FORTH
INSTITUTE OF ASTROPHYSICS

SKINAKAS OBSERVATORY

https://skinakas.physics.uoc.gr

Vassilis Charmandaris
Director, Institute of Astrophysics FORTH & Skinakas Observatory
Professor, Department of Physics, University of Crete

IA-FORTH History & Goals

Founded in 2018 after 20+ years of successful astrophysics activities within IESL-FORTH

- **Targeted Scientific Research**
  - ✓ Theoretical Astrophysics
  - ✓ Observational Astrophysics (ground based and space born)
    - ✓ Fields: compact objects, high-energy astrophysics, ISM physics, galaxy evolution, cosmology, astrostatistics, pulsar timing arrays, time domain astrophysics.
- **Major Research Infrastructures**
  - ✓ Skinakas Observatory - @1750m altitude, ~50km from Heraklion
  - ✓ High Performance Computing cluster “Metropolis” of the Dept. of Physics
- **Education and Public Outreach**
  - ✓ Training of students and postdocs to address key outstanding problems in astrophysics
  - ✓ Organizing astronomy stargazing PO events across Crete – engaging public in science
  - ✓ Directly involved in influencing astronomy & STEM curricula in K-12 levels

➢ Small in size - Emphasis on Excellence – “Boutique” Institute

FORTH – Timeline

Research Center of Crete (RCC), Heraklion
Institute of Electronic Structure and Laser (IESL)
Institute of Molecular Biology and Biotechnology (IMBB)
Institute of Computer Science (ICS)

Institute of Applied and Computational Mathematics (IACM), Heraklion
Institute for Mediterranean Studies (IMS), Rethymnon

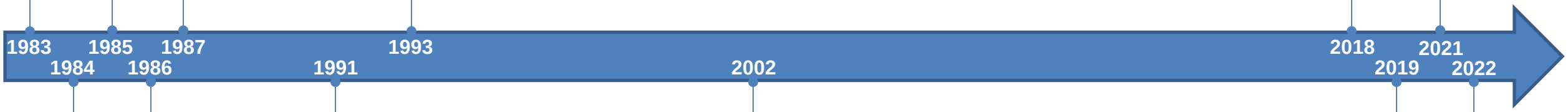
Foundation for Research and Technology – Hellas (FORTH)
Institute of Chemical Engineering Sciences (ICE-HT), Patras

Science and Technology Park of Crete (STEP-C), Heraklion

Budget: ~62 MEuros (20% from state)
Personnel: ~1,500 (~500 Researchers,
~550 Technical
~350 PhD/MSc
~100 Admin)

Biomedical Research Institute (BRI), Ioannina

Institute of Astrophysics (IA), Heraklion



PRAXI Network

Skinakas Observatory, Rethymnon

Biomedical Research Institute (BRI), Ioannina

Institute of Geoenergy (IG), Chania

Crete University Press (CUP)

Greek Institute of Human Genomics (GIHG), Athens

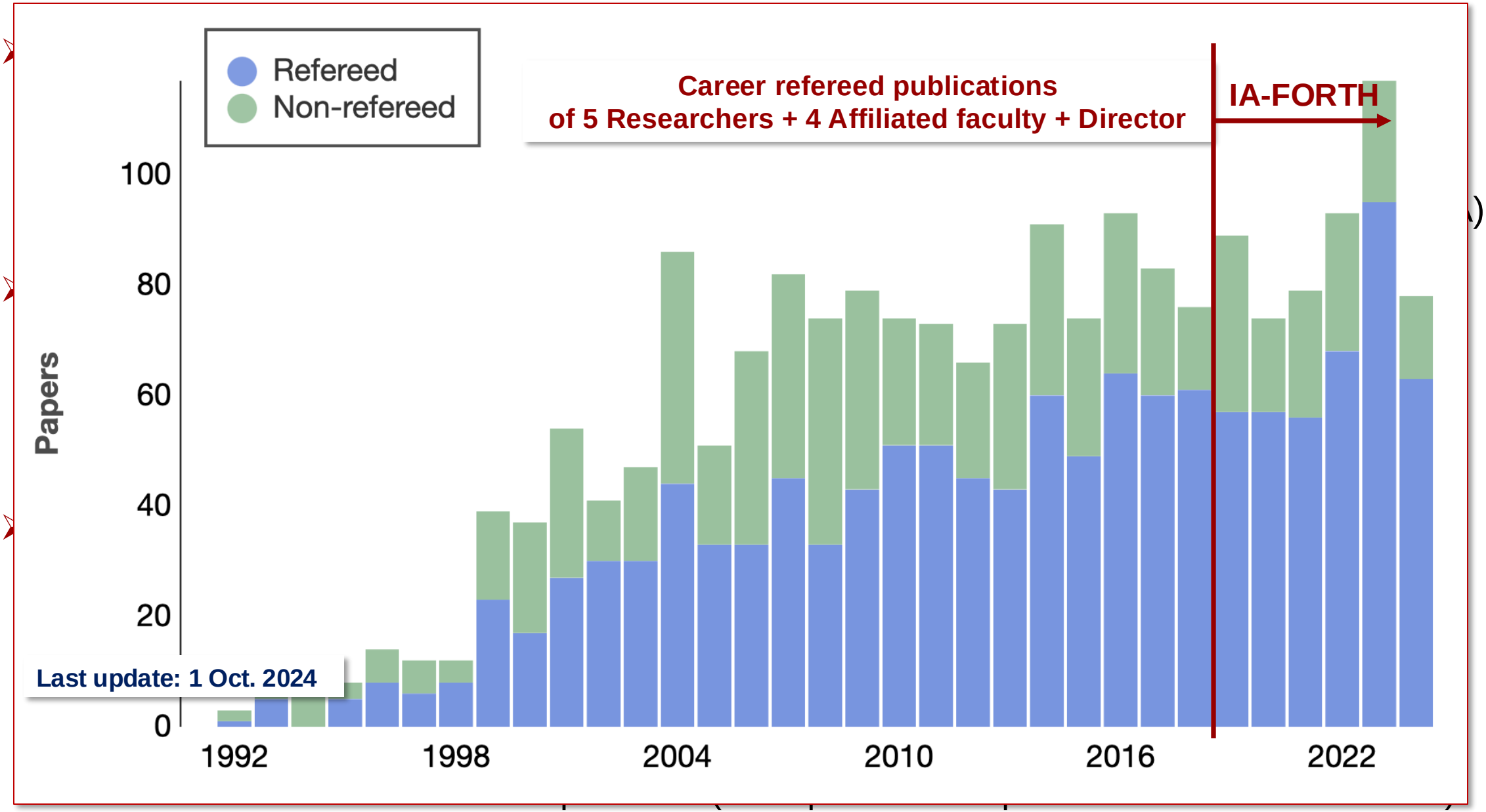
IA-FORTH Personnel & Key Figures

- **Current Permanent Personnel (13+7)**
  - ✓ 5 Researchers (2 funded by ERC) & 4 UoC Affiliated Faculty & Director
  - ✓ 1 Engineer, 1 IT support & 1 UoC dedicated technician for Skinakas Observatory
  - ✓ 4 affiliated faculty outside Greece & 3 lifetime honorary fellows (Caltech, Cambridge, CEA)

- **Current Soft Money Full time Personnel**
  - ✓ 3 Observatory support & 1 Public Outreach & 1 Secretary & 1 Project officer
  - ✓ 13 postdoctoral researchers + 1 visiting postdoc
  - ✓ 23 PhD students – 6 MSc students

- **Scientific Output & international recognition (over the past 18 years: 2005-2023)**
  - ✓ 885 refereed papers (7 in Nature & 4 in Science)
  - ✓ World quality research: most citations per astrophysics researcher in Greece
  - ✓ **Awarded 5 ERC Grants** (+2 other graded A but not funded: 80% of hires since 2008)
  - ✓ Awarded ~11MEuros in competitive funding (EC, ESA, Greece) since 2014
  - ✓ Trained 22 PhD students + 34 postdocs (23 in perm. acad. positions: 13 outside Greece)

IA-FORTH Personnel & Key Figures



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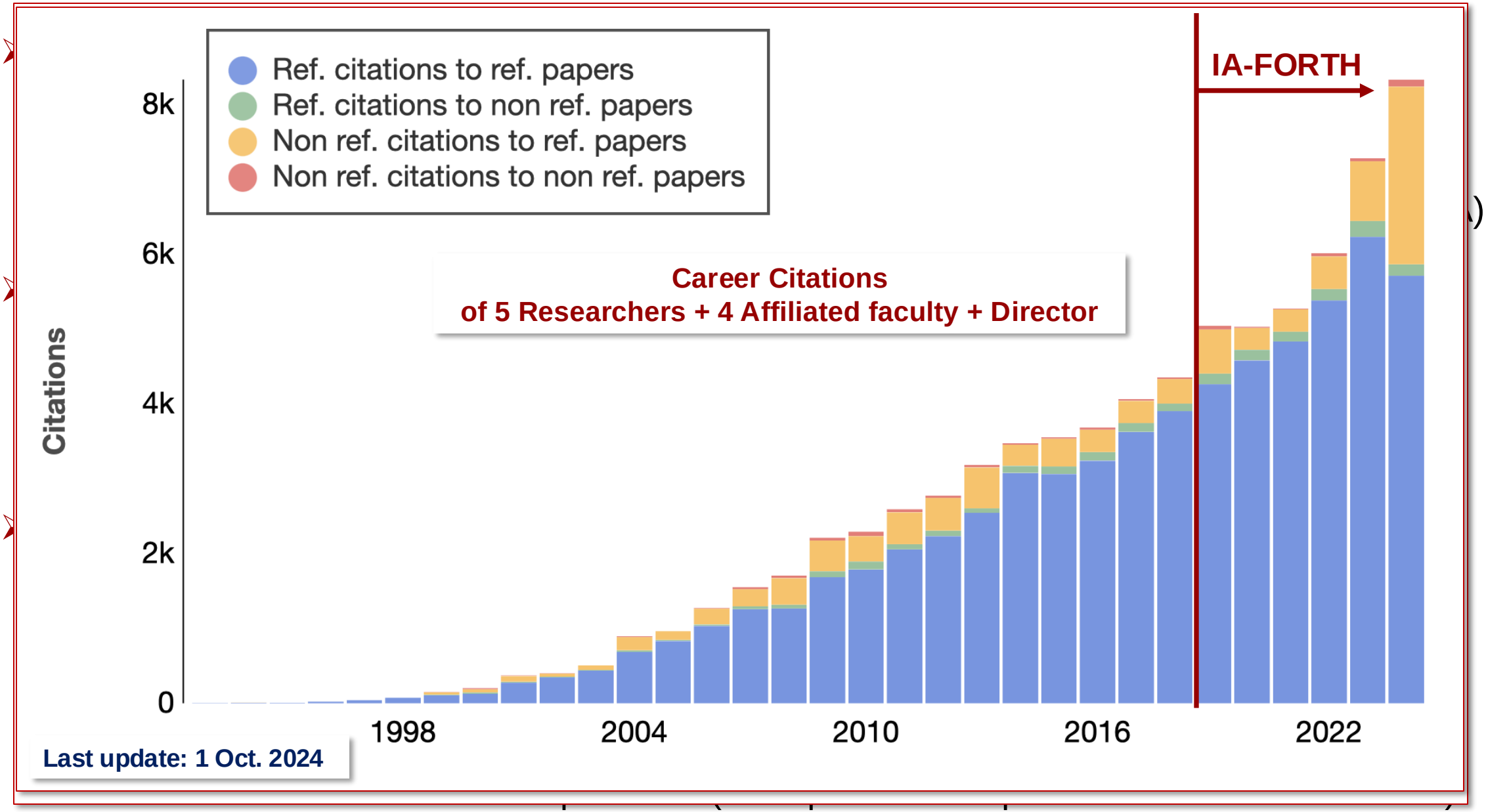


IA-FORTH - Strategic Collaborations

- **Strategic Collaborations within FORTH/UoC**
  - ✓ Univ. of Crete: Operation of Skinakas Observatory
  - ✓ FORTH-IESL: Context of EuroQCI and ESA/Scylight initiatives
  - ✓ FORTH-ICS: Signal Processing Lab and Astrostatiscs & Astroinformatics Initiatives
    As of 2023, an ERA Chair for Dr. Jean-Luc Starck (CEA/Saclay)
  - ✓ FORTH-IACM: Context of advanced computational algorithms, sparse inverse problems

- **Strategic Collaborations with external Institutes**
  - ✓ Caltech: Context of Robopol, PASIPHAE, SMILE
  - ✓ Univ. Minnesota: Context of TURBO – Time domain in optical
  - ✓ Cambridge: Science with GAIA under the auspices of GAPSTI – Impact for Greece
    Coordination of small/medium size telescopes in Europe in TDA & Telecom
  - ✓ MPIfR & CEA: Context of ARGOS – Time domain in radio
  - ✓ Additional long term science collaborations with CfA/Harvard, Northwestern, Imperial College, CEA, Geneva Obs., (etc) in EU funded research projects

- **Strategic Collaborations with other stakeholders**
  - ✓ Town of Anogeia: Involve infrastructure at Skinakas in astrotourism activities.

