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On the role of coronal shocks for accelerating solar energetic electrons

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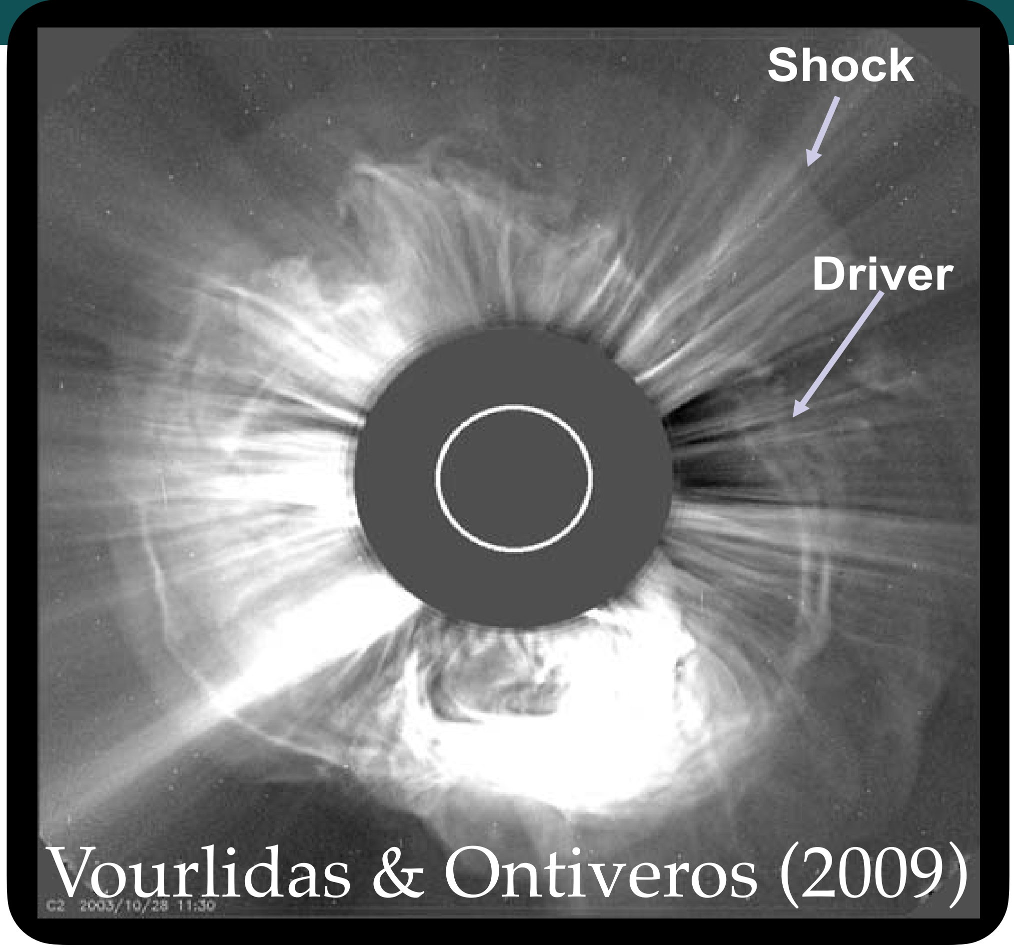
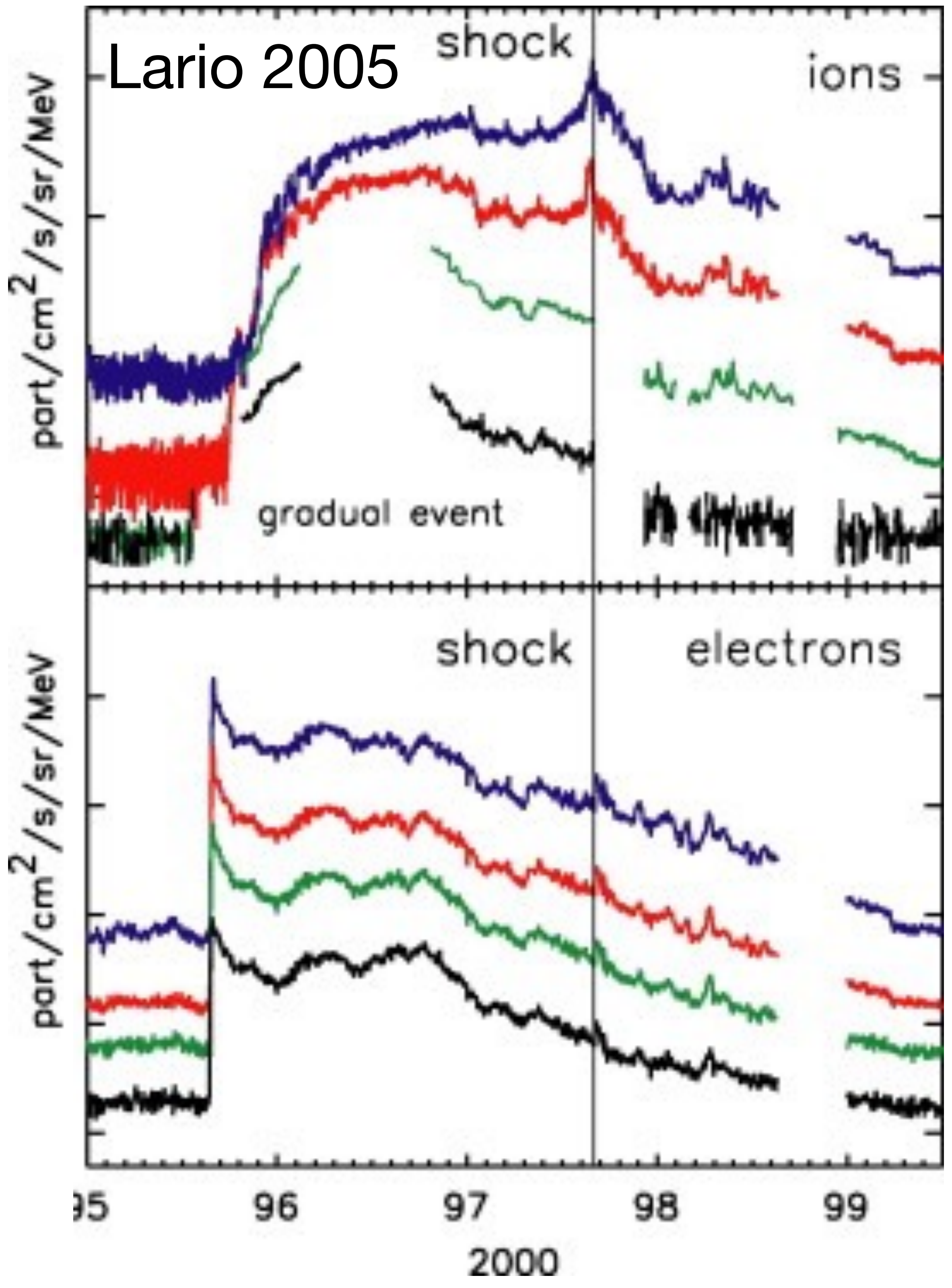
WHAT IS THE ROLE OF (CME-DRIVEN) SHOCKS FOR SOLAR ENERGETIC ELECTRON EVENTS?



