



Data transfer from ALMA to North America

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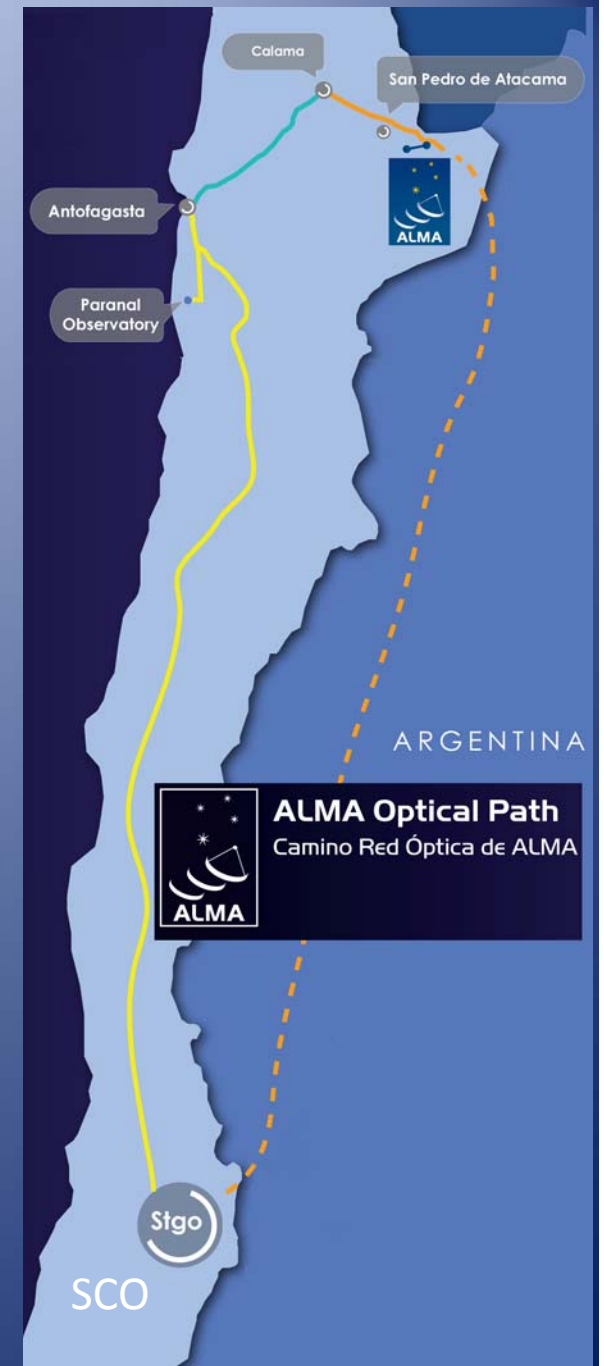


