



ESCAPE

European Science Cluster of Astronomy &
Particle physics ESFRI research Infrastructures

Data Lake as a Service for Open Science

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Science Projects



ESCAPE

European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures



EUROPEAN OPEN SCIENCE CLOUD



Horizon2020
European Union Funding
for Research & Innovation

Partners

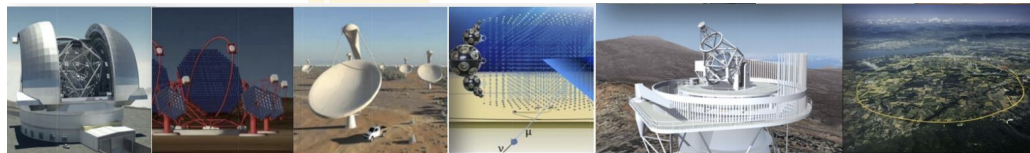


rijksuniversiteit
 groningen



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



The Data Lake

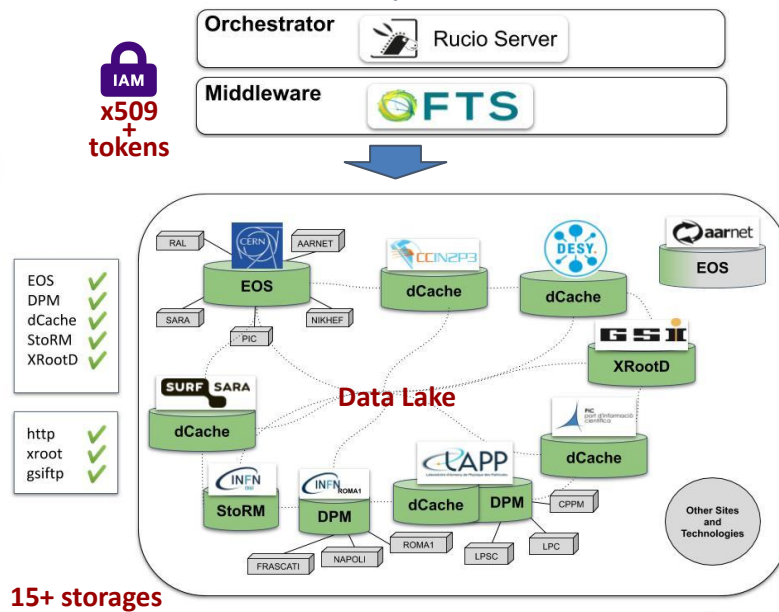
- Data Lake as modular ecosystem of services and tools shaped around the ESCAPE scientific communities
 - federated data management and access solution
 - heterogeneous resources
 - e.g. integration of HPC and **commercial Clouds**
- Hiding complexity and providing transparent access to data
 - layer 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

Sciences



NETWORK OPTIMIZATION

CACHING SOLUTION



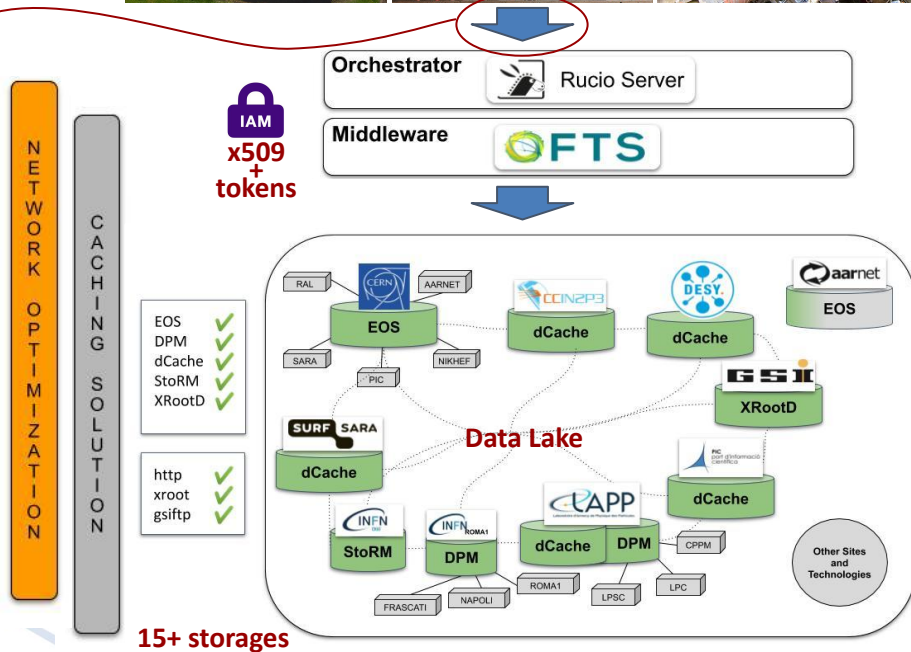
Further info: [https://wiki.escape2020.de/index.php/WP2 - DIOS#Datalake Status](https://wiki.escape2020.de/index.php/WP2_-_DIOS#Datalake_Status)



DLaaS for Open Science

- **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**

Sciences



As It All Started

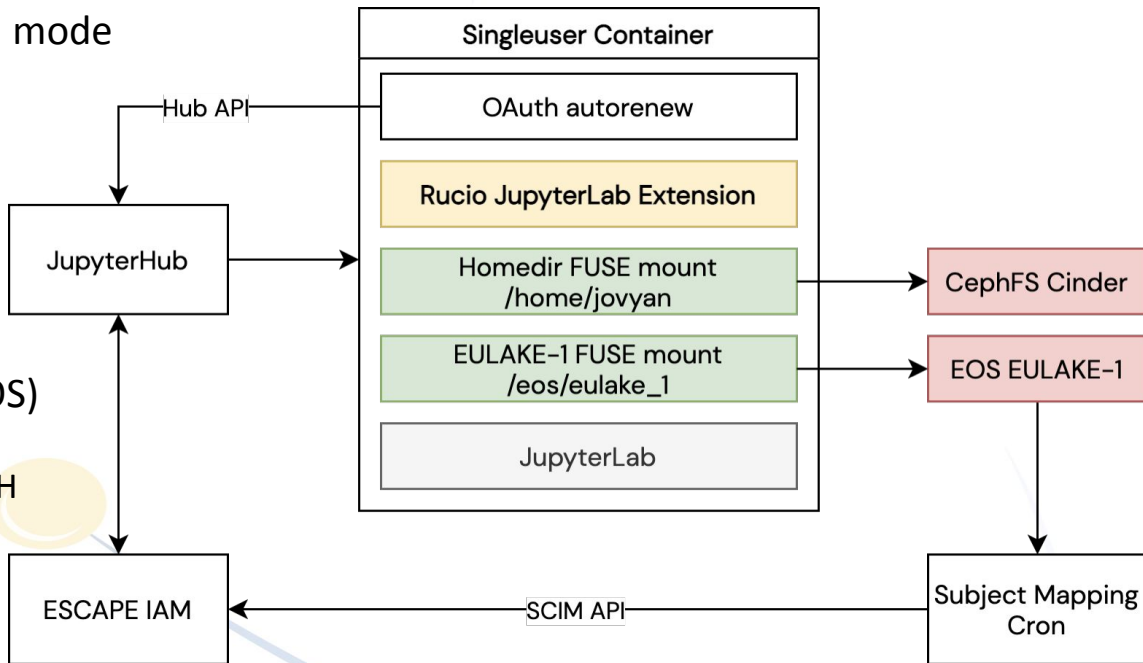
- An idea presented at CS3 2020 by the Rucio team [1]
- Development of a “Rucio JupyterLab Extension” as part of GSoC 2020 [2,3]
- A long time has passed, many things have happened...
 - CERN OpenLab Summer Student to concretise the effort in 2021
 - [deployment](#), [docker-images](#), [documentation](#)
 - DataLake-as-a-Service (DLaaS) in production-like phase
 - extensively exploited during ESCAPE “Data and Analysis Challenge” in November 2021 by SKA, MAGIC, CTA, ATLAS, KM3NET, LOFAR, FAIR
→ [3rd ESCAPE DIOS Workshop](#)
 - EU projects e.g. EOSC-Future and CS3Mesh4EOSC/ScienceMesh
 - other communities e.g. EGI



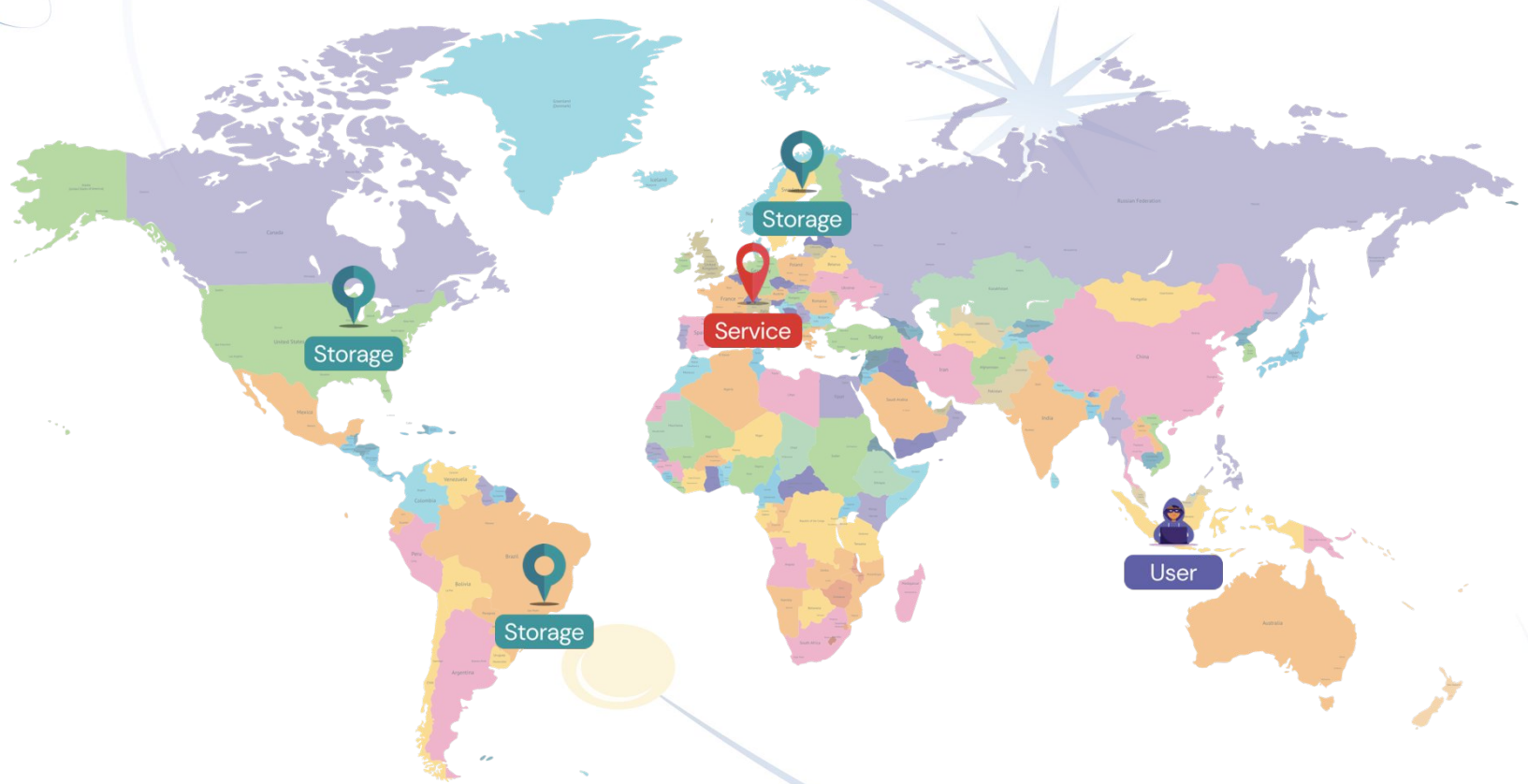
- Deployed in Kubernetes, using Zero-to-JupyterHub Helm chart → <https://escape-notebook.cern.ch>
- OAuth authentication using ESCAPE IAM (X509 still supported)
- [Rucio JupyterLab Extension](#) in Replica mode

(i.e. TPC to local storage) used

- download mode still possible (if configured)
- connected to ESCAPE Data Lake
- automatically pre-configured to use OpenID Connect
- 2 FUSE mounts to EULAKE-1 (EOS)
 - ESCAPE RSE in r-only
 - additional RSE in r/w: SCRATCH
- making files available *aka* creating a replication rule to move files to EULAKE-1



