Welcome to the Univ. of Toledo CHARA Community Workshop

Douglas Gies

Director
Center for High Angular Resolution Astronomy
Georgia State University

www.chara.gsu.edu

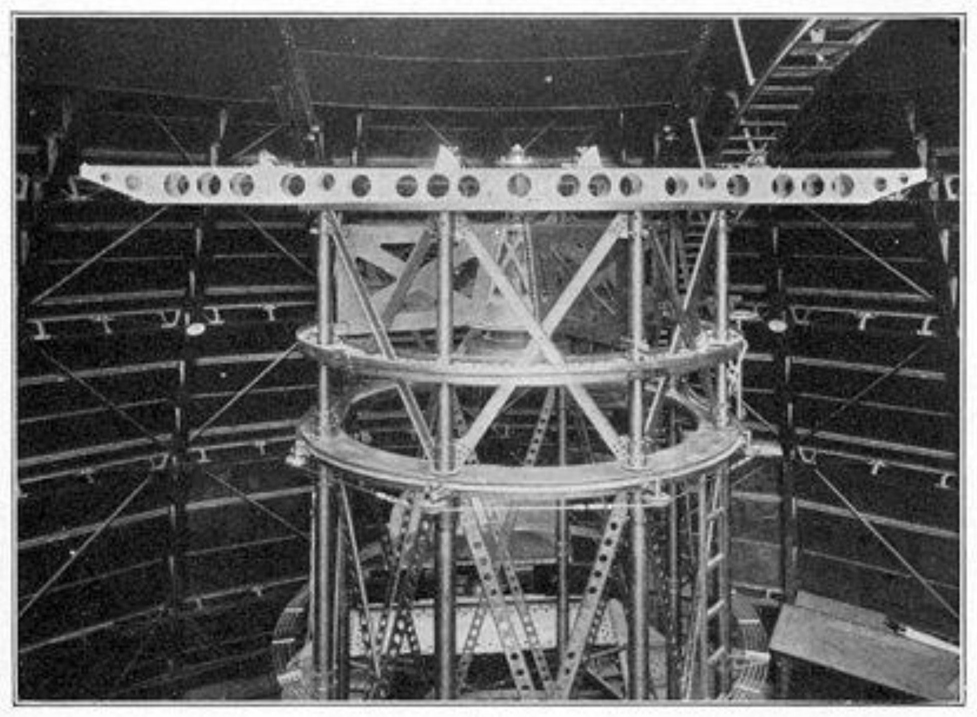
Your hosts

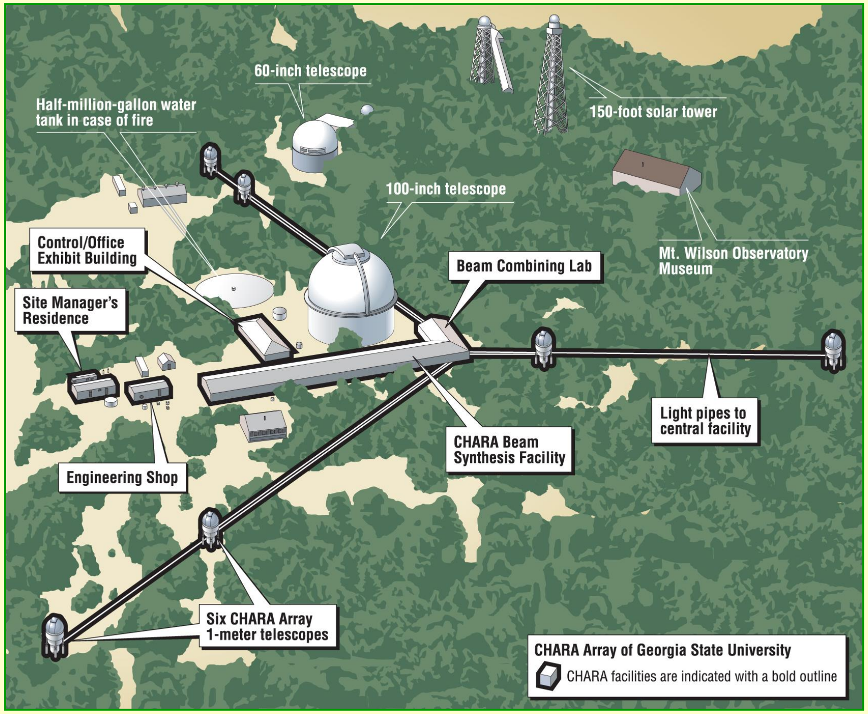
- **Douglas Gies**, CHARA Director, Dept. of Physics and Astronomy, Georgia State University, Atlanta, Georgia
- **Gail Schaefer**, Visitor Support Scientist, GSU CHARA Array, MWO, California
- **Noel Richardson**, Department of Physics and Astronomy, University of Toledo
- THANKS to University of Toledo and NSF!

GeorgiaStateUniversity NSF NOAO l'Observatoire de Paris LESIA NExScI NASA Exoplanet Science Institute SUSI Observatoire de la CÔTE d'AZUR UNIVERSITY OF EXETER

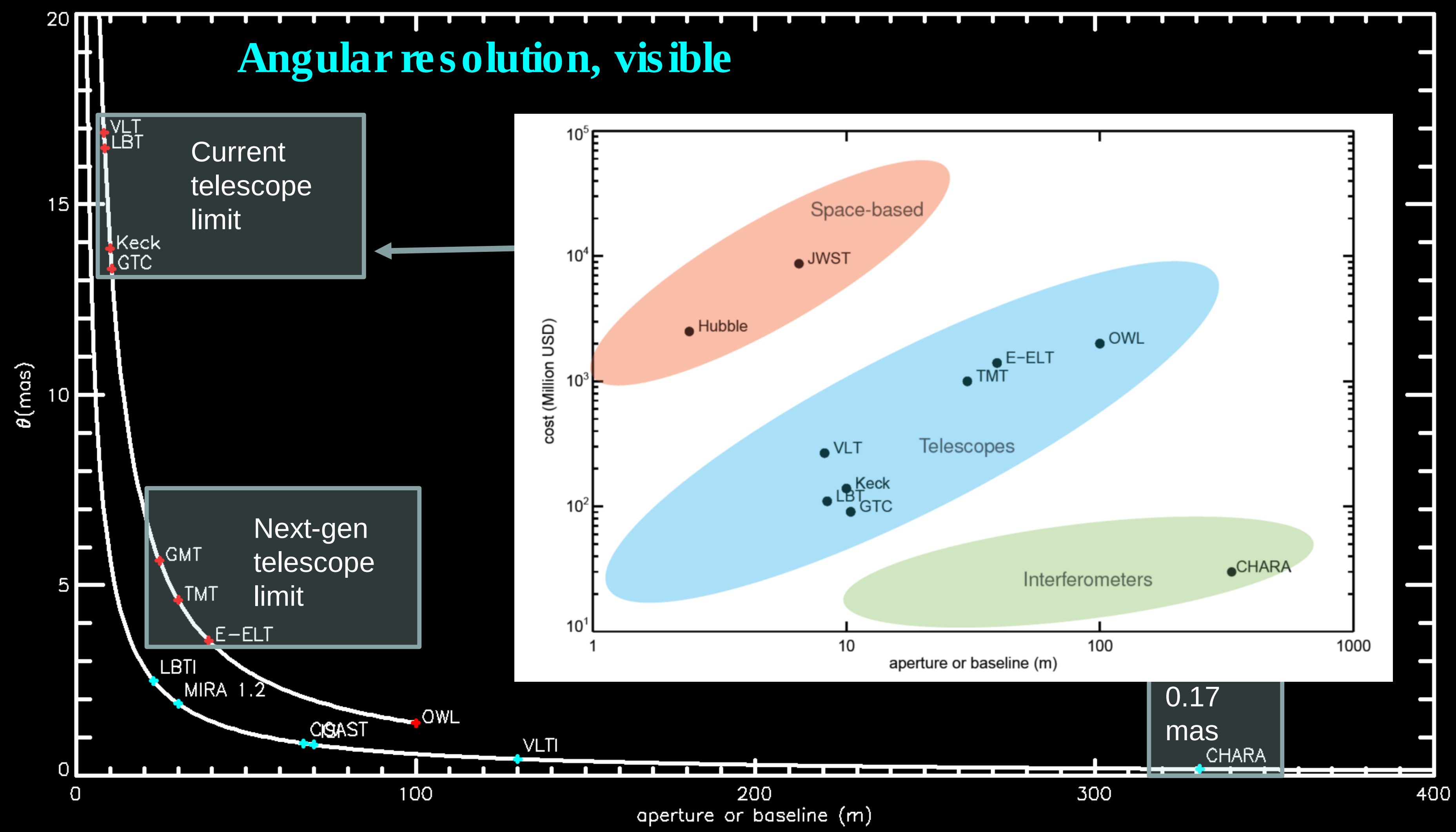
Stellar interferometry: measuring star size

- Michelson and Pease (1920): Betelgeuse
- Required technology (lasers, optics, computers)
- Culmination at Mount Wilson in CHARA Array: resolves most stars visible to human eye




60-inch telescope
150-foot solar tower
Half-million-gallon water tank in case of fire
100-inch telescope
Control/Office Exhibit Building
Beam Combining Lab
Mt. Wilson Observatory Museum
Site Manager's Residence
Light pipes to central facility
CHARA Beam Synthesis Facility
Engineering Shop
Six CHARA Array 1-meter telescopes
CHARA Array of Georgia State University
CHARA facilities are indicated with a bold outline

