SIMONS OBSERVATORY

A STATUS UPDATE

SIMONE AIOLA

(CENTER FOR COMPUTATIONAL ASTROPHYSICS, NY)

SAACC 04/13/2021

SIMONS FOUNDATION

SIMONS OBSERVATORY

PARQUE ASTRONÓMICO ATACAMA, CHILE

www.simonsobservatory.org

HEISING-SIMONS FOUNDATION

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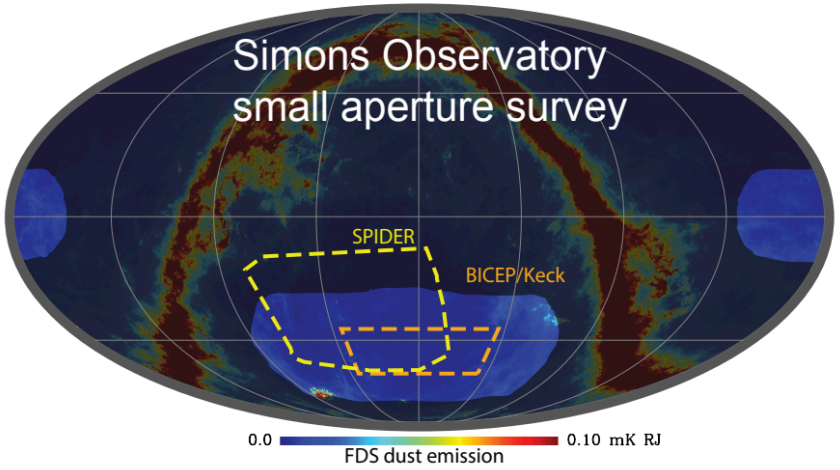
SIMONS OBSERVATORY (SO) — MULTIFREQUENCY 5YR SURVEY AND SCIENCE GOALS

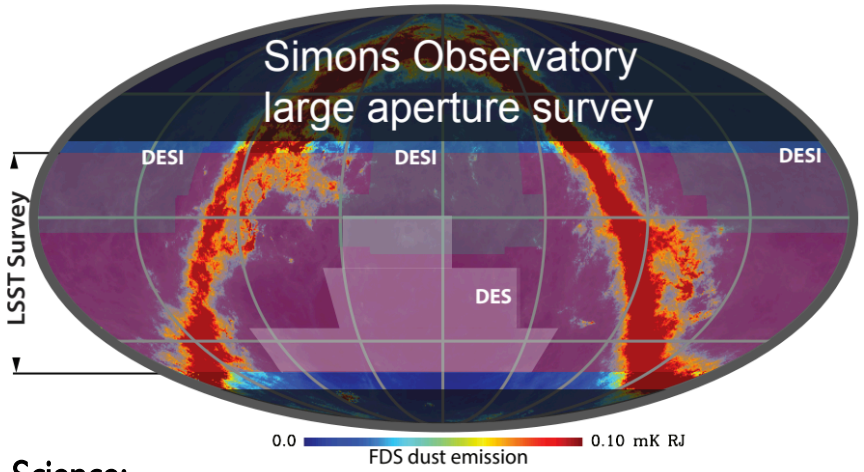


Science:

- high-risk, high-reward
- Signature of inflation

SAT Survey:

- low-dust 10% of the sky
- Large-Scale polarization, B-mode



Science:

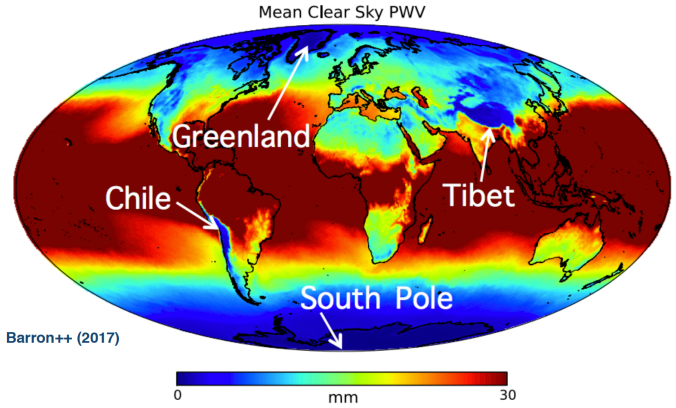
- Primordial perturbation
- Neutrino mass
- Relativistic species
- Reionization
- Dark energy
- Galaxy evolution
- Transients

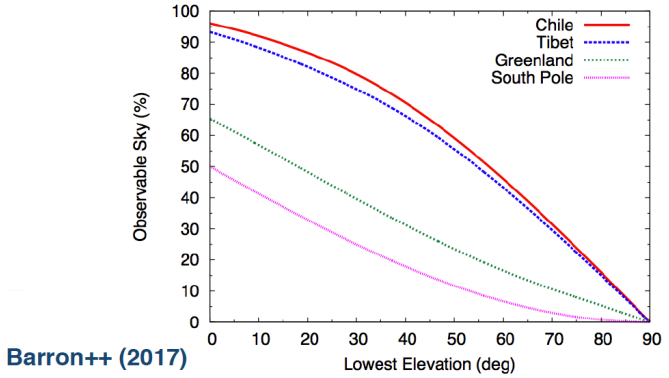
LAT Survey:

