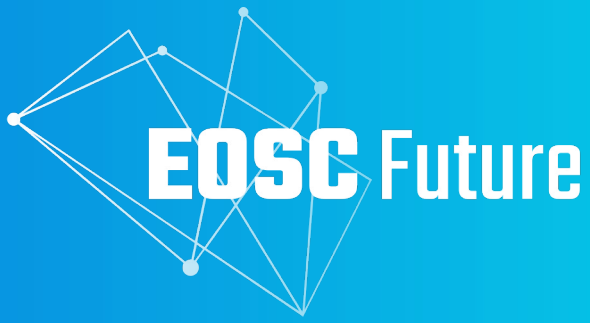


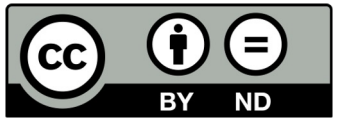
Demonstration:

Dark Matter Test Science Project

Mikhail Smirnov (FAU, ECAP), Lukas Heinrich (TUM)

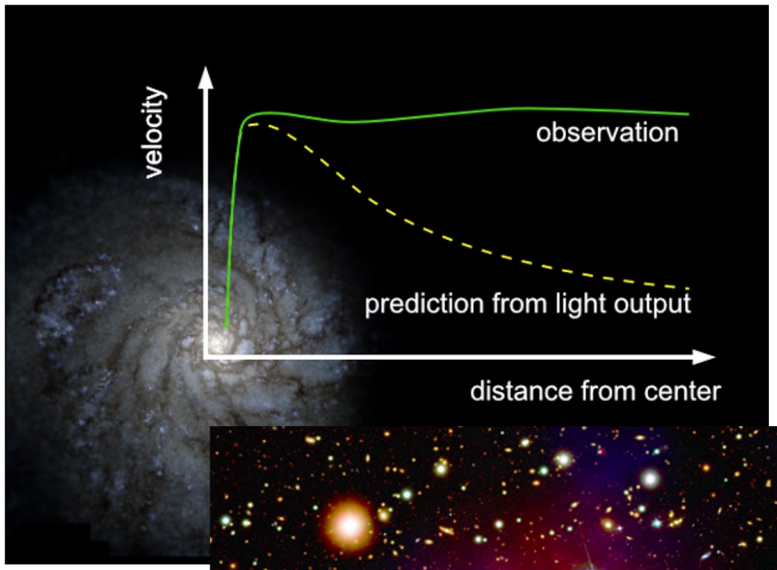
EOSC Symposium

The EOSC Future project is co-funded by the European Union Horizon Programme call INFRAEOSC-03-2020, Grant Agreement 101017536

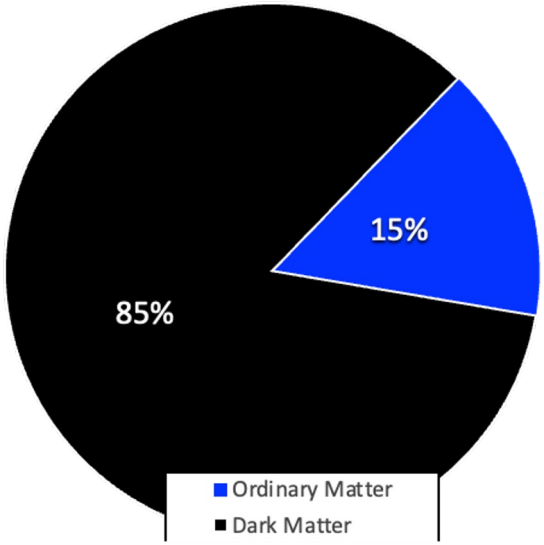


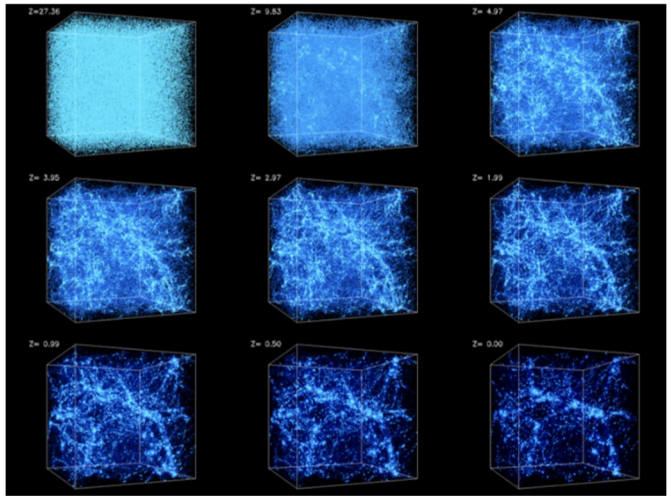
The Scientific case in a nutshell - Dark Matter

We are completely in the dark about 85% of the matter in the universe: ***Dark Matter!***



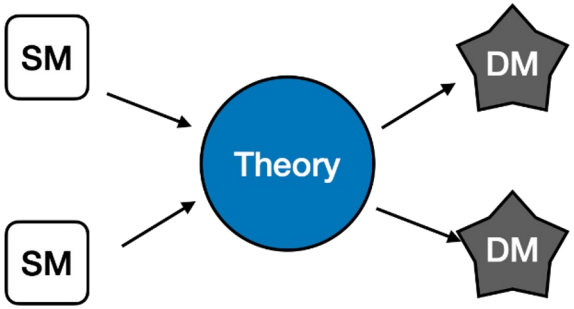
We know it's there, we do not know ***what*** *it is*





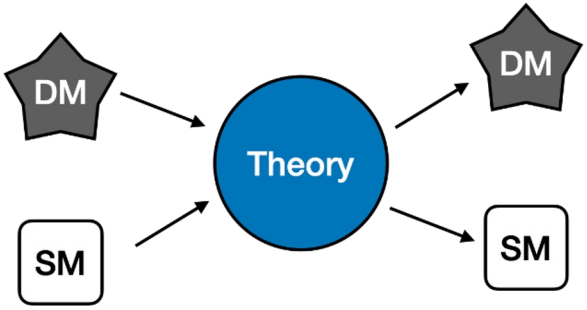
Where and How to find Dark Matter

Dark Matter is a **multi-disciplinary science driver** across astronomy and physics



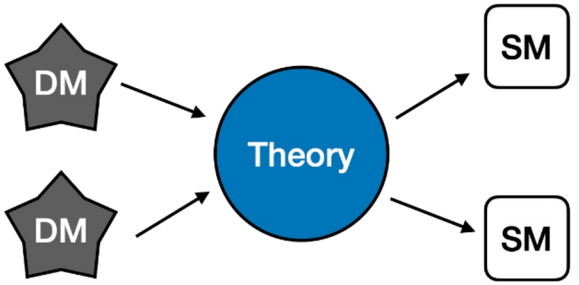
Direct Production

Create Dark Matter
in the Particle Collisions



Direct Detection

Observe DM Interactions
with Standard Matter

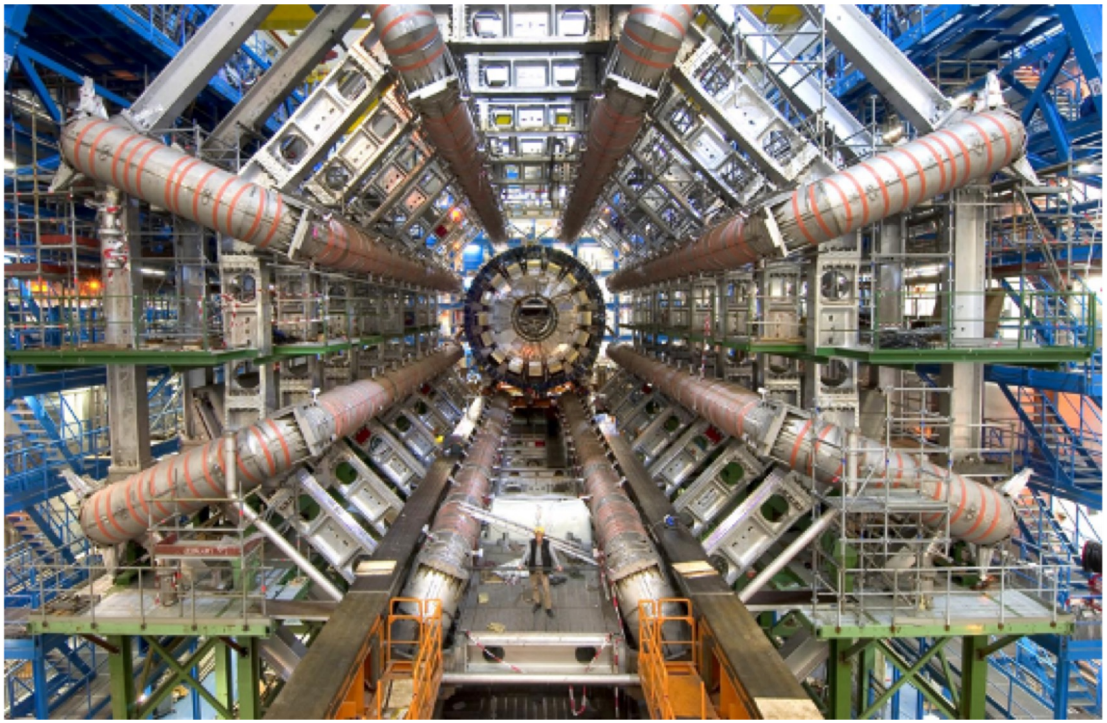


Indirect Detection

Observe Remnants of
Dark Matter interactions

Where and How to find Dark Matter

Efforts to find **Dark Matter** are some of the most complex experiments worldwide

