



The ESO Programme

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ESO





The ESO Mission

- ESO: European Organisation for Astronomical Research in the Southern Hemisphere
- Mission (Convention):
 - Build and operate world-class ground-based astronomical facilities
 - Foster collaboration in Astronomy
- ESO enables:
 - Scientific discoveries & understanding of the Universe
 - Other: Development of new technologies, impact in economy, international cooperation
- Complementing other ground & space facilities
- In collaboration with scientists, institutes and industry



ESO today

Currently 16 Member States

- Last: Poland (2015) and Ireland (28 Sep 2018)
- 10-year partnership with Australia in La Silla Paranal programme signed in 2017
- Brazil and ESO signed accession agreement in 2010, but accession process incomplete. BR not a member of ESO, but welcome to join/renegotiate at any stage

Personnel ~700+. Budget 2019 ~300 MEUR (incl ELT contributions)

ESO Programmes:

- La Silla Paranal – in operation
 - La Silla
 - VLT/I Programme in Paranal
 - APEX (Partnership MPIfR/OSO/ESO)
- ALMA (Partnership ESO/NSF/NINS) – in operation
- ELT – in construction
- CTA-S – finalising design phase by CTAO

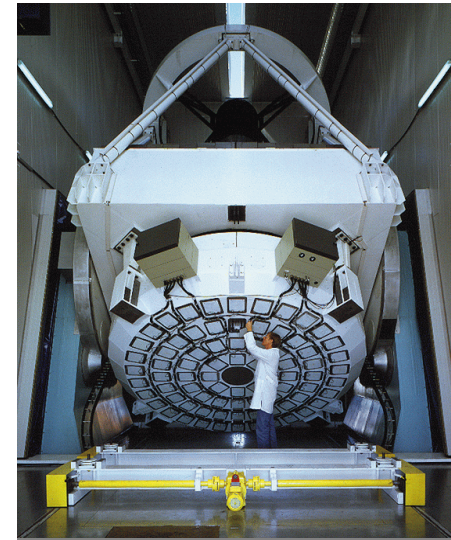
ESO is a key actor in the European Research Area, with a central role in European astronomy.

- Member of EIROforum, ASTRONET
- Specific agreement with ESA (Sci, Tech, Ops, Comm), CERN...
- Working with the EC in several areas (eg ESFRI)

La Silla



ESO 3.6 Metre

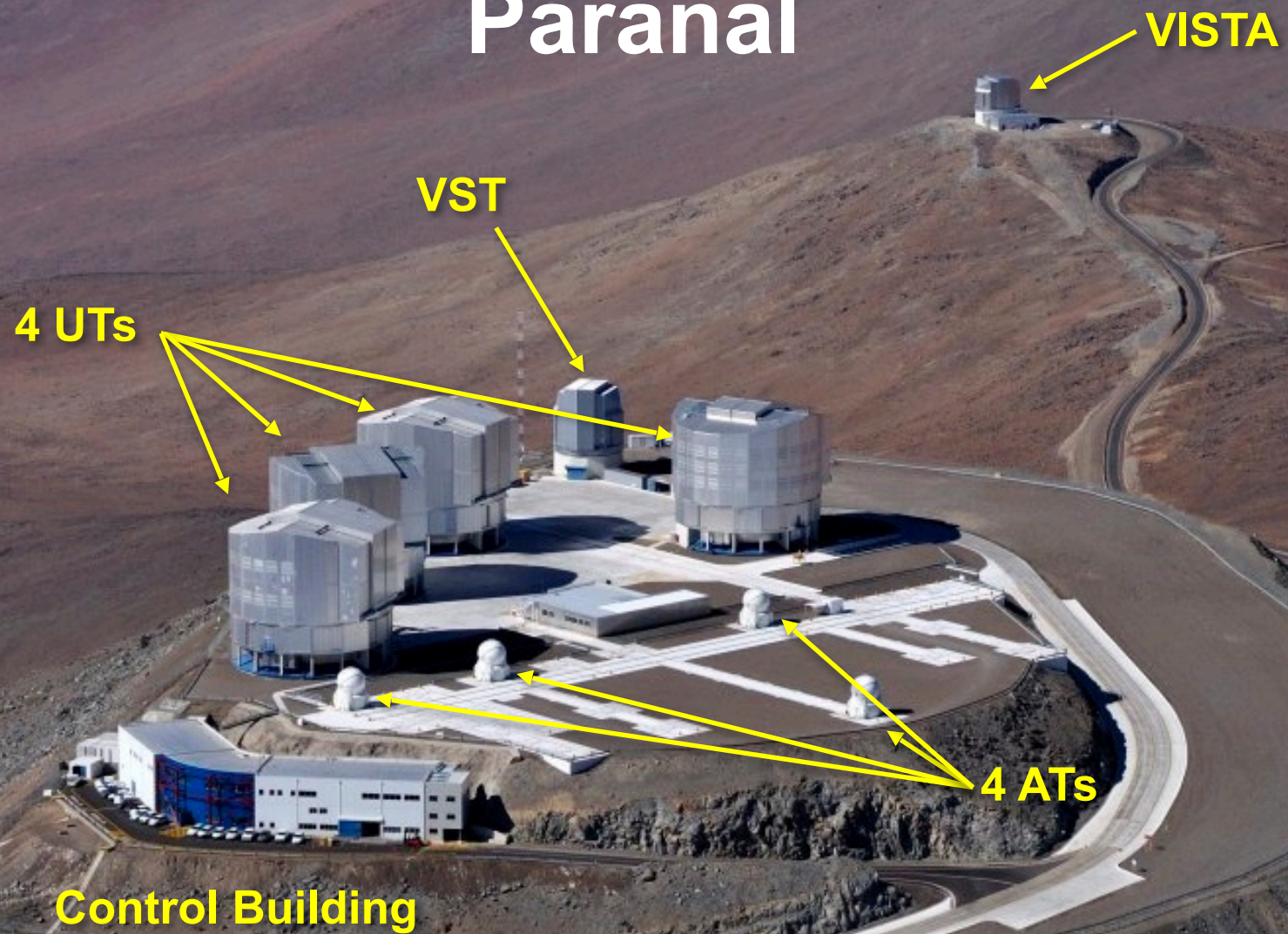


New Technology Telescope
– 3.5 Metre

- Workshop on 50 years of La Silla (14-18 Mar 2019) <https://www.eso.org/sci/meetings/2019/lasilla2019.html>
- New instruments for the facility telescopes
 - SoXS (**S**on of **X**-Shooter) @NTT
 - Broad-band spectrograph for transient follow-up
 - NIRPs (**N**ear **I**nfra-**R**ed **P**lanet **S**earcher) @3.6m
 - Near-IR Radial Velocity spectrograph
 - First light expected over the next 2~ years
- (New) hosted telescopes:
 - ExTrA – first light Jan 2018
 - MASCARA - operational
 - BlackGEM (site work started)
 - TBT and NEOSTEL from ESA



Paranal



Twenty years since VLT 1st light

■ VLT first light on the night of 25 to 26.05.1998 on UT1



Planetary Nebula NGC 6302



The Paranal model

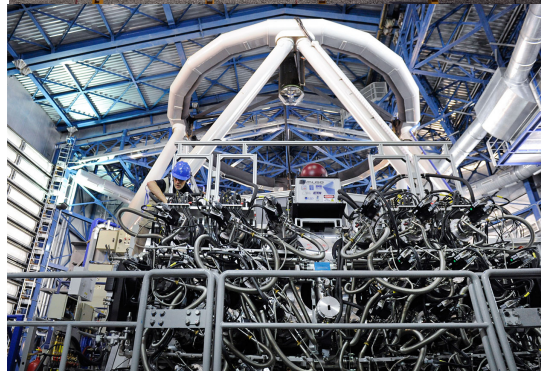
ESO builds the telescopes and all the infrastructure

Instruments developed in partnership with consortia

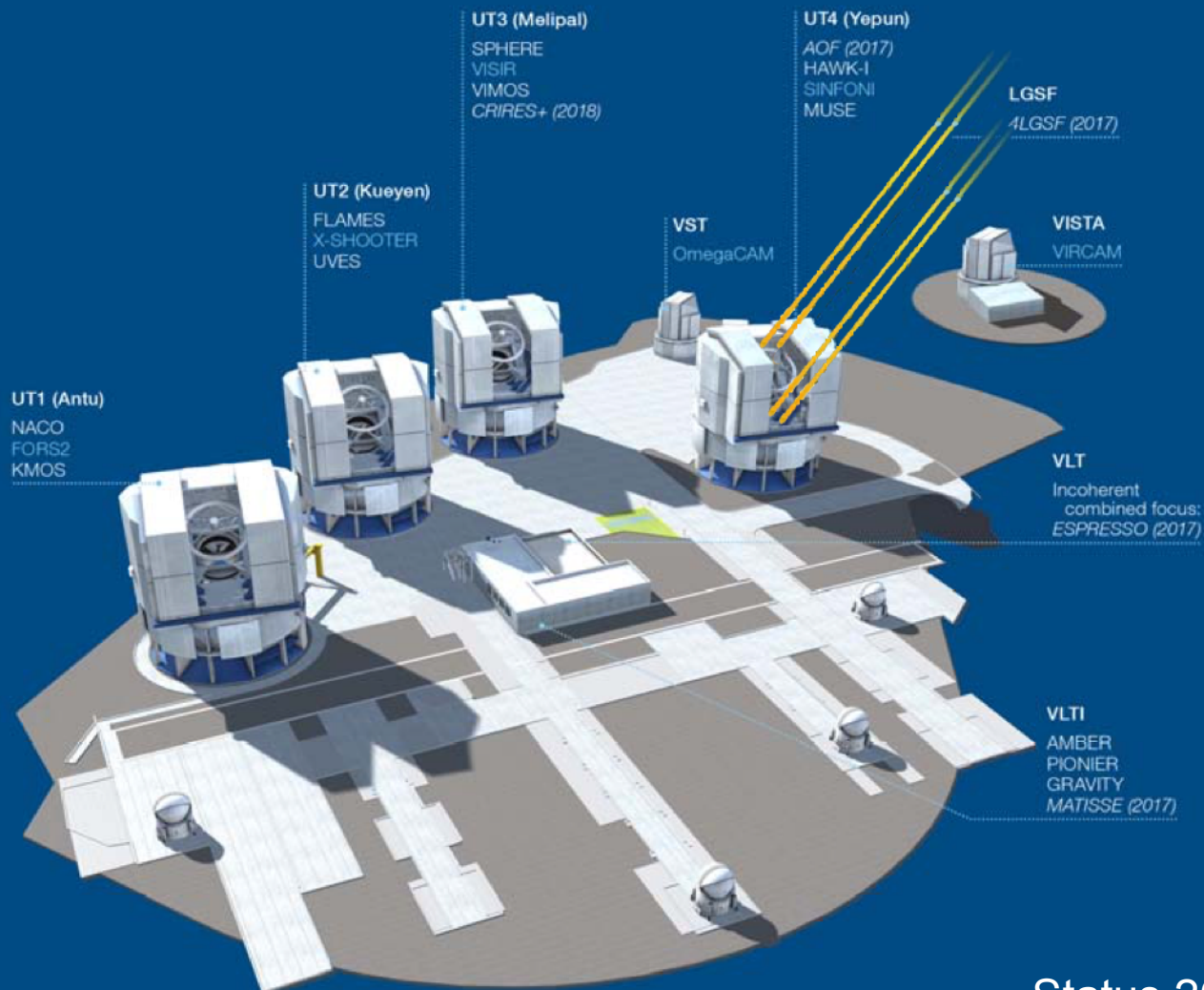
- ESO provides capital costs and oversight
- Effort from consortia compensated by GTO

