Databases status update

Fedor Prokoshin

JINR, DLNP

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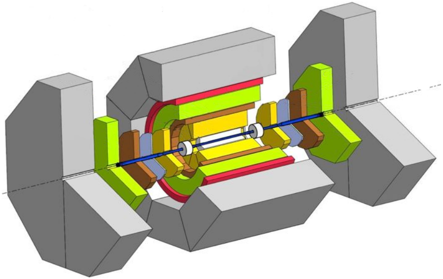
SPD Information



- The SPD Experiment have to produce large amounts of data, both collected from the detector and simulated
- The processing of the experimental data requires a wide variety of auxiliary information from many systems

- Huge volumes of the detector condition and management data should be stored in the databases
  - should be used in every stage of data taking, processing and analysis
  - are essential at nearly every stage of data handling
  - for use in number of versatile applications each with its own requirements

Information Systems

- Databases can not be considered as the thing in itself, but as a part of complex information system that include
  - Data collection tools
  - Data transportation tools (messaging services, etc)
  - Application layer between the client and the database server
  - Client software including GUI
  - APIs for access from the producton and analysis software
  - Supervisors and monitoring
- Databases and applications should be designed aiming for scalability, long term operation in the varying conditions, data flows and rates.
- Development and deployment would take quite a long period, some technologies may become obsolete or not available,others may emerge
- Information systems are related to each other and to the detector components, this defines the priorities in development

SPD Information Systems

Data

- Distributed Computing and Data Management
- EventIndex
- Physics Metadata IS

Collaboration

- Personnel and Publication Databases

Detector

- Conditions and Calibration Databases
- Monitoring Information Systems
- Logging and Bookkeeping
- Hardware and Mapping Database

EventIndex

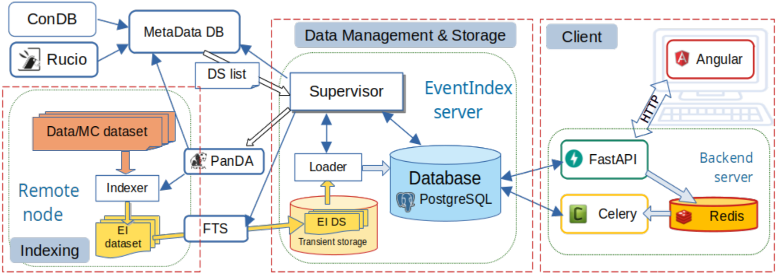
- Complete catalog of SPD events, real and simulated data
- An information system that should provide
  - retriving event metadata by indexing data files on distributed storage
  - transfer of this information to the EI server
  - verifying of recieved data and loading to the database
  - access to information via universal API
  - interactive and asynchronous user interfaces.

Event record content

- Event ID, Online Filter results, UID in the distributed storage of the RAW data file, UID of the dataset containing this file
- UIDs of files and datasets with reconstructed events (AOD)
  - Will be added when ready.
- Important event parameters for classification and selection (TBD).

EventIndex: architecture

- The EventIndex employs micro-service architecture
  - Each component is a separate service operating independently
  - Each microservice can be updated and deployed independently
  - Provide flexibility, simplifies development and improves scalability
- The system consists of three main blocks:
  - Data indexing: collecting event metadata
  - Data management and storage system: import to the DB
  - The client part: API, Web interface and queries handling



EventIndex: development progress

PostgreSQL DBMS is used for storage and processing of data

- The estimated data flow from 10s k up to 150 k events per second
- Various optimization methods were investigated to speed up the process of writing data to the DB.
- Using of asyncronous bulk loading showed sufficient performance

A program interface that uses the RESTful API is being developed

- The front-end part was developed using the Angular framework
- Server side employs a fastAPI: a light weighted asynchronous RESTful framework for Python
- For asynchronous task processing Redis and Celery were used.
  - Celery manages tasks that require long-term processing.
  - Redis acts as a message broker and temporary storage for task results.
- Users can launch long queries simultaneously, no need to wait

Event Index: deploy

- The SPB Event Index project is configured for instant deployment using GitLab CI/CD (Continuous Integration/Continuous Delivery).
- CI/CD allows you to automate assembly, testing and deployment, ensuring fast delivery of updates to production.
- This approach minimizes manual operation time and reduces the probability of errors, making the deployment process faster and more reliable.
- The assembled images generated at the CI/CD stages are stored in the Gitlab Registry, which allows you to centralize management, track versions at the image level and control access rights.

