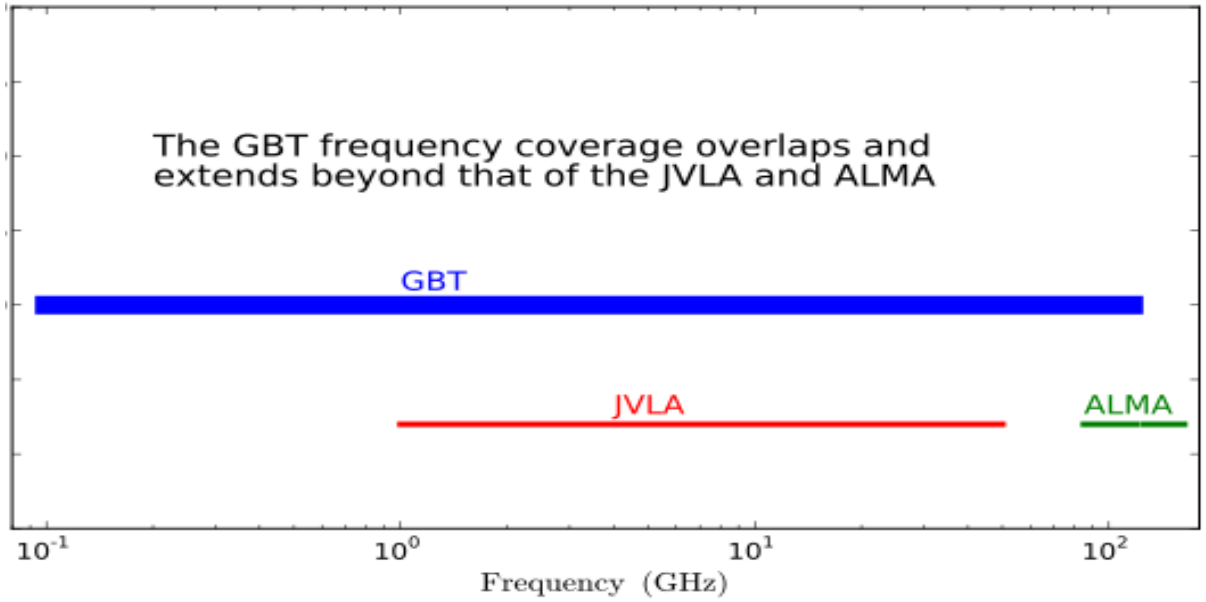
HII Region Metallicity Distribution in the Milky Way Disk

Dana Balser (NRAO)
Loren Anderson (WVU), Tom Bania (BU), & Trey Wenger (UVa)

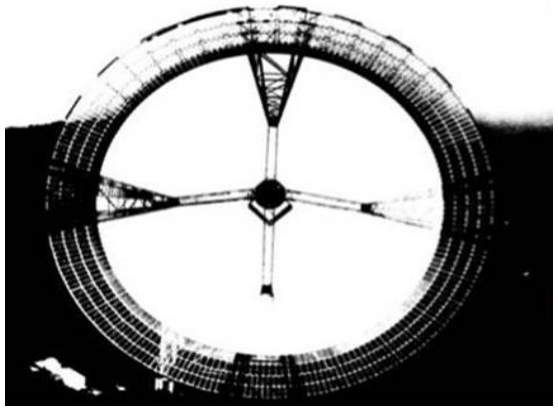
Photo: Harry Morton

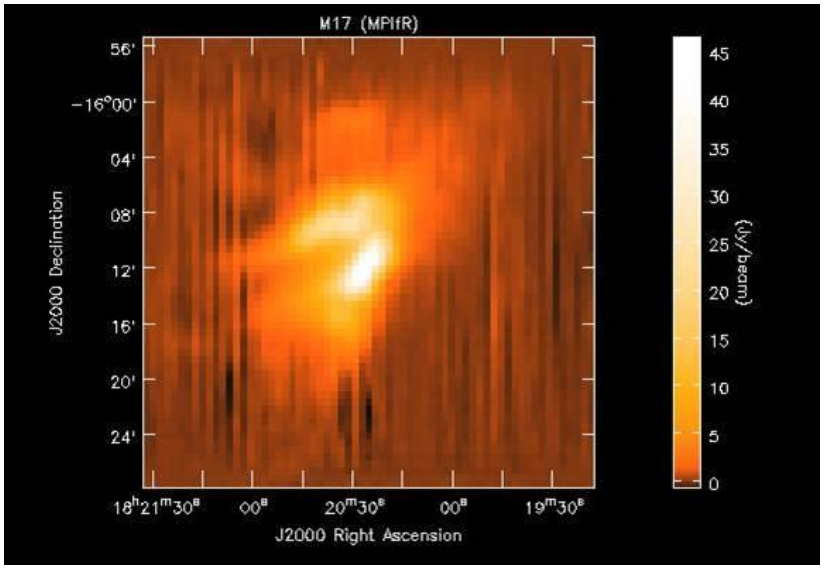
Key Capabilities of the GBT

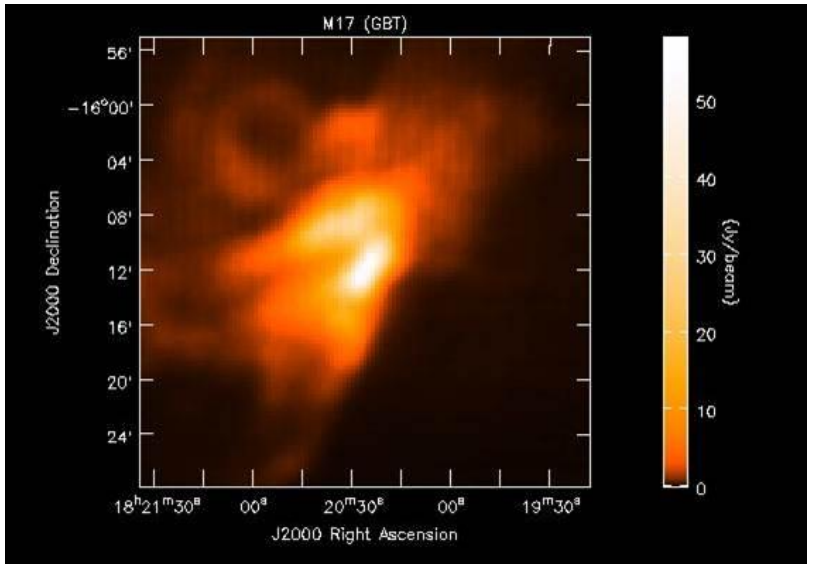
- Receivers cover 0.1 to 100 GHz
- Excellent point-source sensitivity
- Excellent sensitivity for low surface-brightness mapping
- >85% of total sky covered $\delta \geq -46°$
- Location in the National Radio Quiet Zone



Unblocked Optics for High Dynamic Range





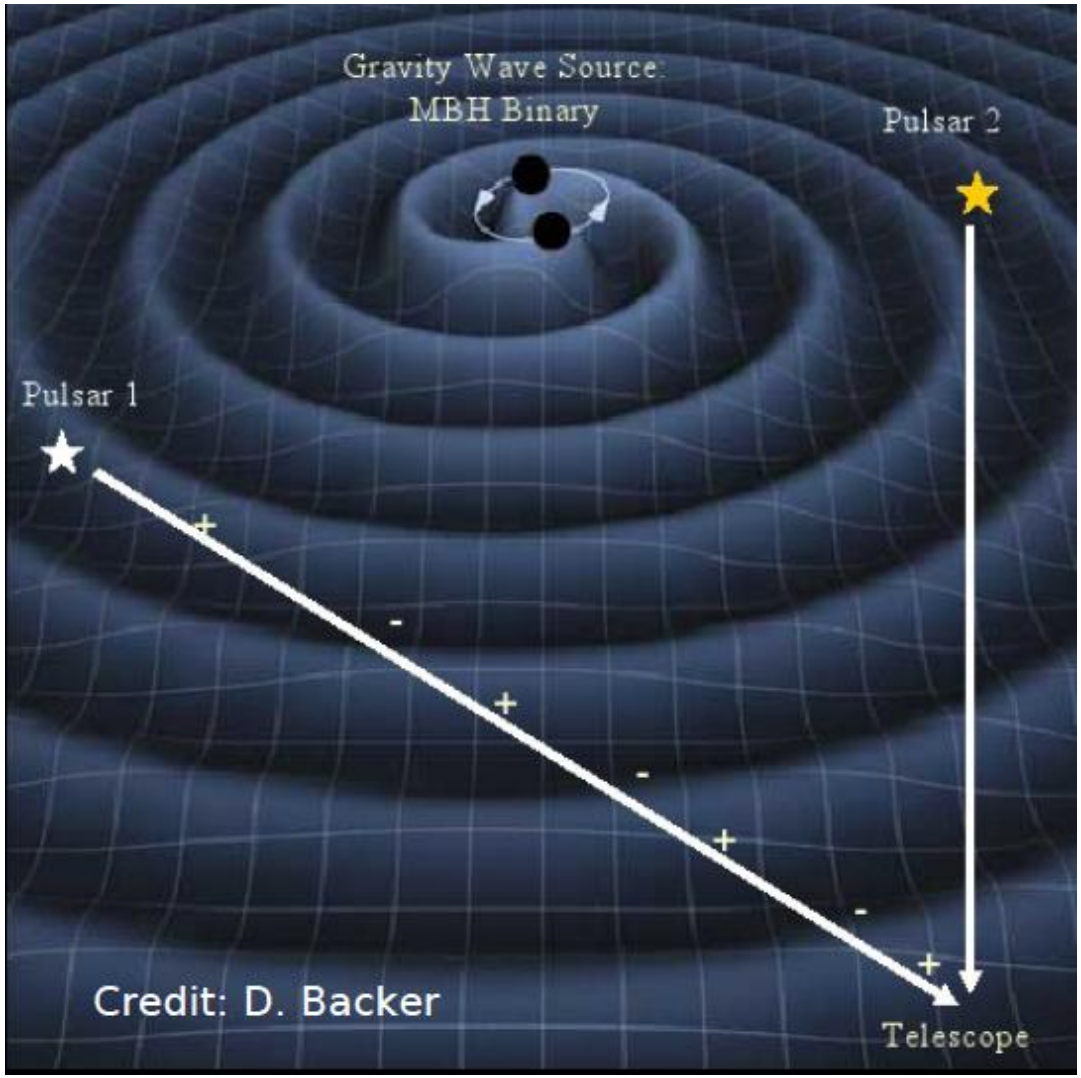


science.nrao.edu/facilities/gbt

Discoveries with the Green Bank Telescope

The Green Bank Telescope (GBT) is used by the scientific community for an extraordinary range of research. This document gives a brief summary of some of the resulting discoveries, with an emphasis on measurements that would be difficult or impossible to make on any other telescope.

Using Pulsars to Detect Gravitational Radiation

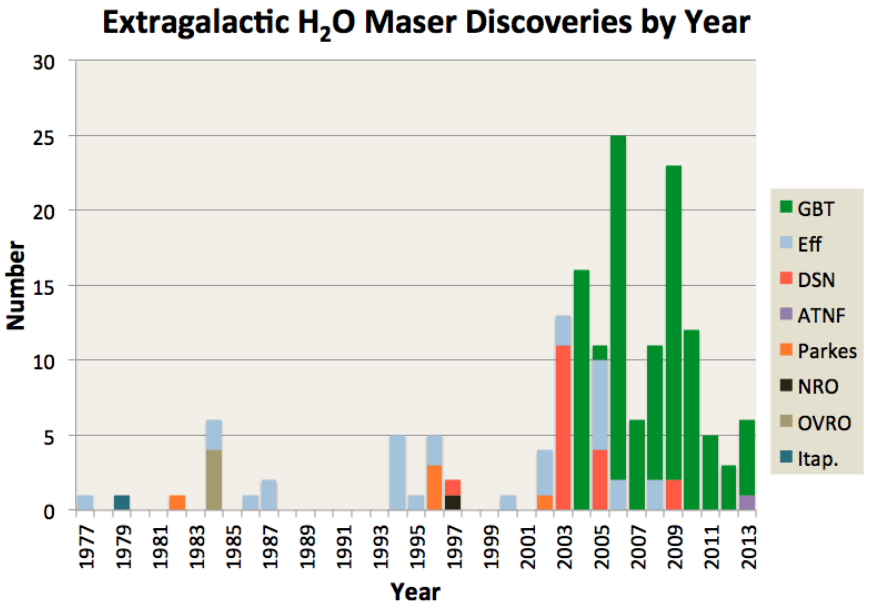


Water Masers in AGN

Mass of the Black Hole
Hubble Constant (Ho)

