



AIP



DLR



Preparing the second data release of CoSEE-Cat



Frédéric Schuller & the CoSEE-Cat working group

(**Alexander Warmuth**, Song Tan, Jake Mitchell, Raúl Gómez Herrero, Ignacio Cernuda, Fernando Carcaboso, Daniel Pacheco, Javier Rodríguez-Pacheco, Glenn Mason, Nina Dresing, Annamaria Fedeli, Aleksy Yli-Laurila, Robert Wimmer-Schweingruber, Alexander Kollhoff, Sam Krucker, Sophie Musset, Laura Rodríguez-García, Matthieu Kretzschmar, Nicole Vilmer, David Paipa, Milan Maksimovic, Antonio Vecchio, Krzysztof Barczynski, Luciano Rodriguez, Daria Shukhobodskaya, Manon Jarry, Alexis Rouillard, Radoslav Bucik, George C. Ho, David Lario, Karl-Ludwig Klein, Frederic Effenberger, Vratislav Krupar, Oleksiy Dudnik, Hamish Reid, Camille Lorfing, Arun Awasthi, Silvio Giordano, Catia Grimaldi, Federico Landini, Giuliana Russano, Clementina Sasso, Marco Romoli, Cecilia Mac Cormack)

CoSEE-Cat:
a Comprehensive Solar Energetic
Electron events catalogue



CoSEE-Cat: the Comprehensive Solar Energetic Electron events catalogue

- compiled by a joint Working Group of eight of Solar Orbiter's ten instruments
- comprehensive catalogue of all SEE events recorded by EPD and associated solar events (99 parameters)
- online access to catalogue and ancillary information for the wider community

<https://coseecat.aip.de/>

• for details, see
Warmuth et al. 2025,
A&A 701, A20



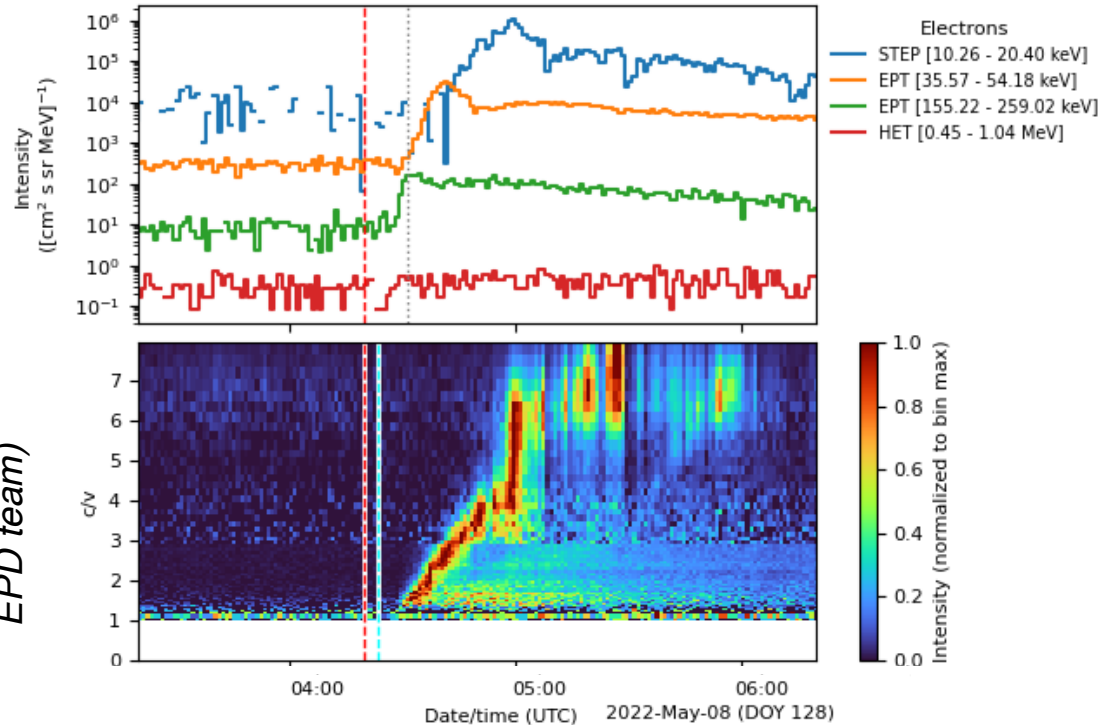
SWA

MAG

Measuring solar energetic electrons with the Energetic Particle Detector (EPD)



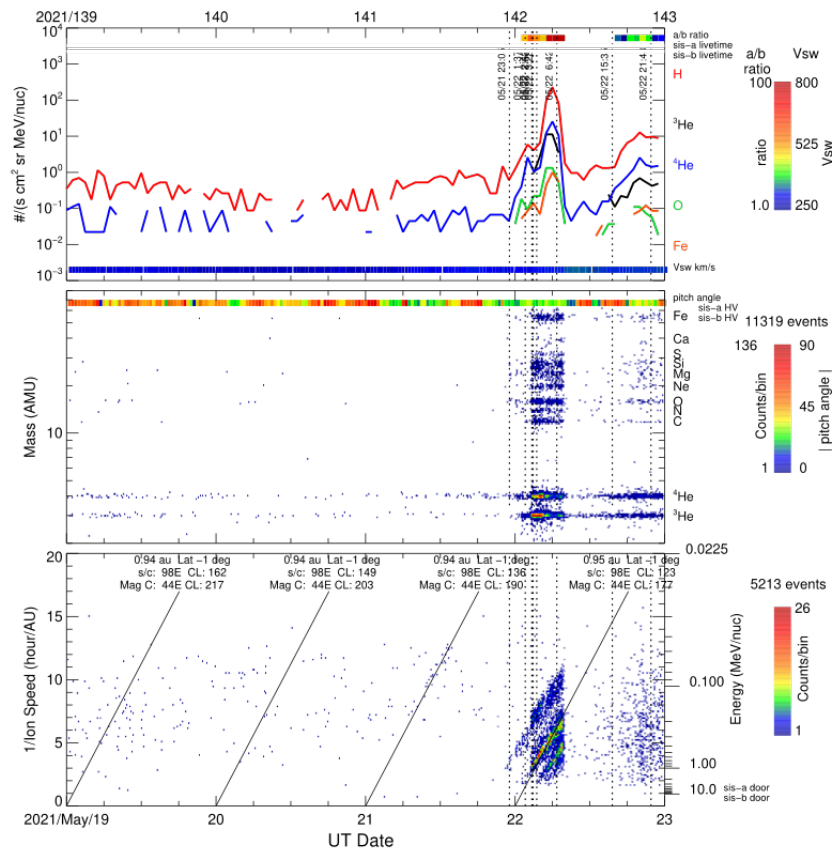
- covers electrons in range 2 keV – 80 MeV (STEP, EPT, HET)
- constrains anisotropy (EPT)
- allows determination of solar release time



(R. Gómez-Herrero/
EPD team)

