

Solar Energetic Electron Events And Related Radio Signatures

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Goals

- ***ACE/EPAM Solar Energetic Electron (SEE) Events catalog***
 - *Procedures for Identifying the electron events and criteria for solar origin*
 - *Statistical relationship with their origin (Pearson & Partial correlations)*
- ***Radio Emission Signature Catalog***
 - *Procedures for Identifying electron events radio signatures*
 - *Radio burst occurrence trends in IP space related to SEE events*

ACE/EPAM Electron Event Catalog

Solar cycle 23: 1996-2008

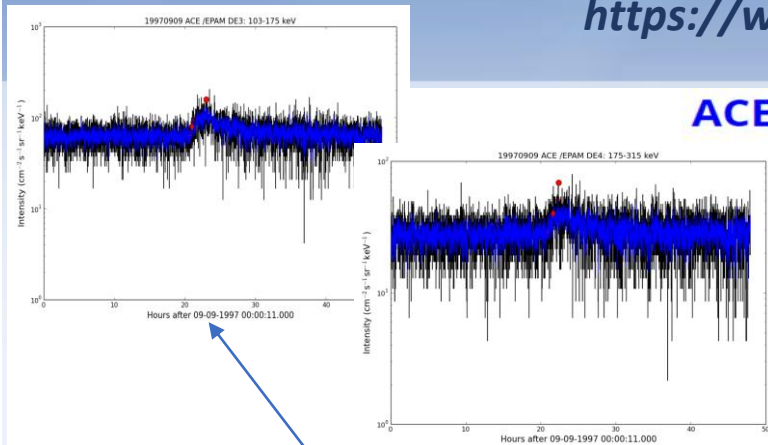
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[Solar Cycle 24: \(2009-2019\)](#)



Date			Electrons		103-175 keV		175-315 keV		GOES SXR Flare				SOHO/LASCO CME				19-28 MeV		28-72 MeV	
yyyy	mm	dd	Onset	Peak	J_e	F_e	J_e	F_e	Onset	Peak	Class	Location	time	Speed	AW	MPA	J_p	F_p	J_p	F_p
1997	9	9	20:59	23:00	97.897655	667146	41.631	103008	20:04	20:11	B7.1	u	20:06	726	101	303	no	no	no	no
1997	9	18	00:41	01:00	294.480444	291933	39.422	43255	17:45 ^{pd}	18:03 ^{pd}	M1.0	N21W84	20:29 ^{pd}	377	360	263	no	no	no	no
1997	9	18	19:13	22:29	378.120216	2326729	no	no	17:05	17:10	C1.5	N22W91 ^v	18:03	285	55	268	no	no	no	no
1997	9	20	03:45	06:22	291.9095	2027564	37.457	57980	00:27	00:48	B8.0	u	00:44	522	39	247	no	no	no	no
1997	9	24	03:21	04:55	142.357054	549724	48.435	292824	02:43	02:48	M5.9	S31E19	03:38	532	76	117	0.0059	u	0.0017	0.004793
1997	10	7	13:27	15:14	212.825833	830850	50.032	312133	u	u	u	u	13:30	1271	167	204	0.0108	0.008223	0.0012	0.000753
1997	10	21	19:11	21:36	78.596128	767376	no	no	17:00	17:54	C3.3	N16E07	18:03	523	360	90	no	no	no	no
1997	11	3	10:31	12:52	209.470783	1373986	58.315	372628	09:03	09:10	M1.4	S20W15	09:53	338	71	239	no	no	no	no

Electron events (SC23&24)

103–175 keV: 965 events

175–315 keV: 800 events

Electron events (SC23)

103–175 keV: 633 events

175–315 keV: 530 events

Electron events (SC24)

103–175 keV: 332 events

175–315 keV: 270 events

- Solar Energetic Electrons (SEEs)
 - ACE/EPAM (103-175 keV), (175-315 keV)
 - <https://cdaweb.gsfc.nasa.gov/index.html/>
 - Onset/Peak time (UT),
 - Intensity; J_e (e/cm² s sr keV),
 - Fluence F_e (e/cm² sr keV)