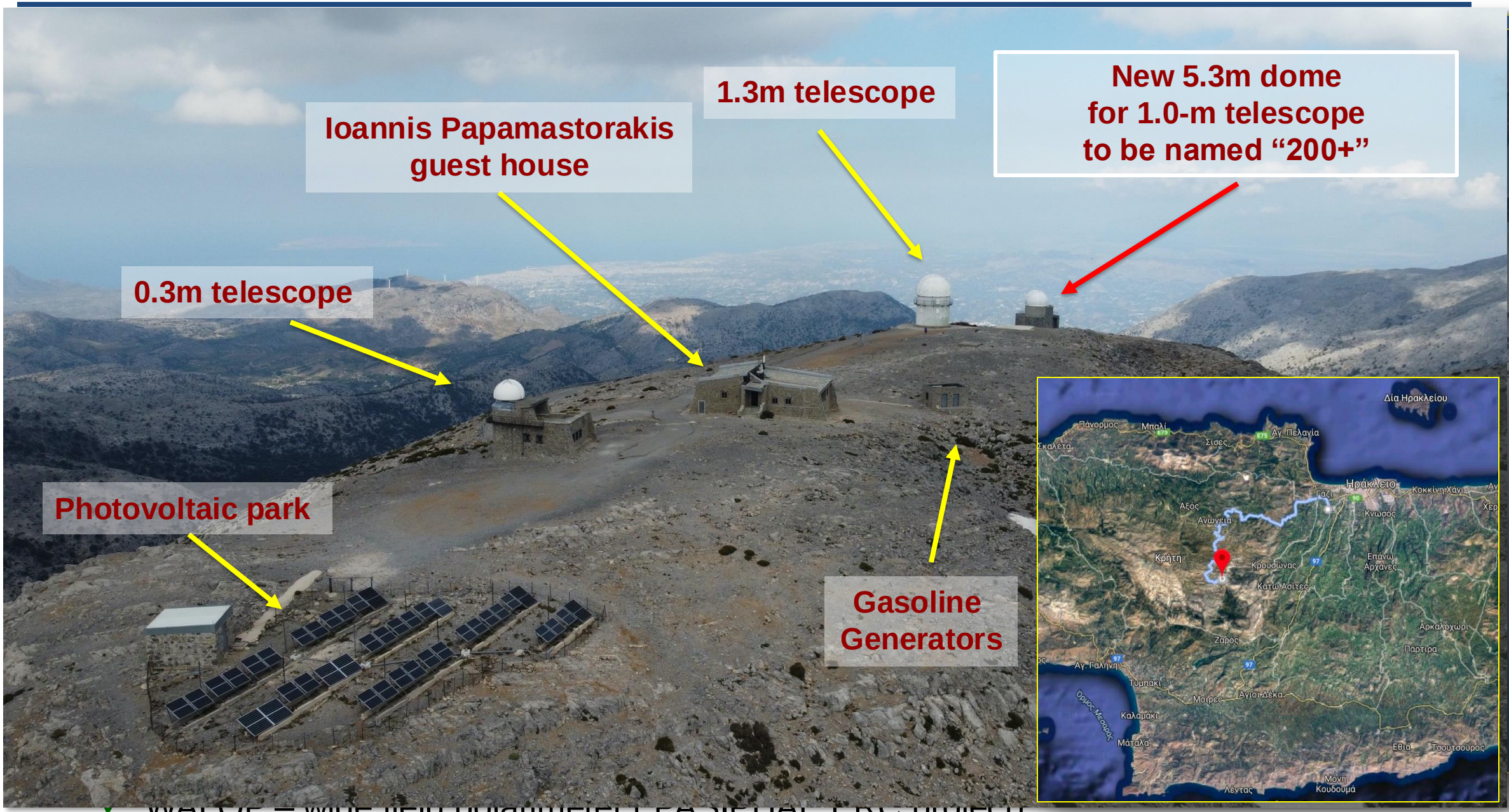
IA-FORTH - Public Outreach & Education

- **Open Nights at Skinakas Observatory**
  - ✓ Typically 5 to 10 nights per year (~2000 visitors), started 25 years ago – Improved experience
  - ✓ Produce PO material – ie via the GEOSTARS project (also CUP Skinakas photos albums)

- **Support STEM education at K-12 via astronomy projects**
  - ✓ Directly involved in creating educational material (1 FTE)
  - ✓ Organizing since 2021, the Annual Crete School of Astrophysics (~100 high school students /yr)
  - ✓ Established in 2021 and support the annual "Eureka Prize" to recognize motivated high school teachers using astronomy as a tool to inspire their students in STEM

- **Create quality science content in social media**
  - ✓ Active YouTube channel (~280 videos, >2100 subscribers)
  - ✓ Vibrant Facebook page (>5700 subscribers): https://www.facebook.com/ia.forth
    - ✓ Regular astronomy news in Greek/English
    - ✓ Inform on achievements of IA scientists
    - ✓ Announce PO & Educational events broadly
  - ✓ IA-FORTH photo gallery (>1100 photos) : https://gallery.ia.forth.gr
    - ✓ A selection of our spectacular astronomical images

IA-FORTH – Skinakas Observatory (1 of 2)



- WALOP – wide field polarimeter (PASIPHAE ERC project)

IA-FORTH – Skinakas Observatory (1 of 2)

- **Skinakas Observatory**
  - ✓ Located at Anogia region (~1750m altitude)
  - ✓ Excellent seeing conditions (due to laminar air flow)
  - ✓ Infrastructure investment of ~8MEuros (1MEuro from MPE)
  - ✓ 280 refereed papers produced with Skinakas data

- **0.3m Schmidt telescope (first telescope in 1986)**
  - ✓ Wide field of view (3 degrees)
  - ✓ 1st CCD camera in Greece (study of PNe and comets)

- **1.3m Ritchey-Chretien Telescope (1995)**
  - ✓ Best equipped small telescope in continental Europe
  - ✓ Optical cameras (complete filter suite) & long-slit spectrogra
  - ✓ Near-IR camera (complete filter suite)
  - ✓ OPTIMA MPE fast photometer (μsec cadence – fastest in w
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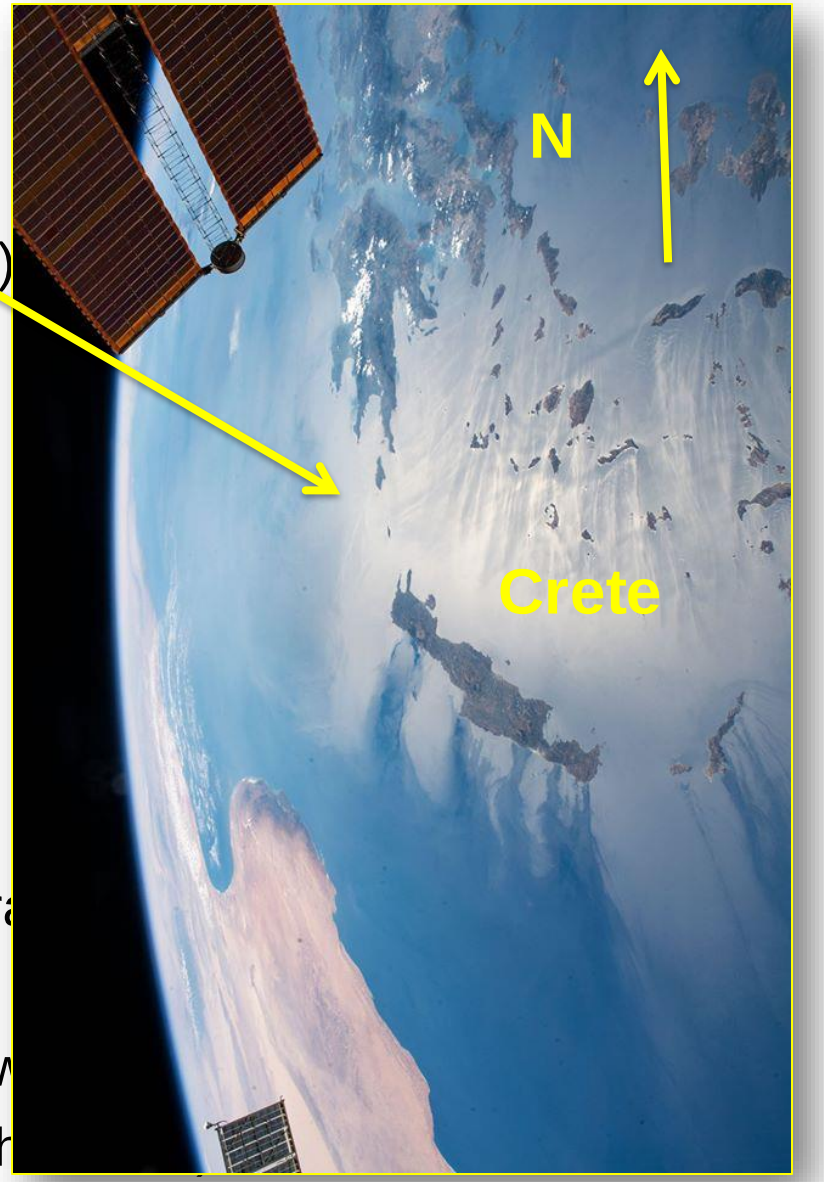

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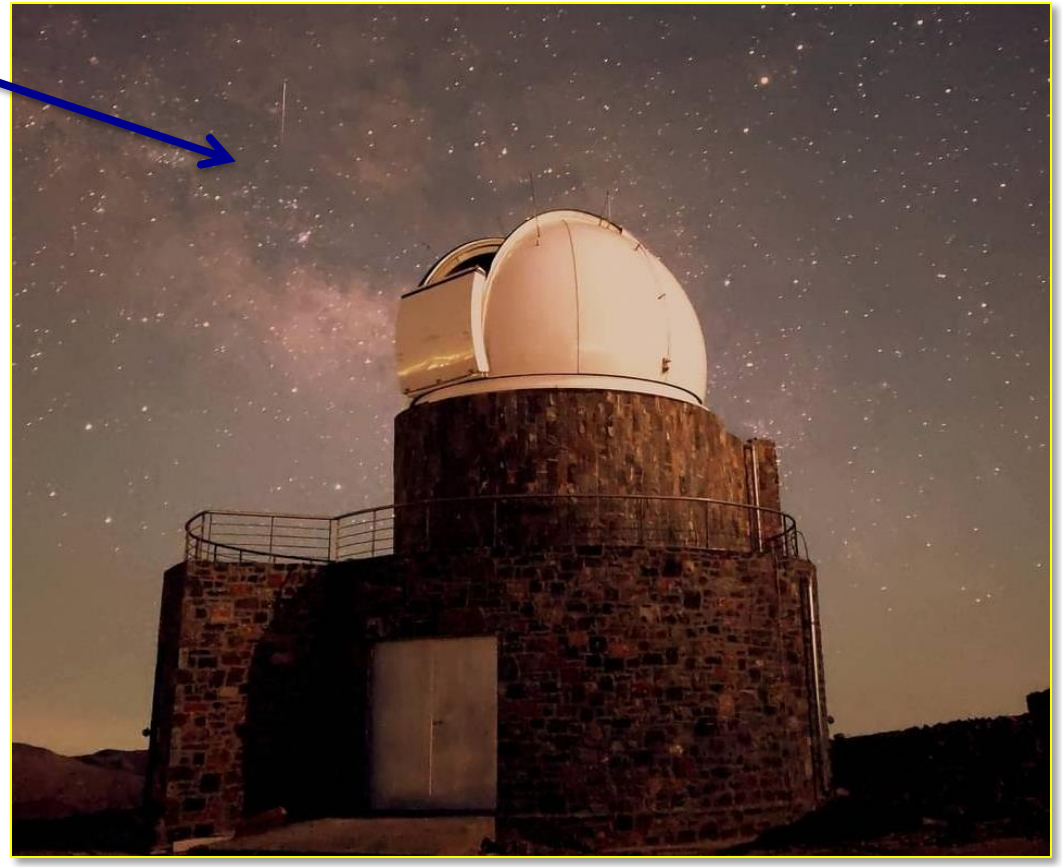
IA-FORTH – Skinakas Observatory (2 of 2)

- **Skinakas Observatory New Building**
  - ✓ Fast (12 deg/sec) 5.3m Baader dome
  - ✓ Full construction completed in May 2022



