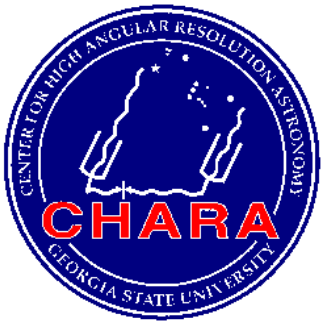
But How Do You Build One?



Theo ten Brummelaar

CHARA – Georgia State University

Warning: This talk will contain opinions.

These opinions are mine, and do not reflect the views of the MSC.

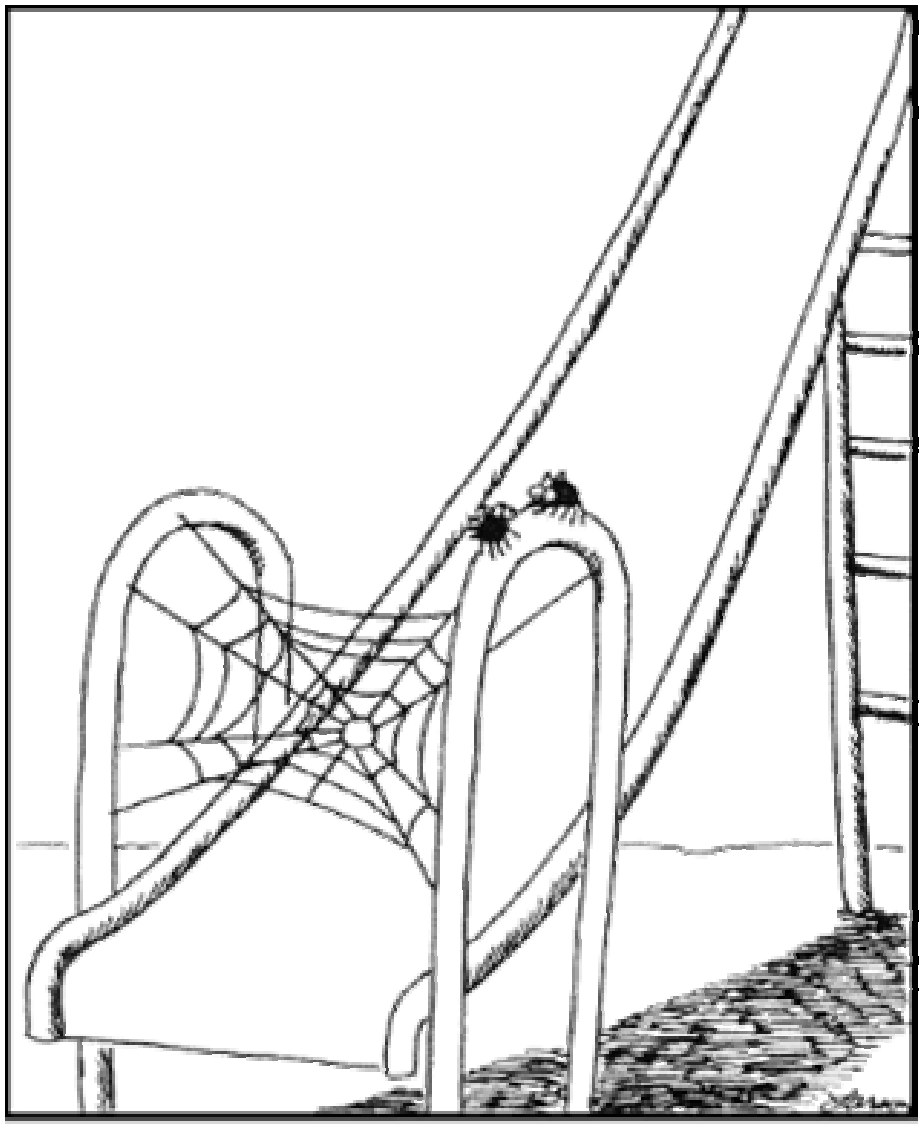
So if you have a problem with anything I say don’t annoy Gerard about it, come talk to me.

Of course, coming to a school like this you must expect to hear opinions a lot of the time. After all, you are here to pick up the intellectual droppings of your seniors, aren’t you? Or is it the free trip to Los Angeles that brought you here? In any case you shouldn't be upset if I say something bad about your favorite interferometer. What do you know about the subject anyway? The fact that you're here listening to this stuff means that you either wish to learn or have come here to meet other students, even find a potential mate like Mike Fischer did. So sit back, relax and listen up, or not, just don't get upset. Hell, this isn't important enough to raise your blood pressure really is it?

Interferometry and Stellar Interferometers

Optical Interferometry is not easy. Building them is hard, collecting the data is difficult, and calibrating that data is all but impossible.

Interpreting the final result is even harder, and can lead to embarrassment, even press releases you may come to regret.



"If we pull this off, we'll eat like kings."

Things to Think About

- Operating wavelength, bandwidth, site location
- Match apertures to r0?
- Tip/tilt and/or adaptive optics
- Optical path length compensation & phase stability
- Dispersion: vacuum or air?
- Metrology

More Things to Think About

- Optics: quality & quantity
- Coatings
- Polarization—dynamic & geometrical phase shifts
- Diffraction
- Control & data acquisition systems

Even More Things to Think About

- Beam Combination Scheme: Fringe Modulation Temporal or Spatial ?
- Fringe tracking: Separate from Science Engine ?
- Spatial Filtering ?
- Use of Fibers: Before or after Beam Combination ?

Interferometry and Stellar Interferometers

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(180)	165	2.2 - 10	initial 2001
VLTI	ESO	Cerro Paranal	4(3)	840(250)	200	0.45-12	initial 2001
MIRA	NAOJ	Tokyo	2	13	30	??	initial 2002

Site Selection Concerns

- Morphology
- The atmosphere above
- The ground below
- Vibration
- Facilities
- Location

KECK: Sierra Club member opposes plan

From Page 1

A draft of an environmental assessment report was completed in December 2000 but the final report is not expected until March or April.

Ho wrote to DLNR Chairman Gilbert Coloma-Agaran and the board that the permit application is premature, and that the IfA is recommending the project without an environmental impact statement, which entails a more critical look at the potential impact of the project.

"Every agency and community organization that reviewed the NASA Environmental Assessment — including the university's Office of Mauna Kea Management — made the opposite recommendation," Ho wrote.

Walter Heen, former interim director of the OMKM, said it is "inaccurate to say there is no, or at most minimal, impact from the construction activity necessary to install the ... outrigger telescopes."

Heen said excavation for the telescopes could disturb ancient burial sites, and that native Hawaiian cultural concerns are "deserving of greater in-depth analysis." A lack of understanding for the impact of the construction project in spiritual terms renders the Keck plan "utterly inadequate," he said.

The project would use less than half an acre of the five-acre site subleased for the W.M. Keck Observatory for its outrigger telescopes project, which includes the addition of six 1.8-meter telescopes on the site. Only four would be built in the initial phase.

The outriggers would be used in conjunction with the existing twin Keck telescopes in a process called "interferometry," which increases their light-gathering power. NASA said the $50 million project will provide a boost to its "Origins" program, which studies the beginnings of the universe and searches the heavens for planets that could support life.

The new project would be paid for by the National Aeronautics and Space Administration.

John Lee, a spokesman for the Keck Interferometry Project in NASA's Washington, D.C., office, said Thursday that the final draft of the environmental assessment, which would address the Hawaiian community's concerns, is being prepared, along with an agreement that would satisfy all parties interested in the project.

NASA is still reviewing the reaction to its environmental assessment. "We're taking all the comments very seriously," Lee said. The final EA could be ready in three months.

"If we had our druthers we would have been building two years ago," Lee said, but community concerns for the impact of the project on Mauna Kea and other factors have put the project behind schedule.

The decision whether NASA will seek approval of the project with just the environmental assessment, not a full environmental impact statement, has not been made and will be up to the "senior management" at NASA. "The issue is to address the issues, not the document," he said.

Opponents' recourse if NASA fails to seek the full EIS would be a legal challenge.

Last week Clayton Hee, chairman of the Office of Hawaiian Affairs, which also opposed the project without an EIS, proposed that NASA pay more than $20 million to use the ceded lands atop Mauna Kea, which are leased by the Institute for Astronomy for the Mauna Kea Science Reserve where the telescopes are located.

Hee asked for $10 million as an endowment to fund scholarships for undergraduate and graduate studies of astronomy and Hawaiian culture, and $10 million for five professorships in the same areas of study at University of Hawaii at Hilo.

OHA has previously said it would sue to stop the project if it did not pursue the full EIS.

The Land Board could deny the conservation district use permit if it determined the EIS was needed but rejected by NASA, and no decision by the Land Board on the Conservation District Use permit will be made until the NASA completes its final environmental assessment, said Robert McLaren, IfA associate director. McLaren said the anticipated "finding of no significant impact" from the project indicated in the December OEQC report was probably based on a state environmental assessment prepared in 1999, but that the IfA does not take that position currently. "NASA is taking the lead on this project," he said.

