



Virtual Solar Observatory

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CRAAM/Mackenzie

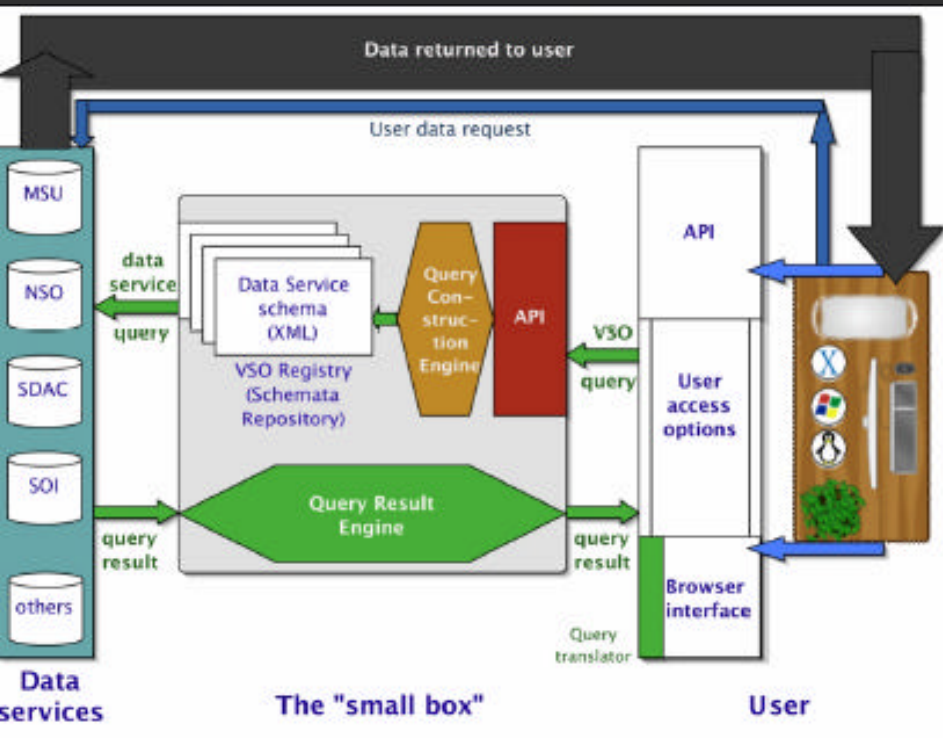
Joaquim E. R. Costa

DAS/INPE

Summary

- Brazilian solar initiative
- The Virtual Solar Observatory (USA)
- Observatories and databases: ROI, SST
- Proposed applications:
 - Magnetic field extrapolation
 - Flare spectra modeling
 - Solar atmosphere model

The Virtual Solar Observatory (USA)



- Browser query interface offers multiple search methods, including combinations
- GUI allows sorting by columns, viewing of thumbnails (where available)

Gurman et al.

VSO

- Since 12/2002
- <http://sdac.virtualsolar.org>
- Search by:
 - Time
 - Observable
 - Instrument/Source/Provider
 - Spectral range
 - Nickname

Instruments

- 512-CHANNEL MAGNETOGRAPH
- 60-FT SHG
- BCS - Yohkoh
- BIG BEAR
- CDS
- CELIAS
- CERRO TOLOLO
- CFDT1
- CFDT2
- CHP
- COSTEP
- DPM
- EIT - SOHO
- EL TEIDE
- ERNE
- GOLF
- HXT - Yohkoh
- IMPACT
- LASCO – SOHO
- LEARMONTH - GONG
- MAUNA LOA
- MDI - SOHO
- MK4
- MOF/60
- MOTH
- O-SPAN
- OVSA
- PLASTIC
- RHESSI
- S/WAVES
- SECCHI
- SOLAR FTS SPECTROMETER
- SPECTROHELIOGRAPH
- SPECTROMAGNETOGRAPH
- SUMER
- SWAN
- SXI-0
- SXT - Yohkoh
- TENERIFE
- UDAIPUR
- UVCS
- VIRGO
- VSM
- WBS - Yohkoh

Search and Selection

- Search by data source and observatory or instrument

 VSO Time / Instrument Search
Version 1.1

Start Date/Time: 2005 Apr 13 / 22 : 00
End Date/Time: 2005 Apr 14 / 01 : 59

Provider : Source : Instrument Drilldown
Select a name to expand the list

- ☐ HANET (H-alpha Network, Big Bear Lake)[?]
- ☐ HAO (High Altitude Observatory, NCAR)[?]
- ☐ LSSP (Laboratory for Space and Solar Physics, NASA/Goddard)[?]
 - ☐ RHESSI (Reuven Ramaty High Energy Solar Spectroscopic Imager)[?]
- ☐ MSU (Montana State University)[?]
- ☐ NGDC (National Geophysical Data Center, NOAA)[?]
 - ☐ GOES-12 (Geosynchronous Operational Environmental Satellite - 12)[?]
- ☐ NSO (National Solar Observatory)[?]
- ☐ OBSPM (Departement d'Astronomie Solaire de l'Observatoire de Paris)[?]
- ☐ OVRO (Owens Valley Radio Observatory)[?]
- ☐ SDAC (Solar Data Analysis Center, NASA/Goddard)[?]
 - ☐ SOHO (Solar and Heliospheric Observatory)[?]
 - ☐ TRACE (Transition Region And Coronal Explorer)[?]
- ☐ SHA (Stanford Helioseismology Archive, Stanford U.)[?]

