

# **MezzoCielo**

## **a novel ultra-wide field telescope for all-sky transient phenomena**

Demetrio Magrin

(demetrio.magrin@inaf.it)

INAF – Osservatorio Astronomico di Padova

on behalf of a bunch of people (project supporters)

# Introduction

Traditional astronomical surveys typically rely on one, or a small number of, individual telescope and detector systems that scan the sky sequentially: exposure times are fixed, and sky coverage increases over time as different sky regions are tiled. Such an approach is not optimal for the efficient discovery and characterization of transient and rapidly variable objects.

Our aim is to adopt a fundamentally different strategy. The **sky coverage is fixed**, encompassing the **entire visible sky** in the full implementation, while **sensitivity improves progressively through the stacking of repeated exposures**. This approach is particularly well suited for the **detection and monitoring of transient phenomena**, as it enables **observation cadence and sensitivity limits to be tailored on an object-by-object basis, according to source brightness and characteristic variability timescales**.

We are not alone of course...

# Similar Projects

**BlackGEM:** it is a wide-field array of optical telescopes to be located at ESO's La Silla Observatory.

- **3 telescopes x 0.65m** diameter (15 telescope planned)
- Instantaneous FoV: **8 degrees<sup>2</sup>** (40 degrees<sup>2</sup> planned)
- **Seeing-limited (0.33 Gpixel images)**
- Robotic wide-field array

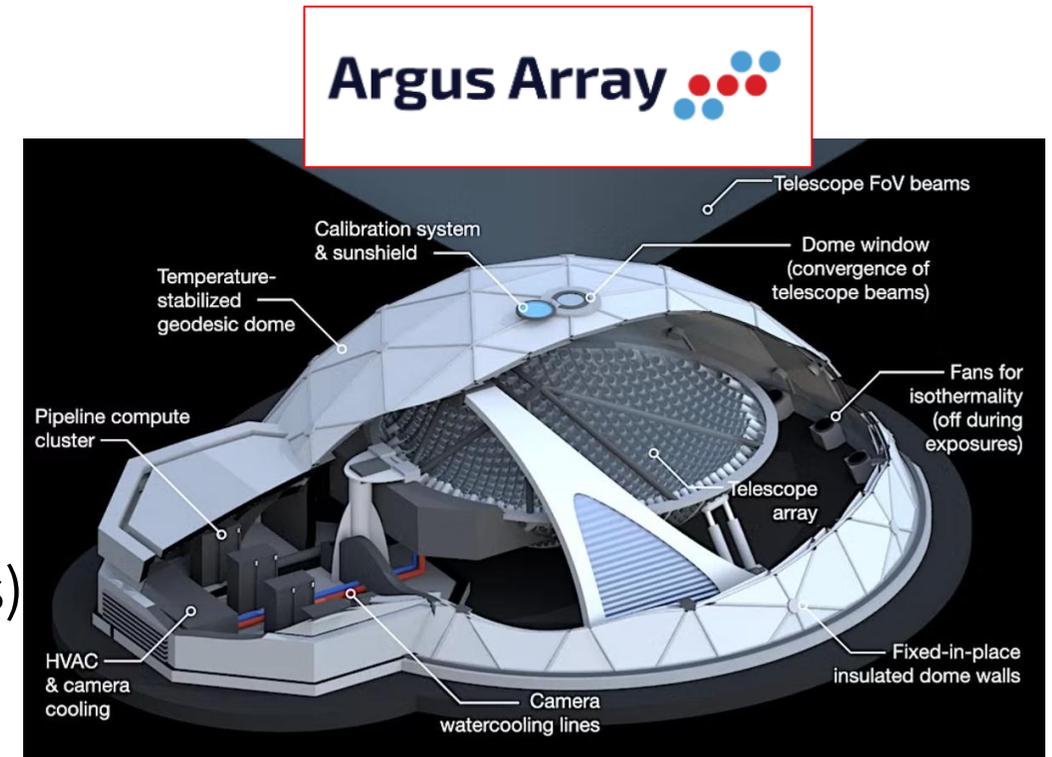
The array is largely robotic and remotely controlled from Radboud University, the Netherlands. It was jointly developed by Radboud University, the Netherlands Research School for Astronomy (NOVA), and the KU Leuven, Belgium.



# Similar Projects

**ARGUS ARRAY:** Argus is under construction at a Northern Hemisphere site and planned to be completed in **2027** by University North Carolina Chapel Hill.

- **1200 telescopes x 0.28m diameter**
- Instantaneous FoV: **8000 degrees<sup>2</sup>**
- 1 arcsec/pixel, 2 arcsec FWHM (**120 Gpixel images**)
- Strategy: many small telescopes for full-sky coverage



# Similar Projects

**ARGUS ARRAY:** Argus Northern Hemisphere completed in **2027** by Chapel Hill.

- **1200 telescopes x 0.5m**
- Instantaneous FoV: **1000x**
- 1 arcsec/pixel, 2 arcsec/pixel
- Strategy: many small telescopes for wide coverage

## L'ex CEO di Google finanzierà quattro nuovi osservatori astronomici, lo Schmidt Observatory System

di Mariasole Maglione — Gennaio 8, 2026 in Astronomia e astrofisica, News, Scienza

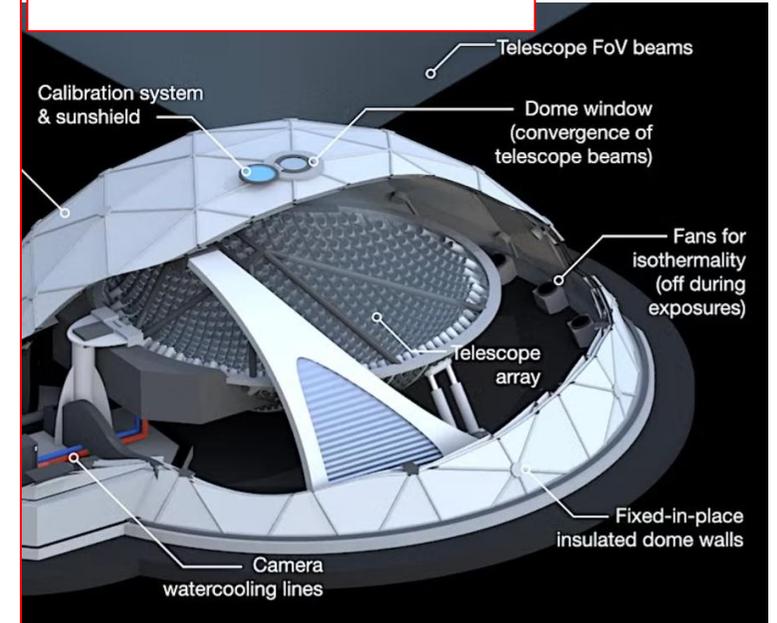


I quattro osservatori parte dello Schmidt Observatory System. In alto: il Deep Synoptic Array e il Lazuli Space Observatory. In basso: il Large Fiber Array Spectroscopic Telescope e l'Argus Array. Credits: Schmidt Observatory System



Eric Schmidt, ex CEO di Google e attuale CEO di Relativity Space, e la moglie Wendy Schmidt, fondatori dell'organizzazione filantropica Schmidt Sciences, hanno annunciato il 7 gennaio 2026 il finanziamento di **quattro nuovi osservatori per lo studio dell'Universo**.

Questi strumenti hanno l'obiettivo di completare e ampliare le capacità scientifiche esistenti entro la fine del decennio, attraverso approcci diversi: un telescopio spaziale da 3 metri di diametro chiamato Lazuli, e tre osservatori terrestri con concept innovativi nei settori dell'osservazione ottica e della radioastronomia.

