ESCAPE

European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures

# The ESCAPE Data Lake as the bridgehead for the EOSC: the DataLake-as-a-Service

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CERN

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ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures

## Science Projects

HiLumi HL-LHC PROJECT
SKA SQUARE KILOMETRE ARRAY
VIRGO
FAIR
KM3NeT
JIVE Joint Institute for VLBI ERIC
cta cherenkov telescope array
LSST
EST european solar telescope
ESO
CERN

# ESCAPE

European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures

EUROPEAN OPEN SCIENCE CLOUD

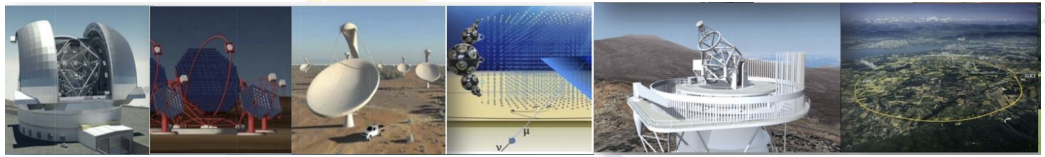
Horizon2020
European Union Funding
for Research & Innovation

## Partners

CERN
INFN
GSI
DESY
Nikhef
SURF SARA
rijksuniversiteit groningen
CCIN2P3
CNRS
PIC port d'informació científica
LAPP Laboratoire d'Annecy de Physique des Particules
INAF ISTITUTO NAZIONALE DI ASTROFISICA NATIONAL INSTITUTE FOR ASTROPHYSICS

## Project Goals

- Prototype an infrastructure adapted to exabyte-scale **future needs** of large science projects
- Ensure sciences drive the development of EOSC
- Address FAIR data management principles





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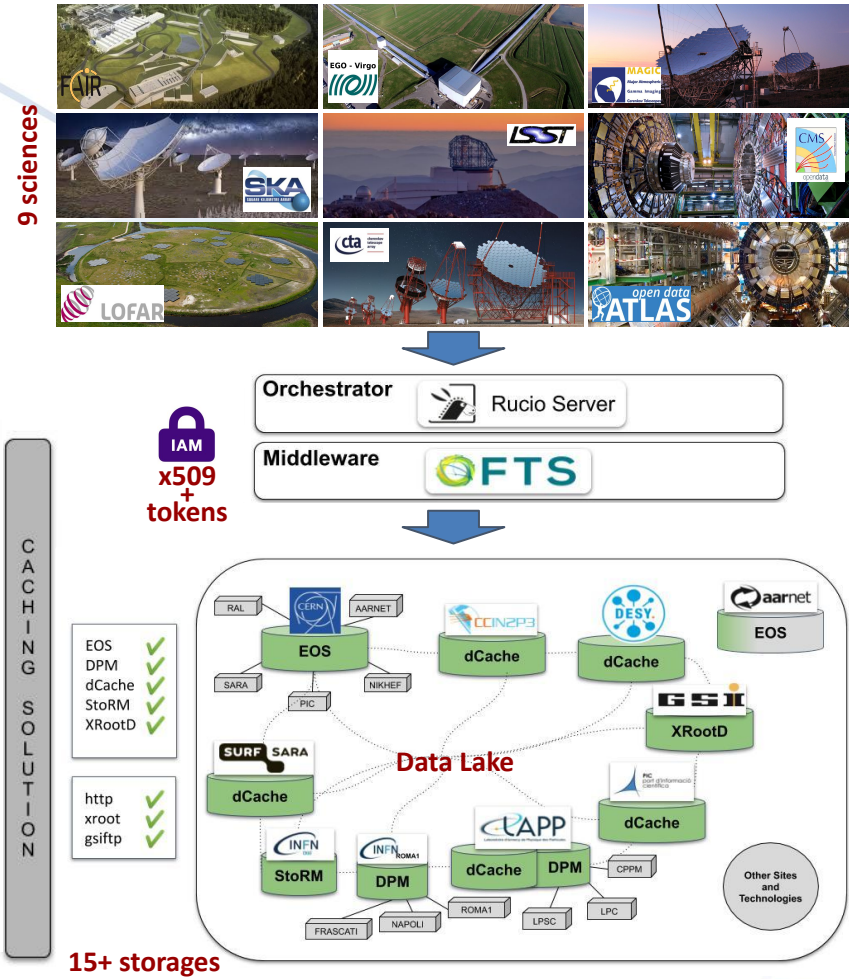
# The Data Lake

- Data Lake as modular ecosystem of services and tools shaped around the ESCAPE scientific communities
  - federated data management and access solution
  - heterogeneous resources
    - e.g. integration of HPC and **commercial Clouds**
- Hiding complexity and providing transparent access to data
  - layer for orchestration of resources as entry point for sciences
    - define data policies and rules
  - content delivery and caching layer
    - HTTP data access and Tokens awareness for future sustainability
    - latency hiding and file re-usability
    - facilitate ingress/egress with Clouds and HPC
- Storage and compute resources not necessarily colocated




Further info: https://wiki.escape2020.de/index.php/WP2_-_DIOS#Datalake_Status



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# DataLake-as-a-Service for Open Science

- Challenging project as time-constrained (CERN OpenLab Summer Student programme)
- Goal: make **end-user comfortable** in embarking on a Data Lake experience
  - abstract the complexities of the Data Lake from the scientists
    → focus on doing science instead of data procurement
- An ever-increasing number of experiments are looking at Rucio Data Management system
  - **DLaaS** potentially interesting for both **aficionados** and **newcomers**
  - we are working for experiments and sciences → fresh feedback and ideas are very appreciated!
- Always looking for new collaborations and partnerships - *please step forward!*


