The Galactic Bar in terms of orbiting AGB stars

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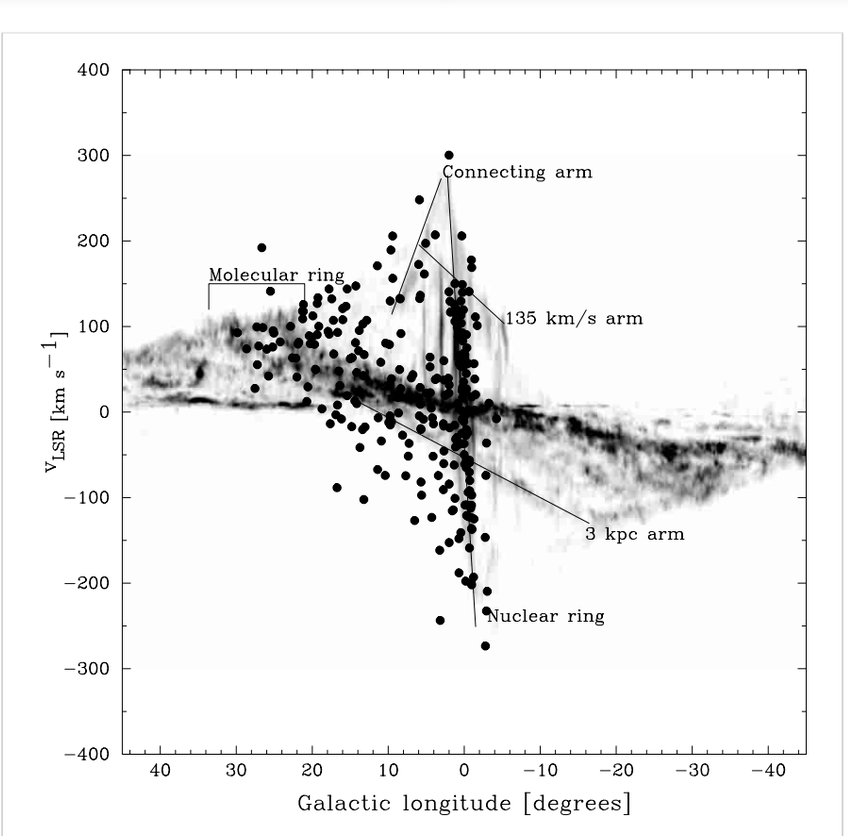
BAaDE

- Bulge Asymmetries and Dynamic Evolution
  - Aims to measure the bar by detecting SiO masers in AGB stars
  - Complementary to Gaia for probing obscured inner Galaxy
    - But overlap important for characterisation of overlap

- Large collaboration started 2 years ago
  - VLA targeted survey at 7mm
  - ALMA survey proposed at 3mm
  - VLBA astrometry at 7mm

