Type II burst recorded at Humain associated with the CME/flare event on 18 March 2010

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* Introduction

• the coronal large-amplitude disturbances (shock waves, EIT waves)
can be generated by

CMEs or **flares** or **combination of both**?

→ still an open question

• physical relationship between CME/flare and coronal waves can be very complex

• flare-generated coronal shocks & CME-driven interplanetary shock waves
(e.g. Gopalswamy *et al.,* 1998, Sheeley *et al.,* 1984, Vršnak *et al.,* 1995)

• CME-driven coronal and interplanetary shock waves
(e.g. Cliver *et al.,* 1994, 2004, Gopalswamy *et al.,* 2001, Liu *et al*., 2009)

• flare-generated coronal shock waves associated with slow CMEs
(Magdalenić et al., 2008, 2010)

• multiwavelength study of CME/flare event on 18 March 2010

• ROB coordinated observations: Humain, PROBA2 (SWAP, LYRA)

* Radio observations

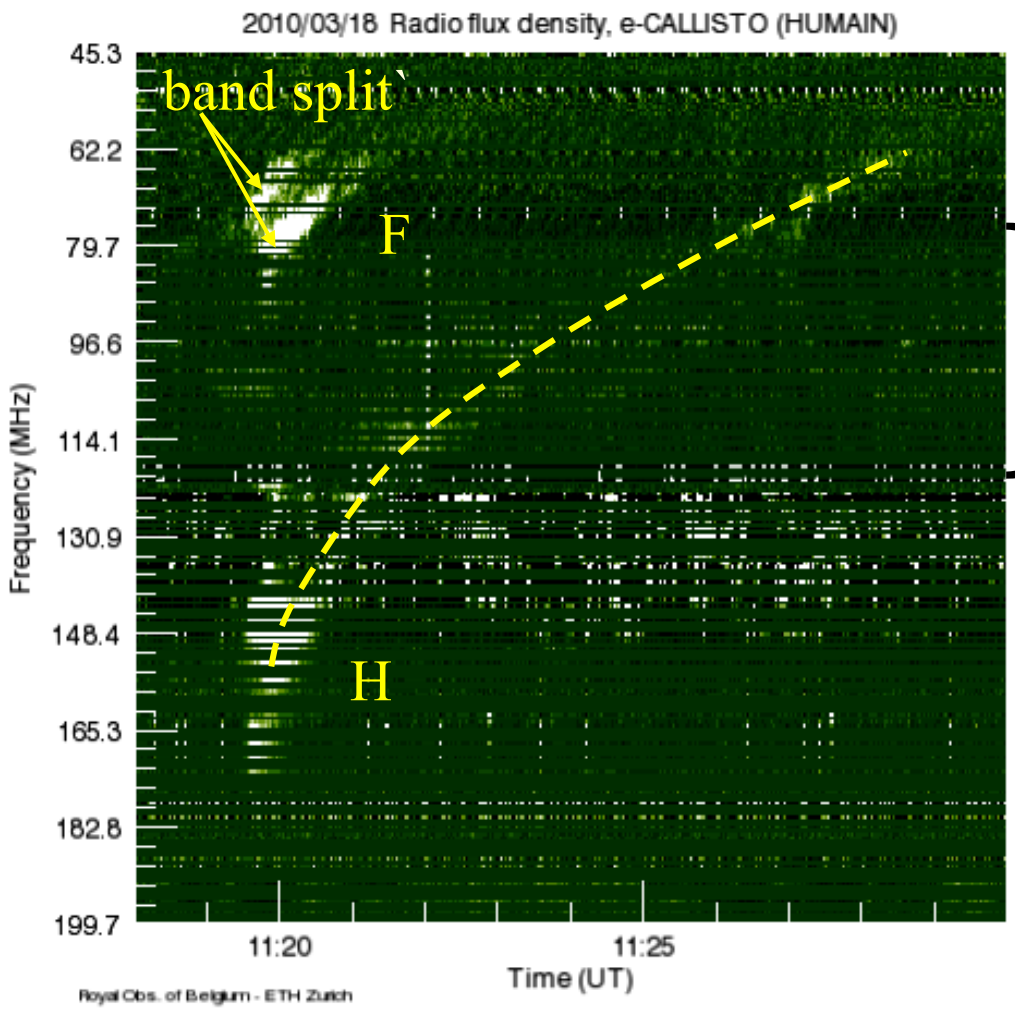
- 3x Saito coronal density model
- the type II burst fundamental band

→ $v_{typeII} \approx 1100$ km s^{-1}

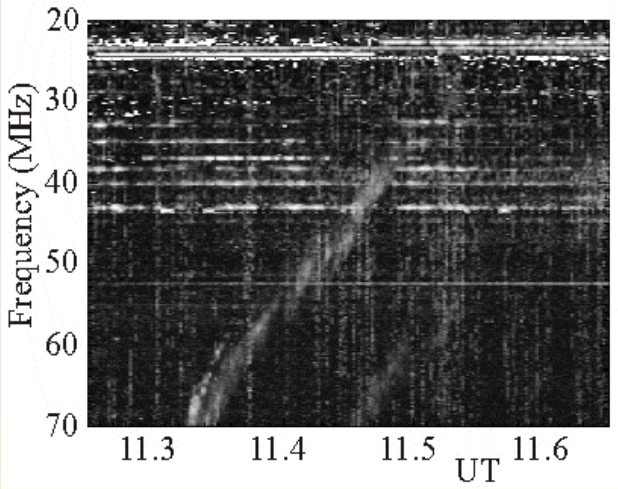
- the type II burst harmonic band

→ $v_{typeII} \approx 1100, 700$ km s^{-1}

Humain Callisto Spectrometer (SIDC, Belgium)

