Why Build Stellar Interferometers?

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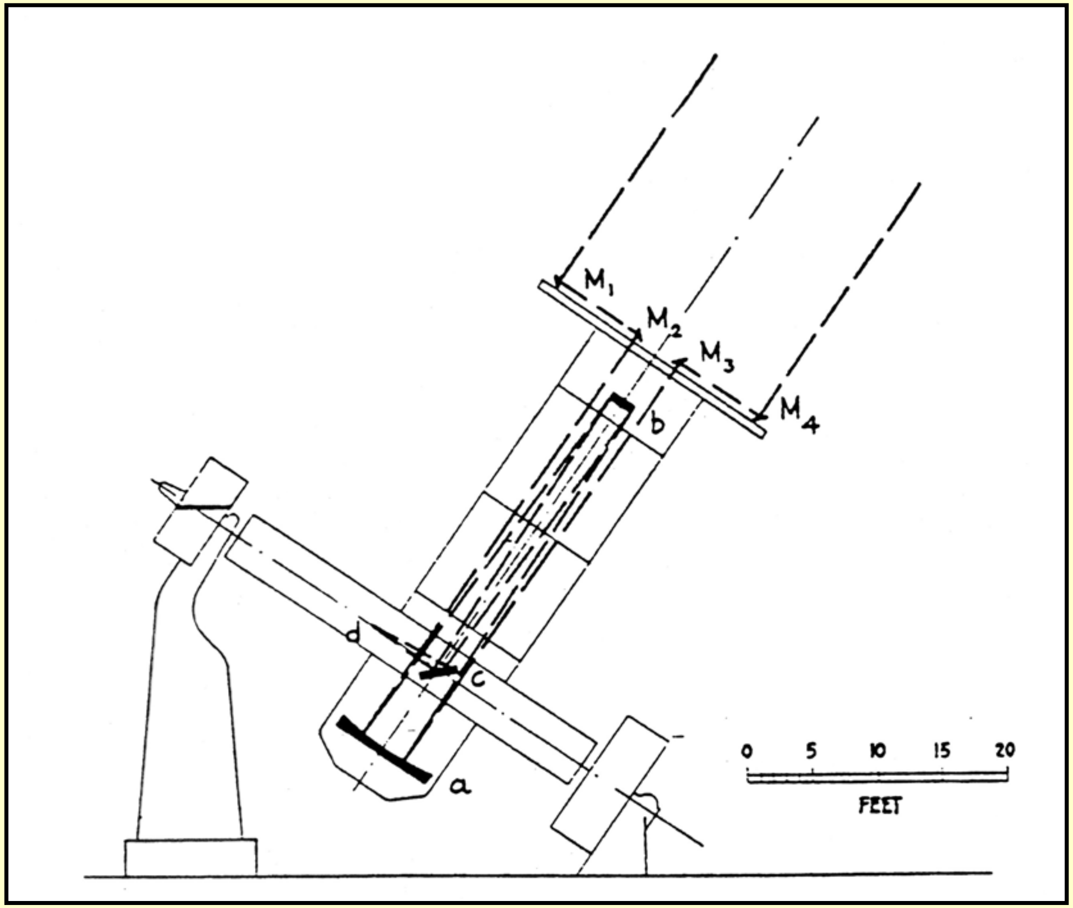
Because they are there!?