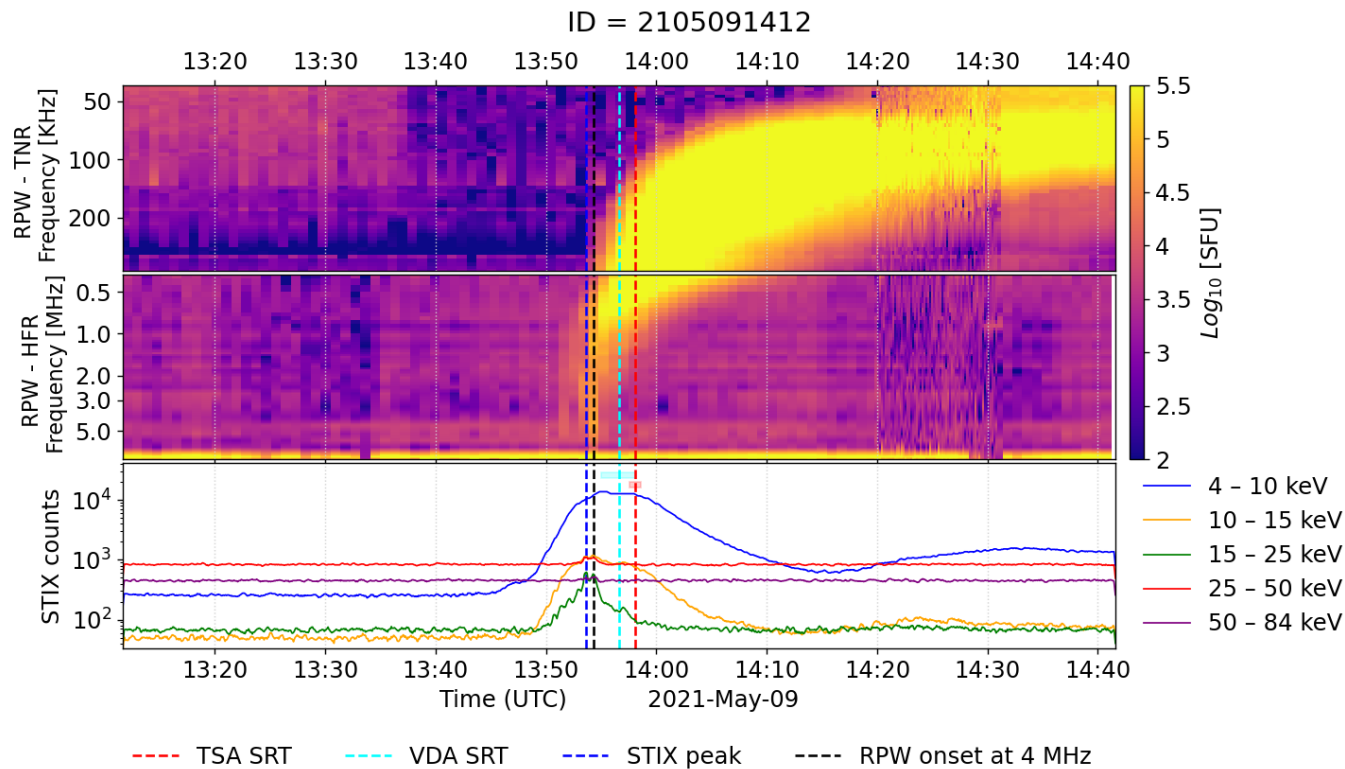
Measuring the composition of associated energetic ions with EPD

- ion composition measured by EPD/SIS
- impulsive events:
 - enriched in ^3He and Fe/O
 - flare-related
- gradual events:
 - no significant enhancements
 - shock-related



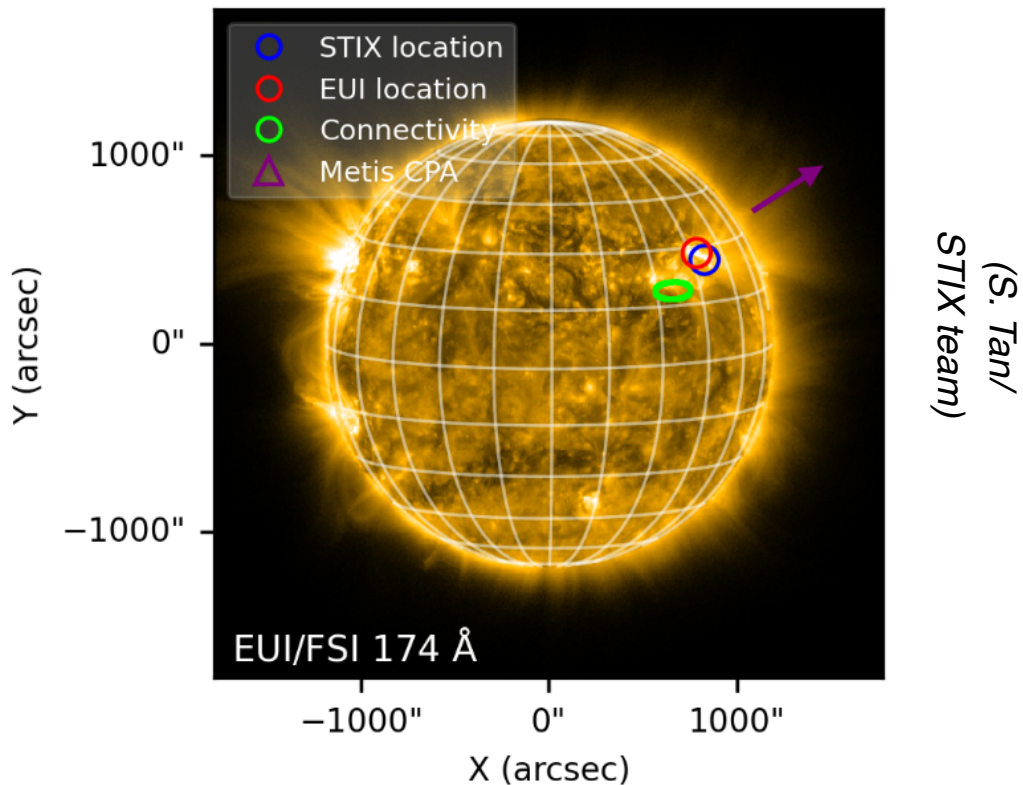
(G. Mason/
EPD-SIS team)

Associating SEE events with X-ray flares (STIX) and type III radio bursts (RPW)



- association based on inferred injection times

Flare source positions, magnetic connectivity, CME direction: STIX, EUV, IRAP connectivity tool, Metis



First data release is online!

coseecat.aip.de



From DR1 to DR2

- DR1 is online since September 2025
 - 303 events until end of 2022
 - 99 columns

event_id	event_date	solo_dist	solo_lon	solo_lat	epd_tonset	epd_delta_t	epd_tpeak	epd_ipeak	epd_epeak	tsa_itime	vda_itime	vda_time_unc	vda_lpath	vda_path_unc
2011170942	2020-11-17	0.928	122.2	-6.0	2020-11-17T09:42:30	60	2020-11-17T10:21:30	3.42E+04	43	2020-11-17T09:27:27				
2011171841	2020-11-17	0.926	122.1	-6.0	2020-11-17T18:41:30	60	2020-11-17T18:48:30	2.7E+04	43	2020-11-17T18:26:29	2020-11-17T18:25:24	0.9	1.15	0.03
2011181056	2020-11-18	0.924	122.1	-6.0	2020-11-18T10:56:30	60			24	2020-11-18T10:34:33				

event_id	c	nominal_path	epd_aniso	epd_compo	epd_series	epd_dispersive	goes_class	goes_estim	stix_status	stix_tpeak	stix_emax	stix_tpeak_epd	stix_tpeak_rpw	stix_hpc_x	stix_hpc_y
2011170942		1.06	large	impulsive	Y			C1	1	2020-11-17T09:32:45	25.0	2020-11-17T09:26:49		929.0	-285
2011171841	3	1.06	large	impulsive	Y	Y		B6	1	2020-11-17T18:26:57	15.0	2020-11-17T18:26:57	2020-11-17T18:26:57	949.0	-383
2011181056		1.05		impulsive	Y			C1	1	2020-11-18T10:26:53	25.0	2020-11-18T10:26:53	2020-11-18T10:26:53	928.0	-470

