Narrow CMEs, Jets - Progenitors of Impulsive SEP Events

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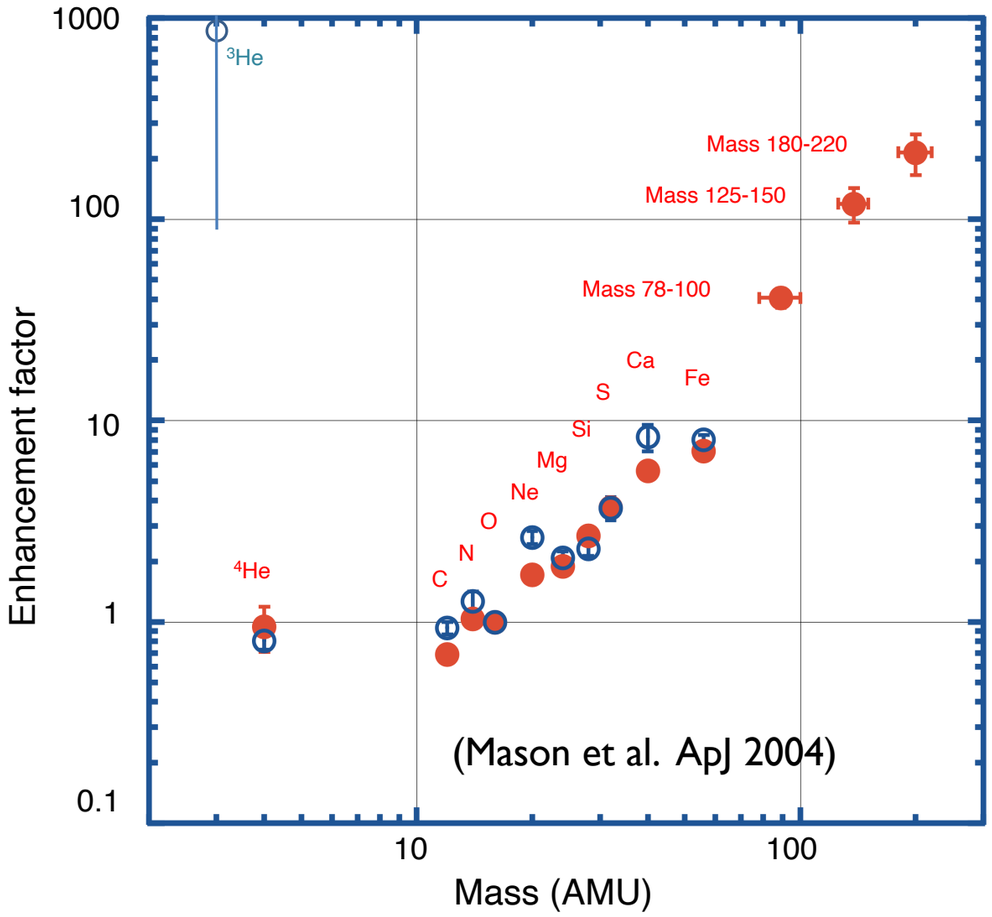
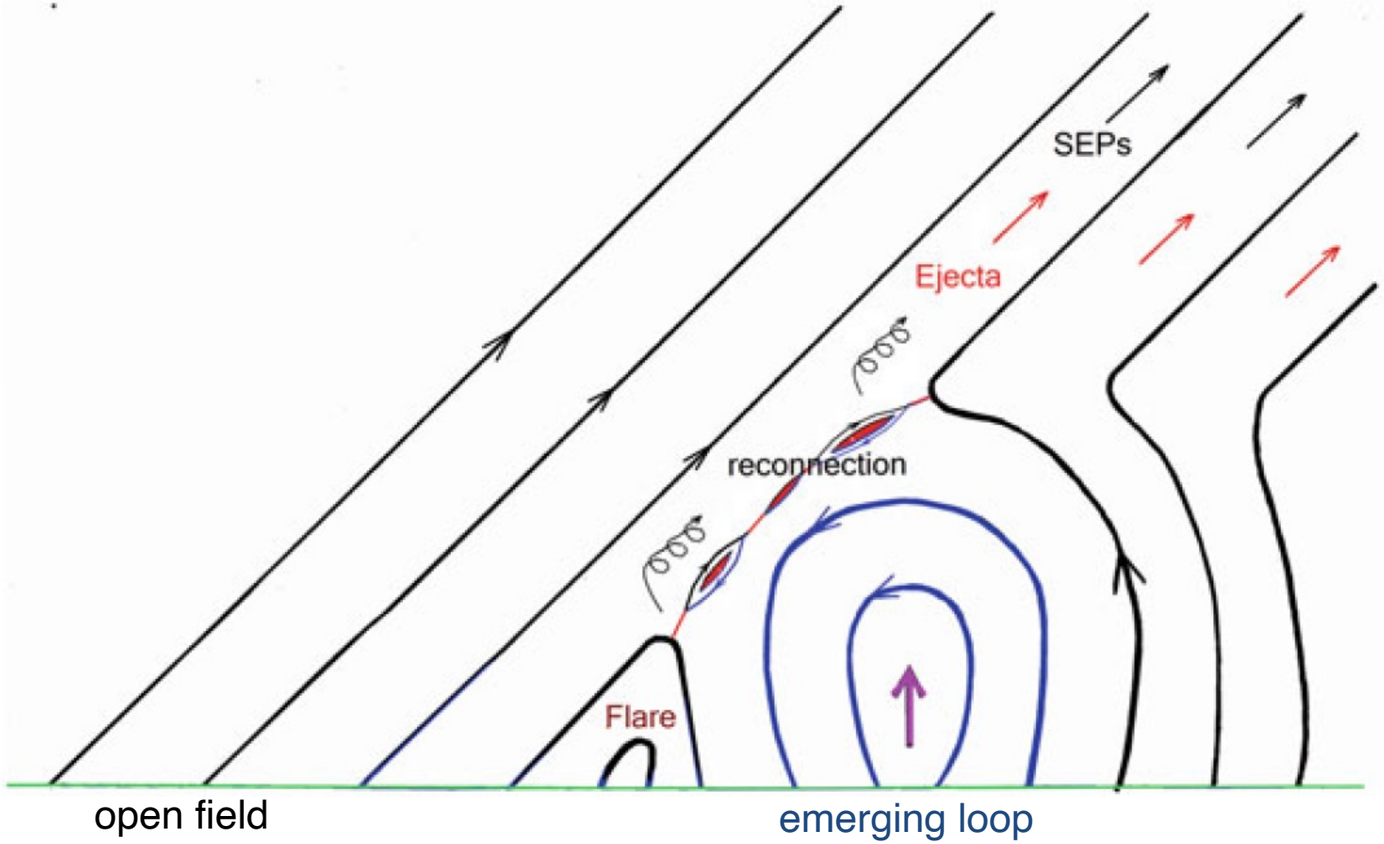
Impulsive SEPs abundances



- peculiar elemental composition

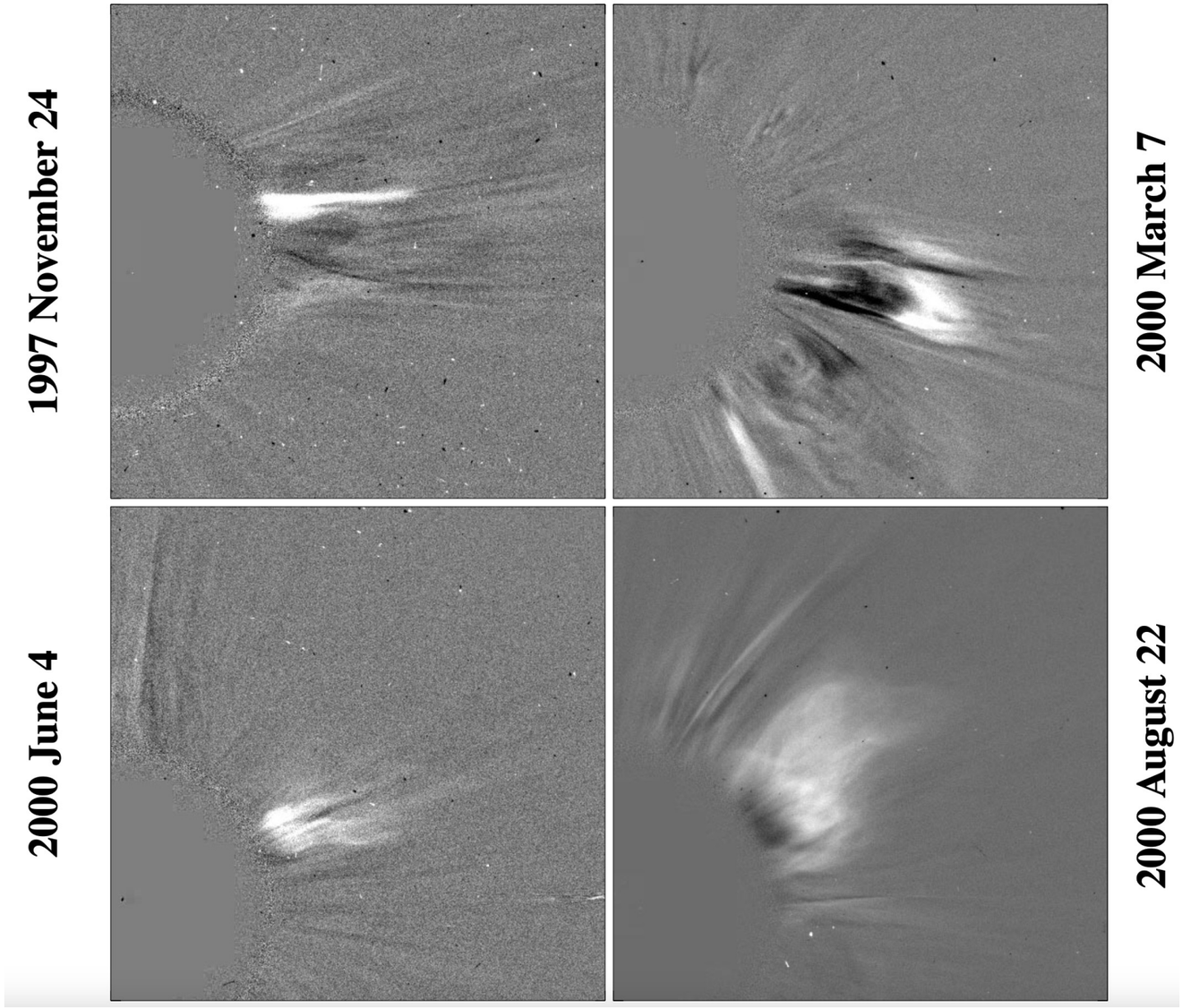
Impulsive SEPs source



(Reames et al. ApJL 2000, Frontiers 2021 after Shimojo & Shibata ApJ 2000)

