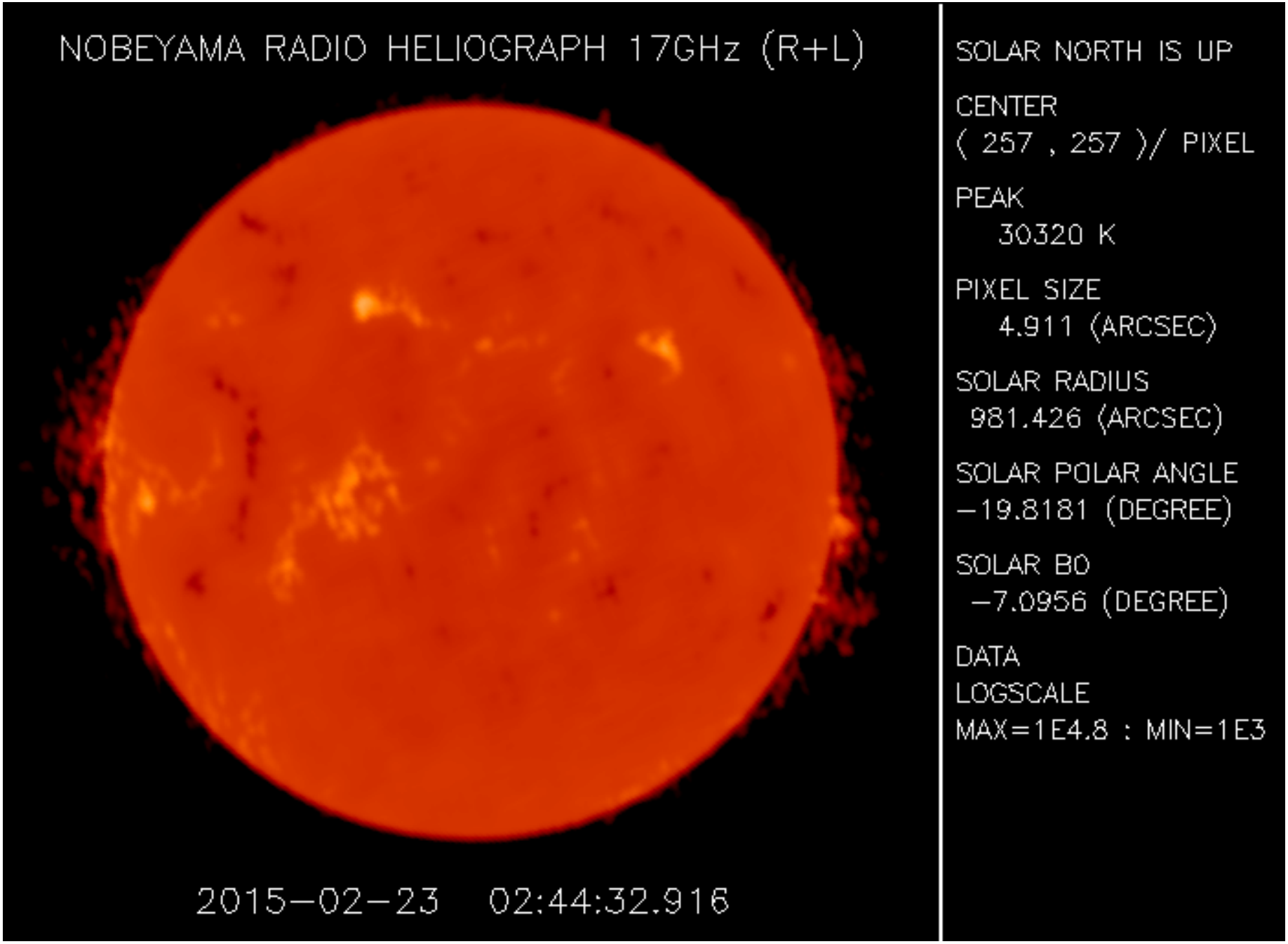
Contributions of the Nobeyama Radioheliograph to Space Weather Research

S. Masuda (STEL, Nagoya University), K. Shibasaki (NSRO, NAOJ)
and N. Gopalswamy (GSFC, NASA)

Nobeyama Radioheliograph (NoRH)

