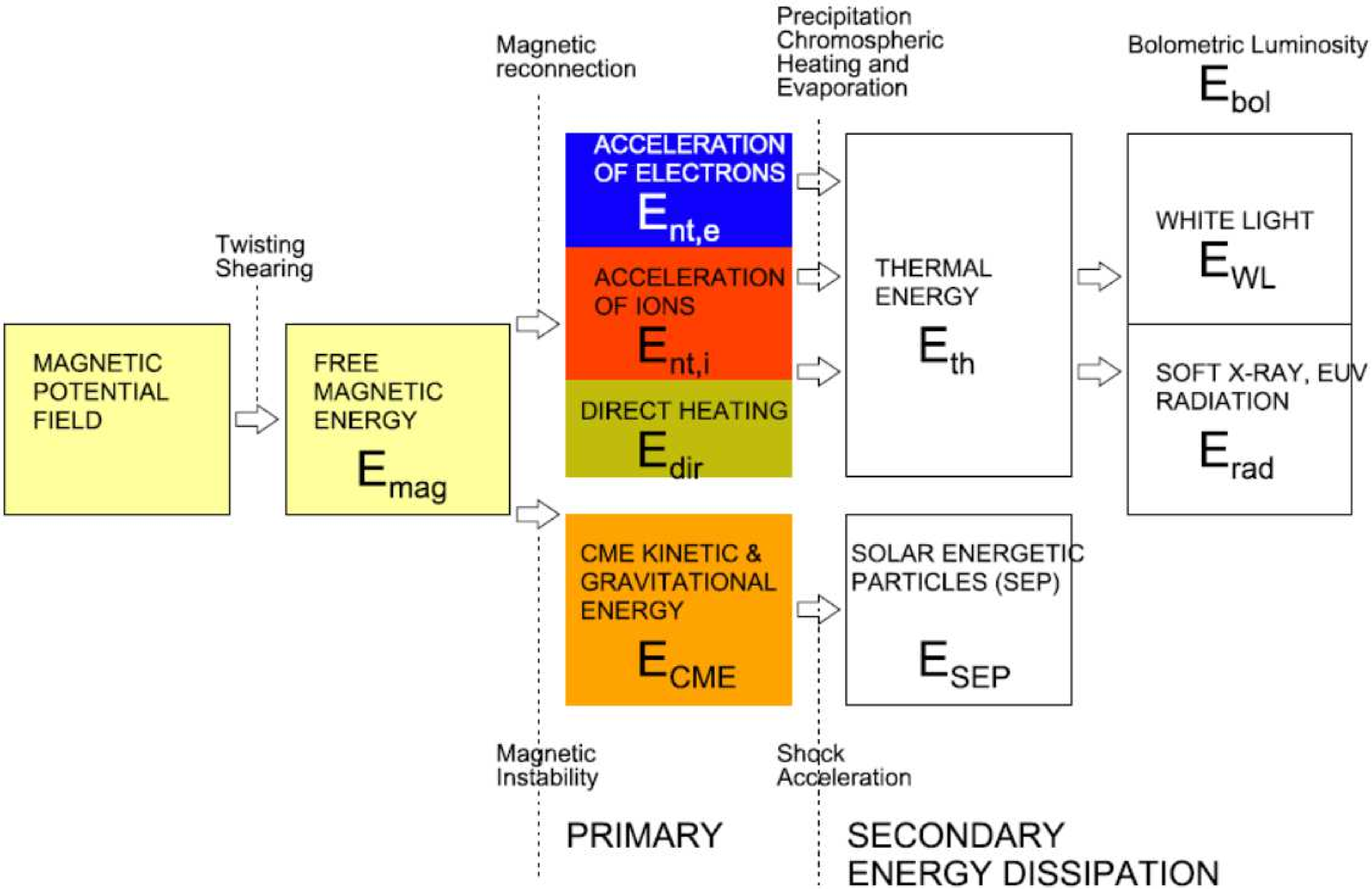
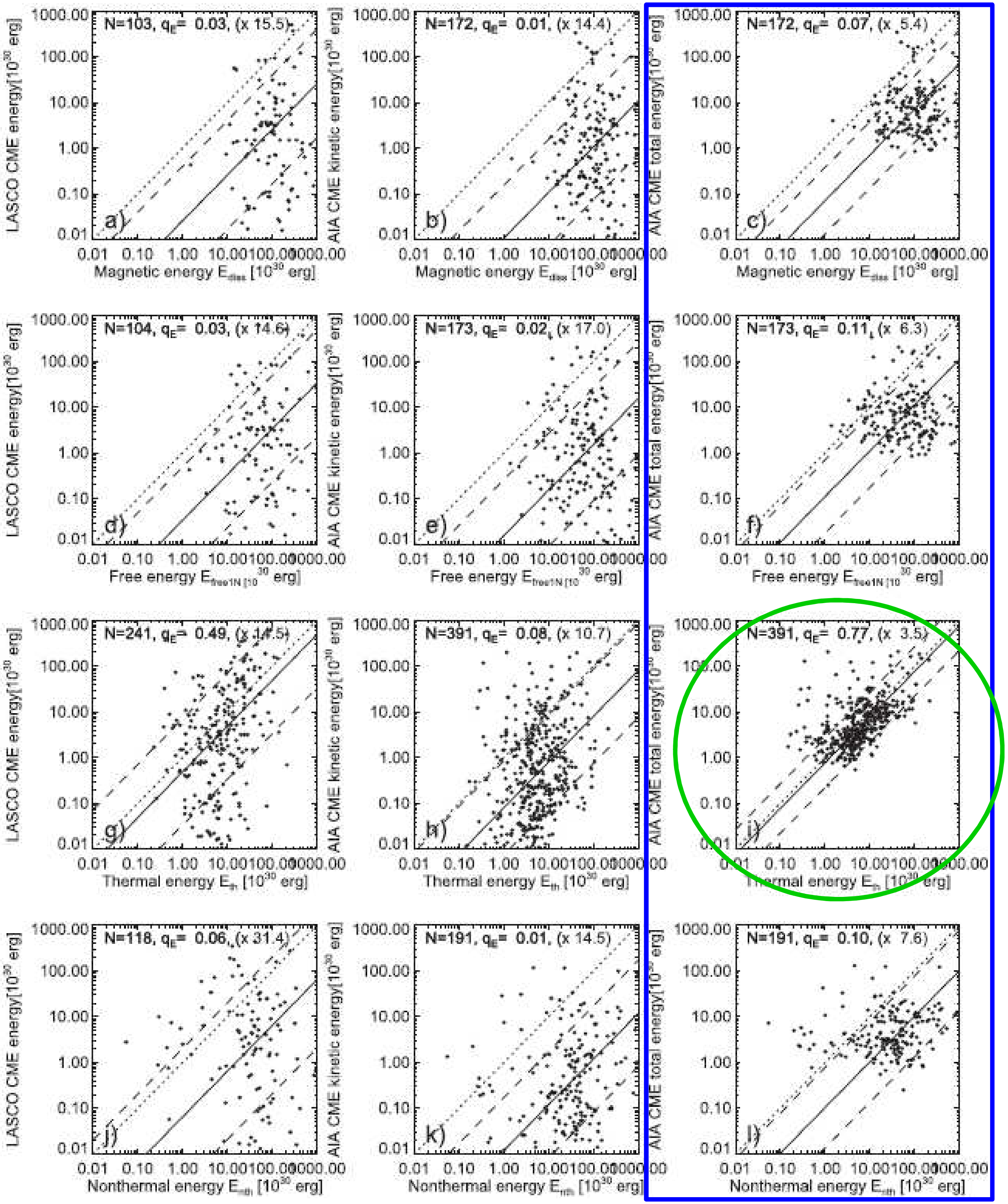
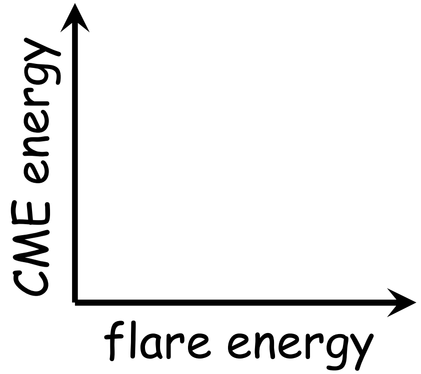
Global Energetics



Aschwanden et al. (2017)

