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HELCATS WP7 Update - overview

Mario Bisi on behalf of
Jonathan Eastwood
HELCATS month 12 meeting, 18-22 May 2015, Göttingen, Germany

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Work Package 7 (reminder)

Assessing the complementary nature of radio measurements of solar wind transients

- *Duration*: Months 10 – 36
- *Participants*: Imperial, ROB, STFC
- *Work package leader*: Jonathan Eastwood (Imperial)

- *Objectives*:
  - To identify and analyse potentially-geoeffective solar wind events that are observed by both HI and interplanetary scintillation (IPS), and use IPS to augment the HI observations.
  - To identify and analyse solar wind transients that are observed by both HI and in radio, and add value to the HI data by establishing/cataloguing the relationships between them.

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Motivation (reminder)

- Recognising that radio observations are associated with heliospheric transients, this work package links **Interplanetary Scintillation (IPS)** and **Type II radio emission** to the established Heliospheric Imager observed events.

- **IPS**: Solar wind density; solar wind speed can be retrieved if signals from the same radio source are received at spatially-separated receiver sites; results can be used for input to tomographic reconstructions.

- **Type II radio emission**: generated at shocks driven by coronal mass ejections, frequency corresponds to (harmonics) of the local plasma frequency, which is a function of density. Coordinated analysis of HI data and radio-burst observations has been performed only on a case-by-case basis (*e.g.* Harrison *et al*., 2012; Magdalenic *et al*., 2014)

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Tasks and deliverables (reminder)

- **T7.1** - Identifying and analysing potentially-geoeffective solar wind events that are observed by both HI and IPS [Months: 10-36] STFC
- **T7.2** - Identifying and analysing solar wind transients that are observed by both HI and in Type II radio burst emission [Months: 10-36] IMPERIAL, ROB

- **D7.1** : Catalogues of EISCAT and LOFAR IPS data events and of S/WAVES events, both extending throughout the STEREO HI Mission timeline [month 27]
- **D7.2** : Report of initial comparison between IPS events and HI events. [month 30]
- **D7.3** : Report of initial comparison between solar radio-burst events and HI events. [month 30]

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High level strategy for WP7 (reminder)

- Start month 10
- Initial construction of catalogues, in the context of initial work on the HI catalogue (D7.1)
- Identification of events for case study and detailed analysis
- Analysis of case studies (D7.2 and D7.3)
- Feedback into main HELCATS catalogue(s) (precise format TBD)
- Requires HI catalogues with non-changing event IDs to build off of (IPS can be used both for CMEs and for SIRs/CIRs)

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Update: Organisational preparation

- **New Post-Doctoral Research Associated at Imperial:** Dr. Vratislav Krupar
  - PhD Charles University/Paris Observatory 2012 “Stereoscopic Observations of Solar Radio Emissions by the S/Waves Instrument onboard the STEREO Spacecraft”
  - Official start 1st July, but already working on HELCATS-oriented science

- Organisation: WP7 mailing list

  Helcats-fp7@imperial.ac.uk

- If you would also like to subscribe, please visit:

  https://mailman.ic.ac.uk/mailman/listinfo/helcats-wp7

- Everyone is welcome even if you won’t be working directly with this WP!

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WP7 overview summary

- WP7 has now started!
- Initial progress sets the stage for work to be accomplished in year 2 and year 3
- Now present updates and aspects of the science specific to individual tasks:

1. **Type II: T7.2** - Identifying and analysing solar wind transients that are observed by both HI and in Type II radio-burst emission
2. **IPS: T7.1** - Identifying and analysing potentially-geoeffective solar wind events that are observed by both HI and IPS

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HELCATS WP7 Update – Type II emission

Mario Bisi on behalf of
Jonathan Eastwood, Vratislav Krupar, Jasmina Magdalenic, Bob Forsyth
HELCATS month 12 meeting 18-22 May 2015, Göttingen, Germany

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Type II radio emission (Task 7.2)

Identifying and analysing solar wind transients that are observed by both HI and in Type II radio burst emission

- Combining STEREO solar radio-burst, coronagraph and HI observations enables unique study of the propagation of shock waves and their drivers (CMEs), as well as interaction of fast CMEs, all the way from the low corona to 1 AU.

