Future Plans For the CHARA Array

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CHARA Planning

1 Imagining the Future

2 Science Goals

3 Telescopes, Sites, Beam Transport

4 OPLE, BCL, Combiners

5 The Way Forward

1 Imagining the Future

- What will be the role of the CHARA Array in the next decade?
- Future funding support from NSF will be influenced by recommendations of the Astro2020 review (next discussion)
- Relation to plans for NPOI, MROI, VLTI, Planet Formation Imager
  Monnier et al. 2018 arXiv:1807.11559
  http://www.planetformationimager.eu/Planet_Formation_Imager_Project/Home.html
- Build on current strength and support from
  GSU, NSF, and our user community

Ground work for discussion

- *Future of optical-infrared interferometry in Europe*
  Pott & Surdej 2018, Experimental Astron., 46, 381
- CHARA Futures Meeting, Sept. 22, 2017
  http://www.chara.gsu.edu/internal-meetings/futures-2017
- *High Angular Resolution Universe*
  Gail Schaefer's presentation at NOAO Workshop, February, 2018
  https://www.noao.edu/meetings/2020decadal/#agenda
- CHARA/SPICA Science Group meeting, January 2019, Nice,
  Organized by Denis Mourard and Nicolas Nardetto.
  Especially development of plans in relation to PLATO mission
  https://chara-spica-ws.sciencesconf.org/

Guidelines for discussion

- Build on current strengths
- Use our infrastructure at Mount Wilson Observatory
- Consider new components that work together with current telescopes and/or combiners for new capability
- Consider plans that can be accomplished on a 5 to 10 year time scale

2 Science Goals

- Important science drivers in contemporary astrophysics
- Stellar imaging as CHARA specialty;
  follows community path in radio astronomy (ALMA)
- Fundamental parameters and exoplanet hosts
- Environments: YSOs, mass loss processes
- AGN: work by Matt Anderson and Makoto Kishimoto
- Needs: angular and spectral resolution, wavelength domains, sensitivity

***** DISCUSSION *****

3 Telescopes, Sites, Beam Transport

- Beam transport: light tubes or fiber optics? critical choice for sites in direct line of sight
- ‘OHANA Iki project at Mauna Kea Woillez et al. 2017, A&A, 602, A116
- Demonstration using 300 m long fibers (now at CHARA) for *J* and *H* bands
- Fiber issues: star light injection, wavelength range, transmission, dispersion, polarization, protection from the environment (Labadie et al. 2016)