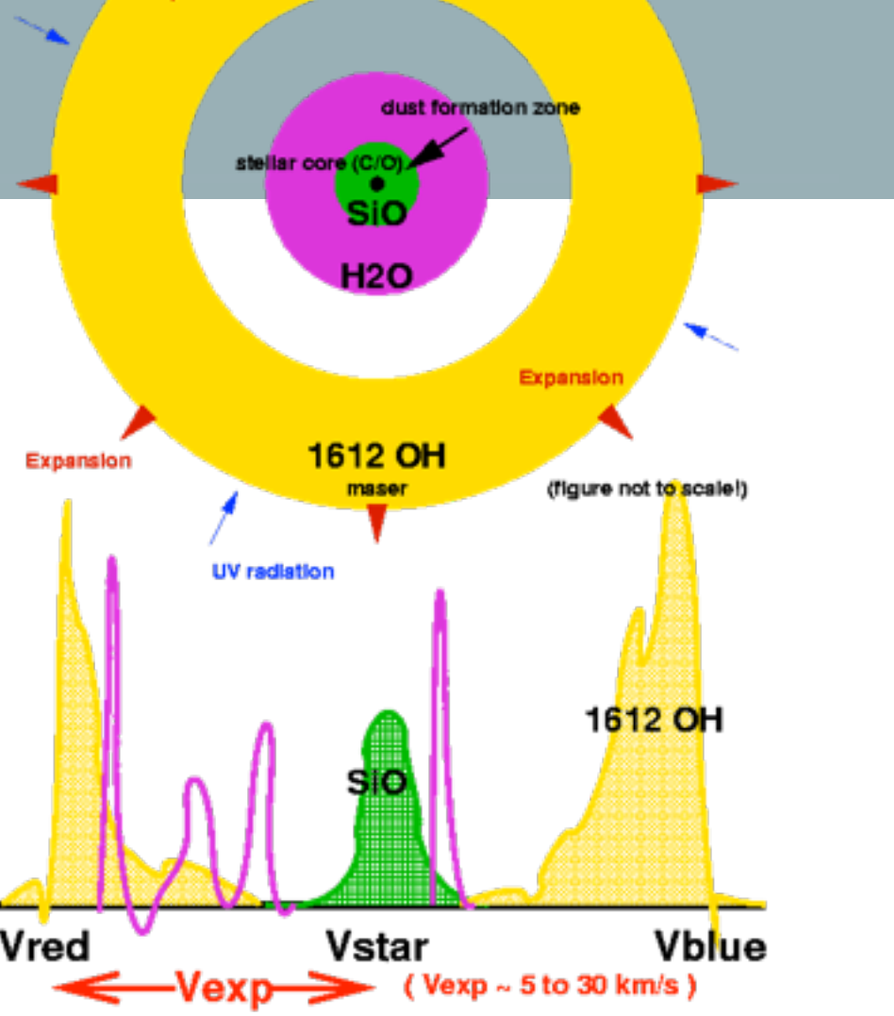
- Builds on previous work
  - AGB stars and Galactic structure in Leiden
  - Involvement in BeSSel project
    - Using methanol masers associated with HMYSOs
    - To measure spiral arms and galactic rotation

