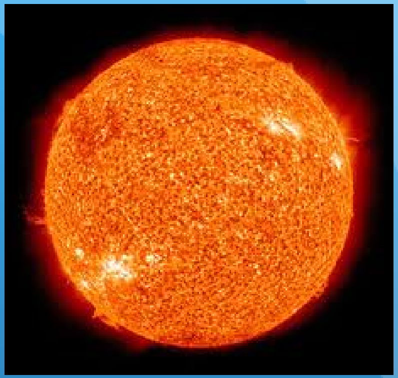
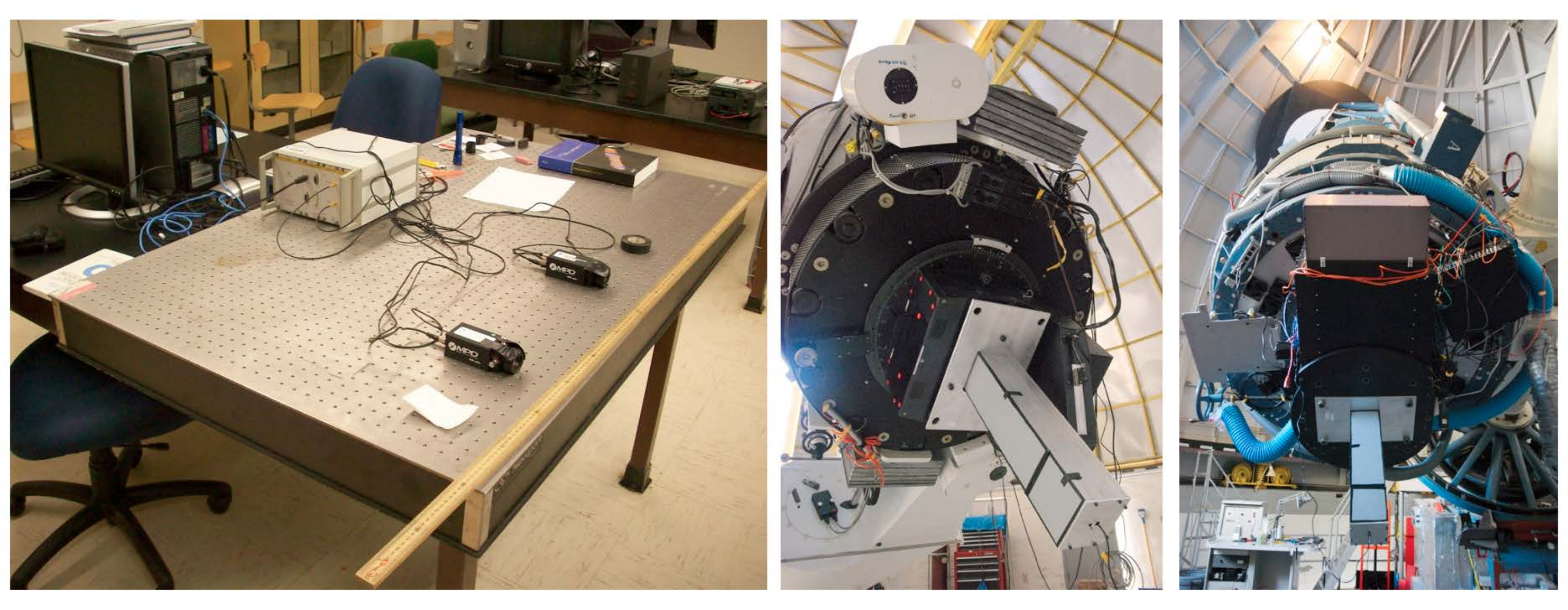
Intensity Interferometry at Lowell Observatory

