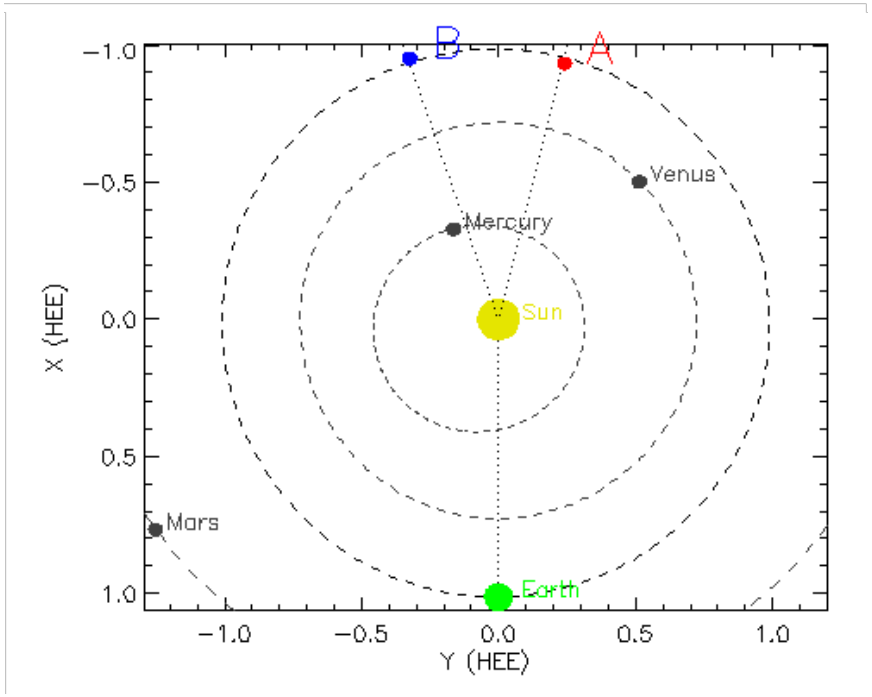
First electron spike event observed simultaneously by both STEREO spacecraft

A. Klassen, R. Gómez-Herrero, N. Dresing and B. Heber

University of Kiel, Germany
SRG, Universidad de Alcalá, Spain

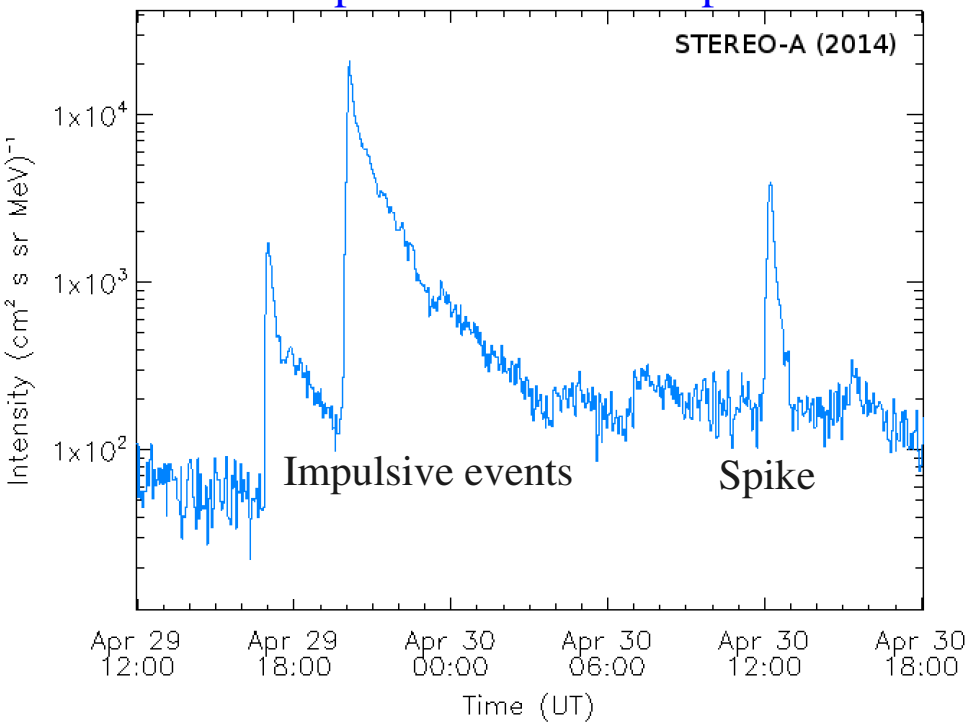
STEREO is a twin s/c mission, equipped with identical instruments, and perform heliocentric orbits following the motion of the Earth in the ecliptic plane.



