Astronomy, Astroparticle and Astrophysics

J.C. D'Olivo (MX), F. Sánchez (AR), M. Subieta (BO)

White papers (5+1):

1)	Cherenkov Telescope Array (x2)	**CTA**
2)	Latin American Giant Observatory	**LAGO**
3)	Southern Wide-FoV Gamma-Ray Observatory	**SWiGO**
4)	Pierre Auger Observatory	**PAO**
5)	Large Latin American Millimiter Array (-1)	**LLAMA**
6)	Giant Radio Array for Neutrino Detection	**GRAND**

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The politic/regional view

1) Cherenkov Telescope Array **CTA**
2) Latin American Giant Observatory **LAGO***
3) Southern Wide-FoV Gamma-Ray Observatory **SWiGO**
4) Pierre Auger Observatory **PAO***
5) Large Latin American Millimiter Array **LLAMA**

All these projects are/will be hosted in Latin America.

6) Giant Radio Array for Neutrino Detection **GRAND** → China + LA? (for sub-arrays)

* already operative

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The politic/regional view

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6) Giant Radio Array for Neutrino Detection **GRAND**

These 3 projects (CTA, PAO, LLAMA) have their **sites** already **selected**:

Argentina (x2)
Chile

* already operative

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The politic/regional view

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6) Giant Radio Array for Neutrino Detection **GRAND**

This is an extended Observatory (**LA network** of detectors) spanning from México to Antarctica Peninsula.

* already operative

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The politic/regional view

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Host country not yet selected, but suitable sites identified (most of them **jointly to other projects**):

Chile (ALMA)
Argentina (LLAMA & QUBIC)
Bolivia (ALPACA)
Perú

* already operative

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The politic/regional view

1st take-home message: to foster our academic community, to strength the LA science & technology capabilities (research-industry link) it is ideal to host large international projects

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The politic/regional view

2nd take-home message: LA region has a strong commit in the Astro3 field & counts with comparative advantages to host large international projects.

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"...doing big science and running large scientific projects, is not a prerogative of developed countries only..."

Freely adapted from N.Ferroni (INFN) at 20th Anniversary of P. Auger Obs.

* already operative

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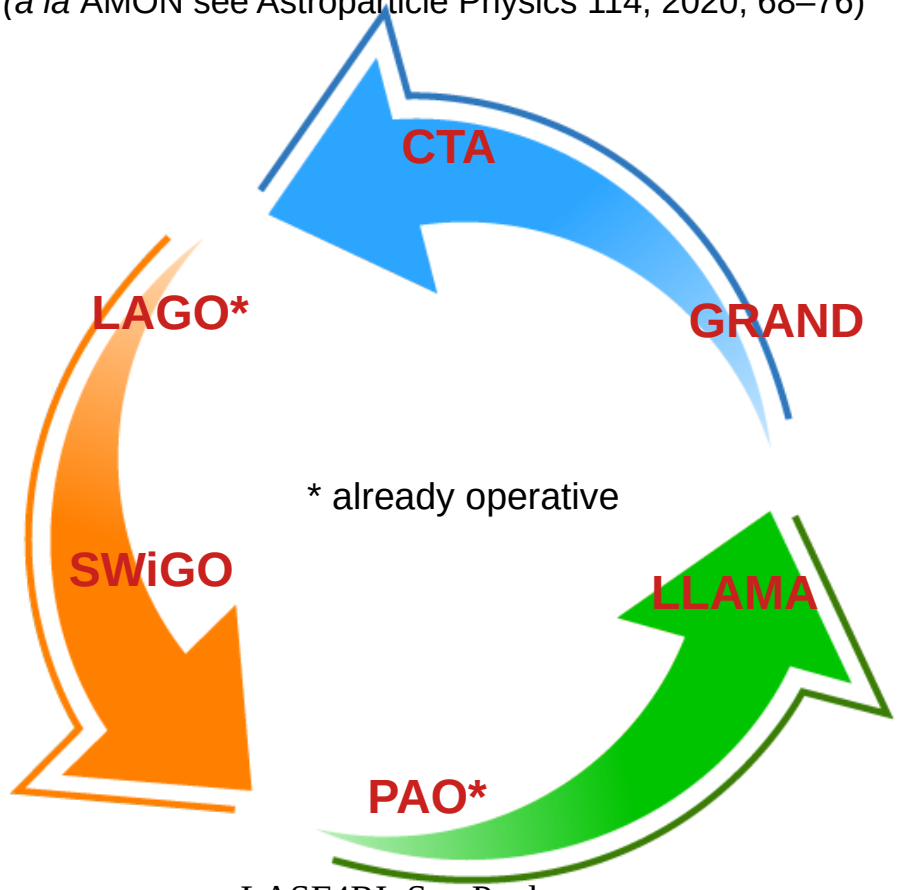
The science view: **Multi-Messenger Era**

triggering/followers Observatories

(*a la* AMON see Astroparticle Physics 114, 2020, 68–76)



