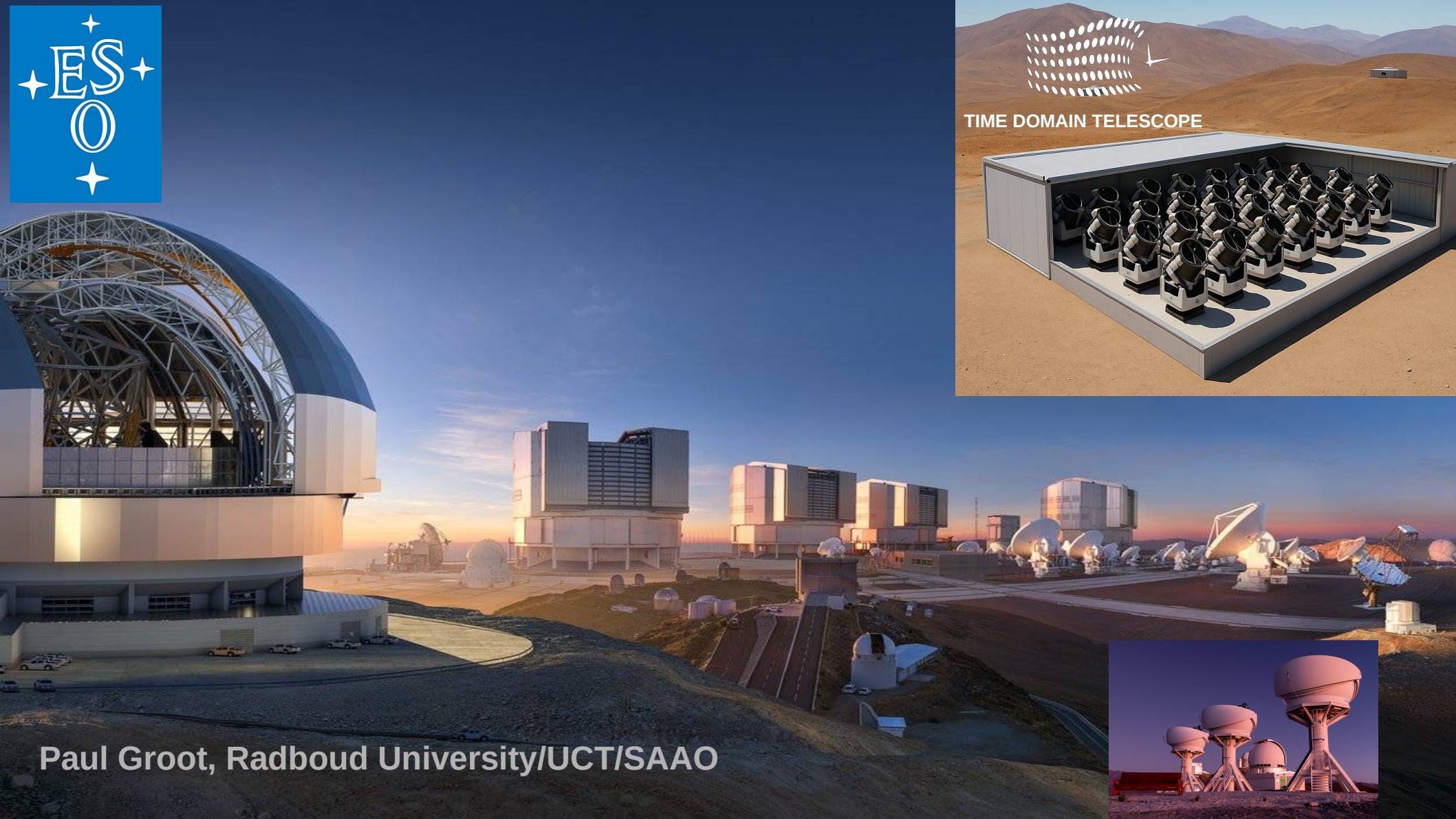


Paul Groot, Radboud University/UCT/SAAO

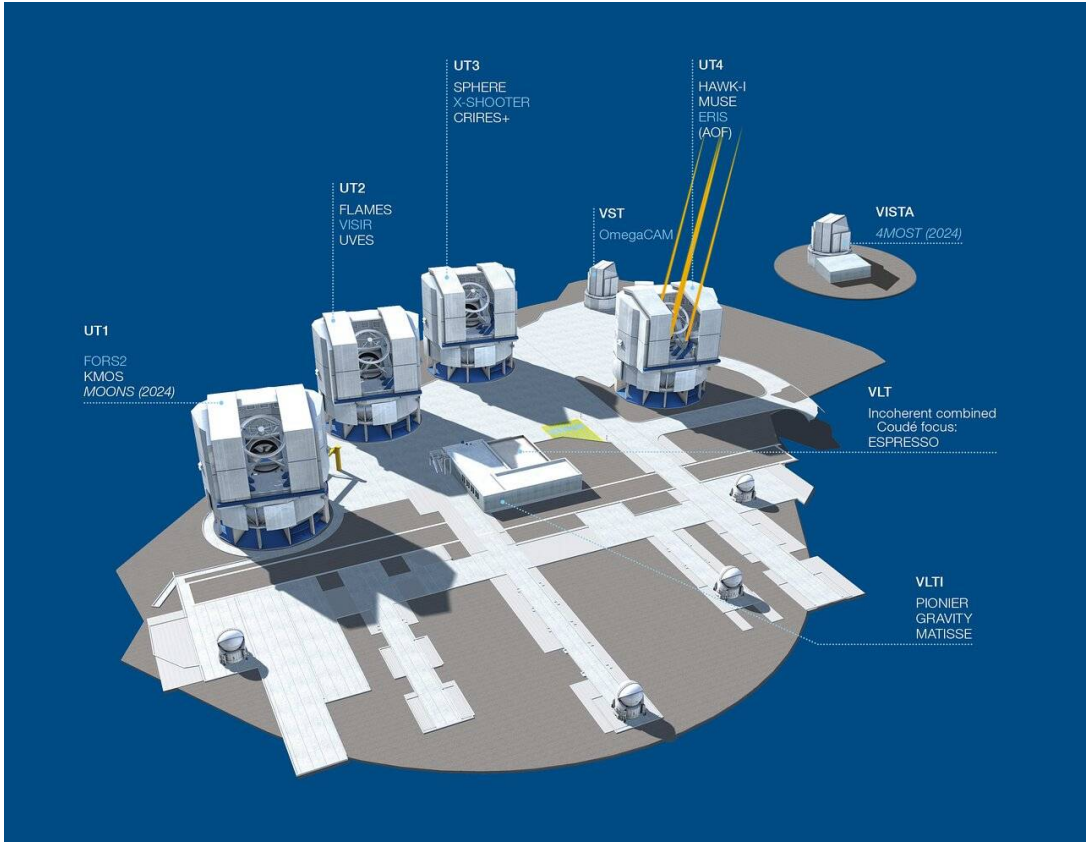
European Southern Observatory

- World's premier observatory
- Sixteen Member States → **In NL, NOVA is homebase**
- Provides access to, now:
  - → ***Very Large Telescope & VLT Interferometer***
  - → ***Atacama Large Millimeter Array***
  - → ***VISTA***
  - → La Silla: ***ESO 3.6m, NTT*** + Hosted facilities, incl. ***BlackGEM***

- In near future: 2030+