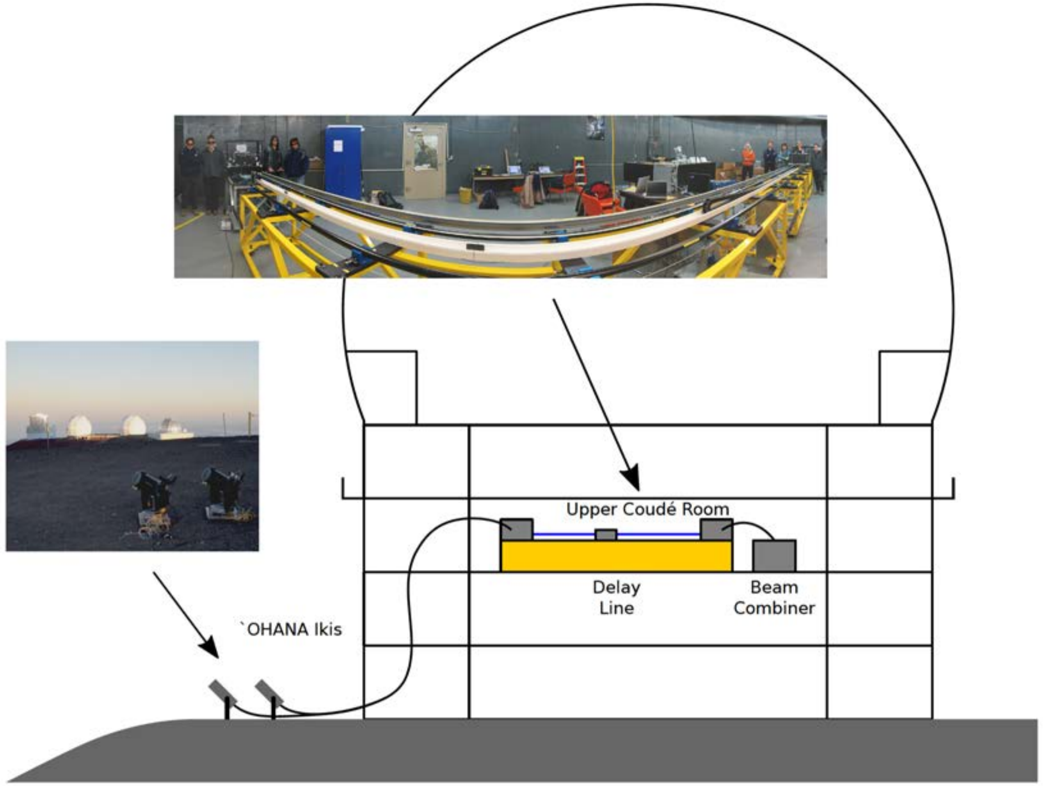
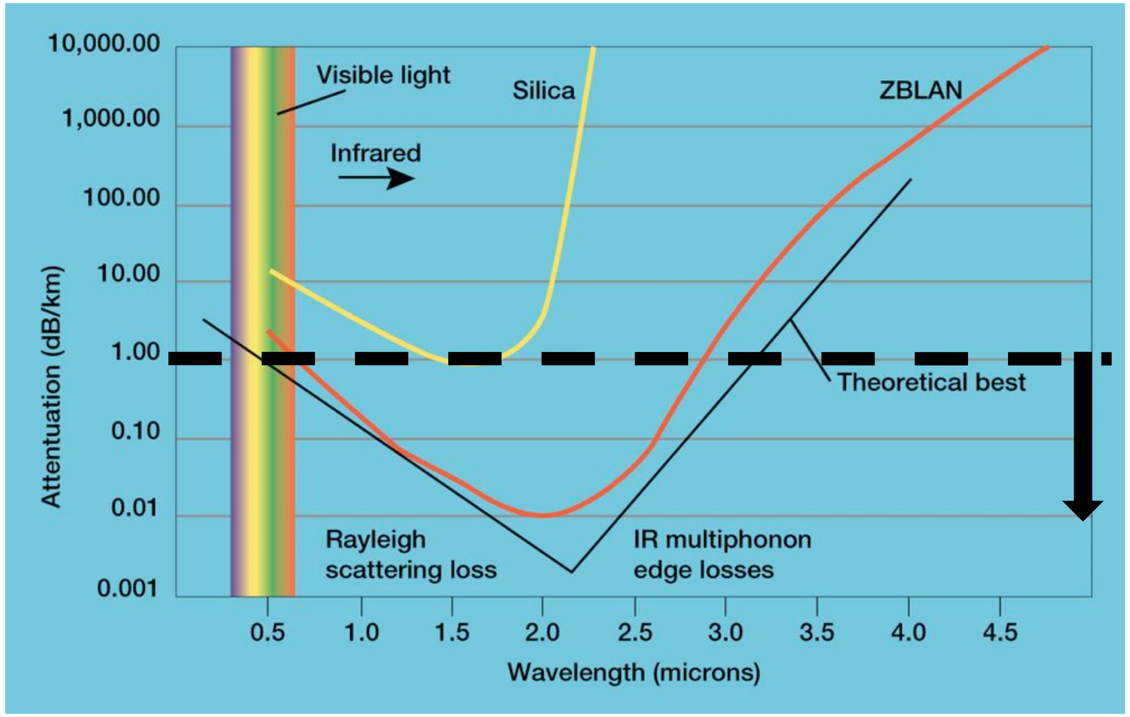


Fig. 2. Layout and pictures of the ‘OHANA Iki demonstration.