WORKING TOWARD THE INTERFEROMETER IN A SUITCASE



Elliott Horch,
Southern Connecticut State University

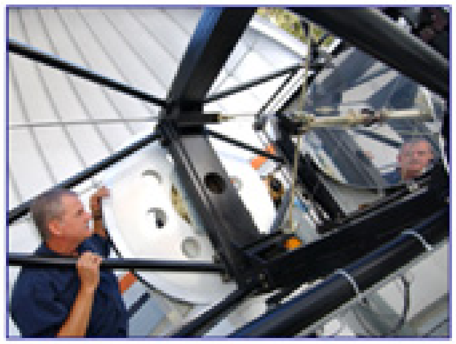


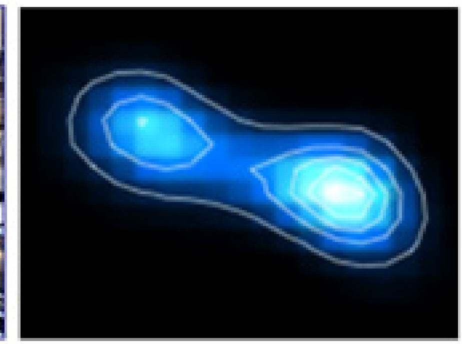
Origins of Stellar Interferometry

- 1920's: Albert Michelson builds first stellar interferometer by using two sub-apertures of Mt. Wilson 100-inch telescopes.
- Measured several stellar diameters.
- Tried to extend the baseline, but mechanical issues prevented progress.

How Optical Interferometry is Done Today…

Center for High Angular Resolution Astronomy





<u>Light is made to interfere prior to detection.</u>
(Michelson Interferometry).

Higher signal-to-noise, but expensive. Certainly NOT portable.

~300 m baselines. Much Larger? Hmmm…

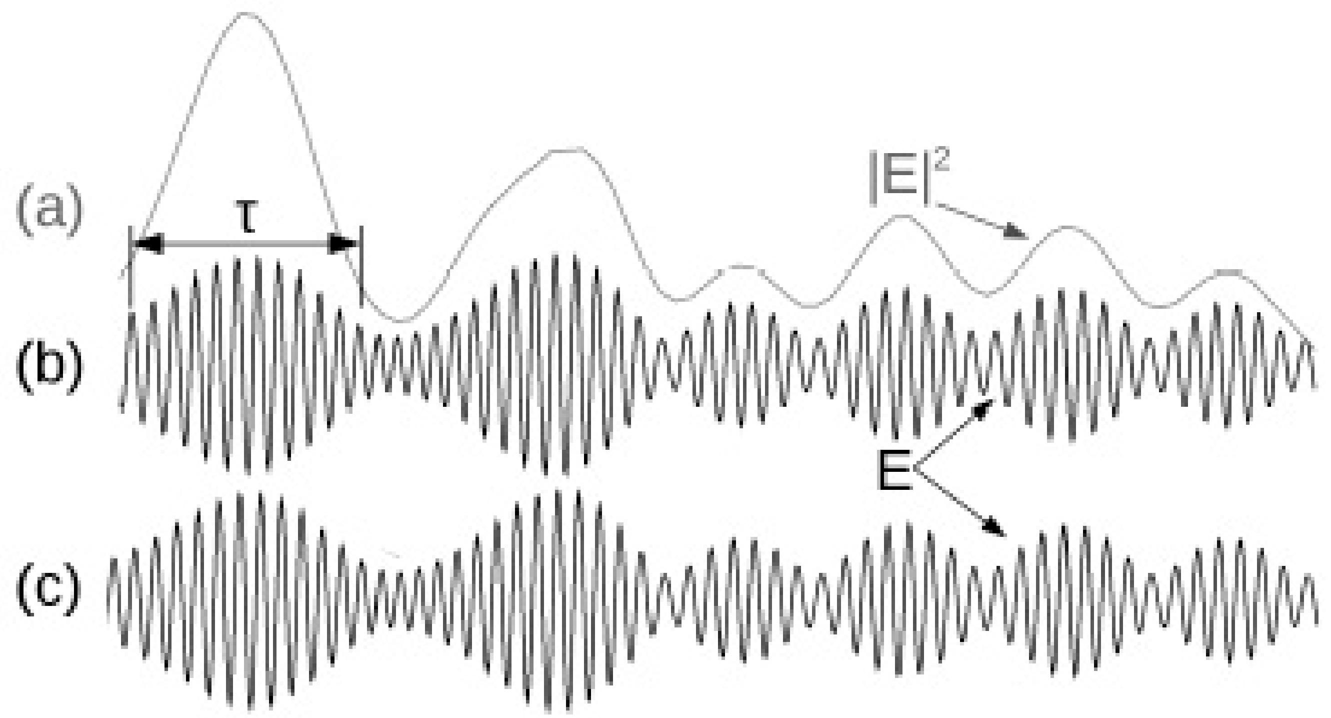
Intensity Interferomety

- There is a weak correlation in the arrival times of photons when viewed by two different detectors. “Wave Noise.”
- Related to beat frequencies, in the most extreme case.
- This effect was used in astronomy in the 1970’s to measure diameters of bright stars.
- One configuration of the two telescopes yields one Fourier component of the image
- (well, $|\gamma|^2$).
- But, huge collectors were needed to detect this weak signal on the photomultiplier tubes of the day.