- 40% of the sky
- Overlap with Rubin Observatory/LSST and other LSS

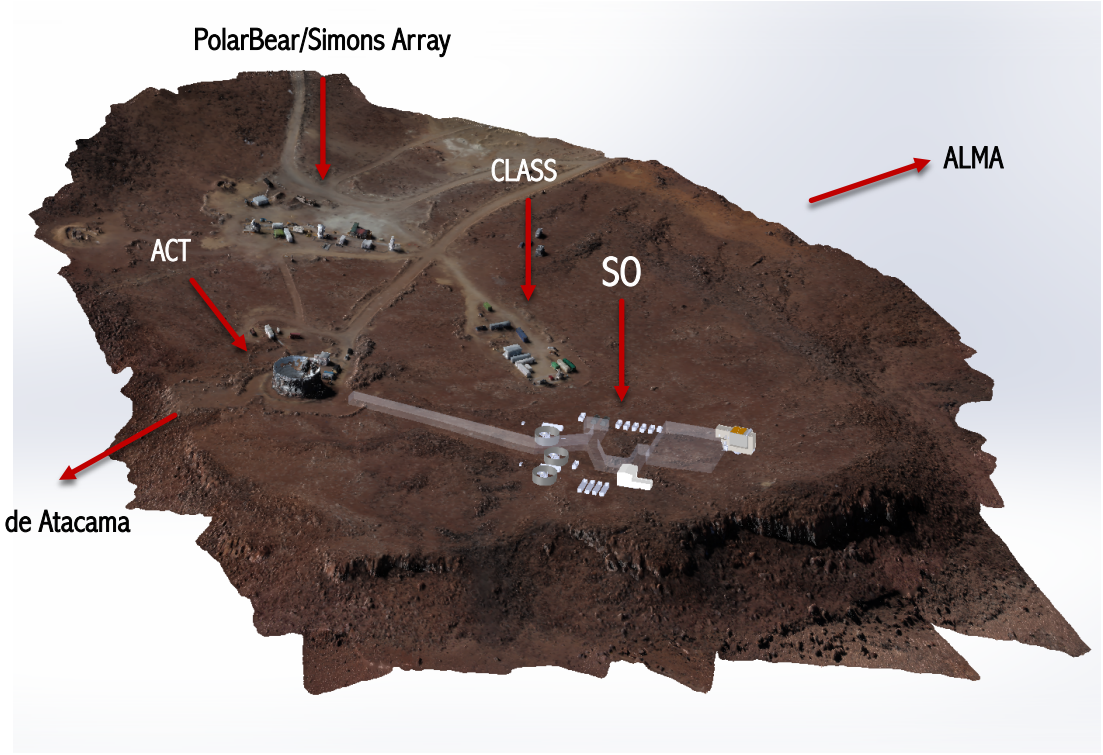
Periodic data releases: CMB, lensing maps, source and cluster catalogs, transient events

SIMONS OBSERVATORY (SO) — SITE

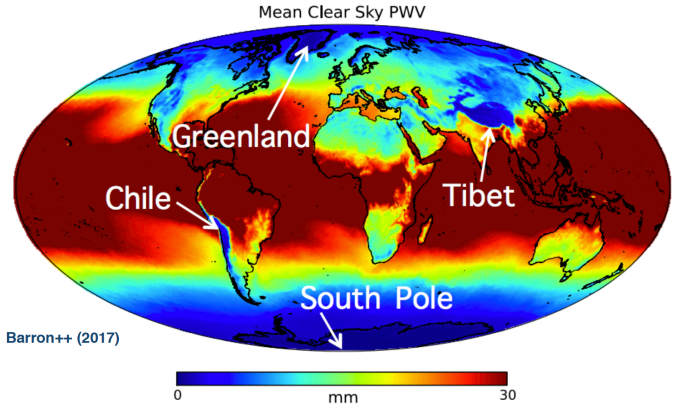


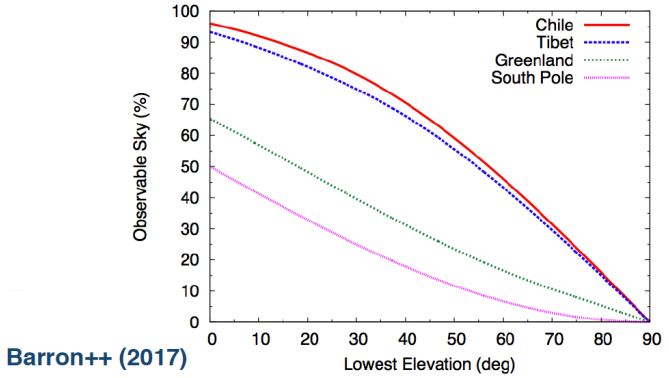


- Chajnantor platau, Atacama Desert, Chile @5,190m a.s.l.
  - Ideal for ~half-sky measurements
- Median precipitable water vapor ~0.8mm
  - Ideal for 20-280 GHz measurements