Angular resolution, visible



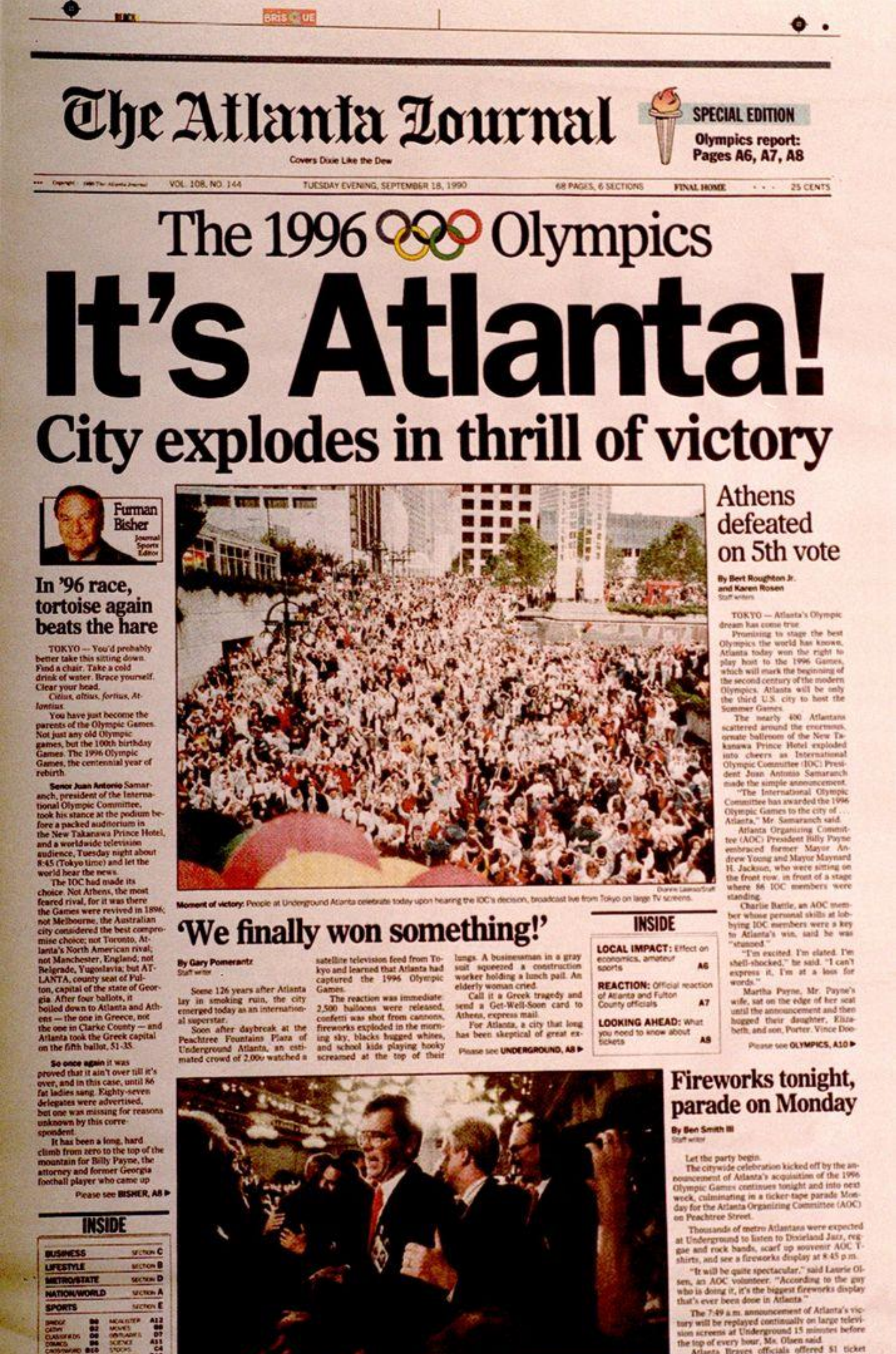
Current telescope limit

Next-gen telescope limit

0.17 mas

Workshop 2017-09-08

Resolving power of CHARA equivalent to seeing astronauts on the Moon ...



The Atlanta Journal

Covers Dixie Like the Dew

SPECIAL EDITION

Olympics report: Pages A6, A7, A8

VOL. 108, NO. 144 TUESDAY EVENING, SEPTEMBER 18, 1990 68 PAGES, 6 SECTIONS FINAL HOME 25 CENTS

The 1996 Olympics

It's Atlanta!

City explodes in thrill of victory

Furman Bisher
Journal Sports Editor

In '96 race, tortoise again beats the hare

TOKYO — You'd probably better take this sitting down. Find a chair. Take a cold drink of water. Brace yourself. Clear your head.

Citius, altius, fortius, Atlantius.

You have just become the parents of the Olympic Games. Not just any old Olympic games, but the 100th birthday Games. The 1996 Olympic Games, the centennial year of rebirth.

Senor Juan Antonio Samaranch, president of the International Olympic Committee, took his stance at the podium before a packed auditorium in the New Takanawa Prince Hotel, and a worldwide television audience, Tuesday night about 8:45 (Tokyo time) and let the world hear the news.

The IOC had made its choice. Not Athens, the most feared rival, for it was there the Games were revived in 1896; not Melbourne, the Australian city considered the best compromise choice; not Toronto, Atlanta's North American rival; not Manchester, England; not Belgrade, Yugoslavia; but ATLANTA, county seat of Fulton, capital of the state of Georgia. After four ballots, it boiled down to Atlanta and Athens — the one in Greece, not the one in Clarke County — and Atlanta took the Greek capital on the fifth ballot, 51-35.

So once again it was proved that it ain't over till it's over, and in this case, until 86 fat ladies sang. Eighty-seven delegates were advertised, but one was missing for reasons unknown by this correspondent.

It has been a long, hard climb from zero to the top of the mountain for Billy Payne, the attorney and former Georgia football player who came up

Please see **BISHER, A8** ▶

INSIDE

BUSINESS	SECTION C
LIFESTYLE	SECTION B
METRO/STATE	SECTION D
NATION/WORLD	SECTION A
SPORTS	SECTION E

Duane Lawson/Staff

Moment of victory: People at Underground Atlanta celebrate today upon hearing the IOC's decision, broadcast live from Tokyo on large TV screens.

'We finally won something!'

By Gary Pomerantz
Staff writer

Some 126 years after Atlanta lay in smoking ruin, the city emerged today as an international superstar.

Soon after daybreak at the Peachtree Fountains Plaza of Underground Atlanta, an estimated crowd of 2,000 watched a satellite television feed from Tokyo and learned that Atlanta had captured the 1996 Olympic Games.

The reaction was immediate: 2,500 balloons were released, confetti was shot from cannons, fireworks exploded in the morning sky, blacks hugged whites, and school kids playing hooky screamed at the top of their lungs. A businessman in a gray suit squeezed a construction worker holding a lunch pail. An elderly woman cried.

Call it a Greek tragedy and send a Get-Well-Soon card to Athens, express mail.

For Atlanta, a city that long has been skeptical of great ex-

Please see **UNDERGROUND, A8** ▶

INSIDE

LOCAL IMPACT: Effect on economics, amateur sports A6

REACTION: Official reaction of Atlanta and Fulton County officials A7

LOOKING AHEAD: What you need to know about tickets A8

Athens defeated on 5th vote

By Bert Roughton Jr. and Karen Rosen
Staff writers

TOKYO — Atlanta's Olympic dream has come true.

Promising to stage the best Olympics the world has known, Atlanta today won the right to play host to the 1996 Games, which will mark the beginning of the second century of the modern Olympics. Atlanta will be only the third U.S. city to host the Summer Games.

The nearly 400 Atlantans scattered around the enormous, ornate ballroom of the New Takanawa Prince Hotel exploded into cheers as International Olympic Committee (IOC) President Juan Antonio Samaranch made the simple announcement.

"The International Olympic Committee has awarded the 1996 Olympic Games to the city of . . . Atlanta," Mr. Samaranch said.

Atlanta Organizing Committee (AOC) President Billy Payne embraced former Mayor Andrew Young and Mayor Maynard H. Jackson, who were sitting on the front row, in front of a stage where 86 IOC members were standing.

Charlie Battle, an AOC member whose personal skills at lobbying IOC members were a key to Atlanta's win, said he was "stunned."

"I'm excited. I'm elated. I'm shell-shocked," he said. "I can't express it. I'm at a loss for words."

Martha Payne, Mr. Payne's wife, sat on the edge of her seat until the announcement and then hugged their daughter, Elizabeth, and son, Porter. Vince Doo-

Please see **OLYMPICS, A10** ▶

Fireworks tonight, parade on Monday

By Ben Smith III
Staff writer

Let the party begin.

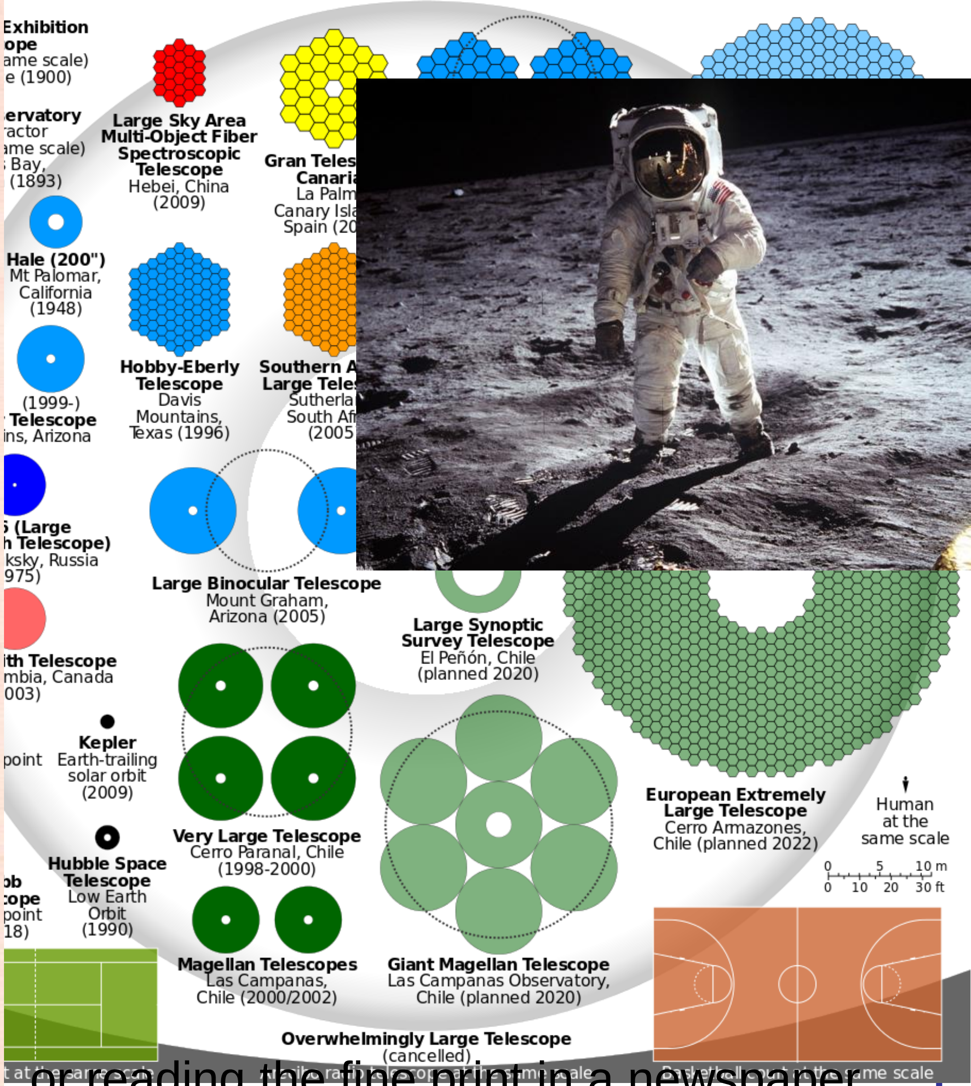
The citywide celebration kicked off by the announcement of Atlanta's acquisition of the 1996 Olympic Games continues tonight and into next week, culminating in a ticker-tape parade Monday for the Atlanta Organizing Committee (AOC) on Peachtree Street.

