LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

INAF ISTITUTO NAZIONALE DI ASTROFISICA

R&D for space-based High-Contrast Imaging in Europe 2/3

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The newborn European HCI network

March 2024: first edition of the workshop “R&D for Space-Based HCI in Europe” at Paris Observatory

R&D for Space-Based HCI in Europe

21-22 Mar 2024 Paris (France)

May 2025: second edition at MPIA-Heidelberg

R&D for Space-Based High-Contrast Imaging in Europe II

12-14 May 2025 , Haus der Astronomie, Max-Planck Institute for Astronomy, Heidelberg (Germany)

Goal: consolidate European expertise and foster collaboration on HCI technologies.

2024 workshop - Topics

- Current European R&D activities
- Other activities in Europe, Identification of R&D areas
- Identification of relevant R&D areas and technologies, Overlap of HWO/LIFE tech
- Role and expectations of ESA representatives, raising awareness and engagement in Europe
- Synergy between space- and ground-based R&D
- Consolidation and strengthening of European laboratory facilities
- European roadmap avoiding duplication of efforts, what's next after this workshop, funding opportunities

2024 workshop - Key outcomes

Immediate outcomes

- ➢ Consolidation of European expertise and Collaboration
- ➢ Follow-up Workshop and Networking
- ➢ Informing HWO Activities

Key Conclusions and Recommendations

- ➢ Urgency for European Alignment (coordinated European Roadmap)
- ➢ Get ESA formal endorsement to HWO
- ➢ Invest in High-TRL Technologies
- ➢ Establishment/Upgrade of Laboratory Facilities
- ➢ Bridging Funding Gaps

Advancing European High-Contrast Imaging R&D Towards the Habitable Worlds Observatory

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White paper by Laginja et al., 2025, ApSS

2024 workshop - Key outcomes

Key technologies

- Deformable Mirrors
- Wavefront Sensing and Control, particularly on segmented telescopes
- Detector Technologies (e.g. EMCCDs)
- Coronagraphs and Polarimetric Components

2025 workshop - Topics

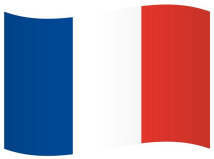
- WP1: Wavefront sensing, control & AO
- WP2: Ground-based facilities
- WP3: Coronagraphs
- WP4: Post-processing
- WP5: Nulling interferometry
- WP6: Deformable Mirrors
- WP7: Telescope Design & Optics
- WP8: Detectors

High Contrast Imaging in Europe

Other institutes/organizations represented:

- CNES
- ESA
- JPL
- StScI

FRANCE



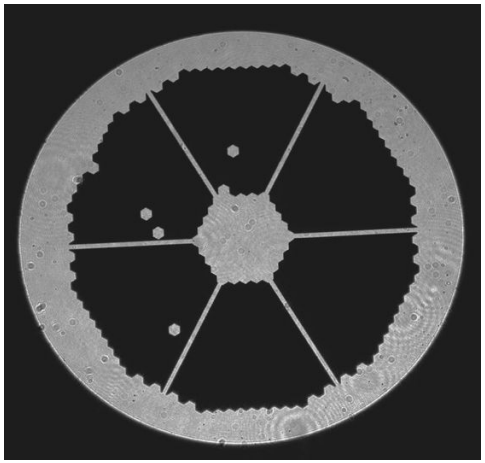
LIRA (OBSPARIS):

