The Frequency Agile Solar Radiotelescope

AUI, NRAO, UCB, CIT, NJIT, UMd/USAF

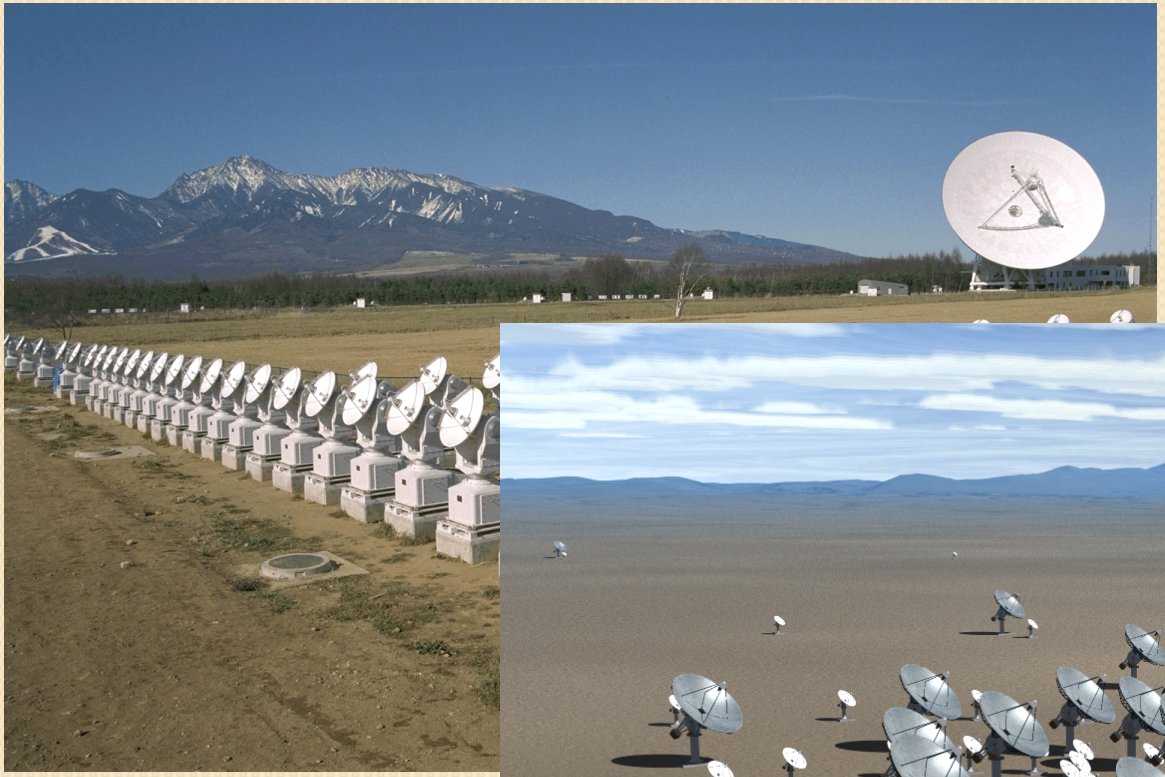
The Innovation

Ultra-wideband imaging spectroscopy of the solar atmosphere from the chromosphere to the outer corona with temporal, angular, and spectral resolution matched to the physical process that occur.