FoV: full Sun
Antenna diameter: 80 cm
Number of antennas: 84
Baseline: NS 250 m, EW 500 m
Frequencies: 17, 34 GHz
Spatial res.: 10 arcsec@17GHz, 5 arcsec@34 GHz
Polarization: circular pol. @17 GHz
Time res.: normal 1 sec, event 0.1 sec
Operation start: July 1992 (17GHz),
November 1995 (34GHz)
Observational time: 22:30 – 6:30 UT


NOBEYAMA RADIO HELIOGRAPH 17GHz (R+L)
2015-02-23 02:44:32.916
SOLAR NORTH IS UP
CENTER
(257 , 257)/ PIXEL
PEAK
30320 K
PIXEL SIZE
4.911 (ARCSEC)
SOLAR RADIUS
981.426 (ARCSEC)
SOLAR POLAR ANGLE
-19.8181 (DEGREE)
SOLAR B0
-7.0956 (DEGREE)
DATA
LOGSCALE
MAX=1E4.8 : MIN=1E3

Scientific topics

NoRH is a powerful tool for space weather research.

Solar flares

17 and 34 GHz
→ High-energy electrons (~MeV)
0.1 sec time resolution
→ transport of high-energy electrons

Prominence eruptions

no weather (rain, cloud) effect
→ good for monitoring
no Doppler shift
→ possible to follow it even at the higher altitude (~ 2 Rs)

~ 700 solar flares were observed with NoRH since 1992.
All of images/movies are open at the web page of NoRH.

