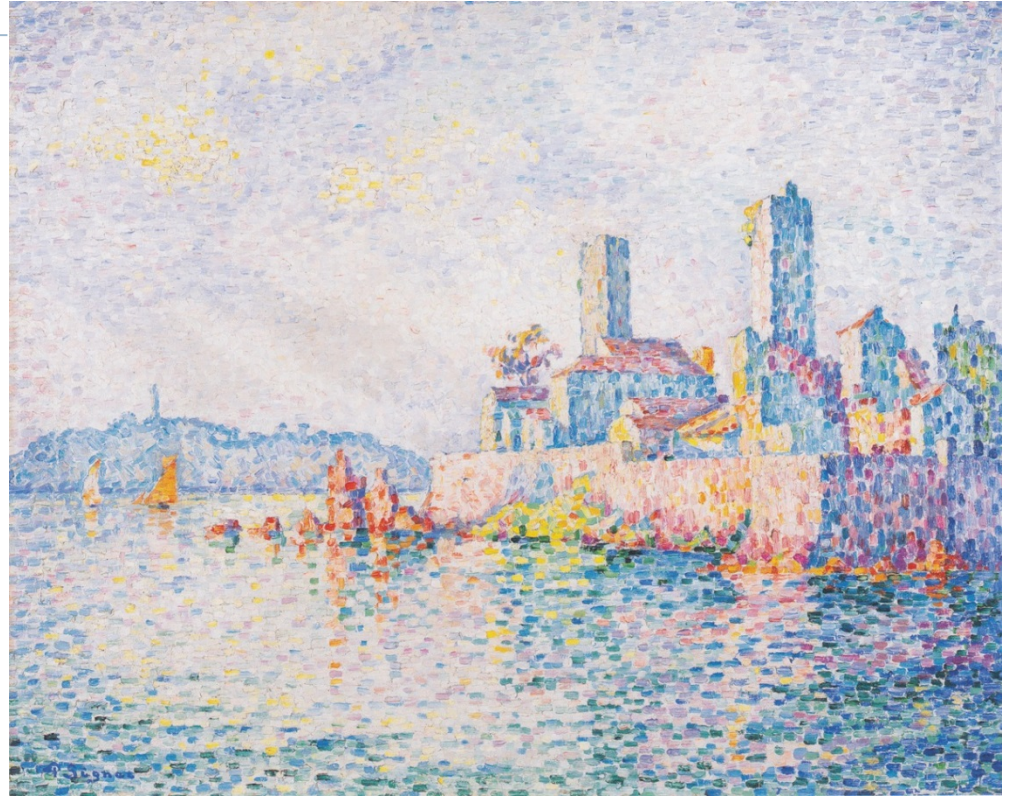


# NPOI Update

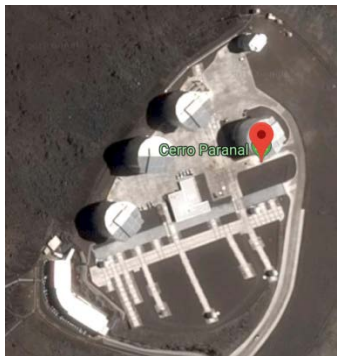
Gerard van Belle (Lowell Observatory)

