



ESCAPE

European Science Cluster of Astronomy &
Particle physics ESFRI research Infrastructures

The ESCAPE Project – Objectives and Plans

LineA Workshop – 13th April 2021

Ian Bird, LAPP-CNRS/ESCAPE



EOSC is a European Commission action in response to EU member states' shared policy on the uptake of Open Science:

- EOSC is a cloud for research data in Europe allowing universal access to data
- EOSC will federate existing resources across national data centres, e-infrastructures, and research infrastructures, allowing researchers and citizens to access and re-use data produced by other scientists



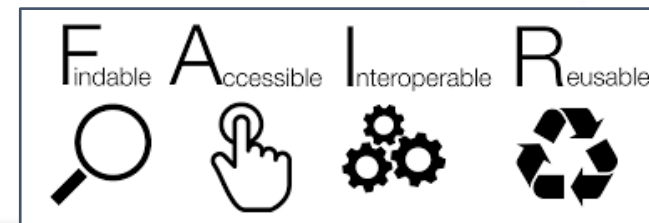
ESCAPE proposal in response to H2020-INFRAEOSC-04-2018 call Clusters to ensure the connection of the ESFRI RIs with EOSC (and the construction of EOSC)

Expected impact:

- *Improve access to data and tools leading to new insights and innovation*
- *Facilitate access of researchers to data and resources for data driven science.*
- *Create a cross-border open innovation environment.*
- *Rise the efficiency and productivity of researchers through open data services and infrastructures for discovering, accessing, and reusing data.*
- *Foster the establishment of global standards.*
- *Develop synergies and complementarity between involved research infrastructures.*
- *Adopt common approaches to the data management for economies of scale.*



Working together making data FAIR ...



ESCAPE: Astronomy and Particle Physics ESRIs

- ❑ Builds on communities' complementary excellences in data stewardship:
 - Astronomy Virtual Observatory infrastructure
 - HENP expertise in Exabyte-scale data management and large-scale distributed computing
- ❑ Builds on existing inter-RI synergies, intersections; overlapping competence and authority of national stakeholders
- ❑ Recognises that ESCAPE communities will be Exascale data generators, early adopters of ICT and data management innovations, push state-of-the-art
- ❑ Both Observatory- and Facility- operations require global, open access to data, long term curation, and sustainability



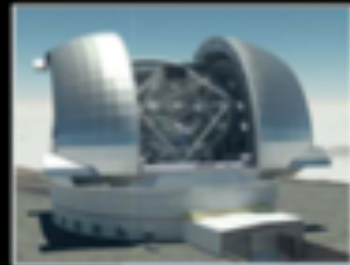
Radio



SKA

JIVE-VLBI

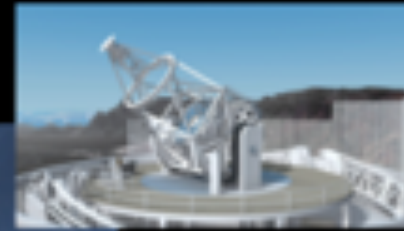
Visible light



ELT



ESO



EST

Gamma rays



CTA

Accelerator-based Particle Physics

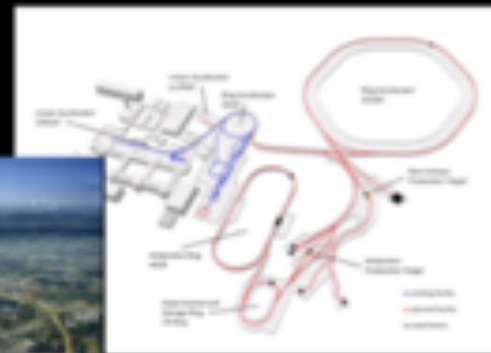


HL-LHC



CERN

Accelerator-based Nuclear Physics



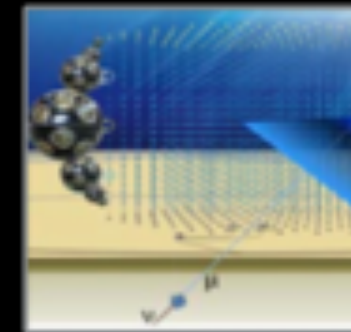
FAIR

Gravitational Waves



EGO-VIRGO

Cosmic-rays Neutrinos



KM3NeT

ESFRI and other large RIs in ESCAPE



ESCAPE in a nutshell

- 31 partners (including 2 SMEs)
- 7 ESFRI projects & landmarks: CTA, ELT, EST, FAIR, HL-LHC, KM3NeT, SKA
- 2 pan-European International Organizations: CERN, ESO (with their world-class established infrastructures, experiments and observatories).
- 2 European research infrastructures: EGO and JIV-ERIC

Formal commitment of their legal entities and management boards required by EC

- 1 involved initiative/infrastructure: EURO-VO
- 4 supporting European consortia: APPEC, ASTRONET, ECFA and NuPECC.
- Budget: 15.98 M€
- Started: 1/2/2019
- Duration: 48 months (end date 31/1/2023)
- Coordinator: CNRS-LAPP





The 2020 European Strategy

D. Large-scale data-intensive software and computing infrastructures are an essential ingredient to particle physics research programmes. The community faces major challenges in this area, notably with a view to the HL-LHC. As a result, the software and computing models used in particle physics research must evolve to meet the future needs of the field. ***The community must vigorously pursue common, coordinated R&D efforts in collaboration with other fields of science and industry, to develop software and computing infrastructures that exploit recent advances in information technology and data science. Further development of internal policies on open data and data preservation should be encouraged, and an adequate level of resources invested in their implementation.***

The scientific outcomes of particle physics experiments are made possible by the development of an efficient computing and software infrastructure. Computing and software are profound R&D topics in their own right and are essential to sustain and enhance particle physics research capabilities. There is a need for strong community-wide coordination for computing and software R&D activities, and for the development of common coordinating structures that will promote coherence in these activities, long-term planning and effective means of exploiting synergies with other disciplines and industry. Some recently initiated examples are the HEP Software Foundation addressing the common computing and software challenges related to particle physics, and **ESCAPE** (European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures) exploring the synergies in the areas of astronomy, astroparticle and accelerator-based particle physics.

B. The particle physics community and the European Commission have a strong record of collaboration. ***The relationship between the particle physics community and the European Commission should be further strengthened, exploring funding-mechanism opportunities for the realisation of infrastructure projects and R&D programmes in cooperation with other fields of science and industry.***

C. European science policy is quickly moving towards Open Science, which promotes and accelerates the sharing of scientific knowledge with the community at large. Particle physics has been a pioneer in several aspects of Open Science. ***The particle physics community should work with the relevant authorities to help shape the emerging consensus on Open Science to be adopted for publicly-funded research, and should then implement a policy of Open Science for the field.***

2020 UPDATE OF THE EUROPEAN STRATEGY
FOR PARTICLE PHYSICS
by the European Strategy Group



Data Lake:

- Build a scalable, federated, data infrastructure as the basis of open science for the ESFRI projects within ESCAPE. Enable connection to compute and storage resources.



Software Repository:

- Repository of "scientific software" as a major component of the "data" to be curated in EOSC. Implementation of a community-based approach for the continuous development of shared software and for training of researchers and data scientists.



Virtual Observatory:

- Extend the VO FAIR standards, methods within a broader scientific context; prepare the VO to interface the large data volumes anticipated from new facilities.



Science Platforms:

- Flexible science platforms to enable the open data analysis tailored by and for each facility as well as a global one for transversal workflows.

