VLBI Follow Up of SiO masers in AGB stars (?)

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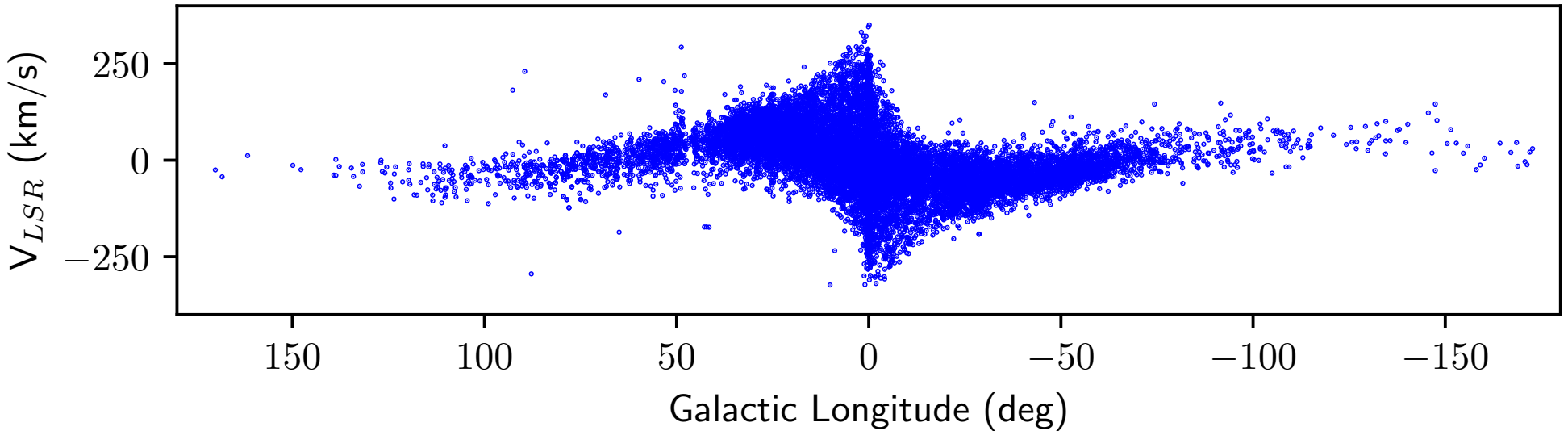
Background

BAaDE: VLA and ALMA search for 43 and 86 GHz SiO masers in IR selected evolved stars.

Talk by M. Lewis, poster by L. Sjouwerman

=> Velocities and positions for ~15,000 objects.

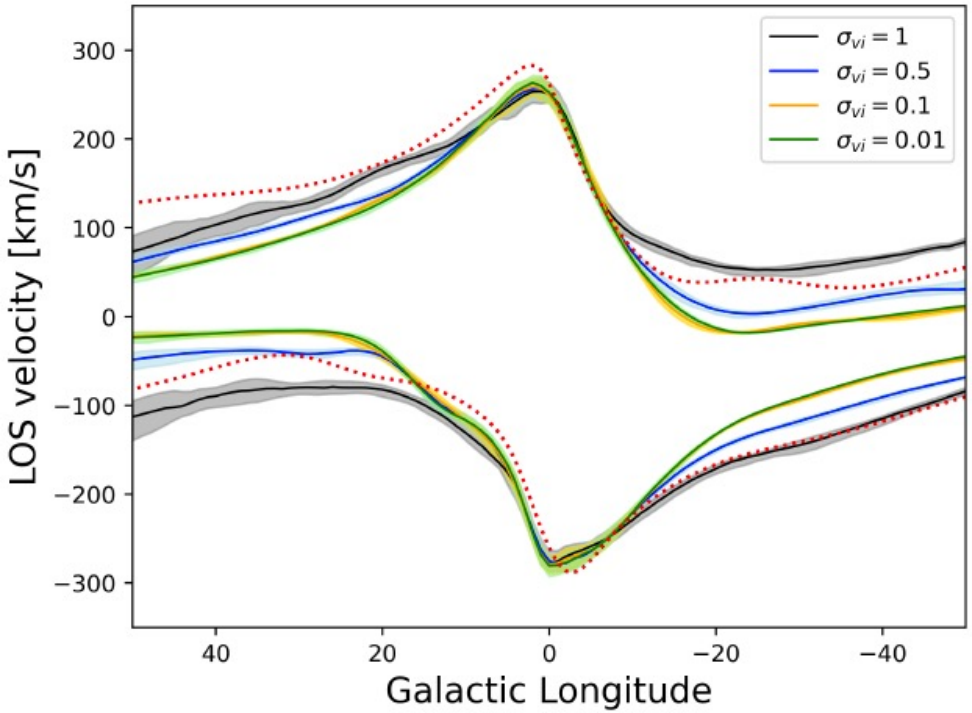


Background

Dynamical models can be tested through, e.g., LV diagrams.

Adding distances:

- Luminosities, mass-loss rates to better characterize populations
- Determining near/far side of the GC additional modeling information
- 3D distribution



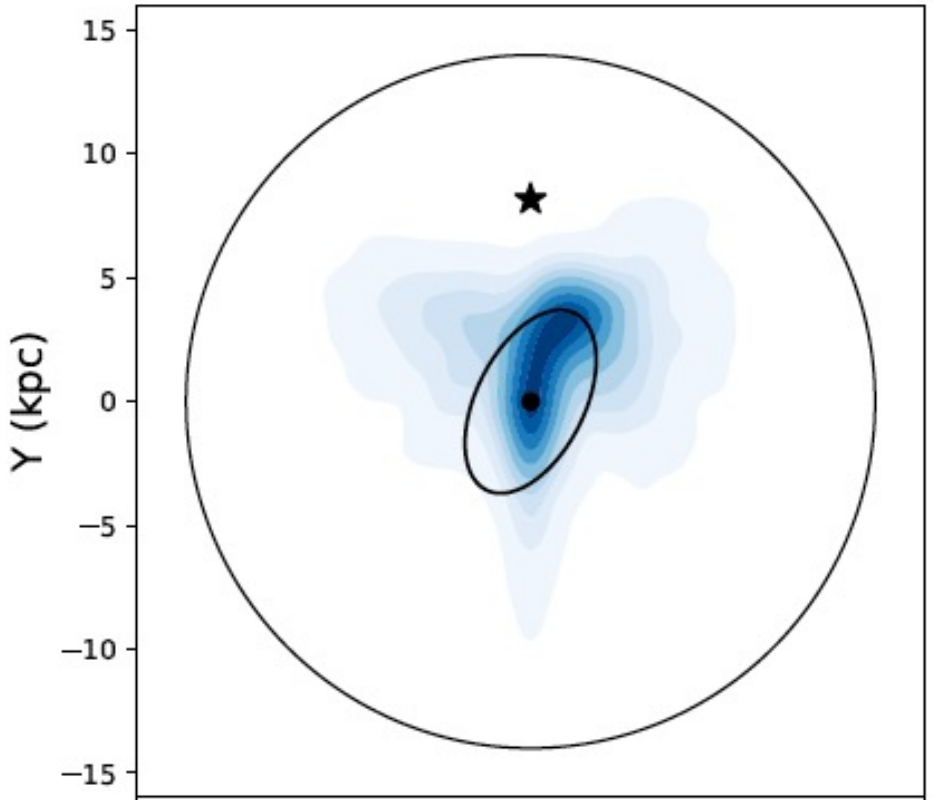
Xia et al., submitted

Methods

- Parallax (Gaia, VLBI)
- PL relationships
- SED color-matching and scaling to template (11,000 targets)

Indirect methods need calibration, which VLBI parallaxes can provide.

