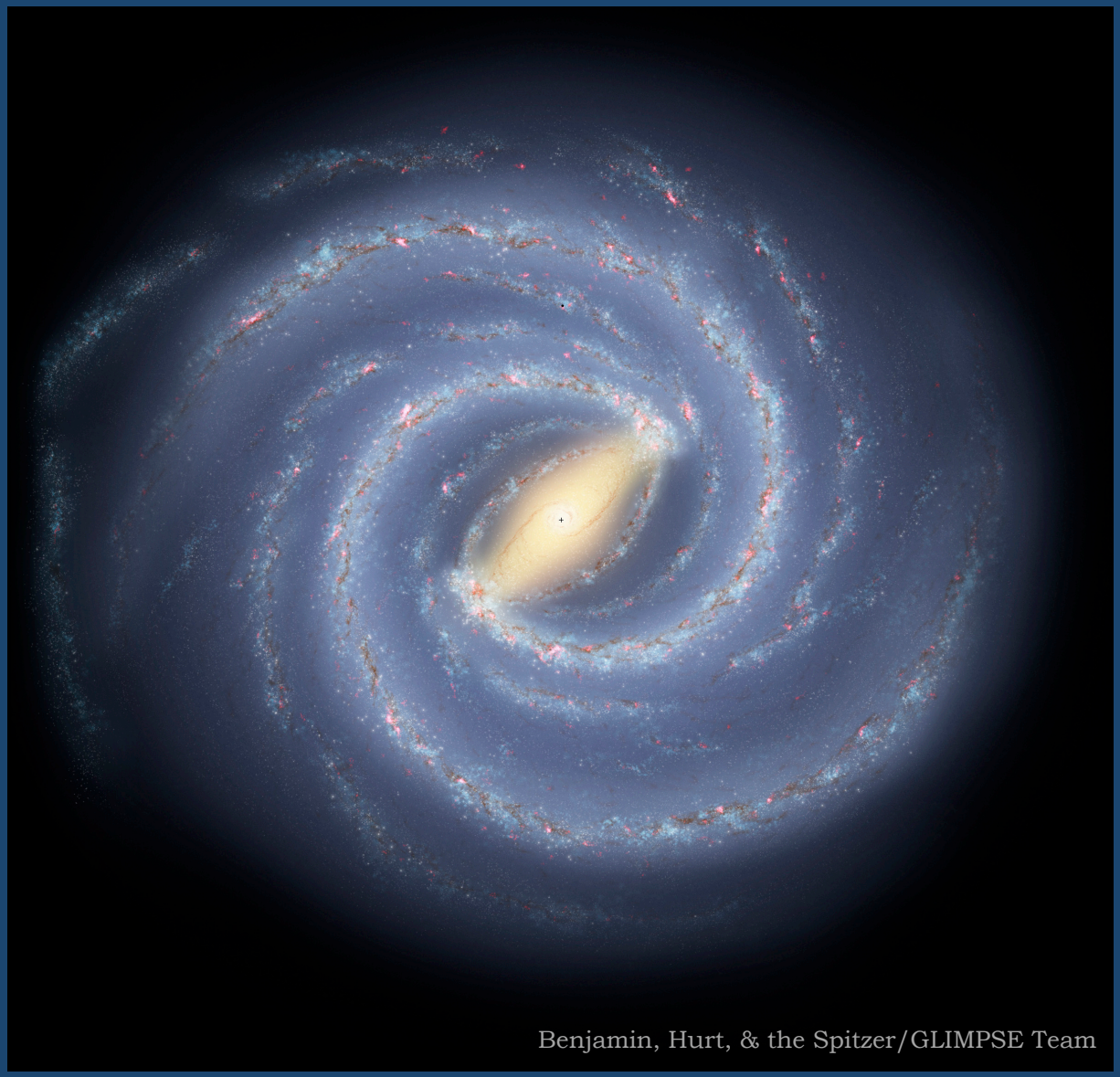
Mapping Spiral Structure with Trigonometry*

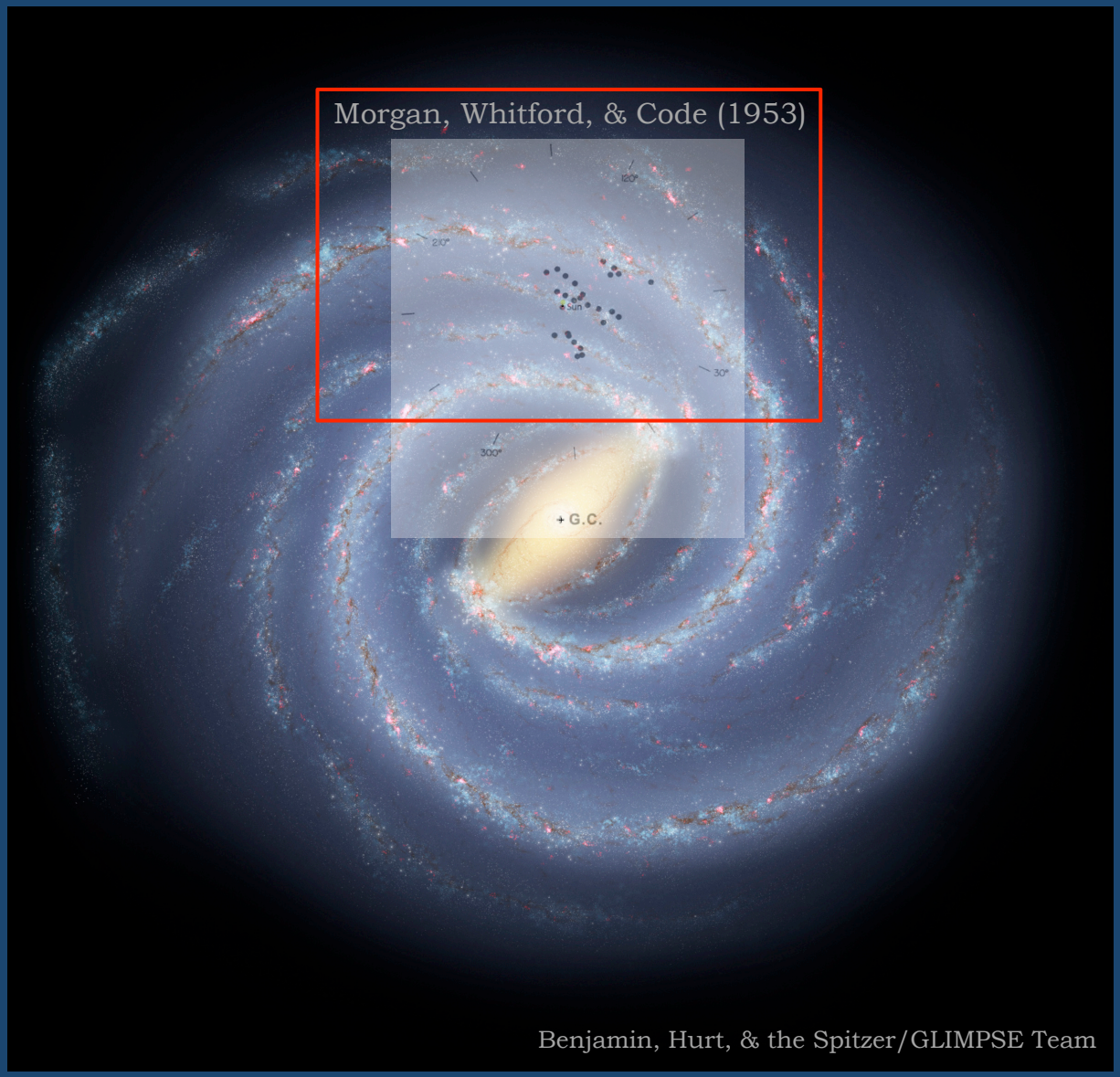
T. M. Dame, Harvard-Smithsonian CfA



*Maser parallax surveys with VLBI (BeSSeL, VERA, EVN)

