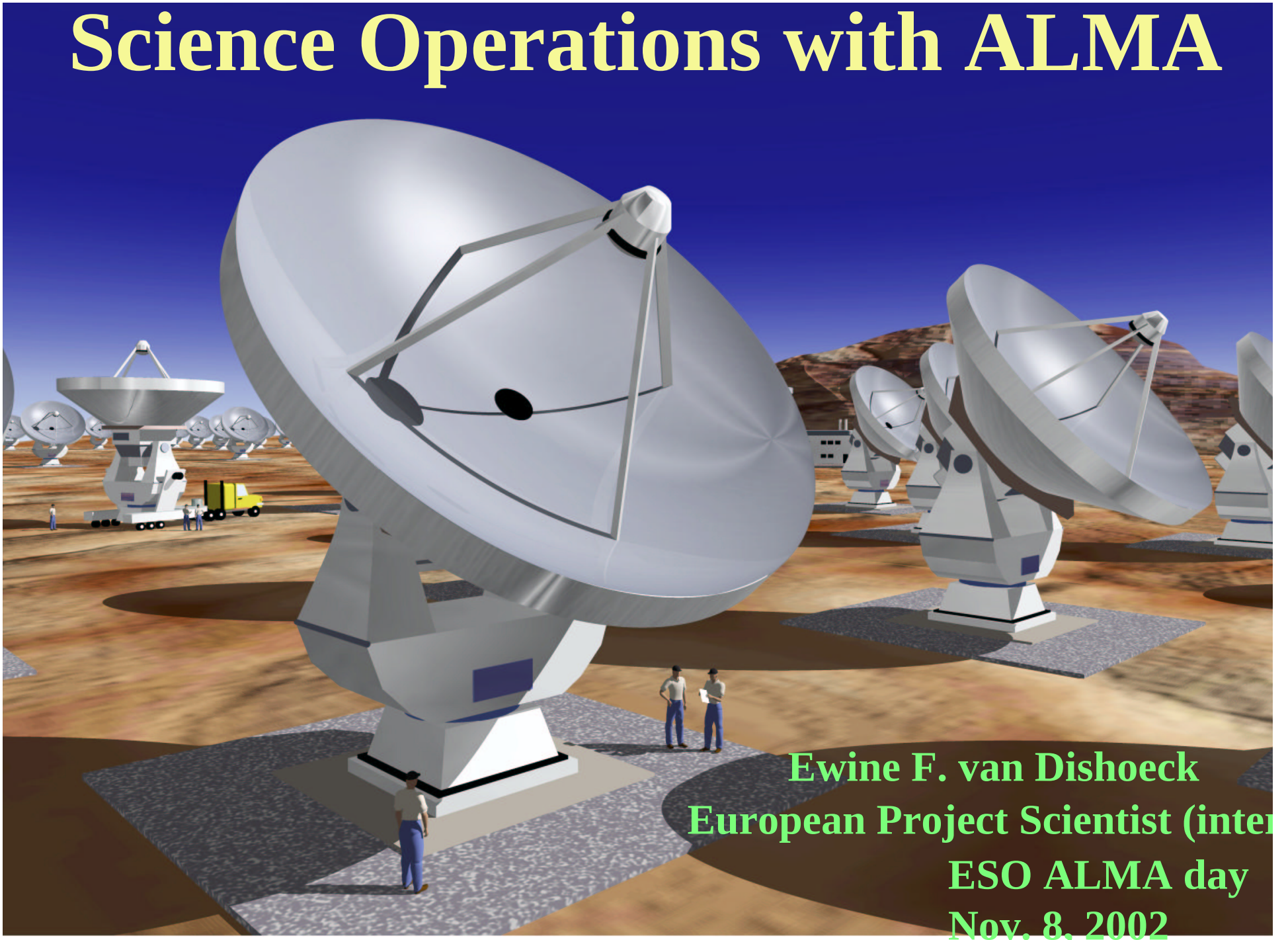
Science Operations with ALMA



Ewine F. van Dishoeck
European Project Scientist (inter
ESO ALMA day
Nov. 8, 2002

Outline

- Introduction
- ALMA operations in Chile
- ALMA operations in Europe
- Early science observing

Important dates

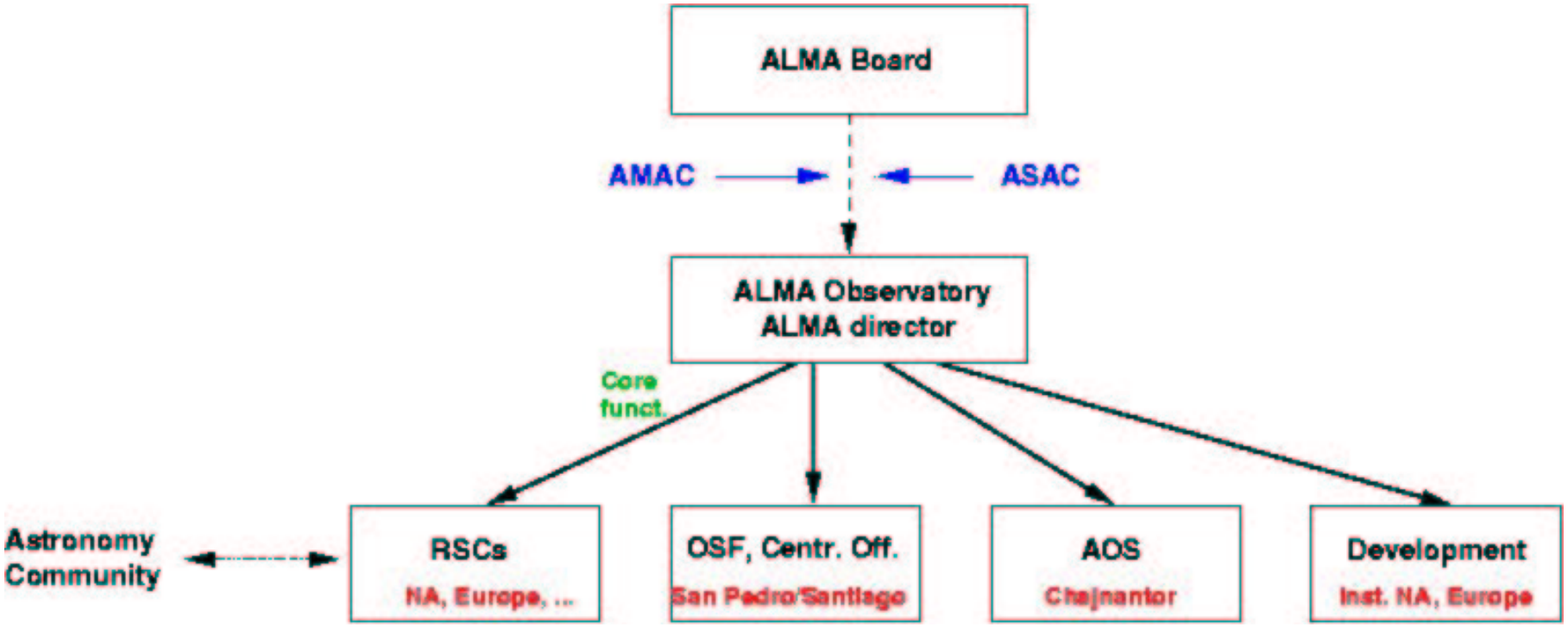
- **Q3 2007: Start of early science observing**
- **Q4 2011: Completion of construction**

Astronomers can start using ALMA while construction and commissioning is on-going!

