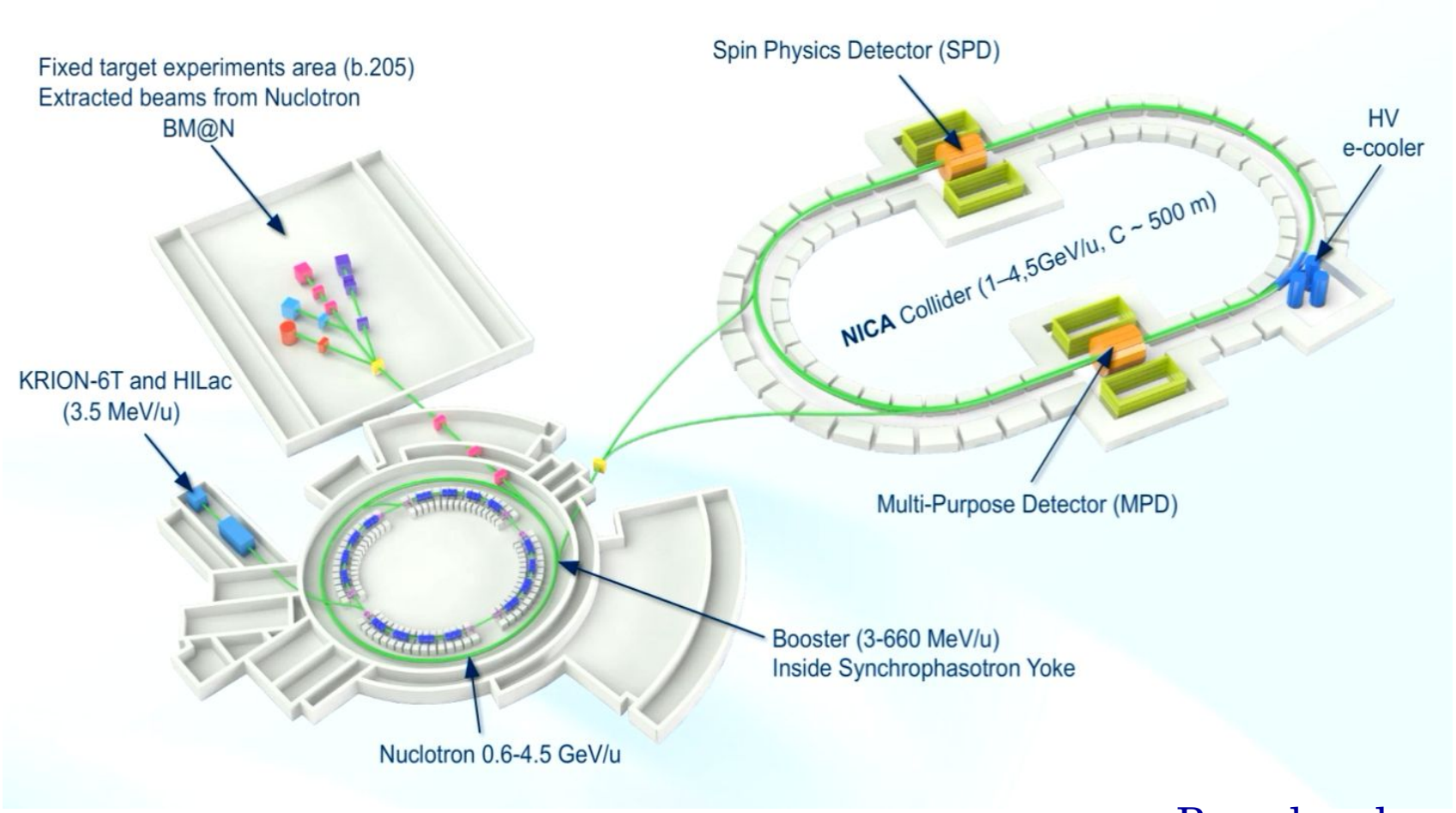
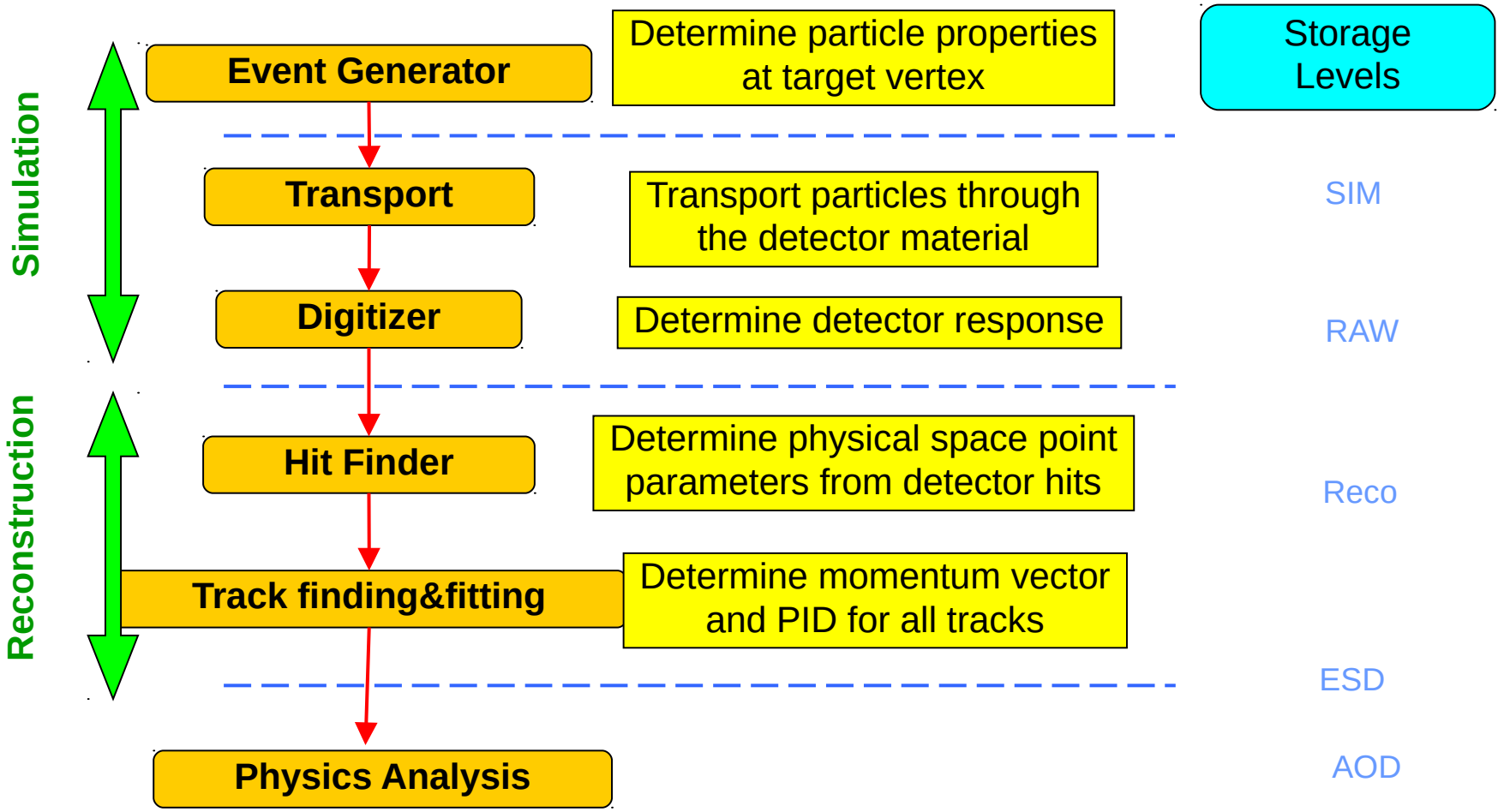
Software development for the NICA experiments



