The CME-driven shock wave on 2012 March 05 & radio triangulation of associated radio emission

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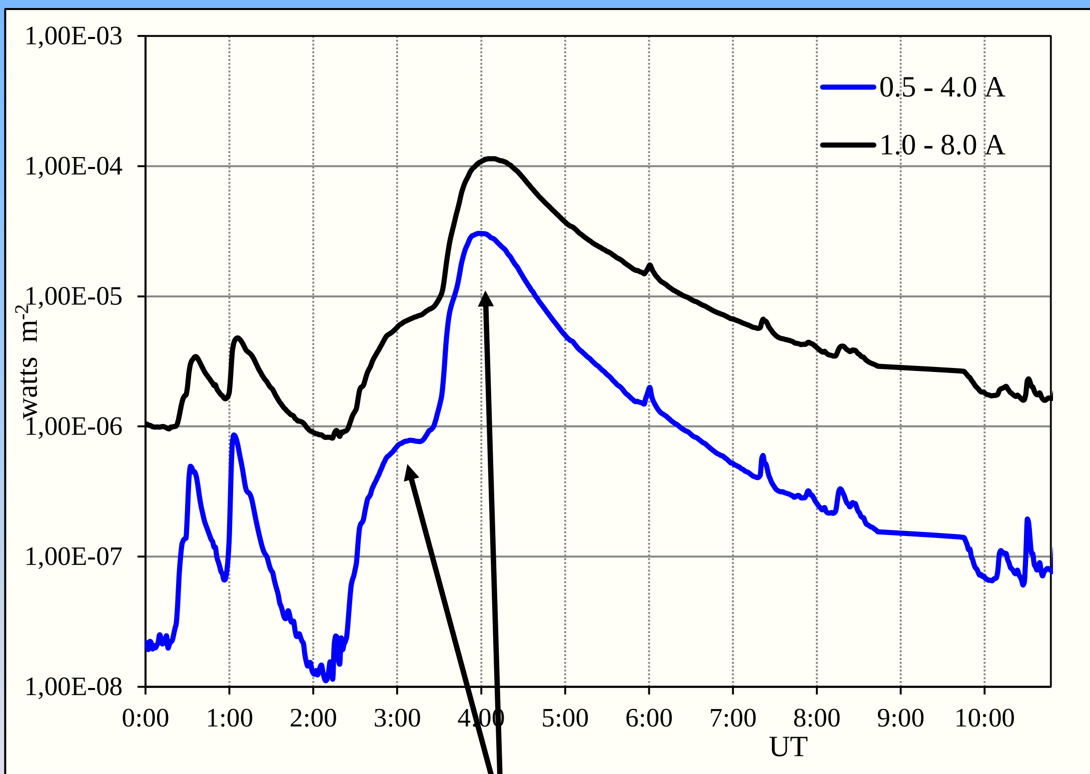
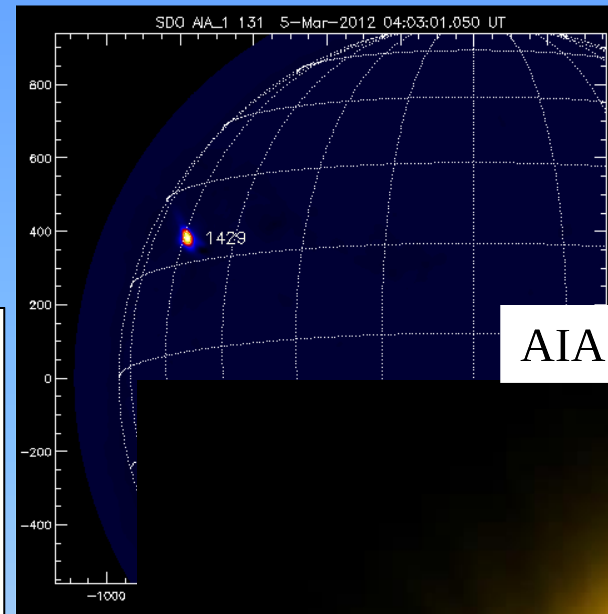
Magdalenić et al., 2014, ApJ, 791, 115

* Characteristics of the flare

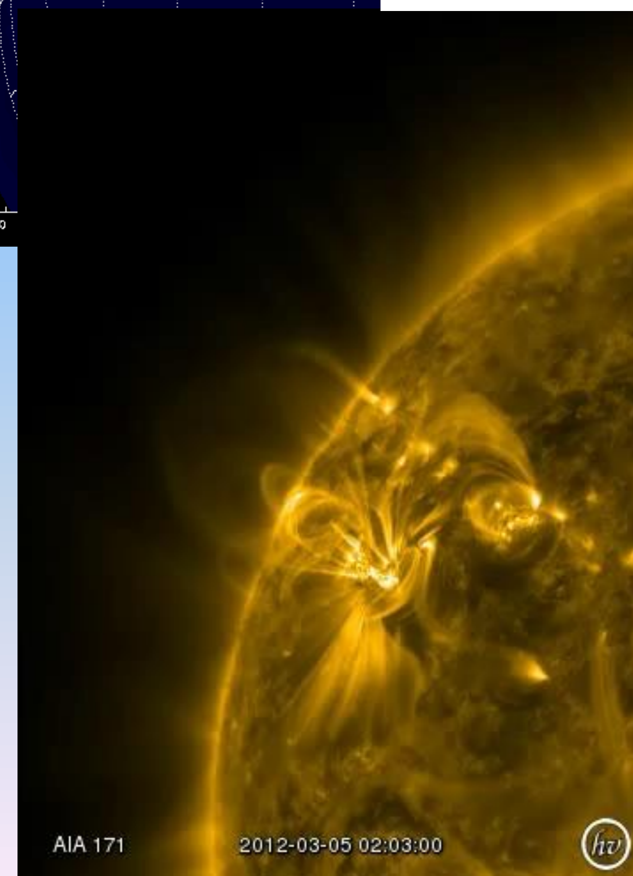
- X1.1 flare
  (0.5 – 4 and 1 – 8 Å GOES 15)
- 02:30 – 04:05 – 04:43 UT
- NOAA AR 1429 (N19° E58°)



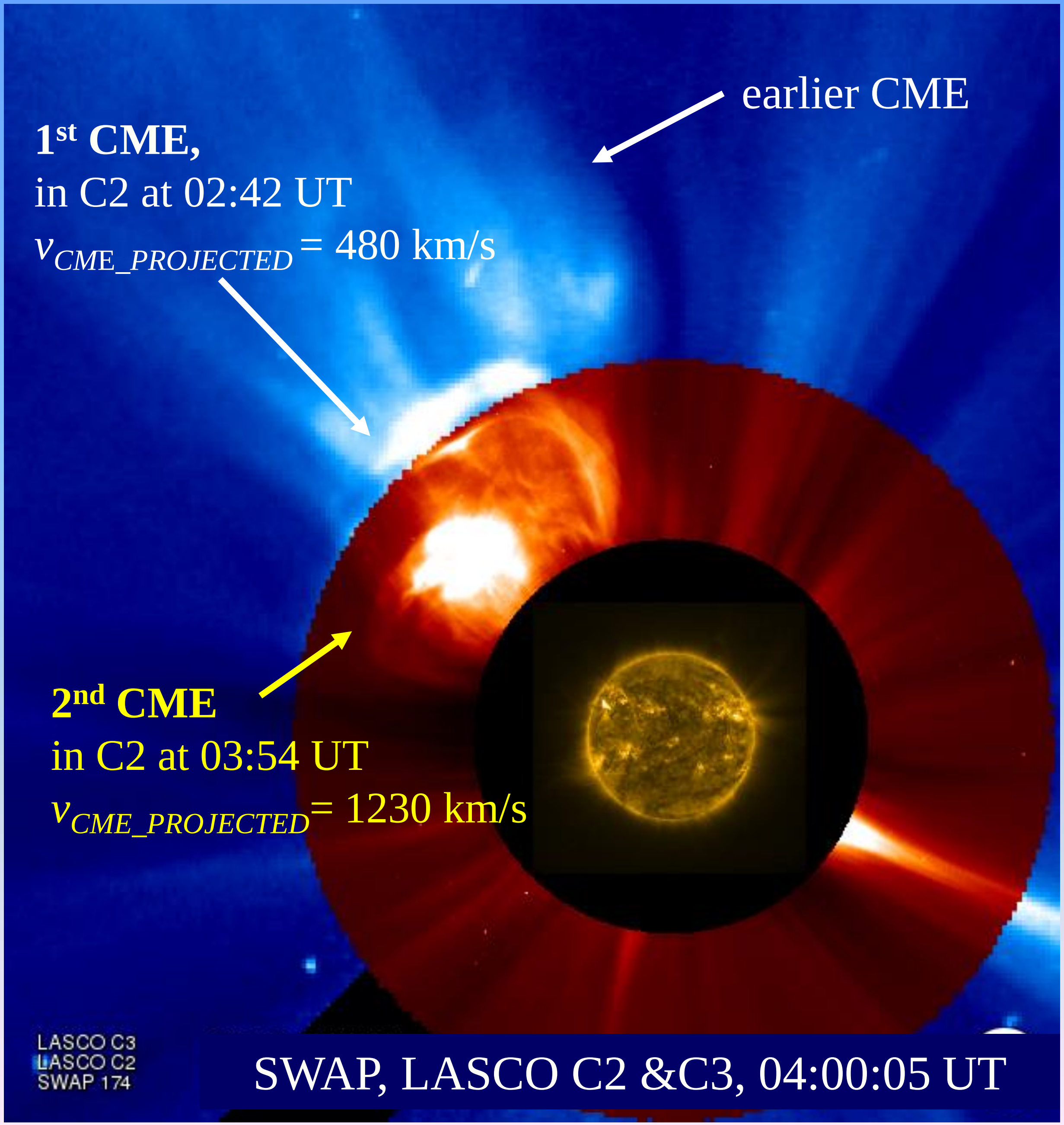
Complex profile of the GOES flare
→ more flares, more CMEs?!