- produced in jets by a mechanism associated with magnetic reconnection

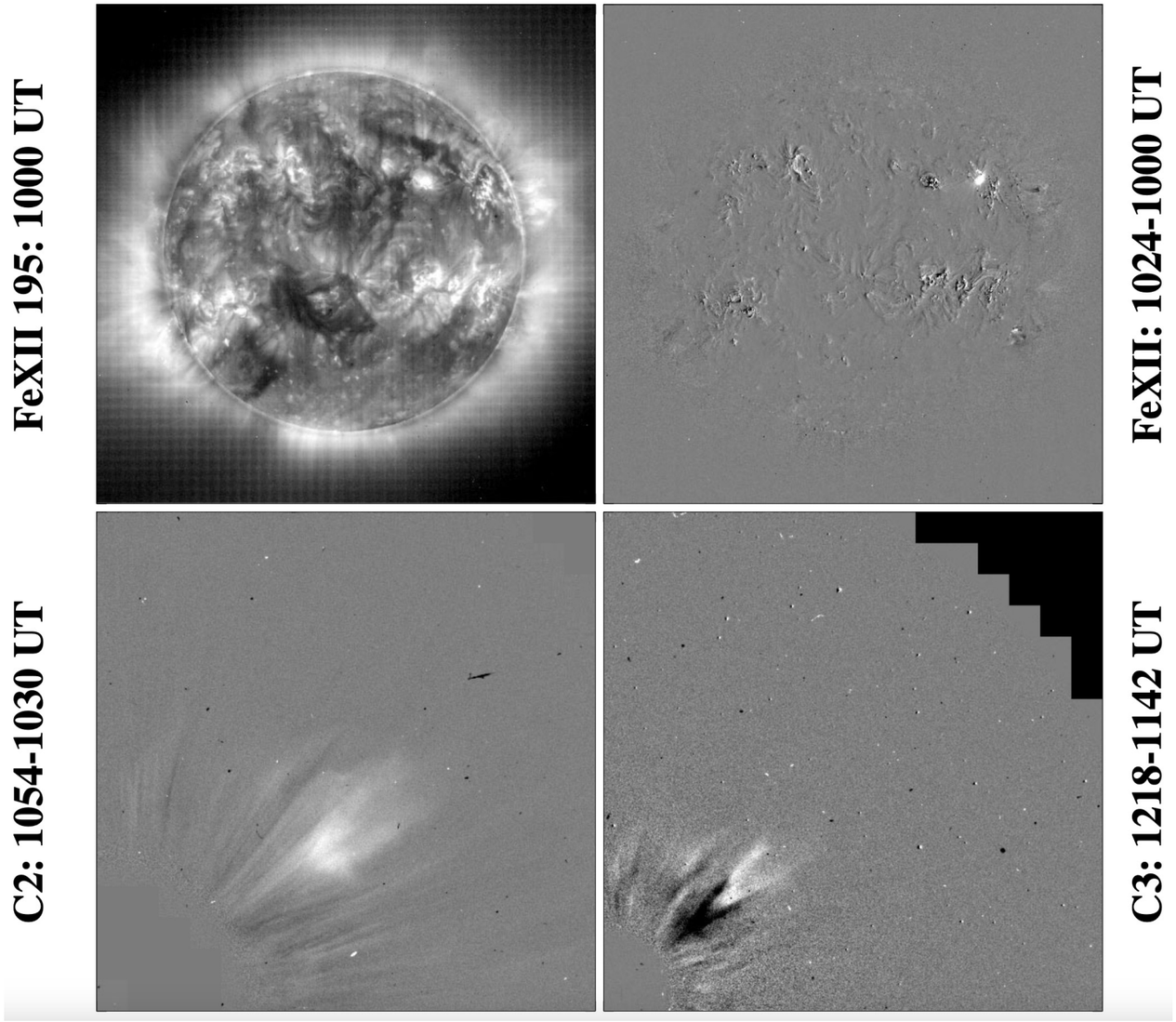
Narrow CMEs associated with impulsive SEP events



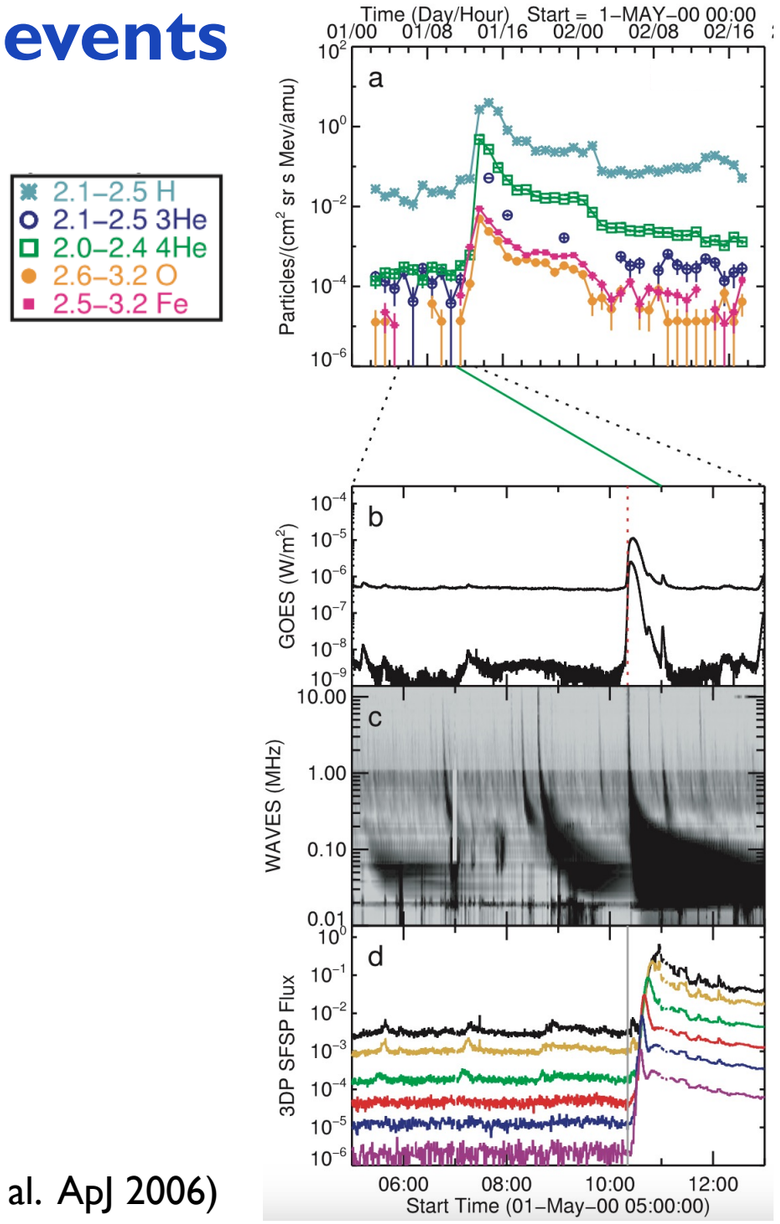
(Kahler et al. ApJ 2001)

- Impulsive SEP events have been associated with small-size flares, and observations of CMEs in these events were a surprise
- These CMEs are, however, much narrow compared to CMEs associated with gradual SEP events
- Later jets were observed in impulsive SEP events together with these narrow CMEs

Narrow CMEs associated with impulsive SEP events

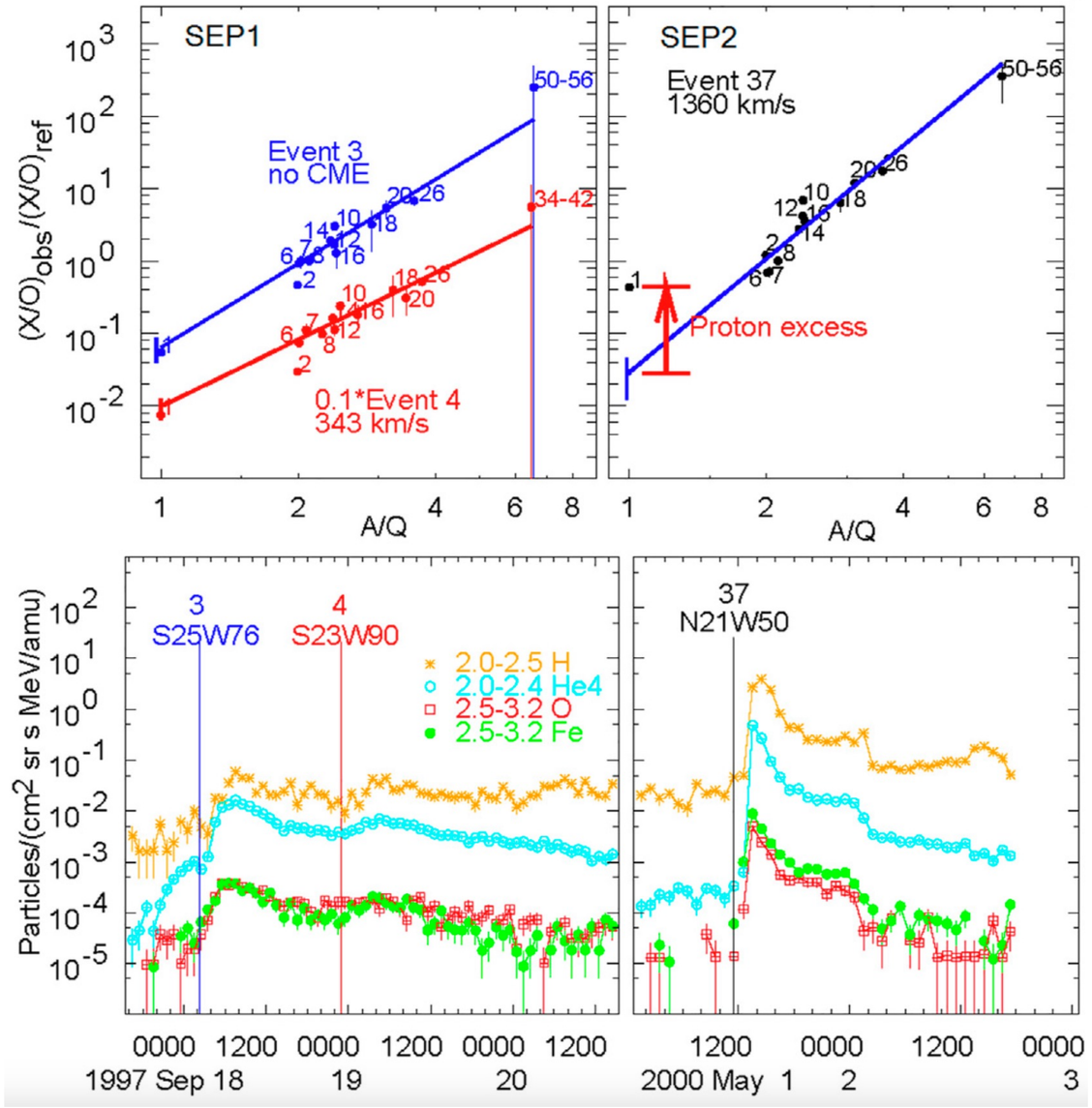


(Kahler et al. ApJ 2001)



(Nitta et al. ApJ 2006)

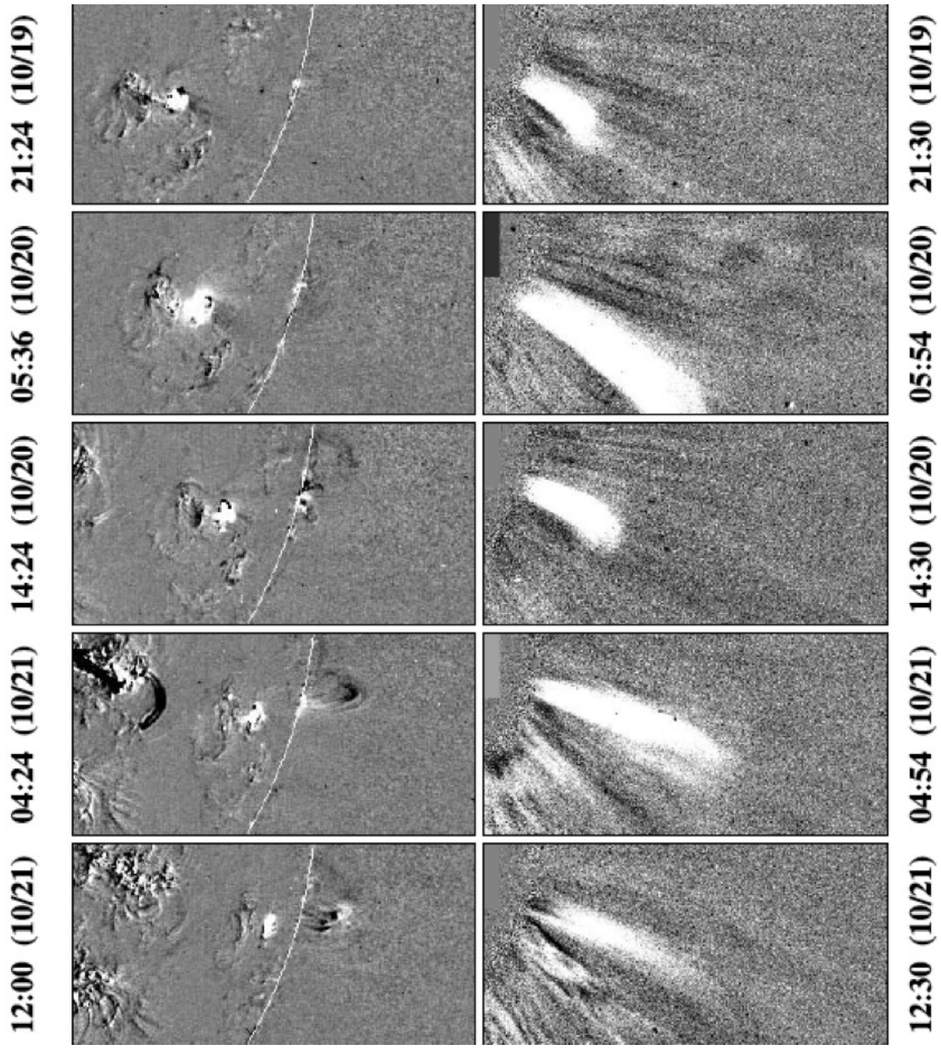
Narrow CMEs associated with impulsive SEP events