event_id	stix_hgs_lat	stix_hgs_lon	stix_carr_lon	stix_ar_num	stix_epd_qual	eui_status	eui_hpc_x1	eui_hpc_y1	eui_hgs_lat1	eui_hgs_lon1	eui_carr_lon1	eui_ar_num1	eui_type1	eui_hpc_x2	eui_hpc_y2
2011170942	-18.1	-167.1	340.6	12786	2	1	969.0	-317.0	-18.8	-156.3	351.4	12786	flare	510.0	628.0
2011171841	-22.6	-154.9	347.9	12786	1	1	983.0	-267.0	-16.0	-157.2	345.5	12786	flare	555.0	680.0
2011181056	-26.8	-150.6	343.5	12786	1	1	977.0	-292.0	-17.4	-157.7	336.2	12786	flare	693.0	-379.0

event_id	eui_hgs_lat2	eui_hgs_lon2	eui_carr_lon2	eui_ar_num2	eui_type2	eui_hpc_x3	eui_hpc_y3	eui_hgs_lat3	eui_hgs_lon3	eui_carr_lon3	eui_ar_num3	eui_type3	rpw_status	rpw_t3_time
2011170942	32.4	157.8	305.5	12787	flare								1	
2011171841	36.6	163.9	306.6	12787	flare	560.0	-379.0	-26.2	159.0	301.8	12789	flare	1	2020-11-17T18:21:00
2011181056	-25.4	169.6	303.4	12789	flare								1	2020-11-18T10:29:00

event_id	rpw_t3_freq	rpw_t3_num	rpw_t2	metis_status	metis_tstart1	metis_tend1	metis_fov_min1	metis_fov_max1	metis_cpa1	metis_width1	metis_speed1	metis_tlaunch1
2108280525	4	single		1	2021-08-28T07:10:31	2021-08-28T11:35:31	3.71	7.89	256.0	44.0	0.0	
2109241623	1	multiple		1	2021-09-24T17:21:11	2021-09-24T19:55:47	3.65	7.77	240.0	25.0	363.0	2021-09-24T15:56:28
2109261200	4	multiple	y	1	2021-09-26T12:57:11	2021-09-26T23:41:11	3.69	7.87	266.0	65.0	607.0	2021-09-26T12:05:45
2109271157	4	single		1	2021-09-27T12:03:12	2021-09-27T14:19:15	3.72	7.9	245.0	34.0	430.0	2021-09-27T10:49:47

event_id	metis_tstart2	metis_tend2	metis_fov_min2	metis_fov_max2	metis_cpa2	metis_width2	metis_speed2	metis_tlaunch2	solohi_status	solohi_tstart
2108262336									0	
2108280525									0	
2109241623									0	
2109261200									0	
2109271157	2021-09-27T18:19:15	2021-09-28T11:03:12	3.72	7.95	96.0	38.0	67.0	2021-09-27T10:28:09	0	

event_id	sw_speed	shock_delay	icme_sheath_delay	icme_mo_delay	post_icme_delay	sir_comp_delay	sir_si_delay	sir_rar_delay	hcs_delay
2108262336		40.00							13.00
2108280525	301	12.00							-4.00
2109241623	247.6	26.00							
2109261200	372.7	-18.00	-8.00	0.00					

event_id	ss_fr_delay	sw_condition	mag_polarity	ip_complex	ip_confidence	conn_carr_lon	conn_lon_unc	conn_hgs_lat	conn_lat_unc	conn_conf
2108241208	46.00	s	p	n	1	18.68	4.82	59.50	4.00	1
2108241222	46.00	s	p	n	1	18.68	4.82	59.50	4.00	1
2108241250	46.00			n	1	18.68	4.82	59.50	4.00	1
2108261824	0.00			n	1	12.07	6.43	59.37	3.13	3

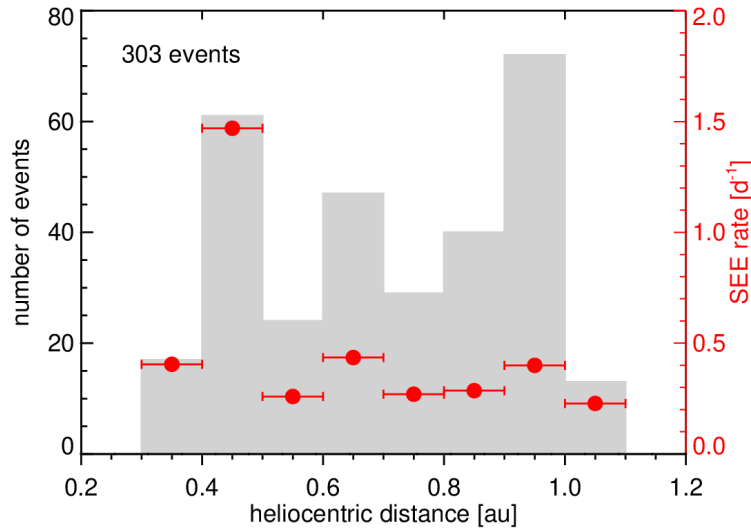
From DR1 to DR2

- DR1 is online since September 2025
 - 303 events until end of 2022
 - 99 columns
- working on next release:
 - 517 events until end of 2023
 - still to-do:
 - finish STIX imaging for associated flares (~100 events missing)
 - associations with CME
 - IP context
 - ...

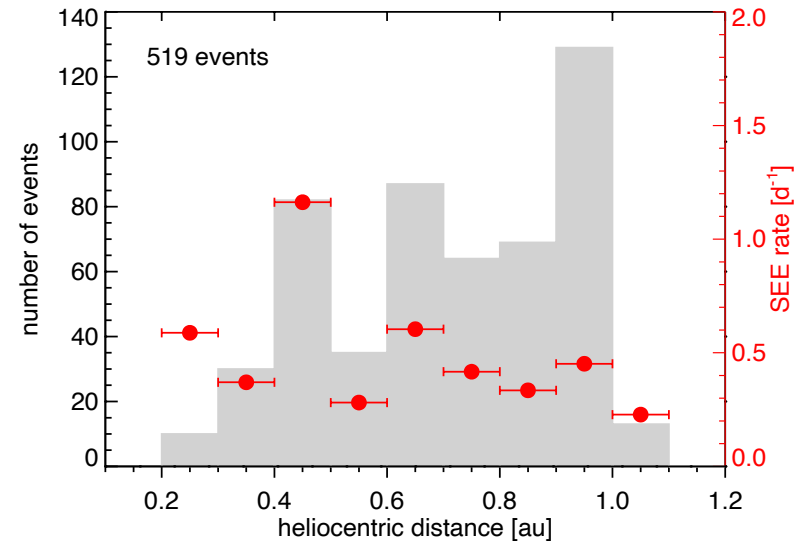
First statistical results:
from DR1 to DR2



Event sample and basic characteristics



Nov 2020 – Dec 2022: 303 SEE events



Nov 2020 – Dec 2023: 519 SEE events
(1183 until May 2026)

