MezzoCielo: a novel ultra-wide-field telescope for continuous all-sky monitoring

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INAF – Osservatorio Astronomico di Padova

High Energy Astrophysics and Cosmology in the era of all-sky surveys, 15-19 June 2026, Yerevan

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.

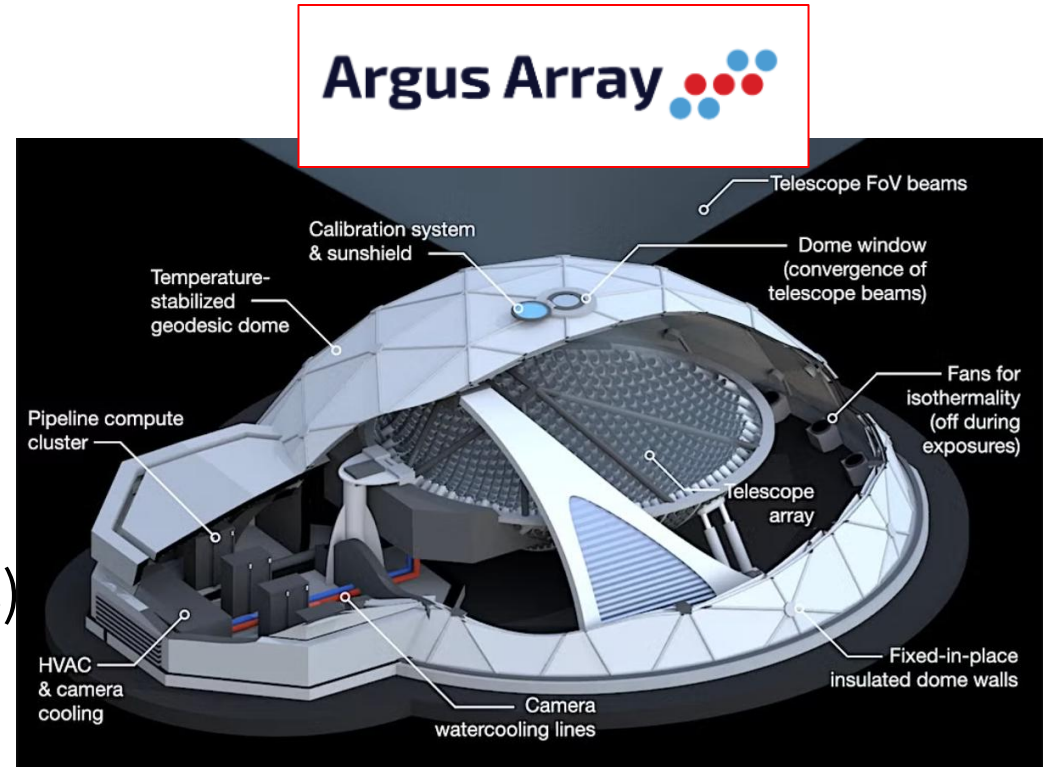
- **3 telescopes x 0.65m** diameter (15 telescope planned)
- Instantaneous FoV: **8 degrees²** (40 degrees² planned)
- **Seeing-limited** (**0.33 Gpixel** images**)**
- Robotic wide-field array

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 degrees²**
- 1 arcsec/pixel, 2 arcsec FWHM (**120 Gpixel** images)
- Strategy: many small telescopes for full-sky coverage



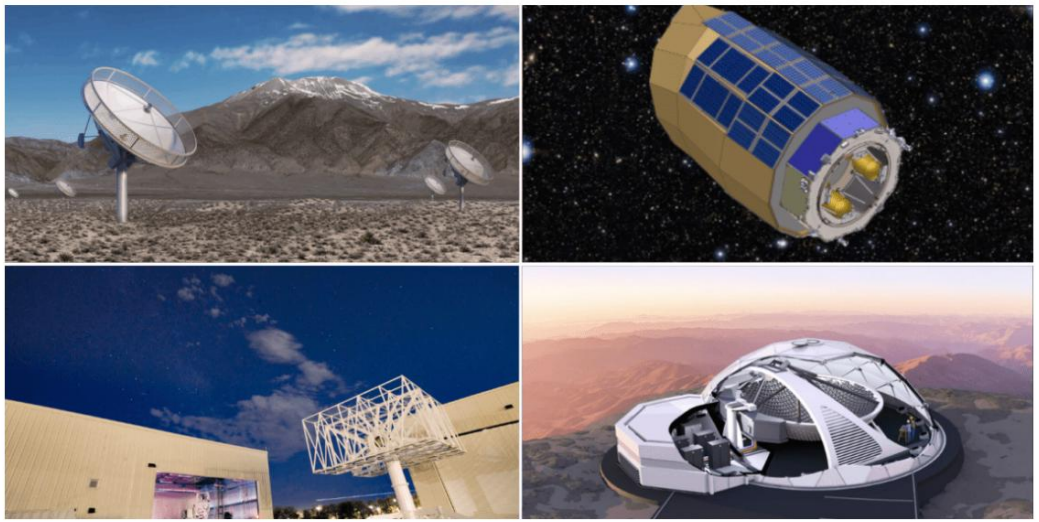
Similar Pro

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

- **1200 telescopes x (**
- Instantaneous FoV:
- 1 arcsec/pixel, 2 arc
- Strategy: many sma
  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

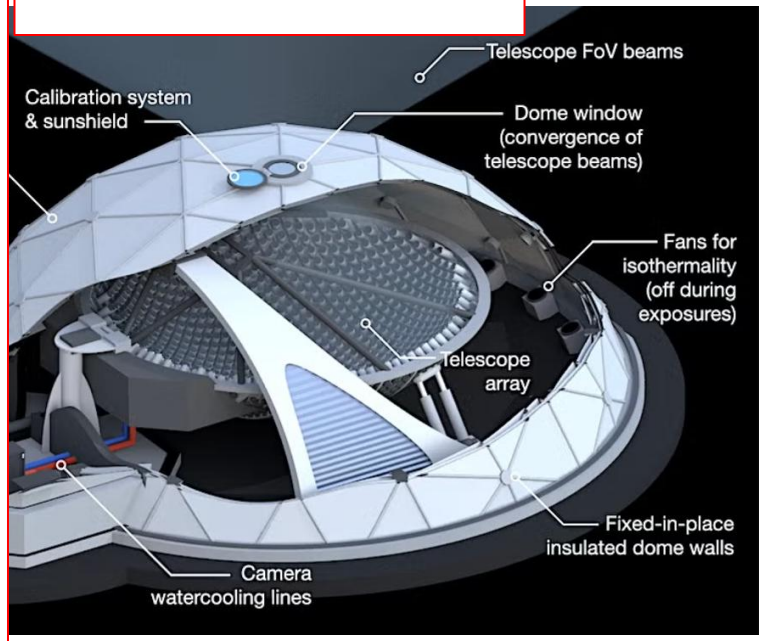


I quattro osservatori parte dello Schmidt Observatory System. In alto: il Deep Synoptic Array e il Lazuli Space Observatory. In basso: il Large Fiber Array Spectroscopic Telescope e l'Argus Array. Credits: Schmidt Observatory System

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.

Argus Array

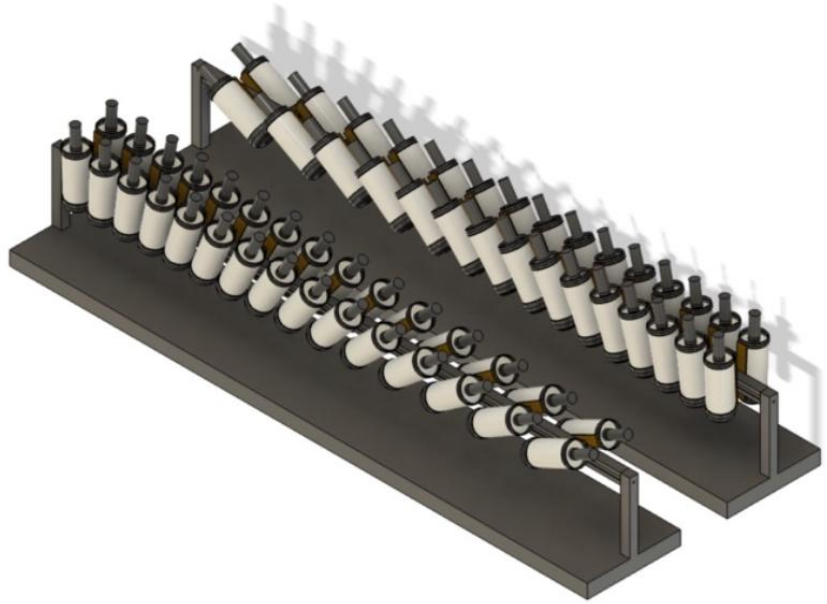


Rumors say about 50 M$

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 degrees²**
- 1.38 arcsec/pixel (~**100 Gpixel** images)
- Strategy: continuous all-sky movie



Similar Projects

The Digital
lead by Univ

- **825 teles**
- Instantar
- 1.38 arcs
- Strategy:

BBC

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".

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 (equivalent diameter 1.7m)**
- Instantaneous FoV: **~600 degrees^2** (per-unit FoV: **25 degrees^2**), about ~**0.4 Gpixel** images
- Survey speed: ≥ **10,000 degrees^2 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.