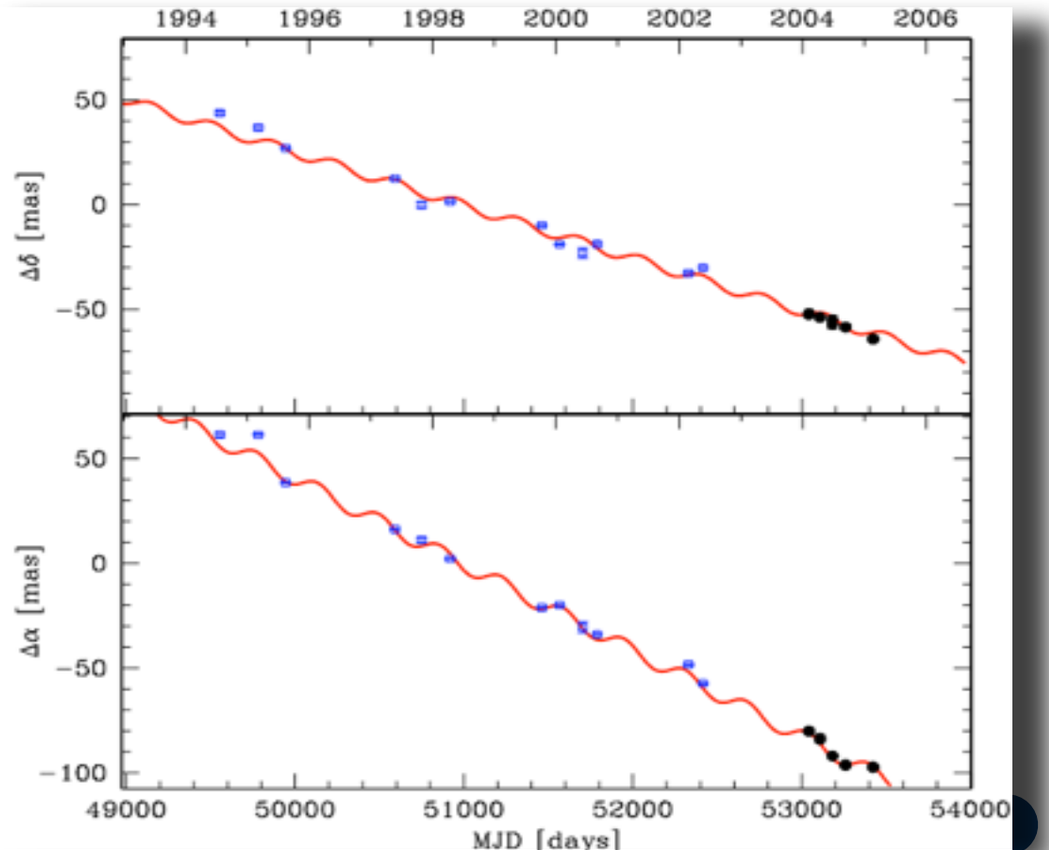


Messineo et al., 2002

Circumstellar Masers

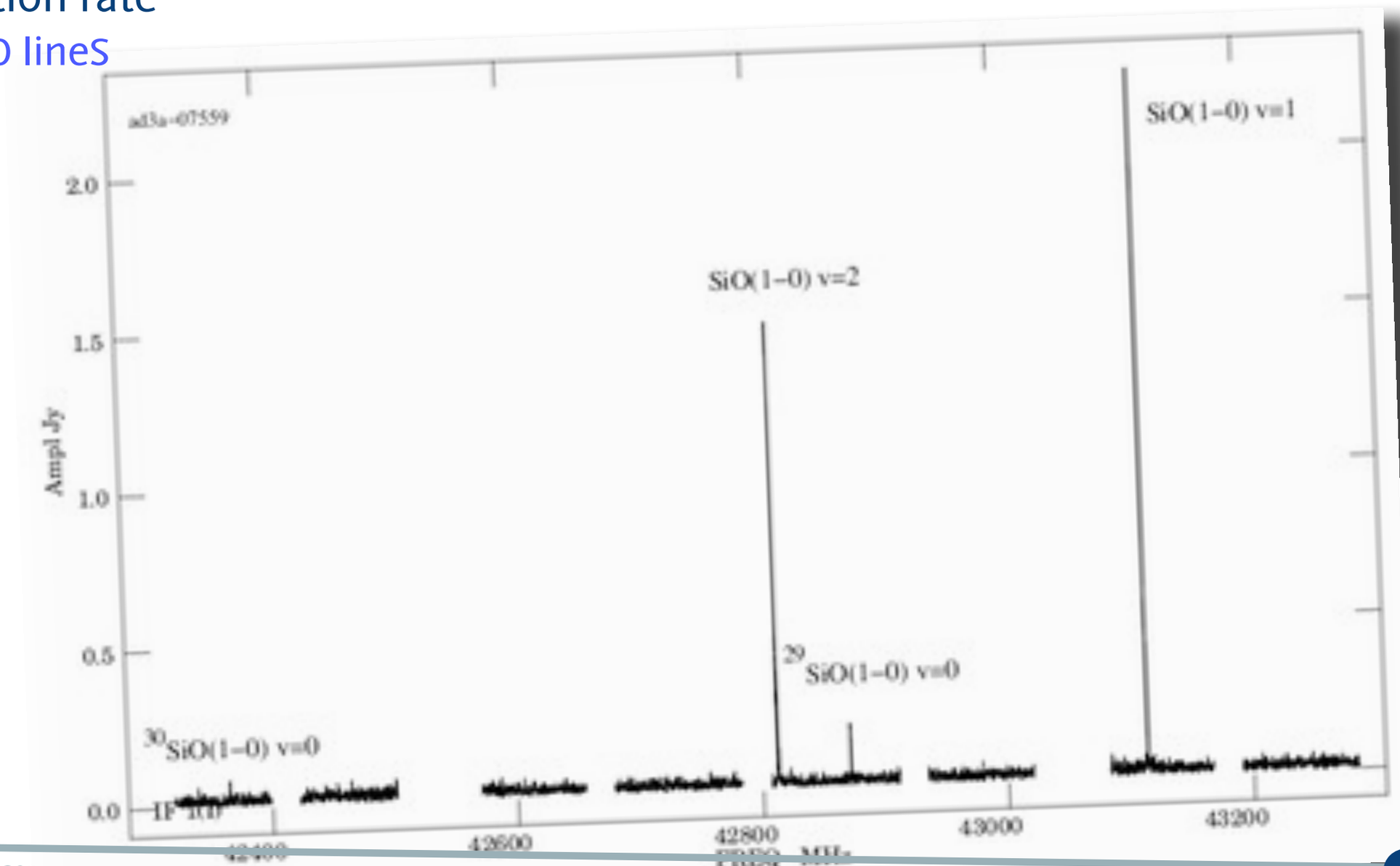
- Asymptotic Giant Branch
  - Last phase low mass star
  - Evolving into Planetary Nebulae
  - Highly variable
  - Huge mass loss
- "Onion model"
  - Dust at few AU
  - Molecular gradients
- Excitation varies
  - SiO at few AU
  - Water at up to few 100 AU
  - OH at 500 – 2000 AU
- Bright masers
  - Targets for VLBI
  - Allowing sub-mas relative astrometry
    - The OH in U Her
    - Done for 12 years: $\pi = 3.76 \pm 0.26$





