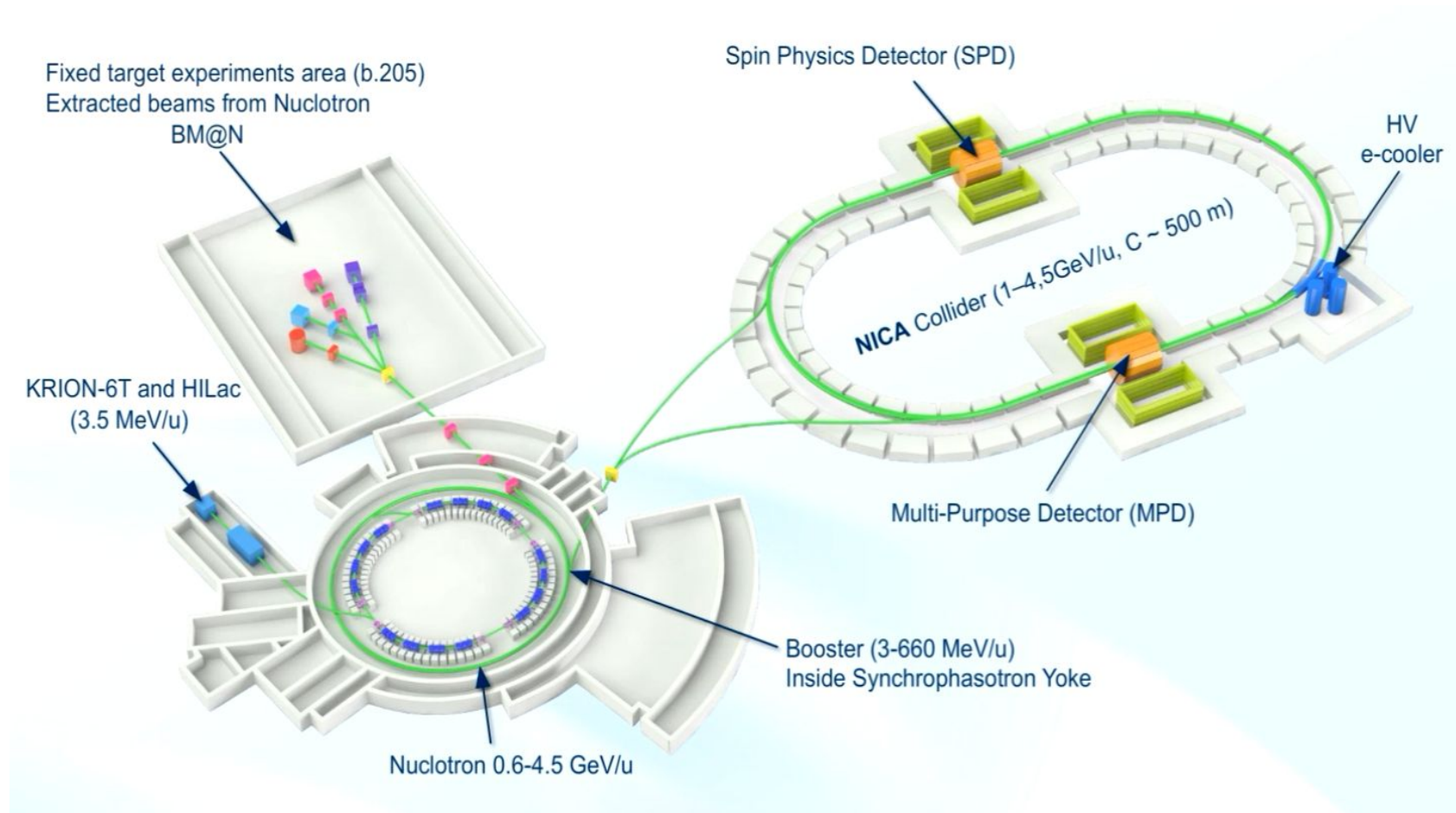


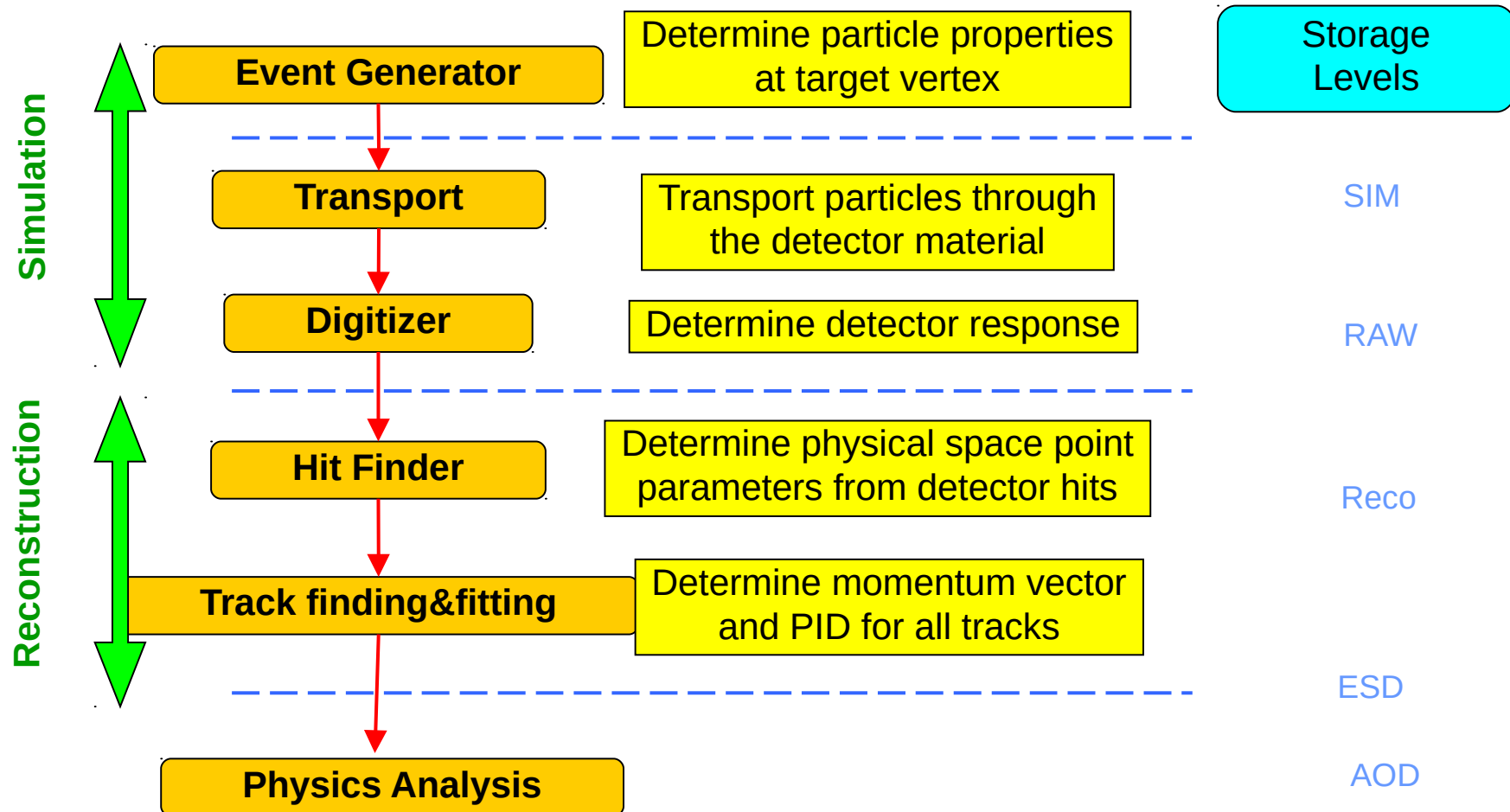
# Software development for the NICA experiments



Workshop on spin physics at NICA  
July 11 2018  
Prague

Rogachevsky  
Oleg

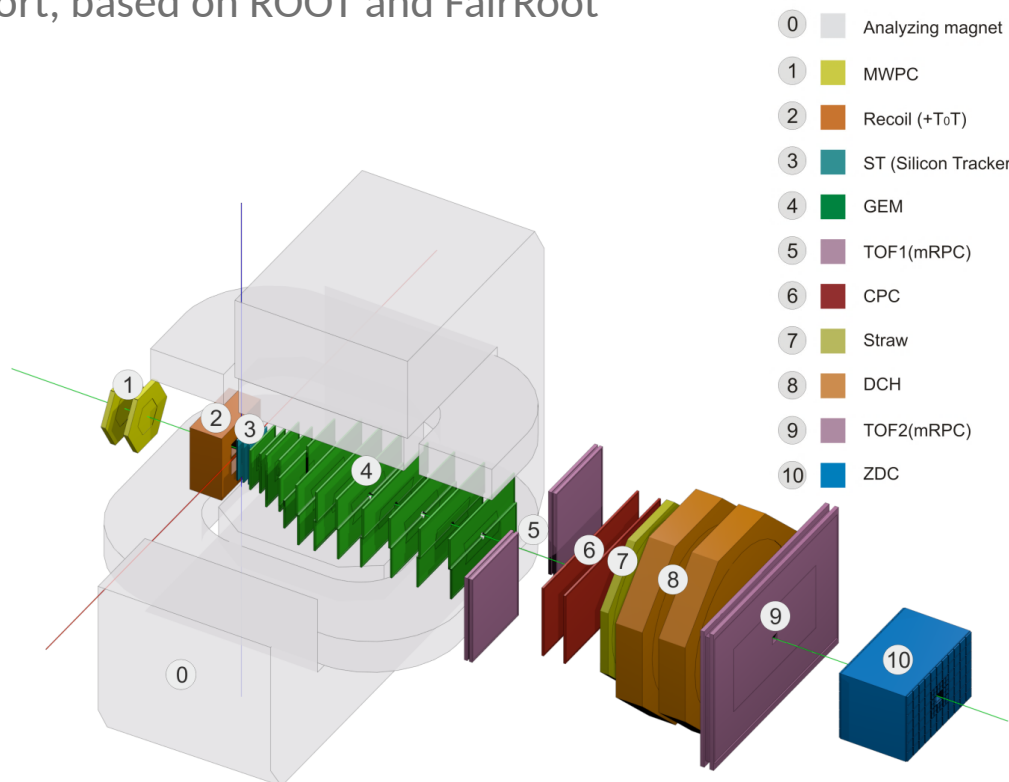
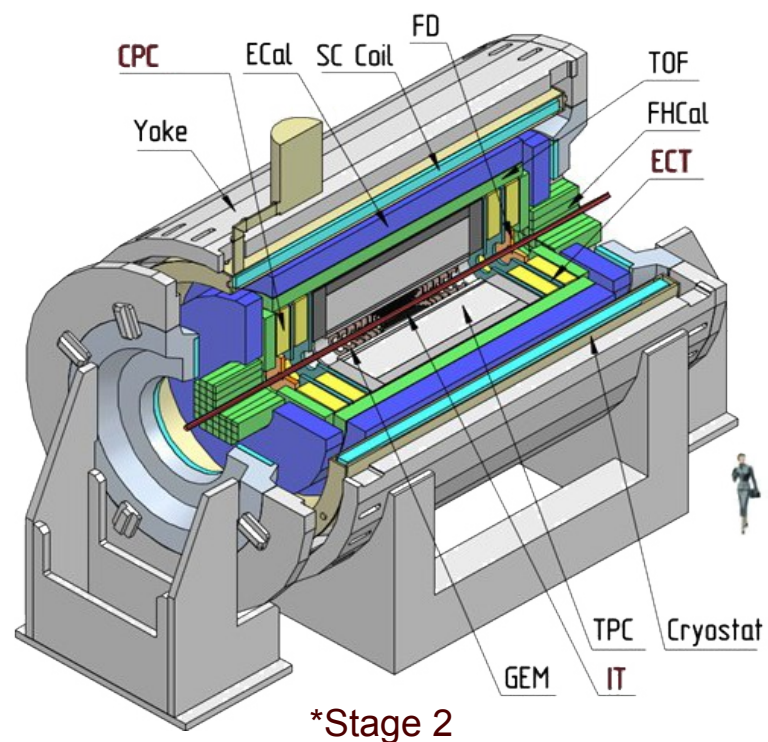
# HEP experiments data flow



