

Particles, Universe, NuClei and Hadrons for the NFDI

A consortium in the NFDI

PUNCH4NFDI infrastructure and use cases
DMLab@Paris, 21 October 2026



Outline

- **NFDI and PUNCH4NFDI**
- Current infrastructure components
- Second funding phase: use cases examples
- Conclusions



Gemeinsame
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GWK



Deutsche
Forschungsgemeinschaft

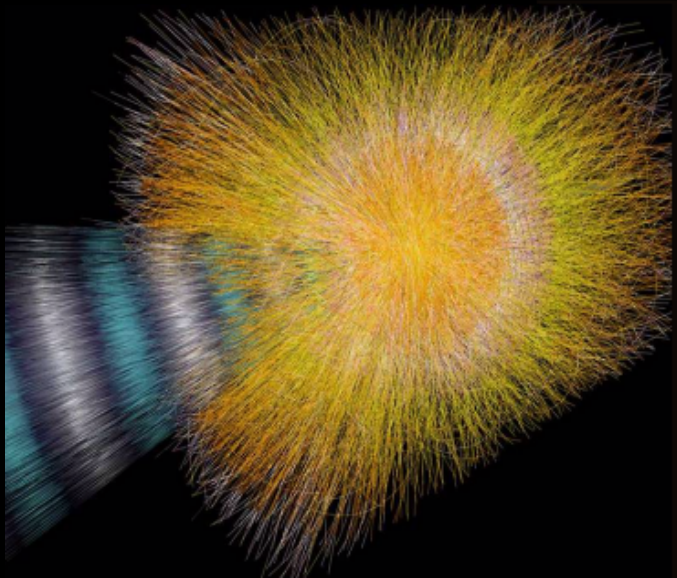
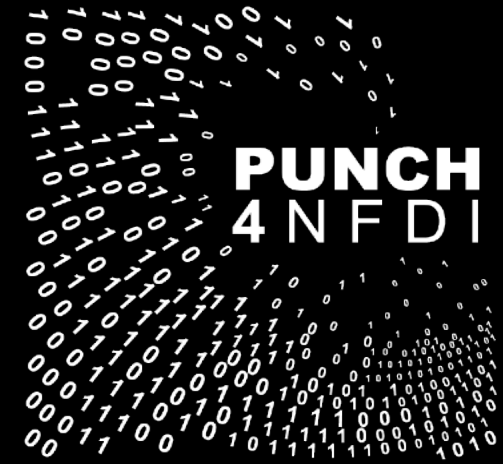
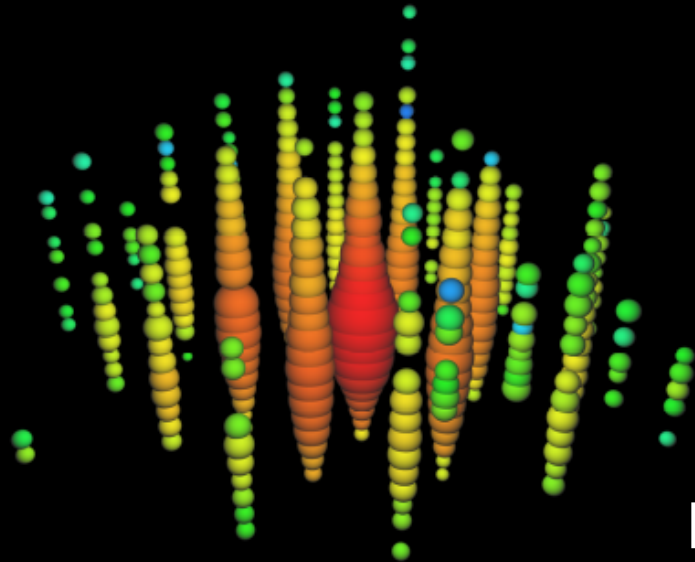
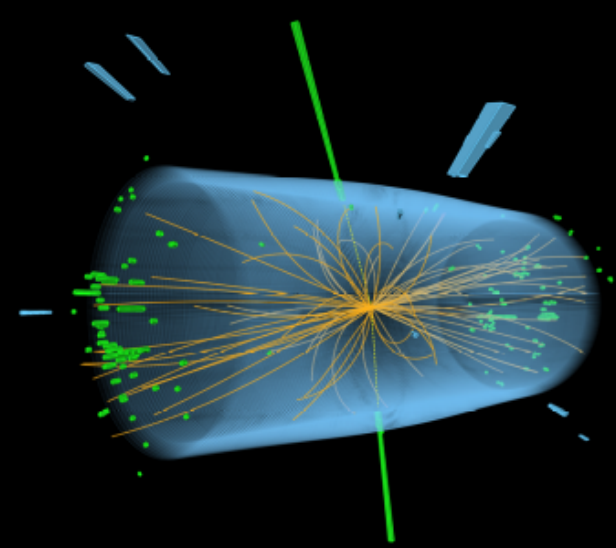
Nationale Forschungsdaten- infrastruktur (NFDI, since 2020)