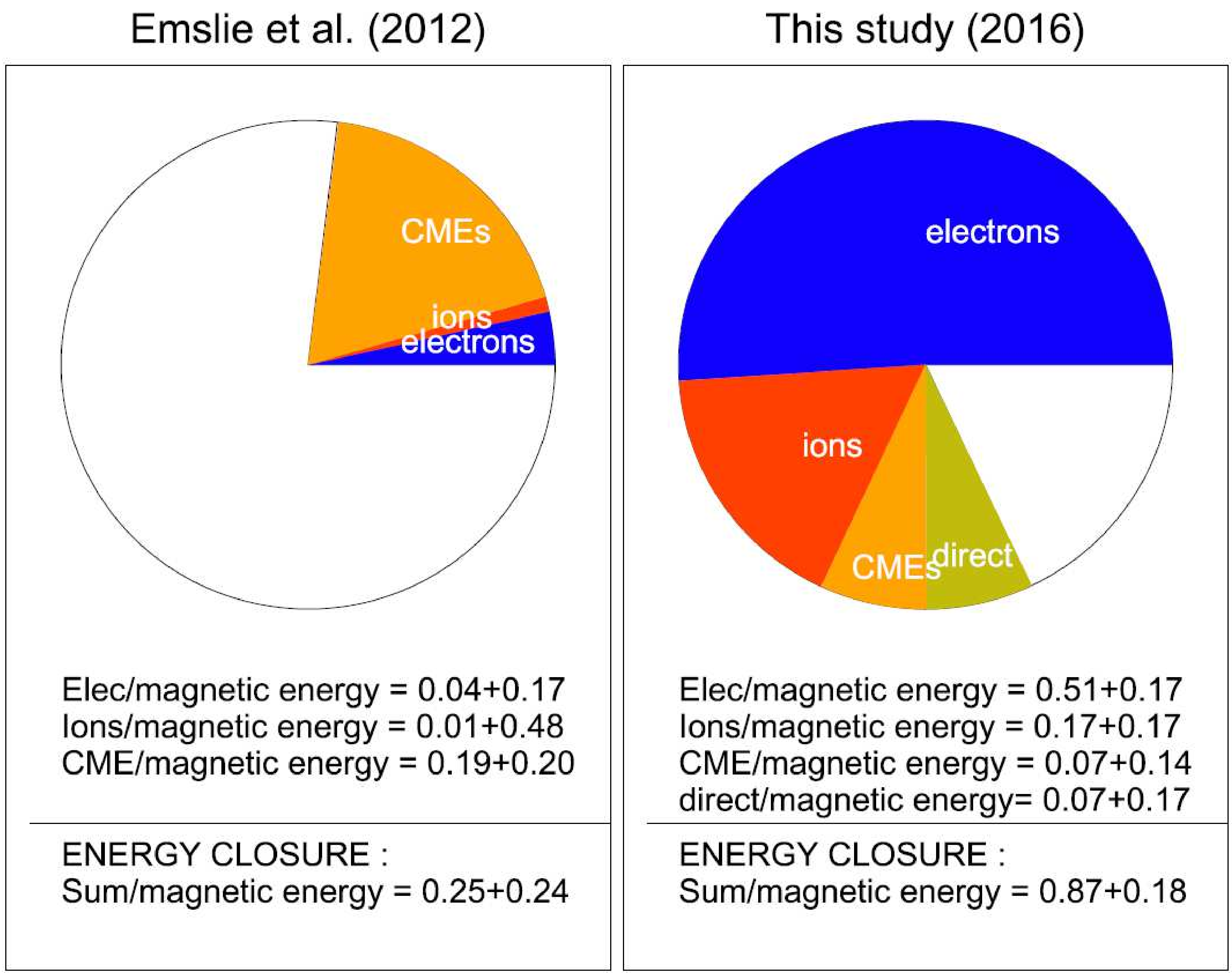




It is imperial to include both the kinetic and gravitational energy in comparisons with other flare-generated energies.

The energy that goes into a CME is most closely related to the heating of the flare plasma.

Aschwanden (2016)

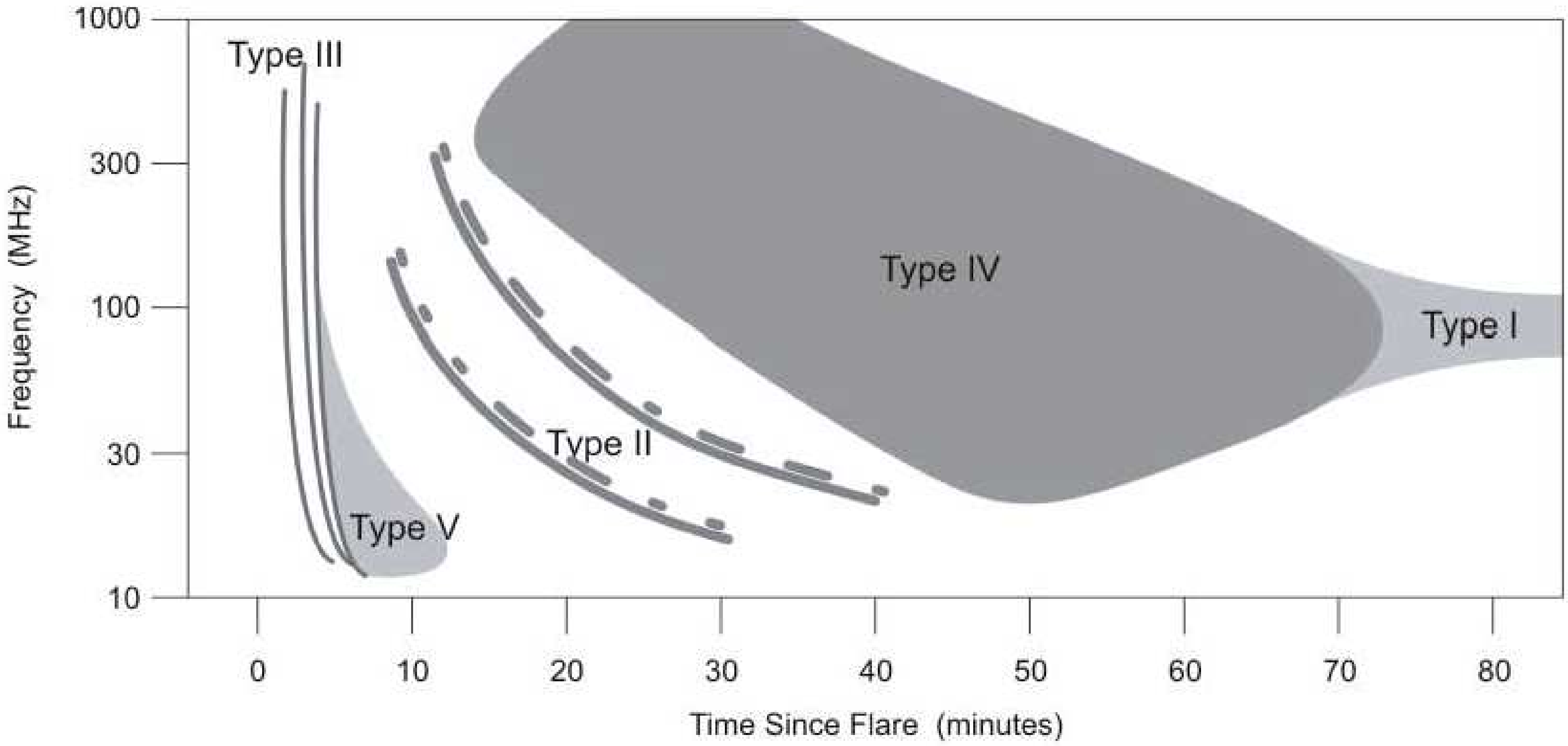


Aschwanden et al. (2017)

Solar Radio Bursts

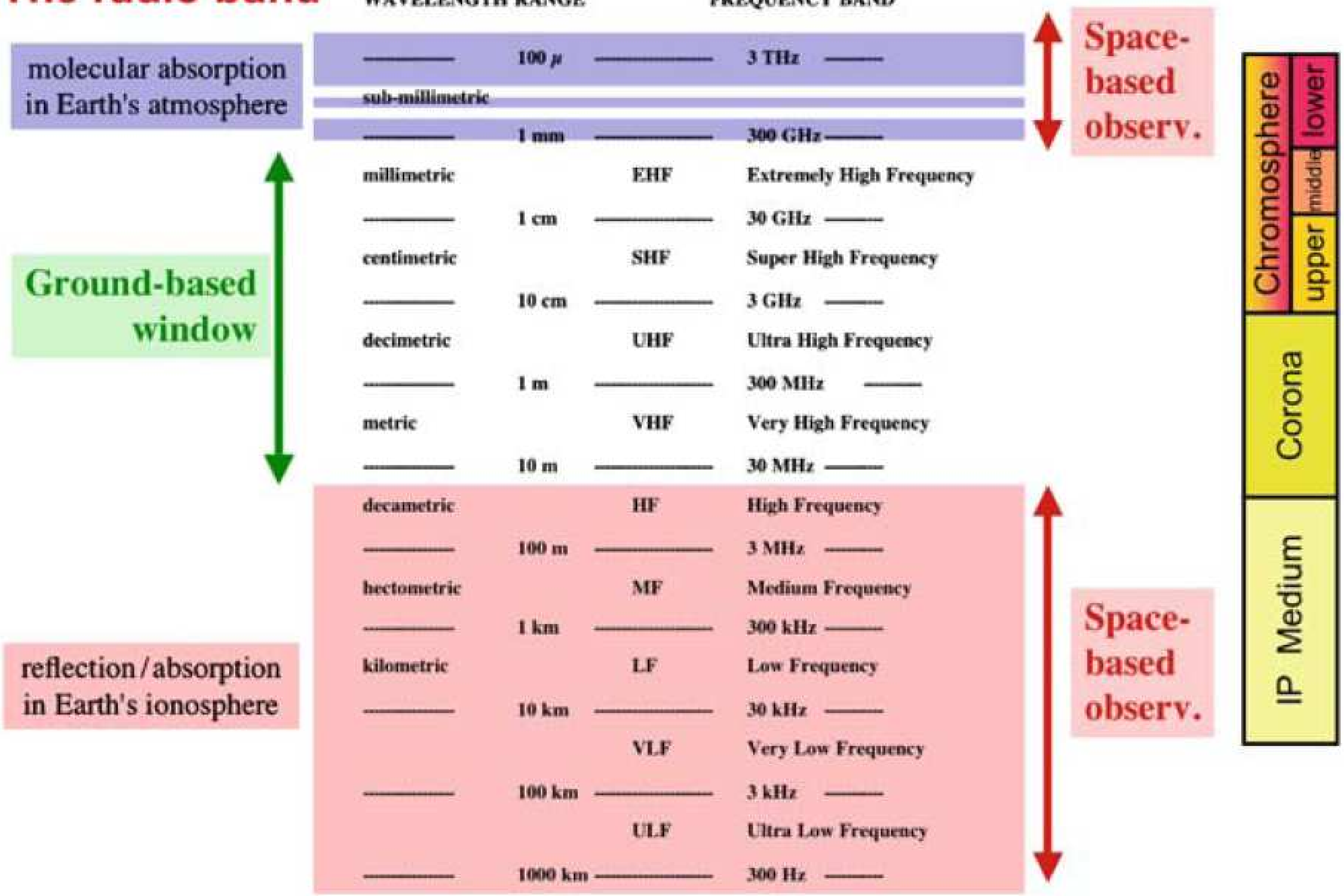
Schematic Radiospectrogram

This diagram illustrates all of the major burst types in a typical configuration following a large flare.
It should be noted that it is **not** common for **all** of these features to be observed after a flare.