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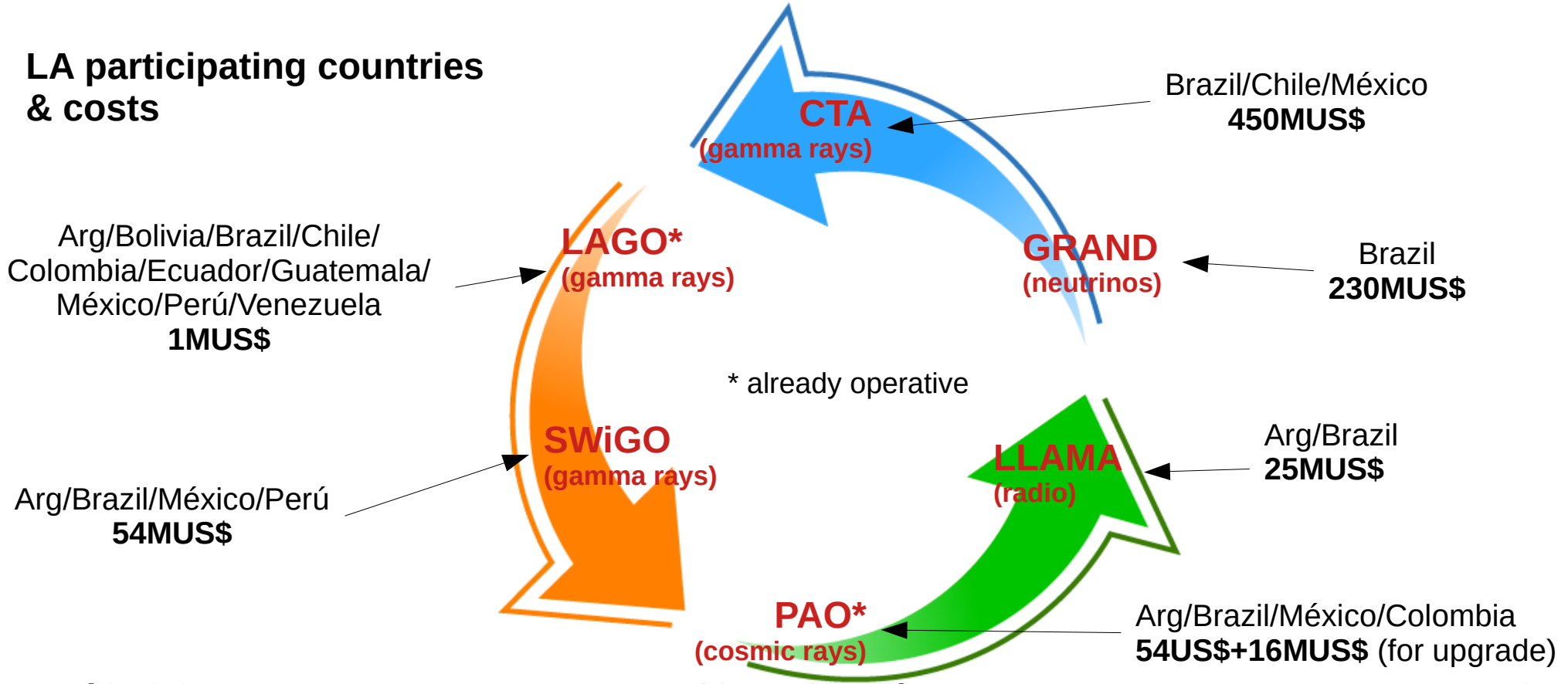
The science & political/regional view ($$$)

