ESA multimessenger approach

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What do we mean with “multimessenger”?

- Observation of targets at (almost) the same time
  - Serendipitously (see eg Integral/Fermi/LIGO/Virgo on GW170817)
  - Planned
- Follow-up observations
  - Via “targets of opportunity” (ToO)
  - Planned as part of a larger campaign (Cheops, Ariel)
  - “as they happen” (see https://esdcnews.esac.esa.int/news/2022-03/#ESASKY)
- Different conduits
  - Electromagnetic: radio/optical/X-ray/Gamma-ray
  - Neutrino
  - Gravitational Waves

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LISA & Athena

- LISA and Athena were the first missions with a dedicated multimessenger operational concept
  - Operational concept of LISA allows obtaining data in time immediately before and during a major merger event
  - LISA has the abiity to alert EM telescopes about immanent mergers
    - Follow well-known formats, i.e. ATEL for alerts, Virtual Observatory (VO) compatible data for images etc.
  - Operational concept is “tuned” so that an Athena-like telescope can slew across the sky in time
    - Data download concept is adjusted to enable “real-time” observation when needed.
    - Data processing is enabled to have a quick turn-around when needed.
- No other missions have that kind of ability (yet)
  - Cross-dependency of operational concepts are difficult and costly to maintain
  - Base on “typical” or “expected” performances of the missions

Targets of Opportunity

- Other ESA observatories use the ToO mechanism
- Example XMM-Newton:
    - ToO are astronomical events observable by XMM-Newton that cannot be predicted and scheduled well ahead
    - Scientifically important enough to justify interruption of the scheduled observation programme
    - Observations are conducted on a best-effort basis
    - Decision lies with the Project Scientist
- Proposals are typically submitted through a web-interface
    - Some kind of low-level protocol is probably available (or can be made available in the future)
- Different missions have different timescales for ToO execution
- Current ESA observatories with ToO capability
    - JWST, HST, XMM-Newton, INTEGRAL
- All future observatories will have a ToO component
    - Athena, …

Archival electromagnetic follow-up via ESASky

- ESA's ESASky portal greatly simplifies archival follow up of electromagnetic counterparts to Gravitational Wave alerts and Neutrino alerts by listening to NASA's Gamma-ray Coordinates Network (GCN) alert stream and updates the events every minute 24/7.

    - **Gravitational waves:** ESASky displays Gravitational Wave alert events from the currently running O3 LIGO/VIRGO observing run and previous ones, including 50% and 90% confidence maps on the sky.

    - **Neutrinos**: ESASky displays Gold, Bronze and Cascade Neutrino events from the IceCube Neutrino Observatory and shows their location uncertainty with a 90% containment probability.

