SIMONS OBSERVATORY

A STATUS UPDATE

SIMONE AIOLA (CENTER FOR COMPUTATIONAL ASTROPHYSICS, NY)

SAACC 04/21/2020

SIMONS FOUNDATION

PARQUE ASTRONÓMICO ATACAMA, CHILE

SIMONS OBSERVATORY

www.simonsobservatory.org

HEISING-SIMONS FOUNDATION

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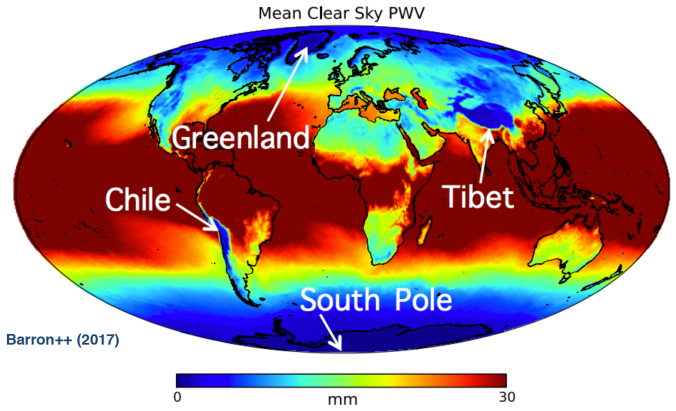
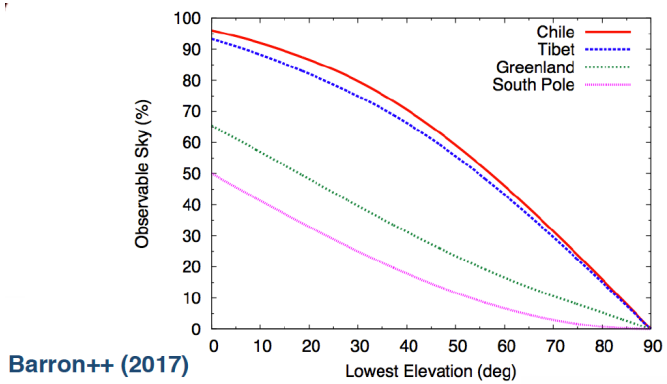
SIMONS OBSERVATORY (SO) — SITE





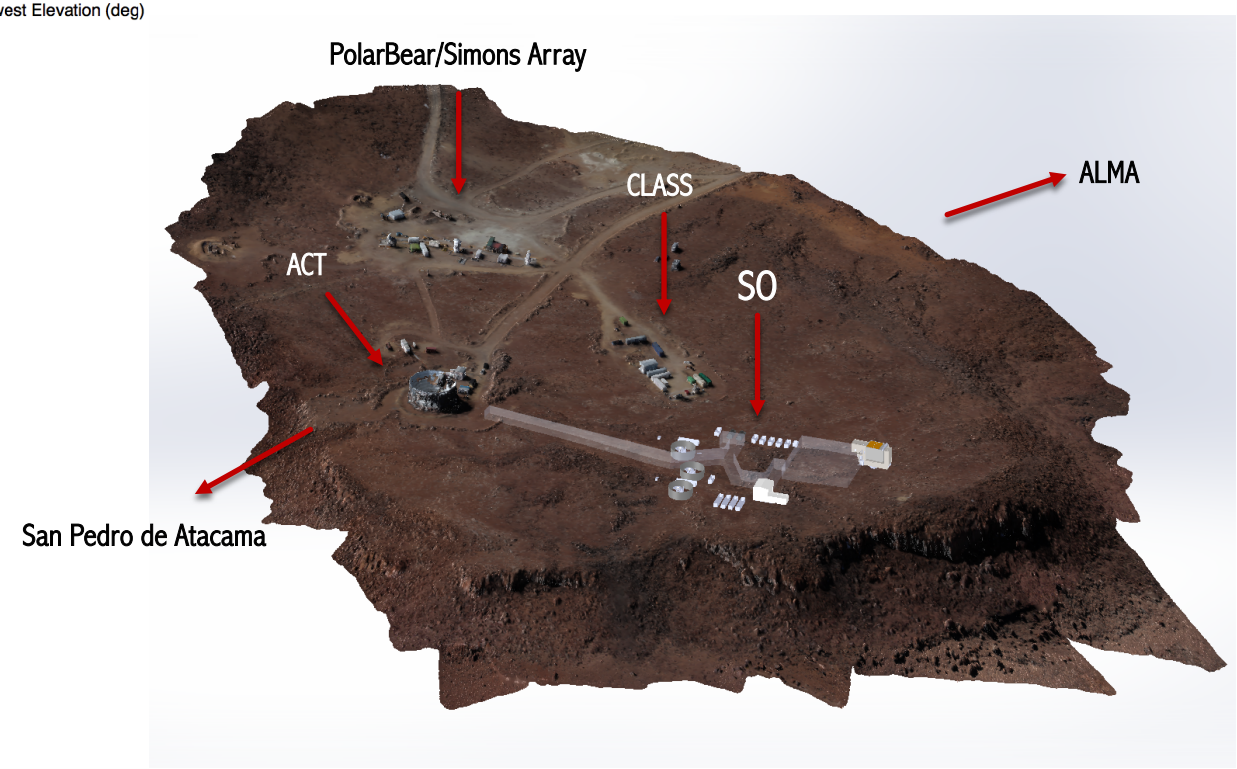
- Chajnantor platau, Atacama Desert, Chile @5,190m a.s.l.
- Median precipitable water vapor ~ 0.8mm
  - Ideal for 20-280 GHz measurements

