WP3: Deriving/cataloguing kinematics of STEREO/HI CMEs based on geometrical and forward modelling
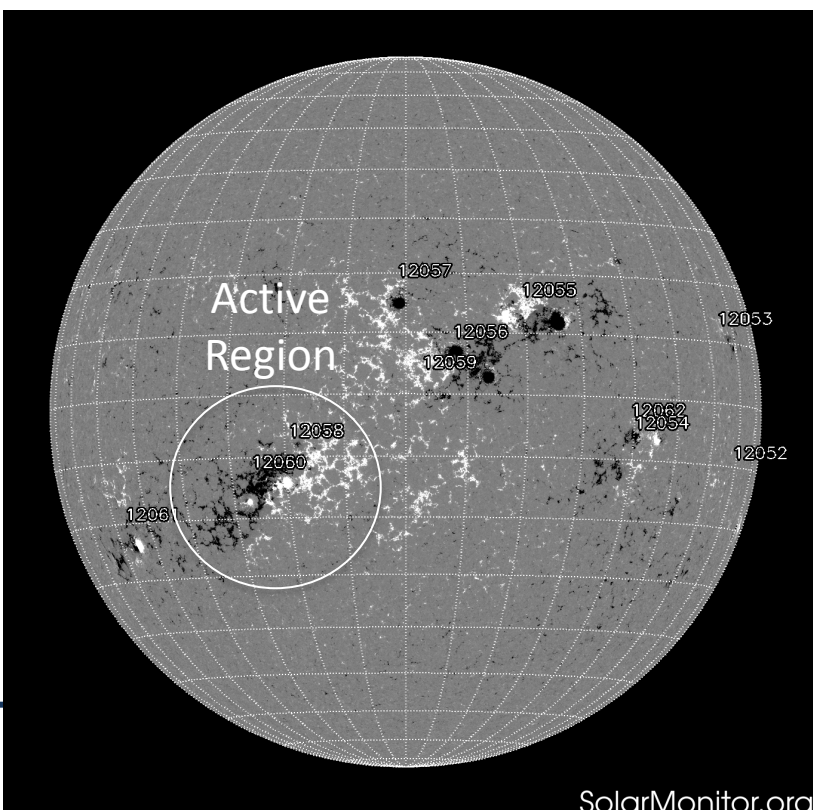