LA participating countries & costs



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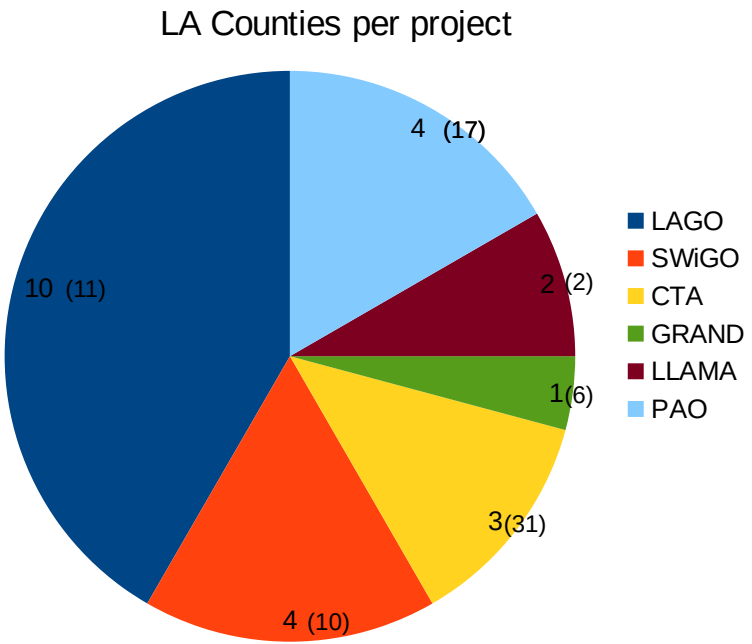
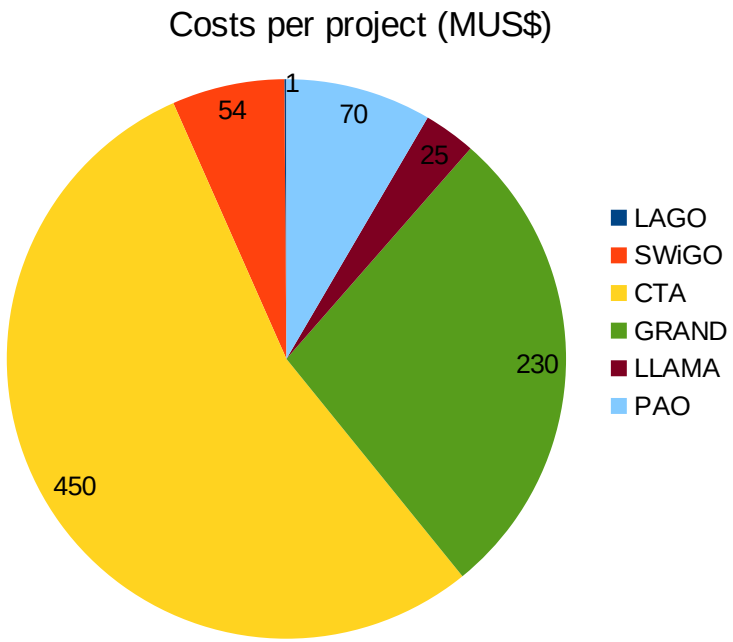
The science & political/regional view ($$$)

Q:Is this picture balanced for regional-hosted projects?

LA participating countries & costs





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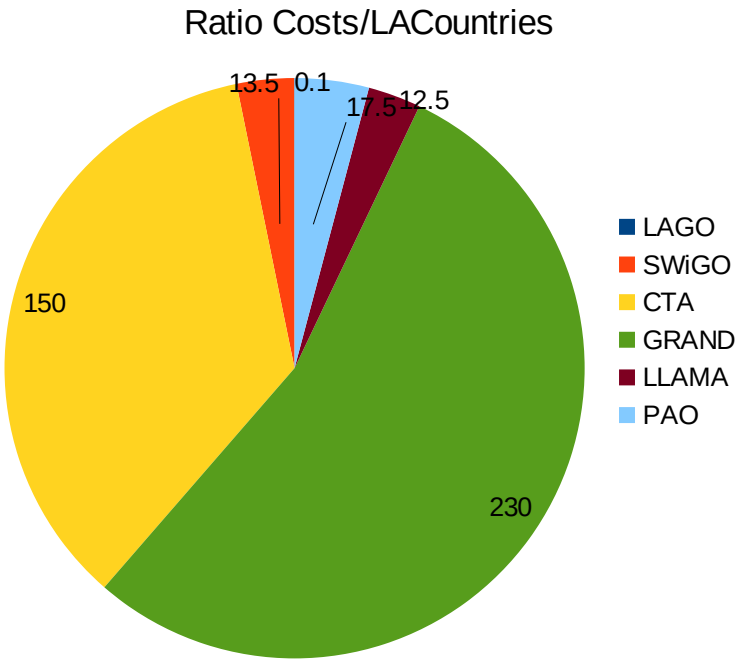
The science & political/regional view ($$$)

Q:Is this picture balanced for regional-hosted projects?
A:Probably is not.

