Grant Agreement No: 101057511

# EURO-LABS

EUROpean Laboratories for Accelerator Based Science

HORIZON-INFRA-2021-SERV-01-07 Project EURO-LABS

## DELIVERABLE REPORT

# Release of the first functional version of the openNP catalogue

## DELIVERABLE: D5.3

| | |
|---|---|
| **Document identifier:** | EURO-LABS-Del-D5-3 |
| **Due date of deliverable:** | End of Month 35 (August 2025) |
| **Report release date:** | 31/08/2025 |
| **Work package:** | WP5: Open, Diverse and Inclusive Science |
| **Lead beneficiary:** | IFIC |
| **Document status:** | Final |

**Abstract:**

This document constitutes Deliverable D5.3 of the EURO-LABS project. It reports the status and technical details about the release of the first functional version of the openNP catalogue for nuclear physics experiments. This platform enables Research Infrastructures and researchers to centralize metadata for their datasets, supporting Open Science practices and alignment with FAIR data principles. By standardizing the submission and search of cross-domain metadata tailored to nuclear physics, openNP will enhance dataset findability for the scientific community and facilitate integration with future services in the European Open Science Cloud (EOSC) ecosystem.

The EUROpean Laboratories for Accelerator Based Science (EURO-LABS) project has received funding from the Horizon Europe programme dedicated to Research Infrastructure (RI) services advancing frontier knowledge under Grant Agreement no. 101057511. EURO-LABS began in September 2022 and will run for 4 years.

## Delivery Slip

| | Name | Partner | Date |
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Executive summary

*The aim of the EURO-LABS WP5.2 on Open Data is to provide the tools necessary for the community to share their scientific productions in a standardized way and respecting the FAIR principles, promoting reproducibility of the results, open science, and maximising cross-fertilisation by reuse of datasets. One of the key components to achieve this goal is openNP: a dataset catalogue adapted to the needs of the nuclear physics community. The present document reports on the specifications of the first release of openNP.*

*The openNP service, based on the InvenioRDM framework, allows authenticated and identified users to register datasets in an open access catalogue using persistent identifiers, ensuring they are traceable, findable, and citable. In openNP, each entry combines generic dataset metadata (aligned with existing metadata schemas) with nuclear physics–specific cross-domain metadata.*

*The platform does not aim at storing data directly, but rather references their existence, relation, and storage location.*

*The document outlines the technical architecture, hosting, authentication, data structuring, and integration of datasets into the catalogue, illustrated through a use case with a GANIL experiment dataset. It concludes with perspectives on long-term support, governance, data curation, and strategies for promoting adoption of the catalogue.*

## 1. INTRODUCTION

The Research Infrastructures (RI) in EURO-LABS are engaged in open science practices and FAIR practices of their data, software and science tools to allow reproducibility of science results and the development of open science analyses across domains and infrastructures.

The aim of EURO-LABS WP5.2 on Open science and Data is to provide the tools necessary for the communities to share their science products in a harmonised way respecting the FAIR principles, promoting reproducibility of the results, open science, and maximising cross-fertilisation by re-use of datasets. One of the key components to achieve this goal is the datasets catalogue. The present conceptual design report documents the work needed to build a demonstrator for the openNP catalogue.

# 2. DESCRIPTION OF THE OPENNP CATALOGUE

## 2.1. GOALS

The openNP catalogue (accessible at https://opennp.in2p3.fr) [1] is being developed as a central service for referencing and accessing nuclear physics datasets through a web application integrated into the European Open Science Cloud (EOSC).

In this context, datasets refer to collections of digital objects, such as data files, software, and documentation, described by structured metadata.

These metadata include both standard descriptors (*e.g.*, title, creators, contributors, etc.) and domain-specific elements relevant to RIs, such as experimental setups, beam characteristics, targets, facilities, data formats, analysis software and logbooks.

The openNP catalogue serves several core functions:

- Centralizing metadata records for nuclear physics experimental, simulated, and analyzed (processed) datasets;
- Acting as a trusted entry point for authenticated users to discover datasets via a web portal;
- Supporting findability and FAIR data practices across the EURO-LABS projects;
- Providing a standardized dataset registration procedure tailored to the needs of RIs and collaborations;
- Continuously integrating the requirements from participating RIs.

