Development of the **Online Data Processing System** (ODP) for the BM@N experiment at NICA

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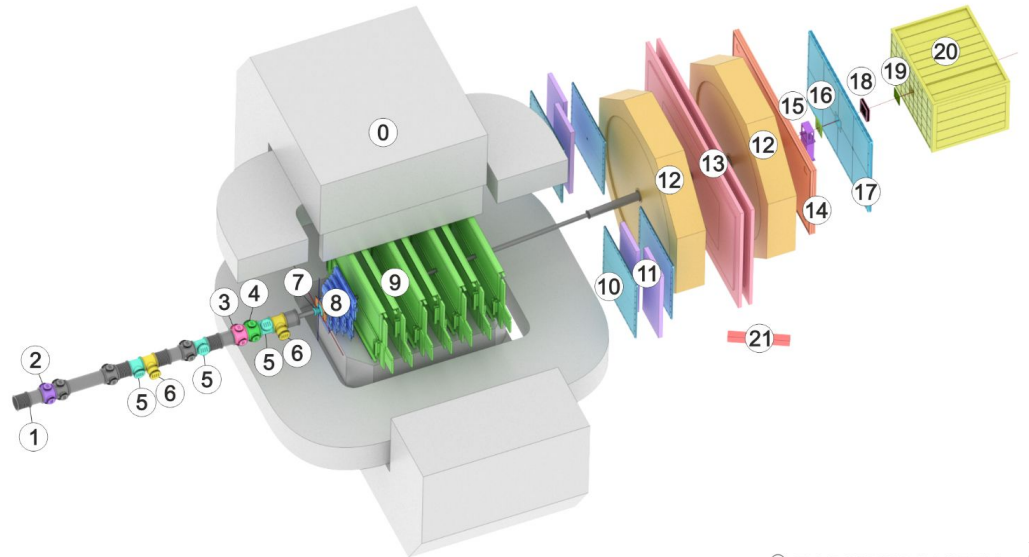
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BM@N experiment

Baryonic Matter at Nuclotron (BM@N) is a fixed-target experiment and the first experiment in the NICA project.

It's **an ongoing** experiment. The first physics run was from December 2022 to February 2023.

Magnet SP-41 (0)
Vacuum Beam Pipe (1)
BC1, VC, BC2 (2-4)
SiBT, SiProf (5, 6)
Triggers: BD + SiMD (7)
FSD, GEM (8, 9)
CSC 1x1 m^2 (10)
TOF 400 (11)
DCH (12)
TOF 700 (13)
ScWall (14)
FD (15)
Small GEM (16)
CSC 2x1.5 m^2 (17)
Beam Profilometer (18)
FQH (19)
FHCal (20)
HGN (21)

Purpose and requirements

The purpose of the ODP system is selective data processing for data quality analysis.

The system must be able to **customize the task flow**, since a number of tasks and their types may change from run to run.

Distributed architecture of the ODP system

The messaging system allows you to **customise the task flow** as each task publishes the results of its work to which other tasks can subscribe.

It can enable **parallel processing of tasks** because multiple replicas of a task can be run.

