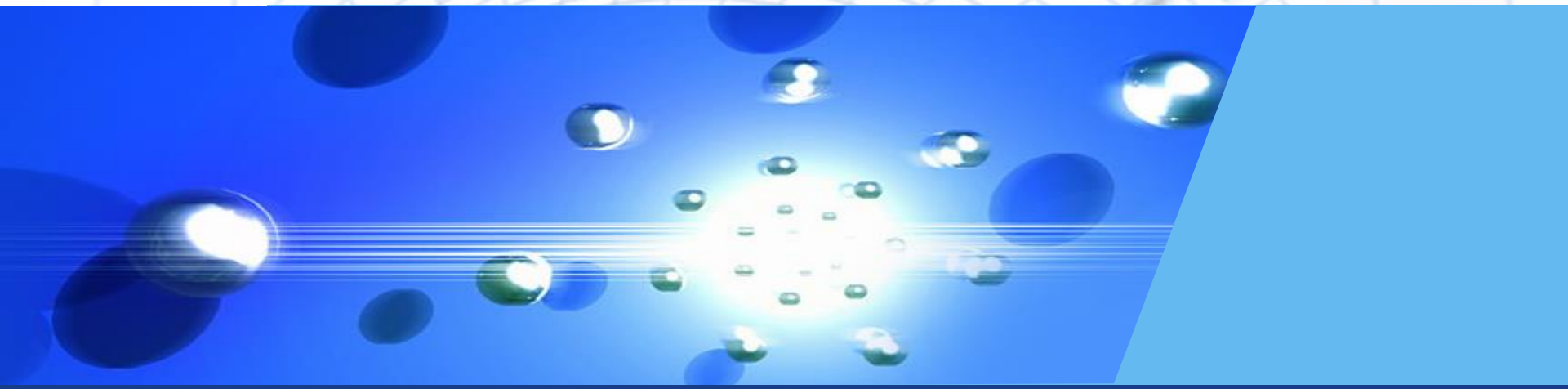


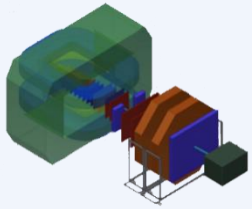
BM@N Software Development
Summary of the Software Section

Konstantin Gertsenberger
V. Veksler and A. Baldin Laboratory of High Energy Physics

JINR, Dubna
26-27 October 2020

Information Systems:
Databases + Services

BM@N Data Processing Pipeline



DRE

LDC

FLP

First Level Processor

Data Check
Flow Control
Formatting

EvB

Event Builder

Buffering
Sorting
Distribution

RQ

Raw Data Quality Check

FT REC

Fast Event Reconstruction

TDS

Transient Data Storage

HIST

Online Histograms

EvM

Event Monitor

Digitizer

ROOT Format
Mapping
Alignment

REC

Event Reconstruction

PA

Physics Analysis

BM@N distributed clusters

PDS

Permanent Data Storage

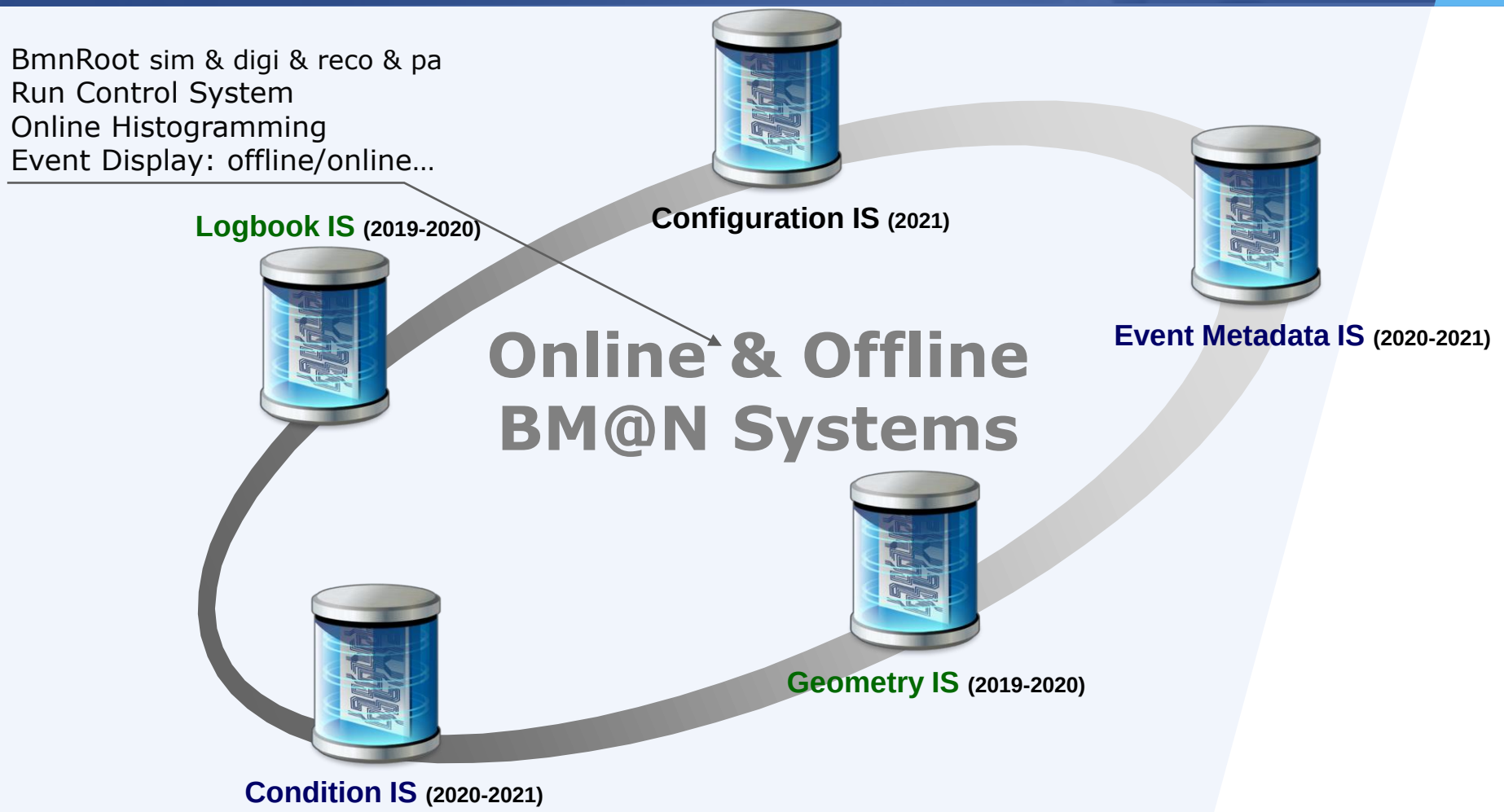
Information Systems (DB)

Ilnur Gabdrakhmanov (26 October 11:30)
Online Histogramming System and perspectives of its integration with DQA

DAQ → Online Processing → Offline Processing

matched from “Data Acquisition System TDR”

Information Systems for online & offline processing



RFBR Grant 2019 – 2021: Development of Information Systems for Online and Offline Data Processing for the Experimental Setups of the NICA Complex

e-Log Platform Status

BM@N Electronic Logbook — bmn-elog.jinr.ru — **Logged in as shift**

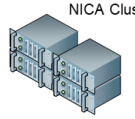
Home New Find Last day Account Reference Book

Page: 1 of 282 Number of items per page: 10 Logout

Date	Shift Leader	Type	№ Run	Trigger	DAQ Status	SP-41, A	SP-57, A	VKM2, A	Beam	Energy, GeV	Target	Comment	Attachment
2018-04-05 11:47:06	Rumyantsev	Inform All	5185 per.7	Special Trigger	All	0	0	0	Kr	2.94	Cu (2 mm)	End of the RUN7	
2018-04-05 11:09:20	Rumyantsev	New Run	5184 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3 VKM2: I=125A, SP-57=50A, SP41=1250A; 100 k	
2018-04-05 08:12:35	Rumyantsev	New Run	5183 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>2 VKM2: I=125A, SP-57=50A, SP41=1250A; 120 k	
2018-04-05 07:46:35	Babkin	New Run	5182 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3 VKM2: I=125A, SP-57=50A, SP41=1250A; 208 kev	
2018-04-05 07:41:29	Babkin	New Run	5180 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3; VKM2: I=125A, SP-57=50A, SP41=1250A; 201 kev	
2018-04-05 07:25:08	Babkin	New Run	5179 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3; VKM2: I=125A, SP-57=50A, SP41=1250A; 201 kev	
2018-04-05 06:01:07	Babkin	New Run	5178 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3; VKM2: I=125A, SP-57=50A, SP41=1250A; 201 kev	
2018-04-05 05:27:39	Babkin	New Run	5177 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3; VKM2: I=125A, SP-57=50A, SP41=1250A; 204 kev	
2018-04-05 05:27:06	Babkin	New Run	5176 per.7	Beam Trigger + BD>3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & BD>3; VKM2: I=125A, SP-57=50A, SP41=1250A; 150 kev	
2018-04-05 04:47:27	Babkin	New Run	5174 per.7	Beam Trigger + BD>3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & BD>3; VKM2: I=125A, SP-57=50A, SP41=1250A; 213 kev	

2020 - software team (contact e-mail: gertsen@jinr.ru)

Common FreeIPA Authentication: Administrator, Editor, Reader roles



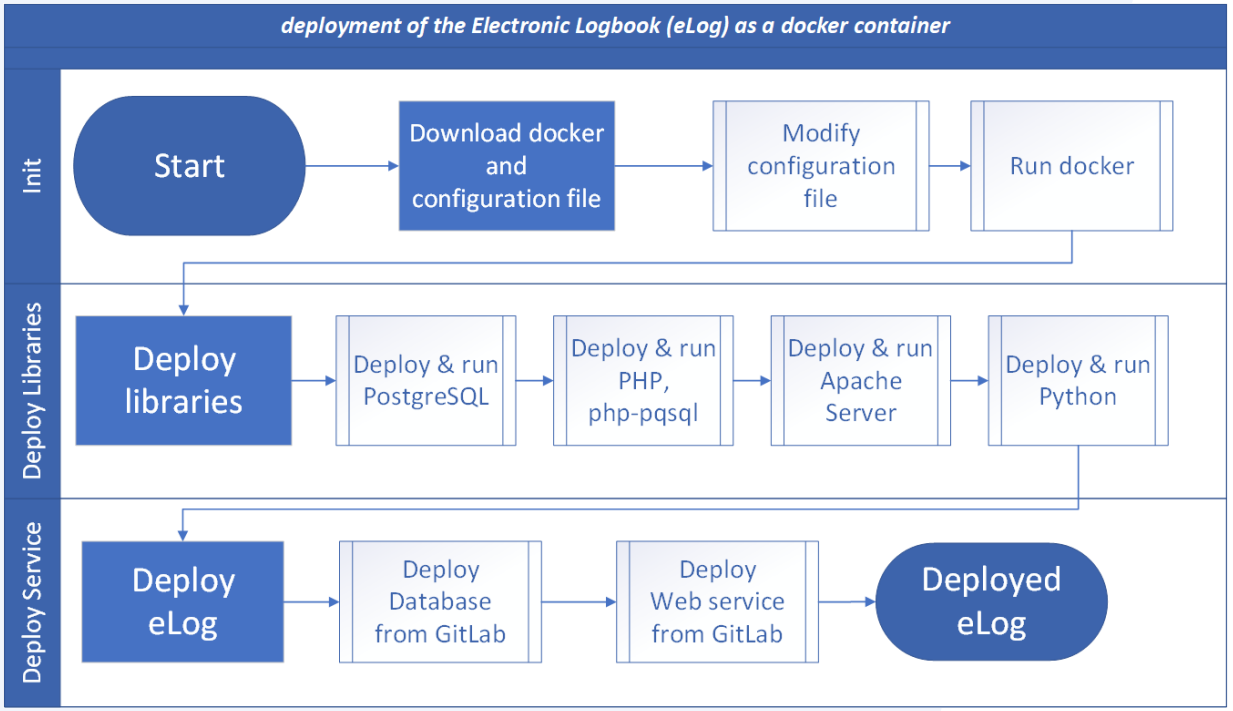
File Attachments (text description, photo) Multi-Column Sorting Easy Searching