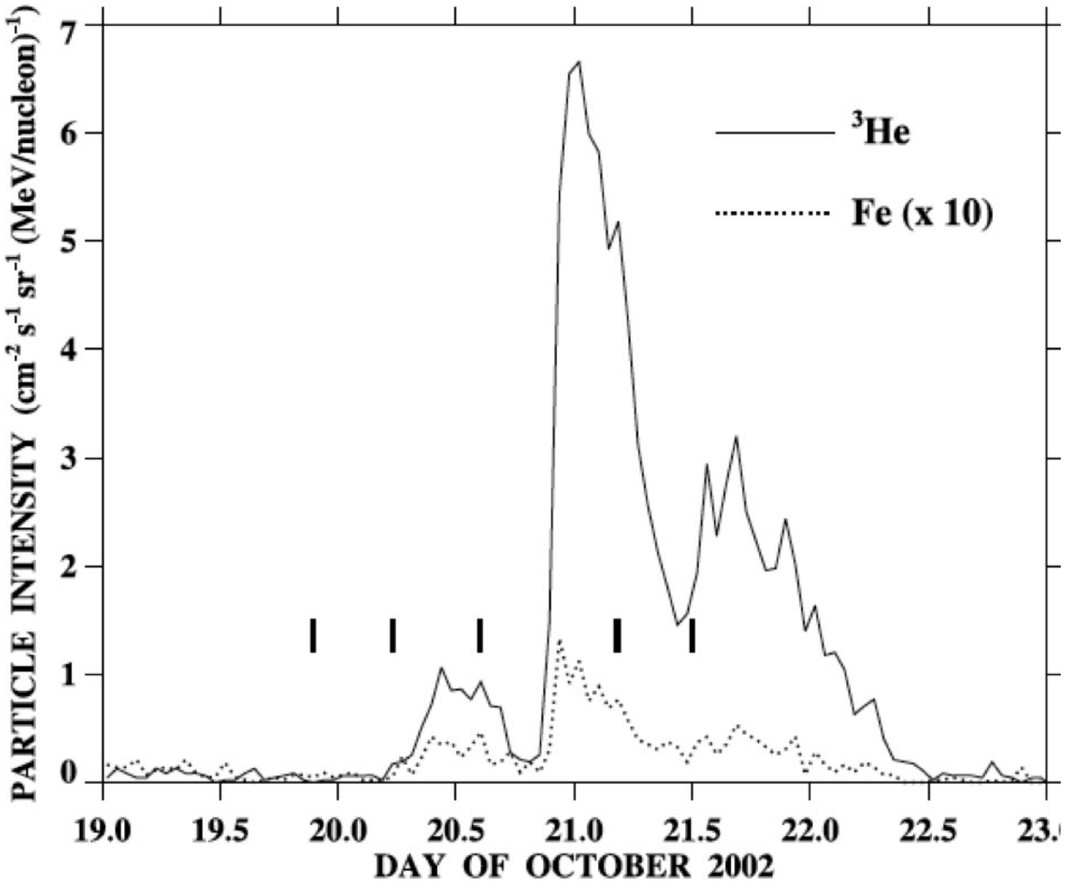


- CME in 2000 May 1 impulsive SEP event is fast enough to drive shock that could re-accelerate suprathermals from earlier magnetic reconnection as well as abundant ambient H and cause the H excess

(Reames et al. Frontiers 2021)

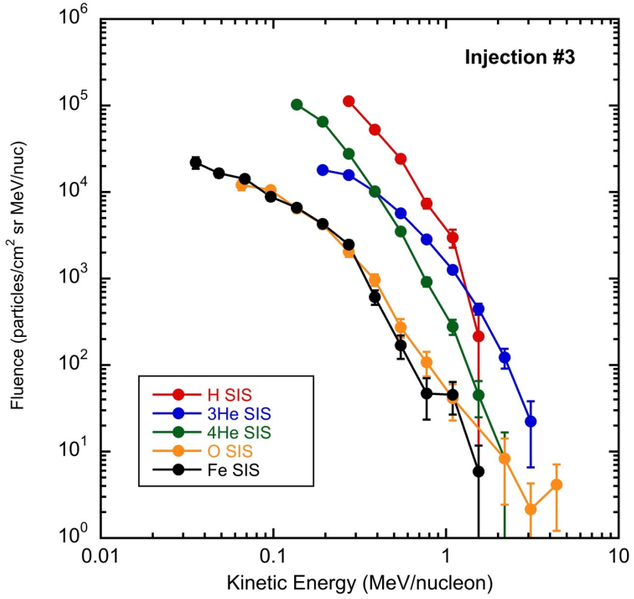
Narrow CMEs and associated jets in impulsive SEP events

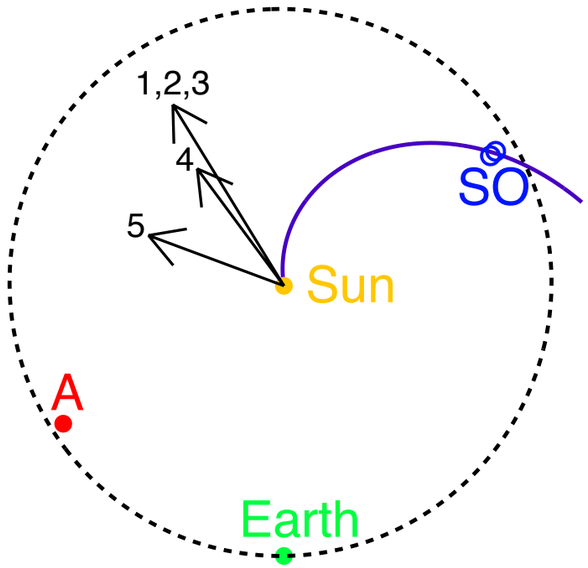


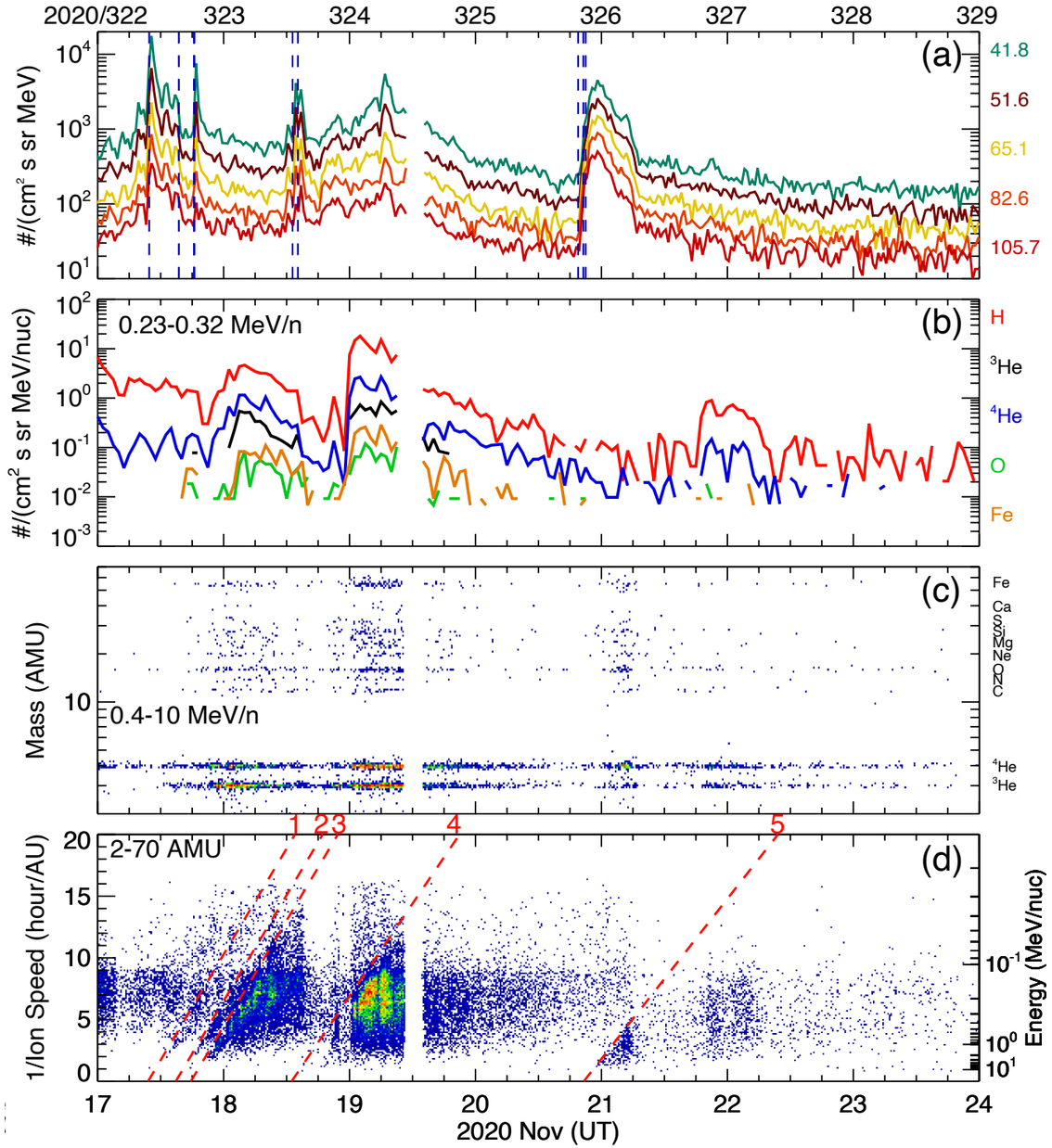


(Wang et al. ApJ 2006)

Solar Orbiter Impulsive SEP event 2020 Nov 17 (#3)