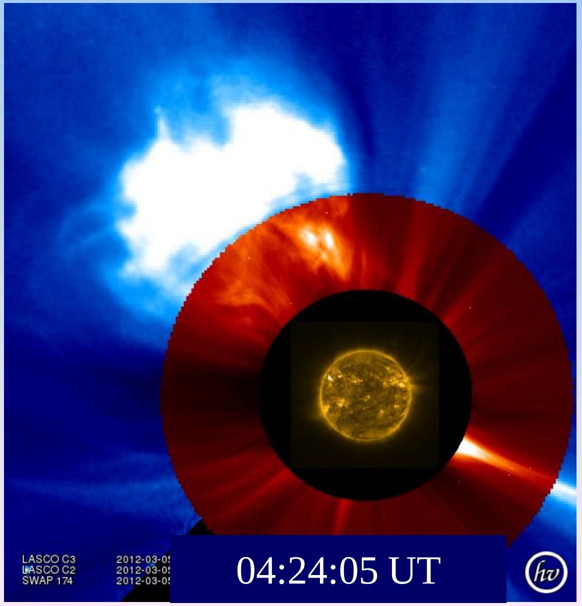


AIA 171 Å

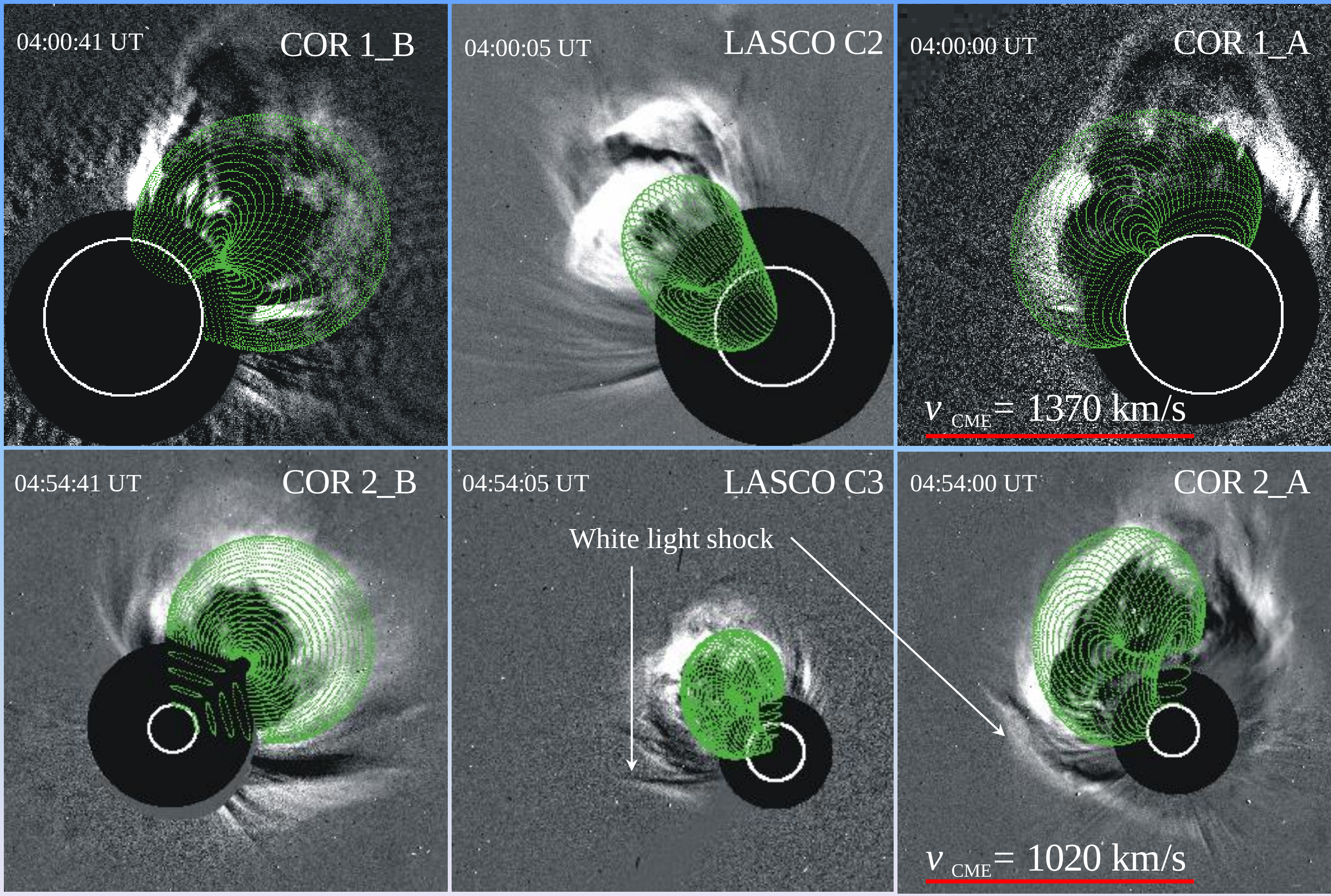


* Characteristics of the CMEs



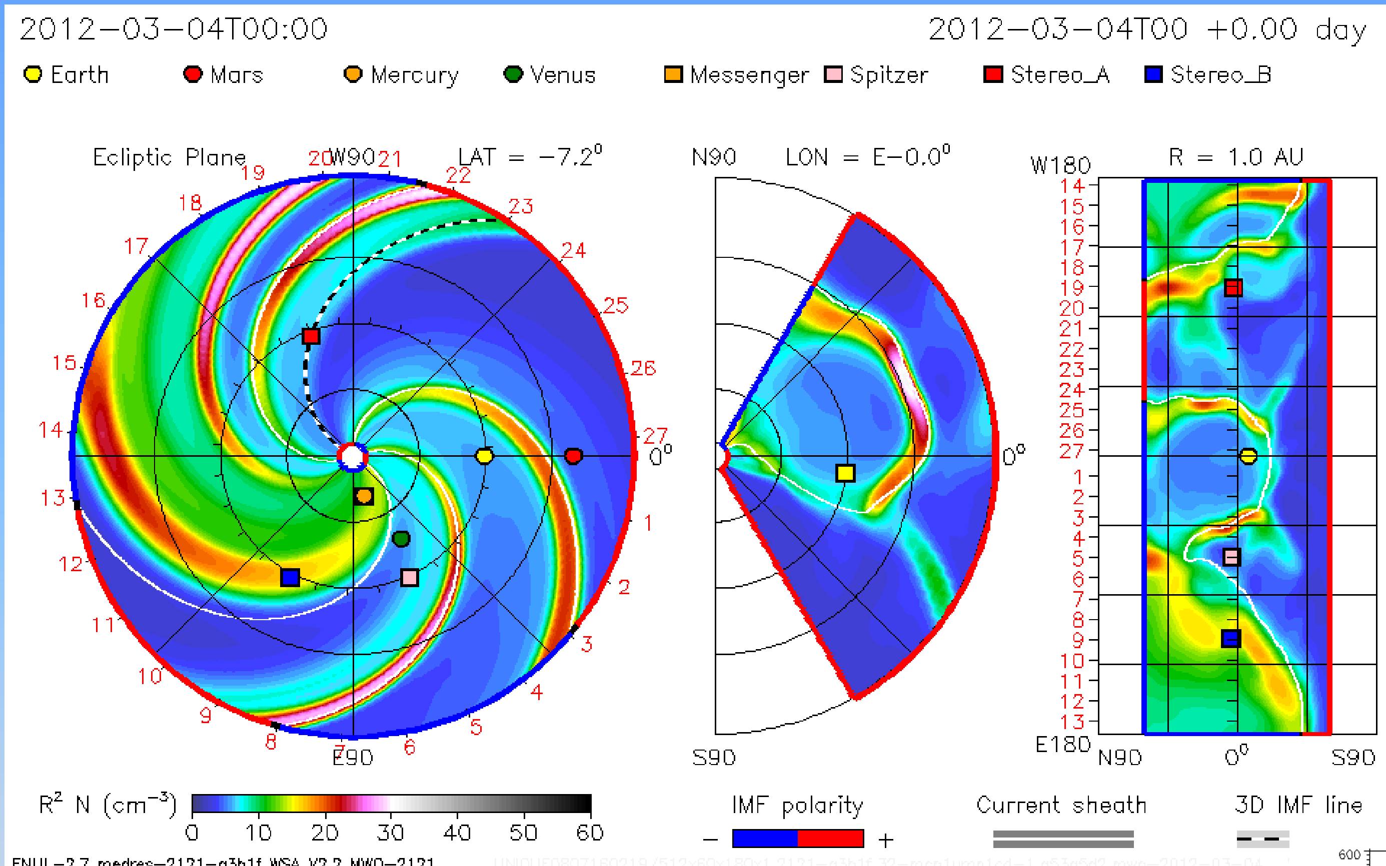


* 3D reconstruction of the CME



- The 3D reconstruction of the CME using the graduated cylindrical shell model (Thernisien et al., 2006, 2009) → forward modeling technique for flux-rope-like CMEs.

