The MEGA CME of July 2012:

some preliminary analysis

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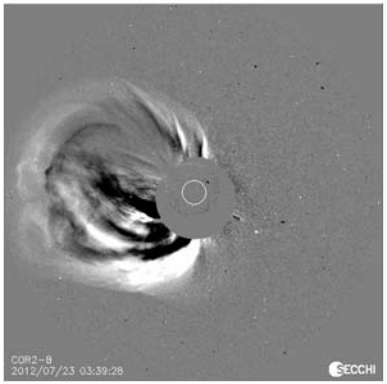
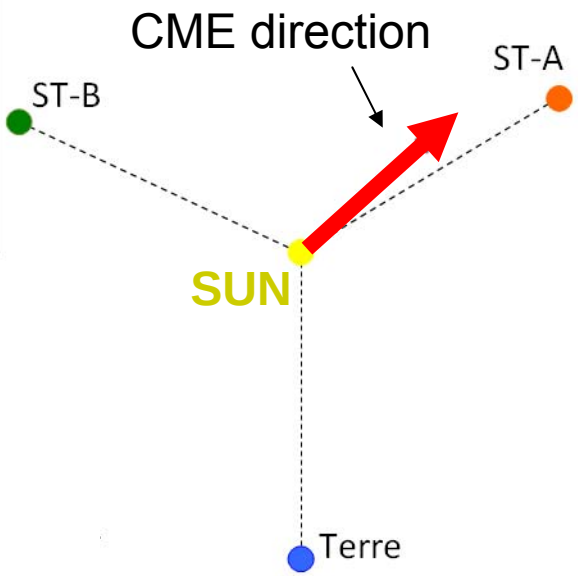
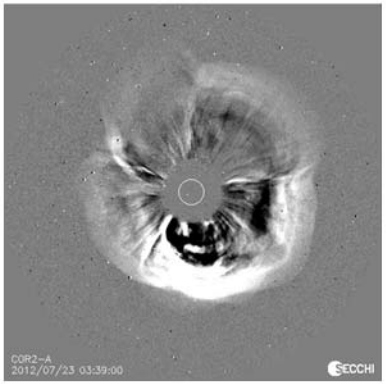
The Mega-CME of July 2012: remote sensing



COR-2B

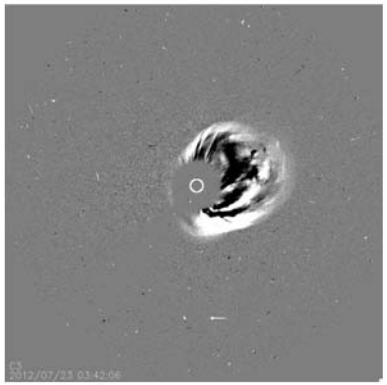




COR-2A

COR-2B observations give maximum speed of 3400 km/s

But it decelerates
→ End speed more like Carrington's 2400 km/s



C-3

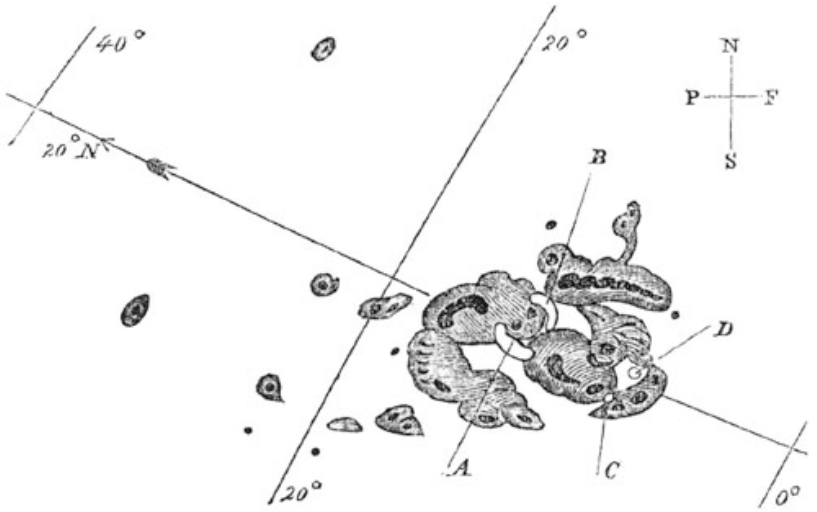
→ Among 4 fastest CMEs ever measured from coronographs:

The Mega-CME of July 2012: transit time

- Transit time of July 2012 CME is of 18 h from Sun to STEREO A

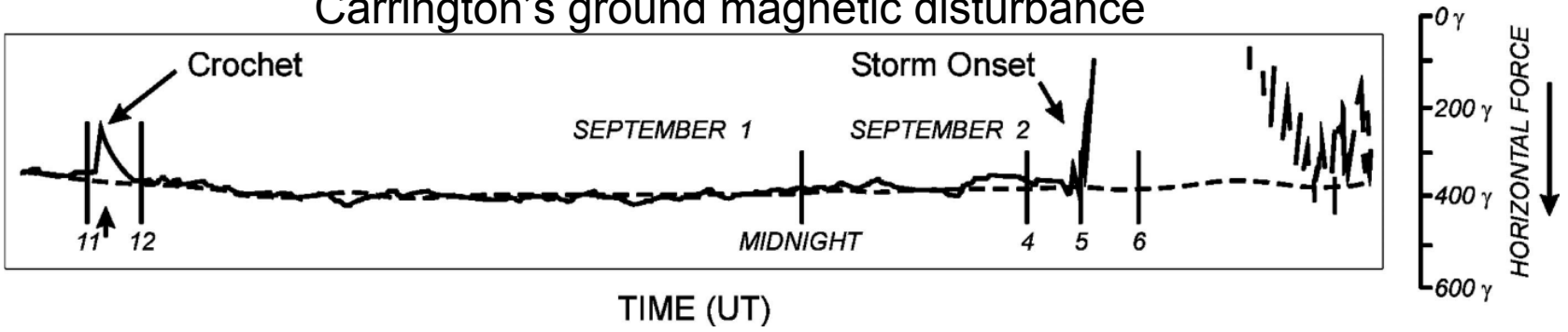
→ Average speed ~ 2400 km/s

- Carrington event speed can also be evaluated thanks to ionospheric effects from soft X-rays and storm Sudden Commencement (SSC)



Carrington's drawing of the active region

Carrington's ground magnetic disturbance



→ CME speed equivalent to the Carrington event

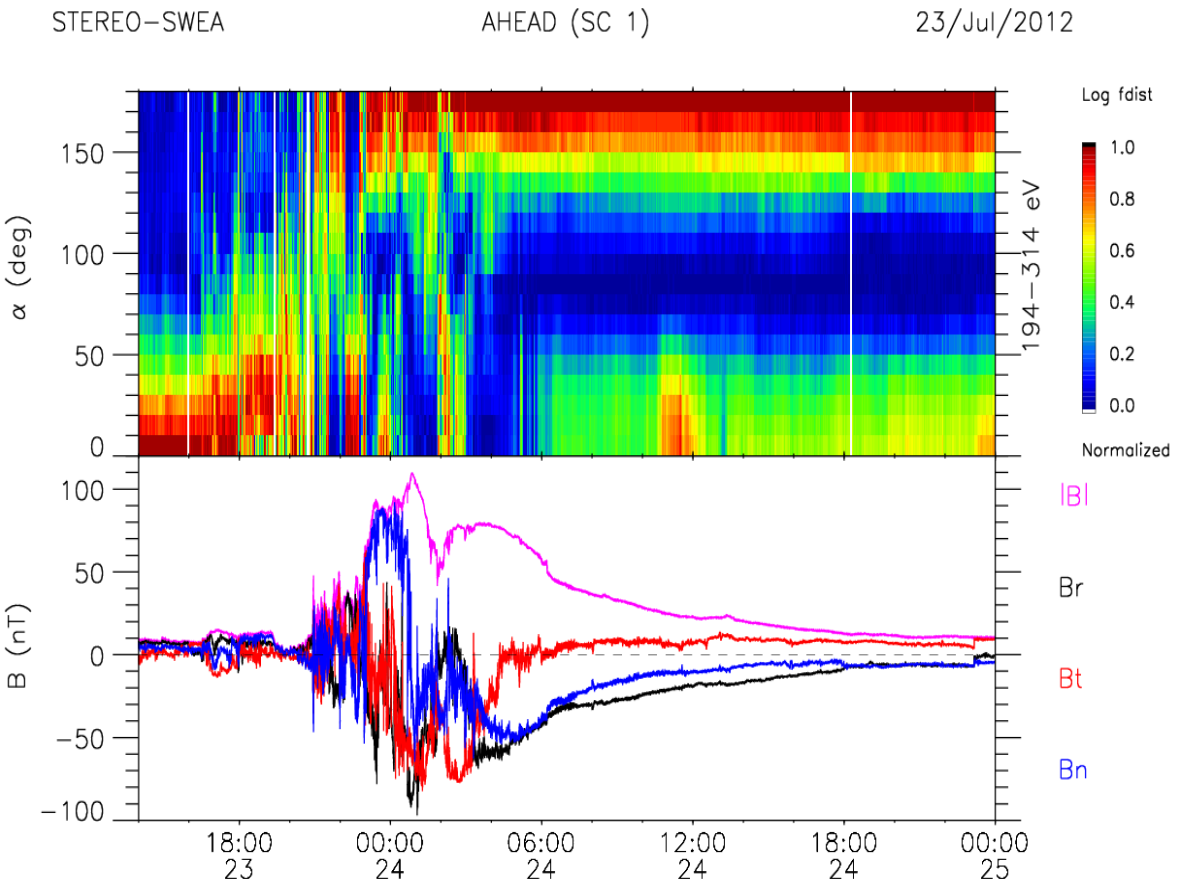
The Mega-CME of July 2012: In situ data

… and most intense ever observed in situ

STEREO / SWEA
suprathermal electrons

|V| ~ 2200 km/s

|B| > 100 nT at ~1 AU
B_Z ~ -50 nT
and worse if reversed polarity!