0.2-2.0 MeV/nuc

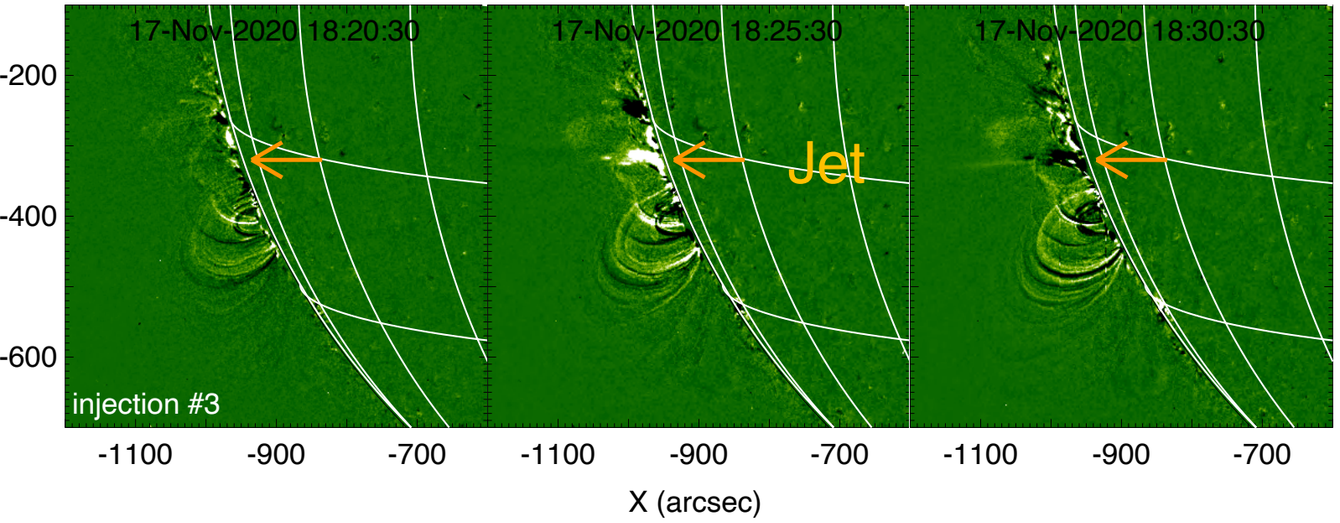
3He/4He=0.90±0.03

Fe/O =0.91±0.01

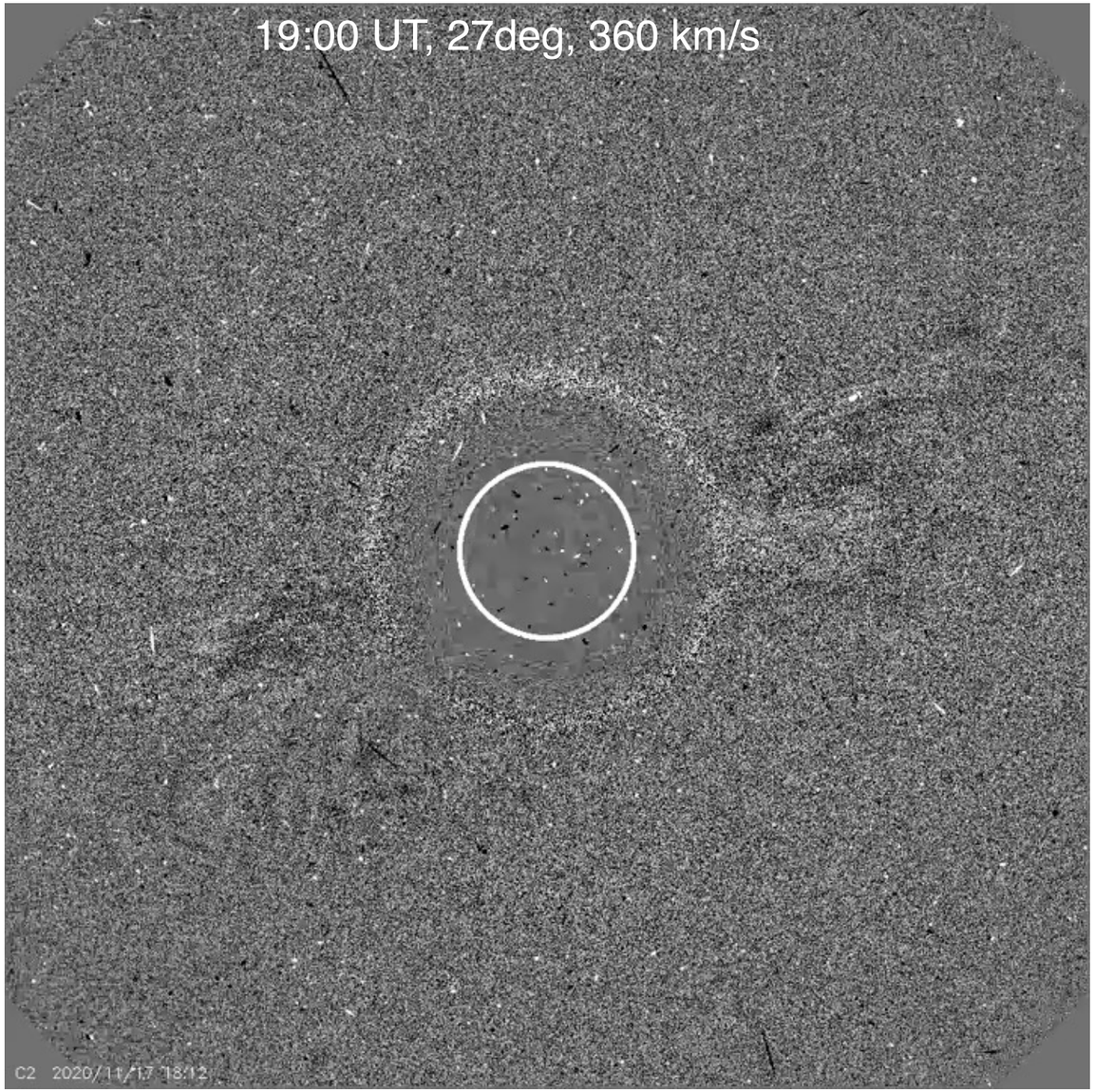
SolO at 0.93 au

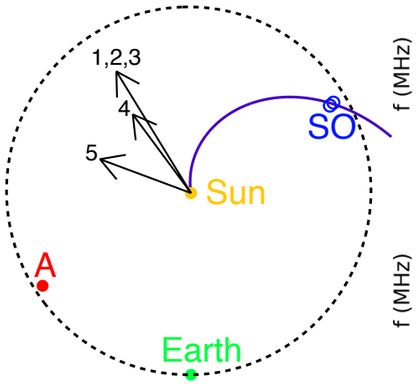
(Bucik et al. A&A 2021)

