Initial Results of Mingantu Ultrawide Spectral Radioheliograph --- the Chinese Spectral Radioheliograph

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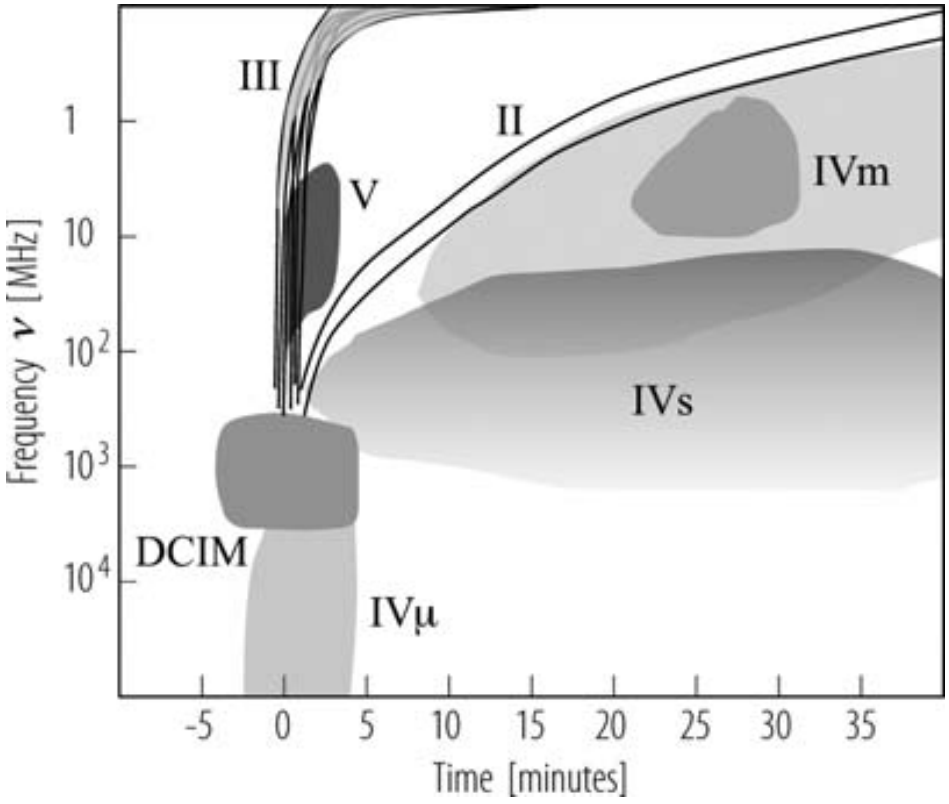
National Major Scientific Research Facility R&D Program （ZDYZ2009-3）

Outline

- Radio imaging-spectroscopy
- Construction of CSRH
- Initial Observations
- Summary

Scientific Motivations:

- **Radio bursts are prompt indicators of the various solar activities including flares and CMEs, etc.**



（Benz 2009）

Scientific Motivations:

- **The available radio facilities are either with high time and spectral resolution but without spatial resolution, or with high time and spatial resolution but at only one or a few frequencies.**
- **It is needed to have high spectral resolution over wide band as well** (Gary 2013).
- **Imaging spectroscopy over cm-λ & dm-λ is important for addressing the problems of primary energy release, particle acceleration, and transportation processes, and the coronal magnetic fields** (Bastian, et al., ARAA, 1998; Gary & Keller 2004; Aschwanden 2004; Pick & Vilmer 2008, Klein et al. 2008; Tomczyk et al. 2013).
- **MWA, LOFAR, etc., at metric and lower frequencies, and ALMA at mm, THz.**

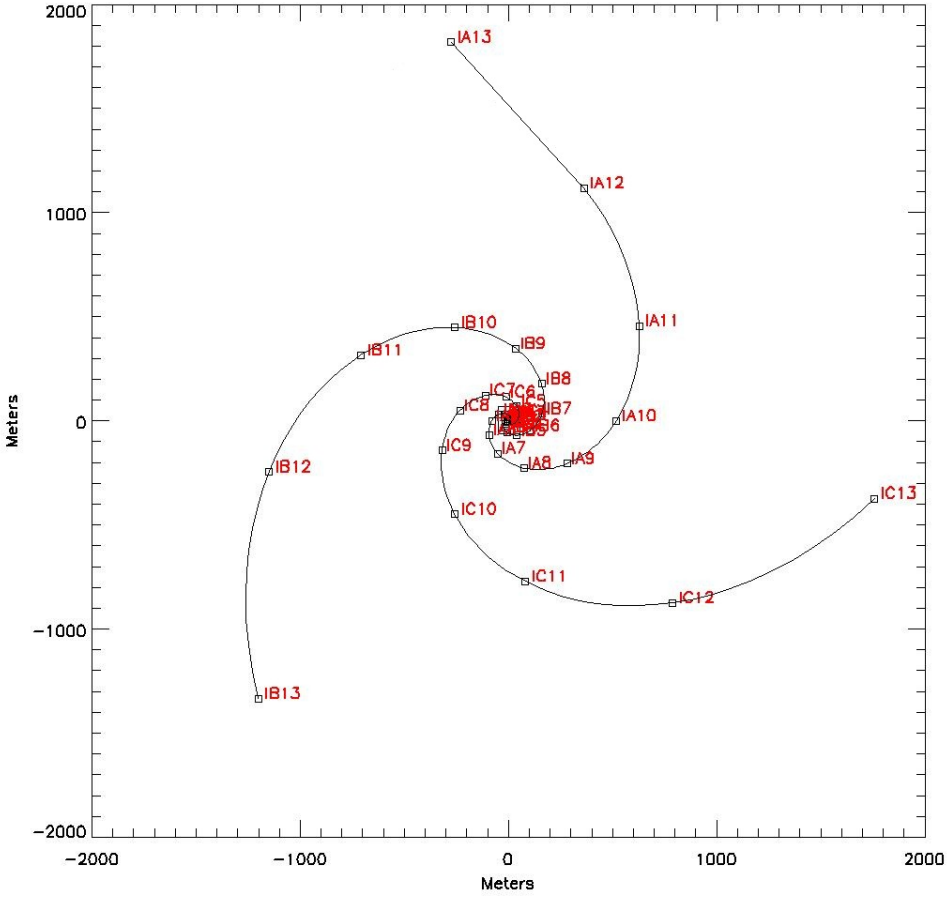
→ **require a new instrument: capable of true imaging spectroscopy, with high temporal, spatial, and spectral resolution ---- CSRH or FASR**(Hudson & Vilmer 2007, Pick & Vilmer 2008, Klein et al 2008, Tomczyk, et al 2013).

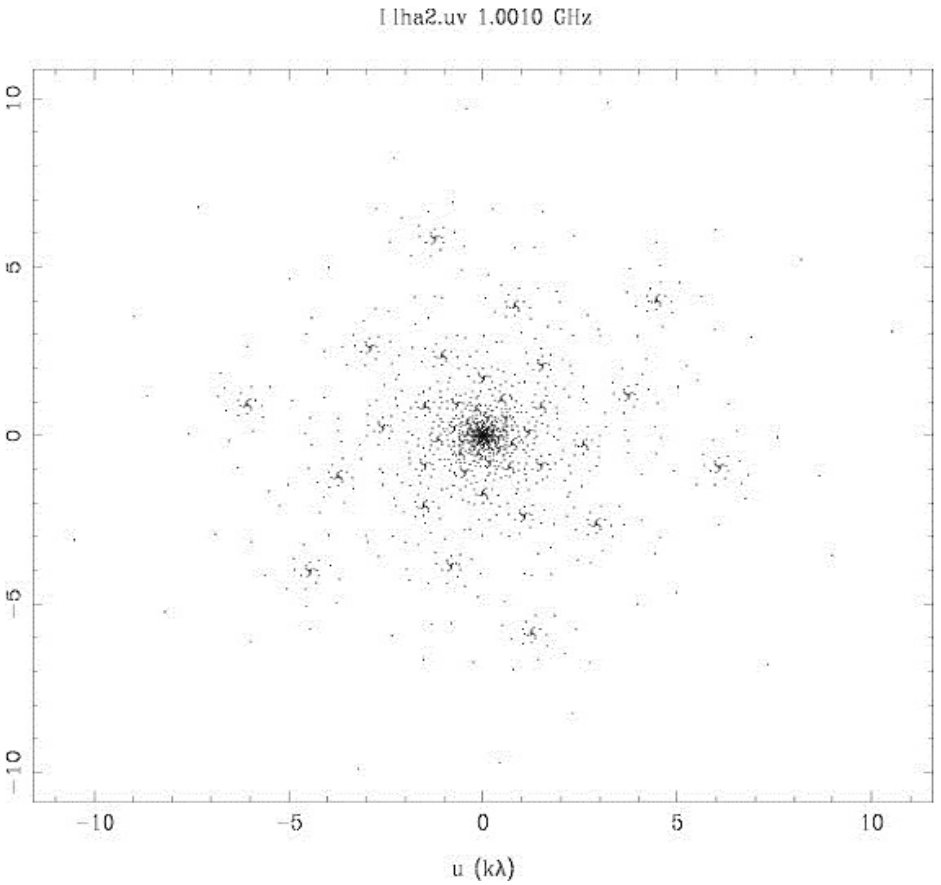
CSRH Specifications

(Yan et al. 2009 Earth, Moon Planet; 2013 IAUS 294; Wang et al. 2013 PASJ)

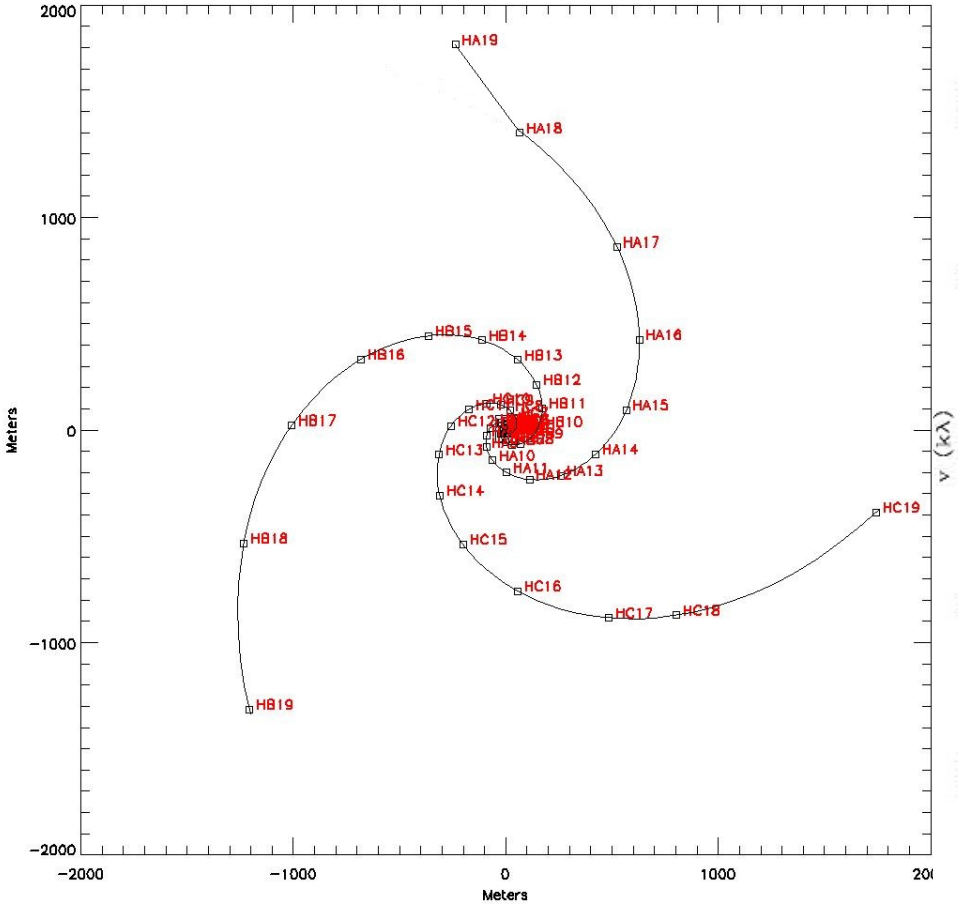
Range	**~0.4–15 GHz （λ：~75 –2 cm）**
Frequency Res.	**64 chan (I: 0.4-2 GHz)**
	>32 (520) chan (II: 2-15 GHz)
Spatial Res.	**1.3”– 50”**
Temporal Res.	**I: ~ 25 ms**
	II: ~200 ms
Dynamic Range	**25 db （snapshot）**
Polarizations	**Dual circular L, R**
Array	**I: 40×4.5m**
	II: 60×2m parabolic antennas
Lmax	**3 km**
Field of view	**0.6°– 7°**

