

# ● The Metadata4Ing Ontology

## Metadata4Ing Working Group

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Dorothea Iglezakis (IZUS/UB Stuttgart)

All contributors:

[https://git.rwth-aachen.de/nfdi4ing/metadata4ing/metadata4ing/-  
/blob/master/documentation/Authors.md](https://git.rwth-aachen.de/nfdi4ing/metadata4ing/metadata4ing/-/blob/master/documentation/Authors.md)

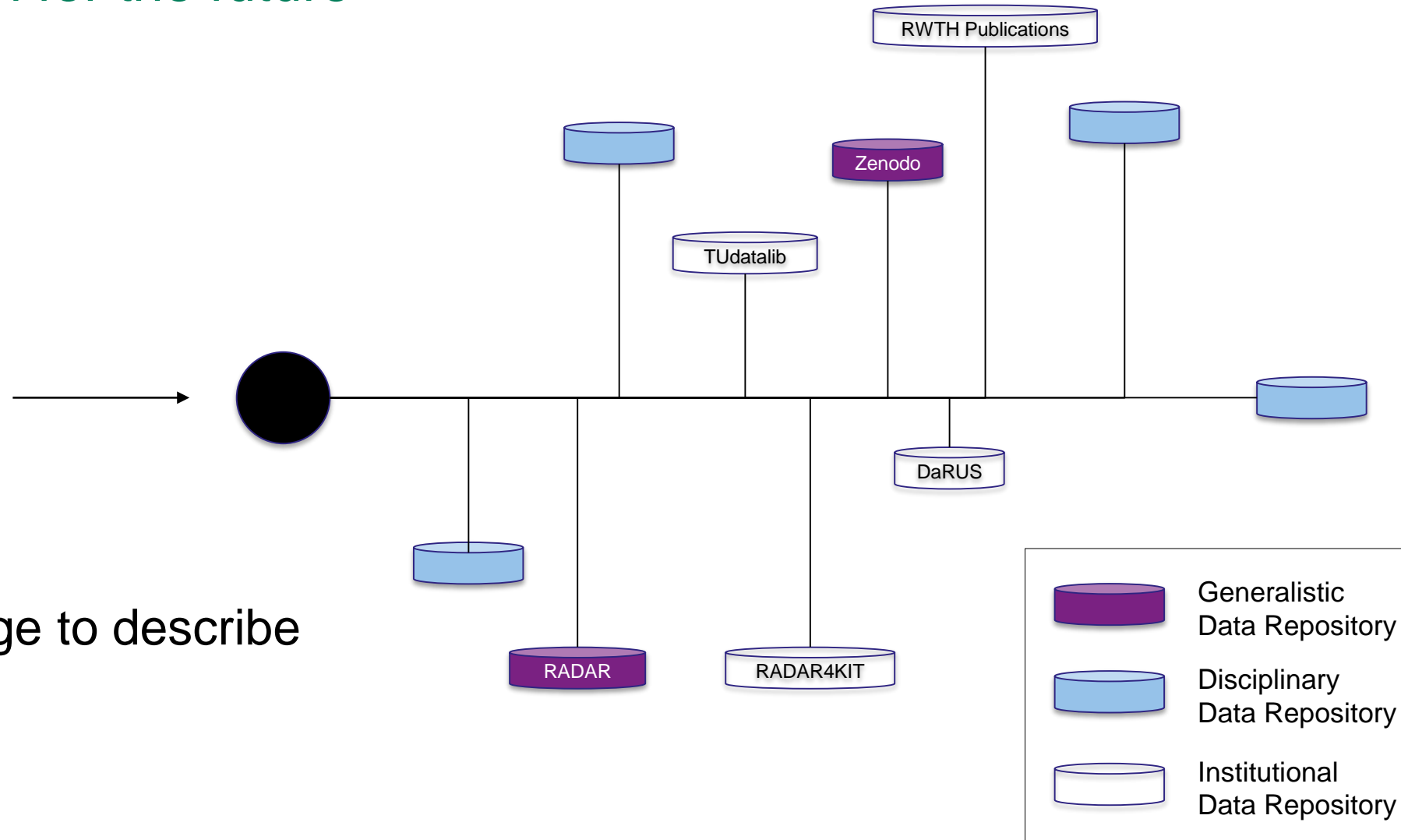
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# Motivation

## Vision for the future

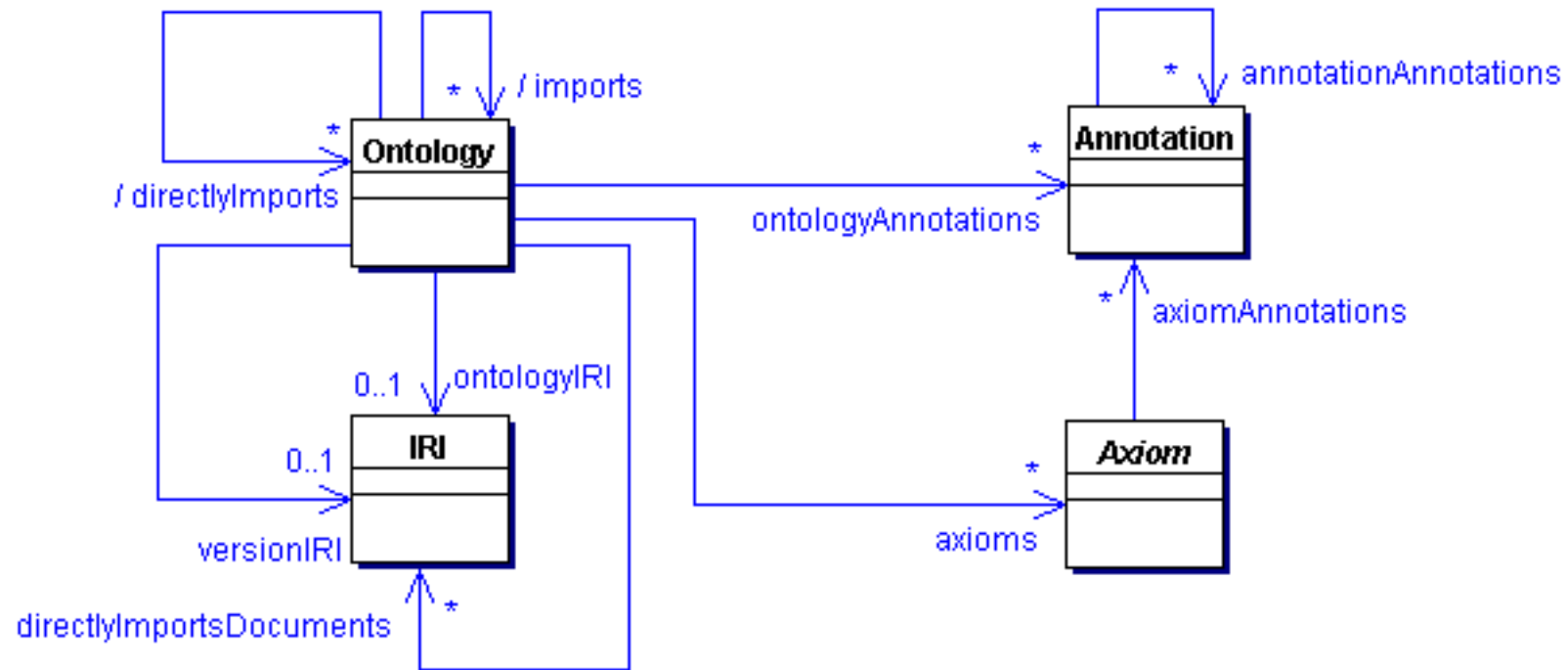


Common language to describe  
engineering data



## ● Basic elements and scope

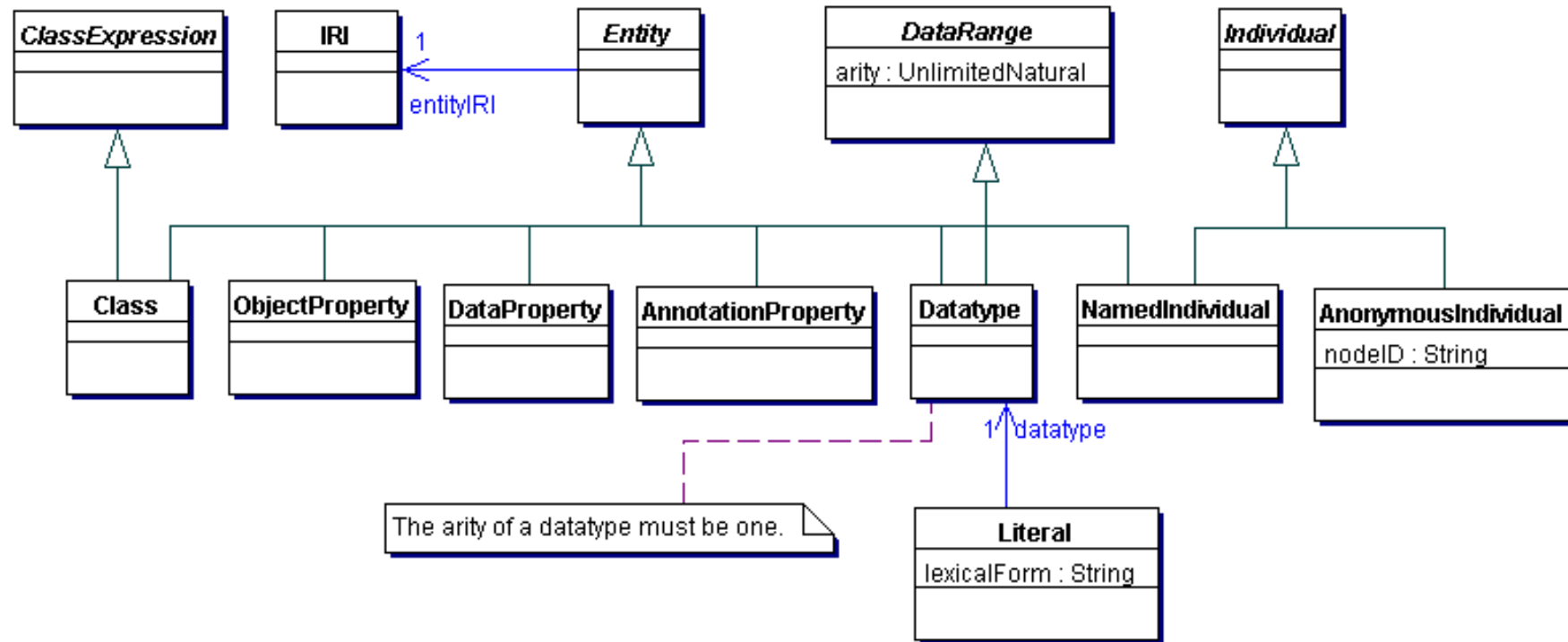
## Ontology elements



Source:

*OWL 2 Web Ontology Language: Structural Specification and Functional-Style Syntax (Second Edition)* Boris Motik, Peter F. Patel-Schneider, Bijan Parsia, eds. W3C Recommendation, 11 December 2012, <http://www.w3.org/TR/2012/REC-owl2-syntax-20121211/>. Latest version available at <http://www.w3.org/TR/owl2-syntax/>. Copyright © 2012 W3C® (MIT, ERCIM, Keio), All Rights Reserved. W3C [liability](#), [trademark](#) and [document use](#) rules apply.