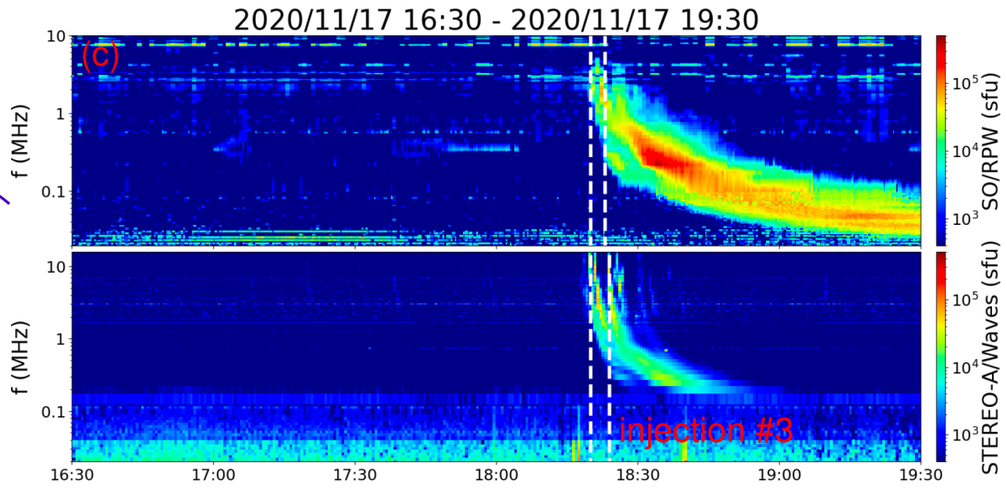
STEREO-A at type III time 18:20 UT



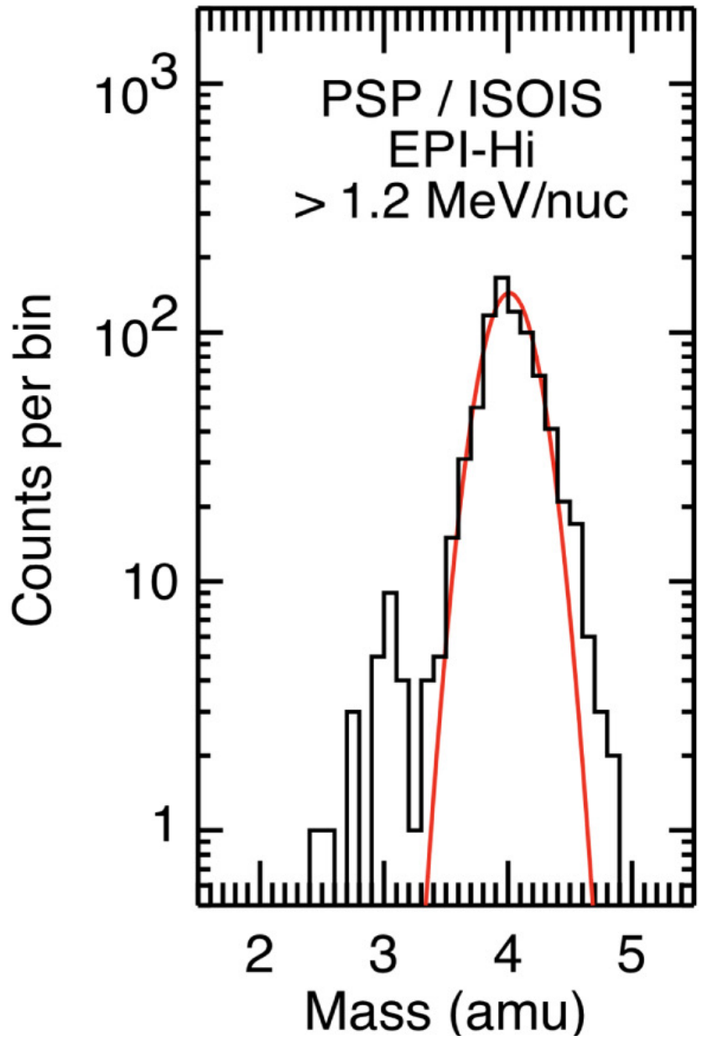
SOHO/LASCO C2





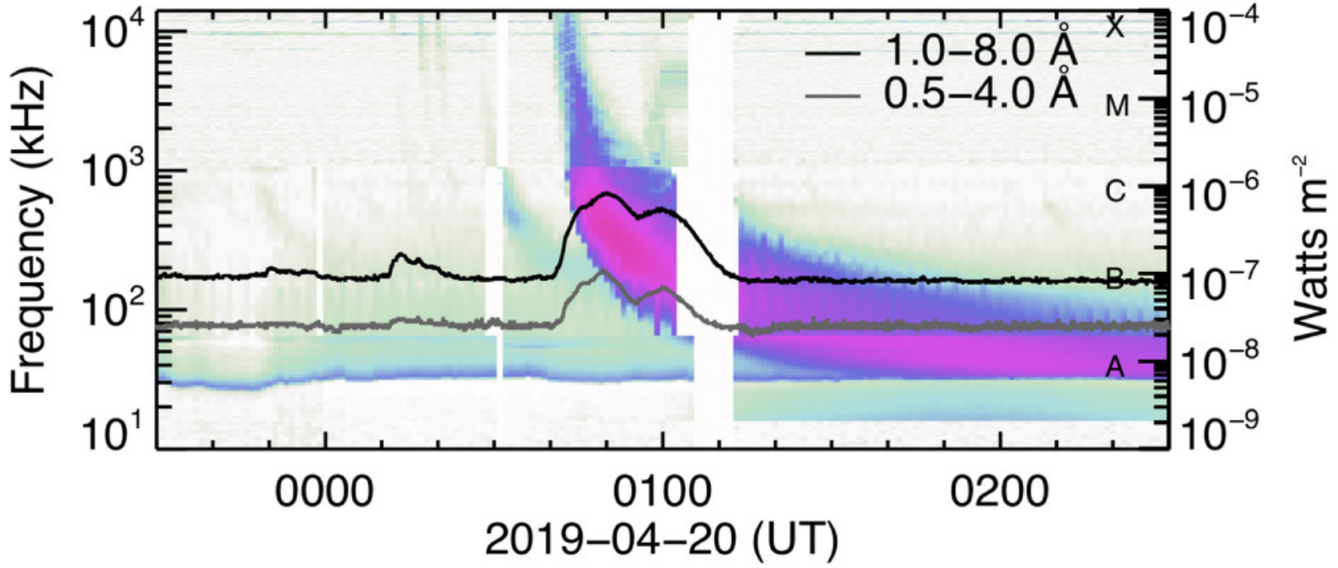


PSP Impulsive SEP event 2019 Apr 20



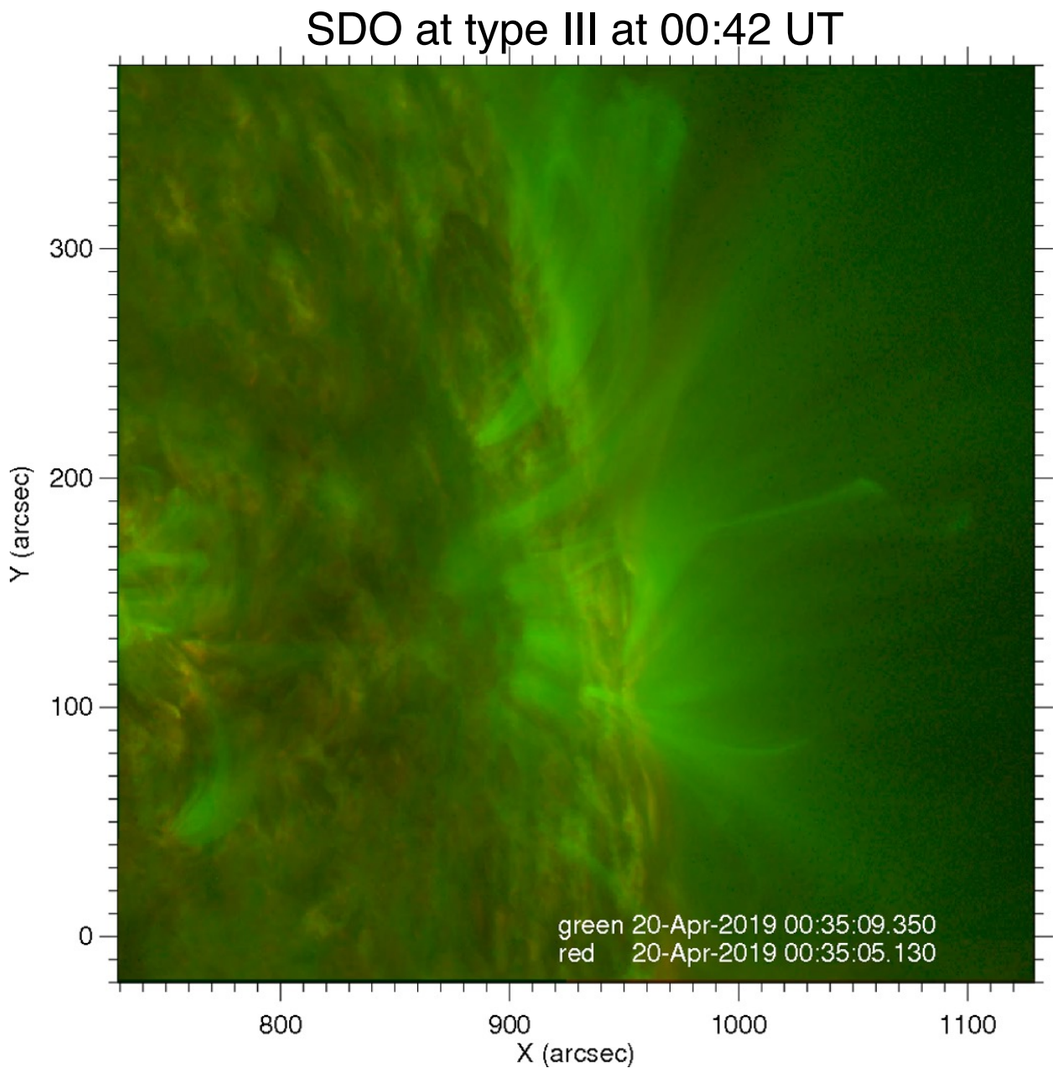
1.35-1.75 MeV/nuc
3He/4He=0.063±0.016

PSP at 0.46 au



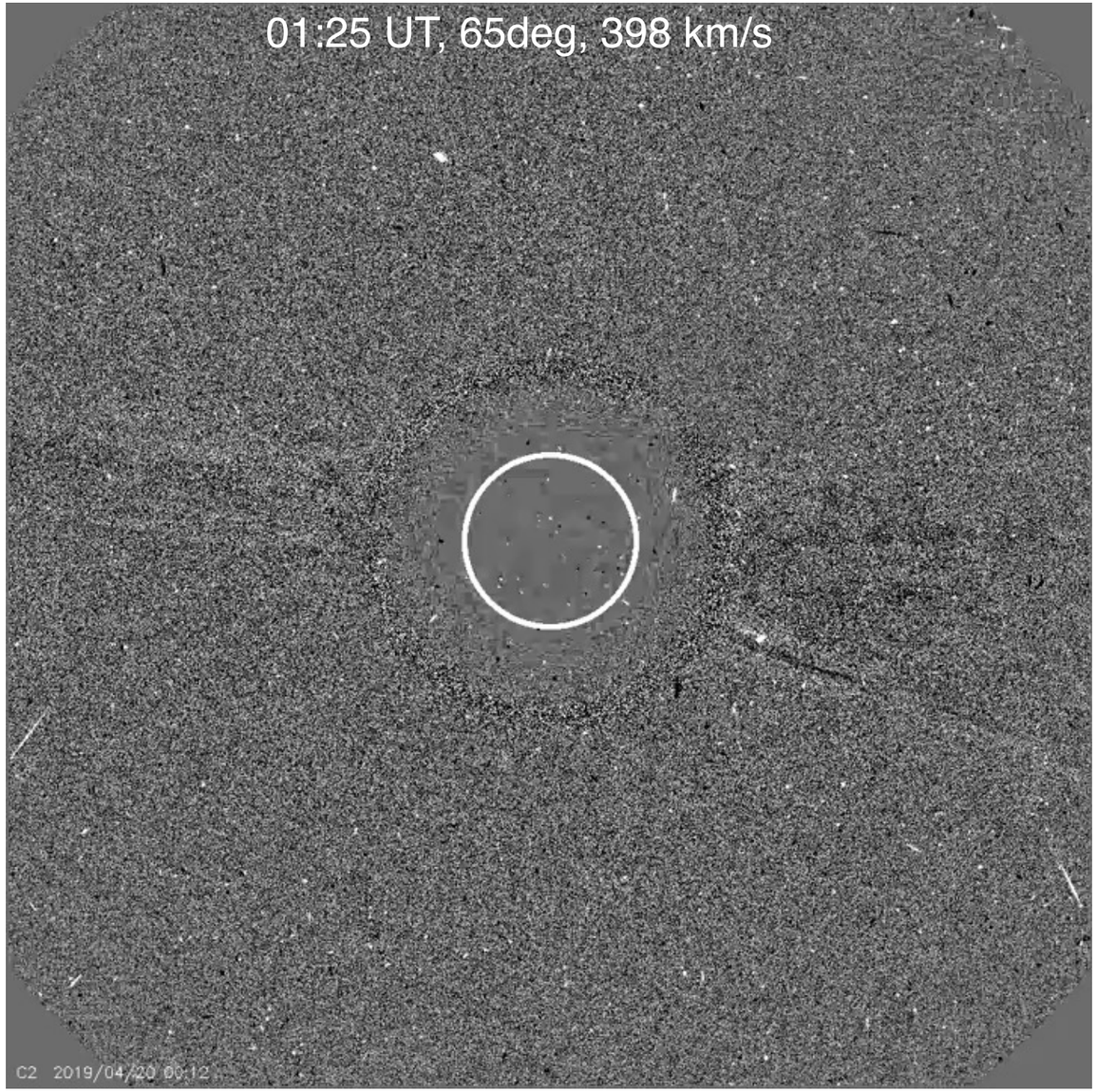
(Wiedenbeck et al. ApJS 2020)

PSP Impulsive SEP event 2019 Apr 20

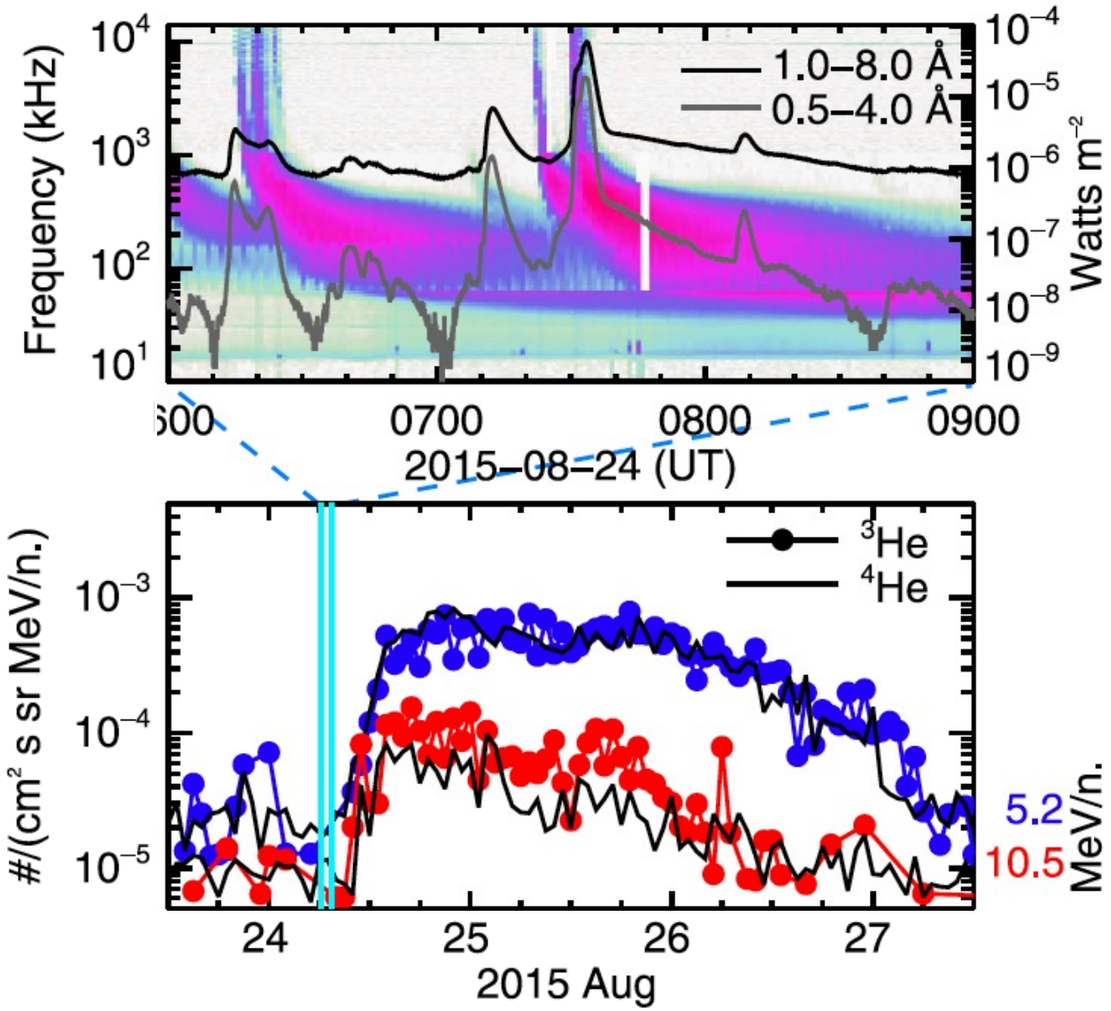


(Wiedenbeck et al. ApJS 2020)

SOHO/LASCO C2



ACE Impulsive SEP event 2015 Aug 24



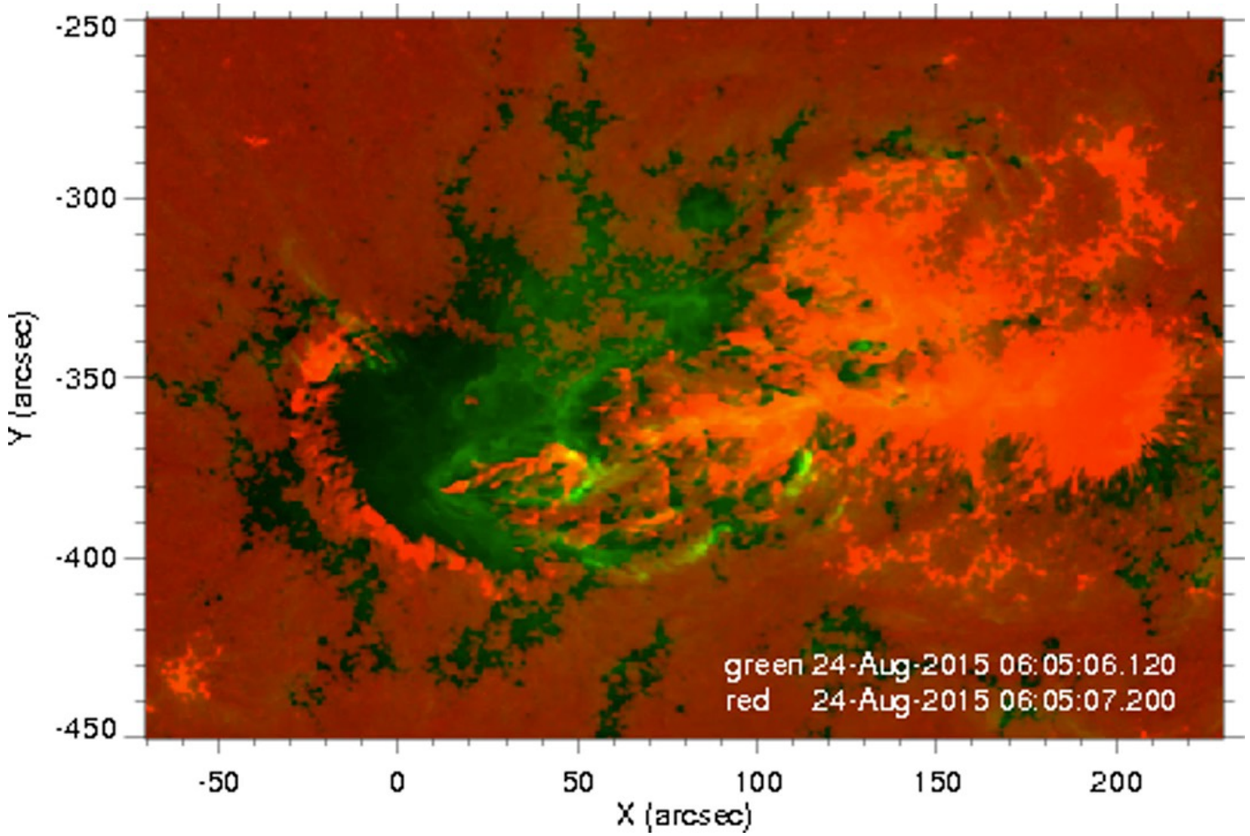
(Bucik et al. ApJL 2018)

The most intense high-energy 3He-rich SEP (3He/4He >1 at 10 MeV/nuc) event in the solar cycle 24.