Importantly, openNP is designed as a metadata-only catalogue: it does not intend to host the datasets themselves. Instead, data remain stored at the producer level (RIs, collaborations, etc.), in accordance with their own Data Management Plan (DMP) and institutional policies. This separation ensures a unified, interoperable catalogue for dataset findability and referencing across EURO-LABS community projects.

## 2.2. TECHNICAL SPECIFICATIONS

### 2.2.1. FROM DATAVERSE TO INVENIORDM

Following the conceptual design described in Milestone Report MS35 [2], the Dataverse framework was initially considered for developing the openNP catalogue.

After further evaluation, we reconsidered our choice and finally adopted the InvenioRDM framework [3], because it better meets the specific requirements of a metadata repository for nuclear physics.

Similarly to Dataverse, InvenioRDM is an open-source framework widely adopted in the research ecosystem for managing repositories and data catalogues aligned with FAIR data principles. However, it offers a more flexible and extensible metadata model, allowing an easier integration of domain-specific fields and controlled vocabularies.

The architecture of InvenioRDM is built on the Flask Python framework, allowing a modular and easy integration with external tools and API[1]. It also interfaces with powerful search engines, such as OpenSearch [4], for advanced indexing and semantic search capabilities. Its modular user interface (UI) also facilitates customization and adaptation to RIs demands.

InvenioRDM also benefits from strong active community support, particularly from institutions like CERN (Zenodo service [5]), making it well-suited to the needs of accelerator-based and nuclear physics research.

Finally, by choosing InvenioRDM we also benefit from the support of the IN2P3 Computing Center [6] (CC-IN2P3). Indeed, CC-IN2P3 is working on a parallel InvenioRDM instance, providing a solid foundation for continuous integration and development of the catalogue, based on a OKD (OpenShift Kubernetes Distribution) infrastructure [7-9] and Helm Charts deployment [10].

### 2.2.2. THE INVENIORDM FRAMEWORK

InvenioRDM [3] is a turn-key open-source research data management repository solution built on the InvenioRDM Framework [11] and drawing on the experience and features developed for Zenodo [5].

It is a collaborative, open and transparent project governed by CERN and managed by a variety of research institutions with a common need to manage, curate and disseminate digital resources across disciplines and user communities.

The main features of InvenioRDM are:

- Simple and intuitive UIs;
- Records versioning, preview and embargo support;
- Custom vocabularies for resources types support;
- Support for registering DOI (Digital Object Identifier) with DataCite [12] (and also other schemes);
- Metadata aligned with the DataCite Metadata Schema [13];
- Auto-completed metadata fields (persistent identifiers, names, affiliations, ROR, ORCID, etc.) and pre-selected licenses;
- Versioned REST API for all operations on the repository;
- Various standard export formats for record's metadata (DataCite JSON/XML, Dublin Core, etc.);
- OAI-PMH protocol support for harvesting metadata [14];
- Citation formatting using the Citation Style Language (BibTex, etc.);
- Advanced query syntax (regular expression, custom sorting);

[1] Application Programming Interface: A set of protocols that enables software applications to communicate with each other.

- Integration of custom institutional authentication provider (KeyCloak [15]);
- Access control to records and share by link (records can be shared via secret links).

### 2.2.3. INFRASTRUCTURE OVERVIEW

The openNP catalogue is currently based on InvenioRDM v12.0 LTS.
This long-term support (LTS) version was released in July 2024 [16] and benefits from constant support of the InvenioRDM Community.
The openNP catalogue follows the same architecture as a basic InvenioRDM instance and consists of:

- A PostgreSQL **database** [17];
- A Redis **cache** [18]: Redis (REmote DIctionary Server) is an extensible key-value database management system offering low-latency reads and writes. It is used for caching the database;
- A **search solution** (OpenSearch [4]): it is a fully open source search and analytics suite used to explore, enrich, and visualize the data with built-in performance;
- A **message queue** (RabbitMQ [19]): it is a messaging/streaming broker, used to absorb notification load spikes, without interrupting the whole service;
- A **monitor background worker** (Celery [20]): Celery is an asynchronous task queue/job queue based on distributed message passing. It is used for executing tasks asynchronously. With InvenioRDM, the distributed job queue is made using Celery and takes care of executing jobs inside the Flask application.

### 2.2.4. HOSTING

The pre-production and production infrastructures of the application were deployed in collaboration with GANIL and CC-IN2P3 IT groups.