## NPOI: The Basics

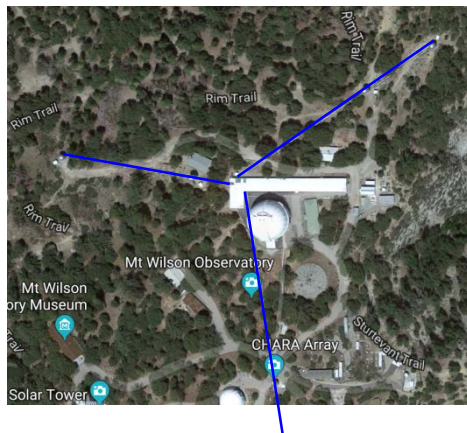


Paul Signac, "Antibes, die Türme", 1911

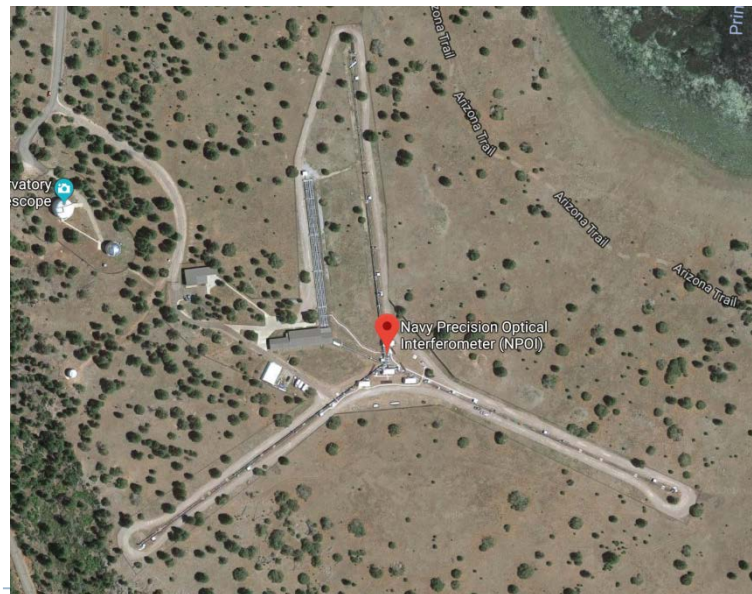




# Current Operational Interferometers

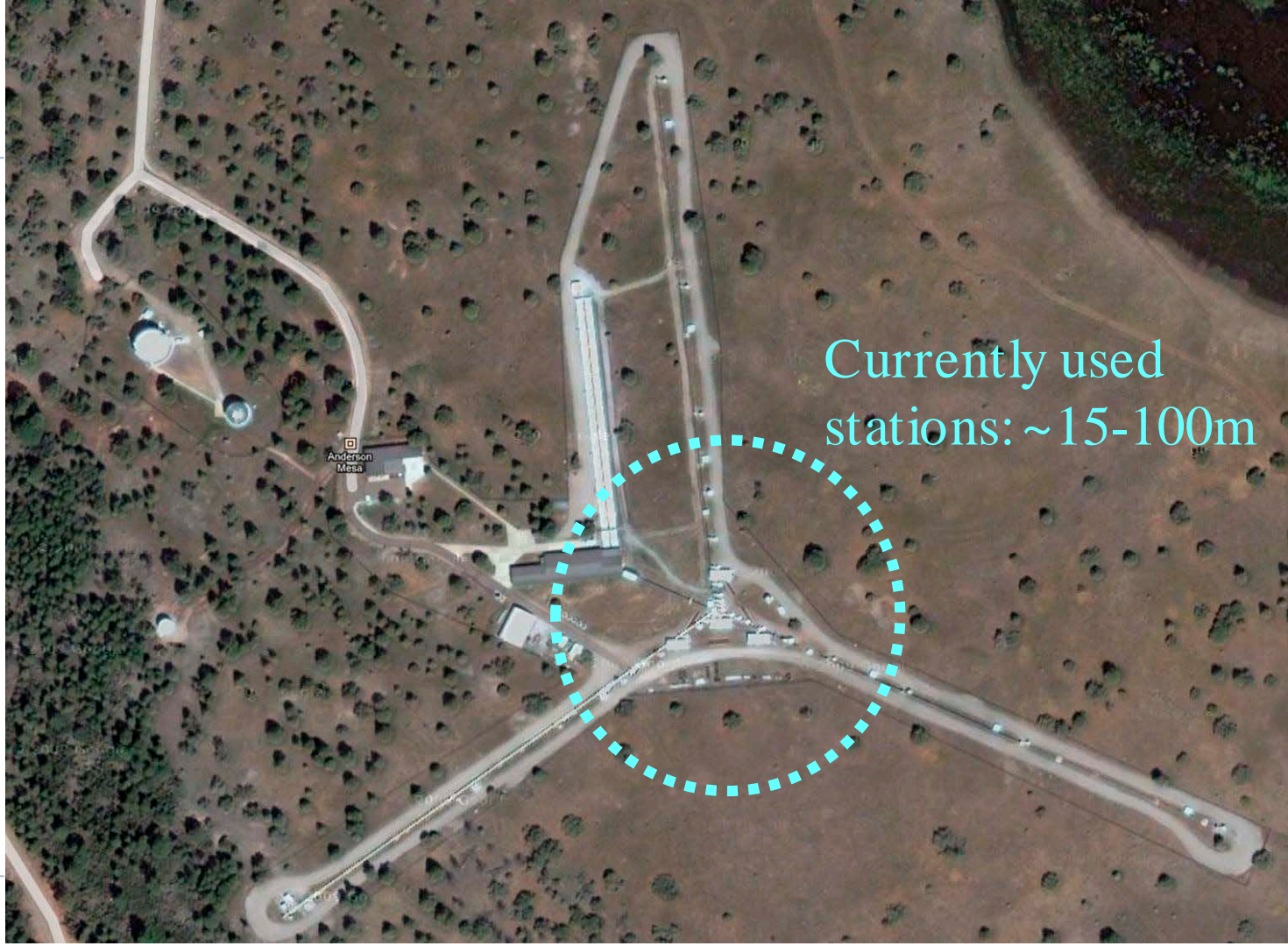


(to scale)