ESO operates the entire facility

- Technical downtime < 3%



VLT system



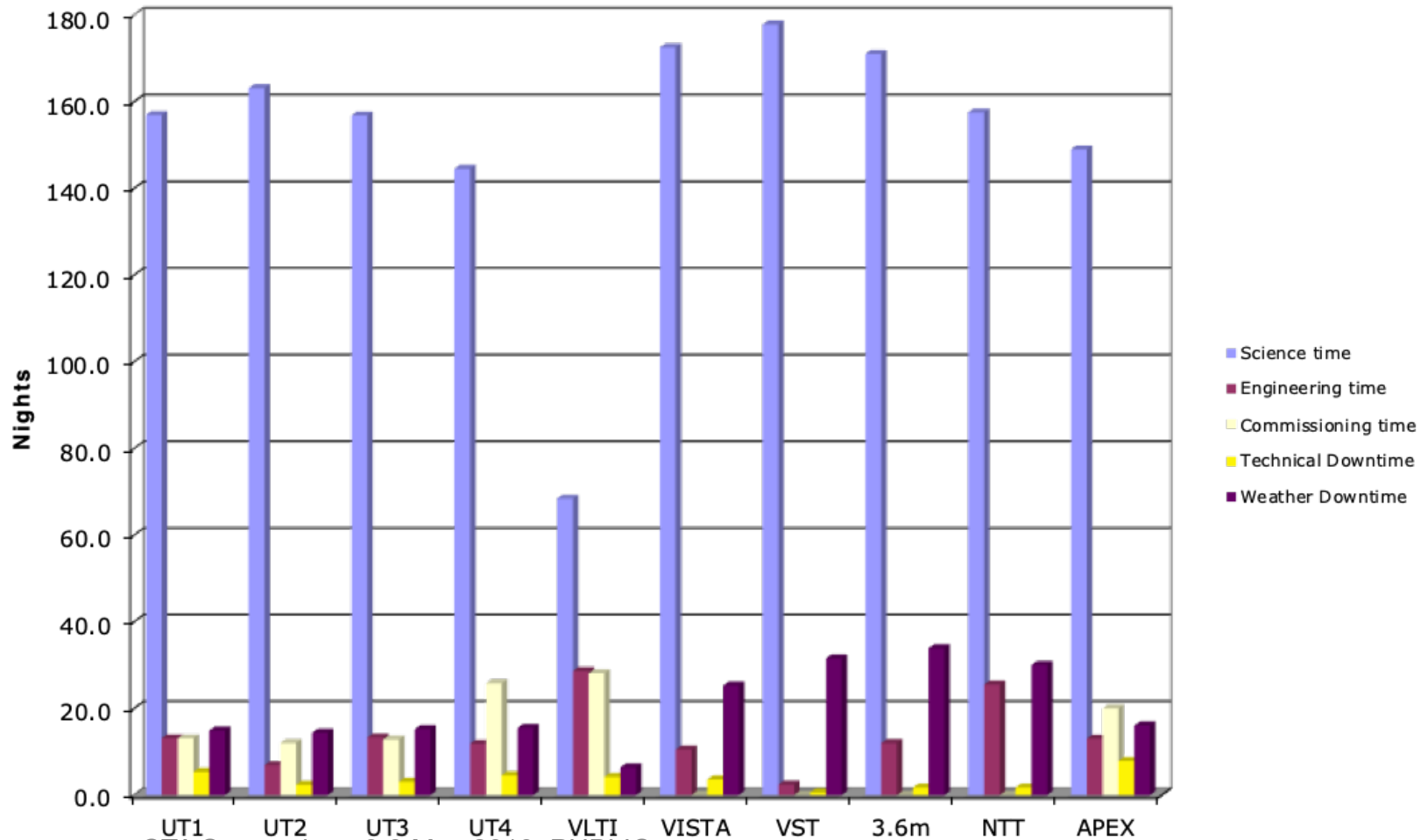
Status 2019

- Partnership MPG/OSO/ESO
 - ESO operates the facility
 - APEX Board meets 2 times/year
- 5-year extension started Jan 2018
 - ESO has 32% share
 - Novel instrumentation under development
- Major overhaul from Sep 2017 to April 2018
 - Science operations re-started in April 2018
 - Further interventions completed in 2019



LPO Observatory Operations

Telescope Statistics P101 (April 2018 - September 2018)



The ESO Programme, CTA Symposium, 6-9 May 2019, PUBLIC

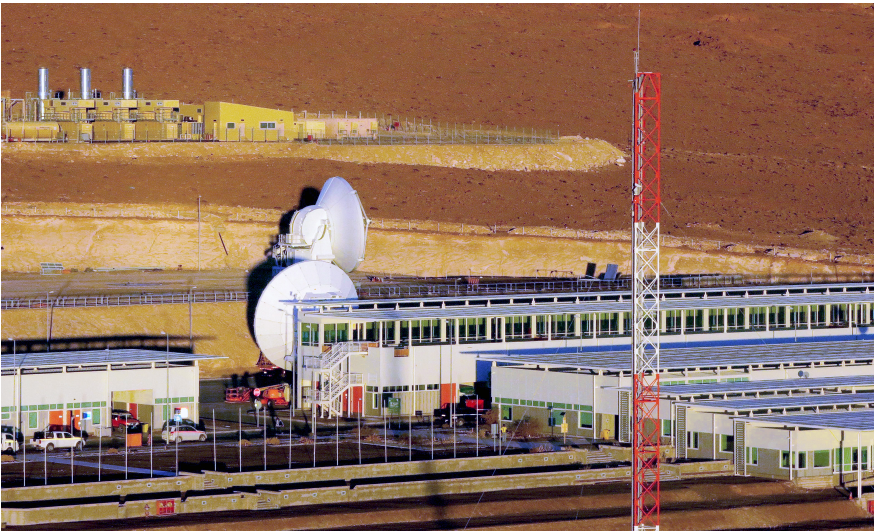
- Largest sub/mm radio interferometer
 - In operations since 2011
- Global partnership: ESO, NSF (USA) and NINS (JP)
- Array Operations Site in Chajnantor (5050m)
 - 66 (movable) antennas, over a 16 km plateau
 - Back end and correlator
- Operations Support Facility at 3000m, near San Pedro de Atacama





ALMA on the Chajnantor plateau,
at 5050m altitude





I would suggest:

- Development plan -> Development Roadmap
- Band 2 development -> Band 2 production

Science ops & development

ons

our obs

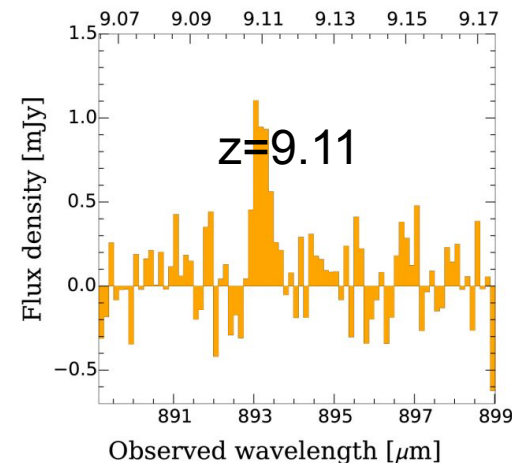
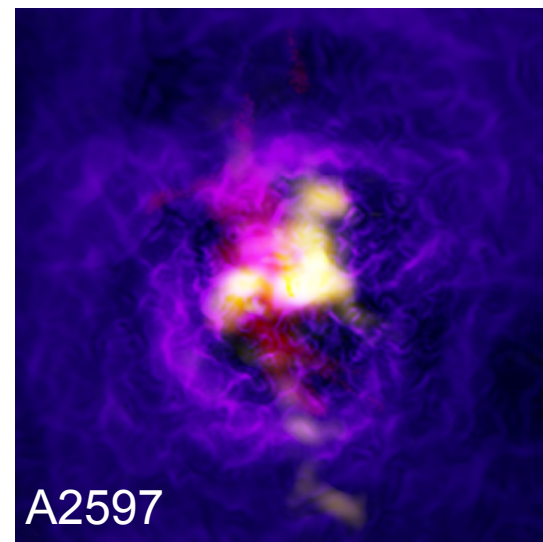
- Cycle 6: on-going
 - 66 antennas available
 - Target: 4300 hr
- Cycle 7: >1800 proposals submitted