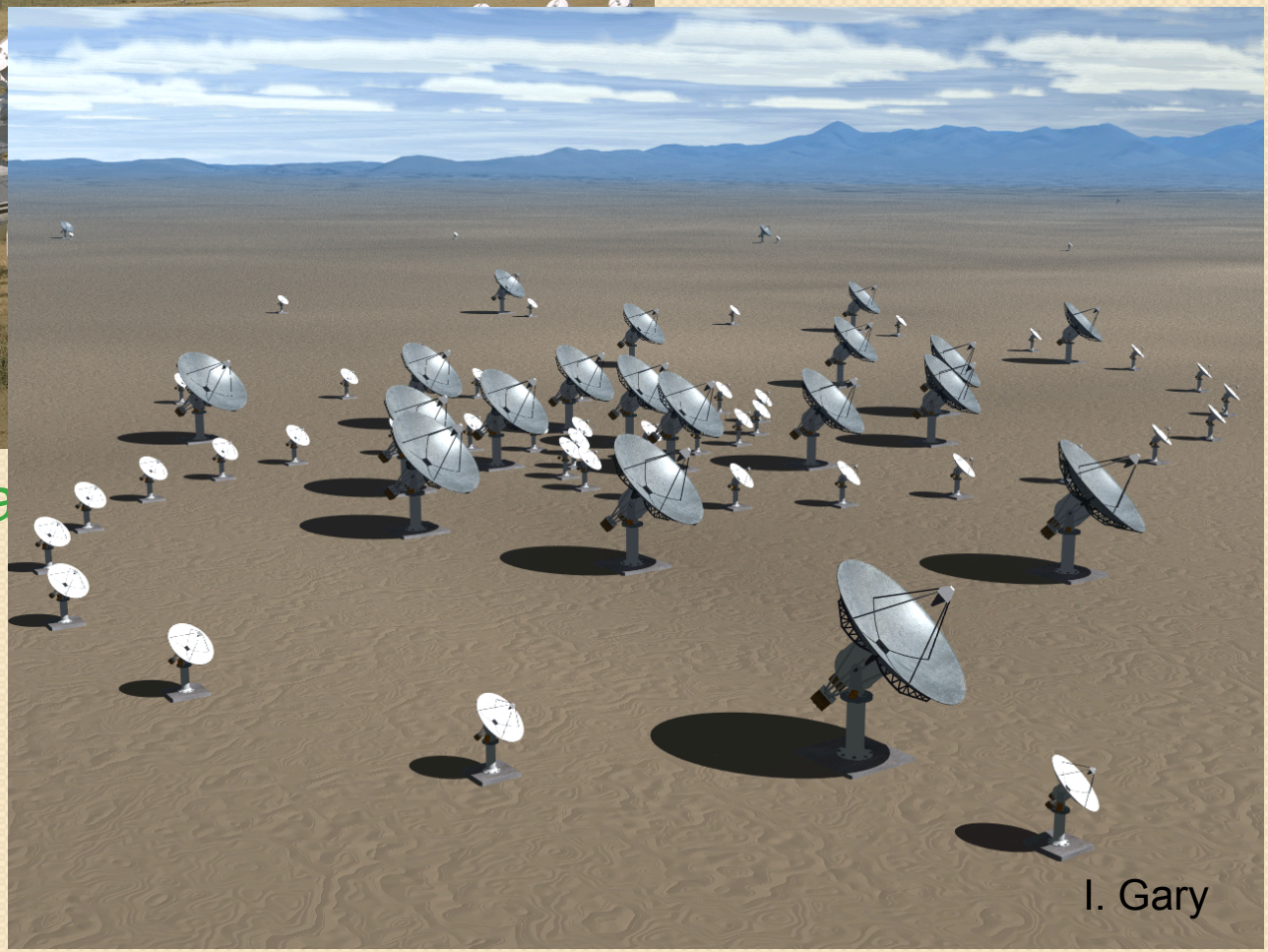
$$T_B(x, y, \nu, t, \sigma)$$

Brightness temperature as a function of position, frequency, time, and polarization

The entire solar atmosphere will be imagined in 3D from the mid-chromosphere to the outer-corona once every second!



Nobeyama



FASR Specifications

FASR A: ~2.5-21 GHz

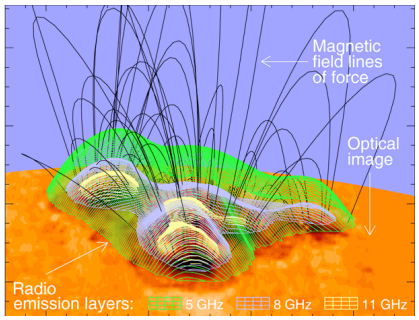
FASR B: ~0.25-3 GHz

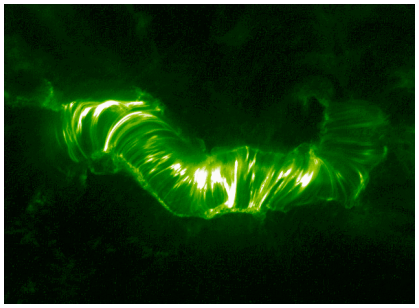
FASR C: ~50-300 MHz

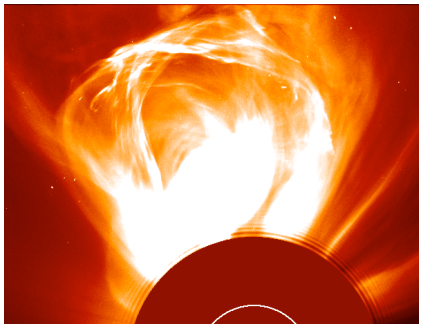
Proposed site is OVRO

Frequency range	50 MHz - 21 GHz
Data channels/ bandwidth/ freq. channels/ int. time	2/ 500 MHz/ 4000/ 20 ms
Number antennas	A: ~100 (4950 pairs) B: ~80 (3160) C: ~60 (1770)
Size antennas	A: 2 m B: 6 m C: LPD tiles or similar
Polarization	Stokes IV(QU)
Angular resolution	$20/\nu_9$ arcsec
Footprint	~4.5 km
Field of View	>0.5 deg