Images courtesy Google Earth



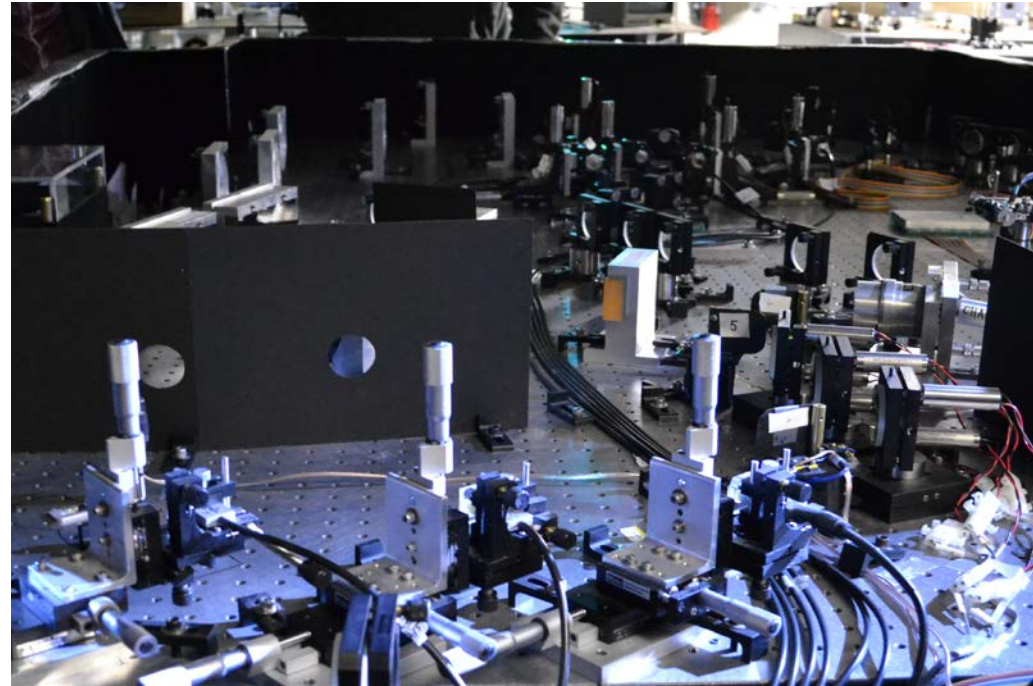


Currently used  
stations: ~15-100m



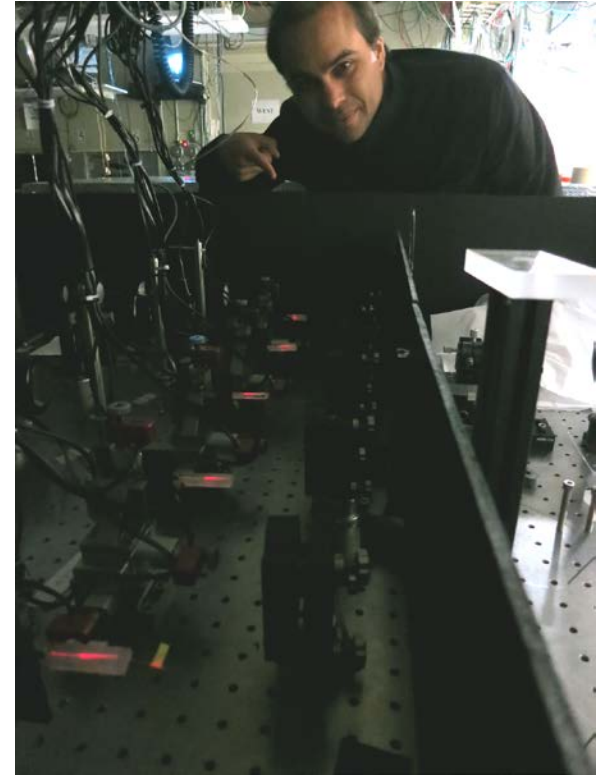
# NPOI Current Combiner

- ▶ ‘Classic’ Combiner
  - ▶ APD-based temporally modulating combiner
  - ▶ Spectral resolution:  $R=40$  (16 channels) over 550-850nm
  - ▶ Collects many N-way permutations
    - ▶ 1/3 of data dropped
    - ▶ Also missing 1 of 3 outputs, 50% of spectral coverage, limited buffer (30°)
  - ▶ Sensitivity limit of  $m_V \approx 5.5$



# NPOI 'Next-Gen' Combiner

- ▶ VISION (Garcia et al. 2016)
  - ▶ EMCCD-based spatially modulating combiner
  - ▶ Sensitivity limit of  $m_V \approx 5.5$ 
    - ▶ New EMCCDs with reduced CIC
  - ▶ Spectral resolutions:  $R=200, 1000$  over 570-850nm
  - ▶ Collects all N-way permutations
  - ▶ Automatic data pipeline adapted from MIRC