H2O Masers in
Nuclear Accretion Disks

Discovered by the GBT
Monitored by the GBT
Imaged by the VLBA+GBT



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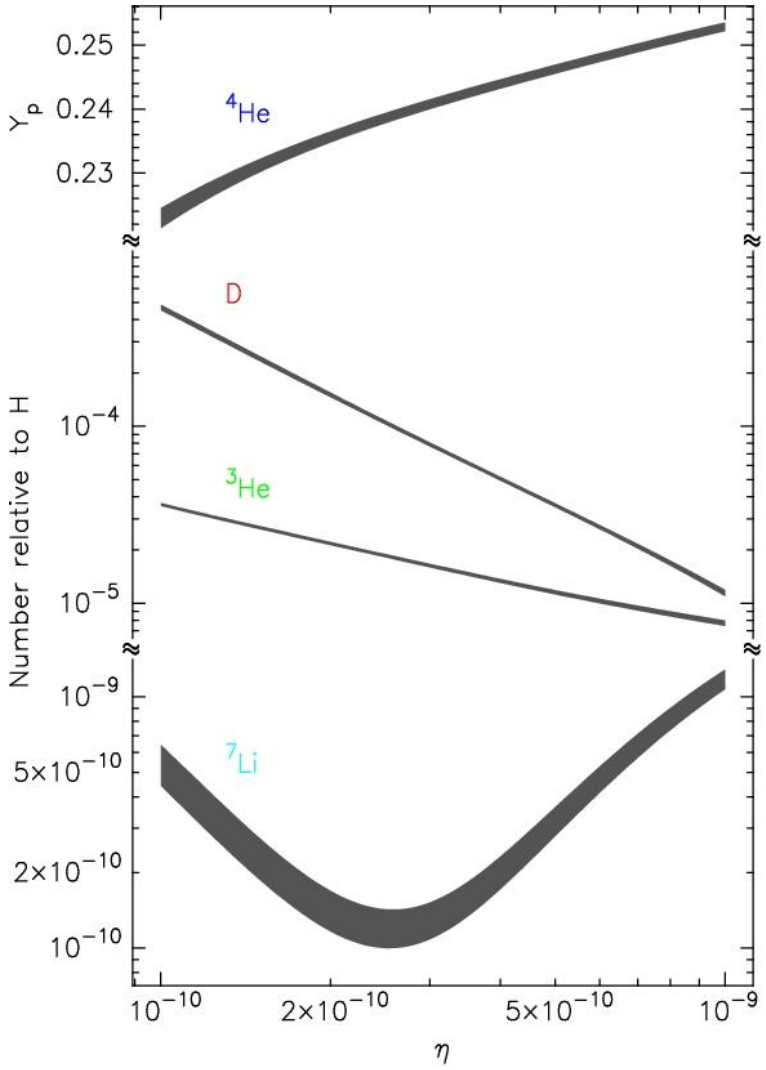
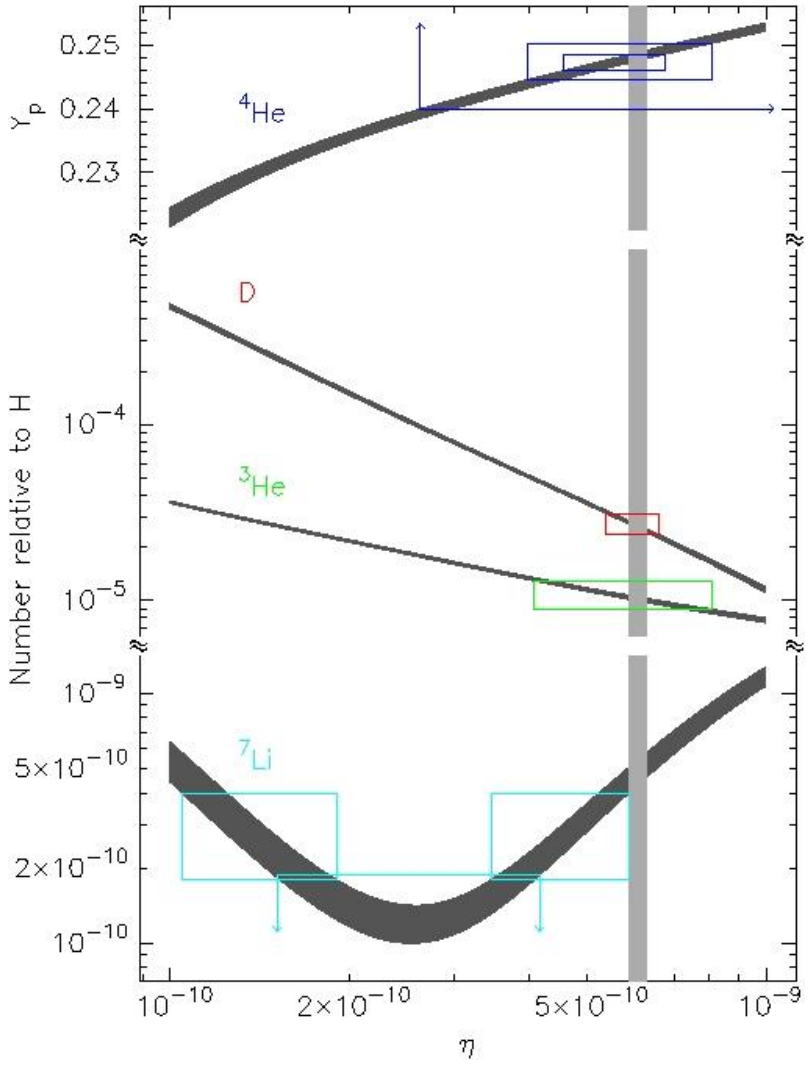
Primordial Nucleosynthesis



Burles+ (2001)

Primordial Abundances



- Izotov+ (2007)
- Peimbert+ (2007)
- Olive & Skillman (2004)

Kirkman+ (2003)

Bania, Rood & Balser (2002)

Ryan+ (2000)
Boesgaard+. (2005)

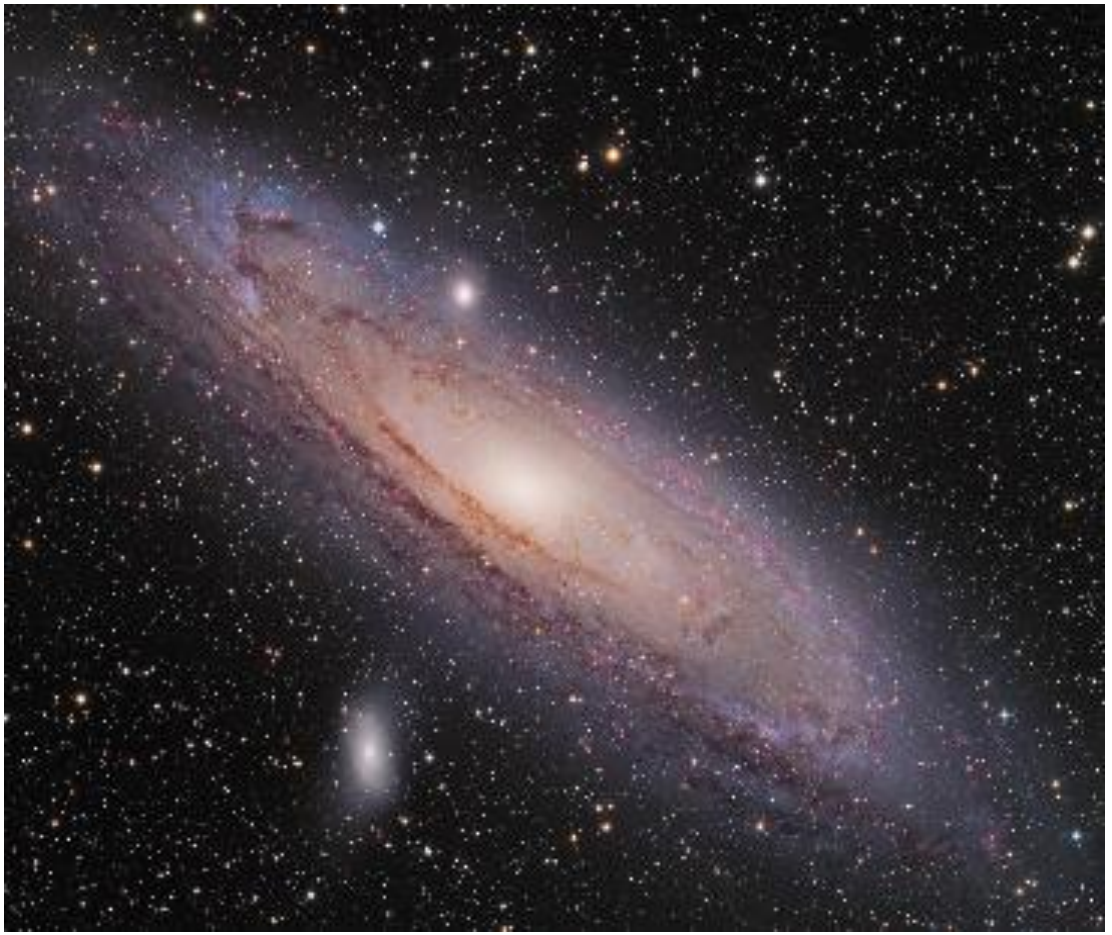
Burles+ (2001)
Spergel+ (2006)

Stellar Nucleosynthesis

Cat's Eye
(NGC 6543)

Corradi &
Tsvetanov

Galaxy Formation and Evolution



Andromeda
(M31)

Martin Pugh

Radial Abundance Gradients

THE ASTROPHYSICAL JOURNAL, 168:327–341, 1971 September 15

EVIDENCE FOR COMPOSITION GRADIENTS ACROSS THE DISKS OF SPIRAL GALAXIES

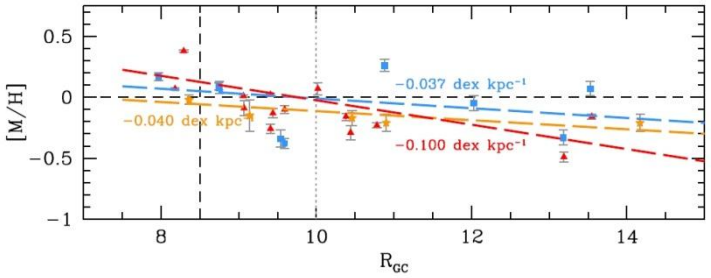
LEONARD SEARLE
Hale Observatories, Carnegie Institution of Washington, California Institute of Technology
Received 1971 April 7

ABSTRACT

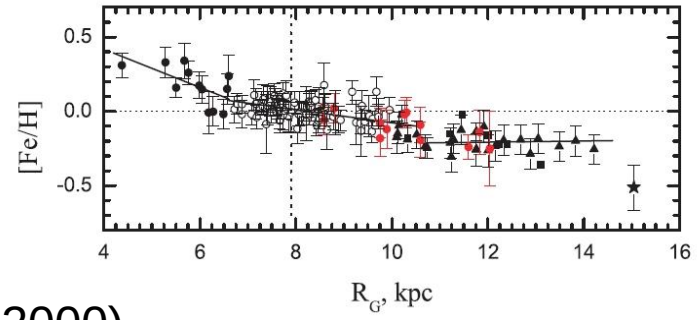
The integrated spectra of H II regions located in the inner spiral arms of Sc galaxies are systematically different from those of H II regions in the outer arms. This is, in part at least, an abundance effect. The N/O ratio (and probably also the abundance ratios O/H and N/H) decreases from the inner to the outer arms.