The Science

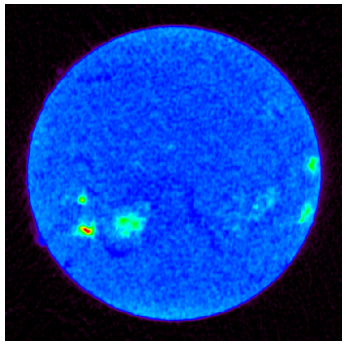


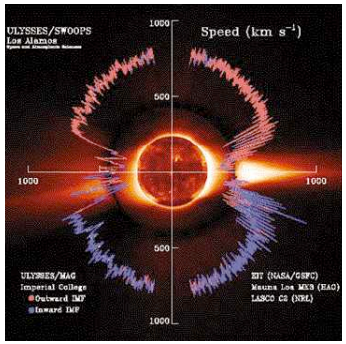


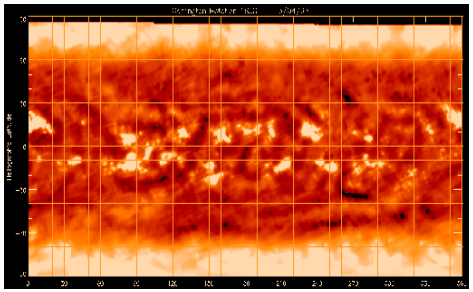


- Coronal Magnetic Fields
  - Coronal magnetography
  - Spatiotemporal evolution of fields
  - Role of electric currents in corona
  - Coronal seismology
- High energy solar physics
  - Magnetic energy release
  - Plasma heating and dynamics
  - Electron acceleration and transport
  - Origin of SEPs
- Drivers of Space Weather
  - Birth & acceleration of CMEs
  - Prominence eruptions
  - Origin of SEPs
  - Fast solar wind streams