Interferometry and Stellar Interferometers

Interferometry and Stellar Interferometers

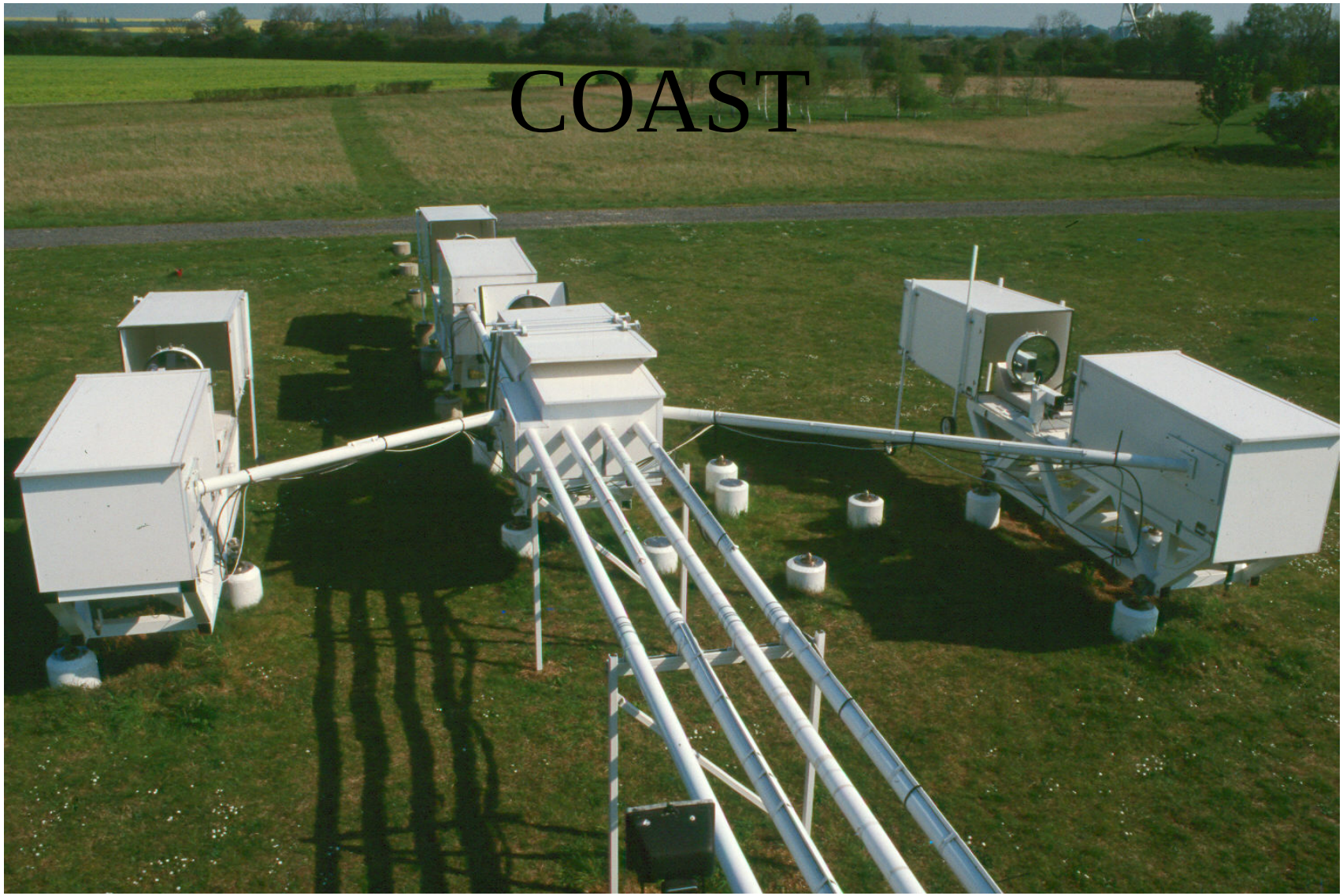
Interferometry and Stellar Interferometers

The Tour Begins……

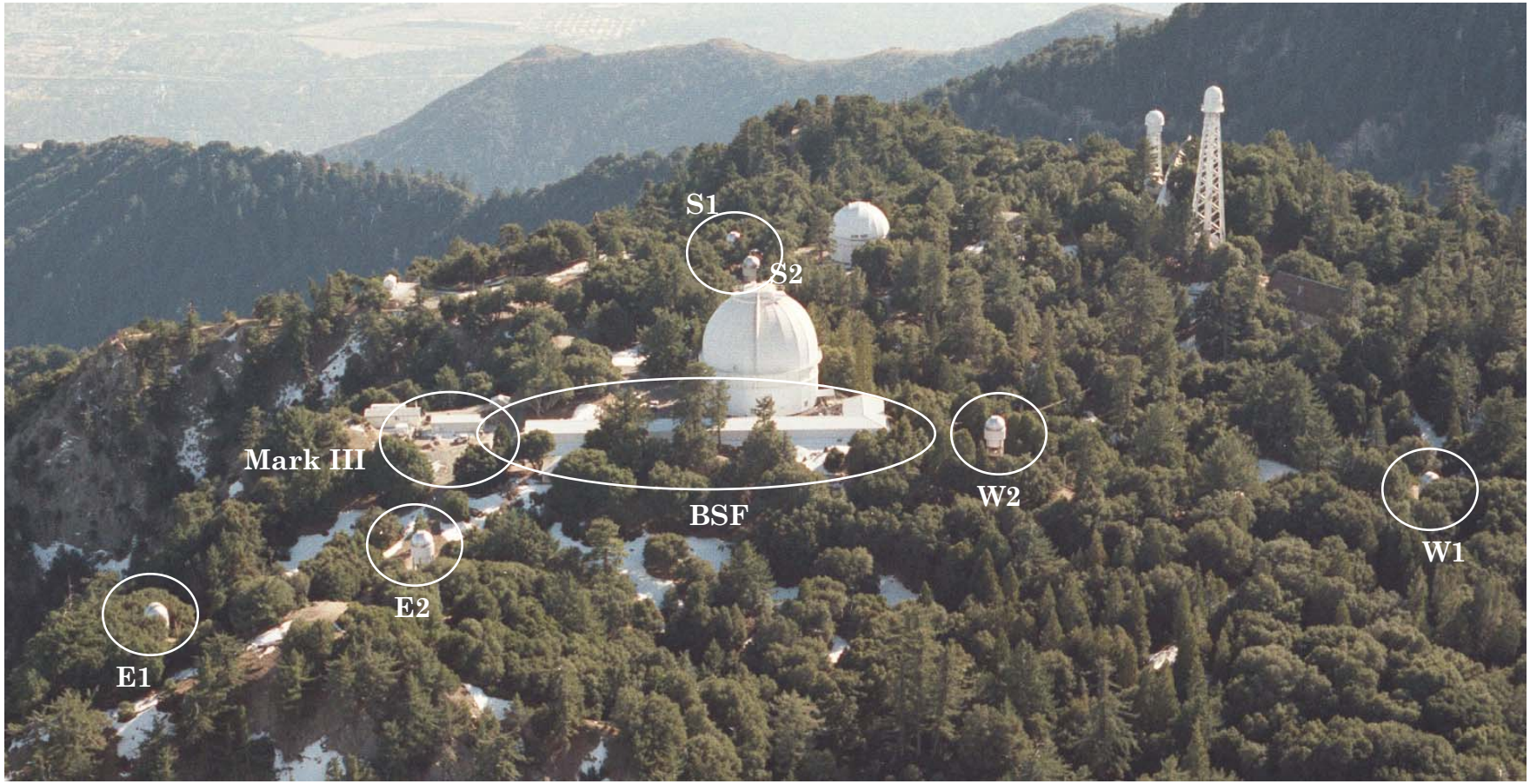
Interferometry and Stellar Interferometers