# NICA HIC experiment frameworks

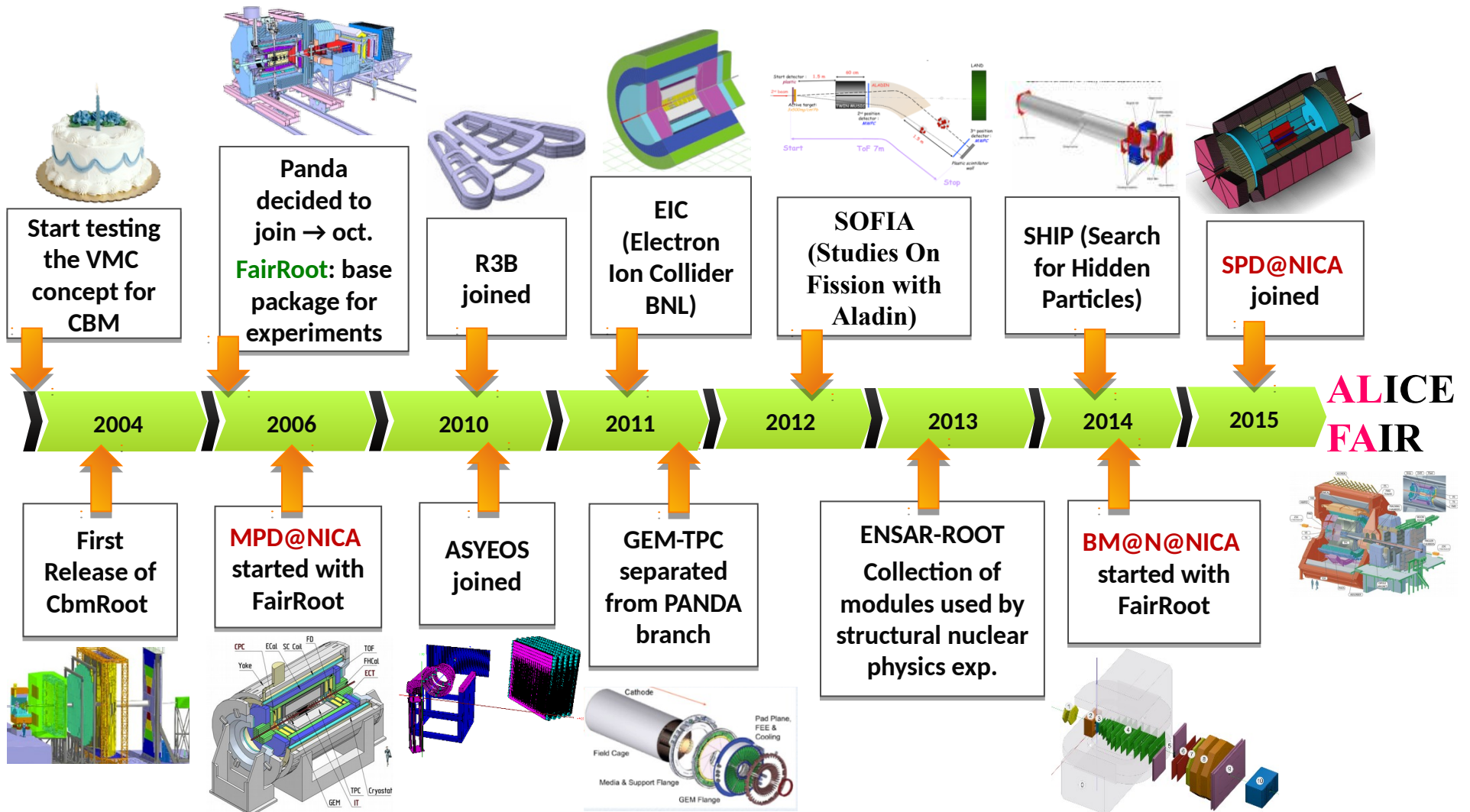
The frameworks **MpdRoot** and **BmnRoot** are developed for the MPD and BM@N event simulation, reconstruction of experimental or simulated data and following physical analysis of heavy ion collisions registered by the detectors.

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

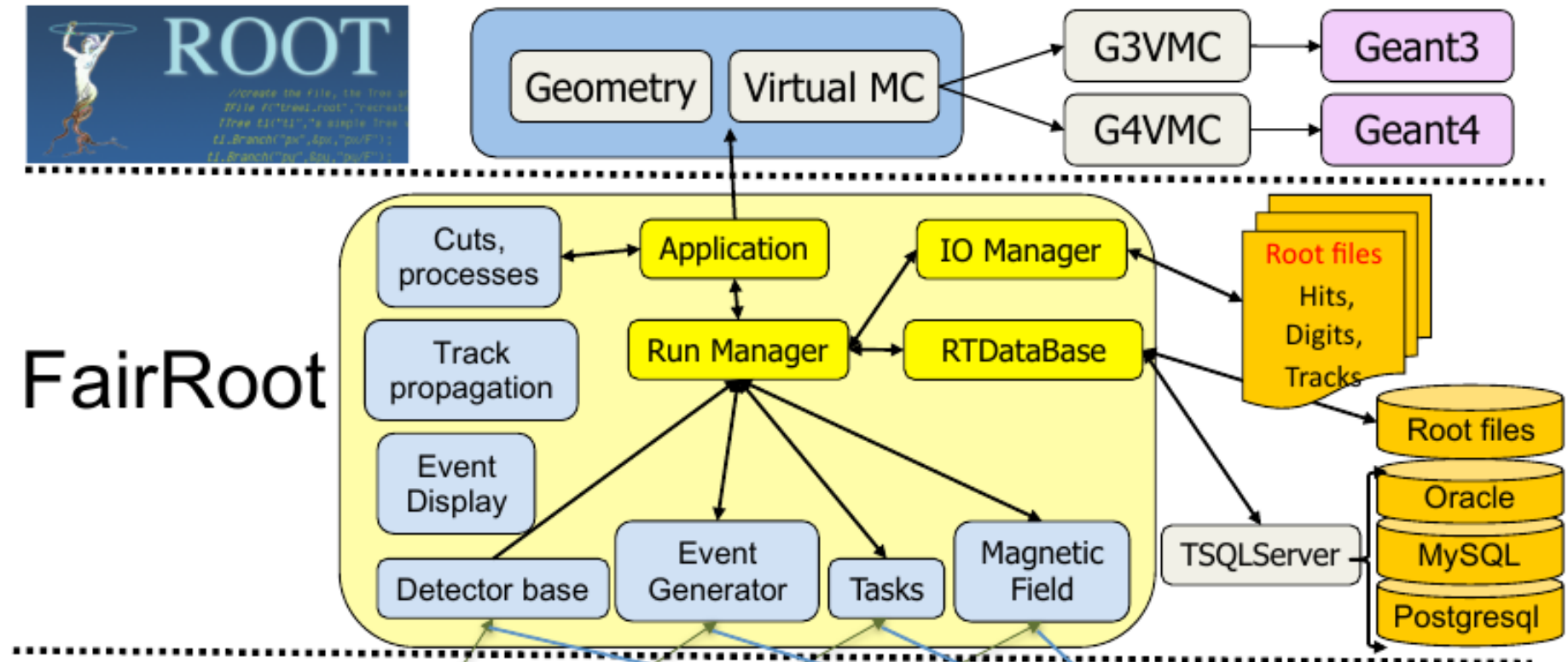


The MpdRoot and BmnRoot software are available in the GitLab <https://git.jinr.ru/nica>

# FairRoot family



# FairRoot structure



The basic idea of FairRoot is to provide a unified package with generic mechanisms to deal with most commonly used tasks in HEP. FairRoot allow the physicist to:

- ✓ Focus on physics deliverables while reusing pre-tested software components.
- ✓ Do not submerge into low-level details, use pre-built and well-tested code for common tasks.
- ✓ Allows physicists to concentrate on detector performance details, avoiding purely software engineering issues like storage, retrieval, code organization etc.




# FairRoot

<https://fairroot.gsi.de/>

## FairRoot

[HOME](#)[INSTALLATION](#)[CLASS DOCUMENTATION](#)[REPOSITORY](#)[ABOUT](#)[HOWTO](#)[@GSI](#)[CONTACT](#)



The FairRoot framework is an object oriented simulation, reconstruction and data analysis framework based on ROOT. It includes core services for detector simulation and offline analysis. The framework delivers base classes which enable the users to easily construct their experimental setup in a fast and convenient way. By using the Virtual Monte Carlo concept it is possible to perform the simulations using either Geant3 or Geant4 without changing the user code or the geometry description.

# MpdRoot & BmnRoot & ... design

Use **FairSoft** external packages

ROOT, XRootD, Pythia, PLUTO, HepMC, MillePede, Geant3/4, VGM, GSL, boost...

