Discovering Milky Way HII Regions

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Institute for Astrophysical Research
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GBT HRDS

Green Bank Telescope HII Region Discovery Survey

AO HRDS

Arecibo Observatory HII Region Discovery Survey

SHRDS

Southern HII Region Discovery Survey

Milky Way H II Regions

HII regions are zones of ionized gas surrounding O and B type stars (Masses > 8 $M_\odot$)

- Lifetimes <10 Myr

→ Trace star formation at present epoch

Emit at radio wavelengths via Bremsstrahlung (free-free) continuum and radio recombination line (RRL) emission

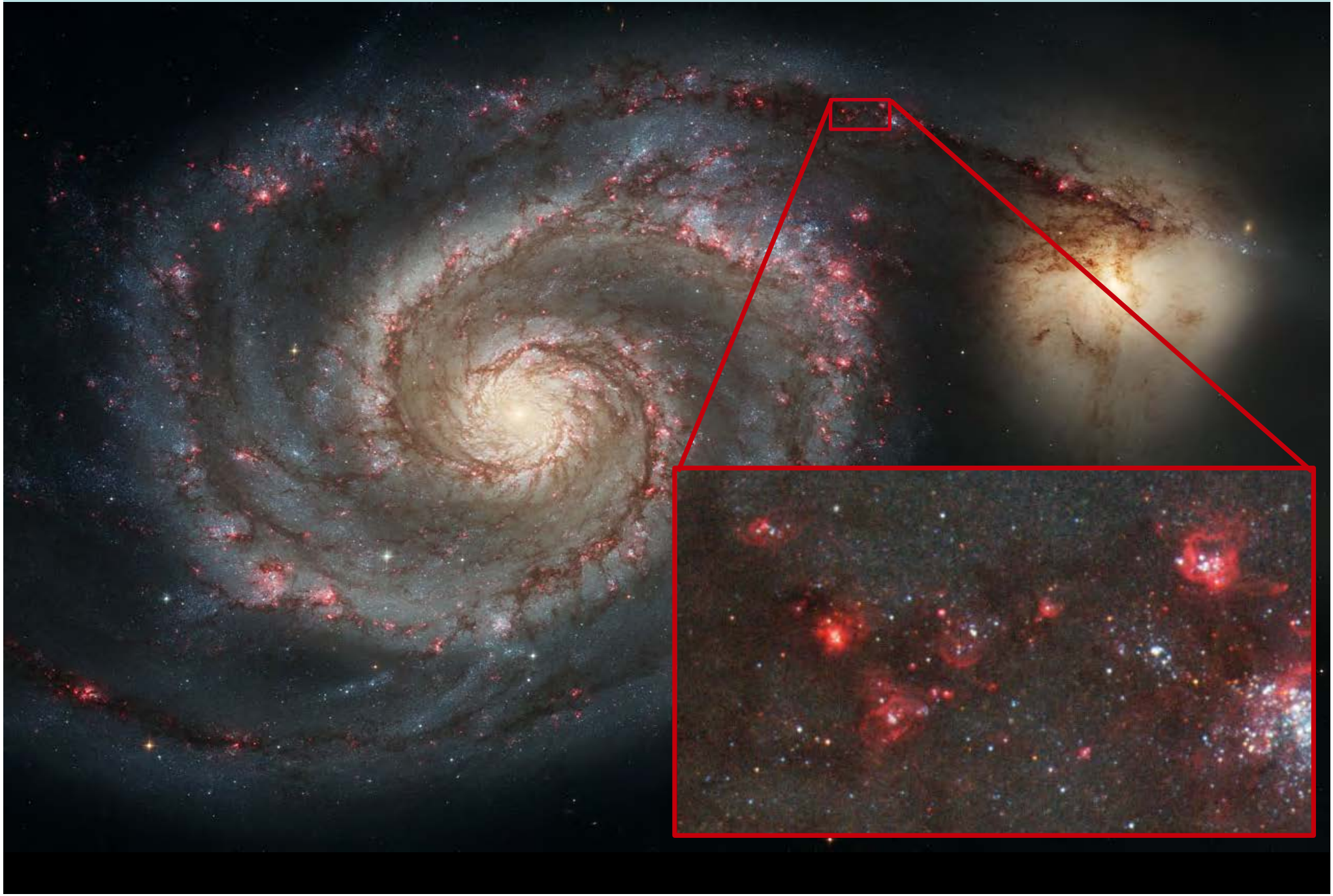
→ Thermal plasma emission mechanisms

Emit at infrared (IR) due to presence of dust

→ The brightest objects in the Galaxy at radio and IR wavelengths!

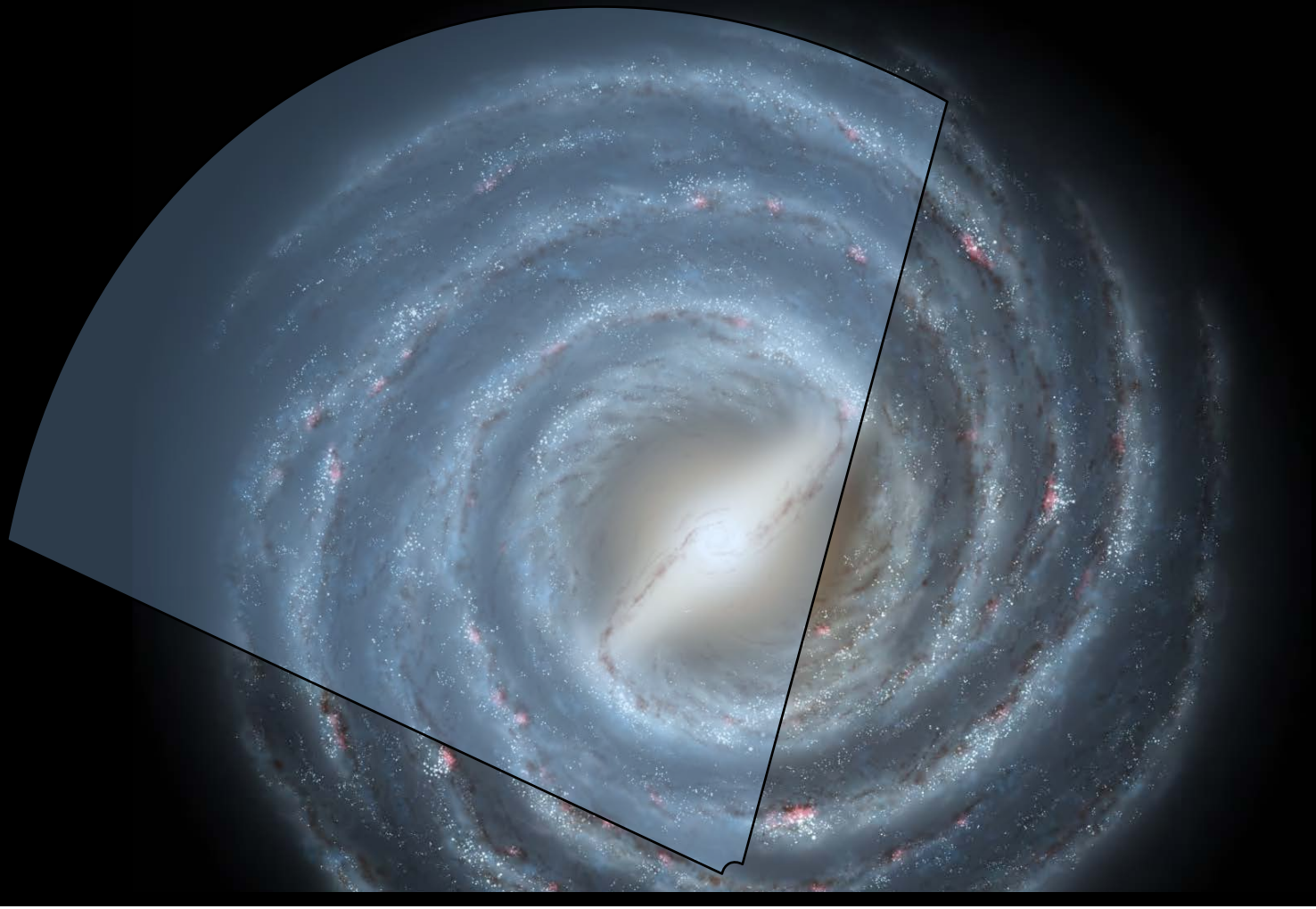
The signature of HII regions is a high IR and radio flux

H II Regions and Galaxies



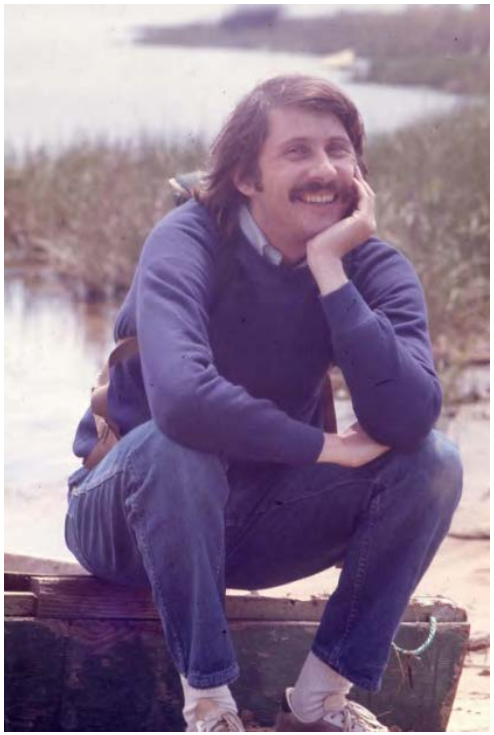
The GBT Galactic H II Region Discovery Survey

T.M. Bania (Boston University),
L. D. Anderson (West Virginia University)
Dana S. Balser (NRAO), and Robert T. Rood (University of Virginia)



GBT HRDS Collaborators Normalized to Age 30

Tom Bania
(Boston University)



Dana Balser (NRAO)

Loren Anderson
(West Virginia University)