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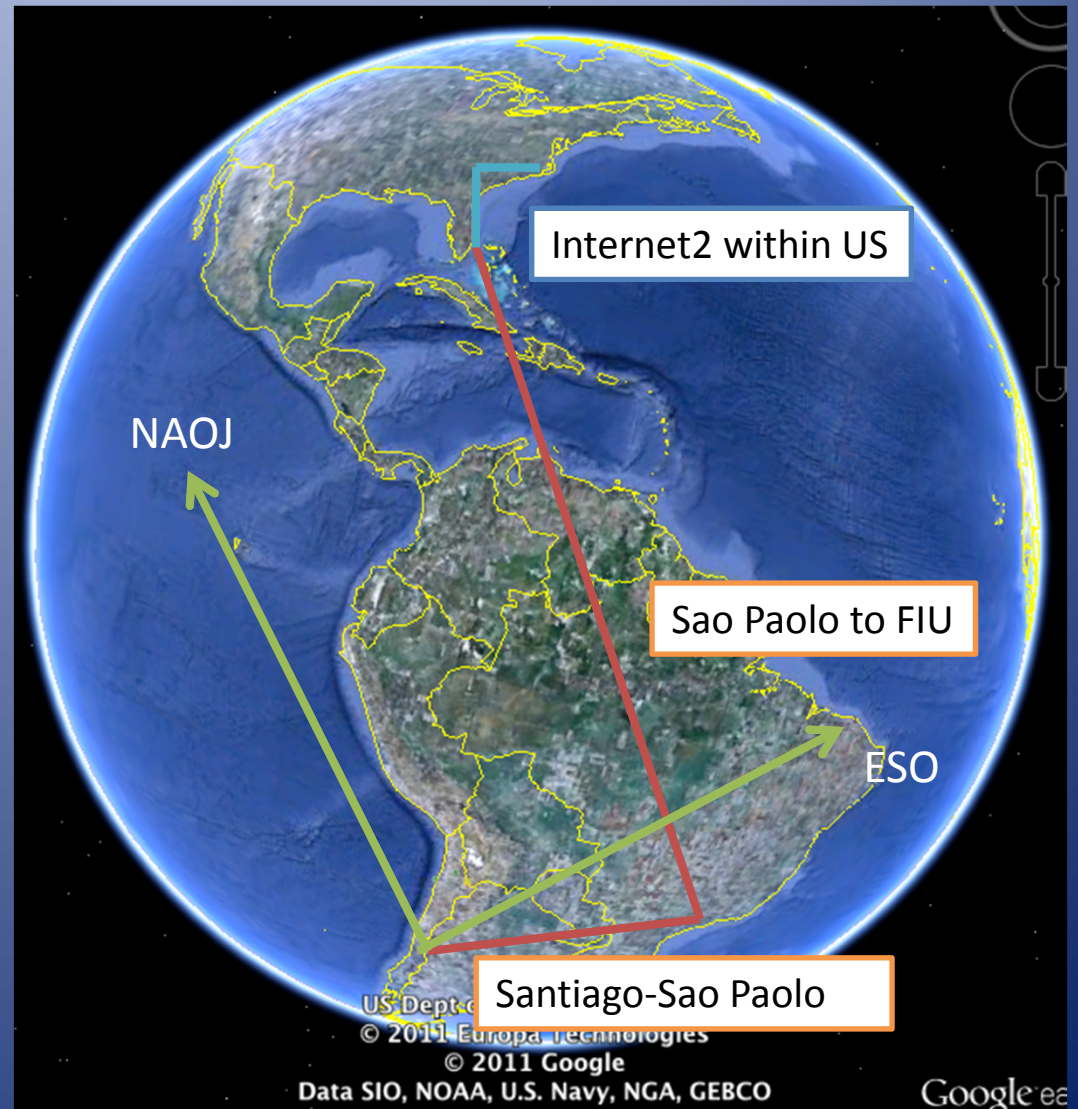
Data Transfer within Chile

- AOS to OSF: 48 dedicated fibers
 - (1Gbp/s upgradable to 10Gb/s)
- AOS to Santiago upgraded in Jan 2015 to 2.5Gb/s with a new fiber link to Calama.
 - Calama to Antofagasta provided by Telefonica/Silica
 - 2.5Gb/s from Antofagasta to SCO from EVALSO/REUNA
 - Redundant fiber loop via Argentina planned
- Pipeline run in Santiago, will ultimately produce L2/L3 data products, increases data size by 10-30%.
- Primary ALMA archive in Santiago (SCO)
- Santiago to ARCs: individual ARC contracts with REUNA and NRENs

