Candidate sites in Argentina for air-shower particle detectors at high altitudes

Adrián Rovero (IAFE)

Wide FoV Southern Observ.- Puebla - November 2016

Outline

- Experience on High Energy Astrophysics in Argentina
- Elevated regions in the country:
  SAC area, sites for high altitude experiments
- Infrastructure being build for current experiments
- Weather data taken on the site area
- Proposed and alternative sites for the southern observatory
- Summary

Experience on the field in Argentina

Recent few decades:
Observatories and experiments on High Energy Astrophysics

Pierre Auger Observatory (+ extensions + spin-off: LAGO, ANDES)
DSA-3 (Deep Space Antenna 3, ESA: fully operational in 2013)
CTA (site proposal during site selection process)

-> Man power + gained experience
-> High energy astrophysics community formed during the last two decades
-> Close cooperation with Brazilian colleagues (favors grant applications)

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The Ministry of Science (since 2007) has a permanent Board to analyze proposals for large scientific projects in astrophysics to operate in the country:
LLAMA (7MUSD); QUBIC (500 kUSD);

Provincial support:
The Province where the project is installed contributes with infrastructure:
Auger, DSA-3 (Province of Mendoza); LLAMA, QUBIC (Province of Salta: ~2MUSD)

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Customs and VAT: free importation for scientific projects (like Auger)

Groups with people interested in a southern observatory

CAB (Centro Atómico Bariloche - Comisión Nacional de Energía Atómica)
(Auger, DSA-3, QUBIC) → 5 scientists + Engineers + PhD students

IAFE (Instituto de Astronomía y Física del Espacio - CONICET)
(Auger, VERITAS, CTA, LLAMA) → 4 scientists + PhD students

IAR (Instituto Argentino de Radioastronomía - CONICET)
(DSA-3, CTA, LLAMA, QUBIC) → 4 scientists + Engineers + PhD students

ITEDA (Instituto de Tecnología de Detección y Astropartículas)
(Auger, DSA-3, CTA, QUBIC) → 6 scientists + Engineers + PhD students

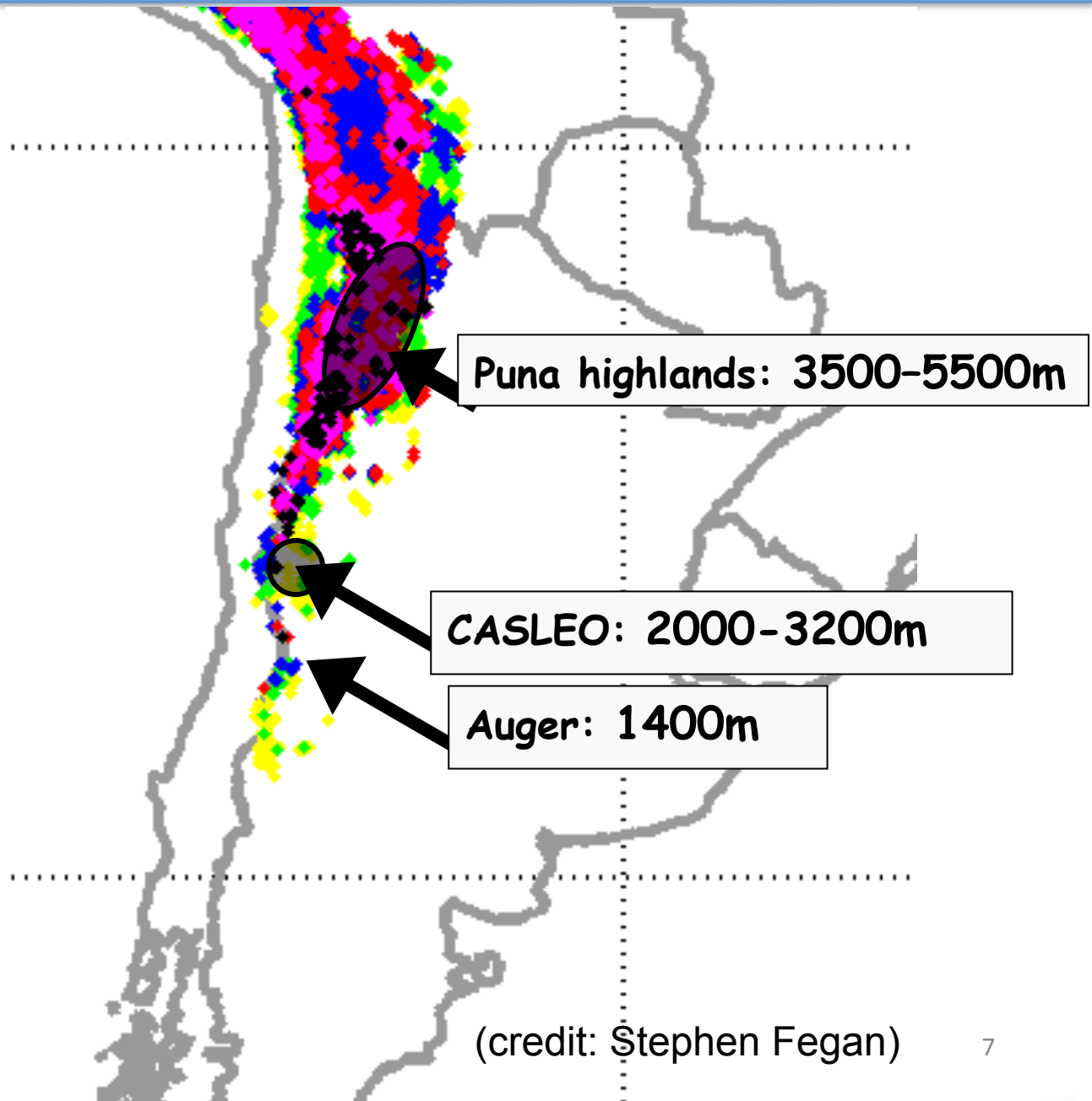
Brazilian groups have also shown interest

IFSC (Instituto de Fisica de São Carlos – Universidade de São Paulo)
(Auger, CTA, others) → 3 scientists + PhD students

Others…….

Elevated regions in Argentina

Area > 1 km^2
Satellite radar data



(credit: Stephen Fegan)

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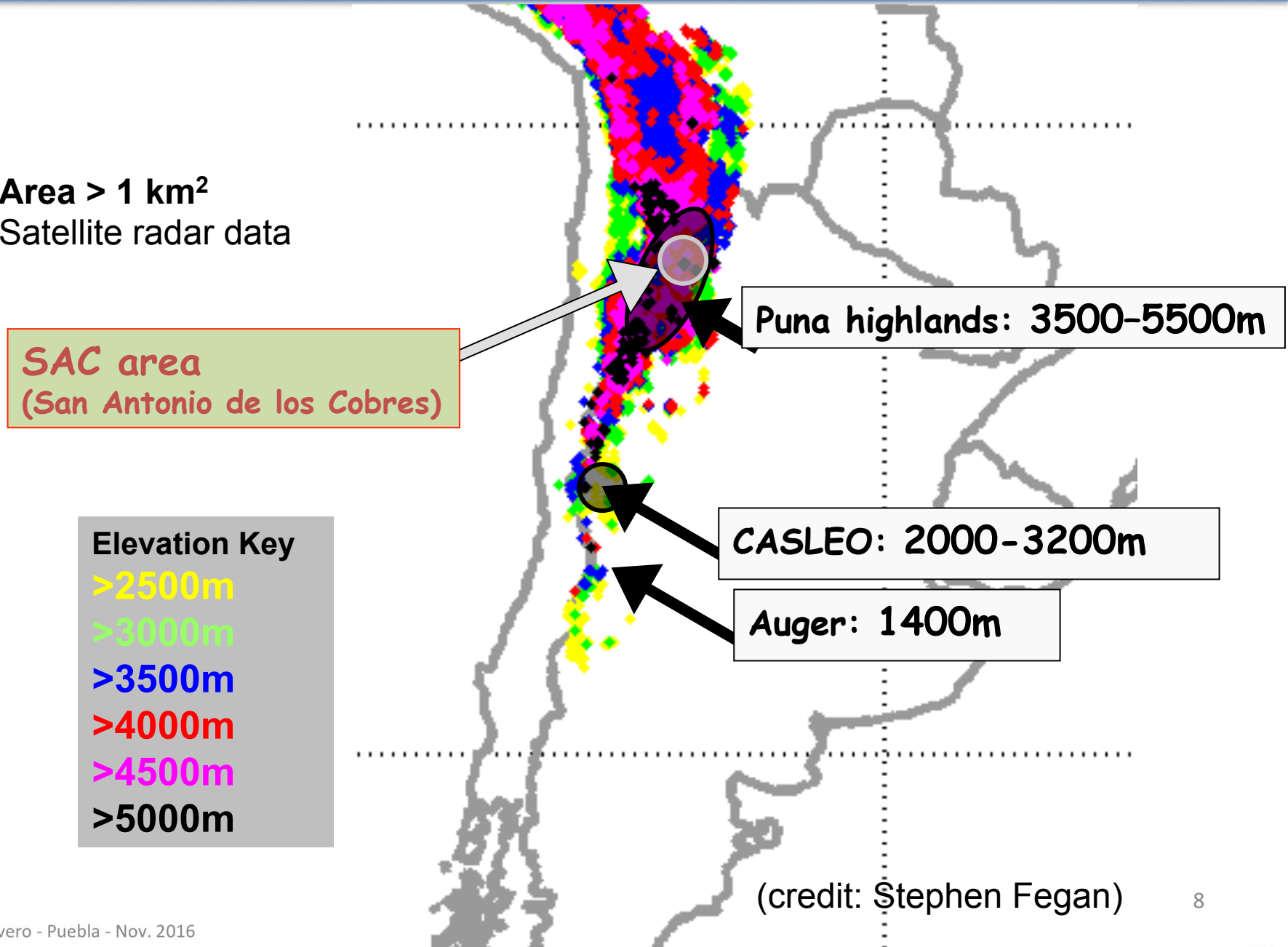
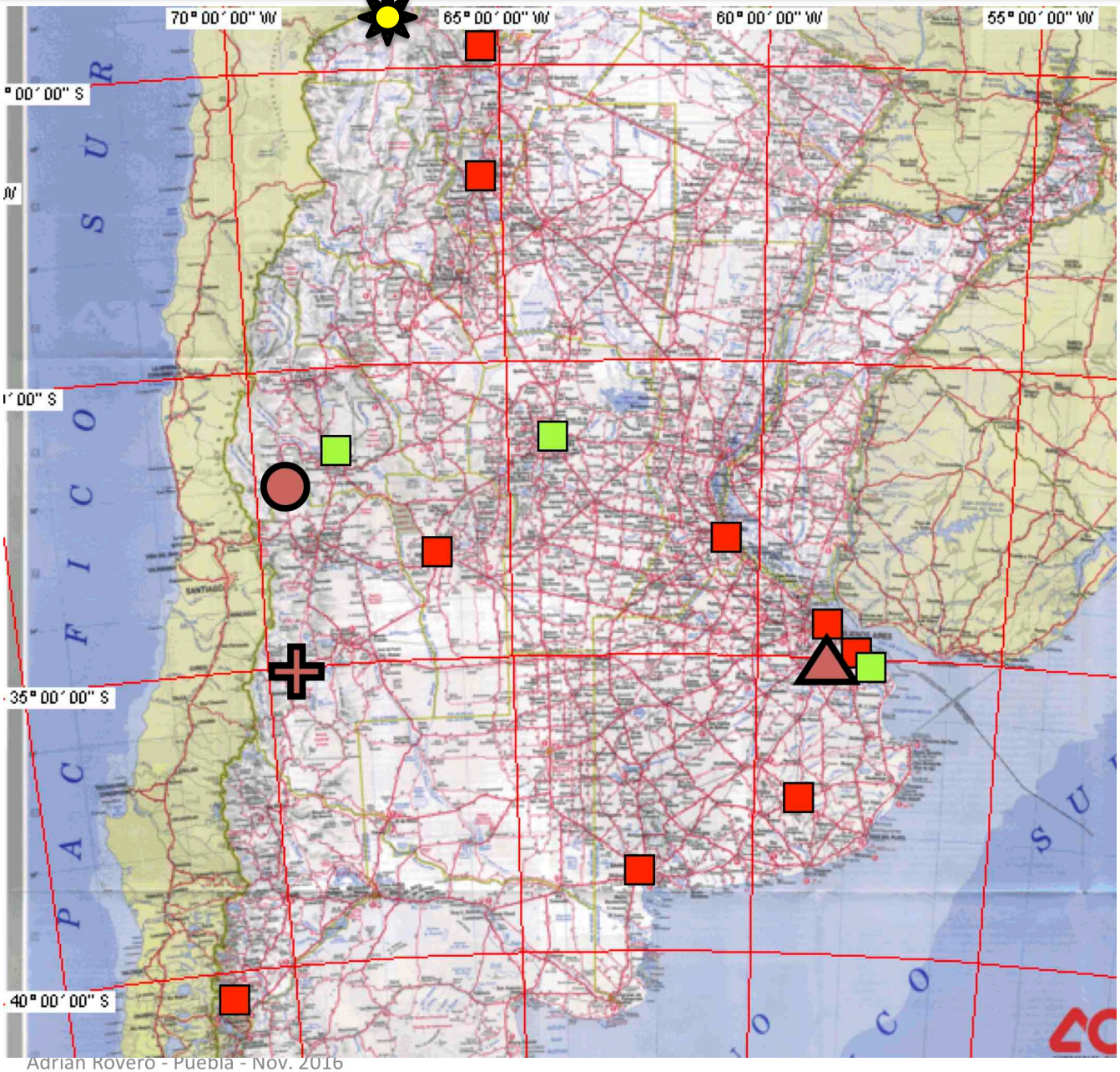


(credit: Stephen Fegan)