More details on development are presented in paper ▸ Link, reports by Zamira Budtueva ▸ Link, Alan Gazzaev ▸ Link and Richard Gurtsiev ▸ .docx

Event Index: further delevoment

Supervisor manages collecting and import of the EventIndex data:

- Tracks the distributed storage system for a new datsets appearance
- Launches as panda task PanDA of a indexing program that will go through the events and produce dataset with EventIndex information
- Manages the transfer of data to the EventIndex server
- Runs the loader program that fill the data to the database
- Monitors the processes and collects information for logging

- Datasets will be indexed on the server where they reside
  - The indexing task will be run by PanDA on Superviser request
  - Alternatively, it may be initiated by production task on its completion
  - The data obtained will be transfered to the EI server via FTS
- A program for indexing being created, assuming ROOT data format

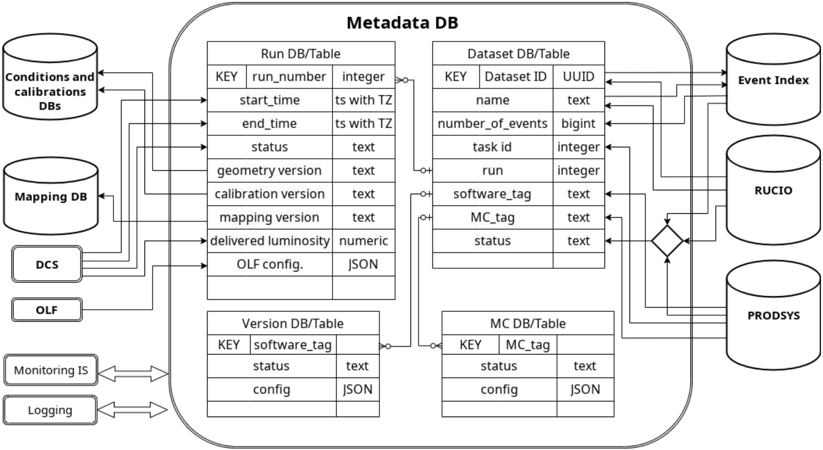
Physics Metadata

- Contain information about
  - Datasets and data samples
  - Provenance chains of processed data linked to production tasks info
  - Data-taking runs
  - Cross-sections and configurations used for simulations
  - Online filter and luminosity information for real and simulated data.

- Should collect a great part of its information from other IS's and provide links to data for them
- Conventions for the runs and dataset naming have to be defined, as well as for software and MC configuration versioning
- Tha amount and scopes of unformation will be understood in the progress of experimet development

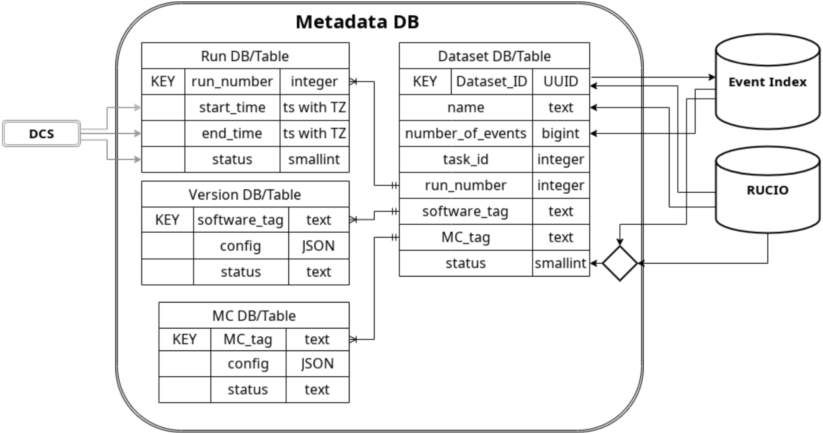
A conceptual prototype has been developed

Physics Metadata: prototype



The conceptual scheme of Metadata Information System

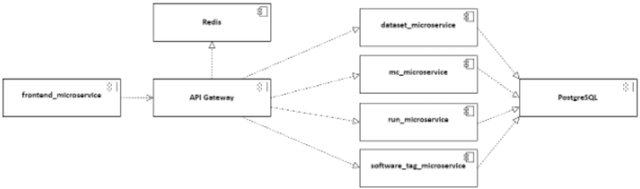
Physics Metadata: prototype



The prototype of Metadata Information System

Physics Metadata: prototype architecture

- The three-level microservice architecture is taken as a basis
- For each PostgreSQL schema a type of microservices will be created
- Each microservice consists of a structure of three layers: an API layer, a service layer, and a database layer
- The Gateway API pattern was used, which made it possible to distribute the load between microservices



Details are presented in report by Nikita Shkerin ▸ Link and Rinat Korotkin ▸ Link

Database of personnel and documents

- About 400 people are currently participating in the SPD project,
  - number of participants is expected to grow close to experiment start
- In order to organize effective cooperation with the shared use of computing and other resources, it is necessary to have IS for
  - handling of a personnel and organizations data
  - support for working groups: membership, access rights,
  - accounting of the contribution (if implemented)
  - generating reports broken down by various parameters
- Procedures for creating, approving and editing related documents
  - Registration and changes of membership in the collaboration
  - Creating and editing lists of groups and privileges
  - Inclusion in the author's lists
- The resources of the working groups should use a single authentication and authorization system
  - An IAM service has been developed and already used for some tasks

Database of publications and conferences

- SPD already produced some publication and conference reports
- An IS is necessary for preparing and publishing results
  - Tracking the progress of publications,
  - Organizing the exchange of messages between authors, reviewers and curators
  - Searching through documents
  - Tracking of SPD publications in external information systems.
  - Reports on the number of publications, broken down by authors, topics...
- Organization of presentations and reports at conferences and meetings:
  - Compiling a list of conferences and available reports
  - Organization of call for speakers and selection
  - Acceptance, review and approval of titles, abstracts and slides
  - Tracking the publication of proceedings