Technical Challenge
&
Scientific Opportunity

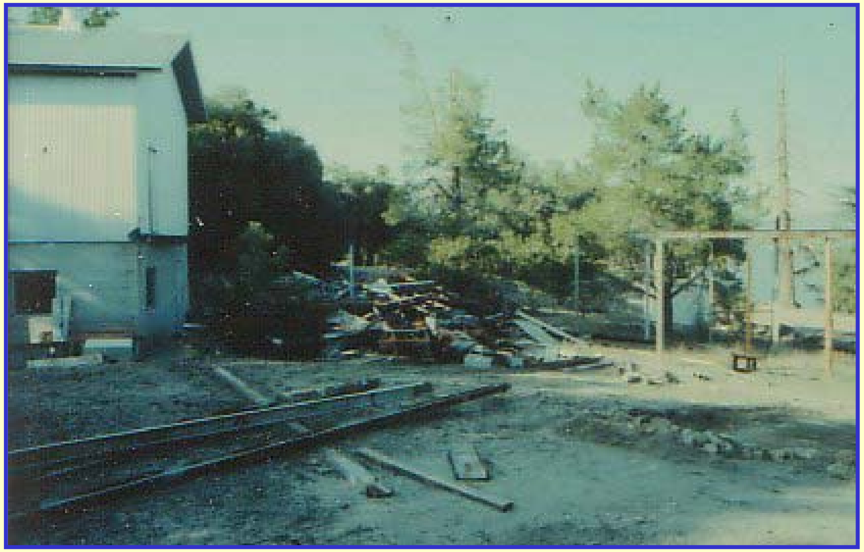
Leveraging Resolution



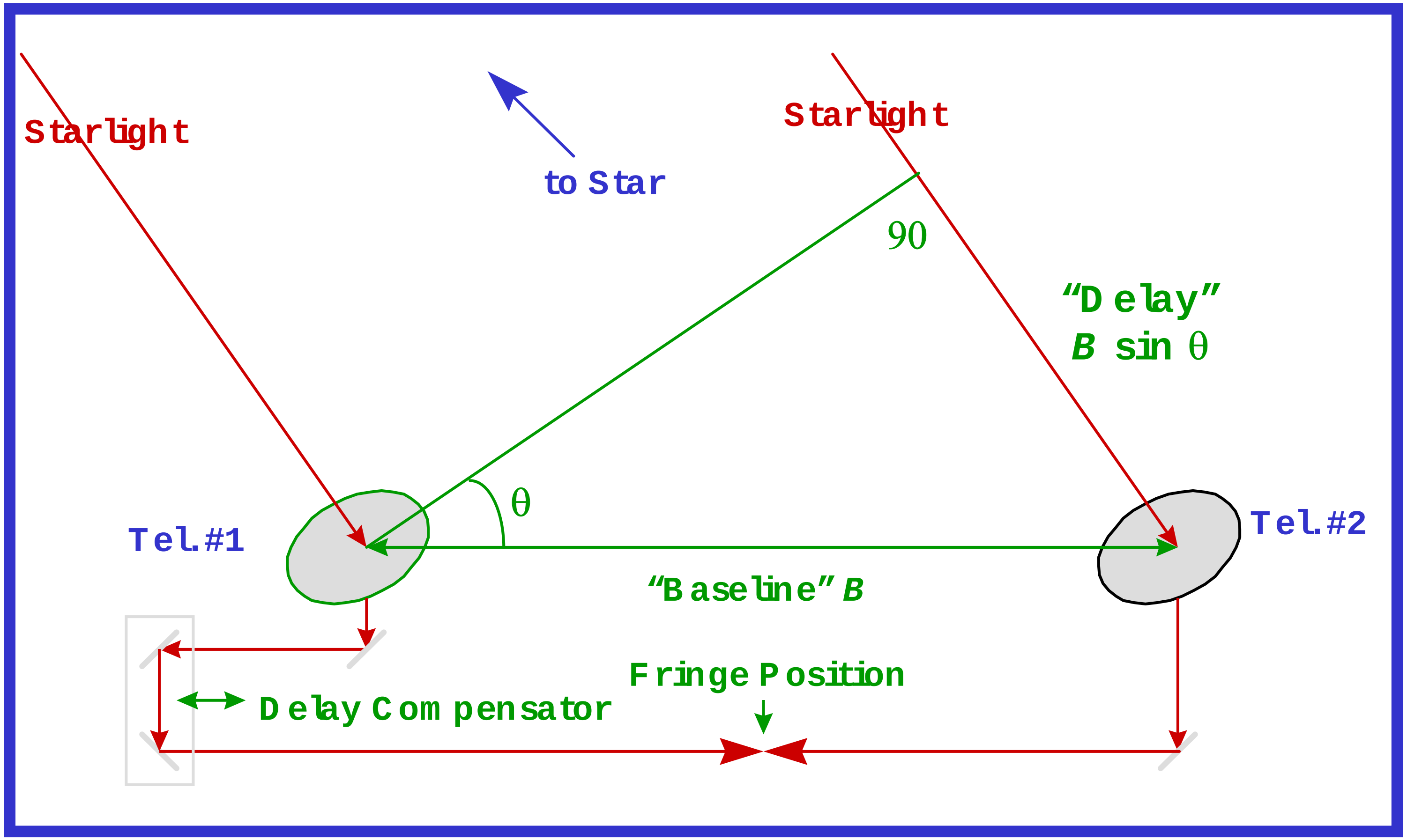
But, This is a Tough Business

Pease's 50-ft Interferometer on Mt. Wilson, c. 1935

