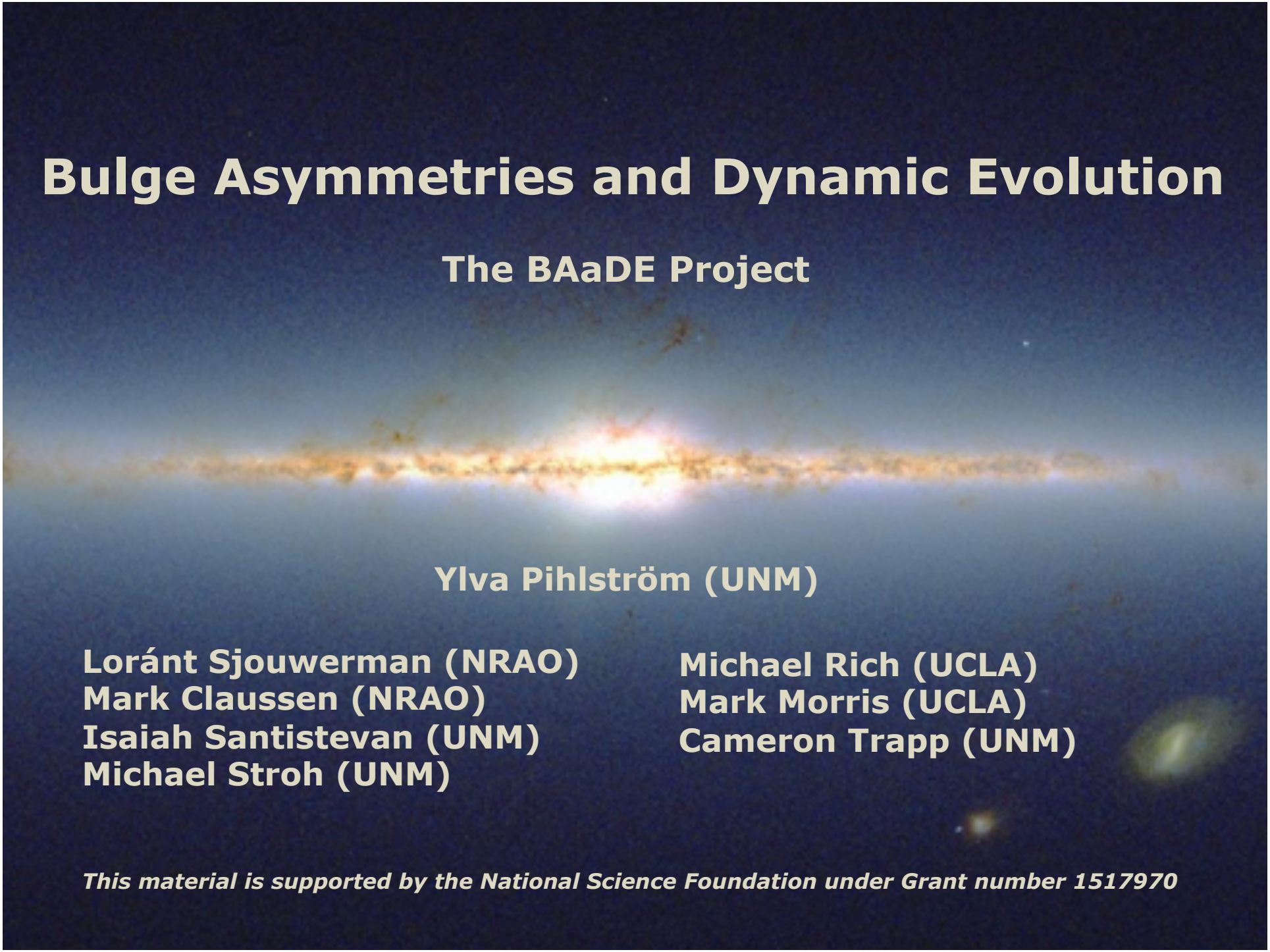


Bulge Asymmetries and Dynamic Evolution

The BAaDE Project

Ylva Pihlström (UNM)

Loránt Sjouwerman (NRAO)
Mark Claussen (NRAO)
Isaiah Santistevan (UNM)
Michael Stroh (UNM)

Michael Rich (UCLA)
Mark Morris (UCLA)
Cameron Trapp (UNM)

This material is supported by the National Science Foundation under Grant number 1517970

The BAaDE project

Aim: To significantly improve models of the dynamics and structure of the Galactic bulge and the inner Galaxy.

- Using radio detected point-masses probing into regions not reachable with optical surveys ($-6<b°<6$).
- Surveying ~34,000 stars for SiO maser emission using VLA and ALMA.
  - Direct line-of-sight velocities obtained for 20,000+ stars
- Using VLBA for detailed orbit characteristics in a subsample of the sources.

Main research goals (A)