- Solar radio-burst observations cover a broad frequency domain corresponding to different distances from the Sun.

- Key advantages of space-based radio measurements
  - effectiveness in tracking CMEs between coronagraph and HI FOV
  - analysis of events where fast CMEs interact.

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Type II radio emission (Task 7.2)

- Preliminary catalogues have been received from the HI database
- Here we show an initial case study which illustrates how radio data might be used
- A deep understanding of initial case studies enable sensible strategies for surveying the data
  - 29 November 2013 – 01 December 2013 (analysis by V. Krupar)
  - Strong radio signature
  - Analyse frequency drift and direction finding
  - Coronagraph imaging
  - Heliospheric imaging
  - CME encountered by MESSENGER and STEREO A (radial alignment)
- This is a comprehensively-observed CME event!
  - Analysis is ongoing: *e.g.* differences in different speed calculations…
  - See poster later in the week

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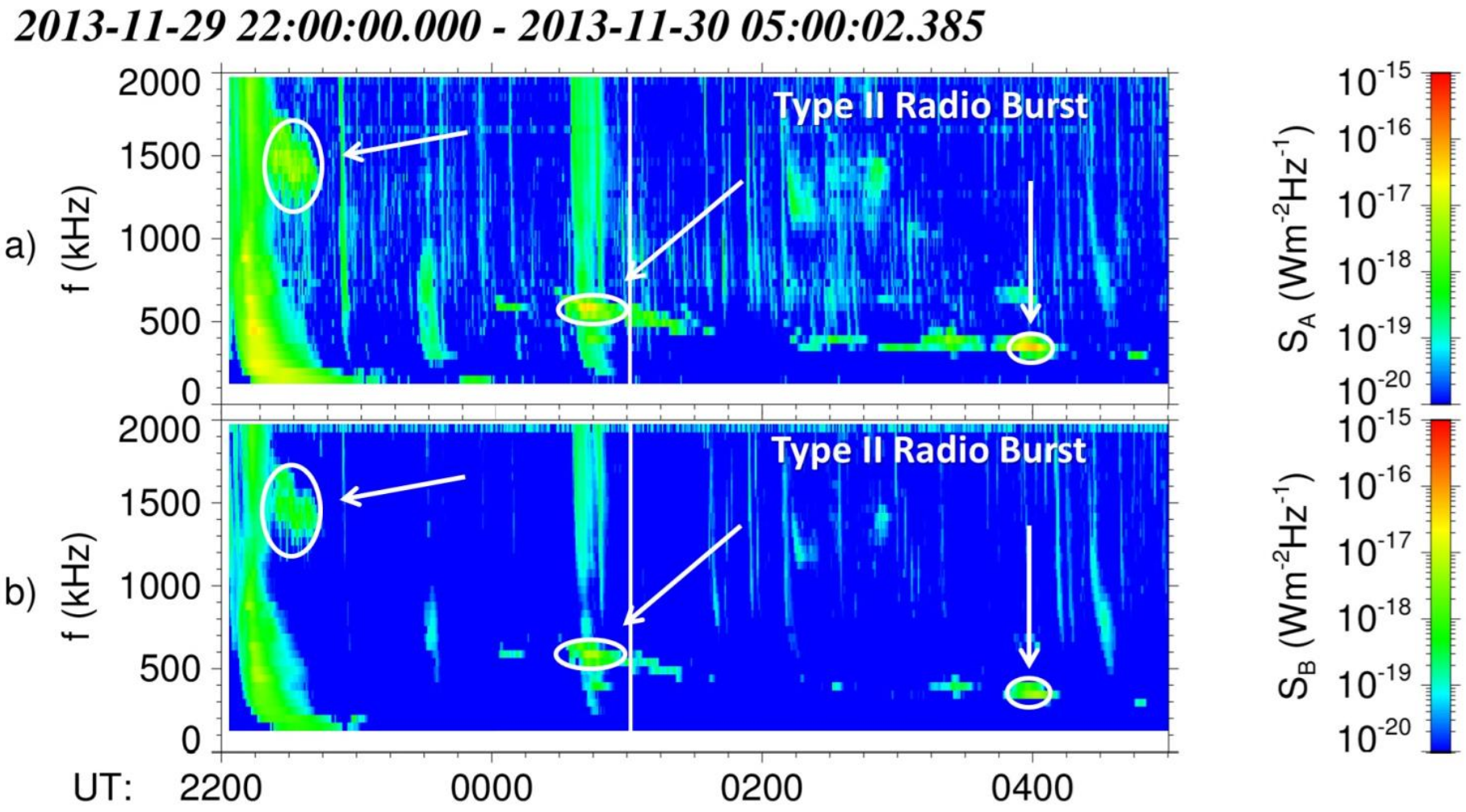
Analysis by Vratislav Krupar

