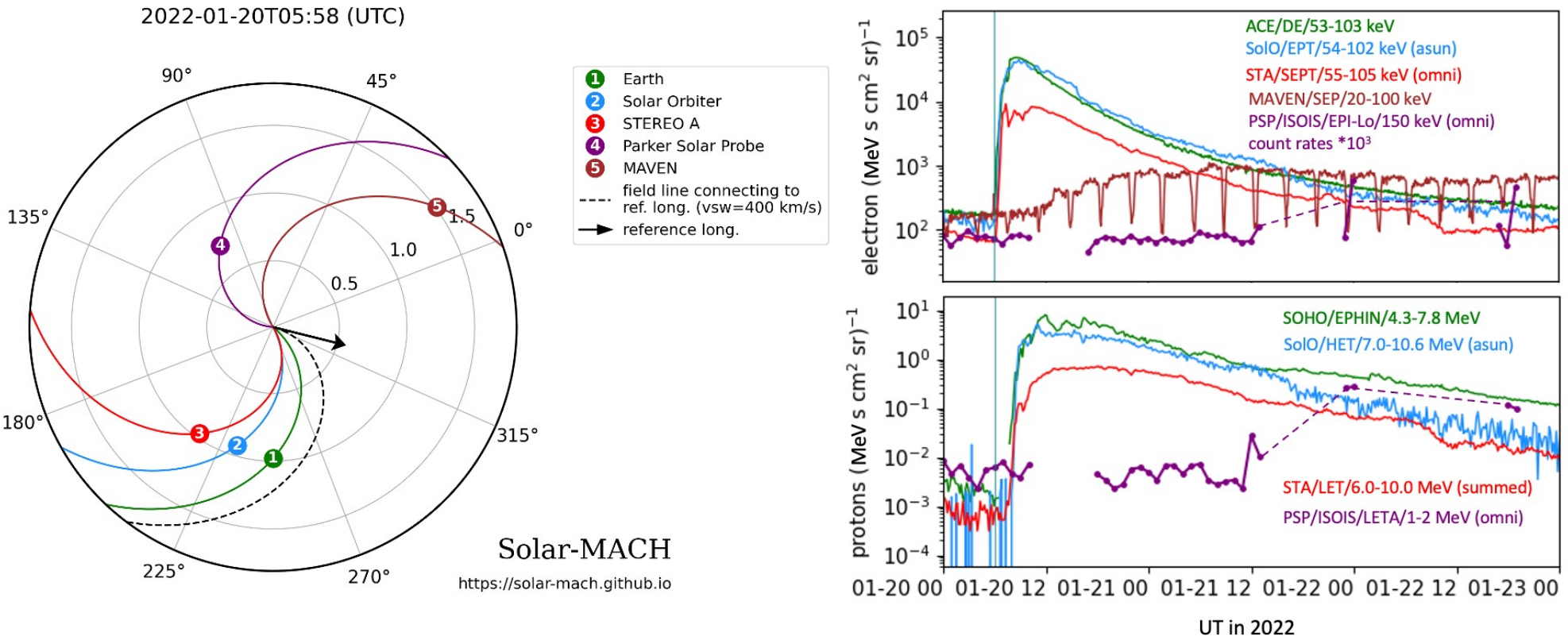
Disentangling the possible accelerator of solar energetic particles (SEPs) thanks to combined ground- and space- based radio data: SEP event on 2022 January 20

Laura Rodríguez-García, Research Fellow, ESA
Main expertise: Spaced-based instrumentation, multi-spacecraft, use of MHD simulations (ENLIL); solar energetic particles, coronal mass ejections

