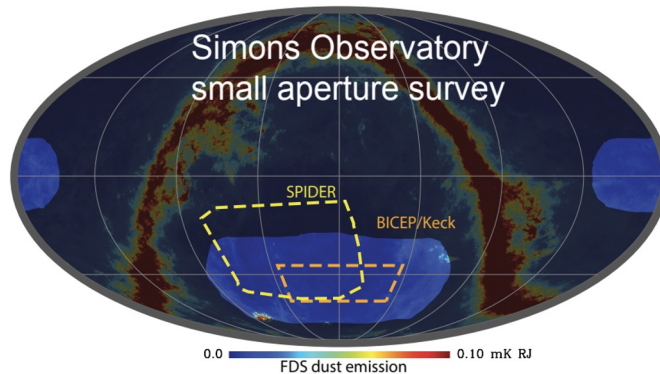


(Advanced)
Simons
Observatory
A STATUS UPDATE

AMLIGHT SA3CC 2023, August 1, 2023
James Aguirre, University of Pennsylvania
For the SO collaboration

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

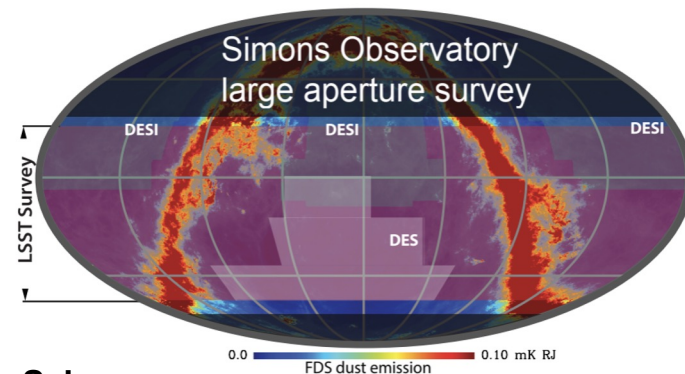


Science:

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

SAT Survey:

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



Science:

- Primordial perturbations
 - Neutrino mass
 - Relativistic species
 - Reionization
 - Dark energy
 - Galaxy evolution
 - Transients
- ### LAT Survey:
- 40% of the sky
 - Overlap with Rubin Observatory/LSST and other LSS

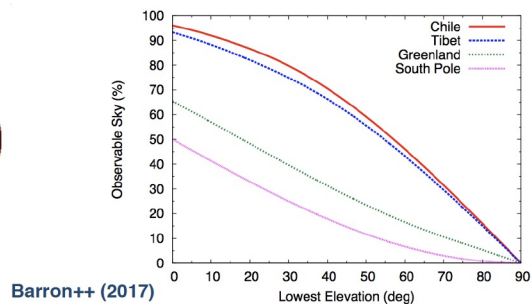
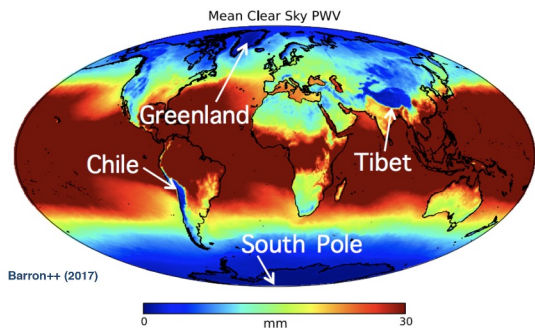
Periodic data releases: CMB, lensing maps, source and cluster catalogs, transient events



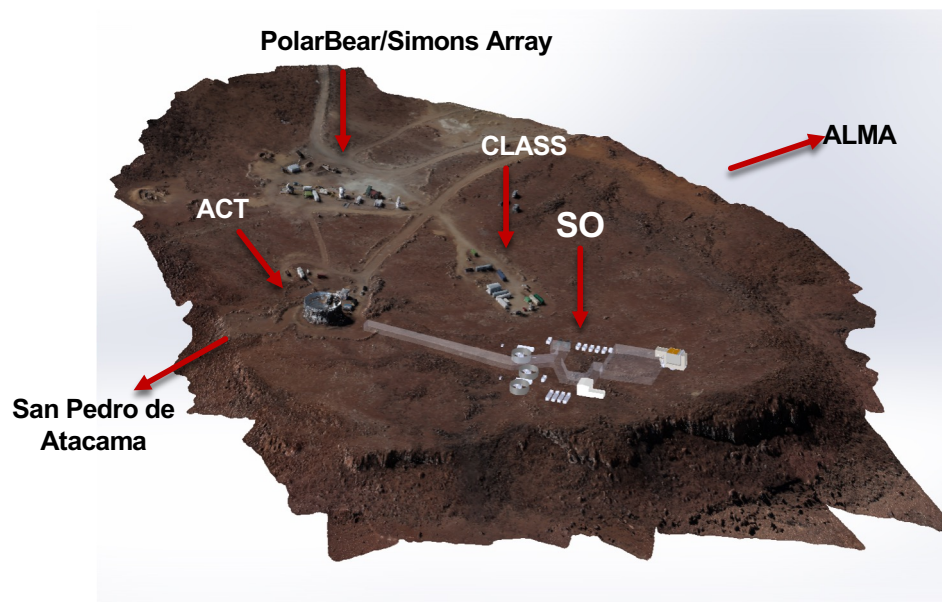
SIMONS FOUNDATION



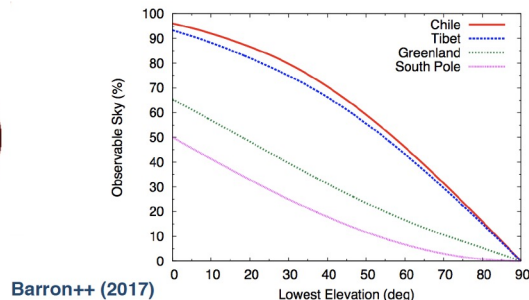
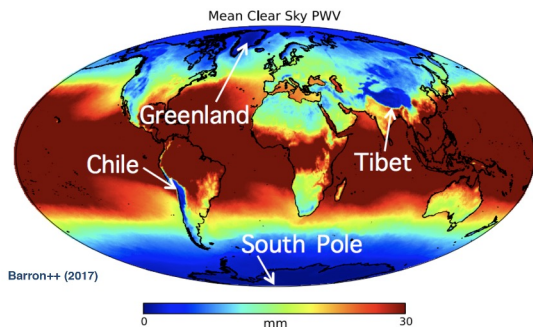
SIMONS OBSERVATORY (SO) — SITE