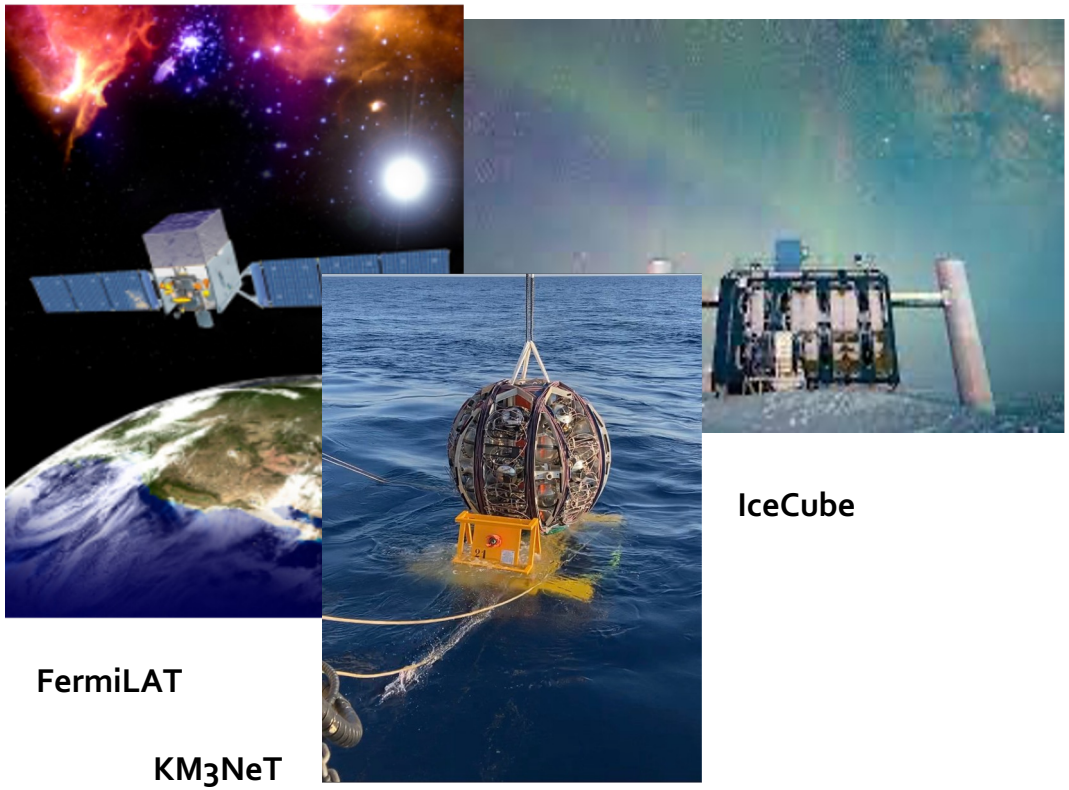


The ATLAS Experiment

The Experiments at Large Hadron Collider (LHC) at CERN

Where and How to find Dark Matter

Efforts to find **Dark Matter** require some of the most complex experiments worldwide



FermiLAT

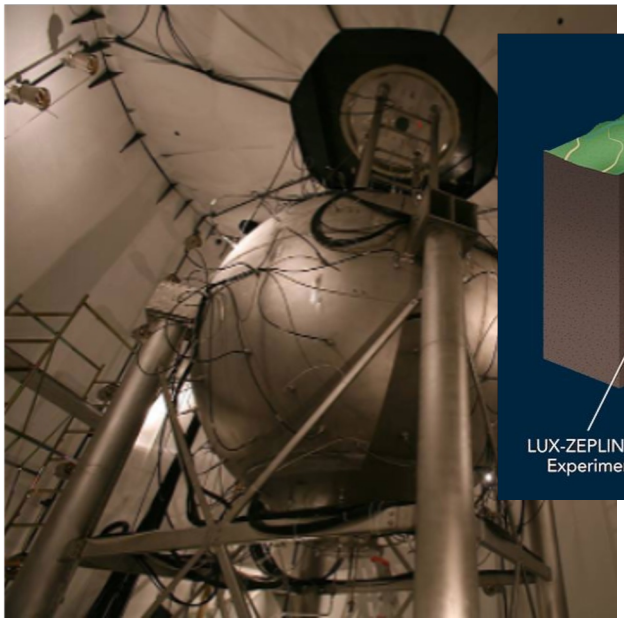
IceCube

KM3NeT

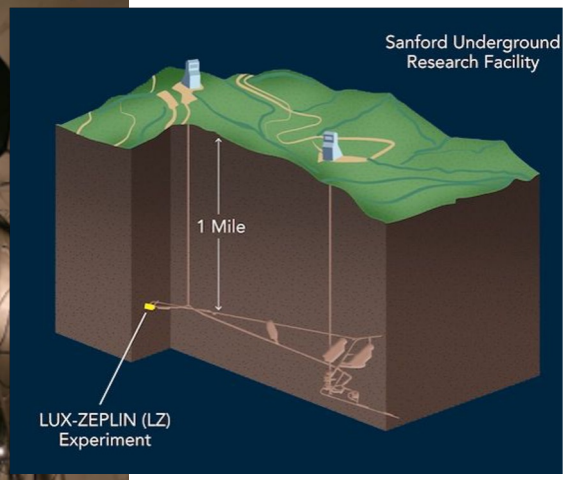
Neutrino and Gamma-Ray Telescopes (in the ocean, in the ice and in space)

Where and How to find Dark Matter

Efforts to find **Dark Matter** require some of the most complex experiments worldwide



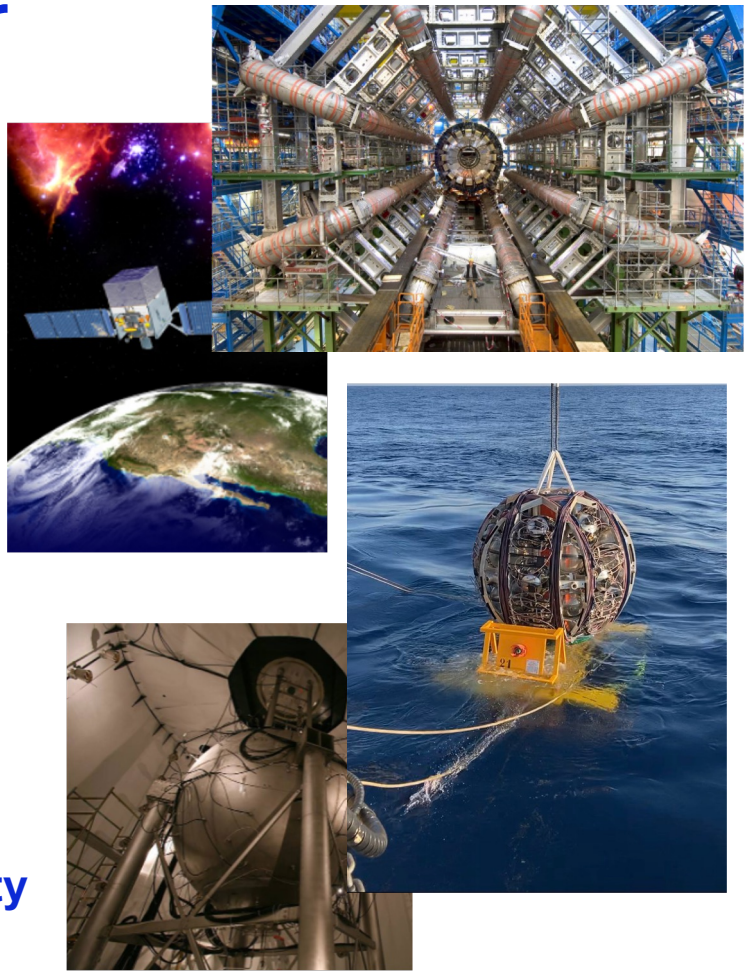
DarkSide



LUX

Direct Detection Experiments
In Cavern deep underground.