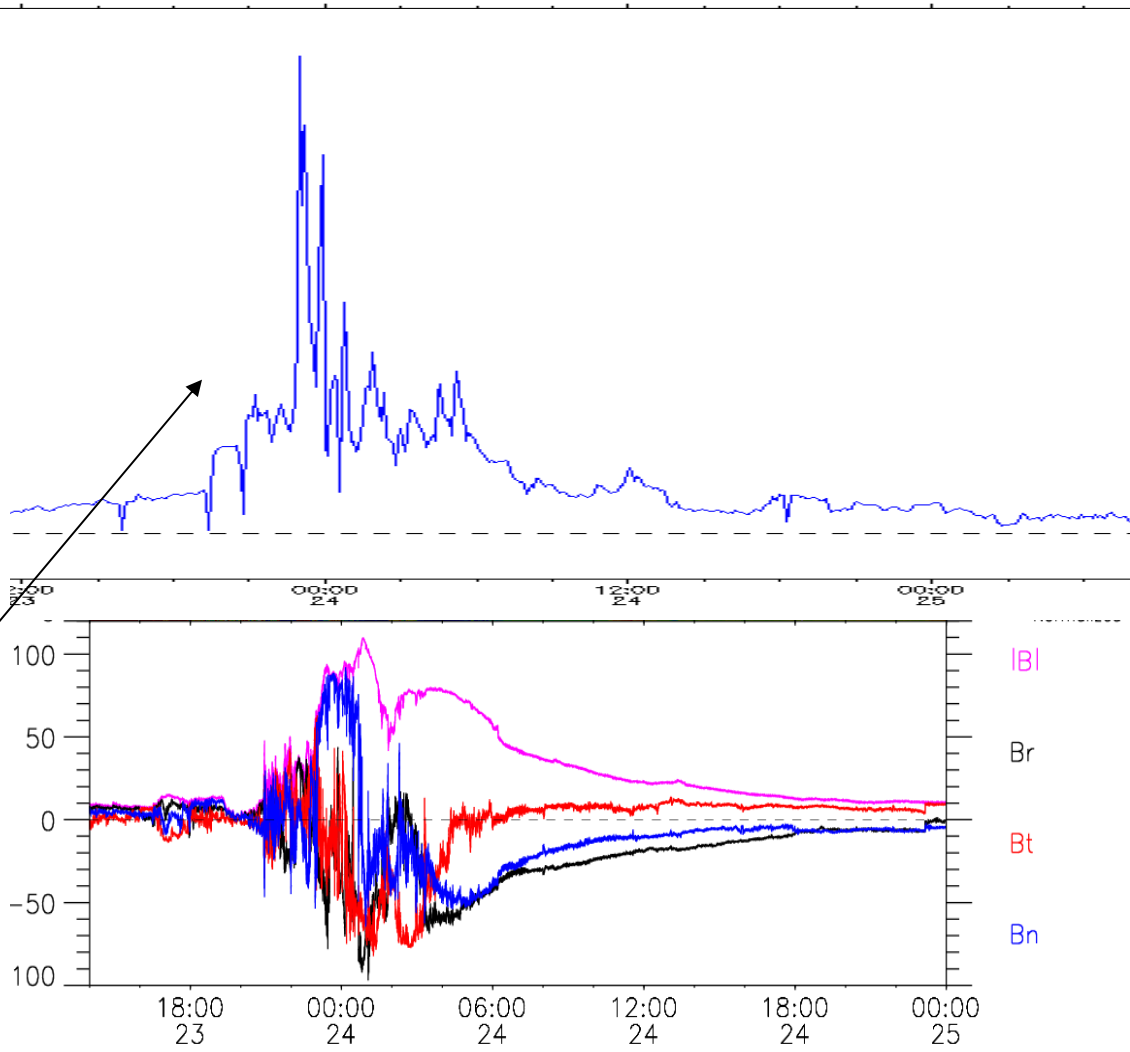
→ Luckily (not for us?!), it was not directed at Earth

The Mega-CME of July 2012: In situ data

|V| ~ 2200 km/s at max near front head according to some data from PLASTIC, but not released so far

