HELCATS

WP 3

Deriving/cataloguing the kinematic properties of STEREO/HI CMEs based on geometrical and forward modelling

Summary & Progress

Volker Bothmer & WP3 Team

HELCATS 4th BAM, 7 June 2016, Albena, Bulgaria

WP 3 - Objectives

- To obtain the kinematic properties for the STEREO/HI CMEs in the catalogue established in WP2, through application of geometrical and forward-modelling techniques to the HI data

- To augment the STEREO/HI CME catalogue with the model results, and supply those results as input for comparisons with coronal source and in-situ observations in the validation of WP4

- To update the STEREO/SECCHI/COR2 CME catalogue, initiated under the SOTERIA FP7 project, until the end of 2011 (including the application of forward modelling to the appropriate CMEs)

- To compare the results from the geometrical and forward modelling of HI CMEs with the modelling results for COR2

- To prototype the use of inverse modelling to derive typical HI CME parameters (speed, size, mass), for photospheric and low coronal source regions typically associated with CMEs

WP 3 – Task Summary (PMs: UGOE 21, TCD 15, STFC 9, UNIGRAZ 6)

- **Task 3.1: Geometrical modelling of STEREO/HI CMEs (Task leader: STFC; Additional participant: UNIGRAZ)**

  Instruments used: STEREO/HI

  Role of participants: STFC: J-map provision/CME extraction; STFC and UNIGRAZ: geometrical modelling application and development

  Presentation by P. Barnes (STFC)

- **Task 3.2: Forward modelling of STEREO/HI CMEs (Task leader: UGOE)**

  Instruments used: STEREO/SECCHI/HI, COR2

  Role of participants: This task will be undertaken by UGOE.

  Presentation by A. Pluta (UGOE)

- **Task 3.3: Inverse modelling of STEREO/HI CMEs (Task leader: UGOE; Additional participant: TCD)**

  Instruments used: STEREO/SECCHI/HI, COR2

  Role of participants: UGOE: modelling; TCD: source region input expertise.

  Presentation by P. Gallagher (STFC)

- **Task 3.4: Comparison of modelling results (Task leaders: RAL, UGOE; Additional participant: TCD)**

  Instruments used: STEREO/SECCHI, SOHO/MDI, SDO/HMI

  Role of participants: RAL will collate, with input from all participants.

WP 3 – Deliverables

- D3.1: Provision of time-elongation (j) maps for the CMEs in the STEREO/HI catalogue (from WP2), and incorporation of the results of the geometrical fitting into the catalogue (first release in M12, updates to follow, type: O, lead: STFC)

- D3.2: Incorporation of the results of the forward-modelling techniques into the CME catalogue established in WP2 (M 12, updates to follow, type: O, lead: UGOE)

- D3.3: Report on modelling results (M 36, type: R, lead: RAL)

- D3.4: Report on prototype inverse model based on photospheric and low coronal source region characteristics for 3-D HI CME structure (M 36, type: R, lead: UGOE)

Update Task 3.2 - Forward modelling of STEREO/HI CMEs (Task leader: UGOE)

- GCS (Graduated Cylindrical Shell) modelling of the STEREO/HI CMEs of the WP2 catalogue

- Augmentation of CME catalogue with the derived parameters - CME geometries, speeds, propagation directions and mass estimates, including update of the COR 2 catalogue until end of 2011

- Calculation of back-projected launch time/location and forward-projected arrival time estimates at various solar system locations and inclusion of information into CME catalogues

Deliverable in PY 1

- D3.2: Incorporation of the results of the forward-modelling techniques into the CME catalogue established in WP2 (M 12, updates to follow, type: O, lead: UGOE)

KINematic CATalogue

KINCAT - Catalogue   KINCAT - small

You can **download** the data as ASCII-file here.

☑Select smaller table

show comrimised table   show all data

☑ HEL no	☑ CME no	☑ Preevent date	☑ Preevent time	☑ Last COR2 date	☑ Last COR2 time	☑ GCS carlon	☑ GCS stony lon	☑ GCS stony lat	☑ GCS tilt
☐ HI first date	☐ HI first time	☐ APEX speed	☐ CME mass	☐ FPF speed	☐ FPF lon	☐ FPF lat	☐ SSEF speed	☐ SSEF lon	☐ SSEF lat

HEL no	CME no	Preevent date	Preevent time	Last COR2 date	Last COR2 time	GCS carlon	GCS stony lon	GC
[-]	[-]	[yyyymmdd]	[hh:mm:ss]	[yyyymmdd]	[hh:mm:ss]	[deg]	[lon]	
28	288	31.10.2009	03:08:15	31.10.2009	10:08:15	157	33	
29	299	21.11.2009	07:08:00	21.11.2009	15:09:00	169	-36	
30	307	16.12.2009	02:08:15	16.12.2009	07:08:15	238	-2	
31	325	01.02.2010	14:08:15	01.02.2010	22:09:04	39	67	
32	333	11.02.2010	12:00:00	12.02.2010	01:10:00	219	20	
33	337	13.02.2010	20:08:15	14.02.2010	06:08:15	198	28	
34	347	24.02.2010	12:08:15	25.02.2010	01:08:15	340	-48	
35	351	01.03.2010	00:08:37	01.03.2010	07:08:37	19	47	
36	369	19.03.2010	10:08:15	19.03.2010	21:08:15	106	19	
37	373	26.03.2010	07:08:15	26.03.2010	17:08:15	21	24	
38	377	30.03.2010	00:08:15	30.03.2010	13:08:15	254	-52	
39	391	18.04.2010	21:08:15	19.04.2010	05:08:15	92	45	
40	392	19.04.2010	18:08:15	20.04.2010	00:08:15	86	50	

"KINematic CATalogue" available on the AFFECTS-FP7 homepage:

http://www.affects-fp7.eu/helcats-database/database.php

Check link to HELCATS website

KINematic CATalogue – Legend

Table-Legends (Click to expand/collapse)

HEL no :	KINCAT Catalogue Number
CME no :	AFFECTS Catalogue Number
Preevent date :	Date for preevent image
Preevent time :	Time for preevent image
Last COR2 date :	Last image in COR2 with full visibility of the CME
Last COR2 time :	Last image in COR2 with full visibility of the CME
GCS carlon :	GCS source region longitude in carringoton coordinate system
GCS stony lon :	GCS source region longitude in stonyhurst coordinate system
GCS stony lat :	GCS source region latitude in stonyhurst coordinate system
GCS tilt :	GCS tilt angle
GCS Asp. Ratio :	GCS aspect ratio
GCS h_angle :	GCS half angle
HI first date :	First appearance in STEREO / HI
HI first time :	First appearance in STEREO / HI
APEX speed :	GCS apex speed in COR2 (linear fit)
CME mass :	CME mass
FPF speed :	Fixed Phi Fitting velocity
FPF lon :	Fixed Phi Fitting longitude in stonyhurst coordinate system
FPF lat :	Fixed Phi Fitting latitude in stonyhurst coordinate system
SSEF speed :	Self Similar Expansion Fitting velocity
SSEF lon :	Self Similar Expansion Fitting longitude in stonyhurst coordinate system
SSEF lat :	Self Similar Expansion Fitting latitude in stonyhurst coordinate system
HMF speed :	Harmonic Mean Fitting velocity
HMF lon :	Harmonic Mean Fitting longitude in stonyhurst coordinate system
HMF lat :	Harmonic Mean Fitting latitude in stonyhurst coordinate system