- SOHO/LASCO CMEs
- https://cdaw.gsfc.nasa.gov/CME_list/

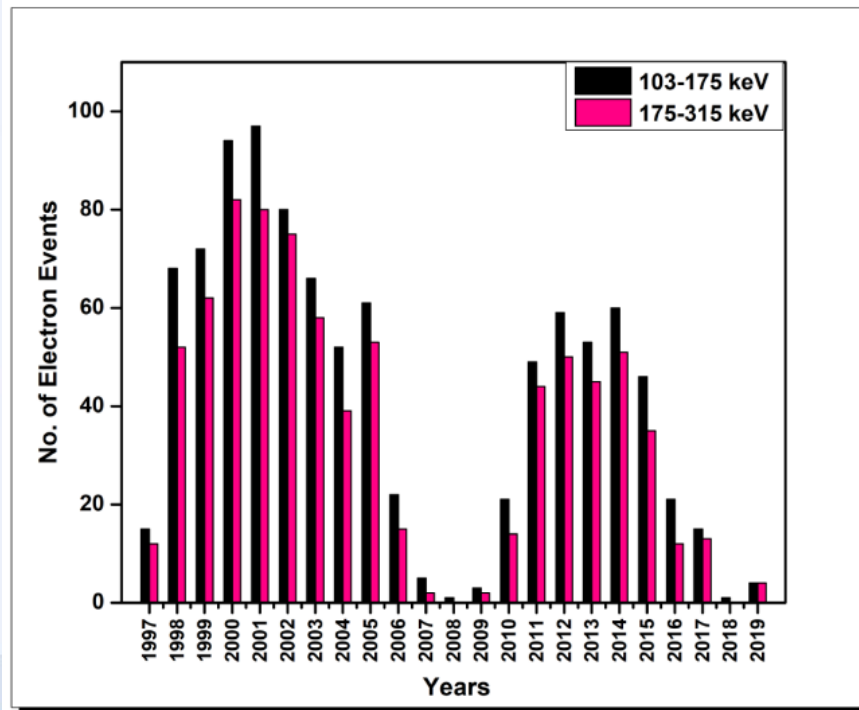
- GEOS SXR flares
- https://hesperia.gsfc.nasa.gov/goes/goes_event_listings/

- Solar Energetic Protons (SEPs)
 - WIND/EPACT(19-28 MeV), (28-72 MeV)
 - Miteva et al., 2018 [DOI: [10.1007/s11207-018-1241-5](https://doi.org/10.1007/s11207-018-1241-5)]
 - <http://newserver.stil.bas.bg/SEPcatalog/index.html>

Results

Susan W Samwel, Rositsa Miteva, Catalogue of *in situ* observed solar energetic electrons from ACE/EPAM instrument, *Monthly Notices of the Royal Astronomical Society*, Volume 505, Issue 4, August 2021, Pages 5212–5227, <https://doi.org/10.1093/mnras/stab1564>

Yearly distribution of the electron events for solar cycle 23 and 24. The length of the color bar denotes the number of events in either energy channel given by the respective colour and explained in the legend, using 1 yr binning.



Pearson Correlation

Correlation coefficients	103–175 keV		175–315 keV	
	J_e	F_e	J_e	F_e
SC23				
I_{SXR}	0.52 ± 0.04 (430)	0.52 ± 0.04 (429)	0.52 ± 0.04 (374)	0.54 ± 0.04 (373)
V_{CME}	0.51 ± 0.04 (441)	0.54 ± 0.04 (439)	0.49 ± 0.04 (381)	0.51 ± 0.04 (380)
AW_{CME}	0.39 ± 0.04 (445)	0.46 ± 0.03 (443)	0.39 ± 0.04 (385)	0.48 ± 0.04 (384)
SC24				
I_{SXR}	0.59 ± 0.05 (190)	0.58 ± 0.05 (189)	0.59 ± 0.05 (157)	0.57 ± 0.06 (156)
V_{CME}	0.50 ± 0.05 (271)	0.53 ± 0.05 (269)	0.51 ± 0.05 (224)	0.56 ± 0.05 (222)
AW_{CME}	0.28 ± 0.05 (271)	0.33 ± 0.06 (269)	0.25 ± 0.06 (224)	0.29 ± 0.07 (222)
SC23 + 24				
I_{SXR}	0.54 ± 0.03 (620)	0.54 ± 0.03 (618)	0.54 ± 0.04 (531)	0.55 ± 0.03 (529)
V_{CME}	0.51 ± 0.03 (712)	0.53 ± 0.03 (708)	0.50 ± 0.03 (605)	0.52 ± 0.03 (602)
AW_{CME}	0.33 ± 0.03 (716)	0.41 ± 0.03 (712)	0.32 ± 0.03 (609)	0.41 ± 0.03 (606)

