Challenges and Synergies of Ground and Space Astronomy: The Ground-Based (ESO) View

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Ground-Based Opportunities

Bright Present and Future

- A plethora of facilities
  - Optical-Infrared ground-based telescopes up to 40m aperture
    - surveys, adaptive optics, interferometry, state-of-the-art instrumentation, synoptic programmes
  - mm and sub-mm telescopes
    - ALMA, NOEMA, SMA, APEX, Planck, Herschel, SOFIA
  - Radio telescopes of all sizes covering many frequencies
    - EVN/JIVE, LOFAR, VLBA, EHT, MeerKAT, ASKAP, SKA
  - Space-based telescopes
    - Gaia, HST, JWST, Euclid, Nancy Grace Roman Observatory
    - Spitzer, Kepler, CoRoT, Cheops, TESS, PLATO, SVOM, …
  - X-ray sky available through
    - XMM/Newton, Chandra, eROSITA and Athena
  - Gamma-ray sky
    - INTEGRAL, Fermi, MAGIC, HESS, VERITAS, CTA


Voyage 2050
Final recommendations from the Voyage 2050 Senior Committee
Radio Astronomy in the Next Decade
Up to, and beyond, 2
Pathways to Discovery in Astronomy and Astrophysics for the 2020s
CONSENSUS STUDY REPORT
EUROPEAN ORGANISATION FOR ASTRONOMICAL RESEARCH IN THE SOUTHERN HEMISPHERE
ESO/STC-551
Date: 07.04.2015
Roadmap
Ian Robson
NATIONAL RESEARCH COUNCIL

Further Challenges

- Combine the many opportunities/facilites
  - Electromagnetic of all sizes and forms
  - Gravitational waves: aLIGO/VIRGO/KAGRA
  - Neutrinos: IceCube, KM3NeT
  - Cosmic Rays: HAWC, LHAASO, AugerPrime
- Appec European Astroparticle Physics Strategy 2017-2026
- Astronet Roadmap

Science Vision & Infrastructure Roadmap 2020-2030

The new European roadmap for Astronomy

Synergies and Challenges

- Astronomers
  - Coherent proposals across energy ranges and messengers
    - e.g. VinROUGE, ENGRAVE, Gaia-ESO, KiDS/VIKING
  - Alert systems/Brokers
    - GW, EM, ν
- Observatories
  - Coordinated facilities
    - Complementary capabilities
    - ‘Continental/Global’ facilities (EVN/JIVE, EHT)
  - Coordinated operations
    - Coordinated scheduling
  - Archives
    - Data standards
    - Follow FAIR principles

Synergies and Challenges

- Funding agencies
  - Multi-national projects requiring ‘local’ funding
  - Funding stability for long-term projects
- Facilities
  - Dedicated ↔ General Purpose
    - Vera C. Rubin Observatory (LSST) vs. 8/10m telescopes
  - ‘Experiment’ ↔ ‘Multi-Purpose’
    - Planetary transit searches vs. ALMA
  - Flagship ↔ ‘Volume’
    - ELTs, ALMA, HST, JWST, Euclid, Plato, Rubin, SKA, CTA
    - 8/10m telescopes, 4m telescopes
  - Public ↔ Private

Challenges and Synergies

- Science exploration
  - SCIOPS conferences
    - project planning
    - project execution
    - project support
- Coordination of observations
  - Examples from the past
    - transient objects
    - follow-up of gravitational wave events
  - Planning the Future
- Data curation

ESA-ESO History

- Close collaboration on HST
  - Space Telescope – European Coordinating Facility (ST-ECF) hosted at ESO
    - European HST archive
    - Development of the ESO archive
    - Interaction on definition of VLT operations model
      - service observing
- Joint observing time VLT – XMM/Newton
- Science collaborations
  - VST observations of Gaia
  - Near-Earth Object coordinated observations
  - Gaia-ESO Survey (community driven)

ESA-ESO Operations Conferences

SCIOPS Conferences

- 2013
  - “Working Together in Support of Science”
- 2015
  - Science Data Management
- 2017
  - Distributed Science Operations
- 2019
  - Cross Facilities Collaboration in the Multi-Messenger Era

SCIOPS Conferences

- Synergies between space and ground-based missions
  - Importance of early planning
    - avoid 'blackmailing' situations
    - community involvement/community-driven
      - e.g. through regular observing proposals
      - prepare relevant complementary instrumentation
        - » PLATO radial velocities
        - » EUCLID ground-based calibrations (e.g. redshift surveys)
    - how much should be done at corporate level?
  - differentiate between mission critical calibrations and scientific harvest
    - e.g. monitoring of Gaia position vs. Gaia-ESO survey
  - difference between observatory and survey missions

Strategies for the Future

- Facilities are part of observational systems
  - Ground-space coordination
    - Proposals to cover several facilities
    - Exchange scheduling information
  - Coordinated observations at many telescopes
    - Multi-wavelength programmes
      - ALMA - optical synergies
        - » star/planet formation, distant universe
      - radio - optical synergies
        - » non-thermal and thermal universe
    - Exo-planet search and characterisation
      - transit photometry, spectroscopic monitoring, multi-wavelength observations (planet-star contrast!)
    - Milky Way structure and local dwarf galaxies
      - spectroscopic follow-up of the photometric catalogues (SDSS, Gaia-ESO, APOGEE, 4MOST)