- Sustainable utilisation of scientific research data
- Establishment of FAIR data management and science
- Connection to European and international efforts (like EOSC)
- Bottom-up approach of 26 consortia
- Consortia with up to 5 MEUR / year

See [DFG.de/nfdi](https://www.dfg.de/nfdi) and [nfdi.de](https://www.nfdi.de)

NFDI and beyond





Particles, Universe, NuClei and Hadrons for the NFDI (PUNCH-2.0: 34 partners)

Prime goal: setup of federated and "FAIR" science data platform (SDP), offering the infrastructures and interfaces necessary for the access to and use of data and computing resources of the involved communities and beyond.

PUNCH-1 funded 2022-26

PUNCH-2.0 funded 2027-28

How to get from our many diverse instruments and the data they produce and typically store in institutional archives



arXiv:2504.01688v2 [hep-ex] 20 Jun 2025

Enhancing European Cooperation in the Search for Dark Matter

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Abstract

The search for dark matter is an exciting topic that is pursued in different communities over a wide range of masses and using a variety of experimental approaches. The result is a strongly correlated matrix of activities across Europe and beyond, both on the experimental and the theoretical side. We suggest to encourage and foster the collaboration of the involved institutions on technical, scientific and organisational level, in order to realise the synergies that are required to increase the impact of dark matter research and to cope with the increasing experiment sizes. The suggested network — loosely titled "DMInfraNet" — could be realised as a new initiative of the European strategy or be based on existing structures like IDMEU or DRD. The network can also serve as a nucleus for future joint funding proposals.

... more easily to (more) science output?

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- NFDI and PUNCH4NFDI
- **Current infrastructure components**
- Second funding phase: use cases examples
- Conclusions



AAI
Portal
DRPs and registry
RDMO

Retrieval

Preparation

Curation
Selection, combination
MD catalogues
REANA

Analysis

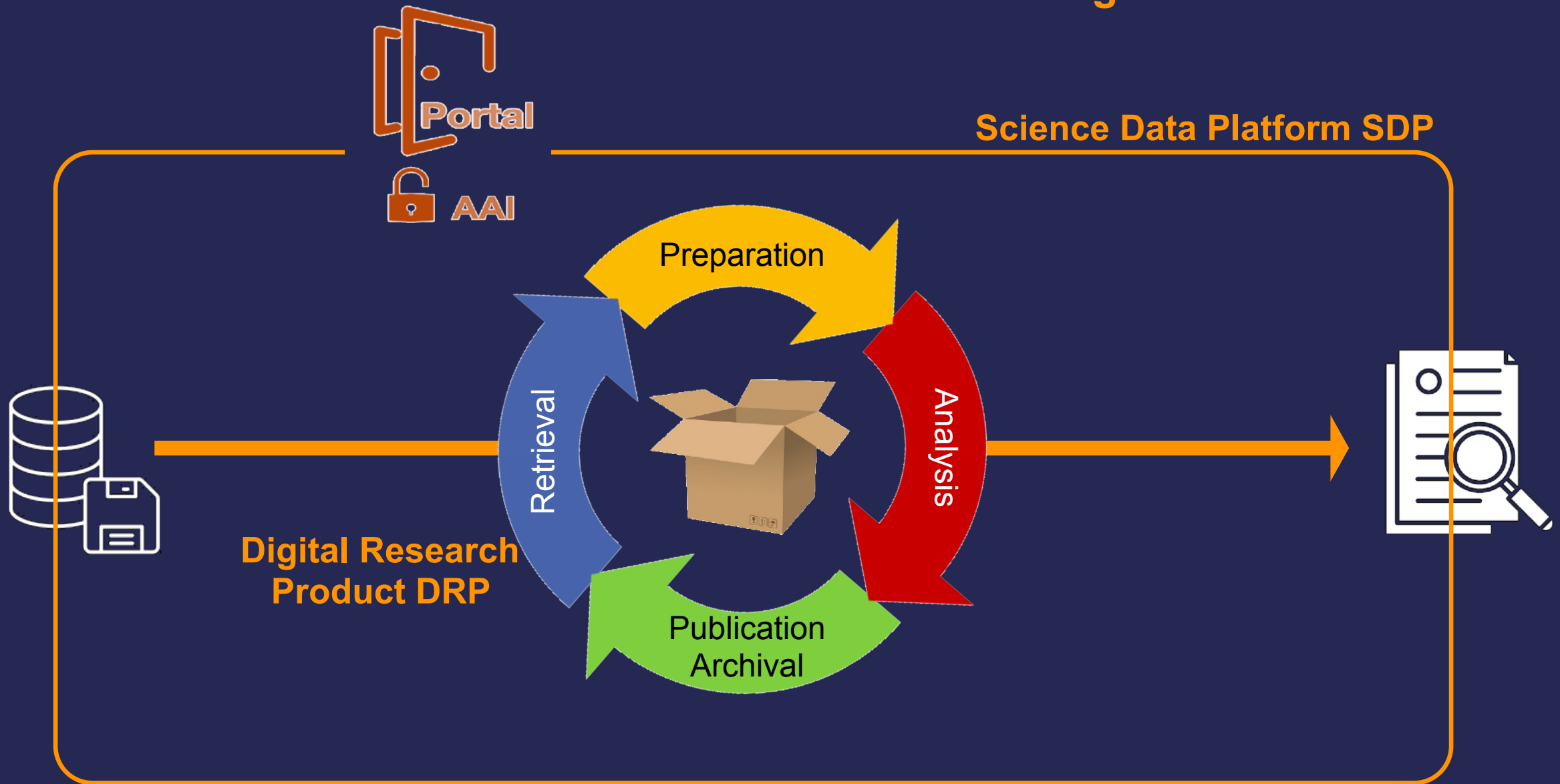
Storage4PUNCH
DRPs and registry
MD catalogues
Portal