Abundance Tracers

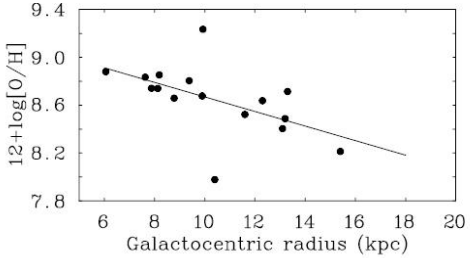
Open Clusters (Frinchaboy+ 2013)



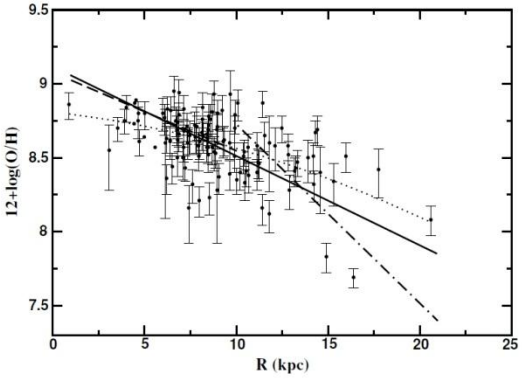
Cepheids (Andrievsky+ 2004)



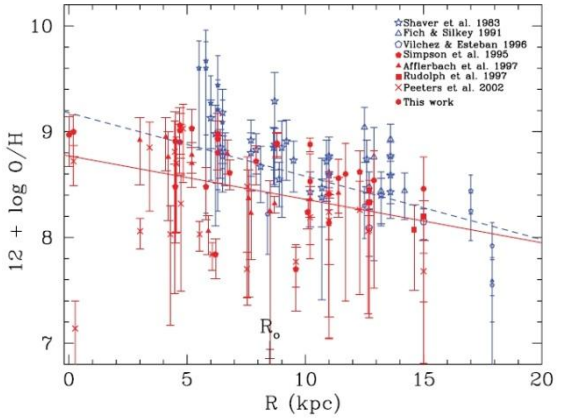
OB Stars (Rolleston+ 2000)



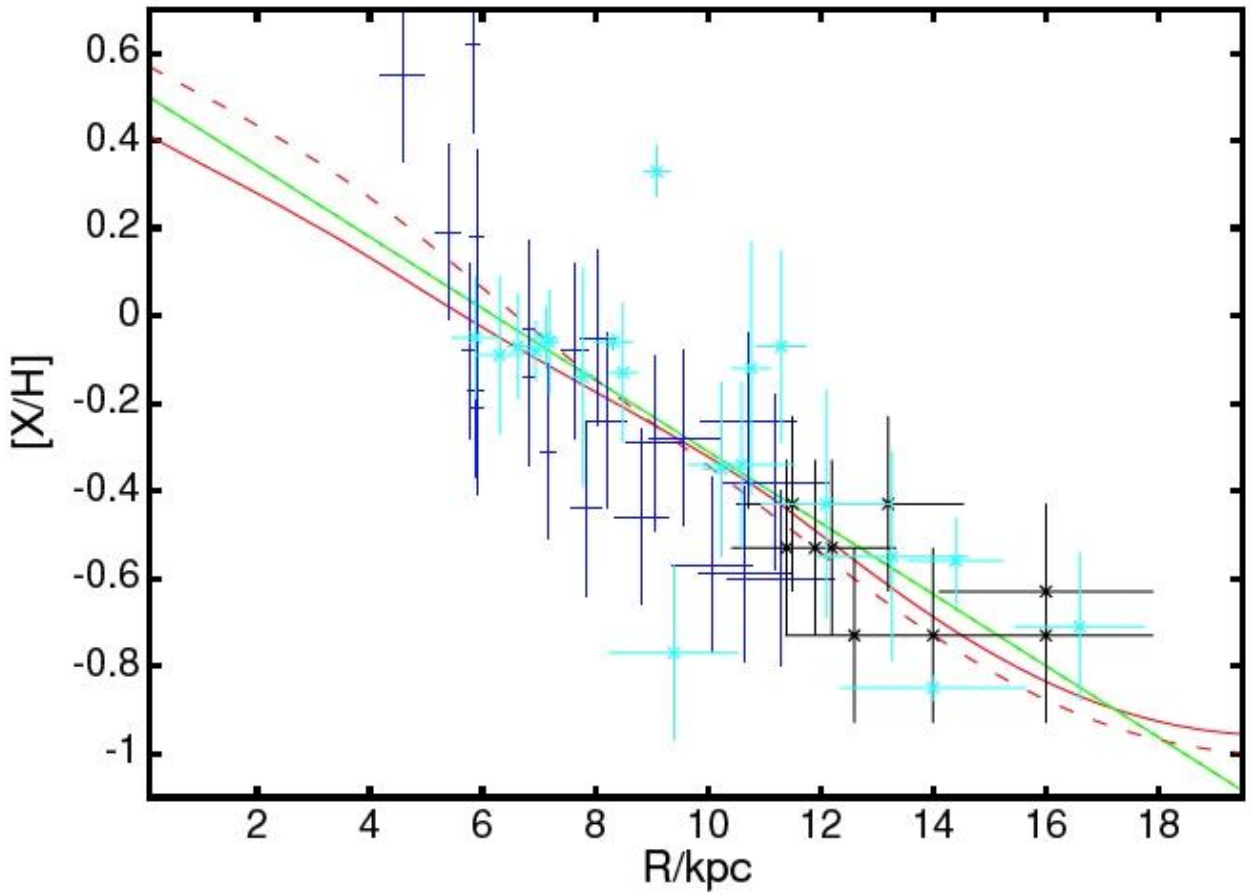
PNe (Henry+ 2010)



HII Regions (Rudolph+ 2006)

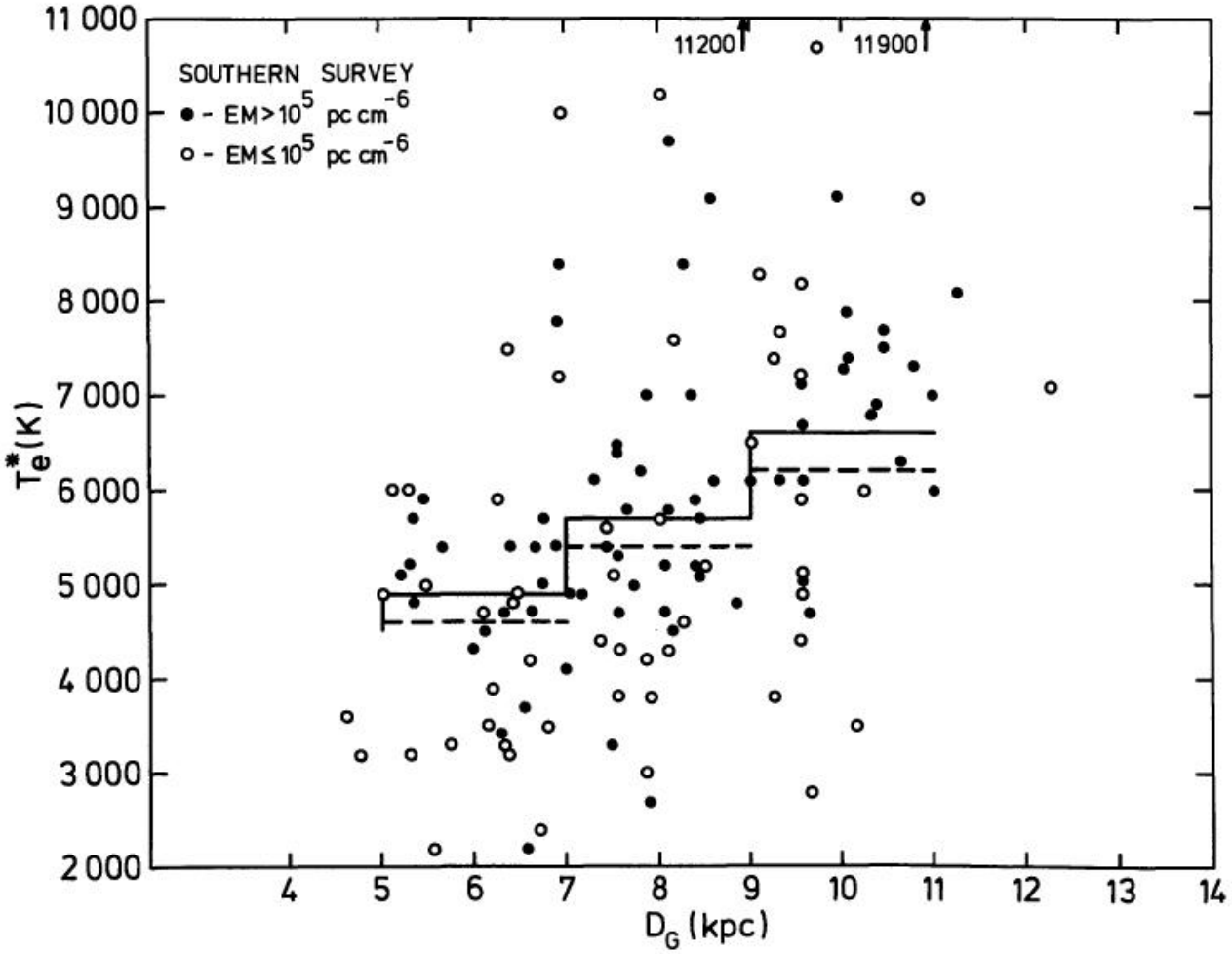


Chemodynamical Models



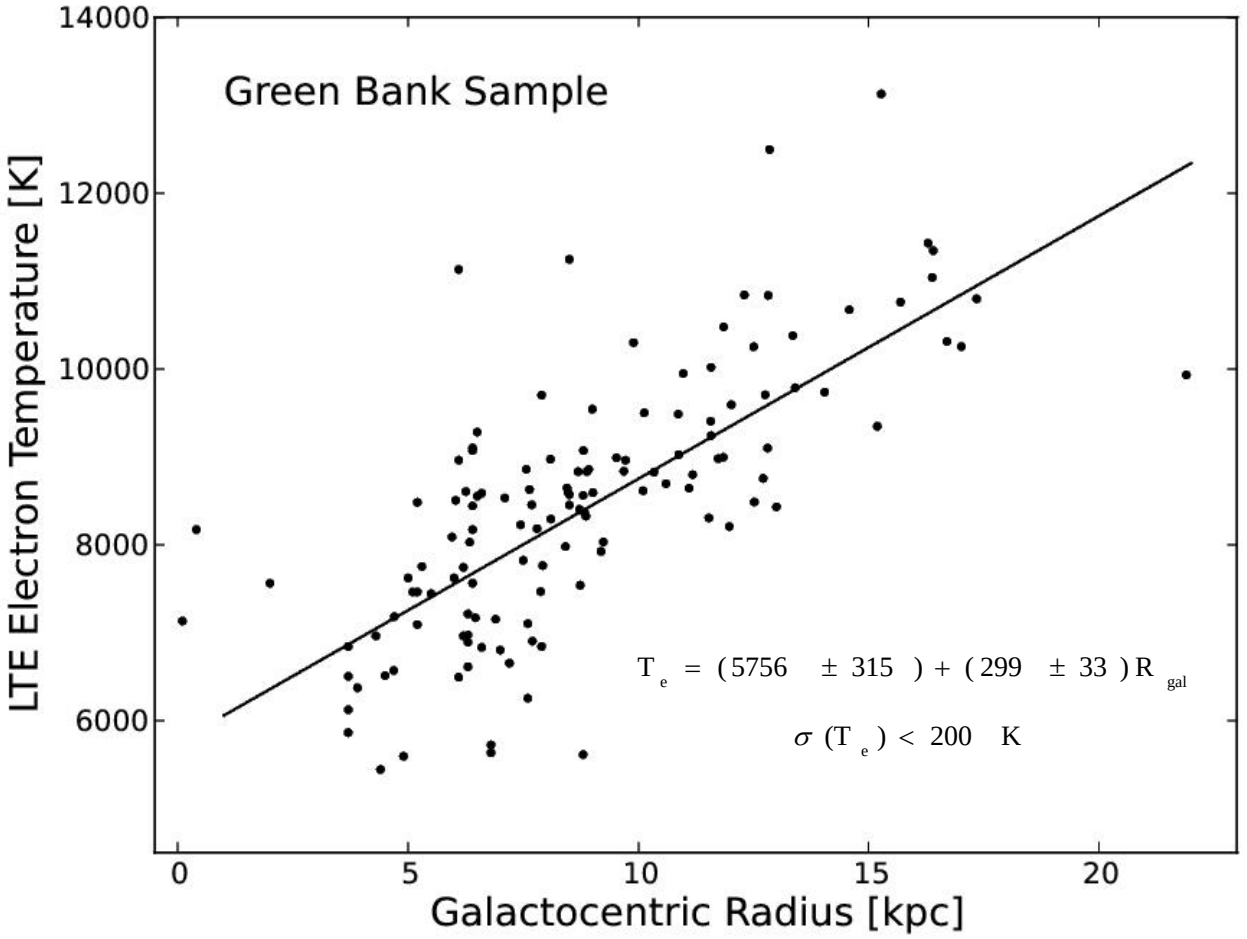
Schonrich & Binney (2009)