VLA survey under way

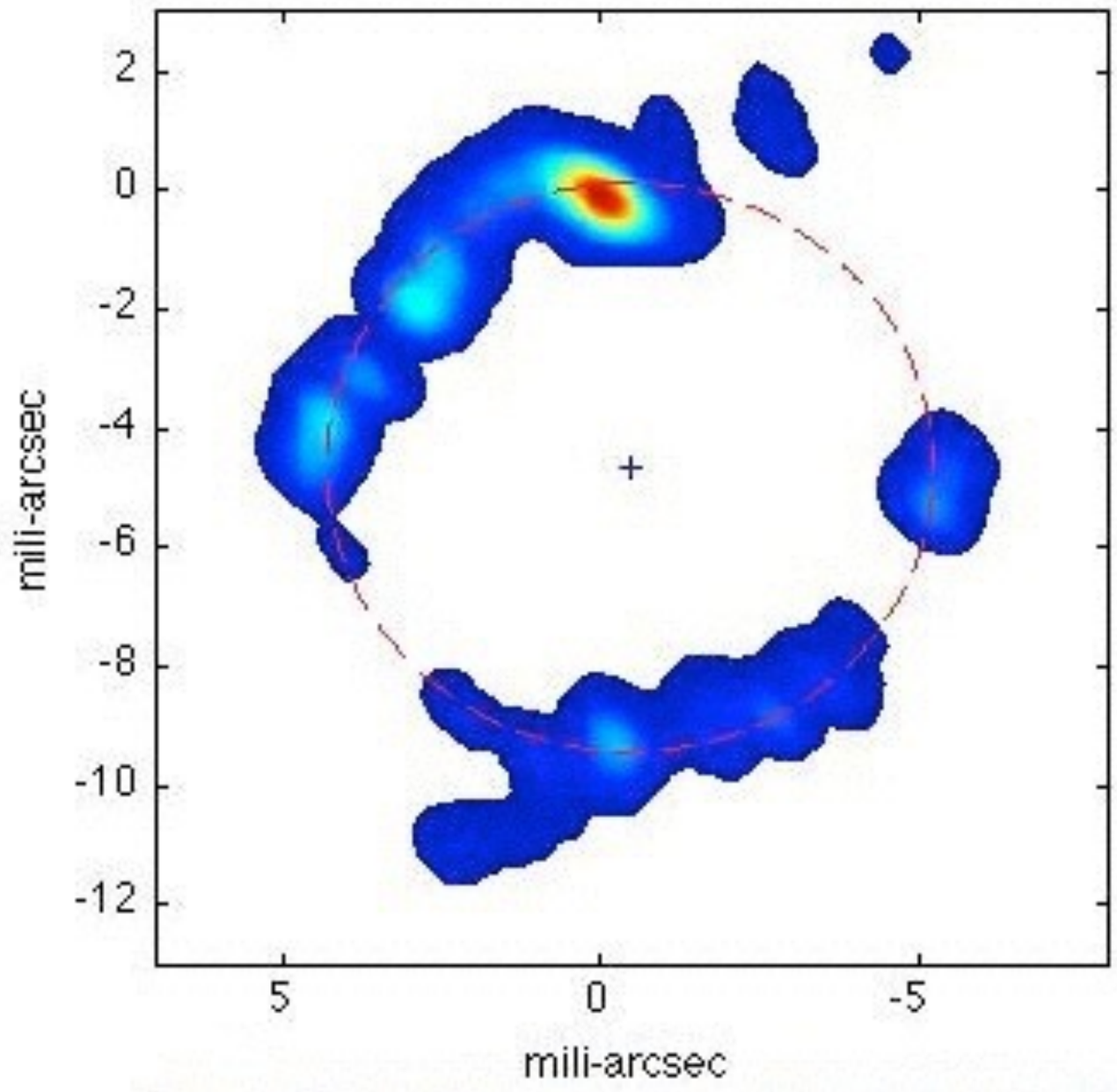
- Bulge Asymmetries and Dynamic Evolution
  - IR selected targets
  - Very fast observing technique with JVLA
  - Observed > 7000 targets
  - 50-70% detection rate
    - Multiple SiO lineS