Solar electron spikes are special subclass of impulsive SEPs:

- short duration < 20 min at FWHM
- nearly symmetric intensity time profiles
- narrow PAD during the whole spike duration, suggesting a weak particle scattering between Sun and spacecraft
- close association with type III radio bursts and EUV jets

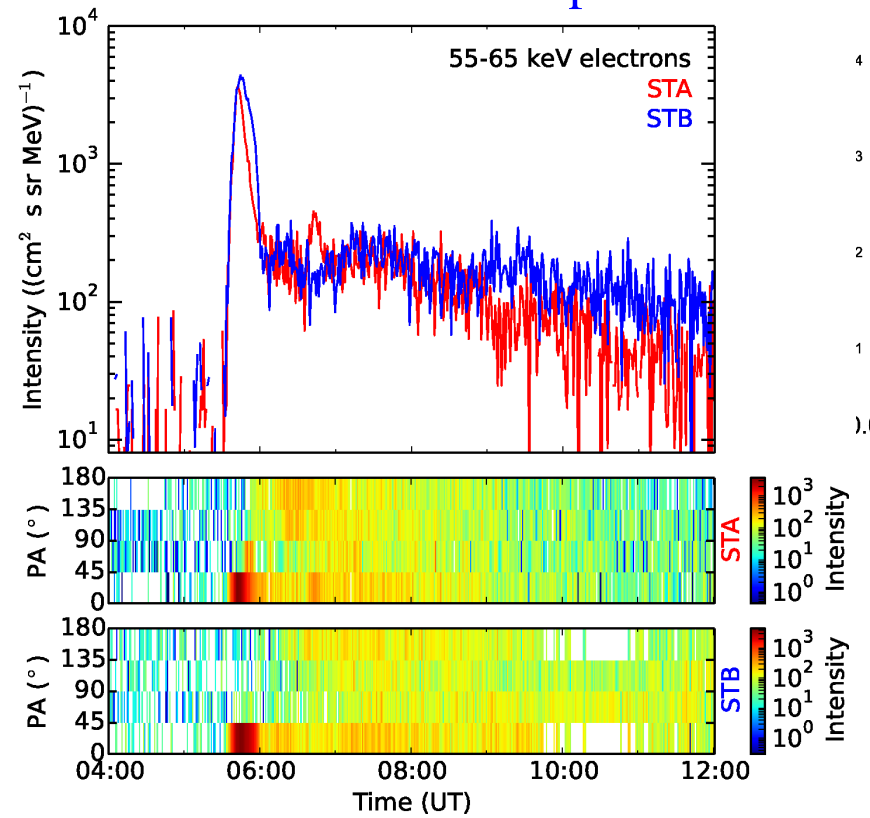
Impulsive events vs Spike

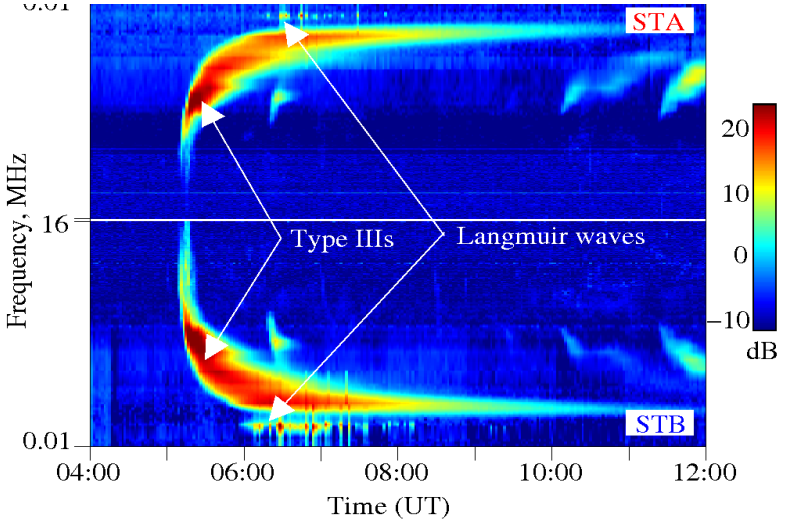


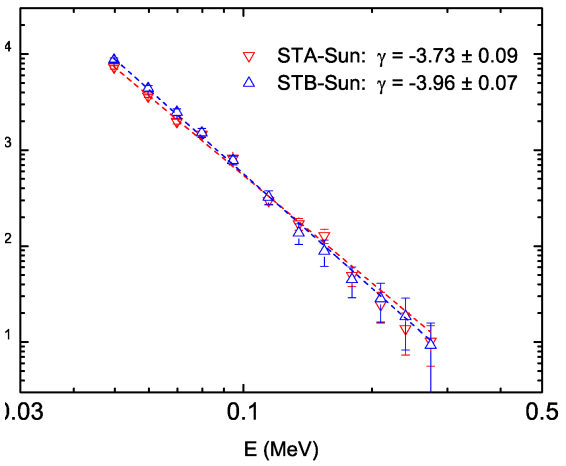