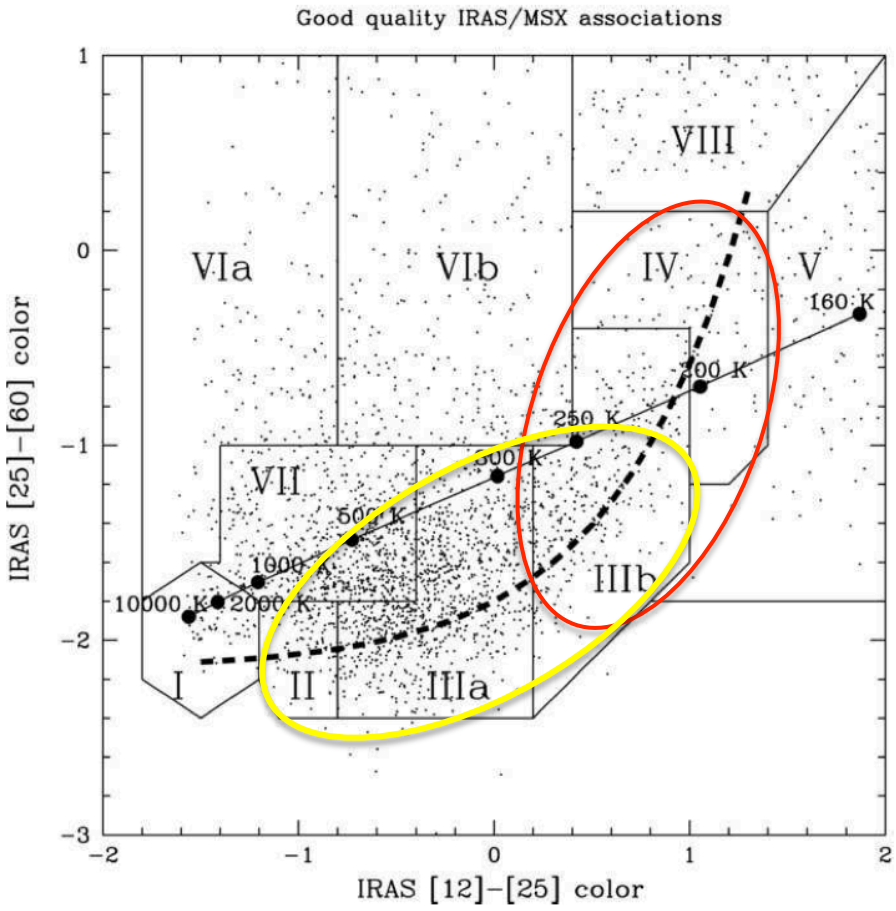
1. Galactic dynamics and detailed Galactic structure
   - LOS velocities + location => global dynamical model
   - Velocity rotation curves & velocity dispersions (for dynamical models)
   - Instabilities and asymmetries
   - High-velocity stars, are they an entire population influenced by the bar?

2. Statistics of SiO masers in the Galaxy
   - Detection statistics as functions of MSX color, Galactic location and velocity
   - Comparison with 2MASS, GLIMPSE, WISE, AKARI, etc.
   - Correlation between different maser transitions in the shell

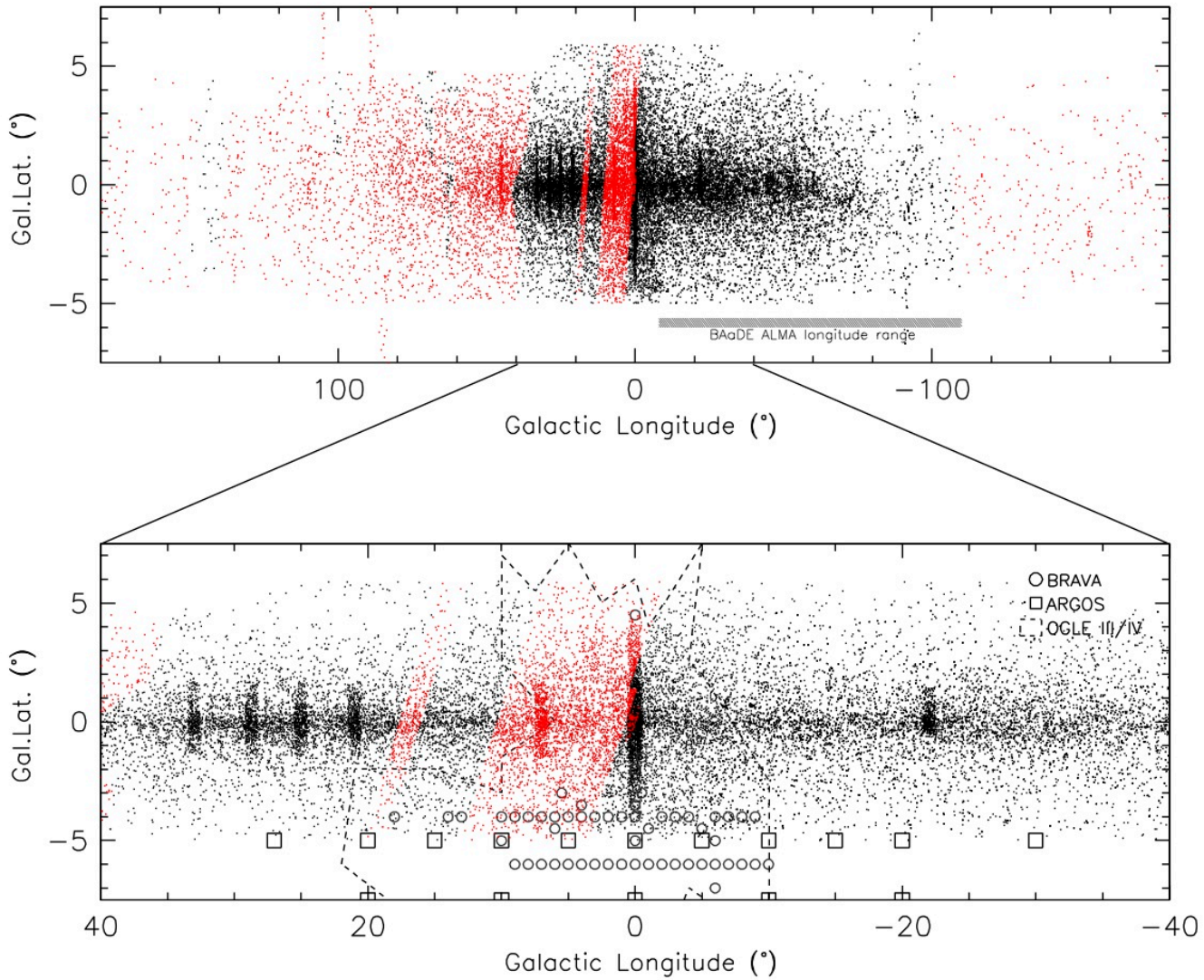
OH and SiO maser stars: IRAS and MSX

- Masers in OH/IR stars have previously been used for kinematical studies of the Milky Way (e.g., Habing et al. 2006)
  - Only 3000 OH maser stars in MW
- IRAS colors predictive of finding sources with circumstellar material.
- Works also for MSX; in comparable color regions the detection rate of SiO masers is 50-90%.