Email Subscription to selected event types Logbook Monitoring User Cabinet

e-Log Configuration and Deployment

Configuration File

```
{ "host" : "nc13.jinr.ru",    //Database host
"port" : "5432",              //Database port
"dbname" : "bmn_elog",        //Database name
"dbA":true,                   //Authorization type
//Experiment specific data columns
"colVal": {  "sp_41" : "SP-41, A",
   "sp_57" : "SP-57, A",
   "vkm2"  : "VKM2, A"},
"columns" : [ {"column" : "sp_41 int null"},
{"column" : "sp_57 int null"},
{"column" : "vkm2  int null"}],
"expName":"MPD",                      //Experiment name
"loginImage" :"login/images/bmn2.png", //Login image
"loginLink":"http://bmn.jinr.ru",     //Link to Web site
"fillRunDB":true,                     //whether fill DB
"sendNotif":true,                     //Notifications
```



Deployment Scheme

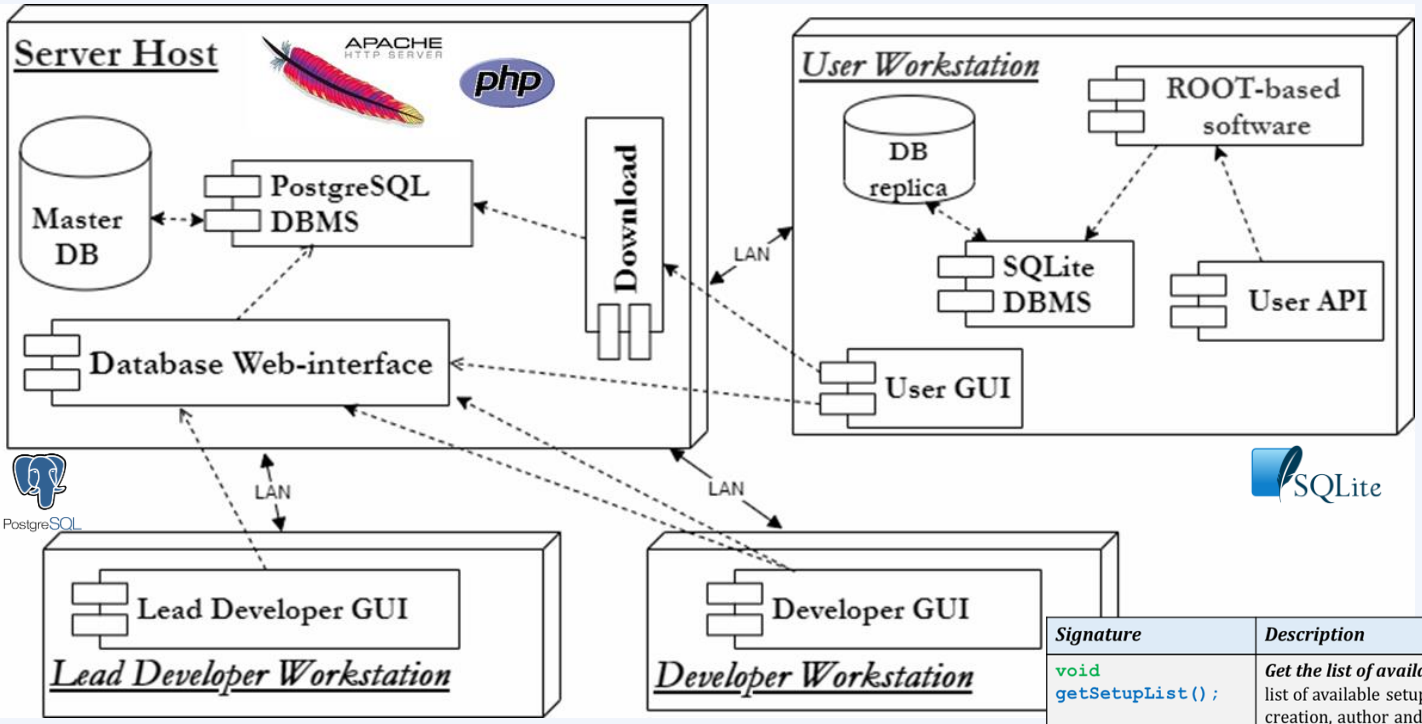
The Common Deployment System is based on Docker containers and shell scripts

It allows to install the Online Logbook System for all the experiments of the NICA project taking into account some specifics of the experiments

Geometry Information System

- is based on the Geometry Database to work with detector geometries of the NICA experiments and intended for storing, using and managing information on the geometry models of the detectors
- manages geometry modules as ROOT binary objects
- each setup module stores a tag, version, transformation matrix, optional parameter file, and link to the parent module
- manages full setups as a combination of geometry setup modules, magnetic field and materials
- manages the versions of the modules and setups
- provide the detector geometries for online (e.g. monitoring the current events) and offline (e.g. event reconstruction and analysis) systems

Client-Server Architecture of the Geometry IS



Evgeny ALEKSANDROV
(26 October 11:45)

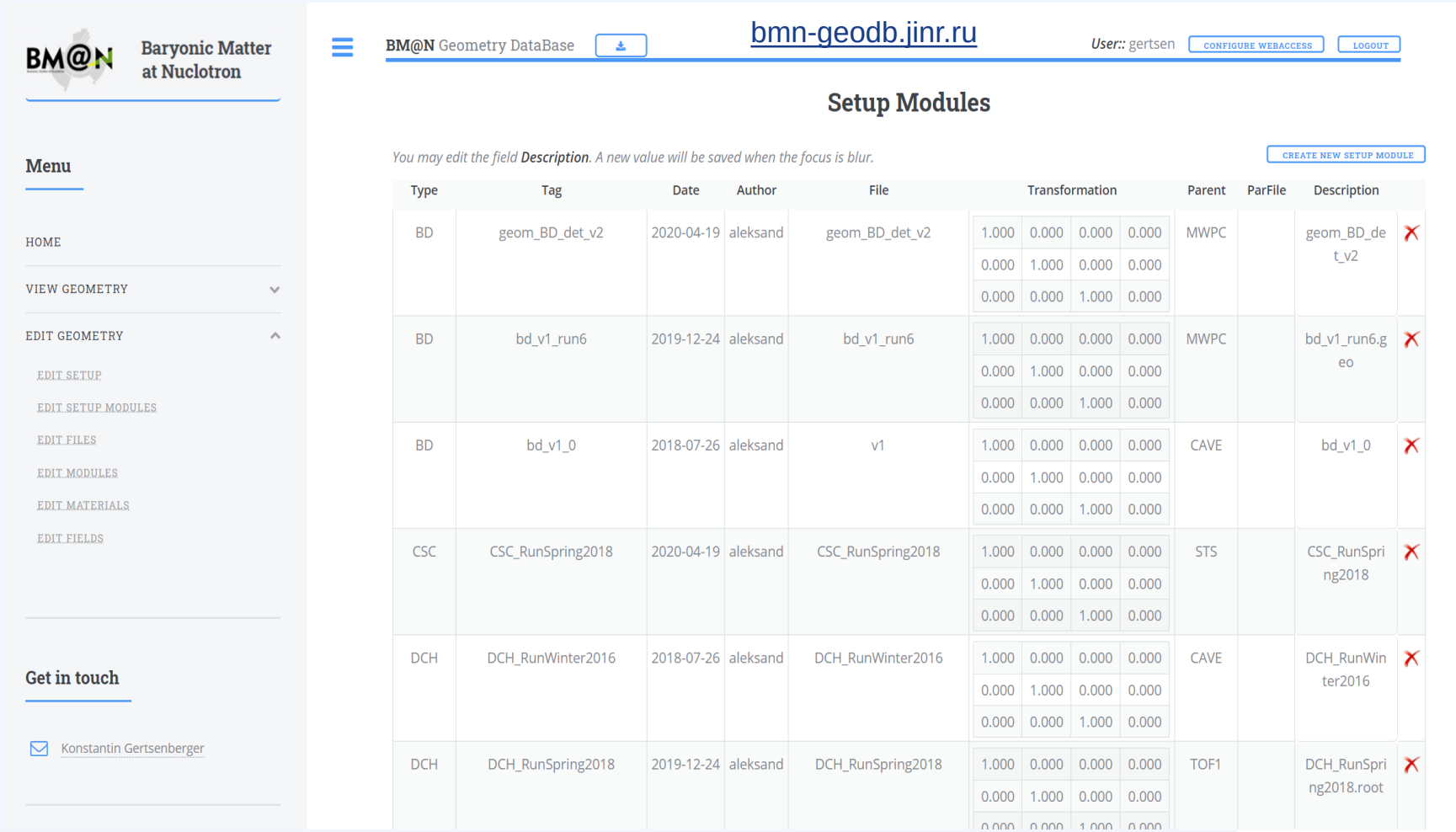
Geometry Information System for the BM@N and other experiments

Three user roles:
Lead Developer | Developer | User (Reader)

Geometry API provides a set of ROOT macros for selecting and loading a required setup geometry and its components into BmnRoot to perform simulation, reconstruction and physics analysis

Signature	*Description*	*Call Example*	*Comment*
`void getSetupList();`	***Get the list of available setups.*** Print the list of available setups including tag, date of creation, author and description parameters for each approved setup.	getSetupList.c();	Return the available setups' list
bool loadSetup(const char* setupTag, const char* moduleName);	***Load setup into the Fair framework.*** The Geometry can be used in ROOT framework afterwards. Return FALSE if setup is not loaded, and TRUE if the loading is successful.	bool res = loadSetup("sis100_electron", "*");	"*" – all setup modules to be loaded
void installLocalDB.C();	***Install local database from server to client.*** Download replica of central database to client computer.	installLocalDB();	Require set variable **DBL_FILE_PATH** before use.
void installServerDB.C();	***Install new server instance.*** Install and init PostgreSQL database server	installServerDB();	Required config file with name **geodb.config.xml**