Mapping Spiral Structure with Trigonometry*

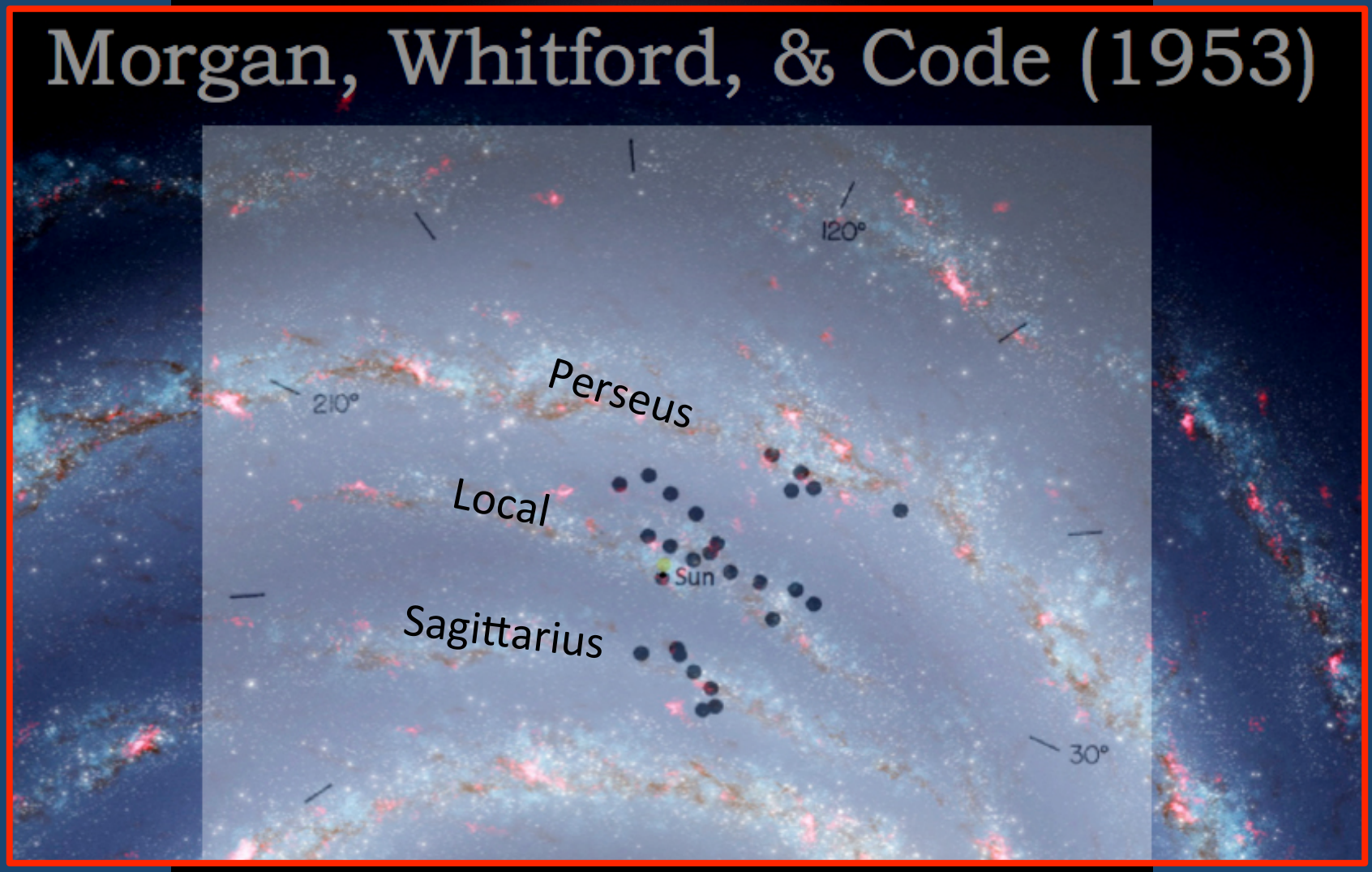
T. M. Dame, Harvard-Smithsonian CfA



*Maser parallax surveys with VLBI (BeSSeL, VERA, EVN)

Mapping Spiral Structure with Trigonometry

T. M. Dame, Harvard-Smithsonian CfA

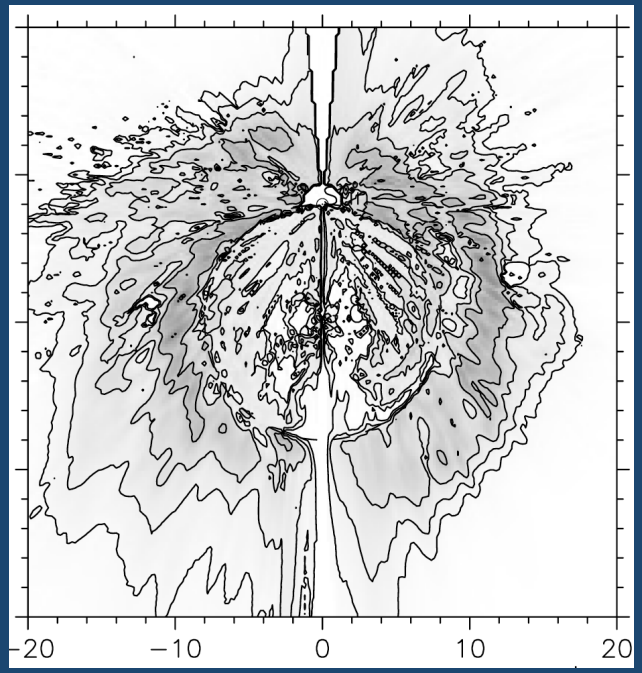


Kinematic Distances: Issues

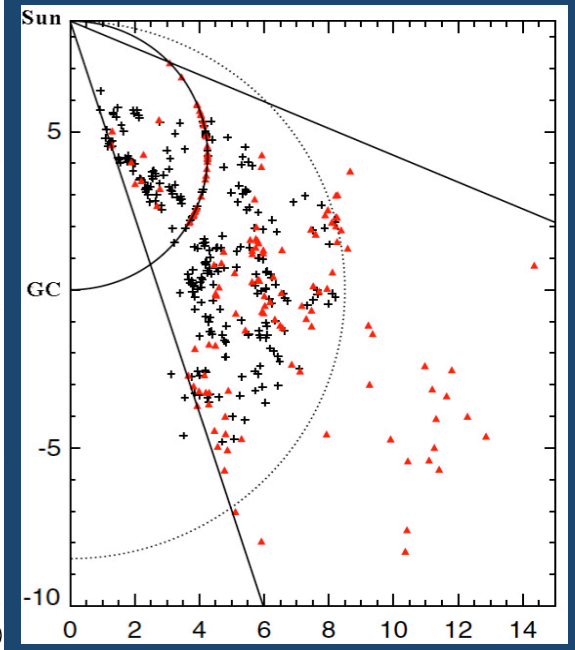
- Bi-valued within solar circle
- Must assume circular rotation
  (maps warped & blurred by streaming & velocity jitter)
- Fails toward Galactic center and anticenter
- Must know rotation curve, including R_o, Θ_o, and solar peculiar motion

Recent Spiral Structure Studies Based on Kinematic Distances:

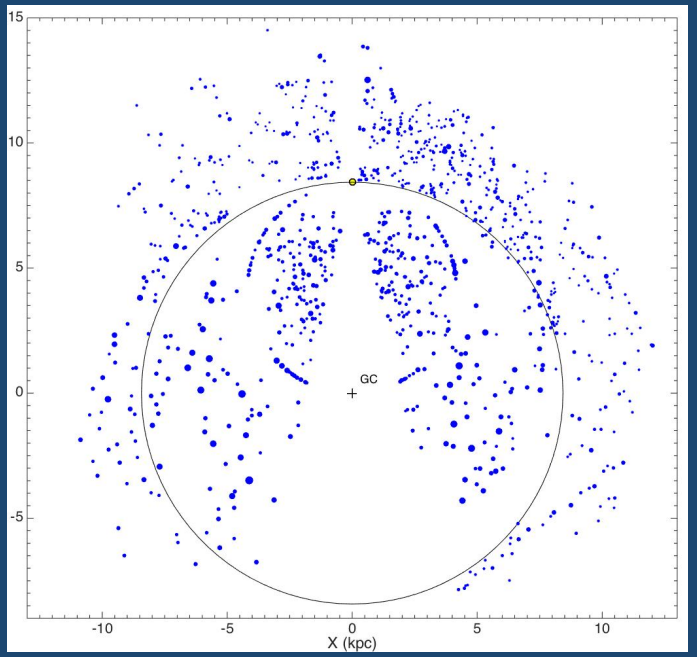
H I Surface Density
(Nakanishi & Sofue 2003)