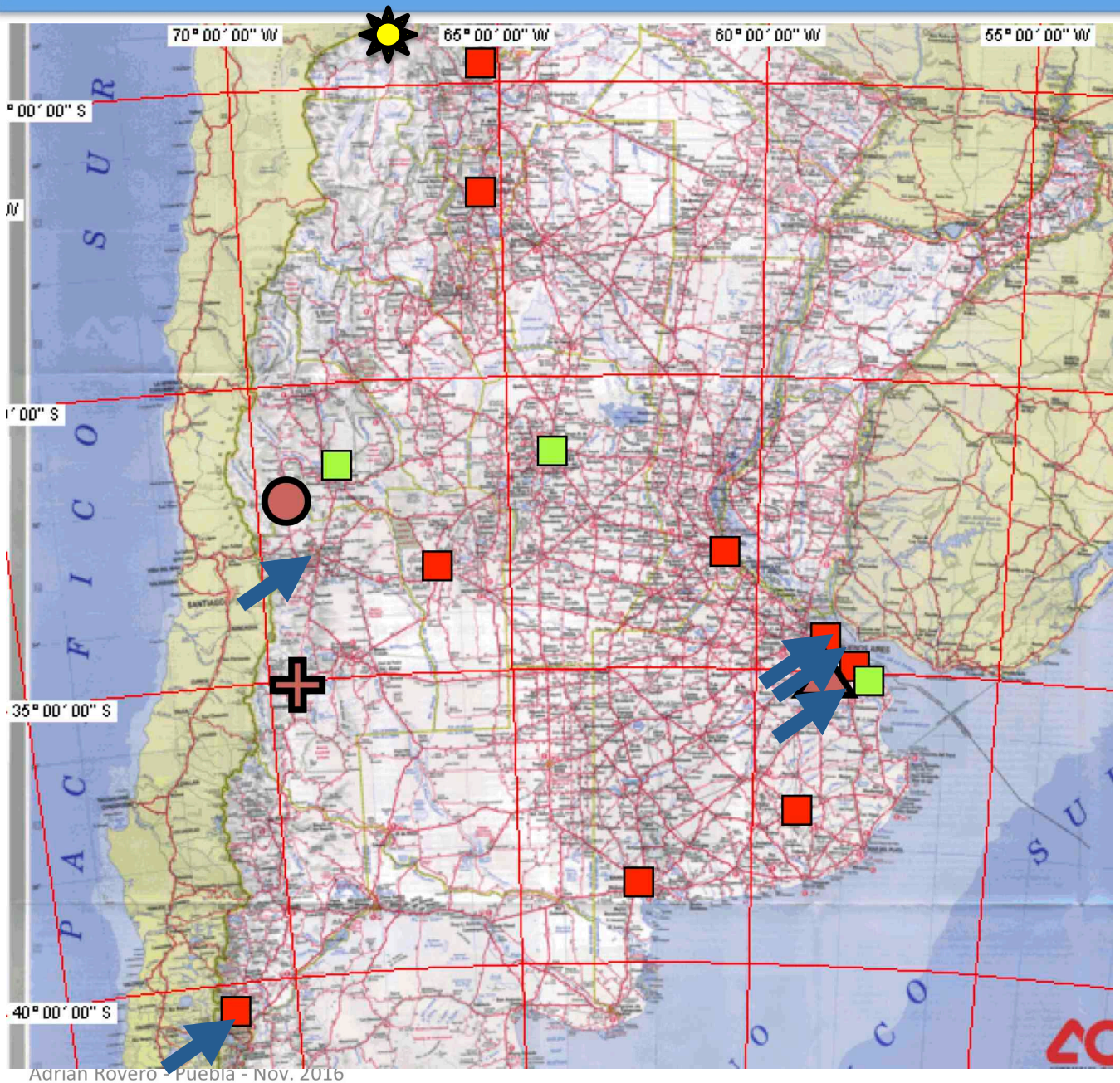
Physics and Astronomy in Argentina



Universities
- Physics
- Astronomy

Observatories
- El Leoncito
- IAR
- Auger/DSA-3
- LLAMA (**SAC area**)

Physics and Astronomy in Argentina



Universities
- Physics
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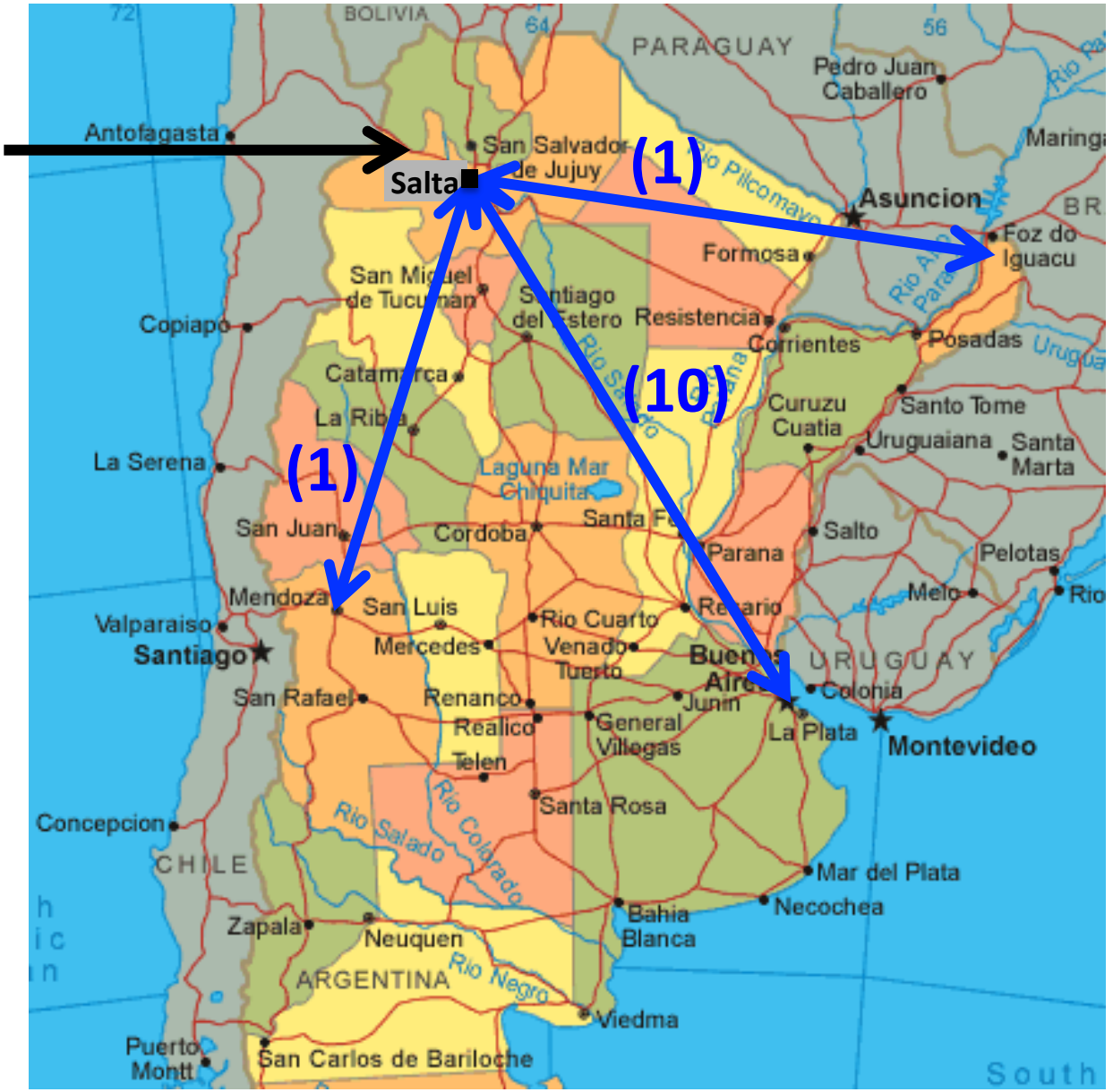
Observatories
- El Leoncito
- IAR
- Auger/DSA-3
- LLAMA (**SAC area**)

Interested groups
- CAB (CNEA)
- IAFE (CONICET)
- IAR (CONICET)
- ITeDA (CNEA)
- ITeDA-M (CNEA)

SAC area: nearest city: Salta

SAC area



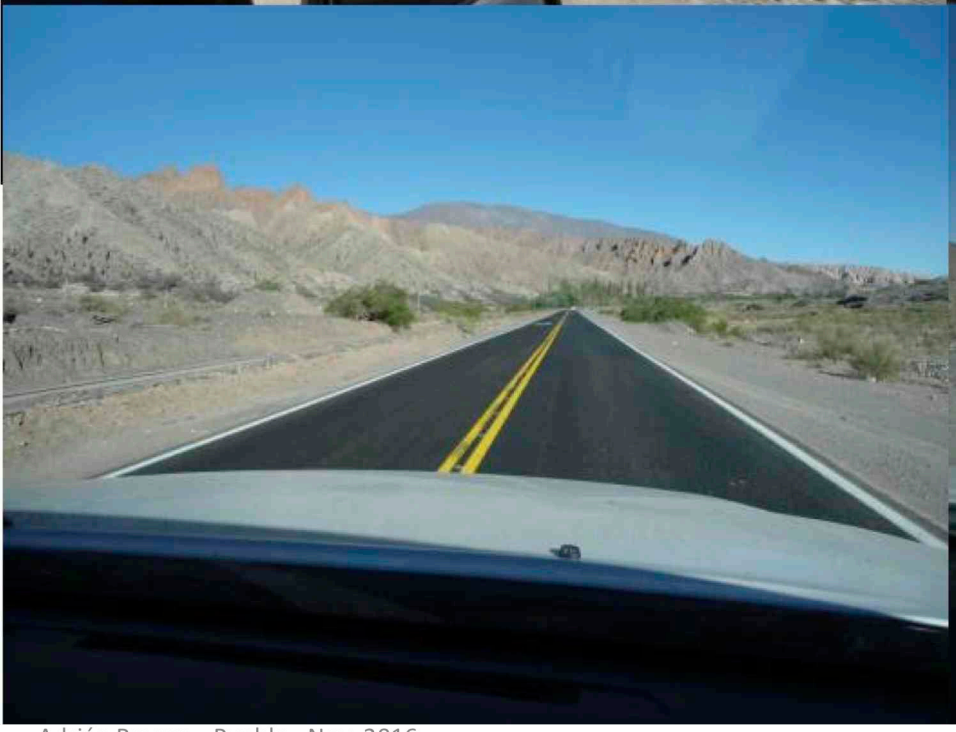
Daily flights:

-Buenos Aires (2:20 hr)
-Mendoza (1:40 hr)
-Iguazú (2:05 hr)

SAC area: nearest city: Salta

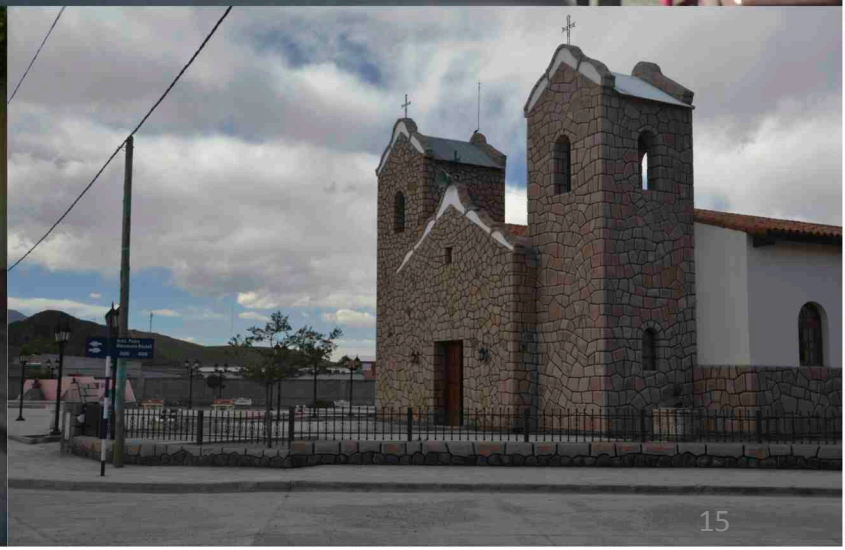
-Highly developed province capital city, pop. 550.000
-University of Salta (physics, engineering)
-Airport on the road to the site
-Several car rentals at the airport