New Web platform of the Geometry Database

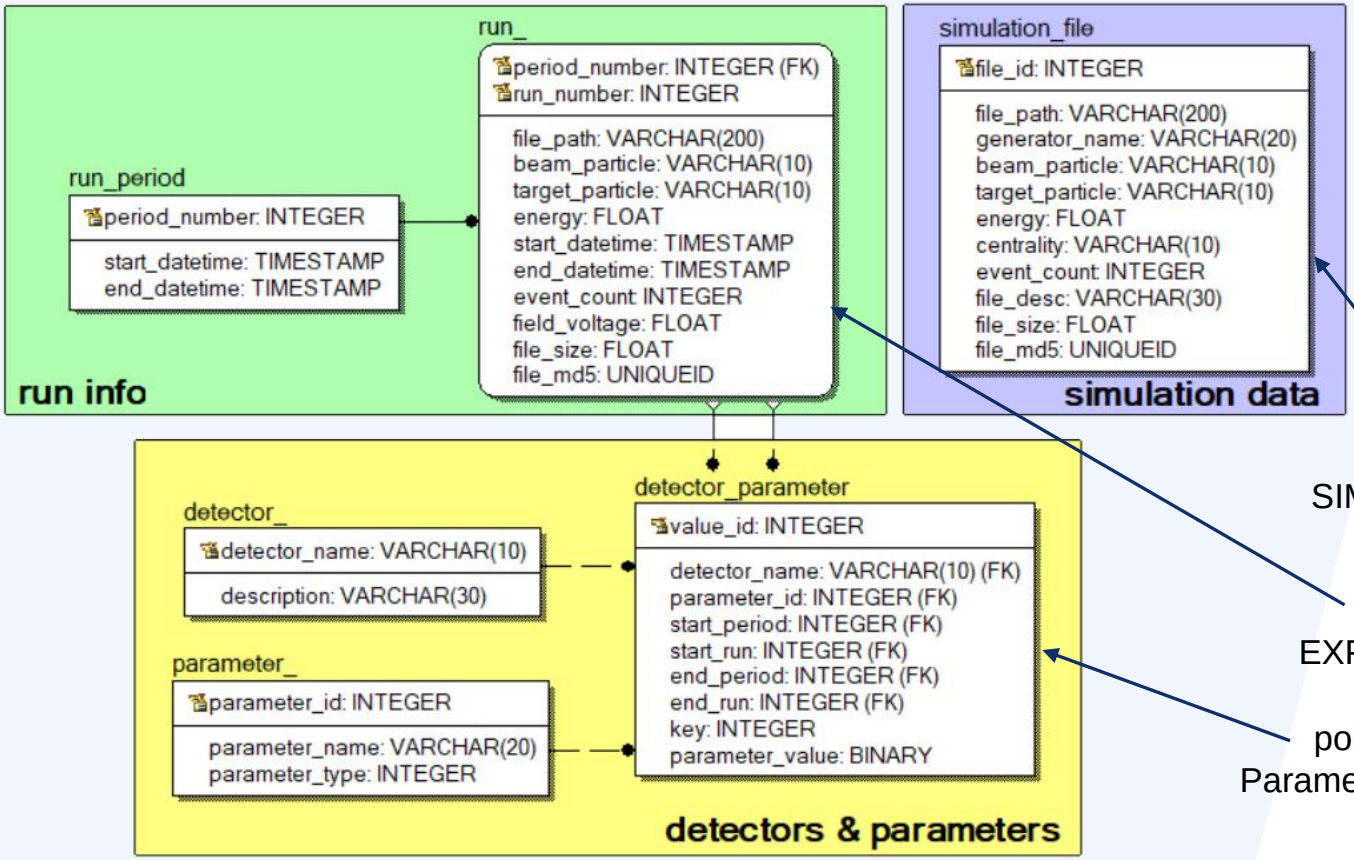


BM@N Geometry Database has filled with setup geometries for Run 7 and 6

Graphical User Interface Functions:

View Edit Download

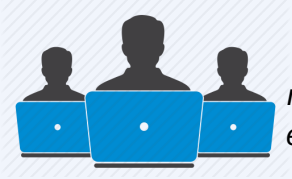
Unified → Condition Database



storing information on experiment sessions and runs, detectors, parameters and parameter values, and generated simulation files

PostgreSQL

BM@N Database for offline processing



detector simulation
raw data processing
event reconstruction
physics analysis

BmnRoot

C++ database interface w/o SQL
(connect, SQL I/O)

ROOT

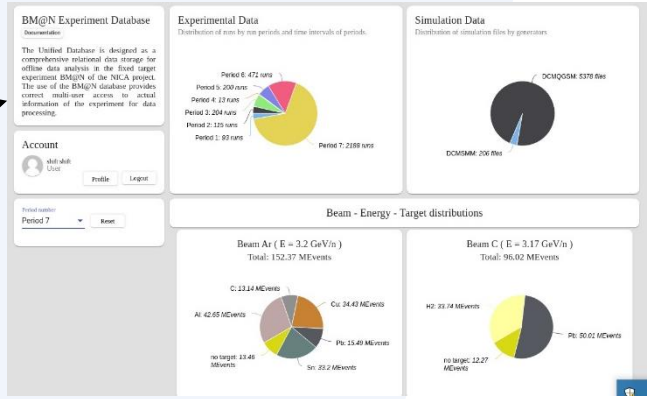
Node.JS

Condition Database

Local Condition Database
as a local replica
of the central Condition Database
is under closer consideration

users

FreeIPA authentication

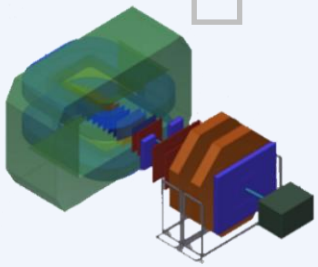


Web interface (bmn-unidb.jinr.ru)

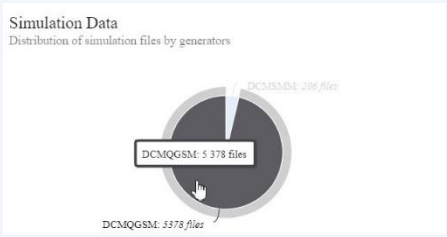
- Web GUI has been improved
- Added dynamic elements and some bugs have been corrected
- *Select & Jump* function for diagrams and tables has been implemented

configuration calibration

parameter and algorithm data



python script for auto update of simulation file list



Alexander CHEBOTOV (26 October 12:05)
Architecture of the Web service for offline database of the BM@N experiment

Event Metadata System (EMS)

- main functions are description of particle collision events, storing of necessary event metadata, their management and convenient access, and organizing online and offline interfaces to the metadata
- is based on the Event Database called Event Catalogue, which contains summary properties of particle collision events and references to their storage location
- allows user to quickly search for a set of events required for a particular physics analysis by various criteria and parameters
- is responsible for creating, maintaining and checking the quality of the catalogue of physics events

Metadata Structure in the Event Catalogue

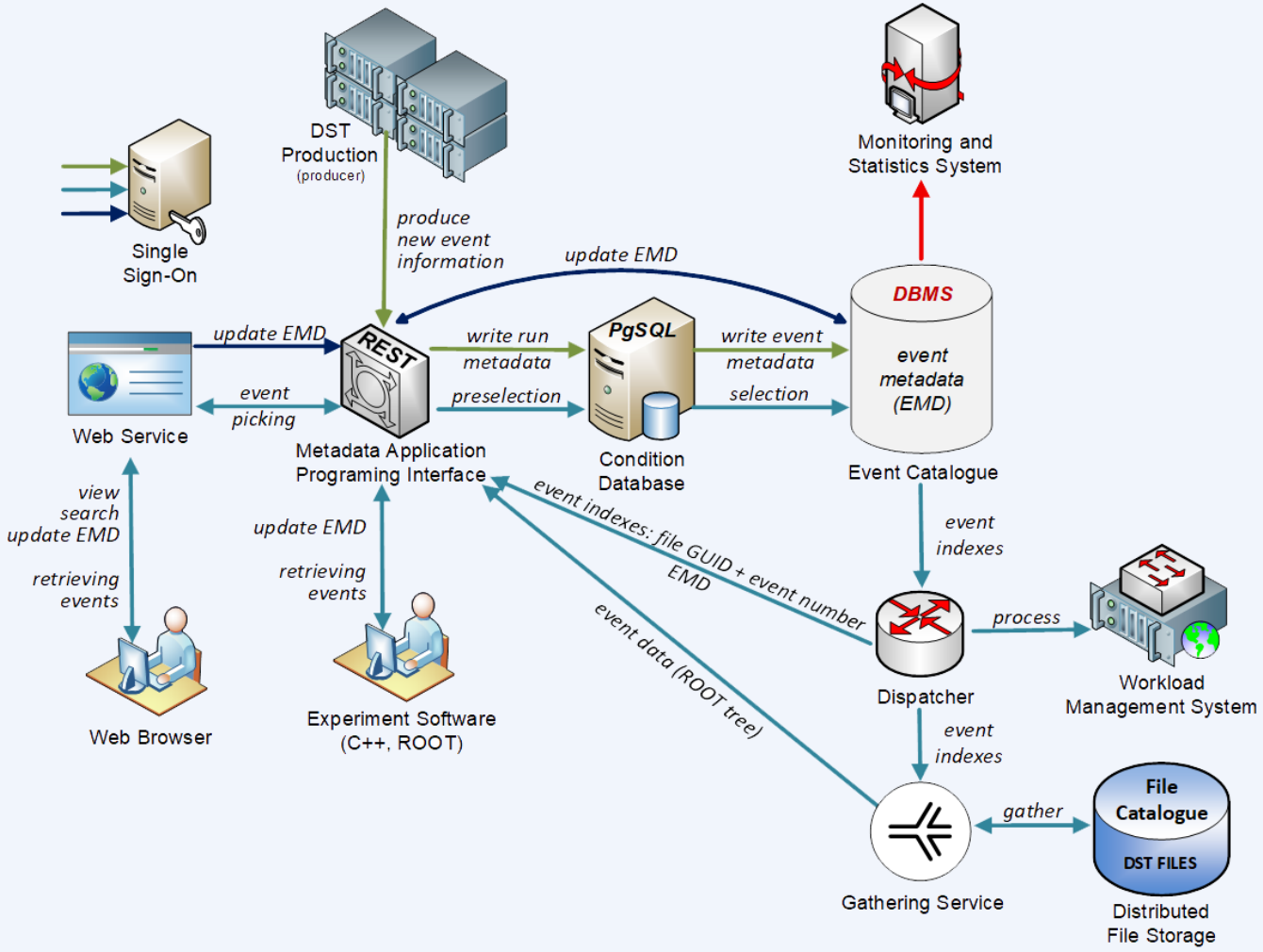
- period and run number

- **file pointer (GUID)**
- **event number**

- software version
- event time
- number of primary and all reconstructed tracks
- track number of positively and negatively charged particles
- primary and secondary particles found
- number of hits by detectors
- total input and output charge in the event…

EMS provide the following functions: summary description of collision events and their identifiers, which can be used to select events for a desired analysis goal, recording and storing event metadata, management and access to the metadata, organization of online and offline interfaces for selecting events of interest

Architecture of the Event Metadata System



Web interface

for viewing and searching for event metadata stored in the Event Catalogue and retrieving events which satisfy given user parameters

Metadata API

for writing new metadata to the Event Catalogue while data processing and requesting events selected by criteria for physics analysis in BmnRoot

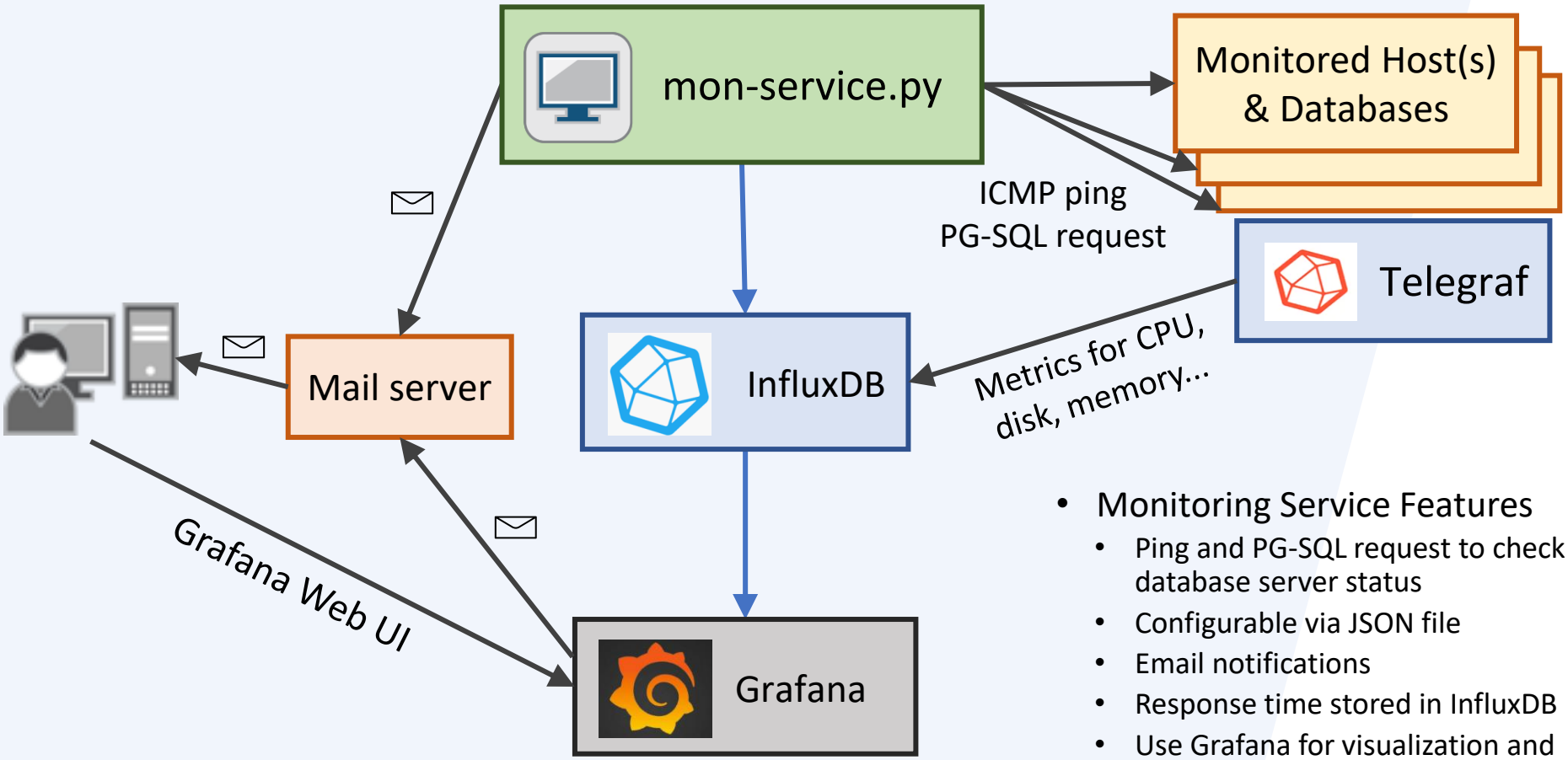
DBMS for Event Metadata System (in progress)

