

Progress Report

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- Published/Submitted studies
 - Solar Eruptive Event, Su et al. ApJL 2012
 - CME - flare relationship, Berkebile-Stoiser et al., ApJ accepted
 - Magnetized Tornadoes, Su et al. Nat. Phys., submitted
- Work in progress
 - Density distribution along flaring loops
 - Fitting spectra for partially occulted flares
 - Direct observation of magnetic reconnection
- Students' work
 - Imaging spectroscopy
 - Study of pre-heating phase

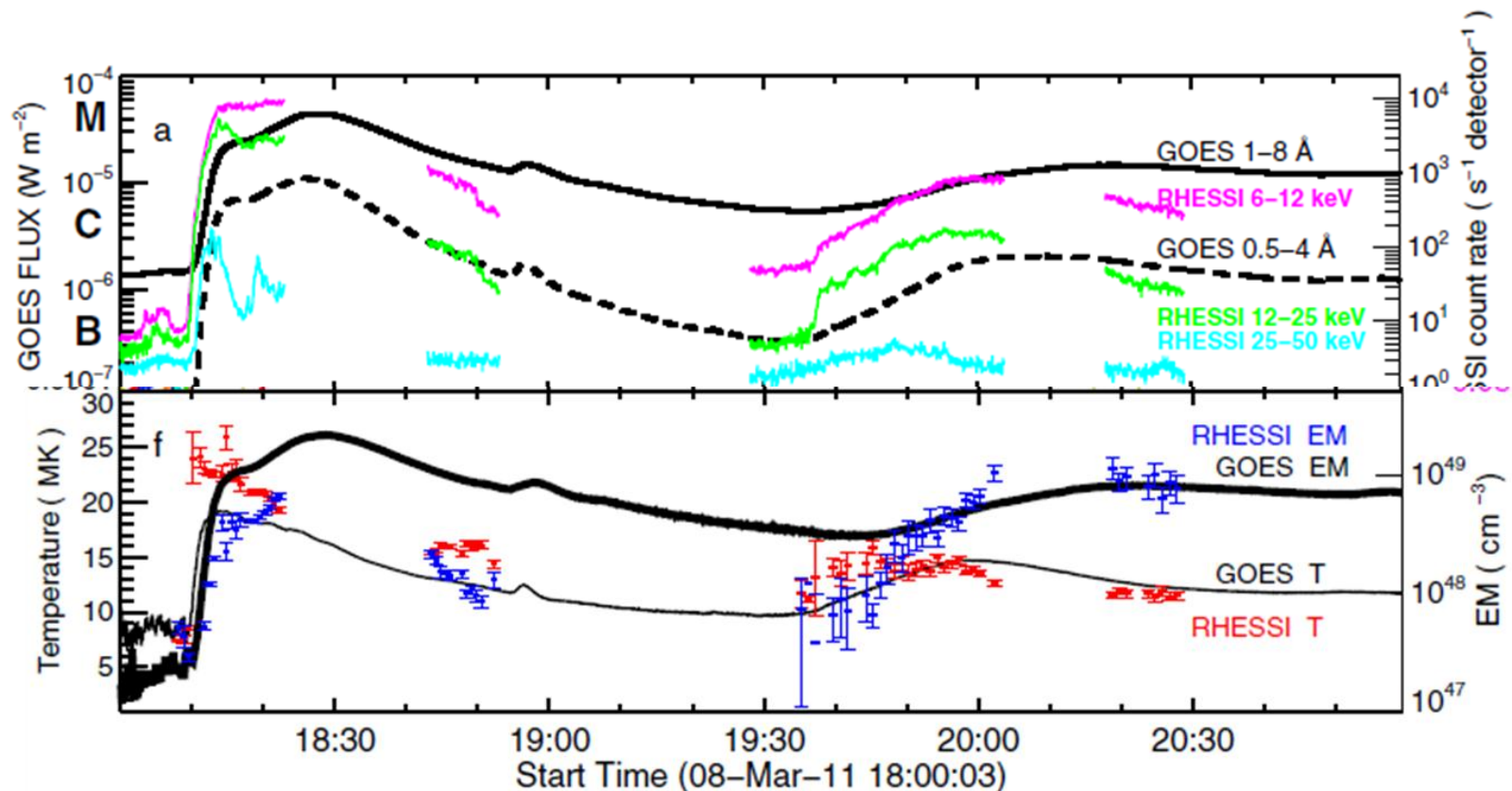
P1. Submitted studies

P2. Work in progress

P3. Students' work

Solar Eruptive Events (SEEs)

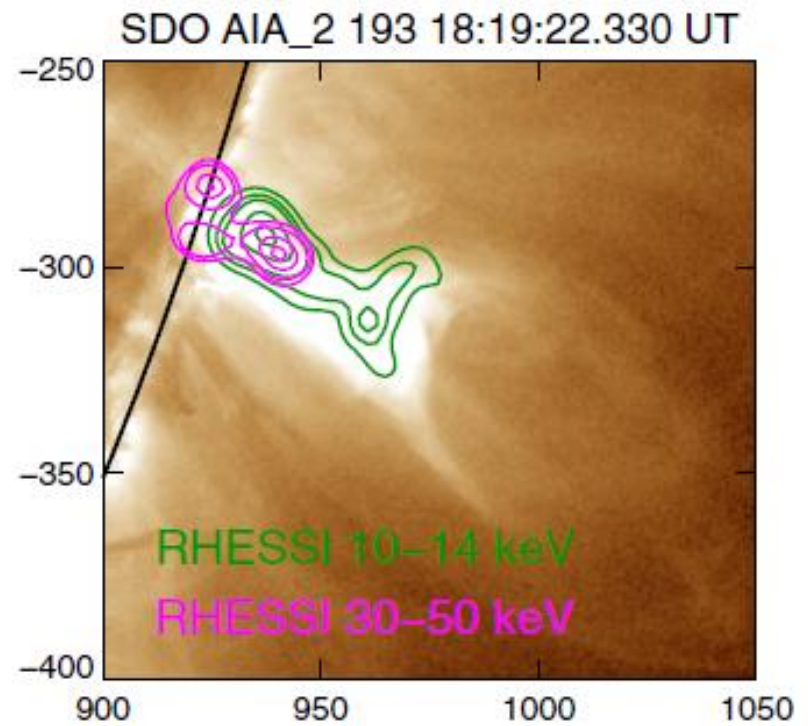
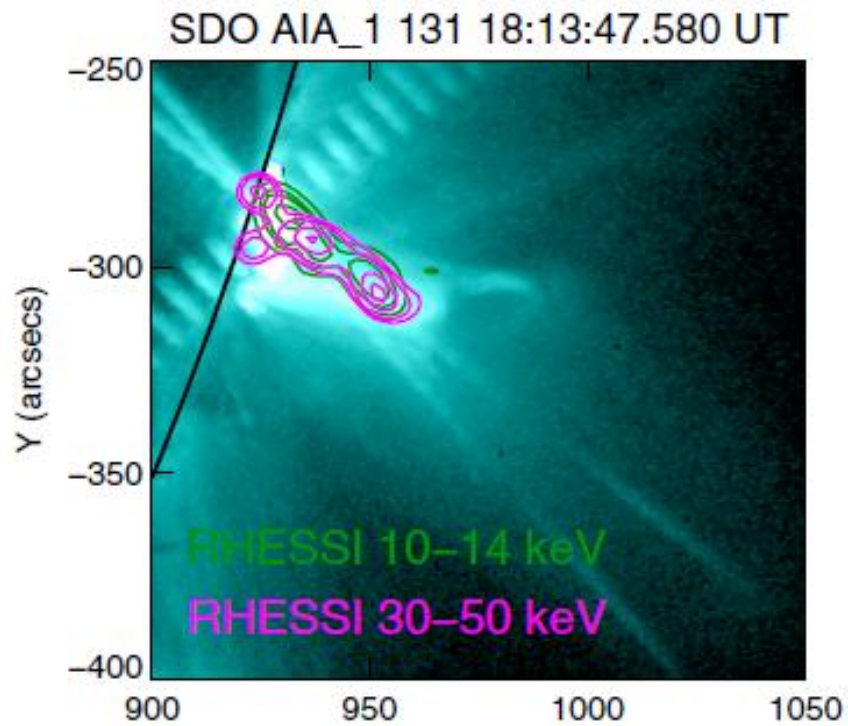
- Flares accompanied by an eruption, i.e., a jet or a CME
- 2011 March 8 event (Su et al. ApJL 2012)
 - Show **secondary heating phase** 2h after first flare
 - Show two stages associated by the **delayed eruption** of a CME