Task 4

Task 1

Task 2

Task 3
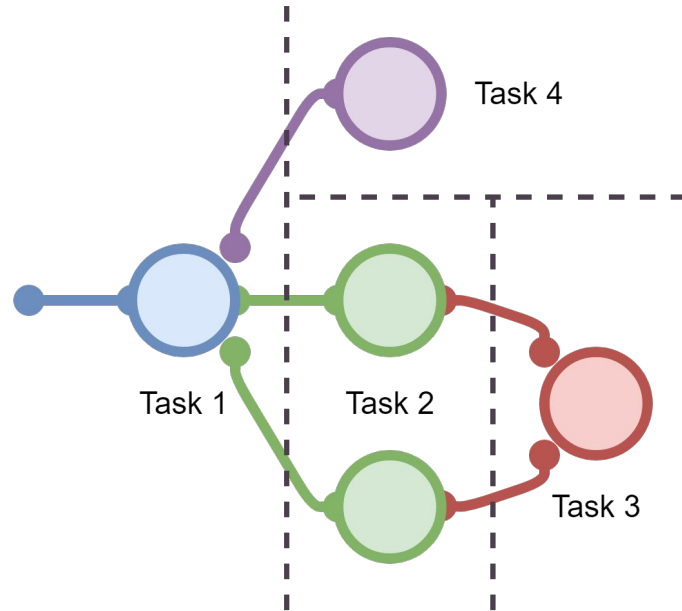
Chosen solutions

Message exchange

FairMQ[*] is a messaging framework focused on building modular systems for data processing in high-energy physics experiments.

It represents an abstraction over various messaging technologies such as ZeroMQ, Nanomsg, etc.

Deployment

DDS[*] (Dynamic Deployment System) is a set of tools that facilitates the process of system deployment.

As a Remote Manipulator System (RMS), it initially provides SSH or SLURM, but also allows you to use other methods.
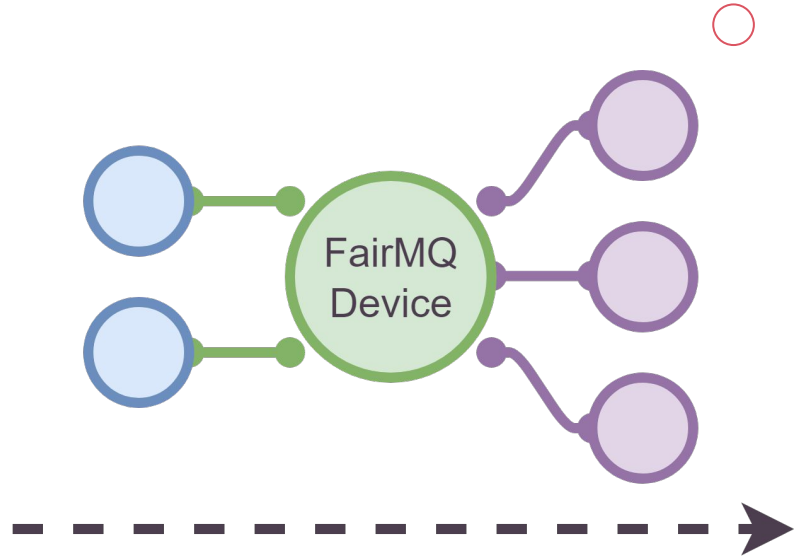
[*] Developed by the FAIR collaboration at the GSI Institute, Germany.
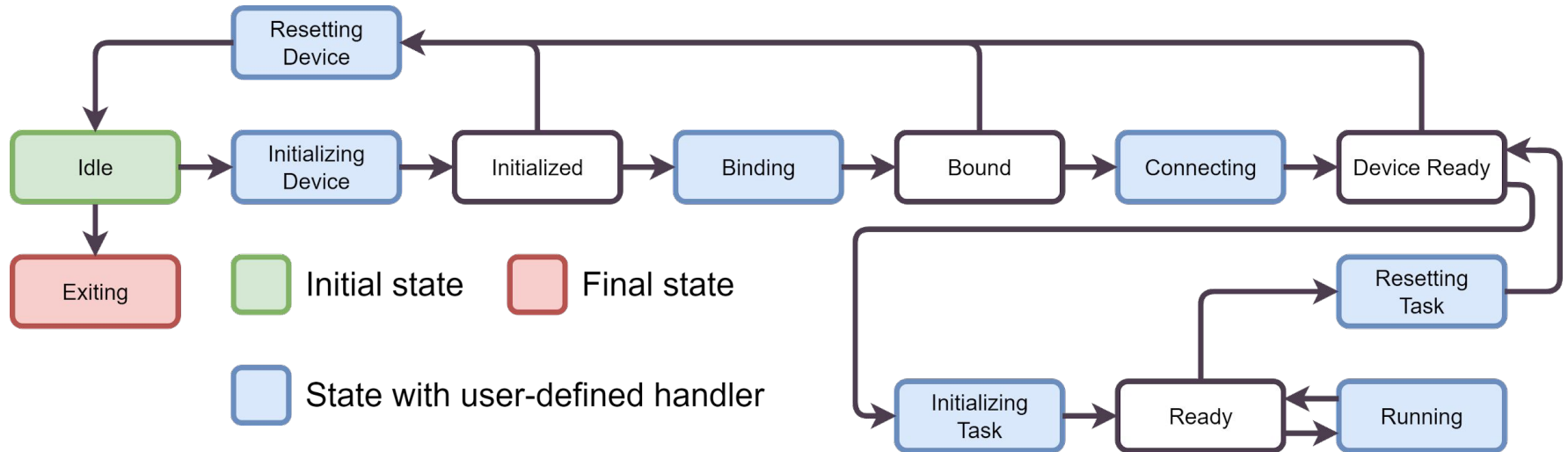
FairMQ Device