Illustrative case study: 29 November 2013



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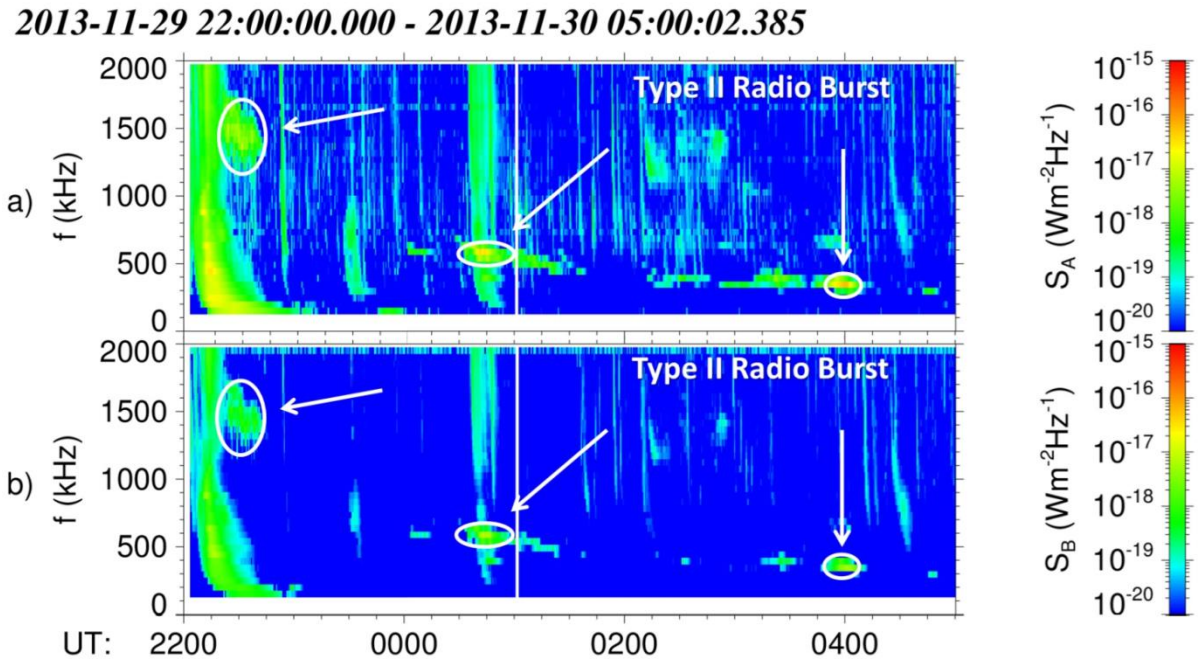
Timing analysis

