Study of a CME-driven shock with EUV, visible light and radio observations

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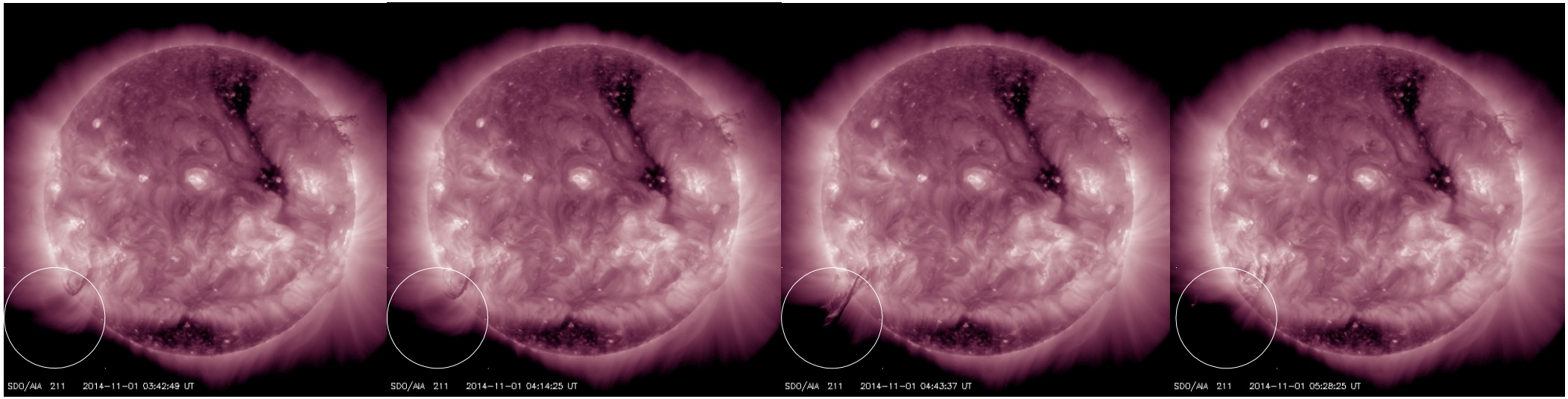
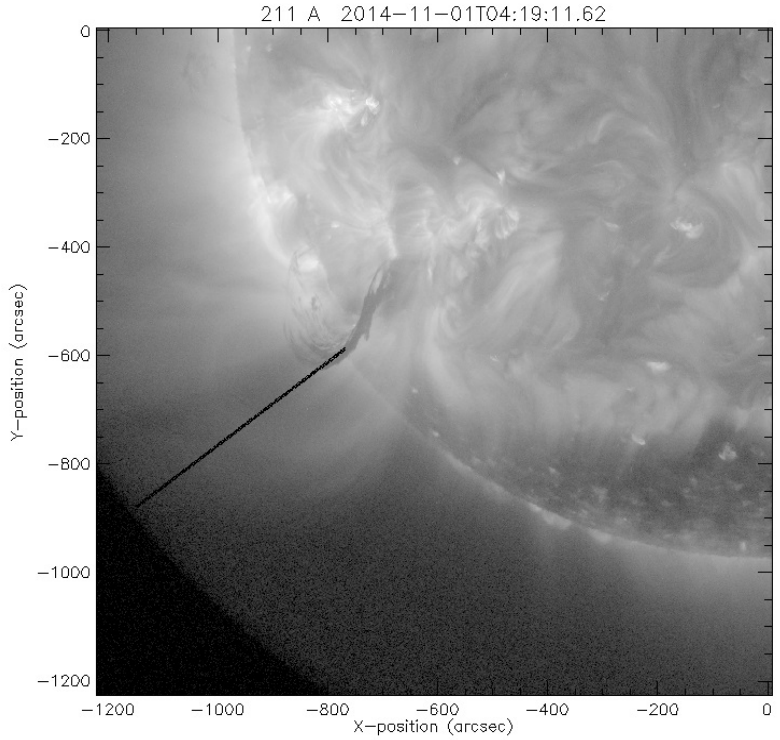
In order to understand the physics of Interplanetary Shocks it is very important to have information on their early excitation and propagation phases



Date : 1st November 2014
Prominence eruption (Source region S22E52)
resulted in a fast CME → front speed ~ 1600 km/s
partial-halo (width ~ 160 deg)
Flare associated (at 04:44 UT) → C2.7

Time range observation→ [03:00 UT – 05:30 UT]

Preliminary study (kinematics) of the erupting prominence and of the expanding flux-rope during the early acceleration phase



The event has been studied in with SDO/AIA at 211A and PROBA2/SWAP at 174A (used because of its larger field-of-view). In every image a radial slice was taken. The slice is long $0{,}5R_{sun}$ and $0{,}98R_{sun}$, in SDO/AIA and PROBA2/SWAP respectively and and its inclination with respect to the equatorial plane is is 37,5 deg.