Thousands of metro Atlantans were expected at Underground to listen to Dixieland Jazz, reggae and rock bands, scarf up souvenir AOC T-shirts, and see a fireworks display at 8:45 p.m.

"It will be quite spectacular," said Laurie Olsen, an AOC volunteer. "According to the guy who is doing it, it's the biggest fireworks display that's ever been done in Atlanta."

The 7:49 a.m. announcement of Atlanta's victory will be replayed continually on large television screens at Underground 15 minutes before the top of every hour, Ms. Olsen said.

Atlanta Braves officials offered $1 ticket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Kepler
Earth-trailing solar orbit (2009)
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Hubble Space Telescope
Low Earth Orbit (1990)
Large Sky Area Multi-Object Fiber Spectroscopic Telescope
Hebei, China (2009)
Gran Teles
Canaria
La Palm
Canary Isla
Spain (20
Hobby-Eberly Telescope
Davis Mountains, Texas (1996)
Southern A
Large Teles
Sutherla
South Af
(2005
Large Binocular Telescope
Mount Graham, Arizona (2005)
Large Synoptic Survey Telescope
El Peñón, Chile (planned 2020)
Very Large Telescope
Cerro Paranal, Chile (1998-2000)
Magellan Telescopes
Las Campanas, Chile (2000/2002)
Giant Magellan Telescope
Las Campanas Observatory, Chile (planned 2020)
European Extremely Large Telescope
Cerro Armazones, Chile (planned 2022)
Human at the same scale
0 5 10 m
0 10 20 30 ft
Overwhelmingly Large Telescope
(cancelled)
t at the same scale
Arecibo radio telescope at the same scale
Basketball court at the same scale

or reading the fine print in a newspaper from across the country

The CHARA Legacy of Prof. Hal McAlister

Founded in 1984 GSU Center for High Angular Resolution Astronomy with goal to build a world-class instrument.

Realized with the CHARA Array, the best of its kind in the world.

Ground breaking July 13, 1996.

First “fringe” November 1999.

Scientific observations since 2004.

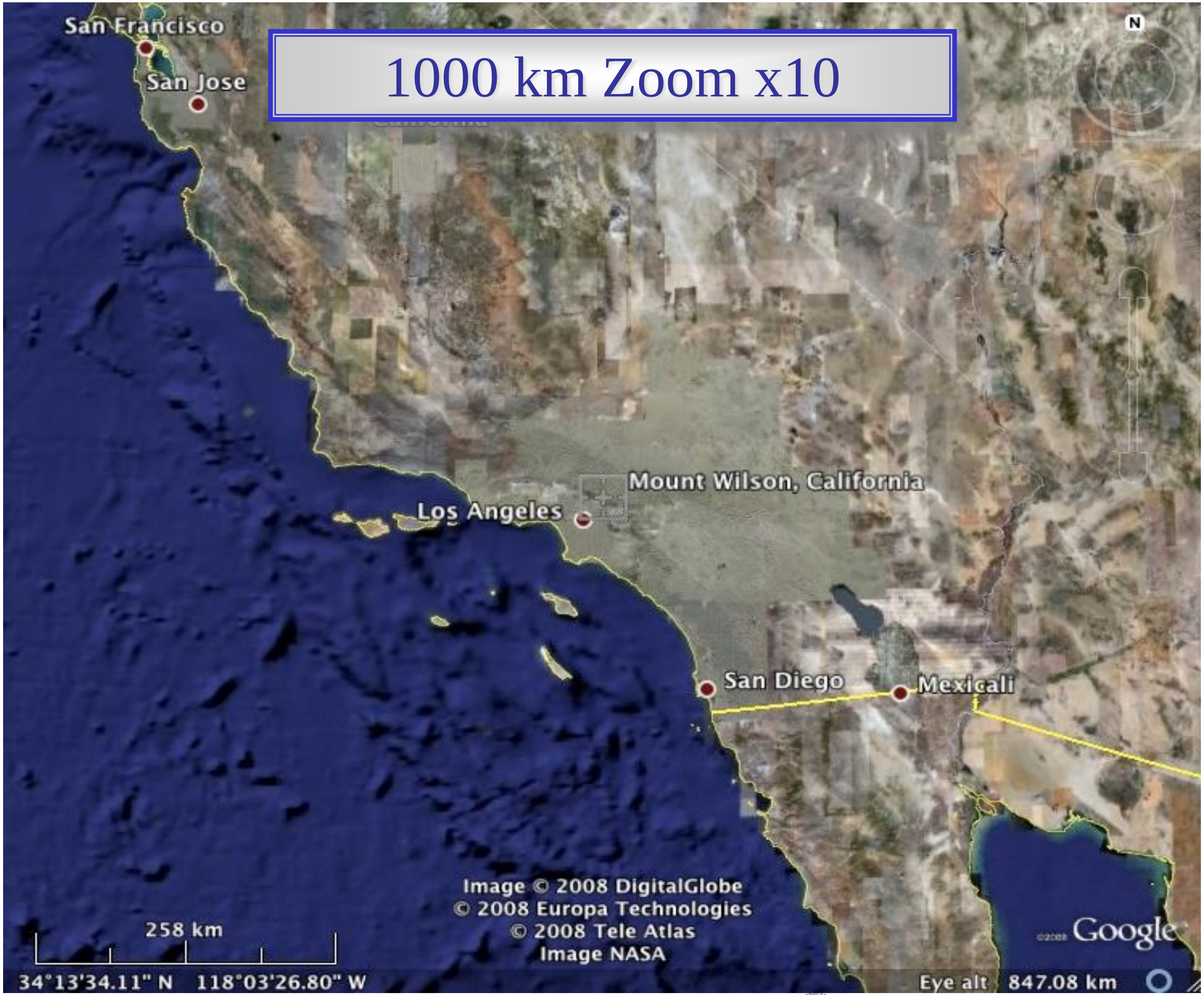
Hal retired (Aug 2015), now emeritus professor at GSU.

10000 km

N
W
E
S
Image © 2005 EarthSat
©2005 Google
Pointer 33°08'16.94" N 108°28'03.21" W
Streaming |||||||||| 100%
Eye alt 4014.55 mi

VLBA spans the Earth and has the highest angular resolution of any observatory

1000 km Zoom x10


San Francisco
San Jose
Mount Wilson, California
Los Angeles
San Diego
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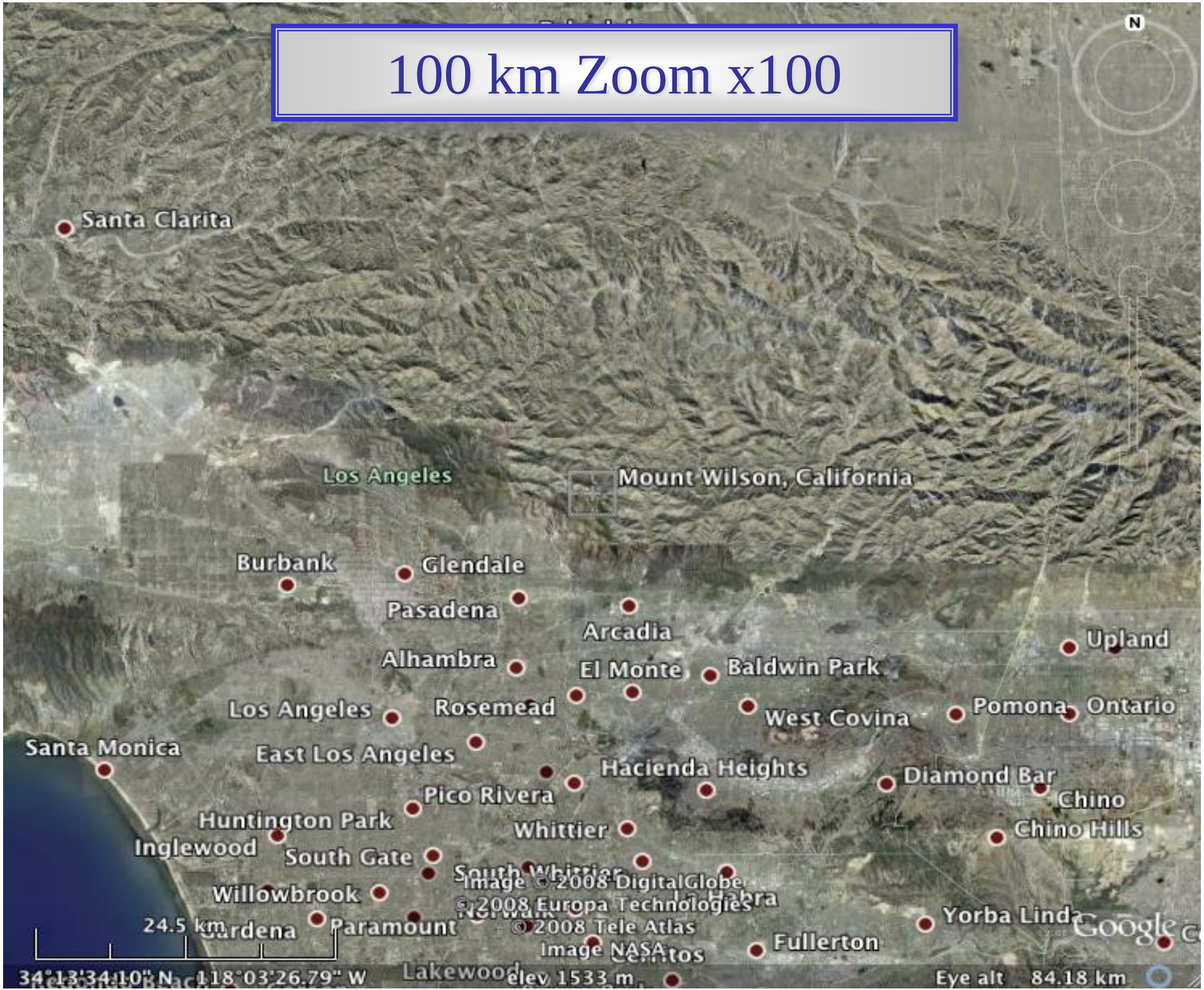
N
258 km
34°13'34.11" N 118°03'26.80" W
Eye alt 847.08 km
Google

