



Detecting faint binary companions using phases and other NPOI developments

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Navy Precision Optical Interferometer



- Joint project between NRL, USNO and Lowell Observatory
- Observes at visible wavelengths (550 to 850 nm) with 16 channels
- Two nested arrays:
 - 4 astrometric stations
 - 6 imaging array stations distributed among 30 piers
- Combines up to 6 beams
- Apertures are 12-cm
- Magnitude limit: 6.0 mag
- Baselines span 9 to 432 m

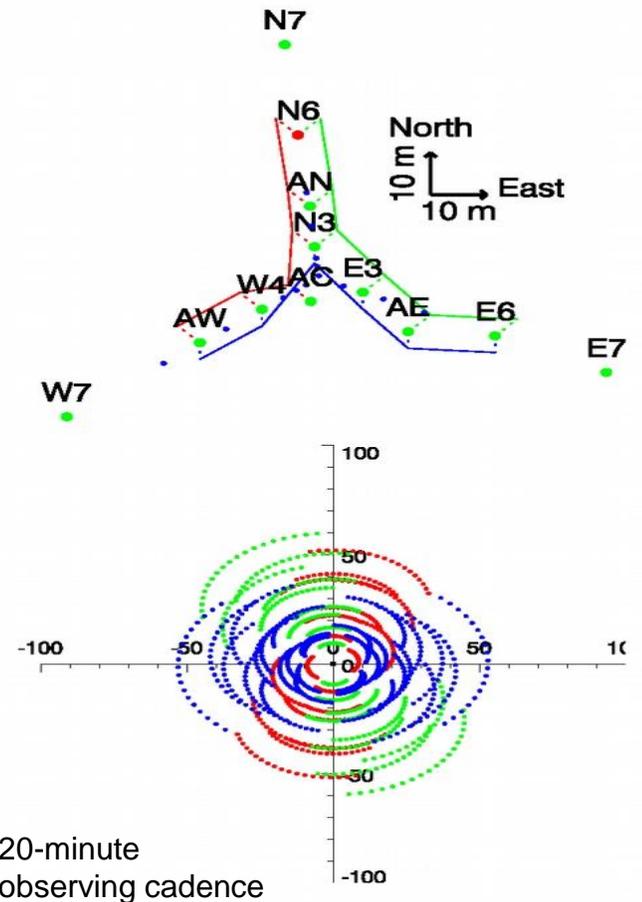
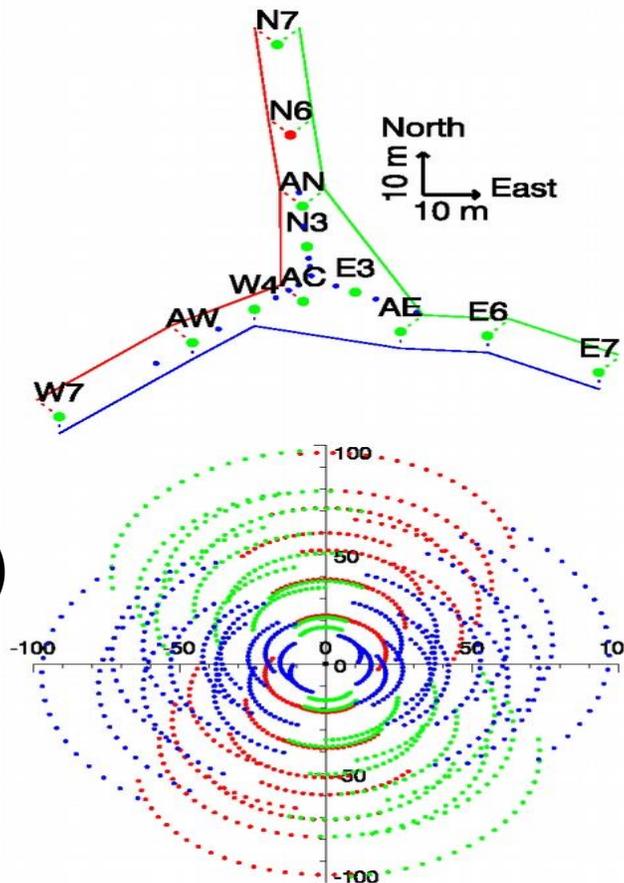