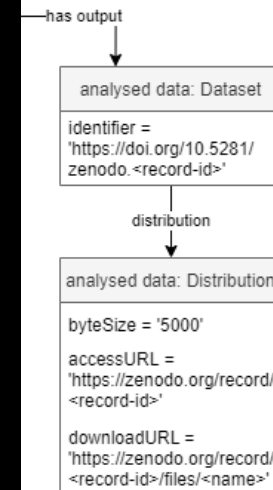
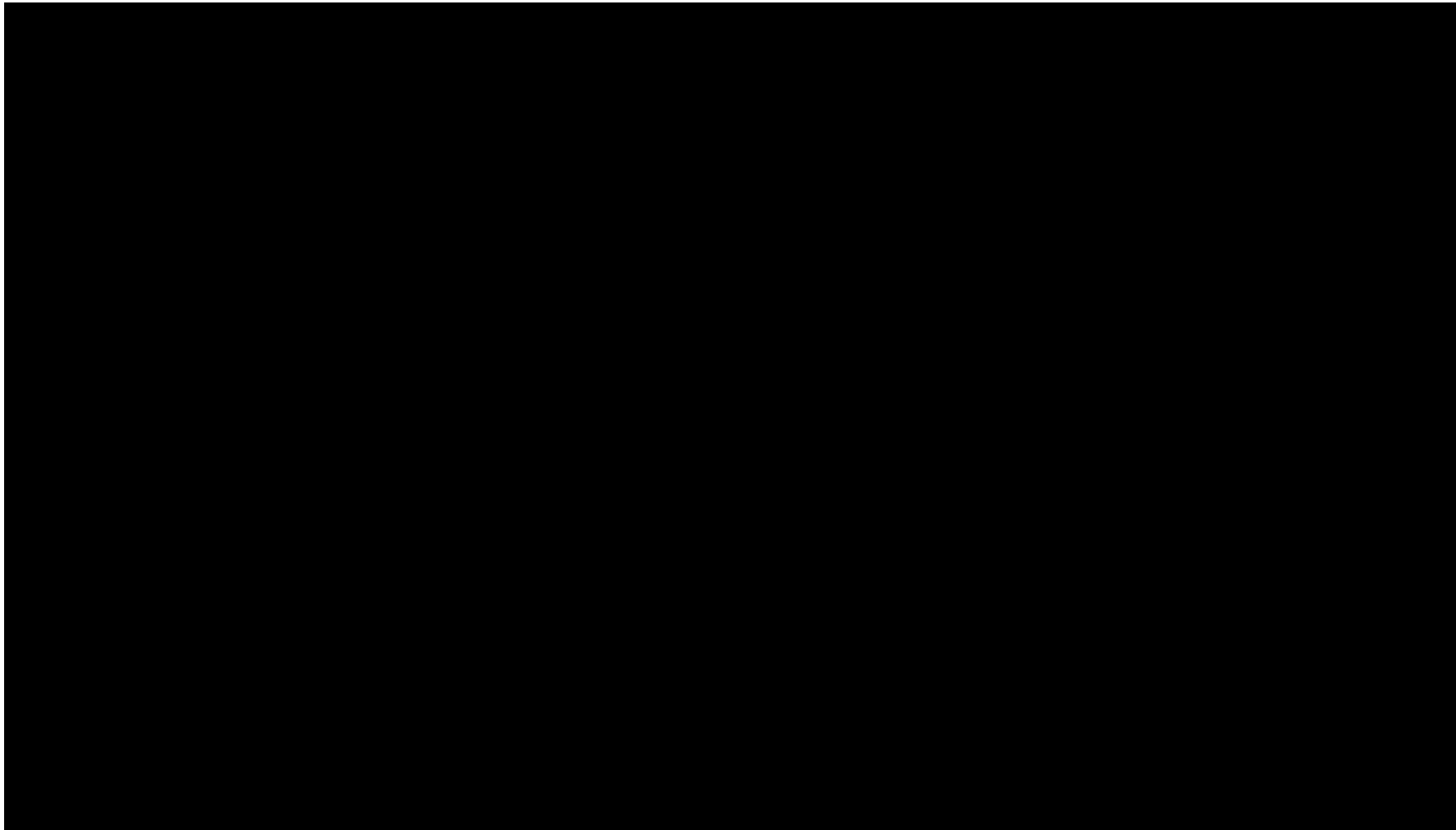
## Ontology elements



Source:

*OWL 2 Web Ontology Language: Structural Specification and Functional-Style Syntax (Second Edition)* Boris Motik, Peter F. Patel-Schneider, Bijan Parsia, eds. W3C Recommendation, 11 December 2012, <http://www.w3.org/TR/2012/REC-owl2-syntax-20121211/>. Latest version available at <http://www.w3.org/TR/owl2-syntax/>. Copyright © 2012 W3C® (MIT, ERCIM, Keio), All Rights Reserved. W3C liability, trademark and document use rules apply.