Currently operating CMB experiments:

- ACT (2007-2022): 1 large-aperture telescope
- PB/SA (2012-2022): 3 small-aperture telescopes
- CLASS (2016-): 2 small-aperture telescopes

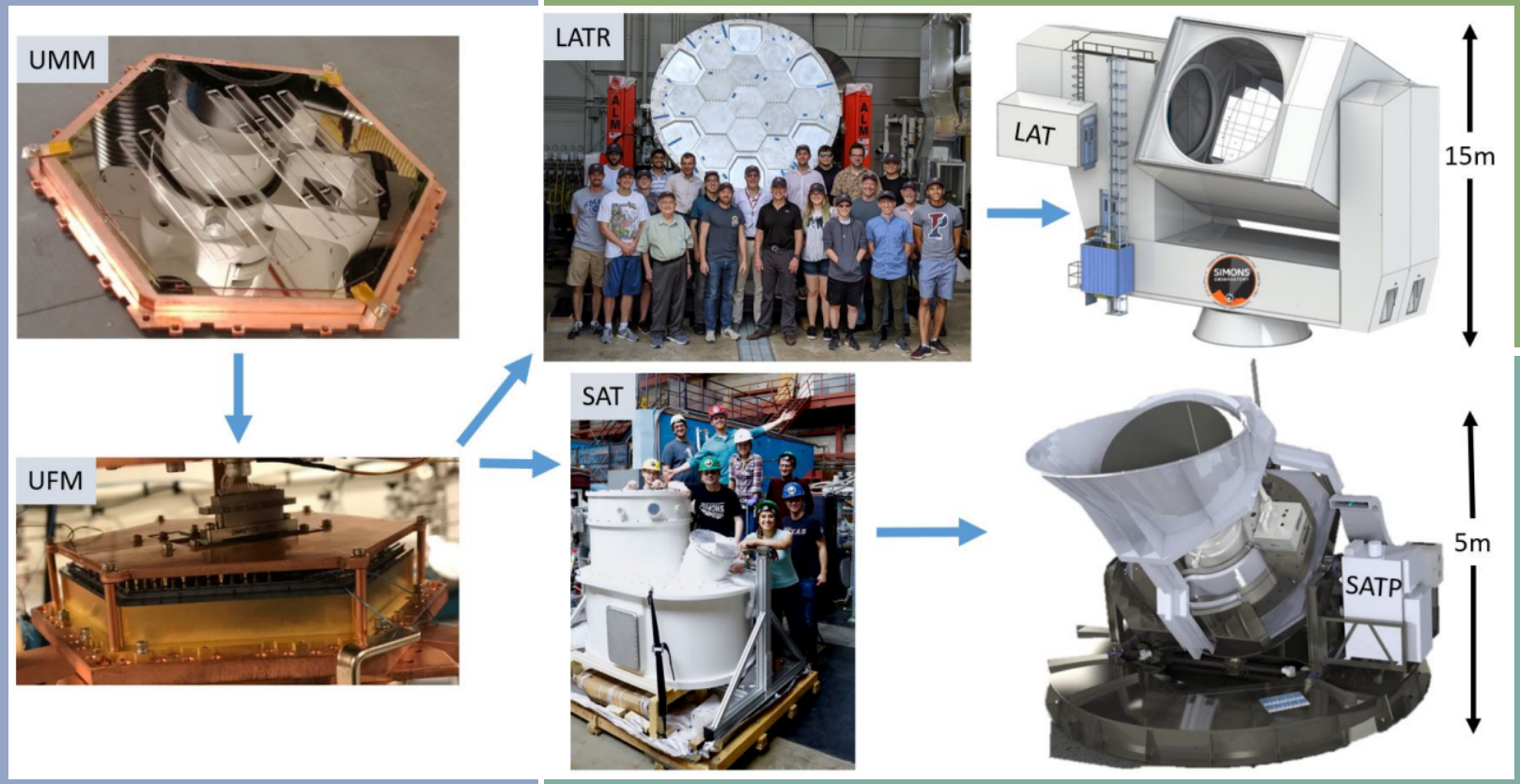
In construction:

- Simons Observatory
  - started by ACT+PB/SA collaborations
  - 62.5M$ from SF/HSF +10M$ institutional commitments
  - Project construction phase (2017-2022)



SIMONS OBSERVATORY (SO) — INSTRUMENTATION

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

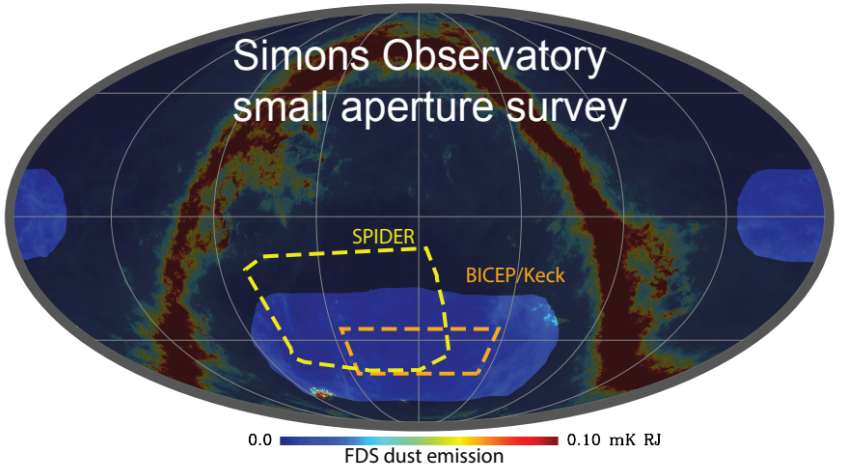


LF (27/40 GHz), MF(90/150 GHz),
UHF (220/270 GHz)

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) — MULTIFREQUENCY 5YR SURVEY AND SCIENCE GOALS

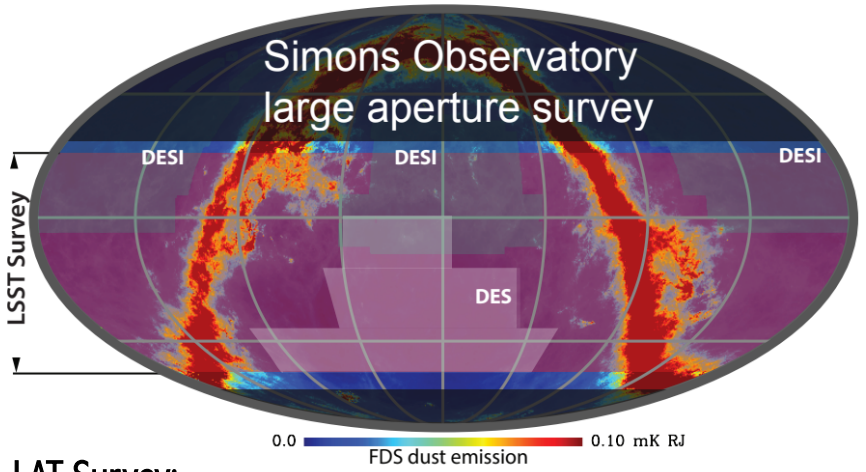


SAT Survey:

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

Science:

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



LAT Survey:

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

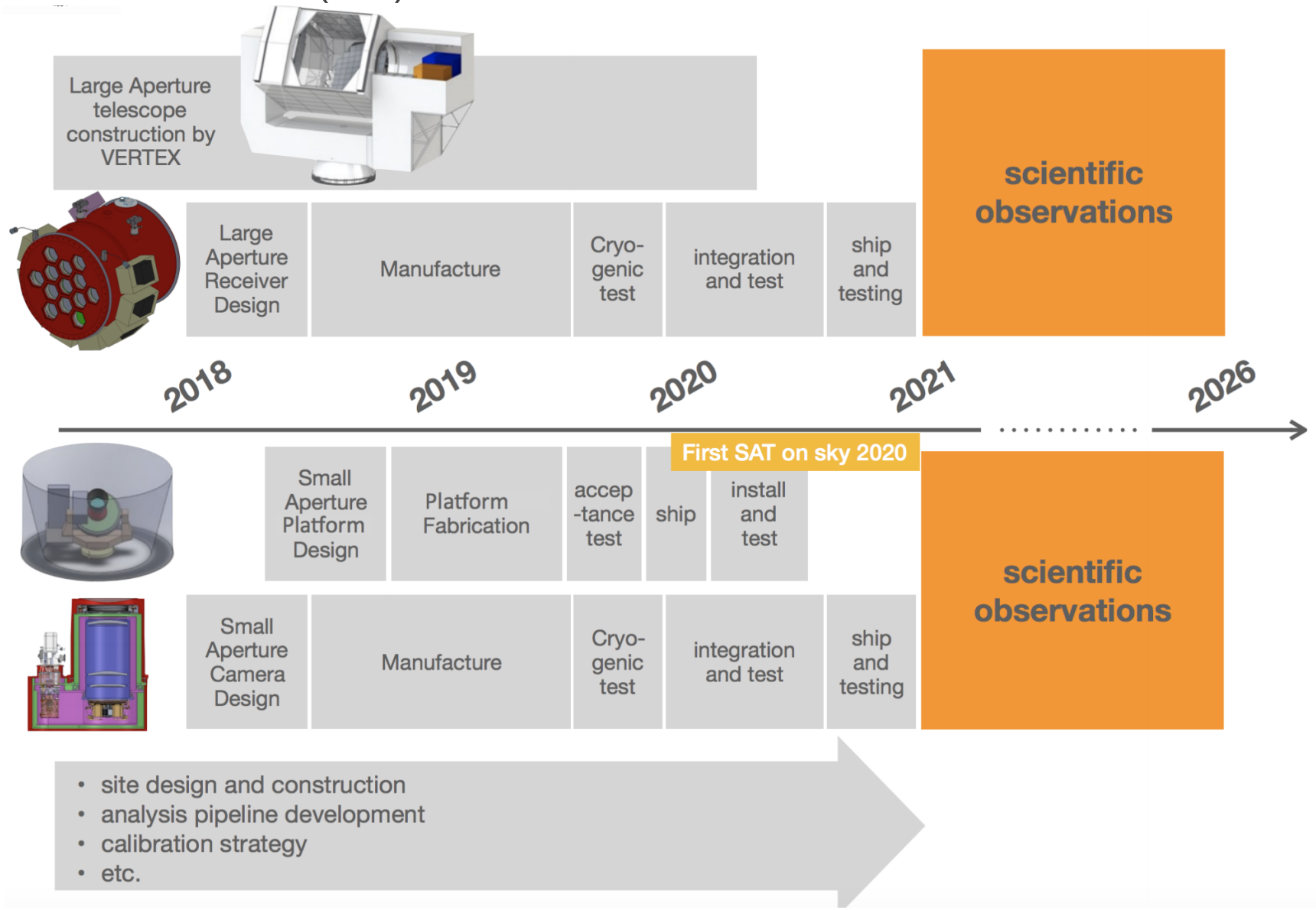
Science:

- Primordial perturbation
- Neutrino mass
- Relativistic species
- Reionization
- Dark energy
- Galaxy evolution
- Transients **(same sky at the same time as LSST)**

Transferring data from Site to US fast is the key!

Periodic and timely data releases, delivering to the community CMB, lensing maps and catalogs