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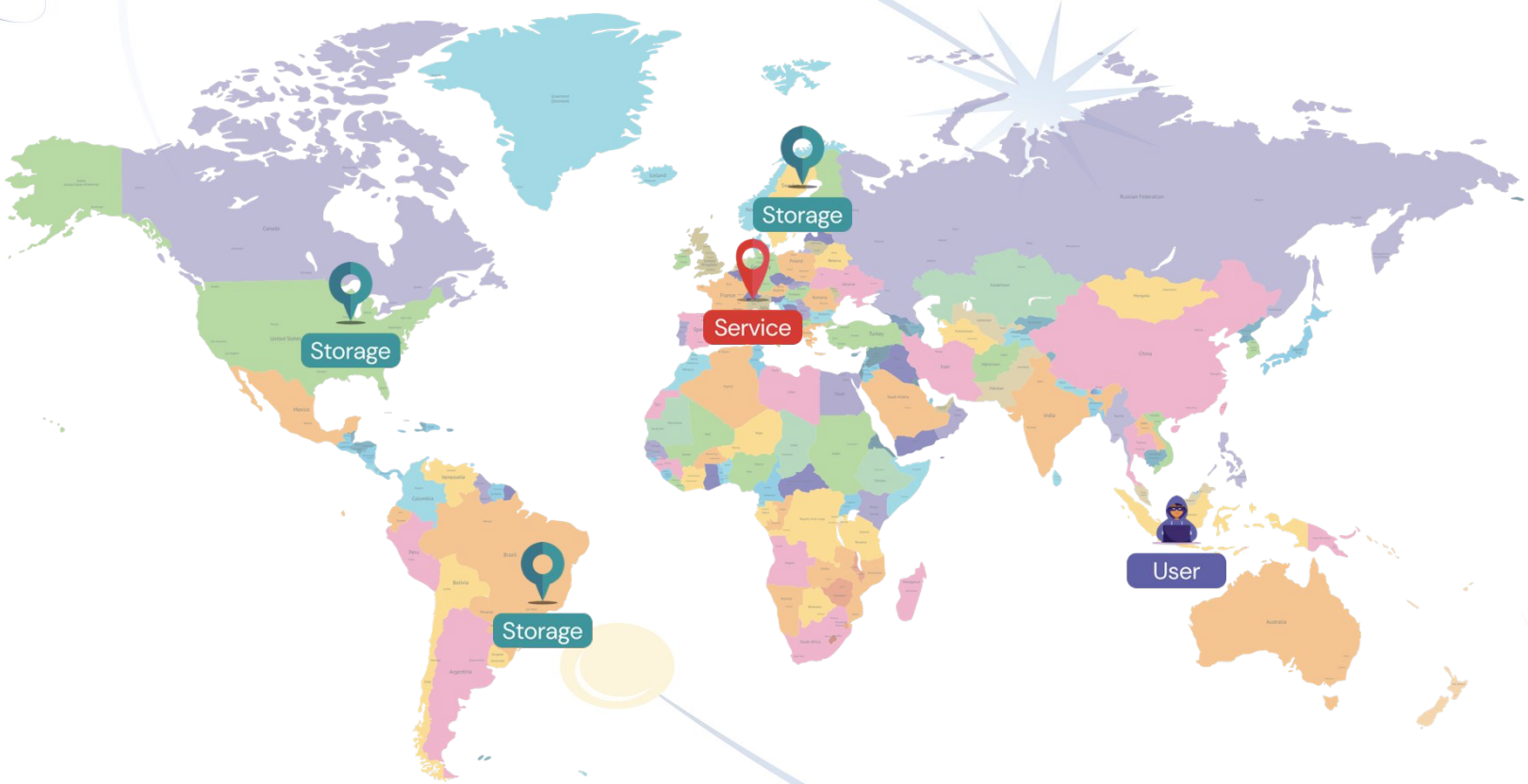
# DataLake-as-a-Service for Open Science





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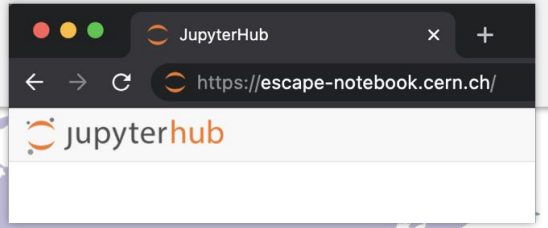
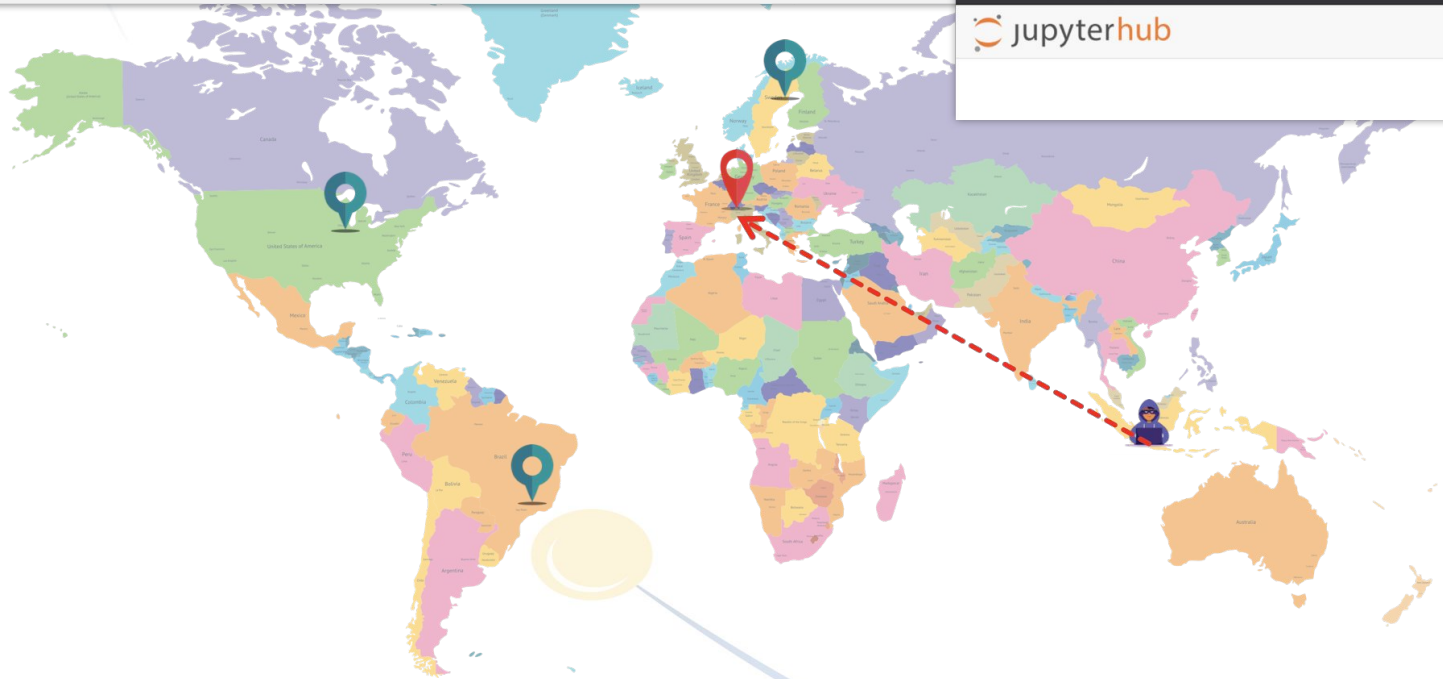
# DataLake-as-a-Service for Open Science