The source code of the application is available on a GitLab repository [21] and follows integrated CI/CD (Continuous Integration and Continuous Deployment) pipelines. This enables you to build and install a Container Registry with a Docker image of the full application [22].

This Docker image is then used in a custom Helm Chart [10], allowing deployment of the application on CC-IN2P3 OpenShift Kubernetes cloud [9] (OKD). OKD presents many advantages, including a web console and CLI tools to easily manage, deploy and scale our application with automated steps and configurations [7-8].

### 2.2.5. AUTHENTICATION AND AUTHORIZATION INFRASTRUCTURE

InvenioRDM supports local authentication, integration with institutional authentication systems or both at the same time.

We have successfully integrated the INDIGO IAM (Identity and Access Management) [23] external authentication service in openNP. It should be noted that this service was deployed for the first time for the nuclear physics community within EURO-LABS WP5.2 and enables a common authentication and authorization infrastructure (AAI) service for EURO-LABS RIs using federation logging in.

The employed INDIGO IAM instance is managed by IJCLab [24] and supports SSO (Single Sign-On), as illustrated in Fig.1, by integrating with institutional identity providers (IdPs) using standard SAML, OpenID Connect or Oauth2 protocols. This instance integrates with identity federations like eduGAIN [25].

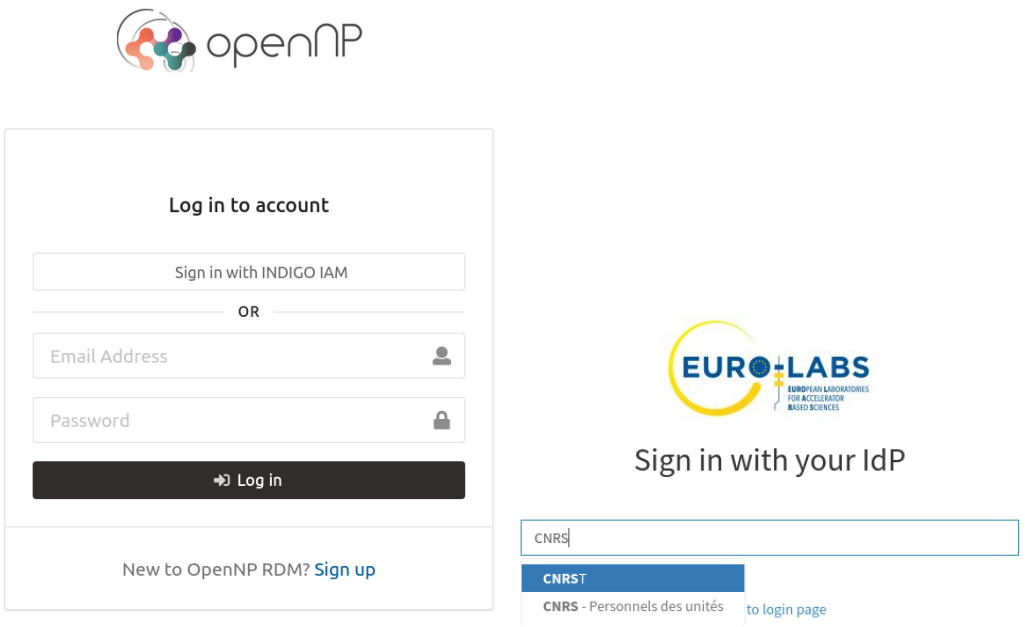


*Fig. 1: Integration of INDIGO IAM in openNP sign-in page (left) and usage of IAM EURO-LABS IdP for authentication (right) [24].*

## 2.3. DATA STRUCTURATION

### 2.3.1. DATASETS

A ***record*** is the core data model used to describe a resource in InvenioRDM [26]. It is a self-contained versioned metadata object, which follows a configurable schema aligned with DataCite metadata schema [13]. Thus, openNP datasets are described using *records* which include metadata, persistent identifiers (DOIs), access rights and versioning.

In InvenioRDM, *records* can be submitted by authenticated ***users***, either by a submission form directly from a browser or programmatically through the API. Each *record* is defined by a stage, either *draft* (unpublished, editable and private version) or *published* (versioned, immutable and publicly visible version).

Once published, the *record* is accessible through search and *record* landing pages of the instance. For a given resource, a *record version* is written every time a *record* is updated, while a *parent record* stores all properties that are common for all *record versions*.