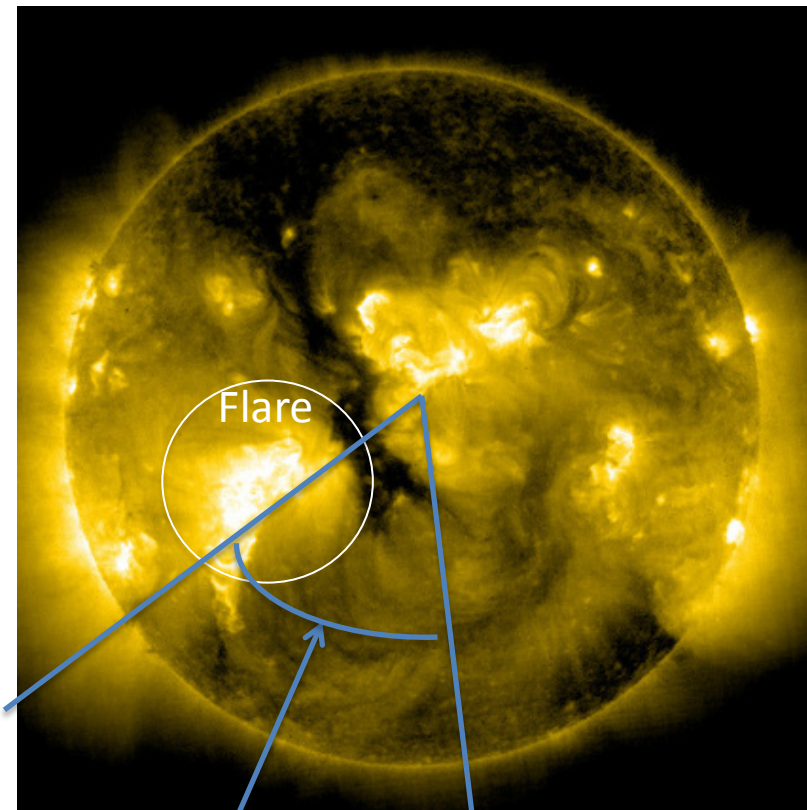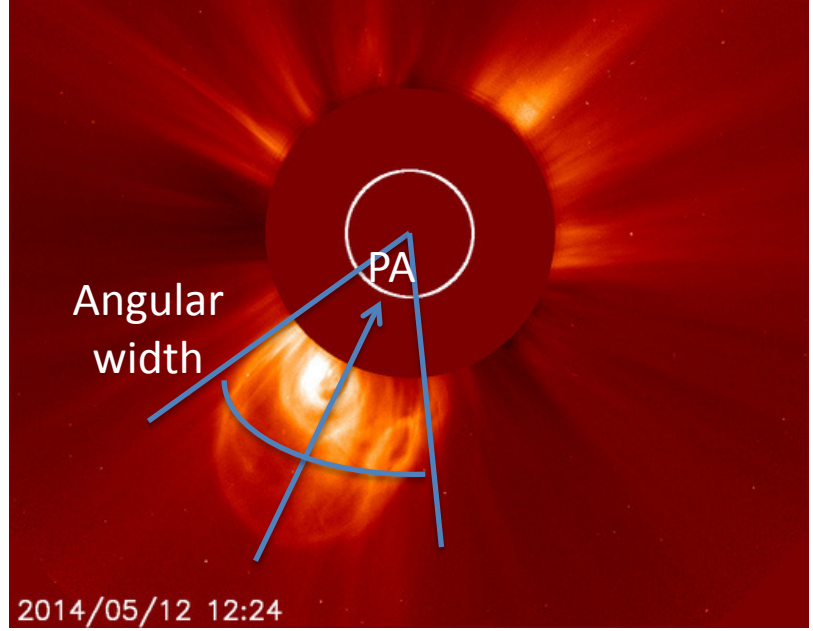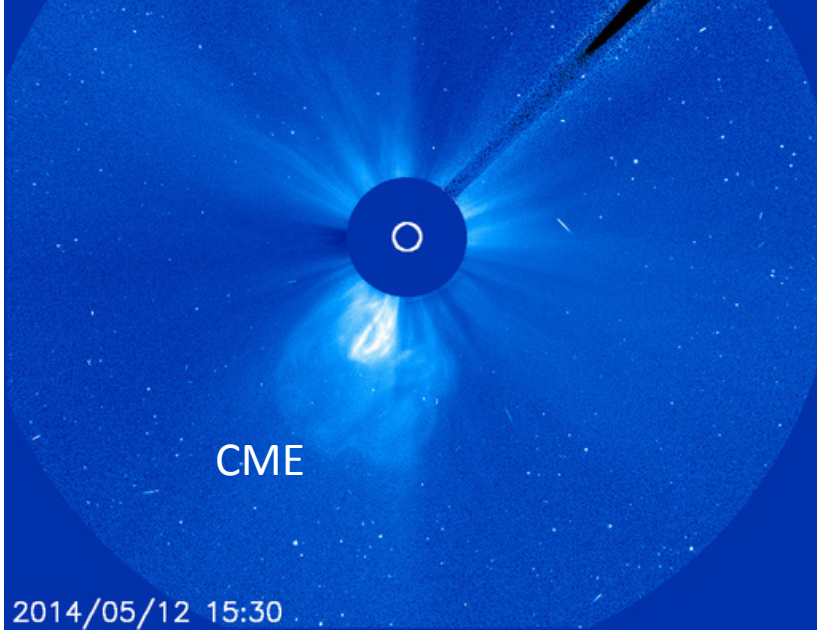
Identification of Solar Sources