Science production: more than 1200 refereed papers so far

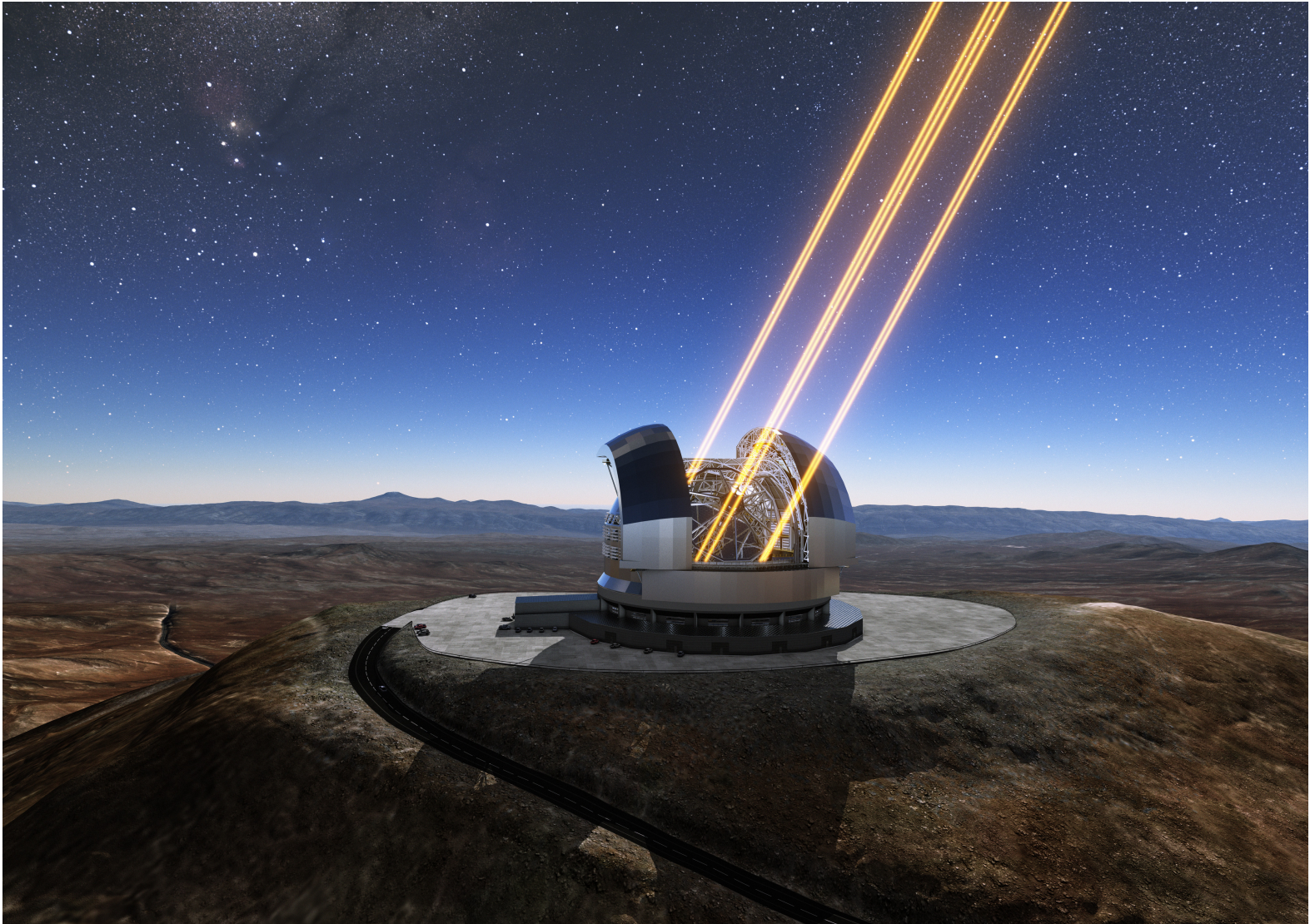
- Typically, the ESO region
 - Submits 41% proposals
 - Leads 41% of the papers
 - Allocated time: 34%

ALMA development:

- Development roadmap for next decade focused in at least doubling sensitivity
- ESO to lead new Band 2 production

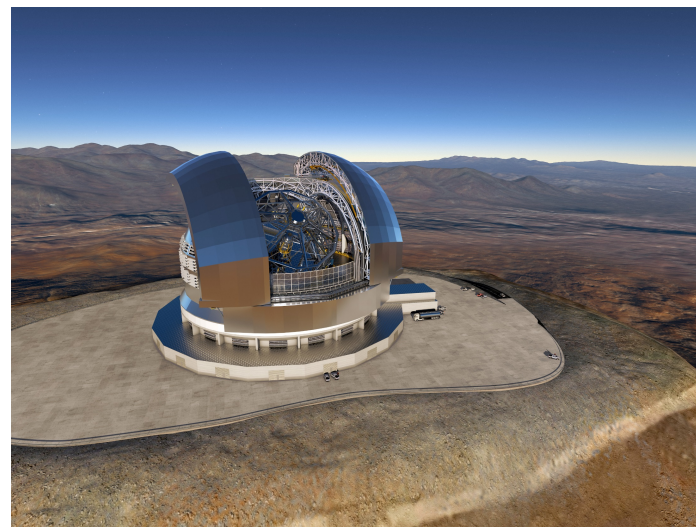


ELT



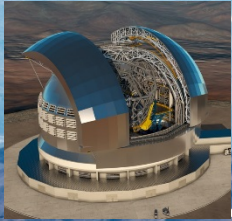
Extremely Large Telescope (ELT)

- Largest optical/infrared telescope in the world
 - 39m segmented primary mirror & adaptive optics
 - Transformational science objectives
 - Including exo-earths, galaxies and first light
 - Construction 2014-2024 (~1200 MEUR)
 - On Cerro Armazones, as part of the Paranal system
 - Operations costs foreseen in ESO's budget