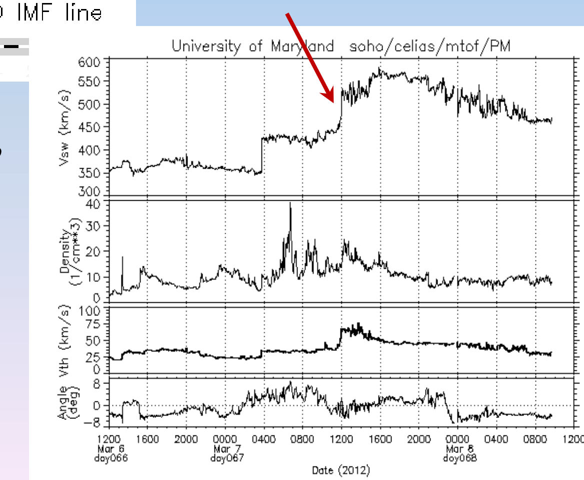
* The WSA-Cone-ENLIL Model



- We used 3D MHD code, the WSA-Cone-ENLIL Model (Odstrčil et al., 1996, 1999, 2005).

- The code calculates the time-dependent behavior of the ideal fluid due to various initial and boundary conditions.

shock-like structure at 1 AU



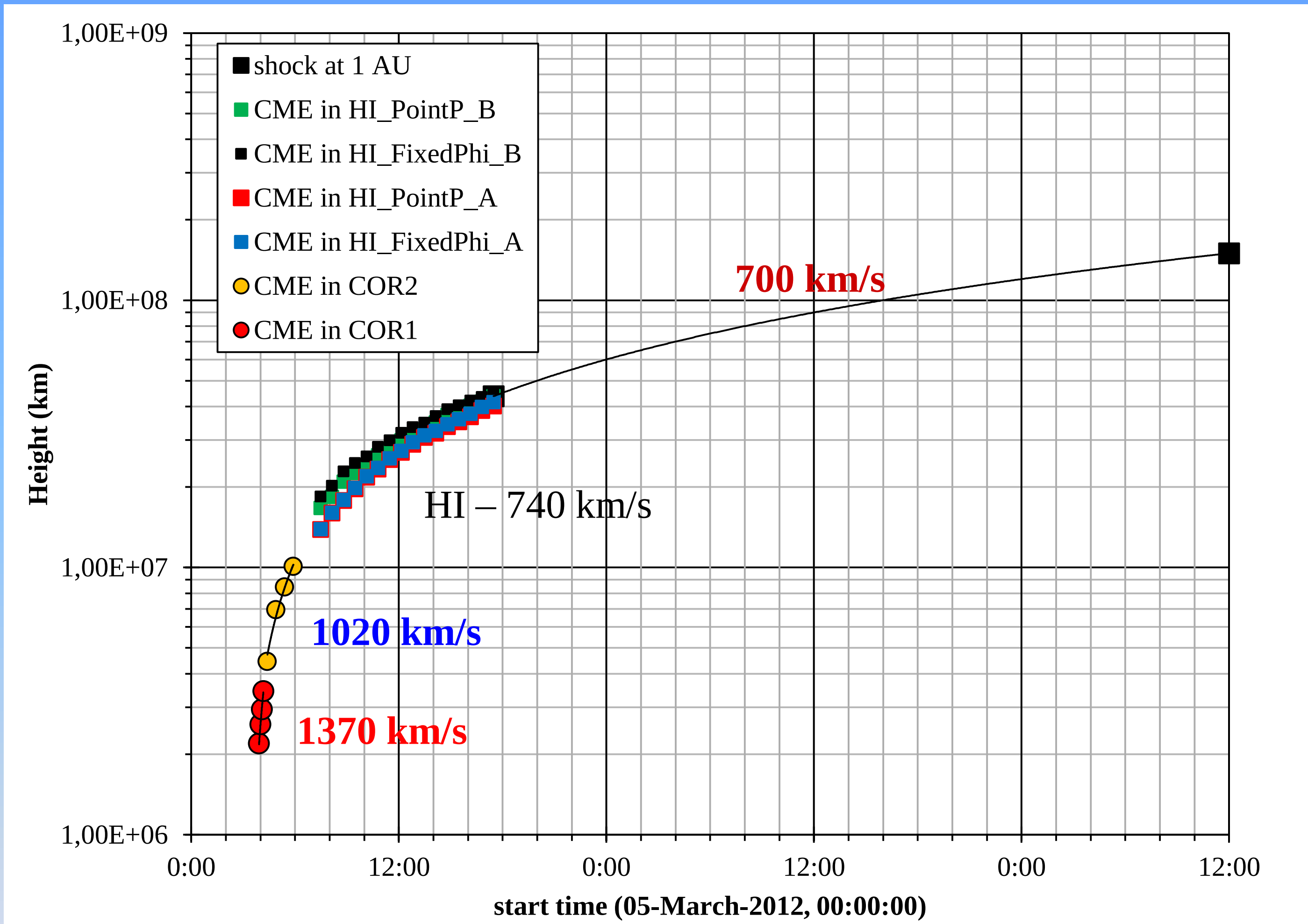
- The CME parameters obtained from the CME reconstruction (latitude, longitude) and the CME speed at 21.5 Ro were input to the model.

- Model predicts

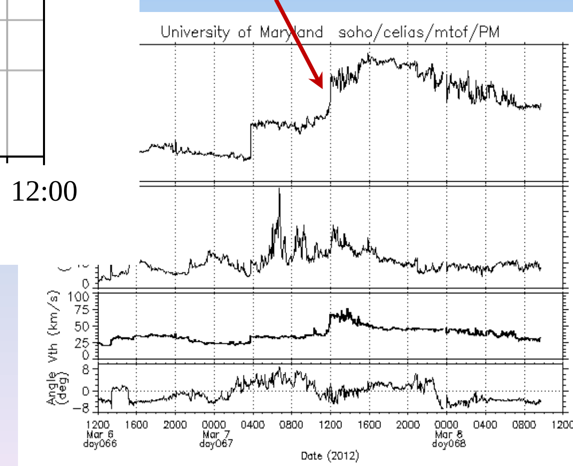
→ the CME arrival time at 1 AU 08:34±7 h on March 07, 2012.

→ that CME does not hit the STEREO B or impact is weak.

