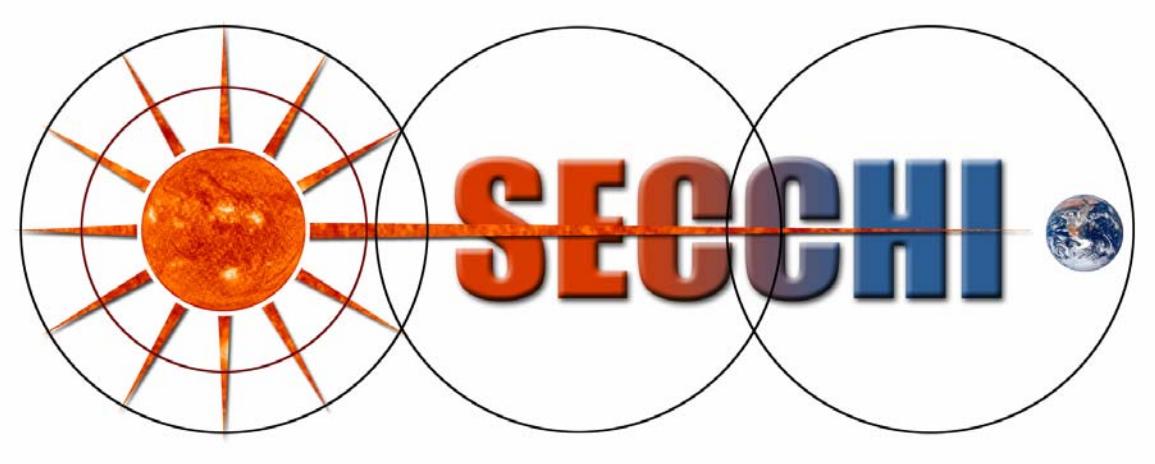

On Combining White Light Images & Radio Data

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NRL

Summary

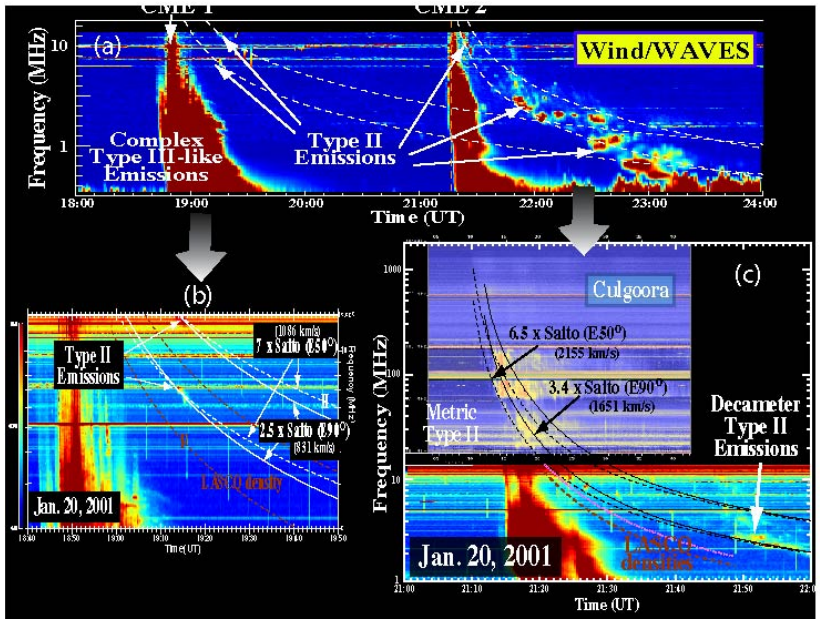
- Contributions of Radio Observations:
  - Accurate timing of eruption initiation and development.
  - Derivation of physical parameters in the eruptive structures (when thermal).
  - Positional information on Type-II (shocks) sources.
  - Identification of electron acceleration sites.
  - Tracking the CME evolution from birth to Earth.
  - Discovery of precursors to solar eruptions.