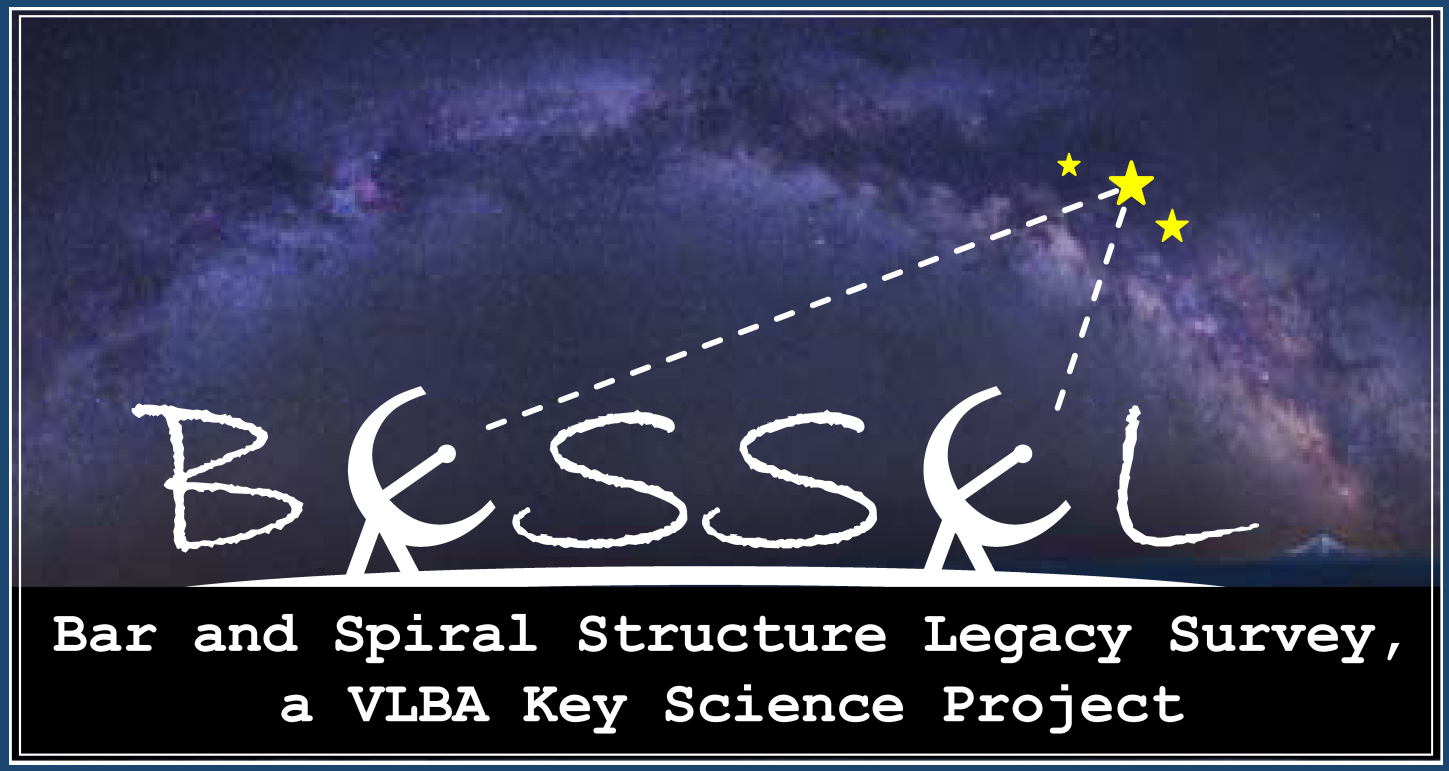
H II Regions
(Anderson et al. 2012)



Molecular Clouds
(Rice et al. 2016)



Not up to the job!



Bar and Spiral Structure Legacy Survey, a VLBA Key Science Project

5000 hours of VLBA time over 5 years to measure maser parallaxes and proper motions in high-mass star forming regions

~100 masers PUBLISHED	~100 more RECENTLY COMPLETED	~20 distant sources IN PROGRESS

BeSSeL Survey Team

M. Reid, T. Dame (CfA)

K. Menten, A. Brunthaler,
M. Sato, B. Hu (MPIfR)

X-W Zheng, Y. Xu (Nanjing)

A. Sanna, L. Moscadelli (Arcetri)

A. Bartkiewicz (Torun)

B. Zhang, K. Hachisuka, Y. Wu,
J. Li (Shanghai)

K. Rygl, H. van Langevelde
(Netherlands)

Y. Choi (Korea)

Very Long Baseline Array (VLBA)