Sydney University Stellar Interferometer

P.S.: Only two stations, So no imaging!

“Wave Noise”



A lot has changed since 1974!

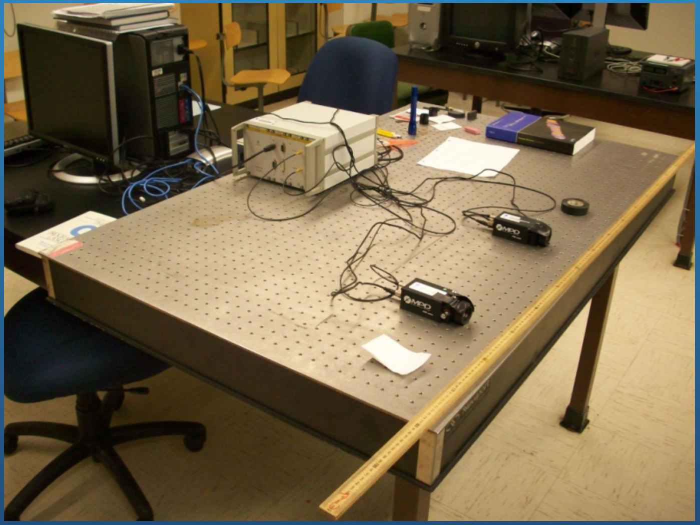
- S/N in Intensity Interferometry depends on telescope size AND speed of electronics.
- Timing capabilities today are about 1000x what they were in the 70's.
- Can achieve the same result today with a much smaller telescope! (Portable Instrument!)

$$\frac{S}{N} = 2.512^{-m} F_0 A \eta |\gamma_{12}^2(B)| \sqrt{\frac{\Delta f T_0}{2}}$$

Intensity Interferometry Revisited

Picoquant Picoharp 300 timing module.