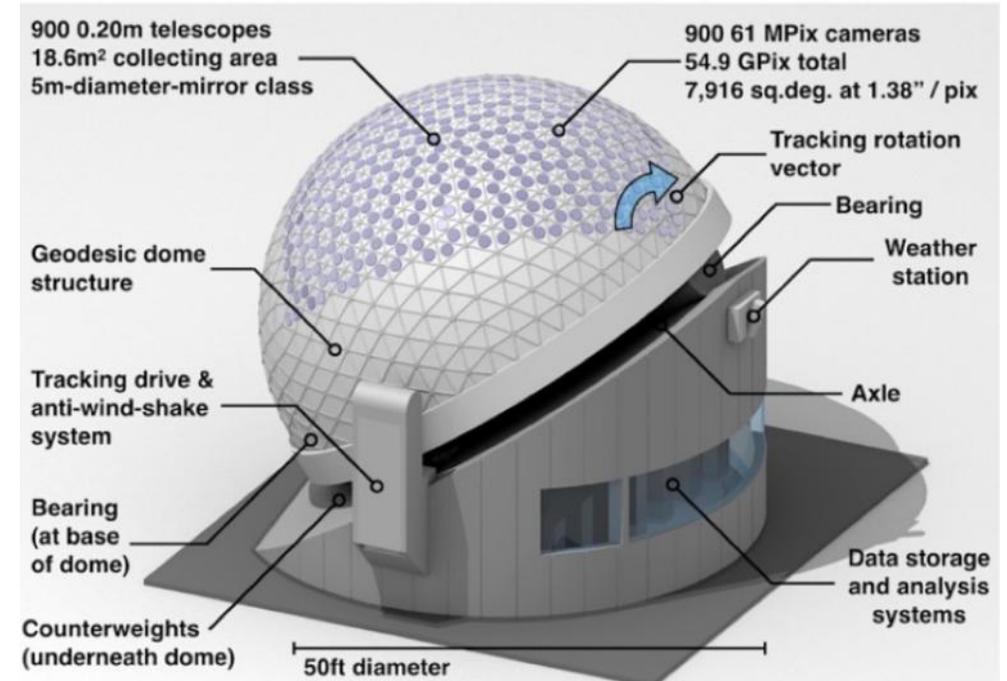


Rumors say about 50 M\$

# Similar Projects

**The Digital Telescope:** it is a full sky survey project lead by University of Warwick (UK).

- **825 telescopes x 0.20m** diameter
- Instantaneous FoV ~ **14500 degrees<sup>2</sup>** instantaneous FoV
- 1.38 arcsec/pixel (~**100 Gpixel** images)
- Strategy: continuous all-sky movie



# Similar Projects

**The Digital**  
lead by Univ



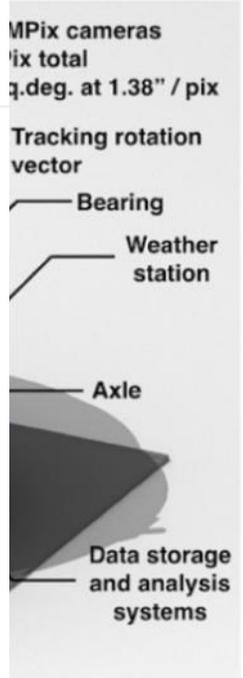
## Digital telescope project awarded £3m

An astronomy project has been awarded £3m to develop a telescope with the aim of detecting the explosions of stars and merging of black holes in real time.

Led by Prof Don Pollacco at the University of Warwick, the team will build the digital device, which will be fed by dozens of smaller telescopes.

It is hoped the project will create a highly sensitive continuous movie of the night sky.

Prof Pollacco described the telescope's potential as "transformational".



- 825 teles
- Instantan
- FoV
- 1.38 arcs
- Strategy:

# Similar Projects

**The SiTian Project** (“Observing the Sky”): it is an ambitious ground-based, all-sky optical monitoring initiative developed by the Chinese Academy of Sciences.

- **72 telescopes x 1.00m** diameter
- **24 units**, each with **3 co-pointed telescopes**
- Instantaneous FoV: **~600 degrees<sup>2</sup>** (per-unit FoV: **25 degrees<sup>2</sup>** ), about **~0.4 Gpixel** images
- Survey speed: **≥ 10,000 degrees<sup>2</sup> every 30 min**
- Approach: fewer, larger apertures for higher sensitivity
- Status: full deployment planned by ~2030, operations ~2032

A reduced **pathfinder** version of the system, consisting of three 30-cm telescopes, has been operational since November 2022 at the Xinglong Observatory. This facility is being used to test the software infrastructure and observational strategies planned for the full SiTian system.

# Why a new telescope configuration?

Driven by economic and complexity considerations, two main strategies emerge. Some projects deploy a very large number of small-aperture telescopes to maximize sky coverage, while others adopt fewer, larger-aperture telescopes to achieve higher sensitivity at the expense of coverage.

MezzoCielo aims to combine the advantages of both approaches, providing large sky coverage together with a substantial collecting area, within a scalable and sustainable system cost.