Type II radio emission

- Three discrete bursts labelled
- Can use the frequency and time difference with a density model to determine the source altitude
- Two estimates of radial source speed: ~500 km/s

Interval	Date	Time	Frequency	Distance F	Speed
1	2013-11-29	22:30	1,500 kHz	6.4 R_S	*
2	2013-11-30	00:45	600 kHz	12.1 R_S	**500 km/s**
3	2013-11-30	04:00	300 kHz	20.9 R_S	**530 km/s**



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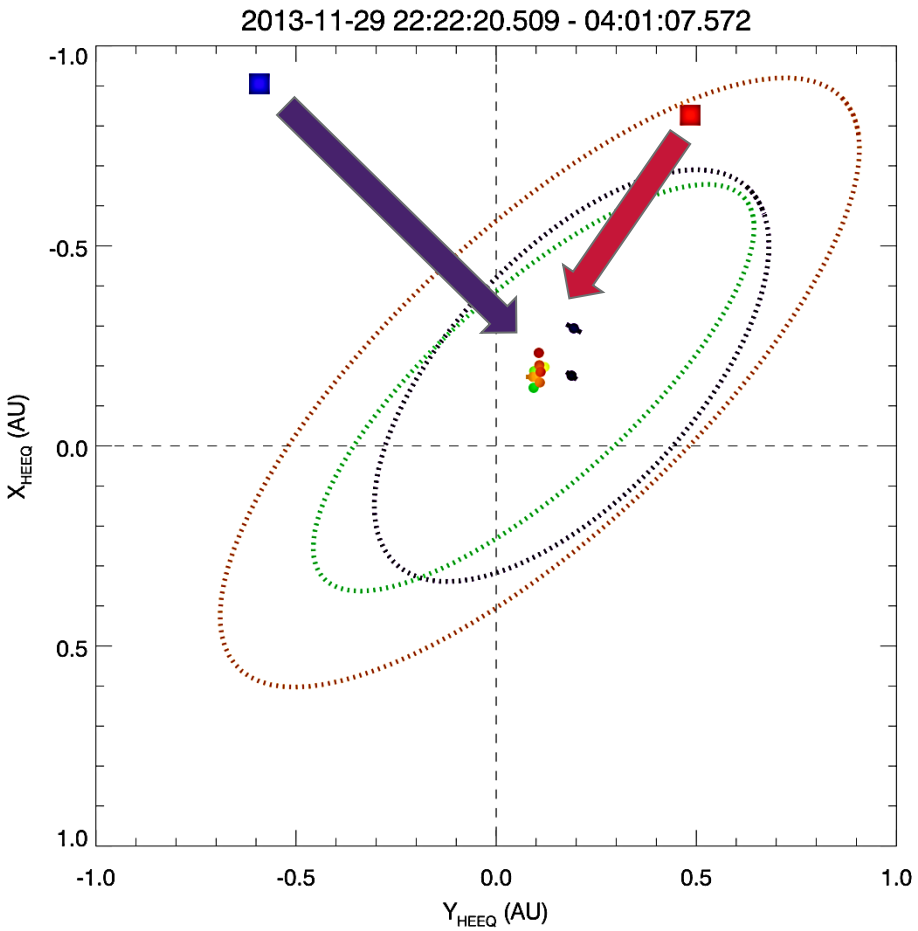
Direction finding (also see Magdalenic *et al*., in full meeting!)