→ **Scientists Contact DataLake-as-a-Service**

Requests are handled by Jupyter servers at CERN, Geneva





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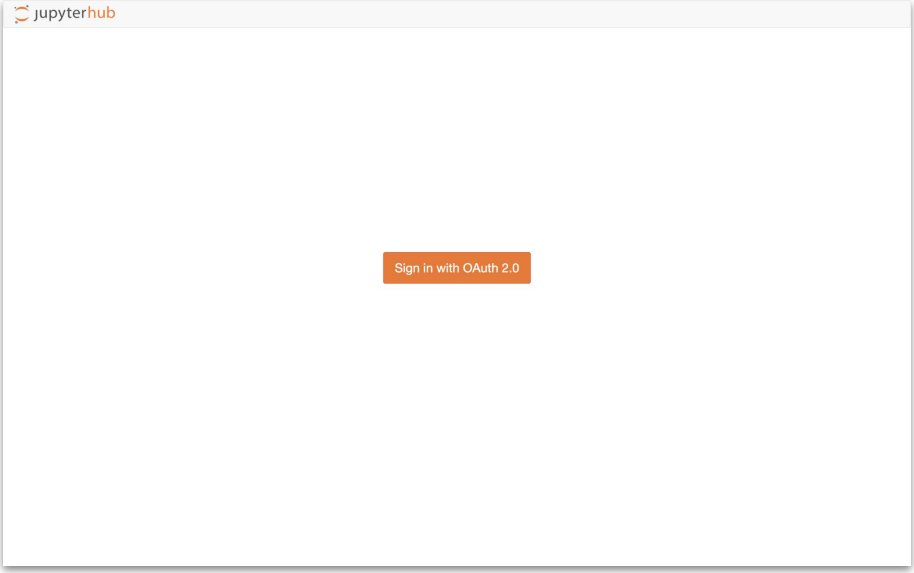
# DataLake-as-a-Service for Open Science




https://escape-notebook.cern.ch/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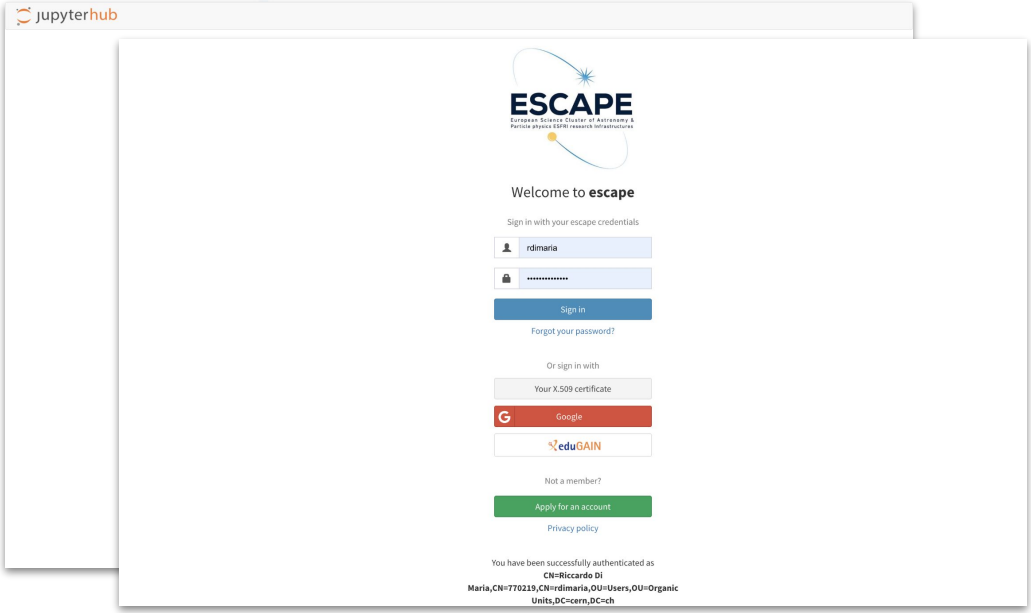
# DataLake-as-a-Service for Open Science



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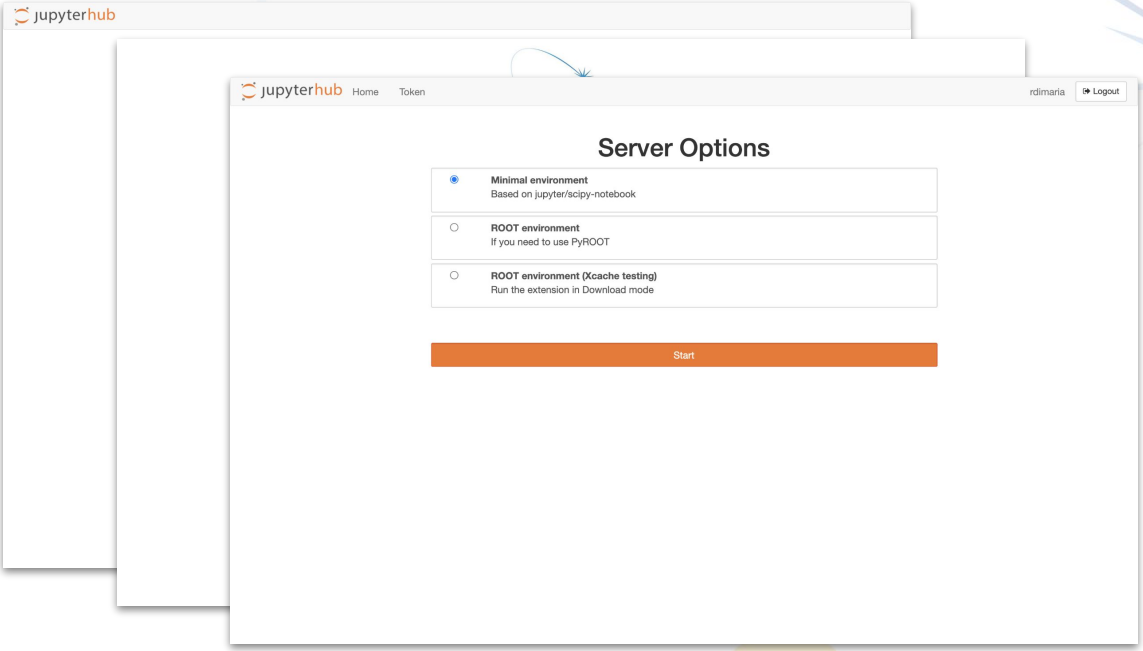
# DataLake-as-a-Service for Open Science





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# DataLake-as-a-Service for Open Science

jupyterhub

jupyterhub Home Token rdimaria Logout

File Edit View Run Kernel Tabs Settings Help

RUCIO

EXPLORE NOTEBOOK

Enter a Data Identifier (DID)

Search Everything

Untitled.ipynb

Code Python 3

[ ]:

Simple 0 1 Python 3 | Idle

File Edit View Run Kernel Tabs Settings Help

RUCIO

EXPLORE NOTEBOOK

Active Instance

ESCAPE Data Lake

Authentication

OpenID Connect

OpenID Connect

X.509 User Certificate

X.509 Proxy Certificate

Username & Password

Save Settings

Untitled.ipynb

Code Python 3

[ ]:

Simple 0 1 Python 3 | Idle Mode: Edit Ln 1, Col 1 Untitled.ipynb



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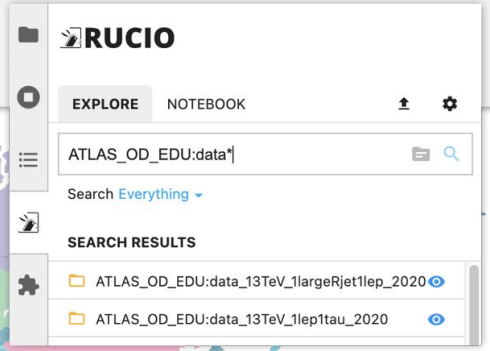
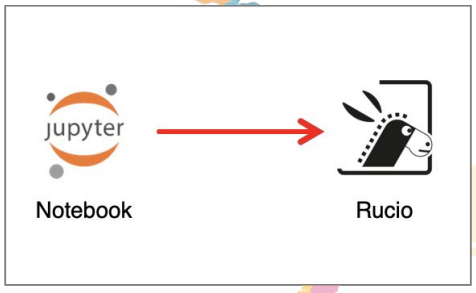
# DataLake-as-a-Service for Open Science

→ Scientists Browse Data in the ESCAPE Data Lake

Requests are relayed to Rucio servers at CERN, Geneva



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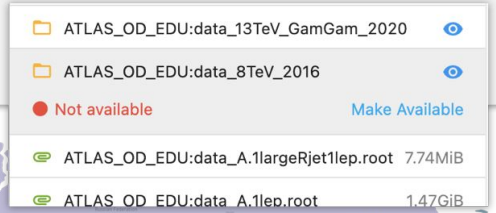
# DataLake-as-a-Service for Open Science

→ **Make Available**

Rucio initiates transfers from worldwide storages to CERN RSE which is serving DLaaS



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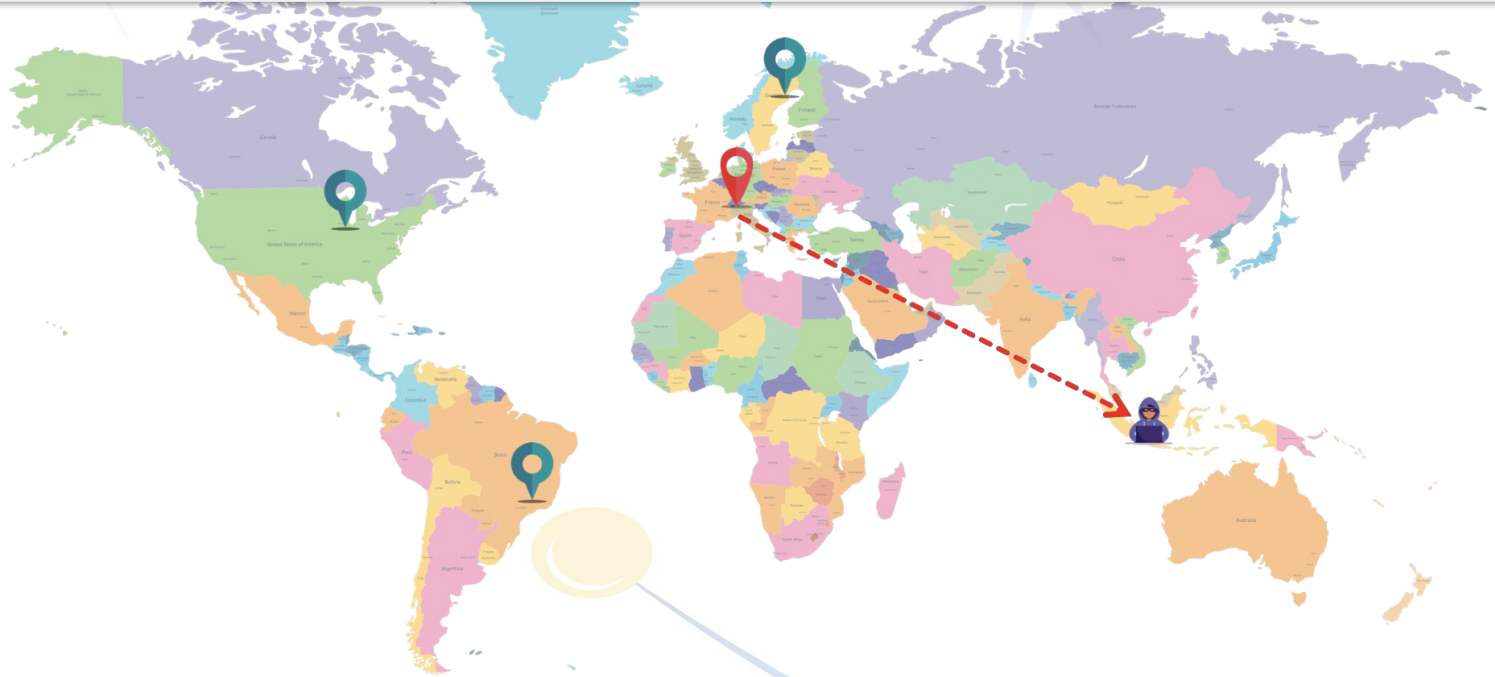
# DataLake-as-a-Service for Open Science

→ **Scientists' Analysis Workflows Read Data**

The code runs on the Notebook server at CERN, and the output is shown to the user





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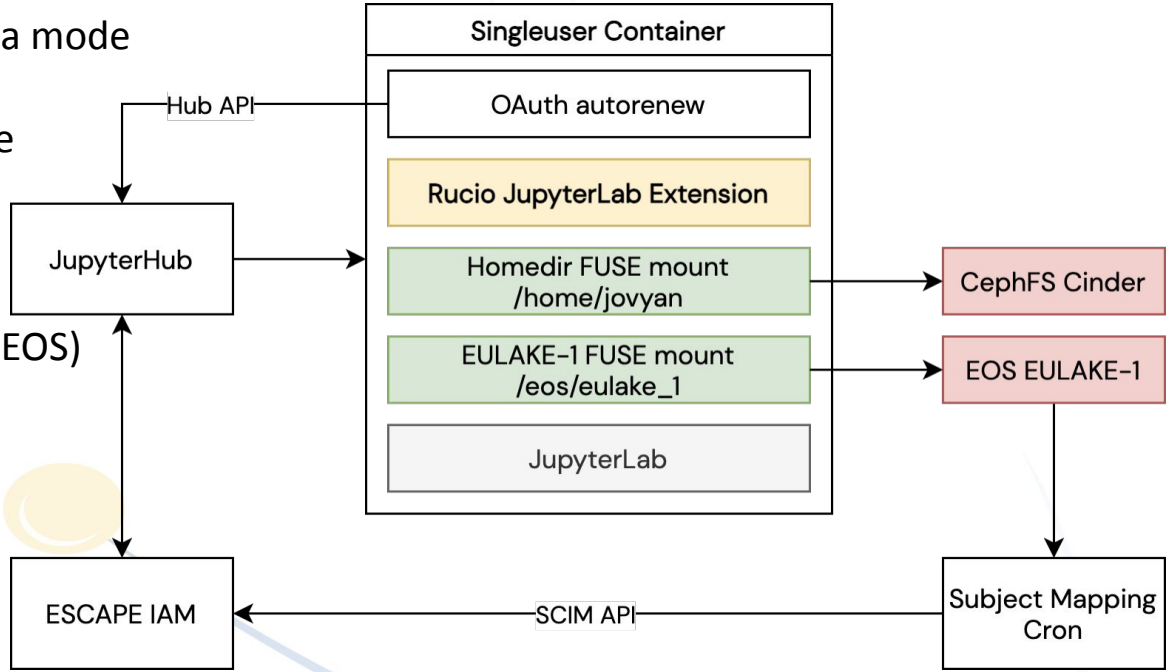
# DLaaS Implementation