SAC: Access roads



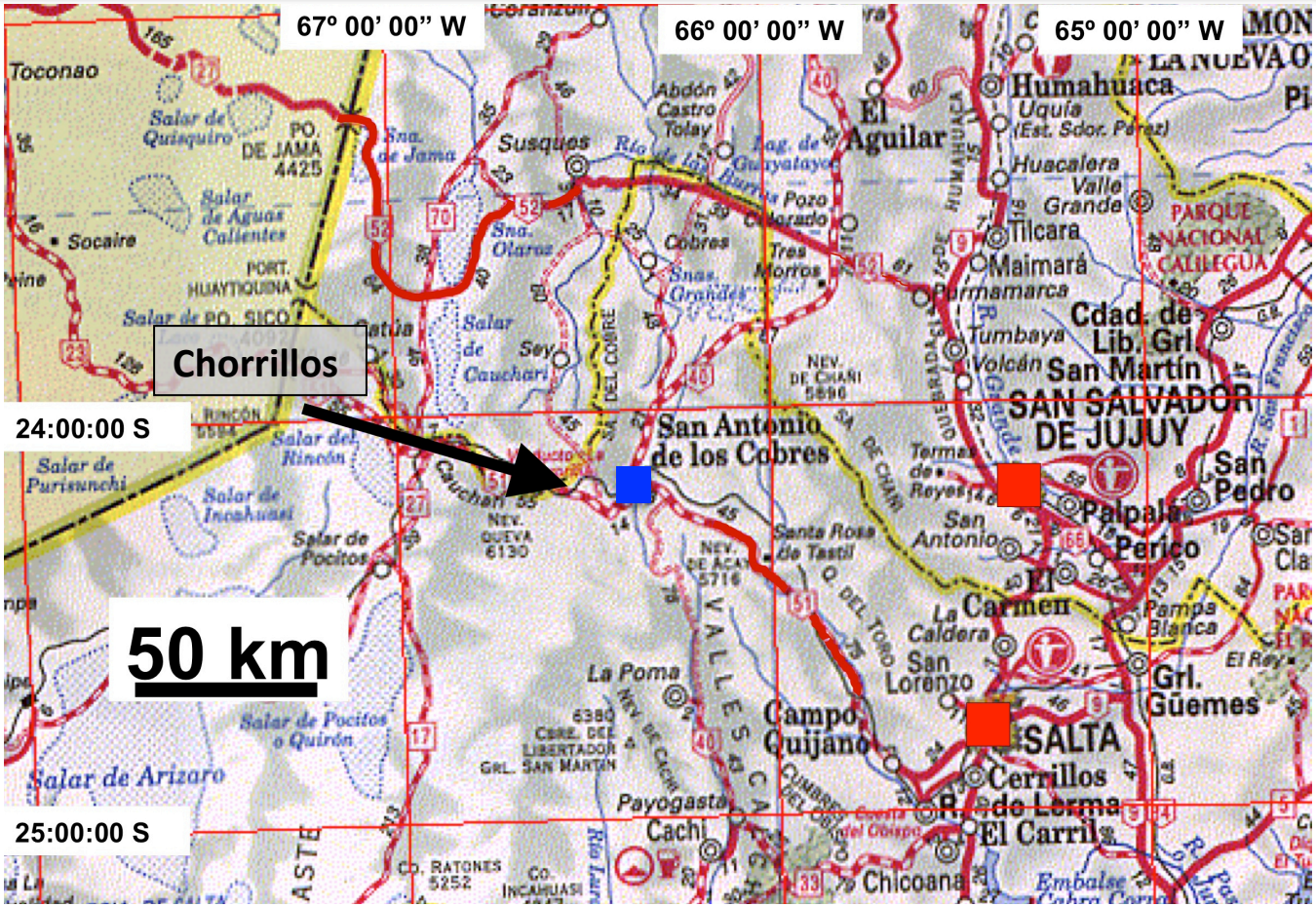
SAC: Lodging: one main hotel + few others

SAC: Street views



SAC area: Chorrillos site of LLAMA

SAC:
3600 masl
160 km from Salta airport
(2.5 hours by car)
Small village, pop. 6.000
Availability of basic services
(gasoline, hospital, hotels, restaurants, stores)
Town for local staff.



Site:
4830 masl
28 km from SAC
(16 km straight line)

Access to site:
- Paved/Gravel road from Salta (Route 51)
- 3 hours by car, 3.5 hours by mini-van or truck.
- Excellent condition all year long (maintained for strategic reasons), suitable for heavy loads.
- Alternative access via Jujuy or Chile (paved road from maritime ports)

Chorrillos, site of LLAMA:

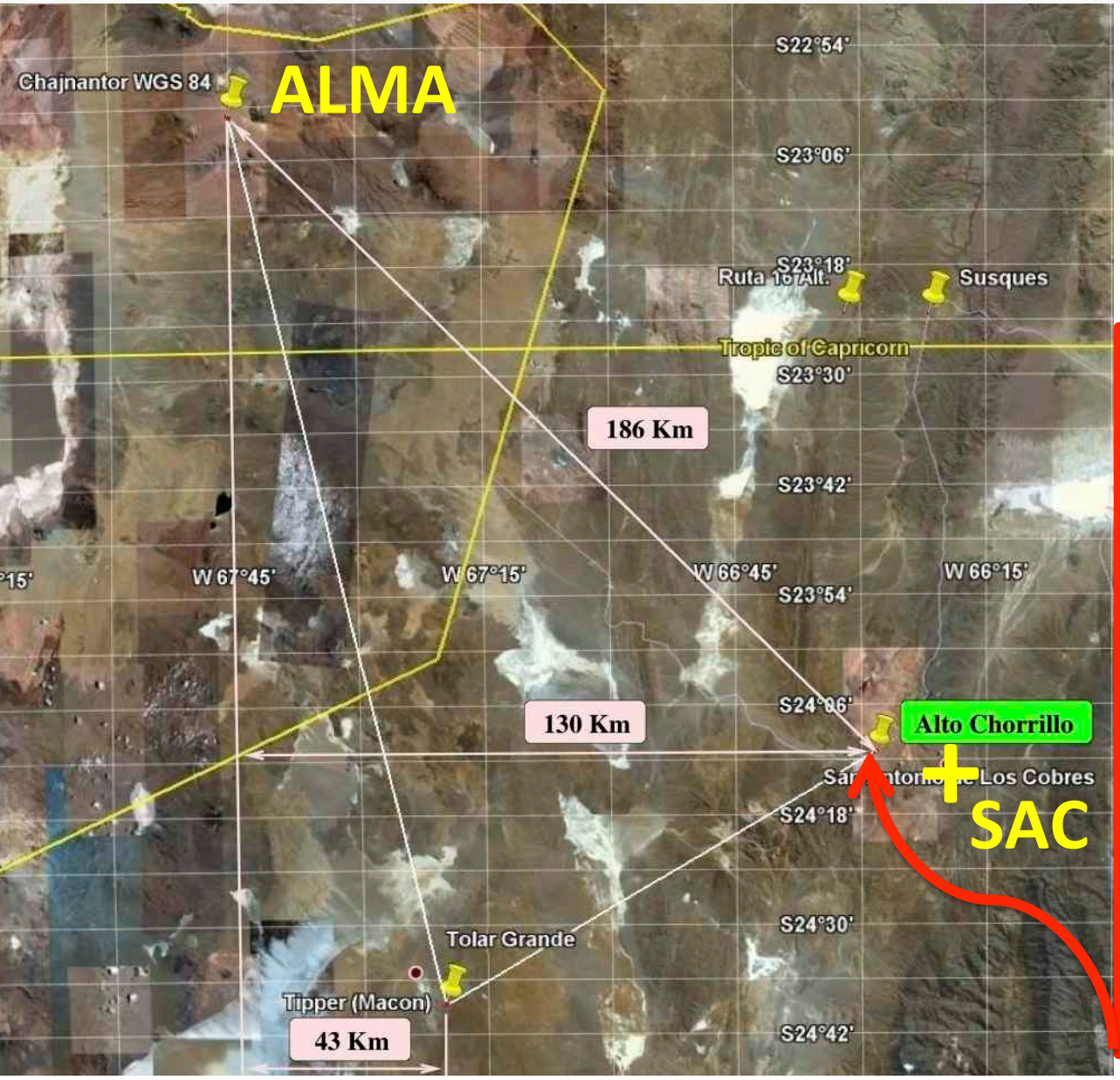
LLAMA (Long Latin American Millimeter Array)

Cooperation with Brazil
Two modes of operation:
- Interferometry with ALMA
- Single dish

-Financed project: **12 M Euro by FAPESP (Brazil) and Ministry of Science (Argentina), 50/50**
-Operated by: Instituto Argentino de Radioastronomía (IAR-CONICET; Argentina)
Universidade de São Paulo (USP; Brazil)

-Single 12 m antenna constructed by Vertex AntennenTechnik GmbH (same as ALMA)
-Operation in the band 35 to 700 GHz.
-Future: to provide the first one in a series of antennas that would make up the first interferometry VLBI network in Latin America.

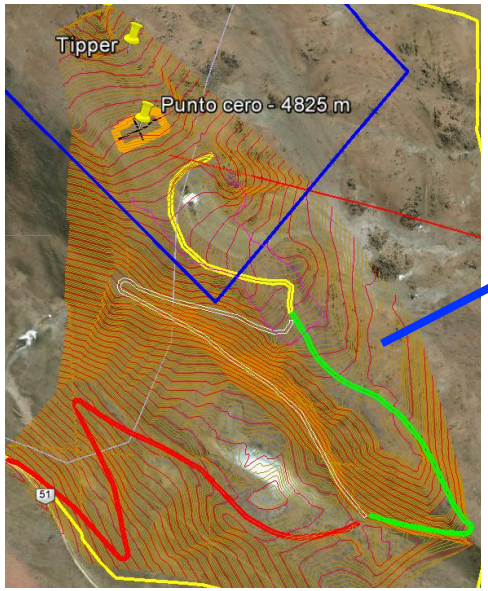
LLAMA: Very Long Baseline Interferometry



VLBI:
186 km from ALMA
(130 km E-W)

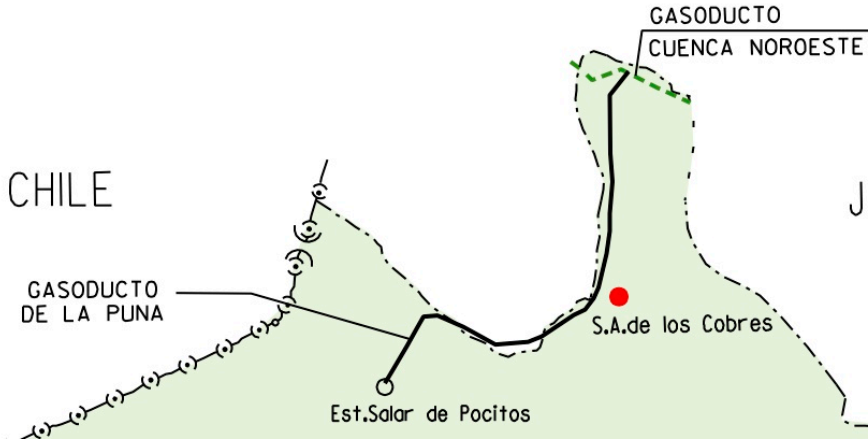
More telescopes would be installed in the SAC area

LLAMA: infrastructure: access road



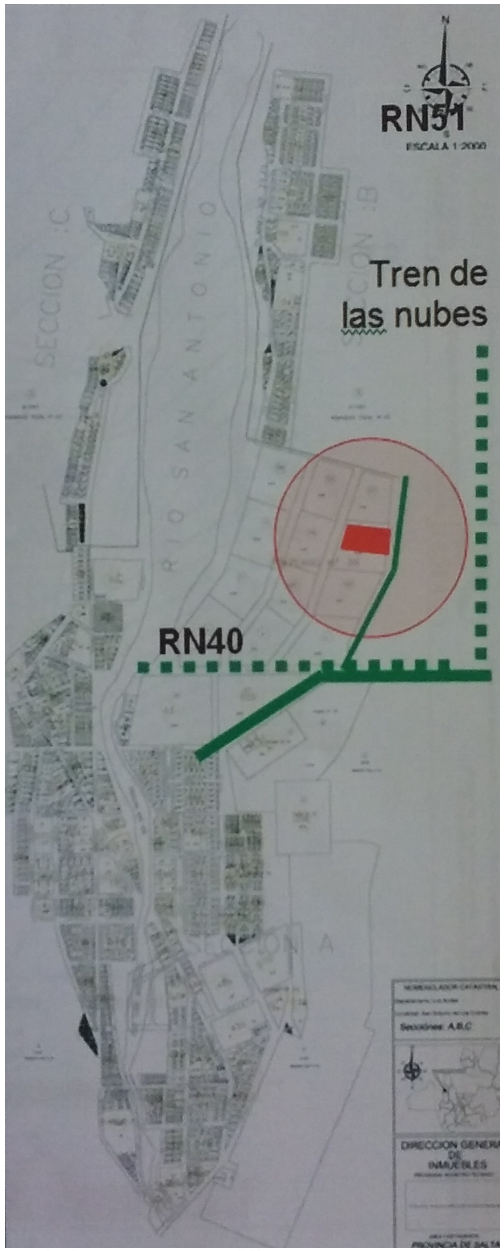
Access road under construction

-Operating room + workshop planned at the site.
-Laboratories and dormitories being constructed in SAC by the Province Government.
-Power plant will be constructed by the Provincial Power Agency (REMSA):
Natural gas generators +
one gas-oil backup generator **(300 kVA)**