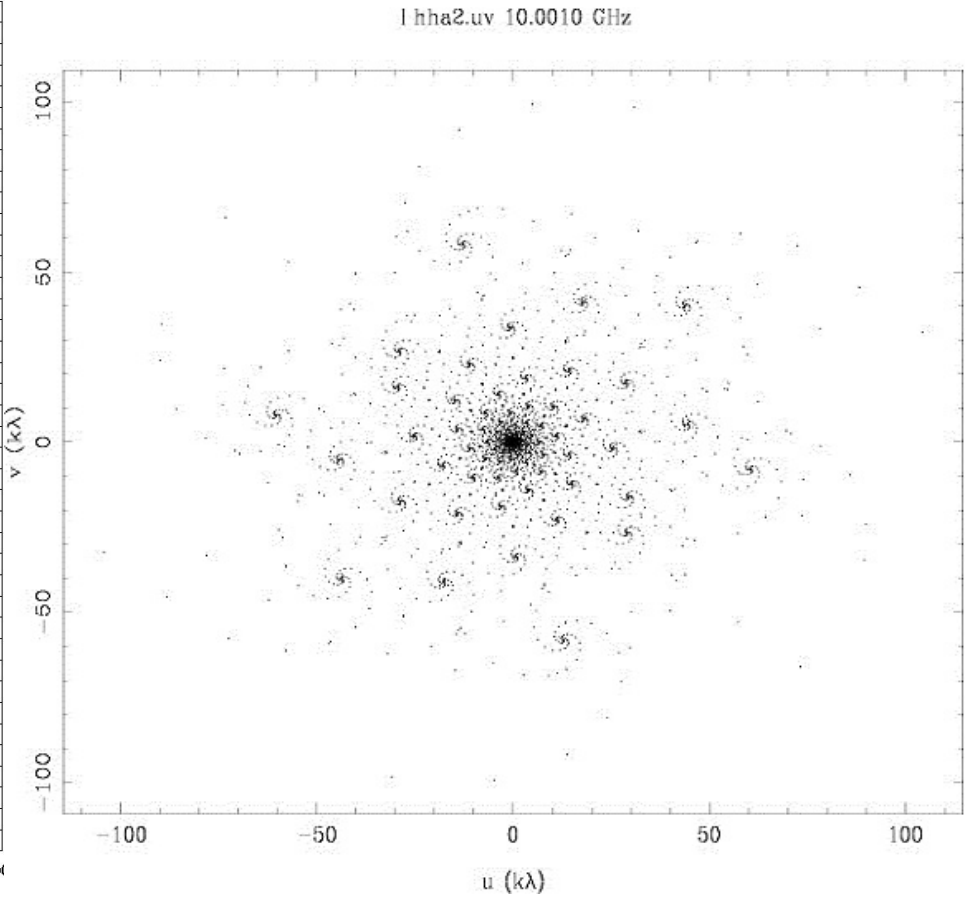
CSRH-I 40-antenna Array & UV Coverage at 1 GHz





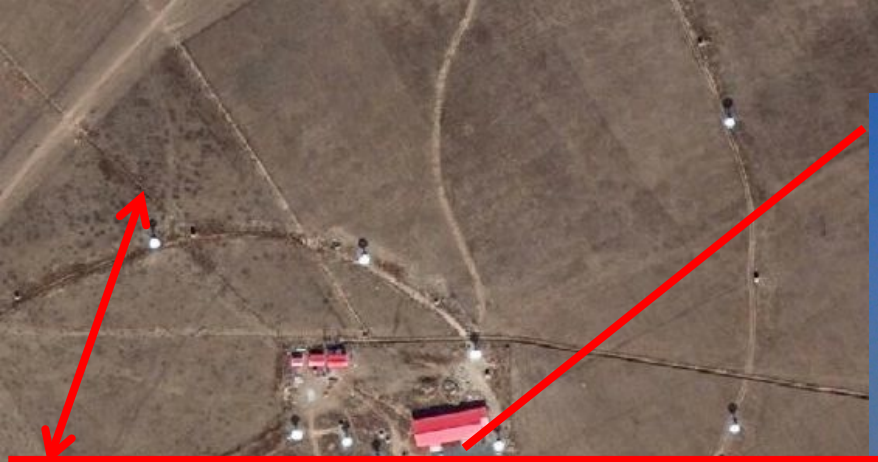
CSRH-II 60-antenna Array & UV Coverage at 10 GHz



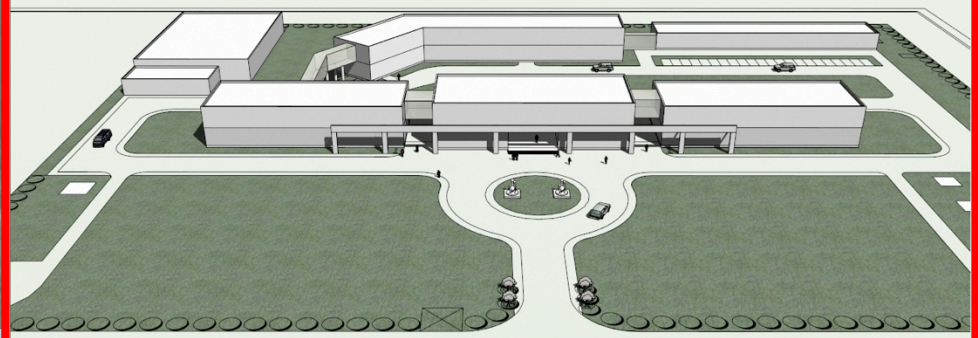


Site and Construction of CSRH

Array Construction

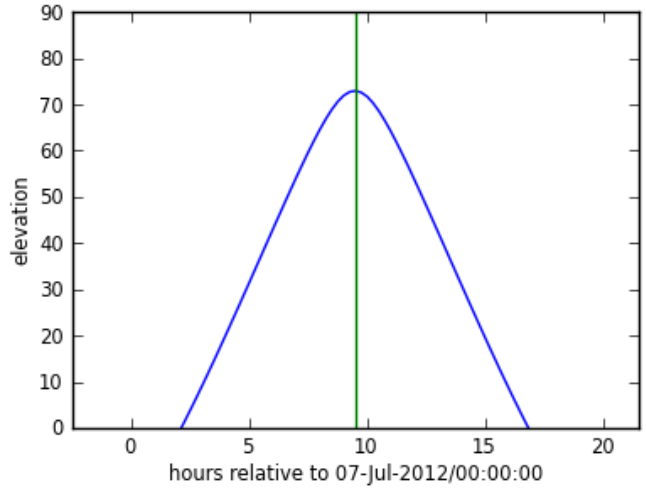


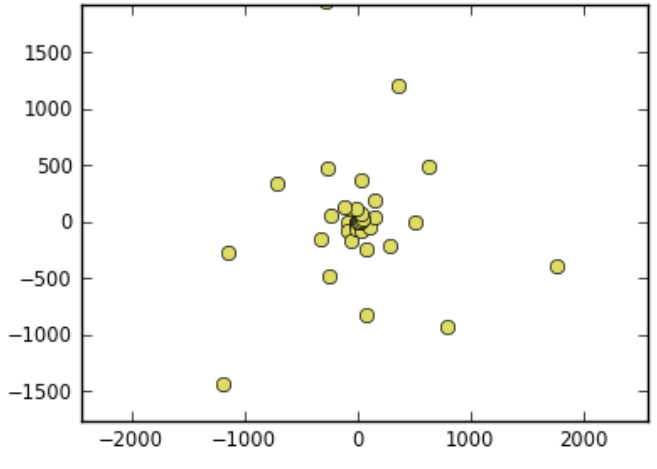
Ming'antu Observing Station Plan

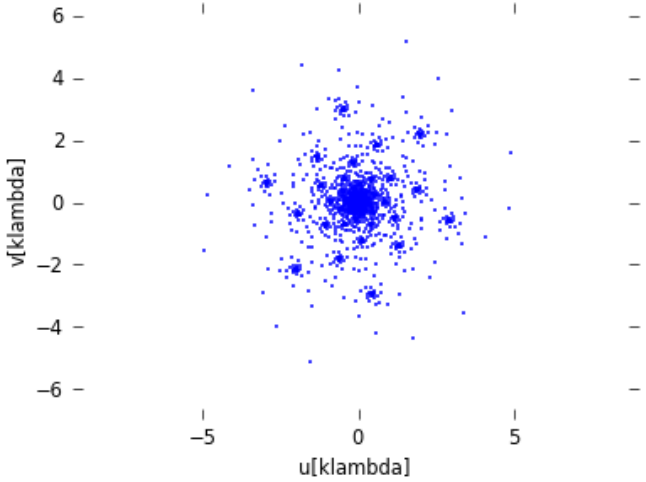


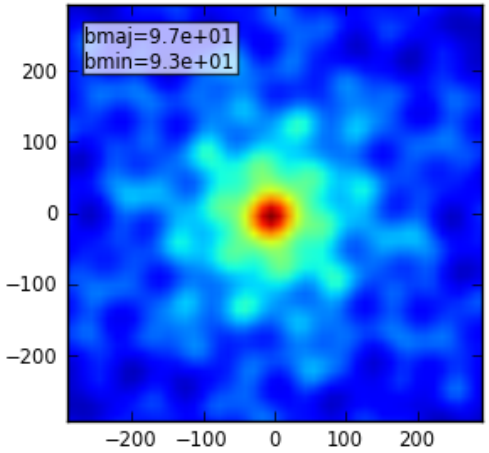
Approved and start construction in 2014

CSRH-I in CASA



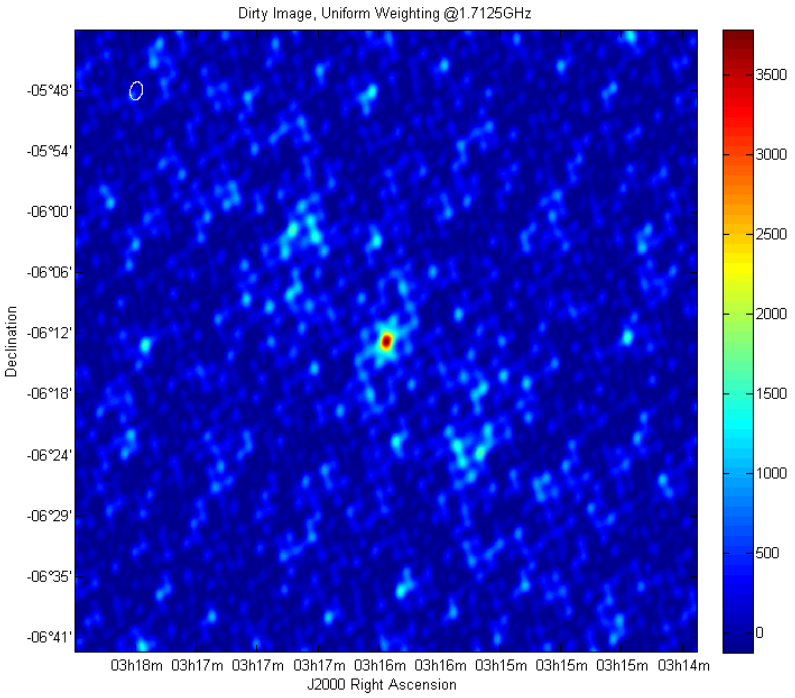


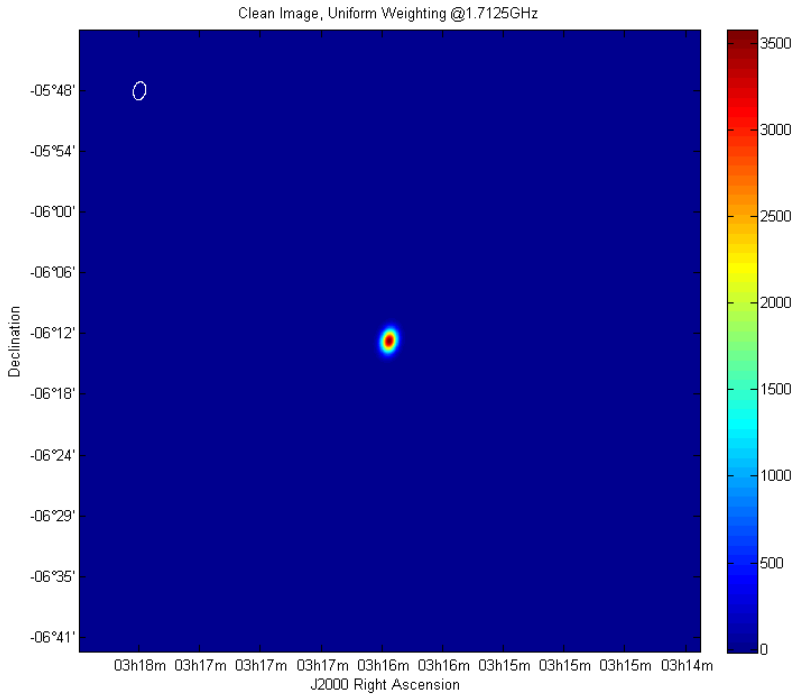




FY-2 satellite 1.7 GHz (CSRH Beam at 1.7GHz)

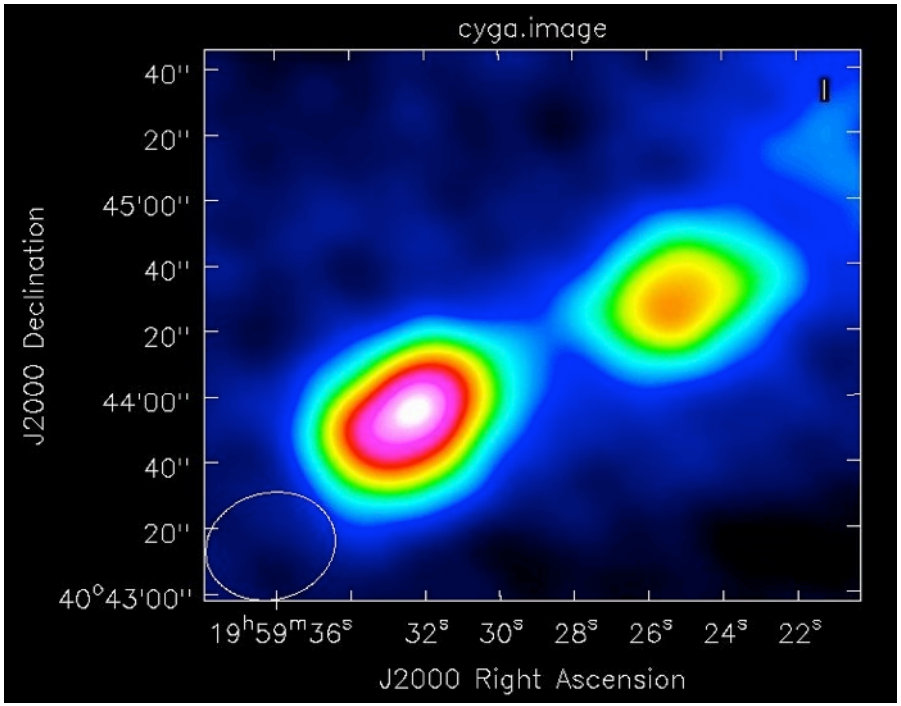
Dynamic Range in cleaned map： about 30dB

