

› COOPERATION IN GROUND BASED ASTRONOMY

Big Science & Knowledge Transfer
Friday, 17 June 2022
Veldhoven

TNO innovation
for life

 **DEMCON** | Focal

› **CONTENT**

- › **Why participating in Ground Based Astronomy?**
- › **Examples of past and current projects**
- › **Lessons learned**
- › **Roadmap Deformable Mirrors**



image credits in this presentation:
ESO/TNO/UH/NWO/Fred Kamphues

› WHY PARTICIPATING IN GROUND BASED ASTRONOMY?

▮ Societal goal:

- ▮ Answering the Big Questions: understanding the universe and our place in it, the hunt for exoplanets, international collaboration and the advancement of human knowledge

▮ Industry goal:

- ▮ Strengthen technical competences
- ▮ Excellent marketing tool
- ▮ Motivate and retain staff with high profile projects
- ▮ Spin-off to aerospace, semicon, medical and ICT



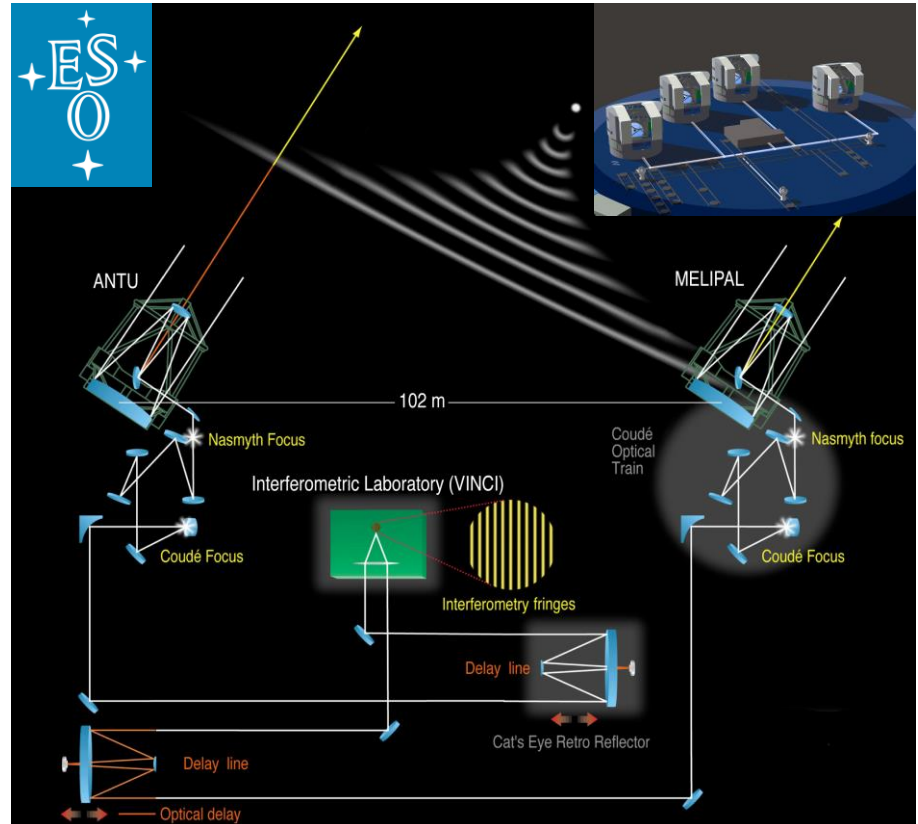
› EXAMPLES OF PAST AND CURRENT PROJECTS

- › VLTl Delay Lines
- › ELT Laser Guide Stars
- › UH2.2 Adaptive Secondary Mirror