From ~ 90 spikes observed at both STEREOs (2010-2014) only ONE was detected by both s/c, and it was the first in 2014 (when STA-STB orbital separation was between 51 - 33°), suggesting that all spikes had rather narrow (< 50°) beam-like intensity distribution at 1 AU.

Our aim is to recognize the electron intensity distribution at 1 AU by close-spaced spacecraft.

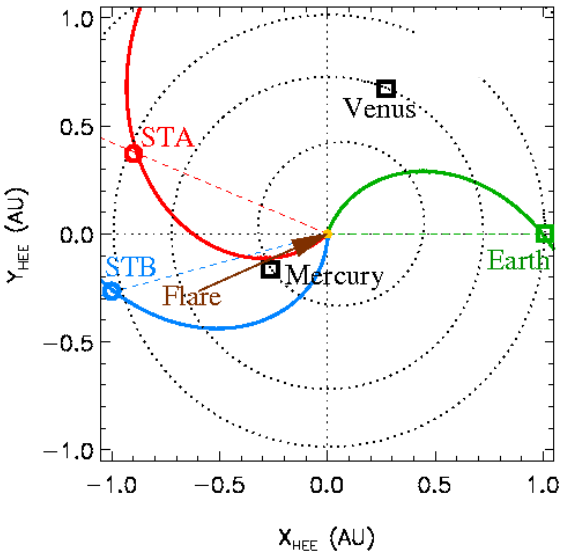
Electron spike on 2014-05-02: in-situ observations