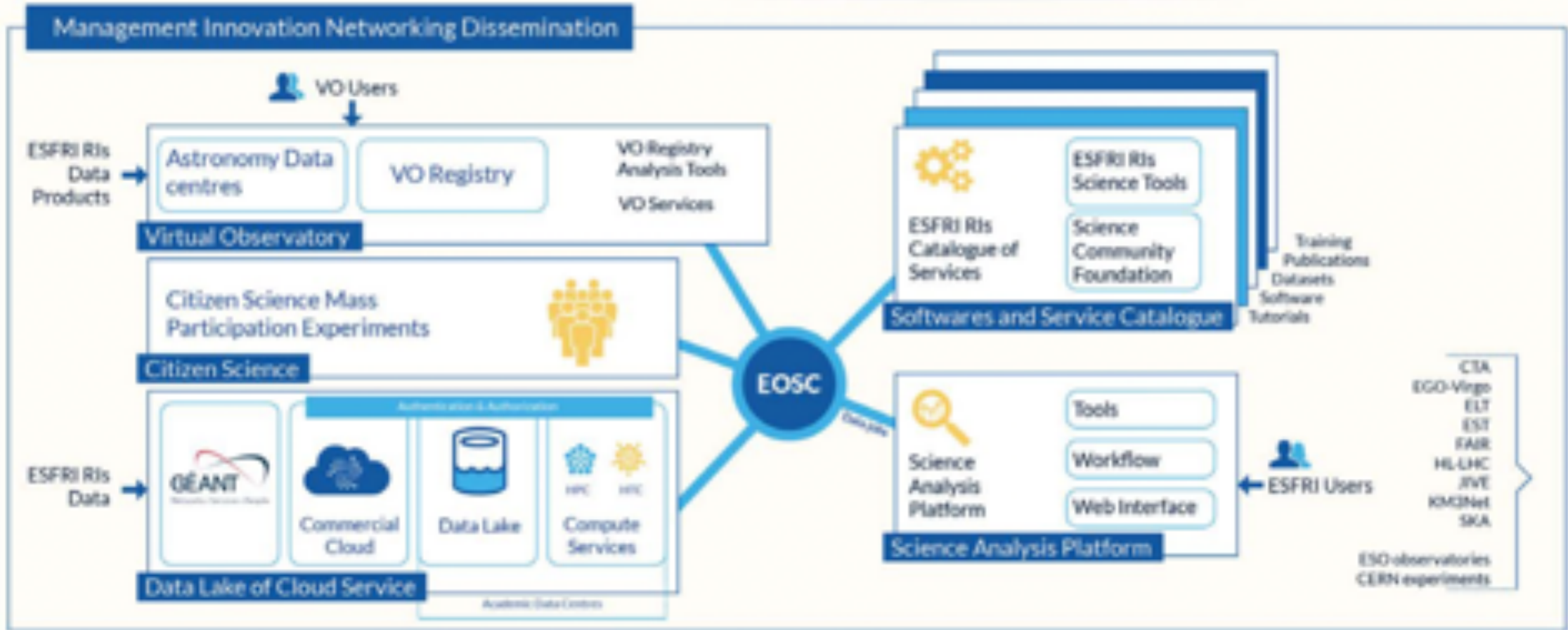


Citizen Science:

- Open gateway for citizen science on ESCAPE data archives and ESFRI community



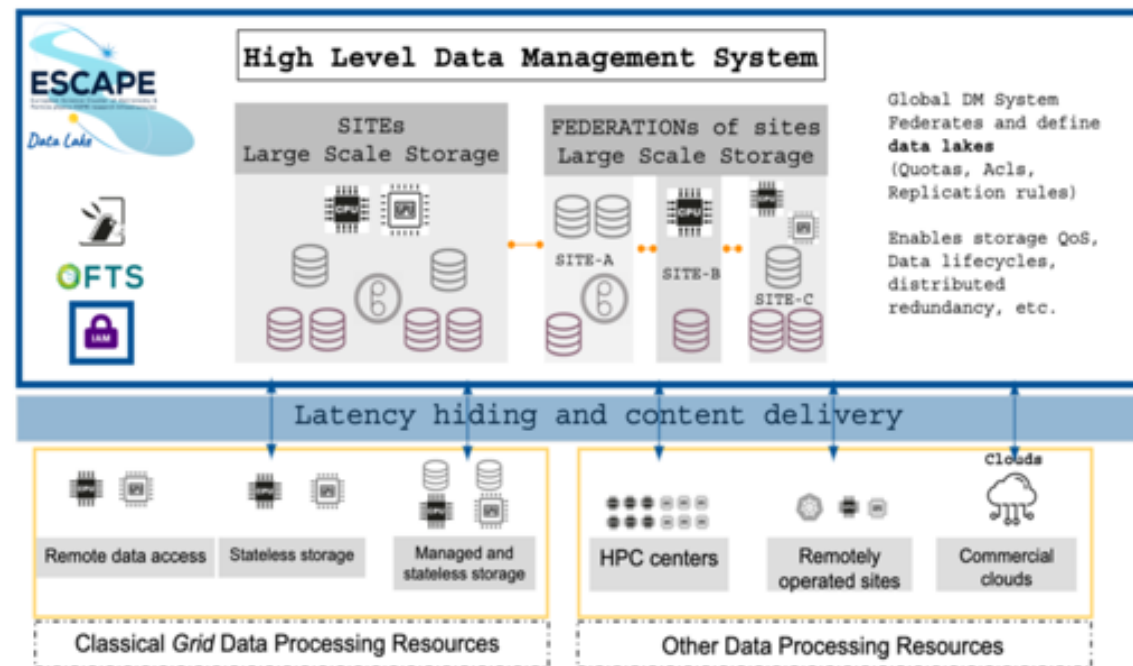
ESCAPE contributions to EOSC



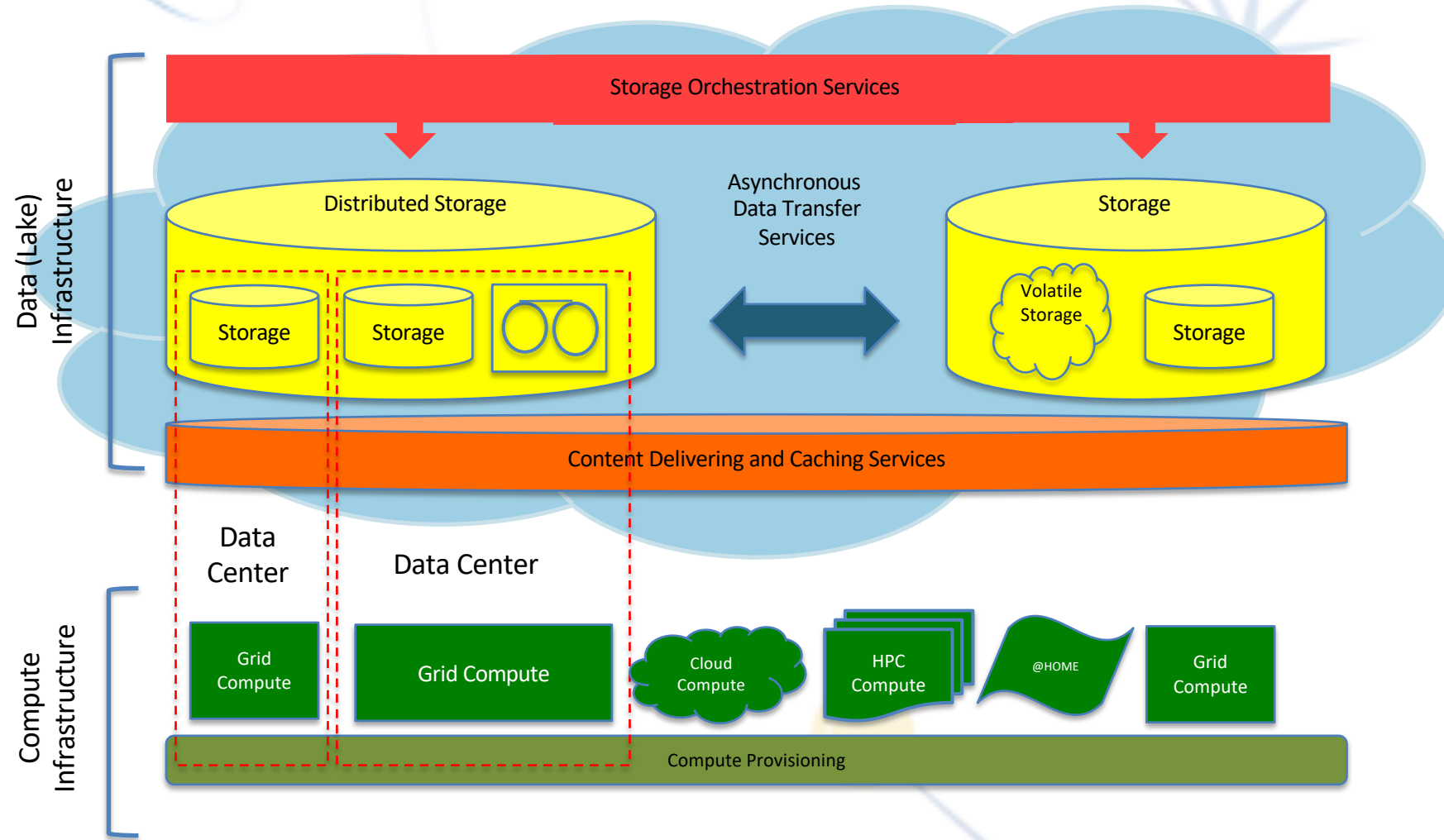
The ESCAPE Data Infrastructure for Open Science