The role of (coronal) CME-driven shocks for solar energetic **(≳100 keV) electrons** is still debated

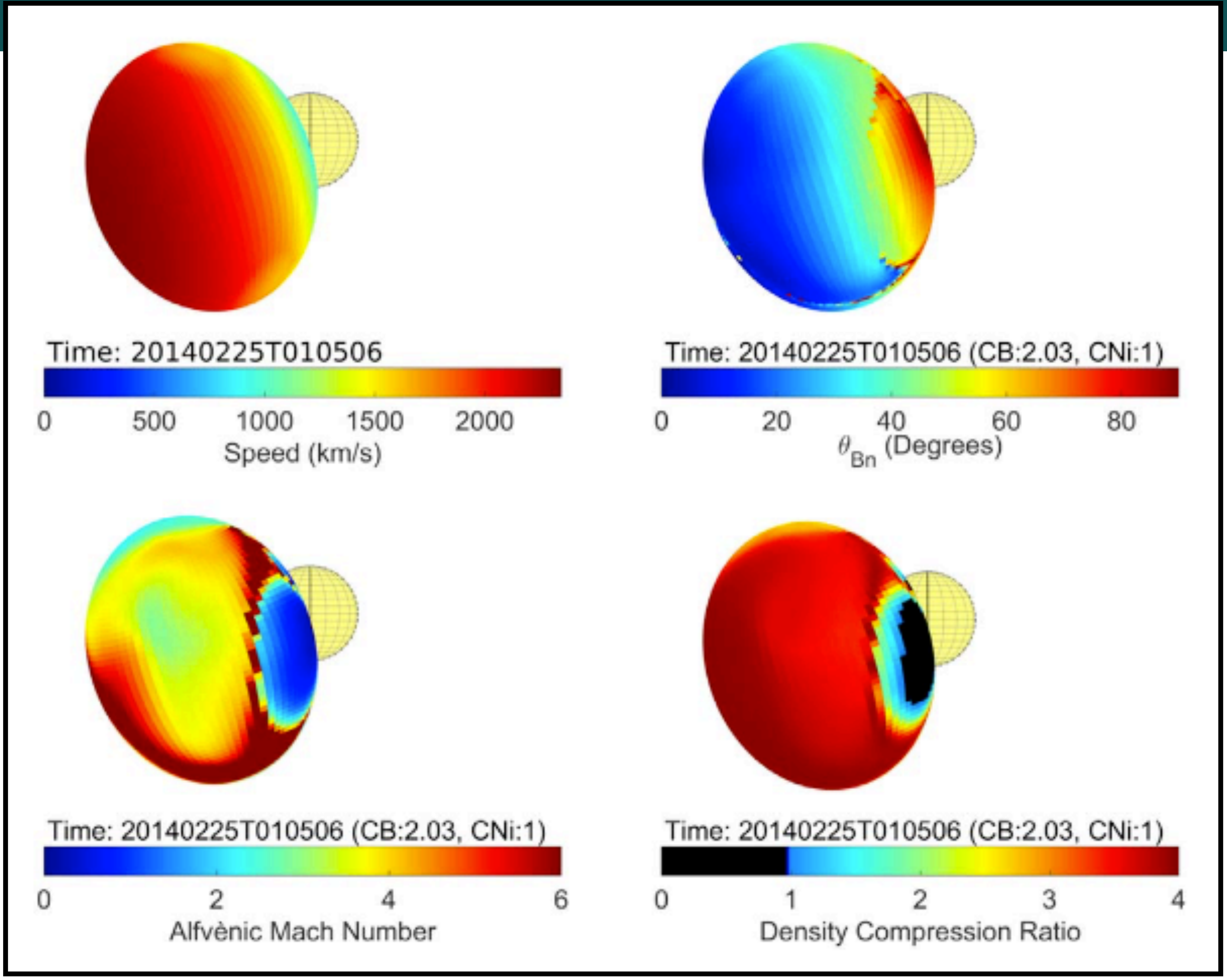
- ✦ Radio type II bursts prove the acceleration of electrons **of a few keV**
- ✦ **shocks at 1 AU are largely ineffective in accelerating ~100 keV electrons** (Tsurutani & Lin 1985, Lario et al. 2003, Dresing et al. 2016, Yang et al. 2019)
- ✦ **Only rare cases of interplanetary shock spikes** at higher energies observed: E.g., Ulysses (Simnett 2003), Voyager (Sarris & Krimigis 1985), PSP (Mitchell et al. 2021)
- ✦ Shock acceleration modeling (e.g. Guo & Giacalone, 2015, Trotta & Burgess, 2019) suggests that ≳ **100 keV can only be reached under special conditions** (e.g., high Mach-number shock, large amplitude magnetic fluctuations)



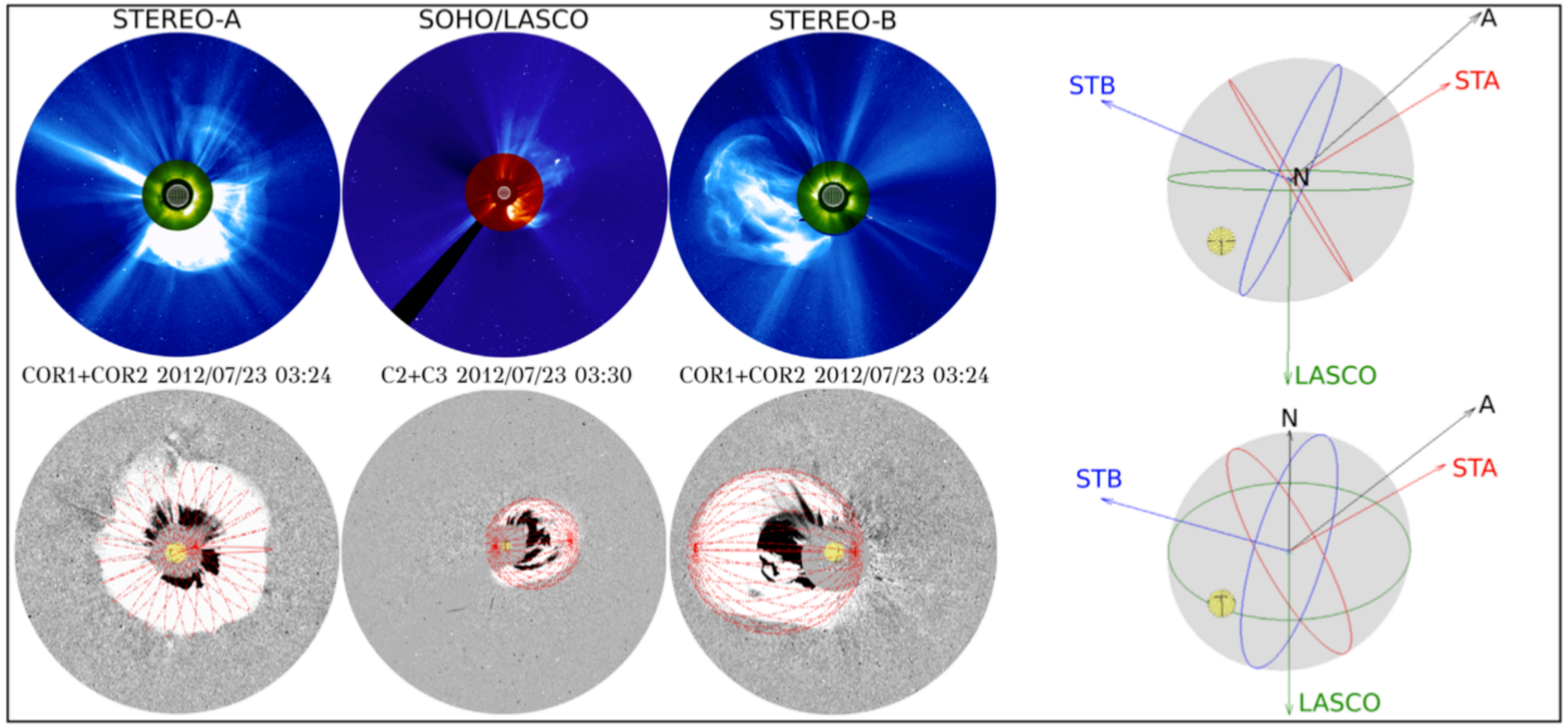
➤ How about the role of the shock close to the Sun?

GLOBAL SHOCK MODELING

- 3D structure of the shock wave is triangulated from images taken by STEREO and the SOHO (Rouillard et al. 2016)
- Global 3D MHD coronal model (PSI/MAST model; Lionello et al. 2009; Riley et al. 2011) is used to obtain the 3D distribution of basic shock parameters (e.g., Mach numbers, compression ratios, ΘBn) along the shock front
- **This allows to infer the corresponding shock parameter at the magnetic connection point of each spacecraft**