# Additional Instrument Lab Upgrades

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- ▶ Upgraded tip-tilt tracker
  - ▶ Uses one 'leftover' EMCCD from original VISION
  - ▶ With VISION, removes need to run 25-year-old APDs
- ▶ Near-IR fringe tracker
  - ▶ Extend coherence time for VISION

## NPOI: PALANTIR



Paul Signac, “La Corne D'or, Les Minarets”, 1907



# Funded Upgrade: PALANTIR

- ▶ \$3.26M project to add  $3\times 1.0$ -m PW 1000 telescopes to NPOI
- ▶ Supported by the NRL to Lowell Observatory (PI: G. van Belle)
- ▶ A Quenyan (Elvish) word meaning ‘far-seeing’
  - ▶ “Precision Array of Large Aperture New Telescopes for Image Reconstruction”



# AstroHaven ET1 delivery: 5/9/2018



► 'ET' = enclosure - transporter



PlaneWave PW1000-1 install: 10am,  
5/29/2018

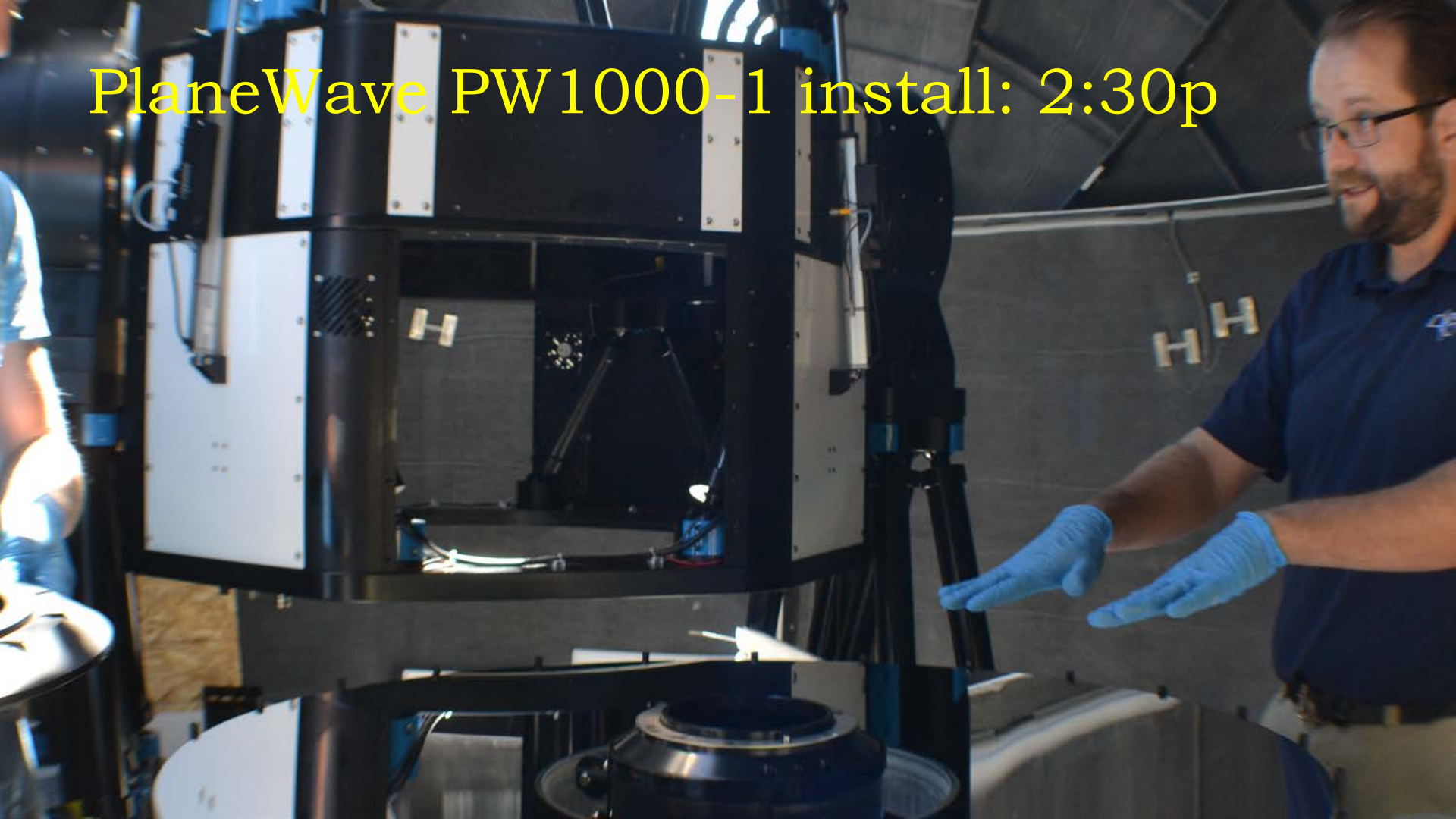