Radio Type-II Emissions and CMEs

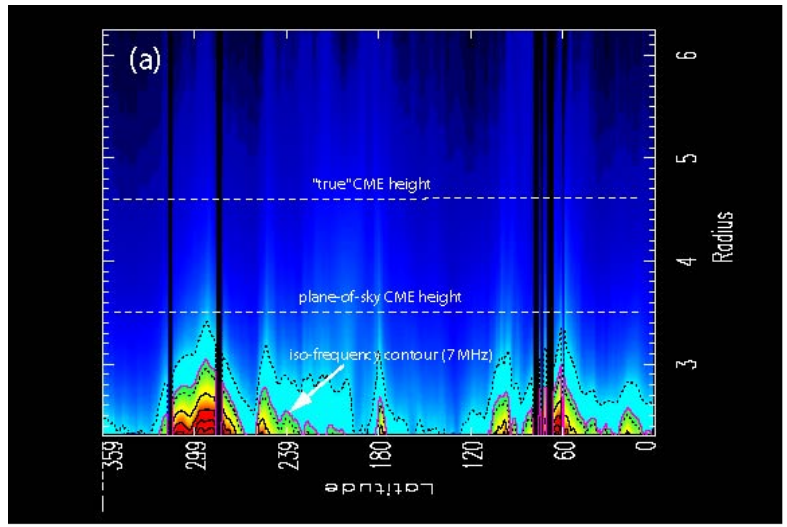
1. Type-II emissions remain unreliable proxies of solar eruptions.

- 90% of EUV waves are associated with metric Type-IIs (Klassen et al. 2000).
- But EUV waves are better correlated to CMEs (Biesecker et al. 2002).
- Type-IIs are blast waves (30%), CME-driven (30%) or behind CME (30%) (Classen & Aurass 2002).

2. A possible new technique for joint Type-II/LASCO data analysis.



- Consistency between LASCO densities and Type-II profiles can pinpoint the CME launch time, position angle and type-II source region (Reiner et al. 2002).