Kouloumvakos et al., 2019



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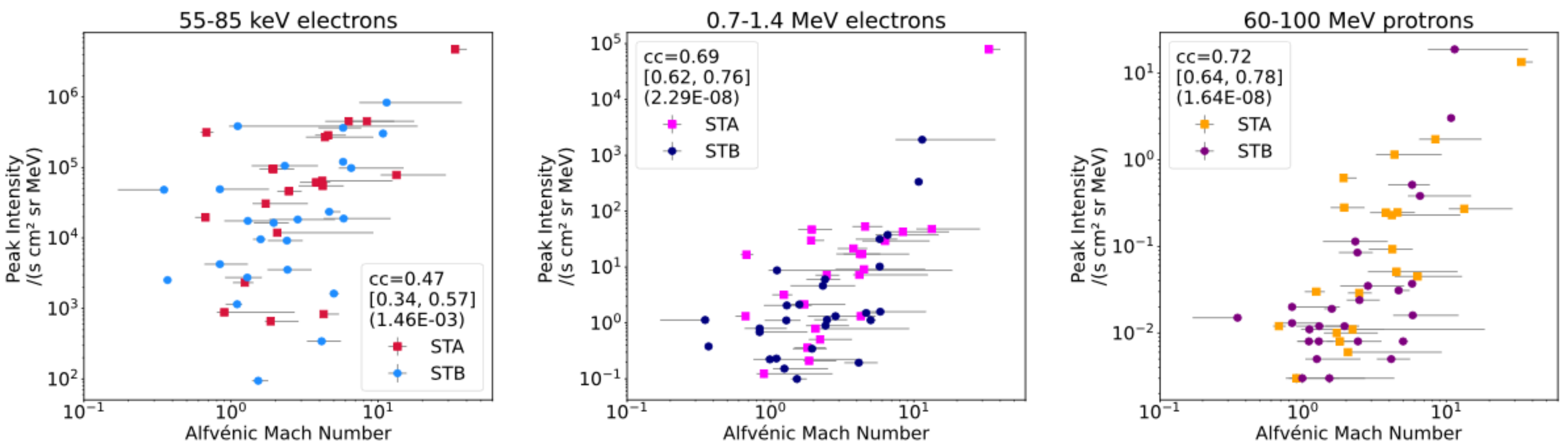
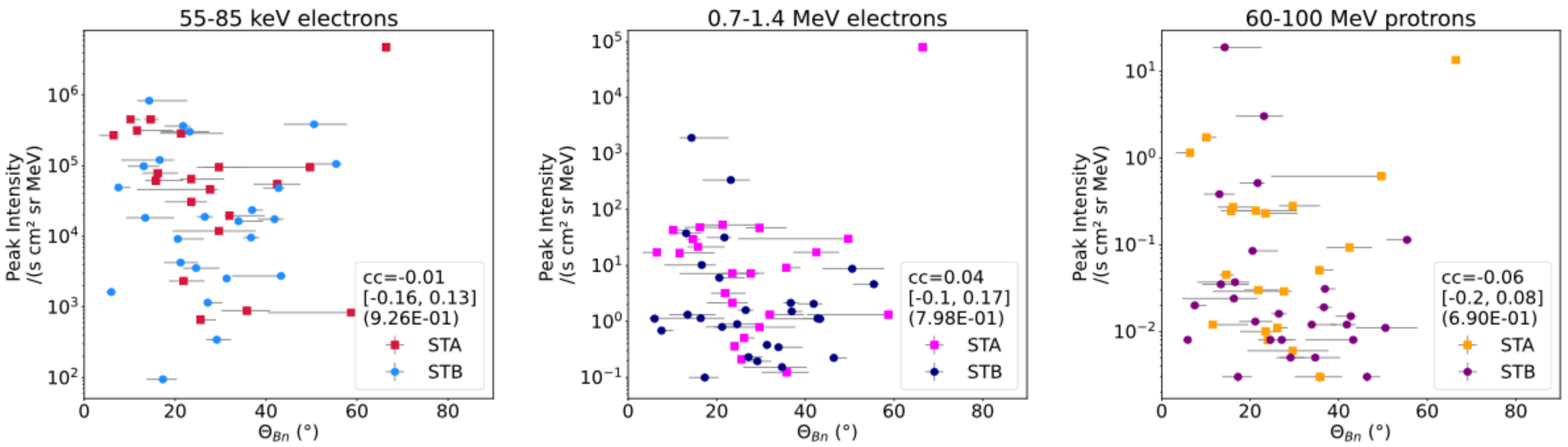
CORRELATING ELECTRONS WITH SHOCK PARAMETERS

- Strong correlation with the Alfvénic Mach number for MeV electrons and protons
- Weaker correlation with <100 keV electrons
- No clear difference between MeV electrons and protons



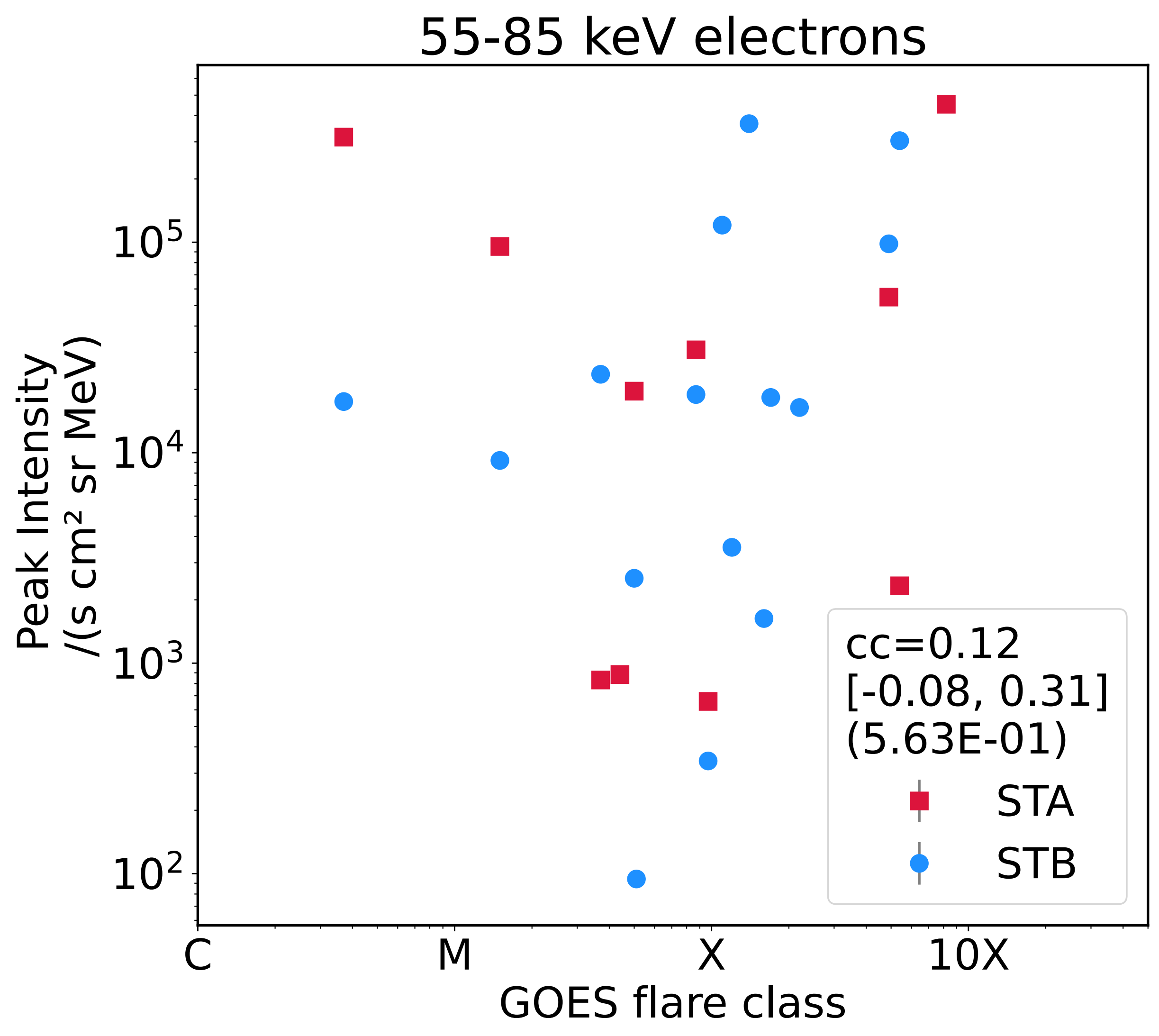
- No correlation with shock geometry (Θ_{Bn})
- No clear difference between electrons and protons