Each data processing task is represented as **a separate** FairMQ device.

It is **an independent** module of the system.

The task processing flow is created by **connecting devices together**.
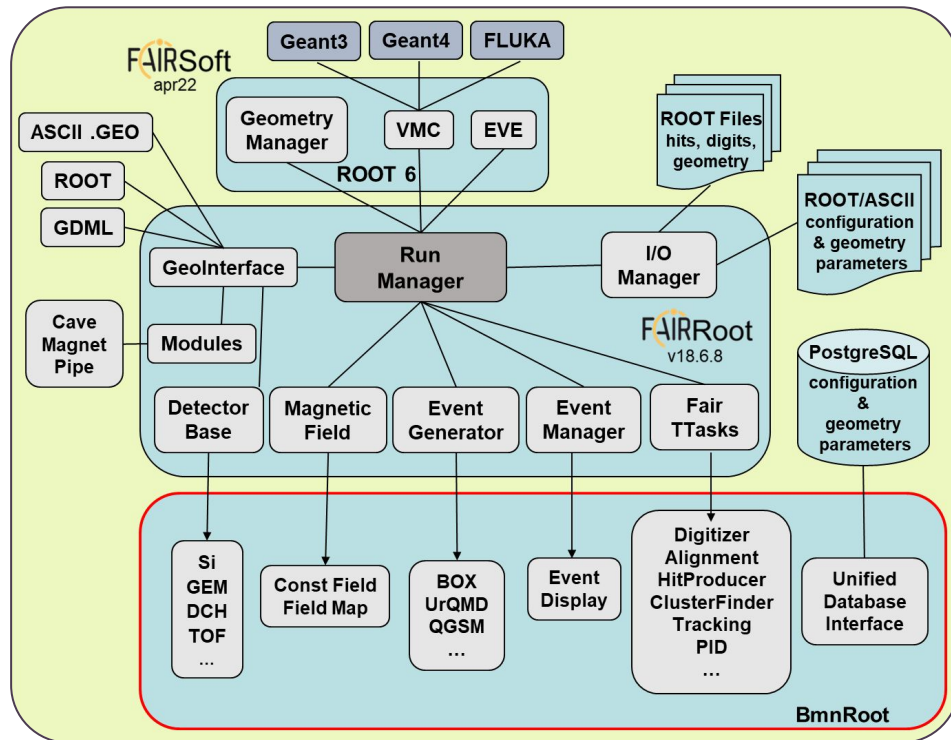
Life cycle of FairMQ Device

BmnRoot Framework

BmnRoot Framework is a software for BM@N experiment.

It provides tools for **simulation**, **reconstruction** and **physics analysis of the data** using ROOT macros[*].

BmnRoot is based on **the ROOT** and **the FairRoot** frameworks.