- Deployed in Kubernetes, using Zero-to-JupyterHub Helm chart → https://escape-notebook.cern.ch
- OAuth authentication using ESCAPE IAM (X509 still supported)
- Rucio JupyterLab Extension in Replica mode (i.e. TPC to local storage) used
  - connected to ESCAPE Data Lake (escape-rucio.cern.ch)
  - automatically pre-configured to use OIDC Auth
  - FUSE mount to EULAKE-1 RSE (EOS)
  - making files available *aka* creating a replication rule to move files to EULAKE-1
  - download mode still possible (if configured)





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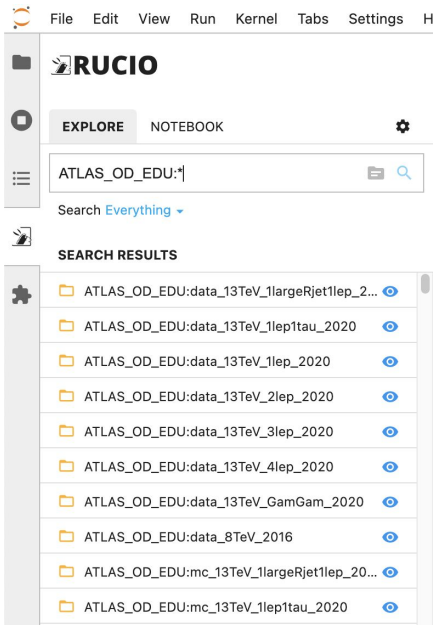
# DLaaS Use Cases