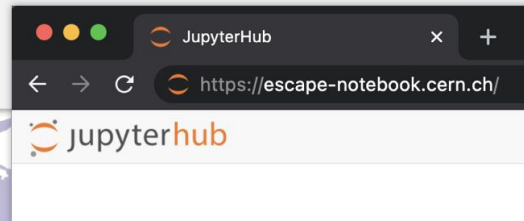
DataLake-as-a-Service for Open Science



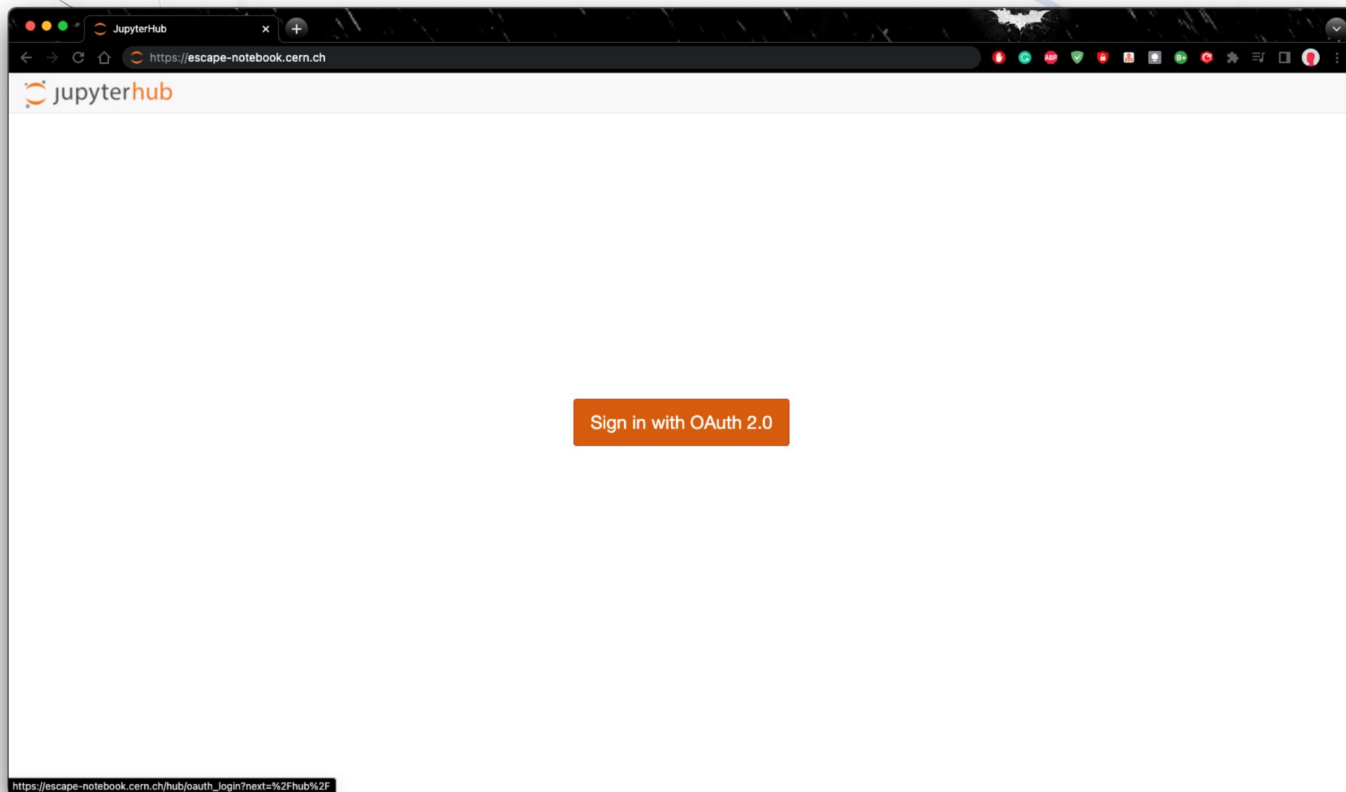
Contact DLaaS

→ Scientists Contact DataLake-as-a-Service

Requests are handled by Jupyter servers at CERN, Geneva



Sign in with OAuth 2.0



ESCAPE Indigo IAM for Auth

INDIGO IAM for escape-Log in x

https://iam-escape.cloud.cnaf.infn.it/login

ESCAPE
European Science Cluster of Astronomy &
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Welcome to **escape**

Sign in with your escape credentials

Sign in

[Forgot your password?](#)

Or sign in with

Your X.509 certificate

Google

eduGAIN

Not a member?

Apply for an account

[Privacy policy](#)

You have been successfully authenticated as
CN=Riccardo Di
Maria, CN=770219, CN=rdimaria, OU=Users, OU=Organic



Multiple Server Options for Sciences

The screenshot shows a web browser window displaying the JupyterHub interface. The URL is `https://escape-notebook.cern.ch/hub/spawn`. The page title is "Server Options". There are eight radio button options:

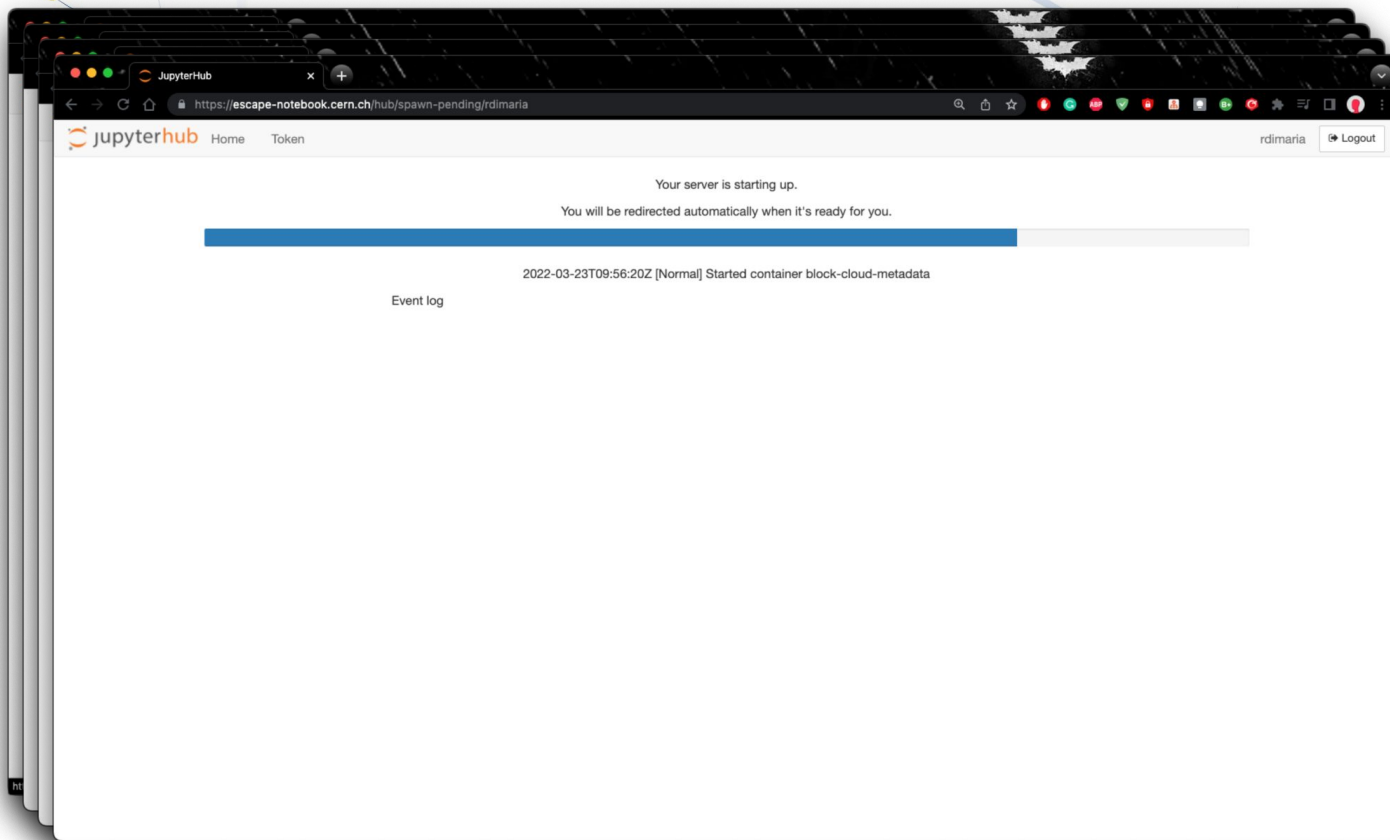
- Minimal environment
Based on `jupyter/scipy-notebook`
- ROOT environment
Contains a C++ kernel and PyROOT
- ROOT environment (Xcache testing)
Run the extension in Download mode
- SKA SDC1
SKA environment profile for SDC
- GCC environment
If you need to use GCC (MAGIC + CTA)
- Micromega environment
Contains the MLFermiLATDwarfs library
- AGNpy environment
Contains the AGNpy library
- Reana environment (with ROOT)
Where to start with flexible analyses

At the bottom of the page is a large orange button labeled "Start".

Each experiment builds and manage the image, which is available to be selected before starting the user session through the **Server Options** page.



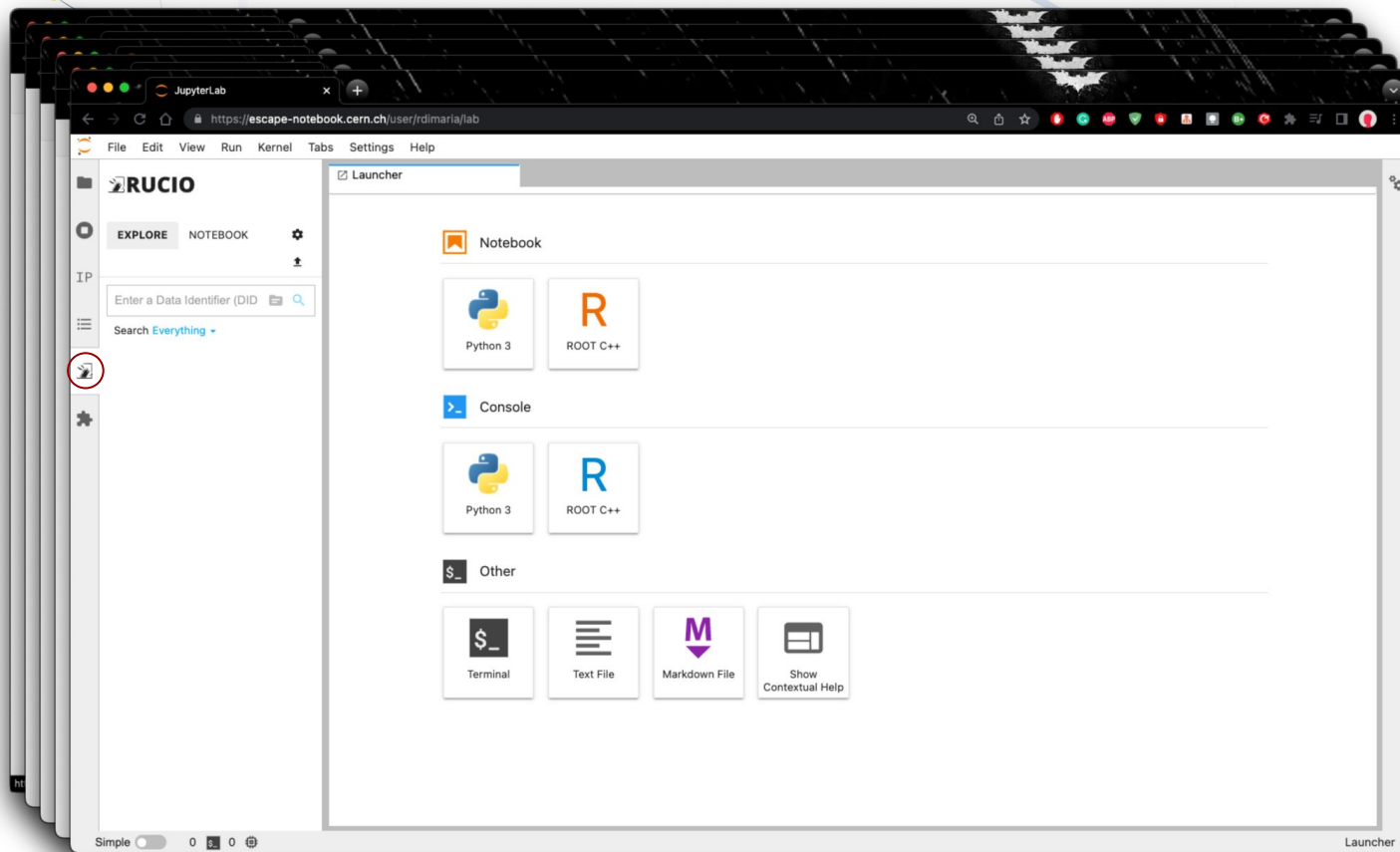
K8s-Pod per User



The user session is realised spawning a dedicated k8s-Pod.



