SIMONS OBSERVATORY (SO) — SITE

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)

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

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

Transferring data from site to US fast is the key!
SIMONS OBSERVATORY (SO) — TIMELINE

- Large Aperture telescope construction by VERTEX
- Scientific observations
- First SAT on sky 2020

- 2018
  - Large Aperture Receiver Design
  - Manufacture
  - Cryogenic test
  - Integration and test
  - Ship and testing

- 2019
  - Small Aperture Platform Design
  - Platform Fabrication
  - Acceptance test
  - Ship
  - Install and test

- 2020
  - Small Aperture Camera Design
  - Manufacture
  - Cryogenic test
  - Integration and test
  - Ship and testing

- 2021
  - Scientific observations

- 2026

- Site design and construction
- Analysis pipeline development
- Calibration strategy
- Etc.
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
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

Site
1 month raw data
little computation

Princeton
full dataset + copy
Data Reduction

SDSC
full (raw) dataset
Data Reduction

NERSC
full dataset
Data Reduction + Sims

Baseline Site-U.S. link

Alternative Site-U.S. link

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)

- 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

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