Publication
Archival

Compute/Storage4PUNCH
REANA
Statistical / ML / simulation tools
Analysis tools, benchmarks
github & gitlab

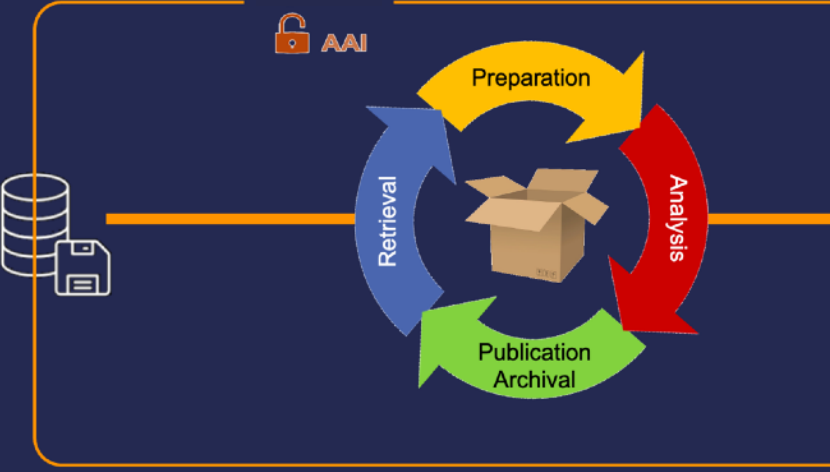
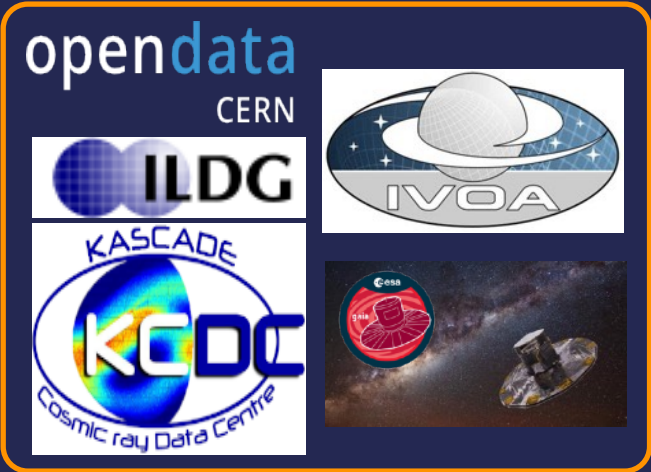


The last golden mile of RDM!



PUNCH4NFDI infrastructure

Services
collection



P4N Gitlab

PUNCH 4 NFDI

PUNCH4NFDI's software repository platform. Code Repository, CI/CD, Container Registry, tutorials Gitlab is hosted at AIP.

