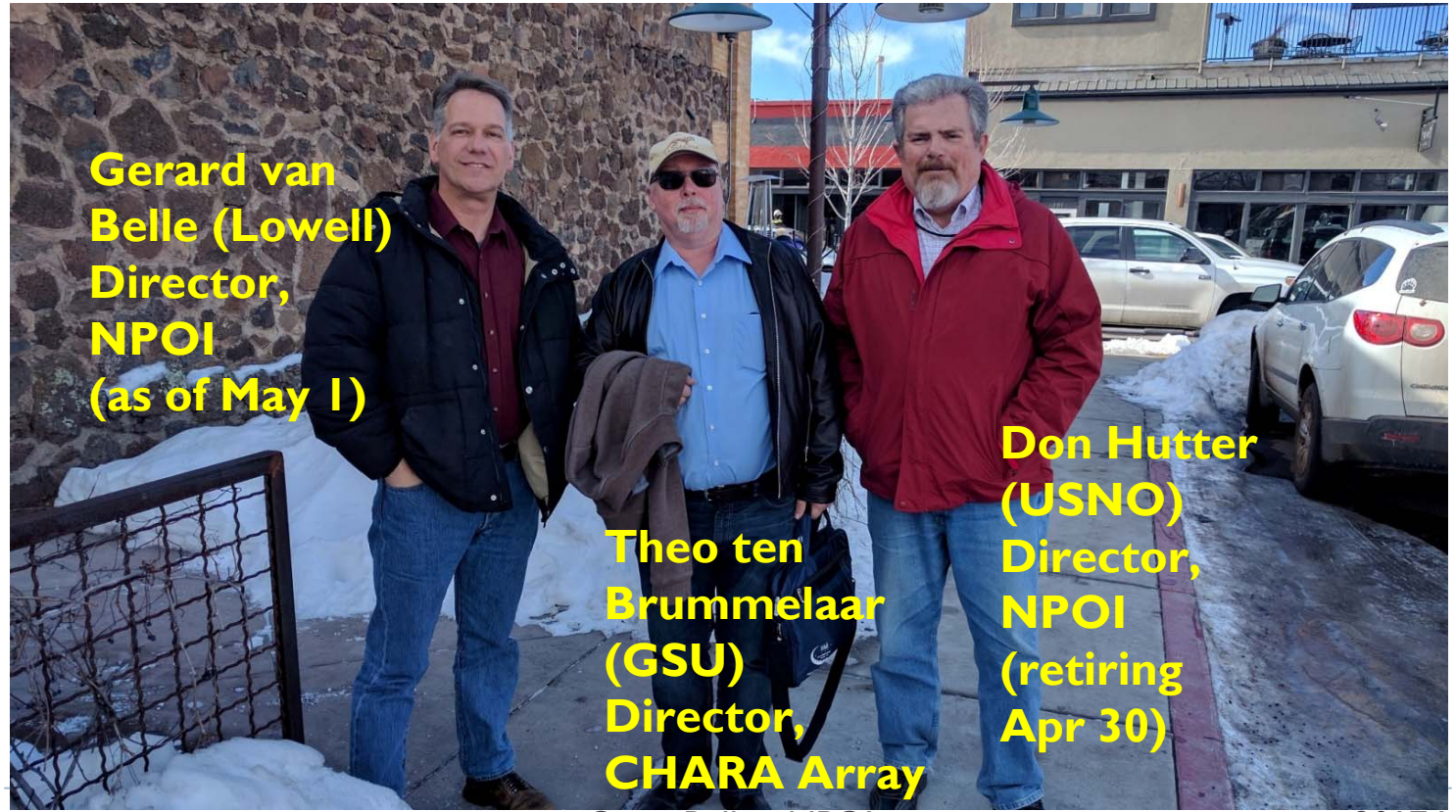


NPOI: Visible Light Operations, Upgrades

Gerard van Belle (Lowell Observatory)