Image © 2008 DigitalGlobe
© 2008 Europa Technologies
© 2008 Tele Atlas
Image NASA

100 km Zoom x100

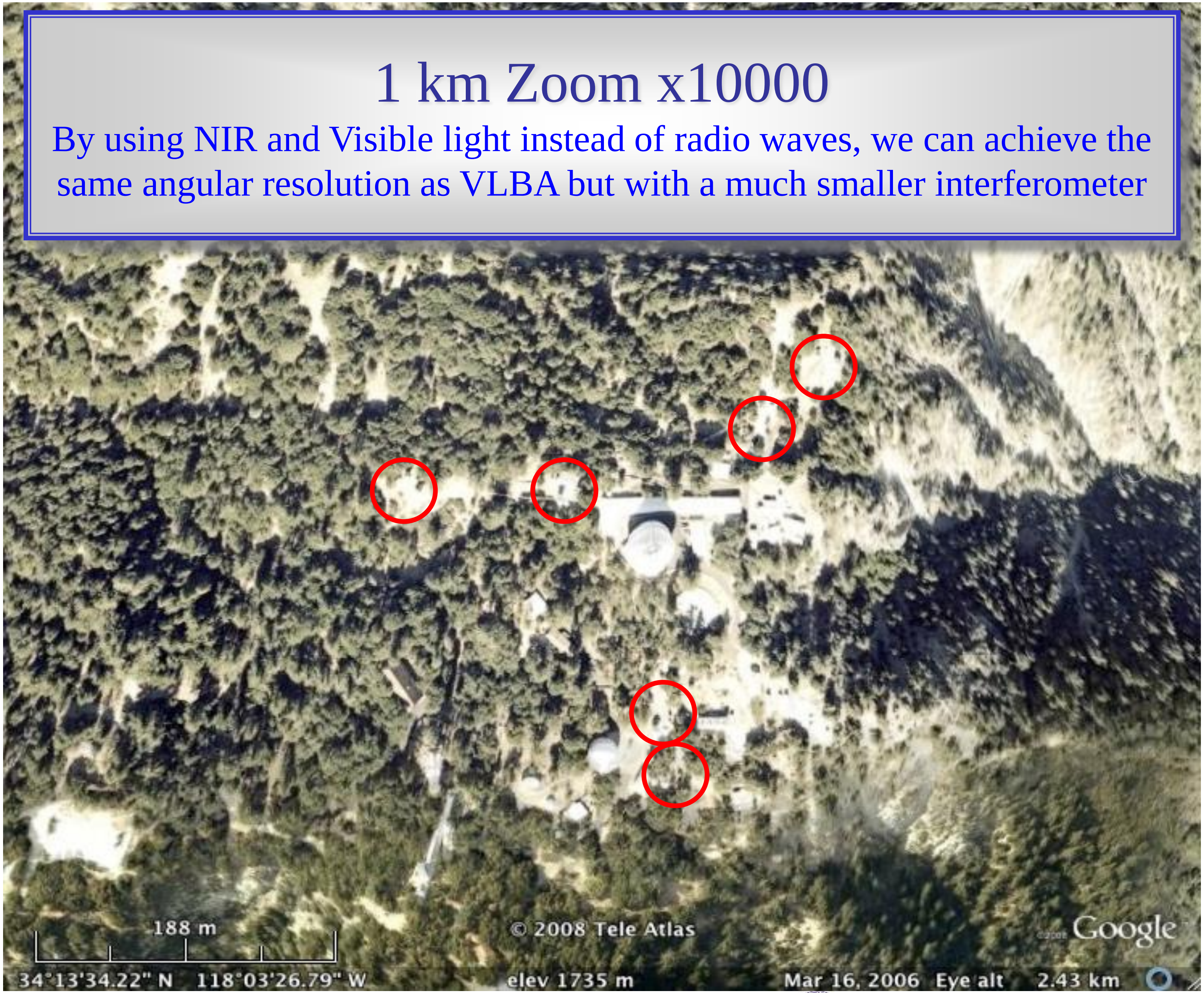

N
Santa Clarita
Los Angeles
Mount Wilson, California
Burbank
Glendale
Pasadena
Arcadia
Upland
Alhambra
El Monte
Baldwin Park
Los Angeles
Rosemead
West Covina
Pomona
Ontario
Santa Monica
East Los Angeles
Hacienda Heights
Diamond Bar
Chino
Pico Rivera
Huntington Park
Whittier
Chino Hills
Inglewood
South Gate
South Whittier
Willowbrook
La Habra
Norwalk
Yorba Linda
24.5 km
Gardena
Paramount
Fullerton
Cerritos
Lakewood
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
© 2008 Tele Atlas
Image NASA
Google
34°13'34.10" N 118°03'26.79" W
elev 1533 m
Eye alt 84.18 km

10 km Zoom x1000

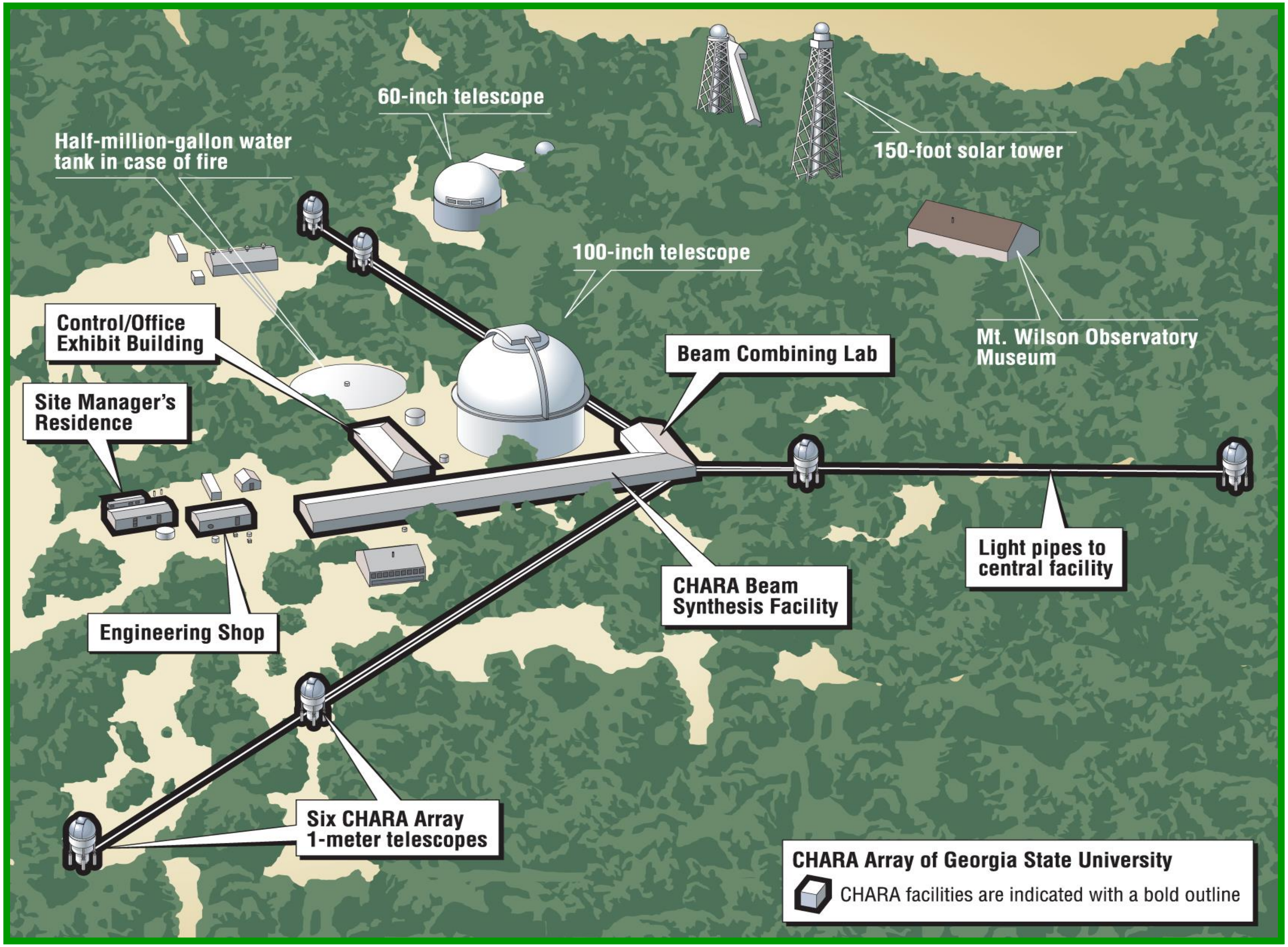
Mount Wilson, California
2808 m
© 2008 Tele Atlas
Google
34°13'34.17" N 118°03'26.79" W
elev 1727 m
Eye alt 10.07 km