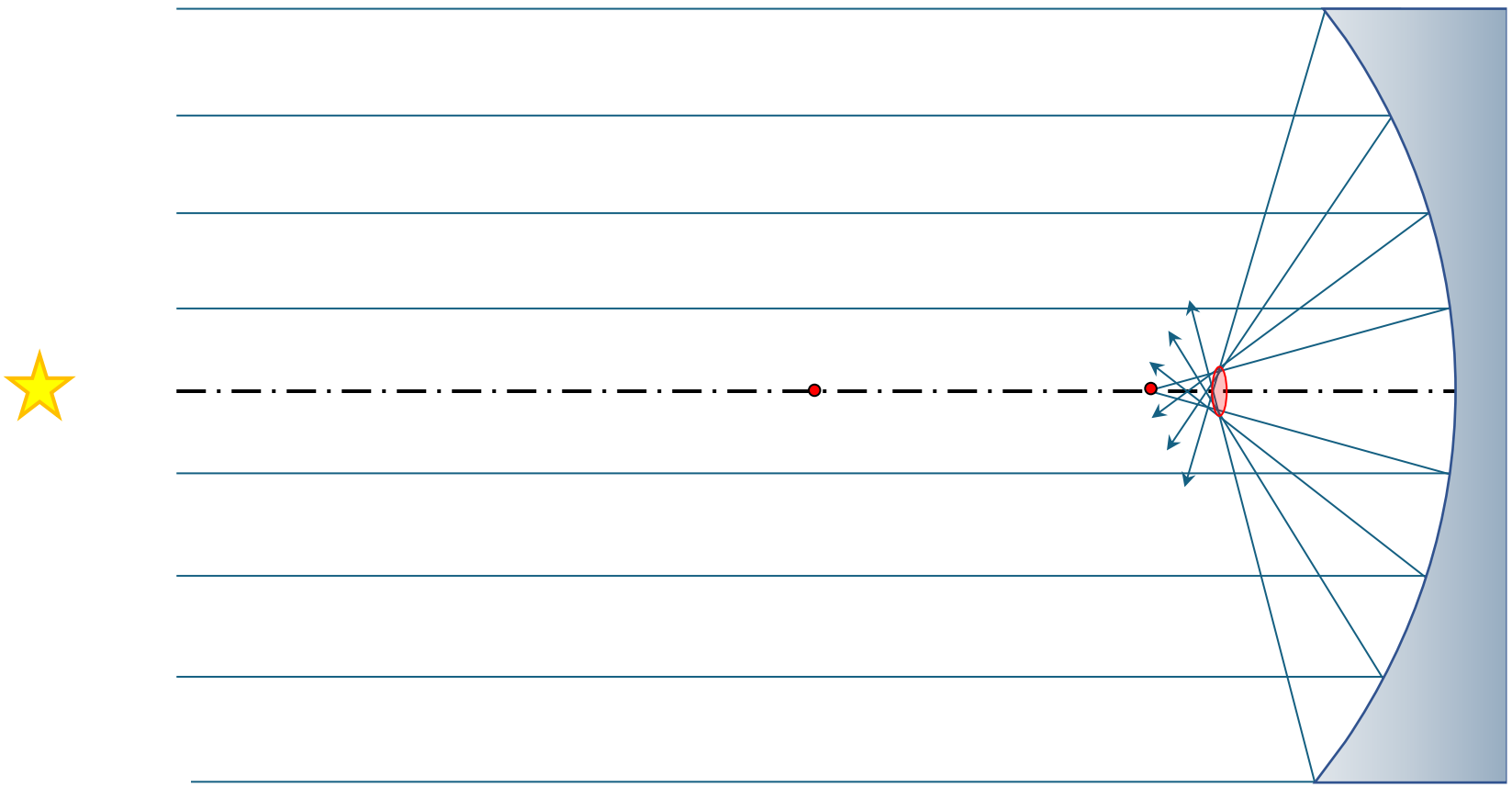
MezzoCielo aims to combine the advantages of both approaches, providing large sky coverage together with a substantial collecting area, within a scalable and sustainable system cost.