LA participating countries & costs



Educated guess:

Increase Investment (if necessary)

Increase LACountries participation

SWiGO highlights

- Next generation southern observatory dedicated to survey the **Gamma Ray sky** in the energy region within **10 GeV to 100 TeV** (high sensitivity to highest energies).
- **100% duty cycle with 8 sr coverage**
- 4K detectors deployed in 0.08km^2 and 1K detectors deployed in 0.22km^2
- Technology **based on Water-Cherenkov detectors**
- **Site candidates**: Atacama dessert (**Chile**), Cerro Vecar (**Argentina**), Alpaca site & Mt. Chacaltaya (**Bolivia**), Laguna Sibinacocha (**Perú**)
- Collaboration 43 institutes from 10 countries, **Argentina**, Australia, **Brazil**, Germany, Italy, **México**, **Perú**, Portugal, UK, USA
- Total construction costs **54M US$** (timeline **2019 - 2037)**

SWiGO physics goals

- Measure **TeV halos** around nearby **Pulsar Wind Nebulas**
- Identify **sources** of PeV **galactic cosmic rays**
- Measure the **galactic center & Fermi Bubbles morphology**
- Measure the **galactic diffuse emission &** the local **galactic cosmic ray anisotropy**
- Measure **solar cosmic rays interactions**
- Search for **new VHE gamma ray galactic sources & neutrino VHE gamma rays counterparts**
- Detect **AGN flares** and issue alerts & search for periodicity and long term emission in AGNs.
- Search for **counterparts to GW events and nearby bright GRBs**.
- Search for new physics: **dark matter** annihilation and decay, **Lorentz Invariance** violation, **primordial black-holes** or **axion-like particles**

LAGO highlights

- Large observatory network deployed in Latin America
- Technology **based on Water-Cherenkov detectors** (WCD)
- Each site has at least 1 WCD installed covering an area about 10 m^2 to 20 m^2
- **Highest site is Mt. Chacaltaya (~ 5240 m a.s.l.) @ La Paz, Bolivia**
- **Lowest site is (~ 10 m a.s.l.) @ Buenos Aires, Argentina**
- On average each WCD is characterized by very short electric pulses from PMTs (100-300 ns) and data storage rate (~ 240 MHz)
- Collaboration: 29 institutes from 11 countries, **Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guatemala, México, Perú, Venezuela**, Spain
- Estimated overall budget of ~ **1M US$ (**timeline **2005 - 20XX)**

LAGO physics goals

- Search of **GRBs events**.
- Study the flux **modulation of galactic cosmic rays** at different location on Earth
- Study of variation of **secondary particles at detection level**
- Study of the **global magnetic structure cloud** reaching the space environment surrounding the Earth.
- **Space weather** studies.

GRAND highlights

- Very large network of air showers detectors with zenith angles close to 90º to be built in several stages: GRANDProto35, GRANDProto300, GRAND10k, GRAND200k
- Prototype in China but future sub-arrays might be in LA
- Technology **based on Radio-Antennas**
- Angular resolution of a fraction of a degree, and large daily coverage of the sky (>80%)
- Combine **direct and indirect strategies**, by collecting unprecedented UHECR statistics and looking for **UHE gamma rays and neutrinos**
- Collaboration: 8 institutes from 6 countries, **Brazil,** China, France, Germany, Netherlands, USA
- Estimated overall budget of ~ **230M US$* (**timeline **2018 – 203X)** *for GRAND200k

GRAND physics goals

- To solve the long-standing mystery concerning the **origin of the UHECRs**
- To perform **neutrino astronomy, study GZK neutrinos & neutrino physics**
- To probe the high-energy **end of the UHECR spectrum** and the most distant UHECR sources
- To detect **UHE neutrinos and gamma rays**
- To discover UHE neutrino **point sources**
- To probe **millisecond astrophysical transients**: fast radio bursts and giant radio pulses
- To map the sky temperature with mK precision and measure the **global signature of the epoch of reionization and study the Cosmic Dawn**

