The need of space solutions to tackle light pollution and protection of the Chilean Astronomy

Edo Ibar – Universidad de Valparaíso

Space Seminar Chile/USA
Santiago. Chile - Spring 2019

SOCHIAS
sociedad chilena de astronomía

ACHIBE

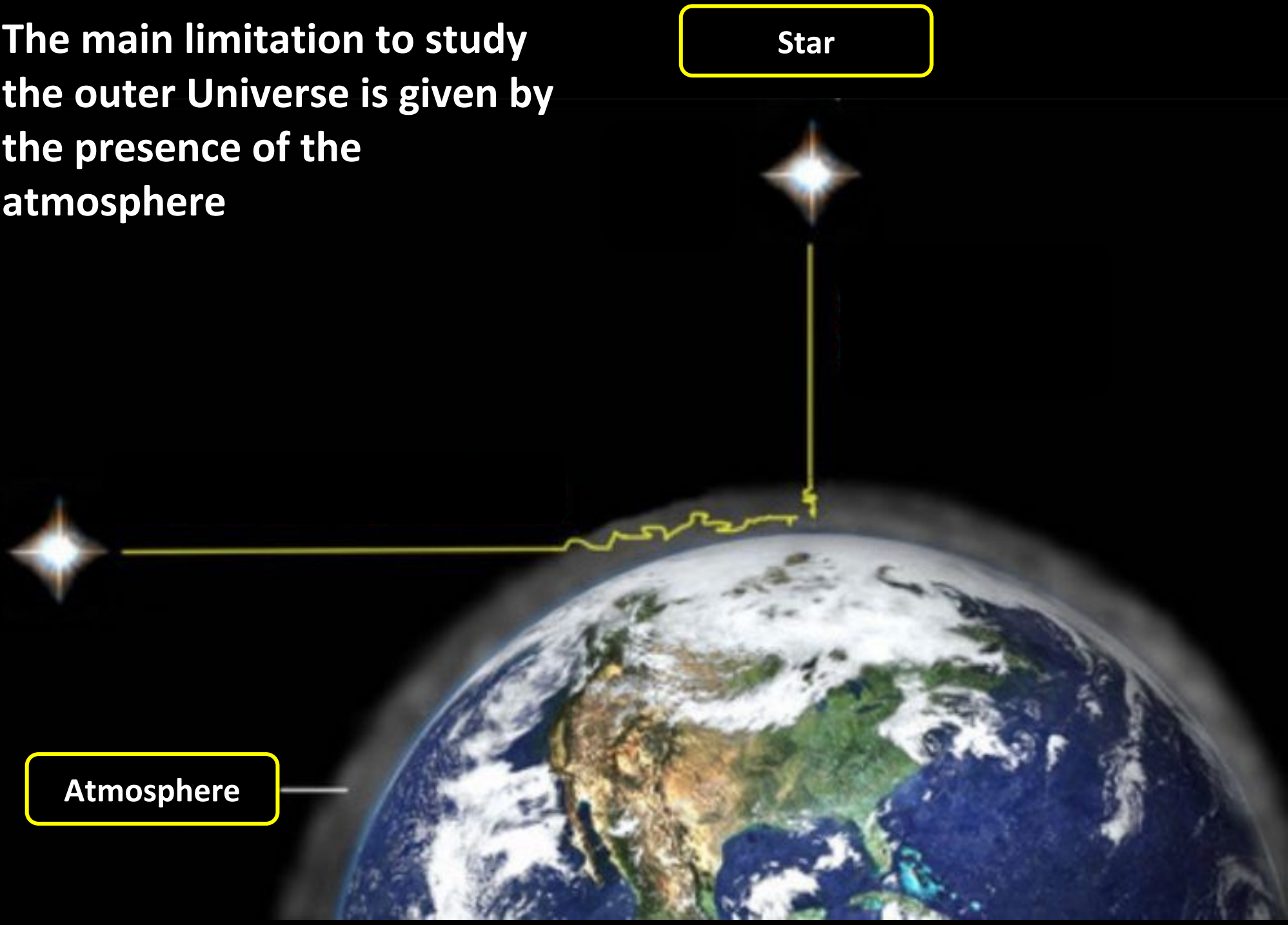
CONICYT
Ministerio de Educación
Gobierno de Chile

