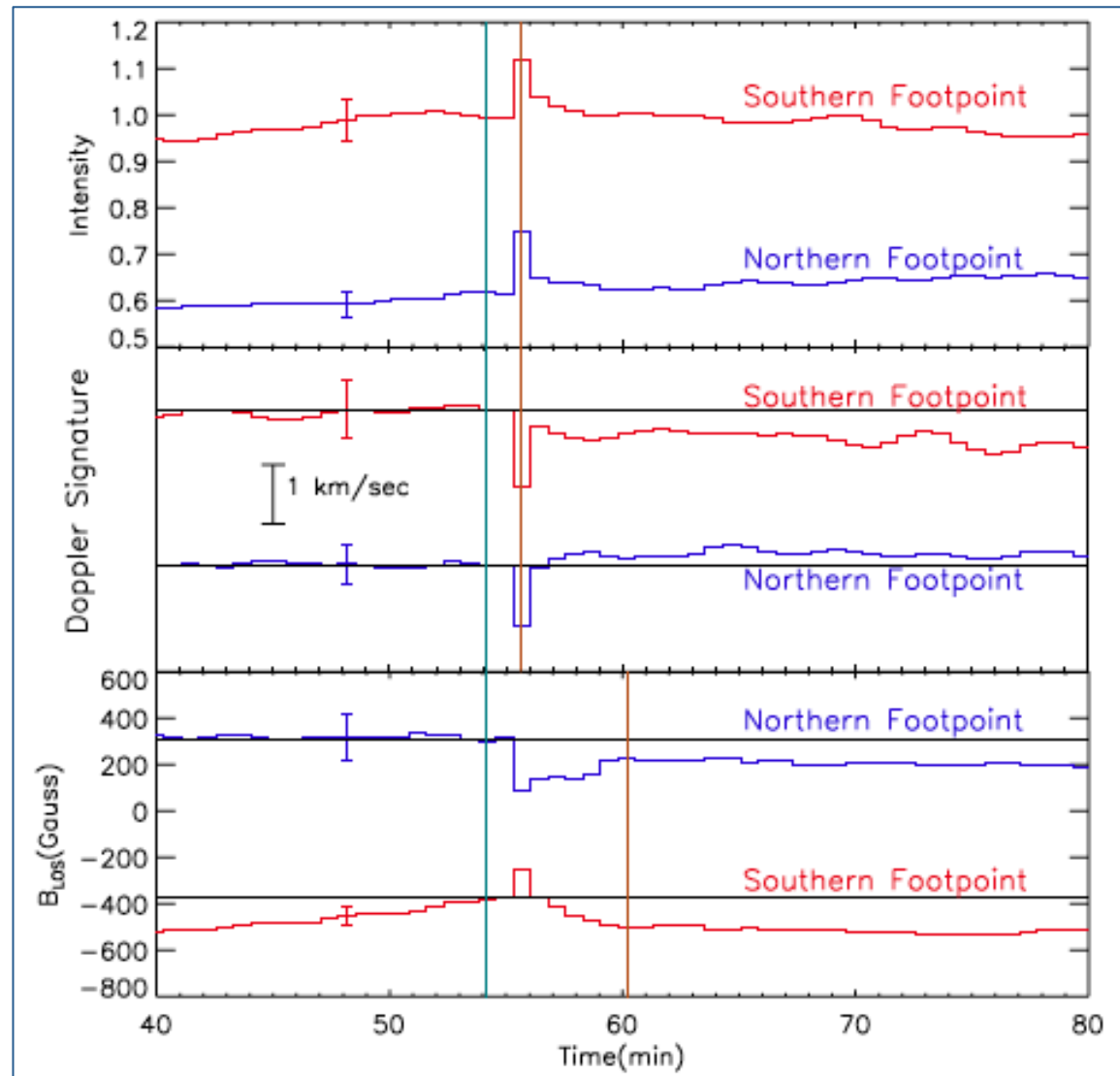
Ackermann et al, 2011

SOL2010-06-12 Timing

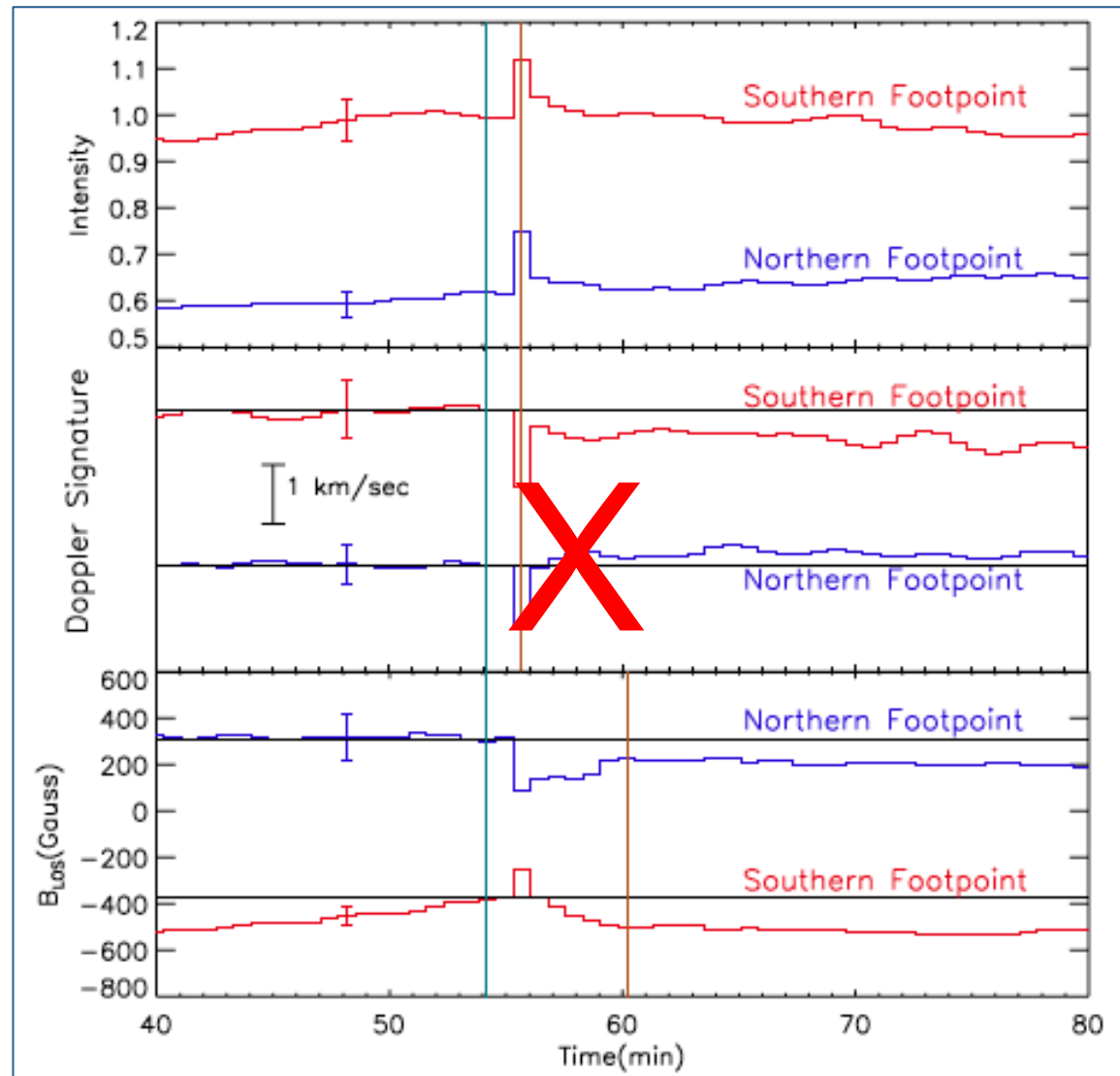


Ackermann et al, 2011

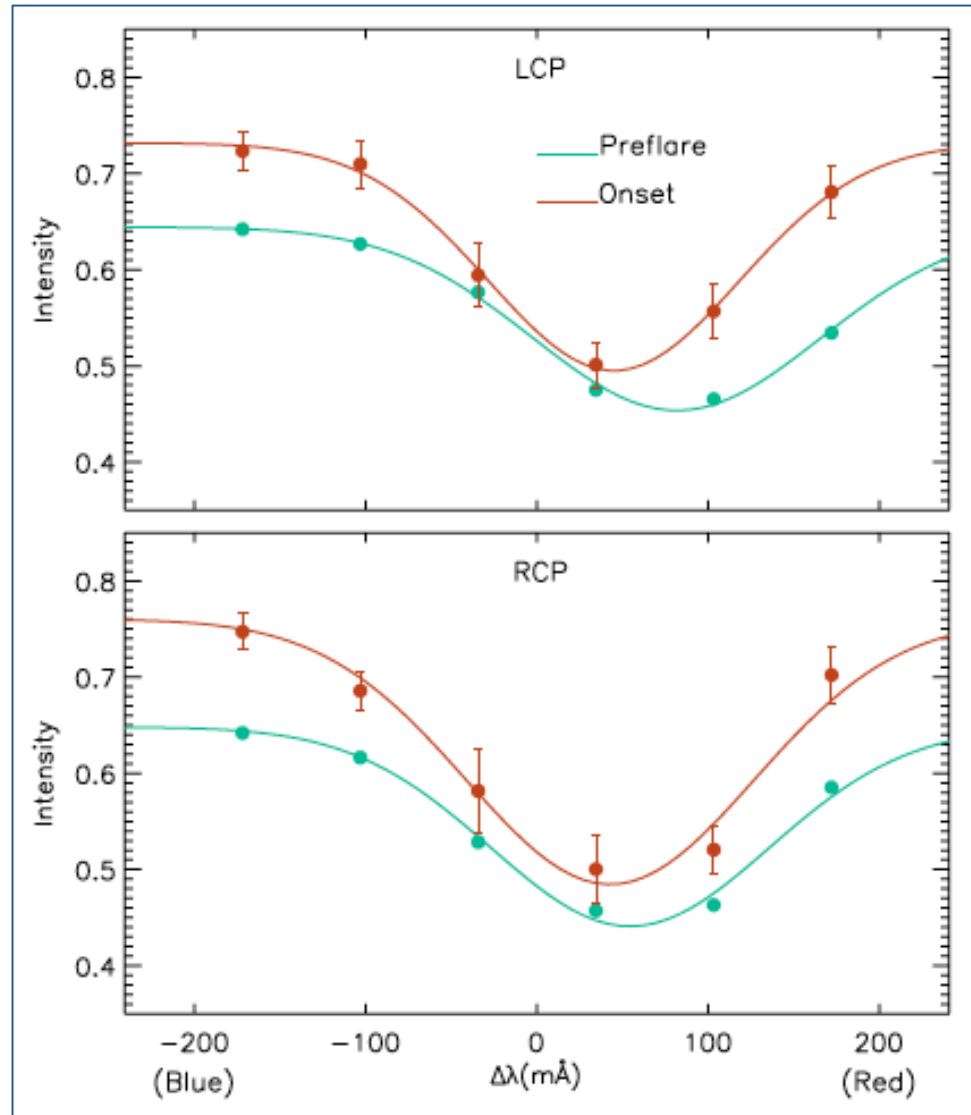
HMI time series



HMI time series



HMI spectra