50-ft Interferometer site in early 1980's

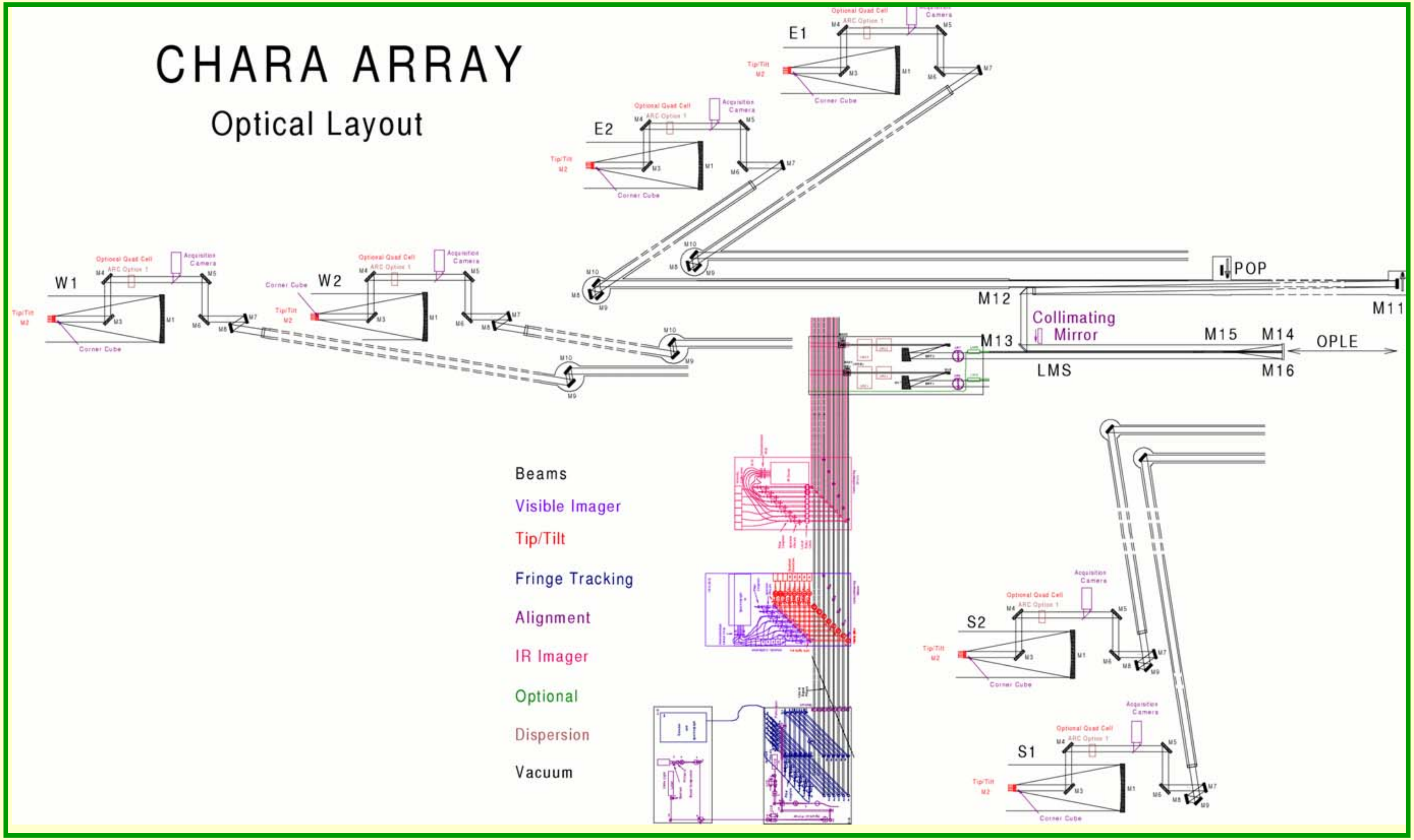


"Simple" Long-Baseline Interferometer



The Real Thing

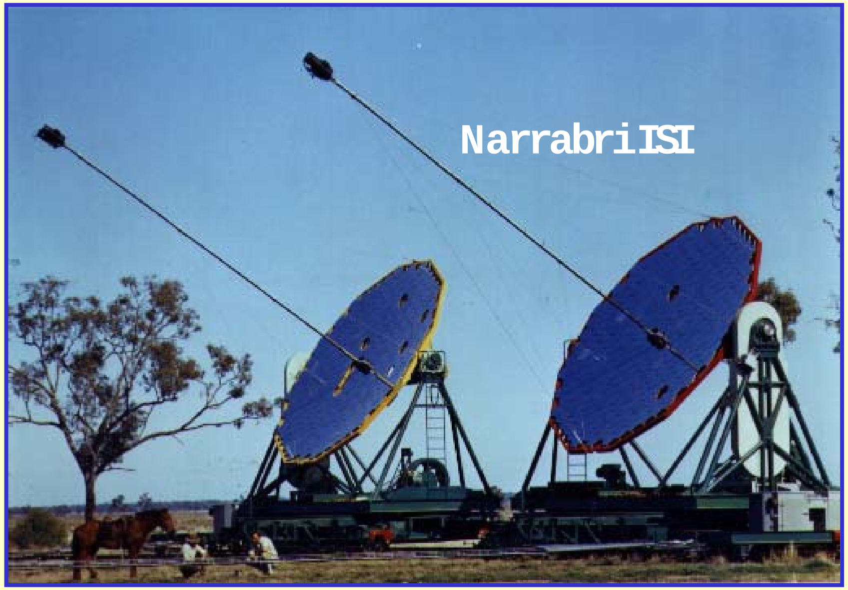
Could Throughput be an Issue Here?