Partial Correlation

Correlation coefficients	103–175 keV		175–315 keV	
	J_e	F_e	J_e	F_e
SC23				
$I_{SXR} V_{CME} AW_{CME}$	0.29 ± 0.04	0.25 ± 0.04	0.29 ± 0.04	0.28 ± 0.04
$V_{CME} I_{SXR} AW_{CME}$	0.26 ± 0.04	0.28 ± 0.04	0.24 ± 0.04	0.22 ± 0.04
$AW_{CME} I_{SXR} V_{CME}$	0.06 ± 0.04	0.16 ± 0.04	0.07 ± 0.04	0.18 ± 0.04
SC24				
$I_{SXR} V_{CME} AW_{CME}$	0.49 ± 0.06	0.45 ± 0.06	0.51 ± 0.06	0.46 ± 0.07
$V_{CME} I_{SXR} AW_{CME}$	0.36 ± 0.06	0.38 ± 0.06	0.41 ± 0.06	0.45 ± 0.07
$AW_{CME} I_{SXR} V_{CME}$	-0.22 ± 0.06	-0.16 ± 0.06	-0.29 ± 0.06	-0.25 ± 0.07
SC23 + 24				
$I_{SXR} V_{CME} AW_{CME}$	0.36 ± 0.03	0.31 ± 0.03	0.36 ± 0.04	0.33 ± 0.04
$V_{CME} I_{SXR} AW_{CME}$	0.29 ± 0.03	0.30 ± 0.03	0.29 ± 0.04	0.27 ± 0.04
$AW_{CME} I_{SXR} V_{CME}$	-0.05 ± 0.03	0.06 ± 0.03	-0.06 ± 0.04	0.06 ± 0.04

Radio Emission Signatures Catalog

<https://catalogs.astro.bas.bg>

Catalogs Of Solar Energetic Protons And Flare Emission Signatures

AIM PROTON EVENTS **RADIO SIGNATURES** X-RAY SIGNATURES UV SIGNATURES GEOMAGNETIC STORMS

Radio signatures

The radio signatures catalog lists the remotely observed radio emission of in situ detected ACE/EPAM instrument electron events separately for solar cycle 23 (1996–2008) and 24 (2009–2019).

Related radio results based on a proton event list:

R. Miteva, S. W. Samwel and V. Krupar, *Solar energetic particles and radio burst emission*, JSWSC (2017), DOI:10.1051/swsc/2017035.

Radio data is mainly used from the following sources: RSTN; Wind/WAVES; Radio monitoring.

Acknowledgements: For the solar source association are used the following sources: GOES flare listings; www.Solarmonitor.org; CDAW LASCO CME catalog.

Disclaimer: This catalog is still under construction. The complete contents will appear after respective publication.