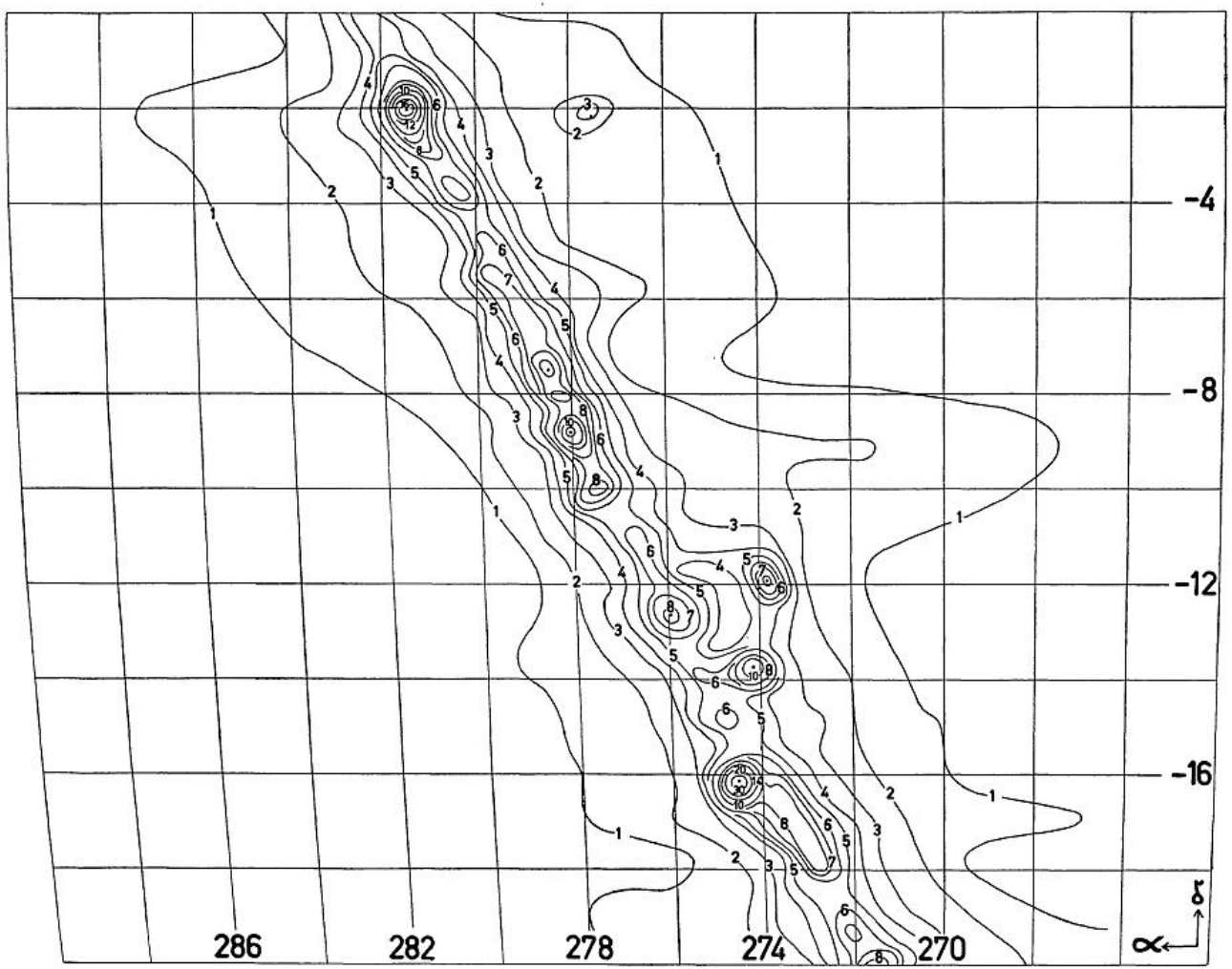
Bob Rood
(University of Virginia)

H II Region Surveys

Eagle Nebula
NGC 6611
M 16
S 49
RCW 165
Gum 83
"Pillars of Creation"

POSS

Radio Continuum Surveys



Dwingeloo 25 m telescope 1390 MHz

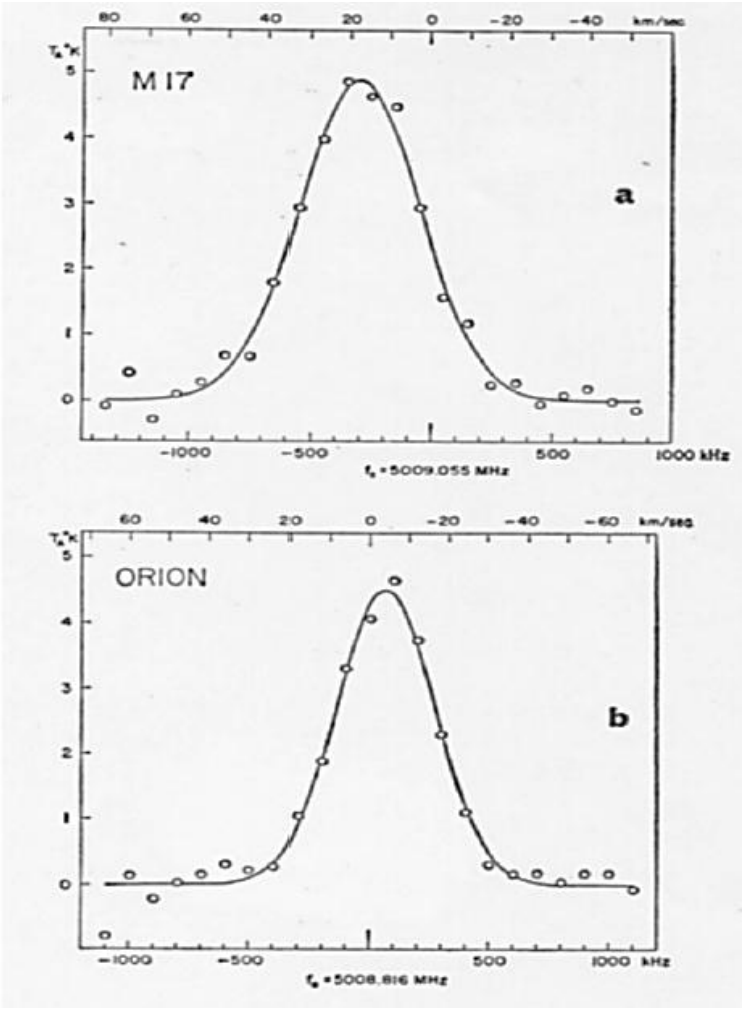
Westerhout (1958)

Radio Recombination Lines (RRLs)

NRAO

Green Bank

140 Foot

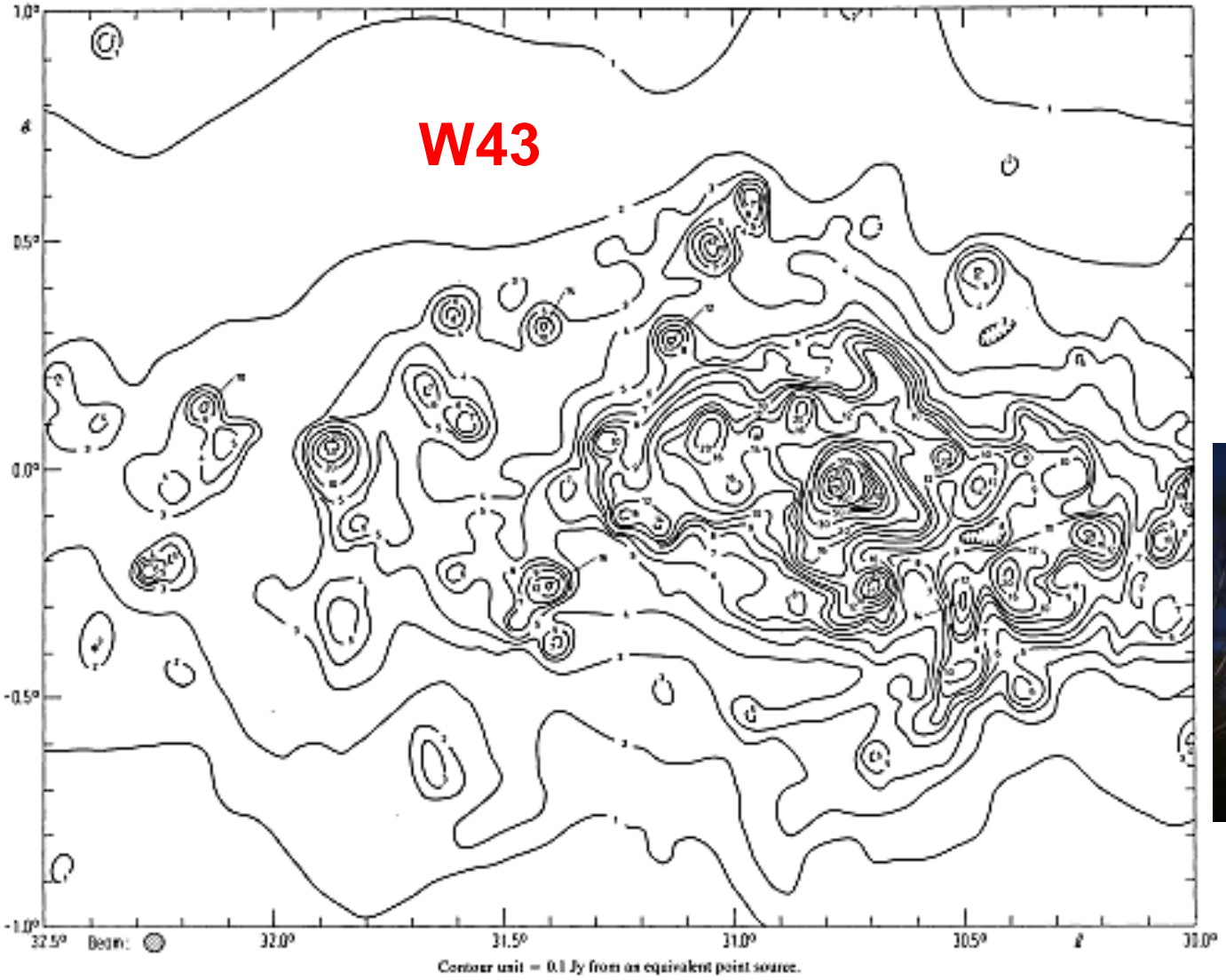


$H109\alpha$

Hoglund & Mezger (1965)