The NPOI Stellar Imaging Project

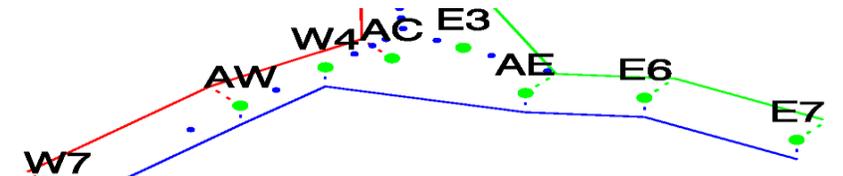
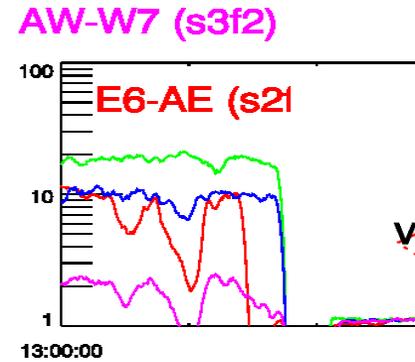
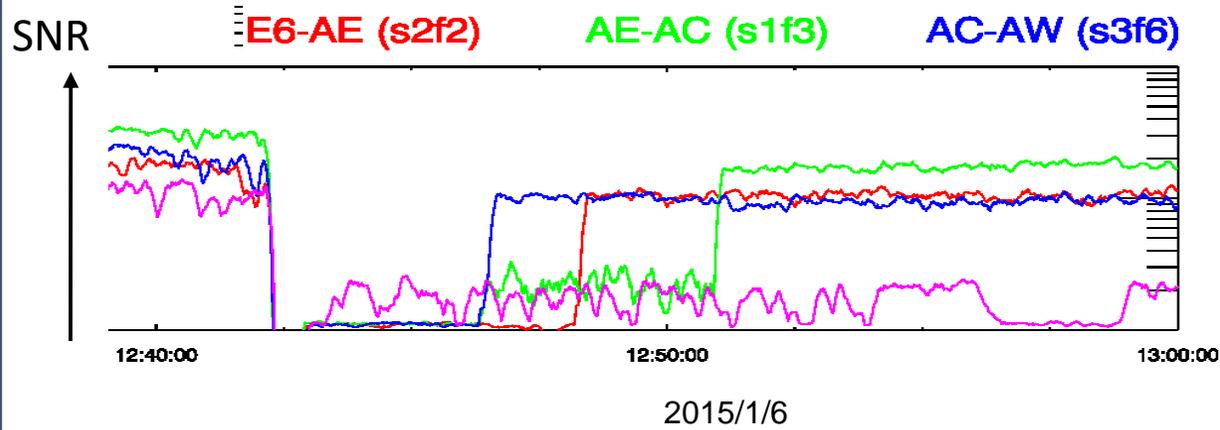
U.S. NAVAL
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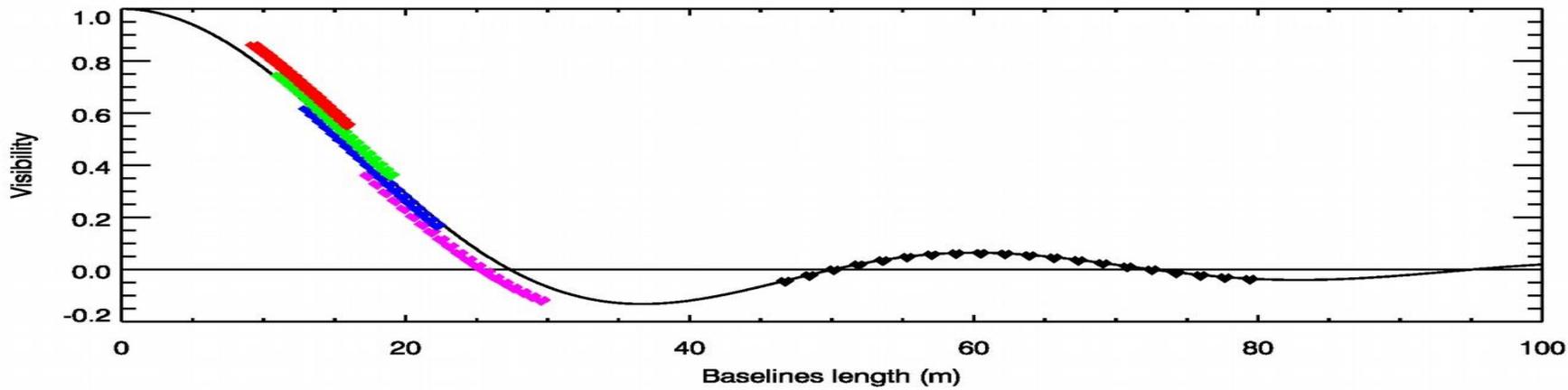
- Lead by Anders Jorgensen (NMT)
- Poor-man's array, 3 roughly equally spaced chains.
- Switch between 3 chains without moving telescopes
- Complete UV coverage in 3 nights
- New data acquisition and fringe-tracking system (New Classic)
- Real-time coherencing (bootstrapping) on short and long baselines.
- Post-observation coherent integration to recover SNR on long baselines.