Use **FairRoot** as a set of base classes and modules of needed by particle experiments

Extended set of **event generators** for collisions:

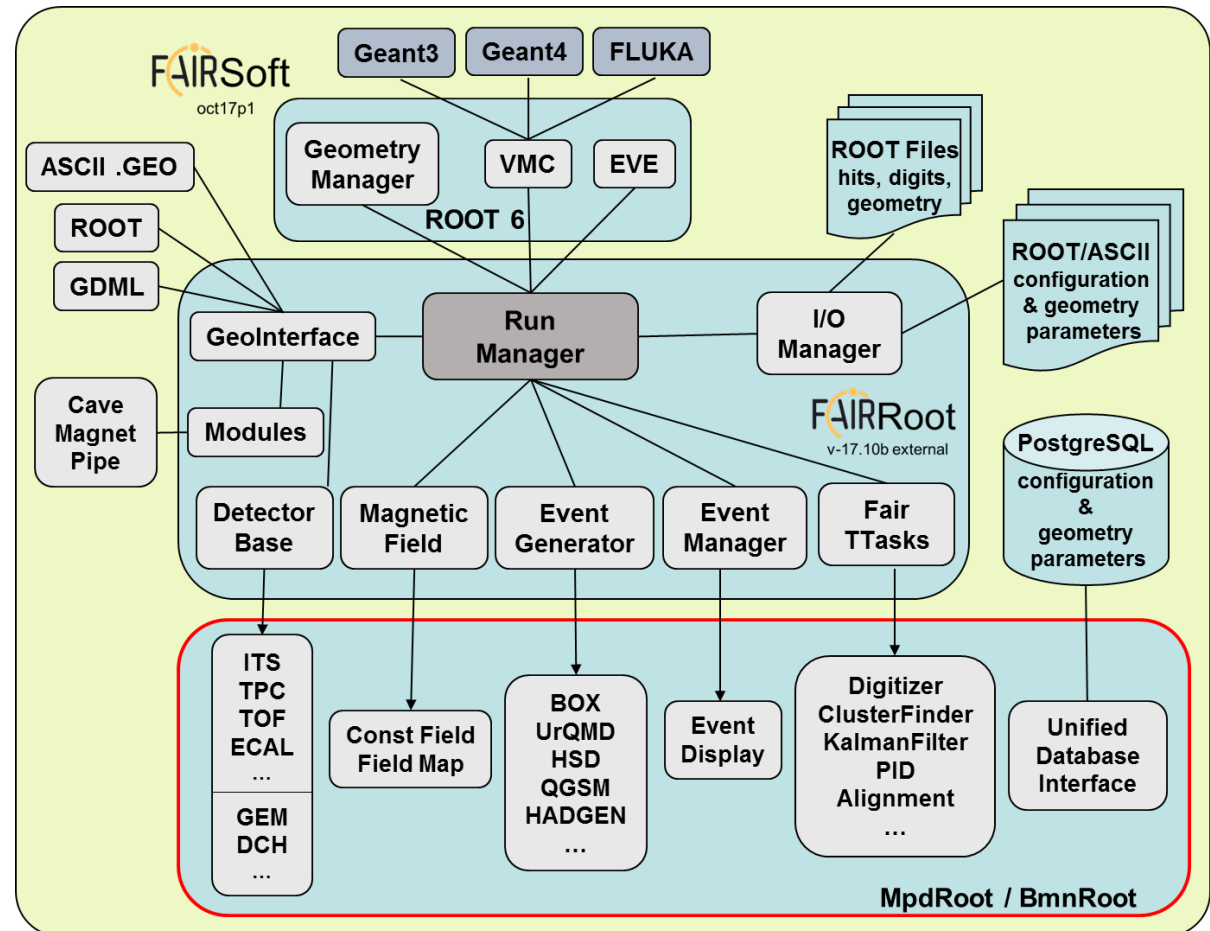
UrQMD, Hybrid UrQMD, vHLLE + UrQMD, QGSM/LAQGSM, HSD/pHSD, HADGEN, 3 Fluid Dynamics, PLUTO  
simple (for testing) - BOX, ION, PART

**Experiment-specific parts and geometry** are developed for each detector independently

**Particle propagation** by GEANT3/4

**Advanced detector response functions, realistic tracking and PID** were included

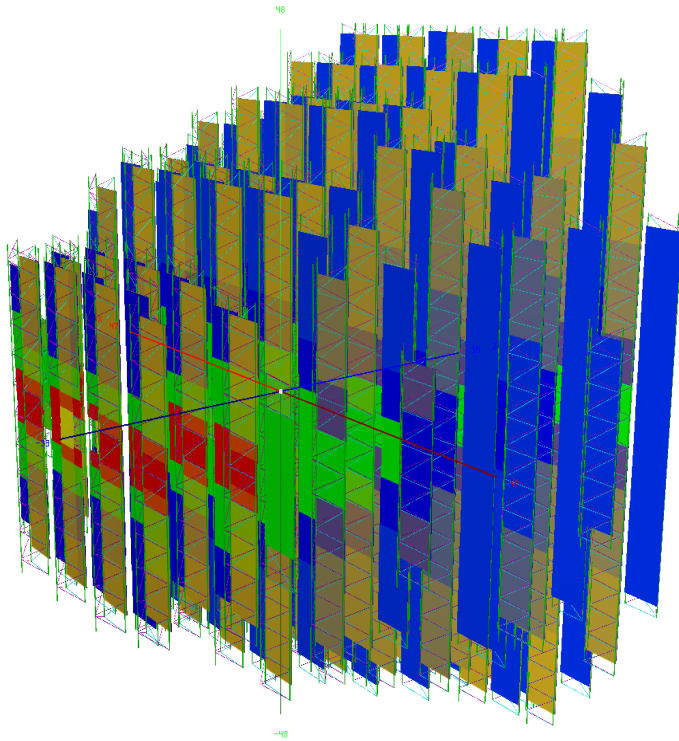
MPD and BM@N homepage: <http://mpd.jinr.ru>



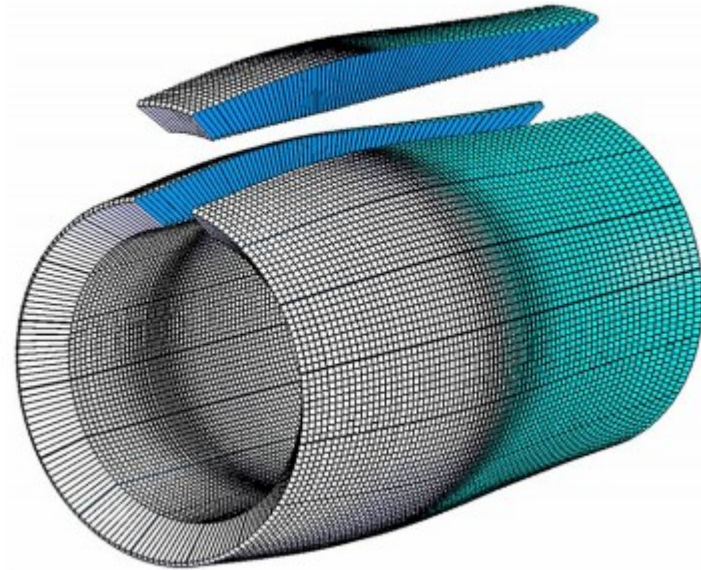
# Detectors simulation

CBM  $\rightarrow$  BM@N  $\rightarrow$  MPD  $\rightarrow$  SPD

Panda (MPD)  $\rightarrow$  SPD



SSD



ECAL



# MpdRoot

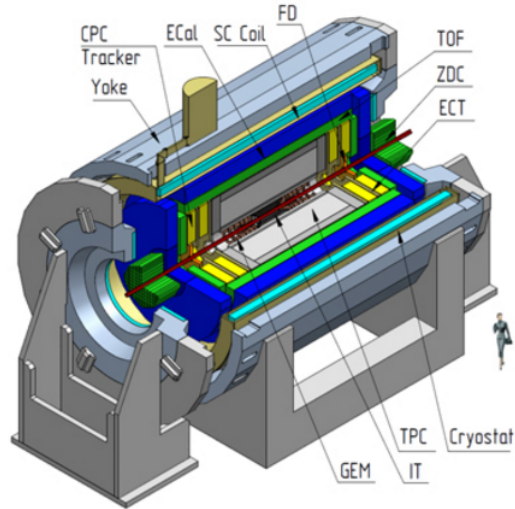
## MPDROOT

SIMULATION AND ANALYSIS FRAMEWORKS FOR MPD AND BM@N AT NICA

GENERAL DOCUMENTS COMPUTING REFERENCES FORUM BM@N SHIFTS

### Multi Purpose Detector (MPD)

The MPD apparatus has been designed as a 4 $\pi$  spectrometer capable of detecting of charged hadrons, electrons and photons in heavy-ion collisions at high luminosity [...]



Relativistic nuclear physics  
collider experiment

#### SOFTWARE

-- BmnRoot  
-- MpdRoot  
-- FairSoft  
-- ROOT

#### TAGS

BATCH BMNROOT GEOMETRY  
GIT GITLAB INTERACTIVE  
LIT FARM LXMPD-UI  
MPDROOT PROOF ROOT  
SCHEDULER SGE SIMULATION

#### META

Log In  
Entries [RSS](#)  
Comments [RSS](#)  
[WordPress.org](#)

#### CONTACTS

Feedback  
Forum

# MpdRoot+BMNRoot

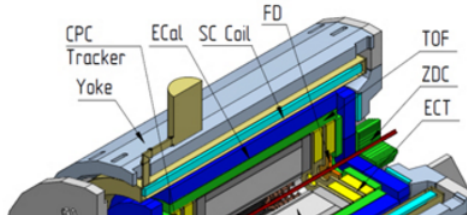
## MPDROOT

SIMULATION AND ANALYSIS FRAMEWORKS FOR MPD AND BM@N AT NICA

GENERAL DOCUMENTS COMPUTING REFERENCES FORUM BM@N SHIFTS

### Multi Purpose Detector (MPD)

The MPD apparatus has been designed as a 4 $\pi$  spectrometer capable of detecting of charged hadrons, electrons and photons in heavy-ion collisions at high luminosity [...]



Relativistic nuclear physics collider exp.

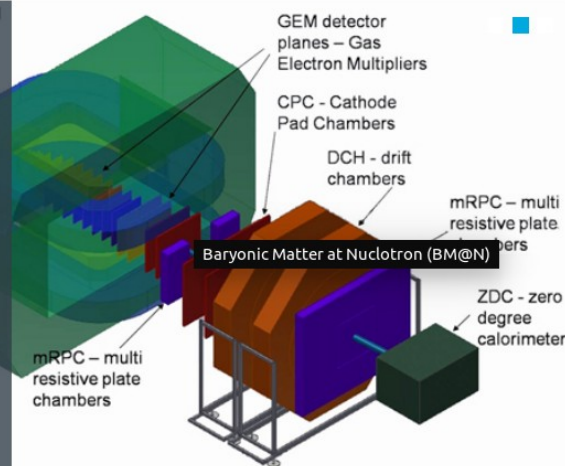
## NICA EXPERIMENTS

TECHNICAL WEBSITE

MAIN DOCUMENTS SOFTWARE COMPUTING FORUM REFERENCES BM@N SPD VIDYO

### Baryonic Matter at Nuclotron (BM@N)

The Nuclotron at JINR will provide beams of heavy ions with energies up to 6A GeV for isospin symmetric nuclei, and 4.65A GeV for Au [...]



Relativistic nuclear physics fixed target exp.

### SOFTWARE

-- BmnRoot  
-- MpdRoot  
-- FairSoft  
-- ROOT

### TAGS

BATCH  
GIT  
GIT  
LIT FARM  
MPDROOT  
SCHEDULE

# MpdRoot+BMNRoot +SPDRoot

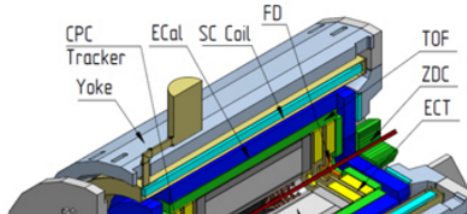
## MPDROOT

SIMULATION AND ANALYSIS FRAMEWORKS FOR MPD AND BM@N AT NICA

GENERAL DOCUMENTS COMPUTING REFERENCES FORUM BM@N SHIFTS

### Multi Purpose Detector (MPD)

The MPD apparatus has been designed as a 4 $\pi$  spectrometer capable of detecting of charged hadrons, electrons and photons in heavy-ion collisions at high luminosity [...]