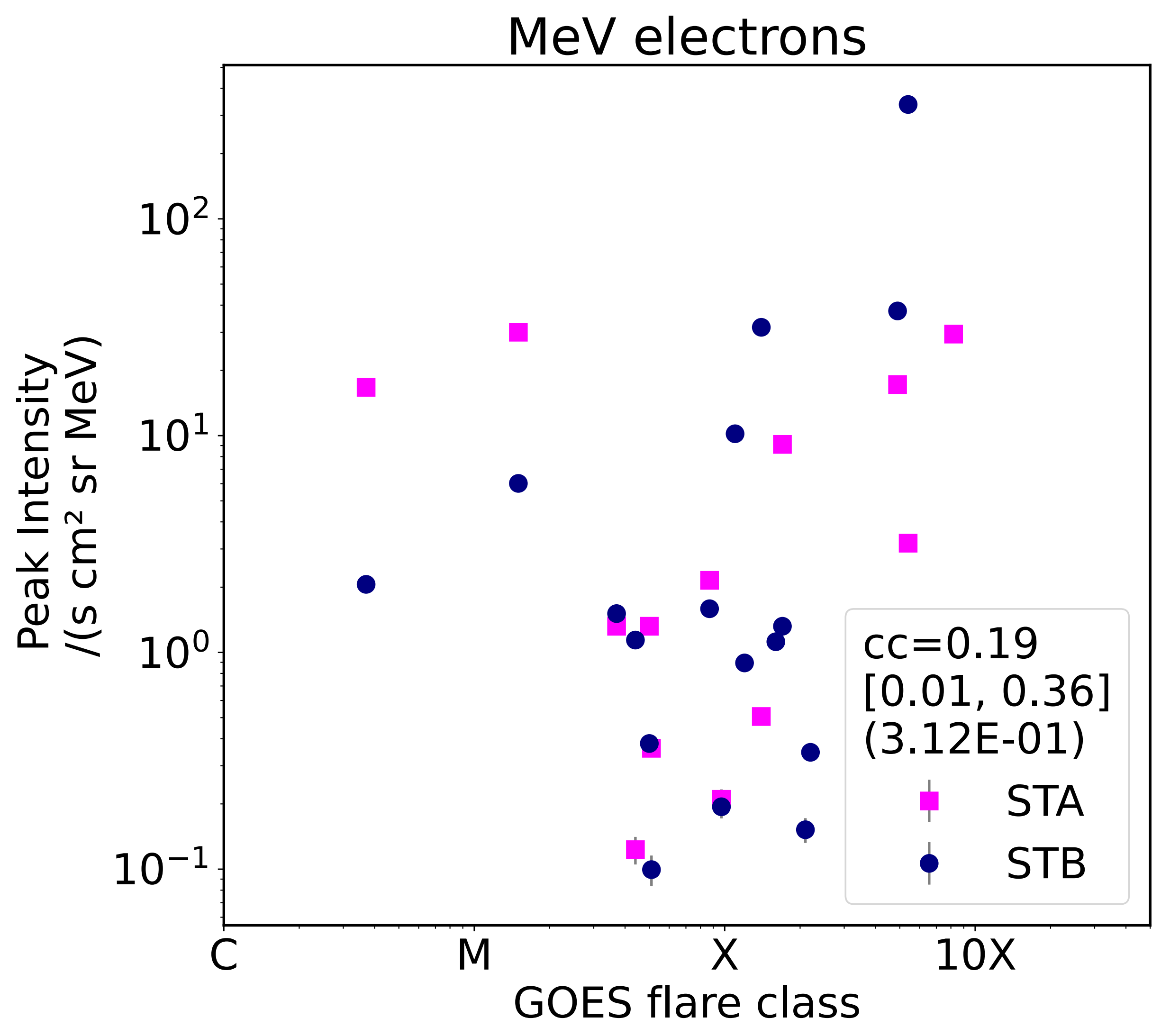


TESTING THE RELATION WITH SHOCK – BIG FLARE SYNDROME?

- ➤ Large eruptions often have both, strong flares and fast/wide CMEs
- ➤ Difficult to separate flare and shock contribution

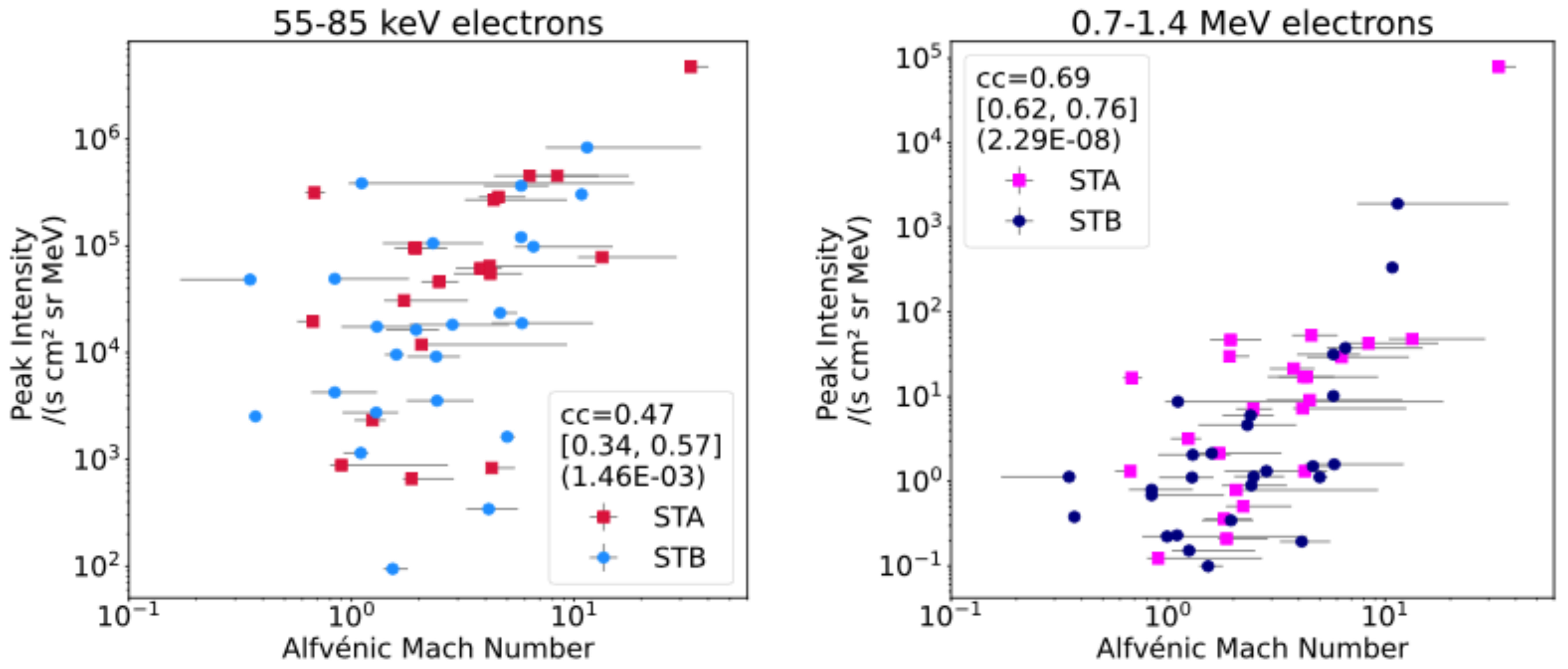
- ➤ However, in our sample the electron peak intensities don't correlate with the flare class





TESTING THE RELATION WITH SHOCK: POSITION OF THE FOOTPOINT MATTERS!

- Correlation of STEREO A (B) peak intensities with shock parameters at the magnetic footpoint of STEREO A (B)