GI2T

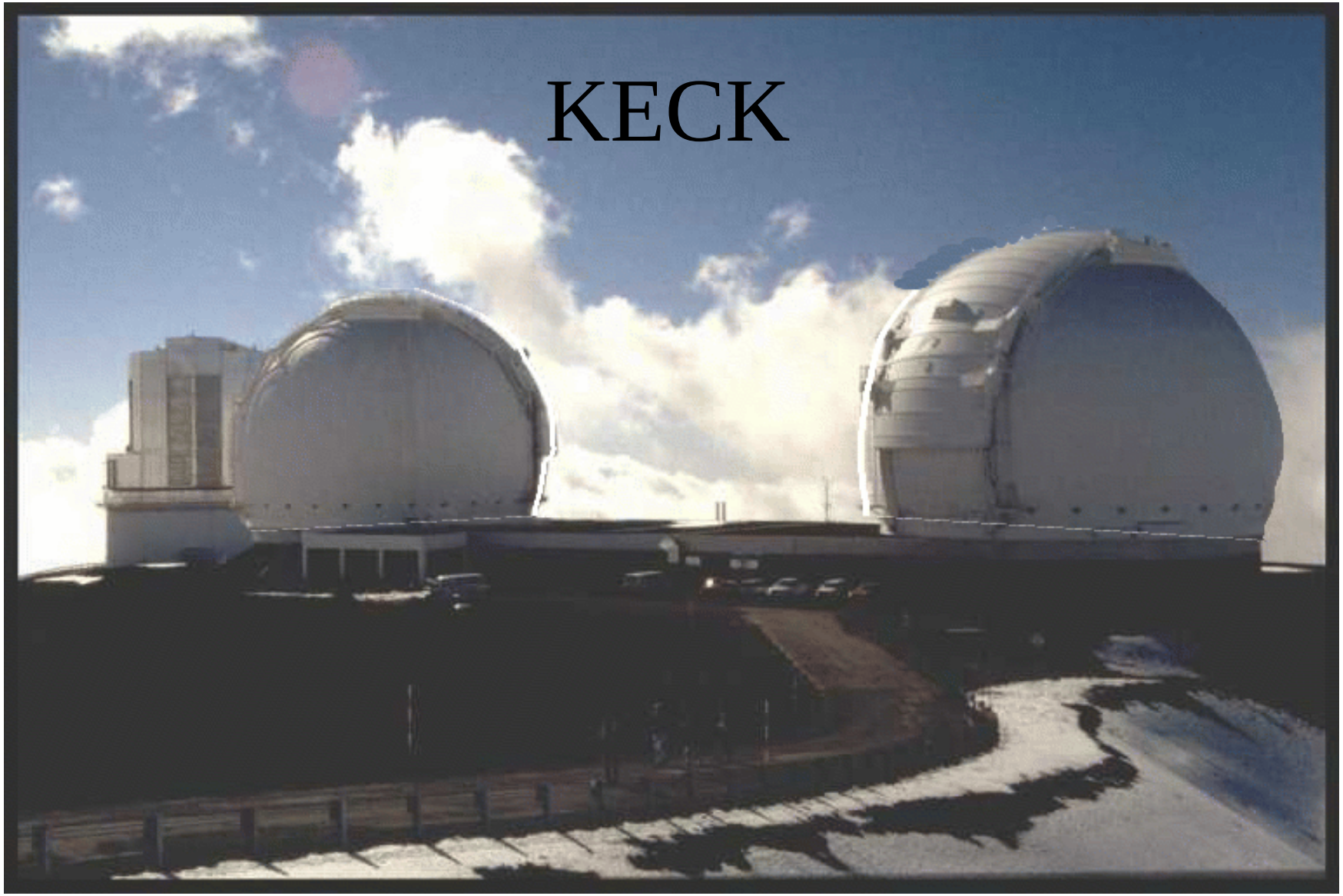
Interferometry and Stellar Interferometers


COAST

CHARA

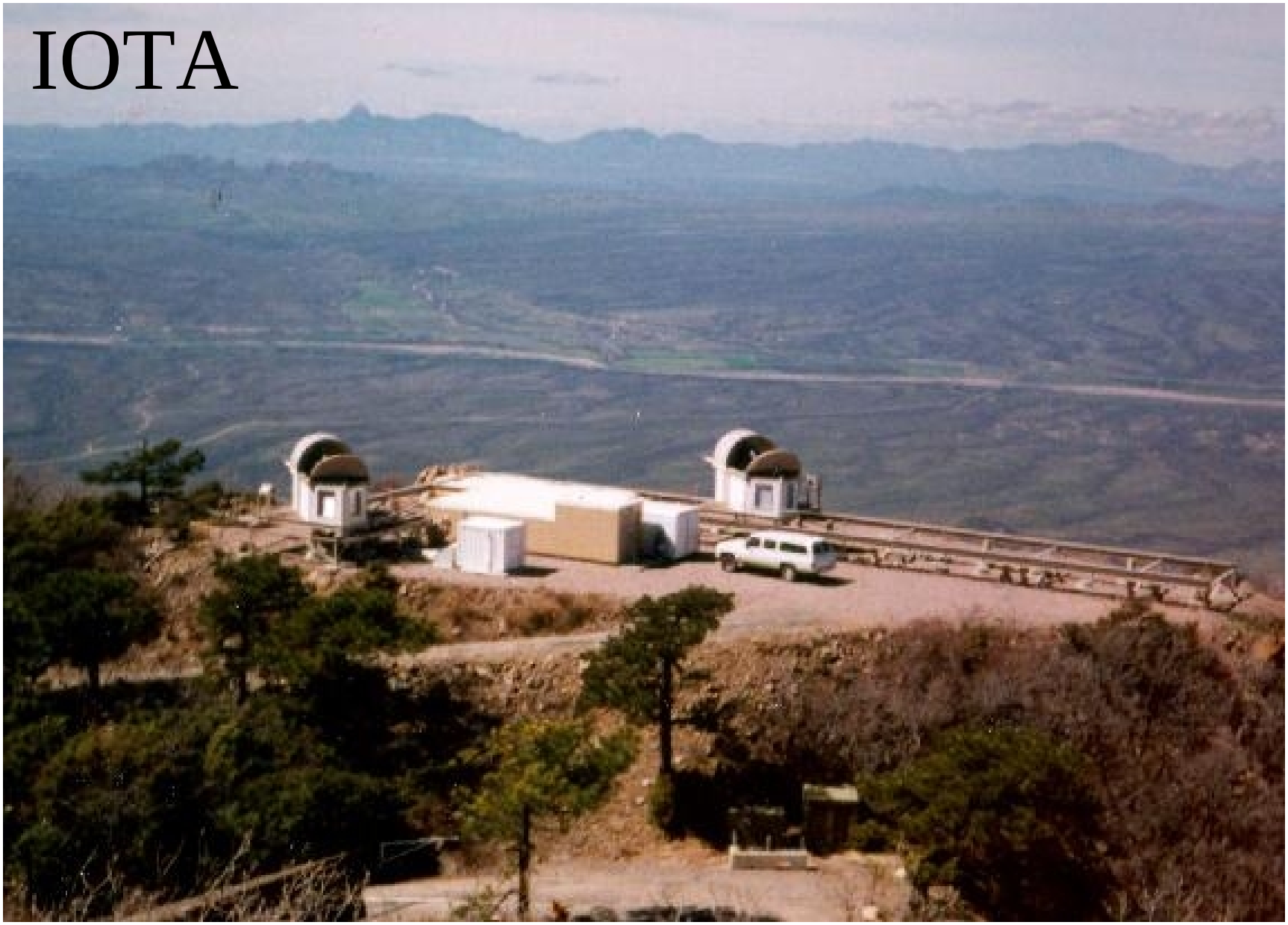



PTI

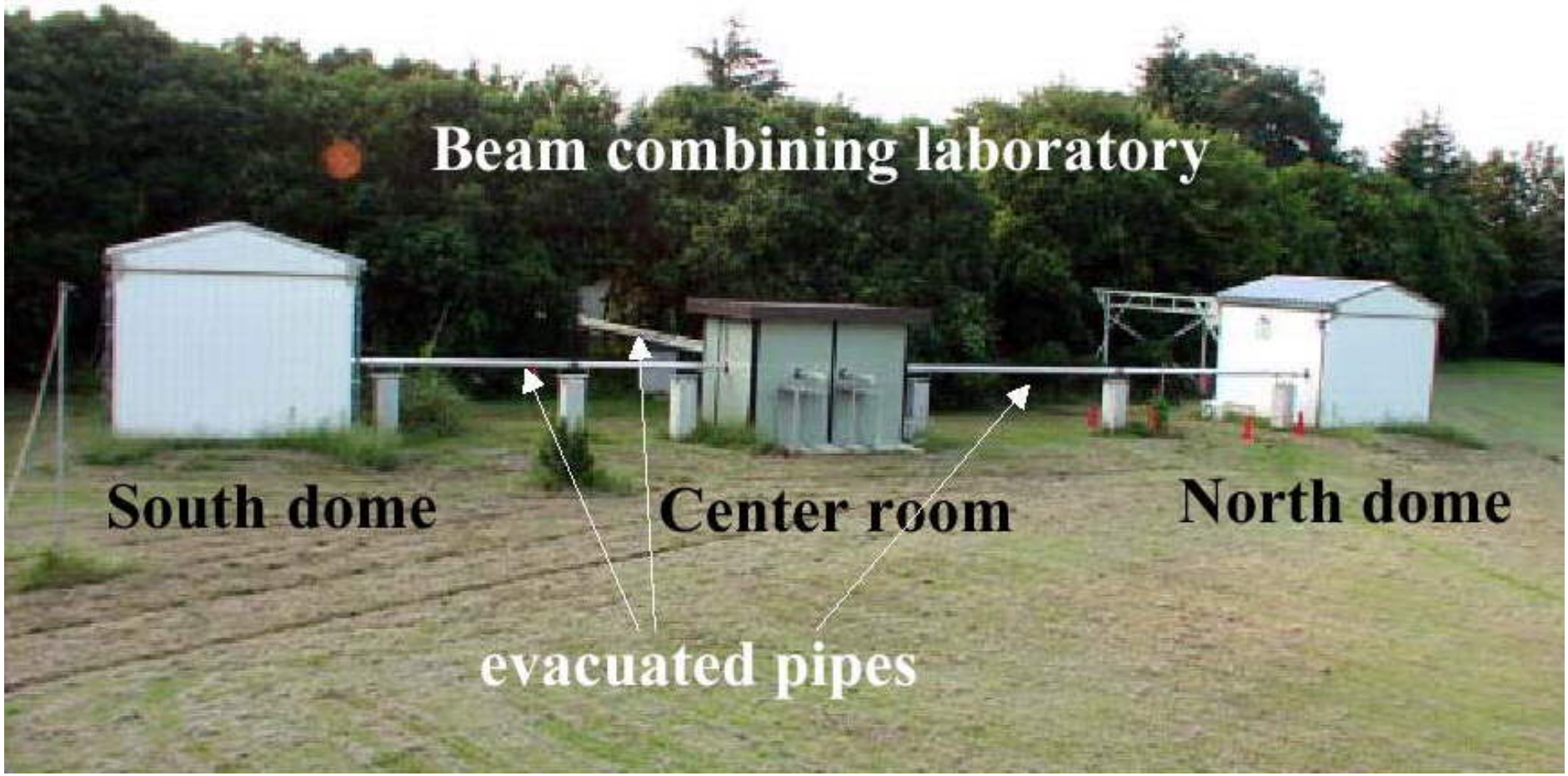

KECK


KECK


VLTI


IOTA

MIRA


Beam combining laboratory
South dome
Center room
North dome
evacuated pipes

Steel and Concrete

- You need to secure things to ‘bedrock’
- Optical and building foundations must be isolated
- Everything needs to be stable at the micron level
- You need to have a contractor you can trust