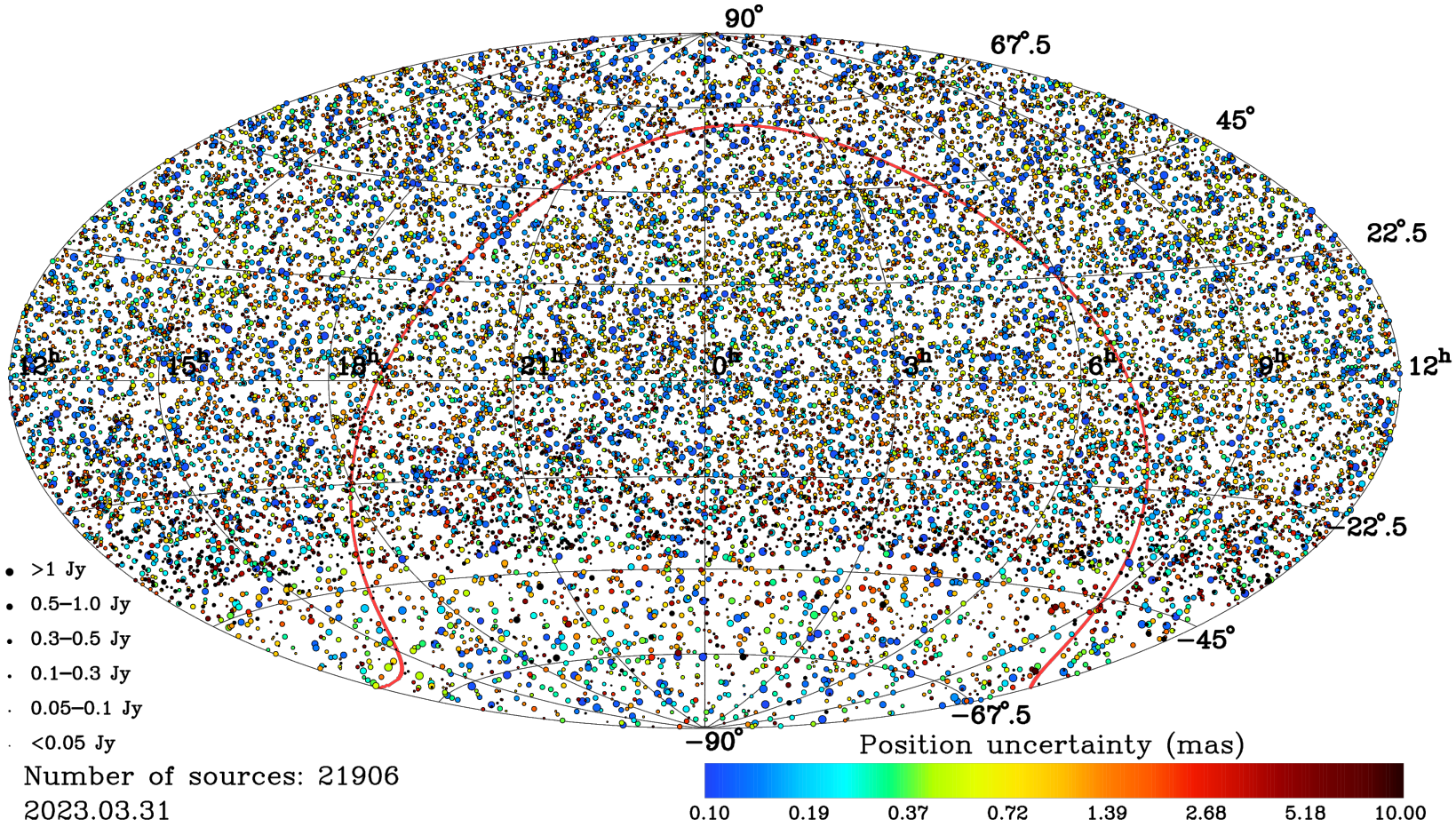
VLBI can also provide proper motions for targets in the bulge, even if full parallaxes are not possible => orbit family determination.



Bhattacharya et al., submitted - SEE POSTER

VLBI astrometry challenges: Calibrators

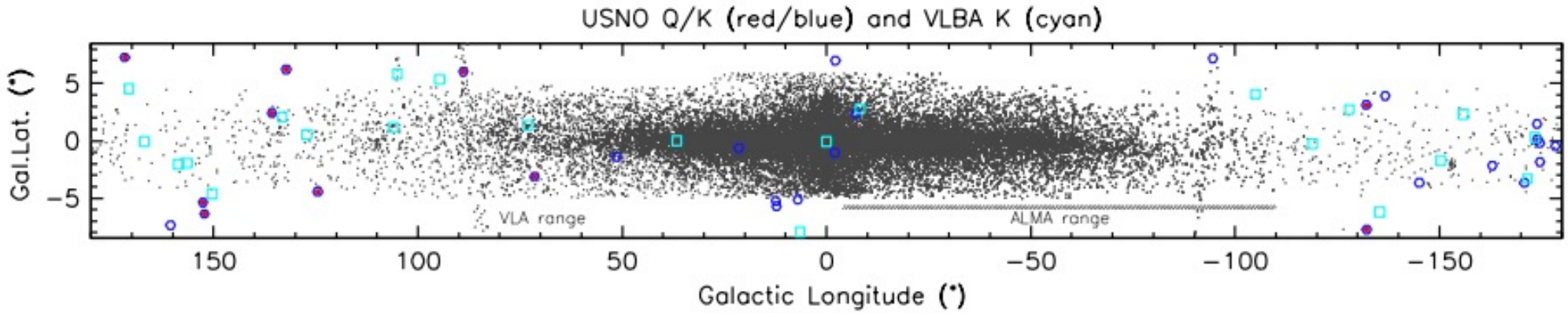
- At 43 GHz, the coherence time is 30 sec or less; calibrators within <1° wanted.



RFC – Petrov/NASA

43 GHz calibrator density

Zoom in to K- & Q-only in the plane, and compare to BAaDE source distribution



Calibrator searches have been performed, but not significantly improving situation.

Sensitivity needs improvement.