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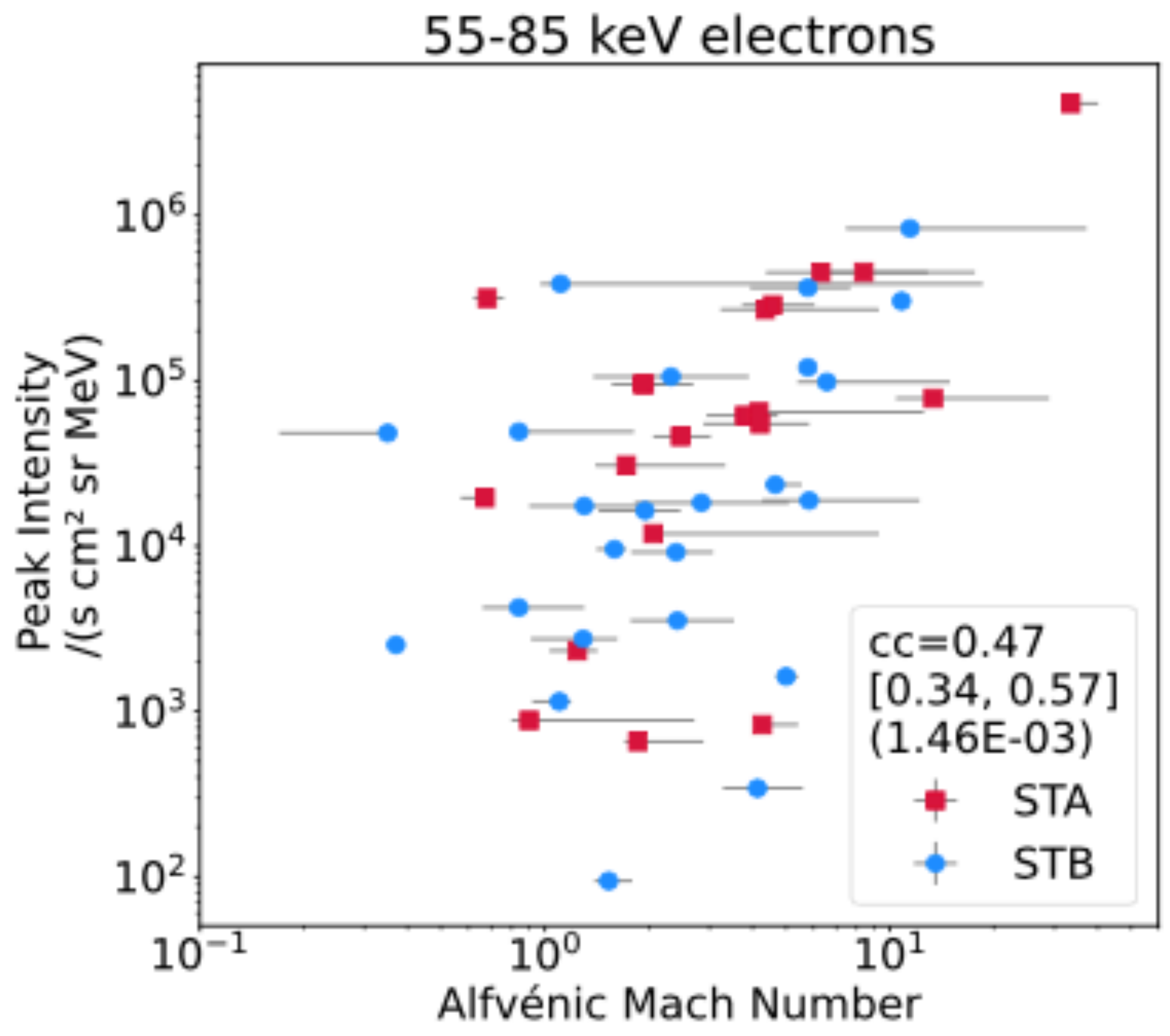