- Chajnantor plateau, 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



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



**SAACC 2022 ⇒
SA3CC 2023**

- SATPs, LAT and LATR are on site
- First installation of SAT ongoing
- Additional SATs installed in fall
- Computers at the site; awaiting completion of fiber link



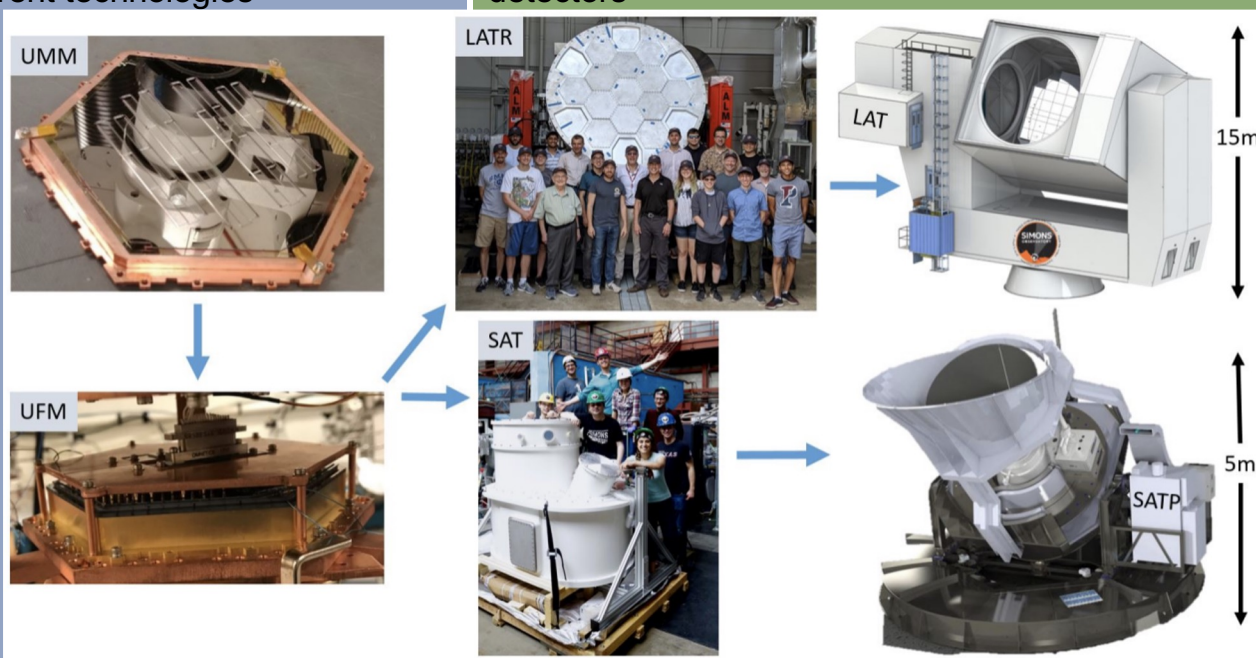
SIMONS OBSERVATORY (SO) — INSTRUMENTATION

Detectors:

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

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



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

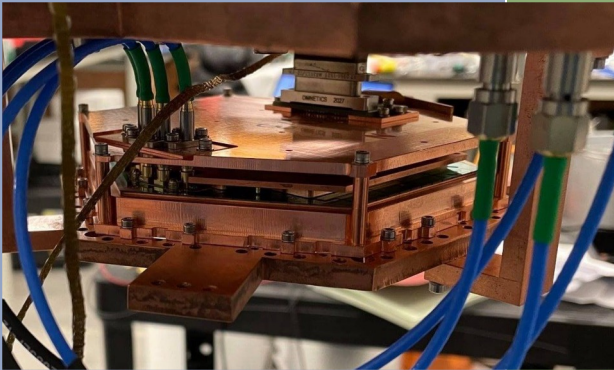
Small-Aperture Telescopes (SATs)

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

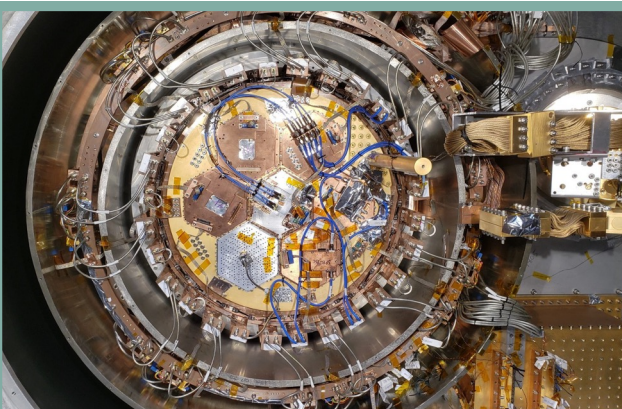
SIMONS OBSERVATORY (SO) — INSTRUMENTATION

SAACC 2022 ⇒ SA3CC 2023

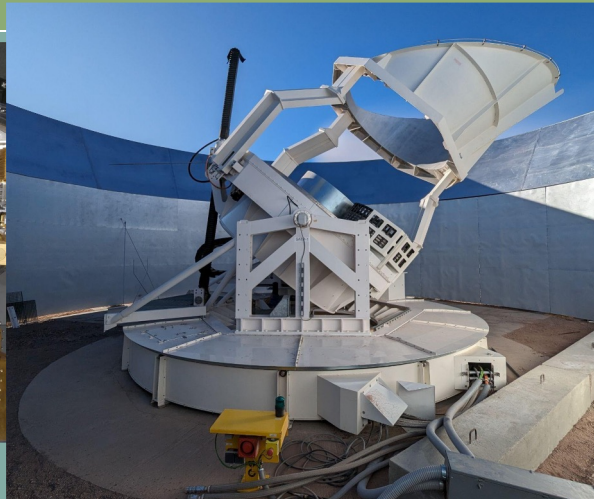
Detectors:



Large-Aperture Telescope (LAT)



Small-Aperture Telescopes (SATs)



Major Developments 2022 ⇒ 2023

Official funding (\$52.66M) from NSF of Advanced Simons Observatory (ASO)

