Fachhochschule Nordwestschweiz

Radio and X-ray Observations of Electron Acceleration in a Series of Solar Microflares

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Executive Summary

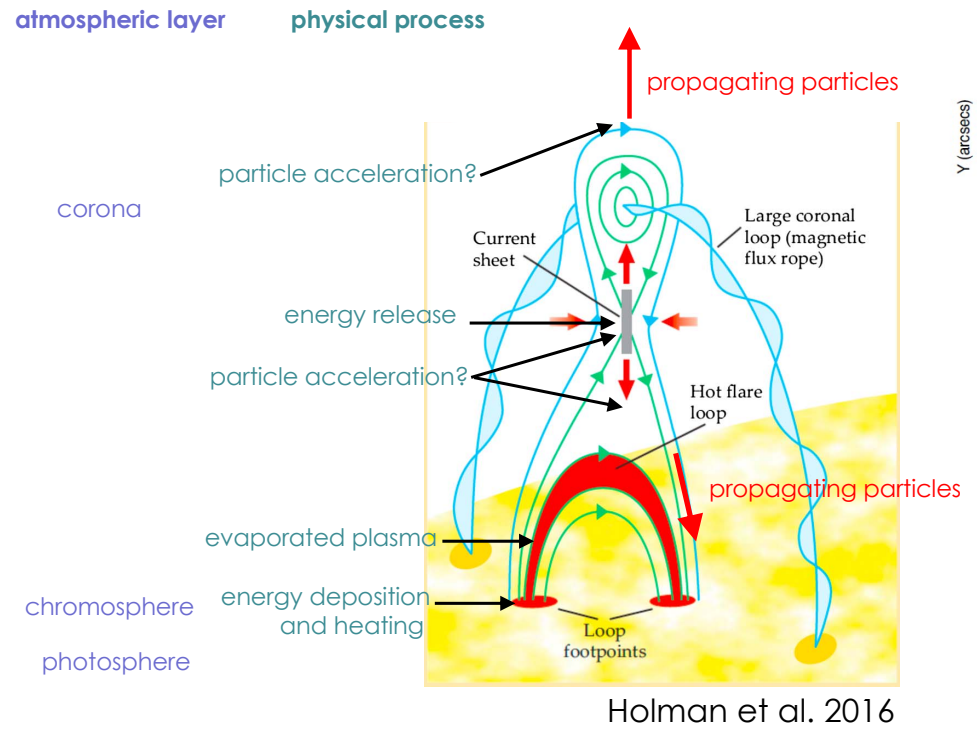
We observe a series of X-ray microflares with RHESSI from different locations within the same active region.

Coherent radio emission (short-lived bursts and spikes, broad-band continuum) was observed with the VLA. It was co-temporal, but not co-spatial with the flares.

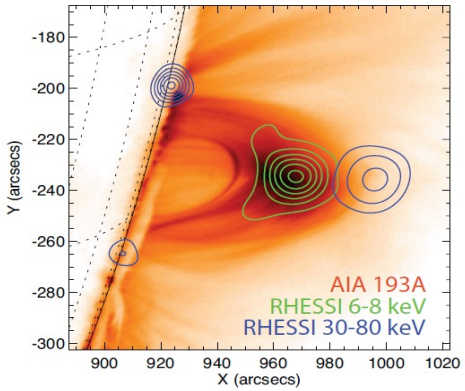
Interpretation:

In some flares, electrons were accelerated near the main flare site and were transported far away. In other flares, the observations suggest secondary acceleration, possibly triggered by the main flare, but potentially completely independent of it.