The InvenioRDM's ***community*** feature enables defining a logical grouping of *users* with shared roles and responsibilities. Thus, *users* can submit *records* to a given *community* while the membership of the *community* grants additional permissions over the *records* submitted to it.

This logic allows us to define who can submit *records* and who can approve them. Also, *communities* can be either *public* (anyone can ask to join) or *restricted* (invitation only and limited visibility). It is also important to note that a *parent record* can be associated with multiple *communities*, allowing flexible cross-organizational collaborations.

By default, the following community roles are defined:

- ***owner***: can perform all actions over settings and members;
- ***manager***: can curate records and manage community members (except *owners*);
- ***curator***: can review/accept/reject records;
- ***reader***: can view and submit records in the community.

### 2.3.2. INTEGRATION IN OPENNP

In summary, in openNP we exploit InvenioRDM SSO integration to enable *users* to authenticate using their institutional identity provider. The catalogue is structured using *communities* that allow to gather and manage in one place deposits from identified RIs.

This setup allows an effective and versatile management of datasets, ensuring that publication, access and curation workflows align with institutional structures. New communities for new RIs or Detector collaboration (AGATA, GRIT, FAZIA, FRS, INDRA, PARIS, MUGAST, NUSTAR, etc.) can easily be added, as illustrated in Fig. 2.

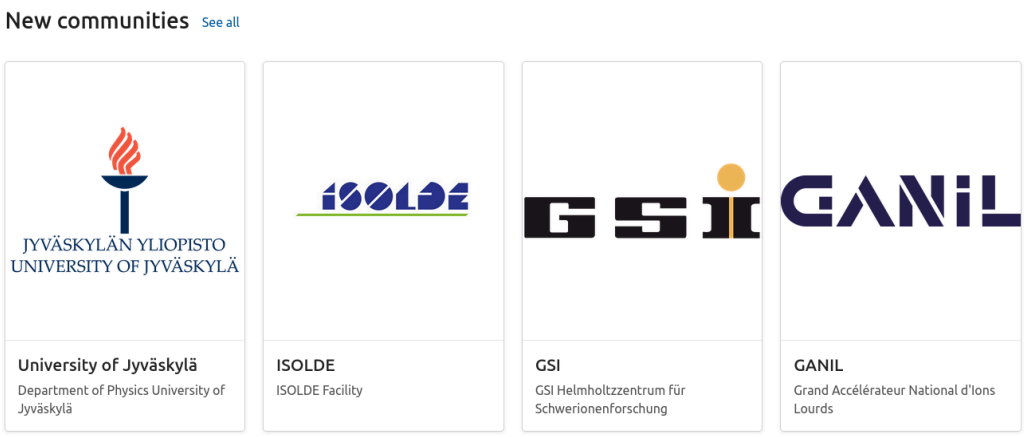


*Fig. 2: Example of communities created in openNP.*

## 2.4. DEMONSTRATION CASE: THE E793S GANIL DATASET

### 2.4.1. THE GANIL E793S DATASET

The e793s dataset originates from an experiment performed at GANIL in 2021, using the combination of VAMOS++, AGATA and MUGAST detection systems. This experiment focused on the first measurement of the $^{47}$K($d,p\gamma$)$^{48}$K transfer reaction, performed in inverse kinematics using a reaccelerated beam of $^{47}$K from the SPIRAL1 radioactive beam facility.

This dataset is an excellent representation of complex, multi-instrument and multi-collaboration experiments with several data and software layers. It has been chosen as a demonstrator for openNP capability to handle real-world experimental datasets and capture their entire acquisition, analysis and simulation environment.

As described in GANIL Data Policy [27], a DOI is created for each dataset record of a performed experiment. The DOI registration is done by the GANIL Data Manager through DataCite API [12]. This DOI uses the **10.26143** prefix, identifying GANIL as the publisher of the data.

A typical GANIL dataset consists of the ***unprocessed*** experimental data obtained from GANIL acquisition systems along with all associated metadata deemed necessary to exploit those data.
The complete list of metadata follows the GANIL metadata schema defined in the GANIL Data Management Plan (DMP). It consists of standard DataCite metadata completed by more specific metadata tailored to a GANIL experiment.