Science Operations: *Project's Perspective*

- **ALMA is a *service* observing facility**
- **Operations in Chile limited to activities needed to acquire, certify and archive scientific data**
- **For safety, number of ALMA staff at 5000 m to be kept at minimum**
- **Main interface between users and ALMA is through Regional Support Centers**
- **Development/upgrades on hardware and software contracted to Executives ¬> Institutes**

ALMA Operations Organization



Science Operations: *Astronomers Perspective*

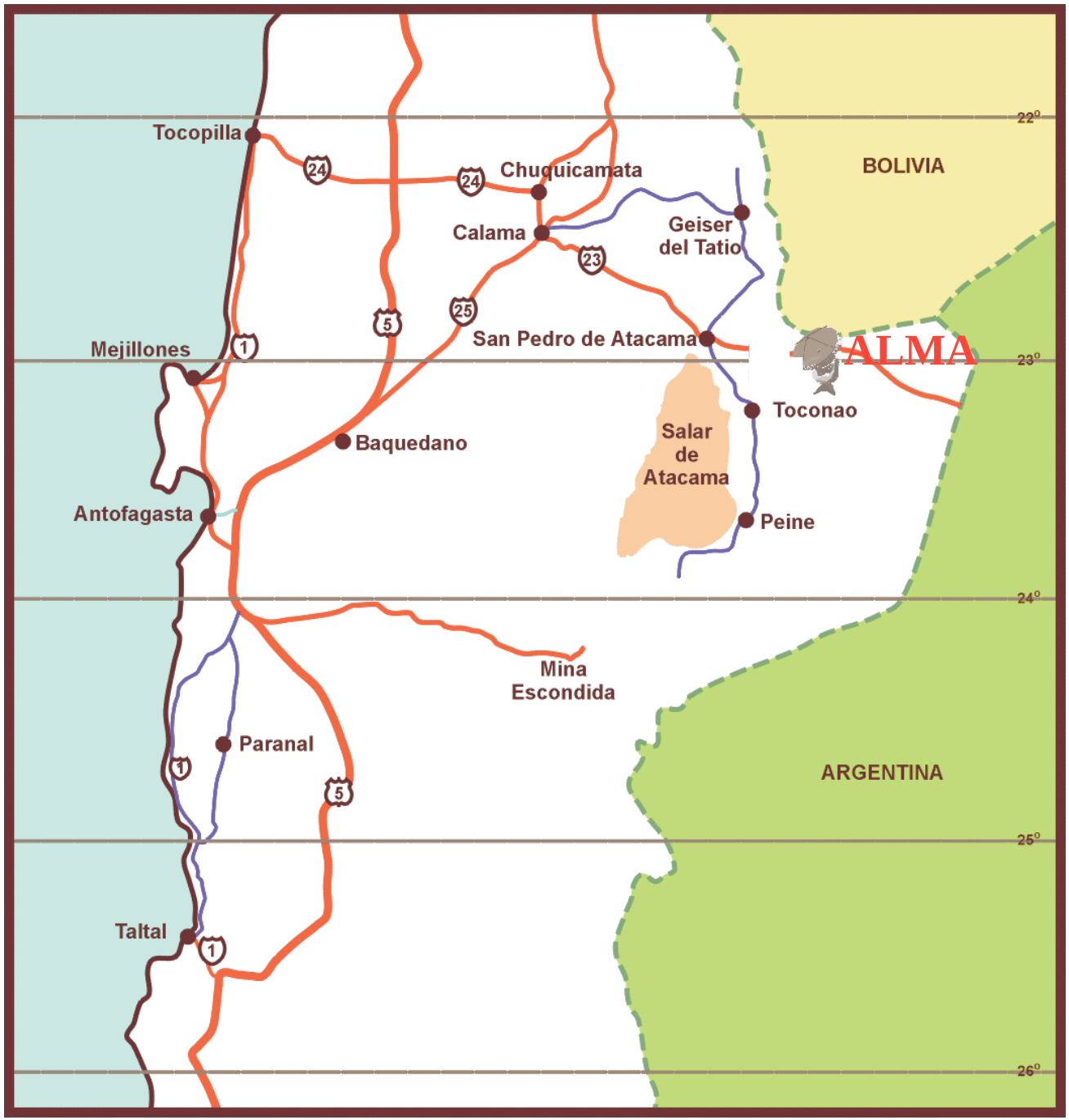
- **Non-experts should be able to use ALMA**
- **Dynamic scheduler to match observing conditions**
- **Reliable and consistent calibration:**
  - **1% at mm, few % at submm goal**
- **Data public in timely fashion**

ALMA Operations

- **Array Operations Site** — **Chajnantor**
- **Operations Support Facility** — **San Pedro**
- **Central Office** — **Santiago**
- **Regional Support Centers** — **NA/EU**
- **Development / Upgrades** — **NA/EU**

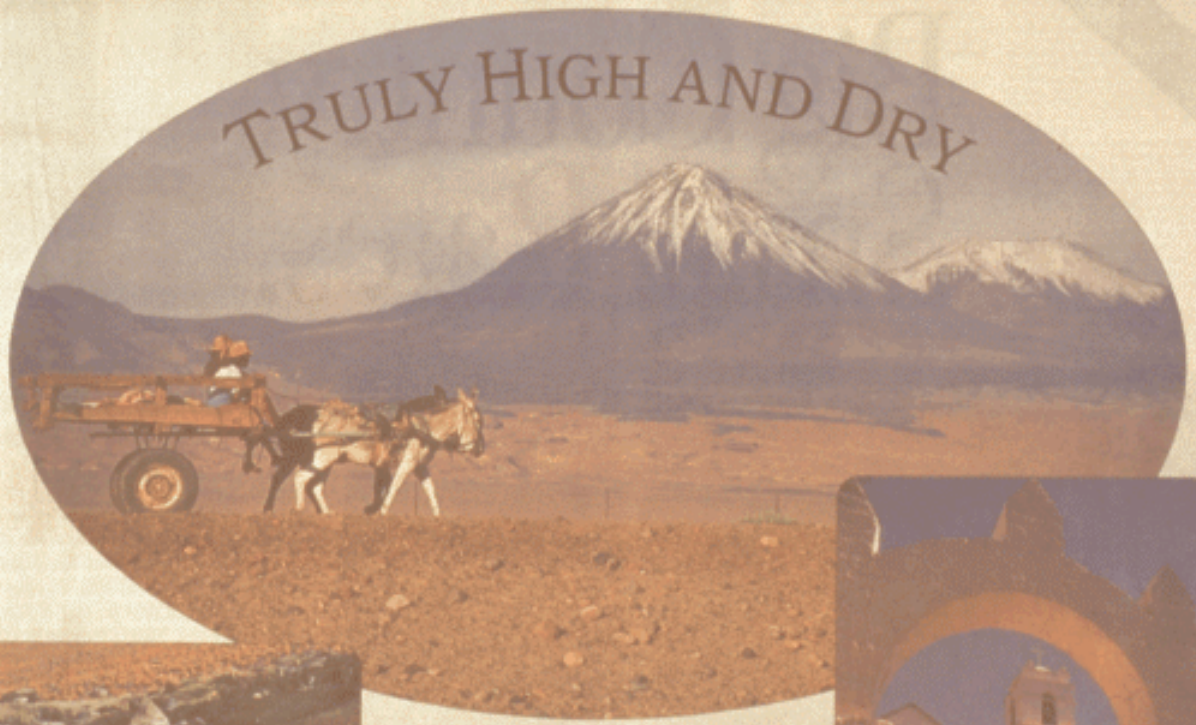
Subject to approval by ALMA Board!