URL <https://gitlab-p4n.aip.de>

Access AAI

Tags git, software, collaboration, Container build (CI/CD), tutorials

P4N AAI

PUNCH 4 NFDI

The Community AAI of PUNCH4NFDI, one of the first NFDI AAI, in operation since start of the consortium and managed by us. Provides authentication to user...

URL <https://login.helmholtz.de/punch/>

Register <https://results.punch4nfdi.de/?md=docs/Documents/punch-aai.md>

Access AAI

Tags DFN-AAI, AARC, HIFIS, EOSC, Single-Sign On,

P4N DRP Registry

PUNCH 4 NFDI

Draft implementation of P4N's DRP (Digital Research Product) registry. Hosted at AIP. See for DRP in <https://zenodo.org/doi/10.5281/zenodo.8358549>

URL <https://rpr-p4n.aip.de>

Access PUNCH-AAI

Tags Workflow, Metadata for Software, Data, Execution

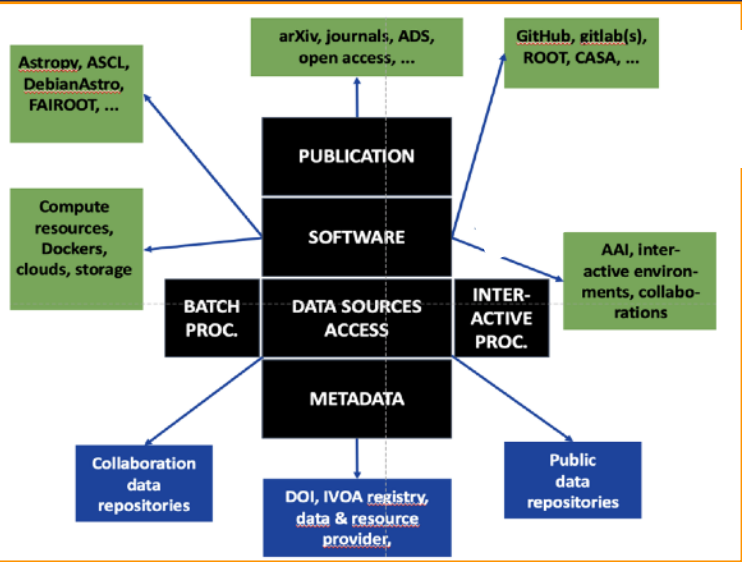
P4N REANA

PUNCH 4 NFDI

REANA allows scientists to run containerised data analysis pipelines on remote compute clouds. PUNCH REANA to capture reproducible workflows and...

URL <https://reana.aip.de>

Connection to / use of archives



Digital Research Product
Registry and catalogues

Digital Research Product Hub
enabling reproducible science

A federated infrastructure provided by the PUNCH4NFDI consortium.

FAIR Principles | Reproducible Workflows | PARTNERS | Federated Infrastructure

FAIR with PUNCH

SDP & P4N infra | IDEA | RESEARCH | PUBLISH | FIND (DRP-HUB) | REPRODUCE (REANA) | SHARE (RPR)

Featured DRPs

25 public research products

→ Sign in to create, bookmark, and manage your own DRPs

DeepSeek Harness vs OpenCode ...

Head-to-head AI coding benchmark: the same task is self-contained, picture-first landing page teaching the idea function to 11th-grade students) was handed to two different coding agents, and each produced its own repository. Both agents

Maturity walkthrough

Maturity Levels Workflow L2 → L4 Level 0 (2 entries required) Create card

Plot Linear Functions with pandas...

Reproducible REANA workflow that plots multiple linear functions $y = mx + b$ using pandas DataFrames and matplotlib. Demonstrates basic data generation and visualization in a containerized, reproducible environment.

Fibonacci (Golden) Spiral

A reproducible REANA workflow that plots the golden Fibonacci spiral with the classic Fibonacci-square construction. Generates Fibonacci spiral grid showing the spirals and squares labeled with Fibonacci numbers.

