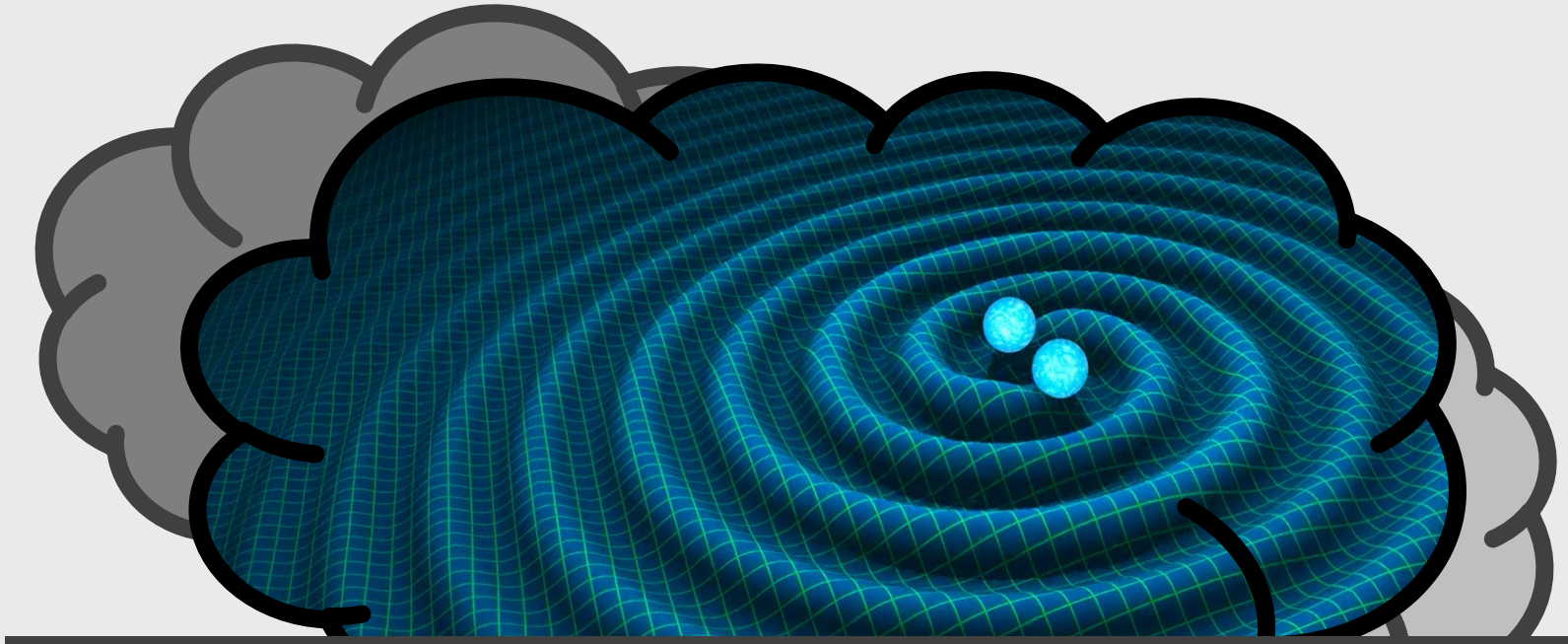


EIB SUMMARY

Stefano Bagnasco, Patrice Verdier,
Nadia Tonello, Achim Stahl

THANKS!

- Development of Computing Model
  - Requirements, architecture, resources,...
  - Computing TDR, PBS, WBS as tools to implement the Computing Model
- Focusing on Mock Data Challenges
  - As a tool for developing analysis techniques, gathering requirements and exercising infrastructure
  - Also, start promoting good practices for sustainability and manageability
- Liaising with the wider physics computing community
  - ESCAPE, IGWN, WLCG,...
- Low-latency alerts also a core item
  - Need not to be left behind

Workshop highlights - the ET scale

The canonical statement is that ET will be something like 10% of an LHC experiment
Message - significant but feasible with existing technology *iff we can leverage the best in class solutions*

IGWN provides an excellent starting point for a computing model, the ET strategy will be to improve on this

However !