ESASky: multi-messenger data exploration portal

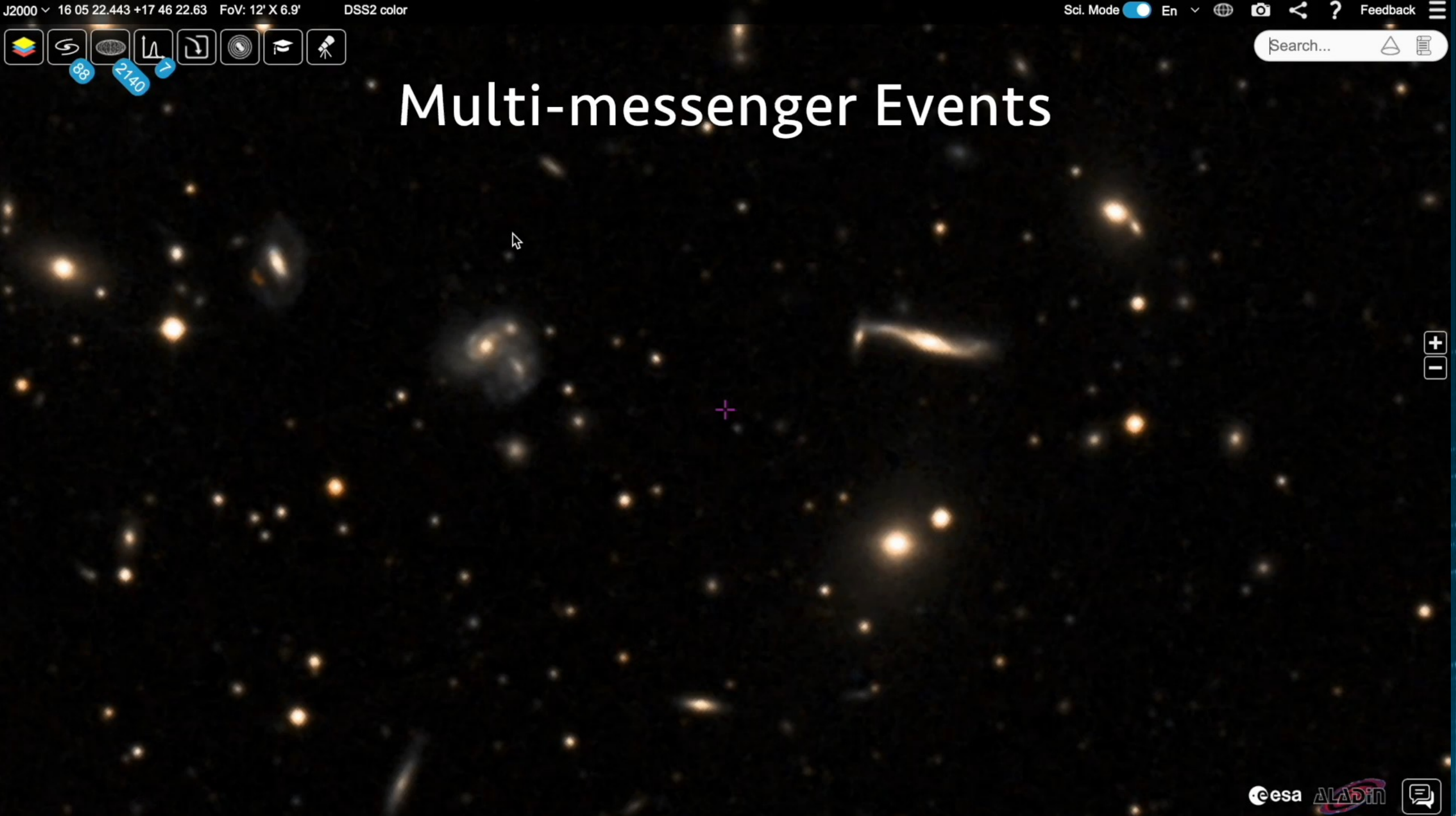
Goal: a scientific tool to facilitate data discovery and archival science

- Multi-wavelength, -mission, -messenger portal
- Access to ~100 mission metadata & data, 54,000+ catalogues, 1200+ HiPS images.
- Driven by scientific use cases and needs from the scientific community
- Exploration and Data Discovery
- Archival science and unplanned science!

- Interface ‘on top of’ all ESA astronomy archives + others

ESASky https://sky.esa.int

Legacy: IUE, Hipparcos etc. | AKARI (JAXA) | ALMA (ESO) | CADC (Data Centre) | Chandra (NASA) | ESO (Data Centre) | EXOSAT | Gaia | Herschel | HST | INTEGRAL | ISO | LAMOST (CAS) | MAST (Data Centre) | Planck | SUZAKU (JAXA) | XMM-Newton | more: CHEOPS JWST Euclid