CERN CVMFS example image

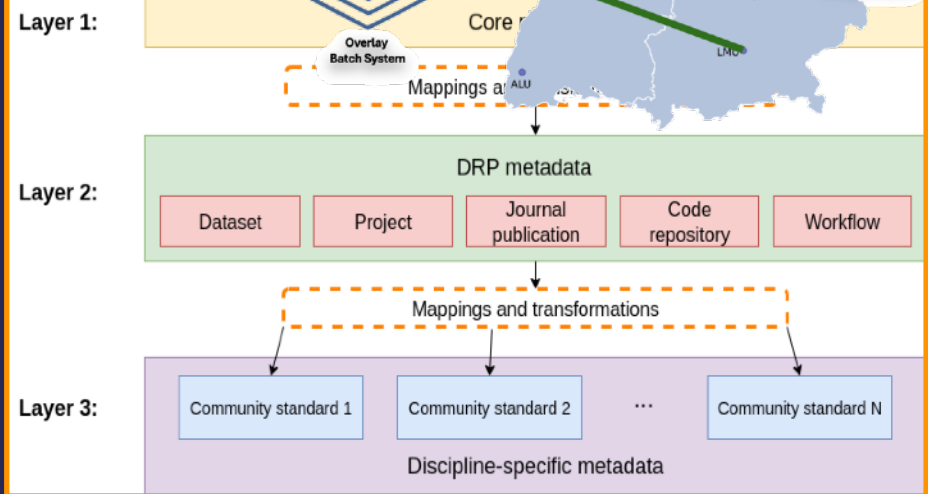
CERN CVMFS example image to mount in the docker container.

Automatic Differentiation: Hands-on

The Workshop "Conceptual Advances in Machine Learning" Anthen, 2026 <https://github.com/Anthen/STAN> Automatic Differentiation - Hands On with Clad

Federated storage
& compute

Metadata schema

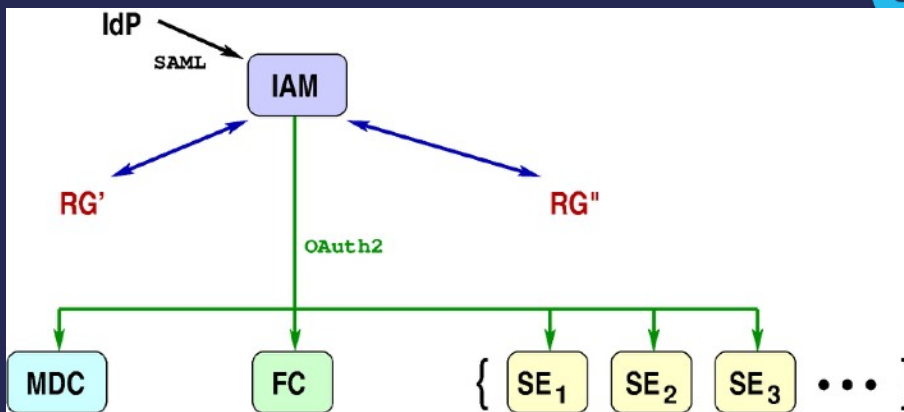


PUNCH4NFDI infrastructure II



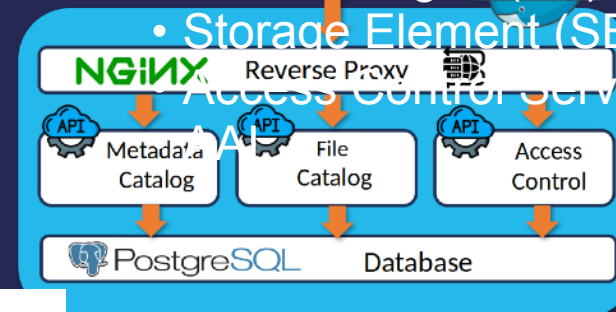
Basic Metadata Catalogue implementation

- based on the ILDG framework
- simple (containerised) deployment
- for small-to-medium sized (international) community



Distinct, modular services

- Metadata Catalogue (MDC)
- File Catalogue (FC)
- Storage Element (SE)
- Access Control Service (ACS)



Current instances

- ILDG (DESY Zeuthen, Bielefeld, Japan,...)
- LOFAR test instance
- DESY testbeam & ALPS



Image courtesy: Basvarajaa Bheemalingappa Sagar, Hubert Simma

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PUNCH-2.0 Objectives

Objective 6: NFDI architecture, sustainability, connections

Objective 5: Education and training

Objective 4: Implementation of use cases

Objective 3: Science Data Platform as user interface

Objective 2: Sustainable services

Objective 1: Technological basis; operation models

TA 3
Service,
Results &
Stakeholder
Management

TA 4
Project Management & Governance

TA 2
Enabling
Science
Exploitation

TA 1
Techn.
Foundation

PUNCH-2.0 Task Areas, Work Packages, Use Cases

3

2.1 Science Data Platform

UC 2.2 Data Management Framework

UC 2.3 Data-Generating Simulations

UC 2.4 Phenomenological Analysis

UC 2.5 Future Observations

UC 2.6 Future Colliders

UC 2.7 Large Datasets

3.1 Services & Results Management

3.2 Training, Education, Open & FAIR

3.3 Stakeholder Management

2

1

1.1 Technical Coordination

1.2 Storage Infrastructure

1.3 Compute Infrastructure

1.4 Software, Containers, Registries, DRP

4

4.1 Overall Project Management

4.2 Financial Management

4.3 Legal Management

4.4 Science Communication

TA2: Use Cases (Selection Today)