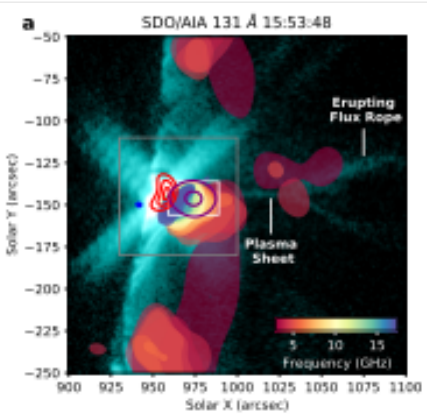
A simplistic solar flare scenario



Holman et al. 2016



Krucker & Battaglia 2014

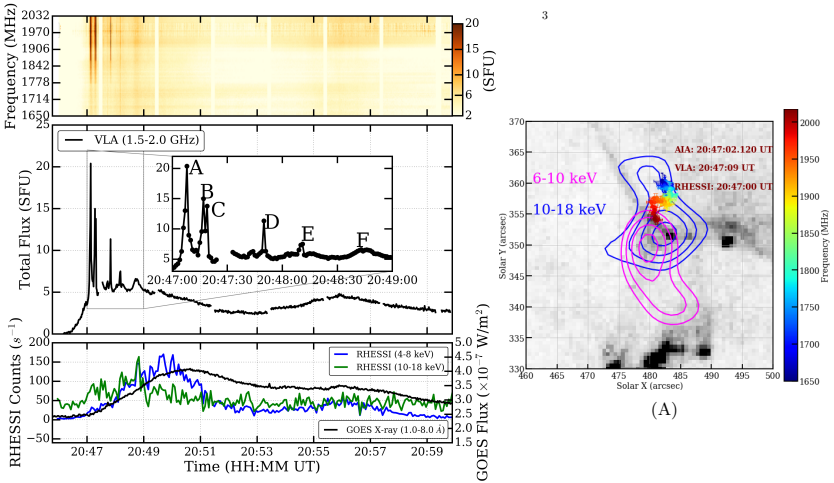


Chen et al. 2021

X-ray and radio emission are signatures of accelerated electrons

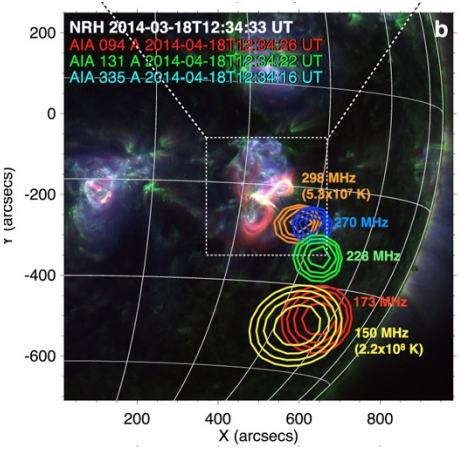
Reality is not 2-dimensional and even small flares can be surprisingly complex

Multiple acceleration instances and sites in the literature

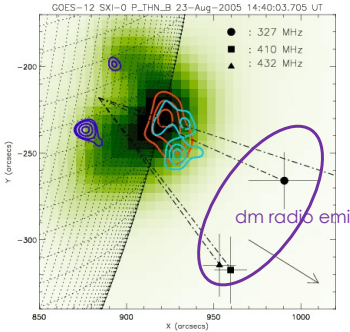


Two different, simultaneous electron populations during a small flare (Sharma et al. 2020)