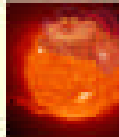
Search and Selection

- Or by physical observable

VSO Time / Observable Search Form

http://vso.nascom.nasa.gov

Applo News science SOHO NASA SDAC senior review

 VSO Time / Observable Search Form Version 1.0 

Start Date/Times: 2005 Apr 13 / 21 : 00

End Date/Times: 2005 Apr 14 / 00 : 59

Physical Observable

- ☐ LOS_velocity
- ☐ vector_velocity
- ☐ LOS_magnetic_field
- ☐ vector_magnetic_field
- ☐ intensity
- ☐ equivalent_width
- ☐ wave_power
- ☐ wave_phase
- ☐ oscillation_mode_parameters
- ☐ polarization_vector
- ☐ number_density
- ☐ particle_flux
- ☐ particle_velocity
- ☐ thermal_velocity
- ☐ composition

Search and Selection

- Or by wavelength or frequency

VSO Time / Sp

<http://sdac2.nascom.nasa.gov/c>

Apple News (250) science SOHO NASA estate SD

 VSO Time / Sp
Version

Start Date/Time: 2005 Apr 22 / 22 : 00

End Date/Time: 2005 Apr 23 / 01 : 59

Spectral Range

☐ soft X-rays [1 - 100 Å]

☐ extreme UV [100 - 1000 Å]

☐ ultraviolet [900 - 3800 Å]

☐ visible [3500 - 10000 Å]

☐ radio [0.3 - 30 GHz]

☐ OR select spectral range:

min

max

unit

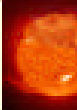
Search and Selection

- Or by “nicknames”, commonly used names for specific data types

VSO Time / Nickname Search Form

http://vso.nascom.nasa.gov

Apple News science SOHO NASA SDOAC senior review

 VSO Time / Nickname Search Form
Version 1.0 

Start Date/Time: 2005 Apr 13 / 22 : 00

End Date/Time: 2005 Apr 14 / 01 : 59

Nickname

Dopplergram

- ☐ Full-disk dopplergram
- ☐ K-7699 dopplergram
- ☐ Na-D dopplergram
- ☐ Ni-6768 dopplergram

Image

- ☐ 10.7cm image
- ☐ Ca-K image
- ☐ EUV image
- ☐ H-alpha image
- ☐ Hard X-ray image
- ☐ He 10830 image
- ☐ Na-D image
- ☐ Soft X-ray image
- ☐ UV image
- ☐ White-light image

Magnetogram

- ☐ Full-disk magnetogram
- ☐ LOS magnetogram
- ☐ Vector magnetogram

Spectrum

- ☐ EUV Spectrum
- ☐ IR Spectrum
- ☐ UV Spectrum
- ☐ Visible Spectrum

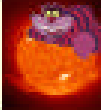
Search and Selection

- Or by combination of search methods

VSO Time / Provider / Spectrum Search Form

http://vso.nascom.nasa.gov

Apple News science SOHO NASA SDAC senior review

 VSO Time / Provider / Spectrum Search Form
Version 1.0 

Start Date/Time: 2005 Apr 13 / 22 : 00
End Date/Time: 2005 Apr 14 / 01 : 59

Provider : Source : Instrument Drilldown

Select a name to expand the list

- ☐ HANET (H-alpha Network (Big Bear Lake))
- ☐ HAO (High Altitude Observatory (NCAR))
- ☐ MSU (Montana State University)
- ☐ NSO (National Solar Observatory)
- ☐ OBSPM (Departement d'Astronomie Solaire de l'Observatoire de Paris)
- ☐ OVRO (Owens Valley Radio Observatory)
- ☐ SDAC (Solar Data Analysis Center (NASA))
- ☐ SHA (Stanford Helioseismology Archive)

Spectral Range

- ☐ soft X-rays [0.1 - 20 keV]
- ☐ extreme UV [50 - 500 Å]
- ☐ ultraviolet [800 - 3500 Å]
- ☐ visible [3000 - 9000 Å]
- ☐ OR select wavelength range:

min
max

Example



VSO at vso.nascom.nasa.gov is searching for solar data that meet the following criteria:

Time

Start 5 Feb 2005 13:00:00
End 5 Feb 2005 13:59:00

Wave

Wave Unit Angstrom
Wave Minimum 100
Wave Maximum 2000

Physical Observable

Intensity

1101001010010

- Search by:
- Time interval (default)
- Nickname = EUV image (wavelength range)
- Physical Observable = Intensity

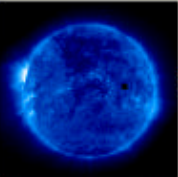
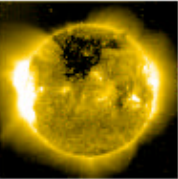
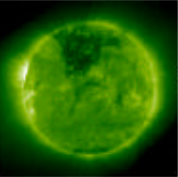
Search results

New Search

10 Records Found
SDAC
10 Returned

Sort Only | Rearrange only |
Sort & Rearrange

Views: Basic | Thumbs | Links | Long

☐ Thumbnail	☐ Time Start	☐ Time End	☒ Min WaveLength	☐ Max WaveLength	☐ Wave Type	☐ Observable	☐ Source	☐ Instrument	☐ Extent
☐	2005.02.05 12:45:57	2005.02.05 13:15:31	346.22 Å	631.33 Å	N/A	intensity	SOHO	CDS	N/A
☐ 	2005.02.05 13:00:14	2005.02.05 13:00:26	171.00 Å	171.00 Å	N/A	intensity	SOHO	EIT	N/A
☐ 	2005.02.05 13:06:09	2005.02.05 13:08:11	284.00 Å	284.00 Å	N/A	intensity	SOHO	EIT	N/A
☐ 	2005.02.05 13:13:50	2005.02.05 13:14:02	195.00 Å	195.00 Å	N/A	intensity	SOHO	EIT	N/A
☐	2005.02.05 13:15:38	2005.02.05 13:45:11	346.22 Å	631.33 Å	N/A	intensity	SOHO	CDS	N/A
☐ 	2005.02.05 13:19:42	2005.02.05 13:20:14	304.00 Å	304.00 Å	N/A	intensity	SOHO	EIT	N/A

Select Check Criteria
Check/Uncheck ...
☐ All Above this box
☐ All Below this box
☒ Just this box
...

