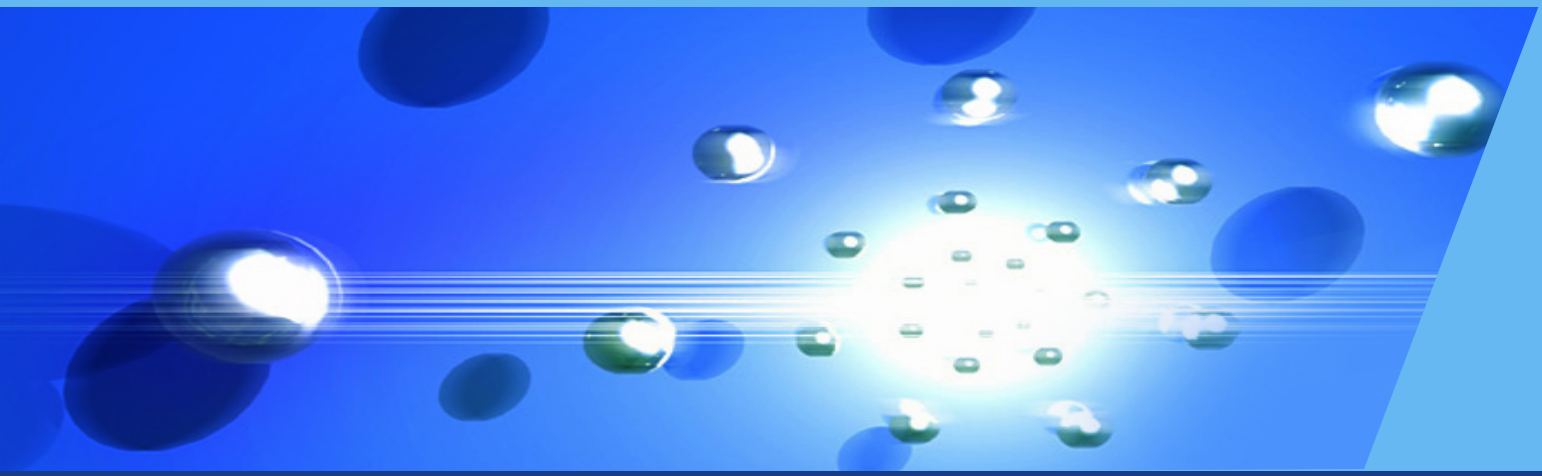


Software Development for the BM@N Experiment

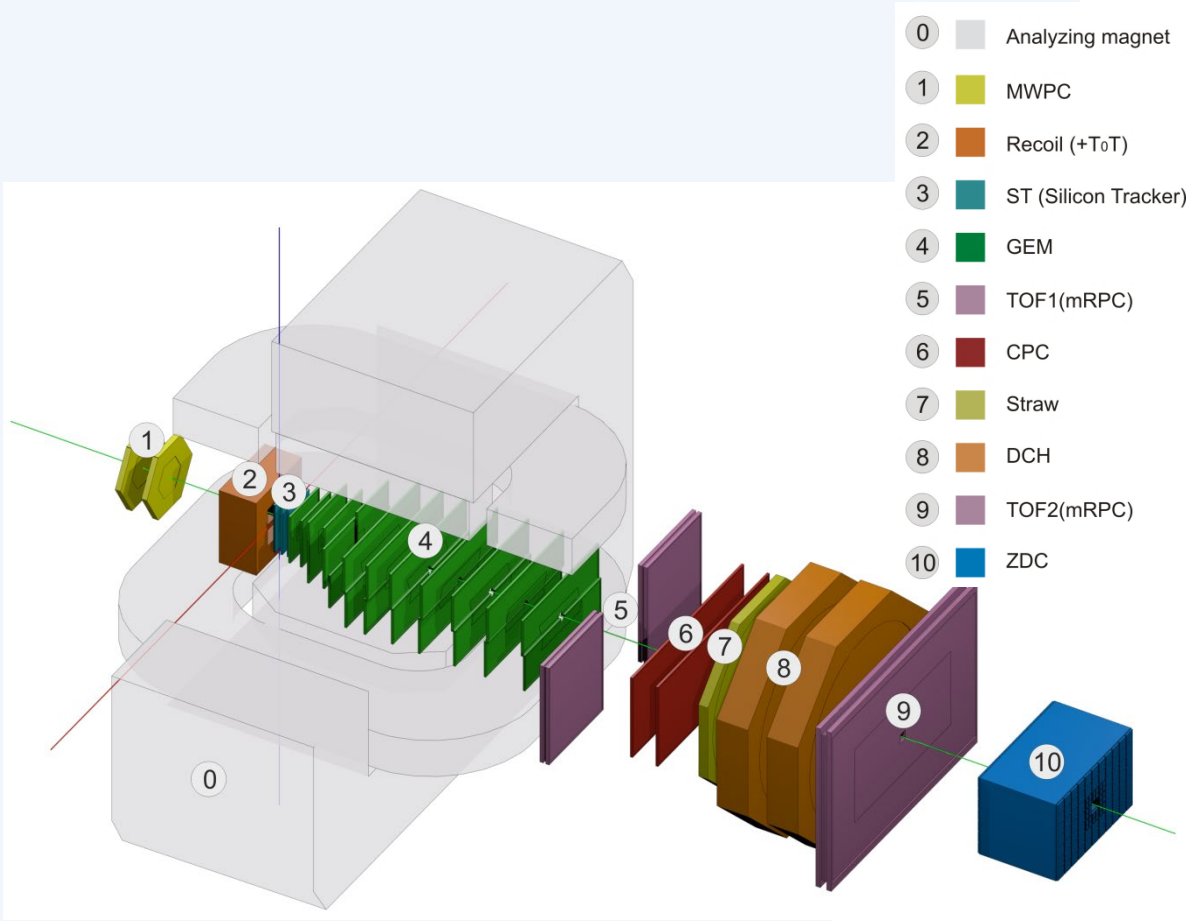
Konstantin Gertsenberger
Veksler and Baldin Laboratory of High Energy Physics, JINR

on behalf of the BM@N collaboration

BmnRoot Software

The software BmnRoot is developed for the BM@N event simulation, reconstruction of experimental or simulated data and following physics analysis of collisions of elementary particles and ions with a fixed target at the NICA collider.