Contact: catalogs [at] nao-rozhen.org

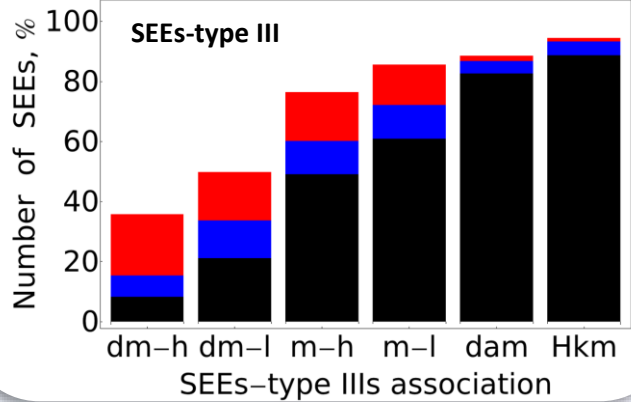
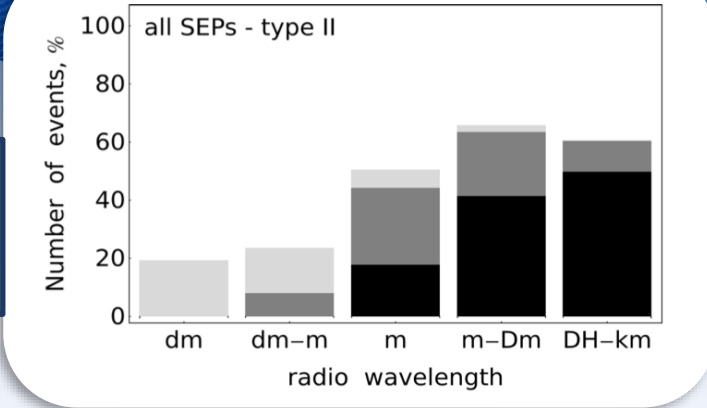
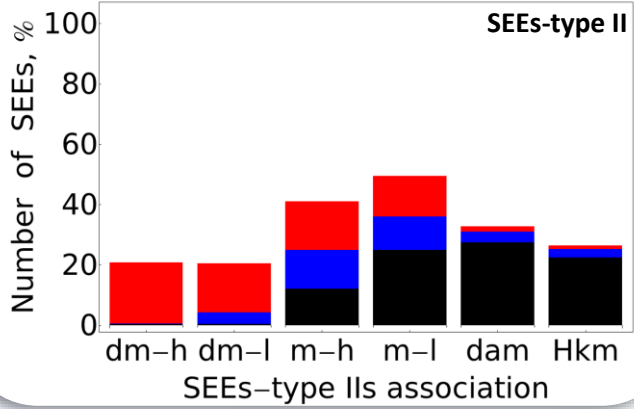
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Under construction