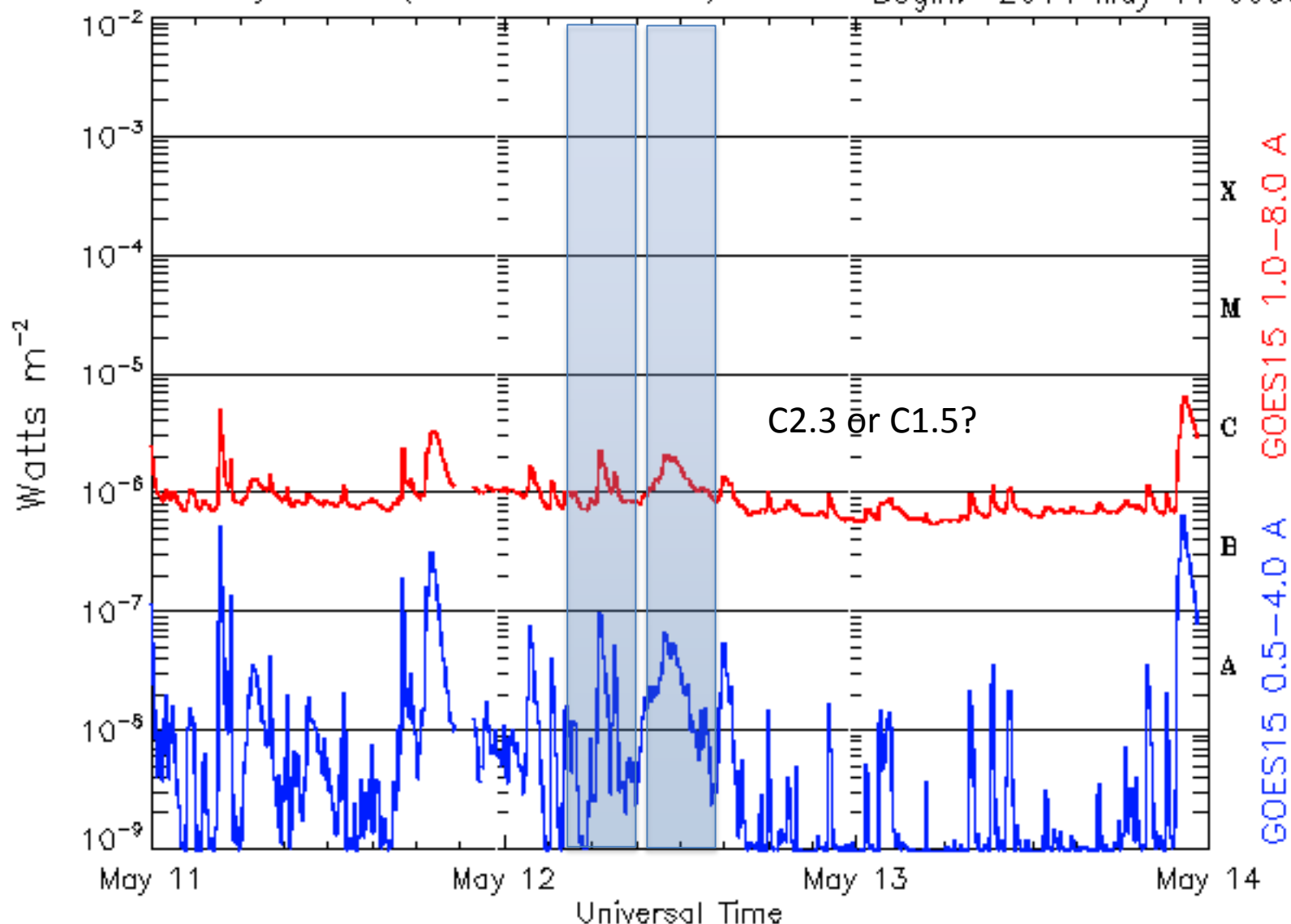**Peter Gallagher & Eoin Carley**

Trinity College Dublin

WP3 Overview

- **WP3: Deriving/cataloguing kinematics of STEREO/HI CMEs based on geometrical and forward modelling**
  - Apply geometrical, forward and *(prototype) inverse modelling methods* to derive CME parameters, which will be added to the catalogue (including **back-** and forward-**projections** to *'predict' CME launch* and arrivals at various solar system locations).