Where and How to find Dark Matter



Cutting edge dark matter experiments are increasingly unique

- large, complex, costly experiments at the exascale
- only one or a few experiments of each type worldwide

Maximising each experiment's science outputs is imperative:

- **create** and store new analyses, datasets and results
- **combine** multiple results studying the same question
- **reinterpret** existing studies for new questions

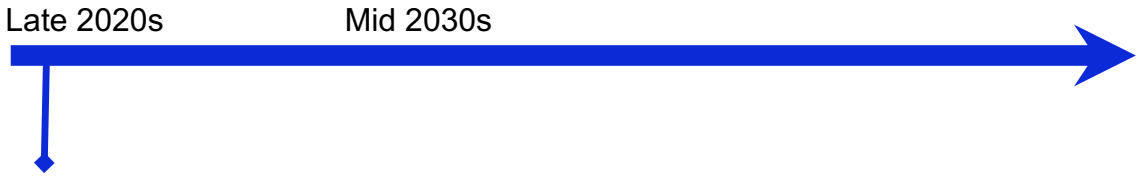
Implies complex infrastructure requirements for science platforms

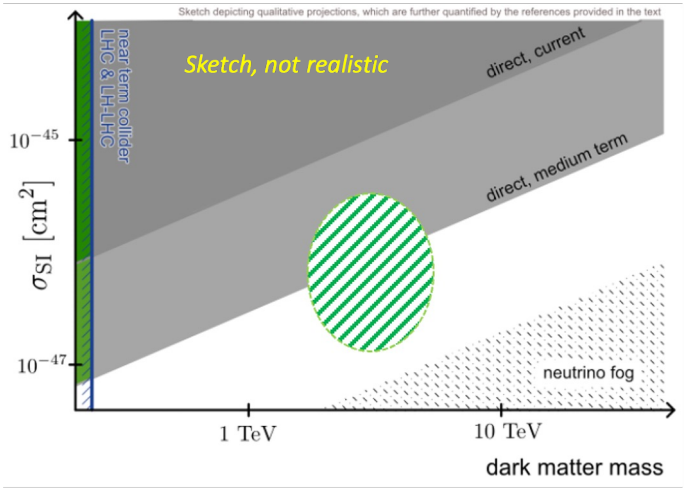
- **Partner with EOSC to build tools for the scientific community**
  learn the most about Dark Matter from all available angles.

A possible Dark Matter timeline

- **Many experiments are coming online - unprecedented level of sensitivity.**
- **If there is something to find, signs would accumulate across different science domains**

A possible Scenario





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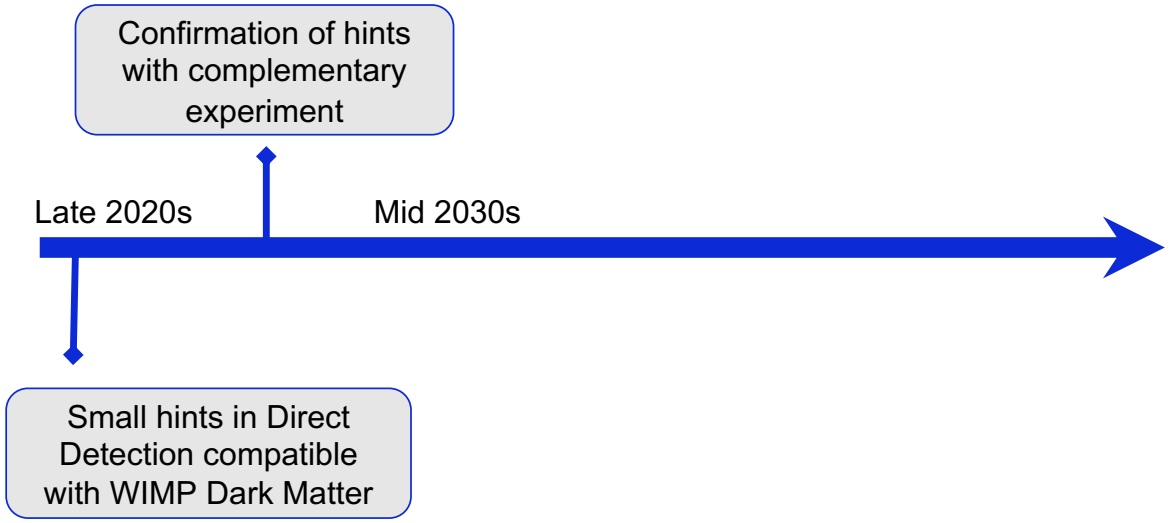

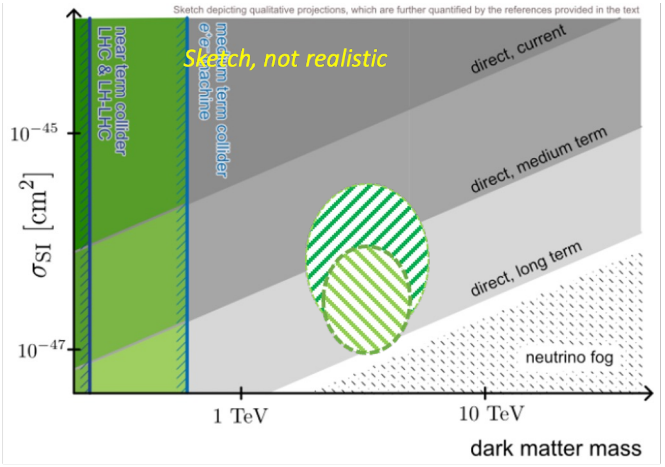

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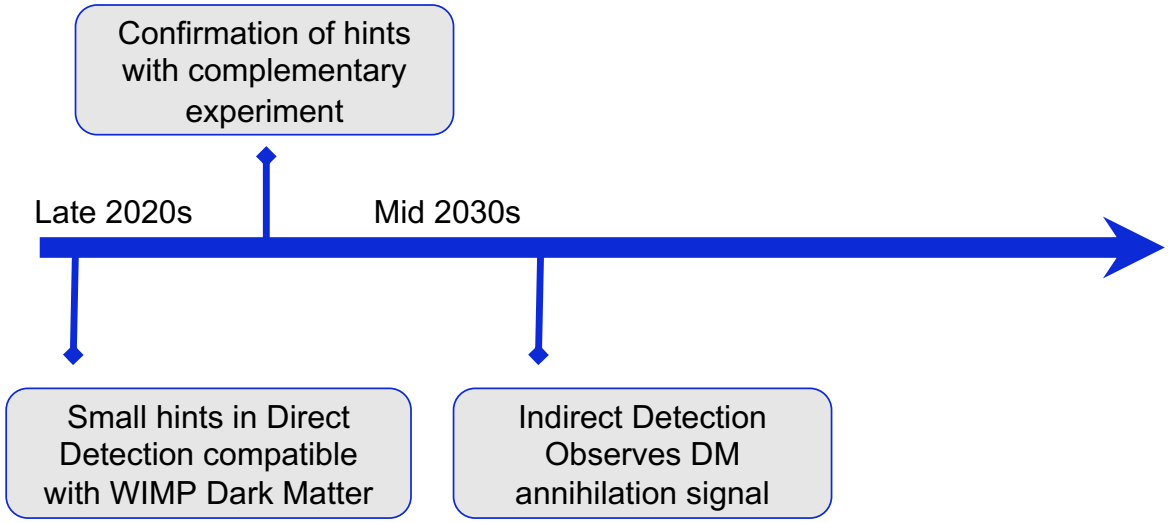