Structure 1

Linear motion → Ht_0~1,33 R_{sun}

V~53.90 km/s

Accelerated motion → Ht_0~1,35 R_{sun}

V_0~73.82 km/s

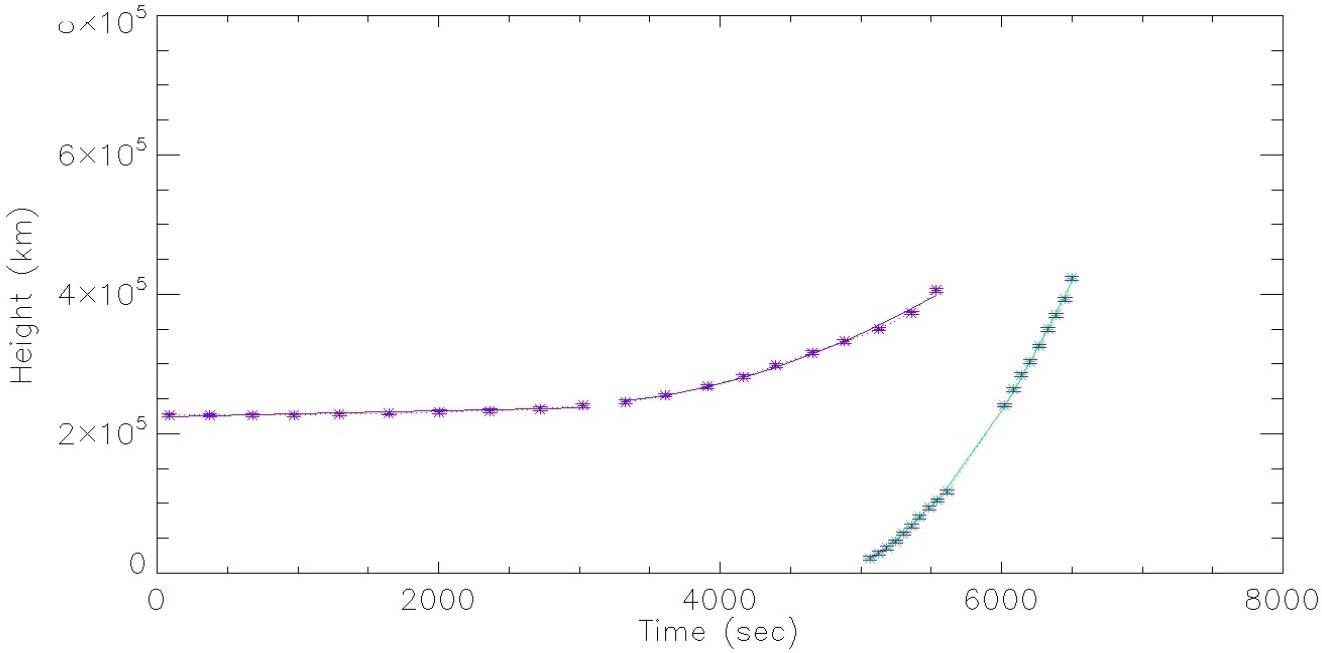
a~10,2 m/s²

Stucture 2

Accelerated motion → Ht_0~1,03 R_{sun}

A~51.09

m/s²



Observed velocities Vs Alfvèn velocities

In order to determine at which altitudes different CME structures are likely accelerated up to super-alfvenic speeds the Alfvèn velocity profile was calculated.

