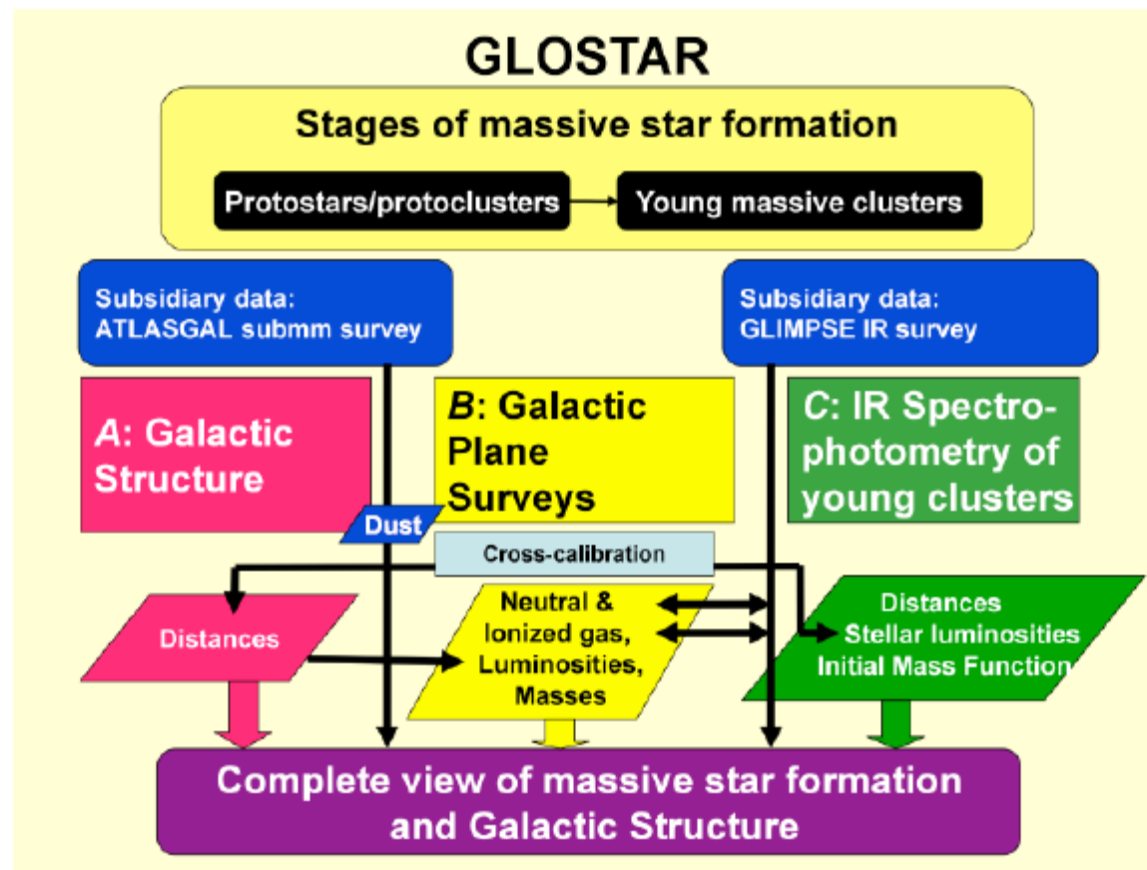


Polarization in GLOSTAR – A Comprehensive Galactic Plane Star Formation Survey at Radio Wavelengths

Karl Menten, **Friedrich Wyrowski**, Andreas Brunthaler,
Nirupam Roy, Timea Csengeri, James Urquhart,
Sergio Dzib, Benjamin Winkel (MPIfR Bonn)
+ **GLOSTAR consortium**

ERC Advanced Grant Karl Menten



Outline of GLOSTAR emphasizing the interconnections between its individual components.

- Part B: → C band Galactic Plane survey !