The e793s dataset led to the publication of a journal article [28], along with the release of the ***processed*** data and the ***software analysis codes*** used in this article, in open-access.

### 2.4.2. IMPLEMENTATION IN THE OPENNP CATALOGUE

The e793s dataset was implemented in openNP as follows:

- A first ***Dataset record*** was created for the ***unprocessed*** data of the experiment (published on DataCite [29]);
- A second ***Dataset record*** was created for the ***processed*** data used for the analysis (published on zenodo [30]);
- A ***Software record*** was created for the analysis codes used for the analysis of the experiment (published on Zenodo [31]).

All three records (based on their DOIs) were submitted to the GANIL *community* in openNP and thus followed a reviewing process before being accepted by the *members* with the appropriate *roles*.

Once accepted, the *records* are open-access and their metadata are searchable in openNP, as shown in Fig. 3.

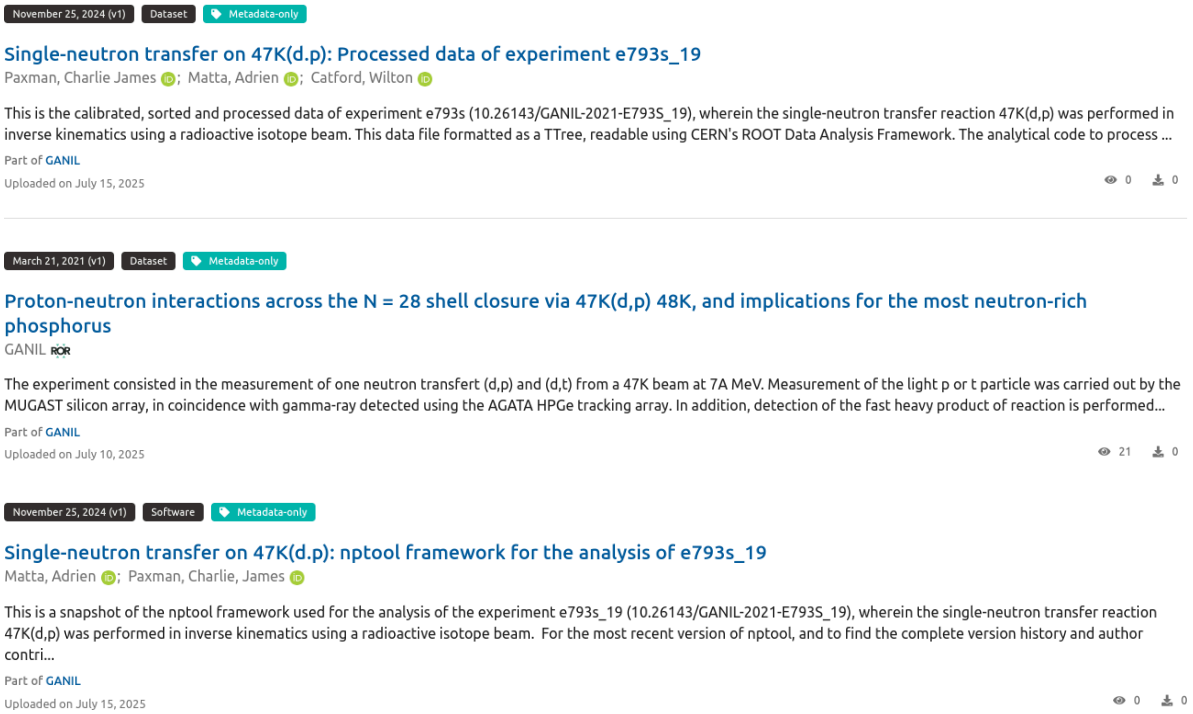


*Fig. 3: Search results for the e793s GANIL dataset in openNP.*

One of the key interests of using DataCite Metadata Schema is the possibility to define a ***RelatedIdentifer*** property to link a *record* with other *records*. More precisely, such property uses a ***relationType*** attribute to define the exact relation between the *records*, based on a unique identifier (*e.g* their DOI). The complete list of *relationType* and their usage is referenced in [32].

For example, for the e793s, this logic allows linking the *processed* data to the *unprocessed* data, along with the journal article and the software used for the analysis, as presented in Fig.4.