C++ classes, Linux OS support, based on ROOT and FairRoot

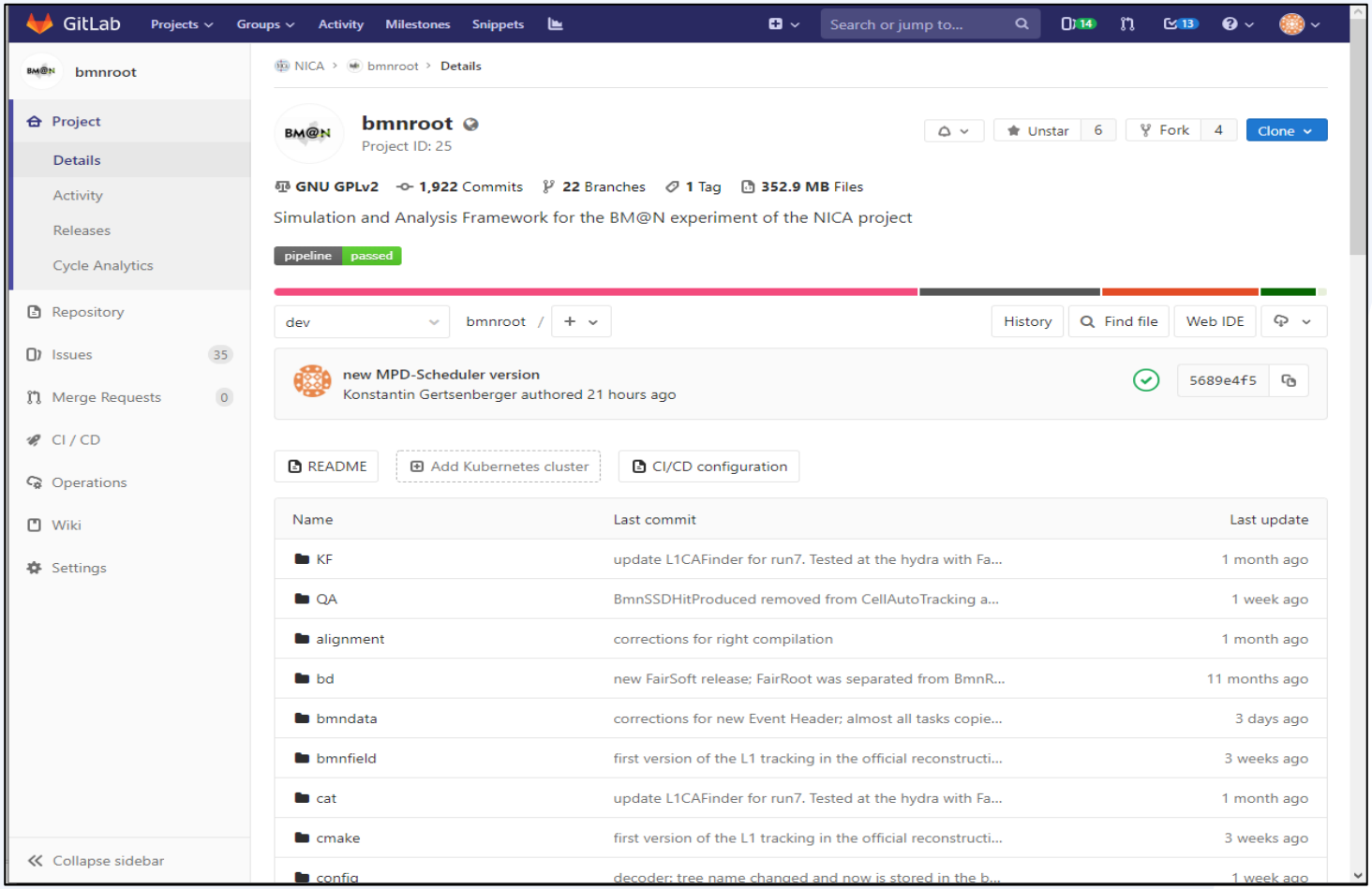


Installation Manual: http://mpd.jinr.ru/howto-install/

GIT repository for BM@N

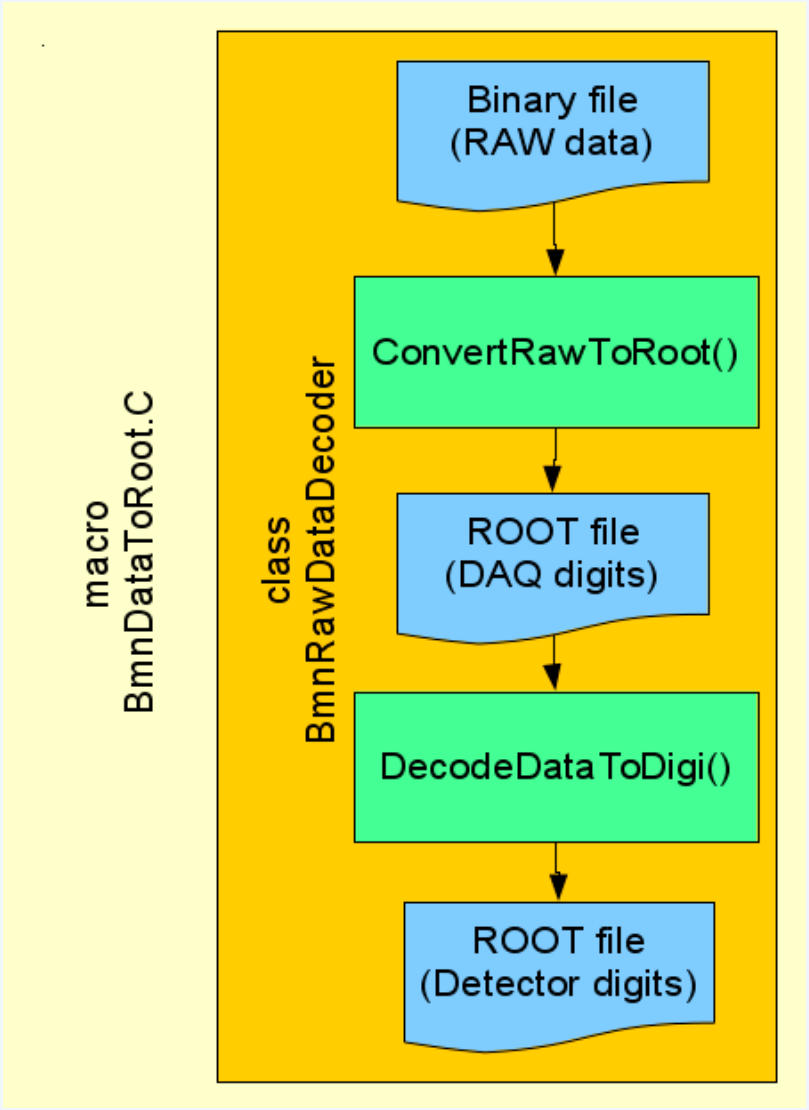
The BmnRoot software is available in GitLab@JINR (LIT): https://git.jinr.ru/nica/bmnroot

The current branch is '***dev***'



advanced opportunity for collective development

First BmnRoot Release preparation



The preparation of the first BmnRoot release is a task of the highest priority because it is required for the mass production of BM@N detector digits and then DST files for Run 7

From the beginning of this year

- separate pieces of raw conversion code for all BM@N detectors have been combined into single Raw Data Converter
- the result tree with detector digits has been renamed and cleaned
- TAI times has been translated to the UTC format
- bugs in raw data conversion, such as wrong mapping, have been corrected
- temporary full digit files have been prepared and can be found on the NICA cluster

Still remaining task

- unification of the silicon and GEMs digits obtaining in two groups is under active development now

The first release will be issued in May 2019

BmnRoot Design

- Use FairSoft external packages

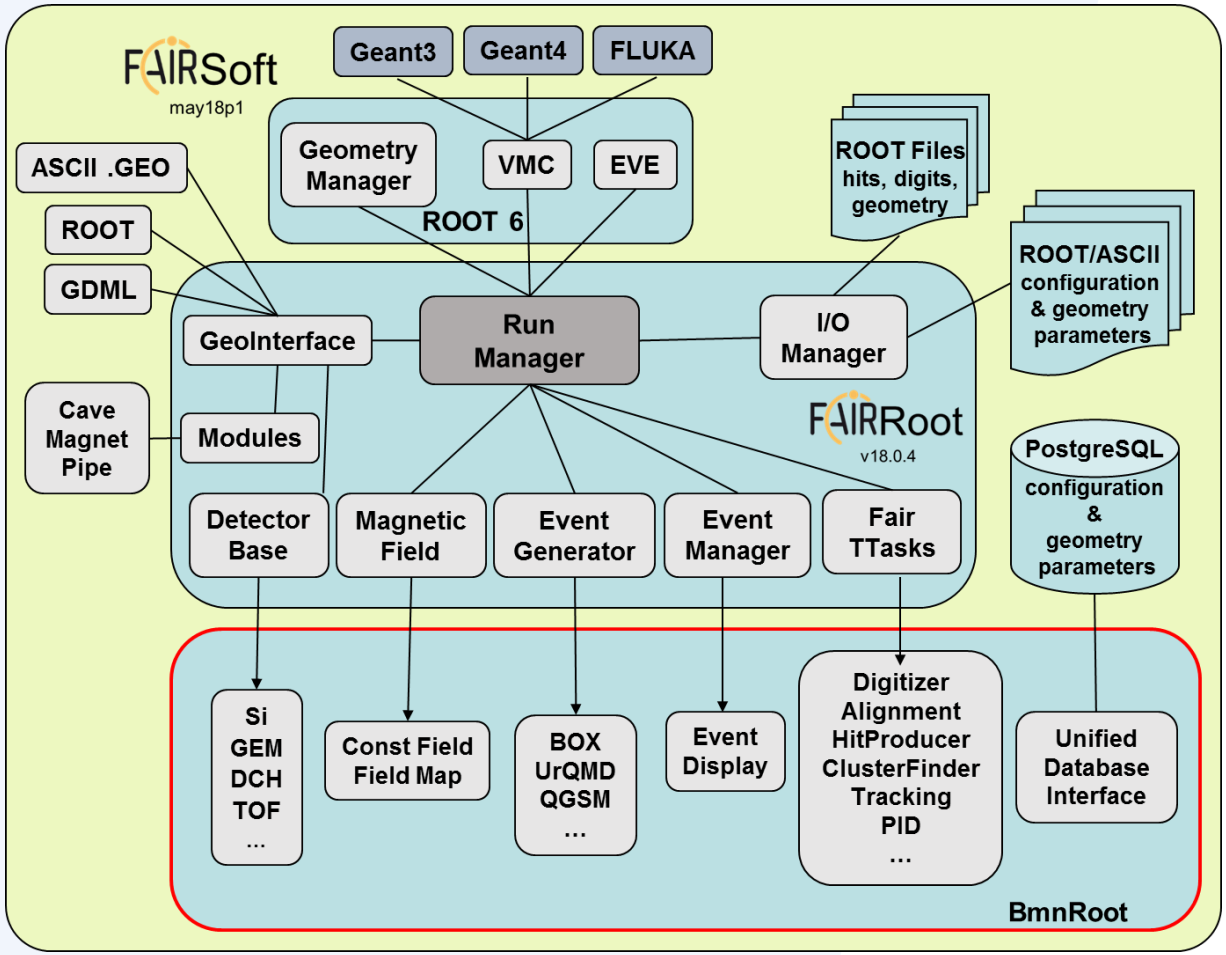
ROOT, XRootD, Pythia, HepMC, VGM, MillePede, Geant3/4, GSL, Boost, DDS…

- Use FairRoot as a set of base classes and modules of needed by particle experiments
- Extended set of event generators for collisions:

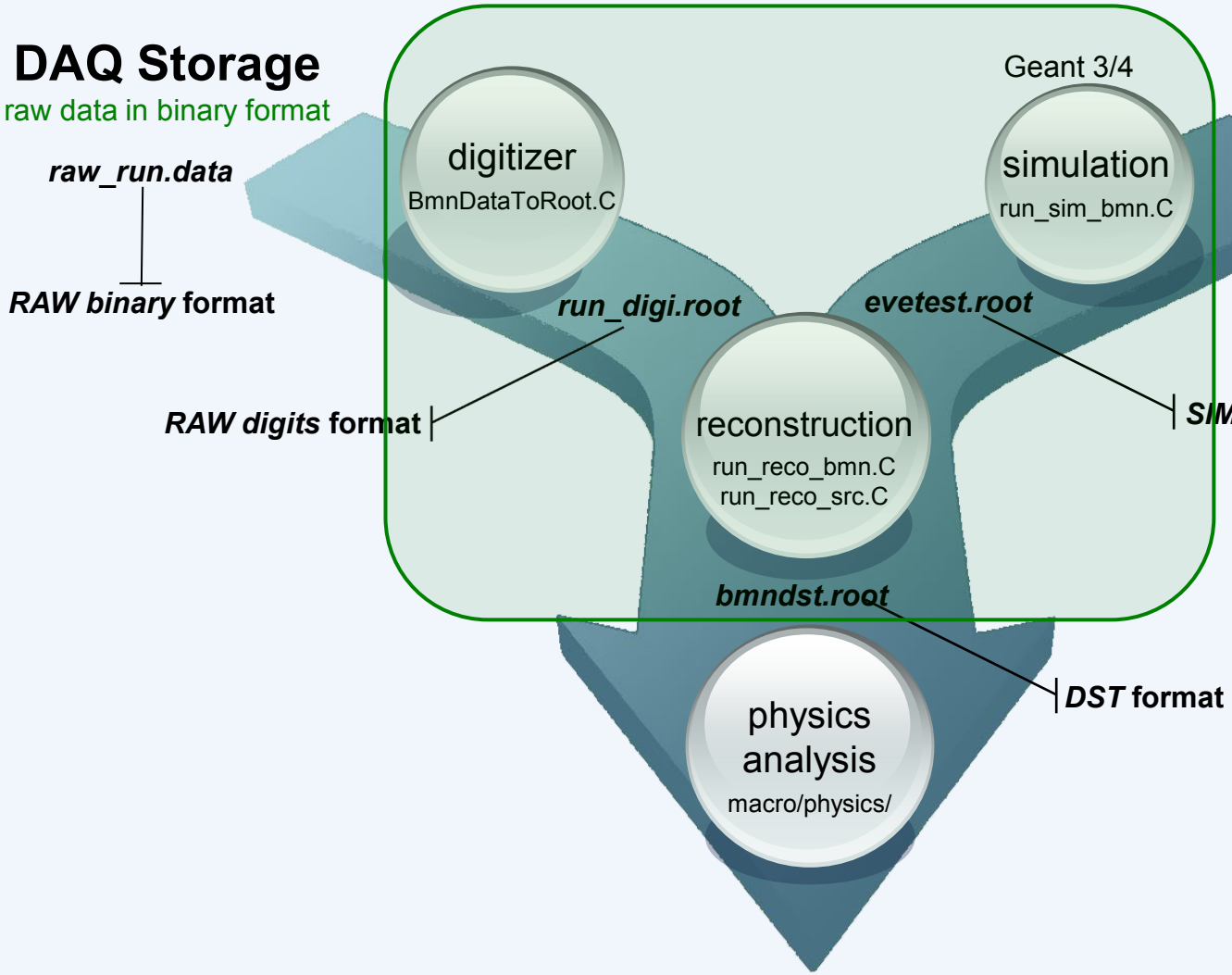
UrQMD, Hybrid UrQMD, vHLLE + UrQMD, QGSM/DCM-QGSM, HSD/pHSD, HADGEN, 3 Fluid Dynamics, PLUTO

simple (for testing) - BOX, ION, PART

- Experiment-specific parts and geometry are developed for each detector independently
- Particle propagation by GEANT3 & GEANT4
- Detector response functions, tracking, PID and other tasks were included as *FairTasks*.