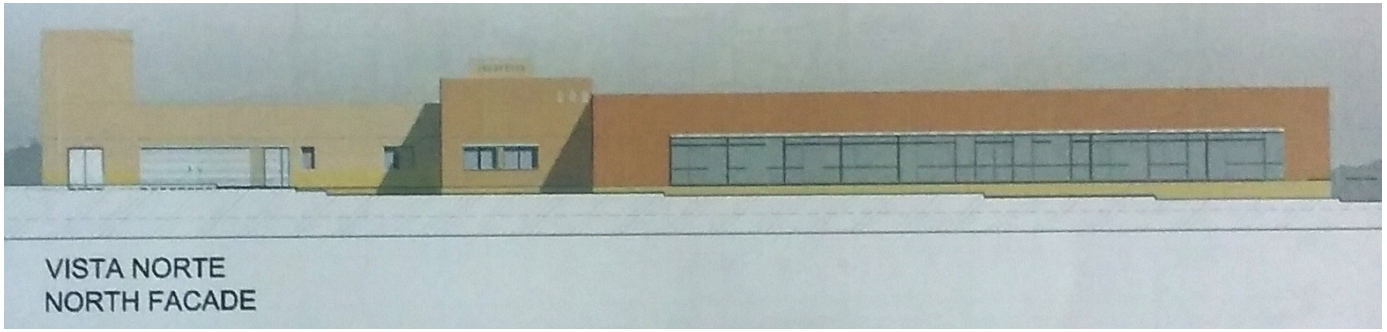


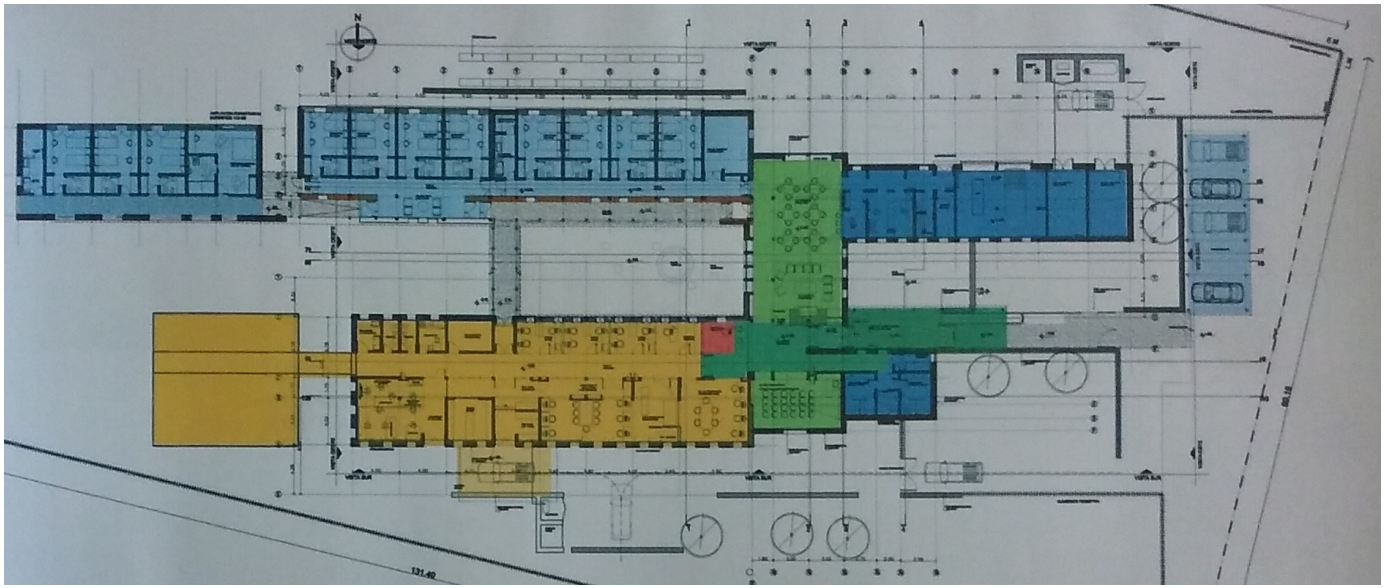
Gas pipeline next to the site

LLAMA: infrastructure: dorms and labs in SAC



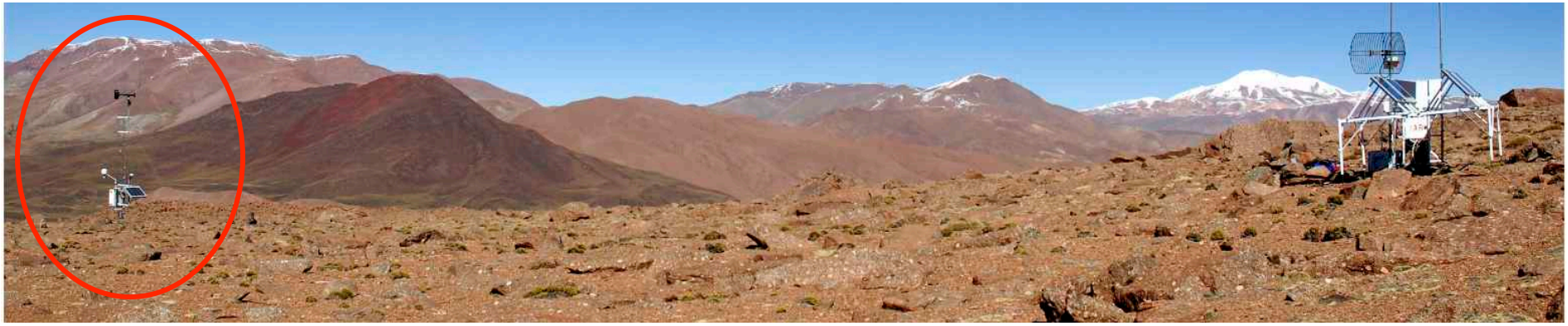
Facilities being constructed by the Provincial Government → will be shared with QUBIC



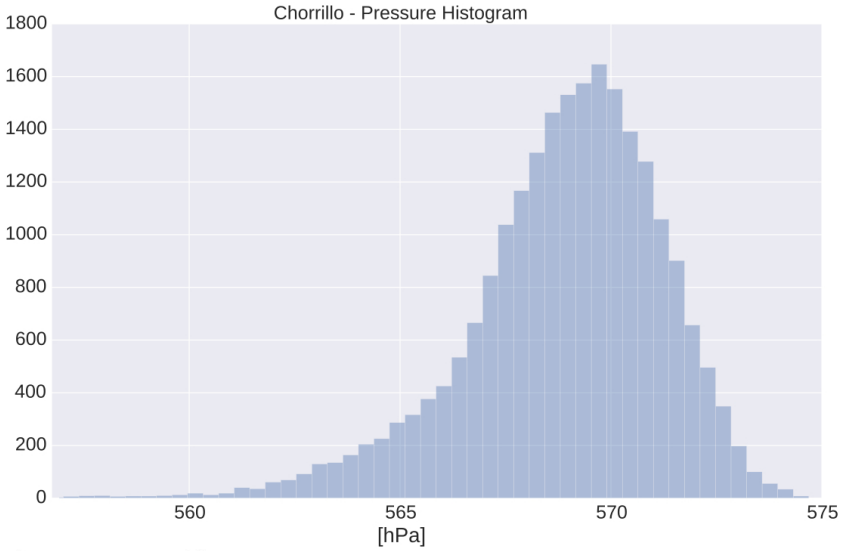


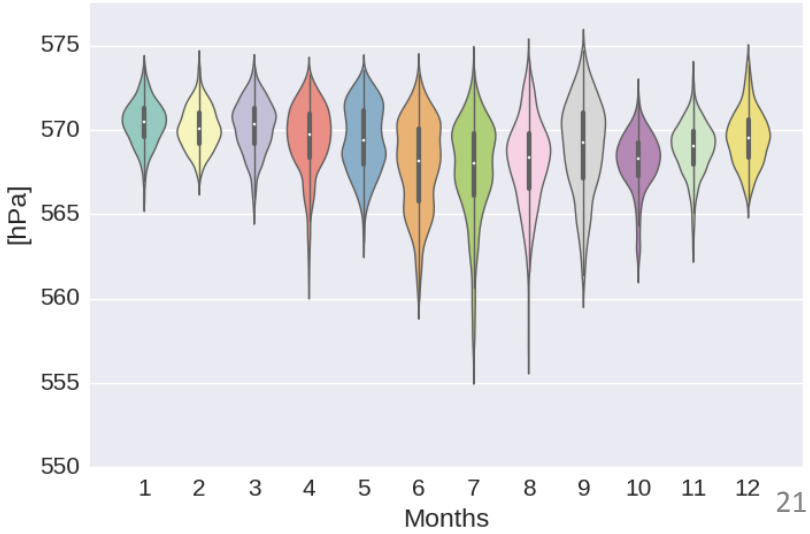
LLAMA: Weather station

data taken May 2011 - Dec 2013: Temp; Rel.Hum.; Wind; Pressure;
Installed and operated by IAR (Instituto Argentino de Radioastronomía)



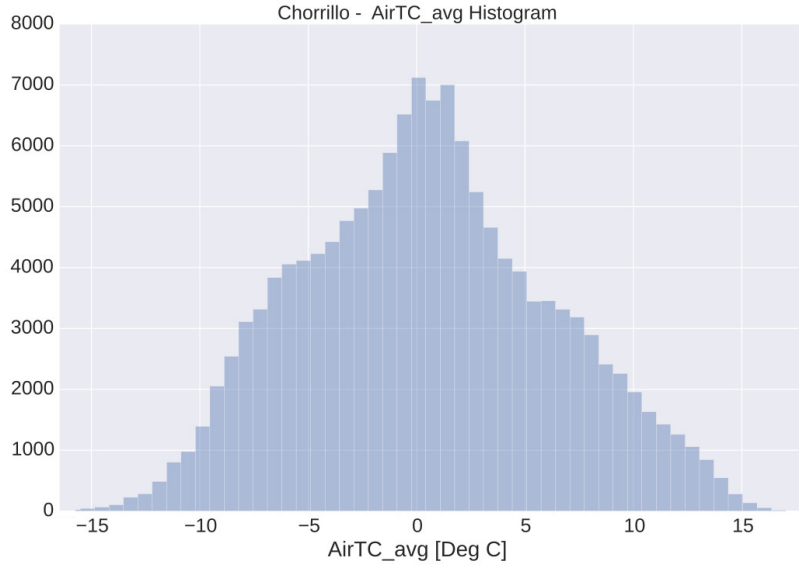
Barometric pressure (hPa)

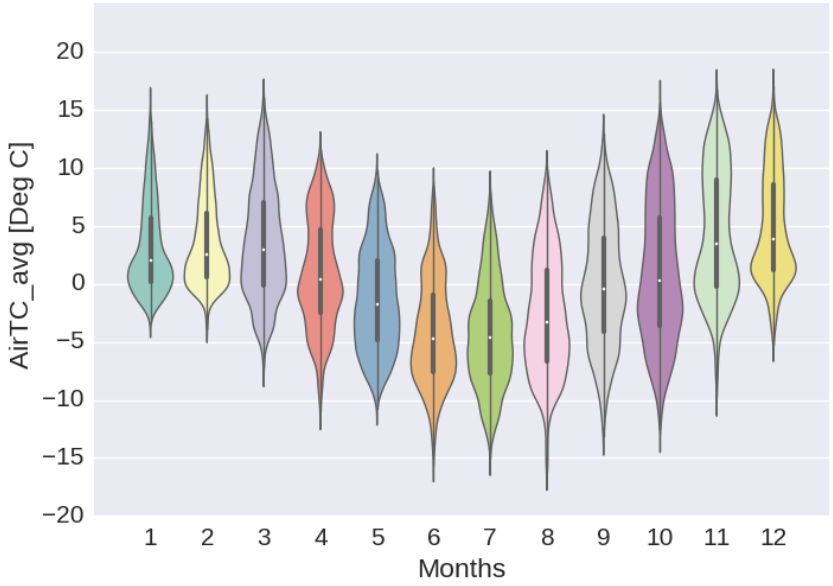




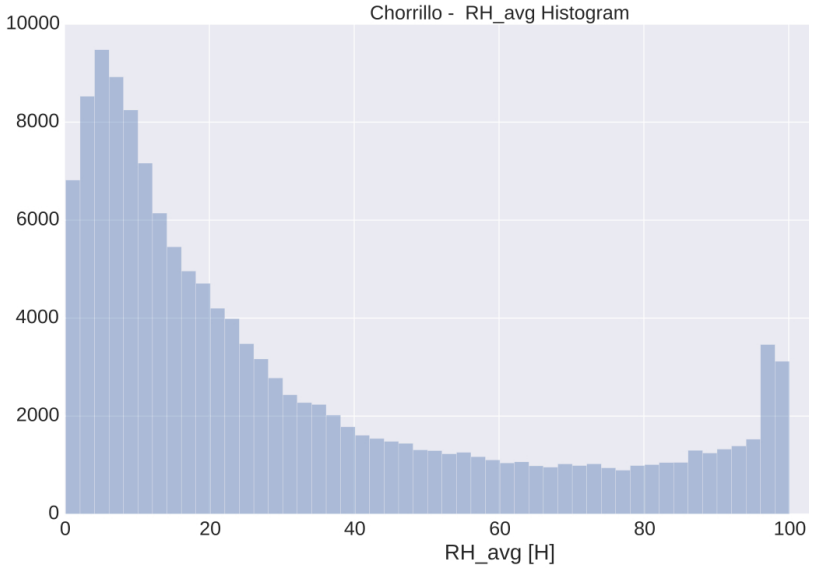
Weather station: Data 2012-2013

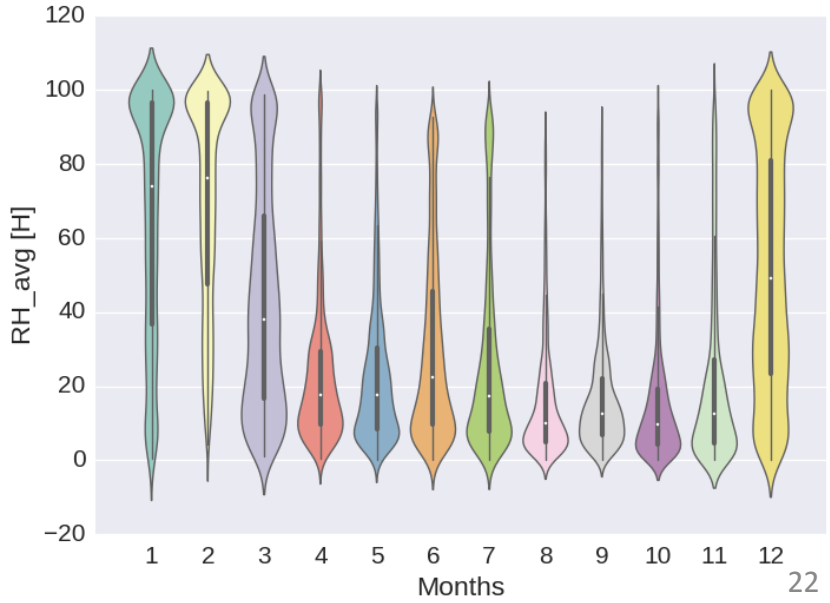
Temperature (ºC)