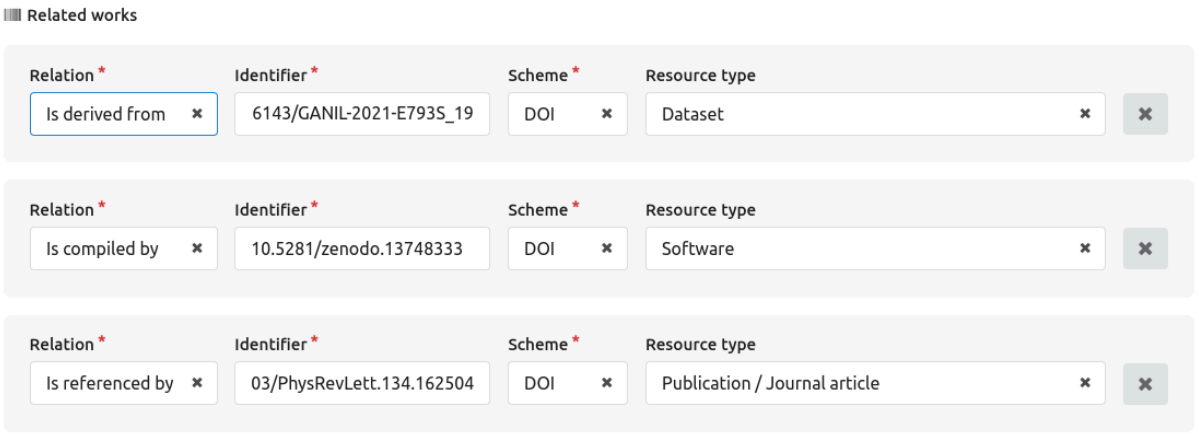


*Fig. 4: Illustration of the relations between records associated with the e793s GANIL dataset in openNP.*

### 2.4.3. TOWARDS AUTOMATIC FETCHING OF THE RESEARCH INFRASTRUCTURE DOIS

We would like to stress that the InvenioRDM community has already released various tools enabling a user to speed up the process of submitting *records* to an InvenioRDM instance using its API.

As an example, it is possible to use the ***commonmeta*** CLI tool [33] to fetch and convert metadata from various repositories (*e.g* Crossref [34], DataCite [12] or another InvenioRDM instance) and create the corresponding *record* in openNP.

# 3. PERSPECTIVES

## 3.1. CUSTOMIZATION OF FIELDS AND VOCABULARIES

While the InvenioRDM metadata [13] schema includes a wide range of standard bibliographic fields, it needs to be adapted to include nuclear physics specific information relevant for the EURO-LABS RIs.

This can be achieved by adding custom ***fields*** and ***vocabularies*** to the *records*.
In InvenioRDM, a *field* is a specific metadata element of a *record* while a *vocabulary* is a controlled set of terms used inside defined *fields*. In other words, *fields* are used to extend the default *record*'s metadata schema while *vocabularies* are used to customize, standardize and support the filtering/discovery with search services.

We are currently working on customizing openNP to include cross-domain metadata. The main issue we encountered is the lack of comprehensive metadata schema for nuclear physics. In the context of EURO-LABS, we are planning to extend the *record*'s metadata schema based on the standard proposed by the NAPMIX (Nuclear, Astro, and Particle Metadata Integration for eXperiments) project [35]. This is a work in progress as we are actively participating in NAPMIX.

## 3.2. AUTOMATIC IMPORT OF THE DATASETS

A convenient tool to automate the import of datasets is the ***commonmeta*** library.
Indeed, *commonmeta* relies on standard metadata schemas, such as DataCite or Crossref, and is suitable to convert generic metadata from a standard to another, including the InvenioRDM format.

With *commonmeta*, we successfully automated the fetching of GANIL experiment datasets [36] from DataCite API [12] and imported them into openNP. This process can be adapted to import datasets from other laboratories, as long as the metadata standard adopted by the RI is covered by *commometa*.

Nonetheless, we still need to foresee the import of metadata specific to nuclear physics, such as beam, target and setup information. To this purpose, the implementation into *commonmeta* of a cross-domain metadata schema for nuclear physics, such as the one proposed by the NAPMIX project [35] is a good option.

The developed tools to inject the dataset in openNP will be shared with RIs of EURO-LABS.

## 3.3. PROMOTION OF THE CATALOGUE

To promote the catalogue to the EURO-LABS RIs, we plan to:

- Present openNP at the Fourth EURO-LABS Annual Meeting, planned in September 2025 [37];
- Promote openNP within the RIs;
- Continuously integrate GANIL datasets as proof of concept.