FONDECYT
Fondo Nacional de Desarrollo Científico y Tecnológico

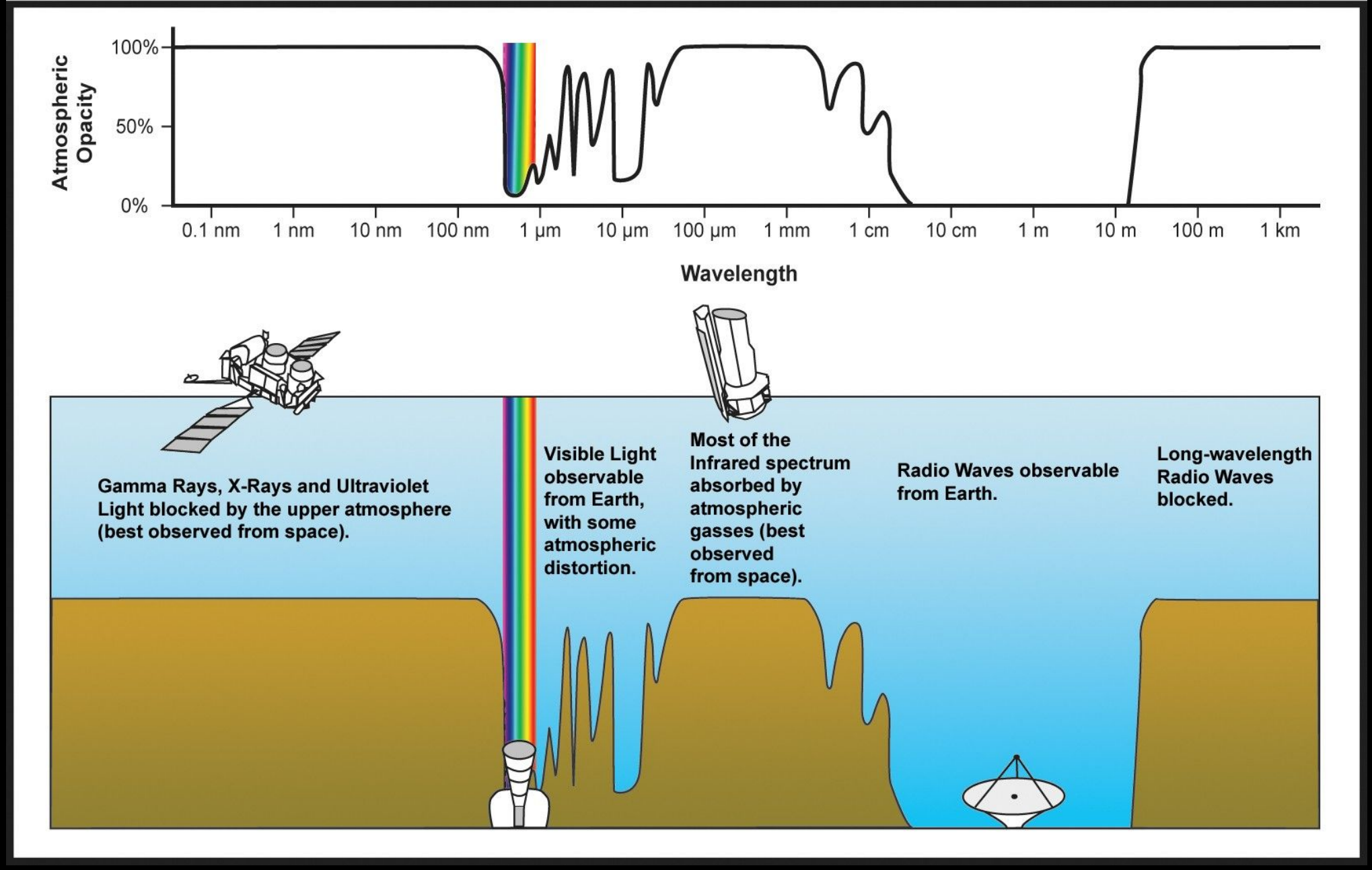
INSTITUTO FISICA Y Astronomia

Universidad de Valparaíso
CHILE

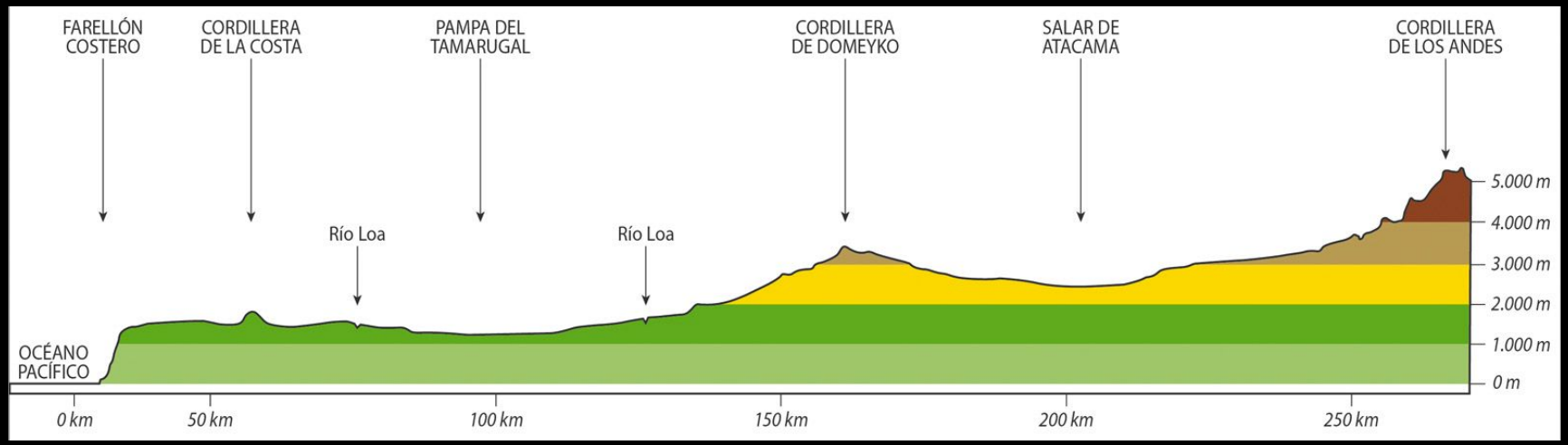
The main limitation to study the outer Universe is given by the presence of the atmosphere



The atmosphere's opacity



Astronomy in Chile



Source IGM Chile

Credits: ESO/J. Girard

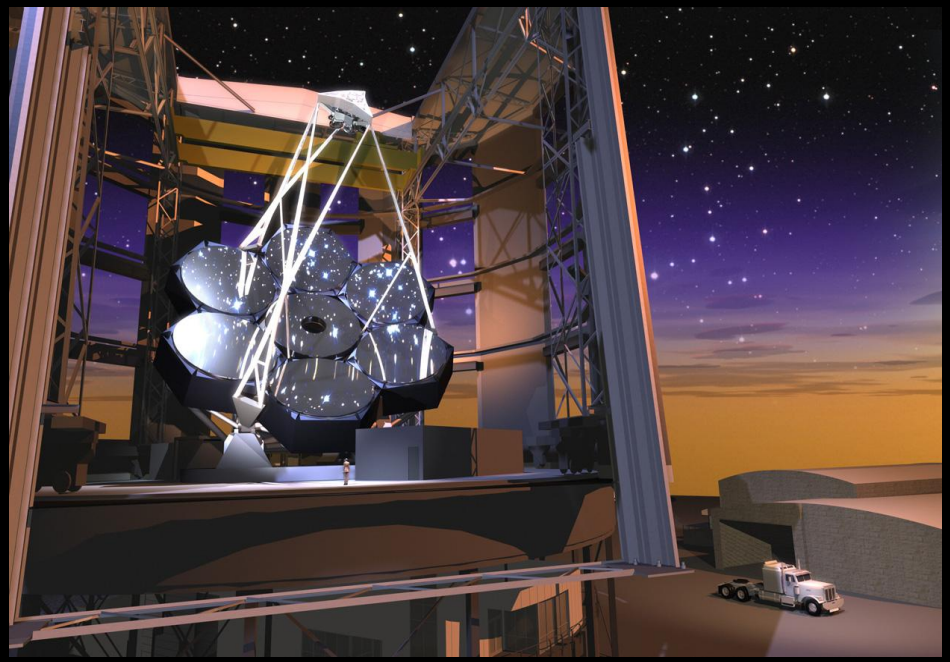
Its uniqueness is given by the:

- **Cold sea (Humboldt current)**
- **High altitude (The Andes)**
- **Dry weather (Atacama Desert)**

Chile is a world-wide leader in optical and submillimetre astronomy

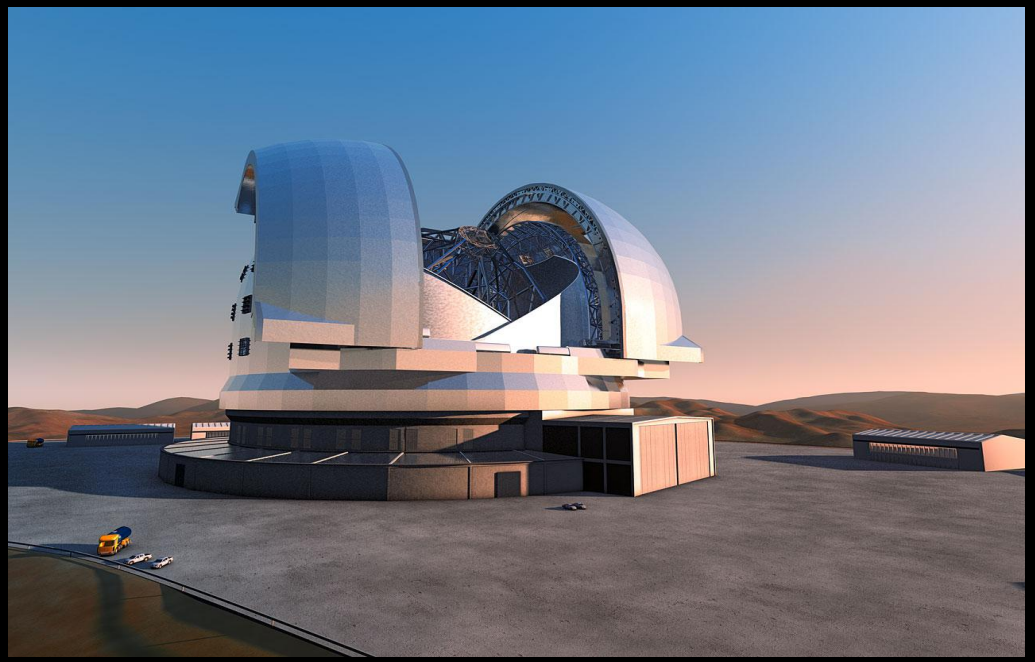
The era of the Giant Telescopes

Giant Magellan Telescope (GMT)



Located at Las Campanas Observatory. Expected to start working on 2022. It is composed of 7 mirrors, 8.4m each, reaching an effective diameter of 24.5m.

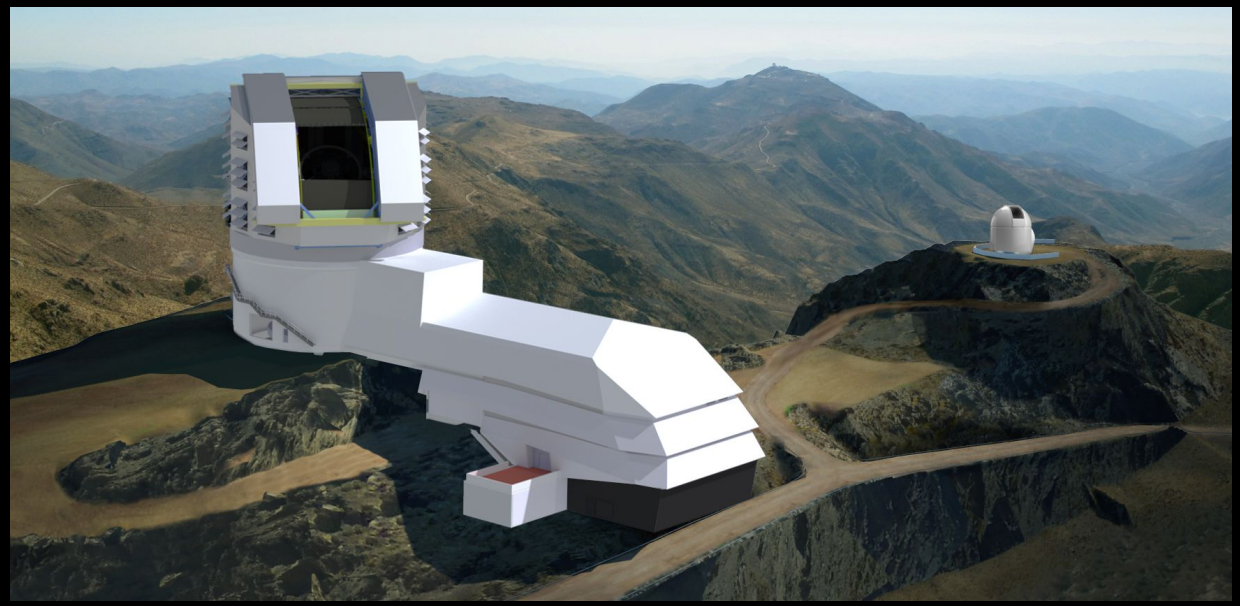
Extremely Large Telescope (ELT)



Located at Cerro Armazones, Chile. Expected to start observing on 2024. It is composed of 798 hexagons of 1.4m each, reaching an effective diameter of 39m.

The era of the Big Data

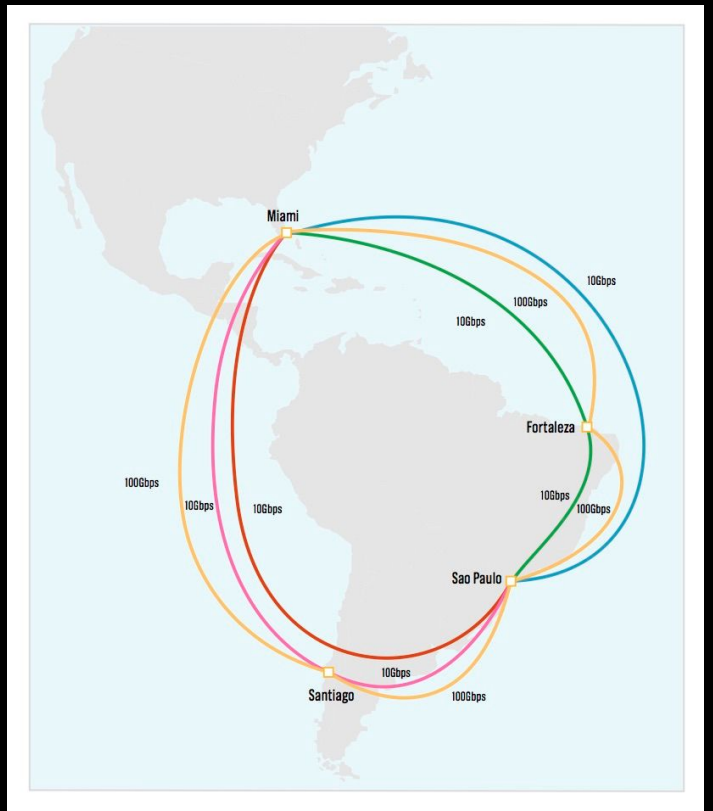
Large Synoptic Survey Telescope (LSST)