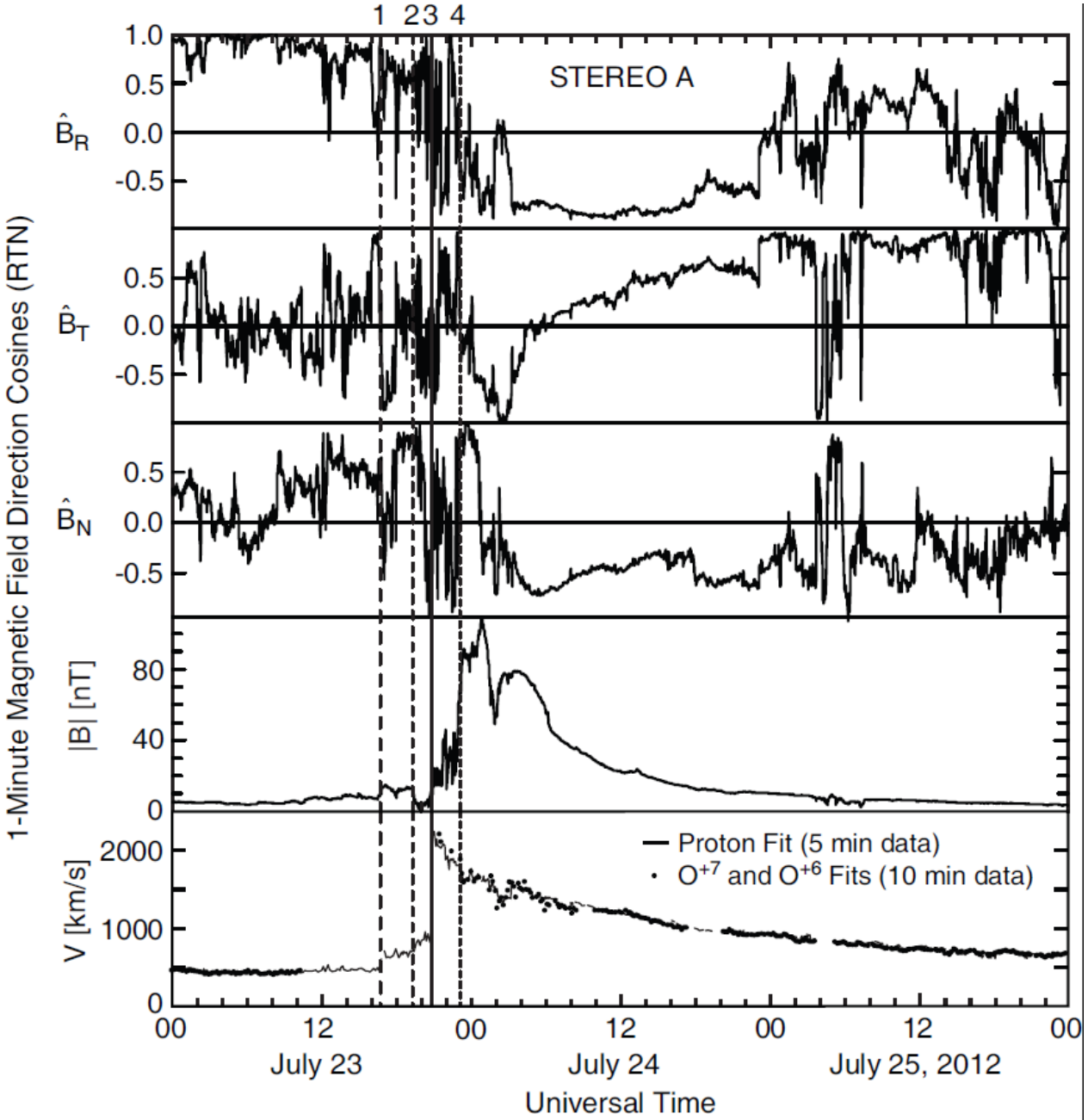
No ion density so far

But we may use estimates from electrons (actually secondary electrons)



→ Need good data for accurate geo-effectiveness studies

Data from Russell et al. (2013)