The ESCAPE Data Infrastructure for Open Science (DIOS) aims at **delivering a prototype of the Data Lake concept**, a **common storage infrastructure** that:

- Provides **global data management** orchestration
- Delivers **Open Access and FAIR data services**: trustable data repositories; enable data management policies; transparent data access layer.
- Science **projects to drive** the service requirements to address their needs.



Data Lake concept

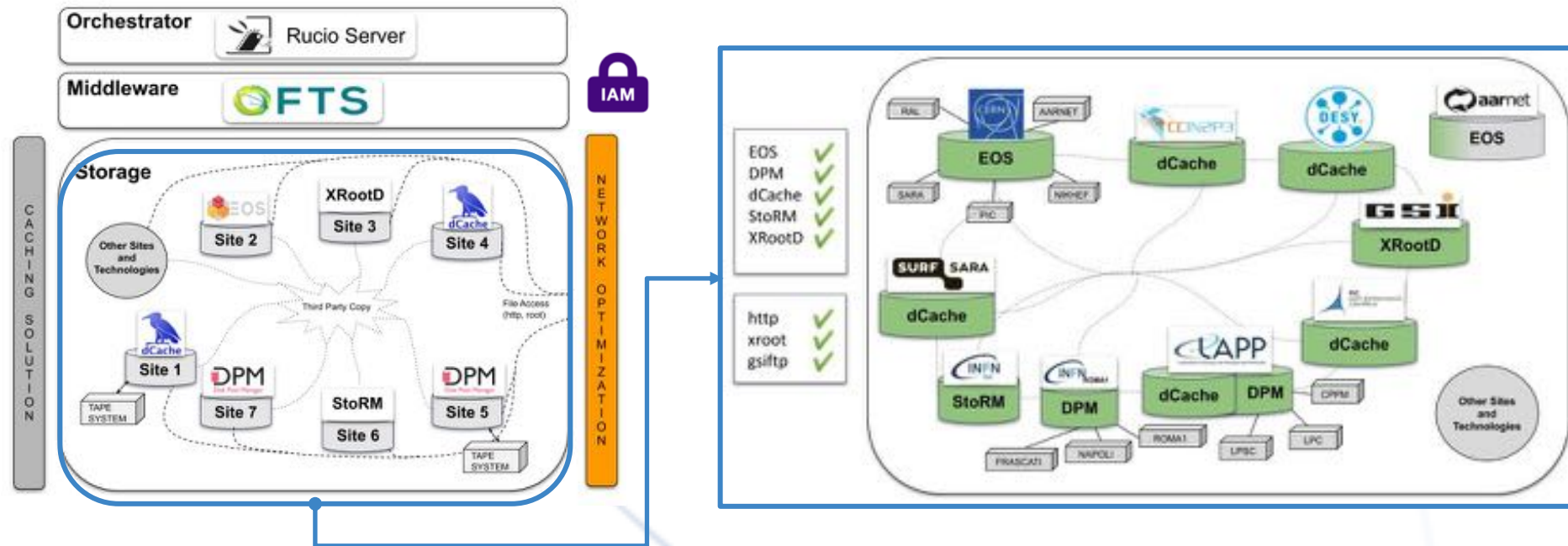


- ❑ Federation through token-based AAI
- ❑ Policy-driven data replication and distribution
- ❑ Distributed storage for reliability, accessibility, sustainability
- ❑ Serving data, remote, cached, streaming, to heterogeneous compute facilities
- ❑ Hide complexity – transparent access to data



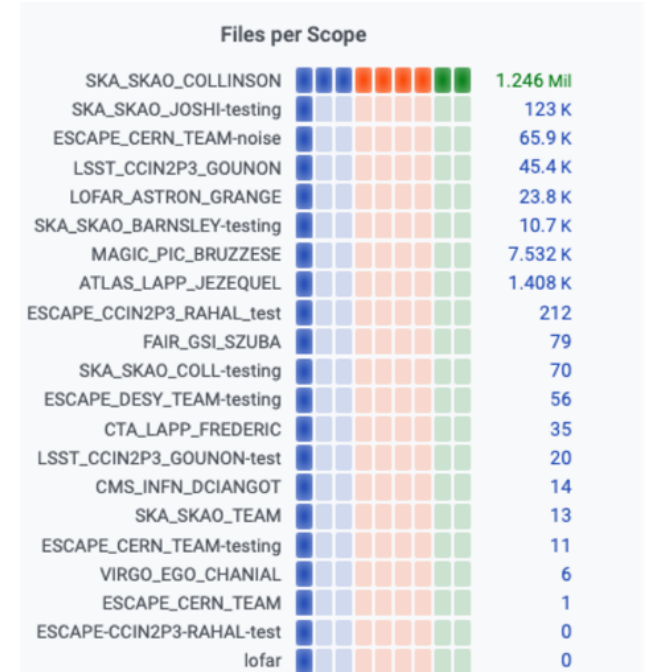
First achievements : a functional Data Lake pilot

- Pilot Data Lake with **10** storage endpoints **functional**:
 CERN, DESY, GSI, IFAE-PIC, IN2P3-CC, INFN-CNAF, -ROMA, -Napoli, LAPP-MUST and SURF-SARA
- The high level Data Lake orchestration layer is **consolidated**



First achievements : Science in the Data Lake

- Strong involvement of ESFRI RIs and other experiments:
 - **Data injection** within the Data Lake by:
 - ATLAS, CMS, CTA, FAIR, LOFAR, LSST, MAGIC, SKA, and VIRGO/EGO**
- Data management demonstrator from **Astroparticle, Radio-astronomy, Gravitational Waves, Cosmology and Particle Physics** communities together on a **common** data management infrastructure
- **Pipeline data analysis tests** currently in progress



DEMO



Software repository as part of the EOSC catalogue



Objectives:

- Each ESCAPE ESFRI RI needs individually to expose and make accessible data & software (each one needs a sort of “start-kit”).
- All together they wish to adopt common solutions and offer a virtual space for interoperability and multi-messenger & multi-probe data research to next generation scientists (Astro. & Particles)
- All are willing to co-develop new methods/algorithms, share (novel) software and expose the open science tools under the EOSC catalogue

ESCAPE deliverables:

- Establish a **community-foundation**
- Expose/share software to users via the EOSC **catalogue**
- **Train** and guide the scientists/users
- **Provide a scheme to acknowledge and reward scientists** for their commitment