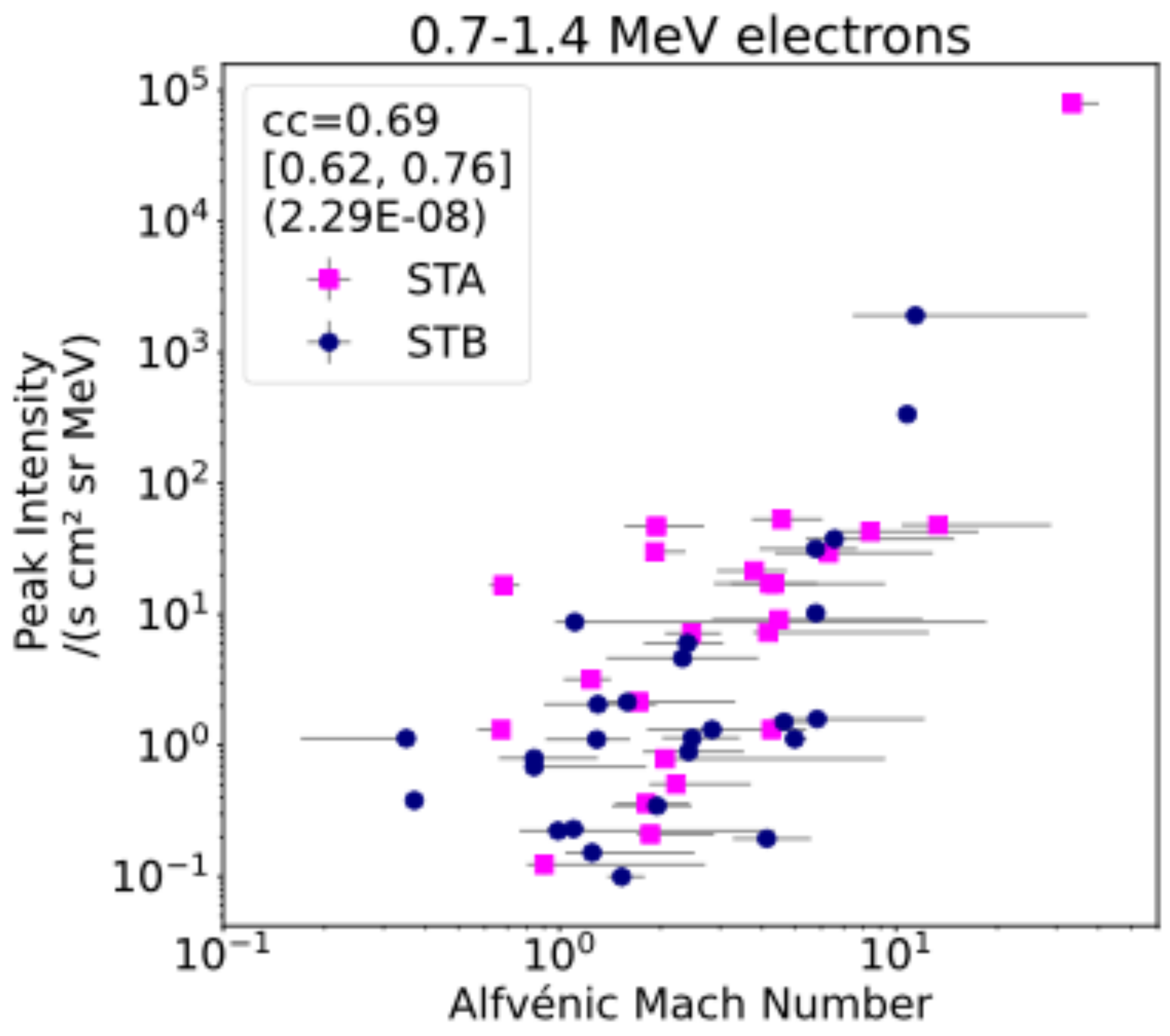
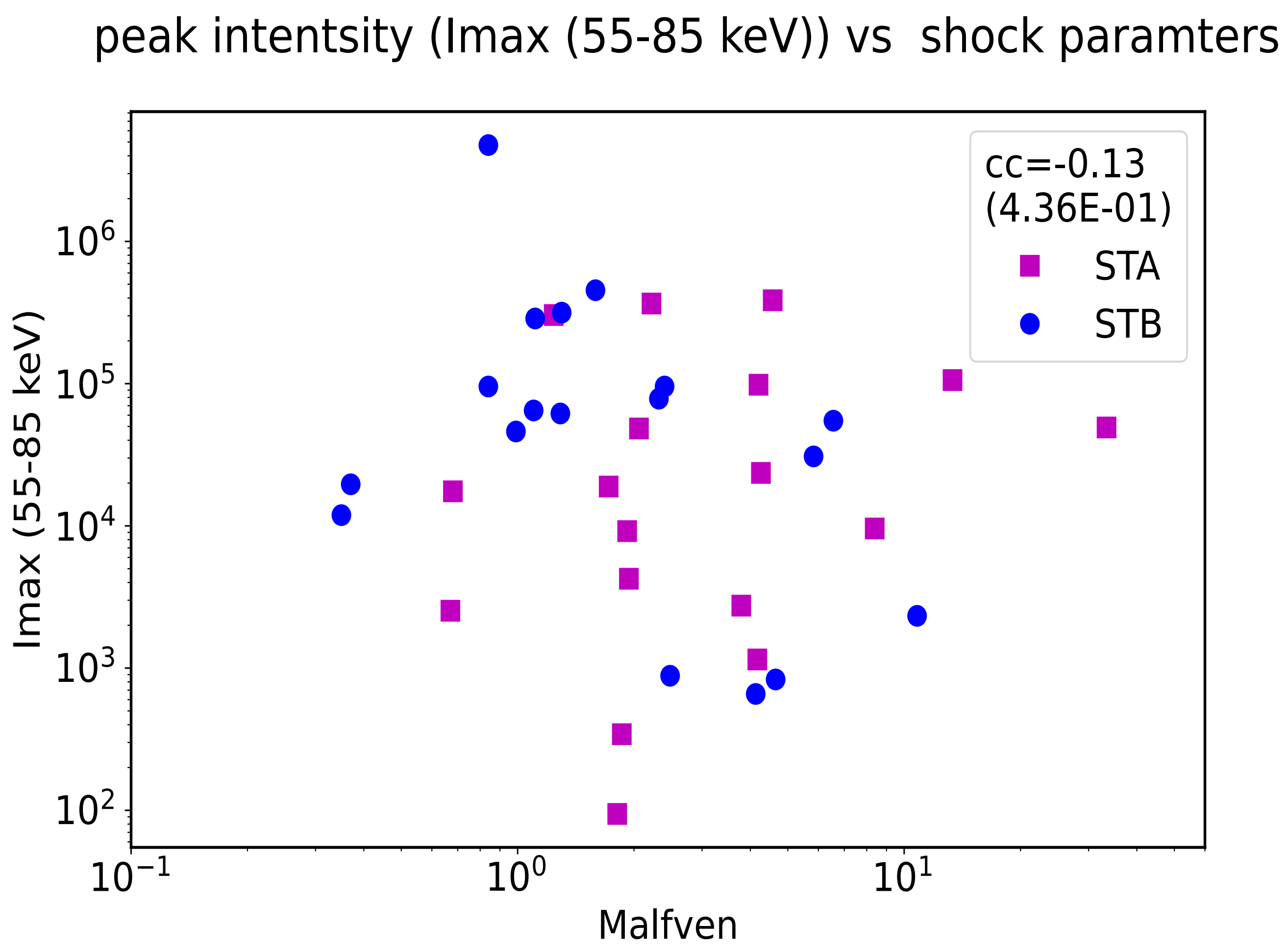
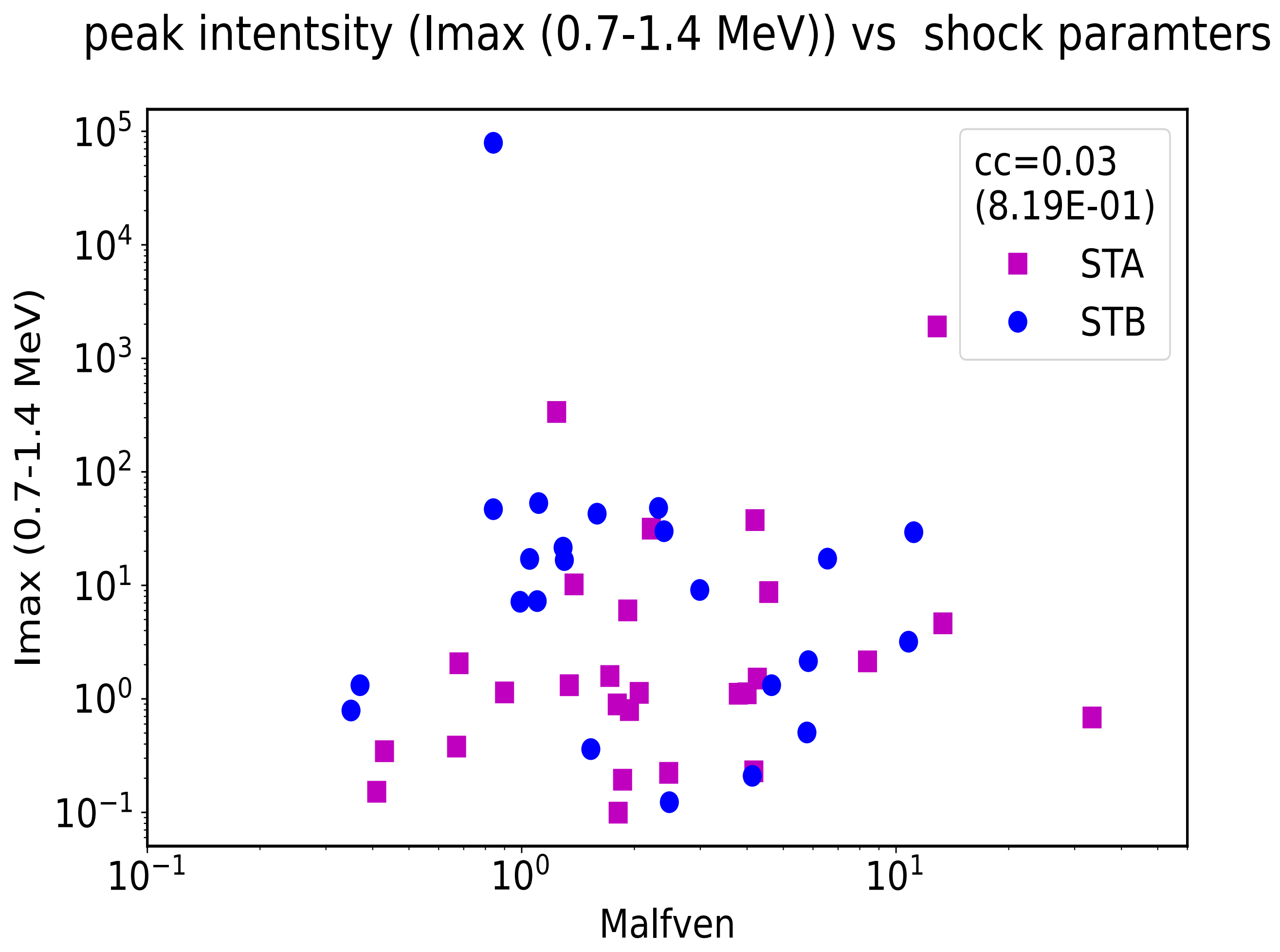