$$N_e = N_0 \times 10^{4.32\,Rs/R}$$

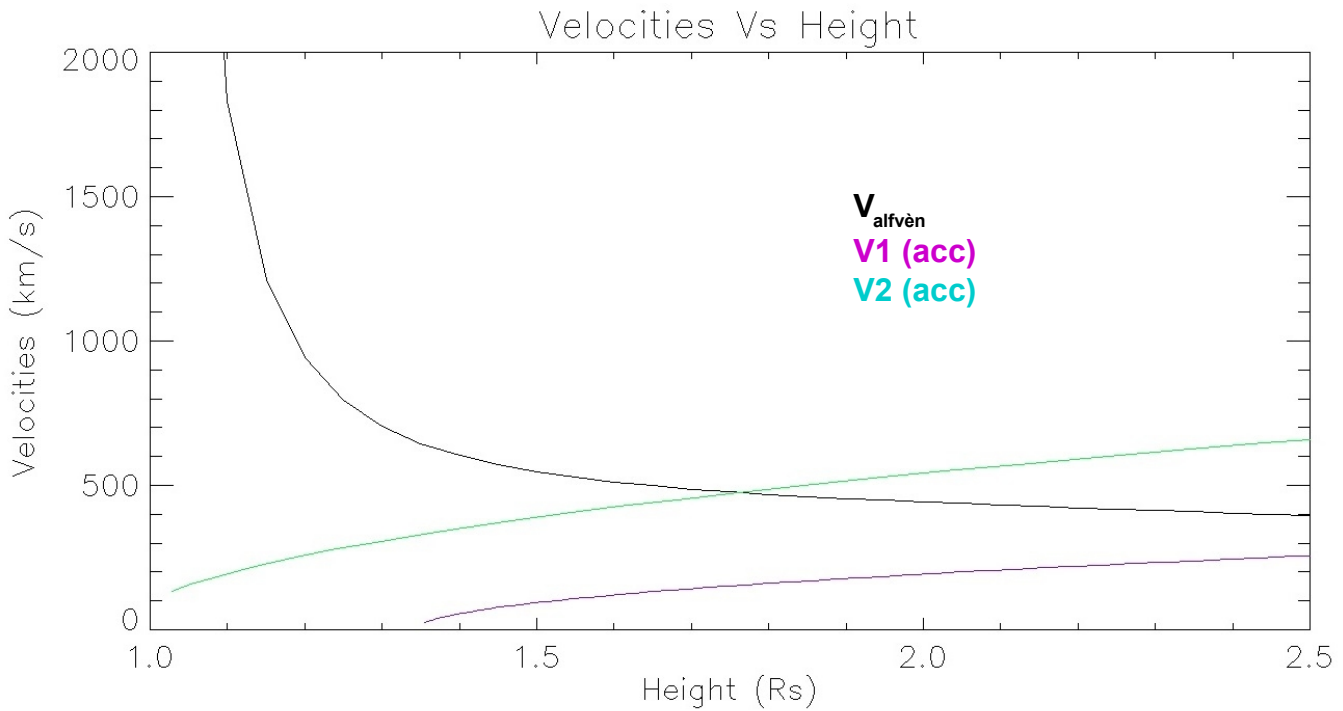
(Newkirk electron density model, R< 1,8 R_{sun})

$$B(r) = 0.5(r-1)^{-1.5}$$

(Dulk & McLean radial magnetic field profile, R<10 R_{sun})

$$V_{Alfvèn} = B/(4\pi N_e m_p)^{1/2}$$

Alfvén speed profile as a function of altitude



2D maps : Emission Measure

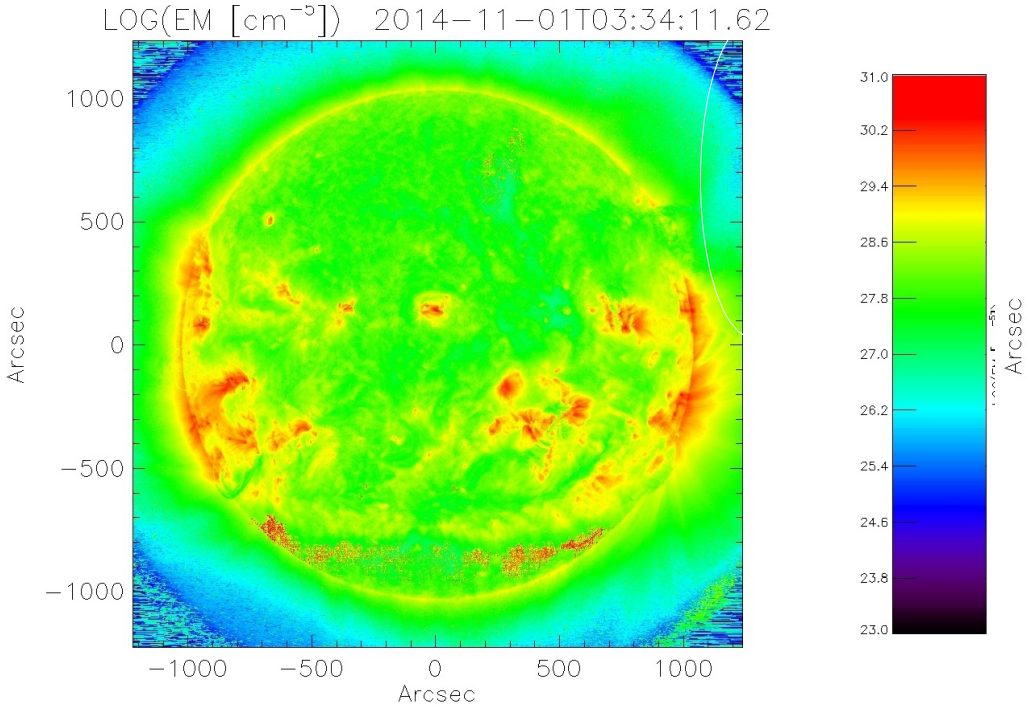
The Emission Measure has been calculated. The method used was been developed Aschwanden → Reconstruction of the differential emission measure dEM/d*T* (using the intensity of the six SDO/AIA filters) for each pixel with a gaussian distribution