STA – STB = 38°

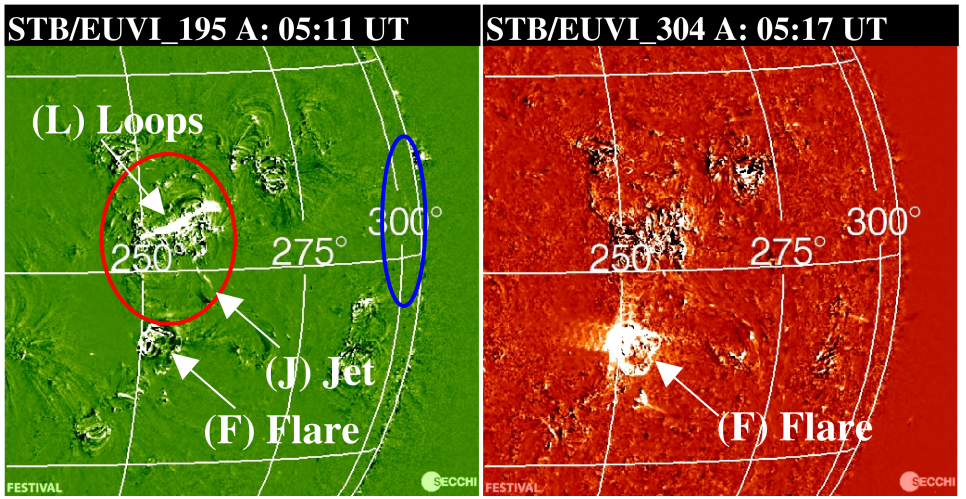


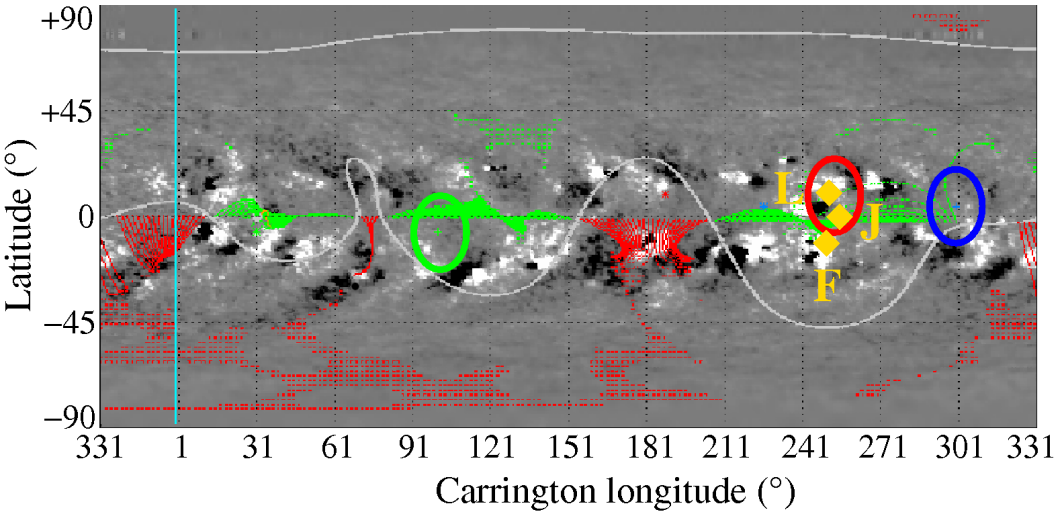
- Very similar time profiles, durations (8 & 12 min), PADs and peak energy spectra,
- Farther separated STB has 20% higher peak than the better connected STA
- Onset delay STA wrt STB = 2 min (STB earlier than STA)
- Spike onset delay wrt type III burst: STA=10 min; STB=8 min
- Ramp: bi-directional PADs: electrons pending between "mirrors" situated farther away and between the Sun and the s/c
- Associated with type IIIs and local Langmuir waves
- Beam width >= 38° at 1 AU, corresponding to the longitudinal separation between STA & STB

It seems: both S/C were very well connected to the source.
But the orbital separation between STA & STB was 38°.

How it is possible that both S/C detected similar profiles, peak intensities, PADs, etc, by this separation?

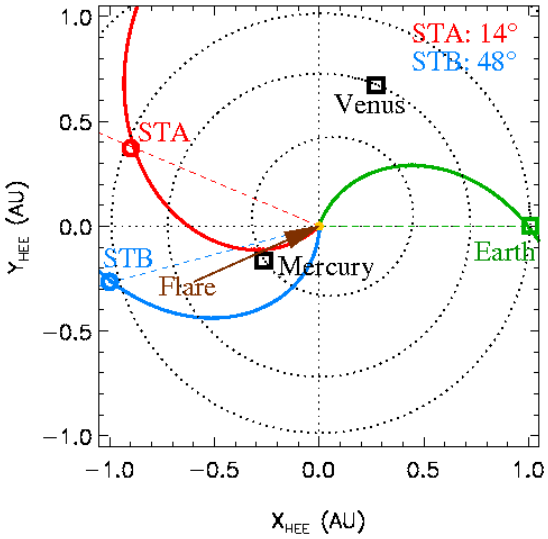
Spike origin (EUV) and magnetic connections