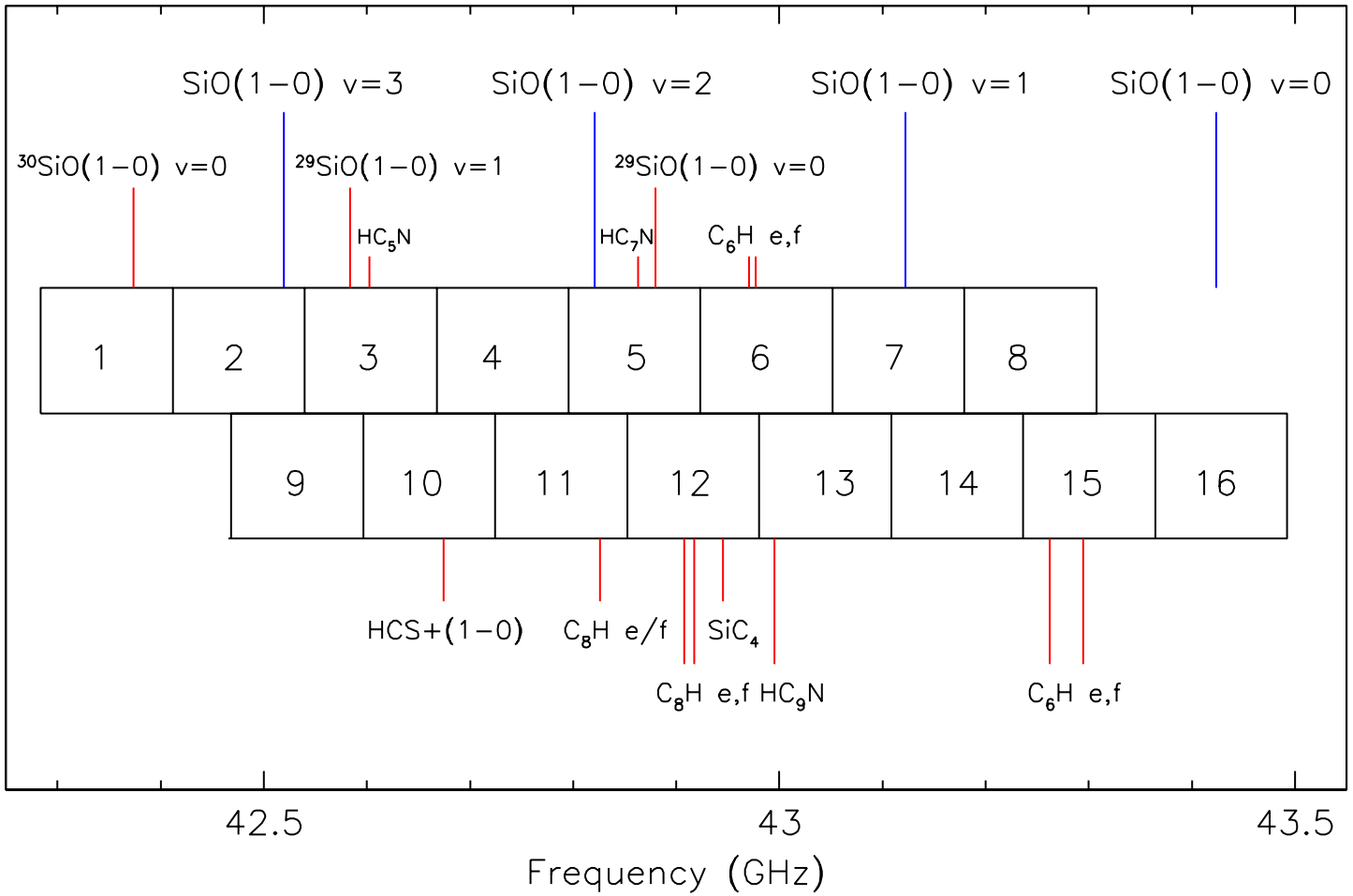
Sjouwerman et al. 2009,
Messineo et al. 2002.