## Metadata4Ing – Scope & Overview

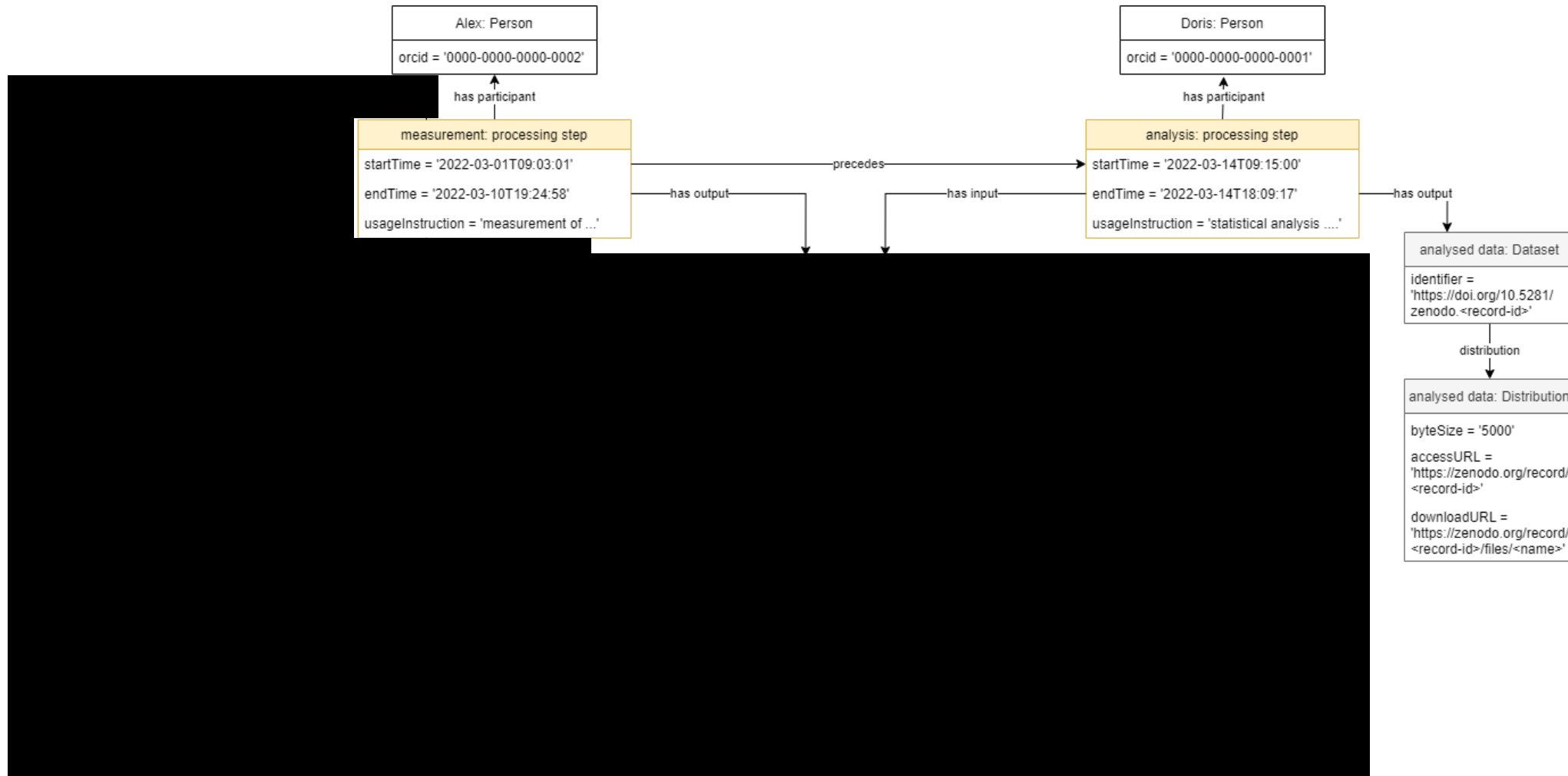


## Metadata4Ing – Scope & Overview

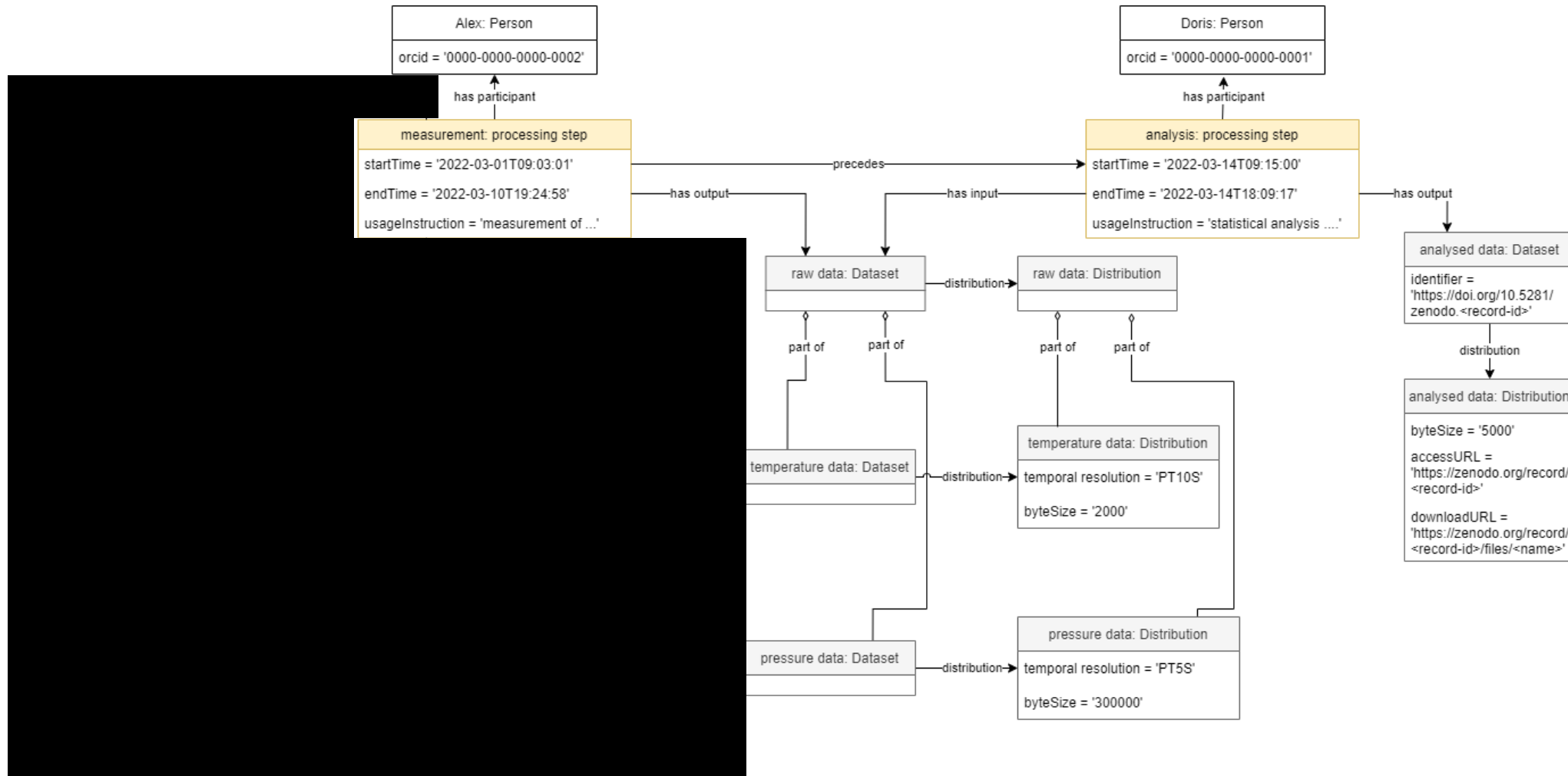




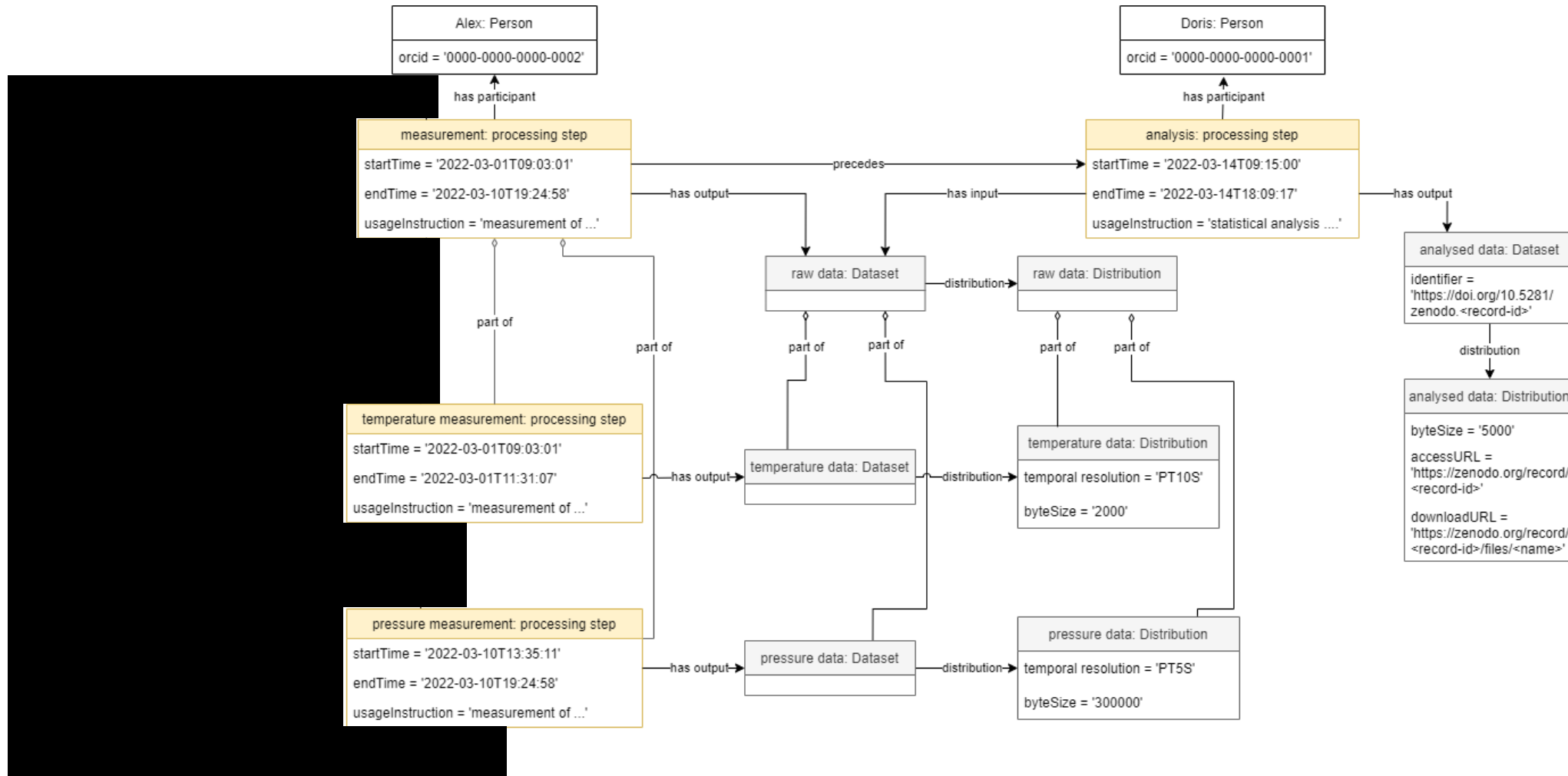
## Metadata4Ing – Scope & Overview



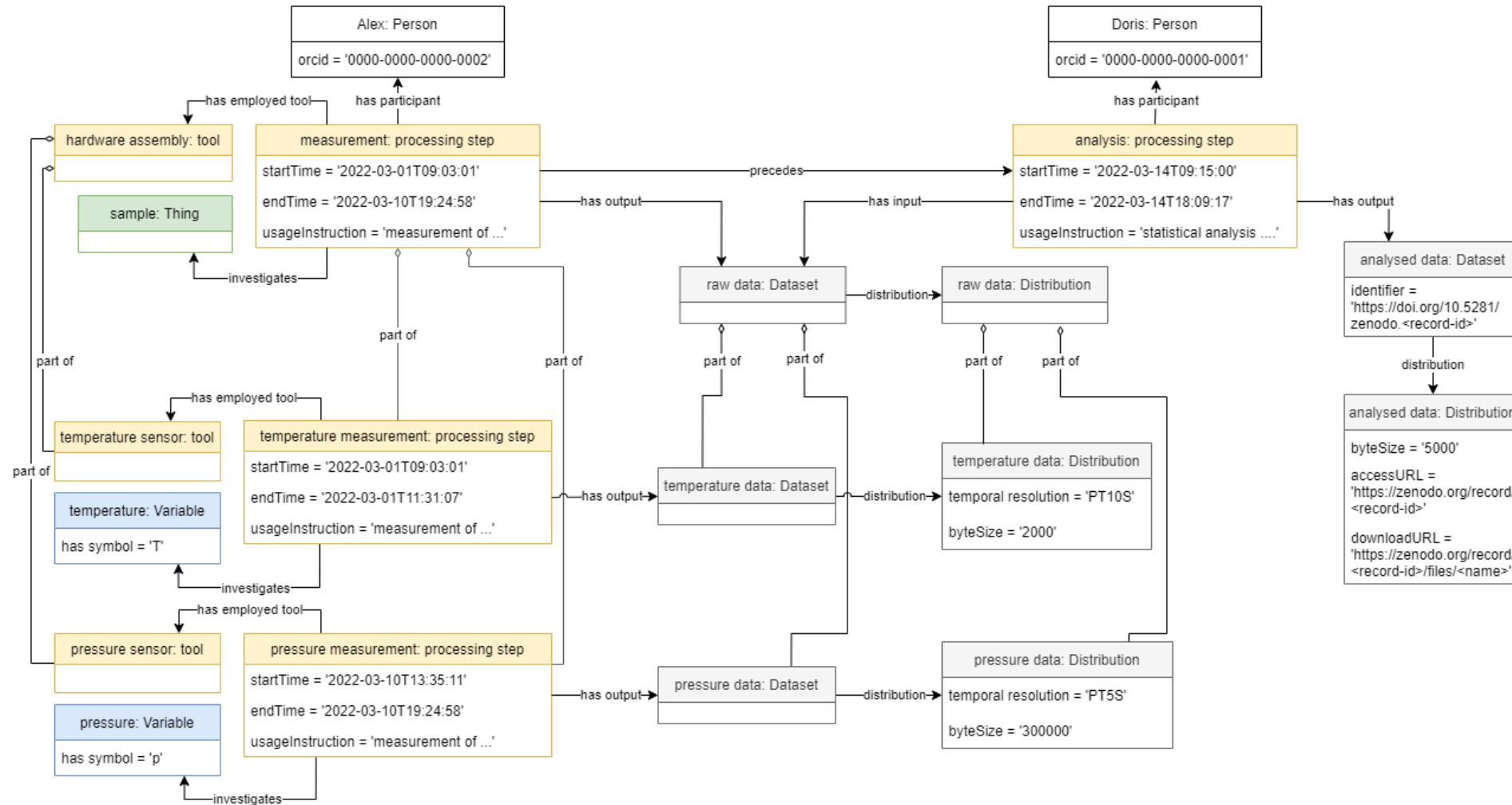
## Metadata4Ing – Scope & Overview



## Metadata4Ing – Scope & Overview



# Metadata4Ing – Scope & Overview



## ● Metadata & application Example

## The example (from Matthias Ruf & Holger Steb)

**Publication:** <https://doi.org/10.1063/5.0019541> ~~~ **DataSet:** <https://doi.org/10.18419/darus-639>

- Examination of a sample (asphalt concrete) with an XRCT-scanner
  - Step 1: preparation and positioning of the sample, and configuration of the parameters
  - Step 2: data generation in form of the XRCT scan,
  - Step 3: image processing with the help of reconstruction algorithms and
  - Step 4: post-processing of the data
  