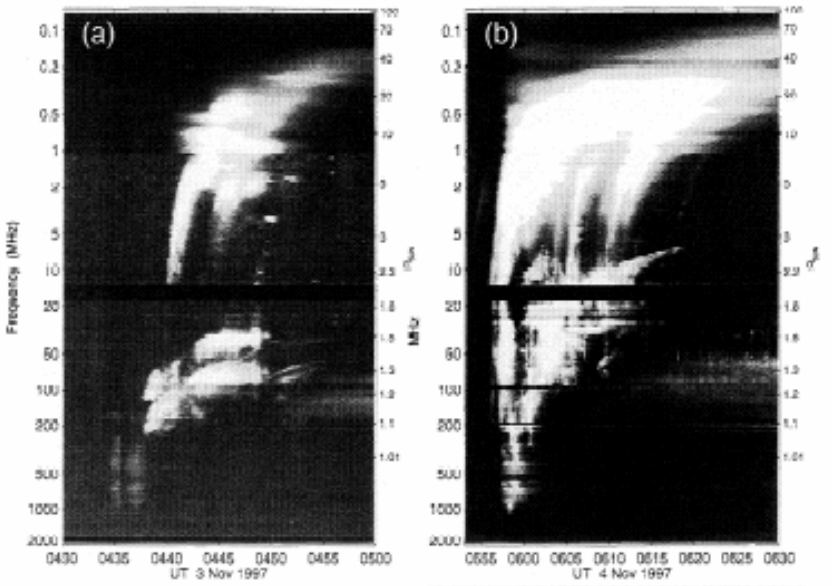


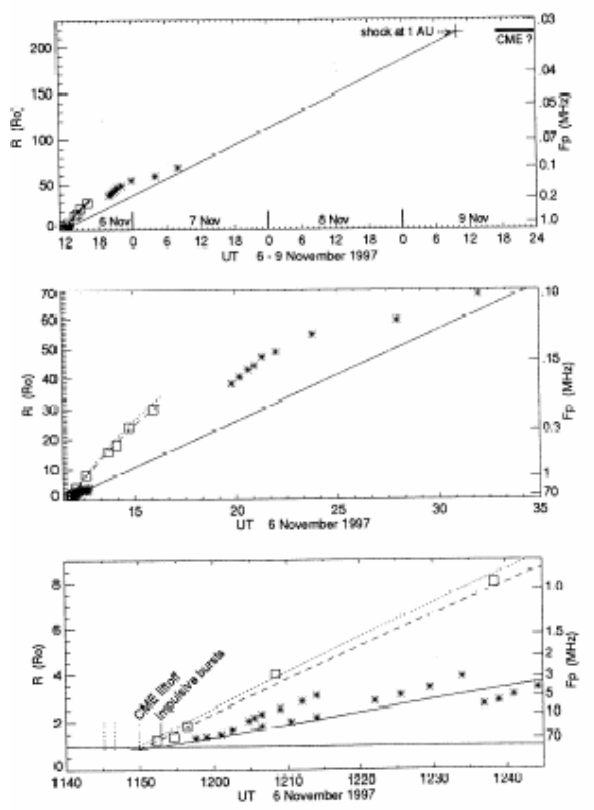
Radio Spectra of CMEs

1. Continuous Spectral Coverage of Radio Solar Emissions.

Several Spectrometers
(2 GHz – 100 KHz)

(Dulk et al. 2000)





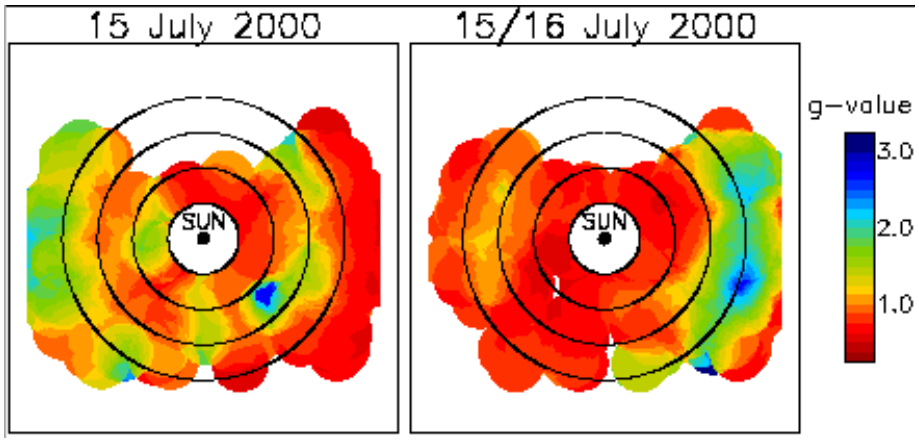
(Leblanc et al. 2000, 2001)

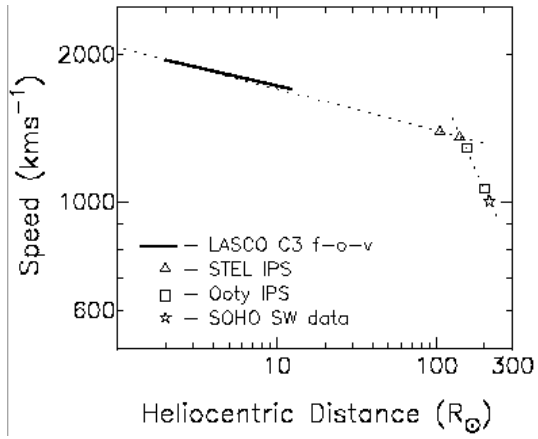
- **Establish the flare/CME/Type-II temporal relation.**
- **Multiple Type-II sources.**
- **Evidence for shock-accelerated electrons.**