- TCD contribution: Inverse CME modelling to study of *solar sources* and *associated activity*.

CME

2014/05/12 15:30

Angular width

PA

2014/05/12 12:24

Flare

Active Region

12057   12055
12056   12053
12059
12062
12058   12054
12060   12052
12061

GOES Xray Flux (5 minute data)   Begin: 2014 May 11 0000 UTC

C2.3 or C1.5?

Updated 2014 May 13 23:30:12 UTC   NOAA/SWPC Boulder, CO USA

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```
:Product: 20140512events.txt
:Created: 2014 May 12 2332 UT
:Date: 2014 05 12
# Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center
# Please send comments and suggestions to SWPC.Webmaster@noaa.gov
#
# Missing data: ////
# Updated every 30 minutes.
#                              Edited Events for 2014 May 12
#
#Event     Begin    Max       End   Obs  Q  Type  Loc/Frq    Particulars        Reg#
#-------------------------------------------------------------------------------------

7770      B0001    0007      0019  LEA  3   FLA  S14E37     SF                   2060

7790       0020    0103      0302  LEA  1   FLA  S14E35     SF         ERU       2060

7800       0133    0151      0209  G15  5   XRA  1-8A       C1.8       3.1E-03   2056
7800       0143    0150      0237  LEA  3   FLA  N06E07     1F         ERU       2056

7810       0315    0321      0332  G15  5   XRA  1-8A       C1.3       1.1E-03   2060
7810       0316    0322      0329  LEA  3   FLA  S17E36     SF         ERU       2060

7820       0434    0434      0436  LEA  3   FLA  S13E34     SF                   2060

7830       0625    0642      0655  G15  5   XRA  1-8A       C2.3       3.4E-03   2059

7870       0626    0636      0704  LEA  3   FLA  N04W02     SF         ERU       2056

7830 +     0626    0640      0707  LEA  3   FLA  S04E04     SF                   2059

7840       0723    0736      0744  G15  5   XRA  1-8A       C1.5       1.7E-03   2060
7840       0729    0730      0745  LEA  3   FLA  S17E34     SF         ERU       2060