- Data discovery and access
- Submitting jobs to external services (remote computing)
  - conveniently browse data in Rucio through the extension
  - access file PFN directly from the Notebook




```
[3]: for item in hyy_20:
         print(item.pfn)

root://eoseulake.cern.ch:1094//eos/eulake/tests/rucio_test/eulake_1/ATLAS_LAPP_JEZEQUEL/6f/98/data_A.GamGam.root
root://eoseulake.cern.ch:1094//eos/eulake/tests/rucio_test/eulake_1/ATLAS_LAPP_JEZEQUEL/f1/3a/data_B.GamGam.root
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```


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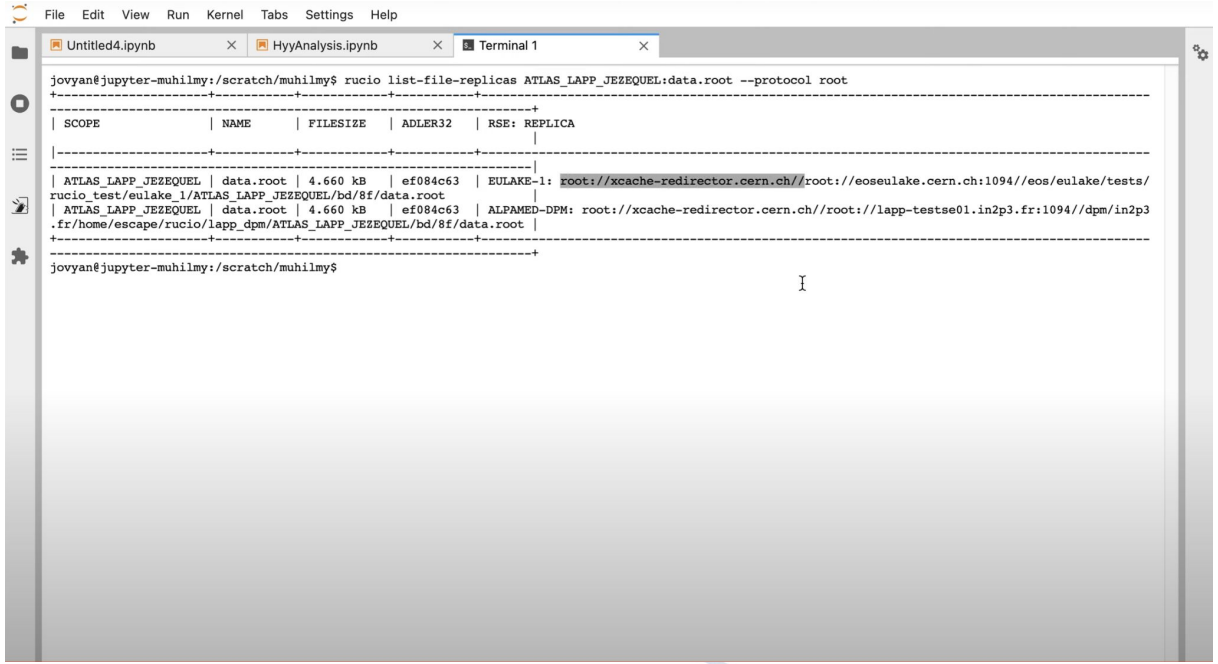
# DLaaS Use Cases

- Data access
  - <u>bonus track</u>: content delivery and caching layer (*aka* XrootD-XCache)





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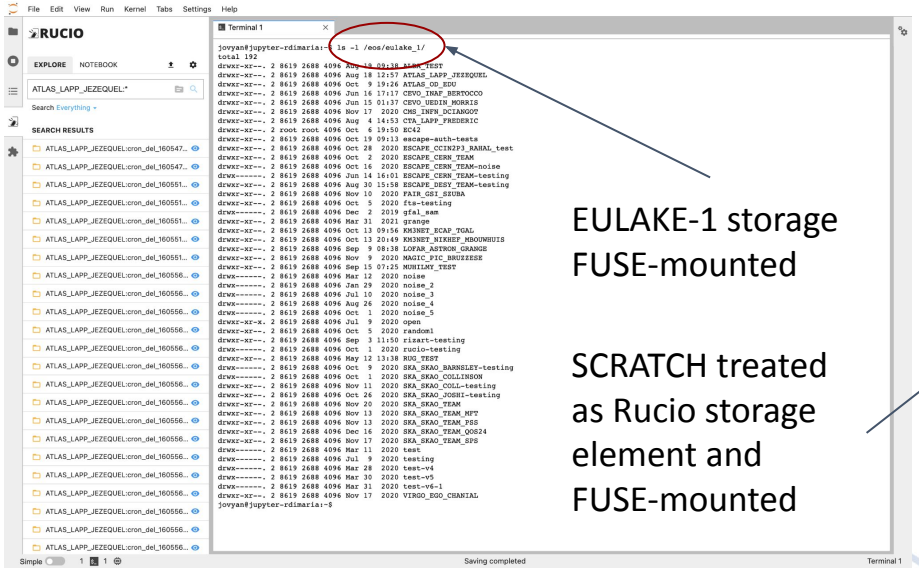
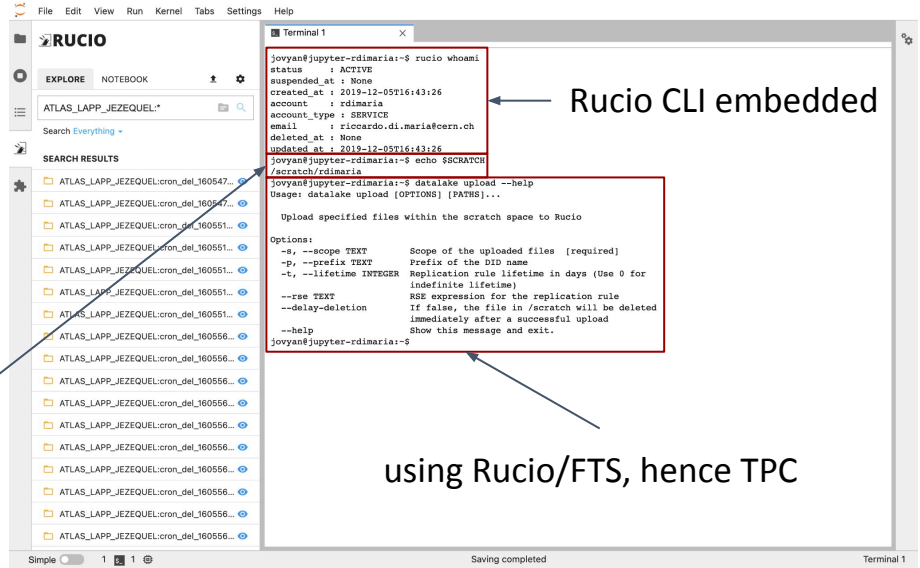
# DLaaS Use Cases

- Data preparation and processing
  - prepare/process data and upload back to the Data Lake




EULAKE-1 storage FUSE-mounted

SCRATCH treated as Rucio storage element and FUSE-mounted




Rucio CLI embedded

using Rucio/FTS, hence TPC



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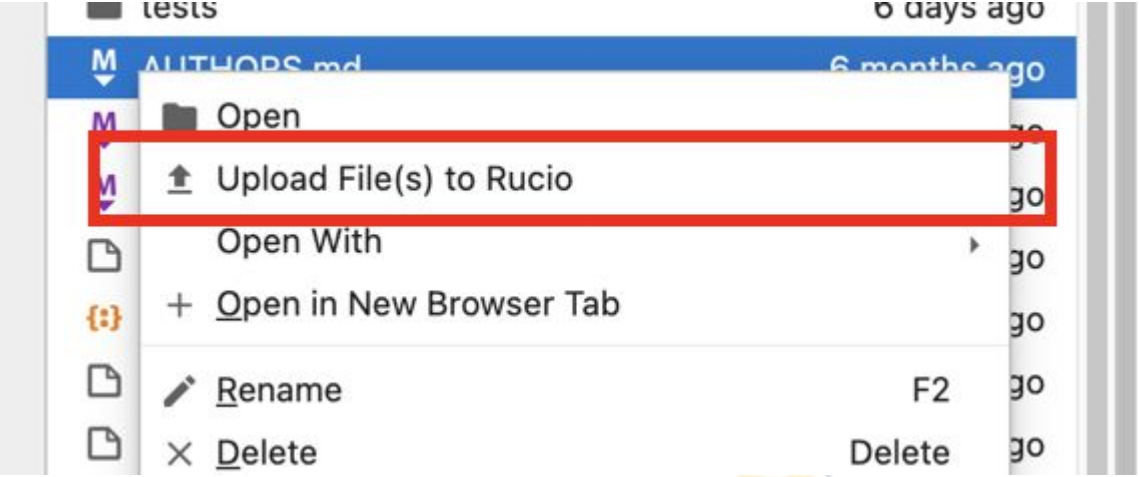
# DLaaS Use Cases

- Data preservation
  - produce data and upload to the Data Lake



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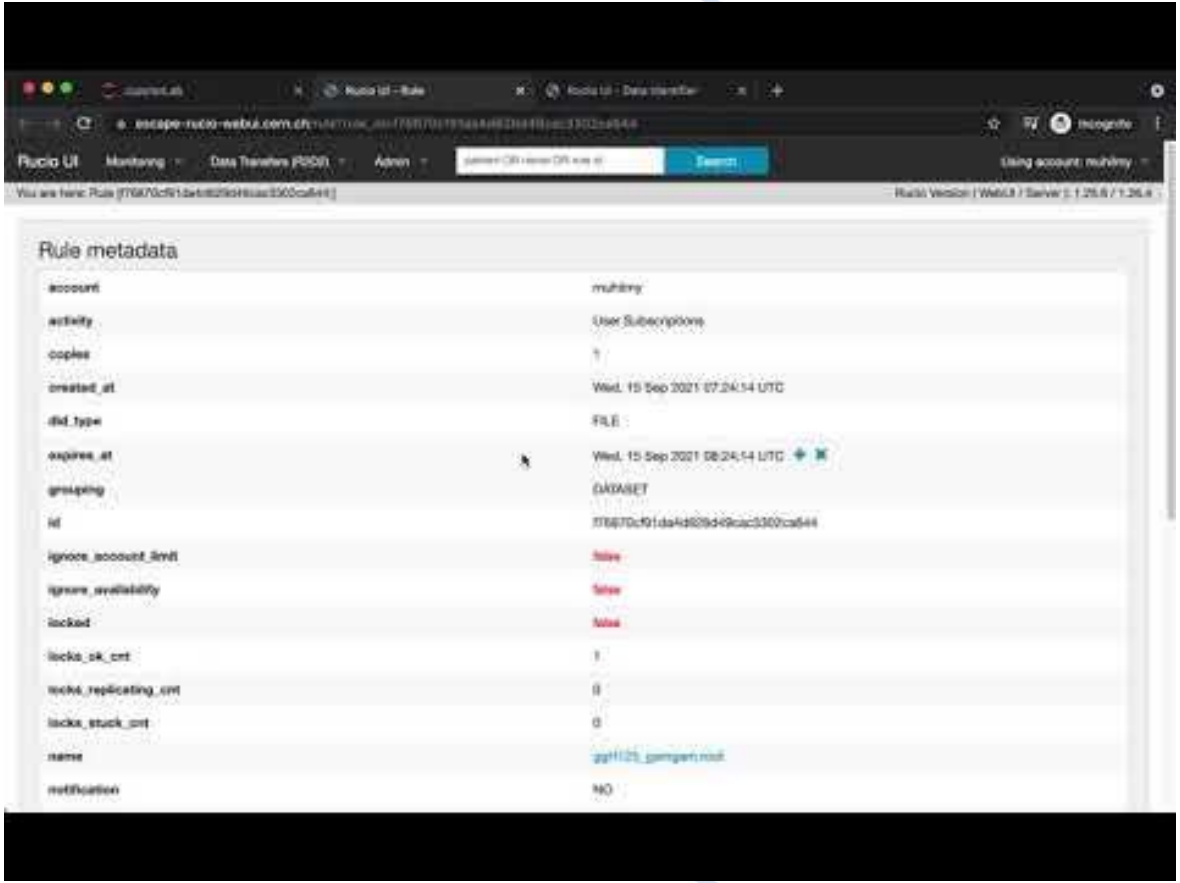
# DataLake-as-a-Service for Open Science





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# Conclusion and Next Steps

- **DLaaS** hides the complexities of the Data Lake from the end users (so that they are happy and productive!)
  - interesting for both **aficionados** and **newcomers** of **Rucio**
  - community-driven development, hence driven by the needs of different experiments and sciences
- Successful assessment of the pilot Data Lake, pivotal to test model and concepts for several communities
    - Astro-particle Physics, Electromagnetic and Gravitational-Wave Astronomy, Particle Physics, and Nuclear Physics **pursuing together** FAIR and open-access data principles
- ESCAPE at prototype phase ⟶ full scale exercise for November 2021
  - close-to-production test on data management and data processing
    - complementing existing efforts in WLCG ⟶ ESCAPE as perfect environment to test new models/concepts
    - exploring non-HEP-standard scenarios
  - collaboration with other communities, e.g. PaNOSC, ExPaNDS, CS3MESH4EOSC
    - sharing common challenges, potentially address-able with common solutions


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# Backup Slides

- *25th International Conference on Computing in High-Energy and Nuclear Physics* (vCHEP2021) talks and proceedings
  - ESCAPE Data Lake: Next-generation management of cross-discipline Exabyte-scale scientific data