It is assumed that the number of the events will increase from the current value of hundreds of million BM@N events to billions of events per year

	PostgreSQL	HBase	Cassandra
Configuration 1: Intel Core i9-10900F DDR4 64Gb 3200MHz SSD 1Tb Samsung **500 million events**	**123 GB** Select 1: 9 / 10 sec Select 2: 9 / 10 sec Select 3: 10 / 15 sec Select 4: 10 / 11 sec		deployed, configuring
Configuration 2 (VM): 2xIntel Xeon E5-2680 DDR4 256GB 2133 MHz SSD 400 GB Intel **500 million events**	Select 1: 18 / 23 sec Select 2: 18 / 22 sec Select 3: 21 / 39 sec Select 4: 20 / 24 sec	deployed, profiling 1027 sec	

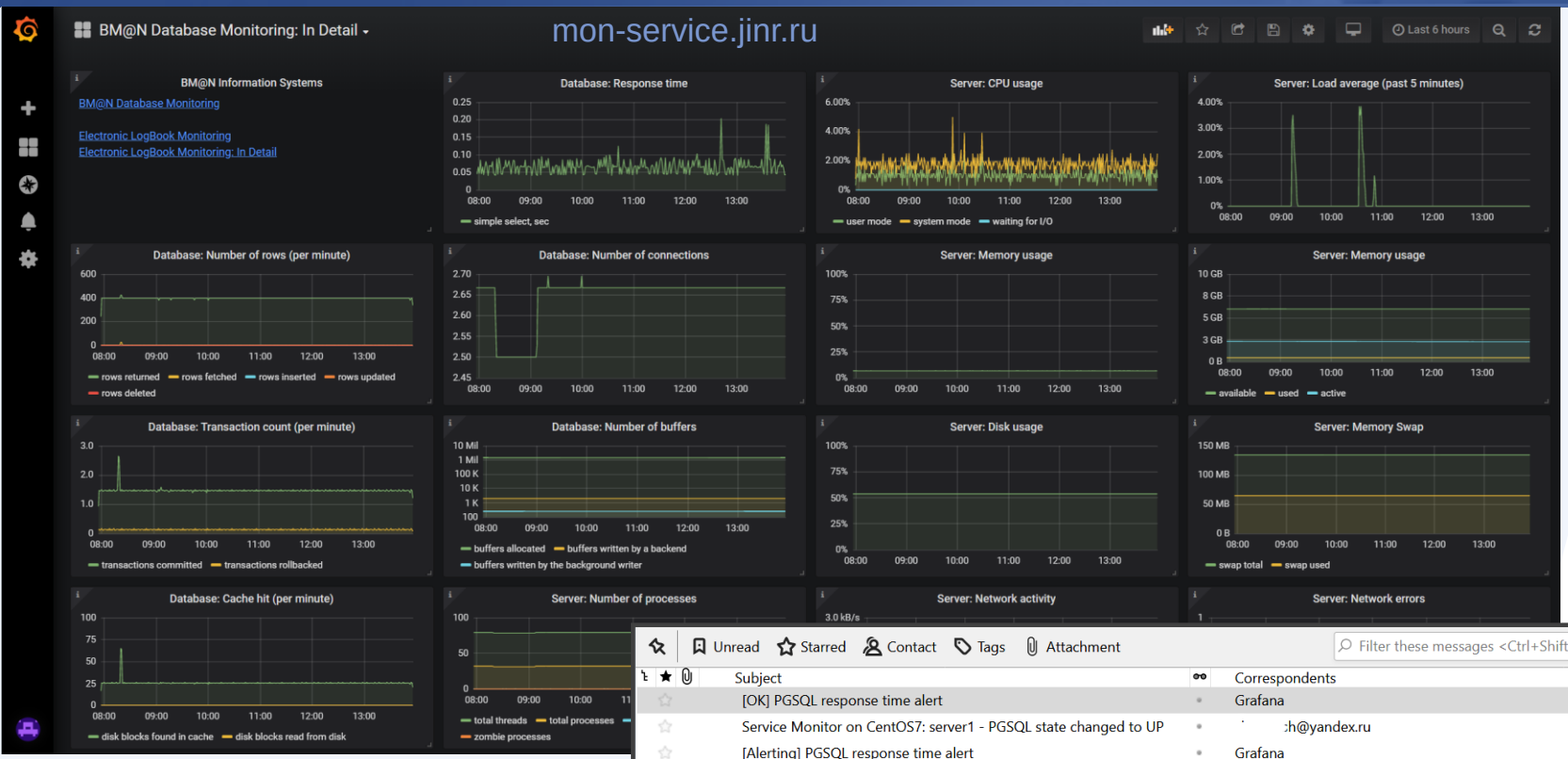
Services for the Ecosystem

Monitoring Service



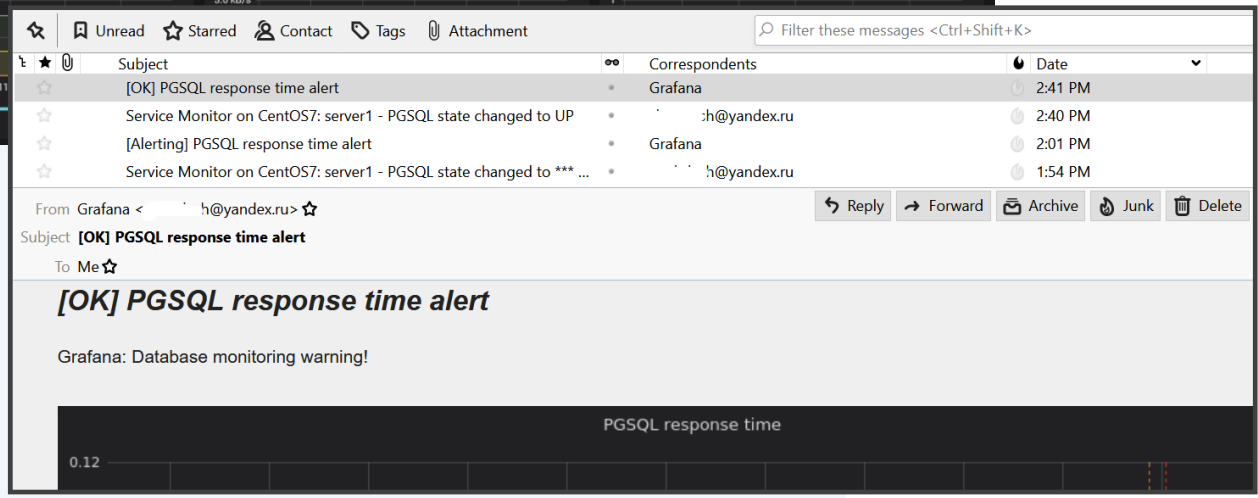
- Monitoring Service Features
  - Ping and PG-SQL request to check database server status
  - Configurable via JSON file
  - Email notifications
  - Response time stored in InfluxDB
  - Use Grafana for visualization and additional alerting
  - NEW: Monitor server parameters such as Disk, CPU, Memory, etc.

Monitoring Information Systems



Grafana View

- BM@N Database + detailed
- Electronic Logbook + detailed

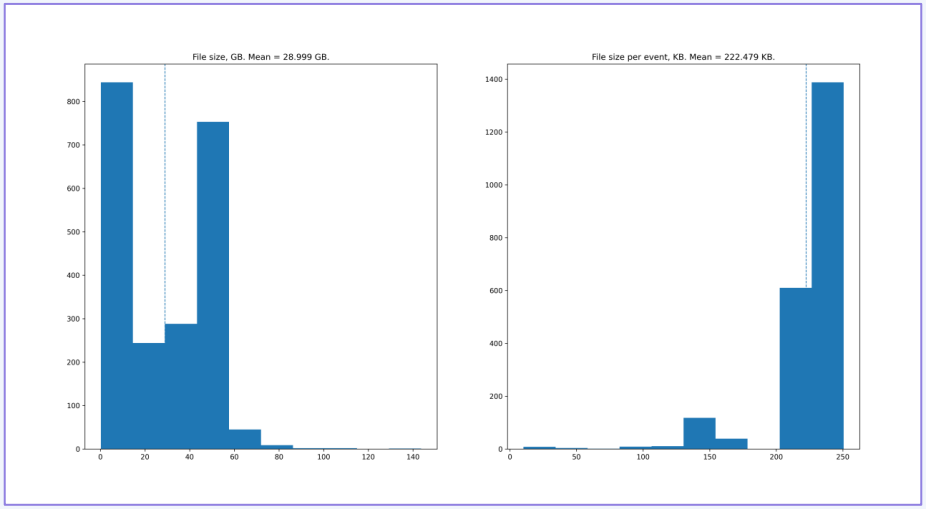


Email Notifications

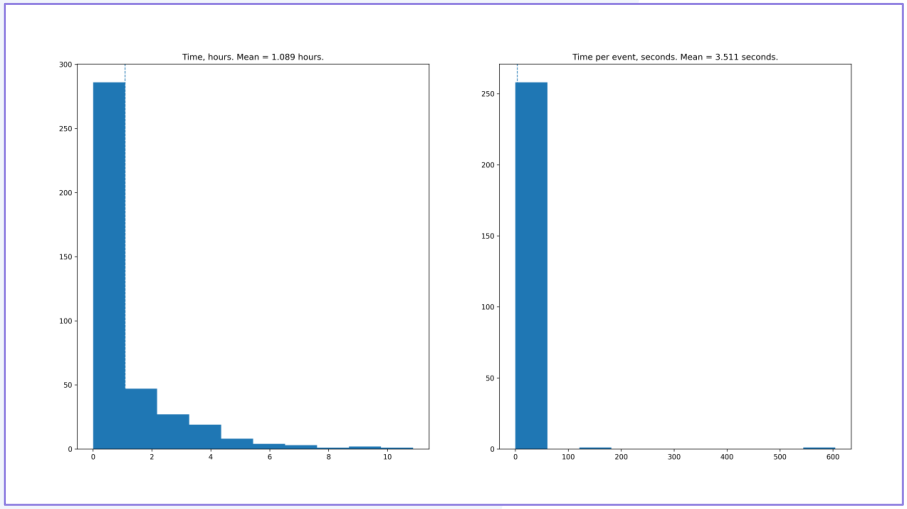
Statistics Collection

- Shows histograms and summary data for:
  - File size and size per event for given directories with data
  - Parsing job logs to get processing time for run and time per event, as well as to define failed jobs
- Implemented as Python script
- https://git.jinr.ru/nica/bmnroot/uni_db/services/statistics

```
# python3 stats.py --size --dir /eos/nica/bmn/exp/raw/run7/ --config config-size.json --recursive
```