Conditions and Calibration Data

Conditions data - non-event data representing the detector status

- Detector hardware conditions
- Detector calibrations
- Detector read-out conditions
- Detector alignments
- Physics calibrations
- Luminosity and polarization measurements

Conditions data usage

- Subsystem calibration
- Online data processing, reconstruction and reprocessing
- User analysis

Conditions Data organization

- Various pieces of information are heterogeneous both in data type and in time granularity
- The data should be organized by "Intervals of Validity" (IOV), which is the span in time over which that data is valid
- Can be recomputed later if the understanding of the detector behavior improves or the quality of the input data increases.
  - except for the detector and trigger configurations
- Careful versioning of groups of conditions data for production use cases is a critical item to guarantee reproducibility.
- Conditions data are typically written once and read frequently
  - read-rates up to several kHz must be supported for distributed computing use

Development will start later, when appropriate systems will be defined

Hardware Database

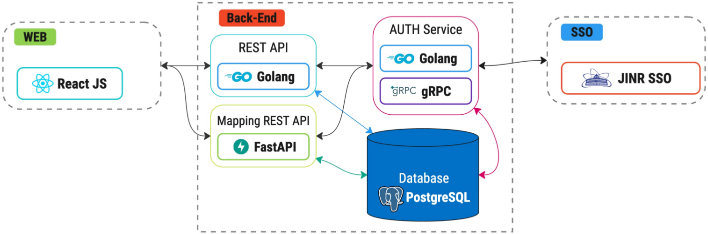
- A catalog of hardware components that SPD detector consist of.
- It should contain the information about the detectors and the electronic parts, cables, racks, and crates, as well as the location history of all items
- It include equipment models, provider, parameters and other (semi)permanent characteristics
- This should help in maintenance of the detector systems and especially helpful in knowledge transfer between team members.
- Filling of the hardware database should take place gradually, and updates will be rare
- The requirements for the speed of recording information in the database are low

Mapping database

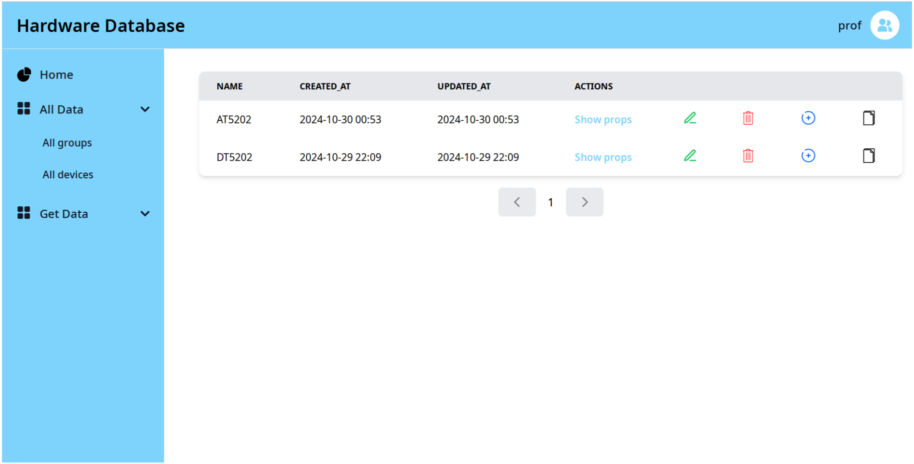
- The construction of the connection diagram and its changes will also be performed rarely (no more than once a week)
- The requirements for the speed of recording information in the database are low
- Mapping information may be required when processing each file.
  - It is possible that tens of thousands of processes will try to simultaneously access the system.
  - It is necessary to ensure their processing, avoiding database overload due to too high frequency of requests
- Due to the large number of elements in the system, it is almost impossible to build mapping manually
- For the elements involved in the transmission of digital signals, an automatic mapping procedure should be implemented
  - The element must issue a HW ID over the data channel in response to a special signal

Hardware Database: architecture

- A prototype system is being developed
  - PostgreSQL for a data storage
  - Back-end providing enpoints for access through the REST API
  - Web front-end providing interface for fill, searc and display data
  - JINR SSO for autorization, acces can be requested from web front
- The architecture of the project is built on the basis of microservices
- A stack of modern platforms is used to ensure good performance, flexibility and ease of development and maintenace



Hardware Database: Web Front



Hardware Database: groups

- Similar devices are organized in a groups
- Group typycally describe some model of the device
  - For exmple: A5202 front end board
- For group, defined a set of properties, common for its devices
- Each property has data type
  - Data type can be numeric, string, boolean, date-time, IP and enumerated (set of values)
  - More data types can be implemented when needed
- Units of measurement, value ranges and defaults can be specified
- For example:
  - Output voltage. Type: decimal. Range: 20÷85. Default value: 29.0
  - Voltage Range. Type: enum. Options: 4.5, 2.5, DISABLED
  - Manufacture date. Type: date
- Groups can be cloned with all their properties