High mass star formation: The quest for an evolutionary scheme

ATLASGAL

- **Pre-protocluster cores:** cold ($<20\text{K}$), massive ($\sim 100\text{-}1000\text{ M}$)
- **Pre-hot cores:** IRAS sources, with/without strong MIR. “Warm” sources, $T\sim 50\text{K}$
- **Hot cores:** internally heated, $T>100\text{K}$, dense ($\sim 10^7$), HII region quenched

- Class II **methanol masers**
- **Hyper-/ultra-compact HII regions:**
 $d<0.05\text{pc}$, $EM\sim 10^9$ / $d<0.1\text{pc}$, $EM\sim 10^7$

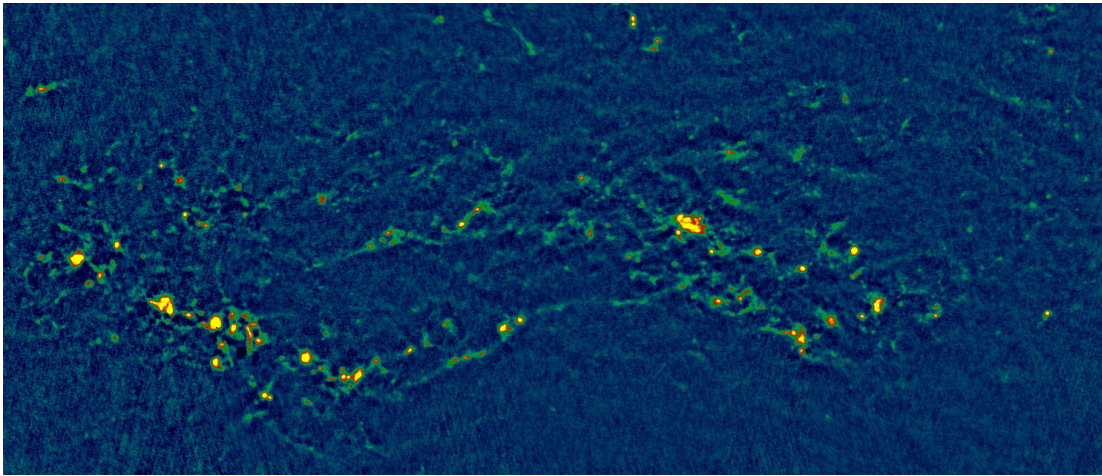
- (compact) HII regions

JVLA Survey

- Endproducts: OB clusters/associations

ATLASGAL: APEX Telescope Large Area Survey of the Galaxy

- **Unbiased survey of the inner Galactic Plane at $870\mu\text{m}$**
 - Census of massive star formation throughout the Galaxy
 - study large scale structure of the cold ISM
 - associate w. other Galactic surveys (JVLA, Spitzer, MSX, Hi-GAL)
 - → evolutionary sequence of massive star forming clumps



JVLA C band survey:

Main science goals

- Complete census of MSF tracers such as ultra/hyper-compact HII regions and CH₃OH masers, covering range of evolutionary stages
- ~5-10 deeper than CORNISH & MMB survey
→ entering new discovery space
- Combined with Effelsberg: unprecedented view of ionized gas on all scales down to 1arcsec
- Combined with ATLASGAL/IR surveys: complete view of hot ionized gas/masers with cold/warm dust
- Simultaneously: extragalactic background sources & polarization