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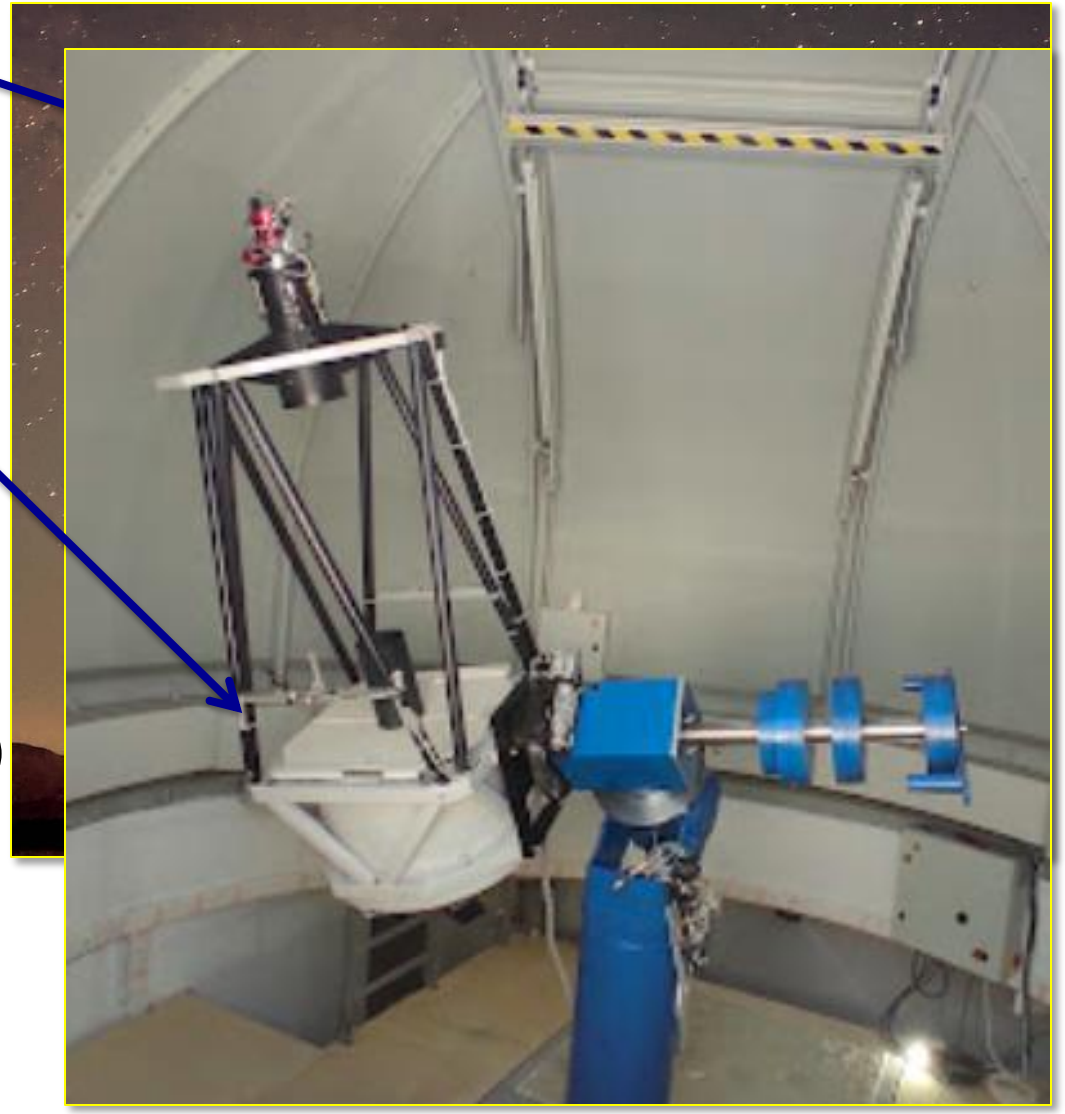
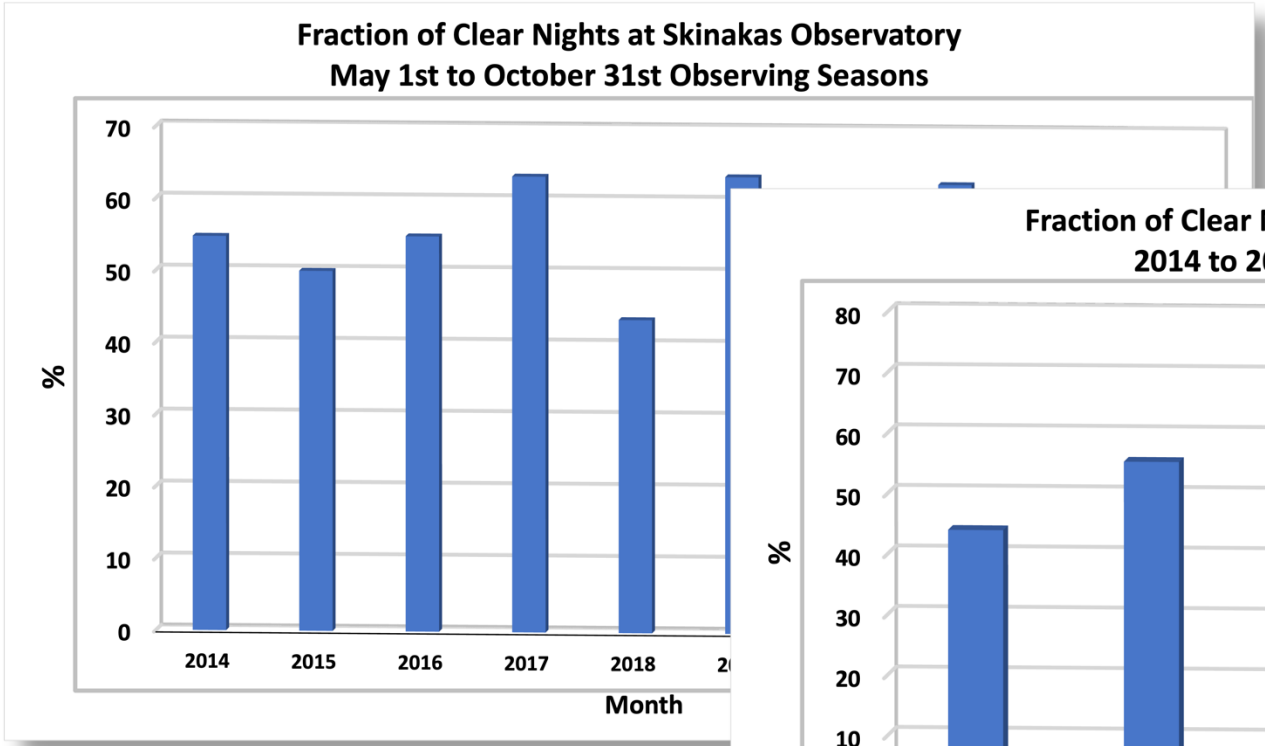
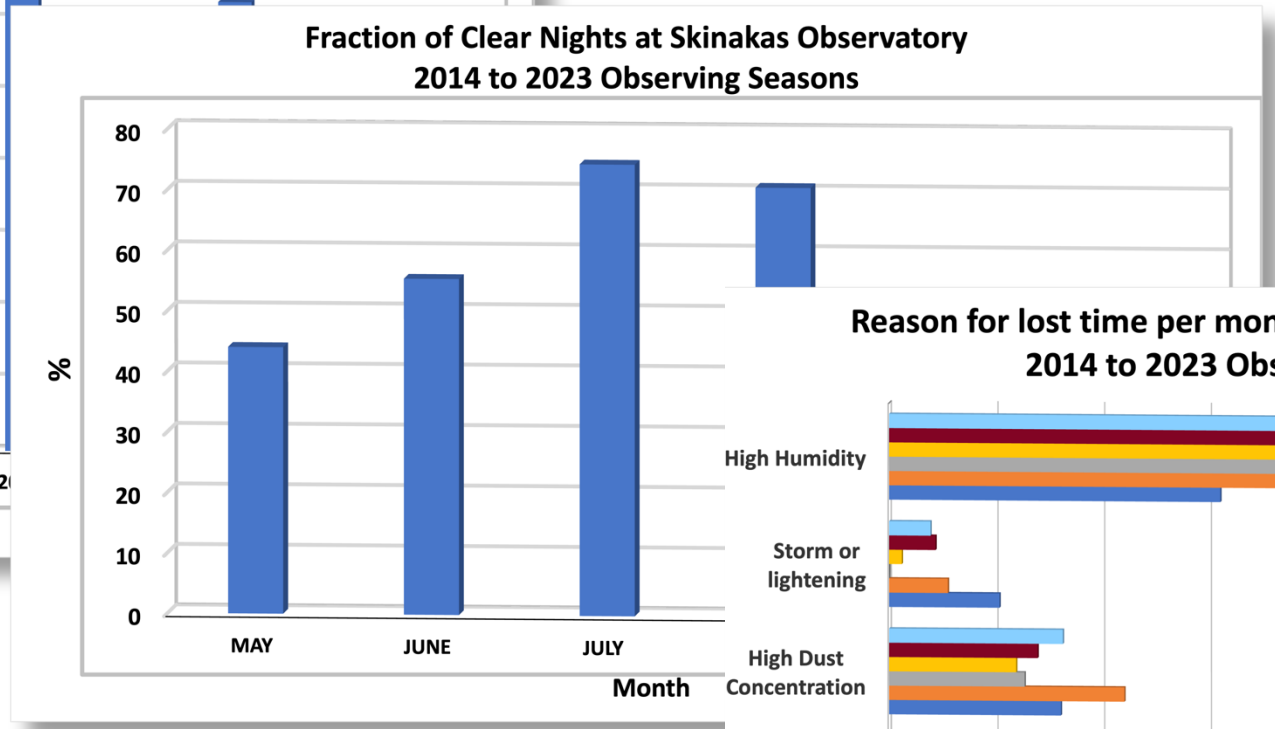
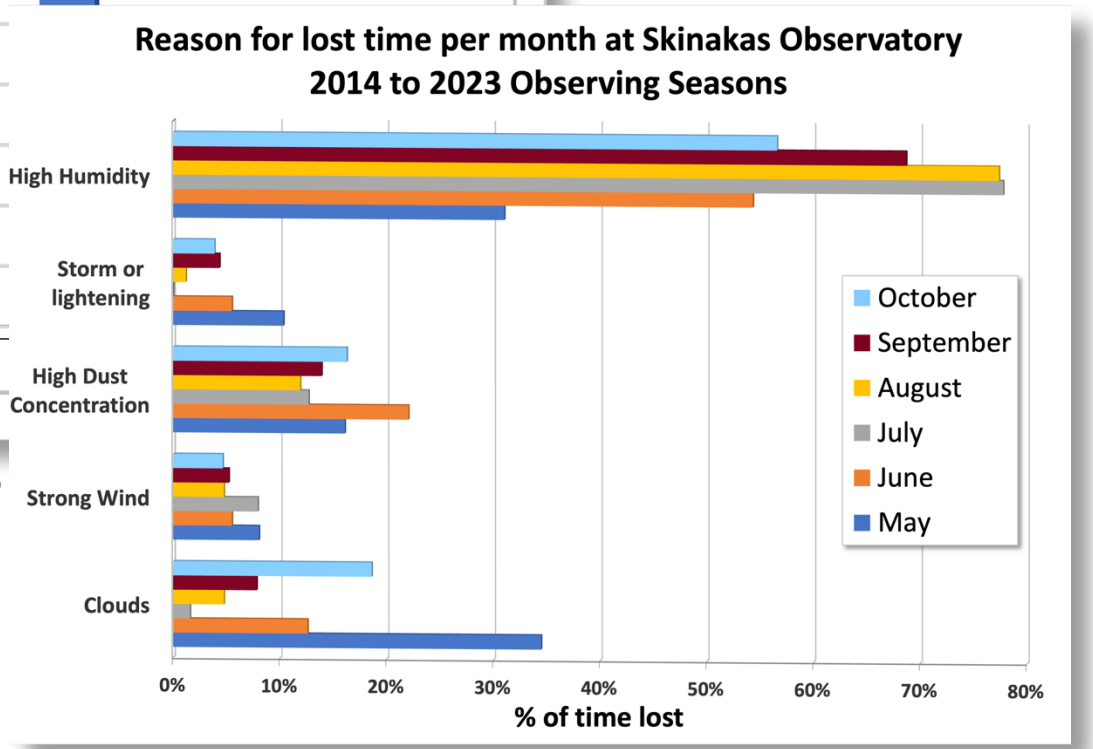
- **Telescope 0.6m (f/8) Cassegrain**
  - ✓ **FOV: 29'x20' or 60' x 30' on prime focus**
  - ✓ Reinstalled in May 2022 (past 2006-2013)
  - ✓ Rapid follow-up of transients
  - ✓ Monitoring of astrophysical objects
  - ✓ Astrophotography (amateurs of Tuebingen area)
  - ✓ Training of undergraduates of Univ. of Crete
  - ✓ Educational & STEM activities with schools
  - ✓ Applied research (satellite monitoring EU-SST)



IA-FORTH – Skinakas Weather (1 of 3)