That computing power usage is very significant, meaning that the efficiency of ET software will be very important

Paradigm change: ET software is not your personal software

Best practice is to make the software open source, allowing among other things the people who wrote it to show off their work to future employers

ET software will be heavily vetted for performance, benefitting from the collective expertise of the collaboration, and using modern software practices. Automated CI/CD pipelines will constantly profile code and massively reduce if not eliminate buggy, inefficient code

Workshop highlights - expertise

The rapidly evolving computing landscape will be the biggest challenge for ET

Apart from onsite, ET will largely use shared computing resources, where ET will typically be a small %

Heterogeneity of computing architectures will be standard (not just CPU, GPU/TPU, hybrid clusters)

Meanwhile efficiency will become more important, from sustainability to demonstrating scientific value for money

All of the above motivates a paradigm change, ET will work *iff we can leverage the best in class solutions*:

ET will need experts in computing infrastructure to adapt to (r)evolutions (across many computing centres)

ET will need experts in software to design frameworks allowing optimisation for different compute architectures

This expertise is highly sought after in industry, experts will demand viable careers if we want to retain them

Conclusions - workshop outcomes

We made a good start at the workshop, most important was to ***define the scope of the ET-PP deliverable D8.1***

Aim to release a first draft before Christmas, final deadline is end of February 2024

Excellent input from ISB and OSB was and will continue to be absolutely critical !

The conversations have only just started and need to continue

Requirements should come from ISB and OSB, specifications for solutions need to come from Computing

e.g. OSB ask Computing *"what information do you need from the MDC?" (and Computing might need to help OSB gather it)*

Computing can't define solutions top-down (top-down doesn't get traction, bottom-up doesn't scale, ask me about ATLAS !)

In other words, defining a computing model is a process that depends on excellent communication in both directions

Training and retaining computing and software experts will be crucial for the success of ET

INFN-Torino ET cluster

- A new cluster **dedicated to ET** is being built in INFN Torino, dubbed "**TechZoo**"
- **Purpose**
  - test and evaluate new available technologies
  - study technologies applied to ET use cases
  - make available on request a dedicated heterogeneous computing power

- Possible integration in **INFN Data Cloud**
- Funds from two PNRR projects (National Plan for Recovery and Resilience, after COVID-19 pandemic):
  - **ETIC**, Einstein Telescope Infrastructure Consortium
  - **TeRABIT**, Terabit Network for Research and Academic Big data in Italy