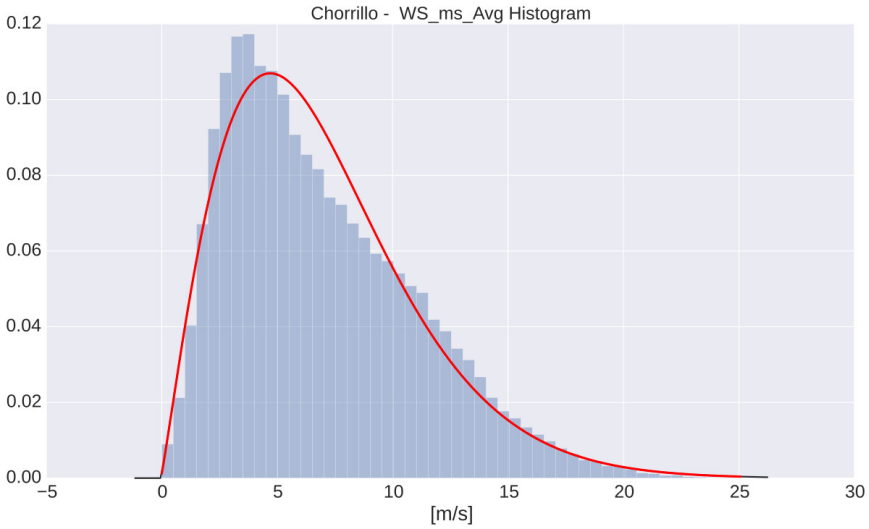
R.H. (%)

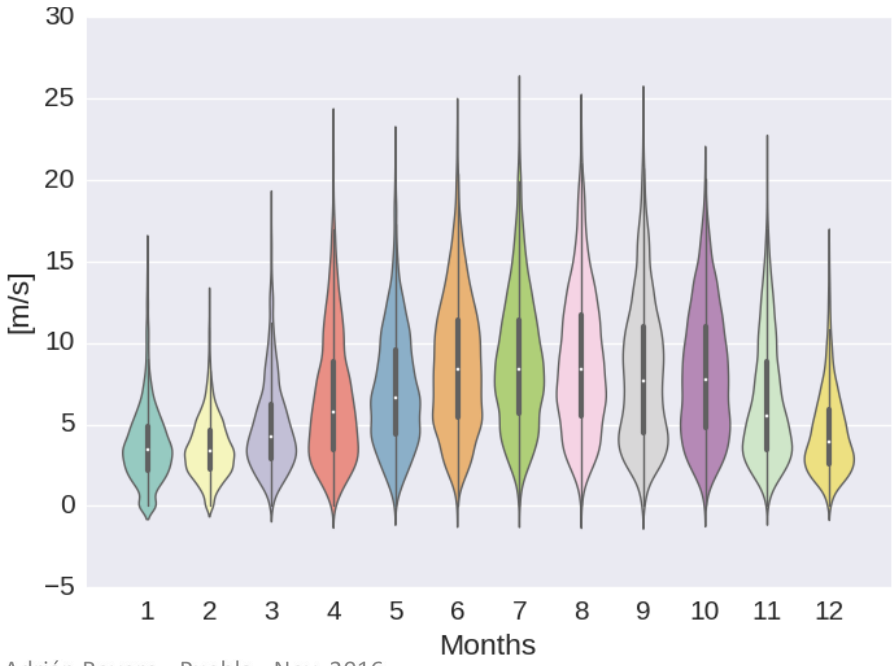




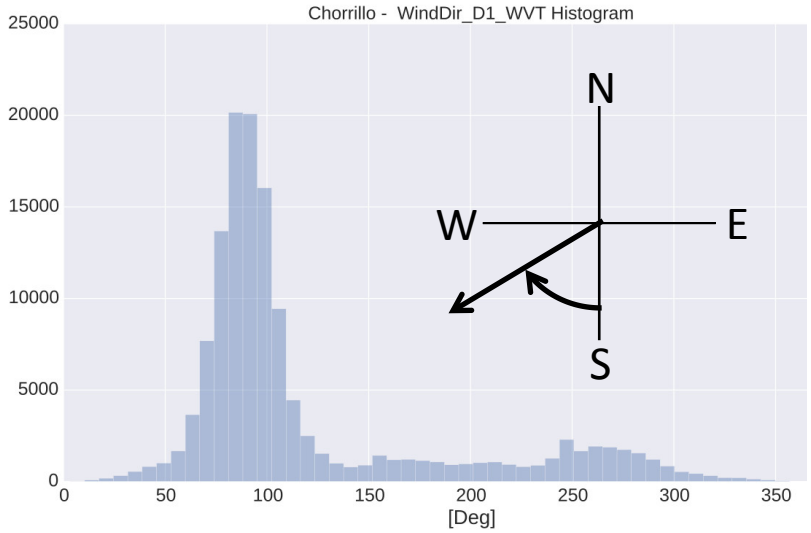
Weather station: Data 2012-2013

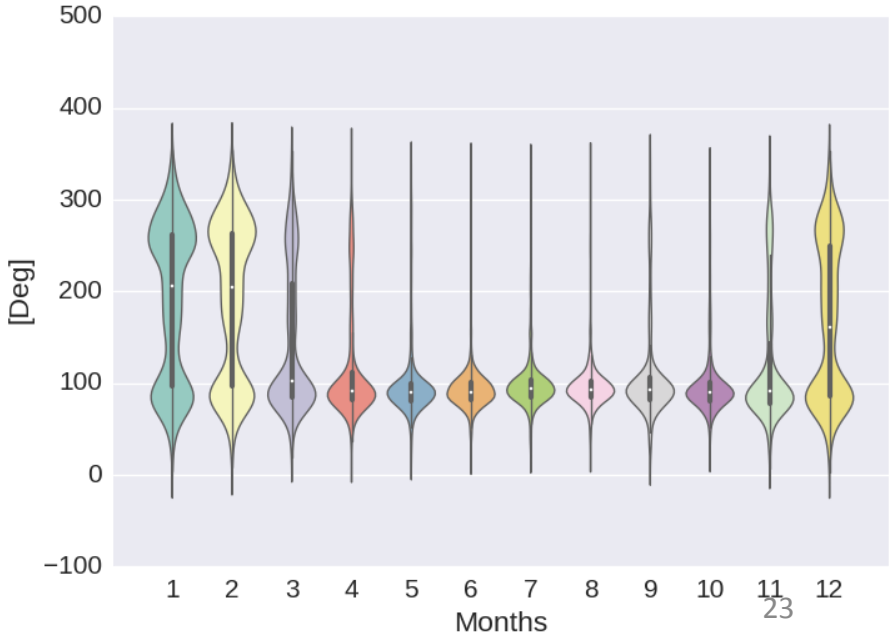
Wind speed (m/s)





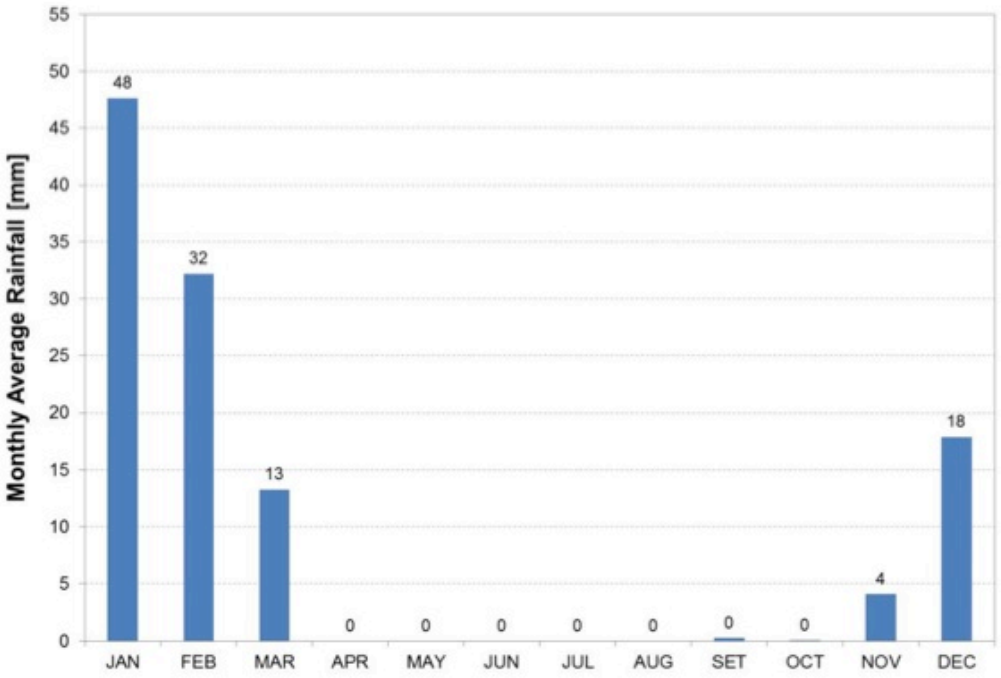
Wind direction (deg)



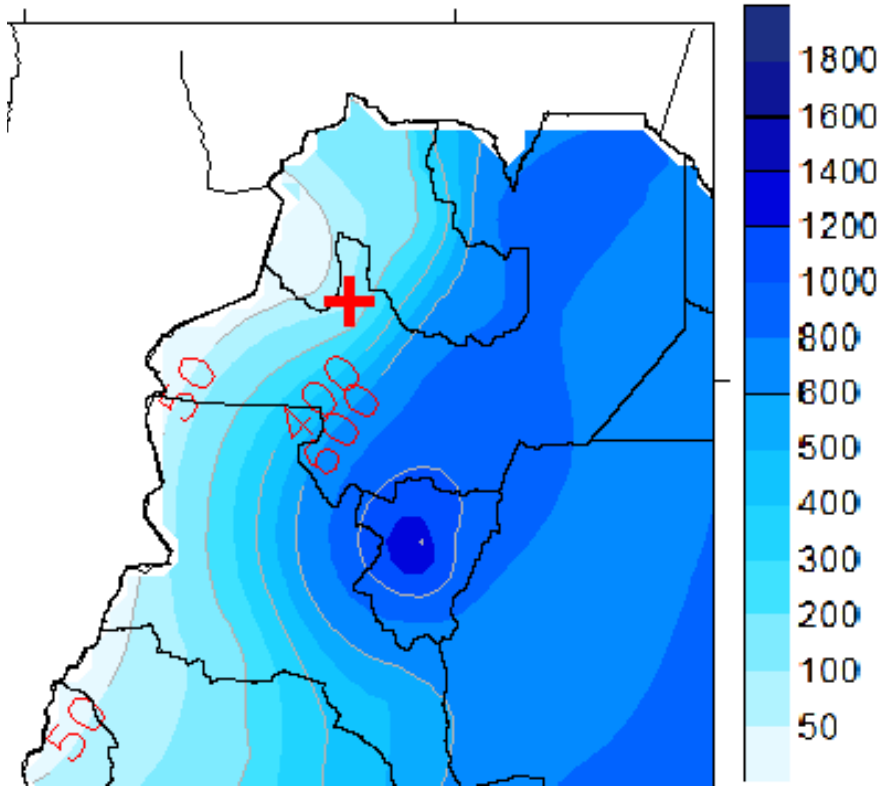


Historical weather data:

Precipitation in SAC: total annual ~120 mm
Snow: scarce: no accumulation



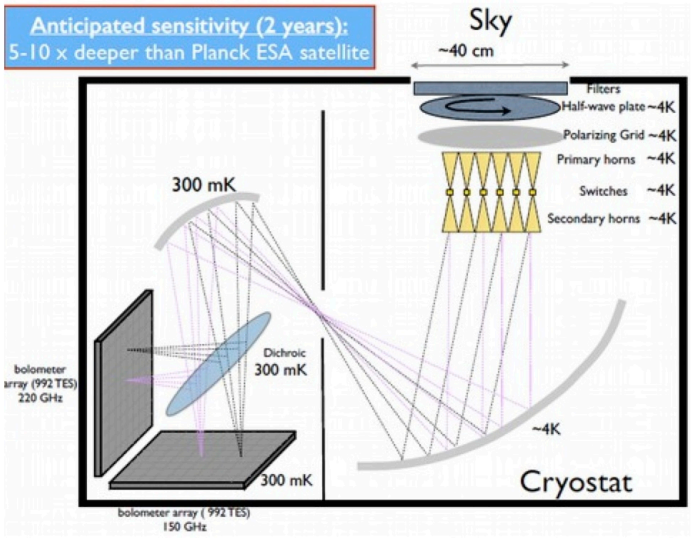
Monthly annual rainfall for SAC in the period 1949-1990. Records obtained by INTA (Instituto Nacional de Tecnología Agropecuaria)



Annual average rainfall in SW Argentina
(Servicio Meteorológico Nacional).

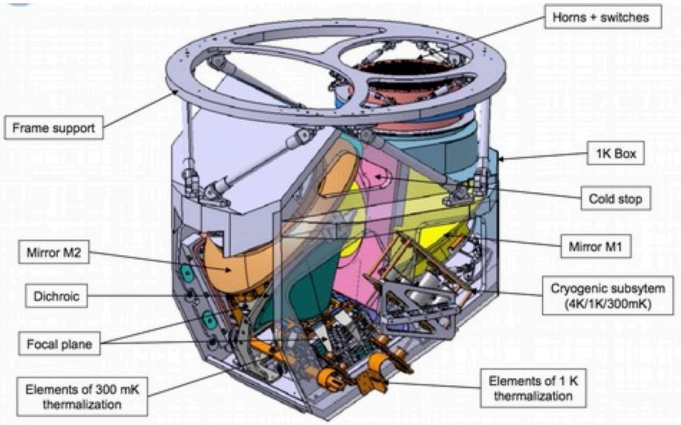
Chorrillos, site of QUBIC:

QUBIC (Q&U Bolometric Interferometer for Cosmology)



French-Italian instrument to be installed in Argentina
(decision made in June 2016)

Cosmology experiment which aims to measure the B-mode polarization of the Cosmic Microwave Background.

