

Presentation for admission to the 2° year

PhD Program of National in Technologies for fundamental research in
Physics and Astrophysics (Curriculum: Detectors, Lasers and Optics)

Optical Design for the MezzoCielo Telescope

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Supervisor: Demetrio Magrin

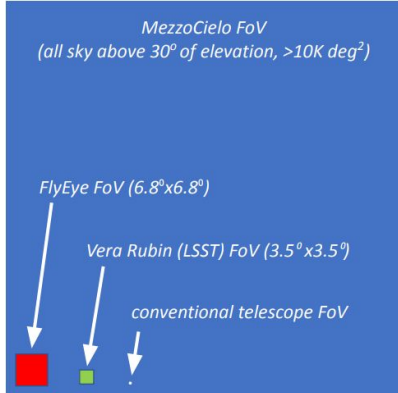
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MezzoCielo Concept

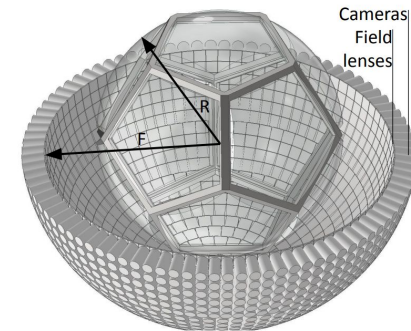
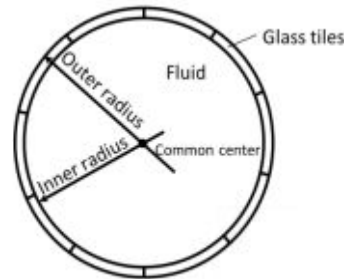
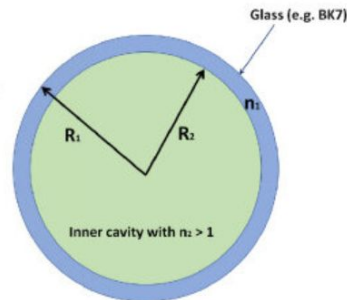
A novel global telescope

- Monocentric spherical system
- Ultra-wide sky coverage ($\sim 10^4$ deg²)



FoV coverage Comparison

- Preliminary transparent, low index & non-toxic! liquid
- **900** identical camera channels



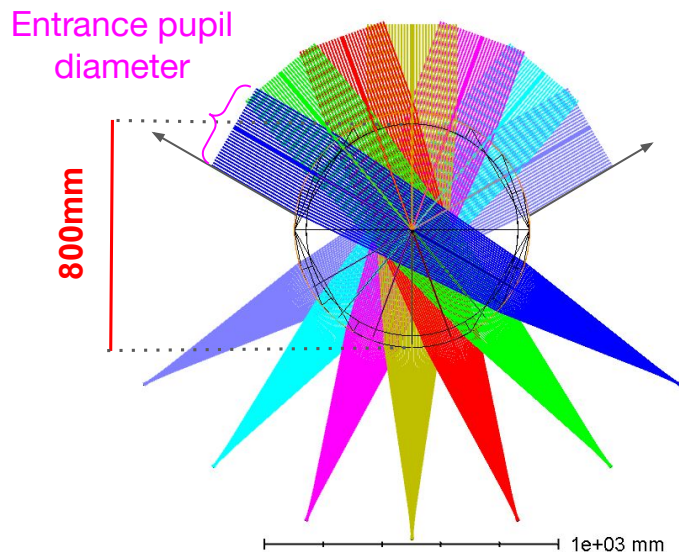
A 3D rendering of a possible layout of MezzoCielo



Optical materials:
BK7 glass: $n_1 = 1.5168$,
FC-72 optical fluid: $n_2 = 1.2512$
at $T = 20^\circ\text{C}$ and $\lambda = 580.7$ nm