1 km Zoom x10000

By using NIR and Visible light instead of radio waves, we can achieve the same angular resolution as VLBA but with a much smaller interferometer


188 m
© 2008 Tele Atlas
Google
34°13'34.22" N 118°03'26.79" W
elev 1735 m
Mar 16, 2006 Eye alt 2.43 km

Layout of the CHARA Array


60-inch telescope
150-foot solar tower
Half-million-gallon water tank in case of fire
100-inch telescope
Control/Office Exhibit Building
Beam Combining Lab
Mt. Wilson Observatory Museum
Site Manager's Residence
Light pipes to central facility
CHARA Beam Synthesis Facility
Engineering Shop
Six CHARA Array 1-meter telescopes
CHARA Array of Georgia State University
CHARA facilities are indicated with a bold outline

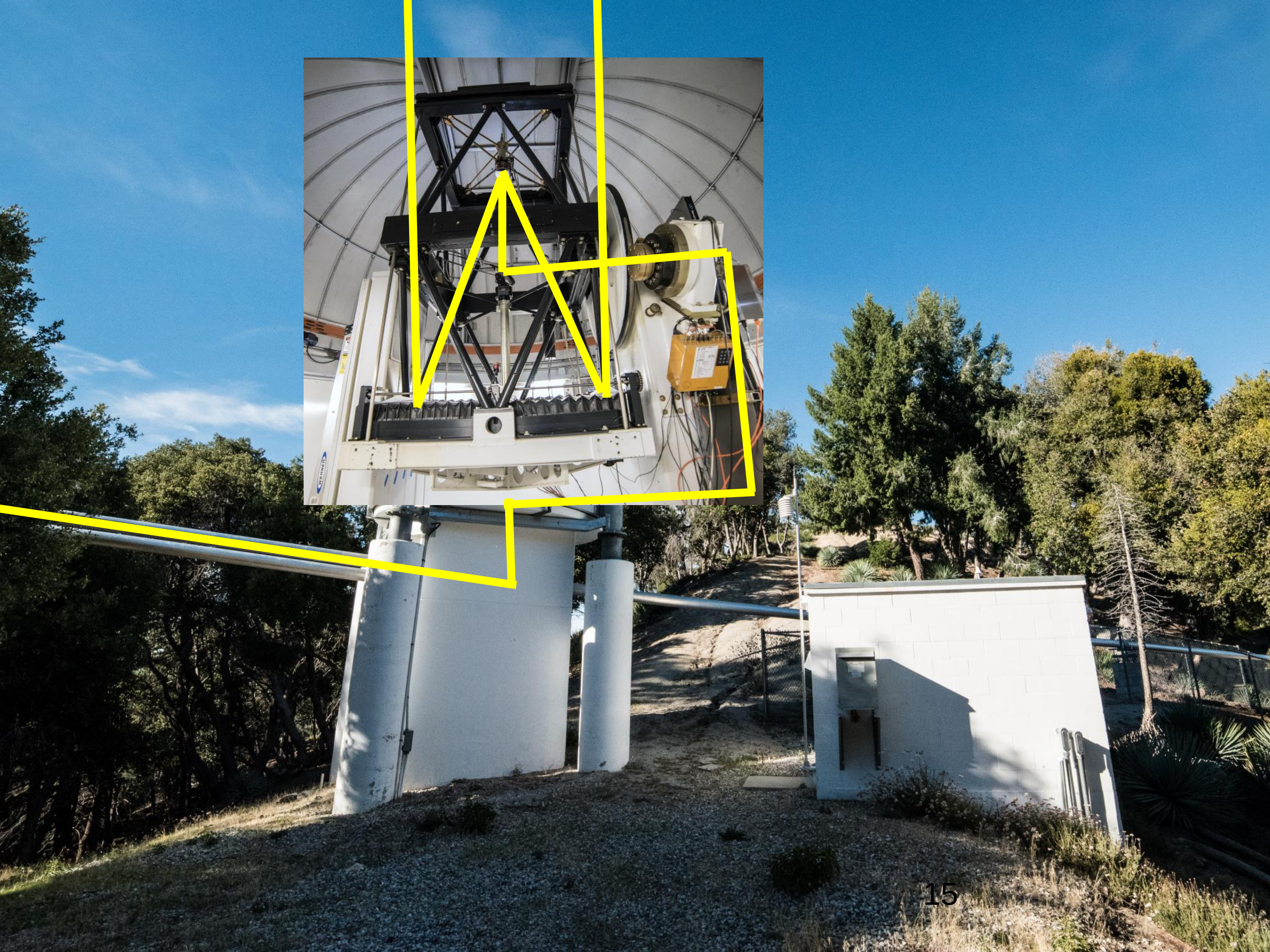
A short visit to Mount Wilson

Telescopes

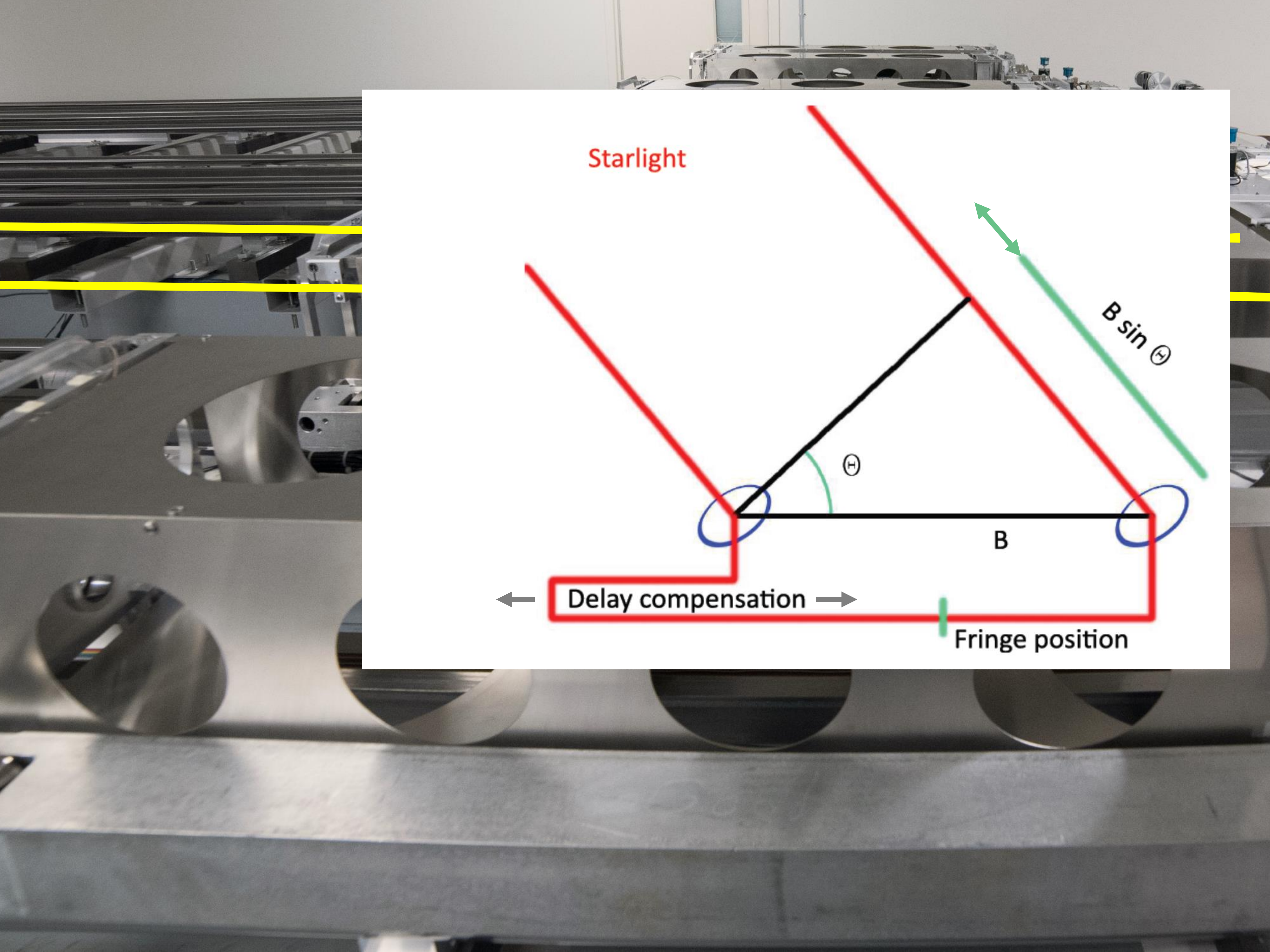
CAD by Laszlo

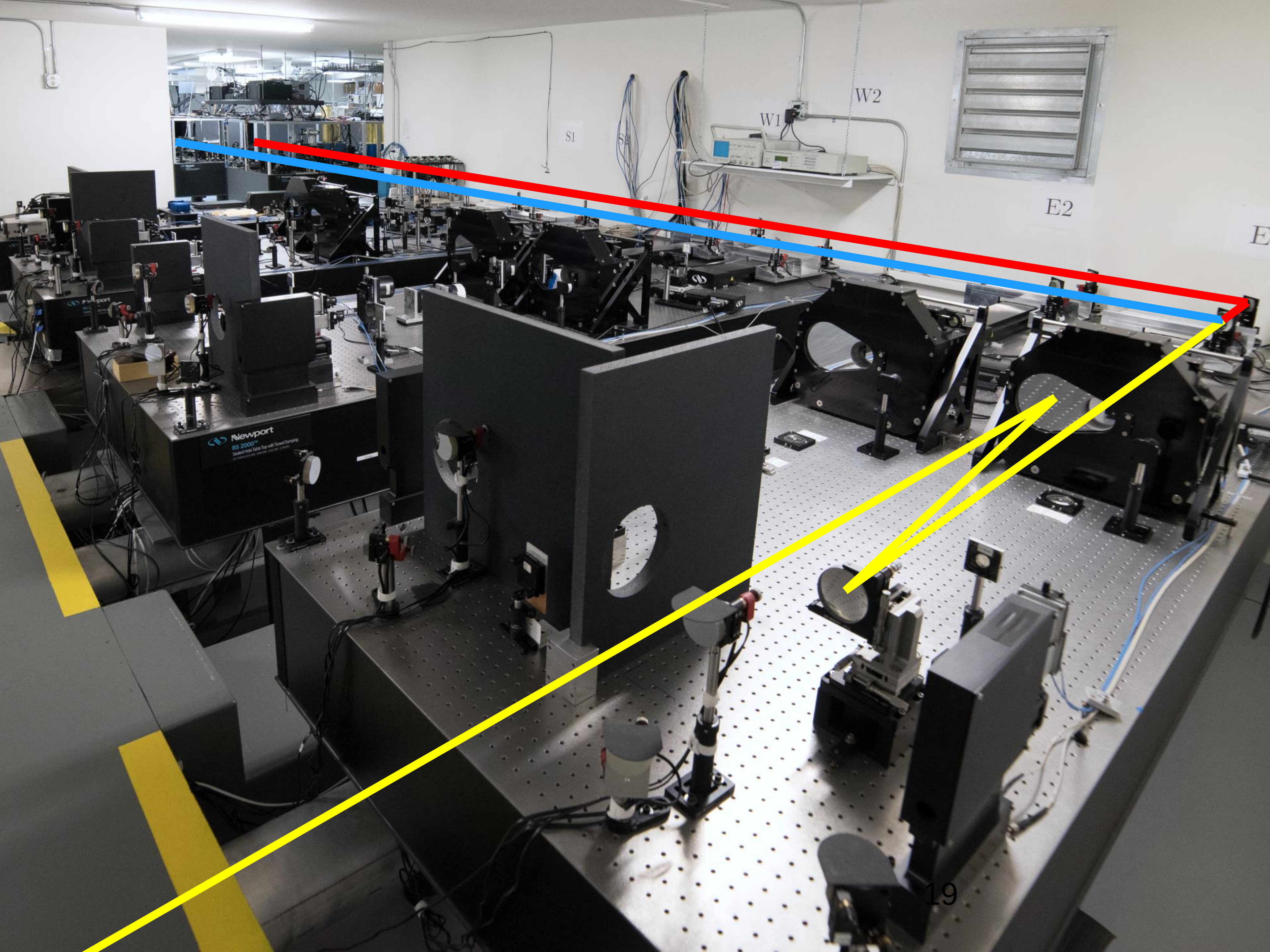
Photo by Steve Golden

~6 ft



Vacuum Light Tubes Feed Light from Each Telescope to the Central Lab


Starlight
B sin Θ
Θ
B
Delay compensation
Fringe position


W2
W1
S1
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E2
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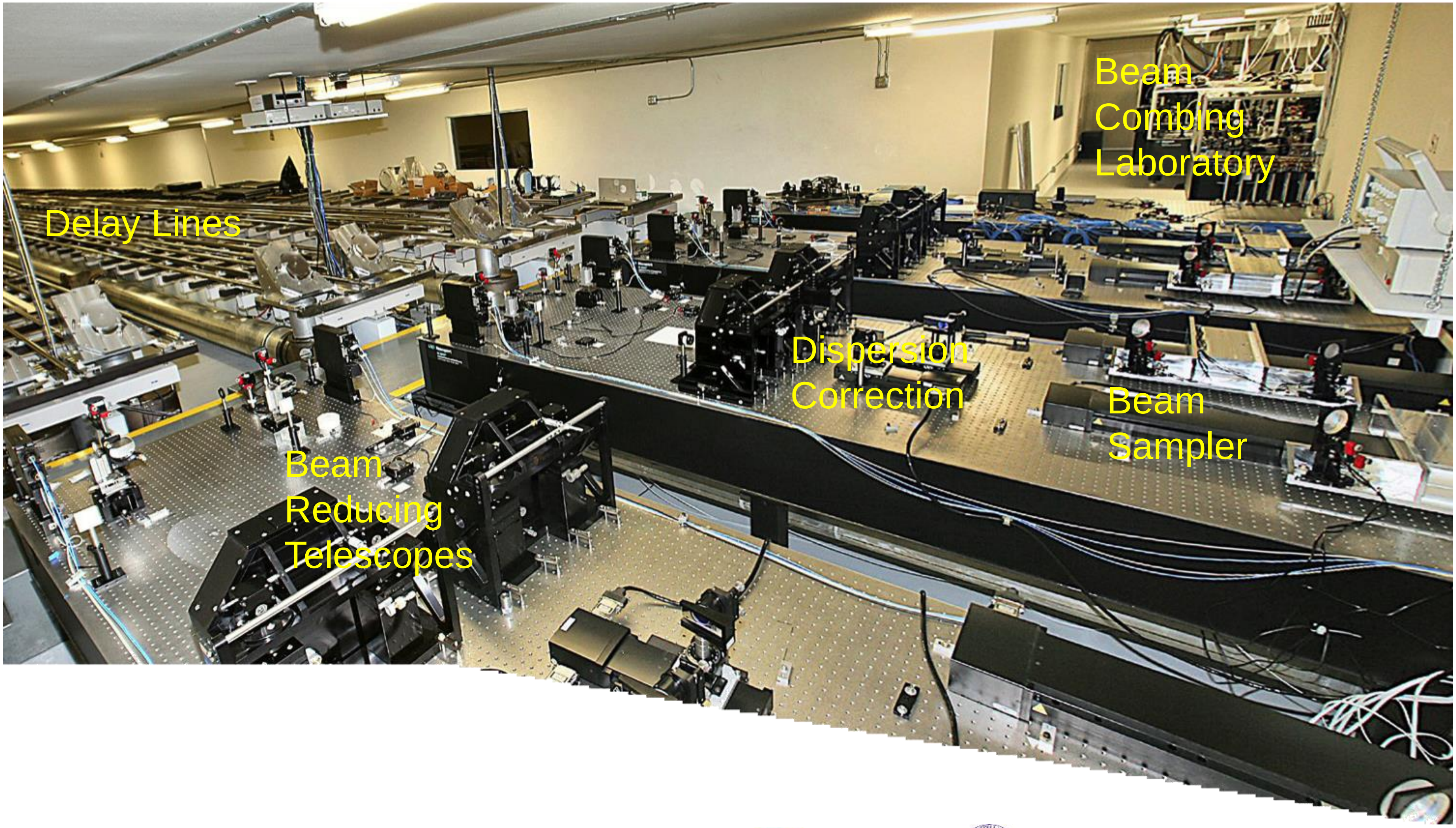
Newport
RS 2000

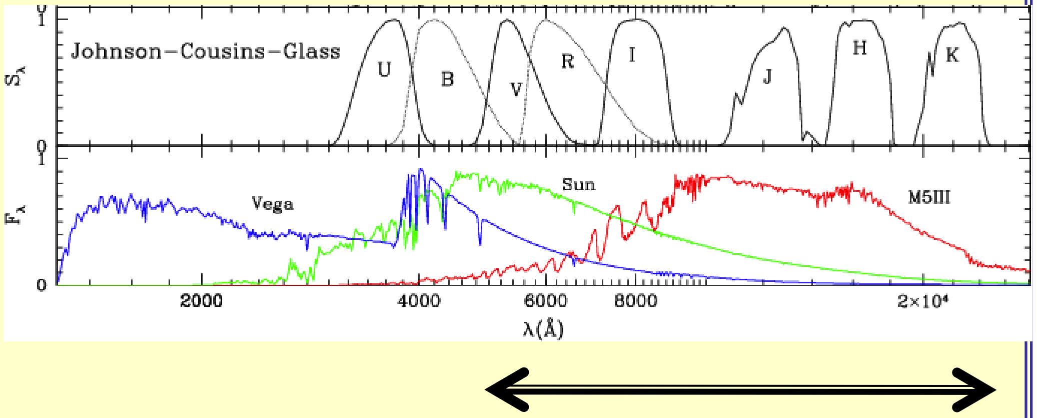
Optics Laboratory


Beam
Combing
Laboratory
Delay Lines
Dispersion
Correction
Beam
Sampler
Beam
Reducing
Telescopes

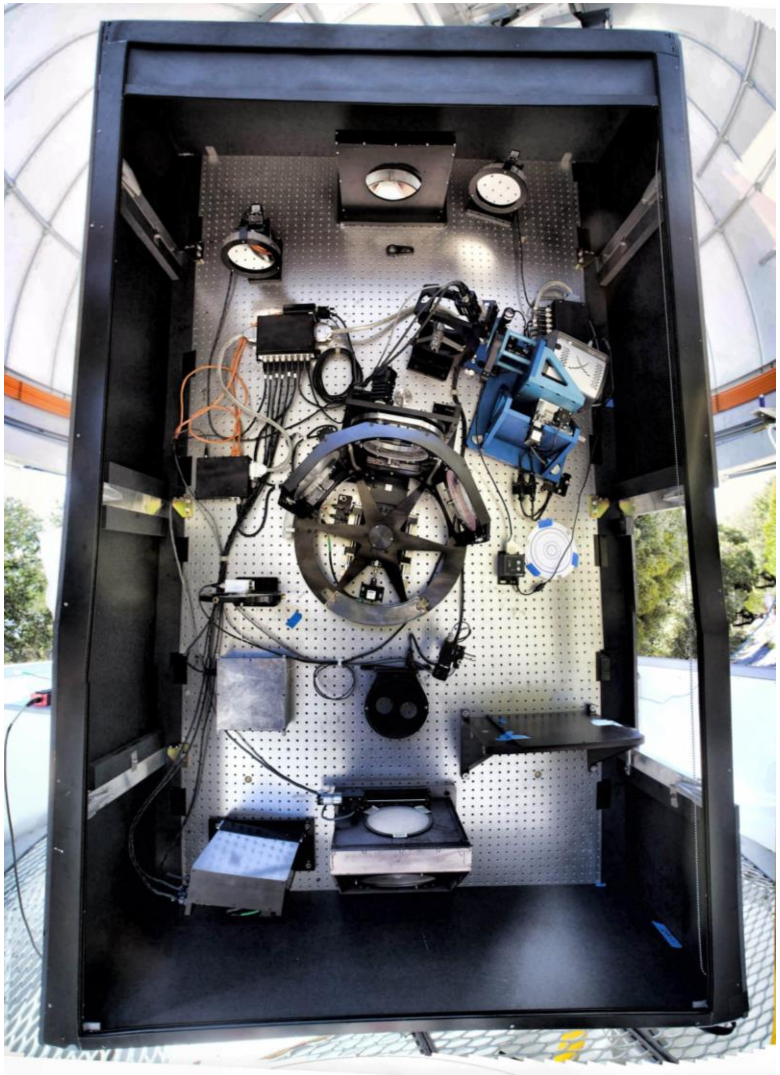
The 30 second CHARA tour.