Workshop on spin physics at NICA
July 11 2018
Prague

Rogachevsky
Oleg

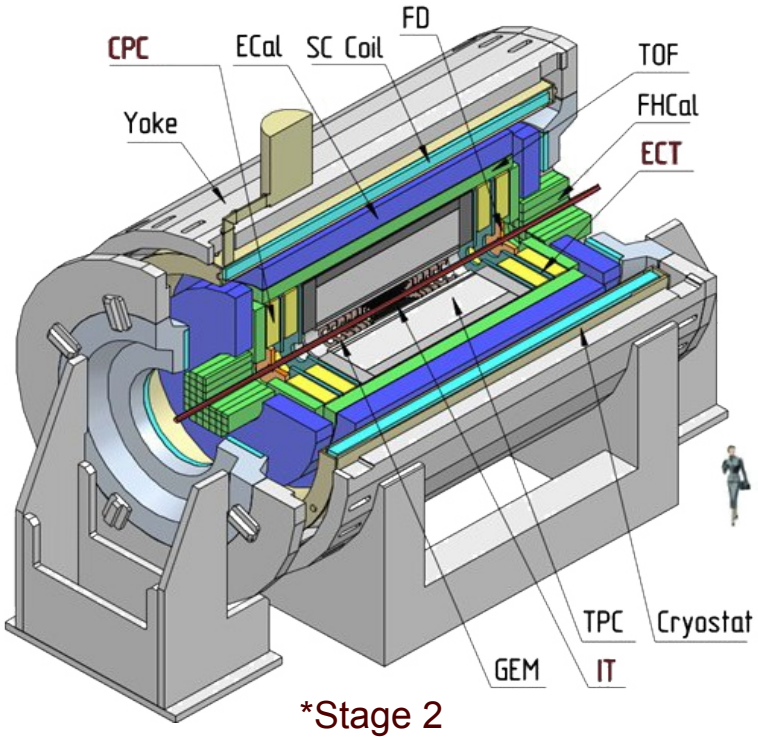
HEP experiments data flow



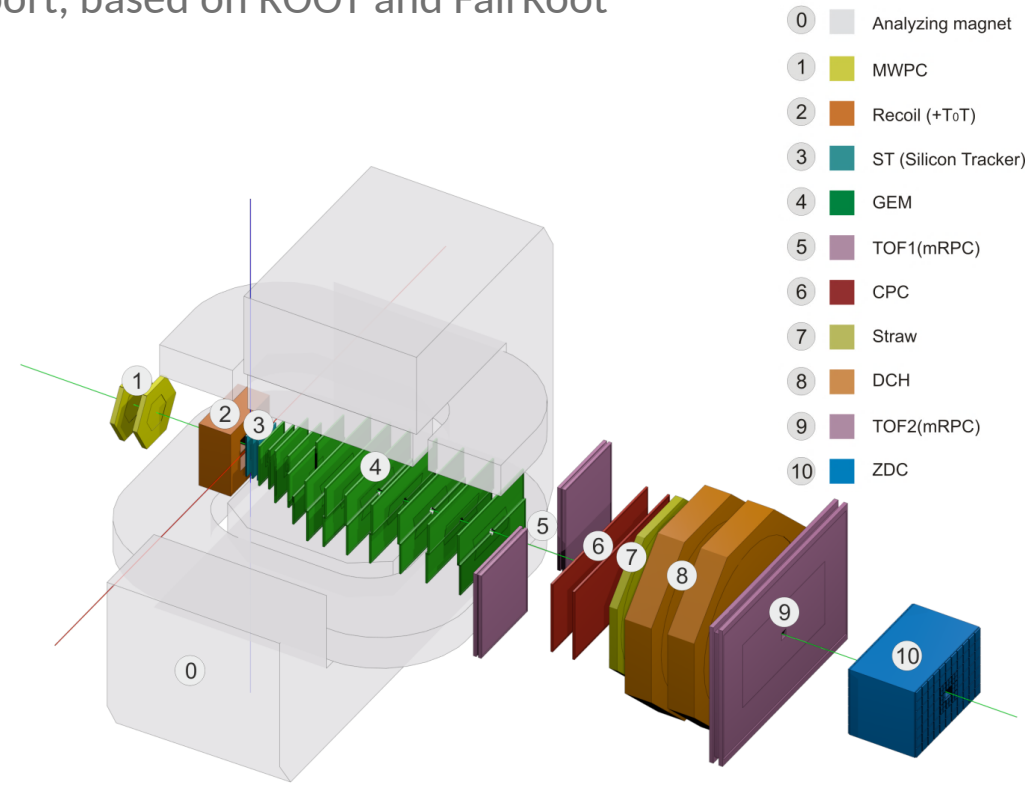
NICA HIC experiment frameworks

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



*Stage 2



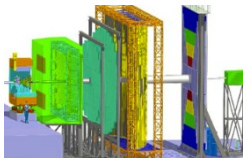
The MpdRoot and BmnRoot software are available in the GitLab https://git.jinr.ru/nica

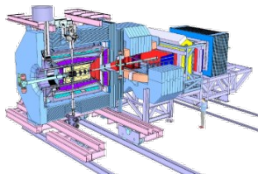
FairRoot family

Start testing the VMC concept for CBM

2004

First Release of CbmRoot



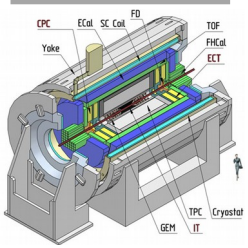


Panda decided to join → oct.