	10.5 MeV/nuc
3He/4He	=1.61±0.08
Fe/O	=1.16±0.74

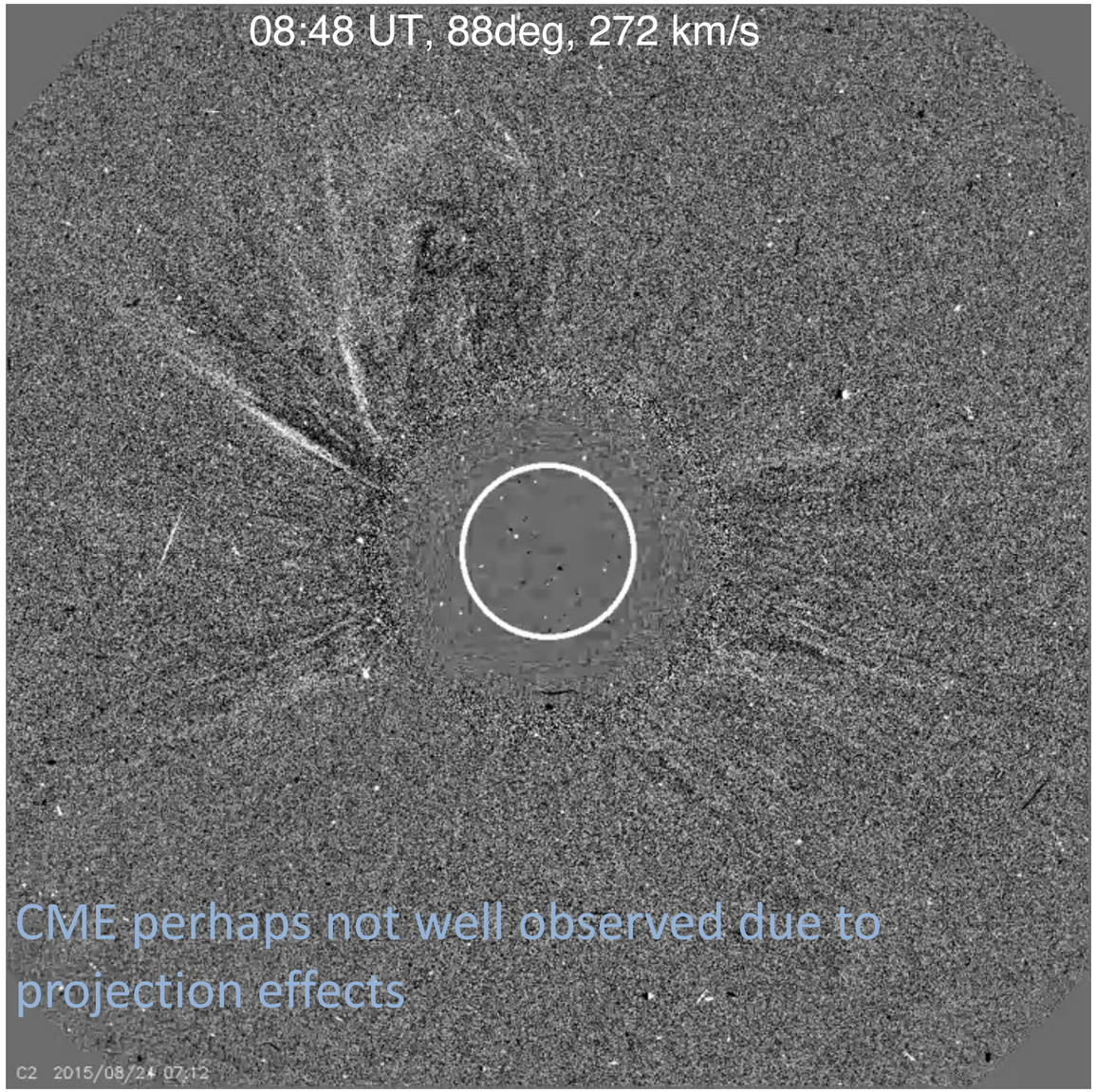
ACE Impulsive SEP event 2015 Aug 24

SDO during 4 type III bursts; only one at 07:30 UT has CME



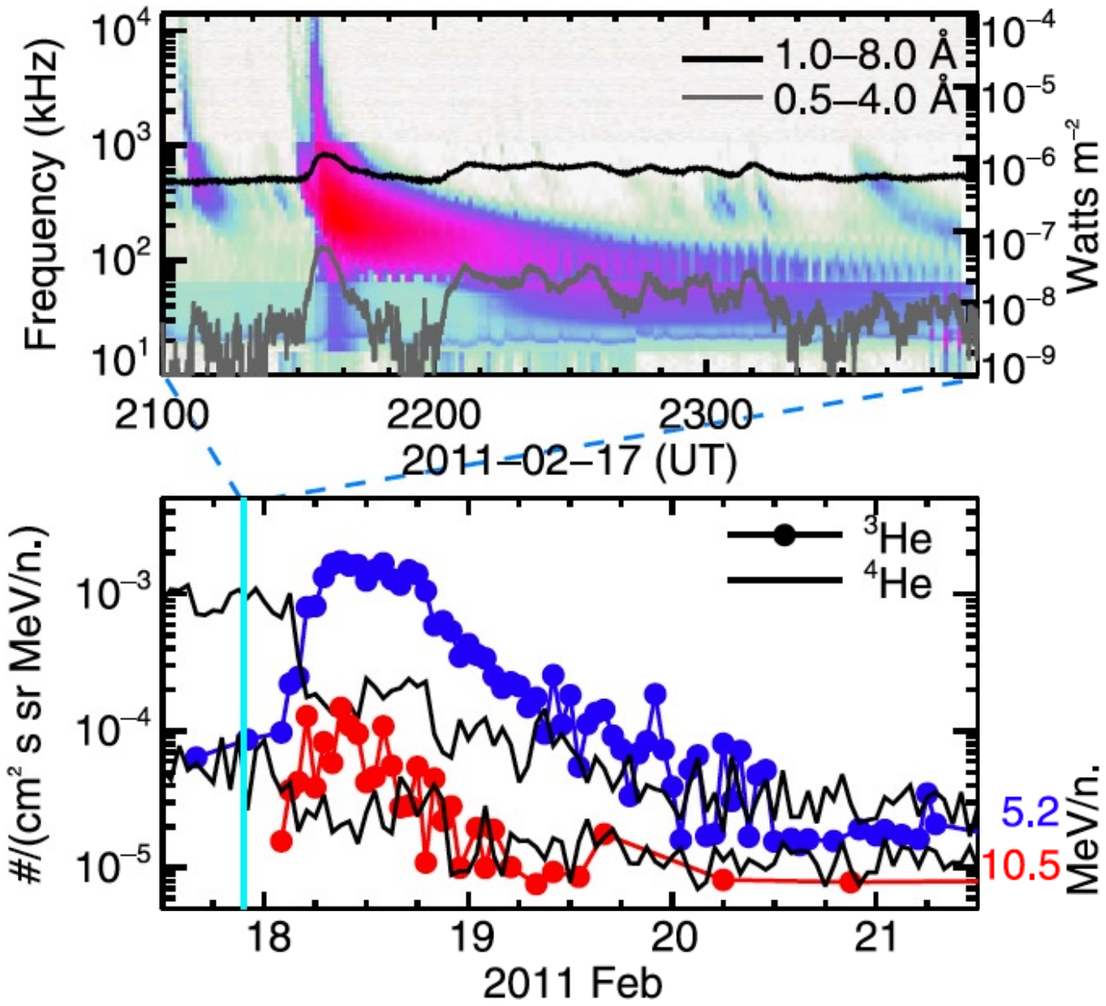
- sunspot with the most complex βγδ magnetic configuration
- among 10 largest sunspots in previous solar cycle

SOHO/LASCO C2



CME perhaps not well observed due to projection effects

ACE Impulsive SEP event 2011 Feb 18



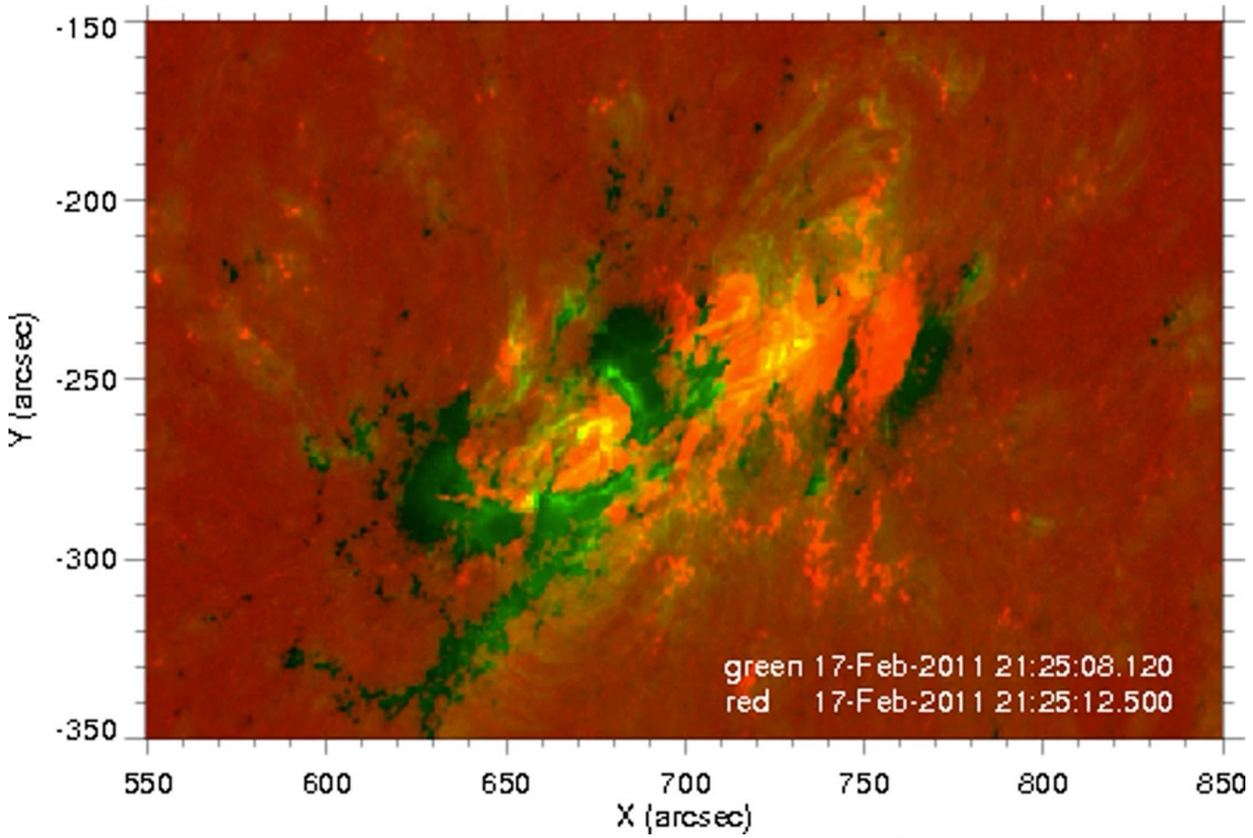
The high-energy 3He-rich SEP (3He/4He >1 at 10 MeV/nuc) event with the highest 3He enrichment in the solar cycle 24.

10.5 MeV/nuc
3He/4He =2.33±0.20
Fe/O =1.46±0.13

(Bucik et al. ApJL 2018)