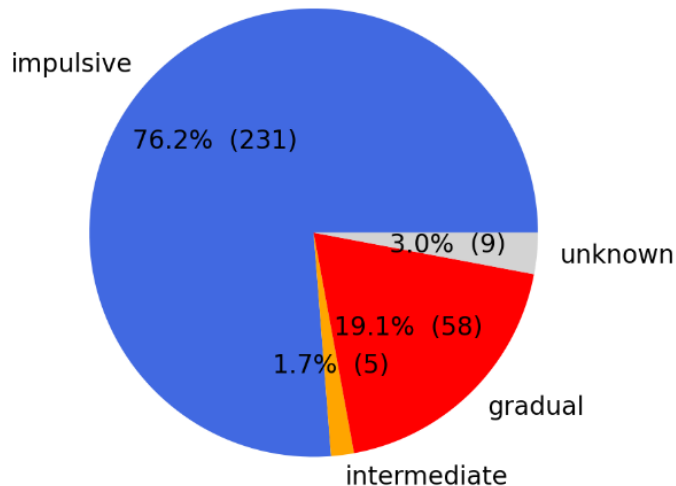
no dependence of event rate on solar distance

SEP composition: impulsive vs. gradual



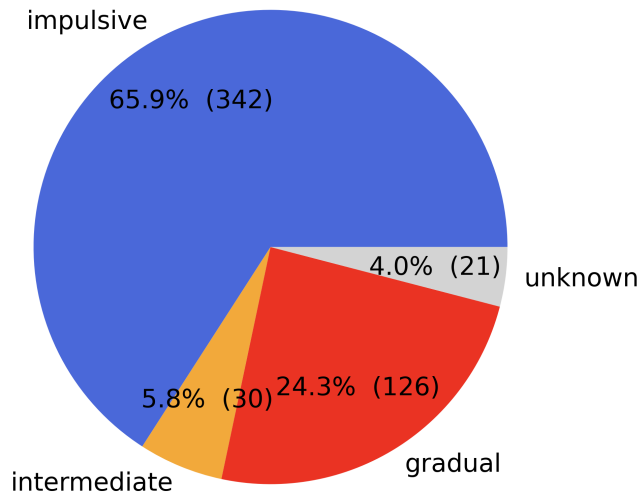
DR1

composition



DR2

composition (all events)

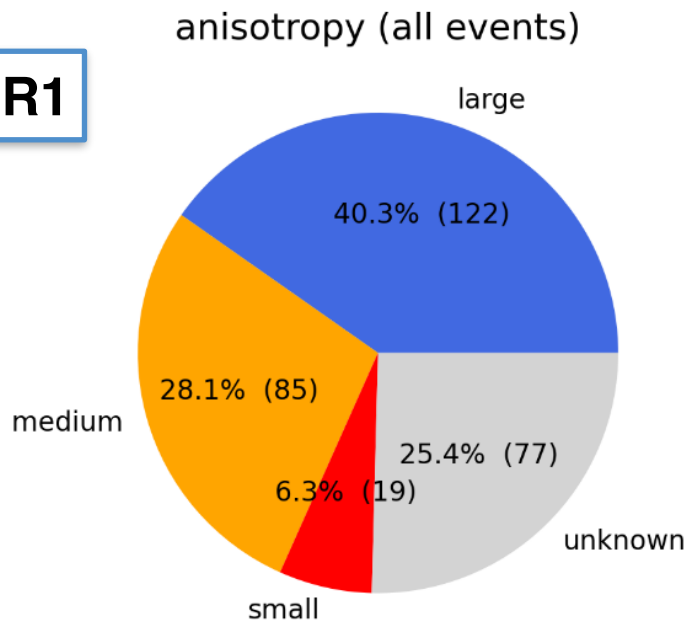


dominated by impulsive events, fraction of gradual + intermediate increasing

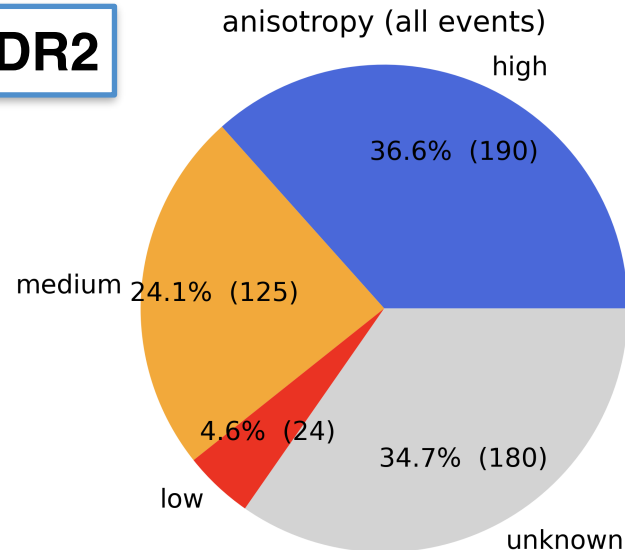
Electron anisotropy



DR1



DR2



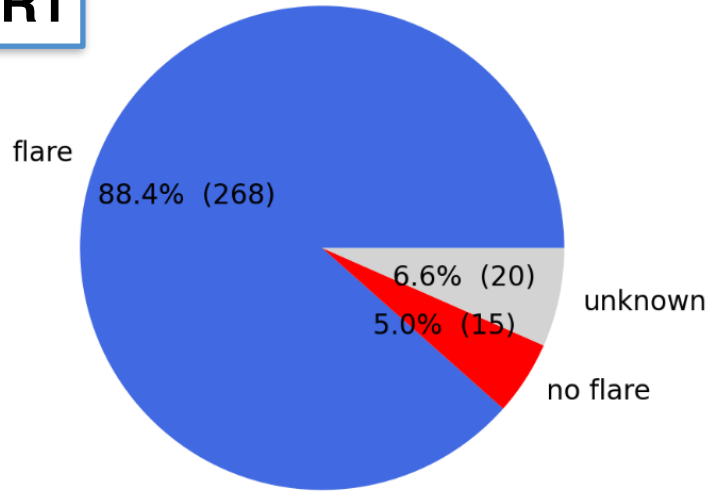
few events with low anisotropies
(increasing fraction of unknown due to confusion)