A 8.4m diameter telescope designed to map the entire sky every three days for over 10 years. Expected to start science operations on 2023. It will delivery 20 terabytes of raw-data per night, producing a total of 500 petabyte set of images and data products.

Ring of Fiber Connectivity

This network will permit LSST data to travel in seconds from Cerro Pachón to the LSST Data Facility at NCSA where it will be processed into scientific data products including real-time alerts of transient events



Large Synoptic Survey Telescope (LSST)

The main science themes that drive the LSST design are:

- Tackle the nature of the Dark Matter and Understanding of the Dark Energy
  - Cataloguing the mass of galaxies and characterise their distortion of space time

- Structure and formation of the Milky Way
  - Hundreds of observations of each surveyed area of sky
  - Final survey will yield a map over 1000 times the volume of past surveys
  - Billions of new identified stars

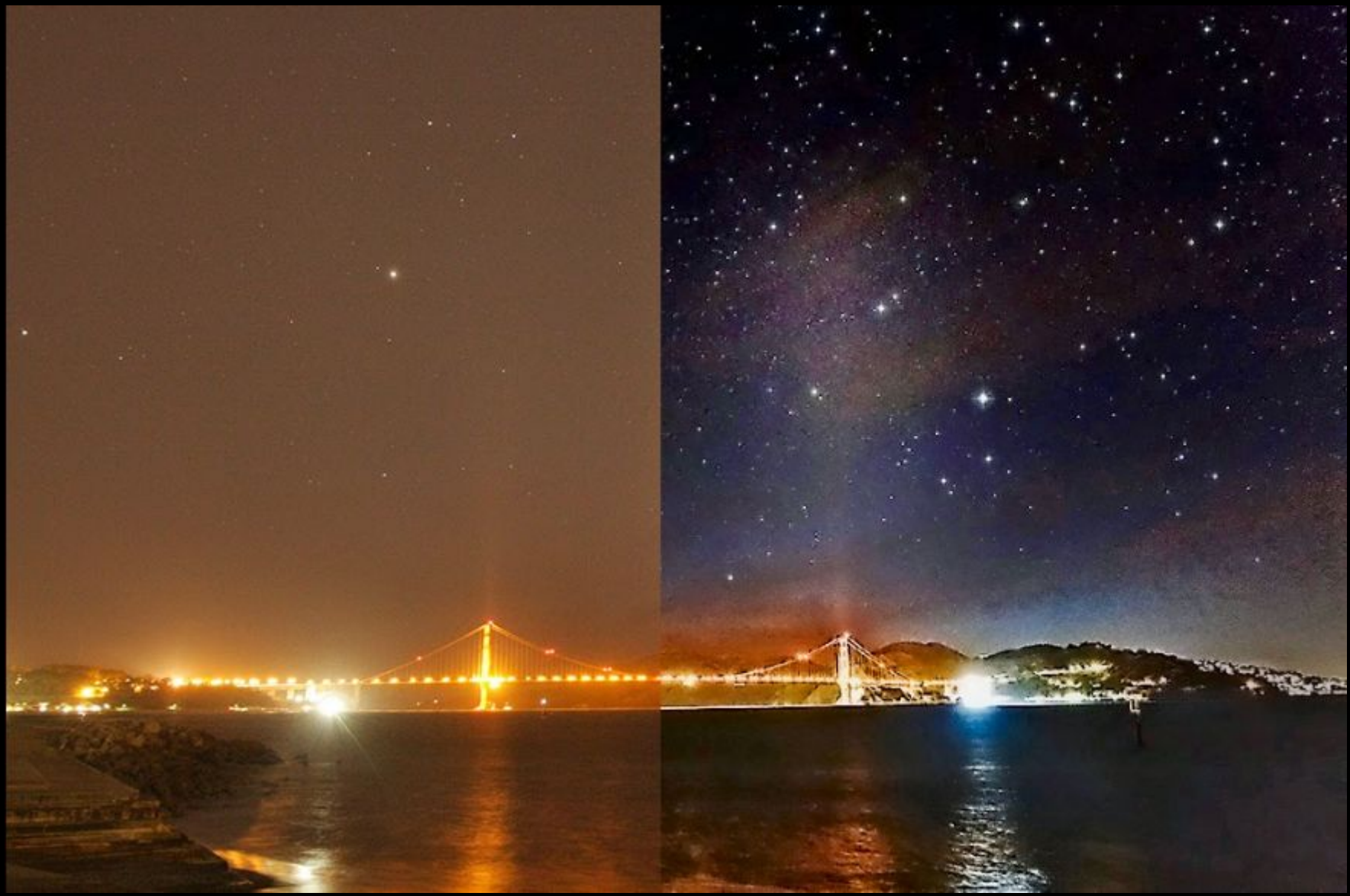
- Identification of Solar System objects
  - Orbit, color and variability information for several million moving objects
  - Near-Earth Objects (NEOs) as small as 140m in diameter as far as Main Belt asteroids
  - Something between 60-90% of all potentially hazardous asteroids larger than 140m

- Exploration of the Changing Sky
  - Variable stars and cosmic explosions
  - Transient events within a minute in the sky
    (LSST will generate an alert for the community to respond and catch events before they fade away forever)

There is no doubt that Chile is the worldwide capital for astronomy.
On 2025, Chile will harbor ~60-70% of the whole optical and near-IR astronomical infrastructure of the entire World
(investments of the order of ~7,000 million USD in total)