Bernard Schmidt

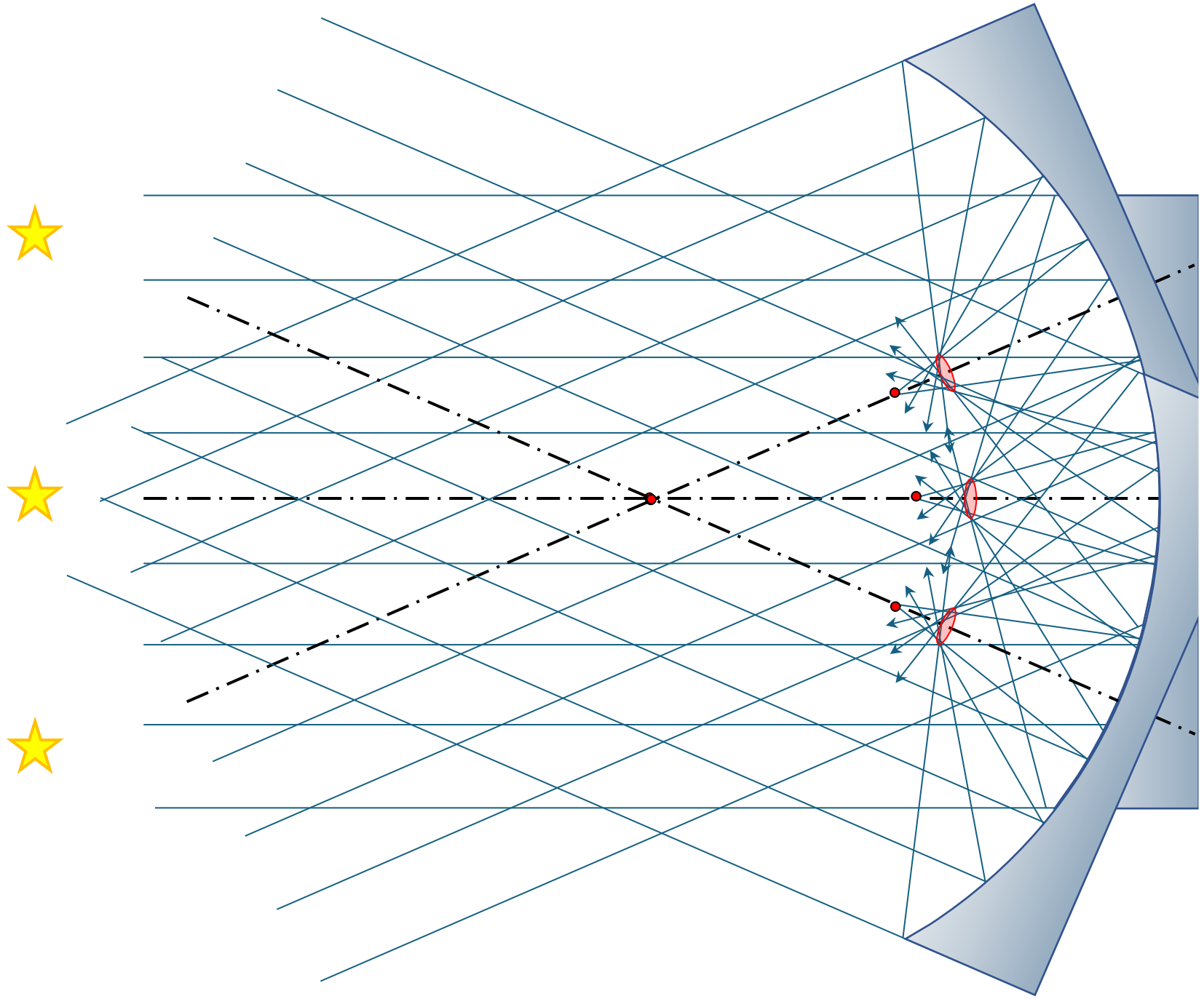
Once upon a time…

… about 100 years ago

A spherical mirror

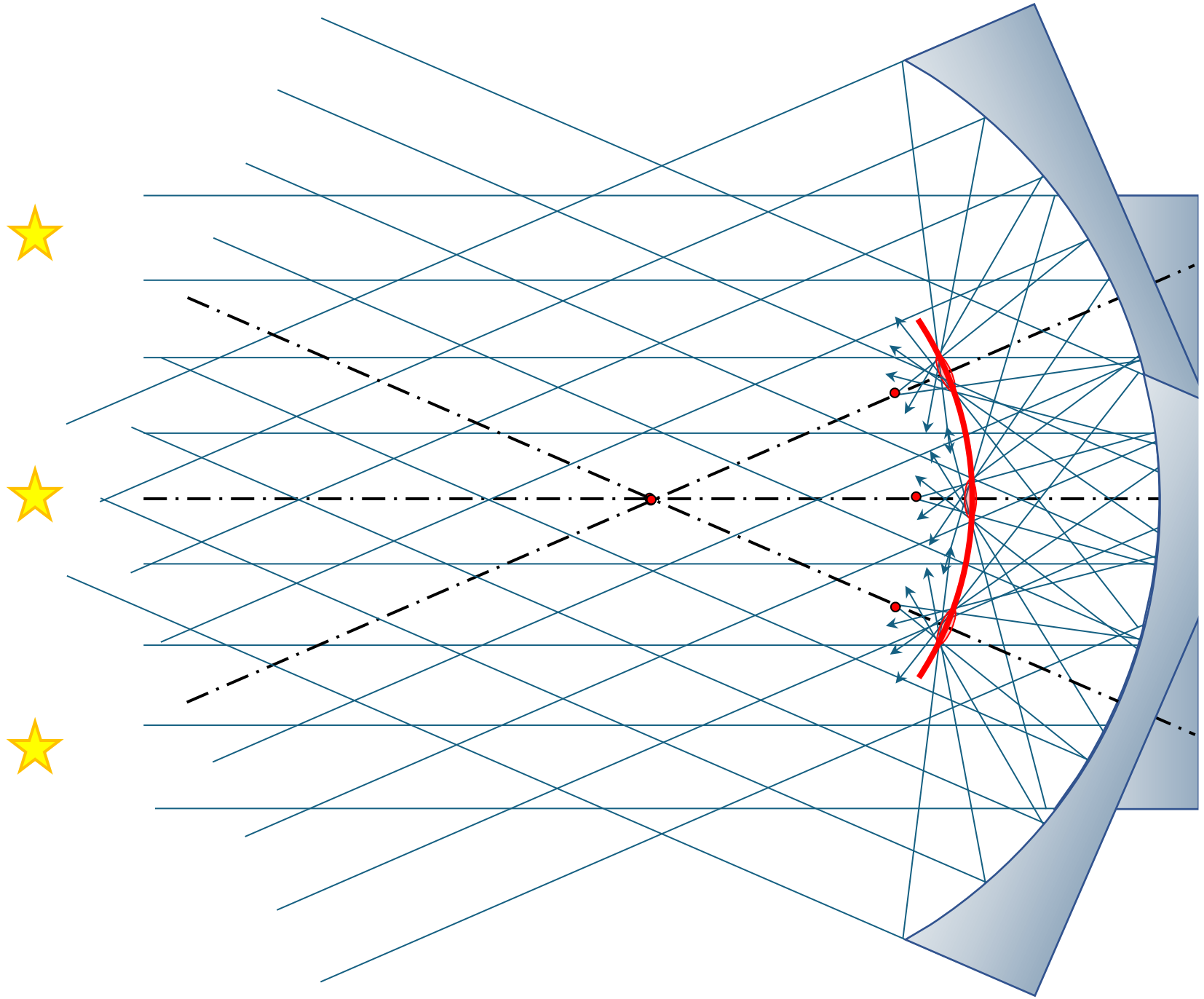


😟 Severe Spherical Aberration



😟 Severe Spherical Aberration

😊 … but uniform across the Field of View

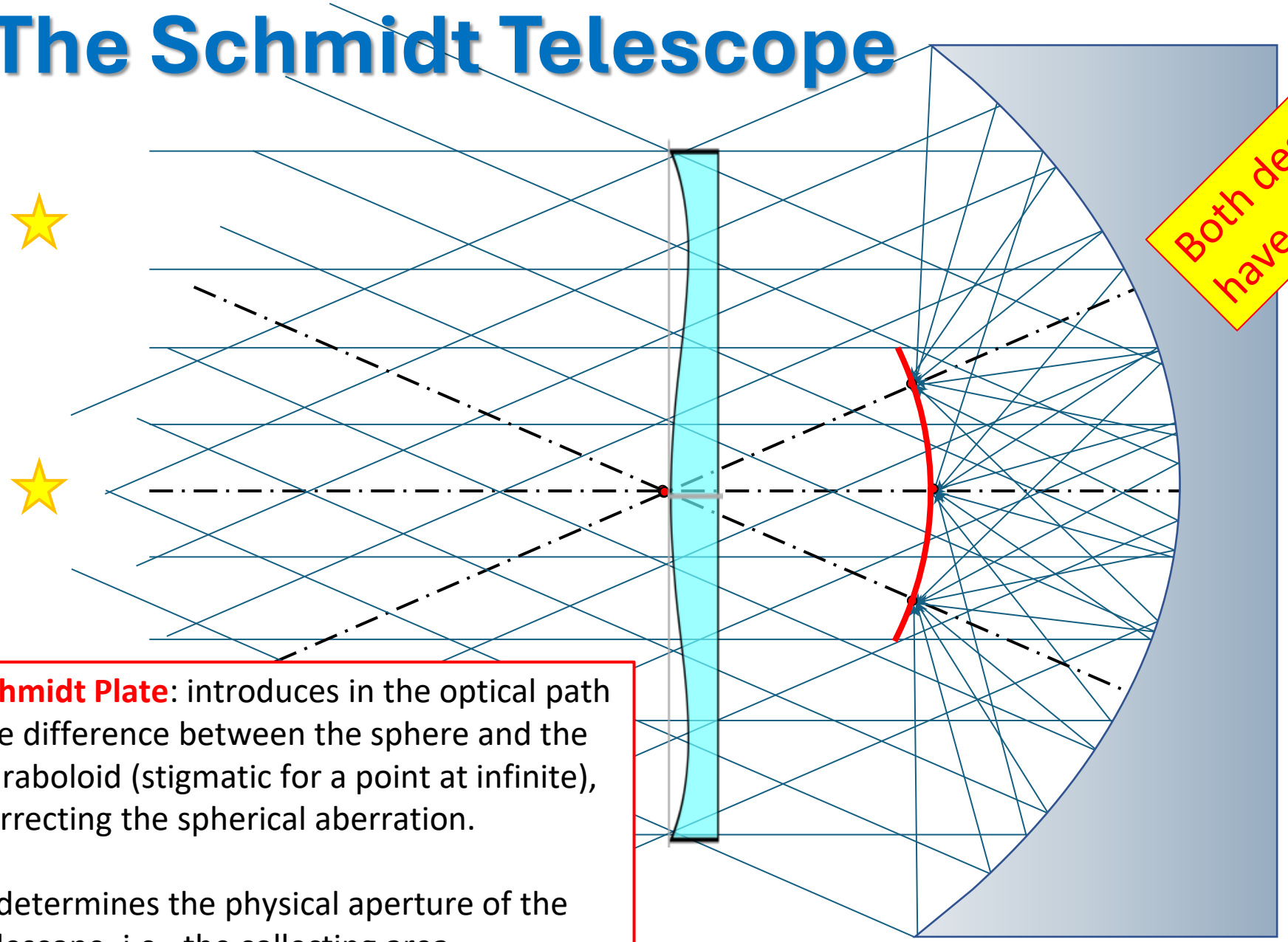


😟 Severe Spherical Aberration

😊 … but uniform across the Field of View

😐 and curved Focal Plane

The Schmidt Telescope



Both designed to have ~5°x5° FoV

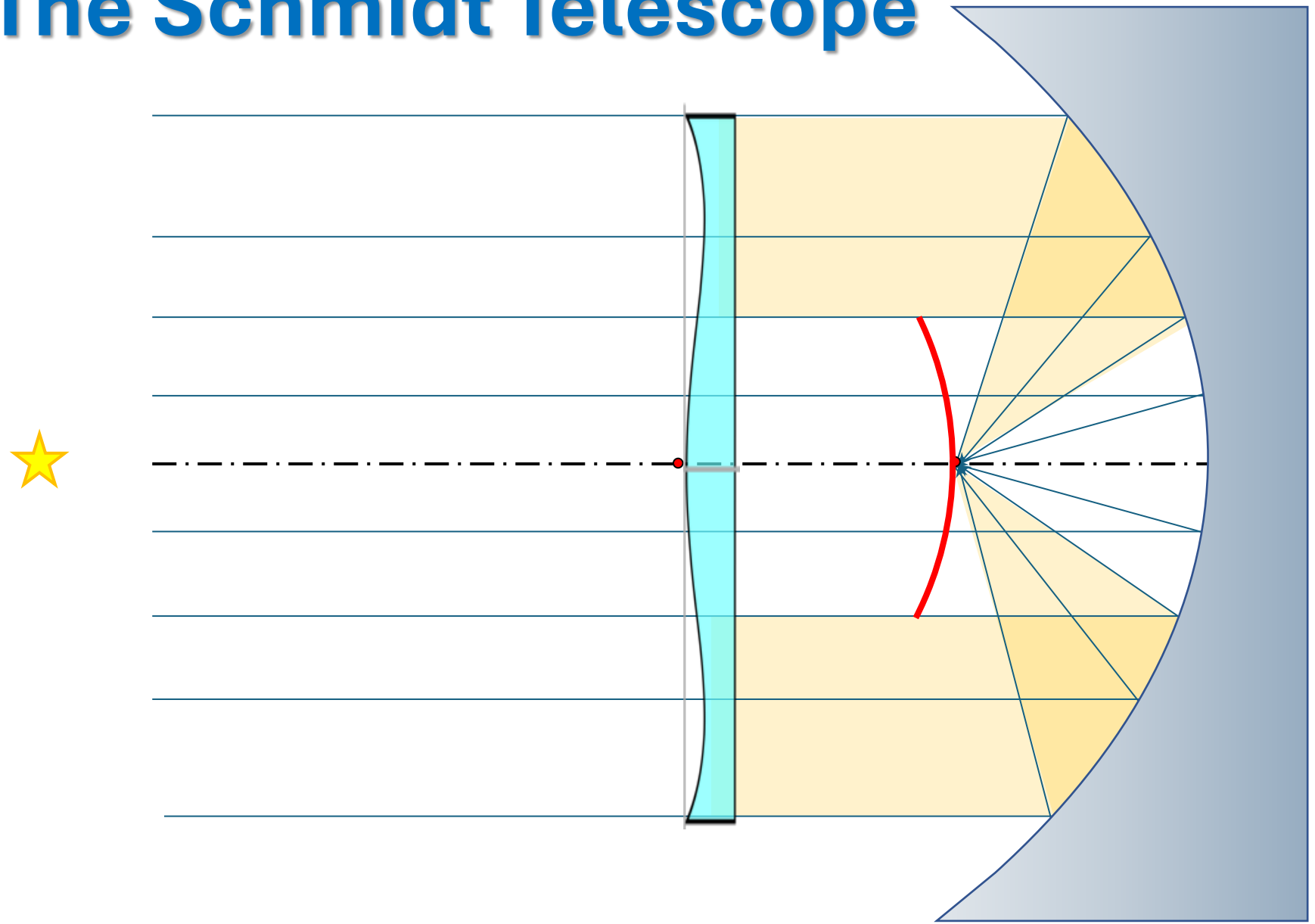
Palomar 122cm /182cm

Asiago 67cm /92cm

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.