2.1 Science Data Platform

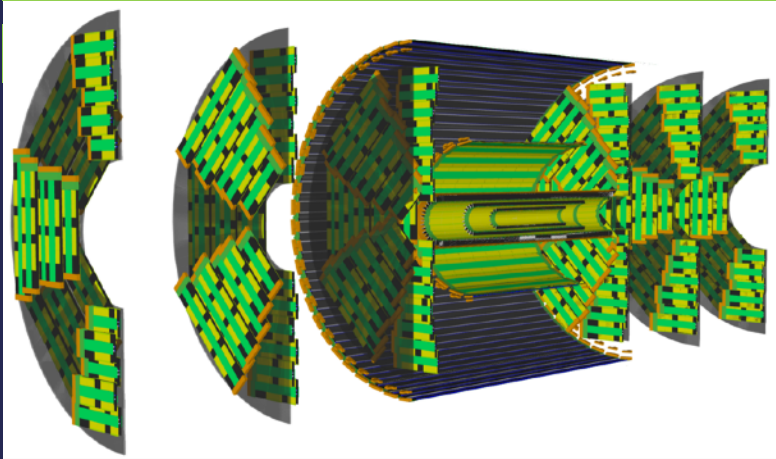
UC 2.2 Data Management Framework

UC 2.3 Data-Generating Simulations

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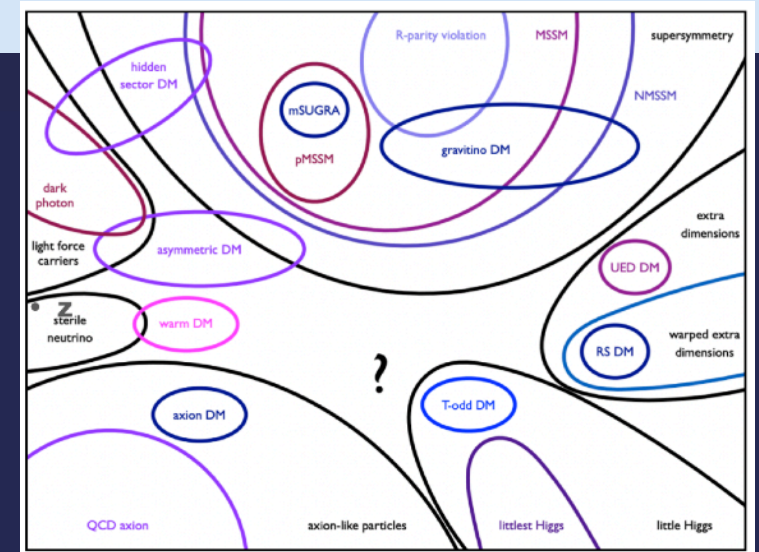


UC 2.6 FCC-ee detector simulation and physics studies

UC 2.2 Data Management Framework

- Support use case specific assembly of modules
- Build appropriate interfaces to ingest the data & metadata
 - Data validation during ingestion
- Develop search interfaces / GUI
- Configuration of ACS
- Consulting of users
- Maintenance