  - → ***Extremely Large Telescope***
  - → ***Cerenkov Telescope Array (10%)***

- Further afield: 2040+
  - → ***Expanding Horizons*** project, to be decided

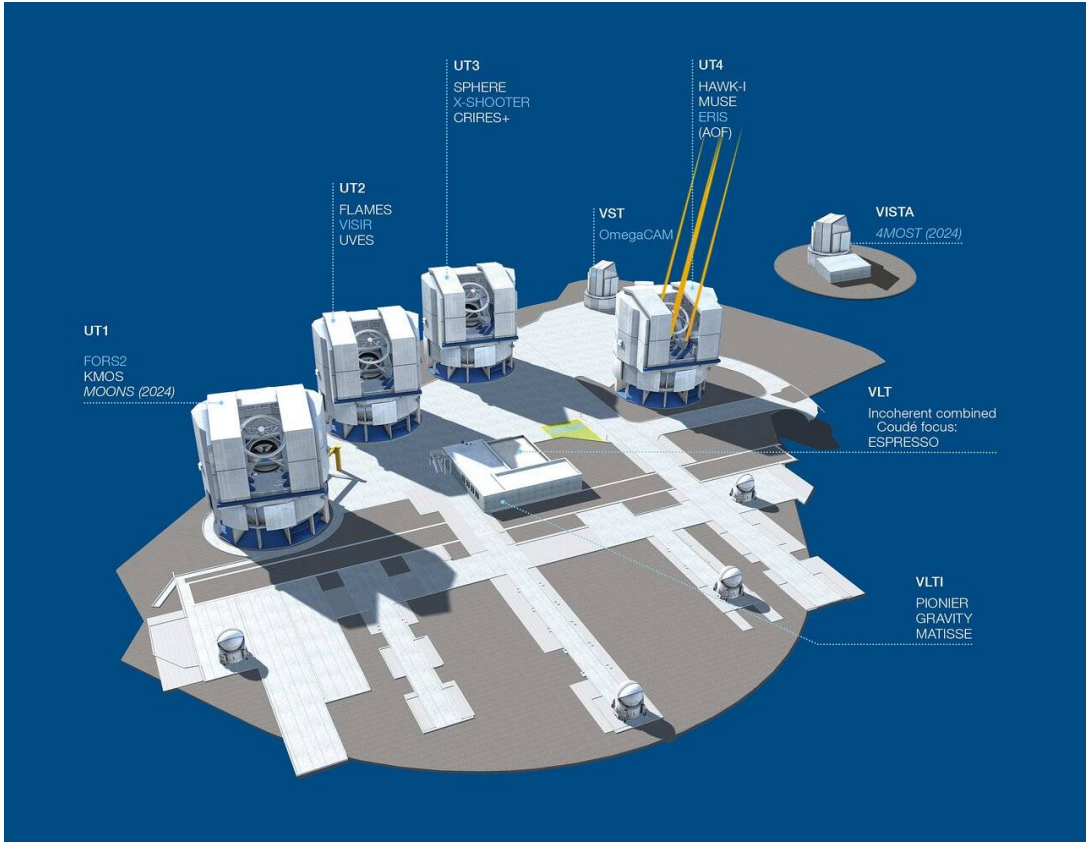
VLT, VLTI, VISTA: Optical – near IR



Very diverse set of instruments

- Spectrographs
  (X-Shooter, UVES, FORS2, CRIRES+, ESPRESSO, VISIR)
- Imaging (AO-assisted)
  (FORS2, SPHERE, HAWK-I, ERIS)
- MOS/IFU spectroscopy
  (MUSE, 4MOST, MOONS, FLAMES)
- Interferometry
  (PIONIER, GRAVITY, MATISSE)

