

The H II Region Discovery Survey

Dana S. Balser

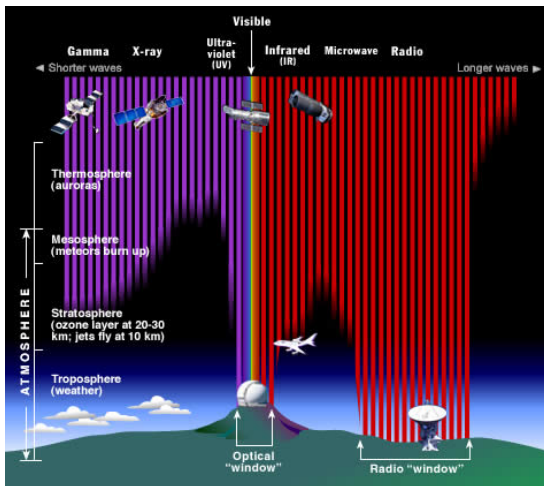
National Astronomy Radio Observatory

Texas A&M University-Commerce

29 March 2018



Radio Astronomy

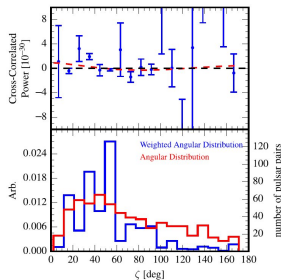
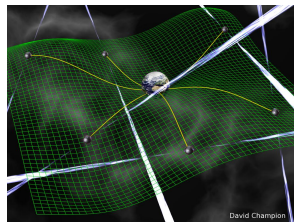
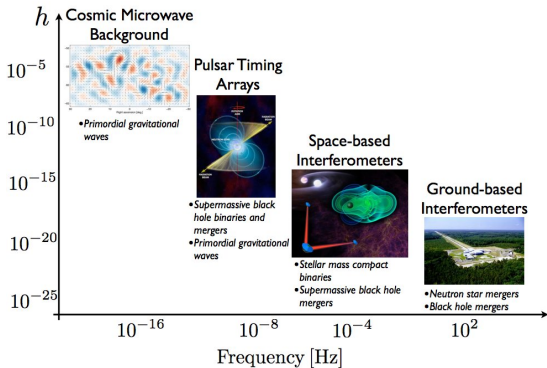


Green Bank Telescope (GBT)



- 100 m unblocked aperture
- Frequency coverage: 0.1 – 100 GHz (3 m–3 mm)
- Spatial resolution: 7 arcsec at 100 GHz

GBT: Gravitation Waves (NANOGrav)



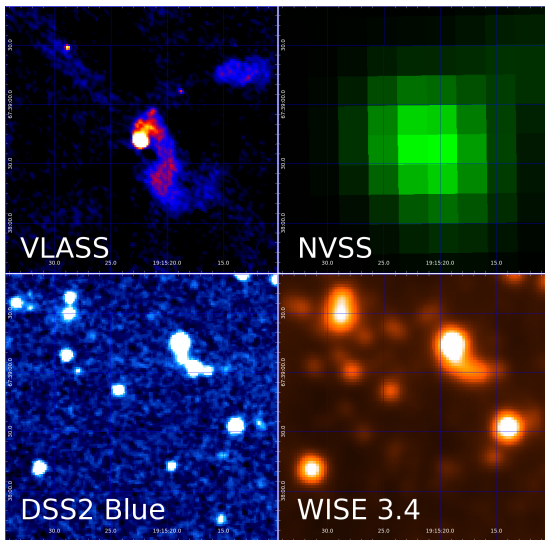
NANOGrav; Arzoumanian+ (2016)

Very Large Array (VLA)