7850      B0828   U0833     A0835  SVI  3   FLA  S15E34     SF         ERU       2060

7860      B0849   U0853     A0906  SVI  2   FLA  S15E33     1F         ERU       2060

7880       0925   U0933      1023  SVI  3   FLA  S17E33     SF                   2060

7910       1000    ////      1122  SVI  2   DSF  S53E35     23

7890      B1100   U1106     A1110  SVI  2   FLA  S18E32     SF         ERU       2060

7900      B1153   U1201     A1218  SVI  2   FLA  S18E32     SF         ERU       2060

7920       1500    1502      1514  HOL  2   FLA  N06W01     SF         ERU       2056

7930       1532    1532      1536  HOL  3   FLA  S18E26     SF         ERU       2060
```

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Solar Sources
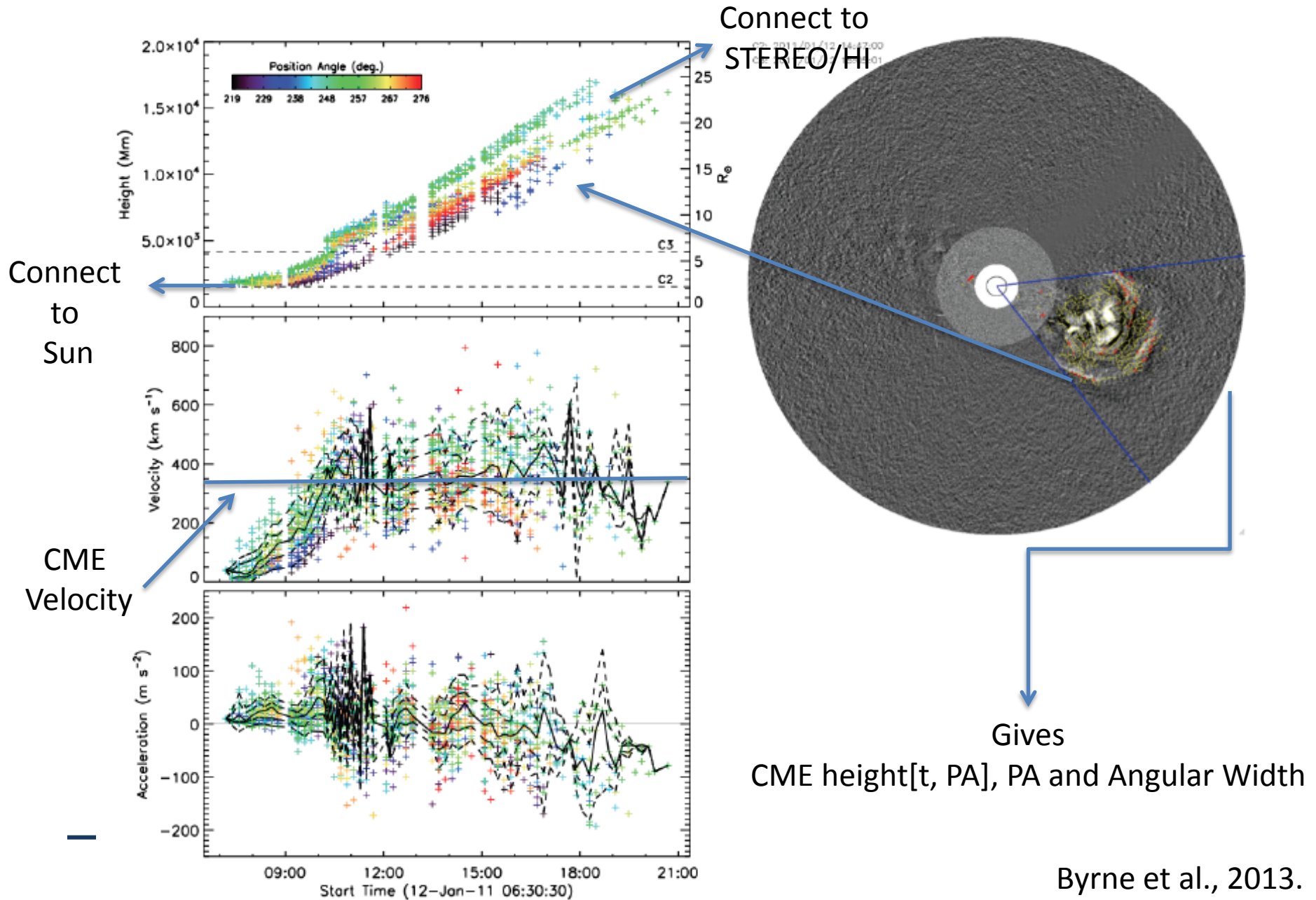
- **PA ± ΔPA + launch time (t ± Δt) + 3D Trajectory**
        => Latitude and longitude windows

- **Active regions:** NOAA/SWPC Solar Region Summary