VLT, VLTI, VISTA



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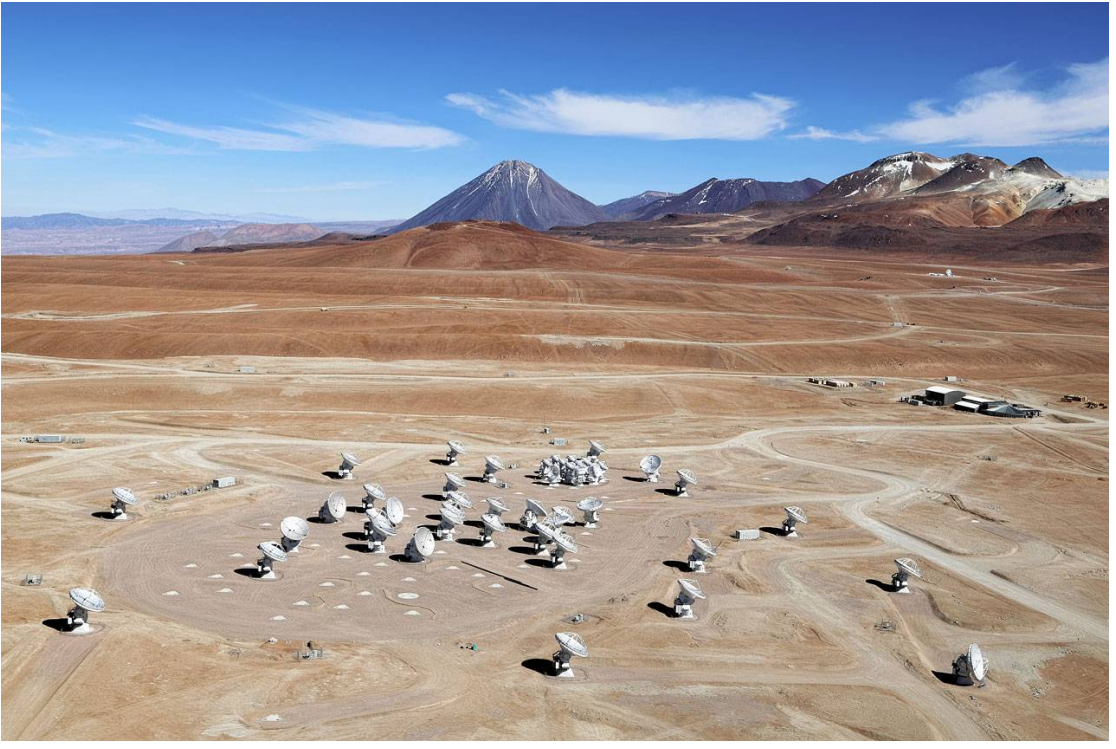
- Interferometry
  (PIONIER, GRAVITY, *MATISSE*)

ALMA: Submm (35-950 GHz)



ESO European partner in
Joint Alma Observatory

- 9 Receiver bands covering full range (**Band 2, Band 5, Band 9**)
- Mulitple array configurations
- Includes Time-Domain
- Includes VLBI participation

EUROPEAN ARC
ALMA Regional Centre || Allegro

La Silla : 3.6m, NTT + Hosted

3.6m and NTT operated by ESO

- **3.6m:** High-res spectroscopy (HARPS + NIRPS)
- **NTT:** Time – domain (SOXS, Ultracam)
- **Hosted: BlackGEM (synoptic survey)**

ESO: Yours too!

- Access provided through **national** contribution
- Time distributed **solely** on scientific merit
- **Yearly** application deadline (late September)

First ***Fast Track Channel*** call P117A:

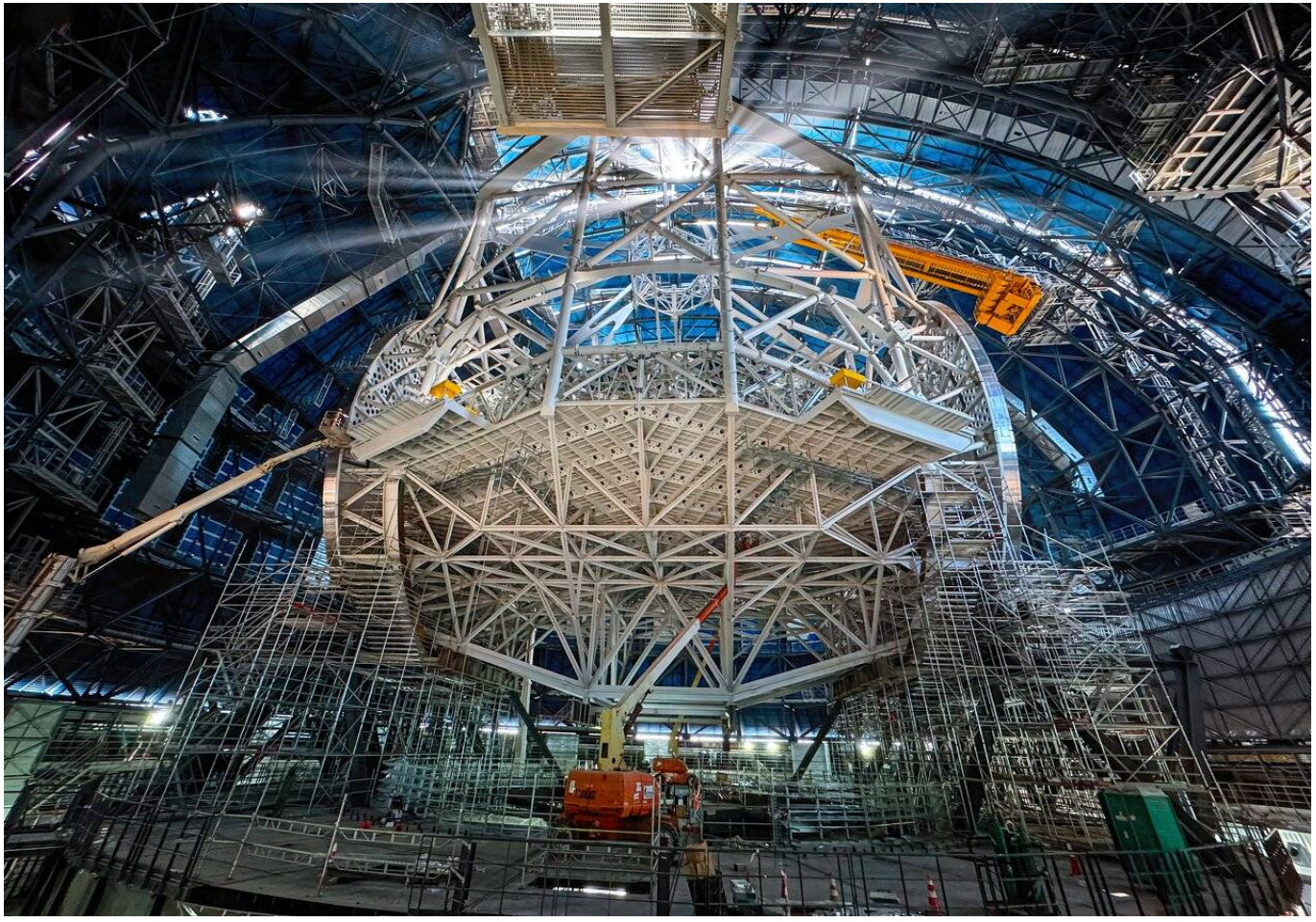
end of May, deadline ***mid-June***
https://www.eso.org/sci/observing/phase1/fast-track-channel.html