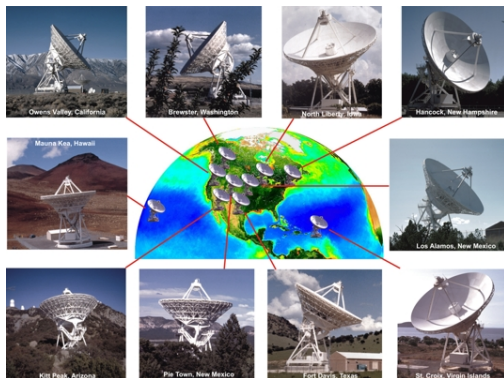


- Twenty-seven 25 m antennas
- Frequency coverage: $\sim 1 - 50$ GHz (30 cm–6 mm)
- Spatial resolution: 43 mas at 50 GHz (36 km baseline)

VLA Sky Survey

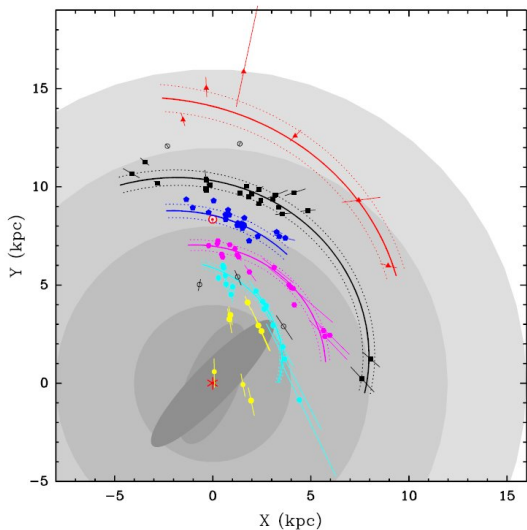


Very Long Baseline Array (VLBA)



- Ten 25 m antennas
- Frequency coverage: $\sim 1 - 100$ GHz (30 cm–3 mm)
- Spatial resolution: 0.1 mas at 100 GHz (8000 km baseline)

VLBA: Bar and Spiral Structure Legacy Survey



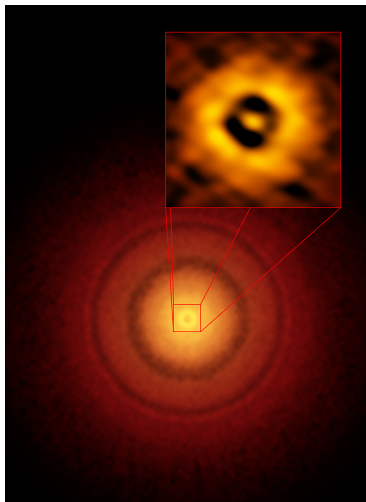
Reid+ (2014)

Atacama Large Millimeter/submillimeter Array (ALMA)



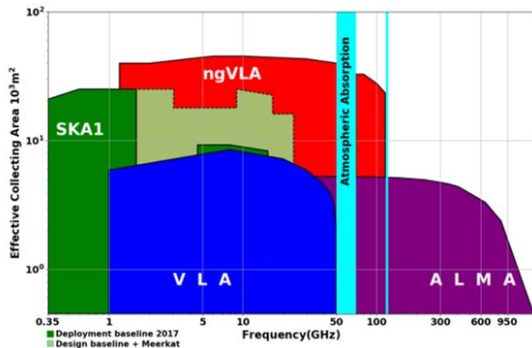
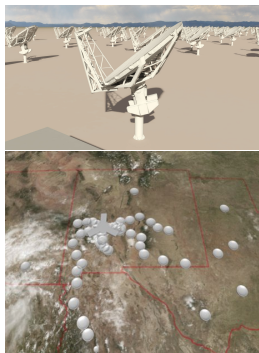
- 12 m Array: fifty 12 m; ACA: twelve 7 m + four 12 m
- Frequency coverage: $\sim 100 - 1000$ GHz (3 mm–300 μm)
- Spatial resolution: 20 mas at 230 GHz (16 km baseline)

ALMA: Planet Formation (TW Hydrae)



S. Andrews (Harvard-Smithsonian CfA), ALMA (ESO/NAOJ/NRAO)

Next-Generation VLA (ngVLA)