Radio Wavelength Sky Surveys

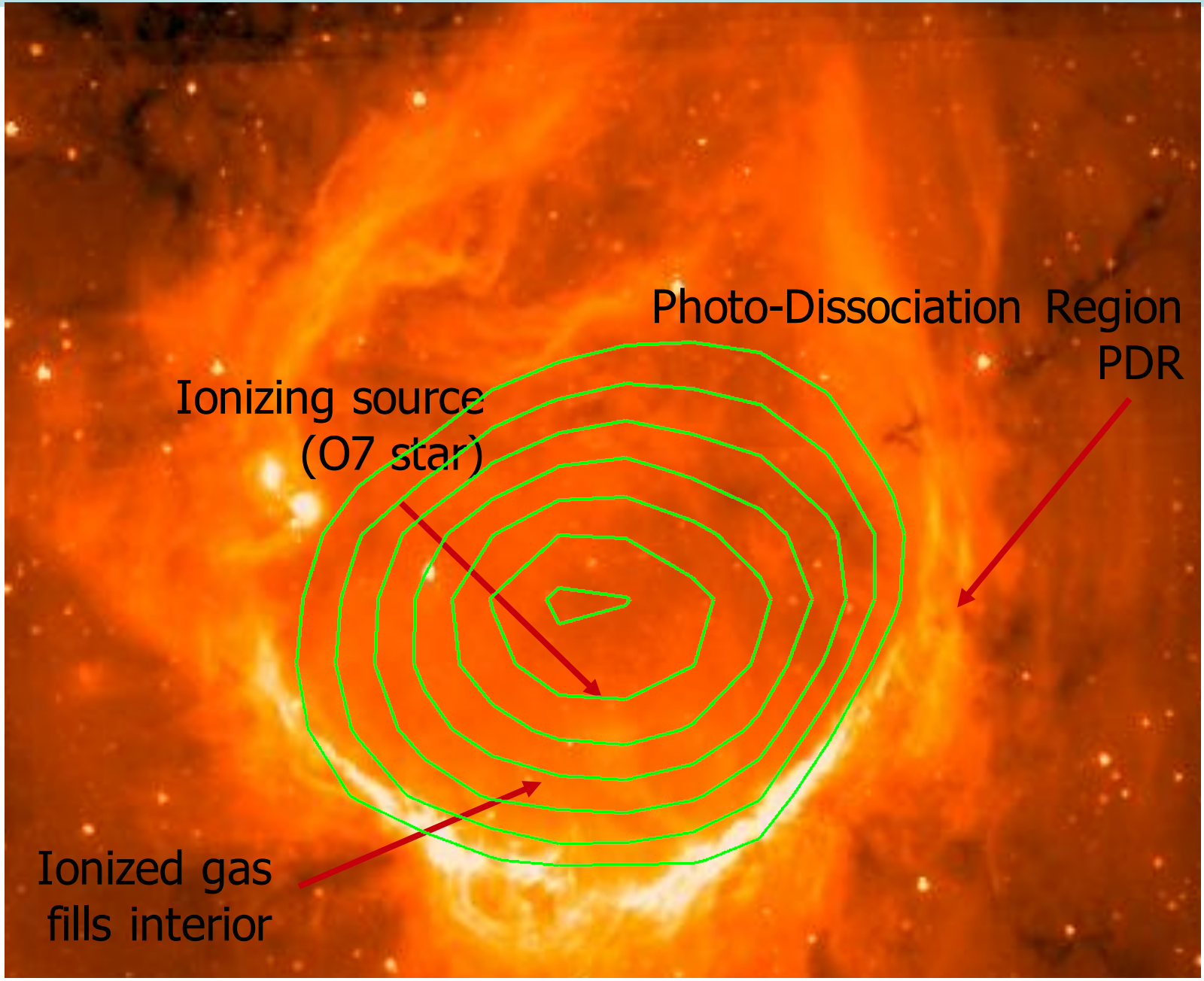
Continuum surveys began in the 1950s
Recombination line surveys began in the 1960s



MPIfR
100 m
4.875 GHz

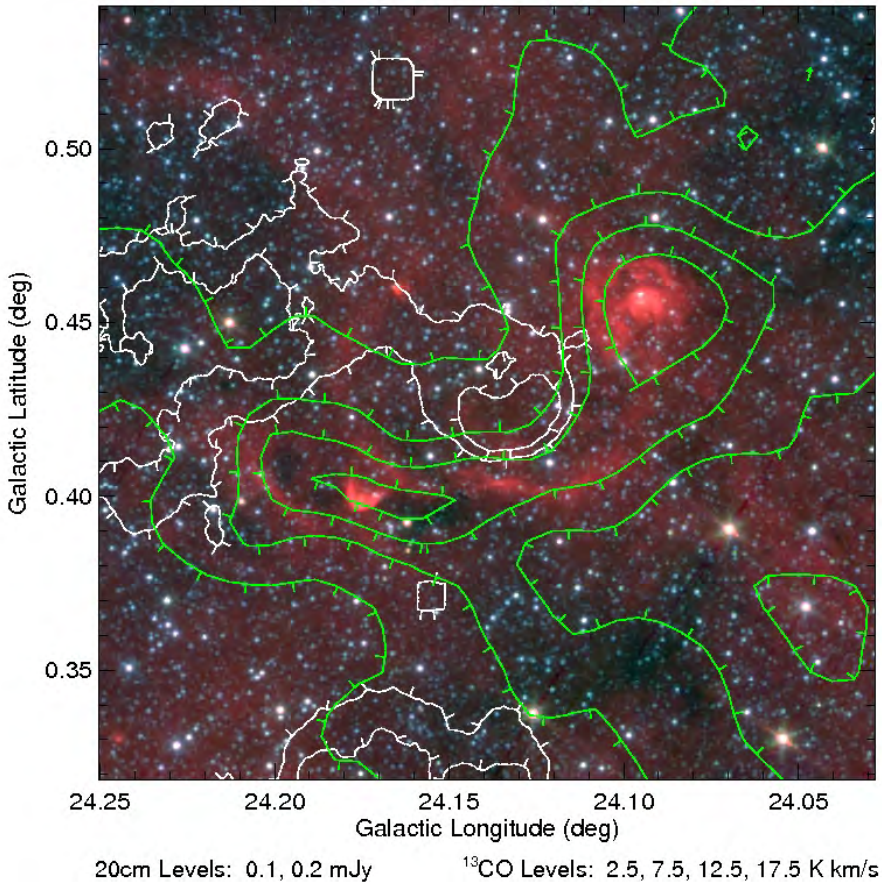
Altenhoff et al., 1979

H II Region Evolution

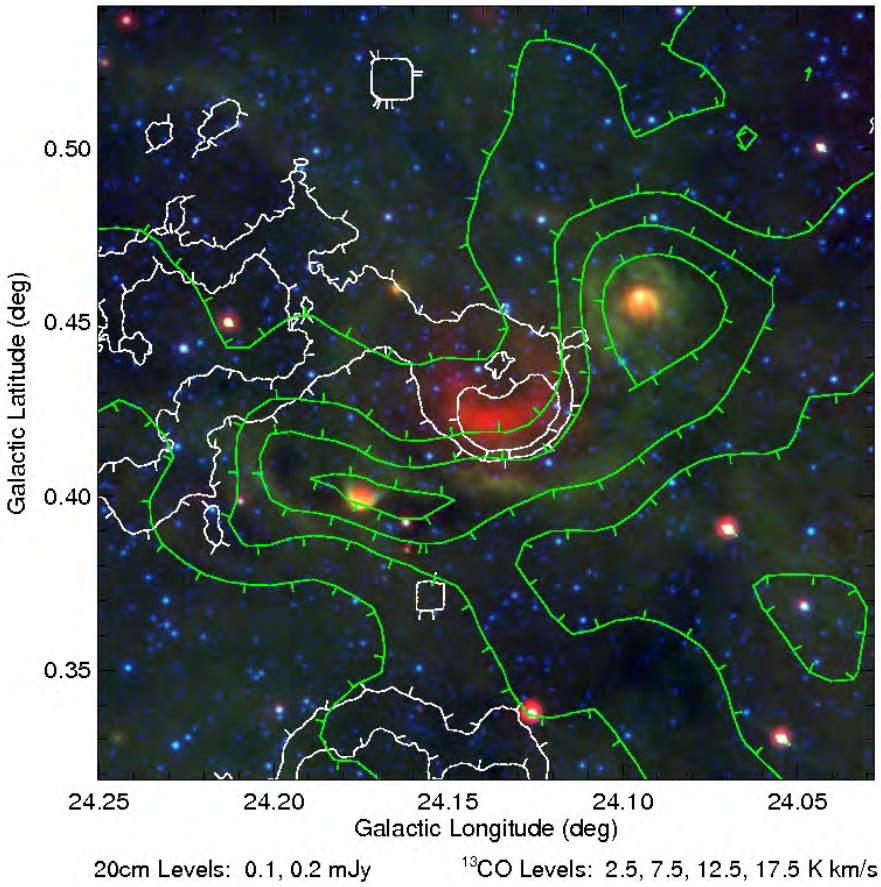


H II Region Case Studies

RGB → 8, 4.5, 3.6 microns



RGB → 24, 8, 3.6 microns



Spitzer IR MAGPIS 20cm (white contour) GRS ^{13}CO (green contour)

GBT H II Region Discovery Survey

GBT HRDS

Coincident $24\,\mu$ m and 20 cm

Flux > 100 mJy @ 20 cm

$-16^{\circ} < \ell < +67^{\circ}$ and $-1^{\circ} < b < 1^{\circ}$

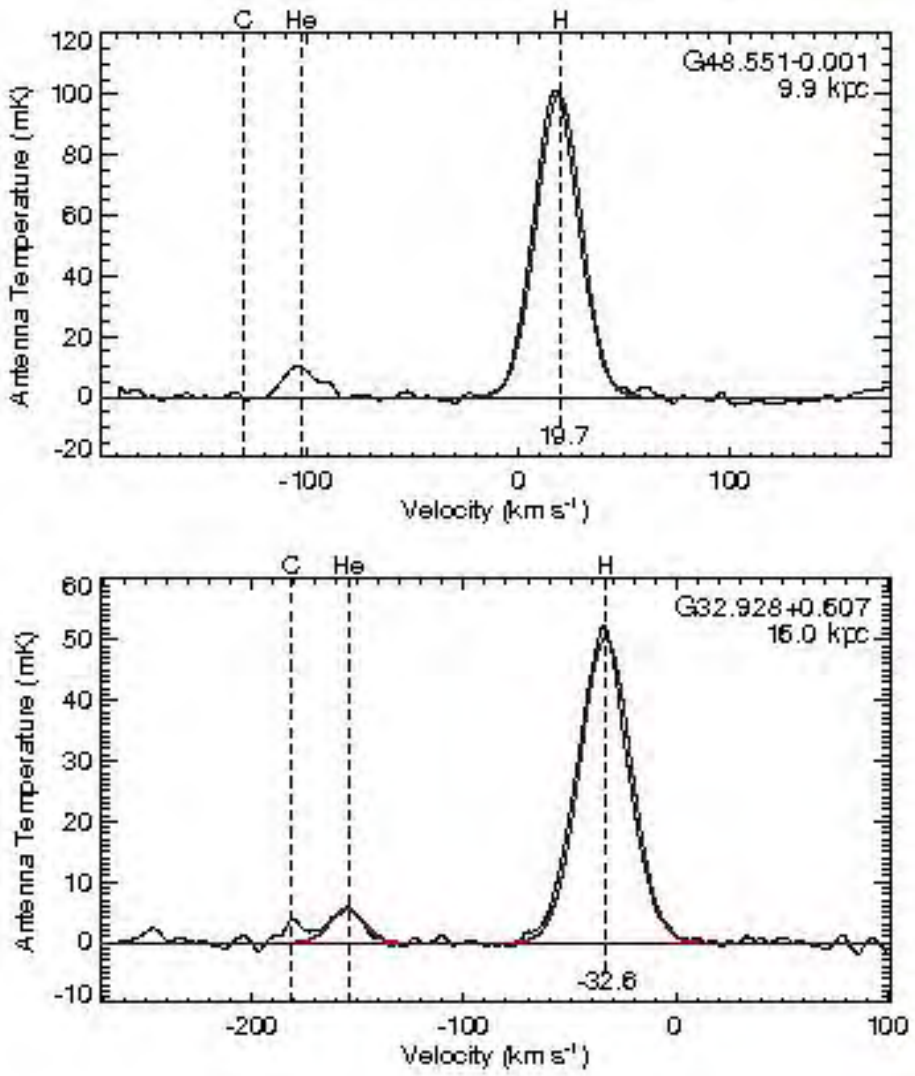
H87α - H93α (8 - 10 GHz)