ALMA Location



The New York Times
Travel
Sunday, March 3, 1996
Section 5

TRULY HIGH AND DRY



In southwestern Bolivia, the sun paints thousands of miles of salt and even the inn is made of it.

By Logan Ward **13**

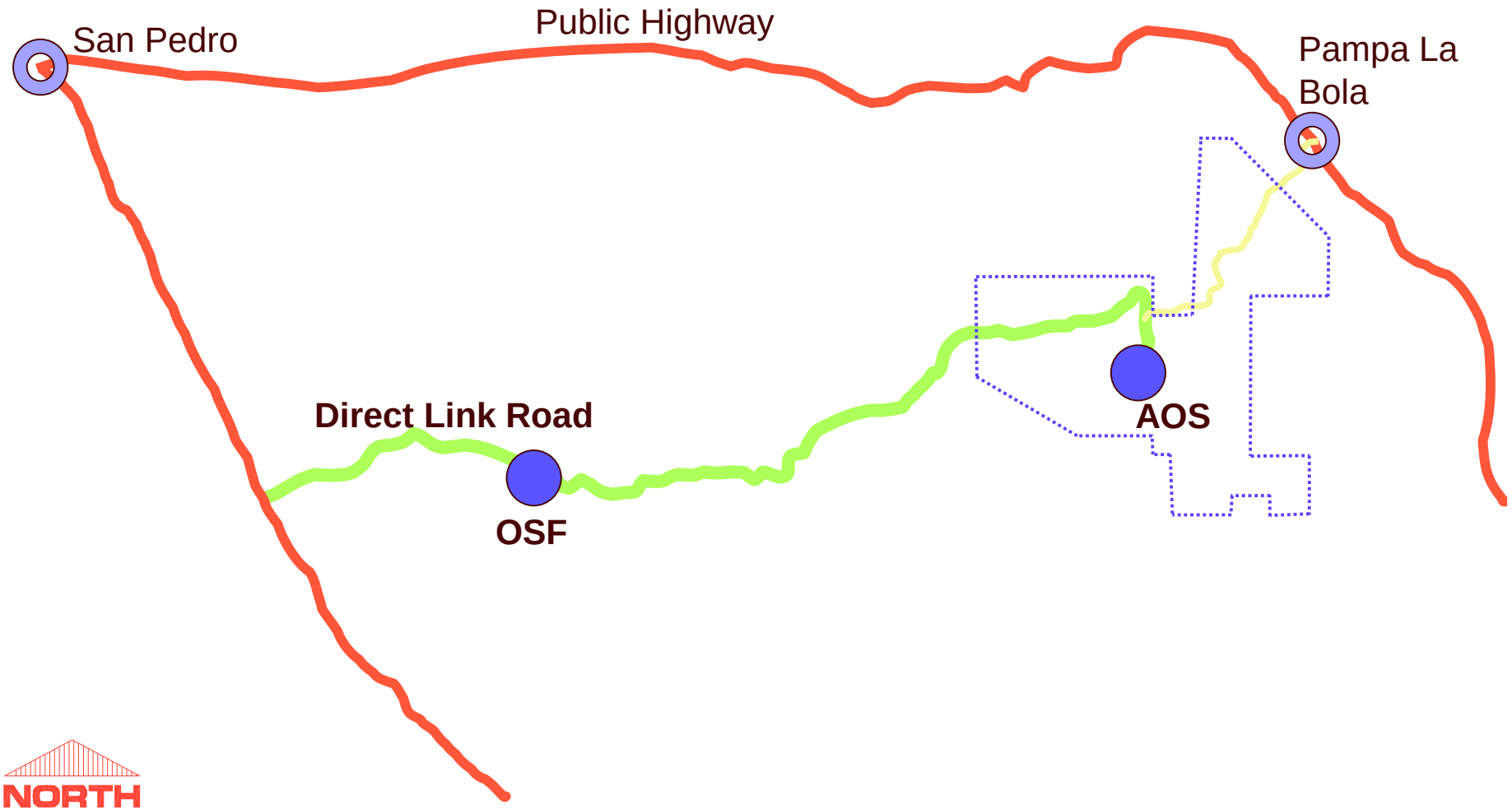
The archeological center of Chile is perhaps the driest place on earth.

By John R. Aldon **12**

ABOVE: Church in San Pedro de Atacama, Chile, 1745.
TOP: Andean volcanoes near San Pedro.
LEFT: Enjoying a natural hot spring in Bolivia.