HR 4377 5-Station Bootstrapping



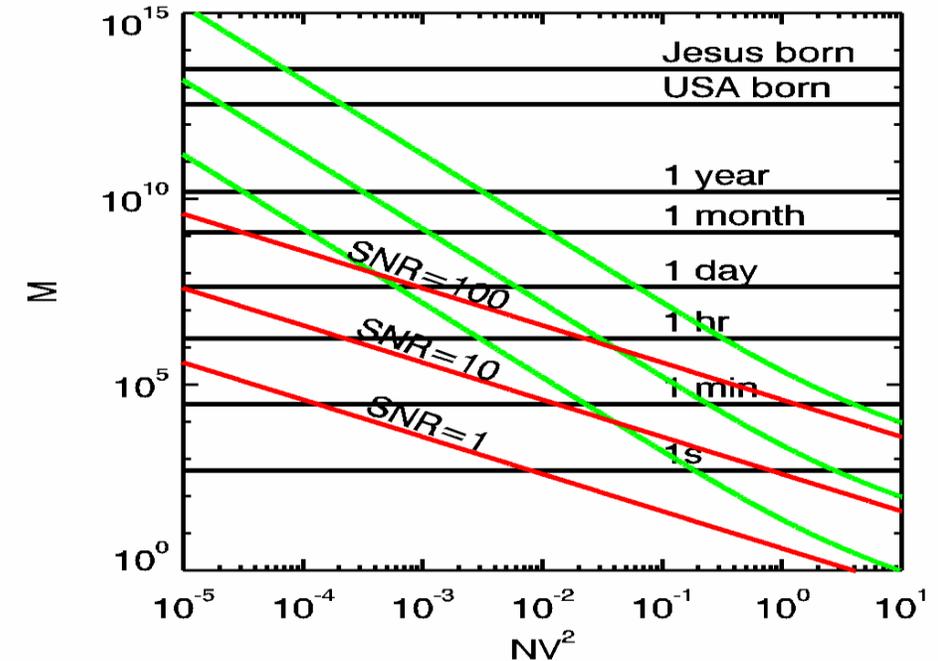
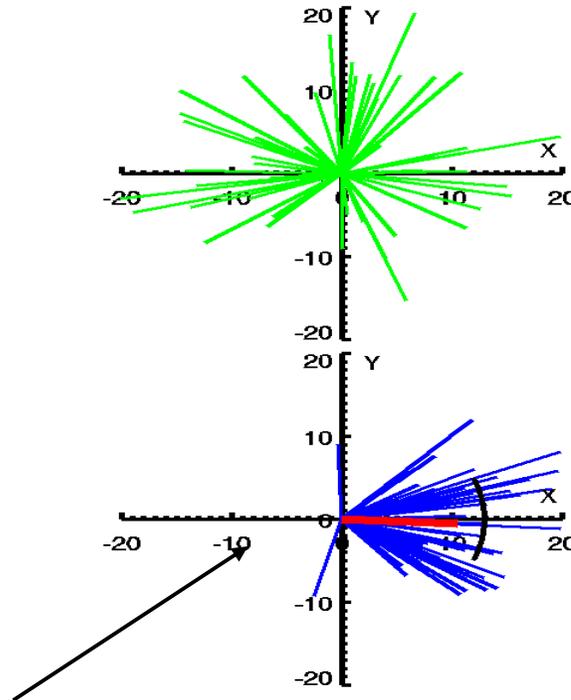
ν Uma - K3III
4.6 mas
V=3.5



Coherent Integration



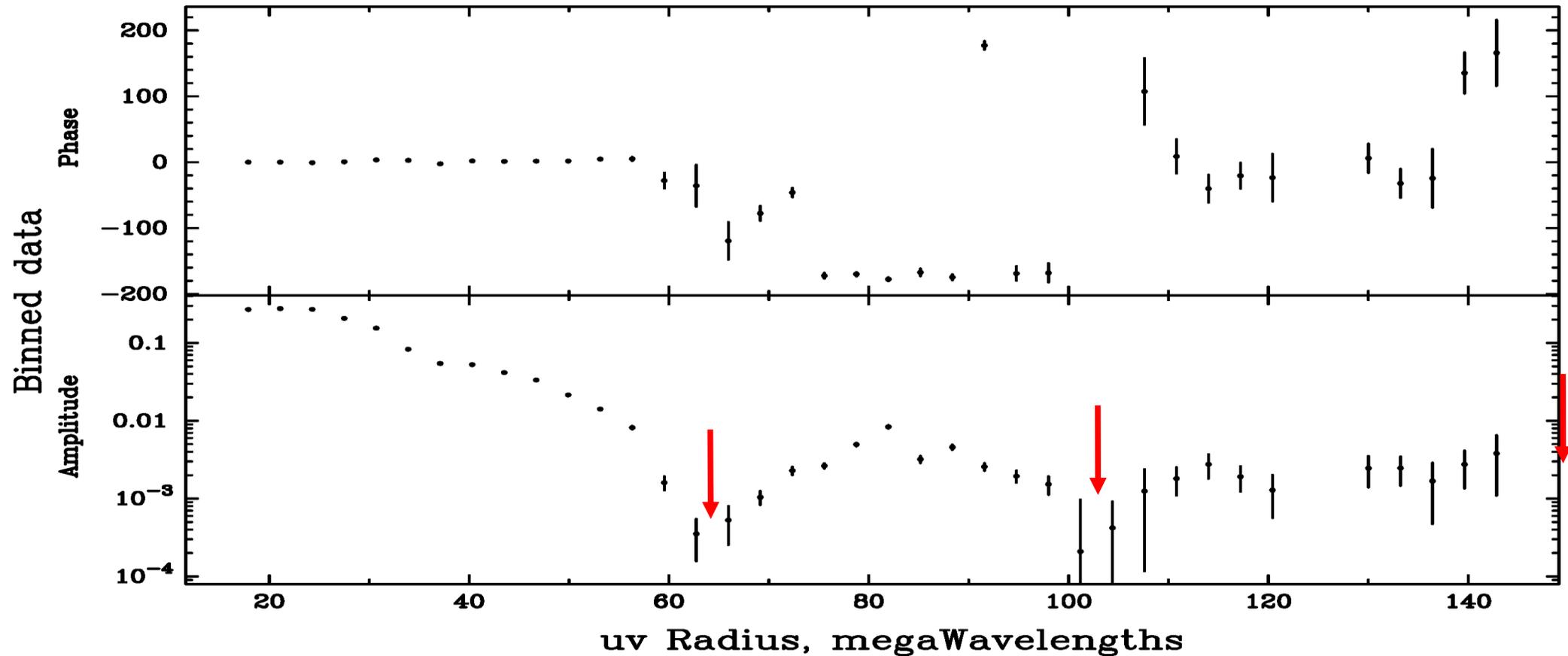
- Make use of phase information instead of throwing it away as is done with V^2 and V^3 .
- Rotate complex visibilities by a phase reference, e.g. based on phase at different wavelengths or different baseline.
- Better SNR product.
- Use coherent integration on (a) faint targets, (b) resolving baselines, (c) individual channels of high-resolution observations.
- But beware of phase noise amplitude reduction.