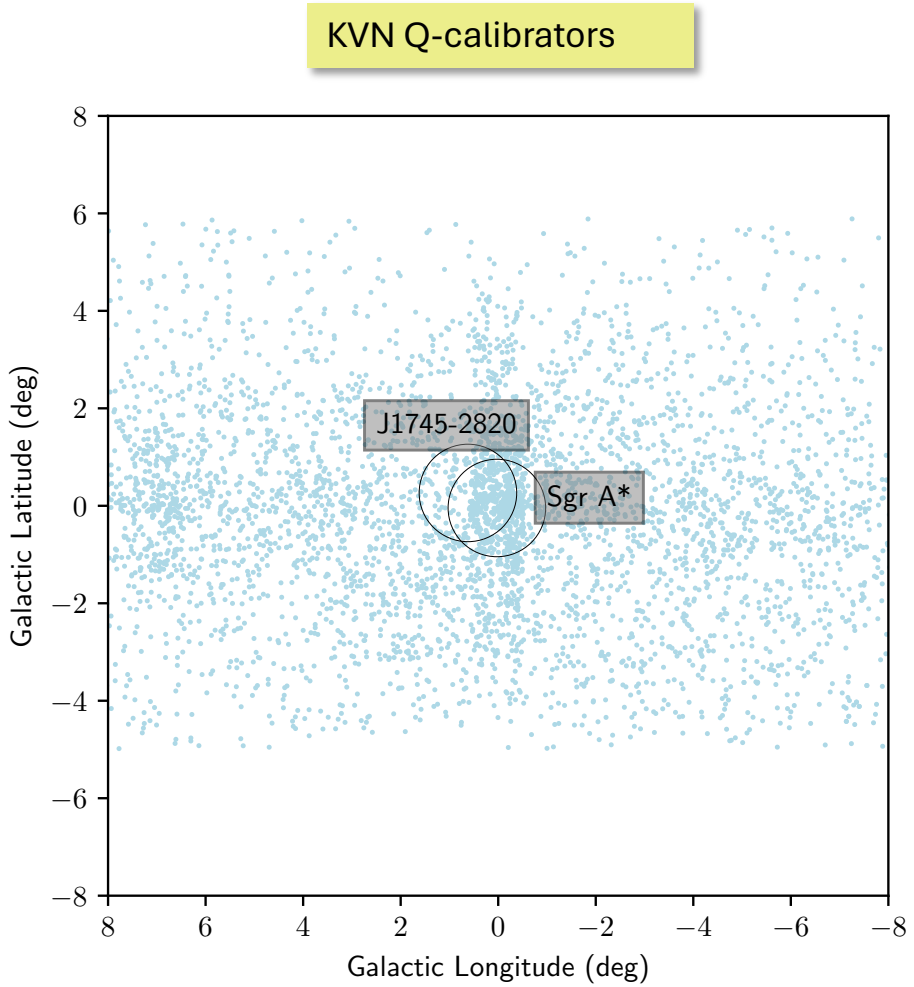
Target density

Existing calibrators provide very limited sky coverage, and as they are resolved solutions are limited to shorter baselines.

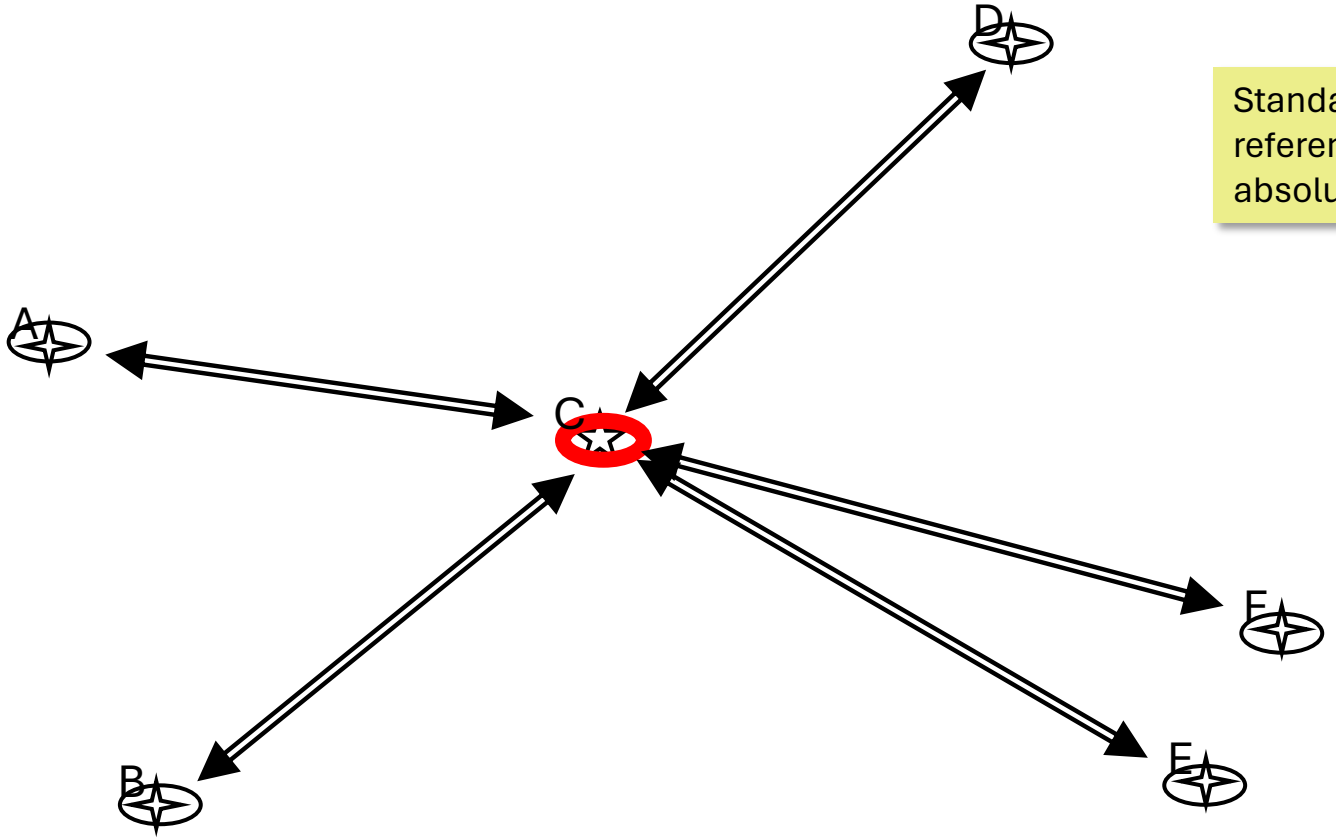
Note that the target density greatly exceeds calibrator density.

Can we use the high SiO detection density to transfer solutions from calibrators?

"Shared astrometry":
Concept under development.