P1. Submitted studies

P2. Work in progress

P3. Students' work

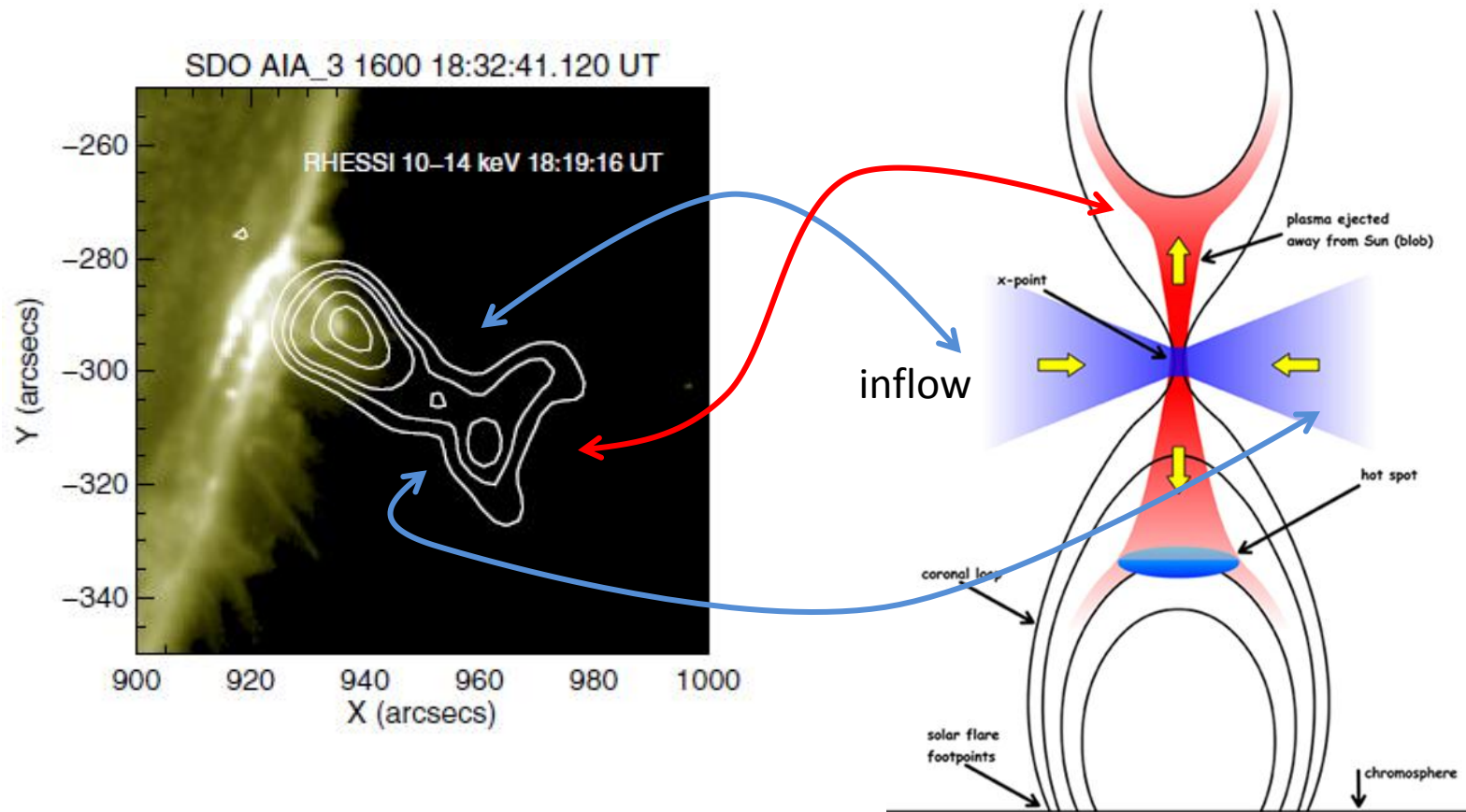


P1. Submitted studies

P2. Work in progress

P3. Students' work

Show evidence for magnetic reconnection (second paper)



Movie

- http://cse.ssl.berkeley.edu/segwayed/lessons/exploring_magnetism/in_Solar_Flares/s4.html

P1. Submitted studies

P2. Work in progress

P3. Students' work

Associated CMEs and flares observed by RHESSI

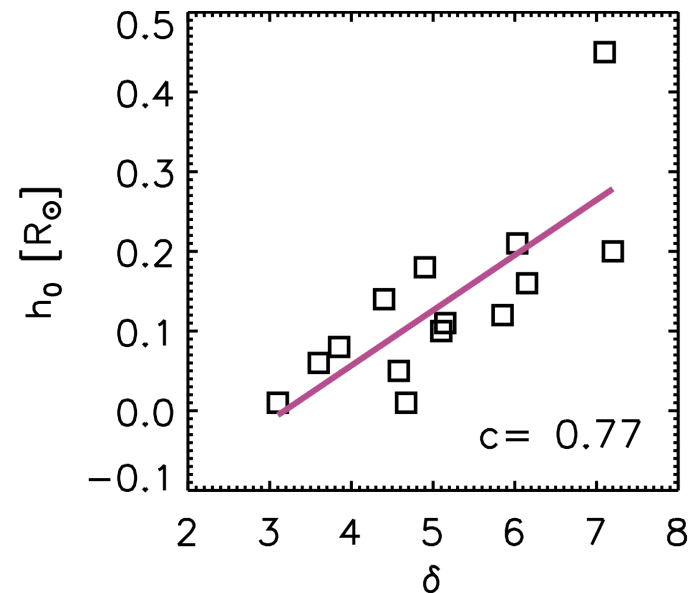
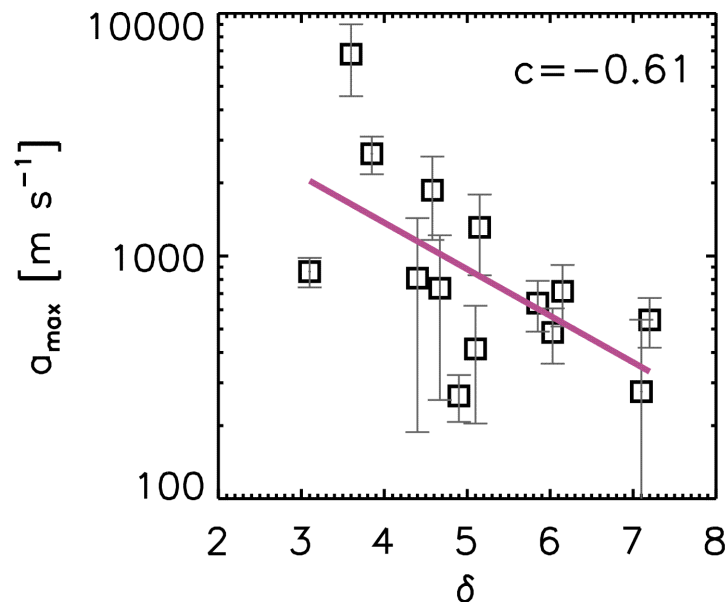
(Berkebile-Stoiser et al., ApJ accepted)

Timing:

- CME acceleration starts **before** nonthermal flare emission(80%) →
- Current sheet length at start of impulsive energy release $\approx 21 \pm 7$ Mm
- Peak of nonthermal flare emission & CME acceleration occur within 5 min (75%)

Correlations:

- Hardness of RHESSI spectrum is most closely related to CME initiation height h_0 and CME peak acceleration a_{\max} (low height → stronger magnetic field)