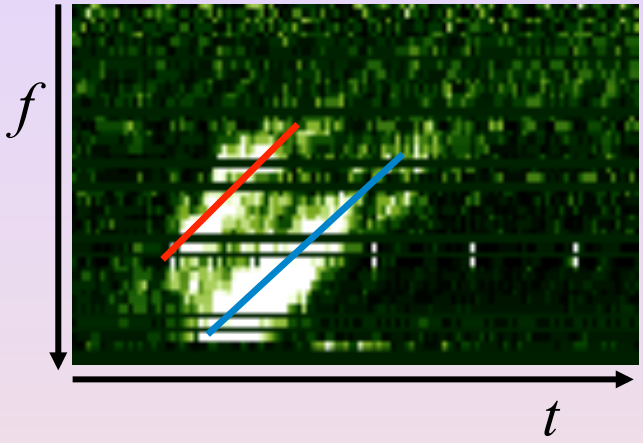


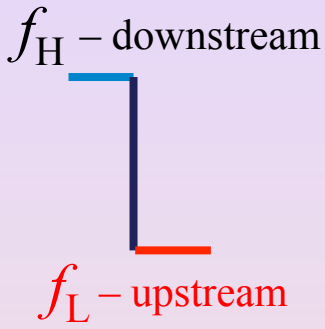
Ootacamund (Ooty) Callisto Spectrometer, (Tamil Nadu, India)



Nancay Decameter Array (DAM), Paris, France

* type II band split





- band-split of type II bursts
  → plasma emission from the upstream and downstream shock regions
  (Smerd *et al.* 1974, 1975; Vršnak *et al.* 2001, 2002, 2004)

relative band-split *BDW* → compression *X*

$$BDW = \frac{f_H - f_L}{f_L} = \sqrt{\frac{n_H}{n_L}} - 1 \qquad X = \frac{n_H}{n_L} = (BDW + 1)^2$$

Alfvén Mach number M_A & Alfvén velocity v_A

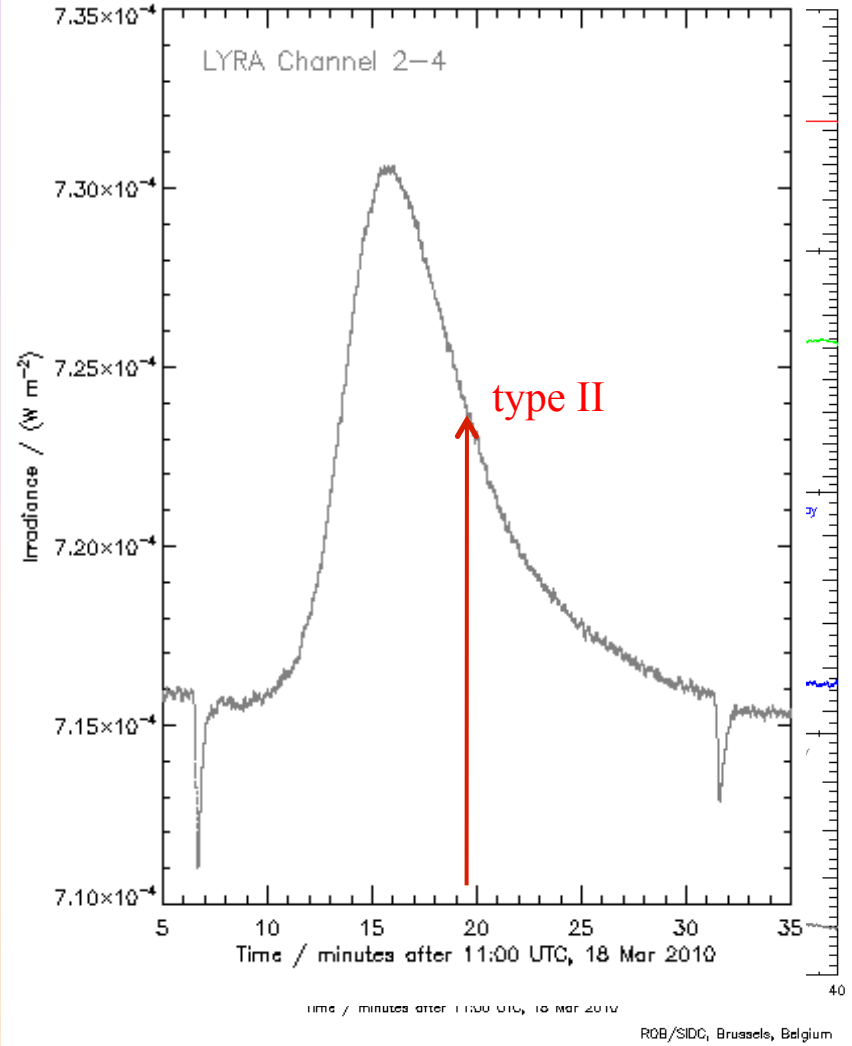
$$M_A = \sqrt{\frac{X(X + 5 + 5\beta)}{2(4 - X)}} \qquad v_A = \frac{v_S}{M_A}$$