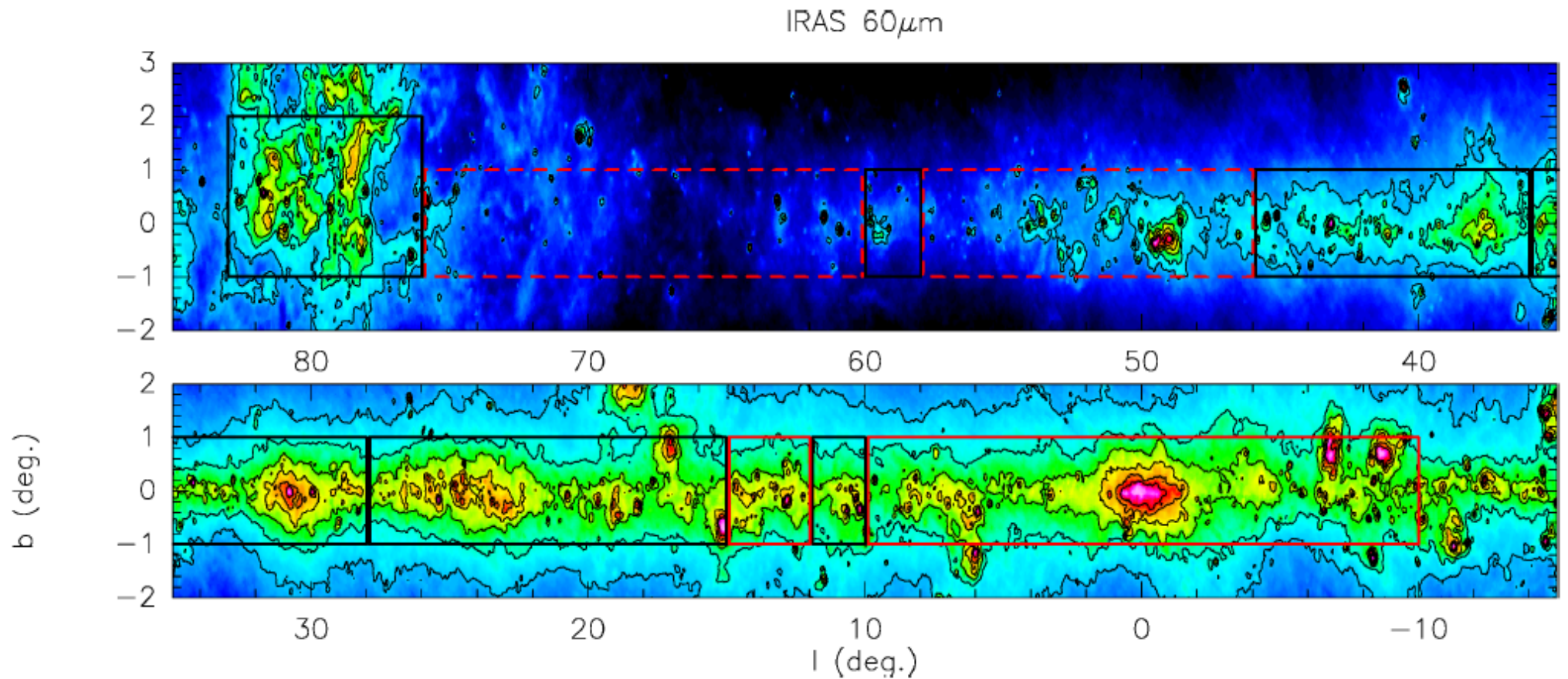
GLOSTAR Galactic Plane Survey

- C-band JVLA D+B configuration, Effelsberg
 - → all spatial scales down to 1 arcsec
 - JVLA setup:

Line	Frequency [MHz]	bandwidth [MHz]	chan. & pol. prod.	resolution [km s ⁻¹]	coverage [km s ⁻¹]	1 σ rms in 15 sec [mJy beam ⁻¹]
Continuum	4200–5200	8×128	8×64×4	-	-	0.09
H ₂ CO	4829	4	1024×2	0.25	260	45
H112 α -H115 α	4268–4619	4×8	4×128×2	~4.2	~530	11
Continuum	6400–7400	8×128	8×64×4	-	-	0.08
CH ₃ OH	6668	8	2048×2	0.18	370	38
H96 α -H98 α	6881–7318	3×8	3×128×2	~2.8	~360	10
Total			12032 ch.			

Table 1: List of observed lines, bandwidth, number of channels and polarization products, channel spacings, velocity coverage, and sensitivity for two visits of one pointing (for the full 1 GHz for the continuum and 1 channel for the lines). For the innermost part, we will increase the velocity coverage of the formaldehyde line at the cost of reduced resolution to cover also the extreme velocities found there.