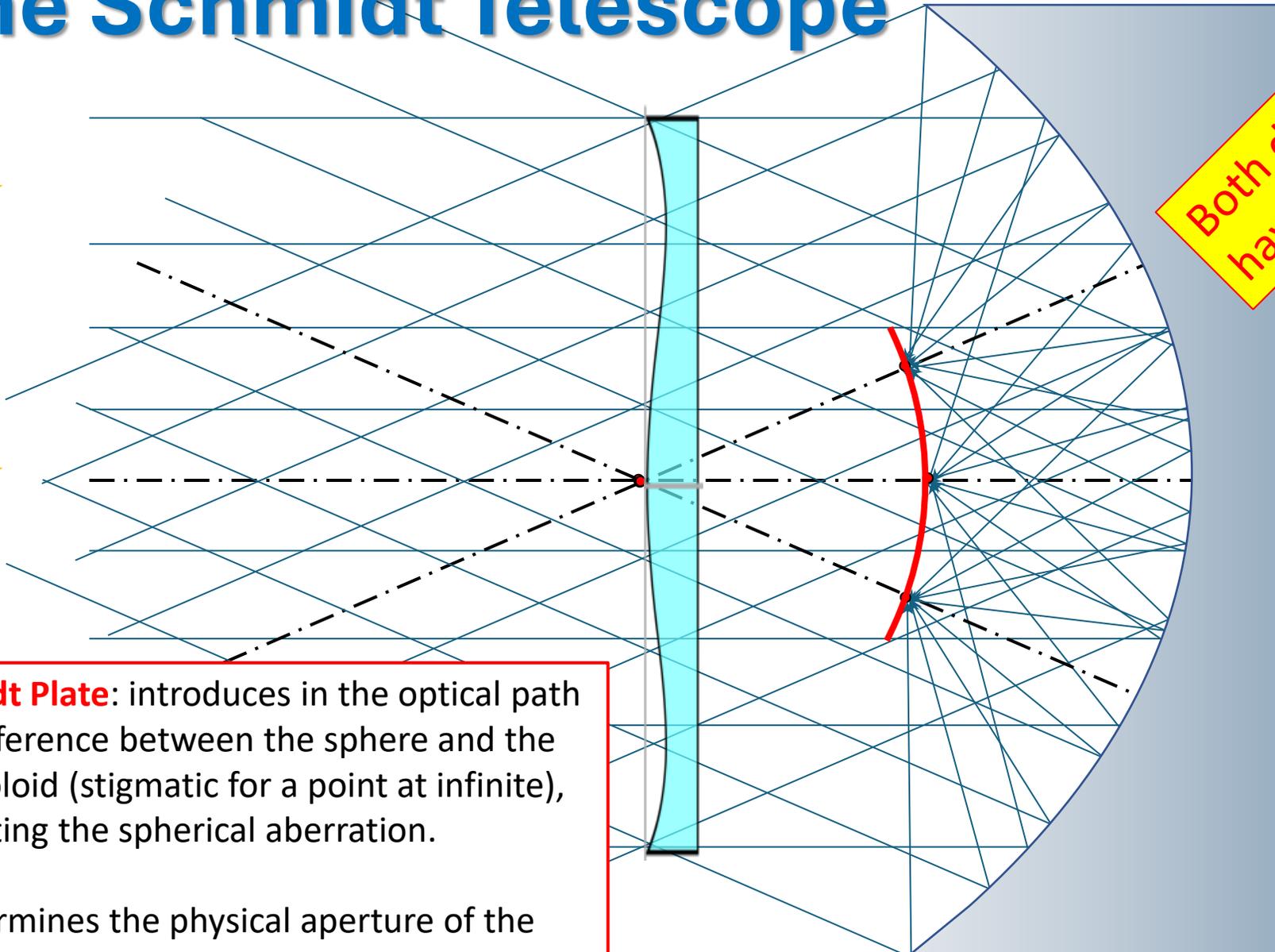


Bernard Schmidt

Once upon a time...

... about 100 years ago

# The Schmidt Telescope



**Schmidt Plate:** introduces in the optical path the difference between the sphere and the paraboloid (stigmatic for a point at infinite), correcting the spherical aberration.

It determines the physical aperture of the telescope, i.e., the collecting area.

Both designed to have  $\sim 5^\circ \times 5^\circ$  FoV

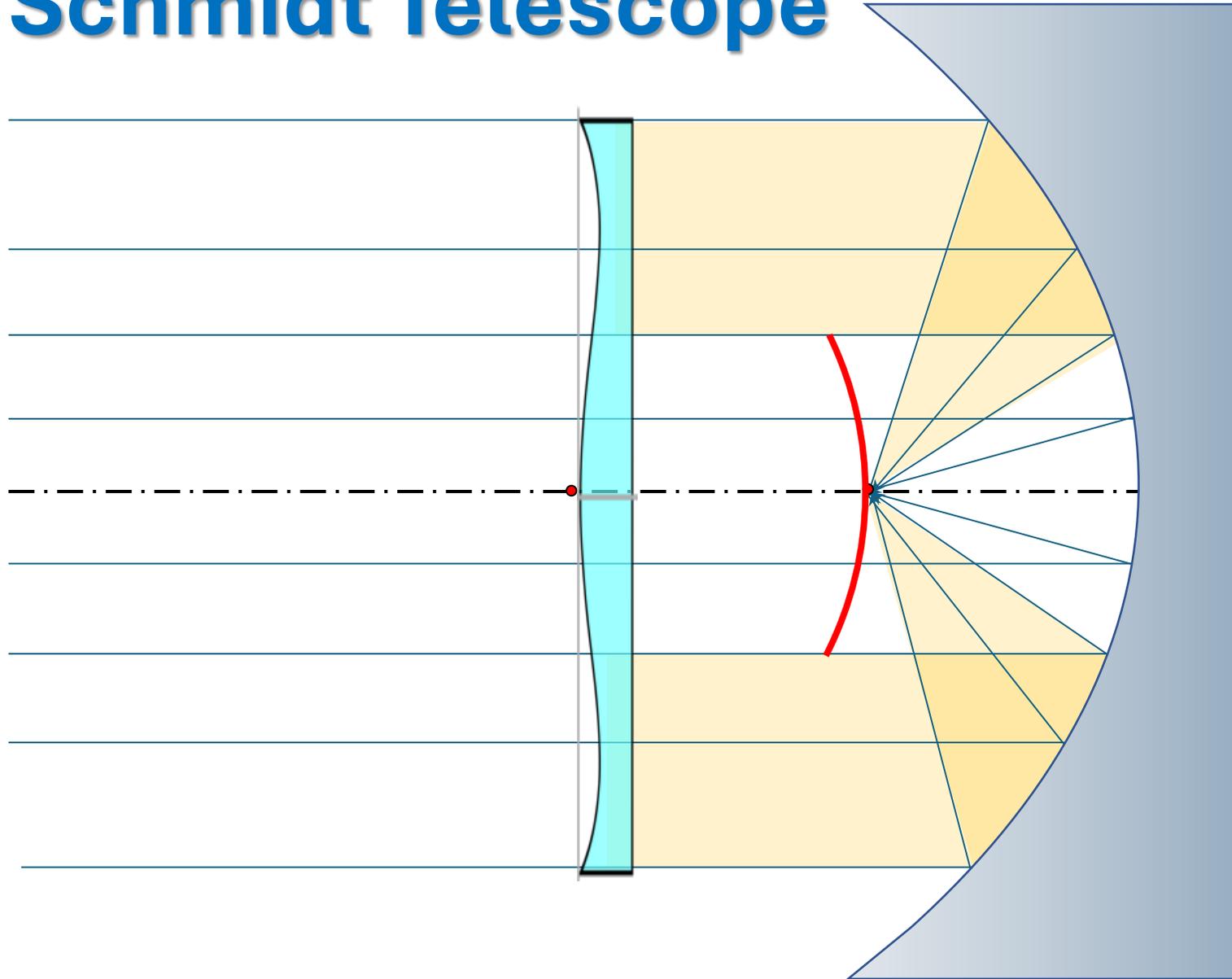


Palomar 122cm /182cm



Asiago 67cm /92cm

# The Schmidt Telescope



- 😊 Large corrected FoV
- 😞 Central obstruction increases with the FoV, i.e., less efficiency
- 😞 Spherical aberration correction is less and less effective as FoV increases because of Schmidt Plate view factor