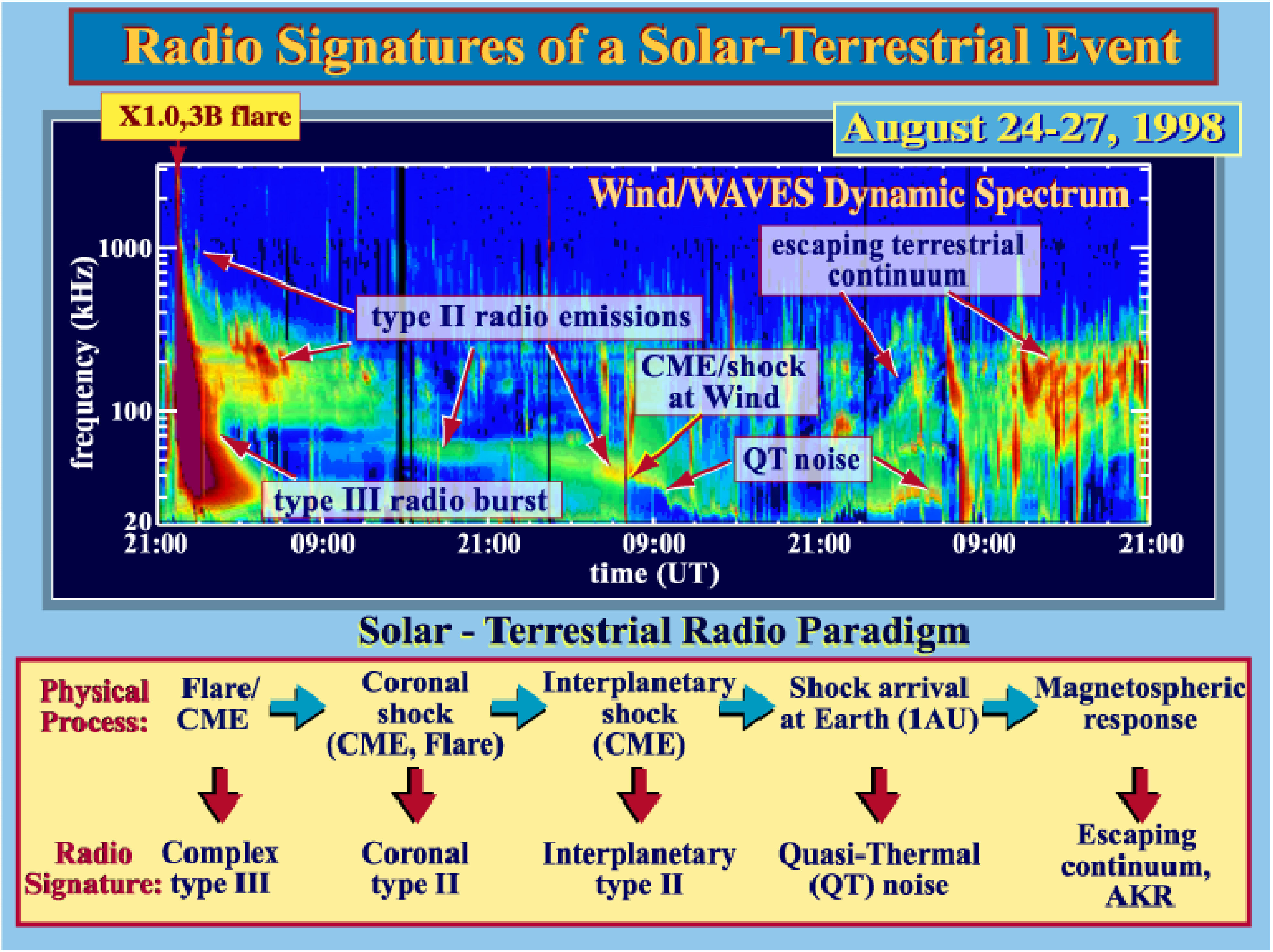
http://www.ips.gov.au/Category/World%20Data%20Centre/Data%20Display%20and%20Download/Spectrograph/Schematic%20Radiospectrogram.pdf

The radio band

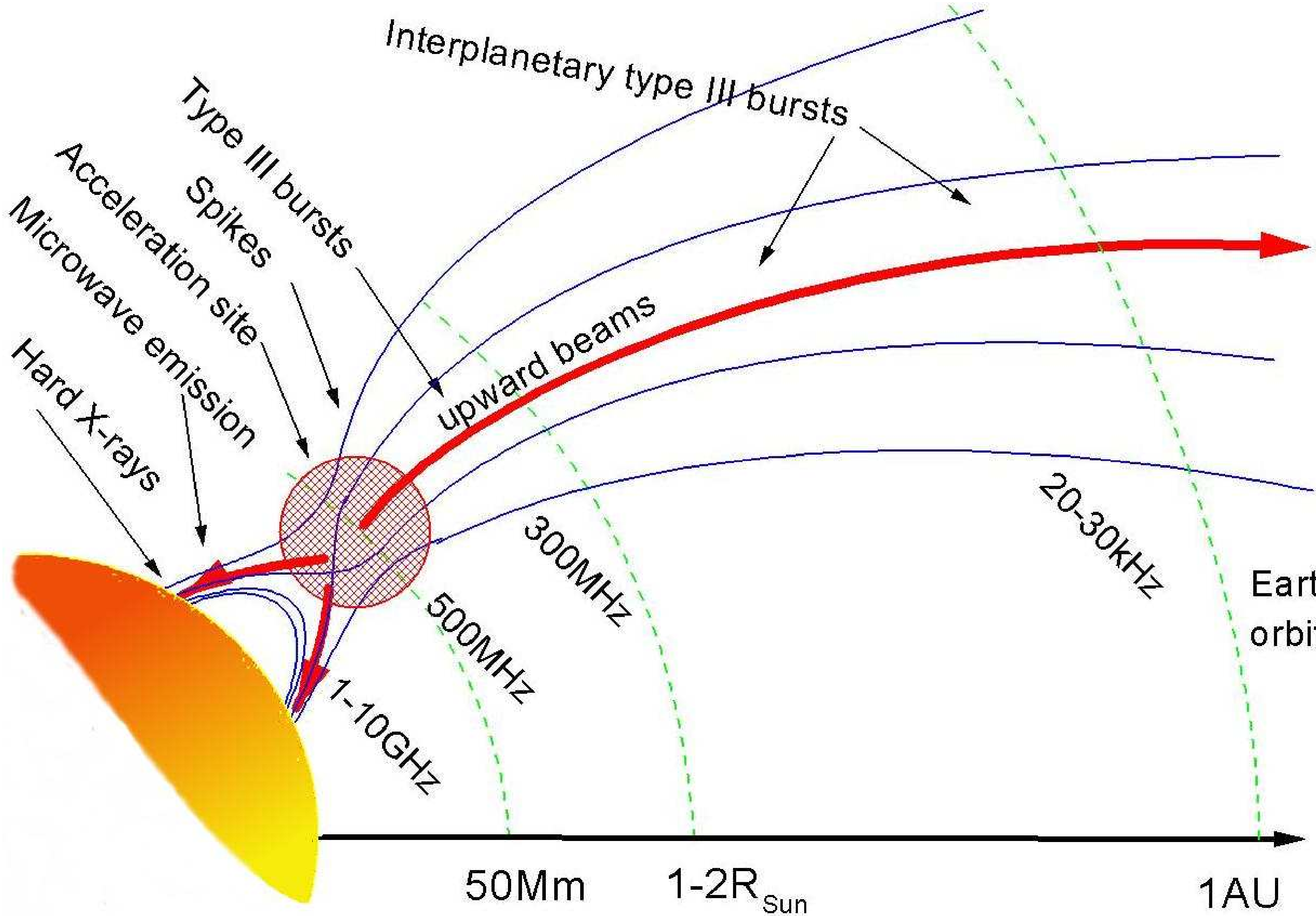


→ The shorter wavelengths are absorbed in the Earth's atmosphere and the longer wavelengths are blocked by the terrestrial ionosphere.

Fig. 6.1 & Fig. 6.2 in Yohsuke Kamide & Abraham C.-L. Chian (2007)