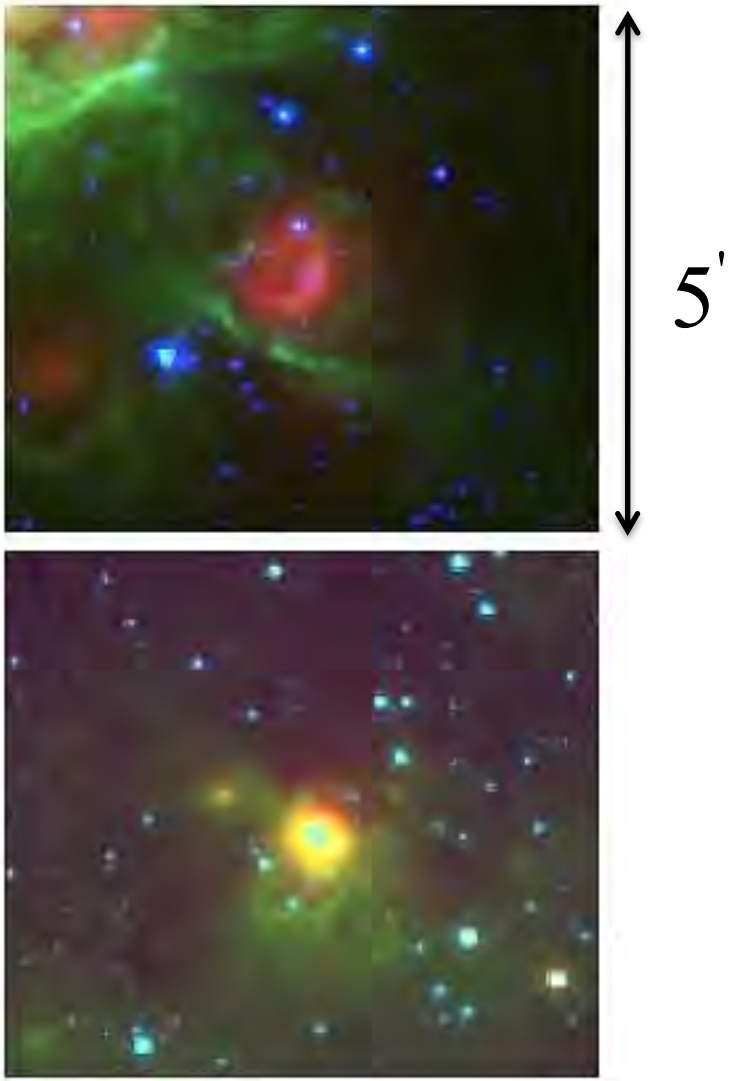
HPBW ~ 80 arcsec

$\Delta\nu = 12$ kHz ($\Delta v = 0.4$ km s^{-1})

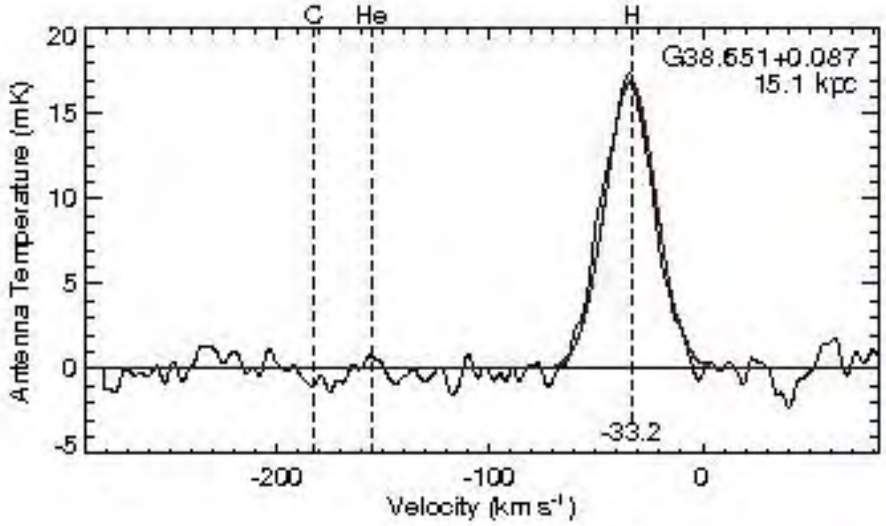
All HII regions ionized by a single O-type star within the Solar orbit