Relativistic nuclear physics collider

## NICA EXPERIMENTS

TECHNICAL WEBSITE

MAIN DOCUMENTS SOFTWARE COMPUTING FORUM REFERENCES BM@N SPD VIDYO

### Baryonic Matter at Nuclotron (BM@N)

The Nuclotron at JINR will provide beams of heavy ions with energies up to 6A GeV for isospin symmetric nuclei, and 4.65A GeV for Au [...]

Target, Recoil

Analyzing Magnet

mRPC - resistive chamber

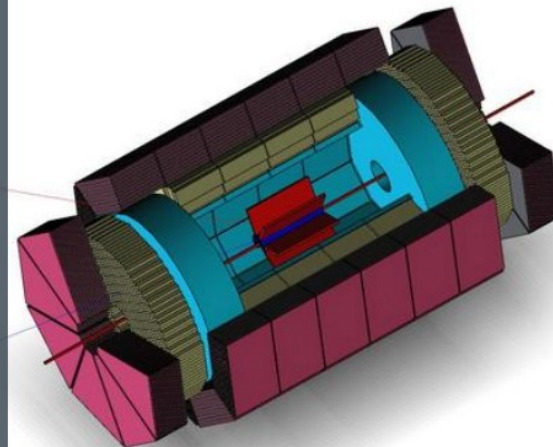
## NICA EXPERIMENTS

TECHNICAL WEBSITE

MAIN DOCUMENTS SOFTWARE COMPUTING FORUM REFERENCES BM@N SPD VIDYO

### Spin Physics Detector (SPD)

Measurements of asymmetries in the lepton pair (Drell-Yan) production in collisions of non-polarized, longitudinally and transversally polarized protons and deuterons beams are suggested to be [...]



Relativistic nuclear physics fixed target

Spin physics collider exp.

### SOFTWARE

-- BmnRoot  
-- MpdRoot  
-- FairSoft  
-- ROOT

### TAGS

BATCH  
GIT  
GIT  
LIT FARM  
MPDROOT  
SCHEDULE

# Documentation

mpd.jinr.ru/howto-install-mpdroot/

MAINDOCUMENTSSOFTWARECOMPUTINGFORUMREFERENCESBM@NSPDVIDYO

BMNROOTMPDROOTSPDROOTDATABASES

HOWTO

CURRENT JOBS LIST

SOFTWARE INSTALLATION

BMNROOT START GUIDE

HOW TO USE GIT

## How to install BmnRoot

Before installing MpdRoot or BmnRoot, the following packages are installed on the system:

- Install packages needed for Redhat-based OS (e.g. CentOS):

```
su
yum install subversion git make cmake gcc-gfortran glibc-devel libX11-devel libXmu-devel libXpm-devel libXft-devel libXext-devel mesa-libGLU-devel libxml2-devel expat-devel zlib-devel postgresql-devel mysql-devel openssl-devel curl-devel automake libtool fftw3-devel
```
- Install packages needed for Debian-based OS (e.g. Ubuntu):

```
sudo su
apt-get install subversion git make cmake gcc gfortran binutils patch libsb-release libx11-dev libxmu-dev libxpm-dev libxft-dev libxext-dev dpkg-dev xlibmesa-glu-dev libglew-dev libxml2-dev libexpat1-dev zlib1g-dev libpqxx3-dev libmysqlclient-dev libssl-dev libcurl4-openssl-dev automake libtool fftw3-dev
```

## Installing the external packages

- Set an installation path for the external packages, e.g. /opt  
NOTE: If you are installing FairSoft/FairRoot to a system directory like /opt, then switch user to superuser 'root' ("sudo su" command).

NICA Experiments > All posts > How To > How to install MpdRoot or BmnRoot

SEARCH ...

8					
	W	T	F	S	S
					1
2	3	4	5	6	7
8					
9	10	11	12	13	14
15					
16	17	18	19	20	21
22					
23	24	25	26	27	28
29					
30	31				
«	Apr				

TAGS

BATCHBMNROOTGITGITLAB

HOWTOINTERACTIVELIT FARM

MPDROOTPROOFROOTSCHEDULER

SGESOFTWARE

CATEGORIES

Computing

gory/software/

INSTALLATION\_PATH=/opt

12



# External packages

cmake	3.11.1
gtest	1.7.0
gsl	1.16
icu4c	53.1
boost	1_67_0
Pythia6	416
HepMC	2.06.09
Pythia8	212
Mesa	7.10.3
Geant4	10.04.p01
xrootd	4.8.3
ROOT	6.12.06

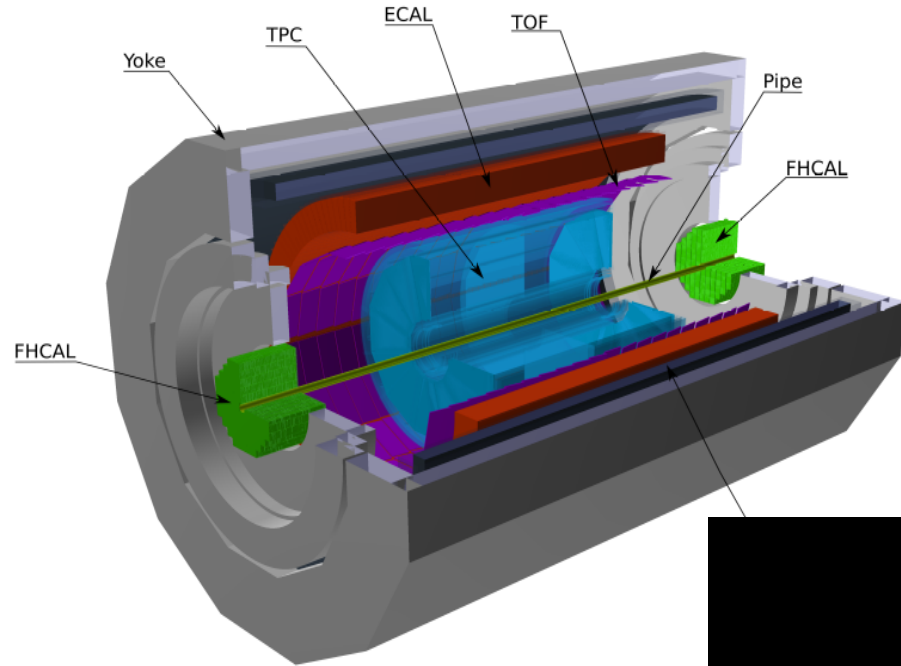
Geant321+_vmc	v2-5
VGM	v4-4
G4VMC	v3-6
MillePede	V04-03-04
ZeroMQ	4.2.5
Procoll Buffers	3.4.0
nanomsg	1.0.0
FlatBuffers	1.9.0
MessagePack	2.1.5
DDS	2.0
FairMQ	1.2.3
FairLogger	1.2.0

In case the python bindings are build the following additional packages should be installed