http://swaves.gsfc.nasa.gov/content_images/swavesf1.png



Eduard Kontar in 2010 RHESSI Workshop

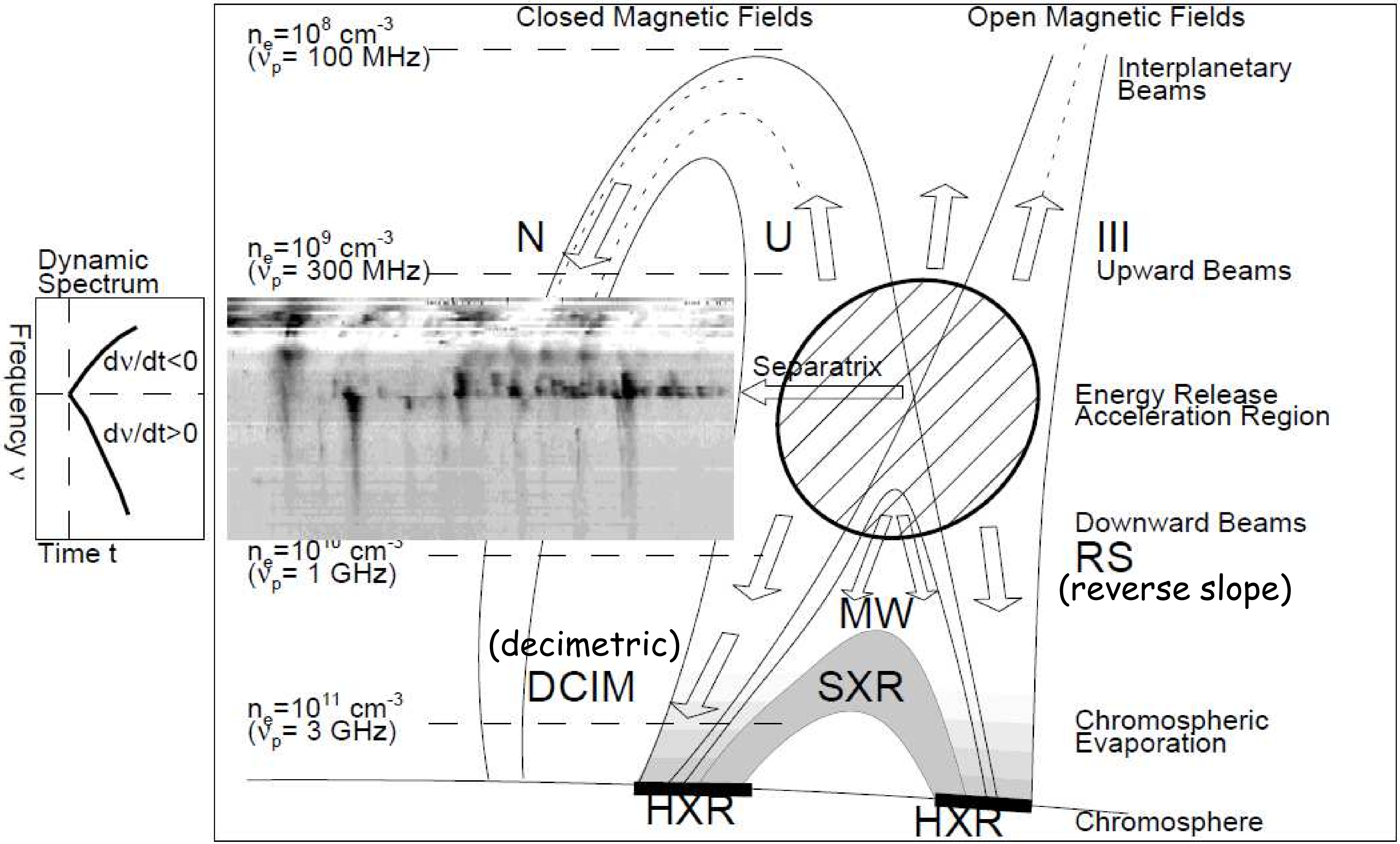
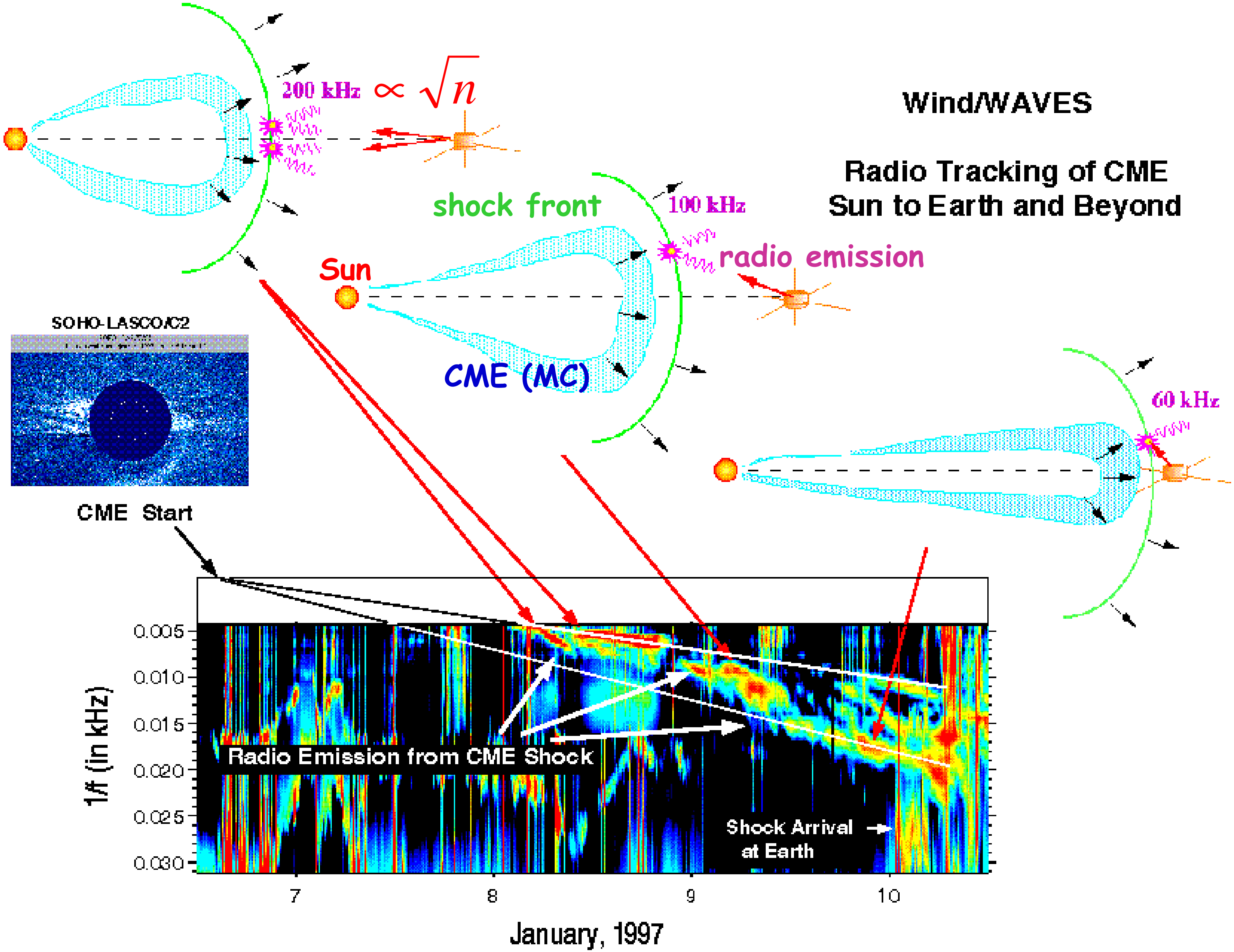
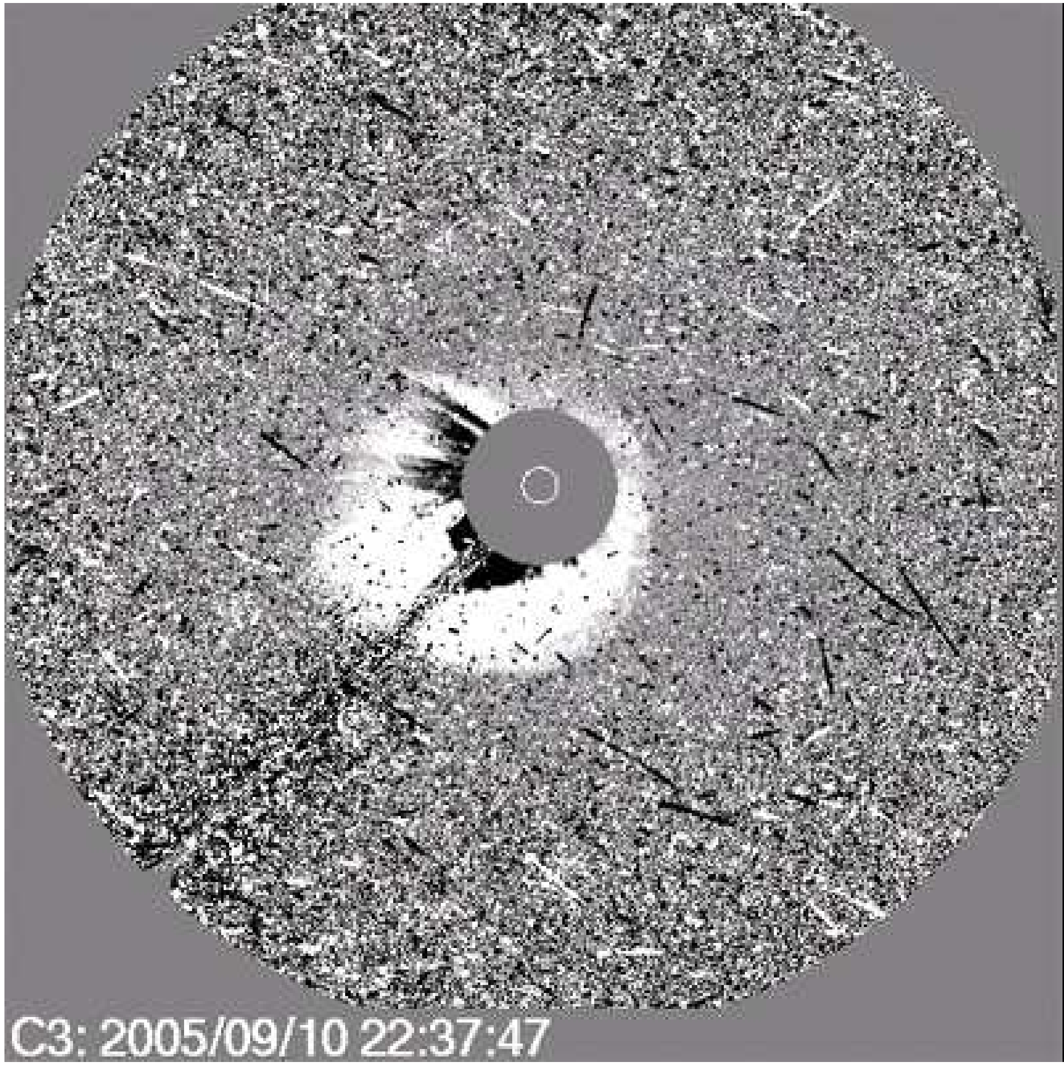


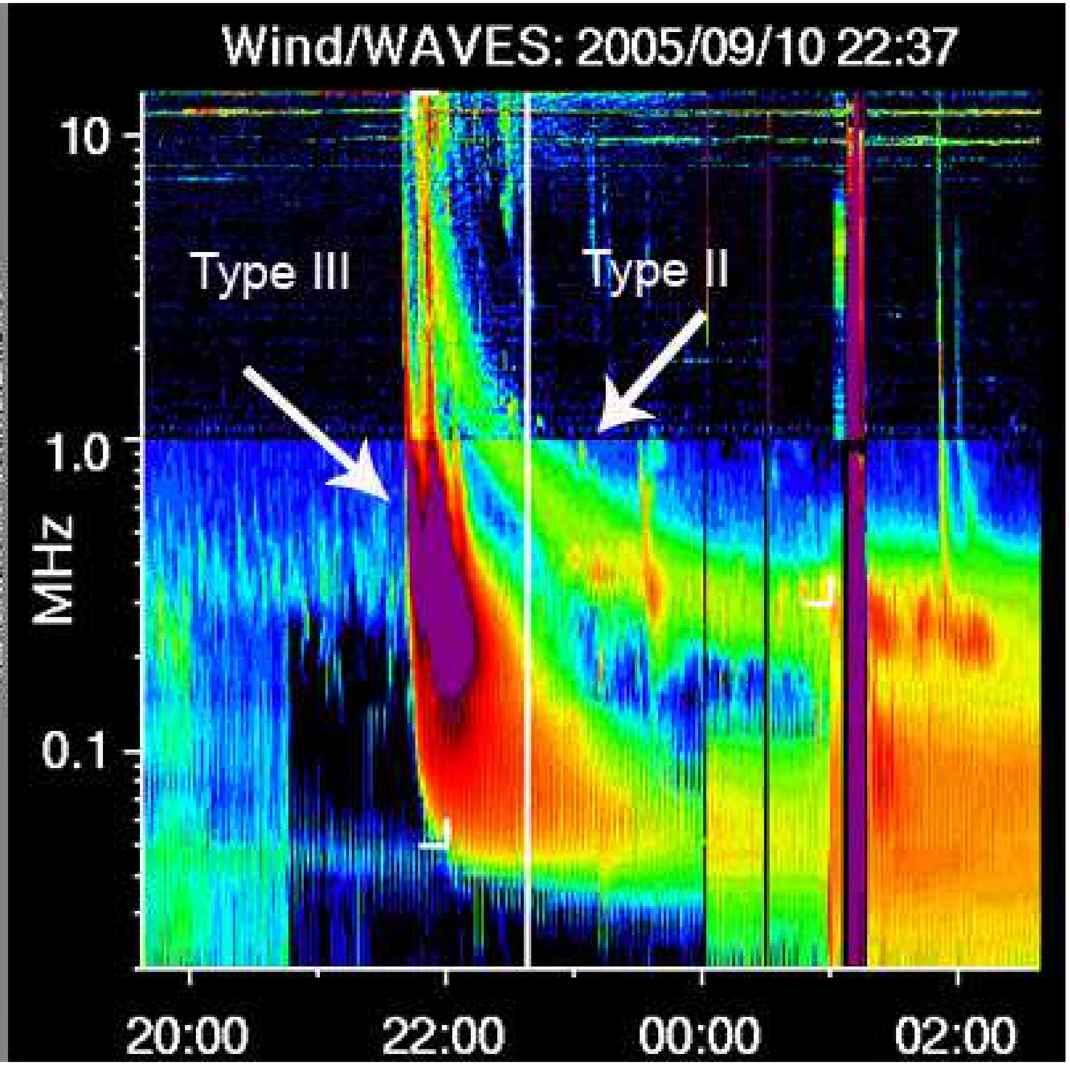
Fig. 15.15 in Markus J. Aschwanden (2005)