THD2 testbed

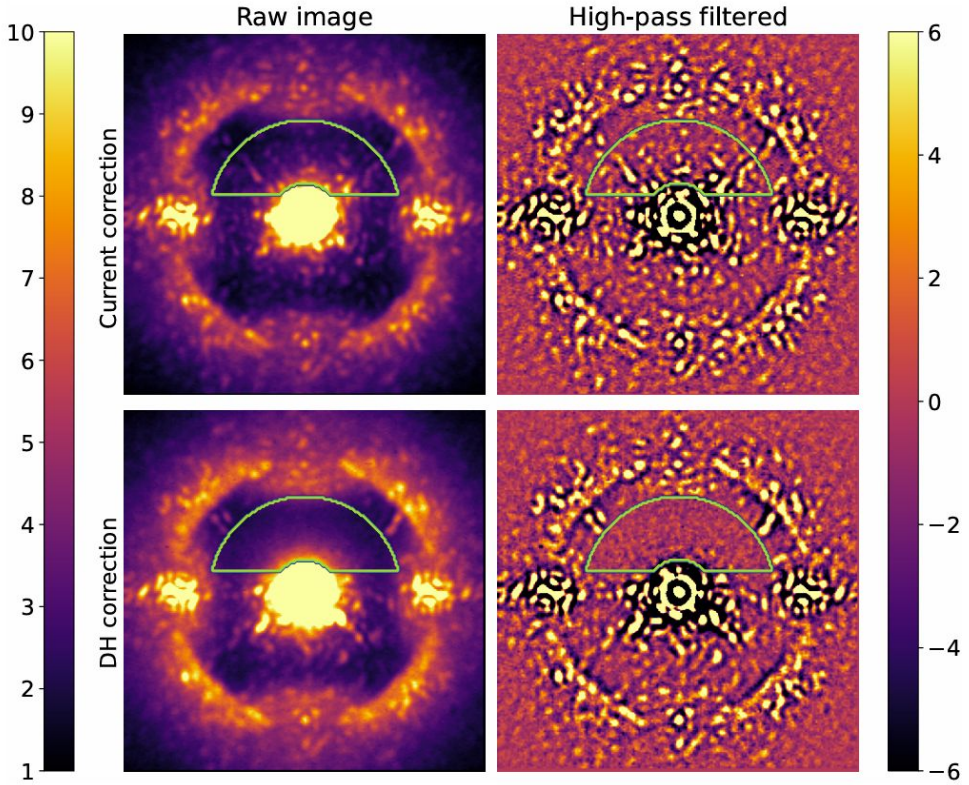
➔ Coronagraphy (phase masks)
➔ WFS&C (SCC, EFC)

IPAG (Grenoble):