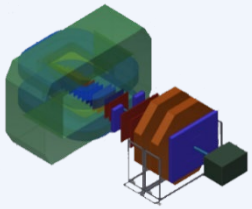


Data processing in BmnRoot



Sergei MERTS
Status of BM@N simulation and data processing

BM@N DAQ Data Flow *(proposal)*



DRE

LDC

FLP

First Level Processor

Data Check
Flow Control
Formatting

EvB

Event Builder

Buffering
Sorting
Distribution

HLT

High Level L3 Trigger

RQ

Raw Data Quality Check

Rootifier

ROOT Format Mapping Alignment

REC

Event Reconstruction

PA

Physics Analysis

distributed cluster

TDS

Transient Data Storage

PDS

Permanent Data Storage

FT REC

Fast Event Reconstruction

HIST

Online Histograms

EvM

Event Monitor

Database

DAQ

On-line Processing

Off-line Processing

matched from “MPD Data Acquisition System TDR”, DAQ Collaboration

Electronic Logbook (e-Log)

BM@N common e-log, Page 1 of 282 — **Logged in as shift**

Home Find Last day — Number of items per page: 10 — Logout

1 2 3 4 5 6 7 8 9 10 11 ... 282 > >>

Date	Shift Leader	Type	№ Run	Trigger	DAQ Status	SP-41, A	SP-57, A	VKM2, A	Beam	Energy, GeV	Target	Comment
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

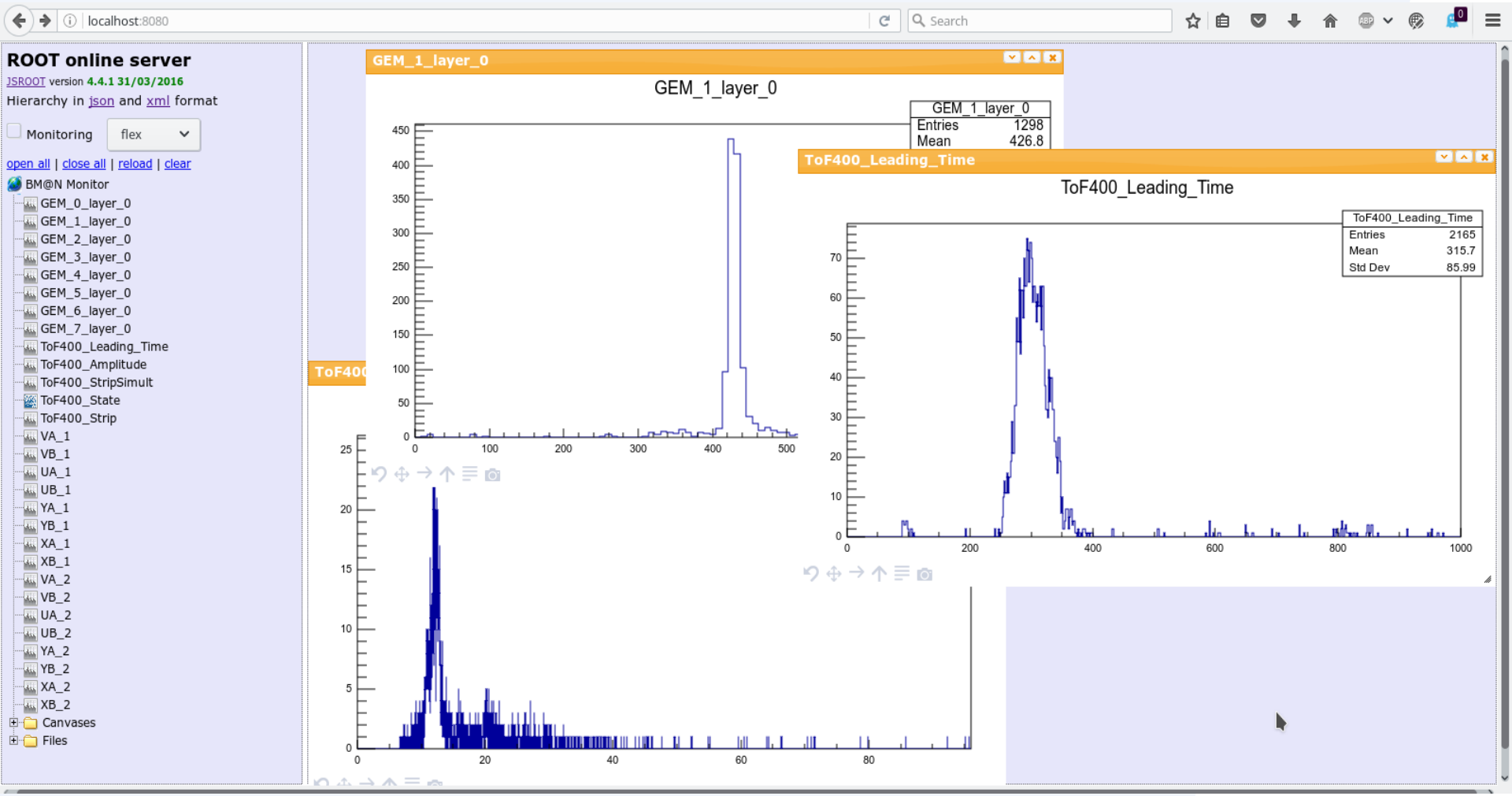
1 2 3 4 5 6 7 8 9 10 11 ... 282 > >>

2018 - software team (contact e-mail: gertsen@jinr.ru)

1. The e-Log platform is a collaborative tool, which provides an interface for shift crews to store and share information with offline users on various events or problems occurring in the experiment during its operation.
2. The e-Log uses a developed Logbook Database based on PostgreSQL DBMS.
3. A part of e-Log data is automatically transferred to the Unified Database of the experiment to use in offline analysis.

Online Histogramming: Web-interface

jsROOT server provides processed data via the Web



BM@N Central Database for offline processing

detector simulation
raw data processing
event reconstruction
physics analysis

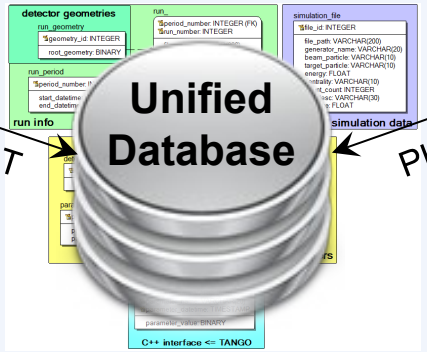
BmnRoot

reading and changing data

users

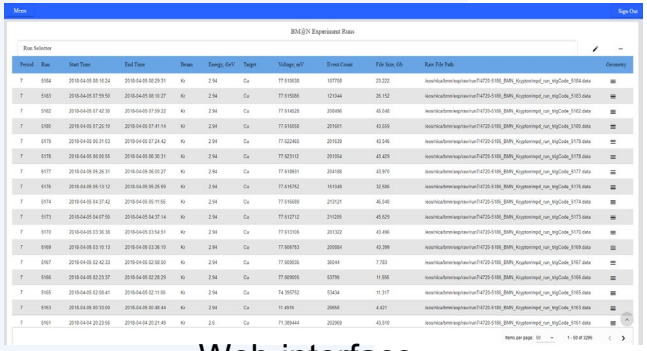
C++ database interface w/o SQL
(connect, SQL I/O)

ROOT



PHP

PostgreSQL



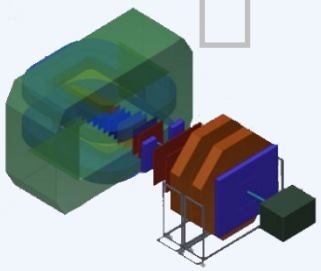
Web-interface

Tango Interface

Slow Control System

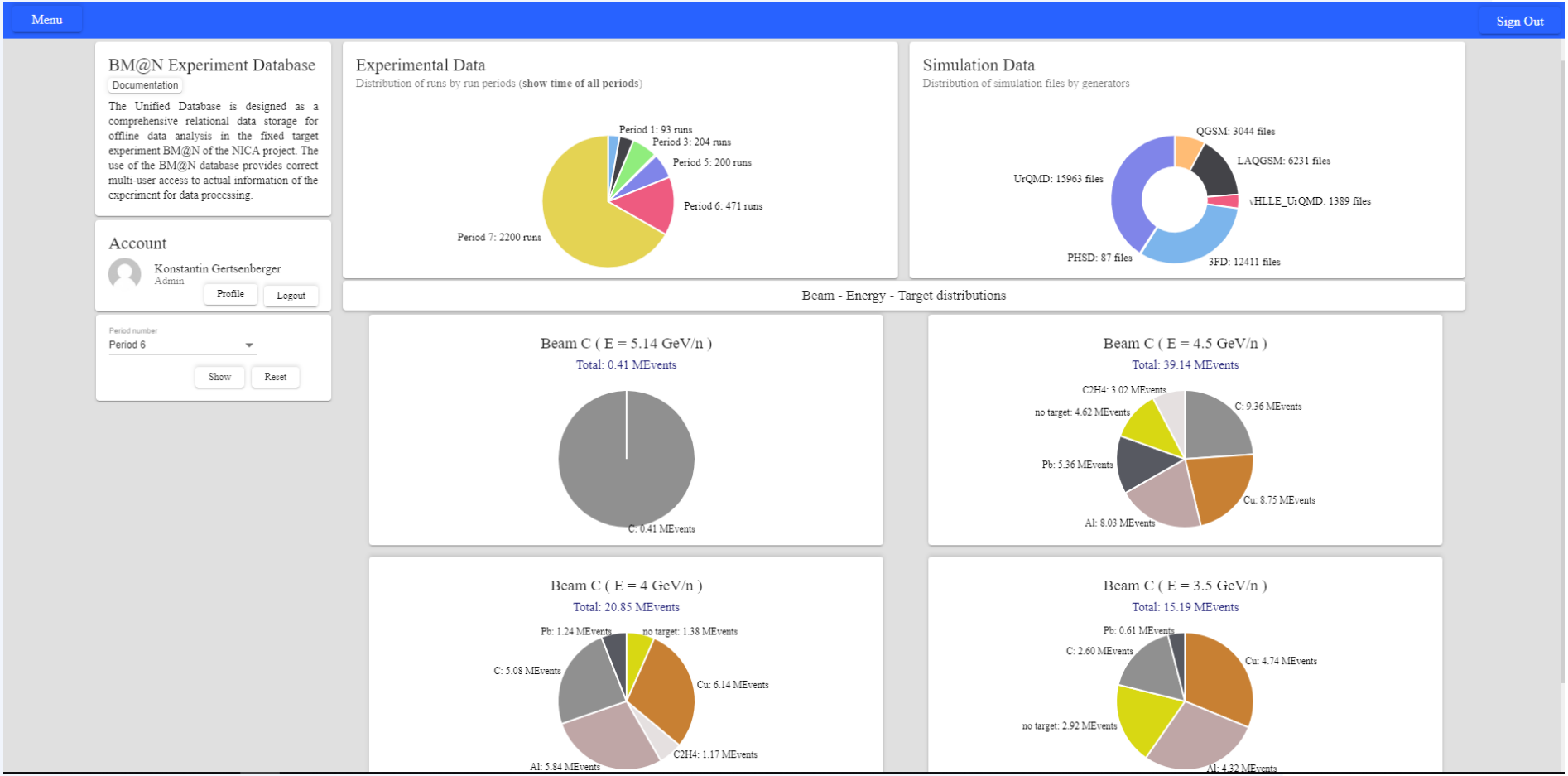
configuration calibration

parameter and algorithm data



- central data storage for offline data analysis
- unified access and data management
- correct multi-user data processing
- ensuring the actuality, data consistency and integrity
- excluding the multiple duplication and use of outdated data
- automatic backup