Interferometry and Stellar Interferometers

Interferometry and Stellar Interferometers

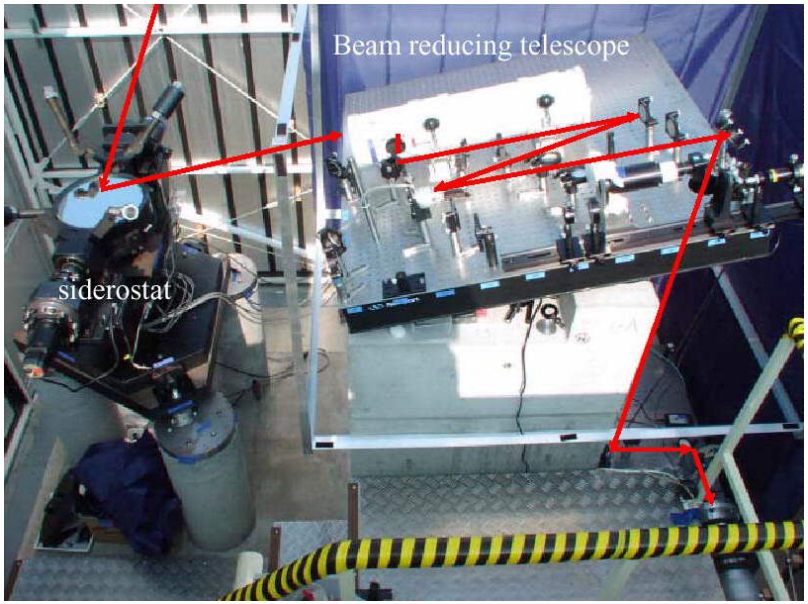
The Light Must Get In Somehow

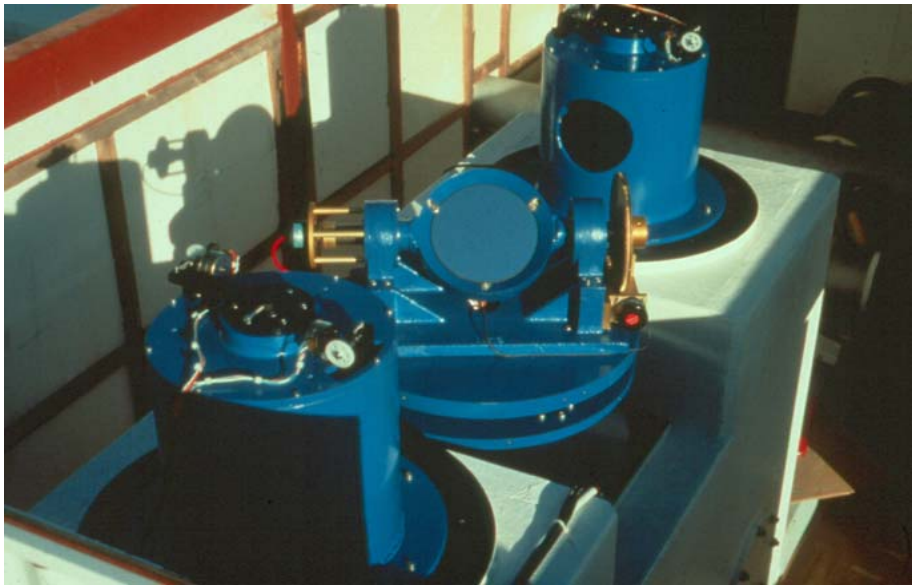
- Aperture size: seeing and adaptive optics
- Siderostat Vs Telescope
- How many apertures can you afford?
- Movable Vs Stationary

Interferometry and Stellar Interferometers

Interferometry and Stellar Interferometers

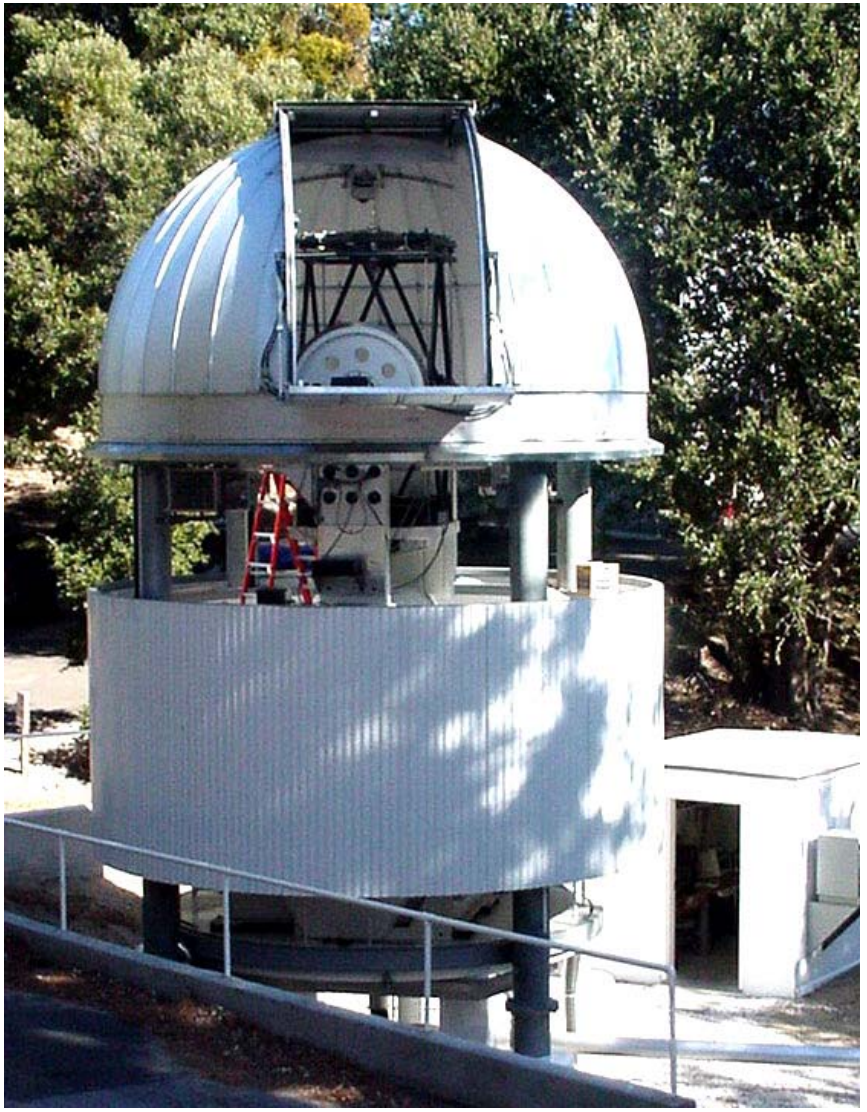
Interferometry and Stellar Interferometers