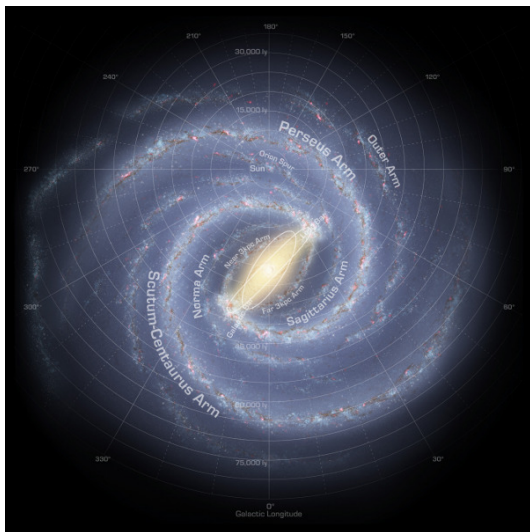
- 214 18 m offset antennas
- Frequency coverage: $\sim 1 - 100$ GHz (30 cm–3 mm)
- Spatial resolution: 4 mas at 100 GHz (1000 km)

The H II Region Discovery Survey (HRDS)



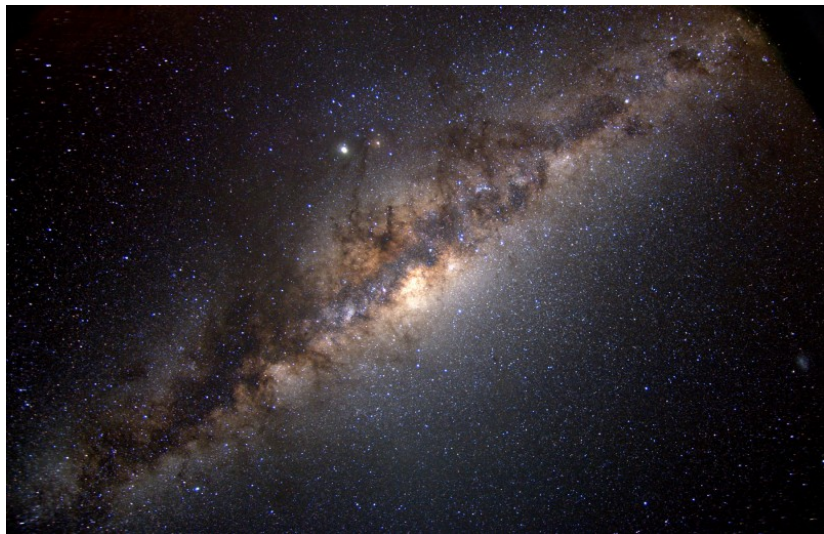
Collaborators: **L.D. Anderson (WVU)**, W.P. Armentrout (WVU), **T.M. Bania (BU)**, J.R. Dawson (CSIRO), **John. M. Dickey (UT)**, C. Jordan (ICRAR), N.M. McClure-Griffiths (ANU), **Trey V. Wenger (UVa/NRAO)**.

Motivation: Milky Way \rightarrow Cartoon!!!



NASA/JPL-Caltech/R. Hurt

Motivation: Milky Way



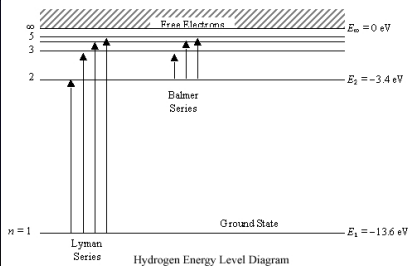
NASA/APOD Acknowledgement: Serge Brunier

Motivation: Spiral Structure (Lord Rosse 1845)