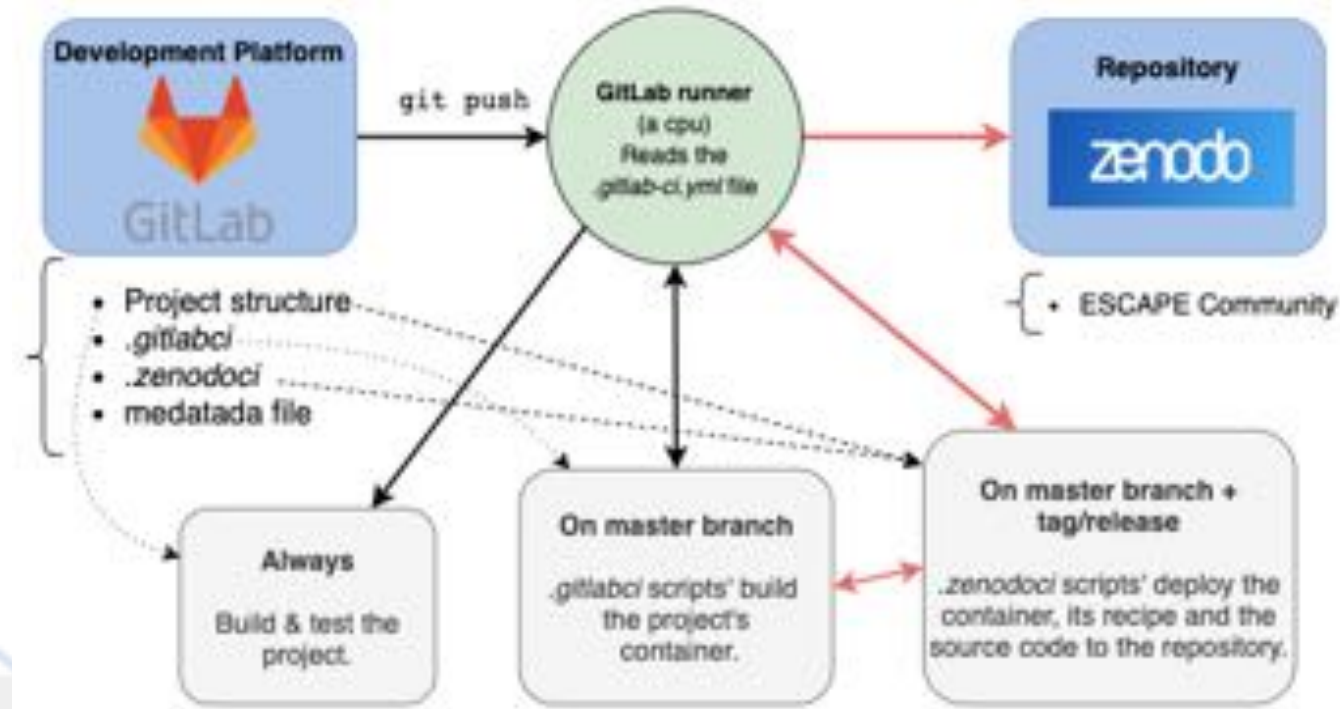


ESCAPE repository

❑ Aim: expose the tools of the ESCAPE ESFRI projects in a repository under the EOSC catalogue of services

❑ Objectives:

- continuous development, deployment, exposure and preservation of software/tools/services
- interoperability, software re-use and cross-fertilisation
- open innovation environment for open standards, common regulation and shared (novel) software for multi-messenger & multi-probe data

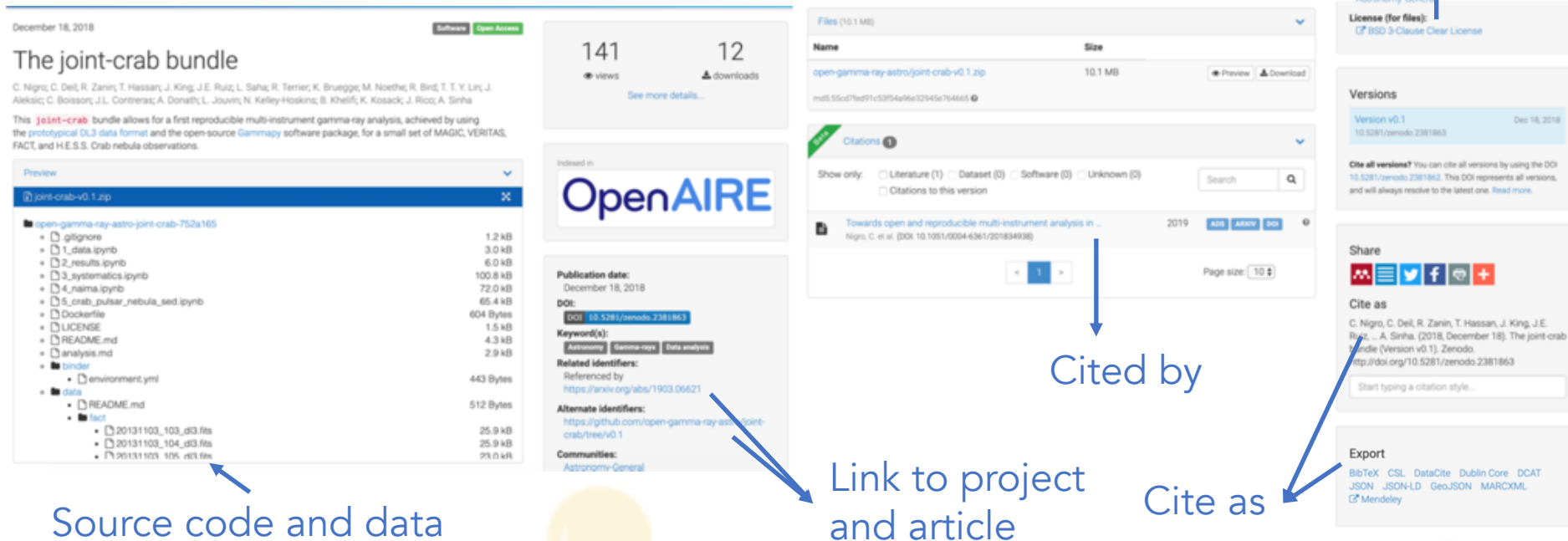


Example project: The CRAB bundle

The CRAB multi-instrument gamma-ray analysis with MAGIC, VERITAS, FACT and H.E.S.S.

<https://zenodo.org/record/2381863#.XkxcD5NKhhA>

<https://github.com/open-gamma-ray-astro/joint-crab/tree/v0.1>



The screenshot shows the Zenodo project page for 'The joint-crab bundle'. Annotations with blue arrows point to various features:

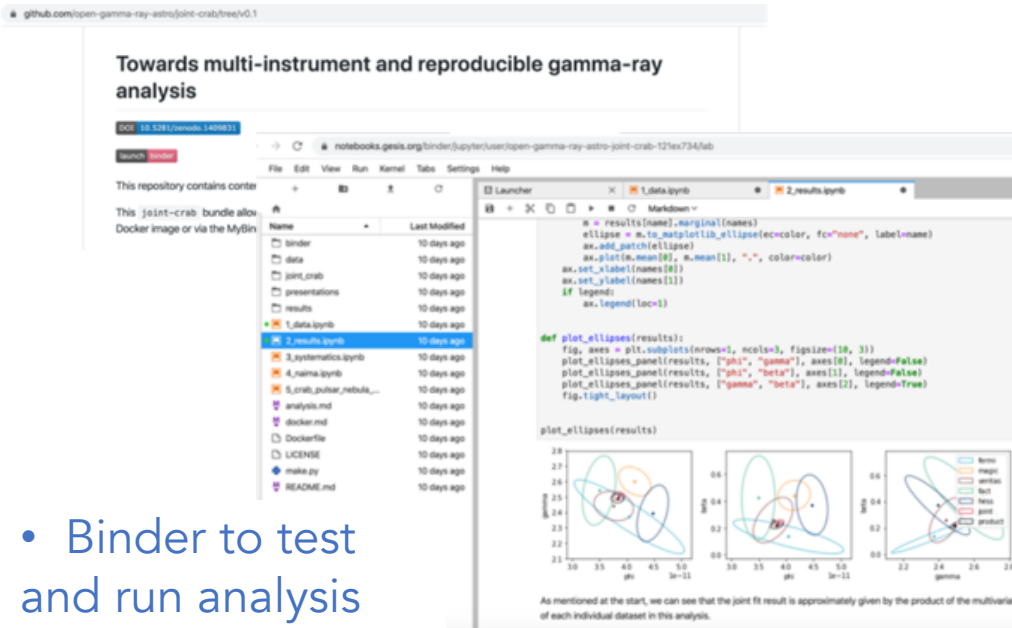
- Source code and data:** Points to the file list on the left, specifically to the 'data' folder containing FITS files.
- Link to project and article:** Points to the 'DOI: 10.5281/zenodo.2381863' and the 'Publication date: December 18, 2018' section.
- Cited by:** Points to the 'Citations' section, which shows a citation from Nigro, C. et al. (2019) in the journal 'Towards open and reproducible multi-instrument analysis in...'.
- Cite as:** Points to the 'Cite as' section, which provides the citation text: 'C. Nigro, C. Dell, R. Zanin, T. Hassan, J. King, J.E. Ruiz, ... A. Sinha. (2018, December 18). The joint-crab bundle (Version v0.1). Zenodo. <http://doi.org/10.5281/zenodo.2381863>'.
- license:** Points to the 'License (for files):' section, which indicates the project is licensed under 'BSD 3-Clause Clear License'.