Hardware Database: devices

- Device is the specific exemplar from the group
  - For example: A5202 front end board with S/N ABC123456.
- Each device has unique ID assigned to it,
- For the properties defined for the group, values can be specified.
- Values can be within range, or selected from enum.
- If no value specified, used default from group description
- For example:
  - Output voltage: 28.5 V. (29.0 if not specified)
  - Voltage Range: 4.5
- Each device has special property, *component ID*
  - specifies its *geographical* position on SPD
  - for example: SiPM board for 8-th sector of BBC
  - can be changed, as the same device may be used in different subsystems

Hardware database: Tests and deploy

- Several levels of testing implemented for the REST API service:
  - Unit tests, Integration tests, Functional and E2E tests

- Each component of a hardware database project is isolated and can be developed, deployed, and updated independently of the others.
- For this and to simplify service management, containerization is used.
- Eeach service is packaged in a separate container with its dependencies and environment, making it independent of the underlying operating system and other elements.
- A working version of the system is installed on VM in the JINR Cloud.
- Also it can be deployed on on your linux machine .

See reports by Boris Dvizov ▸ .docx, Soslan Gussalov ▸ .docx and Rolen Magkaev ▸ .docx

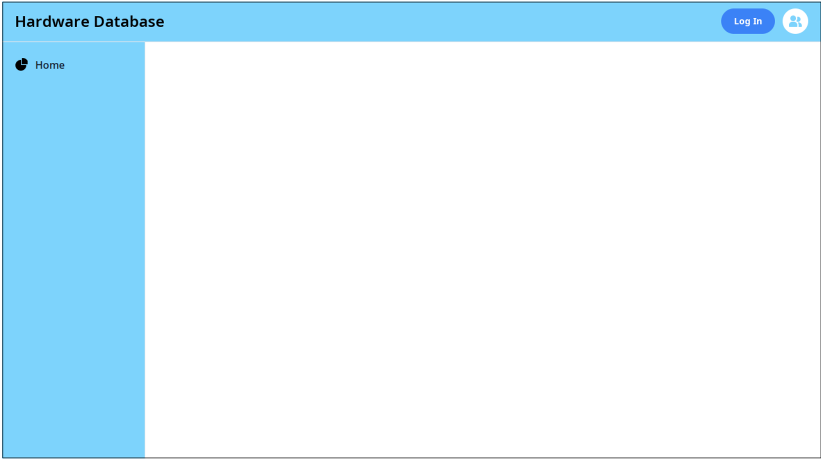
Conclusion

- If you willing to participate in the Database, API or user Interface development, please join
- Information systems should be tailored to the needs of the project and to the nature and amount of data
- We need input both from hardware and analysis groups to create information systems fitting their need
    - If you created some database for your subsystem, please share your experience so it may be implemented elsewhere
    - If you have list of hardware (with parameters) that will be used in your system, contact us so we may adjust database and interface to it
    - The same if you group needs API to one of the information systems

BACKUP SLIDES

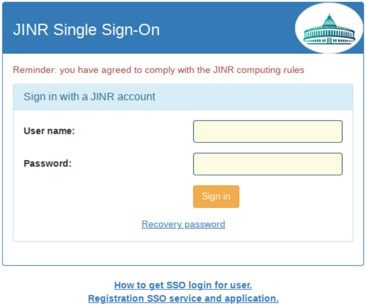
Hardware Database: Autorisation

- Uses JINR SSO for autorization



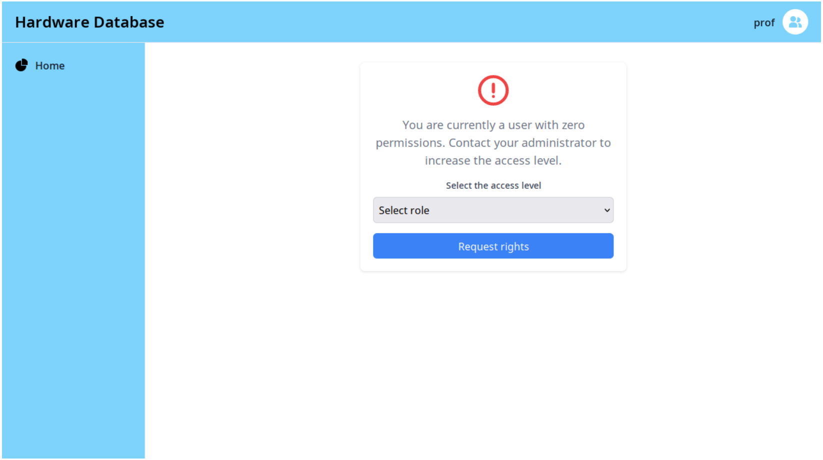
Hardware Database: Autorisation

- Uses JINR SSO for autorization



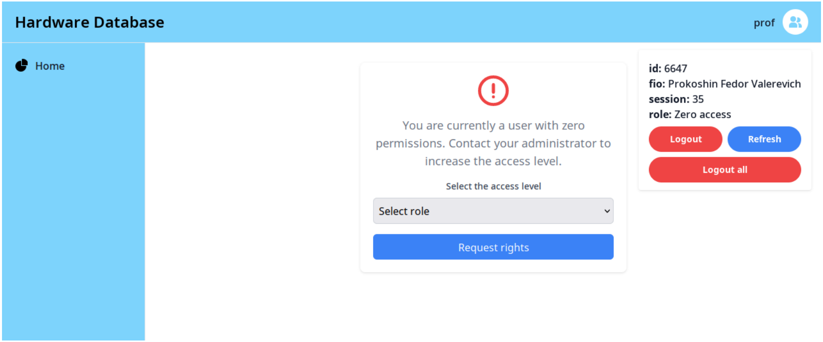
Hardware Database: Autorisation

- After authorising with SSO, user can send request for access
  - Currently via e-mail. Use of JINR Help desk proposed for production.