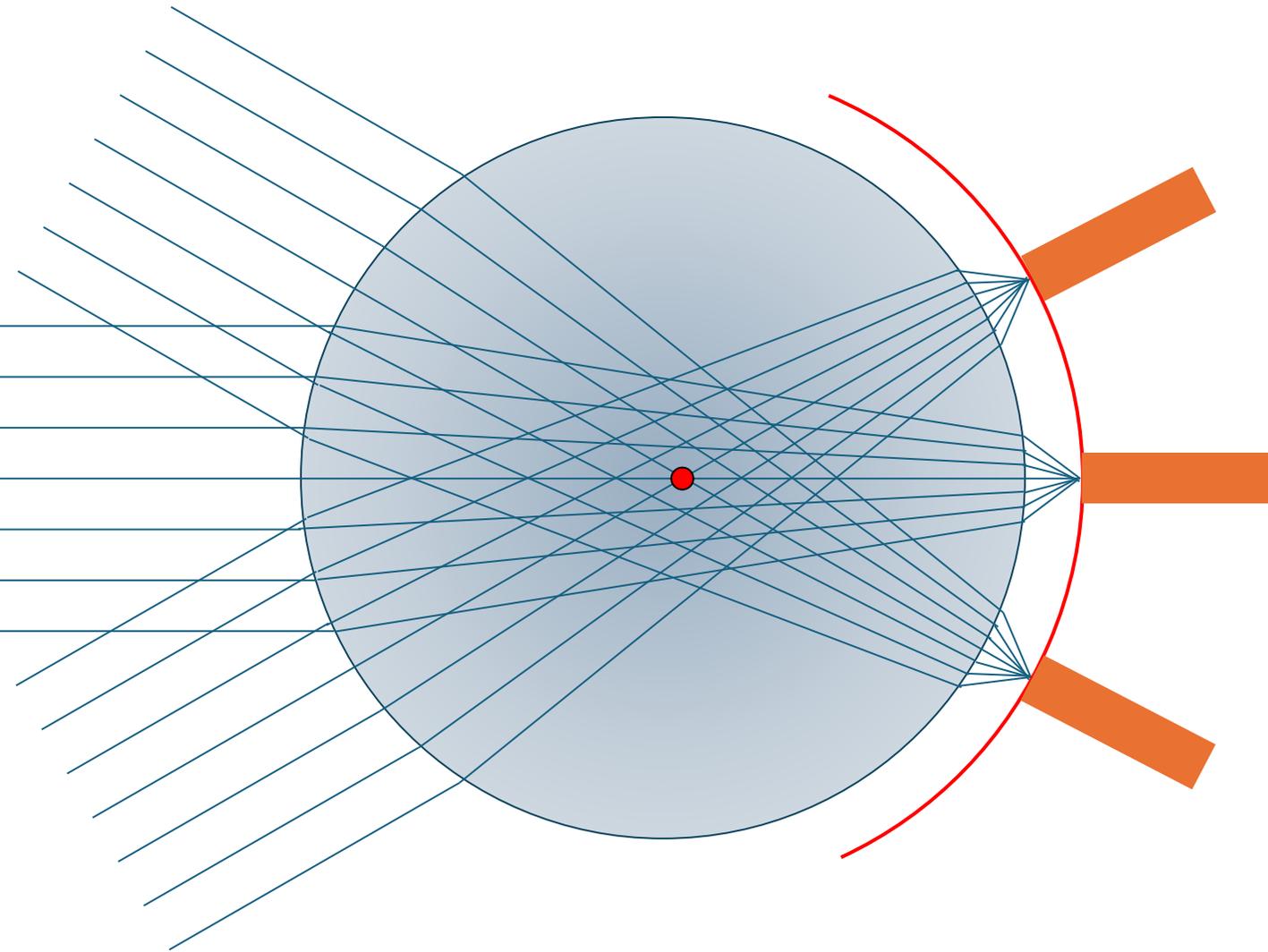


Roberto Ragazzoni

Once upon a time...

... a few years ago

# A spherical Lens: monocentric refractive design



- ☹️ Severe **Sphero-Chromatic** Aberration (much larger than spherical mirror)
- 😊 ... but uniform across the Field of View
- ☹️ Curved Focal Plane, but locally almost flat
- 😊 Modularity: identical, fixed local correctors
- 😊 Potentially enabling access to the full hemisphere without any obstruction
- ☹️ Quite complex correctors



Sunshine recorder

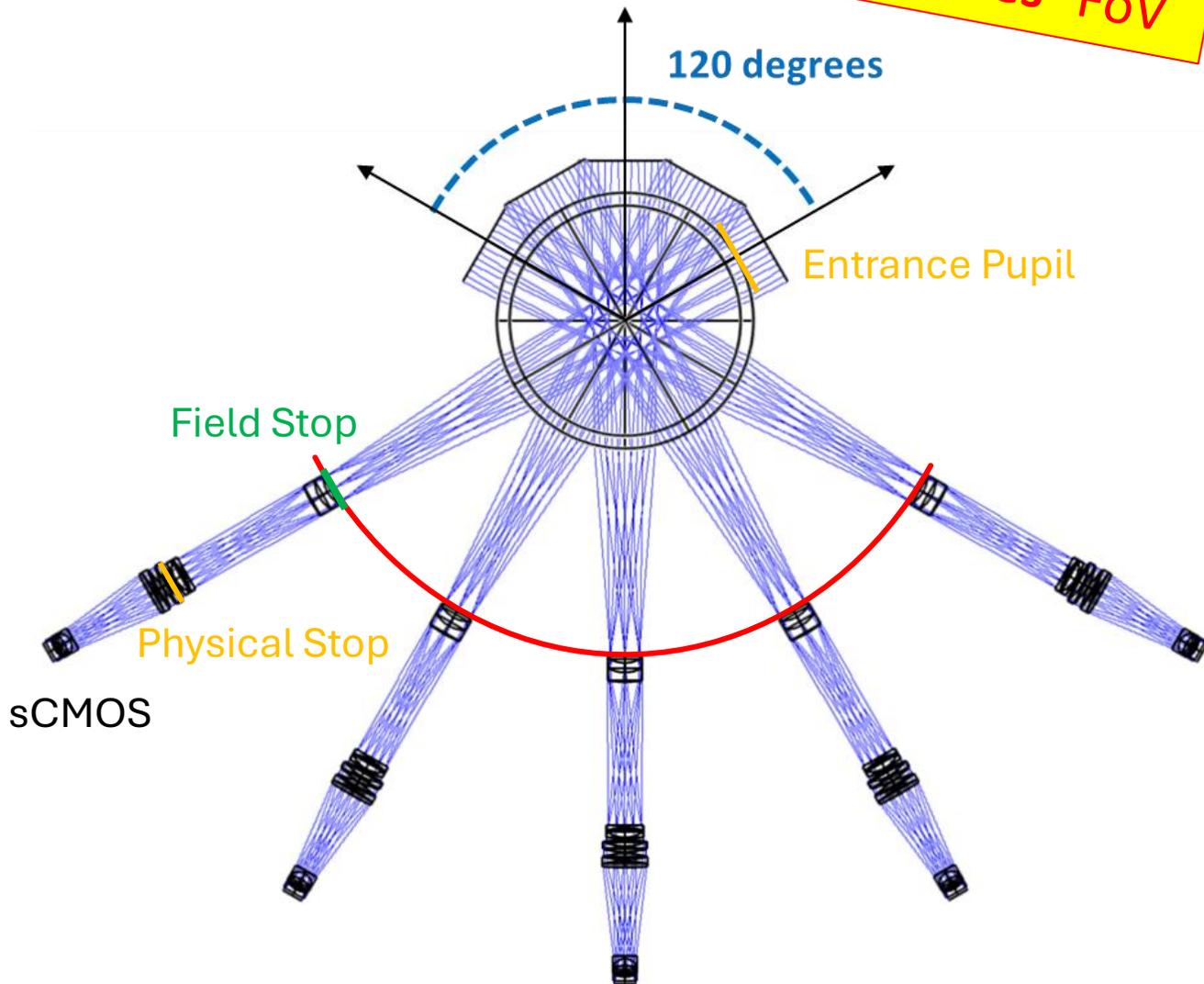
... after a while (not without its share of suffering)



... MezzoCielo

# MezzoCielo

Designed to have  
~10,000 degrees<sup>2</sup> FoV



A spherical assembly of N-BK7 **glass meniscus shells**, mechanically supported by a dodecahedral **metallic structure** and filled with a low refractive index, high-transparency **fluid** (perfluorohexane).

This sphere reimages nearly half of the celestial sphere onto a hemispherical curved surface (red line), exhibiting significant spherical and chromatic aberrations, but with uniformity across the entire field of view.

An array of **identical optical cameras**—defining both the **collecting area** and the **field of view**—populates the curved focal plane. Each optical camera compensates for aberrations and delivers seeing-limited images of small sky regions onto sCMOS-like detectors.