- Experimental Set-up (cf. Figure 1 in <https://doi.org/10.1063/5.0019541>)
  - holder for precise sample positioning
  - X-Ray source
  - detector
  
- Result
  - Images/ radiograms (cf. Figure 9 in <https://doi.org/10.1063/5.0019541>)
  - 3D reconstructions

## Metadata description in JSON-LD

### Set up a JSON file

```
{  
  "@context":  
  {  
  },  
  "@graph": [ ]  
}
```

used to map terms to IRIs

Contains all the metadata related to the dataset

## Metadata description in JSON-LD

### Import context file

```
{
  "@context":
  {
    "@import": "https://w3id.org/nfdi4ing/metadata4ing/m4i_context.jsonld",
  },
  "@graph": [ ]
}
```

m4i-based context file



## Metadata description in JSON-LD

### Context file excerpt

Define prefixes for  
namespaces

```
{
  "@context" : {
    "@vocab" : "http://w3id.org/nfdi4ing/metadata4ing#",
    "m4i" : "http://w3id.org/nfdi4ing/metadata4ing#",
    "dcat" : "http://www.w3.org/ns/dcat#",
    "dcterms" : "http://purl.org/dc/terms/",
    "foaf" : "http://xmlns.com/foaf/0.1/",
    "owl" : "http://www.w3.org/2002/07/owl#",
    "prov" : "http://www.w3.org/ns/prov#",
    "qudt" : "http://qudt.org/schema/qudt/",
    "rdf" : "http://www.w3.org/1999/02/22-rdf-syntax-ns#",
    "rdfs" : "http://www.w3.org/2000/01/rdf-schema#",
    "schema" : "https://schema.org/",
    "skos" : "http://www.w3.org/2004/02/skos/core#",
    "ssn" : "http://www.w3.org/ns/ssn/",
    "emmo" : "http://emmo.info/emmo#",
    "obo" : "http://purl.obolibrary.org/obo/",
    "pims-ii" : "http://www.molmod.info/semantics/pims-ii.ttl#",
    "preferred label" : {"@id": "skos:prefLabel"},
    "label" : {"@id": "rdfs:label"},
    "description" : {"@id": "dcterms:description"},
    "measurement unit" : {"@id": "emmo:EMMO_b081b346_7279_46ef_9a3d_2c088fcd79f4"},
    "process" : {"@id": "obo:BFO_0000015"},
    "realizable entity" : {"@id": "obo:BFO_0000017"}
  }
}
```

Info on used vocabulary

Map terms to  
prefixed IRIs

## Metadata description in JSON-LD

### Context file excerpt

Define prefixes for  
namespaces

```
{  
  "@context" : {  
    "@vocab" : "http://w3id.org/nfdi4ing/metadata4ing#",  
    "m4i" : "http://w3id.org/nfdi4ing/metadata4ing#",  
    "dcat" : "http://www.w3.org/ns/dcat#",  
    "dcterms" : "http://purl.org/dc/terms/",  
    "foaf" : "http://xmlns.com/foaf/0.1/",  
    "owl" : "http://www.w3.org/2002/07/owl#",  
    "prov" : "http://www.w3.org/ns/prov#",  
    "qudt" : "http://qudt.org/schema/qudt/",  
    "rdf" : "http://www.w3.org/1999/02/22-rdf-syntax-ns#" .  
  }  
}
```

Info on used vocabulary

**label = <http://www.w3.org/2000/01/rdf-schema#label>**

Map terms to  
prefixed IRIs

```
    "skos" : "http://www.w3.org/2004/02/skos/core#",  
    "ssn" : "http://www.w3.org/ns/ssn/",  
    "emmo" : "http://emmo.info/emmo#",  
    "obo" : "http://purl.obolibrary.org/obo/",  
    "pims-ii" : "http://www.molmod.info/semantics/pims-ii.ttl#",  
    "preferred label": {"@id": "skos:prefLabel"},  
    "label": {"@id": "rdfs:label"},  
    "description": {"@id": "dcterms:description"},  
    "measurement unit": {"@id": "emmo:EMMO_b081b346_7279_46ef_9a3d_2c088fcd79f4"},  
    "process" : {"@id": "obo:BFO_0000015"},  
    "realizable entity" : {"@id": "obo:BFO_0000017"}  
  }  
}
```

## Metadata description in JSON-LD

### Define local namespace + add processing steps

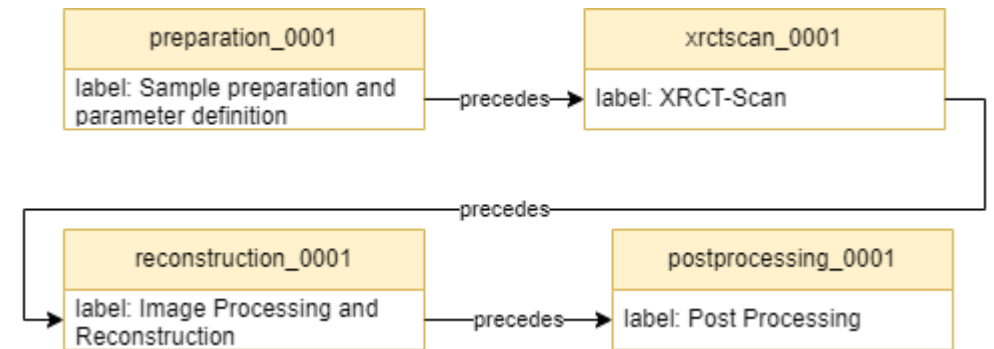
```
{
  "@context":
  {
    "@import": "https://w3id.org/nfdi4ing/metadata4ing/m4i_context.jsonld",
    "local": "https://local-domain.org"
  },
  "@graph": [
    {
      "@id": "local:preparation_0001",
      "@type": "processing step",
      "label": "Sample preparation and parameter definition"
    },
    {
      "@id": "local:xrctscan_0001",
      "@type": "processing step",
      "label": "XRCT-Scan"
    },
    {
      "@id": "local:reconstruction_0001",
      "@type": "processing step"
    }
  ]
}
```

Add processing  
steps

Define local  
namespace

## Connect processing steps

```
{  
  ...  
  "@graph": [  
    {  
      "@id": "local:preparation_0001",  
      "@type": "processing step",  
      "label": "Sample preparation and parameter definition",  
      "precedes": "local:xrctscan_0001"  
    },  
    {  
      "@id": "local:xrctscan_0001",  
      "@type": "processing step",  
      "label": "XRCT-Scan",  
      "precedes": "local:reconstruction_0001"  
    },  
    {  
      "@id": "local:reconstruction_0001",  
      "@type": "processing step",  
      "label": "Image Processing and Reconstruction",  
      "precedes": "local:postprocessing_0001"  
    },  
    {  
      "@id": "local:postprocessing_0001",  
      "@type": "processing step",  
      "label": "Post Processing"  
    }  
  ]  
}
```



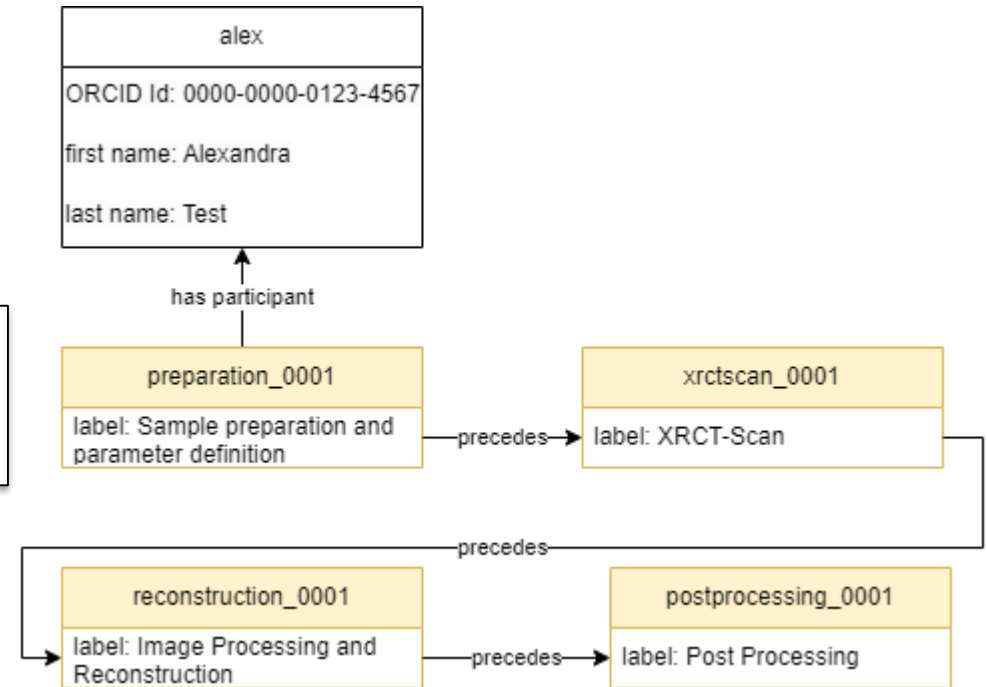
### Legende

Processing Step

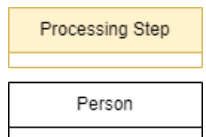
## Add actors

```
{
  ...
  "@graph": [
    {
      "@id": "local:preparation_0001",
      "@type": "processing step",
      "label": "Sample preparation and parameter definition",
      "precedes": "local:xrctscan_0001",
      "has participant": "local:alex"
    },
    ...
    {
      "@id": "local:alex",
      "@type": "person",
      "ORCID Id": "0000-0000-0123-4567",
      "first name": "Alexandra",
      "last name": "Test"
    }
  ]
}
```