- **Movies of fits for A and B established**

- **Synoptic COR2 movies for comparisons added**

- **STEREO position diagrams added**

- **h-t diagrams (higher order fits for those events with more than 6 dataponts in COR2 FOV) established**

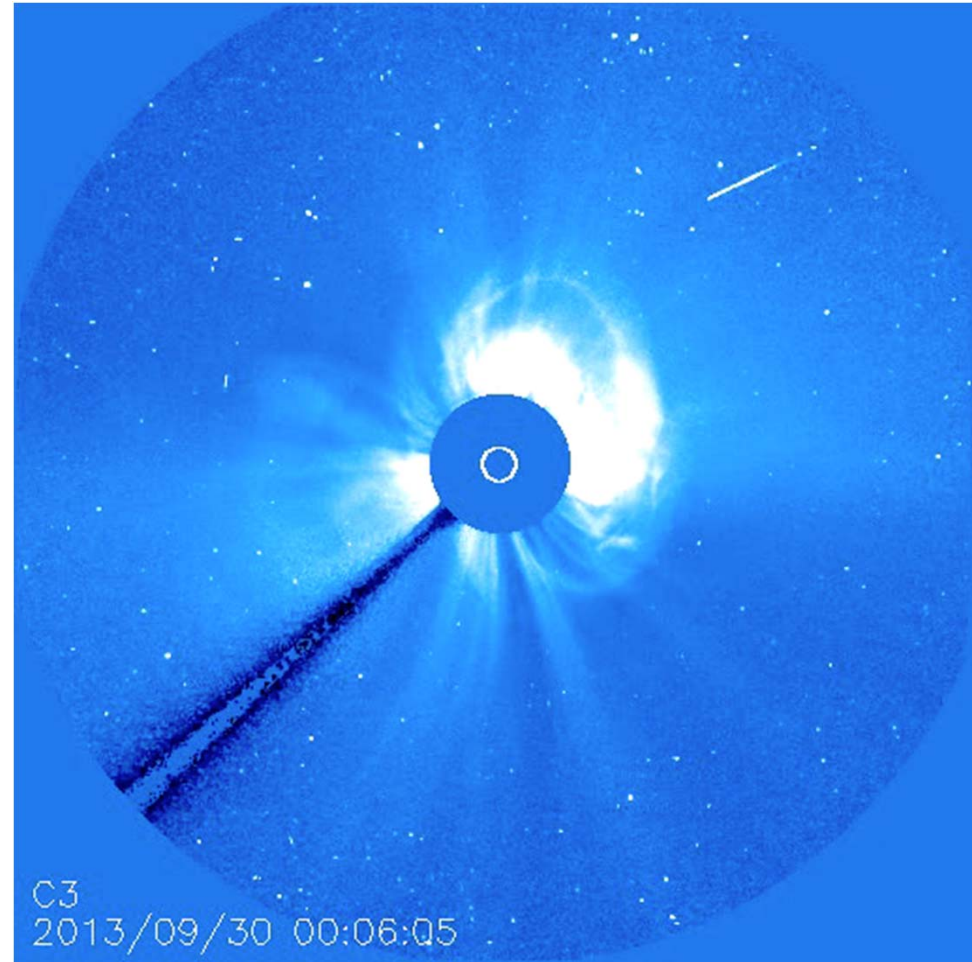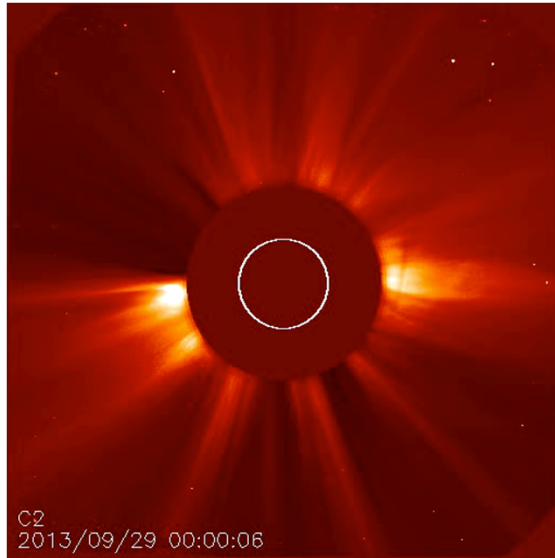- **Speeds normalized to 12 R_S**

- **Added 14 events until end of 2013 (now 122 events in total) based on comparison with LINKCAT (on-disk events)**

- **Source region list established for KINCAT**

- **KINCAT compared with LINKCAT and SRs determined for WP4**

- **KINCAT SR list also established based on STEREO, SDO, SOHO and HEK data (sent to TCD for SR analysis, incl. In LOWCAT)**
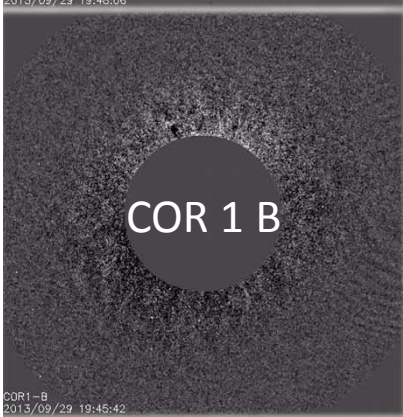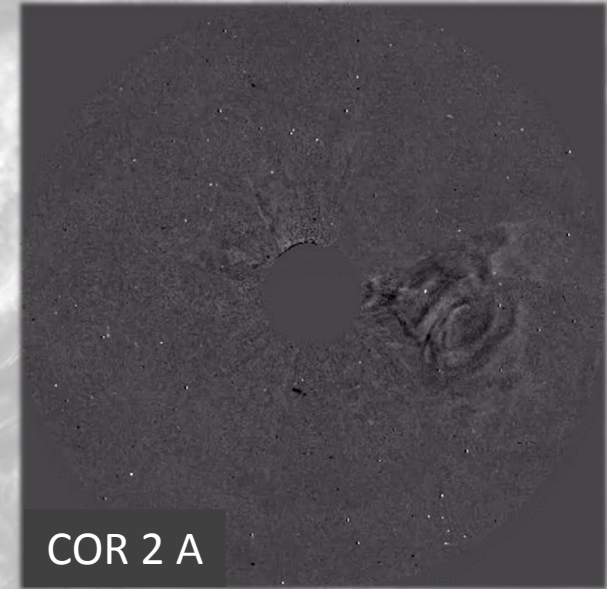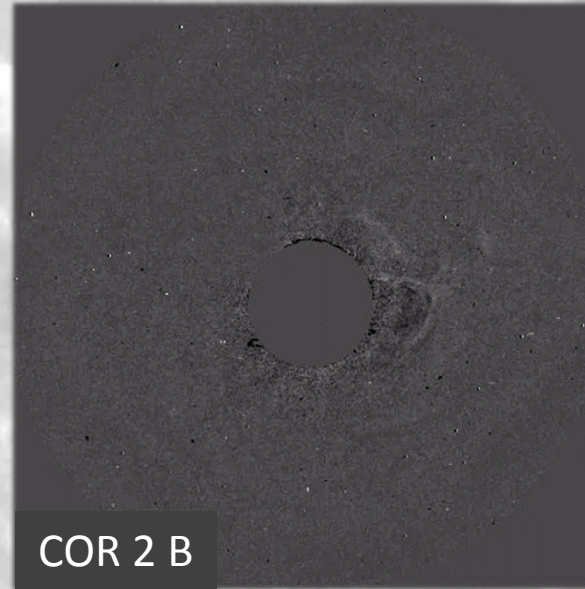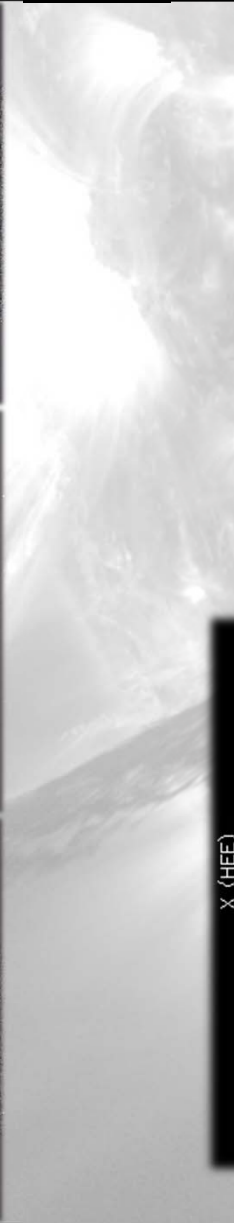
CME on 29 September 2013 - SDO, STEREO/SECCHI/COR2 & COR1 A observations