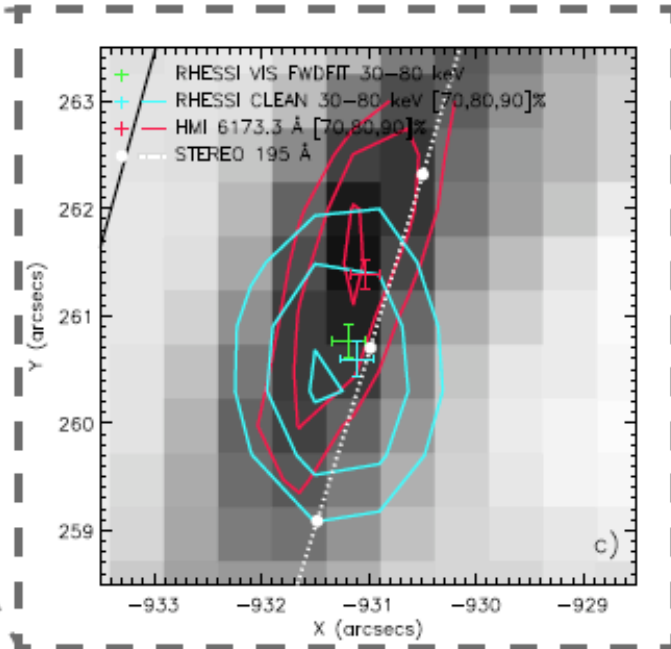
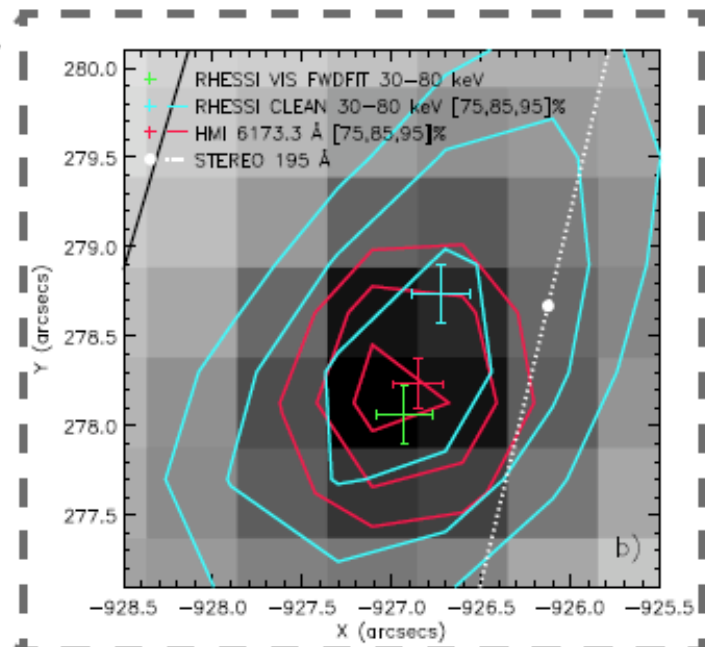
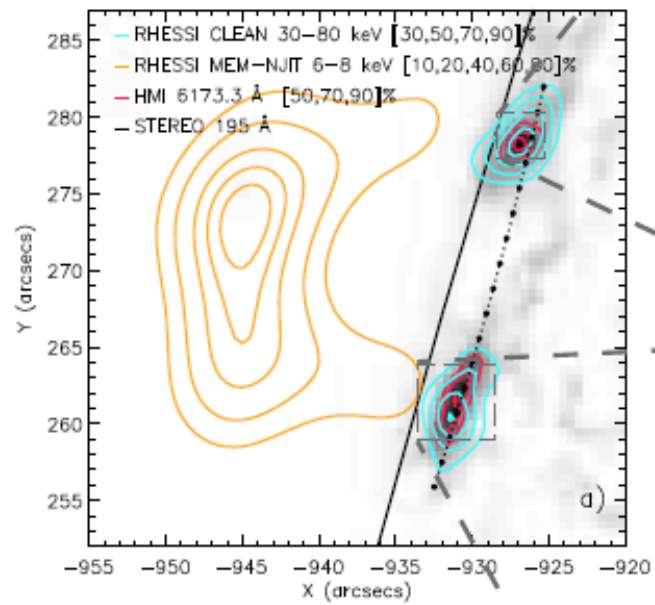


Comments on SOL2010-06-24

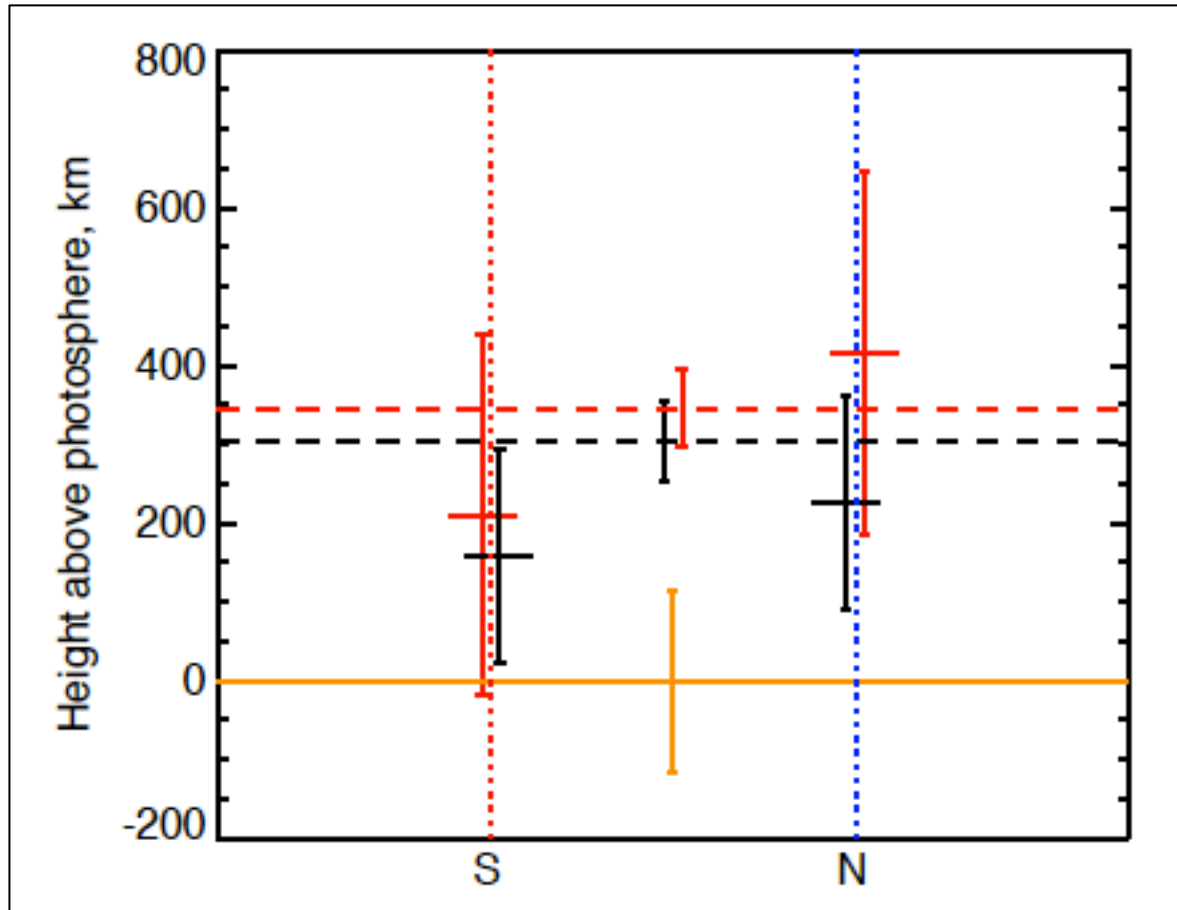
- This simple M-class flare produced strong γ -ray emission, as detected by Fermi/LAT
- Otherwise, it seemed to be a classical WL/HXR event, but now with excellent spatial registration and full imaging spectroscopy
- One of the key new questions regarding such events is the problem of momentum conservation in the excitation of interior acoustic disturbances (“**sunquakes**,” alas not detected in this event)
- The few-sec timing discrepancy between >300 keV and >100 MeV supports the Shih et al. finding from RHESSI: these particle populations are strongly associated