Add actor to step



### Legende

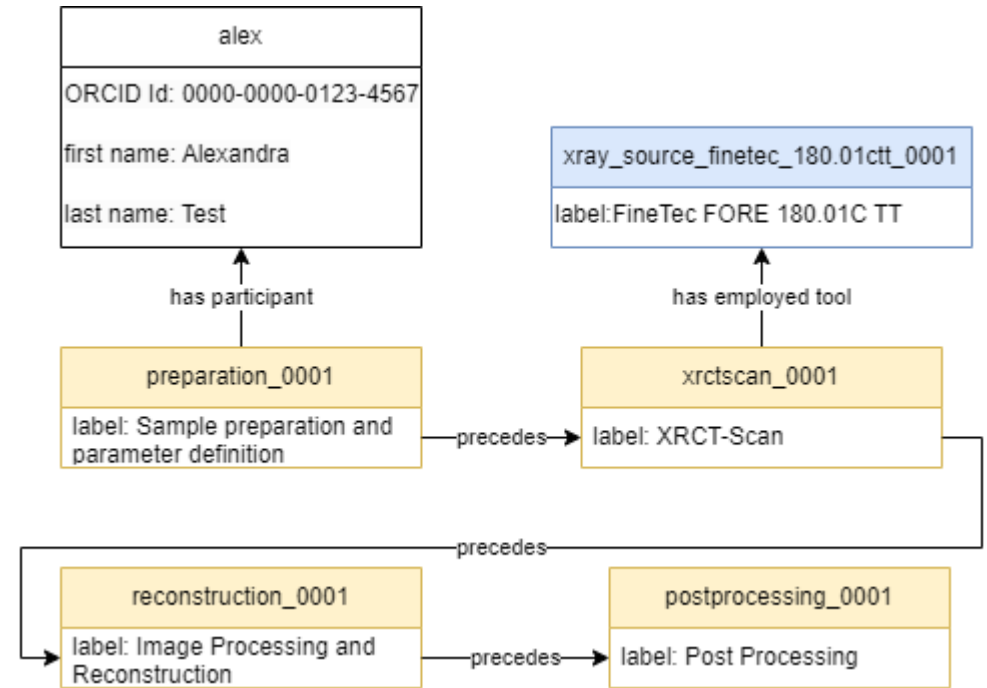


## Add tool

```

...
"@graph": [
  ...
  {
    "@id": "local:xrctscan_0001",
    "@type": "processing step",
    "label": "XRCT-Scan",
    "has employed tool":
      "local:xray_source_finotec_180.01ctt_0001"
  },
  ...
  {
    "@id": "local:xray_source_finotec_180.01ctt_0001",
    "@type": "tool",
    "label": "FineTec FORE 180.01C TT"
  }
]
}

```

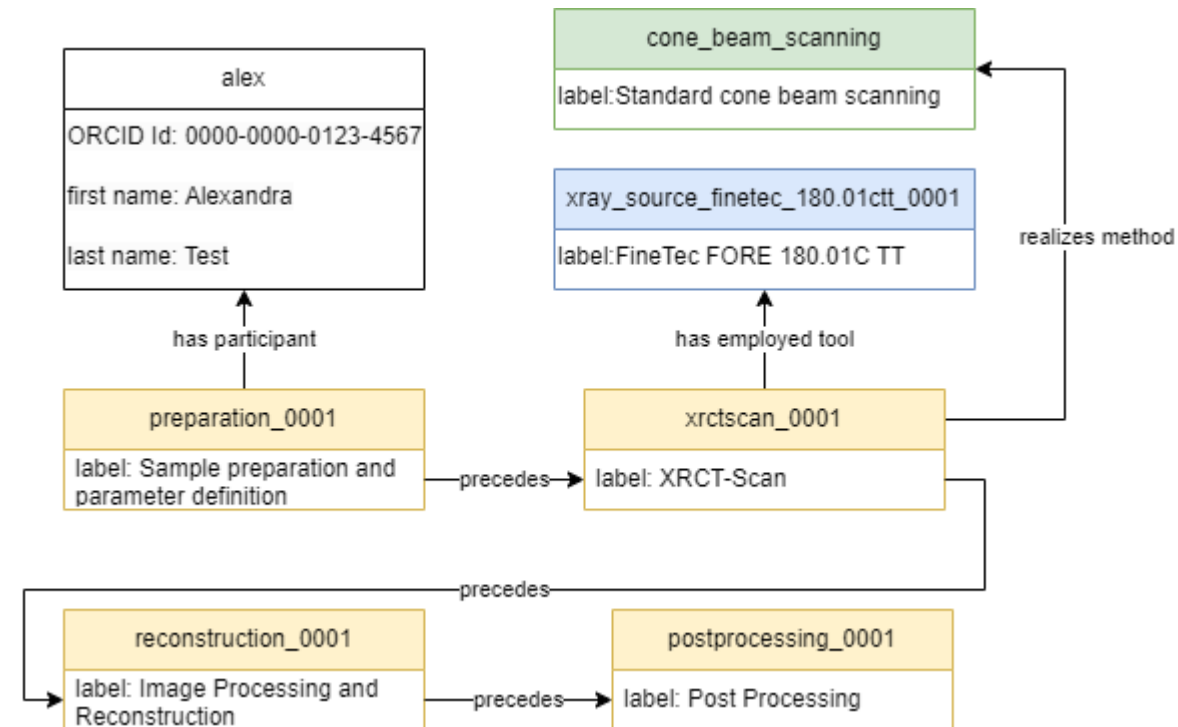


### Legende



## Add method

```
{
  ...
  "@graph": [
    ...
    {
      "@id": "local:xrctscan_0001",
      "@type": "processing step",
      "label": "XRCT-Scan",
      "has employed tool":
        "local:xray_source_finotec_180.01ctt_0001",
      "realizes method": "local:cone_beam_scanning"
    },
    ...
    {
      "@id": "local:xray_source_finotec_180.01ctt_0001",
      "@type": "tool",
      "label": "FineTec FORE 180.01C TT"
    },
    {
      "@id": "local:cone_beam_scanning",
      "@type": "method",
      "label": "Standard cone beam scanning",
      "description":
        "Standard cone beam scanning"
    }
  ]
}
```

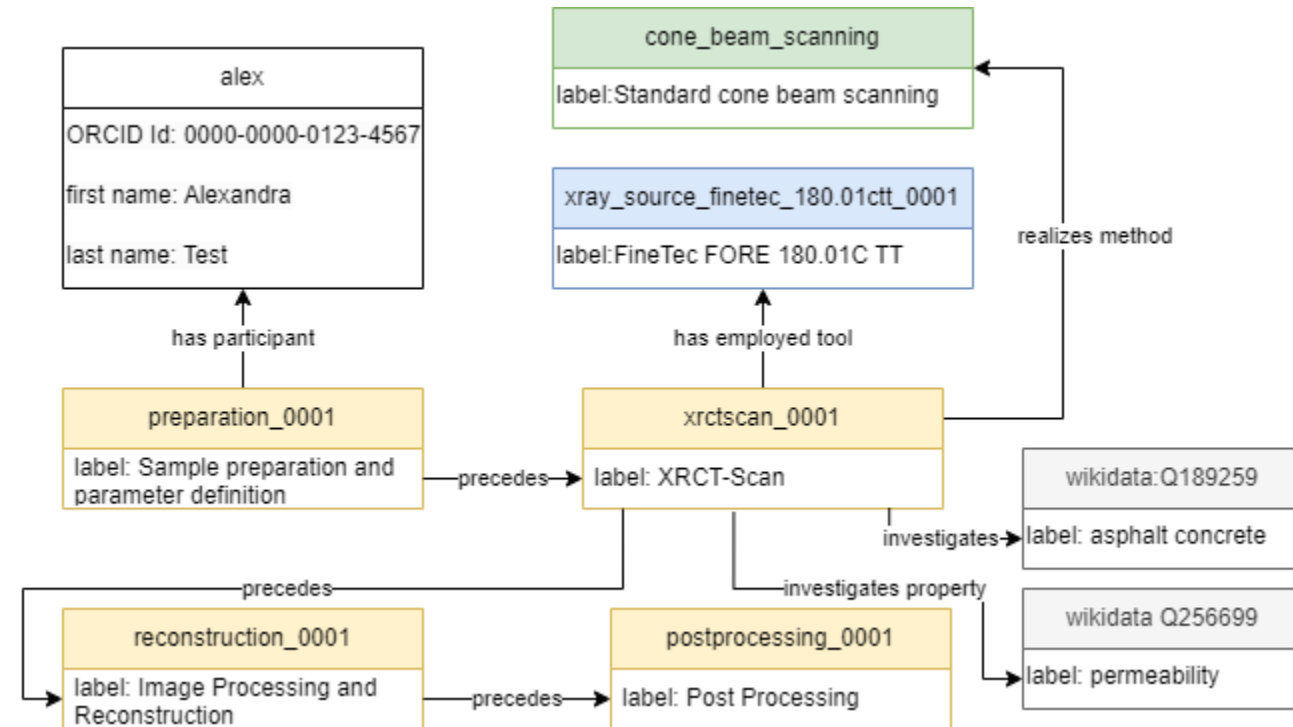


### Legende

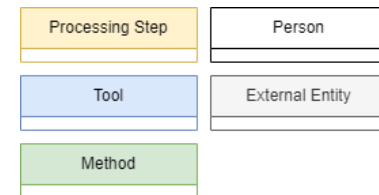


## Add object of research

```
{
  ...
  "@graph": [
    ...
    {
      "@id": "local:xrctscan_0001",
      "@type": "processing step",
      "label": "XRCT-Scan",
      "has employed tool":
        "local:xray_source_finotec_180.01ctt_0001",
      "realizes method": "local:cone_beam_scanning",
      "investigates":
        "https://www.wikidata.org/wiki/Q189259",
      "investigatesProperty":
        "https://www.wikidata.org/wiki/Q256699"
    }
    ...
  ]
}
```



### Legende





<https://www.wikidata.org/wiki/Q189259>



Item [Discussion](#)

Read

[View history](#)

Search Wikidata

## asphalt concrete (Q189259)

material used for paving roads

[blacktop](#) | [asphalt](#) | [pavement](#) | [tarmac](#) | [bitumen macadam](#) | [rolled asphalt](#) | [asfaltový beton](#)