Recent Meeting of Interferometry Minds

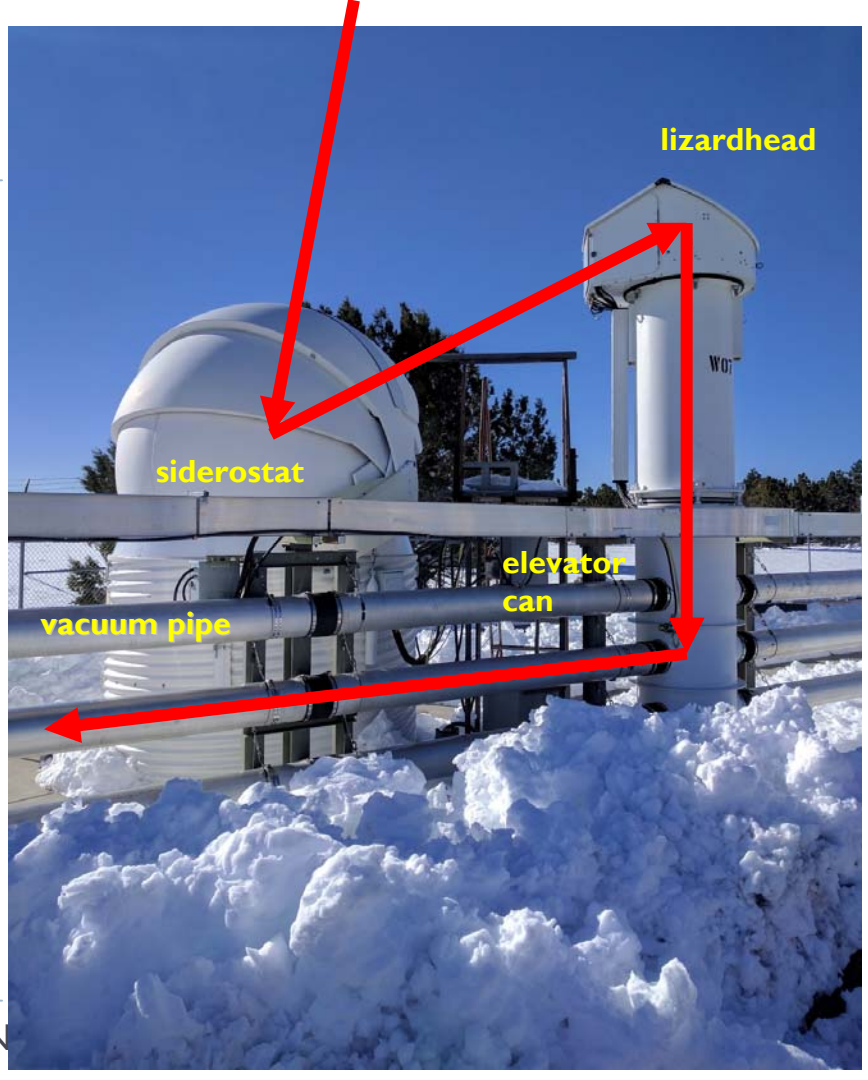


Funded Upgrade: Palantir

- $3.26M project to add 3×1.0-m CDK1000 telescopes to NPOI
- Supported by the NRL to Lowell Observatory (PI: G. van Belle)
- A Quenyan (Elvish) word meaning ‘far-seeing’
  - “Precision Array of Large Aperture New Telescopes for Image Reconstruction”

Infrastructure Reuse

- Vacuum feed system
  - Up to 3 beams per arm
  - Combinations of 6 beams selectable at array center
- Significant facility infrastructure investment
  - Elevator cans, lizard heads, vacuum beam pipes, foundations
- Rule of thumb: 1 λ of wavefront distortion for every 5-10m of air propagation *in a lab setting*