Participating Institutions

CfA

Max-Planck-Institut für Radioastronomie

NANJING UNIVERSITY 1902

INAF - Arcetri

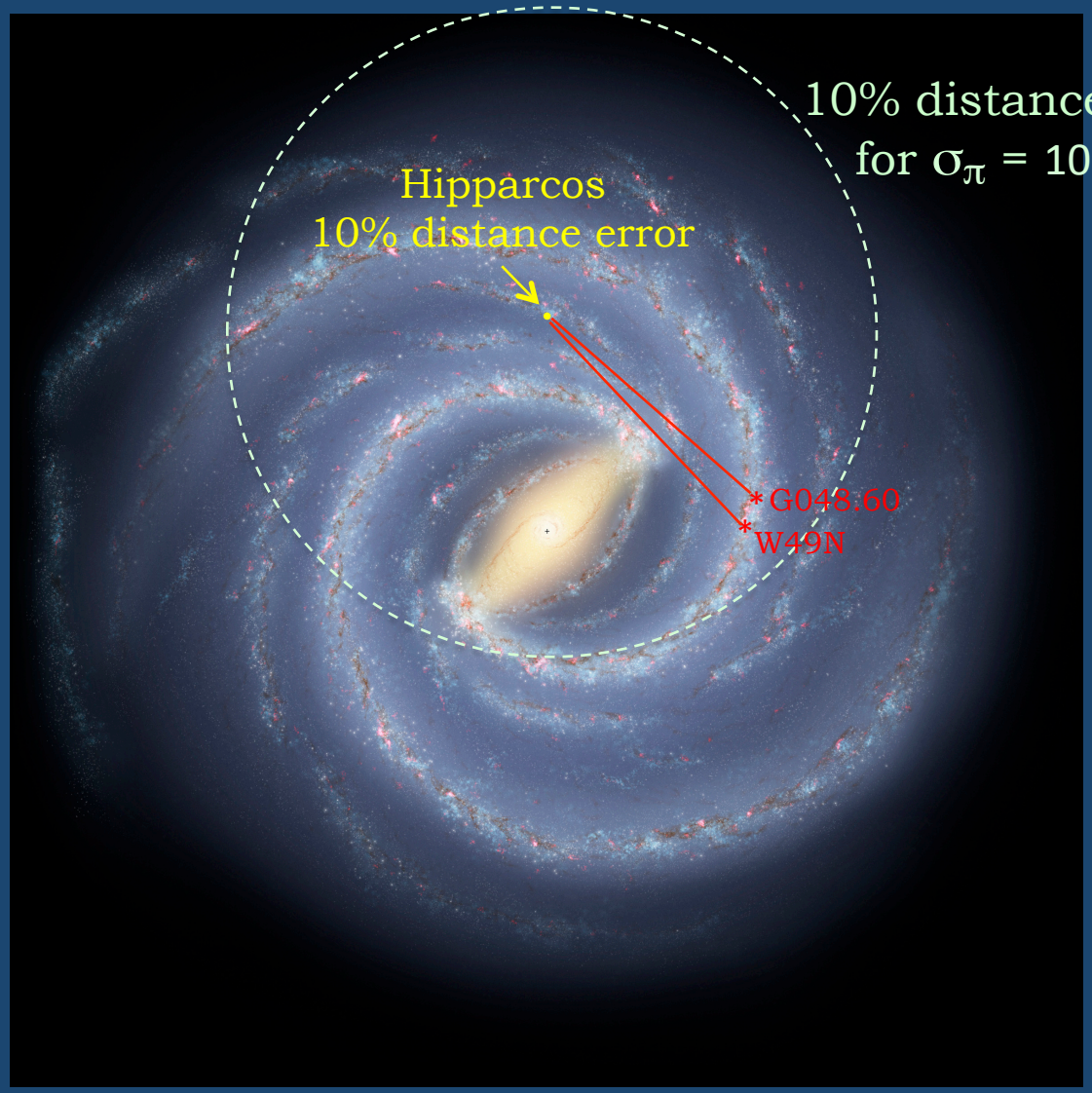
iaps

NRAO

UNIVERSITAS NICOLAI COPERNICI TORUN

JIVE
JOINT INSTITUTE FOR VLBI IN EUROPE

Hipparcos, Gaia, & BeSSeL



Parallax Errors

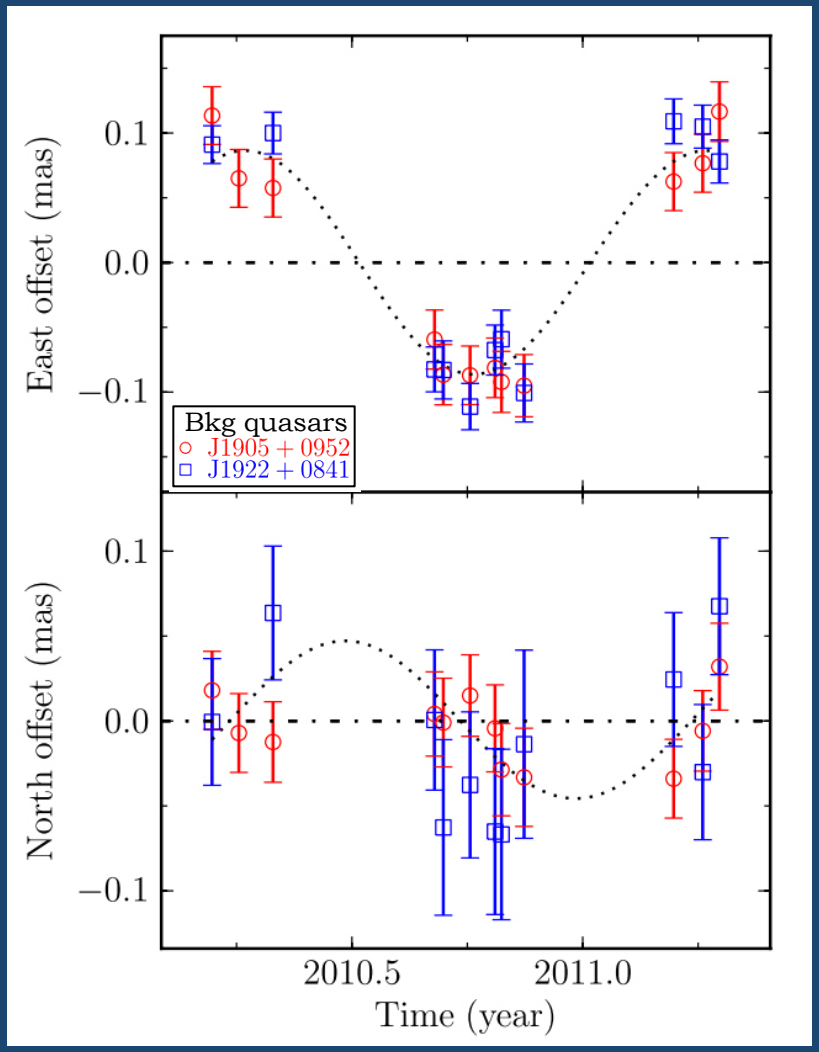
Hipparcos: 1000 μas

Gaia: 10 – 20 μas