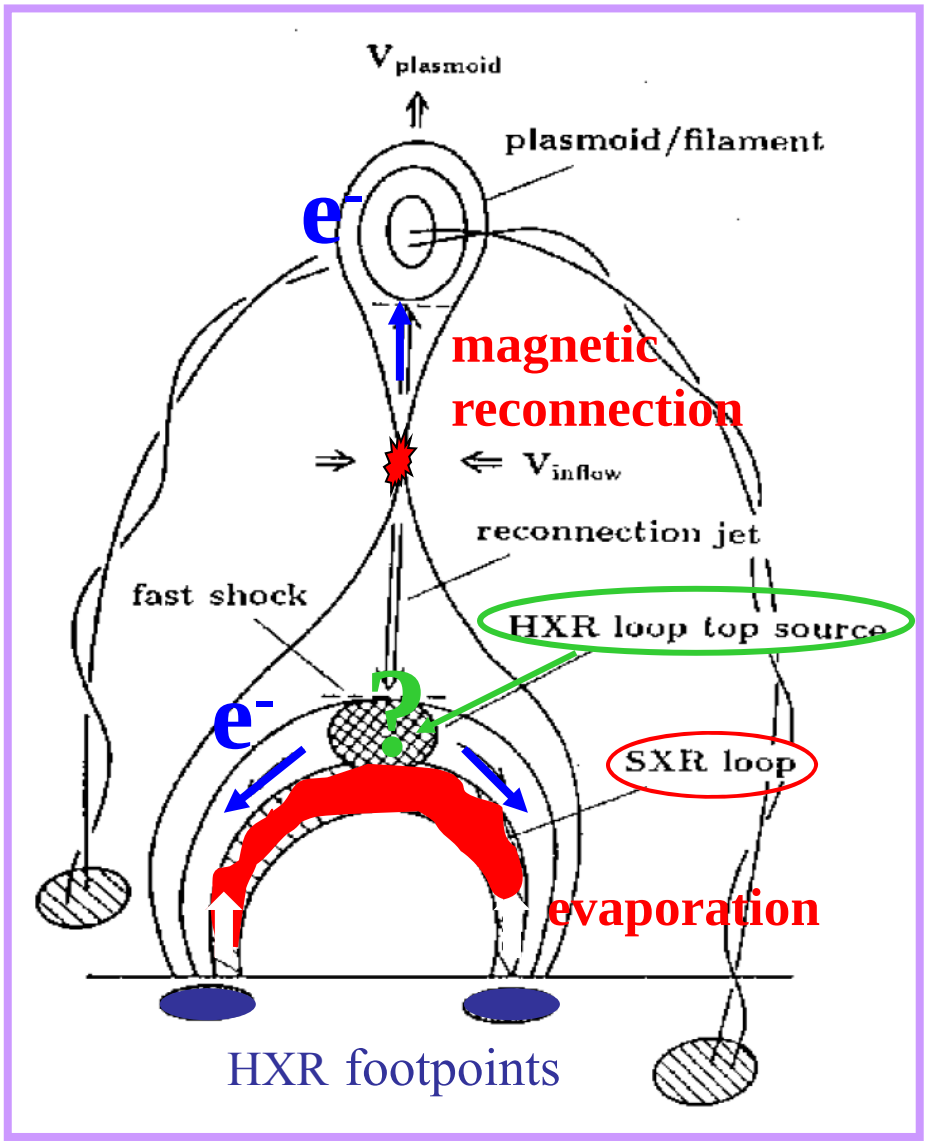
Nobeyama Radioheliograph Event List

See **Note** below.

2014

EventID	Date	Peak (UT)	Durat-n(sec)	Cor (x 1.e-4)	Bright-ness(K)	F17G (SFU)	F34G (SFU)	Area Ratio	Posi-tion	X (")	Y (")	#imp-ulse	GOES	NOAA Keyword	RHESSI Energy(keV)
20141220 0021	2014-12-20	00:21:48	7318	496	4.7e+07	1561	757	9.5	S18W28	447	-300	11		Flare	---
20141217 0432	2014-12-17	04:32:08	8808	225	8.0e+06	236	52	4.5	S17E09	-152	-285	0		Flare	---
20141214 0128	2014-12-14	01:28:14	991	268	3.4e+06	48	21	2.0	S09E69	-913	-157	0		Flare	---
20141213 0516	2014-12-13	05:16:21	3611	1101	1.2e+07	228	113	2.6	S09E78	-953	-162	0		Flare	---
20141208 0038	2014-12-08	00:38:11	1998	500	6.0e+06	97	27	2.1	S20W72	879	-349	0		Flare	---
20141122 0601	2014-11-22	06:01:07	1760	246	3.4e+06	107	37	2.4	S13W24	393	-265	0		Flare	---
20141122 0057	2014-11-22	00:57:24	797	165	2.2e+06	34	3	2.1	S14W23	383	-275	0		Flare	---
20141113 0601	2014-11-13	06:01:18	1816	256	2.9e+06	72	22	2.0	S10E75	-933	-187	0		Flare	3-6
20141110 0221	2014-11-10	02:21:47	801	740	2.0e+07	238	88	2.8	N14E03	-64	187	0		Flare	12-25
20141030 0128	2014-10-30	01:28:46	1392	248	6.8e+06	85	3	0.9	S14W78	928	-255	0		Flare	25-50
20141030 0035	2014-10-30	00:35:31	525	1075	1.7e+07	220	1204	0.6	S13W76	923	-250	0		Flare	100-300
20141029 2301	2014-10-29	23:01:47	303	318	3.0e+06	50	1	0.6	S13W74	913	-250	0		Flare	12-25
20141029 2249	2014-10-29	22:49:22	41	1262	1.1e+07	169	130	2.1	S18W73	889	-324	0		Flare	---
20141029 0528	2014-10-29	05:28:42	7362	179	1.7e+06	26	18	0.1	S13W66	874	-255	0		Flare	25-50
20141029 0339	2014-10-29	03:39:03	1087	1153	4.8e+07	903	614	2.1	S13W68	884	-255	0		Flare	---
20141029 0313	2014-10-29	03:13:00	293	239	5.1e+06	54	5	0.4	S13W66	874	-260	0		Flare	12-25
20141029 0249	2014-10-29	02:49:00	91	173	4.5e+06	25	3	0.4	S13W66	869	-260	0		Flare	12-25
20141029 0113	2014-10-29	01:13:49	65	400	7.2e+06	59	19	0.8	S17W65	850	-329	0		Flare	25-50
20141029 0003	2014-10-29	00:03:39	3020	155	2.8e+06	29	0	0.2	S13W64	859	-265	0		Flare	6-12
20141028 2252	2014-10-28	22:52:18	41	170	2.1e+06	8	1	0.0	S14W64	855	-270	0		Flare	---
20141028 0557	2014-10-28	05:57:03	544	344	4.3e+06	71	87	1.0	S14W56	786	-295	0		Flare	6-12
20141028 0327	2014-10-28	03:27:17	1682	331	1.7e+07	216	92	-0.0	S14W55	776	-285	0		Flare	25-50
20141028 0217	2014-10-28	02:17:29	1389	199	6.3e+06	52	31	0.7	S15W54	766	-300	0		Flare	25-50