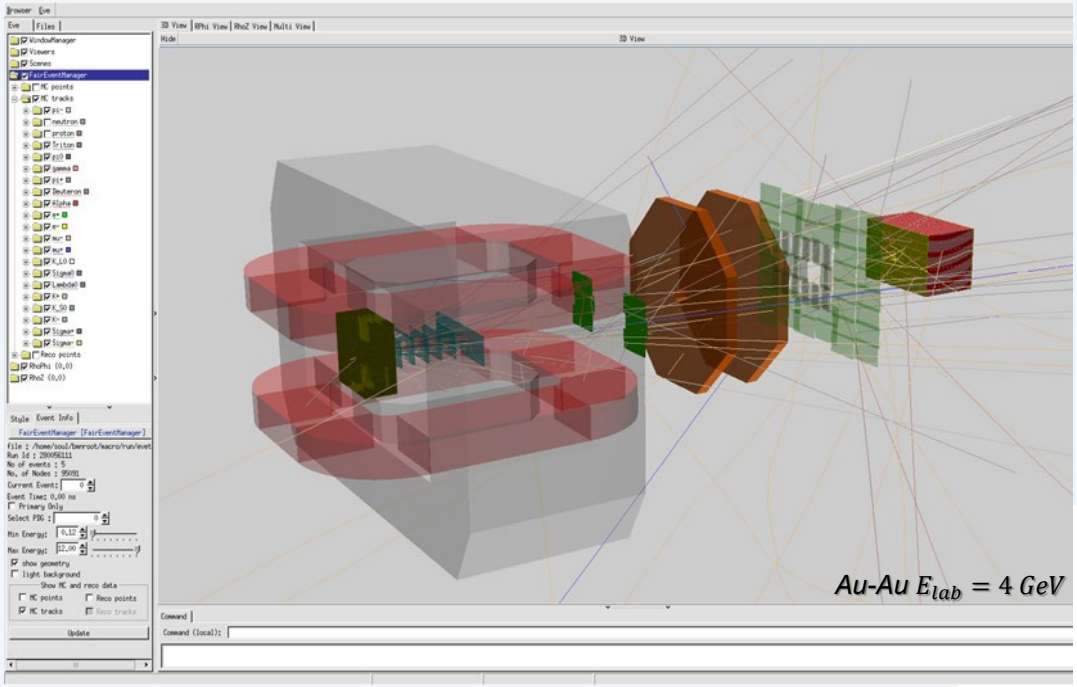
Web-interface of the BM@N database



storing information on BM@N experiment sessions and runs, setup geometries, detectors, parameters and parameter values, and generated simulation files

http://bmn-web.jinr.ru:4200

Event Display for the BM@N experiment



*based on **ROOT EVE package***

graphically presents the events by means of ROOT GUI and OpenGL

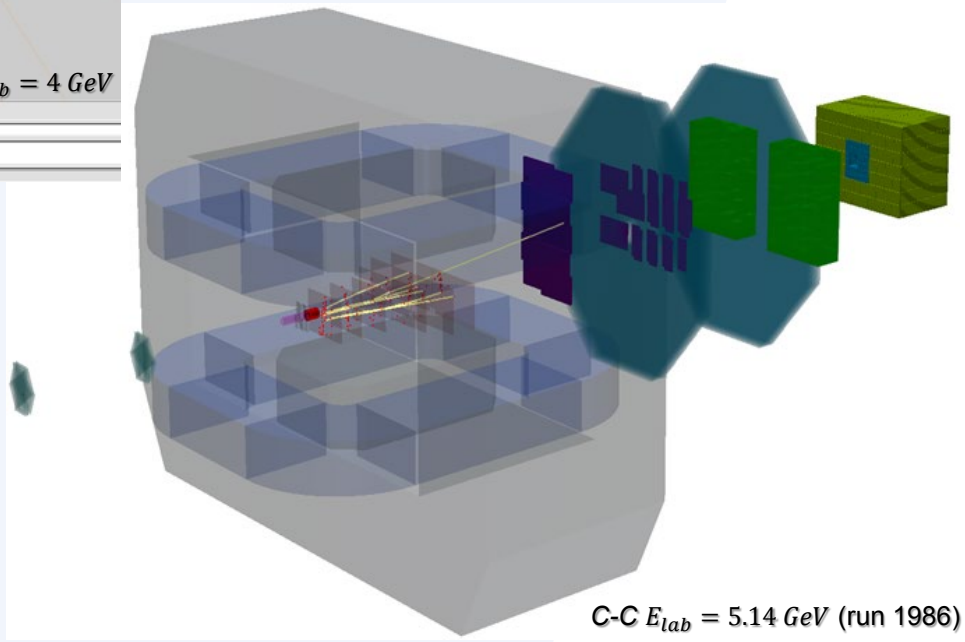
Event Display for simulated event data:

MC points, tracks, calorimeter towers

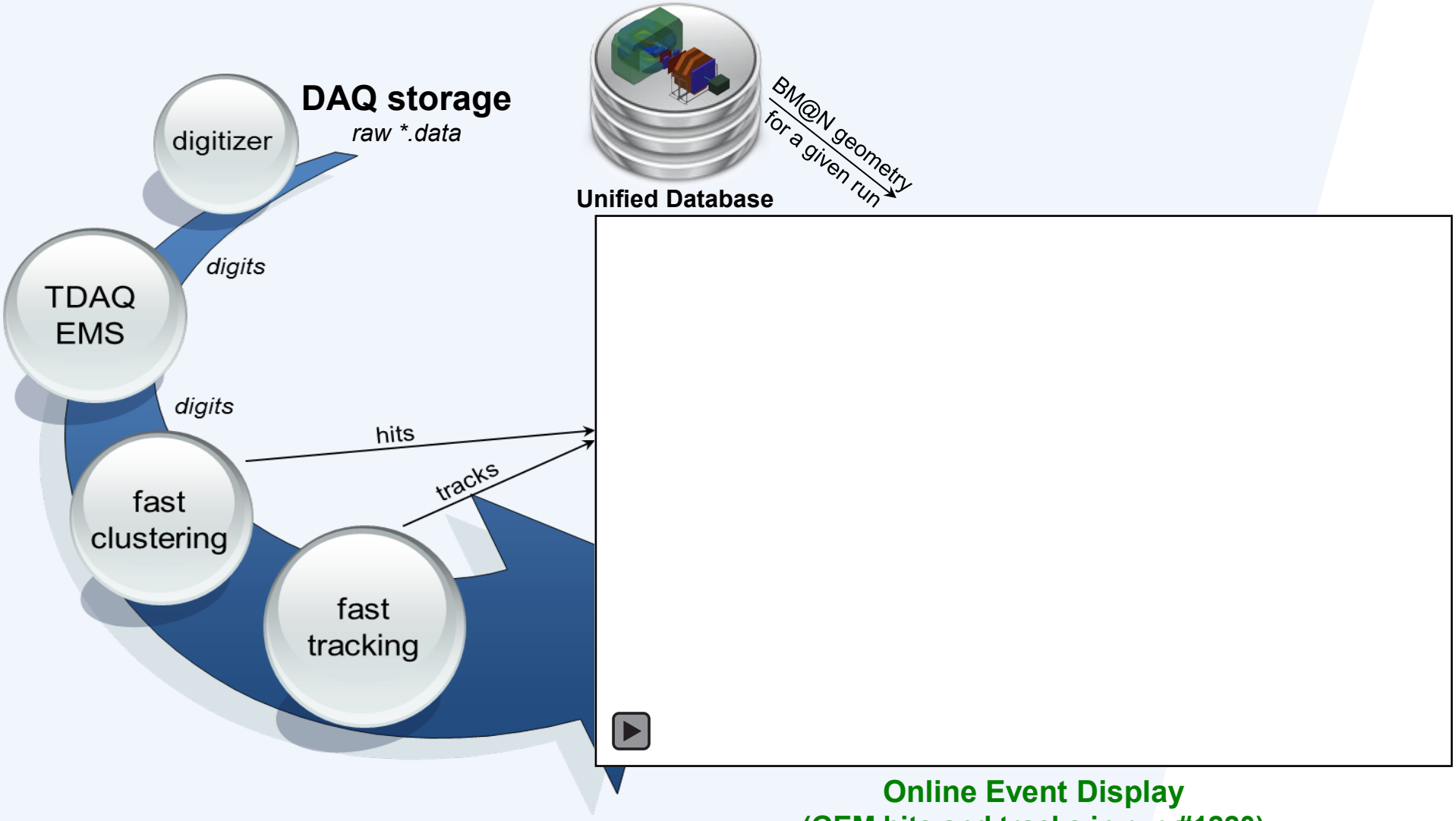
bmnroot/macro/eventdisplay/eventdisplay.C

Event Display for reconstructed data:

hits, tracks, calorimeter towers



Online Event Display



Online Event Display
(GEM hits and tracks in run #1220)

Computing Clusters for NICA

NICA Cluster
nc[2,3,8,9].jinr.ru
(LHEP, b.215, b.216)

OS: Scientific Linux 7
Exp. software: Local

GlusterFS: 320 TB (*replicated*)
→ EOS: 4 PB (replicated)

Sun Grid Engine: 1 496 cores
→ 4 000 Intel Xeon cores

MICC Tier1/2 Center
lx[pub,mpd-ui].jinr.ru
(LIT, b.134)

OS: Scientific Linux 6
Exp. software: CVMFS

EOS: 4 PB

Torque/Maui:
Tier2: **~200 IX cores**
Tier1: **~500 IX cores**

HybriLIT platform
hydra.jinr.ru
(LIT, b.134)

OS: CERN CentOS 7
Exp. software: CVMFS, modules

EOS 300 TB, **ZFS** 200 TB**, Lustre** 120 TB_{ssd}

SLURM: 2880 (IX cores) +
6048 (IX Phi cores) +
40 GPU NVidia Tesla V

All external packages for BmnRoot were installed & configured.