# PlaneWave PW1000-1 install: 10:50a



PlaneWave PW1000-1 install: 2:30p



# PlaneWave PW1000-1 install: 8pm





# PlaneWave PW1000-1 first light: 9:00p



- ▶ M51: 3-min unguided exposure, SBIG STXL11002, no filter

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NPOI PALANTIR:  
First Fringes  
Punchlist,  
Schedule



Ferdinand du Puigaudeau, "The Customs Cabin"

# PALANTIR milestones

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- ▶ PW 1000-2, -3: delivered (in storage on site)
- ▶ Delivery of ET2: Feb 12, 13
- ▶ Delivery of ET3: 'soon'
- ▶ AO integration: 2019Q 1
- ▶ Beam feed integration: 2019Q 1
- ▶ USFS Permit amendment: 2019Q 1
- ▶ First fringes target: 2019 Jul 1
  
- ▶ Schedule driver: NSF 2019 MSIP, ~Nov 1<sup>st</sup> (more on this later)

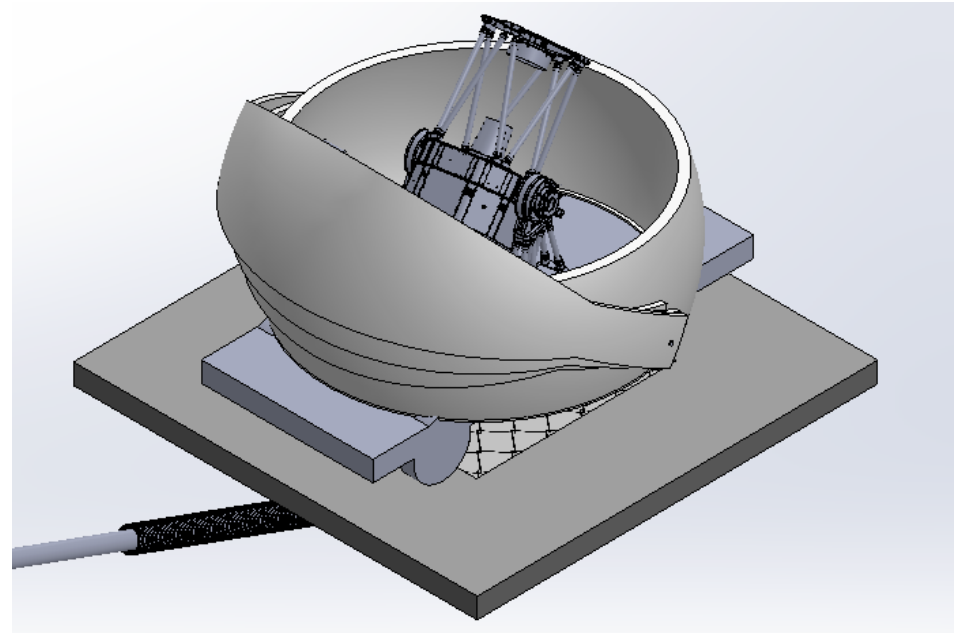
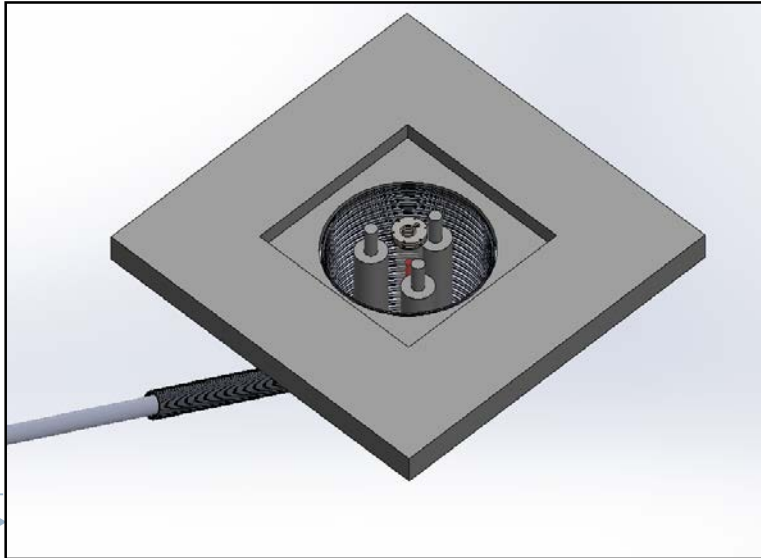
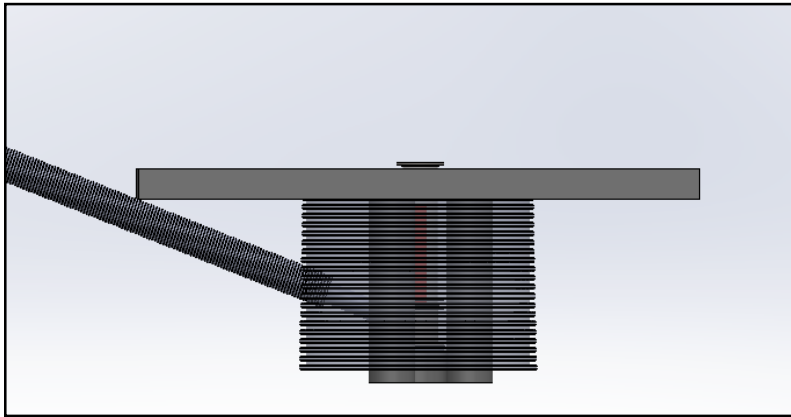