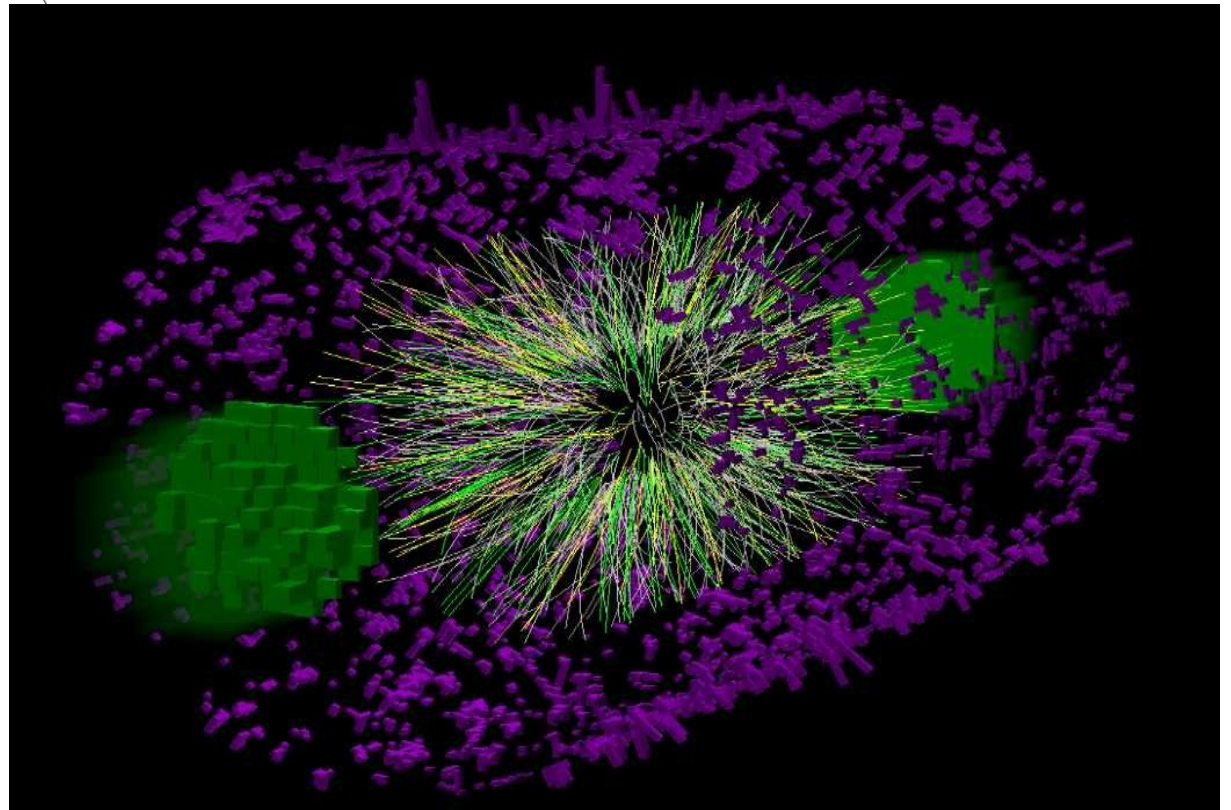
XercesC 3.1.2

G4Py Version which comes with Geant4

# MPD



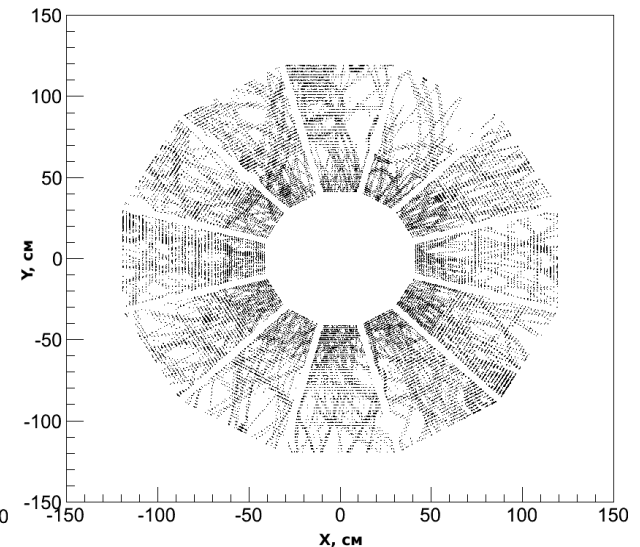
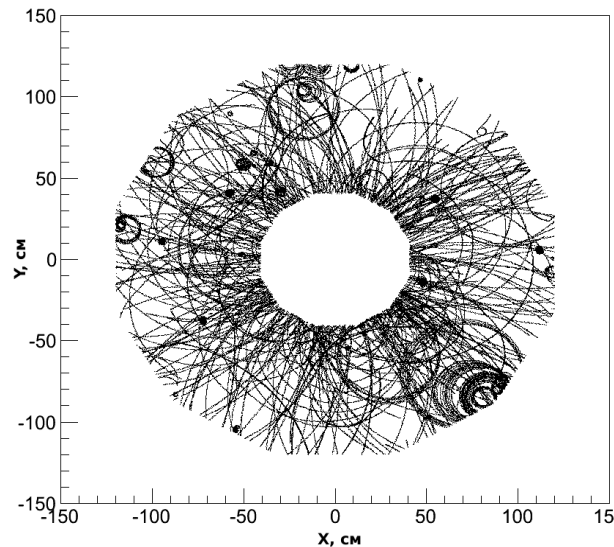
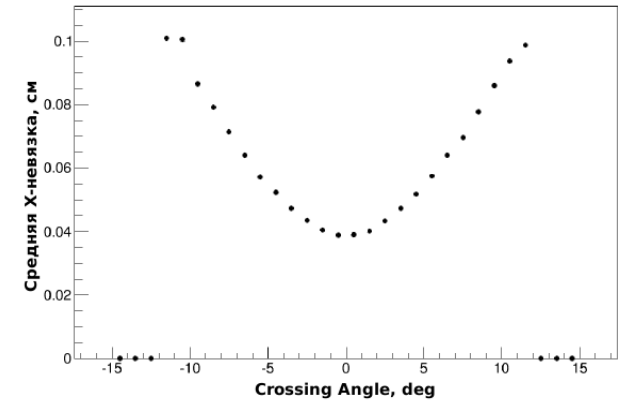
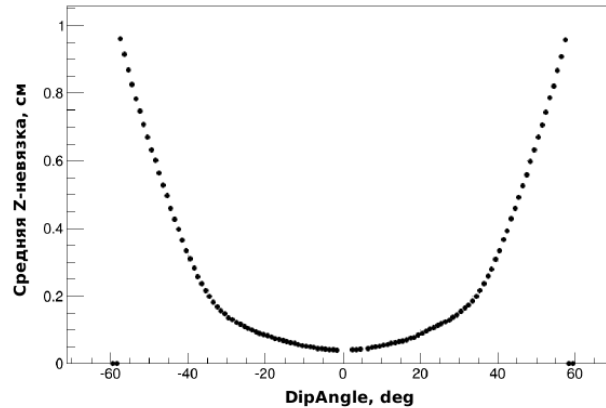
AuAu  $\sqrt{s} = 11$  GeV



# Clustering in MPD TPC

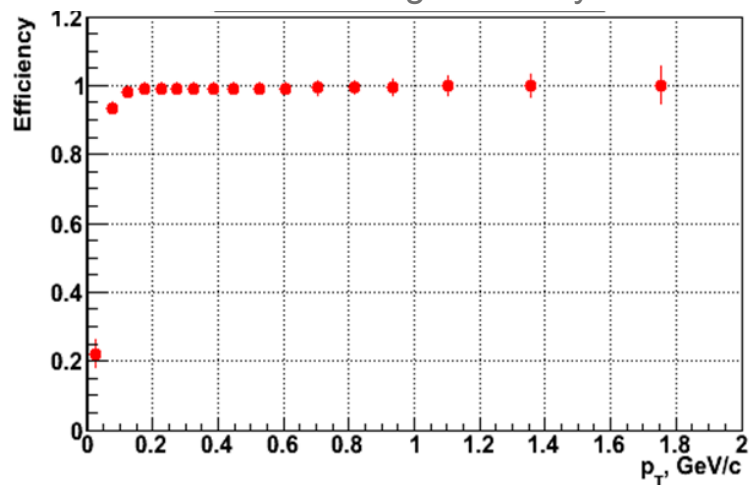
The hit reconstruction algorithm contains the following main steps:

- 1) Searching for extended clusters in (Pad-Time) for each pad raw.
- 2) Searching for peaks in time-profile for each pad in the found extended cluster.
- 3) Combining the neighboring peaks into resulting hits.

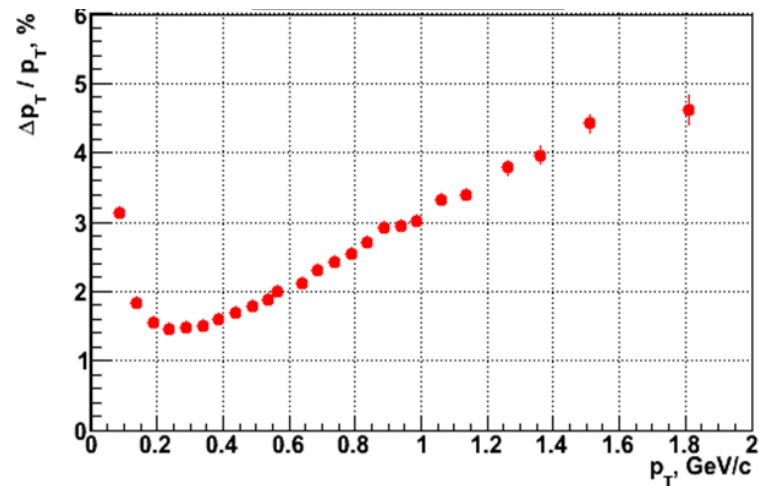


# Tracking in MPD TPC

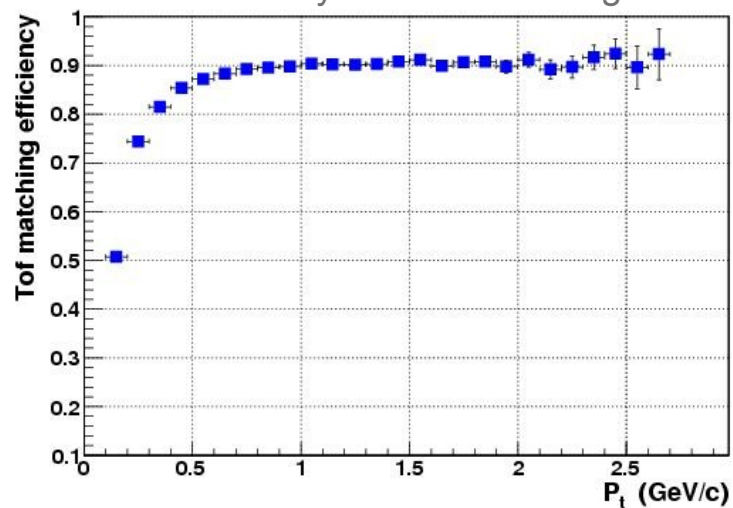
TPC tracking efficiency



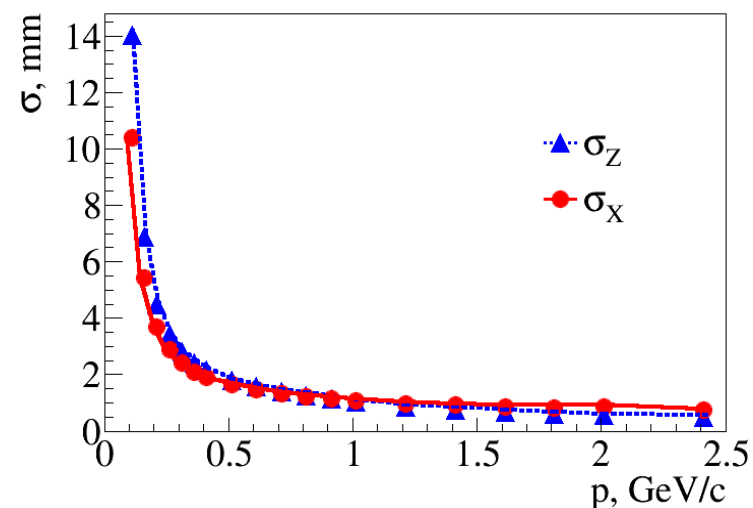
Momentum resolution



Efficiency of TOF matching



Primary vertex resolution

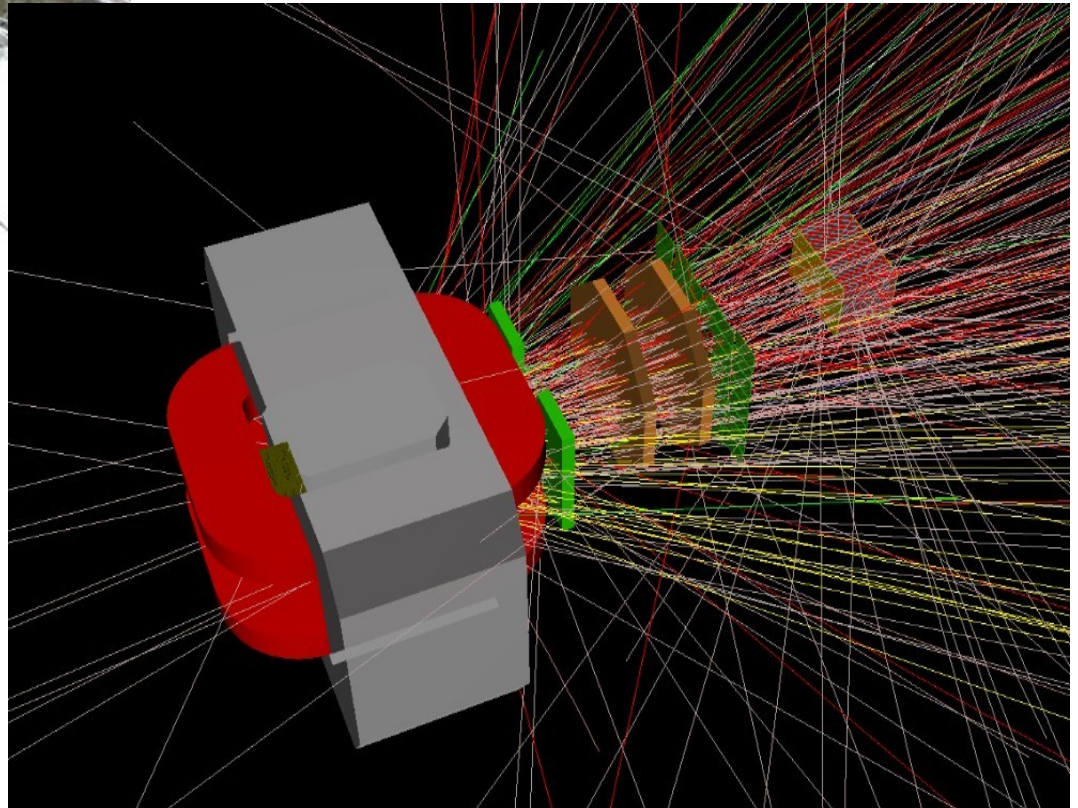




# BM@N

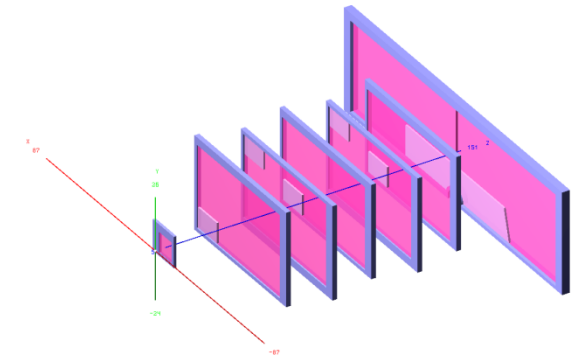
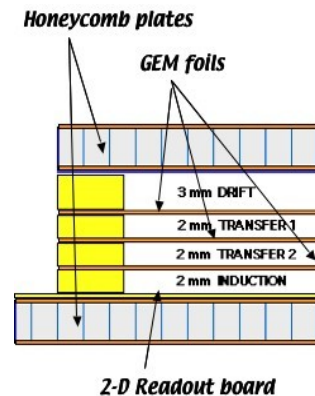