[*] The ROOT macro contains pure C++ code, which is interpreted at runtime.

Comparison of reconstruction processes

run_reco_bmn.C
(macro)

FairRunAna is used to store and manage the list of reconstruction tasks (initialization, execution, completion).

FairMQ Device

Reconstruction tasks are stored in a special array. They are managed through a sequential call to the methods **InitTask**, **Exec** and **FinishTask** when the device is in **the running state**.
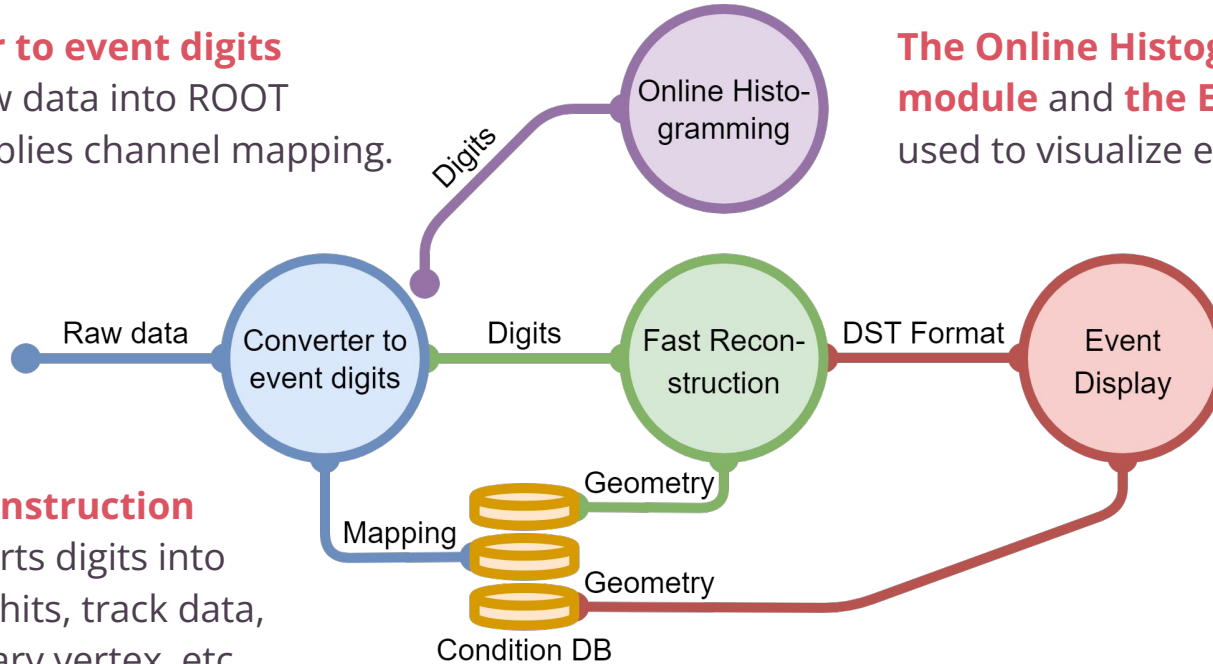
Online processing task diagram

The converter to event digits transforms raw data into ROOT format and applies channel mapping.

The Online Histogramming module and **the Event Display** are used to visualize event data.

Online Histo-gramming

Digits

Raw data — Converter to event digits — Digits — Fast Recon-struction — DST Format — Event Display

The Fast Reconstruction module converts digits into reconstructed hits, track data, finds the primary vertex, etc.