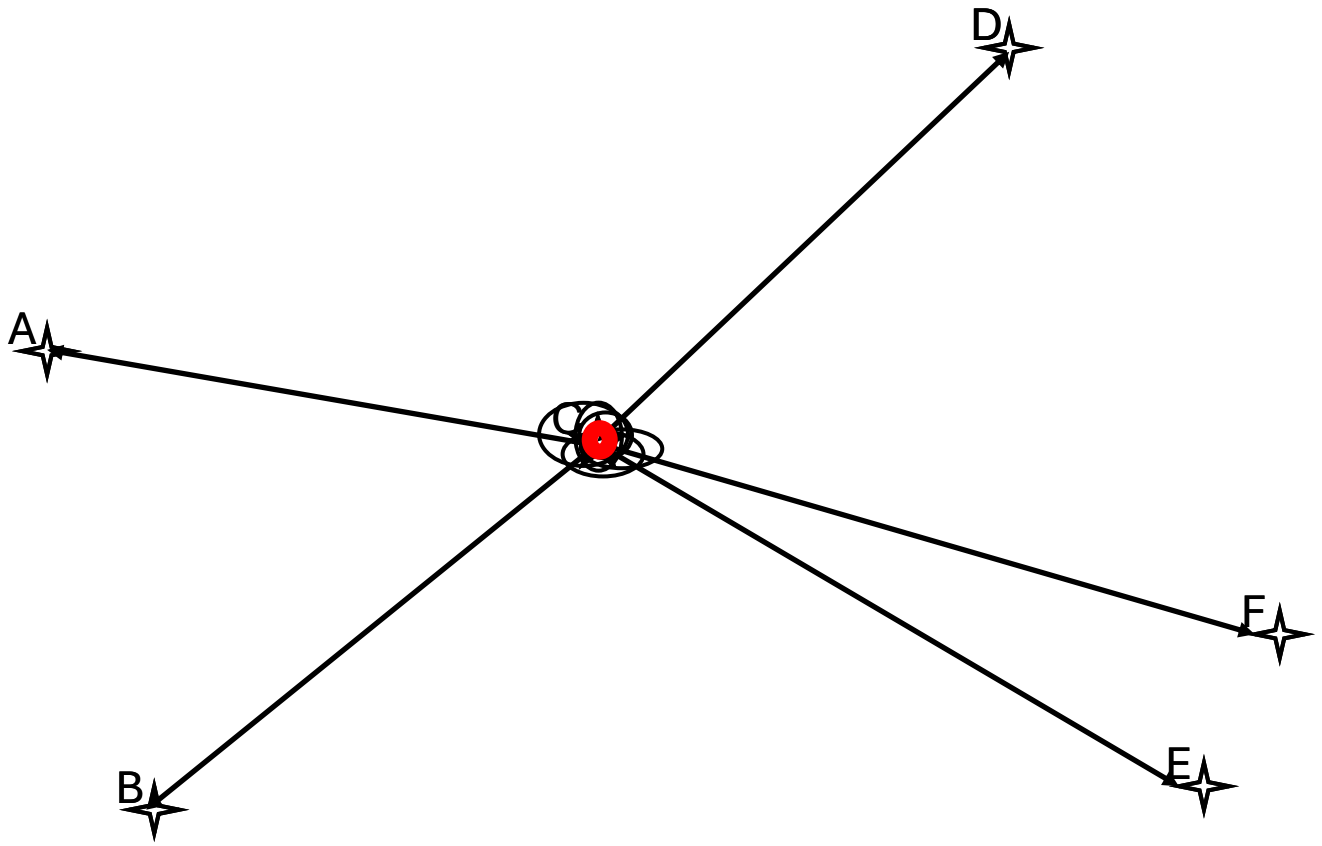


Shared astrometry concept



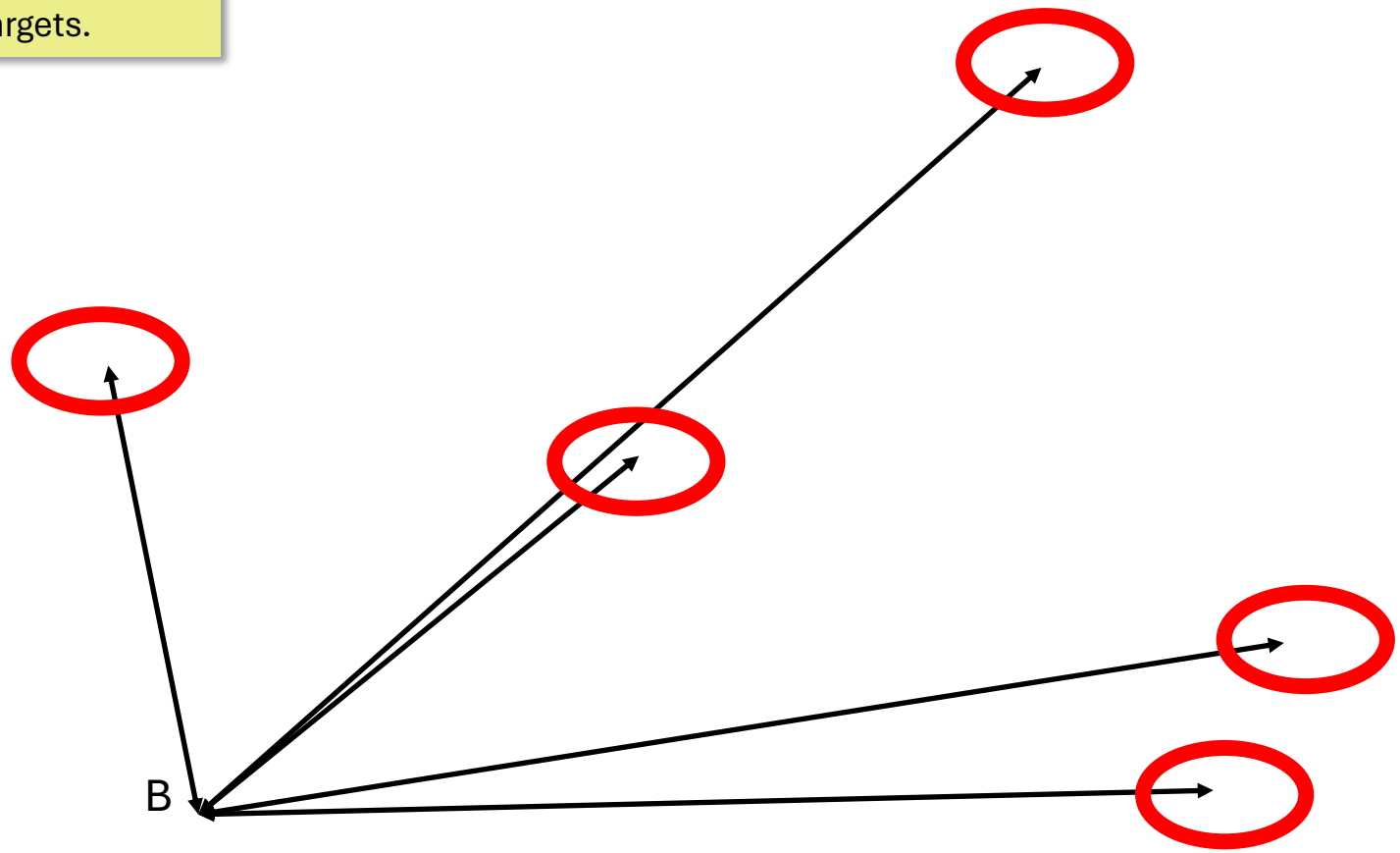
Standard phase-referencing for absolute positions.