SIMONS OBSERVATORY (SO) — TIMELINE



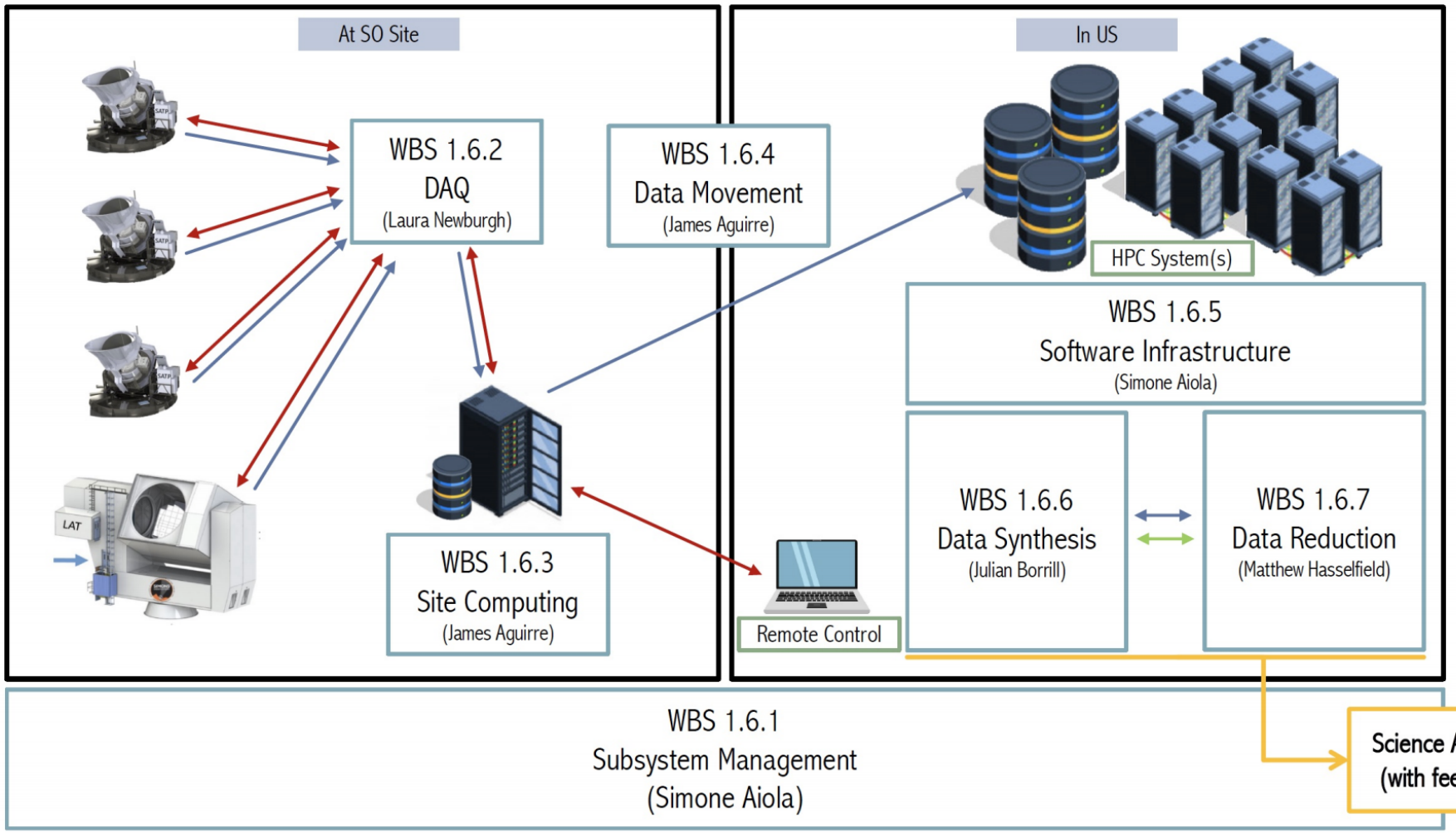
SIMONS OBSERVATORY (SO) — DATA MANAGEMENT

Software is a key part of the observatory.

- Observatory Control System developed, deployed to the SO labs, and publicly available
- Pipeline for data reduction and simulation in development

Laura Newburgh
(Yale)

James Aguirre
(U Penn)