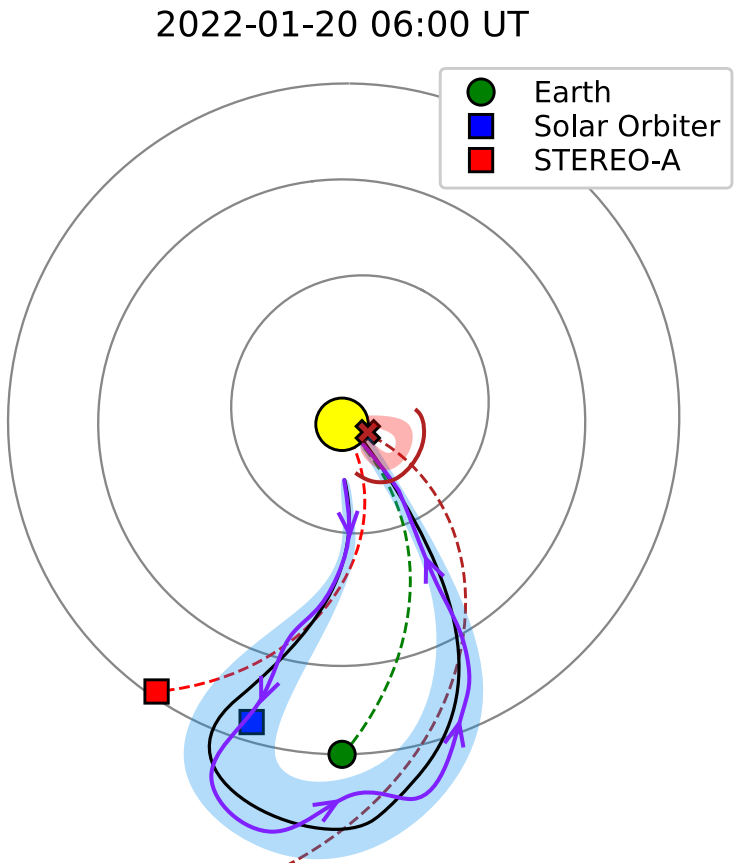
20/11/2024

SEP event on 2022 January 20



L. Rodríguez-García, R. Gómez-Herrero, N. Dresing, L. A. Balmaceda, E. Palmerio, **A. Kouloumvakos**, **I. C. Jebaraj**, F. Espinosa Lara, M. Roco, C. Palmroos, A. Warmuth, G. Nicolaou, G. M. Mason, J. Guo, T. Laitinen, I. Cernuda, T. Nieves-Chinchilla, A. Fedeli, C. O. Lee, C. M. S. Cohen, C. J. Owen, G. C. Ho, O. Malandraki, R. Vainio, and J. Rodríguez-Pacheco