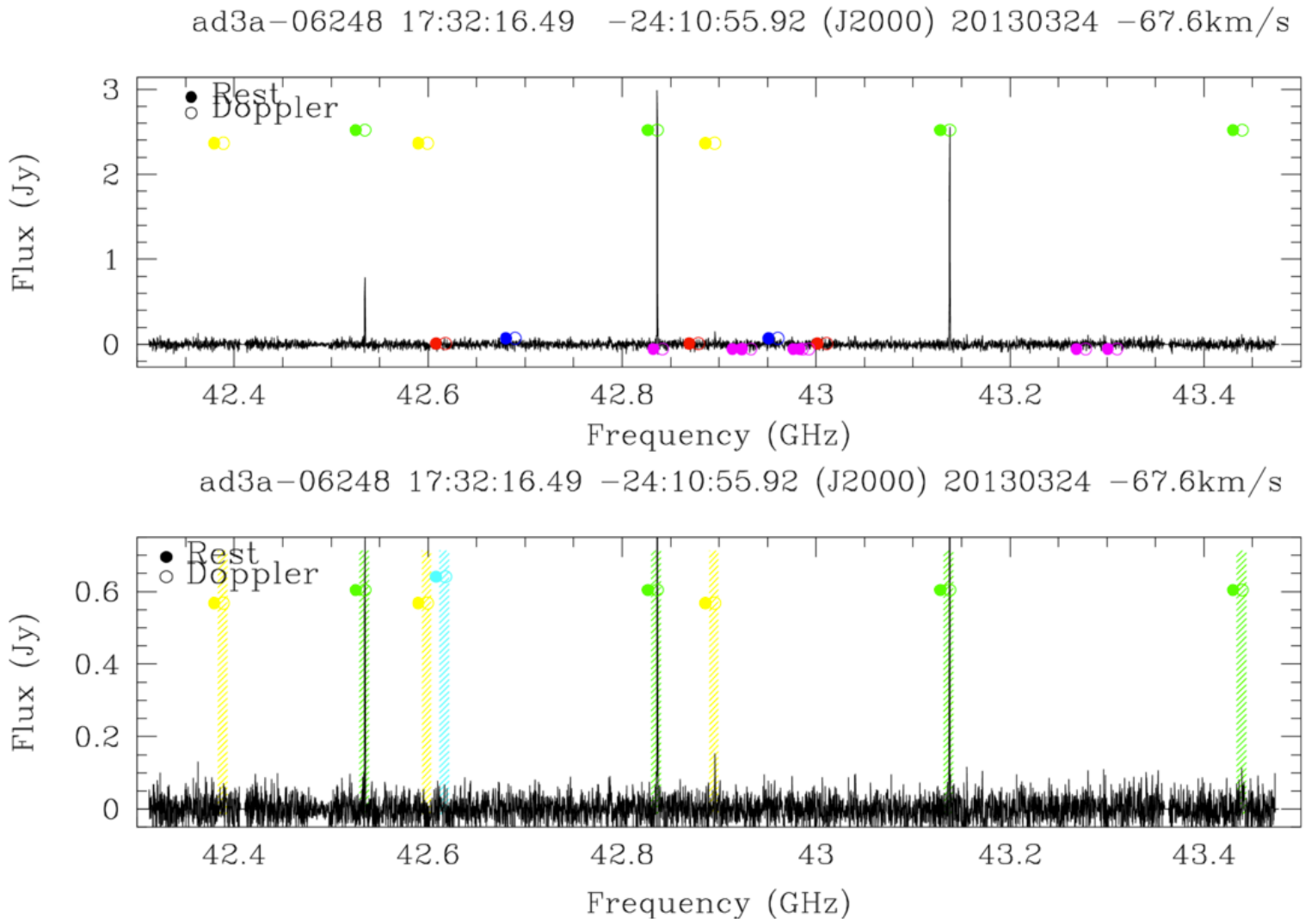
Van der Veen & Habing 1988
Habing 1996


Gal.Lat. (°)
5
0
−5
100
0
−100
Galactic Longitude (°)
BAaDE ALMA longitude range
BRAVA
ARGOS
OGLE III/IV
40
20
−20
−40