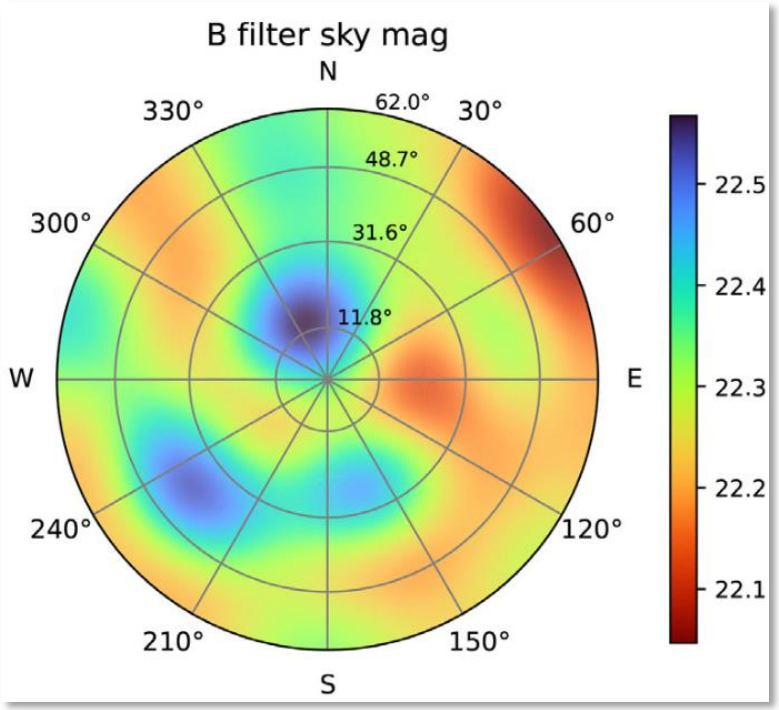


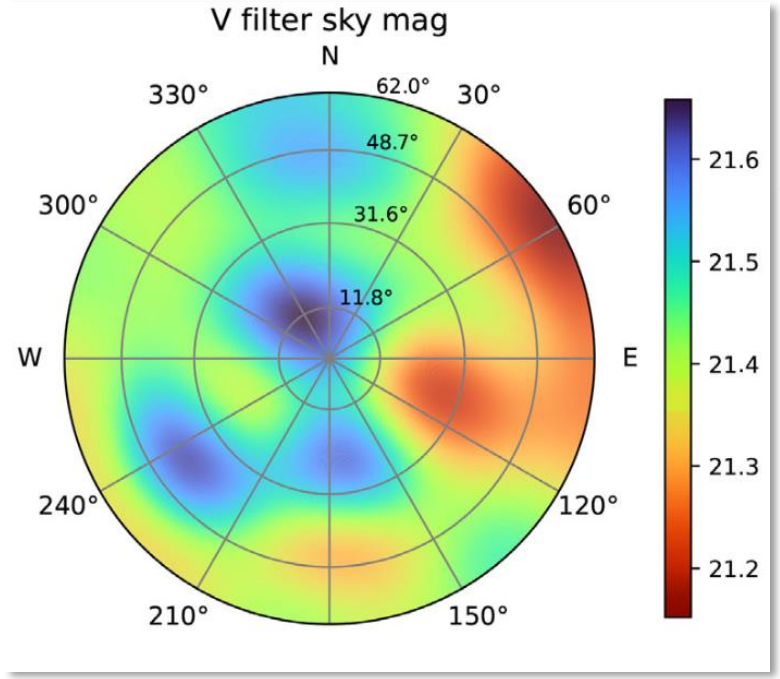


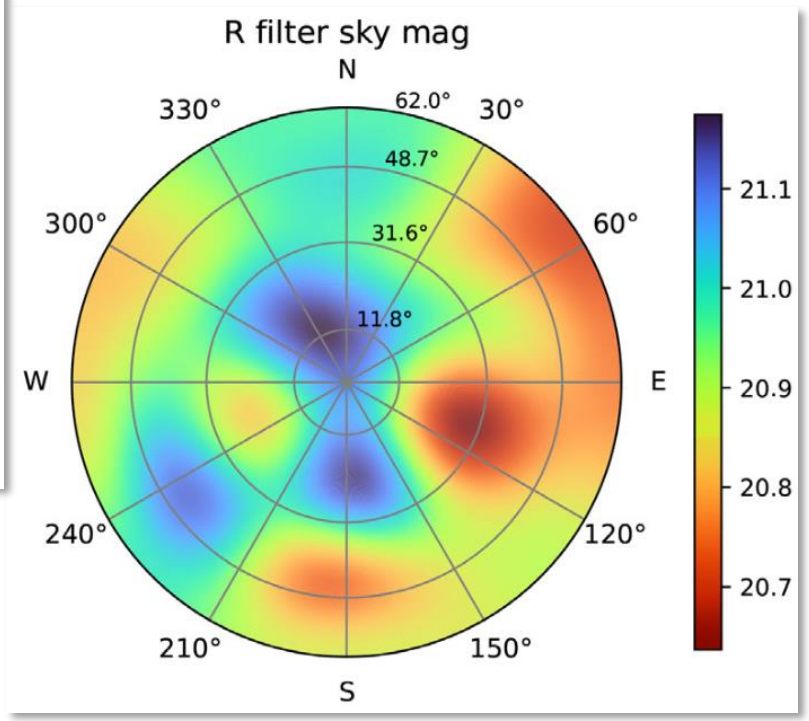
Our plans are to **become fully operational during the whole year** starting in 2026.
(thanks to connection to the electric grid and ensuring cleaning the road from snow using equipment of the town of Anogeia)

https://skinakas.physics.uoc.gr/en/index.php/weather

IA-FORTH – Skinakas Weather (2 of 3)

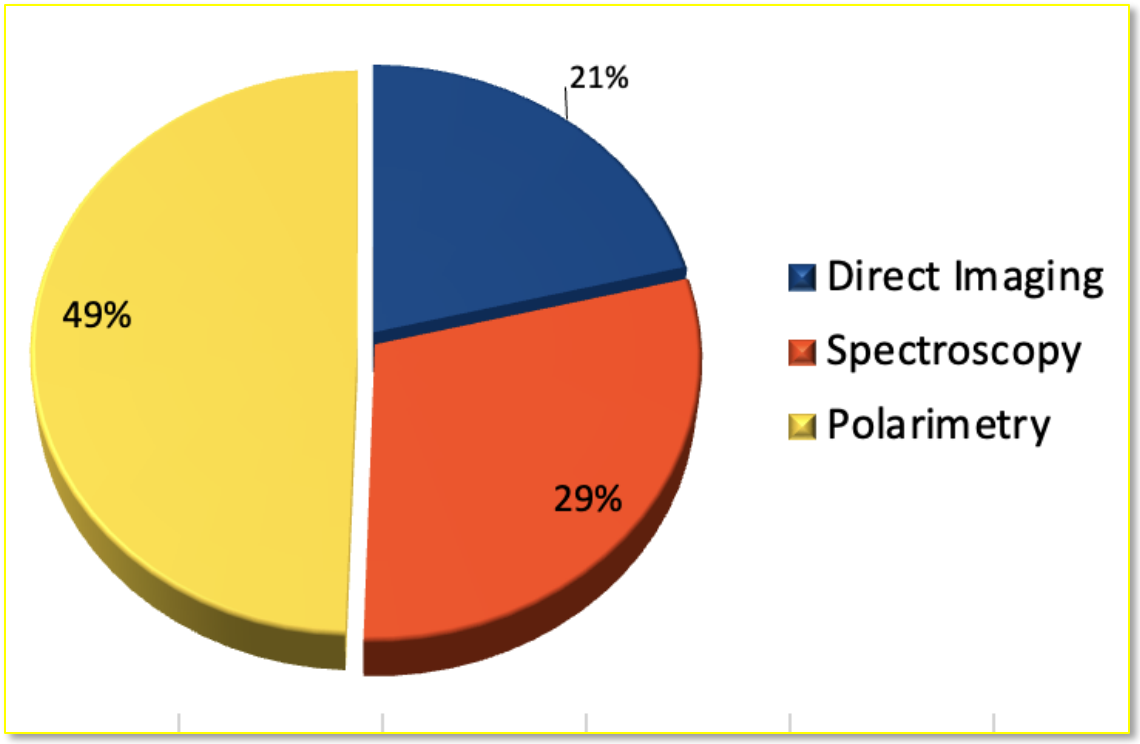


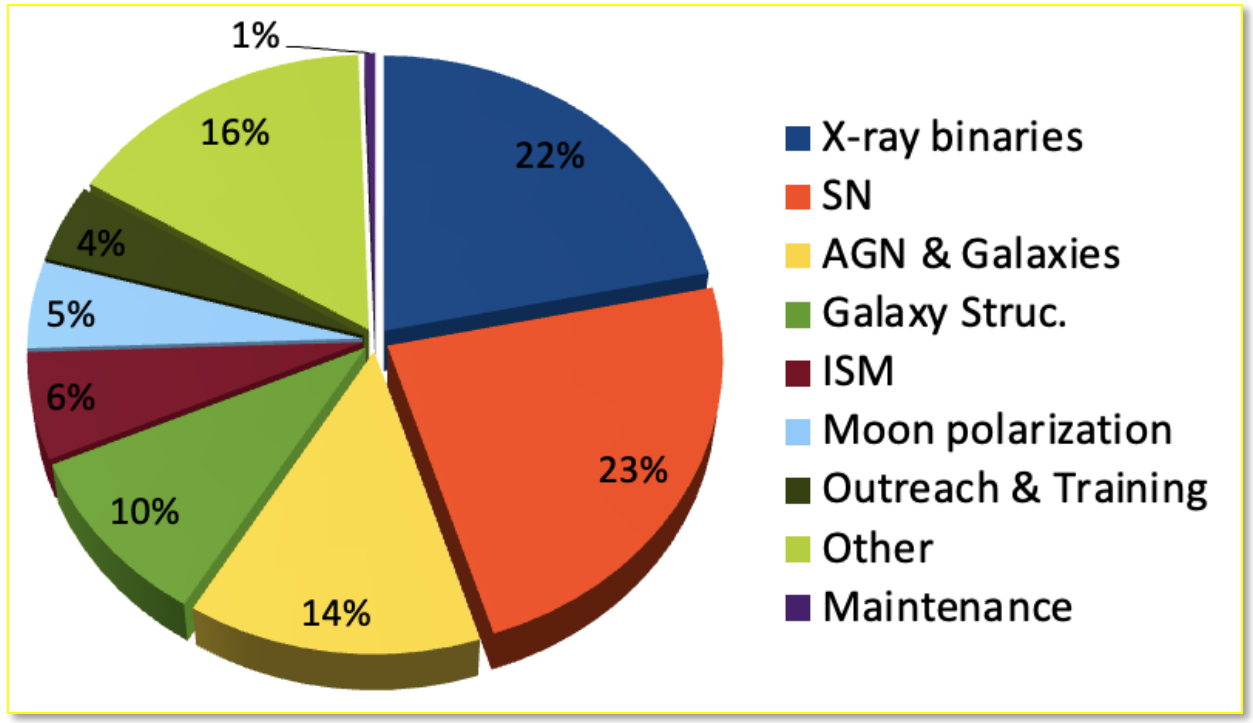




A campaign in 2016 found that the average night sky surface brightness towards zenith was : **B=22.80±0.10, V=21.02±0.09, R=21.39±0.07**

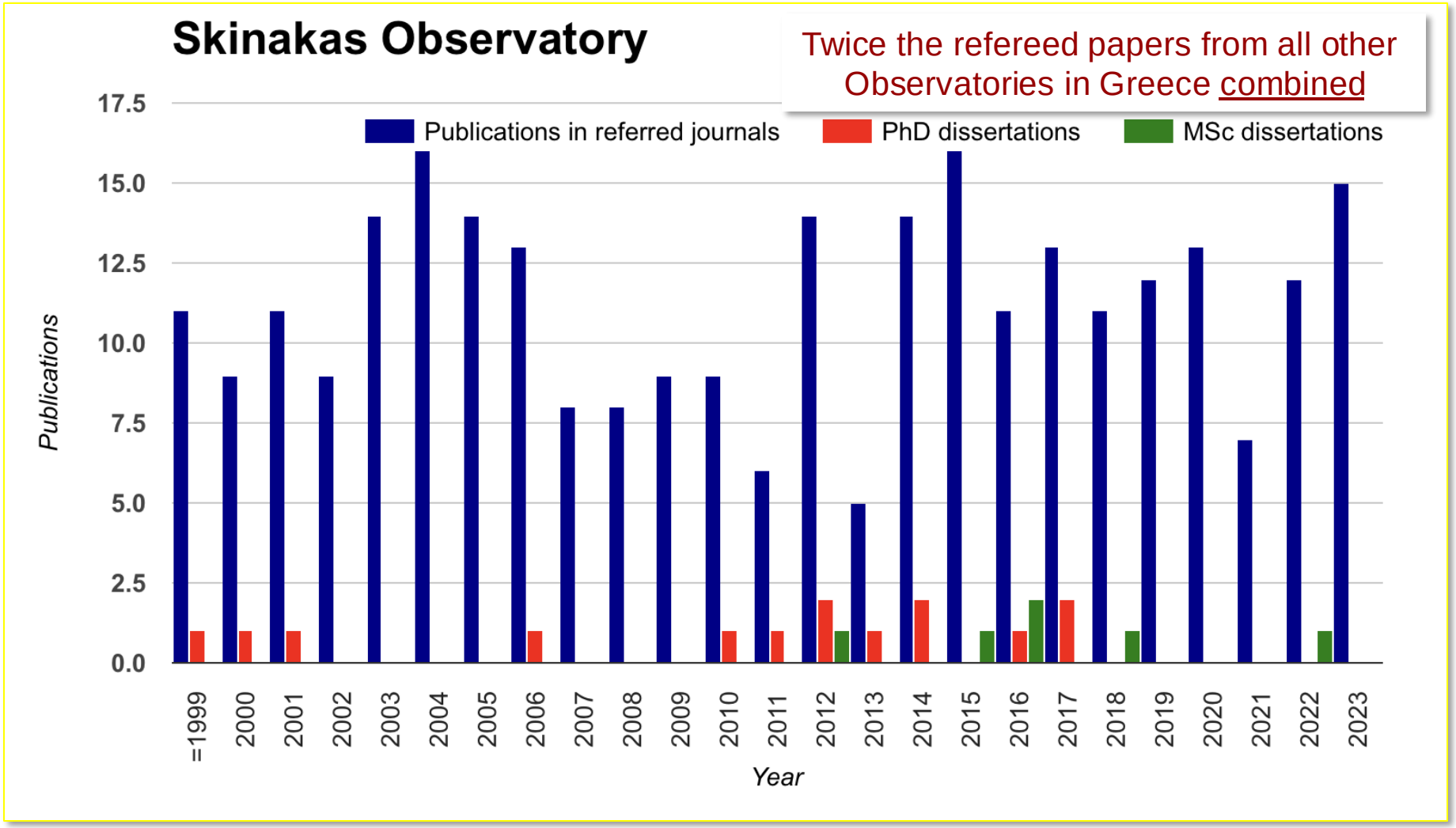
IA-FORTH – Skinakas Observations in 2023





