Testing methods of accurate low frequency astrometry for hydroxyl masers

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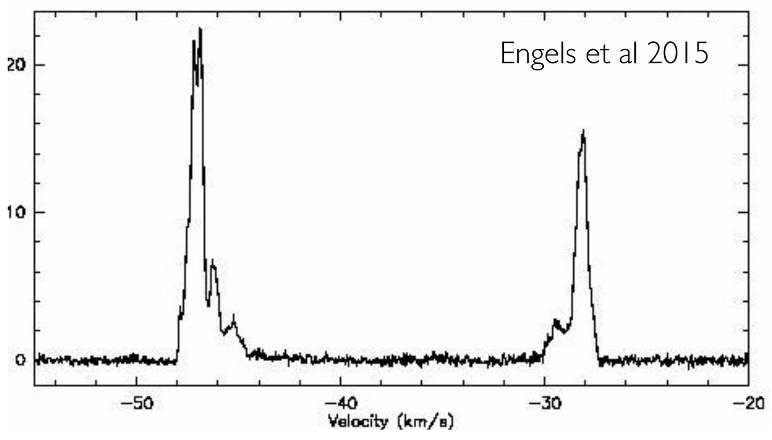
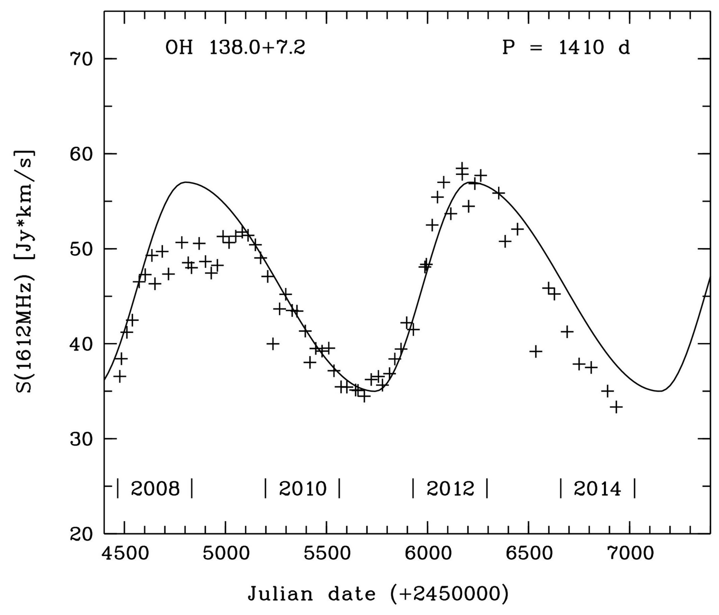
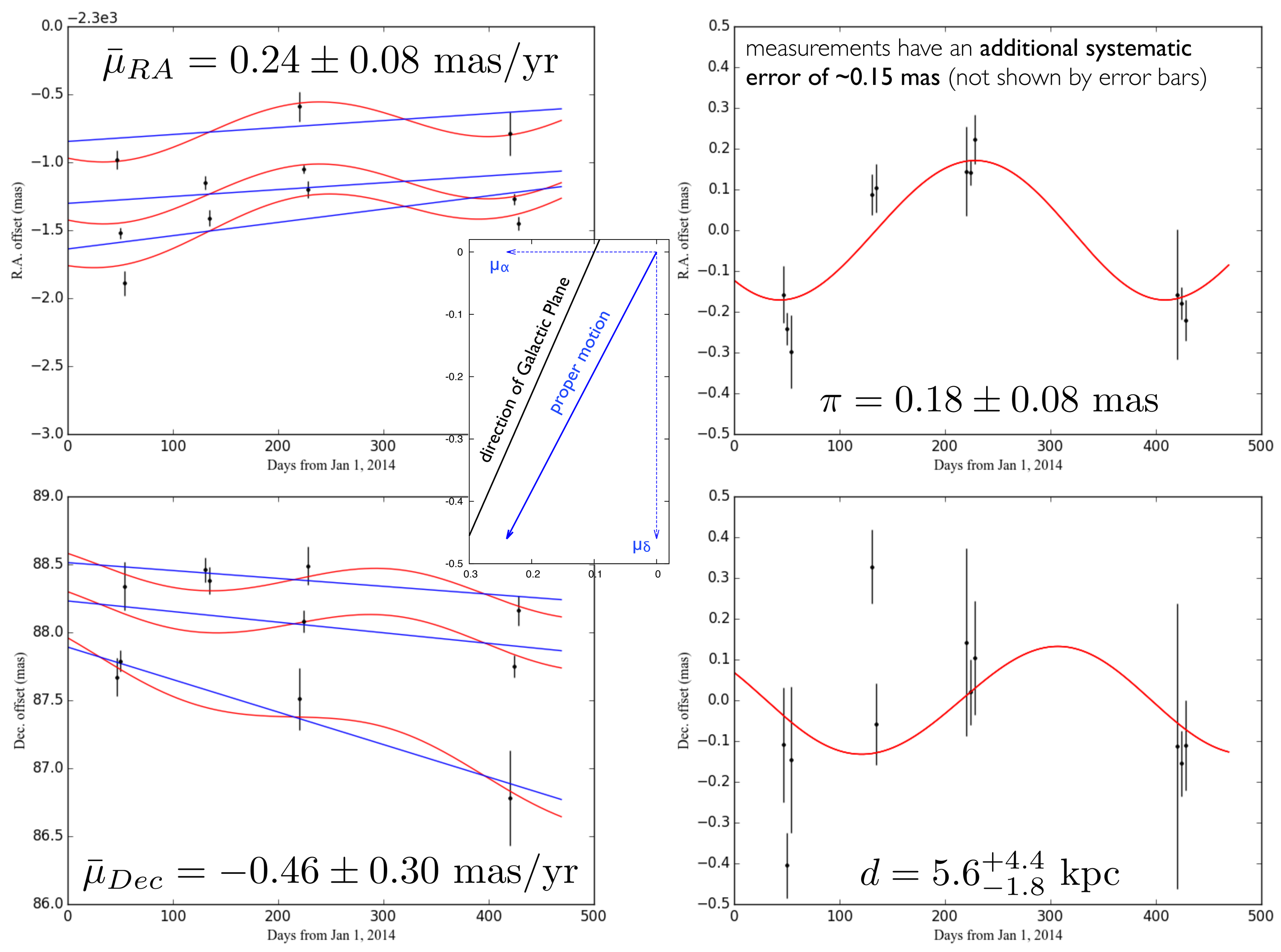
OH 138.0+7.2