Automatic BmnRoot deployment on CVMFS with GIT CI was implemented.

NICA Cluster: from a prototype to the future

OS: Scientific Linux 7

(LHEP, b.215, b.216)

Cluster Administrator:
Schinov B. G.

Storage

GlusterFS: 320 TB (NICA) distributed FS (*replicated*)

sim. data: /nica/data4mpd[1,2]

exp. data: /dataBMN/bmndata[1-7]

for users: /nica/mpd[0-21]/$USER

scratch: /monthly/$USER, /weekly/$USER

4PB EOS soon

Software

FairSoft:

/opt/fairsoft/bmn/pro → may18p1

FairRoot:

/opt/fairroot/bmn/pro → v18.0.4

SetEnv.sh:
need correction!

Computing

Batch System: **Sun Grid Engine**

Intel Xeon: **1496 log. cores**

4K cores soon

Registration

Email to the cluster administrator from the spokesperson or software coordinator (more preferable)

MICC Tier1/2 Center: a piece for NICA

OS: Scientific Linux 6

(LIT, b.134)

Cluster Administrator:
Mitsyn V. V.

Storage

EOS: **4 PB** (NICA) distributed FS

sim. data: /eos/nica/bmn/sim
exp. data: /eos/nica/bmn/exp
for users: /eos/nica/bmn/users/$USER
scratch: /scr/u/$USER

Software

CVMFS: distributed software FS

scl enable devtoolset-4 python27 bash

SetEnv.sh: need correction!

FairSoft: **/cvmfs/nica.jinr.ru/sl6/fairsoft/latest** (may18)
FairRoot: **/cvmfs/nica.jinr.ru/sl6/fairroot/latest** (v18.0.4)

Computing

Batch System: **Torque/Maui**
Tier2 queue 'mpd': **~200 log. cores** (Intel Xeon)
Tier1 queue 'mpd@bfsrv': **~500 log. cores** (Intel Xeon)

Registration

http://lxs-s03.jinr.ru/cicc/index.php/en/registration-at-cicc/

HybriLIT Platform: from education to SC Govorun

OS: CERN CentOS 7

(LIT, b.134)

Cluster Administrator:
HybriLIT team

Storage

EOS:

exp. data: /eos/hybrilit.jinr.ru/nica_bmn (90 TB)
for users: /eos/hybrilit.jinr.ru/user/
scratch: /eos/hybrilit.jinr.ru/scratch, /run/user/$UID
/eos_jinr → MICC EOS

Software

CVMFS: distributed software FS
module avail – print all modules
FairSoft: module add FairSoft/may18p1
FairRoot: **module add FairRoot/v18.0.4**

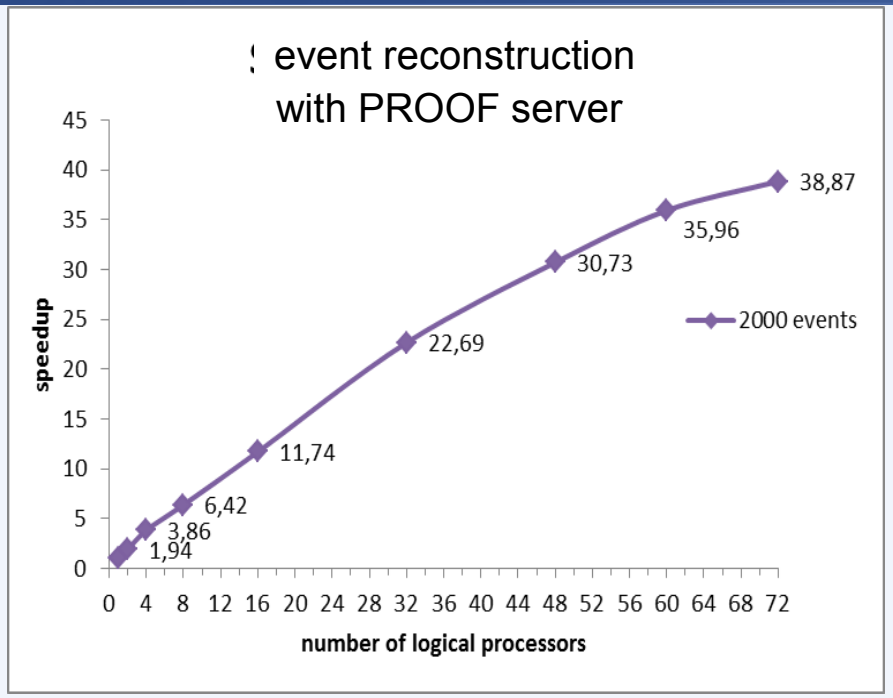
Computing

Batch System: **SLURM**
Intel Xeon (queue 'cpu') + NVidia Tesla (queue 'gpu')
module add GVR/v1.0-1 → SuperComputer Govorun
Intel Xeon Gold (queue 'skylake'): **2880 log. cores**
Intel Xeon Phi (queue 'knl'): **6048 log. cores**
NVidia Tesla V (queue 'dgx'): **40 GPU cards**

Registration

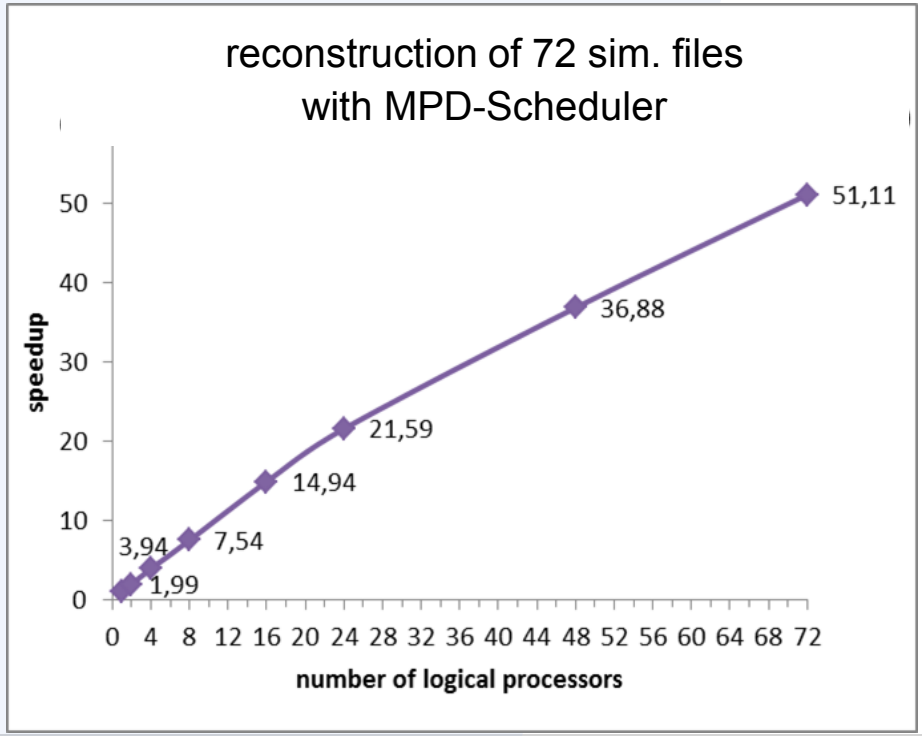
http://hlit.jinr.ru/for_users/registration/

Tools for parallel data processing



PROOF (**P**arallel **ROO**T **F**acility) is a part of the ROOT software

Parallel NICA event data processing in ROOT macros on the parallel architectures: user multicore machines, heterogeneous distributed clusters and GRID system



MPD-Scheduler for task distribution to parallelize NICA data processing on multicore machines and cluster nodes