Extremely Large Telescope

39-m diameter, AO-corrected, optical-nearIR telescope

Extremely Large Telescope

2030+



39-m diameter, AO-corrected, optical-nearIR telescope

Extremely Large Telescope

Instrument	Main specifications			Schedule				
	Field of view/slit length/ pixel scale	Spectral resolution	Wavelength coverage (μm)	Phase A	Project start	PDR	FDR	First light
MICADO	Imager (with coronagraph) 50.5″ × 50.5″ at 4 mas/pix 19″ × 19″ at 1.5 mas/pix	*I, Z, Y, J, H, K* + narrowbands	0.8–2.45	2010	2015	2019	2024	
	Single slit	*R* ~ 20 000						
MORFEO	AO Module SCAO – MCAO		0.8–2.45	2010	2015	2023		
HARMONI + LTAO	IFU 4 spaxel scales from: 0.8″ × 0.6″ at 4 mas/pix to 6.1″ × 9.1″ at 30 × 60 mas/pix (with coronagraph)	*R* ~ 3 200 *R* ~ 7 100 *R* ~ 17 000	0.47–2.45	2010	2015	2018		
METIS	Imager (with coronagraph) 10.5″ × 10.5″ at 5 mas/pix in *L*, *M* 13.5″ × 13.5″ at 7 mas/pix in *N*	*L, M, N* + narrowbands	3–13	2010	2015	2019	2024	
	Single slit	*R* ~ 1400 in *L* *R* ~ 1900 in *M* *R* ~ 400 in *N*						
	IFU 0.6″ × 0.9″ at 8 mas/pix (with coronagraph)	*L, M* bands *R* ~ 100 000						
ANDES	Single object	*R* ~ 100 000	0.4–1.8 simultaneously	2018	2024			
	IFU (SCAO)							
	Multi object (TBC)	*R* ~ 10 000						
MOSAIC	~ 7-arcminute FoV ~ 200 objects (TBC)	*R* ~ 5 000–20 000	0.45–1.8 (TBC)	2018				
	~ 8 IFUs (TBC)	*R* ~ 5 000–20 000	0.8–1.8 (TBC)					
PCS	Extreme AO camera and spectrograph	TBC	TBC					

Expanding Horizons

- Definition of project ***after*** the ELT: ***2040+***
- Open call to community for projects
- Based on **science**, complementarity to ELT, VLT(I), ALMA

Expanding Horizons timeline

Expanding Horizons: Transforming Astronomy in the 2040s

Jarle Brinchmann [1]
Xavier Barcons [1]
Mariya Lyubenova [1]
Bruno Leibundgut [1]
Paul Callanan [2]
Sara Krauss [1]

[1] ESO
[2] School of Physics, University College Cork, Ireland

The Expanding Horizons process will within a few years ESO's Extremely Large Telescope (ELT) will see first light, providing the next transformational step for astronomy.

Experience has shown that the time required to develop a new major facility is typically 15–20 years; it is clear therefore that the time is now ripe for planning the next major ESO facility to start exploring the sky in the 2040s. To this end, ESO has initiated the Expanding Horizons process[1], a consultation with the community to identify the most pressing scientific challenges

In collaboration with the European Astronomical Society (EAS), ESO organised a symposium at the EAS Annual Meeting in Cork on 25 June 2025, a report of which can be found on page 51 of this issue of The Messenger. In this symposium the community presented some ideas for the main scientific questions that will need answering in the 2040s.

To complement this effort, the SSC also decided to ask the community to provide input through brief science White Papers, with a deadline of 15 December 2025[6].

ESO Messenger, April 2026

July 2024–Q3 2026

- Present and explain the process to the community
- Trigger dialogue about astronomy challenges & disruptive technologies in 2040s

Jun-Dec 2025

- Launch of call for White Papers: 25 June 25
- White papers due: 15 Dec 2025
- 3 pages max
- Science focus

Q3 2026–Q2 2027

- Launch of call for Ideas: Q3 2026
- Letters of Intent due 1 Dec 2026
- Proposals due: 1 Jun 2027

Q3 2027–Q3 2028

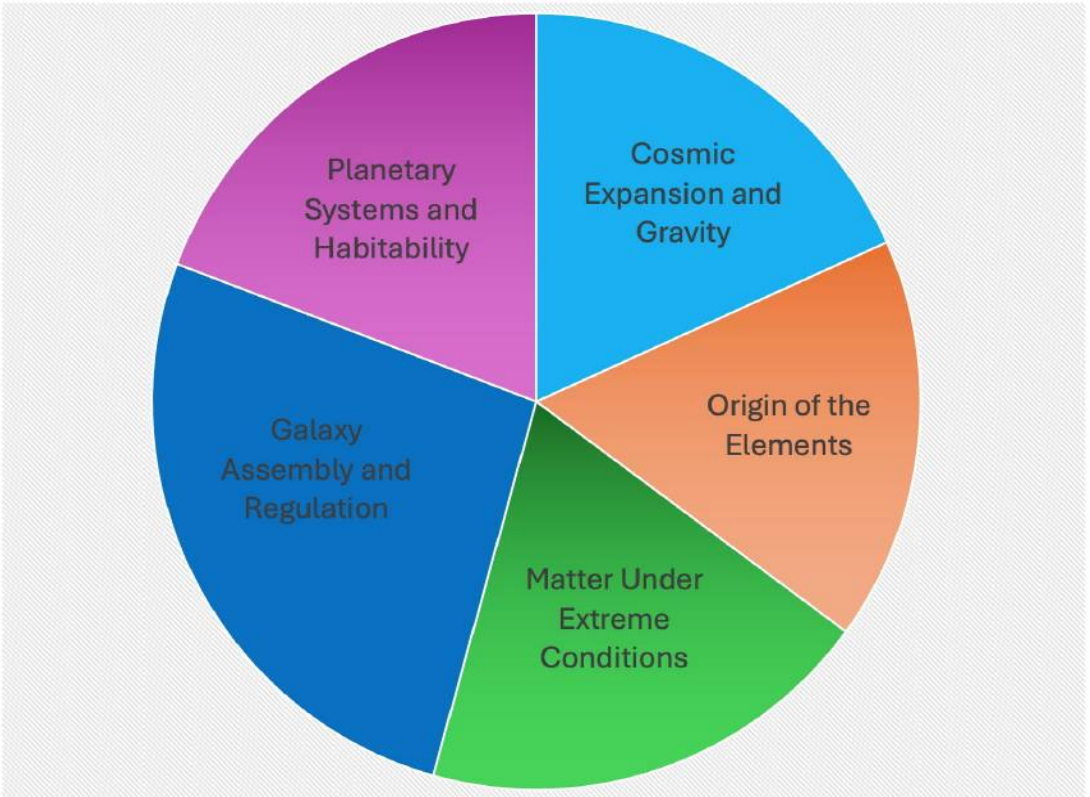
- Performed by SSC and ESO Executive
- Transparently share what ideas are being proposed at a dedicated community workshop