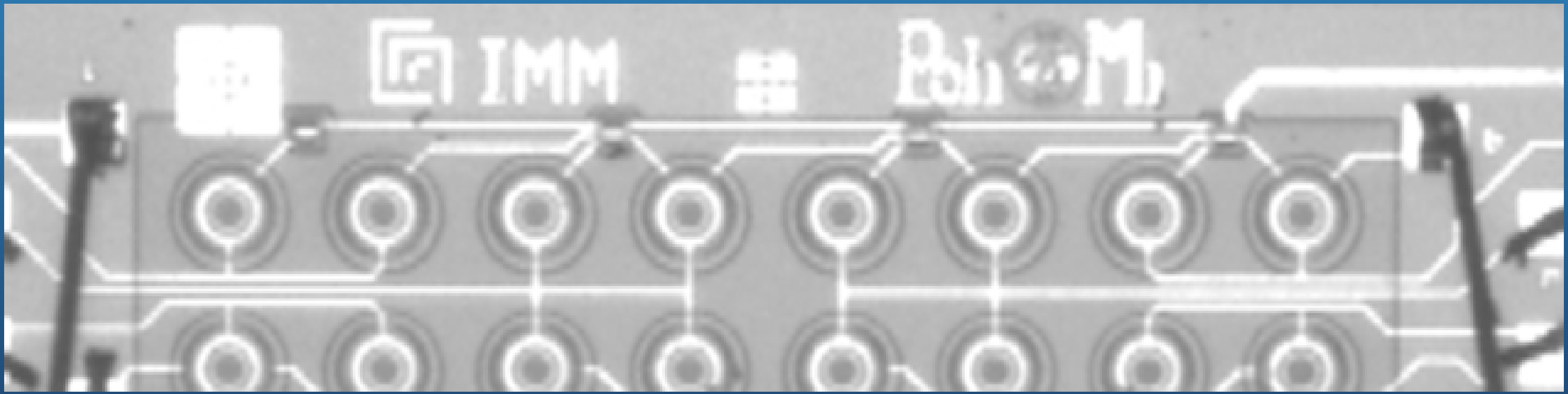
Two SPAD detectors



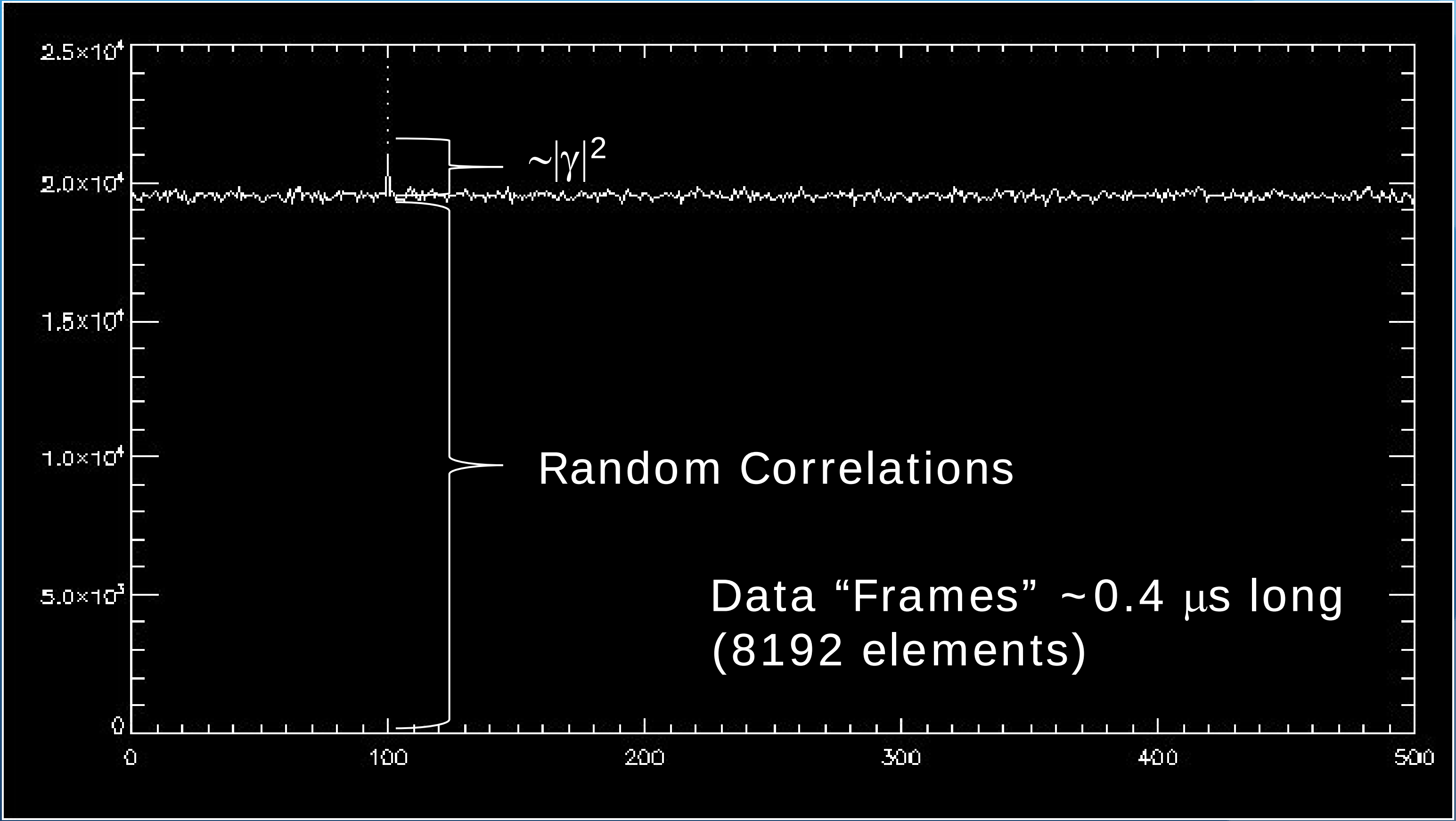
Issues: Small size, dead time.