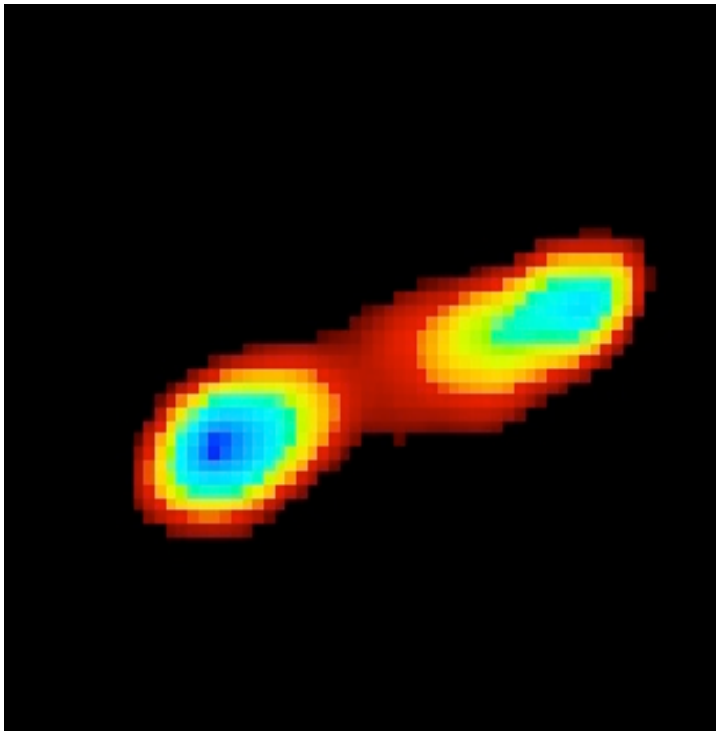




Dirty Beam Cleaned Beam

Test observations with CSRH-I



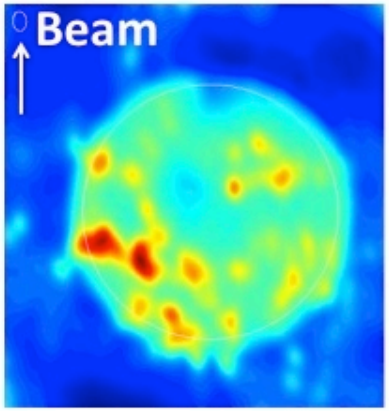


Test of Cyg A observed at 1.7 GHz on 5 Jun 2013 at 5:30 UT with 1s integral time.

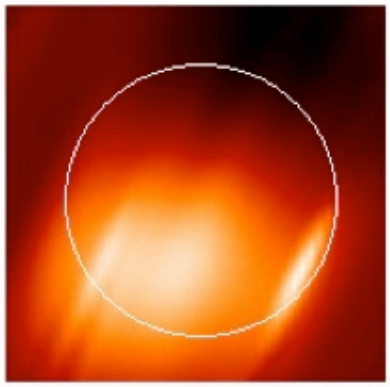
GMRT 610 MHz Image （not scaled, GMRT web）

(Signals 2 orders weaker than that of the Sun!)

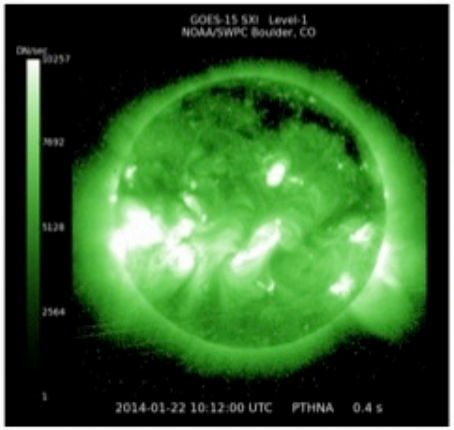
Preliminary result with 30 ms integral time



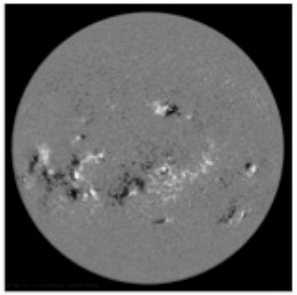
(a) CSRH-I 1.7 GHz 05:15:00UT



(b) NRH 432 MHz 08:46:02UT

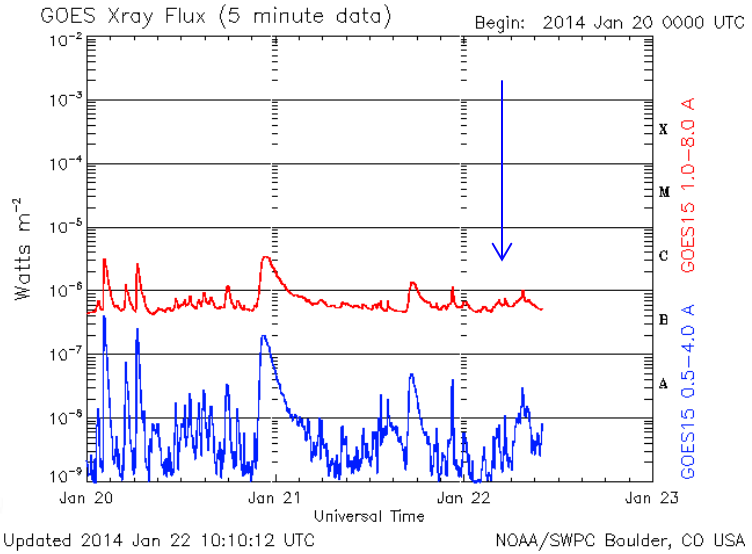


(c) GOES SXR 10:12:00UT

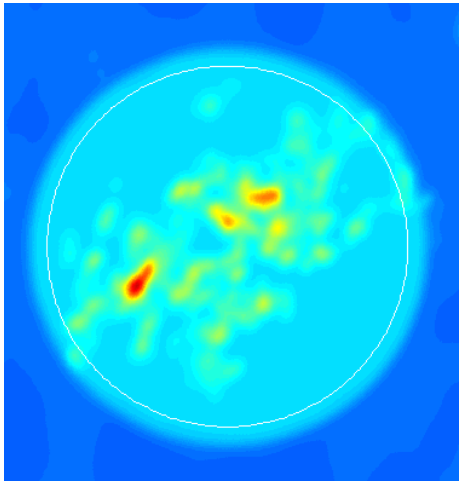


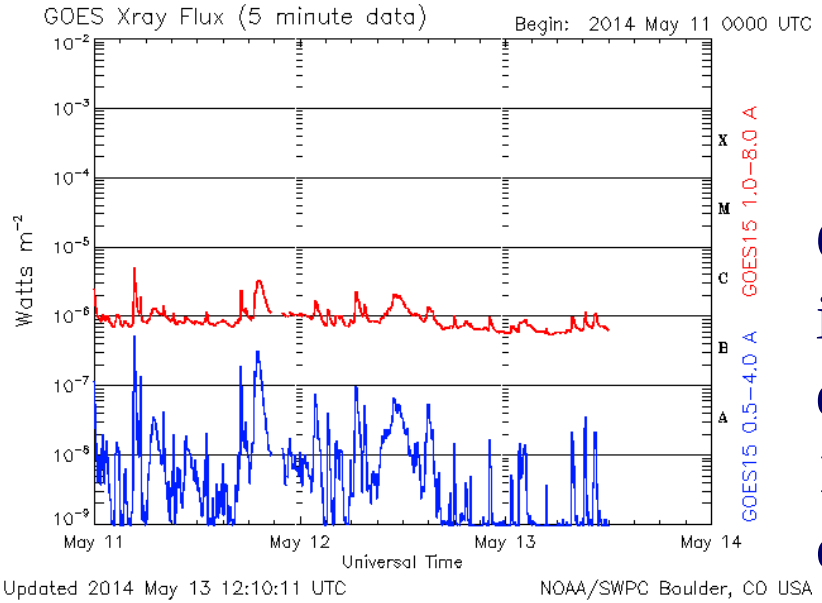
(d) HMI/SDO Bz 05:15:00UT

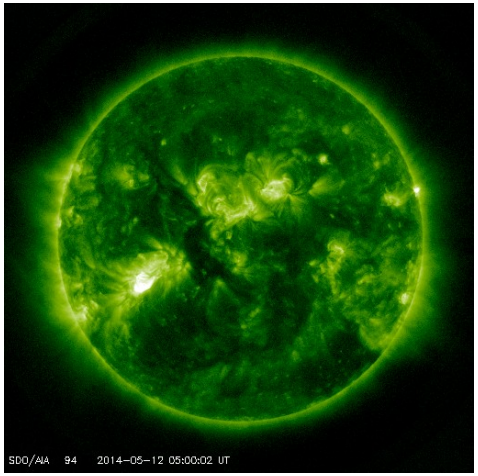
CSRH-I image of the quiet Sun at 1.7GHz and comparisons with other observations on 22 Jan 2014

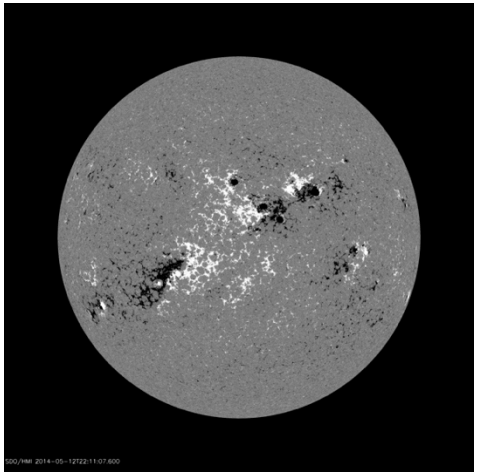


Preliminary result with 30 ms integral time



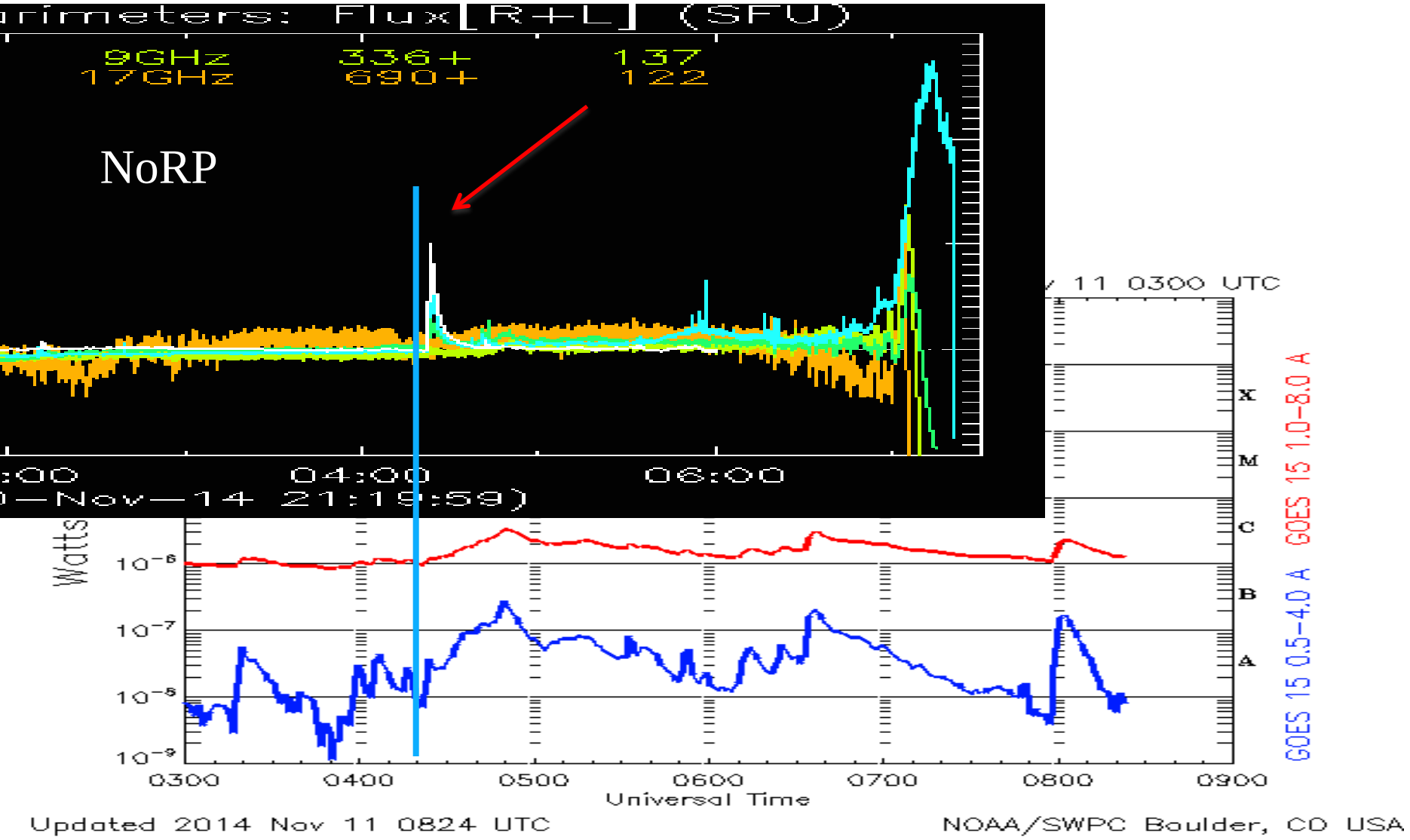




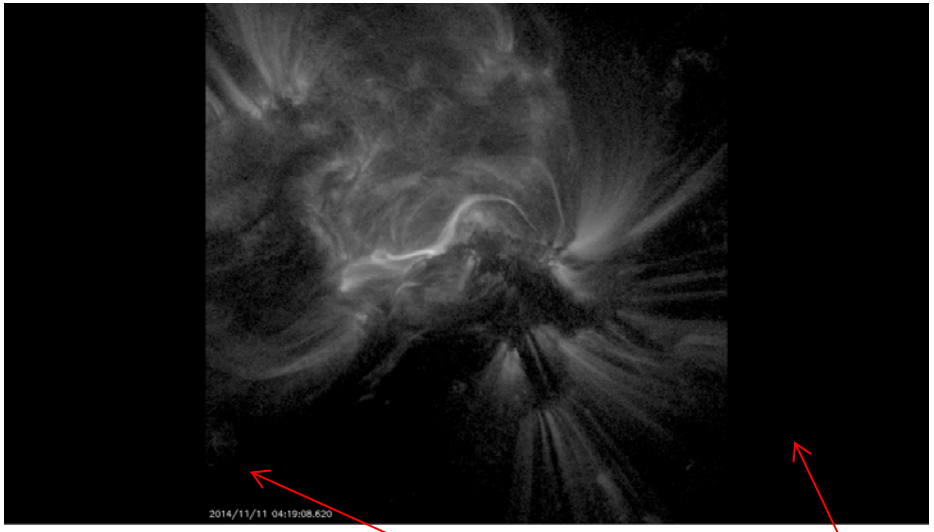


CSRH-I image of the quiet Sun at 1.7GHz and comparisons with SDO EUV 171A image and magnetogram on 12 May 2014 at 05:15UT