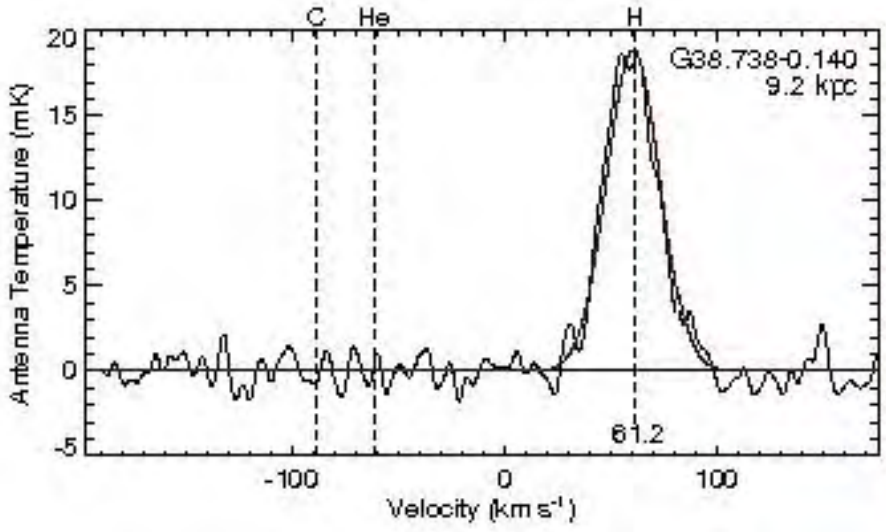
GBT HRDS RRL Composite Spectra

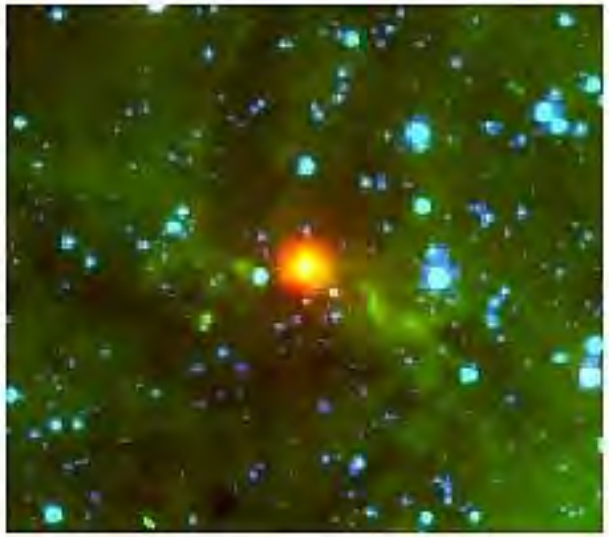


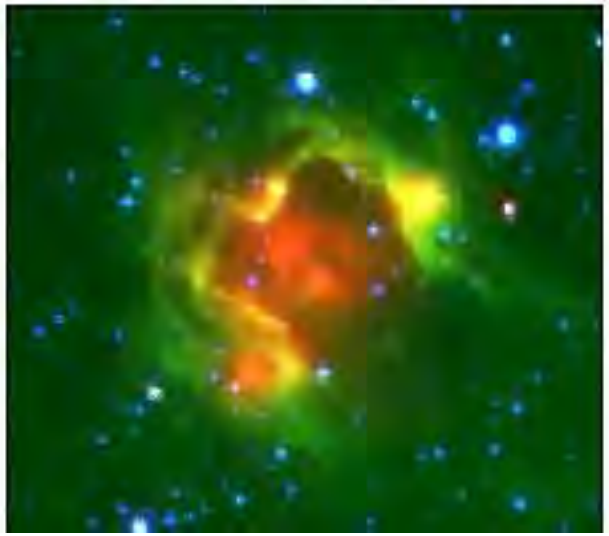


GBT HRDS RRL Composite Spectra



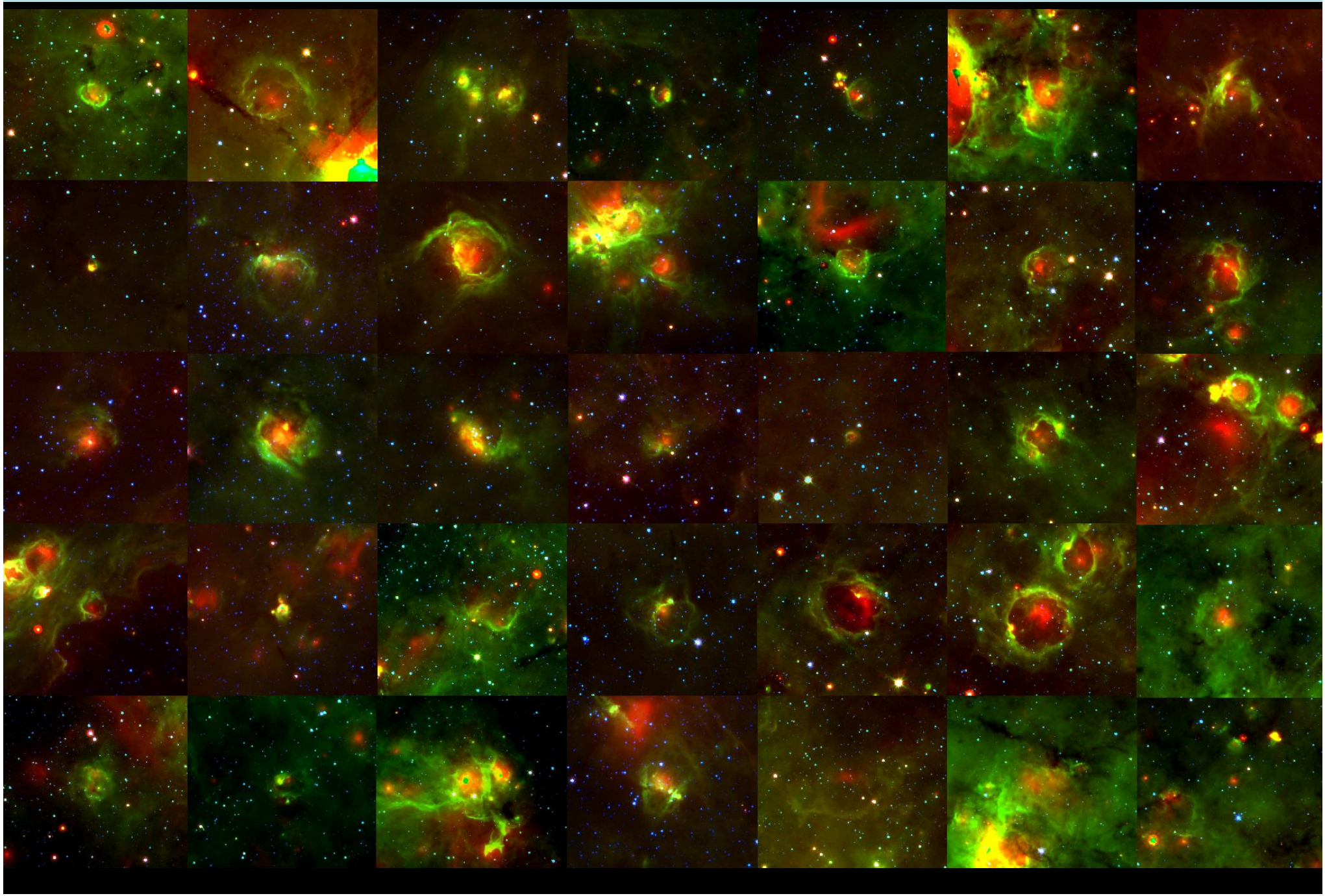




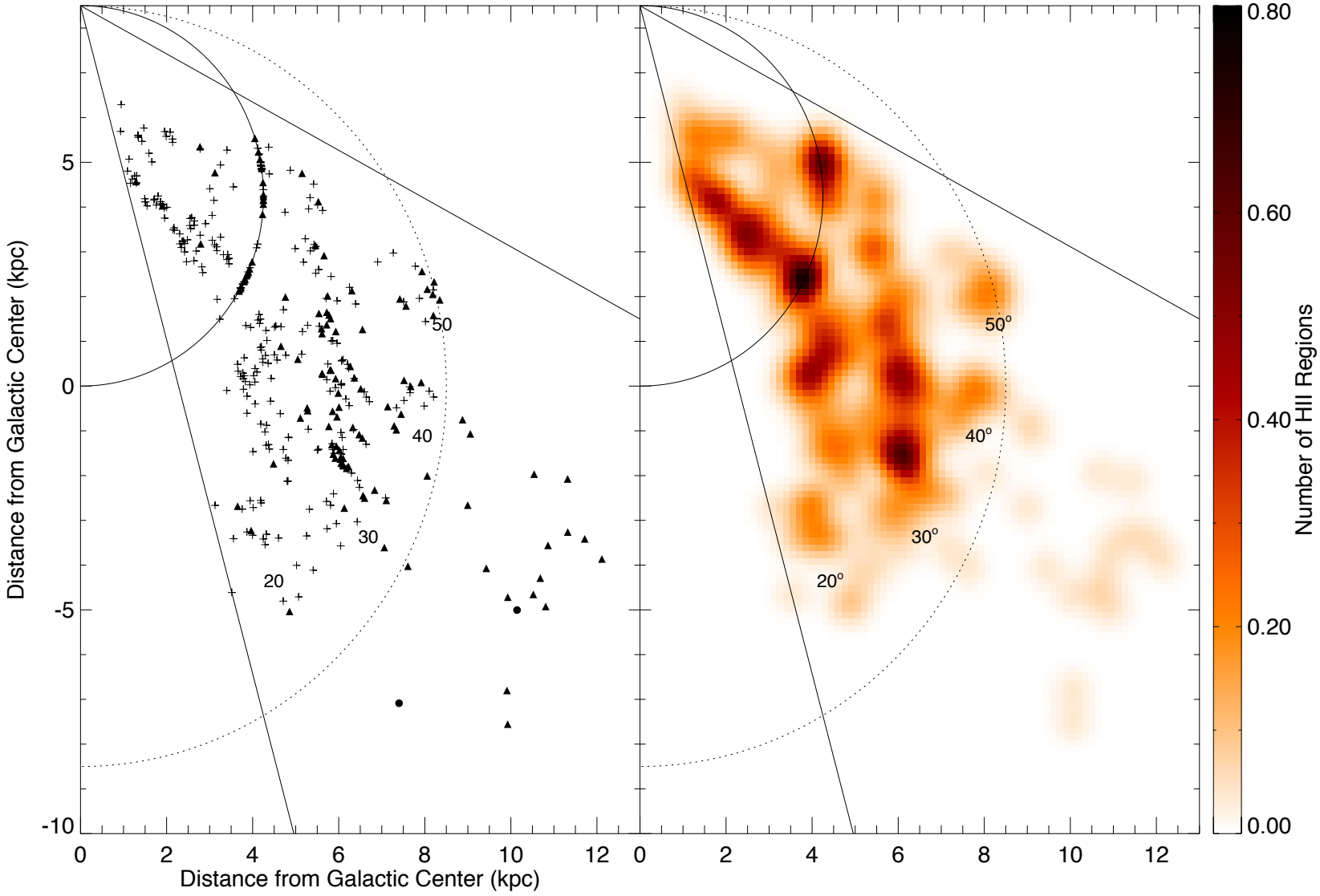


5'

HRDS H II Regions



Map of Milky Way H II Regions



Southern HII Region Discovery Survey

Trey Wenger
University of Virginia
SHRDS Guru

ATCA

Australia Telescope Compact Array

ATCA + CABB-CX

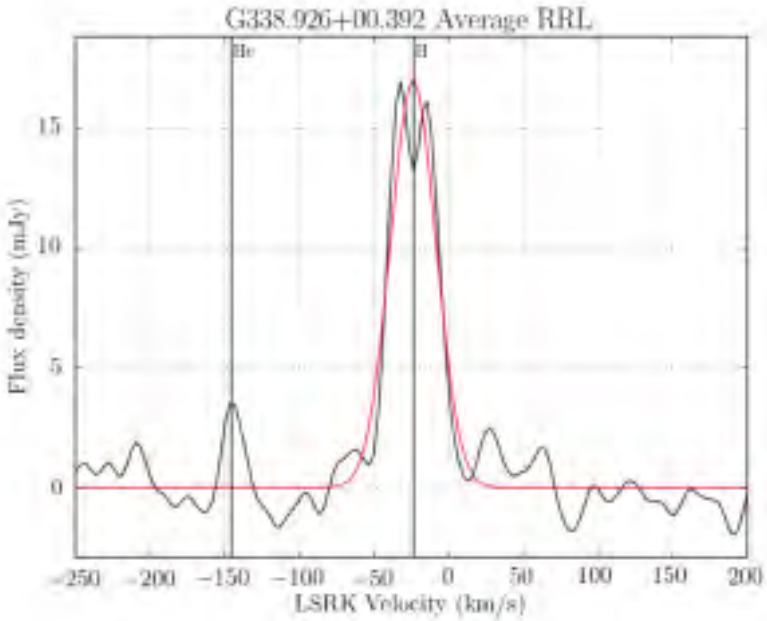
CAAB-CX

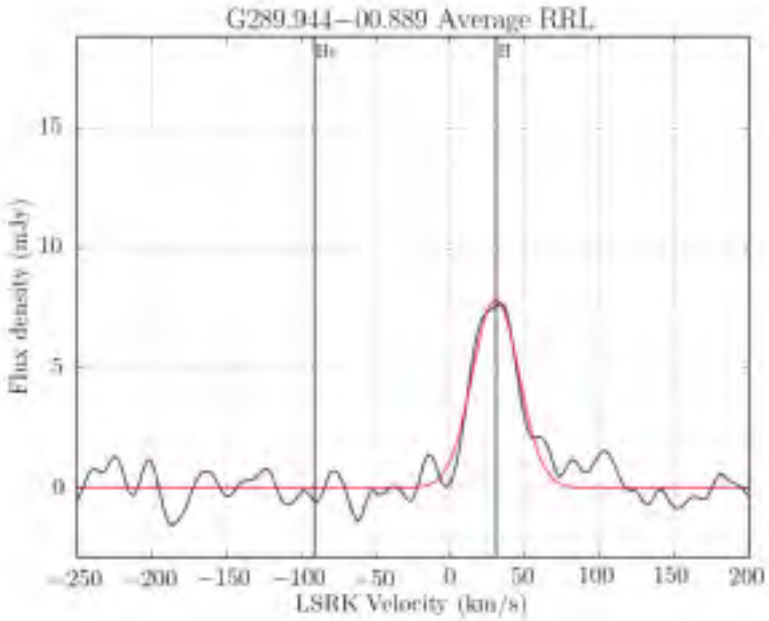
Compact Array Broadband Backend

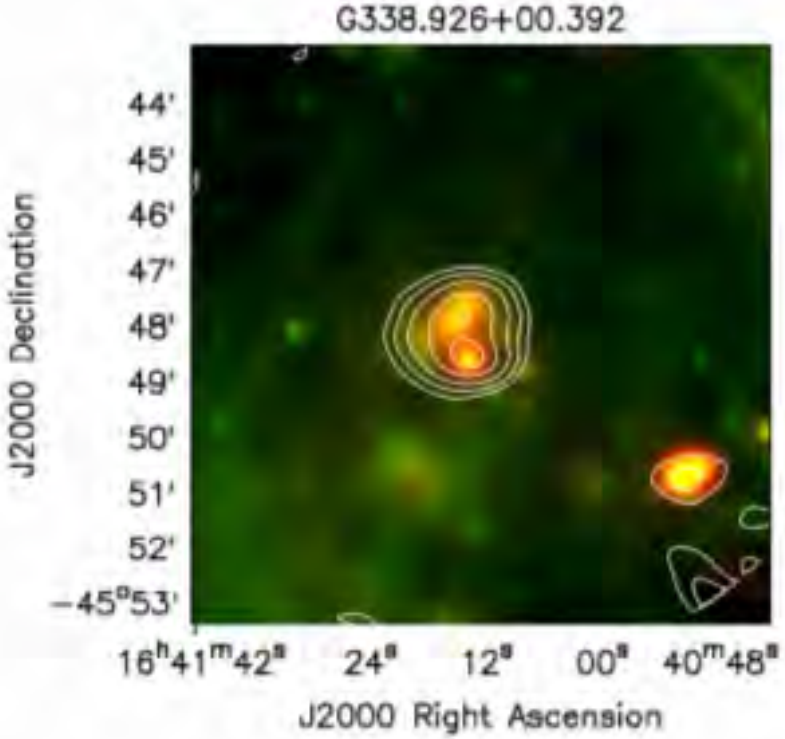
- Two 2 GHz wide bands can be placed anywhere between 4.1 and 10.4 GHz
- Within these can place 32 ‘zoom bands’ that can have widths of either 64 MHz or 1 MHz
- Zoom Bands have 2048 channels each