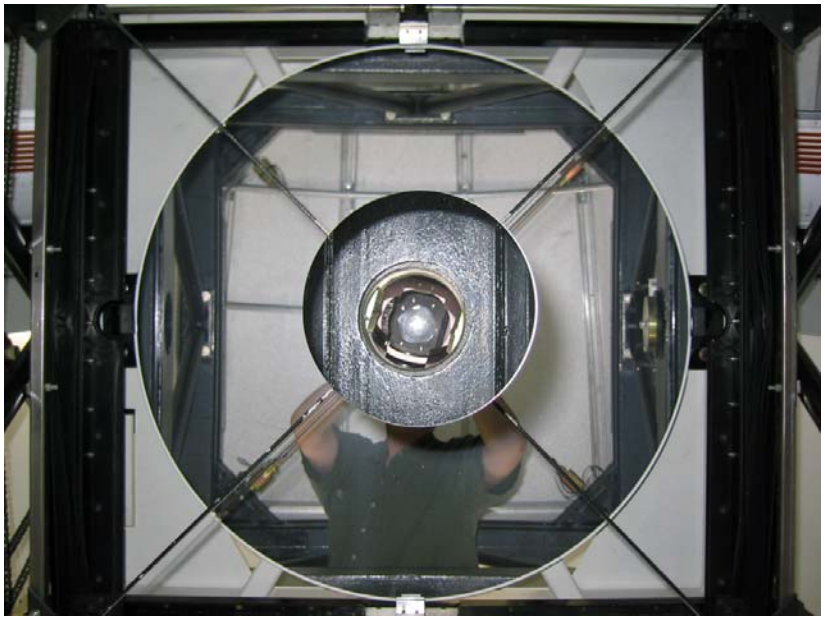


Interferometry and Stellar Interferometers

Interferometry and Stellar Interferometers



Interferometry and Stellar Interferometers



Interferometry and Stellar Interferometers

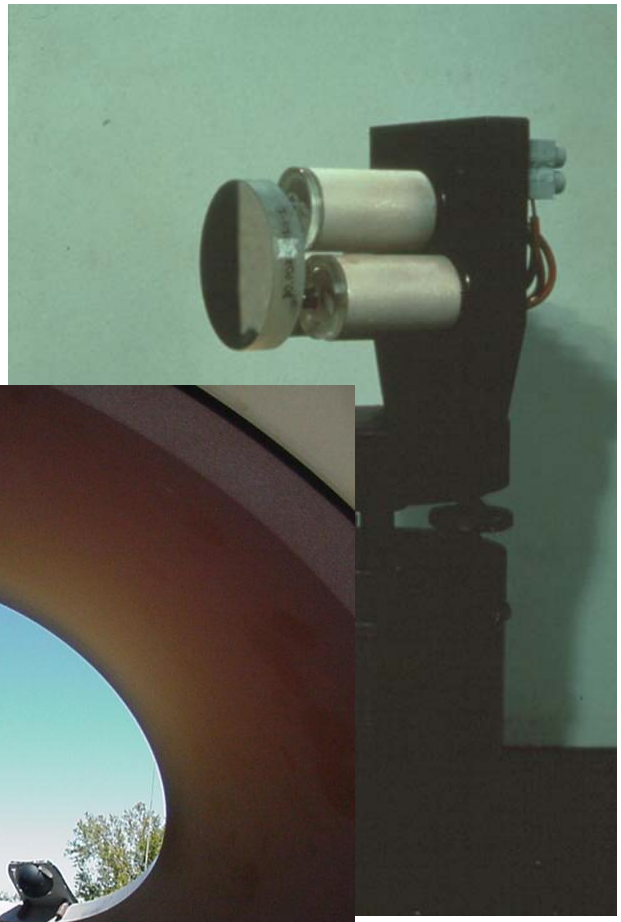
The Light Has to Reach the Center

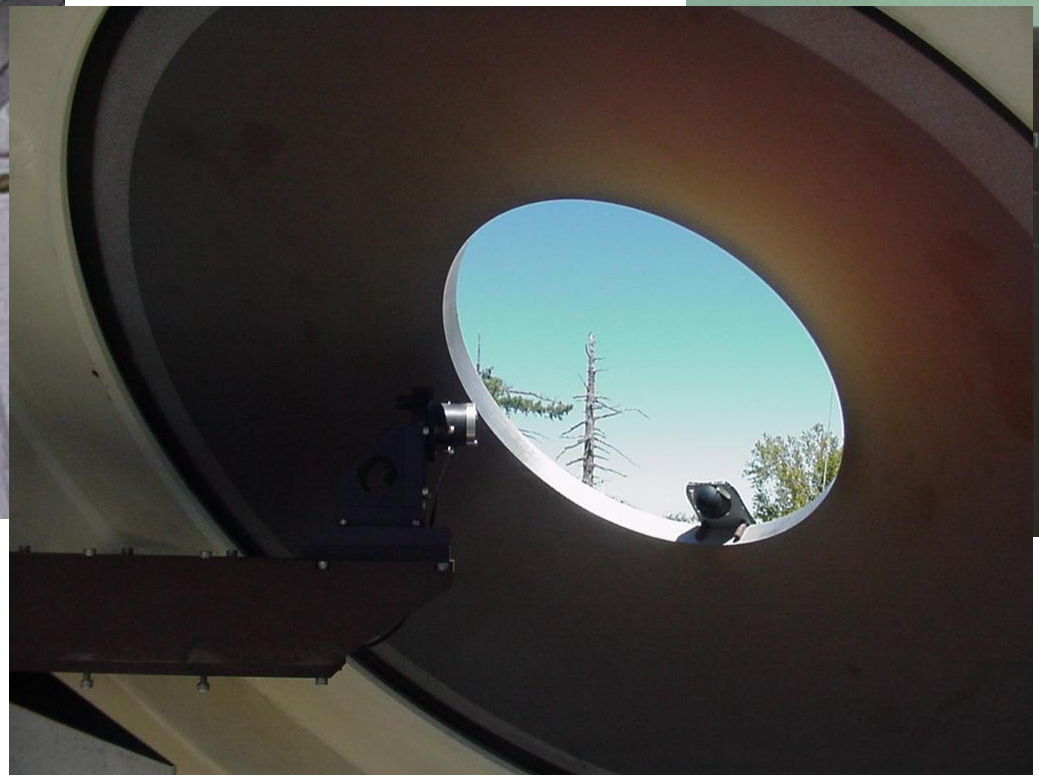
Interferometry and Stellar Interferometers

The Light Needs to be Stable

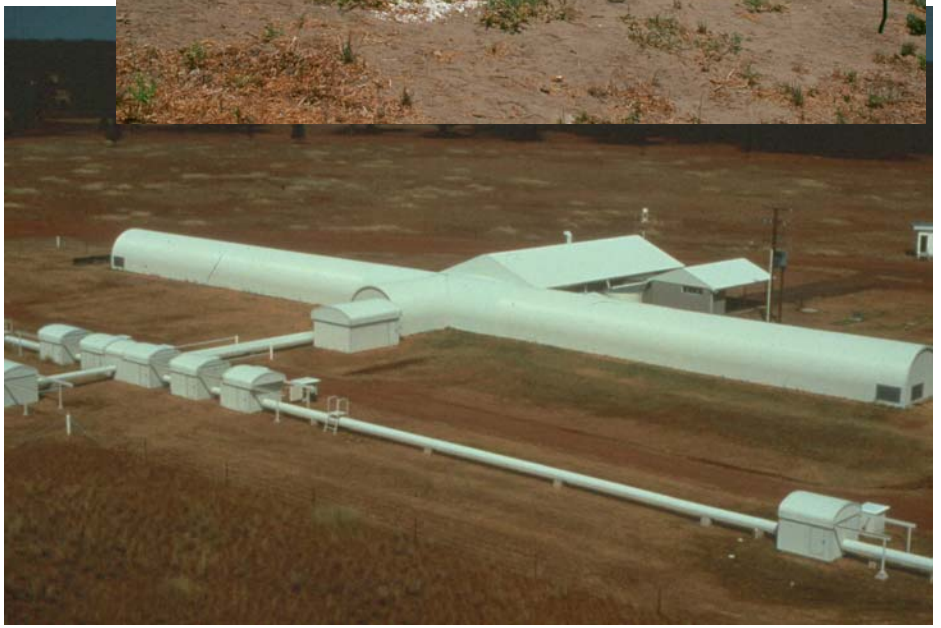
- You must have tip/tilt
- Your beam size should be well matched to the seeing
- Adaptive optics may help
- The optical train should not introduce any more instabilities (site/mount vibration)

Interferometry and Stellar Interferometers





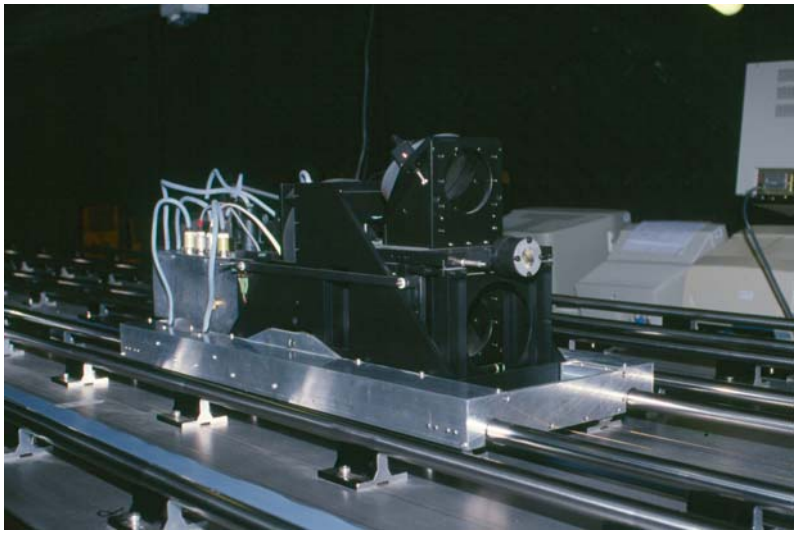
The Instruments need enclosing….