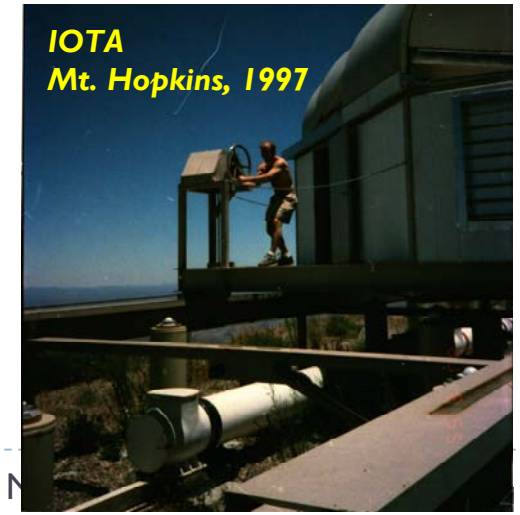


Large Apertures for NPOI

- New 1.0 m model (CDK1000) from PlaneWave Instruments
  - Robust, turnkey operations
  - CDK700 proven with MINERVA and other projects
  - Coudé train to be added to unmodified telescope
  - Breadboard for AO
- 70× increase in collecting area: Δm of up to +4.5mag

Large Apertures: Rapid Relocation

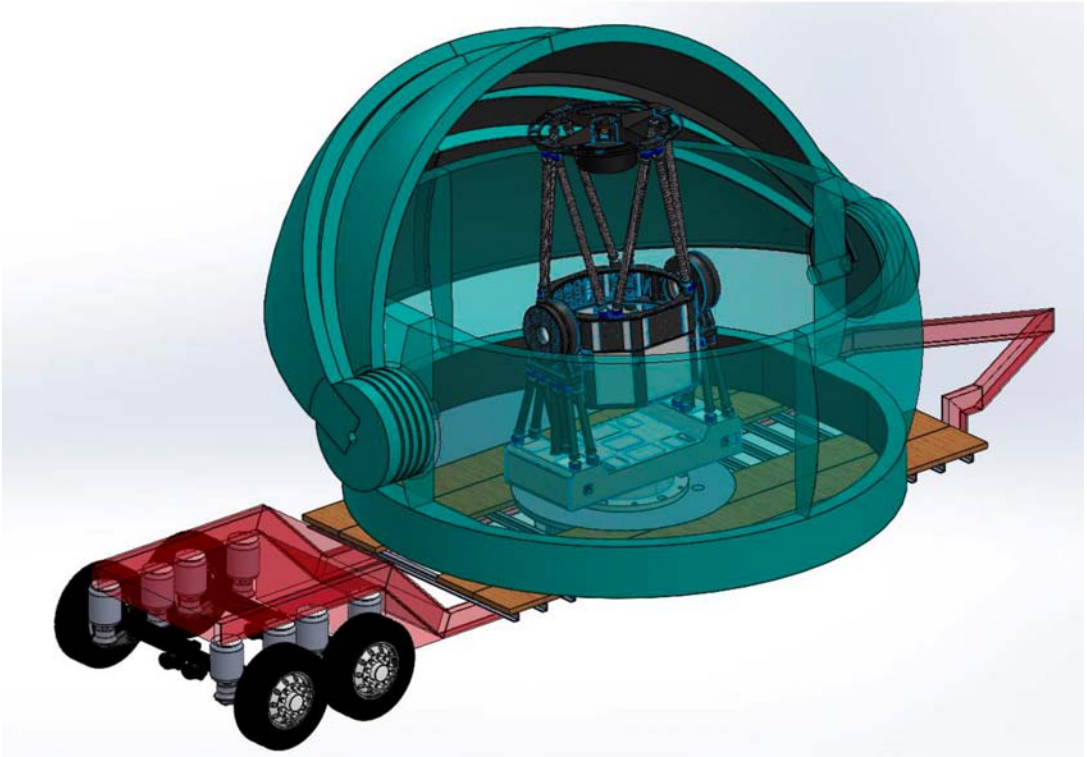
- Apertures will be easily relocatable throughout site
  - Enables 'compact' (~8m baselines)
  - Enables longest (~432m) baselines
  - Daytime repositioning
- Simple yet effective technology
  - 'Horse trailers'
  - Large kinematic pads
  - Proven at IOTA, VLTI



