The Solar-B EUV Imaging Spectrometer: Science with EIS and Stereo with Focus on Velocity Measurement

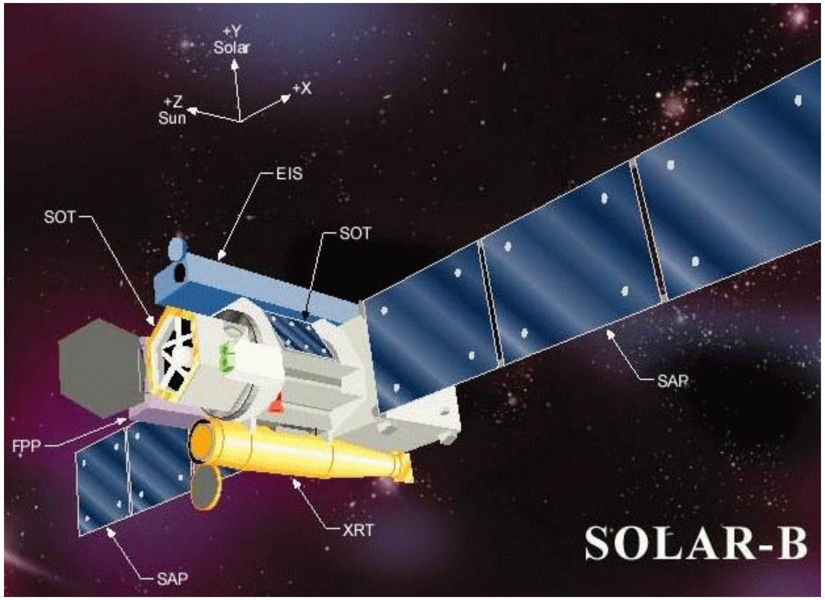
J. L. Culhane

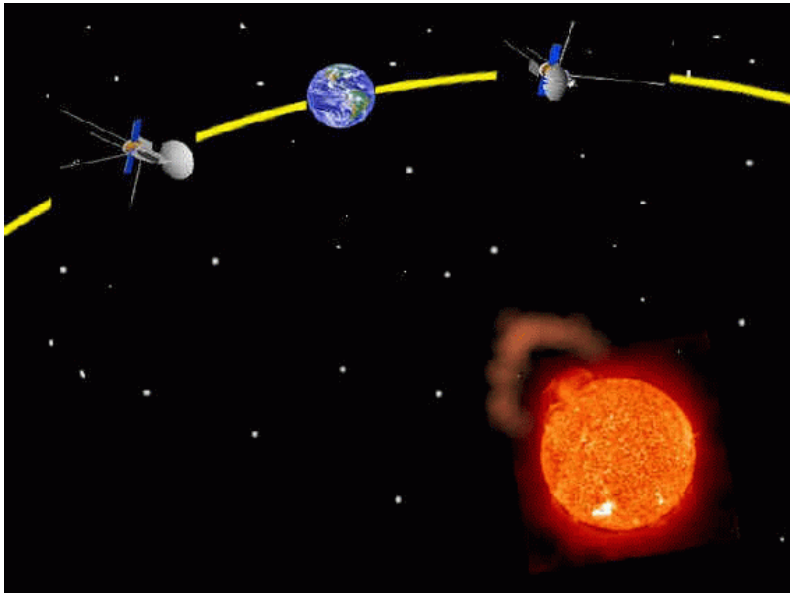
Mullard Space Science Laboratory
University College London

Solar-B and STEREO Features

- Solar-B
  - Optical telescope has a field of view that gives optimum AR coverage
  - EIS can cover a larger field
    - Must raster with slits for high spectral resolution
    - Can image with slots
      - 40” FOV with some spectral resolution
      - 250” FOV to detect transient events
  - XRT provides full Sun filter images, AR context and flare alerts
- STEREO
  - Coronagraphs observe CMEs after launch
  - EUVI provides full Sun coverage at lower T_e than XRT
  - STEREO/WAVES characterizes shocks and shock velocities
- Summary
  - Solar-B emphasizes detailed studies of potential launch sites
  - STEREO emphasizes global coverage of CME events
  - XRT and EUVI together provide solar images over a very broad T_e range

Solar-B and STEREO





Solar-B will observe the smaller-scale magnetic and velocity fields from the photosphere to the corona