- ✓ **Type of observations during 184 nights in 2023**
- ✓ **Resulted in 15 refereed papers (1 in Nature and 1 in Science)**

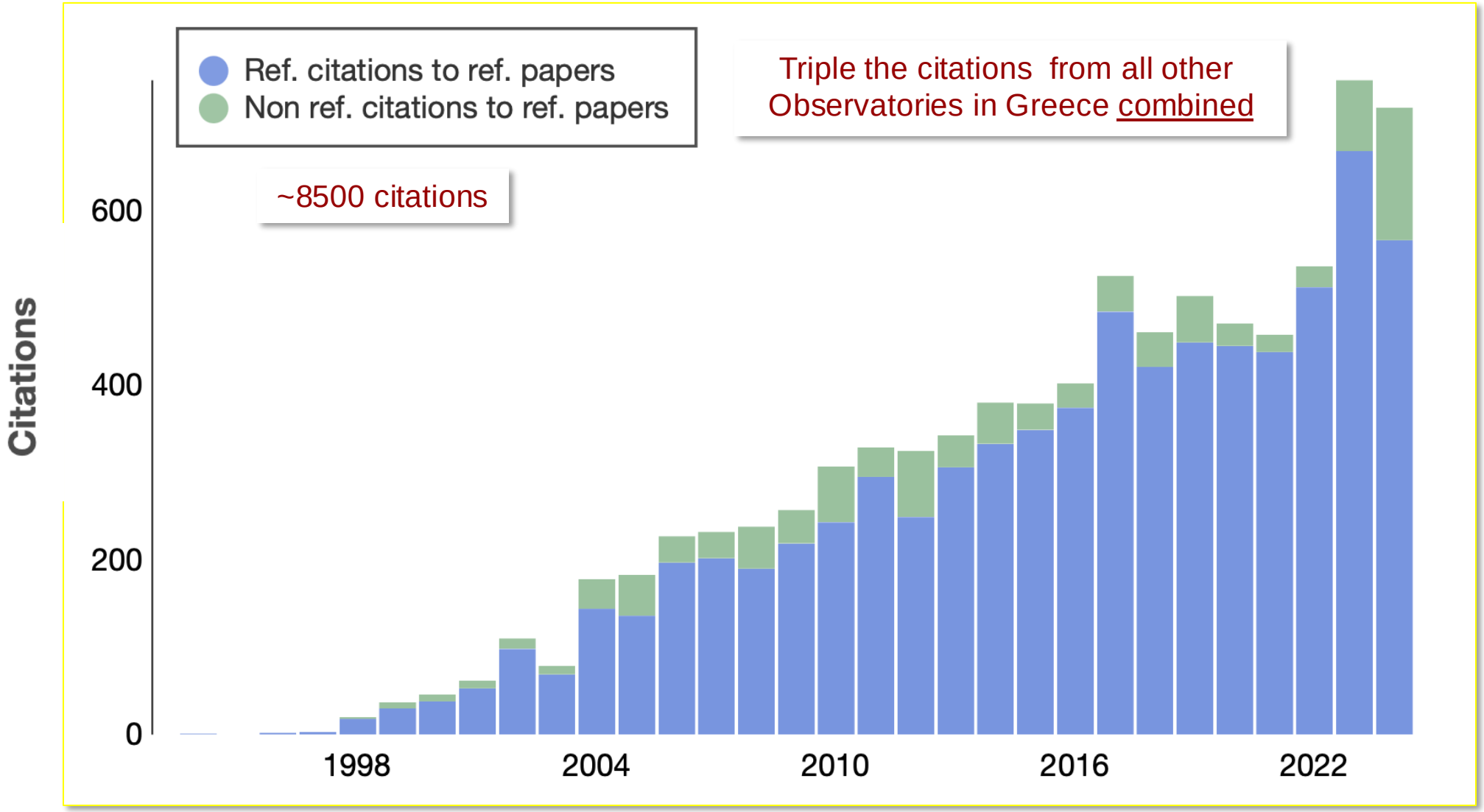
IA-FORTH – Skinakas Publications



A total of 280 refereed papers (~10 per year) + 15 PhD theses

https://skinakas.physics.uoc.gr/en/index.php/research

IA-FORTH – Skinakas Publications



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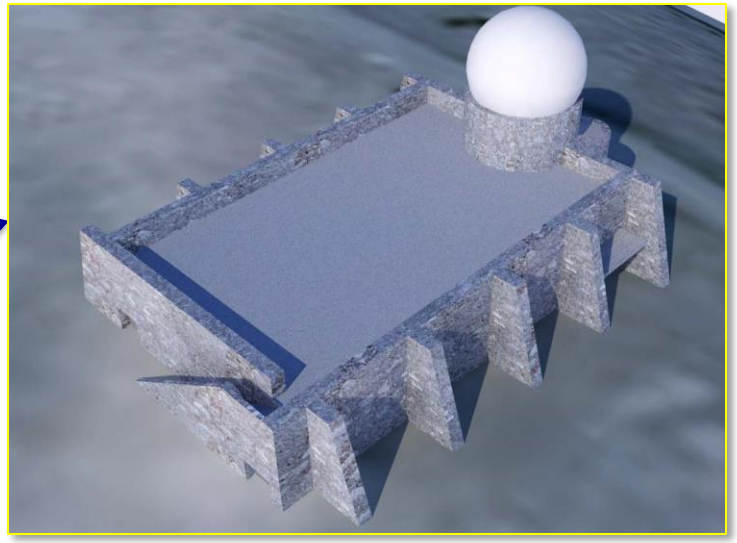
IA-FORTH – Skinakas Observatory Telescope Upgrades

- **New Skinakas 1.0m Robotic Telescope (to be named “200+”)**
  - ✓ Secured 325kEuros from UoC structural funds in 2019
  - ✓ Additional 520kEuros was awarded in April 2022
    - ✓ Private donation from Committee “Greece 2021”
  - ✓ Order placed in June 2022 to ASA Astrosysteme
  - ✓ Expected delivery in November 2024
  - ✓ Polarimetry of transients (via RoboPol)
  - ✓ Add applied research component (satellite monitoring test-bed for ESA’s laser telecom projects – Scylight, synergies with quantum optics & telecom at FORTH)
  - ✓ Contribute to covering operational costs of facility

- **New Skinakas 1.2m AltAz Robotic Telescope**
  - ✓ Approved 1.3MEuros within the ~50MEuro FORTH EIB project.
  - ✓ Order placed in June 2024 - delivery expected at end of 2025.

IA-FORTH – Skinakas Infrastructure Upgrades

- **Repairs of road to Skinakas peak**
  - ✓ Secured 650kEuros from Region of Crete towards the full repair of last ~ 5km paved road to Skinakas
    Supervised by the town of Anogeia, commenced in 2023 – to be completed in May 2025



- **Construction of 85 seat visitor center with 5.3m dome**
  - ✓ Awarded ~1MEuros in 2021 from the state (under the auspices of “Greece 2021” & “A. Tritsis” program)
  - ✓ Supervised by the town of Anogeia, works begun in June 2023 – to be completed in fall of 2025

- **Connecting Skinakas Observatory to electric grid**
  - ✓ The Region of Crete approved 210kEuro for the works
  - ✓ Works (5km of poles) to commence in Spring 2025

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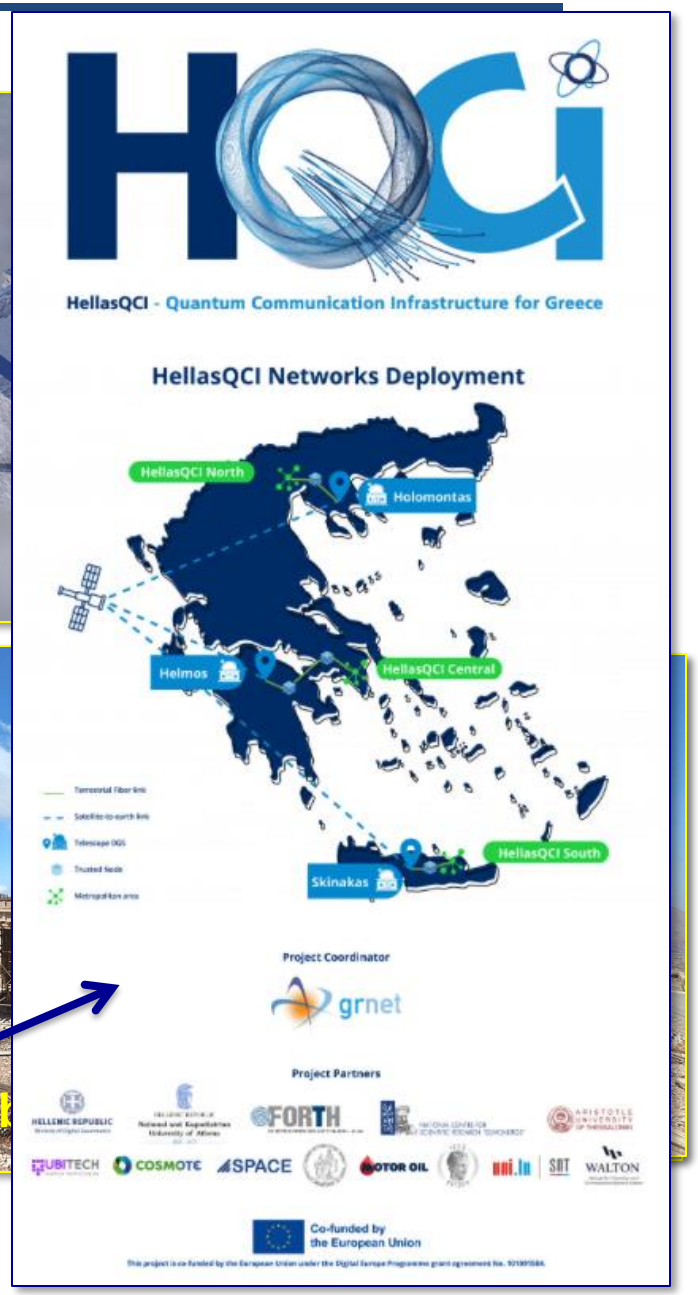
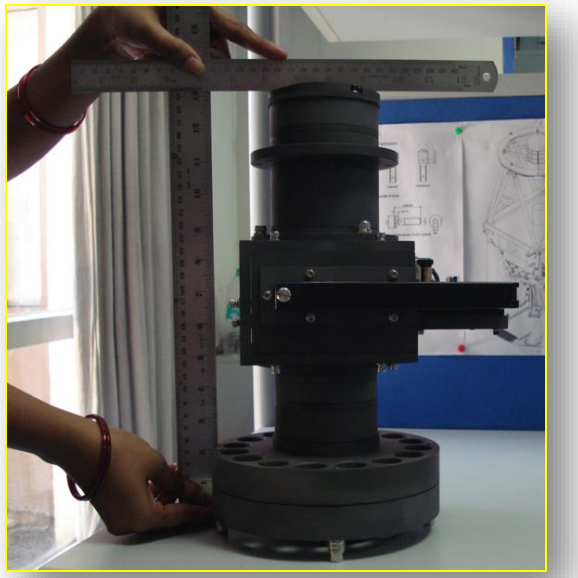
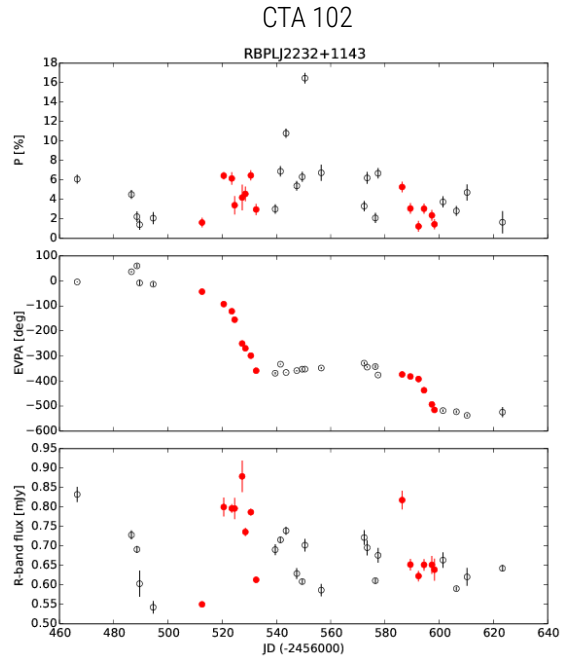
- **Connecting Skinakas to national fiber optic network**
  - ✓ Secured via Hellas/Euro-QCI (~10MEuro) context: Sep. 2024