Enlargement of small-scale features
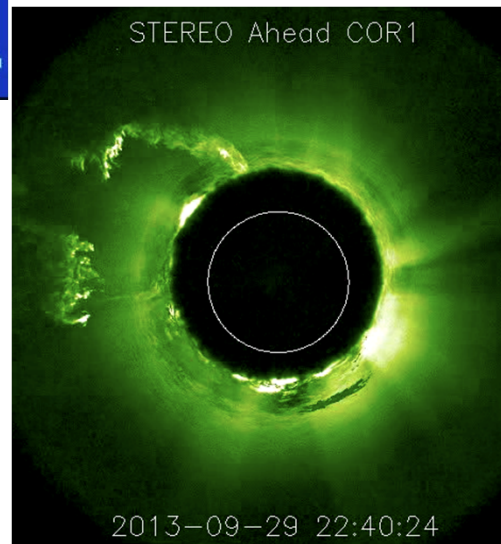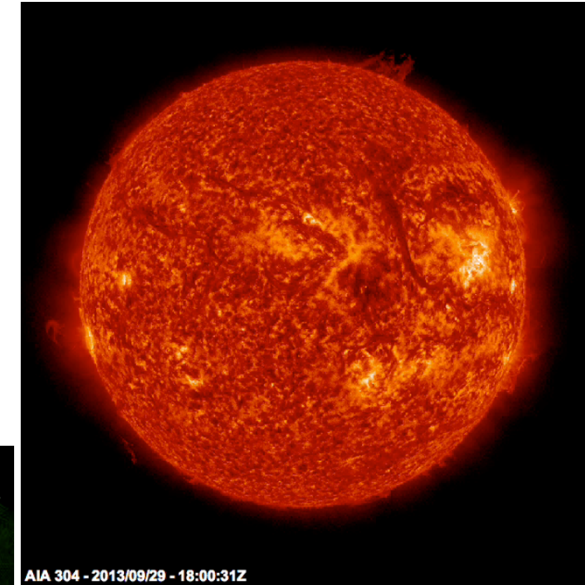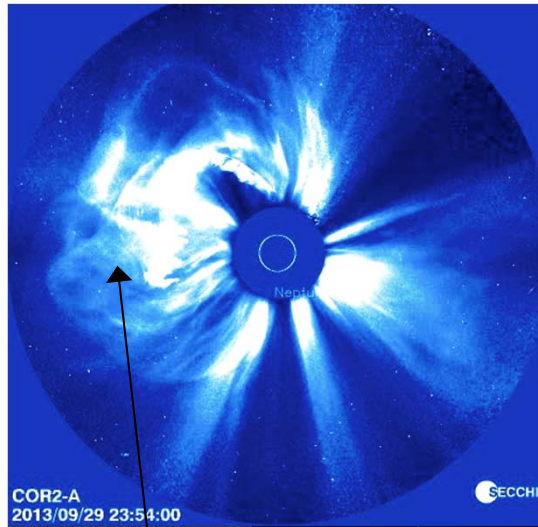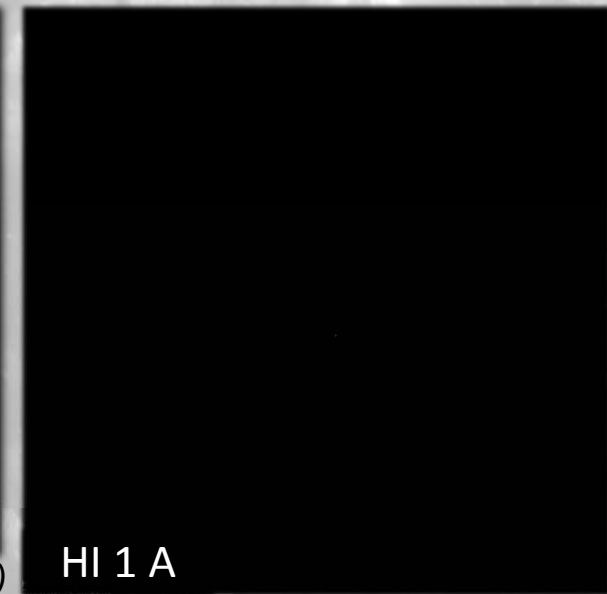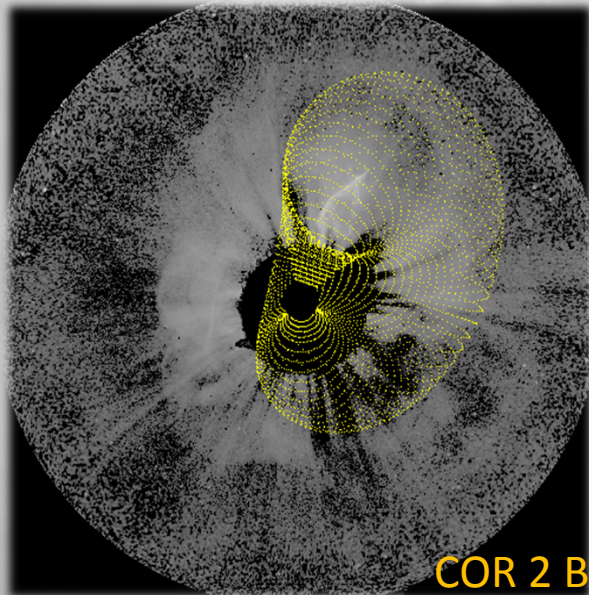

Expansion of fine-scale features
- Arrival times will depend on observer's position wrt CME SR

COR 1 A

C 2

COR 1 B

COR 2 B

COR 2 A

(Stereo Orbit Tool)

HI 1 A

CME Analysis – N . Mrotzek UGOE

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COR 2 B

HI 1 B
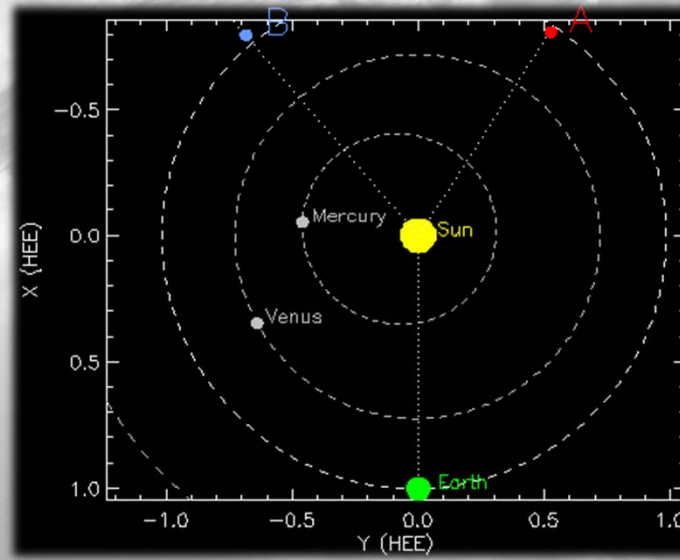
Position on Sun:

$\Phi = 12°$ $\theta = 25.12°$
Associated C1.2 Flare at:
$\Phi = 33°$ $\theta = 10°$

C 3

COR 2 A

HI 1 A
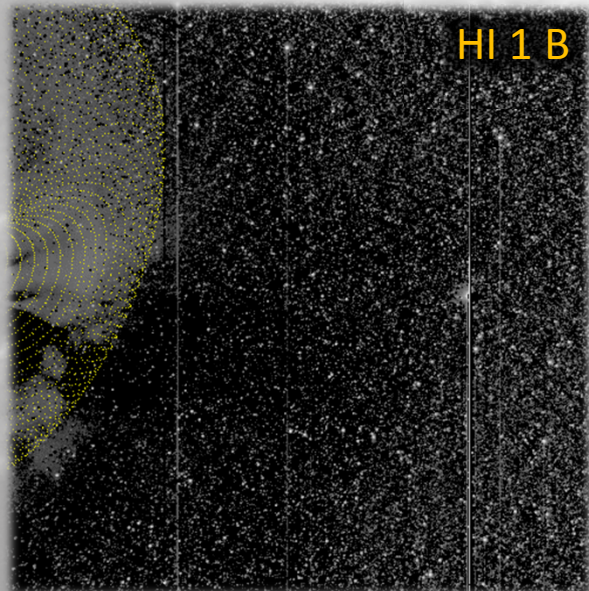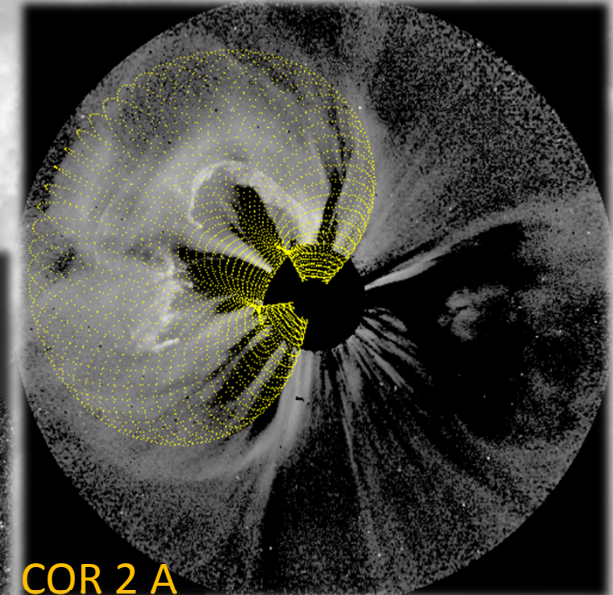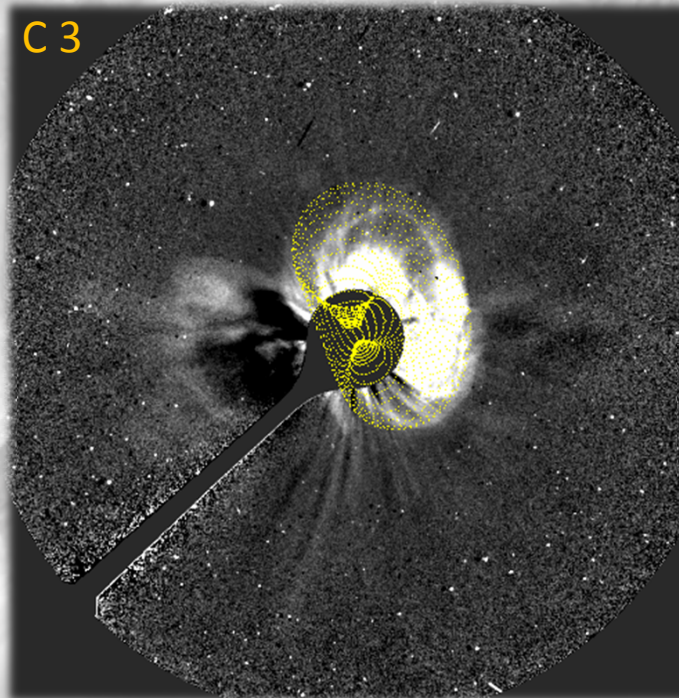
Geometrical parameter:
$\alpha = 63°$
$\gamma = -74.87°$
$\kappa = a/r = 0.54$

GCS Modelling 2013-09-29

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ASTROPHYSIK
GÖTTINGEN
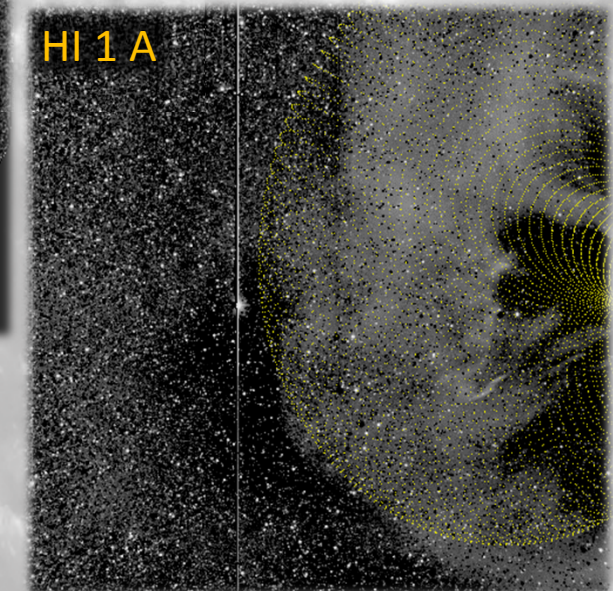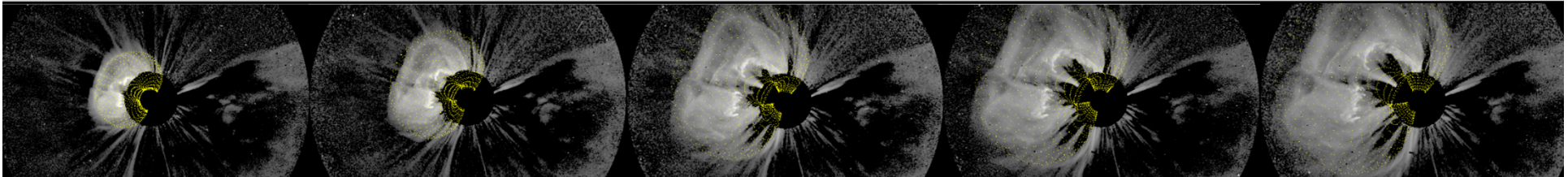
- Fit coronagraph Images for HT-Data.
- Fit polynomial to get inital CME speed.
- Use fit result for Drag-Fit.