FairRoot: base package for experiments

2006

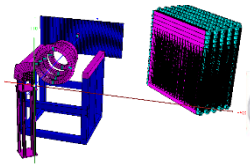
MPD@NICA started with FairRoot

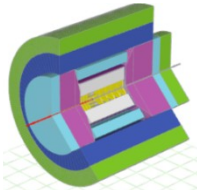


R3B joined

2010

ASYEOS joined

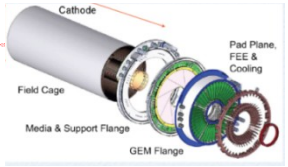


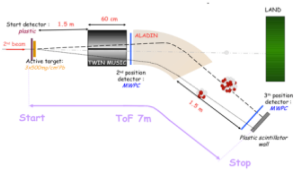


EIC (Electron Ion Collider BNL)

2011

GEM-TPC separated from PANDA branch





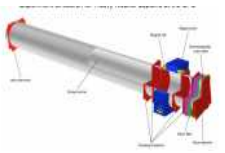
SOFIA (Studies On Fission with Aladin)

2012

ENSAR-ROOT

Collection of modules used by structural nuclear physics exp.

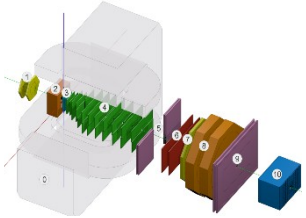
2013

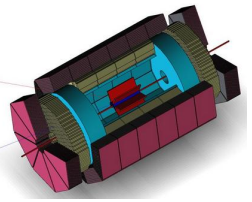


SHIP (Search for Hidden Particles)