BeSSeL: 5 – 20 μas

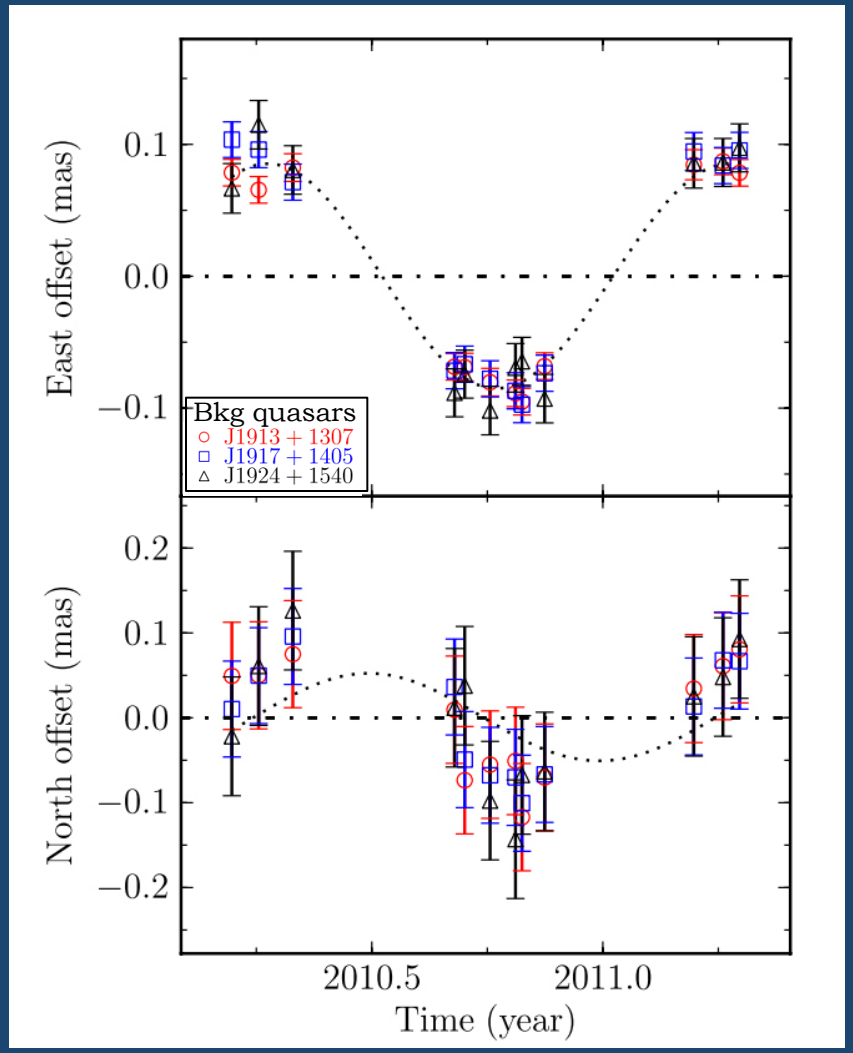
Sample Parallax Data

W49N



π = 90 ± 7 μas
D = 11.1 ± 0.9 kpc

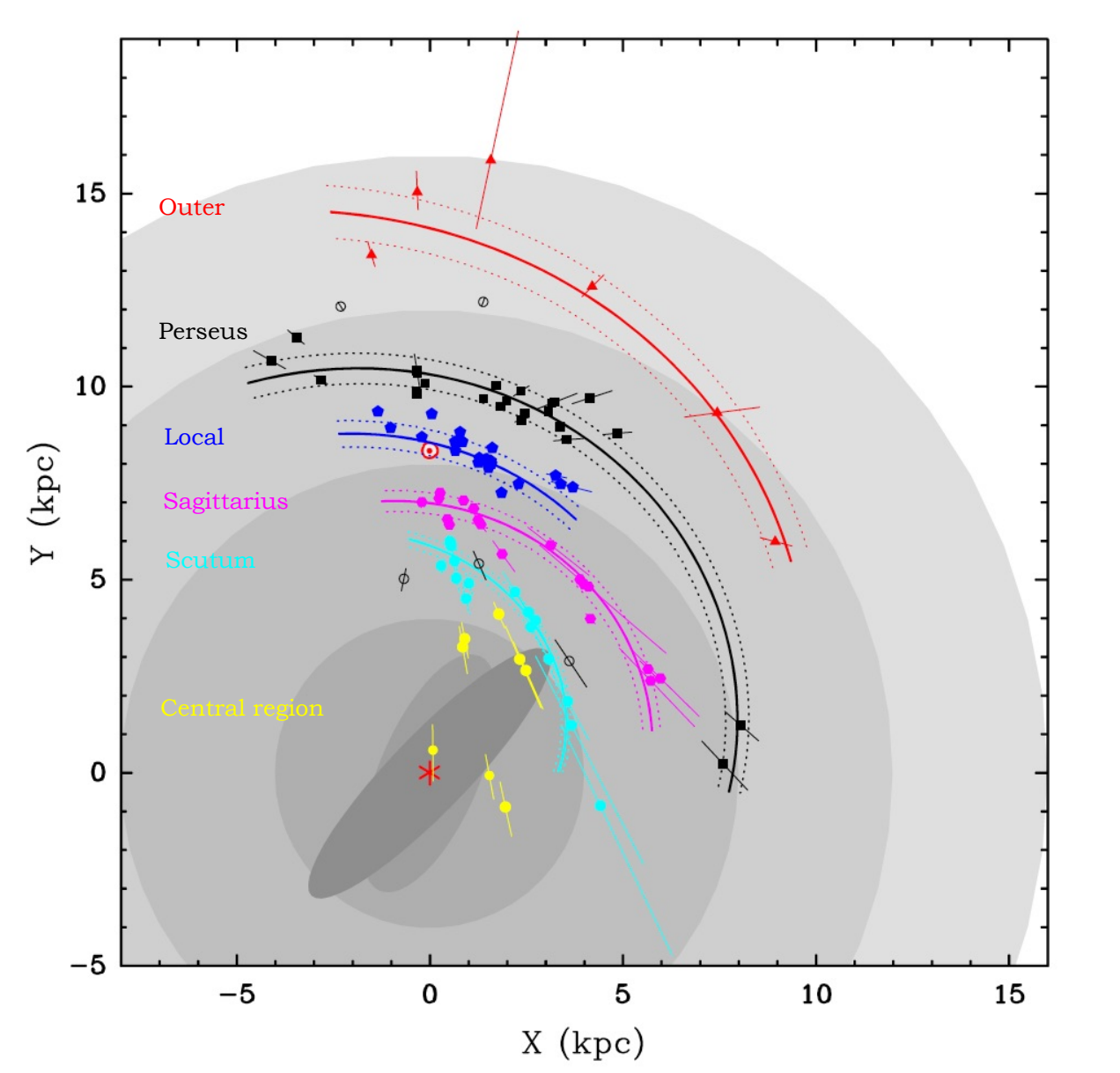
G048.60+0.02



π = 93 ± 5 μas
D = 10.7 ± 0.6 kpc

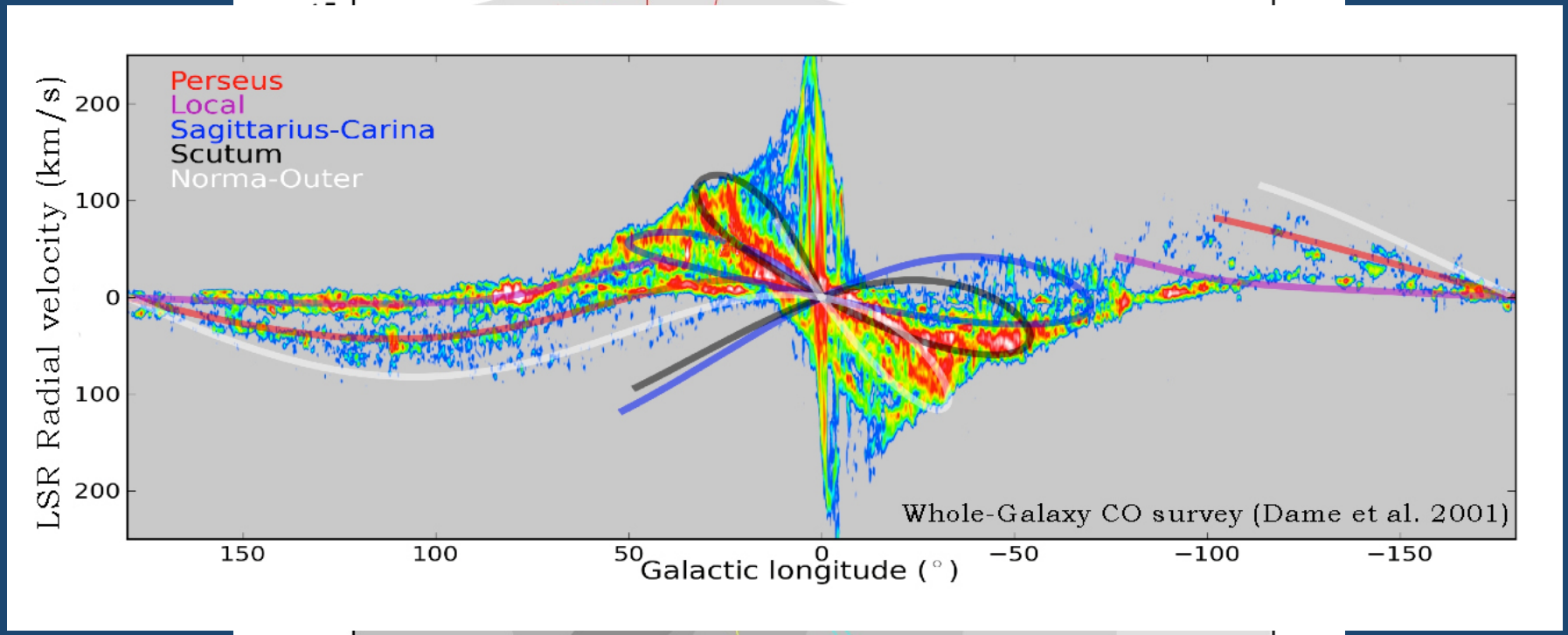
(Zhang et al. 2013)

Spiral Arms Traced with Maser Parallaxes



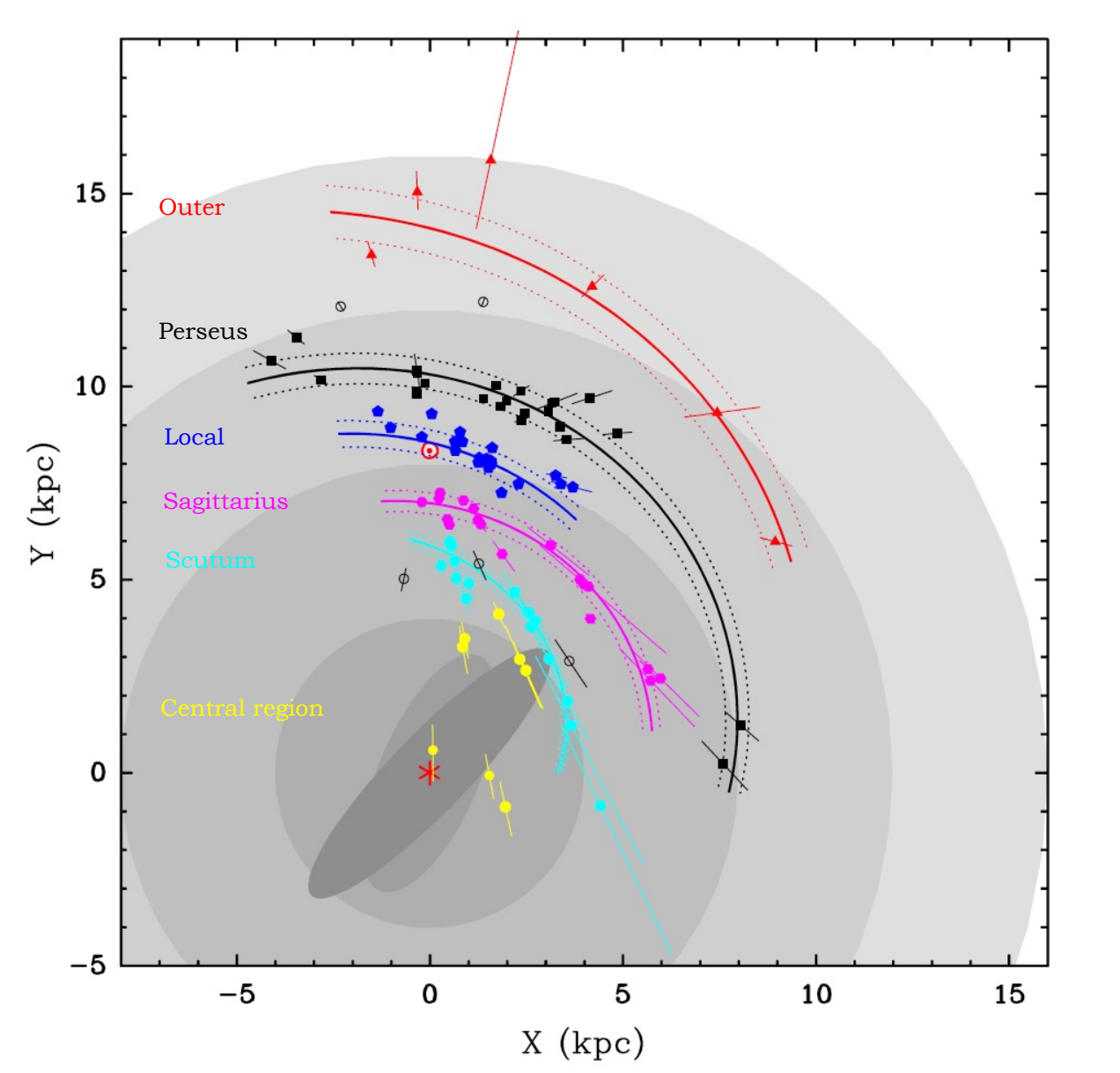
Reid et al. (2014)