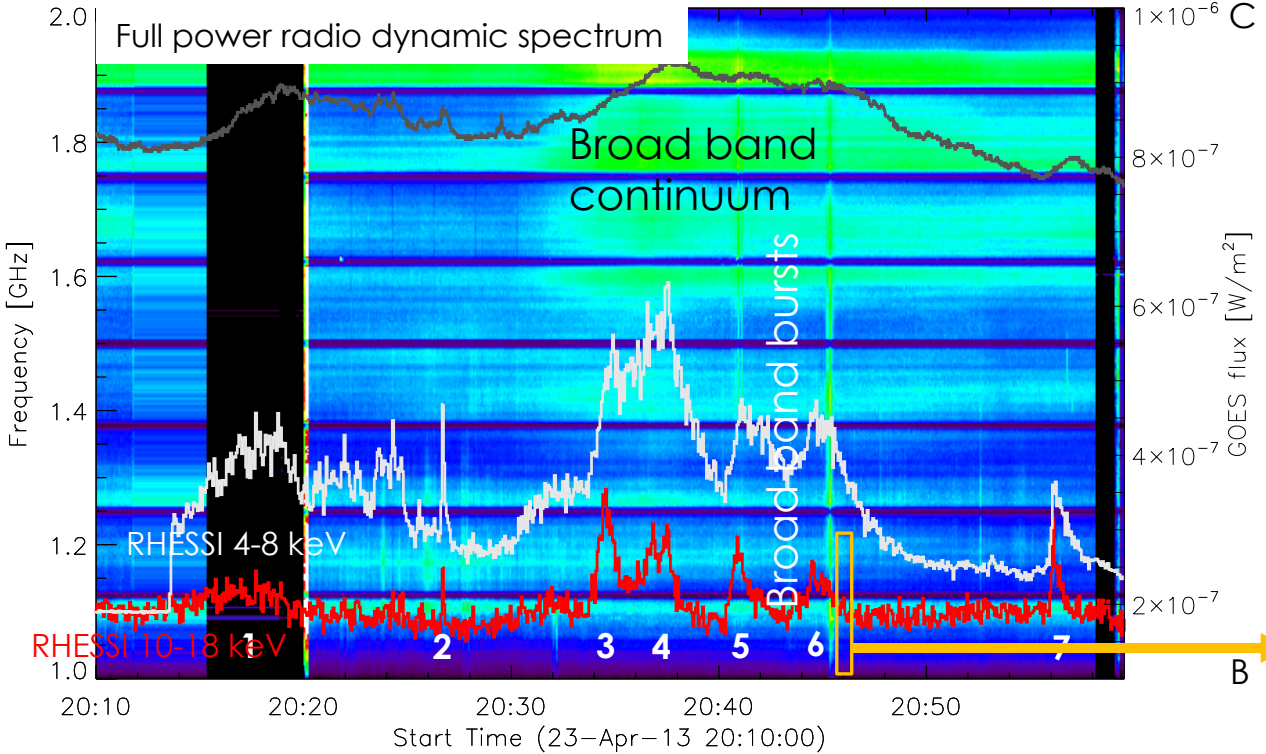
Secondary acceleration associated with an erupting flux rope (Carley et al. 2016)



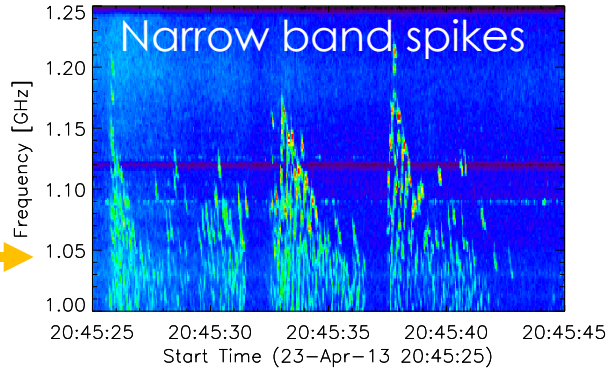
Secondary acceleration associated with CME (Battaglia et al. 2009)