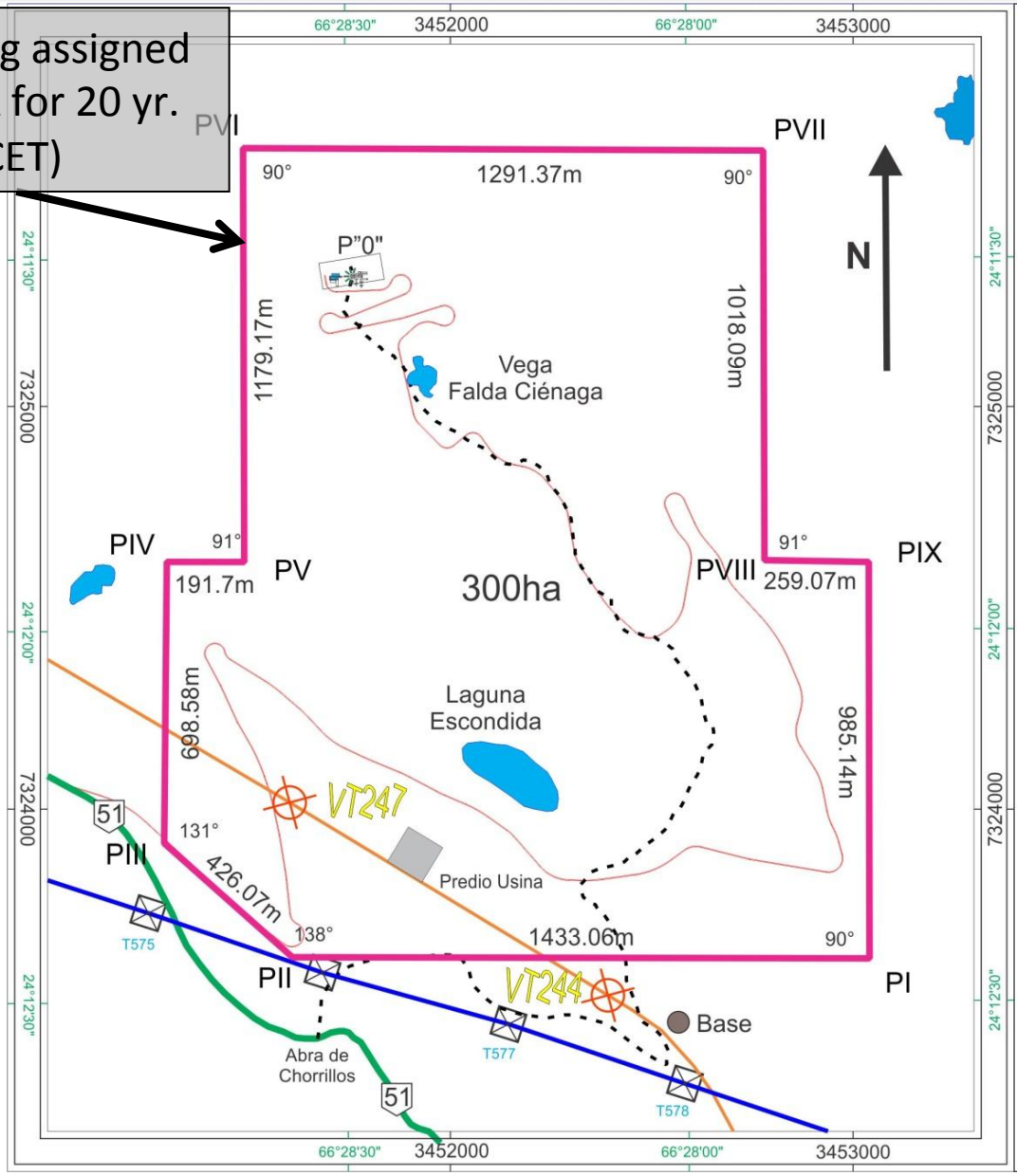


Financed project:

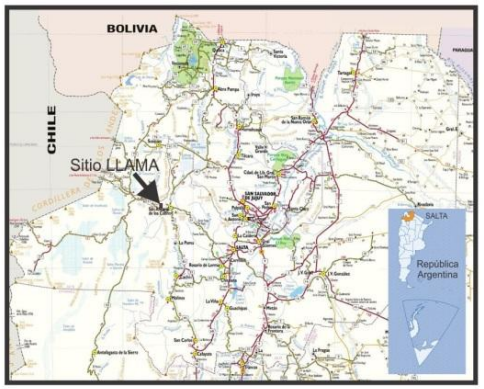
- Instrument: France-Italy
- Infrastructure on site: Argentina:
  Initial budget of 500k USD from Ministry of Science

Chorrillos: land assigned

Area being assigned to LLAMA for 20 yr. (to CONICET)



Mapa de Ubicación



Ubicación Mojones Esquineros

Punto	Nombre	Latitud	Longitud	Altitud	X	Y
Unsa	Base Unsa	24°43'38.98783 S	65°24'27.48166 W	1245.494	7265967.40	3559931.34
BASE	Base Chorrillos	24°12'31.60090 S	66°28'02.97693 W	4662.606	7323629.33	3453040.86
P1LL	PUNTO 1 CHORRILLOS	24°12'26.59141 S	66°27'44.09033 W	4626.414	7323473.43	3452508.40
P2LL	PUNTO 2 CHORRILLOS	24°12'26.34051 S	66°28'34.87184 W	4578.972	7325641.37	3451485.25
P3LL	PUNTO 3 CHORRILLOS	24°12'17.10223 S	66°28'46.11916 W	4553.990	7325635.72	3452776.61
P4LL	PUNTO 4 CHORRILLOS	24°11'54.39945 S	66°28'45.80171 W	4619.341	7324613.84	3453039.01
P5LL	PUNTO 5 CHORRILLOS	24°11'54.42964 S	66°28'38.98746 W	4638.439	7324618.26	3452779.98
P6LL	PUNTO 6 CHORRILLOS	24°11'21.02767 S	66°28'38.97133 W	4829.203	7324613.67	3451488.30
P7LL	PUNTO 7 CHORRILLOS	24°11'21.35249 S	66°27'53.21779 W	4691.987	7324613.94	3451295.99
P8LL	PUNTO 8 CHORRILLOS	24°11'54.42182 S	66°27'53.21821 W	4677.556	7323915.39	3451289.43
P9LL	PUNTO 9 CHORRILLOS	24°11'54.59342 S	66°27'44.04038 W	4644.533	7323632.24	3451607.80

Referencias Cartográficas

- Ruta Nacional N°51
- Ferrocarril C14
- Huella Acceso al Sitio LLama
- Gasoducto
- Progresivas Gasoducto
- Electroducto
- Torres Cable AT
- Camino Proyectando
- Límite interprovincial
- Superficie base 10ha
- Mojones Esquineros
- Predio Solicitado (400ha)
- Punto Geodésico IGM
- Lagunas y Vegas