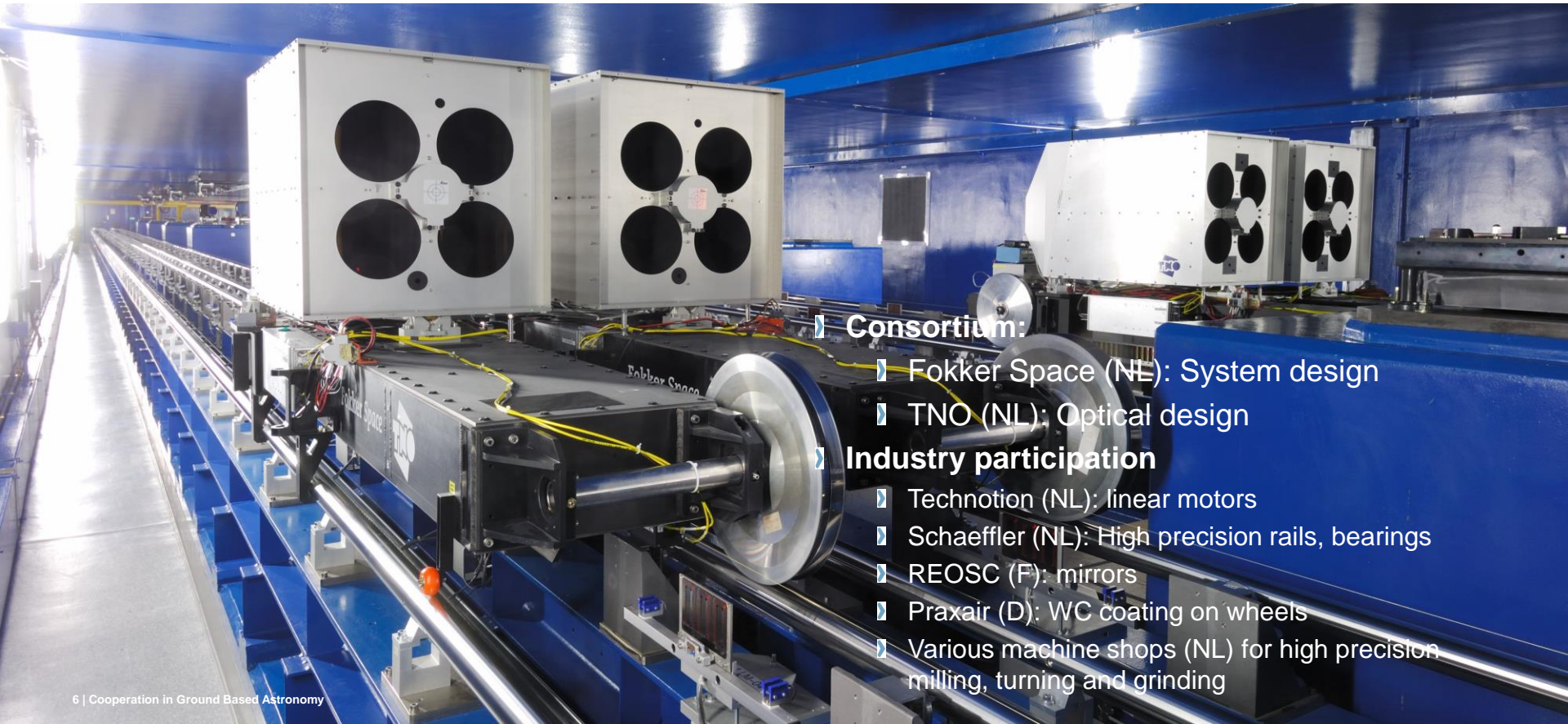


› VLT DELAY LINES

- › 6 Delay Lines installed at ESO Paranal observatory in Chile
- › Optical interferometry with up to 6 telescopes simultaneously
- › Fokker Space/TNO cooperation (1997-2003)
- › Nanopositioning over 120 meter optical path
- › Very challenging requirements on WFE and pointing stability



› VLTl DELAY LINES



› Consortium:

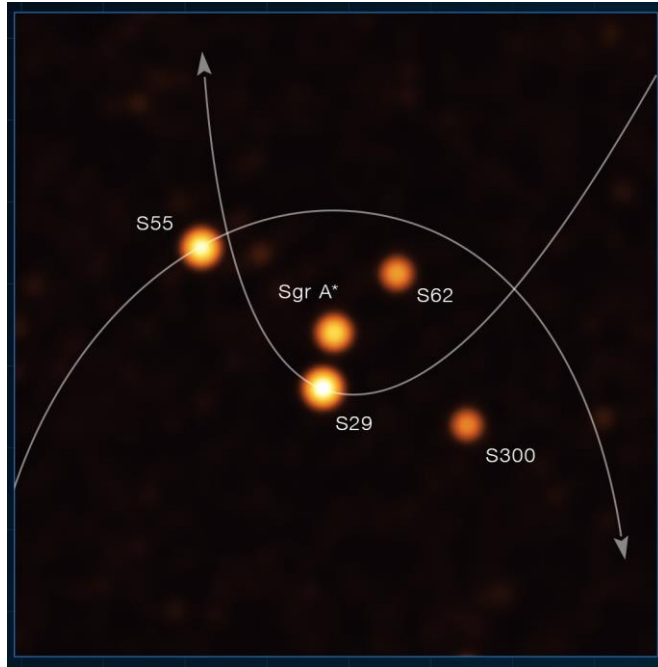
- › Fokker Space (NL): System design
- › TNO (NL): Optical design

› Industry participation

- › Technotion (NL): linear motors
- › Schaeffler (NL): High precision rails, bearings
- › REOSC (F): mirrors
- › Praxair (D): WC coating on wheels
- › Various machine shops (NL) for high precision milling, turning and grinding

› VLT DELAY LINES

› Contributing to world class research



eso2017 — Organisation Release

2020 Nobel Prize in Physics awarded for research with ESO telescopes on Milky Way's supermassive black hole

6 October 2020



Reinhard Genzel and Andrea Ghez have jointly been awarded the 2020 Nobel Prize in Physics for their work on the supermassive black hole, Sagittarius A*, at the centre of our galaxy. Genzel, Director at the Max Planck Institute for Extraterrestrial Physics in Germany, and his team have conducted observations of Sagittarius A* for nearly 30 years using a fleet of instruments on European Southern Observatory (ESO) telescopes.

› ELT LASER GUIDE STARS

▣ 6 Laser Projection Units for the ESO Extremely Large Telescope at Cerro Armazones in Chile

▣ Main characteristics

- ▣ Suitable for laser power of 50W
- ▣ FoV of 7" (half cone angle)
- ▣ WFE < 65 nm rms
- ▣ Defocus across FoV < 120 nm PV
- ▣ Pointing resolution of 0,2" on sky
- ▣ Absolute line of sight pointing error <10"
- ▣ Relative pointing error <0.25" (120s interval)
- ▣ Size: 2.4 x 1.7 x 1.4 m (H x L x W)