  - The ESCAPE Data Lake: The machinery behind testing, monitoring and supporting a unified federated storage infrastructure of the exabyte-scale
  - Experience with Rucio in the wider HEP community


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# Architecture

- Data Storage Services and Usage
  - proven technologies from WLCG
  - perfect playground for the implementation of storage Quality of Service intelligence

CERN Tape Archive

- Data Orchestration
  - Rucio customised to the needs of ESCAPE community
- File Transfer Service → WLCG FTS
  - continuous testing for both FTS and file access libraries
- Networking → exploiting [perfSONAR infrastructure]
- Information System → WLCG CRIC
  - ESCAPE instance containing services information and configuration for Rucio
  - synchronisation services designed to pull necessary information

Computing Resource Information Catalog

- AuthN/Z, and Identity layer → INDIGO Identity and Access Management (IAM) service
- Probes and monitoring exploiting open source solutions
  - access availability and reliability of the services
  - ESCAPE dashboards as multi-VO


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# Deployment Model and Techniques

- **Goal**: common infrastructure and core services for ESCAPE sciences that operate services and tools according to their scientific needs
  - improved project sustainability and successful exportability adoption by sciences
- Beyond ESCAPE term: ability to deploy, customise, and manage services at convenience
  - infrastructure should be resource-aware - Kubernetes & GitOps-Flux
    - properly-scaled, according to needs/necessities of partners
    - flexible, portable, plug-able, and easy-sizable
  - deploy a manifold system utilising a lightweight but complete implementation
  - sciences at different scale and trying to address multiple future use case
    → ESCAPE includes experiments with different data management requirements than LHC ones
- Contribution to Rucio on functionalities relevant for ESCAPE partners
  - expand Rucio scope and capabilities e.g. to address million-file rule injection use case
- Synergies and collaborations within and beyond ESCAPE
  - Rucio/JupyterLab Integration Project within CERN-HSF GSoC, exploited by LOFAR to analyse data during the FDR


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# Data Lake **24-hour Full Dress Rehearsal**

- Aim: demonstrate fulfilment of communities needs
  - functionalities and use cases specific per experiment
- ESCAPE Data Lake not a production service → specific testing-focused time-window
  - even out differences in knowledge and acquiring know-how on management and utilisation
  - workflow and lifecycle of experiment-specific data
  - assessment of robustness of the various Data Lake components, tools, and services
- Experiments injected data as during runs
  - effort to mimic realistic conditions in terms of object sizes and data organisation