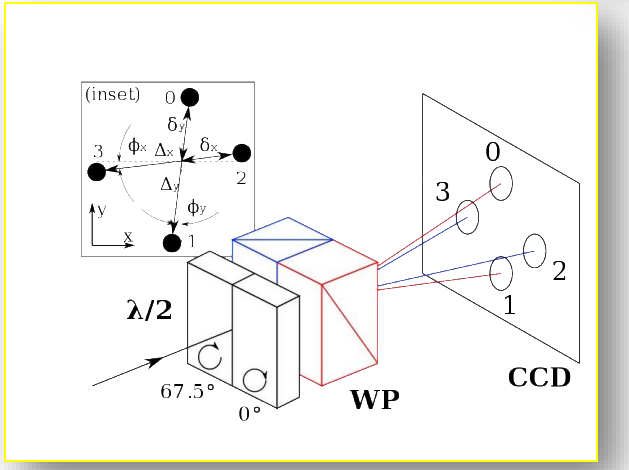


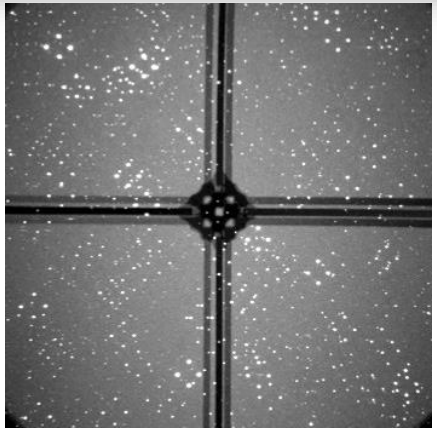
IA-FORTH – Skinakas Observatory Basic Research

- **Robopol (PI V. Pavlidou)**
  - ✓ Robopol:
  - ✓ Crete/Caltech/IUCAA/NCU
  - ✓ No moving parts
  - ✓ low systematics
  - ✓ high sensitivity
  - ✓ @ Skinakas since 2013
  - ✓ **48 refereed papers**
- **Blazar monitoring**
- **GRBs & Be/X-ray binaries**
- **Advent of PASIPHAE/WALOP**







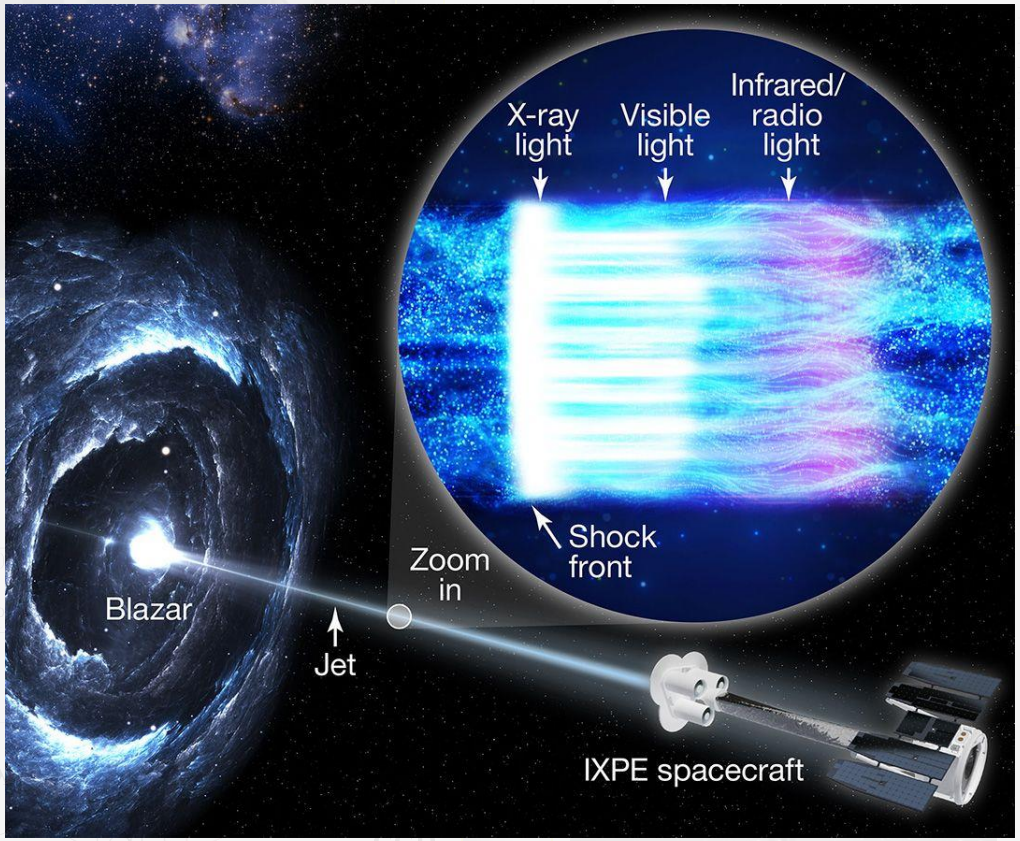


robopol

http://robopol.physics.uoc.gr

IA-FORTH – Skinakas Observatory Basic Research

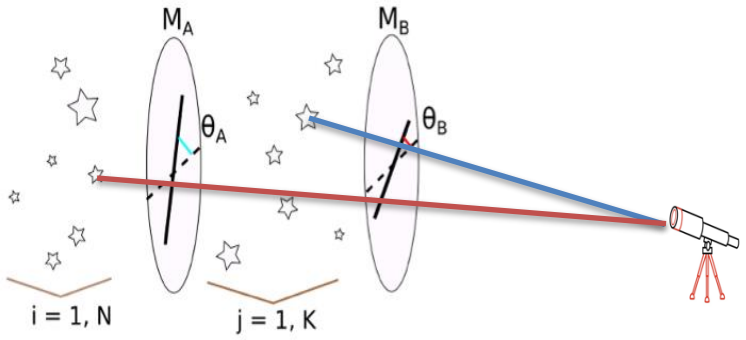
- **New Future for Robopol – BOOTES: 2024-2028**
  - ✓ ERC StG Project led by Yannis Liodakis (UoC PhD 2017, NASA/MSFC Fellow)
  - ✓ Probe the physics of matter accretion onto supermassive black-holes by multiwavelength polarization observations in both steady and transient BH systems in rapid timescales.
  - ✓ Optical: Robopol ~100 nights/yr @1.0m telescope
  - ✓ X-ray: Imaging X-ray Polarimetry Explorer (IXPE) NASA's first X-ray polarization mission.



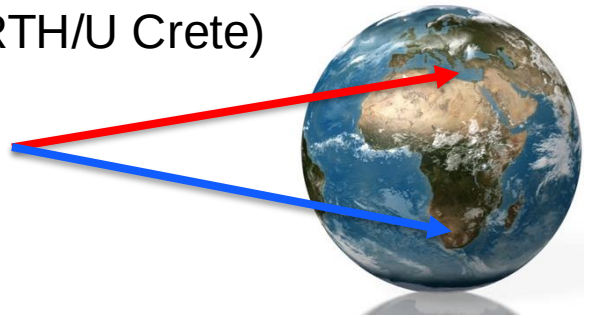
http://robopol.physics.uoc.gr

IA-FORTH – Skinakas Observatory Basic Research

- **Galactic B-field tomography with Stellar polarizations (PI K. Tassis)**
  - ✓ Measure stellar optical polarizations using innovative WALOP optopolarimeters (0.1% accuracy in systematics) – funded by ERC 1.8MEuro + SNF 1.4MEuro
  - ✓ Combine with stellar distances measured by Gaia
  - ✓ Map the 3D structure Galactic magnetic field (solving the inverse problem)
  - ✓ Aid in foreground removal in maps of the cosmic microwave background
  - ✓ Targets of opportunity
  - ✓ Start operations in spring/summer 2025 (south/north respectively)



Location: Skinakas Obs. (FORTH/U Crete)
+ Sutherland (South Africa)



PASIPHAE

http://pasiphae.science

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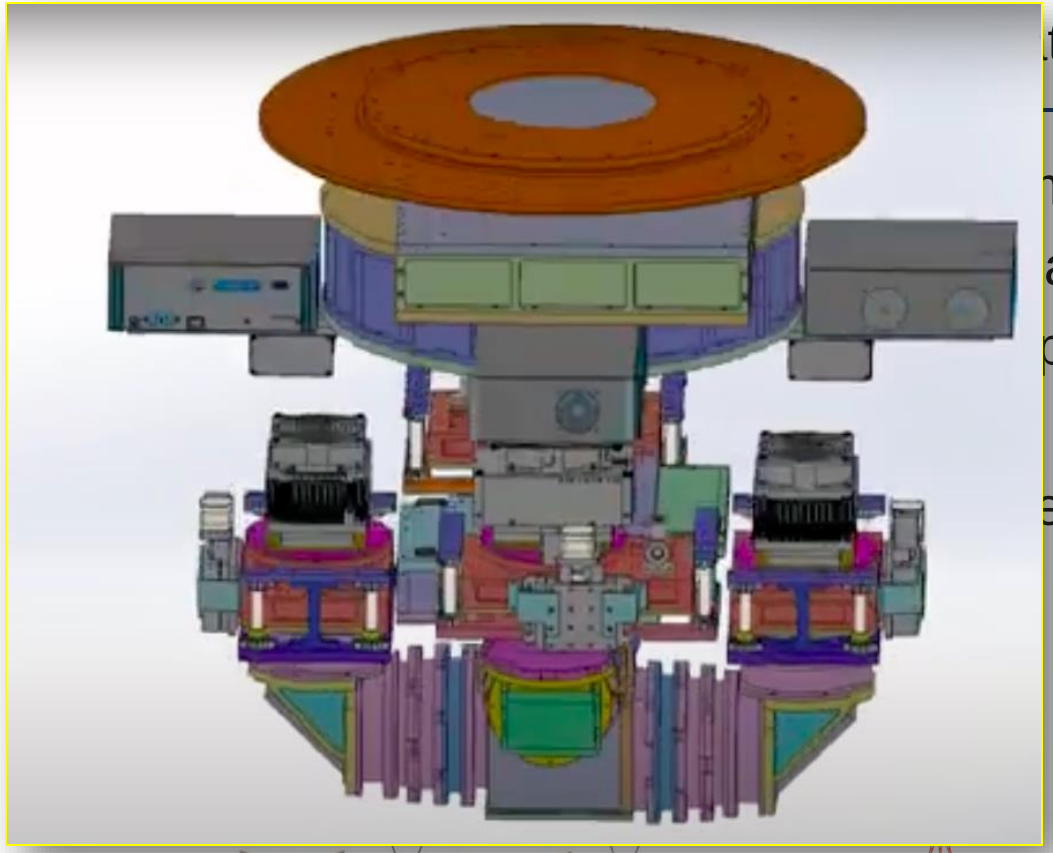