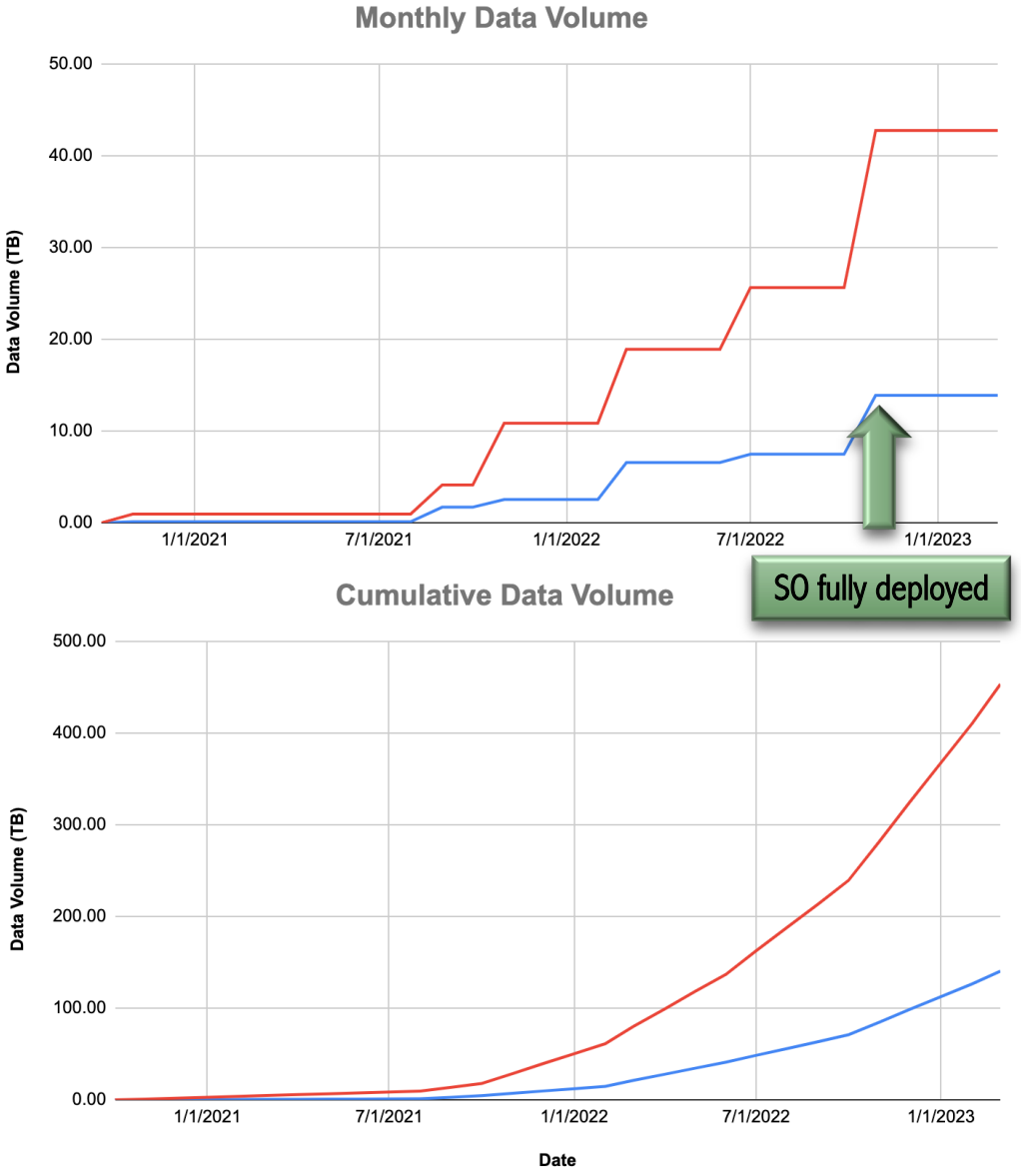
Matthew Hasselfield
(CCA)

Julian Borrill
(LBNL)