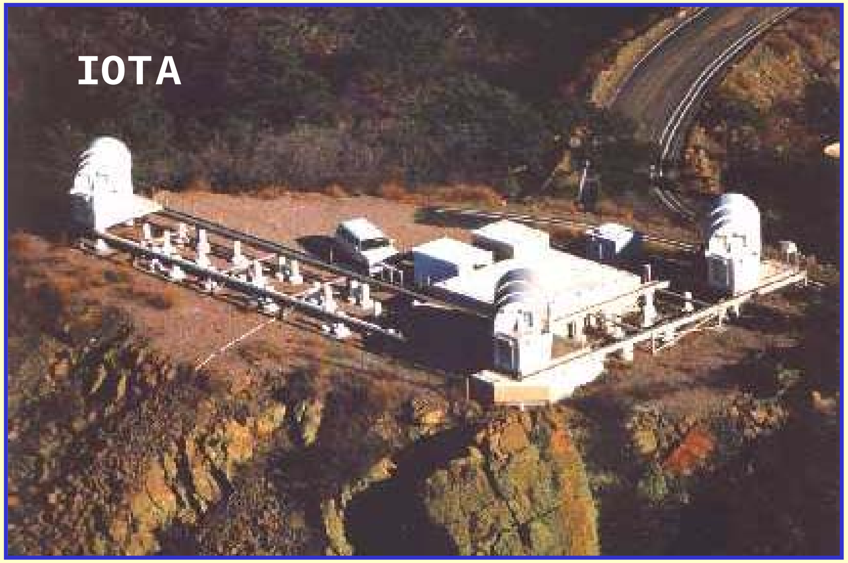
Currently Operating Instruments

Name	Institution	Site	Number of Elements	Element Aperture (cm)	Max. Baseline (m)	Operating Wavelength (microns)	Operating Status
GI2T	CERGA	Calern	2	150	35	0.4 - 0.8 & >1.2	since 1985
COAST	Cambridge U	Cambridge	4	40	100	0.4 - 0.95 & 2.2	since 1991
SUSI	Sydney U	Narrabri	13	14	640	0.4 - 0.66	since 1991
IOTA	CfA	Mt. Hopkins	3	45	38	0.5 - 2.2	since 1993
ISI	Berkeley U	Mt. Wilson	3	165	30(+)	10	since 1990
NPOI	USNO/NRL	Anderson Mesa	6	60	435	0.45 - 0.85	since 1995
PTI	JPL/Caltech	Mt. Palomar	2	40	110	1.5 - 2.4	since 1995
CHARA	Georgia St. U	Mt. Wilson	6	100	350	0.45 - 2.4	since 1999
Keck	CARA	Mauna Kea	2(4)	1,000(150)	165	2.2 - 10	fringes 03/01
VLTI	ESO	Cerro Paranal	4(3)	840(250)	200	0.45-12	fringes 03/01

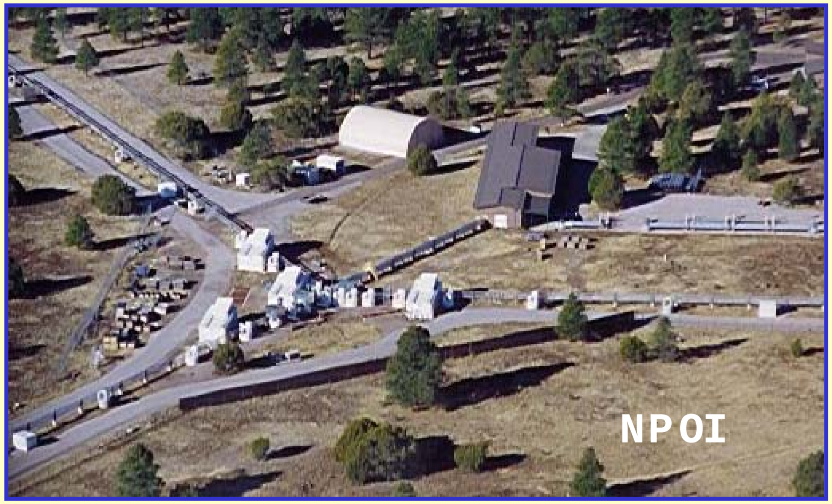
Postcards from the Fringe I.



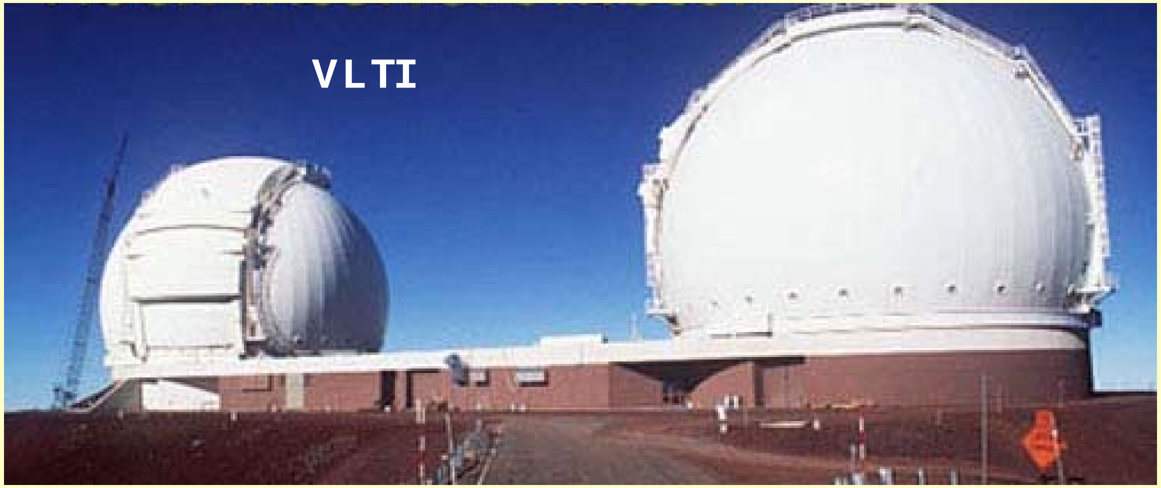
Postcards from the Fringe II.