Spiral Arms Traced with Maser Parallaxes



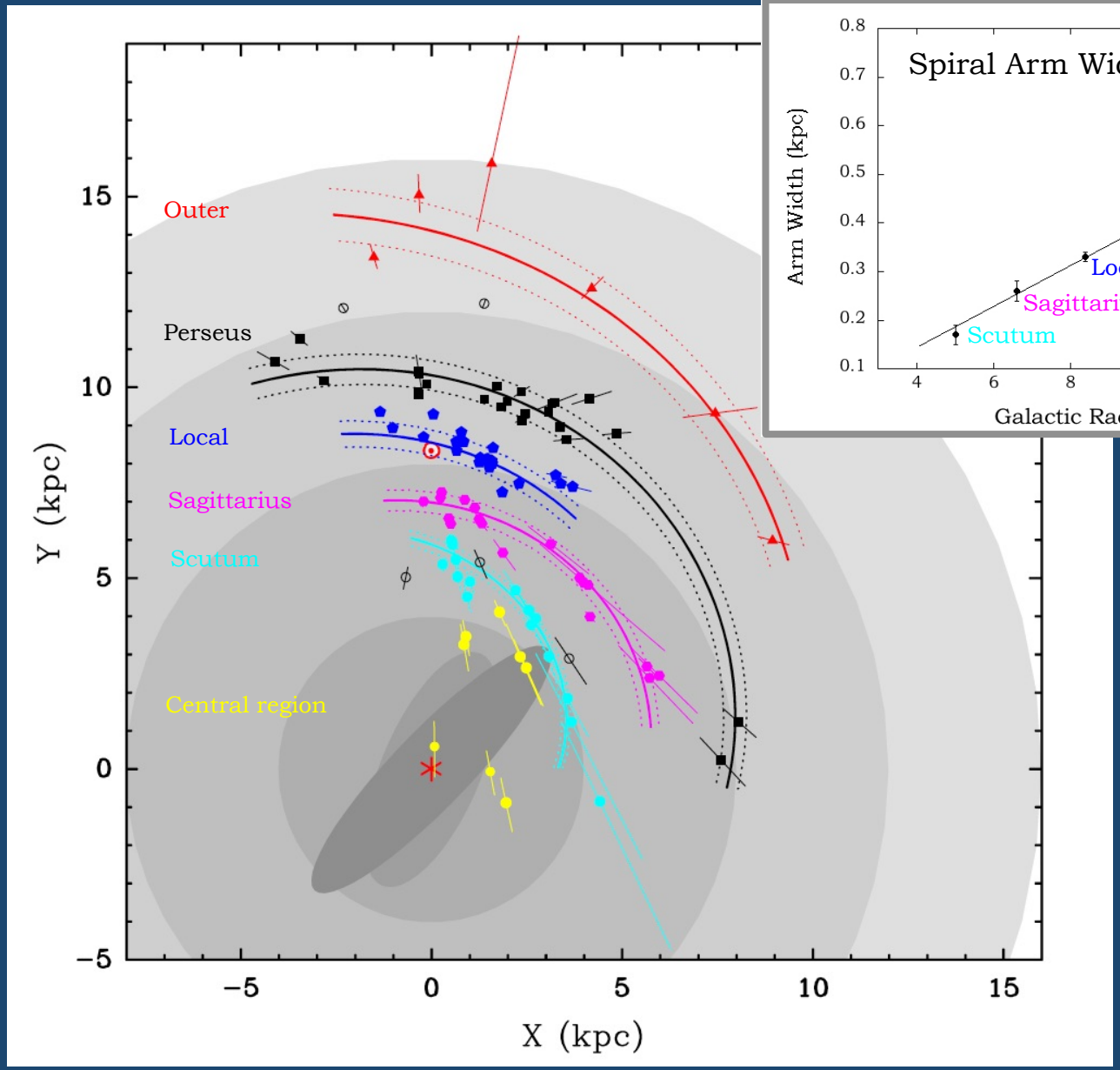
Reid et al. (2014)

Spiral Arms Traced with Maser Parallaxes



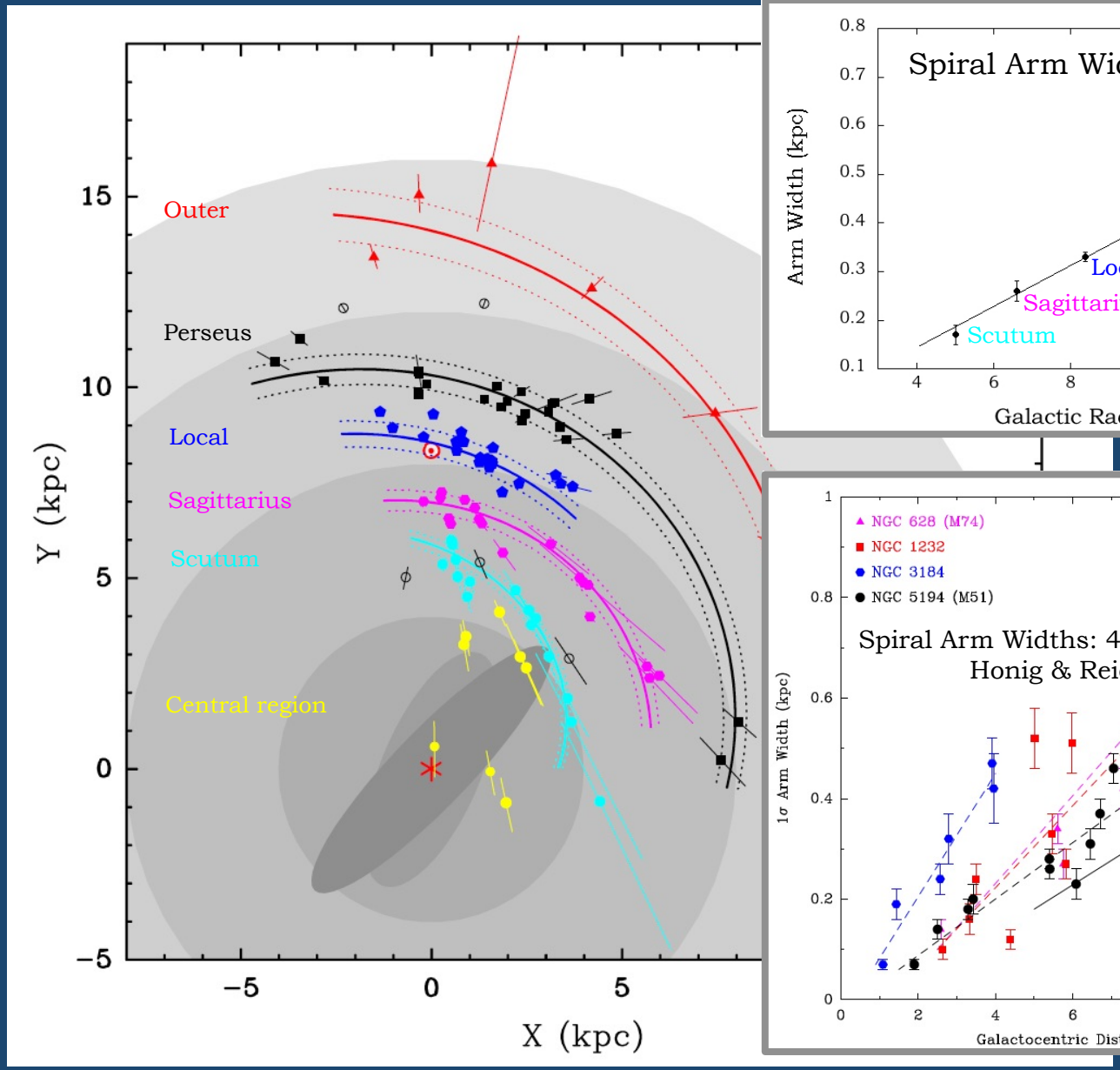
Reid et al. (2014)