Jupyter Notebook with Rucio Extension

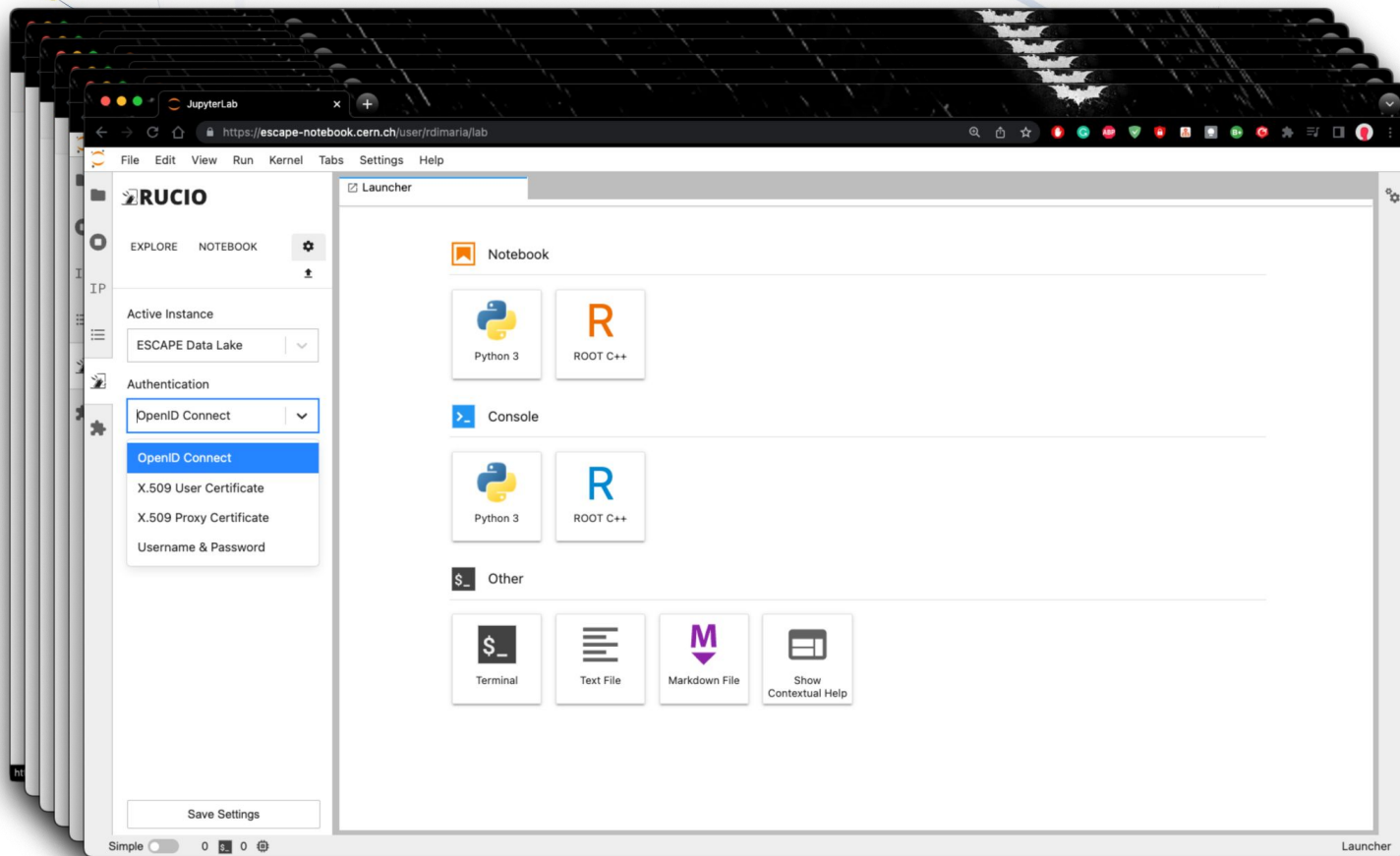


The [Rucio JupyterLab extension](#) is the core of DLaaS.

The relegated repo is hosted by Rucio, and jointly maintained with ESCAPE and EOSC-Future, and whoever is interested in improving it.



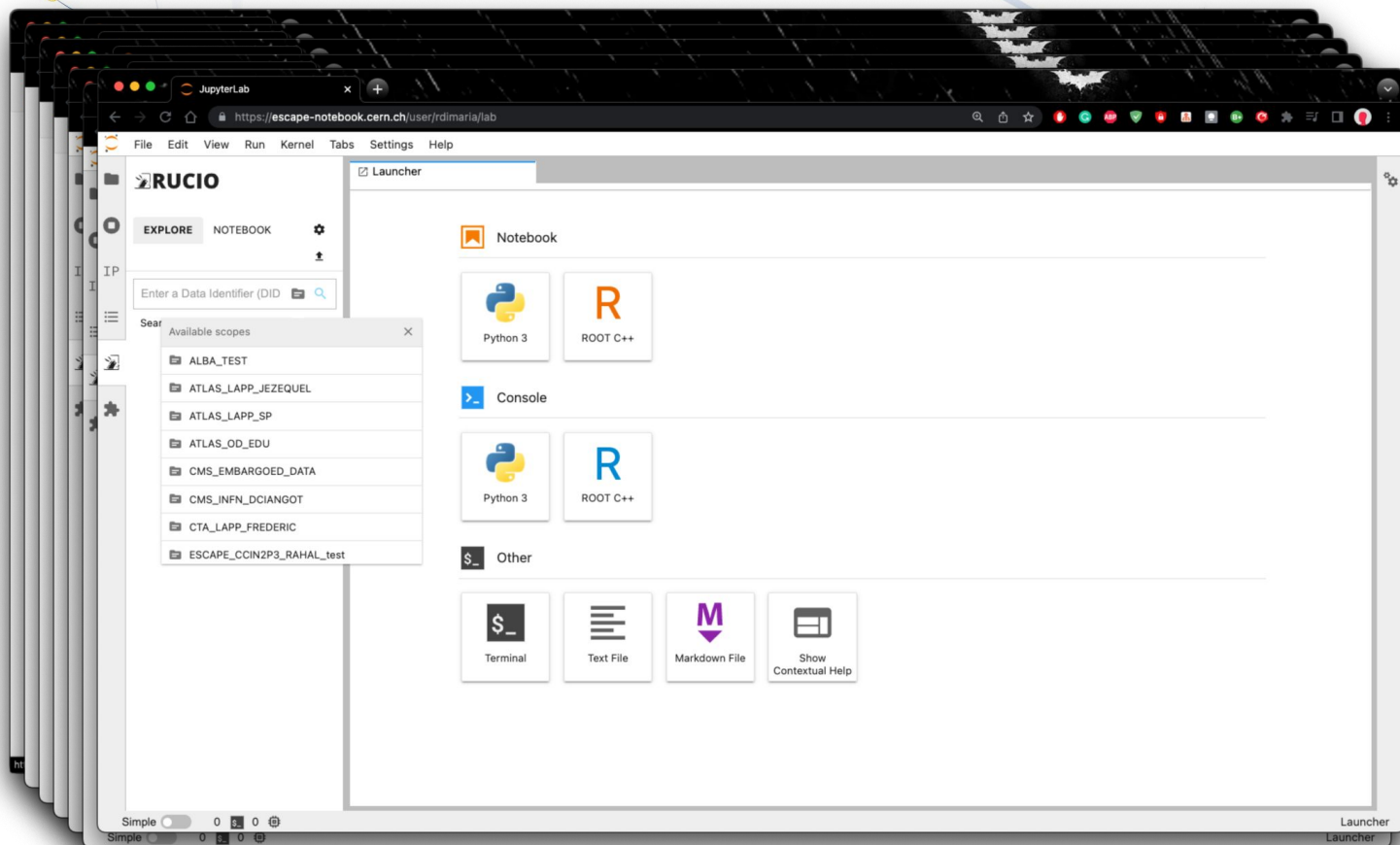
ESCAPE Rucio Instance and OpenID Connect



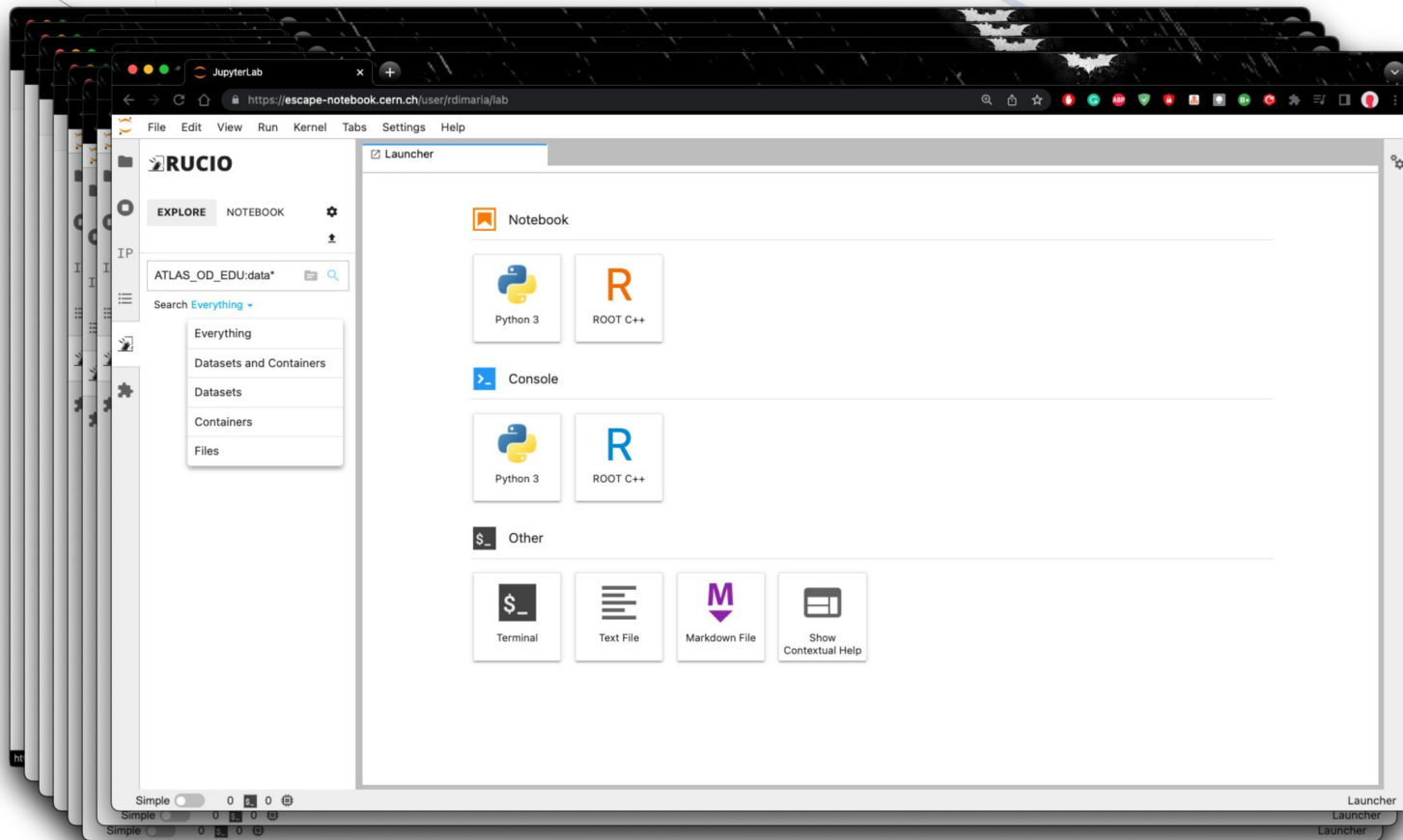
OpenID Connect Auth is by default. Changing it to X509 cert or proxy results in a manual action needed from the user (rucio.cfg to be changed accordingly). Dev work is needed in this respect.



Data Browsing



Data Browsing



Data Browsing

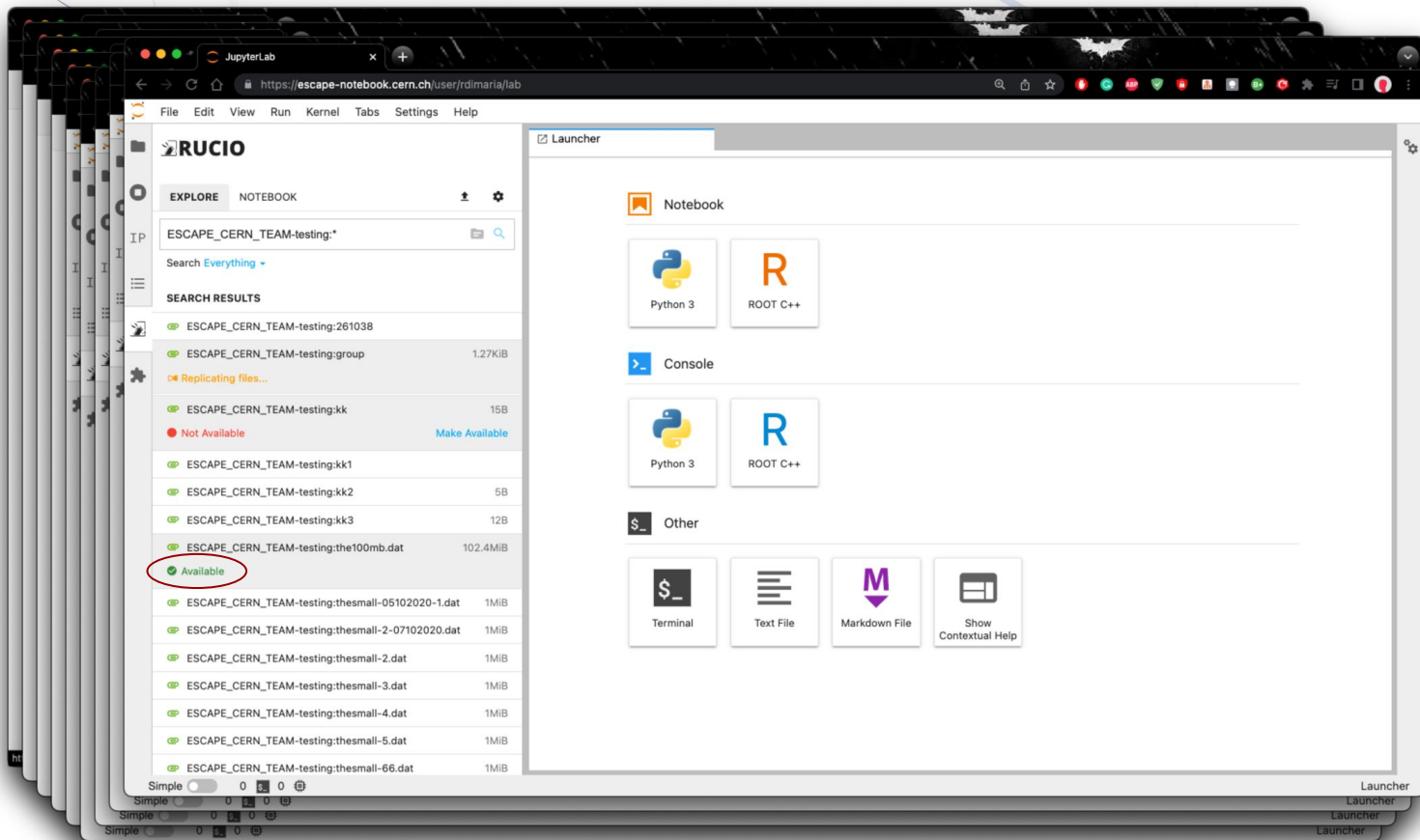
→ Scientists Browse Data in the ESCAPE Data Lake

Requests are relayed to Rucio servers at CERN, Geneva

The image features a world map with several location pins: a blue pin in the United States, a blue pin in Europe, and a red pin in Europe. A blue figure is also visible in Southeast Asia. Overlaid on the right side of the map is a screenshot of the Rucio web interface. The interface shows the Rucio logo, tabs for 'EXPLORE' and 'NOTEBOOK', a search bar containing 'ATLAS_OD_EDU:data', and search results for 'ATLAS_OD_EDU:data_13TeV_1largeRjet1lep_2020' and 'ATLAS_OD_EDU:data_13TeV_1lep1tau_2020'. Below the map, a diagram shows the Jupyter Notebook logo with a red arrow pointing to the Rucio logo, indicating the integration of the two systems.