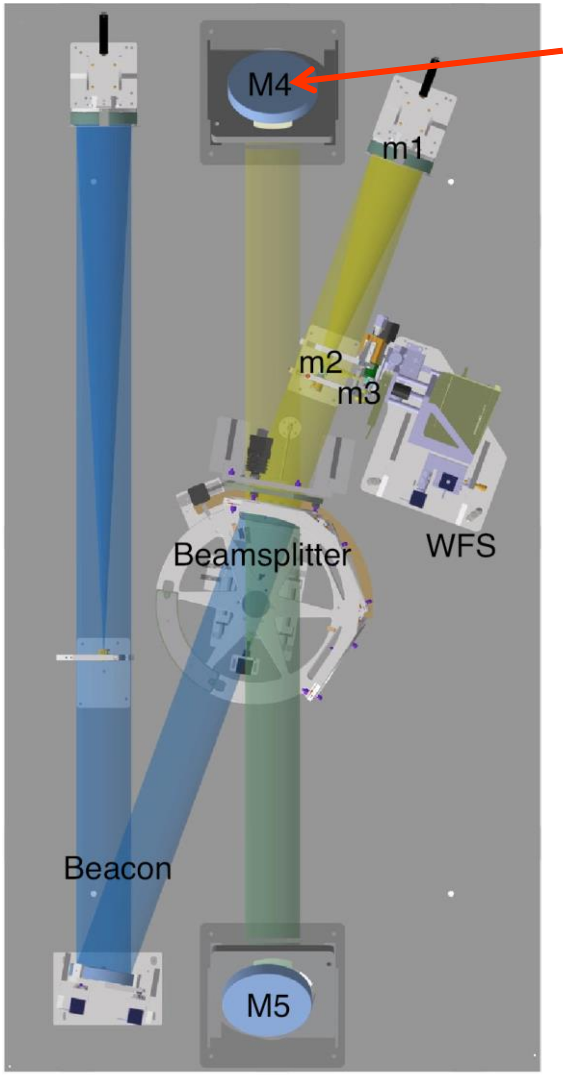
Beam Combiners: 0.5 - 2.2 microns

- *Classic (GSU)*
  2-tel open-air J,H,K
- *CLIMB (GSU)*
  Dual 3-tel open-air J,H,K
- *JouFLUOR (Paris)*
  2-tel fiber-based K band
- *MIRC (Michigan)*
  6-tel fiber-based imager H
- *VEGA (Nice)*
  4-tel open-air V,R,I R=6000, 30000
- *PAVO (Sydney)*
  2-tel aperture-plane V,R,I
- *In progress: AO plus MIRCX, MYSTIC, SPICA*



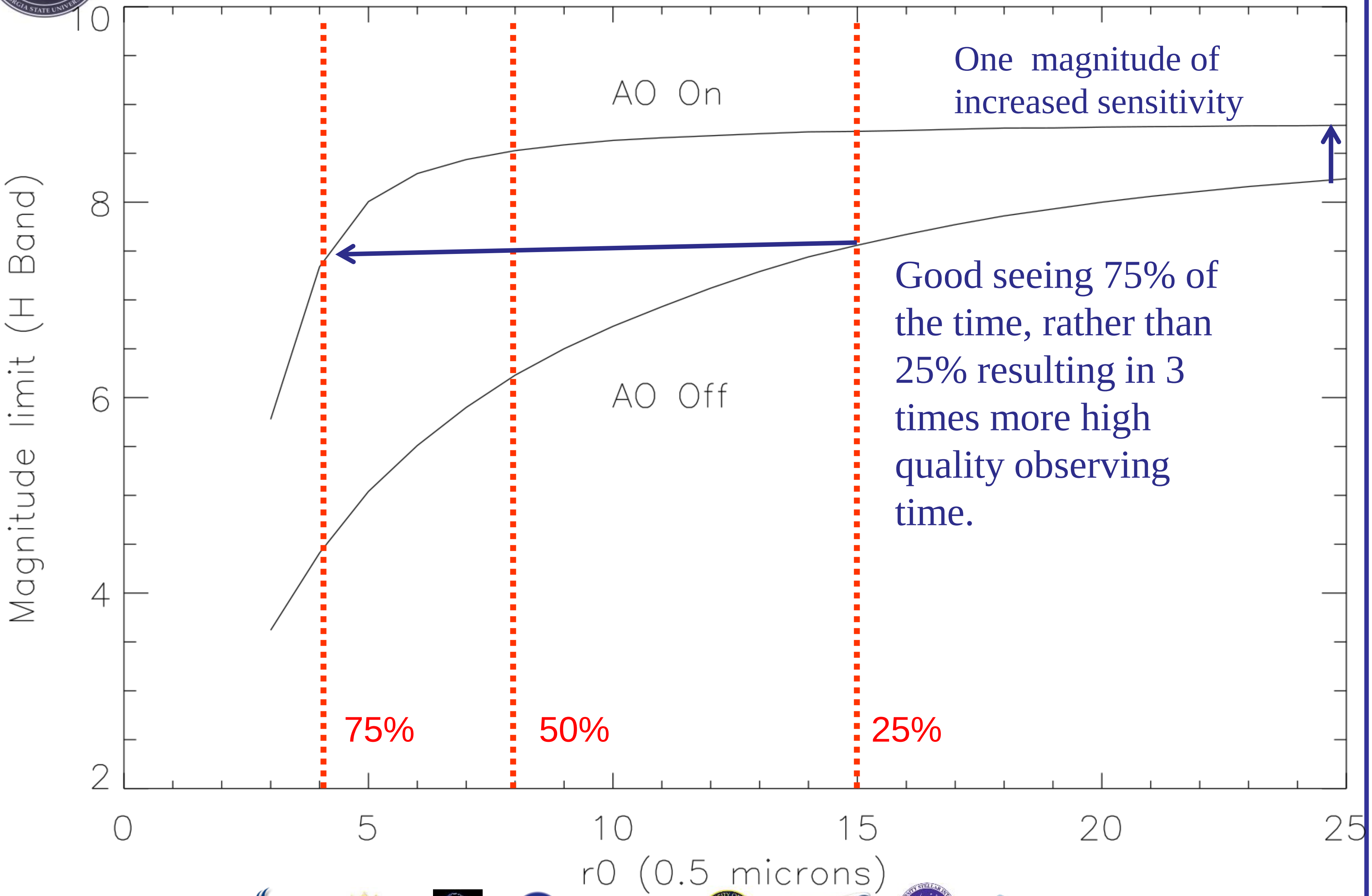
CHARA-AO: Telescopes and Lab




M4
m1
m2
m3
Beamsplitter
WFS
Beacon
M5

We will replace M4 with a deformable mirror at each telescope. This will enable us to correct for atmospheric seeing and increase scientific throughput.