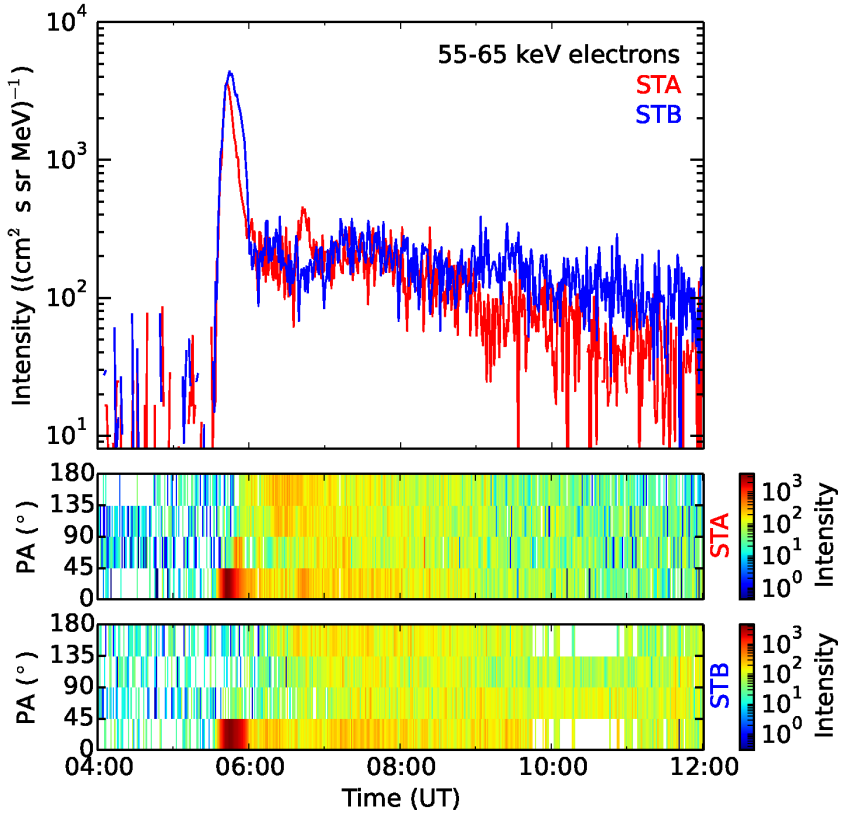
Spike & type IIIs associated:
with mixed activity close to STA nominal footpoint:
– the main source is the flare (F)
– and a narrow CME (width < 76°; speed < 780 km/s).
No EIT-wave, no type II burst (shock).

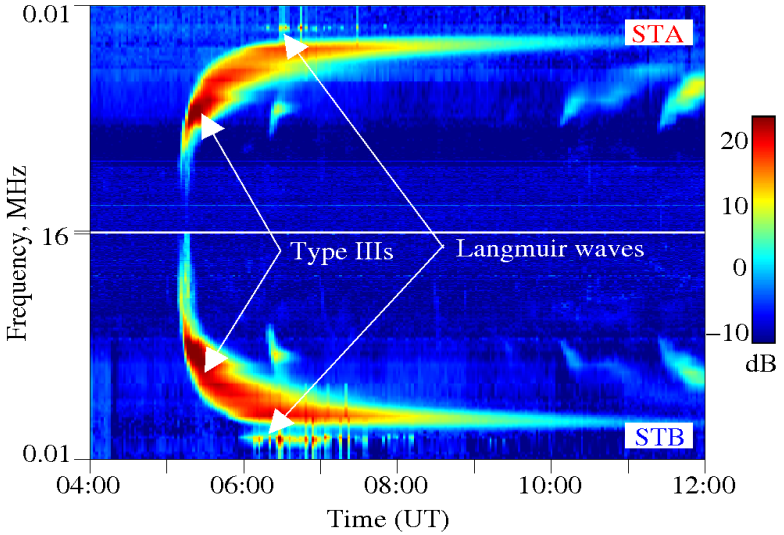
Mag. footpoints separation:
STA-Flare = 14°
STB-Flare = 48°



Expectation: the intensity peak at STA should be larger than at STB and the onset earlier.
Observed is vice versa: the peak intensity at STA is 20% smaller than at STB and the onset 2 min later.