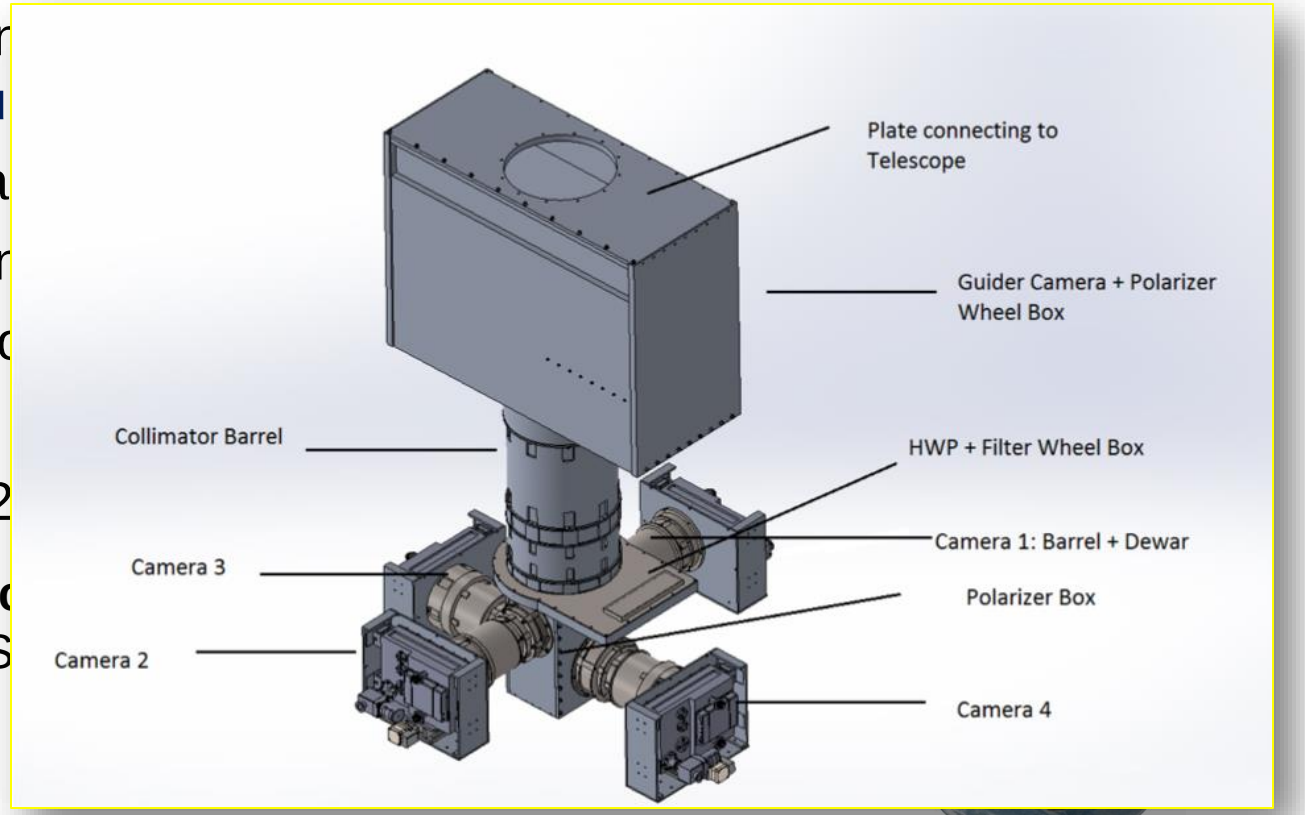

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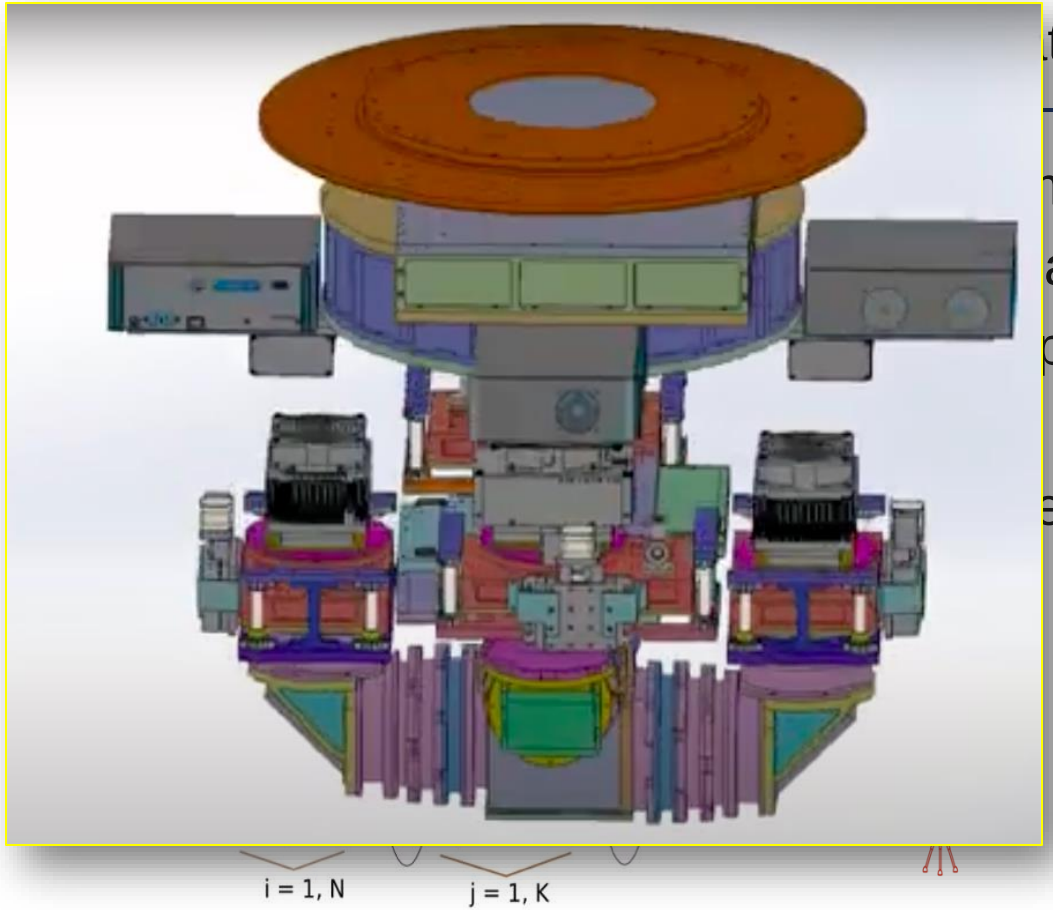
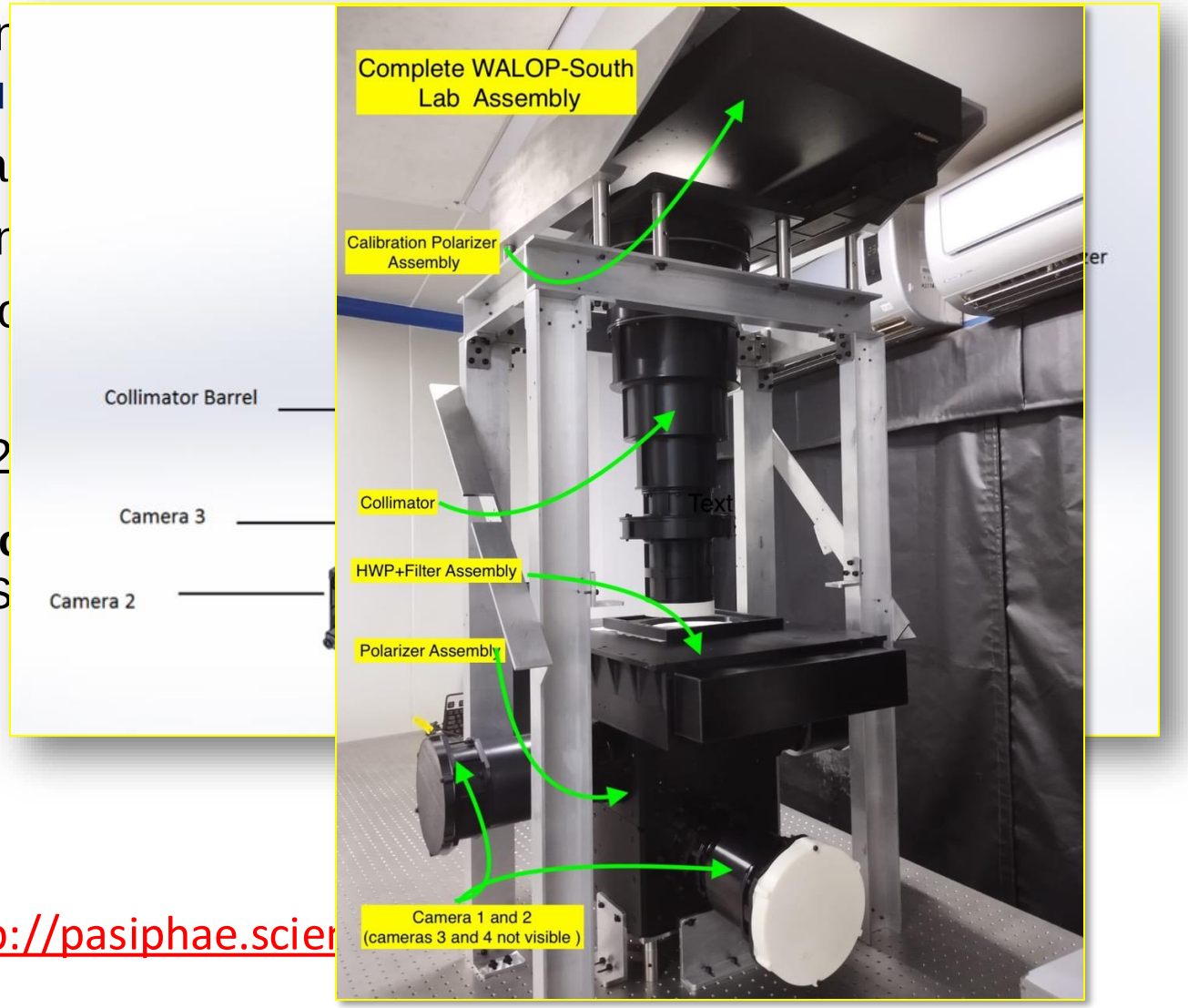




PASIPHAE

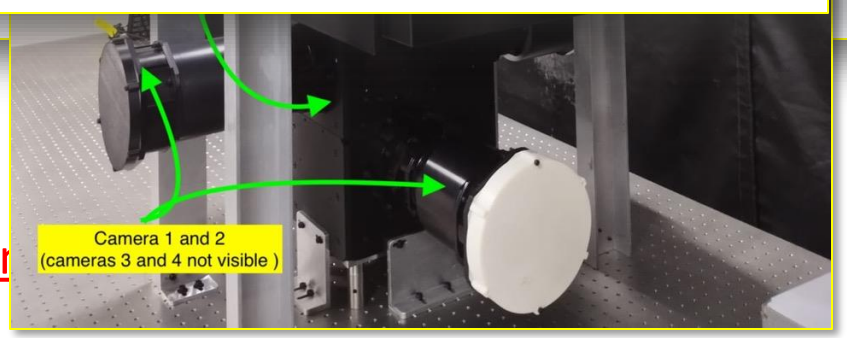
http://pasiphae.scier

IA-FORTH – Skinakas Observatory Basic Research

- **Galactic B-field tomography with Stellar polarizations (PI K. Tassis)**

Decadal Survey on Astronomy & Astrophysics 2020

Our view of the Milky Way's ISM has been hampered by seeing it in projection. As a result, we have little information about volume density; observed quantities are line-of-sight averages; constraints on kinematics are highly incomplete; and studies of the 3D magnetic field are compromised. We are on the verge of a revolution, enabled by Big Data methods to exploit the stellar distances provided by Gaia, to construct a backbone for a 3D view of the ISM. Photometric and spectroscopic surveys plus Gaia distances already have been used to create spatial maps of dust extinction. High-resolution optical spectroscopy of absorption lines (NaI, KI, CaII, CH, CN, C_2) toward stars of known distances would allow the gas to also be dissected in 3D; 21 cm emission components can then be associated with optical absorption lines at the same velocity. Large surveys of stellar polarization (e.g., PASIPHAE) and filamentary HI features can outline the spatial structure of the magnetic field. Early results from these approaches are spectacular. For example, the 3D structure of the Orion A molecular cloud has been found



PASIPHAE

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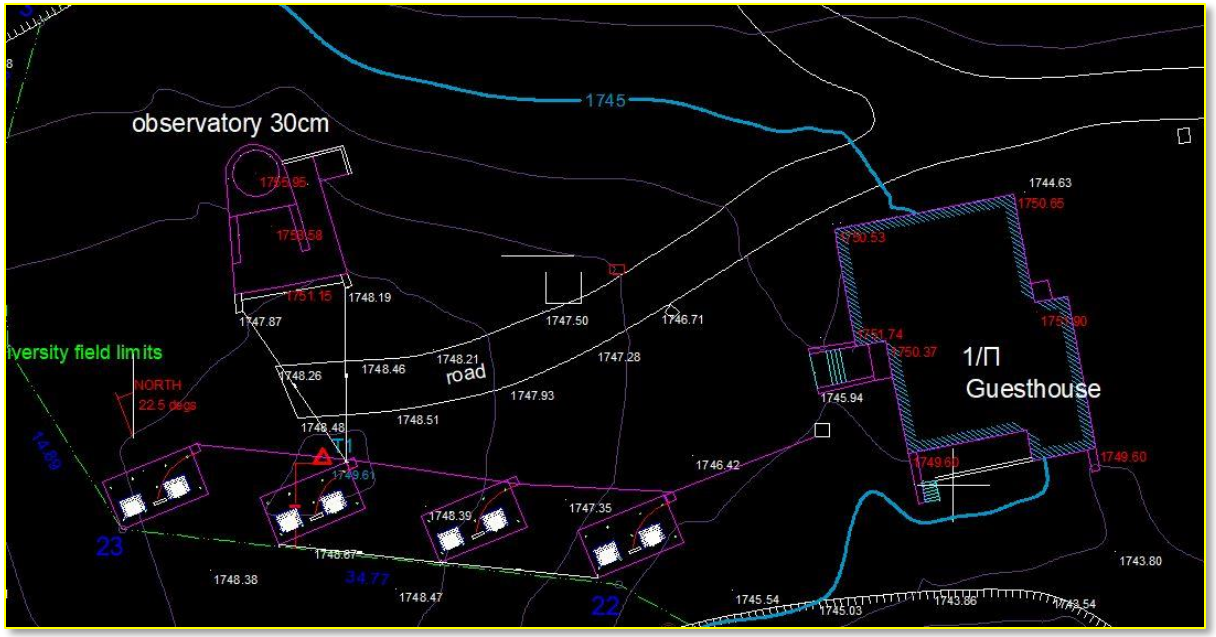
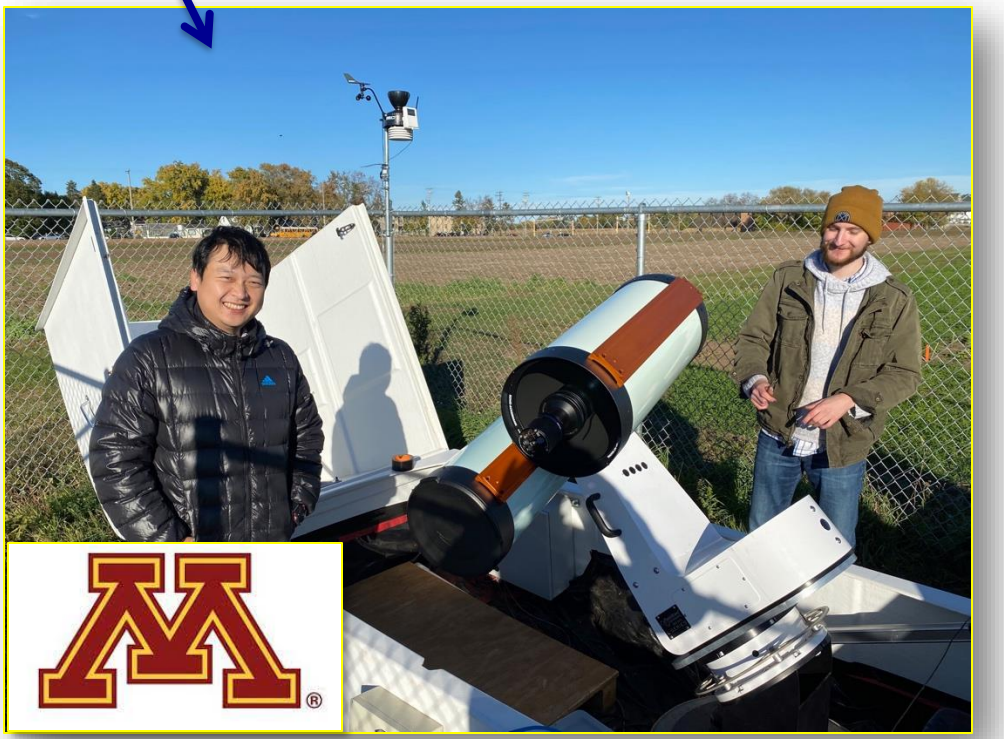
IA-FORTH – Skinakas Observatory Basic Research