Mapping

Geometry

Geometry

Condition DB

The Condition Database stores various parameters that are used in the data processing algorithms.
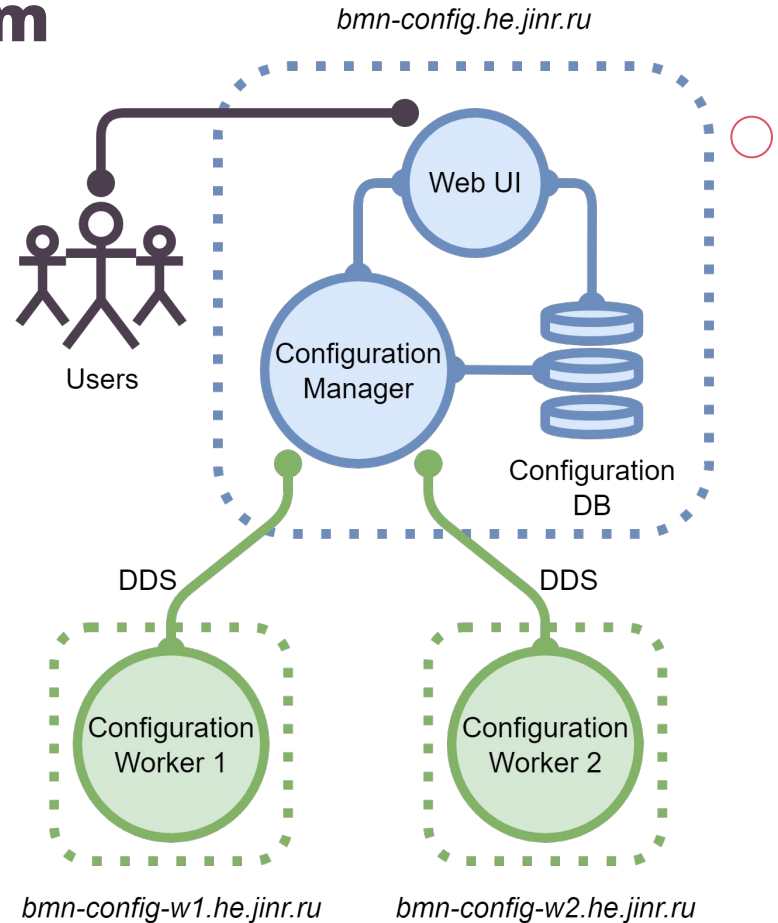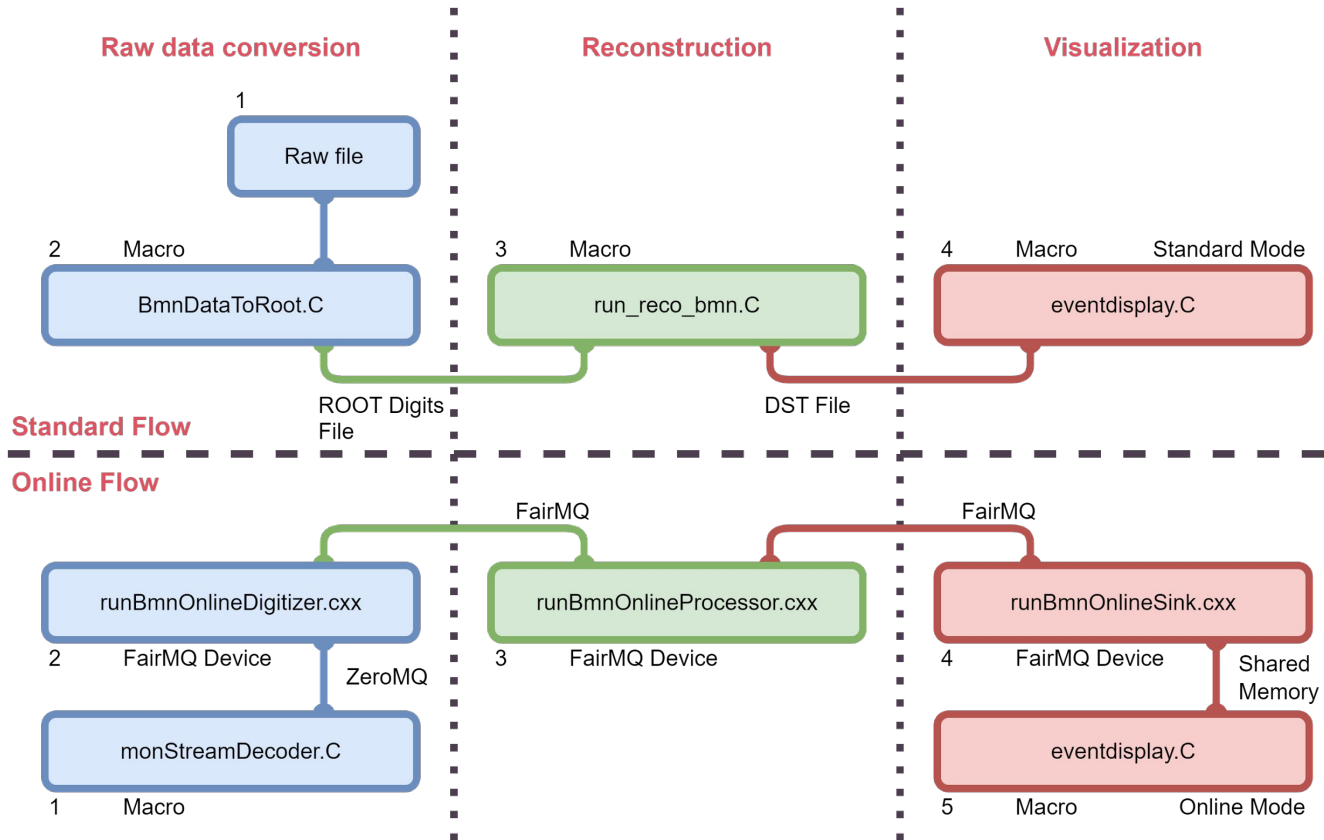
Process management **system**