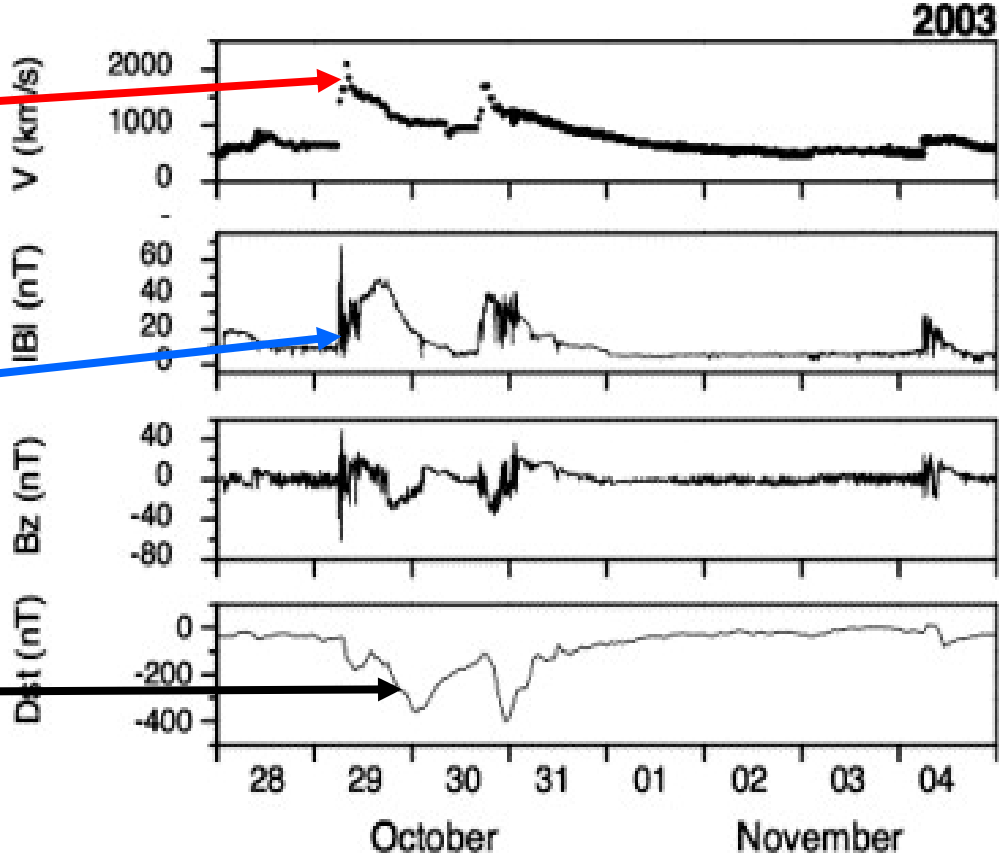
The Mega-CME of July 2012: comparison

… with the Halloween 2003 storm

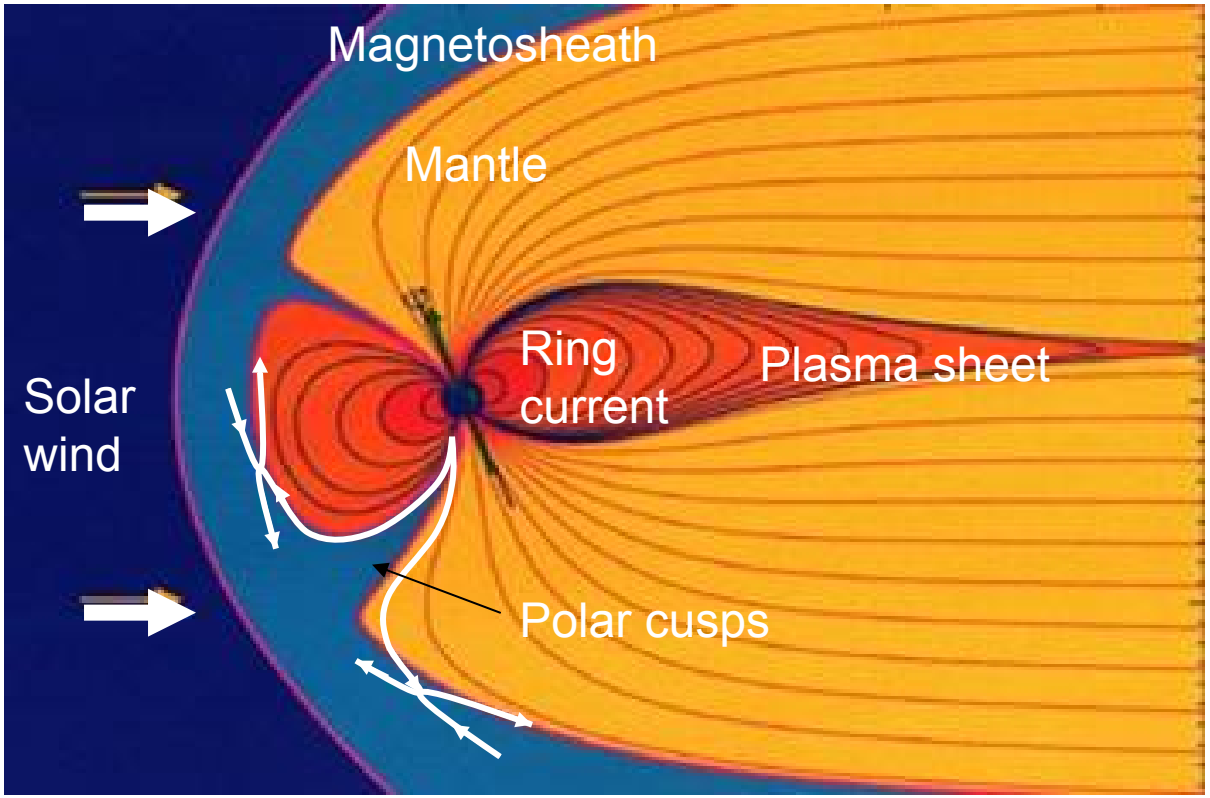
|V| > 2000 km/s at max

|B| ~ 40 nT at ~1 AU

Dst ~ 400 nT
(storm intensity)



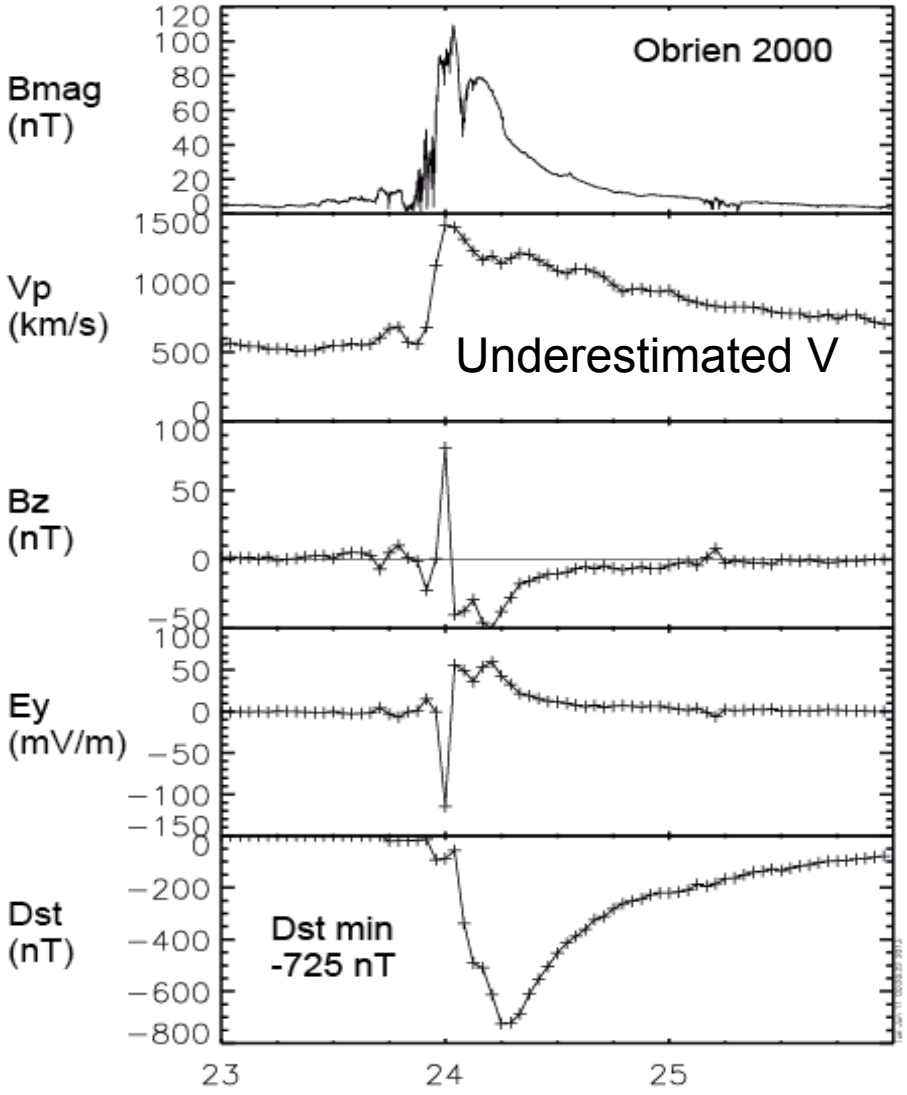
Basic storm paradigm: reconnection and Dungey cycle