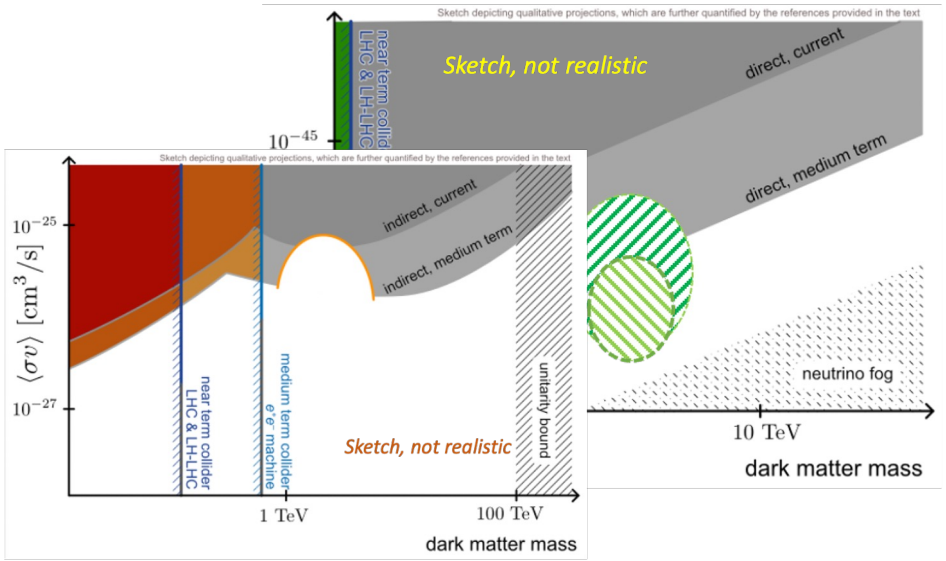

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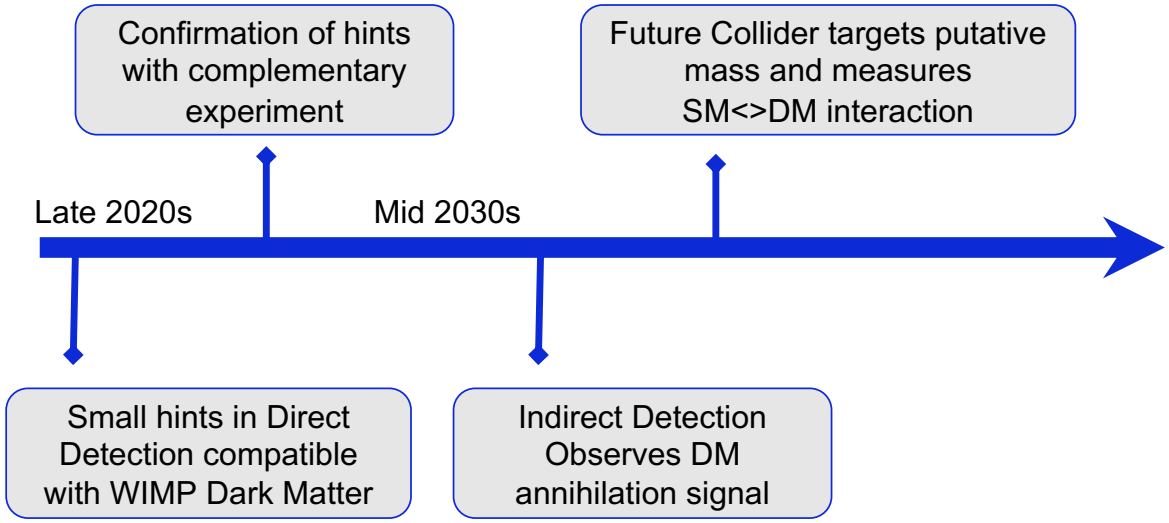

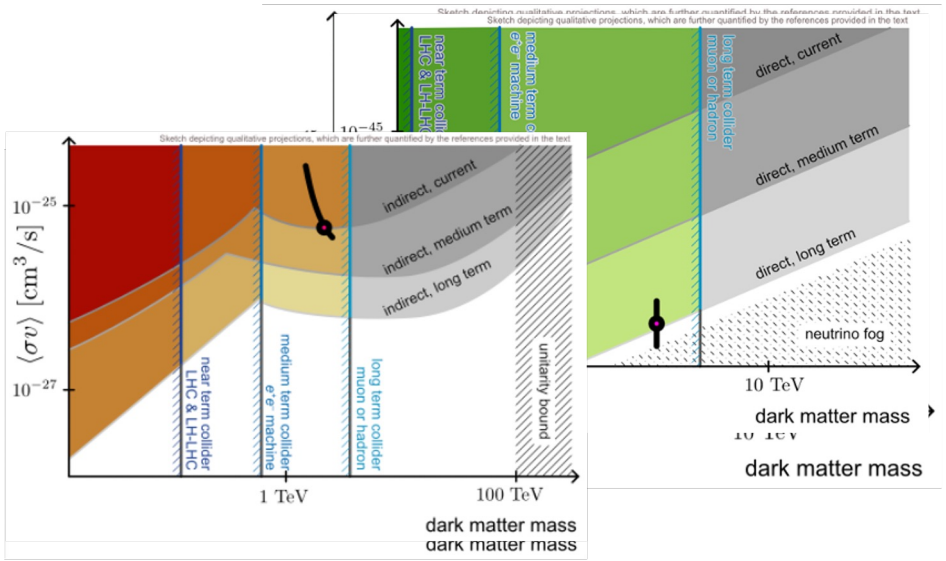

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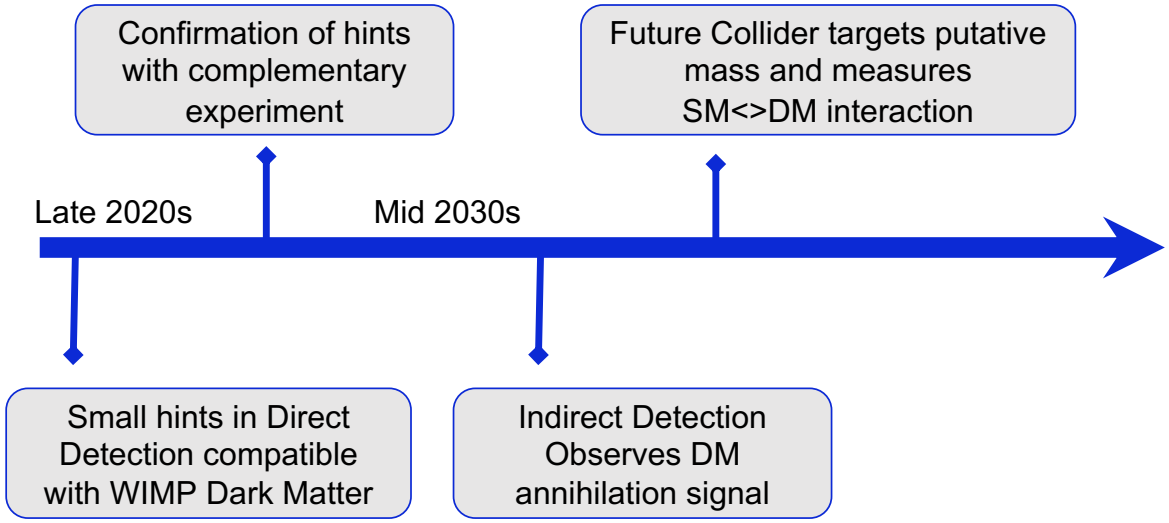
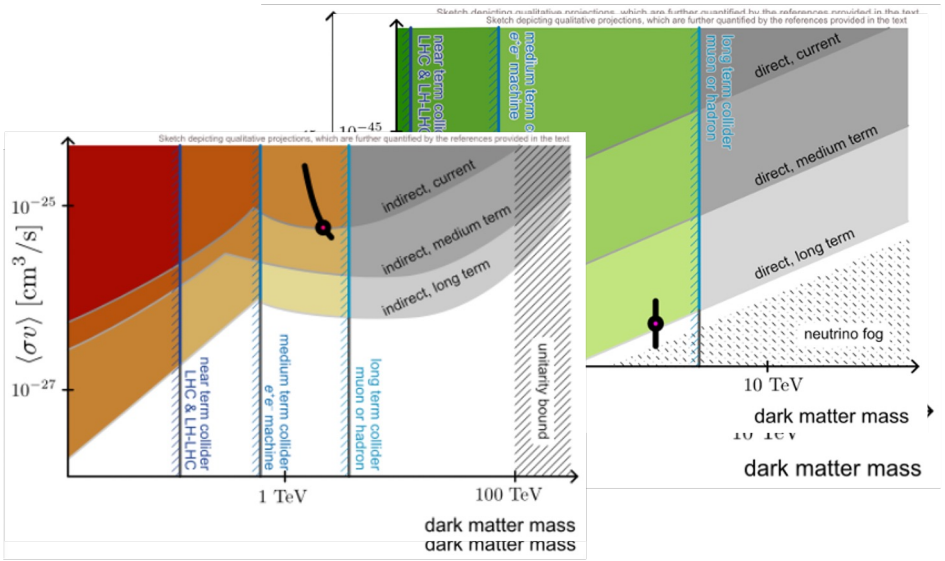




