OSCARS
Open Science Clusters' Action for Research & Society

ESPPU DM working group tools

DM Summary plots and the Virtual Research Environment

Léo Chazallet, 12th November 2025
LHC BSM Working Group General meeting
Inputs from Giovanni Guerrieri, Caterina Doglioni, Yohei Ema, Maximilian Amerl

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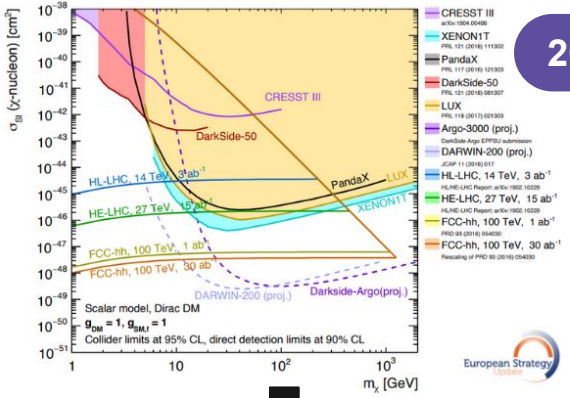
DM Summary Plots reproducibility issue

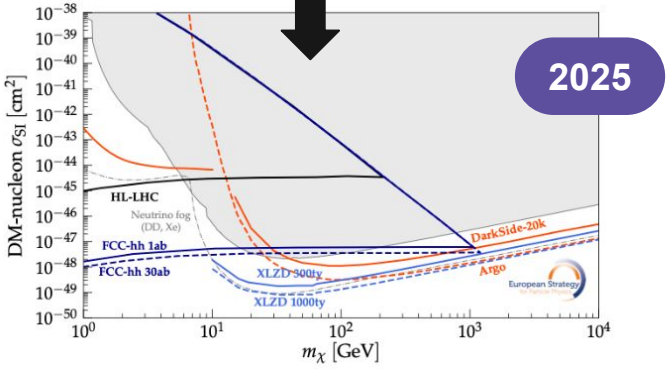
Difficulties with reproducing and updating summary plots from 2019 to 2025 ESPPU:

- **Git** repository to make the final plot available, but **private** (by student who worked on the plots in 2019)
- **Software** to translate HL-LHC results **only shared privately** via e-mail
- **References** on where to find the curves only available in figure caption, and **not descriptive enough** (HL-LHC report: 1418 pages, many plots...)
- **No README** or documentation

→ not an uncommon situation in the sciences



Contains input for



*Portraying the **complementarity of colliders and direct detection** for **heavy dark matter** (s-channel simplified model with scalar mediator, WIMP-like Dirac DM)*

DM Summary Plots reproducibility issue

Think of an optimistic situation: if **one (or more) experiments discover hints of dark matter**, the community will want to **compare** and **scrutinise**:

- Experimental techniques
- Assumptions and uncertainties
- Datasets
- Data analysis software

Our solutions:

- Develop **notebooks** following **code quality** / **FAIR guidelines**
- Execute them on a **dedicated computing cluster** that **helps reproducibility**, the **ESCAPE Virtual Research Environment**
  → more on this in the next slides, and in J. Wurzinger's talk!

Aligns perfectly with the goals of the **OSCARS** project and with the **ESCAPE** Open Collaboration

OSCARS
Open Science Clusters' Action for Research & Society

ESCAPE: The European Science Cluster of Astronomy & Particle Physics ESFRI Research Infrastructures

OSCARS

ESCAPE and related initiatives have supported and **funded services** that are used in HEP and beyond (e.g. **REANA**, **RUCIO/data lake**, **authentication** services, a Zenodo **software catalogue**, the **VRE**, …)

An **open collaboration** that aims to **address the Open Science challenges** shared by **ESFRI facilities** (e.g. HL-LHC) and pan-European **research infrastructures** (e.g. CERN) in astronomy and particle physics

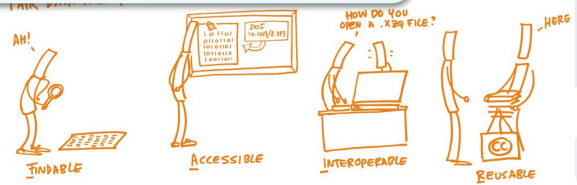
reana

SCIENTIFIC DATA MANAGEMENT
RUCIO

OSCARS, Open Science and FAIR principles

Fostering the uptake of Open Science in Europe

EU grant that aims to enhance adoption of **Open Science** and supporting interdisciplinary **FAIR data services** and **practices**



€ 16 MILLIONS
IN OPEN CALLS FOR
OPEN SCIENCE
PROJECTS AND SERVICES

OBJECTIVES

Setup and implementation of **Clusters' Open Science Competence Centres (CLOCCs)**