SOL2011-02-24 Limb Flare

- Martínez-Oliveros et al, ApJ 753, 26 (2012)
- First high-resolution analysis of WLF and HXR in a limb flare, with STEREO location
- First direct determination of source heights, thanks to STEREO
- WLF and HXR source centroids match within small uncertainties
- There are puzzling results for source absolute heights



Abstract view of error estimates



Red, HXR; black, WLF;
Heights for $\tau = 1$

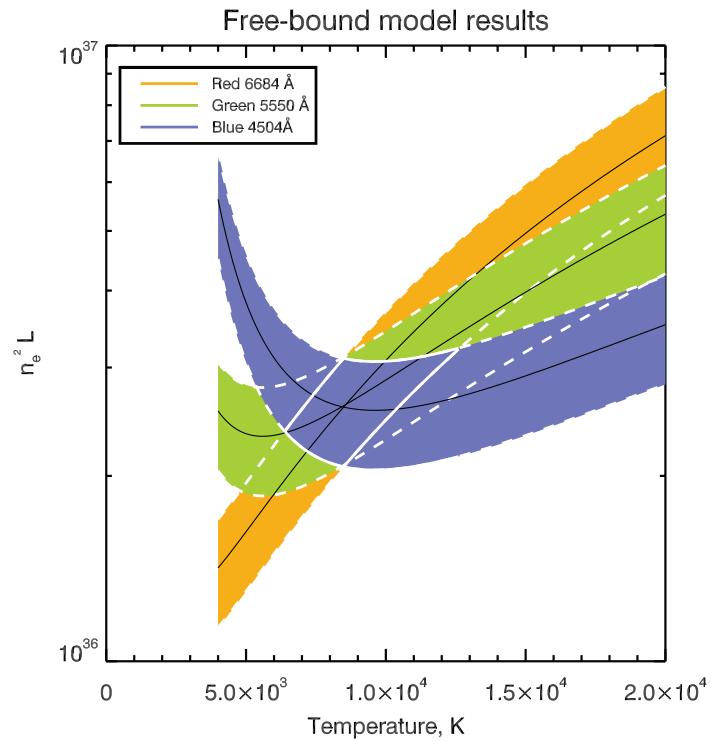
Limb inferred via
STEREO image

Footpoints

Conclusions

- WLF forms close to the photosphere, but we have insufficient observations
- Hint from the “opacity minimum” (Xu et al.)
=> WLF is deep
- Hint from opacity (Potts et al.) => WLF is shallow
- First direct measurement (Martinez Oliveros) => deep, but disturbingly so

Color temperatures



Kerr et al. 2013