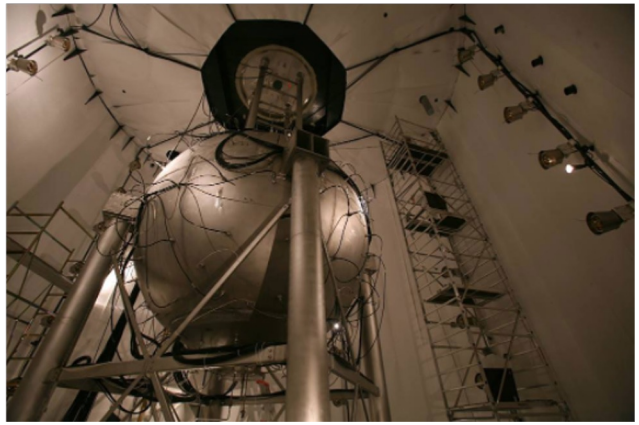
Putting all puzzle pieces together would require a common and open computing and data infrastructure

The Dark Matter Test Science Project

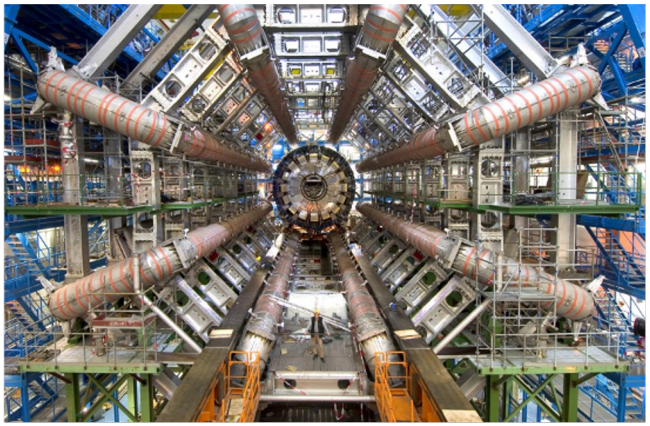
As part of EOSC-Future we build a integrative platform to develop an understanding of the key computing and data challenges for Dark Matter:

- **Provide EOSC with input:** which services and infrastructure do we need to build for high-impact open science
- **Build prototype infrastructure:** enables unified view across domains with experiments from each major field

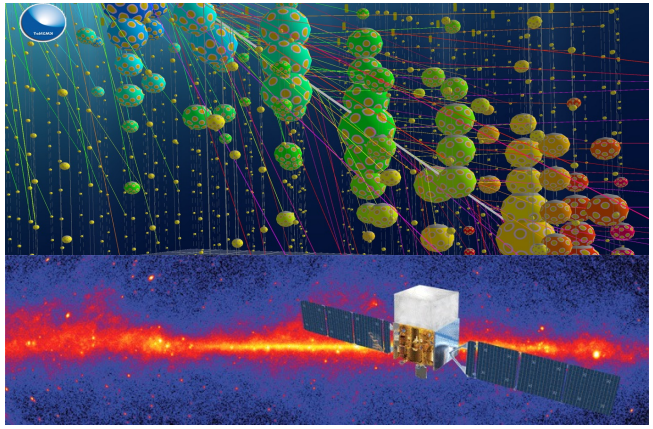
Direct Detection: DarkSide



Colliders: ATLAS Experiment



Indirect Detection: Fermi & KM3NeT



…and their evolutions: ***DarkSide-20k / Argo, ATLAS @ HL-LHC, CTA***
Some of the ***analysis & ML tools*** *necessary for these evolutions are also part of this Science Project*

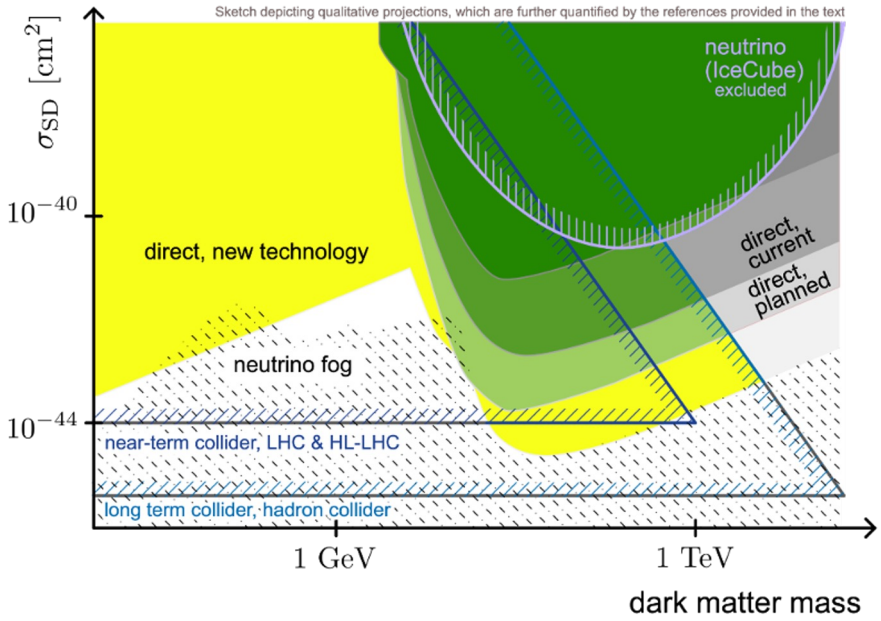
The Dark Matter Test Science Project

Science output of the Dark Matter TSP

- **Individual results from participating experiments**
- **Summary Results to showcase complementarity of participating experiments**
- **Possible: Combination of Results**
  [looking for personpower]

Data and Software

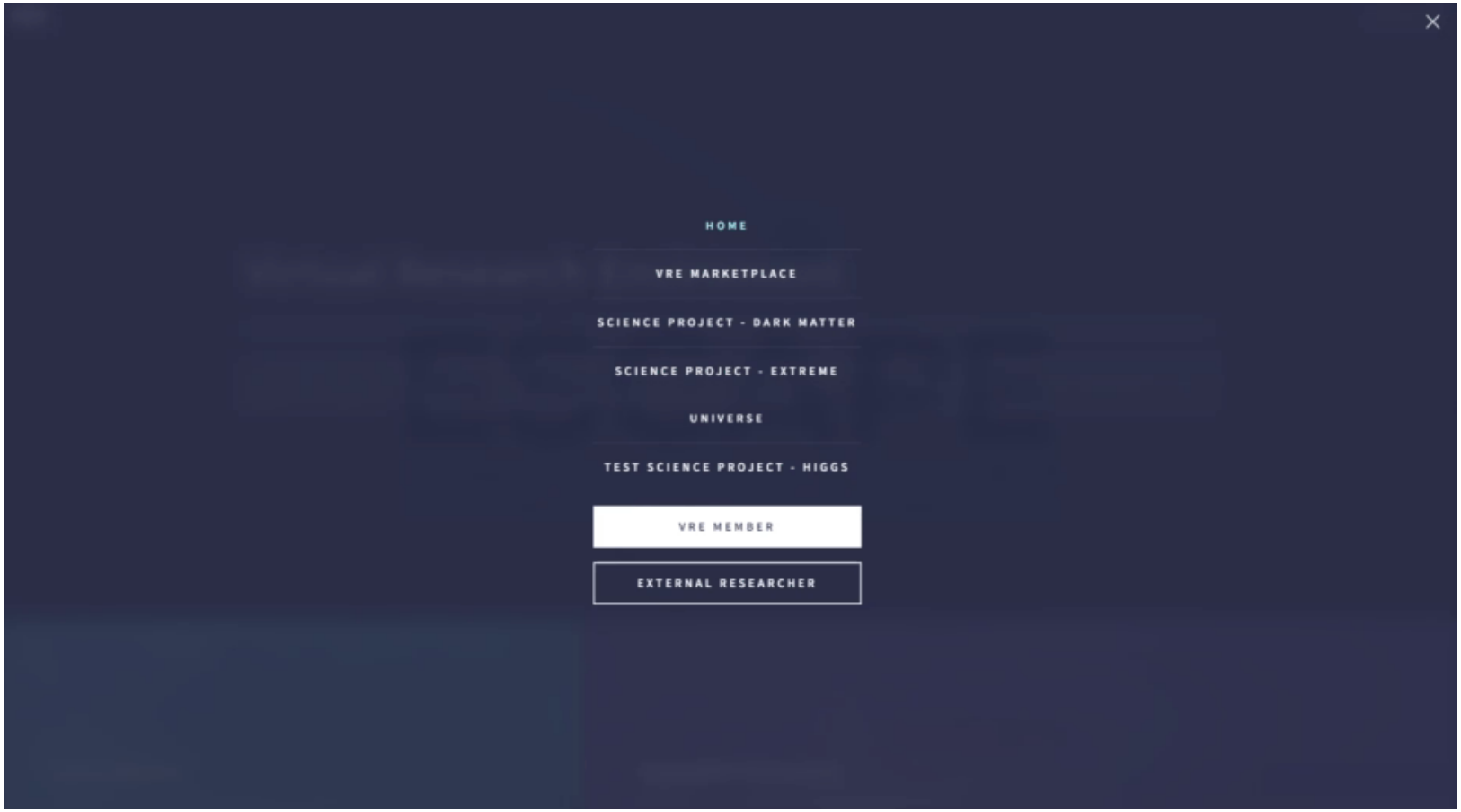
- **Data deposited on the ESCAPE Data Lake**
- **Software and Software pipelines archived on ESCAPE Software Catalogue**
- **Should be ready for reusing / reproducing**