- **Solar flares:** NOAA/SWPC Events List & LMSAL Latest Events

- **EUV Dimming Regions:** HEK

- **EUV Waves:** HEK/CorPITA (Long et al. 2010)

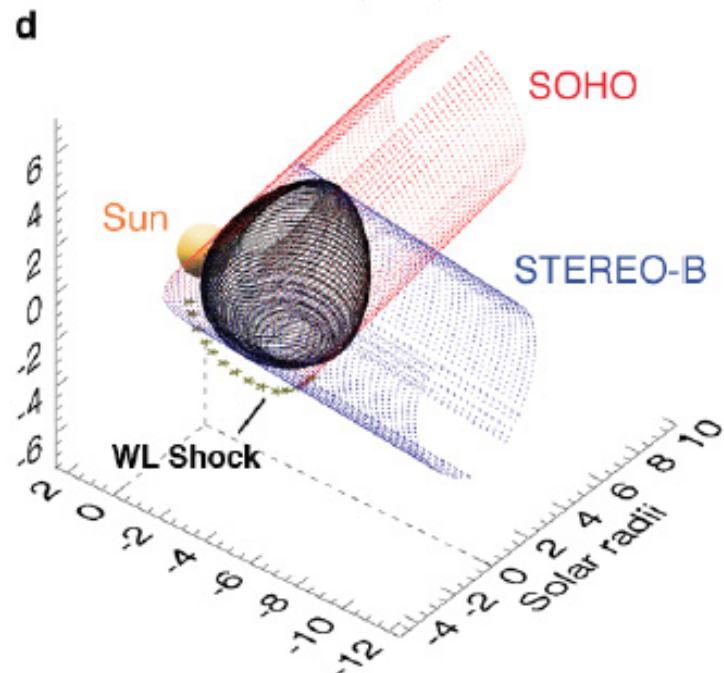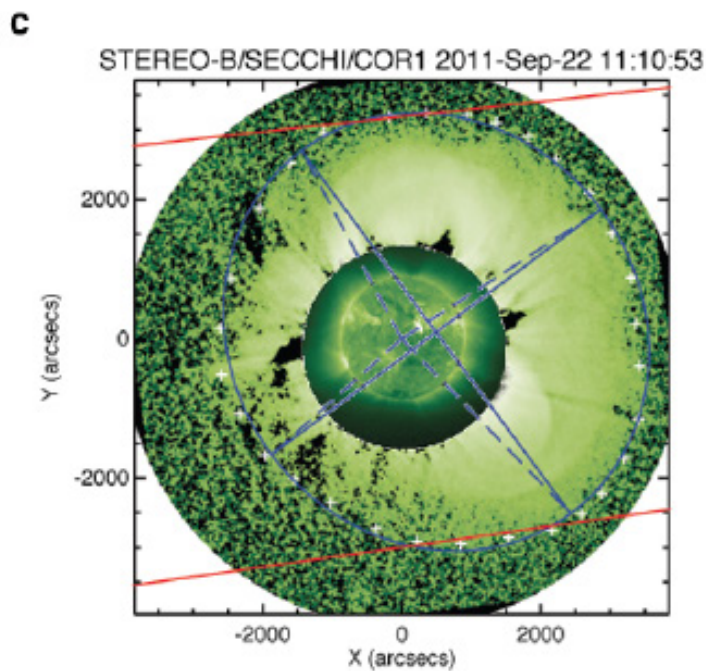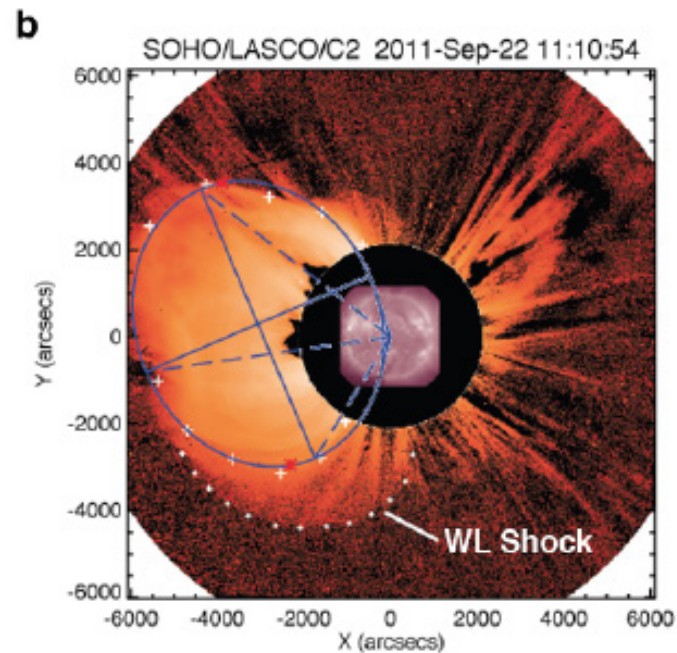- **Coronal holes:** HEK/SPOCA & CHARM (Krista & Gallagher 2009)

Constraining CME Launch Information

- Use CME kinematics at <32 R_S

- STEREO/COR1 & COR2 & SOHO/LASCO

- Automated CME properties including kinematics from CORIMP (Byrne et al. 2012, 2013)

- CORIMP will have kinematics for **all** well-observed STEREO CMEs.

- Gives **PA ± ΔPA** and **launch time (t ± Δt)**.

Elliptical tie-pointing (Byrne et al 2010)

Coronal Image Processing (CORIMP)

Connect to STEREO/HI

Connect to Sun

CME Velocity

Gives
CME height[t, PA], PA and Angular Width

Byrne et al., 2013.

a Heliocentric Earth Equatorial (HEEQ)

b SOHO/LASCO/C2 2011-Sep-22 11:10:54

WL Shock

c STEREO-B/SECCHI/COR1 2011-Sep-22 11:10:53

d SOHO