Time t in [h]

x^3-Fit-GCS

COR 1

COR 2 , C2 & C3

HI 1

$v(R_\odot=12)=1540 \frac{km}{s}$

$v_{last}(GCS)=821 \frac{km}{s}$

HI 1 SSE speed from HICAT (RAL):

$v_{CME} = 992$ km/s

Radial distance r in [$R_\odot$]

CME Kinematics 2013-09-29
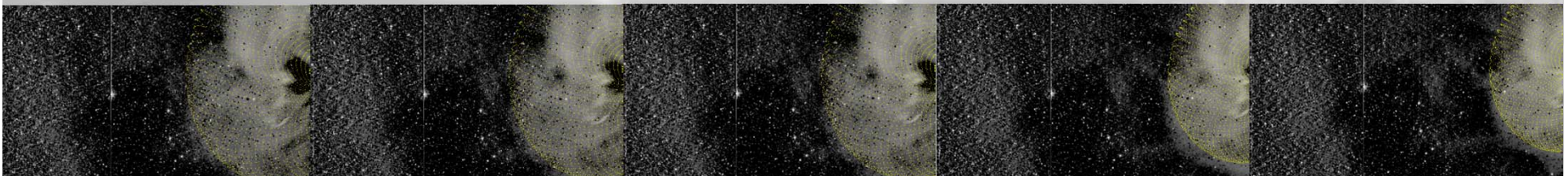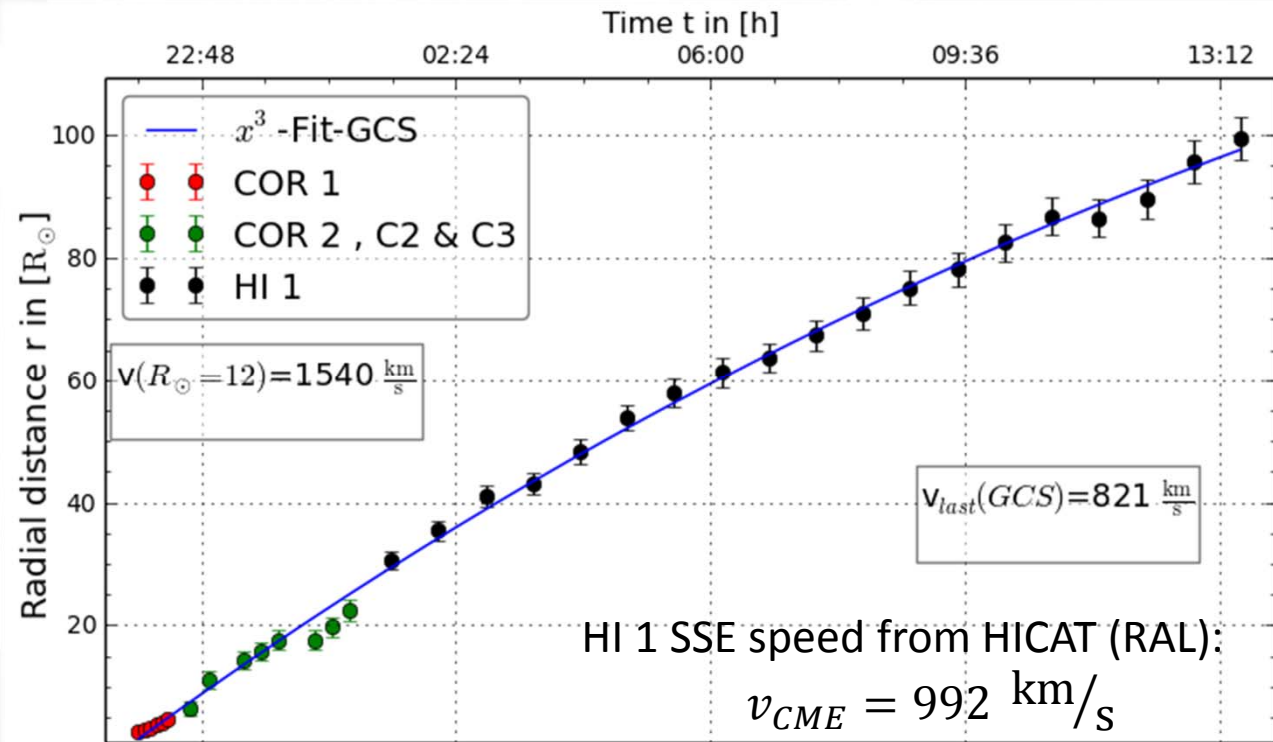
Inverse modelling of STEREO/HI CMEs

- UGOE has established an "Inverse Modelling List" which has been used by TCD to provide a "Low Coronal Event Catalogue".

- Includes source regions for 1,673 CMEs.

- Note: Uses constant velocity to track CMEs back to source regions. Note VB: should be compared with singlke event h-t diagram results from KINCAT!

Low Coronal Event Catalogue

Catalogue of events occuring the low corona which were associated with CMEs detected with the Heliospheric Imagers on board the STEREO spacecraft.

<1> No.	<2> Spacecraft (Stereo A/8)	<3> HI Date and Time (UT)	<4> HI PA North and HI PA South (degrees)	<6> COR2 Date and Time search window (UT)	<7> COR2 Candidate Date and Time (UT)	<8> COR2 Candidate PA, width (UT)	<9> COR2 Candidate speed (min,max) km/s (UT)	<10> Flare Date and Time search window (UT)	<11> Flare Candidate Date and Time (UT)	<9> GOES Class	<10> NOAA Region
1	B	15-Apr-2007 (04:10)	285-245	14-Apr-2007(15:17) 15-Apr-2007(02:52)	14-Apr-2007 (16:38)	247 - 279	227 - 245	14-Apr-2007(14:05) 14-Apr-2007(14:41)	NO FLARE	no flare	H alpha
2	A	17-Apr-2007 (16:50)	105-125	17-Apr-2007(03:57) 17-Apr-2007(15:32)	17-Apr-2007 (04:37)	105 - 129	265 - 284	17-Apr-2007(02:45) 17-Apr-2007(03:21)	NO FLARE	no flare	H alpha
3	A	19-Apr-2007 (13:30)	40-140	19-Apr-2007(00:37) 19-Apr-2007(12:12)	19-Apr-2007 (00:37)	53 - 149	107 - 367	18-Apr-2007(23:25) 19-Apr-2007(00:01)	NO FLARE	no flare	H alpha
4	A	2-May-2007 (00:50)	65-100	1-May-2007(11:57) 1-May-2007(23:32)	1-May-2007 (12:37)	84 - 104	245 - 284	1-May-2007(10:45) 1-May-2007(11:21)	NO FLARE	no flare	H alpha
5	B	3-May-2007 (16:50)	325-280	3-May-2007(03:57) 3-May-2007(15:32)	3-May-2007 (11:08)	288 - 332	117 - 320	3-May-2007(02:45) 3-May-2007(03:21)	NO FLARE	no flare	H alpha
6	A	6-May-2007 (06:50)	85-120	5-May-2007(17:57) 6-May-2007(05:32)	5-May-2007 (05:37)	80 - 108	219 - 543	5-May-2007(16:45) 5-May-2007(17:21)	5-May-2007 16:24:	GOES	NO AR
7	A	9-May-2007 (13:30)	50-125	9-May-2007(00:37) 9-May-2007(12:12)	9-May-2007 (04:07)	15 - 151	215 - 265	8-May-2007(23:25) 9-May-2007(00:01)	8-May-2007 23:08:	GOES	NO AR
8	A	16-May-2007 (01:30)	30-120	15-May-2007(12:37) 16-May-2007(00:12)	15-May-2007 (19:37)	56 - 124	260 - 337	15-May-2007(11:25) 15-May-2007(12:01)	15-May-2007 11:25	GOES	10955