* Summary A

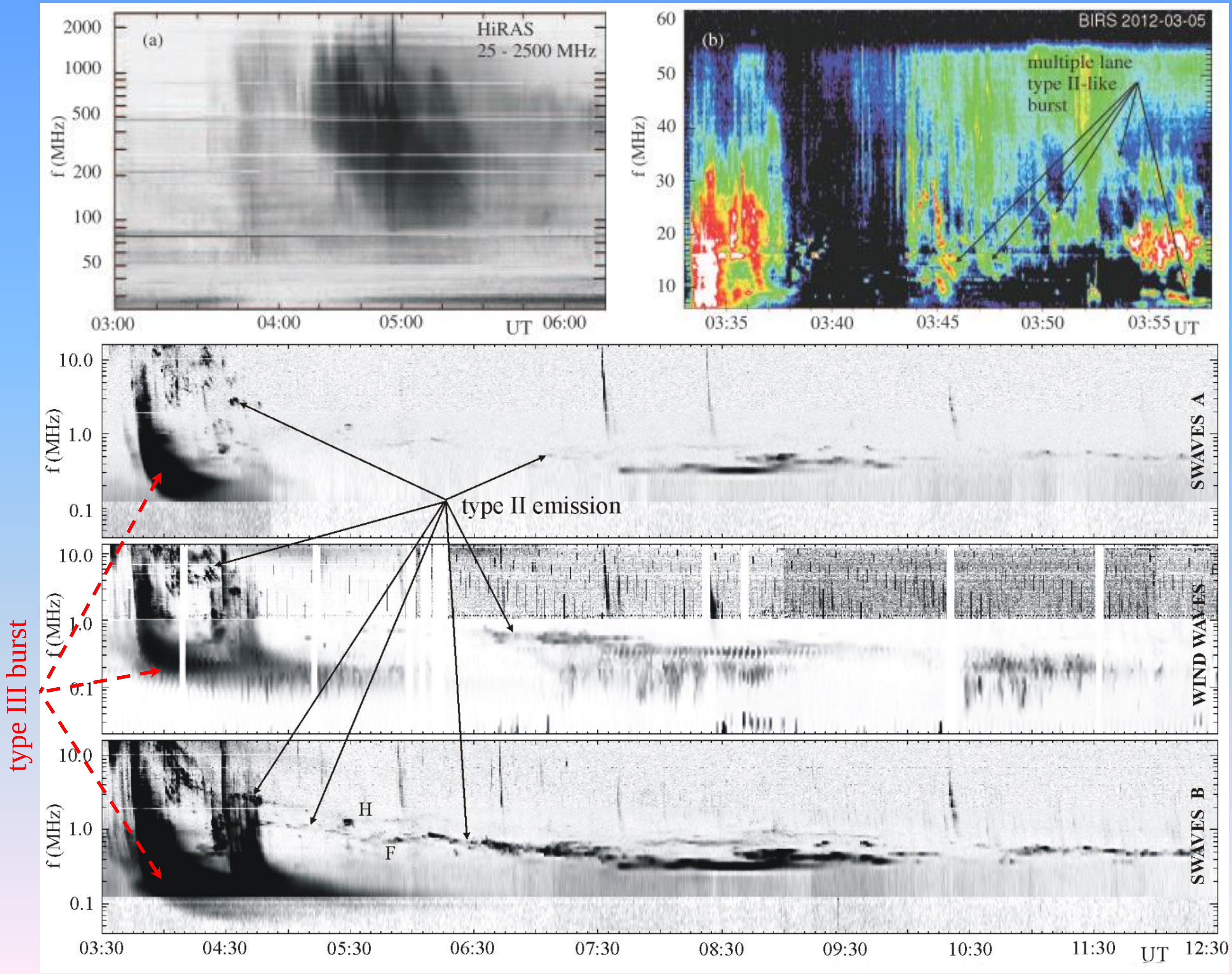


shock-like
structure at 1 AU

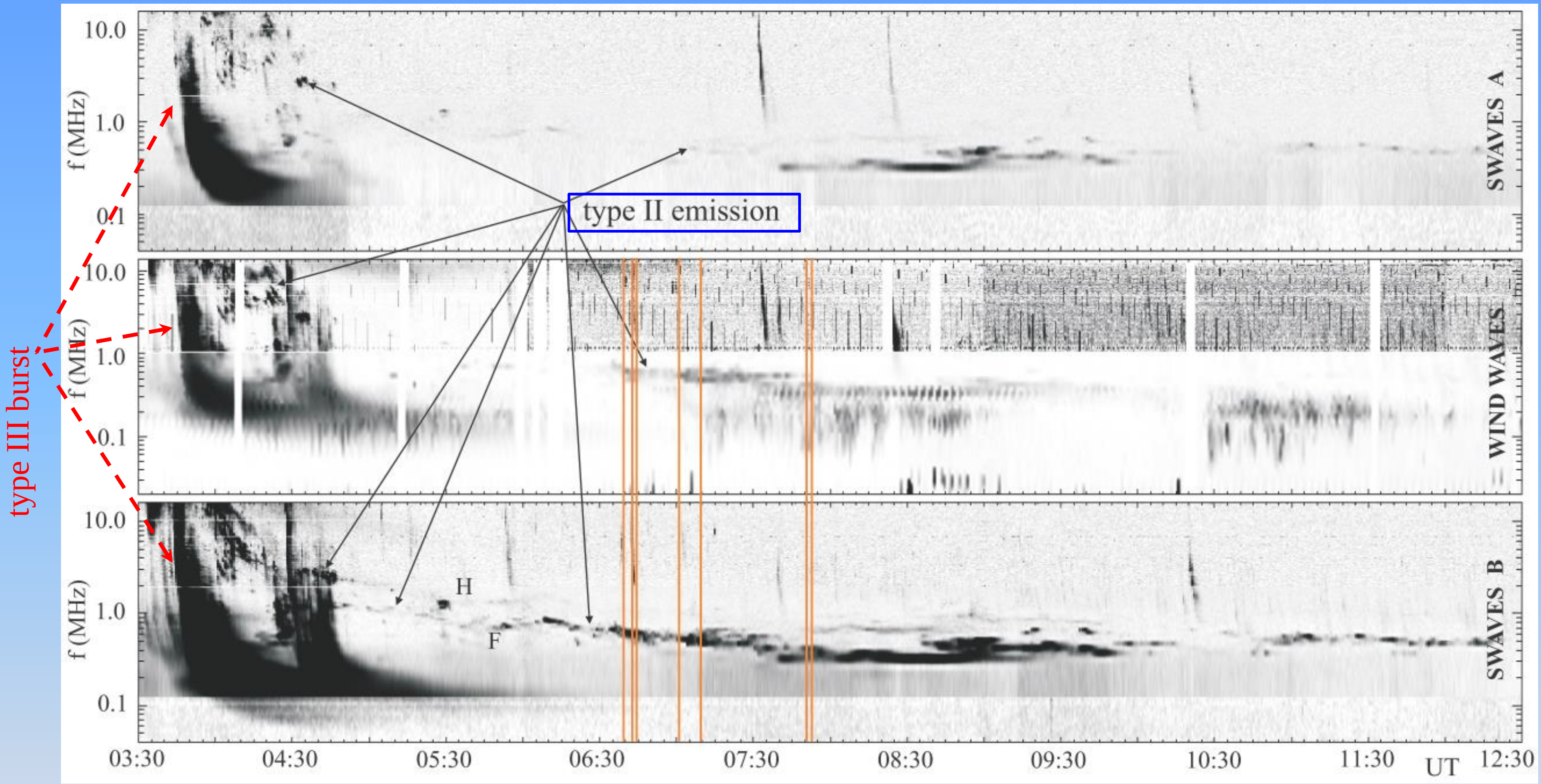


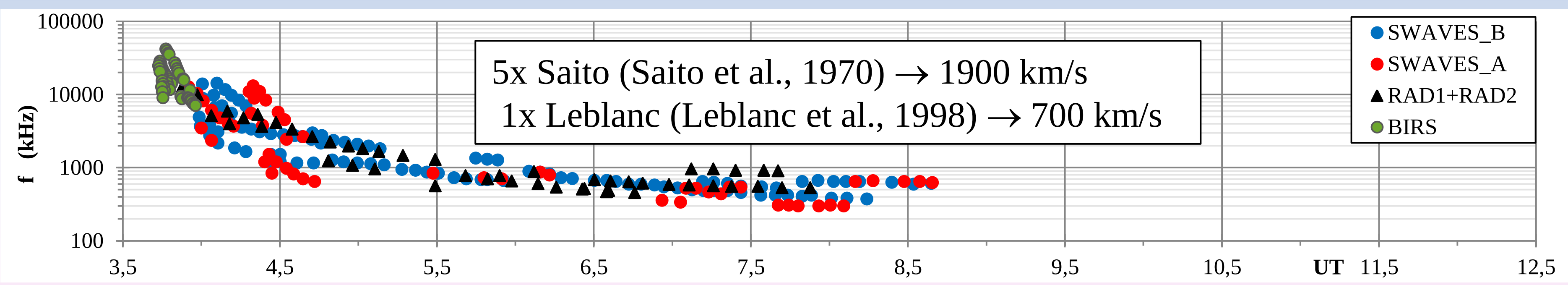
- shock-like structure arrived to the Earth (1 AU) at 12:00 on March 07, 2012, and to STEREO B at 18:00 UT on March 7.