- Using the SVD method of Krupar *et al*. (2012), we can localise the emission at different frequencies: potential to compare with remote imaging.
- From three quasi-instantaneously acquired measurements of S/WAVES HFR1 we can build the correlation matrix P that yields Direction Finding (DF) information.
- **See Magdalenic *et al*. for direction finding applied to the 5 March 2012 event**



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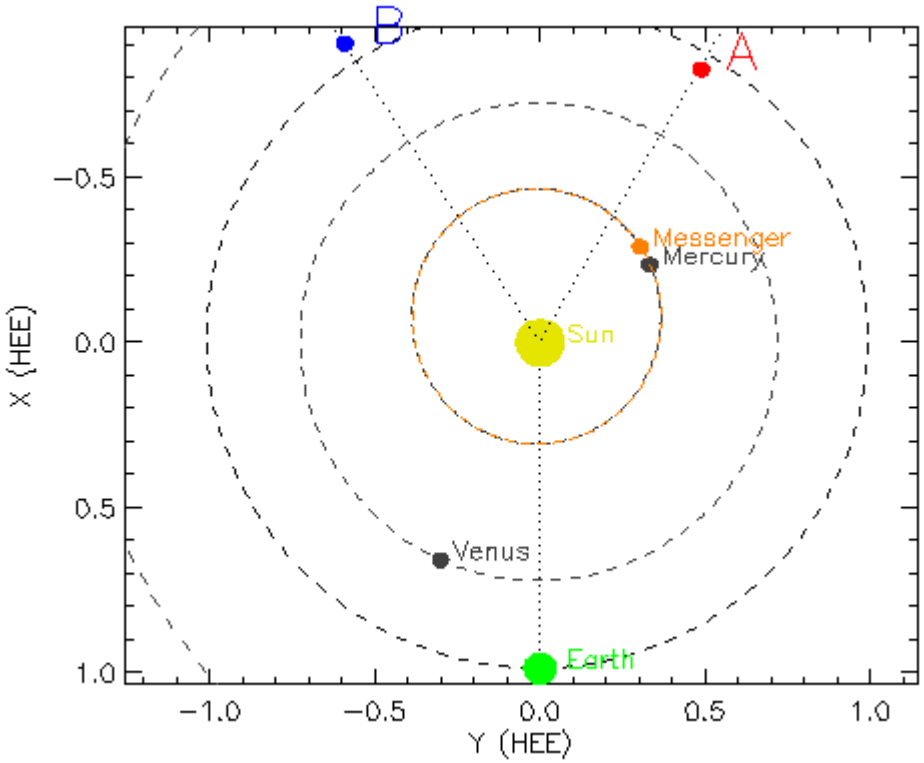
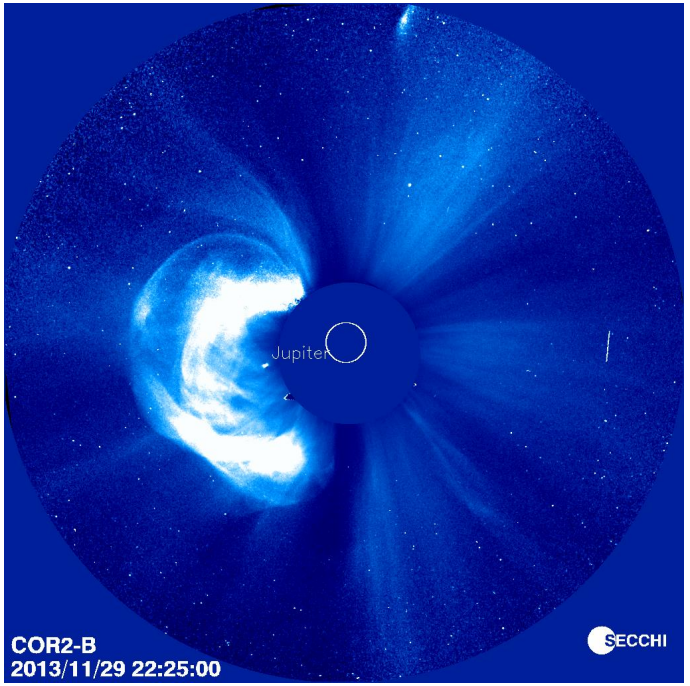
Context: remote sensing (general)





Coronagraph

- CME lift off at ~20:00 on 29/11/2013
- Directed towards STEREO-A, imaged by STEREO-B in *e.g.* COR2