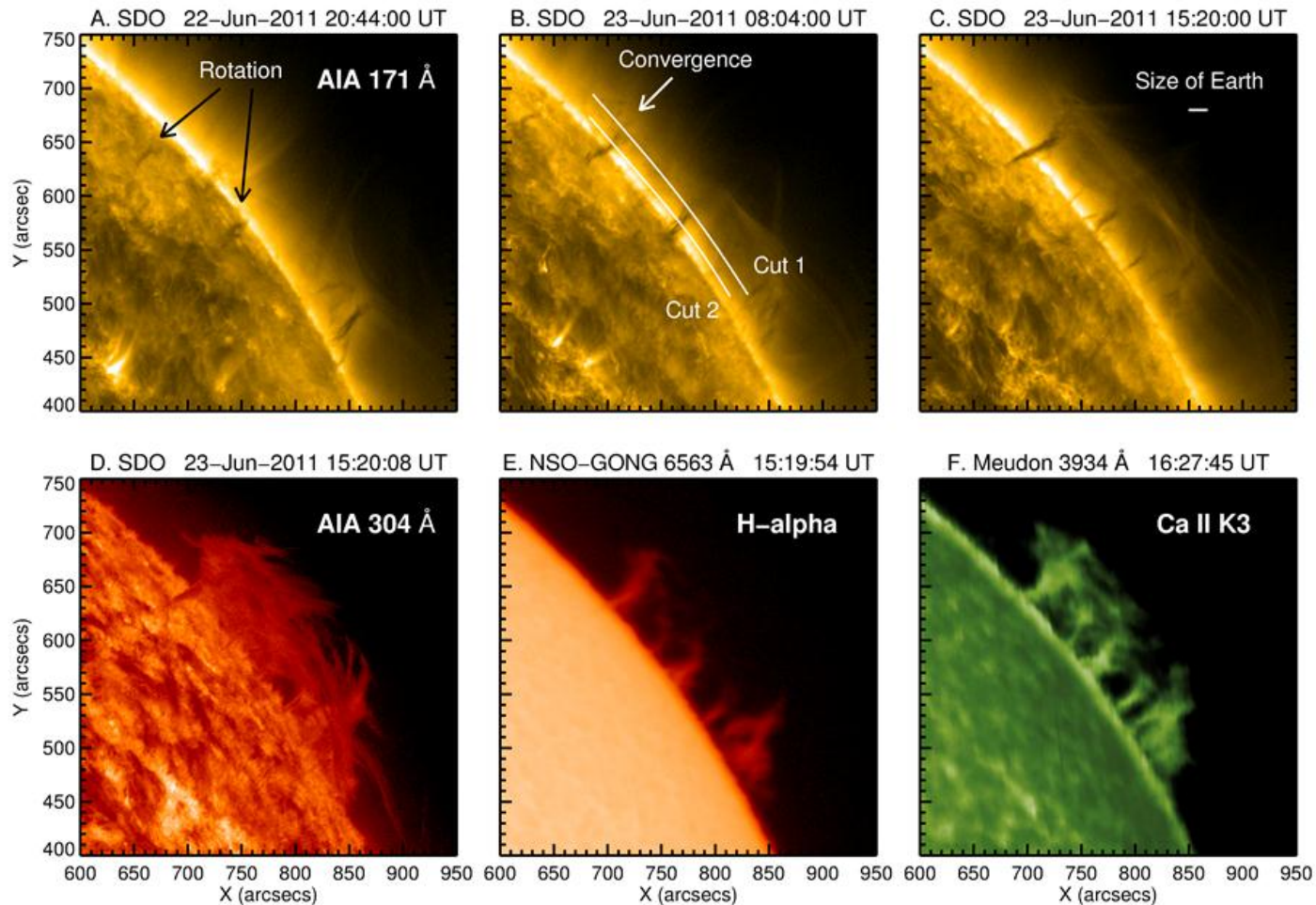


P1. Submitted studies

P2. Work in progress

P3. Students' work

- Solar magnetized tornado, a new phenomenon
 - Rotating magnetic structures in the corona

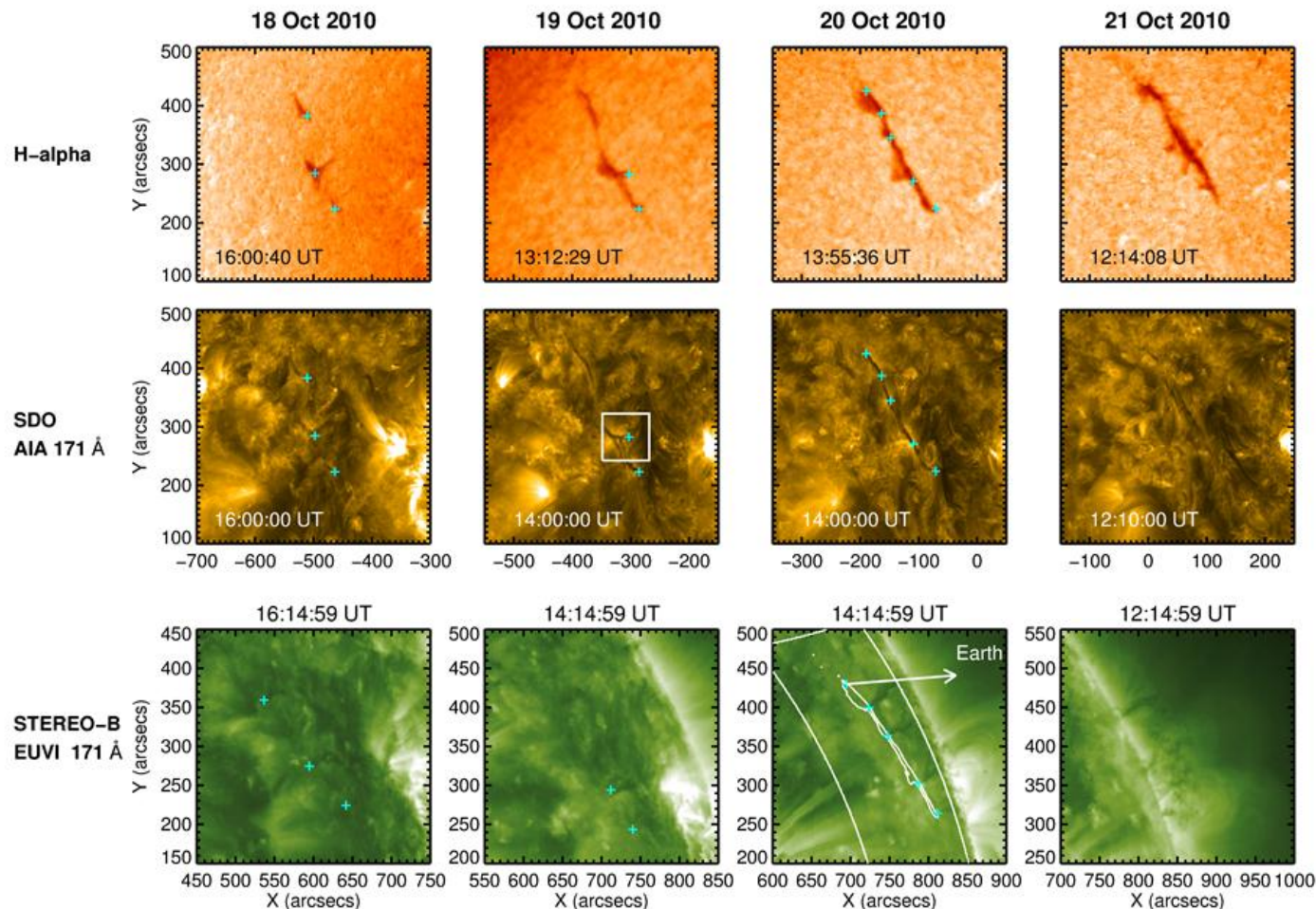


P1. Submitted studies

P2. Work in progress

P3. Students' work

- Solar tornadoes and filaments (from formation to eruption)
 - Solar tornadoes appear first
 - They are connected by overlaying filament
 - Barbs are projections of solar tornadoes