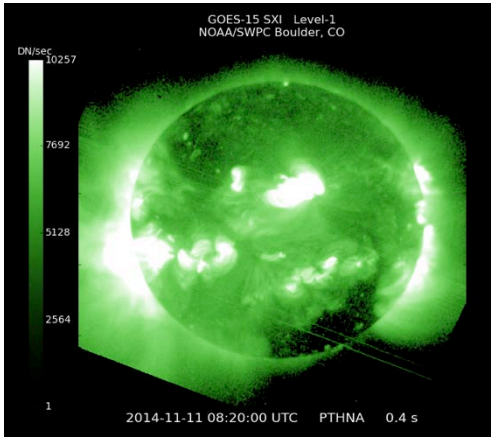
A solar flare and radio bursts on 11 Nov, 2014



The solar flare starting at 04:22 on 11 Nov 2014

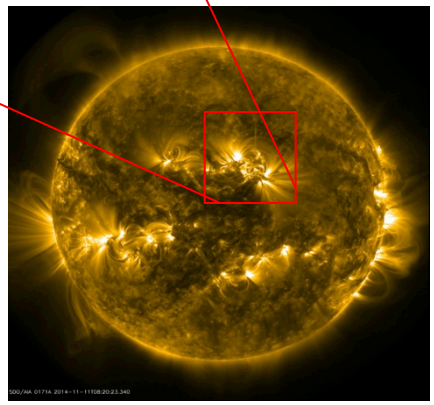


AIA131 movie

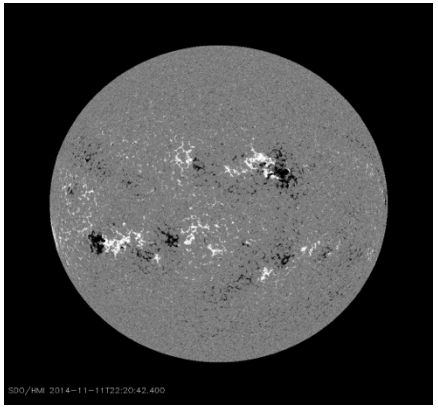


GOES SXR

SGD associates the radio burst with the disk center flare event



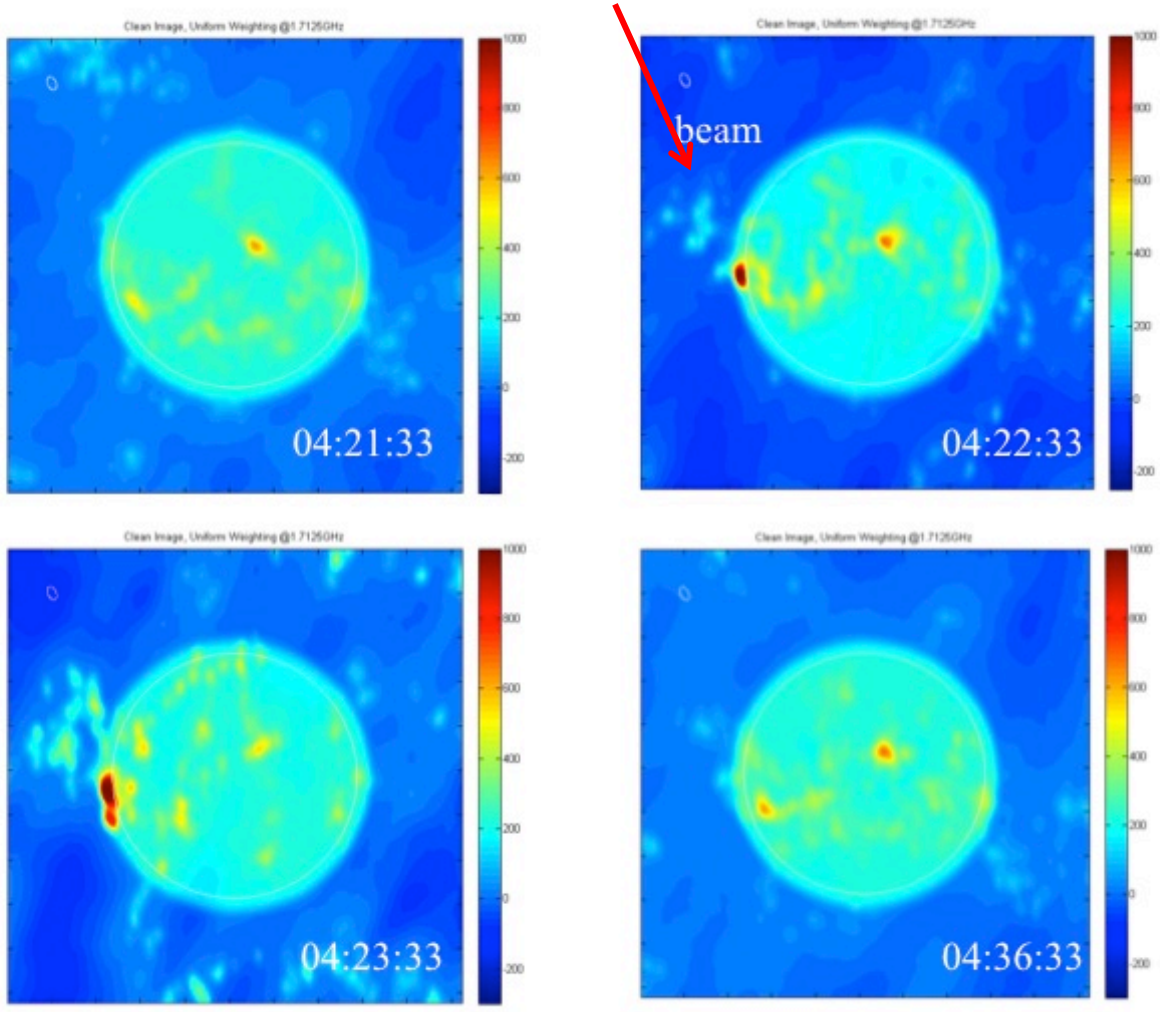
AIA 171

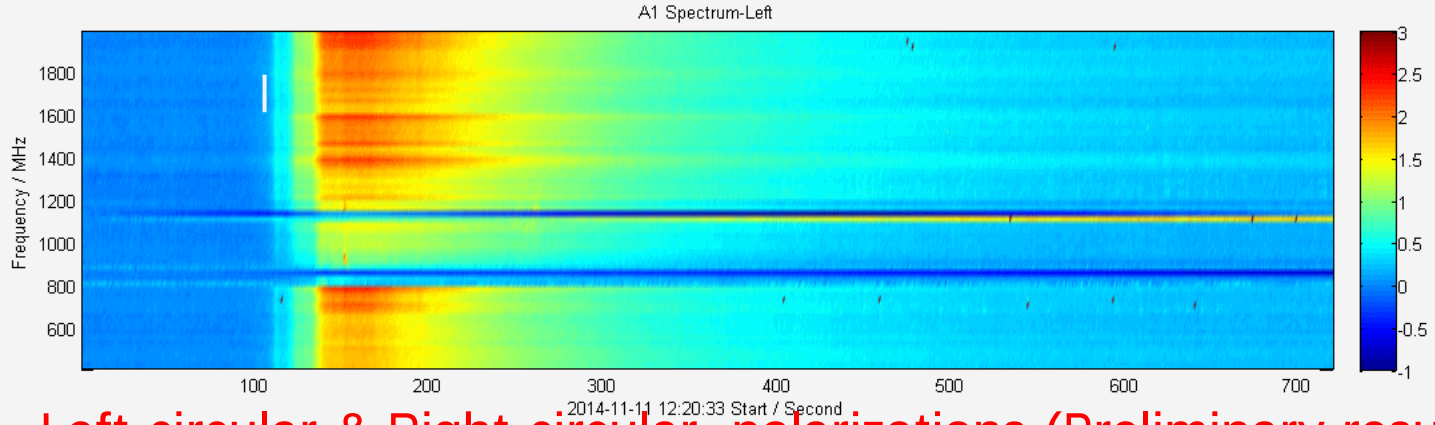


HMI / SDO

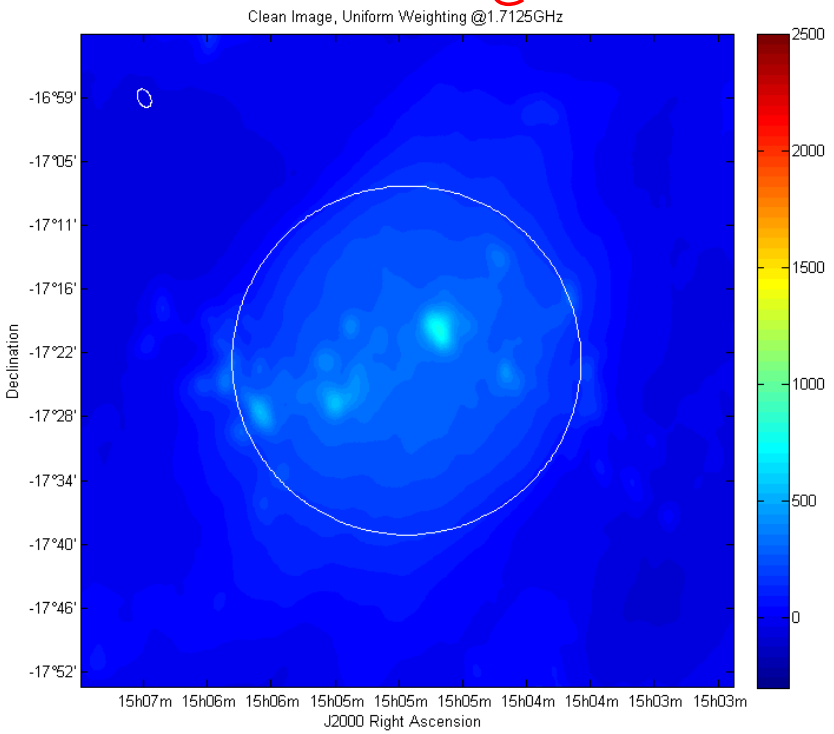
200		B0422	0449	0606	LEA	1	FLA	N16W11	1F	ERU	2205
200		0422	0422	0423	LEA	G	RBR	245	730		2205
200		0423	0423	0423	LEA	G	RBR	1415	100		2205
200	+	0423	////	0424	CUL	C	RSP	018-430	III/1		2205

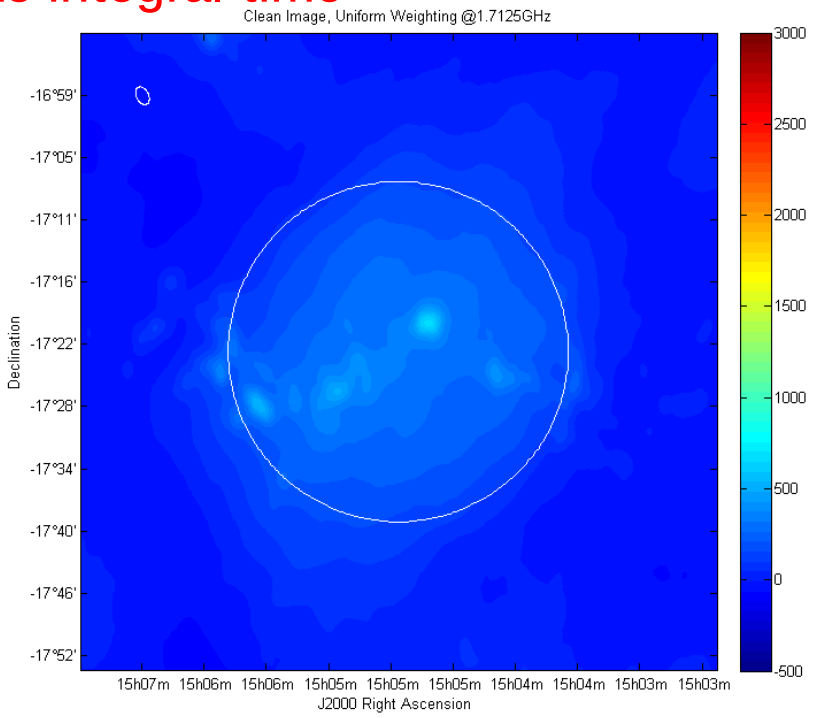
The source of radio bursts starting at 04:22:20UT located at east limb (Preliminary results)