Data Browsing

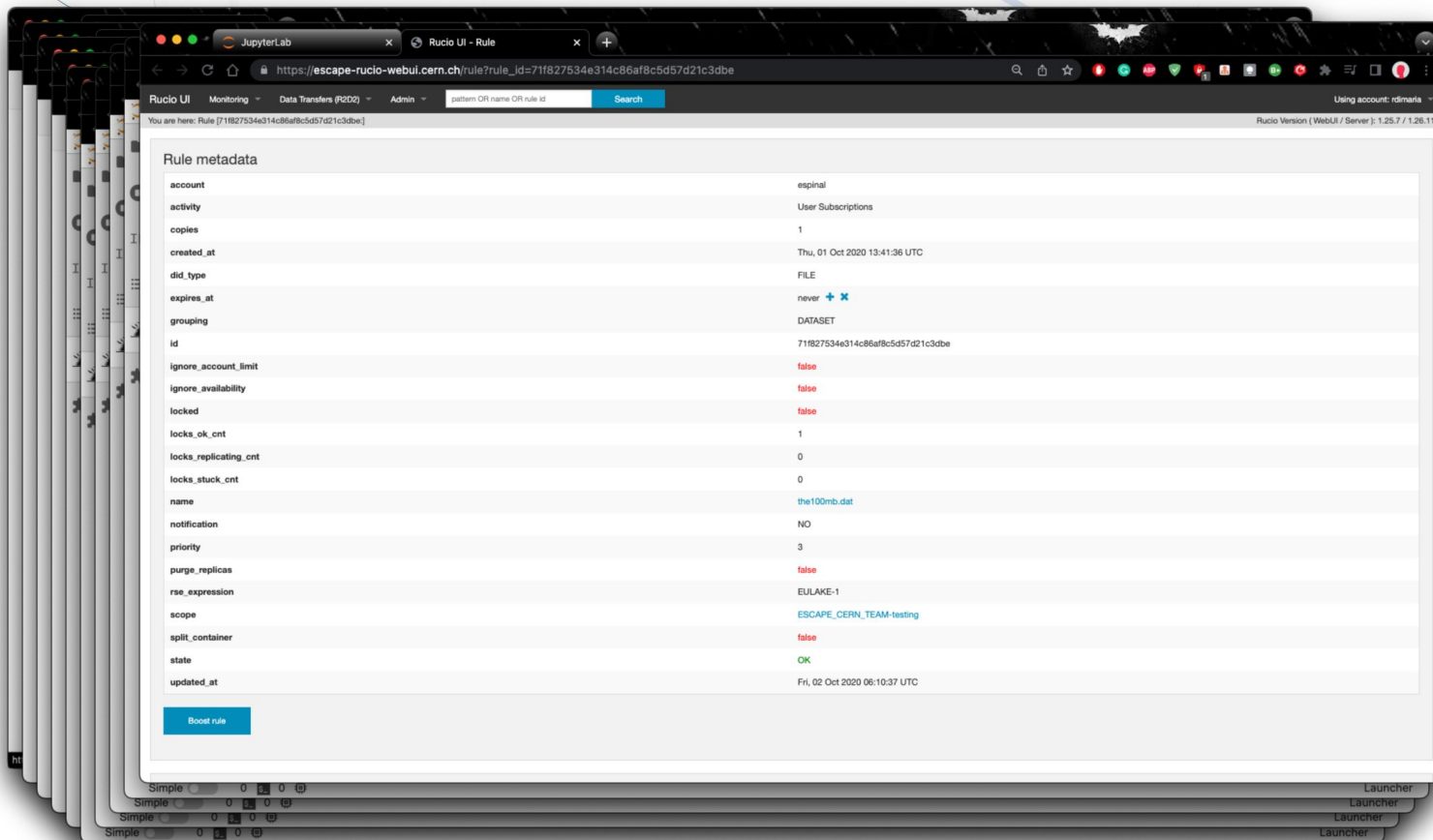


The screenshot shows a JupyterLab interface with a file browser on the left and a launcher on the right. The file browser displays a list of files under the 'ESCAPE_CERN_TEAM-testing:' prefix. The file 'ESCAPE_CERN_TEAM-testing:the100mb.dat' is highlighted with a red circle and has a green checkmark and the word 'Available' next to it. The launcher on the right offers options for Notebook (Python 3, ROOT C++), Console (Python 3, ROOT C++), and Other (Terminal, Text File, Markdown File, Show Contextual Help).

File Name	Size	Status
ESCAPE_CERN_TEAM-testing:261038		
ESCAPE_CERN_TEAM-testing:group	1.27KiB	
ESCAPE_CERN_TEAM-testing:kk	15B	Not Available
ESCAPE_CERN_TEAM-testing:kk1		
ESCAPE_CERN_TEAM-testing:kk2	5B	
ESCAPE_CERN_TEAM-testing:kk3	12B	
ESCAPE_CERN_TEAM-testing:the100mb.dat	102.4MiB	Available
ESCAPE_CERN_TEAM-testing:thesmall-05102020-1.dat	1MiB	
ESCAPE_CERN_TEAM-testing:thesmall-2-07102020.dat	1MiB	
ESCAPE_CERN_TEAM-testing:thesmall-2.dat	1MiB	
ESCAPE_CERN_TEAM-testing:thesmall-3.dat	1MiB	
ESCAPE_CERN_TEAM-testing:thesmall-4.dat	1MiB	
ESCAPE_CERN_TEAM-testing:thesmall-5.dat	1MiB	
ESCAPE_CERN_TEAM-testing:thesmall-66.dat	1MiB	



Redirection to ESCAPE Rucio WebUI



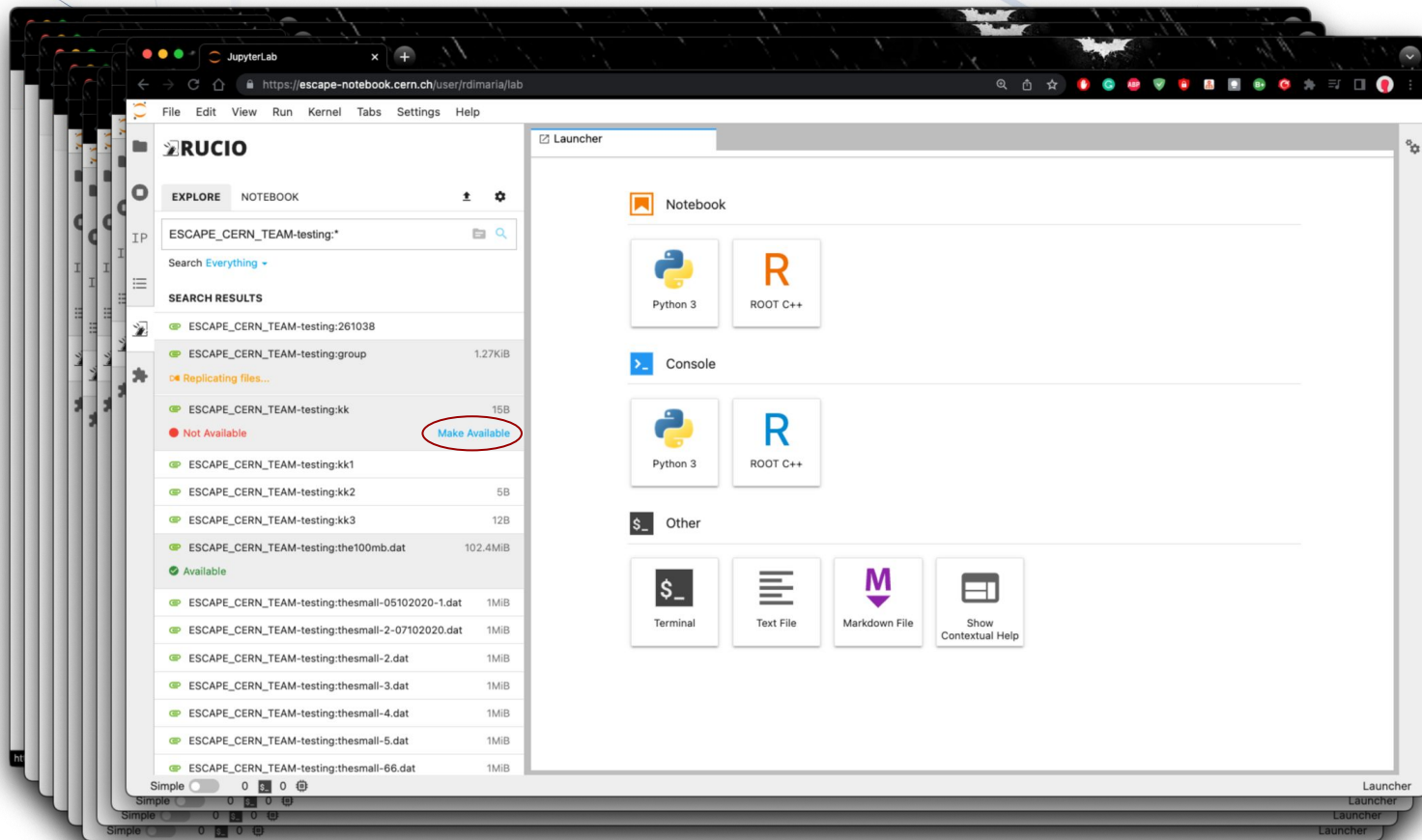
The screenshot shows the Rucio UI interface in a browser window. The URL is `https://escape-rucio-webui.cern.ch/rule?rule_id=71f827534e314c86af8c5d57d21c3dbe`. The page title is 'Rucio UI - Rule'. The main content area displays 'Rule metadata' for a specific rule. The metadata is presented as a table with various attributes and their values.

Attribute	Value
account	espinal
activity	User Subscriptions
copies	1
created_at	Thu, 01 Oct 2020 13:41:36 UTC
did_type	FILE
expires_at	never + ✕
grouping	DATASET
id	71f827534e314c86af8c5d57d21c3dbe
ignore_account_limit	false
ignore_availability	false
locked	false
locks_ok_cnt	1
locks_replicating_cnt	0
locks_stuck_cnt	0
name	the100mb.dat
notification	NO
priority	3
purge_replicas	false
rse_expression	EULAKE-1
scope	ESCAPE_CERN_TEAM-testing
split_container	false
state	OK
updated_at	Fri, 02 Oct 2020 06:10:37 UTC

At the bottom of the metadata table, there is a blue button labeled 'Boost rule'.



Make Data Available “Locally”



The screenshot shows a JupyterLab interface with a file browser on the left and a launcher on the right. The file browser displays a list of files under the 'ESCAPE_CERN_TEAM-testing:' directory. One file, 'ESCAPE_CERN_TEAM-testing:kk', is marked as 'Not Available' and has a red 'Make Available' button next to it, which is circled in red. The launcher on the right shows options for Notebook (Python 3, ROOT C++), Console (Python 3, ROOT C++), and Other (Terminal, Text File, Markdown File, Show Contextual Help).

Extension used in Replica Mode, i.e. TPC.

Make Available aka creating a replication rule (lifetime configurable - 7d) to move files to EULAKE-1 (read-only).

Once replication status is OK, extension translates PFN into local path.

EULAKE-1 is a design choice as RSE and server are co-located → FUSE mount. Files accessible as if they were local.