VLTI
Paranal, ca. 2010

Implementation at NPOI

- Current strawman design
- Flatbed trailer
- Standard 16' AstroHaven dome
- Telescope lifted by trailer for relocation
- On-station, telescope isolation from trailer on kinematic legs / piers

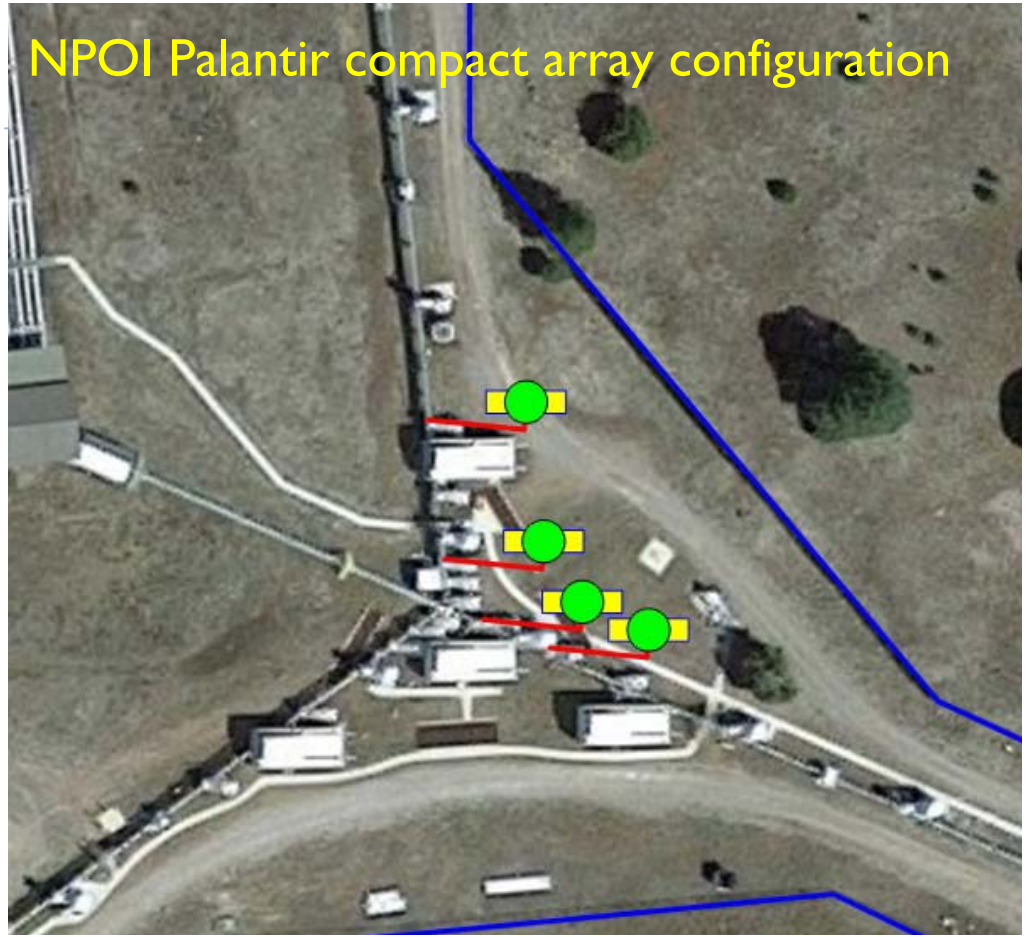


Other Large Apertures

- Lightweight 1.4-m carbon fiber reinforced plastic
  - Remain under development at CMA
- 1.8-m Keck 'outrigger' telescopes
  - No longer available for NPOI