Photovoltaic power station

Full complement of optics tubes for LAT (from 7 to 13; doubling of mapping speed)

Significant Data Management effort for public and timely distribution of science data

All telescope platforms (SATP, LAT) and LAT receiver (LATR) on-site and undergoing testing

One SAT on-site; others shortly

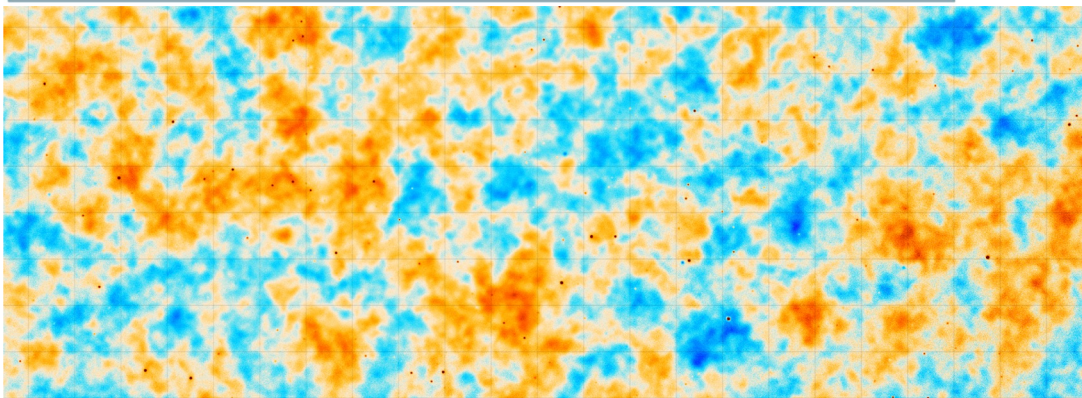
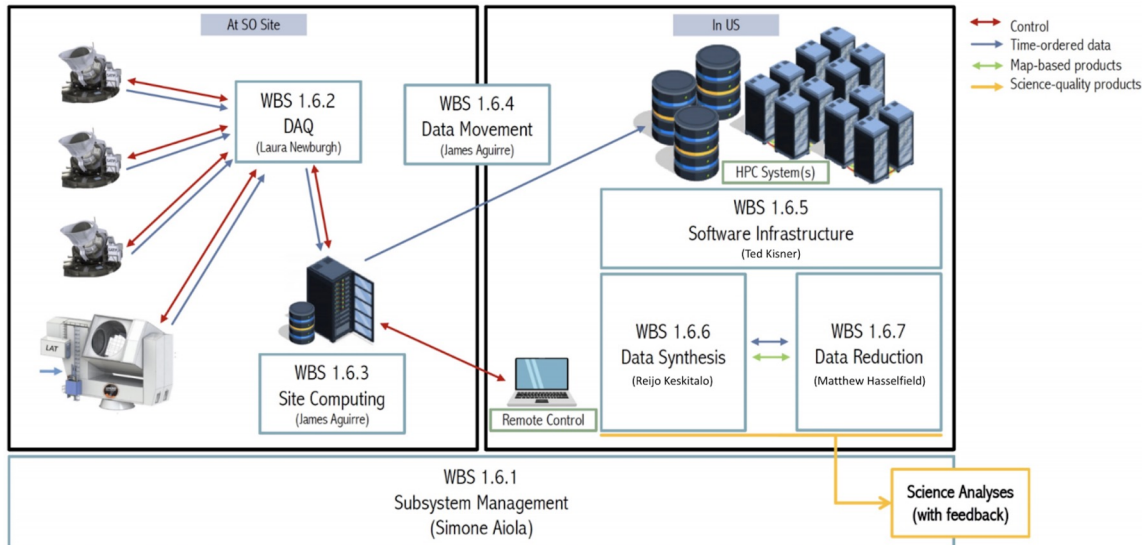
SO:UK funded

SIMONS OBSERVATORY (SO) — TIMELINE

Current (mid '23)	Late '23	Early '24	Mid '24
SAT deployment and commissioning	First light for SAT	First light for LAT First science observations expected	Full science observations expected

- SO Construction Project: 2016 - 2024
- SO Operations: 2024 – 2029/2030 (4 yr survey followed by ASO operations)

DATA MANAGEMENT



Open source philosophy. Most software is public on the `simonsobs` GitHub account; Software Developers' Guide.

- An observatory control system to monitor and acquire data; software for live data viewing.
- Hardware infrastructure for computing at the SO site, and use of CMB community resources at NERSC, as well as SDSC and NERSC
- A software library to process raw time-ordered-data.
- A simulator of time-ordered-data, and simulations of observed sky maps.
- Software to perform quality cuts and calibrations.
- Software to turn time-ordered data into maps.

DATA MANAGEMENT

Observatory Control System + Data Acquisition (DAQ) system:

- *Current status:* [OCS](#) Fully developed (general + SO specific hooks), tested, documented and public on GitHub
- Adopted as DAQ baseline for CMB-S4
- Used in SO labs for testing and soon deployed at the site
- Includes: control and monitoring of hardware and site, data aggregation and collection, real-time visualization

The Simons Observatory: Overview of data acquisition, control, monitoring, and computer infrastructure
<https://arxiv.org/abs/2012.10345>