SPAD Arrays

- Deadtime and small size can be mitigated if you have many SPADs all looking at the same source.
- Development of SPAD arrays is being started, e.g. the SPADlab at Everyphotoncounts.com

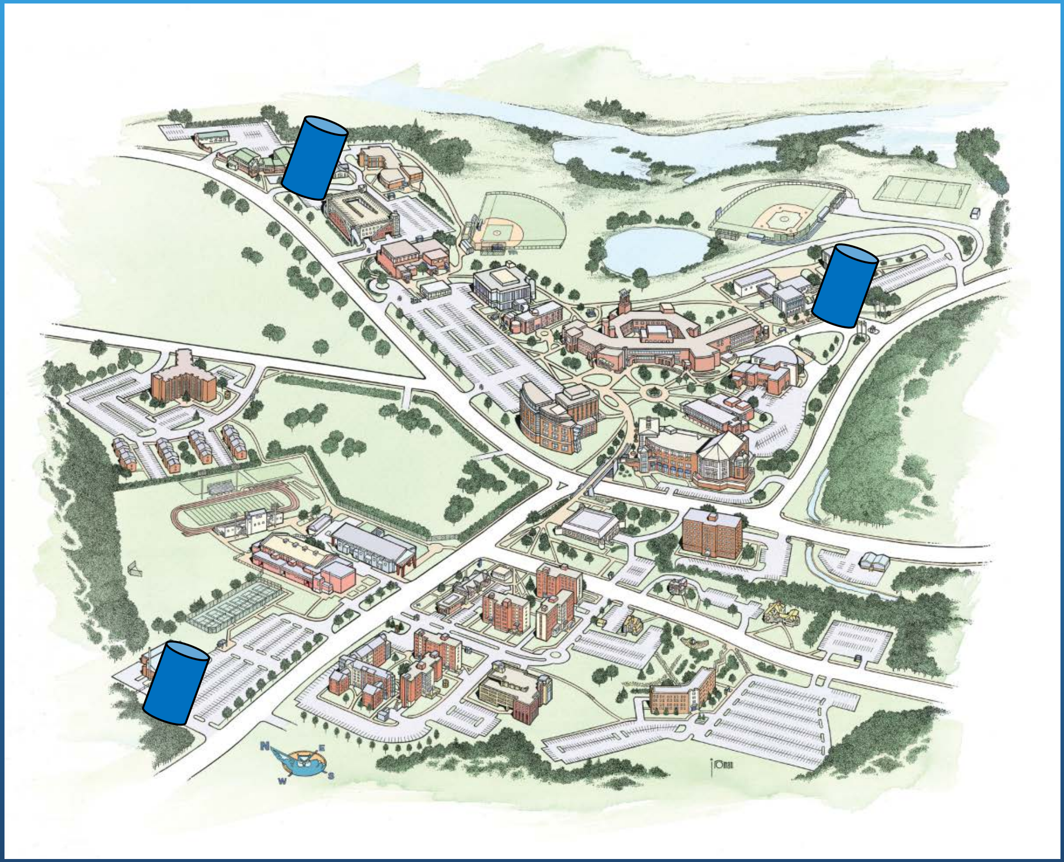


Simulation Data



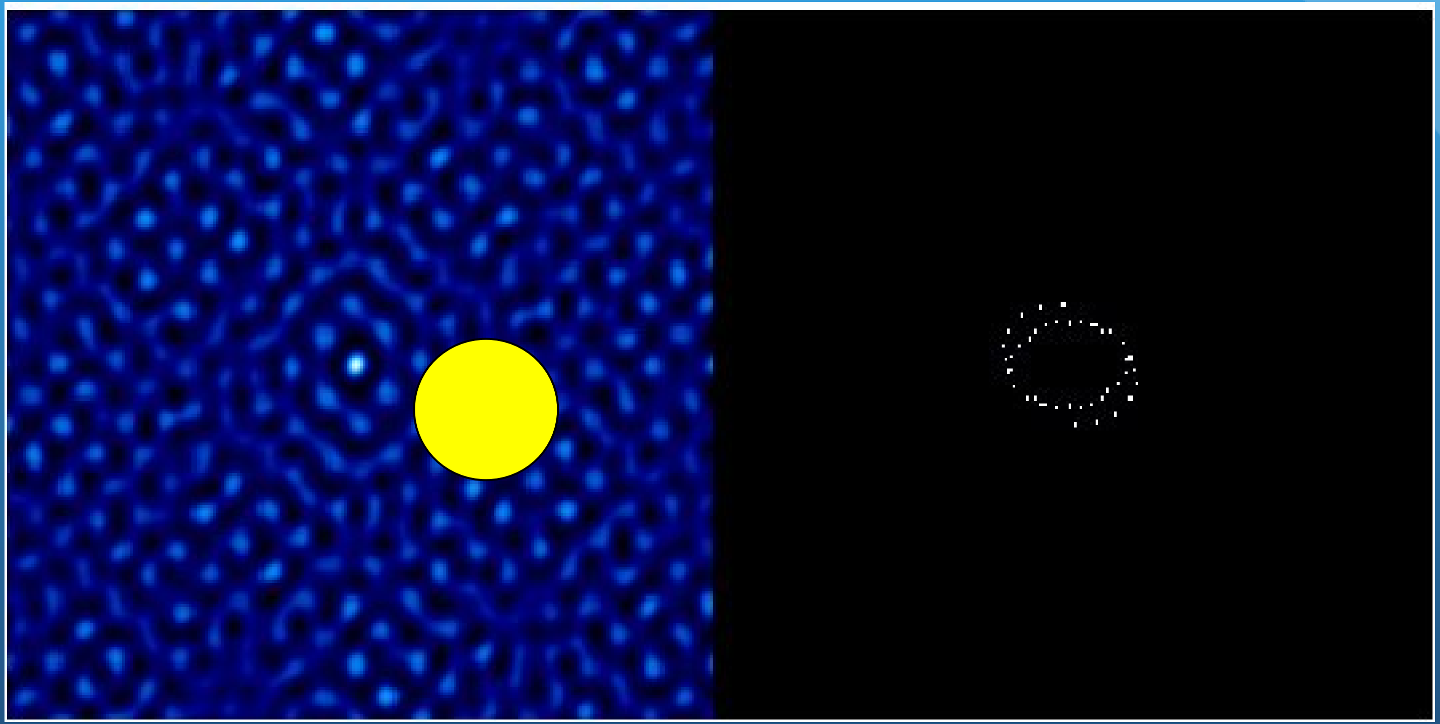
Big Glass is getting cheap!