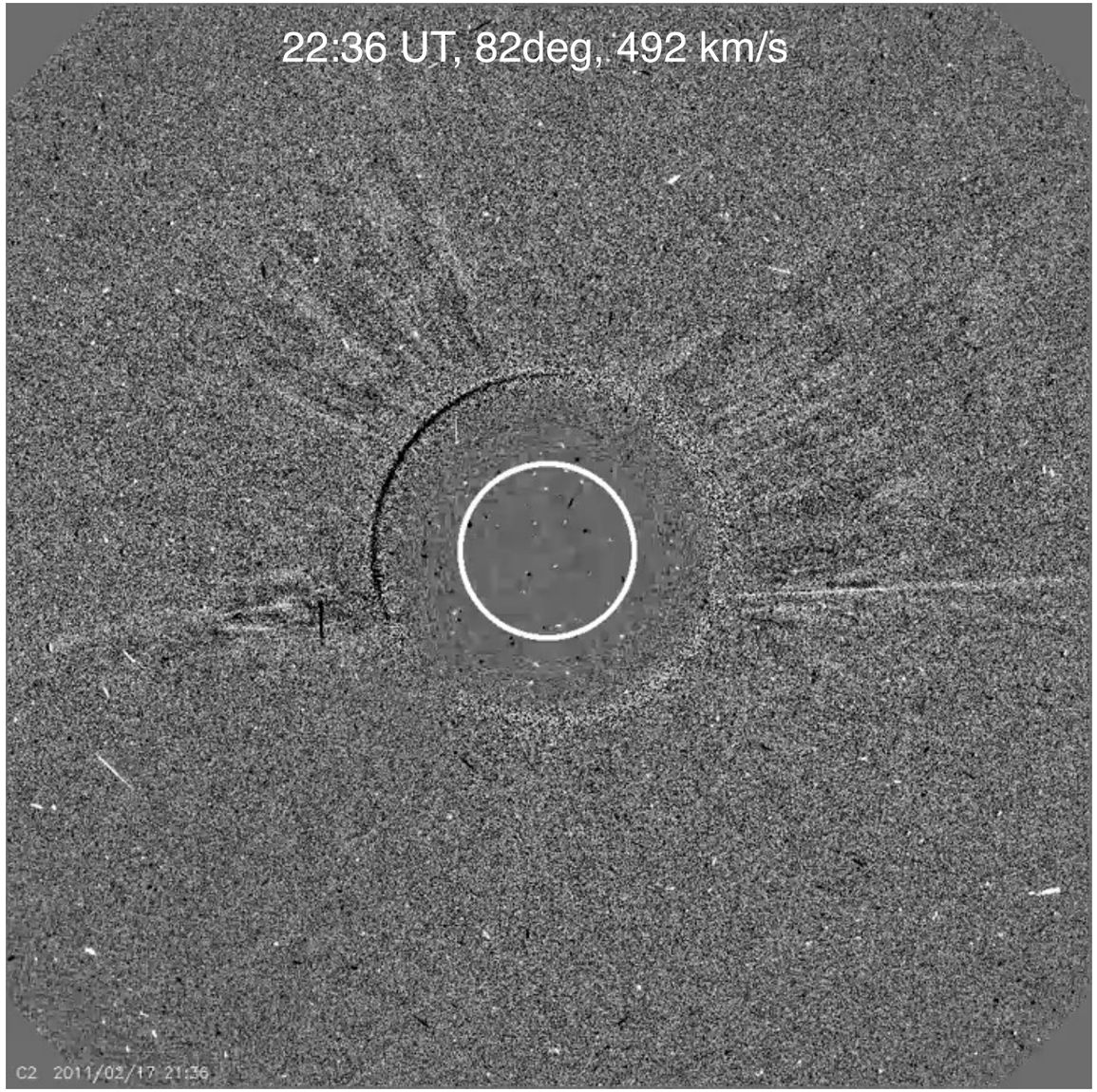
ACE Impulsive SEP event 2011 Feb 18

SDO at type III at 21:33 UT



- sunspot with the most complex βγδ magnetic configuration

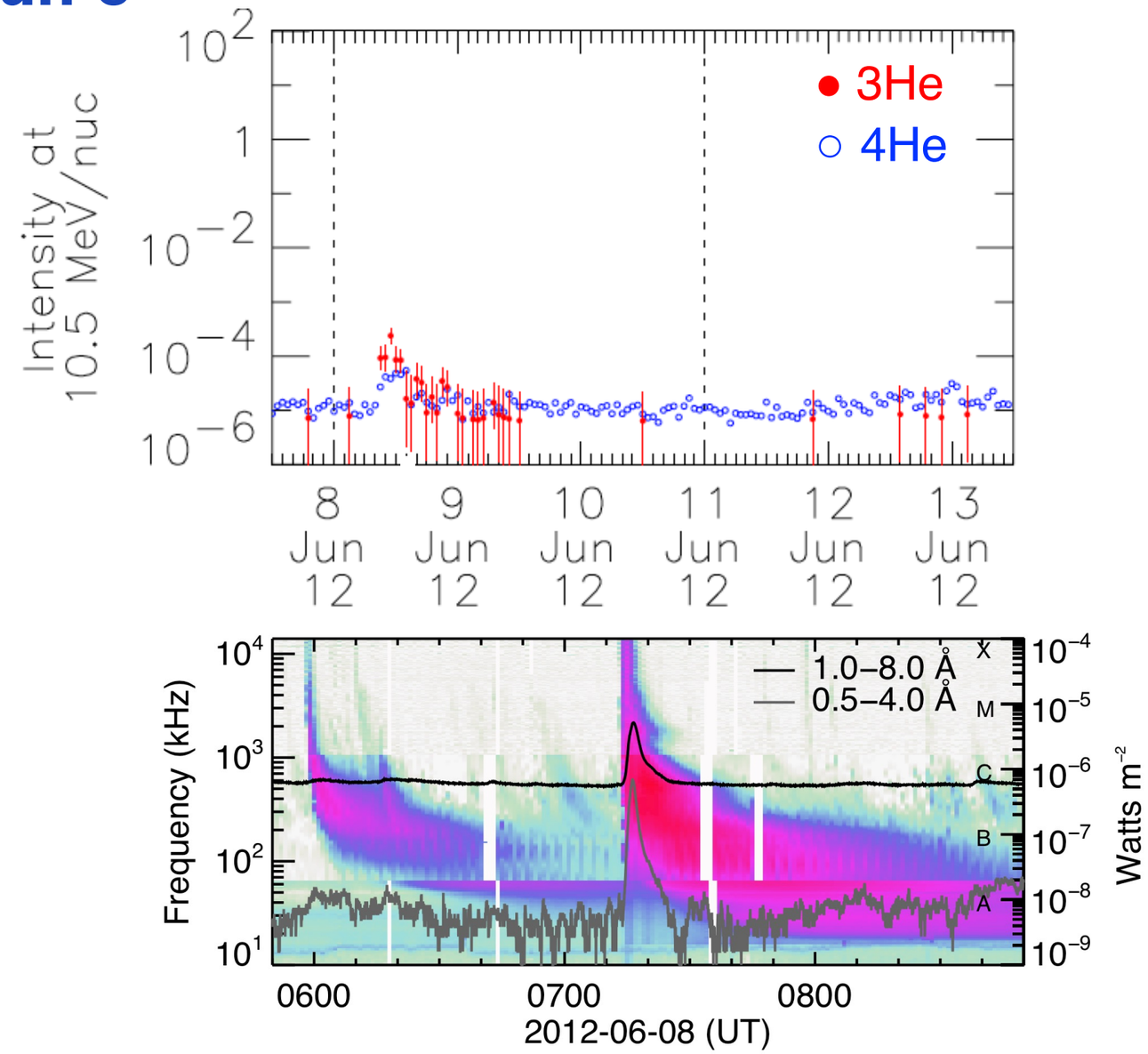
SOHO/LASCO C2



ACE Impulsive SEP event 2012 Jun 8

0.320-0.453 MeV/nuc
3He/4He =0.38±0.04 (2.18±0.23 10.5 MeV/n)
Fe/O =2.00±0.33

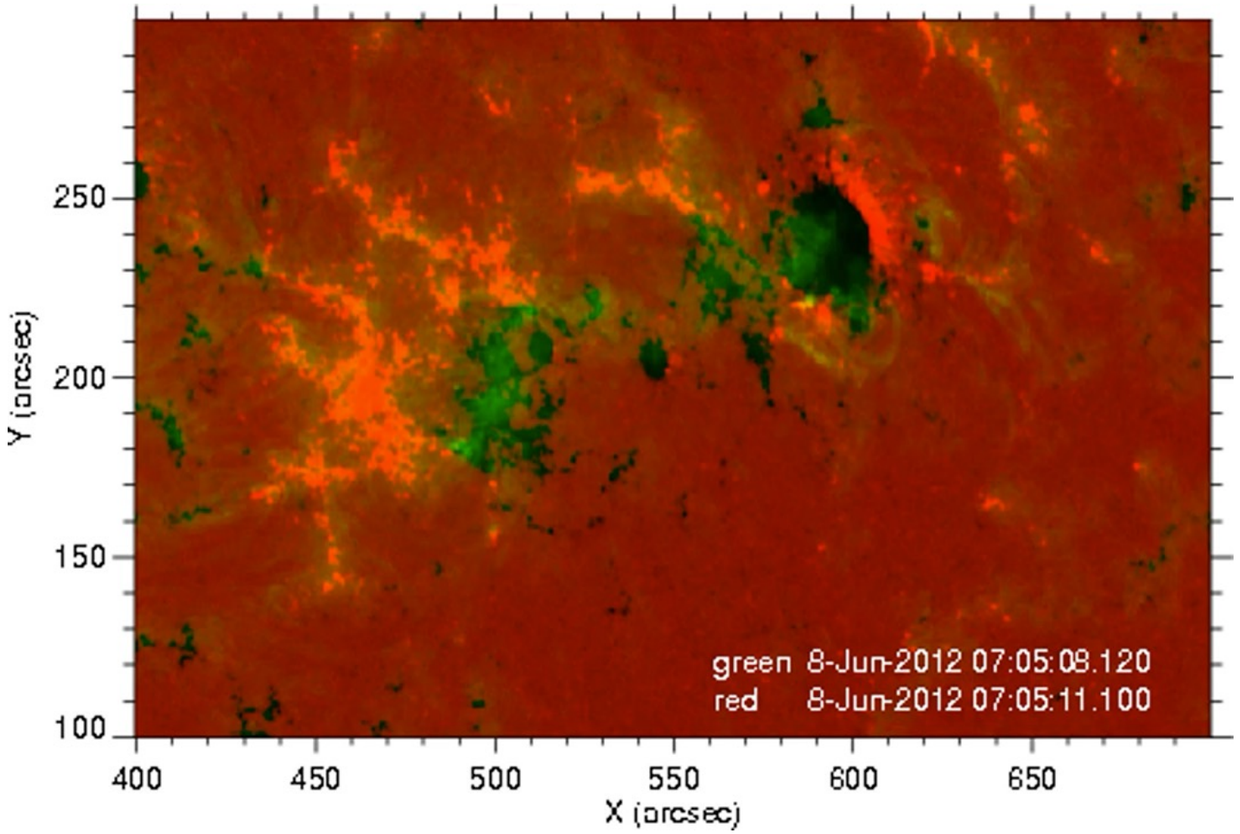
10.5 MeV/nuc
3He/4He =2.18±0.23



Provided Mark Wiedenbeck (JPL/Caltech)

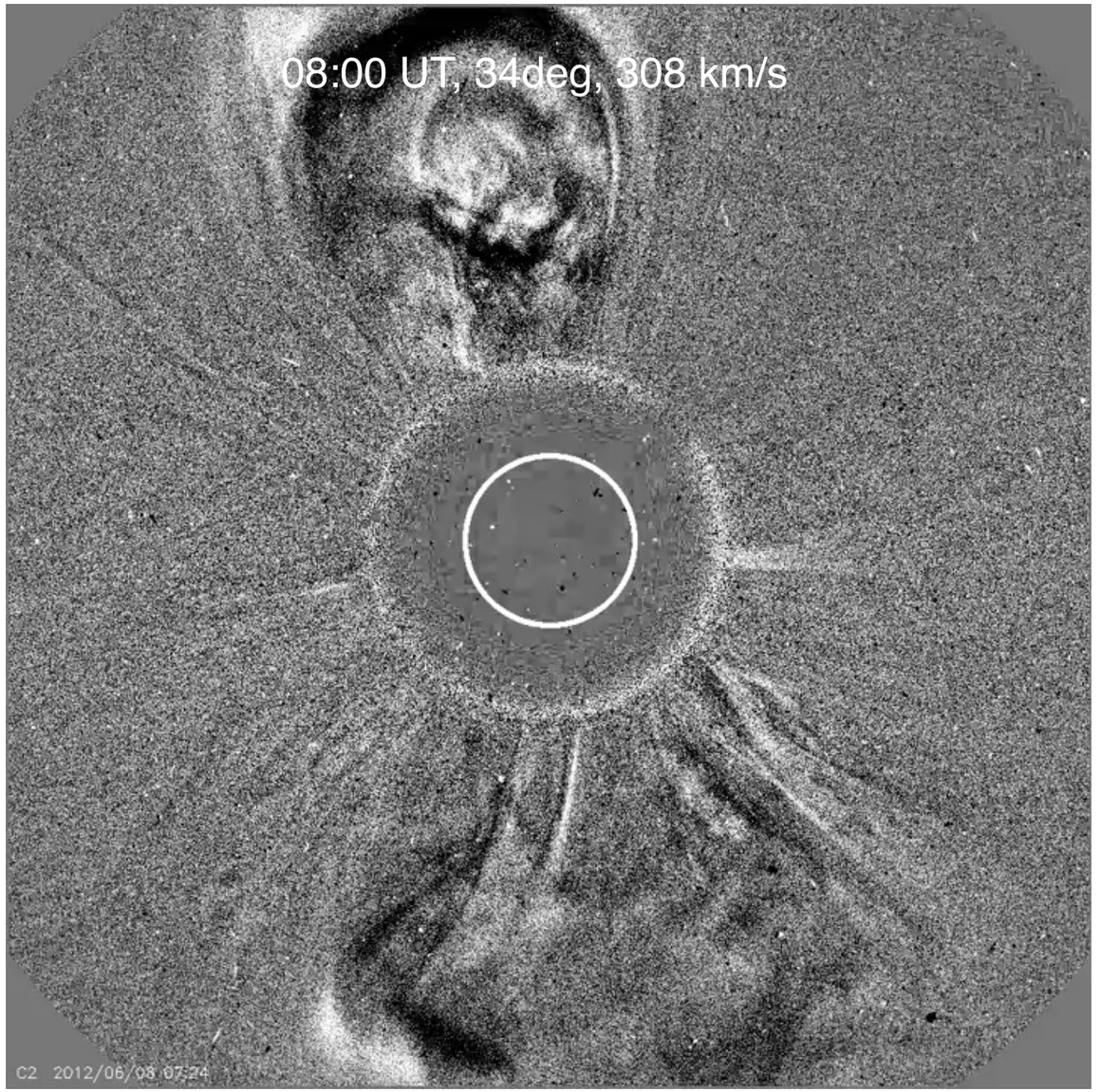
ACE Impulsive SEP event 2012 Jun 8

SDO at type III at 07:13 UT



(Bucik et al. ApJ 2021)