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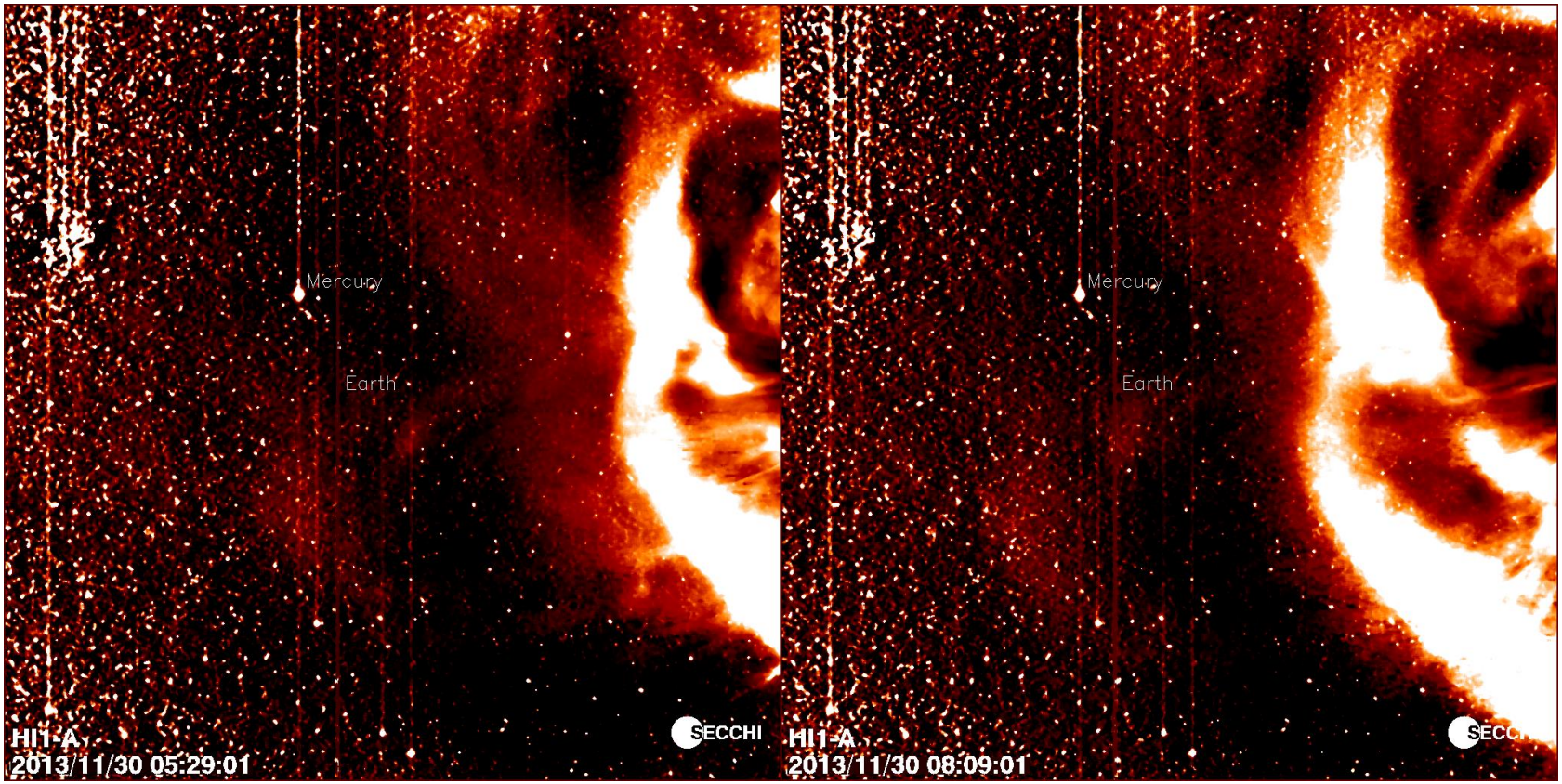
Context: heliospheric imaging



- Imaged by HI-1 in STEREO A
- STEREO B HI: not in field of view
- Analysis TBD!!!