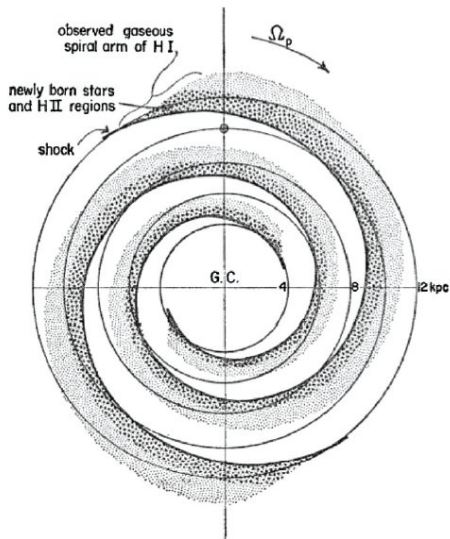
M51 (Whirlpool Galaxy), NASA/ESA

Motivation: H II Regions: Orion Nebula



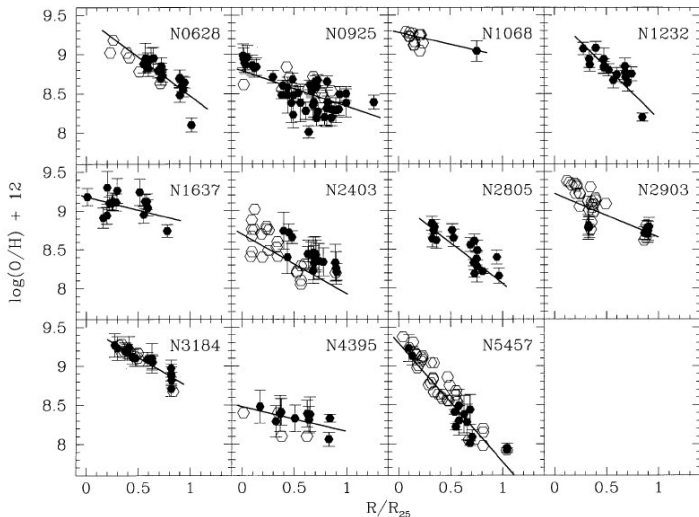
Bill Schoening, KPNO 4 m telescope, October 1st 1973; Gary (NJIT)

Motivation: Spiral Density Waves



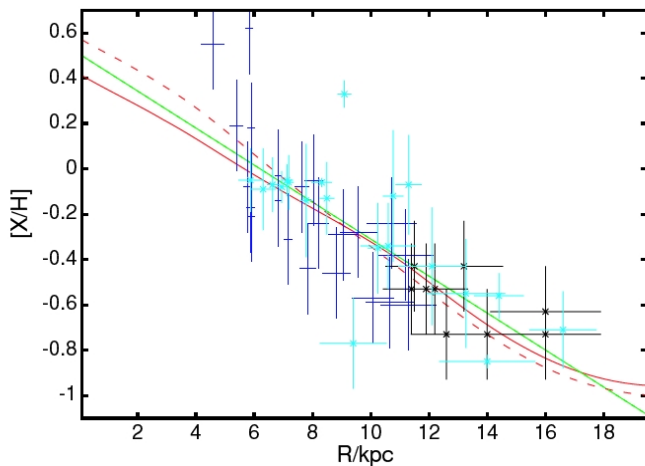
Roberts (1969)

Motivation: Chemical Structure (Searle 1971)



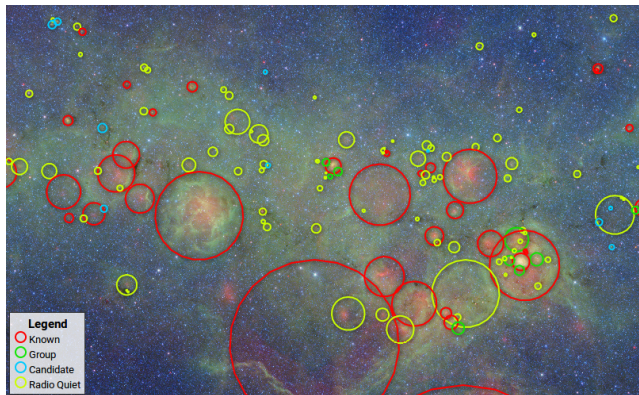
van Zee+ (1998)

Motivation: Chemodynamical Models



Schörrich & Binney (2009)