* Radio observations, overview:

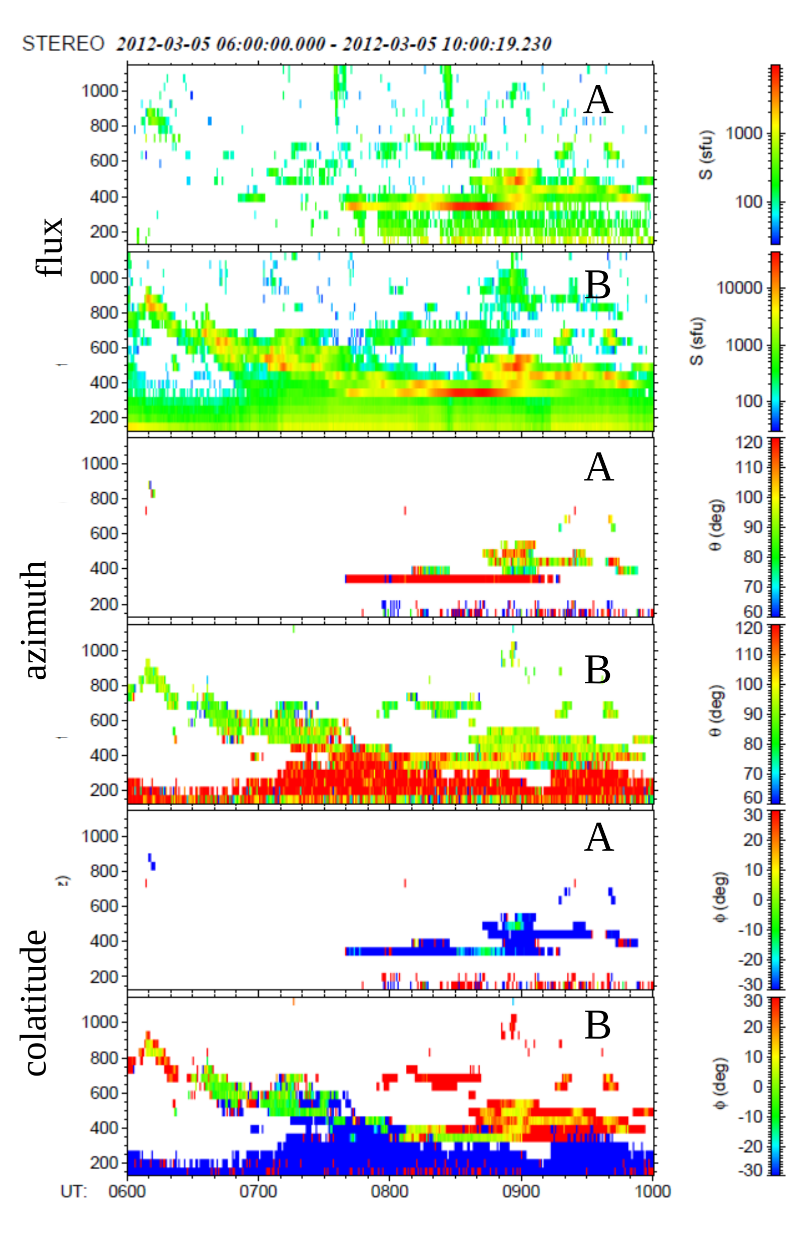


* Radio observations:





* Radio triangulation - goniopolarimetry



SWAVES

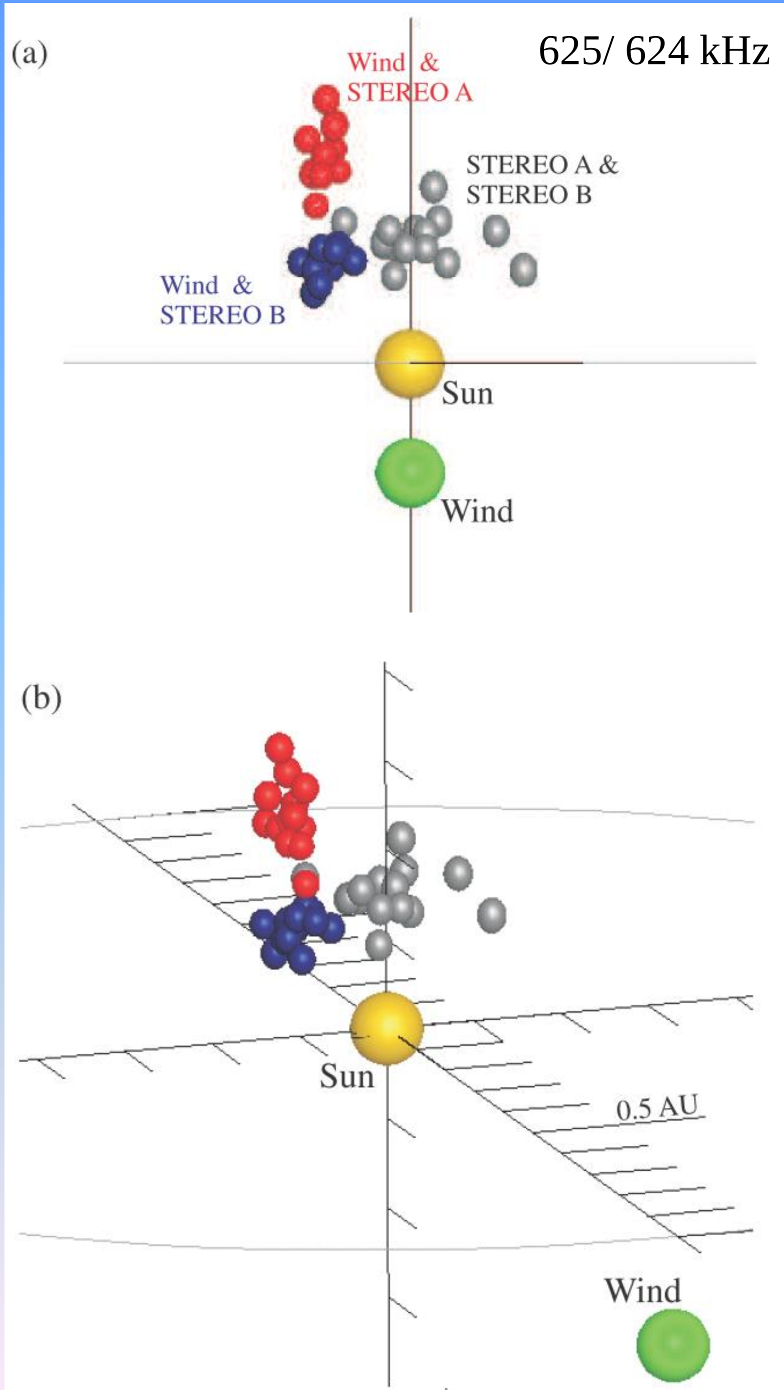
- Goniopolarimetric (GP) inversion of a signal measured on non-orthogonal antennas using the Singular Value Decomposition (SVD) technique (Krupar et al., 2012) was applied for SWAVES observations.

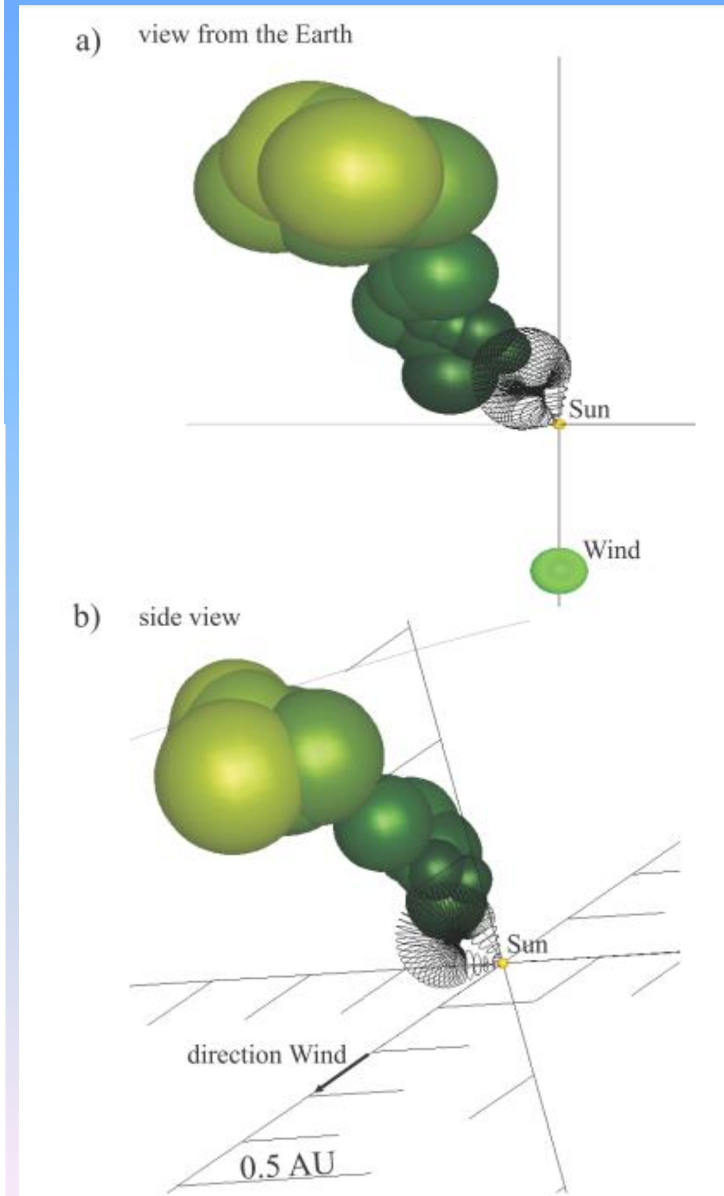
WIND WAVES

- For the WIND WAVES data we used the spinning demodulation goniopolarimetry - the direction finding method from Manning & Fainberg (1980).
- Determining the angular and polarization properties of low frequency radio sources from measurements made on a spinning spacecraft.

- The source size is obtained with the assumption of a uniform source brightness distribution (Manning & Fainberg, 1980).