SIMONS OBSERVATORY (SO) — SITE





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  - Ideal for ~half-sky measurements
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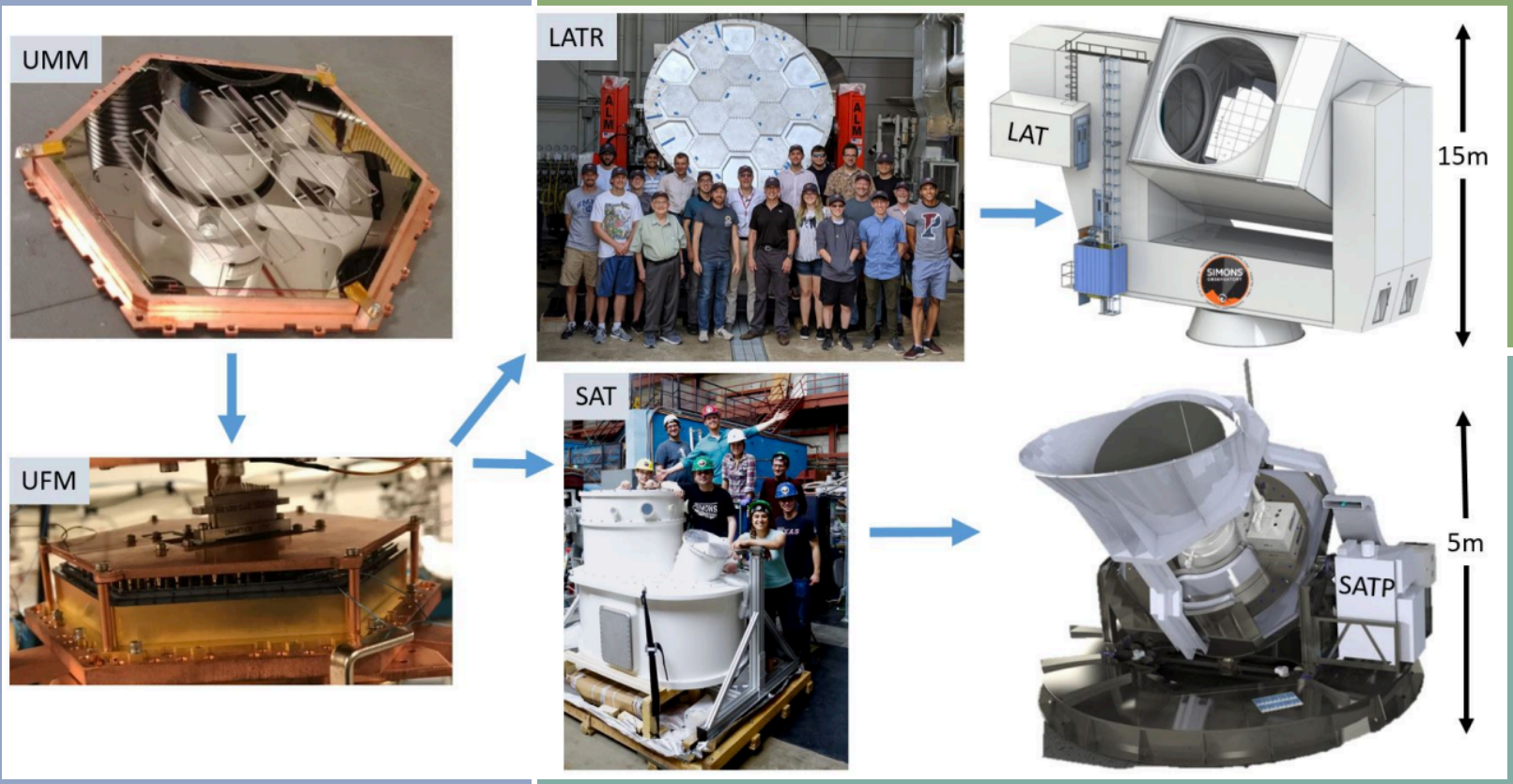
SAACC 2020 → SAACC 2021

- Site construction is underway!
- We expect remote connectivity (via radio link) to the Site before end of 2021

SIMONS OBSERVATORY (SO) — INSTRUMENTATION

Detectors:
70,000 dichroic detectors operating at 100 mK
Two different technologies



LF (27/40 GHz), MF(90/150 GHz),
UHF (220/270 GHz)

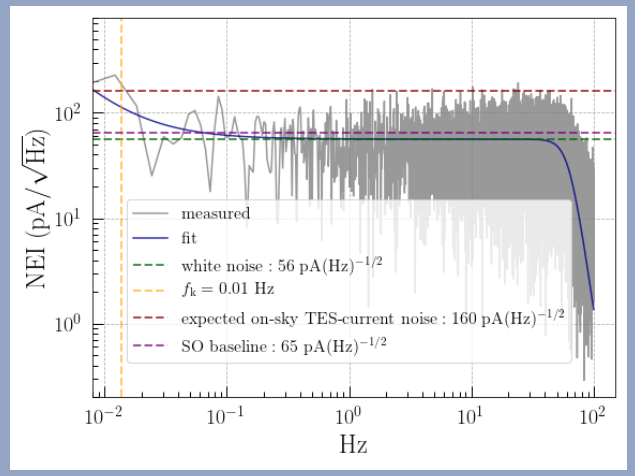
Large-Aperture Telescope (LAT)
6m primary mirror, 8deg FOV, 1.5' resolution @ 150 GHz
Largest cryogenic camera ever built for CMB experiments, 27-270 GHz detectors

Small-Aperture Telescopes (SATs)
3 telescopes, 42-cm aperture, 35deg FOV, ~0.5deg resolution @ 150GHz
Cryogenic Half-Wave Plate to modulate polarization, 27-270 GHz detectors

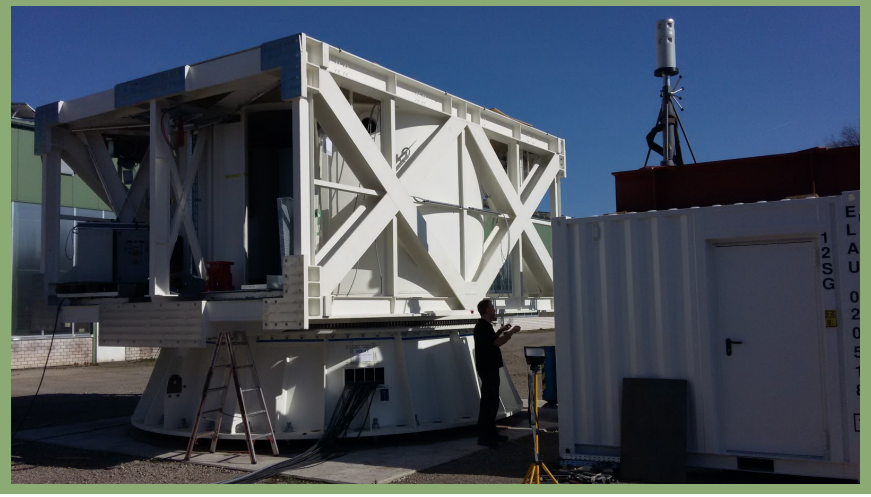
SIMONS OBSERVATORY (SO) — INSTRUMENTATION