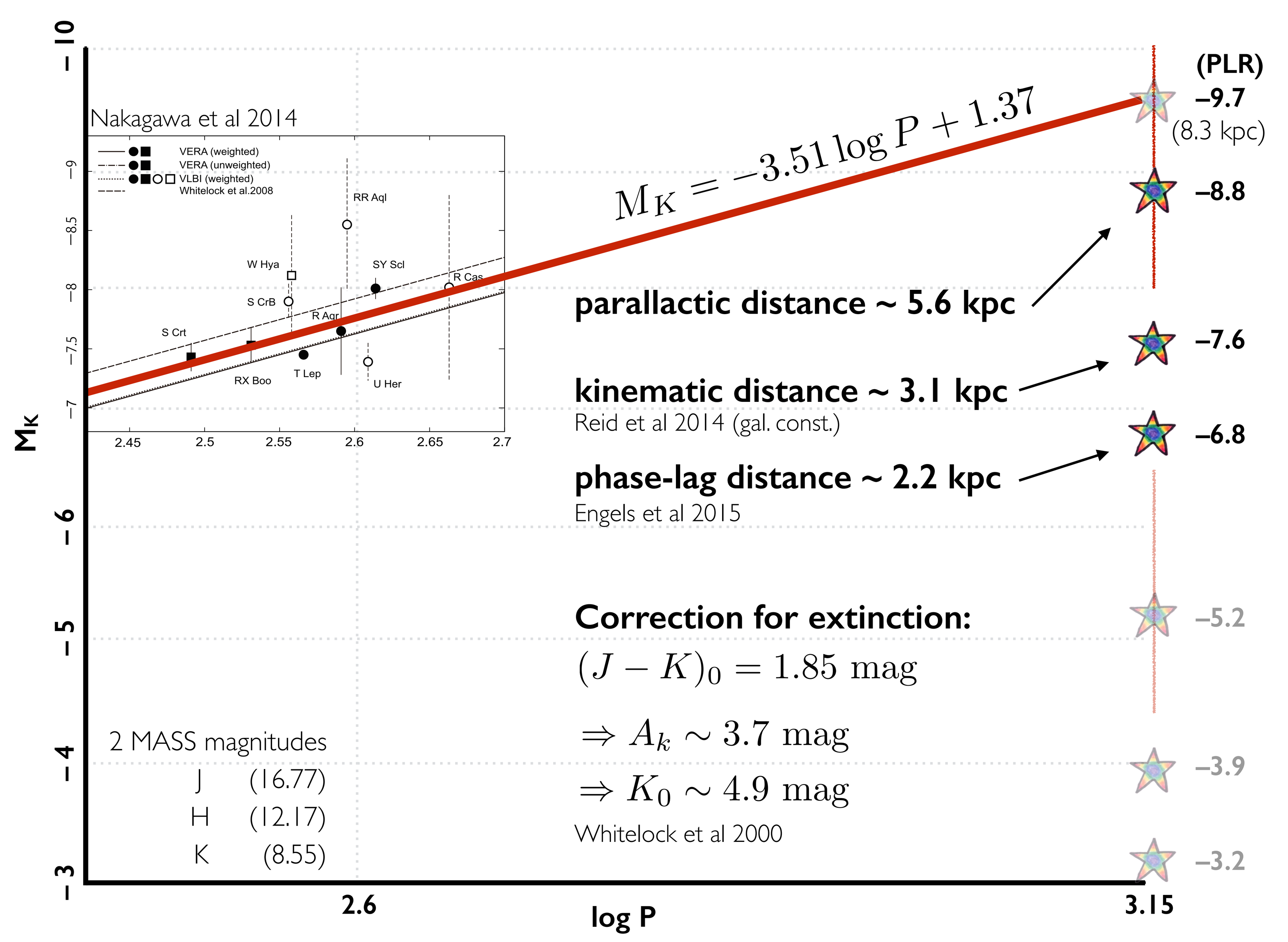




The 1612 MHz maser spectrum and integrated flux variation of our target OH/IR star is measured with the Nancay Radio Telescope (D. Engels and S. Etoka, Nancay 1612 MHz monitoring of OH/IR stars, Engels et al 2015).



The measured annual parallax is a preliminary result (only in-beam) and is estimated to still have uncorrected ionospheric errors of ~0.15 mas (cf. Asaki et al 2007). The parallax of the OH/IR star can be used to study the higher-end part of the period-luminosity relationship of Mira variables, or to evaluate less direct distance estimators (e.g. phase-lag or kinematic).



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Reid et al 2014, ApJ 783, 130
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Vlemmings et al 2003, A&A 407, 213
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VLBI astrometry of 1612 MHz OH masers