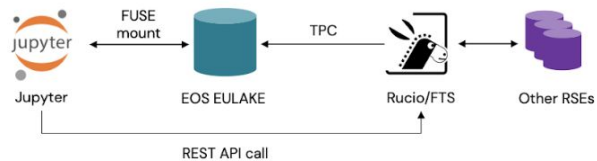


Make Data Available “Locally”

→ Make Available

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

📁 ATLAS_OD_EDU:data_13TeV_GamGam_2020	👁️
📁 ATLAS_OD_EDU:data_8TeV_2016	👁️
🔴 Not available	👉 Make Available
📄 ATLAS_OD_EDU:data_A.1largeRjet1lep.root 7.74MiB	
📄 ATLAS_OD_EDU:data_A.1lep.root 1.47GiB	



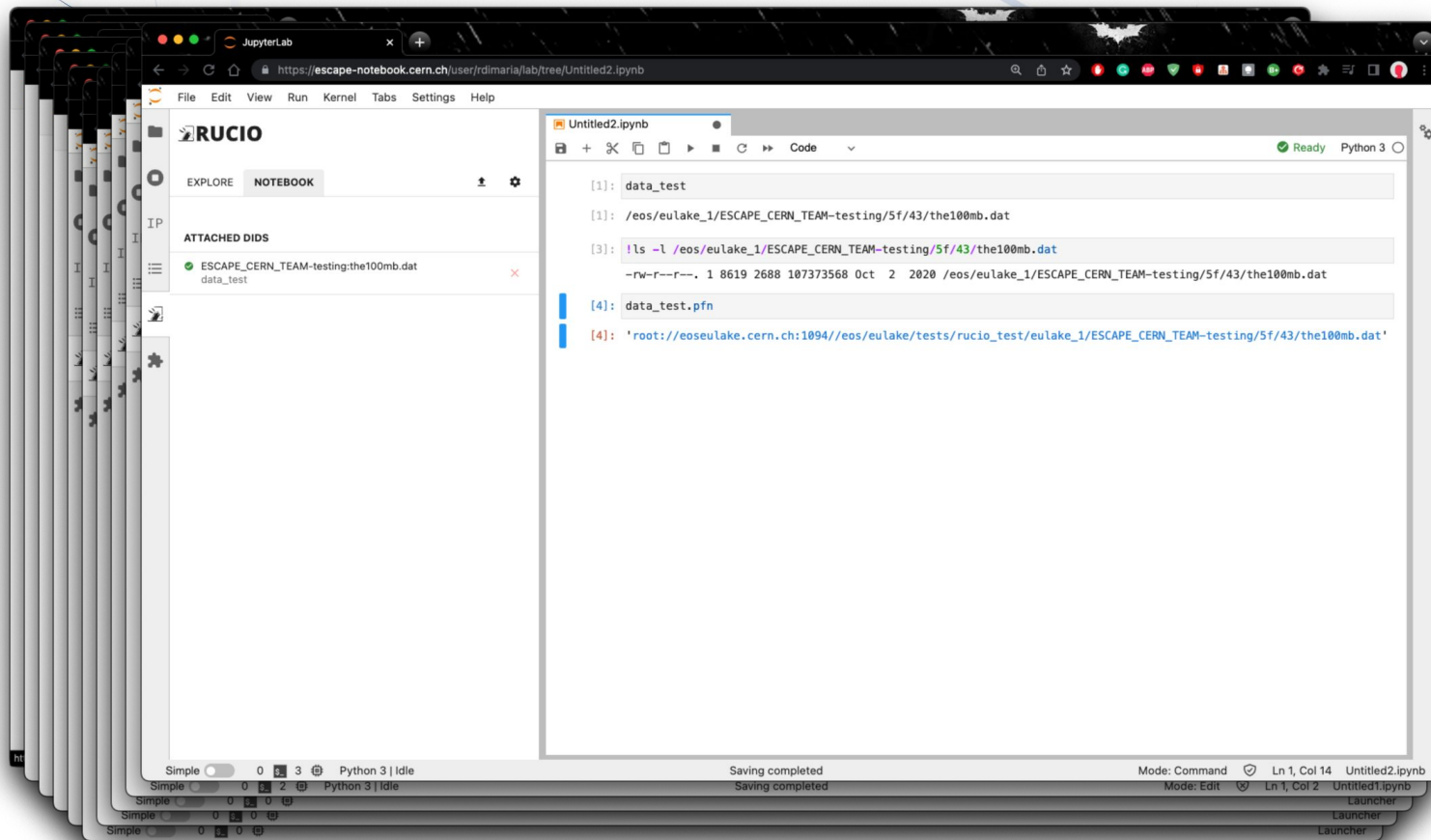
Add Data to Notebook

The screenshot shows a JupyterLab interface with a file browser on the left and a code editor on the right. The file browser displays a list of files from the ESCAPE_CERN_TEAM-testing directory. The file 'ESCAPE_CERN_TEAM-testing:the100mb.dat' is selected, and a context menu is open with the 'Add to Notebook' option highlighted in red. The code editor on the right is empty and shows a Python 3 environment.

File Name	Size
ESCAPE_CERN_TEAM-testing:261038	
ESCAPE_CERN_TEAM-testing:group	1.27KiB
ESCAPE_CERN_TEAM-testing:kk	15B
ESCAPE_CERN_TEAM-testing:kk1	
ESCAPE_CERN_TEAM-testing:kk2	5B
ESCAPE_CERN_TEAM-testing:kk3	12B
ESCAPE_CERN_TEAM-testing:the100mb.dat	102.4MiB
Available	
ESCAPE_CERN_TEAM-testing:thes data_test	
ESCAPE_CERN_TEAM-testing:thes	Press Enter to proceed, Esc to cancel
ESCAPE_CERN_TEAM-testing:thesmall-2.dat	1MiB
ESCAPE_CERN_TEAM-testing:thesmall-3.dat	1MiB
ESCAPE_CERN_TEAM-testing:thesmall-4.dat	1MiB
ESCAPE_CERN_TEAM-testing:thesmall-5.dat	1MiB
ESCAPE_CERN_TEAM-testing:thesmall-66.dat	1MiB
ESCAPE_CERN_TEAM-testing:thesmall.dat	1MiB
ESCAPE_CERN_TEAM-testing:ykajdakdaspkkR0K.txt	324.56MiB



Use Data for Analysis



The screenshot shows a JupyterLab interface with a notebook titled 'Untitled2.ipynb'. The notebook contains the following code and output:

```

[1]: data_test
[1]: /eos/eulake_1/ESCAPE_CERN_TEAM-testing/5f/43/the100mb.dat
[3]: !ls -l /eos/eulake_1/ESCAPE_CERN_TEAM-testing/5f/43/the100mb.dat
-rw-r--r--. 1 8619 2688 107373568 Oct  2  2020 /eos/eulake_1/ESCAPE_CERN_TEAM-testing/5f/43/the100mb.dat
[4]: data_test.pfn
[4]: 'root://eoselake.cern.ch:1094/eos/eulake/tests/rucio_test/eulake_1/ESCAPE_CERN_TEAM-testing/5f/43/the100mb.dat'
  
```

The interface also shows a sidebar with 'RUCIO' and 'ATTACHED DIDS' sections, and a bottom status bar with 'Simple' mode and 'Python 3 | Idle'.

.pfn feature allows distributed analysis, retrieving the file location from within the Notebook session.



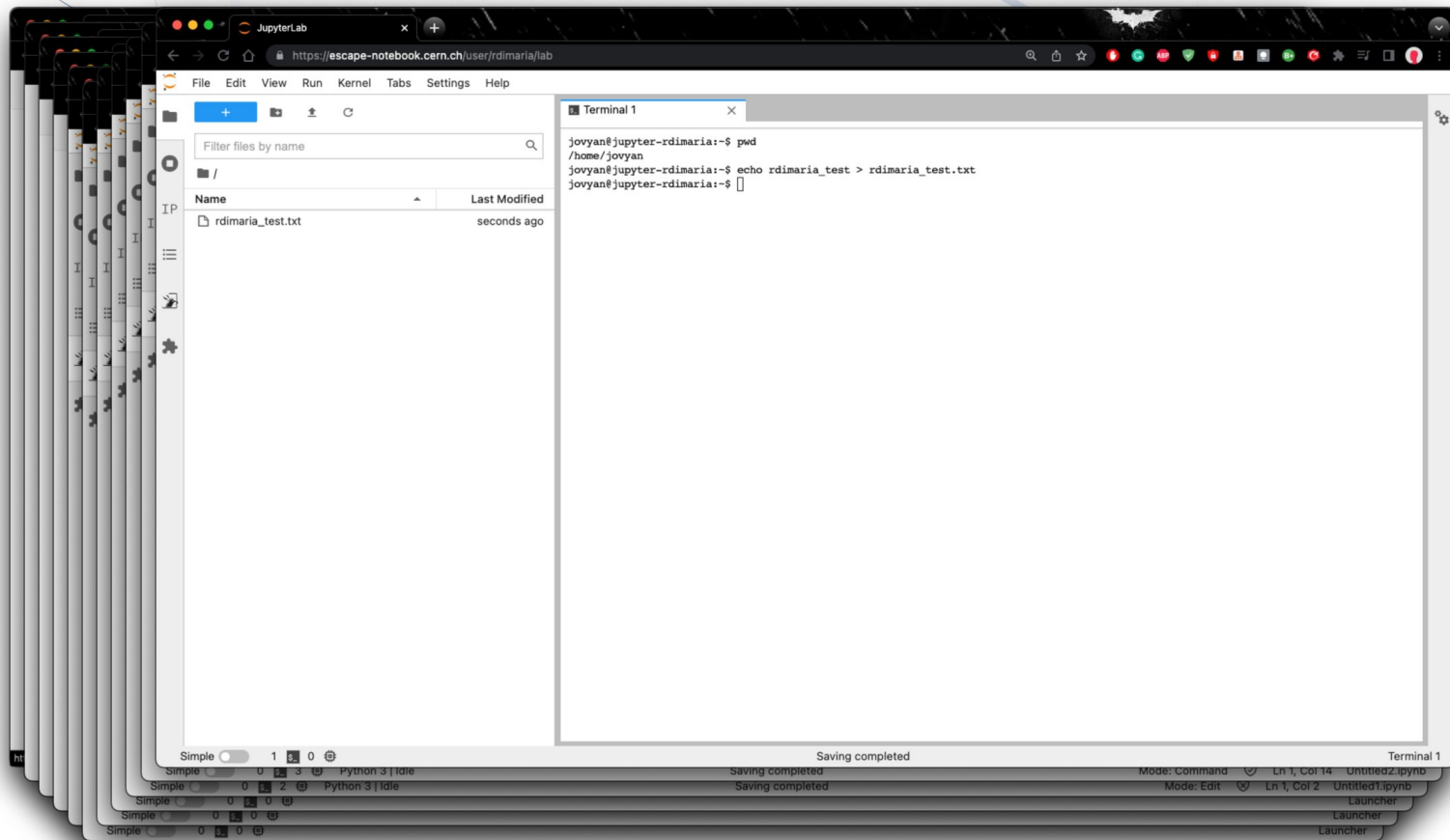
DataLake-as-a-Service for Open Science

→ Scientists' Analysis Workflows Read Data

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



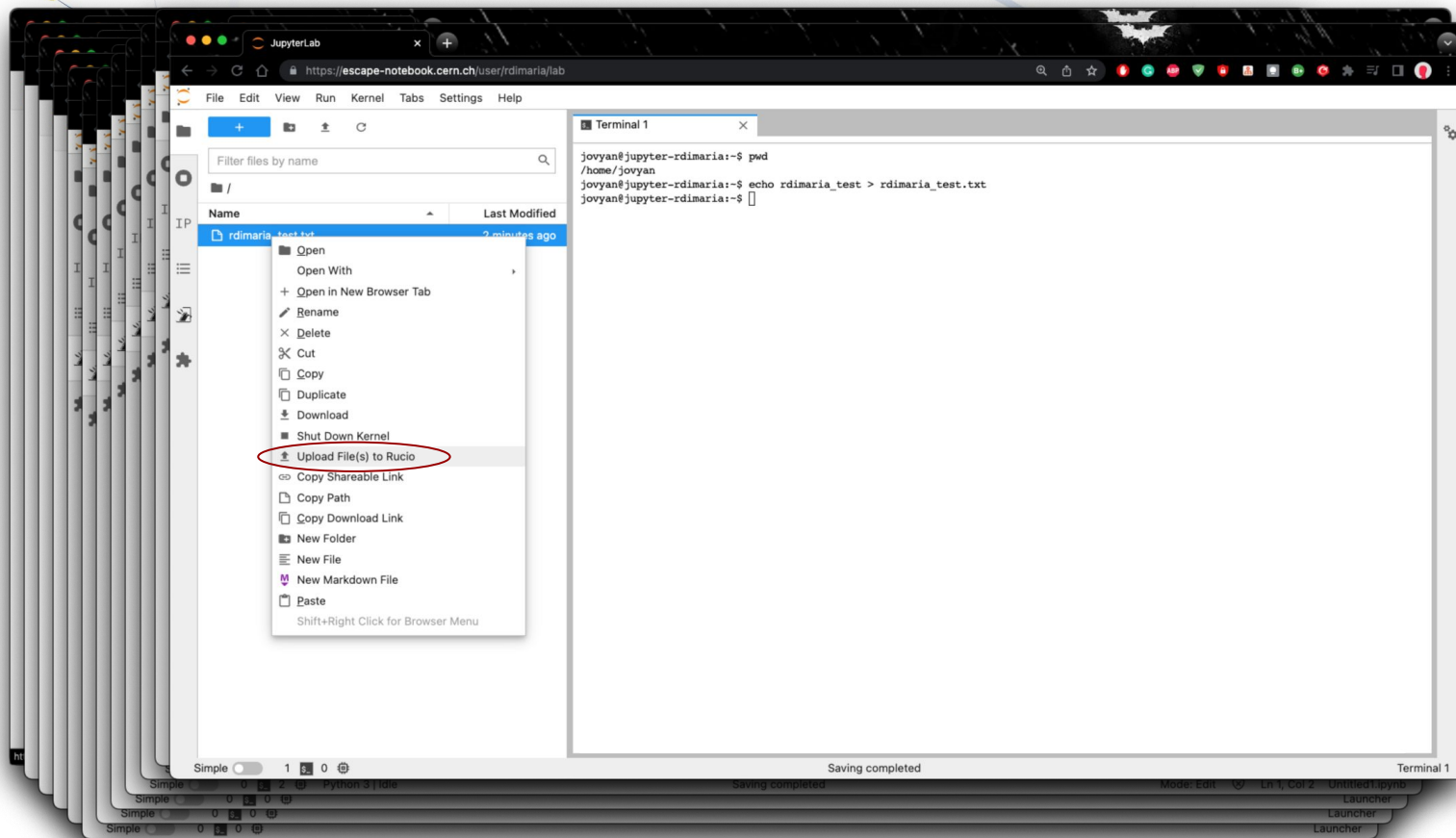
Output of Analysis (Small-Sized Files)



Small-sized files are automatically stored in the common volume (homedir decoupled, space shared).