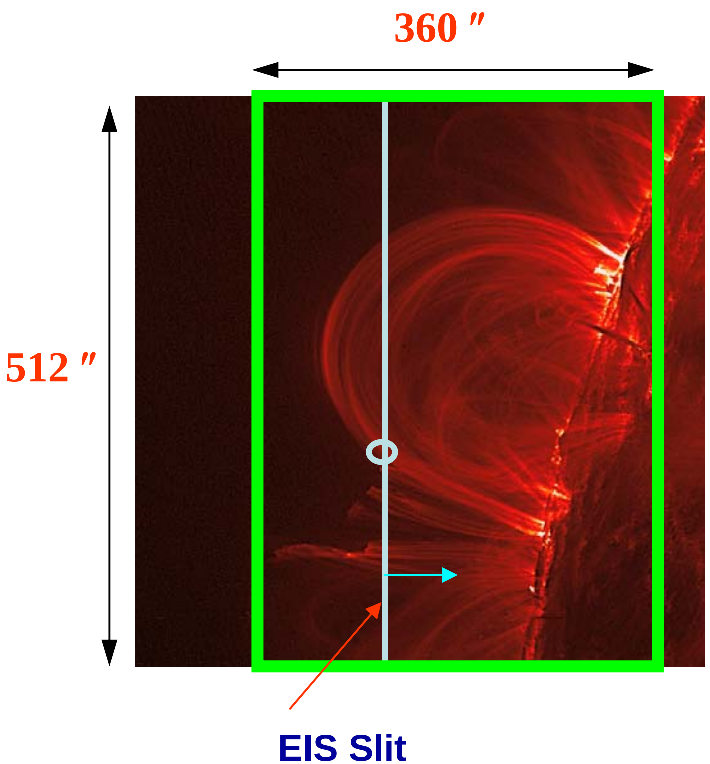
Stereo will observe the global coronal phenomena in 3-D

EIS Performance Gains

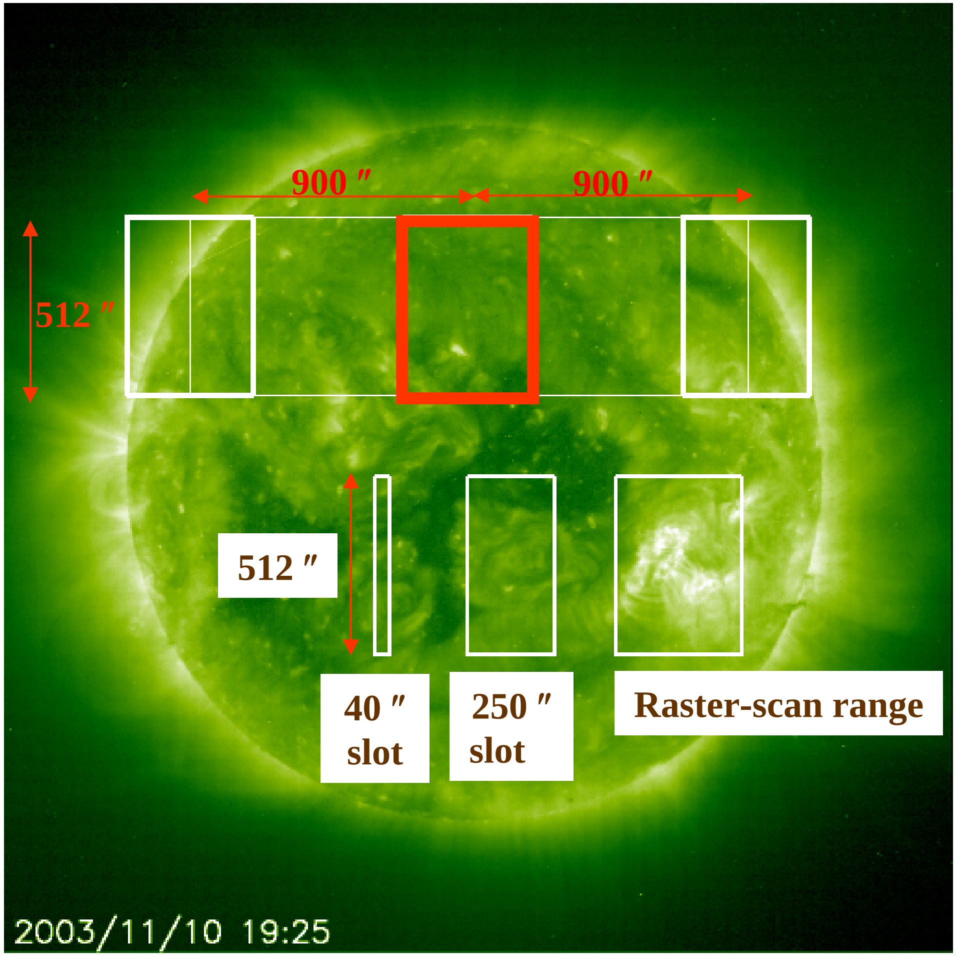
- Following SOHO CDS, the EIS instrument will provide the next steps in 150 – 300 Å spectral imaging of the corona:
  - x 10 enhancement in A_{eff} from use of multilayers and CCDs
  - x 5 enhancement in spectral resolution
  - x 2-3 enhancement in spatial resolution
  - Like CDS; absolute calibration performed to ± 20%