Identify and provide **Composable Open Data and Analysis Services (CODAS)**

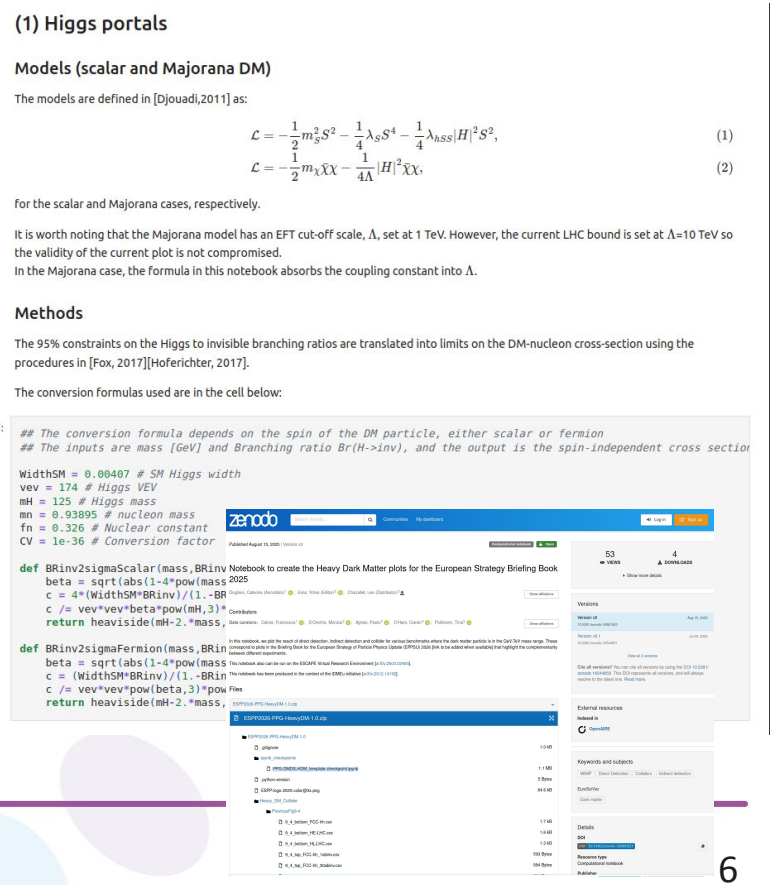
Contribute to a **Data space for science, research and innovation**

Back to summary plots: Jupyter Notebook

The 2025 summary plots are now made using a **Jupyter notebook** with:

- tracking of **imported package** versions (using the uv package manager)
- installation **instructions** and **commented** code blocks
- light-touch **explanations** of model and parameters, with citations
- **Metadata tables** with provenance for the curves (location of digitized curves, citation with figure location)
- An **Open Source license** for conditions of reuse

The notebook is available on **Zenodo:**
DOI 10.5281/zenodo.16544850



This follows many of the guidelines of the ICFA Data Lifecycle Panel and of the EVERSE Project's RSQKit

Where does this Jupyter notebook run?

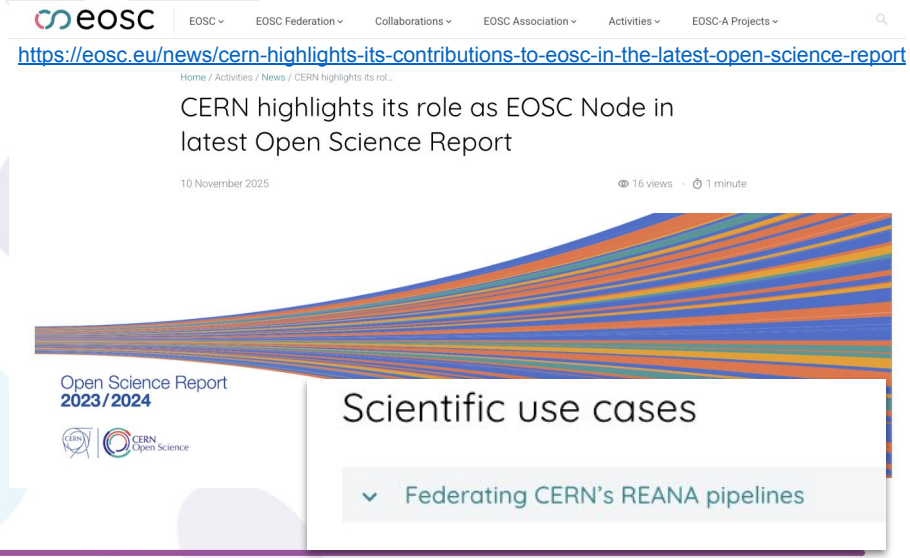
Anyone's laptop! Start from Zenodo 10.5281/zenodo.16544850, install uv, and you're ready to go

But what if I wanted an even **easier** way to **rerun** my workflow (especially applies for more **complex** ones, e.g. full reinterpretation, REANA-based…)

It would be nice to have a platform where *everything is already installed* and I can just *log in and run*!