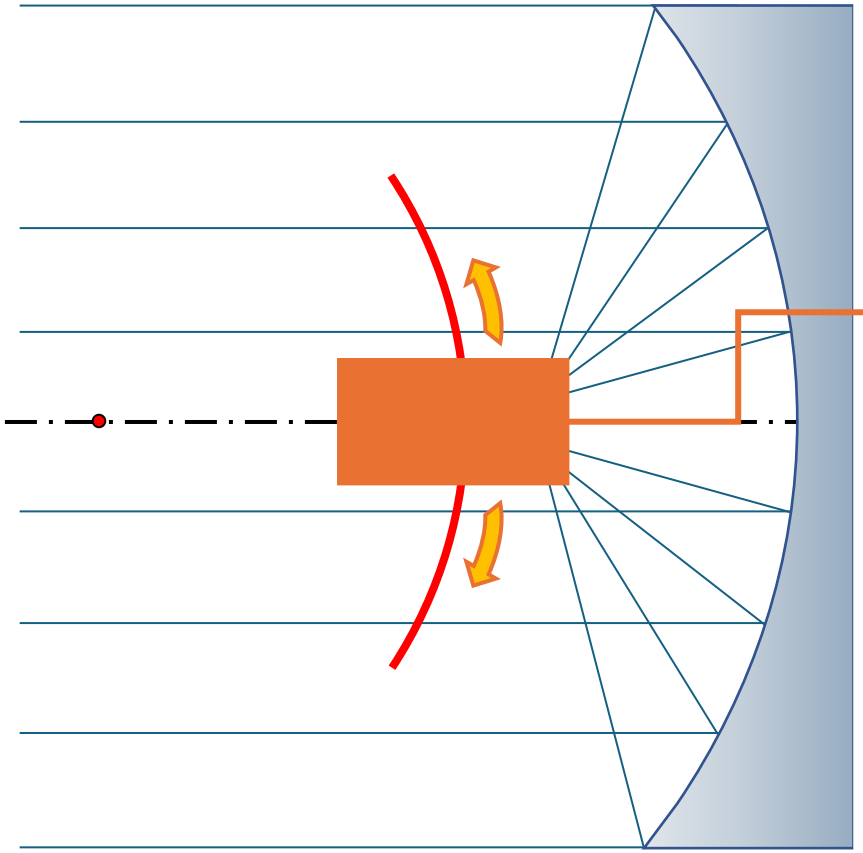
It determines the physical aperture of the telescope, i.e., the collecting area.

The Schmidt Telescope



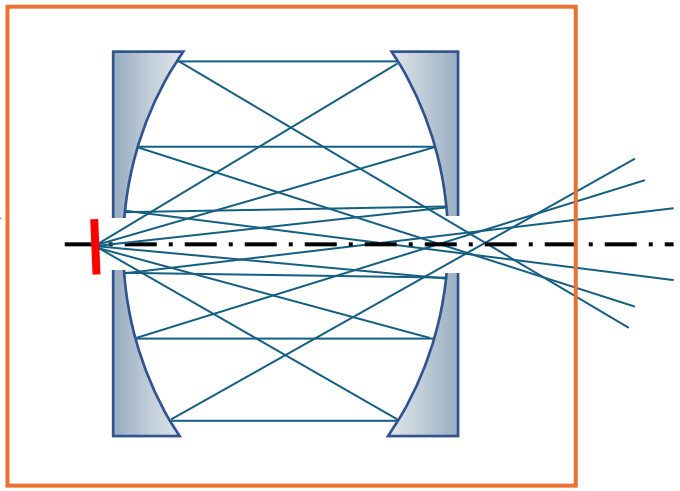
- 😊 Large corrected FoV
- 😟 Central Obstruction increases with the FoV, i.e., less efficiency
- 😟 Spherical aberration correction is less and less effective as FoV increases because of Schmidt Plate view factor

Arecibo-like Telescope



Movable Corrector

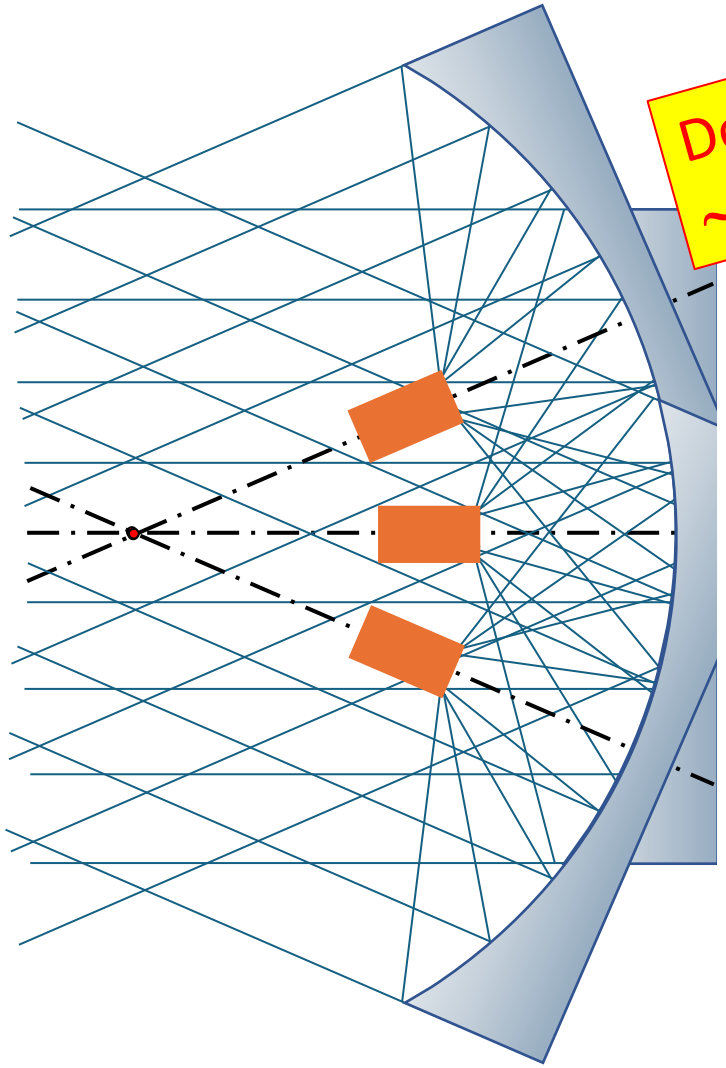
Collimator + Spherical Corrector



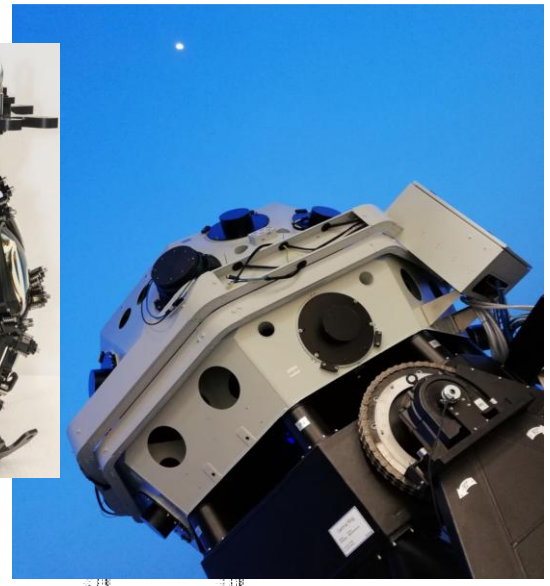
A movable corrector can cover the primary mirror focal plane correcting locally the uniform spherical aberration. It allows extremely large and static primary mirror. The Field of View is covered by moving the corrector… but not instantaneously.

Arecibo Antenna 305 m
(1963 - 2020)

FlyEye-like Telescope

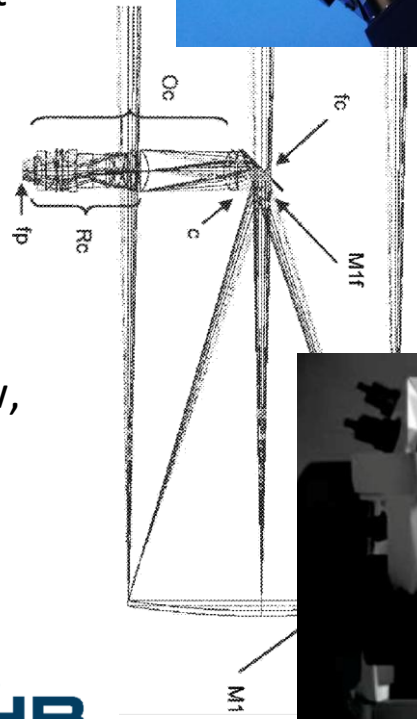


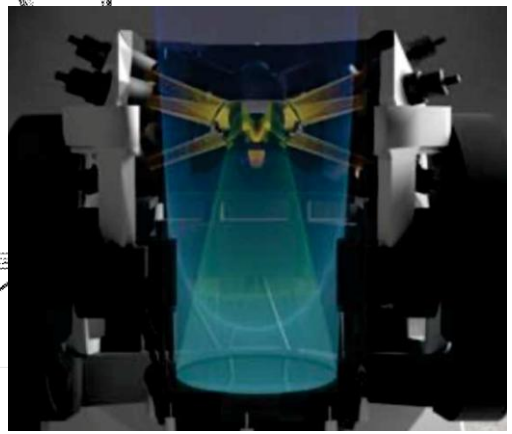
Designed to have
~6.8º×6.8º FoV



Modularity is introduced to exploit identical, fixed local correctors, enabling the coverage of a wide Field of View through a replicated optical solution.