EIS Field-of-View

Maximum FOV for raster observation



Shift of FOV center with coarse-mirror motion



Some Relevant EIS Observations

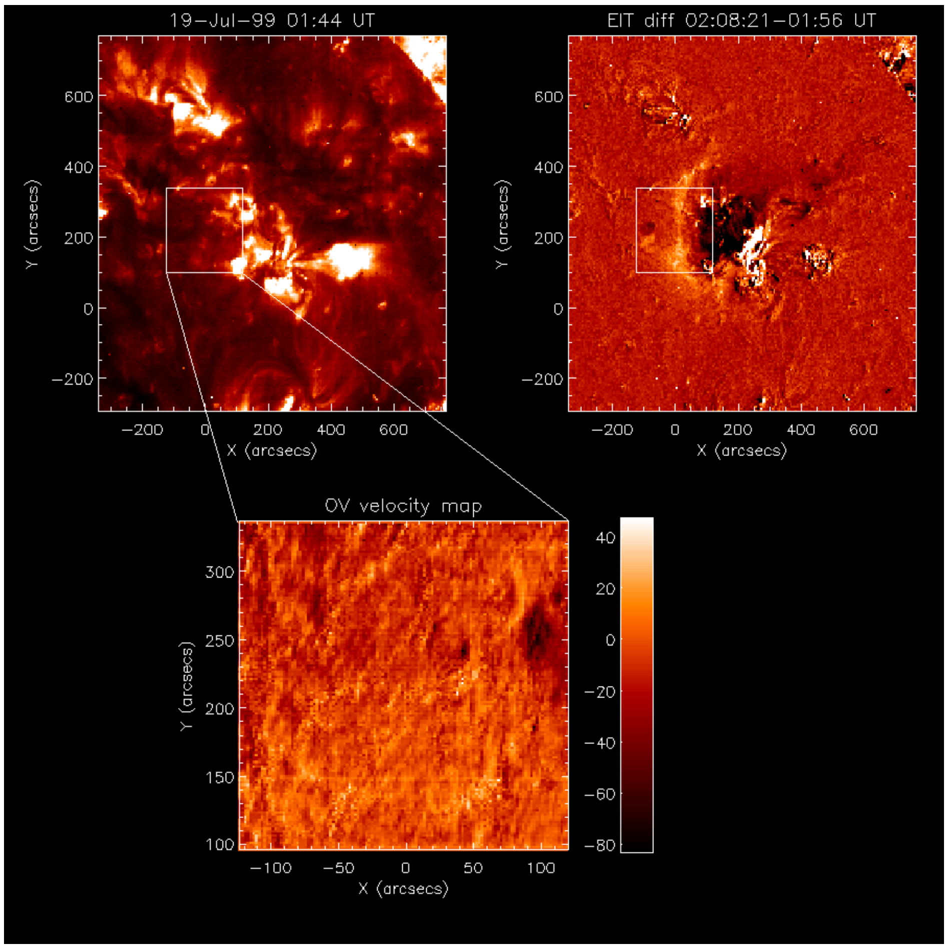
- Solar-B/EIS can contribute to studies of:
  - CME-associated dimming outflows
  - CME acceleration
  - Coronal waves and CMEs
  - CME-asociated trans-equatorial structures

- Examples are presented from:
  - SOHO CDS with TRACE, EIT and Yohkoh images

- Necessary data from:
  - Observations of active region CME launch sites
  - Spectral images of active regions during flares/CMEs
  - Measurement of T_e, n_e and especially v as f(T_e) in e.g. dimming sites
  - Velocity measurements on disc for e.g. acceleration of ejected material