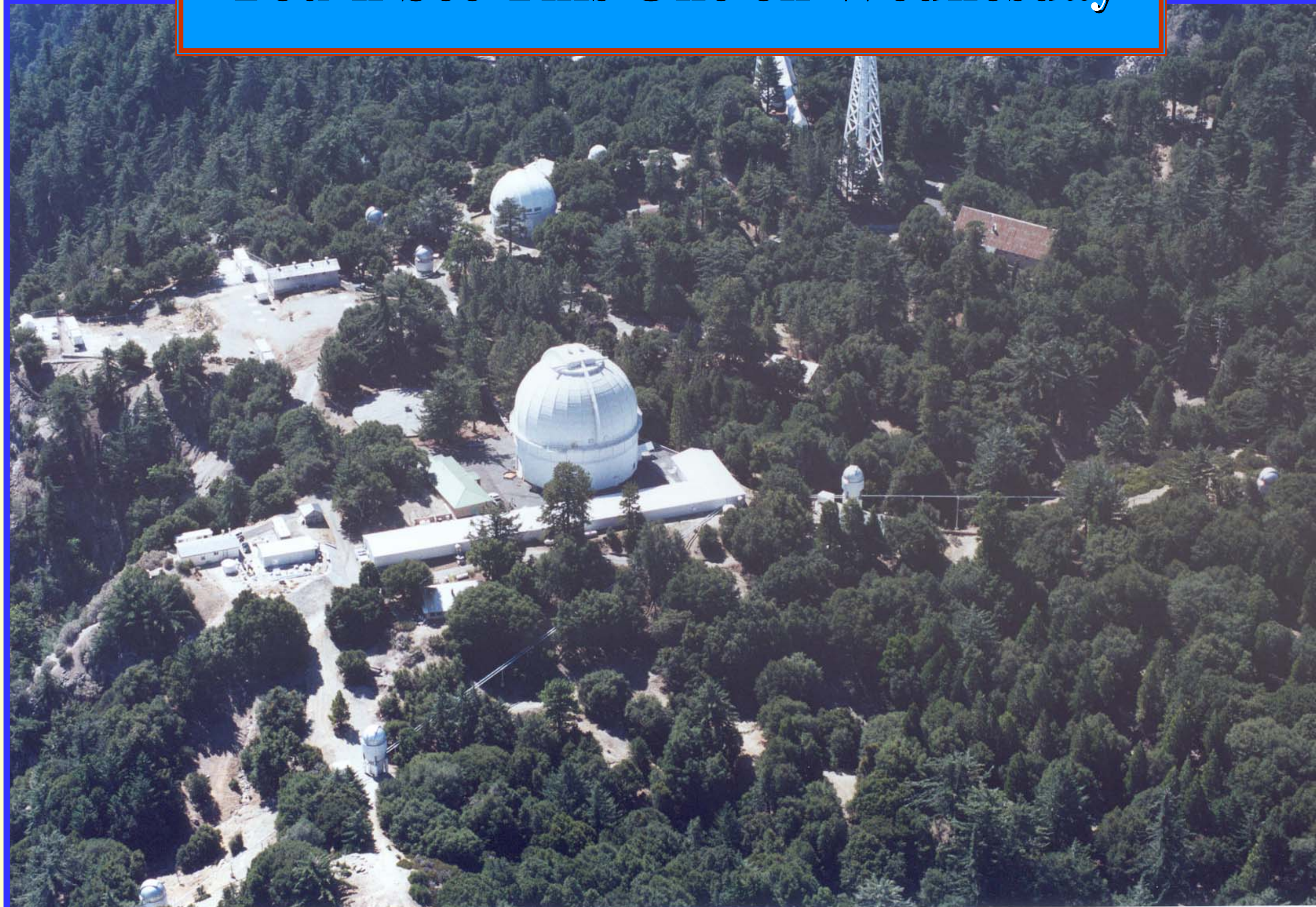
Postcards from the Fringe III.