“Standard flare model”



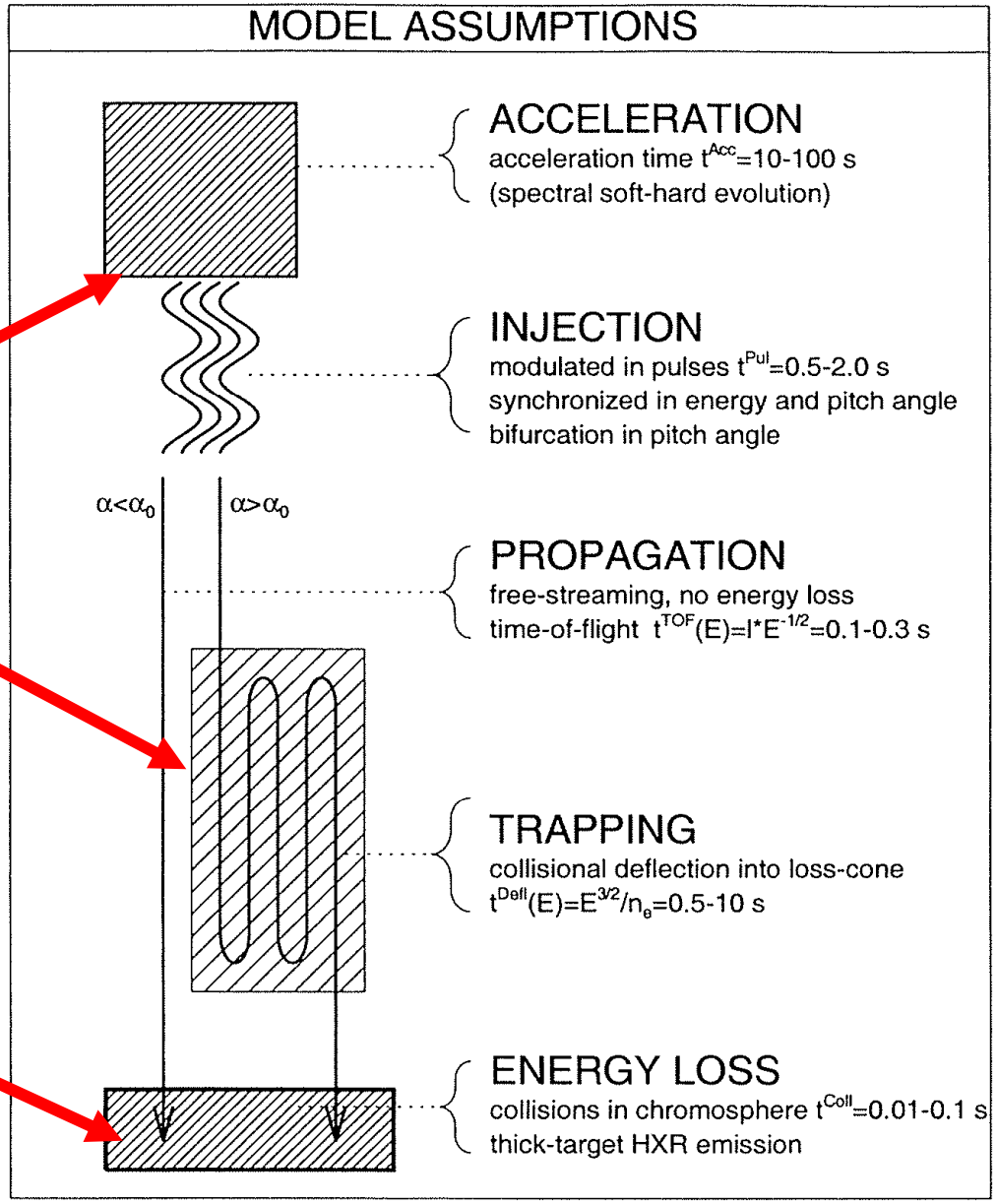
1) Release of magnetic energy
2) particle are accelerated (not understood)
3) Acc. electrons produce HXR emission (mostly footpoints)
4) Above loop top HXR source not understood
5) collisional losses of acc. electrons heat plasma
6) “evaporation” fills loop