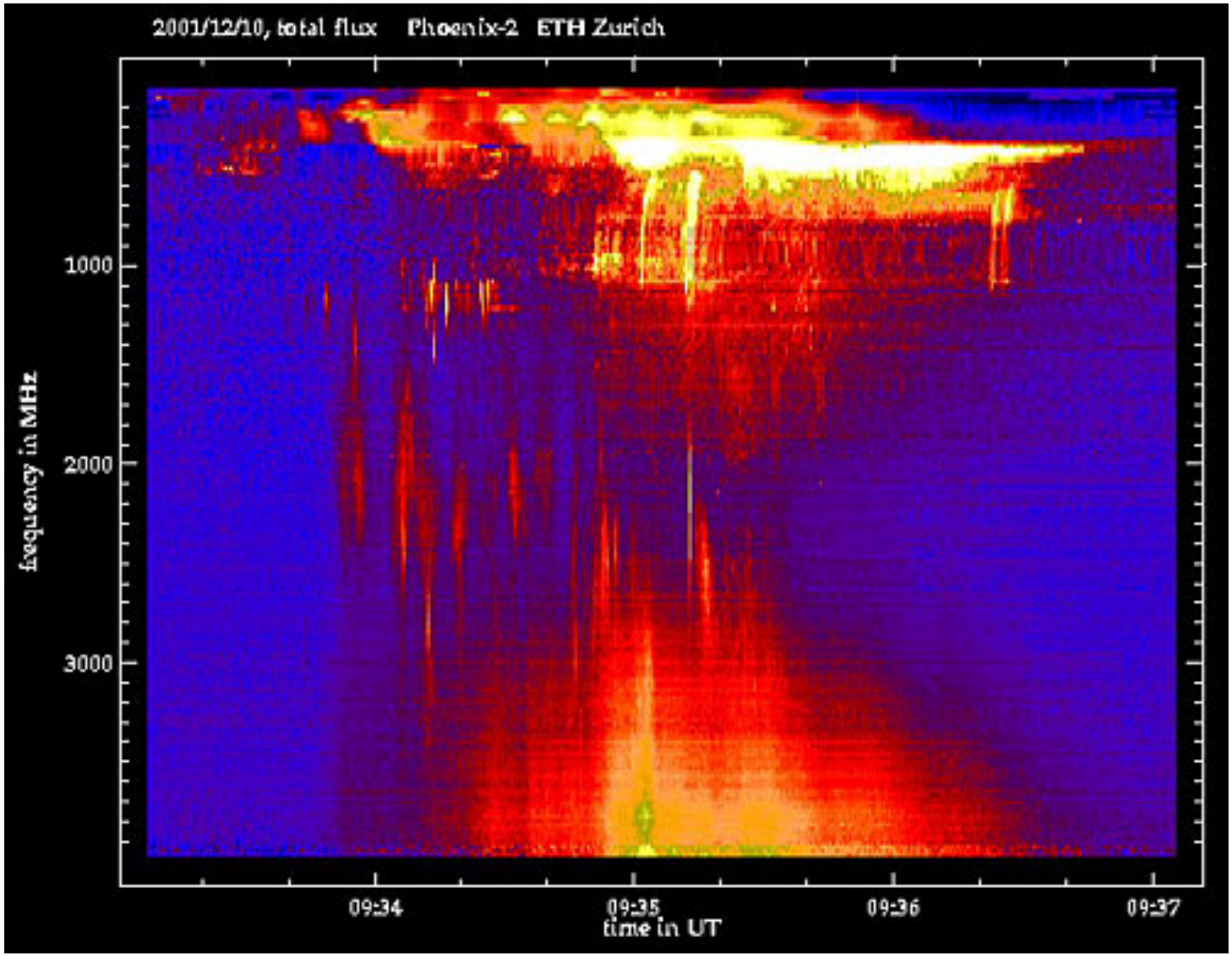
The Science





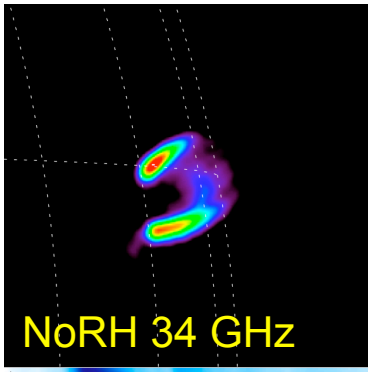


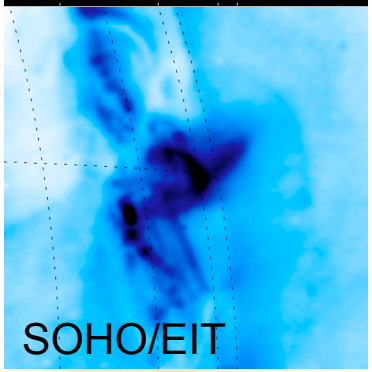
- The "thermal" solar atmosphere
  - Coronal heating - nanoflares
  - Thermodynamic structure & dynamics
  - Formation & structure of filaments
- Solar Wind
  - Birth in network
  - Coronal holes
  - Fast/slow wind streams
  - Turbulence and waves
- Synoptic studies
  - Radiative inputs to upper atmosphere
  - Global magnetic field/dynamo
  - Flare statistics

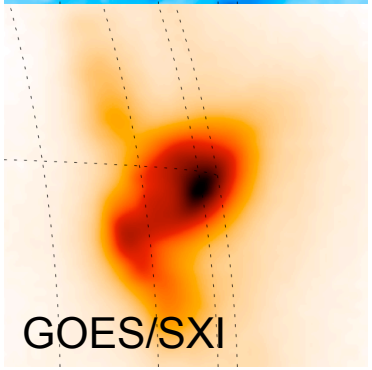

2001/12/10, total flux Phoenix-2 ETH Zurich
1000
2000
3000
frequency in MHz
09:34
09:35
09:36
09:37
time in UT