Q3–Q4 2028

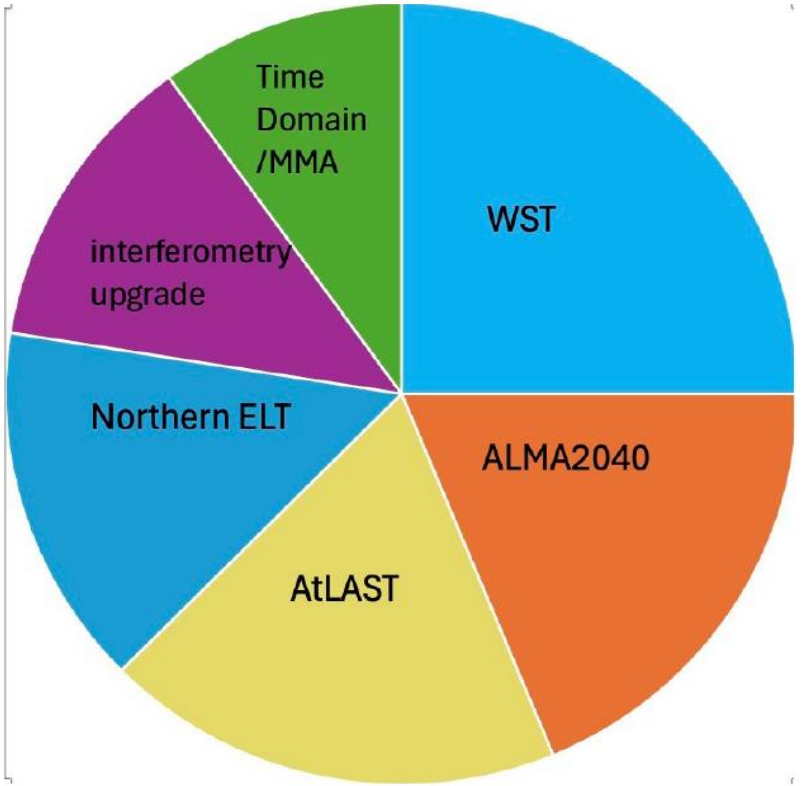
- Presented at STC and Finance Committee
- Council decision
- Decision is **not** the start of the new Programme

Expanding Horizons

White Papers by general science theme



White Papers by facility type

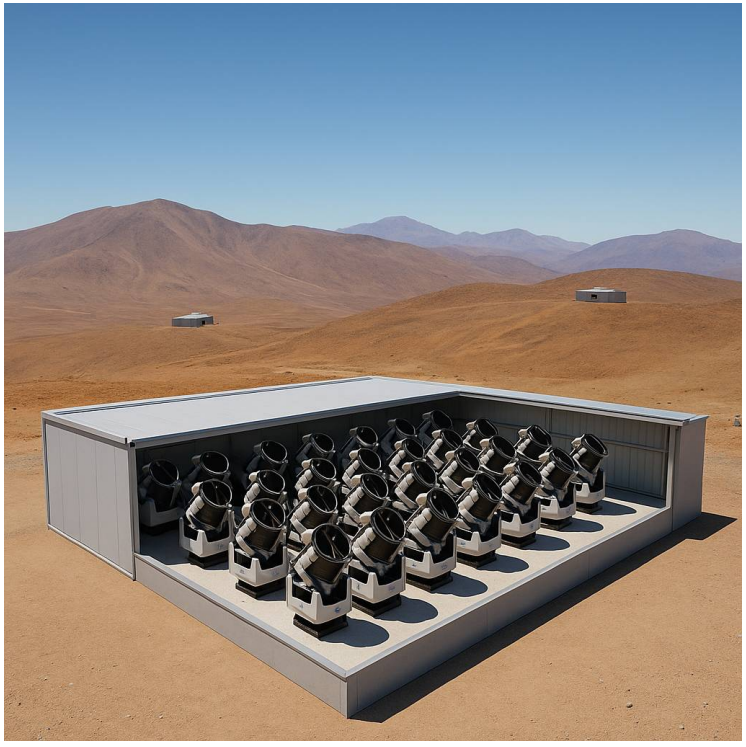


From Presentation SRC, March 2026

TIME DOMAIN TELESCOPE

Overview

1. What is the TDT?
2. Science with the TDT
3. Conceptual lay-out
4. Who are the TDT team?
5. Precursors
6. Possible next steps.



www.tdtelescope.org

May 12, 2026

TIME DOMAIN TELESCOPE

What is the TDT?

- ***Spectroscopic*** **telescope array for time-domain, time-constrained observations**
- **Distributed robotic array of unit telescopes**
- **Unit telescopes of size ~2 m, AO enabled → Diffraction limited (*2m@0.12”)***
  - → ***Essential in background-limited regime (21 < m < 27)***
  - → ***Essential in crowding-limited regions***
    (Bulge, Glob.Clust., MagClouds, Galaxy Bulges, Galaxy Cluster)
- **Unit telescopes *individually* steerable/programmable**
- **Multiple units (‘25’) feed into cluster set of spectrographs**
  (e.g. $\Re = 10^3$, 10^4 and 10^5 per cluster): VIS-NIR: 0.35 – 2.5 µm
- **Go big or go wide: N x 1 unit or 1 x N units or m x n units,**
  e.g. 200 x 1 units, or 1 x 200 units or 5 x 40 units.
- **Read-noise free detectors** → No read-noise penalty
- **Global coverage**

“ Spectra when you need them. Anywhere, Anytime!”