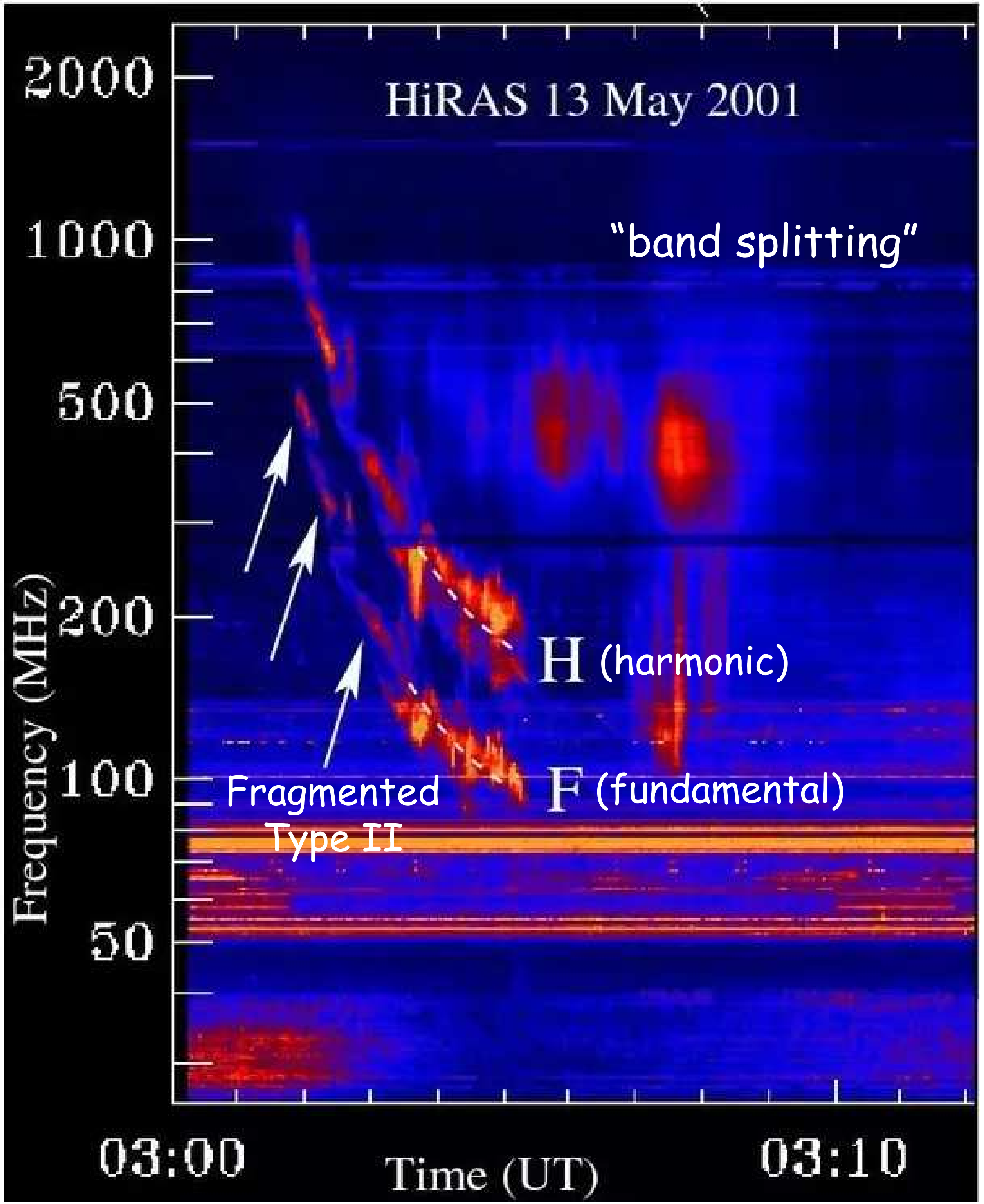
http://pwg.gsfc.nasa.gov/istp/cloud_jan97/waves_cme.html

Radio-Loud CME

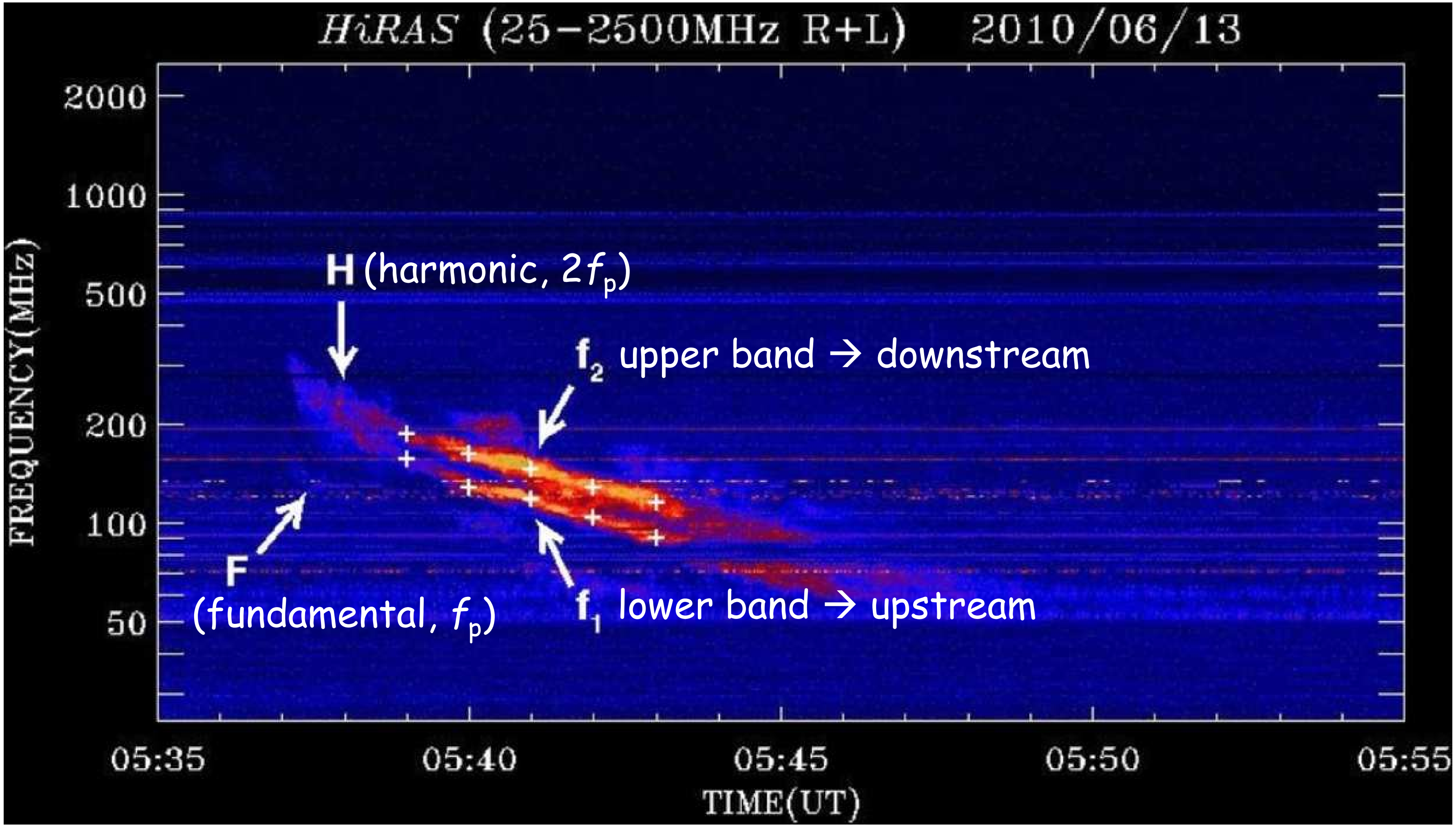




http://www.nasa.gov/vision/universe/starsgalaxies/screaming_cmes.html



https://www.quora.com/How-does-the-Sun-emit-radio-frequencies-What-is-the-mechanism