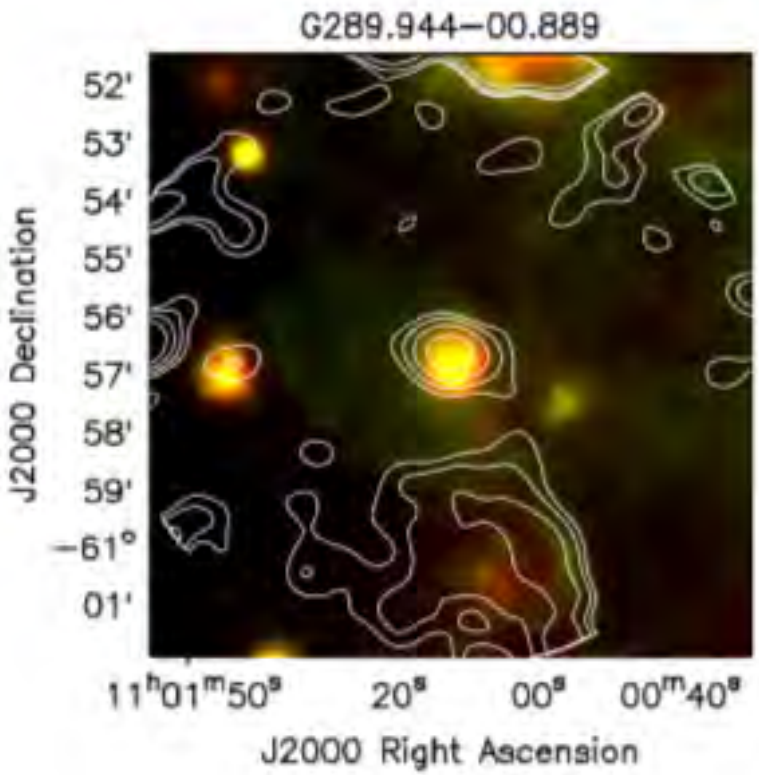
Simultaneously **observe 20 RRLs with 2 orthogonal polarizations**

Stacking these improves SNR ~ 5 x


G338.926+00.392 Average RRL
He
H
Flux density (mJy)
LSRK Velocity (km/s)


G289.944−00.889 Average RRL
He
H
Flux density (mJy)
LSRK Velocity (km/s)


G338.926+00.392
J2000 Declination
J2000 Right Ascension


G289.944−00.889
J2000 Declination
J2000 Right Ascension

SHRDS

Last HII region survey of Southern Sky was Caswell & Haynes (1987) using Parkes

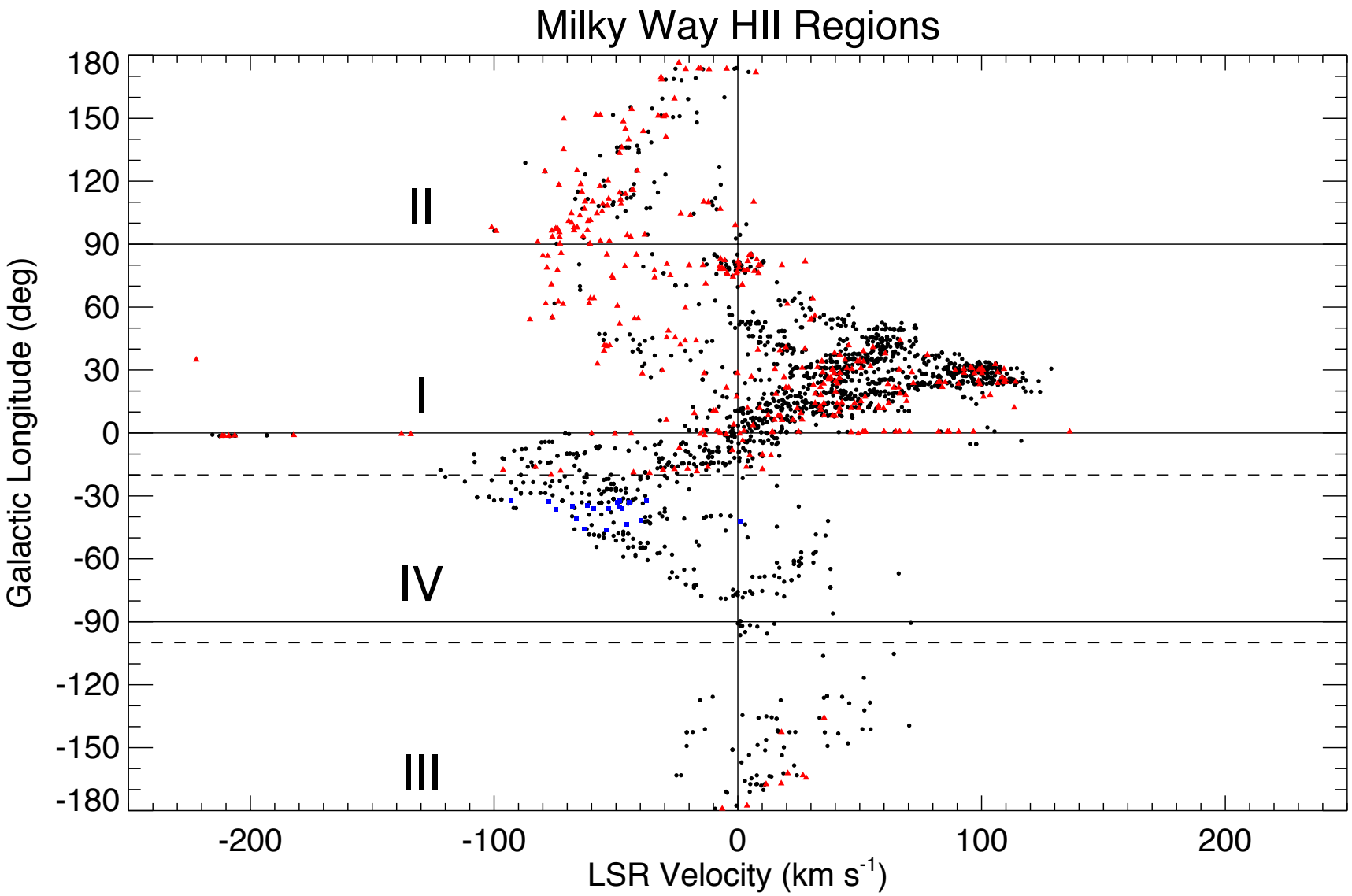
SHRDS will discover ~ 500 HII regions

Most will be located at great distances on the far side of the Galactic Centre *beyond the Solar Orbit*

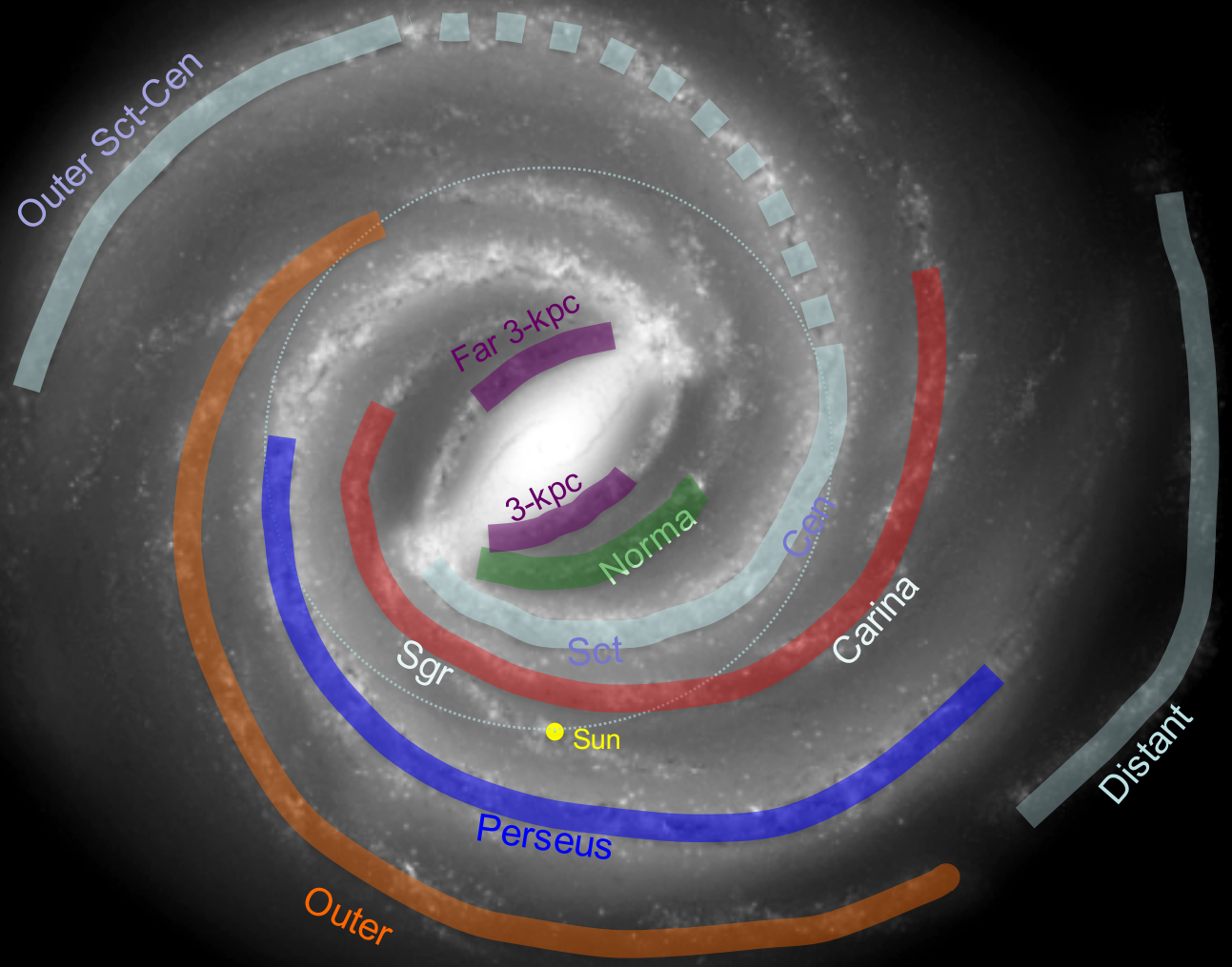
Outer Scutum – Centarus Arm

L – V Plots are not to be feared:

DON'T PANIC !