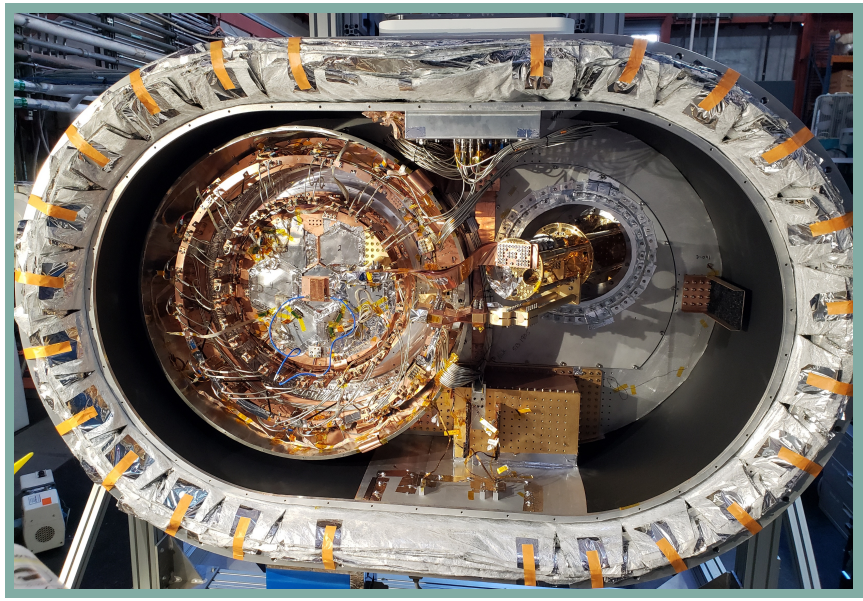
SAACC 2020 → SAACC 2021

Detectors:



Large-Aperture Telescope (LAT)





Small-Aperture Telescopes (SATs)

DATA ACQUISITION (DAQ)

- Observatory Control System (OCS): a modular system to control motion of telescopes, operate devices, acquire detector data, and store all data and metadata. Communication is handled with Web Application Messaging Protocol (WAMP).
- Grafana/InfluxDB/sisock/Lyrebird: software to visualize and analyze real-time and/or archival data
- Alarms: integrated system of alarms to monitor observations and site