- The correlation disappears if we swap STEREO A and B: correlation of peak intensities of STEREO A (B) with shock parameters at STEREO B (A) footpoint





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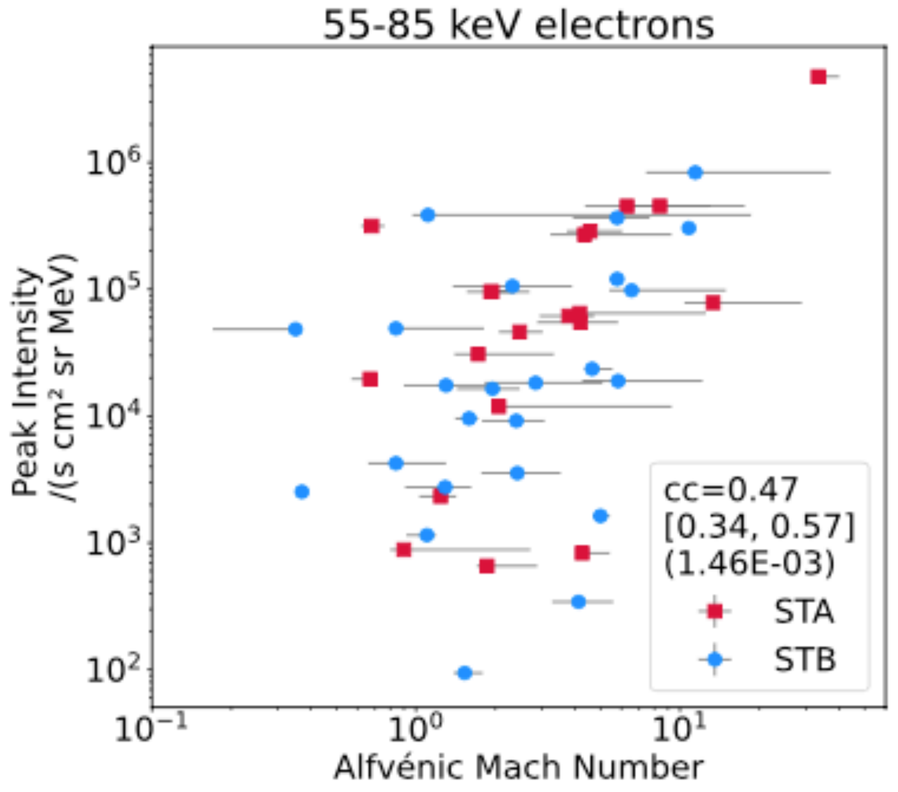
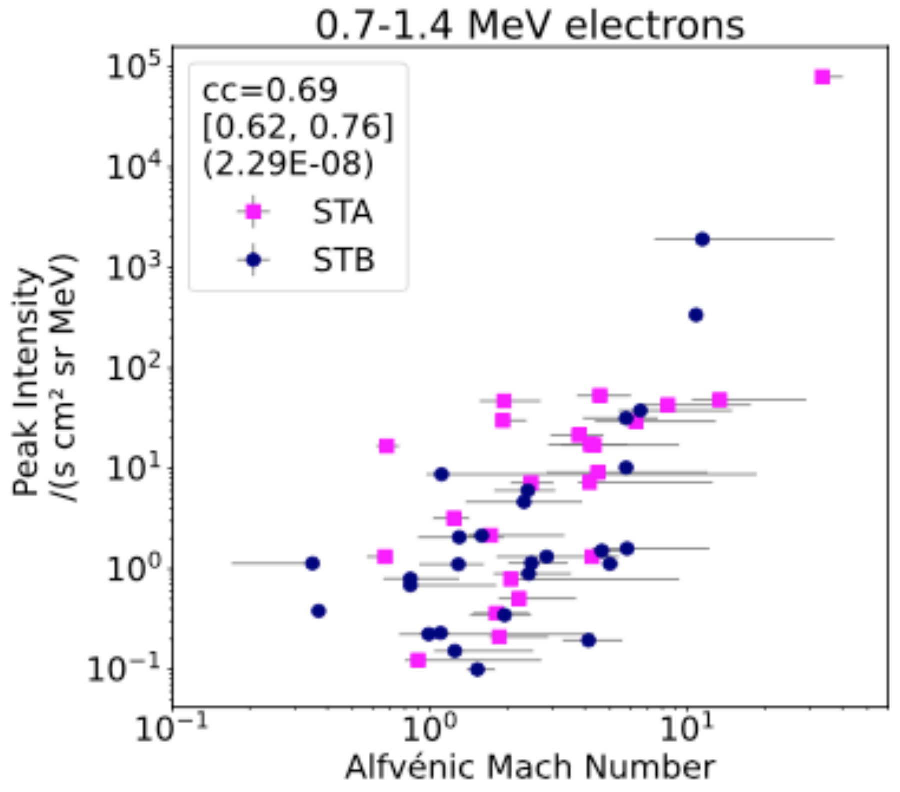
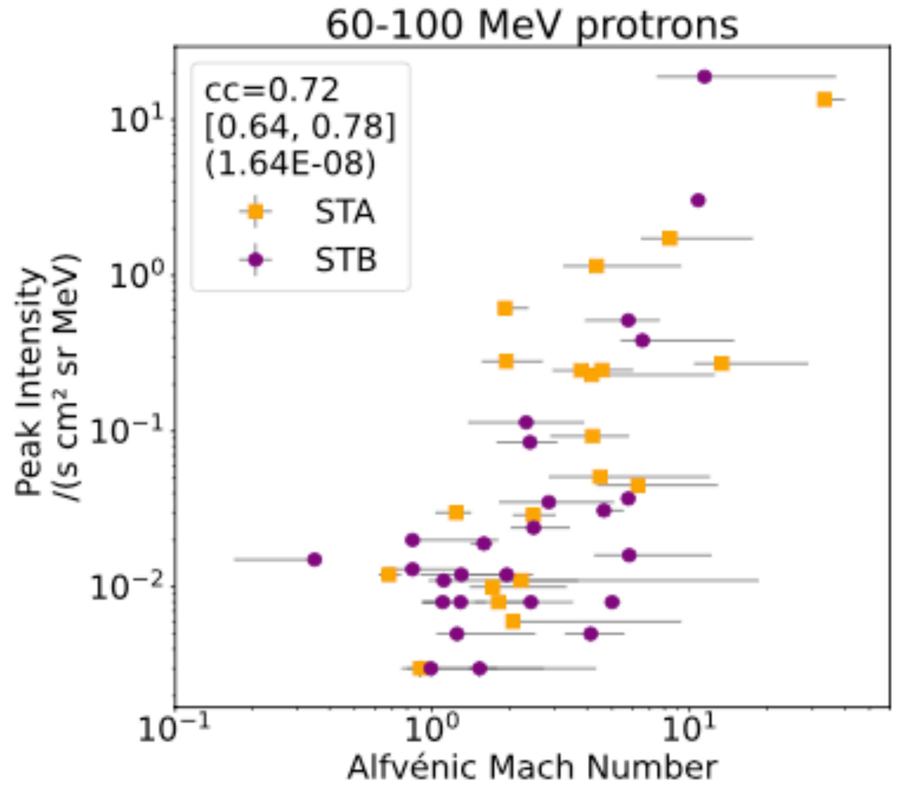
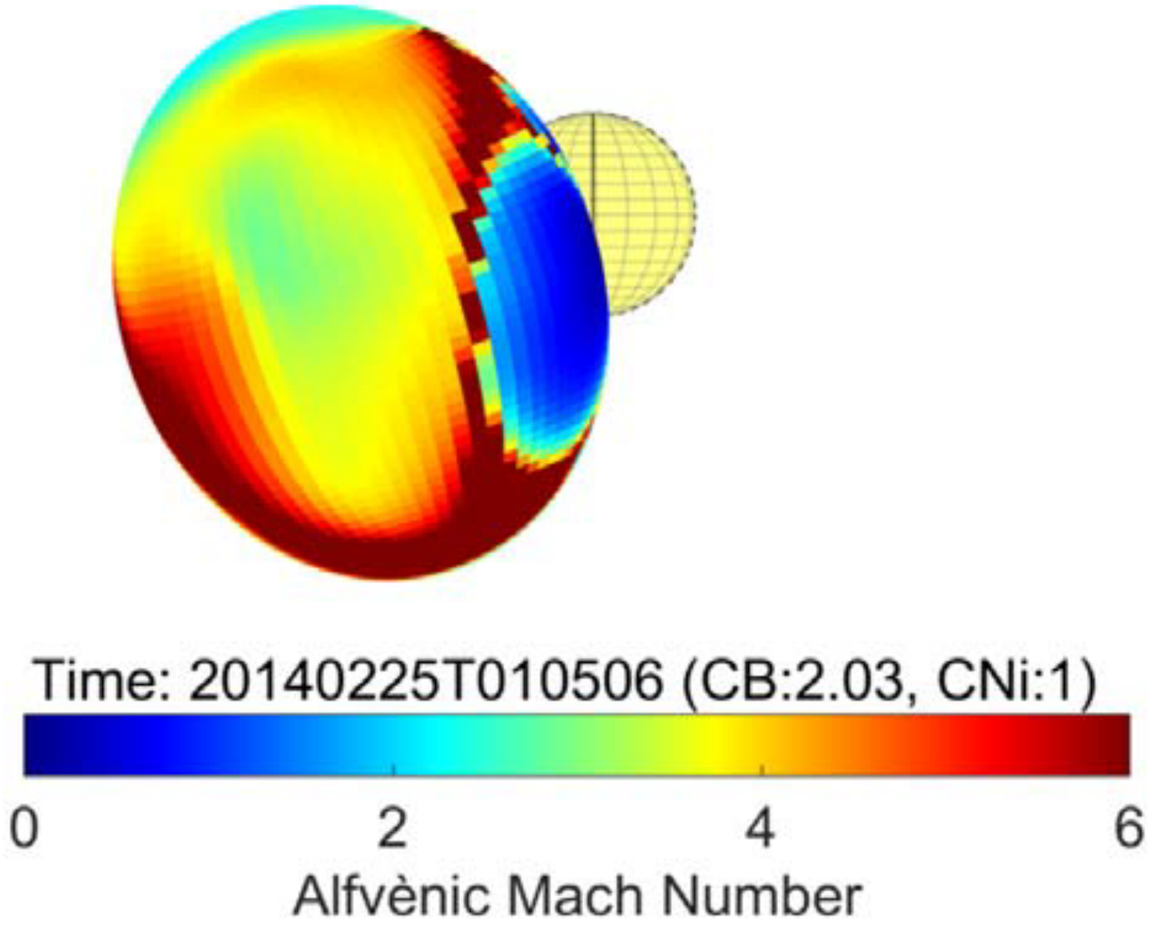
SUMMARY

- We compared electron peak intensities (STEREO, cycle 24) with modeled shock parameters at the magnetic footprint of the spacecraft (33 events, Kouloumvakos+(2019))
- **We find a strong correlation between ~1 MeV electron peak intensities and the shock Mach number of 0.69**
- **No significant differences between 1 MeV electrons and 60-100 MeV protons, which suggests a similar acceleration region (and mechanism?!) at the shock**
- Correlation of < 100 keV electrons with various shock parameters is always weaker and might represent a mixture of flare and shock acceleration