Spiral Arms Traced with Maser Parallaxes



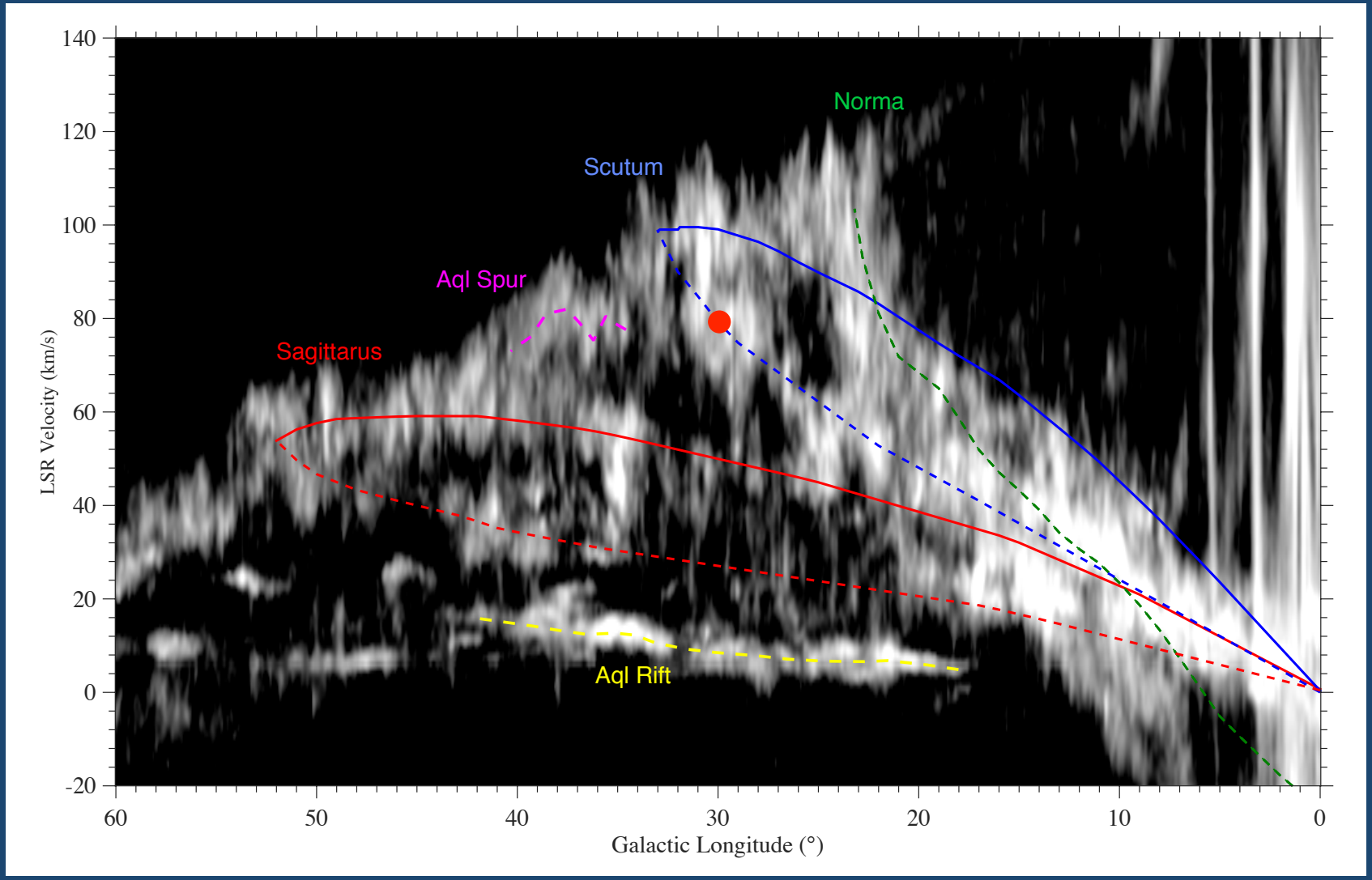
Reid et al. (2014)

Spiral Arms Traced with Maser Parallaxes

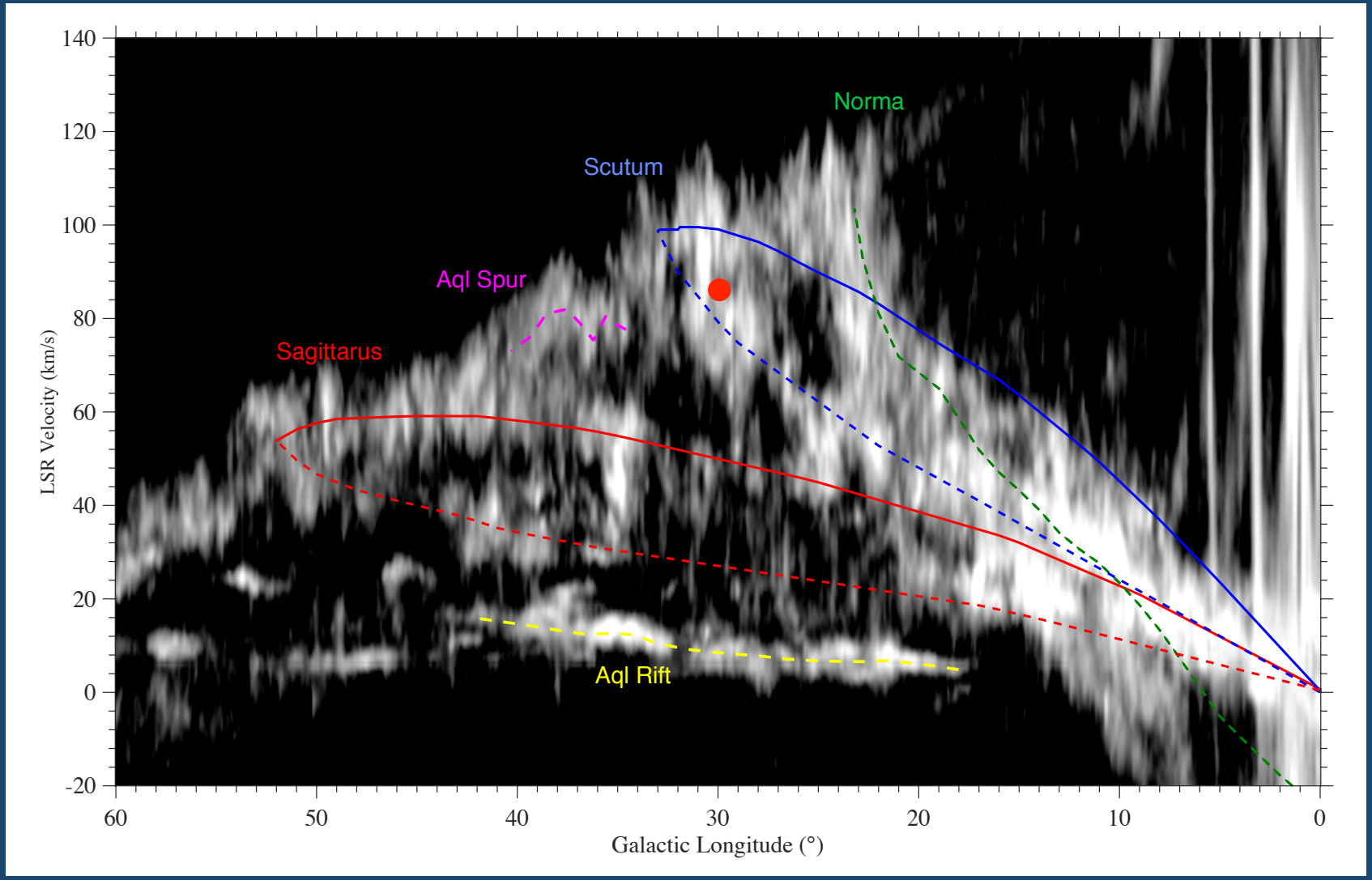


Reid et al. (2014)

Finding the Distance to *Any* Spiral Arm Source

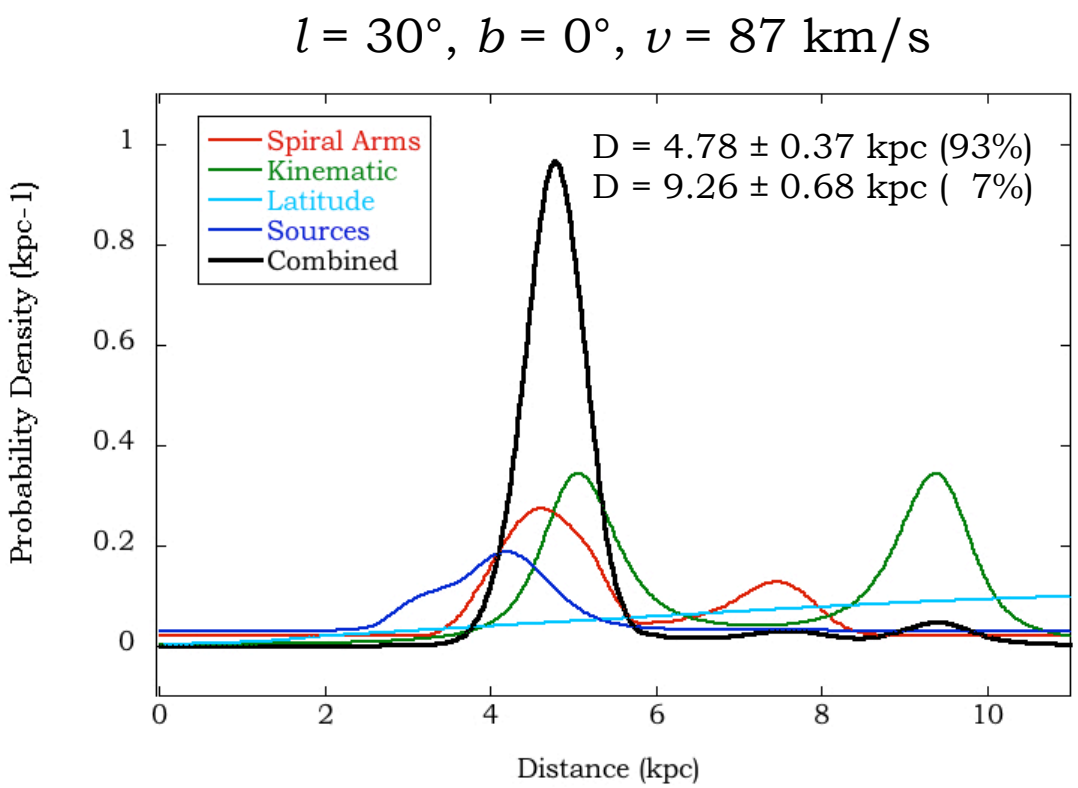


Finding the Distance to *Any* Spiral Arm Source



A PARALLAX-BASED DISTANCE ESTIMATOR FOR SPIRAL ARM SOURCES

M. J. Reid[1], T. M. Dame[1], K. M. Menten[2], and A. Brunthaler[2]
[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
Received 2015 November 20; accepted 2016 April 4; published 2016 May 25