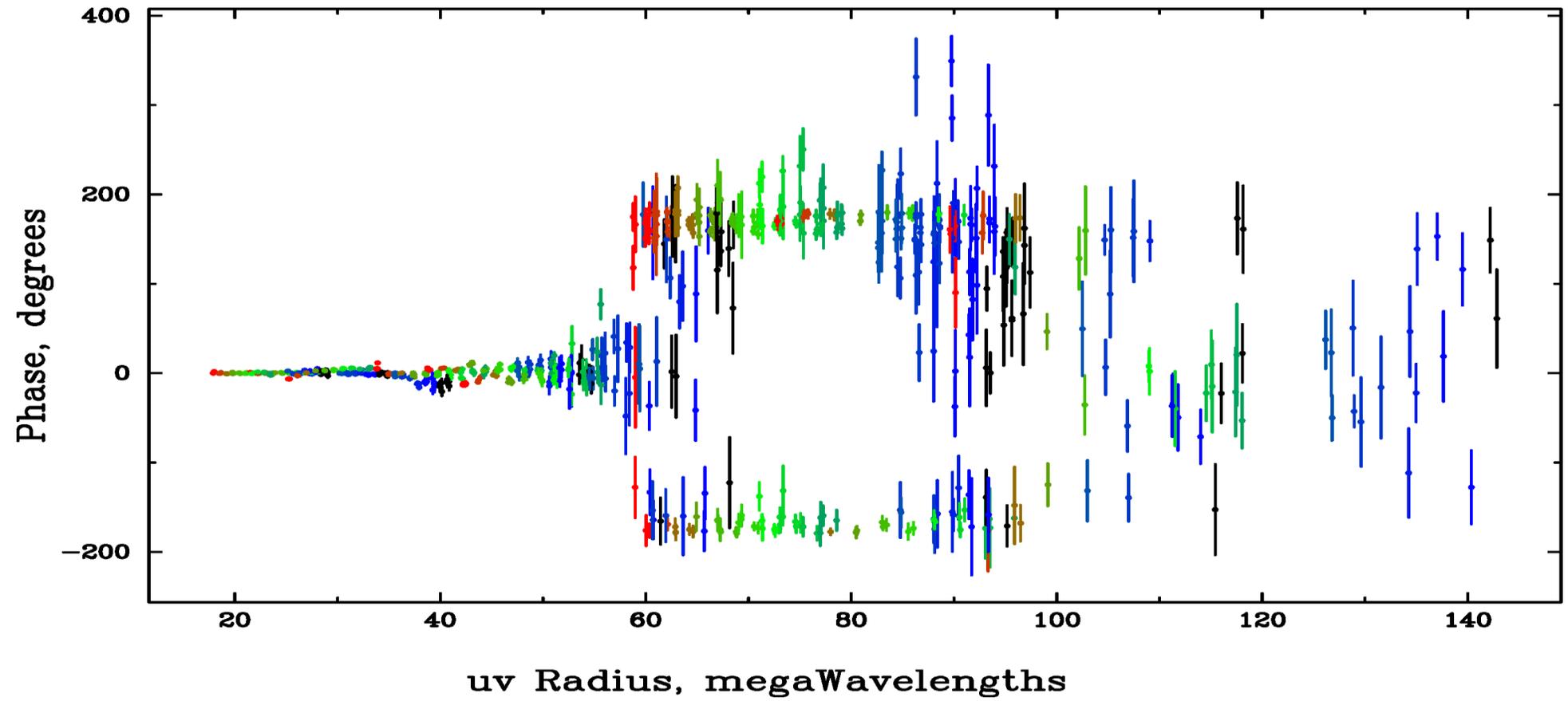
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For a uniform disk expect nulls at ratios 3.8, 7.0, 10.1, corresponding to e.g. 62, 114, and 152.
4 minutes of data.