This approach provides an instantaneously large Field of View, at the cost of a significant central obstruction, resulting in reduced overall optical efficiency.





esa asi OHB ITALIA

Roberto Ragazzoni

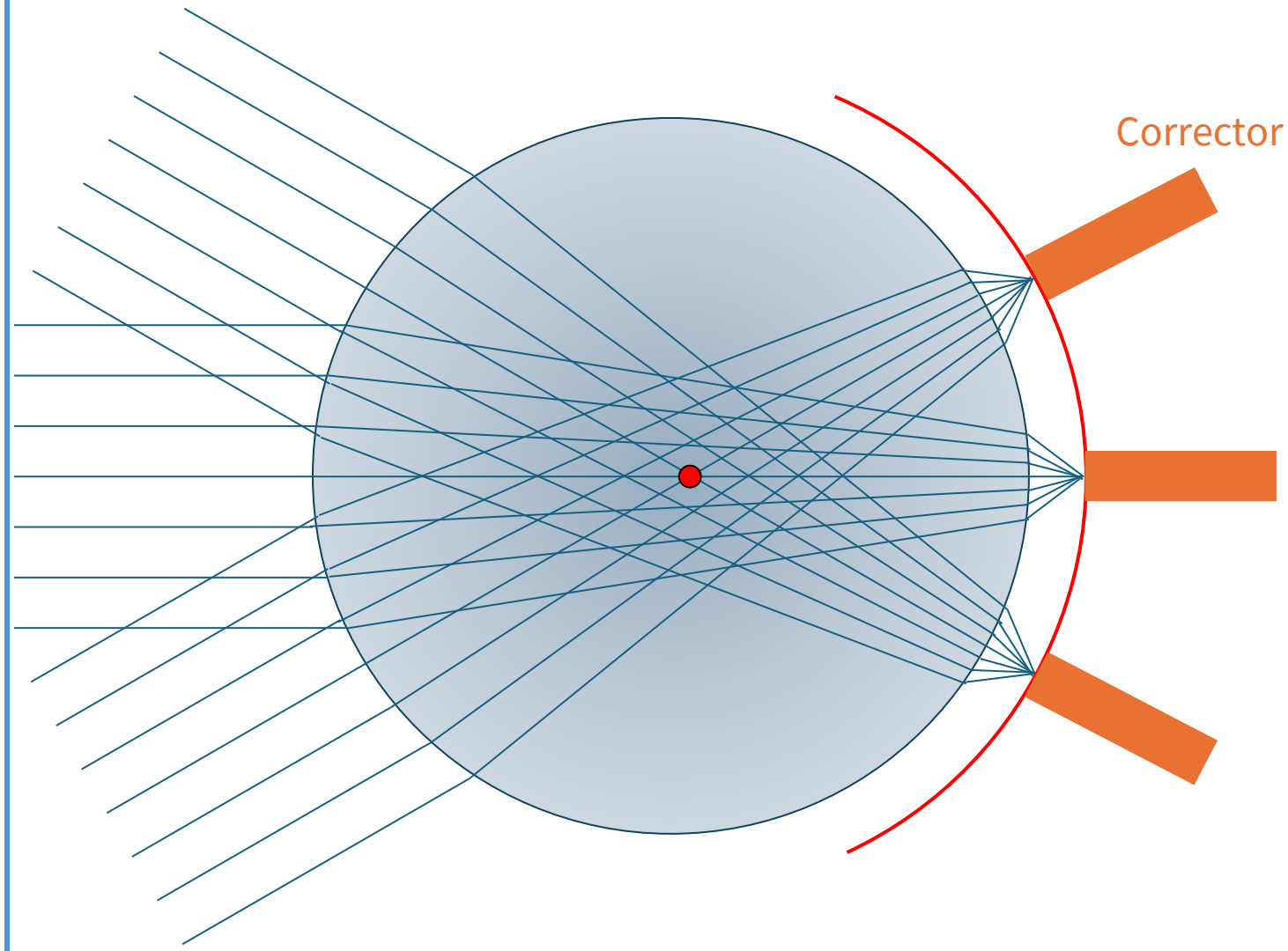
Once upon a time…

… a few years ago

…with some help

… MezzoCielo

A spherical Lens: monocentric refractive design

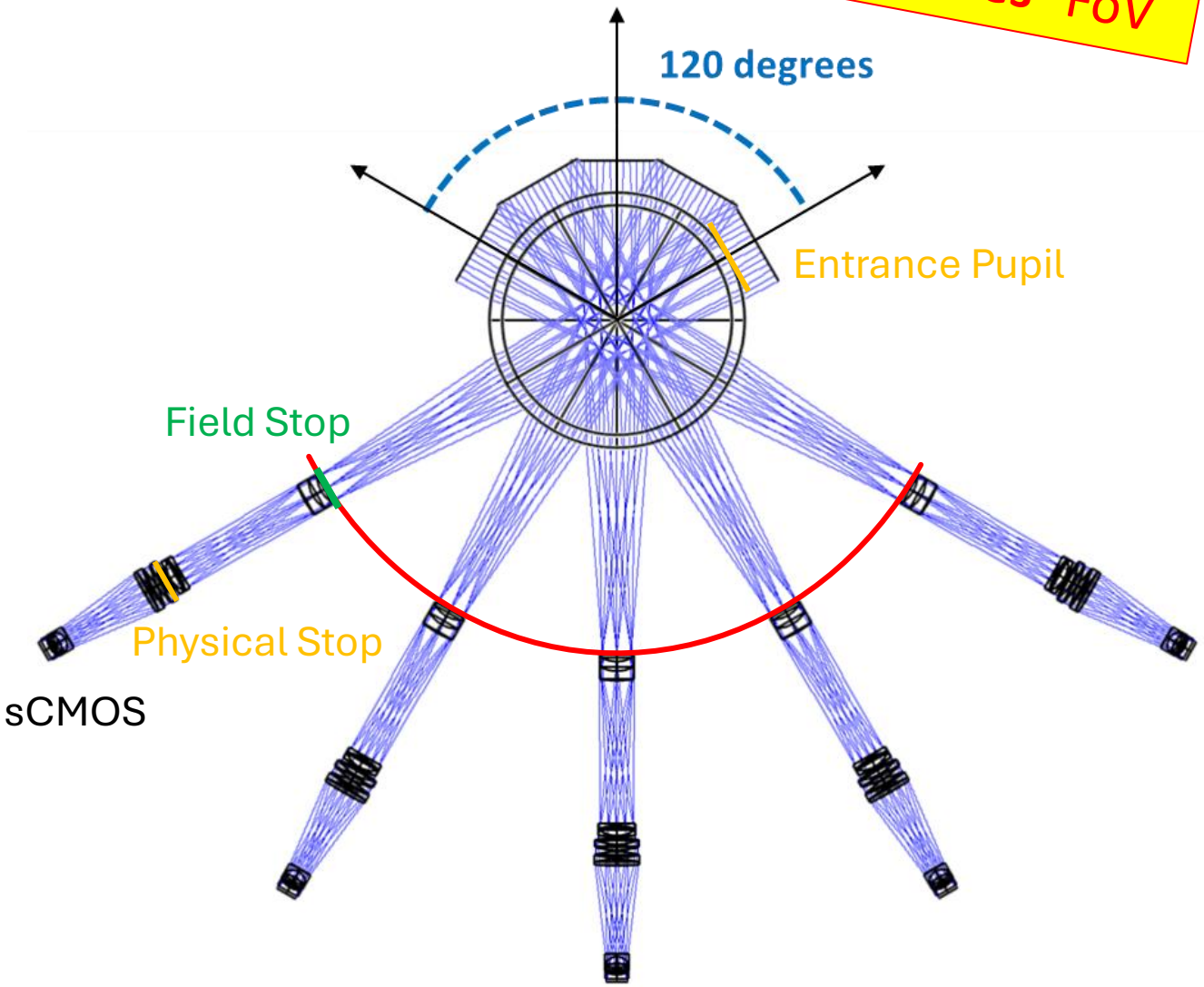


- ☹️ Severe **Sphero-Chromatic** Aberration (much larger than spherical mirror)
- 😊 … but uniform across the Field of View
- 😐 Curved Focal Plane, but locally almost flat
- 😊 Modularity: identical, fixed local correctors
- 😊 Potentially enabling access to the full hemisphere without any obstruction
-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

Sunshine recorder

MezzoCielo

Designed to have ~10.000 degrees² 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.

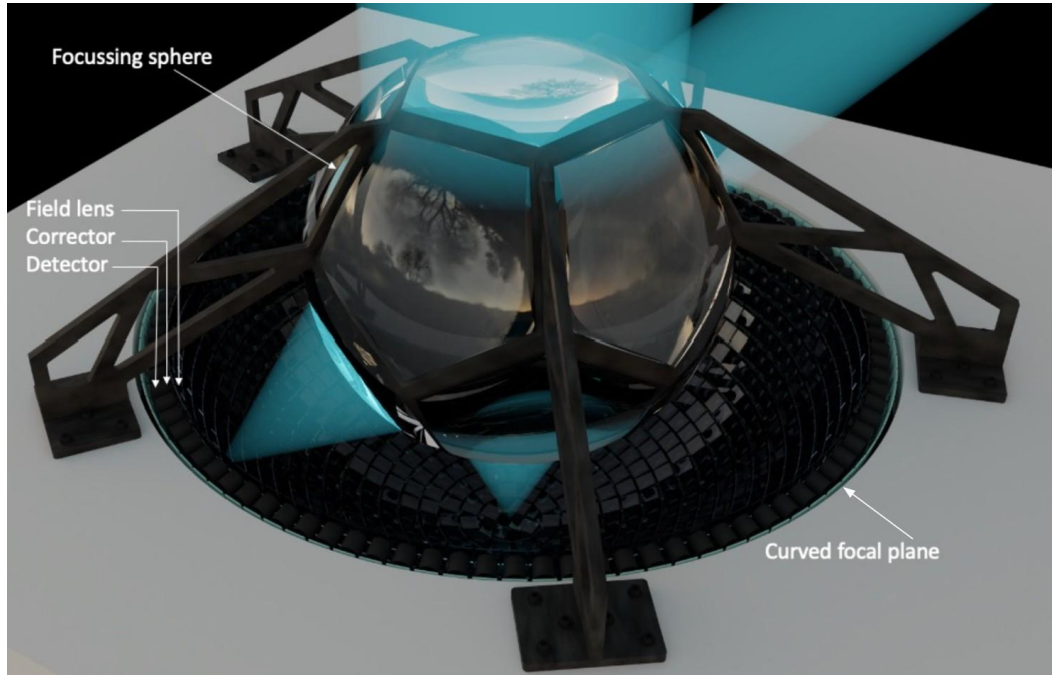
The design is scalable!