Sun

STEREO-B

WL Shock

Solar radii
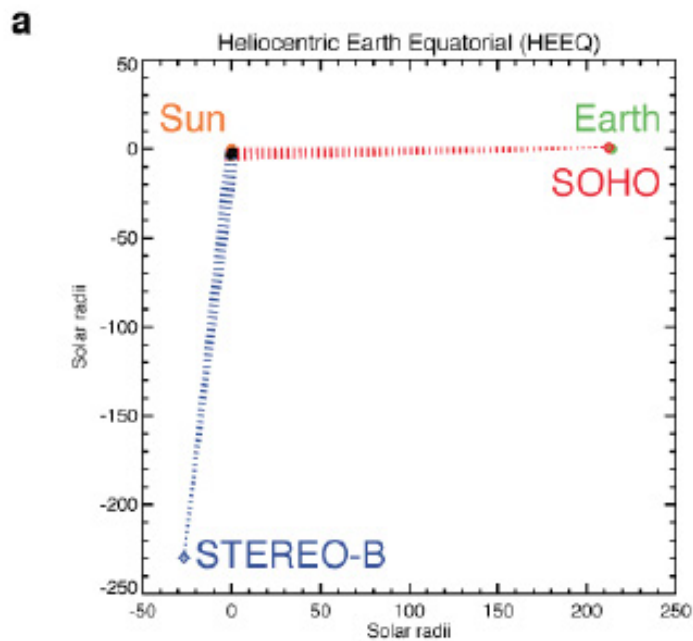
Elliptical tie-pointing (Byrne et al., 2010; Carley et al., 2013)

Estimating Launch Time and Associated Activity

- For constant velocity CME:

$$t_{Earth} = t_{Sun} + \frac{1AU}{v_{CME}}$$

- But CME velocity not constant, so launch time:

$$t_{Sun} = t_{r_f} - \int_{r_{Sun}}^{r_f} \frac{dr}{v_{CME}(r)}$$

- Use to define *launch-time window* and search for associated **flares** and **EIT waves**.

Source Identification using Combined Spatial and Temporal Information

- Use CME
  - Position angle (PA ± ΔPA)
  - Velocity (v ± Δv)

- To estimate on-disk flare, AR, etc
  - Launch position window (latitude ± Δ, longitude ± Δ)
  - Launch time window (t ± Δt)

Source Observations

- Photospheric, chromospheric and coronal observations from:

  - SOHO
  - SDO
  - STEREO
  - RHESSI
  - GOES

- Investigate solar sources of heliospheric phenomena, by ***back-projecting*** to Sun.