$$\frac{dEM(T,x,y)}{dT} = EM_p(x,y)\exp\left(-\frac{[\log(T)-\log(T_p(x,y))]^2}{2\sigma_T^2(x,y)}\right)$$

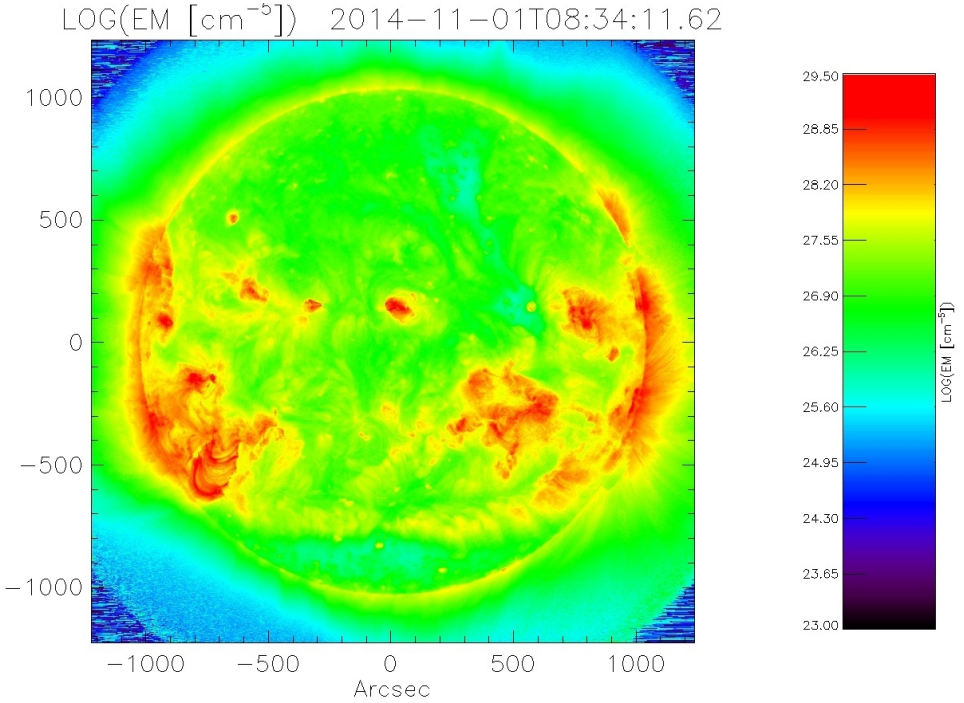
EM_p,T_p,s are peak in each pixel

→ Emission Measure

Pre-event



Post-event



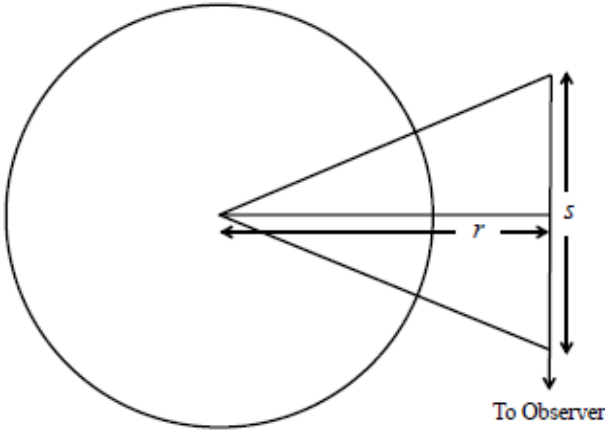
2D maps : Electron Density

The plasma electron density has been calculated by estimating an effective path length of the emitting plasma along the LOS **s(r)**