Radio Imaging of CMEs

6. IPS Mapping of CMEs.

ORT (327MHz)



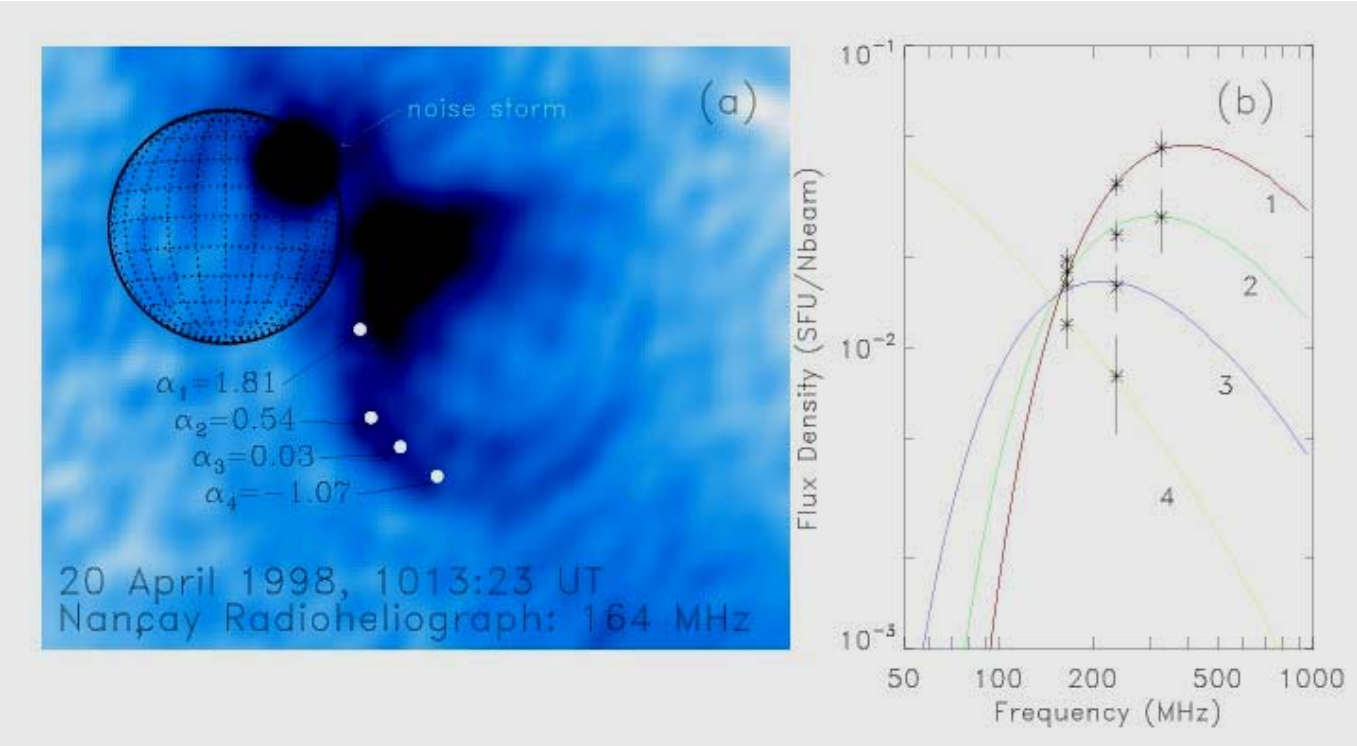


(Manoharan et al. 2001)