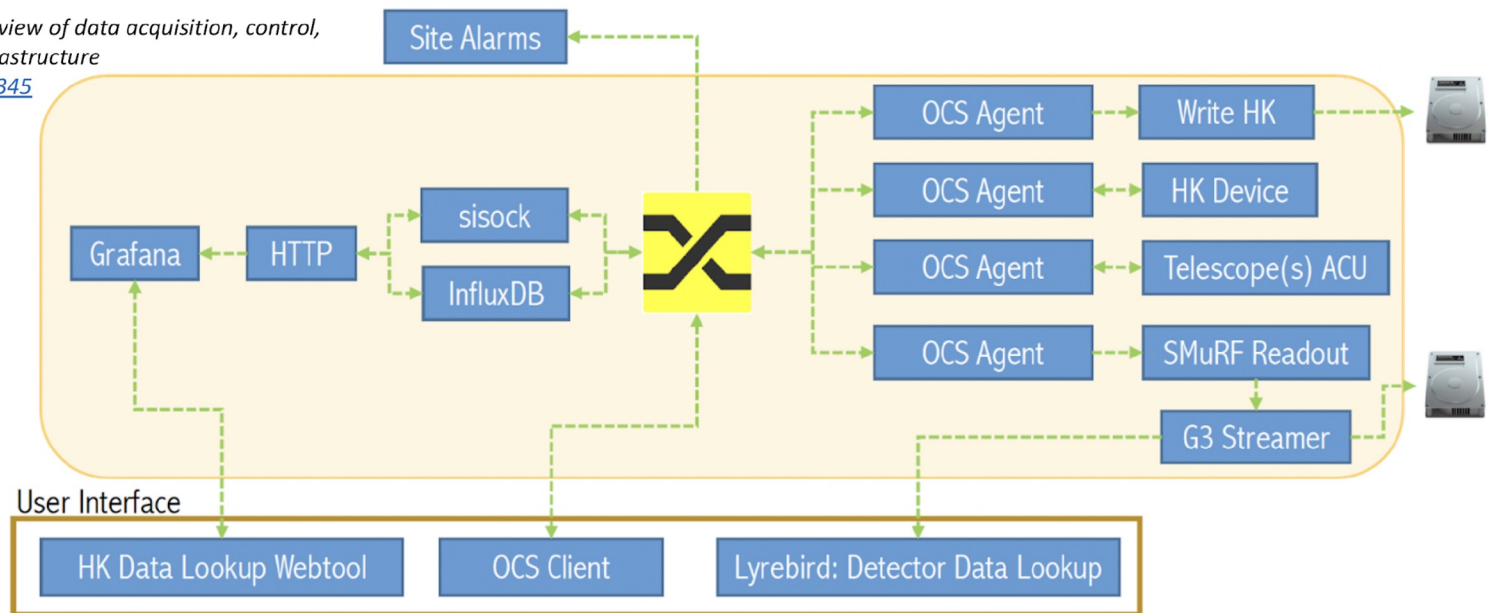
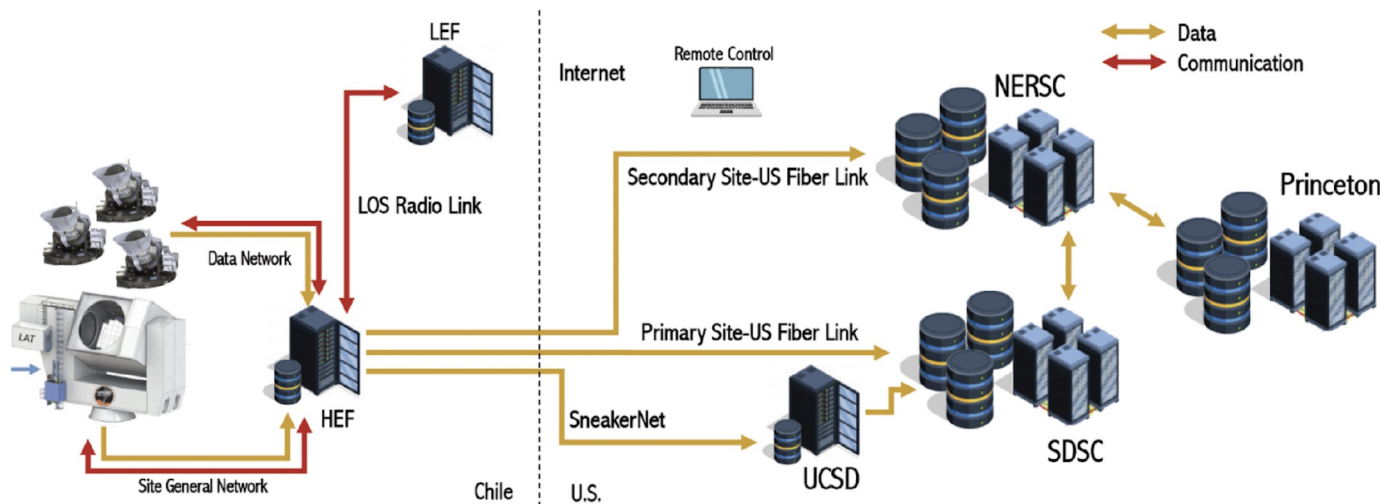


Figure credit: inspired by B. Koopman

DATA MANAGEMENT

Data collection, data registration, and data transport

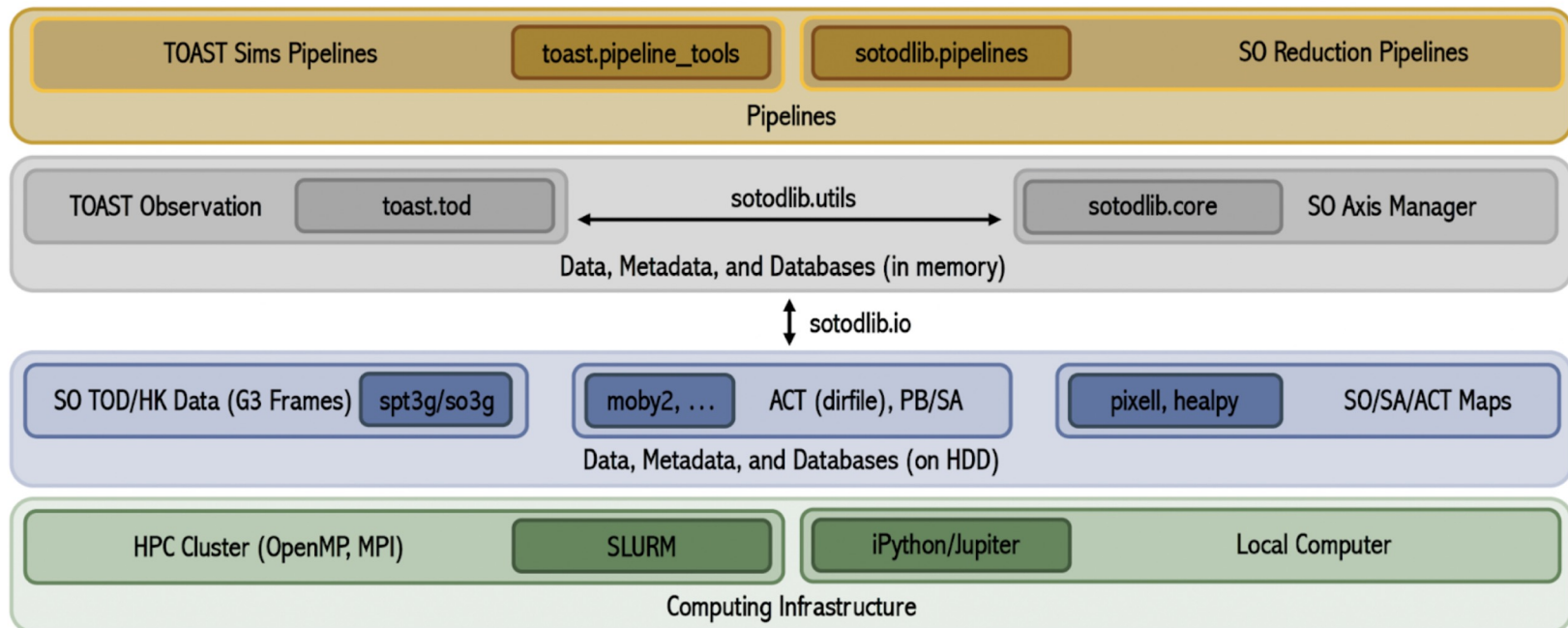
- *Current Status:* data transfer manager software into testing phase ([Librarian](#) on SO GitHub).
 - Will manage: two 1-month copies at the site, three full copies in US, transfer from Site to US and US to US.
- Implemented SneakerNet (manual transport of disk) and also transfer via fiber. All handled by the same software
- Cross-development group with CMB-S4 who will need a scaled version of this implementation.