Data Preservation Use Case



Data Preservation Use Case

The screenshot shows a JupyterLab environment with a terminal window and a RUCIO upload dialog box. The terminal window displays the following commands and output:

```

jovyan@jupyter-rdimaria:~$ pwd
/home/jovyan
jovyan@jupyter-rdimaria:~$ echo rdimaria_test > rdimaria_test.txt
jovyan@jupyter-rdimaria:~$
  
```

The RUCIO dialog box is titled "Upload rdimaria_test.txt to Rucio" and contains the following information:

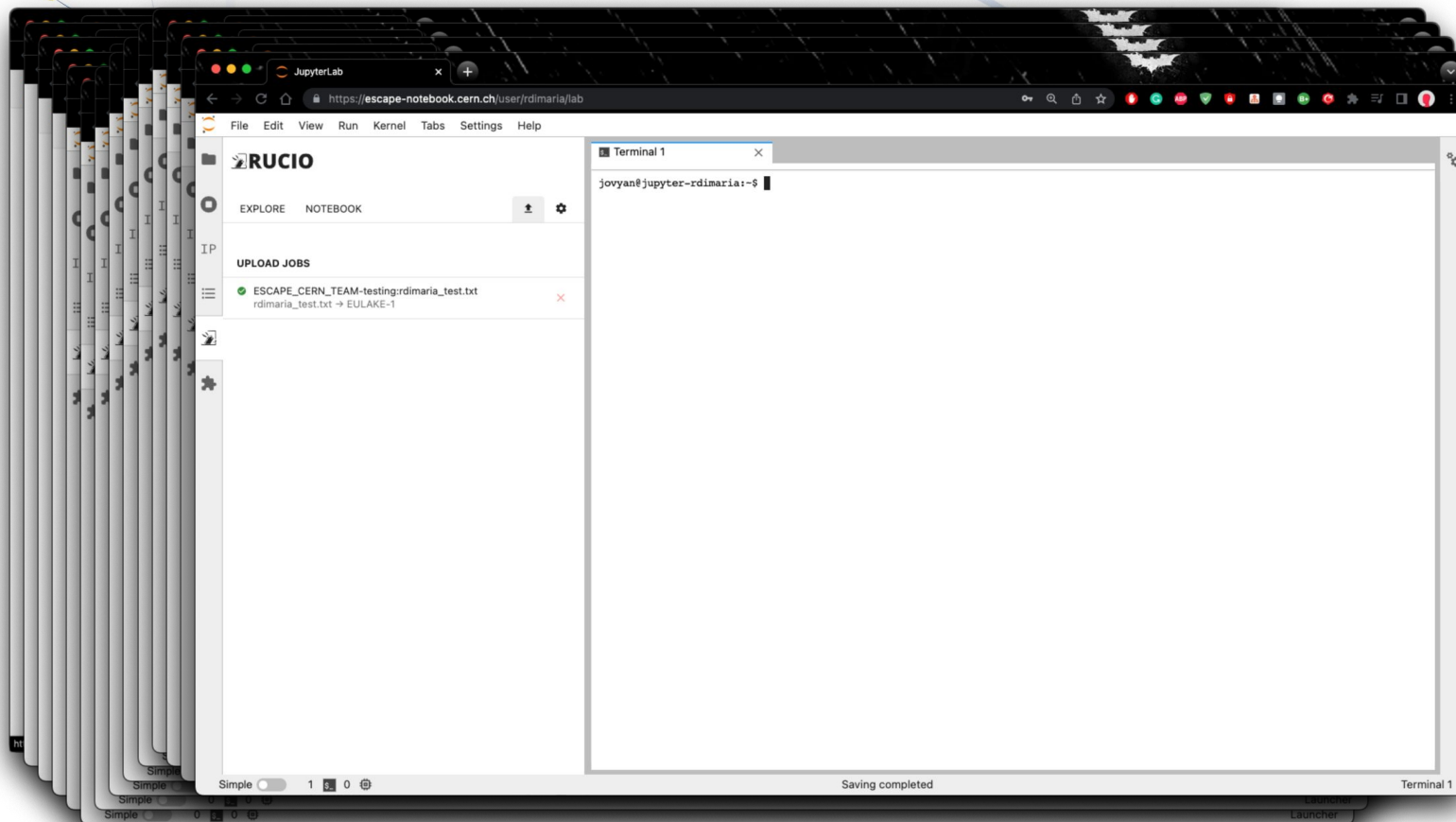
- Warning:** You are not using X509 as the authentication method, upload may fail if the destination RSE does not support your authentication method.
- Destination RSE:** EULAKE-1
- Lifetime (in seconds):** Leave empty for indefinite
- Scope:** ESCAPE_CERN_TEAM-testing
- Add files to a dataset
- Buttons:** Cancel, Upload

RSE should be compliant with the provided token, and end2end token flow should be properly tested.

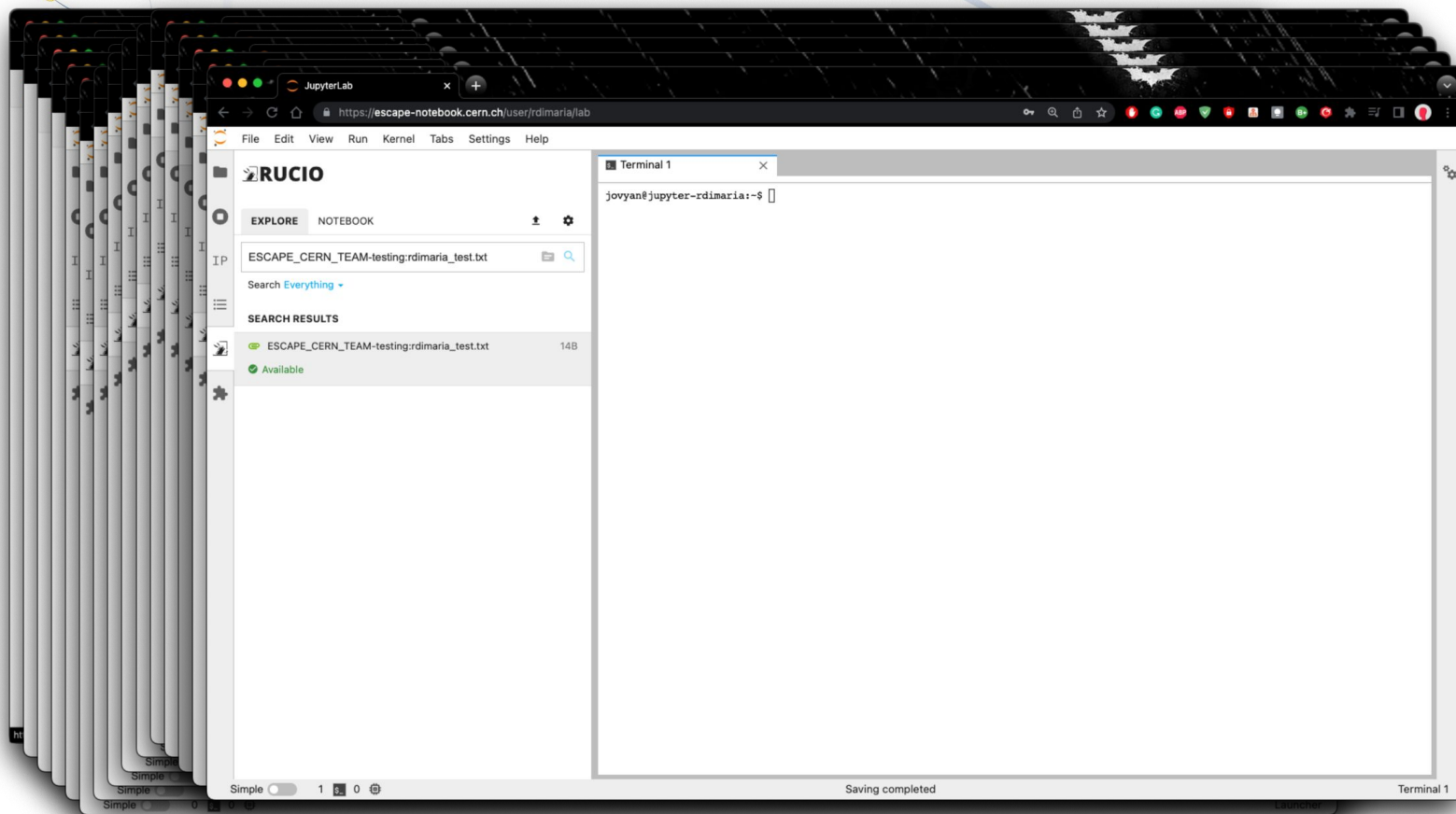
For direct upload/download, X509 is the solution till dev work is performed in this respect.