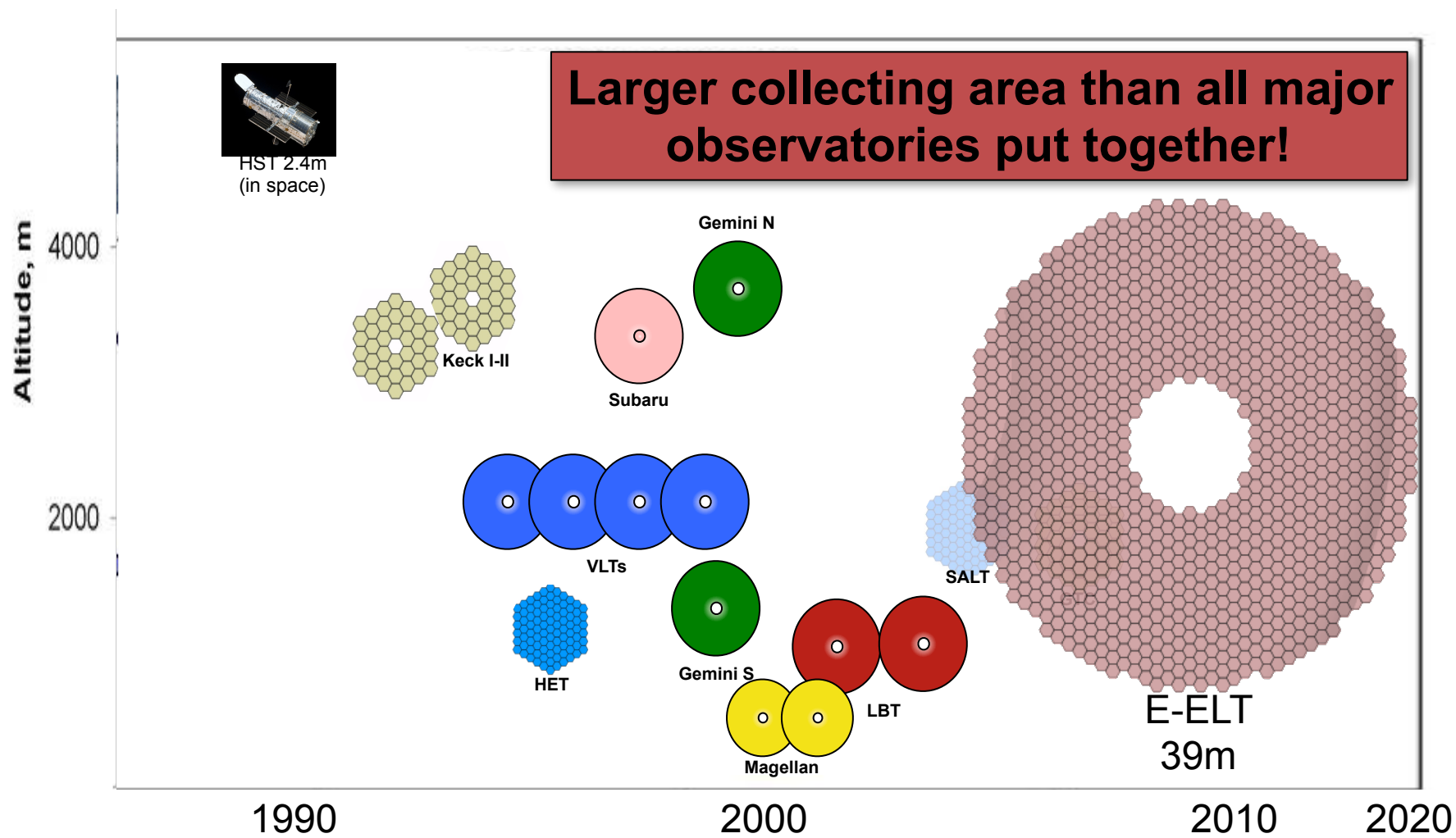




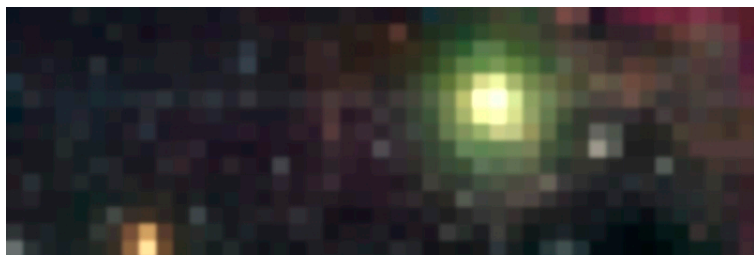
Paranal and Armazones



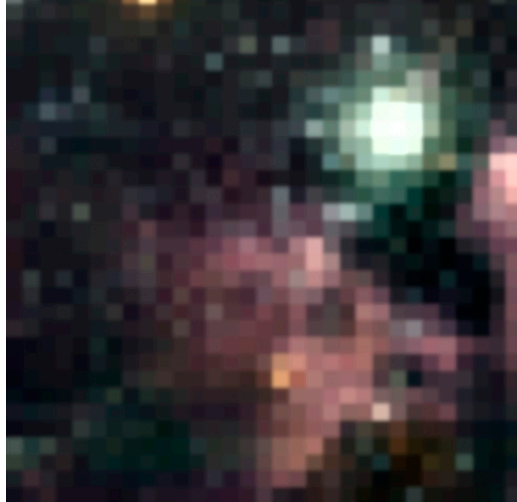
ESO's ELT: A new era



ELT spectacular resolution



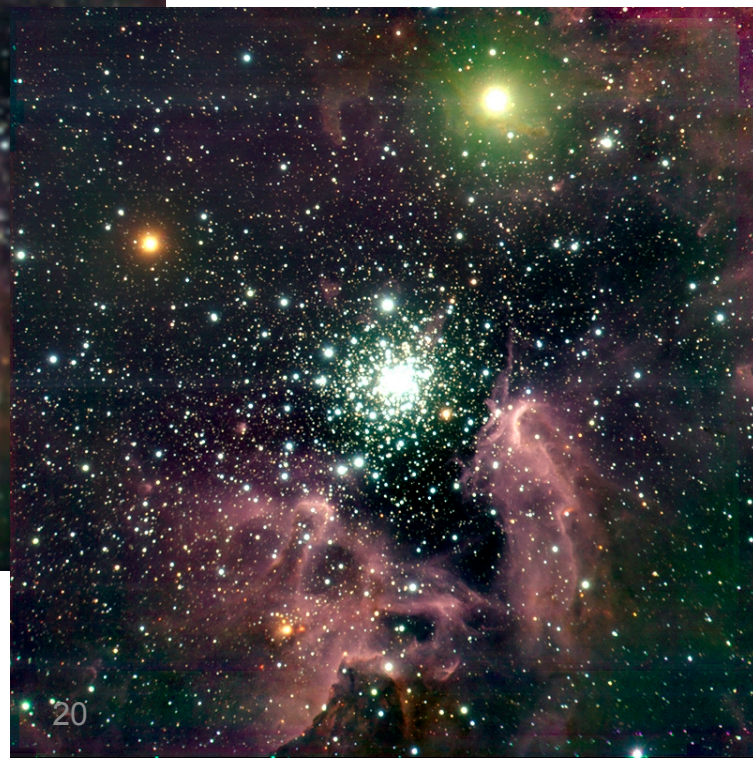
VLT+AO



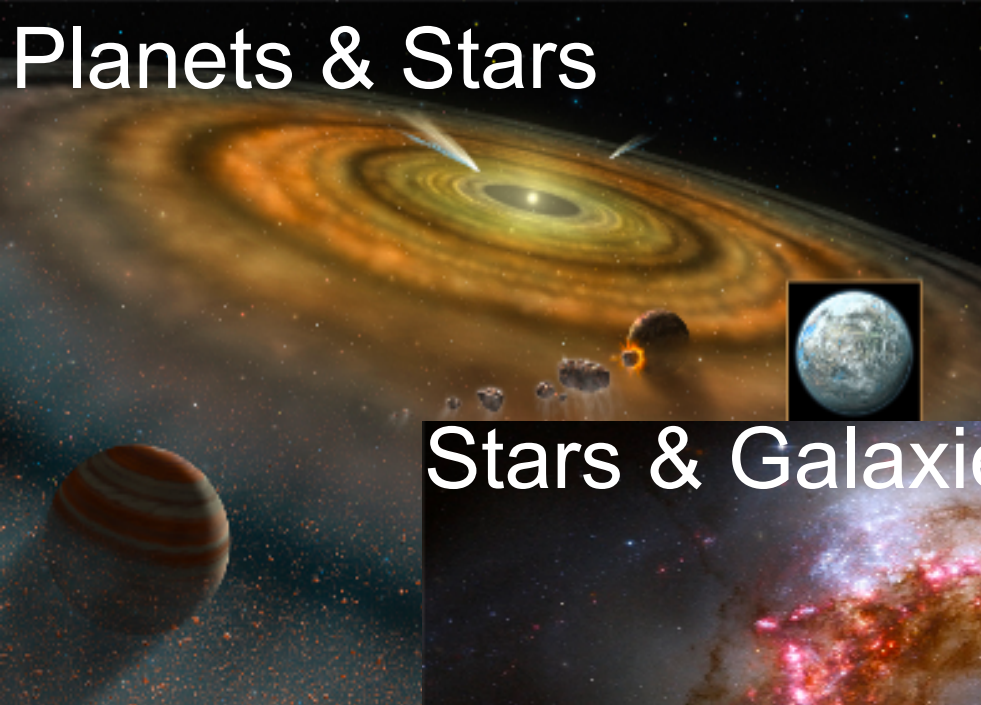
HST



ELT



Planets & Stars



ELT Science

Stars & Galaxies



Galaxies & Cosmology



Armazones

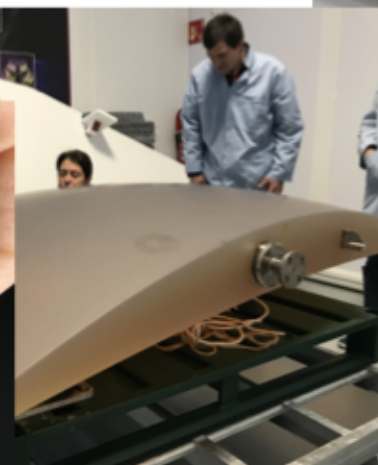
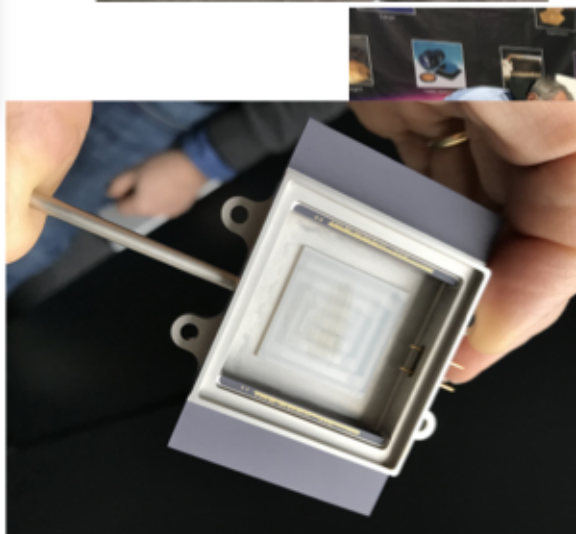
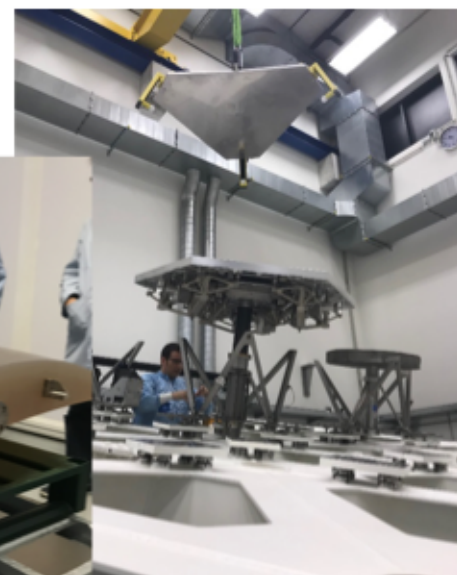
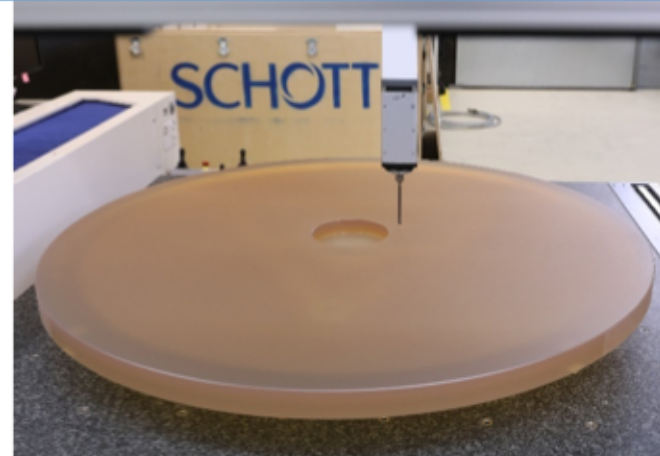




M1 LCS Development Status

green = 1st version available, yellow = in progress, red = not started

Subsystem	Libraries and Applications
RuntimeDB	LPC (def) NPC (impl)
Data Framework	FEAdapter FESimMgr FEMeasMon (FEsMon, FEPactMon) FEReflMgr ESIMon FESim (ref impl)
Sync	PlsAdapter SyncAdapter SyncMgr SyncMon
Net	NetAdapter NetMon NetConfig
PDC	PdcAdapter PdcMgr PdcMon PDCCode PDCSim PDCConfig
FDIR	FDIRMgr FDIRSMeasMgr
Data Recorder	DataRecorder
Scripts	Tests Configuration LVS/LCS
GUIs	FE (pymudpigui) RuntimeDB (DBBrowser) Status (m1StatusGui) PDC M FDIR
Common	mudapi mgui Mgr
Tools/Config	sim flogbox percent repoloader msgsend msgpub msgsub mudrecvproc mudpostsend templates