A series of microflares observed by RHESSI and the VLA

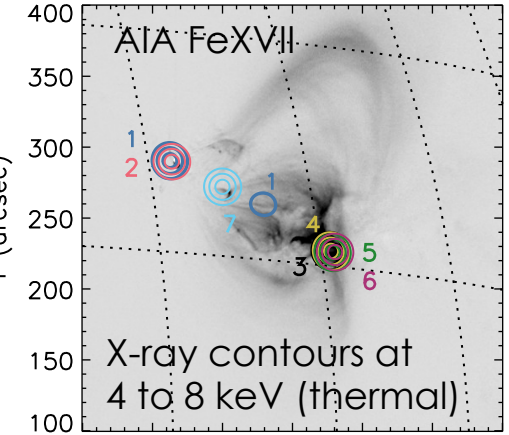


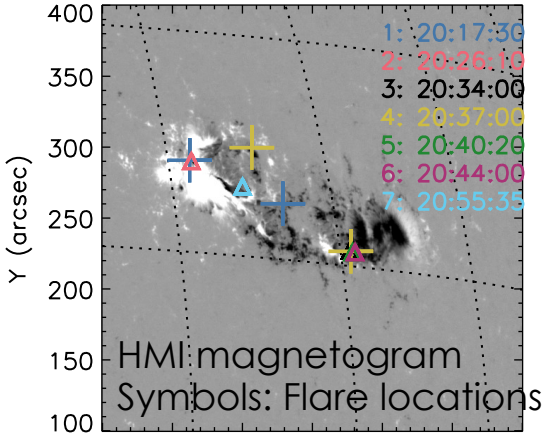
23 April 2013
50 minutes
7 X-ray flares
Multiple associated radio features