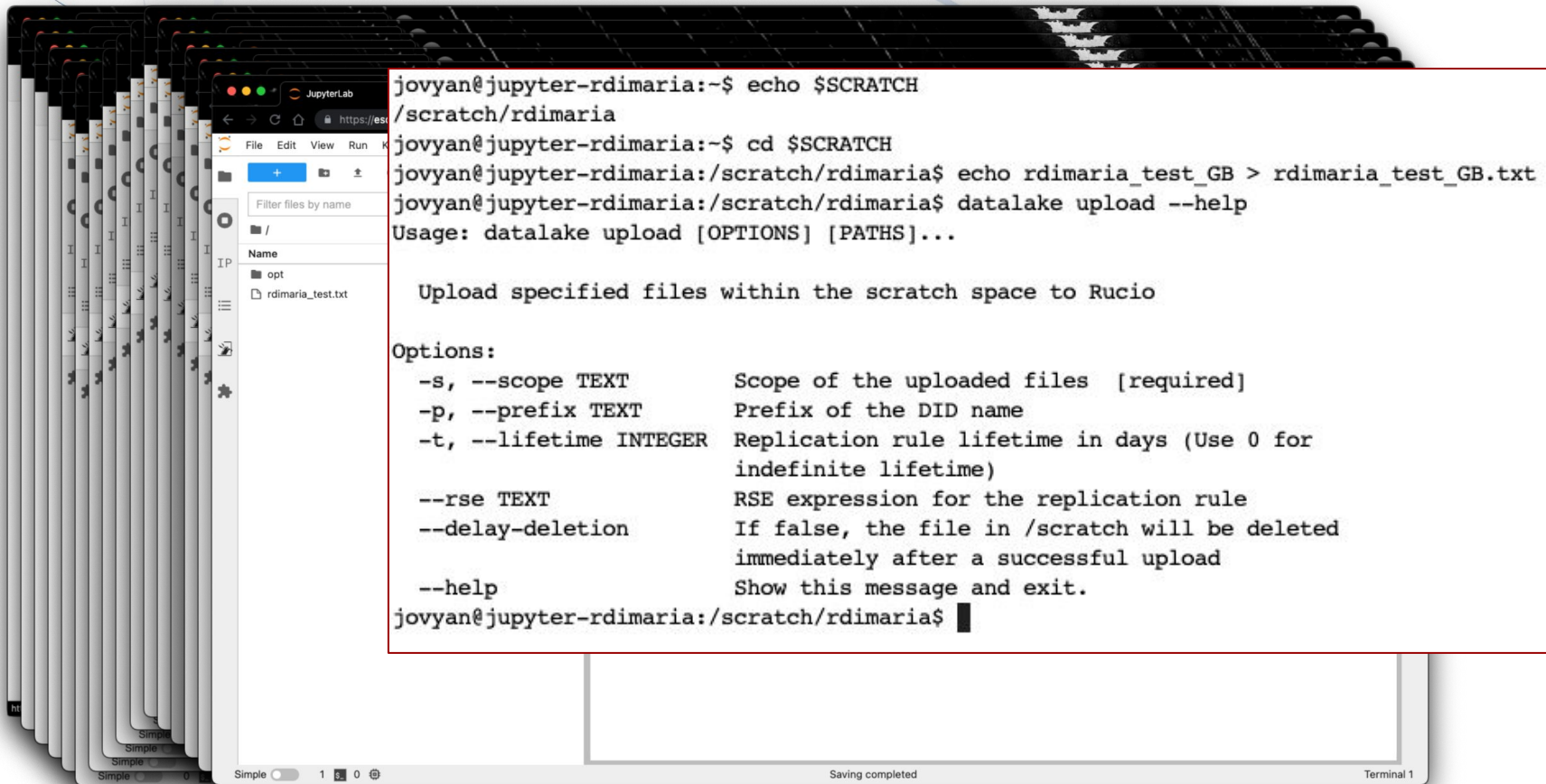
Data Preservation Use Case



Data Preservation Use Case



Output of Workflow or Analysis (Large-Sized Files)



```

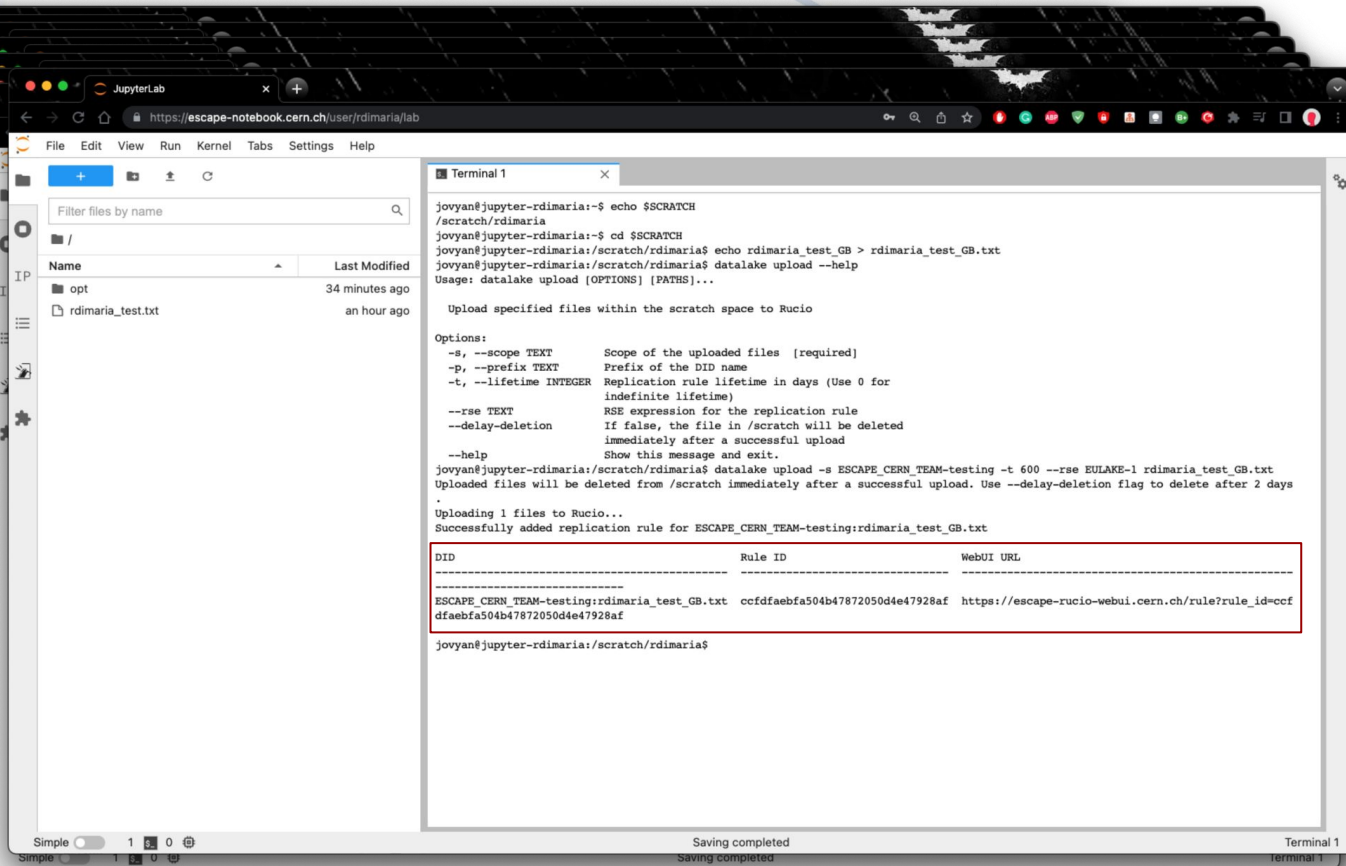
jovyan@jupyter-rdimaria:~$ echo $$SCRATCH
/scratch/rdimaria
jovyan@jupyter-rdimaria:~$ cd $$SCRATCH
jovyan@jupyter-rdimaria:/scratch/rdimaria$ echo rdimaria_test_GB > rdimaria_test_GB.txt
jovyan@jupyter-rdimaria:/scratch/rdimaria$ datalake upload --help
Usage: datalake upload [OPTIONS] [PATHS]...

Upload specified files within the scratch space to Rucio

Options:
-s, --scope TEXT           Scope of the uploaded files [required]
-p, --prefix TEXT         Prefix of the DID name
-t, --lifetime INTEGER    Replication rule lifetime in days (Use 0 for
                           indefinite lifetime)
--rse TEXT                 RSE expression for the replication rule
--delay-deletion           If false, the file in /scratch will be deleted
                           immediately after a successful upload
--help                    Show this message and exit.
jovyan@jupyter-rdimaria:/scratch/rdimaria$
  
```



Data Preparation and Processing Use Case



```

jovyan@jupyter-rdimaria:~$ echo $SCRATCH
/scratch/rdimaria
jovyan@jupyter-rdimaria:~$ cd $SCRATCH
jovyan@jupyter-rdimaria:/scratch/rdimaria$ echo rdimaria_test_GB > rdimaria_test_GB.txt
jovyan@jupyter-rdimaria:/scratch/rdimaria$ datalake upload --help
Usage: datalake upload [OPTIONS] [PATHS]...

Upload specified files within the scratch space to Rucio

Options:
  -s, --scope TEXT      Scope of the uploaded files (required)
  -p, --prefix TEXT     Prefix of the DID name
  -t, --lifetime INTEGER Replication rule lifetime in days (Use 0 for
                        Indefinite lifetime)
  --rse TEXT            RSE expression for the replication rule
  --delay-deletion      If false, the file in /scratch will be deleted
                        immediately after a successful upload
  --help               Show this message and exit.
jovyan@jupyter-rdimaria:/scratch/rdimaria$ datalake upload -s ESCAPE_CERN_TEAM-testing -t 600 --rse EULAKE-1 rdimaria_test_GB.txt
Uploaded files will be deleted from /scratch immediately after a successful upload. Use --delay-deletion flag to delete after 2 days
.
Uploading 1 files to Rucio...
Successfully added replication rule for ESCAPE_CERN_TEAM-testing:rdimaria_test_GB.txt

-----
DID                               Rule ID                               WebUI URL
-----
ESCAPE_CERN_TEAM-testing:rdimaria_test_GB.txt  ccfdfaebfa504b47872050d4e47928af  https://escape-rucio-webui.cern.ch/rule?rule_id=ccfdfaebfa504b47872050d4e47928af
-----

jovyan@jupyter-rdimaria:/scratch/rdimaria$
  
```

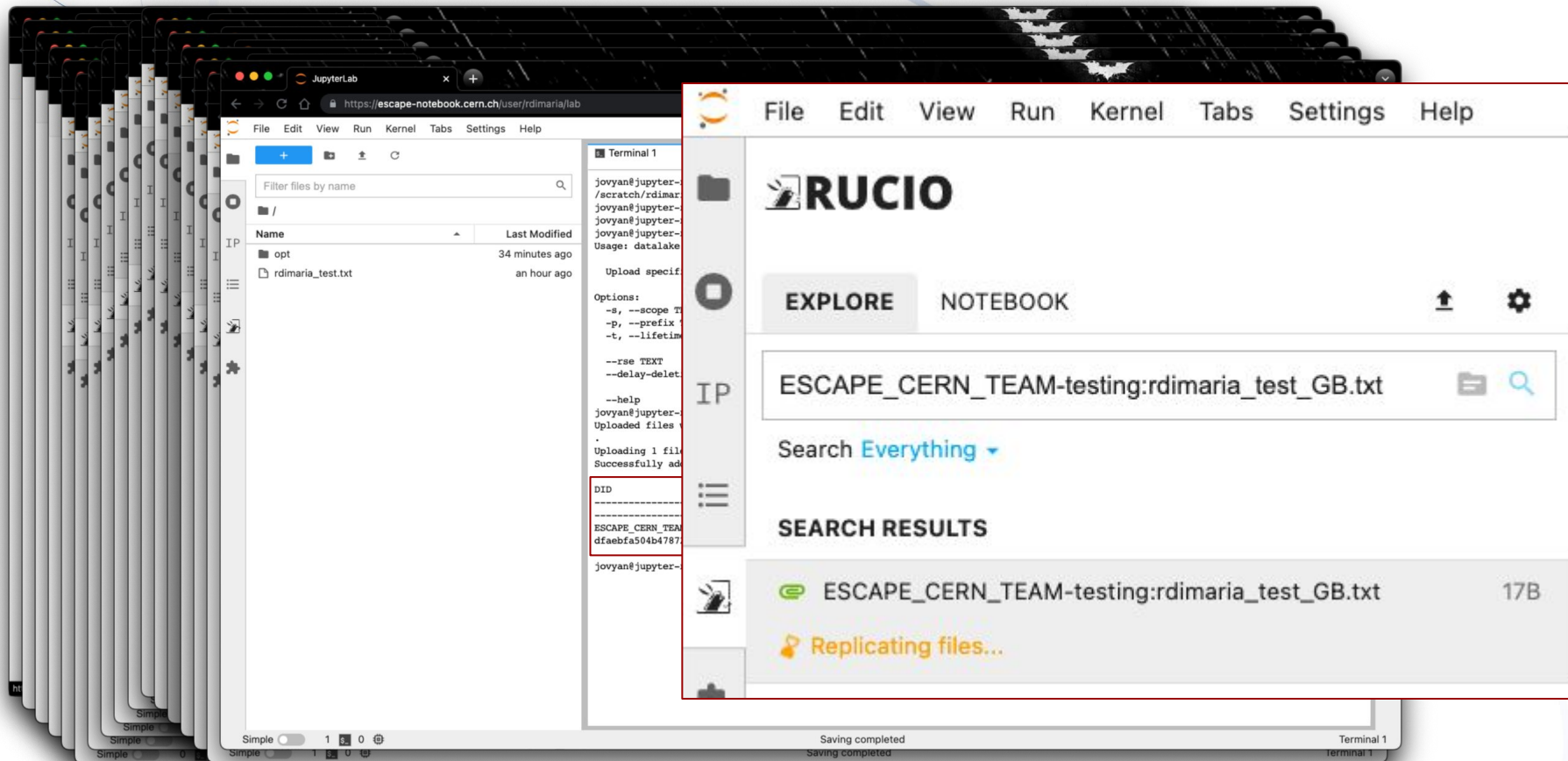
datalake upload translates local path to PFN, the file is added to Rucio replica catalogue, and a replication rule is created.

When the replication status is OK, Rucio deletes files from SCRATCH.

Cron job cleans old files and folders that might not be in the Rucio catalogue.



Data Preparation and Processing Use Case



The screenshot displays a JupyterLab environment with a file browser on the left and a terminal on the right. The terminal shows the execution of the `rucio upload` command to upload a file named `rdimaria_test.txt`. The output indicates that the file was successfully uploaded and is now being replicated by RUCIO.

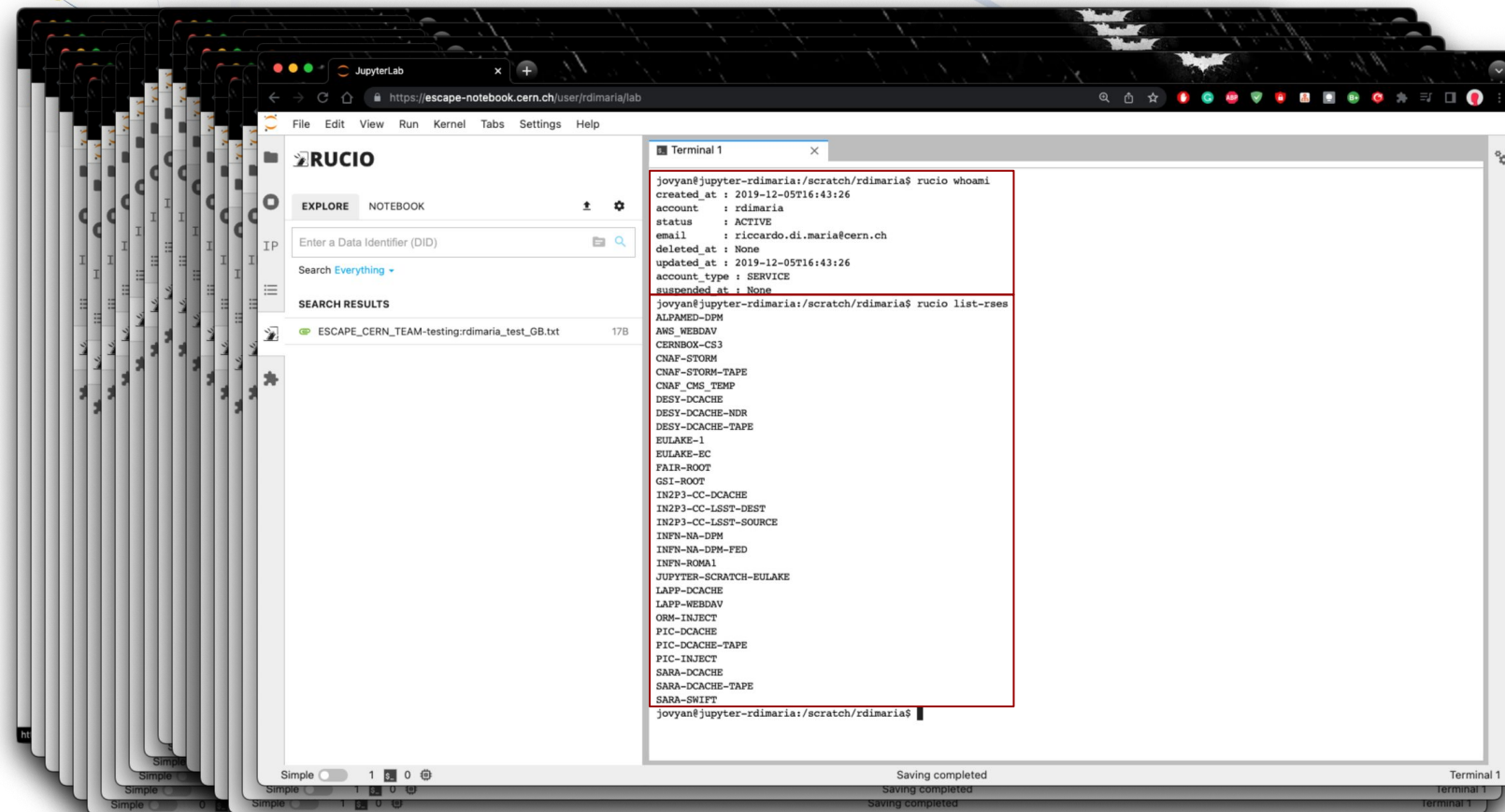
The RUCIO interface on the right shows the search results for the file `ESCAPE_CERN_TEAM-testing:rdimaria_test_GB.txt`. The search results table is as follows:

File Name	Size
ESCAPE_CERN_TEAM-testing:rdimaria_test_GB.txt	17B

Below the search results, the status `Replicating files...` is displayed.