› ELT LASER GUIDE STARS

› TNO

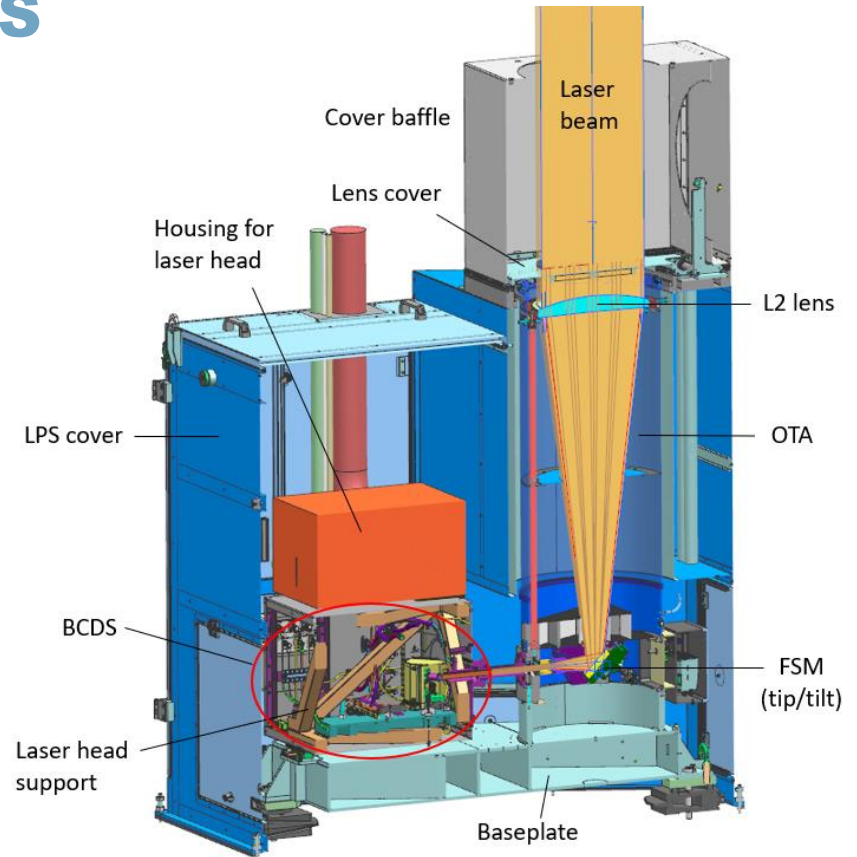
- › System responsibility
- › OTA design

› Demcon Focal

- › Beam Conditioning and Diagnostics System (BCDS) and Control Electronics

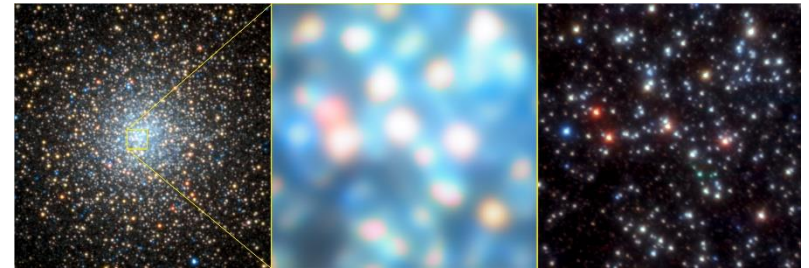
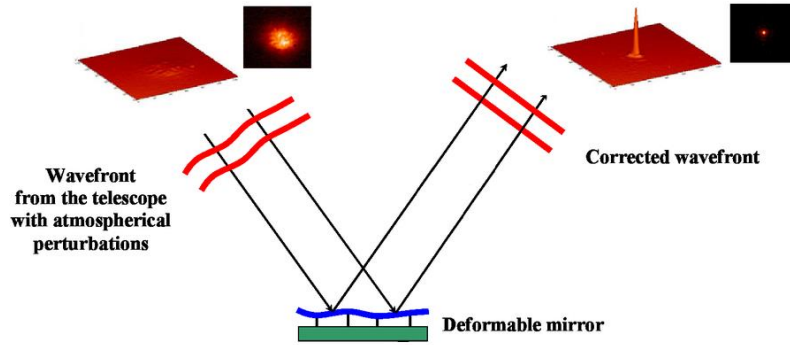
› West End

- › Baseplate Detailed Design
- › Cover Assembly Detailed Design



› UH2.2 ADAPTIVE SECONDARY

- › Part of the new UH Adaptive Optics (AO) facility in Hawaii
- › First on-sky demonstration of new TNO deformable mirror technology



VLT

(zoomed in)

VLT+AO

› UH2.2 ADAPTIVE SECONDARY MIRROR

› Consortium:

- › TNO: design, integration, functional testing
- › VDL: actuators and mechanics manufacturing
- › Hyperion: drive electronics and digital interface
- › Fraunhofer IPT: face sheet slumping
- › UH: performance testing, end user