CME Dimming Outflows

- Coronal dimming directly associated with outflow (Harra & Sterling, 2001)



- Bottom panel shows a CDS O V velocity map for a disc event where ~ 80 km/s outflow is seen from the edge of the dimming region

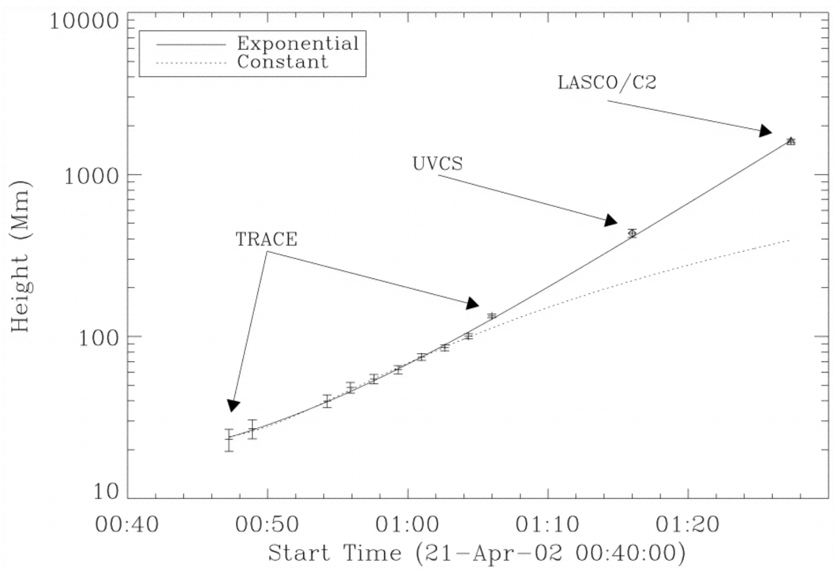
- EIT and CDS limb event observations show intensity reduction and outflow velocities in He I, O V, Mg IX and Fe XVI

- Using EIS:
  - select HeII, SiVII, Fe X, Fe XIII, Si X, Fe XIV, Fe XV, Ca XVII lines
  - raster slit over 6’ x 8’ in 30 min.
  - raster 40” slot over 6’ x 8’ in 1 min.

- Respond quickly to dimming onsets

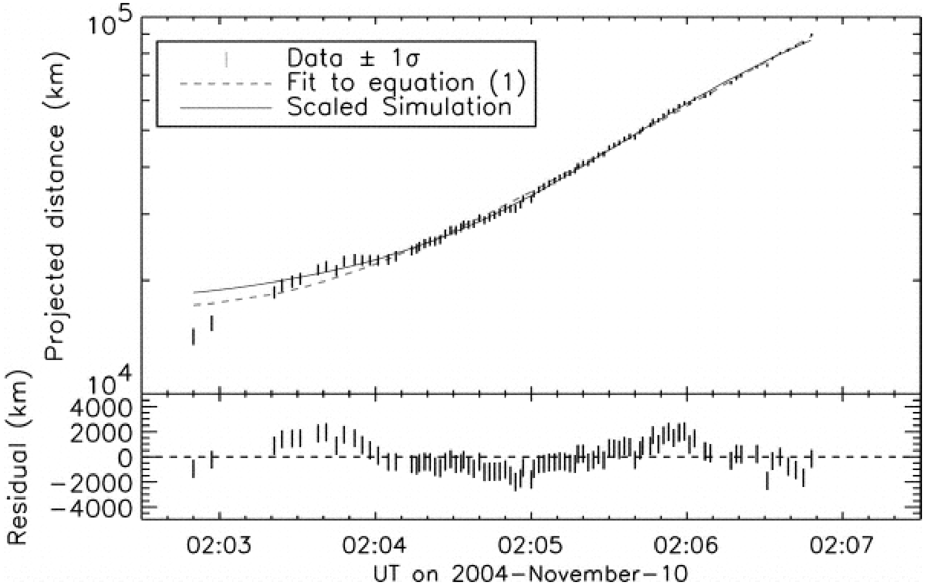
CME Velocities for Disc Events

- High velocity CME seen on limb by TRACE, UVCS and LASCO (Gallagher et al., 2003)
- Exponential acceleration and deceleration with constant velocity phase observed in LASCO – often the case