Starting with VLBA

- Pilot data taken
- Various challenges
  - VLBI astrometry at 7mm
  - Must track stellar position
    - Structure extended
    - And variable
- Resolution 200μas
  - Theoretical accuracy 20μas
  - Systematics 50μas?
- Proper motions bulge
  - Paralaxes for brightest/nearest

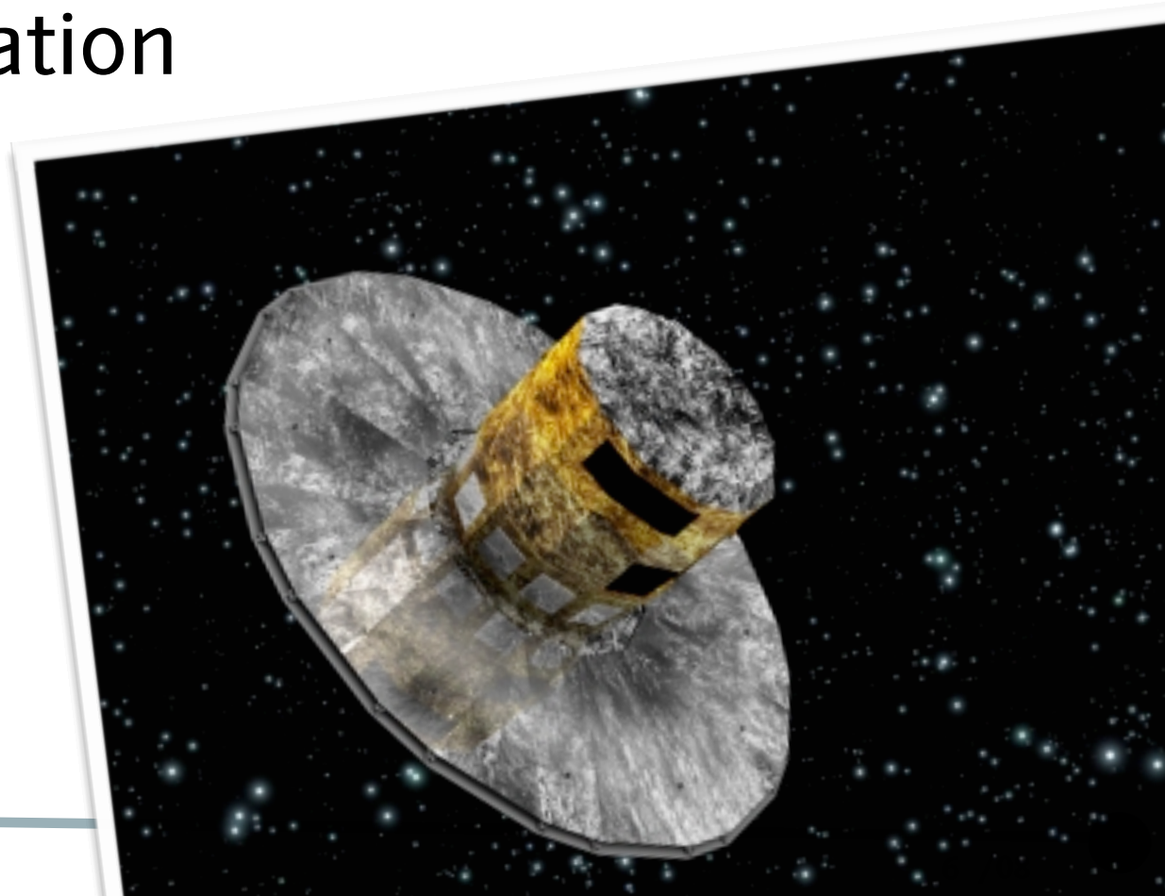
SiO maser OH44.8
at 1.13 kpc (phase lag)
SiO masers extend 5mas (=6AU)
Stellar position < 1 mas