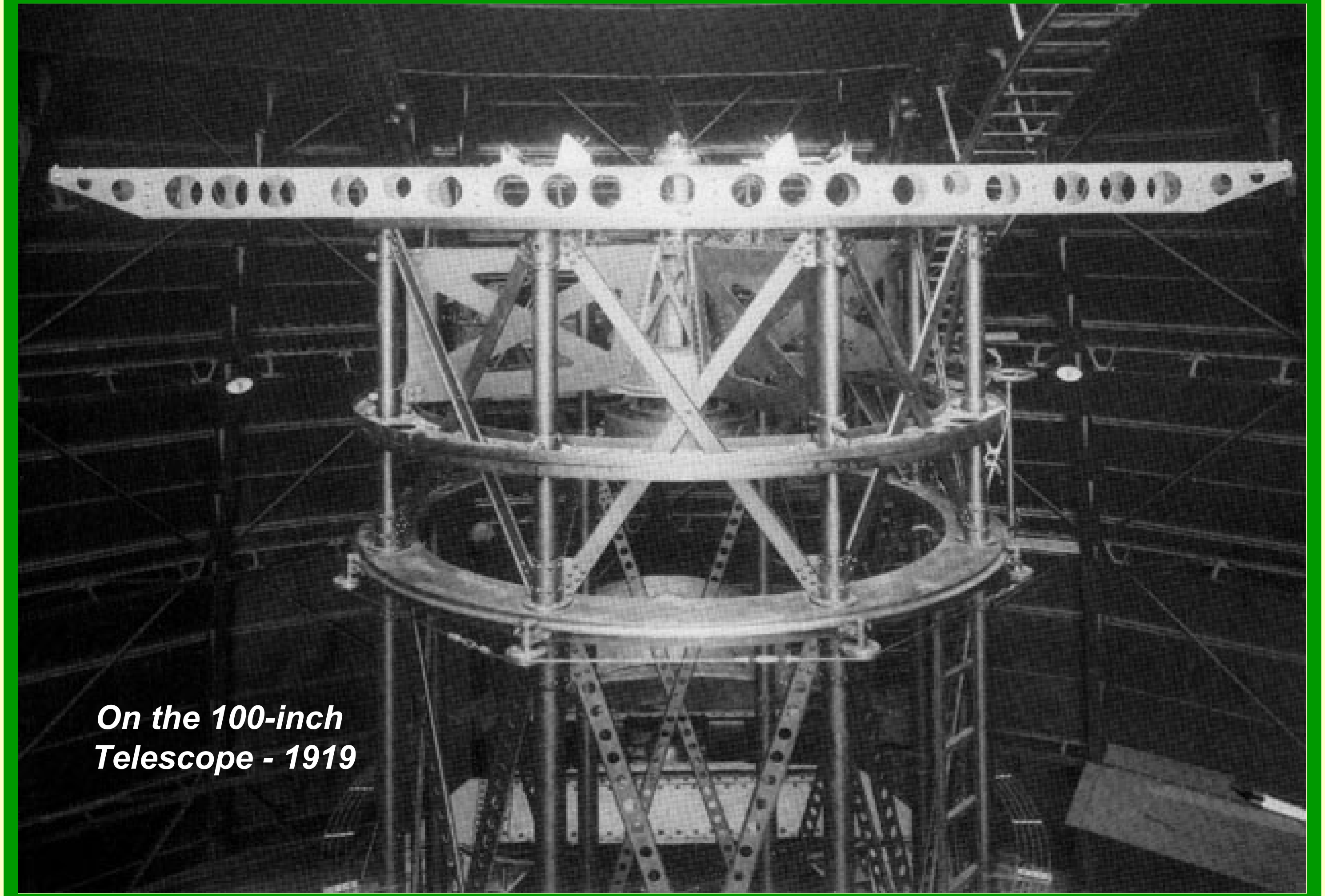
Postcards from the Fringe IV.