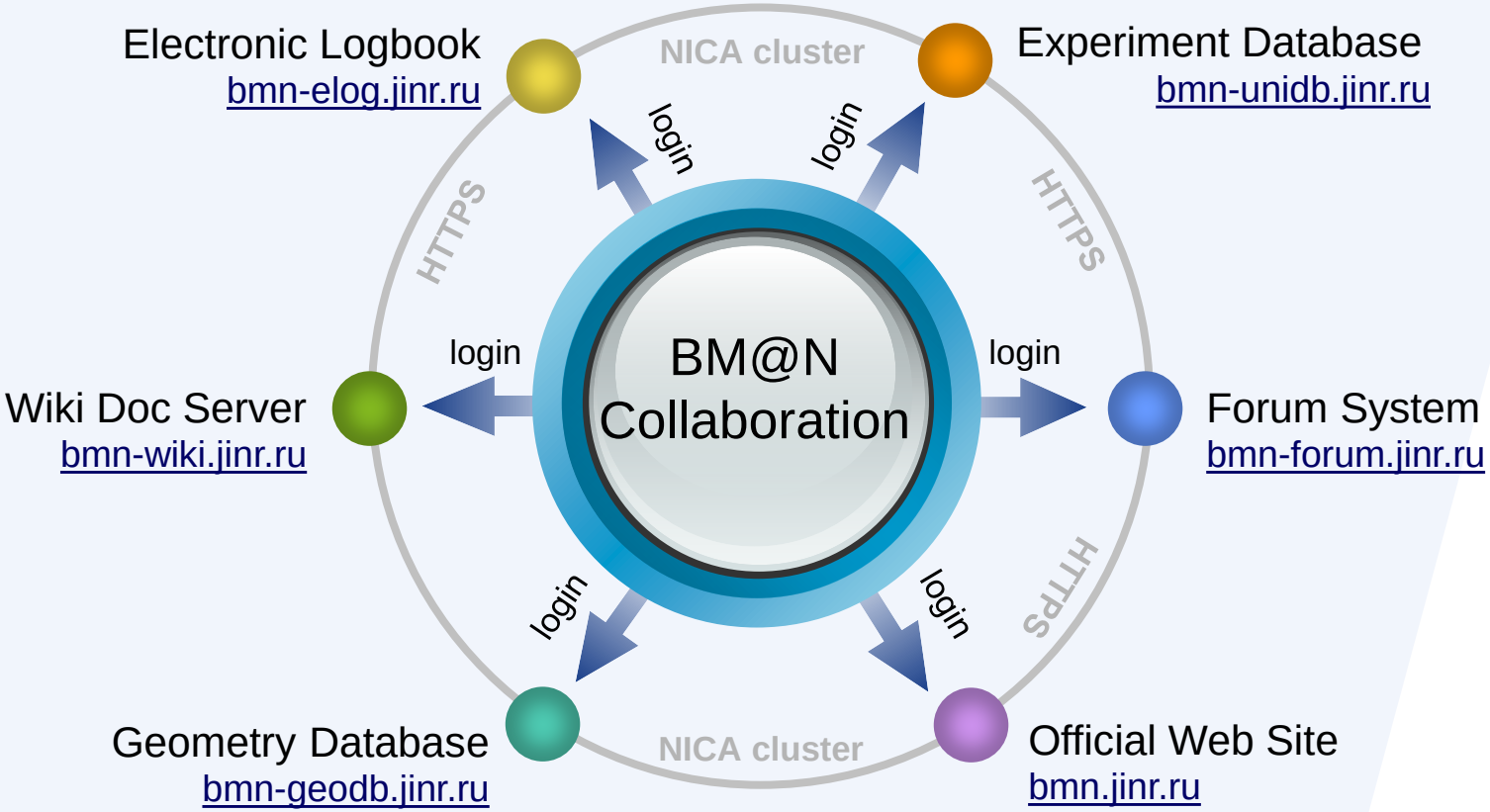


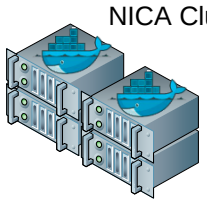

```
# python3 stats.py --time --dir /eos/nica/bmn/users/logs/ --config config-time.json
```



Collaboration Services

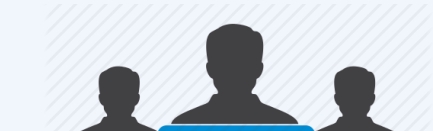
Completeness of the BM@N Collaboration Services





Ivan SLEPOV (26 October 11:15)
Status of information services for the BM@N experiment

FreeIPA: Single Authentication & Autorization



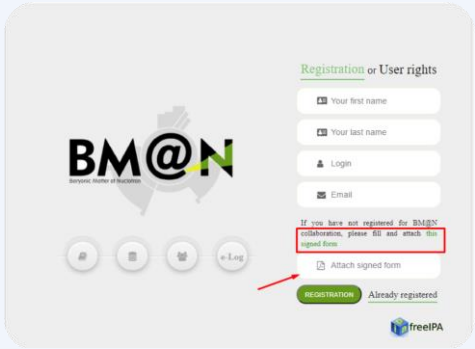
Collaboration members

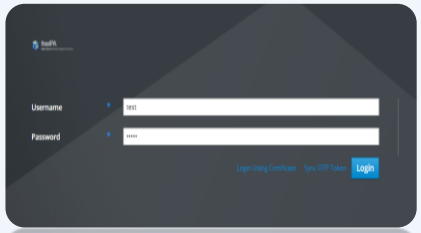
Single Account

FreeIPA

register

request special rights





bmn-ipa.jinr.ru

admins *writers* *users*

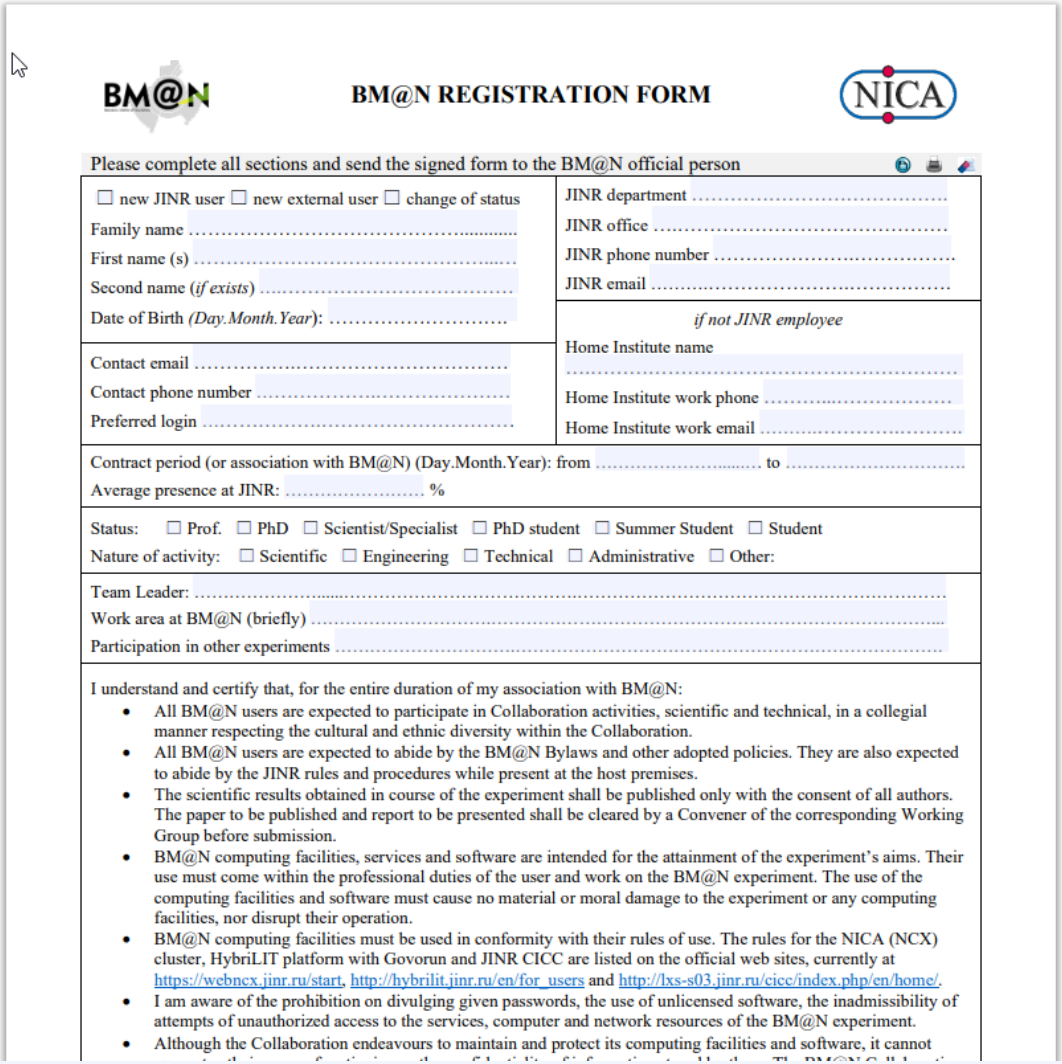
Electronic Logbook

Wiki Document Server

Experiment Database

BM@N Forum

User Registration Form



BM@N REGISTRATION FORM

Please complete all sections and send the signed form to the BM@N official person

☐ new JINR user ☐ new external user ☐ change of status

Family name .....

First name (s) .....

Second name (*if exists*) .....

Date of Birth (*Day.Month.Year*): .....

JINR department .....

JINR office .....

JINR phone number .....

JINR email .....

if not JINR employee

Home Institute name .....

Home Institute work phone .....

Home Institute work email .....

Contact email .....

Contact phone number .....

Preferred login .....

Contract period (or association with BM@N) (Day.Month.Year): from ..... to .....

Average presence at JINR: ..... %

Status: ☐ Prof. ☐ PhD ☐ Scientist/Specialist ☐ PhD student ☐ Summer Student ☐ Student

Nature of activity: ☐ Scientific ☐ Engineering ☐ Technical ☐ Administrative ☐ Other:

Team Leader: .....

Work area at BM@N (briefly) .....