M_A=1.15

v_A= 950 km s^{-1}

* Characteristics of the flare on 18 March 2010

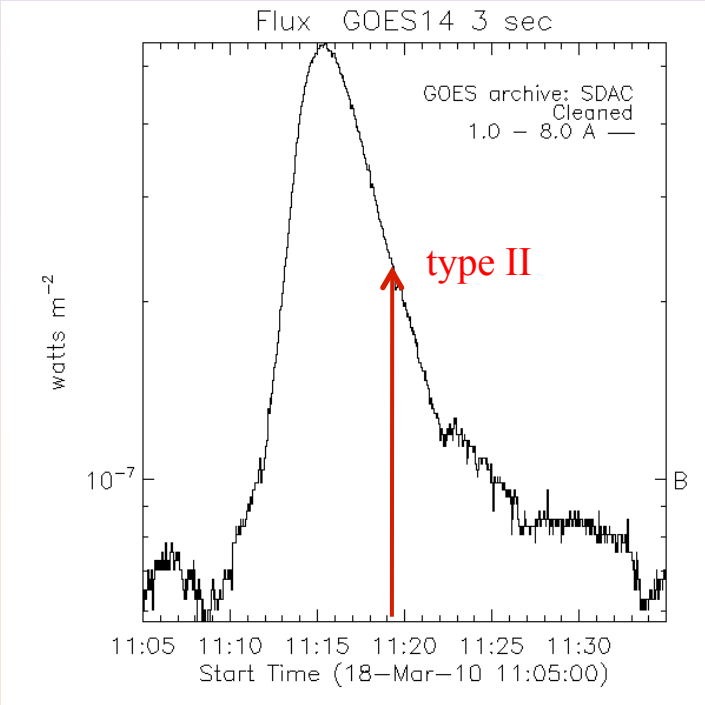
LYRA (PROBA 2)



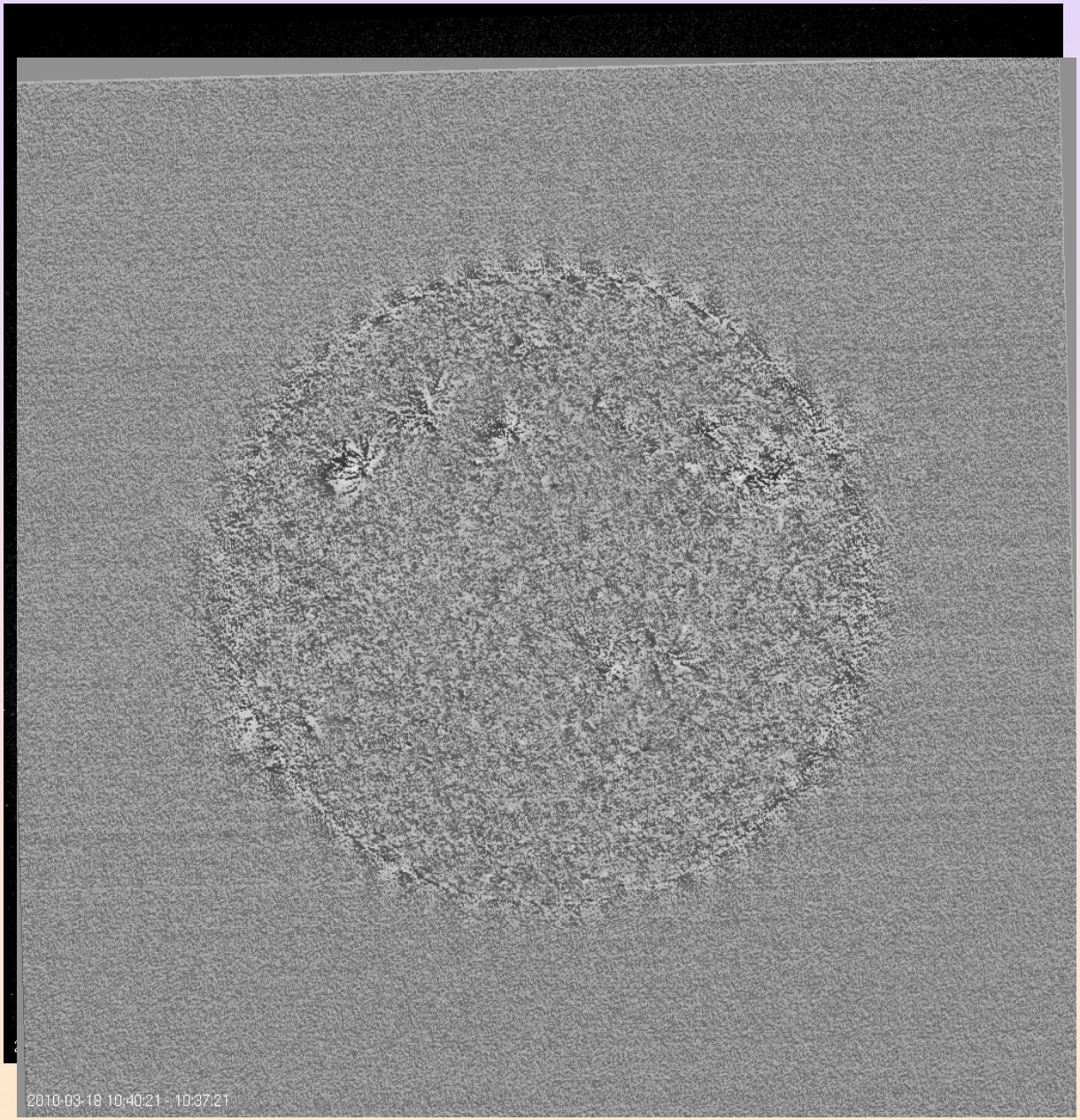
GOES 14 (1 - 8 Å)