AuAu  $E_{\text{beam}} = 4 \text{ GeV}$

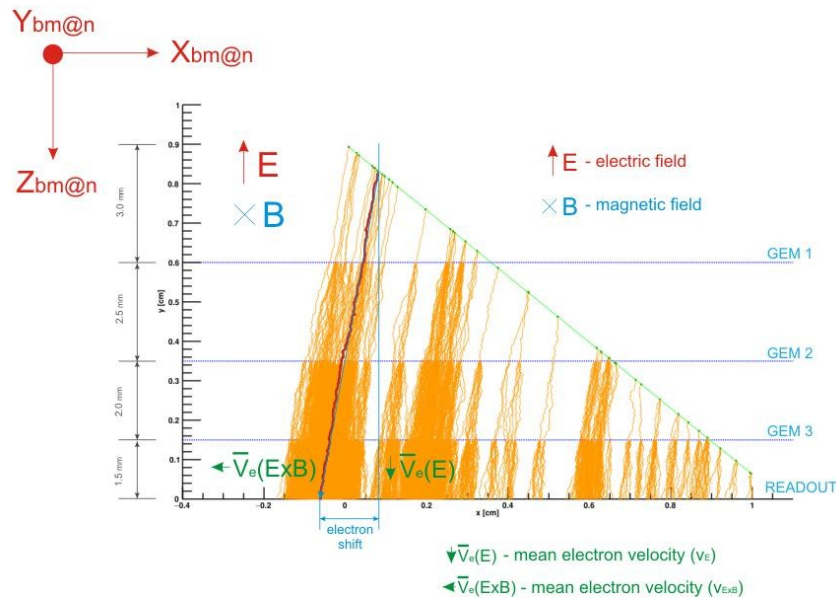


# Clustering in GEM

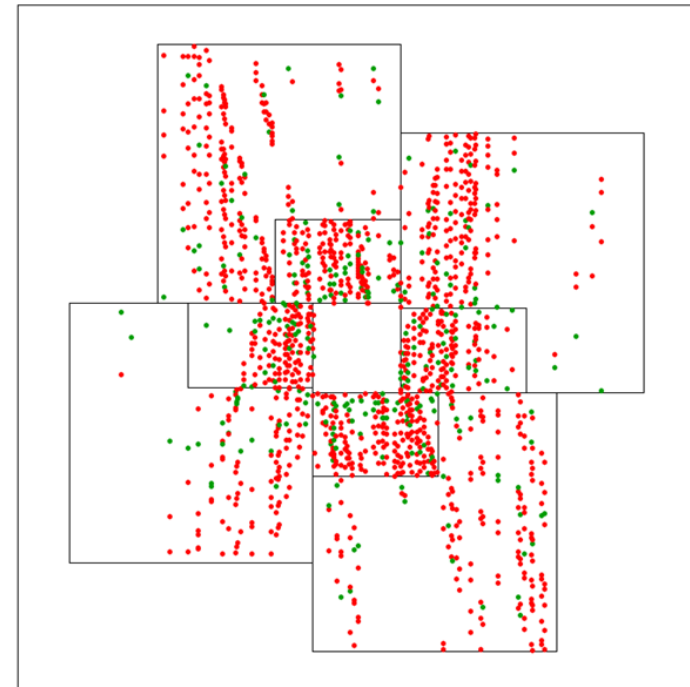
- There are realistic hit finder in GEMs (Garfield)
- For the GEM stations procedure of the fake hits production is implemented



Station 0 (what is it)



electron avalanches in the BM@N GEM chamber




# Git repository for the NICA experiments


<https://git.jinr.ru/>

[Your Projects](#) [Starred Projects](#) [Explore Projects](#)


---

 **NICA / bmnroot**  
Simulation and Analysis Framework for NICA/BM@N Detectors


---

 **NICA / mpdroot**  
Simulation and Analysis Framework for NICA/MPD Detectors


---

 **NICA / spdroot**  
Simulation and Analysis Framework for NICA/SPD Detectors

---

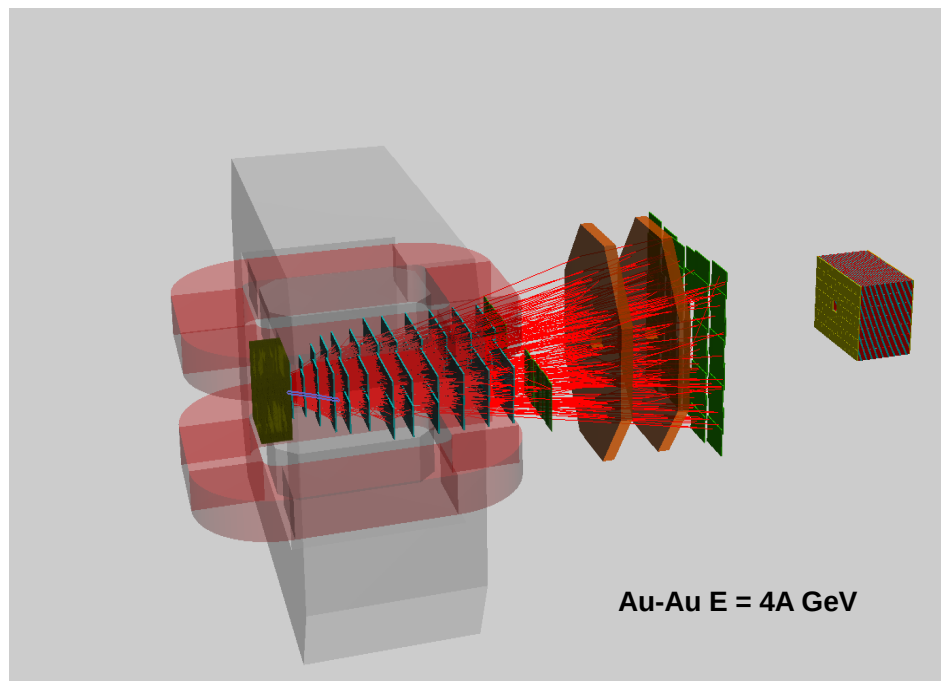
 **NICA / nicafermto**  
Framework from Daniel Wielanek

---

 **NICA / flowpack**

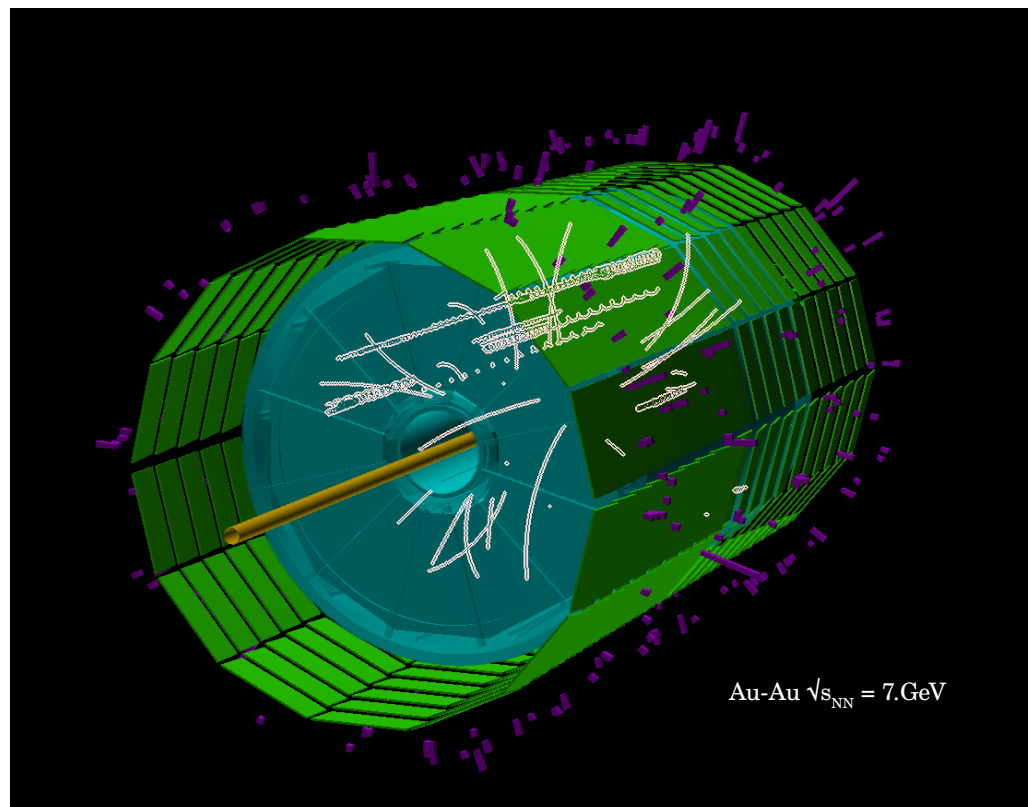
# Event Displays for the NICA experiments