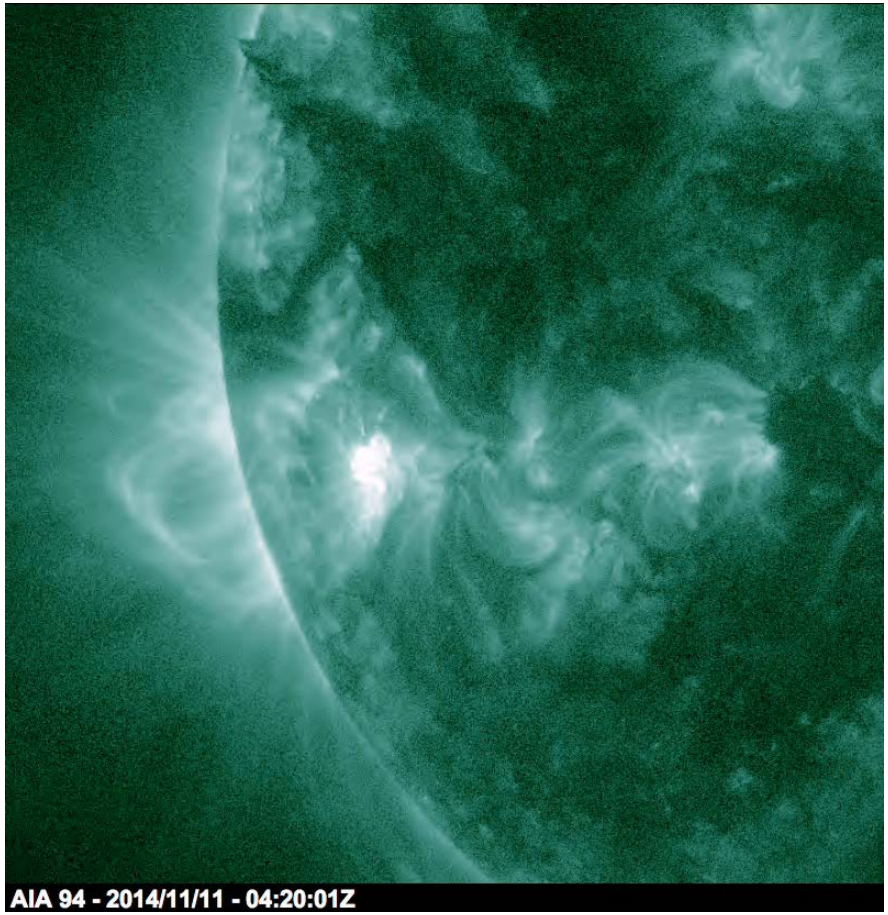
- Left-circular & Right-circular polarizations (Preliminary results)
- 04:23-04:24UT@5s interval & 3ms integral time

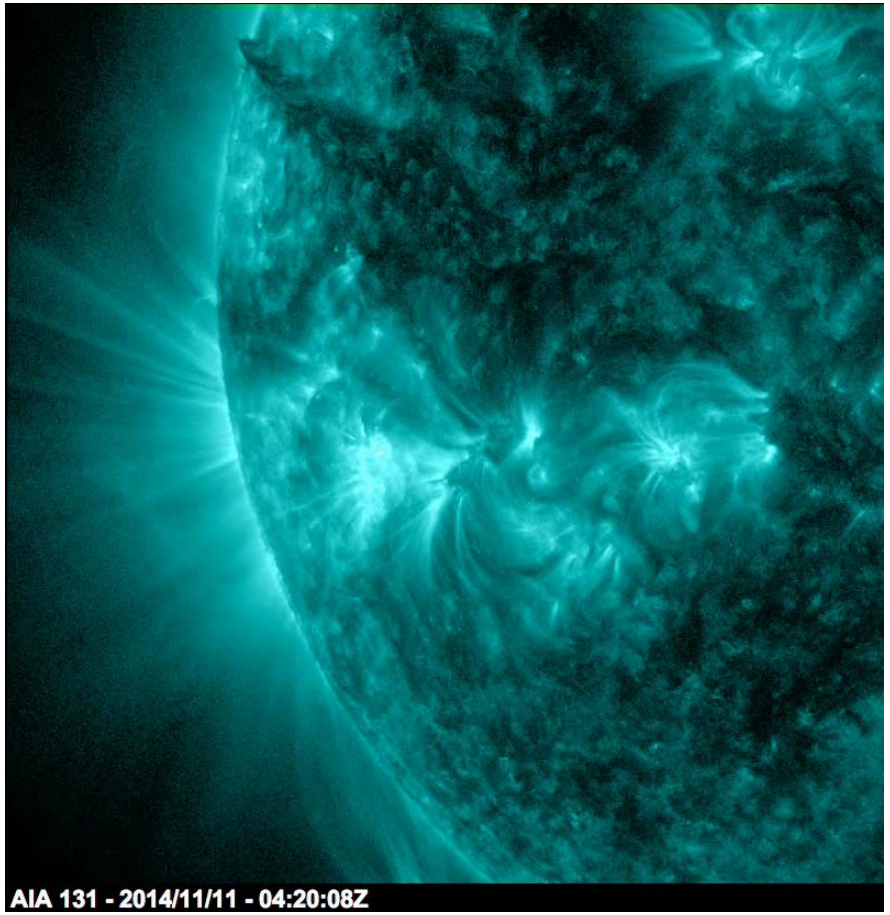




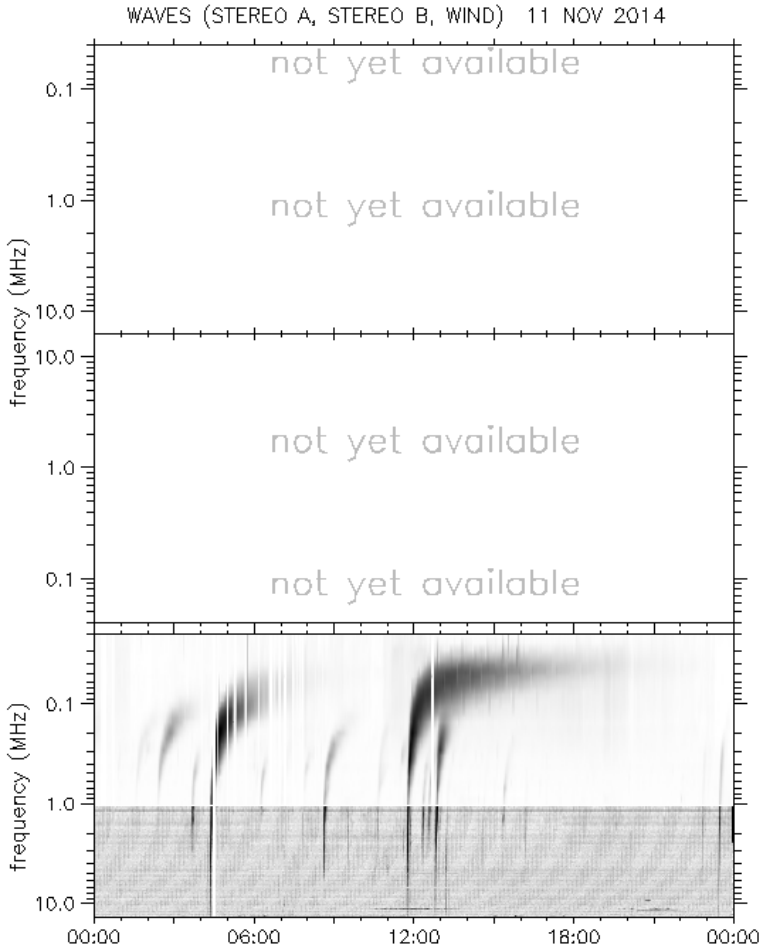
SDO / AIA 94、131、171、304A movie

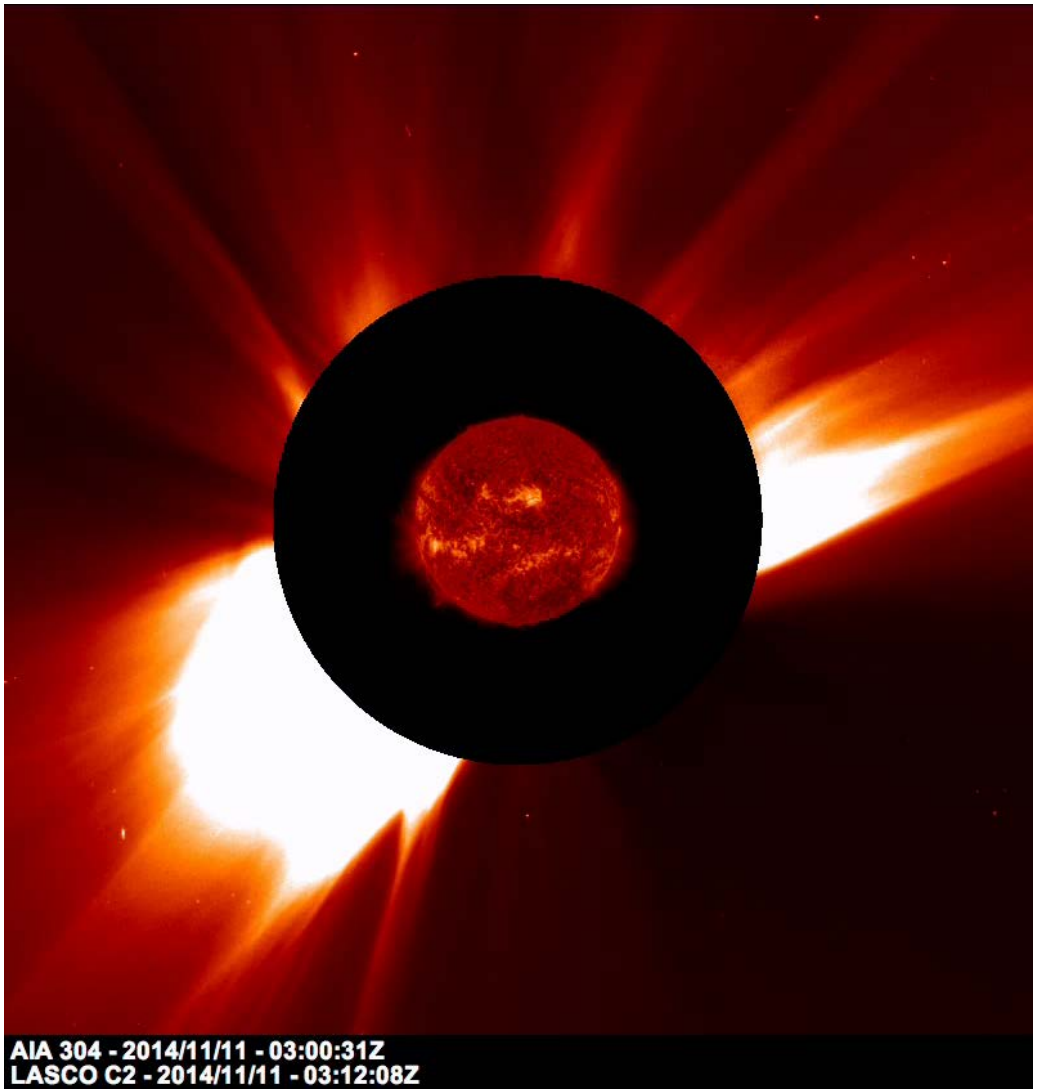
SDO/AIA observations indicate an eruptive process





LASCO / C2 & Wind radio bursts





2014/11/11

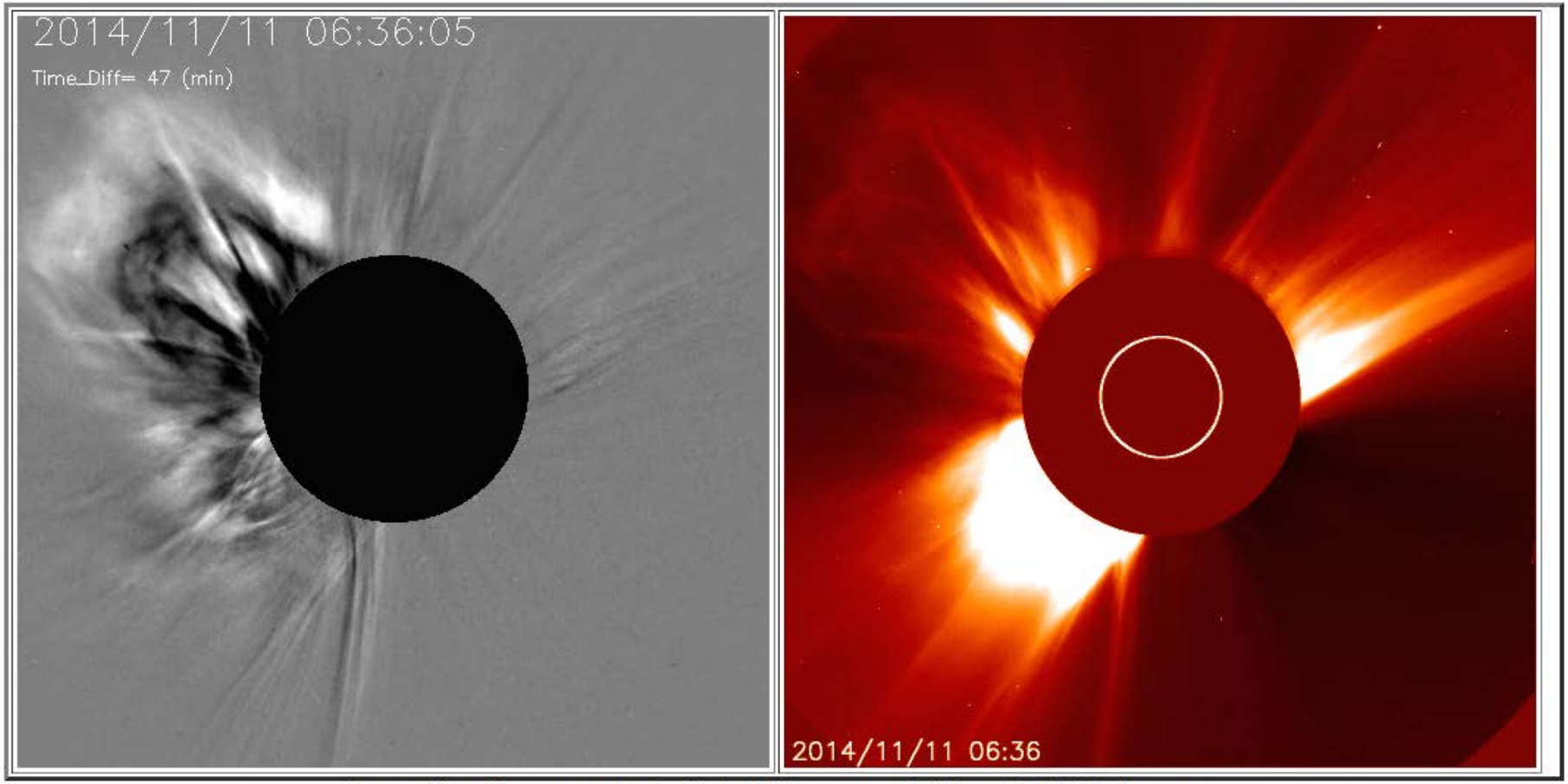


Image of the solar corona, taken by the LASCO coronagraph (C2) on the SOHO observatory