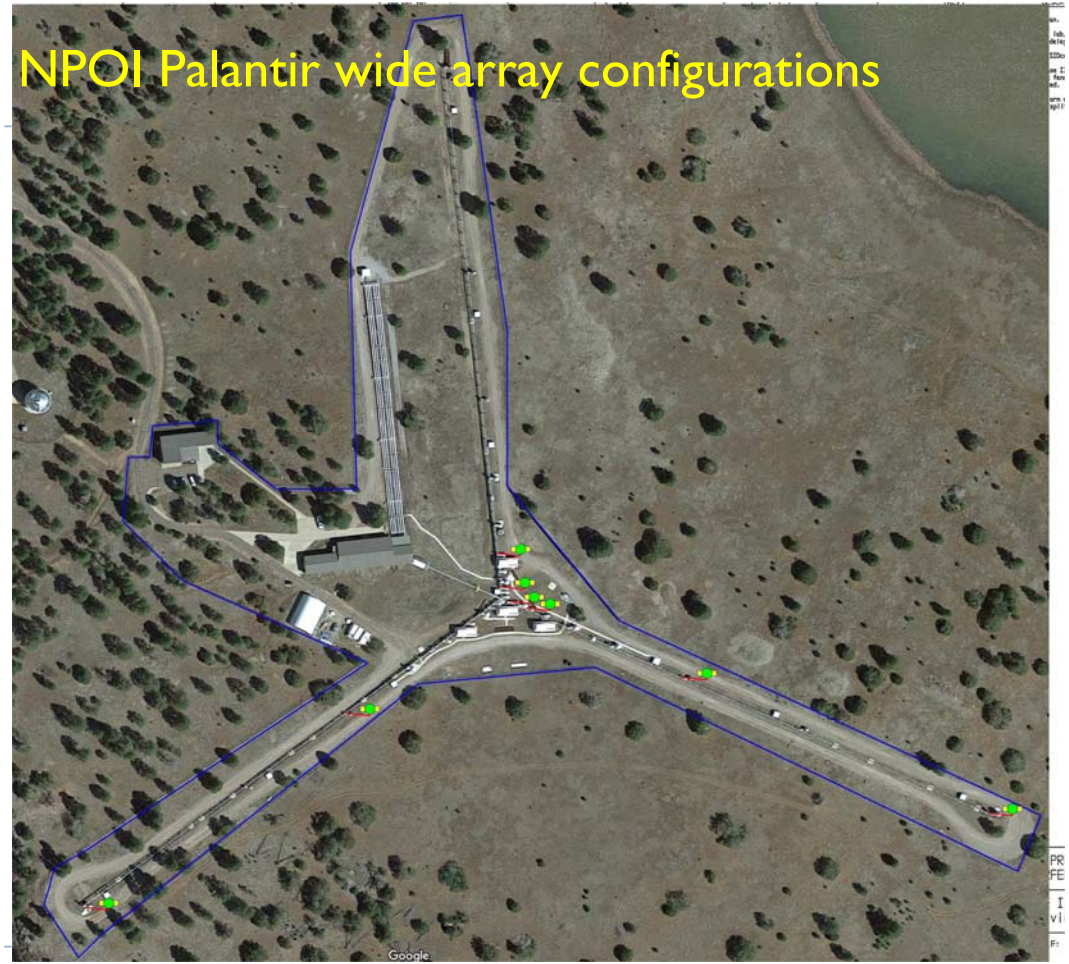
Initial Layout (I)

- Compact array
  - Observing large (~50mas) objects
  - Roughly 8-32m baselines
- Medium, wide array
  - Observations of ~0.25mas objects
  - Baselines at 100, 200, 430m



Initial Layout (II)

- Wide array
  - 432m will be longest optical baseline in the world
- December 2017 delivery for 3×CDK1000s