DATA MANAGEMENT

Data reduction and simulation unified framework

- [SOTODLIB](#): Public library to characterize and reduce real and simulated data. Also used in labs for data manipulation
- [TOAST](#): suite of simulation and reduction pipelines optimized for HPC
- Unified framework to simulate+reduce data on-the-fly



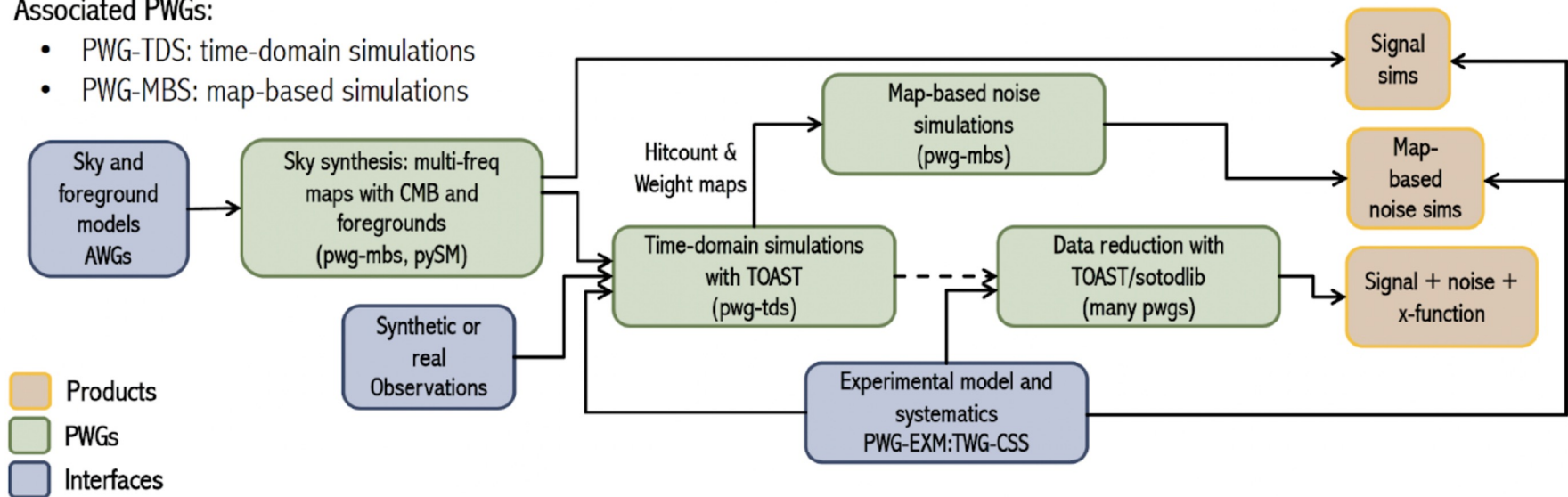
DATA MANAGEMENT

Simulations

- Two methods implemented: map-based and time-domain simulations
- Used to test/benchmark reduction pipelines and deliver SO-like data to AWGs (science groups)
- Planned released before end of SO project
- *Current Status:* pipelines are mature and should deliver products in 2022-2023

Associated PWGs:

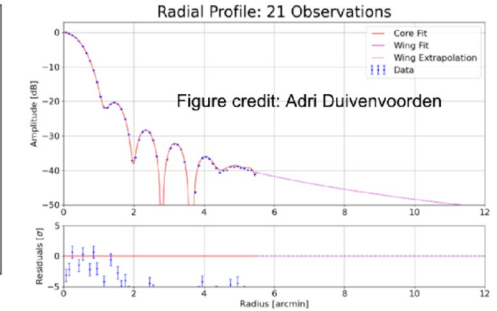
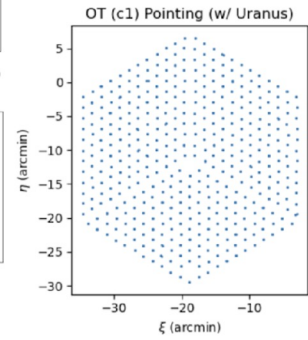
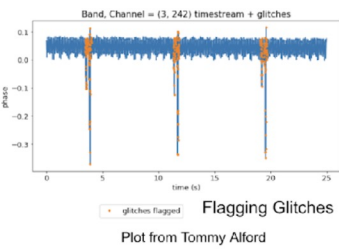
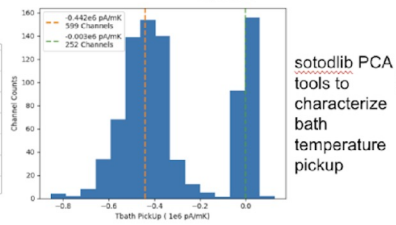
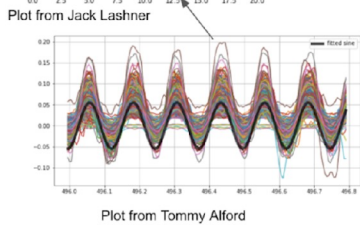
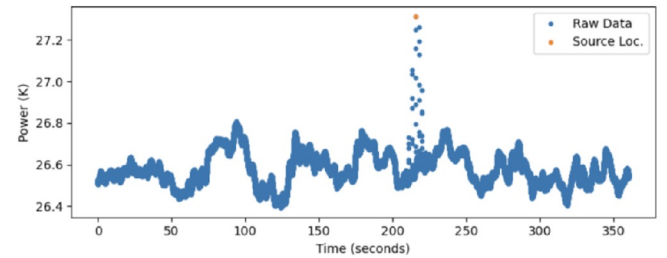
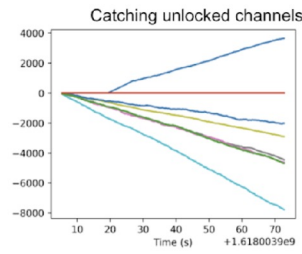
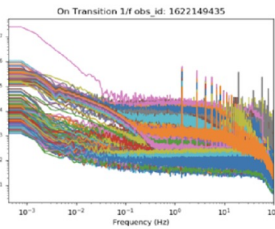
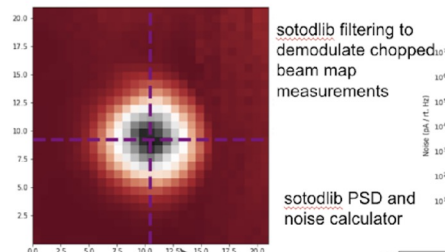
- PWG-TDS: time-domain simulations
- PWG-MBS: map-based simulations