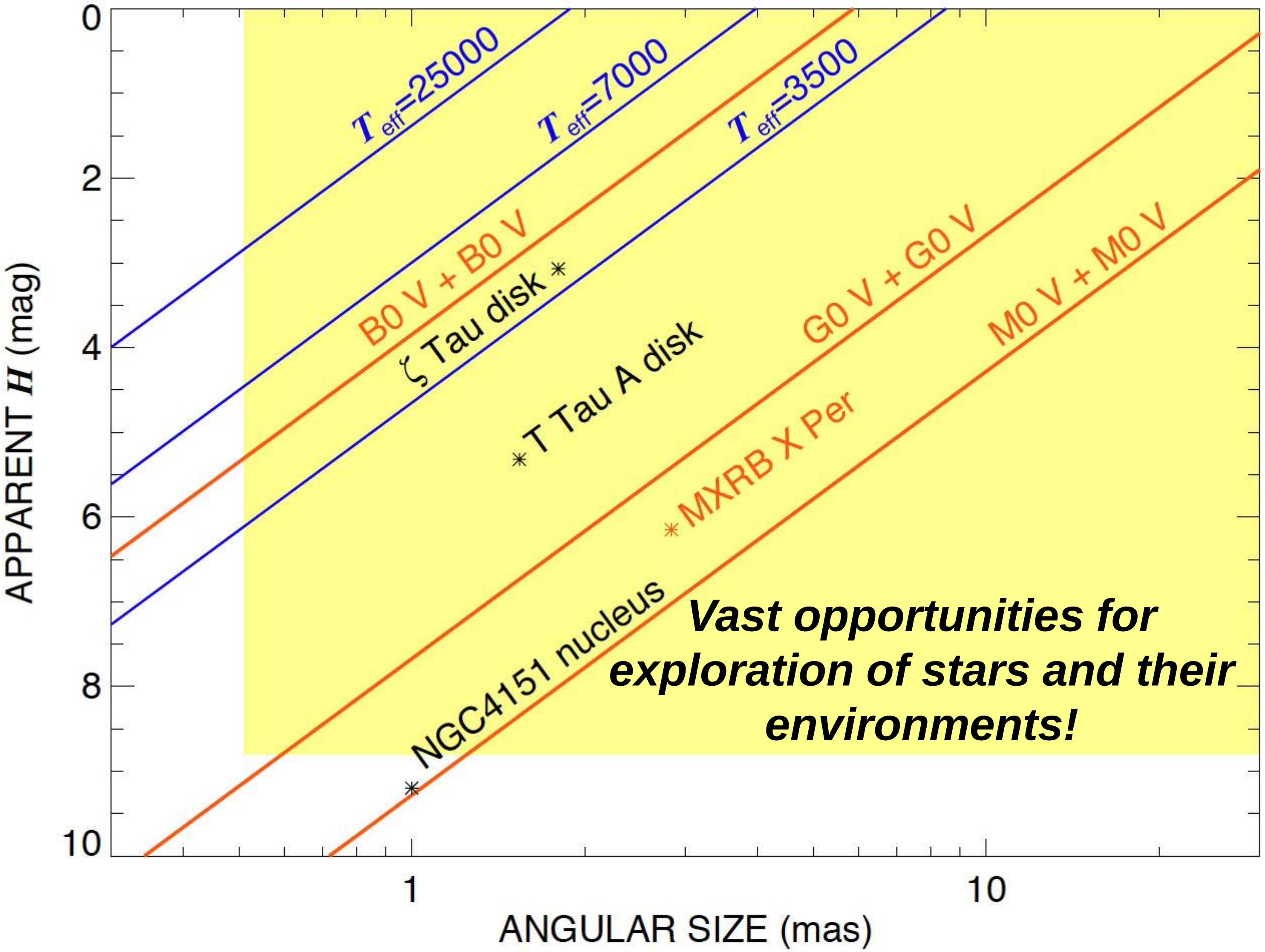
Introduction of Adaptive Optics Underway



One magnitude of increased sensitivity

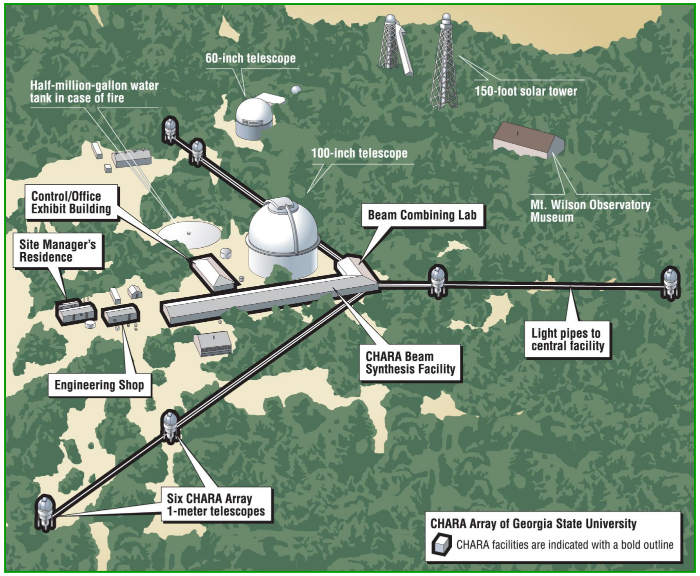
Good seeing 75% of the time, rather than 25% resulting in 3 times more high quality observing time.

Working limits for Classic BC: stellar diameters, disk diameters, binary star separations (P=10d)



Vast opportunities for exploration of stars and their environments!

Other Long Baseline Interferometers


60-inch telescope
Half-million-gallon water tank in case of fire
150-foot solar tower
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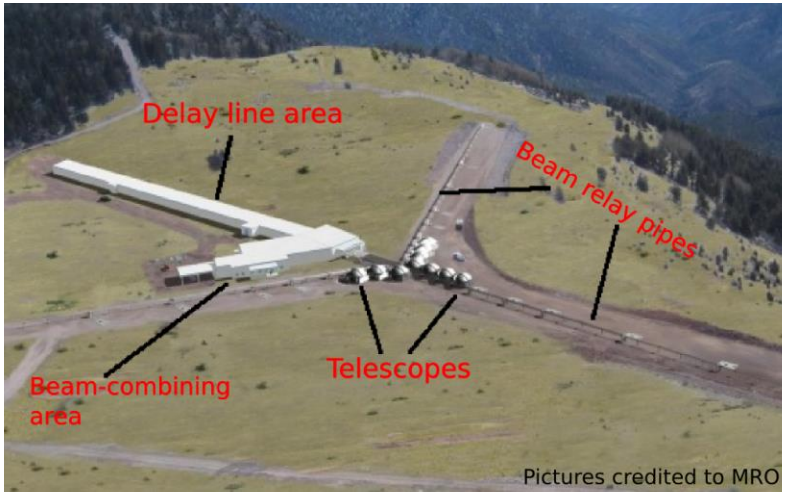
CHARA


Delay line area
Beam relay pipes
Telescopes
Beam-combining area
Pictures credited to MRO

MROI (under construction)

NPOI

VLTI

Goal: provide background for you to propose observations with the CHARA Array.

Morning Program

Time	Topic	Speaker
11:00	Overview of the CHARA Array	Douglas Gies
11:30	Interferometry & Science Review	Gail Schaefer
12:10	Applying for time at CHARA	Douglas Gies
12:40	Applying for time at VLTI	Jean-Baptiste Le Bouquin
1:00	Lunch	

Afternoon Program

Time	Topic	Speaker
2:00	Observing strategies and planning software	Gail Schaefer
2:20	Data format and modeling/imaging software	Gail Schaefer
2:40	*Science topic:* Imaging results with MIRC	John Monnier
3:00	*Science topic:* Massive stars	Noel Richardson
3:20	*Science topic:* Disk physics	Aaron Sigut
3:40	Open discussion	All
4:00	Optional visit to Ritter Observatory	Noel Richardson

CHARA Research
Sponsored by

National Science Foundation
GSU College of Arts & Sciences
plus resources obtained
by the
CHARA Collaboration Members

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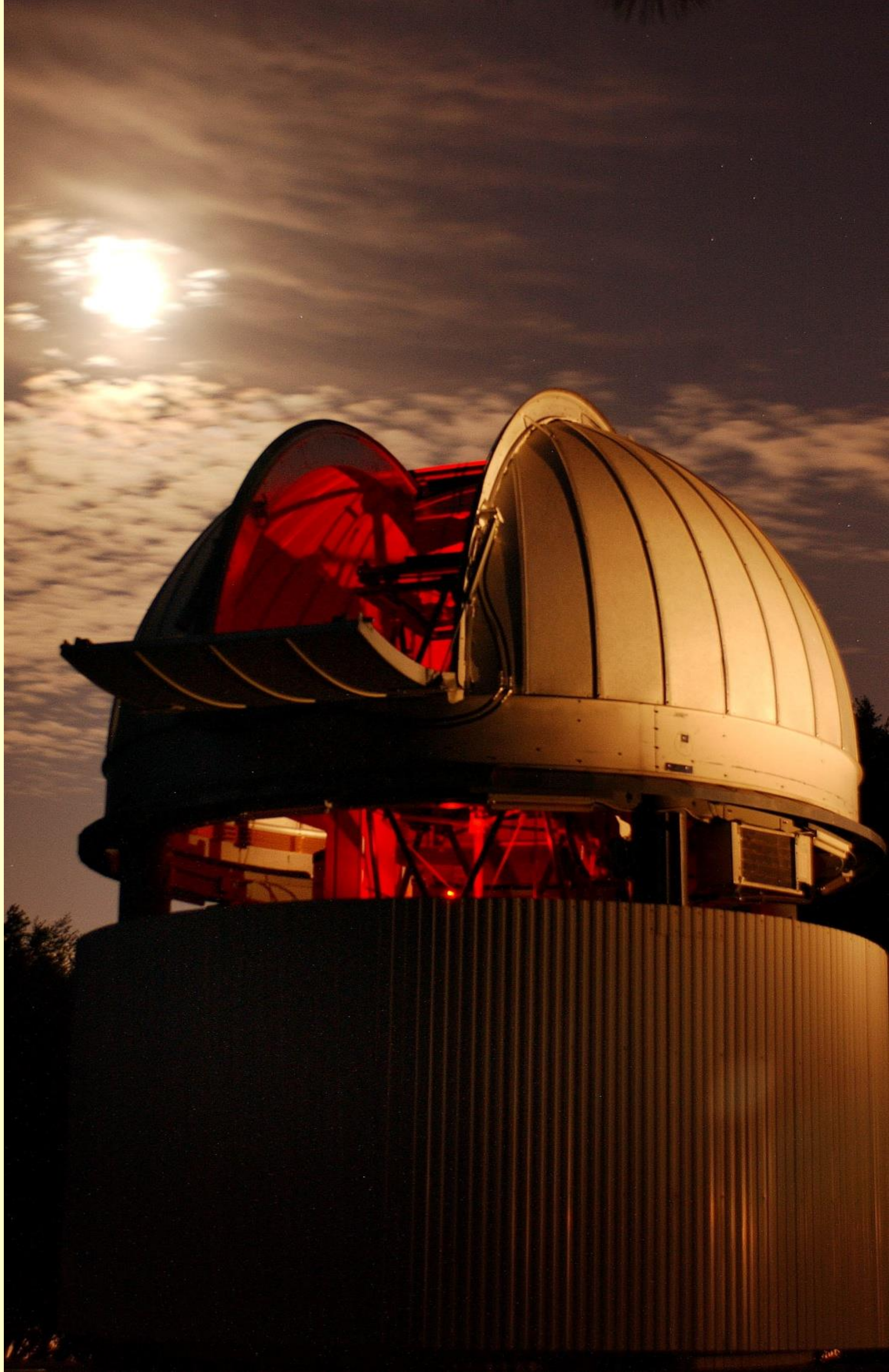www.chara.gsu.edu