Example sketch (not using ESCAPE experiments yet) highlighting direct detection, neutrino experiment indirect detection and collider complementarity

The Virtual Research Environment

VRE – online platform for doing research in framework of EOSC Future Science Projects

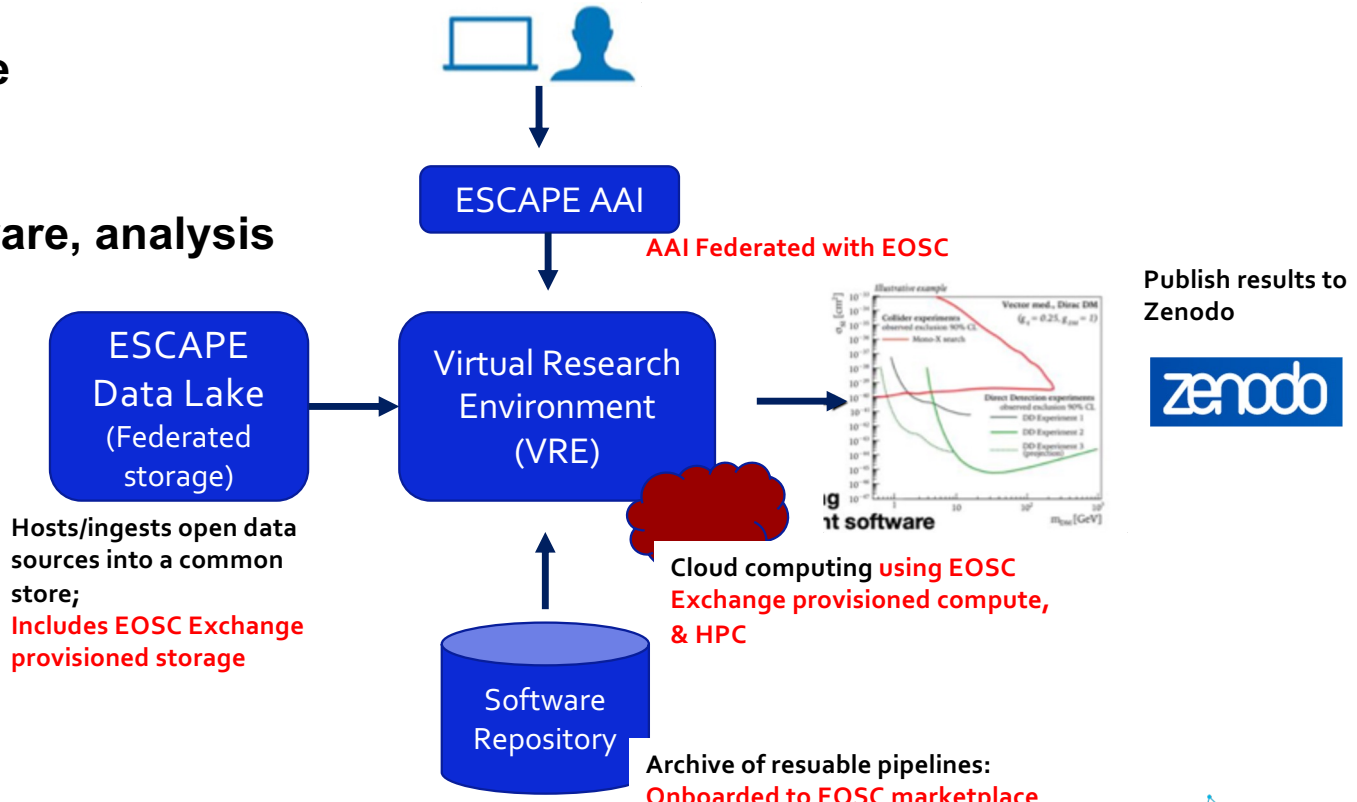


https://escape2020.pages.in2p3.fr/virtual-environment/home/

The Virtual Research Environment

Core Component of the DM TSP is the Virtual Research Environment

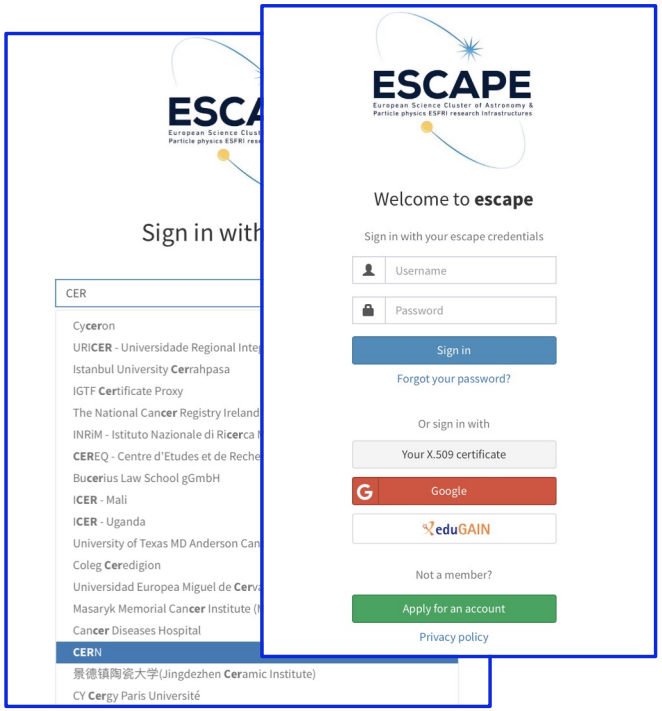
- **EOSC tools for a unified science entry point for scientists**
- **Provide access to domain software, analysis pipelines and data**
- **Demonstrate ability to run Real-world workflows from all participating domains**
- **Based on modern cloud computing & reproducible scientific tools**



The Virtual Research Environment

VRE gives access to researchers from all institutions using EOSC federated identity AAI

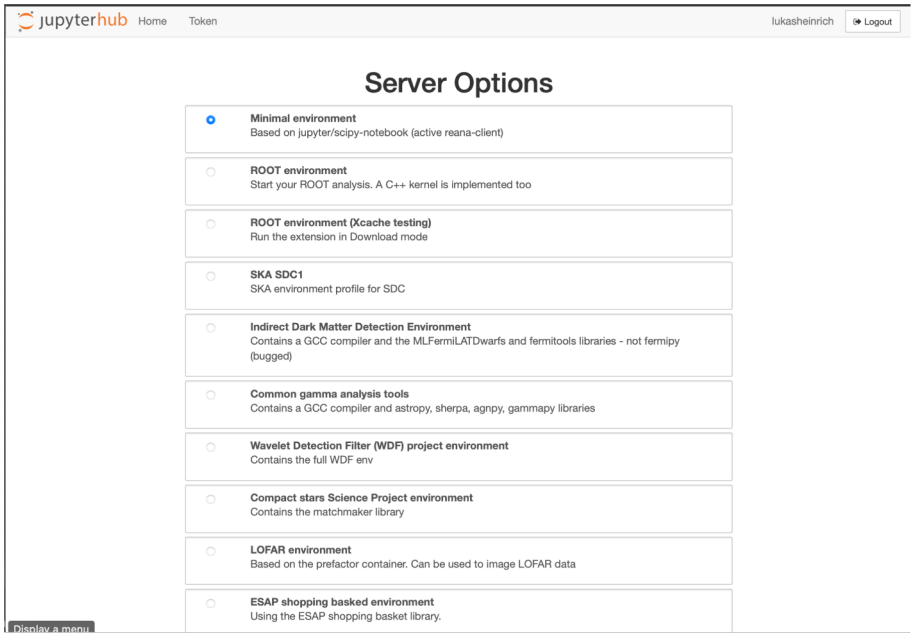
- **Common experience independent of Researches science domain**
- **Integration with Institutional and VO Authentication mechanisms**