TDT Science

TIME DOMAIN TELESCOPE

Q1: What is the origin of the elements?

- → *Gravitational wave mergers*
- → *Supernovae & Gamma-Ray Bursts*
- → *Stellar furnaces*

Q2: What powers the Universe?

- → *Accretion physics in compact binaries*
- → *Stellar mergers incl. LISA sources*
- → *Changing look quasars*
- → *Growth of supermassive black holes*

Q3: What is the expansion history of the Universe?

- → *Is the expansion constant in space and time?*
- → *Supernovae Type Ia as tracers*
- → *Gravitational wave sirens*
- → *Cosmic Distance Ladder, near and far*

Q4: What is the structure of exoplanetary systems

- → *Host star – planet interactions/interplay*
- → *Remnants of exoplanetary systems*
- → *The outer Solar System*

Relativistic transients

GW counterparts, GRBs, and the new zoo of fast blue transients.

Supernovae

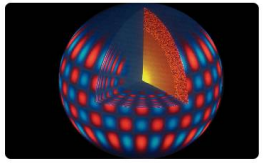
Forensic analysis of stellar death, from shock breakouts to failed detonations.

Accretion across the scales

Spectral-timing of turbulent flows, from compact binaries to supermassive black holes.

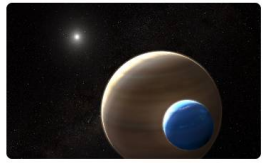
Stellar & binary evolution

Dynamic interactions, common envelope phases, and the progenitors of GW sources.



Stellar interiors

Asteroseismology, eclipsing binaries, stellar populations, protostars...

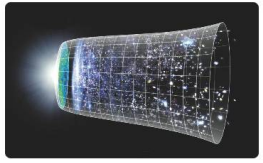


Exoplanets and exomoons

Transit spectroscopy, planets & remnants, disrupted systems...

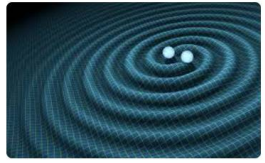
Minor bodies of the Solar System

Asteroids, comets, trans-Neptunian objects...



Cosmology and Fundamental Constants

Dark Energy, Dark Matter, and the expansion of the Universe...



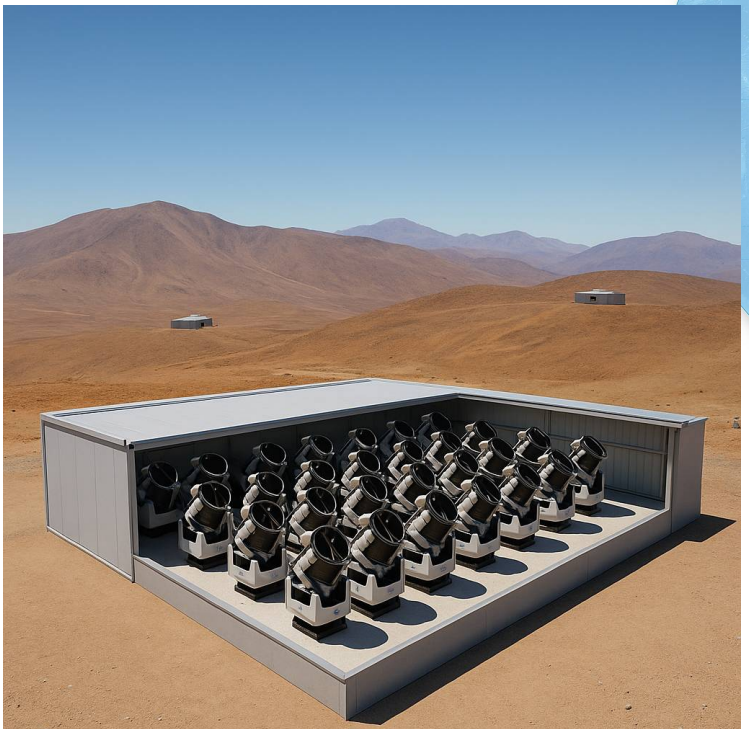
Synergies

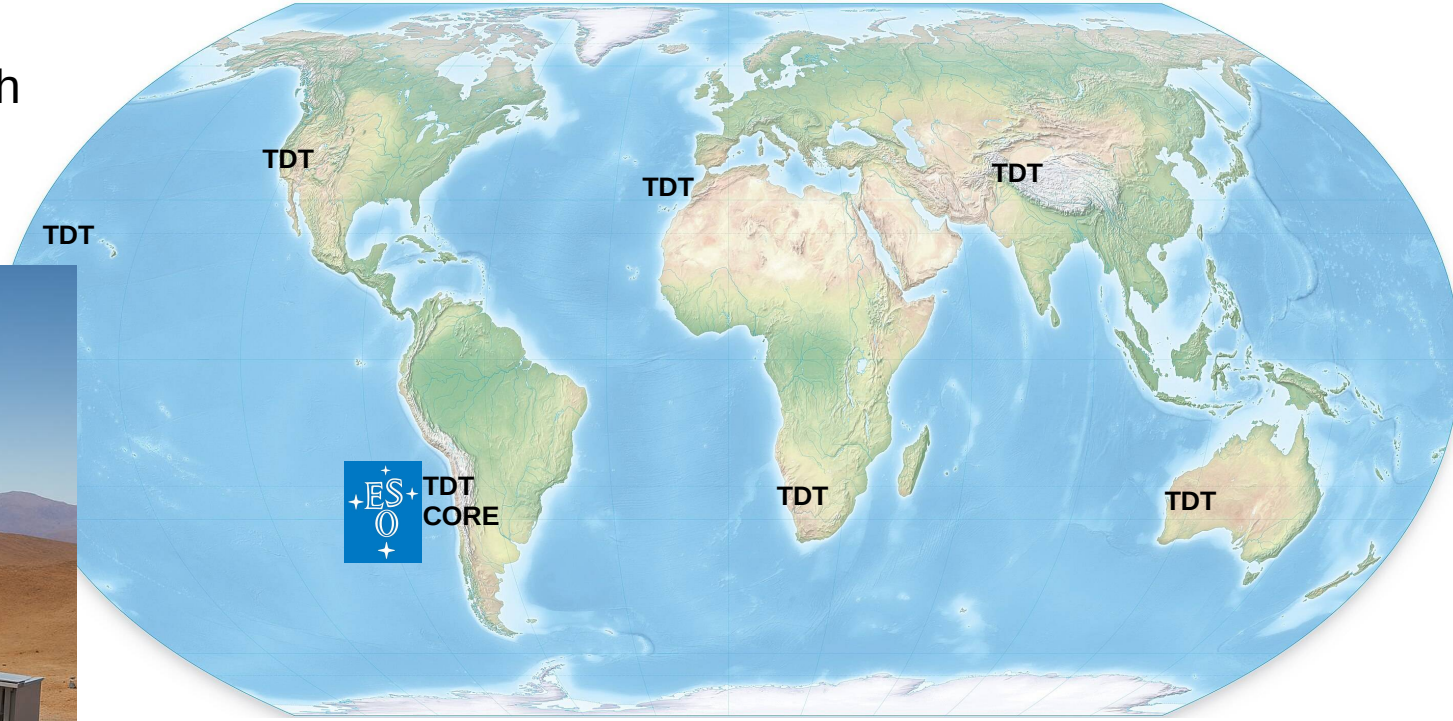
LISA, Athena, and other multi-messenger approaches...