Amiri et al., 2012

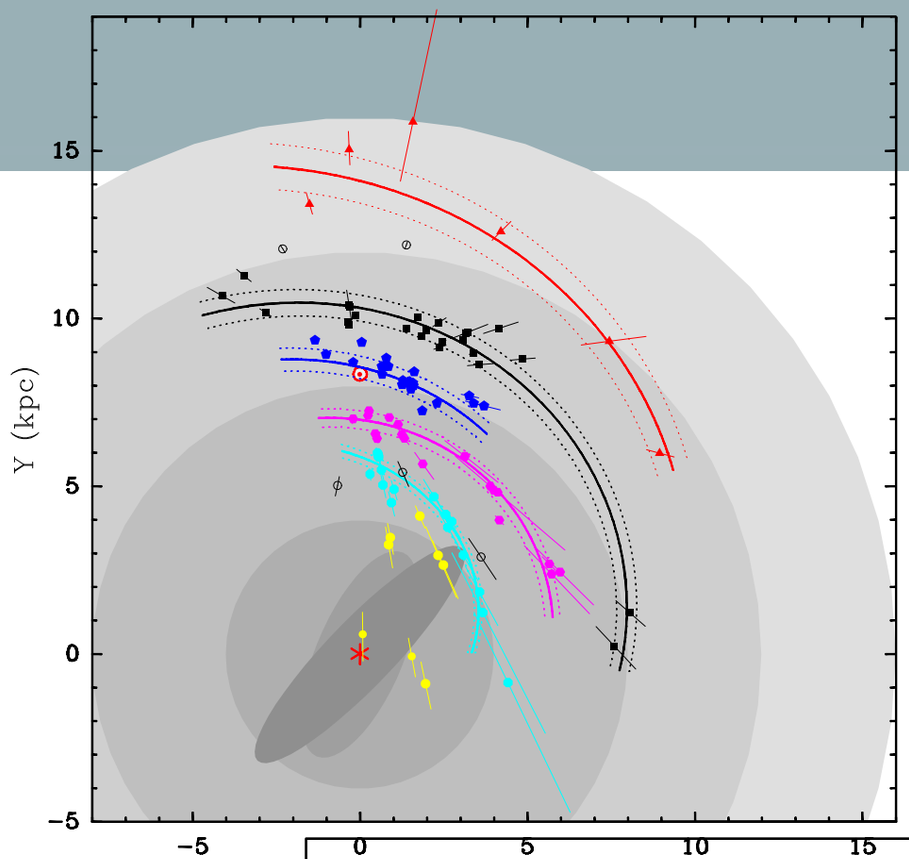
Gaia link

- Gaia will observe the same population
  - Red, but not (completely) obscured LPV's
    - Like Mira
    - With unprecedented statistics
- Gaia will observe some of the same stars
  - At higher latitudes or the nearer ones
  - Will provide distances, luminosities, periods
- Important to characterise population
  - Main sequence masses,
    - from luminosity and periods
  - And ages
  - Origin of these stars
    - Merger/starburst events in galactic past