The CRAB multi-instrument gamma-ray analysis with MAGIC, VERITAS, FACT and H.E.S.S.

<https://zenodo.org/record/2381863#.XkxcD5NKhhA>

<https://github.com/open-gamma-ray-astro/joint-crab/tree/v0.1>



Towards multi-instrument and reproducible gamma-ray analysis

notebooks.gesis.org/binder/ipython/open-gamma-ray-astro-joint-crab-121ex734/lab

This repository contains code for the joint-crab bundle. This joint-crab bundle allows Docker image or via the MyBin.

```

# = results[name].margin(names)
ellipse = m_to_matplotlib_ellipse(ec=ecolor, fc="none", label=name)
ax.add_patch(ellipse)
ax.plot(m.mean[0], m.mean[1], "o", color=ecolor)
ax.set_xlabel(names[0])
ax.set_ylabel(names[1])
if legend:
    ax.legend(loc=1)

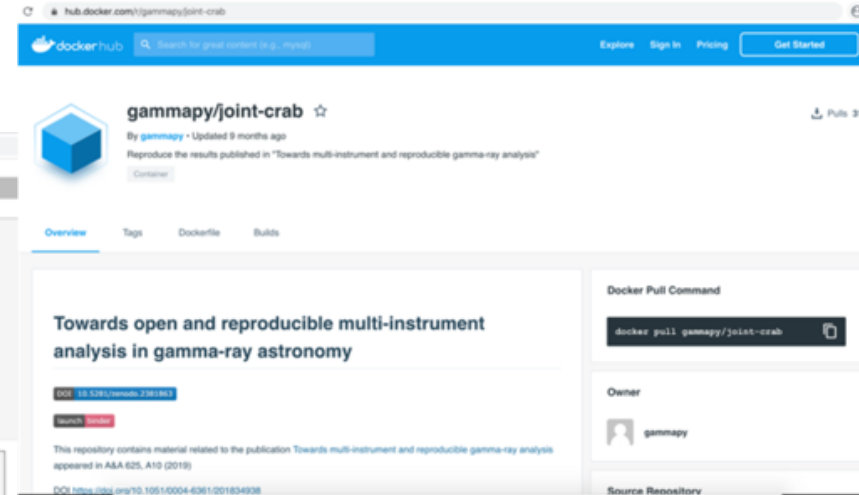
def plot_ellipses(results):
    fig, axes = plt.subplots(nrows=1, ncols=3, figsize=(10, 3))
    plot_ellipses_panel(results, ["phi", "gamma"], axes[0], legend=False)
    plot_ellipses_panel(results, ["phi", "beta"], axes[1], legend=False)
    plot_ellipses_panel(results, ["gamma", "beta"], axes[2], legend=True)
    fig.tight_layout()

plot_ellipses(results)

```

As mentioned at the start, we can see that the joint fit result is approximately given by the product of the multivariate normal approximation for θ of each individual dataset in this analysis.

- Binder to test and run analysis interactively online



hub.docker.com/gammapy/joint-crab

gammapy/joint-crab

By gammapy · Updated 9 months ago

Reproduce the results published in "Towards multi-instrument and reproducible gamma-ray analysis"

Overview Tags Dockerfile Builds

Docker Pull Command

```
docker pull gammapy/joint-crab
```

Owner

gammapy

Source Repository

- Docker to ensure reproducibility



Virtual Observatory

Built from VO Registry

1000s All-Sky data sets

Largest catalogues: PanSTARRS, Gaia etc.

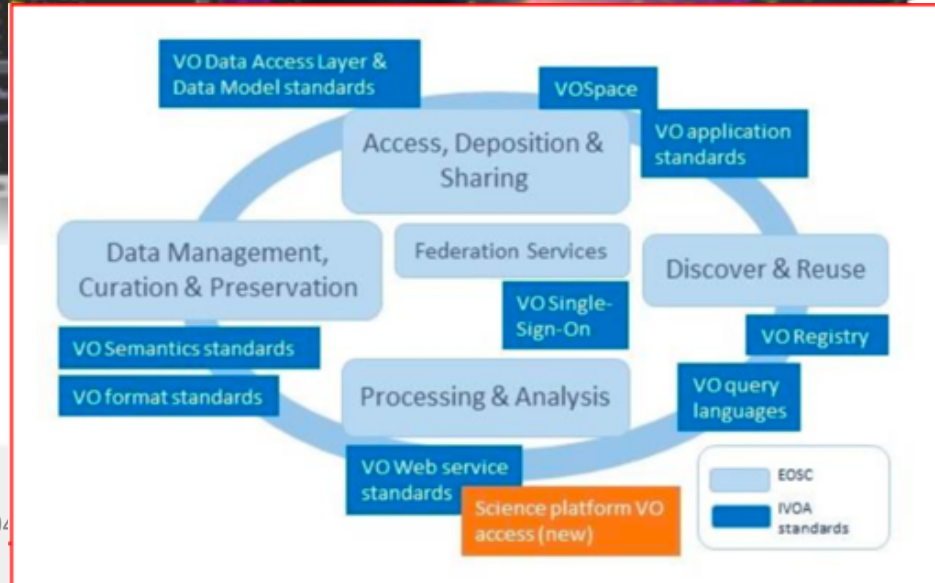
Complex ADQL queries

Multi-resolution techniques for Big Data

Interoperability of data

Interoperability between applications

Data from many observatories and missions



ESFRI-VO-EOSC connection:

- Map VO framework into EOSC
- VO Registry in EOSC
- Portfolio of Astronomy VO services
- Contribution to EOSC hybrid cloud
- Containerised domain-specific services
- Training – interoperable data schools
- Ensuring EOSC connects with VO and astronomy needs



Integrators: Test Science Projects

- ❑ Two projects are proposed to demonstrate science integration across ESCAPE
- ❑ Demonstrate new cutting-edge open science capabilities, making use of the services implemented within ESCAPE
- ❑ Provide feedback on the capabilities delivered by ESCAPE
- ❑ Ensure a clean integration of facilities across the project

*Linked to two corresponding JENAA EoIs
(with already about 1000 subscribed scientists)*



JENAS Eoi: Initiative for Dark Matter in Europe and beyond: Towards facilitating communication and result sharing in the Dark Matter community (iDMEu)

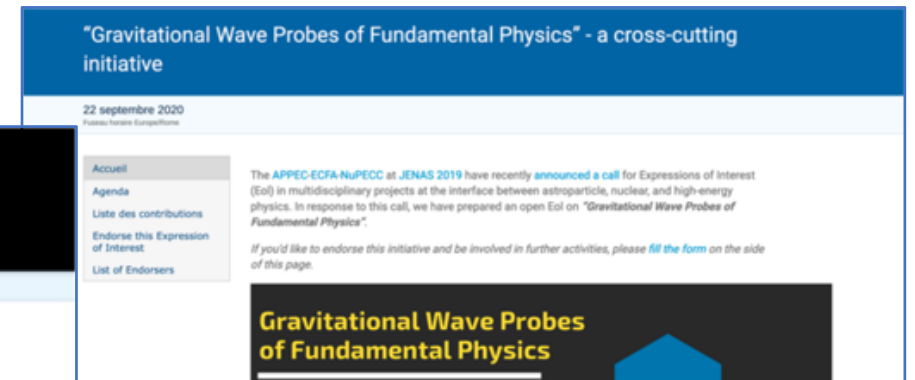
5 décembre 2019 à 30 décembre 2020

Rechercher...