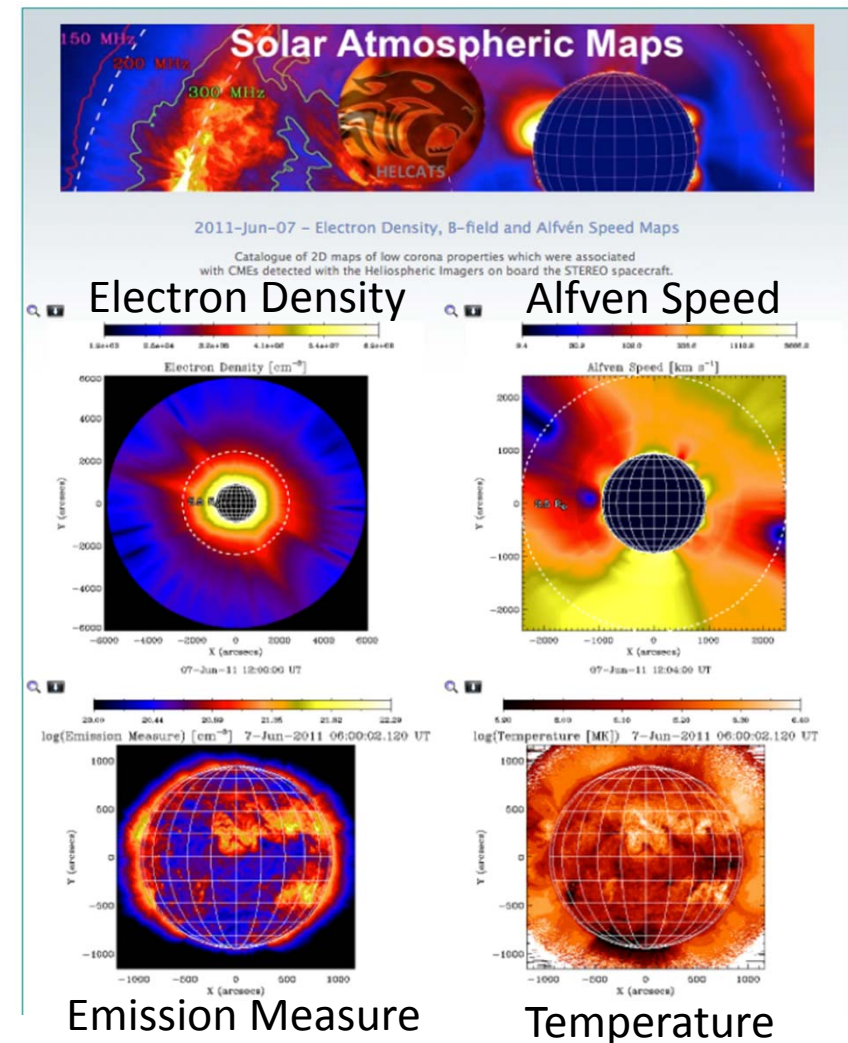http://data.rosseobservatory.ie/helcats/lowcat/

Shock Properties from Coronal Maps

- An essential aspect of analysing type II radio bursts is determine the underlying shock speed and starting height using coronal density models (part of WP3).

- To do aid, TCD produced density and Alfvén speed maps in a number of events in the HELCATS catalogue.

- These maps are produced from SDO AIA and LASCO C2.

Solar Atmospheric Maps

2011-Jun-07 – Electron Density, B-field and Alfvén Speed Maps

Catalogue of 2D maps of low corona properties which were associated with CMEs detected with the Heliospheric Imagers on board the STEREO spacecraft.

Electron Density   Alfven Speed

Emission Measure   Temperature

http://data.rosseobservatory.ie/helcats/mapscat/

Next Steps for Solar Sources

SMART Detections

- Produce list of AR properties associated with all CMEs.
  - Area
  - Mt Wilson Class
  - Hale Class

- Will produce extensive list of AR properties using SMART (SolarMonitor Active Region Tracker; Higgins et al.)
  - Area, magnetic flux, R-index, flux imbalance, neutral line props, etc.

- Also producing AR properties list for KINCAT SR list supplied by UGOE

3-Oct-2003 08:03:03.564
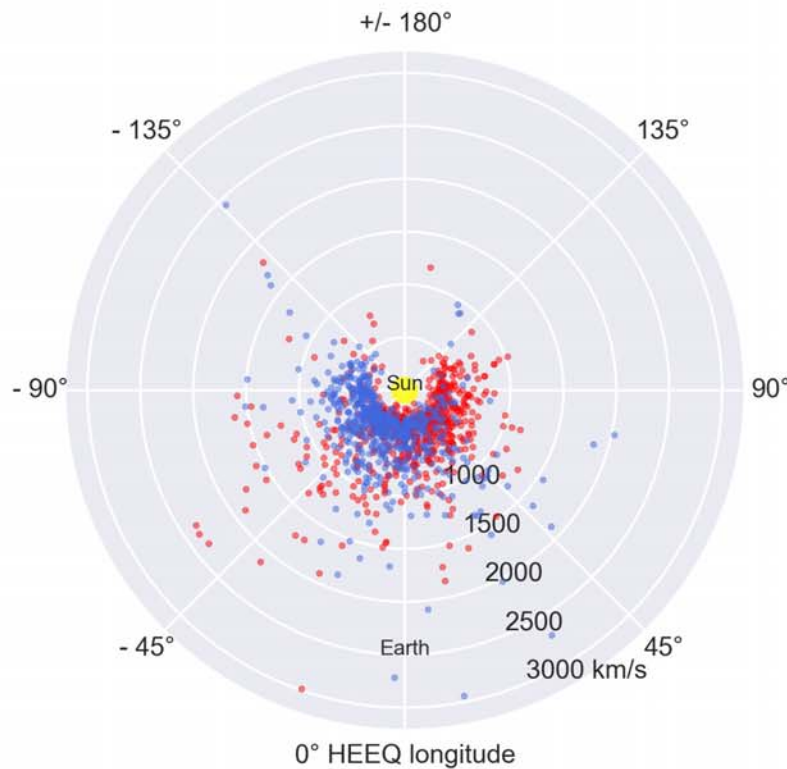
A

9-Oct-2003 11:15:03.527
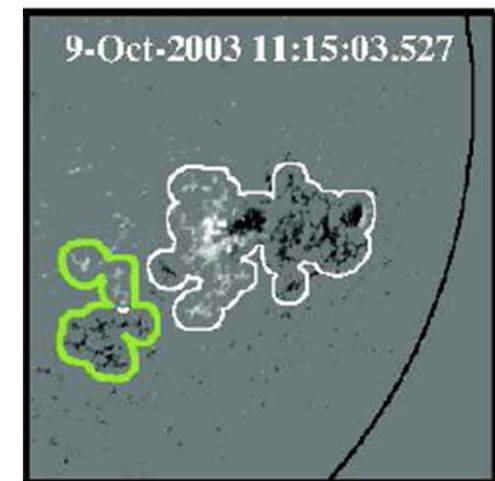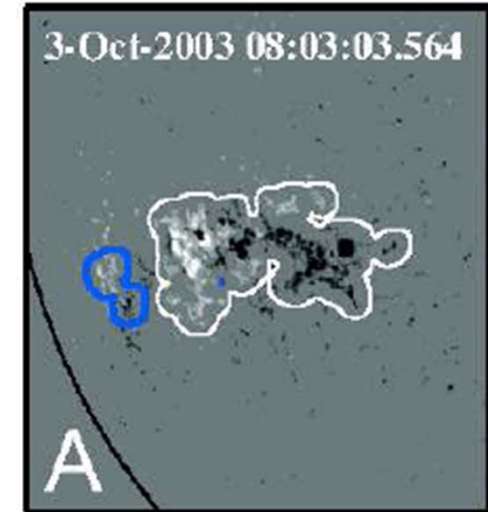
UNIGRAZ - **Arrival catalogue ARRCAT -**