  - demonstrator categories
    - **injection** - **rules and policies** - **data lifecycle** - **access** → *Backup slides*


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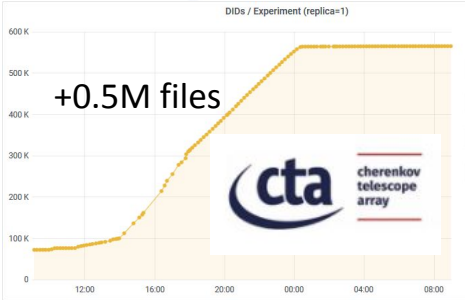
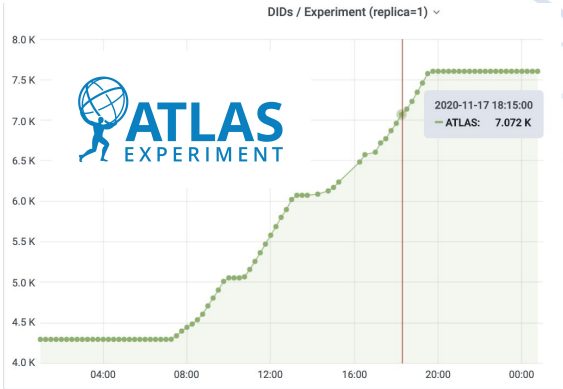
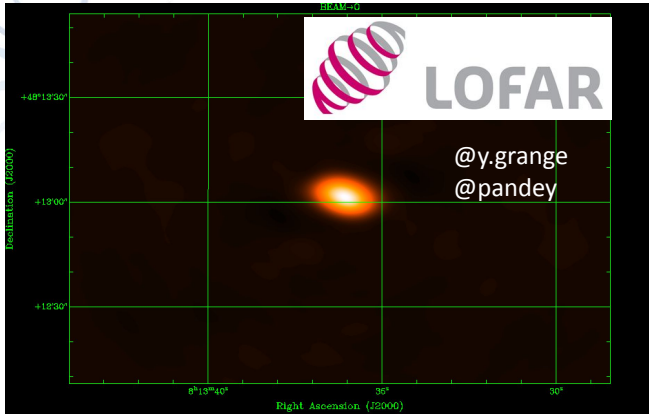
# DL **24-hour Full Dress Rehearsal** Takeaway → Workshop



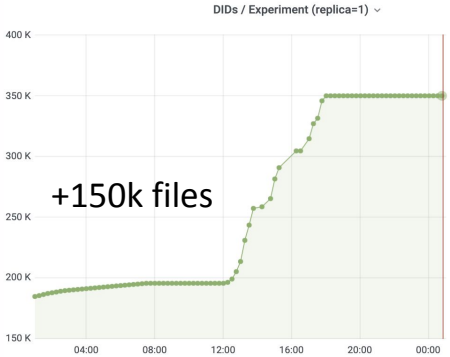

**CTA**
**night-data-captured from telescope in Canary Island**

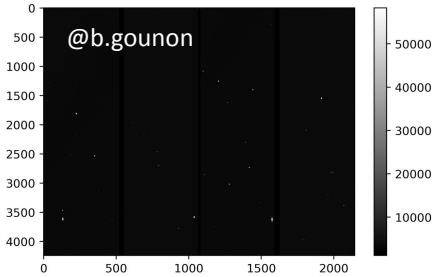



**ATLAS**
**request transfer to QoS-specific storages**
**QoS functionalities**




**LOFAR**
**astronomical radio source 3C196 image via notebooks**




**LSST**
**realistic LSST data rate (20TB/24h)**
**confirm integrity and accessibility of the data via notebooks**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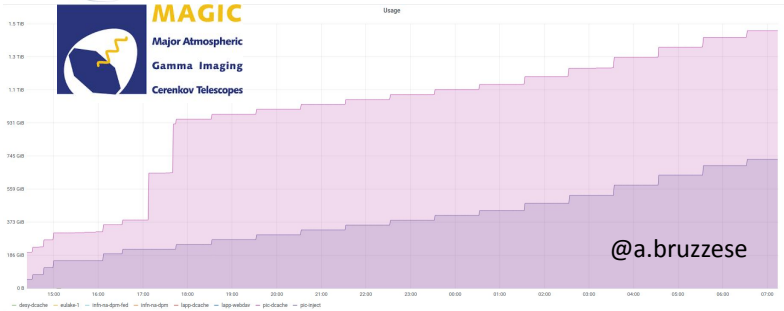
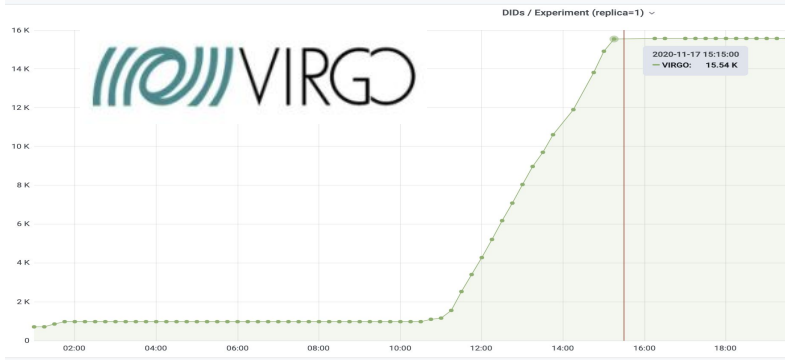
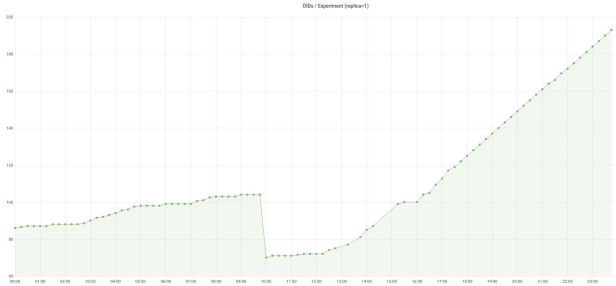
# DL **24-hour Full Dress Rehearsal** Takeaway → Workshop



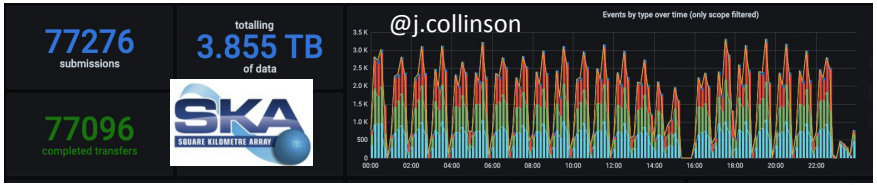

**MAGIC**
**mimics a real MAGIC observation use case**
**remote storage next to the telescope as a buffer for injection**
**local deletion**




**EGO/VIRGO**
**4h VIRGO public data sampled at 4 kHz**
**download to CNAF-STORM and assess data quality**



**FAIR**
**mock data ingestion from CBM (FAIR experiment)**
**request 2 replicas in different QoS**




**SKA**
**Pulsar Observations injection**
**files fall into two containers, representing different SKA Projects**
**24h test moving data on basis of QoS class**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# Future Developments

- Additional kernel compatibility
  - currently, only Python supported
- Token-support for direct download and upload
  - OIDC integration ongoing to all remaining ESCAPE RSEs
- Integration with content delivery and caching layer
  - XCache can be integrated to allow faster file download
  - completely transparent from the user PoV
  - successfully tested at small scale


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# References

- ESCAPE, https://projectescape.eu/ - https://doi.org/10.1051/epjconf/202024504019
- ESCAPE Data Lake, https://wiki.escape2020.de/index.php/WP2_-_DIOS#Datalake_Status
- ESCAPE Data Lake deployment, https://gitlab.cern.ch/escape-wp2/flux-rucio
- ESCAPE Data Lake tools, https://github.com/ESCAPE-WP2
- CERN-HSF GSoC project: Rucio-SWAN Integration
- Data Lake 24-hour Full Dress Rehearsal (FDR) results, https://indico.in2p3.fr/event/22693/
- Rucio, https://rucio.cern.ch/
- FTS, https://fts.web.cern.ch/fts/
- GFAL, https://dmc-docs.web.cern.ch/dmc-docs/gfal2/gfal2.html
- PerfSONAR, https://www.perfsonar.net/
- PaNOSC, https://www.panosc.eu/
- ExPaNDS, https://www.panosc.eu/
- CS3MESH4EOSC, https://cs3mesh4eosc.eu/


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