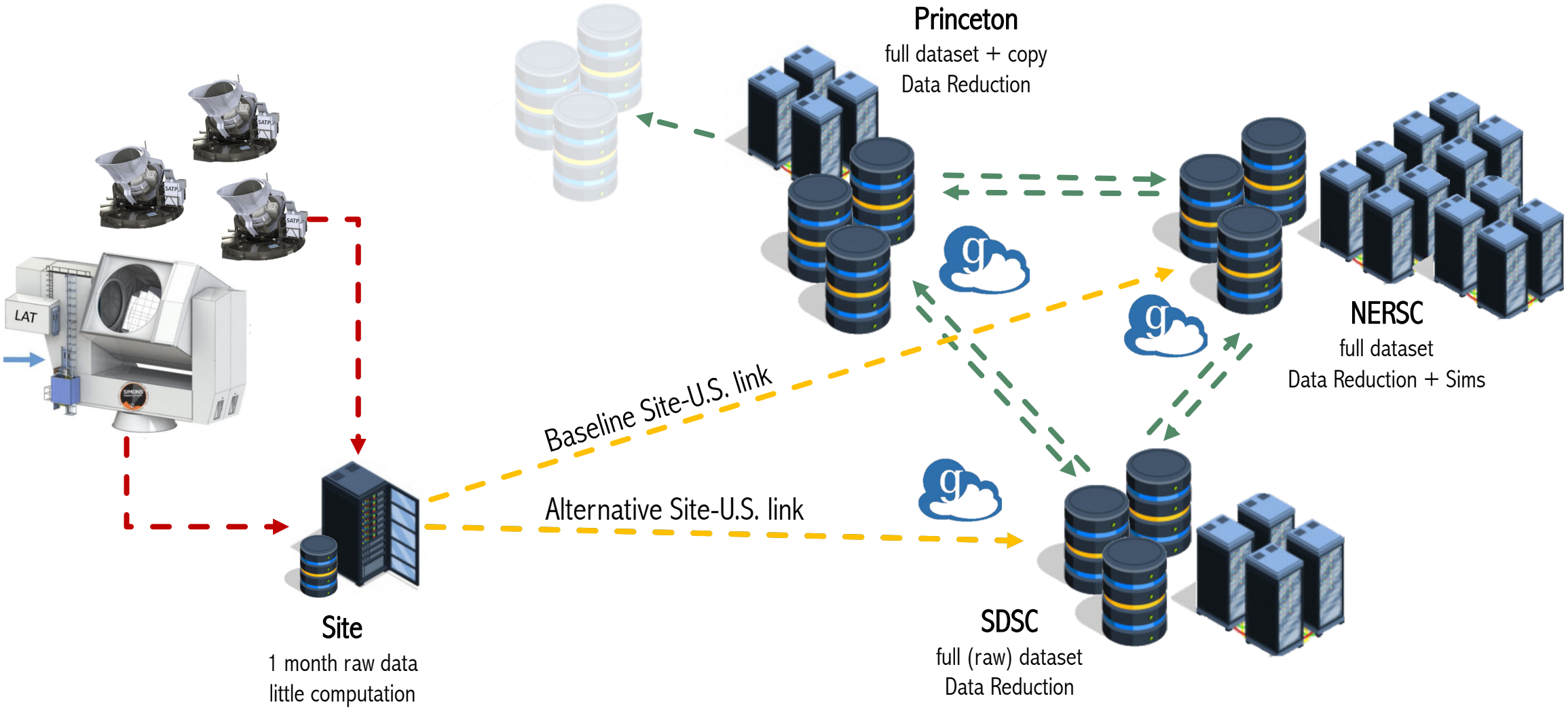
DATA AND COMPUTATION REQUIREMENTS

- **Storage**
  - Storage at the site to hold ~1 month of data (and 1 copy)
  - Data moves from Site to North America within 24 hrs
  - At least 3 copies of the raw dataset (collocated with analysis centers)
  - Total 5yr survey data volume ~3PB, ~500TB/yr
  - Data rate: 132 Mbps

- **Computing**
  - Most of the reduction and simulation pipeline requires MPI+OpenMP
  - Atmospheric noise correlations (often) require matrix operations on large data volumes:
    - LAT: ~5400 dets for 15min @ 200 Hz → 4GB/chunk + 300M pixel maps + metadata
    - SATs: ~12,000 dets for 2hrs @ 30 Hz → 11GB/chunk + small maps and metadata
  - Estimated computational cost: 3M CPU-hrs to reduce 1yr of SO data. Time-domain simulations would require more