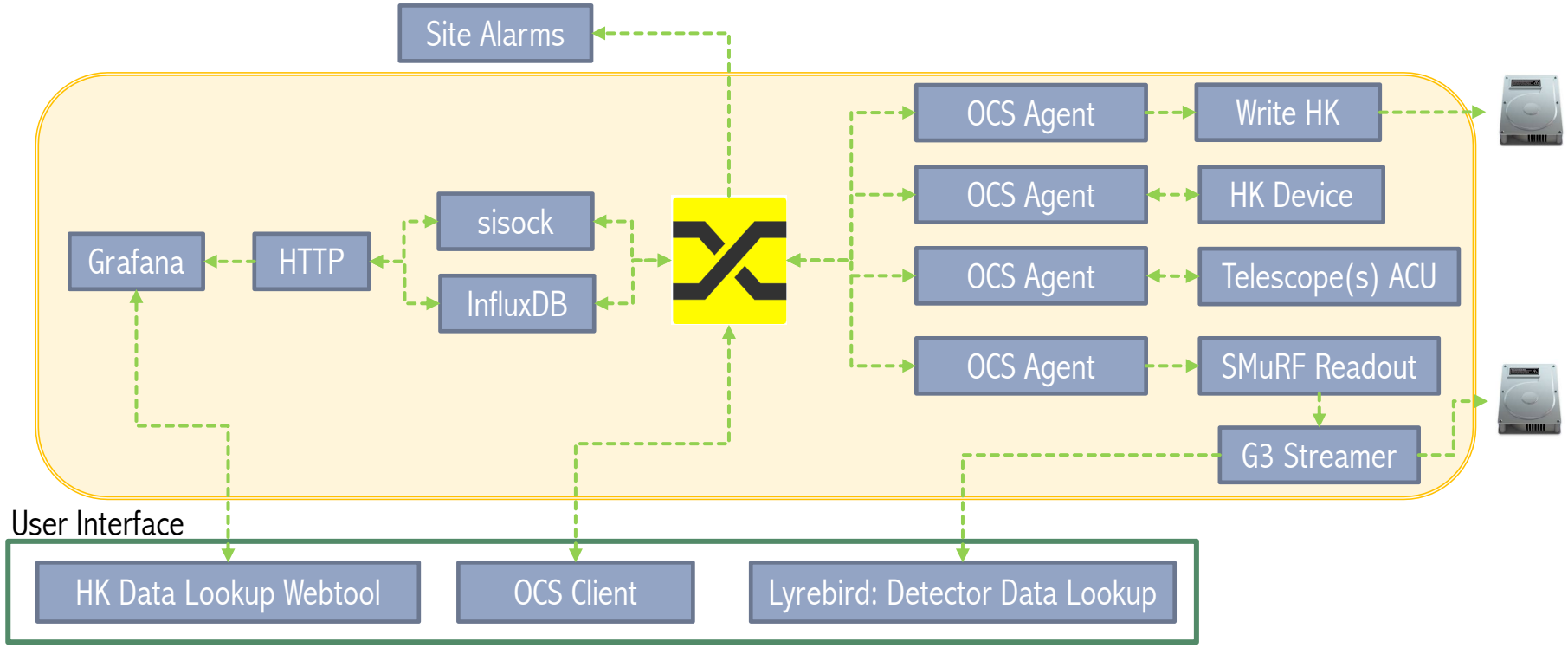


Figure credit: inspired by B. Koopman

SIMONS OBSERVATORY (SO) — TIMELINE

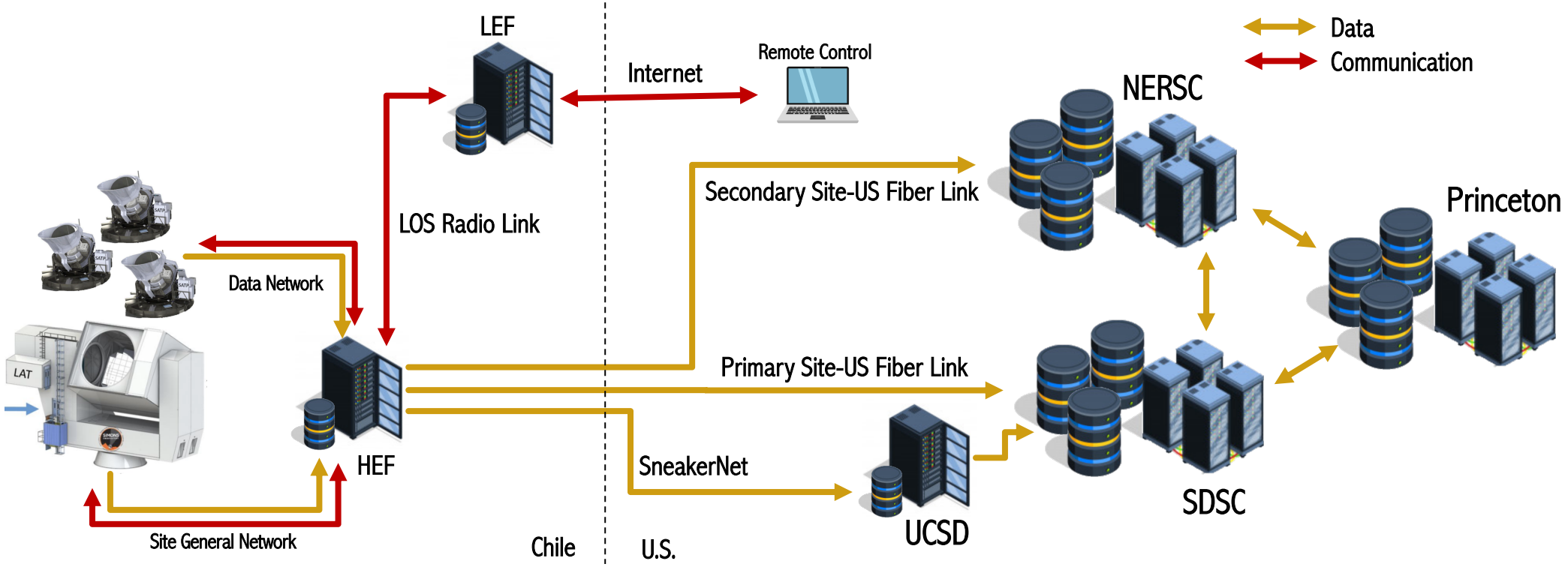
Early ‘21	**Mid ‘22**	**Early ‘23**	**Mid ‘24**
Testing and integration, optical validation	First light for both SAT + LAT	**First** science observations expected	**Full** science observations expected

- SO Construction Project: 2016 - 2024
- SO Operations: 2024 – 2029/2030 (5yr survey + 1/2yr to finalize data reduction)
  - We had the first “SO Operations” review

DATA DISTRIBUTION

We want to guarantee:

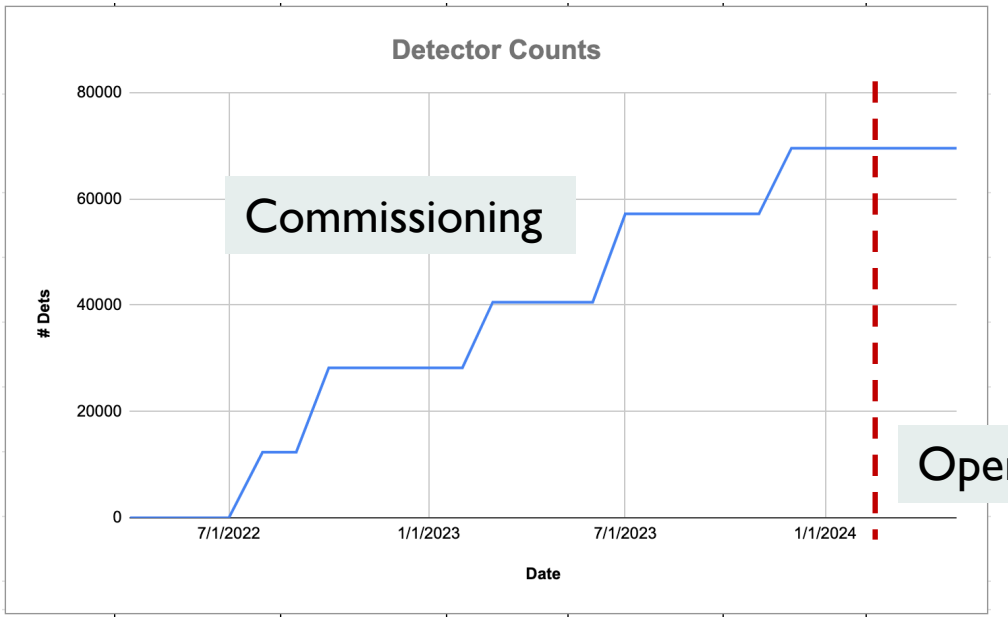
- Redundant data storage, both at the site (HEF) and in North America
- Redundant communication, between HEF and North America to ensure safety at the site
- Redundant data transfer paths, against computing centers downtime
  - We do not have a strict requirement on data getting to the US.