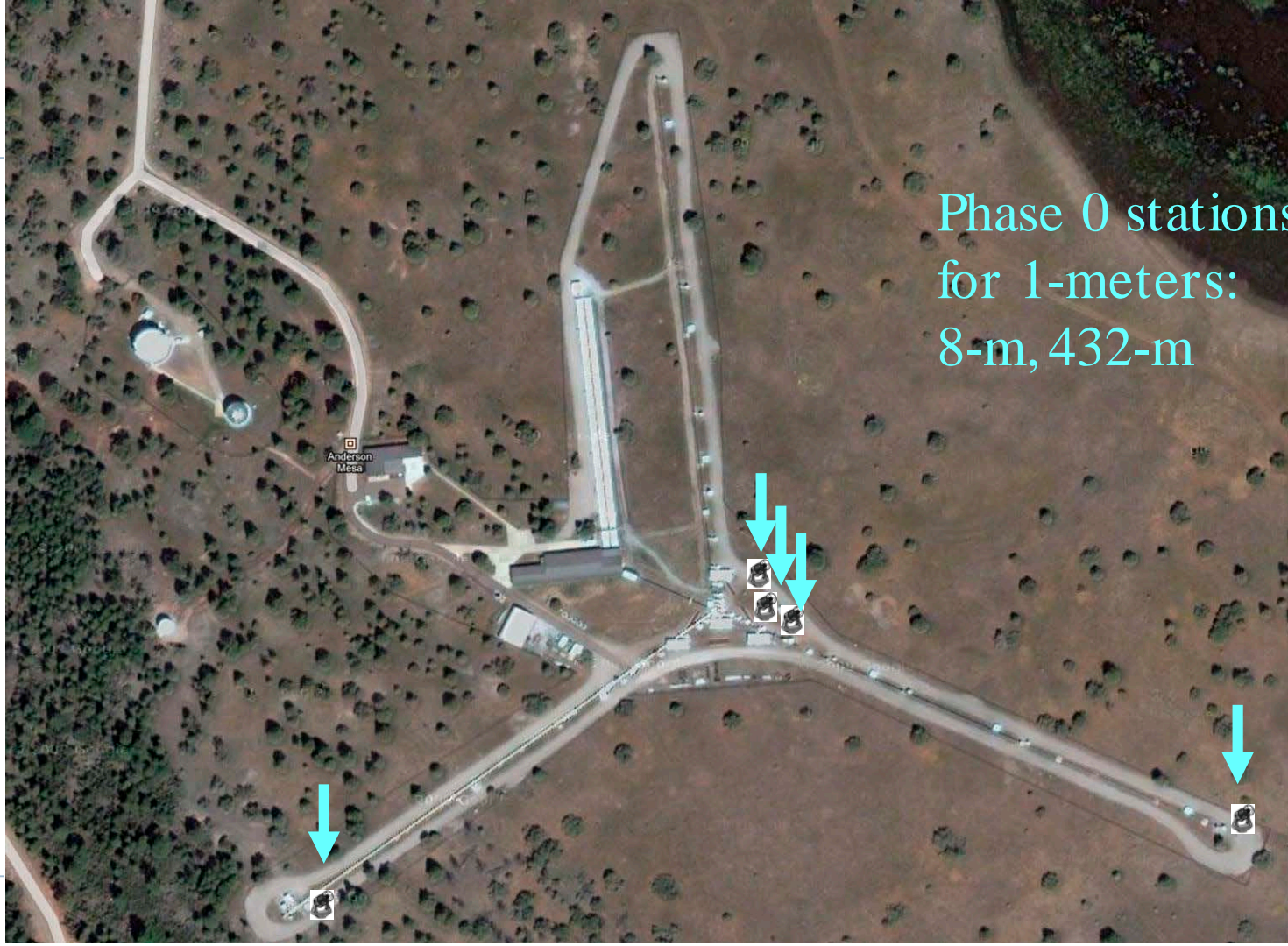


# Station Design





Phase 0 stations  
for 1-meters:  
8-m, 432-m



# Punchlist for First Fringes

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- ▶ USFS Permitting
- ▶ Telescopes 2, 3
- ▶ Beam routing / Station prep
- ▶ Adaptive optics
- ▶ On-sky ops