Three-Station Wireless Interferometer at SCSU



GPS Computer Cards: ~0.5μs synchronization

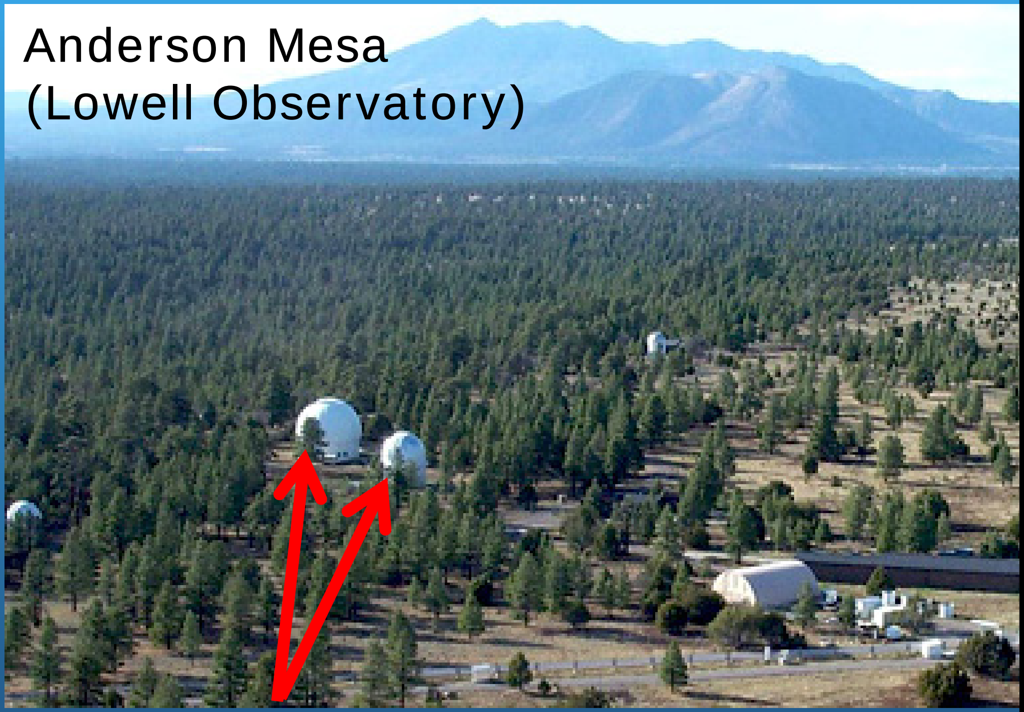
Dirty Beam Simulation

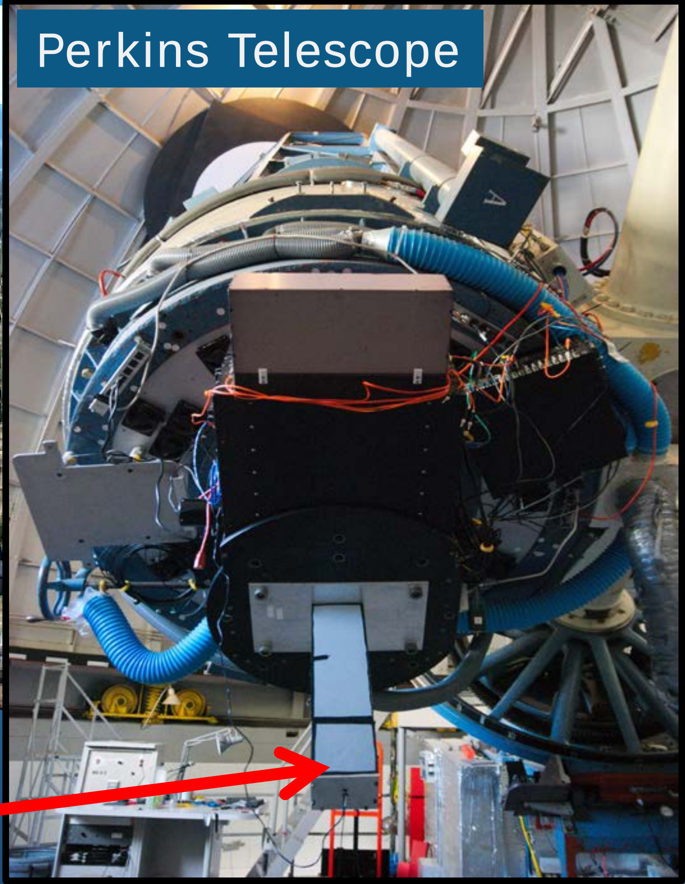


FWHM ~ 0.1 mas

uv-plane coverage
6-hour observation

Truly Portable





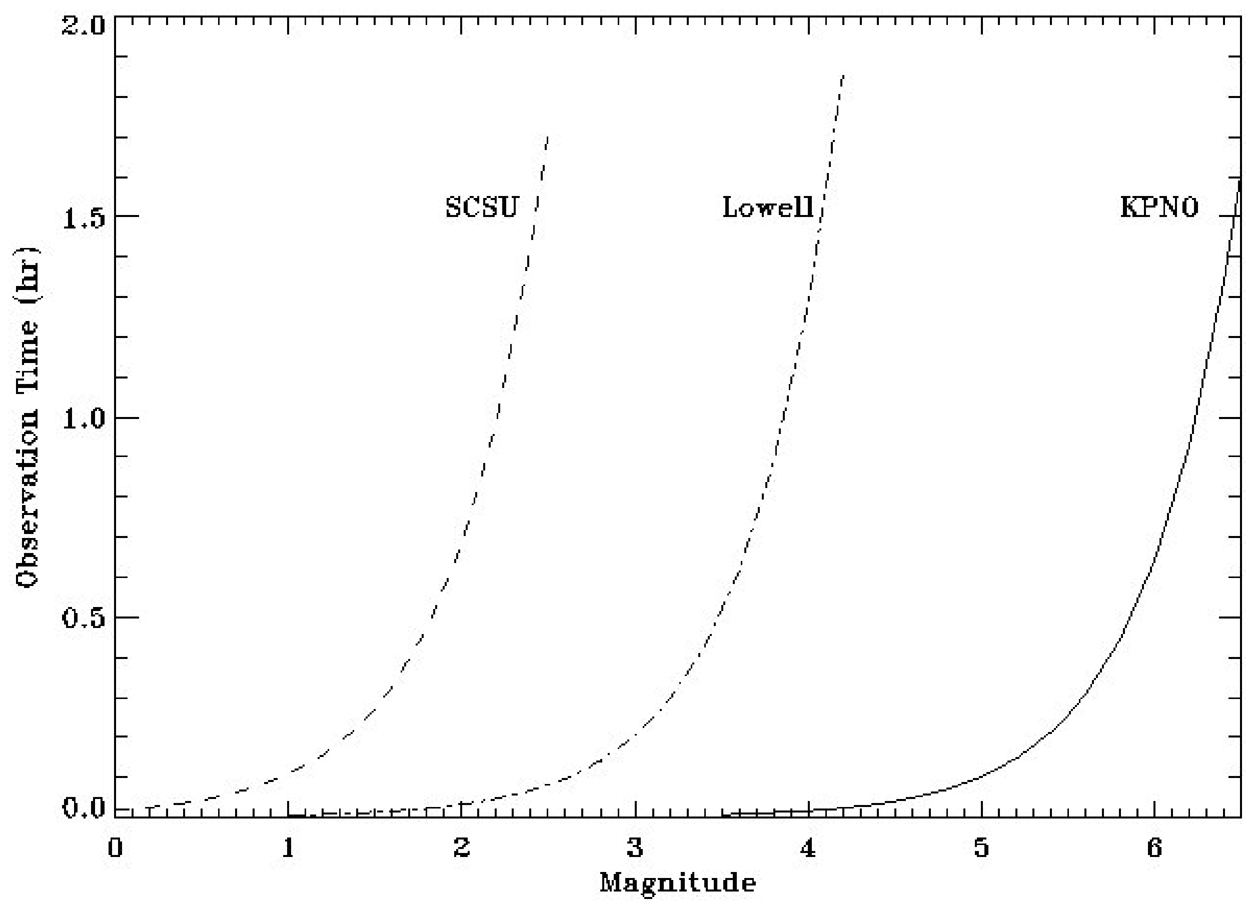
53-m baseline

SPAD

Two runs: Dec 2011 & June 2012
Issues: Focus, Sky Position, Temp.

Kitt Peak: Another Possibility?

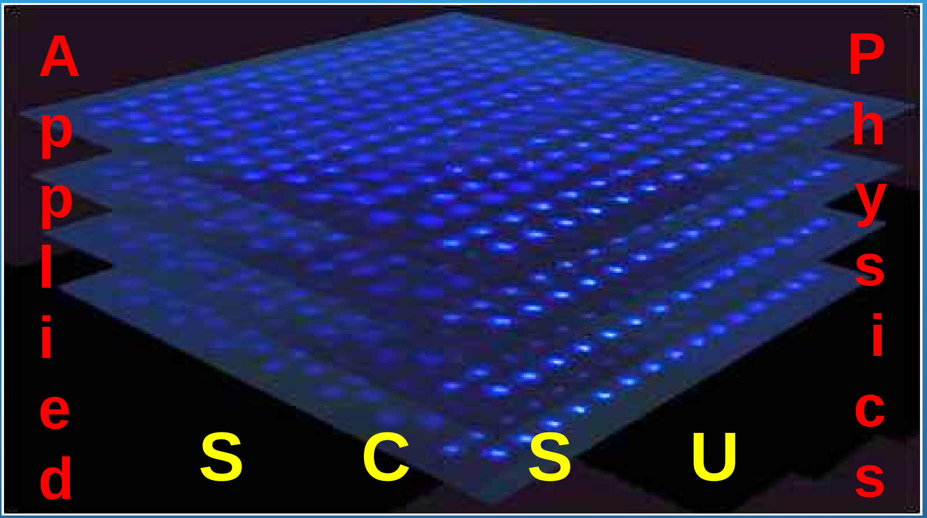
Observation Time



Conclusions

- Intensity Interferometry Opportunity Today
  - We've got great instrumentation for intensity interferometry: SPADs, Picoharp
  - Large Dobsonian Telescopes are affordable for on-campus observing.
  - Need to explore GPS Technology For wireless operation.
  - Take timing correlator and the SPAD detectors to larger telescopes. "Interferometer in a suitcase."
    - Lowell: Already doing this.
    - Kitt Peak: A possibility for the future.
- Science:
  - Imaging close binaries, stellar surfaces
  - Imaging an exoplanet transit? (One fine day…)

Master of Science in Applied Physics



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