Proposed scenario for the SEP event



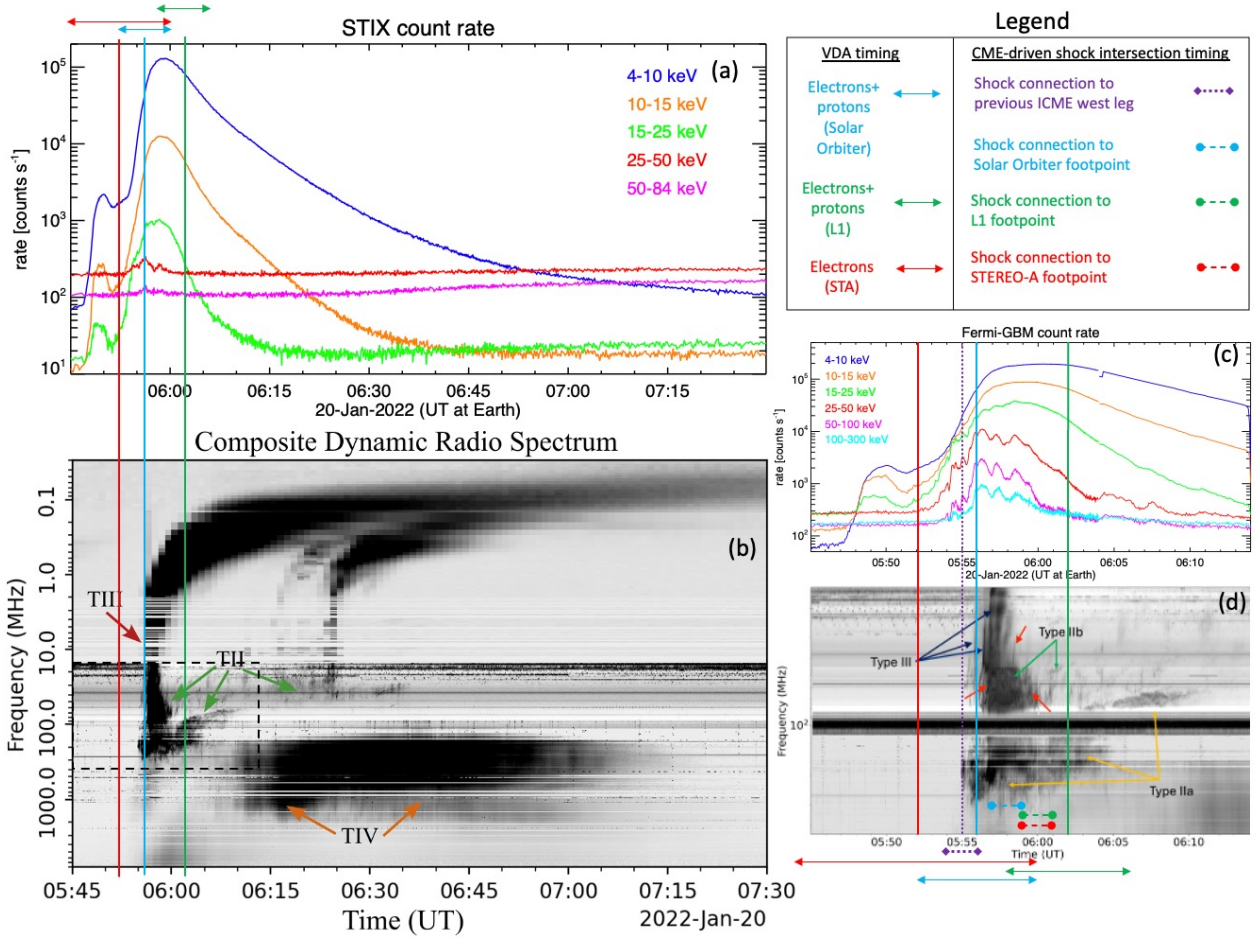
- Solar source: The solar source associated with the widespread SEP event on 2022 January 20 is likely the shock driven by the CME eruption observed near the west side from Earth's perspective.
- Particle injection: The energetic particles are injected over a wide angular region into and outside of a previous MC ejected on 2022 January 16 present in the heliosphere at the time of the particle onset on January 20. The sunward propagation particles measured by Solar Orbiter are produced by the injection of particles in the longer (western) leg of the MC, which is still anchored to the Sun.

Key part of the analysis: Combined radio data analysis

Radio observations are provided by the Radio and Plasma Wave Investigation (SWAVES; Bougeret et al., 2008) instrument on board the STEREO mission and the YAMAGAWA solar radio spectrograph (Iwai et al., 2017), and the e-Callisto network, in particular data from the Astronomical Society of South Australia (ASSA; Benz et al., 2009).