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Context: *in-situ* measurements

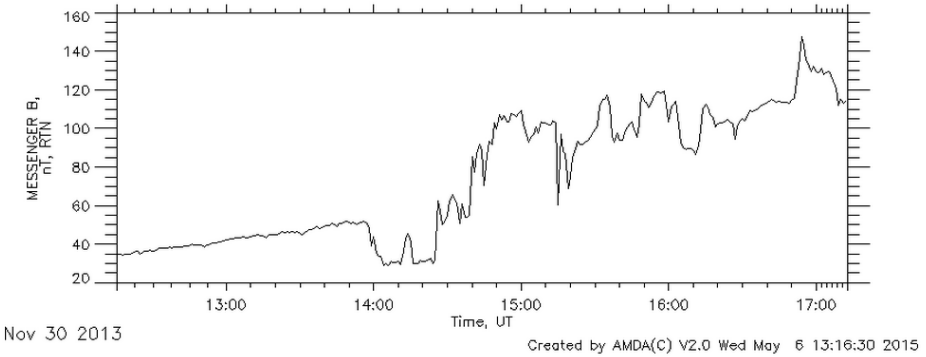
In-situ measurements:

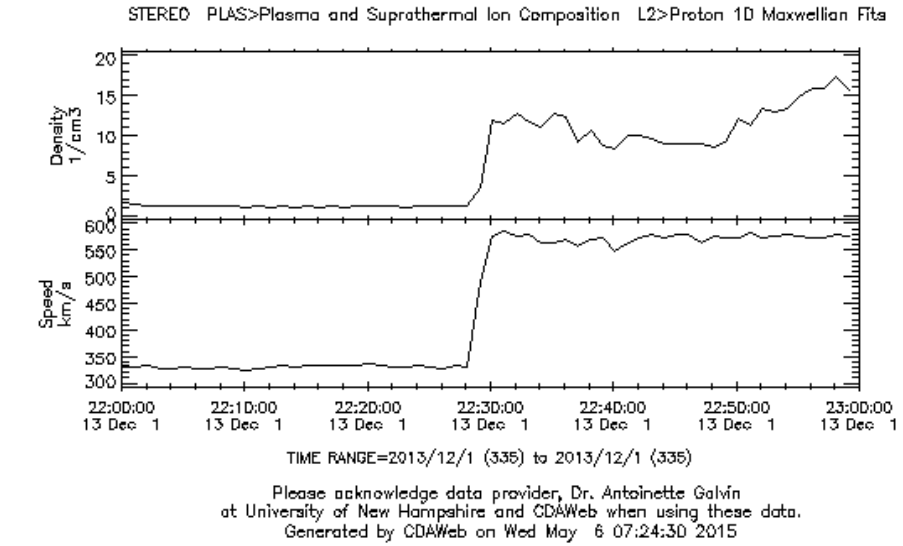
MESSENGER

- MESSENGER at Mercury was radially aligned with STEREO-A
- MESSENGER was in the solar wind and detected the shock (magnetic field only)

STEREO-A

- STEREO-A also measured the shock arrival
- Reached STEREO-A in ~50 hours
- Average speed: ~ 830 km/s





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Summary (WP7, Task 7.2)

- Initially performing case studies
  - Gain a deeper understanding of the data
  - Knowledge gained will enable sensible strategies for surveys
  - Will inform decisions about what data should be included in the radio catalogue

- *e.g.* 29 November 2013: a comprehensively-observed event
  - Radio
  - Coronagraph
  - HI
  - *In situ* (MESSENGER and STEREO-A)
  - *See poster later in the week!*

- Preliminary examination of the first ~100 events in the HELCATS catalogue implies ~15-20% have associated Type II emission
  - This is a very preliminary result!