2014

BM@N@NICA started with FairRoot



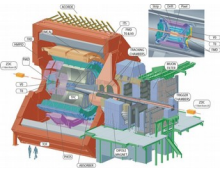


SPD@NICA joined

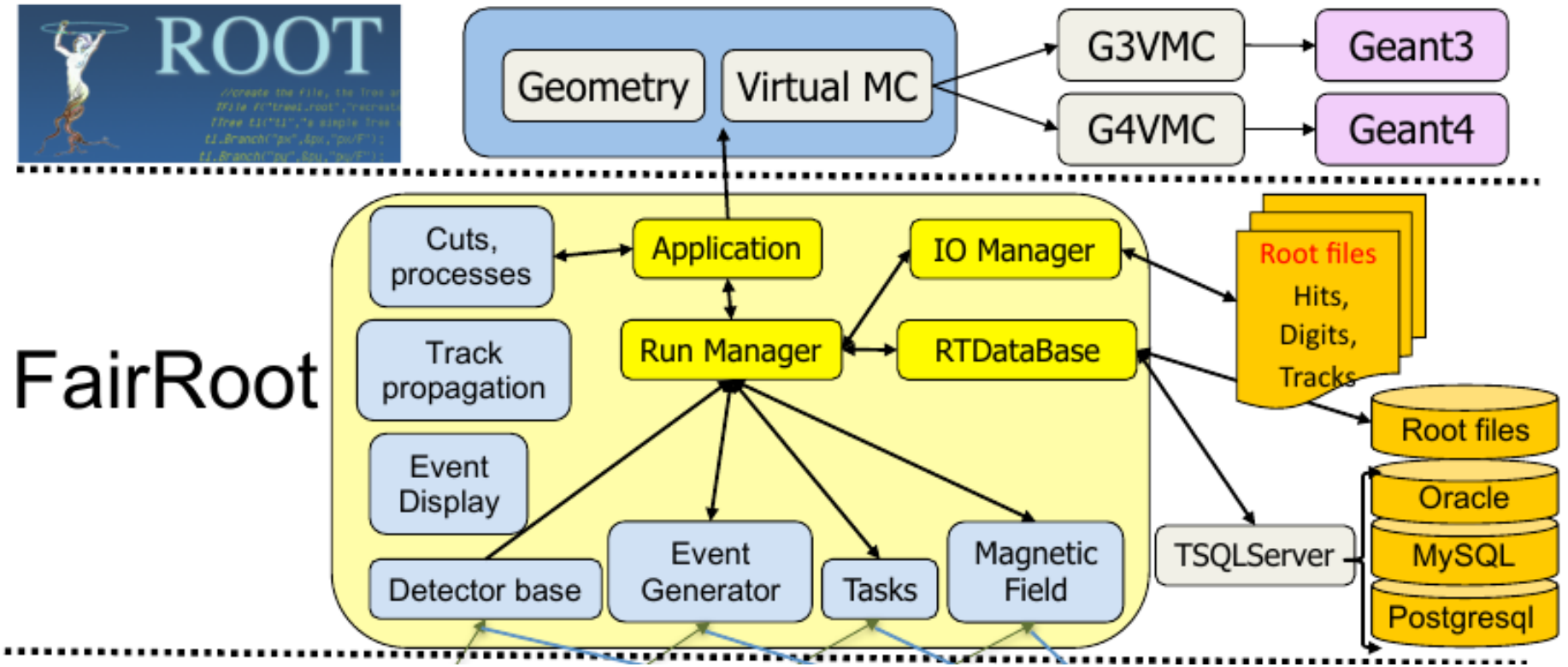
2015

ALICE

FAIR



FairRoot structure

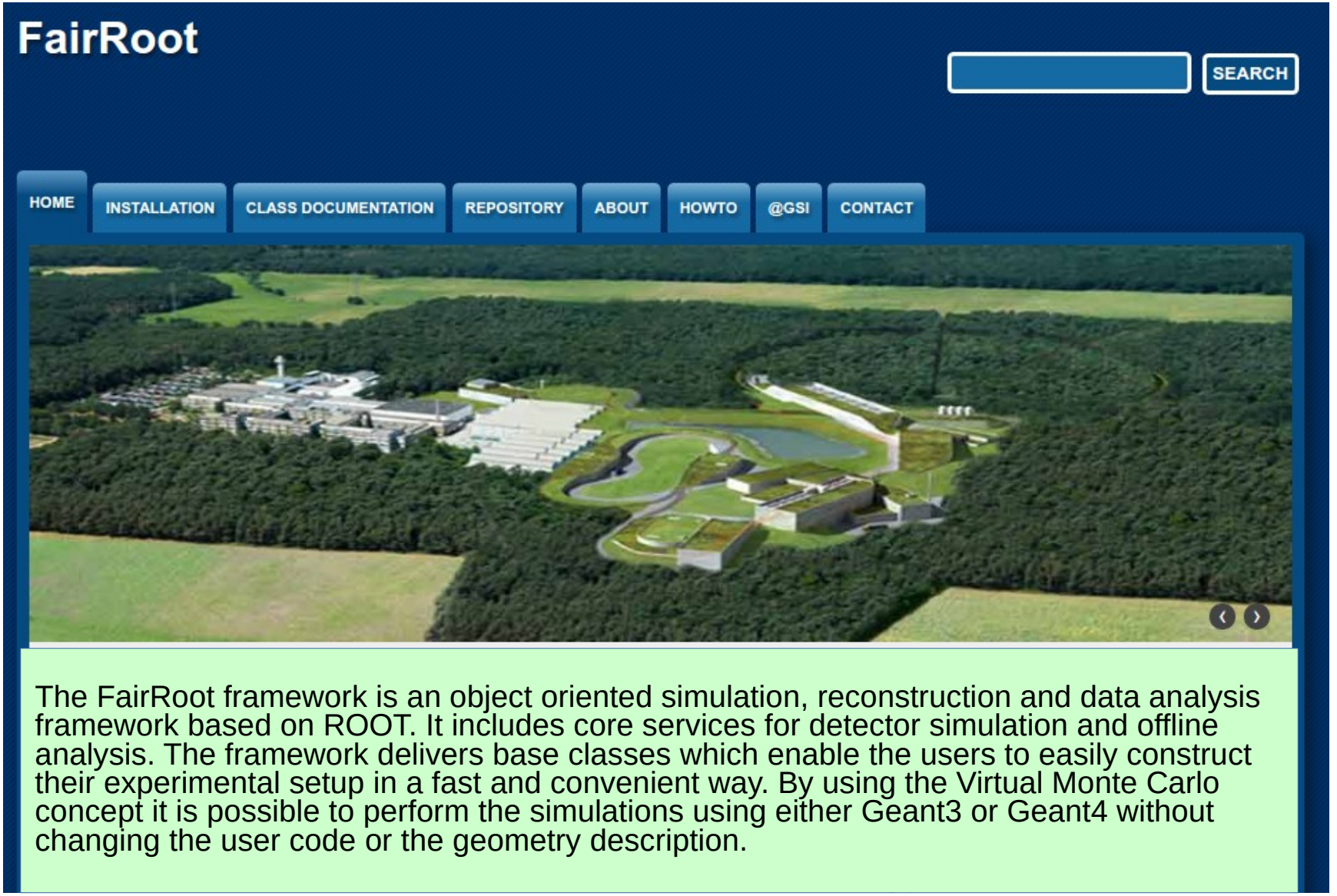


The basic idea of FairRoot is to provide a unified package with generic mechanisms to deal with most commonly used tasks in HEP. FairRoot allow the physicist to:

- ✔ 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/



MpdRoot & BmnRoot & … design

- Use FairSoft external packages

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

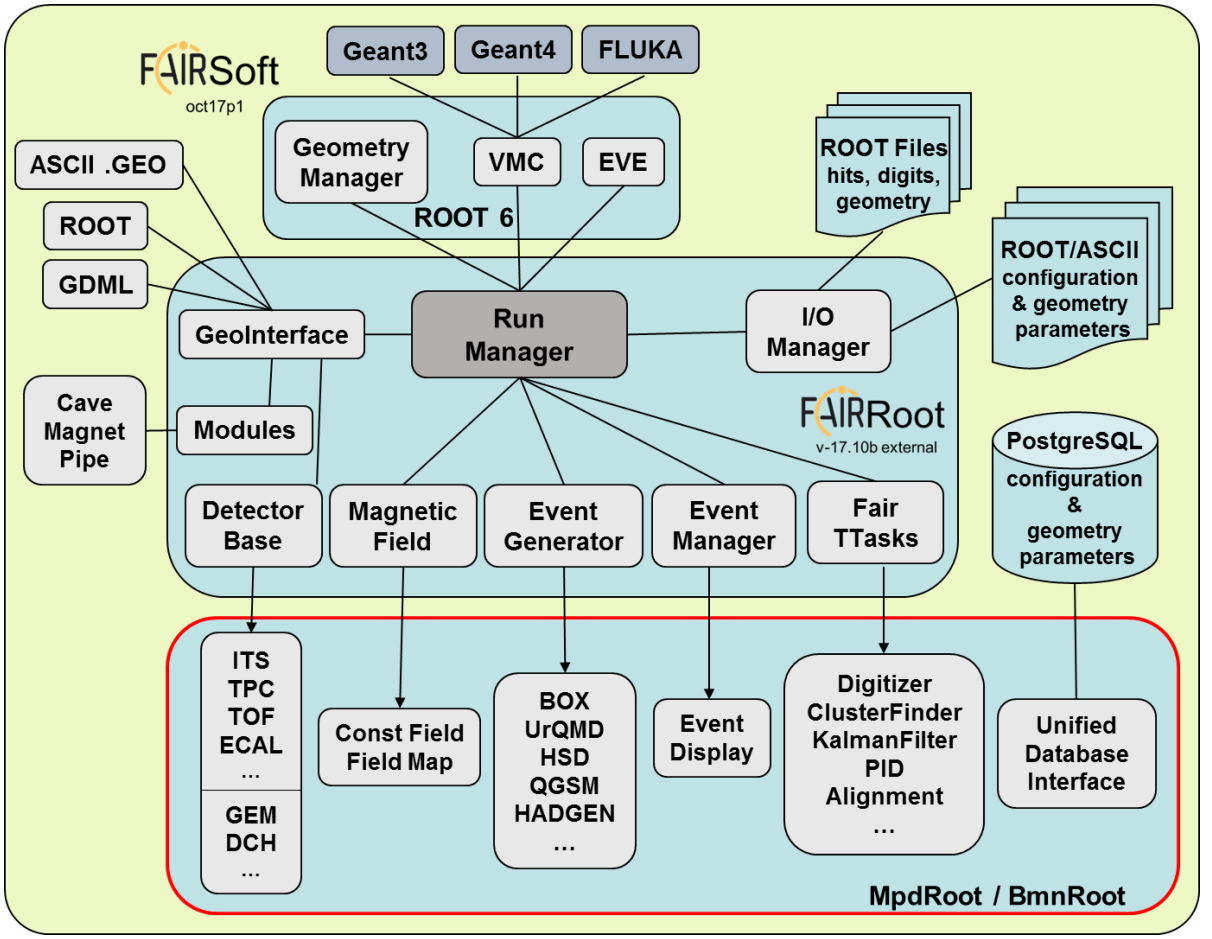
- Use FairRoot as a set of base classes and modules of needed by particle experiments
- Extended set of event generators for collisions:

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

simple (for testing) - BOX, ION, PART

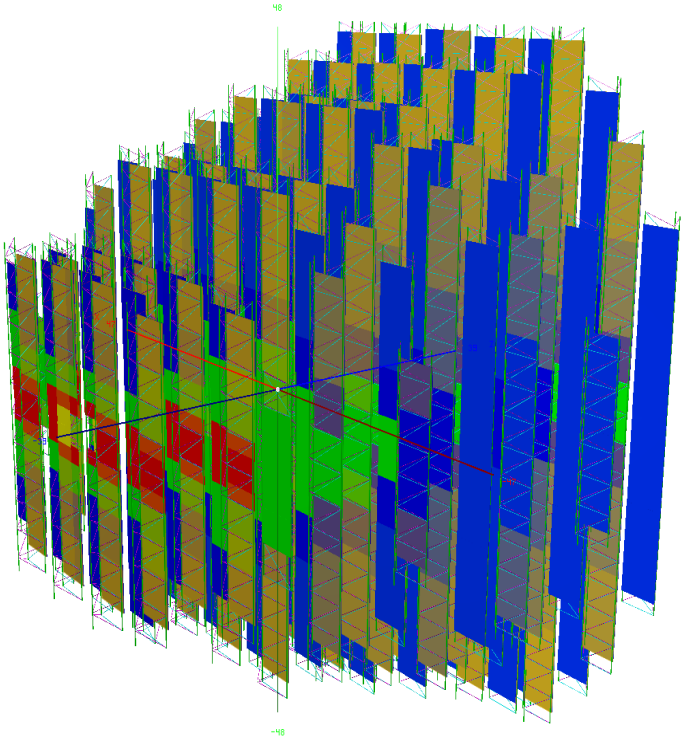
- Experiment-specific parts and geometry are developed for each detector independently
- Particle propagation by GEANT3/4
- Advanced detector response functions, realistic tracking and PID were included