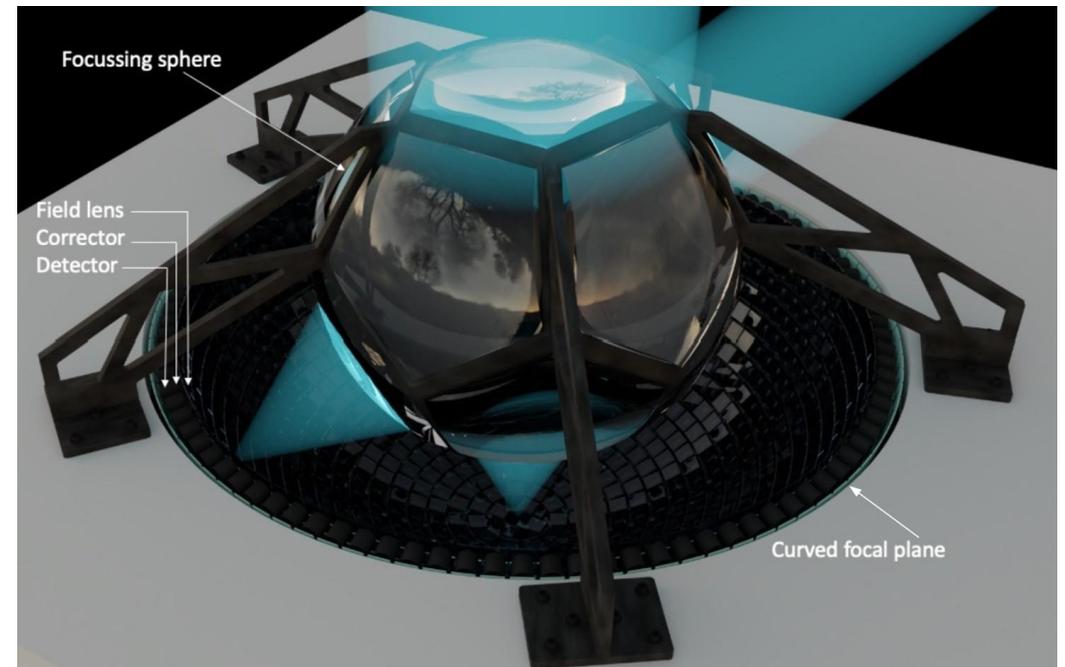
**The design is scalable!**

Filling Factor  $K = \text{Entrance Pupil Diameter} / \text{Sphere Diameter}$

# MezzoCielo

In its final configuration, **MezzoCielo** will feature:

- Spherical structure: ~2 m diameter
- Unobstructed aperture diameter: ~**0.8 m** (K ~0.4)
- Instantaneous FoV: entire sky above 30° elevation (~**10000 degrees<sup>2</sup>**)
- Spectral range: ~0.5-0.8 nm
- Curved focal plane populated by ~**900 optical cameras**
- Per-camera FoV: ~5° diagonal
- Detector: 9.4k × 9.4k CMOS per camera
- Pixel scale: ~1–1.3 arcsec / pixel
- Total focal plane: ~**80 Gpixel** images
- Concept: continuous all-sky monitoring with high cadence



# Prototype



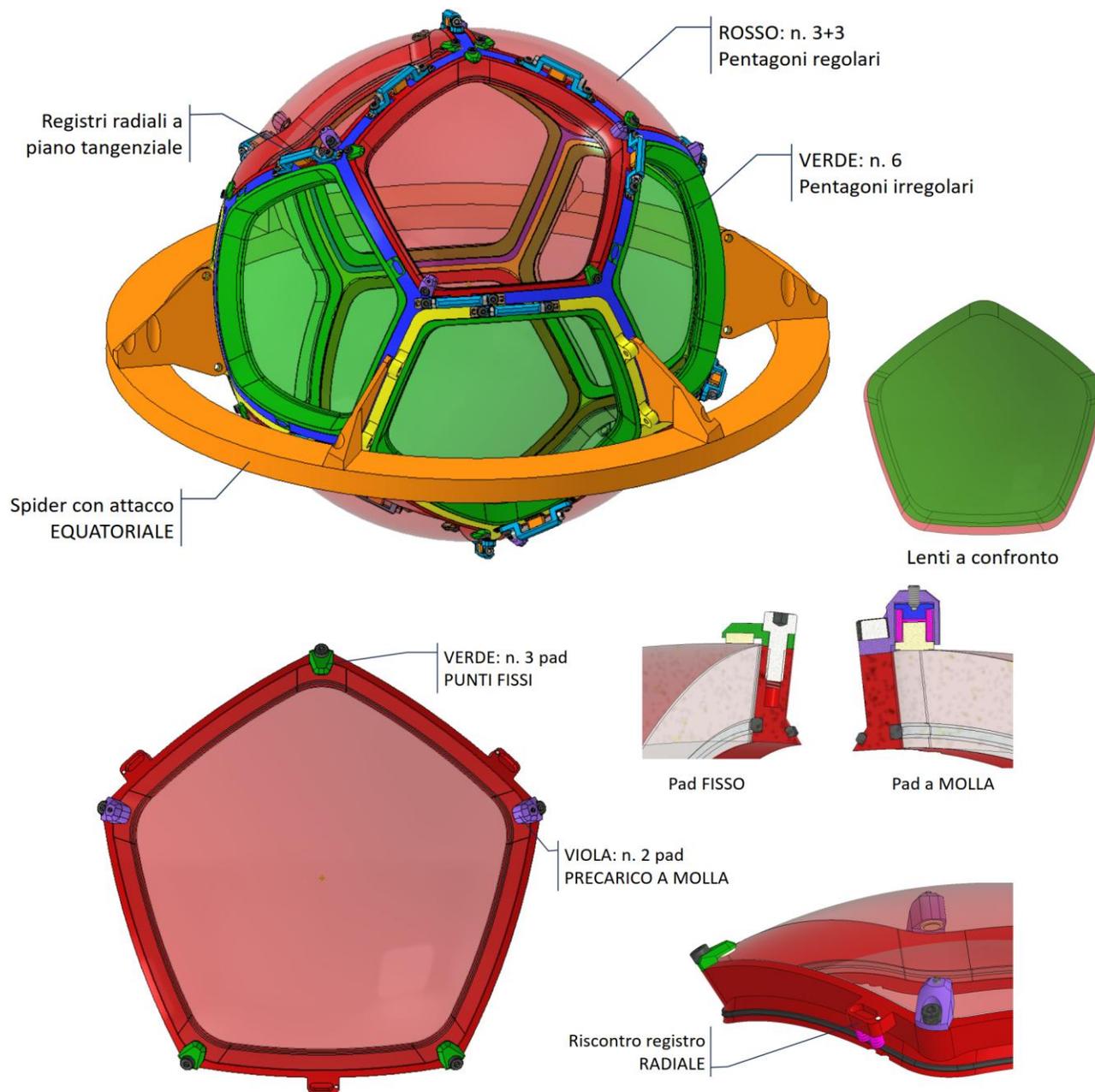
Contract no. 2025-3-HH.0

Activities: designing and building a **prototype of the sphere**, with a **40 cm diameter**, representative of the final opto-mechanical concept—a regular dodecahedron. The objective is to validate the feasibility of the design and evaluate both optical and mechanical performance, including the structural tightness of the fluid containment. Additionally, the prototype will allow assessment of the fluid's optical characteristics and the overall thermal behavior.