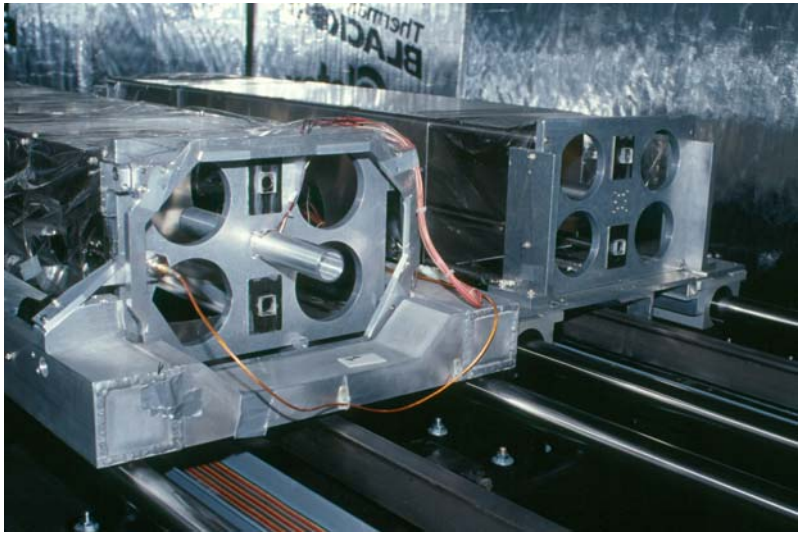


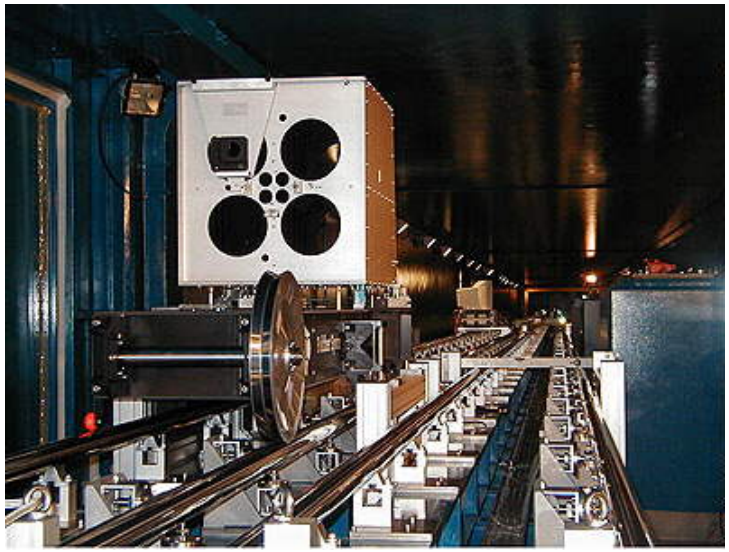
…. and Thermal Stability

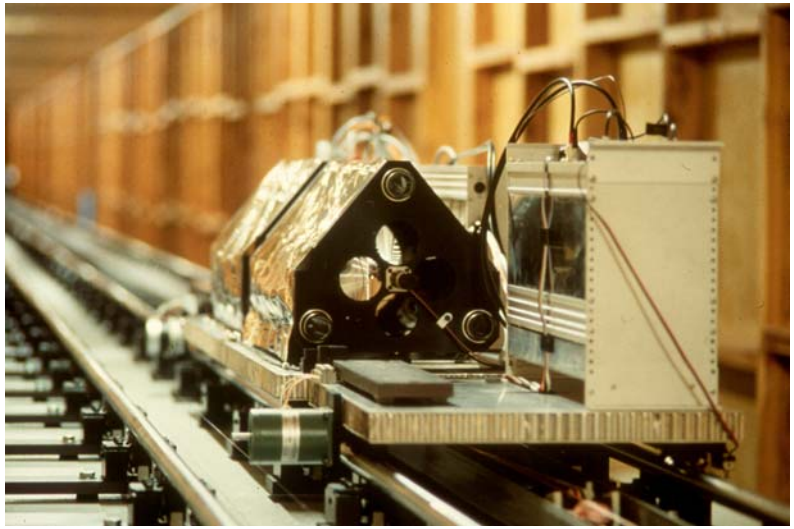
Delay Lines sit on Rails….

… and Delay the Light.