[edit](#)

[In more languages](#)

[Configure](#)

Language	Label	Description	Also known as
English	asphalt concrete	material used for paving roads	blacktop asphalt pavement tarmac bitumen macadam rolled asphalt asfaltový beton
German	Asphalt	Mischung aus Gesteinskörnungen und Bitumen, häufiger Straßenbelag	Asphaltbeton asfaltový beton
French	enrobé	matériau mélangeant granulats et bitume employé principalement pour les chaussées des routes	enrobé bitumineux béton bitumineux poste d'enrobage
Bavarian	No label defined	No description defined	

[All entered languages](#)

Wikipedia (43 entries) [edit](#)

- [ar](#) (أسفلت (هندسة))
- [az](#) Asfalt
- [bat\\_smg](#) Ekspaltos
- [be\\_x\\_old](#) Асфальт
- [be](#) Асфальт
- [bg](#) Асфалтобетон
- [ca](#) Formigó asfàltic
- [cs](#) Asfaltový beton
- [cv](#) Асфальтбетон
- [da](#) Asfalt
- [de](#) Asphalt
- [en](#) Asphalt concrete
- [eo](#) Asfalto
- [es](#) Hormigón asfáltico
- [et](#) Asfaltbetoon
- [eu](#) Aglomeratu asfaltiko
- [fa](#) بتن آسفالتی
- [fi](#) Asfaltti
- [fr](#) Enrobé
- [hy](#) Ասֆալտբետոն
- [is](#) Malbik
- [it](#) Conglomerato bituminoso
- [ja](#) アスファルト混合物
- [ko](#) 아스팔트 콘크리트
- [ky](#) Асфальт-бетон
- [lt](#) Asfaltbetonis

### Statements

subclass of	<span><span></span></span> <a href="#">composite material</a> <a href="#">edit</a>
	<a href="#">0 references</a>
	<a href="#">+ add reference</a>
	<a href="#">+ add value</a>

[Main page](#)  
[Community portal](#)  
[Project chat](#)  
[Create a new Item](#)  
[Recent changes](#)  
[Random Item](#)  
[Query Service](#)  
[Nearby](#)  
[Help](#)  
[Donate](#)

[Lexicographical data](#)  
[Create a new Lexeme](#)  
[Recent changes](#)  
[Random Lexeme](#)

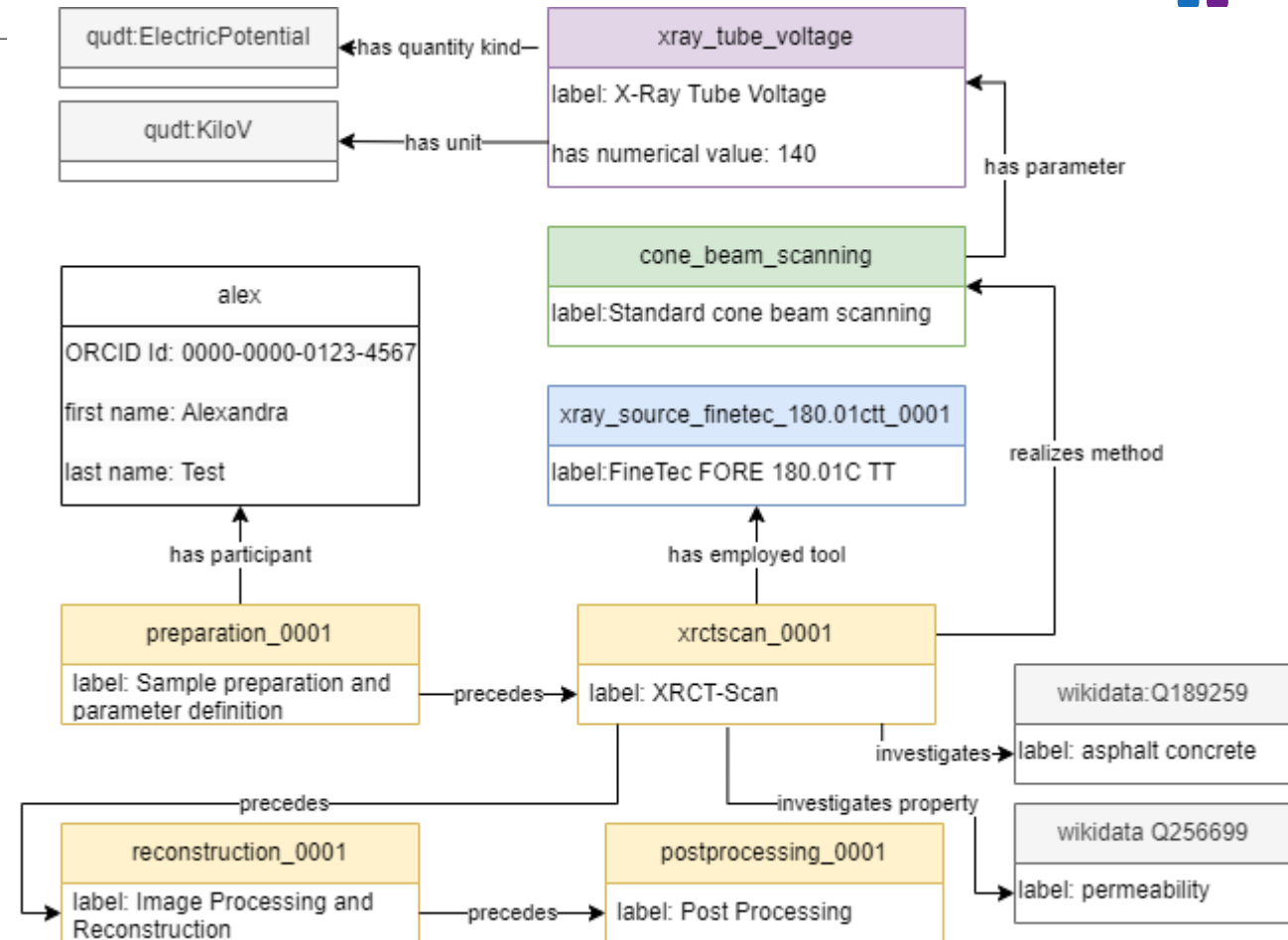
[Tools](#)  
[What links here](#)  
[Related changes](#)  
[Special pages](#)  
[Permanent link](#)  
[Page information](#)  
[Concept URI](#)  
[Cite this page](#)

## Add parameter to the method

```

{
  ...
  "@graph": [
    ...
    {
      "@id": "local:cone_beam_scanning",
      "@type": "method",
      "label": "Standard cone beam scanning",
      "description":
        "Standard cone beam scanning",
      "has parameter":
      {
        "@id": "local:xray_tube_voltage",
        "@type": "numerical variable",
        "label": "X-Ray Tube Voltage",
        "has numerical value": "140",
        "has kind of quantity" :
          "http://qudt.org/vocab/quantitykind/ElectricPotential",
        "has unit":
          "http://qudt.org/vocab/unit/KiloV"
      }
    }
  ]
}