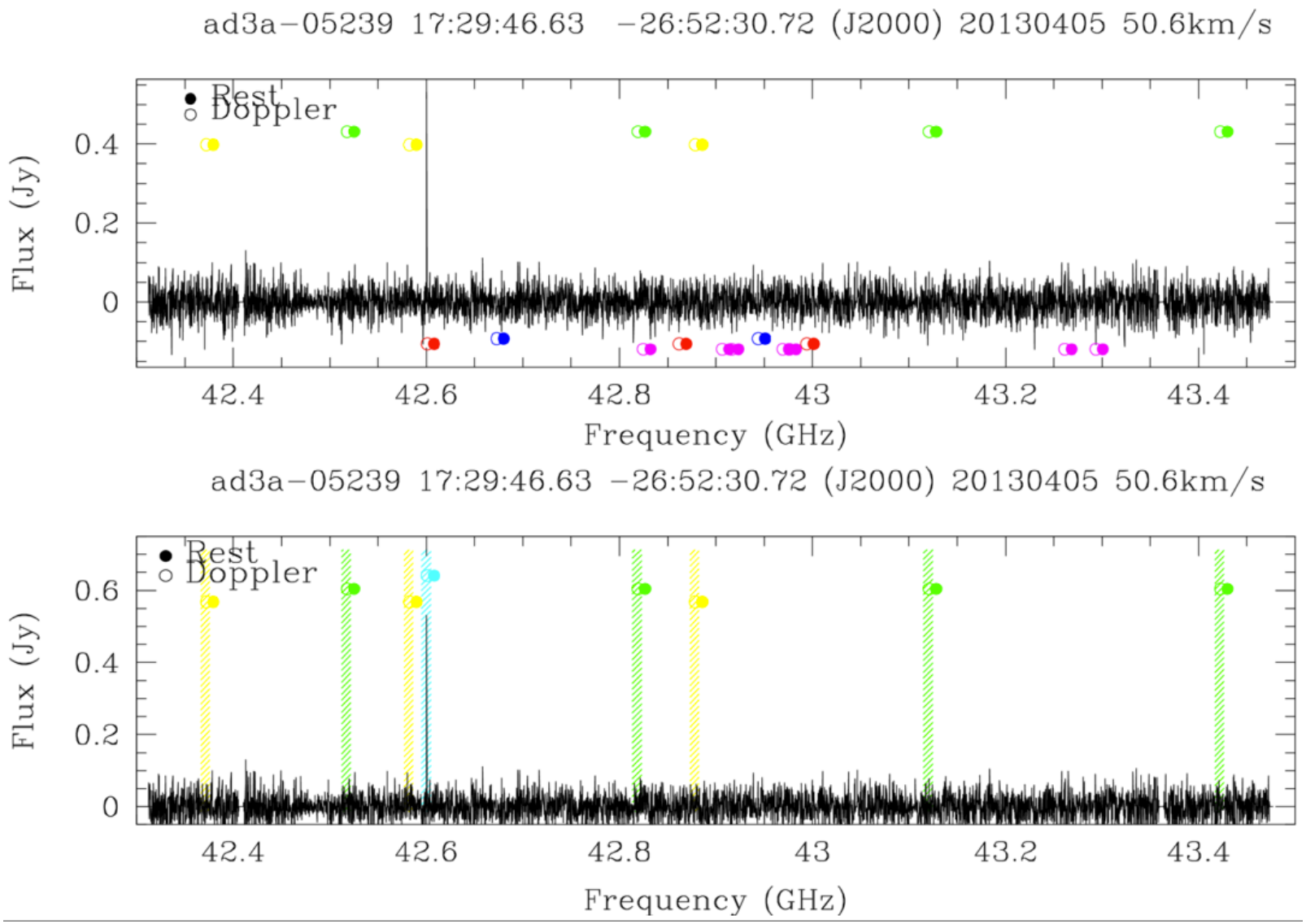
VLA frequency coverage



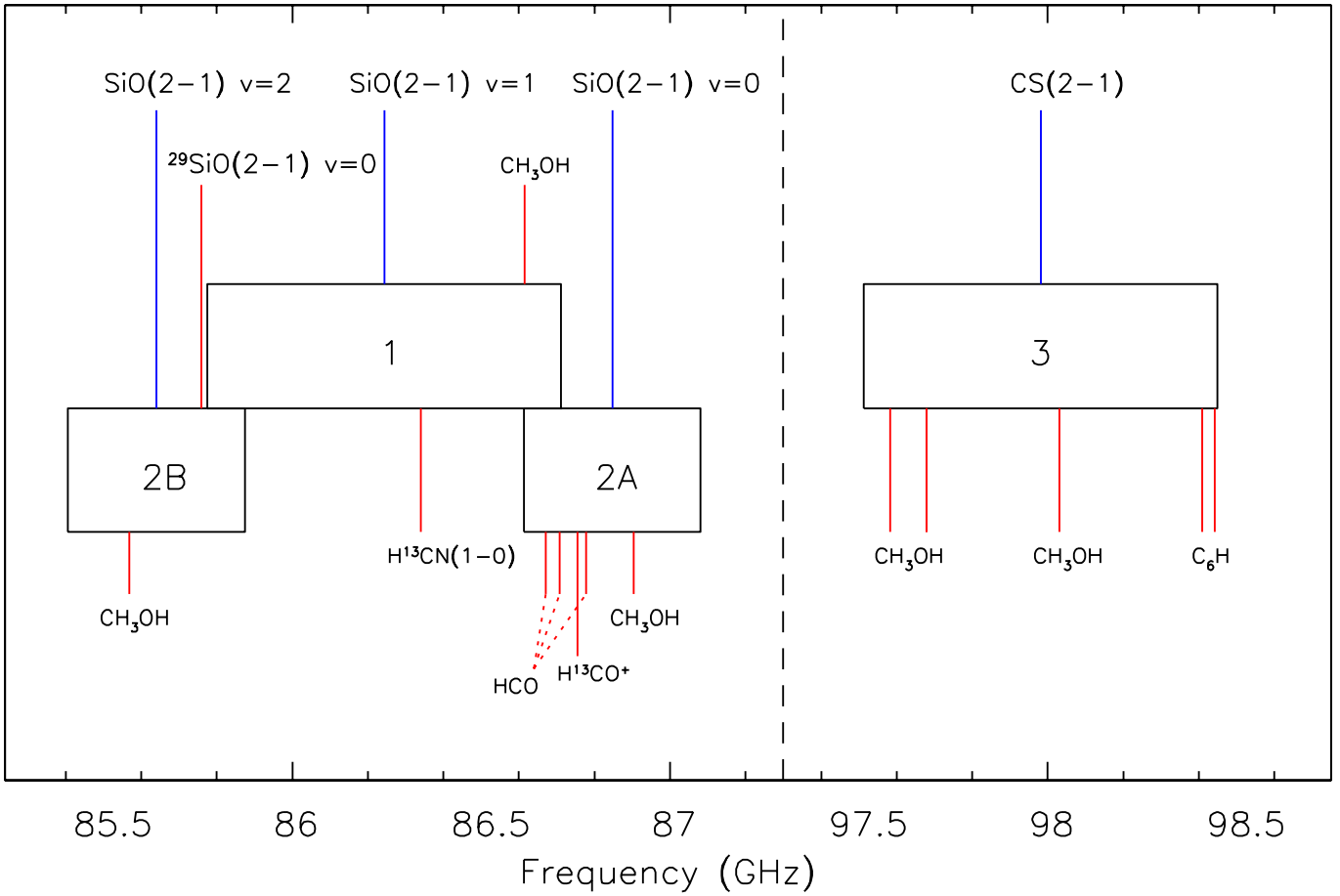
Example VLA spectra: (v=1,2,3 and isotope ^{29}SiO v=0)