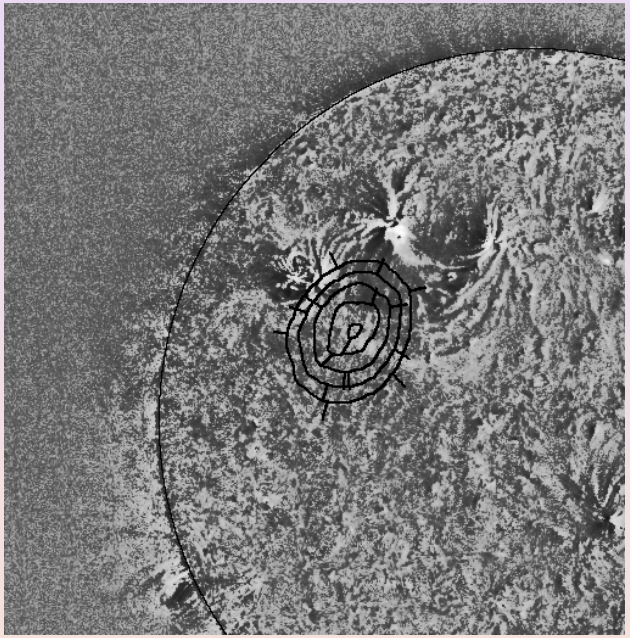
- B5.3 flare
- NOAA AR 1056, N17° E47°

11:09:00–11:15:30–11:27:00 UT



** SWAP (PROBA 2)



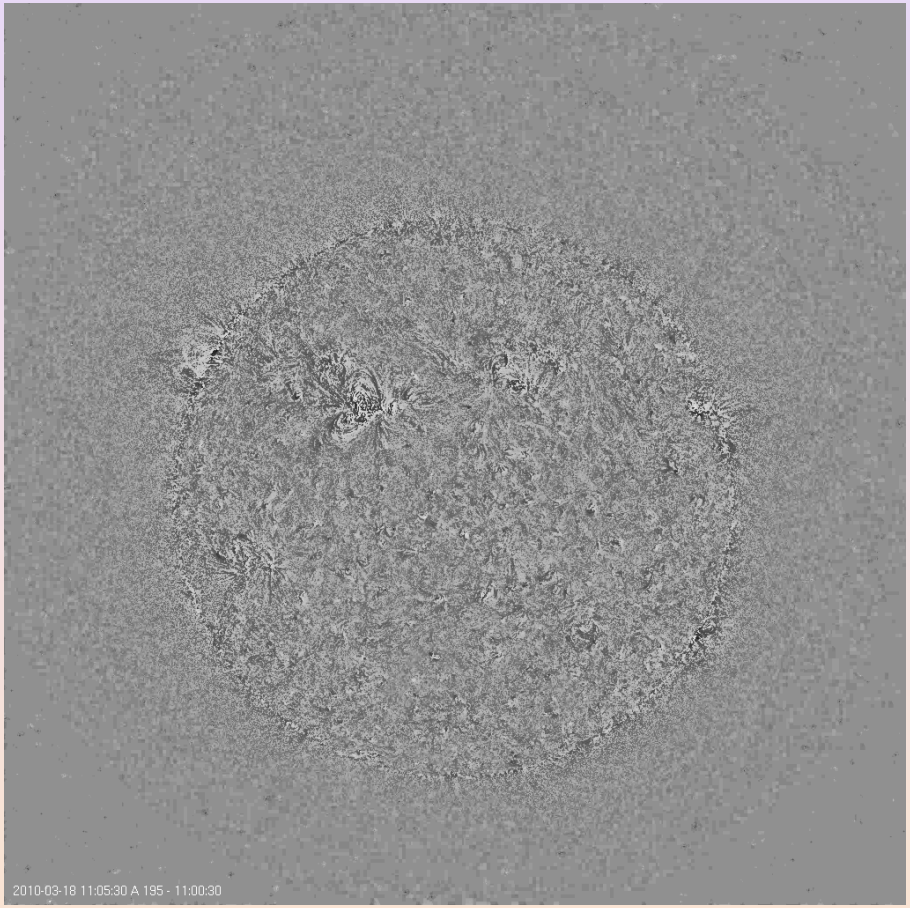


- NRH source 11:19:58 UT
- SWAP image 11:19:21-
  11:04:21 UT

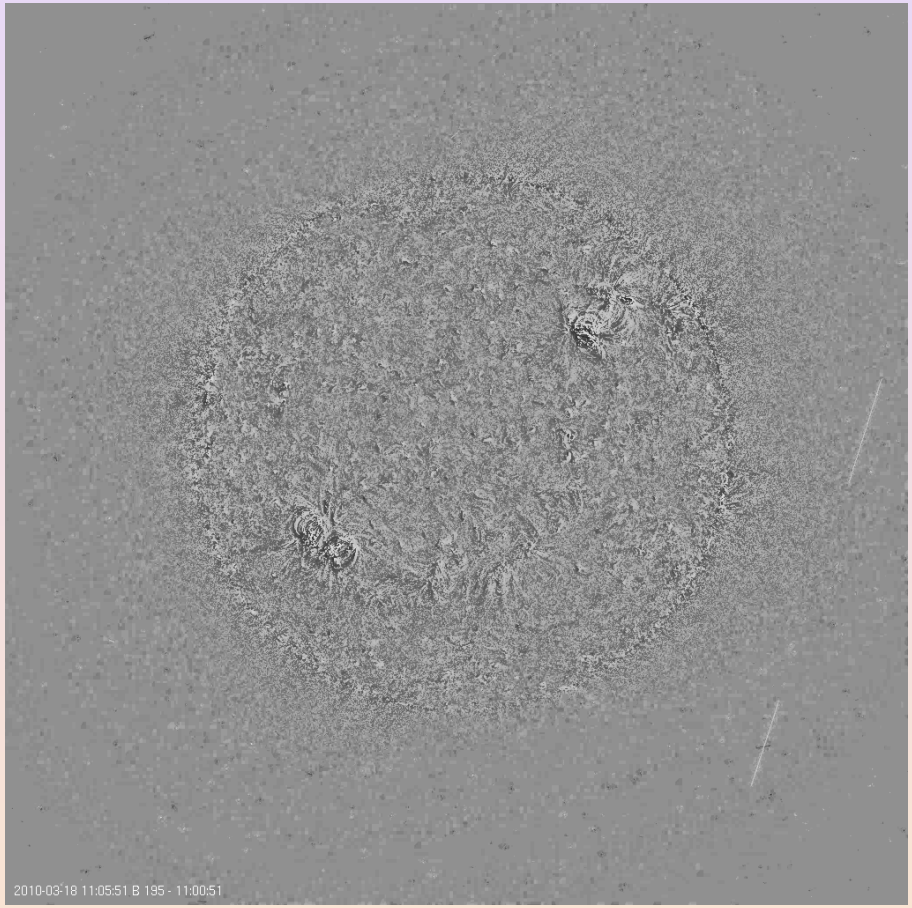