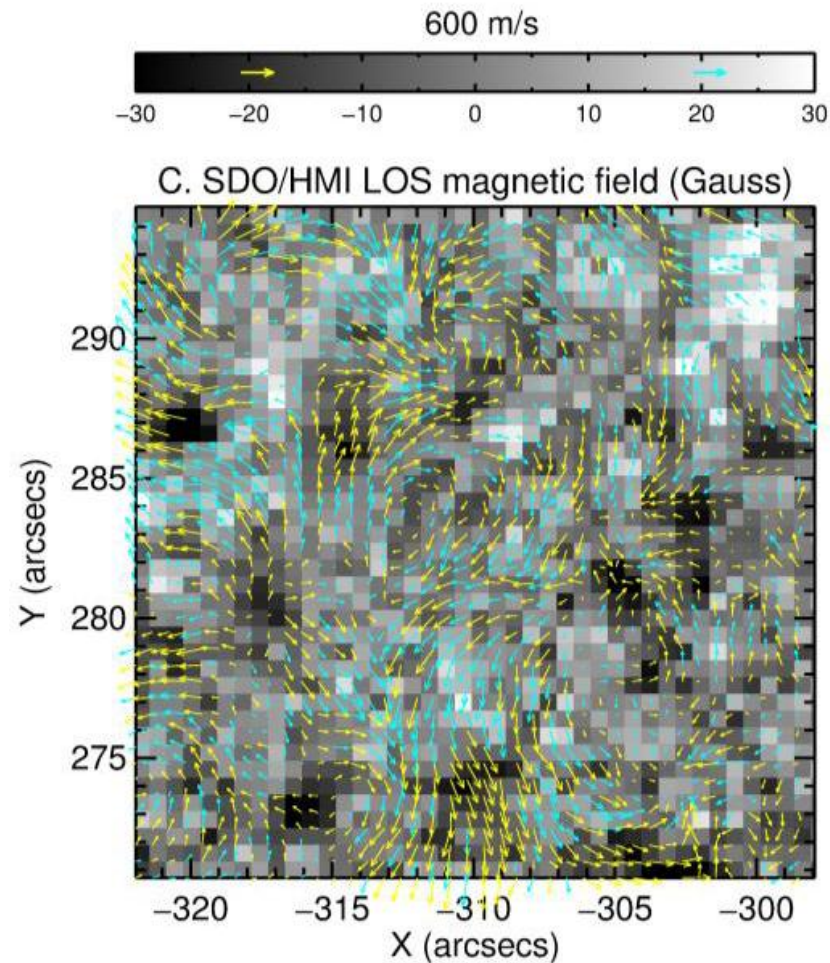
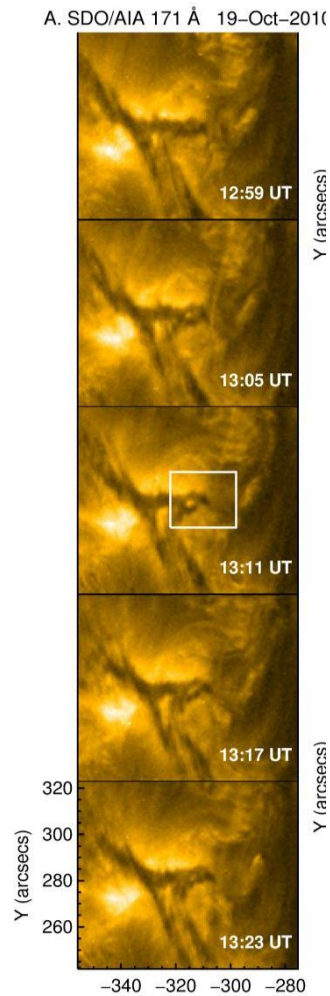


P1. Submitted studies

P2. Work in progress

P3. Students' work

- Solar tornadoes may be related to vortexes in the photosphere

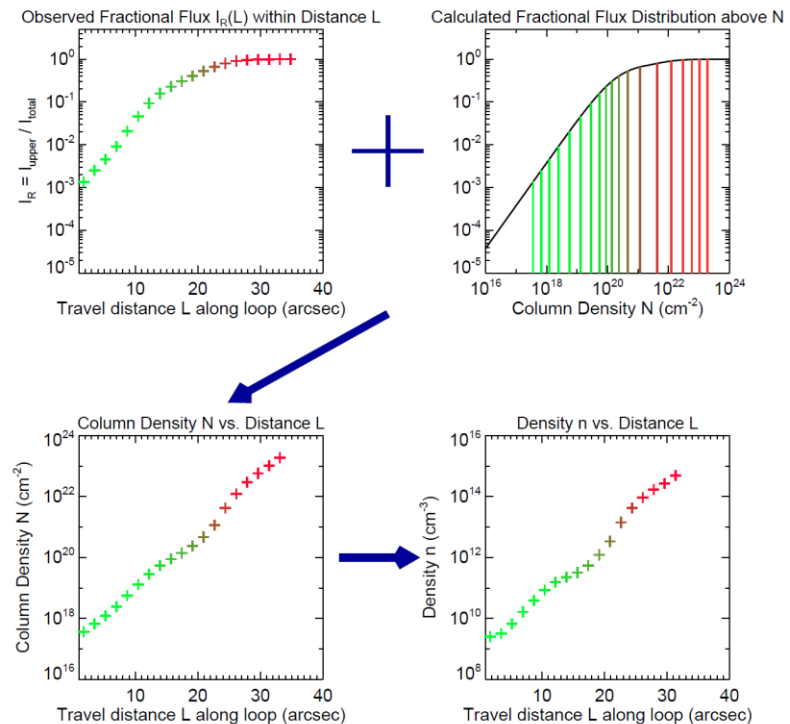
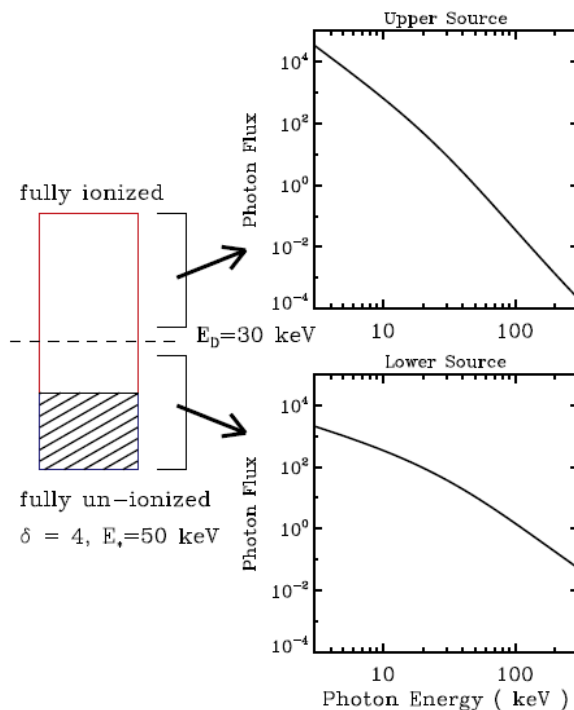


P1. Submitted studies

P2. Work in progress

P3. Students' work

- **Deriving plasma density distribution in Flaring loops**
- Thick Target Or
- NonUniform Ionization thick-target model (NUI, Su et al. 2009, 2011)