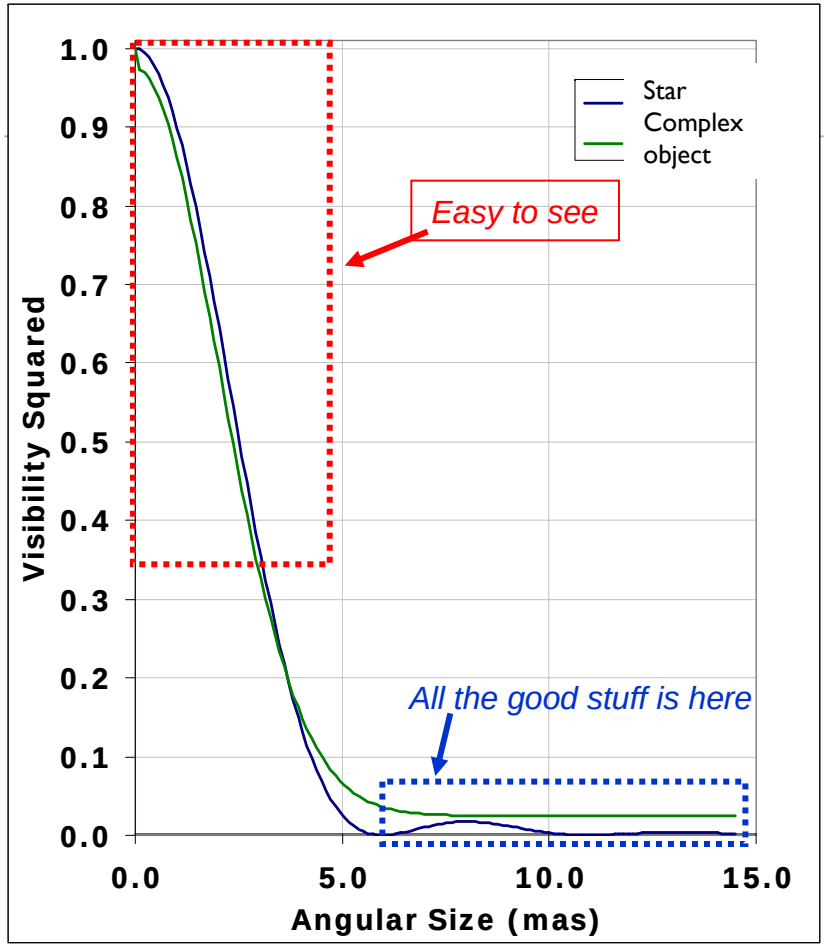
The Other Problem

- Two kinds of fringes
  - Those that are easy to see
  - Those that are interesting
- Signal-to-noise goes as NV^2

- Mozurkewich's law:

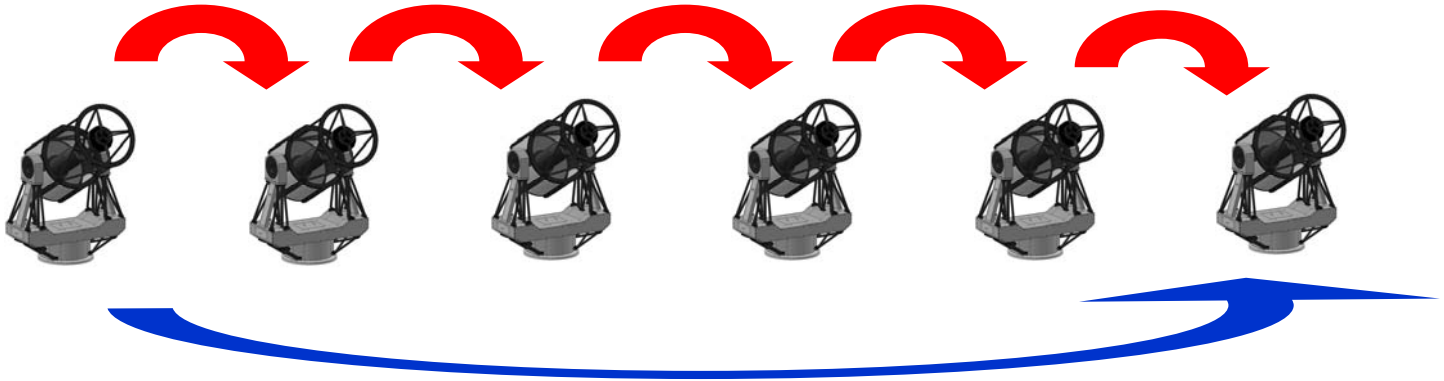
"Determine which fringes are easy to see, and declare they are therefore interesting"