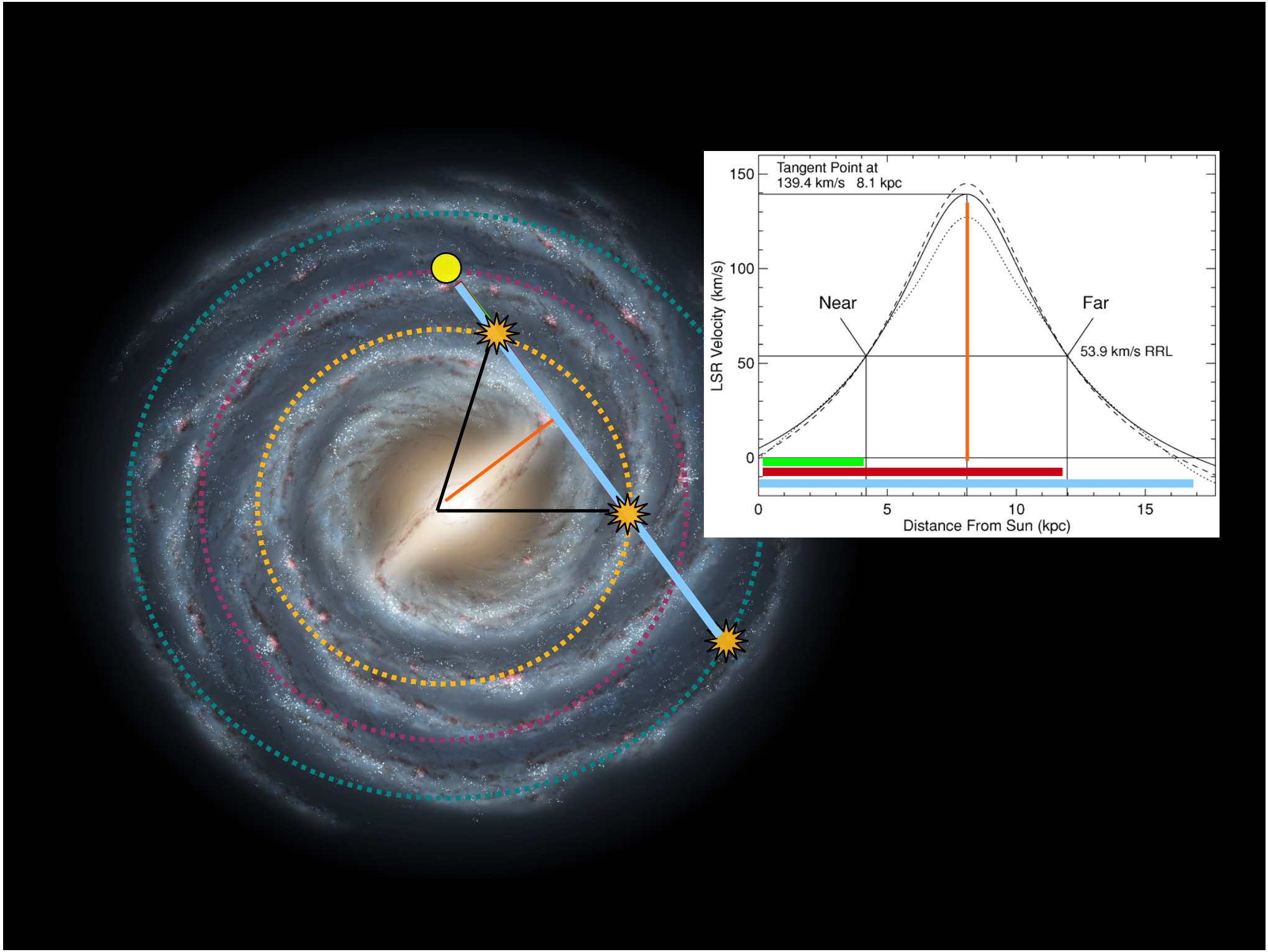


This is a cartoon. It is not a model. It is not a map.

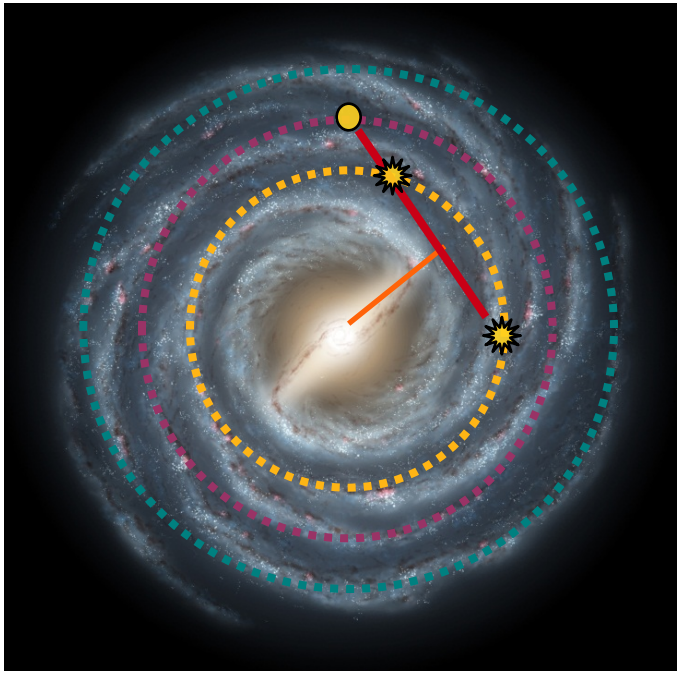


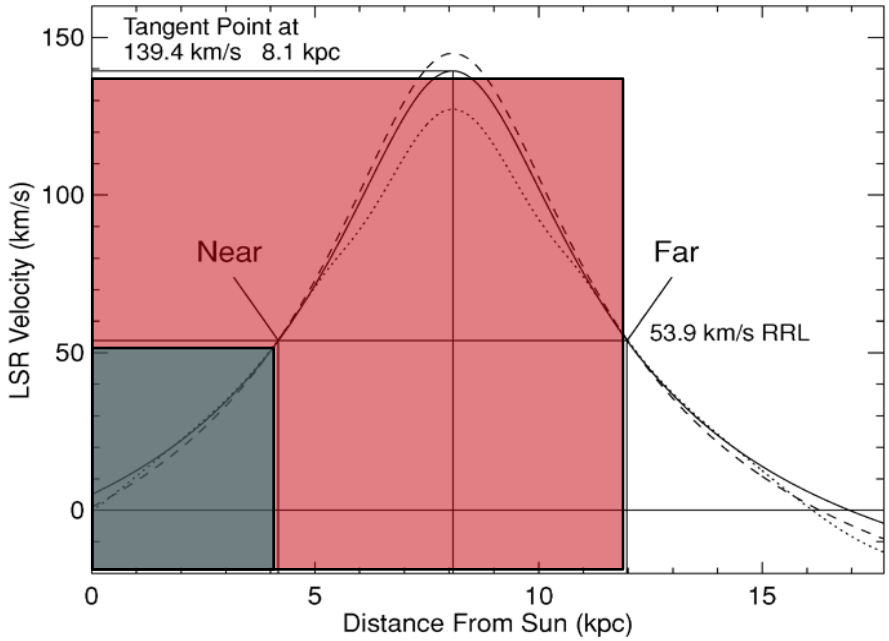
Benjamin & Hurt have a lot to answer for …

FINIS


Tangent Point at
139.4 km/s 8.1 kpc
150
100
50
0
LSR Velocity (km/s)
Near
Far
53.9 km/s RRL
0
5
10
15
Distance From Sun (kpc)

Resolving the KDA with H I Absorption





HI Emission/Absorption (HI E/A): Absorption of H II region emission by foreground H I

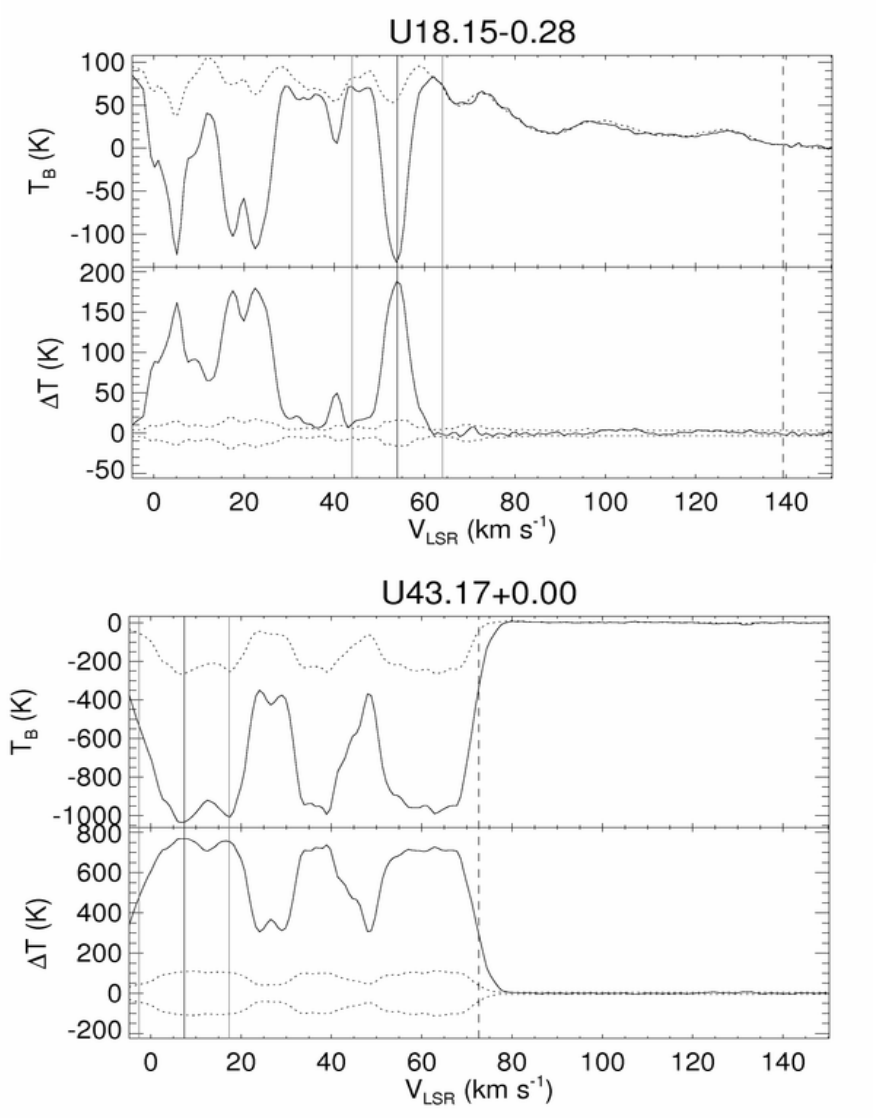
- HI absorption up to HII region velocity→ Near
- HI absorption up to tangent point velocity → Far