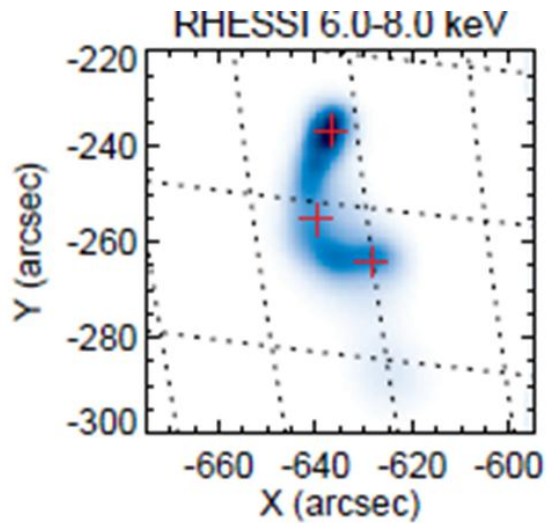


Oct. 31 2002 flare, photon energy : 30-34 keV

P1. Submitted studies

P2. Work in progress

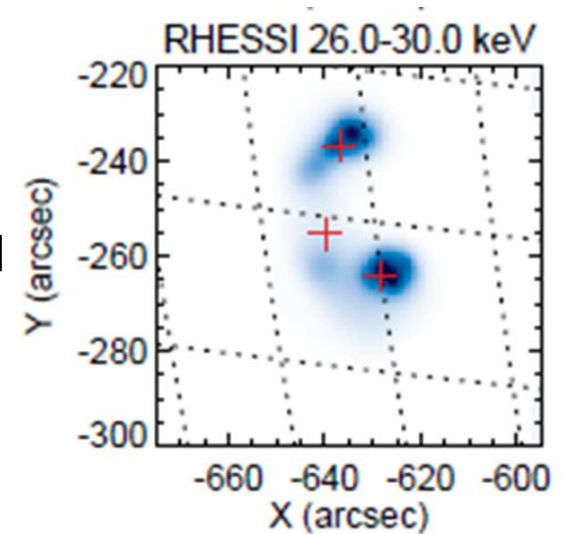
P3. Students' work



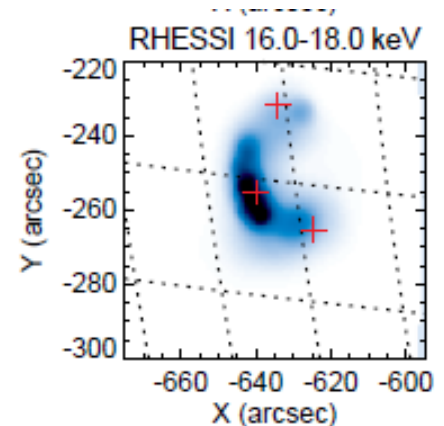
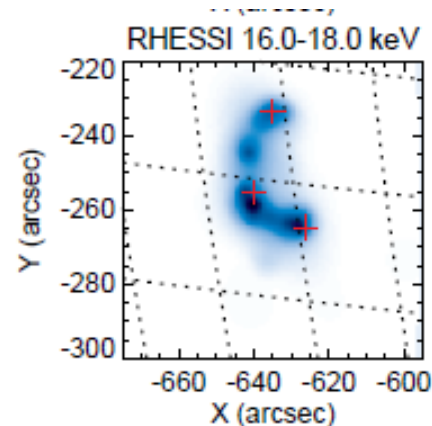
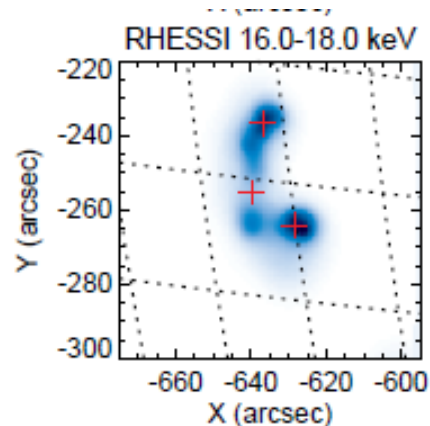
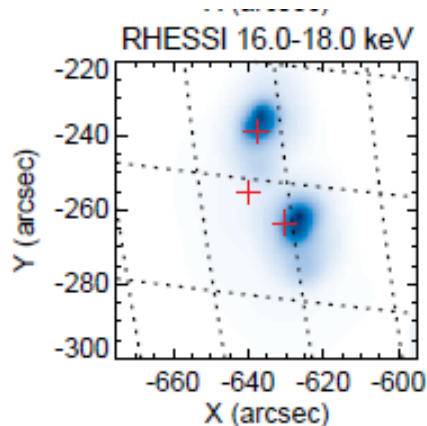
2002 Sep. 10 event

thermal

nonthermal



nonthermal \rightarrow thermal (16-18 keV)



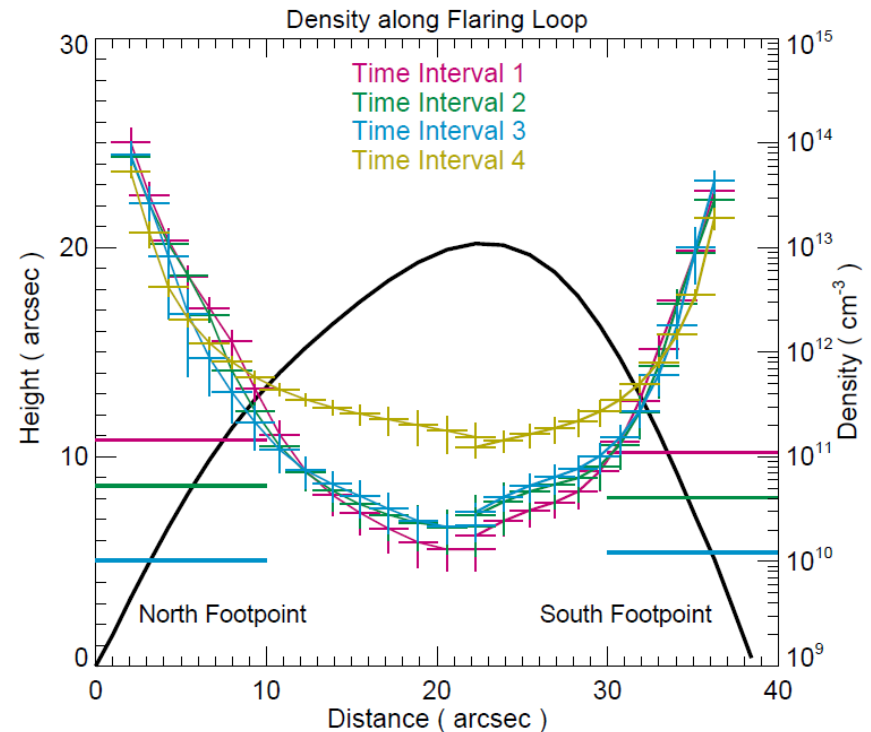
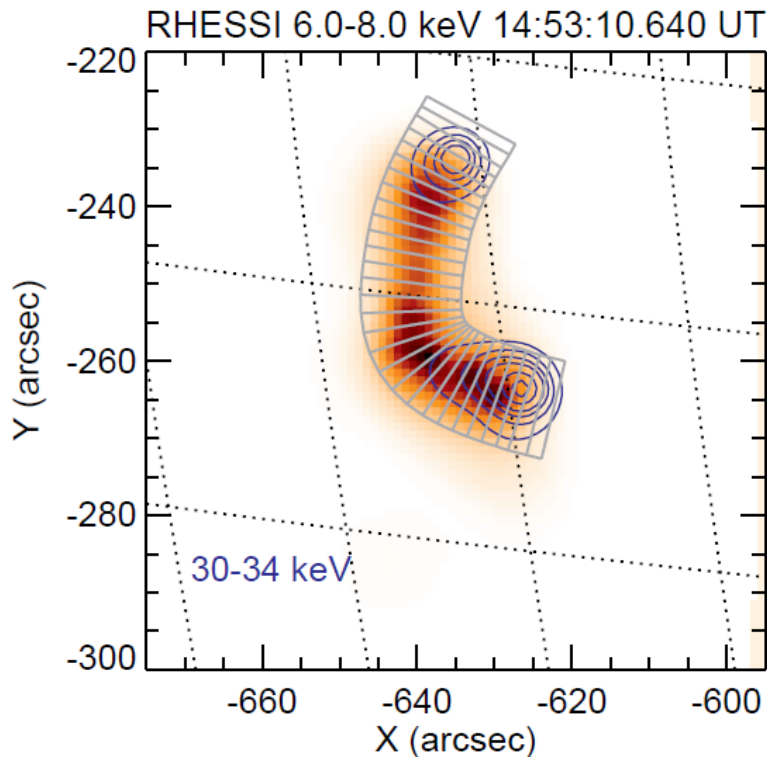
P1. Submitted studies

P2. Work in progress

P3. Students' work

- Results

- show increase of density in the loop top
- Show decrease of transition layer (between ionization 0 and 1) in height
- Support standard flare model and chromospheric evaporation



