



# Goldstone Apple Valley Radio Telescope (GAVRT) Solar Patrol as a New Citizen Scientist Program in the Era of the Parker Solar Probe (PSP) and a Gateway to NASA Heliophysics Missions



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## GAVRT Program

- Unique partnership between NASA, JPL and the Lewis Center
- Participants control decommissioned NASA DSN 34-m antenna for science education
- K-12 students and teachers partner with scientists to conduct cutting edge scientific research.

\*Also see GAVRT poster: ED55D-0313

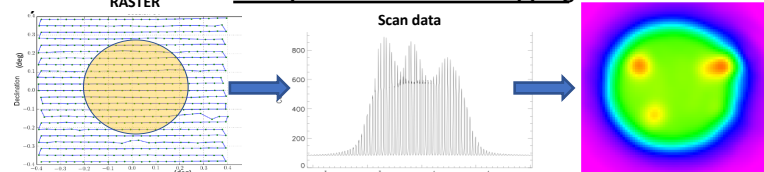


GAVRT Antenna DSS-28 at Goldstone, CA

## GAVRT Solar Patrol

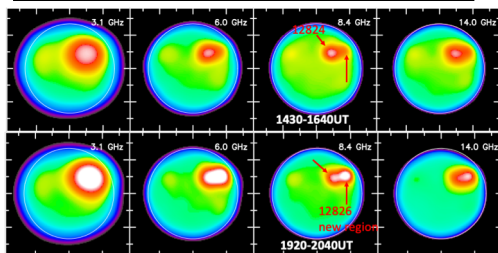
- New opportunity to engage citizen scientists outside of K-12 schools, using ROSES 2020 Citizen Science seed funding
- Radio images of the Sun provide information about structure of the solar atmosphere including corona, transition region, and upper chromosphere
- Conducts daily observations producing maps of Sun in left & right circular polarization at four frequencies (between 3 GHz and 14 GHz)
- Covers gyroresonance regime of solar radio emission
- Daily maps include data +/-30 days of Parker Solar Probe perihelion on April 29 and November 21 2021

## Example of Raster Scan Mapping



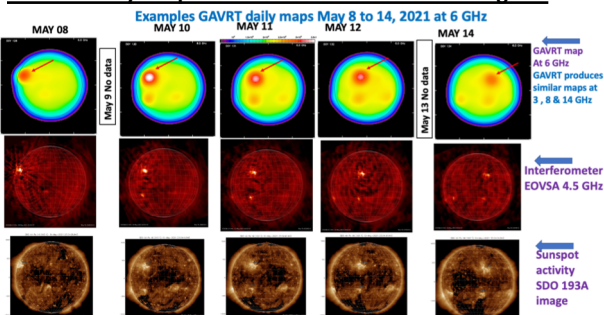
- GAVRT Solar Patrol conducts raster scans to generate radio maps of the Sun
- Students control GAVRT antenna remotely to take scans across the Sun (top left)
- Raster scan data (top middle) recorded as counts changing with time as the telescope moves across the Sun
- The raster time-counts data are gridded on to 2-D map grid to produce radio image of sun (top right) that you can “see” which eyes cannot see.
- Example shown is for one frequency (6 GHz) left polarization. Radio maps are generated simultaneously at four frequencies in two polarizations (see maps from November 9, 2021 below)

## GAVRT Detected Emerging New Active Region



Example of events of particular interest to citizen scientists: New bright active region appeared within just a few hours

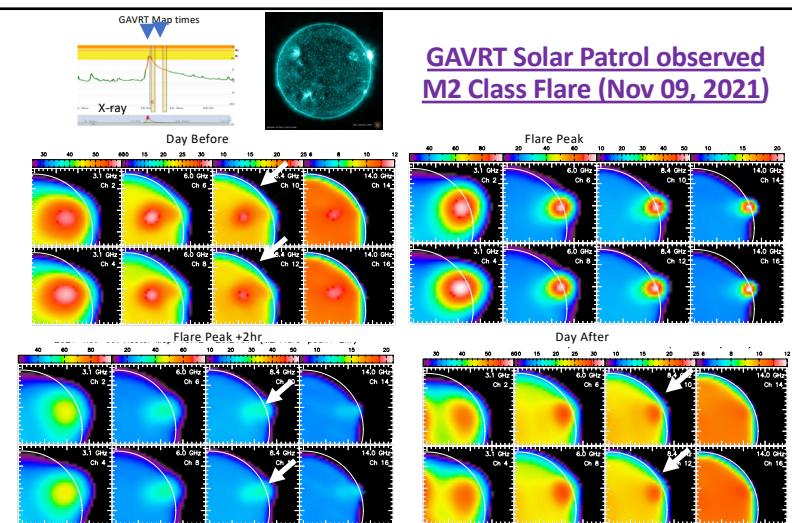
## GAVRT Daily Maps Track Evolution of Active Regions



GAVRT daily, multi-frequency, radio maps are excellent resource for citizen scientists to engage in identifying and monitoring evolutionary changes in solar activity (for example, see region marked by arrow in top panels)

## Opportunities for Citizen Scientist

- Our team offers mentoring to interested citizen scientists
- **Routine observation & processing**
  - Take raster scan data & make 2-D maps of Sun
  - Identify & track regions of interest (above sunspots) as they move across solar disk
  - Compare maps from different frequency channels
- **Special Events: Example of Nov 09, 2021 M2 Flare**
  - Use GAVRT Solar Patrol maps to analyze flare, pre-/post-flare energetics
  - Subtract quiet Sun disk and limb for detailed analysis
  - Spectral analysis of flux density, peak brightness, size, and polarization RCP/LCP (magnetic field)
  - Excellent opportunity to combine GAVRT single dish map with EOUSA interferometer map, to take advantage of GAVRT’s measurements of large scale structures and total flux and EOUSA’s higher resolution & small scale structures
  - Follow up multi-wavelength studies combining image data from ground and space along with magnetograms
  - Ground based radio data support to Parker Solar Probe (PSP) data analysis. This flare occurred during PSP perihelion E#10.
  - Finally, pursue M2 flare event and its impact on space weather



## GAVRT Solar Patrol observed M2 Class Flare (Nov 09, 2021)

Brightness temperature maps for the frequencies 3.1 GHz to 14 GHz (left to right); Arrows mark flare location  
Shown are Right Circular Polarization (top panels) and Left Circular Polarization (lower panels)  
For clarity, only maps of the north-west quadrant of the Sun are shown

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