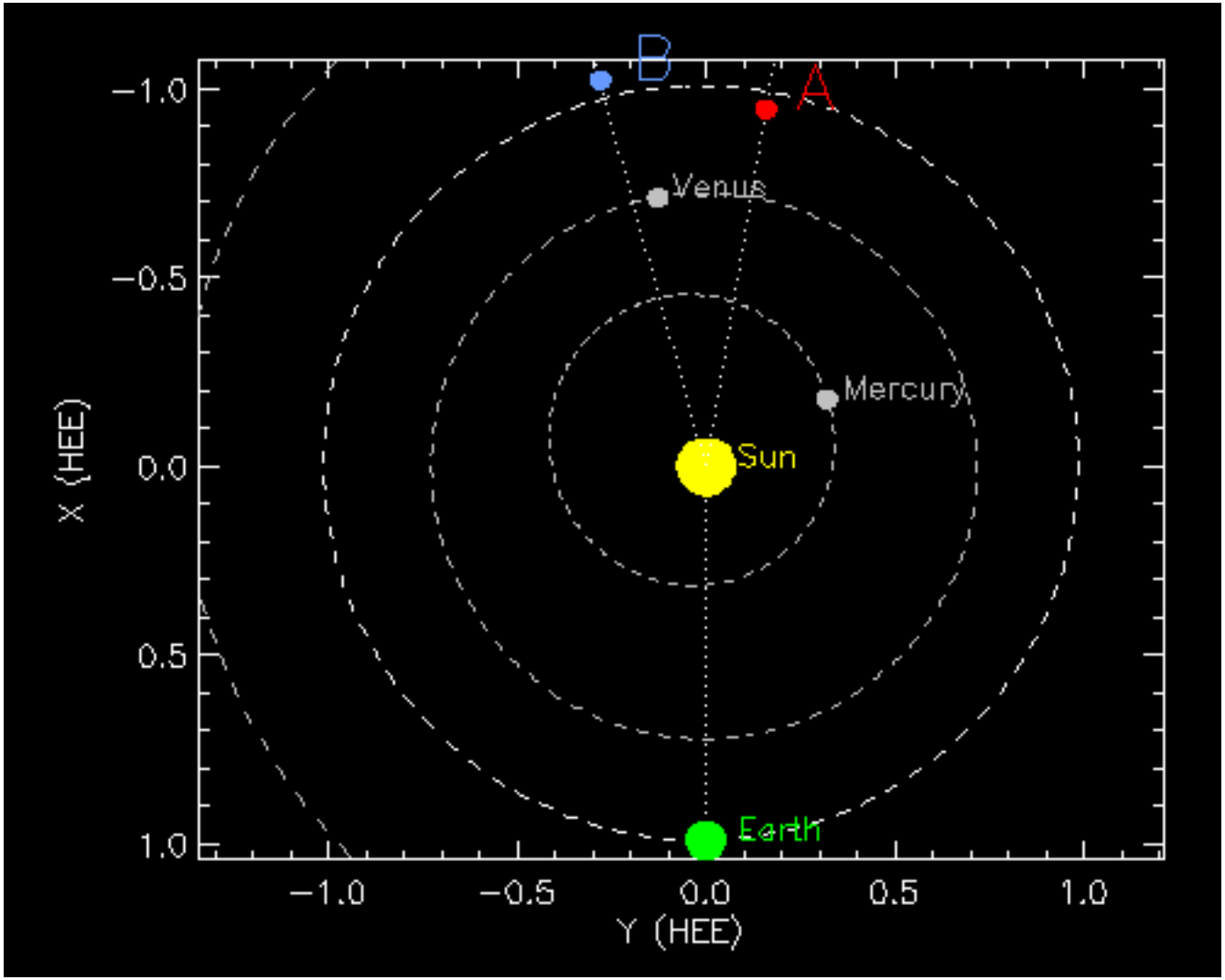
Start | Pause | Faster | Slower | Reverse | Rewind | Next | Prev.

Frame: Displaying 30 of 107 Speed: 1 (frames/sec)

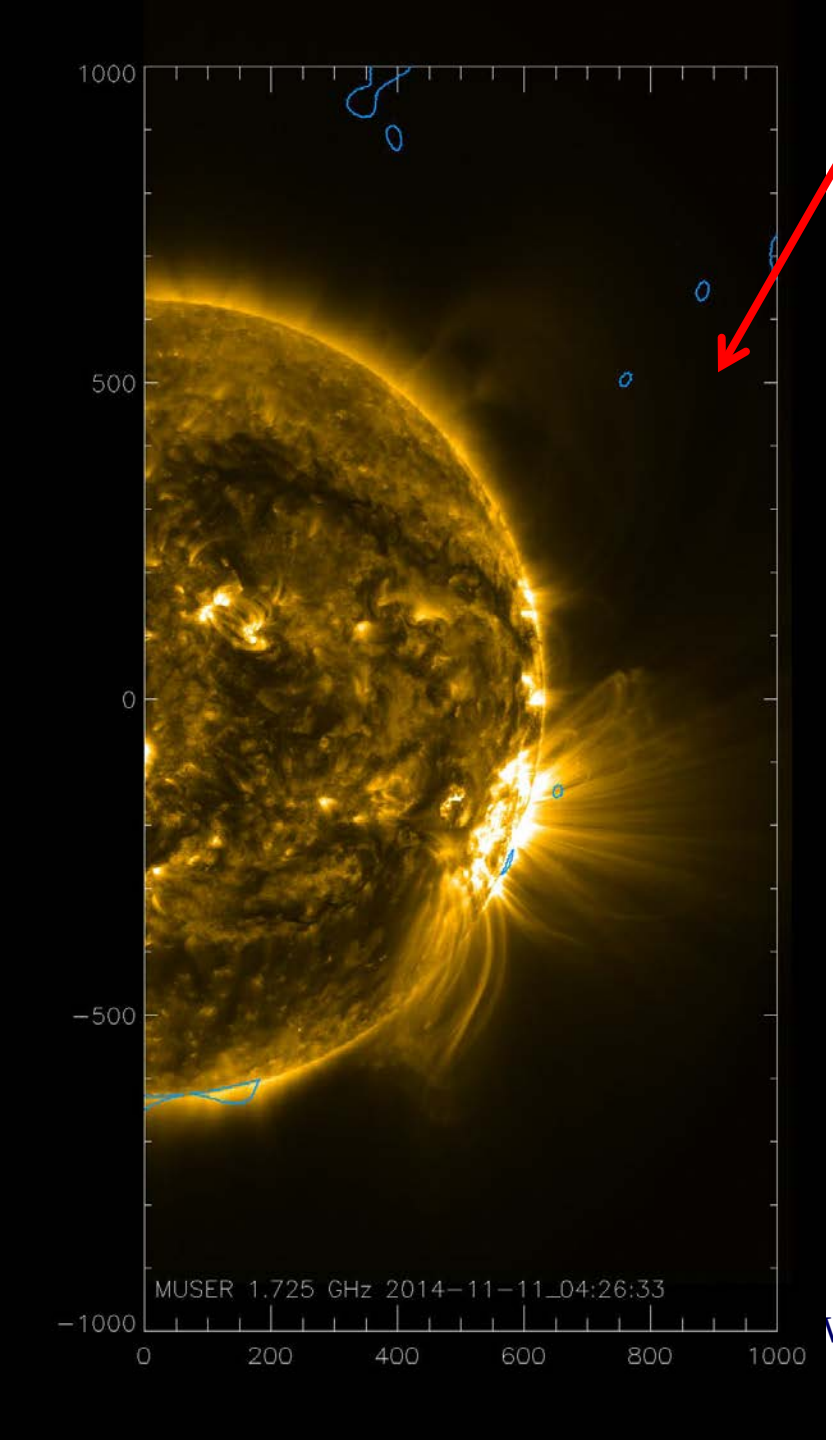
Monthly Table (2014/11)

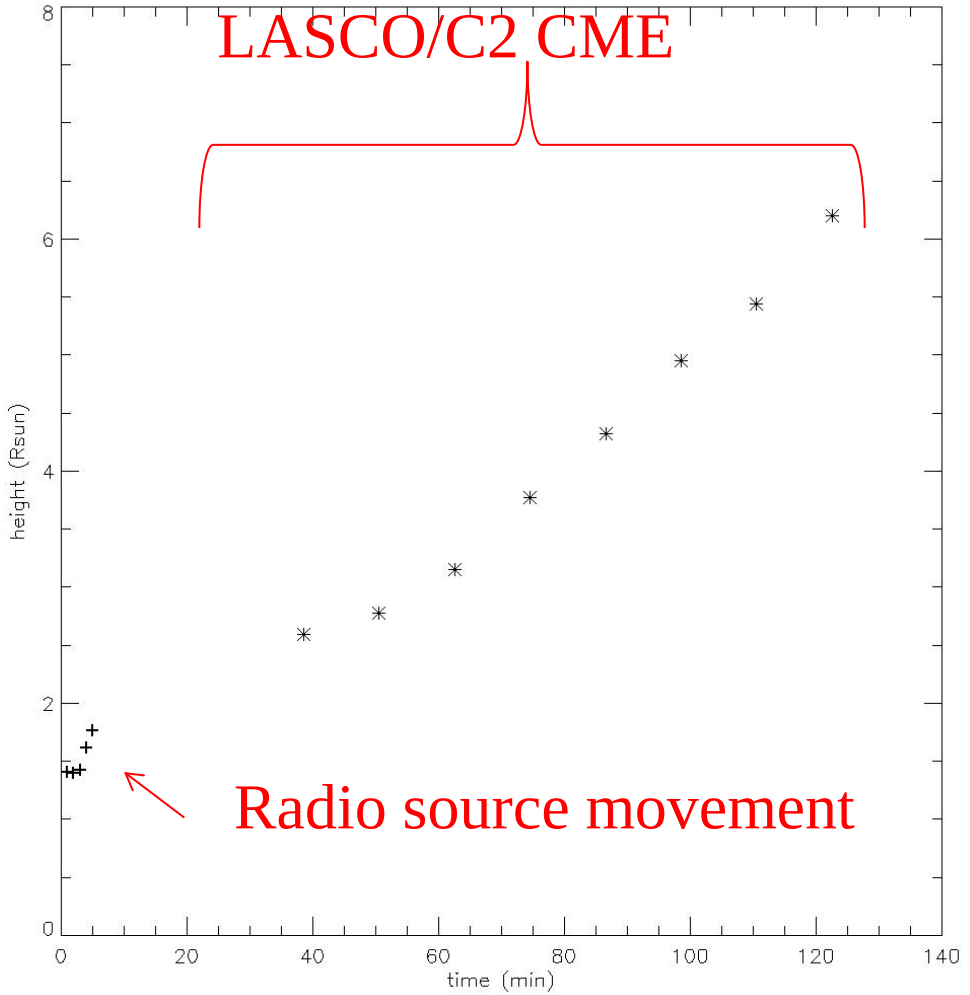
Home

Positions of STEREO A and B for 2014-11-11 04:20 UT

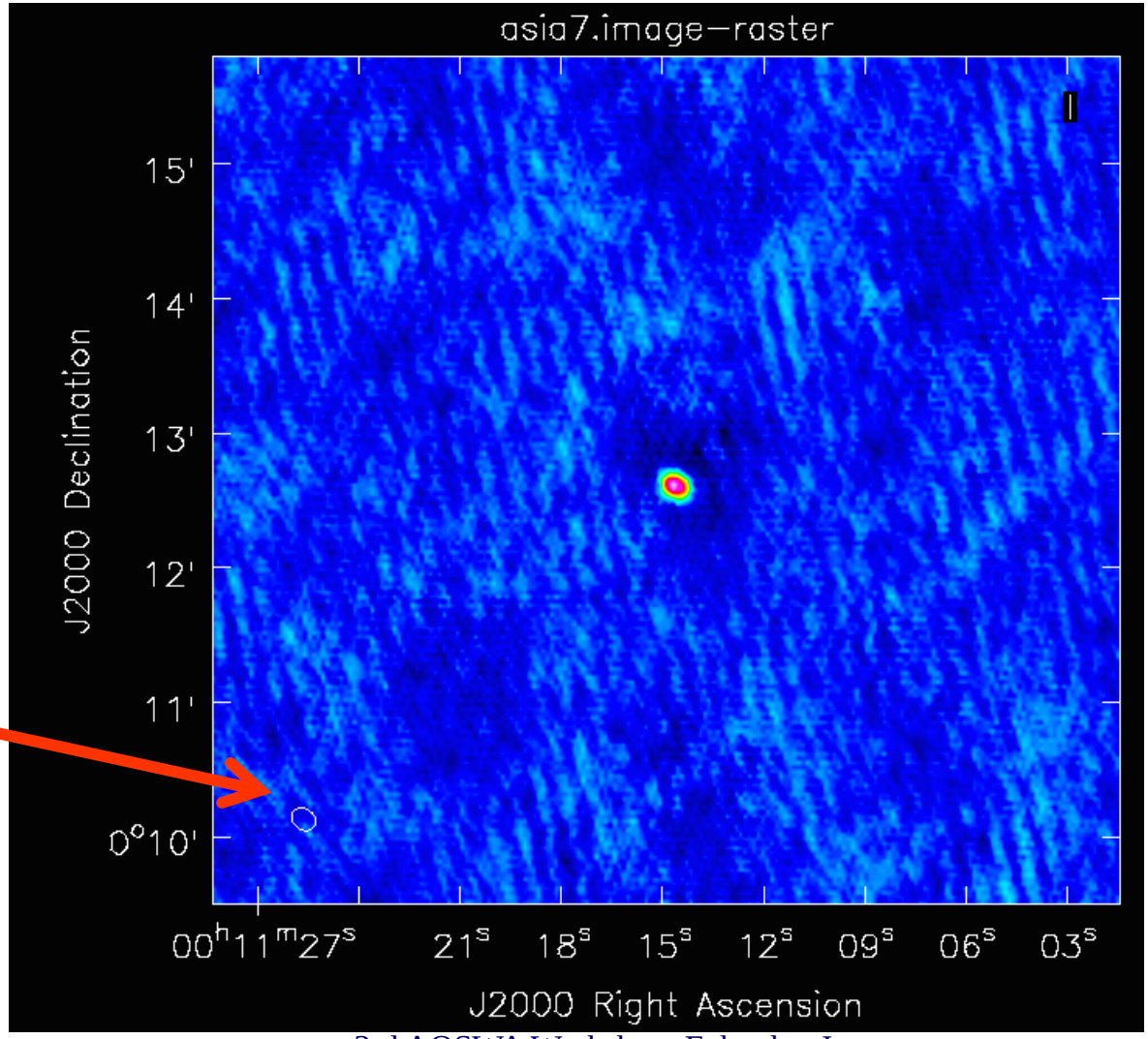


Radio sources & STEREO image (Preliminary results)