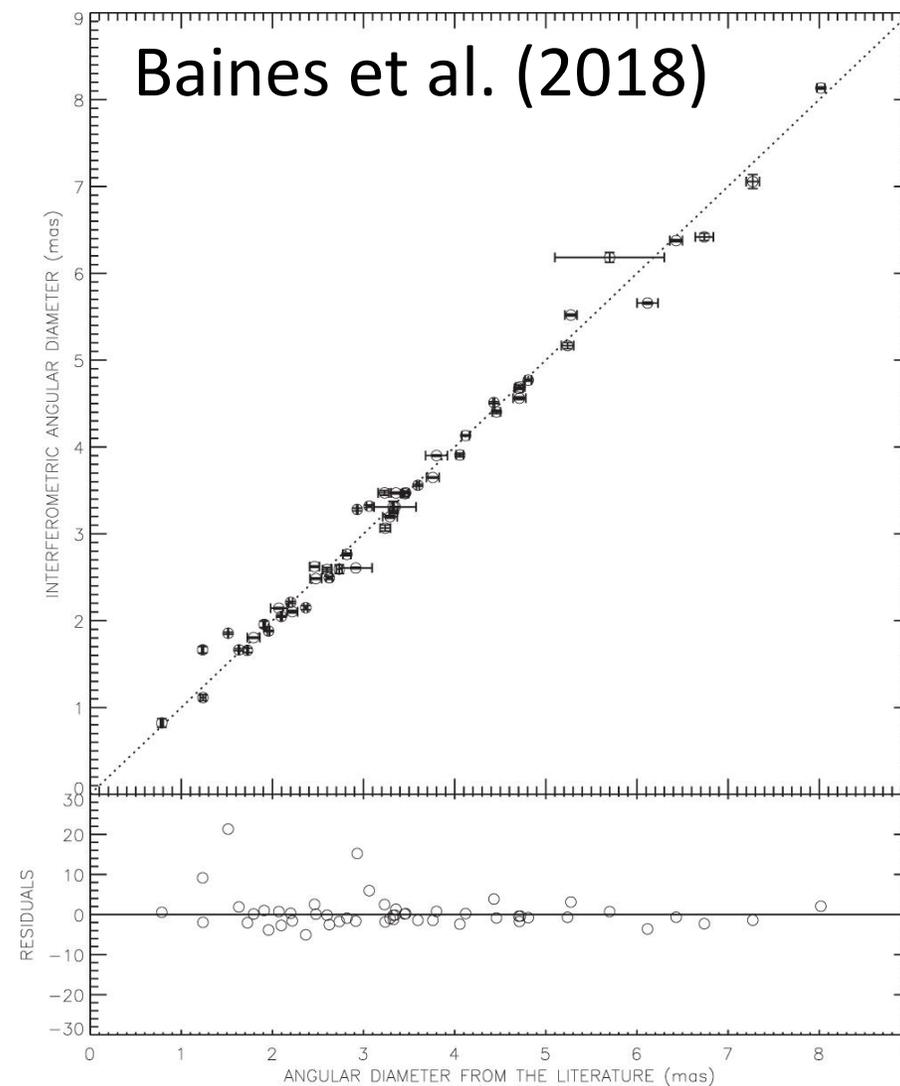
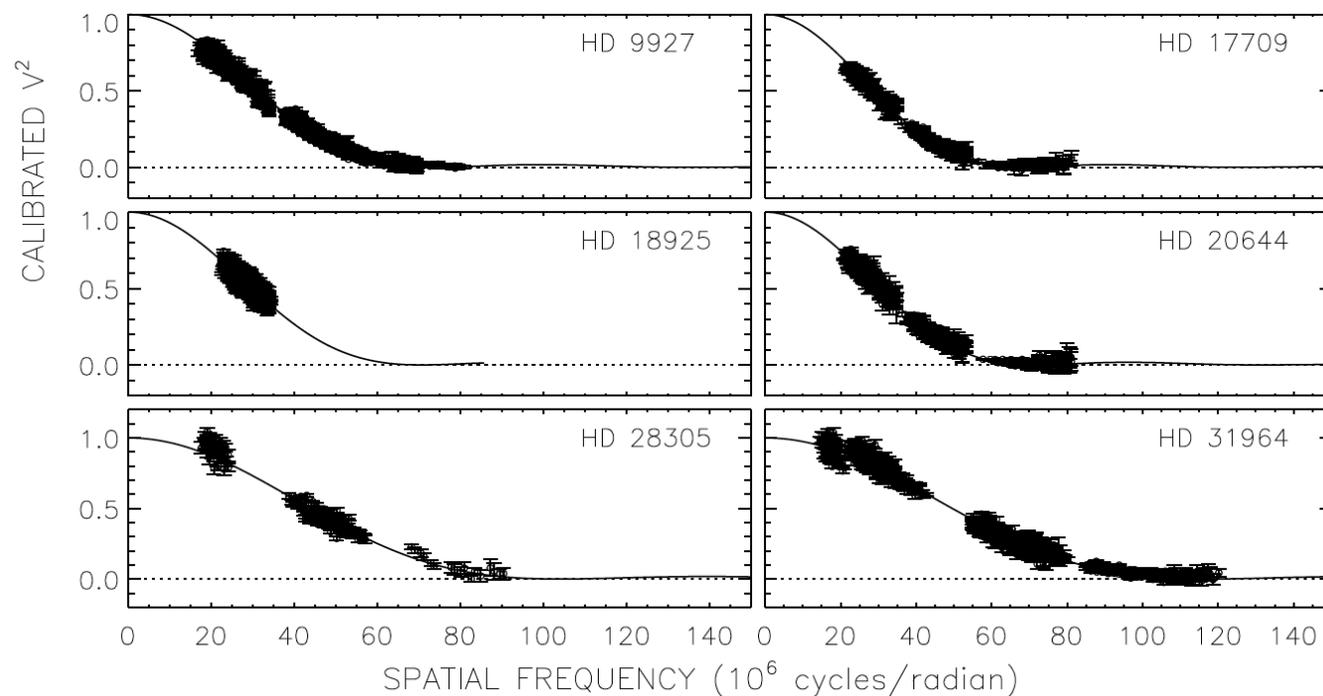
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Diameter measurements with the NPOI