```

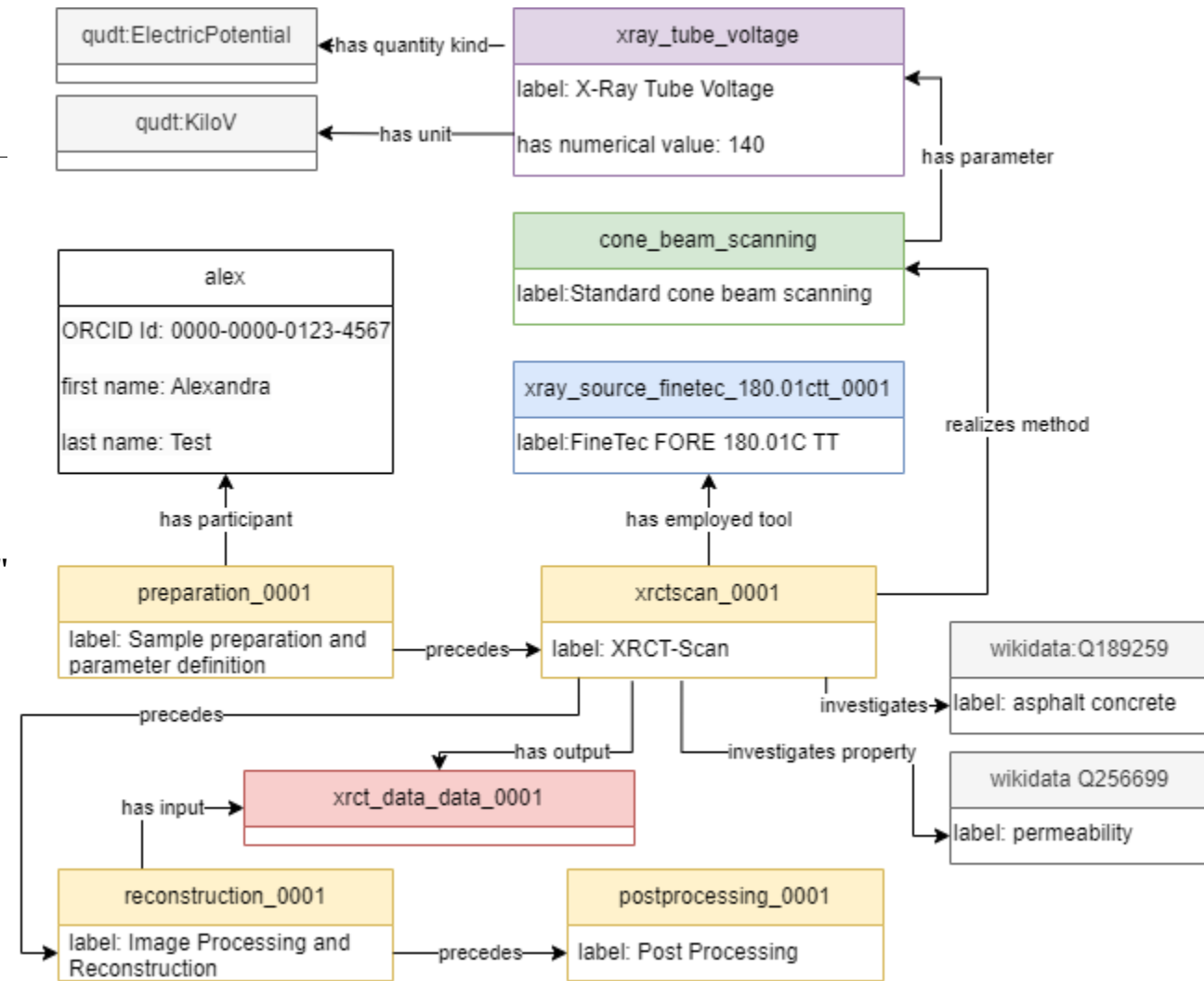


### Legende

Processing Step	Person
Tool	External Entity
Method	Variable

## Add output and input to processing steps

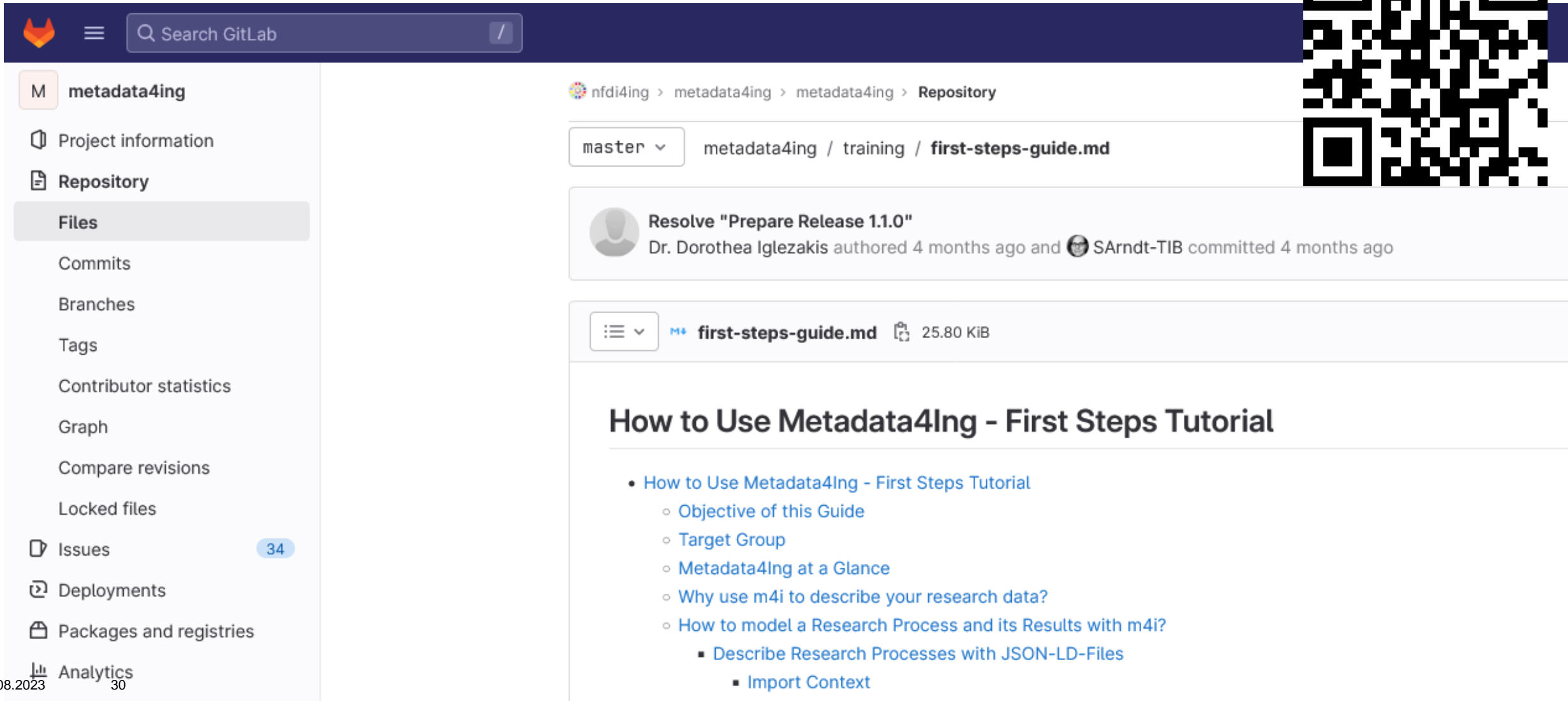
```
{
  ...
  "@graph": [
    ...
    {
      "@id": "local:xrctscan_0001",
      "@type": "processing step",
      "label": "XRCT-Scan",
      "has employed tool":
        "local:xray_source_finetec_180.01ctt_0001",
      "realizes method": "local:cone_beam_scanning"
      "investigates":
        "https://www.wikidata.org/wiki/Q189259",
      "investigatesProperty":
        "https://www.wikidata.org/wiki/Q256699",
      "has output": {
        "@type": "dataset",
        "@id": "local:xrct_data_0001",
      }
    },
    {
      "@id": "local:reconstruction_0001",
      "@type": "processing step",
      "label": "Image Processing and Reconstruction",
      "precedes": "local:postprocessing_0001",
      "has input": "local:xrct_data_0001"
    },
  ],
}
```



### Legende

Processing Step	Person
Tool	External Entity
Method	Variable
Dataset	

# Guide and complete example



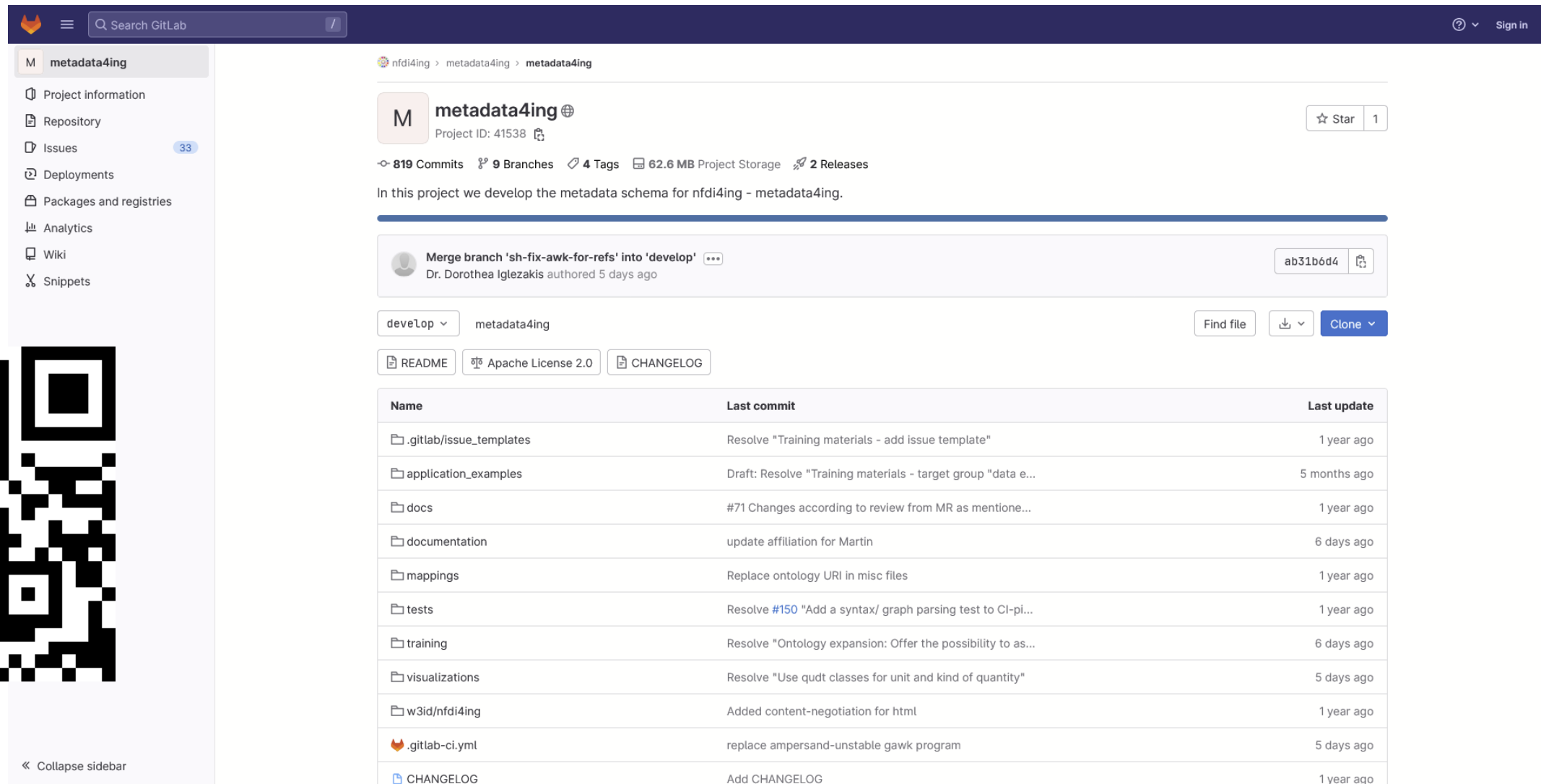
The screenshot shows a GitLab repository page for the file `first-steps-guide.md`. The breadcrumb path is `nfdi4ing > metadata4ing > metadata4ing > Repository`. The file is located in the `training` directory. The commit history shows a commit titled "Resolve 'Prepare Release 1.1.0'" by Dr. Dorothea Iglezakis, with a commit by SARndt-TIB. The file size is 25.80 KiB. The main content area displays the title "How to Use Metadata4Ing - First Steps Tutorial" and a list of topics:

- [How to Use Metadata4Ing - First Steps Tutorial](#)
  - [Objective of this Guide](#)
  - [Target Group](#)
  - [Metadata4Ing at a Glance](#)
  - [Why use m4i to describe your research data?](#)
  - [How to model a Research Process and its Results with m4i?](#)
    - [Describe Research Processes with JSON-LD-Files](#)
    - [Import Context](#)

---

# ● Background

# Metadata4Ing Development



The screenshot shows the GitLab interface for the 'metadata4ing' repository. The left sidebar contains navigation options: Project information, Repository, Issues (33), Deployments, Packages and registries, Analytics, Wiki, and Snippets. The main content area displays the repository name 'metadata4ing' with Project ID 41538, 1 star, and 819 commits. A recent merge commit by Dr. Dorothea Iglezakis is shown. Below the commit list, there are buttons for 'Find file', 'Clone', and 'deveLop' branch. A table lists the repository's structure and the last commit for each directory.