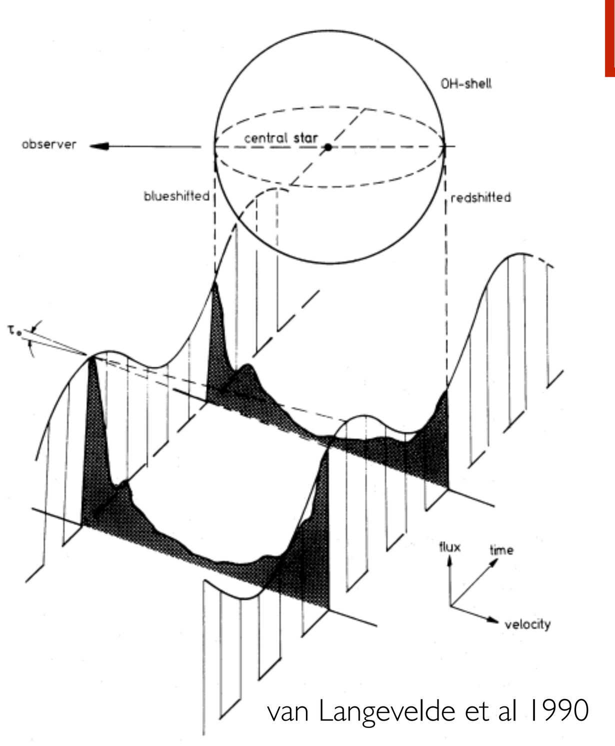
VLBI astrometry can be used to measure the accurate positions of masers relative to quasars (calibrators). However, at low frequencies the dispersive ionosphere degrades the accuracy, introducing a large systematic error. We can try to correct for this error by using an in-beam calibrator and several secondary calibrators, to measure short-term dynamic variations and the two-dimensional phase gradient around the maser. With precise astrometry of hydroxyl masers around OH/IR stars, we can determine the parallax and proper motion of these sources. OH astrometry can be used to study the shells of these heavily enshrouded and massive AGBs, evaluate and calibrate other distance methods and prepare new techniques for the SKA.
(For prior results in OH astrometry, see van Langevelde et al 2000, Vlemmings et al 2003, 2007.)