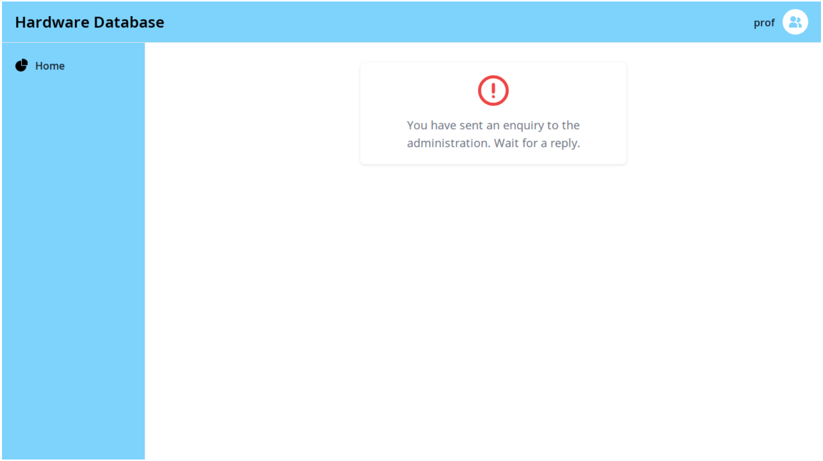
Hardware Database: Autorisation

- Now there are 4 levels of access
  - **Zero**: only to send request to admin
  - **Restricted**: Read-only, Only view information
  - **Full**: Can both view and fill data
  - **Admin**: Can change access levels for users



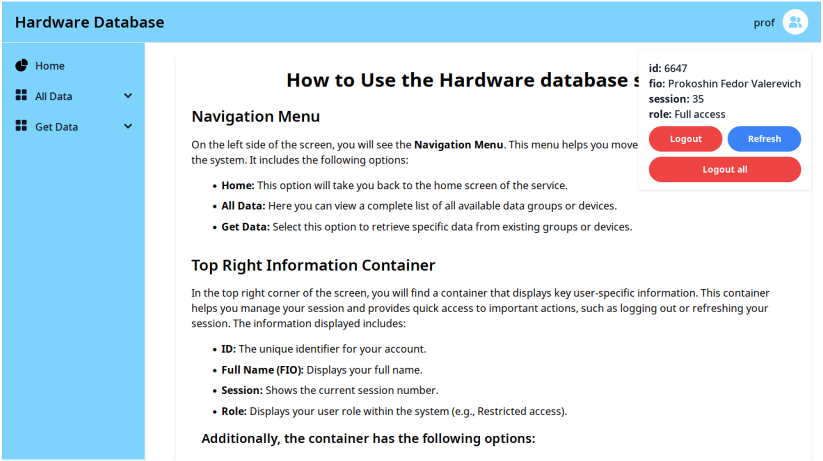
Hardware Database: Autorisation

- You have to wait for Admin grant you access



Hardware Database: Autorisation

- When you receive acess, you see instructions


Hardware Database

prof

Home

All Data

Get Data

id: 6647

fio: Prokoshin Fedor Valerevich

session: 35

role: Full access

Logout

Refresh

Logout all

How to Use the Hardware database s

Navigation Menu

On the left side of the screen, you will see the **Navigation Menu**. This menu helps you move
the system. It includes the following options:

- **Home:** This option will take you back to the home screen of the service.
- **All Data:** Here you can view a complete list of all available data groups or devices.
- **Get Data:** Select this option to retrieve specific data from existing groups or devices.

Top Right Information Container

In the top right corner of the screen, you will find a container that displays key user-specific information. This container helps you manage your session and provides quick access to important actions, such as logging out or refreshing your session. The information displayed includes:

- **ID:** The unique identifier for your account.
- **Full Name (FIO):** Displays your full name.
- **Session:** Shows the current session number.
- **Role:** Displays your user role within the system (e.g., Restricted access).

Additionally, the container has the following options:

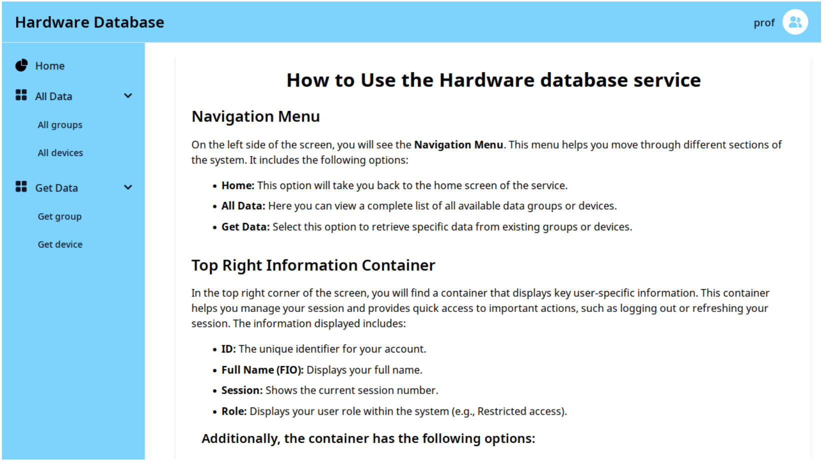
Hardware Database: workflow

The typical workflow for filling database is the following:

- User creates group, specifies its name and adds properties
  - For each specifies its name and datatype
  - Optionally: units, min, max and default values
  - For enums, specify list of values
- Groups can be cloned, properties can be added or changed
  - This can be used for creating groups for similar models,
  - For example: A5204 front end board
- Groups can be saved to JSON file or read from it
- After creating a group, user can create components based on this group, and fill the values of the parameters.
- Cloning and creation of series of components have to be implemented

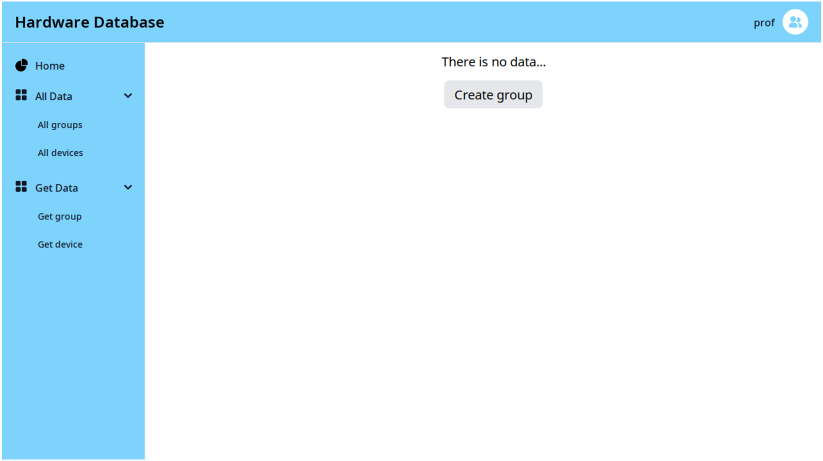
Hardware Database: filling groups

- To see groups information, click on the 'All groups'