There are, however, some main threats for this astronomical development

The Light Pollution from the ground



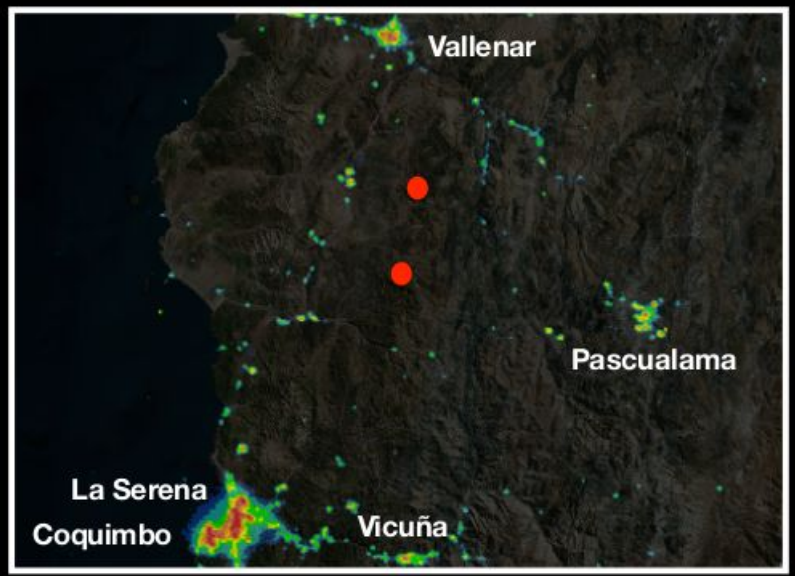
The Light Pollution from the ground

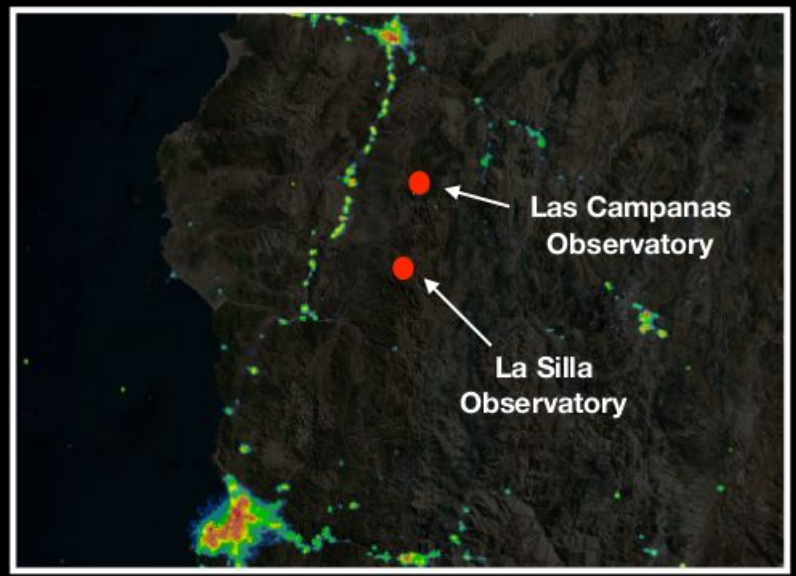
The most efficient way to monitor the night light pollution is by monitor it from space.

Today, the main remote sensing platform is the Visible Infrared Imaging Radiometer Suite Day-Night Band (VIIRS-DNB) abroad the *Suomi* NPP satellite

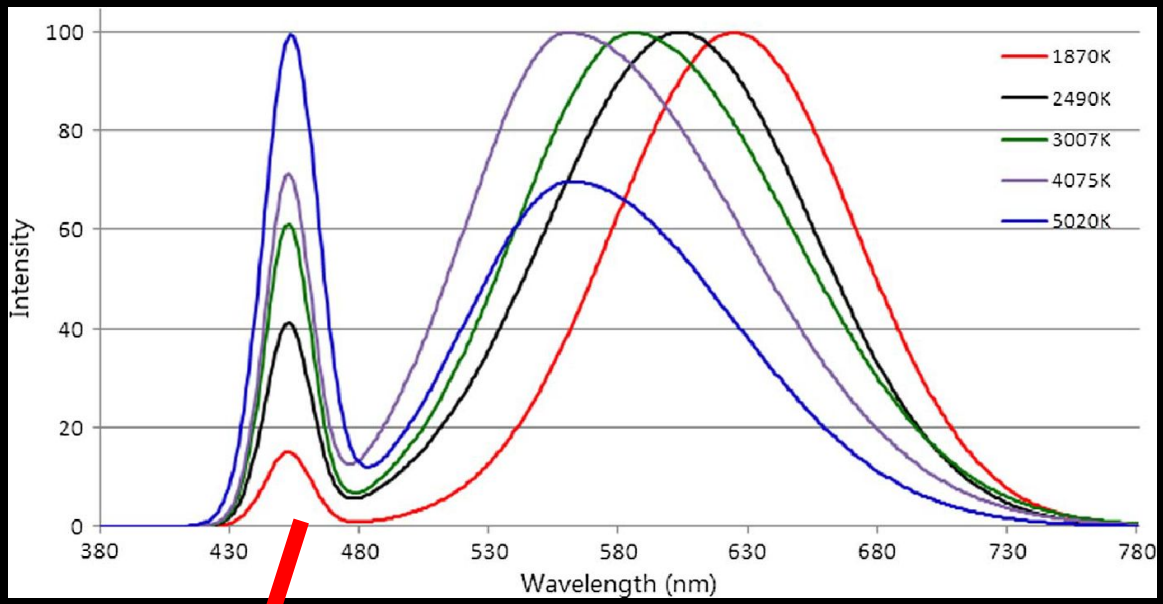
"The Milky Way is hidden from more than one-third of humanity"