The Online Configuration System (OCS) is a process management system based on the DDS deployment system.

The OCS system consists of the central manager, the database, the web interface and a set of workers.

Data processing tasks are configured and run using **the web interface**.

bmn-config.he.jinr.ru

Users

Web UI

Configuration Manager

Configuration DB

DDS

DDS

Configuration Worker 1

Configuration Worker 2

bmn-config-w1.he.jinr.ru

bmn-config-w2.he.jinr.ru

Implemented solution

OCS Designer and Task Monitor

Conclusions

- **The distributed architecture** has been designed for the ODP system
- The ODP system has been implemented using **FairMQ**
- The system is run and managed using **the OCS system** based on **DDS**.
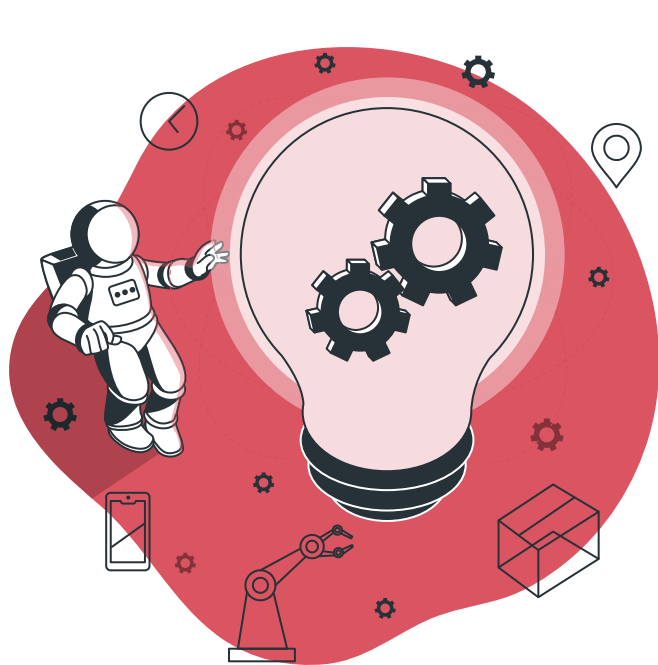
Thank you for your **attention!**