Dresing *et al.* (2022) *ApJL* **925** L21, doi: 10.3847/2041-8213/ac4ca7

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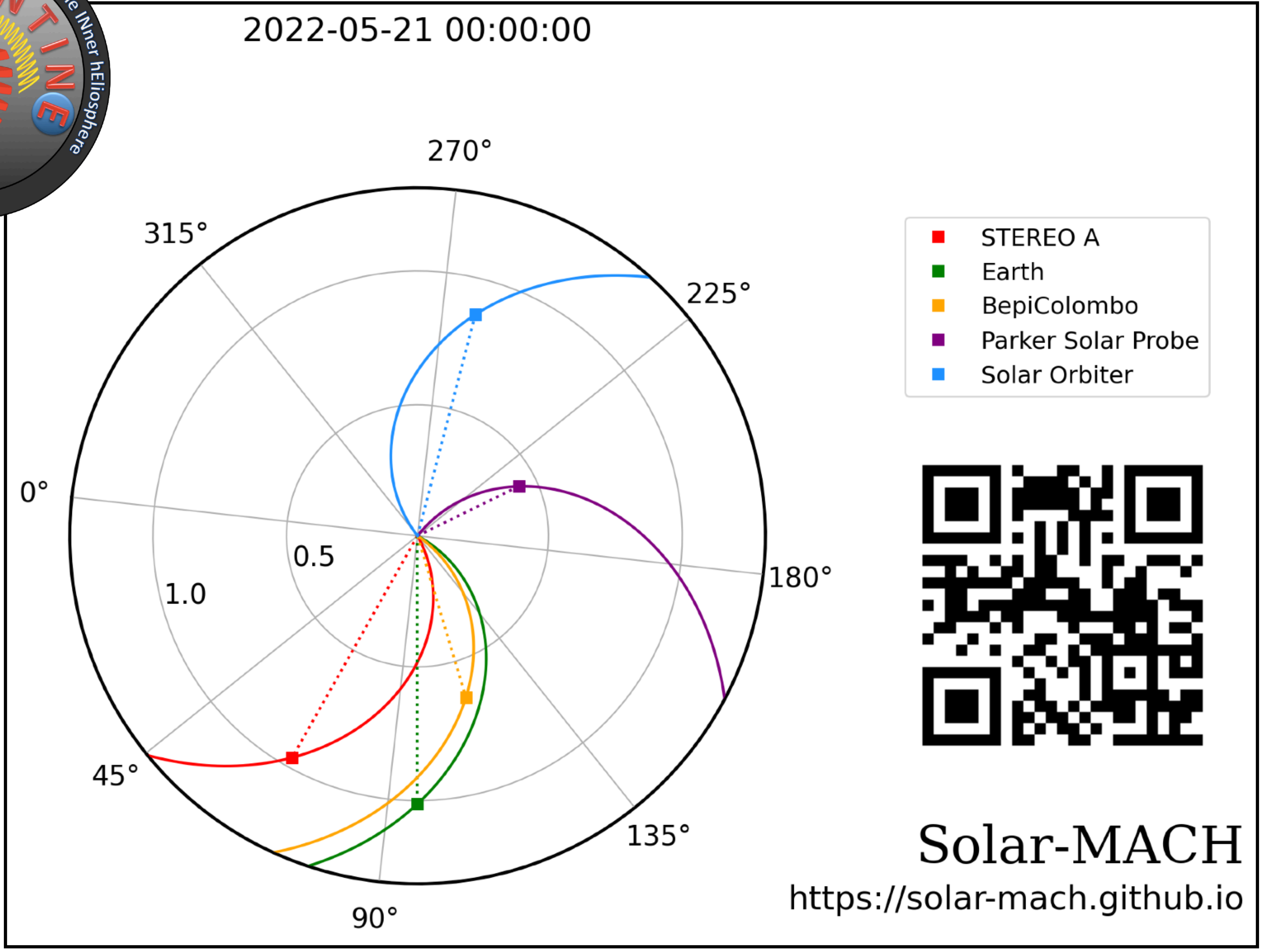

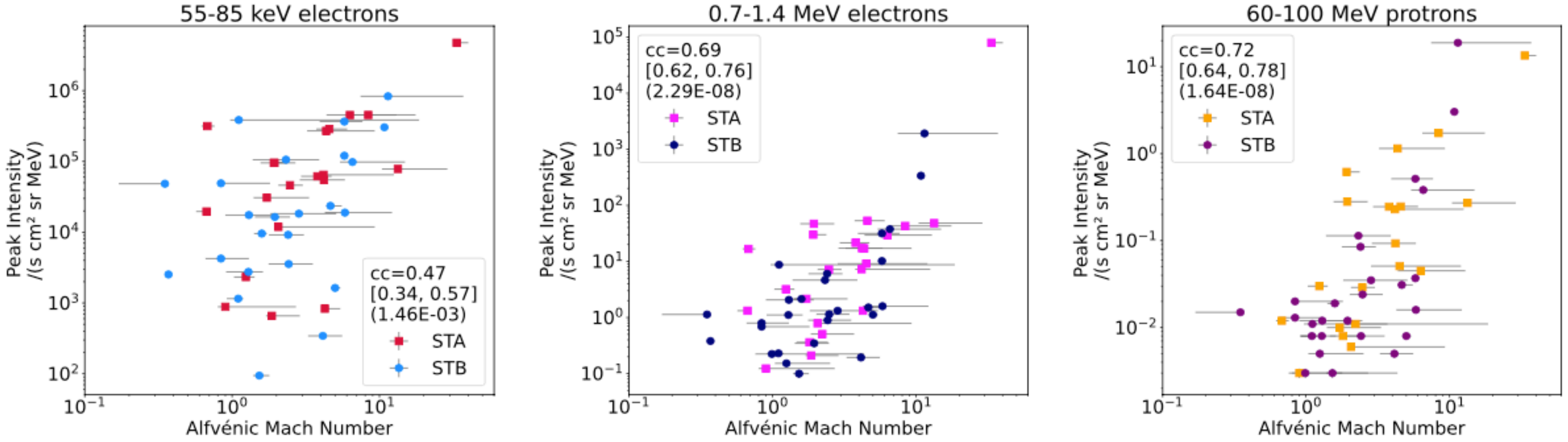

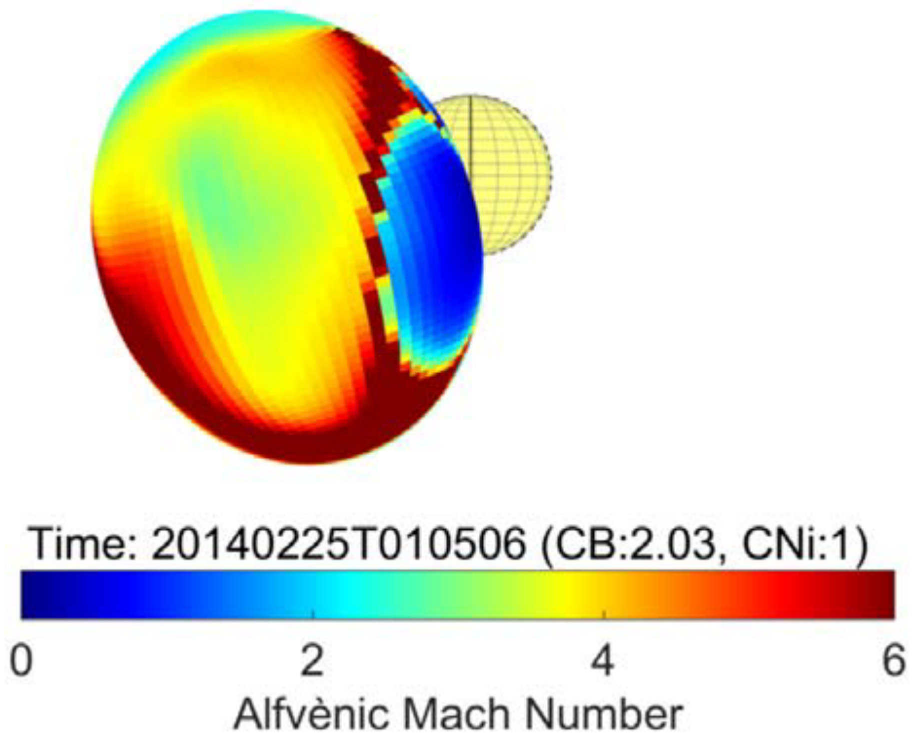

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