Based on HIGeoCat V3 calculated CME arrivals (speed and time) from SSEF30
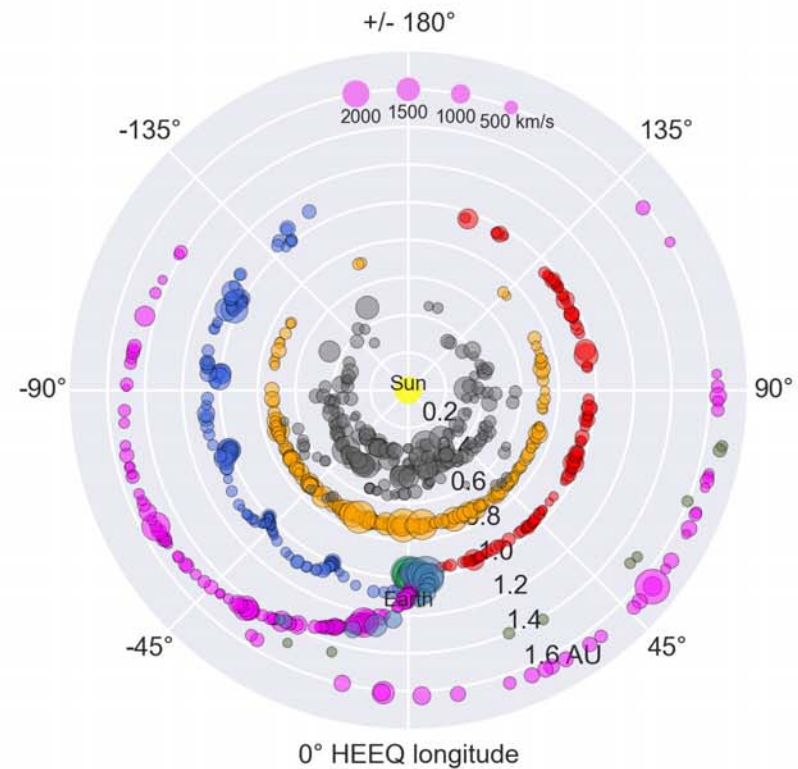
2087 arrivals in total (shown on the figure are 1381) at **Earth/L1, Venus Express, MESSENGER, STEREO-A/B, Mars, Rosetta, MAVEN, MSL, Saturn, Ulysses**

HI: CME speeds and predicted arrivals   HELCATS - HICAT / ARRCAT

HICAT: 1330 events   ARRCAT: 1381 events

Mercury   MESSENGER   Venus   STEREO-A   STEREO-B   Earth   Mars   MSL   Maven   Ulysses   Rosetta

Collaborations and Publications

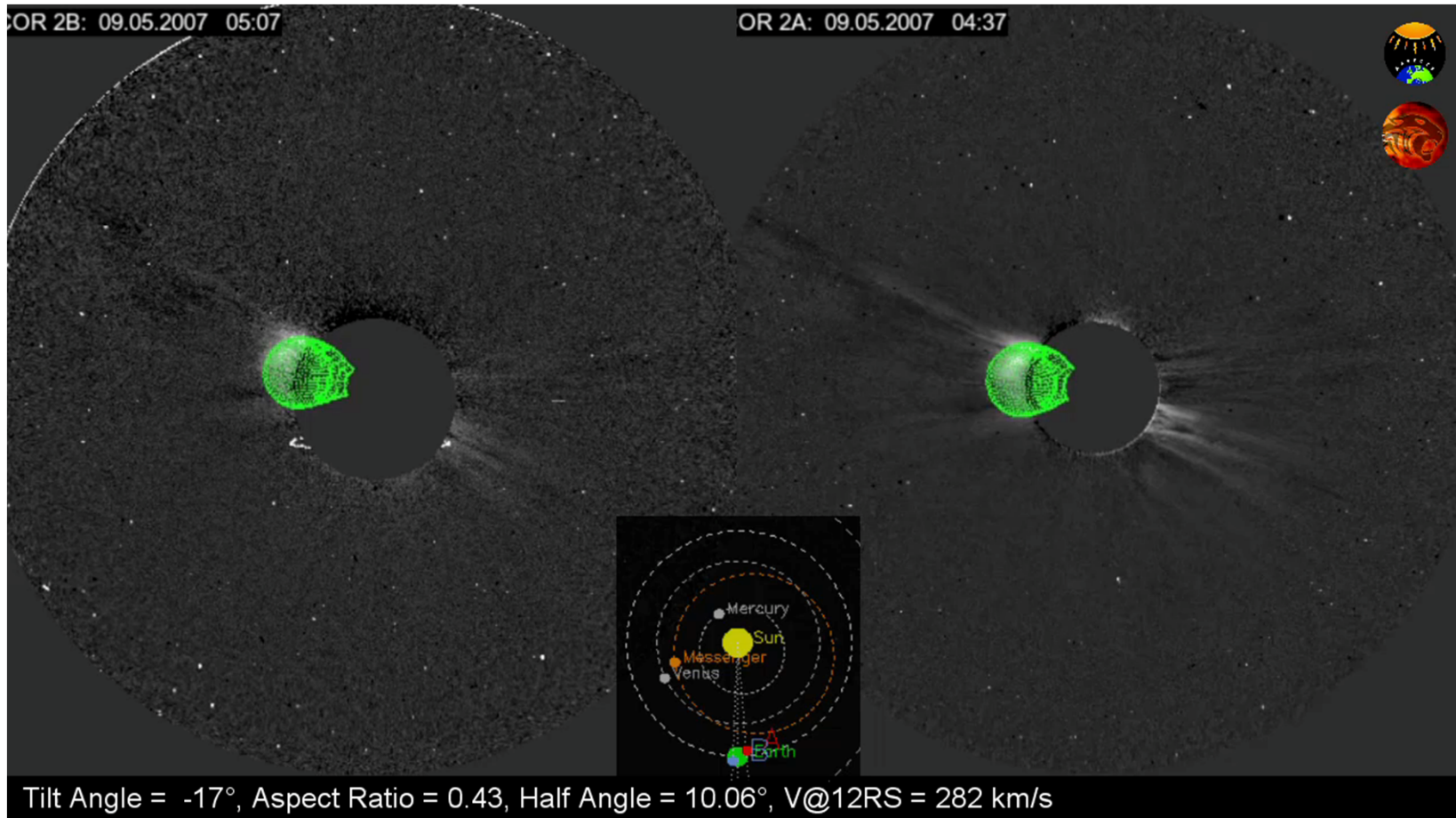- **KINCAT used for various studies (Lugaz et al., Merla et al., Krupar et al.)**