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



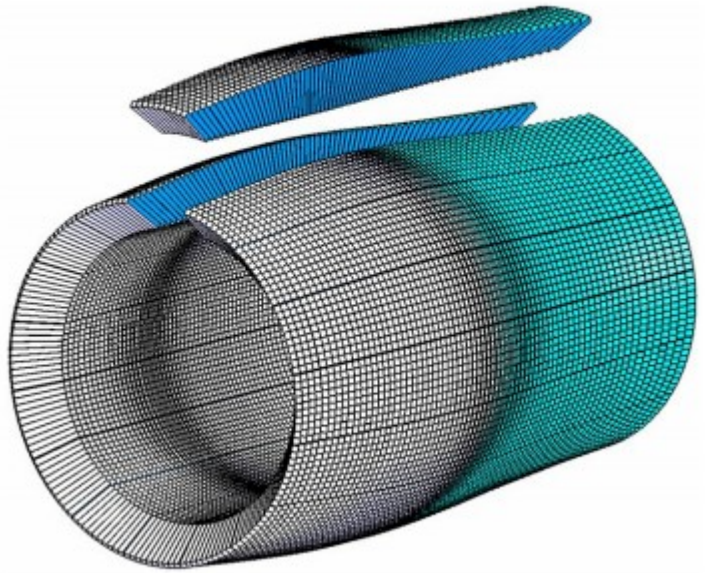
Detectors simulation

CBM → BM@N → MPD → SPD



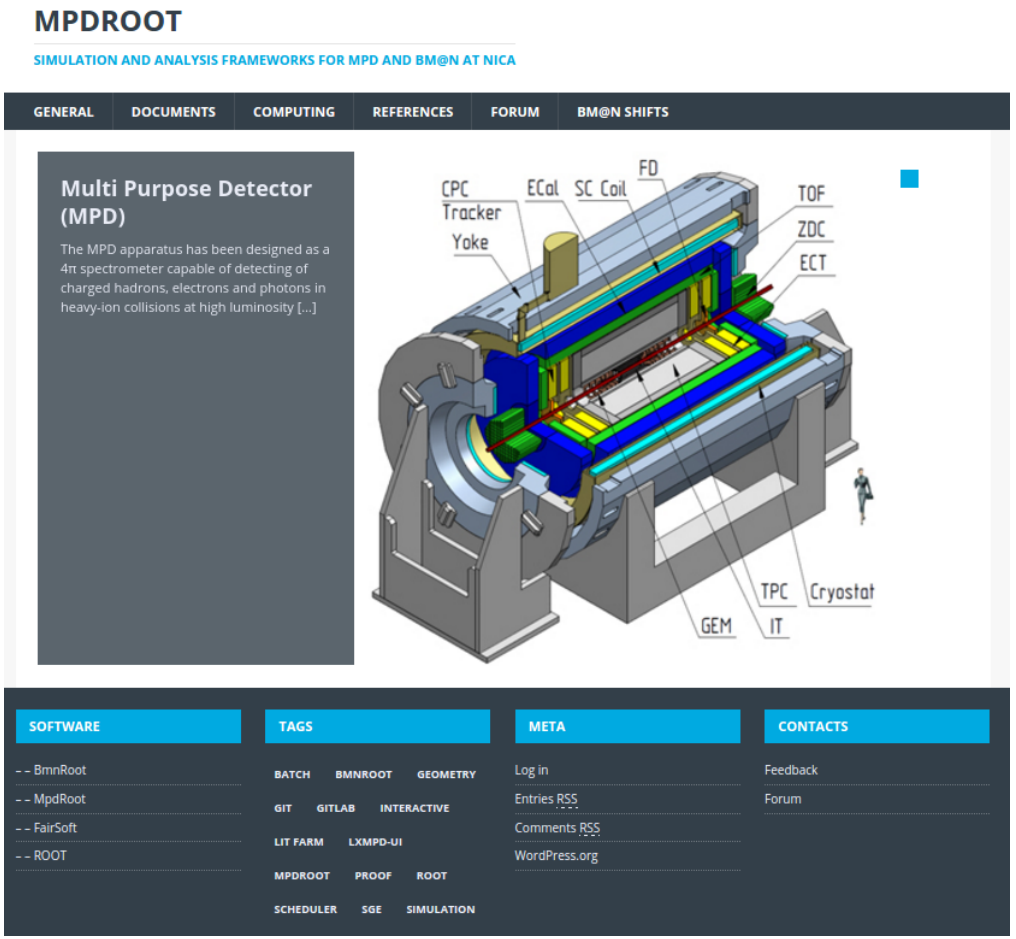
SSD

Panda (MPD) → SPD



ECAL

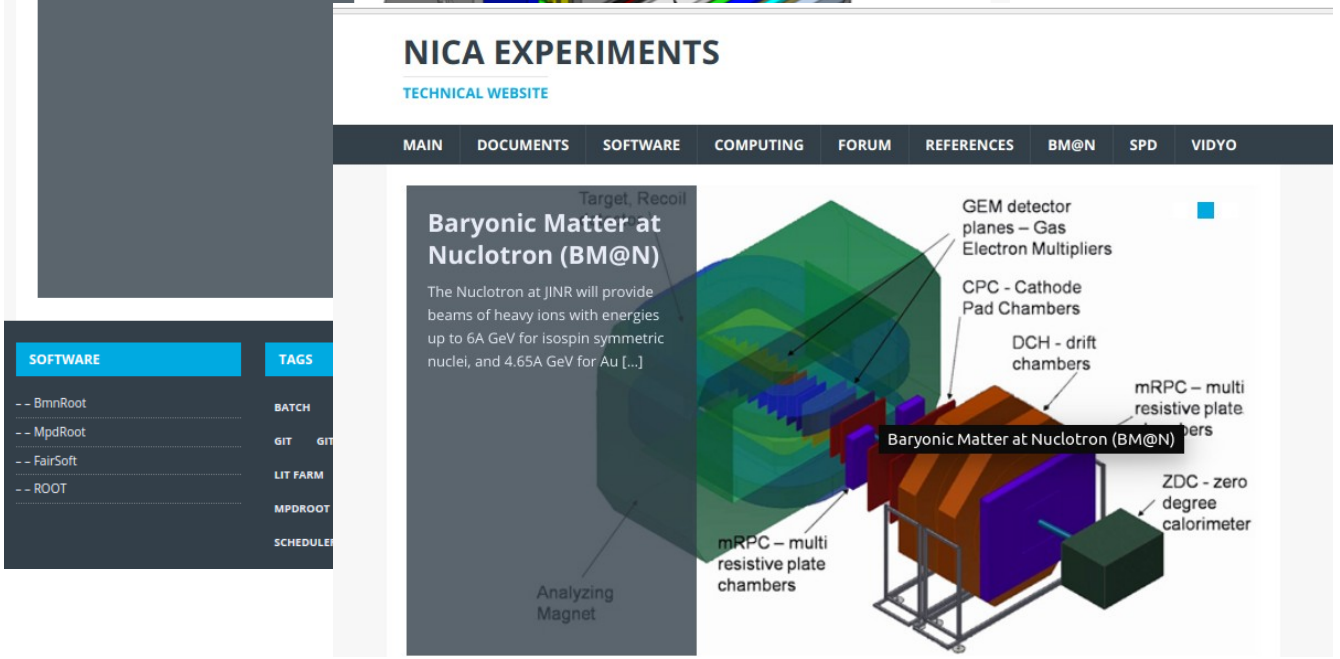
MpdRoot



Relativistic nuclear physics collider experiment

MpdRoot+BMNRoot

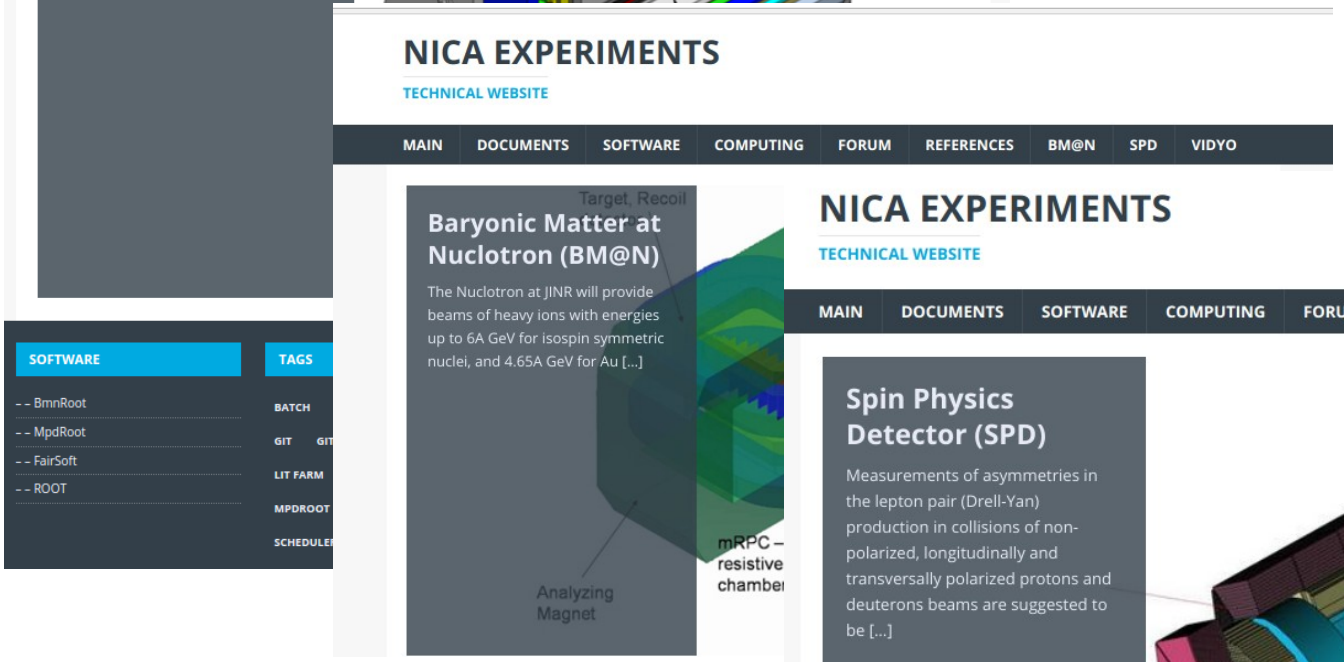
Relativistic nuclear physics collider exp.