- EIS will measure velocity for on-disc events

- Similar acceleration behaviour seen in erupting flux-rope (Williams et al., 2005)
- Velocities from TRACE
  - SOHO CDS has seen similar structures but with poor cadence

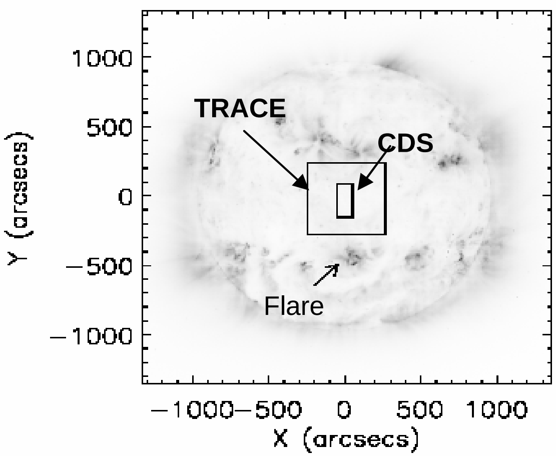


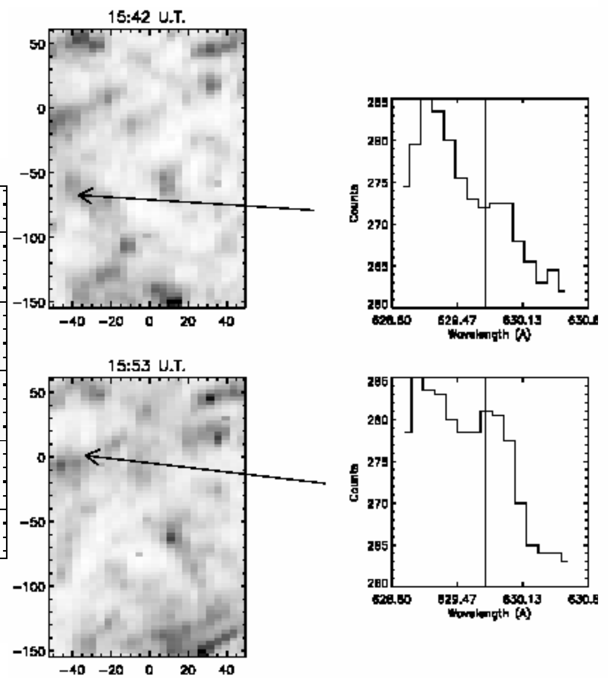
- EIS will operate at much higher cadence

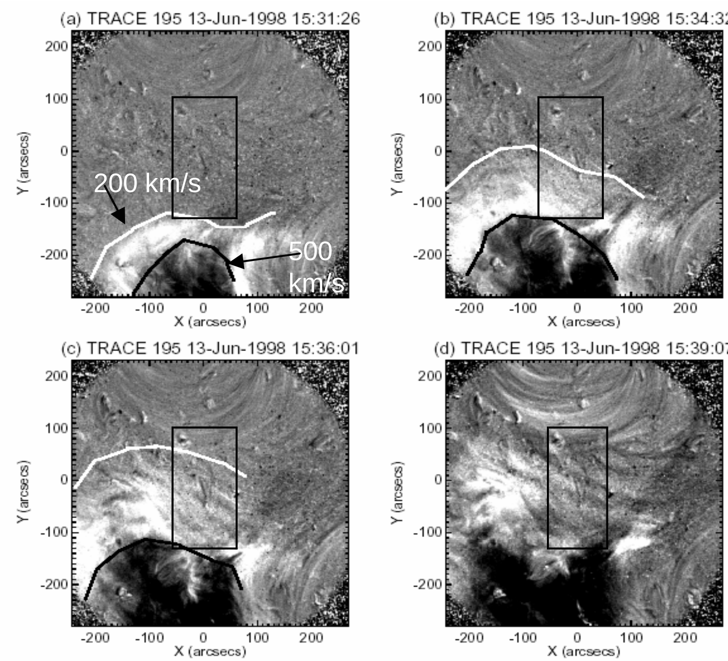
Coronal Wave and Ejection Observations

- Harra and Sterling, 2003, using TRACE and SOHO CDS, observed a flare with associated Coronal Wave and CME

- EIT 195Å image with TRACE and SOHO CDS FoVs
  - waves in TRACE; v ~200 and 500 km/s
  - erupting filament material; v ~ 150 - 300 km/s measured from CDS O V, He I and Mg X lines