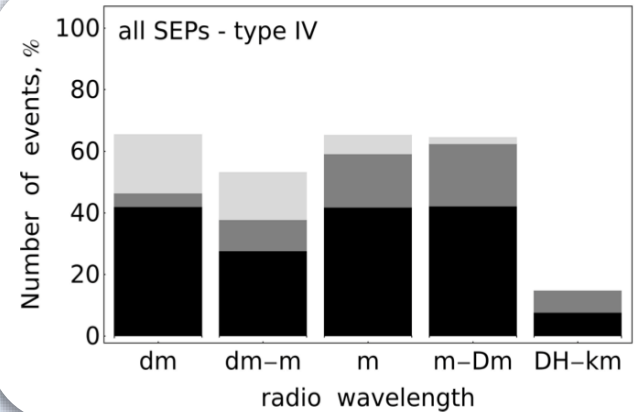
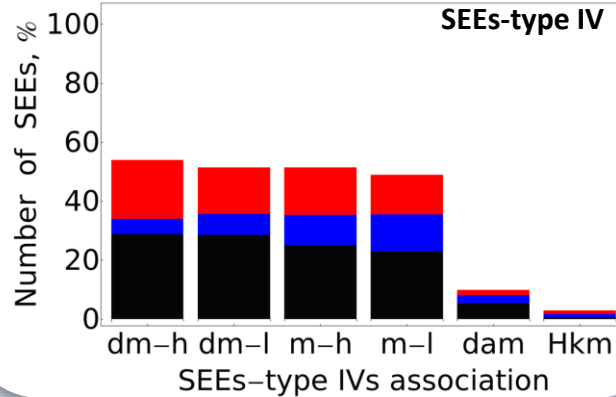
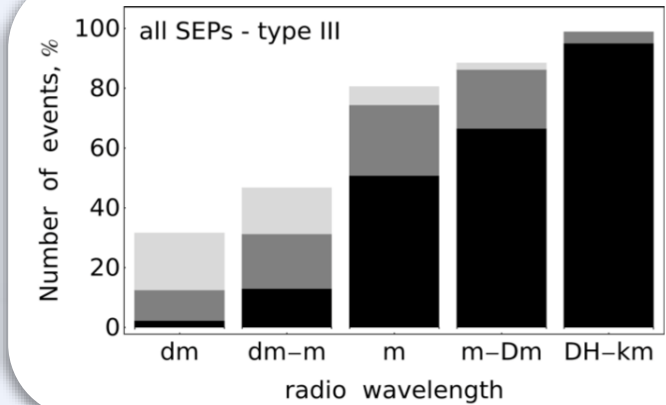
Radio observatory	frequency range, MHz	Data link	<i>Sources</i>
Ondrejov	800–5000	http://www.asu.cas.cz/~radio/info.htm	
e-Callisto/Phoenix	10–5000	http://soleil.i4ds.ch/solarradio/callistoQuicklooks/ http://soleil.i4ds.ch/solarradio/data/1998–2009_quickviews/	
HiRAS	25–2500	http://sunbase.nict.go.jp/solar/denpa/index.html	
Culgoora	18–1800	http://www.sws.bom.gov.au/World_Data_Centre/1/9	
Green Bank	5–1100	http://www.astro.umd.edu/~white/gb/index.shtml	
Radio Monitoring	0.02–1000	http://secchirh.obspm.fr/select.php	
ARTEMIS	20–600	http://artemis-iv.phys.uoa.gr/Artemis4_list.html	
IZMIRAN	25–270	http://www.izmiran.ru/stp/lars/s_archiv.htm	
Bruny Island	6–62	http://www.astro.umd.edu/white/gb/index.shtml	
Wind/WAVES	0.02–14	https://solar-radio.gsfc.nasa.gov/wind/data_products.html	
RSTN (Sagamore Hill, Palehua, San Vito, Learmonth)	245, 410, 608, 1415, 2695, 4995, 8800 & 15400	ftp://ftp.ngdc.noaa.gov/STP/space-weather/solar-data/solar-features/solar-radio/rstn-1-second/	

Results

Black<----- certain identification -----> **Black**
Blue<--- uncertain or only observatory reports ---> **Dark gray**
Red<----- no dynamic spectral plots found -----> **Light gray**



dm-h/dm : 3-1 GHz
dm-l/dm-m : 1000-300 MHz
m-h/m : 300-100 MHz
m-l/m-Dm : 100-30 MHz
dam } **DH-** : 30-3 MHz
Hkm } **km** : 3 MHz-20 kHz



Miteva R, Samwel SW, Krupar V. 2017. Solar energetic particles and radio burst emission. J. Space Weather Space Clim. 7: A37

- **This study presents the first Comprehensive catalogue of in situ electron events over solar cycles 23 and 24**
https://www.nriag.sci.eg/ace_electron_catalog/
- The ACE/EPAM catalogue contains 965/800 electron events in low/high energy channels.
- The influence of SFs on the generation of SEE events is slightly larger (but not statistically significant) compared to CME.
- The partial correlations in SC24 with SF class and CME speed are stronger compared to the respective values in SC23. There is no correlation with the CME AW.
- There is no substantial difference between the correlations when using the SEE intensity or fluence.
- **This study presents the first Comprehensive catalogue of Radio burst signatures related to the so-identified solar origin of the solar energetic electrons** <https://catalogs.astro.bas.bg>
- With increasing of radio wavelength, type II bursts occurrence rate is found to decrease (in dam/HKM range; IP space), while type III increase, and is kept almost flat for type IV bursts.
- Type III bursts are the most numerous radio burst type at longest wavelength (low freq., high corona/IP space), followed by type II bursts, then type IV.
- Generally, at dm-range (low corona), the occurrence of type II and III bursts is low, if any, au contraire to type IV bursts.
- The trend of occurrence of type III and IV radio bursts associated with protons and electrons is the same, while for type II bursts, the occurrence rate of radio bursts associated with electrons is less compared to that with protons, at longer wavelength (IP space) which may indicate that IP shock wave acceleration might be more proton-efficient.