HII Region Electron Temperature Radial Gradient



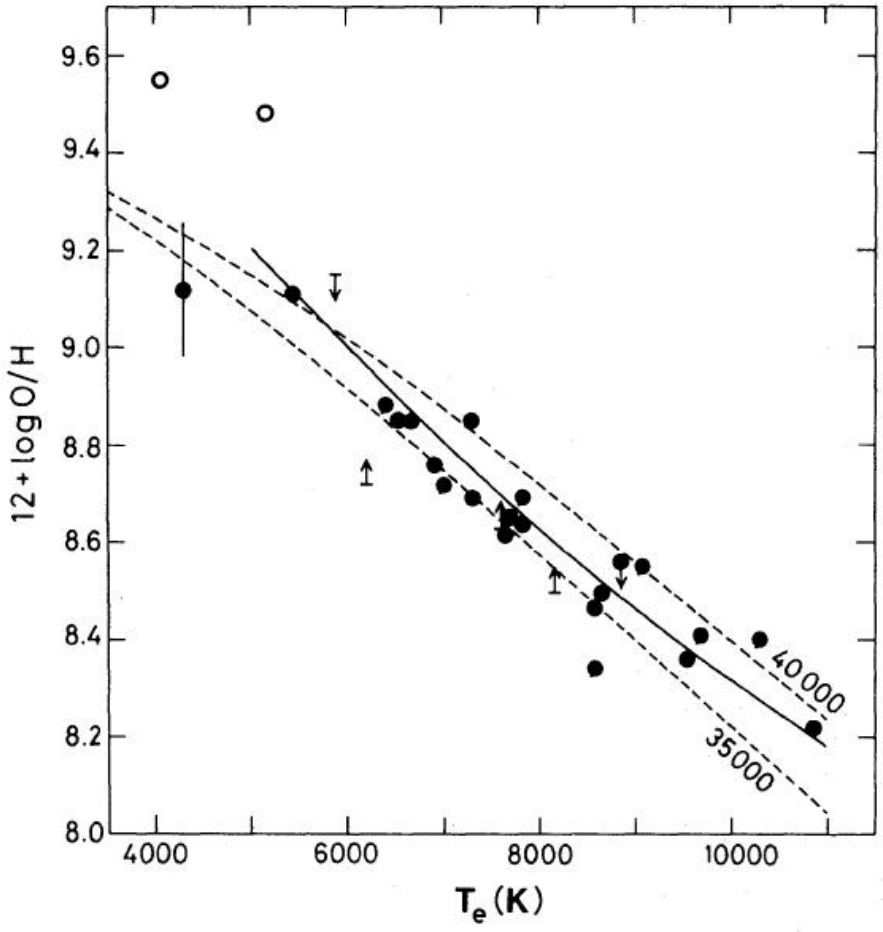
Churchwell & Walmsley (1975)

Electron Temperature Radial Gradient



Balser+ (2011)

HII Region Electron Temperature and Metallicity

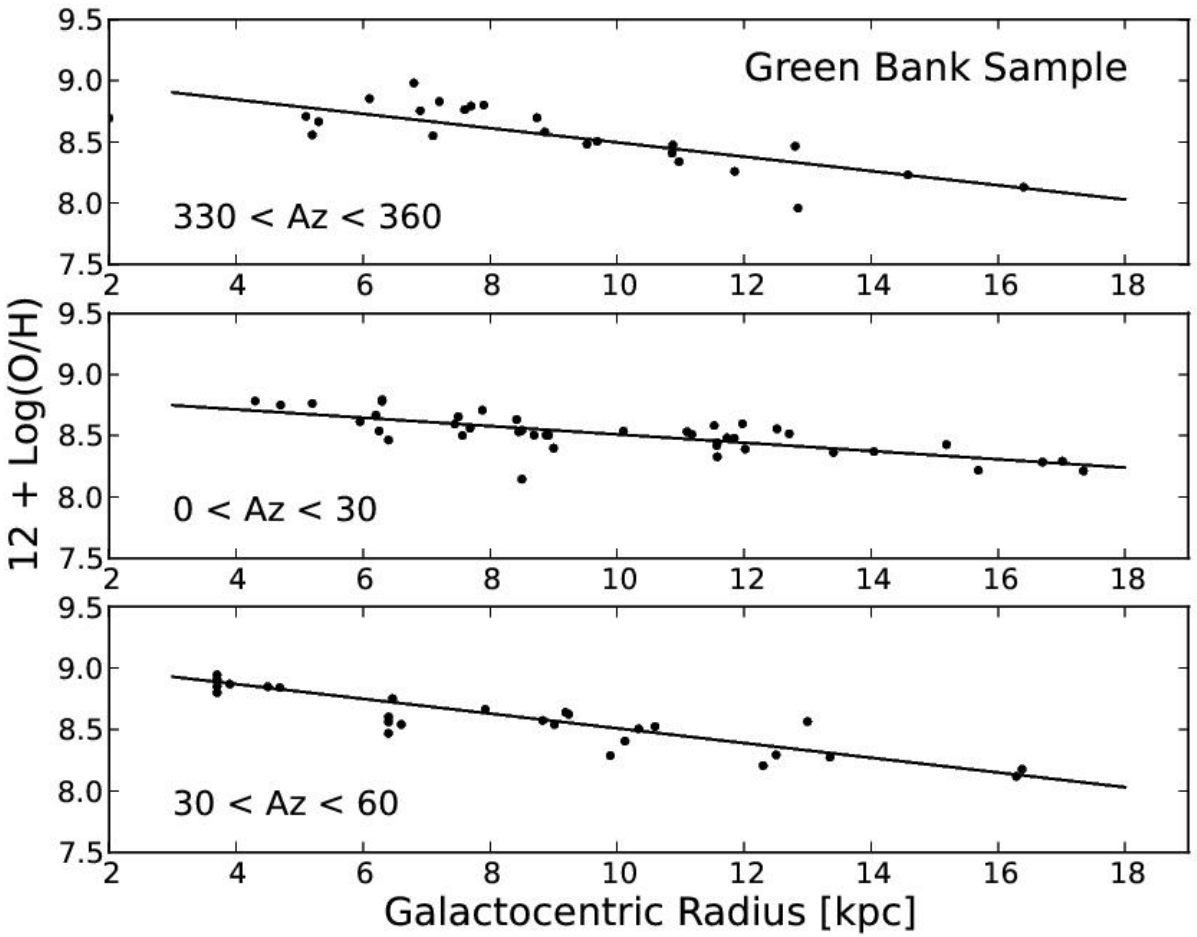


$$\frac{T_L}{T_C} \propto T_e^{-1.15}$$

RRL and free-free continuum emission in LTE at 3 cm.

Shaver+ (1983)

O/H Radial Gradient



Slope (dex/kpc)

-0.058 ± 0.013

-0.0339 ± 0.0039

-0.0602 ± 0.0063

Balser+ (2011)

HII Region Discovery Survey (HRDS)

Hn α RRLs (H87 α - H93 α)

Free - Free Thermal Continuum (3 cm)

343 ^{o} < l < 67 ^{o} ; | b | < 1 ^{o}

95 % Detection Rate

603 Discrete Hn α RRLs; 448 Targets

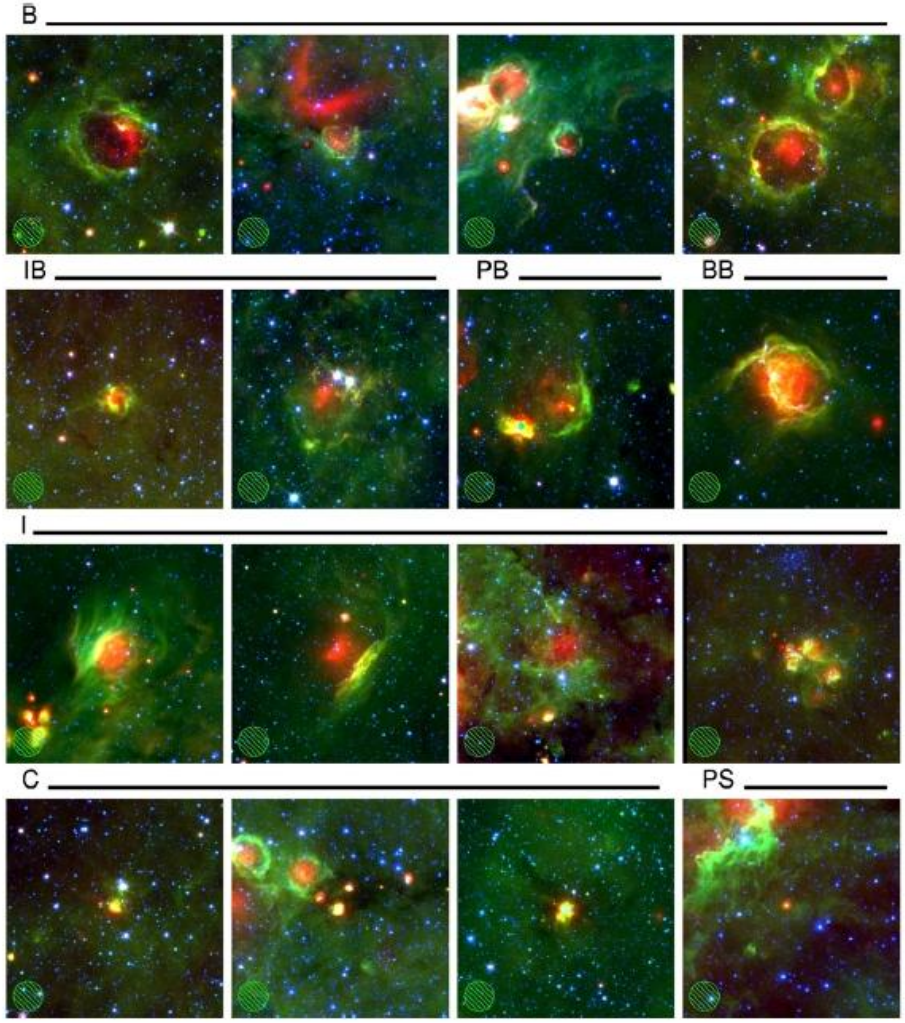
GBT 100 m

Target Selection :

IR Surveys : Spitzer (GLIMPSE, MIPSGAL)

Radio Continuum : VLA (NVSS, MAGPIS); VLA/GBT (VGPS)

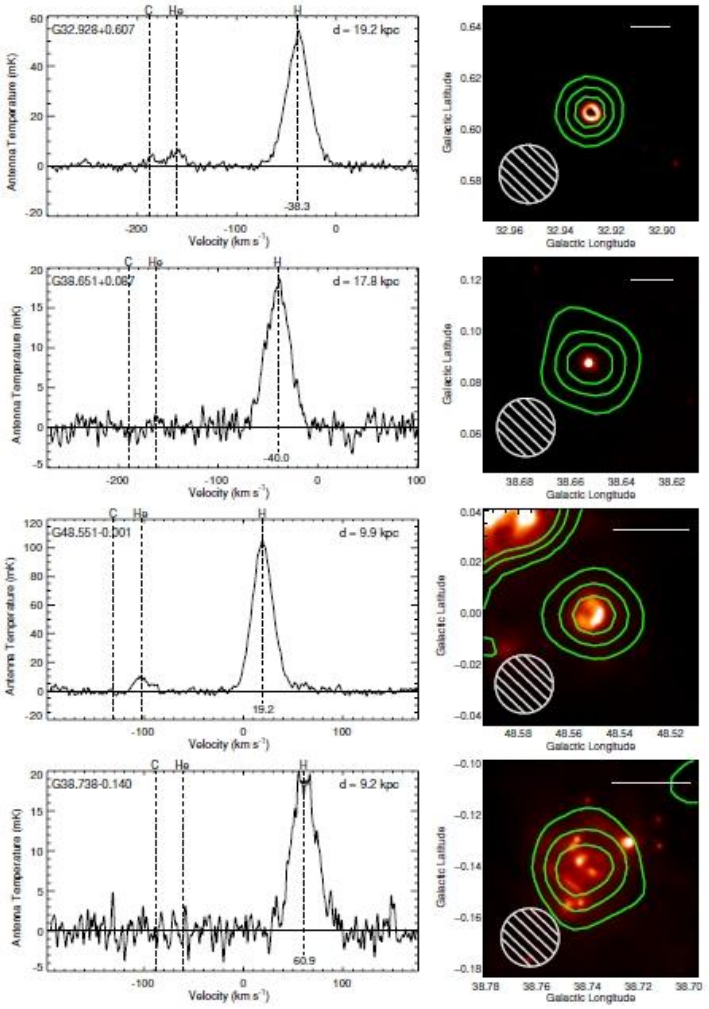
Spitzer IR HII Region Candidates



MIPSGAL 24 micron (red)
GLIMPSE 8 micron (green)
GLIMPSE 3.6 micron (blue)