Designing a **demonstrator** as a scaled proof-of-concept

- Sphere diameter of 800mm
- N-bk7 glass shell of 40mm

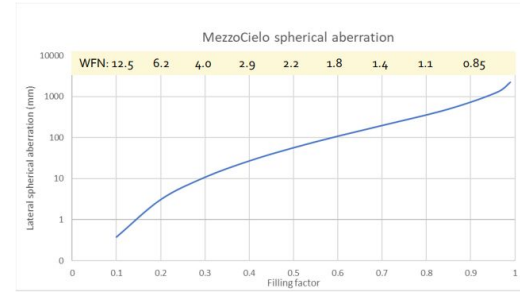
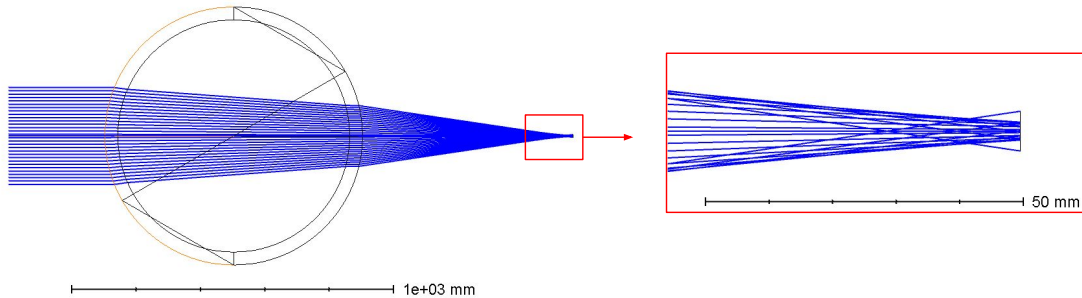


Fixed Parameters (Design Constraints)

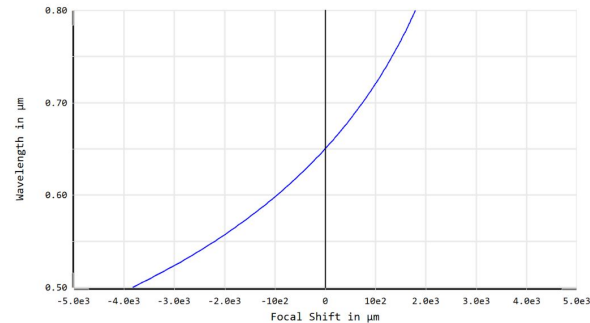
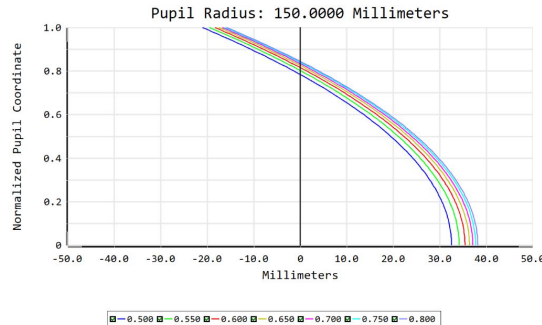
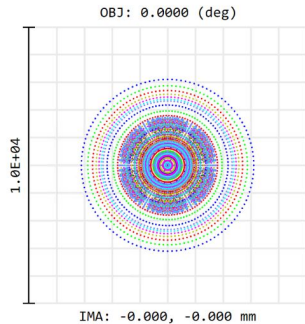
- **Detector:** Use of typical CMOS format
1.3 arcsec/pixel, 2x2 binning
- **Effective focal length :** Matches detector resolution
EFL = 800 mm
- **Required image quality**
EE(80%) < 3.8 μm
- **Waveband:**
Visible to Near Infrared

Aberrations in the Spherical System

- **Spherical Aberration: Core Challenge** Rays from a point source do not converge at a single focus, creating a blurred image.