* Position of the type III sources

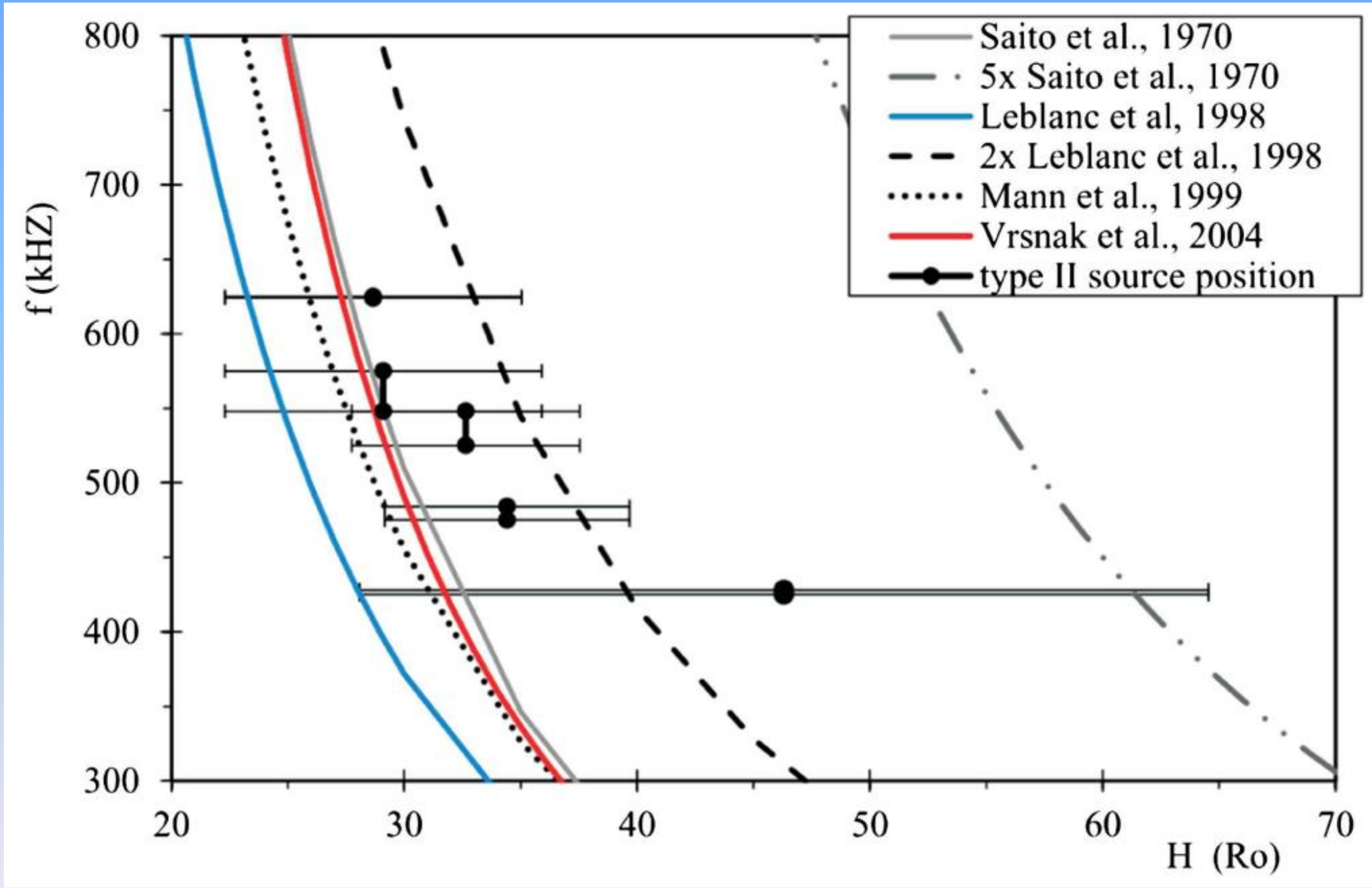




- Position of **type III radio sources** at 1025/1040, 825/804, **625/624**, 575/548, 525/548, 475/484, 425/428, 325/332, 275/292, 225/224, 175/176 kHz

* Radio triangulation of type II burst

- Selected frequency pairs **625/624, 575/548, 525/548, 475/484, 425/428 kHz,** at STEREO B & WIND, respectively.



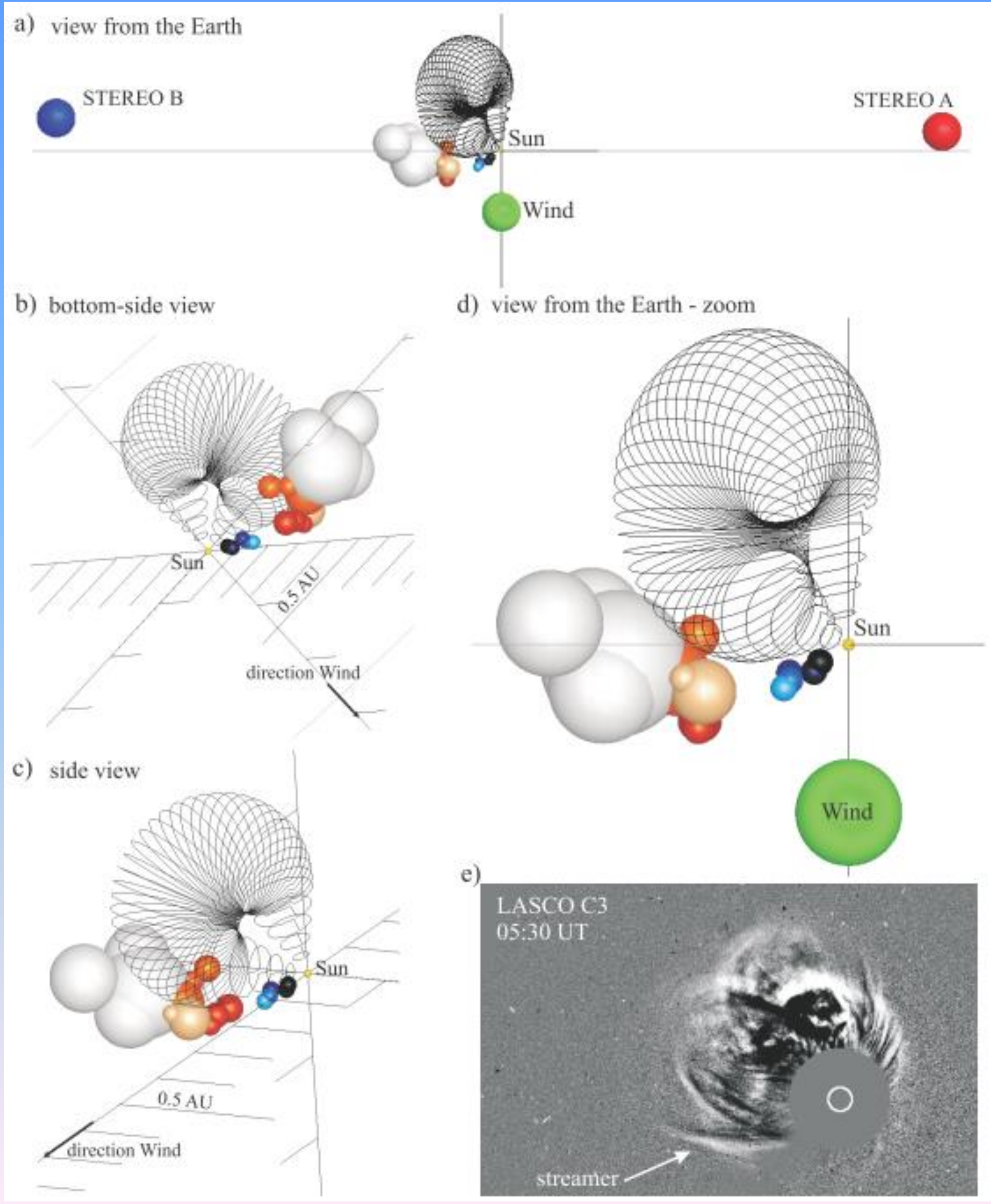
- The coronal electron density is found to be between 1-fold and 2-fold Leblanc.

* Summary B: Position of the type II burst sources & streamer in space

- Positions of **type II radio sources** at 425/428, 475/484, 525/548, 575/548, 625/624 kHz.

- Radio triangulation shows
  → the source of the type II radio burst was situated southward of the CME nose, i.e. at the southern flank of the CME

  → indication that the interaction of the shock wave and the streamer resulted in the enhanced emission of the type II burst.