- **Installation of TURBO: 16 x 25cm telescopes in pairs on 8 mounts: 100 sq FOV**
  - ✓ TURBO: “Total-Coverage Ultra-Fast Response to Binary Mergers Observatory”
  - ✓ Rapid pointing: within 2sec to any point on the sky. (GW, X-ray, SNe follow up & localization)
  - ✓ Two mirror sites: Skinakas Observatory, Crete & Magdalena Ridge, New Mexico (USA)
  - ✓ **PI Prof. P. Kelly**, Univ. of Minnesota (USA) - To become operational in fall of 2024
  - ✓ A ~$350,000 NSF investment at Skinakas Obs.
  - ✓ Additional ~50,000 Euros from IA-FORTH funds





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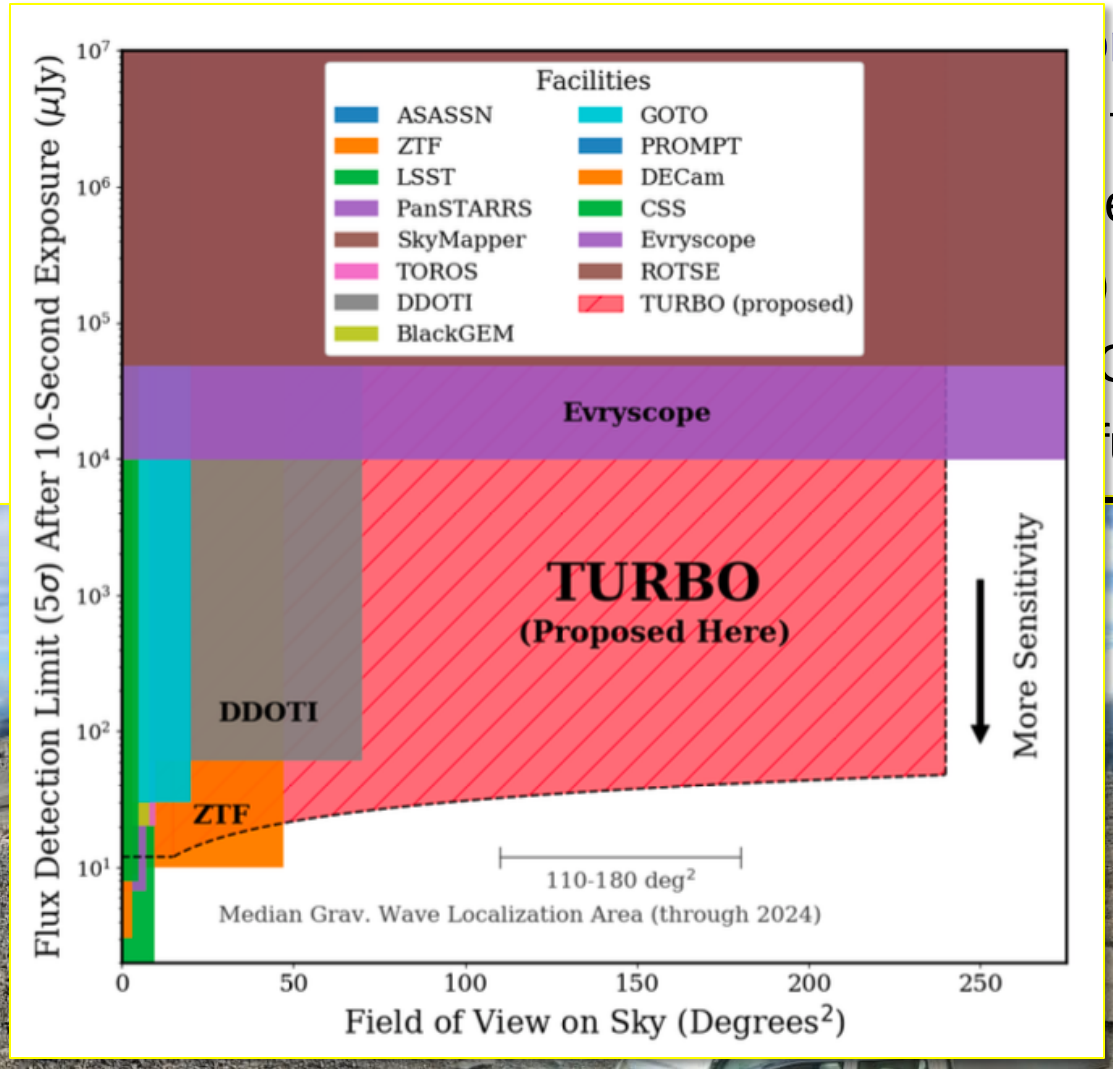
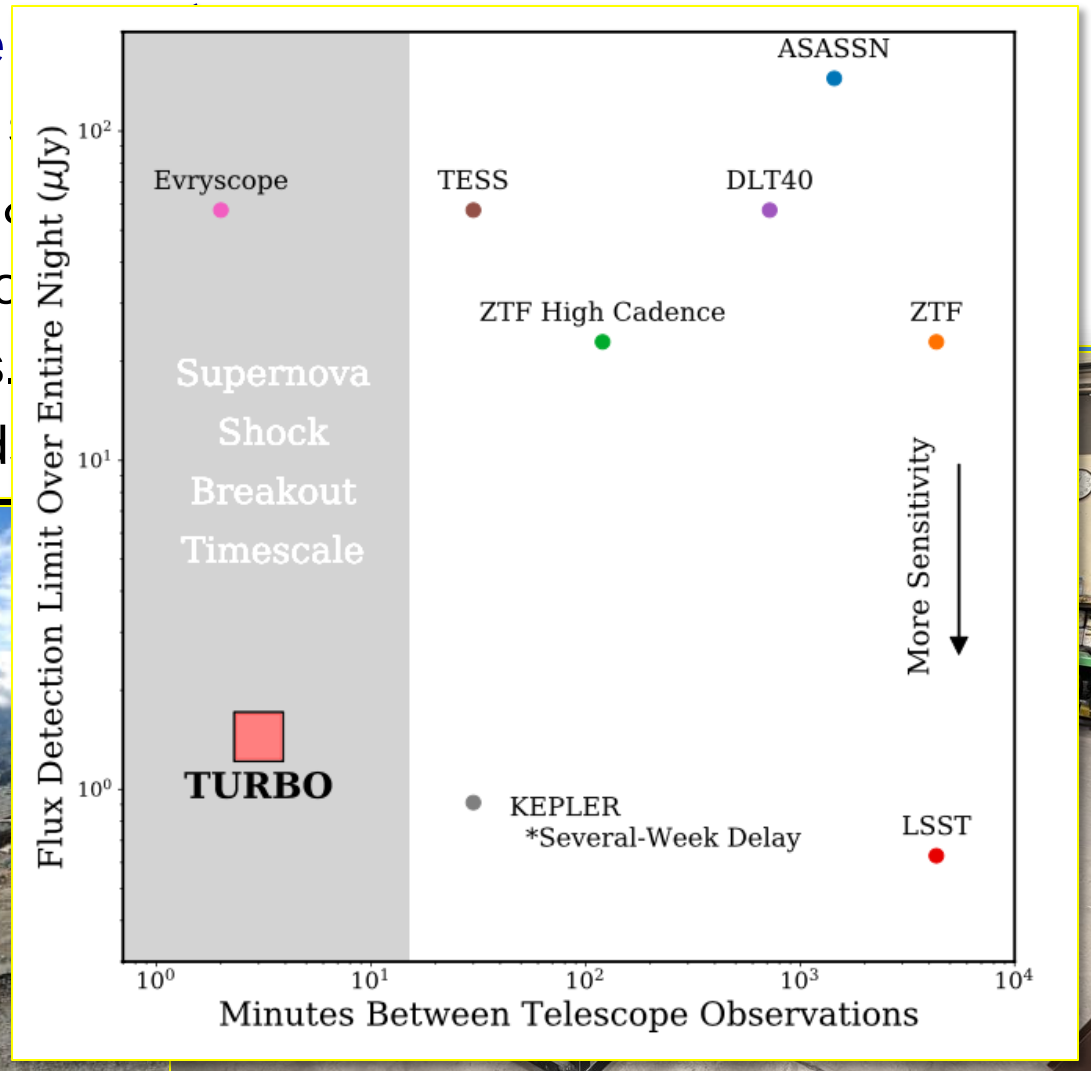


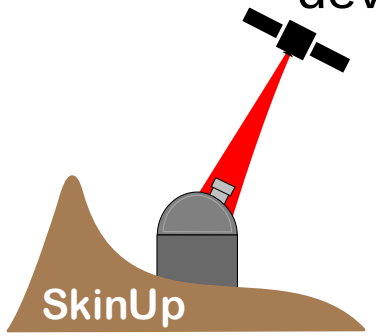


IA-FORTH – Skinakas Observatory Basic Research

- **TIME DOMAIN ASTROPHYSICS in RADIO**
  - **ARGOS: 5 x 6m parabolic antennas (3MEuro – EC HORIZON-INFRA-DEV in 2023)**
    - ✓ Key characteristics: Concept (TRL2), low cost, scalable, expandable radio interferometer, 2023-25 (PI. J Antoniadis – FORTH, Univ. of Piraeus, CEA/Saclay France, MPIfR Germany)
    - ✓ Specifications: band 2-3GHz, FOV 3 deg, Resolution 15'', pointing <1'', RMS 5.3μJy (30min)
    - ✓ Science: Slow Transients, GW counterparts, Pulsars & Timing Arrays, Fast Radio Bursts
  - **TARGET: Transforming the ARGOS Radio telescope with an Extreme-precision Timing system**
    - ✓ Funded by HFRI (400kEuros in 2024) to purchase a high-precision active hydrogen maser clock for the ARGOS array.
    - ✓ ARGOS could join European VLBI network

IA-FORTH – Skinakas Observatory Applied Research

- **Skinakas 1.3m Telescope upgrade**
  - ✓ Telescope has been validated for EU-SST activities in 2021, part of EU consortium to play an active role in space traffic management.
    - ✓ Part of EU-SST space traffic management consortium (SpaceReg & TOP1/2/5)
  - ✓ In spring 2023, the current 1.3m telescope commenced its upgrade via a dedicated ESA ~450,000 Euro project (**SkinUp**), in order the be able to support the activities of the ScyLight program for Secure and Laser communication technologies
  - ✓ Strategic collaboration with FORTH-IESL (Space Optics Lab)
  - ✓ Focus on telecom (classical and quantum encrypted) with LEO/MEO satellites
  - ✓ Additional ESA proposal (~180,000 Euro) commenced in 2023 to support development and operations of the 1.3m telescope during 2023 - 2025.



- **The goals of SkinUp by the end of 2025 are:**
  - ✓ Development of active optical stabilisation including lasers & electronics
  - ✓ Demonstration of optical communication with a satellite in LEO orbit.
  - ✓ Preparation of a quantum channel interface for future use.

IA-FORTH – Skinakas Observatory – GrObs2OGS

- **Skinakas 1.0m Telescope**
  - ✓ A Raymetrics led 8MEuro ESA project (**GrObs2OGS**), started in January 2024 will use the new 1.0m telescope for telecom (classical and quantum encrypted) with LEO/MEO satellites
  - ✓ Future endeavors for Earth-Moon telecom
  - ✓ To be also included in EU-SST activities

- **The goals of GrObs2OGS by the end of 2026 are:**
  - ✓ Development of active optical stabilisation including lasers & electronics
  - ✓ Demonstration of optical communication with a satellite in LEO orbit.
  - ✓ Preparation of a quantum channel interface for future use.

IA-FORTH & Skinakas Observatory: The sky is not our limit…

http://skinakas.physics.uoc.gr

Skinakas Observatory in the winter