- **Follow the CME evolution in IP space.**

Radio Imaging of CMEs

4. Image directly radio CME loops for the first time.



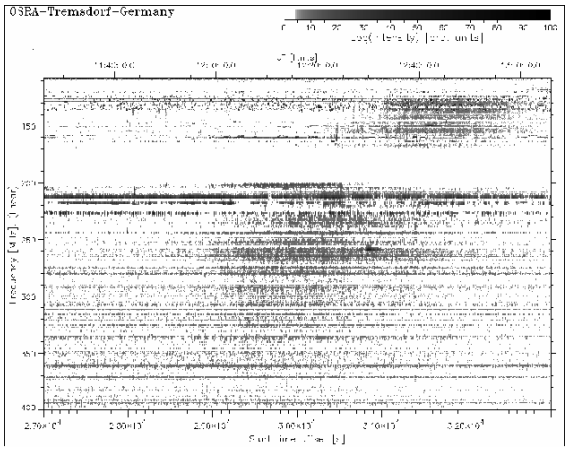
(Bastian et al. 2001)

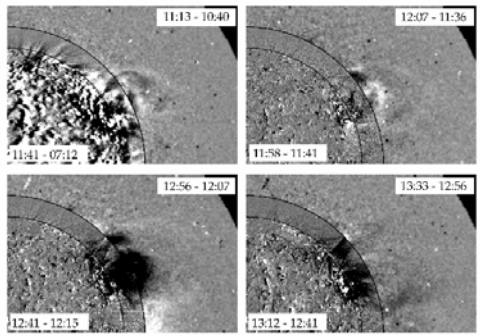
- **Image fine-scale CME structures.**
- **Derive physical parameters:**

  B_{CME} ~0.1-few G, E ~ 0.5-5MeV, n_{th} ~10^7 cm^{-3}

Radio Precursors of CMEs

1. Drifting continuum sources may signal the birth of the CME.





(Aurass et al. 1999)

2. The role of Noise Storms remains controversial.

- Some NS changes correlate with CME (Chertok et al. 2001).
- NS starts before CME (Ramesh & Sundaram, 2001) or after CME (Willson, 1998).

•More work is needed to establish reliable radio precursors for CMES.

Coordination Issues

Need to add or coordinate:

- With radio GBOs to provide spectra on a regular basis (extent the S/WAVES spectrum to solar corona).

- With imaging interferometers to provide images.
  - Nancay RH is already collaborating
  - Gauribidanur RH should be added.

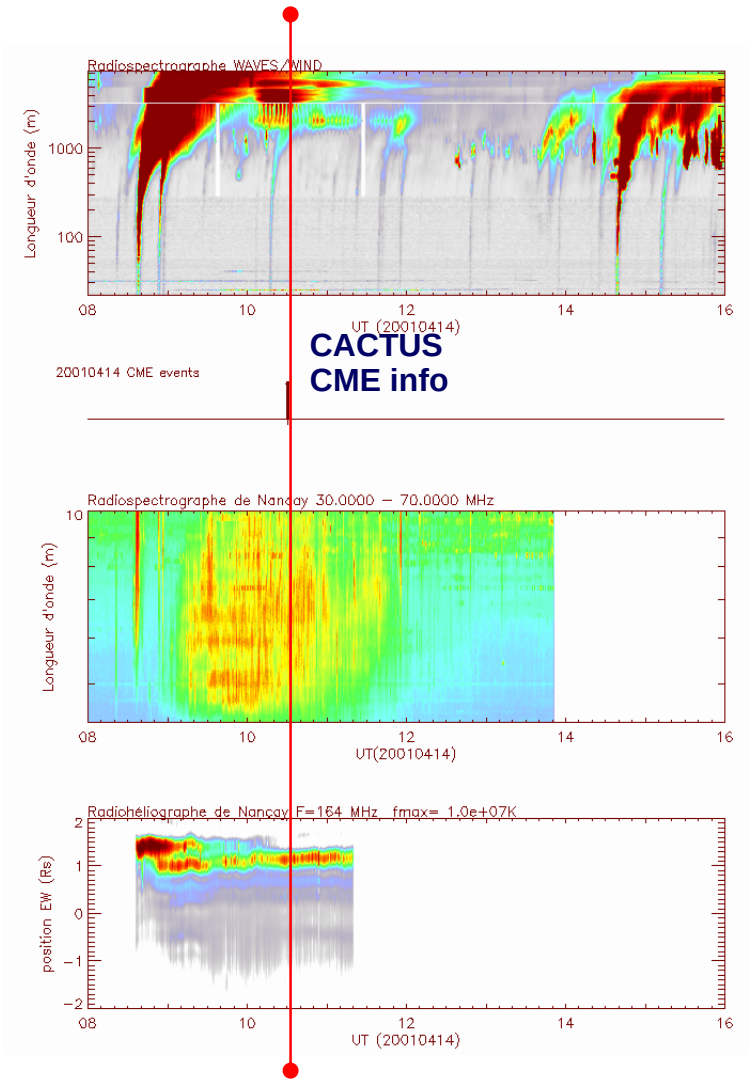
- With IPS instruments to provide continuous coverage of IP space
  - EISCAT is not IP-dedicated, time allocation is a problem
  - MEXART opens officially next month (12/05)
  - Ooty has manpower problems?