UC 2.4 Phenomenological Analysis



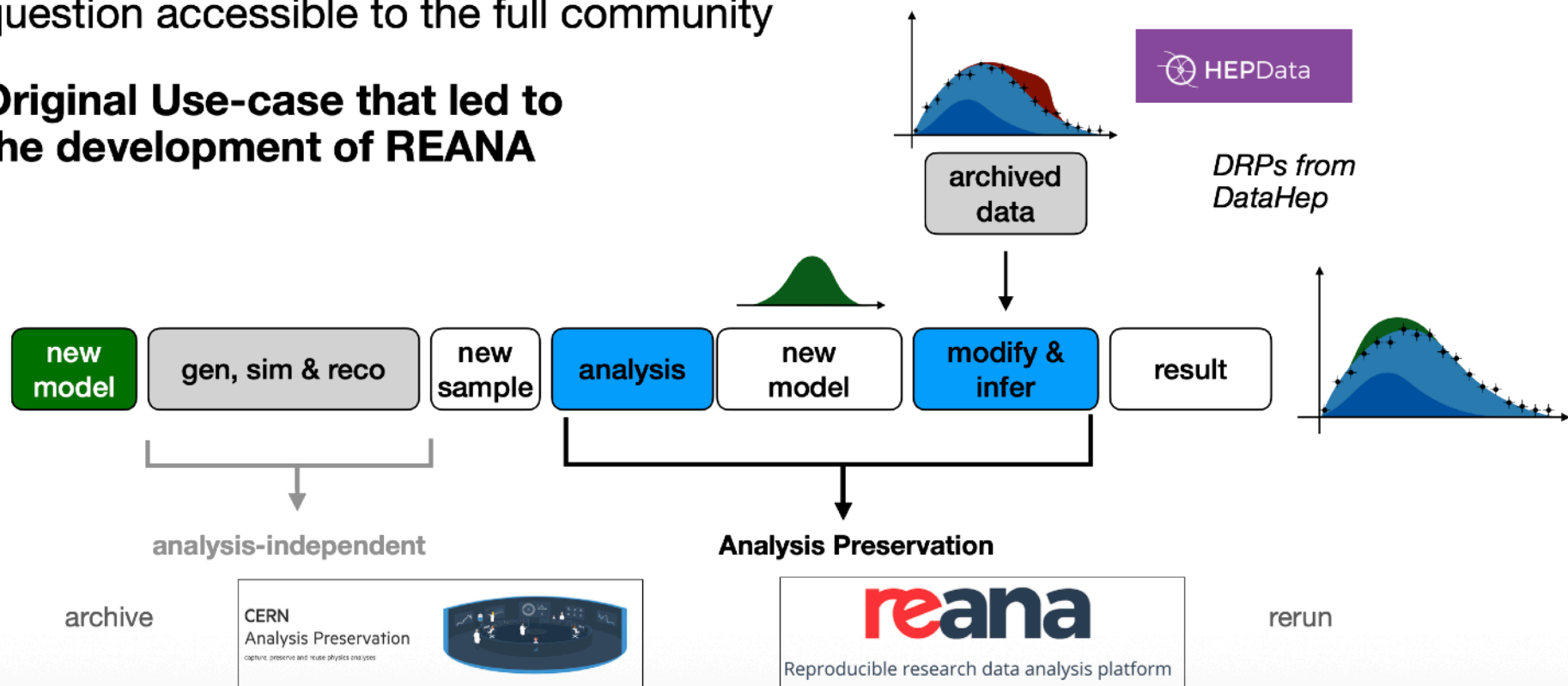
TA2: Use Case 2.4

HEP case: Answering “is my theory already excluded by the LHC” is difficult for outsiders

Reinterpretation

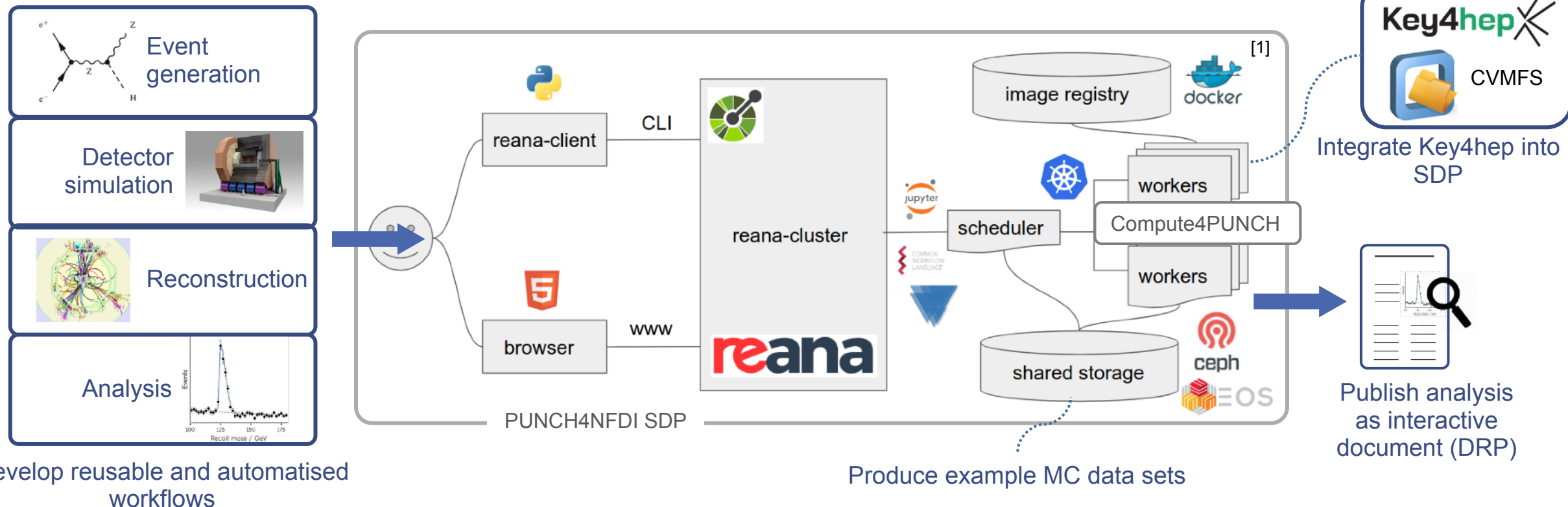
By preserving and reusing analysis pipelines, we can make answering this question accessible to the full community