Company contracts:



End of work ~ late 2026

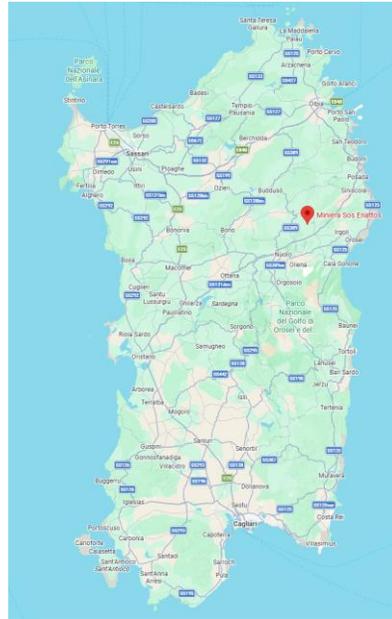


# On-Sky Demonstrator

In parallel, we are developing an **on-sky demonstrator** to be installed at **SunLab** in Sos Enattos, Nuoro, Italy. It features an **80-100 cm diameter sphere** with over **100 optical cameras** and CMOS detectors. The project also includes optimization of mass production for optics, mechanics, and camera detectors, as well as validation of the data acquisition system and dedicated data reduction pipelines. The intrinsic modularity allows future expansion, increasing the number of installed optical cameras.

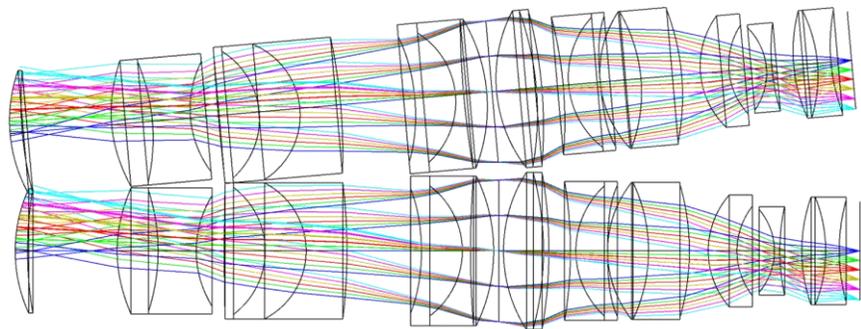
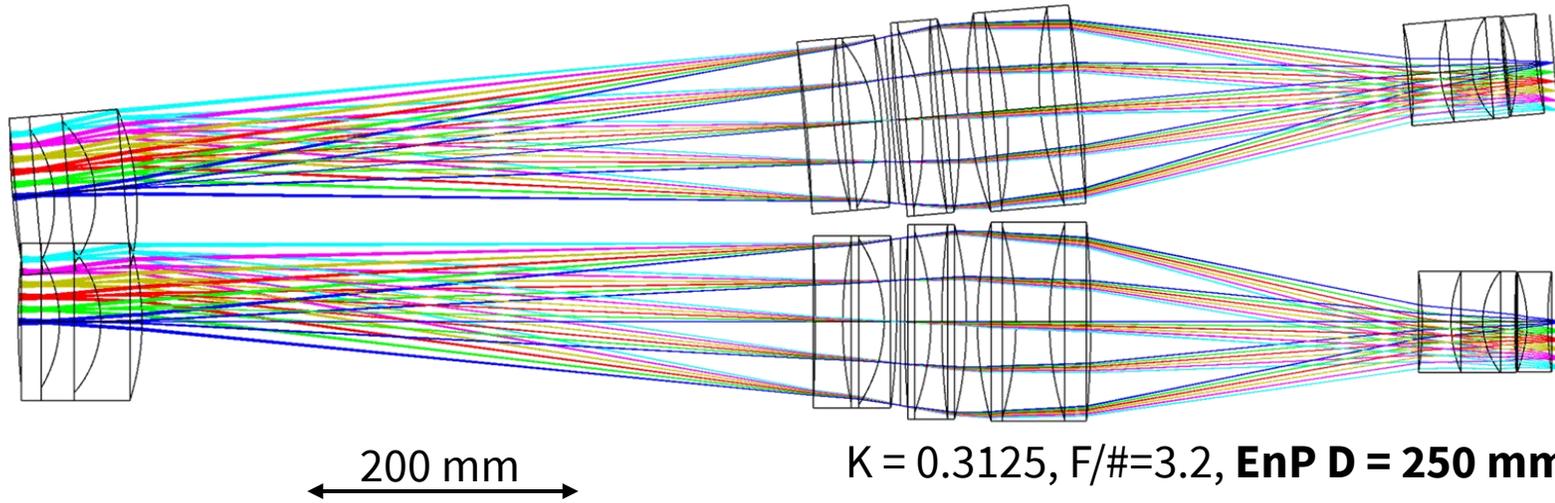
In the framework of **ETIC**, it has been financed the construction of MezzoCielo on-sky demonstrator **Building** (contract ongoing, end of work ~mid 2027).

**One meter class sphere, one optical channel prototype (including CMOS) and data-handling hardware prototype** is financed through **PNRIC 21-27 - DD 310 2025, ASTRASud project** (contract almost started, end of work ~mid 2029)



# On-Sky Demonstrator

For a sphere having **800 mm diameter**



$K = 0.45$ ,  $F/\# = 2.2$ , **EnP D = 360 mm**

Increasing the filling factor, i.e., the efficiency, the Focal Ratio decrease, i.e., the complexity of optical camera is increasing as well.

The current figure of merit is:

**Single channel FoV =  $3.54^\circ \times 3.54^\circ$**

**Plate Scale = 1-1.3 arcsec/pixel**

**Quality 80%EE < 2-2.6 arcsec**

# Science Activities

## Science Cases

- Electromagnetic counterpart of Gravitational Waves
- Electromagnetic counterparts of neutrinos
- Gamma Ray Burst optical prompt emission
- Fast Radio Burst counterparts
- Fast Blue Optical transients
- Shock breakout of Core-Collapse Supernovae
- AGN variability
- Monitoring of Near-Earth Asteroids
- ...
- Space Situational Awareness (SSA): Space Surveillance and Tracking (SST), Near-Earth Objects (NEO), Space Weather Events (SWE)

**High-level Requirements**  
to be used as driver for

**Opto-mechanical concept**

**Focal Plane and Cameras architecture**

**Data Handling and Data reduction strategies and architecture**

# Science Activities

## Science Cases

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**High-level Requirements**  
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**Focal Plane and Cameras architecture**

**Data Handling and Data reduction strategies and architecture**

These represent challenges common to all projects of this type.

900 cameras x 9.4kpx x 9.4kpx (80Gpx) data is the “one frame” data volume (typically 160GB, 2 byte/pixel). One night (12 hrs) at 60sec cadence is a further x720 making **115 TB per day** (SKA is producing 2000TB per night, Vera Rubin Telescope 20TB per night).



S

Science and Tracking  
Events (SWE)

Hi  
to

## Preliminary Scientific Cases for MezzoCielo

Nancy Elias-Rosa<sup>1</sup> and Matteo Pais<sup>1</sup>

<sup>1</sup>INAF - Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, 35122, Padova (PD), Italy

February 5, 2026

### Abstract

MezzoCielo is a concept for an ultra-wide-field optical/near-IR facility dedicated to high-cadence monitoring of the transient sky. Its design allows near-continuous coverage of a large fraction of the hemisphere, enabling rapid follow-up of Gamma-Ray Bursts, kilonova candidates, tidal disruption events, fast faint optical transients – including potential orphan GRB afterglows or shock-cooling signatures –, and other fast optical transients down to  $\sim 21\text{--}22$  mag (in definition phase). MezzoCielo will also support surveys of short-timescale variability from stellar and compact sources and long-term monitoring of AGN. By providing dense time-domain sampling with minimal pointing overhead, MezzoCielo offers a complementary platform to high-energy trigger missions and a high-yield capability for multi-messenger astrophysics.