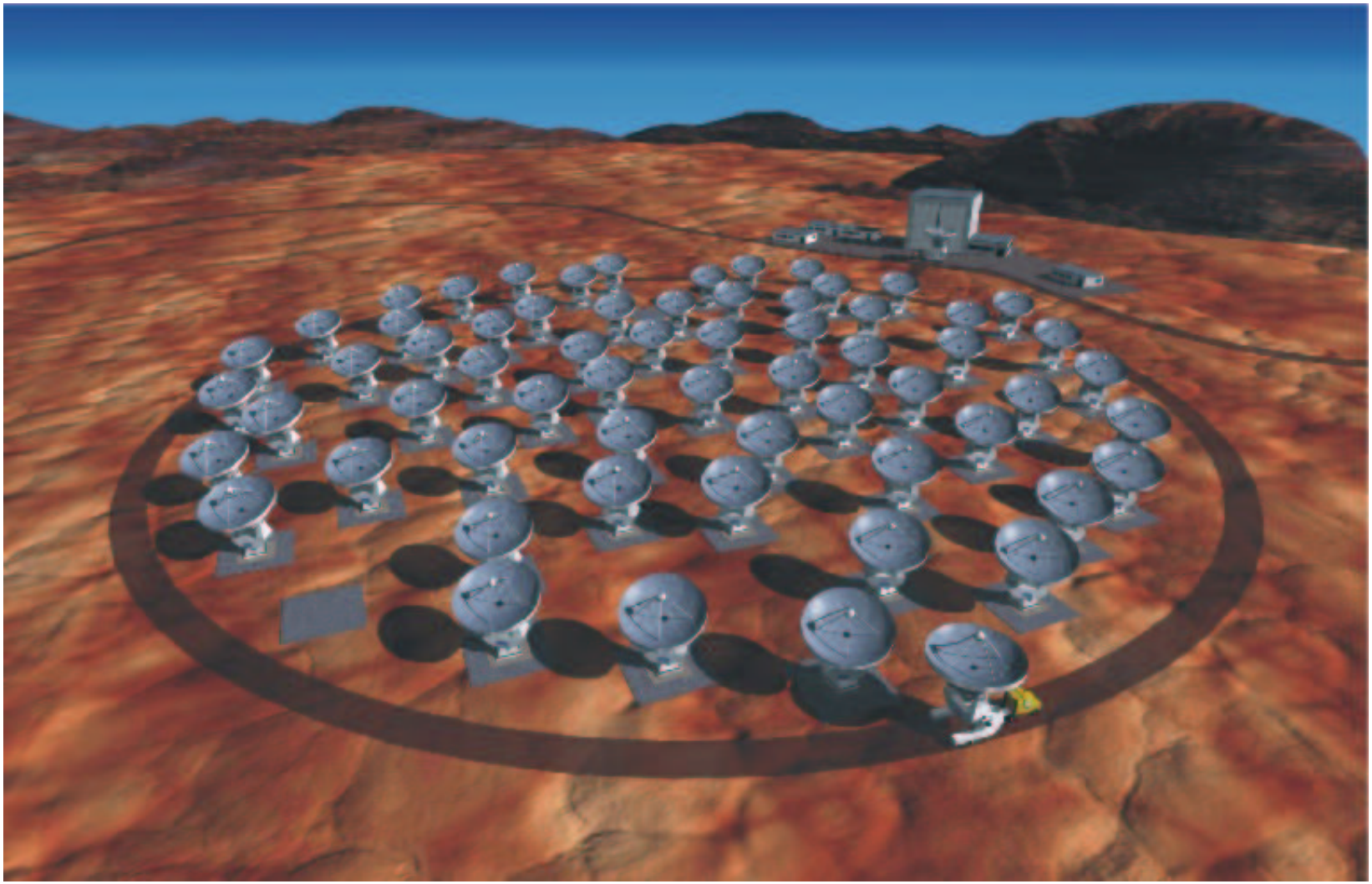
Church
San Pedro

Main square San Pedro

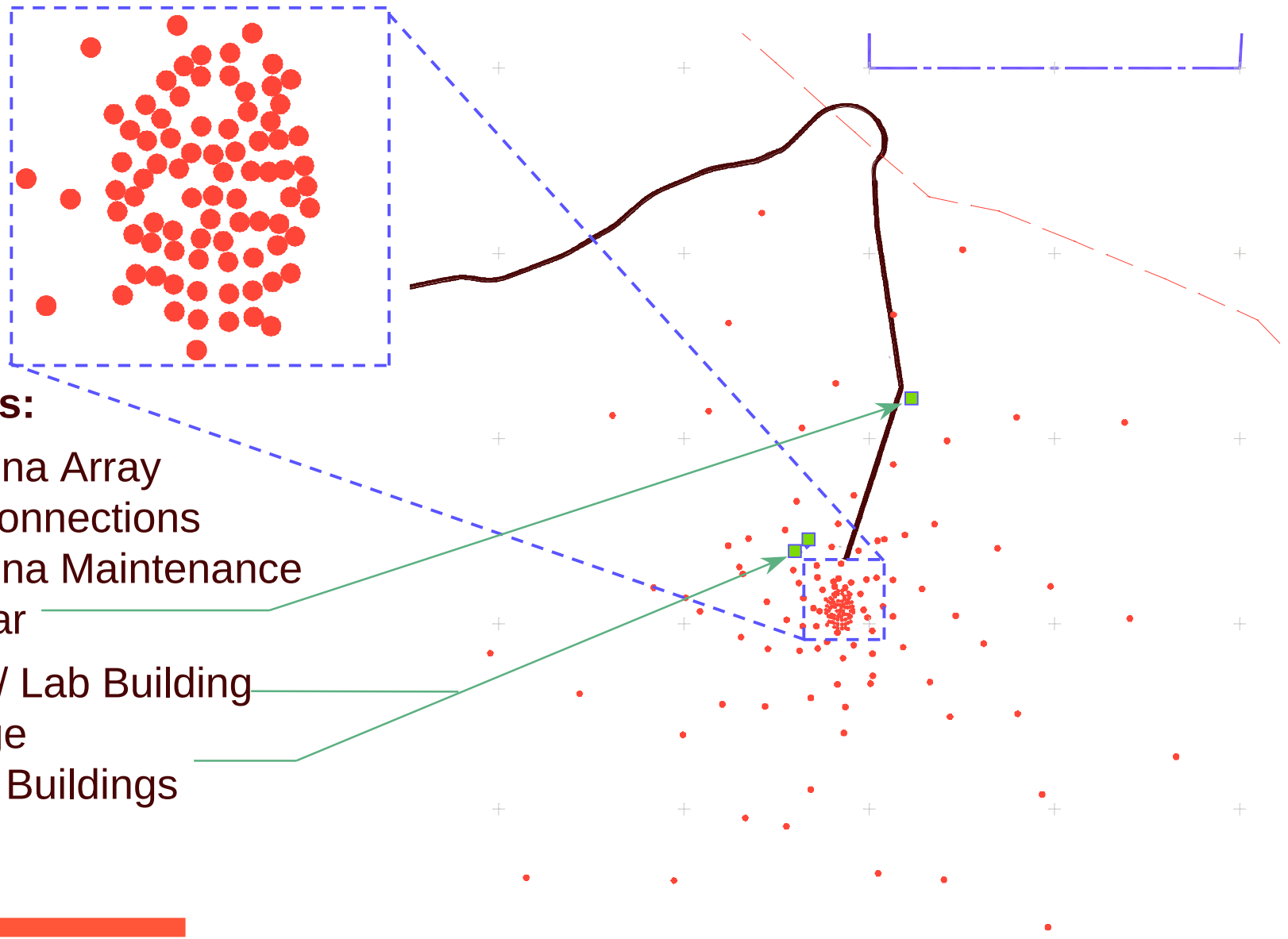

San Pedro
Public Highway
Pampa La Bola
Direct Link Road
OSF
AOS

Chajnantor

ASAC at center of ALMA array



Array Operations Site



Facilities:

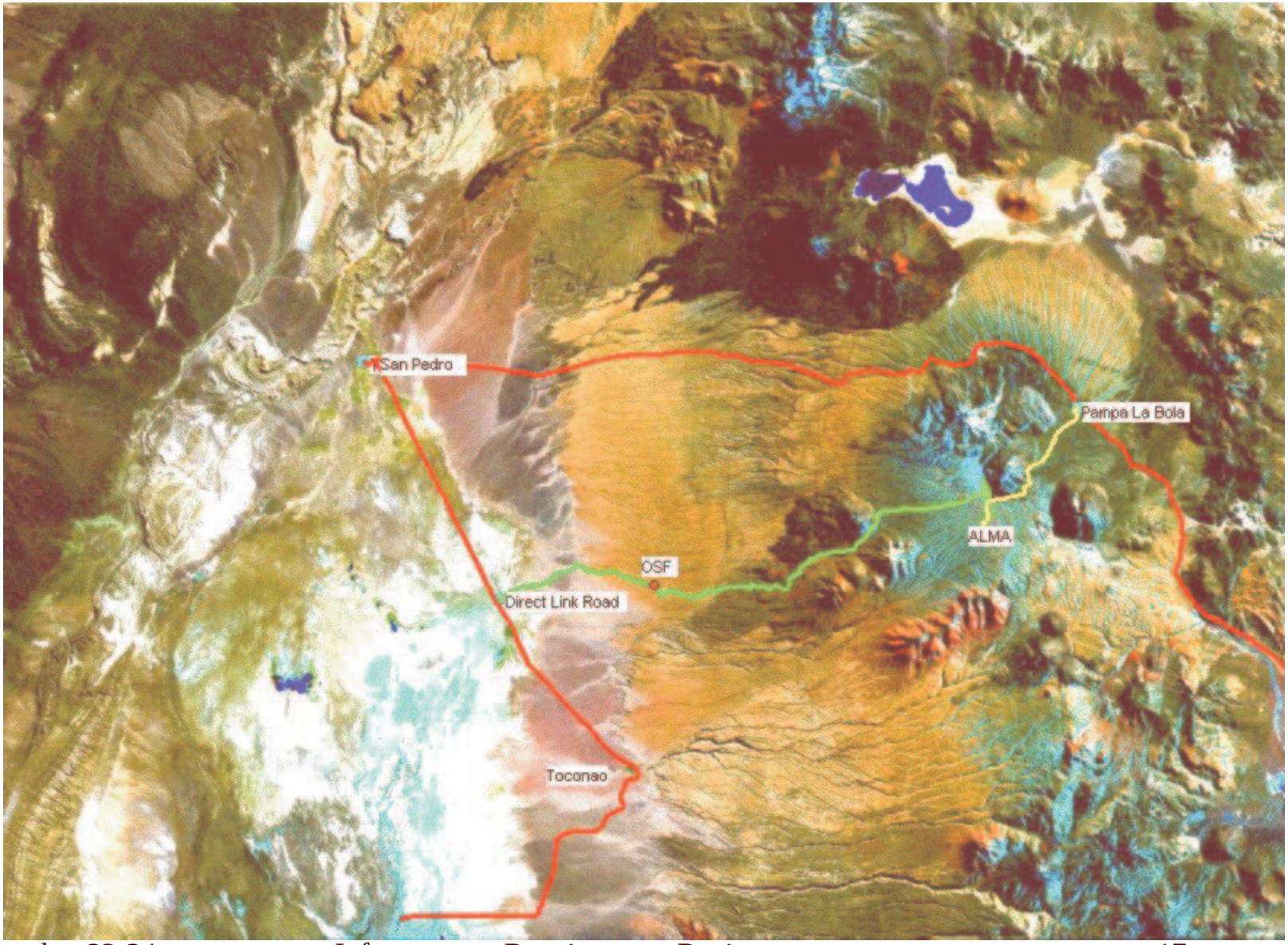
- Antenna Array
- Interconnections
- Antenna Maintenance Hangar
- Tech / Lab Building
- Refuge
- Utility Buildings