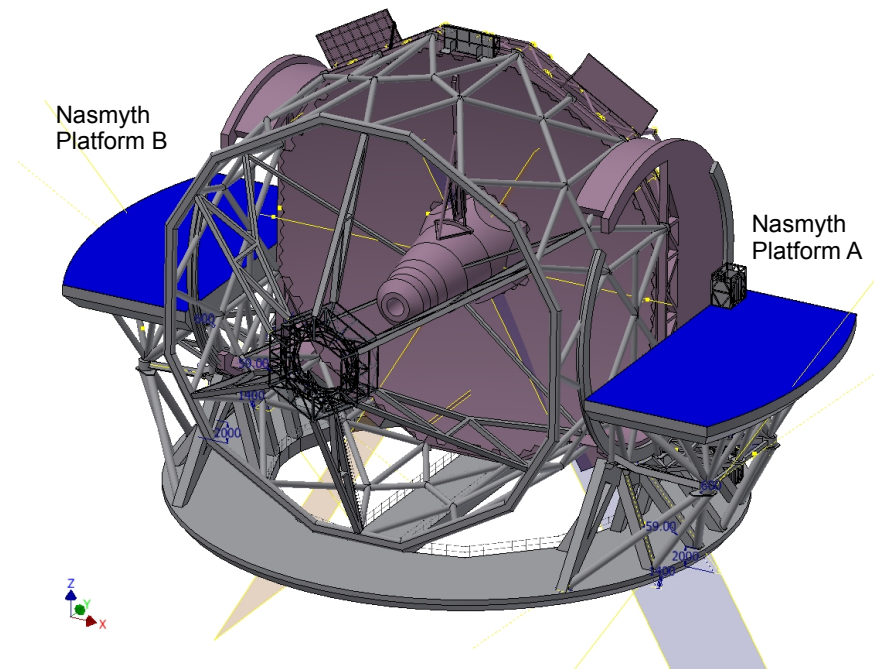
ELT Instrumentation Status

Construction programme instruments

- HARMONI (PDR closed)
- H-LTAO (PDR closed)
- MICADO (PDR almost closed)
- MAORY (PDR in late 2019 TBC)
- METIS (PDR May 2019)

Next generation instruments to be funded mostly by GTO MOSAIC and HIRES

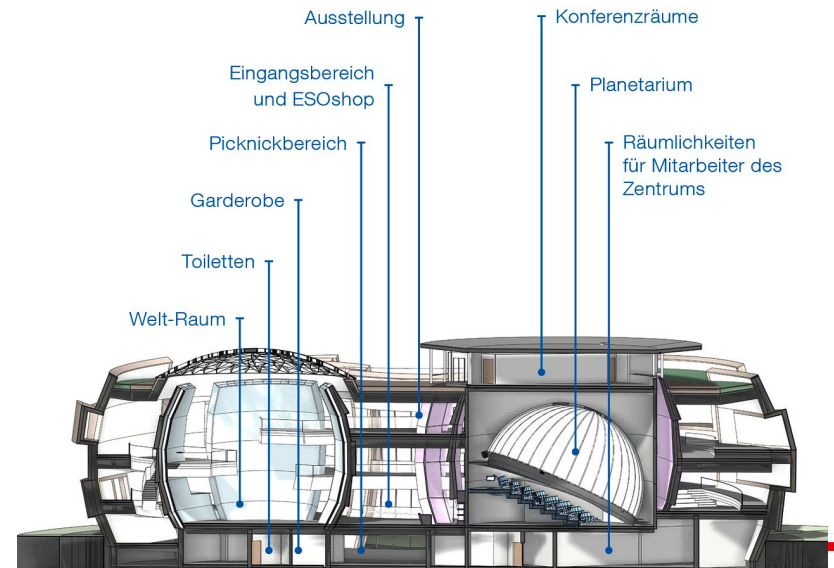
- Partners from non ESO-member states welcome
- Not ready to start any of them until Phase 1 instruments are underway



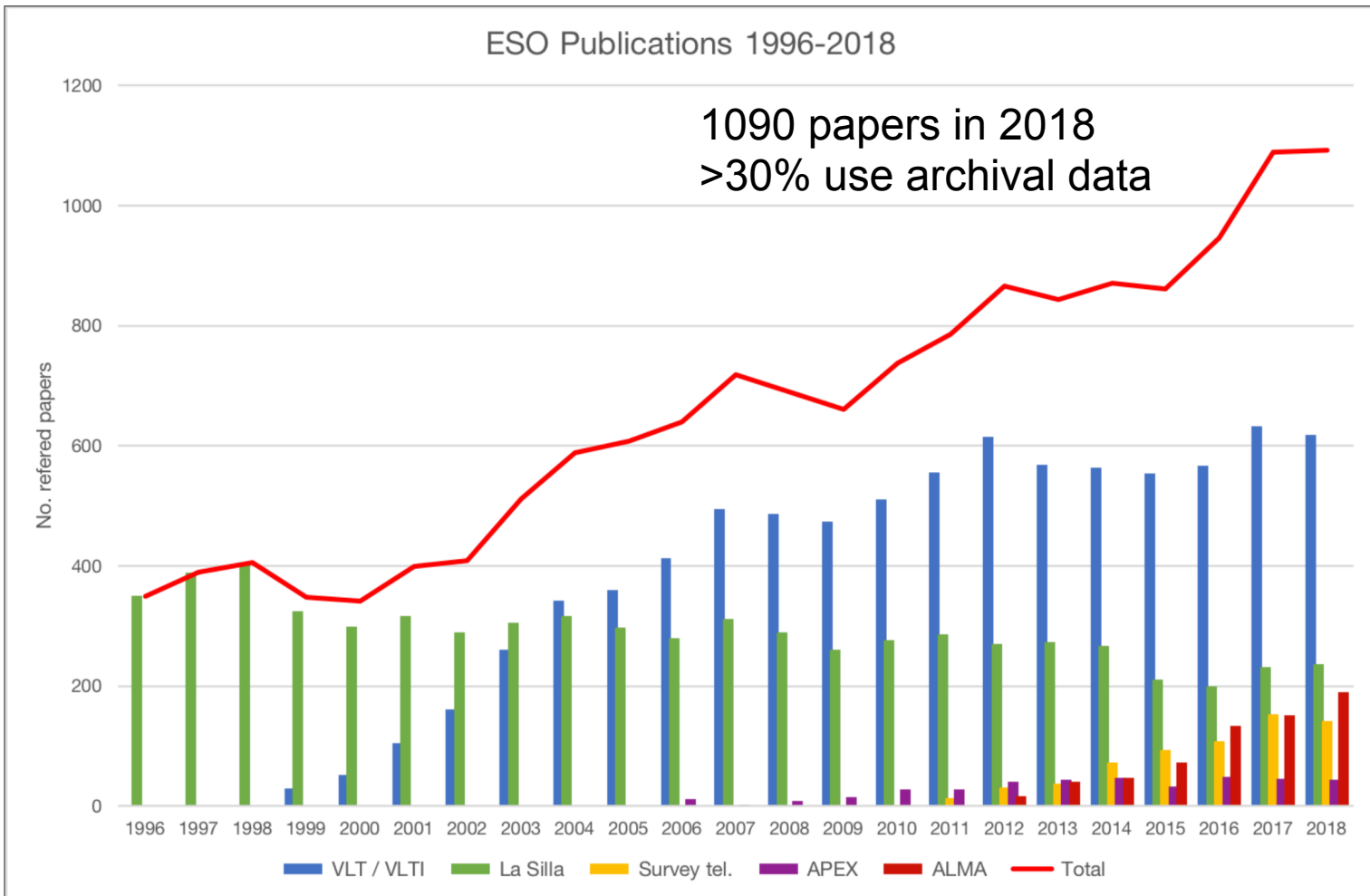


Supernova Planetarium and Visitor Centre

- A gift from the Klaus Tschira Foundation
- Opened 26 April 2018
- 2200 sqm exhibition on 13 astronomical themes
- State-of-the-art planetarium with 109 seats
- Comprehensive education programme
- Seminar rooms



Science enabled by ESO



<http://www.eso.org/sci/libraries/edocs/ESO/ESOstats.pdf>

Science access to ESO's LPO

- Split of LPO (La Silla, VLT/I, APEX) observing time
 - Technical & commissioning time
 - GTO – Guaranteed Time Observations (max ~15%)
 - Host country time (10%)
 - DDT – Director's Discretionary Time (max 5%)
 - Open time
- Time allocation
 - Two yearly Calls for Proposals (~900 proposals/period), oversubscription factor ~ 3-4 in open time
 - Time allocation based on science merit within each observing time pot, as assessed by the OPC and its panels
 - DDT continuously open, similar oversubscription (~ 3)
- Visitor Mode (~30%), Service Mode (~70%)
- All data in archive, and public after 1 year proprietary period

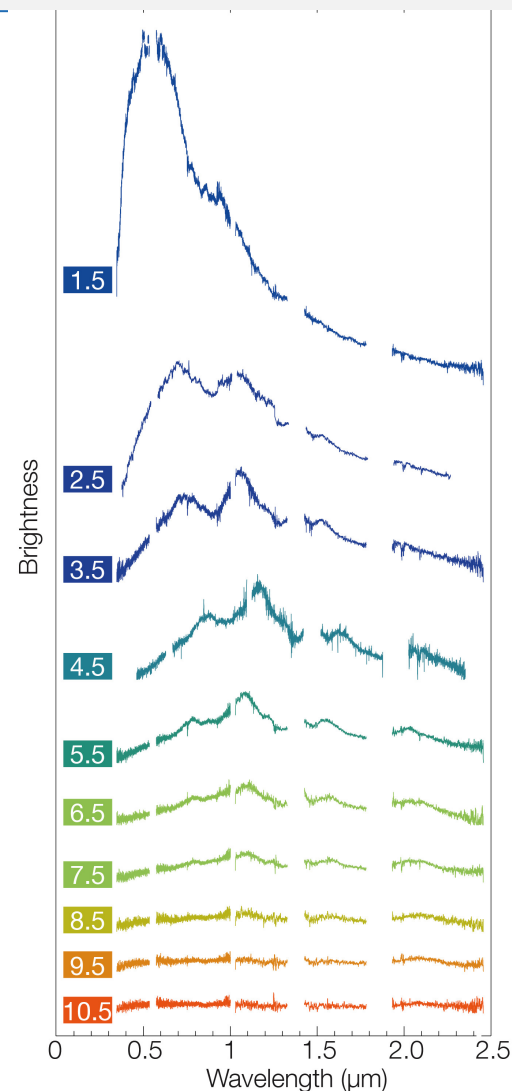
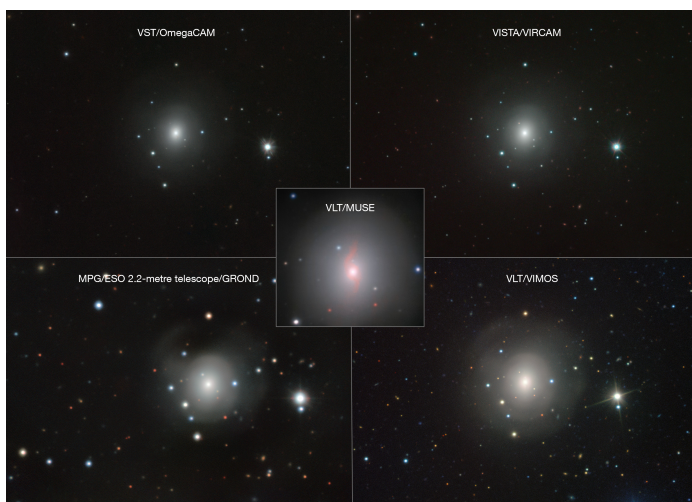