- flare started at 11:09 UT

** SECCHI EUVI (STEREO)

EUVI A



EUVI B

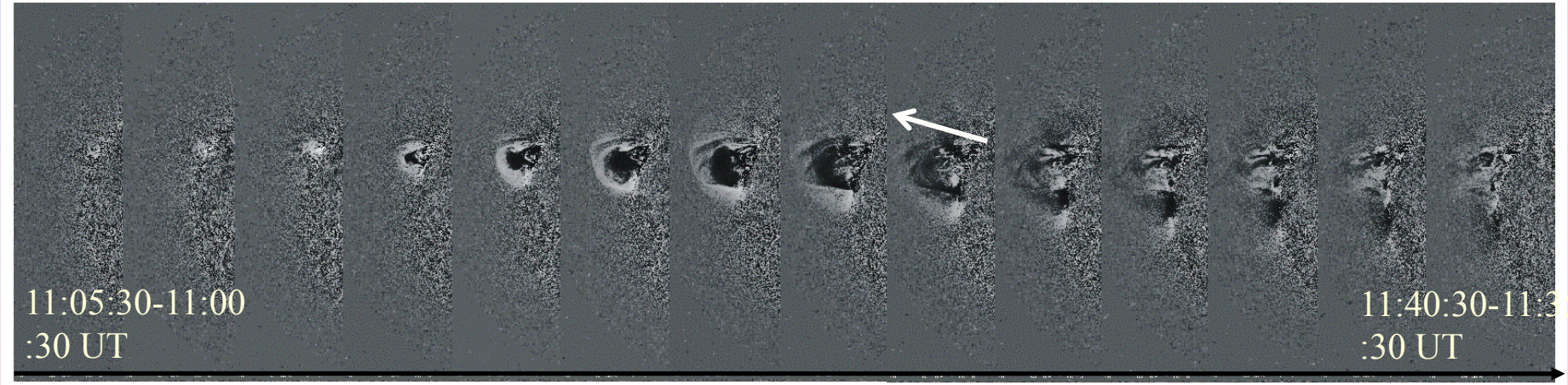


- the radial speed of the EIT wave → 450±30 km/s

- the speed of the EIT wave along the solar surface → 300±30 km/s

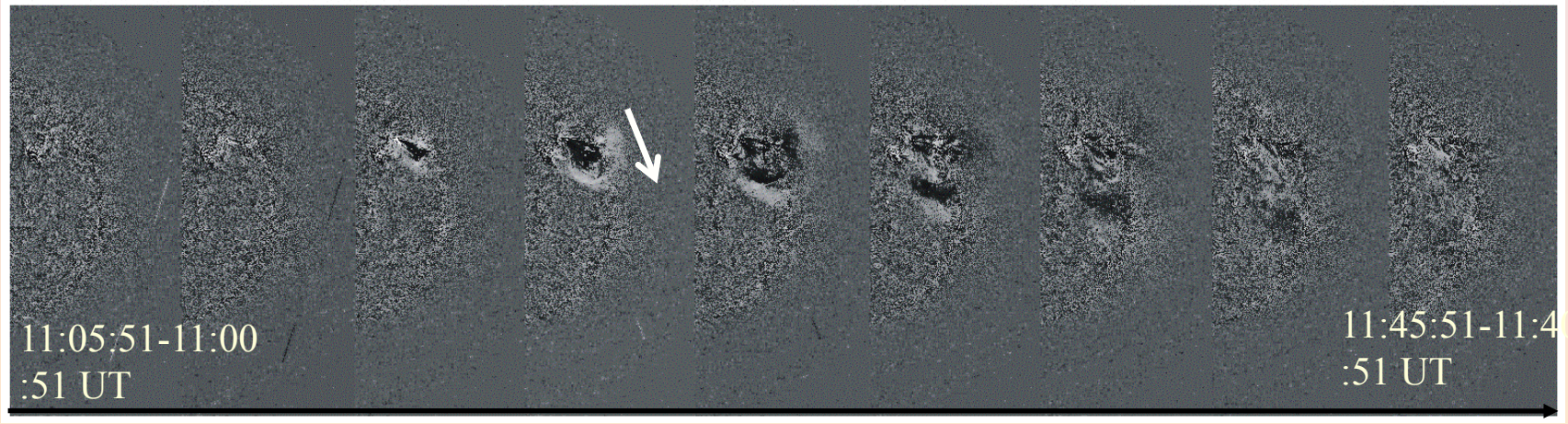
** SECCHI EUVI (STEREO)