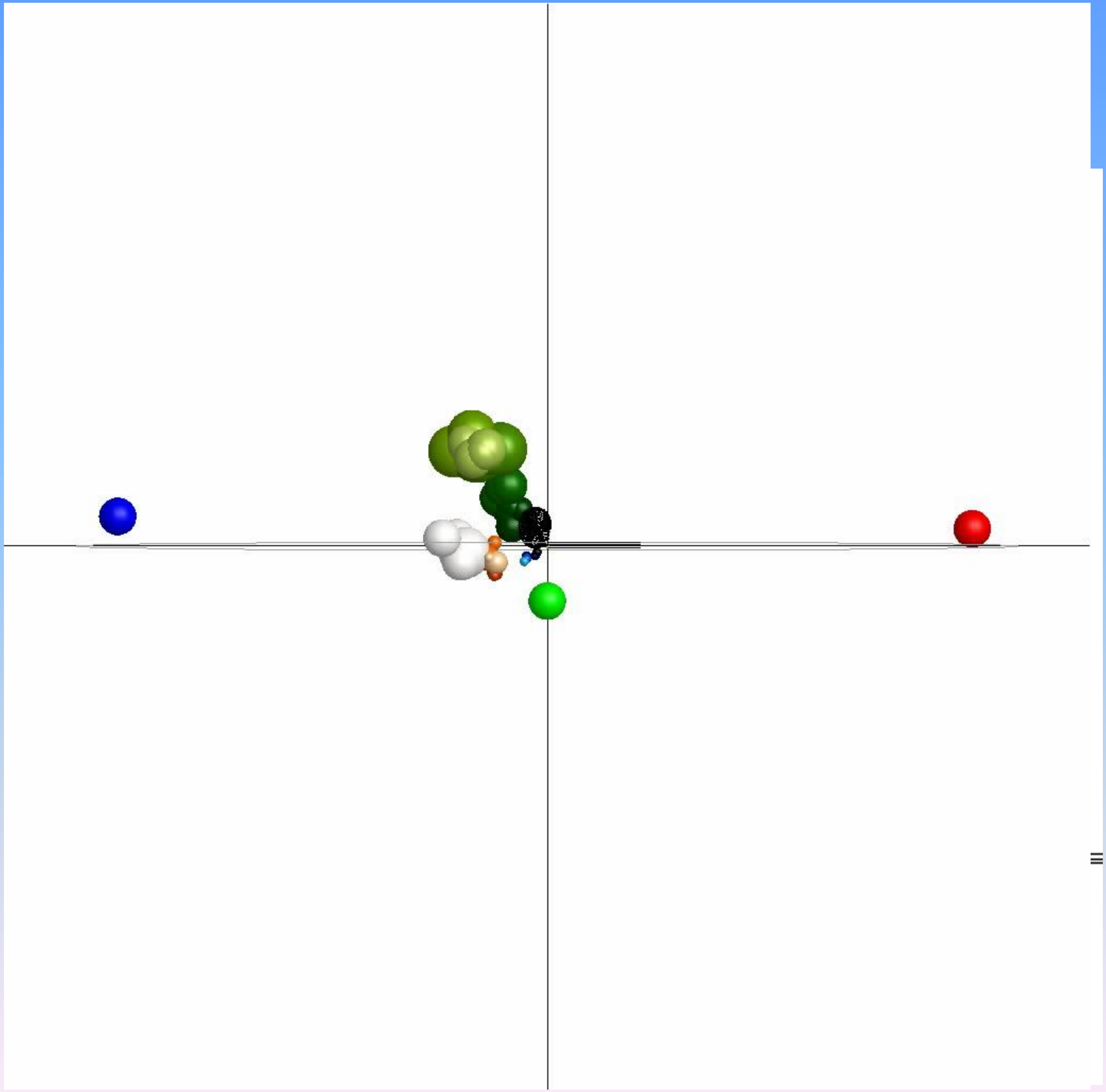


* Position of the type III, type II burst sources & streamer in space

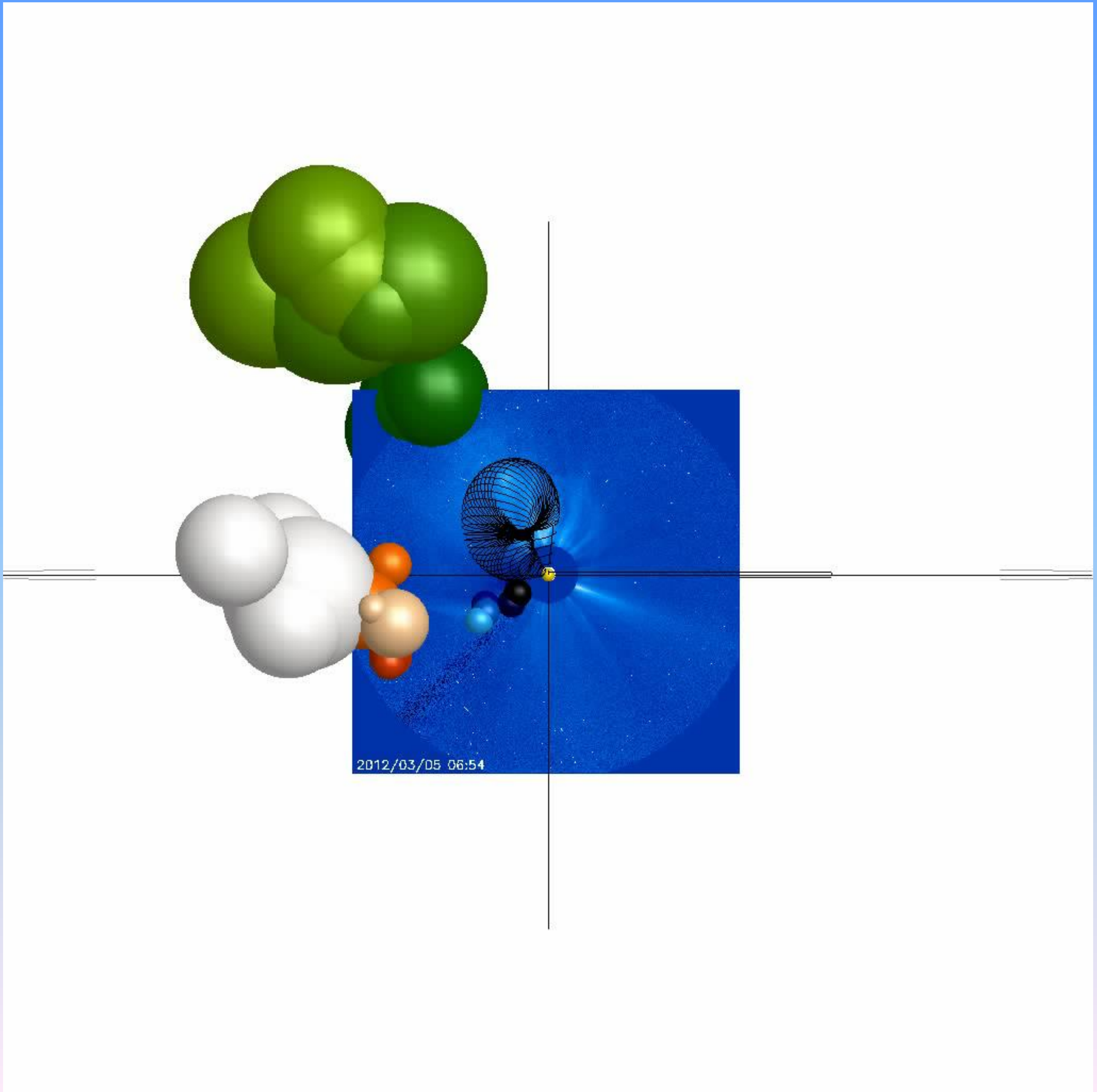
- **type II radio sources** at 425/428, 475/484, 525/548, 575/548 and 625/624 kHz