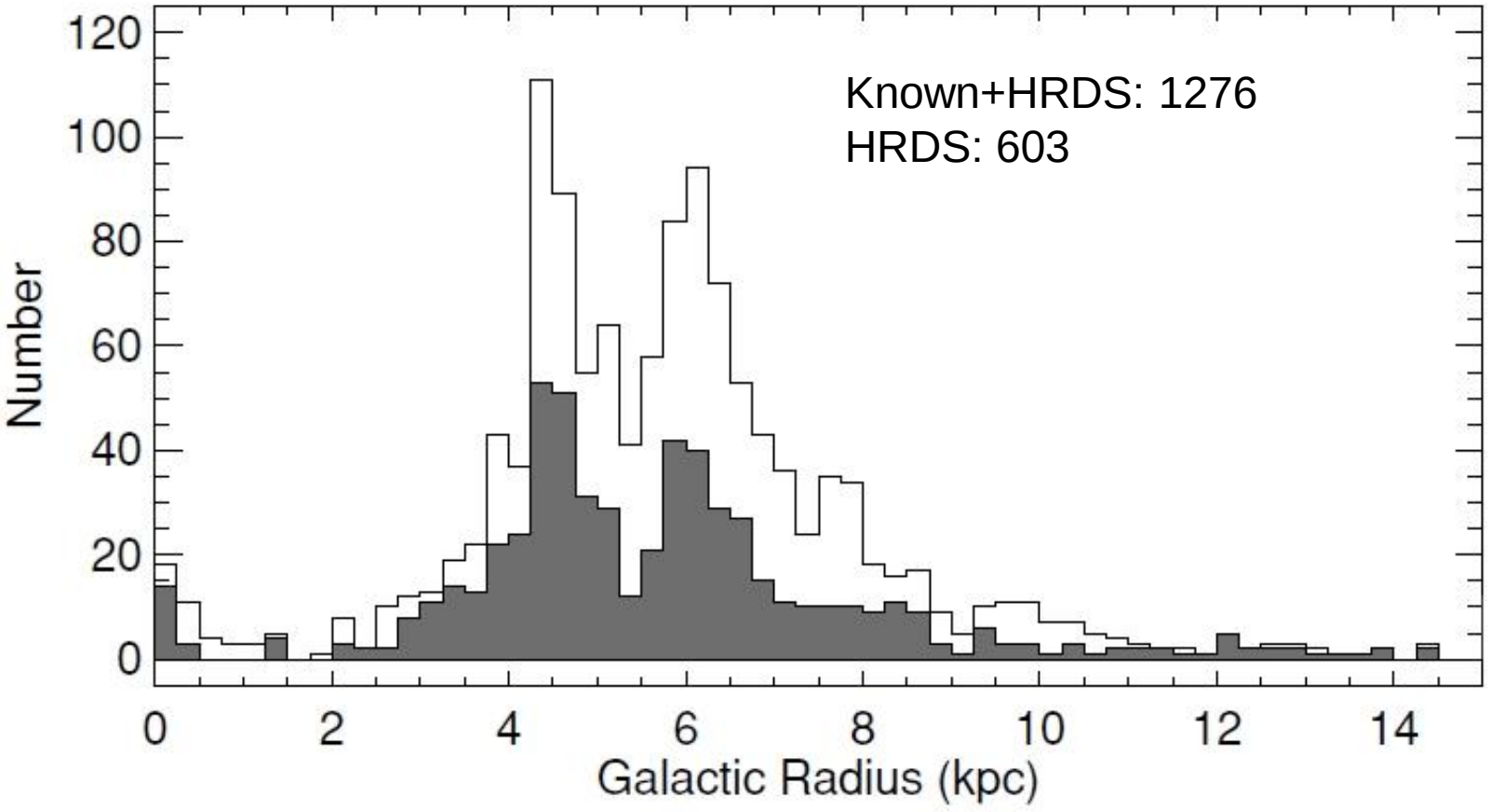
Anderson+ (2011)

HRDS RRL Detections



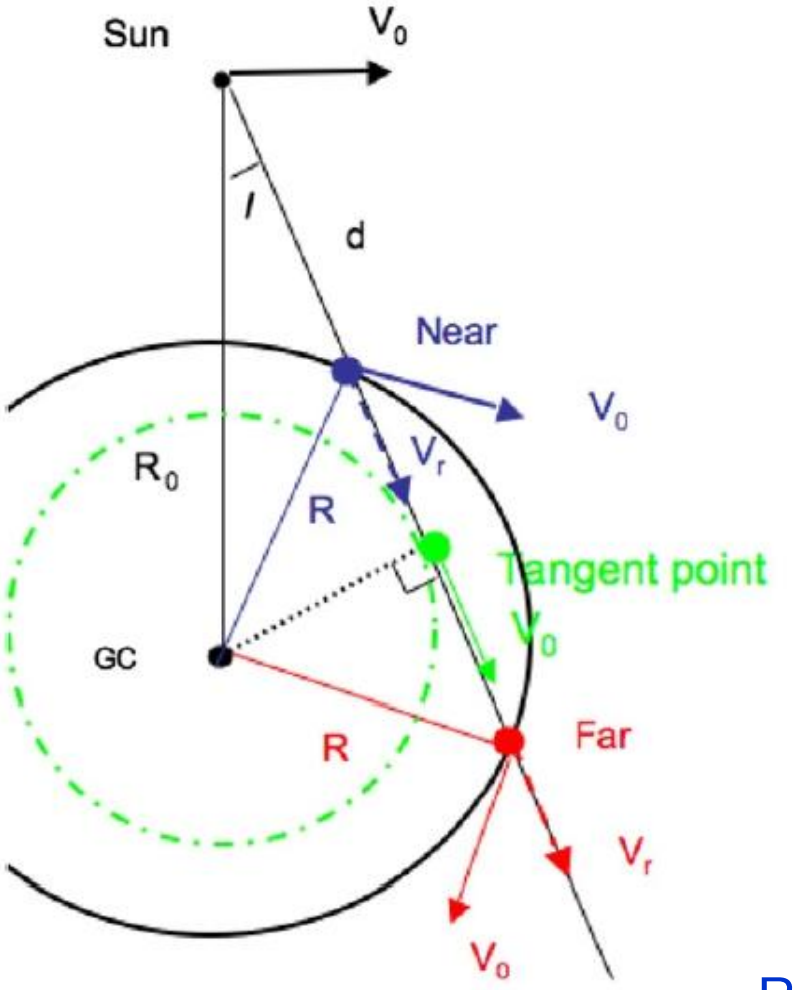
Bania+ (2010)

Galactocentric Radius Distribution



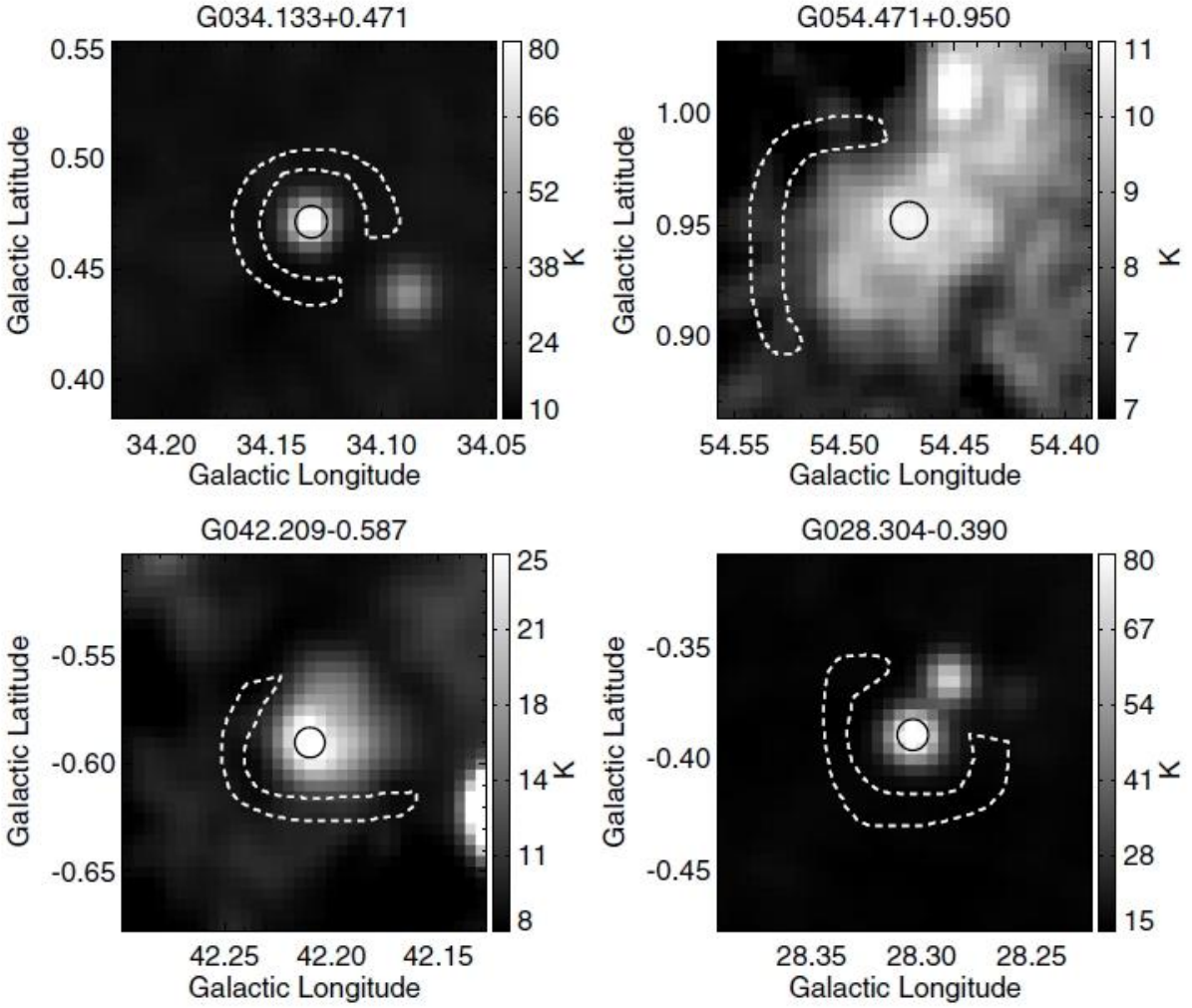
Bania+ (2010)

Kinematic Distance Ambiguity



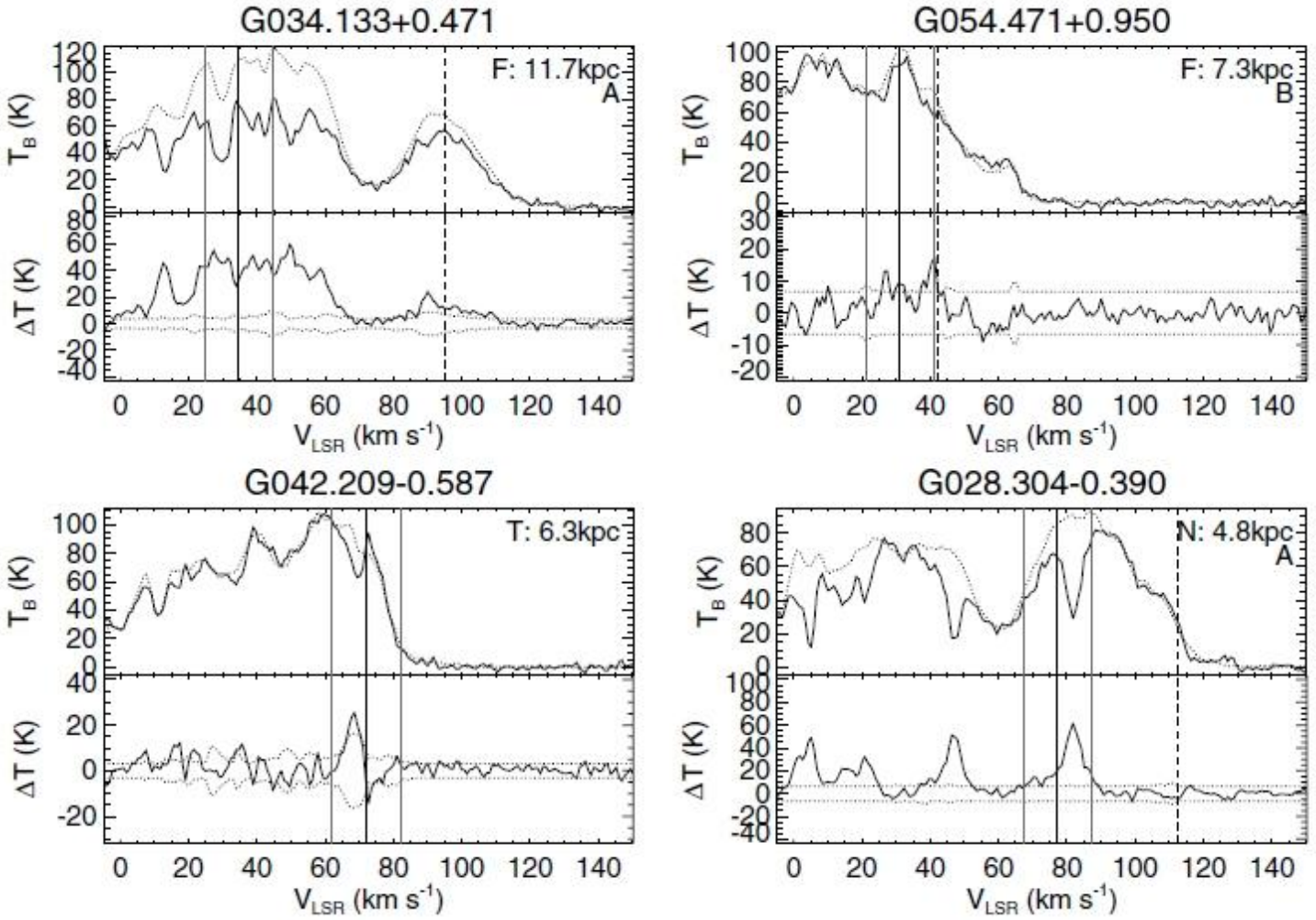
Roman-Duval+ (2009)