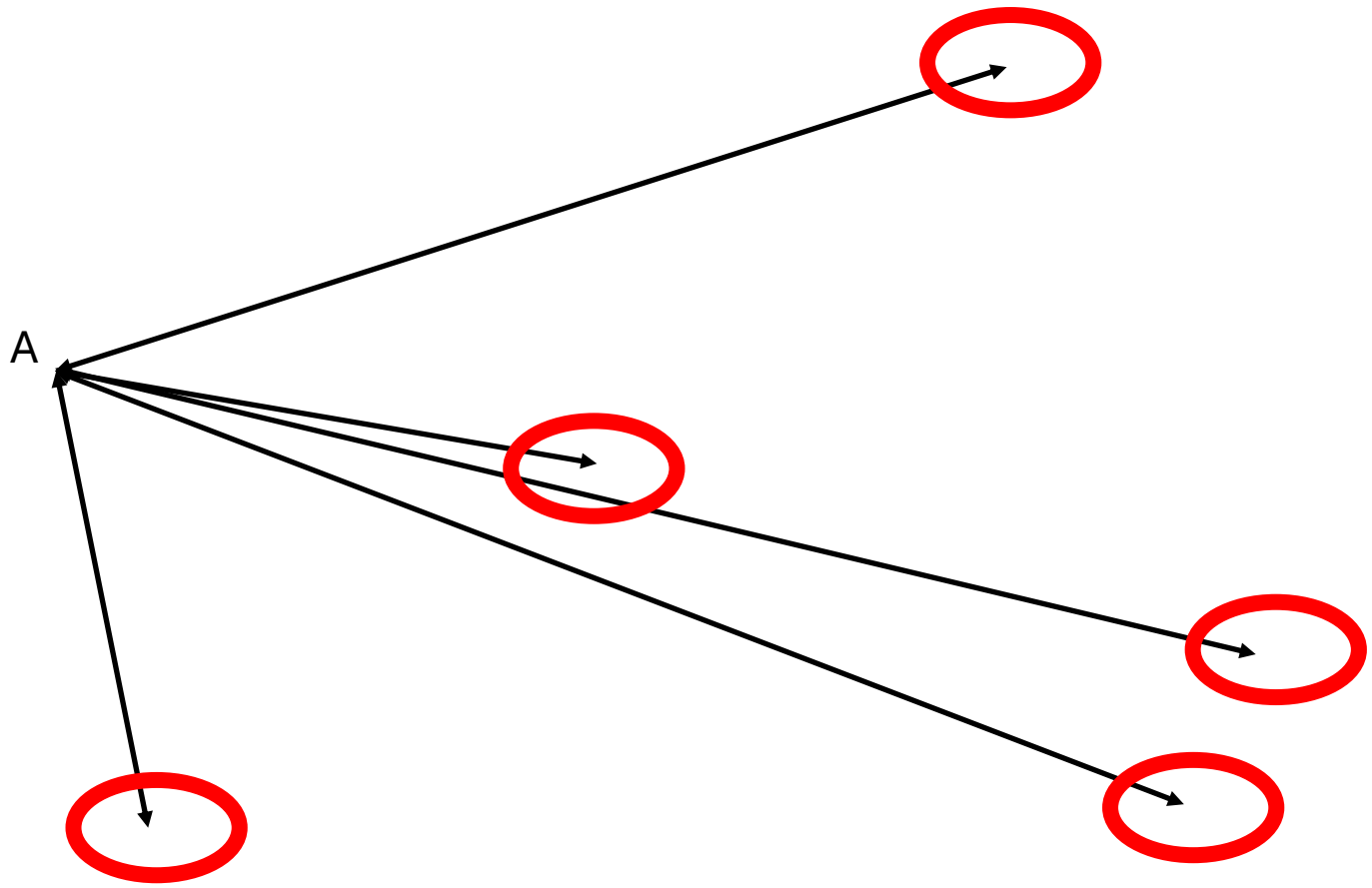
Effective error ellipses are larger when using a not-error-free reference source position
Here C is reference and A, B, D, E, F are target sources; note that this can be reversed!



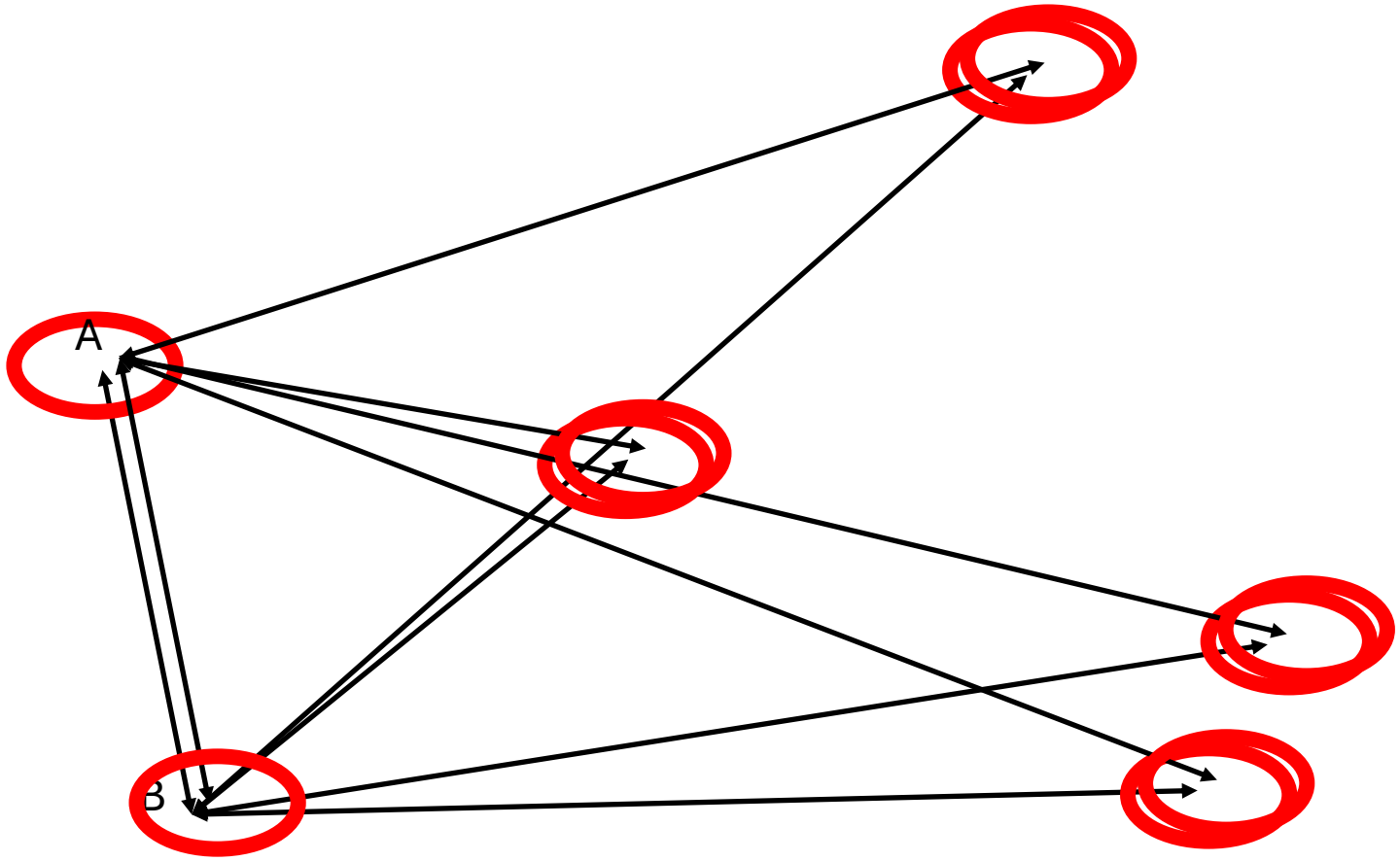
Error ellipses overlap on target if using multiple reference sources with good (absolute) positions. Note: here A, B, D, E, F are reference sources and C is the target source – the error ellipse gets smaller.

Any self-calibratable maser source can be used to measure relative positions to all other targets.