Science access to ALMA

- Split of ALMA Observing time (~ 4000 hours/yr)
 - 10% Chile
 - Up to 5% Open skies
 - Up to 5% DDT
 - Out of the rest 37.5% ESO, 37.5% NA, 25% EA
- Time allocation
 - 1 yearly Call for Proposals (~ 1800 proposals/cycle), oversubscription varies across the regions (ESO~6)
 - Time allocation based on science merit within each observing time pot, as assessed by the APRC and its panels
 - DDT continuously open
- All observations in Service Mode
- All data in archive, and public after 1 year proprietary period

First light from a LIGO/Virgo gravitational wave event

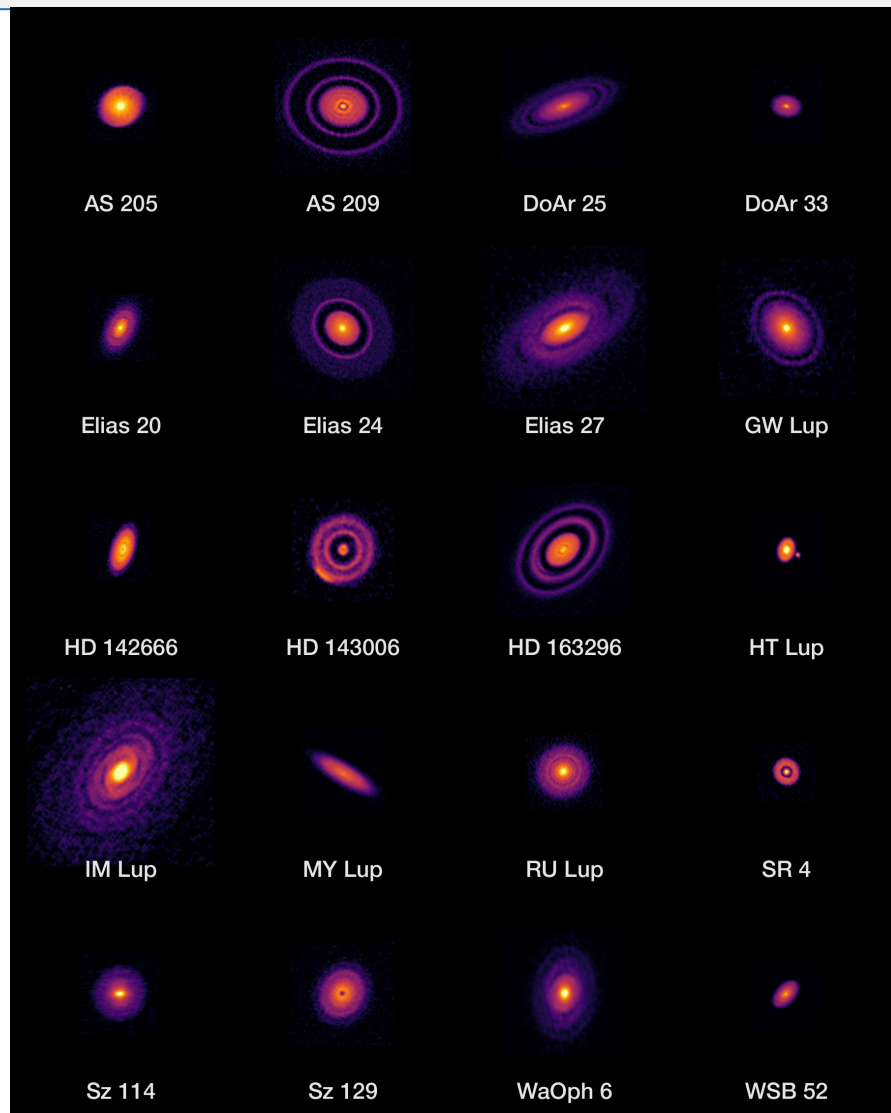
ESO telescopes instrumental in identifying a kilonova as the source for the GW event of 17 Aug 2017



Protoplanetary disks with ALMA

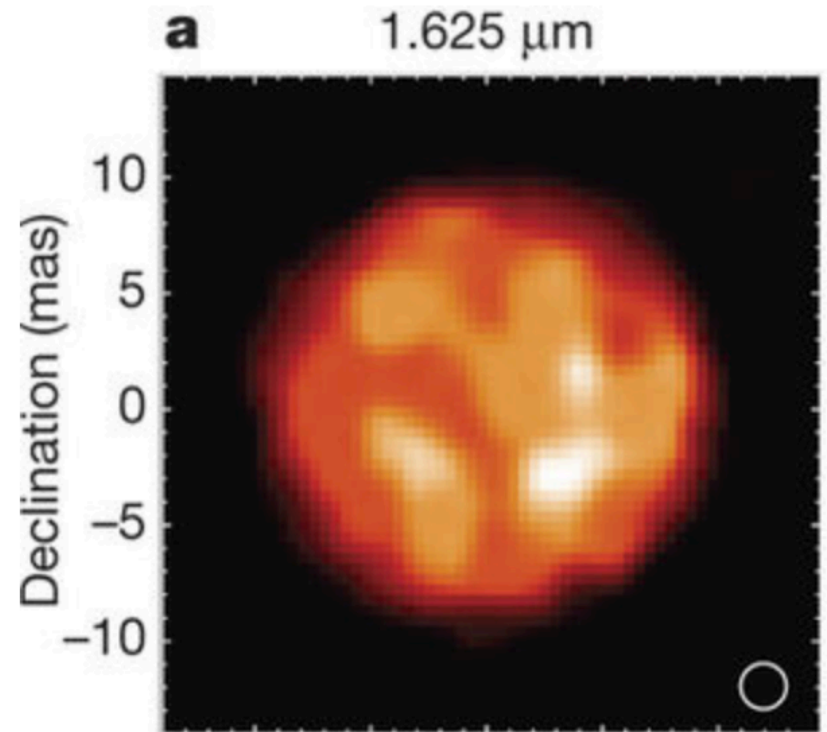
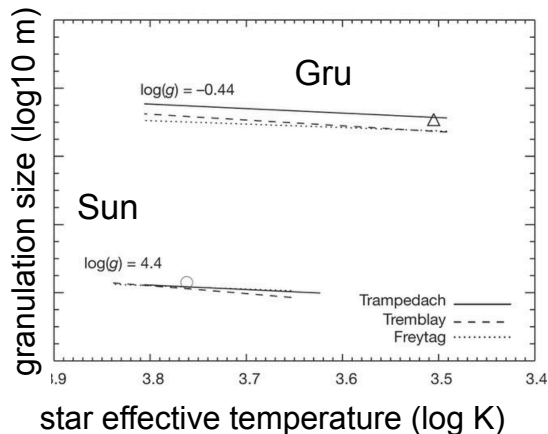
DSHARP

Andrews et al. 2018, ApJL, 869, L41



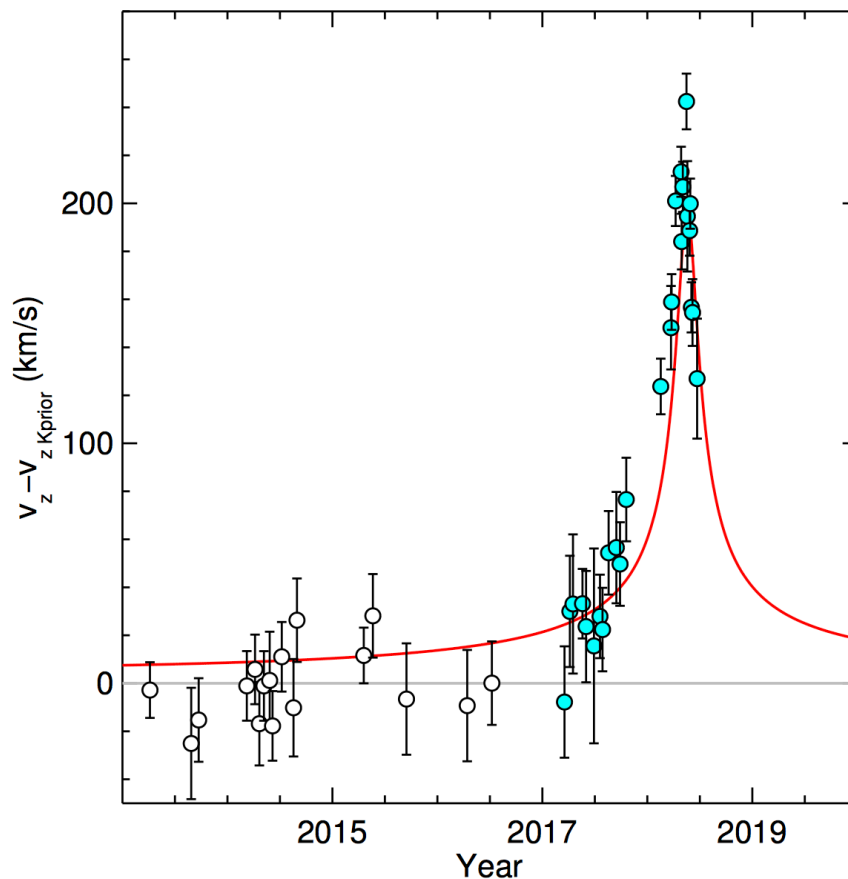
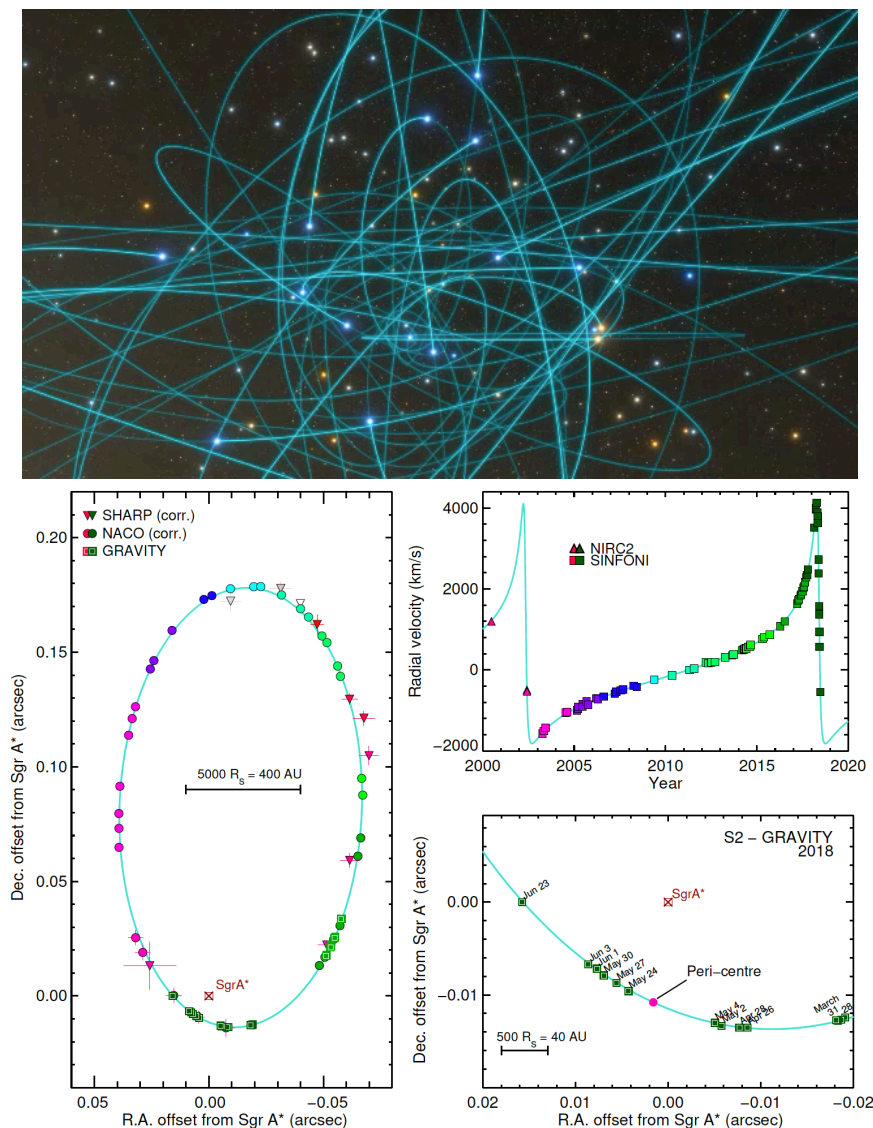
VLTI/PIONIER image of Gru