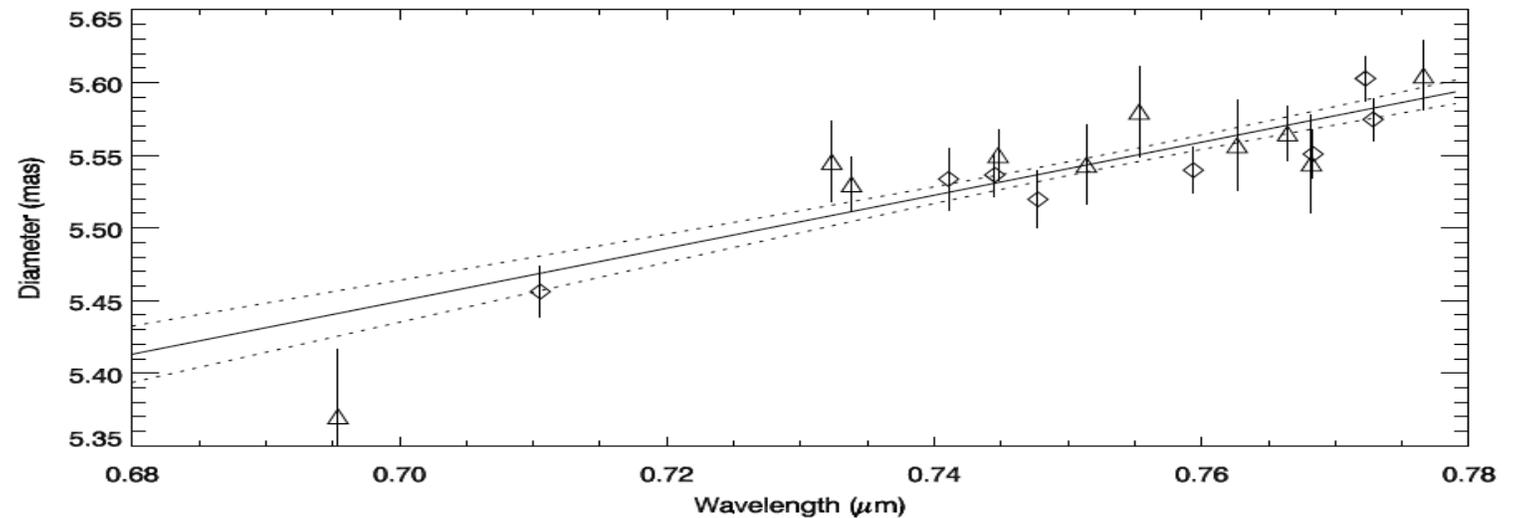
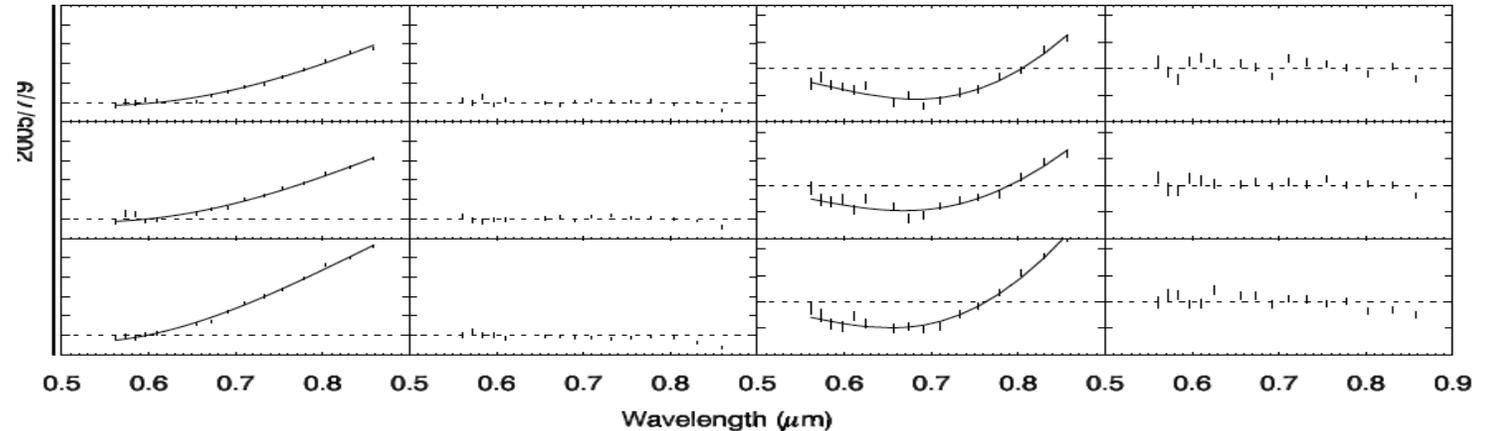
- 87 stars (5 dwarfs, 3 subgiants, 69 giants, 3 bright giants, 7 super giants)
- Determined physical radius, T_{eff} , L_{bol} , luminosity, mass and age