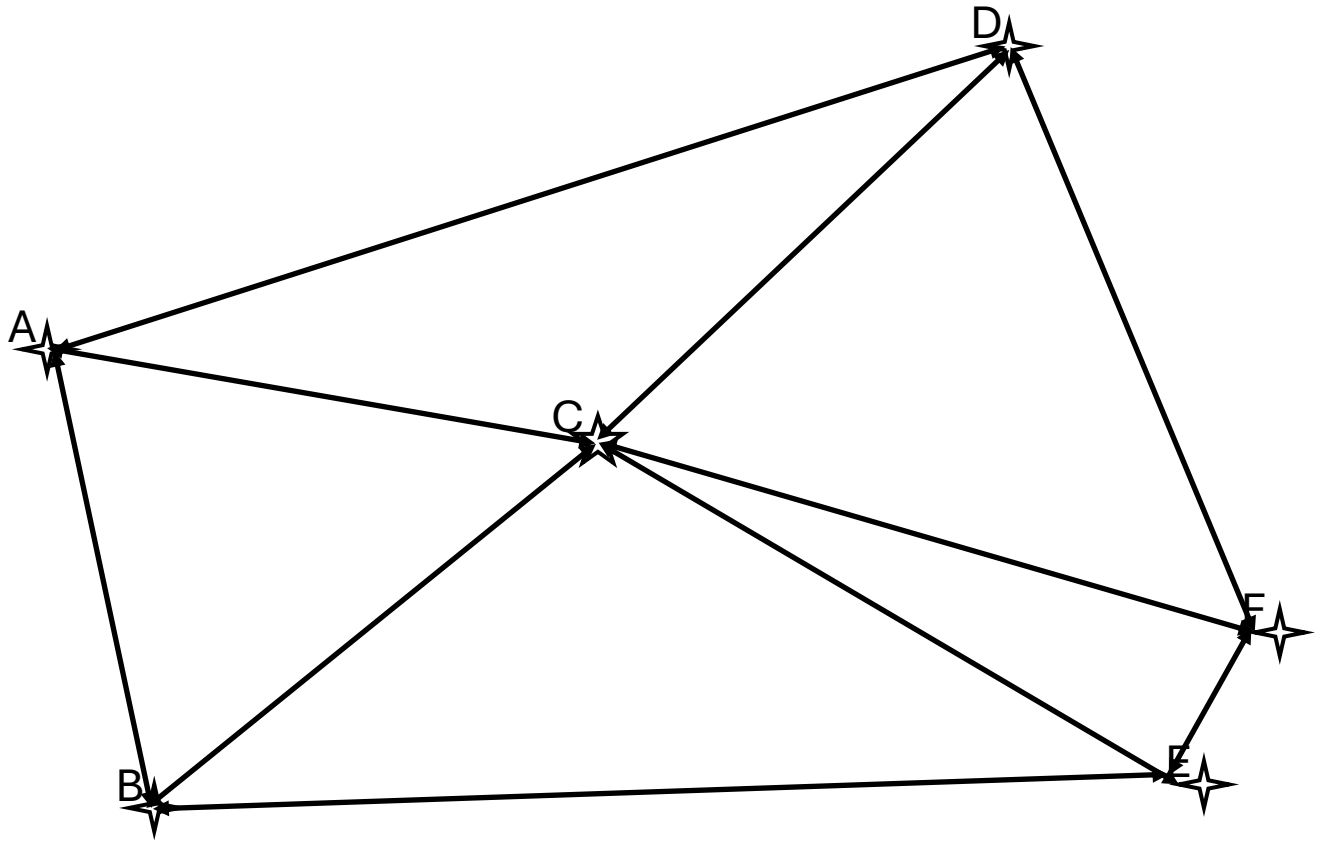




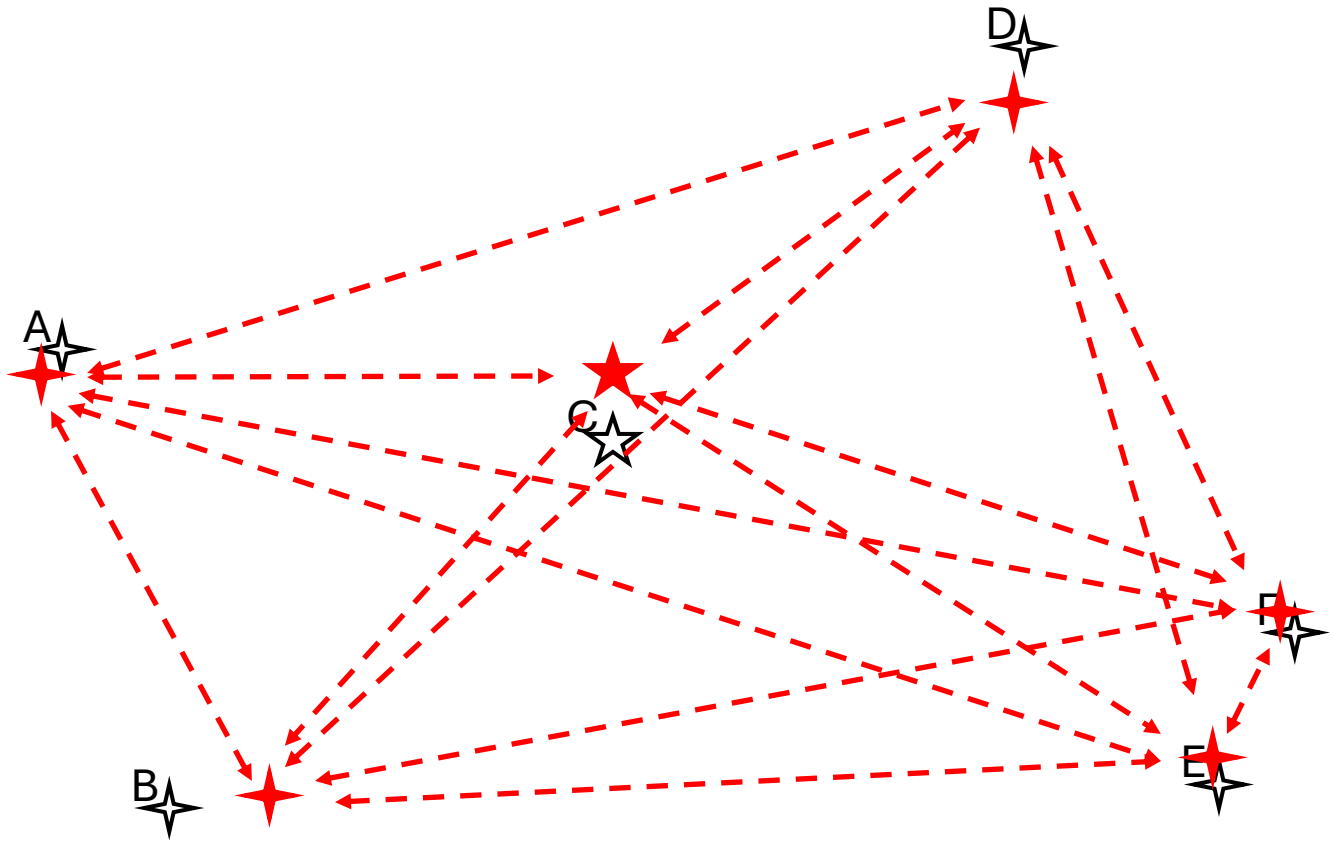
But can measuring many more relative positions make a vector frame/grid more robust than single anchor?