➔ Adaptive coronagraphs (DMD apodizers)
➔ Photonic coronagraphs



Carlotti et al. 2023

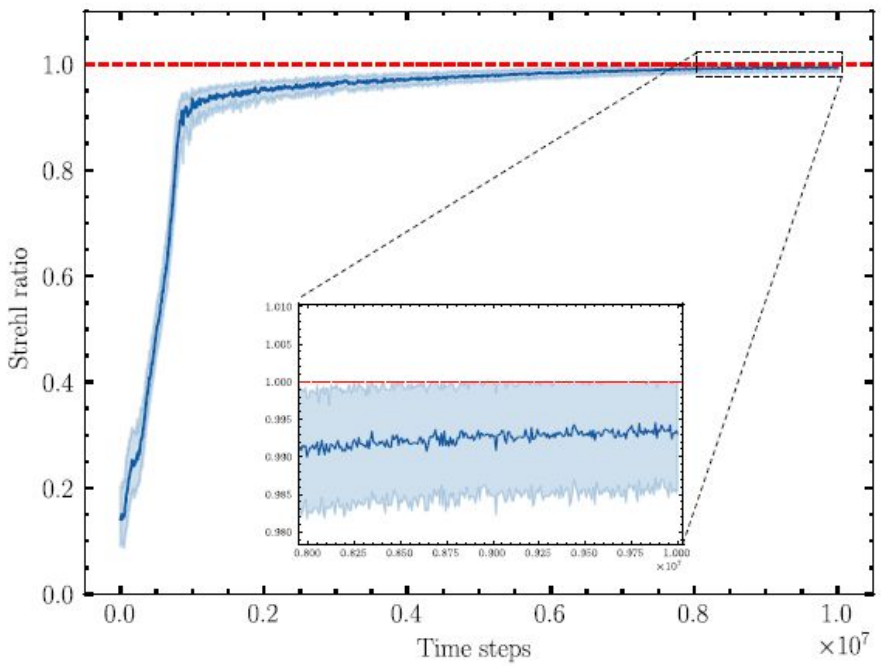


Potier et al. 2022

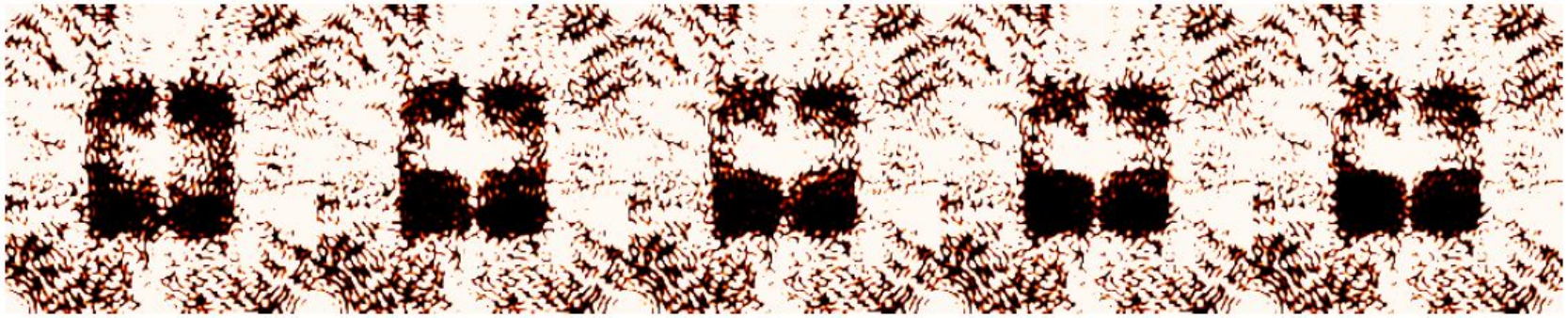
FRANCE

ONERA/LIRA/LAM:

- ➔ HCI with segmented telescopes (STScI)
- ➔ Focal-plane WFS&C using AI (NN-driven reinforcement learning)
- ➔ Non-Linear Dark Hole (NLDH)
- ➔ Coronagraphic Phase Diversity (COFFEE)



Gutierrez et al. 2024



Herscovici-Schiller et al. 2018 (NLDH)

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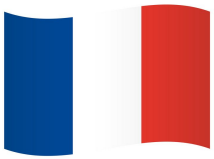


LAM:

➔ Super-polished off-axis parabolas ⟶ Roman CGI

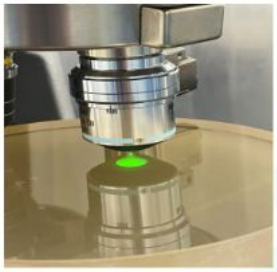
➔ Hyper-polished surfaces (< 1 Å rms roughness using nanoparticles)

➔ Segmented Off-axis parabolas (STScI)

➔ Observing strategies and Post-processing techniques (ESCAPE project)

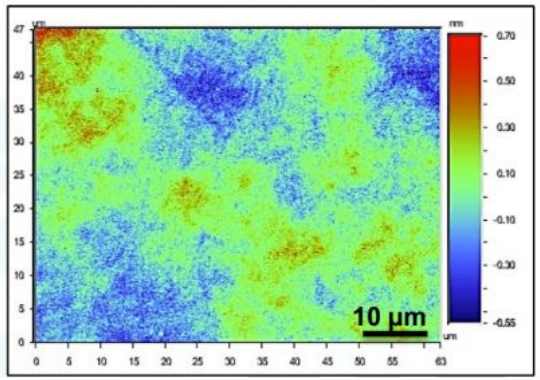
H. Bellahsene & al. 2023

First polishing tests using 30 nm NPs slurries



P-Zerodur® Felt + SiO_2 30 nm

Ra = 1.1 Å rms



Gain x 4 in time

Already ~ 1 Å rms

OTHER INSTITUTES

SRON/ULeiden:

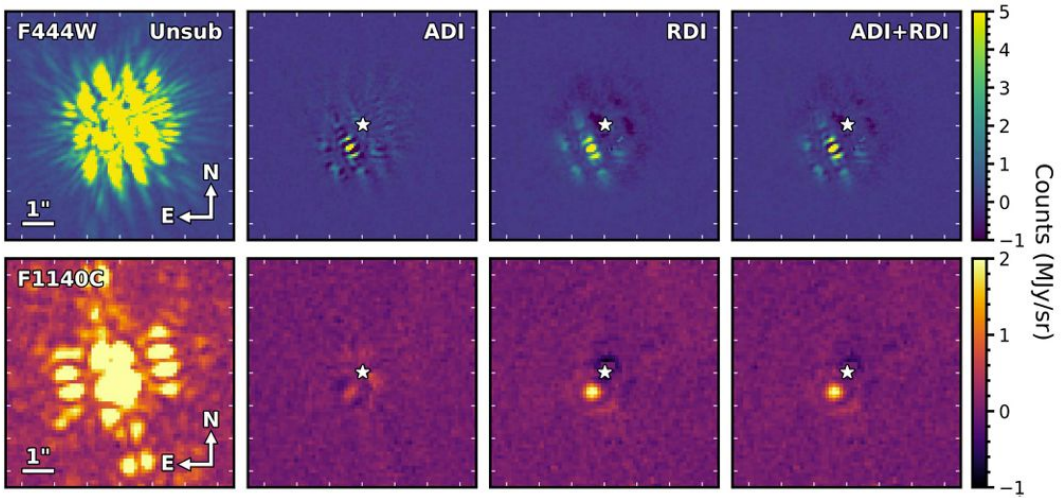
- ➔ Liquid-crystal coronagraphs (ESA TDE)
- ➔ Microwave kinetic inductance detectors (MKID) development for HCI