EUVI A – running difference images



• the radial speed of the EIT wave → 450±30 km/s

EUVI B – running difference images

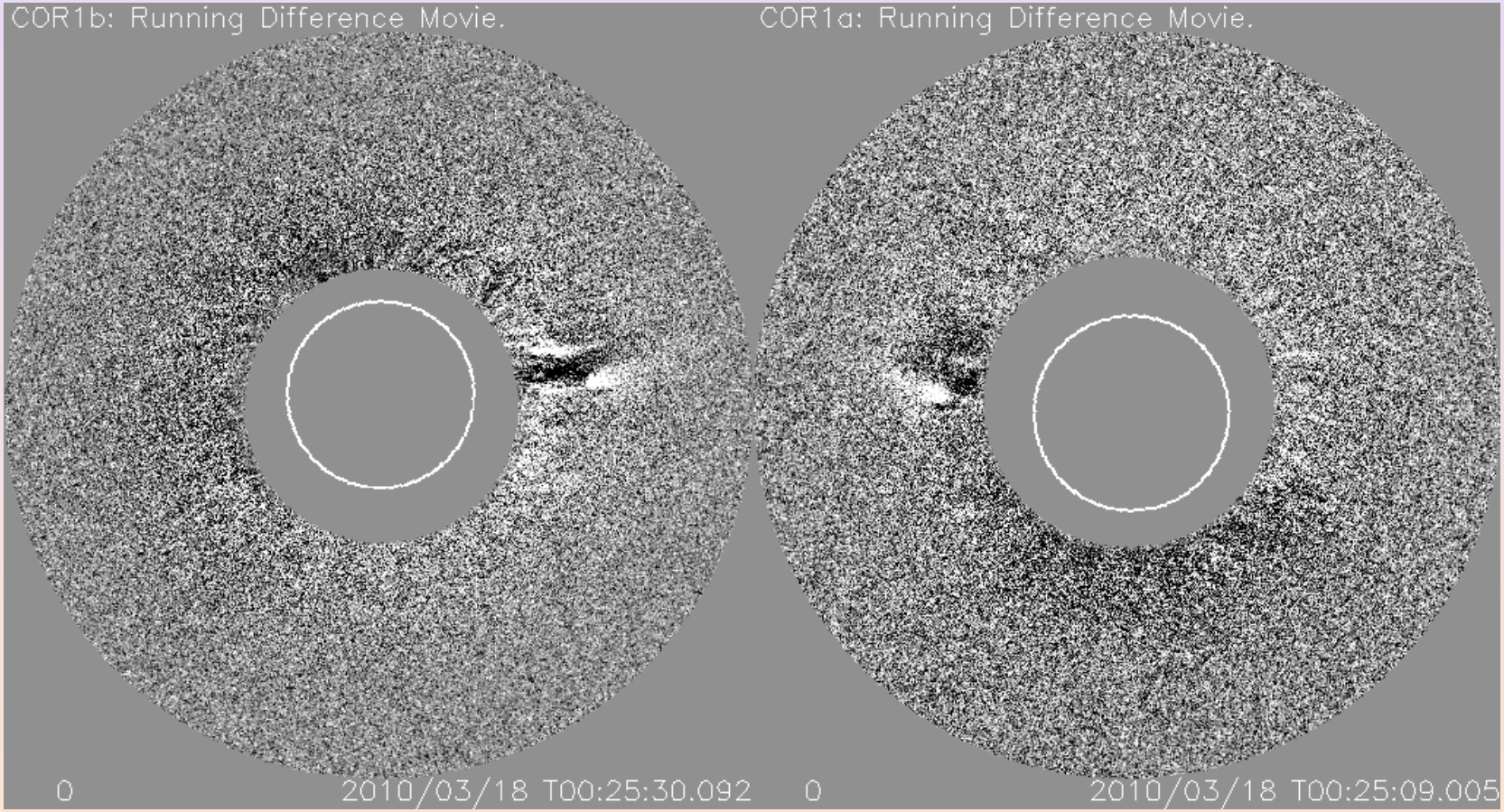


• the speed of the observed EIT wave along the solar surface → 300±30 km/s