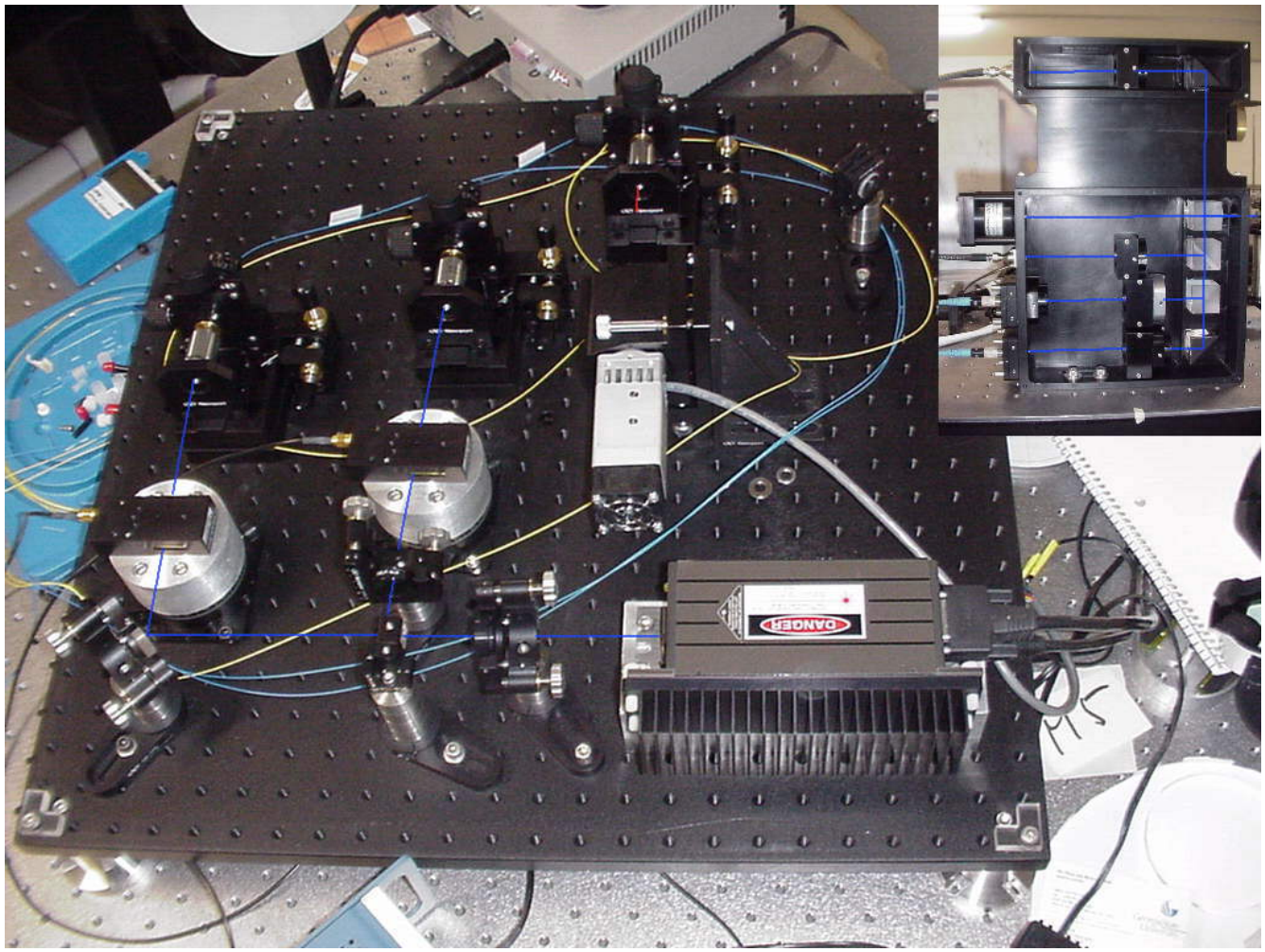






Interferometry and Stellar Interferometers

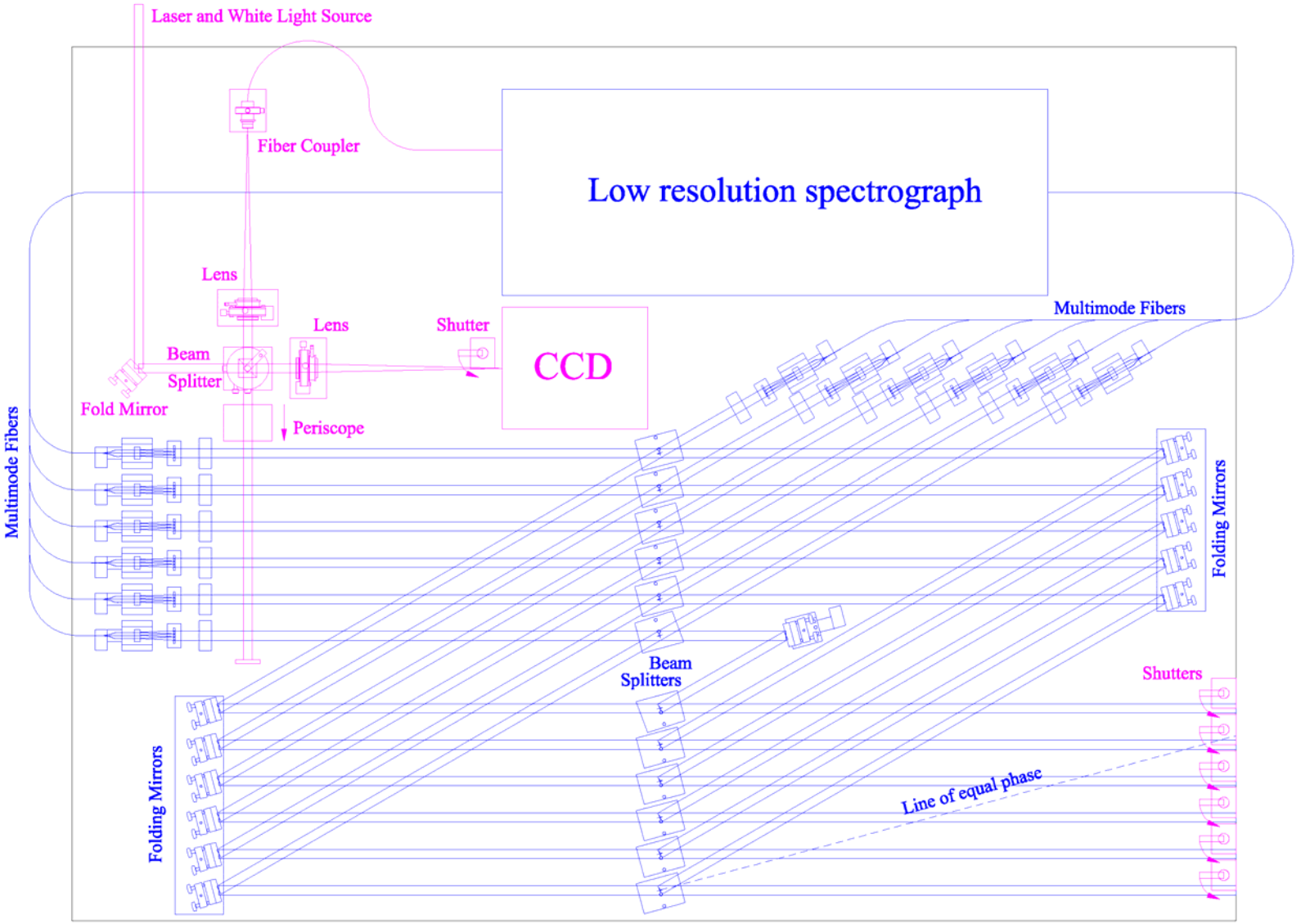
You Need Metrology that Works



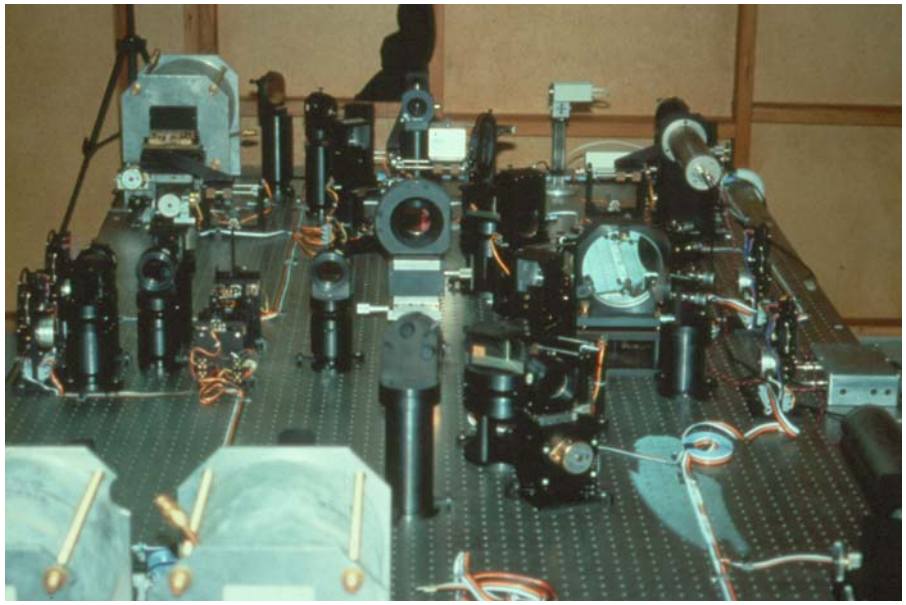
What About a Beam Combiner?

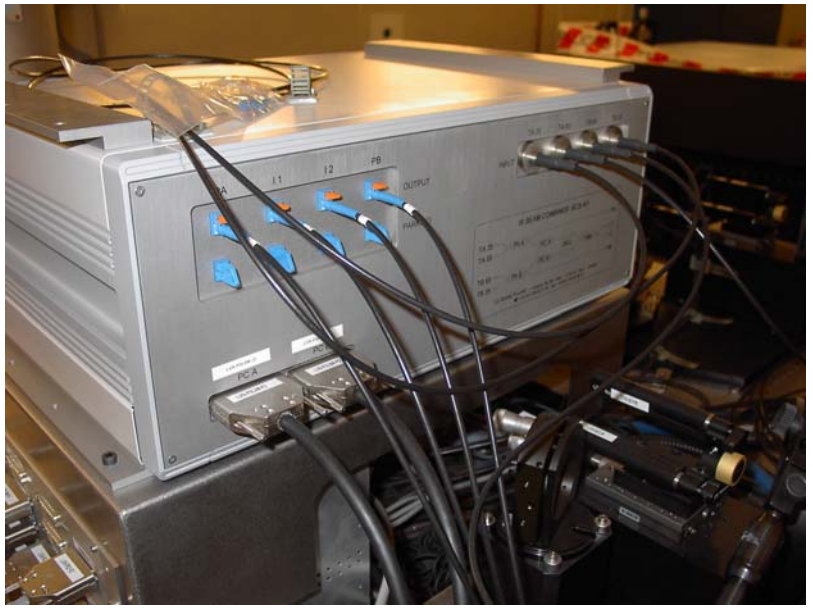
- Modulation scheme – temporal or spatial?
- Open air, fiber or a combination?
- How many beams at a time?
- How do you divide the light – gray, color or polarization?
- Are fringe tracking and imaging the same thing?

Interferometry and Stellar Interferometers

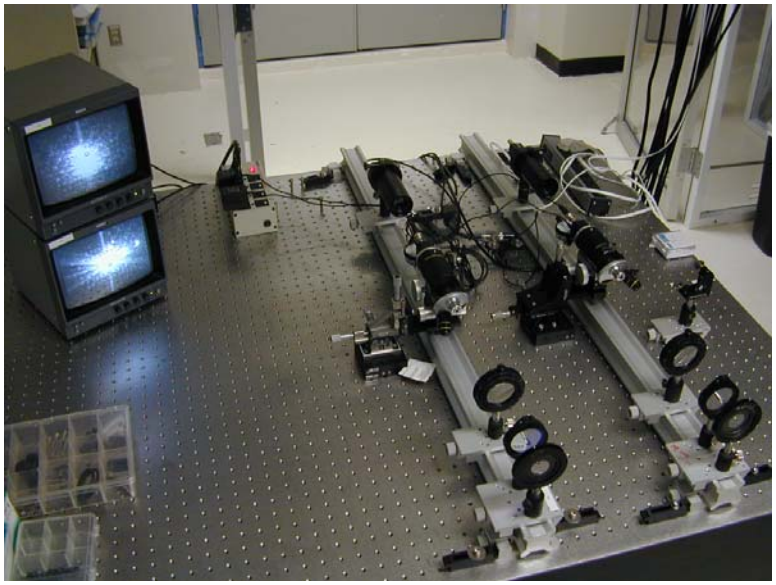


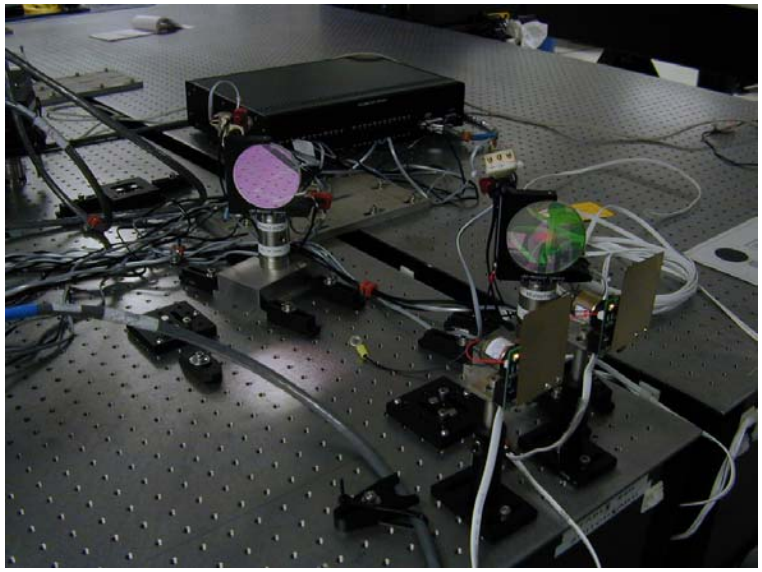
Interferometry and Stellar Interferometers

