ESO in the Multi-Messenger Era

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European Southern Observatory - Today



Chajnantor – Atacama Large Millimeter/submillimeter Array (ALMA) & APEX partnerships



European Southern Observatory - in the 2020s



Cherenkov Telescope Array

Multi-programme/-wavelength observatory







ESO across the electromagnetic spectrum







VLT Instruments 2022













ERIS



KMOS





UVES

FLAMES



CRIRES



SPHERE







MUSE



HAWK-I



Cascina | 11 October 2022

Optical/Near-IR coverage



Optical/Near-IR Coverage



ALMA

Observe the cold universe

wavelengths from 300µm to 1.3mm (1 THz to 200 GHz)
 Global Partnership

• Europe (ESO), North America (USA/NSF and Canada/NRC), East Asia (Japan/NINS, Taiwan/NSC/ASIAA, South Korea/KASI)

66 antennas located at 5000m altitude

- 50 12m antennas
- 12 7m + 4 12m antennas (compact array)

European Southern Observatory

ESO's role in the first optical counterpart observations of multi-messenger events

- Efficient and flexible scheduling of observations: rapid follow-up of transients
- Complementary suite of telescopes and instruments
- Curated data archives

Simultaneous ESO observations of GW170817 at different wavelengths





ESO's upcoming Extremely Large Telescope ears

ELT Instrumentation Programme







The ESO Transient Sky

Traditionally challenging for community observatory operational modes

- flexible scheduling
- variable timescales
- large Target of Opportunity fraction
- rapid response mode
- → service mode operations
- → dedicate telescopes
- Systematic archiving
 - time series

Fast Reaction

- Rapid Response Mode
 - Provide opportunity to users to activate observations directly at the telescope
 - Requires approved program
 - Electronic "trigger key"
 - Turn-around within minutes
 - GRB observations within 10 minutes of X-ray position





Gamma-Ray Bursts

- Most distant stellar objects ever observed
 - redshifts 6.7 and 8.2 (tentative)
 - lookback time of nearly 12.5 billion years (or 95% of the age of the universe)



Most distant stellar object yet observed – GRB 090423



Tanvir et al. 2009

Long-Term Monitoring Programs

- SN 1987A
 - ALMA and VLT observations since start of o
- QSO monitoring for H_0
- LMC variables
 - VISTA Magellanic Cloud Survey (VMC)
 - Araucaria project (Gieren)
- VISTA Variables in the Via Lactea (VVV)
 - Galactic plane
 - Public Spectroscopic Survey
- PESSTO, PESSTO+, ePESSTO+
 - 90 nights per year for spectroscopic SN follow-up
 - concentrate on peculiar and rare types of supernovae



ESO Opportunities

Flexibility

• large instrumentation complement

Uniqueness

- explore special features of our observatories
 - e.g. interferometry (VLTI)
- provide unique capabilities for simultaneous coverage of large wavelength ranges
 - e.g. observations of Comet Shoemaker-Levy 9 or Hale-Bopp, AT2019gfo/GW170817

Complementarity

- spectral follow-up of imaging surveys
- monitoring of special objects

ESO – an integrated system

- ALMA and ELT: flagship facilities
- VLT: unique capabilities
 - Interferometry \rightarrow VLTI
 - Large instrument complement, adaptive optics, flexibility, modern operations model
- La Silla/4m telescopes: dedicated
 - Transients: NTT; SOXS
 - Exo-planets: 3.6m; HARPS/NIRPS
 - Multi-object spectroscopy: 4MOST@VISTA
 - Platform for smaller experiments: La Silla
- ESO and ALMA Archives
 - Rich resources of optical/NIR and sub-mm data
 - Large coherent data sets from surveys
 - Advanced data products

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Coordinated Observations

Example: gravitational wave events

- Coordinated observing run with the gravitational wave obseratories science runs
- ESO community organization
 - single VLT proposal \rightarrow ENGRAVE
- Preparations of future observatories
 - Early interactions to build bridges between the communities

Example: transients/supernovae

- Community organized itself
 - PESSTO \rightarrow ePESSTO \rightarrow PESSTO+ \rightarrow ePESSTO+
 - Transient brokers (e.g. ANTARES, AMPEL, ALeRCE, Fink, Lasair)
 - X-ray community
 - Leiden workshop 2015 Paving the way to simultaneous multi-wavelength astronomy <u>Middleton et al. 2017</u>, New Astr. Reviews 79, 26

Optical/Infrared Telescopes in the Multi-Messenger Era





Conclusions

Dark energy, dark matter, GWs, neutrinos, gamma rays:

- Posing profound new science questions
- Answered only alongside observations of conventional EM radiation

Genuine, powerful synergies in multi-messenger era
 ESO offers a wide spectrum of electromagnetic
 observational opportunities

- Optical and near-infrared facilities from 4m to 40m apertures
- OIR mm/sub-mm characterization of sources discovered at different wavelengths or by different messengers
- Extensive archive of objects in the southern sky