Strategies for the Future

- "Guidelines" for OIR observatories
  - Flexibility
    - adapt to new topics and discoveries
  - Uniqueness
    - explore features of your observatory others don't have
      - 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
    - complementarity to space missions
    - support observations for other facilities

Strategies for the Future

- "Internet Astrophysics"
  - Most research based on databases
    - Products of surveys
  - Coordinated programmes produce coherent data
  - Context for many new observations
  - Open Data proved to be key to success
    - SDSS, 2MASS/DENIS, Kepler, eventually LSST
    - observatory data archives

→Make data available to the whole community

  - Easy to find
  - Easy to understand
  - Easy to use

OIR Observational System of the 2020s

- Flagship facilities
  - ALMA, ELTs, JWST, LSST, EUCLID, (SKA, ATHENA)
- Archives
  - Planck, Gaia, HST, Spitzer, Herschel, Kepler, XMM-Newton, INTEGRAL, Chandra, observatory archives
  - Literature
- General user facilities (with some specialisation?)
  - 6-10m telescopes (16 ground-based)
    - “people’s observatories”
    - large variety of instrumentation, also interferometry
    - built-in flexibility
    - main resource for follow-up work
  - 2-4m telescopes
    - pick your specialisation
    - dedicate telescope to specific science question

ESO – an integrated system

- ALMA and ELT: flagship facilities
- VLT: unique capabilities
  - interferometry → 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: VISTA; 4MOST
  - platform for smaller experiments: La Silla
- ESO and ALMA Archives
  - Rich resource of optical/NIR and sub-mm data
    - large coherent data sets from surveys
    - advanced data products

Coordinated Observations

- Example: gravitational wave events
  - Coordinated observing run with the aLIGO science runs
- ESO Community organization
  - single VLT proposal – ENGRAVE
    - following an ESO workshop to discuss coordination

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- Preparations of future observatories
  - Early interactions to build bridges between the communities

Coordinated Observations

- Example: transients/supernovae
  - Community organized itself
    - HST proposals
    - ePESSTO+
    - Transient brokers (ANTARES, AMPEL, ALeRCE, Lasair)
    - X-ray community
      - Leiden workshop 2015
        Paving the way to simultaneous multi-wavelength astronomy
        Middleton et al. 2017, New Astr. Reviews 79, 26
- Separate proposals for different observatories
  - Often separate research groups

Coordinated Observations

- Example: joint proposals VLT/I and ALMA
  - Preparations of a workable way forward
    - only acceptable to ESO – other ALMA partners will not join
    - still need agreement of all ALMA partners, even if only ESO time is affected
    - ALMA explores joint proposals with JWST
- Future
  - Coordination between different observatories
    - ESA missions Gaia, EUCLID, PLATO
    - left to the community
  - Start planning coordination with future observatories
    - SKA, CTA, Einstein Observatory,

Data Curation/Archives

- Increasing importance of data products
  - Community expects uniform data products for surveys
    - Legacy
    - GAIA, ESO surveys, EUCLID, PLATO
  - Archives most useful, when data can be applied to science questions (“science-ready data”)
- Data access
  - Importance of data discovery
  - Synergies between ESA and ESO archives
    - ESASky:
    - ESO portal to LPO and ALMA data
    - Coordination of some developments

Archive – Data Products

GENERIC | SPECTRAL | IMAGING | VISTA

PHASE3 ARCHIVE INTERFACES

HELP | DATA TYPES | FAQ | DATA RELEASES | DATA STREAMS

Generic Data Products Query Form

*This form provides access to **reduced or fully calibrated data sets**, and **derived catalogs**, that were contributed by PIs of ESO programmes or produced by ESO (using ESO calibration pipelines with the best available calibration data), and then integrated into the ESO Science Archive Facility starting April 2011, through the Phase 3 process. Included are optical, infrared, and APEX (millimetre, submillimetre) data products. Each available data set is fully described;*

Read more...

Search | Reset | Output preferences: html table | Return max 200 rows. | All Fields | Syntax Help

Target/Position Information

Target name | SIMBAD name | Query by Target List: | Browse... | No file selected.