2014 Falchi et al. (2016) 2016

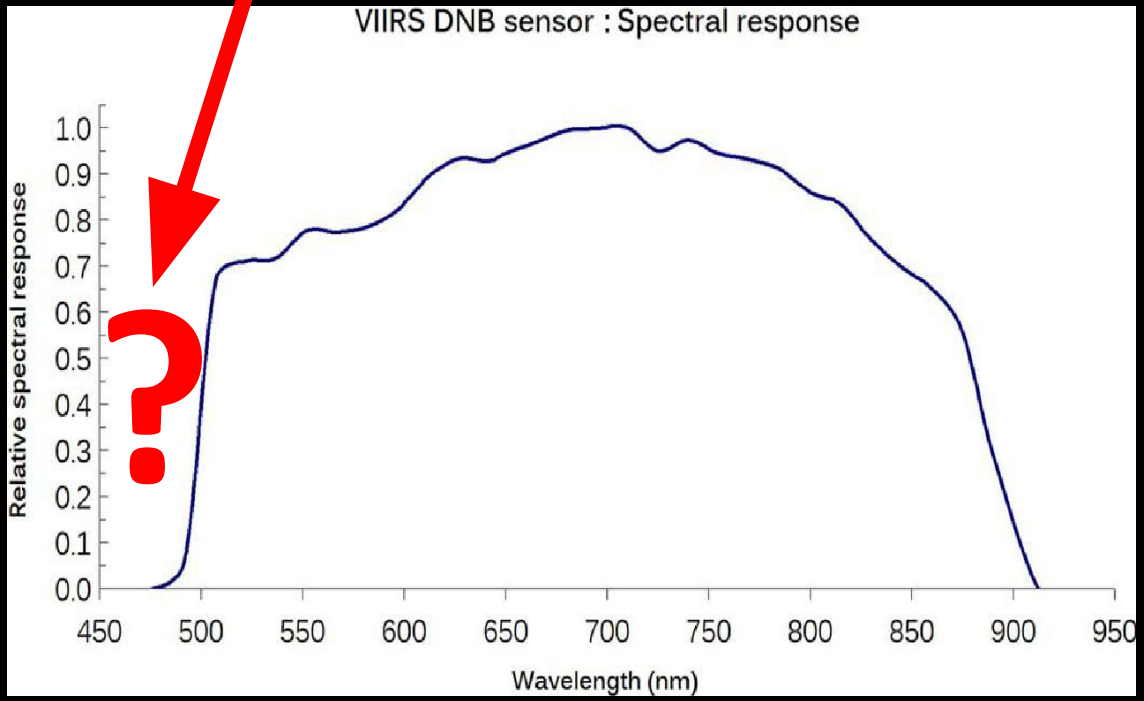




The Light Pollution from the ground



LED's spectra at different colour temperature



Falchi et al. (2016)

The new market dominance of white light emitting diodes (LEDs) is a key responsible for the light pollution around astronomical observatories.

The blue light is more prone to scattering than the red light.

Astronomy needs protection and surveillance from space but most importantly in the blue part of the spectrum, which is invisible to VIIRS-DNB

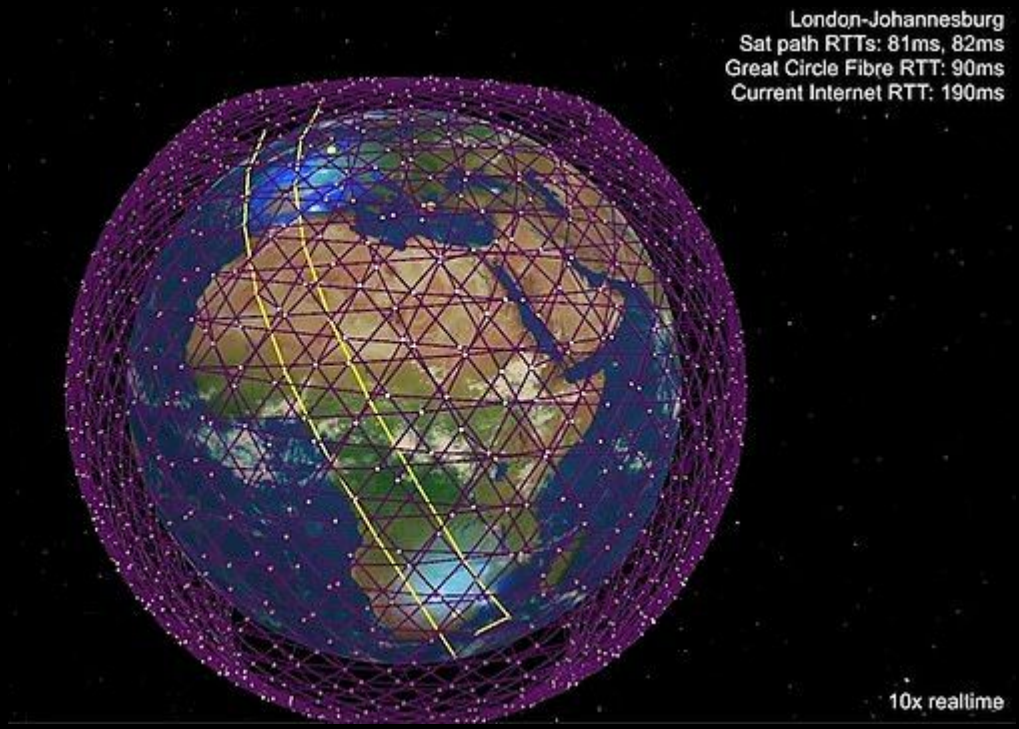
We have a network of Chilean Universities looking for funding to build and launch a camera to protect the Chilean dark night sky

The Light Pollution from Space

The launch of Starlink's satellites on May 2019 mark a before and after date in terms of sky light pollution

SpaceX Starlink, Amazon Kuiper, OneWeb, and other companies are pushing forward large numbers of small satellites

Definitely a good idea to provide internet to the whole World, but **PLEASE DO NOT FORGET THE ASTRONOMICAL RESEARCH**