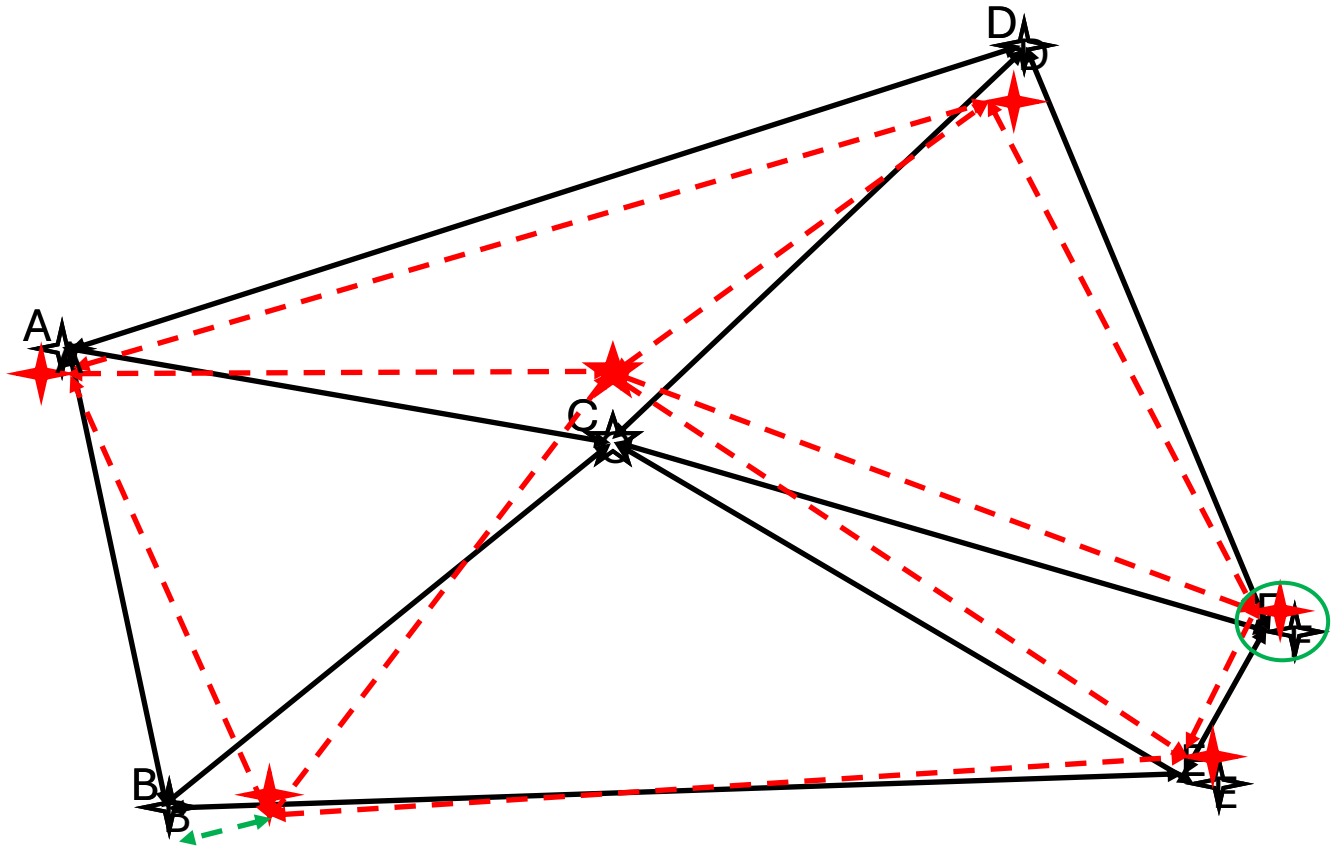
Using each source as reference we get these frames that should fit together with overlapping error ellipses.



Rigid frame of best triangles.



Now over time everything moves, a new grid can be determined using minimizing common error ellipses. Vector grids must be tied together with known individual positions and/or known individual proper motions.

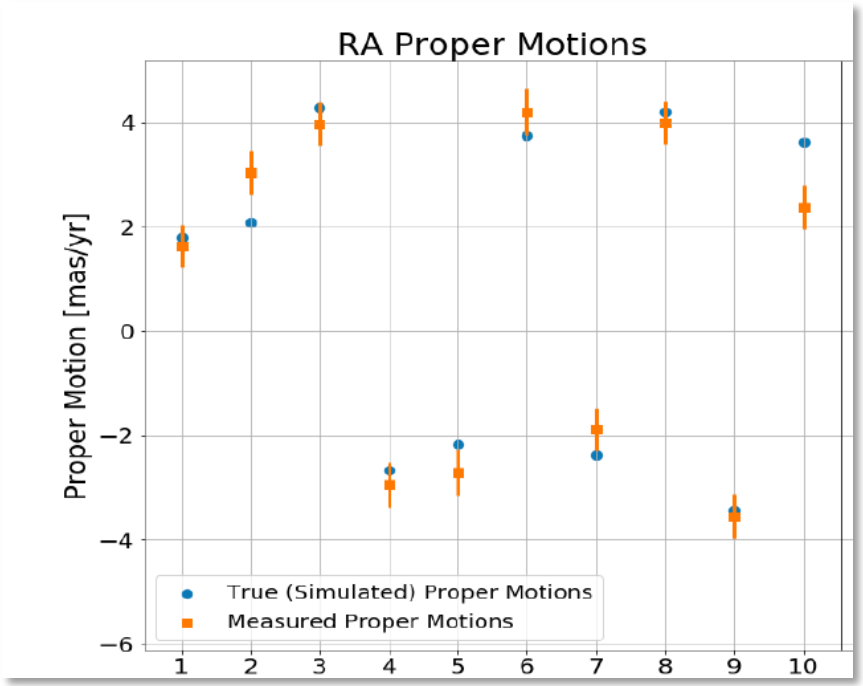


For example: Frames are tied using a known/fixed position (background quasar source F) or a known independently measured moving source (BAaDE Gaia maser source B with position and proper motion to a new position between the epochs).

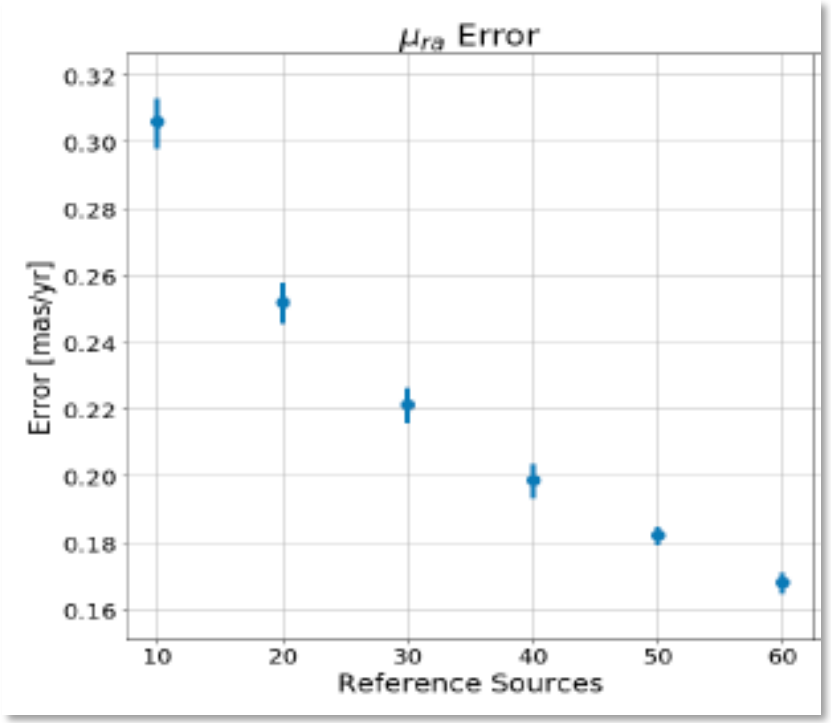
Now positions and proper motions of all other sources can be determined from the old/new frames.

MC simulation tests

Using a test population of sources in an exponentially decaying disk density distribution, proper motions and positions as a function of time can be described.