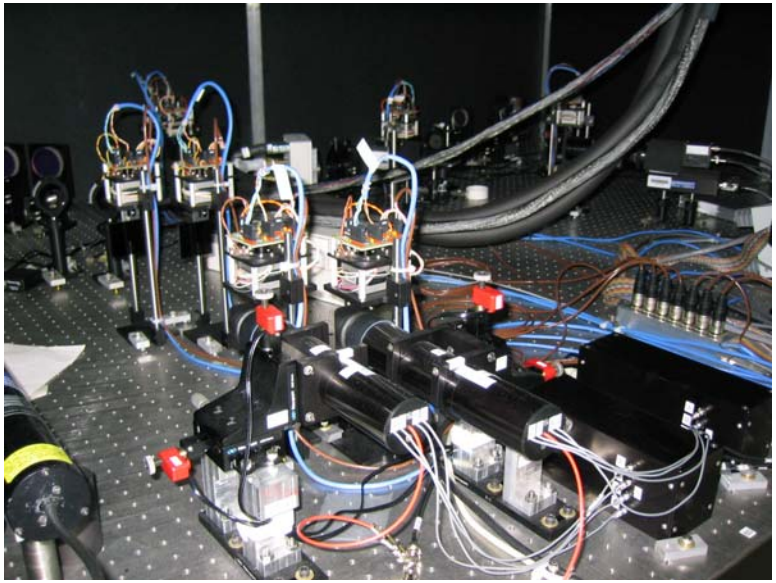


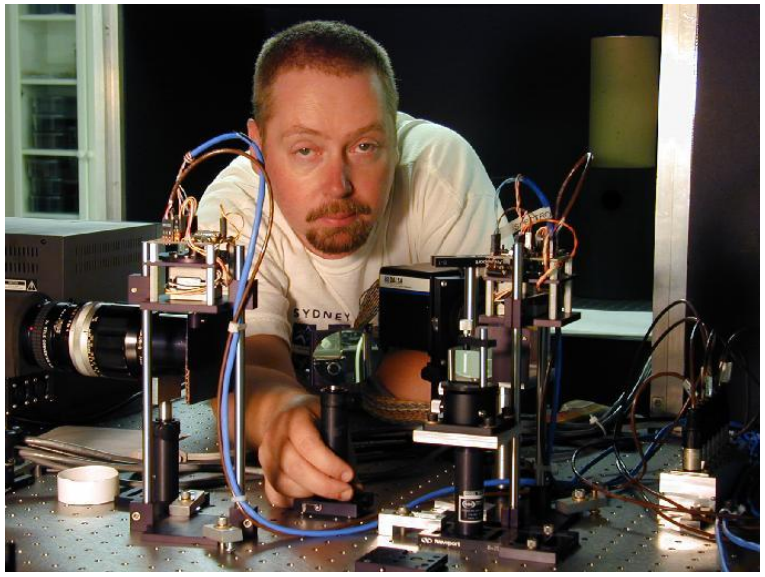


Interferometry and Stellar Interferometers





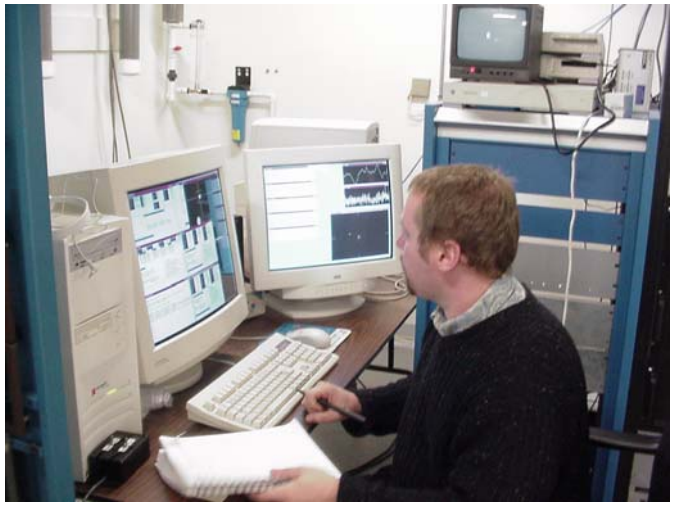




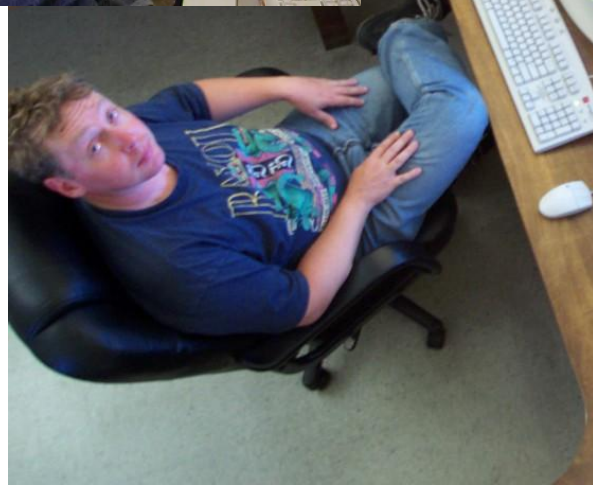
You will Need a lot of Electronics

And Don’t Forget the Control System

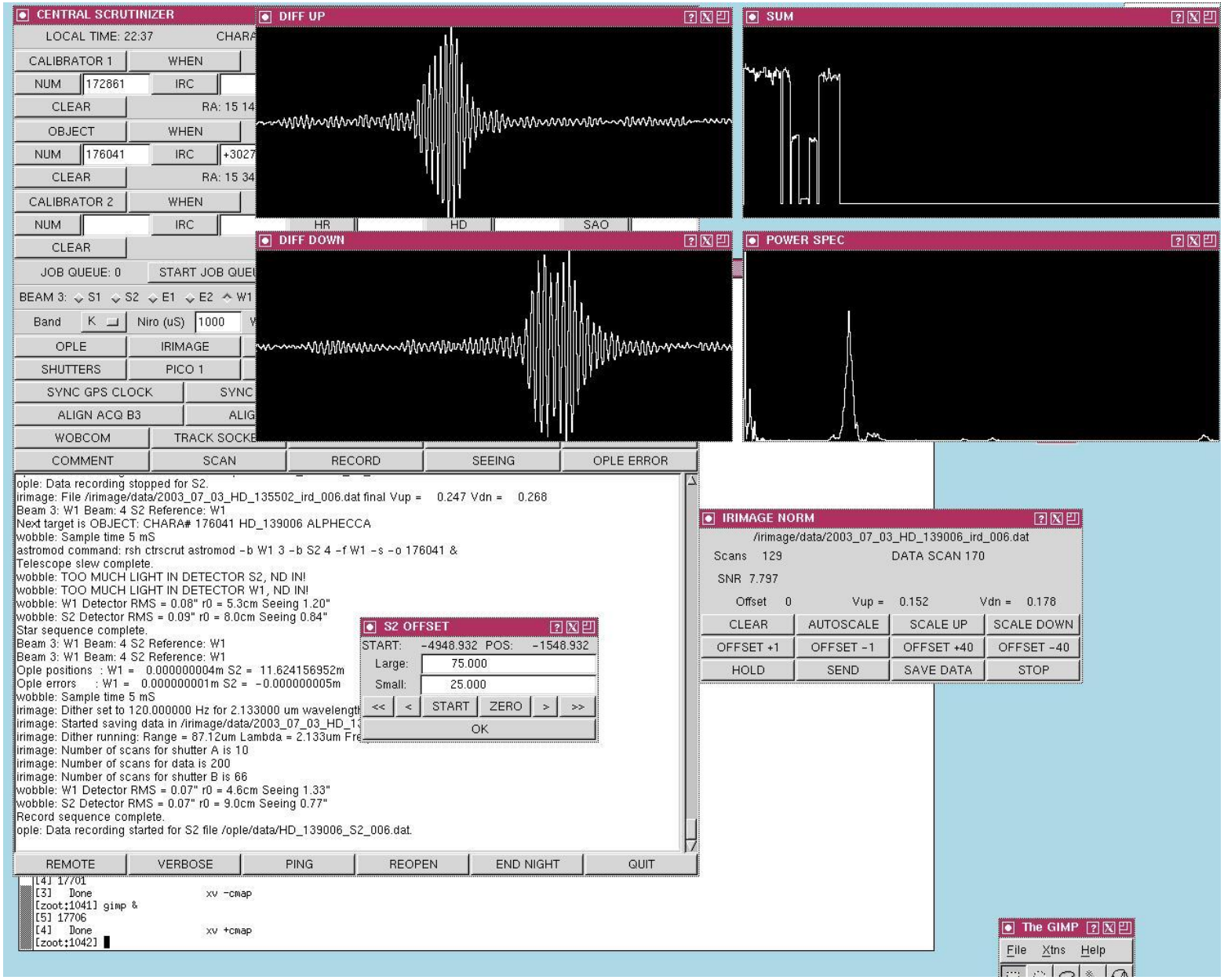


Interferometry and Stellar Interferometers



Interferometry and Stellar Interferometers



Both will Need Debugging

If it all works… you party.

The next big thing: The BLT

The next next big thing: MRO

- 10 elements
- 1.4m class telescopes
- Reconfigurable array in a Y shape
- B min approx 6m, B max approx 400m
- RIJHK operation
- Vacuum relay and delay lines
- Separate optical and near-IR beam combiners
- Separate science and fringe-tracking beam combiners
- First light (whatever that means) 2008

So that's what an interferometer looks like.

- They do tend to look the same.
- Should we continue to build them like this? (See: D. F. Buscher and C. A. Haniff. Interferometric fitness and the large optical array. In Interferometry for Optical Astronomy II, volume 4838 of Proc. SPIE.)

Optical Long Baseline Interferometry Newsletter

- **http://olbin.jpl.nasa.gov**
- **Contains links to all existing and proposed optical/IR interferometer projects.**
- **News**
- **Papers and preprint information**
- **Upcoming meetings**
- **Contact information**
- **Translations of selected papers**
- **List of PhD and Masters theses**
- **Photographs and resources**
- **Job listings**