NORTH 0 km 1

Main Functions AOS

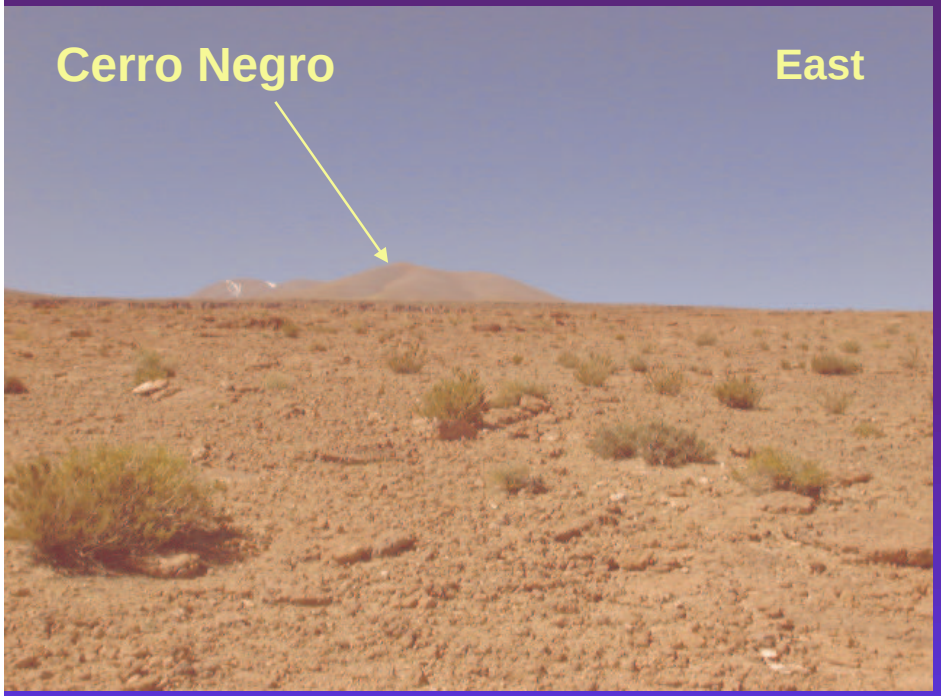
- Antenna re-configuration (continuous)
- Instrument module exchange
- Security of site

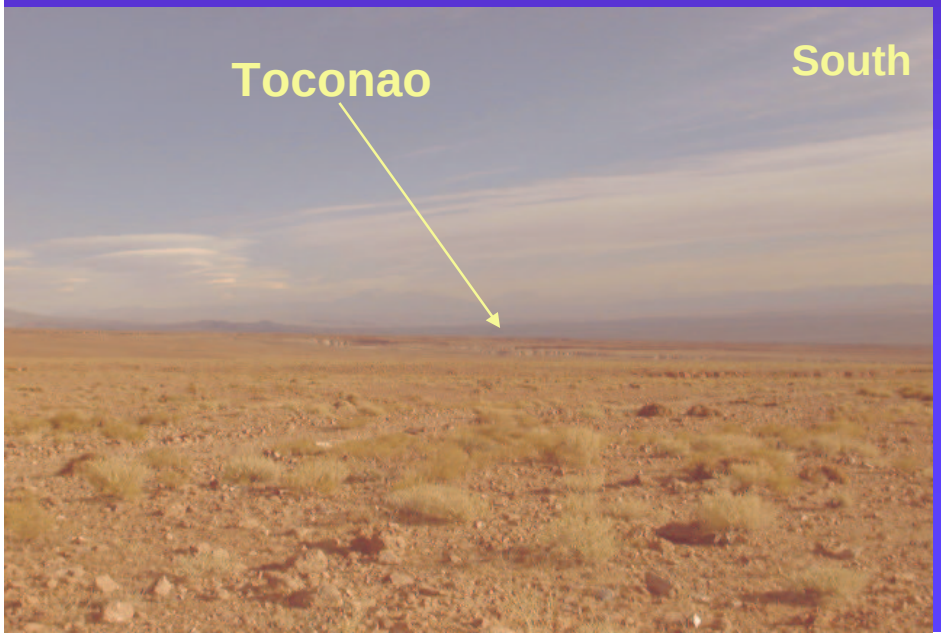
Location OSF

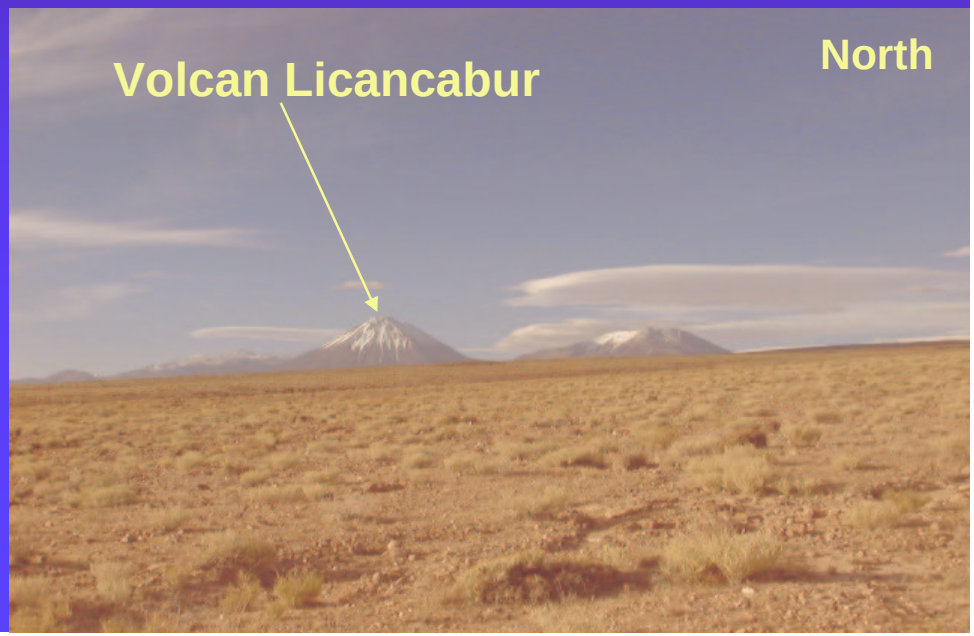


Access Road to O.S.F.