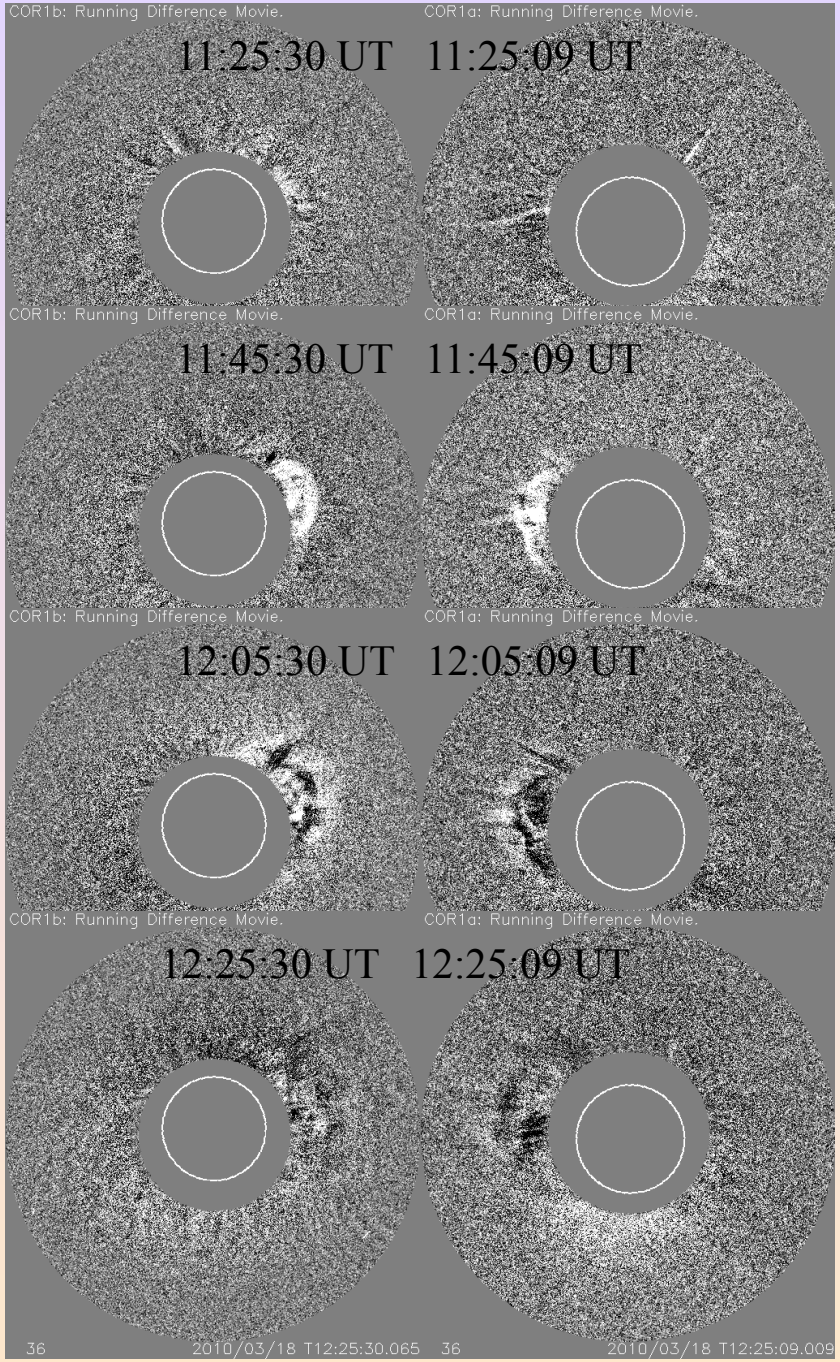
* STEREO SECCHI COR1

COR1 – B
- east directed CME

COR1 – A
- north-west directed CME



- faint eruption first observed at 11:25 UT at height of 0.6 R_O
- $v_{CME} \approx 350$ km/s