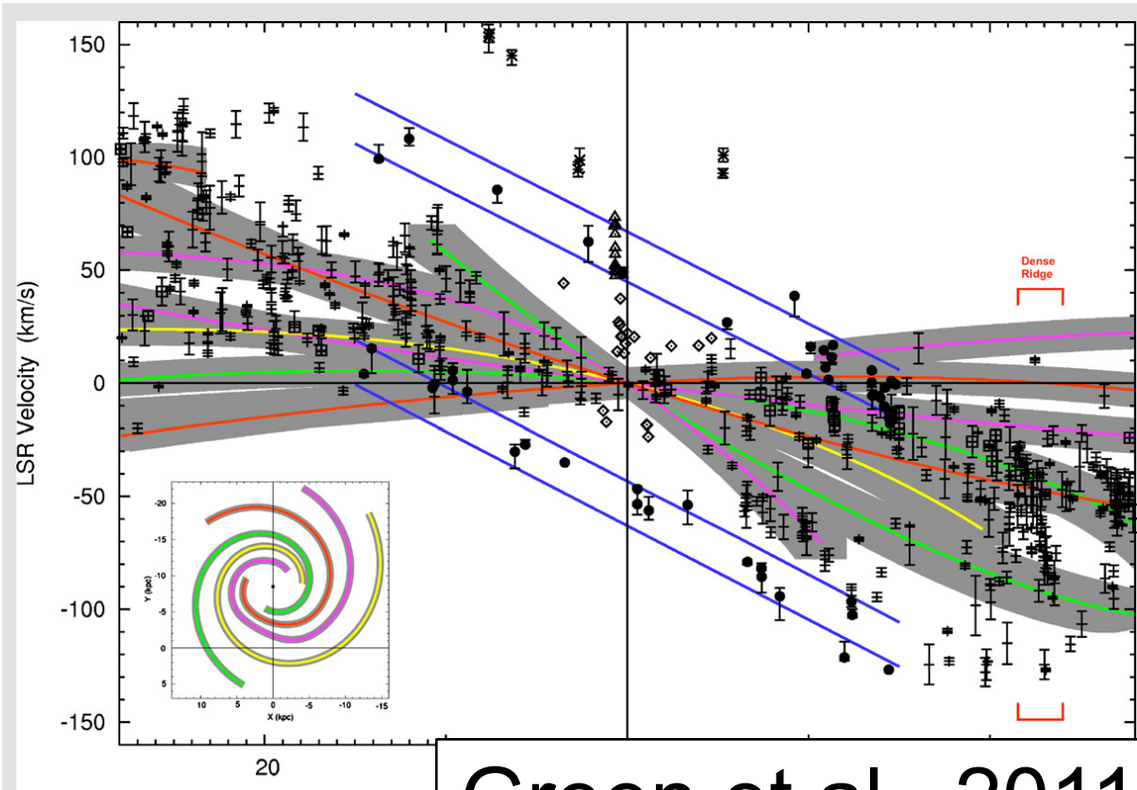


Galactic parameters

- BeSSel project
  - Mostly VLBA water and methanol masers
  - 400 massive star forming regions in the Milky Way
  - Parallaxes and proper motions
    - Mapping out 6D phase space
- Accurate measurements
  - Ro=8.34 ± 0.16 kpc (vs 8.5 kpc)
  - ΘO=240 ±8 km/s (vs. 220 km/s)
  - Spiral structure
- Zooming in on central parts
  - With Southern instruments



Reid et al., 2014



Green et al., 2011

The End

(the start of the JIVE the movie....)