Backup Slides

Radio Data + CME Catalog

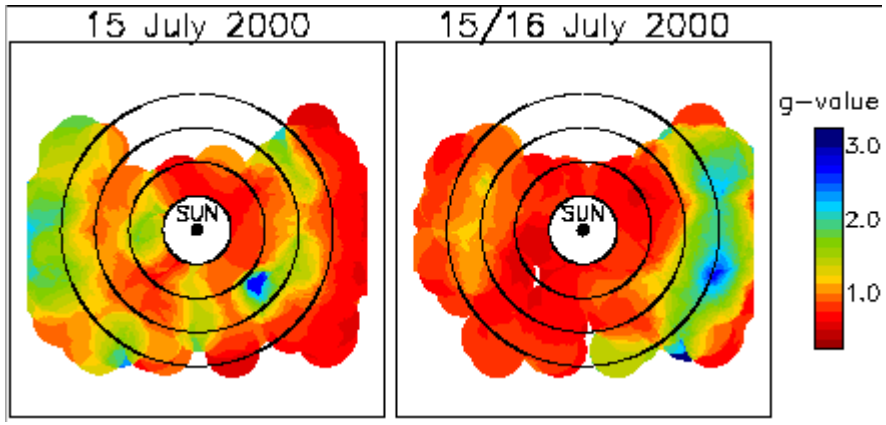
Need to add or coordinate:

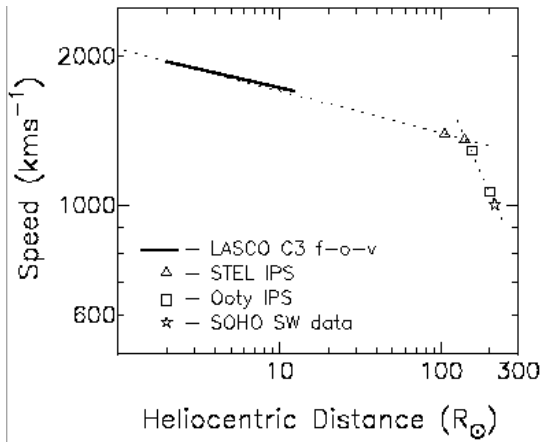
- More ground-based radio spectra to extent the S/WAVES spectrum to solar corona
- Gauribidanur images at 109MHz.

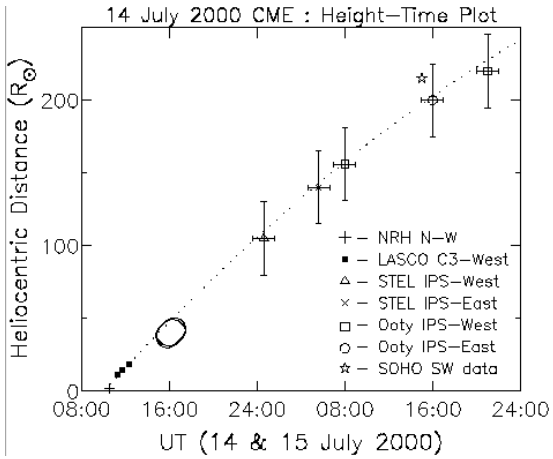


IPS

- **Indirect maps of CME**
- **Possibility of continuous coverage (EISCAT?, STEL, Ooty, MEXART)**
- **Data complimentary to coronagraph data (Ne along LOS, speed of solar wind)**