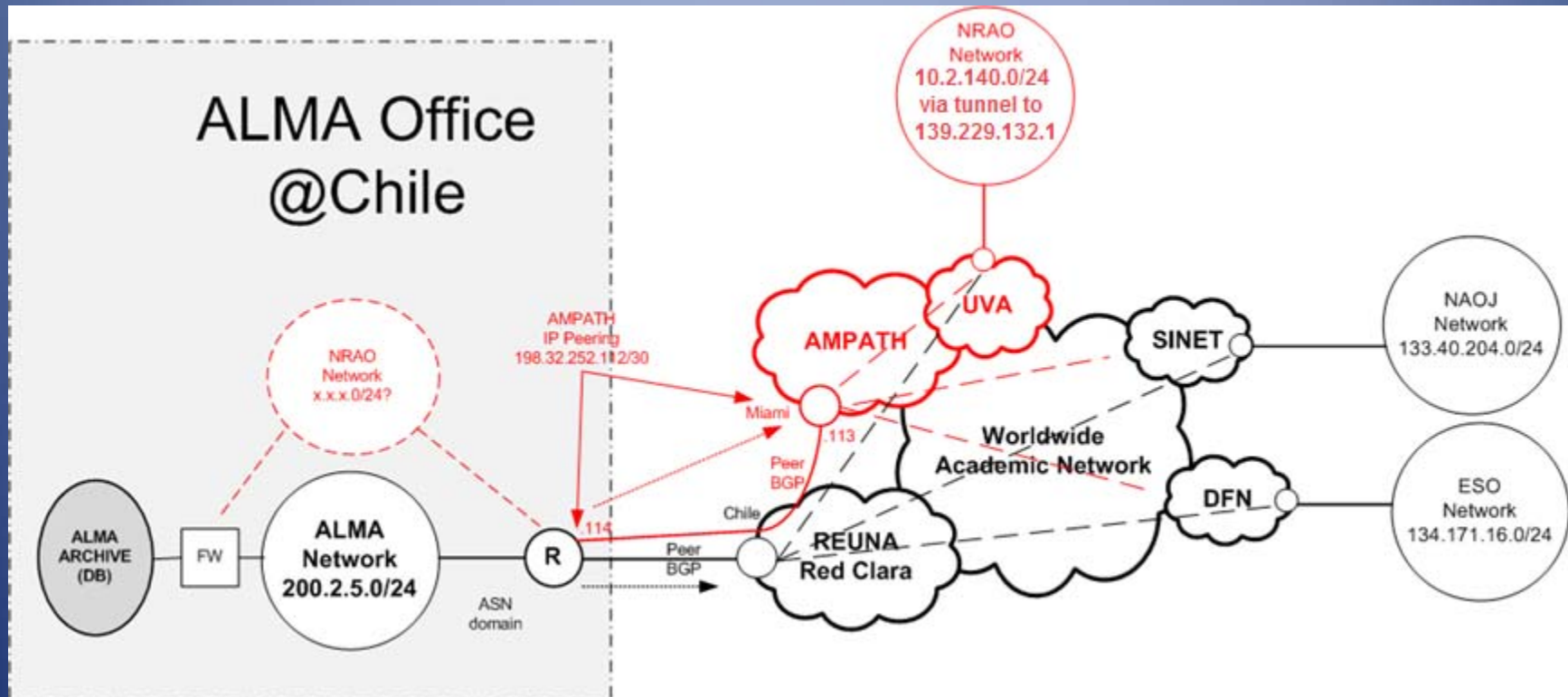


Data transfer – Chile to NA

- Joint AURA-AUI agreement for NRAO to have 100Mb/s committed (burstable to capacity) of AURA's 622Mb/s link to Chile through Sao Paolo and Miami (FIU/AmLight) to the US research network backbone (NREN) via Internet2.
- MOU signed between AUI/REUNA
 - local link to SCO.
 - implementing international links.
- Will need 1Gb/s to the ARCS by 2016.
 - Large data volumes now being seen.
 - High rates \gg 100Mb/s needed for specific operations over \sim 10hr periods.
 - e.g. time critical science verification data (\sim 1TB).
 - VLBI data (\sim 2.5Gb/s)?
- **100Mbps from SCO to REUNA for NRAO**
 - **Requested upgrade to 1Gb/s**
- MOUs in place between AURA/AUI and AUI/REUNA.



Paths from ALMA



Note: NRAO has now abandoned be 146.88.164.x/24 IP space previously used for the link