Associations with flares



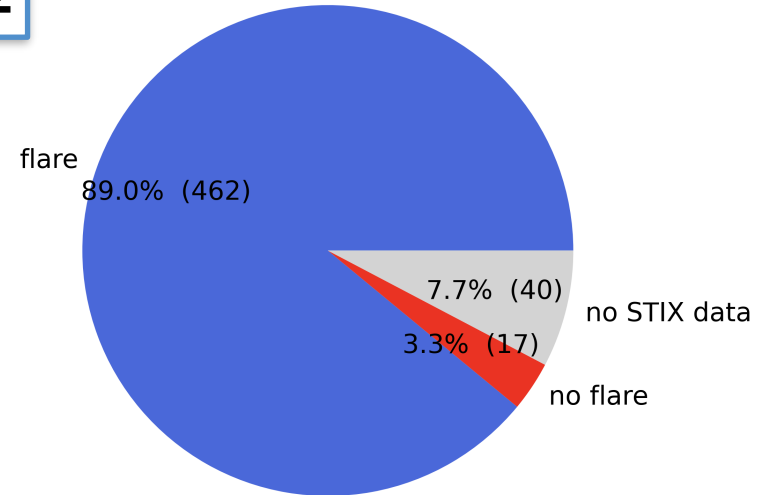
association with STIX flares

DR1



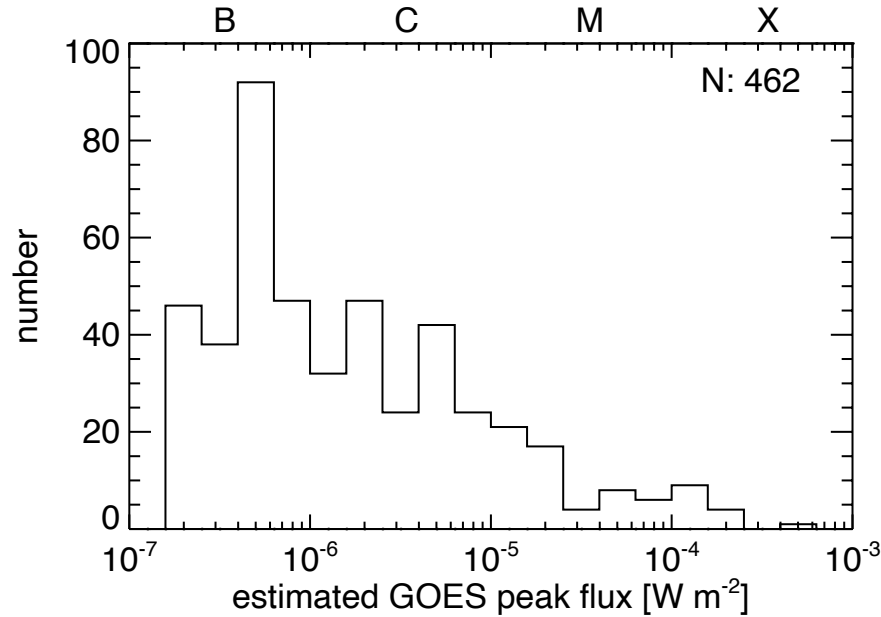
association with STIX data (all events)

DR2



we can find a STIX flare counterpart for the vast majority of events

Associations with flares

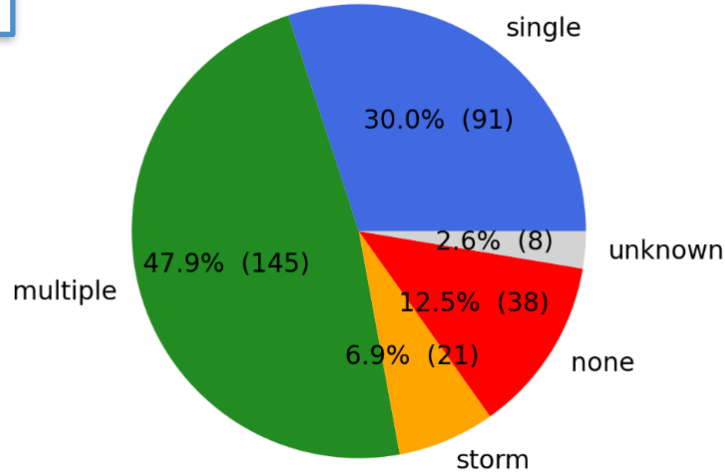


Associations with radio bursts



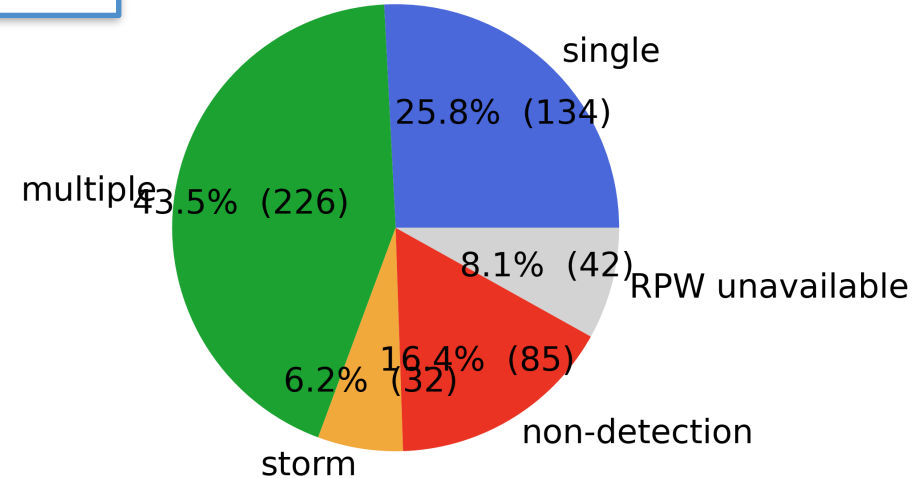
DR1

association with RPW type III bursts



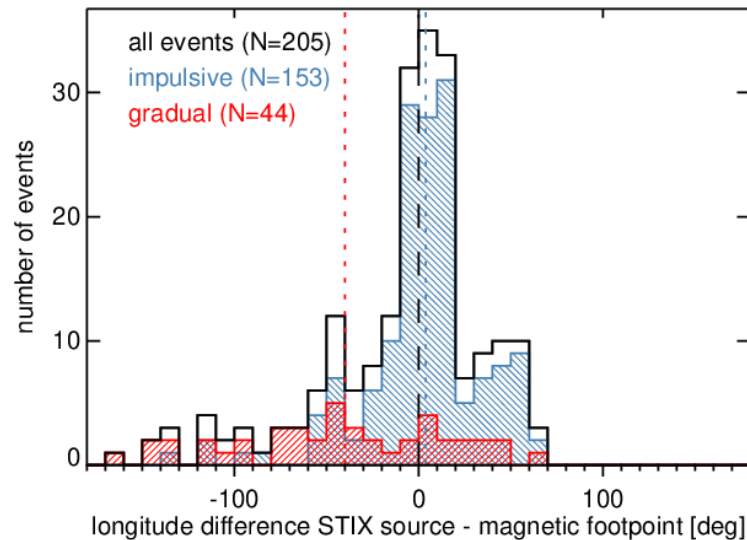
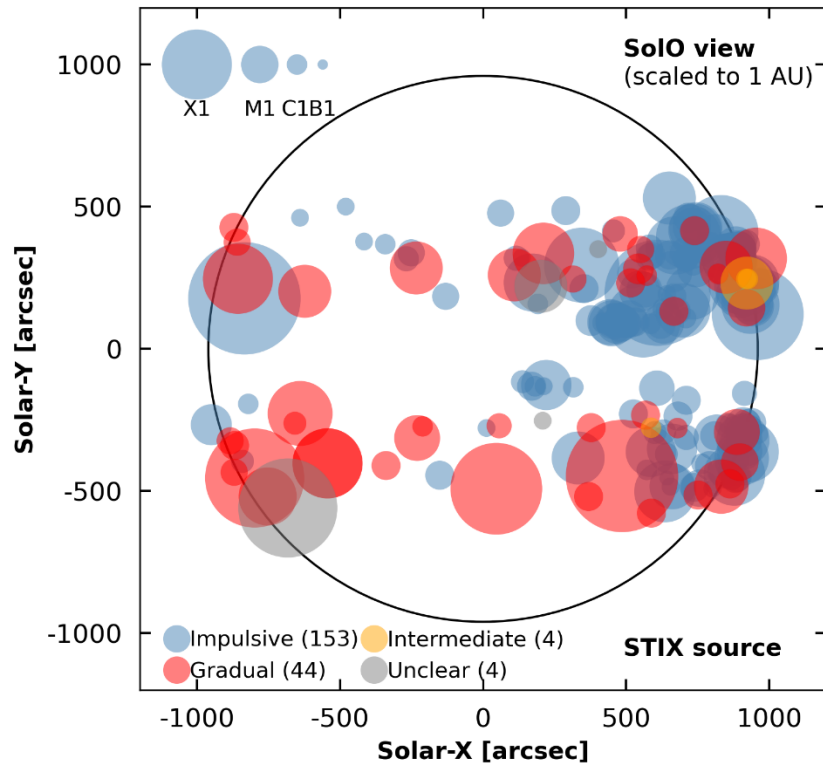
DR2

association with type III bursts (all events)



high association rate with type III bursts

Source positions and magnetic connectivity (only DR1)