Views from O.S.F. Area at 2800 m







Main functions OSF: *near San Pedro*

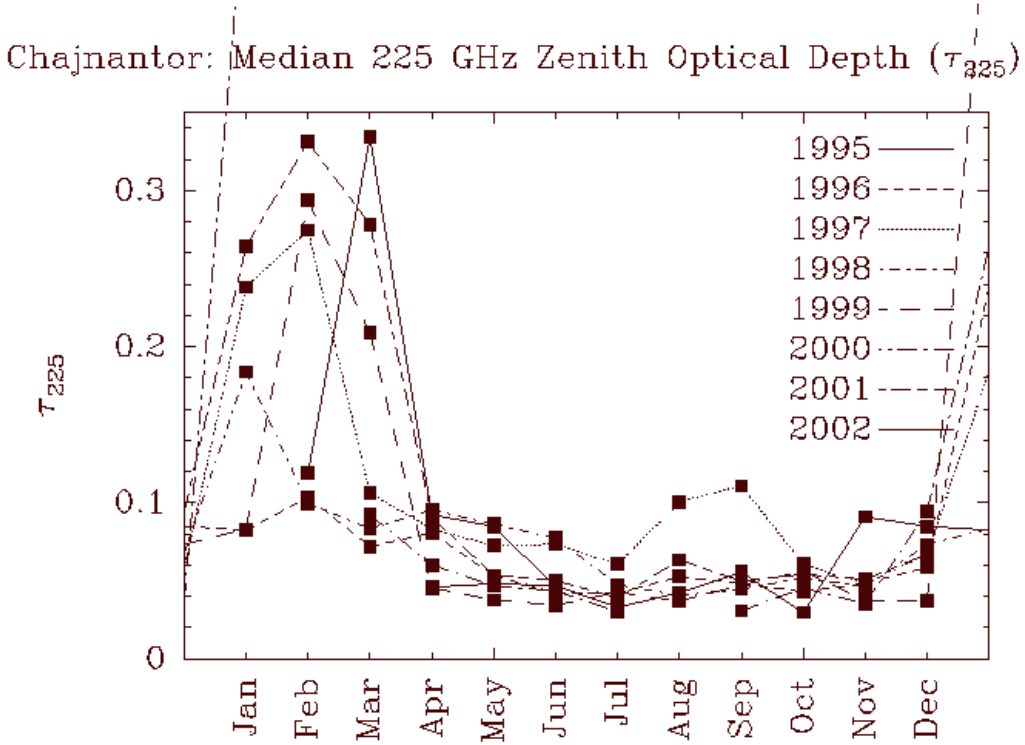
- Array scheduling and operations
- Quick-look data reduction
- Maintenance and repair antennas
- Maintenance and repair instrumentation
- Administration, safety

Dynamic Scheduler

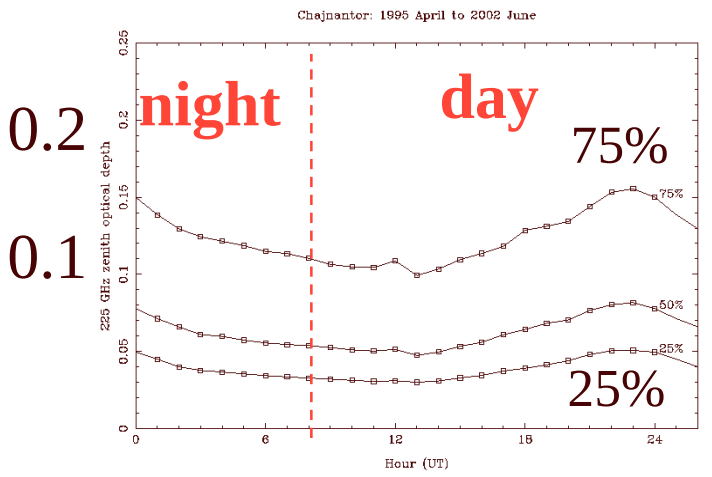
- **Dynamic scheduler selects programs according to:**
  - **Science rating**
  - **Weather conditions: transparency, phase rms , …. (`stringency')**
  - **Execution status**
  - **Array configuration**
  - **Partner parity**