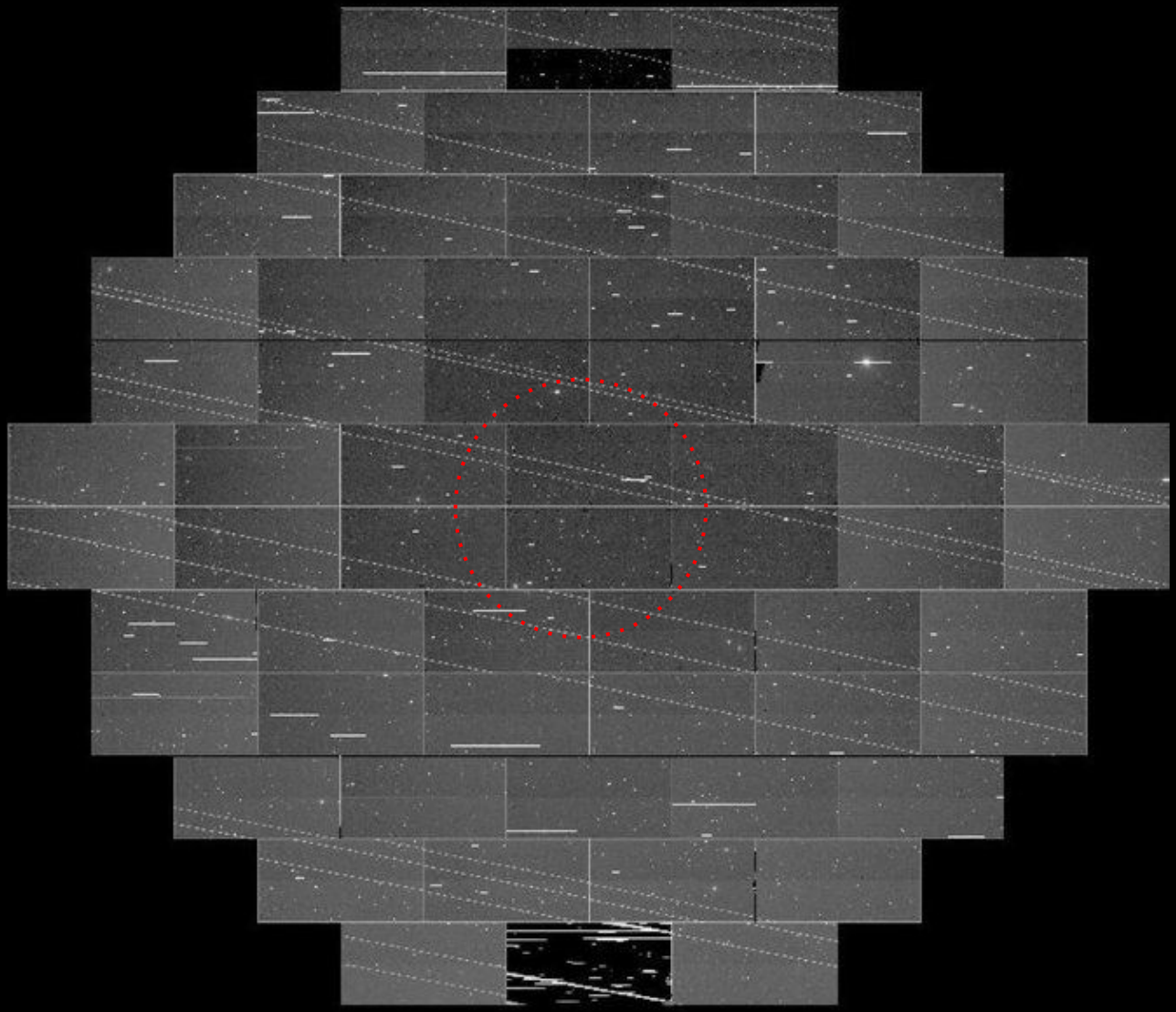
The aluminium's reflectance from low-orbit satellites is high, and could seriously damage the possibility to identify new faint and/or transient objects in the sky.

These sort of projects could potentially create a serious damage to the astronomical research, in particular that driven by LSST.

The large number of small satellites can potentially create dangerous space debris. **There are currently over 18,000 >10 cm objects with well determined orbits (<10% are active).**

The Light Pollution from Space

DECam: 62, 2048x4096 pixel red-sensitive science CCDs



Starlink satellites trail across images from DECam. Cliff Johnson, Clara Martínez-Vázquez, DELVE Survey

This image was taken from Cerro Tololo on 11 November 2019.

Cerro Tololo is just 20 km Northwest from LSST

The trails are produced by 19 (of the 60) new SpaceX Starlink satellites which were put into orbit on Nov.

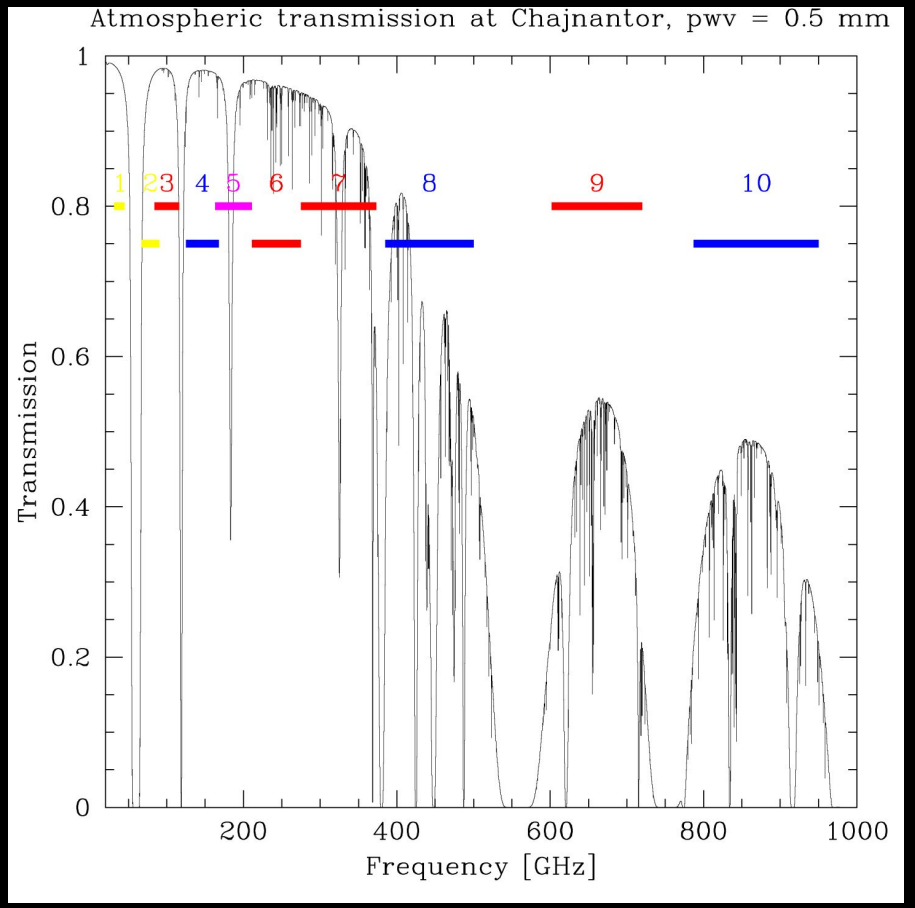
An effective collaboration between these space projects, and the astronomical community is mandatory to find ways to mitigate the impact on scientific research