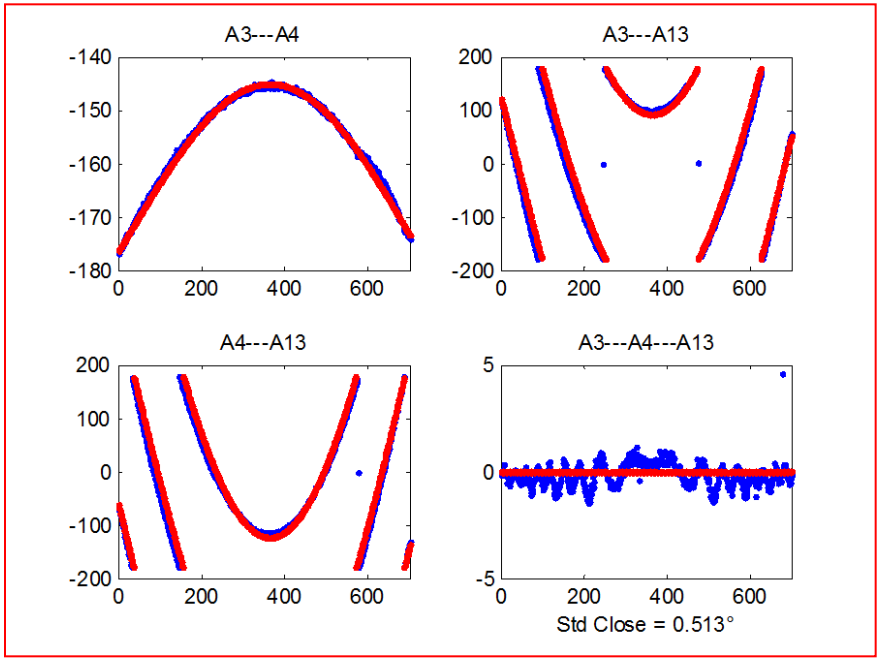


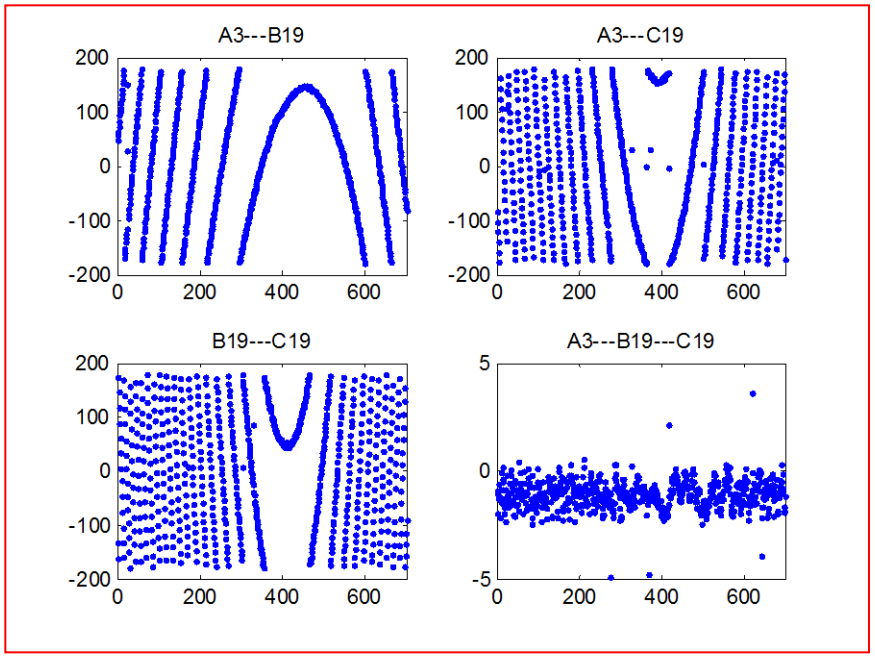
CSRH-II Preliminary Results of ASIA-7 satellite at 12 GHz on 15 Aug, 2014



Beam

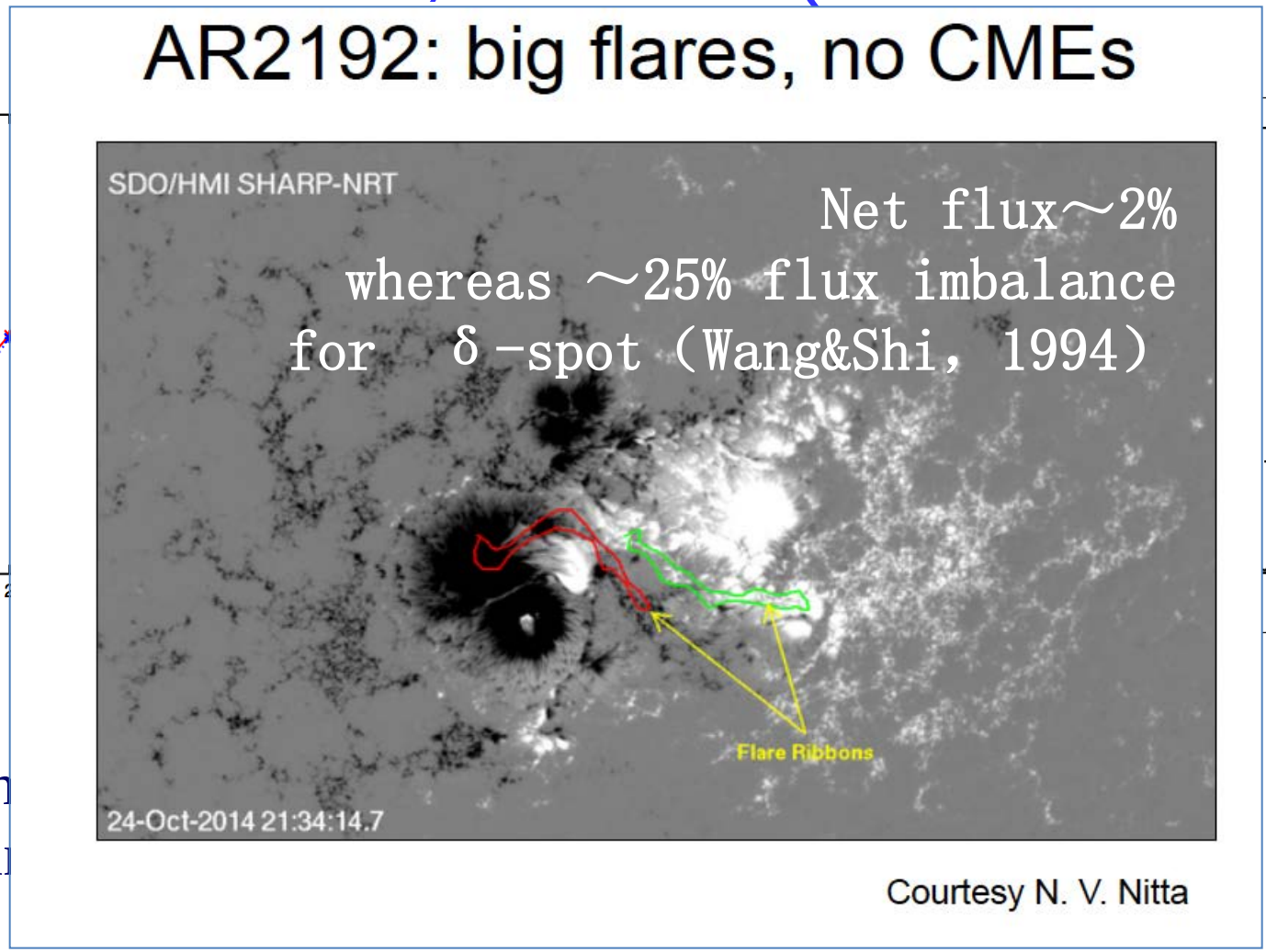
Phase closure ~<1° (RMS) for satellite signal of 700 min in the night of 4-5 Feb 2015 for all baselines until 3 km of CSRH-II

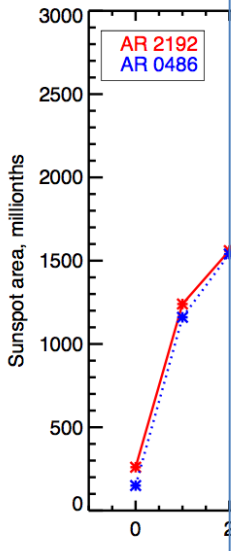


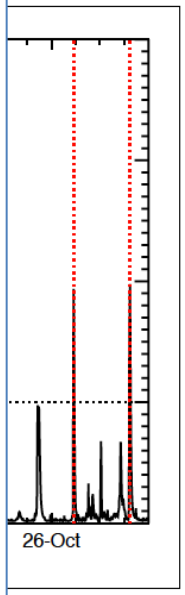


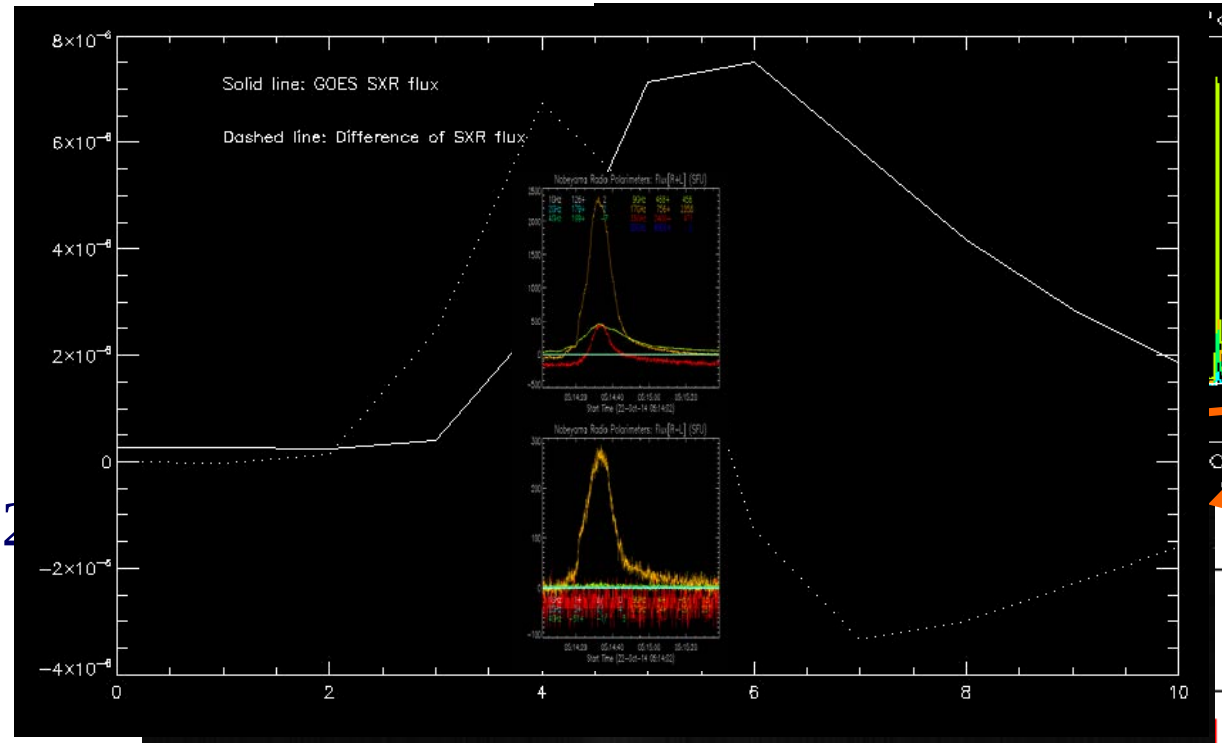
(N.B. Specification Phase closure <7° should be OK)

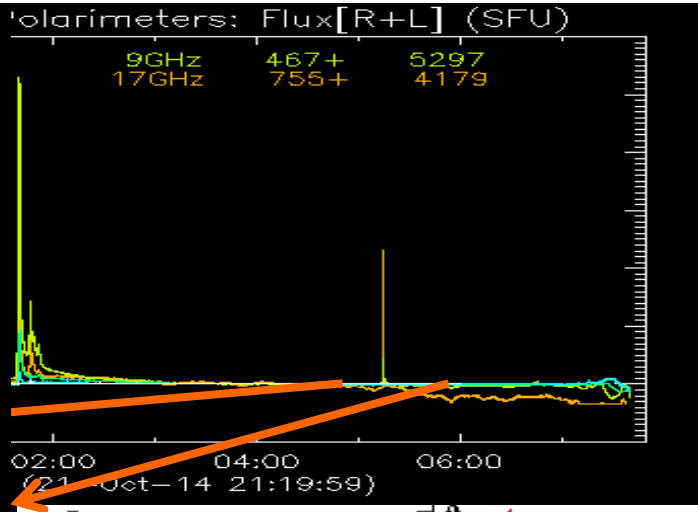
AR2129：Largest sunspot, energetic X-class two-ribbon flares, no CMEs (Hudson，2014)