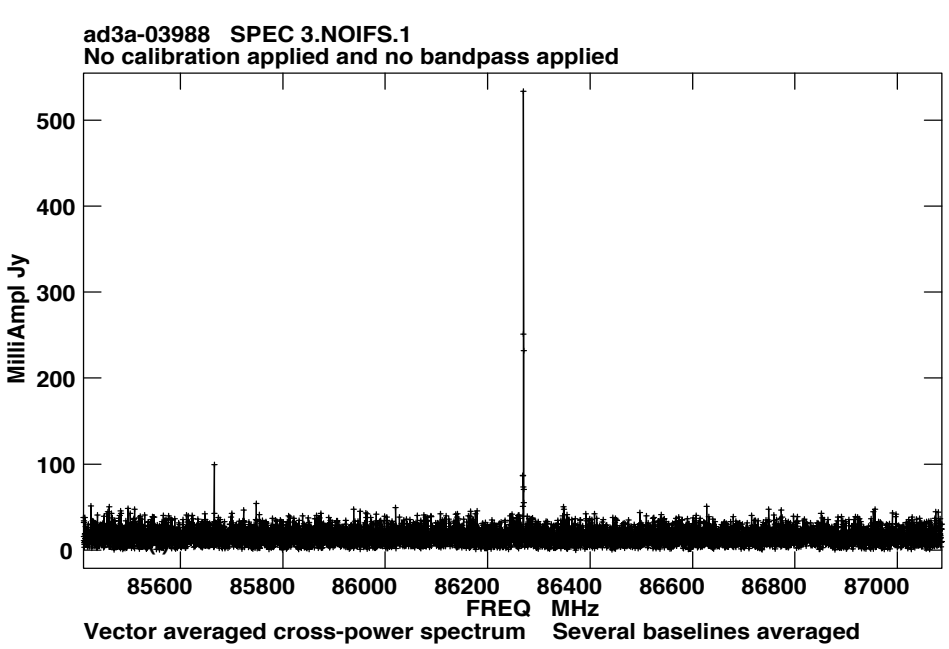
Example VLA spectra: carbon

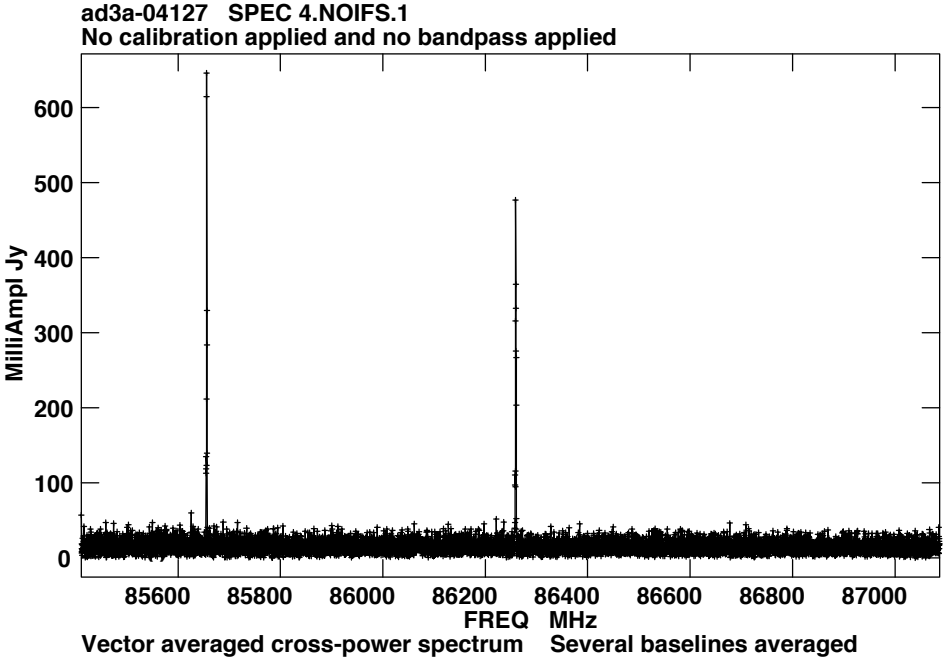


ALMA Frequency Setup

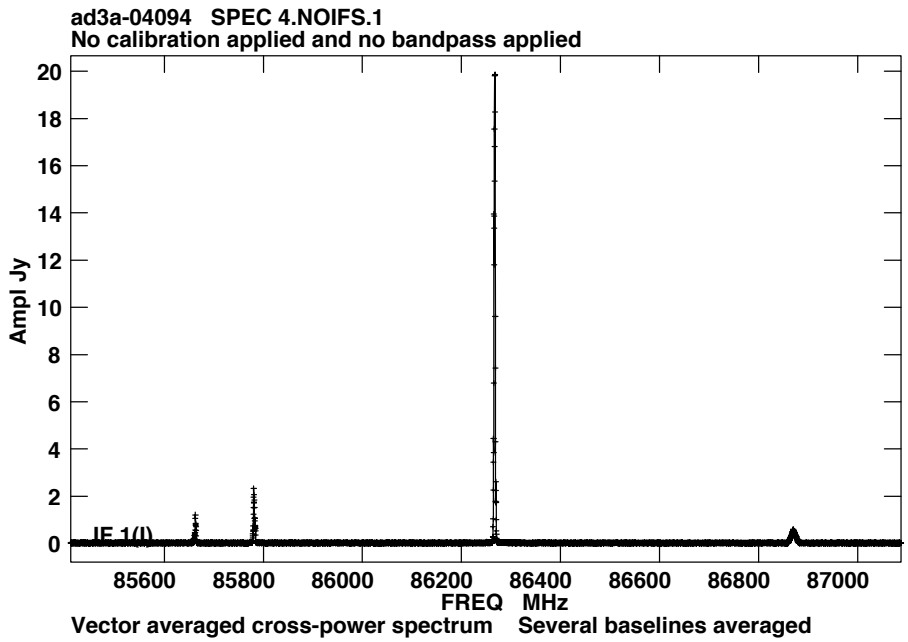


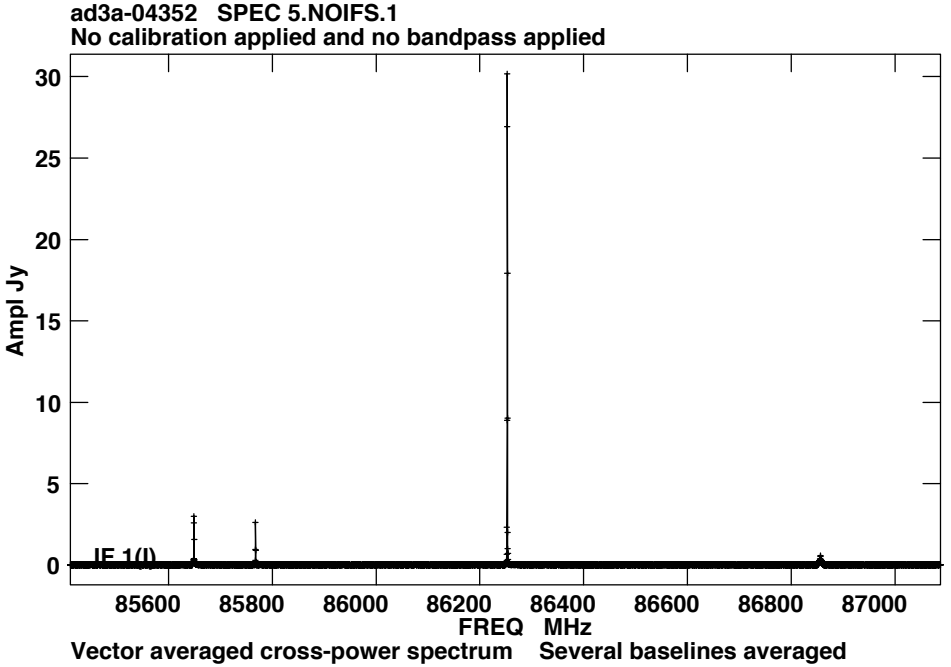
Example ALMA spectra: Dual (v=1, v=2)