- Shopping cart: data request
- Delivery method (depends on data provider): e-mail or link

The Brazilian Virtual Solar Observatory

- Multi-frequency data from different Observatories: 12, 22, 48, 212 & 405 GHz;
- Probe different heights in the atmosphere: emission at higher radio frequencies originate deeper than that at lower freqs. – determine temperature and density of various layers of the solar atmosphere;
- Time profiles of flux density for flares;
- Flare spectra: emission mechanism, energetic particle population, magnetic field, etc;
- Maps/images: active regions, limb brightening, coronal holes, etc.

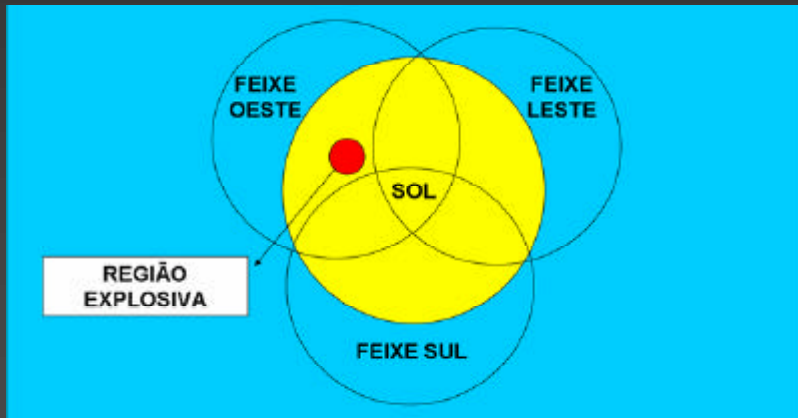
Database

Database – 12 GHz

- Radio Observatory of Itapetinga (ROI), in Atibaia, SP;
- Patrol telescope;
- Flux density of solar flares and position in heliographic coordinates daily from 11 - 19 UT;
- Temporal resolution of 100 ms, spatial resolution of 30 arcsec, and sensitivity of 1 sfu;
- Real time international alert for microwave burst occurrence.

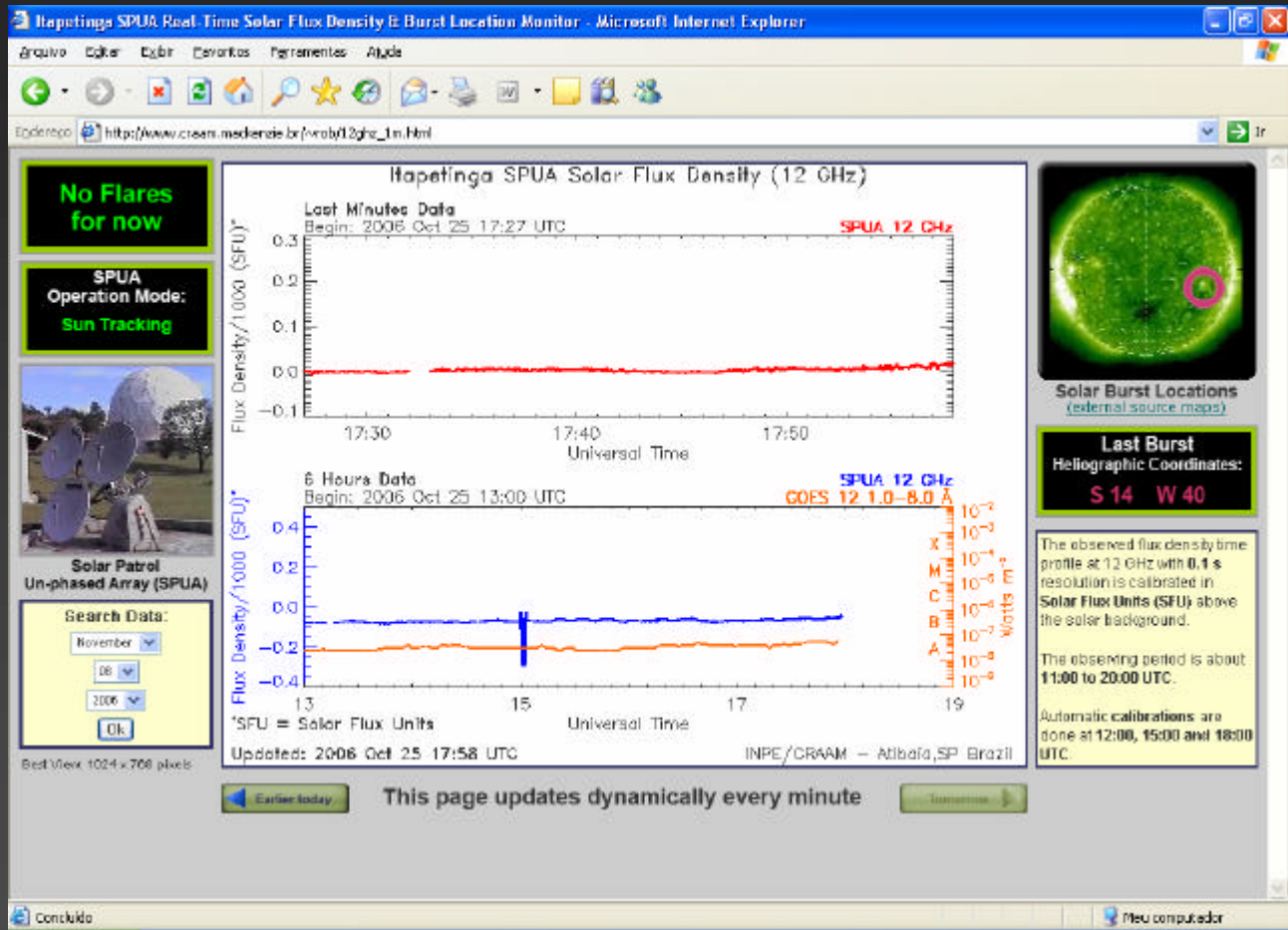


Burst location – 12 GHz



- Measured flux density in the three antenna allows for location of the burst.
- Information used for pointing of other telescopes for burst observation.