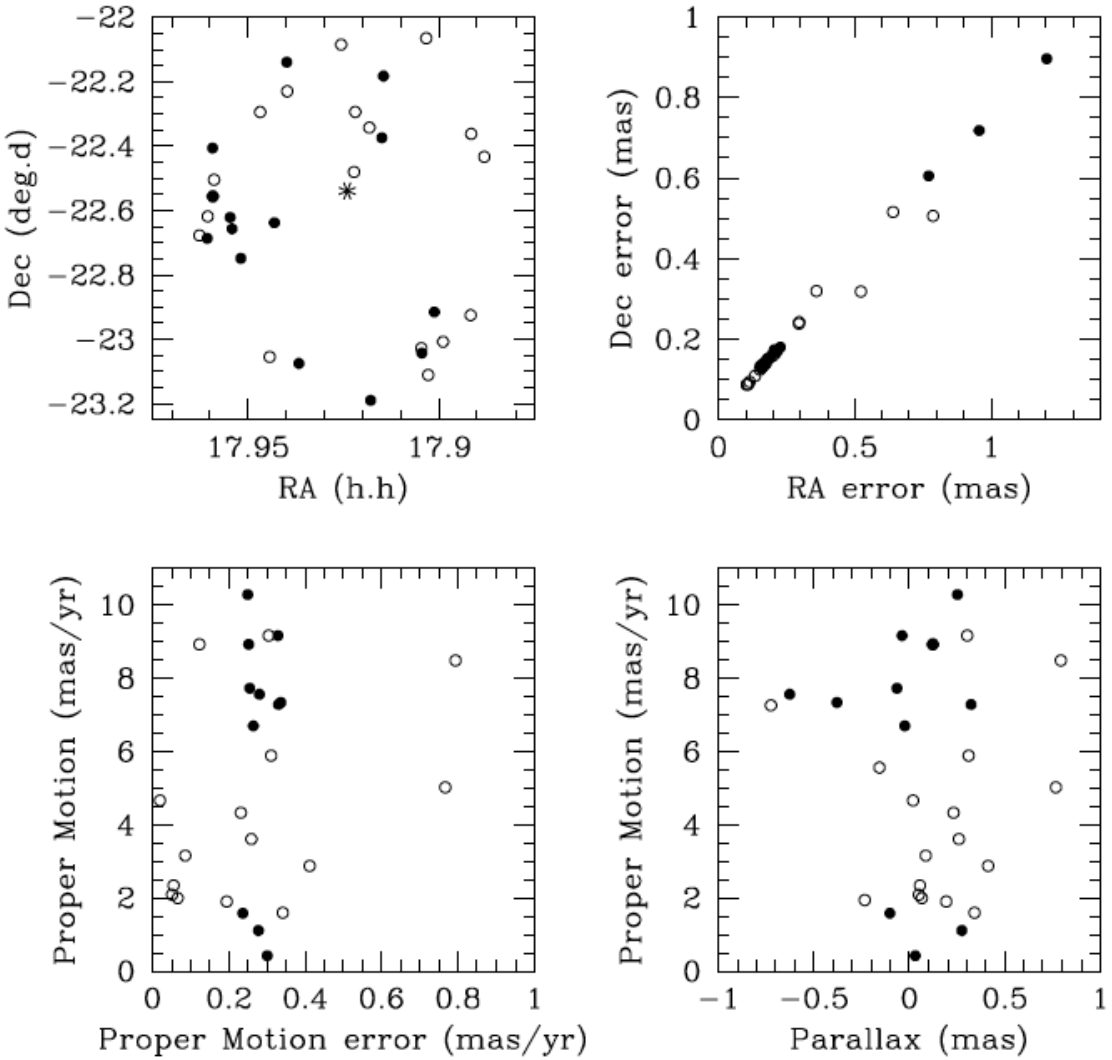
Results in "measured" proper motions for 10 targets using a single reference, compared to the model "true" values.



Modeling improvement in the errors when increasing the number of reference sources.

B. Jiang, NRAO REU student

Initial VLA observational test under way



Begun a test with VLA observations and ~30 maser sources.

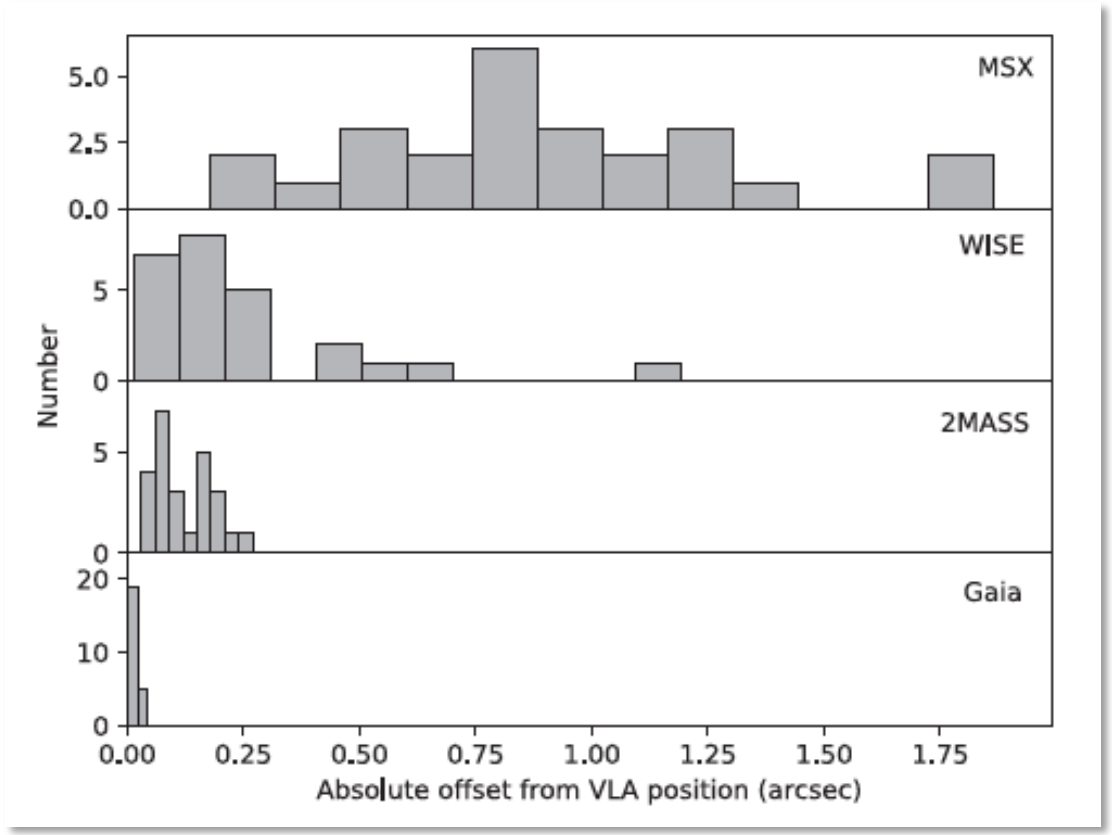
Observed previously using phase-referencing.

Reality test as well: Re-detection rate usually about 80%.

VLBI challenges: positions

The BAaDE VLA survey did not use phase-referencing.

- Target positional uncertainties 1-2” based on MSX data
- Positions for a subsample of SiO masers with phase-referencing compared to MSX, WISE, 2MASS and Gaia positions showed 2MASS catalog positions most favorable to use for the whole sample.



Caution with the Gaia counterparts as the direct ‘nearest neighbor’ did not work well for our extended and obscured radio stars.

Pihlström et al. (2018)

Final remarks

- Promising method to increase the number of sources with astrometric measurements

- Still need lots of observing time, and an ICRF position is always going to be helpful.

Needs to be translated into VLBI –length baselines.

- Observing a large number of sources with VLBI through using shared astrometry will unlikely be feasible, but it may provide a very important method with which to calibrate other distance estimate methods (SED, PL, ML).