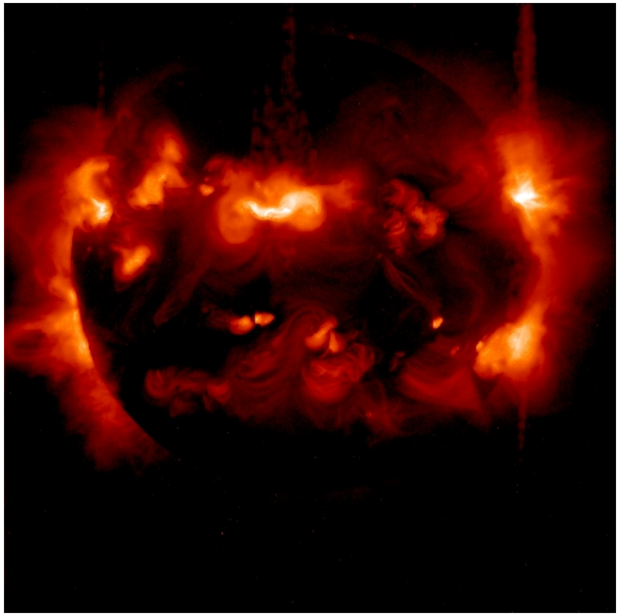




- Optimised EIS raster will respond faster to waves and erupting filament material

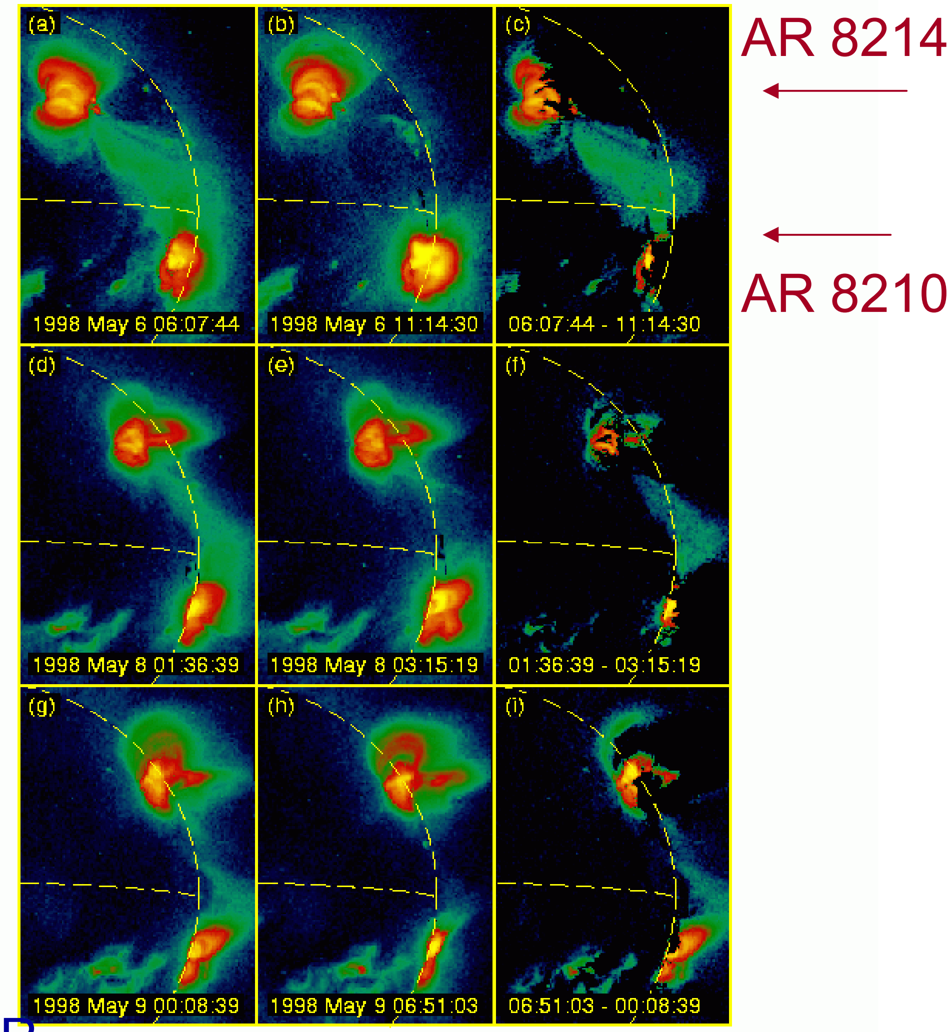
Large Scale Coronal Features

- Large-scale trans-equatorial coronal loops and filaments have been observed for decades
- They are sometimes related to coronal mass ejections (Khan and Hudson, 2000)
- Zhou et al. (2005) find that trans-equatorial filaments erupt with 13% of halo CMEs while for trans-equatorial loops, the association is for 40% of cases