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For each science case, we are defining the instrument technical specifications.



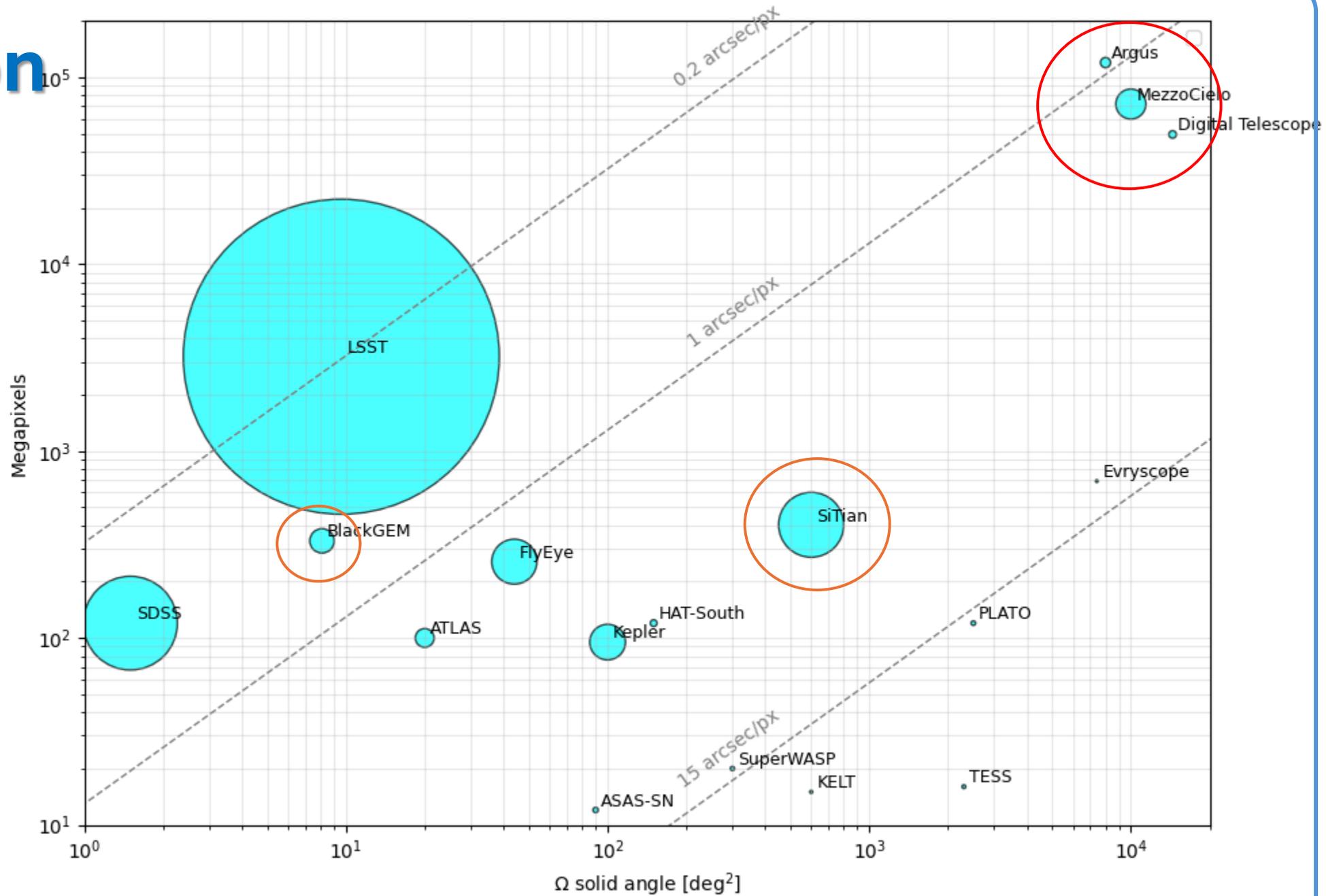
The goal is to finalize a **white book** by end 2026 / early 2027.

If you are willing to participate to the process, please contact:

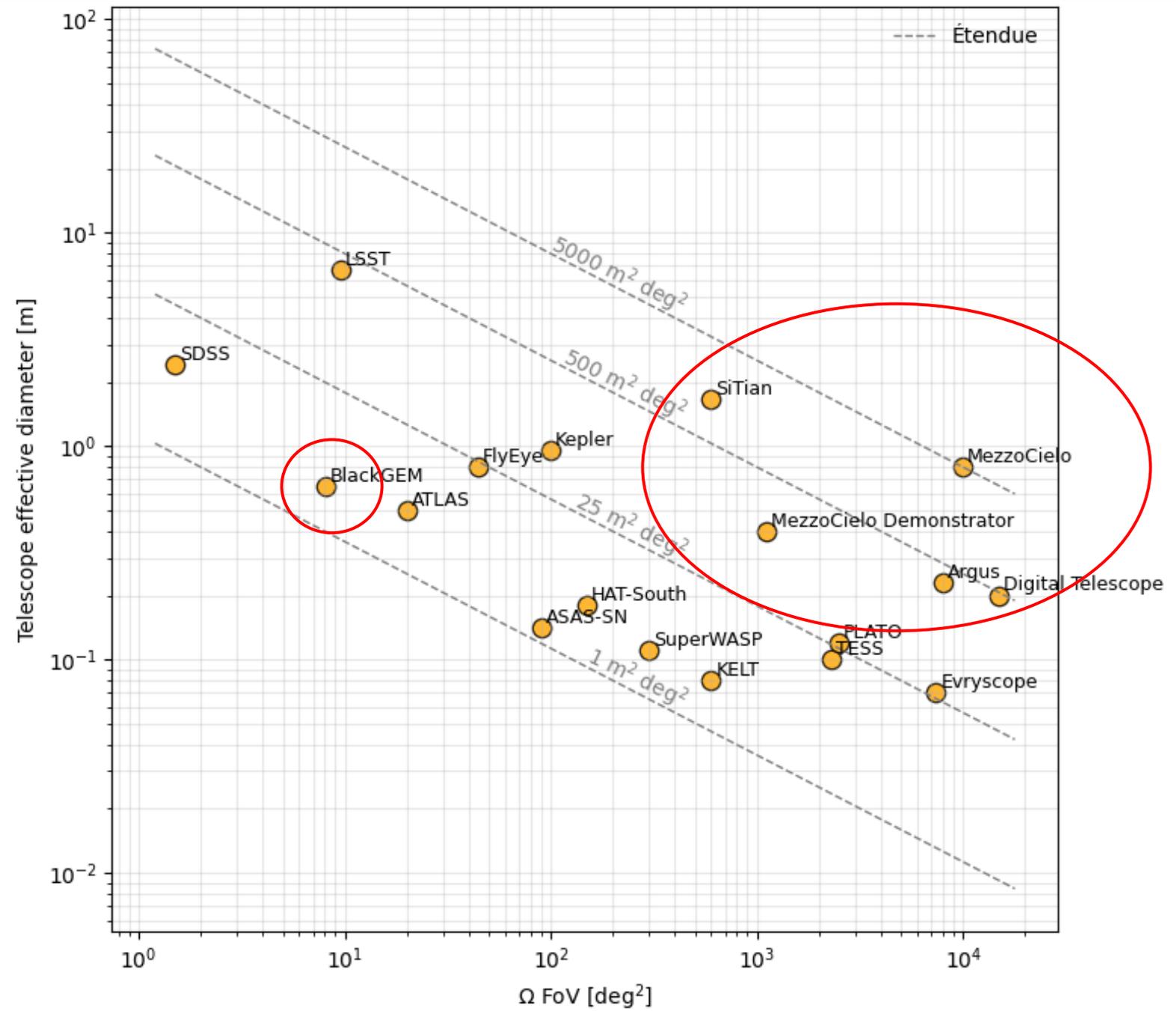
Science team coordinator: [nancy.elias@inaf.it](mailto:nancy.elias@inaf.it)