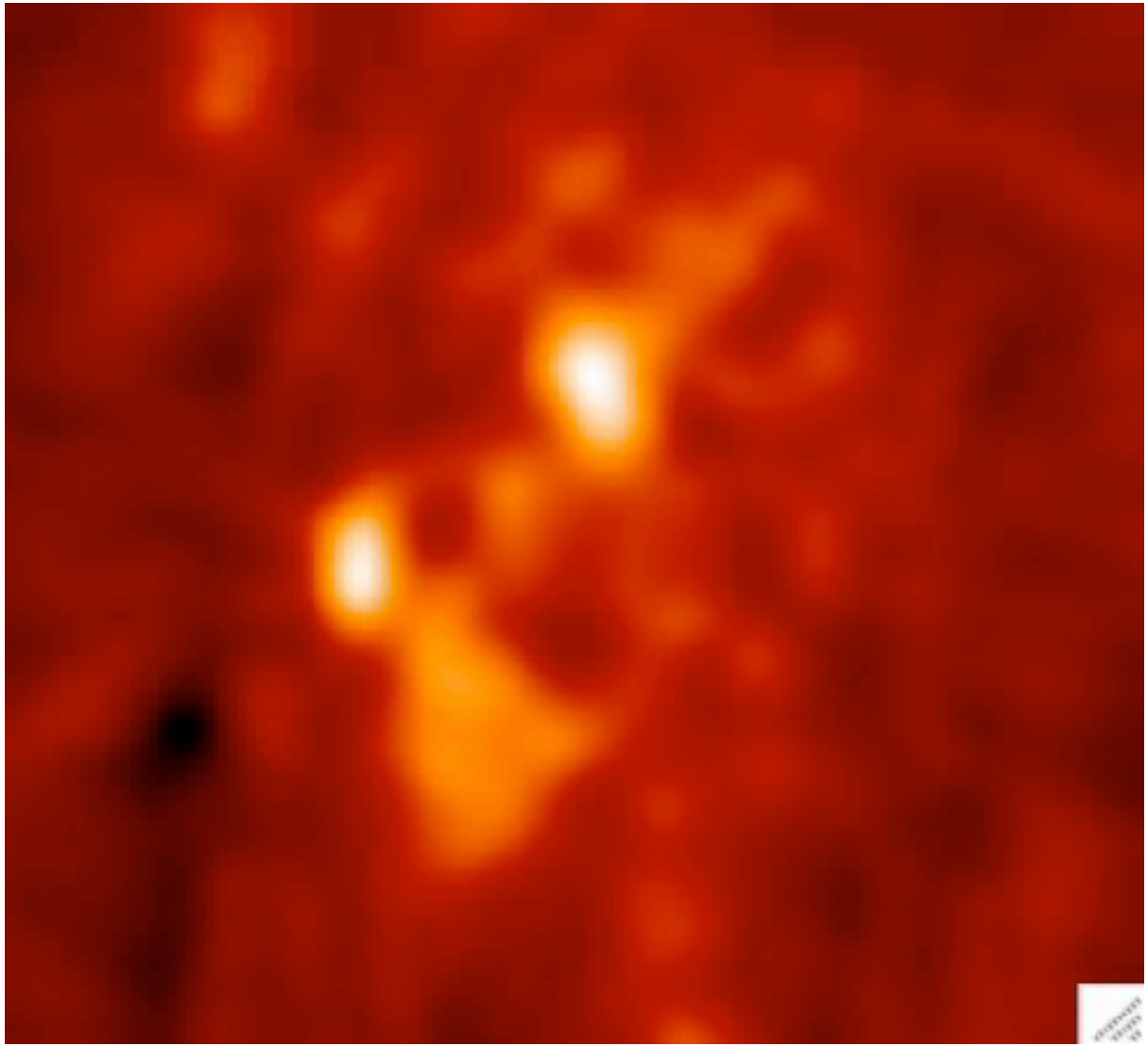
from A. Benz

13 July 2005 LDE: 0230-0500 UT



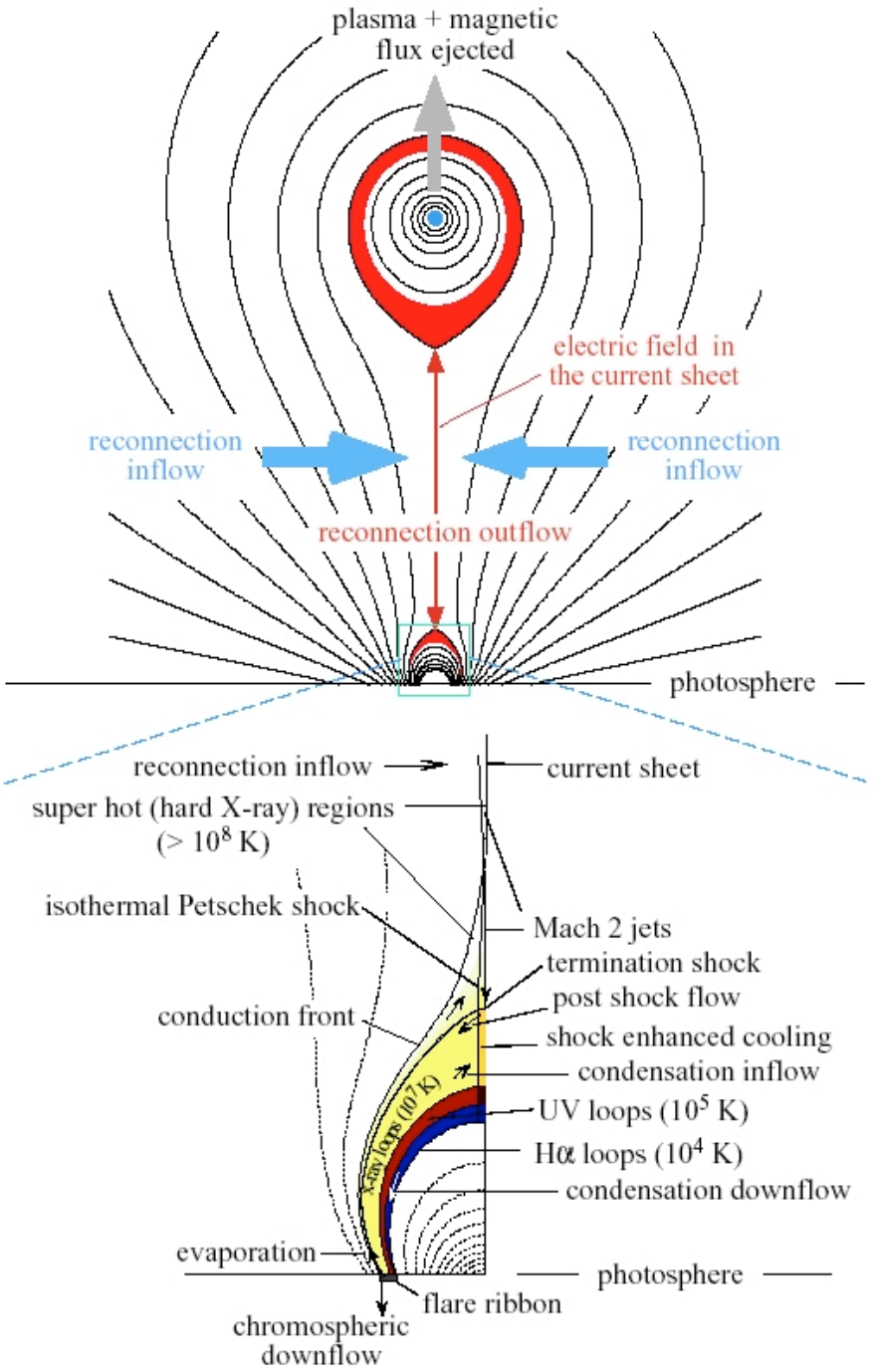






Nobeyama Radioheliograph 17 GHz

FASR will allow the observation of solar phenomena as a coupled system!