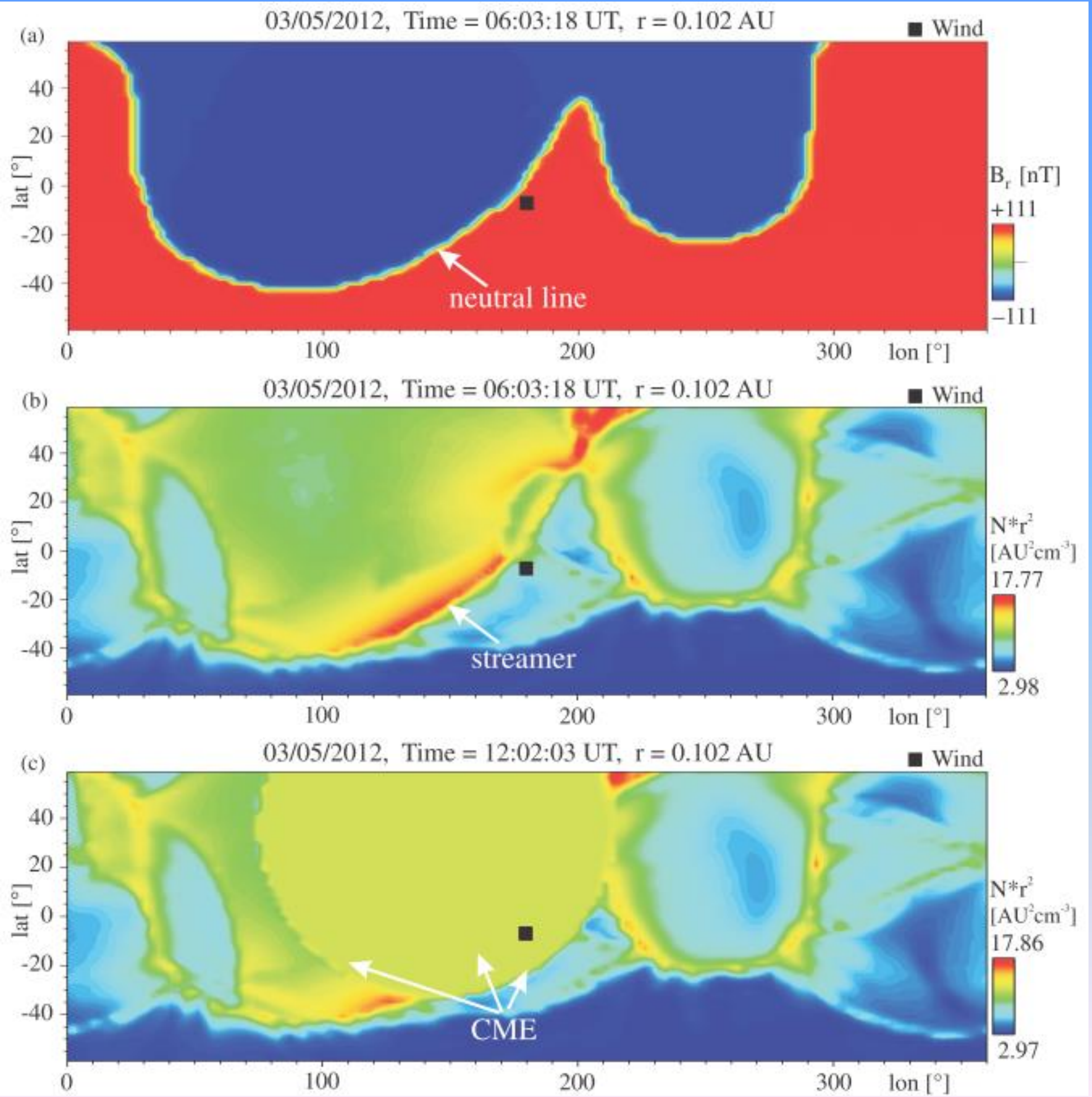
- **type III radio sources** at 1025/1040, 825/804, 625/624, 575/548, 525/548, 475/484 and 425/428 kHz

The type II burst source sizes (source half width angle) → comparable (20° to 40°) with the source sizes of the type III radio bursts.



* * Type III, type II burst sources & streamer in space





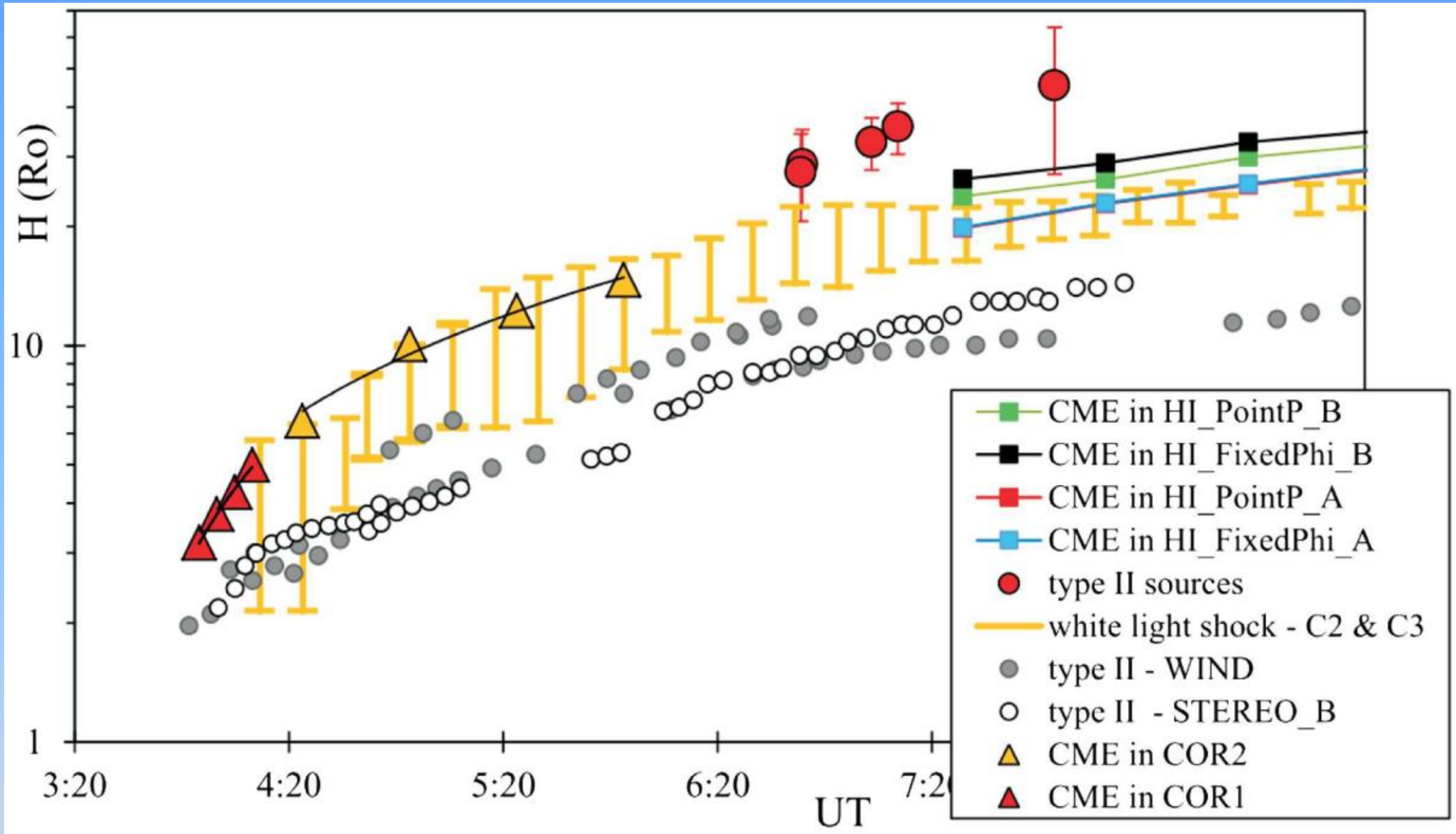
* The WSA-Cone-ENLIL Model

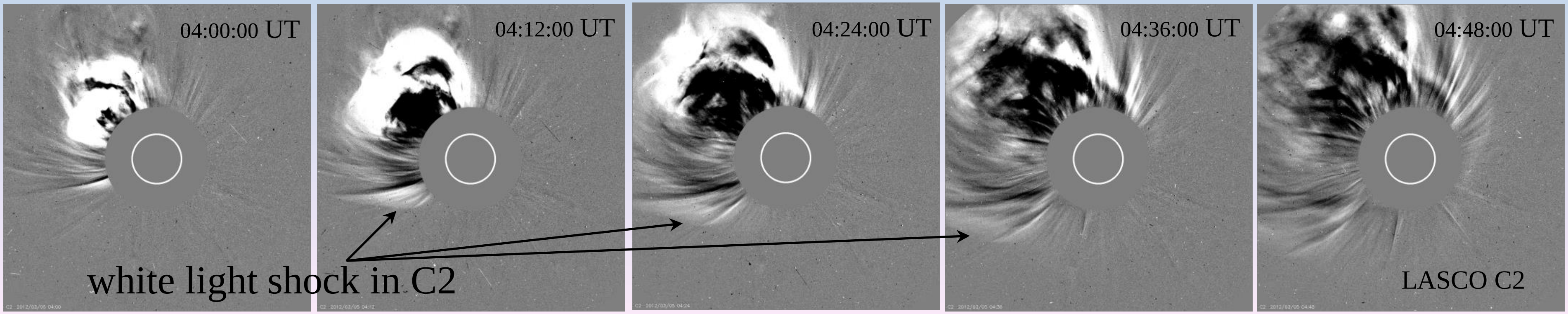
Synoptic maps of the magnetic field/ particle number density (scaled with the radial distance) in the high corona.

The considered radial distance is 0.102 AU.

* Summary C

The heights of the CME & type II source correspond to different radial directions (along the CME nose and along the CME flank respectively).





* Conclusions:

- The results of our study (3D reconstruction of a CME and modeling with the WSA-Cone-ENLIL Model) show that the CME-driven shock wave of the March 5, 2012 event arrived at 1 AU at about 12:00 UT on March 7.

- Coronagraphic observations show the white light shock at the flanks of the CME.

- Radio triangulation shows that the source of the type II radio burst was situated southward of the CME nose, i.e. at the southern flank of the CME

$\rightarrow$ indication that the interaction of the shock wave and the streamer resulted in the enhanced emission of the type II burst.

THANK YOU
FOR YOUR ATTENTION!