Supports SLURM, SGE and Torque system

Can use data of the Unified Database

Jobs are described and passed as XML file

Digits and DST mass production for Run 7

MICC Complex
300 TB available
exp. data:
/eos/nica/bmn/exp/run7

raw_run7.data / run_digi.root

xrdcp

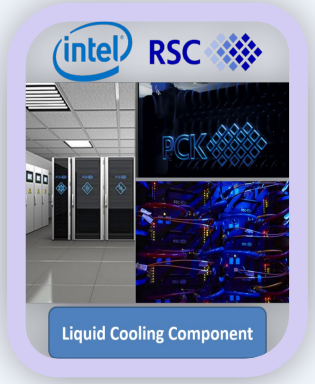
run_digi.root / bmndst.root

UltraFast Storage
30 TBssd available

Supercomputer GOVORUN

MPD-Scheduler

$ mpd-scheduler *raw_run7.xml*

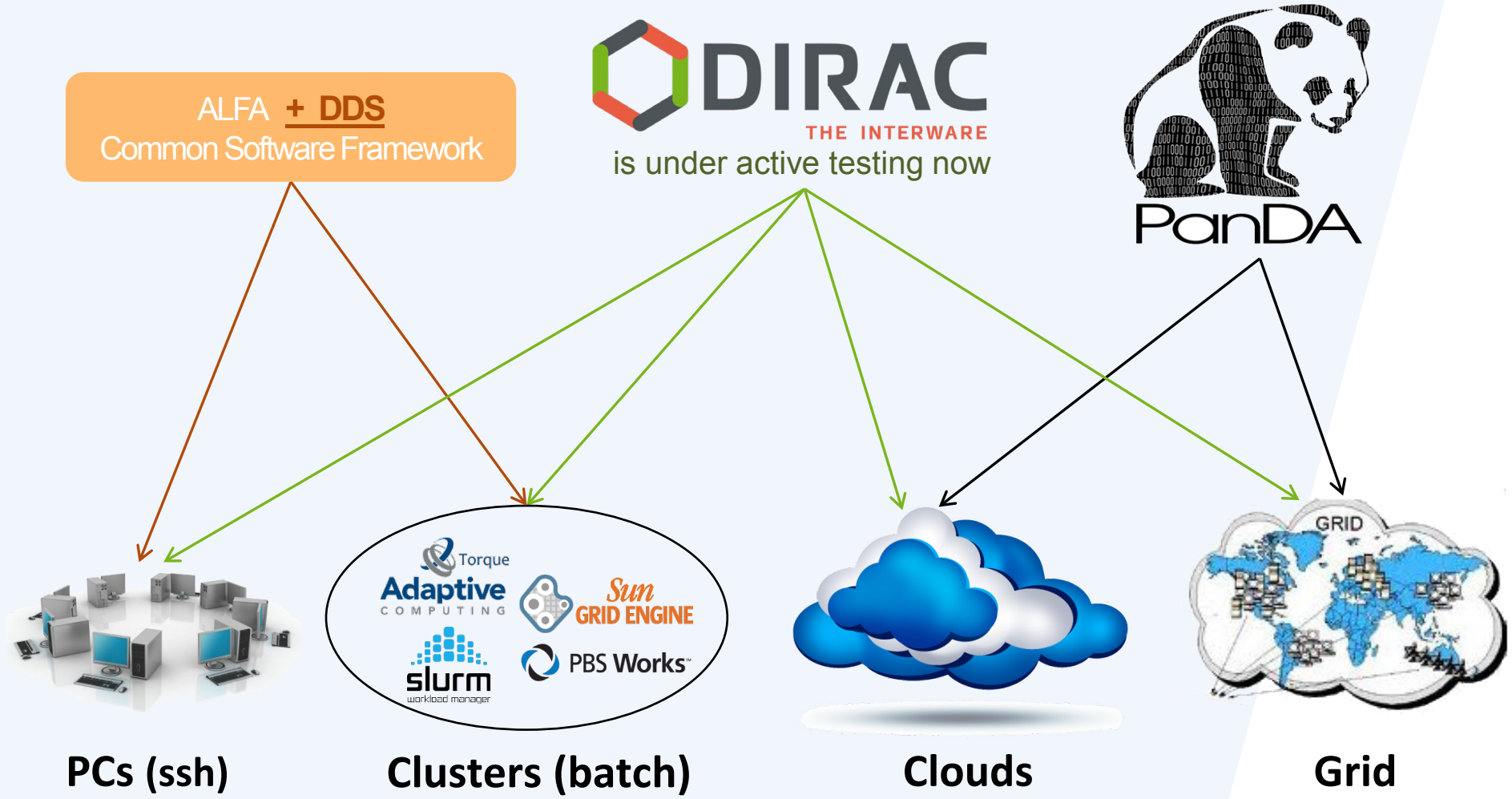


BmnDataToRoot.C

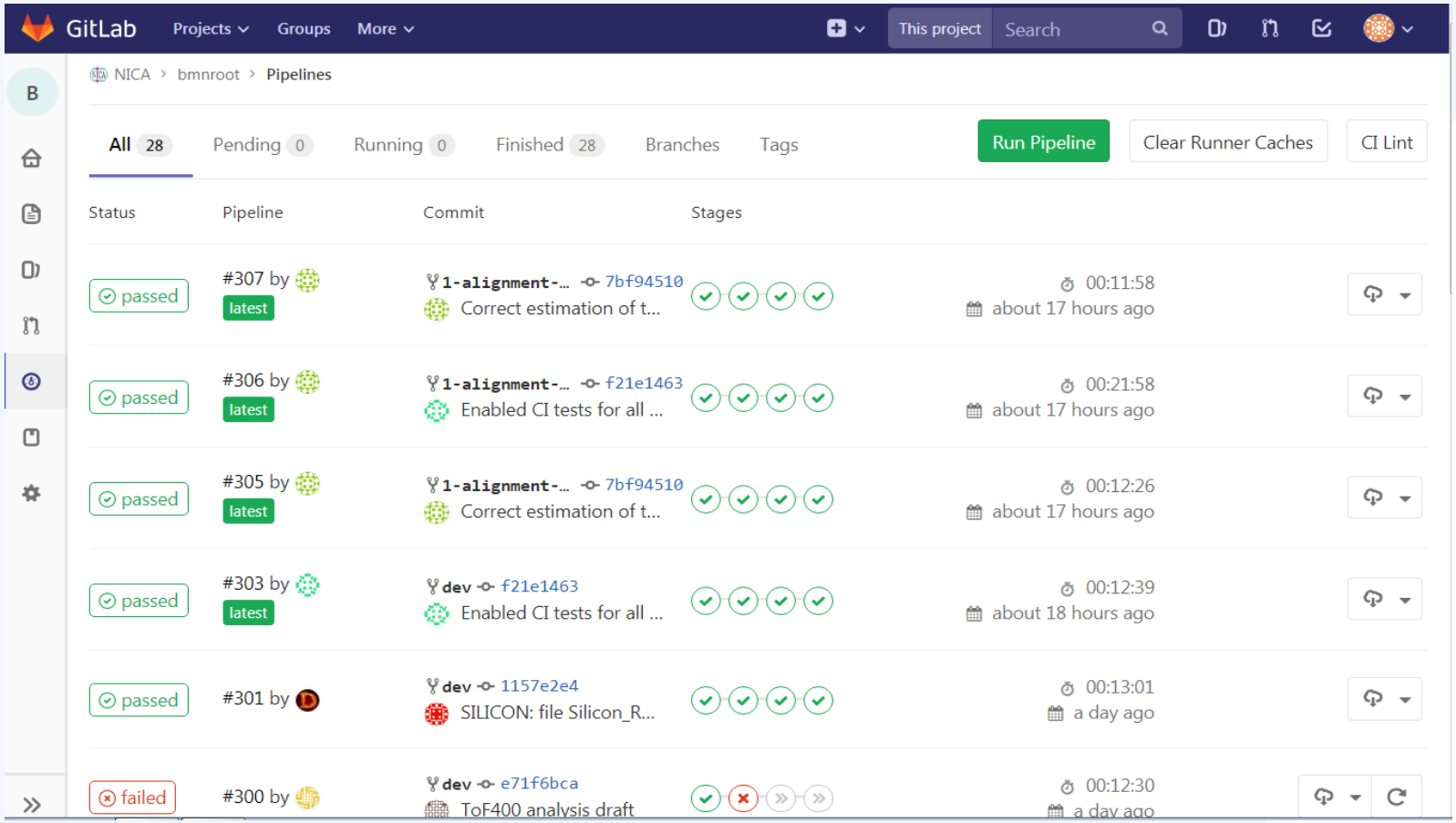
```
<job name="convert_bmn_raw">
 <macro path="~/bmnroot/macro/raw/BmnDataToRoot.C">
  <file input="/eos/nica/bmn/exp/raw/run7/*">
   <put command="xrdcp" path="/lustre/stor/${file_name_with_ext}"/>
   <get command="xrdcp" path="/lustre/stor/bmn_run${last_number}_digi.root"
output="/eos/nica/bmn/exp/digi/run7/bmn_run${last_number}_digi.root"/>
  </file>
 </macro>
 <run mode="global" count="100" config="~/bmnroot/build/config.sh"
work_dir="/lustre/stor"/>
</job>
```

Intel Xeon Gold (queue ‘skylake’): 2880 cores
Intel Xeon Phi (queue ‘knl’): 6048 cores