Input Coord. Sys. | Equatorial (FK5)

Position | RA | DEC | *RA: sexagesimal hours, decimal degrees*

Search Box | 02 09 00

Output Display: RA DEC Gal long Gal lat

Bandpass/Wavelength and Product Category

Filter: Any, u_SDSS, U, B, g_SDSS | OR | Wavelength: Any [nm] E.g.: 656, 393 AND 656, 393..656

Product category: Any catalog cube image source_table spectrum visibility

Observation/Temporal Parameters

Telescope	Instrument	OBSTECH
Any	Any	Any
APEX-12m	APEXBOL	CONTINUUM
ESO-3.6	APEXHET	ECHELLE
ESO-NTT	EFOSC	ECHELLE,ABSORPTION-CELL
ESO-VISTA	EFOSC, SOFI	ECHELLE,ABSORPTION-CELL,SLIC#1

Date Obs | *UT time* (Place the mouse here to see examples)

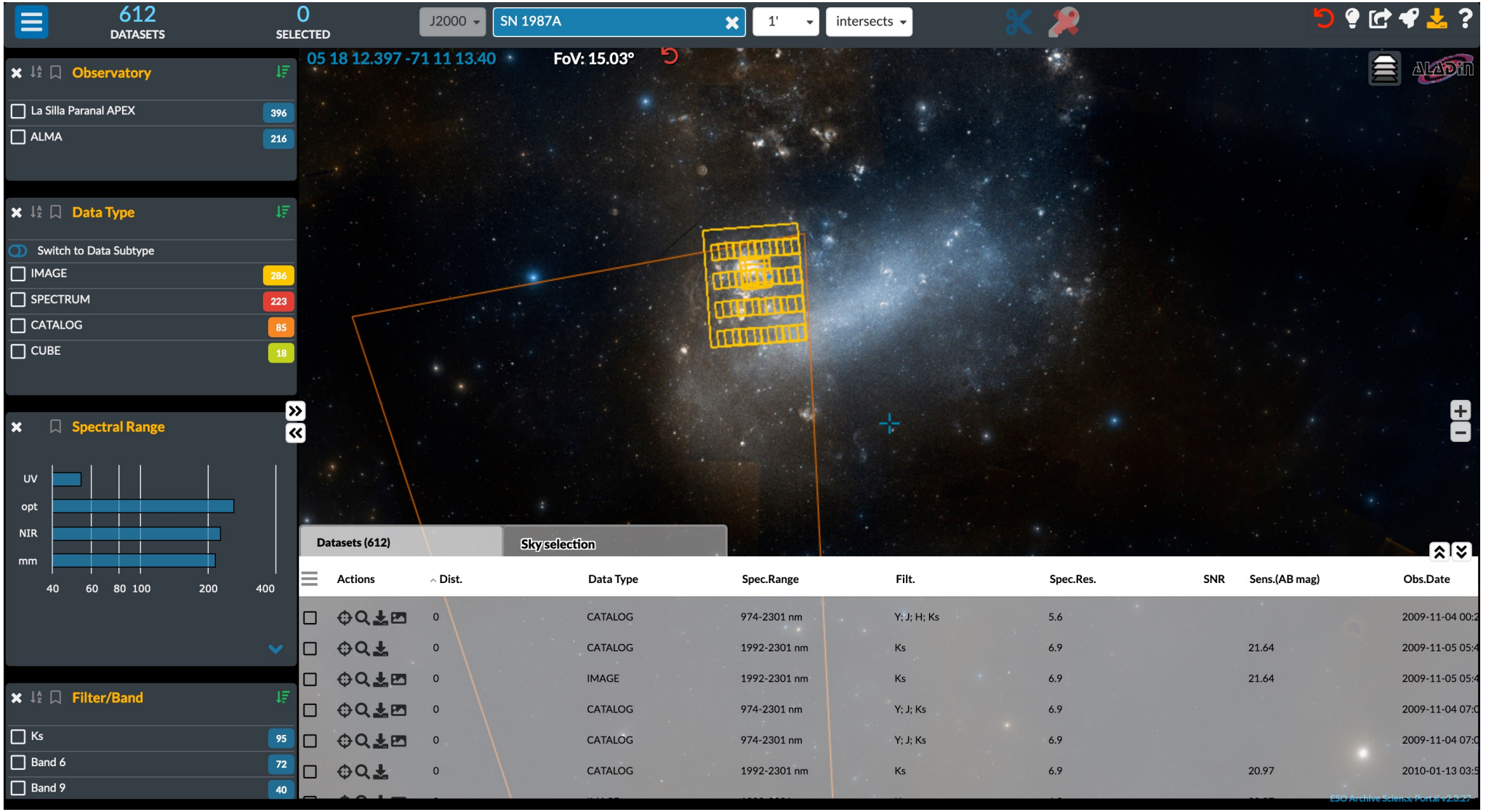
MJD Obs | *Modified Julian Date*

Exptime | Total integration time per pixel [s]

Multi OB | Any

Collections and Observing Programmes

Archive – Discovery Tools



Data Curation/Archives

- Tools
  - Convergent technologies
    - ESA and ESO/ESASky and ESO Archive Science Portal
  - Code to data
    - analysis tools for large data samples/surveys should become available to the community
    - Code depositories

Summary

- Flexibility
  - Astrophysics covers many topics and techniques
  - Completeness of instrumentation
  - Reaction to interesting new events, object and topics
- Coordination
  - Instrumentation programmes at different facilities
    - either through a large pool or through collaboration between observatories
  - Planning between ground and space
  - Time allocation between observatories
- Operations
  - inbuilt flexibility
  - archive → open distribution of data

Ground-Based Opportunities