A PARALLAX-BASED DISTANCE ESTIMATOR FOR SPIRAL ARM SOURCES

M. J. Reid[1], T. M. Dame[1], K. M. Menten[2], and A. Brunthaler[2]
[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
Received 2015 November 20; accepted 2016 April 4; published 2016 May 25

Home | Project | Results | Data Products | **Programs** | Publications | Internal

http://bessel.vlbi-astrometry.org/

Bayesian Distance Calculator

The spiral arms of the Milky Way are being accurately located for the first time via trigonometric parallaxes of massive star forming regions with the BeSSeL Survey, using the Very Long Baseline Array and the European VLBI Network, and with the Japanese VERA project. This calculator leverages these results to **significantly improve the accuracy and reliability of distance estimates to other sources that are known to follow spiral structure**. Using a Bayesian approach, sources are assigned to arms based on their (l,b,v) coordinates with respect to arm signatures seen in CO and HI surveys. A source's kinematic distance, displacement from the plane, and proximity to individual parallax sources are also considered in generating a full distance probability density function. A more detailed description of the methods can be found in Reid, Dame, Menten & Brunthaler 2016, ApJ, in press..

The source code including the paper can be downloaded here: Bayesian_distance_v1.0.tar (~5 MB).

Enter Galactic Longitude. Latitude (in degrees) and the LSR velocity (in km/s)

Longitude: 30 °
Latitude: 0 °
v_{LSR}: 87 km/s
P_{far}: 0.5

Submit

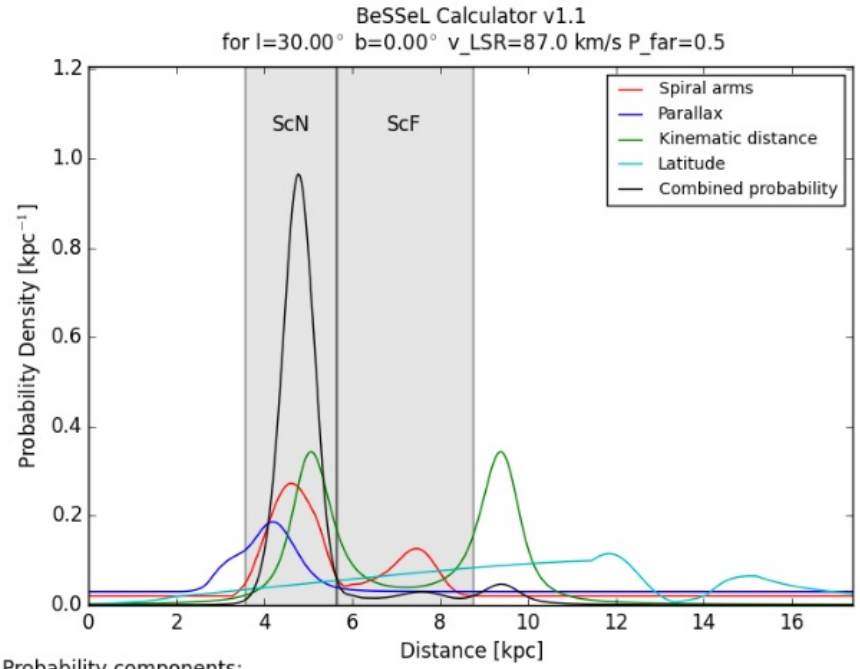
A PARALLAX-BASED DISTANCE ESTIMATOR FOR SPIRAL ARM SOURCES

M. J. Reid[1], T. M. Dame[1], K. M. Menten[2], and A. Brunthaler[2]
[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
Received 2015 November 20; accepted 2016 April 4; published 2016 May 25

Distance: 4.78 +/- 0.37 kpc

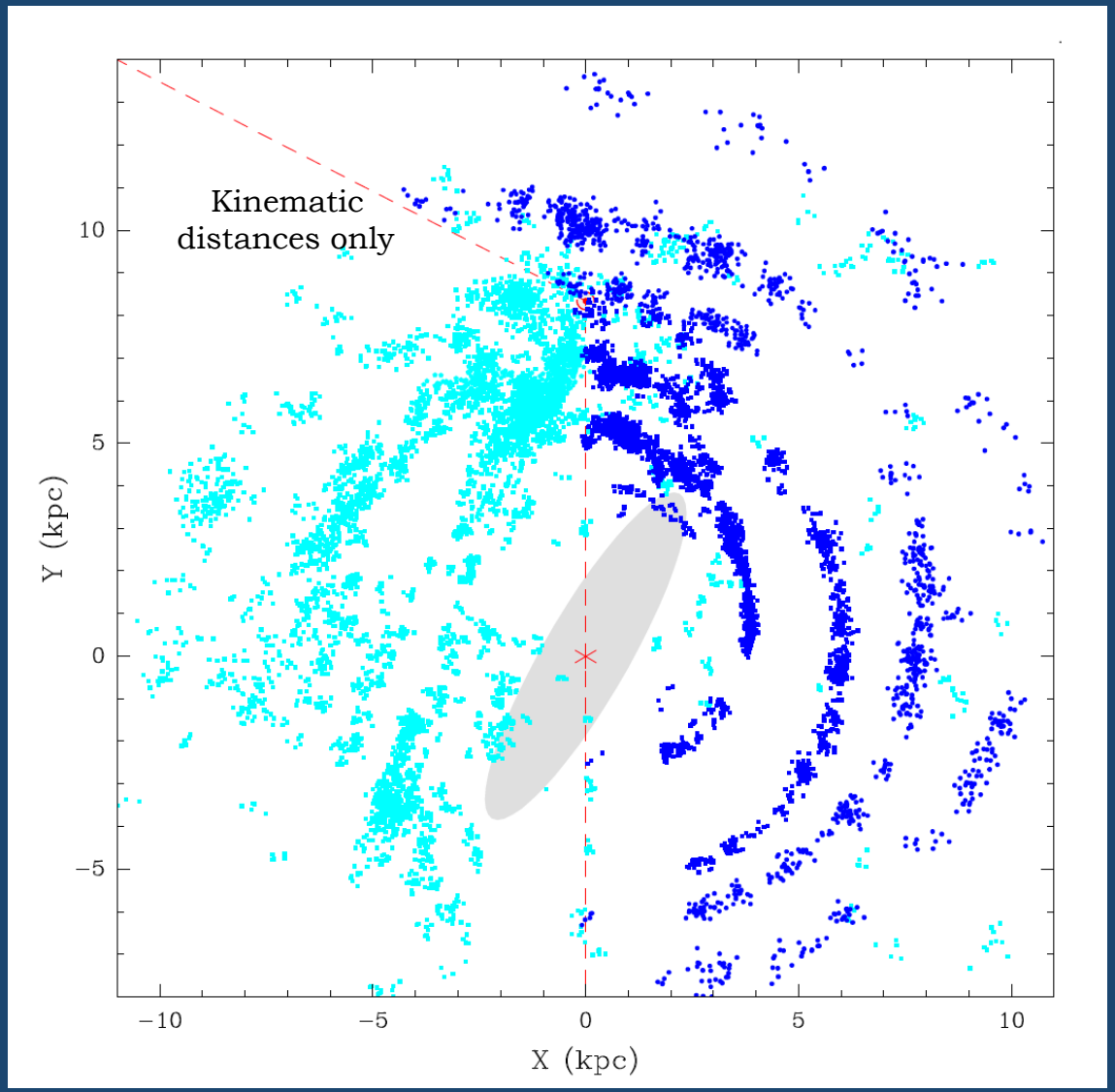
Prob: 0.93, Spiral Arm: Scutum near

Permanent Download link: images/pdf_2016-09-02_22:15:20.438885.png



Probability components:
D=4.78 ±0.37 kpc P:0.93 ScN; D=9.26 ±0.68 kpc P:0.07 ...

Filling in the Spiral Structure with Cataloged Sources



~2000 HMSFRs:

Water & methanol masers
(Valdettaro et al. 2001)
(Pestalozzi et al. 2005)

H II regions
(Anderson et al. 2012)

Red MSX sources
(Urquhart et al. 2014)

Confident arm assignment
Uncertain arm assignment