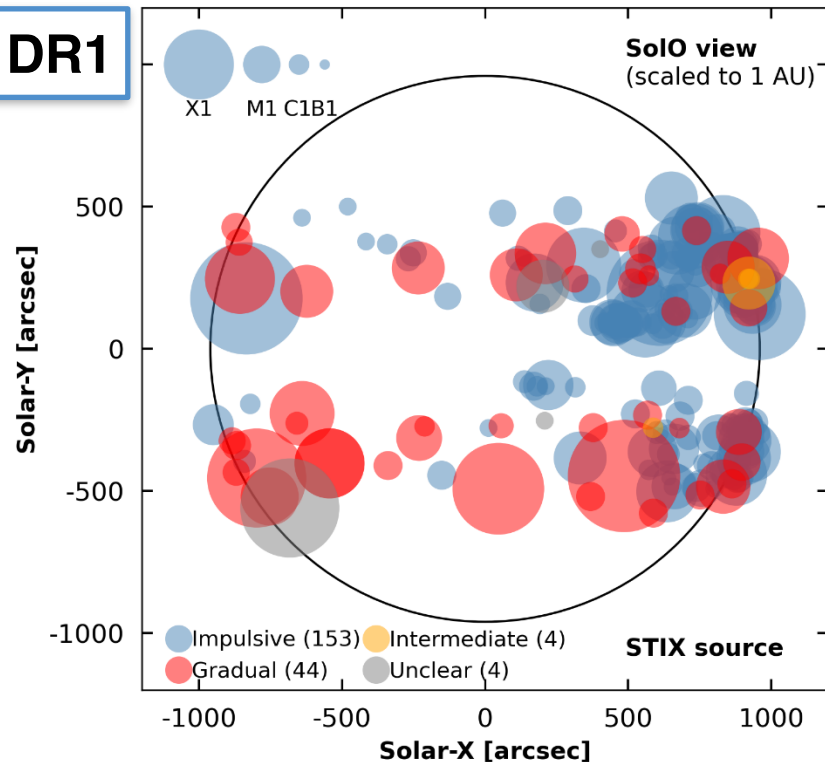


- impulsive events: compact sources near connecting field lines → flares
- gradual events: consistent with broad injection region → CMEs

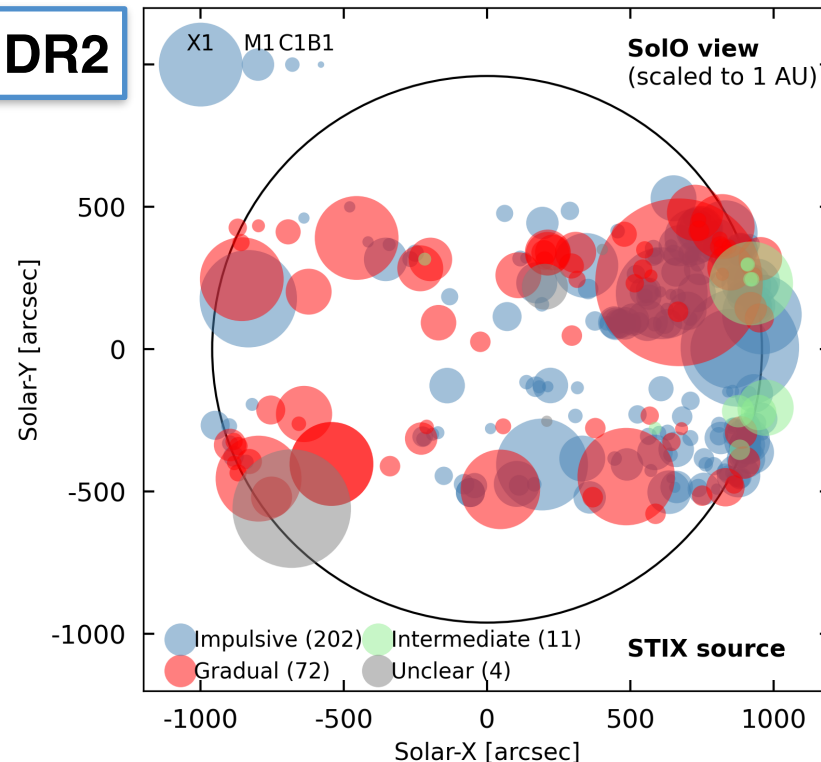
Source positions: impulsive / gradual events



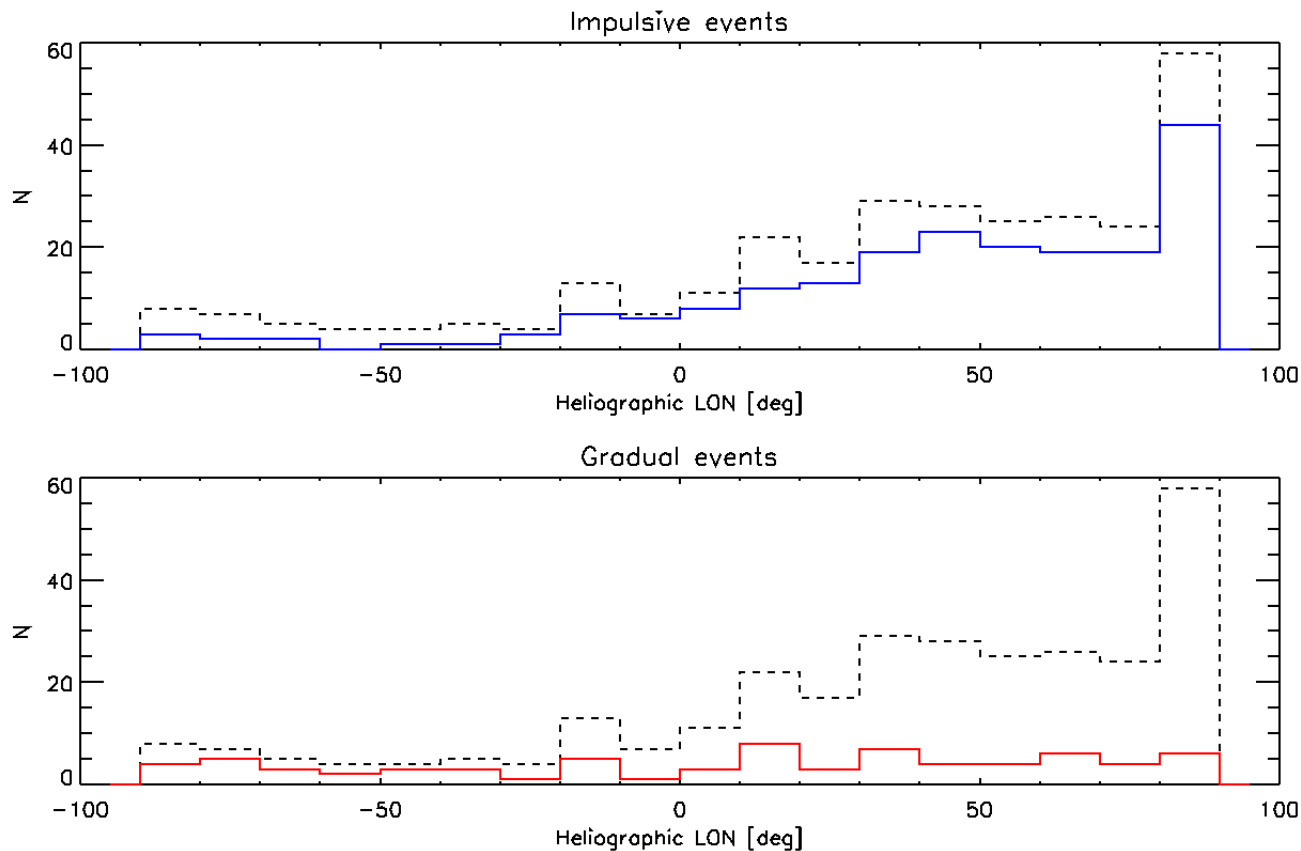
DR1



DR2



Source positions: impulsive / gradual events (DR2)