TIME DOMAIN TELESCOPE

TDT Global: 24/7 coverage

Global coverage of ESO with partnerships



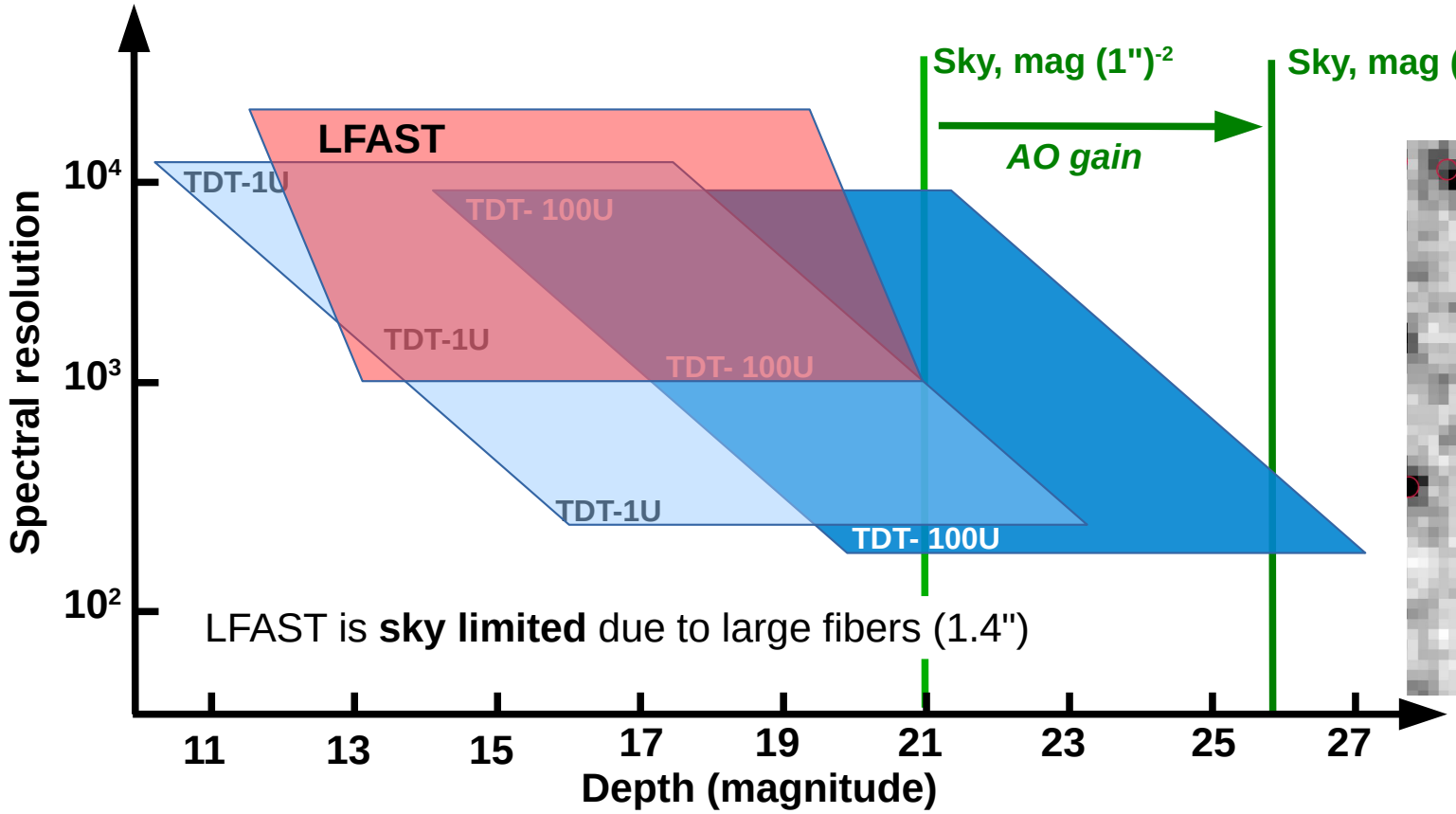


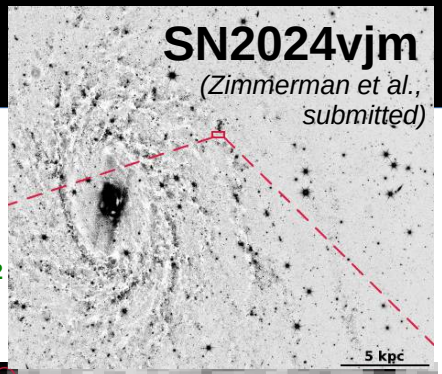
“ Spectra when you need them. Anywhere, Anytime!”