Workload Manager selection



Software Tests and Automatic Deployment



GIT CI Tests on merge requests

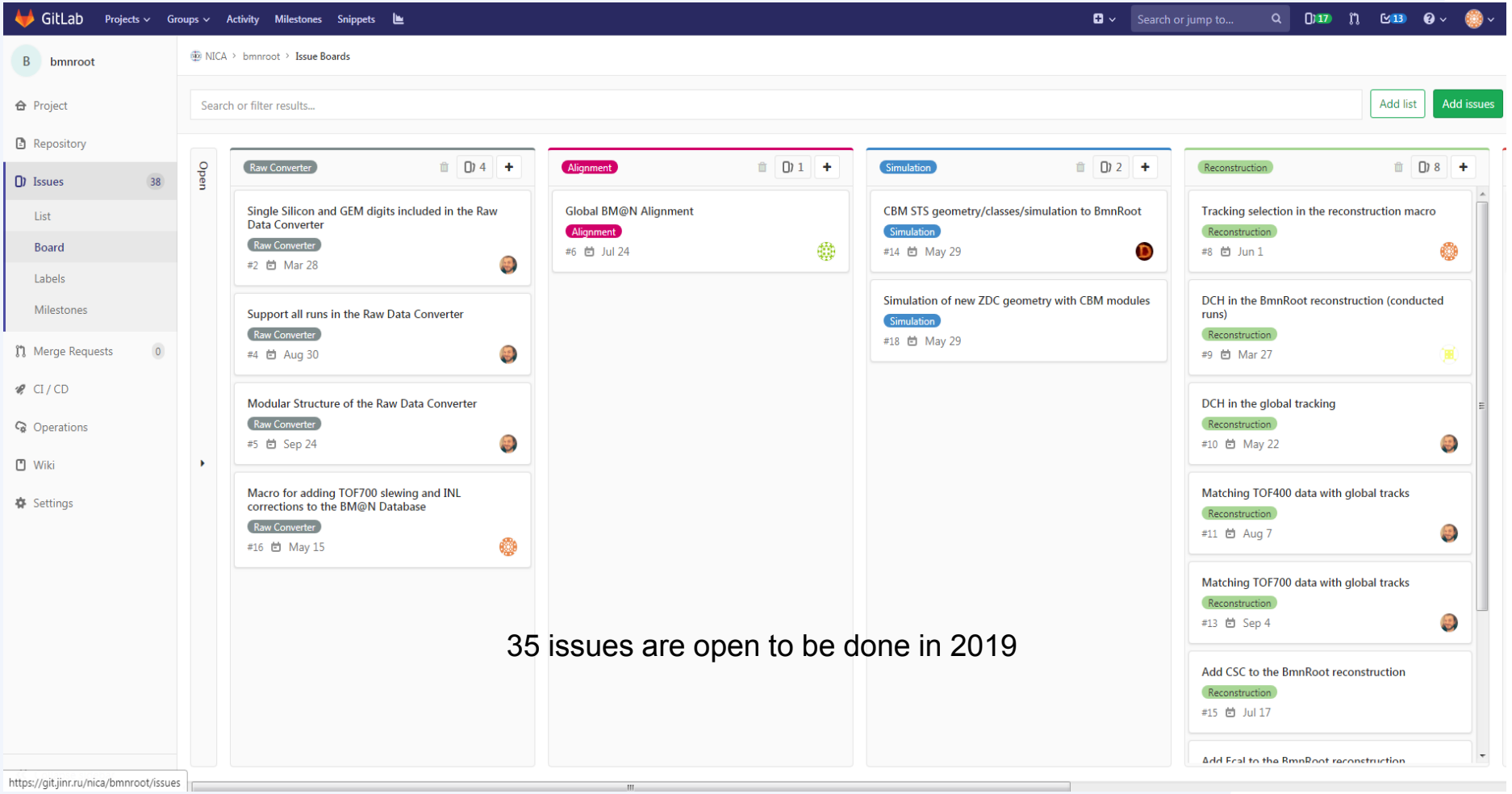
checking compilation and main macros

→ stable *dev* and *pro* branches

In case of compilation or macro errors

e-mail is sent to the software developers

GIT Issues as a Project Management System

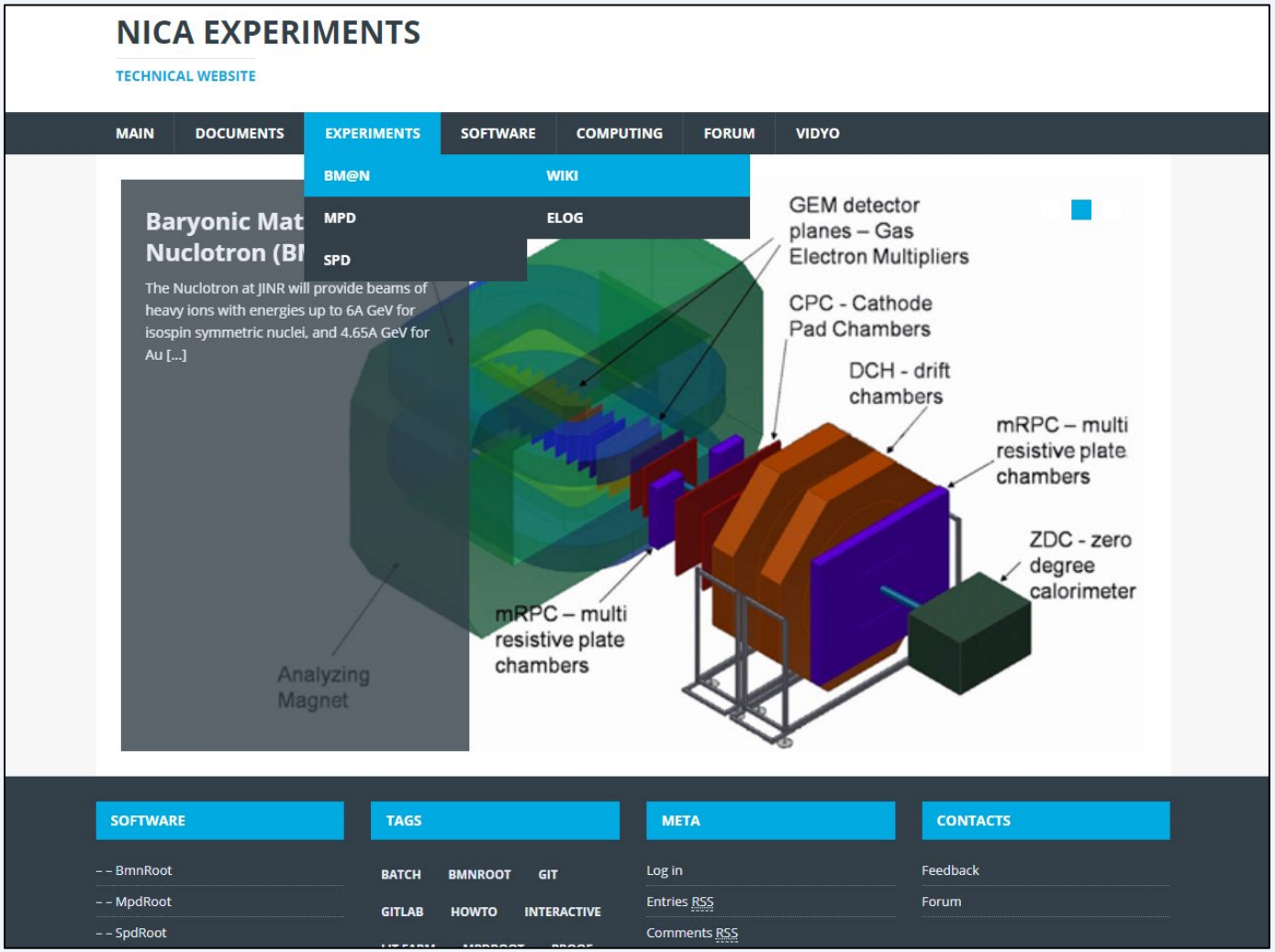


35 issues are open to be done in 2019

GIT Issues:

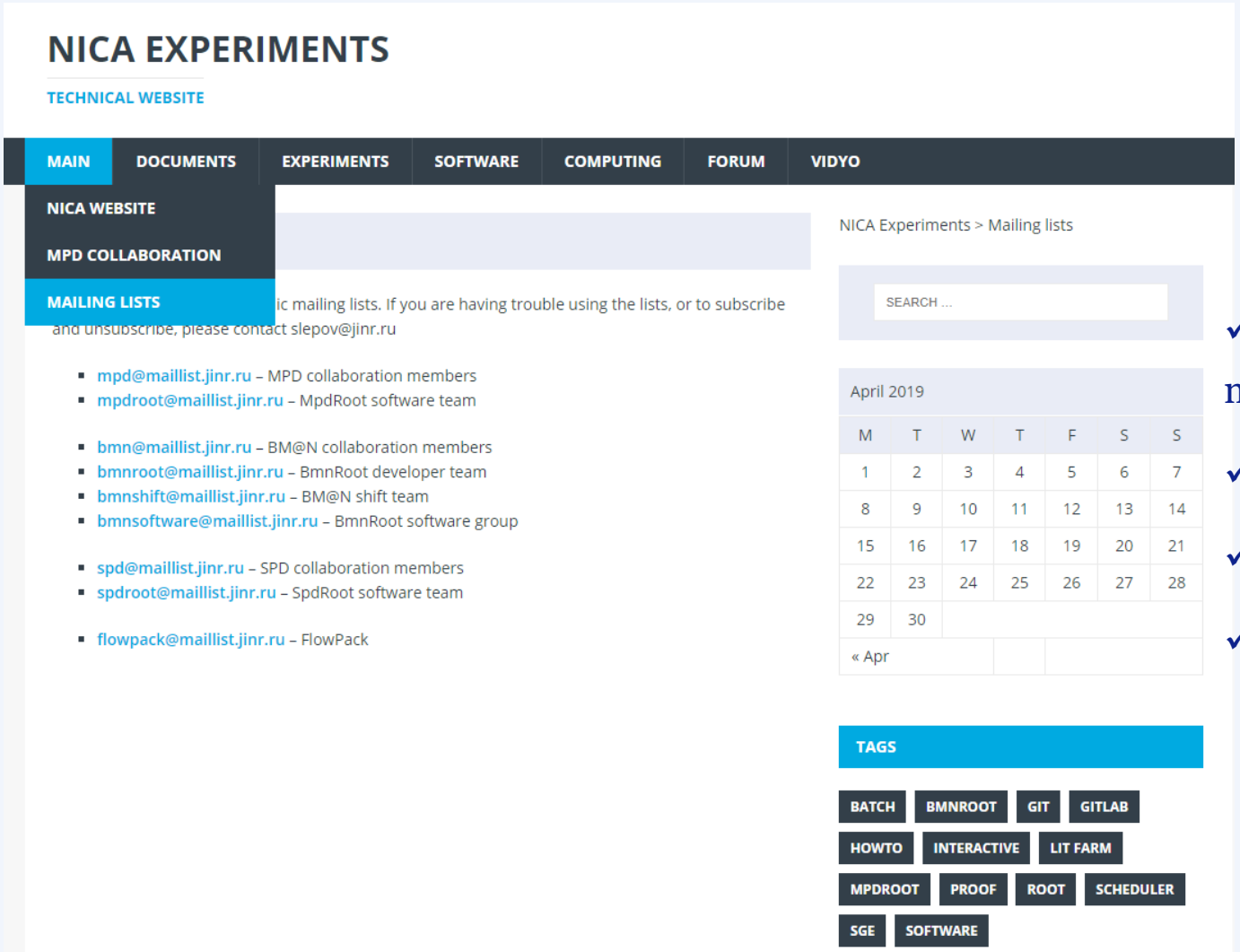
Milestones → Issue List → Boards with Labels

NICA Technical Web-site: *http://mpd.jinr.ru*



- ✓ ***Information***
- ✓ ***Documents***
- ✓ ***Software***
- ✓ ***Computing Section (NICA Cluster, MICC FARM, HybriLIT & Govorun)***
- ✓ ***Tests dashboard***
- ✓ ***Forum***
- ✓ ***Vidyo***
- ✓ ***Mail-lists (updates, errors…)***
- ✓ ***etc.***

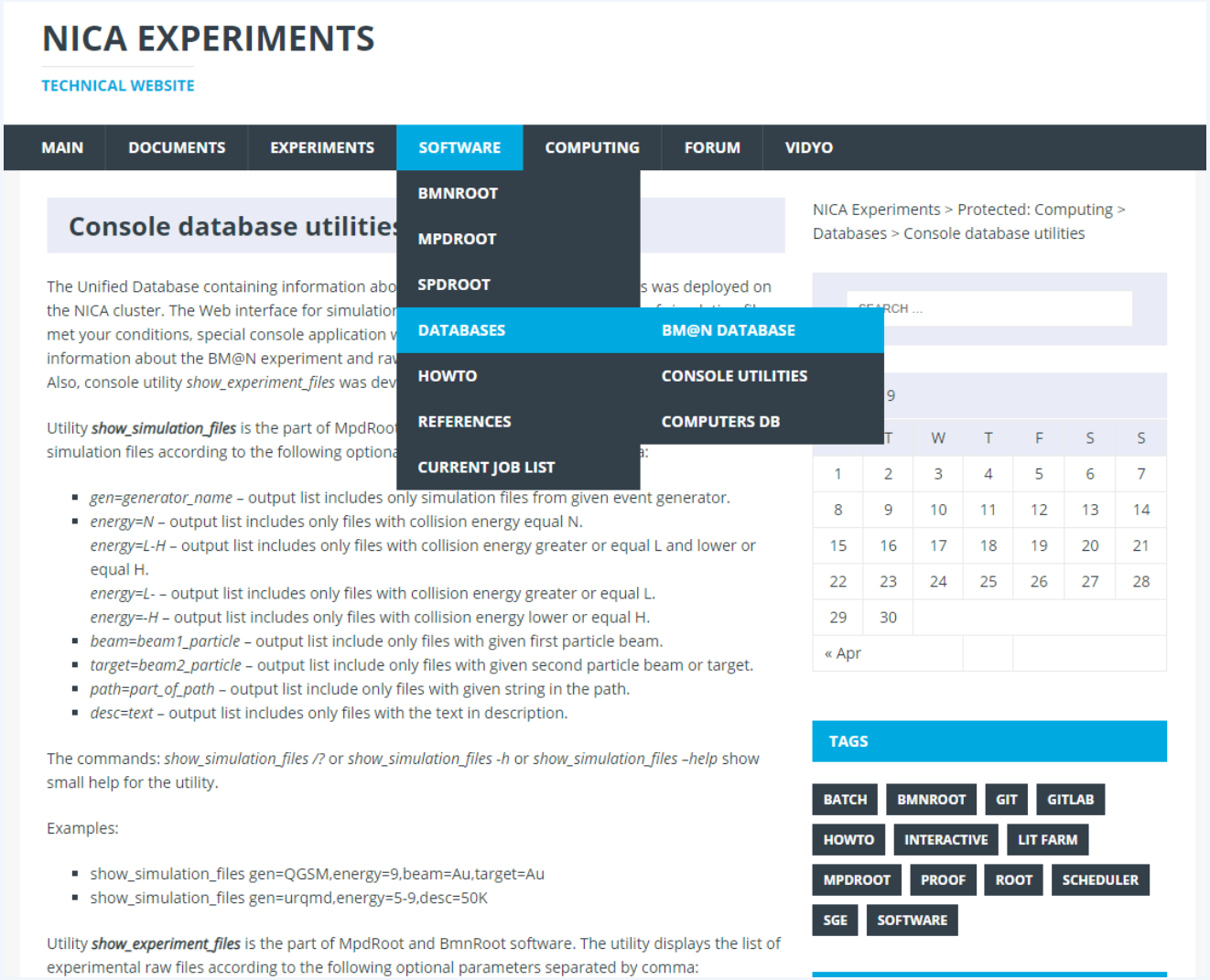
NICA Technical Web-site: *http://mpd.jinr.ru*