Longer X-line and constructive build-up of sheath and reconnection flows for Bz < 0

→ V and Bz prime parameters that control geo-effectiveness

Preliminary analysis of its “what-if” geo-effectiveness



- Versions by *Burton et al.* [1975], *O’Brien and McPherron* [2000] and Wang et al. [2006]
- Semi-empirical model based on a linear relationship between *Dst* and the electric field (*VBz* parameter)
- The formulation is (after correction for magnetopause currents) :

$$\frac{d}{dt}Dst^*(t) = Q(t) - \frac{Dst^*(t)}{\tau}$$

- Parameterization from 30 years of OMNI2 solar wind data

Plot from Emilia Kilpua
Dst ~ -1100 nT if using Wang et al. 06

→ Record storm, but not as large as Carrington event

CONCLUSIONS

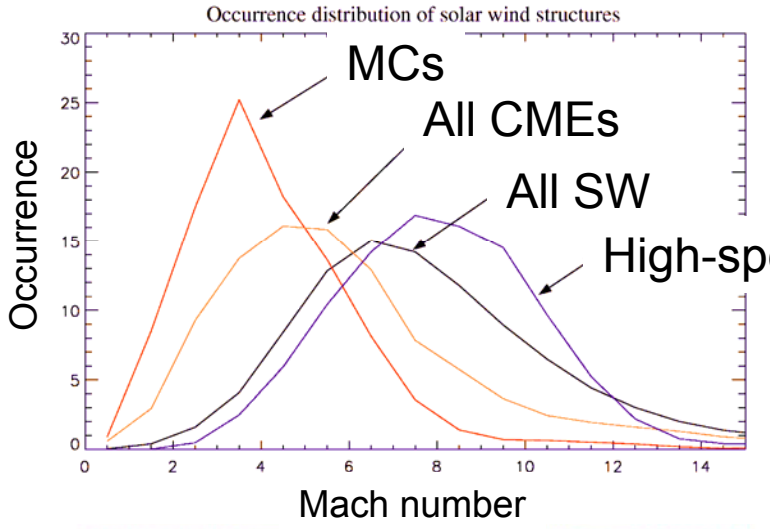
- Had it hit Earth, the July 2012 CME would have led to a record storm, with *Dst* of order -1000 nT…

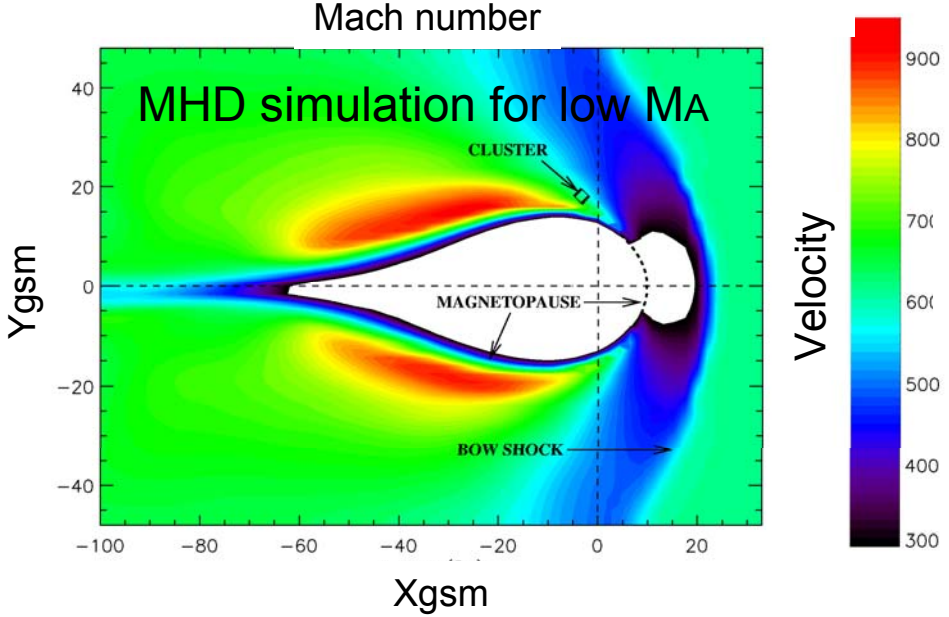
- … but such would not be as large and exceptional as the Carrington storm, which must have had much stronger in situ magnetic field (of order 150 nT or more).

- Even if rotating the CME axis around, the ensuing storm strength would not increase dramatically. This owes to the duration of the large B-field being rather short.

→ Need good plasma data. So far not sure we have them!