J2000 16 05 22.443 +17 46 22.63 FoV: 12' X 6.9' DSS2 color
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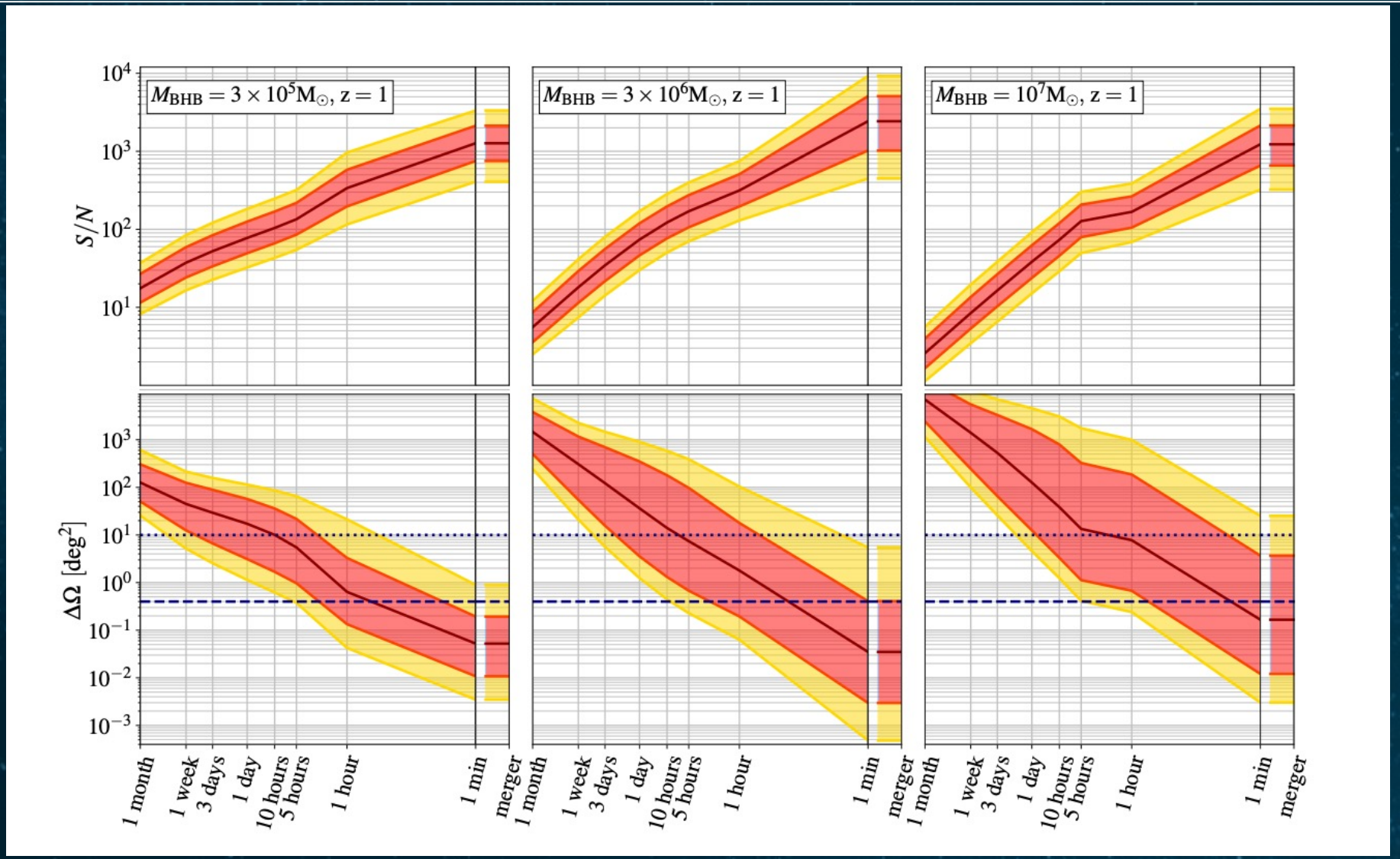
Multi-messenger Events
esa ALADIN

What would ET have to do

- Plan to issue alerts
  - Others will follow–up your sources on their own terms
  - Make sure that you have the right amount of data in the alerts.
- Identify the mission(s) you would want to use (or enable) to follow-up or co-observe mergers
  - Field-of-view of the mission, slew times, etc.
  - Operational concept of the mission (ie how much in advance do you need to tell them what to do)
  - Identify the SNR you need to pinpoint the sources to a commensurable sky-location
    - How much before merger does that happen?
    - How often do you expect such a signal?

SNR vs sly location in LISA



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- Adjust your operational concept accordingly to ToO-requirements
  - Turn-around on data analysis, latency , etc.
  - Note that existing missions are not necessarily optimized for GW co-observations/follow-ups
  - Plan to use the right data formats – at least for the ToO requests/alerts

What would ET have to do

- Most importantly: talk to us
  - Each mission has their own capabilities and limitations
  - Project Scientists are the first point of contact
    - Anybody in science/operations will do, though. We point you to the right person.
- We are interested in learning from your experience
  - Multimessenger as a planned-in concept is new to us as well
  - Let’s learn together – what can we do better, which information is needed, etc.

Questions