Original Use-case that led to the development of REANA



- Implementation of interfaces to execute large-scale reinterpretations (HEP case) and analysis of structure formation simulations (astro case)
- Connect to NHR computing resources
- Provide data analysis examples for teachers and students

TA2: Use Case 2.6

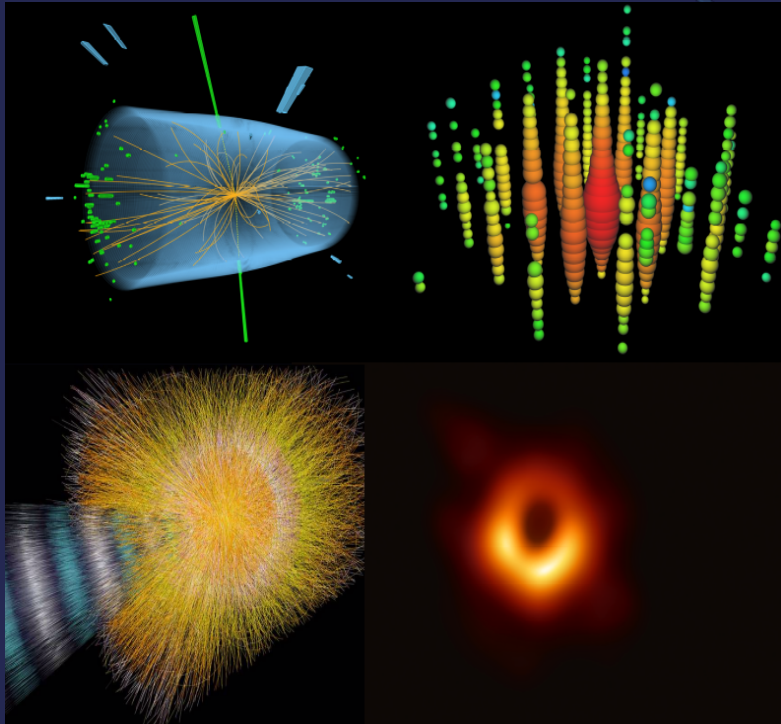


- Enables German HEP community to strongly contribute to preparations of the next flagship collider (physics studies, detector design and optimisation, later data analysis)
- A first of fully reproducible workflows in HEP (benefits for science, newcomers, outreach, D in FCC, ...)
- Involves complete set of components developed in PUNCH-2.0 for workflow management (SDP as environment, DRP to capture results, C4P, S4P, ...)!

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PUNCH Lines

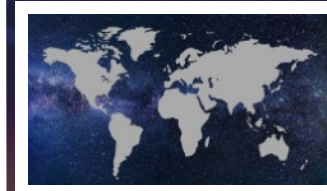


- FAIR science for PUNCH communities
- Synergies and learning from each other
- Longer-term impacts: Tools, methods, concepts for reproducible science, ...



- 2.1 Science Data Platform
- UC 2.2 Data Management Framework
- UC 2.3 Data-Generating Simulations
- UC 2.4 Phenomenological Analysis
- UC 2.5 Future Observations
- UC 2.6 Future Colliders
- UC 2.7 Large Datasets

- PUNCH Science Data Platform and DRP concept combined with workflow machinery and federated infrastructures
- SDP & DRP & DRPHub
- Use cases for dissemination



- Positioning of PUNCH4NFDI in the complex environment of NFDI, EOSC, international embedding, resource providers, ...
- Building a future (One)NFDI, sustainability, ...

Thank you!



The PUNCH4NFDI Consortium

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