CTA highlights

- An array of telescopes of three different sizes
- 10x sensitivity than current gamma-ray instrument
- Wider energy coverage (between **20 GeV and 300 TeV**)
- Unprecedented angular and energy resolution, and wide field of view.
- Technology **based on Imaging Atmospheric Cherenkov Telescopes**
- Two sites, one in the Southern (Paranal, Chile) and one in the Northern hemisphere (Canarian Island, Spain)
- Collaboration: 200 institutes from 31 countries, Armenia, Australia, Austria, **Brazil**, Bulgaria, Canada**, Chile**, Croatia, Checz Rep., Finland, France, Germany, Greece, India, Ireland, Italy, Japan, **México**, Namibia, Netherlands, Norway, Poland, Slovenia, S. Africa, Spain, Sweden, Switzerland, Thailand, Ukraine, UK, USA
- Estimated overall budget of ~ **450M US$* (**timeline **2005 – 2025*)** *for CTA construction completion

CTA physics goals

- **Understanding the Origin and Role of Relativistic Cosmic Particles**:
  - What are the sites of high-energy particle acceleration in the universe?
  - What are the mechanisms for cosmic particle acceleration?
  - What role do accelerated particles play in feedback on star formation and galaxy evolution?
- **Probing Extreme Environments**:
  - What physical processes are at work close to neutron stars and black holes?
  - What are the characteristics of relativistic jets, winds and explosions?
  - How intense are radiation fields and magnetic fields in cosmic voids, and how do these evolve over cosmic time?
- **Exploring Frontiers in Physics**:
  - What is the nature of dark matter? How is it distributed?
  - Are there quantum gravitational effects on photon propagation?
  - Do axion-like particles exist?

PAO highlights

- Presently upgrading its detection system (a.k.a. *AugerPrime*) to provide additional composition-sensitive observables
- 3000 km^2 area embedded with detectors of different kinds and different array spacing
- Technology **based on Water-Cherenkov detectors, Flourescence telescopes, Plastic-Scintillation detectors, Radio-Antennas detectors,** and Resistive-Plate Chambers
- Collaboration: 80 institutes from 17 countries, **Argentina**, Australia, Belgium, **Brazil**, **Colombia**, Checz Rep., France, Germany, Italy, **México**, Poland, Portugal, Romania, Slovenia, Spain, Netherlands, USA
- Estimated overall budget of ~ **54M+16M* US$ (**timeline **2015 – 203X)** *for AugerPrime

PAO (new) physics goals

- To elucidate the **mass composition and the origin of the flux suppression** at the highest energies
- The search for a **flux contribution of protons** up to the highest energies (be sensitive up to 10% fraction of p in the suppression region)
- Understanding extensive air showers and **hadronic interactions**
- To probe **the origin** and characteristics of primary **cosmic rays from 10^{17} eV up to 10^{20} eV**

LLAMA highlights

- Telescope with Cassegrain & Nasmyth cabins with a precisely adjusted mechanical structure of 130 tons with **superconductors receivers cooled @ 4K**.
- The Telescope will operate in the **frequency range of 95 to 950 GHz**.
- The Observatory site has 87x154 m^2 in north-western Argentina (Alto de Chorrillos, Salta Province) @ 4800 m a.s.l.
- LLAMA observations conditions are the same of ALMA, APEX and ASTE (Chile)
- Technology **based on Radio Telescope (12m)**
- Collaboration: institutes from 2 countries, **Argentina**, **Brazil**
- Estimated overall budget of ~ **25M US$ (**timeline **2014 – 20XX)**

LLAMA physics goals

- Astrophysics in multiple wavelengths for: **Solar Physics, Cosmology, Galactic Structure, Astrochemistry, Interstellar Medium, Star Formation, Polarization and Magnetism**
- Single Plate Science: Observations of **atomic molecular spectral lines** coming from astronomical objects located in a wide range of distances
- Southern sky **surveys of different molecular lines**
- Very **Long Baseline Interferometry** (VLBI) observations: LLAMA will join VLBI networks
- Observational cosmology: study of the **polarization of Cosmic Microwave Background Radiation** (CMBR) at small angular scale (complement to QUBIC)

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Summary

To foster our academic community, **to strength the LA science & technology capabilities** (research-industry link) it is **ideal to host large international projects**

LA region has a **strong commit in the Astro3 field & counts with comparative advantages** to host large international projects.

The Astro3 field has proven that LA community may conceive, design and run large scientific projects that reinforce the **connection between basic science and technological applications** to favor progress of the region both in research and innovation

It would be desirable to further **increase the participation of LA countries in the Astro3 projects** hosted by the region.

* already operative