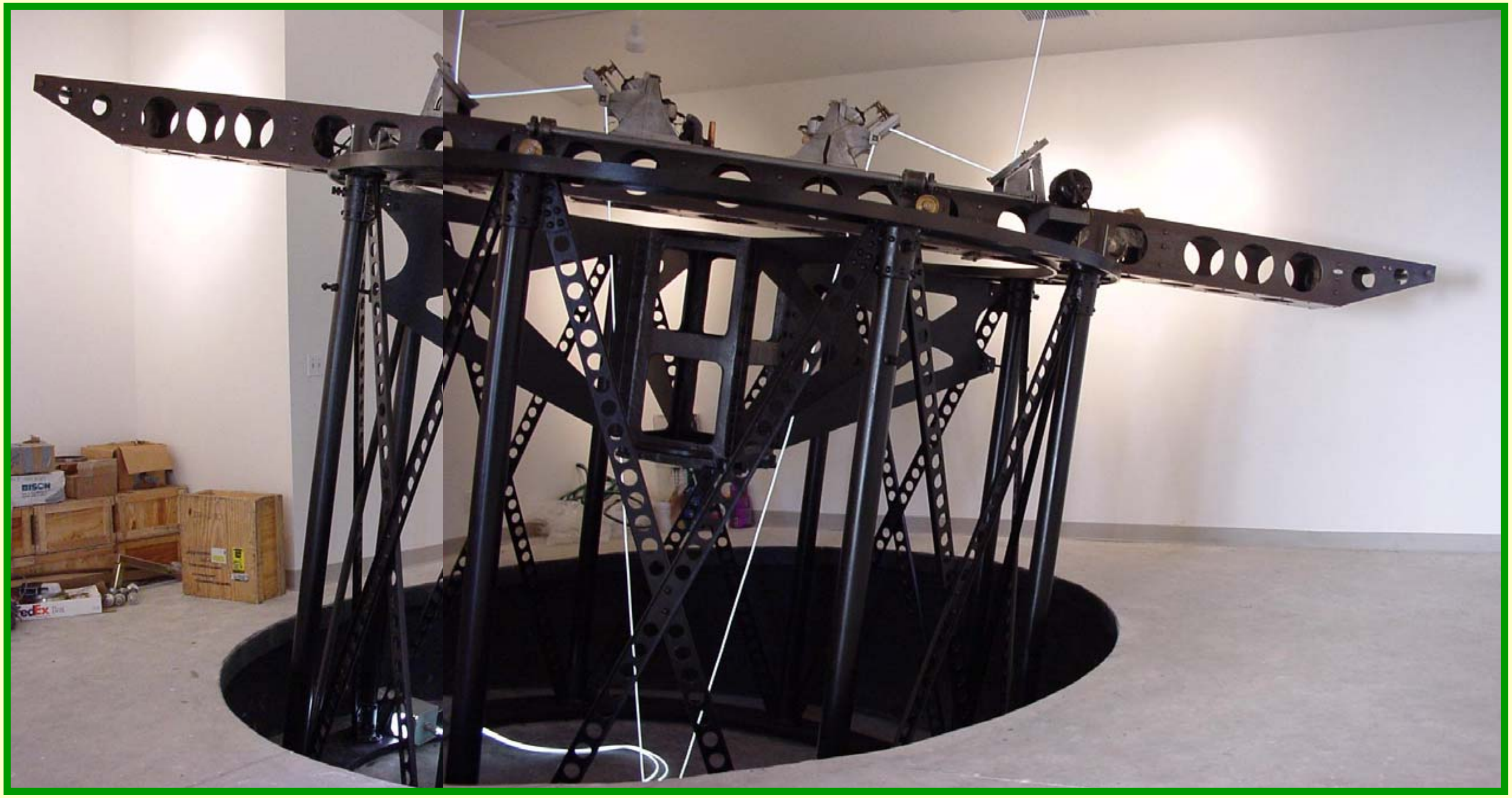
You'll See This One on Wednesday



Lest We Forget…



Awaiting Your Wednesday Inspection



Challenges

- **Interferometers are Complex & Hierarchical Systems**

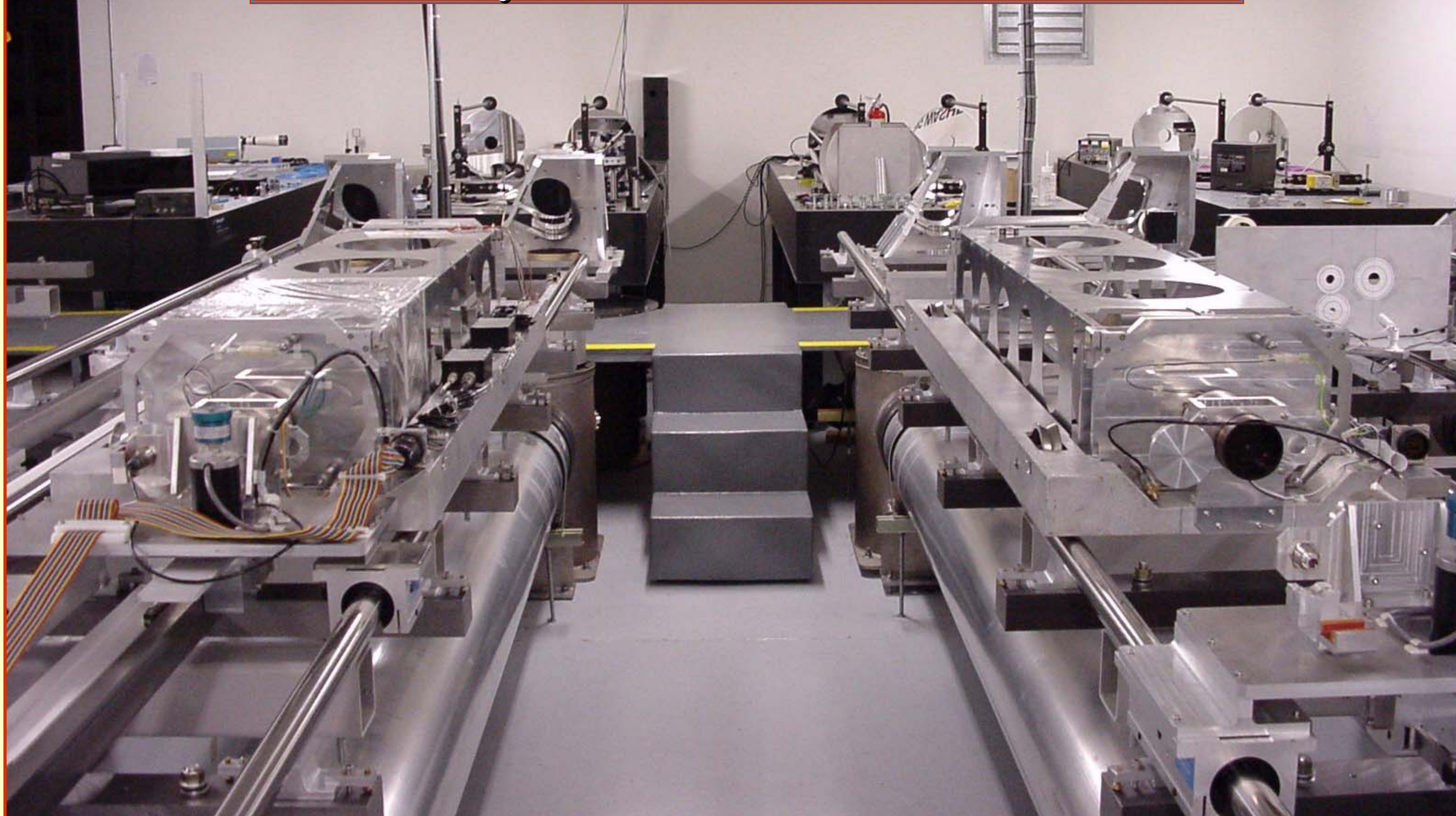
  Numerous sophisticated subsystems:

  Siderostats/Telescopes
  Delay Lines
  Fringe Trackers
  Beam Combiners
  Alignment
  Metrology ***(Astrometry requires exceptional performance)***
  . . .