P1. Submitted studies

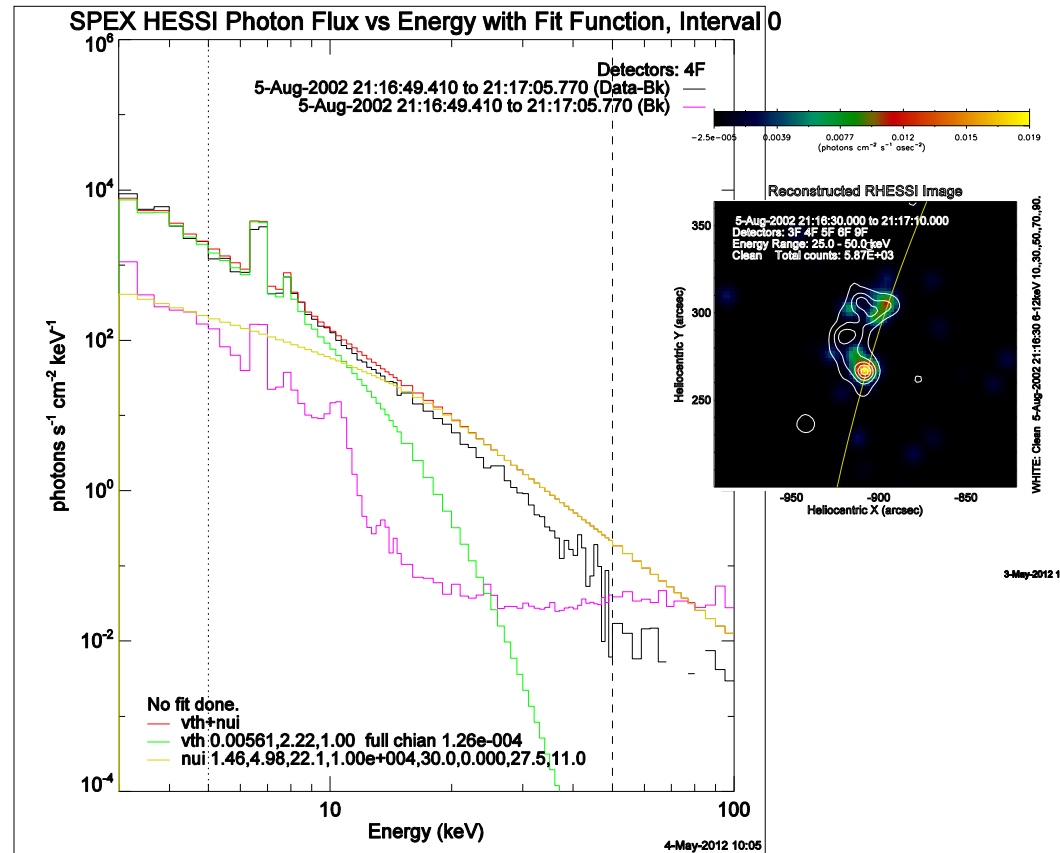
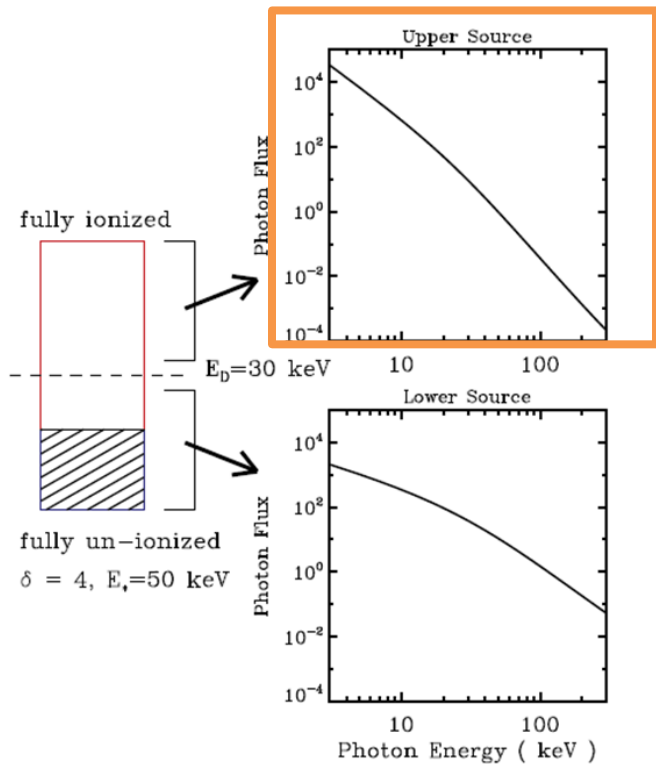
P2. Work in progress

P3. Students' work

- **Fitting spectra for occulted flares**

- $E_D (N_D)$ at limb ? keV
- To get the “true” electron distribution

$$I_{upper}(\varepsilon) = \frac{1}{4\pi(AU)^2} \frac{m_e c^2}{4\pi e^4 \Lambda} \int_{\varepsilon}^{\infty} Q(\varepsilon, E) \beta^2 \left[\int_{E > E_c}^{E_{xd}} \frac{f(E_e)}{\lambda + 1} dE_e \right] dE \quad ,$$



P1. Submitted studies

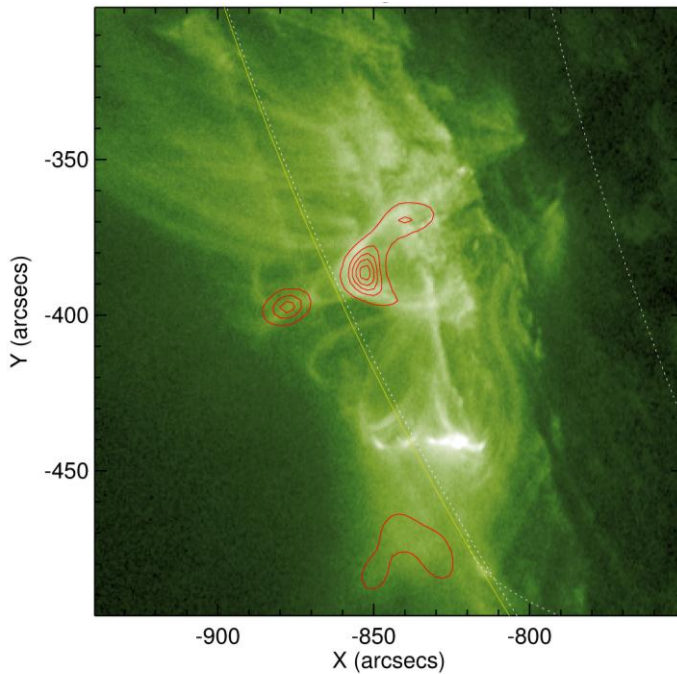
P2. Work in progress

P3. Students' work

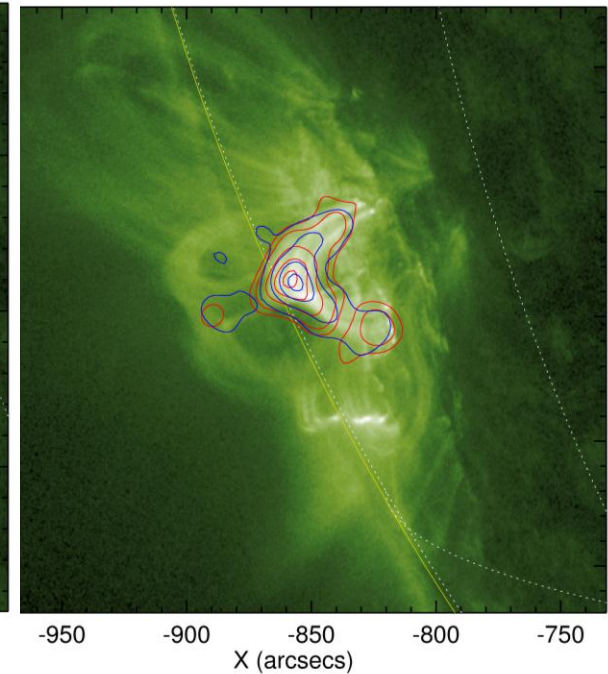
- **Direct observation of magnetic reconnection**