This is **where the Virtual Research Environment** comes in!

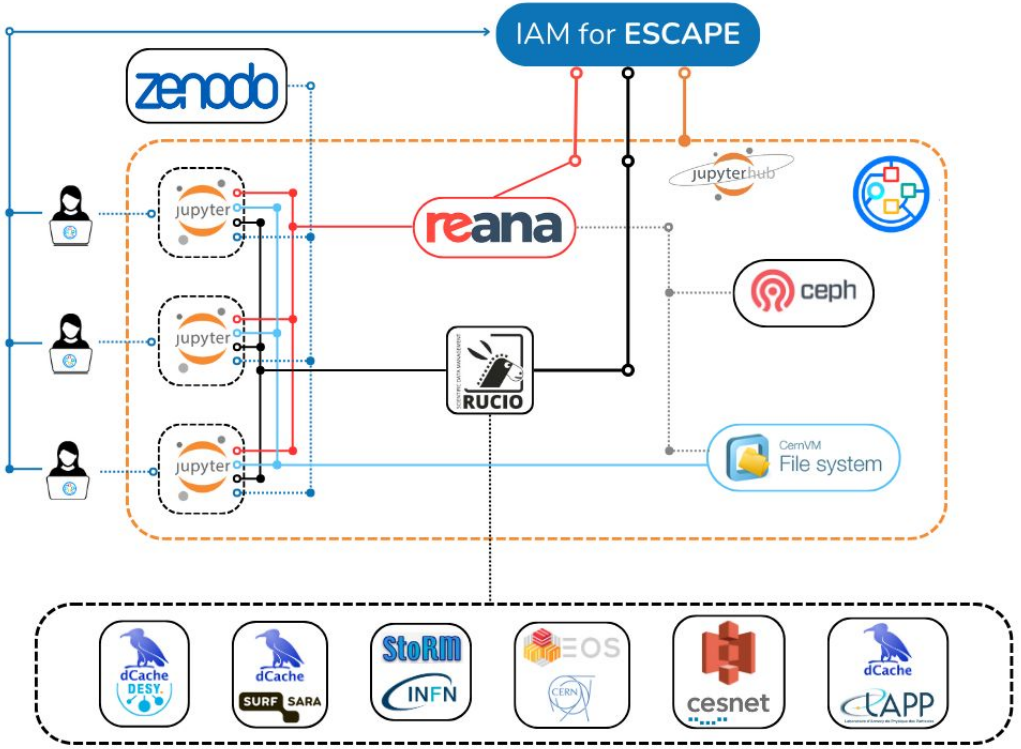
Related: CERN and the European Open Science Cloud (EOSC)