based on EVE package



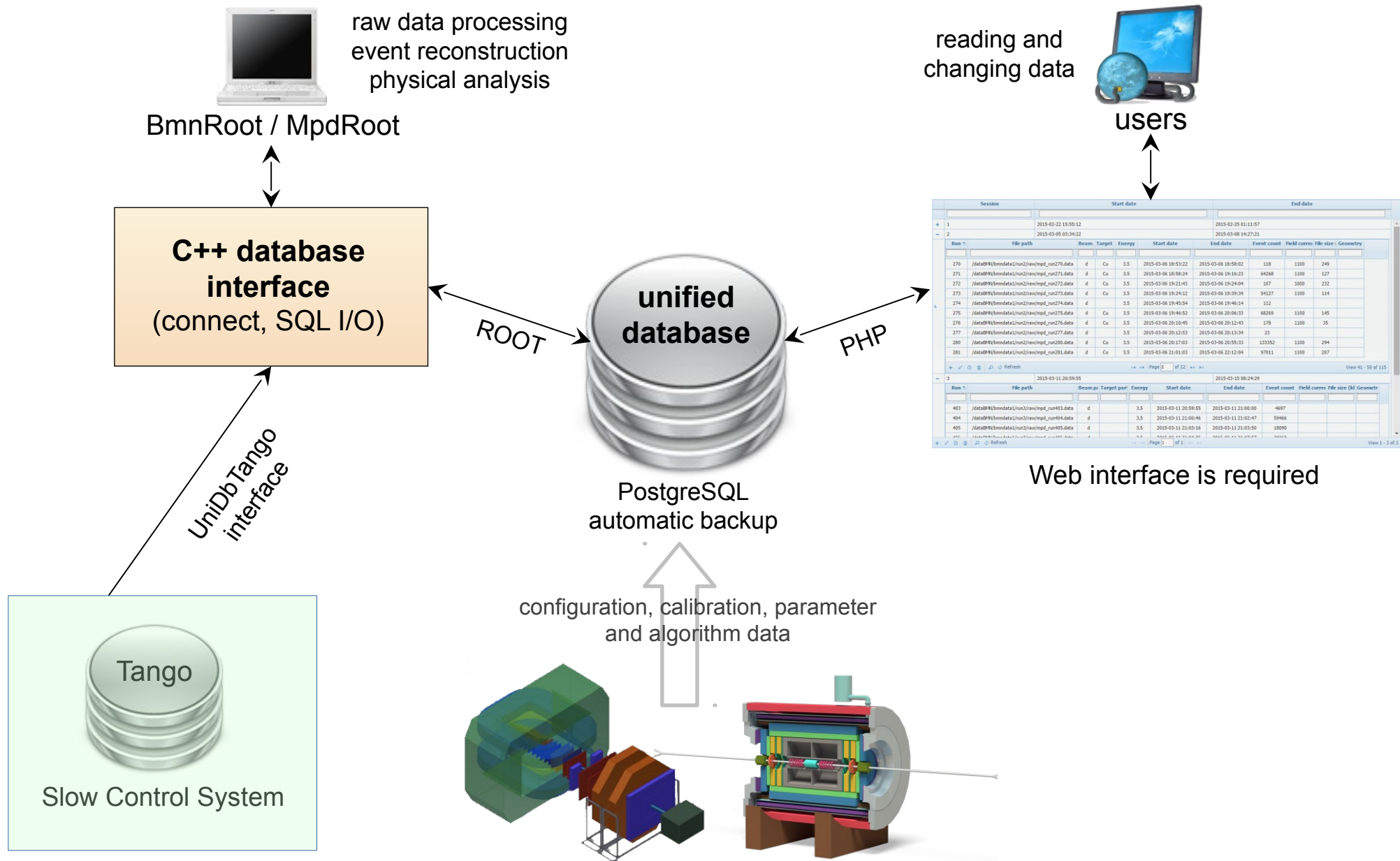
BM@N event data:  
GEM points and reconstructed tracks

MPD event data:  
TPC hits and EMC towers

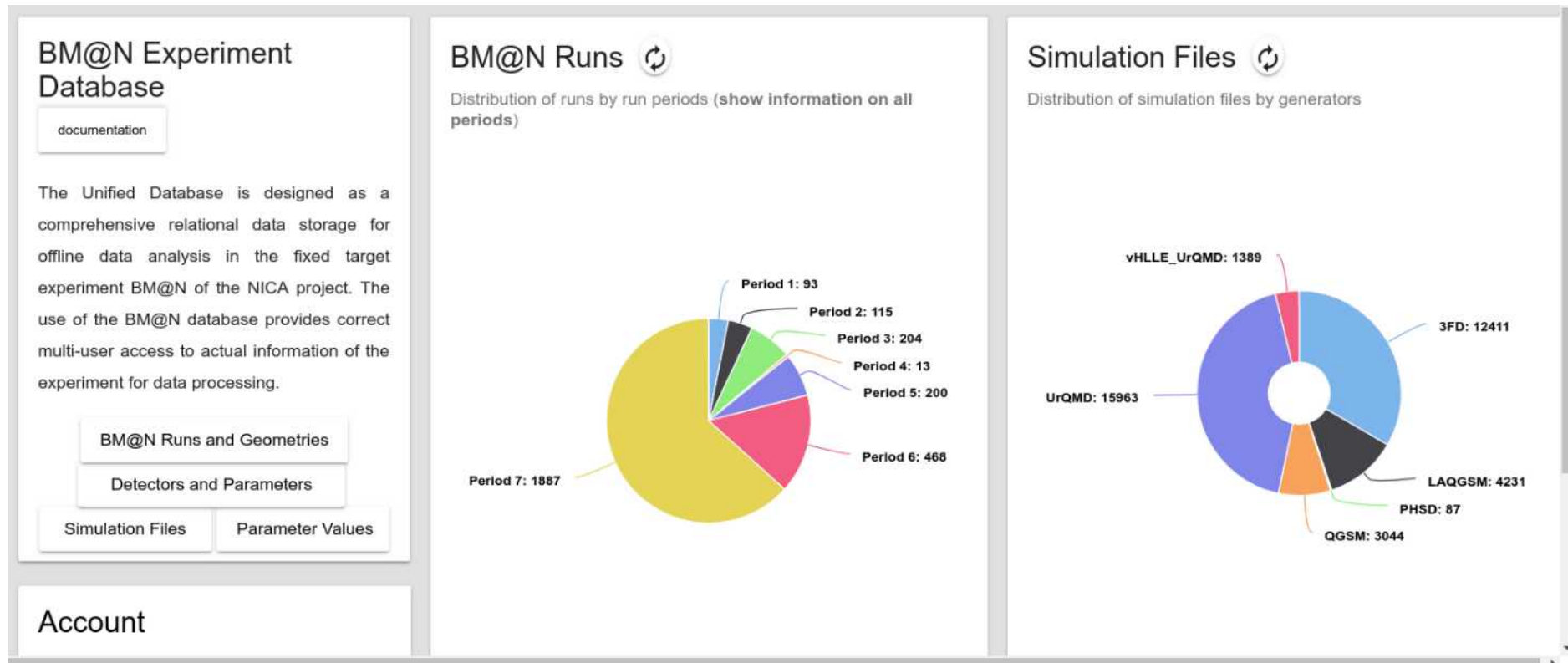




# The Unified Database for offline data processing



# Database for events from MC generators & experiments



- ✓ UrQMD
- ✓ QGSM
- ✓ PHSD


-----

- ✓ Hybrid UrQMD
- ✓ vHLL- UrQMD
- ✓ 3FD(Theseus)

## Exp. Data

- |   |                    |
|---|--------------------|
| • d + C, Al, Cu, Pb                                 | E = 4 GeV, 3.5 GeV |
| • C + C, C <sub>2</sub> H <sub>4</sub> , Al, Cu, Pb | E = 4 GeV          |
| • Ar + C, Cu, Sn, Pb                                | E = 3.2 GeV        |
| • Kr + Cu, Sn, Pb                                   | E = 2.94           |

# BM@N runs database



	Run №	Period №	Start run date	End run date	File path (NICA cluster)	Beam	Target	Energy, GeV	Events	Field	File size, Mb	Geometry id
	<input type="text"/>	All ▼	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
+	12	1	2015-02-22 15:55:12	2015-02-22 15:55:13	/dataBMN/bmndata1/run1/raw/mpd_run012.data	d		3.50	156	null	null	17
+	13	1	2015-02-22 16:01:04	2015-02-22 16:02:56	/dataBMN/bmndata1/run1/raw/mpd_run013.data	d		3.50	5,720	null	null	17
+	14	1	2015-02-22 16:06:33	2015-02-22 16:06:45	/dataBMN/bmndata1/run1/raw/mpd_run014.data	d		3.50	214	null	null	17
+	15	1	2015-02-22 16:10:13	2015-02-22 16:11:13	/dataBMN/bmndata1/run1/raw/mpd_run015.data	d		3.50	41	null	null	17
+	16	1	2015-02-22 16:12:14	2015-02-22 16:13:03	/dataBMN/bmndata1/run1/raw/mpd_run016.data	d		3.50	39	null	null	17
+	17	1	2015-02-22 16:13:09	2015-02-22 16:13:56	/dataBMN/bmndata1/run1/raw/mpd_run017.data	d		3.50	22	null	null	17
+	18	1	2015-02-22 15:11:04	2015-02-22 15:15:07	/dataBMN/bmndata1/run1/raw/mpd_run018.data	d		3.50	12,694	null	null	17
+	25	1	2015-02-22 19:42:23	2015-02-22 20:01:54	/dataBMN/bmndata1/run1/raw/mpd_run025.data	d		3.50	24,469	null	null	17
+	27	1	2015-02-22 21:24:03	2015-02-22 21:25:00	/dataBMN/bmndata1/run1/raw/mpd_run027.data	d		3.50	165	null	null	17
+	32	1	2015-02-22 21:36:09	2015-02-22 21:36:22	/dataBMN/bmndata1/run1/raw/mpd_run032.data	d		3.50	16	null	null	17
+	33	1	2015-02-22 21:36:31	2015-02-22 21:41:41	/dataBMN/bmndata1/run1/raw/mpd_run033.data	d		3.50	115	null	null	17
+	34	1	2015-02-22 21:41:50	2015-02-22 21:53:56	/dataBMN/bmndata1/run1/raw/mpd_run034.data	d		3.50	133	null	null	17
+	35	1	2015-02-22 02:00:00	2015-02-22 00:00:00	/dataBMN/bmndata1/run1/raw/mpd_run035.data	d		3.50	3,454	0	5.00	17
+	36	1	2015-02-22 21:56:00	2015-02-22 22:02:36	/dataBMN/bmndata1/run1/raw/mpd_run036.data	d		3.50	5,724	null	null	17
+	40	1	2015-02-22 22:03:39	2015-02-22 22:21:29	/dataBMN/bmndata1/run1/raw/mpd_run040.data	d		3.50	46,932	null	null	17
+	42	1	2015-02-22 22:23:36	2015-02-22 22:27:32	/dataBMN/bmndata1/run1/raw/mpd_run042.data	d		3.50	9,955	null	null	17
+	44	1	2015-02-22 22:28:56	2015-02-22 22:32:59	/dataBMN/bmndata1/run1/raw/mpd_run044.data	d		3.50	10,675	null	null	17

Refresh
Page 1 of 26
View 1 - 17 of 427

[EDIT MODE](#)