- Loop-loop, loop-open field lines/large loops

AIA 131 + 6-8 keV
MEM NJIT



AIA 131 + 4-6 keV + 10-20 keV
Clean

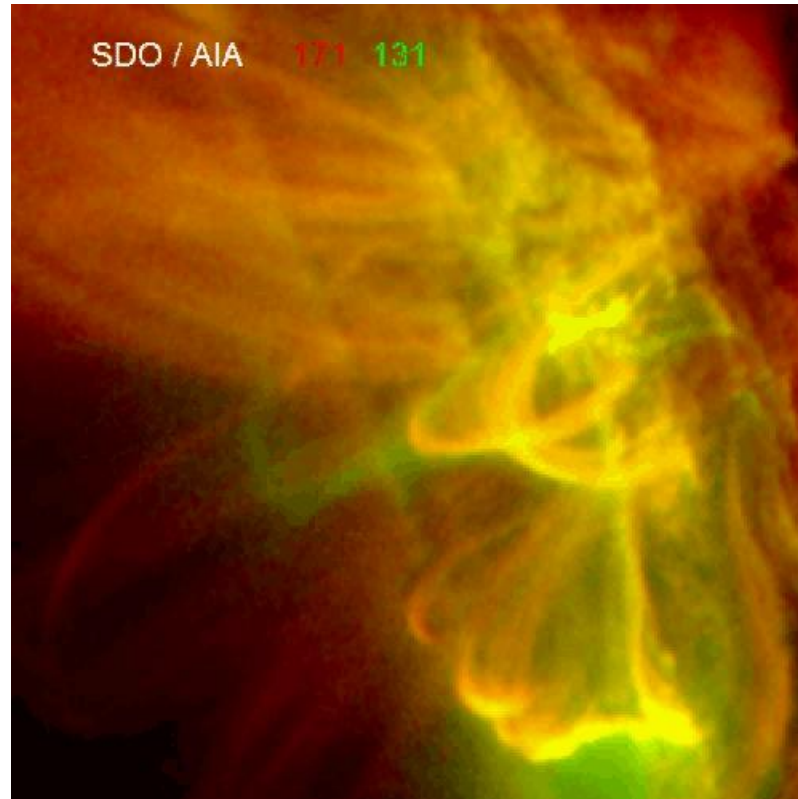


P1. Submitted studies

P2. Work in progress

P3. Students' work

- Movie

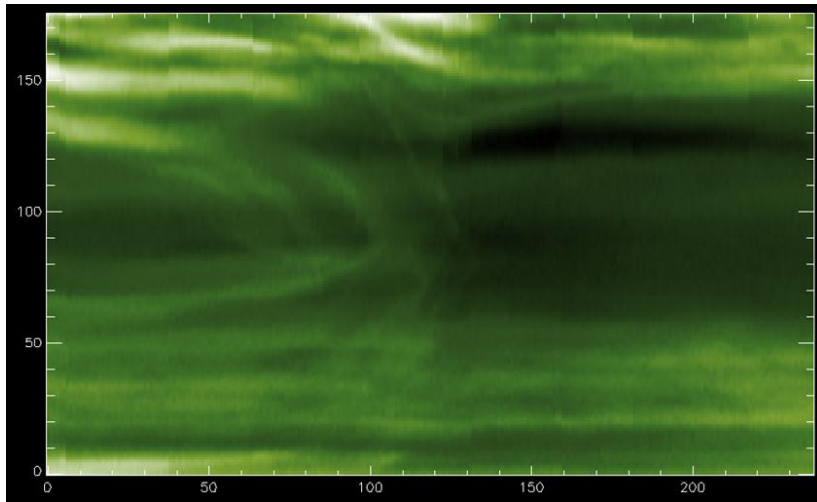


P1. Submitted studies

P2. Work in progress

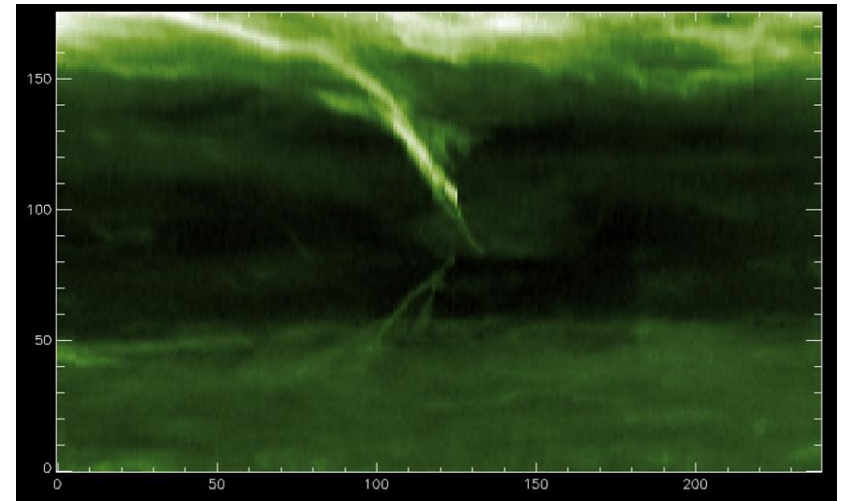
P3. Students' work

- Inflow and outflow

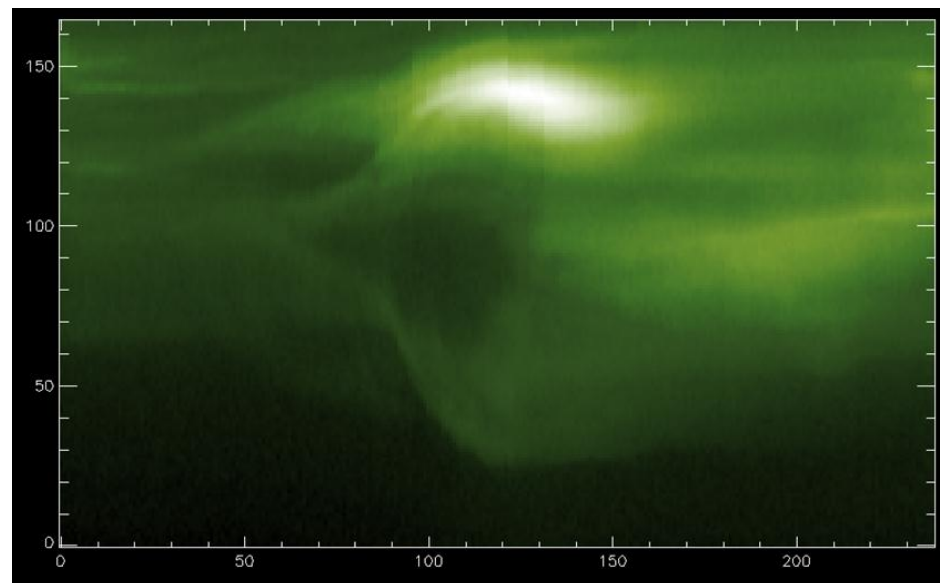


211

304



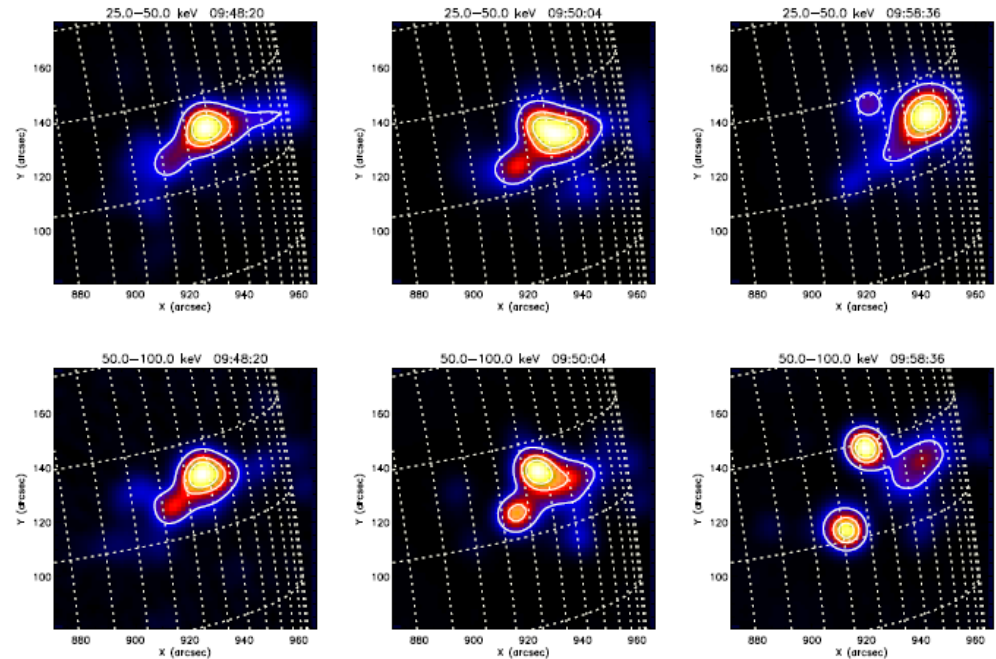
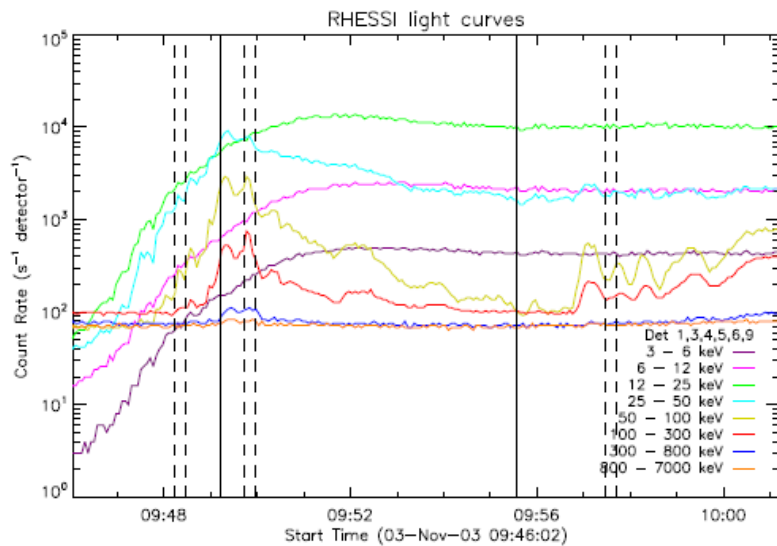
AIA 131