Instrument scientist: [carmelo.arcidiacono@inaf.it](mailto:carmelo.arcidiacono@inaf.it)

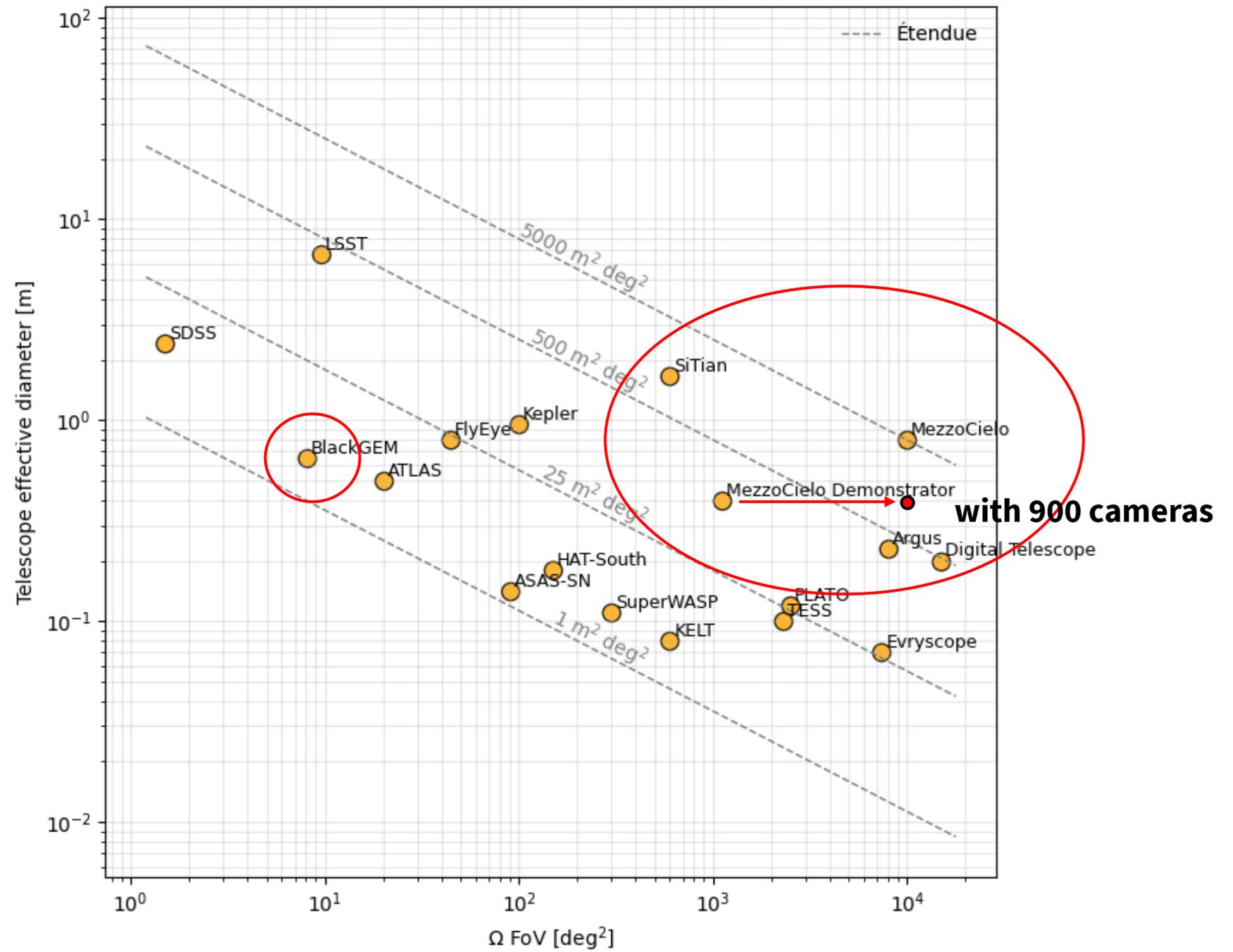
# Resolution



# Etendue

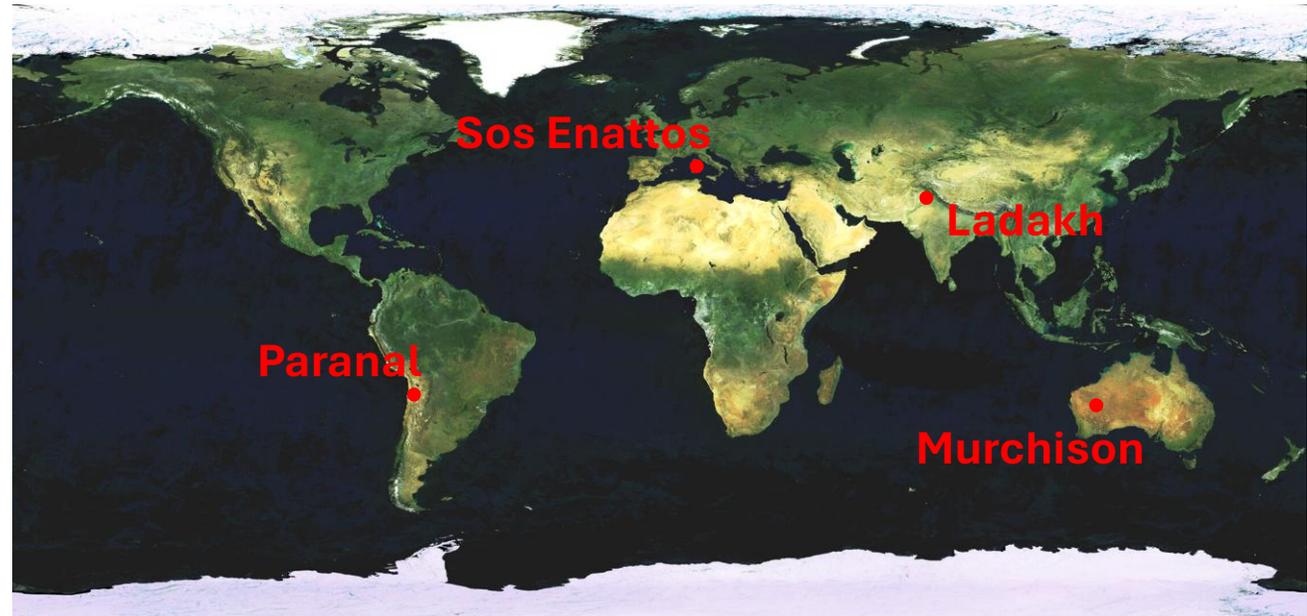


# Etendue



## ... in the future

Let's think to have a one (or a NxN matrix of) MezzoCielo in >2+ sites (North and South Hemisphere)



MezzoCielo is not just a telescope concept, but a scalable paradigm for all-sky, high-cadence, multi-messenger astronomy in the Einstein Telescope era.