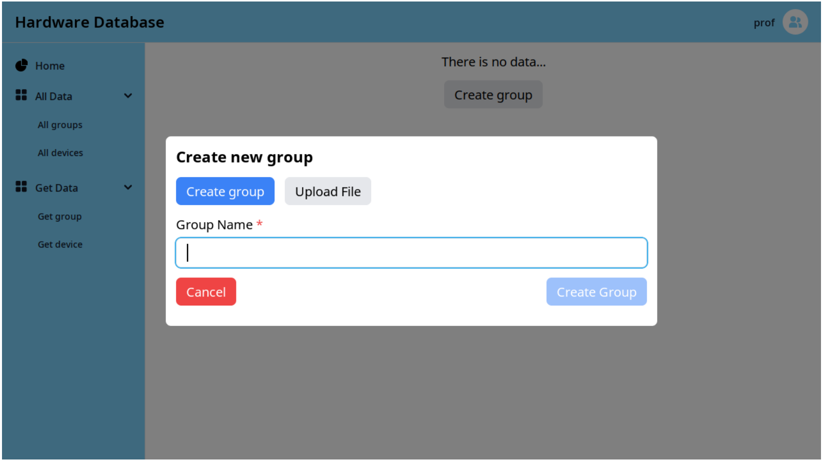
Hardware Database: filling groups

- Now no groups, create one



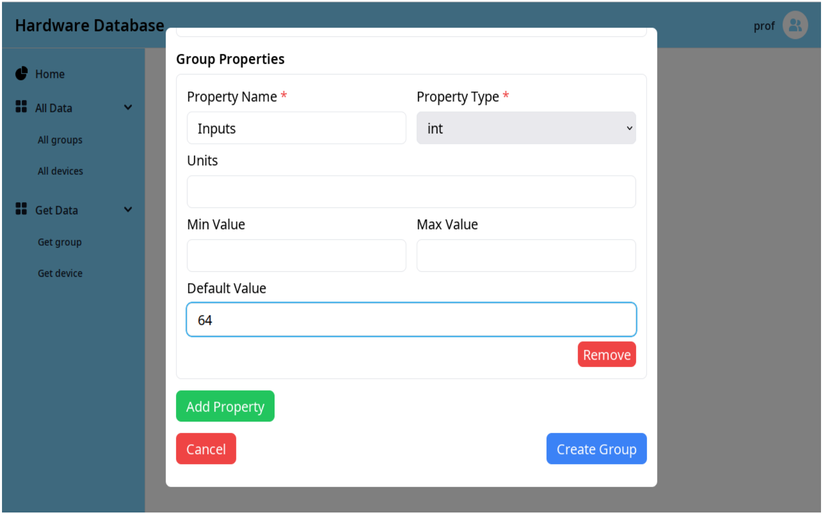
Hardware Database: filling groups

- Type in group name



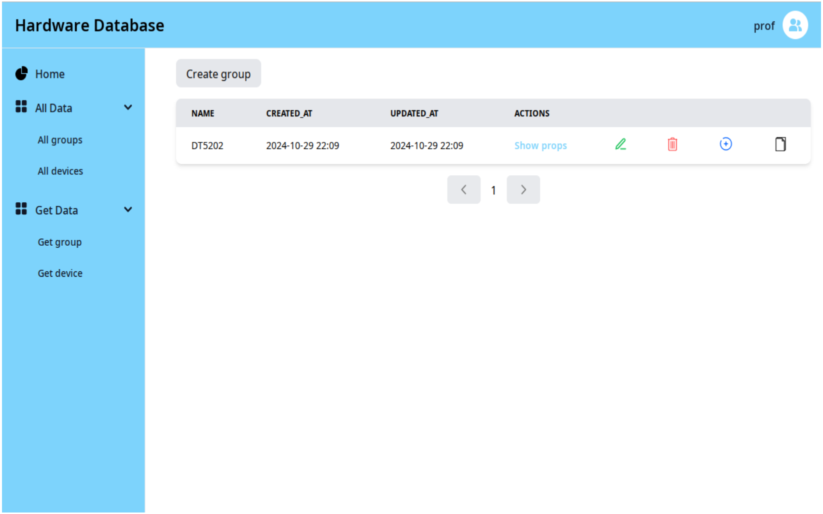
Hardware Database: filling groups

- lets specify first property: Number of channels, and click Create group



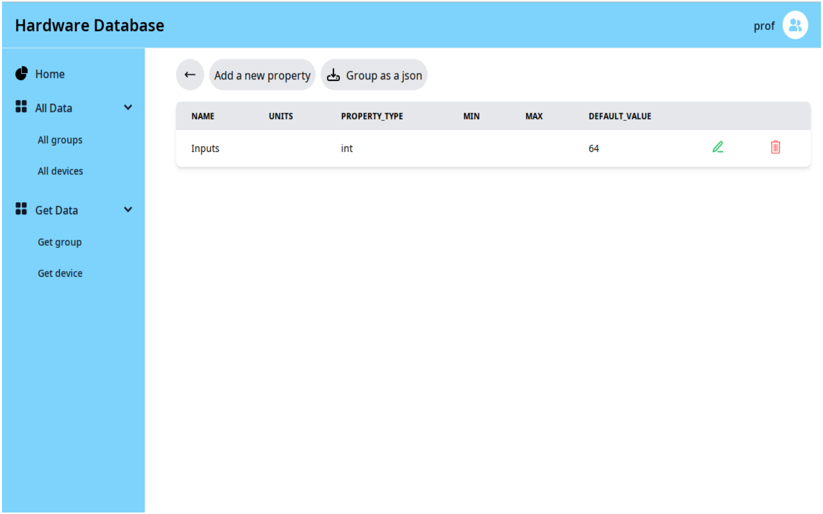
Hardware Database: filling groups

- Now the group is created. Click Show props



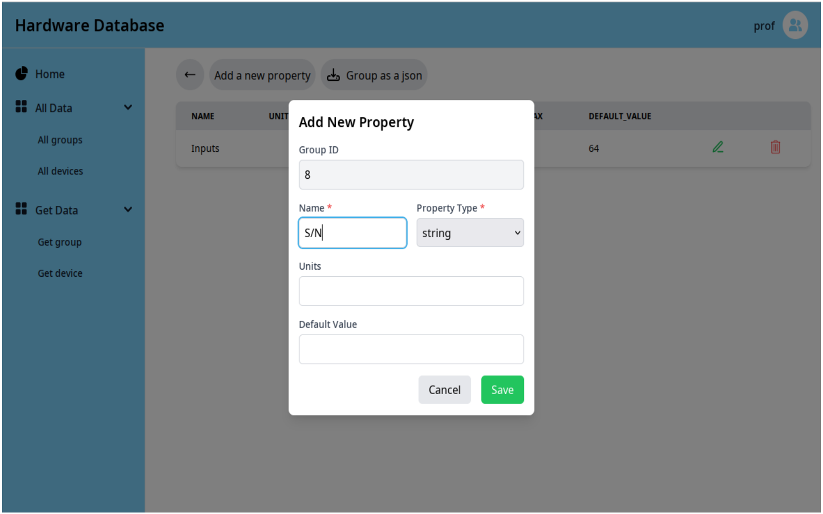
Hardware Database: filling groups

- You can see property. Let's add more



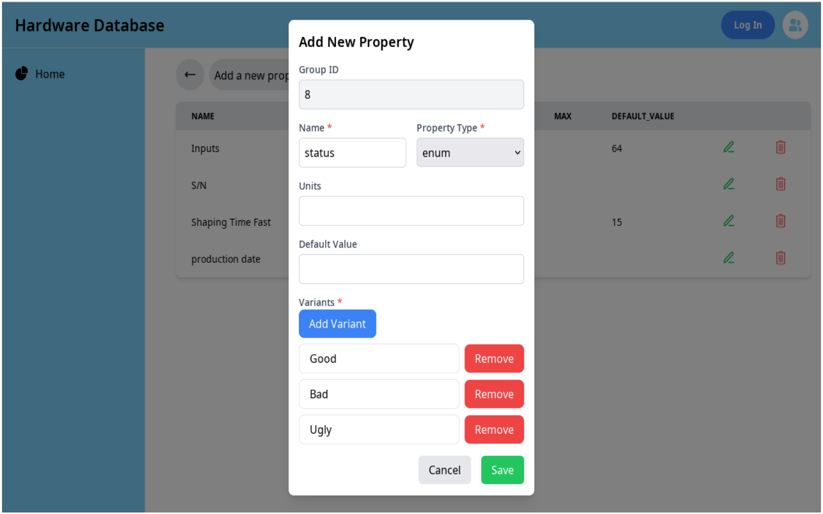
Hardware Database: filling groups

- String.