# First Fringes: Telescopes

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- ▶ Procure, setup local control computers
  - ▶ Environmentally tolerant industrial embedded control
- ▶ ET2 delivery: Feb 12, 13
- ▶ PW 1000-2 install: combine with -3?
- ▶ ET3 delivery
- ▶ PW 1000-3 install



# First Fringes: Beam Routing

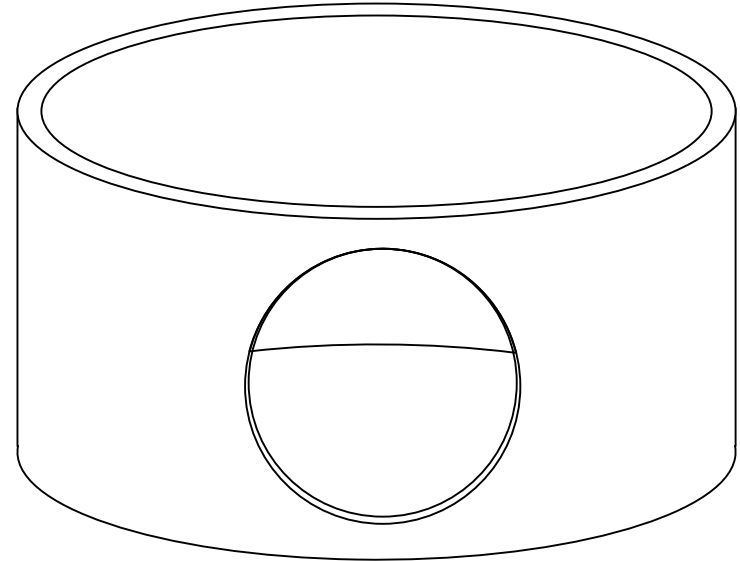
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- ▶ Design/Procure M7-M8
- ▶ Station infrastructure – electrical, internet?
- ▶ Pour station pads
- ▶ Fabricate temporary riser mounts for two[?] stations
- ▶ M5, M6 from Plane Wave
- ▶ Set up lizardheads

# Temporary Riser

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- ▶ Allows for interferometric use prior to vault construction
- ▶ Steel cylinder of suitable wall thickness (1"?) for lowering pedestal+PW 1000 onto
- ▶ M7 is located in center, sends telescope light beam out aperture in side



# First Fringes: AO Mounting

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- ▶ First Vere breadboard
  - ▶ ☒ Design breadboard
  - ▶ ☒ Order breadboard
  - ▶ ☒ Design mounting hardware
  - ▶ ☒ Fabricate mounting hardware
  - ▶ ☒ Receive, ☐ install Vere-1
- ▶ Breadboards 2, 3



# First Fringes: AO System

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- ▶ Resolve AO parts inventory question
- ▶ Build, test first lab setup
- ▶ Transfer lab setup to dome
- ▶ Build, test second lab setup
- ▶ Transfer lab setup to dome
- ▶ Software
- ▶ PW-1 single-telescope on-sky tests
- ▶ PW-2 single-telescope on-sky tests

# Adaptive Optics

- ▶ Ty Martinez visits
  - ▶ Dec 2018, Jan 2019
  - ▶ AO testbed setup in NPOI lab
- ▶ Tall tent-poles
  - ▶ Sufficient parts?
    - ▶ Detectors: EMCCDs
    - ▶ DMs & tip-tilt
    - ▶ Uniformity?
  - ▶ Software



# First Fringes: On-sky Operations

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- ▶ Baseline estimate
- ▶ PW-1, -2 pointing models
- ▶ PW-1, -2 Coude routing, alignment
- ▶ Fringe searching
  
- ▶ Likely scenario: first fringes on short (8m) baseline or long (432m)?
  - ▶ Short baseline ‘easier’ for fringe searching, long baseline infrastructure easier



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# Proposal Opportunities

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# PALANTIR & Proposal Opportunities