# E-log database

BM@N common e-log, Page 1 of 106

HomeFindLast day

Number of items per page: 10

Logout

1234567891011...106>>

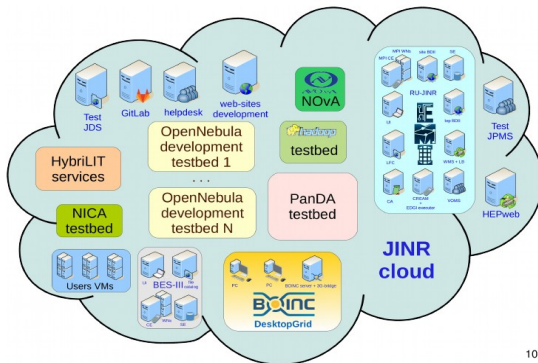
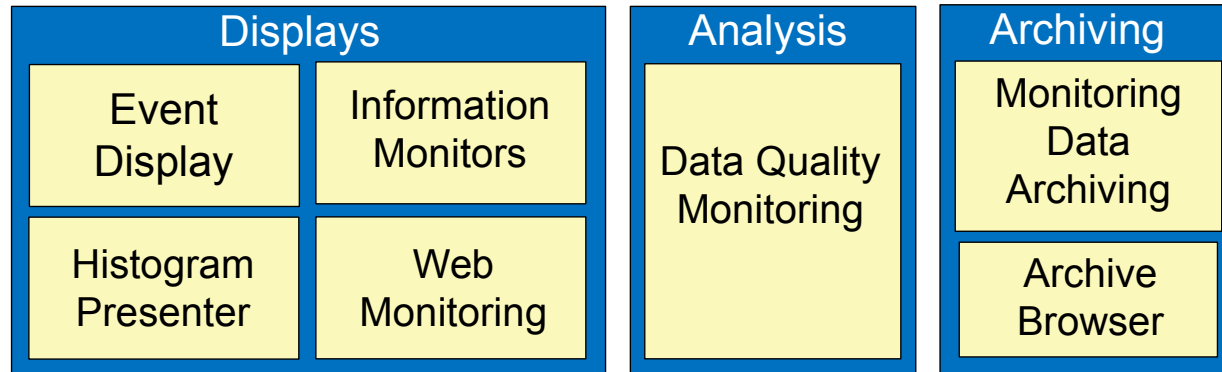
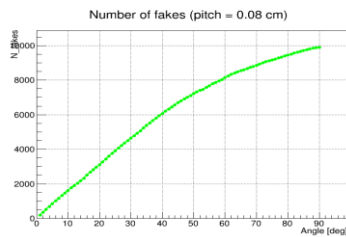
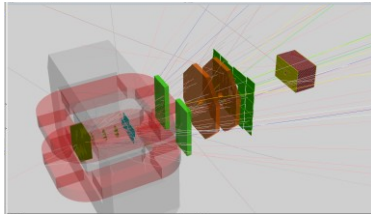
Date	Shift Leader	Type	Nr Run	Trigger	DAQ Status	SP-41, A	SP-57, A	VKM2, A	Beam	Energy, GeV	Target	Comment
2018-03-07 08:14:09	Dryablov	New Run	2487 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 2x10^5 beam duration 2-3 sec, Live time:~100%, #N:50kEvents, decrease the TQDC threshold for new BC4 to 10.
2018-03-07 07:49:29	Dryablov	New Run	2485 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 2x10^5 beam duration 2-3 sec, Live time:~100%, #N:50kEvents, decrease the TQDC threshold for new BC4 to 10.
2018-03-07 07:31:40	Dryablov	New Run	2484 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 2x10^5 beam duration 2-3 sec, Live time:~100%, #N:50kEvents, decrease the TQDC threshold for new BC4 to 10.
2018-03-07 07:05:41	Dryablov	New Run	2483 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 3x10^5 beam duration 3-4 sec, Live time:~100%, #N:50kEvents, decrease the TQDC threshold for new BC4 to 10.
2018-03-07 04:46:18	Dryablov	New Run	2481 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 2x10^5 beam duration 3-4 sec, Live time:~100%, #N:50kEvents, decrease the TQDC threshold for new BC4 to 10.
2018-03-07 04:20:02	Dryablov	New Run	2480 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 2x10^5 beam duration 3-4 sec, Live time:~100%, #N:50kEvents, decrease the TQDC threshold for new BC4 to 10.
2018-03-07 03:52:47	Dryablov	New Run	2479 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 2x10^5 beam duration 3-4 sec, Live time:~100%, #N:50kEvents, decrease the TQDC threshold for new BC4 to 10.
2018-03-07 03:23:23	Dryablov	New Run	2478 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 2x10^5 beam duration 3 sec, Live time:~100%, #N:50kEvents, decrease the TQDC threshold for new BC4 to 10. Ratio of BC2/BC1~0.4 & VC/BC1~0.44, no contact with Rukoyatkin Pavel started at run #2474
2018-03-07 02:56:01	Dryablov	New Run	2477 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 1.5x10^5 beam duration 3 sec, Live time:~100%, #N:51kEvents, decrease the TQDC threshold for new BC4 to 10.
2018-03-07 02:24:48	Dryablov	New Run	2475 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 1x10^5 beam duration 3 sec, Live time:~100%, #N:18kEvents, decrease the TQDC threshold for new BC4 to 10.

1234567891011...106>>

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

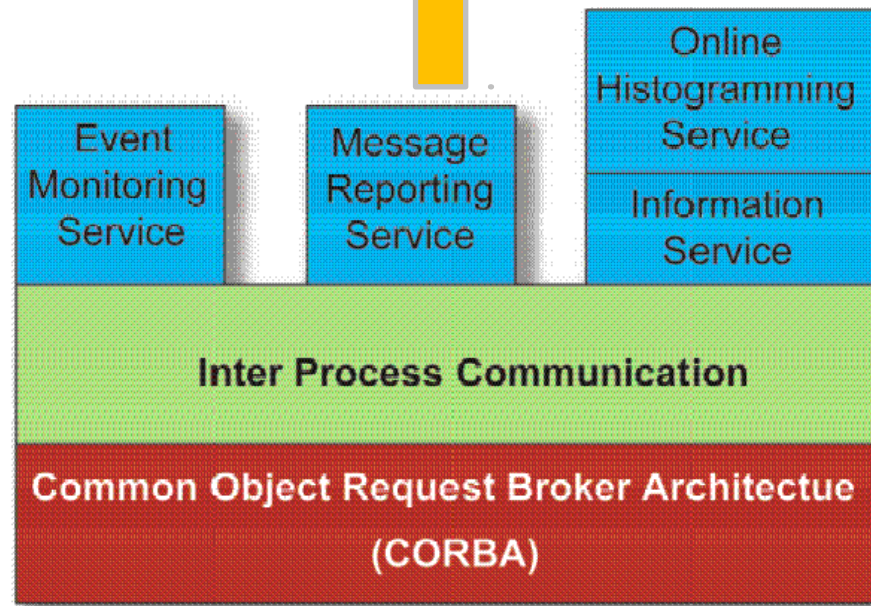


# MPD Run Control System



first prototype is developed on LIT Virtual Machines

10 / 16



**ATLAS TDAQ Online Components**

**Raw Event Builder**

# MpdRoot & BmnRoot distributed computing

NICA Cluster prototype



**460 log. cores**  
180 TB distributed file system  
(*replicated*): **GlusterFS**  
batch system: **Sun Grid Engine**

LIT Tier1 (lxmlpd-ui)



**200 log. cores**  
distributed file system: **dCache**  
batch system: **Torque**


LIT HybriLIT (+SC "Govoron")

Computation component **HybriLIT**

**TOTAL RESOURCES**

- 252 CPU cores;
- 77184 CUDA cores;
- 182 MIC cores;
- ~2,5 Tb RAM;
- ~57 Tb HDD.

**HARDWARE**



SuperBlade Chassis including 10 calculation blades for run user tasks.

**252 log. cores** → 8 000  
300 TB distributed FS: **EOS**  
batch system: **SLURM**

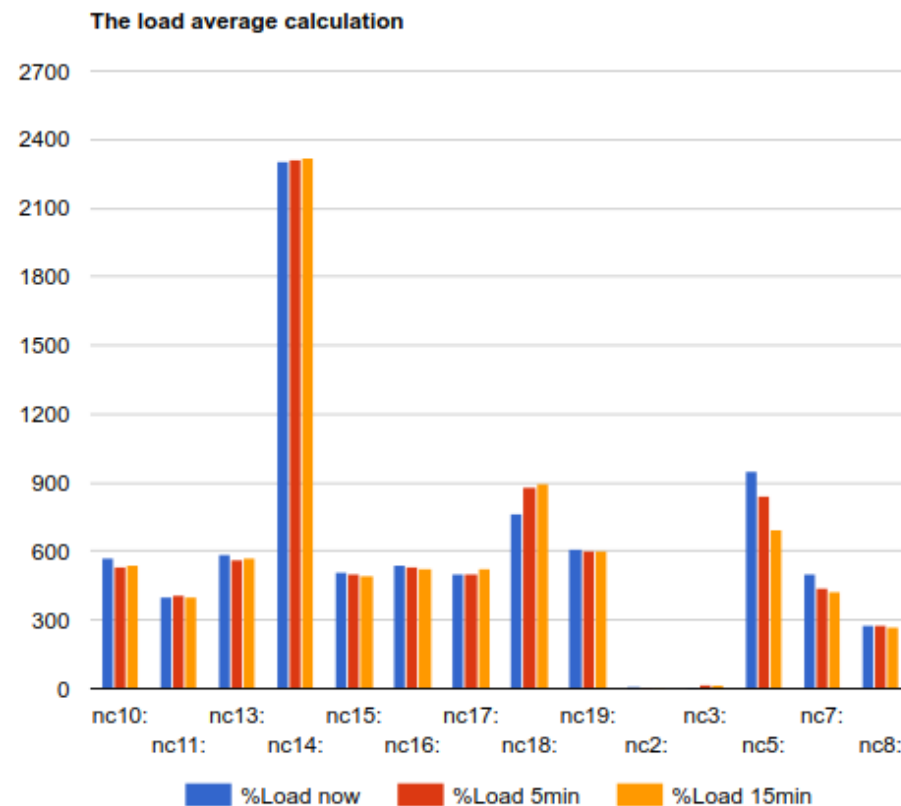
All external packages for MpdRoot & BmnRoot are installed & configured. MpdRoot & BmnRoot is taken from GIT repository. ~ 60 users

# Computing resources: LHEP

## Protected: Cluster monitoring

### ONLINE cluster nodes

Node	%Load now	%Load 5min	%Load 15min	Users	Uptime(days)	Time
nc10:	585	535	540	7	9	14:30:51
nc11:	407	407	405	0	44	14:30:45
nc13:	600	570	572	0	34	14:33:02
nc14:	2302	2312	2321	0	44	14:30:45
nc15:	500	500	495	0	15	14:29:45
nc16:	552	531	525	1	15	14:30:04
nc17:	506	502	523	0	41	14:30:45
nc18:	774	891	901	1	27	14:30:03
nc19:	607	606	600	1	42	14:30:45
nc2:	1	2	5	4	9	14:29:53
nc3:	5	19	17	9	27	14:28:23
nc5:	956	838	696	2	35	14:26:38
nc7:	424	422	417	1	51	14:25:54
nc8:	285	277	271	11	15	14:30:19





# Tier 0 for the NICA experiments





# Thank for your attention