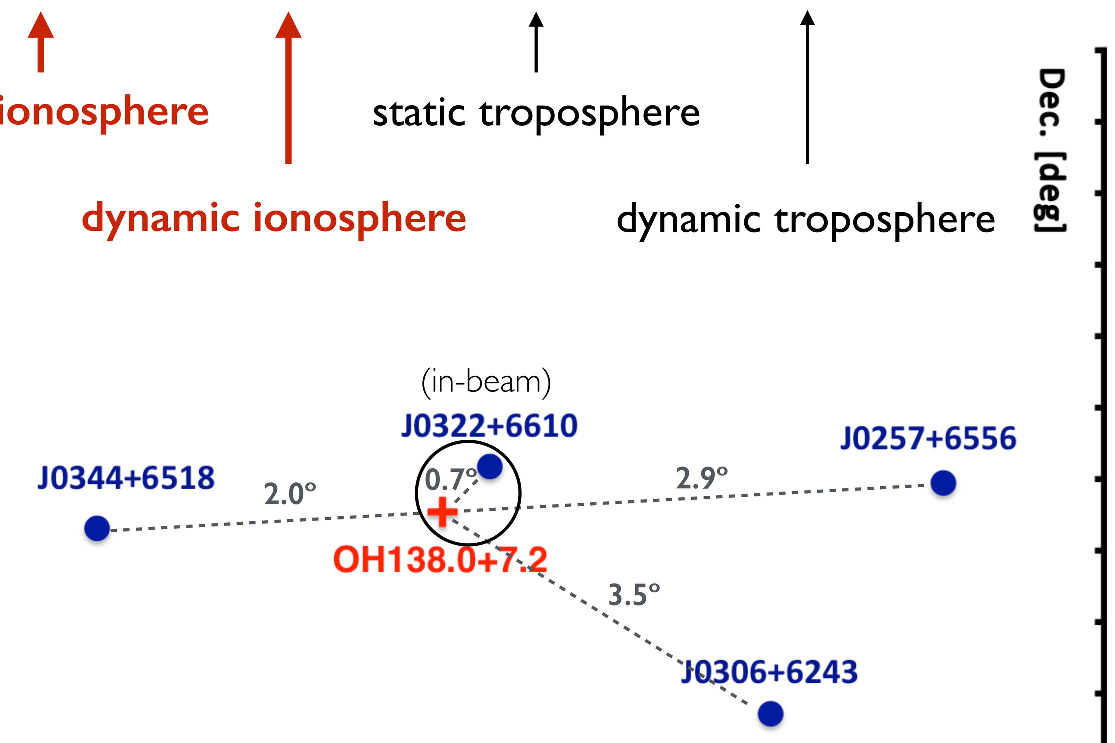
geometric, atmospheric, structural, positional, instrumental, thermal, phase ambiguity