- **Presentations at EGU**

- **E/PO at ESWW12 fair**

- **Publication contribtions: Krupar et al 2016, Plodnikov et al. 2016**

KINCAT Movie – Available on Website

KINCAT Movie – Directors Cut

COR 2B: 09.05.2007 05:07   COR 2A: 09.05.2007 04:37

Tilt Angle = -17°, Aspect Ratio = 0.43, Half Angle = 10.06°, V@12RS = 282 km/s
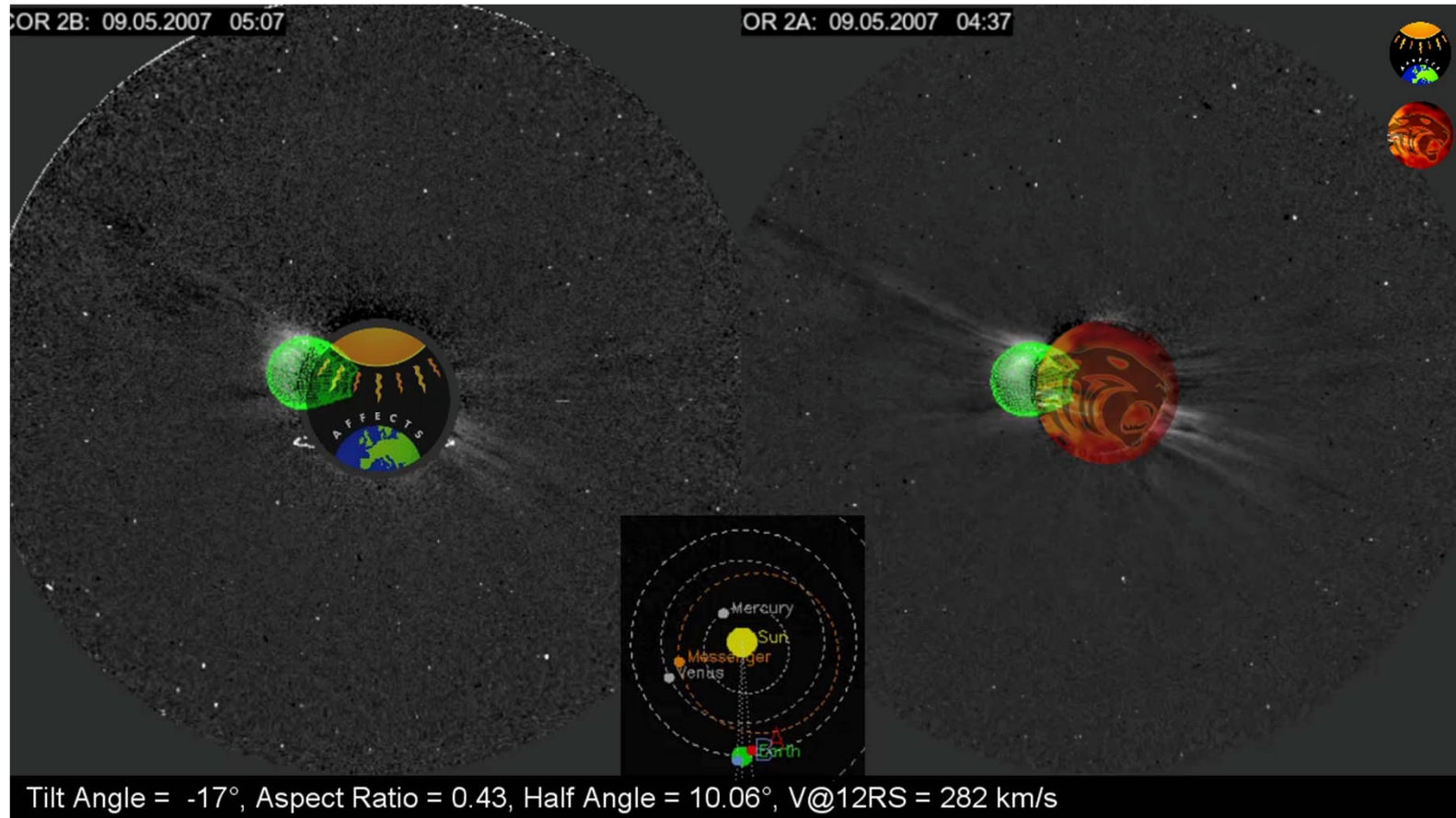
CME cost calculation

- **Existing infrastructure required (software, hardware, experience)**

- **Analysis of 1 CME takes approximately 1 day**

- **122 events (KINCAT) correspond to work of about 6-7 months + establishment of online catalogue (3-6 months)**

- **Amounts to about 1.5 PY, i.e. 1 CME = 1 k€**

Outlook

- **Source region analysis (TCD) under way for comparison with CME kinematics**

- **Read Me of database to be edited**

- **COR2 - HI comparison to be updated**

- **Publications on databases within HELCATS**

Backup Slides

Completed Task 3.1 - Geometrical modelling of STEREO/HI CMEs / Task leader: STFC; Additional participant: UNIGRAZ

- Geometrical modelling of the STEREO/HI CMEs identified and catalogued in WP2

- Creation of J-maps for backward (to source regions) and forward extrapolations (for solar system applications)

- Derivation of CME kinematic properties (propagation speed, direction and potentially size, launch time, source region location) and augmentation of the CME catalogue with these results (for comparisons with WP4 tasks 4.1 SR and 4.2 in-situ)

- Compilation of a catalogue of CME arrival time estimates at Mercury, Venus, Earth, Mars and Saturn as support to European-funded space missions around these planets.

- Integration of the catalogues in AMDA, offering access to the catalogues to the community of planetary scientists that use the European Research infrastructure (EUROPLANET)

Deliverable in PY 1

D3.1: Provision of time-elongation (j) maps for the CMEs in the STEREO/HI catalogue (from WP2), and incorporation of the results of the geometrical fitting into the catalogue (first release in M12, updates to follow, type: O, lead: STFC)

WP 3 – Geometrical Modelling

ID	SC	Quality	PA-fit	SSE speed [kms-1]	SSE Phi [deg]	SSE HEEQ Long [deg]	SSE HEEQ Lat [deg]	SSE Carr Long [deg]	SSE Launch [UTC]
HCME_A__20070419_01	A	good	105	392	61	-58	-15	53	2007-04-19 07:30
HCME_A__20070502_01	A	fair	90	353	129	-124	2	183	2007-05-01 16:29
HCME_A__20070506_01	A	fair	100	489	133	-129	-5	120	2007-05-06 01:00
HCME_A__20070509_01	A	fair	90	559	152	-147	2	59	2007-05-09 06:20
HCME_A__20070516_01	A	good	70	385	61	-54	16	68	2007-05-15 16:32
HCME_A__20070518_01	A	fair	110	580	86	-81	-20	12	2007-05-17 20:47
HCME_B__20070519_01	B	fair	265	264	38	36	-5	122	2007-05-18 11:31
HCME_A__20070520_01	A	fair	120	448	20	-12	-11	57	2007-05-19 17:12
HCME_B__20070521_01	B	fair	305	416	75	67	32	115	2007-05-21 08:18
HCME_A__20070521_01	A	fair	85	306	72	-66	4	337	2007-05-21 15:26

Showing 1 to 10 of 1,201 entries (filtered from 1,210 total entries)   Select   Save   Print   Previous 1 2 3 4 5 .. 121 Next

- This catalogue contains the kinematic properties derived using the geometrical fitting methods applied to STEREO/HI J-maps.
- Speeds, propagation direction and launch times are provided based on three geometrical models, fixed-phi, harmonic mean and self-similar expansion.
- This catalogue contains 1210 CMEs occurring between April '07 and December '13 (635 for STEREO-A and 575 for STEREO-B).