If you would like to endorse this Expression of Interest, please use the menu on the left

Accueil
Endorse this Expression of Interest
Endorsers List

Following the call for Expressions of Interest by APPEC-ECFA-NuPECC at JENAS 2019 (attached below) for possible projects with interest spanning the high energy physics, astroparticle physics and nuclear physics community, we have drafted an open Eoi on dark matter. The text is just below. If you'd like to endorse this initiative and be involved in further activities, please fill the form on the side of this page.



"Gravitational Wave Probes of Fundamental Physics" - a cross-cutting initiative

22 septembre 2020

Accueil
Agenda
Liste des contributions
Endorse this Expression of Interest
List of Endorsers

The APPEC-ECFA-NuPECC at JENAS 2019 have recently announced a call for Expressions of Interest (Eoi) in multidisciplinary projects at the interface between astroparticle, nuclear, and high-energy physics. In response to this call, we have prepared an open Eoi on "Gravitational Wave Probes of Fundamental Physics".

If you'd like to endorse this initiative and be involved in further activities, please fill the form on the side of this page.

Gravitational Wave Probes of Fundamental Physics



ESCAPE TSPs participating to the JENAA Eols

Dark Matter TSP:

- understand the nature of dark matter by collecting data, analysis pipelines and results from complementary astronomy, particle and nuclear physics sources on a broad platform that will be ultimately be hosted on the EOSC Portal
- exploit synergies and complementarities across different communities, creating a unique link between dark matter as a fundamental science question and the Open Science ESCAPE services needed to answer it
- use of common language/resources (plots, scenarios, tools)

Extreme Universe TSP:

- do 'frontier' multi-messenger science to understand extreme matter and particle processes in strongly curved space-time.
- combine astronomy and e-infrastructures and focus on data organisation
- organise data from different wavelengths/messengers - and different types of extreme astrophysical transients (SNe, GRBs, FRBs, TDEs) - so that they can be easily gathered, analysed and modelled holistically, and not remain fragmented
- by building convincing science cases on a proto-EOSC we will be building a first usable platform for MMA



Gravitational Waves & Multimessenger astronomy

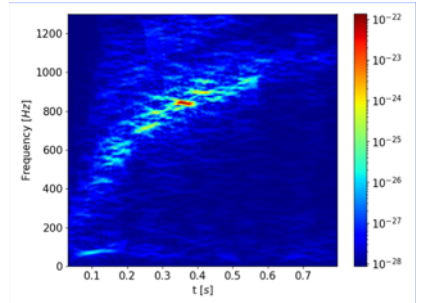
- **Short GRB**
Fermi GBM, INTEGRAL, Astrosat, IPN, Insight-HXMT, Swift, AGILE, CALET, H.E.S.S., HAWC, Konus-Wind
- **Gravitational waves (well-modeled)**
Ligo/Virgo
- **X-Ray**
Swift, MAXI/GSC, NuSTAR, Chandra, Integral
- **UV**
Swift, HST
- **RADIO**
ATCA, VLA, ASKAP, VLBA, GMRT, MWA, LOFAR, LWA, ALMA, OVRO, EVN, e-MERLIN, MeerKAT, Parkes, SRT, Effelsberg
- **IR**
REM-ROS2, VISTA, Gemini-South, 2MASS, SPITZER, NTT, GROND, SOAR, NOT, ESO-VLT, Kanata Telescope, HST
- **Optical**
Swope, DECam, DLT40, MASTER, VISTA, ESO-VLT + [others](#)

EARLY TRIGGERS
(sec to mins)

BROADBAND FOLLOW-UP
(hrs to days)

Binary Neutron Star Merger

- **Neutrinos**
(prompt emission of ~ 90% of total CCSNe energy)
IceCube, ANTARES, Pierre Auger Observatory
- **Gravitational waves**
(prompt emission, unknown waveform, carry little energy)
Ligo/Virgo
- **E.M. emission (delayed emission)**

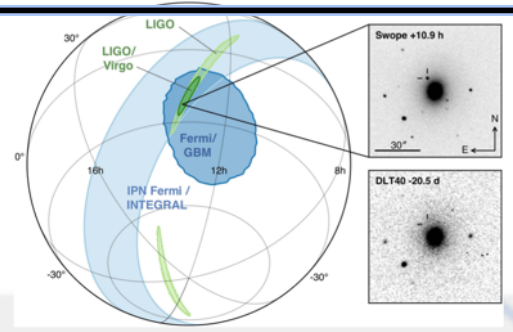


less et al. (2020)

Core-Collapse Supernovae

- Shed Light on explosion mechanism (neutrino-driven, MHD, acoustic)
- Information on physical characteristics of progenitor star (mass, rotation)
- Information on proto-neutron star

- Fast alert and sky Localization for follow-up study
- Better understanding of physical processes (e.g. heavy-element nucleosynthesis)



Abbott et al. (2017)



Example from Caterina Doglioni, Lund/ATLAS

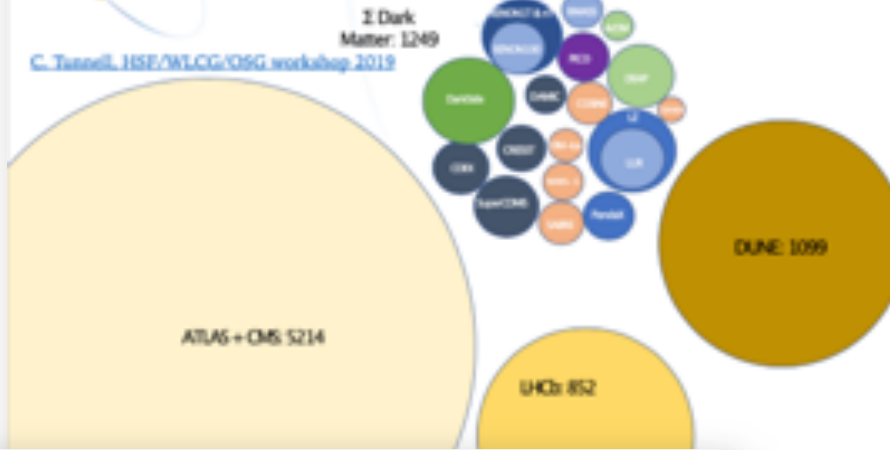
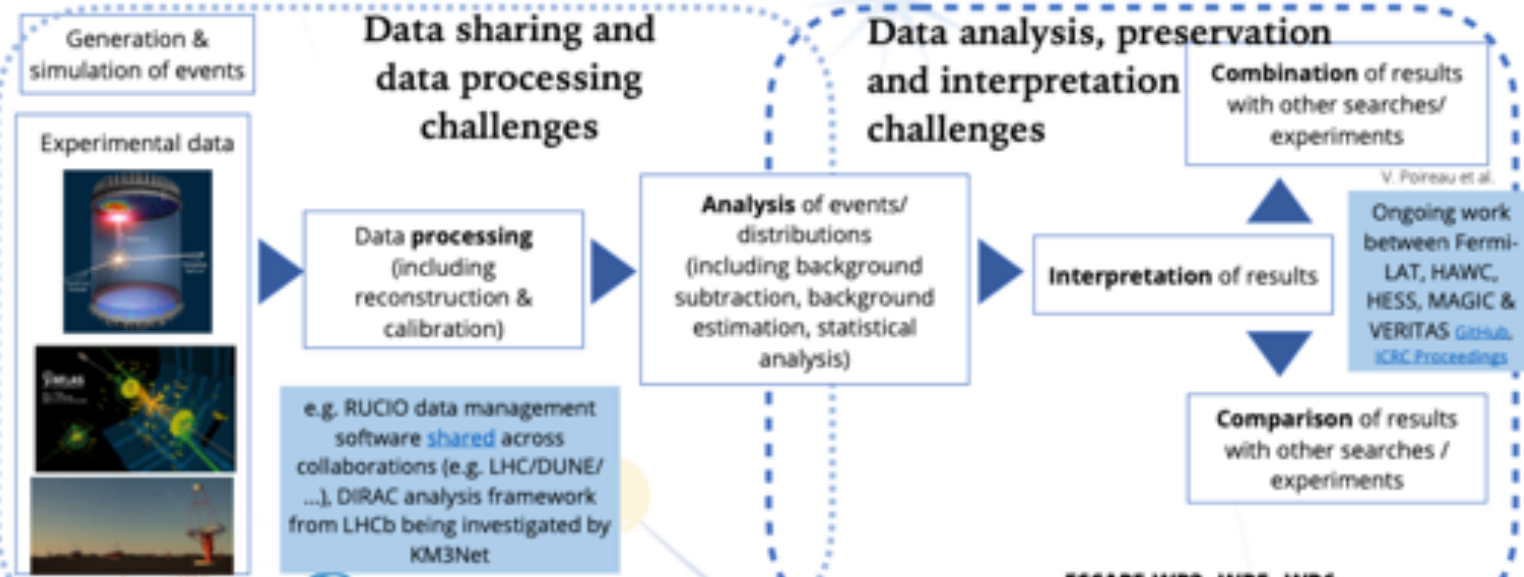