from Shibata

Observations

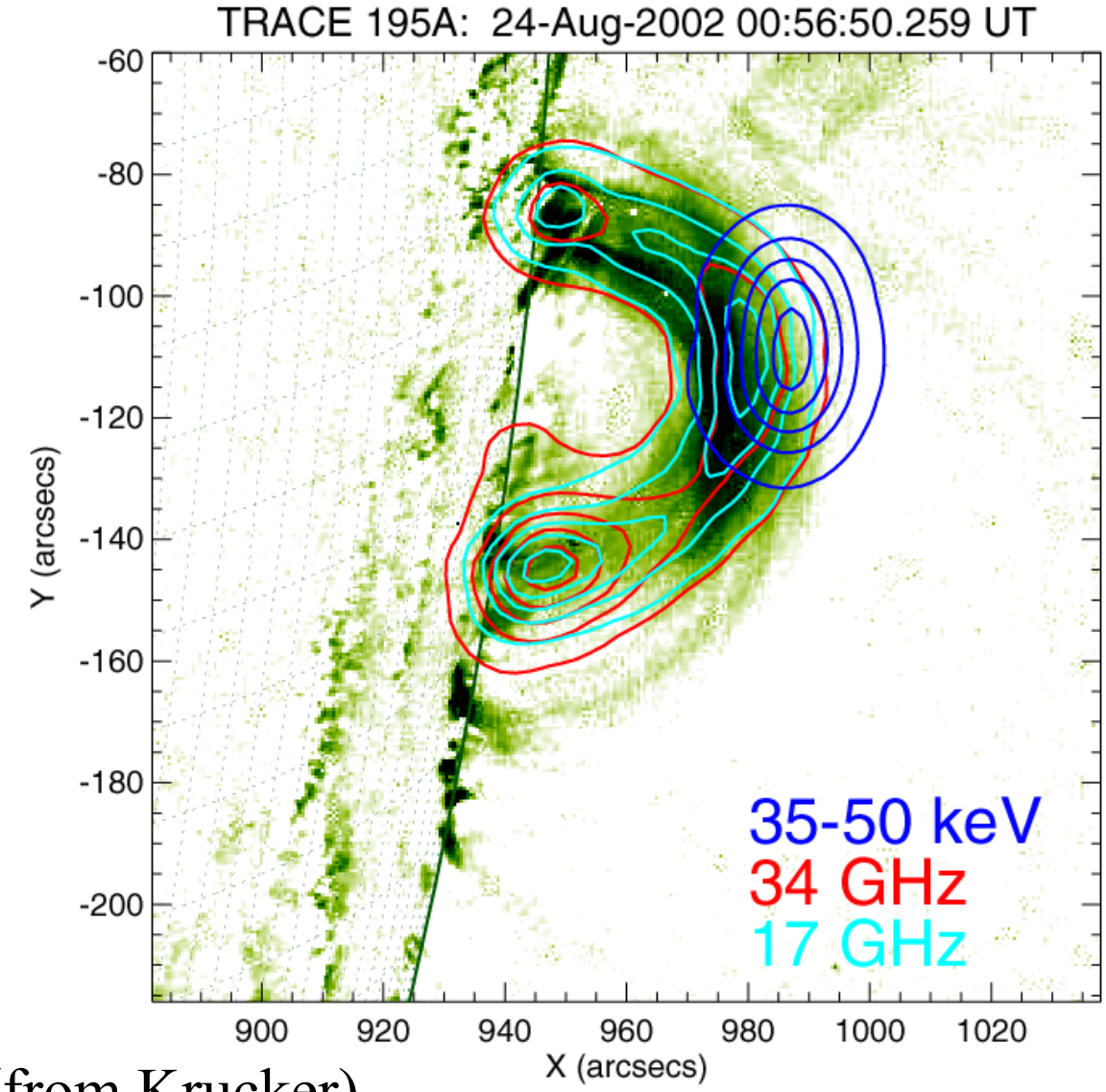
Coronal source
(HXR and radio)
acceleration site?
loss process

Footpoint sources
(HXR, WL, H-alpha)
direct prec.
→ high time and
spatial res.