Transparency Variations

Annual variation



Diurnal variation

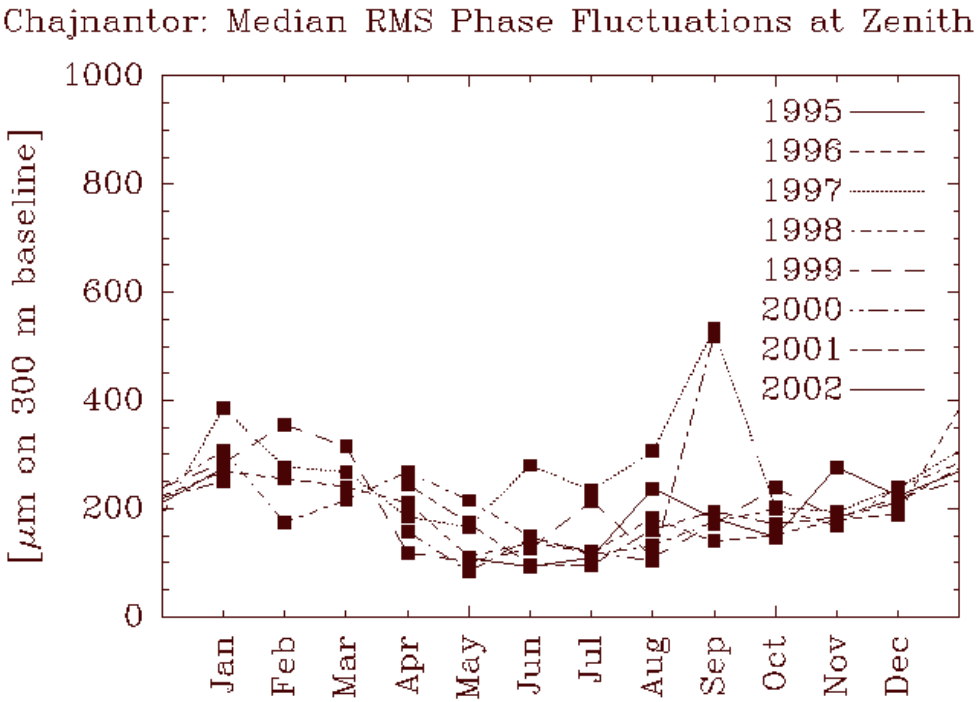


τ=0.05 corresponds to ~1 mm precipitable water vapor

Phase Stability Variations

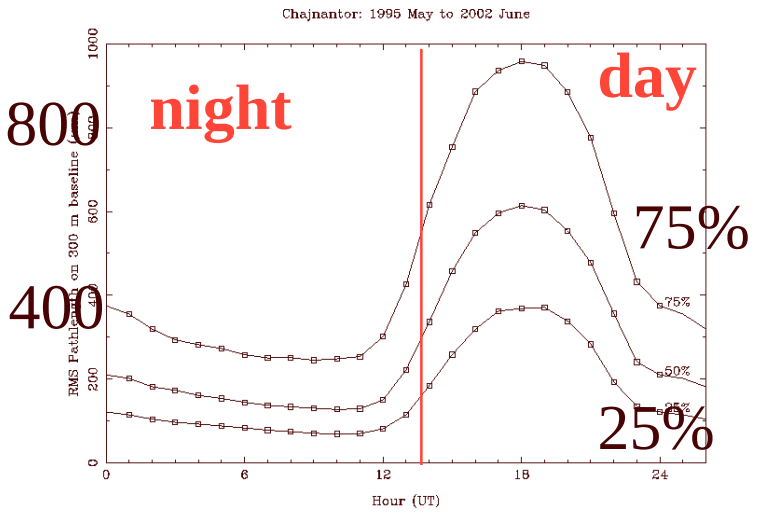
Annual variation

11.2 GHz



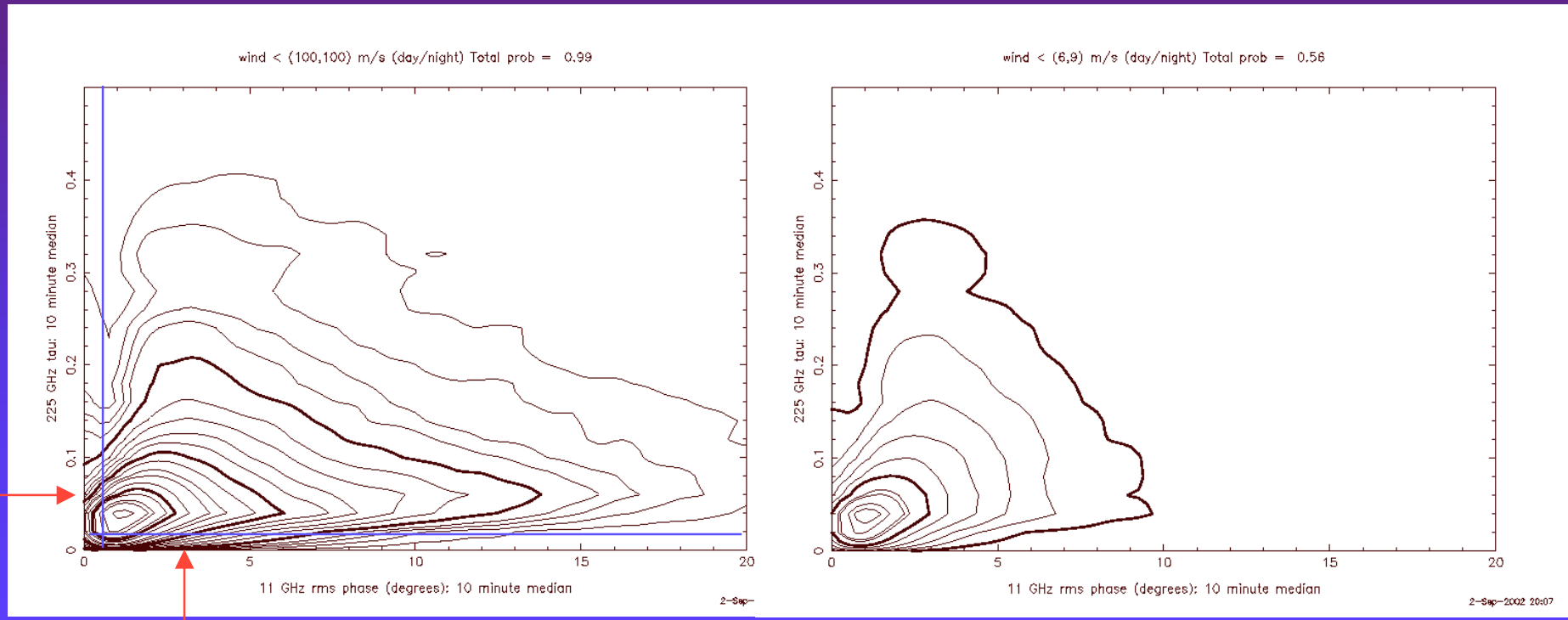
Diurnal variation

36° el.



ϕ<100 μm needed to image to 0.2” at 345 GHz without phase correction

Transparency and Phase Stability



Median

Note tail in statistics of periods with good transparency but large phase rms ¬> phase correction essential!

Main functions Central Office: *Santiago*

- **Pipeline data reduction**
- **Quality assessment**
- **Production of archive**
- **Business functions**
- **Science offices**

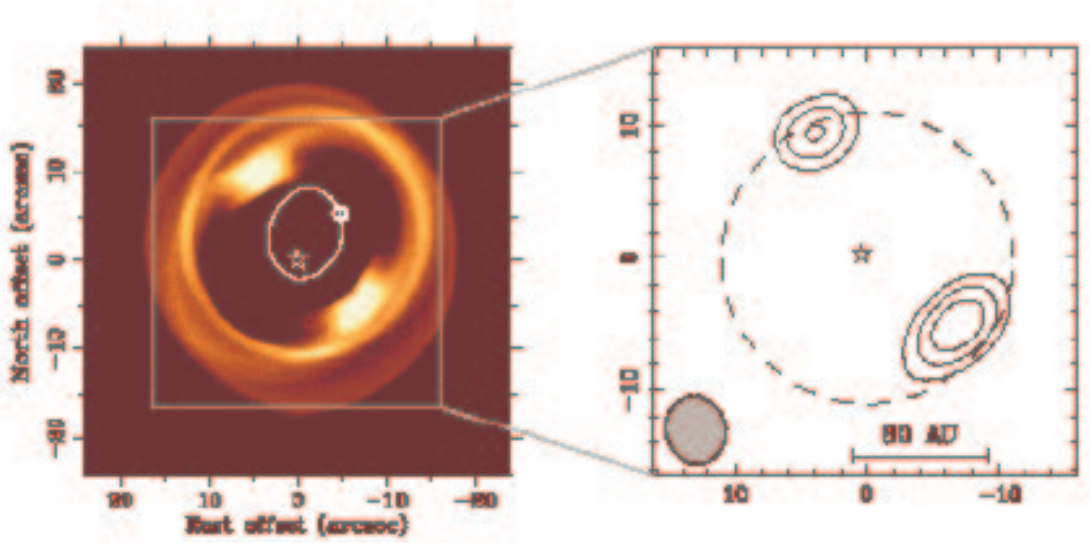
Science operations in practice

- **Phase I + II proposals through RSCs**
  - **Powerful time estimator and end-to-end data simulator ¬> scheduling blocks to OSF**
- **Scheduler selects programs; assures homogeneous + consistent calibration; possibility of eavesdropping and `breakpoints'**
- **Pipeline data reduction, quality control, production of archive, VO compatible**
  - ***Complete data management system***
- **Advanced data reduction at RSCs**

Example: Vega debris disk

Dust trapped in resonances due to unseen planet?

Simulation **PdB 1mm data**



Wilner et al. 2002

Use simulator to `observe' model in same way as actual data

Regional Support Centers: *Core Functions*

- **Proposal handling**
- **User support for proposals and data reduction beyond the standard pipeline products**
- **Host of copy of archive**

Core functions are controlled by ALMA Observatory

Regional Support Centers: *Additional Functions*

- **Advanced software and techniques (e.g. large OTF maps)**
- **Training, summer schools, outreach**
- **Research funding, ……**

Additional functions may differ between RSCs

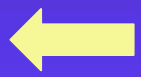
European RSC

- ESO will do phase I proposal handling and some aspects of archiving; rest in RSC
- Call for proposals for RSC in TBD time (>1 yr)
- ESO funds only part of RSC core functions (~10 fte)
- Additional funding to come from national / other sources, i.p. countries hosting RSC

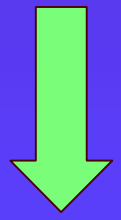
Models for European RSC

True Center in single location

Central Node with distributed network



Favored by ESAC



Virtual Center distributed throughout Europe

Central Node with network

- **Strong Central Node for user support**
- **Development within distributed network, to ensure optimal use of expertise in European institutes**

Community comments welcome!