WISE Catalog of Galactic H II Regions



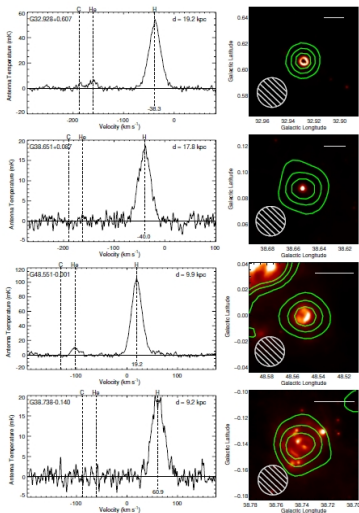
- > 8000 H II regions and H II region candidates
- Co-incident $12\ \mu\text{m}$ (PAH), $22\ \mu\text{m}$ (warm dust) and 20 cm (free-free)

Anderson+ (2014)

HRDS: Northern Sky

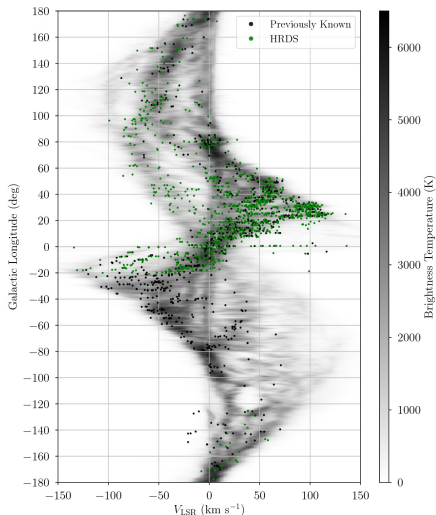


- GBT + Arecibo ($\sim 500 + 50$ hr)
- H9 α –H87 α RRLs (8 – 10 GHz)
- Free-free emission
- 1,115 new H II regions (double)



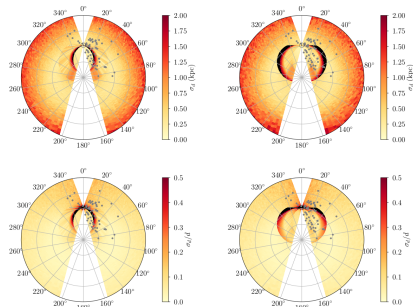
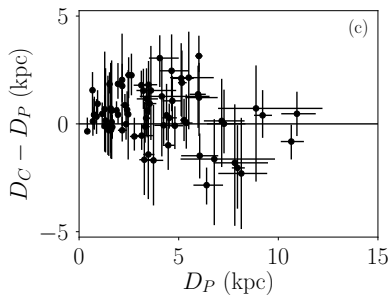
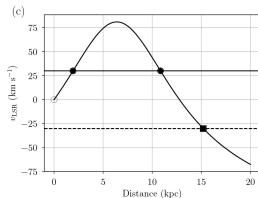
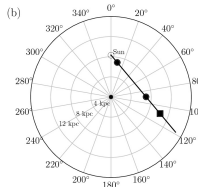
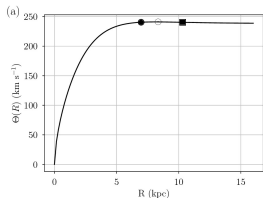
Bania+ (2010), Anderson+ (2011), Bania+ (2012)

HRDS: Longitude-Velocity Diagram

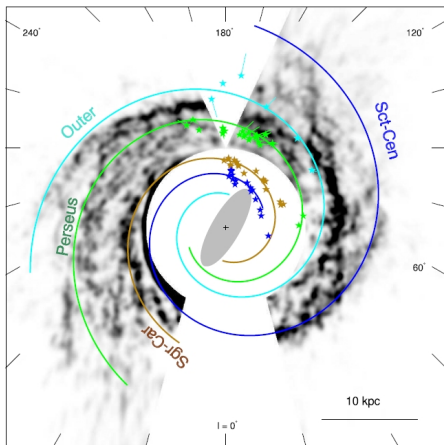
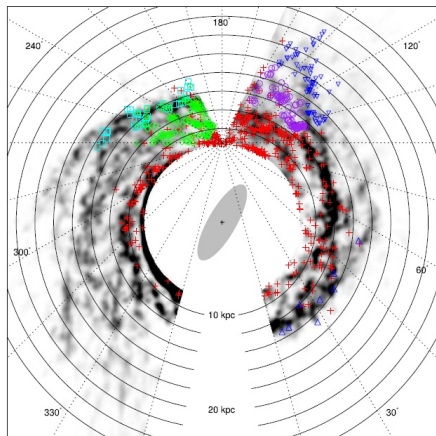