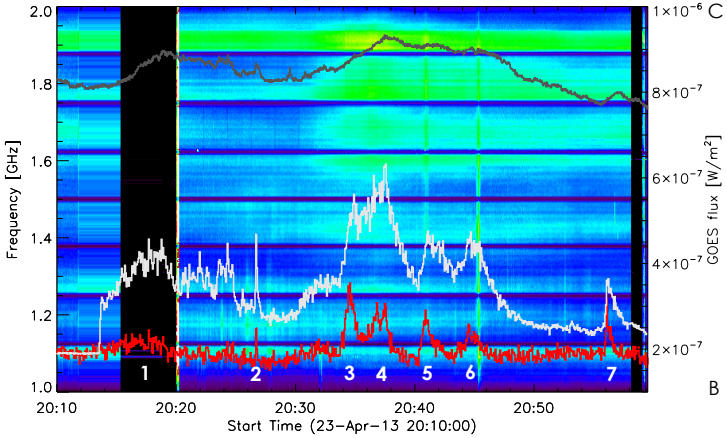


A closer look at relative locations

X-rays

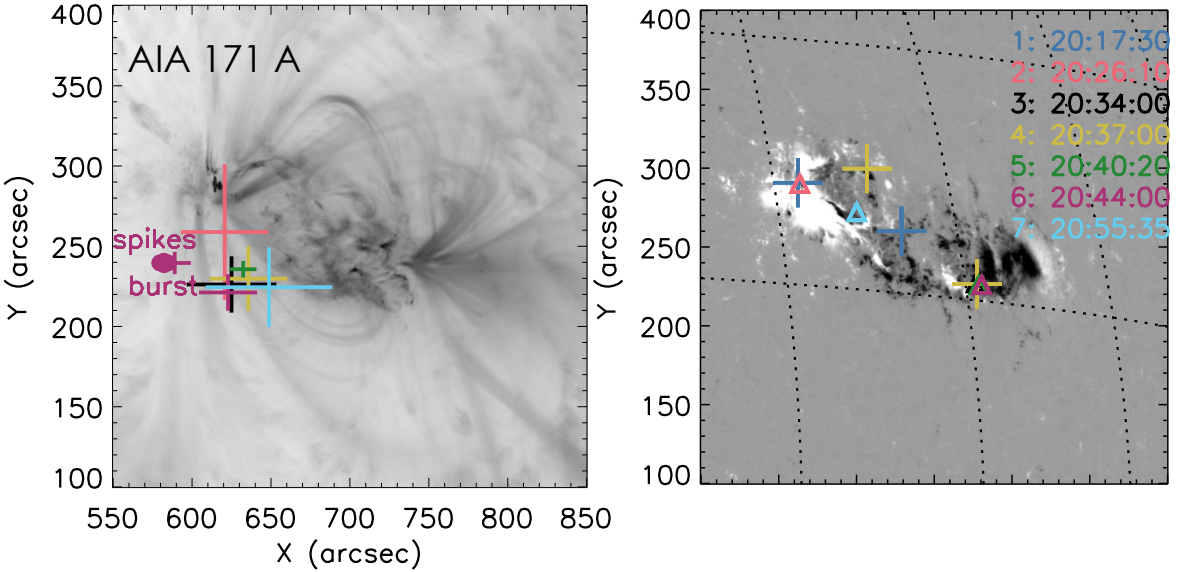


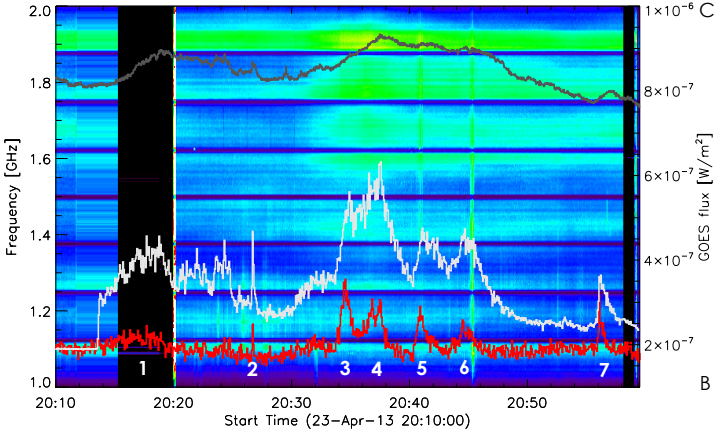


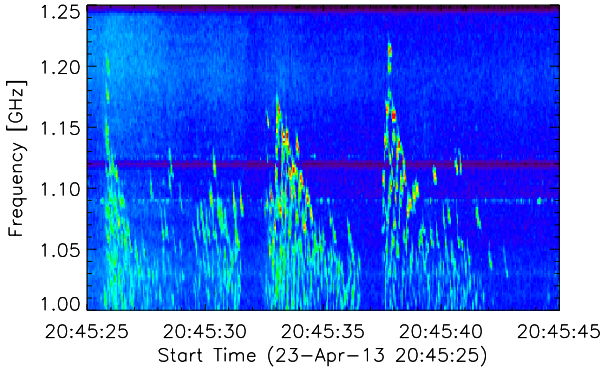


Flares originated at three different locations
F1 and F4: actually two flares! Both sources imaged with RHESSI.

Radio



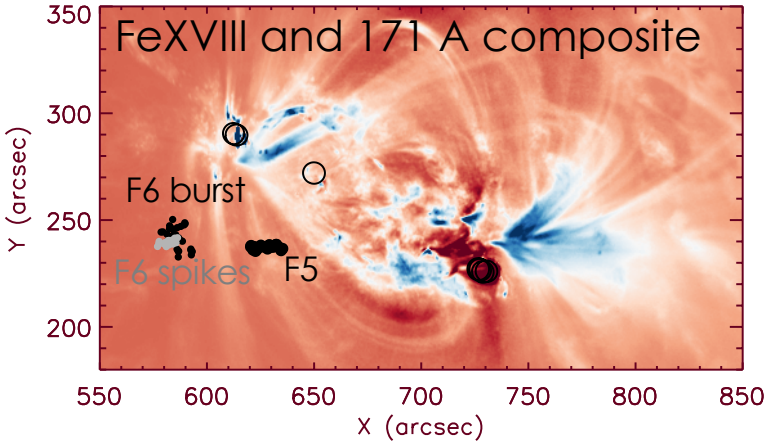




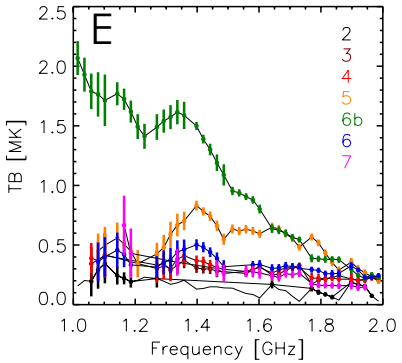
Radio sources far displaced from X-ray sources

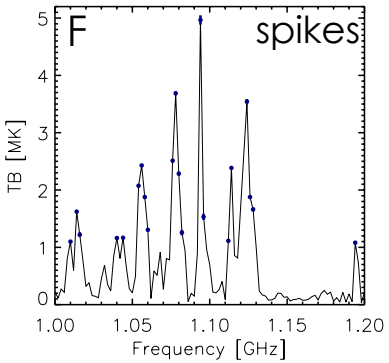
Broad-band continuum is thermal emission from the active region.