3 Telescopes, Sites, Beam Transport

- Woillez (… Reynaud …) et al. 2017
  all fibers need to be same length:
  eases somewhat the OPD problem
  (delay for just position in sky)
- Fibers demonstrated in
  K band (Kotani et al. 2005)
  J, H bands (Vergnole et al. 2004, 2005)
- Single mode, polarization maintaining
  fibers may also work in optical:
  ZBLAN fluoride fibers
- Free air transport (Theo, Stuart)



https://www.fiberlabs.com/

Telescope sites

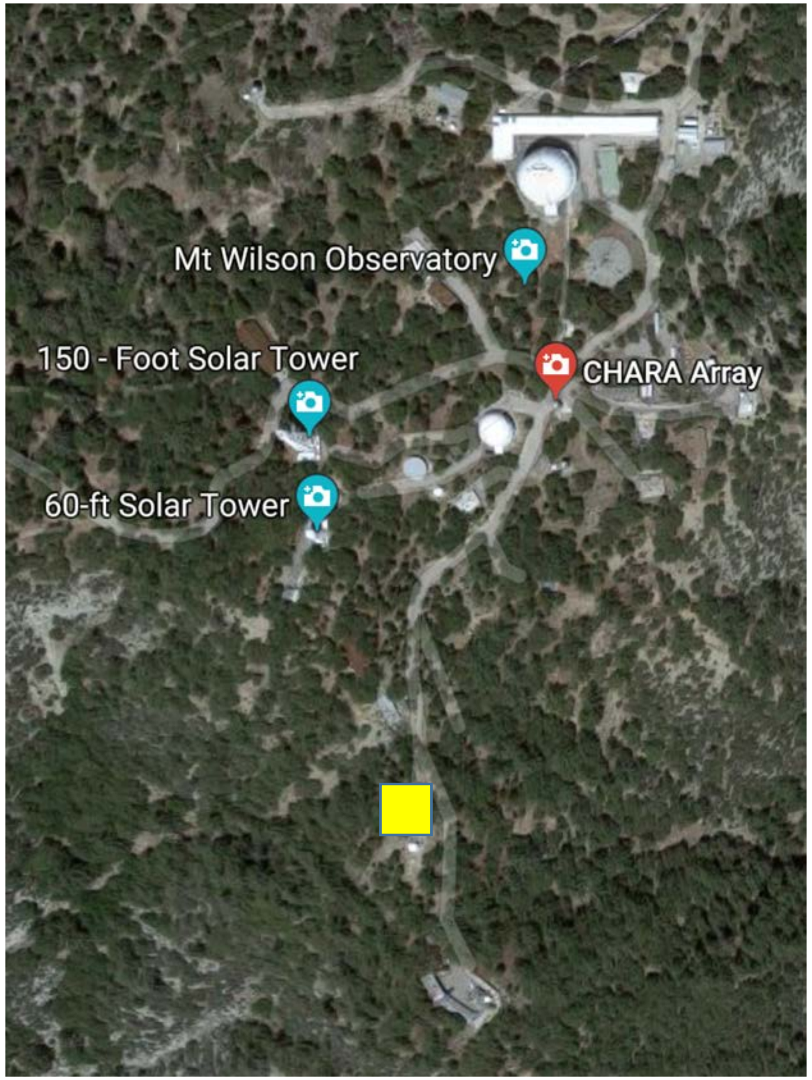
- MWO has complicated terrain but options exist
- More options for fiber transport than for light pipes
- Informal poll at CHARA Paris Meeting (March 2018): five “strawman” concepts

(1) Add central telescope behind CRO

- Use extra M1, M2 and build 1 m telescope of same design
- Place near the center of Array
- Increased short baseline coverage for baseline bootstrapping