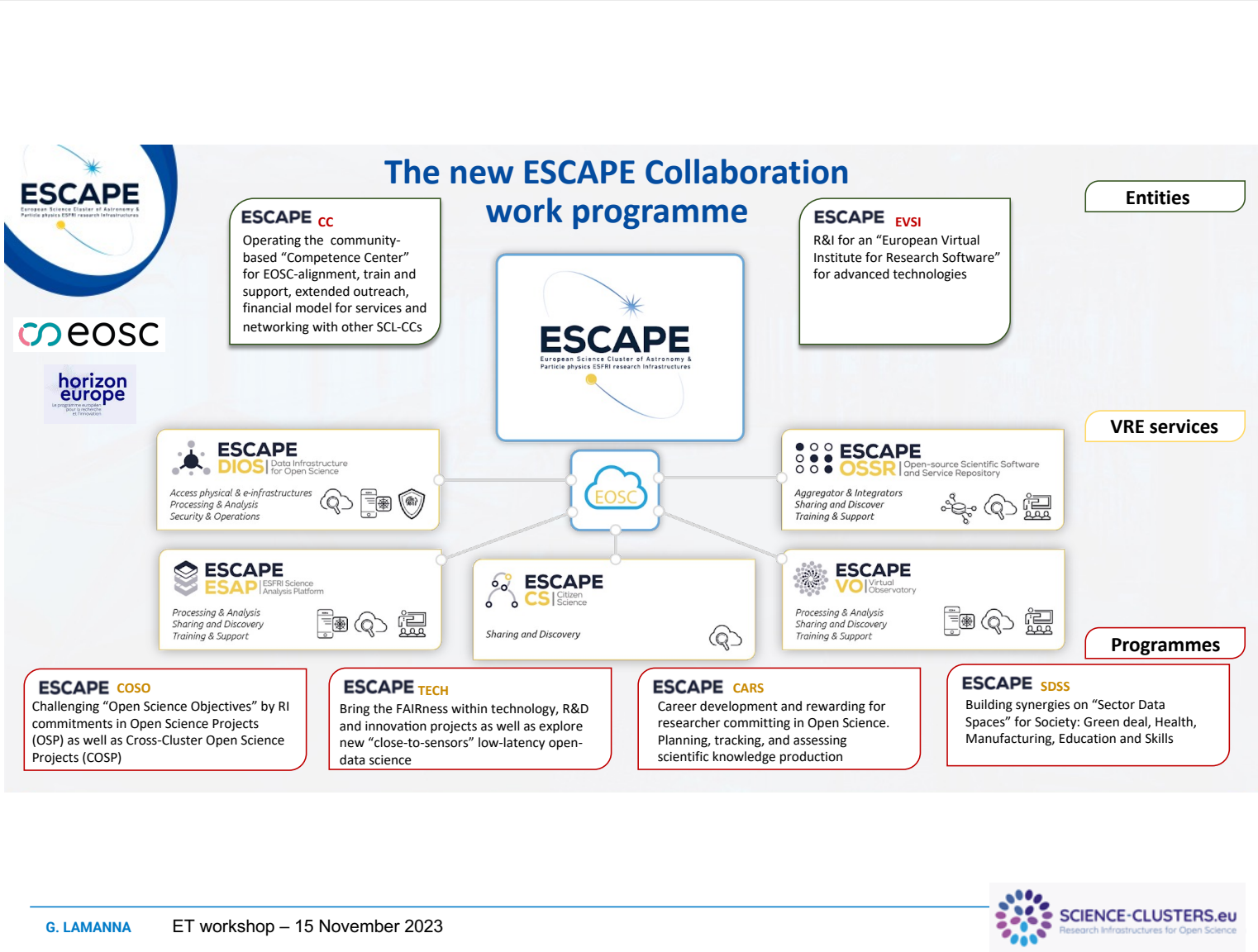
https://home.infn.it/en/all-news/188-pnrr

It will be used mainly for Technology Tracking

What/Why ET MDC

- Training simulated data
- Find out the limitations of current methods
- Encourage the community to develop new tools
- Provide a common dataset for comparison of analysis methods
- Assess the science potential with ET or XG
- Assess the requirements for computing infrastructure

2


The new ESCAPE Collaboration work programme
ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures
eosc
horizon europe
ESCAPE CC
Operating the community-based "Competence Center" for EOSC-alignment, train and support, extended outreach, financial model for services and networking with other SCL-CCs
ESCAPE EVSI
R&I for an "European Virtual Institute for Research Software" for advanced technologies
Entities
VRE services
ESCAPE DIOS | Data Infrastructure for Open Science
Access physical & e-infrastructures
Processing & Analysis
Security & Operations
EOSC
ESCAPE OSSR | Open-source Scientific Software and Service Repository
Aggregator & Integrators
Sharing and Discover
Training & Support
ESCAPE ESAP | ESFRI Science Analysis Platform
Processing & Analysis
Sharing and Discovery
Training & Support
ESCAPE CS | Citizen Science
Sharing and Discovery
ESCAPE VO | Virtual Observatory
Processing & Analysis
Sharing and Discovery
Training & Support
Programmes
ESCAPE COSO
Challenging "Open Science Objectives" by RI commitments in Open Science Projects (OSP) as well as Cross-Cluster Open Science Projects (COSP)
ESCAPE TECH
Bring the FAIRness within technology, R&D and innovation projects as well as explore new "close-to-sensors" low-latency open-data science
ESCAPE CARS
Career development and rewarding for researcher committing in Open Science. Planning, tracking, and assessing scientific knowledge production
ESCAPE SDSS
Building synergies on "Sector Data Spaces" for Society: Green deal, Health, Manufacturing, Education and Skills
G. LAMANNA
ET workshop – 15 November 2023
SCIENCE-CLUSTERS.eu
Research Infrastructures for Open Science

OSCARS project – OPEN CALLS

16 / 25 M€

GOAL:
Build on the science cluster approach to ensure the uptake of EOSC, i.e., consolidate FAIR services of the five Science Clusters and, more broadly, perform excellent science and pursue societal benefits by leveraging an Open Research approach.