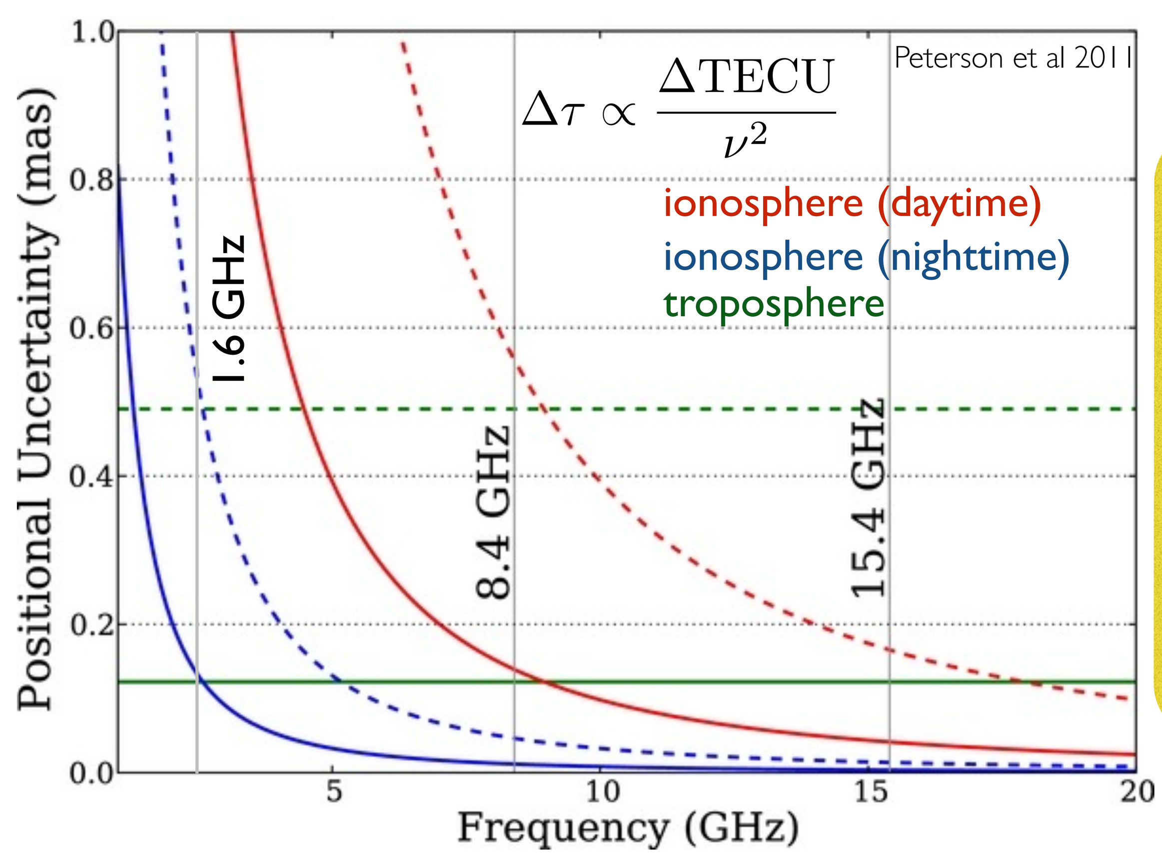
$$\phi_{obs} = \phi_{geo} + \phi_{atm} + \phi_{str} + \phi_{pos} + \phi_{inst} + \phi_{therm} + 2\pi n$$

$$\phi_{atm} \rightarrow \phi_{iono,\theta} + \phi_{iono,t} + \phi_{trop,\theta} + \phi_{trop,t}$$

static ionosphere, dynamic ionosphere, static troposphere, dynamic troposphere

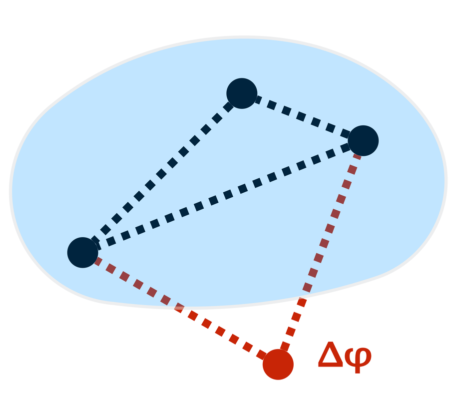






Even after the GPS based corrections the effect of ΔTEC dominates the phase error budget. Multiple calibrators allow the determination of ΔTEC across the field and the removal of this limitation on astrometric accuracy (MultiView, Rioja et al 2009, Dodson et al 2013).

Imaging the same maser spot with all the various 3 antenna subarrays in the VLBA (a total of 120). The ~0.5 mas spread in position is likely due to residual phase errors (from ionosphere, maser structure, thermal noise).



$$\binom{10}{3} = 120$$