0 — 500m

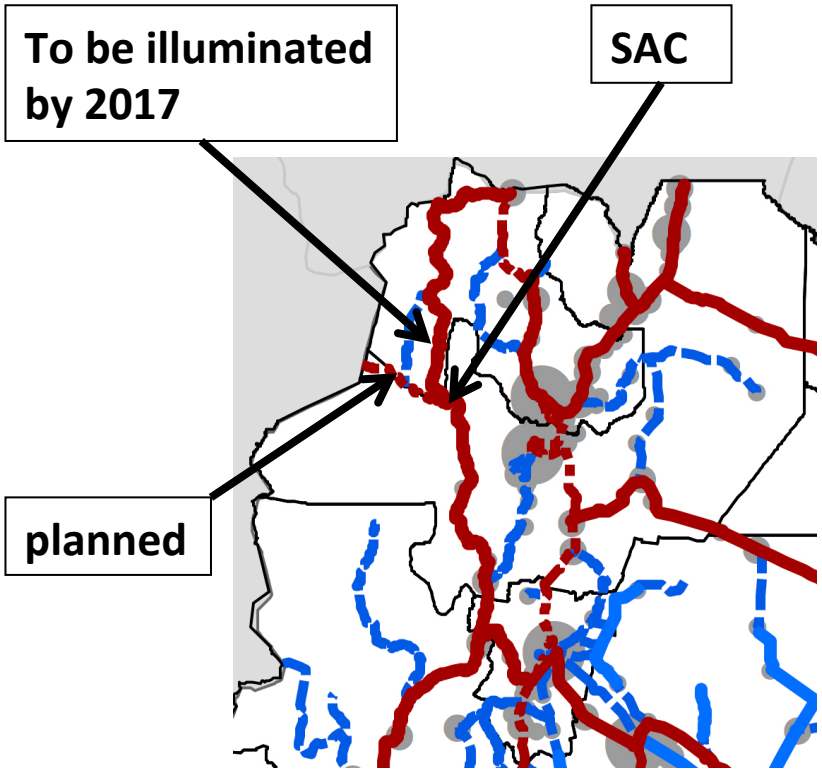
Escala Gráfica

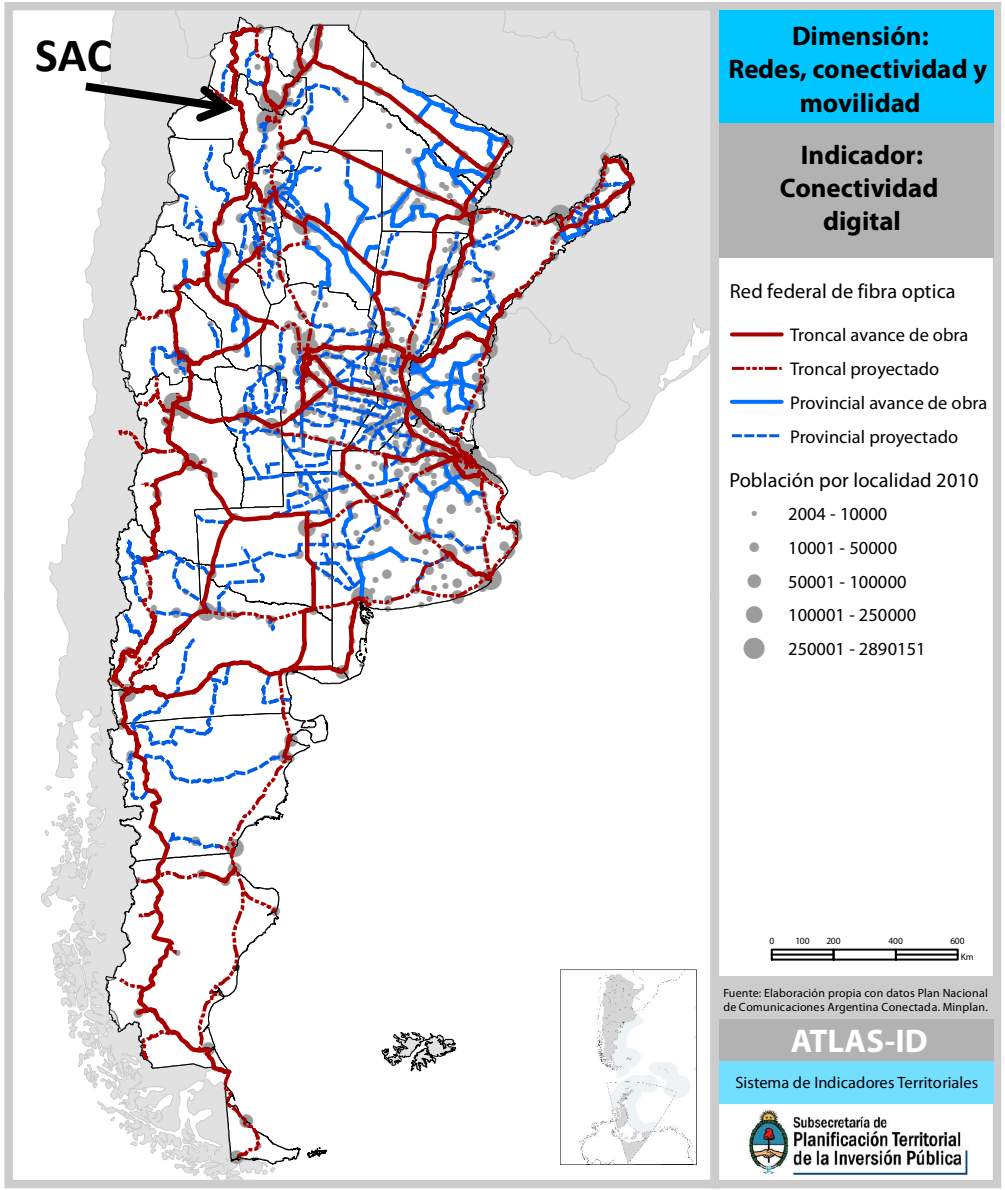
Plano de Referencia Mojones Esquineros

Proyecto LLAMA

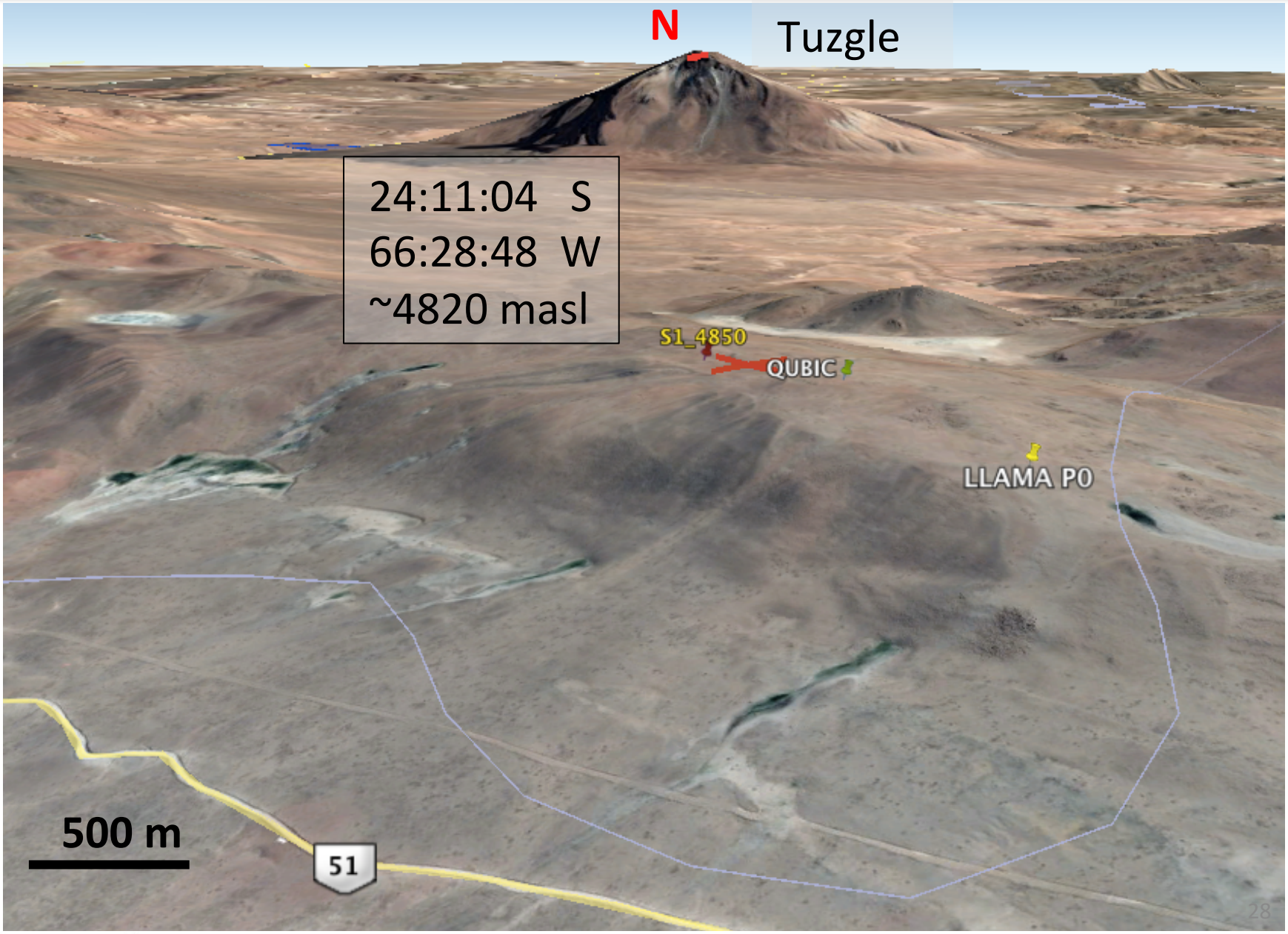
SAC area: connectivity

LLAMA: Optic fiber to SAC planned (8 km) → to connect to the Federal Optic Fiber Network





Wide FoV southern observatory: proposed site



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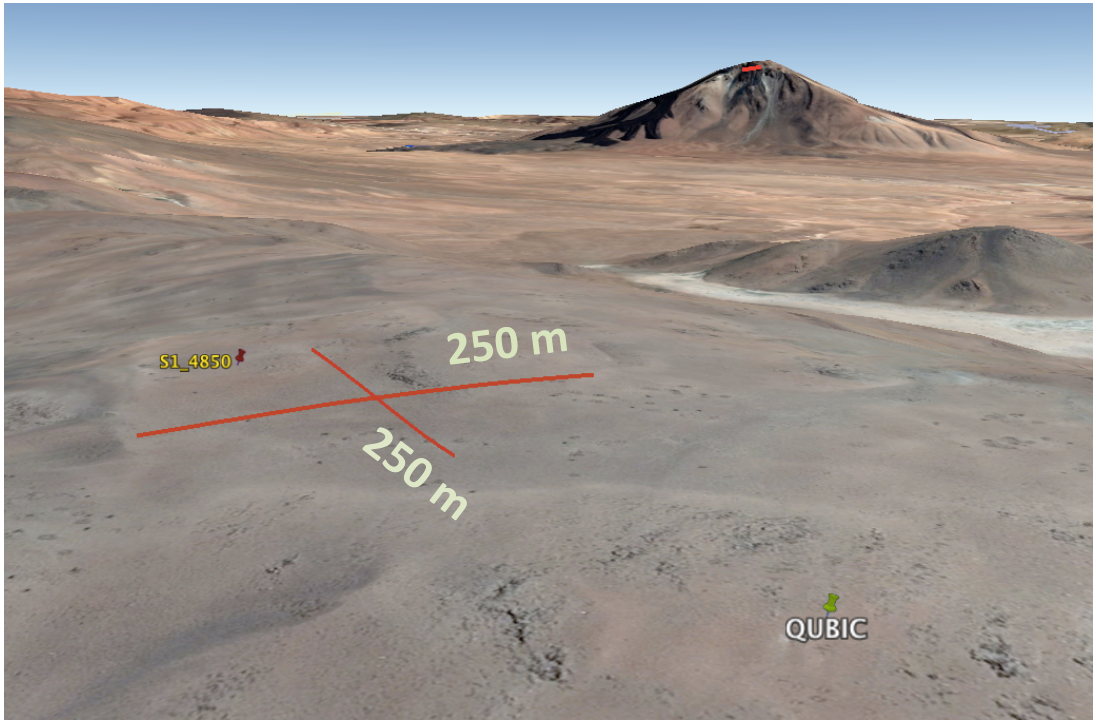
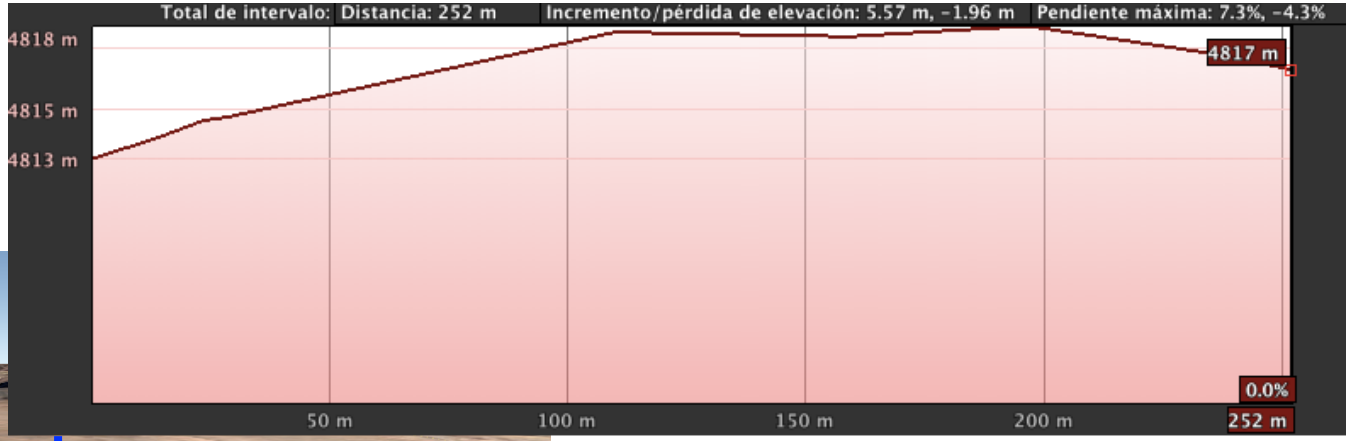
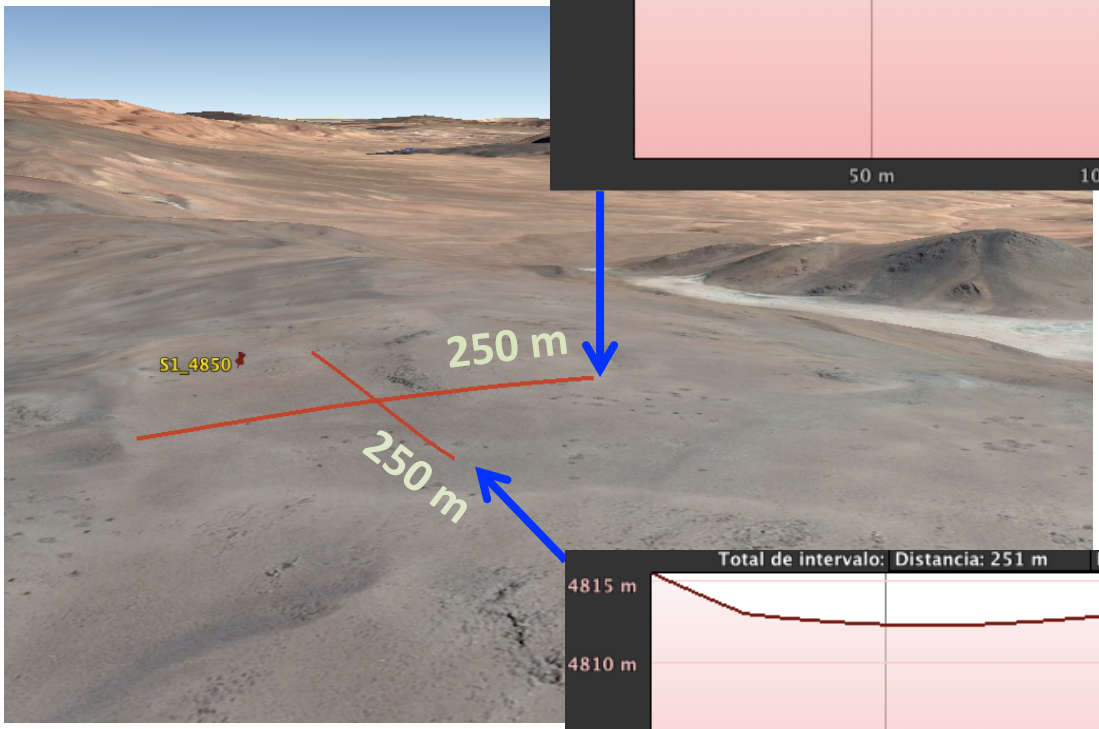


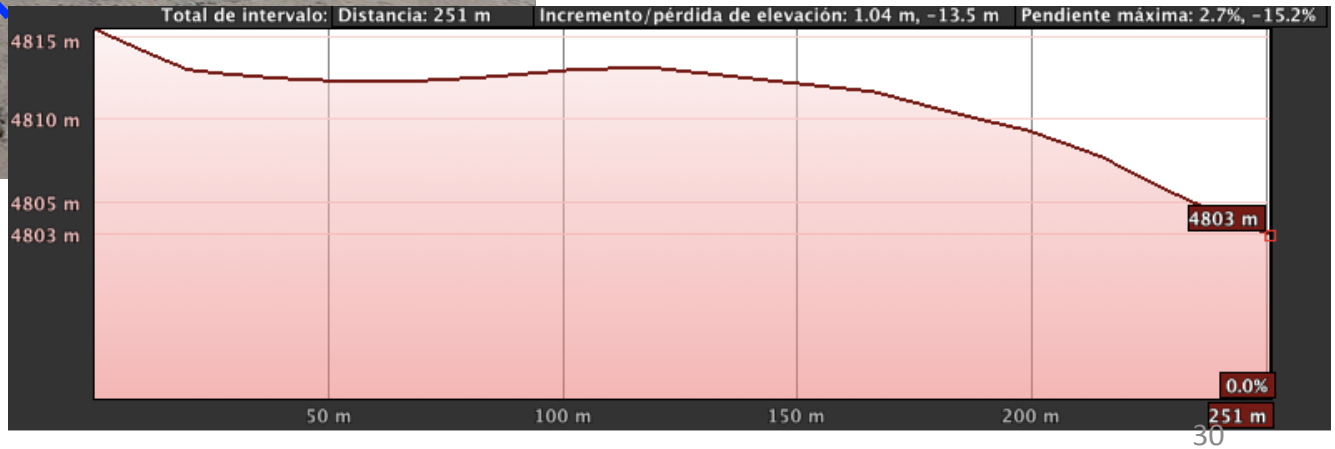
Wide FoV southern observatory: proposed site

250 m → Δ ≈ 5 m





250 m → Δ ≈ 12 m



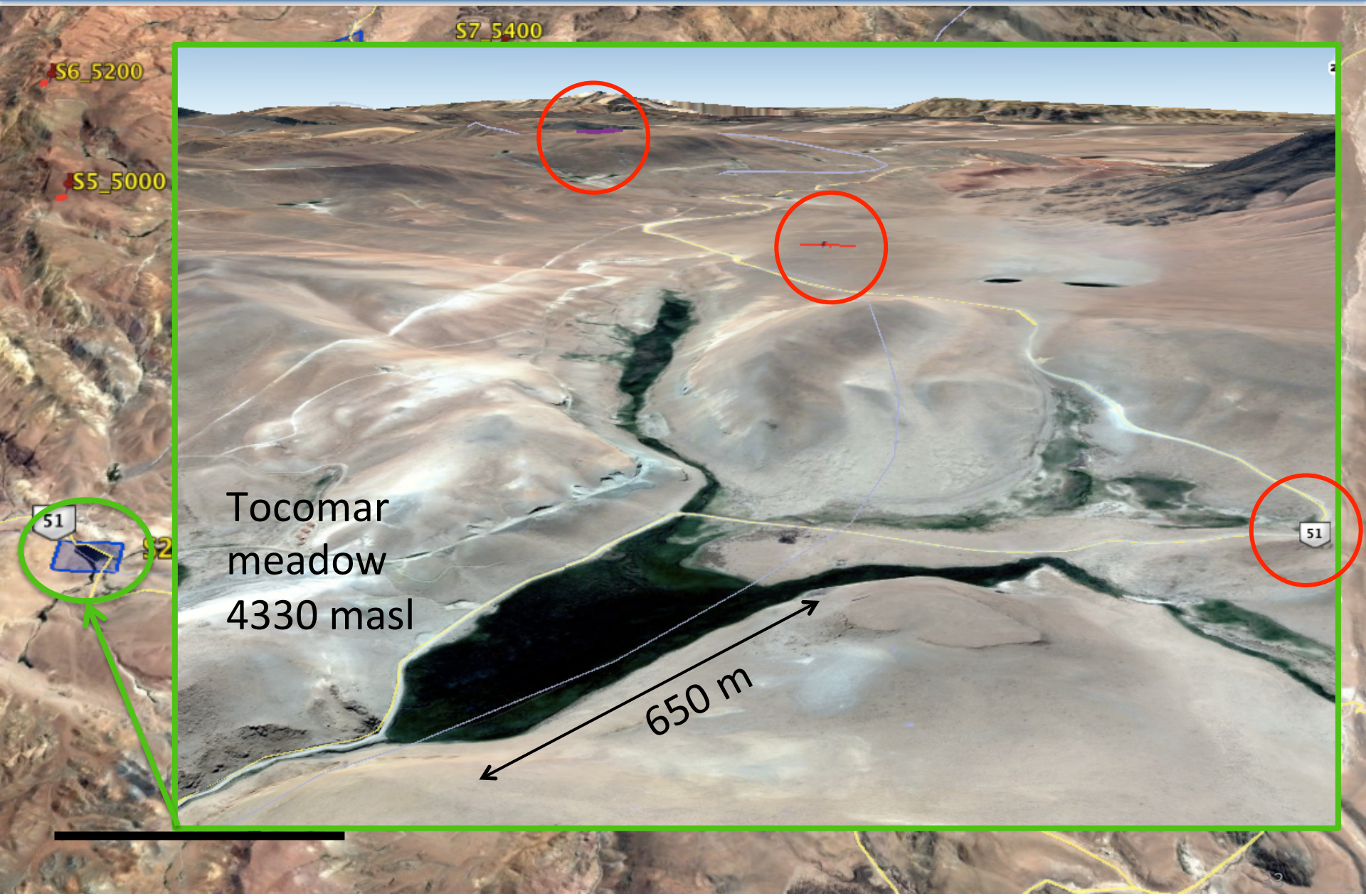
Wide FoV southern observatory: proposed site