ULiege:

- ➔ Focal plane wavefront sensing powered by deep learning
- ➔ Phase masks design and testing (AGPM, meta-surfaces)

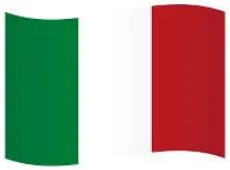
UoLexeter/STScI:

- ➔ High-Contrast Post Processing Strategies



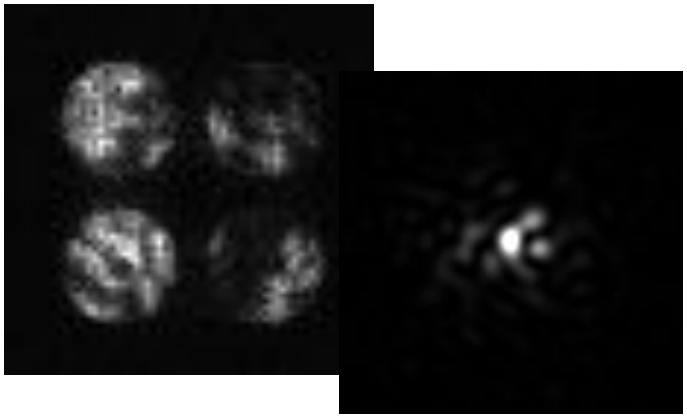
Carter al. 2023

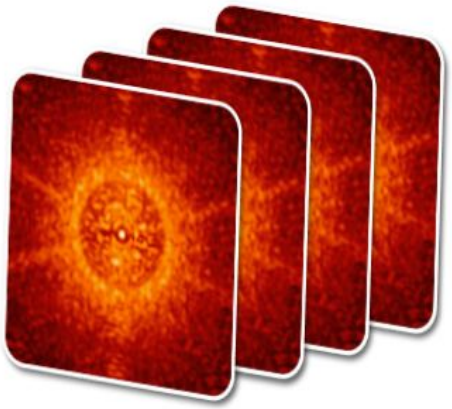
ITALY

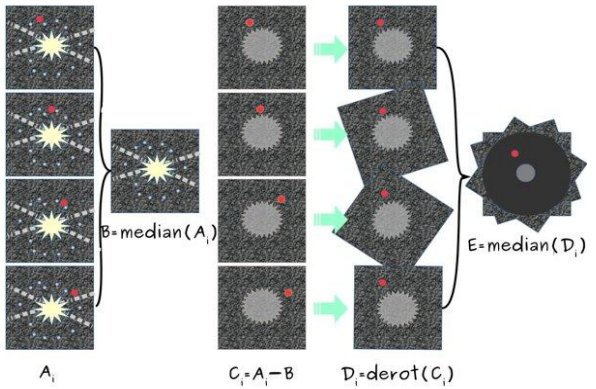


- ➔ Pyramid WFS
- ➔ Contactless active mirrors
- ➔ AO post processing & algorithms
- ➔ Expertise in ground-based coronagraphy (SHARKS)

SPECULA (AO E2E simulator) + E2E Coronagraph simulator + Post Processing







Conclusions

- Keeping an eye beyond Italy will help shaping the Italian contribution to HWO
- A European network on spaced-based HCI is coming together
- Europe can play a role thanks to its well-established expertise in ground-based HCI
- Italy has some cards as well: deformable mirrors, WFS and post-processing.. Let’s play them!