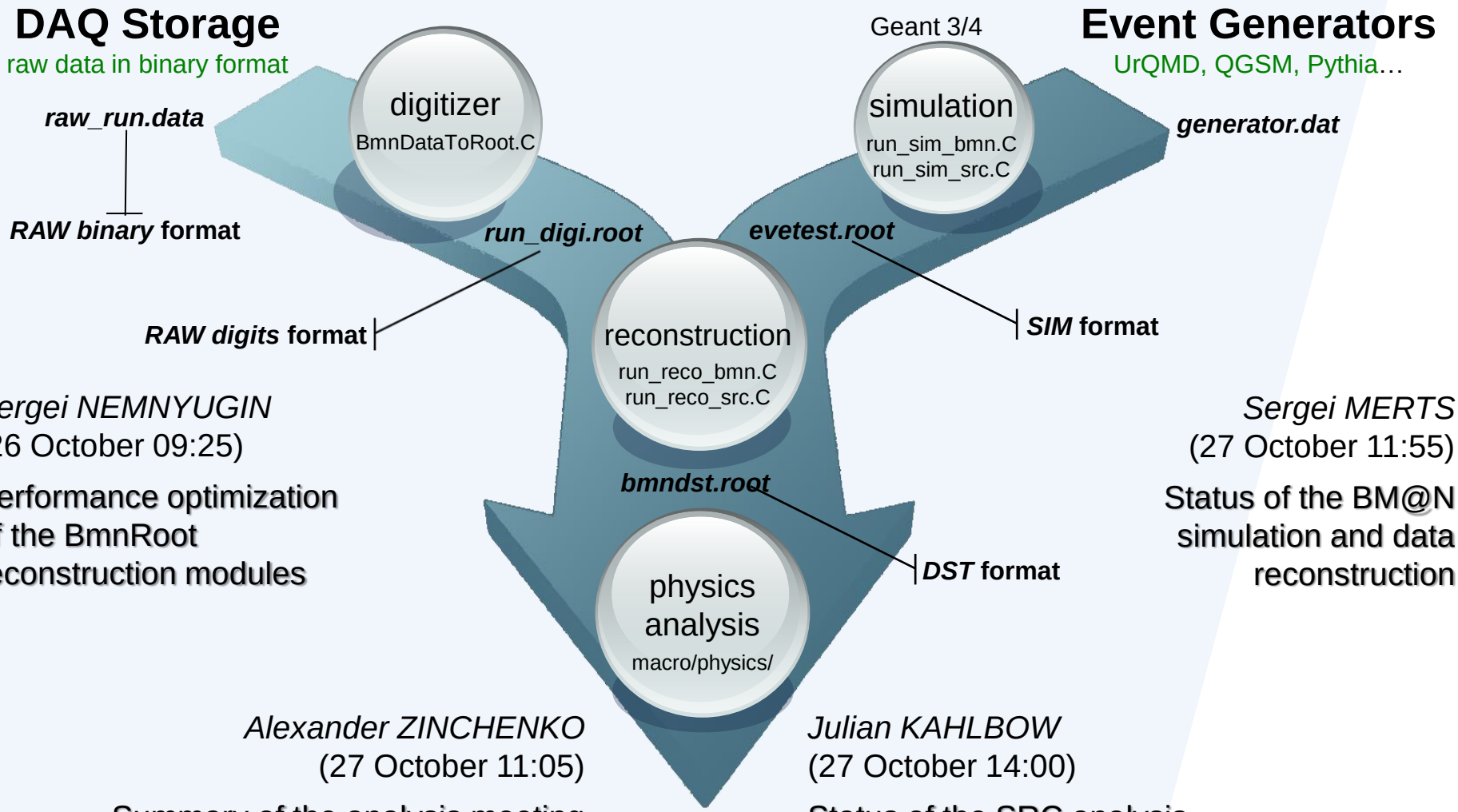
Participation in other experiments .....

I understand and certify that, for the entire duration of my association with BM@N:

- All BM@N users are expected to participate in Collaboration activities, scientific and technical, in a collegial manner respecting the cultural and ethnic diversity within the Collaboration.
- All BM@N users are expected to abide by the BM@N Bylaws and other adopted policies. They are also expected to abide by the JINR rules and procedures while present at the host premises.
- The scientific results obtained in course of the experiment shall be published only with the consent of all authors. The paper to be published and report to be presented shall be cleared by a Convener of the corresponding Working Group before submission.
- BM@N computing facilities, services and software are intended for the attainment of the experiment's aims. Their use must come within the professional duties of the user and work on the BM@N experiment. The use of the computing facilities and software must cause no material or moral damage to the experiment or any computing facilities, nor disrupt their operation.
- BM@N computing facilities must be used in conformity with their rules of use. The rules for the NICA (NCX) cluster, HybriLIT platform with Govorun and JINR CICC are listed on the official web sites, currently at https://webncx.jinr.ru/start, http://hybrilit.jinr.ru/en/for_users and http://lxs-s03.jinr.ru/cicc/index.php/en/home/.
- I am aware of the prohibition on divulging given passwords, the use of unlicensed software, the inadmissibility of attempts of unauthorized access to the services, computer and network resources of the BM@N experiment.
- Although the Collaboration endeavours to maintain and protect its computing facilities and software, it cannot

BmnRoot Development

BmnRoot Data Processing



Sergei NEMNYUGIN
(26 October 09:25)

Performance optimization of the BmnRoot reconstruction modules

Sergei MERTS
(27 October 11:55)

Status of the BM@N simulation and data reconstruction

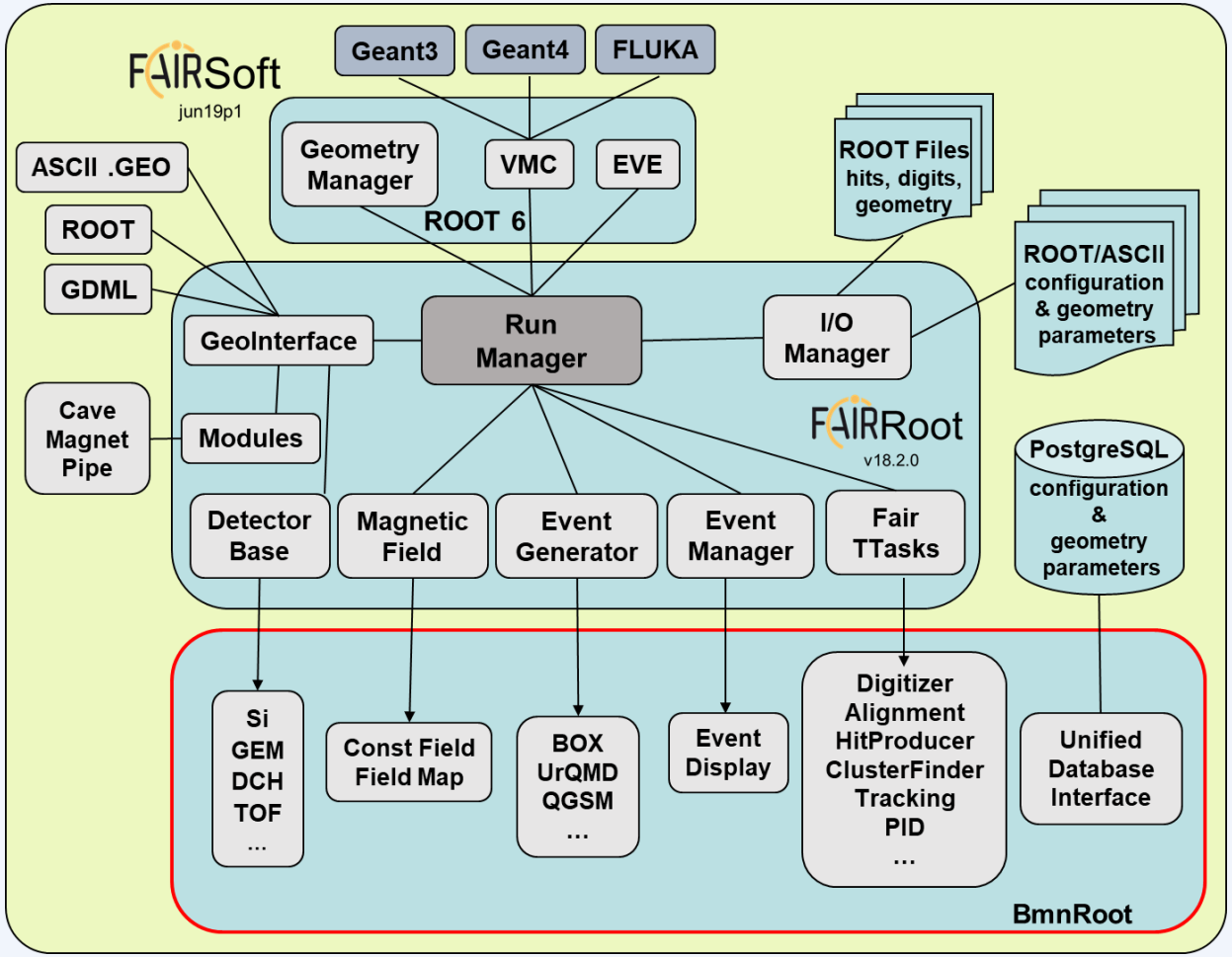
Alexander ZINCHENKO
(27 October 11:05)

Summary of the analysis meeting

Julian KAHLBOW
(27 October 14:00)

Status of the SRC analysis

New BmnRoot Release preparation: 20.11.0



- The new release has to be approved by all detector groups
- The release will be tested at distributed clusters before its issue
- A new structure of the BM@N offline database is scheduled to be implemented before the BmnRoot Release (re-issuing all releases)

The mass production of the BM@N digits and reco data for Run 7 has been started to check pre-release

CI/CD BmnRoot Pipeline in Docker

- Bmnroot Pipeline runs in Docker containers *(dynamically provisioned in the JINR Cloud)*
  - Gitlab-shared-runners – used to run tests before merging a new code: CentOS7/Ubuntu18.04/SL6 images = OS + FairSoft + FairRoot
  - Gitlab-shared-runners-no-cvmfs – used to run deploy jobs
- To build and store container images, a new GitLab project was created: “NICA/Docker Images”
- Automation of BmnRoot build and publishing system
- Evaluation of possible options for running batch jobs in containers
- Checking permissions was added

Nikita BALASHOV
(26 October 09:45)

CI/CD pipeline status and perspectives for BM@N

Distributed Computing

Andrey DOLBILOV
(27 October 12:20)

Status of the computing for BM@N

HybriLIT platform: Application and Report

http://hlit.jinr.ru/en/about_govorun_eng/registration-at-the-govorun-supercomputer/

1. Application Form from the BM@N Collaboration once per year
2. Reporting Form from the BM@N Collaboration before the Application

http://hlit.jinr.ru/en/heterogeneous-cluster-hybrilit/users_publications_eng/

Users Publications

Authors should make references to the use of the resources of the heterogeneous platform in the following way:

Computations were held on the basis of the HybriLIT heterogeneous computing platform (LIT, JINR).

Please also use this link with the description of the heterogeneous platform:

Gh. Adam, M. Bashashin, D. Belyakov, M. Kirakosyan, M. Matveev, D. Podgainy, T. Sapozhnikova, O. Streltsova, Sh. Torosyan, M. Vala, L. Valova, A. Vorontsov, T. Zaikina, E. Zemlyanaya, M. Zuev. IT-ecosystem of the HybriLIT heterogeneous platform for high-performance computing and training of IT-specialists. Selected Papers of the 8th International Conference "Distributed Computing and Grid-technologies in Science and Education" (GRID 2018), Dubna, Russia, September 10-14, 2018, CEUR-WS.org/Vol-2267"

BM@N WorkFlow Implementation

Scalable

Airflow has a modular architecture and uses a message queue to orchestrate an arbitrary number of workers. Airflow is ready to scale to infinity.