The Virtual Research Environment

JupyterHub provides a familiar & common UI

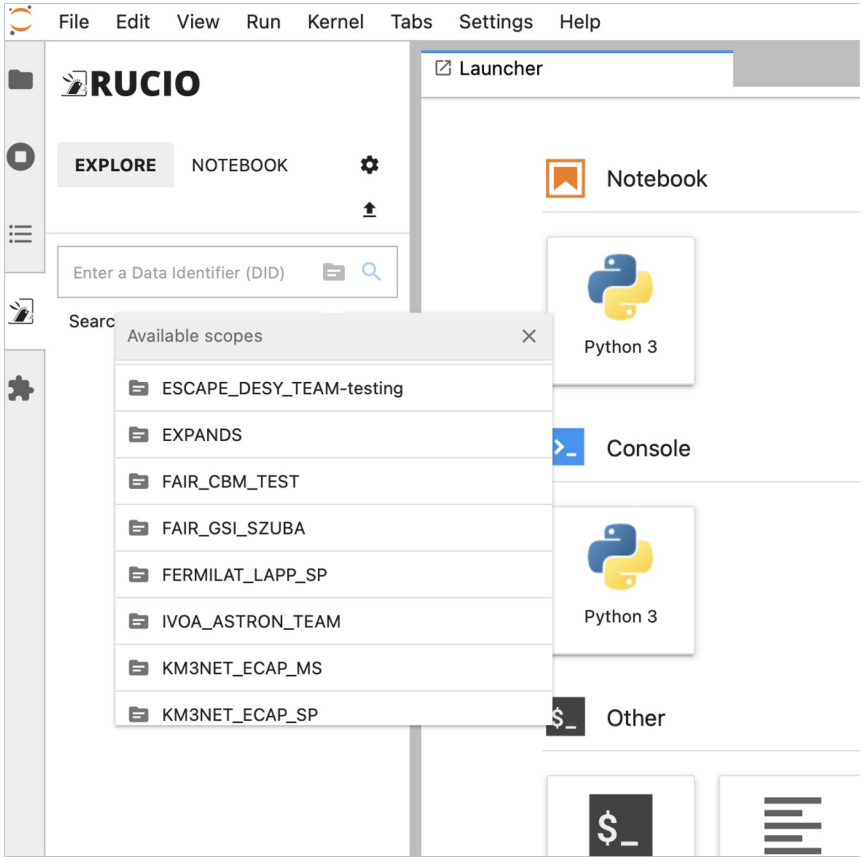
- **Curated list of reproducible software Environment for each science domains**
- **Entrypoint for exploratory data analysis and visualization**
- **Client tools for scale-out systems (e.g. batch) for larger workloads**



The Virtual Research Environment

The ESCAPE Data Lake as a cervice integrated into the Jupyter UI of the VRE

- **Based on Rucio, exascale-ready distributed storage system**
- **Policy-based access to Data**
- **Easy discovery of datasets from all participating experiments**
- **Direct attachment to the research workflow**

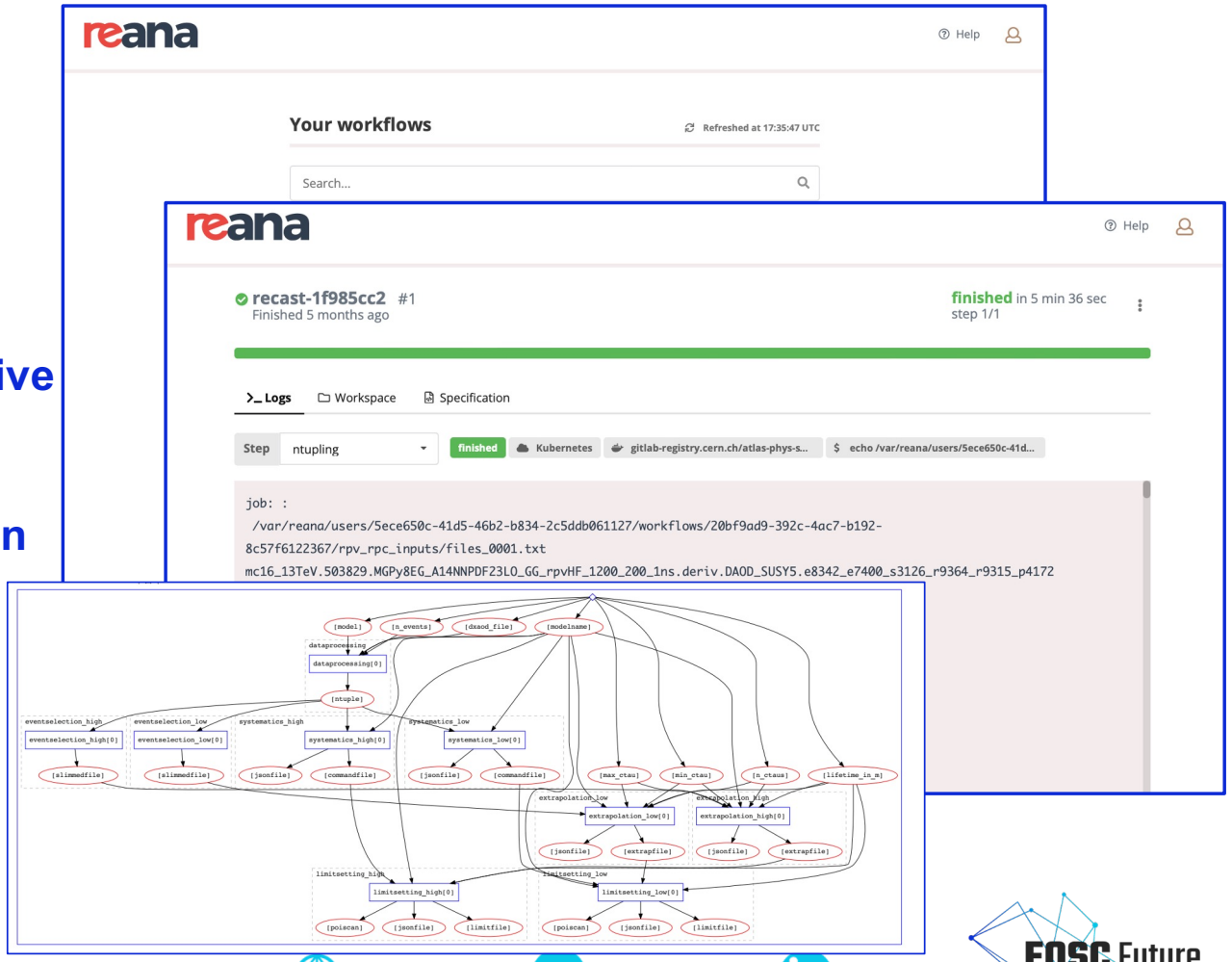


https://rucio.cern.ch/

The Virtual Research Environment

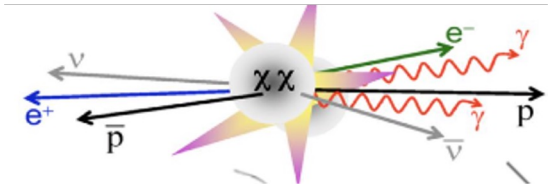
The VRE integrates with REANA

- **Scale beyond single notebook**
- **Run reproducible / reusable declarative containerized pipelines as a service**
- **Variety of workflow structures used in science domains (Serial, Snakemake, CWL, yadage)**
- **Complete deployment at CERN and CNAF resources (EOSC)**