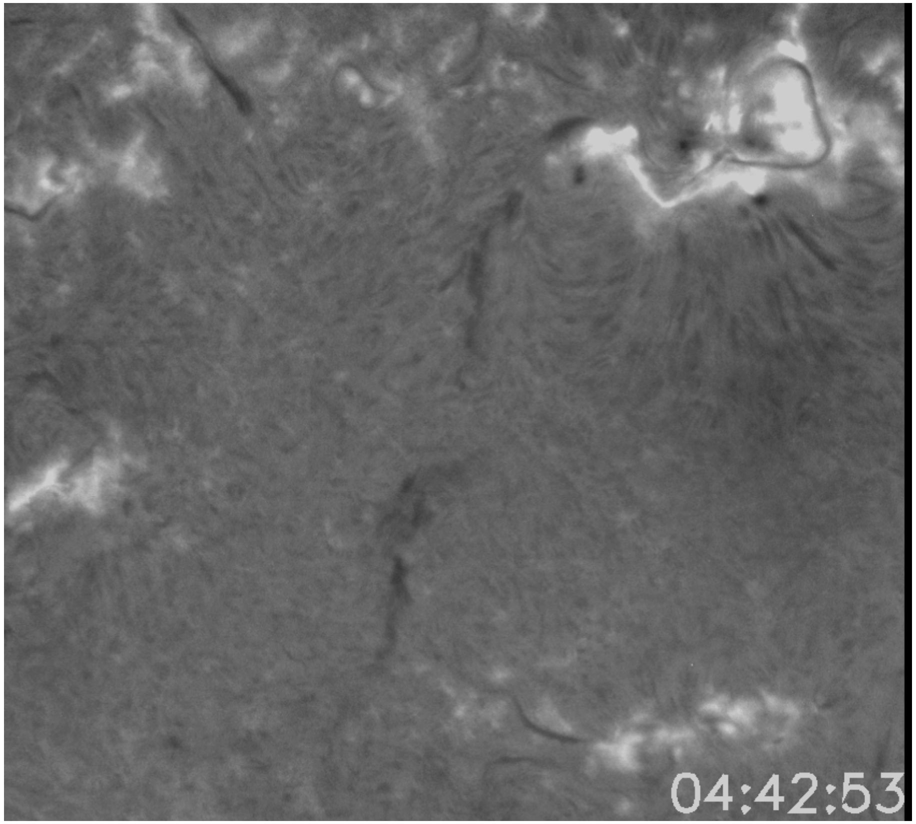
CMEs and Transequatorial Loops

- Sequence of three transequatorial loop disappearances observed with Yohkoh SXT (Khan and Hudson, 2000)
- Each disappearance closely associated with a major flare (X2.7, M3.1, M7.7) and a CME
- X-ray loop plasma masses are similar to those released in CMEs
- Waves from the flare region (AR 8210) play a role in the disappearances
- EIS could measure velocities at flare AR site or at intermediate position on loop



Erupting Filaments

- Wang et al.(2005) show Bastille day flare not isolated to the active region
- Activation of the huge trans-equatorial filament precedes the filament eruption and flare that occur simultaneously in the source active region



- Positioning of EIS raster and operating mode choice are crucial

CONCLUSIONS

- Studies of the CME launch process are important
- Solar-B can investigate launch-related phenomena in some detail
- EIS can measure the properties of coronal and transition region plasma and its flow velocity at potential launch sites
- Combination of slit and slot registration allows spectral imaging or optimized raster scanning for high spectral resolution
- While EIS can be re-pointed E-W limb-to-limb, N-S coverage is limited to ± 4.25 arc min from spacecraft Sun-pointing axis
- Solar-B spacecraft pointing will therefore need to be specified for particular CME-related targets
- Joint Observing Programmes involving EIS will be appropriate for at least:

  - Dimming outflows - Coronal waves

  - CME acceleration - Large-scale structure eruptions

END OF TALK