From QUBIC site to the South

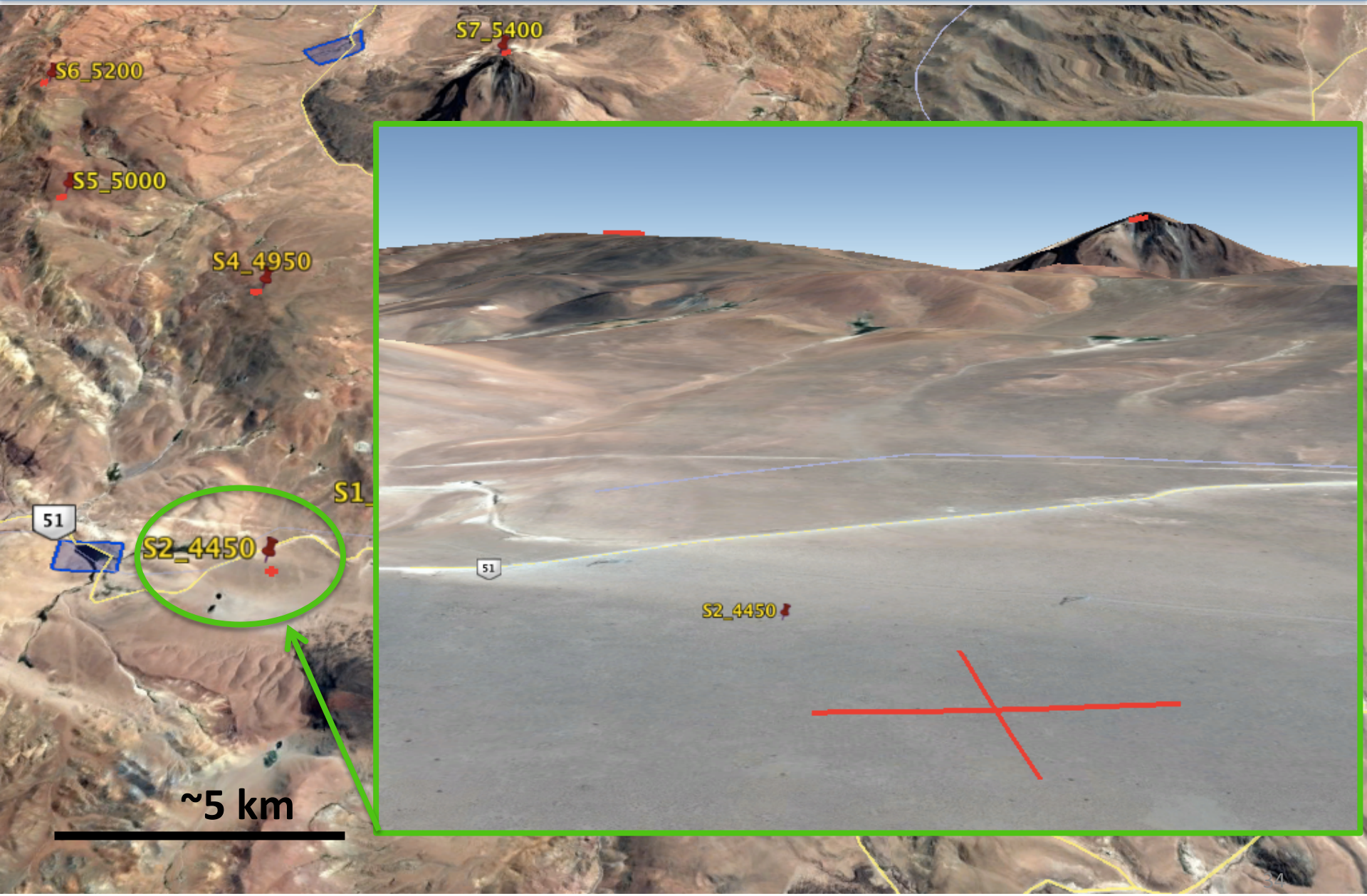
From QUBIC site to the North

Alternative sites:

Alternative sites:



Alternative sites:



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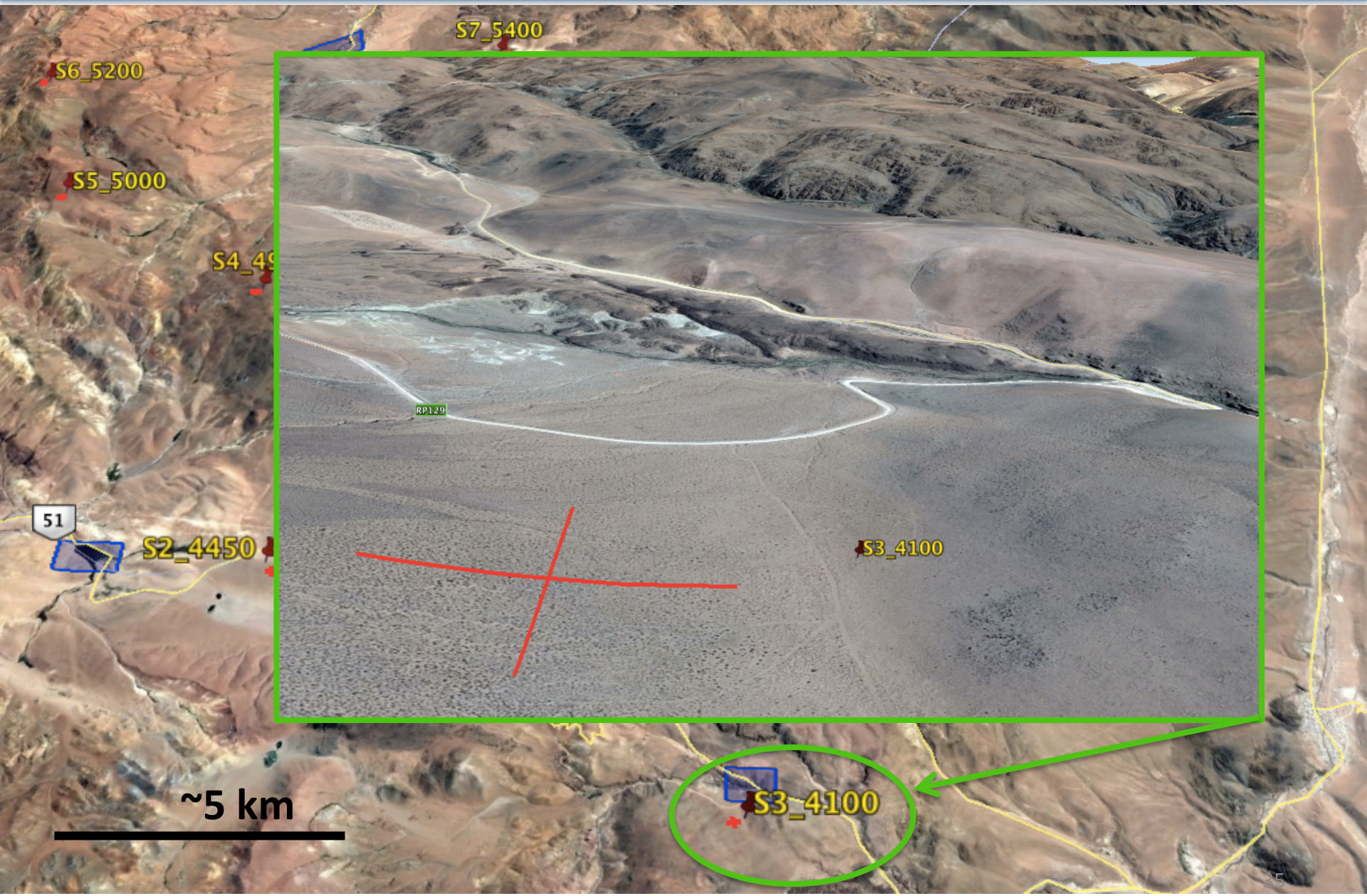

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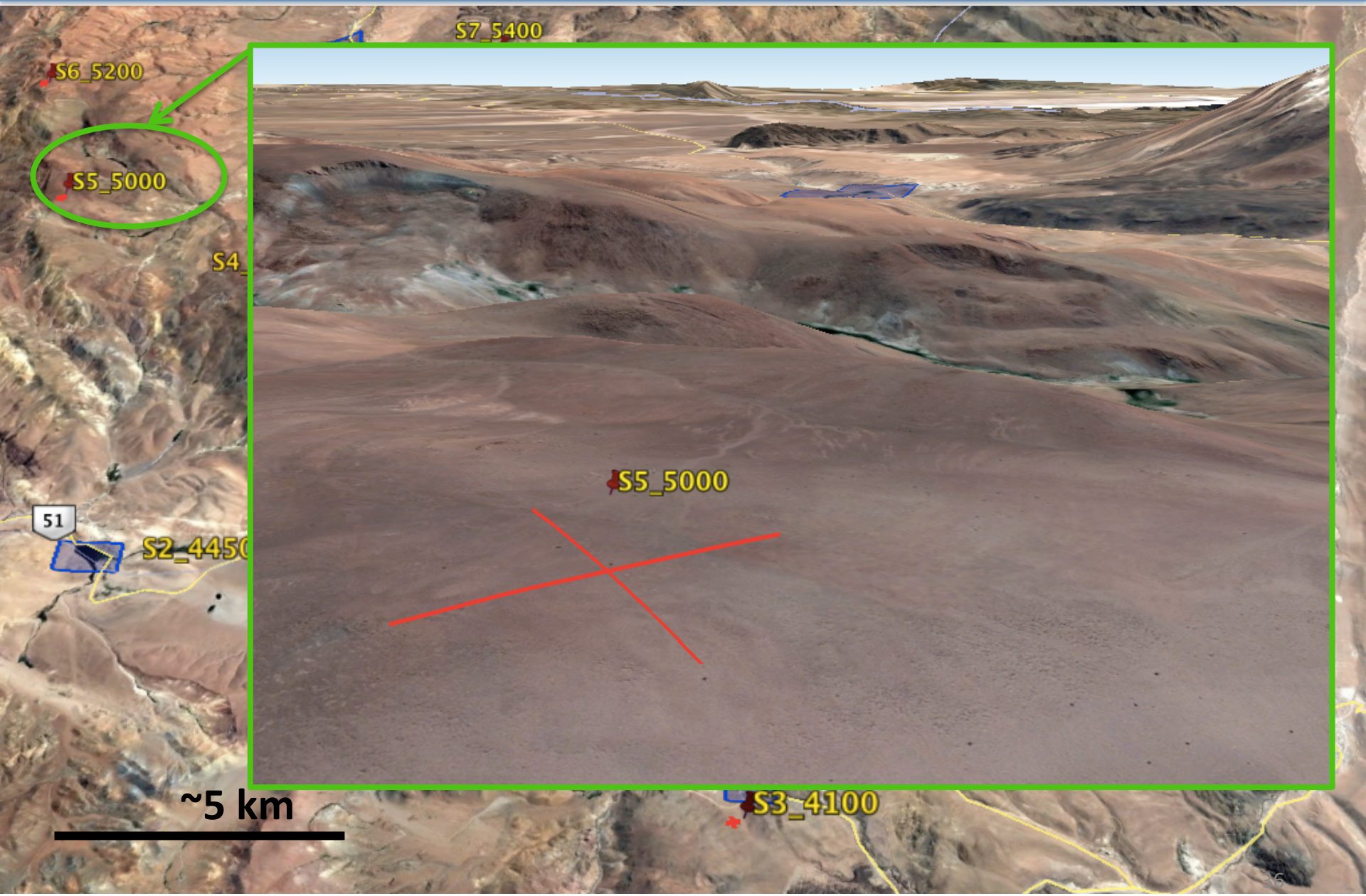

Alternative sites:

Summary

We propose a site at >4800 m close to a town (28km) with minimum infrastructure and good access to a big highly developed city (170km); airport at 160km.

The site is being developed for LLAMA, an Argentinian-Brazilian antenna (same as ALMA). Power, connectivity and access will be provided. Another project has recently been approved to be installed on site (QUBIC), granted by the Ministry o Science with an initial budget of 500 kUSD for infrastructure.

Alternative sites at 4100-5400 m have been identified.

Water sources for WC detectors are available, either from nearby small flood-meadows or from rivers. Lagoons are also available with water for construction (with minerals).

Political support, both at the local provincial level as well as at the maximum national level, has been expressed by the corresponding authorities to further develop Chorrillos (intention to found an National Observatory).

With the successful construction and installation of big projects, a high energy astrophysics community was formed during the last two decades.

There are groups in Argentina that have shown interest in contributing to this initiative, as well as from Brazil.