Development / Upgrades

- New / upgrade instrumentation over lifetime of array, e.g.:
  - Additional receiver bands
  - Second generation correlator
  - Improved software
- To be done mostly at institutes in partner countries, under contract from ESO
- Development funding included in operations budget (~5 MEu/ year Europe)

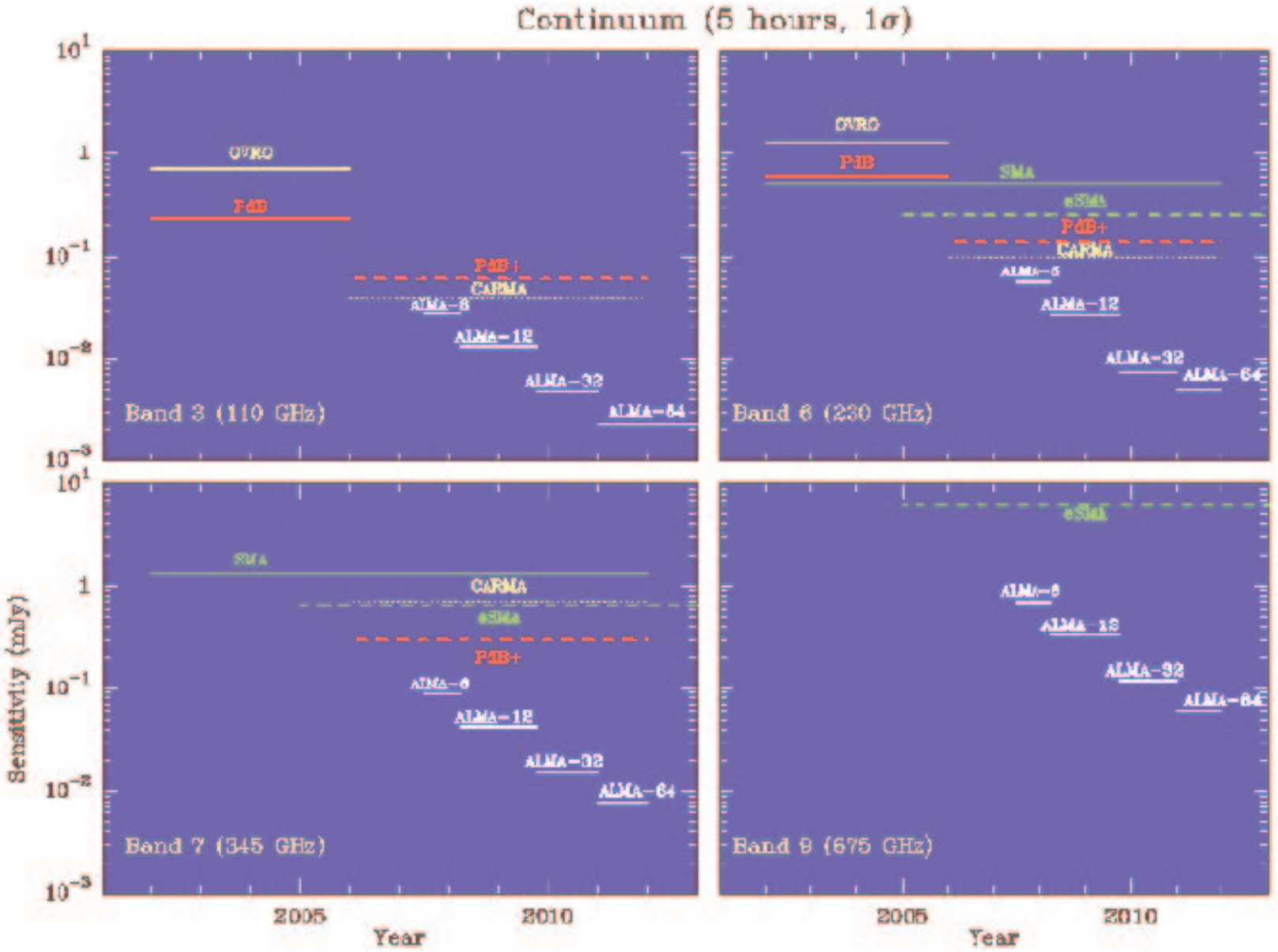
Early Science observing: *>Q3 2007*

- **Follows Commisioning and Science Verification**
- **Open to community through call for proposals**
- **Should demonstrate unique ALMA capabilities to all astronomers**
- **Provides feedback to ALMA operations**

Unique ALMA capabilities for Early Science

- **Sensitivity: gain over existing facilities once >6 antenna's**
- **Long baselines ¬> high angular resolution**
- **High frequencies**
- **Southern sky**
- **Polarization capabilities**

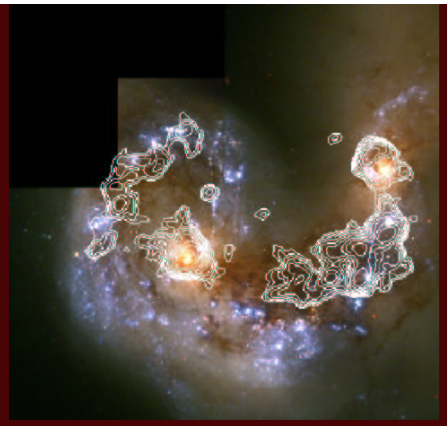
Early science sensitivities

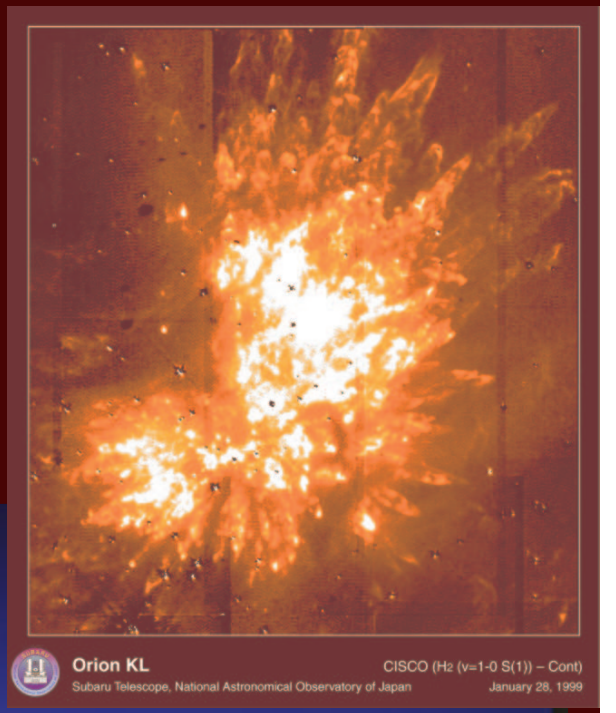


See ASAC Sept. 2002 report for assumptions; numbers subject to change

ASAC Recommendations

- **Start with no less than 6 antenna's, preferably 8-10**
- **Start with at least 2 receiver bands (including Band 3)**
- **Phase correction is essential for Early Science**
- **Polarization to be included a.s.a.p.**
- **Array for Early Science to be separated from commissioning array**





Happy ALMA Observing!

(Only 1585 days left to write you first ALMA proposal)