Anderson+ (2014); HI4PI Collaboration (2016)

Kinematic Distances: A Monte Carlo Method

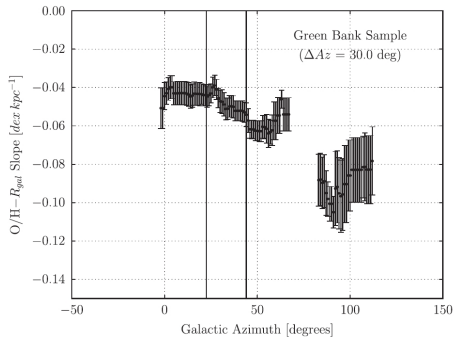
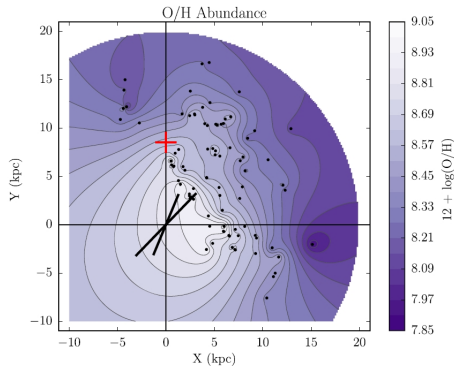


Galactic Spiral Structure



Koo+ (2017)

Galactic Chemical Structure

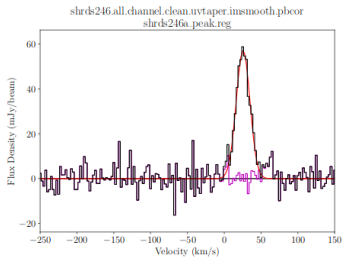
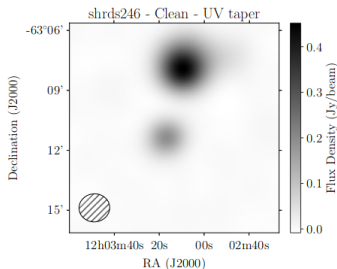


Balser+ (2015)

HRDS: Southern Sky

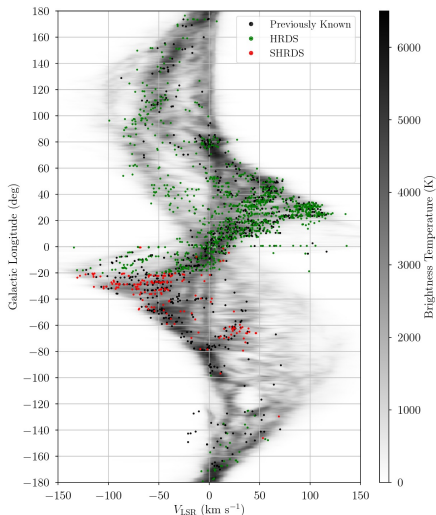


- ATCA ($\sim 600/900$ hr)
- H117 α –H93 α RRLs (4 – 10 GHz)
- Free-free emission
- 163 new H II regions (so far)



Wenger+ (in prep.)

HRDS: Longitude-Velocity Diagram



Wenger+ (in prep.); HI4PI Collaboration (2016)

Summary and Future Work

- Radio astronomy is cool!
- Doubled the number of known H II regions.
- Evidence for four-arm spiral?
- Azimuthal metallicity structure?
- Complete HRDS in the Southern sky.
- Explore Galactic structure across Milky Way disk.