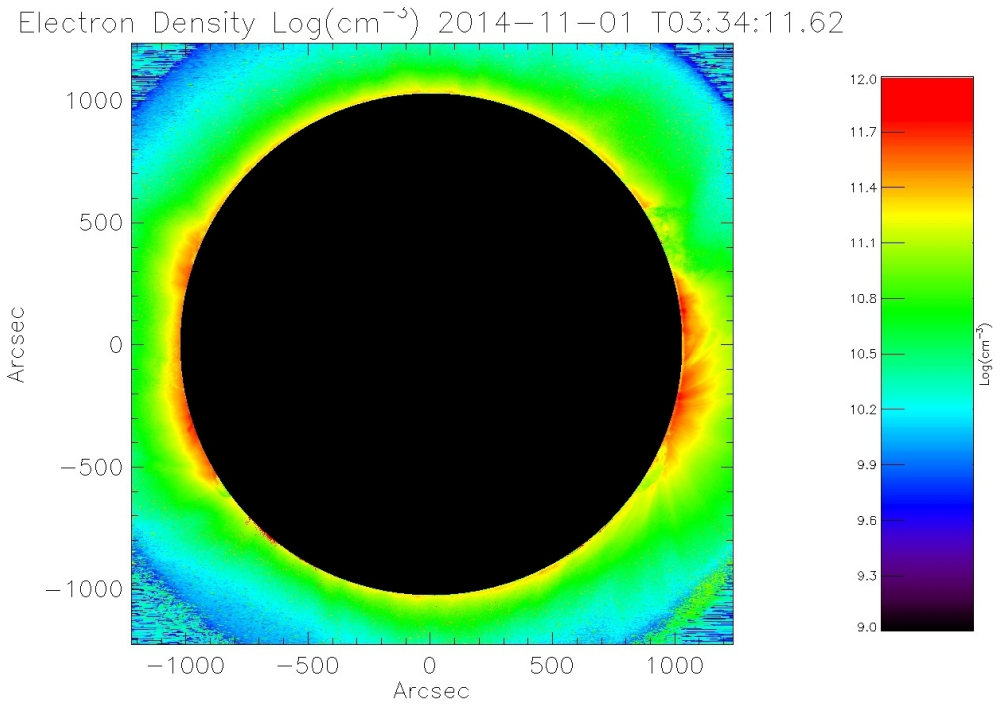
$$N_e(r,\phi) = \sqrt{\frac{\mathrm{EM}(r,\phi)}{s(r)}} \quad [\mathrm{cm}^{-3}].$$