SPUA



- Solar Patrol Un-phased Array
- Monitoring and alert of solar bursts at 12 GHz
- www.craam.mackenzie.br/~rob/12ghz_1m.html

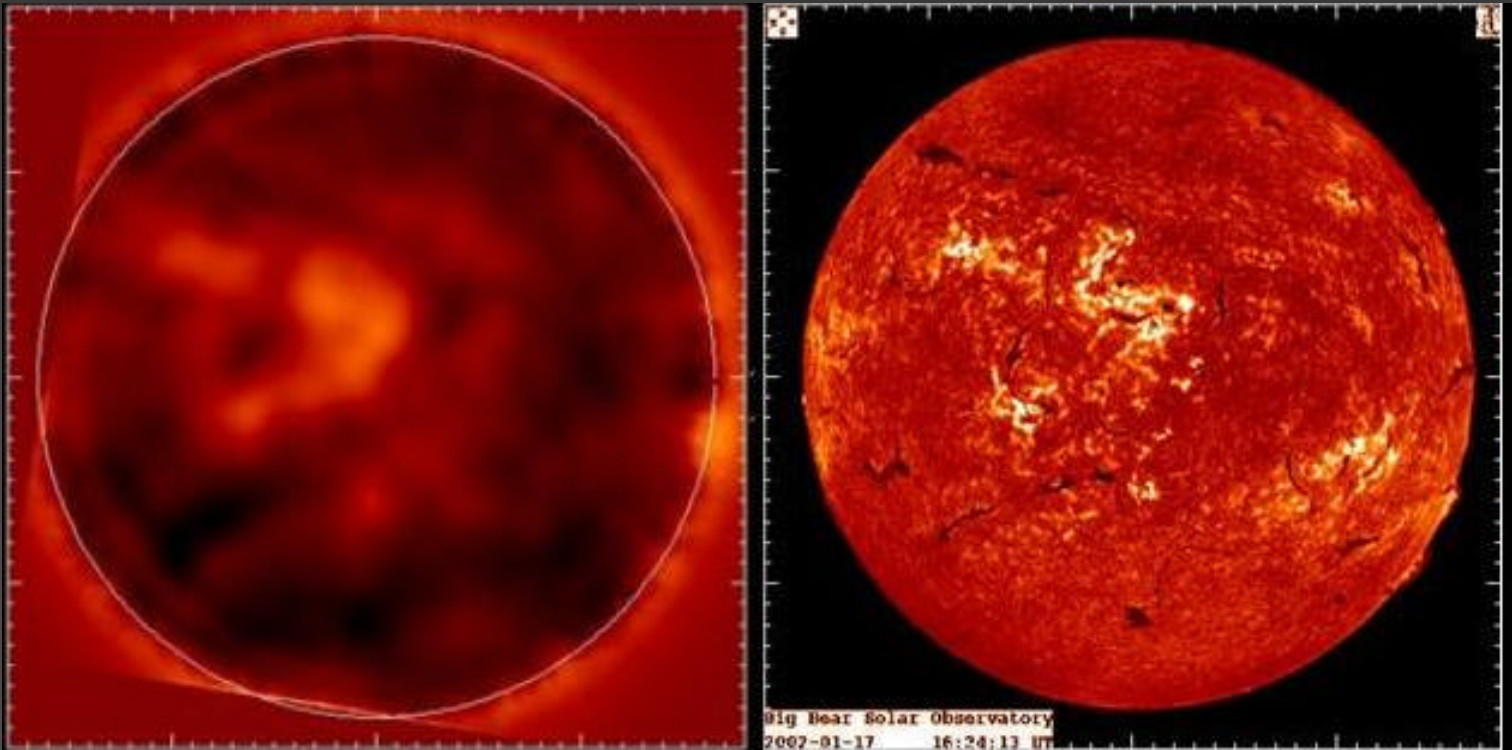
Database – 22 & 48 GHz

- ROI (Atibaia, SP)
- Observing campaigns
- Flux density of solar flares with 0.01 sfu sensitivity and temporal resolution of 1 ms.



Maps/Images – 22 & 48 GHz

- Maps at both frequencies composed of raster scans
- Images of the solar chromosphere: observe bright active regions and dark coronal holes.