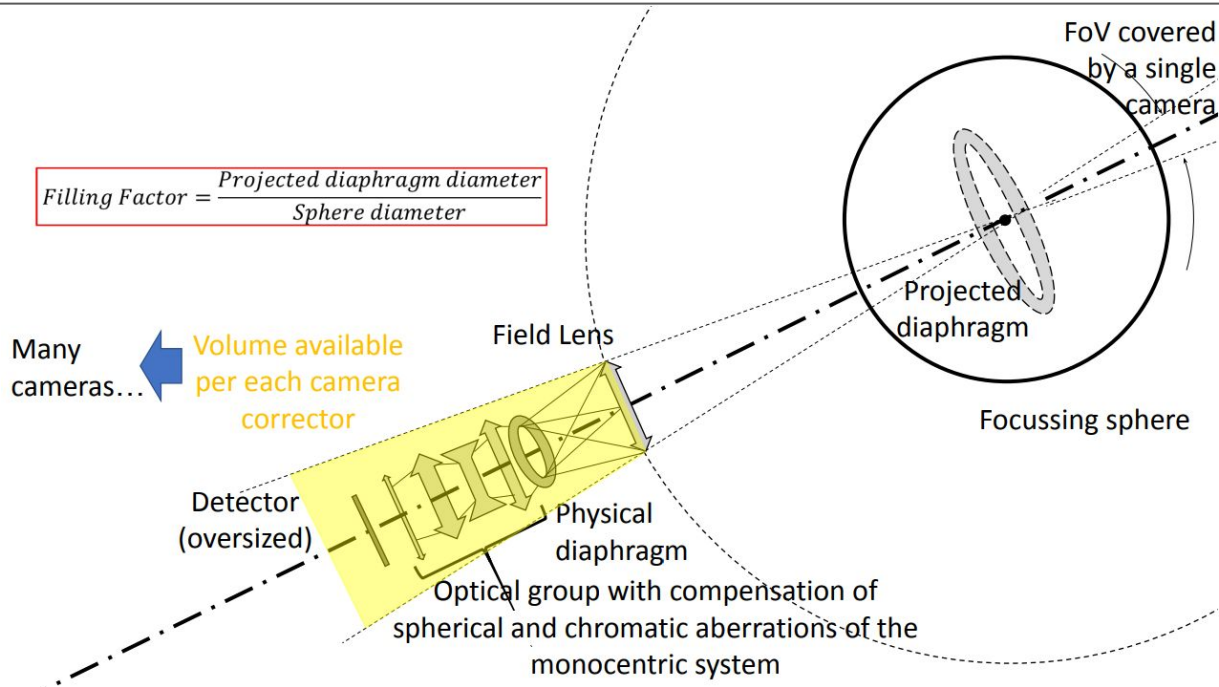


- **Chromatic Effects:** Different wavelengths focus at slightly different points, adding color-dependent blur.



The concept of the corrector

- Placing it close to the focal surface
- Compact group of refractive elements, optimized for selected Field of View & maximum Filling Factor



Corrector Design: Preliminary but realistic

Outlining a stepwise process for developing a corrector design, emphasizing analysis and refinement through four key stages.

Baseline Solution

Establish an initial optical design model using Zemax, focusing on merit function and material selection.

Image Quality

Conduct an image quality analysis to evaluate performance metrics and ensure targets are met.