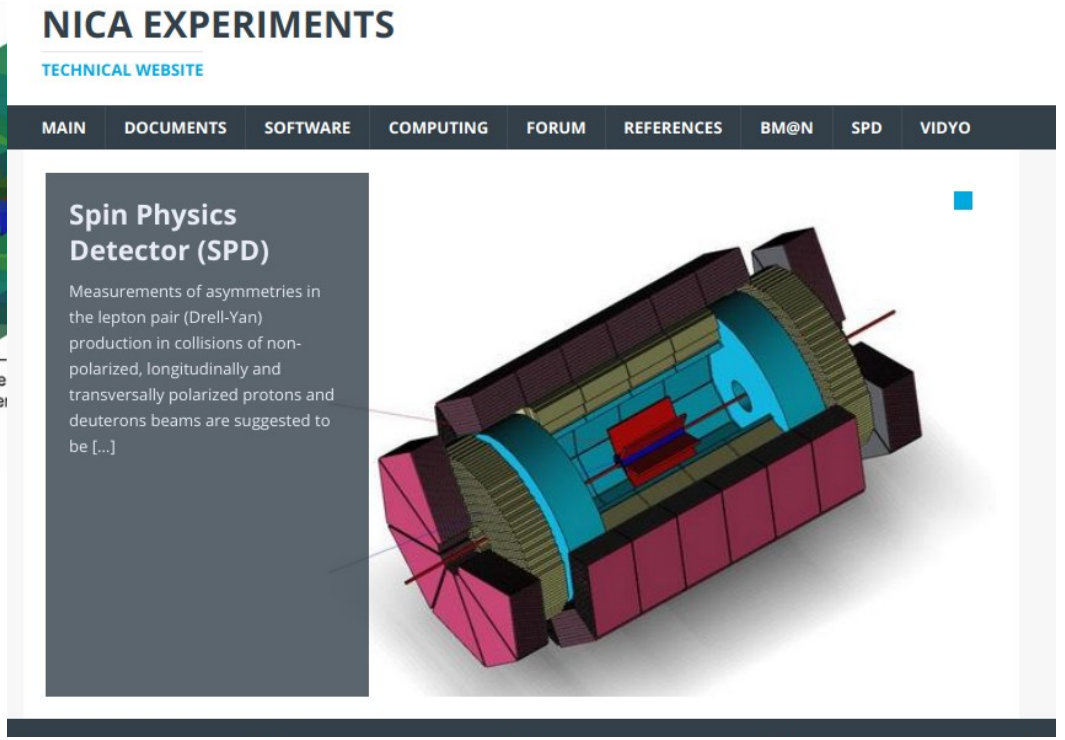
Relativistic nuclear physics fixed target exp.

MpdRoot+BMNRoot +SPDRoot

Relativistic nuclear physics collider

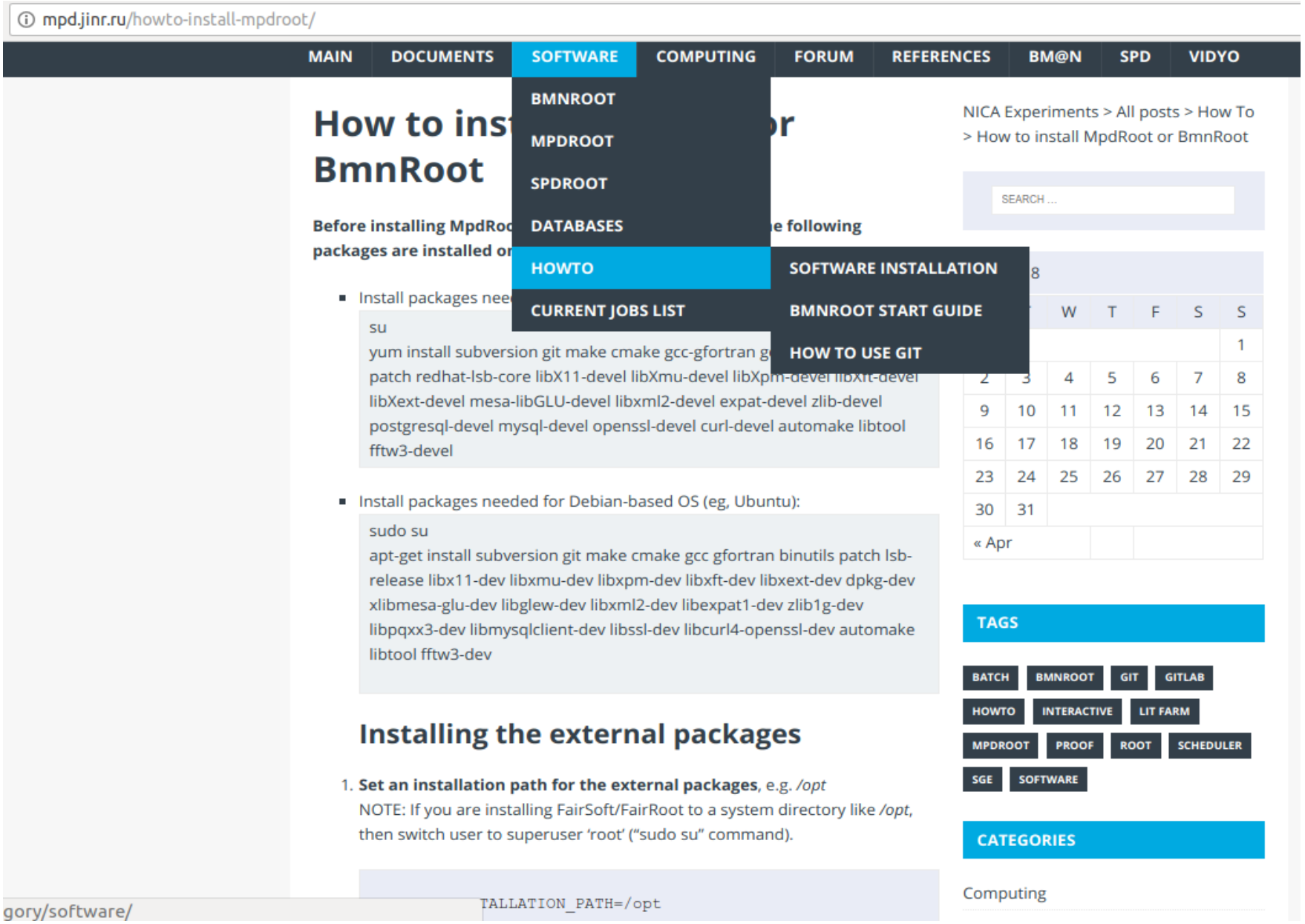


Relativistic nuclear physics fixed target



Spin physics collider exp.