- S-Type giant star
- First model-independent measurement of convection granule other than the Sun



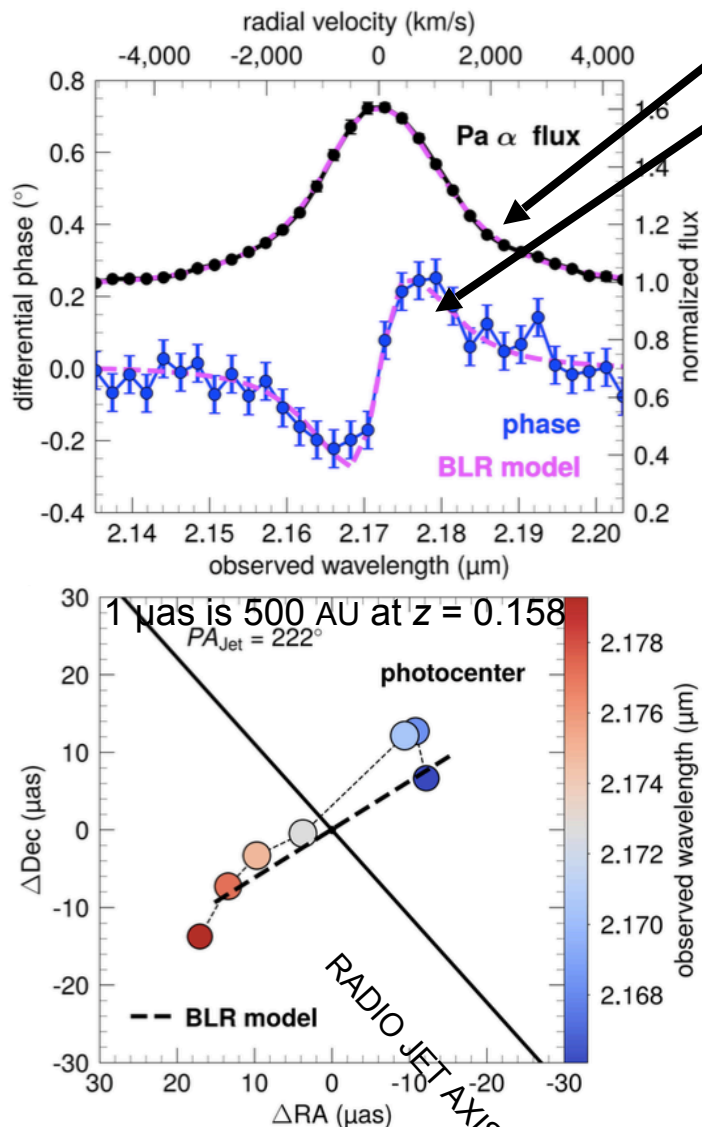
Paladini et al.
Nature **553**-310 (2018)

Unique successful test of General Relativity around the SgrA* BH



GRAVITY collaboration:
Abuter et al. 2018, A&A,
615, L15

GRAVITY resolves broad-line region in quasar, 3C273



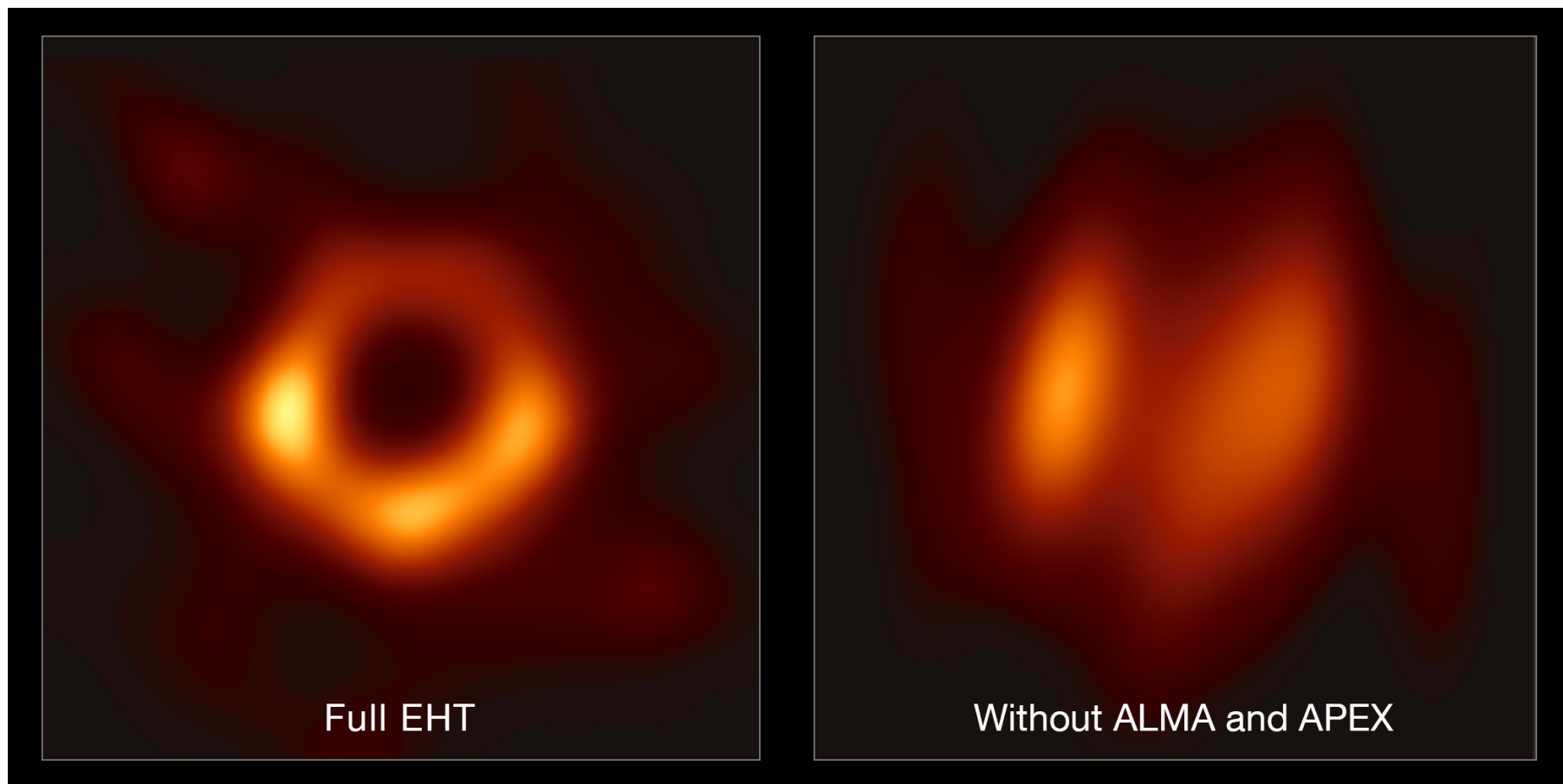
Paschen α line observed by GRAVITY.

Differential phases = S-shape, typical for velocity gradient.