Filling Factor K = Entrance Pupil Diameter/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^2**)
- 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



Survey speed vs complexity/cost

Project	Aperture	FoV	Telescopes
BlackGEM	0.65 m	40 deg^2	15
Argus	0.28 m	8000 deg^2	1200
Digital Telescope	0.20 m	14500 deg^2	825
SiTian	1.70 m	600 deg^2	72
MezzoCielo	0.80 m	10000 deg^2	1 sphere + 900 channels

Prototype

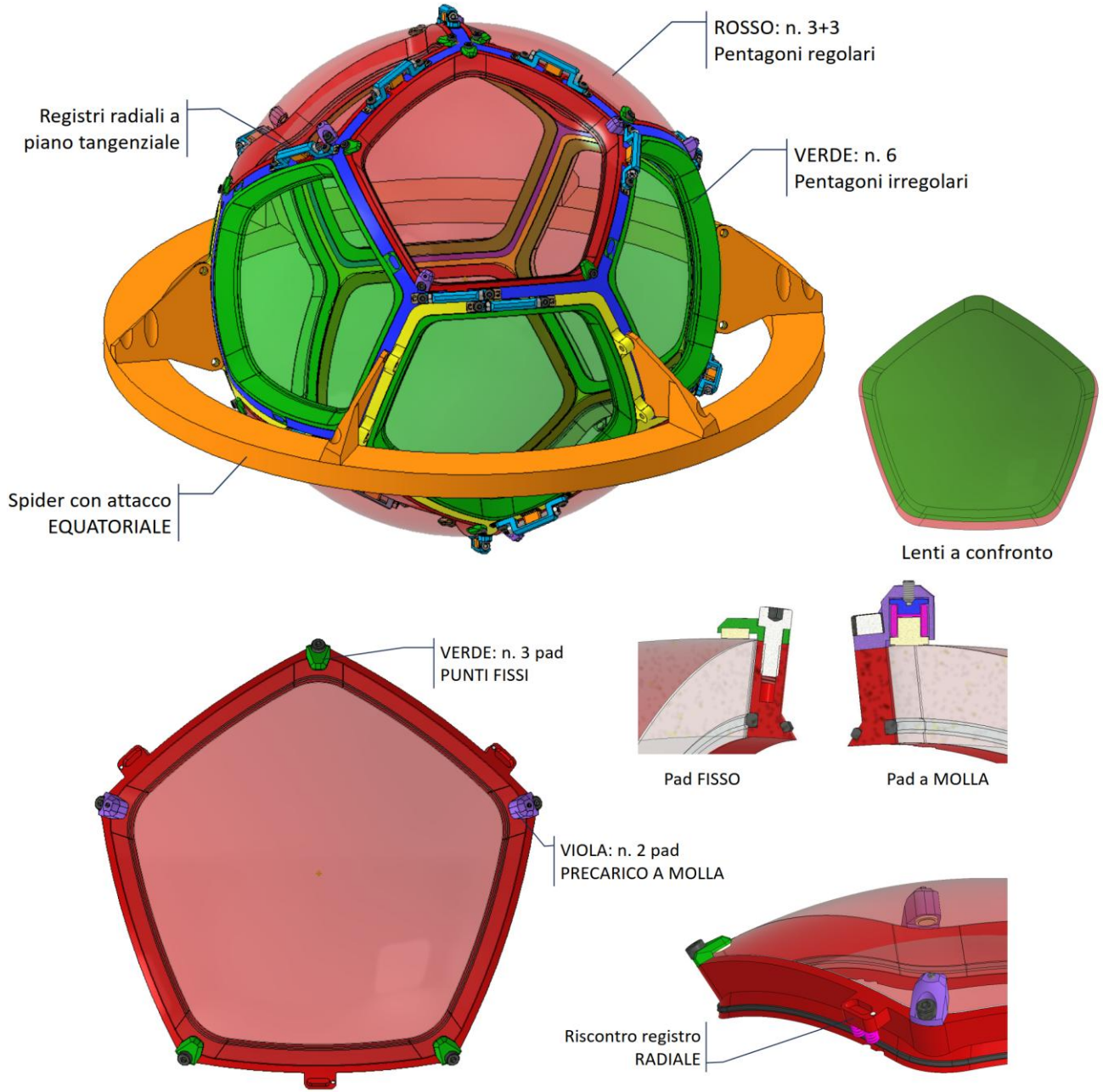
Contract no. 2025-3-HH.0

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: TOMELLERI S.R.L. Quality and innovation

OFFICINASTELLARE WORKSHOP OF THE STARS

End of work ~ late 2026 - early 2027



Concept Demonstrator

PN-RIC 2021-2027: Project STILEMI

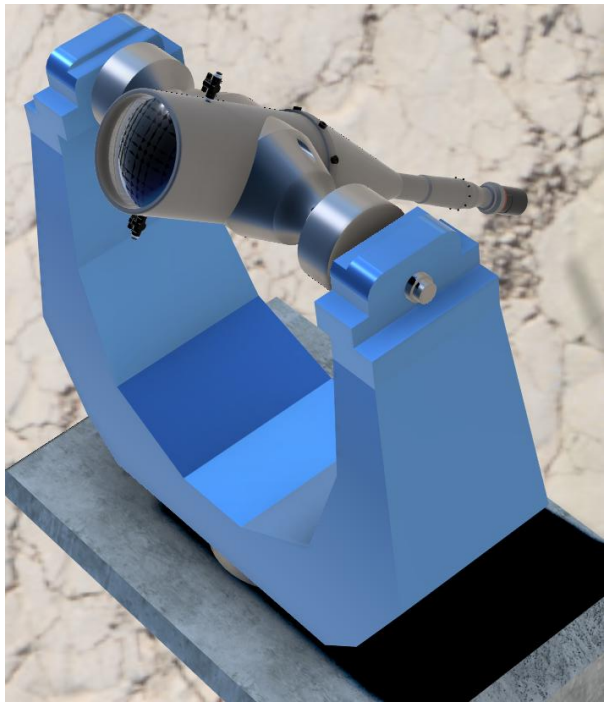
COESIONE ITALIA 21-27 RICERCA, INNOVAZIONE E COMPETITIVITÀ | Cofinanziato dall'Unione europea | Ministero delle Imprese e del Made in Italy | MUR | INAF ISTITUTO NAZIONALE DI ASTROFISICA

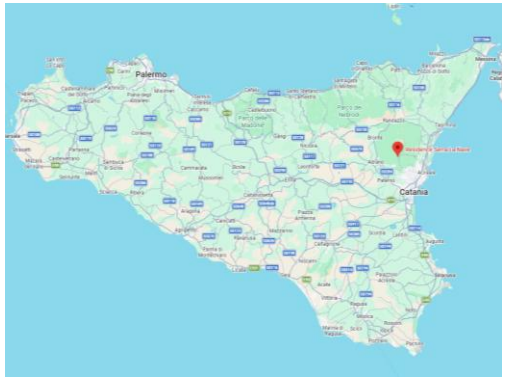
Activities: design and construction of a **60 cm diameter** liquid-filled demonstrator, **representative of a section of the final MezzoCielo sphere**. The system includes two meniscus lenses, **one or two correcting optical channels** equipped with large-format **CMOS detectors** (QHY411 Pro, 150 Mpix), and the associated **control and data-handling infrastructure**.

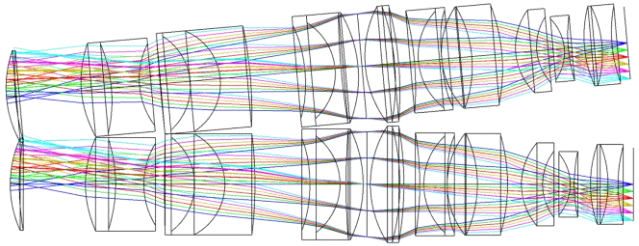
The demonstrator will be installed on an **equatorial mount** at **Serra La Nave Observatory** (Mt. Etna, Italy), providing full-sky pointing capability.

The main objectives are the validation of the optical concept, the characterization of the liquid-filled structure, the verification of the control and cooling systems, and the assessment of data acquisition and preliminary pipeline performances.

Expected completion: late 2028.







Corrector channel:
K = 0.45, F/#=2.2

QHY411 Pro
150 Megapixels

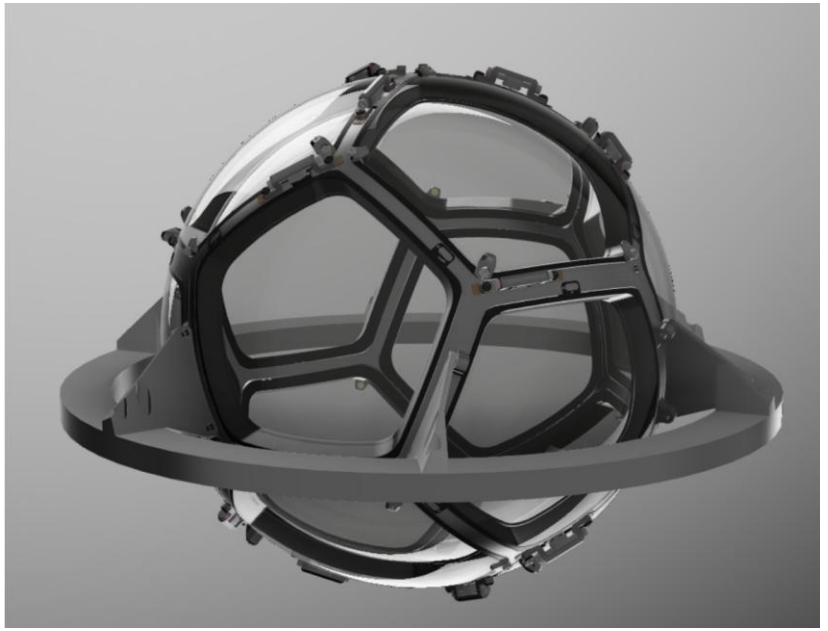
On-Sky Demonstrator

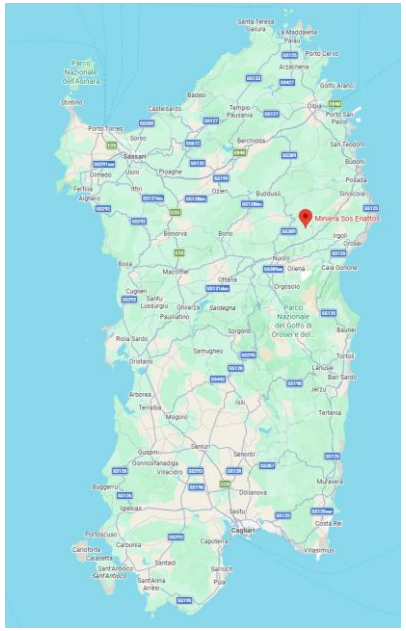
PN-RIC 2021-2027: Project ASTRASUD

Activities: development and construction of a **one-meter-class MezzoCielo sphere equipped with a first optical corrector channel.** The project includes the optimization of **mass-production processes for optics, mechanical components, and detector systems, together with the validation of the data acquisition architecture and dedicated data reduction pipelines**. Owing to its intrinsic modularity, the system is designed for progressive expansion, from an initial configuration with a single channel to a baseline of approximately **100 optical cameras**, with the potential to scale up to about **900 channels**.