  All working together! ***(Just imagine all the lovely single-point failure modes!)***

  Attention to calibration is crucial ***(How do you calibrate very long baselines for which point sources don't exist?)***

Sure, it Isn't Easy, but There's Lots of Really Cool Hardware Involved!



Challenges (Cont.)

- **New Tools & Algorithms Required**
  - *Scheduling & Archiving (Necessary evils)*
  - *Imaging (How do you combine many beams simultaneously? Think about it; It's not easy.)*
- **Science**
  - *What's optimal? What's Realistic?*
  - *Avoid over-heightening expectations (Be careful what you promise to do. People may remember.)*
  - *Get theorists involved (Ultimately, they're our customers)*
  - *Develop collaborations (There are a lot of smart people out there)*
- **Funding**
  - *Still widely regarded as a developmental area providing niche science (Lots of stars, but some galaxy stuff!)*
  - *Patience & perseverance (Hey, CHARA took 11 years to fund!)*
  - *Develop Partnerships (Their money is as green* as yours)*

*with appropriate apologies to non-US participants

Opportunities

- **<u>Wonderful Resolution</u>**

  1,000 mas - classical imaging

  20 mas - adaptive optics

  10 mas - HST

  0.1 mas - SUSI

  2 orders gain over AO & HST

  (but very narrow FOV & limited dynamic range!*)

  ****Yes, NASA/ESA, we do need exquisite telescopes in space***

- **<u>Access to New Science</u>**

  Resolution <u>and</u> Accuracy*

  ****If you do your calibration carefully***

Opportunities (Cont.)

Are Current Projects Stepping Stones to an OVLA?

Well… maybe, but then maybe not.

Significant science, of broad impact, must be forthcoming (Soon!)
Imaging must be demonstrated for complex objects
Partnerships must be established
More black-belt interferometrists needed (Hence this SS!)

- **May be built in the 2010 decade??**
  If so, those in this room will be building it

- **Can we learn from the radio experience?**
  $T_{VLA} - T_{GBI}$ = ***Only ~20 years!***
  But, is O/IR interferometry really analogous?

Interferometry Science
Most Favorable Areas

- **Single Stars**
  - Effective Temperatures & Fluxes
  - Rotational Oblateness
  - YSO Structure & Morphology
  - Stellar Surface Features
  - Novae/Supernovae
- **Binary & Multiple Stars**
  - Resolved Spectroscopic Binaries
    - *Stellar Masses and Luminosities*
    - *Distance Calibrations*
    - *Radii of Components*
  - Detection of Low-Mass Companions
- **Astrometry**
  - Ground (NPOI) & Space (SIM)

Nice Example of a Revolution

Resolved Spectroscopic Binaries

- **Double-Lined Binaries**
  - Spectroscopy gives mass ratio & *a*sin*i*
  - Interferometry gives *a* and *i*
  - Together yield masses & distances
    - *("orbital parallax")*
  - ~200 DSB's have *a*" > 1 mas
- **Single-Lined Binaries**
  - Accurate parallaxes give individual masses
- **70% of SB's are Resolvable**
  - Many radii also measurable

Interferometry Science
Other Areas

- **Single Stars**
  - Limb Darkening
  - Linear Diameters
  - Star Formation Phenomena & Dynamics
  - Pre-Main Sequence Objects
  - Absolute Rotation
  - Flare Star Phenomena
  - Cepheid P-L Calibration
  - Mira Pulsations
  - Non-radial Oscillations
  - Hot Star Phenomena (shells, winds, etc.)
  - Cool Star Shells
- **Binary & Multiple Stars**
  - Duplicity Surveys
  - Close Binary Phenomena
- **Star Clusters**
  - Proper Motions
  - Duplicity Surveys
- **Extragalactic**
  - Binaries in Magellanic Clouds
  - AGN Structure
- **Solar System**
  - Planetary Satellites
  - Minor Planets & Comets
  - Solar Surface
- **Extrasolar Planets**
  - Astrometric Detection
  - Inspection/Verification
  - Imaging exo-zodiacal dust
  - Imaging protoplanetary disks

Interferometry Science
Other Areas (Cont.)

- <u>You'll Think of Something</u>

<u>***(Get the theorists involved!)***</u>

"History has taught us that whenever a new technique enters a new realm of observational phase space, the most striking and productive results tend to be those not anticipated by even the most prescient thinkers"

- Daniel Popper, 1990

Interferometry Science
In Perspective

- **<u>Presently Sensitivity & (U,V) Limited</u>**
  - Low Throughput is Inevitable
  - Adaptive Optics May Help
  - Limited Imaging Capability
- **<u>Outstanding Stellar Science</u>**
- **<u>Limited Extragalactic Science</u>**
  - Provided by VLTI & KI
- ***The success of the current retinue of instruments will determine the future of the field.***