Importance of solar wind Mach number





- CMEs typically have low Mach numbers

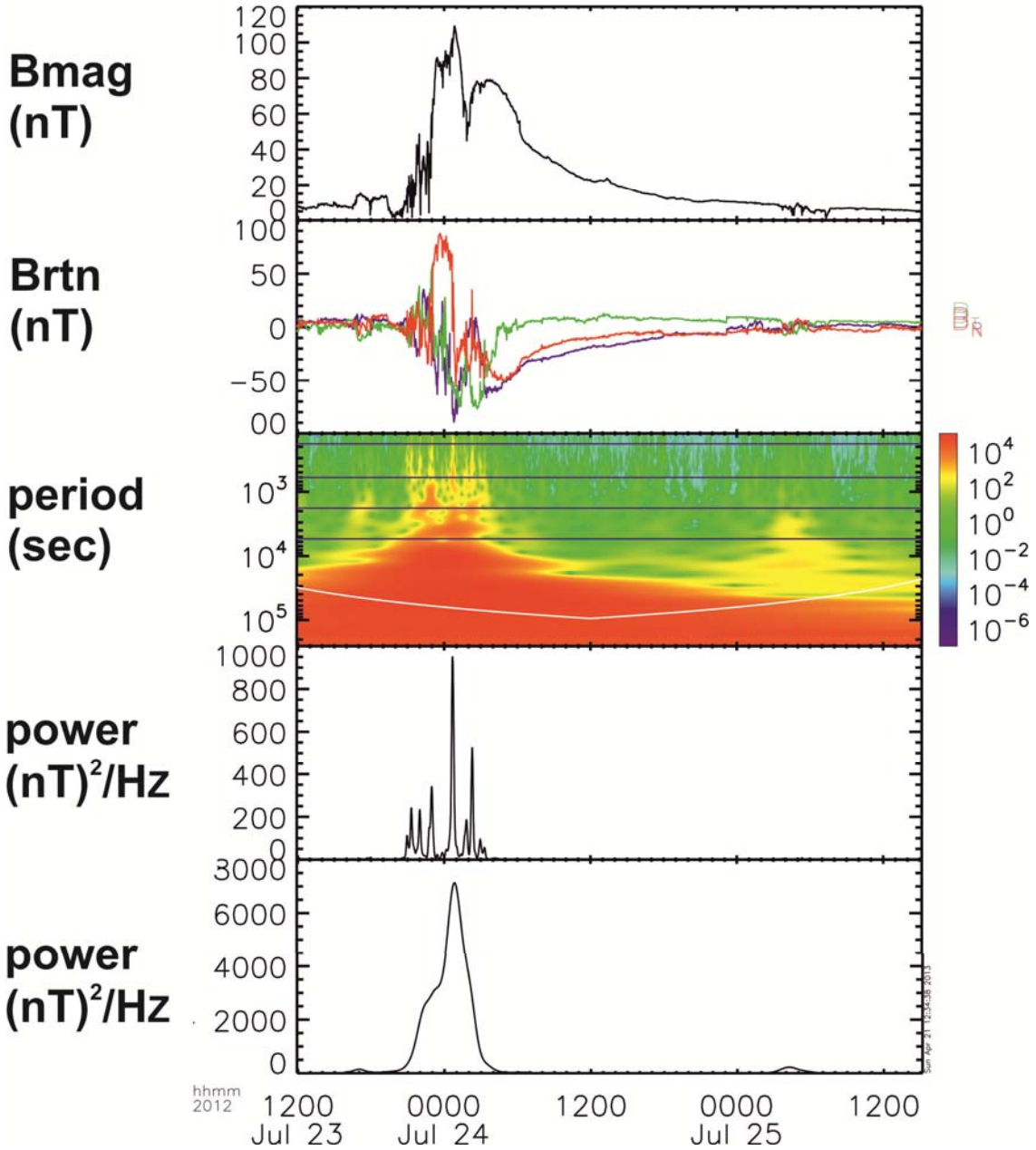
- Expected effects include:

Strong sheath flows
Enhanced K-H waves?
Sawtooth oscillations
Increased reconnection rate
Alfvén wings
Polar cap potential saturation
Etc.

Lavraud and Borovsky [2008]