## 3.4. EXTENSION TO COLLABORATIONS

The proposed integration of datasets in openNP is currently adapted to the laboratory scale. Indeed, we purposely want to restrict the creation of *communities* to Research Infrastructures, while this is also a limitation from the InvenioRDM v12 framework.

On a longer time scale, we plan to narrow-down this concept to a collaboration scale. This is a work in progress, made possible with the recent release of InvenioRDM v13 that introduced the notion of a hierarchical relationships between *communities* through ***sub-communities***.

This will allow defining collaborations (*e.g.* AGATA, GRIT, INDRA-FAZIA, NFS, NUSTAR, etc.) as *sub-communities*, where *records* are automatically indexed in parent *communities* (laboratories).

## 3.5. ESTABLISH POLICIES AND GOVERNANCE

To ensure the sustainability, quality assurance and alignment of openNP with the needs of the EURO-LABS RIs, we have to establish a governance framework.

This framework is based on a **Governing Board**, consisting of 5 to 6 members from different RIs that will:

- Ensure strategic oversight of the catalogue;
- Establish the general policies for metadata curation, preservation and access;
- Ensure alignment with open science and FAIR data principles;
- Define priorities for future development, integrations and service extension;
- Manage the creation of communities and endorse the data curator members;
- Handle potential conflicts during the data curation process.

Concerning the **Policy framework**, a periodic review of key policy documents will be ensured by the Governance board, including:

- **Metadata Schema**: to define what metadata fields are mandatory, recommended, and optional and specify the usage of vocabularies for the nuclear domain-specific terms;
- **Access and Sharing Policy**: to define general rules for the *records*, *communities* and API usage and access conditions;
- **Governance Policy**: to specify the workflow for decision-making processes, roles, responsibilities, and community participation.

This governance process will follow a transparent communication model, with roadmap updates and continuous consultation from RIs.

The first governing board will be constituted after the Fourth Annual Meeting of EURO-LABS, where a call for interest will be presented to the EURO-LABS community.

## 3.6. DATA CURATION

As mentioned, the governing board is responsible for defining general policies for metadata curation, preservation and access, to ensure metadata quality across records.

As a start, it is necessary to define governance responsibility at a general but also at a *community* scale. This is mandatory to provide a standardized dataset registration procedure tailored to the needs of RIs (and collaborations).

This includes:

- Defining **curation workflows** and assigning **responsibilities** (*e.g.*, curator roles);
- Setting **validation policies**, including controlled *vocabularies*;
- Establishing **cross-institutional curator support** mechanisms to ensure consistent metadata across records coming from different *communities*.

Concerning the curation workflows, there are already mechanisms of curation checks in InvenioRDM at a *community* level [38]. Such checks provide a way to run automated verification on *draft review* and *record inclusion* requests for a given *community*.

For openNP, following the InvenioRDM default *community roles*, we plan to define a list of *managers*, allowed to curate *records* and manage *community* members for the involved RIs. The *managers* are thus responsible for establishing the list of *curators* for their own *community*. With the help of the governance board, it will be possible for the community managers to define specific deposition workflow, tailored to their *community* needs.

It is worth noting that the data curation workflow is a hot topic in the InvenioRDM community and subject to many developments for the upcoming versions. Currently, the adopted solution relies on a default deposition process that can be adapted to a more advanced one if necessary.

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## ANNEX: GLOSSARY

| Acronym | Definition |
|---|---|
| AAI | Authentication and Authorization Infrastructure |
| API | Application Programming Interface |
| CI/CD | Continuous Integration/Continuous Delivery |
| DOI | Digital Object Identifier |
| EOSC | European Open Science Cloud |
| FAIR | Findable, Accessible, Interoperable, Reusable |
| IAM | Identity and Access Management |
| IdP | Identity Provider (service) |
| OAI-PMH | Open Archives Initiative Protocol for Metadata Harvesting |
| OKD | OpenShift Kubernetes Distribution |
| ORCID | Open Researcher and Contributor ID |
| REST API | REpresentational State Transfer API |
| RI | Research Infrastructure |
| ROR | Research Organization Registry |
| SSO | Single Sign-On (authentication scheme) |
| UI | User Interface |
| WP | Work Package |