→ *unfortunately does not apply here*



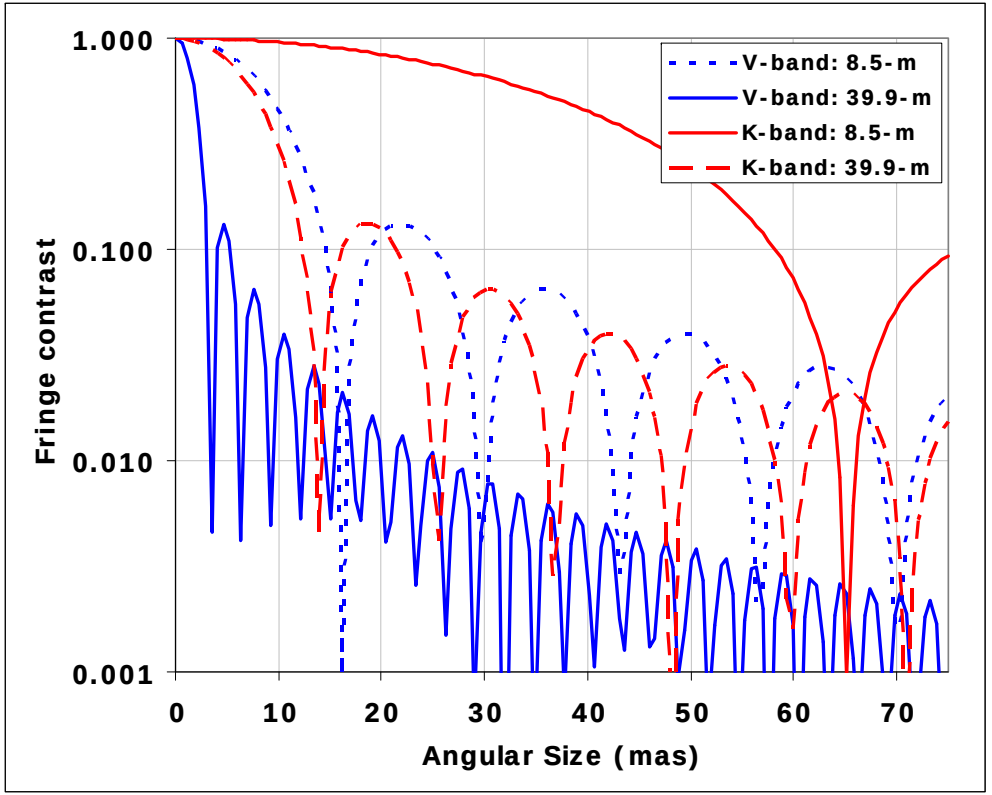
Challenge: How to Collect Interesting Fringes?

- Solution: Wavelength-Baseline Bootstrapping
  - Track in the near-infrared with short baselines
  - Image in the visible with medium, long baselines
- *Also* takes advantage of the very red color of targets



Wavelength-Baseline Bootstrapping

- Tech demo to use real NPOI configuration
  - Longest 'short' baseline is ~8m
  - Longest possible baseline is 39.9m (with 6 stations)
- **Challenge**: tracking well enough in near-IR
  - SNR~50-100 @ K, short baselines
  - For SNR ~3 @ V, long baseline