HRDS: Distances



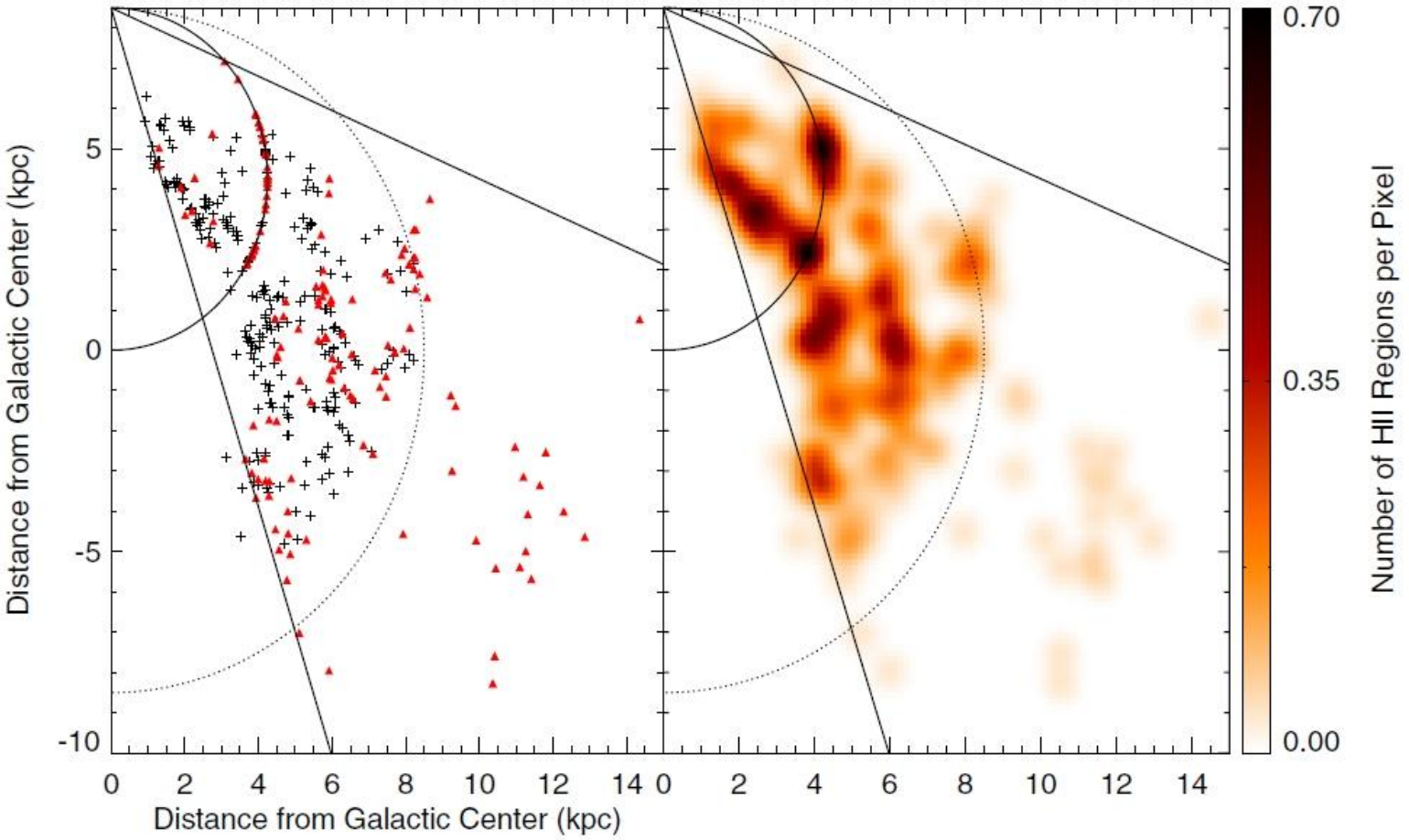
Anderson+ (2012)

HRDS Distances



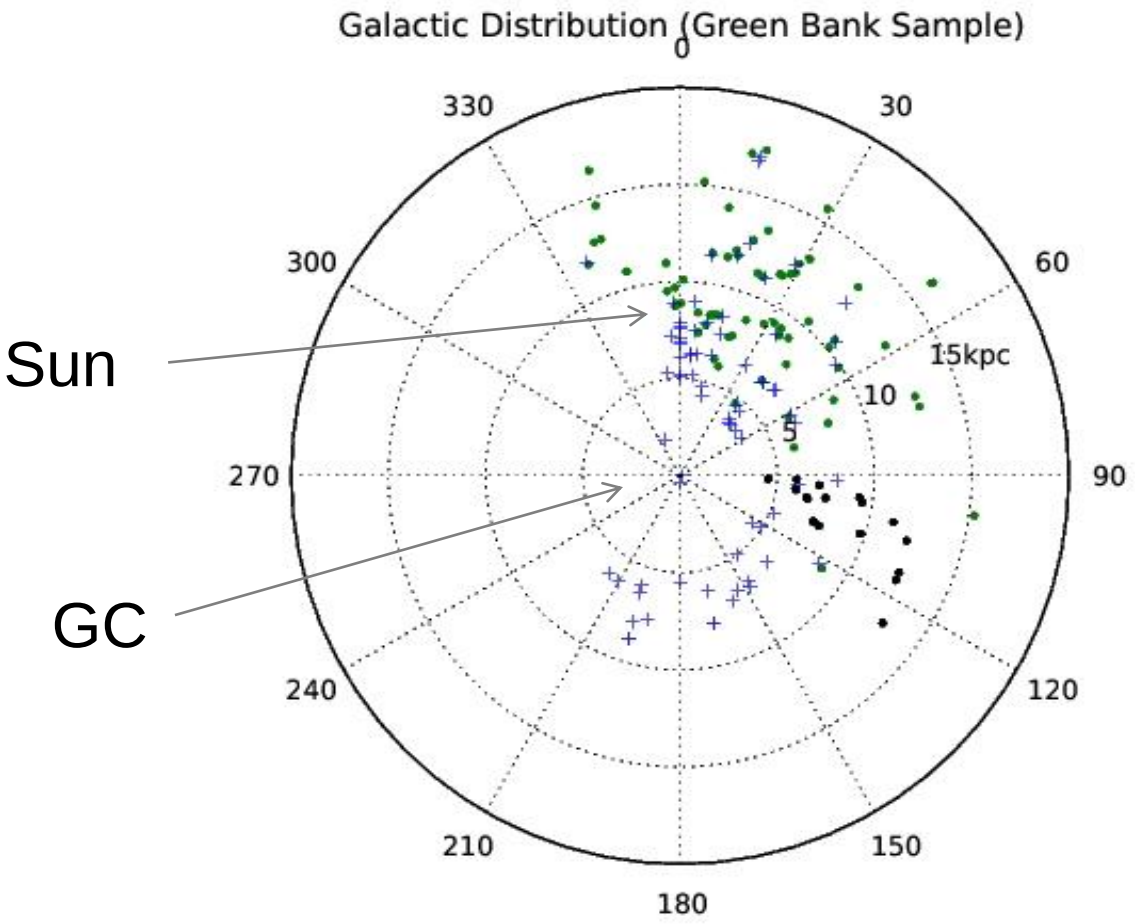
Anderson+ (2012)

HRDS: Face-On Map



Anderson+ (2012)