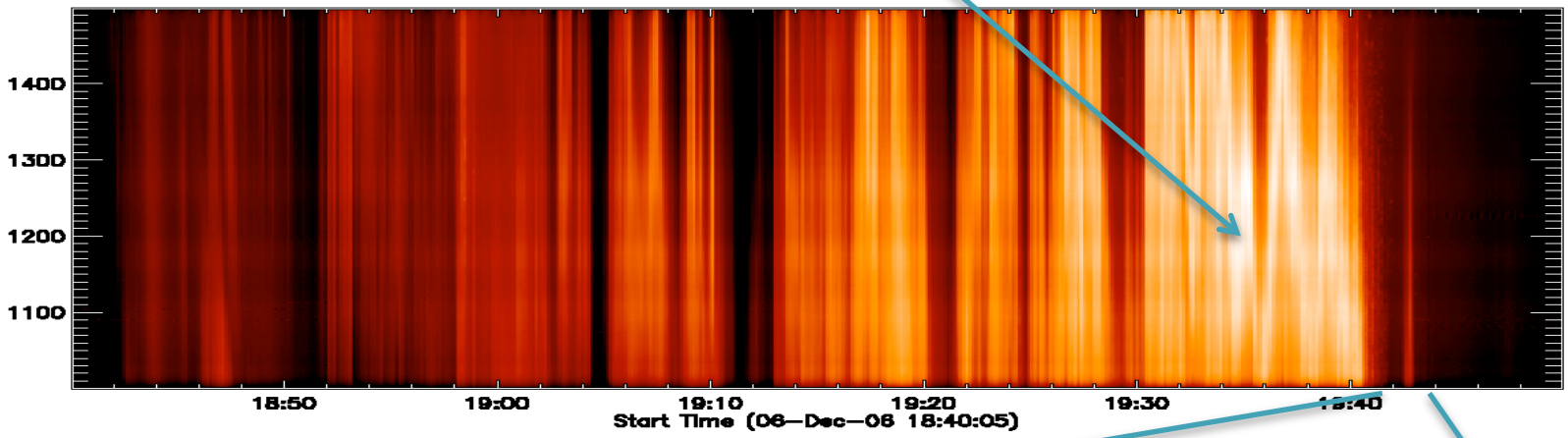
Recent Developments

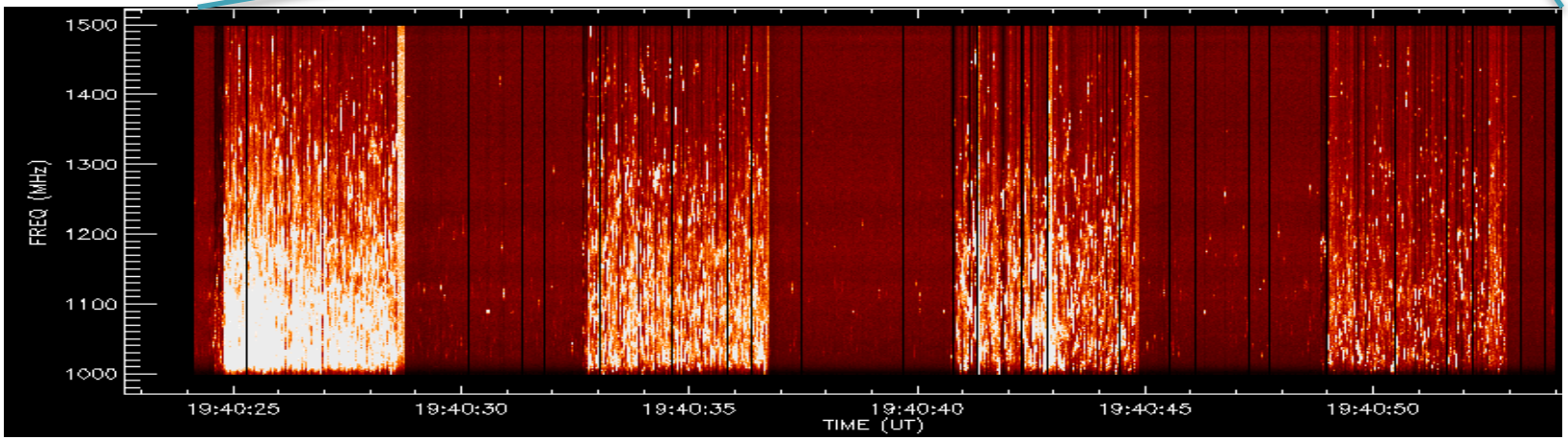
FASR development has been ongoing since 2006:

- NSF/ATM – FASR Design and Development Plan (NRAO, AUI, UCB, NJIT, UM)
  - ✓ Reference design and costing
  - ✓ Operations and maintenance planning
  - ✓ Implementation planning
  - ✓ Design and prototype front ends
  - ✓ Design and prototype "F engines"
  - ✓ Testing of critical COTS components (e.g., FO links)
  - ✓ Site planning
- NSF/AST – FASR Subsystems Testbed (NJIT, UM, UCB)
  - ✓ Design and test DSP strategies
  - ✓ RFI mitigation strategies
  - ✓ FST science (see poster by Gary et al)