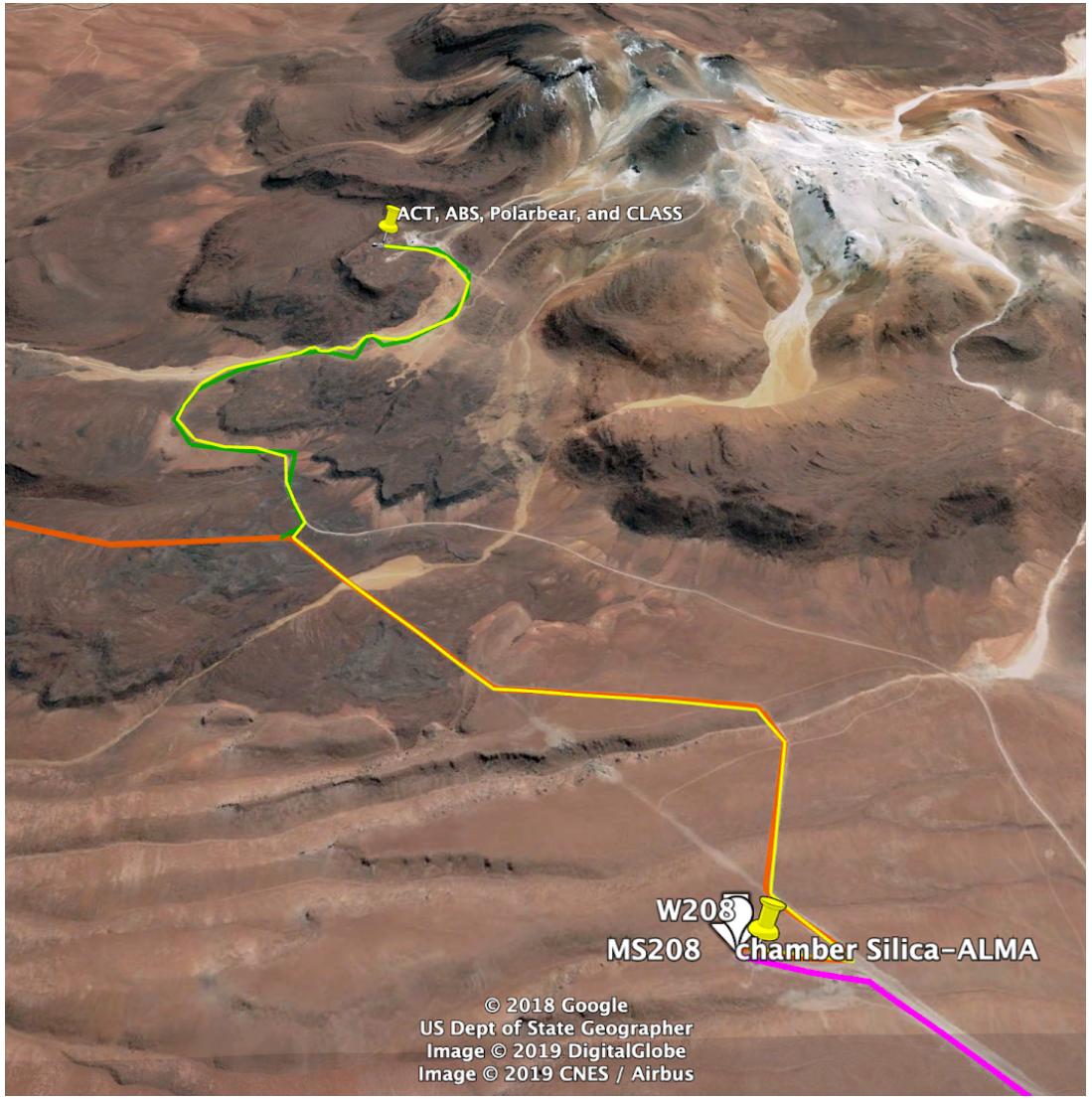


DATA FLOW, STORAGE, AND PROCESSING



Fast and reliable communication/data transfer between SO site and SDSC/NERSC. Fast data transfer between US HPC facilities

DATA MOVEMENT — SO SITE TO U.S. (PART 1)



- Design of Site network is completed and under review
- SO-funded fiber connection from SO site to ALMA REUNA PoP
  - Connection near pad W208
- MoU between SO and ALMA to allow fiber connection is written and under preliminary revision
- Baseline:
  - Fully functional fiber connection and tested Site-US transfer by beginning of science operations
- Risk management:
  - Planning for preliminary data analysis (calibration, small-map tests, transient) at the site
  - Manual transport of disks (baseline solution for previous experiments)

DATA MOVEMENT — SO SITE TO U.S. (PART 2)

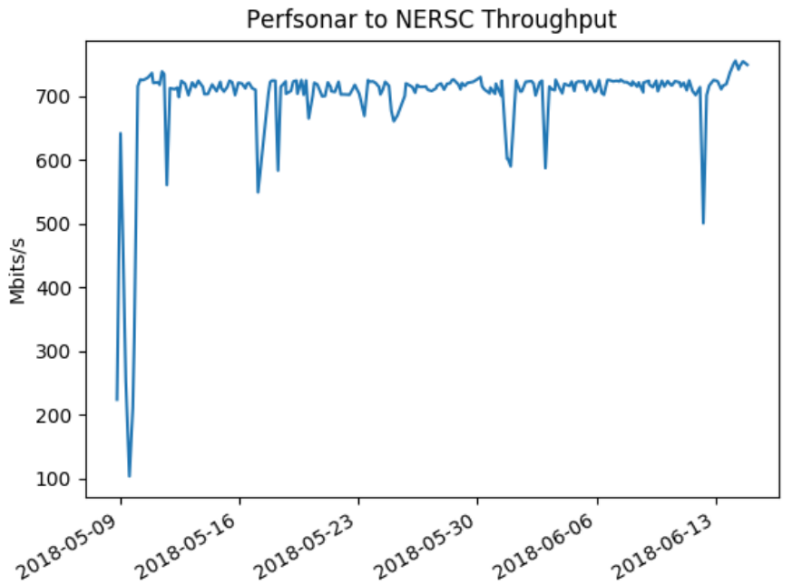


Fig. 6 - Network throughput test (Simons Observatory to NERSC) showing sustained high performance over a month.

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
- Near-term goal:
  - Test NERSC-Princeton-SDSC transfer
  - Setup test case for I&T of automated transfer
  - Site computing hardware I&T at U Penn

CONCLUSIONS

- Simons Observatory will enable cutting edge CMB science in the near future
  - Great synergy with LSST and other surveys, observing same sky at the same time
  - Enabling new scientific exploration: transient sources
  - A wealth of CMB data timely released to the community

- This new scientific endeavors require large amount of data, which needs to be analyzed on short time scales
  - Multiple computing sites for dedicated analyses

- R&E Network providers have a huge impact on the quality and novelty of science that can be done
  - Having substantial computational power at the site is not cost effective
  - Moving data from the site to the U.S. **reliably** has been demonstrated!