Aschwanden, 2002

Event study using RHESSI and NoRH data



(from Krucker)

Green color:
EUV image (TRACE)
thermal plasma

Blue contours:
HXR (RHESSI)
~ 100 keV electrons

Red and light-blue contours: microwave (Nobeyama Radio Heliograph)
~ MeV electrons

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Nobeyama Radioheliograph Limb Events

2014

Event ID	Date	Start (UT)	Peak (UT)	End (UT)	X (arcsec)	Y (arcsec)	Index (Pixel)
PE20140726_2320	26-Jul-14	23:20:02	23:20:02	00:20:02	406	1022	440
PE20140722_2340	22-Jul-14	22:50:02	23:40:02	00:00:02	671	826	407
PE20140710_0620	10-Jul-14	05:50:02	06:20:02	06:20:02	1073	-227	716
PE20140704_0200	04-Jul-14	02:00:03	02:00:03	02:40:03	-822	720	411
PE20140702_0120	02-Jul-14	01:10:00	01:20:00	01:30:00	-983	64	497
PE20140609_0010	09-Jun-14	00:00:01	00:10:01	00:40:01	-1145	-266	2553
PE20140531_0310	31-May-14	02:50:01	03:10:01	03:20:01	802	-676	541
PE20140523_0620	23-May-14	06:00:00	06:20:00	06:20:00	-795	-689	537
PE20140517_0540	17-May-14	05:40:01	05:40:01	06:10:01	-1030	359	403
PE20140511_0020	11-May-14	00:00:01	00:20:01	00:30:01	-564	-852	847
PE20140509_0250	09-May-14	02:30:00	02:50:00	03:10:00	1108	-338	2339
PE20140428_0130	28-Apr-14	01:30:03	01:30:03	02:10:03	1198	-320	1224
PE20140421_0340	21-Apr-14	03:30:02	03:40:02	04:10:02	1017	424	1199
PE20140421_0100	21-Apr-14	00:40:02	01:00:02	01:20:02	947	-649	867
PE20140410_0040	10-Apr-14	00:40:00	00:40:00	01:00:00	-678	-785	571
PE20140406_0200	06-Apr-14	01:40:02	02:00:02	02:20:02	-941	-544	977
PE20140405_0000	04-Apr-14	23:40:02	00:00:02	00:00:02	-933	-594	2967
PE20140326_0520	26-Mar-14	05:10:03	05:20:03	05:40:03	-641	-818	682
PE20140224_2330	24-Feb-14	23:20:01	23:30:01	23:40:01	737	-759	628
PE20140219_0600	19-Feb-14	06:00:01	06:00:01	06:20:01	75	-1015	498
PE20140217_0530	17-Feb-14	04:40:02	05:30:02	05:40:02	1120	-203	2094
PE20140216_0110	16-Feb-14	01:10:03	01:10:03	01:30:03	1029	1012	1808
PE20140212_0620	12-Feb-14	06:00:03	06:20:03	06:20:03	769	-660	676
PE20140117_2300	17-Jan-14	22:50:01	23:00:01	23:10:01	-432	-914	452
PE20140116_2250	16-Jan-14	22:50:02	22:50:02	23:10:02	-527	-861	664
PE20140106_0610	06-Jan-14	06:00:03	06:10:03	06:20:03	-975	592	1695
PE20140103_0340	03-Jan-14	03:30:00	03:40:00	04:00:00	-1142	364	1098