HII Region Sample

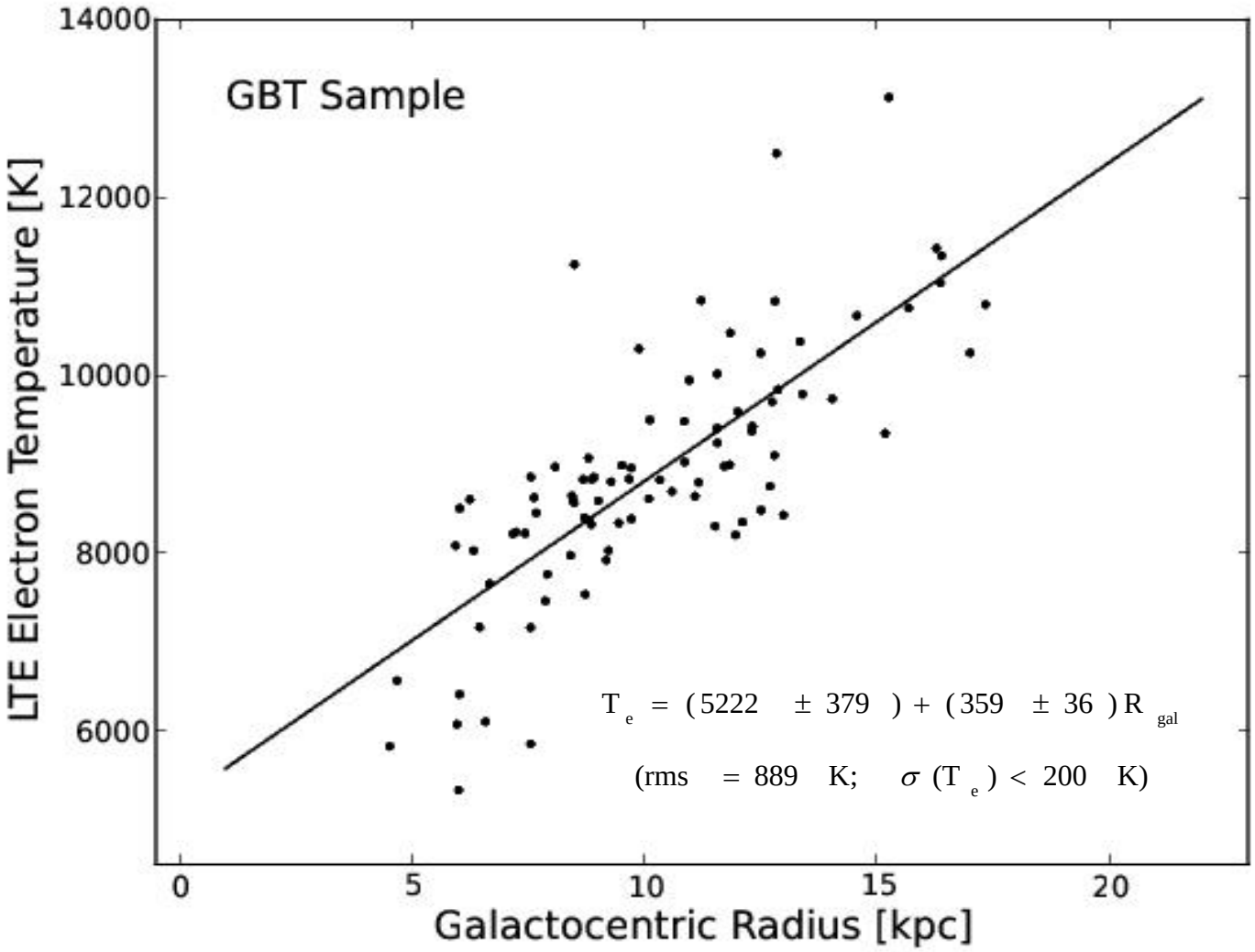


18 HRDS

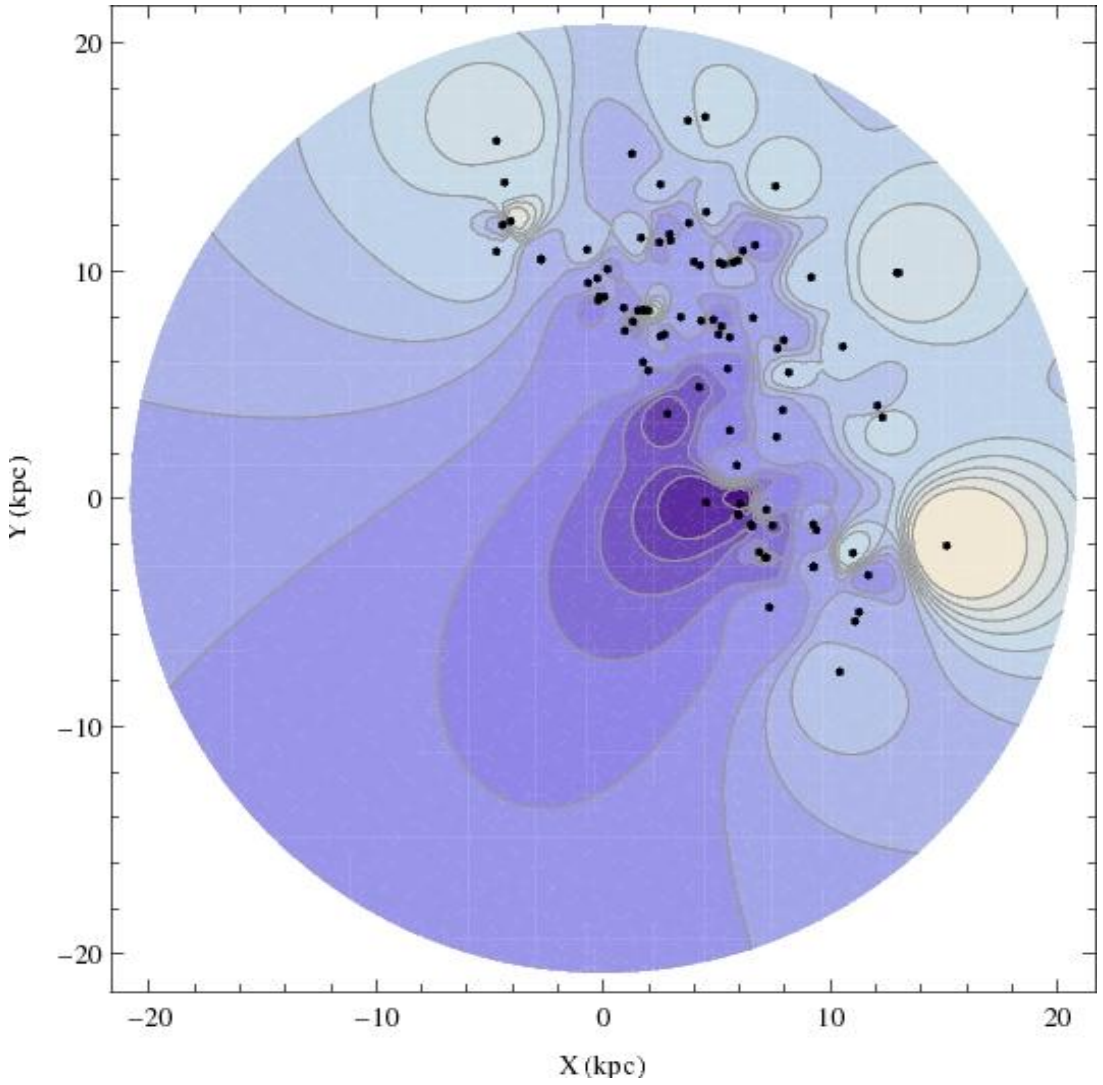
- GBT
- \+ 140 Foot

Quireza+ (2006); Balser+ (2011)

Electron Temperature Radial Gradient



Electron Temperature Azimuthal Structure



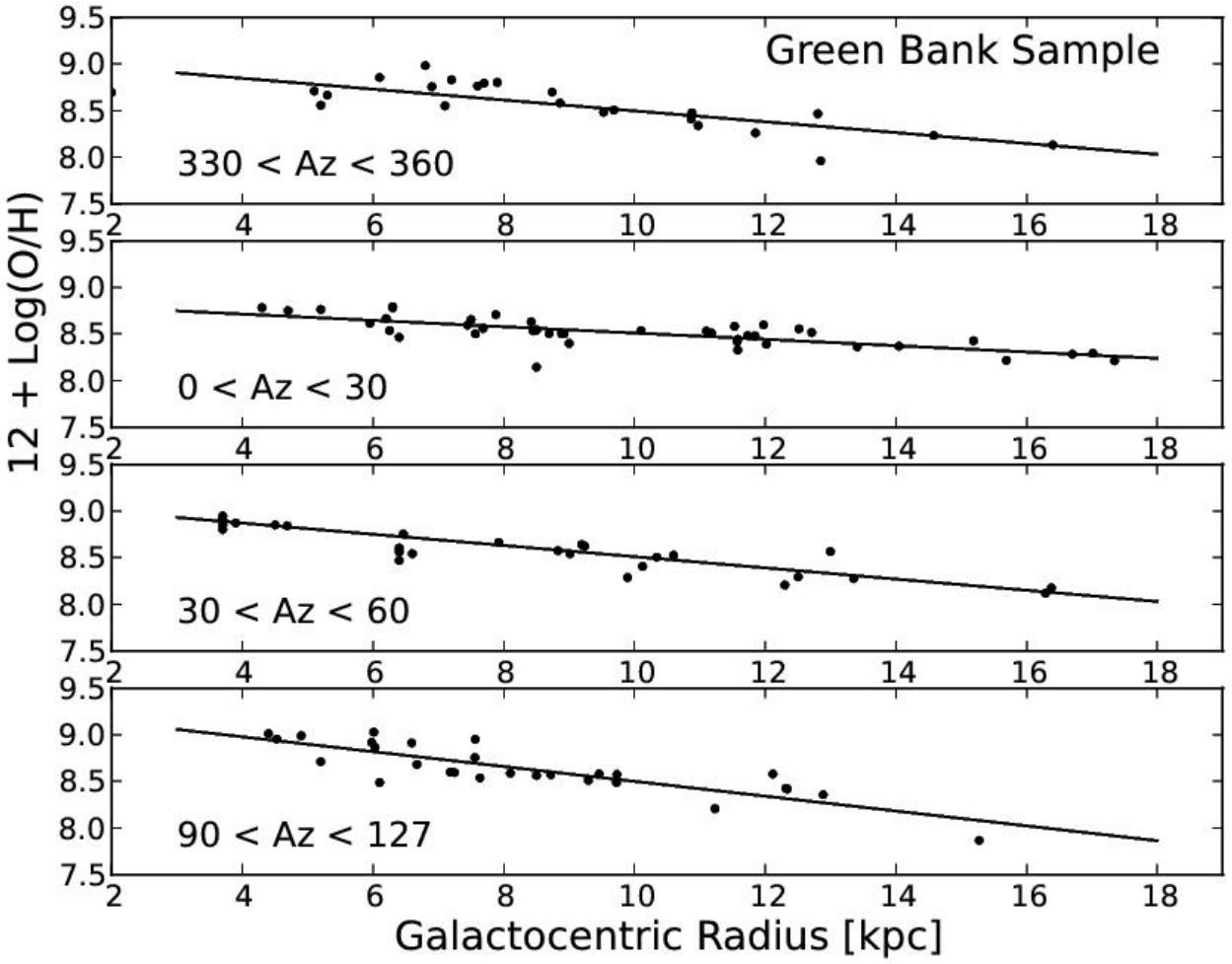
GBT Sample

Contours :

Range : 6240 – 12480 K

Interval : 480 K

O/H Radial Gradient



Slope (dex/kpc)

-0.058 ± 0.013

-0.0339 ± 0.0039

-0.0602 ± 0.0063

-0.080 ± 0.013

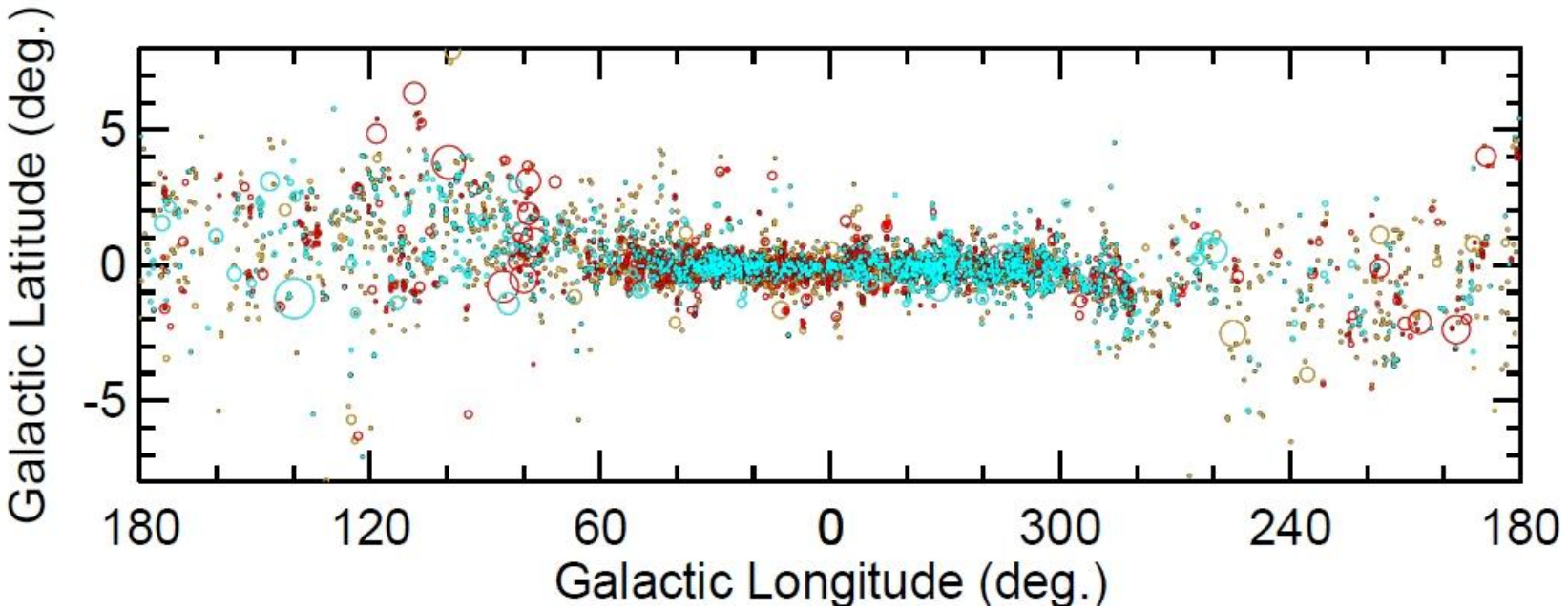
Summary

- HRDS Probes Metallicity Across the Galaxy
- Azimuthal Structure
- O/H radial gradients: -0.03 to -0.08 dex/kpc

Future

- Expand HRDS (WISE)
- Expand Te Measurements (GBT/VLA)
- Explore O/H – Te Relationship
  - Modern Optical/Radio
  - IR data (Herschel/SOFIA)
  - Models (Cloudy)