Database – 212 & 405 GHz

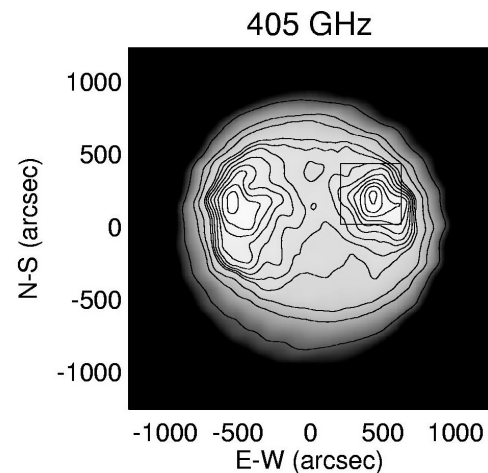
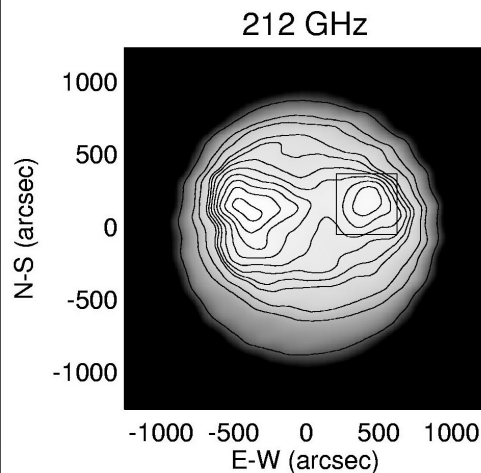
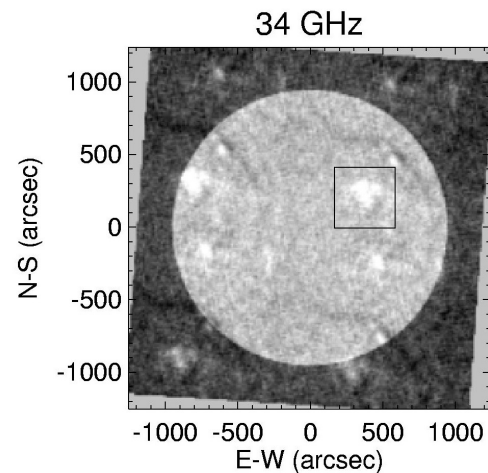
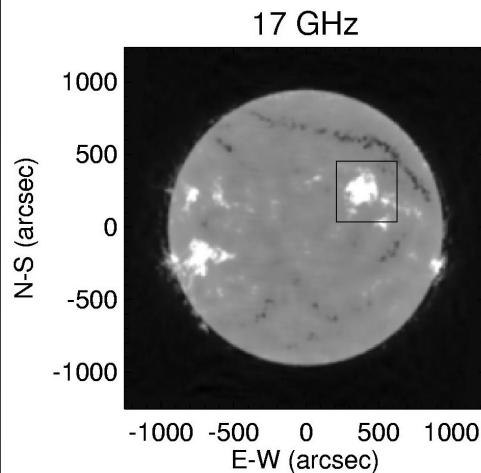
- Submm Solar Telescope (SST), at CASLEO Obs.
 - Argentina at 2500 m
- Since 1999
- Flare observations and daily maps of the Sun
- 4 receivers at 212 GHz and 2 receivers at 405 GHz
- 5 ms temporal resolution



Solar maps – 212 & 405 GHz

(Silva et al. 2006)

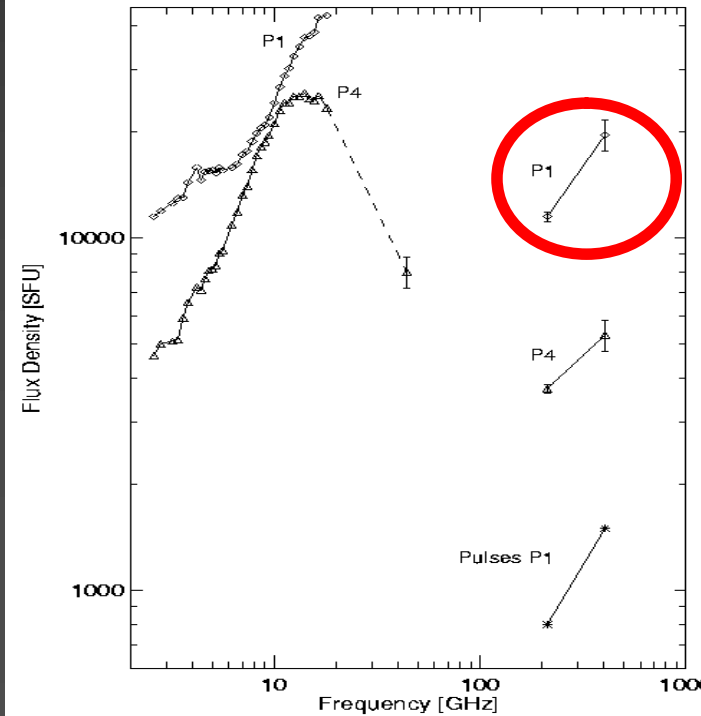
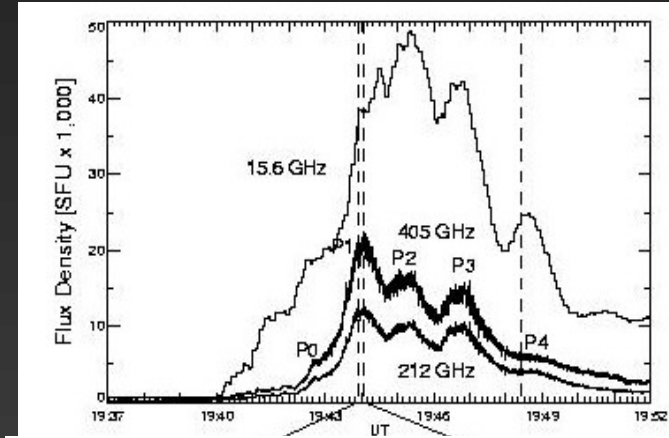
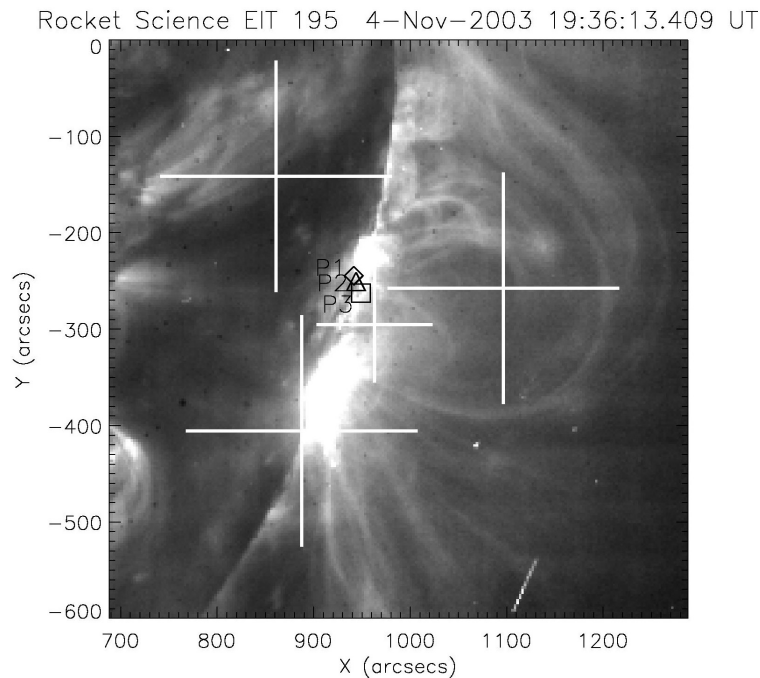
- 4500 Solar maps at each frequency;
- Study:
 - Quiet Sun's atmosphere
 - Active regions
- Improve models of the atmosphere;
- Infer magnetic fields of AR.