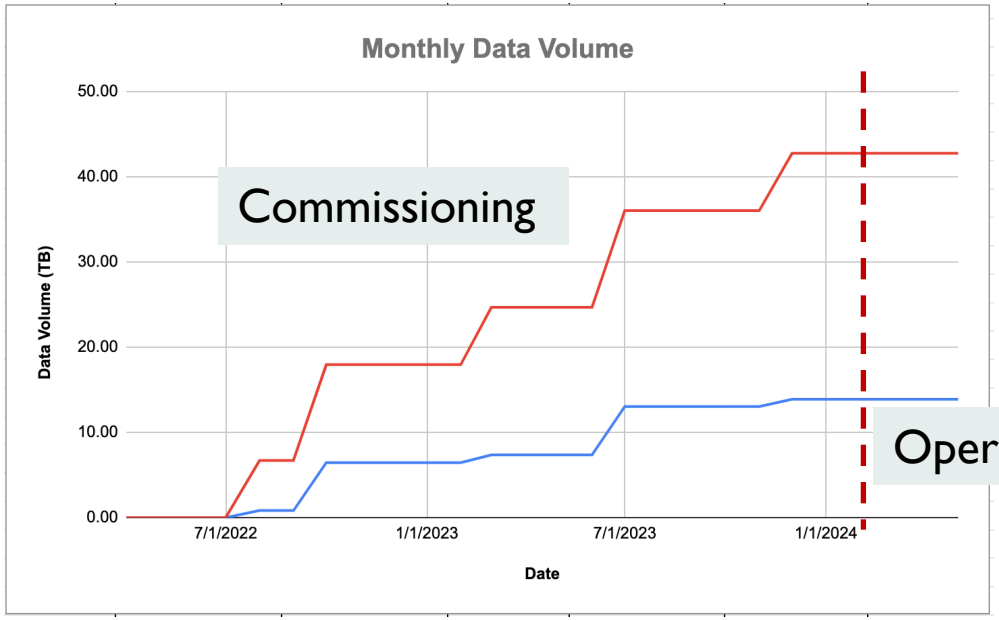


DATA RATES AND DATA VOLUME

- The data rate is dominated by detector time-streams (69,546 detectors) → **132 Mbps**
  - SATs: 37,044 detectors, sampling [min, max]: 27-200 Hz (all frequencies same sampling, HWP dominating factor)
  - LAT: 32,502 detectors, sampling [min, max]: 30-340 Hz

- We baseline the higher data rate (red curve), but we could reduce it during operations depending on the instrument characterization
  - At current baseline rate, **~3PB of raw data for 5yr survey**





HEF-WORLD COMMUNICATION AND DATA TRANSFER

- Communication and remote access to site computing via line-of-sight radio links
  - Two redundant radio links/routers to ensure constant communication with site crew
  - Not meant to move data, but used for webcam streaming/frames
  - All communication hardware is on UPS
- Data transferred via fiber connection
  - Data will reach North American within 24hrs
  - Fiber connection should be operational before June 2023. For commissioning and to mitigate possible delays we have also implemented a “SneakerNet” plan
- We adapted the Librarian software as Data Transfer Manager to be used for SO data:
  - Will run it at the site and all US data hubs: for Site-US and US-US data movement
  - Also support SneakerNet with US-endpoint at UCSD
  - Data stored at the Site (2 copies) until 3 copies appear in US

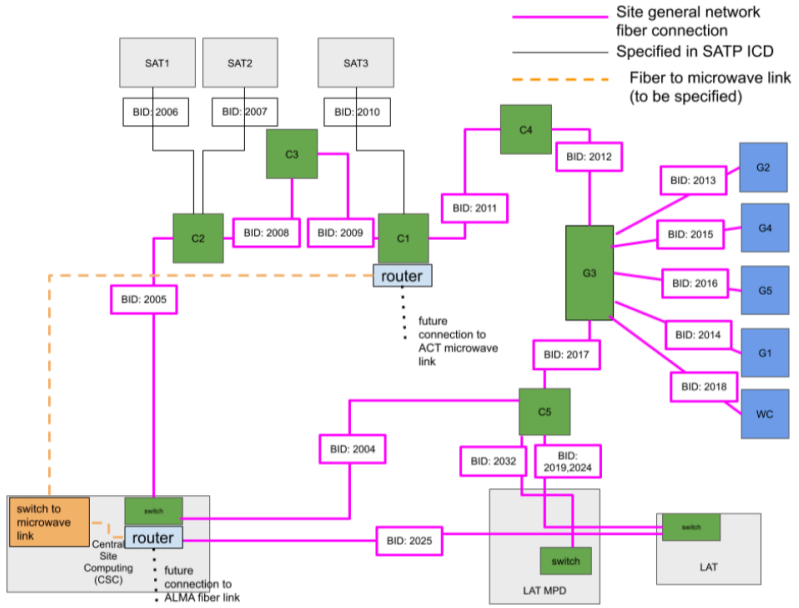
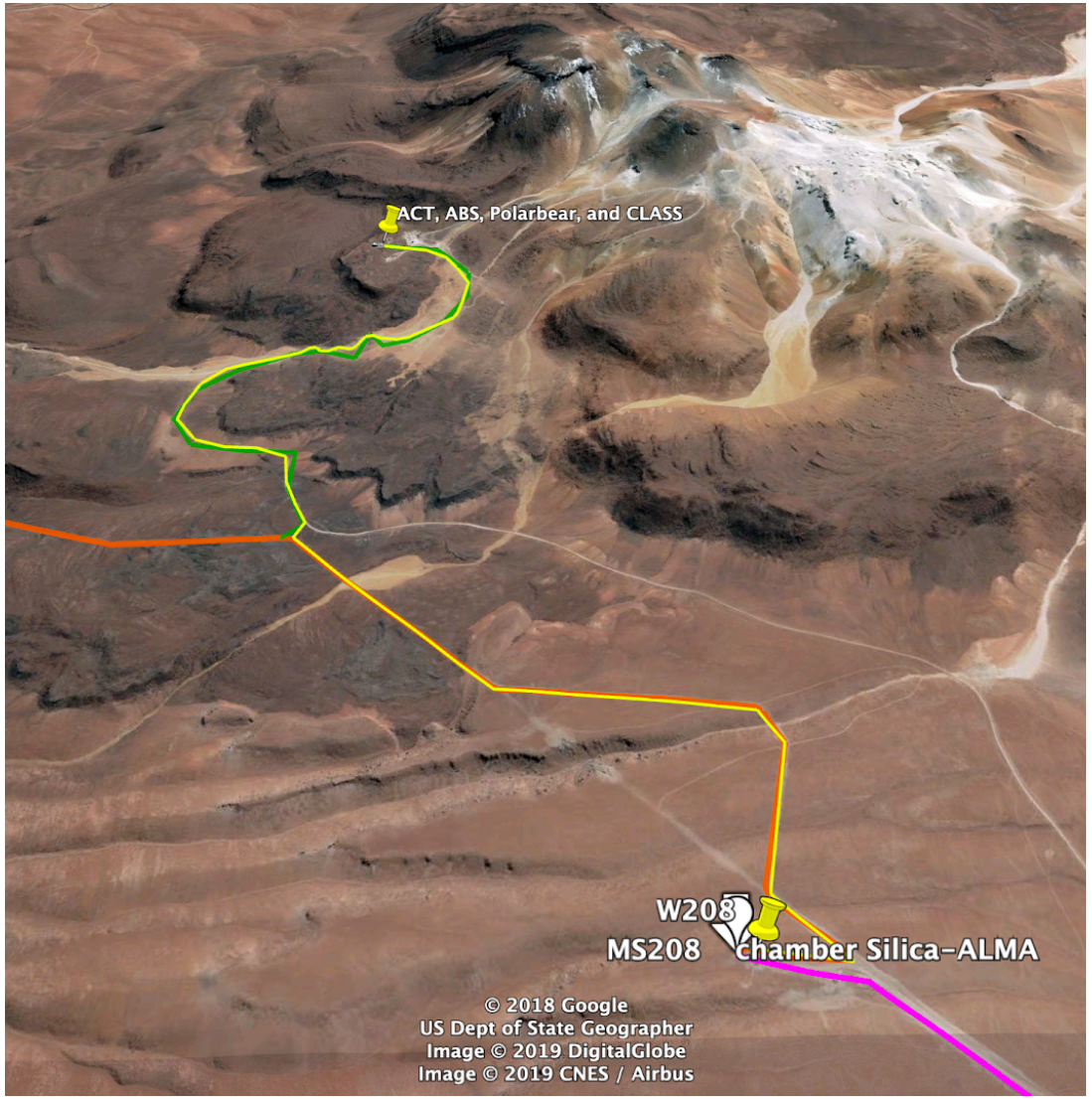