Expected completion: late 2029.

Within the framework of the ET Infrastructure Consortium, funding has been secured for the construction of the **MezzoCielo dome at Sos Enattos** (Sardinia, Italy). The construction contract is currently ongoing, with completion expected by mid-2027.





Science Activities

Contact: Nancy Del Carmen Elias De La Rosa
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Preliminary Science Case for

MezzoCielo

An Ultra-Wide-Field Optical Facility for the Transient Sky

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May 30, 2026

Abstract

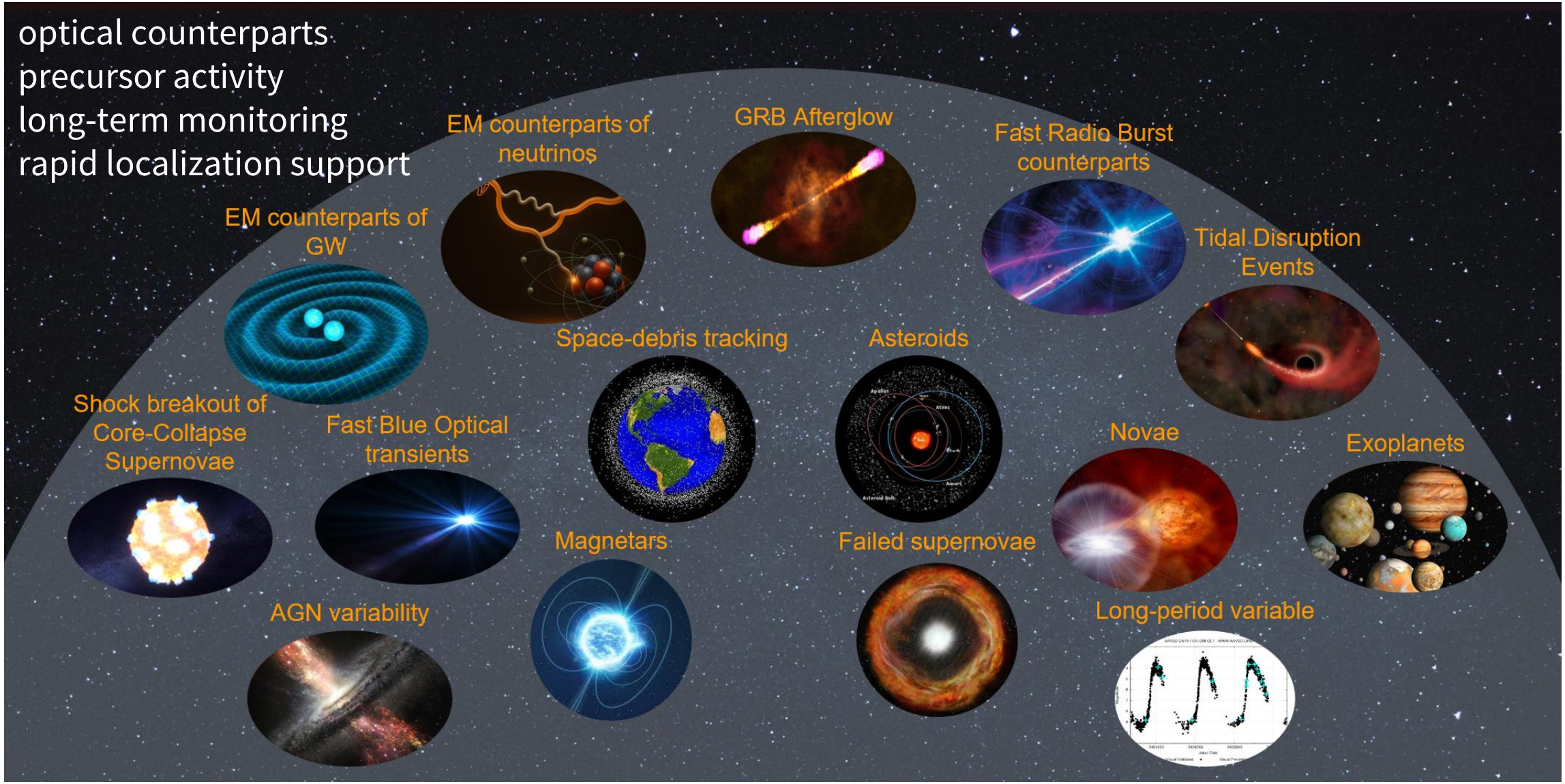
MezzoCielo (*Half-Heaven*) is a concept for an ultra-wide-field optical/near-IR facility dedicated to high-cadence monitoring of the transient sky. Its design allows near-continuous coverage of a large fraction of the hemisphere, enabling rapid follow-up of Gamma-Ray Bursts, kilonova candidates, tidal disruption events, and fast faint optical transients—including potential orphan GRB afterglows and shock-cooling signatures—down to ∼ 21–22 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.

MezzoCielo Science Cases
- Scientific Motivation
- Observational requirements
- The MezzoCielo Advantage

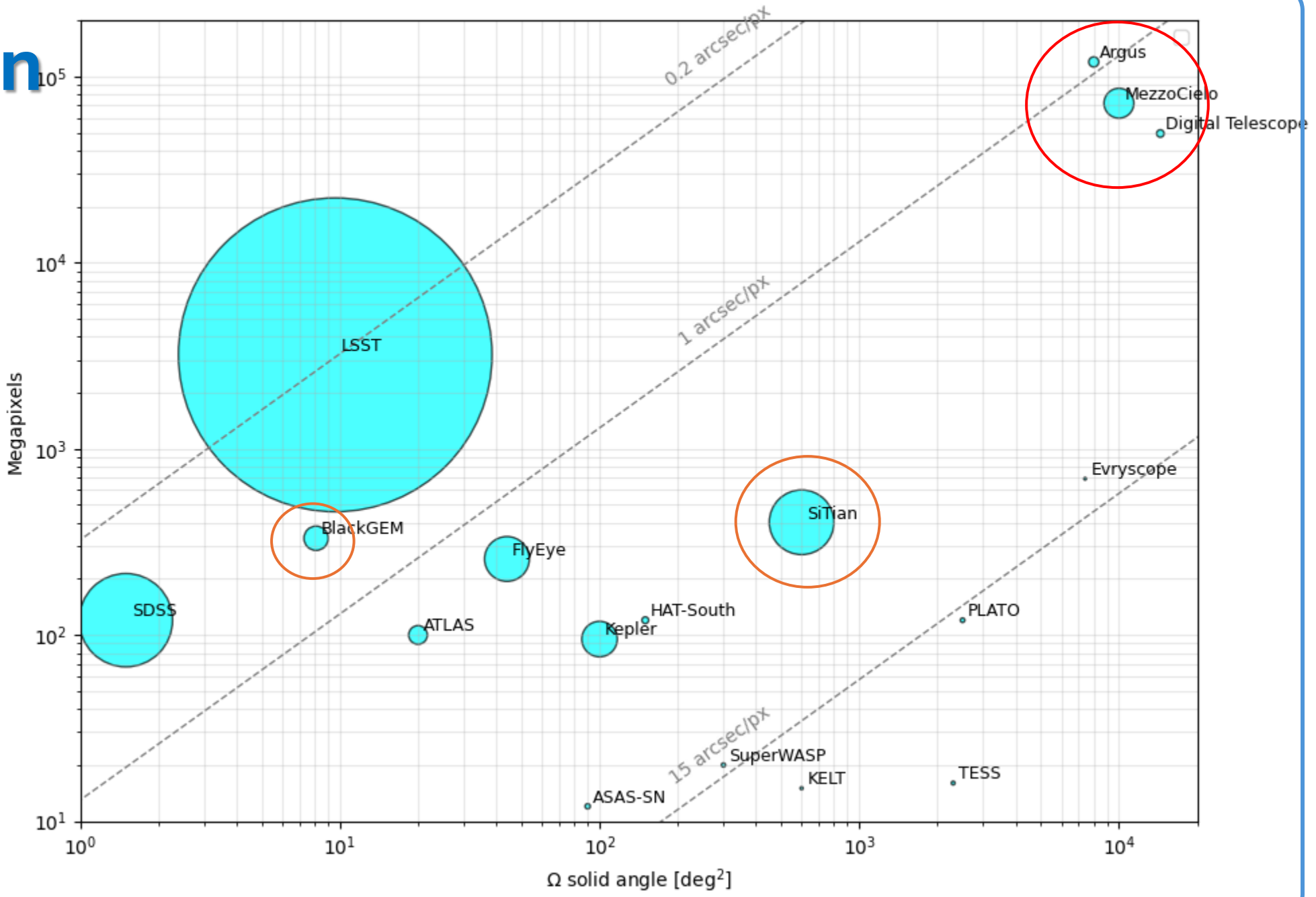
Table 4. Observational requirements and expected properties for shock breakout science.