Flare – 212 & 405 GHz

(Kaufmann et al. 2004)

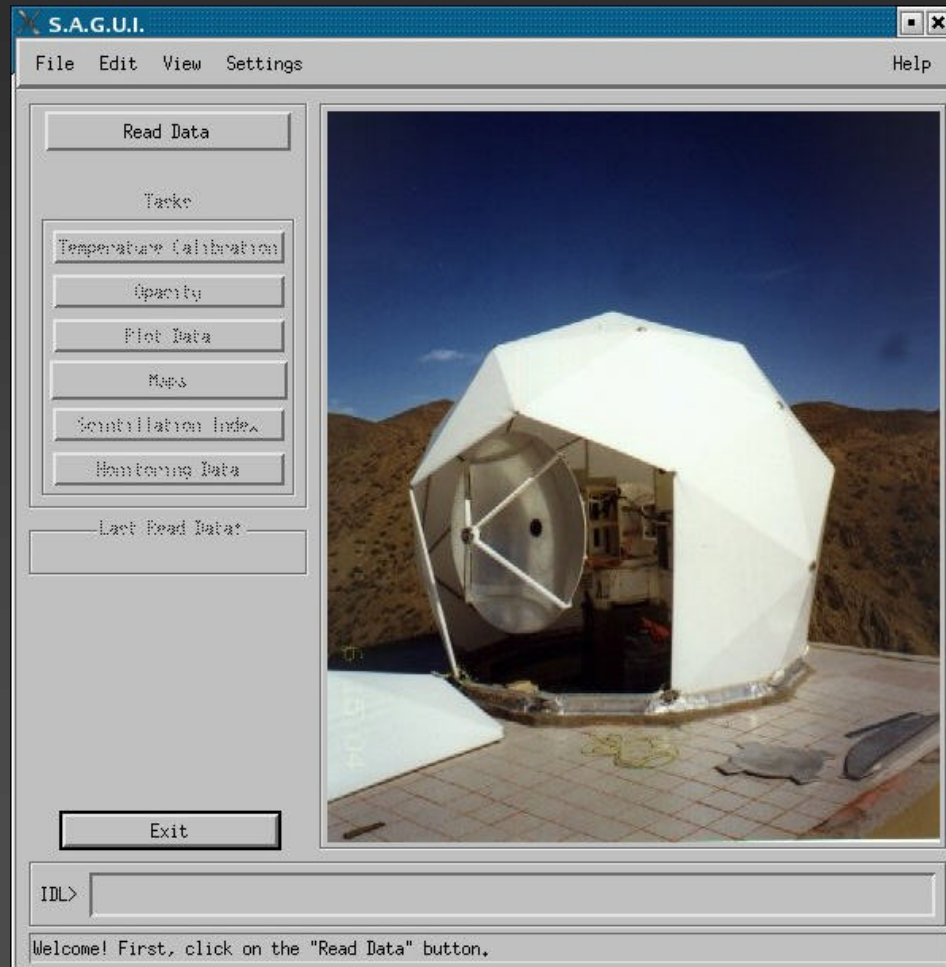
- Time profile – evolution
- Spectra – emission mechanism
- Position (centroid)