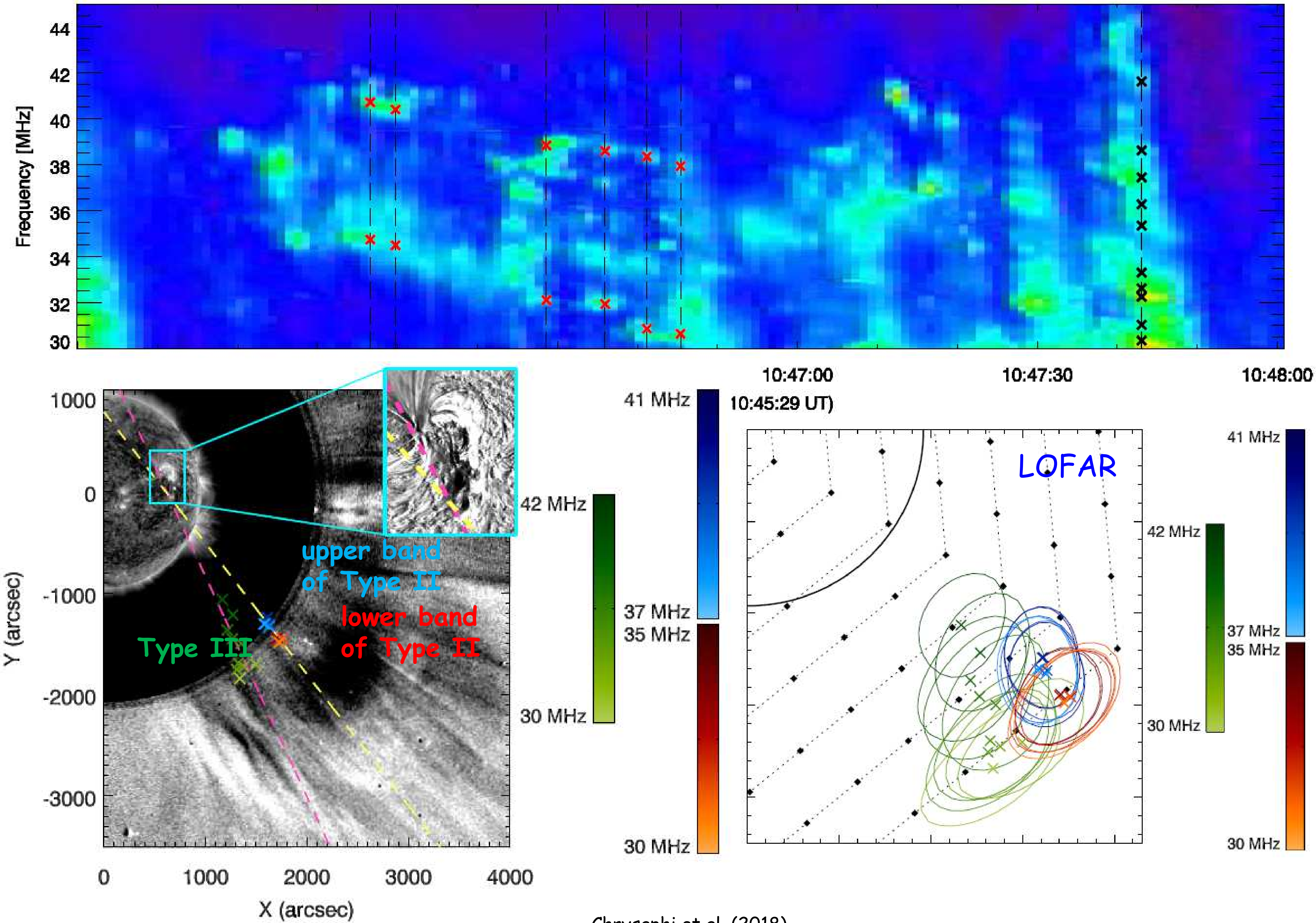
→$f_p = 9 \times 10^{-3} n^{1/2}$ MHz with the electron density n in cm^{-3}

→For example, at 05:40 UT, the upper and lower bands of the harmonic component have frequencies f_2 = 162 and f_1 = 128 MHz, respectively. The local plasma frequencies are therefore f_{p2} = 81 and f_{p1} = 64 MHz, respectively, corresponds with $n_1 = 5.1 \times 10^7 cm^{-3}$.

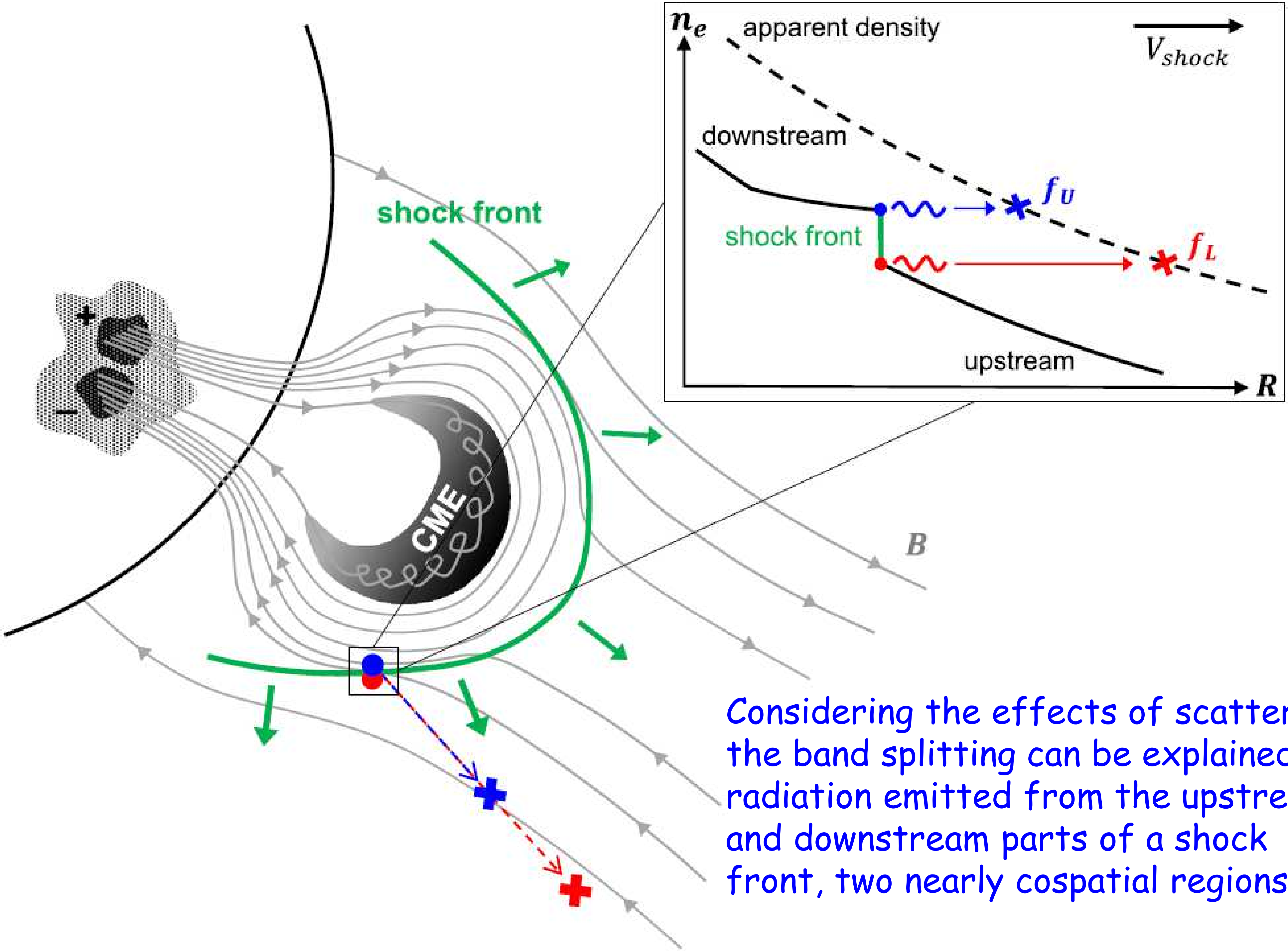
→shock compression ratio n_2/n_1 is simply $(f_{p2}/f_{p1})^2 = (f_2/f_1)^2$

http://iopscience.iop.org/article/10.1088/0004-637X/744/1/72/meta

CME on 2015 June 25 near 10:57 UT



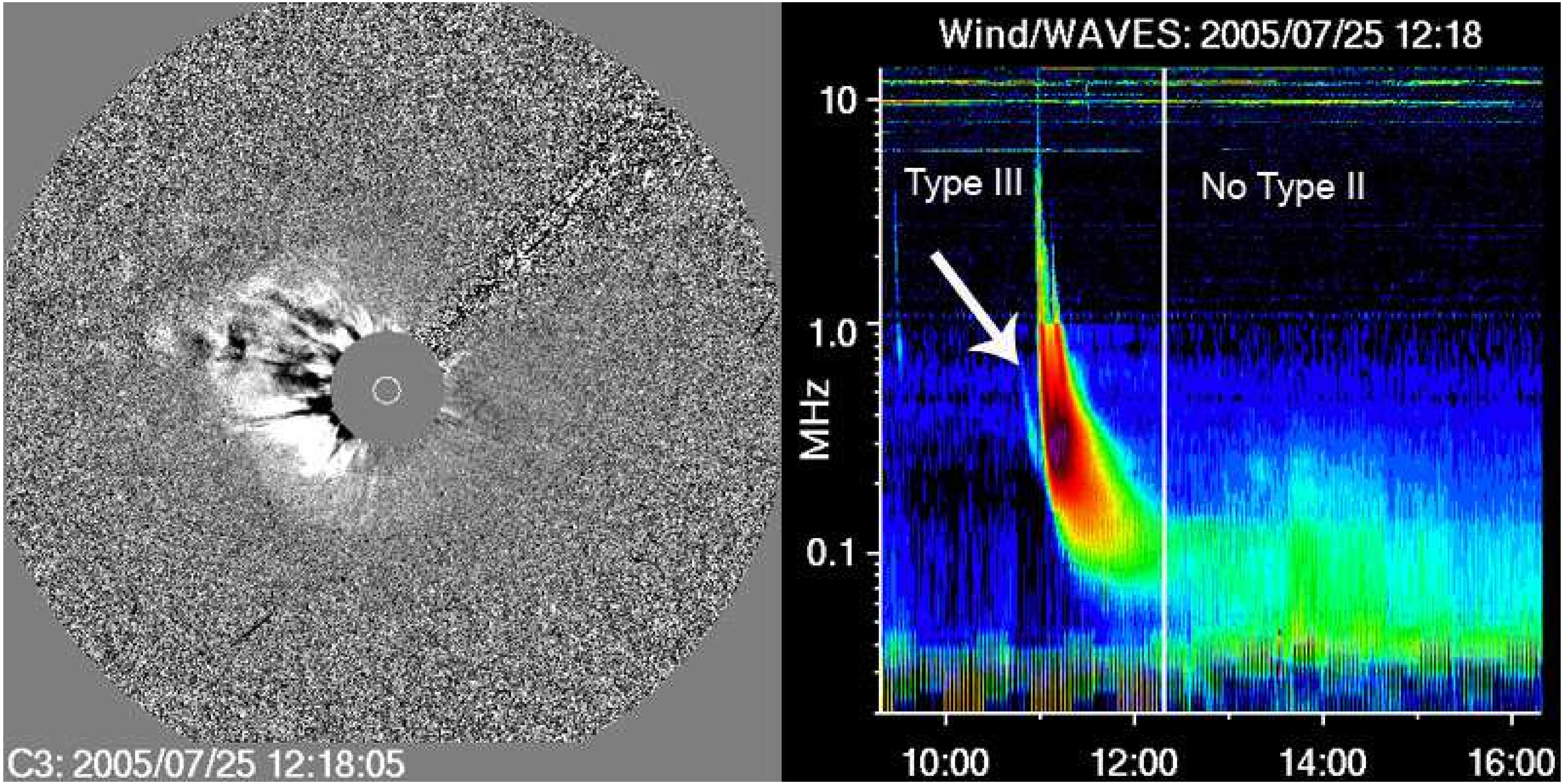
Chrysaphi et al. (2018)



Considering the effects of scattering, the band splitting can be explained as radiation emitted from the upstream and downstream parts of a shock front, two nearly cospatial regions.