Dynamic

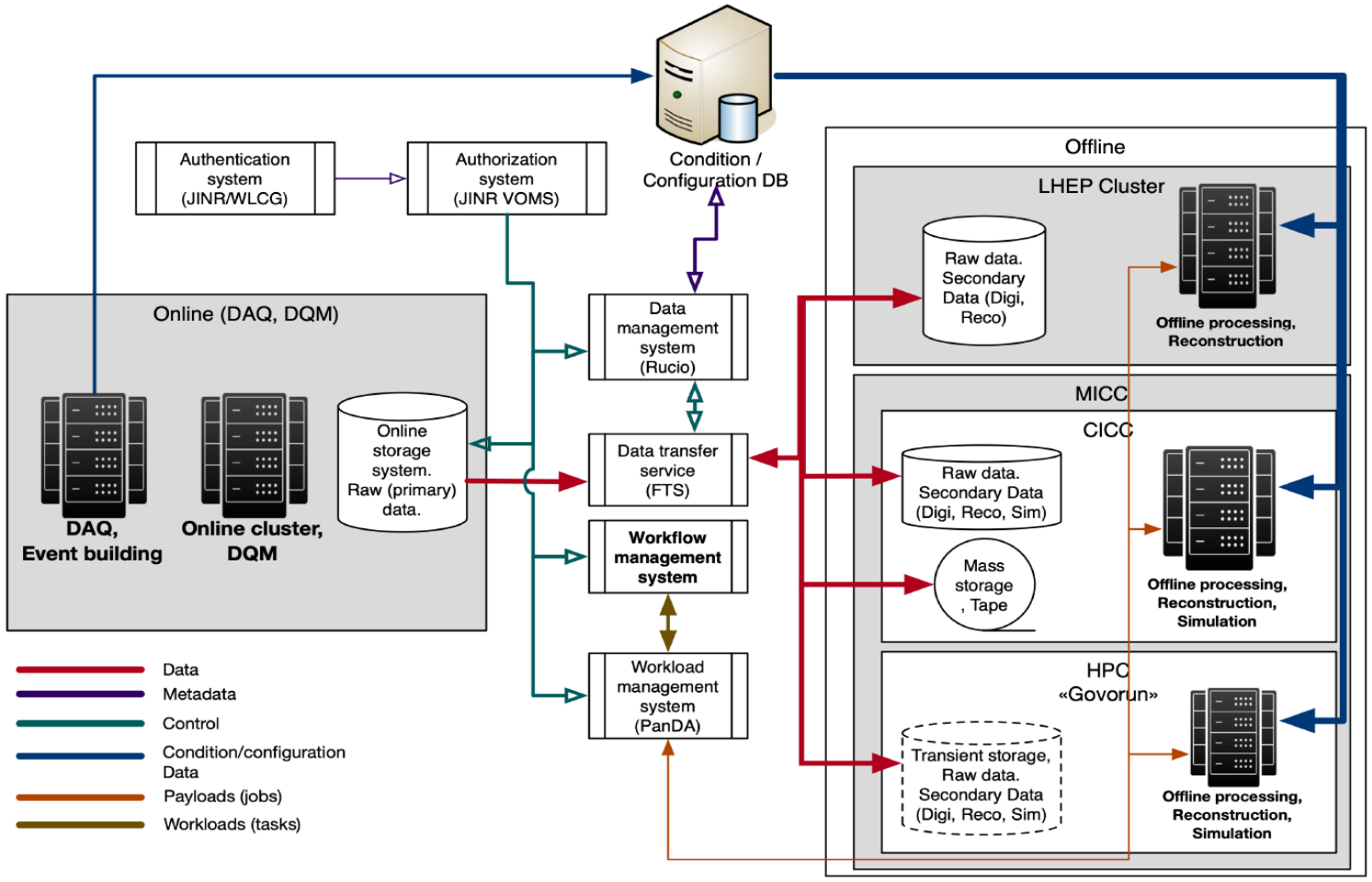
Airflow pipelines are defined in Python, allowing for dynamic pipeline generation. This allows for writing code that instantiates pipelines dynamically.

Extensible

Easily define your own operators and extend libraries to fit the level of abstraction that suits your environment.

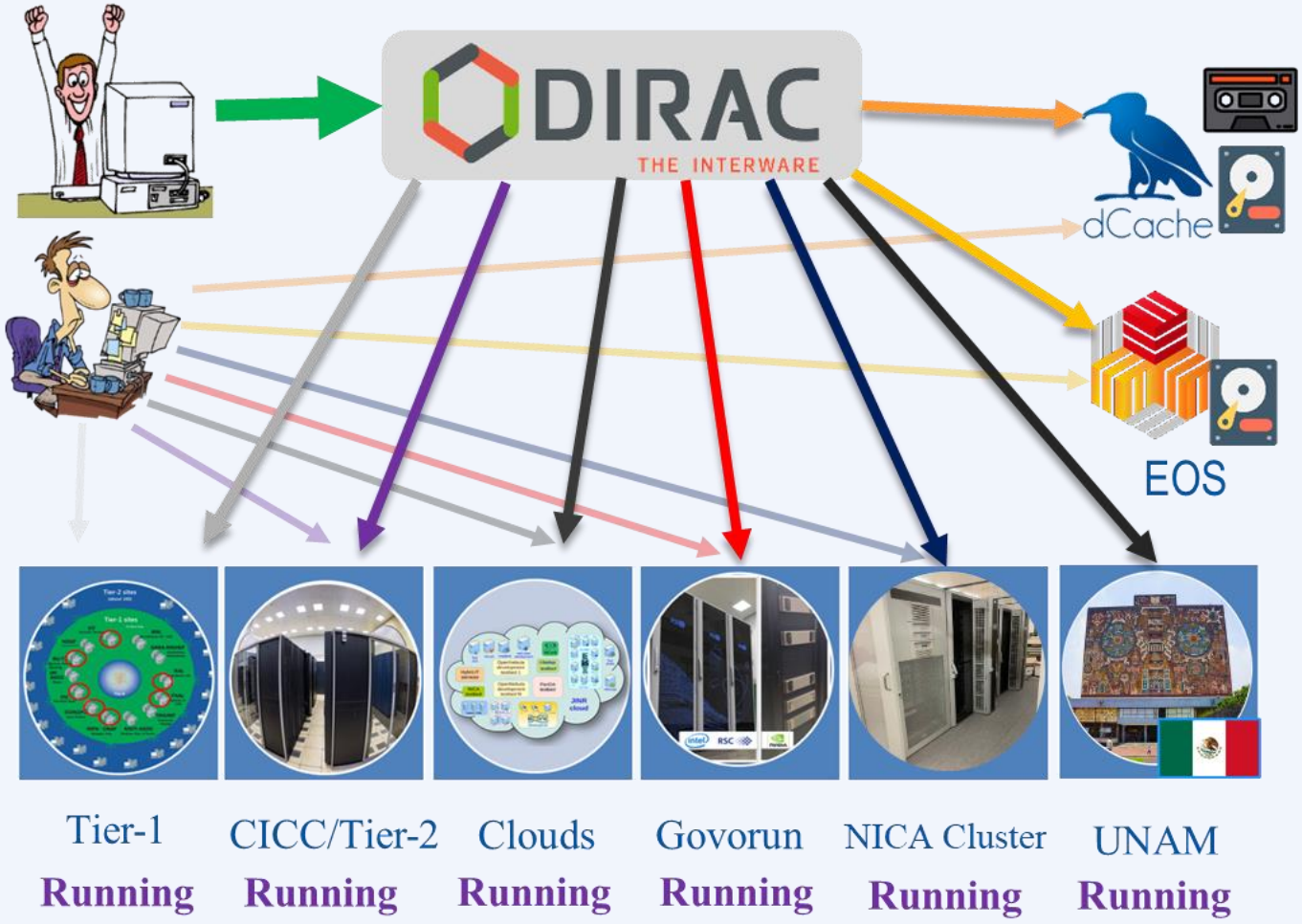
Elegant

Airflow pipelines are lean and explicit. Parametrization is built into its core using the powerful Jinja templating engine.



Artem PETROSYAN
(26 October 12:20)
Status of Workflow Implementation for BM@N distributed processing

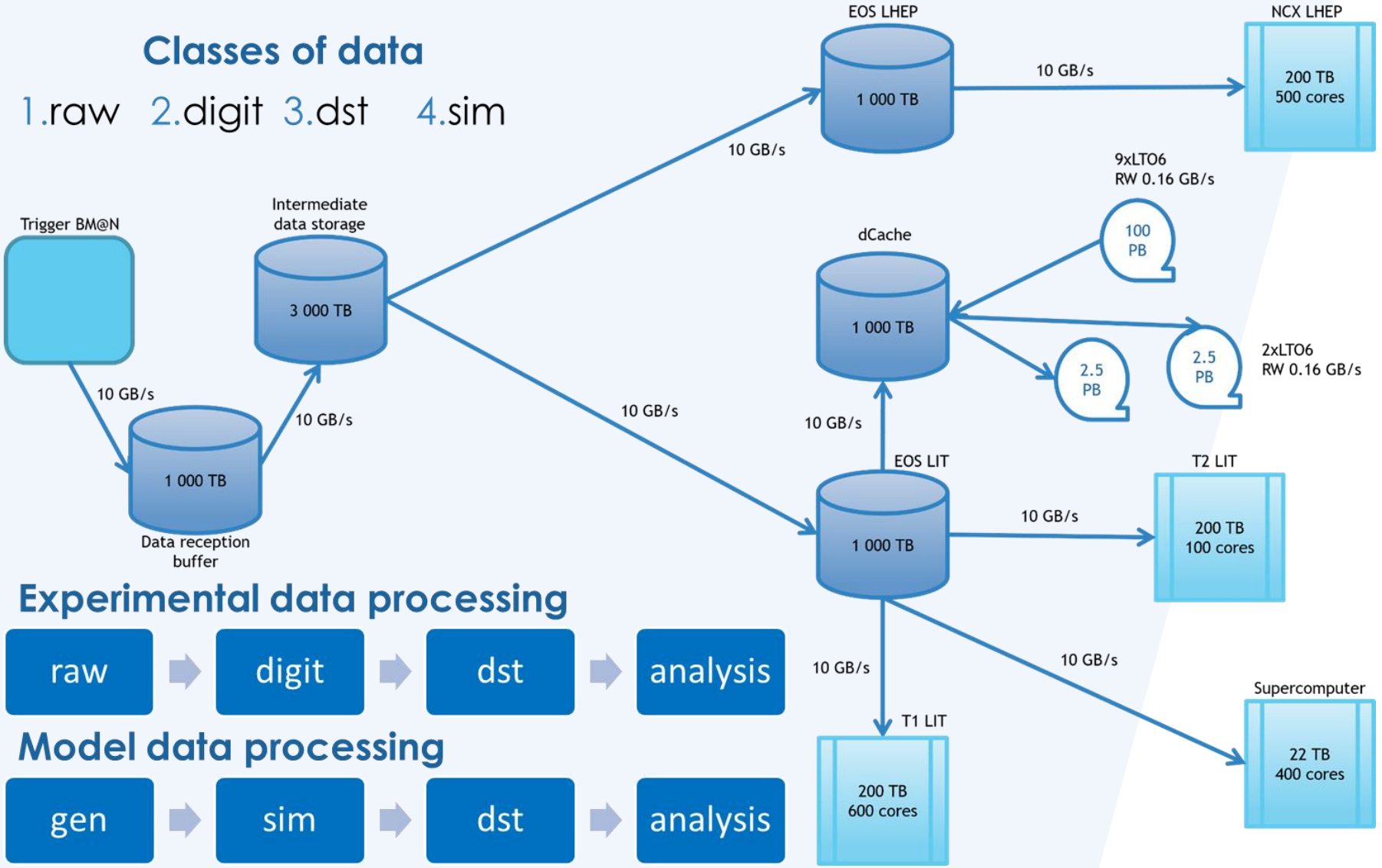
BM@N WorkFlow Services via DIRAC



- Workload management
- Data management
- Metadata management
- File Catalog
- Accounting
- User Interface
- API

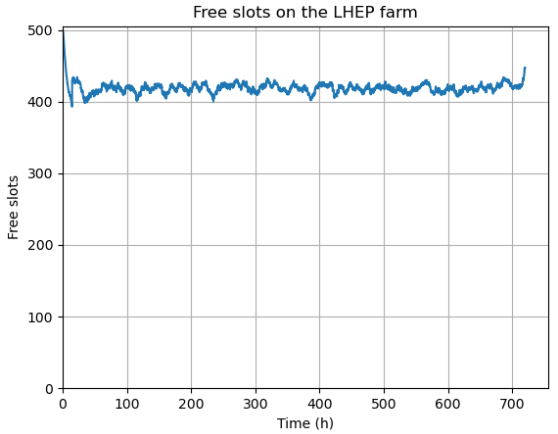
Igor PELEVANYUK
(26 October 10:25)
DIRAC Interware as a tool for the organization of scientific computing