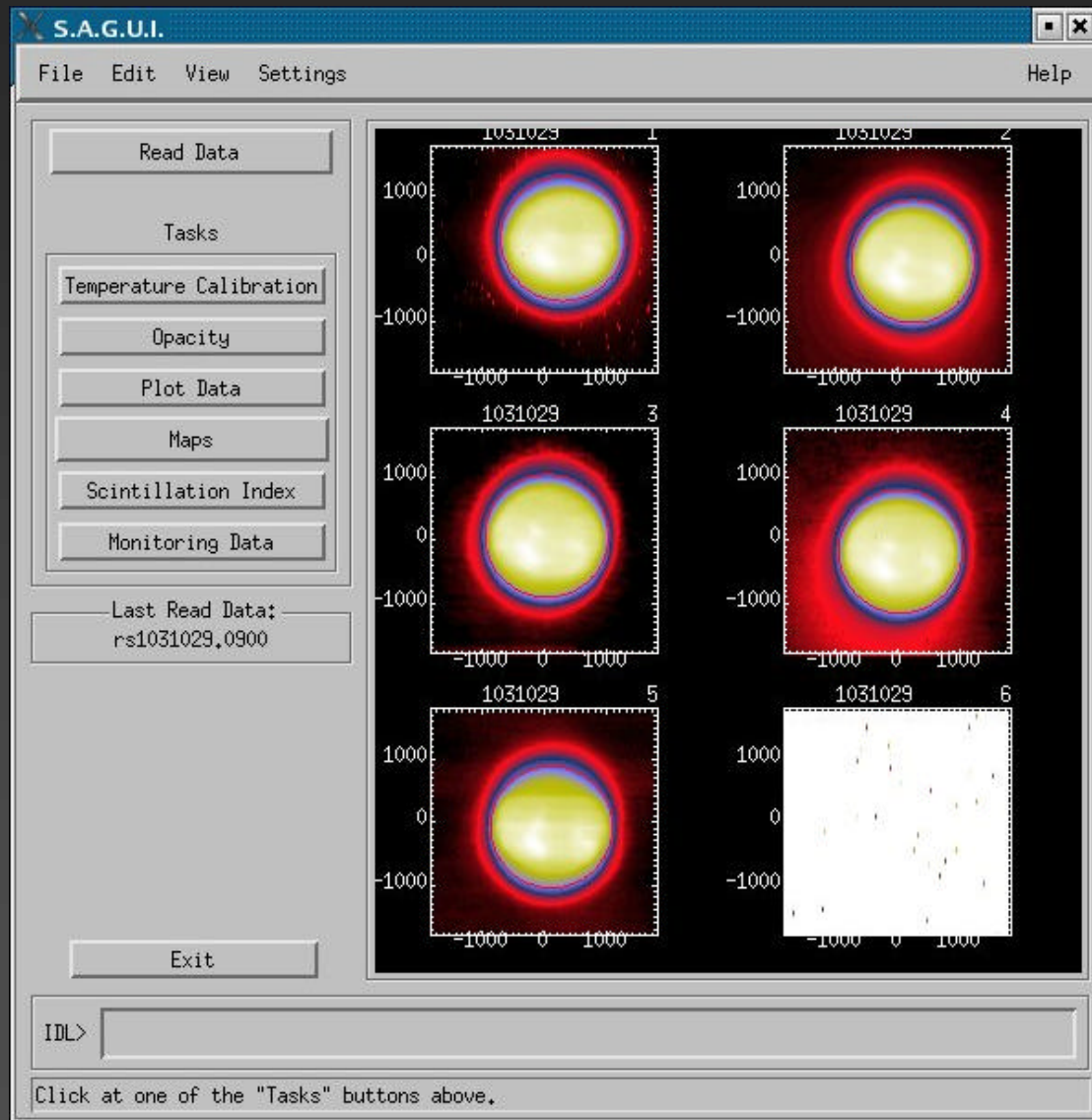


S.A.G.U.I.

- Solar Analysis Graphical User Interface
- Software developed for data visualisation, extraction, and calibration.
- Data from ROI and SST.

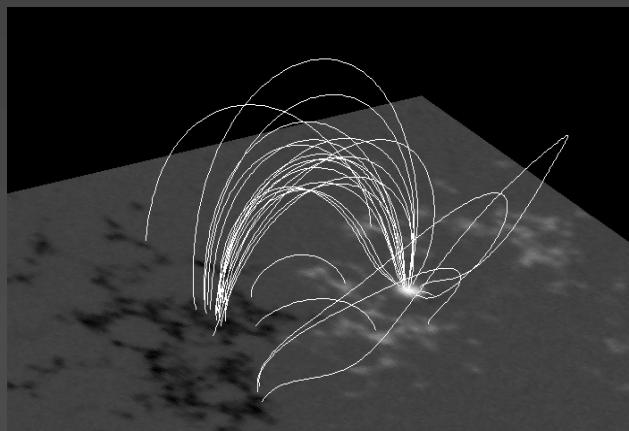
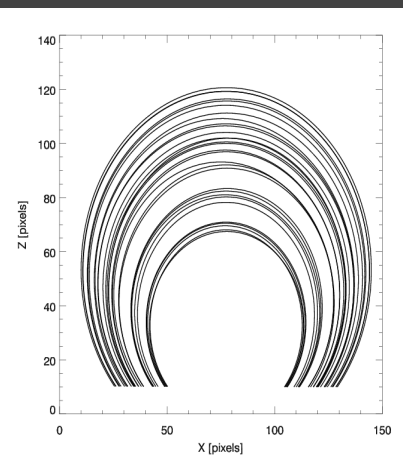
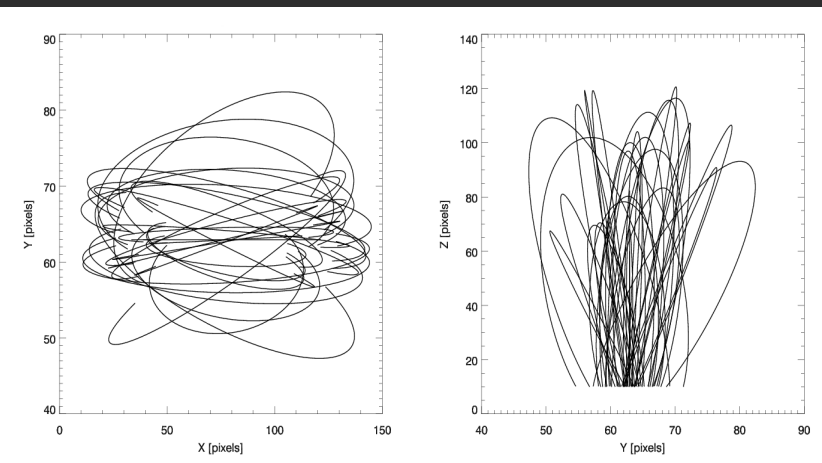