→ Altered coupling at low Mach number

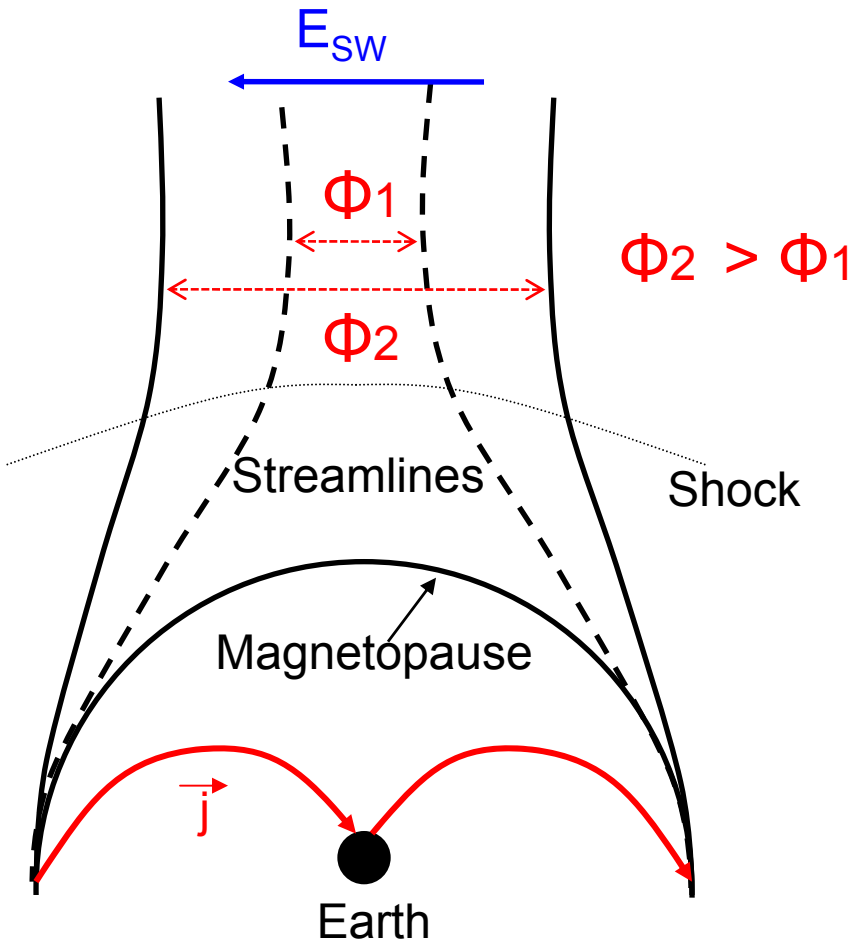
Further analysis from E. Kilpua



Polar cap potential saturation for low Mach numbers

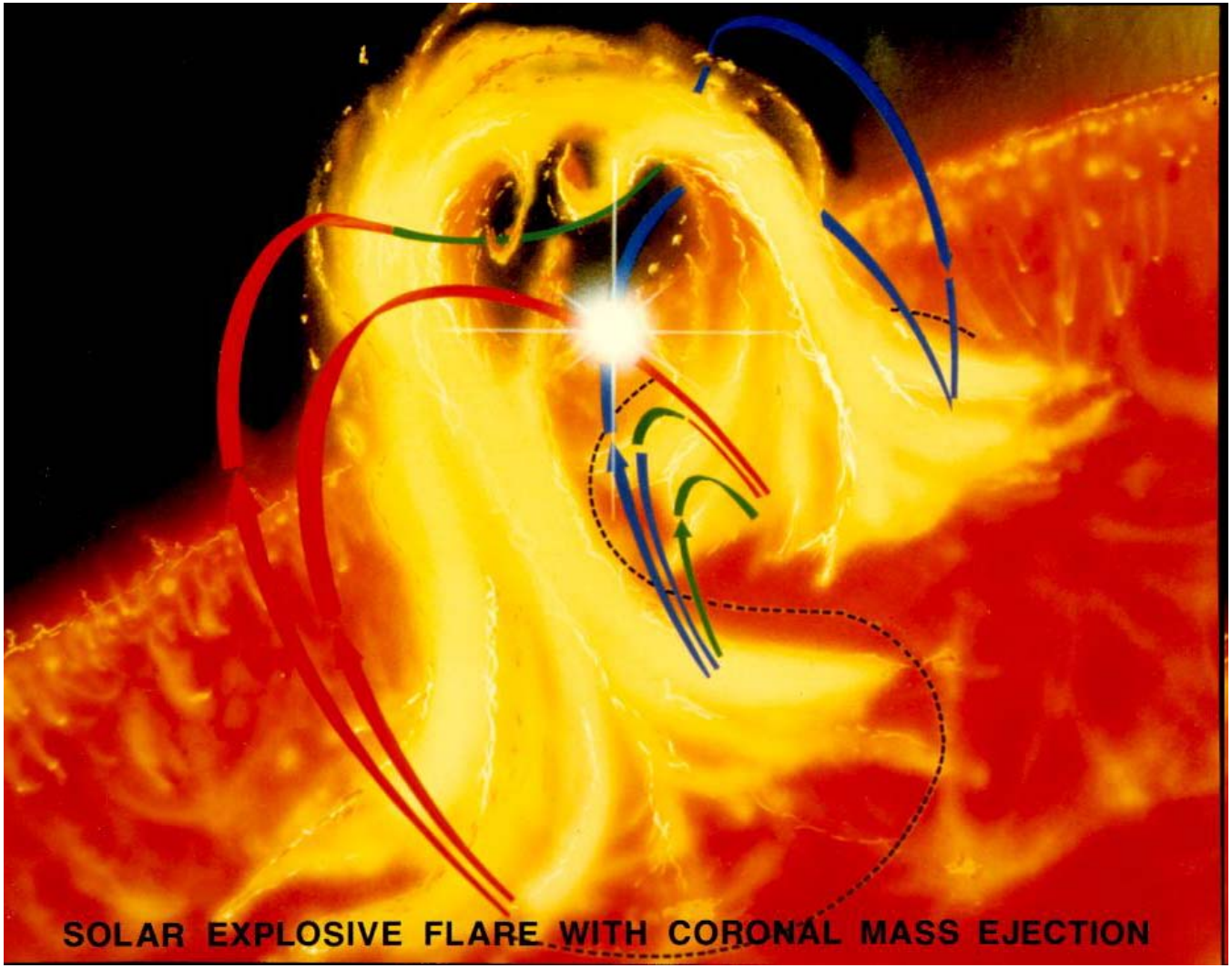
CPCP should match potential across solar wind field lines in which the magnetosphere taps through dayside reconnection

→ Change comes from altered magnetosheath flow patterns under low Mach number



Lavraud and Borovsky [2008]
Lopez et al. [2011]
Cf. also *Kivelson and Ridley* [2008]

→ Lower Pdyn and Mach number = lower coupling and vice-versa!


SOLAR EXPLOSIVE FLARE WITH CORONAL MASS EJECTION