Galactic coverage



- → Various Galactic environs: e.g. nearby Cygnus complex, molecular ring, central molecular zone

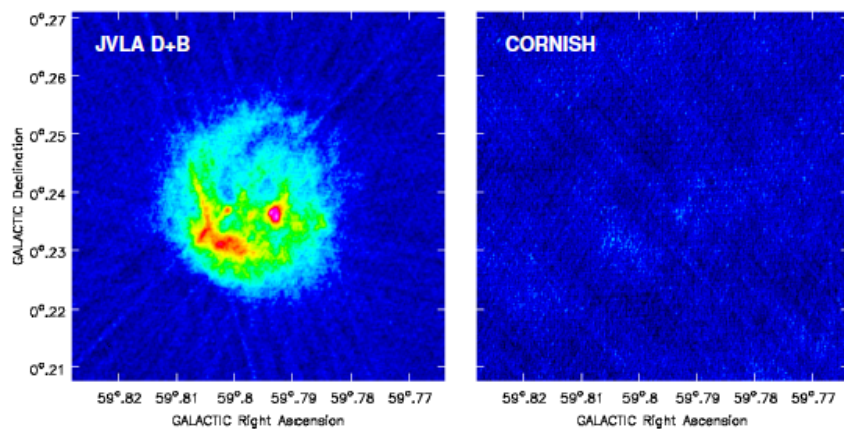
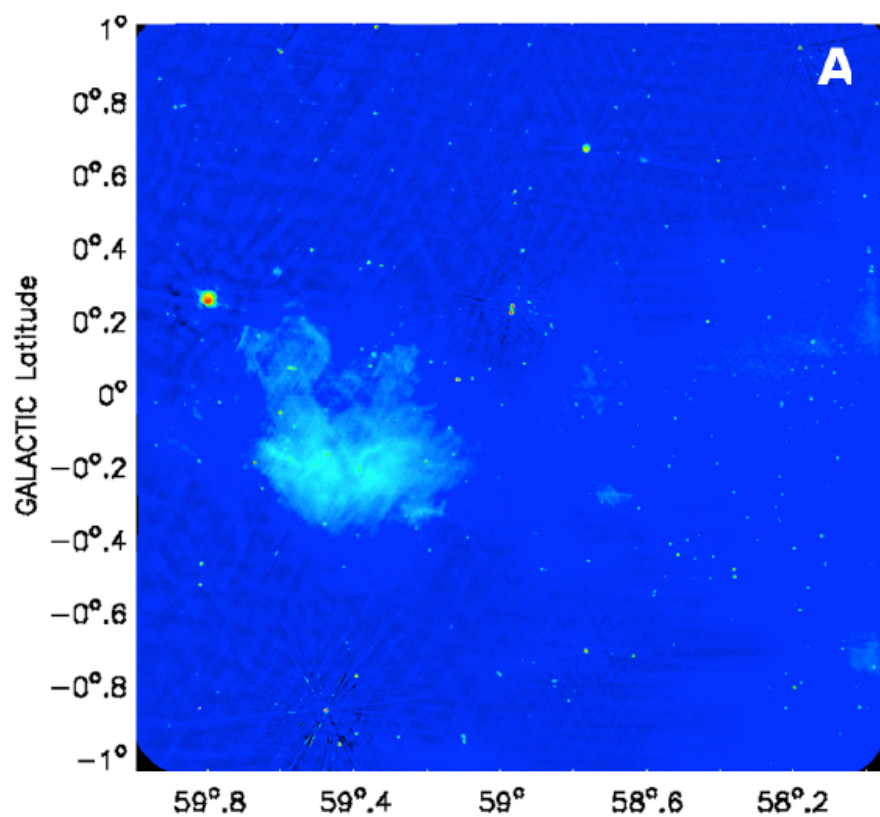


Figure 3: **Top:** The full $2^\circ \times 2^\circ$ from the pilot observation on G59.0 combining the D configuration and Effelsberg data. **Bottom:** A closer view of the strongest HII region in the field from our combined D+B configuration data and the corresponding region in the CORNISH survey.