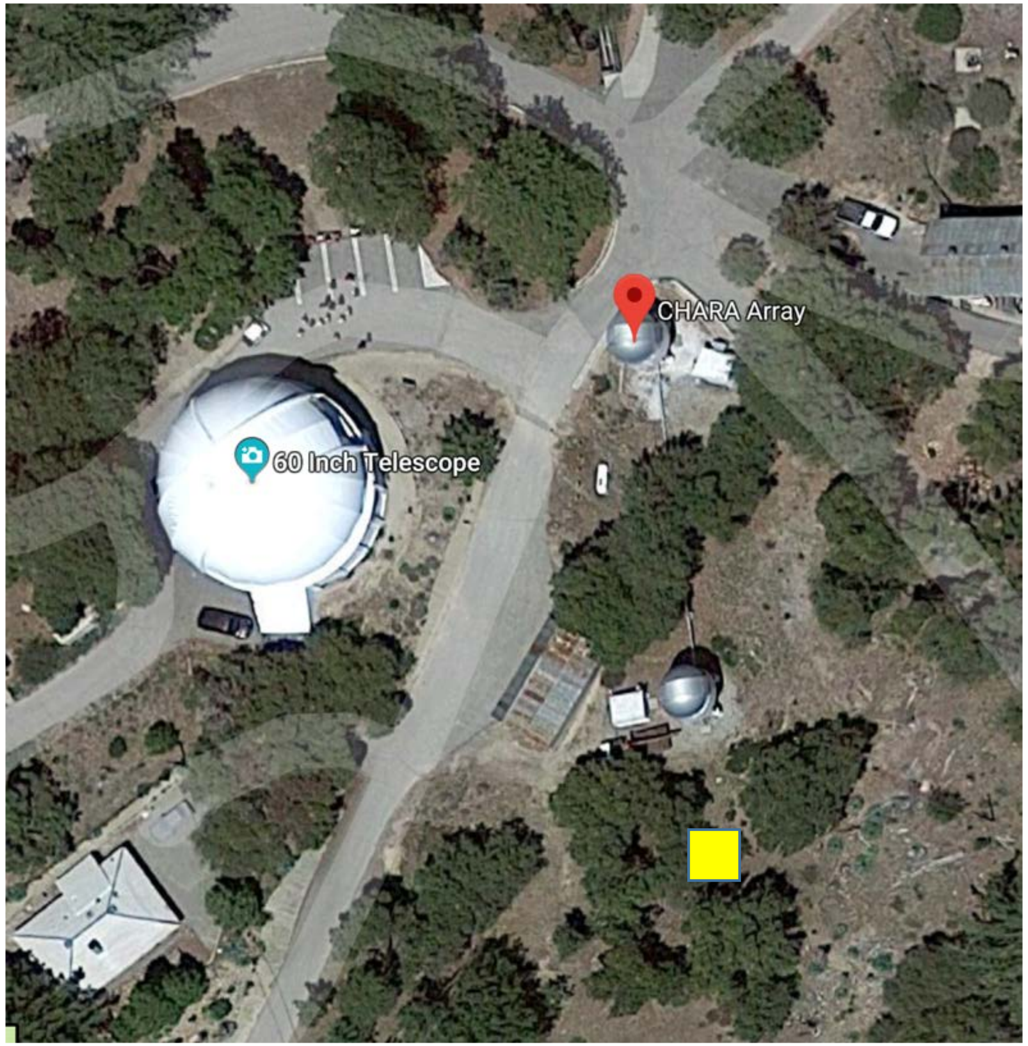
(2) Add 2 m telescope to the far south

- Connect to S1 by fiber
- Use as pathfinder for PFI technology



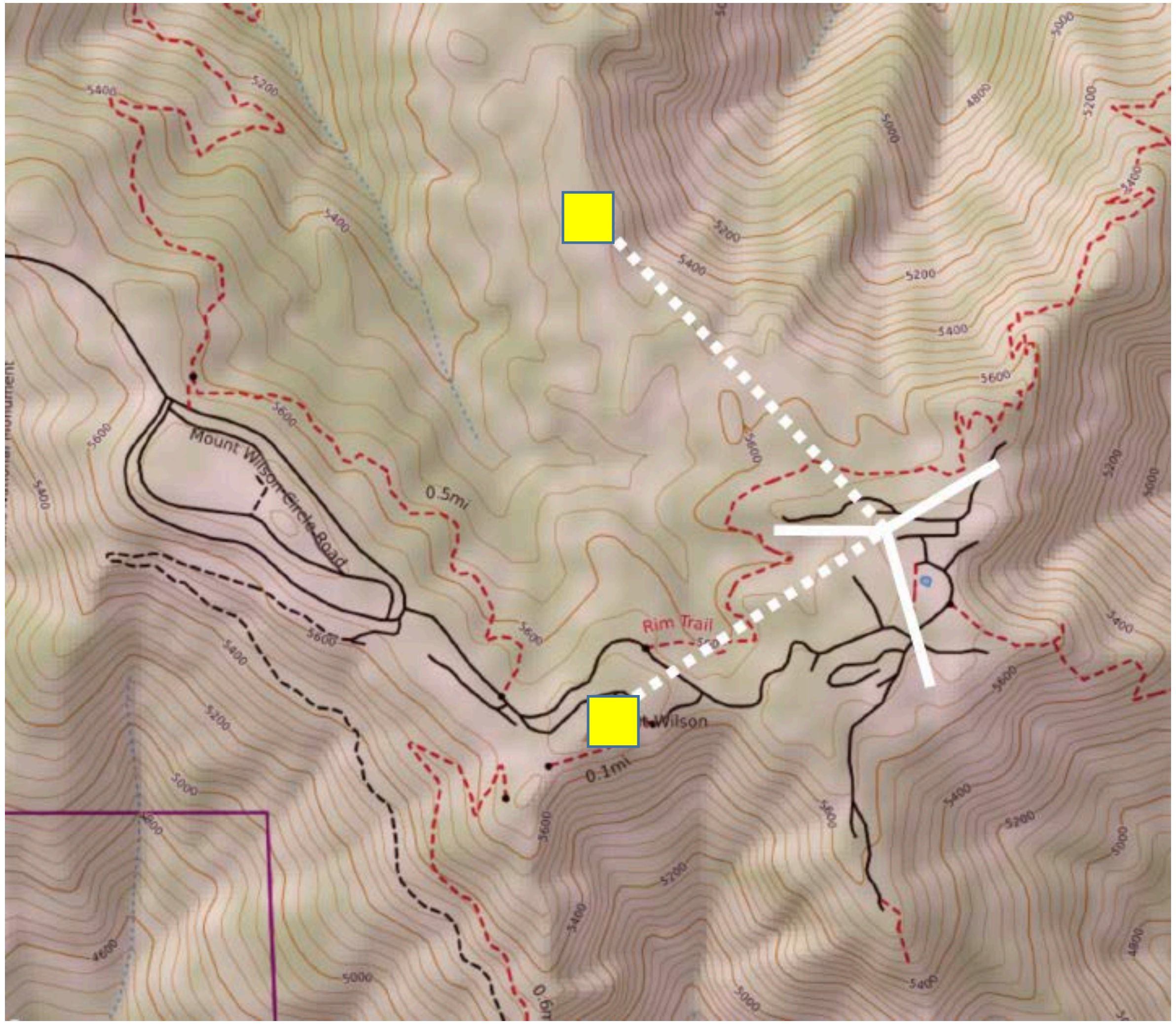
(3) Add 2 m telescope close to S1

- Helpful for large objects like supergiants and exozodiacal disks
- Role in baseline bootstrapping
- Might share light pipe with S1 or S2