* * STEREO SECCHI COR1

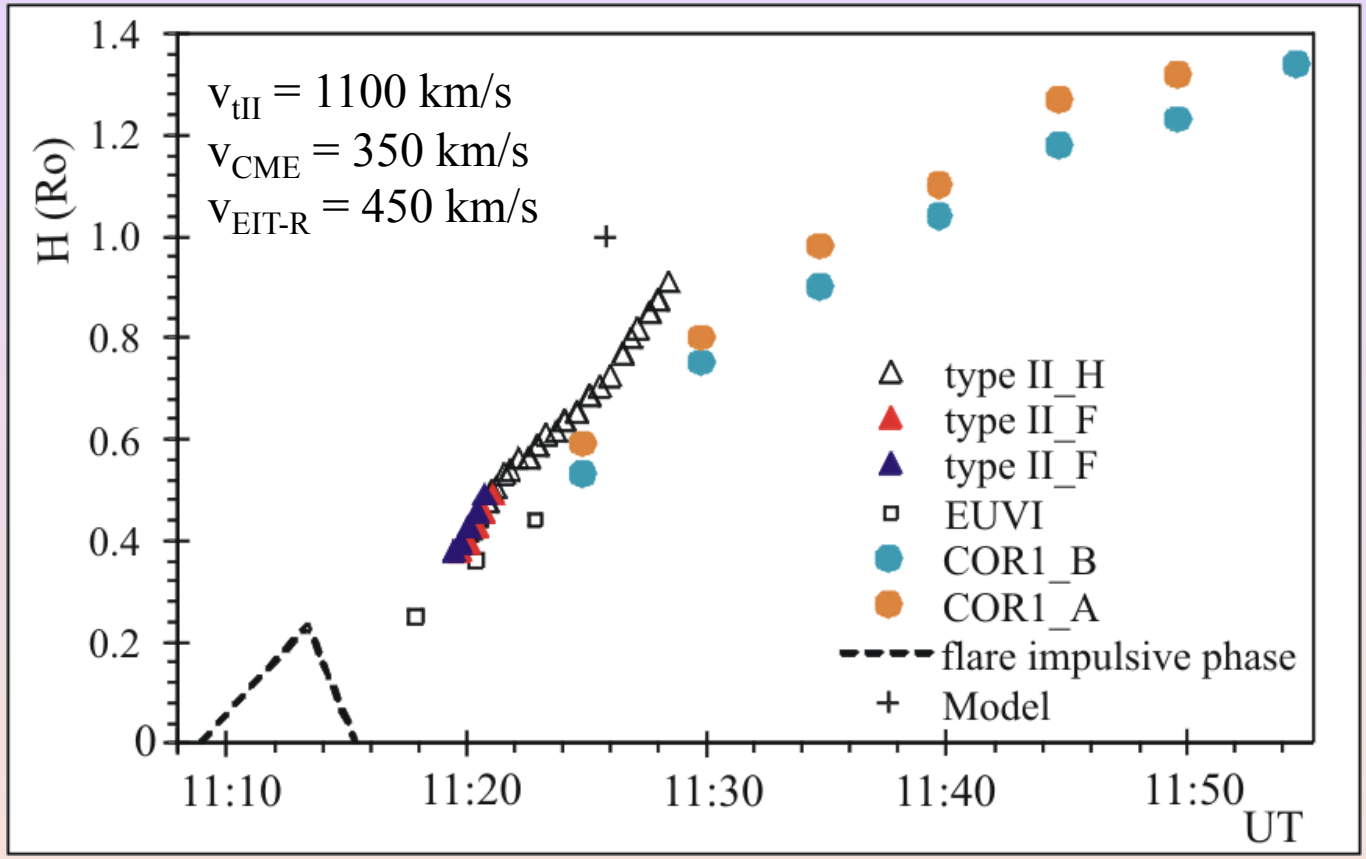
- faint eruption – quickly 'disappearing' CME
- first observed at 11:25 UT, at height of 0.6 R_O
- $v_{CME} \approx 350$ km/s

* STEREO SECCHI COR2

COR2 - A

- weak and narrow CME that quickly ‘disappears’

* Kinematics



→ bow shock scenario can be excluded since CME was subalfvénic

→ theoretical model 3D piston scenario by Žic et al. (2008)

v_A = 950 km/s, r_O=100 Mm & v_{CME} = 0 – 700 km/s (350 km/s)

→ dt = 8 min, ds = 520 Mm (0.7 Ro)

* Summary

• A signature of a propagating coronal shock wave – a type II radio burst (11:19 UT) – was observed on 18 March 2010.

• The velocity of the shock is about 1100 km/s
and decreasing to about 700 km/s.

• The shock was associated with the B5.3 flare from the AR on the disc (S06° E60°).

• The EUVI observations show EIT wave propagating with the speed of (300 – 450) ±30 km/s.

•The associated CME first appears at 11:25 UT at a height of 0.6 R_O, $v_{CME} \approx 350$ km/s.

• The theoretical model by Žic et at. (2008) predicts CME-driven shock formation after the passage of the type II burst, and at significantly larger heights.

→ coronal shock → flare-generated?

Thank you for
your attention.