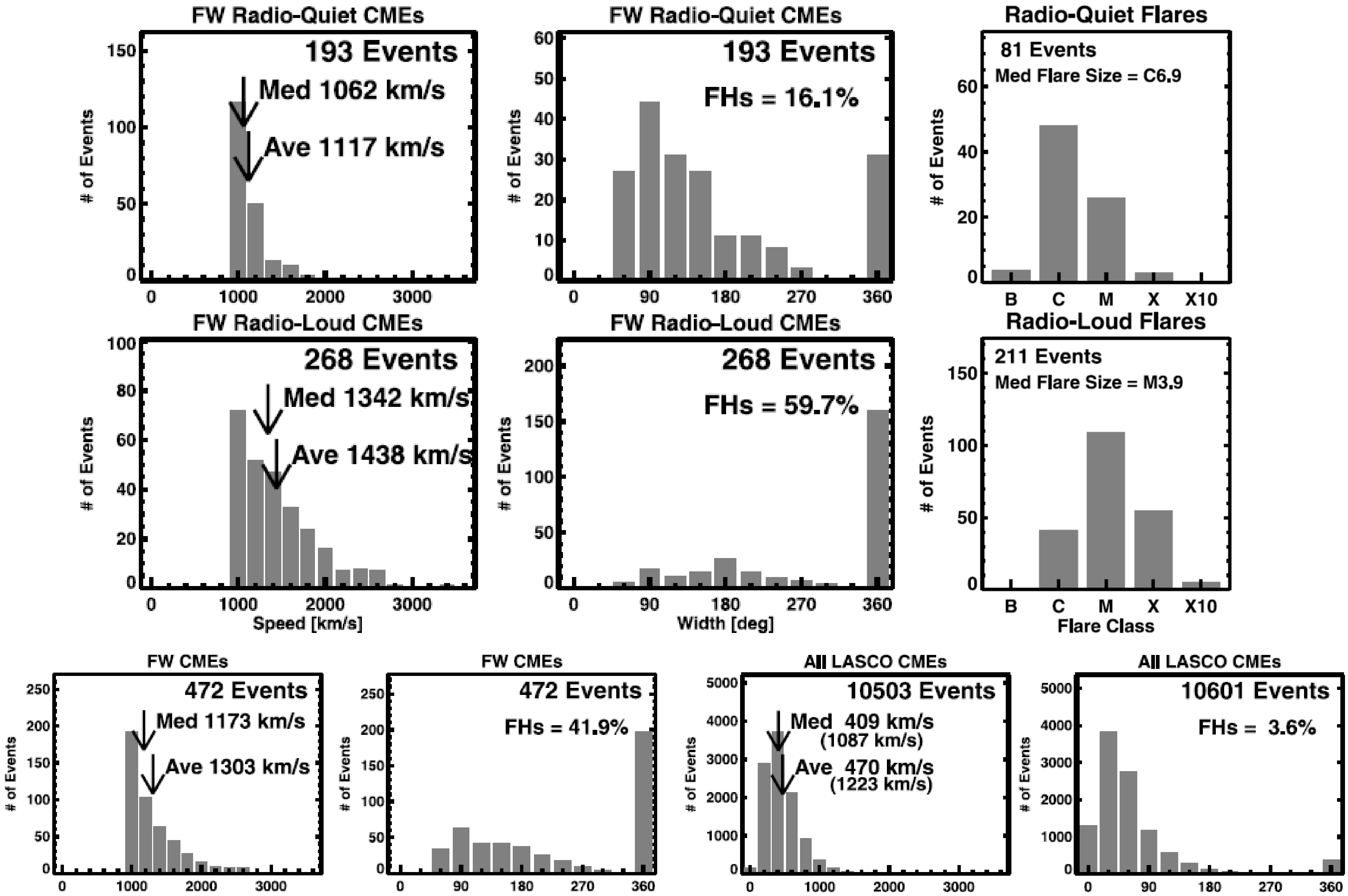
Chrysaphi et al. (2018)

Radio-Quiet CME



http://www.nasa.gov/vision/universe/starsgalaxies/screaming_cmes.html

472 fast (speed >= 900 km^{-1}) and wide (width >= 60°) CMEs during 1996 – 2005 by SOHO/LASCO



Gopalswamy et al. (2008)

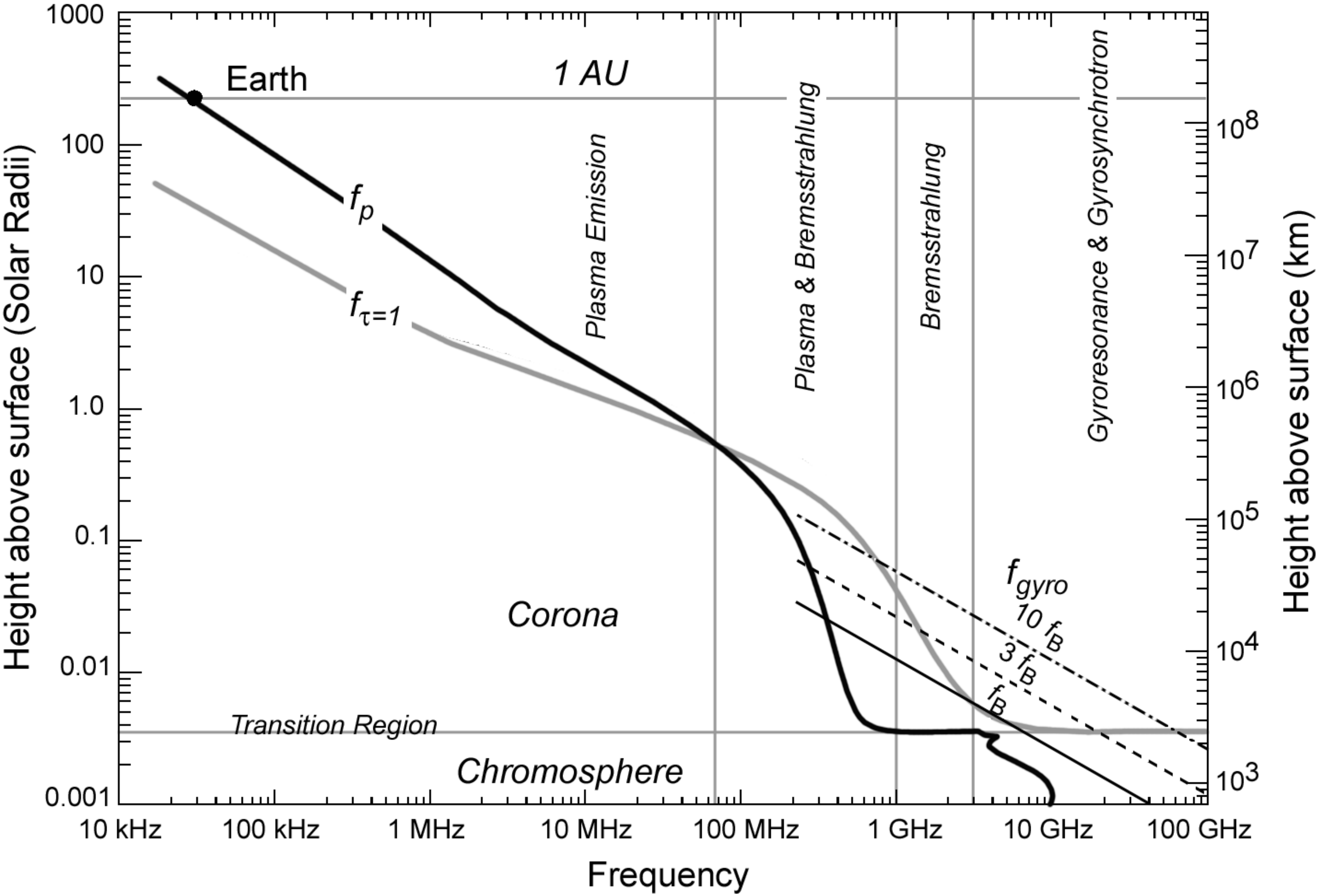
552 events from 891 fast CME events (speed >= 900 km/s) during 1996 – 2012 by SOHO/LASCO

CME properties	Mean values	
	Class-D	Class-A
Radio-quiet		
Position angle (degree)	188	175
Width (degree)	128.7	128
Speed (km s^{-1})	1092	1093
Acceleration (m s^{-2})	−25.89	18.59
Initial acceleration (km s^{-2})	1.89	1.56
Initial speed (km s^{-1})	1254	951
Number of halo events	12.64 %	9.52 %
Radio-loud		
Position angle (degree)	209	171
Width (degree)	279	310
Speed (km s^{-1})	1368	1348
Acceleration (m s^{-2})	−32.63	24.96
Initial acceleration (km s^{-2})	1.53	0.87
Initial speed (km s^{-1})	1567	1094
Number of halo events	65.17 %	68.85 %

Flare properties	Mean values	
	Class-D	Class-A
Radio-quiet		
Duration (min)	33	70
T_{rise} (min)	16	34
T_{decay} (min)	16	35
X	5.79 %	0 %
M	34.78 %	33.33 %
C	59.42 %	66.66 %
Radio-loud		
Duration (min)	48	80
T_{rise} (min)	25	39
T_{decay} (min)	22	41
X	31.7 %	24.48 %
M	48.78 %	46.93 %
C	18.2 %	26.53 %