Diagram only representing **collider and direct detection**

- Differences in collaboration variety and size
- Differences in data volumes:
 - Colliders: "Big Data" volumes (>> PB)
 - DD: smaller data volumes (~TB/PB)
- Synergies in statistical analysis and interpretation of results

Challenges for Test Science Project

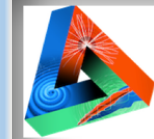
- Not possible to find a one-size-fits-all solution in either case...so work in parallel
- Idea (not original, see [DANCE workshop](#)): review what is done by various collaborations, finding points of contact



Different modus operandi for **indirect detection**

- Collaborations e.g. Fermi release data for general use ("observatory mode"), but also perform high-profile analyses themselves

Caterina Doglioni - TOOLS workshop - 04/11/2020



From the JENAA EOI:

However, there is to date no permanent platform where the different communities can identify cross-fertilization opportunities for mutual benefits, with an even broader perspective of the complementary set of experimental searches, astrophysical/cosmological observations and theoretical benchmarks. Our main goal is to establish such a broad platform, exploiting synergies and complementarities across different communities.



ESCAPE synergies

- Part of ESCAPE work programme is to work with PRACE and GÉANT
- Recent agreement is aligned with ESCAPE goals
- ESCAPE will collaborate on demonstrators and common aspects
 - e.g. AAI, data delivery to PRACE

SKAO Signs HPC Agreement With CERN, GÉANT, PRACE

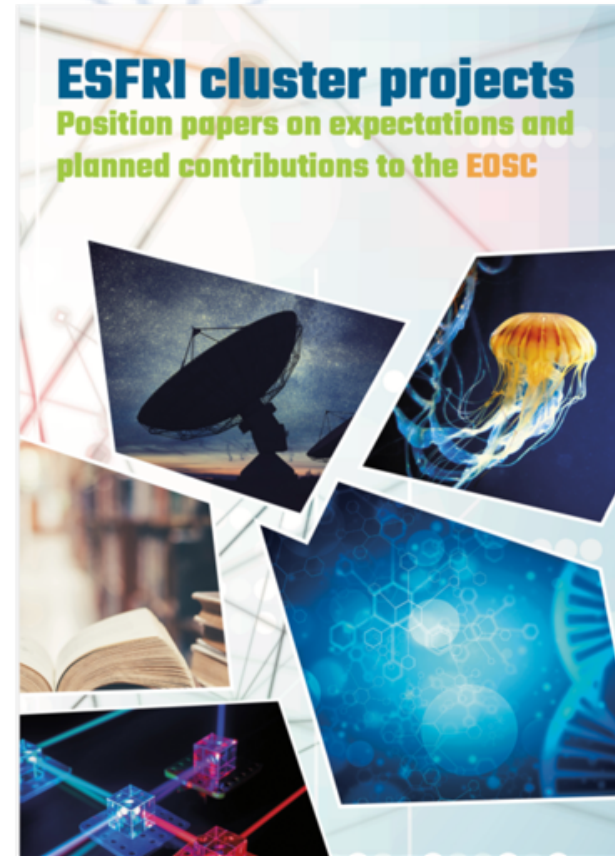
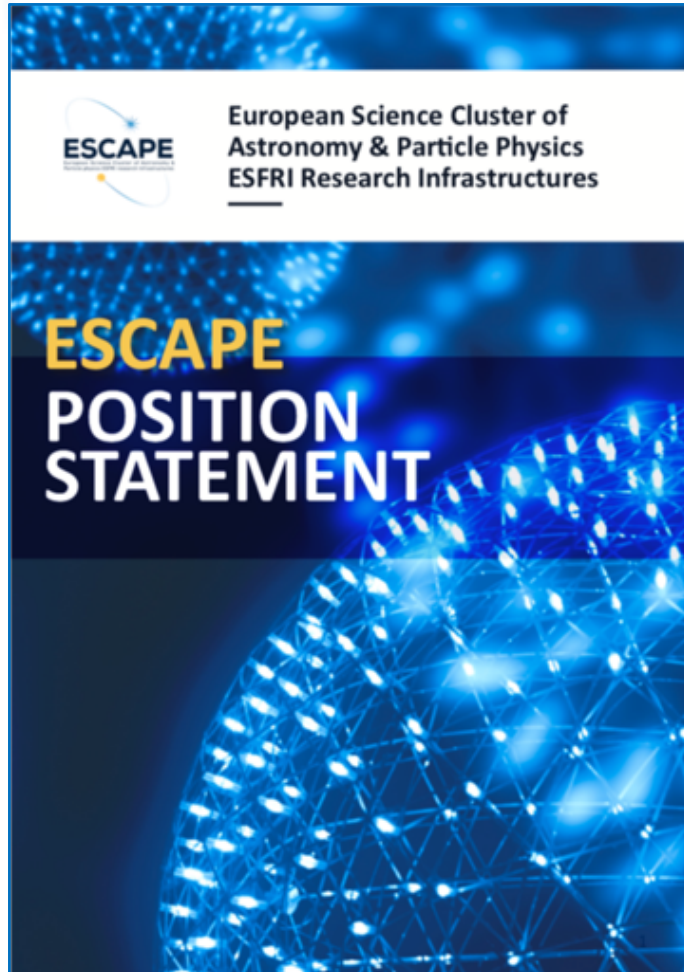


Eckhard Elsen (top left), Director for Research and Computing at CERN; Philip Diamond (top right), SKA Director-General; Erik Huizer (bottom left), Chief Executive Officer of GÉANT; and Philippe Lavocat (bottom right), PRACE Council Vice-Chair, signed the agreement for the new collaboration.

SKA Global HQ, Wednesday 22 July – SKAO has signed a Cooperation Agreement with CERN, the European Organization for Nuclear Research; GÉANT, the pan-European network and services provider for research and education; and PRACE, the Partnership for Advanced Computing in Europe; to overcome challenges related to the use of high-performance computing (HPC) to support large, data-intensive science projects.