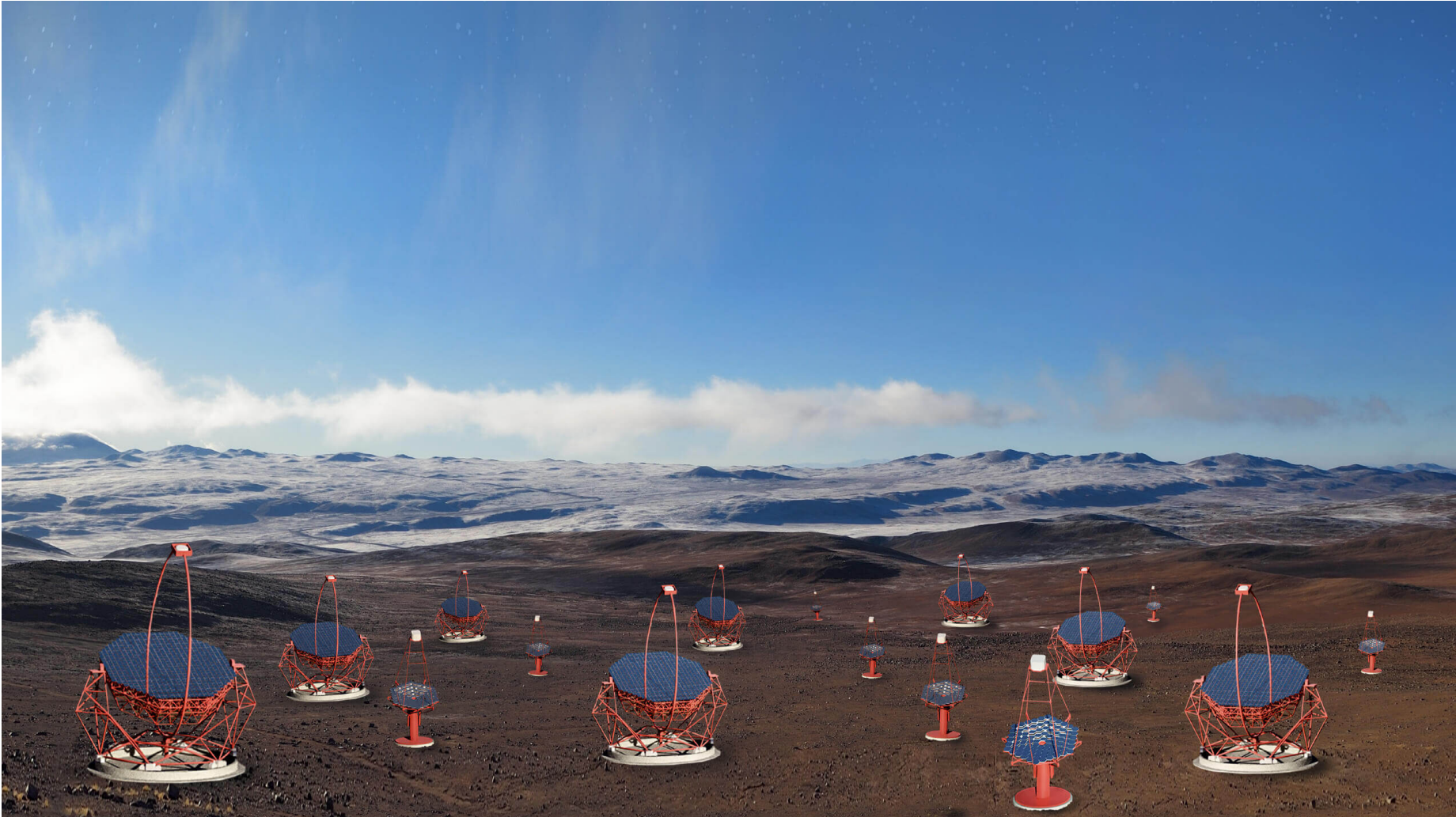
More precise BLR size (and 2x smaller, so ~half the dynamical mass) than from reverberation mapping, accomplished in 8 nights vs. months of photometric monitoring.

First image of a BH (M87)



Event Horizon Telescope 2019, ApJL 875, L1-L6

CTA and ESO



CTA-S hosting agreement

■ Hosting conditions of CTA-South in Paranal.

- CTA-S is an ESO Programme
- CTA-S will be built by CTAO
- ESO is a founding member of the CTAO-ERIC
- CTA-S will be operated by ESO, operation costs will be reimbursed by CTAO
- ESO may place contracts for construction and operation of CTA-S on behalf of CTAO, which will be reimbursed plus an overhead
- In compensation ESO:
 - Will receive 10% of the CTA observing time, both N and S
 - ESO will be part of CTAO with an 8% share, and have veto rights on anything affecting Paranal.

■ Meritorious Chilean proposals will obtain 10% of observing time of CTA-S as per the 1995 agreements

CTA-S agreements

- CTAO-
CONICYT cooperation
agreement signed on 17
Dec 2018
- ESO-CTAO hosting
agreement (approved by
Council) signed on 19 Dec
2018
- ESO-Chile site agreement
for CTA-S signed on 19 Dec
2018



since we have time on CTA N and S the programme scientists should be for CTA.

I learned from Wolfgang that there are

CTA-S: First steps

Meeting at ESO Garching, 7/8 March

- Delegations to CTAO bodies appointed
 - Council: X. Barcons (Alt: A. Kaufer) & N. Gube
 - AFC: C. Burger (& N. Gube if needed)
 - CTA-S Coordination Board: ToR to be developed during 2019
- L. Jochum is ESO CTA coordinator in Paranal effective 1 Jan 2019 (part of the Paranal Project Coordination Office)
 - An ESO CTA Programme Scientist will be appointed in the future to engage with the CTA community in the ESO MS
- ESO recruited (internally) for CTAO the CTA-S site construction manager
 - Duty station in Chile; reports to CTAO
 - Refunded by CTAO; to transition to operations site manager
 - Other 2 local staff positions (Administrative Assistant and Safety Officer) to be recruited soon, also to be refunded

ESO/CTA-S opportunities

■ Operational synergies

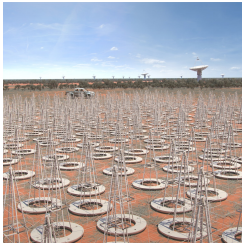
- Operation of VLT/I, ELT and CTA-S in Paranal by an Integrated Operations Team
- Infrastructure, services & support

■ Science synergies

- Multi-messenger astronomy in one site!
 - Simultaneous observing campaigns?
- Joint research activities using ESO's telescopes and CTA on Supernovae, Blazars etc
 - Probing intervening material (ALMA)
 - Origin of non-thermal emission via weak emission lines (VLT/ELT)
 - Measuring the distance to extragalactic VHE sources
 - CTA-S and optical polarimetry to measure magnetic fields
 - ...

The large observatories in the late 2020s

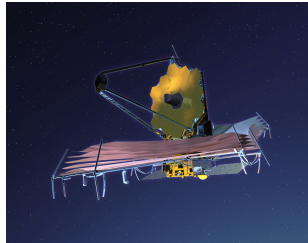
SKA



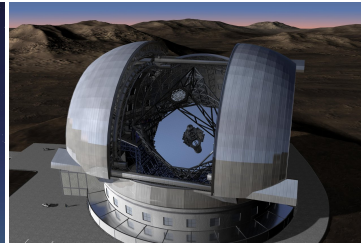
ALMA



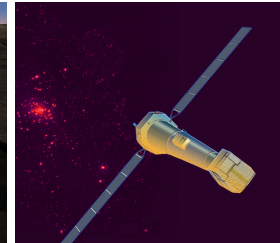
JWST



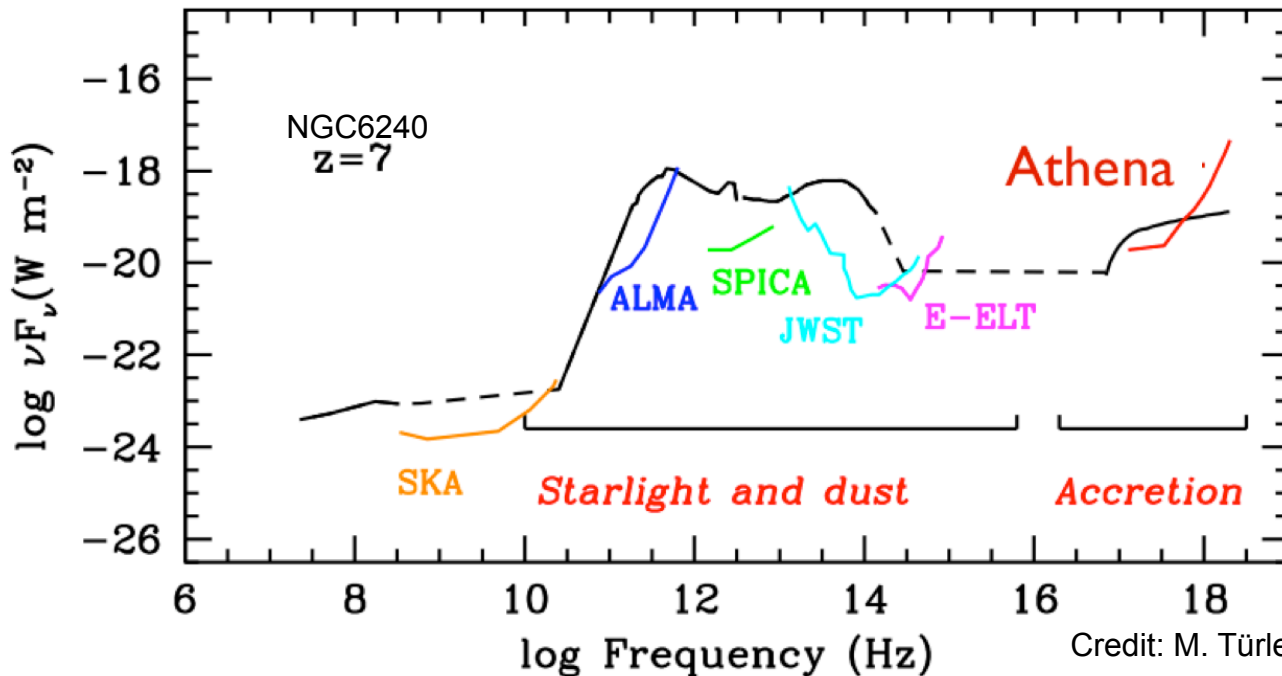
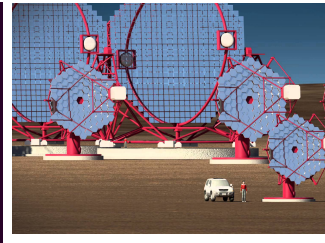
ELT



Athena



CTA





ESO programme landscape