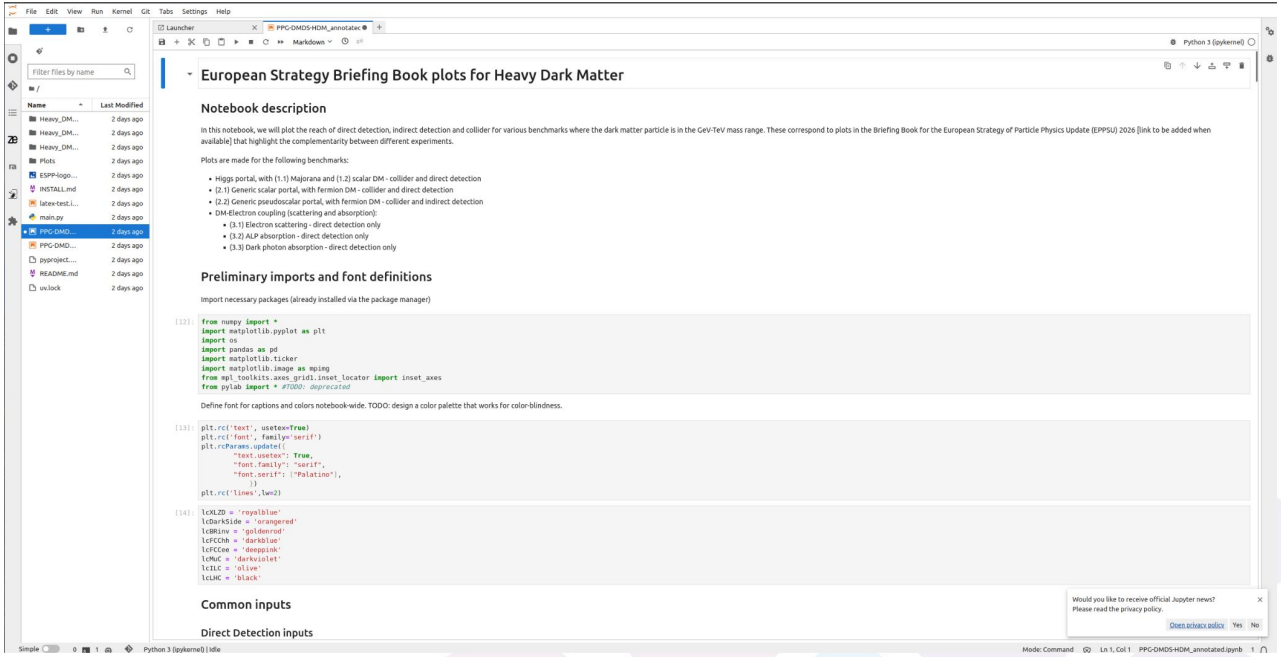
The ESCAPE Virtual Research Environment

OSCARS

1. AAI: A federated and reliable Authentication an Authorization layer for **logging in** and **protectin access** to private data
2. The Rucio Data Lake: A federated distributed storage solution, providing functionalities for **data injection and replication** through a Data Management framework (**Rucio**)
3. REANA: A computing cluster supplying the processing power to **run full analyses** with REANA, a re-analysis service (supports RECAST as well)
4. CVMFS: A read-only file system designed to **distribute software**, and more.
5. JupyterHub: A notebook interface with containerised environments to hide the infrastructure's complexity from the user.



Implementation: LAPP VRE



By executing the notebooks / our workflows on the VRE, we ensure that we have a **suitable computing infrastructure** that others can use

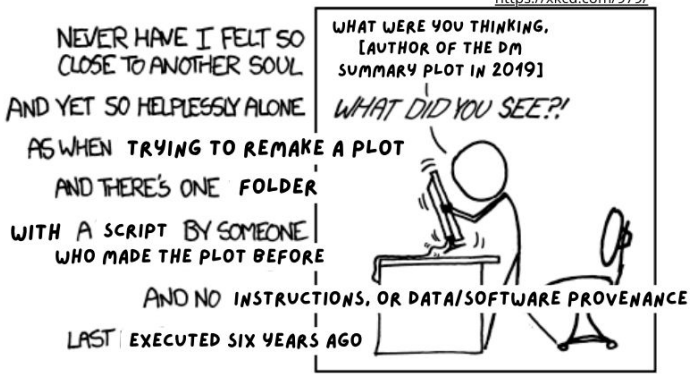
For examples of other workflows (including an ATLAS analysis using RECAST), see the [ESCAPE Dark Matter Science Project]

Conclusions and outlook

Solved the problem of "*not being able to reproduce the European Strategy DM plots*", at least for the next Strategy!

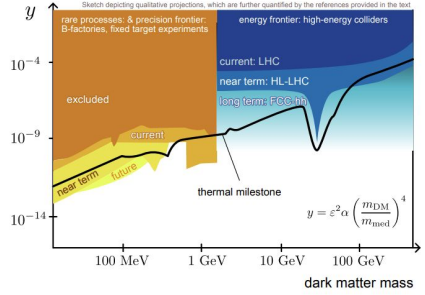
- New plots use a **Jupyter notebook** following FAIR guidelines, on Zenodo
- **Execution** is **enabled** on the ESCAPE Virtual Research Environment (**VRE**)
- The VRE provides an easy-to-use platform for rerunning workflows - and for **reinterpretation**? **TBD**!

https://xkcd.com/979/



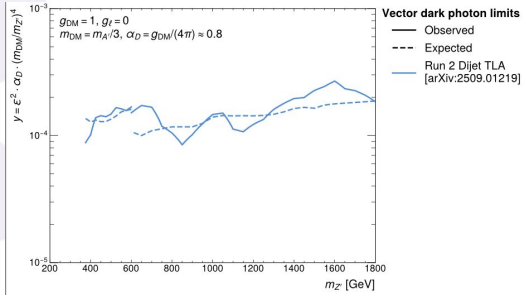
Note: this is even worse when the author of the plot is the same person as the one trying to remake the plot *source: one of the authors of the poster*

Coming soon: other DMWG interpretations (e.g. dark photon)



https://scipost.org/SciPostPhysCommRep.7

https://github.com/mamerl/DMWG-dark-photon-tools, soon to be moved to the DMWG repository after cross-checks



(expert feedback welcome!)

Test rescaling with public Run-2 TLA (dijet scouting) vector mediator results


OSCARS
Thank you

More on Zenodo

Notebooks are available on [Zenodo]

- Open-access research data repository operated by **CERN**
- Supports sharing of **datasets, papers, software, and more**
- Each upload gets a **DOI** for permanent citation
- Promotes **open science** and **data preservation**
- Compliant with **FAIR principles** (Findable, Accessible, Interoperable, Reusable)
- Ensures **long-term storage** and **global accessibility**