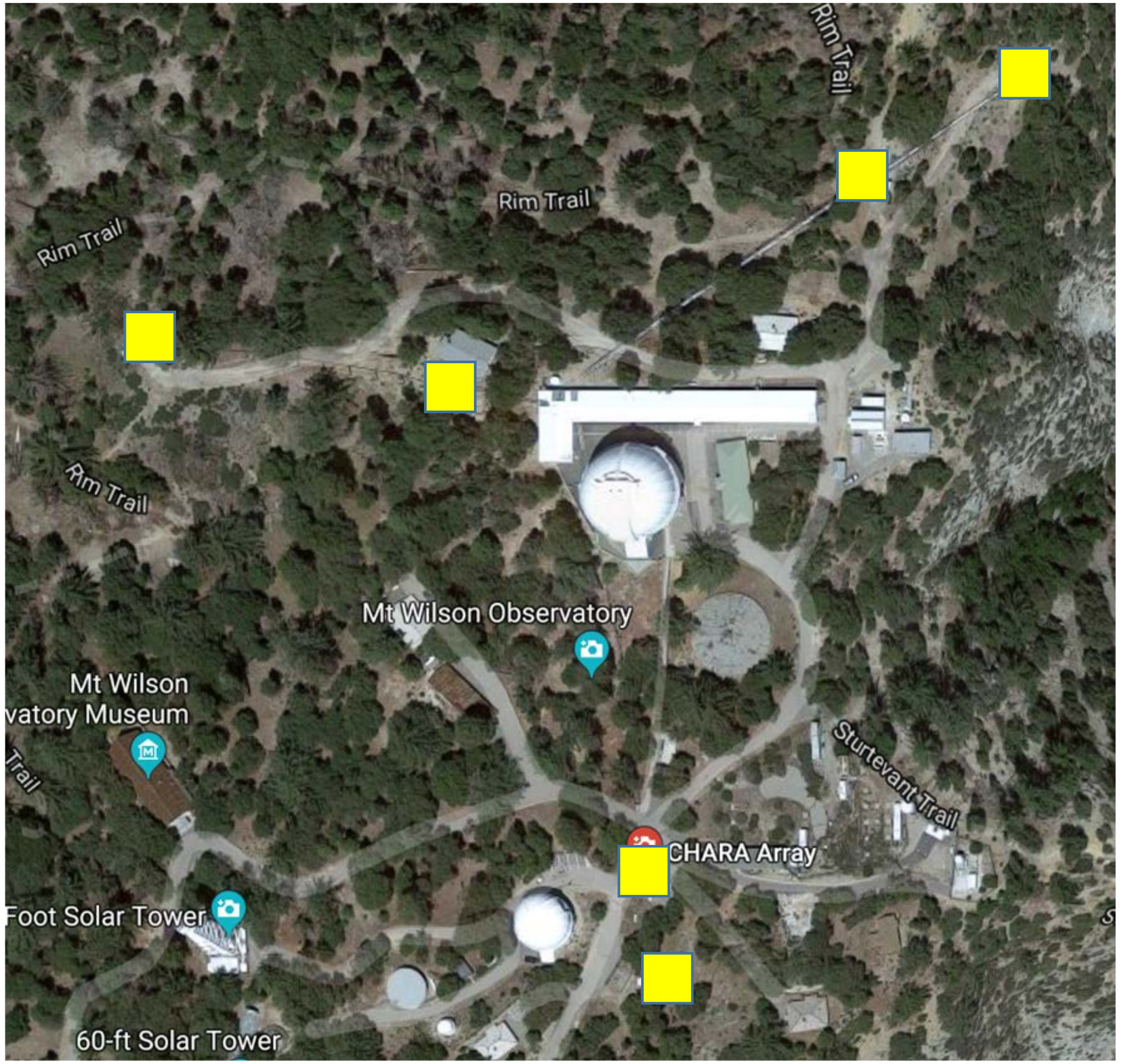
(4) Add two 2 m telescopes to NW and SW

- Very long baselines for highest resolution
- 660 m from NW to S1, 590 m from SW to E1
- Requires strong bridge for SW light pipe
- Stepping stone to km baseline arrays



(5) Replace all six telescopes with 2 m scopes

- Increase sensitivity using existing light pipes
- Invest in high reflectivity optics



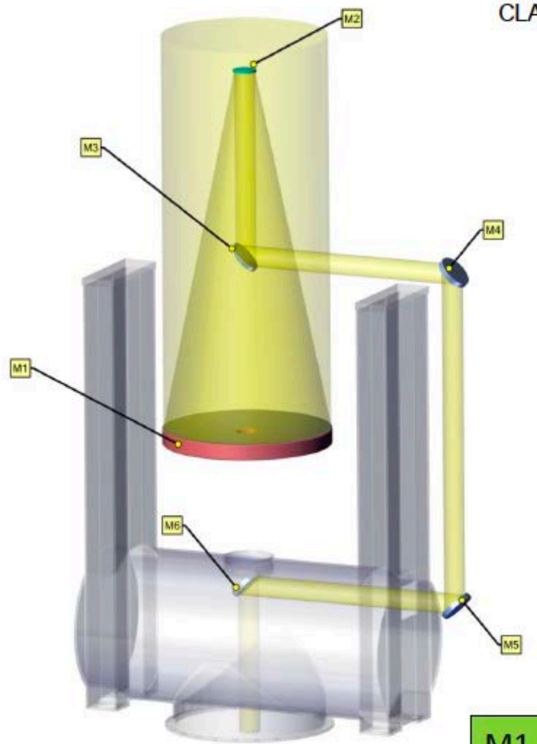
Informal poll from CHARA Paris meeting

#	Concept	☹	😐	☺
1	1m near CRO	13%	35%	**52%**
2	2m far south	23%	**45%**	32%
3	2m near S1	26%	35%	**39%**
4	two 2m to NW and SW	4%	35%	**61%**
5	replace all with 2m	17%	26%	**57%**

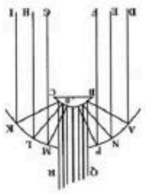
- extend spatial dynamical range (long and short baselines) and enable bootstrapping
- want better sensitivity, but ...
- keep same aperture to combine new and existing telescopes
- optimize (*u*,*v*) sampling for imaging work
- want future *L*, *N* band access
- include other MWI (60-inch and 100-inch) telescopes in Array?