Time delays





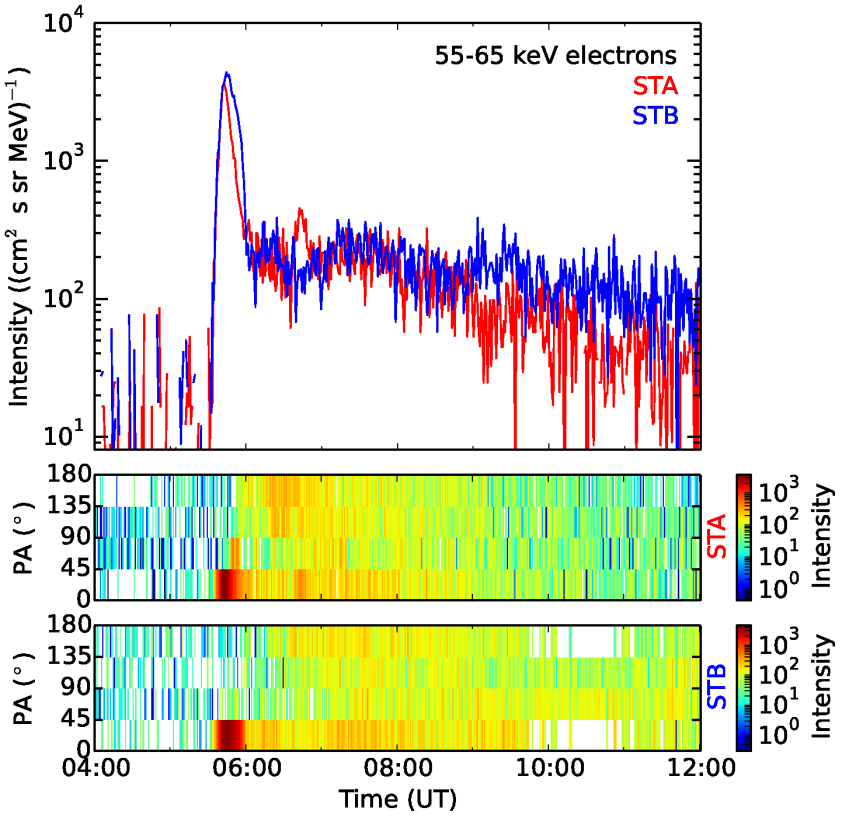
- onset delay STA wrt STB = 2 min;
- onset delay STA wrt type IIIs = 10 min;
- onset delay STB wrt type IIIs = 8 min;

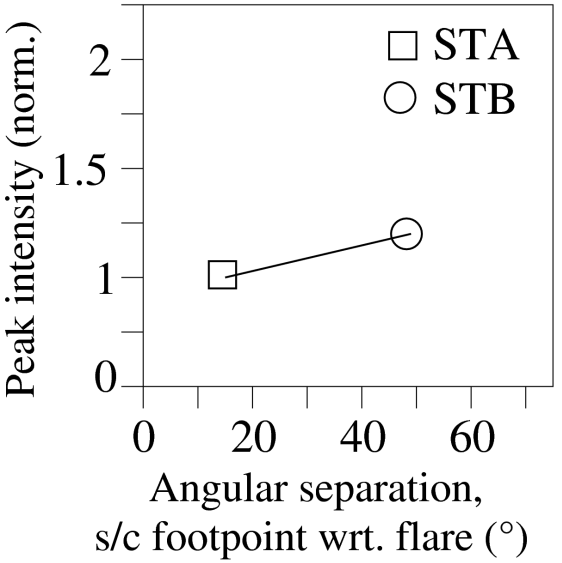
  If both the type III electrons and the near-relativistic spike electrons belong to the same population and were injected simultaneously into IP medium then:

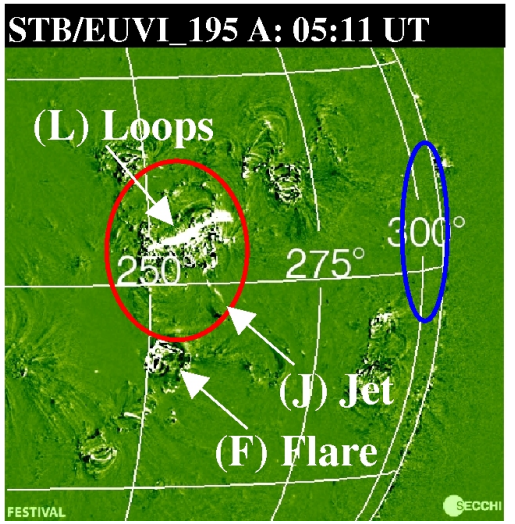
- the "effective" propagation paths are very similar for STA & STB = ~1.7 AU > 1.2 AU = nominal Parker spiral (e.g. Ragot 2006);

It means: spike electrons propagate along non-nominal Parker spirals.

Intensity distribution at 1 AU







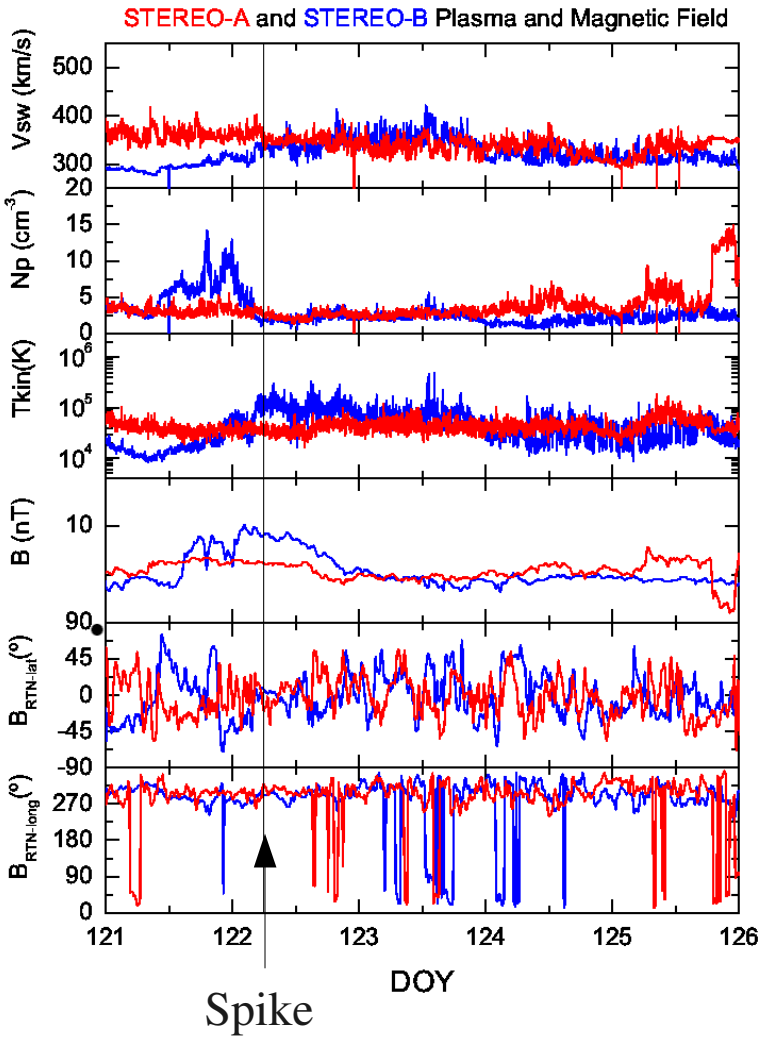
Very similar spikes at both S/C although the nominal magnetic separation was 48°.