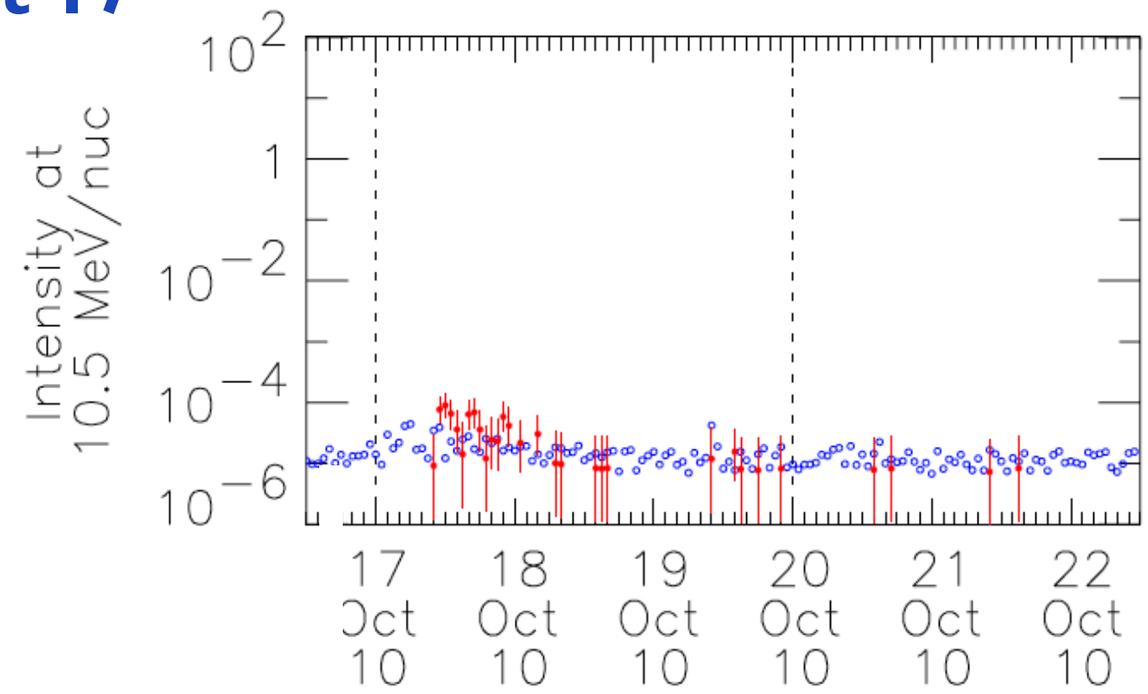
SOHO/LASCO C2

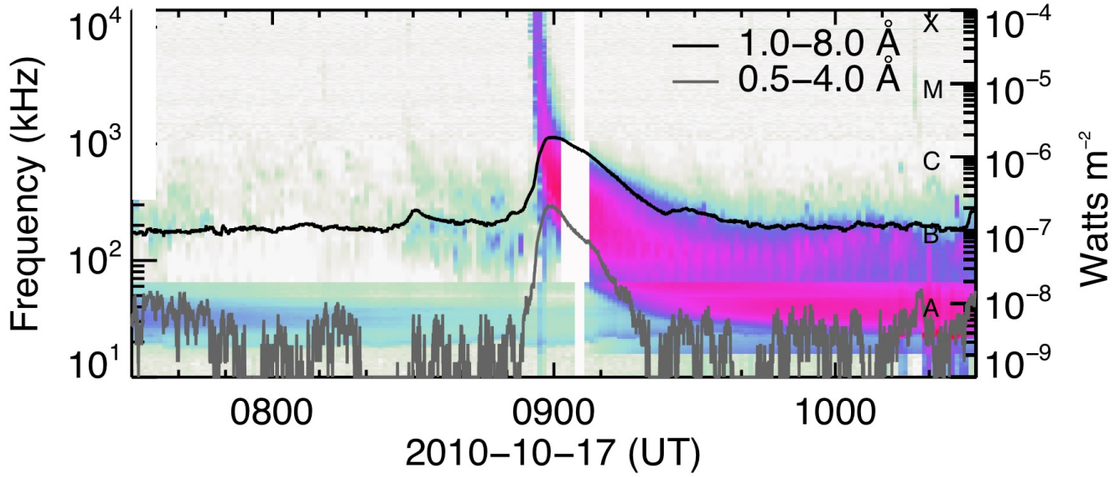


ACE Impulsive SEP event 2011 Oct 17

0.320-0.453 MeV/nuc
3He/4He =0.38±0.04
Fe/O =2.00±0.33

10.5 MeV/nuc
3He/4He =1.75±0.20

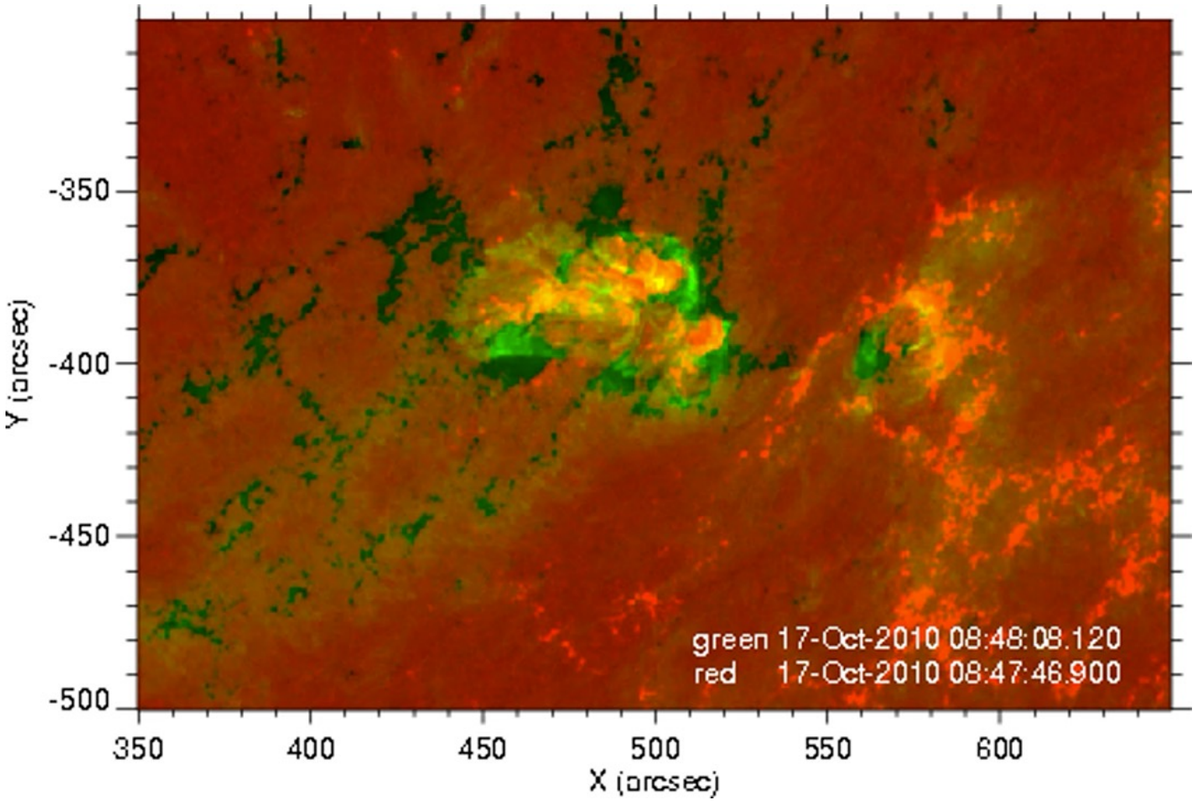




Provided Mark Wiedenbeck (JPL/Caltech)

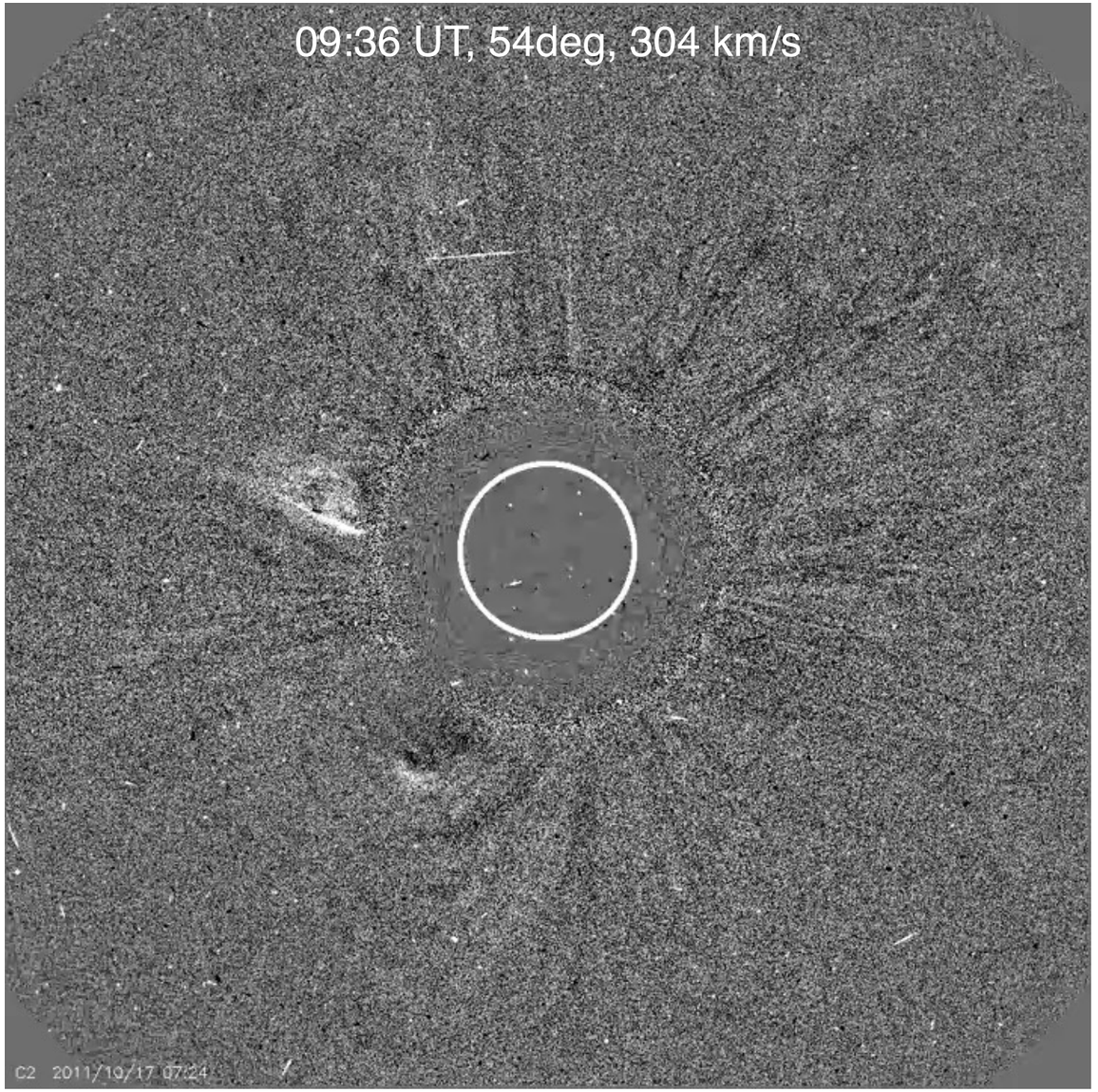
ACE Impulsive SEP event 2011 Oct 17

SDO at type III at 08:55 UT; no EUV jet



(Bucik et al. ApJ 2021)

SOHO/LASCO C2



Conclusion

- There are many papers on solar sources of impulsive SEPs using solar disc EUV observations, but there are practically **no studies using observations of the corona to examine CMEs associated with these events**

- This should be changed with a wealth of existing data from past missions and data from forthcoming missions to understand impulsive SEPs

- Median CME width and speed from 6 strong presented events is ~60deg and 330 km/s, respectively

- How do CMEs in impulsive SEP events affect the elemental composition and energy spectra of these events?

- Do CMEs cause wide azimuthal distribution observed in some impulsive events?