Figure 4: General network layout
The general network has a “circular” topology whose rationale is explained in Section 4.2.2. Magenta indicates single-mode fiber bundles, with bundle ID (BID) as specified. Green indicates IEEE-1588 compliant managed switches, and blue switches which are not currently IEEE-1588.

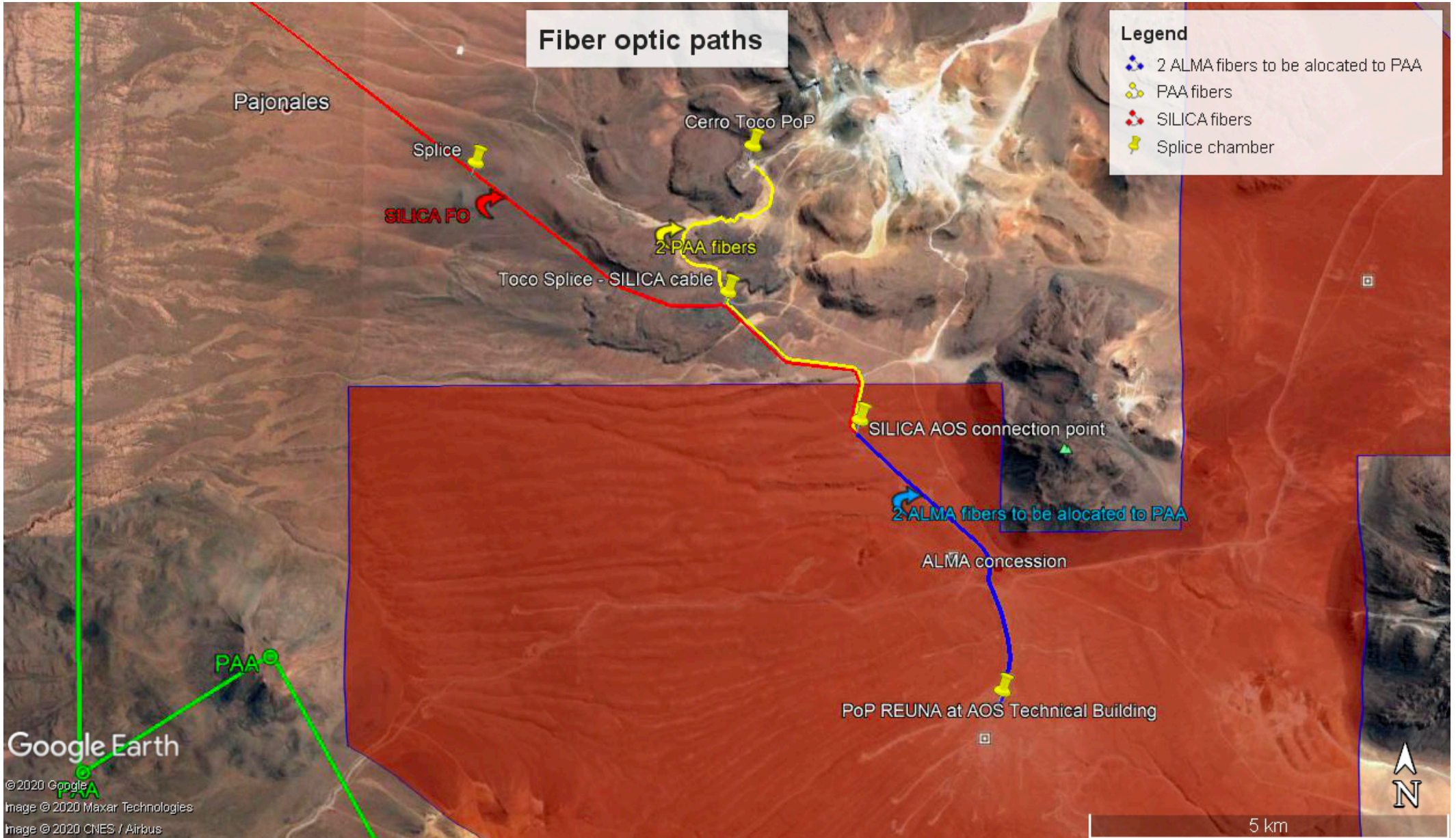
SO Site-Data ICD
External Reviewer: Paul Wong (SF)

DATA MOVEMENT — SO SITE TO U.S.