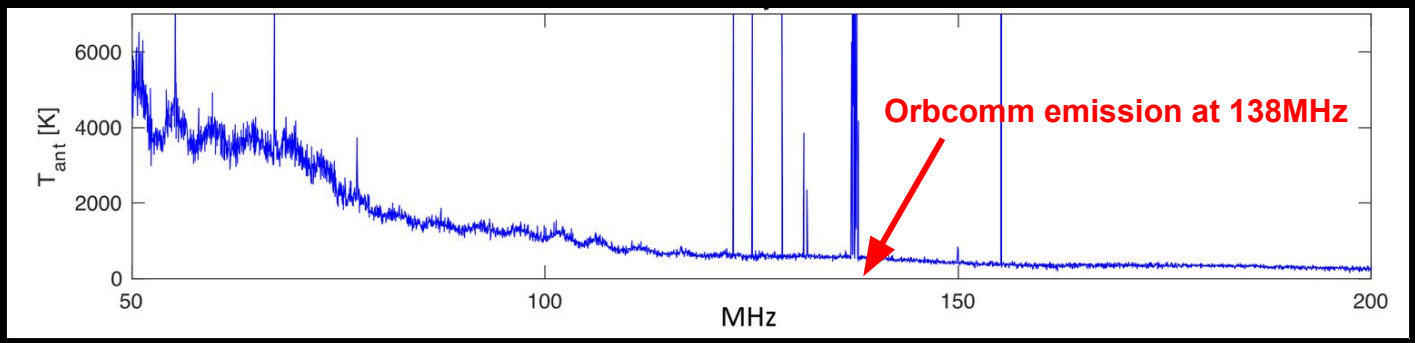
The Light Pollution from Space

Also Radio Astronomy is affected due satellite communications.

For example, ALMA Band 1 observations at 30-45 GHz could be seriously affected by noise if satellites start including 37.5-42.0 GHz and 47.2-50.3GHz for communications.

At lower frequencies, the Very Large Array (VLA) is already suffering from very strong interference, which could reach peaks of 1,000,000 Jy (specially at 10-15 GHz). We as astronomers are interested in detecting signals at micro-Jy levels!

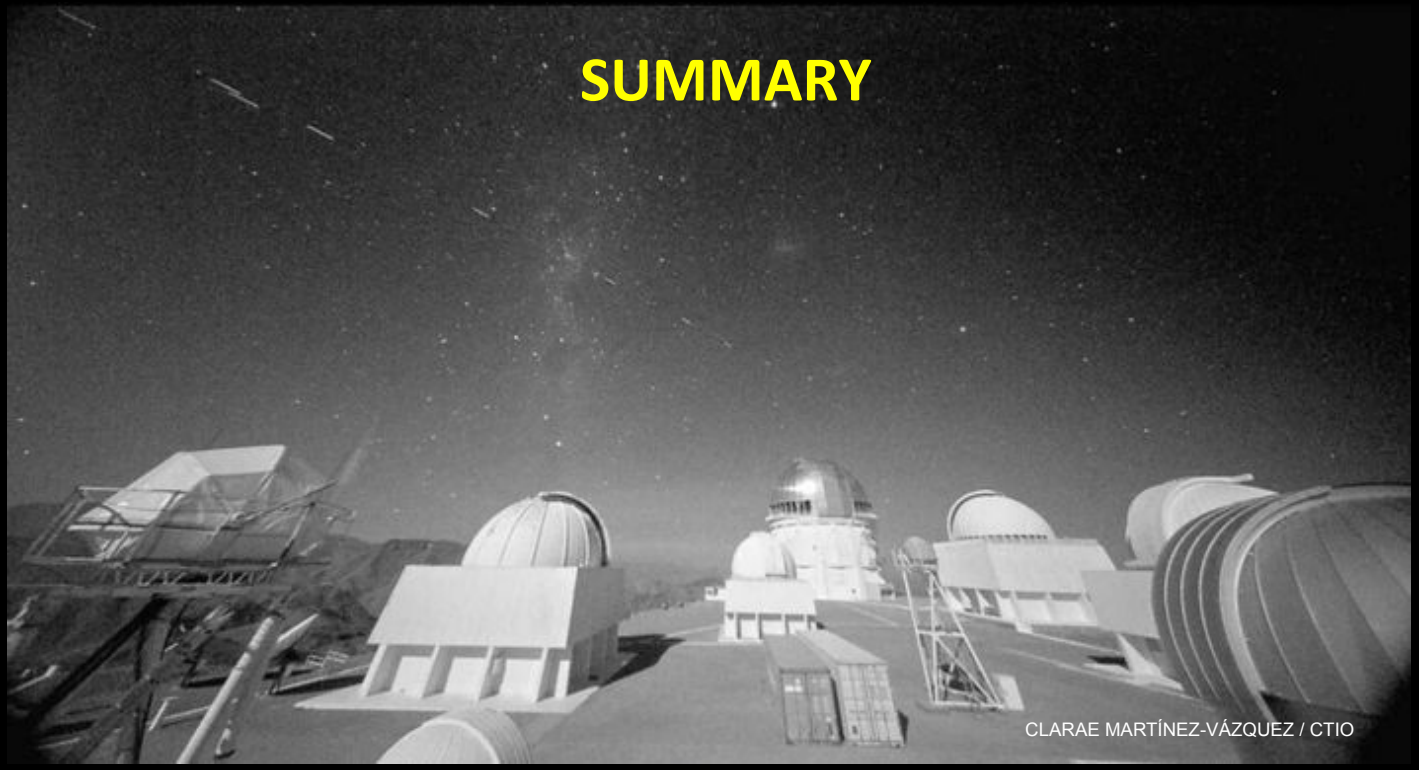




Bustos et al. (in prep)

In northern Chile, the MARI project plans for detecting signals from the cosmic reionisation epoch

SUMMARY



We have a chilean **network of universities looking for funding for developing small satellites** to monitorlight pollution to protect the Chilean dark night skies.

Spacecraft builders and operators, **PLEASE minimize the reflectivity of new satellites**, and try to make designs to **minimize glints or flares which could be interpreted as rapid transient events** in LSST-like data systems.

PLEASE **provide the most accurate and precise orbits possible of satellites** so these can be used to schedule astronomical observations.

We need an **international policy** to manage and regulate the brightness of new satellite constellations, and also protect radio frequencies for astronomical research.