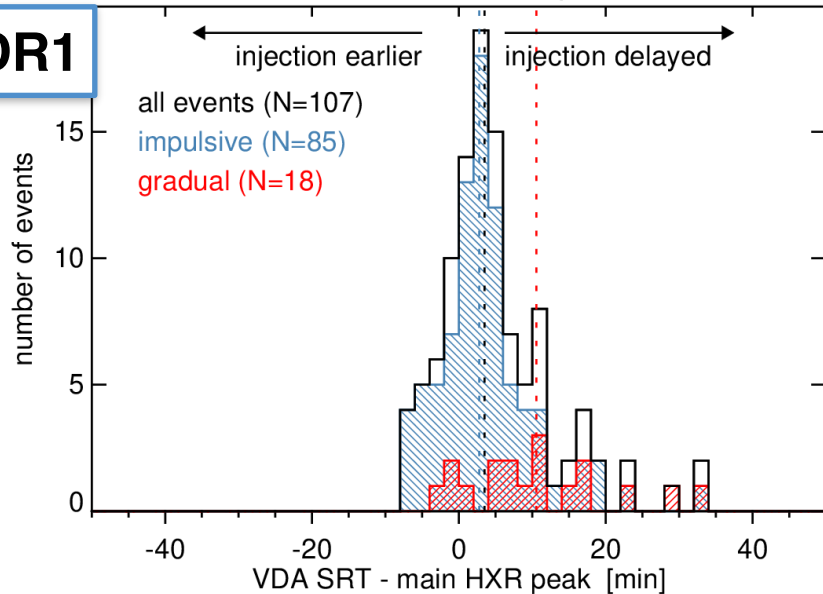


Solar release time differences



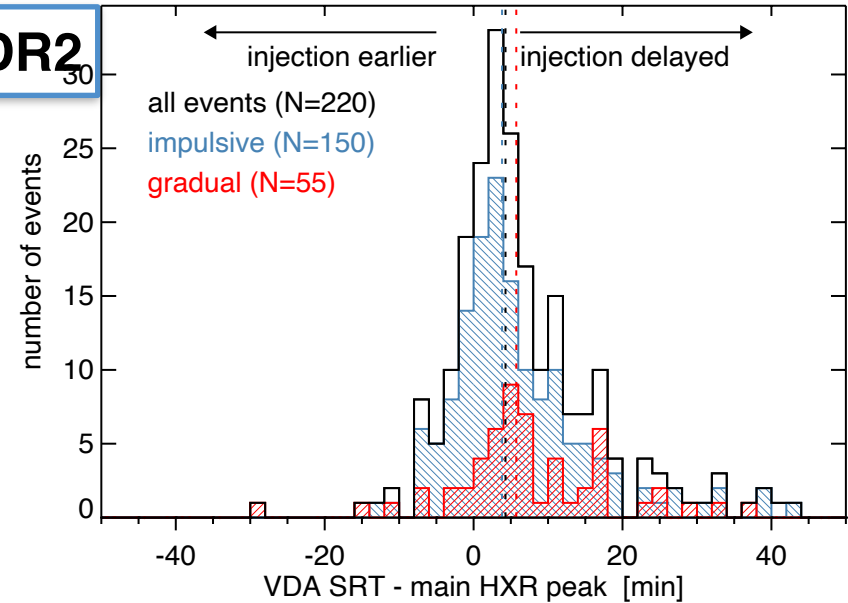
VDA SRT - main HXR peak time

DR1



VDA SRT - main HXR peak time

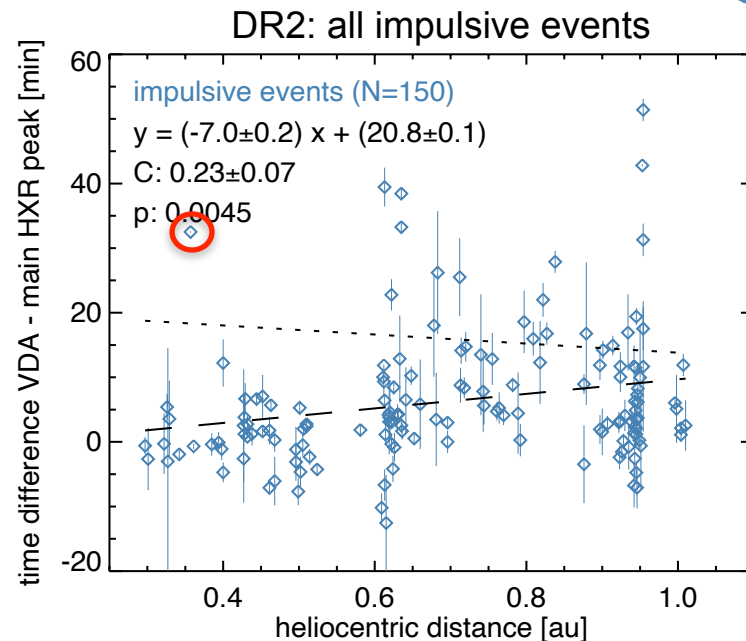
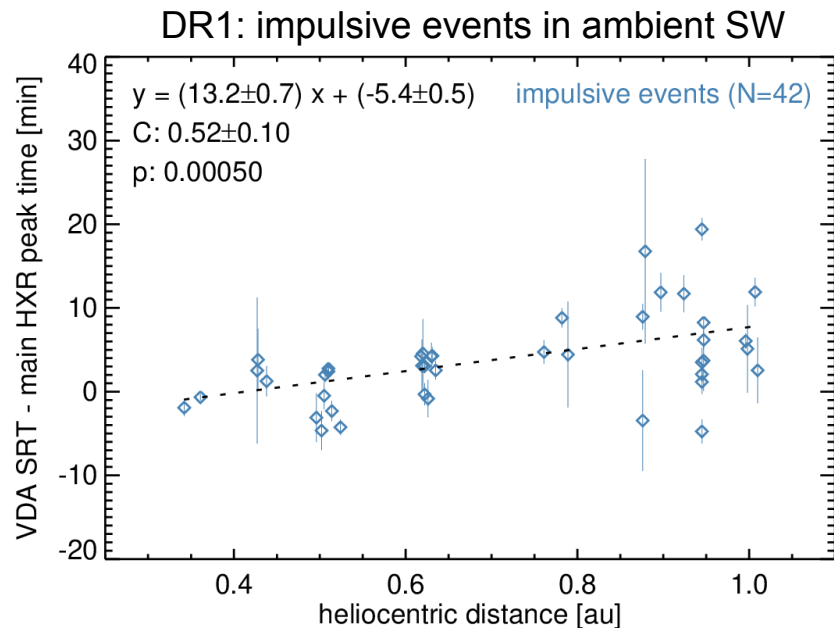
DR2