https://reanahub.io/

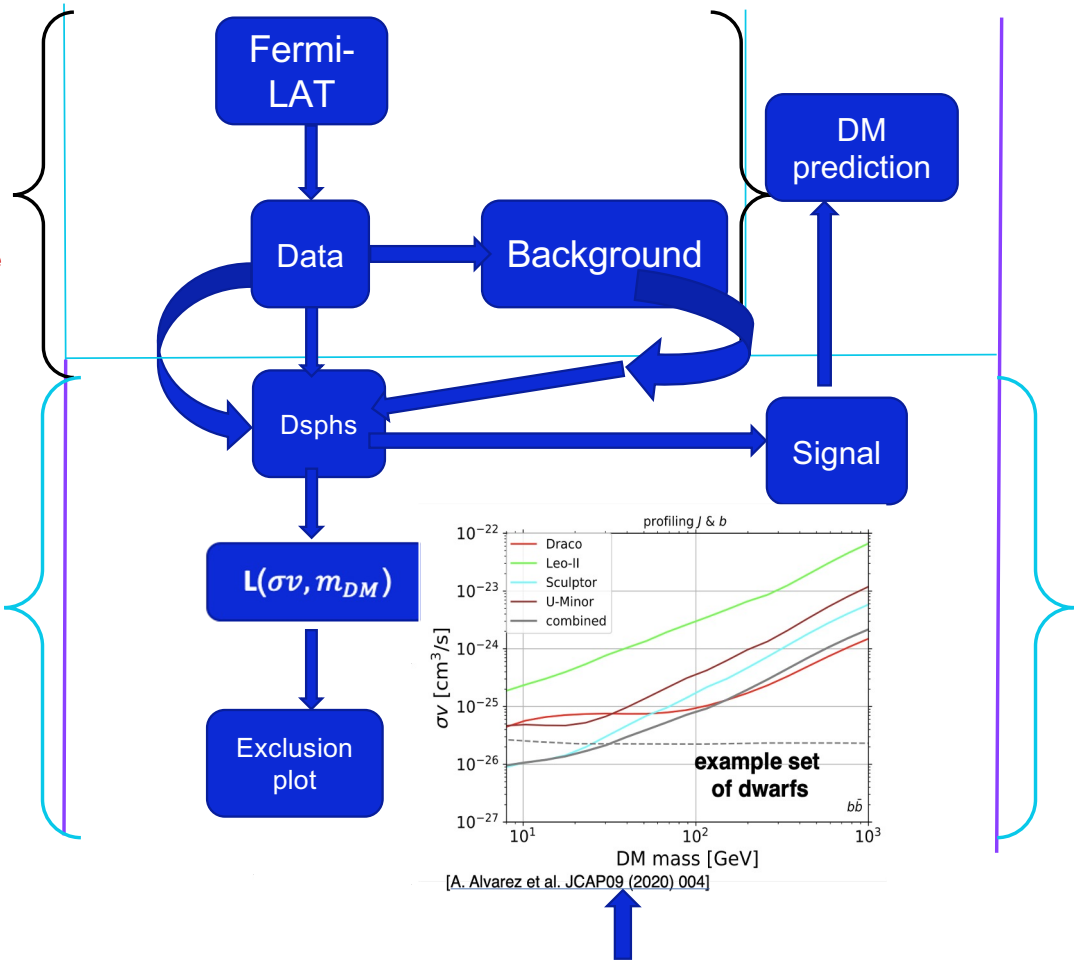
The demo



gamma-ray

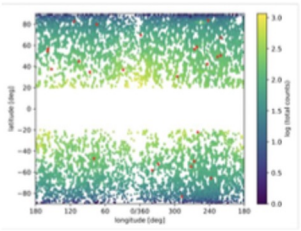
Data stored in Data Lake

Available on VRE



What is the idea behind "MLFermiDwarfs"?

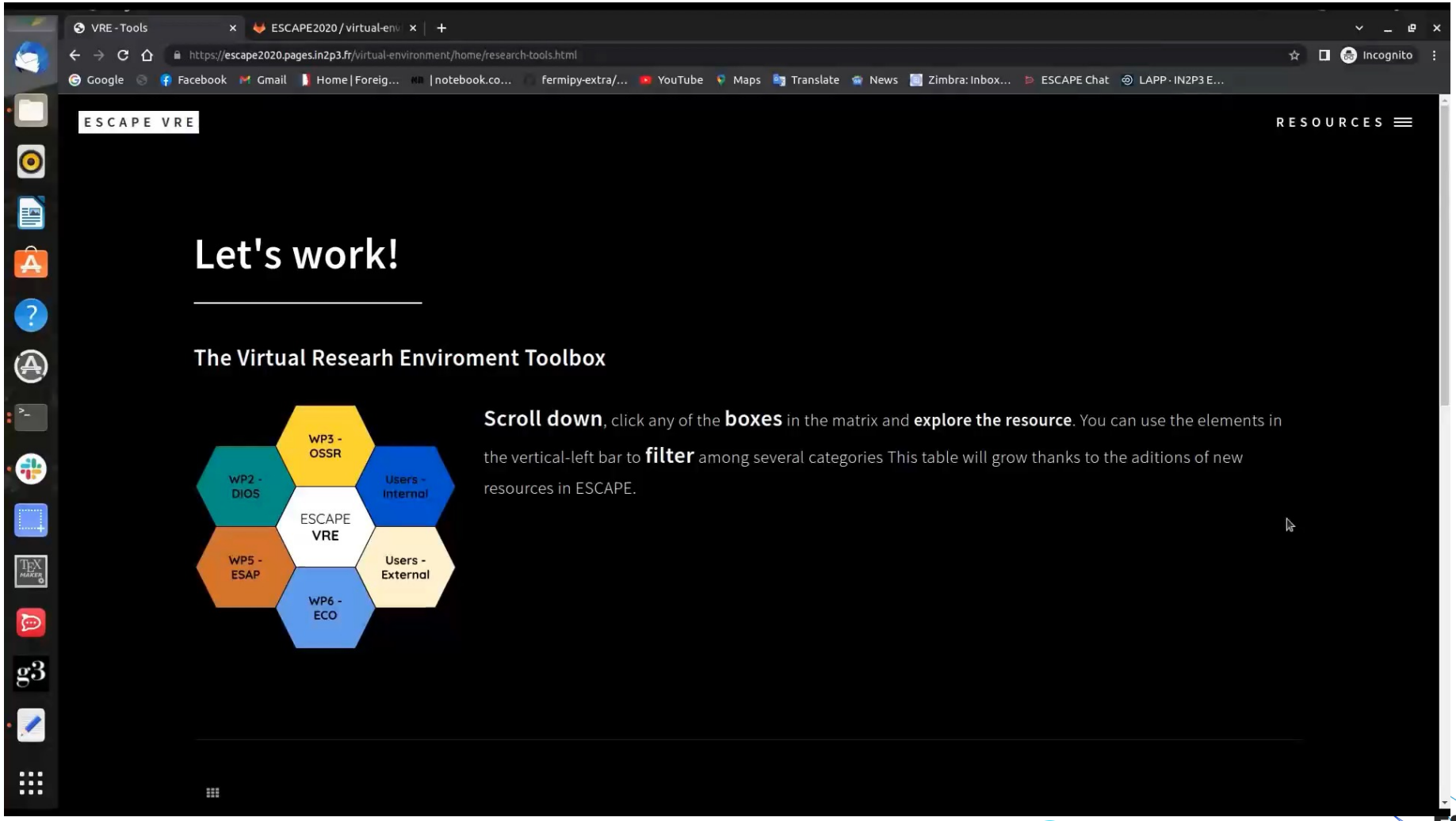
(performance demonstrated in [F. Calore et al. JCAP10 (2018) 029],[A. Alvarez et al. JCAP09 (2020) 004])



Learn to predict the gamma-ray background over the entire sky via training data based on real gamma-ray measurements from Fermi-LAT in **a machine learning based approach.**

In this demo – reproduces results in the paper

The demo


VRE - Tools
ESCAPE2020 / virtual-env
https://escape2020.pages.in2p3.fr/virtual-environment/home/research-tools.html
Incognito
Google
Facebook
Gmail
Home | Foreig...
| notebook.co...
fermipy-extra/...
YouTube
Maps
Translate
News
Zimbra: Inbox...
ESCAPE Chat
LAPP - IN2P3 E...
ESCAPE VRE
RESOURCES
Let's work!
The Virtual Researh Enviroment Toolbox
WP3 - OSSR
WP2 - DIOS
Users - Internal
ESCAPE VRE
WP5 - ESAP
Users - External
WP6 - ECO
Scroll down, click any of the boxes in the matrix and explore the resource. You can use the elements in the vertical-left bar to filter among several categories This table will grow thanks to the aditions of new resources in ESCAPE.

Thank you for your attention

The EOSC Future project is co-funded by the European Union Horizon Programme call INFRAEOSC-03-2020, Grant Agreement 101017536

Backup

Scientific case

Technical requirements

- Interactive Entrypoint
- Scale-out Systems for large-scale workloads
- Large-Scale Storage with

- Support large dynamic range in Workloads (from single notebooks to O(100 TB) workflows
- Cross-Experiment Authentication (-> IAM)
- ...

EOSC as enabler (added value)

- Data Lake
- CNAF Resources
- IAM
- Help

Impact

- Expose state of the art Dark Matter workflows semi-publicly

- ...

Scientific platform – Integration with EOSC

Achieved integrations

- Rucio Data Lake
- IAM
- HelpDesk
- REANA at CERN
- Achieved depl

Next steps

- Full Scale Workflows (Analysis Grand Challenge?)
- Integration with public archives (HepData ? DMDC?)
- Deploy REANA at CNAF
- EOSC Accounting / Monitoring?
- …

EOSC Future contributors: Add list of EOSC Future tasks that contributed to the work

The demonstration in a nutshell

[Include a workflow of what will be presented – step by step]

Q & A – Demonstration:

Scientific demonstration

EOSC Symposium

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INFRAEOSC-03-2020, Grant Agreement 101017536