BM@N Mail Lists:

- ✓ BM@N collaboration members
- ✓ BmnRoot developer team
- ✓ BM@N shift team
- ✓ BmnRoot software group

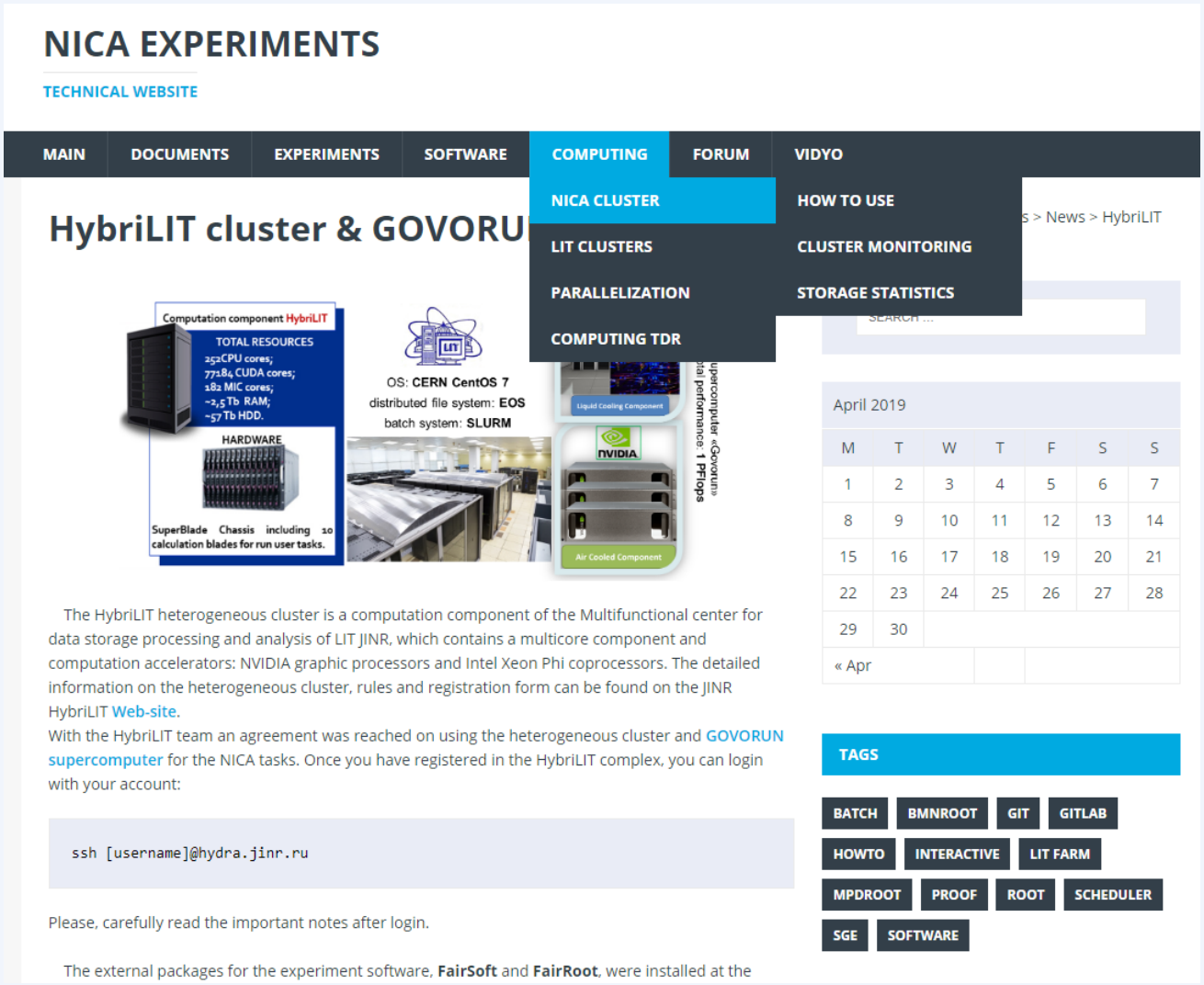
NICA Technical Web-site: *http://mpd.jinr.ru*



BM@N Software:

- ✓ BmnRoot repository
- ✓ BM@N central database
- ✓ HowTo Install BmnRoot
- ✓ BmnRoot Start Guide

NICA Technical Web-site: *http://mpd.jinr.ru*



NICA Computing:

- ✓ NICA Cluster: How to use, Monitoring, Statistics
- ✓ MICC Complex in LIT
- ✓ HybriLIT and Govorun
- ✓ MPD-Scheduler
- ✓ Using PROOF tool

Summary

- The BmnRoot framework for the BM@N experiment provides to users all necessary tools to describe geometries and simulate any kind of detectors for studying their properties, to reconstruct events and make proposed physics analysis both for experimental and simulated data.
- The first BmnRoot release will be issued in the next month to perform the mass production of the BM@N digits and DST files for Run 7. Temporary full digit files have been prepared and can be used before the first release.
- Many offline and online software systems have been developed: BM@N Unified Database, Event Display and Online Histogramming, e-Logbook, PROOF parallelization and MPD-Scheduler, Cluster Monitoring and Software Test System and many others.
- The big work has been done, but a lot of packages should be added or improved for the experimental data taking and BM@N data processing.
- RFBR support with the NICA three-year grant (18-02-40125) enables to significantly improve the Information Systems for online and offline data processing.

Plans for 2019

Raw Data Converter:
- Combine digits for all detectors in the one Raw Data Converter
- Obtain all digits for Run 7
- Implement a Modular Structure of the Raw Data Converter:

BM@N Alignment:
- Macro for BM@N global alignment based on Millepede II in BmnRoot

Tracking:
- Easy selection of the tracking approach in the reconstruction
- Global Tracking implementation

BmnRoot:
- First BmnRoot Release
- Include all the detectors in the simulation and reconstruction
- Prepare DST files for Run 7 to use them in physics analysis

Event Display:
- All detector data and calorimeter towers in the Event Display

Unified Database:
- A new version of the Unified Database with arbitrary parameters
- Filling with the real simulation files
- Automatic insertion of the Run information in online

Monitoring System:
- BM@N Online Monitoring System implementation (DDS framework)

Thank you for your attention!

More information: nica.jinr.ru
mpd.jinr.ru
http://bmnshift.jinr.ru/wiki/doku.php

Forum: http://mpd.jinr.ru/forum/

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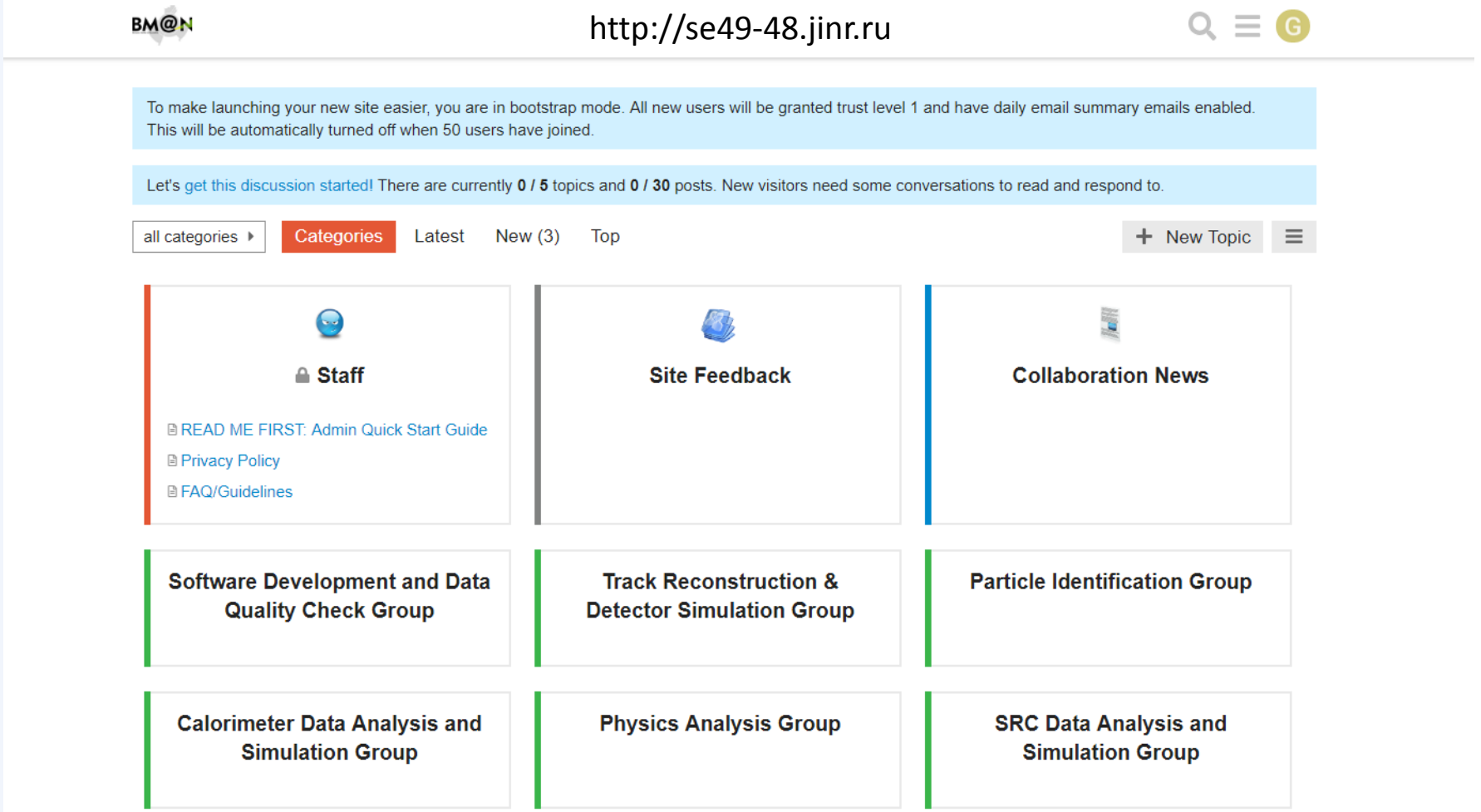
Backup slides

BM@N News system



BM@N News system (built on Discourse) for a quick communication and discussions between collaboration members and groups:

various topics for different groups, subscriptions, comments…