better temporal correlation for impulsive events

shown both by HXR peaks and type III onsets

Solar release time differences vs. distance for impulsive events



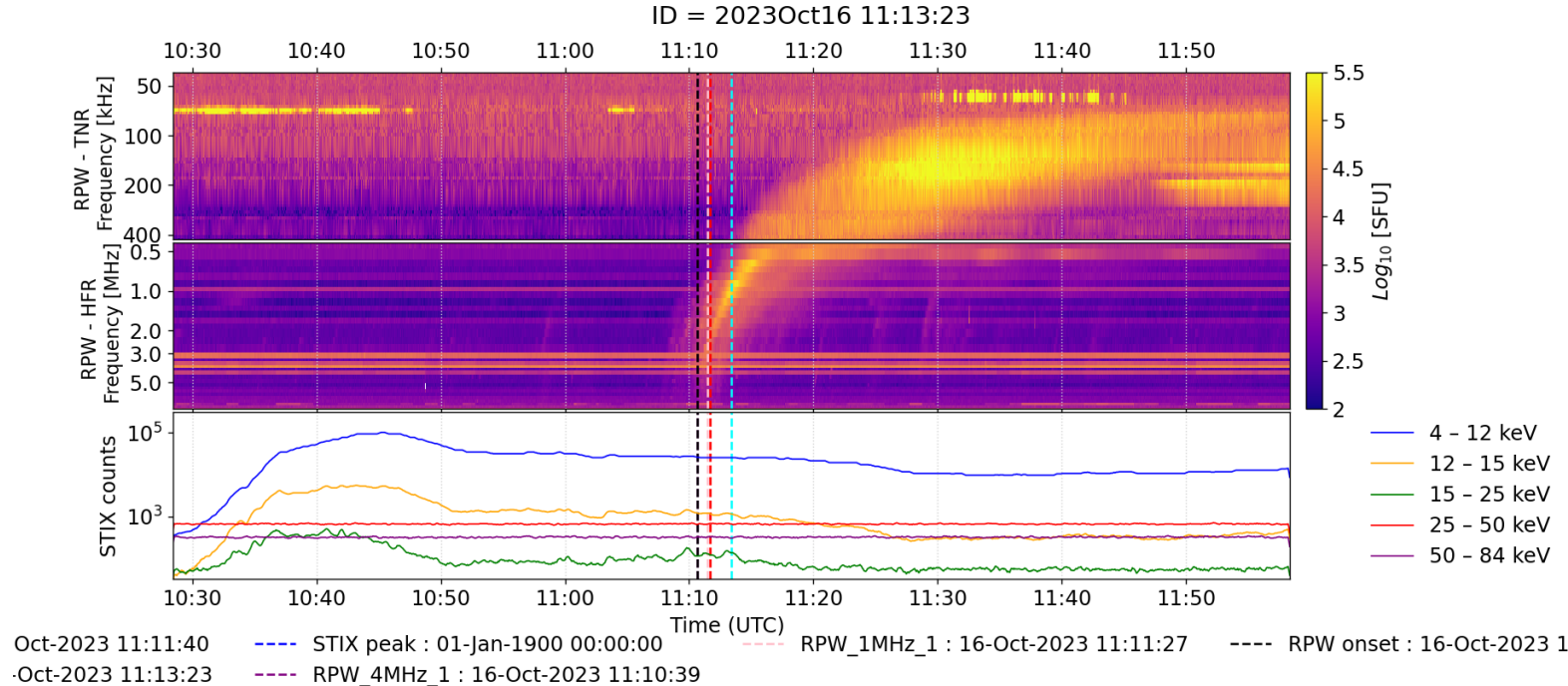
- weak correlation for impulsive events (better when in ambient solar wind)
- delays can be at least partly explained by transport effects

A few outliers with small error bars

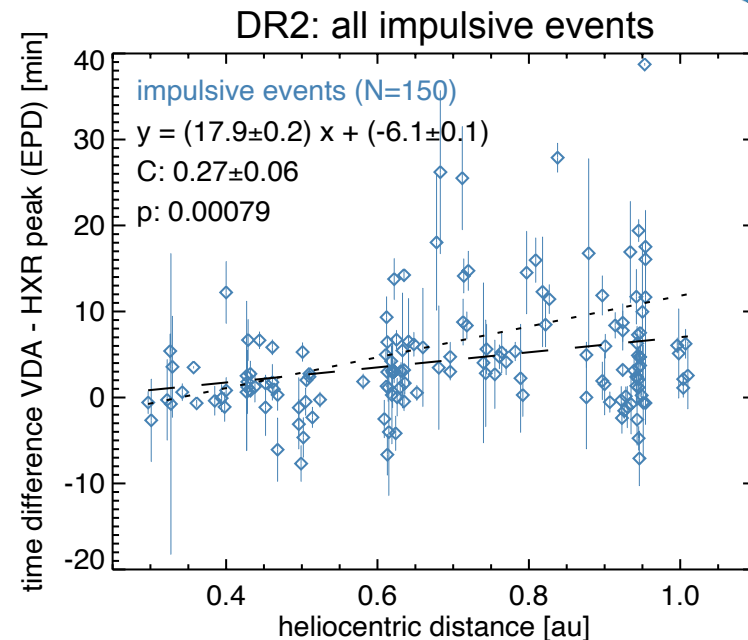
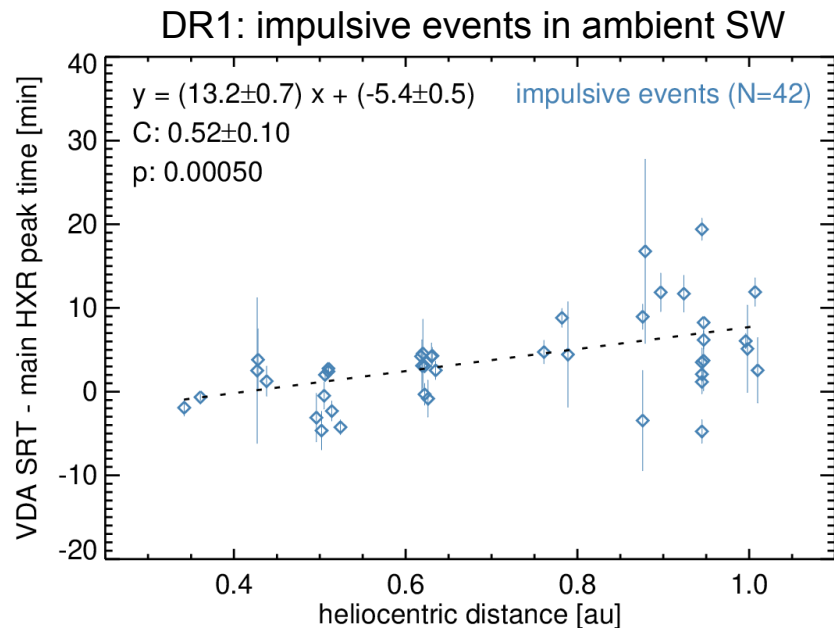
STIX main
peak

≠

STIX peak
closest to
EPD time



Solar release time differences vs. distance for impulsive events



- weak correlation for impulsive events (better when in ambient solar wind)
- delays can be at least partly explained by transport effects

Summary and outlook



Summary and Outlook

- Initial results with DR1:
 - strong support for flare-related origin of impulsive SEE events
 - evidence for propagation effects
- Data Release 2:
 - 500+ events to be published by October 2026
- Next steps
 - focused studies, e.g. statistical study of SEE-associated EUV jets (cf. Song's talk)
 - spectroscopic analysis: electron spectra (EPD) and X-rays (STIX)
 - train machine learning for automatic detection of SEP events
 - multi-spacecraft investigations

Looking forward to DR3, DR4, DR5... with 1000+ events!