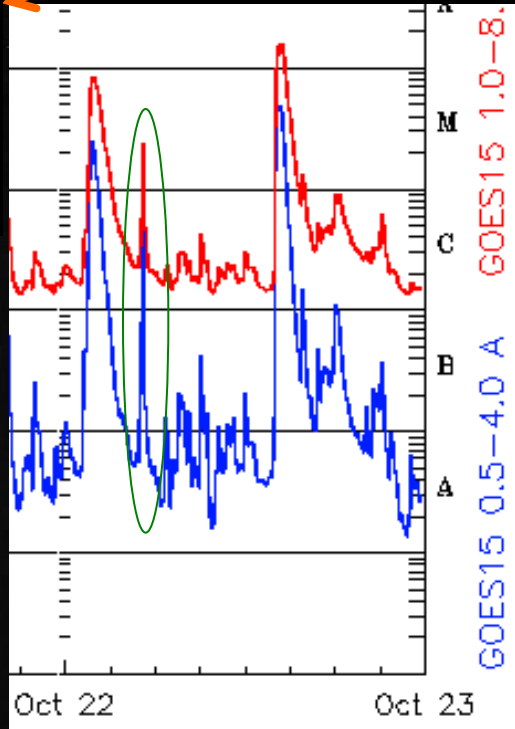






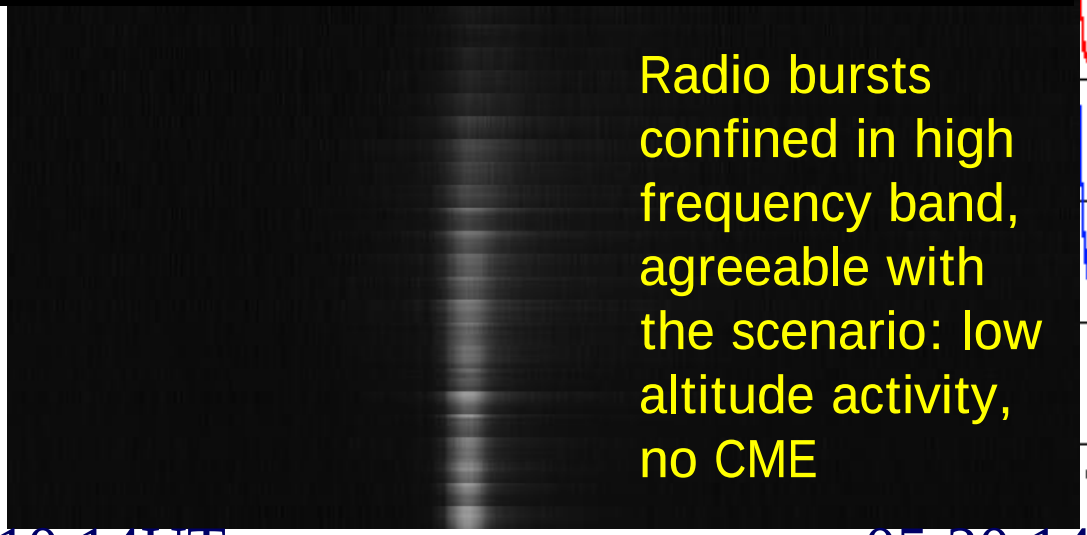






8.5G

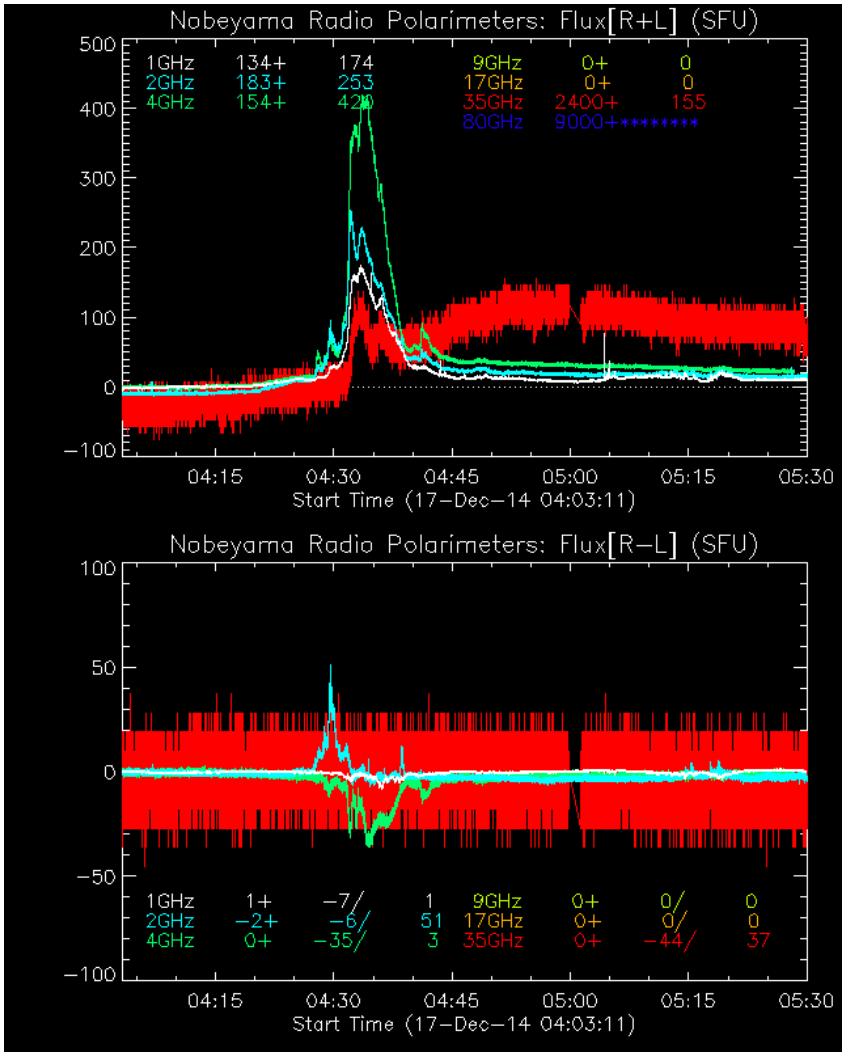
15G

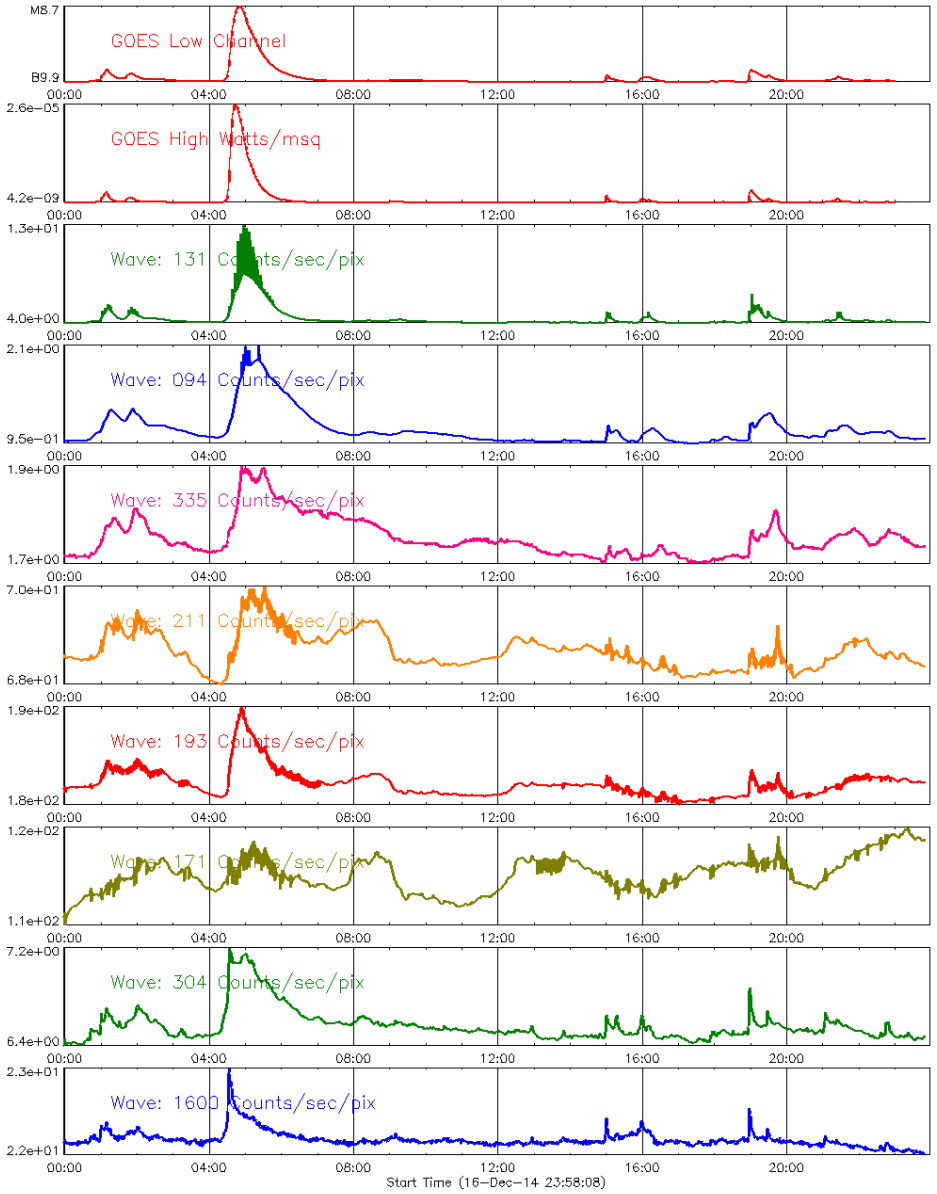


Radio bursts confined in high frequency band, agreeable with the scenario: low altitude activity, no CME

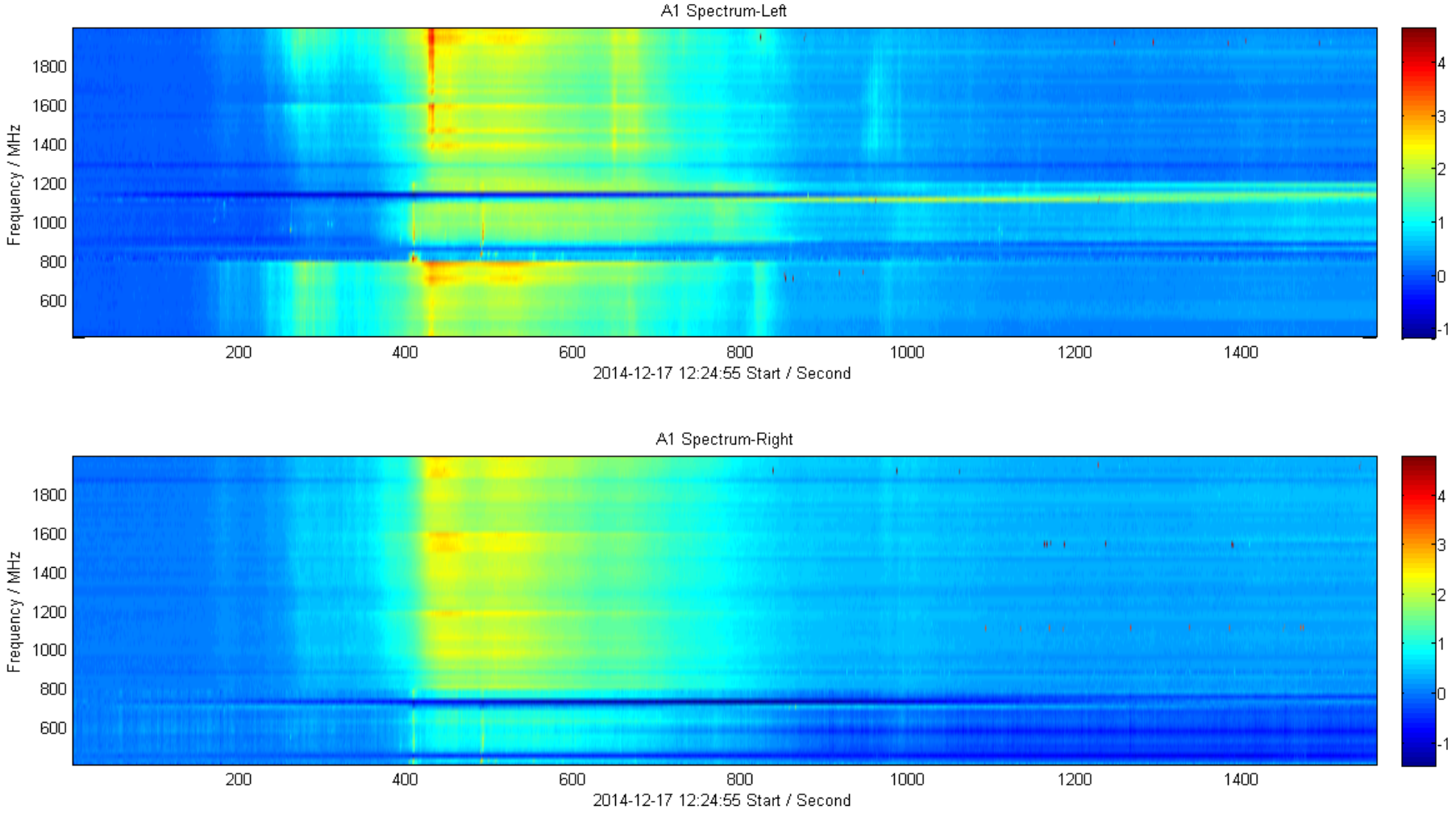
05:10:14UT Updated 2014 Oct 22 23:55:12 UTC 05:20:14UT NOAA/SWPC Boulder, CO USA

Another burst event on Dec 17 2014 for a M8.7 flare





CSRH-I radio burst fine structures, imaging processing being underway



Station Construction Starting

Summary

I. **Solar radio imaging spectroscopy is in its infancy and will open new observational windows on flares and CMEs. It will also provide coronal magnetograms. Complementary to X-ray, γ-ray, UV/EUV etc. observations.**

II. **For CSRH, radio quiet zone protection of 10km radius is established. CSRH-I & II have been constructed and renamed as *MUSER*:**
   - **Calibration and verification**
   - **Commissioning observations**
   - **Put into operation in middle 2015**

III. **Develop data pipe-line**

IV. **Observing Station construction in 2015**

V. **MUSER Initial observations are promising**

(Photo by S.J. Yu)