Possible explanations:

– en route CME/ICME modify the nominal connection

– high solar wind speed deflect the STB connection to the flare

IP conditions

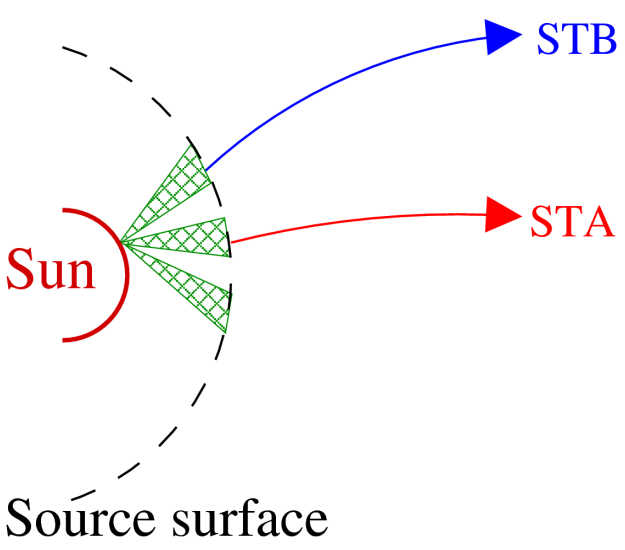


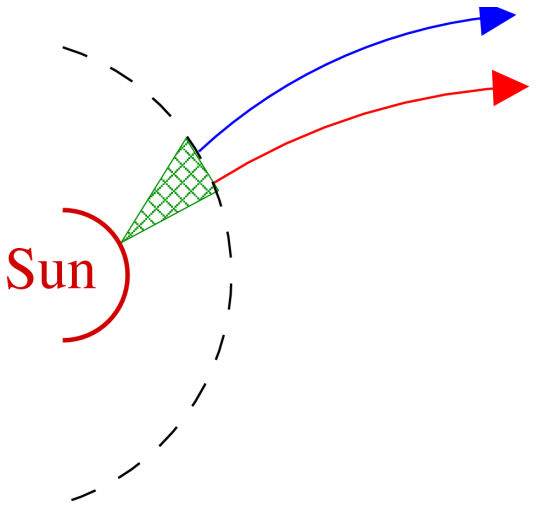
Very quit solar wind conditions at both S/C:

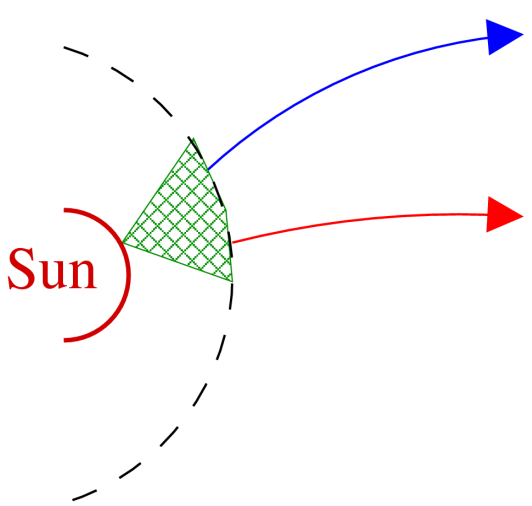
- slow wind < 400 km/s
- no shocks, no ICMEs
- only weak CIR-like disturbance at STB during the spike

Conclusion: the IP conditions did not change the S/C connectivity to the Sun.

Three scenarios







Multi-source

Hard to explain the very similar spike properties at both s/c.

Point-like source

But there is no compelling evidence that an IP structure (ICME) distort the connections and bring STA & STB footpoint together.

Extended source

It is situated in diverging and rather non-radial magnetic fields in the corona along which the electrons escape into the IP medium toward both s/c.

Summary

Both STA and STB detected simultaneously the same electron spike event demonstrating very similar properties in intensities, PADs, and energy spectra, implying the observation of the same single electron beam originating from a small flare activity accompanied by type III radio bursts and a narrow CME.

The spike beam angular extension was larger than 38° at 1 AU and it was injected from the parent AR into the IP medium rather strongly non-radial towards STB along a tilted and diverging magnetic field in the low corona.