Parameter	Value / Description
Scientific information	Progenitor radius & envelope structure; explosion energy & shock velocity; CSM density and extent
Preferred bands	Blue-optical (u/g); red-optical ($r/i/z$)
Early cadence ($\lesssim 1$ hr)	∼ 1–5 min
Median cadence ($\lesssim 1$ day)	Hourly
Long-term tracking (> 1 day)	Daily
Estimated yearly event rate	~ 5–$15\,\mathrm{yr}^{-1}$
Peak magnitude	∼ 17–21 (extended); 20–22 (compact/CSM)
Peak time	Minutes – hours post-explosion
Field of View	MezzoCielo full coverage (targeting galactic latitude > 10deg)
Alert capability	Near-real-time (alerts issued within 2 mins)
Survey efficiency	Continuous & untriggered (zero slew/dead-time)
Data storage strategy	72-hr full-frame buffer; long-term archive limited to target sub-images (few arcmin)

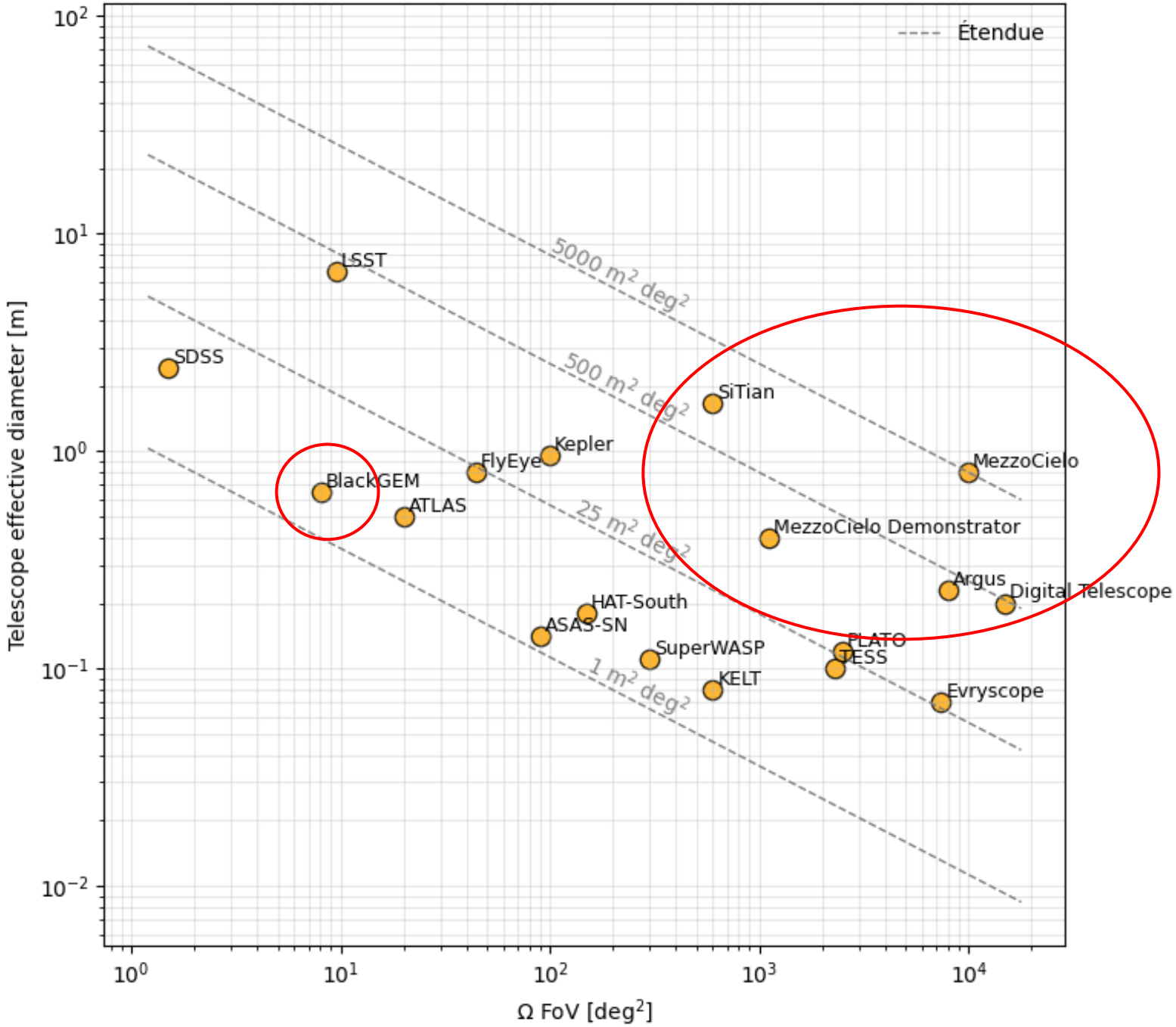
Science Cases



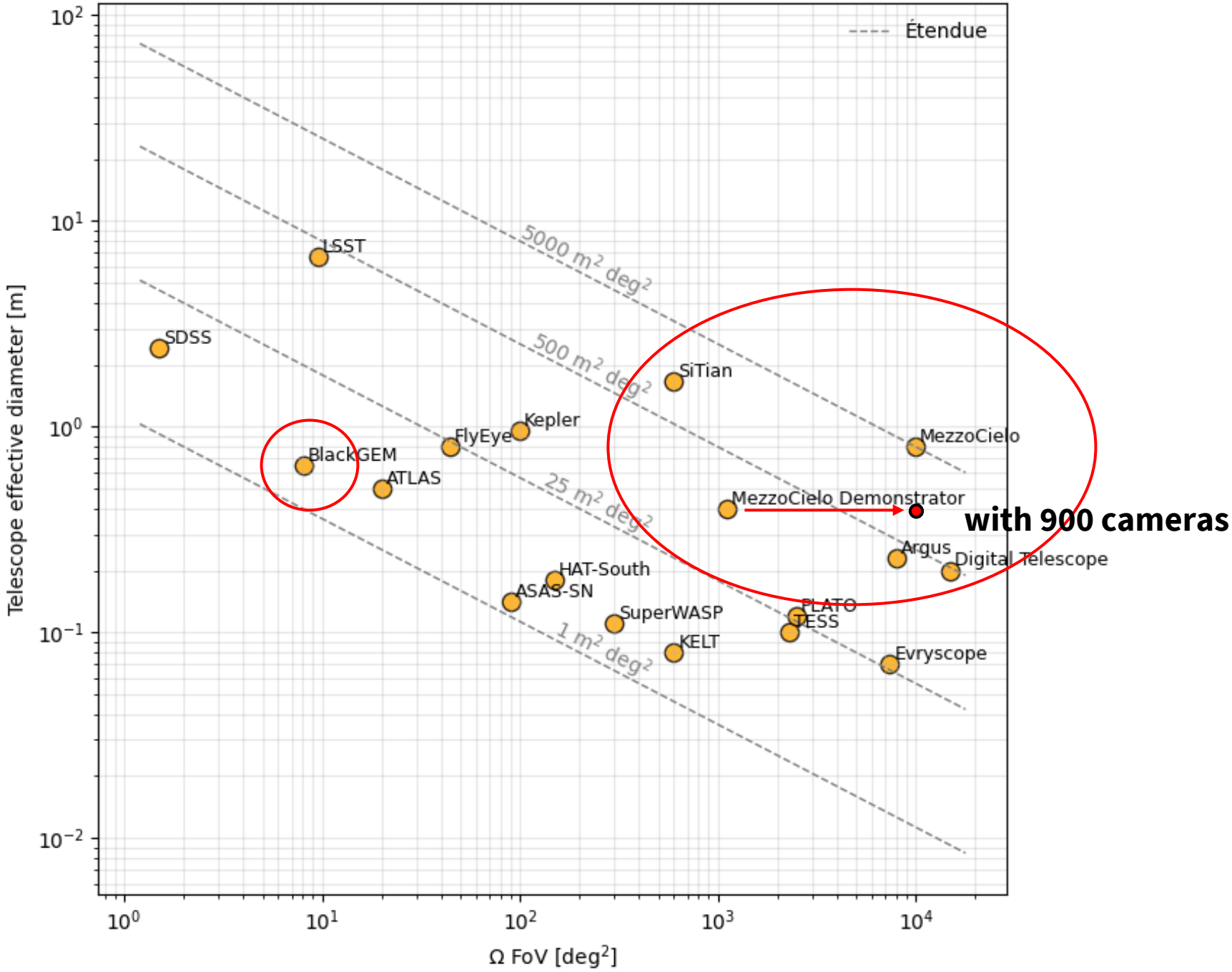
Resolution


0.2 arcsec/px
1 arcsec/px
15 arcsec/px
Argus
MezzoCielo
Digital Telescope
LSST
BlackGEM
FlyEye
SiTian
Evryscope
SDSS
ATLAS
HAT-South
Kepler
PLATO
SuperWASP
KELT
TESS
ASAS-SN
Megapixels
Ω solid angle [deg²]
10^0
10^1
10^2
10^3
10^4
10^1
10^2
10^3
10^4
10^5

Etendue


Étendue
5000 m² deg²
500 m² deg²
25 m² deg²
1 m² deg²
LSST
SDSS
SiTian
Kepler
FlyEye
BlackGEM
ATLAS
MezzoCielo
MezzoCielo Demonstrator
Argus
Digital Telescope
HAT-South
ASAS-SN
SuperWASP
PLATO
TESS
KELT
Evryscope
Telescope effective diameter [m]
Ω FoV [deg²]
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}

Etendue


Étendue
5000 m² deg²
500 m² deg²
25 m² deg²
1 m² deg²
LSST
SDSS
SiTian
Kepler
FlyEye
BlackGEM
ATLAS
MezzoCielo
MezzoCielo Demonstrator
with 900 cameras
Argus
Digital Telescope
HAT-South
ASAS-SN
SuperWASP
PLATO
TESS
KELT
Evryscope
Telescope effective diameter [m]
Ω FoV [deg²]

Take-home Messages

MezzoCielo introduces a new approach to ultra-wide-field astronomy.

It combines large sky coverage and substantial collecting area.

It is being developed through a progressive roadmap from prototype to operational facility.

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