Solar Maps



Applications

1) Magnetic field topology

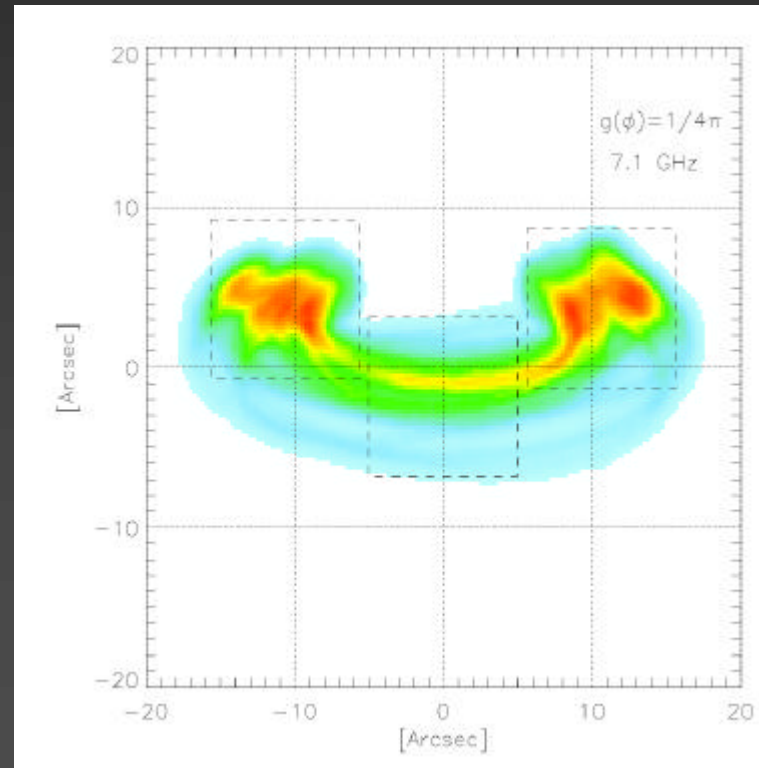


- Extrapolation of chromospheric/coronal magnetic field lines
- From photospheric line-of-sight magnetograms from MDI/SOHO.

2) Flare spectra

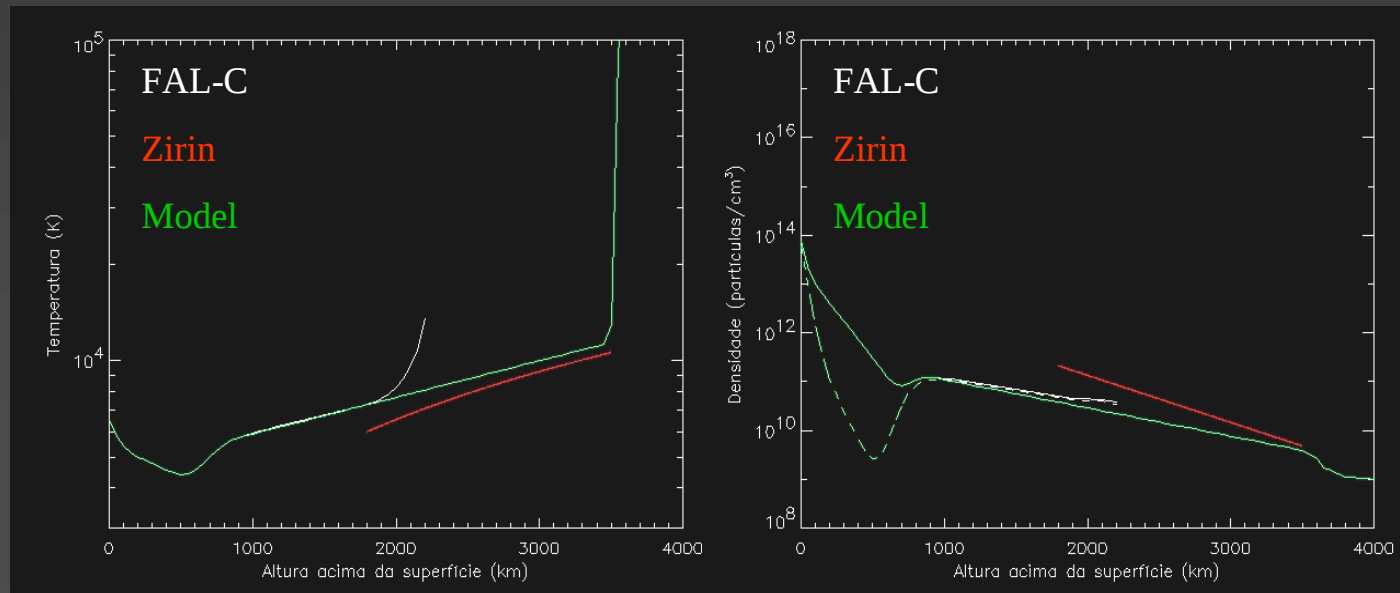
- Spectral analysis of microwave cm-mm solar bursts with gyro-synchrotron emission from general energy/pitch angle distributions.
- Thermal relativistic and non-thermal (simple or multi-power law) energy distribution is included.
- Radiation transfer is included in 3D topology of the magnetic field.

(Simões and Costa 2006)



3) Model of the solar atmosphere

- Temperature and density distributions
- Based on 17 GHz maps from NoRH (Japan): measurement of the radius and limb brightening.
- Extend and improve the model including maps at 22, 48, 212, and 405 GHz.



The Brazilian Virtual Solar Observatory

- Database:
 - Multi-frequency data from different observatories: 12, 22, 48, 212 & 405 GHz;
 - Time profiles of flux density for flares;
 - Maps/images of the Sun.
- Application:
 - Magnetic field reconstruction;
 - Flare spectra;
 - Solar atmosphere model.