Design Refinement

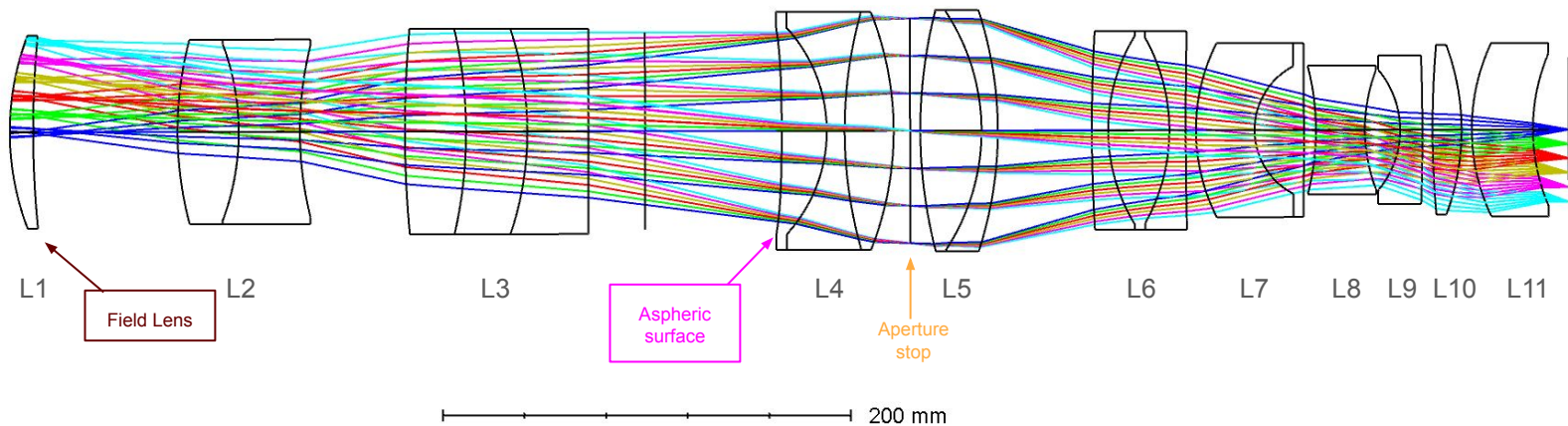
Optimize the design by removing non-critical elements and enhancing manufacturability for improved performance.

Progressive Complexity

Gradually increase the system's field of view, expand the aperture, and extend the spectral range to approach demonstrator-scale parameters.

Current Corrector Design / Layout

Current corrector design — refined through multiple trials to establish the baseline optical path



Entrance Pupil Diameter
300 mm (filling factor 37.5%)