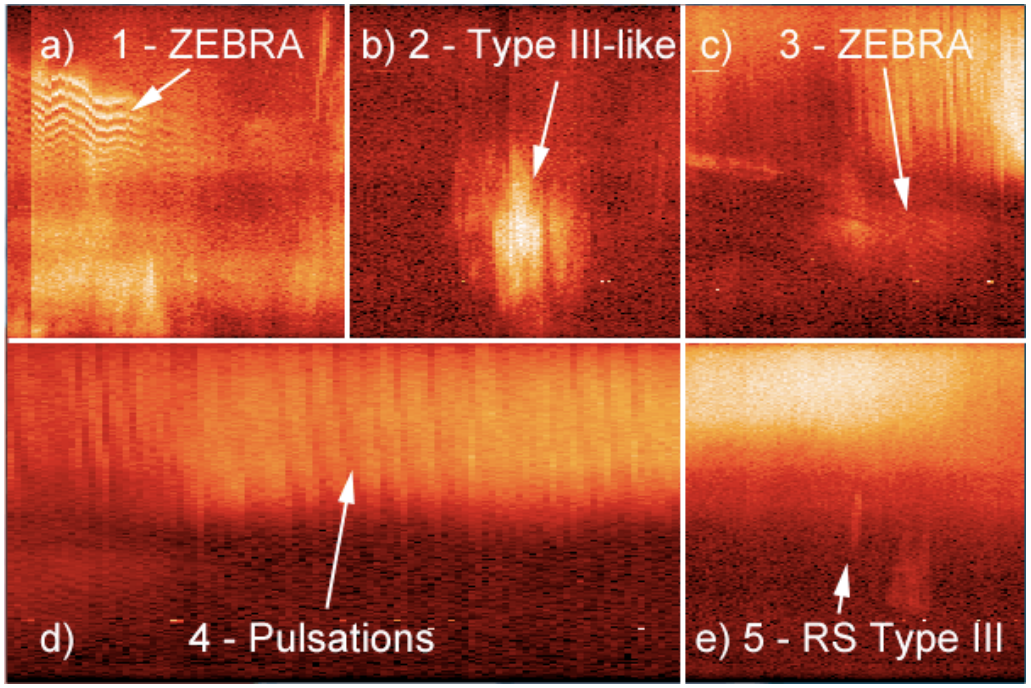
2006 June 12

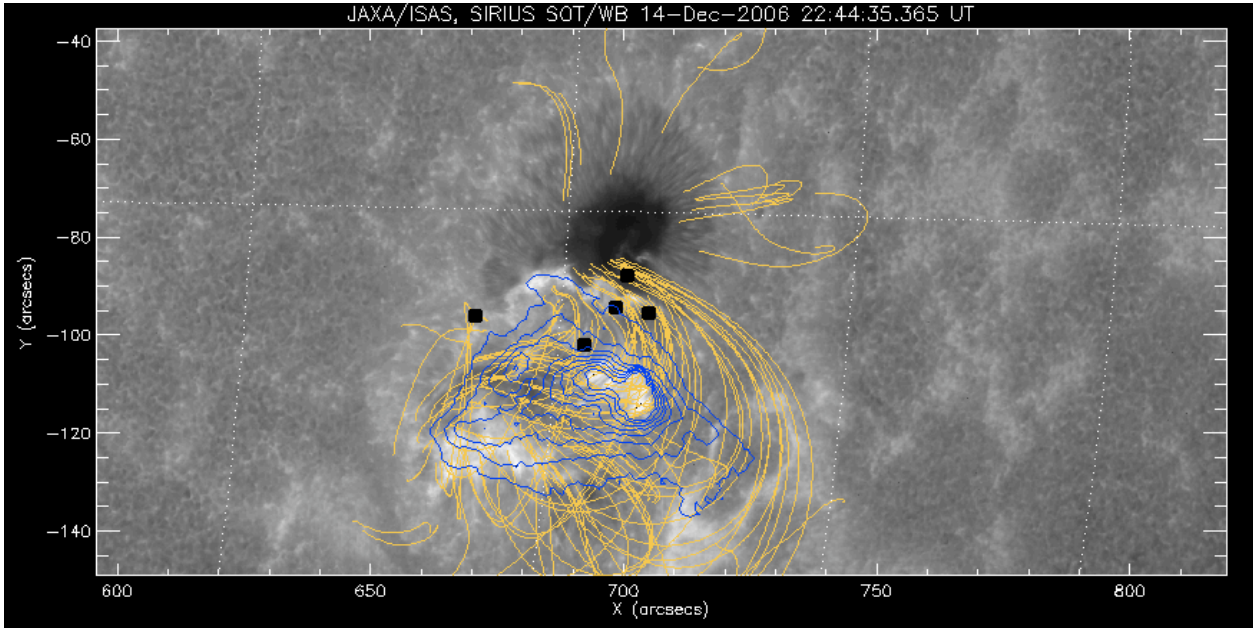
10^6 SFU!!





Gary et al 2009


a) 1 - ZEBRA
b) 2 - Type III-like
c) 3 - ZEBRA
d) 4 - Pulsations
e) 5 - RS Type III


JAXA/ISAS, SIRIUS SOT/WB 14-Dec-2006 22:44:35.365 UT
-40
-60
-80
-100
-120
-140
Y (arcsecs)
600
650
700
750
800
X (arcsecs)

Recent Developments

- In 2007 we were informed that NSF/ATM did not foresee the means of funding a full implementation of FASR

- We were instructed to prepare a plan for no more than $25M with a duration of no more than 5 yrs

- We therefore "de-scoped" FASR in 2007 to fit within the proposed cost cap, but the design allowed for graceful expansion

- In Jan. 2008, we submitted our plan to the NSF/ATM *Mid-Sized Opportunity* program as a "pre-proposal" and were invited to submit a full proposal for the (de-scoped) FASR in Jun. 2008

FASR Specifications (MSI Opp)