P1. Submitted studies

P2. Work in progress

P3. Students' work



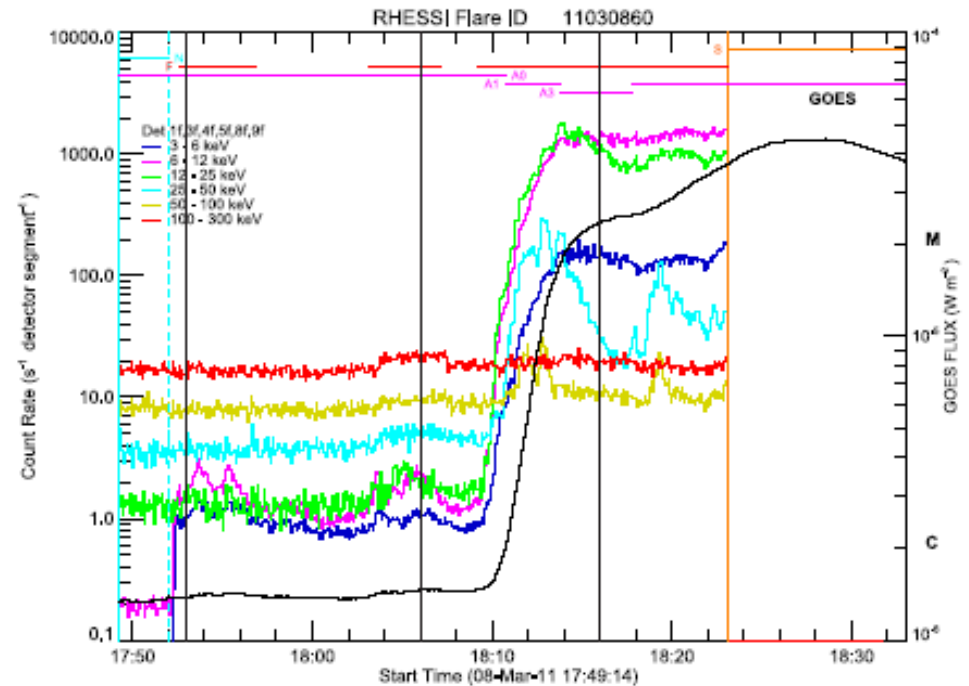
- C. Miksits et al.
 - Imaging spectroscopy for the late phase of 2003-November-3 flare

P1. Submitted studies

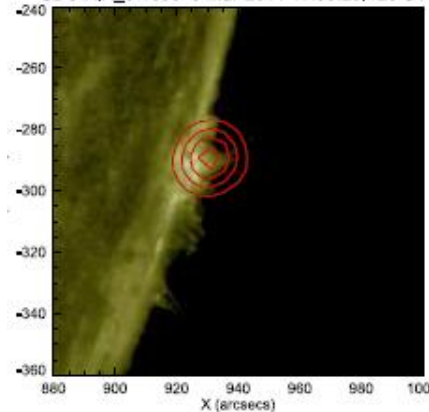
P2. Work in progress

P3. Students' work

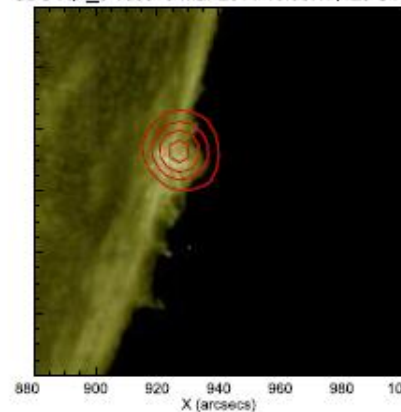
- R. Rott et al.
 - Statistical study on pre-flare activity



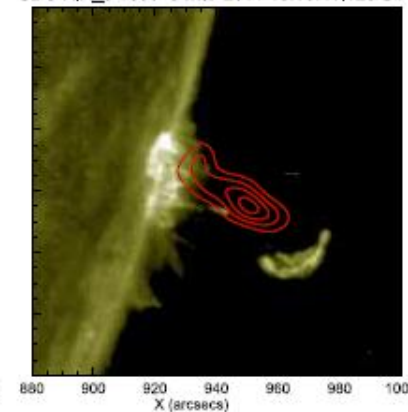
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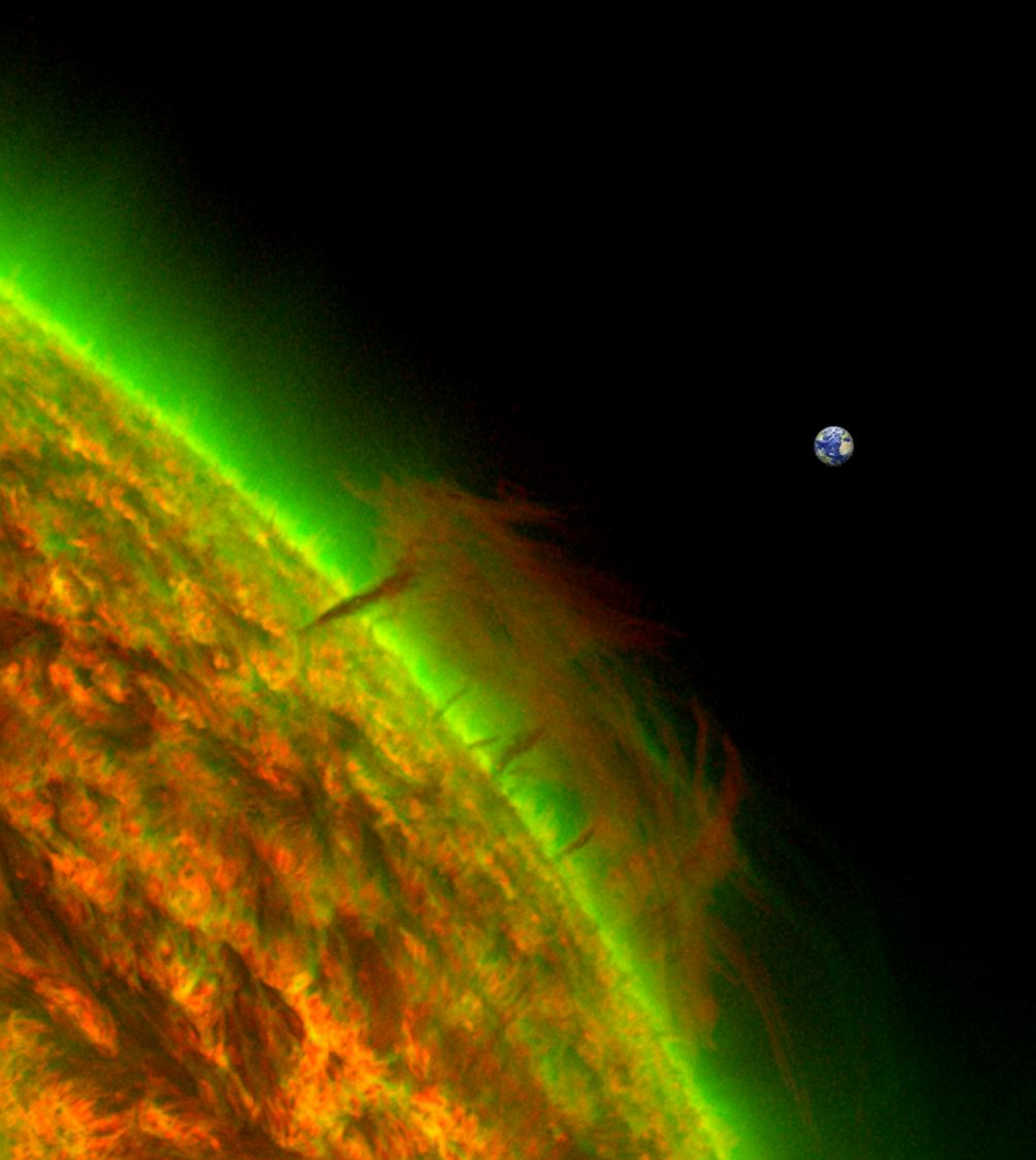


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SDO AIA_3 1600 8-Mar-2011 18:16:41,120 UT





Thanks