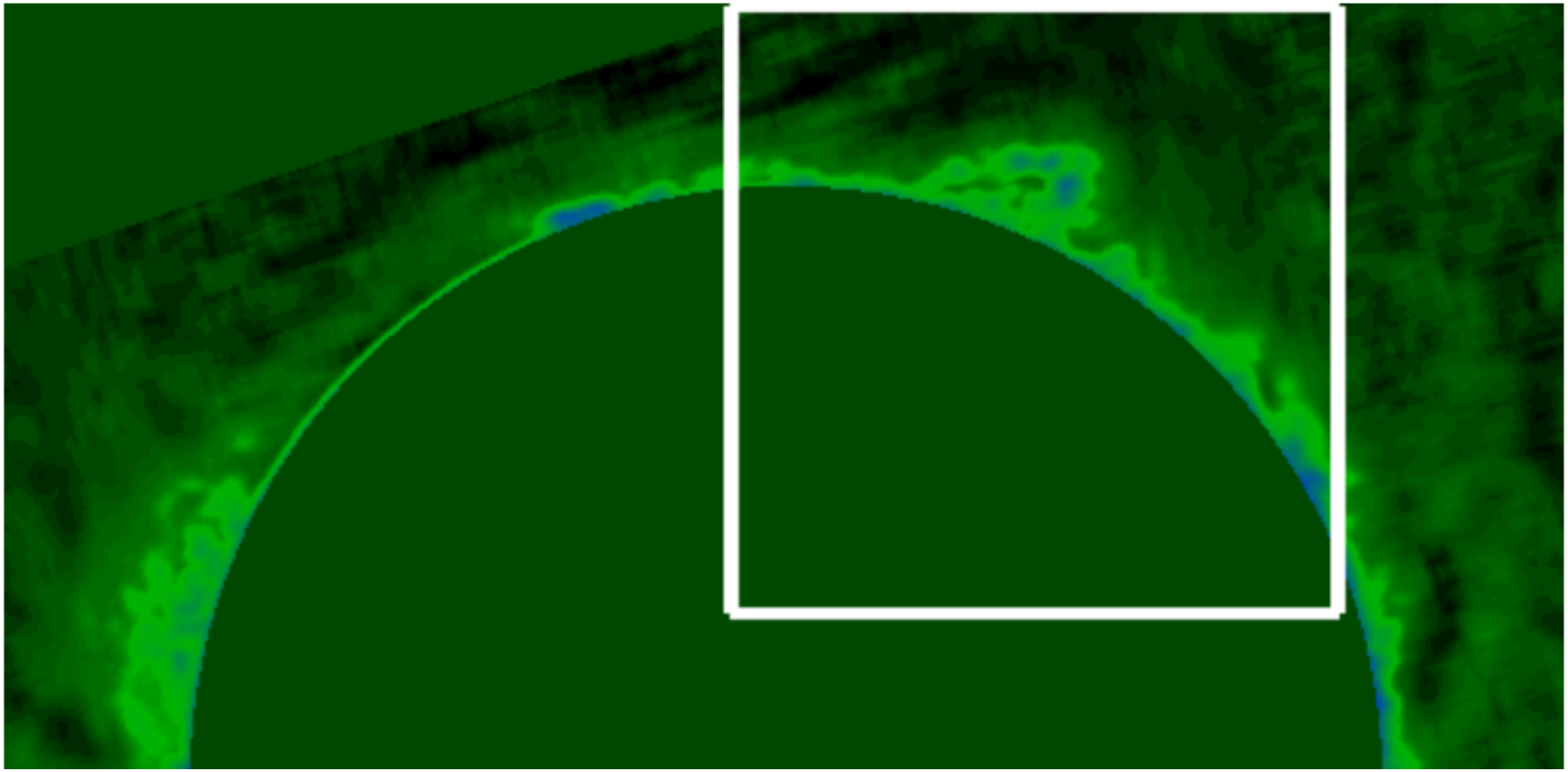
http://solar.nro.nao.ac.jp/norh/html/prominence/

The Resulsts of Automatic Detection of Limb Events using Radio Heliograms (17 GHz)