FASR A: ~2.5-21 GHz

FASR B: ~0.25-3 GHz

FASR C: ~50-300 MHz

Proposed site is OVRO

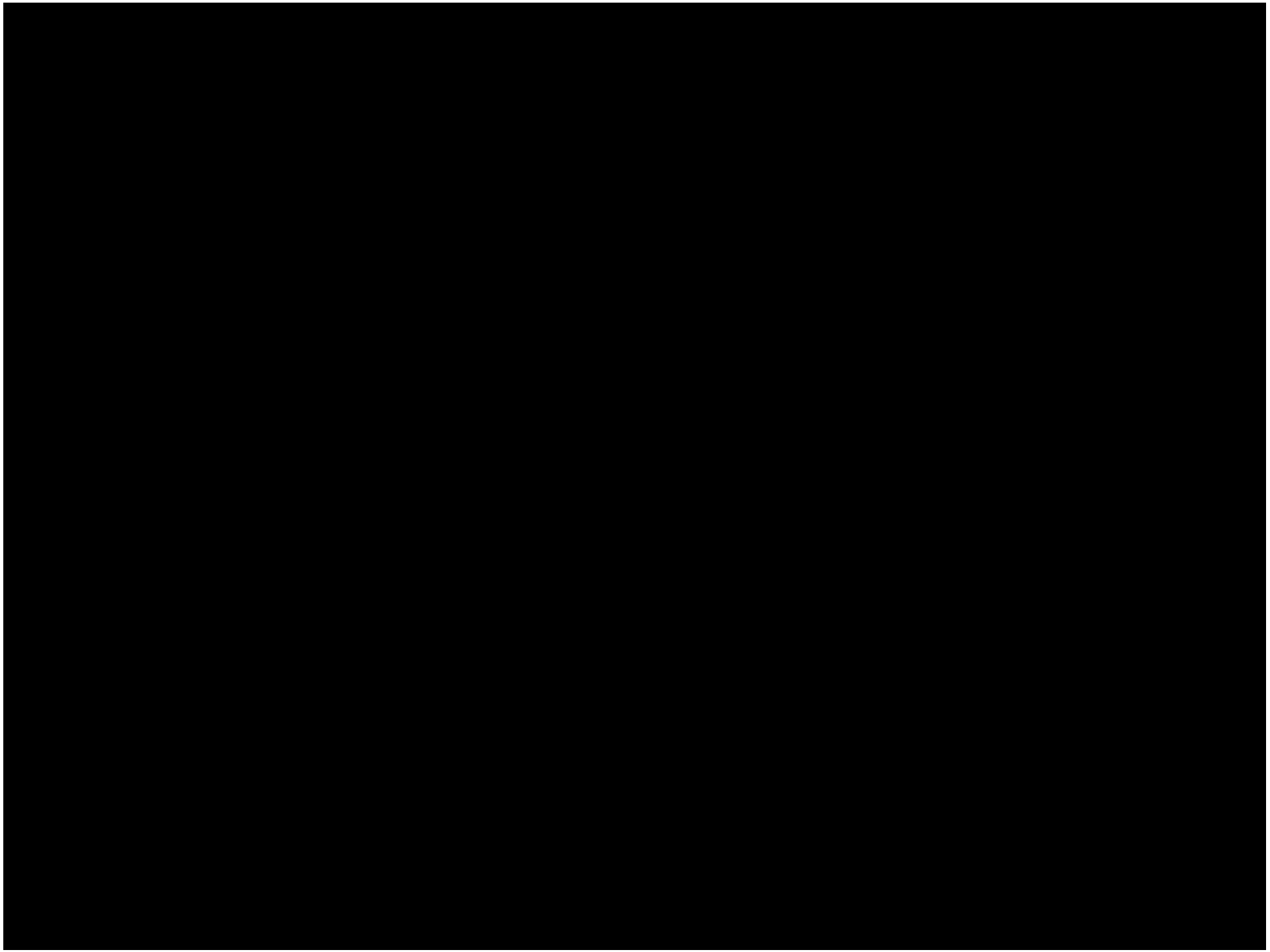
Frequency range	50 MHz - 21 GHz
Data channels, bandwidth, freq. channels, int. time	2/500 MHz/4000/20 ms
Number antennas	A: ~45 (990 pairs) B: ~15 (105) C: ~15 (105)
Size antennas	A: 2 m B: 6 m C: LPD tiles or similar
Polarization	Stokes IV(QU)
Angular resolution	$20/\nu_9$ arcsec
Footprint	~3 km
Field of View	>0.5 deg

Recent Developments

• In Aug. 2008, we were informed that, despite excellent reviews, NSF faced unforeseen fiscal constraints and they could not fund the proposal (or any other proposal of significant size)

• Following much discussion in Sep-Oct 2008 NSF agreed to consider a proposal for the “FASR Pathfinder” (16 + 16 antennas)

• The FASR Pathfinder proposal was submitted in March 2009 for $8M and we are now awaiting a decision




Observations of the Sun and
Heliosphere with the EVLA

The EVLA

- Continuous frequency coverage, 1-50 GHz
- Order of magnitude improvement in continuum sensitivity
- 100 ms dump time; 10 ms possible
- 16k spectral line channels per IF band

- High dynamic range solar observing to be supported in the 1-2 and 12-18 GHz bands (~70 dB)
- Solar observing otherwise supported in the 2-4, 4-8 and 8-12 GHz bands (30-40 dB)