Broader synergies with other research clusters

Gathering the contributions from all RIs Directors (E-SC)



Five thematic Science Clusters founded under INFRAEOSC-04-2018 (80% of ESFRI RIs)

<https://zenodo.org/record/4044010#.X2oaYtaxVcs>

<https://zenodo.org/record/3675081#.X2R2PJNLhTY>

https://www.projectescape.eu/sites/default/files/Escape_position_statement_web.pdf



EOSC-Future

- ❑ A new project – started 1st April;
- ❑ Responding to EU H2020 funding call, (INFRAEOSC-03-2020): 30 months, 40 M euros
- ***EOSC-Future is a prototype of an integrated EOSC***

INFRAEOSC-04 - ESFRI science clusters

- 5 thematic clusters of 52 world-class RIs to implement FAIR data and connect to EOSC
- Develop standards, approaches, requirements, tools
- Create thematic catalogues of resources
- Provide data, services and innovation to the EOSC
- Provide a coordinated requirements and feedback

INFRAEOSC-05b - Regional projects

- 5 regional nodes to implement FAIR data and connect to EOSC
- Provide a link to national resources, programmes, priorities
- Develop standards, approaches, requirements, tools
- Create thematic catalogues of resources
- Provide data and services to the EOSC

EOSC Governance

- Inclusive participation from academia, industry, and member states
- Deliver the EOSC partnership
- Maintain the SRIA
- Work on specific EOSC policies
- Oversee the EOSC landscape

EOSC

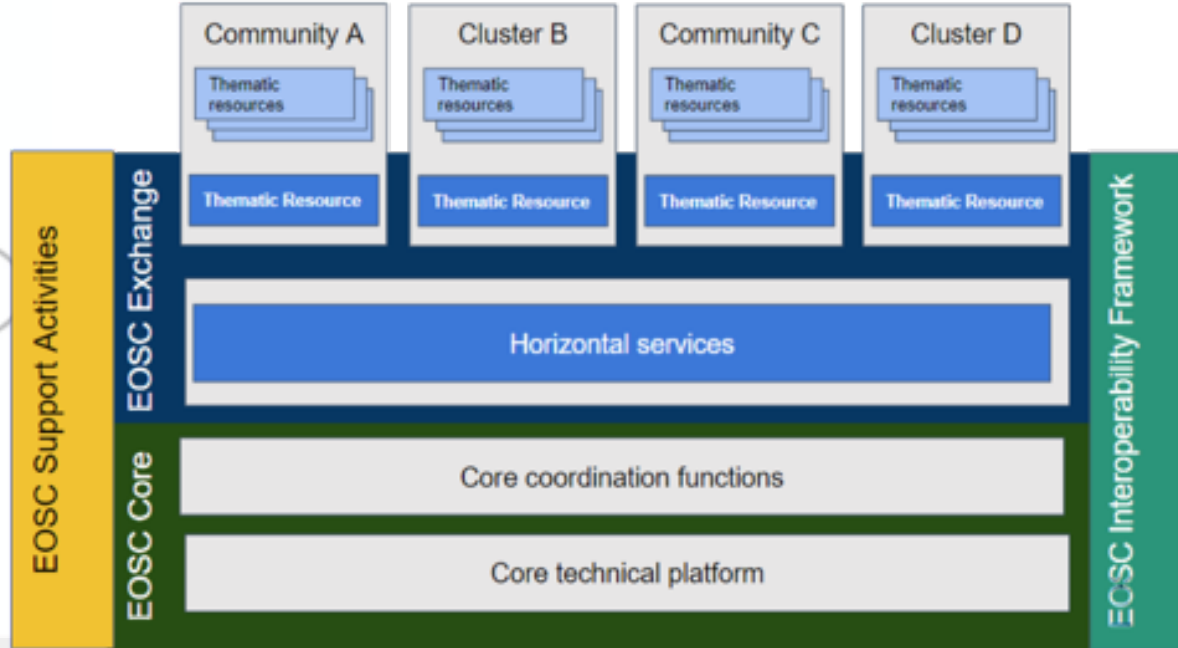
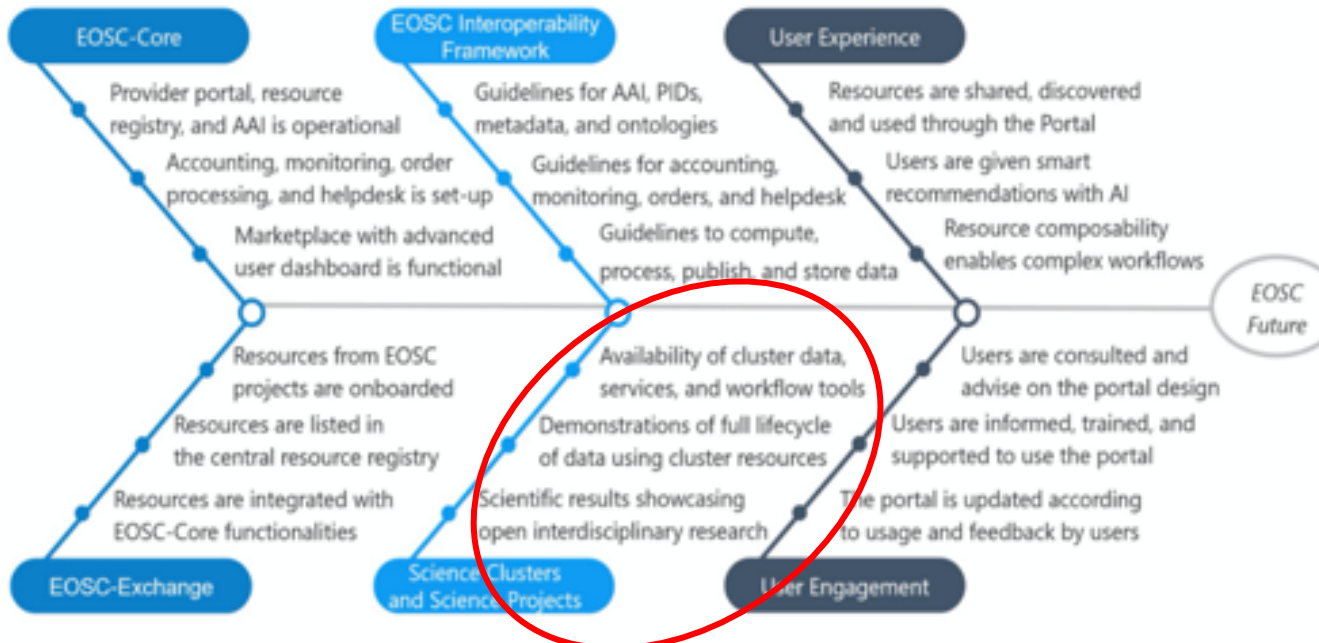
- Provide **EOSC Core** to enable basic EOSC operation, including capacity, service evolution, deployment and operation
- Create and maintain **EOSC Exchange**, including onboarding services from communities, offering them via the Portal and offering integration
- Deliver **EOSC Interoperability Frameworks** to allow integration, harmonisation and composability of resources across the EOSC landscape through the **EOSC Execution Framework**
- Deliver **support activities** including training, engagement and commercial liaison.

INFRAEOSC-07 - EOSC provisioning projects

- Provide horizontal resources and capacity through EOSC Exchange for data processing, storage, management
- Provide services for Open Science and Copernicus data
- Provide a basis for building PaaS and SaaS services on top of services and capacity from EOSC Exchange

Other RIs, thematic, regional and national research communities

- Access and provide resources via the Exchange
- Integrate and benefit from EOSC Core services
- Strengthen and extend new communities



Summary

- ❑ ESCAPE brings together Astronomy, Astrophysics, Astro-Particle, High Energy and Nuclear Physics communities
 - Common interests in Exabyte-scale FAIR data management and open science
 - While European (ESFRI) based, all are global collaborations
 - Objectives are science-driven (MMA, and key science projects) as well as commonality and synergies across infrastructure, services, and tools
- ❑ Broader synergies with the other ESFRI science cluster projects
 - All acting in concert towards the EOSC – aligned goals and common interests across a broad range of European Research actors
 - Future: ESCAPE (& other clusters) foresee long-term collaboration
- ❑ EOSC-Future will be first implementation of EOSC, driven by science