Relative and radio – frequency dependent locations



Brightness temperature spectra

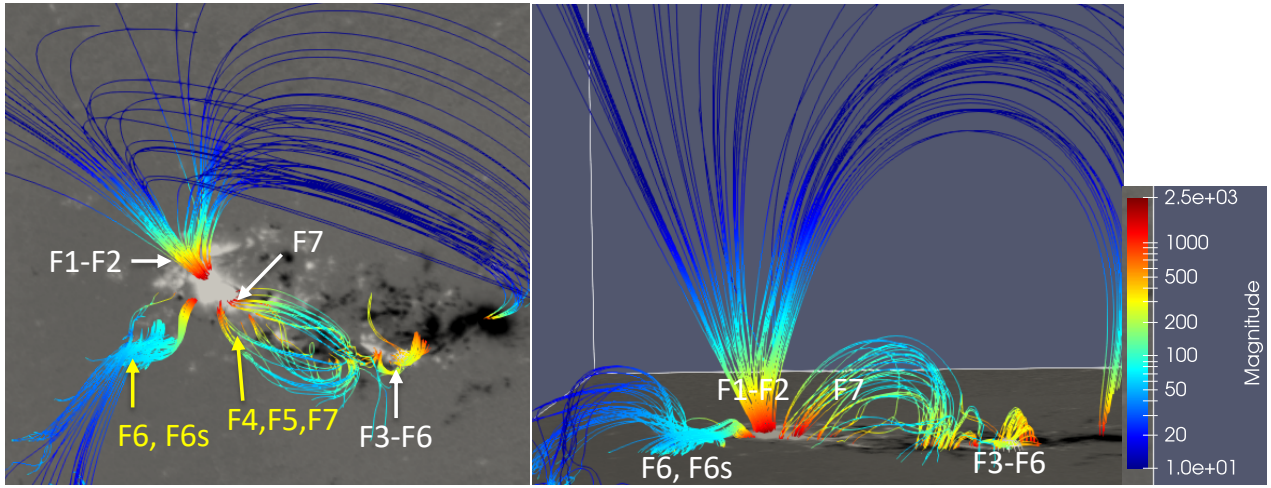


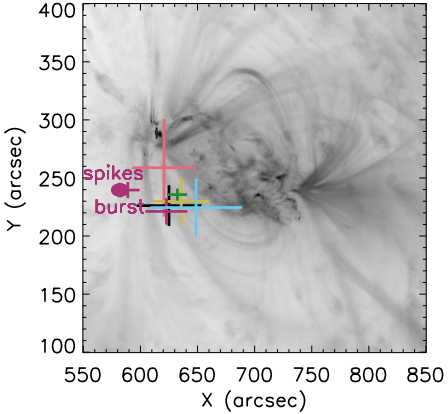


No clear frequency dependence of locations (e.g. along field lines)

Some radio emissions were faint (compare T_B-spectrum) → locations not shown due to high uncertainties.

Magnetic connectivity





white: approximate location of X-ray flares
yellow: approximate location of radio bursts

NLFF extrapolations show multiple loop systems also seen in AIA 171 A
No apparent connection between bursts/spikes and flare No. 6

Conclusions

Variety of radio emissions observed co-temporal, but not co-spatial with a series of X-ray microflares

Two possible scenarios

Electrons are accelerated at flare site and transported away (flare no. 7, possibly 4 and 5)

Electrons are accelerated at a secondary acceleration site, or even completely independently of co-temporal flare (no. 6)

Even microflares can be surprisingly complex with multiple acceleration sites and complex loops systems along which electrons are transported.