s ~ (HπR)$^{1/2}$

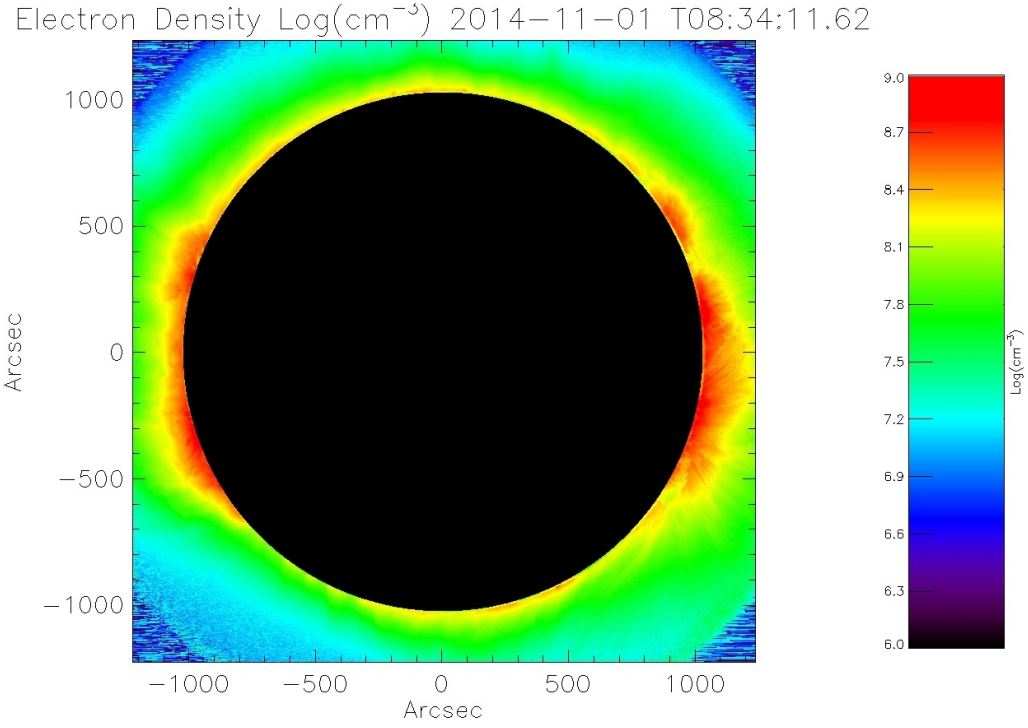
H = scale height



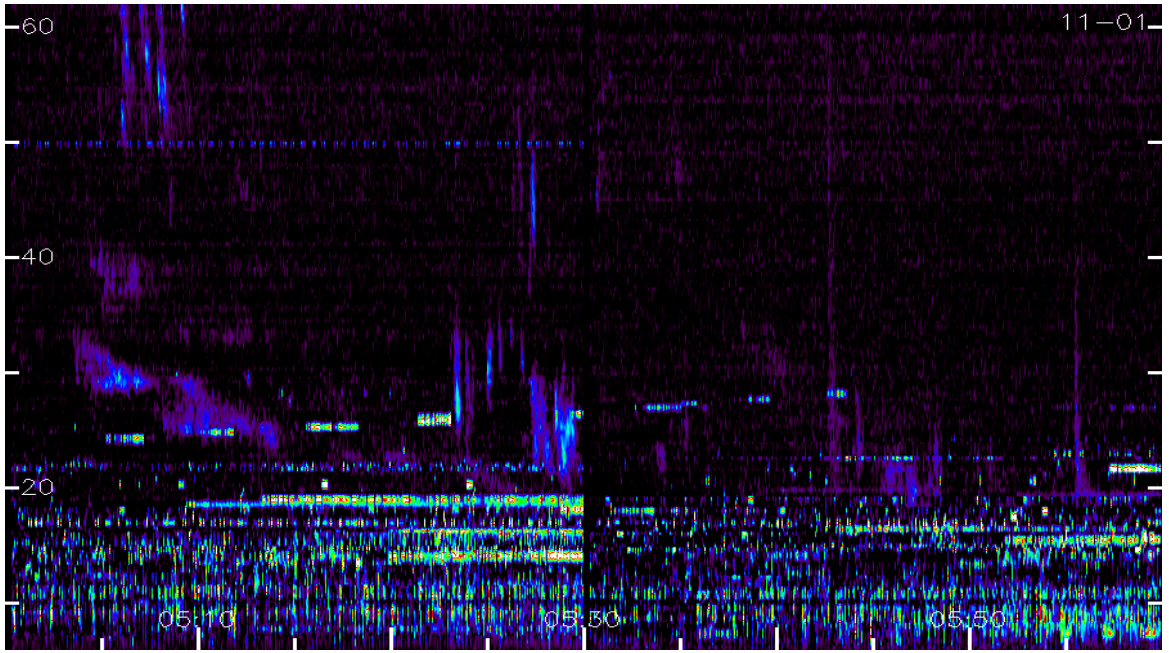
Pre-event



Post-event



Density and radio burst type II



Preliminary analysis with radio data confirm the radio burst type II (important evidence for the presence of the shock)

Future work

- Collect more structures → more velocity to analyse → improvement of kinematic studies
- Combine 2D electron density maps with extrapolated magnetic fields (e.g. PFSS or magnetic field model on plane of skye(Predictive Science - http://www.predsci.com/hmi/home.php)) to derive 2D maps of the pre-CME Alfvèn speed, to be compared with derived kinematical properties of the eruption(see **Bemporad, Susino, Frassati, Fineschi 2016**).
- Complete the study of the CME-driven Shock to measure the shock compression ratio from EUV images and apply MHD Rankine-Hugoniot equations to derive plasma physical parameters across the shock surface (**e.g. Bemporad & Mancuso 2011**).
-To infer the location in the corona where the type-II radio burst is excited along the CME-driven shock