DATA MANAGEMENT

Reduction to maps (some highlights)

- *Current Status:* Developed low-level pipelines to characterize data, used also in labs, and beam and focal plane pipelines very advanced
- For LAT, developed a map making maximum-likelihood pipeline



SITE-TO-WORLD COMMUNICATION AND DATA TRANSFER

- Communication and remote access to site computing via line-of-sight radio links, ~ 1 MBps
 - Two redundant radio links/routers to ensure constant communication with site crew
 - Not meant to move (most) data, but used for login and control
 - All communication hardware is on UPS
- Data transferred via fiber connection
 - Data will reach North American within 24hrs
 - Fiber connection should be operational by April 2024. 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

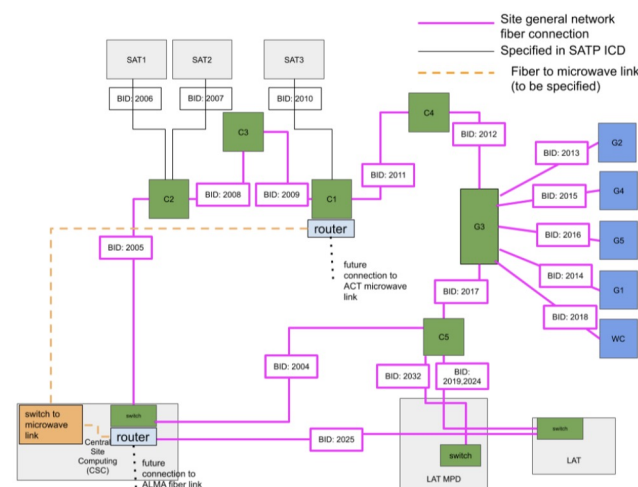


Figure 4: General network layout

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.

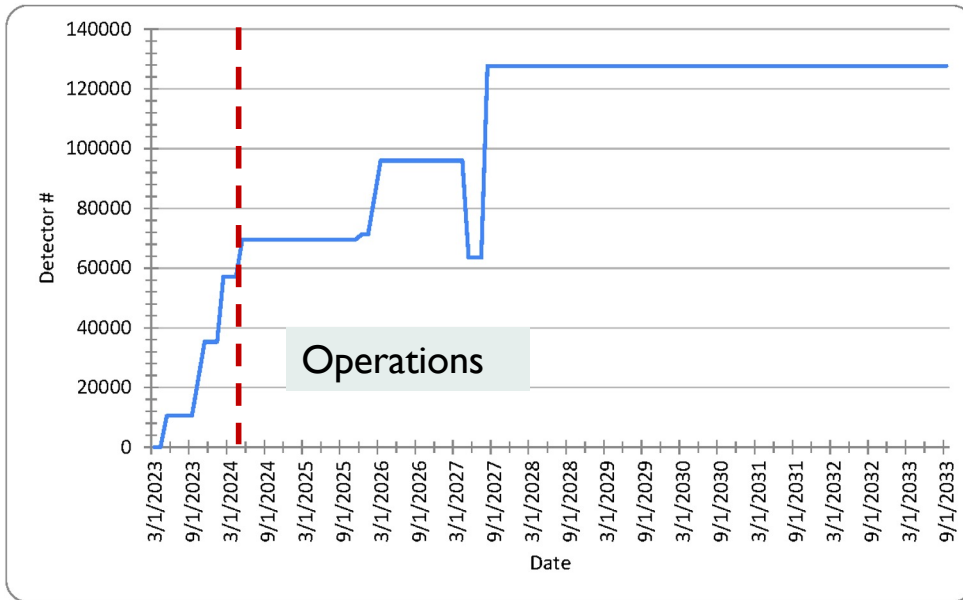
SO Site-Data ICD

External Reviewer: Paul Wong (SF)