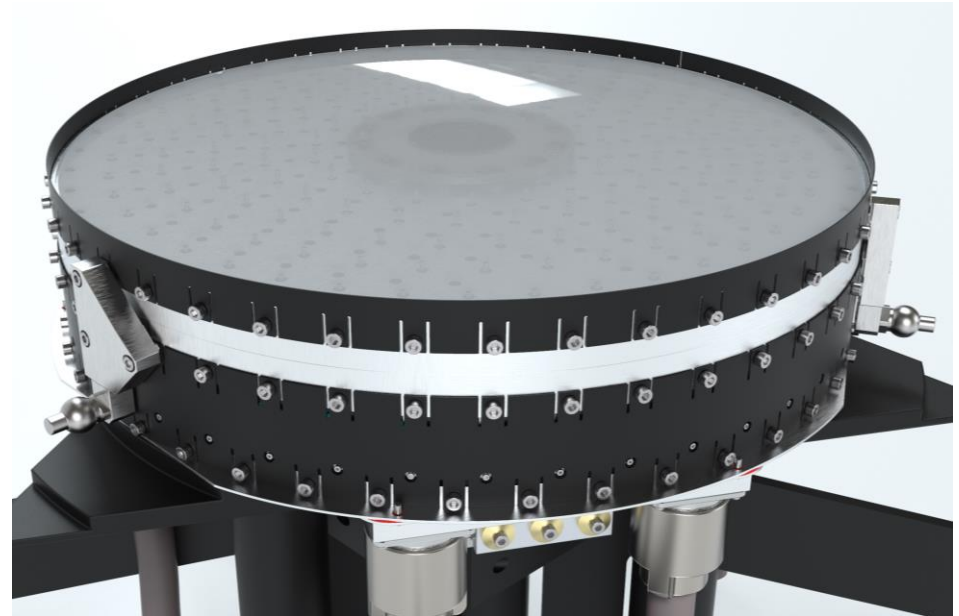
TNO



HYPERION
TECHNOLOGIES

Fraunhofer

IPT



› **LESSONS LEARNED**

- › **Technology development can be risky**
- › **(Limited) series production necessary to offset NRE**
- › **ESO contract conditions are tough; US observatories more willing to reduce contractor risk**
- › **Strengthening of technical competences due to the combination of challenging requirements and slightly longer lead times compared to industry**
- › **Partnership building is very useful**

ROADMAP DEFORMABLE MIRRORS 2022-Q1

2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030

- Larger structures: 0,6 → 1,0 → 3m ϕ
- More actuators (1000+)
- Better dynamic performance (SiC, CFRP)
- Better electronics (speed, dissipation)
- Higher temperature stability
- Advanced control strategies
- Increased robustness

- Better thermal control

FLASH ✓

EST PDR study ✓

Keck –white paper study ✓

APF concept study ✓



UH2.2 - ϕ 63cm/210act/39mm

GAO AO bench ✓

GAO AO bench CDR + Realization

TMT - instrument level

Chara – 15cm/50act/18mm (7x)

Maory (2x) – 80cm/700act/25mm
(80cm/4000act/12mm wish)

VLT Sphere – 15cm/1300act/5mm

Gemini (2x), 90+120mm, 5mm

Keck – instrument level

NASA IRTF ϕ 25cm / 37act

APF ASM ϕ 37cm / 61act

Shane – ϕ 76cm / 300act

KECK, ϕ 1.4 m, 2000 actuators,

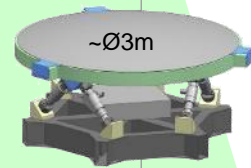
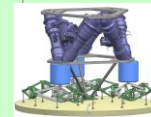
LBTO (2x), ϕ 91cm/672+ act

GAO ASM, ϕ 1.2m; 1000+ act

(Subaru), ϕ 1m; 1000+ actuators

GMT (7x), ϕ 1m, 1200 actuators

TMT M2: ϕ 300cm, 4000+ actuators



Large Adaptive
Secondary Mirrors

Instrument Level
Adaptive Mirrors

- Higher bandwidth: >1kHz
- Thinner facesheet; 3 → 1mm
- Better electronics (speed, dissipation)
- Smaller actuators, higher density (5mm)

› CONTACTS

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› **THANK YOU FOR YOUR
ATTENTION**

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