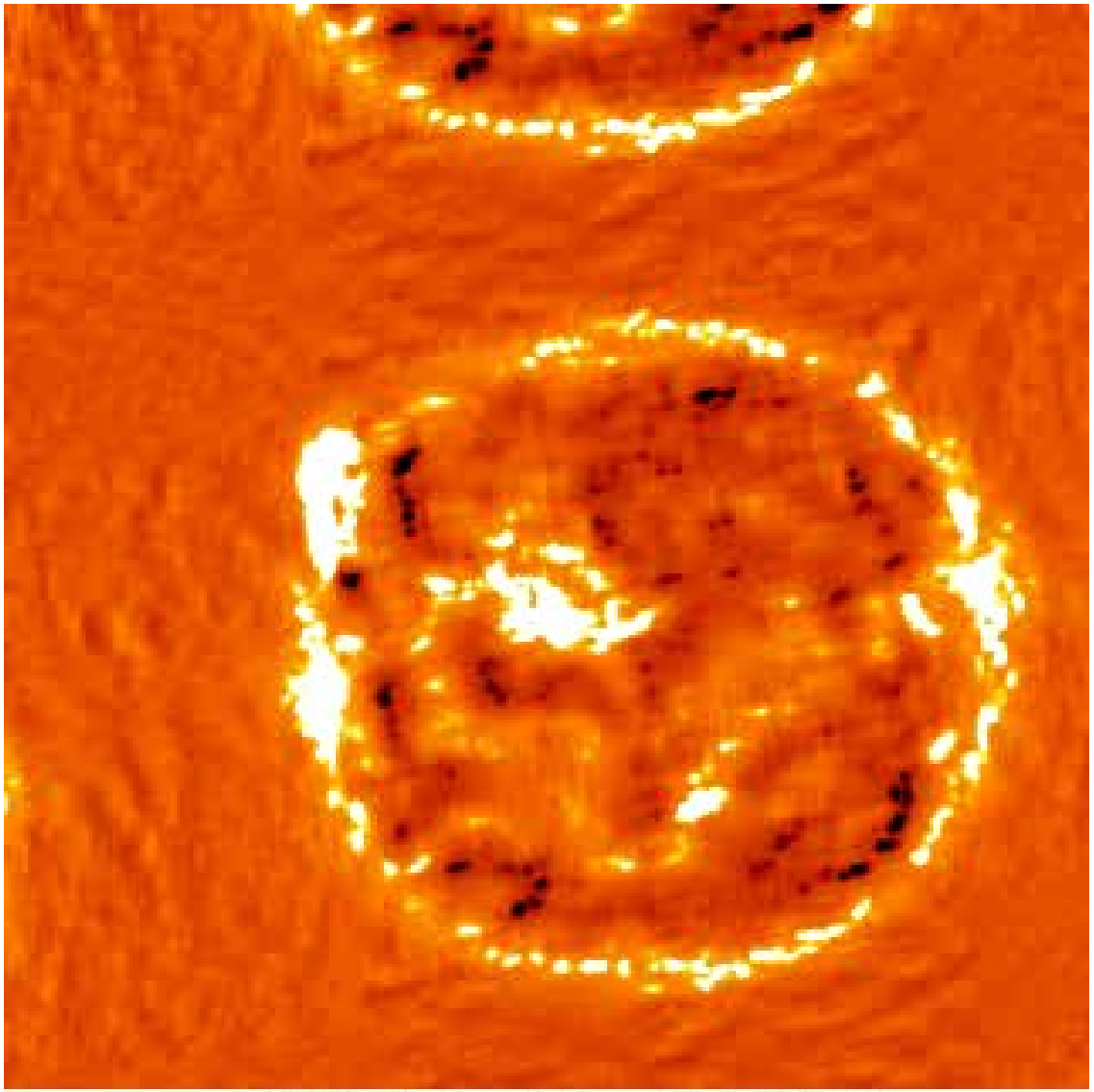
EVENT_ID : PE20140726_2320

Event_ID	Date	Start (UT)	Peak (UT)	END (UT)	X (arcsec)	Y (arcsec)	Index
PE20140726_2320	26-Jul-14	23:20:02	23:20:02	00:20:02	406	1022	440

Radio-Coronagraph



Prominence eruption observed with NoRH



Summary

NoRH is a unique instrument even in the world which provides fundamental and high-quality microwave images in this frequency range. There is no doubt that NoRH is one of the powerful tool for Space Weather and also Space Climate research.

From April 2015, an international consortium, ICCON, will begin the operation of NoRH instead of NAOJ.
We need more contribution for the stable operation of NoRH and for producing more scientific outputs.

Any contribution is welcome for the continued operation.

ICCON: International Consortium for the Continued Operation of Nobeyama Radioheliograph
N. Gopalswamy (NASA), Y. Yan (NAOC), K. S. Cho (KASI), M. Ishii (NICT), K. Shibasaki, and S. Masuda (STEL, Nagoya U.)