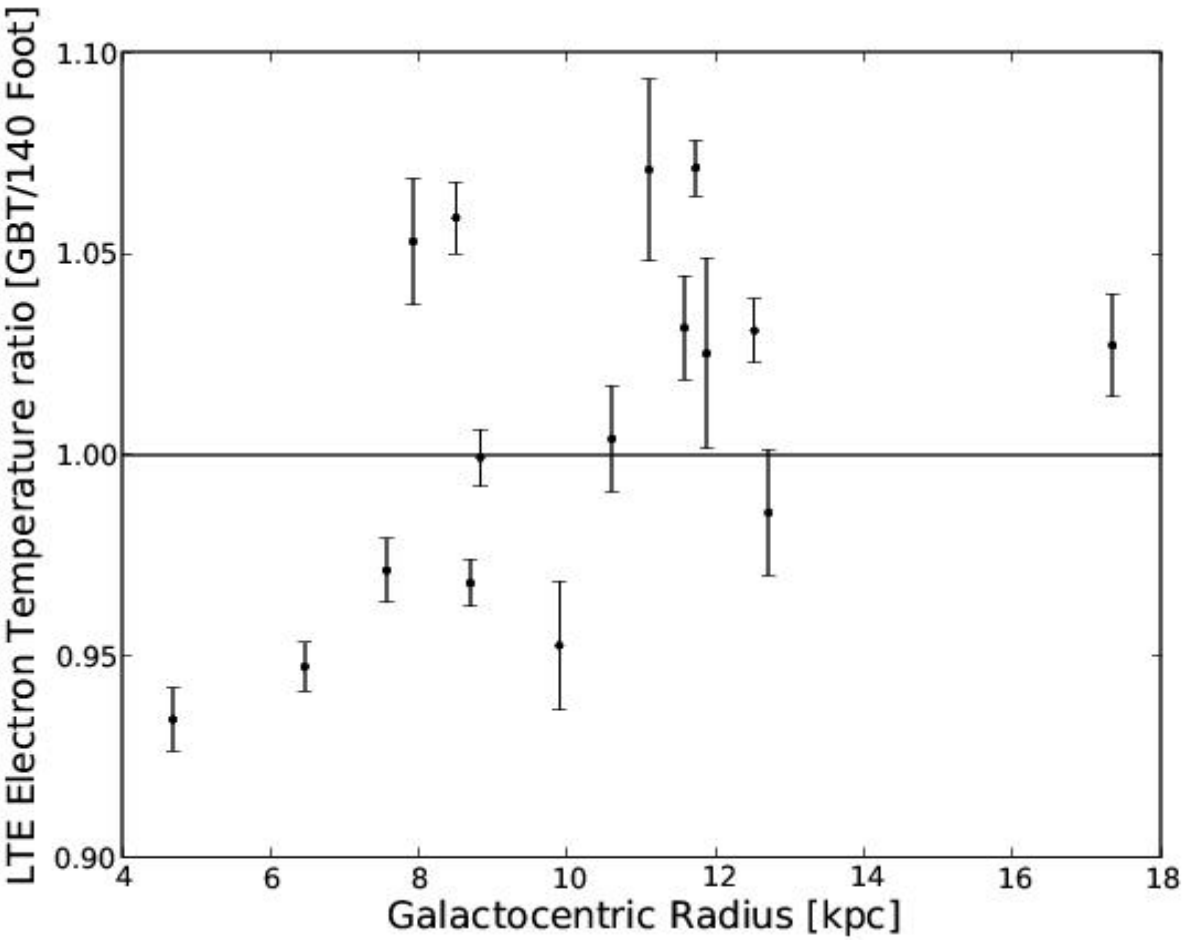
WISE HII Region Catalog Distribution



Questions

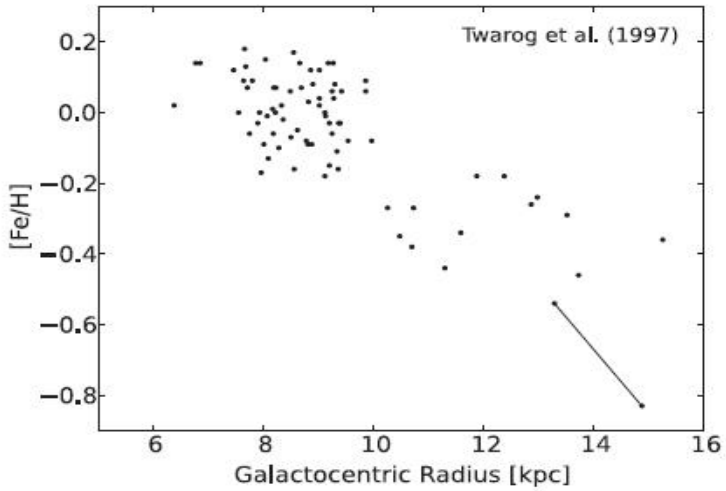
Extra Slides

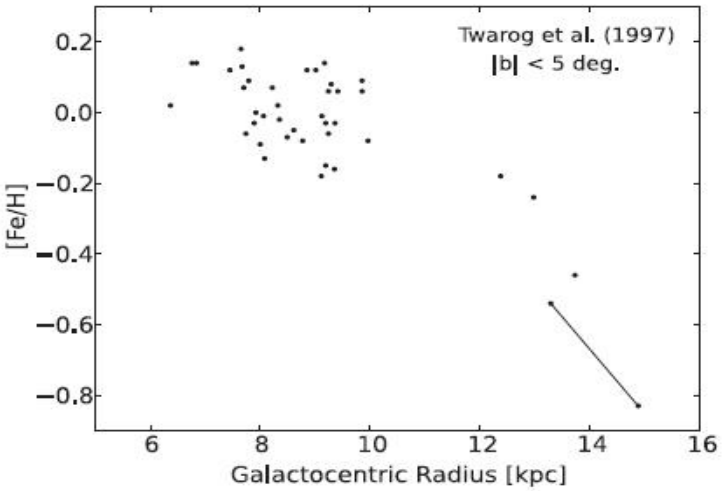
GBT/140 Foot Cross Calibration

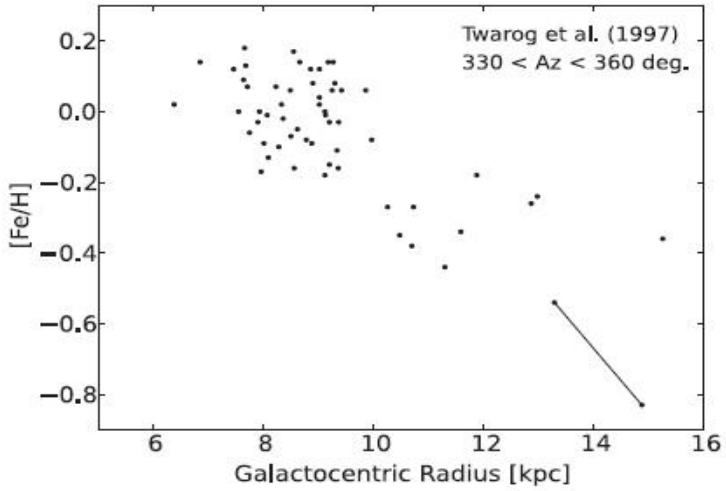


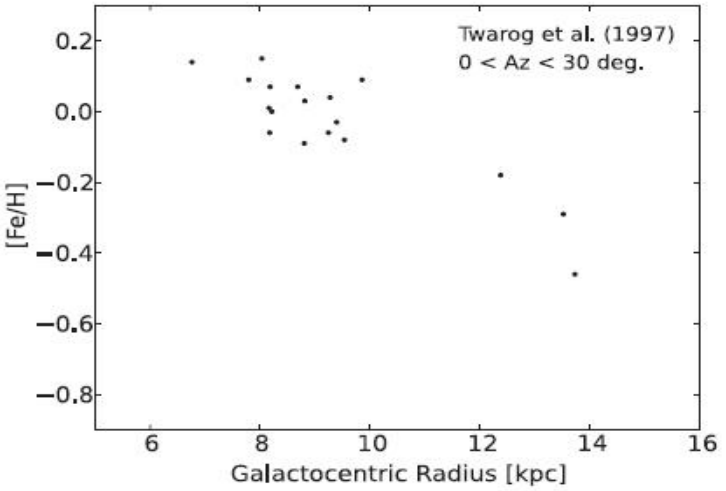
Balser+ (2011)

Open Cluster Data



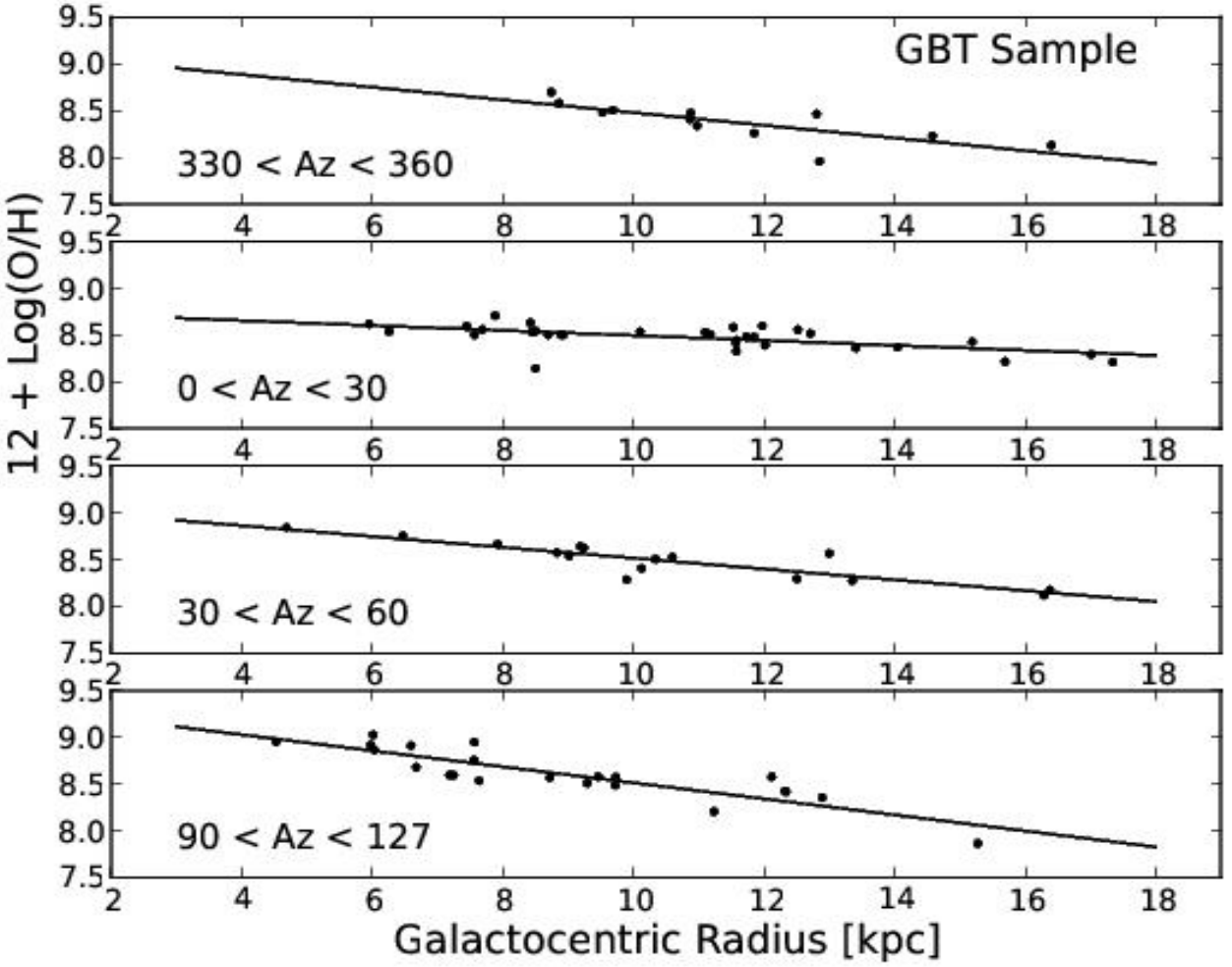






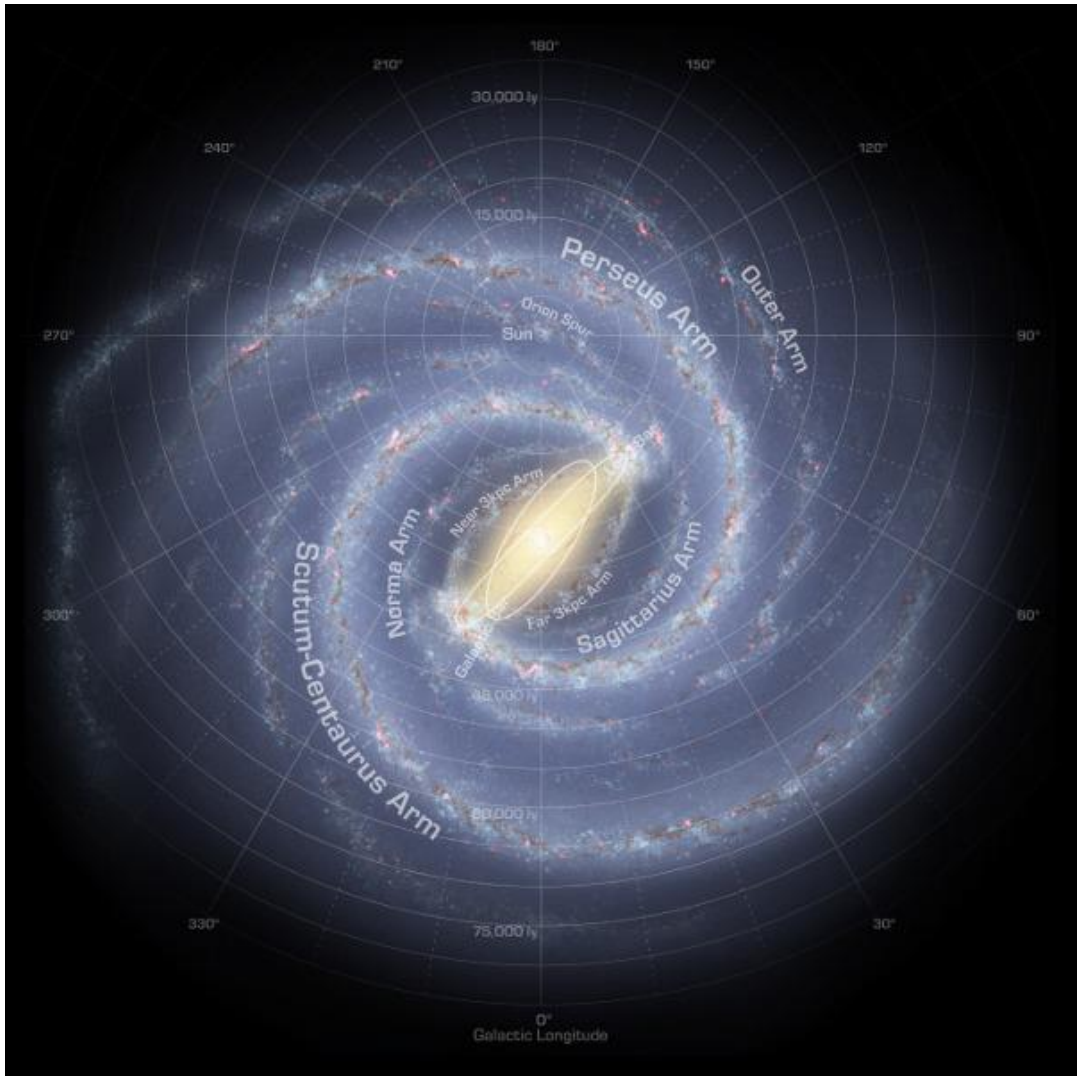
Balser+ (2011)

O/H Radial Gradient - GBT



Balser+ (2011)

Milky Way Spiral Arms



Robert Hurt