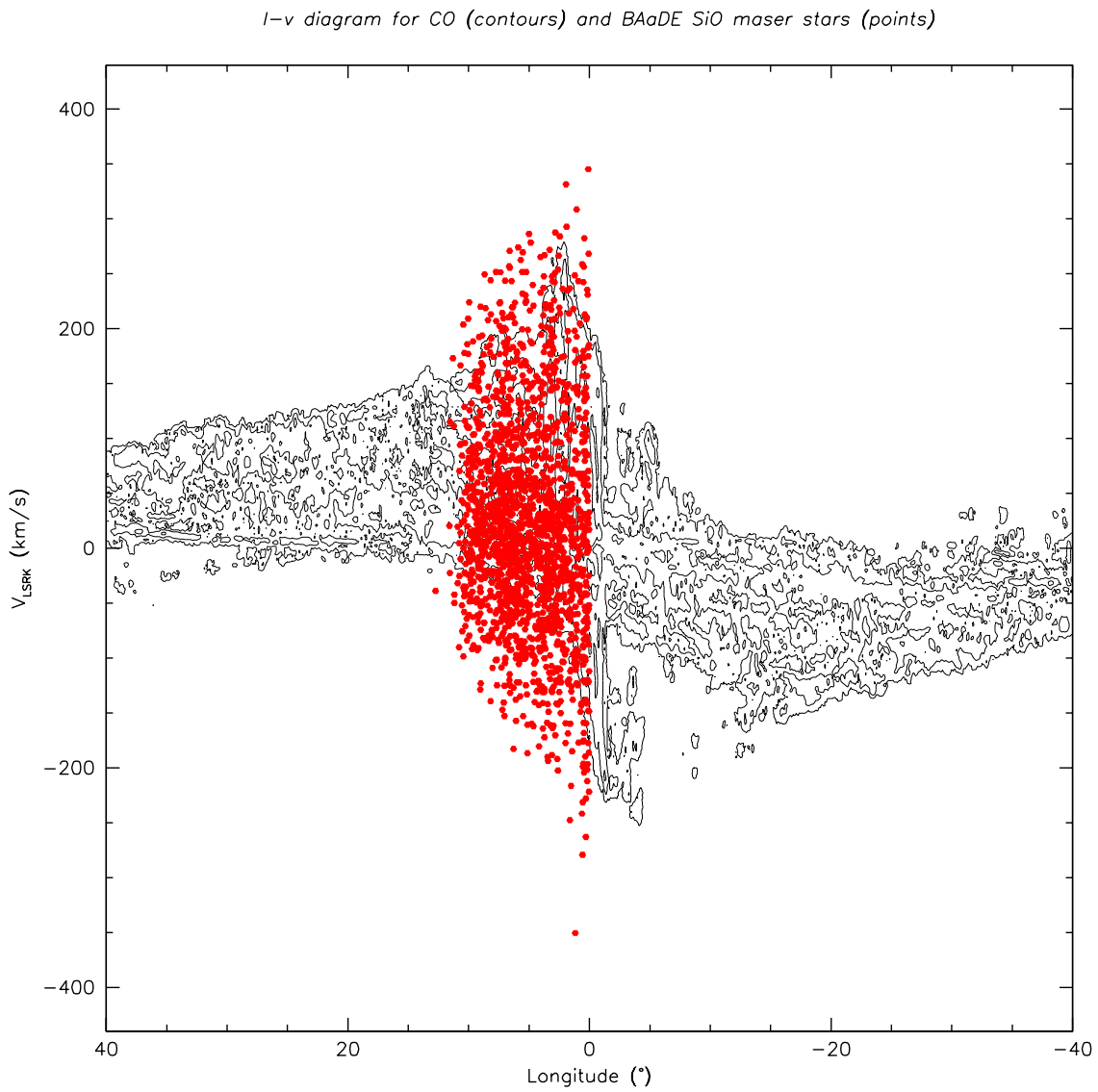




Example ALMA spectra: Isotopes (^{29}SiO), thermal

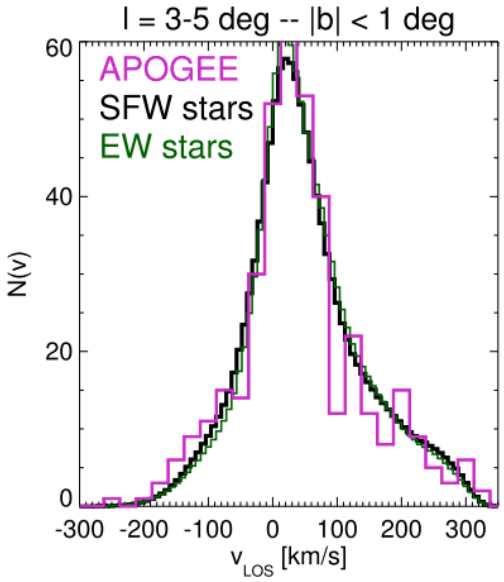


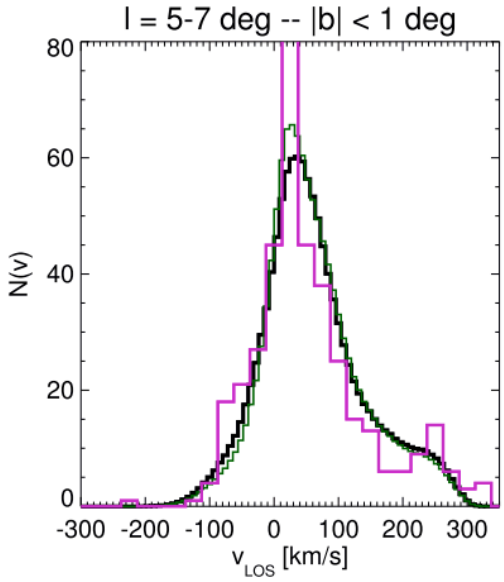


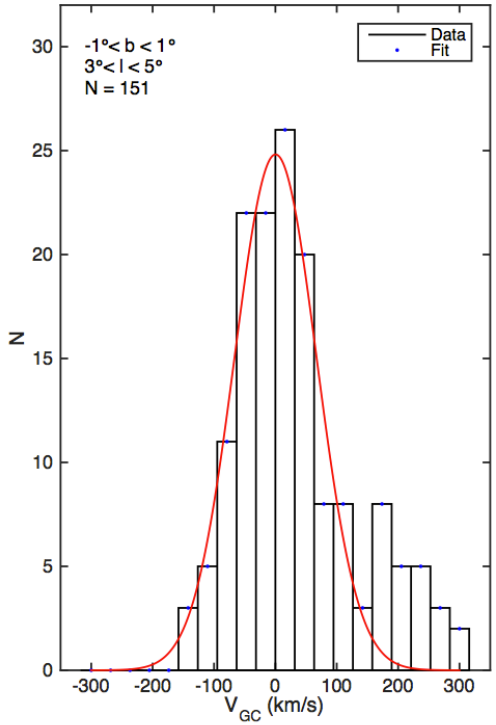


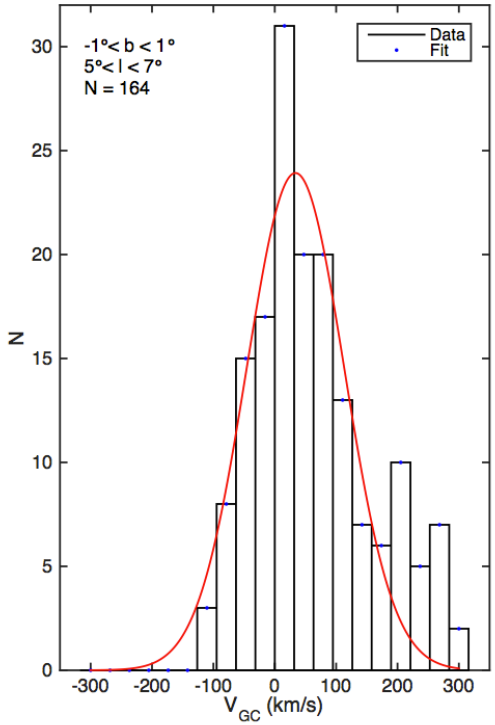
Dame et al. (2001)

- CO distribution along *b*=0°, and the BAaDE first set of detections.
- Different populations.
- Non circular motions.







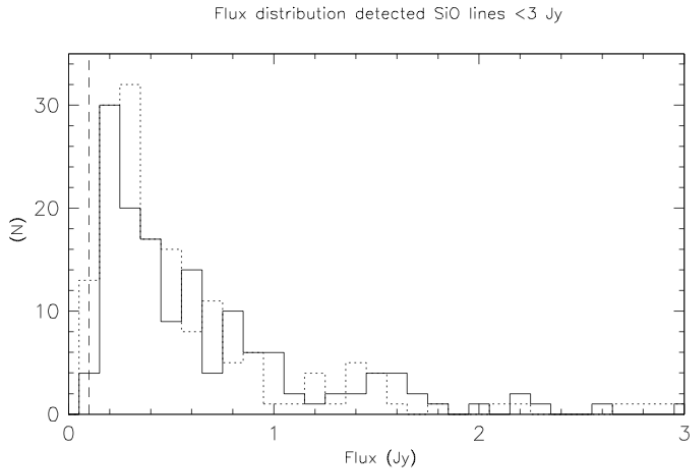


Aumer & Schönrich (2015)

- Modeling investigating the “200 km/s feature”, testing with APOGEE data.
- Dynamically cool and young stars captured by the bar?
- Will be tested by observations to negative longitudes and orbital determinations with the VLBA

Main research goals (B)

3. VLBI proper motions of Galactic orbits and structure of individual stars
   - Proper motions and perhaps orbit family, and parallax distances when possible



4. SiO maser characteristics and stellar and circumstellar properties
   - SiO maser stellar properties like magnitude, color, variability, distance, age, metallicity if possible, SEDs
   - Correlation with maser intensity

Summary

- At the point where we are collecting the basic data (VLA, ALMA)
  - SiO masers/velocities
  - IR data

- Preparing for follow-up VLBA studies
  - Calibrator searches, pilot observations
  - Determining suitable samples/key sources

- First data release/paper early Spring 2016

- http://www.phys.unm.edu/~ylva/baade/

This material is based upon work supported by the National Science Foundation under Grant Number 1517970. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.