Number of Lenses
11 Optical Surfaces



Aspheric Surface
1



Field of View
5°

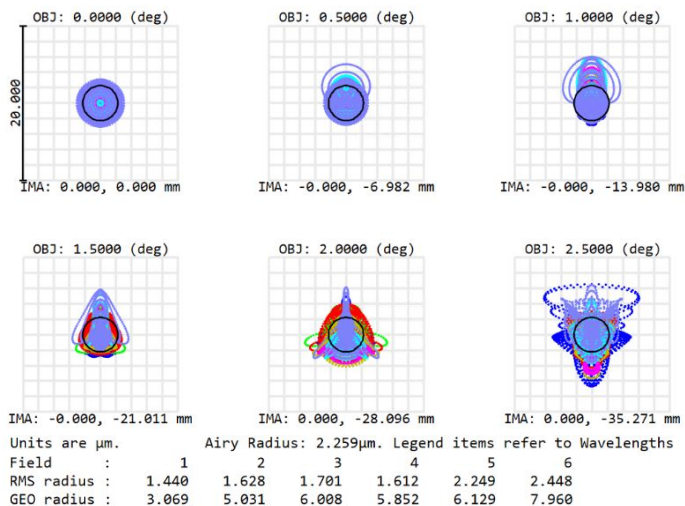


Wavelength Range
500–800 nm

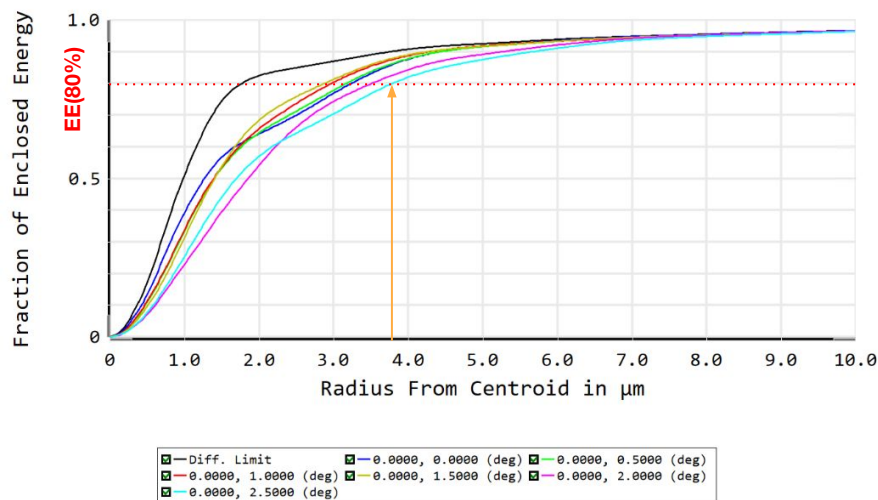
Image Quality Results

image quality assessment of the current corrector layout

Spot diagram



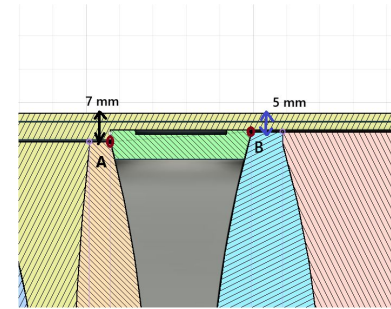
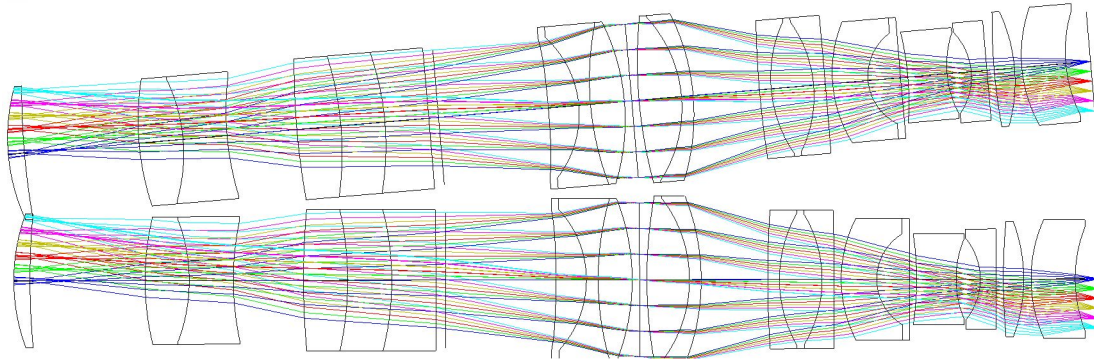
Diffraction Encircled Energy



EE(80%) < 3.8 μm

Challenges / Difficulties Encountered

During the current corrector design, mechanical constraints from the lens mounts limit the maximum lens diameters, making it challenging to increase the entrance pupil beyond 300 mm.



Future Work / Next Steps

Aperture Optimization

Push to increase the entrance pupil diameter to achieve a higher filling factor.

Thermal, Coating & Alignment Studies

Evaluate environmental and material effects on optical behavior.

Tolerancing & Monte Carlo Simulations

Assess performance under realistic manufacturing and alignment variations.

Cost Analysis

Assess manufacturing, coating, and assembly costs to guide design trade-offs.

Courses

- Project Management in Science [Approved]
- Adaptive Optics for Astronomy I [Attended]
- Adaptive Optics for Astronomy II [Attended]
- Radio and Optical Interferometry [Attended]
- Advanced Electronic Sensing Devices [Attended]

Schools

- Gran sasso conference – February 2025
- NYRIA Workshop - September 2025
- Observing with Adaptive Optics International School - October 2025

Published papers/Poster:

- Engineering a whole sky one meter class telescope: MezzoCielo as a patrol of transients, <https://doi.org/10.1117/12.3019730>

Thank you