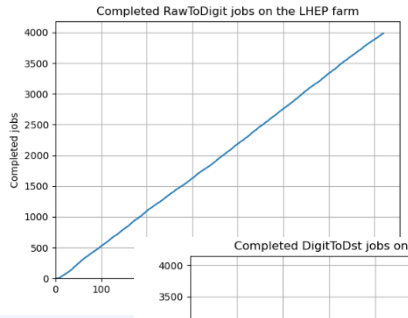
Data Processing Simulation for BM@N

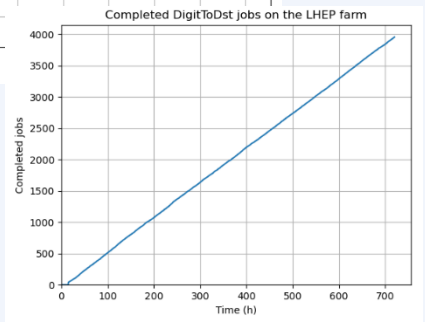


Some Simulation Results (Scenario 1)

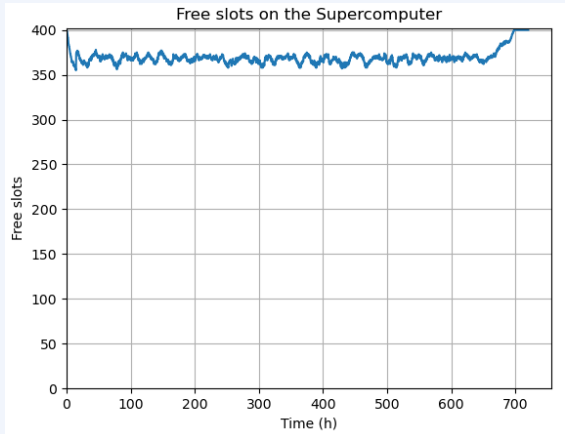
LHEP farm: **500 slots**
RawToDigit jobs – **4 000 (40%)**
DigitToDst jobs – **4 000 (40%)**

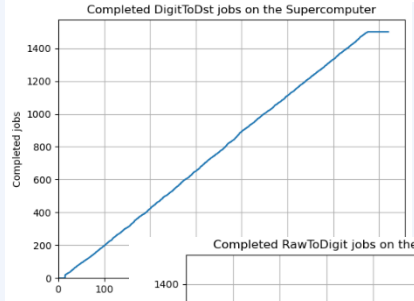


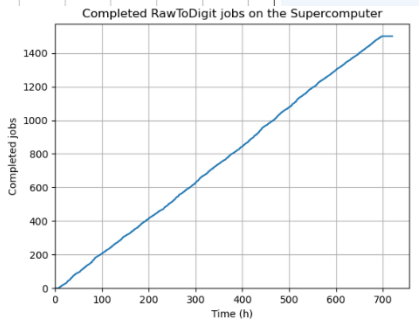




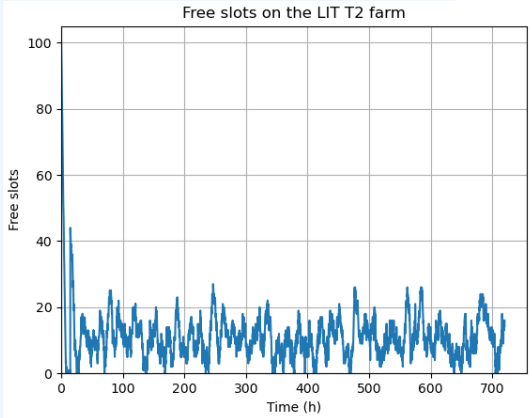
Supercomputer: **400 slots**
RawToDigit jobs – **1 500 (15%)**
DigitToDst jobs – **1 500 (15%)**

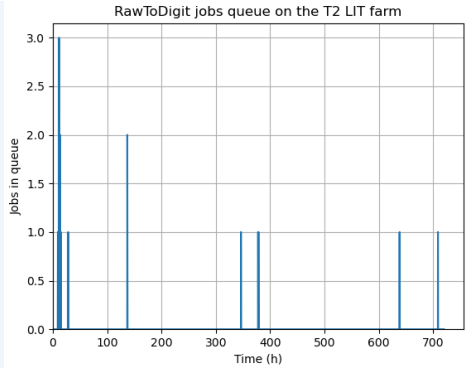






T2 LIT farm: **100 slots**
RawToDigit jobs – **4 500 (45%)**
DigitToDst jobs – **4 500 (45%)**





Daria PRIAKHINA
(26 October 10:05)
First results of applying a probabilistic approach to BM@N data centre simulation

Software Group Status

Software Direction of the BM@N Experiment

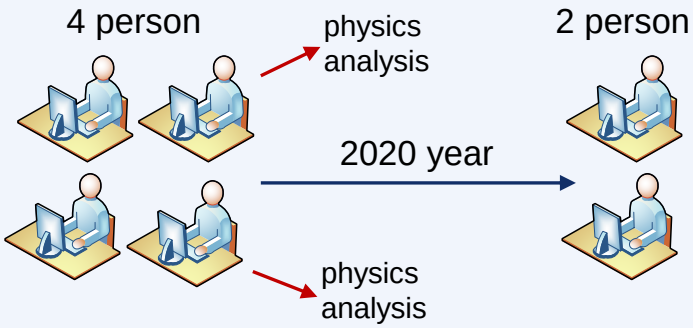
Head of the BM@N Software Group:
Konstantin GERTSENBERGER

BM@N Software Group (2 person):

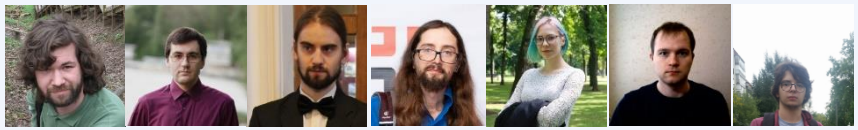
Konstantin GERTSENBERGER: group leader

Alexander CHEBOTOV: software engineer in JINR since 2018

The Software Group has no department connection with the Department of the BM@N experiment → problems with asking the division for resources for the BM@N Software Group



BM@N Software Collaboration



Peter KLIMAI
(26 October 09:00)
Software contribution from MIPT:
development of services and tools for BM@N

BM@N Software Contribution

MIPT – NPM group (Head: Tagir AUSHEV)

JINR LIT (Director: Vladimir KORENKOV)

Nikita BALASHOV: CVMFS Deployment, GitLab Services, Docker Containers

Irina FILOZOVA, Igor ALEXANDROV, Evgeniy ALEXANDROV and staff: Geometry DB and Event Metadata System for the BM@N experiment

Dmitriy PODGAYNY (Head of the HybriLIT team), Oksana STRELTSOVA, Maksim ZUEV: HybriLIT and SC Govorun support

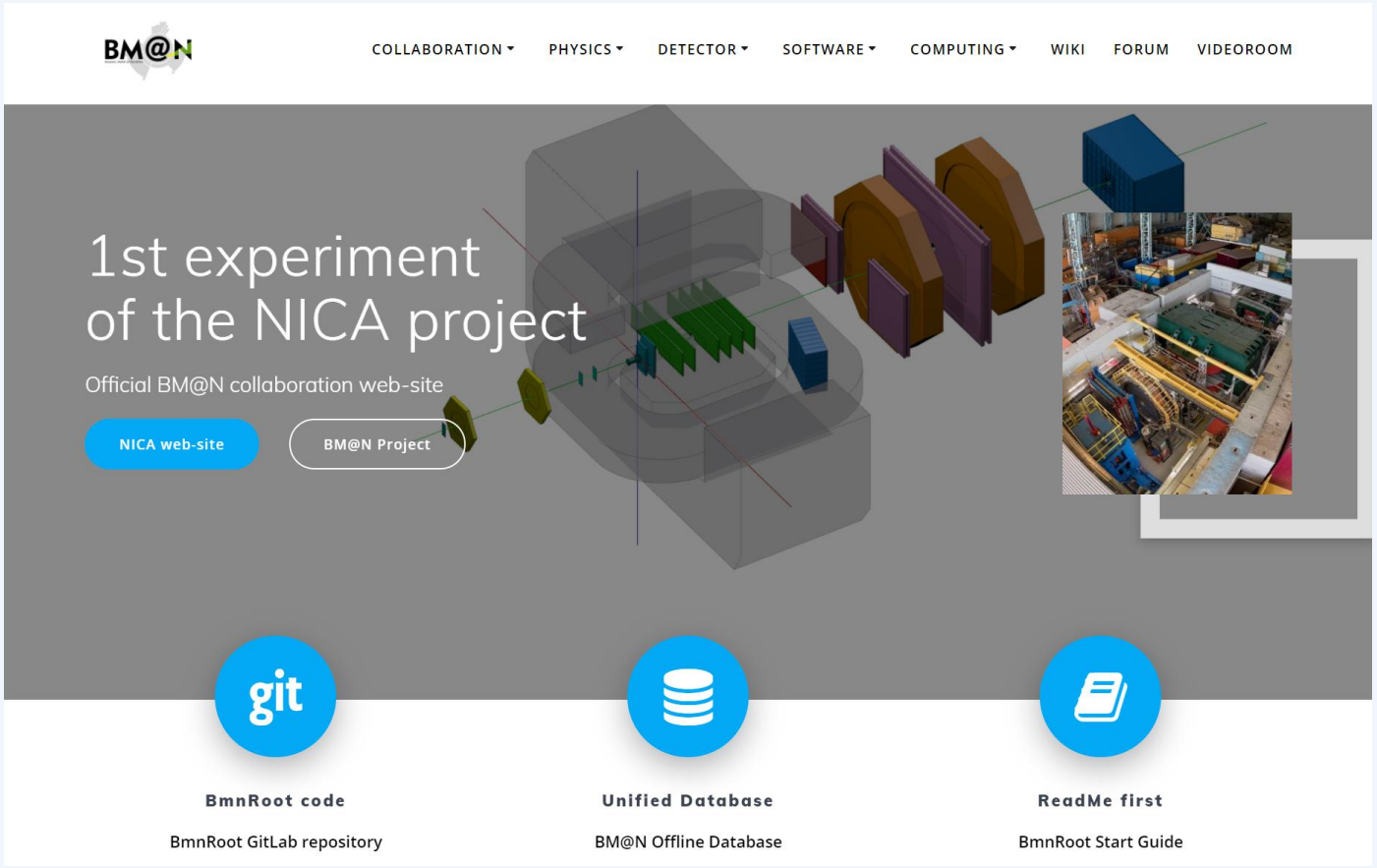
Danila OLEYNIK, Artem PETROSYAN: *BM@N WorkFlow Services*

Daria PRIAKHINA, Vladimir TROFIMOV, et. al: *BM@N Processing Simulation*

JINR LHEP (Spokesperson: Mikhail Kapishin)

Konstantin GERTSENBERGER
Alexander CHEBOTOV

Official BM@N Web-site: *bmn.jinr.ru*



- ✓ ***Collaboration***
- ✓ ***Information***
- ✓ ***Documents***
- ✓ ***Software***
- ✓ ***Databases***
- ✓ ***Computing Section (NICA Cluster, MICC Complex, HybriLIT & Govorun)***
- ✓ ***Guides, Manuals***
- ✓ ***Wiki***
- ✓ ***Forum***
- ✓ ***Webex***
- ✓ ***BM@N Mail-lists***
- ✓ ***etc.***

Conclusions

- The information systems and related services have sufficiently been restructured and improved to simplify their use by members. The development of the Event Metadata System has been started.
- RFBR support with the NICA grant (18-02-40125) enables to significantly improve the Information Systems for BM@N data processing.
- BmnRoot Release 20.11.0 is scheduled to be issued after approval procedure with the latest BM@N and SRC simulation, reconstruction, analysis and software improvements.
- The architecture of the BM@N mass data processing is under development. The related workflow services are under deployment now.
- The serious lack of manpower for BM@N software development is a problem to be solved.

Thank you for your attention!

More information: bmn.jinr.ru
nica.jinr.ru

Email: *gertsen@jinr.ru*