Rucio CLI Available



The screenshot shows a JupyterLab environment with the Rucio web interface on the left and a terminal window on the right. The terminal displays the following commands and output:

```

jovyan@jupyter-rdmaria:/scratch/rdmaria$ rucio whoami
created_at : 2019-12-05T16:43:26
account    : rdmaria
status     : ACTIVE
email      : riccardo.di.maria@cern.ch
deleted_at : None
updated_at : 2019-12-05T16:43:26
account_type : SERVICE
suspended_at : None

jovyan@jupyter-rdmaria:/scratch/rdmaria$ rucio list-rses
ALPAMED-DPM
AWS_WEBDAV
CERNBOX-CS3
CNAP-STORM
CNAP-STORM-TAPE
CNAP_OPS_TEMP
DESY-DCACHE
DESY-DCACHE-NDR
DESY-DCACHE-TAPE
EULAKE-1
EULAKE-EC
FAIR-ROOT
GSI-ROOT
IN2P3-CC-DCACHE
IN2P3-CC-LSST-DEST
IN2P3-CC-LSST-SOURCE
INFN-NA-DPM
INFN-NA-DPM-FED
INFN-ROMA1
JUPYTER-SCRATCH-EULAKE
LAPP-DCACHE
LAPP-WEBDAV
ORM-INJECT
PIC-DCACHE
PIC-DCACHE-TAPE
PIC-INJECT
SARA-DCACHE
SARA-DCACHE-TAPE
SARA-SWIFT
jovyan@jupyter-rdmaria:/scratch/rdmaria$
  
```

Rucio CLI available from Notebook terminal and already configured to connect to the ESCAPE Data Lake.

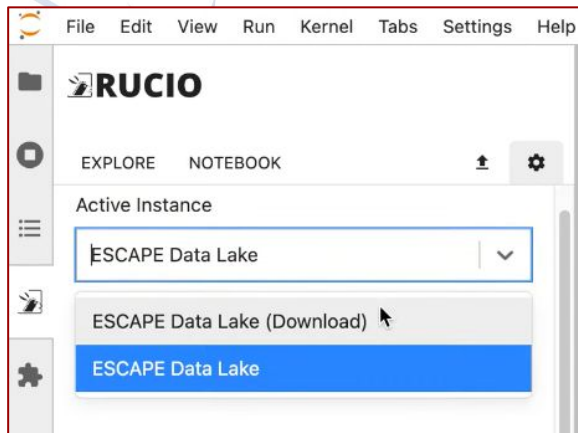
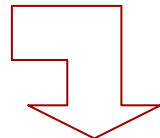


XCACHE Integration

Server Options

- Minimal environment
Based on jupyter/scipy-notebook
- ROOT environment
If you need to use PyROOT
- ROOT environment (Xcache testing)
Run the extension in Download mode

Start

```

jovyan@jupyter-muhilmy:/scratch/muhilmy$ rucio list-file-replicas ATLAS_LAPP_JEZEQUEL:data.root --protocol root
+-----+-----+-----+-----+-----+
| SCOPE          | NAME          | FILESIZE | ADLER32 | RSE: REPLICA |
+-----+-----+-----+-----+-----+
| ATLAS_LAPP_JEZEQUEL | data.root | 4.660 kB | ef084c63 | EULAKE-1: root://xcache-redirector.cern.ch//root://eoseulake.cern.ch:1094//eos/eulake/tests/rucio_test/eulake_1/ATLAS_LAPP_JEZEQUEL/bd/8f/data.root |
| ATLAS_LAPP_JEZEQUEL | data.root | 4.660 kB | ef084c63 | ALPAMED-DPM: root://xcache-redirector.cern.ch//root://lapp-testse01.in2p3.fr/home/escape/rucio/lapp_dpm/ATLAS_LAPP_JEZEQUEL/bd/8f/data.root |
+-----+-----+-----+-----+-----+
  
```



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



Future Developments

- Additional kernel compatibility (currently, only Python supported)
- Token-support for direct download and upload → OIDC integration ongoing at storage level
- Integration with content delivery and caching layer (successfully tested only at small scale)
 - XCache can be integrated to allow faster file download → transparent for the end-user
- Multi-VO or off-site (CERN) deployment, and distribution model for sciences
- **DLaaS** interesting for both **aficionados** and **newcomers** of **Rucio**
 - community-driven “development and operation”
 - needs and requirements of different experiments and sciences
 - addressing long term sustainability beyond ESCAPE mandate
 - ongoing proposal to establish a **Special Interest Group**



Conclusion and Next Steps

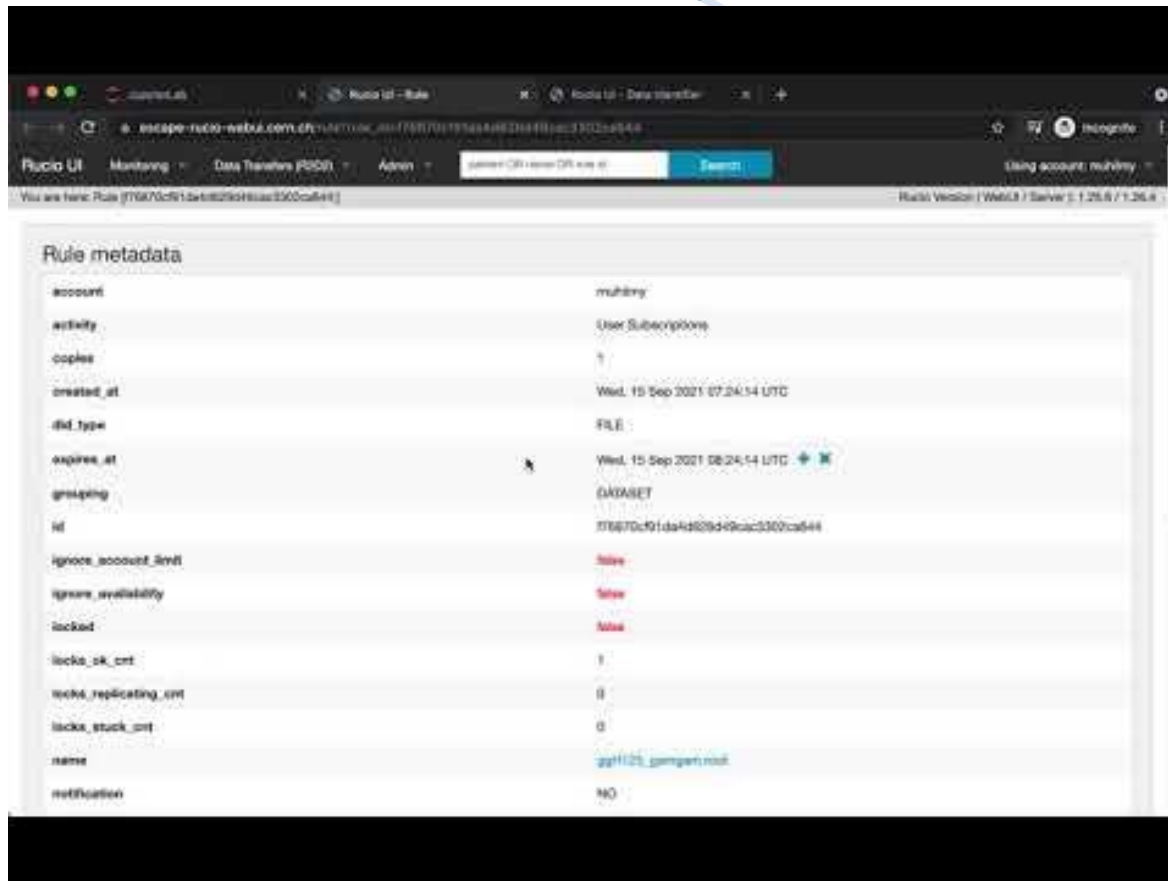
- **DLaaS** hides the complexities of the Data Lake from the end users (so that they are happy and productive!)
 - interesting for both **aficionados** and **newcomers** of **Rucio**
 - community-driven development, hence driven by the needs of different experiments and sciences
- ESCAPE managed to pilot and prototype a Data Lake infrastructure fulfilling functional data management needs of flagship ESFRIs from several scientific disciplines
 - sensible technologies choice from WLCG environment and LHC experiments
 - successful assessments of the Data Lake in 2020 and 2021
 - 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
 - exploring non-HEP-standard scenarios and collaboration with other communities, e.g. PaNOSC, ExPaNDS, CS3MESH4EOSC
- ESCAPE end in 2022 → addressing long term sustainability



Backup Slides



DataLake-as-a-Service for Open Science

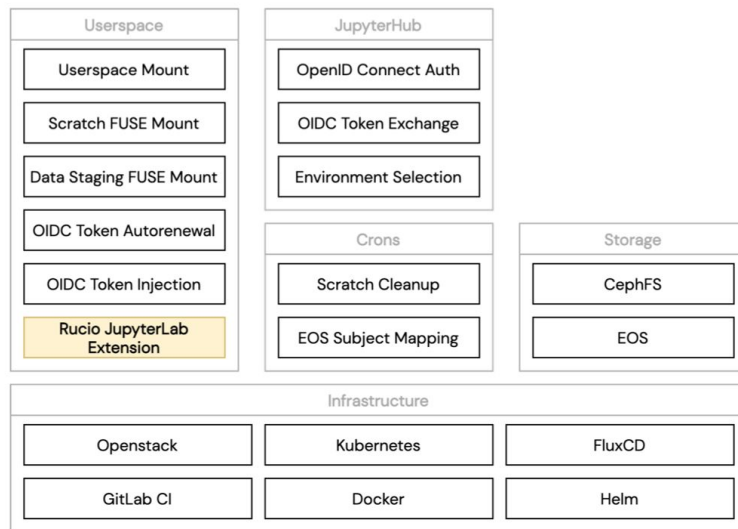


The screenshot shows the Rucio UI interface. At the top, there's a navigation bar with 'Rucio UI', 'Monitoring', 'Data Transfers (PDS)', and 'Admin'. A search bar contains 'pamela@cern.ch:rule'. The main content area is titled 'Rule metadata' and displays a table of rule properties.

Property	Value
account	ruhlfing
activity	User Subscriptions
copies	1
created_at	Wed, 15 Sep 2021 07:24:14 UTC
file_type	FILE
expires_at	Wed, 15 Sep 2021 08:24:14 UTC
grouping	DATASET
id	776670c101da4d829d49cac3301ca644
ignore_account_limit	false
ignore_availability	false
locked	True
locks_ok_cnt	1
locks_replicating_cnt	0
locks_stuck_cnt	0
name	gg/HISL_gangari/rucl
notification	NO

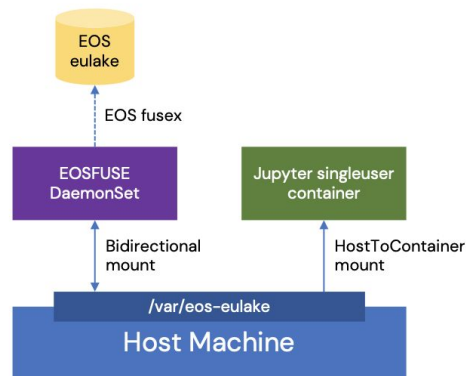


The Data Lake as a Service



FUSE mount to EOS eulake

- There are two FUSE mounts to the same EOS instance:
 - `/eos/eulake_1` → `/eos/eulake/tests/rucio_test/eulake_1`
 - `/scratch` → `/eos/eulake/tests/jupyter-scratch`
- FUSE mount is implemented using k8s DaemonSet, mounting to a folder in the host, with Bidirectional mount propagation
- Singleuser containers bind to the mount folder, with HostToContainer mount propagation
- Uses OAuth2 authentication
 - ESCAPE IAM user is mapped to EOS user using crons



OAuth2 in EOS FUSE mount

- In the singleuser container:
 - JWT is stored in a file in the following format:
 - `oauth2:<jwt>:<token-introspection-endpoint>`
 - Example: `oauth2:eyJ...:iam-escape.cloud.cnaf.infn.it/userinfo`
 - Note: token introspection endpoint doesn't have the "https://" part
 - The token file must have at most 0600 permission
 - An environment variable needs to be set:
 - `OAuth2_TOKEN=FILE:/path/to/token/file`
- In the EOSFUSE DaemonSet container:
 - EOS FUSEx daemon (eosxd) needs to be configured for SSS authentication
 - SSS keytab needs to be present

Docs: <https://eos-docs.web.cern.ch/using/oauth2.html>



Singleuser container setup

Some things need to happen:

- OAuth token exchange (eos-eulake and rucio)
 - Uses a modified version of SWAN's KeyCloakAuthenticator
- Enable token autorenewal
 - Uses [swanoauthrenew](#)
- Write token files to /tmp
- Set OAUTH2_TOKEN env for EOS authentication
- Write rucio.cfg file