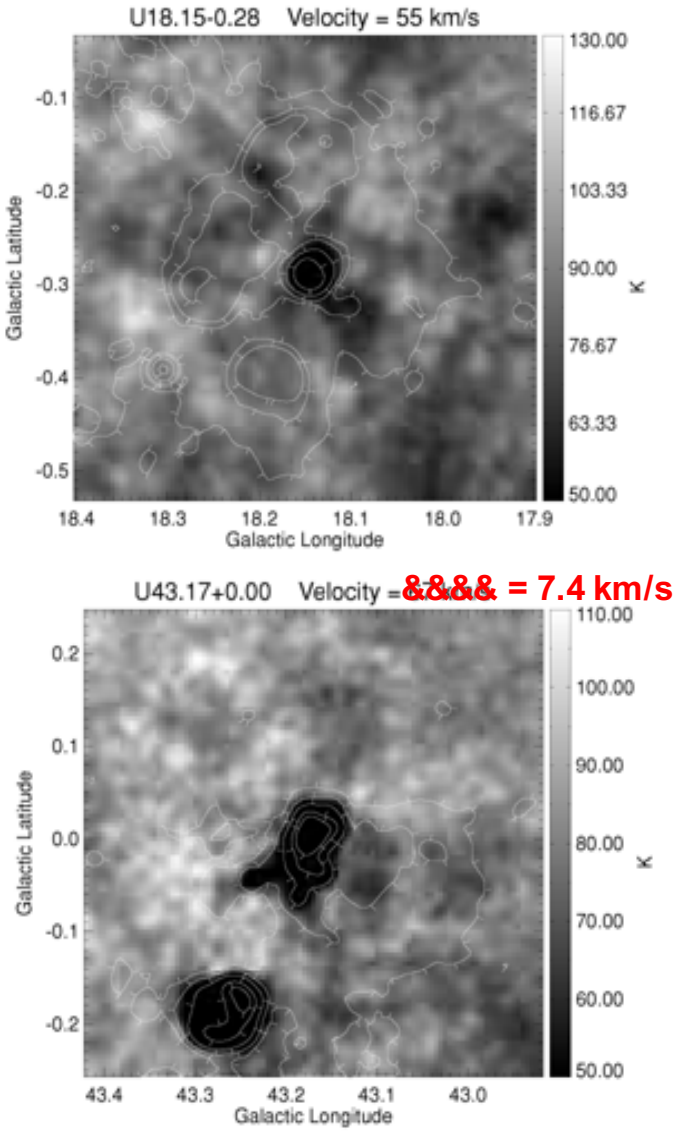
See Kuchar & Bania (1994), Kolpak et al. (2002), Anderson & Bania (2009)

Resolving the Kinematic Distance Ambiguity

Near!

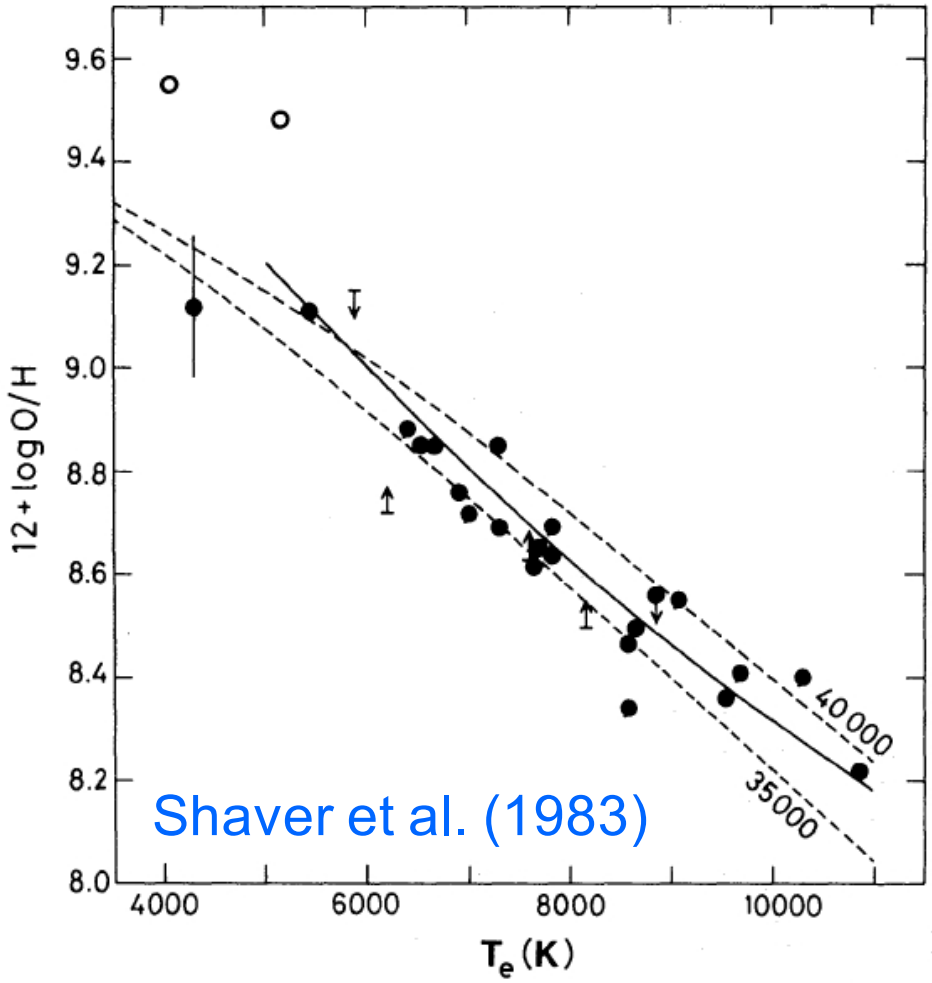
Far!





Anderson & Bania (2009)

H II Region Electron Temperatures

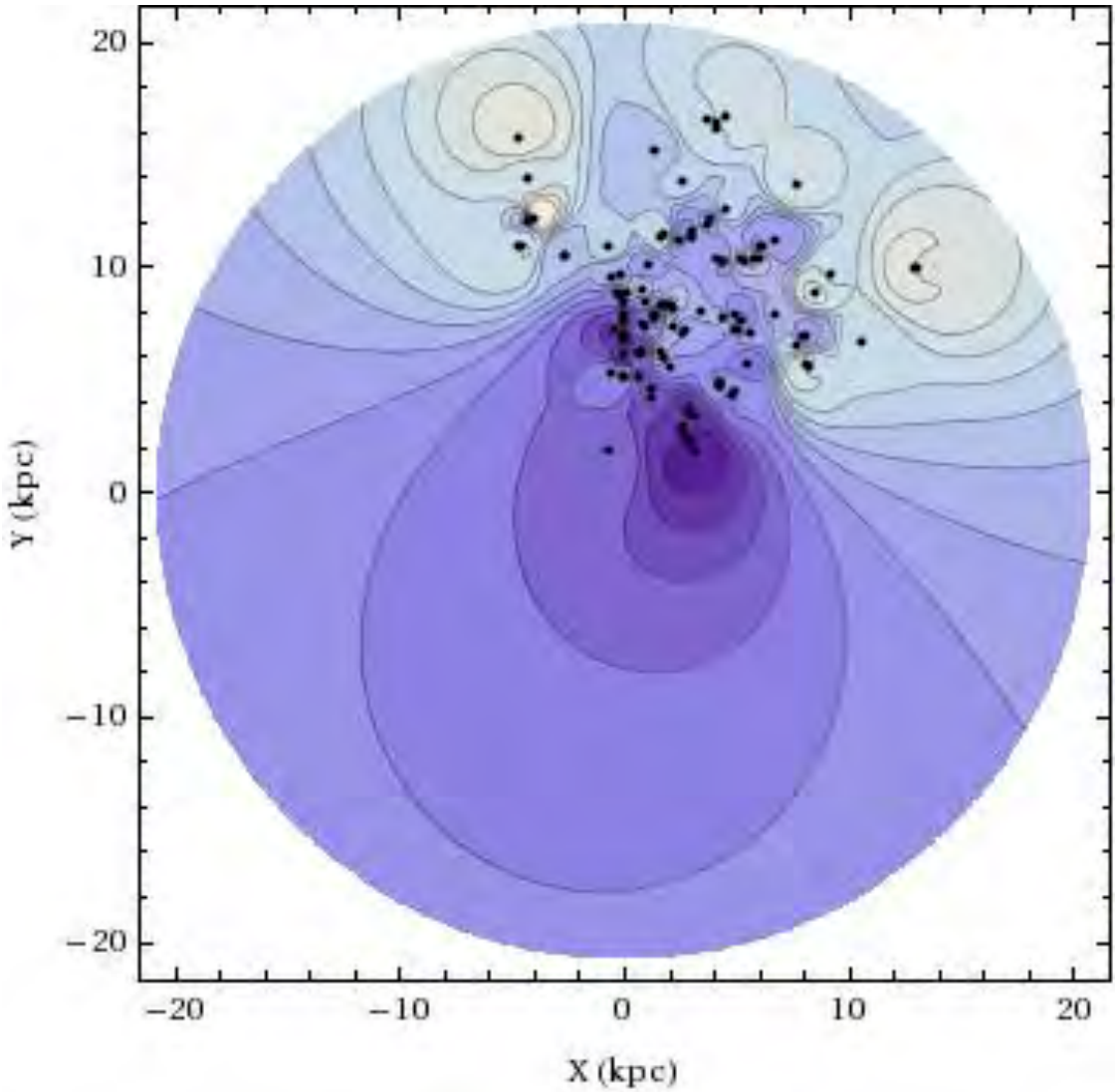


$$\frac{T_L}{T_C} \propto T_e^{-1.15}$$

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

Te is a proxy for the nebular metallicity

Electron Temperature Distribution has Azimuthal Structure !



Sample : GBT + 140 Foot

$330^{o} \leq Az \leq 60^{o}$

Contours :

Range : 6400 – 11200 K

Interval : 400 K