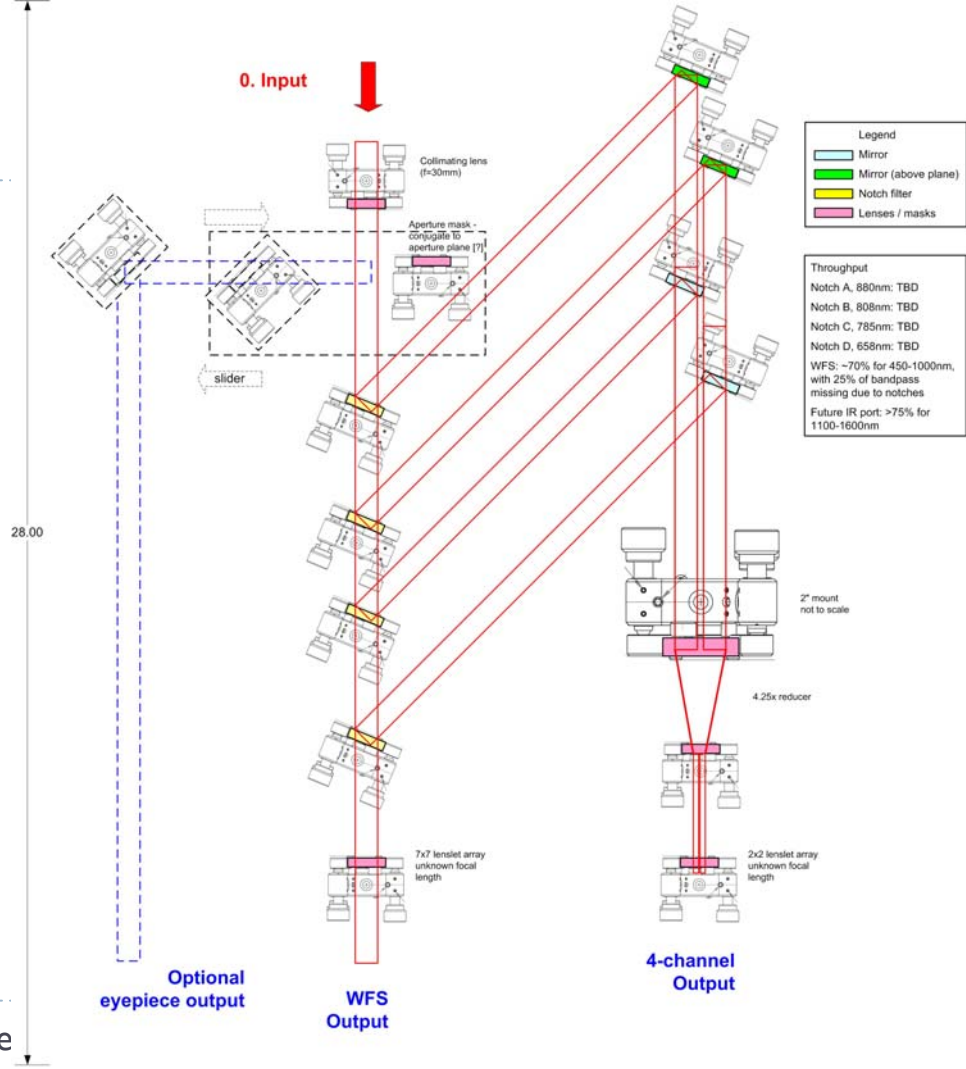


DCT Speckle Imaging

- Speckle imaging
  - Recovers full diffraction-limited resolution of Lowell's 4.3-m Discovery Channel Telescope
  - $\lambda/D \approx 25$mas
  - Sensitive: limiting $m_V \approx 15.5$
  - Visitor instrument: Dual-channel Stellar Speckle Imager (DSSI)
    - Also goes to WIYN, Gemini-N, Gemini-S
- Stellar sources: binaries
  - First DCT paper: Horch et al. 2015
  - ~1,100 sources over ~10 nights
    - Great telescope pointing

DSSI upgrade

- Dual-channel to quad-channel with wave-front sensing: QWSSI
- Includes option for aperture mask
- Provides low-order spatial frequency information to be combined with NPOI
- Leverages off-the-shelf filters
- Simultaneous wavefront sensing
  - Demonstrated at Maui AEOS
  - Significantly improved SNR, contrast ratios



Questions?

Paul Signac, "Port St. Tropez", 1899