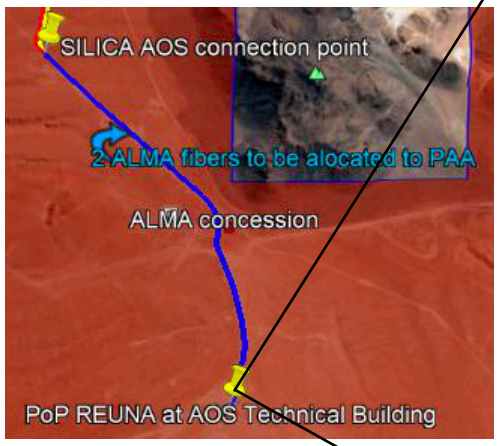
- Design of Site network is completed and under review [DONE]
- ~~SO-funded fiber connection from SO site to ALMA REUNA PoP~~
  - ~~Connection near pad W208~~
  - [UPDATED]: PAA will provide fiber connectivity from ALMA to the Site
- MoU between SO and ALMA to allow fiber connection is written and under preliminary revision
  - [UPDATED]: PAA x ALMA MoU. SO x ALMA kept as risk mitigation
- MoU between SO and REUNA to utilize the service needs to be finalized

DATA MOVEMENT — SO SITE TO U.S.



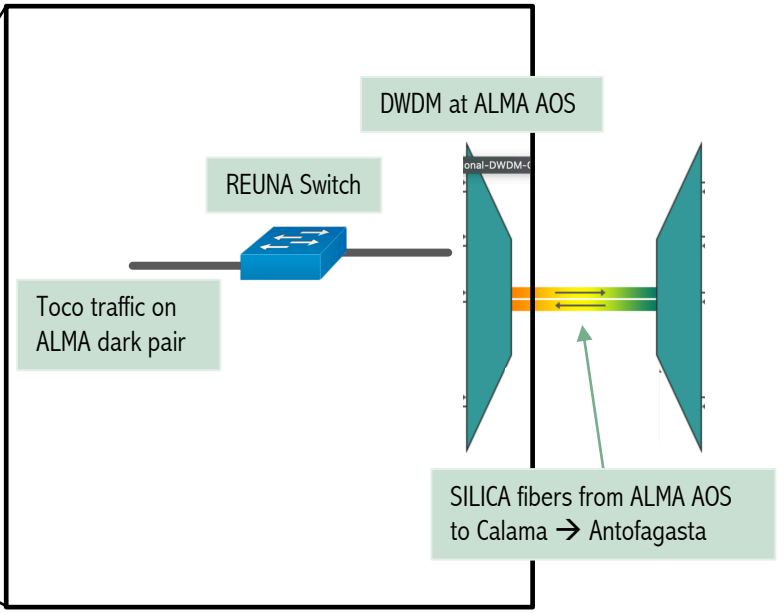
DATA MOVEMENT — SO SITE TO U.S.

SILICA will install a new fiber under PAA contract. Part of the connection will use existing SILICA fibers (red) to SILICA PoP



PAA fibers will patch into ALMA dark fibers from SILICA AOS to REUNA PoP @ ALMA AOS.

PAA working on MoU with ALMA



Toco traffic will travel on a separate OUT2 from ALMA traffic but same fiber

REUNA working on MoU with ALMA (we heard from Jorge Ibsen)

REUNA will mediate between SO and providers (redCLARA, AMLIGHT, ESnet…) to reach North America

DATA MOVEMENT — SO SITE TO U.S.

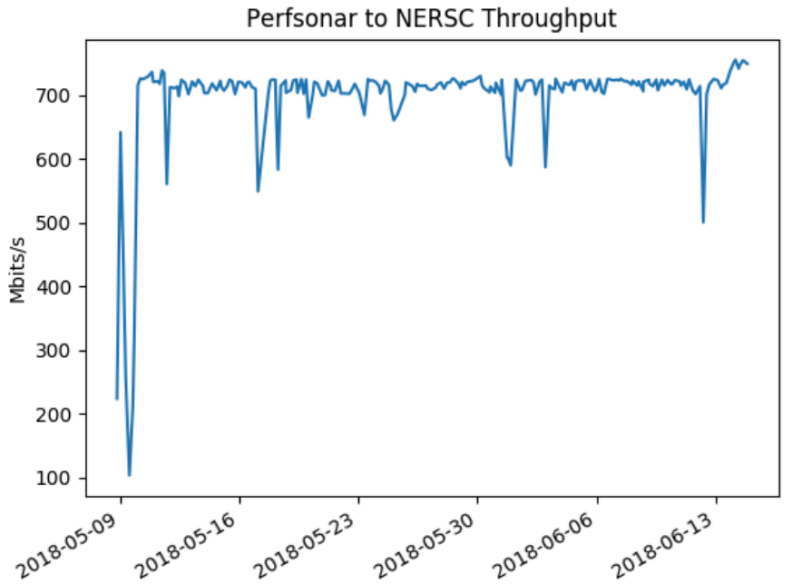


Fig. 6 - Network throughput test (Simons Observatory to NERSC) showing sustained high performance over a month.

James Aguirre
(U Penn)

Eli Dart
(ESnet)

- 1GB connection between ALMA PoP and NERSC tested
  - Performance: >700 Mbps
  - Reliability: stable over ~1 month
  - Performance exceeds SO requirements by factor 2-5
- Great collaborative work:
  - R&E Networks:
    - ESnet and REUNA
    - help from RedCLARA and AMPATH/AMLIGHT
  - Science facilities: ESO, ALMA, and SO