TARGET USER COMMUNITIES:
Science Clusters and wider community (RIs, Universities, Institutes, either consortia, or individual researchers)

Submission process

- Opens: ~ **March 2024 / Nov. 2024**
- 10 pages max
- Submission within **60 days**
- Project start: **Sept-Dec. 2024 / Aug-Oct. 2025**

Limits

- Budget: **100 - 250 k€** / project
- Duration: **1 - 2 years**

Evaluation criteria for the independent expert panel

- Project description: clear objectives, towards **FAIR** and **open**
- Scientific impacts: **multiple RIs** / **cross-cluster**
- Digital resources: use of **EOSC** services / new **EOSC** service
- Implementation: **realistic** within budget

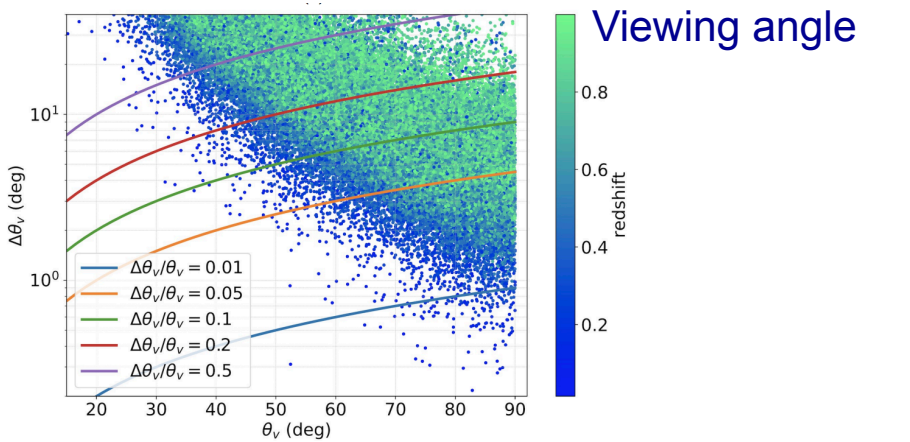
Prioritization of the triggers to be followed

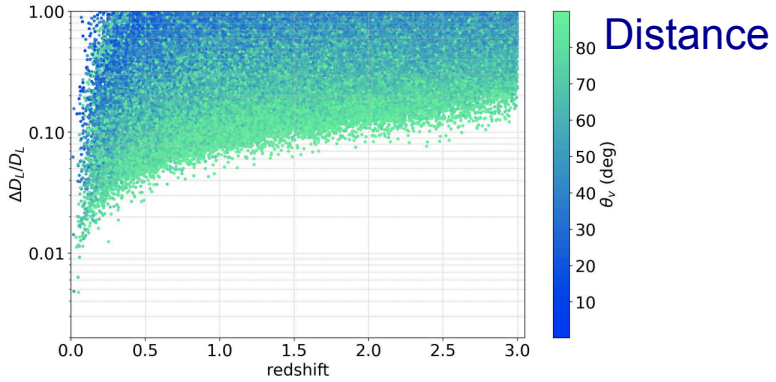
Sky-localization

	ET	ET+CE	ET+2CE
$N_{\rm det}$	143970	458801	592565
$N_{\rm det}(\Delta\Omega < 1\ {\rm deg}^2)$	2	184	5009
$N_{\rm det}(\Delta\Omega < 10\ {\rm deg}^2)$	10	6797	154167
$N_{\rm det}(\Delta\Omega < 100\ {\rm deg}^2)$	370	192468	493819
$N_{\rm det}(\Delta\Omega < 1000\ {\rm deg}^2)$	2791	428484	585317

Too large numbers of triggers well localized to be followed-up

Send in low-latency source parameters and continuous updates





Ronchini et al., A&A 2022

Data products and localization

EVENT PROPERTIES (for CBC events)

- based on the assumption that the event is of astrophysical origin and corresponds to a CBC event
- meaningful only in the case of astrophysical events
- values are **updated** (as well as the localization) after **parameter estimations (PE)** but still have the assumption that the signal is a CBC one.