Name	Last commit	Last update
<code>.gitlab/issue_templates</code>	Resolve "Training materials - add issue template"	1 year ago
<code>application_examples</code>	Draft: Resolve "Training materials - target group "data e..."	5 months ago
<code>docs</code>	#71 Changes according to review from MR as mentione...	1 year ago
<code>documentation</code>	update affiliation for Martin	6 days ago
<code>mappings</code>	Replace ontology URI in misc files	1 year ago
<code>tests</code>	Resolve #150 "Add a syntax/ graph parsing test to CI-pi..."	1 year ago
<code>training</code>	Resolve "Ontology expansion: Offer the possibility to as..."	6 days ago
<code>visualizations</code>	Resolve "Use qudt classes for unit and kind of quantity"	5 days ago
<code>w3id/nfdi4ing</code>	Added content-negotiation for html	1 year ago
<code>.gitlab-ci.yml</code>	replace ampersand-unstable gawk program	5 days ago
<code>CHANGELOG</code>	Add CHANGELOG	1 year ago



# Documentation

<https://w3id.org/nfdi4ing/metadata4ing/>

active

Metadata4Ing: An ontology for describing the generation of research data within a scientific activity.

language **en**

Release 2023-03-08

**This version:**

<https://w3id.org/nfdi4ing/metadata4ing/1.1.0/>

**Latest version:**

<https://w3id.org/nfdi4ing/metadata4ing/>

**Previous version:**

<https://w3id.org/nfdi4ing/metadata4ing/1.0.0/>

**Revision:**

v1.1.0

**Authors:**

Metadata4Ing Workgroup

**Contributors:**

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[Dorothea Iglezakis](#), ([Universität Stuttgart](#))  
[Džulija Terzijska](#), ([Karlsruher Institut für Technologie \(KIT\)](#))  
[Giacomo Lanza](#), ([Physikalisch-Technische Bundesanstalt \(PTB\)](#))  
[Johanna Hickmann](#), ([Technische Universität Berlin](#))  
[Johannes Theissen](#), ([RWTH Aachen University](#))

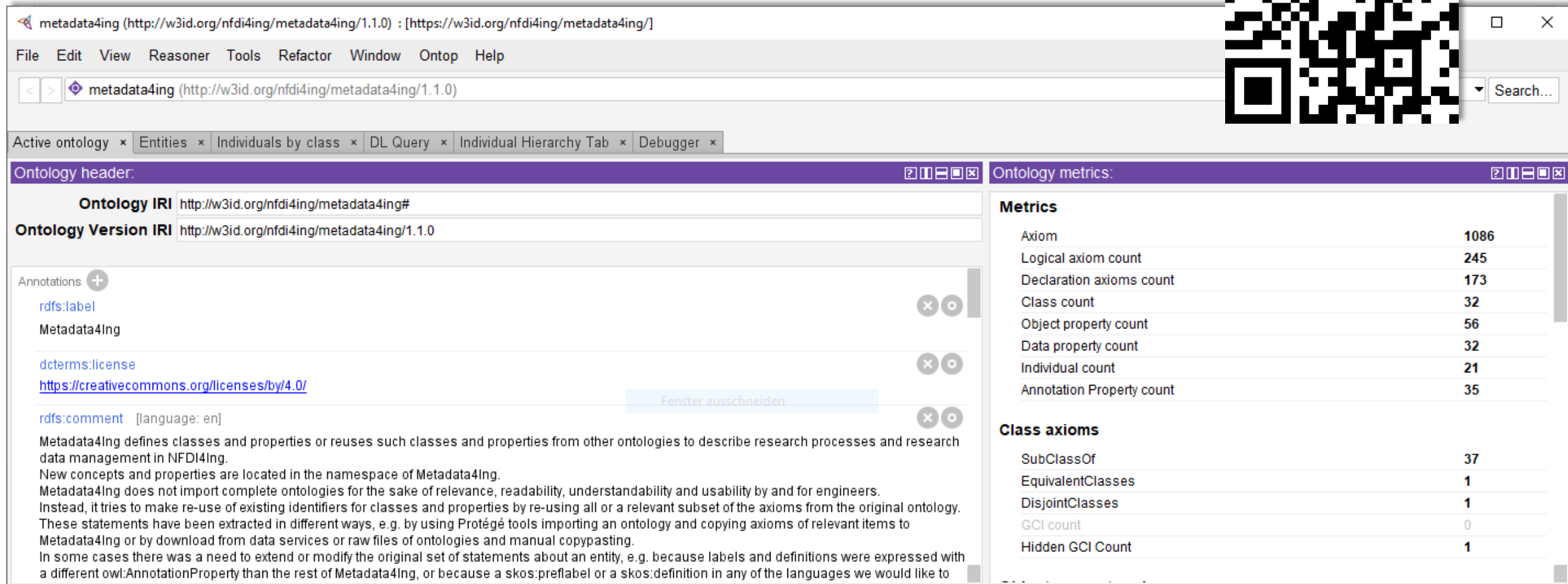


Standard  Expert



# RDF-Serializations

<https://w3id.org/nfdi4ing/metadata4ing/>



metadata4ing (http://w3id.org/nfdi4ing/metadata4ing/1.1.0) : [https://w3id.org/nfdi4ing/metadata4ing/]

File Edit View Reasoner Tools Refactor Window Ontop Help

metadata4ing (http://w3id.org/nfdi4ing/metadata4ing/1.1.0)

Active ontology x Entities x Individuals by class x DL Query x Individual Hierarchy Tab x Debugger x

Ontology header: ? || ≡ □ ×

**Ontology IRI** http://w3id.org/nfdi4ing/metadata4ing#

**Ontology Version IRI** http://w3id.org/nfdi4ing/metadata4ing/1.1.0

Annotations +

rdfs:label × ○  
Metadata4Ing

dcterms:license × ○  
<https://creativecommons.org/licenses/by/4.0/>

rdfs:comment [language: en] × ○  
Metadata4Ing defines classes and properties or reuses such classes and properties from other ontologies to describe research processes and research data management in NFDI4Ing.  
New concepts and properties are located in the namespace of Metadata4Ing.  
Metadata4Ing does not import complete ontologies for the sake of relevance, readability, understandability and usability by and for engineers. Instead, it tries to make re-use of existing identifiers for classes and properties by re-using all or a relevant subset of the axioms from the original ontology. These statements have been extracted in different ways, e.g. by using Protégé tools importing an ontology and copying axioms of relevant items to Metadata4Ing or by download from data services or raw files of ontologies and manual copy-pasting.  
In some cases there was a need to extend or modify the original set of statements about an entity, e.g. because labels and definitions were expressed with a different owl:AnnotationProperty than the rest of Metadata4Ing, or because a skos:preflabel or a skos:definition in any of the languages we would like to

Fenster ausschneiden

Ontology metrics: ? || ≡ □ ×

**Metrics**

Axiom	1086
Logical axiom count	245
Declaration axioms count	173
Class count	32
Object property count	56
Data property count	32
Individual count	21
Annotation Property count	35

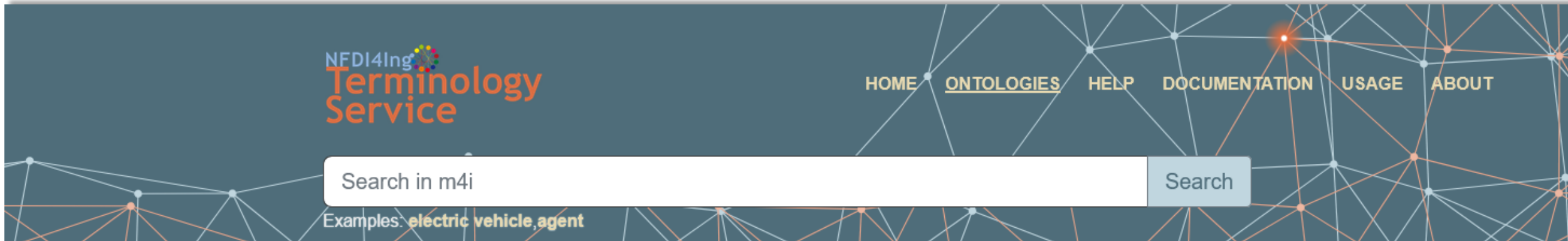
**Class axioms**

SubClassOf	37
EquivalentClasses	1
DisjointClasses	1
GCI count	0
Hidden GCI Count	1



# NFDI4Ing Terminology Service

<https://terminology.tib.eu/ts/ontologies/m4i>



NFDI4Ing  
**Terminology Service**

HOME ONTOLOGIES HELP DOCUMENTATION USAGE ABOUT

Search in m4i

Examples: **electric vehicle, agent**

## Metadata4Ing: An ontology for describing the generation of research data within a scientific activity (v. 1.0.0)

<http://w3id.org/nfdi4ing/metadata4ing#>



Overview **Class Tree** Property Tree Individuals Class List

### Metadata4Ing: An ontology for describing the generation of research data within a scientific activity (v. 1.0.0)

The ontology Metadata4Ing is developed within the NFDI Consortium NFDI4Ing with the aim of providing a thorough framework for the semantic description of research data, with a particular focus on engineering sciences and neighbouring disciplines. This ontology allows a thorough description of the whole data generation process (experiment, observation,

### Metrics

Number of Classes	31
Number of Properties	120
Number of Individuals	21

# TIB Terminology Service API

<https://service.tib.eu/ts4tib/api/ontologies/m4i/>



```
JSON Rohdaten Kopfzeilen
Speichern Kopieren Alle einklappen Alle ausklappen JSON durchsuchen
ontologyId: "m4i"
loaded: "2022-09-23T16:51:29.913+0000"
updated: "2022-09-26T21:11:47.969+0000"
status: "LOADED"
message: ""
version: null
fileHash: "406dcef8082fb25905163e1517d52ff2a4452e98"
loadAttempts: 0
numberOfTerms: 31
numberOfProperties: 120
numberOfIndividuals: 21
▼ config:
  id: "http://w3id.org/nfdi4ing/metadata4ing#"
  versionIri: "http://w3id.org/nfdi4ing/metadata4ing/1.0.0"
  ▼ title: "Metadata4Ing: An ontology for describing the generation of research data within a scientific activity (v. 1.0.0)"
    namespace: "m4i"
    preferredPrefix: "m4i"
```

---

● Thank you!

*Questions?*

NFDI4Ing Community Meeting CC41 2023

## The Metadata4Ing Ontology

An ontology for describing the generation and provenance of research data within a scientific activity

[Susanne Arndt](#) (TIB) &

[Dorothea Iglezakis](#) (IZUS/UB Stuttgart)

## Acknowledgements & License

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