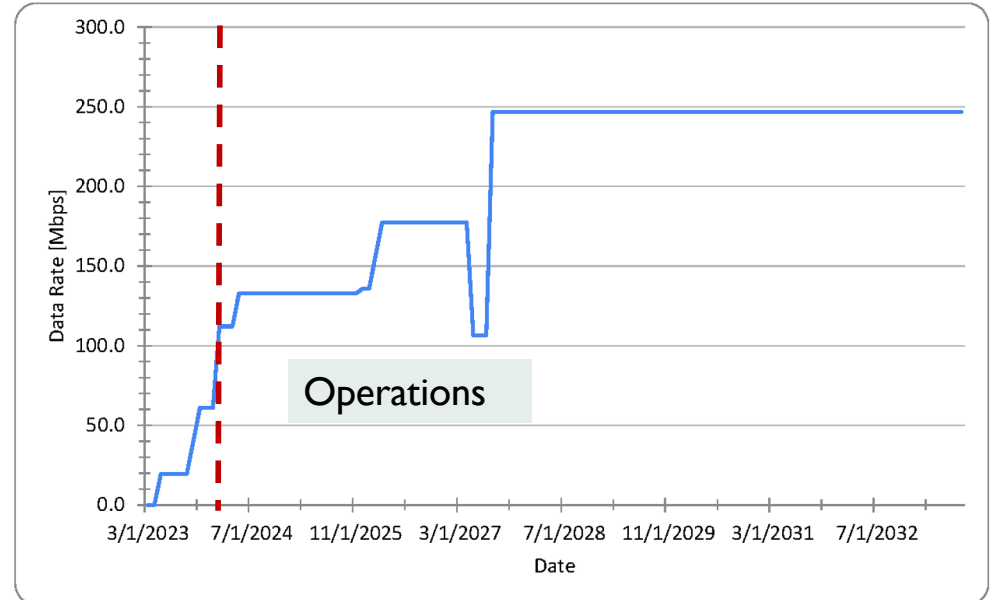
DATA RATES AND DATA VOLUME

- The data rate is dominated by detector time-streams (127,744 detectors) \Rightarrow **247 Mbps**
 - SATs: 63,490 detectors, sampling [min, max]: 27-200 Hz (all frequencies same sampling, HWP dominating factor)
 - LAT: 64,254 detectors, sampling [min, max]: 30-340 Hz
- Note that the data rate closely tracks the number of detectors deployed

Commissioning

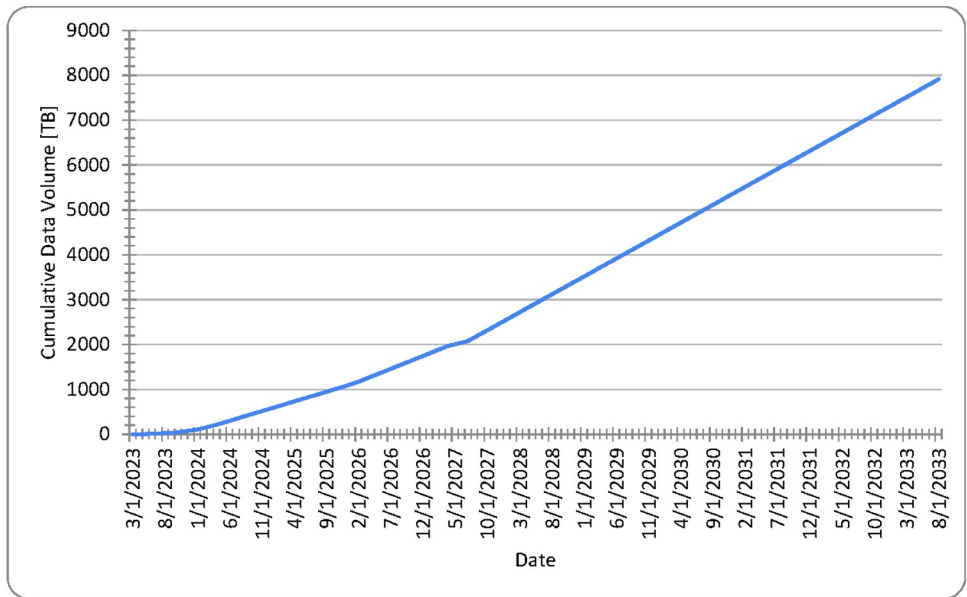
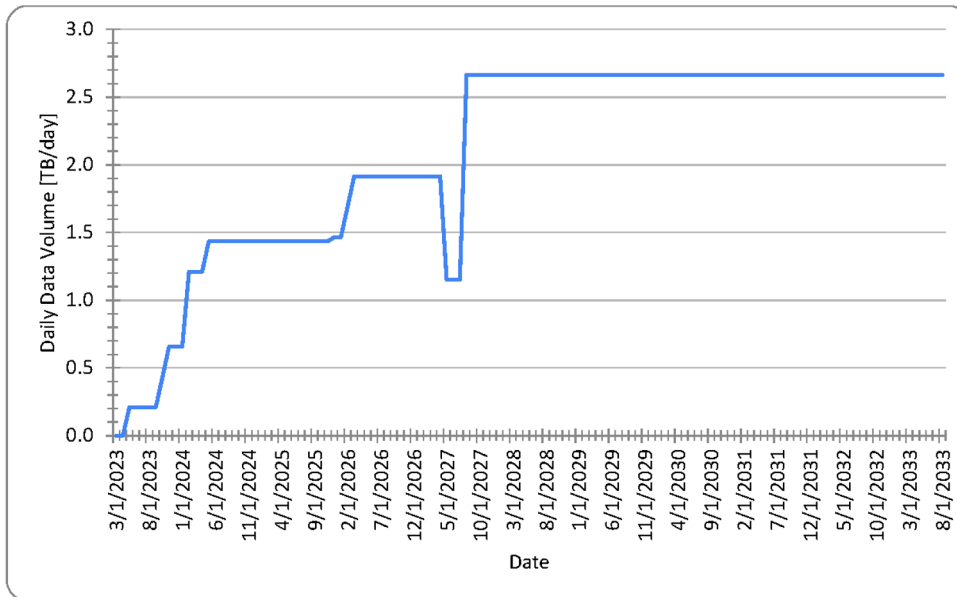