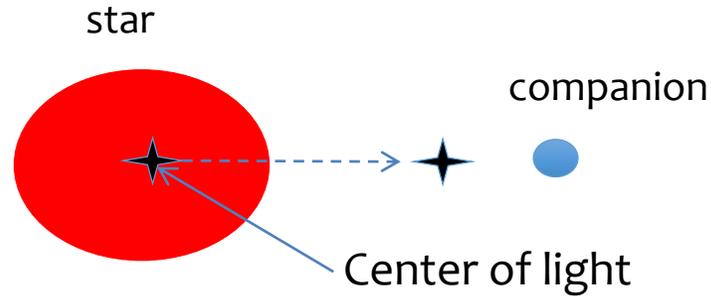
Precise diameter measurements



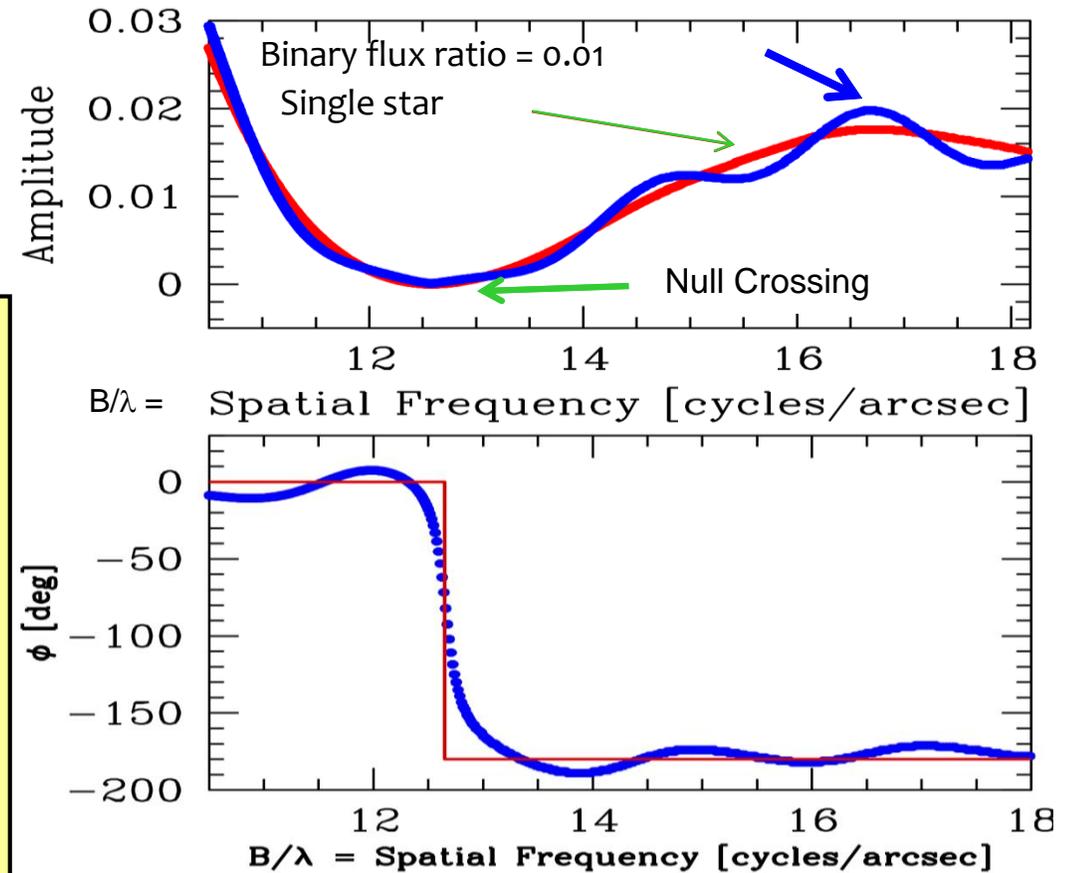
- Use coherent integration to increase SNR and determine the null crossing wavelength (Jorgensen et al. 2012)
- Can determine the null crossing wavelength with a precision better than 1:100 maybe even better than 1:1000, which will be a good tool for precision variability