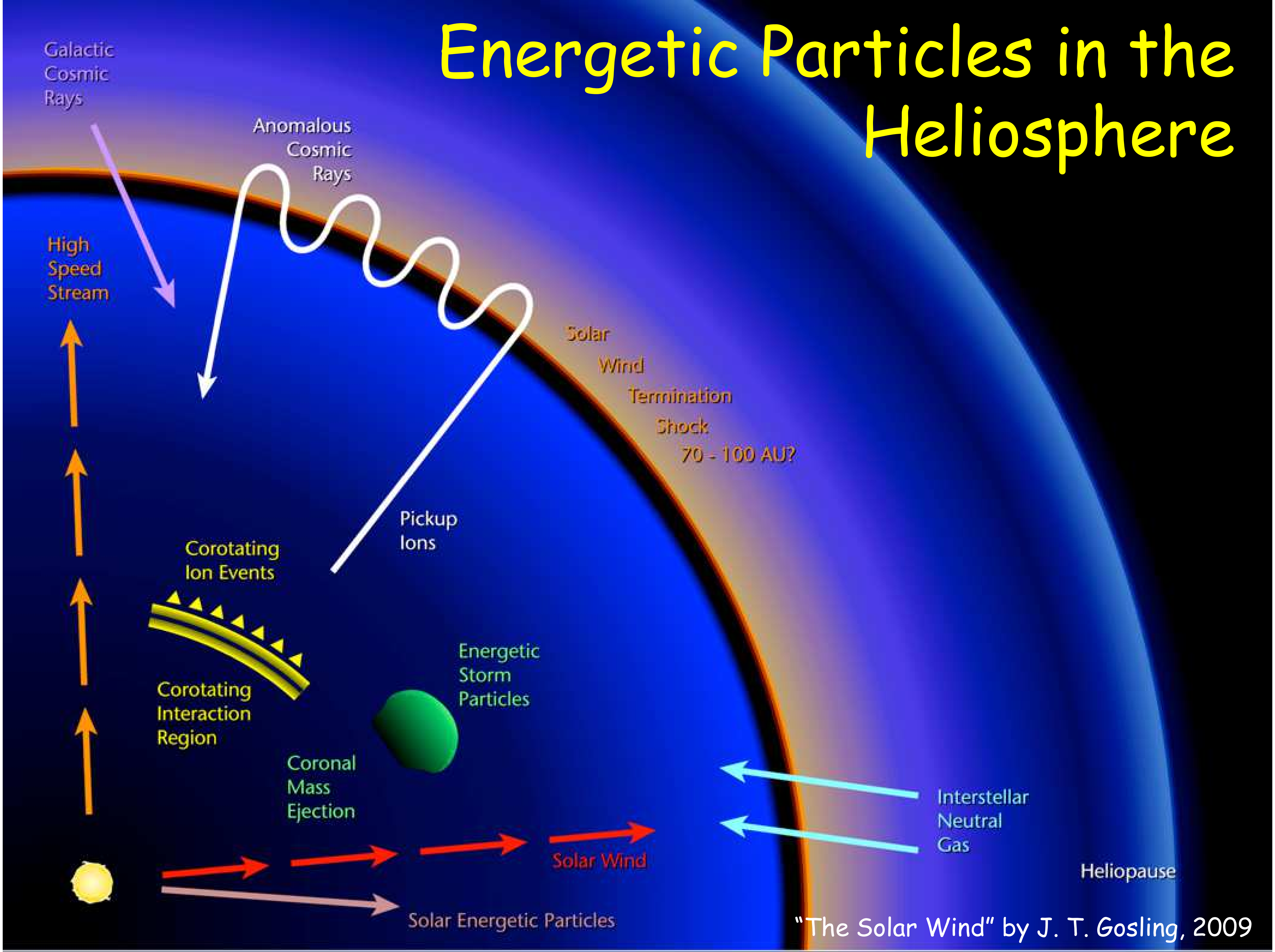
RQ CMEs were found to be less energetic than RL CMEs and are less often associated with intense X-ray flares. This confirms the previous results that RQ CMEs do not often exceed the critical Alfvén speed of 1000 km/s in the outer corona that is needed to produce type II radio bursts.

Suresh & Shanmugaraju (2015)

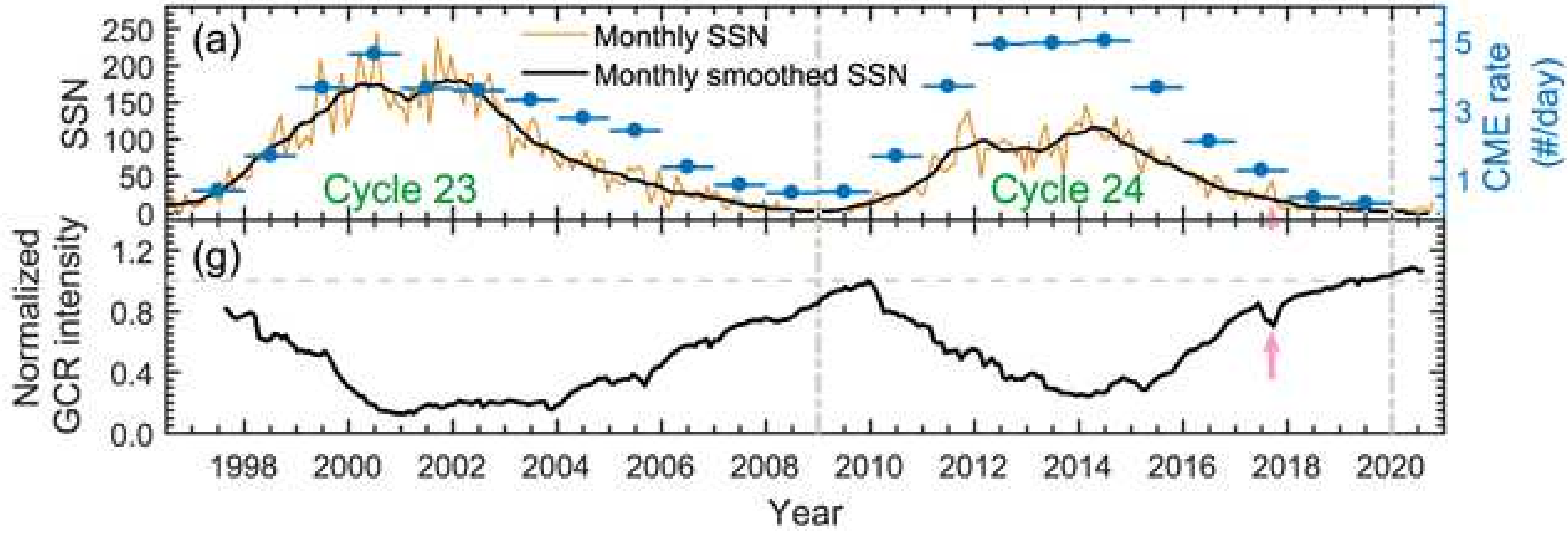


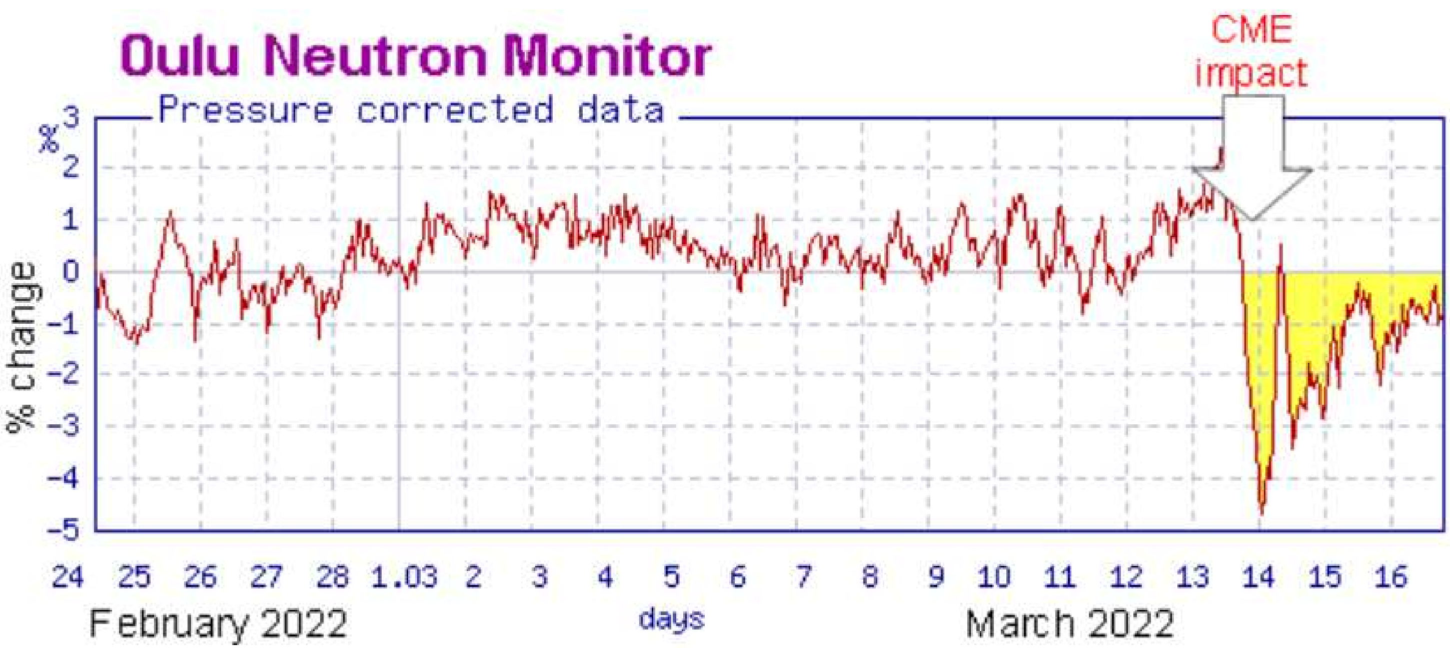
https://web.njit.edu/~gary/728/Lecture10.html

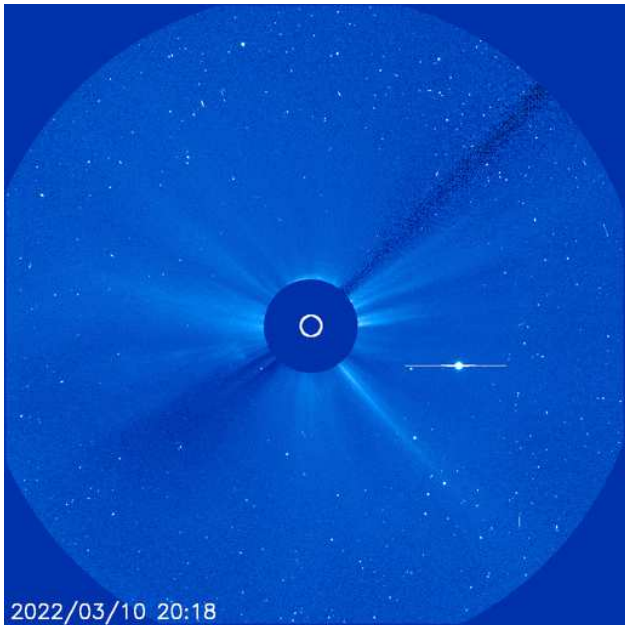
Energetic Particles in the Heliosphere



"The Solar Wind" by J. T. Gosling, 2009







https://www.spaceweather.com/archive.php?view=1&day=17&month=03&year=2022