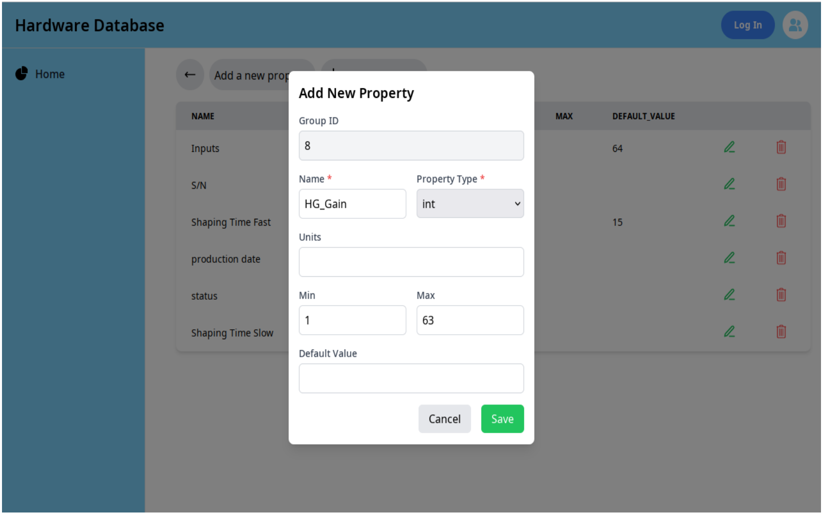
Hardware Database: filling groups

- Enum. Specify possible values



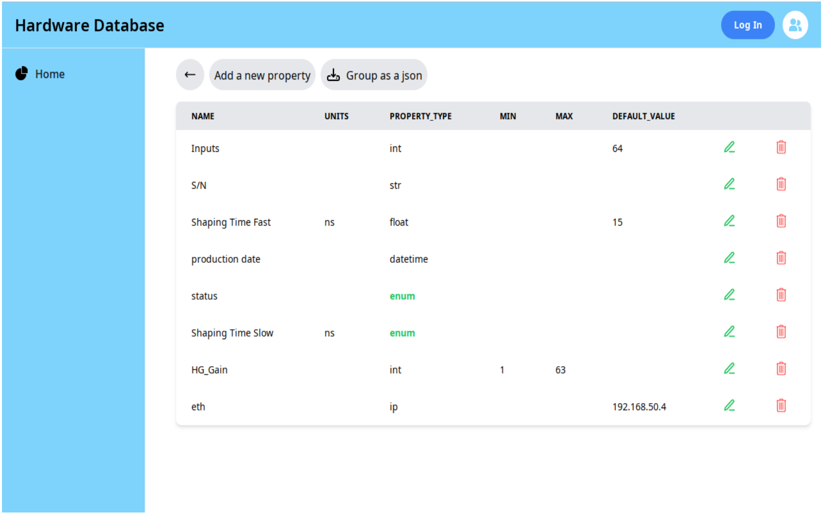
Hardware Database: filling groups

- Integer. Minimal an maximal values specified



Hardware Database: filling groups

- After adding some more properties



NAME	UNITS	PROPERTY_TYPE	MIN	MAX	DEFAULT_VALUE
Inputs		int			64
S/N		str			
Shaping Time Fast	ns	float			15
production date		datetime			
status		enum			
Shaping Time Slow	ns	enum			
HG_Gain		int	1	63	
eth		ip			192.168.50.4

Event Index: further development

- User authorization and authentication, group access policies
- API development (REST, Python, C++, ...)
- Further optimization of user request processing, improving priority management depending on the volume of requested data
- Development of coomunication with other information systems for organising of indexing of data (Rucio, PanDA) and collecting ther results (FTS)
- Supervisor - software for managing, collecting and importing data
- Development of component monitoring system, with graphical representation of data based on popular platforms (Grafana, etc.)

The implementation of these tasks will be carried out in parallel with the development of other Information Systems of the experiment.

Monitoring and logging

Monitoring information system yet have to be developed

- Will become necessary as detector components become ready
- Will use various source of data from the subsystem and other databases
- Data can be transferred in JSON format with variable schema
  - Only few mandatory fields required (source id, time stamp, etc..)
- Data transfer through the HTTP requests can be used
- Time series database should be used as a back-end
- Commonly used solution like Grafana for use for visualization of data
- Solutions that worked well on the other NICA experiments should be used

Monitoring and logging can be shared beetween the NICA experiments