ALMA Science data rate evolution

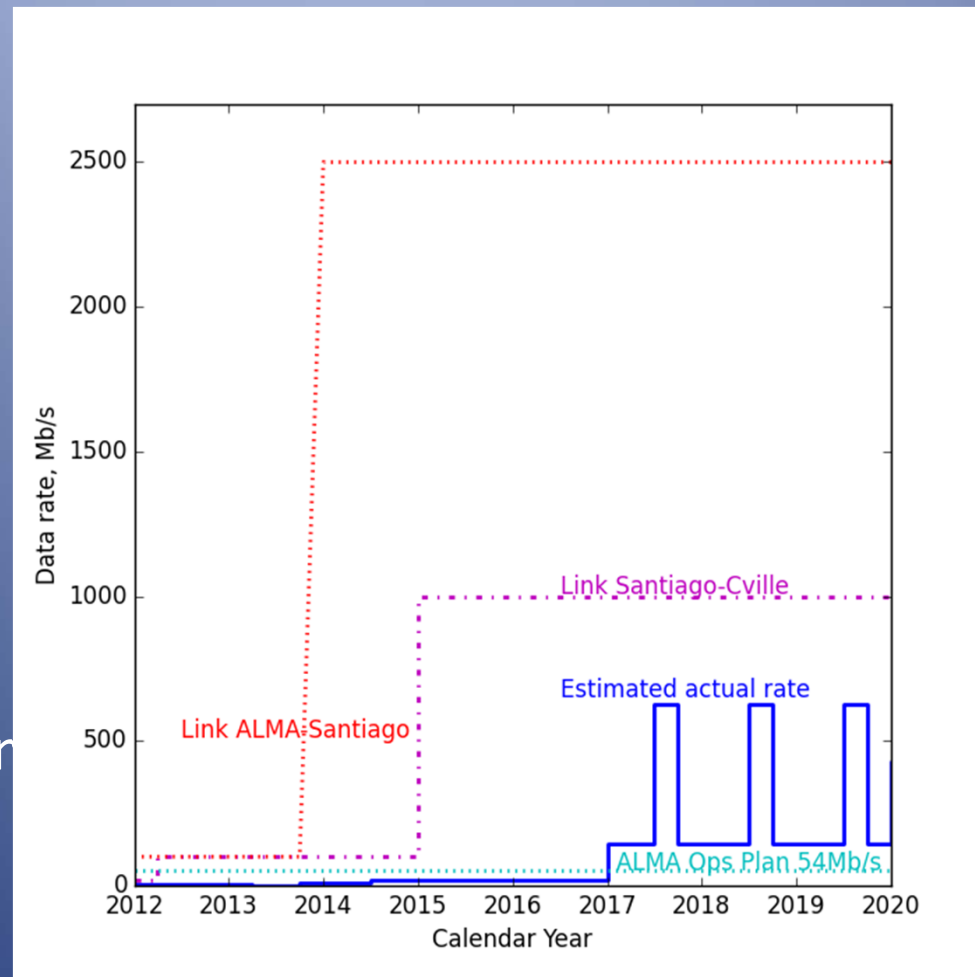
- ALMA Cycle 0 completed (Oct 2011-Jan2013)
 - 16-24/50 antennas used (data rate proportional to square of antenna number)
 - ~5-10% of array time for science
 - Data inflated to supply users with intermediate products
 - Total data volume was about 20TB
- ALMA Cycle 1/2 in progress (~Aug 2013-Nov 2015)
 - 32-40/50 antennas, plus 7-12/12 compact array
 - ~10% of array time for science
 - Best guess is about 40TB/yr (ALMA archive hit 80TB in Dec 2014)
- ALMA Cycle 3 starts in Nov 2015, ends November 2016
 - ~36 main array antennas, all 12 compact array
 - ~15% of array time for science
 - Best guess data volume is around 70TB in a 12 month Cycle.

Future Cycles

- Data rates will increase as we transition into full operations, unclear how fast the ramp-up will be.
- High data rates most likely to start in Cycle 4 (Dec 2016).
- Unthrottled, we expect data rates driven by a typical mix of science use cases to be $\sim 100\text{Mb/s}$, with seasonal peaks $\sim 600\text{Mb/s}$ in the Austral winter/spring.

Current data rate projections

- Assumes no imposed limit on data rate (cyan line is current Operations Plan rate).
- Blue line is for data generation
- Data transmission is per ARC



Summary

- New fiber link from the telescope to Calama will allow 2.5Gb/s transfer rates to/from Santiago for both data flow and remote ops.
- Ramp-up of ALMA data rate has been slower than anticipated, allowing us to stay ahead of the curve overall.
- However, we have identified need for bursts of high data rate ($>1\text{Gb/s}$) even with the current observational parameters.