Telescopes

CHARA TELESCOPE



CLASSICAL TWO MIRROR TELESCOPE
(MERSENNE 1636)



M1:	D = 1m F = 2.5 m CONCAVE PARABOLOID
M2:	D = 0.14 m F = - 0.312 m CONVEX PARABOLOID

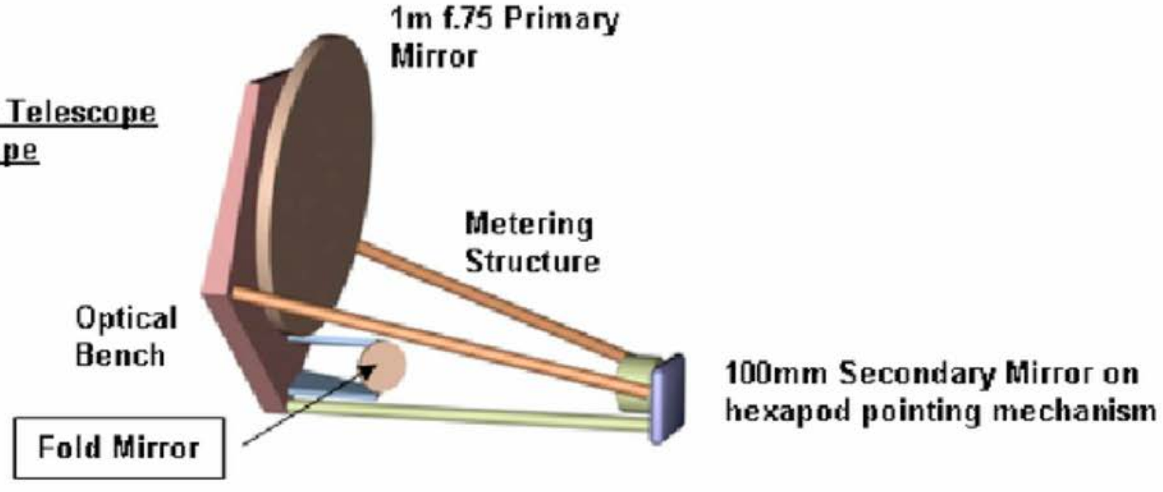
M1 AND M2 CONFOCAL

1:8 BEAM COMPRESSION

M3,M4,M5,M6… FLATS

OUTPUT BEAM ∅ 0.125 m

M1 AND M2 FOR THE 7-TH TELESCOPE ARE IN HAND



Off axis parabolic telescope to AO deformable mirror and into fibers (D. Leisawitz; J. Kuhn)

Maintain current CHARA design

***** DISCUSSION *****

4 OPLE, BCL, Combiners

- Room for 2 traditional beams in OPLE but would require redesign of beam switchyard for additional beams
- Additional delay (for longer baselines) could be obtained by extending the OPLE rails into the storage area at the east end and/or creating double-pass system
- Beam combiners designed for six or fewer beams, so would other beams be included as subsets? New IO beam combiner for 8 beams?
- Plans ahead for SPICA (Mourard) and MYSTIC (Sept 2019; Monnier)

***** DISCUSSION *****

5 The Way Forward

- All aspects need consideration but science goals are primary: need exciting plans that generate enthusiasm
- Need to develop a conceptual paper with general scheme
- Follow with a feasibility study of technical and other challenges
- Build a consensus among all the stakeholders: GSU, CHARA collaboration, MWI, Carnegie, Forest Service, LA County
- Long lead time required (for example, environmental review process)

Approximate timeline

- 2019 – conceptual paper, discussions with stakeholders
- 2020 – feasibility study, funding proposal (MSIP due 11/15/2020)
- 2021 – additional funding, hire project leaders
- 2022 – telescope construction, site preparation, OPLE/BCL parts
- 2023 – telescope installation, OPLE/BCL work
- 2024 – systems integration, software, testing
- 2025 – commence science operations

One final task …

Let’s extend our thanks to our Lowell Observatory hosts:

Gerard van Belle
Jelena Lane