EVENT CLASSIFICATION (for CBC events)

- provided by the pipeline and based on injection campaigns with Astrophysical rates
- tailored to the characteristics of the pipeline and its sensibility to the detector noise
- not (usually) updated because it depends on the real-time pipeline used to generate the localization skymap
- for CBC alerts is **updated** (within few hourw and possibly with the initial alert) by rapid PE tasks**.**

DURATION and **CENTRAL FREQUENCY** (for Burst events)

- frequency position of the signal and the detected signal's duration (signal over the noise).

SKYMAP (for CBC events)

- the case of CBC signal, the localization information also includes distance information
- not available for burst events.

R. De Pietri, S. Vallero, "*LVK strategy on Multimessenger Science*",Einstein Telescope Annual Meeting: Nov. 14, 2023 -- Nov. 16, 2023.

Rubin brokers

Rubin will send the full alert stream to seven brokers; others and individuals will operate downstream.

- ALERCE, AMPEL, ANTARES, Babamul, Fink, Lasair, Pitt-Google

Serve a large scientific community by ingesting, **classifying**, filtering, and redistributing alerts. Classification is a community-driven effort.

All prototyping on ZTF (300k alerts/night), and test deployment of the Rubin Alert Distribution system in the Google Cloud.

What would ET have to do

esa

- 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?
- 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

ELT (and ESO) Ready to respond

- Target of Opportunity and Rapid Reponse Mode planned
- 1-3 minutes telescope slew for the same instrument
- ~5 minutes for instruments within the same platform
- ~15 minutes for swapping platform
- Complexity added by the need for properly preparing the Observing Blocks (telescope guide star, AO star)
- Following the ENGRAVE example, ESO will foster international collaborations to cover MM science cases

Conclusions

Thinking (IVOA) Standards

Taking part in the development of **VO** standards and tools can be highly beneficial for projects that will emerge in the next decades.

FAIR Principles

The IVOA Vision Integrates FAIR Principles for Worldwide Collaboration.

Long term support

The adoption of standards enables long-term support for tools and software, optimizing preparation efforts for instruments that will be operational in a decade.

Current VO Standards&Tools

Currently a few VO standards and Tools are listed in IGWN (Gravitational-Wave Observatory Network). They are mocpy, ipyladin and Aladin Desktop.

IVOA working groups

Semantics Working Group: Expanding Vocabulary and Descriptors for Multimessenger science.

Computing Resources

The implementation of standards enables the quantification of resources required for establishing a potential multimessenger platform during the advanced stages of ET Mock data challenge.

TAKE-HOME MESSAGES 1

- ET computing will be feasible but not easy
  - the "10% of an LHC experiment" mantra works only if we have "best in class" solutions
- Software efficiency will be a key component
  - Both for infrastructure/frameworks and actual algorithms…
  - …on heterogeneous resources!
  - Change of paradigm: organized development, organized analysis, computing best practices
  - "I have this problem to solve" vs. "I need this tool"
- Hiring and retaining computing experts is a challenge
  - Training, career recognition,…
  - We need to build a GW computing community (NOT a data analysis code community!)
  - Please look within your RU if you have such people (training can be provided)!

TAKE-HOME MESSAGES 2

- Mock Data Challenges are THE tool to assess requirements and tune the functionalities to actual workflows
  - Both functionalities and numbers
  - We need excellent communication between challenge organizers, takers and EIB
- We are not building from scratch, though
  - We have a starting point (IGWN) and opportunities for collaboration and common developments (WLCG, ESCAPE,...)
- Multimessenger alert traffic will be huge in the 2030's
  - Huge rate, quickly evolving information
  - Discussion on the requirements already started
  - What do EM observatories need? What will the standards be?
  - Shall we think of ET also as a consumer of alerts?
  - Looking forward to a far away "low-latency" MDC...
- **Lots of fun ahead!**