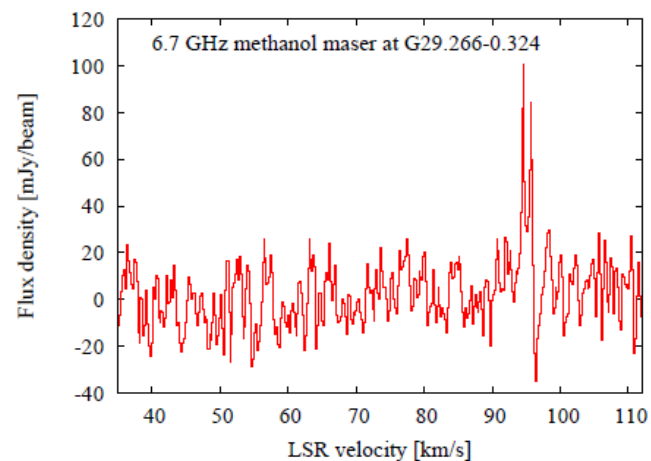
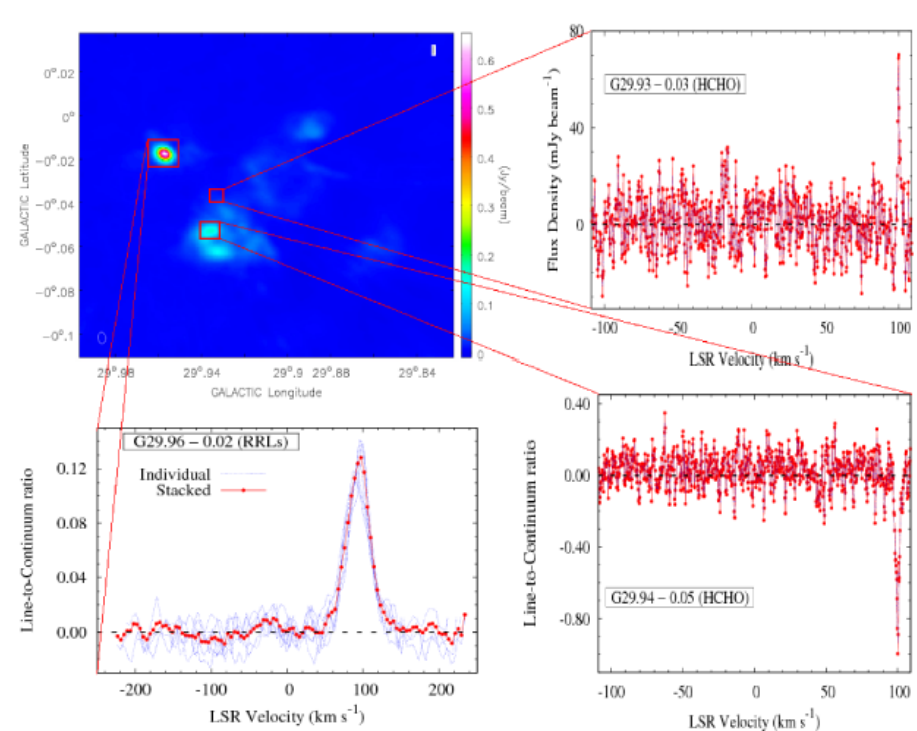


Figure 4: **Top:** Continuum image of a small fraction for the G29 field (upper left), where we detected a formaldehyde maser (upper right), formaldehyde absorption (lower right), and RRLs (lower left). For the RRLs we show the individual lines as well as the stacked version. **Bottom:** A spectrum of a newly discovered weak methanol maser.

Polarization

- JVLA continuum in full polarization
- Lines in dual polarization mode
- full polarization observations of
 - polarized extragalactic continuum sources in the 4-8 GHz range allowing important information about the Galactic magnetic field by measuring Faraday rotation
 - Combined small/large scale polarization (JVLA/EFF) to study galactic magnetized medium, covering range of scales from SF jets to supernova remnants
 - → Requires Eff Stokes Q/U for combination with JVLA data

Summary

- JVLA survey ongoing! → new view of MSF in the Milky Way
- Effelsberg critical to recover ALL scales
- **New polarization potential:**
 - Large bandwidths → frequency dependence
 - Magnetic fields from galactic scales down to star forming regions