Commissioning

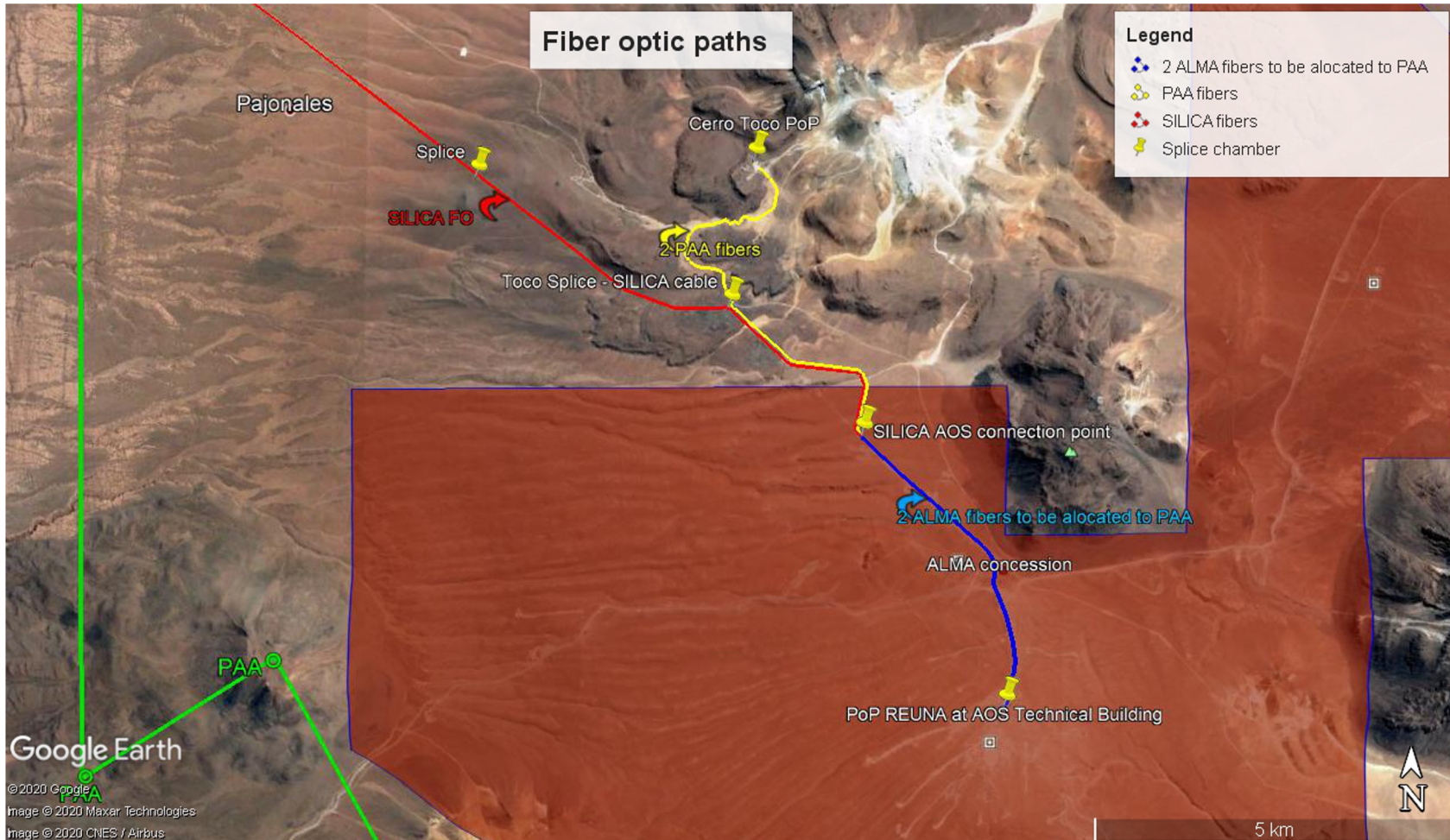


DATA RATES AND DATA VOLUME

- At current baseline rate, **~3PB of raw data for 4 yr survey** (through March 2028)
- Operations of the observatory are expected to continue into the early 2030's



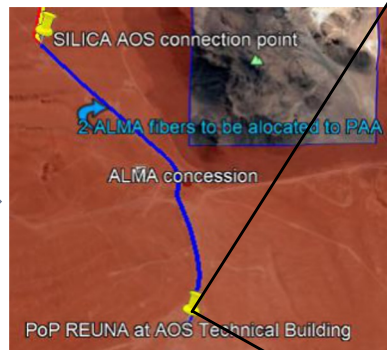
DATA MOVEMENT — SO SITE TO U.S.



DATA MOVEMENT — SO SITE TO U.S.

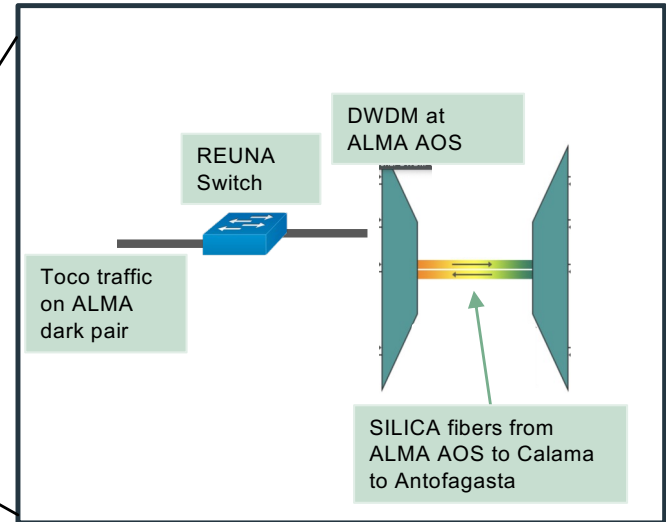


SILICA will install a new fiber under PAA contract. Part of the connection will use existing SILICA fibers (red) to SILICA PoP



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.



- 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



BACKUP

DATA MOVEMENT — SO SITE TO U.S.

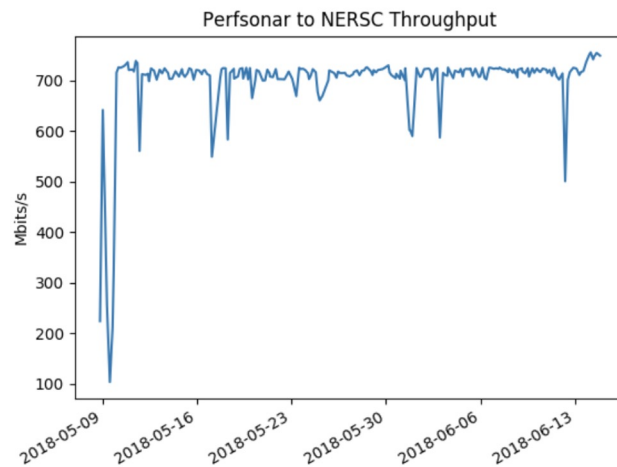
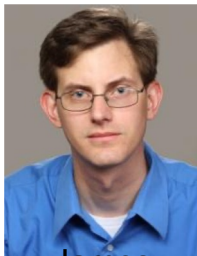


Fig. 6 - Network throughput test (Simons Observatory to NERSC) showing sustained high performance over a month.



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