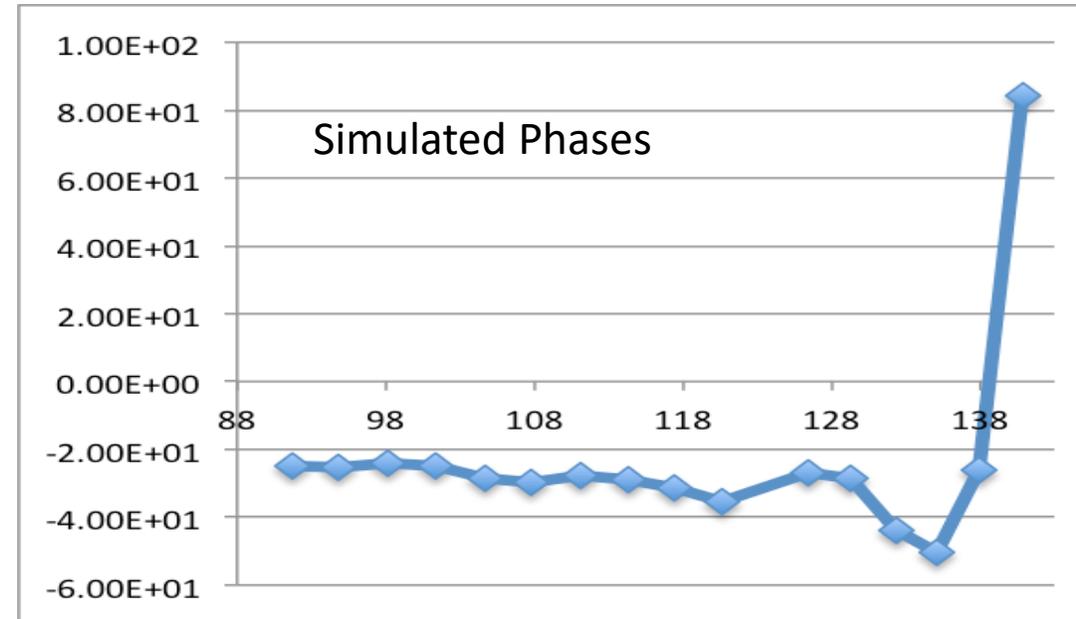
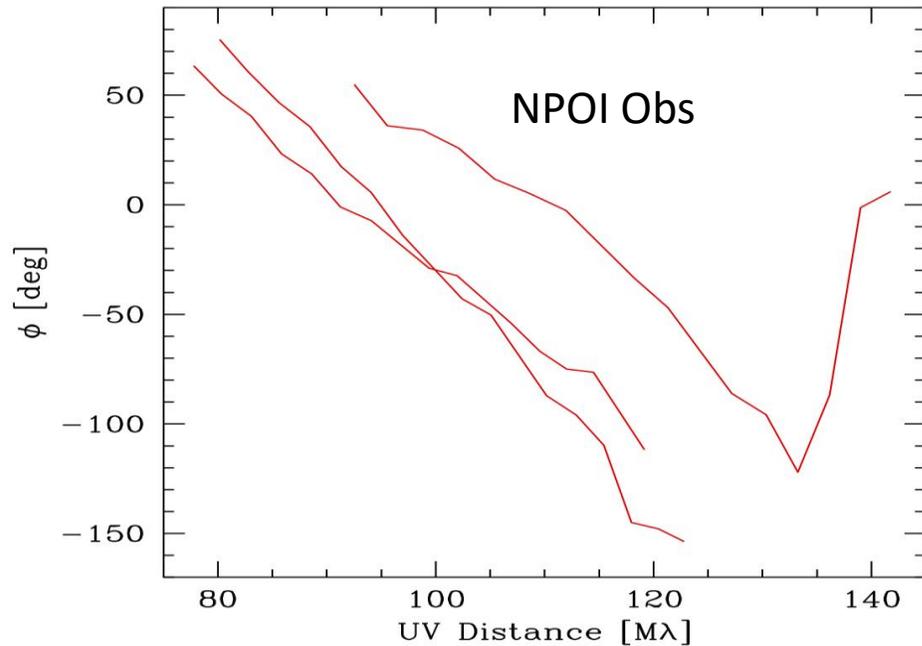
Phase Nulling Interferometry



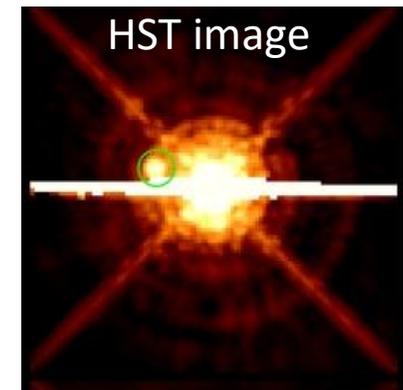
Observing the system around the null crossing, the center of light of the system moves from a position close to the bright star to a position closer to the faint star. The change in the photocenter shows up as strong variations in the phases of the fringes.



Zhao et al. (2010) Duvert et al. (2013)

η Aql

- Classical Cepheid with pulsation period of 7.17 days (Evans et al. 2013)
- Triple stellar system with faint companion
- $V=3.8$ mag and $\theta=1.804$ mas (Baines et al. 2018)
- Observed with baseline lengths of 19 to 79m
- Phase jump is consistent with $\Delta m \sim 5$ mag binary with a separation of 15mas.



Summary



- We recently published a large catalogue of stellar diameters
- We are working towards imaging large targets with the NPOI
- Demonstrated 5 station bootstrapping, reaching the 2nd null
- Working towards precision diameter measurements
- Developing phase nulling technique to detect faint stellar companions