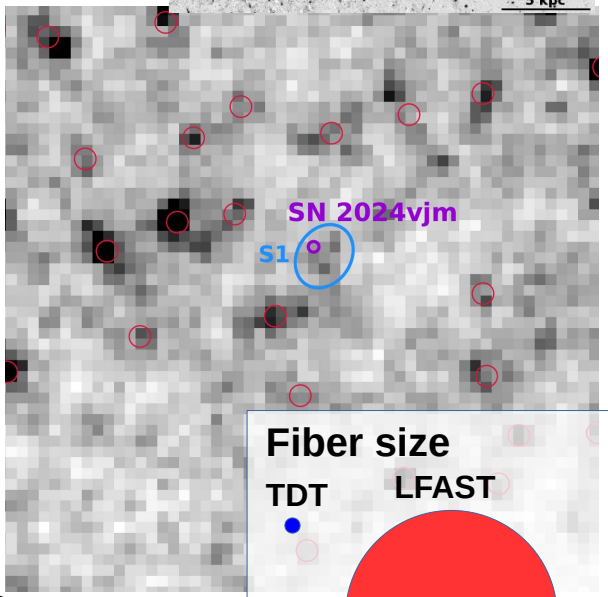
TIME DOMAIN TELESCOPE

TDT Sensitivity vs. LFAST

TDT sensitivity (deepest: SNR = 5 in 900s)

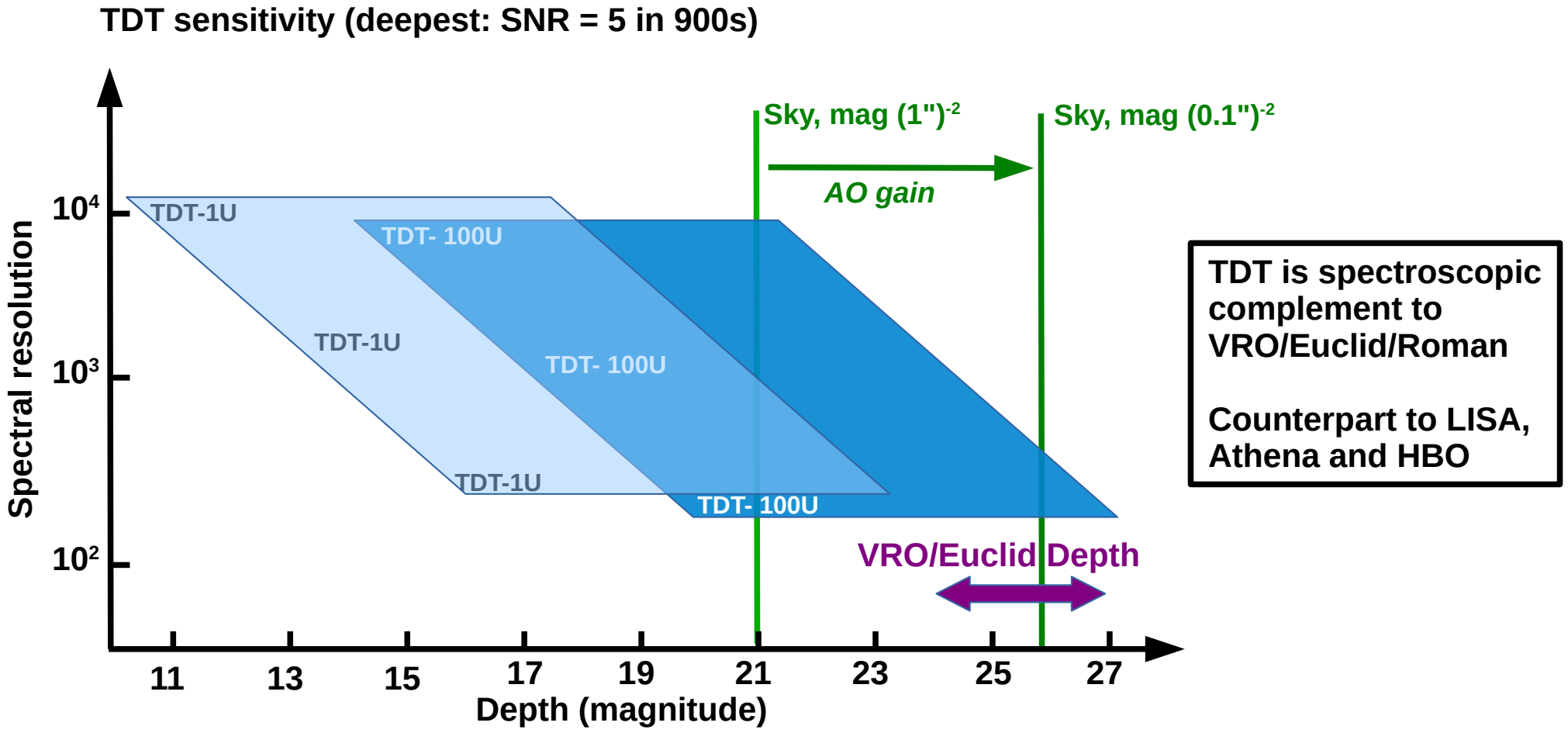






TIME DOMAIN TELESCOPE

TDT Sensitivity vs. VRO/Euclid/Roman



TDT is spectroscopic complement to VRO/Euclid/Roman

Counterpart to LISA, Athena and HBO

TIME DOMAIN TELESCOPE

Who are the TDT?

Europe-based initiative, in the context of the ESO Expanding Horizons program

TDT Steering Committee

Paul Groot
Radboud & Cape Town

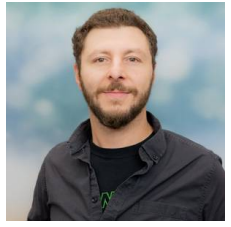
Transients,
Compact Binaries
Instrumentation

Thomas Kupfer
Hamburg Observatory

Compact Binaries &
LISA Sources

Samaya Nissanke
DESY / DZA

Multi-messenger Astronomy
Gravitational Wave Mergers



Simone Scaringi
Durham University

Accretion Physics at
All scales

Broader collaboration with
100+ scientists and
Instrumentalists across Europe

Kieran O'Brien
Durham University

Instrumentation &
X-ray Binaries

Boris Gänsicke
University of Warwick

Compact Binaries &
White Dwarfs