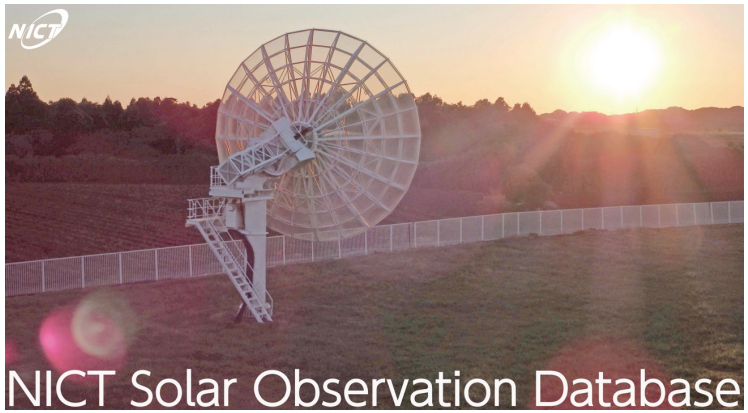
STEREO-A/WAVES
16 MHz to 30 kHz

ASSA + YAMAGAWA
9 GHz to 10 MHz



Combined spaced-based and ground-based instruments

YAMAGAWA (Japan)



9 GHz - 70 MHz

- ✓ Much of the continuum processes related to **active phenomena** are observed in this frequency range.
- ✓ Continuum emissions are due to hot electrons trapped in **coronal loops**. For example, mildly-relativistic electrons emit gyro-synchrotron radiation when a strong magnetic field is imposed on them. These continuum emissions can be directly related to HXR emissions and are through related processes during **solar flares**.
- ✓ It also registers the **start** of high frequency **plasma emission** (< 1GHz). These are emissions from transients like CMEs (**type IV** emission), shock waves (**type II**), and any beams propagating in open or quasi-open field lines (the different kinds of **type III** radio bursts). Regarding type III, when emitted from electrons in a closed loop system, they manifest as U or J bursts.

Combined spaced-based and ground-based instruments

ASSA (South Australia)

80 MHz - 10 MHz

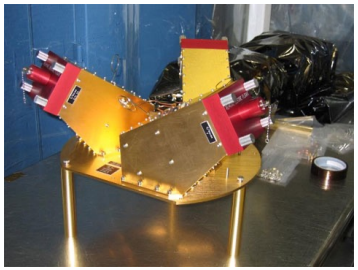
- ✓ Part of the **e-Callisto** network. It is a lower resolution and sensitivity measurement, but provides world-wide coverage, which means **24/7 observations** of the Sun.
- ✓ It registers the **continuation** of **emissions**: These are emissions from transients like CMEs (**type IV** emission), shock waves (**type II**), and any beams propagating in open or quasi-open field lines (the different kinds of **type III** radio bursts).

Radio observatories normally used in this frequency range (not always observing the Sun):

LOFAR, MWA, NenuFAR: Time and frequency resolution of observations is very high-> study some small-scale features of the emissions. Then, we can understand both the ambient plasma and the mechanism of emission quite detailed. In this range, we also have radio imaging.

Combined spaced-based and ground-based instruments

STEREO/WAVES (NASA)



16 MHz to 30 kHz

- ✓ It registers the **continuation** of emissions: These are emissions from transients like CMEs (type IV emission), shock waves (type II), and any beams propagating in open or quasi-open field lines (the different kinds of type III radio bursts).

- ✓ Measurements made by the **new fleet (Solar Orbiter/Parker)** provide an unprecedented view of transient phenomena.

Parker Solar Probe/FIELDS (NASA)

Solar Orbiter/RPW (ESA/NASA)

Coordinating ground to space: challenges, successes, ideas

- ✓ **Radio is poorly utilized**: It provides a wide variety of information for a wide variety of processes associated with a number of space weather phenomena.
- ✓ It seems to be a **challenge** to get people **to consider radio**. Any reasons for this?
- ✓ Another challenge seems to have a **combination of space- and ground-based observations**: Especially, in the combination of state-of-the-art ground-based facilities like LOFAR/MWA. Is this because of the additional work required to process these data? Is the space-based community just too rapid with their work? This combination is vital as it provides an uninterrupted view of Sun-Earth connection - something which no other wavelength provides.
- ✓ **Radio community should expand:** people studying other phenomena such as SEPs for example should probably consider learning how these observations work.
- ✓ **To other communities**: what has stopped you from using radio?