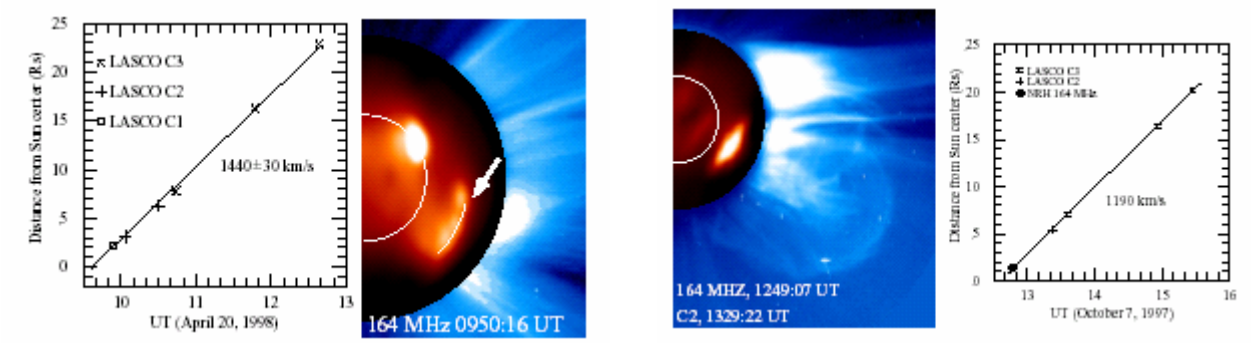




Manoharan et al (2002)

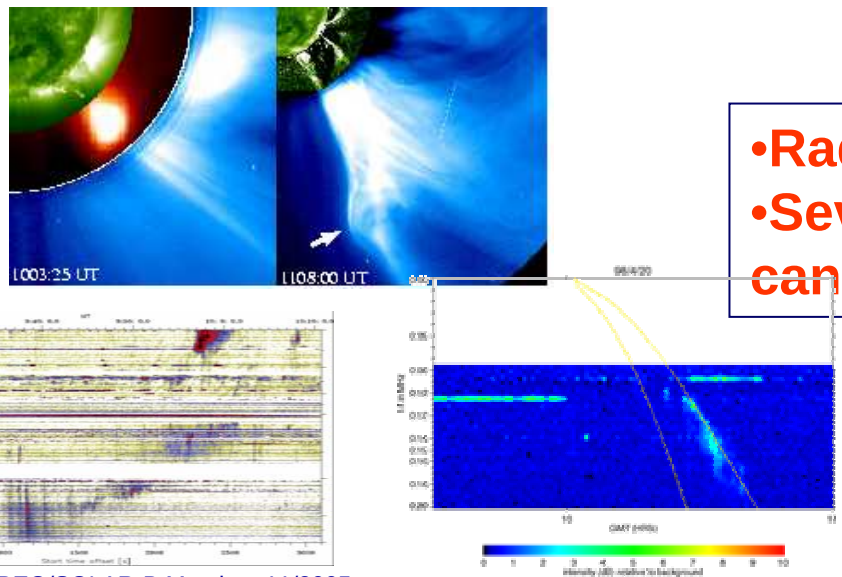
Radio Imaging of CMEs

2. Identify the shock at the CME front.



(Maia et al. 2000)

3. Identify sources of Type-II (shock) emission behind the CME front.



- **Radio CME front is faint.**
- **Several candidates for Type-II emission can be identified.**

(Vourlidas et al. 1999)

Why combine radio + WL images?