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- ▶ **NSF MSIP**
  - ▶ Every 2 years
  - ▶ Phase I proposal: Nov 2019
  - ▶ Important: applicants in 2021 will probably be CHARA, MROI
- ▶ **Current funder of CHARA Community Access**
  - ▶ Open access for community, NOAO TAC awarded
  - ▶ Data support scientist, archiving

# NSF MSIP: What do we have offer?

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## CHARA & MSIP

- ▶ 6 telescopes, AO-corrected
  - ▶ POPs
  - ▶ 30-330m baselines, no bootstrapping
- ▶ Combiners
  - ▶ CHARA-Classic
  - ▶ MIRC → MIRC<sub>x</sub> & MYSTIC
  - ▶ others, incl. PAVO

## NPOI & NSIP

- ▶ 3x1m telescopes, AO-corrected
  - ▶ 430m baseline
  - ▶ No LDLs / POPs operational
  - ▶ Bootstrapping possible
- ▶ Combiners
  - ▶ Classic
  - ▶ VISION
    - ▶ NearIR FTK for VISION





Staff:

# MSIP & NPOI Staffing Challenges

| Line | Group                | Role  | chief duties  | Who currently                              | CHARA                                     |
|------|----------------------|---|---|--|---|
|      |                      |   | <b>Day-to-day operations personnel</b>  |  |   |
| 1    | Admin                | Director  | Responsible for preservation & growth, scientific output, partner coordination  | Jim Clark                                  | Theo ten Brummelaar [Doug in ATL @ 25%]   |
|      |                      | Chief Scientist or Dep. Dir.                                |   | Gerard van Belle                           | Gail Schaefer                             |
| 2    |                      | Site lead   | Direct oversight of day-to-day work   | Teznie Pugh                                | Larry Webster                             |
| 3    |                      | Admin   | timekeeping, purchasing   | [Lowell BOB]                               | Alicia (ATL)                              |
| 4    | Optomechanical group | Lead  | Responsible for ensuring daily operations at a technical level. Specific emphasis on lab hardware: daily alignments, general upkeep | Jim Clark                                  | Judit Sturmann                            |
| 5    |                      | optomechanical tech (optics) ass't                          | lab hardware: daily alignments, general upkeep  | open                                       | open                                      |
| 6    |                      | optomechanical tech (mechanics)                             | telescope, exterior hardware (including AO)   | open                                       | Laszlo Sturmann                           |
| 7    |                      | optomechanical tech (mechanics) ass't                       | telescope, exterior hardware (including AO)   | open                                       | Matt Anderson                             |
| 8    |                      | EE tech   | electrical & electronic infrastructure (incl. IT)   | open                                       | Nils Turner @ 50%                         |
| 9    | System software      | software lead   | realtime systems, data management   | Jim Benson                                 | Theo ten Brummelaar                       |
| 10   |                      | software tech   | realtime systems, data management   | open                                       | Nils Turner @ 50%                         |
| 11   | Site / maintenance   | grounds   | Site infrastructure   | Jim Gorney                                 | Craig                                     |
| 12   |                      | service tech  | Site infrastructure   | open                                       | Steve                                     |
| 13   | Observing            | Observer lead   | Responsible for nighttime operation coord.  | Jason Sanborn                              | Chris Farrington [25%]                    |
| 14   |                      | observer  | Nighttime operator  | Ishara Nisley                              | Chris Farrington [75%]                    |
| 15   |                      | observer  | Nighttime operator  | Casey Kyte                                 | Olli                                      |
|      |                      | observer  | Nighttime operator  | open                                       | Norm                                      |
| 16   |                      | observer (0.5)  | Nighttime operator  | open                                       | <p/t hire pending>                        |
| 17   | Data                 | data scientist  | TAC, daily schedule   | Ellyn Baines                               | Gail Schaefer                             |
| 18   |                      | data scientist  | daily reductions, QC, user support  | Henrique Schmitt                           | visitor support scientist<br>Jeremy Jones |
| 19   |                      | data scientist  | special projects, independent research  | Bob Zavala                                 | Robert Klement - scientist, 20% service   |
|      |                      |   |   |  |   |
|      |                      | NB. these people are separate from system upgrade personnel |   |  |   |
|      |                      | NB. CHARA TOs are exempt employees                          |   |  |   |
|      |                      |   | Staff:  | 9  | 15  |
|      |                      |   |   |  |   |
|      |                      |   |   | <b>Irregular availability (non-local):</b> |   |
|      |                      |   |   | Henrique Schmitt                           |   |
|      |                      |   |   | Tom Armstrong                              |   |
|      |                      |   |   | <del>Chris Wilcox</del>                    |   |
|      |                      |   |   | Ty Martinez                                |   |
|      |                      |   |   | Freddie Santiago                           |   |
|      |                      |   |   | reservists                                 |   |



Questions?



Paul Signac, "Port St. Tropez", 1899