Documentation



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

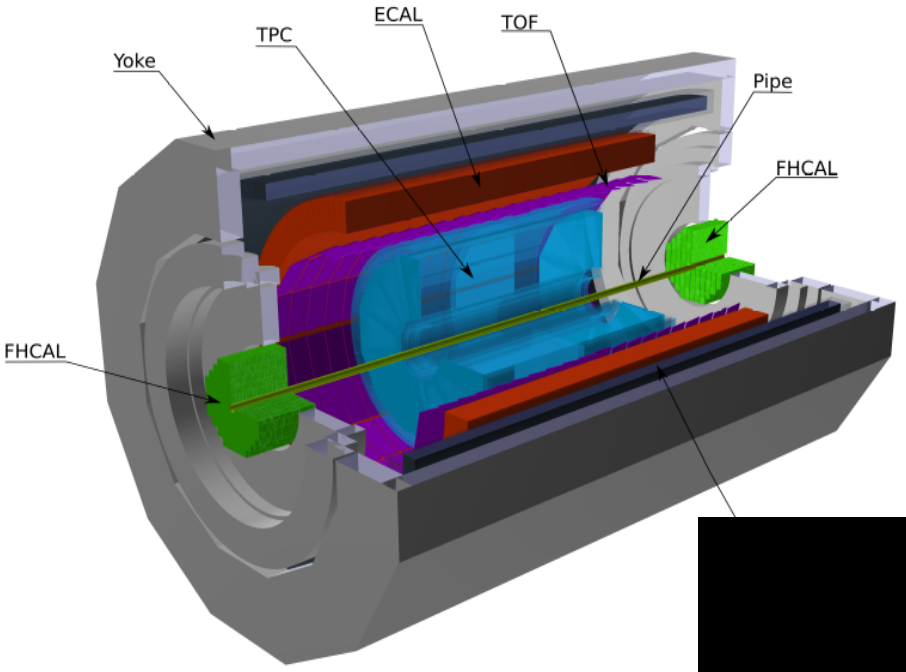
Geant321+_vmc	v2-5
VGM	v4-4
G4VMC	v3-6
MillePede	V04-03-04
ZeroMQ	4.2.5
Protocoll Buffers	3.4.0
nanomsg	1.0.0
FlatBuffers	1.9.0
MessagePack	2.1.5
DDS	2.0
FairMQ	1.2.3
FairLogger	1.2.0

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

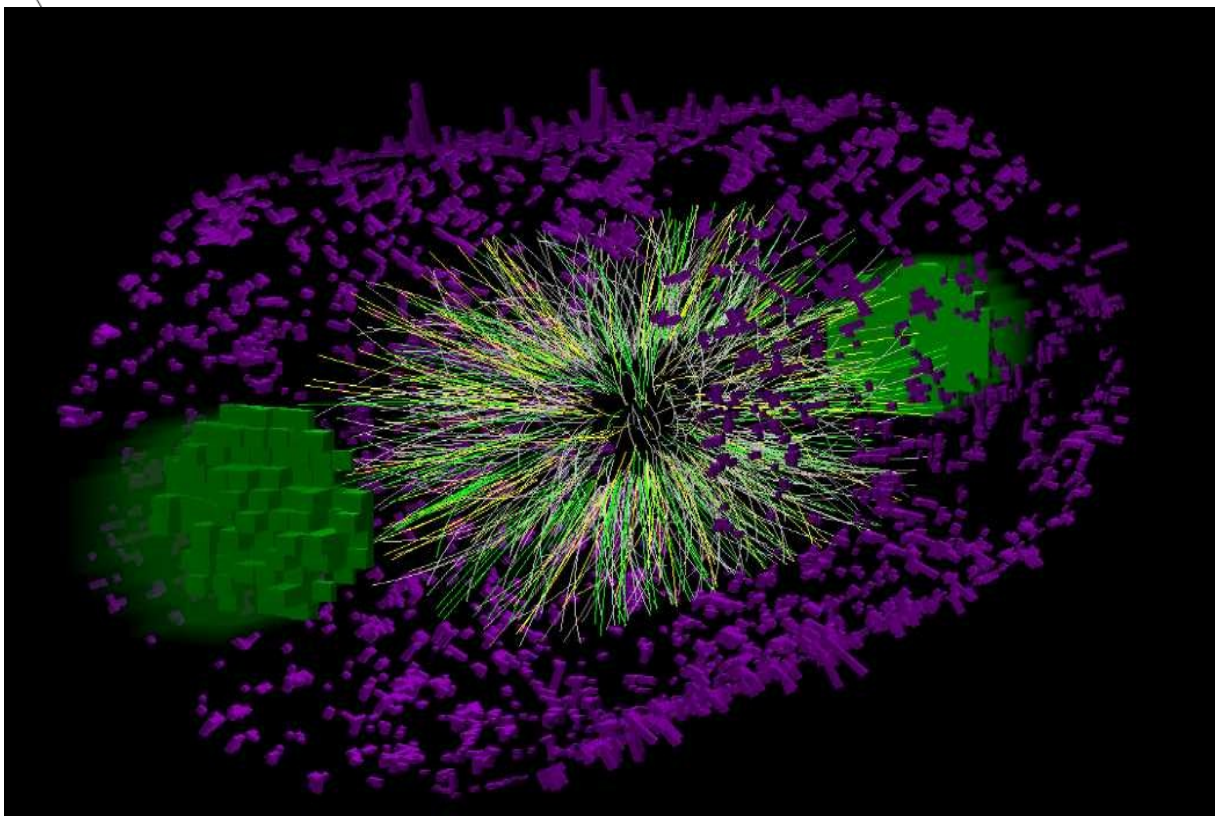
XercesC 3.1.2

G4Py Version which comes with Geant4

MPD



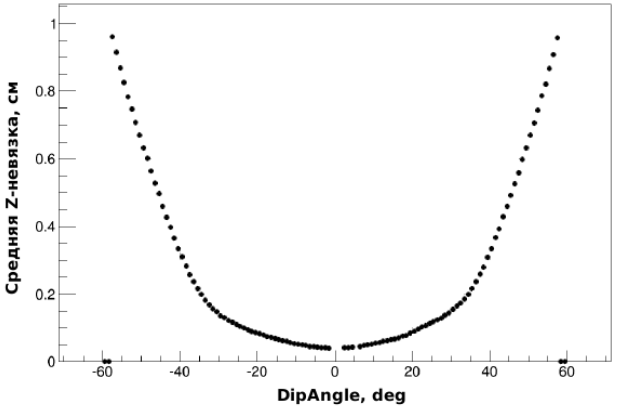
AuAu √s = 11 GeV

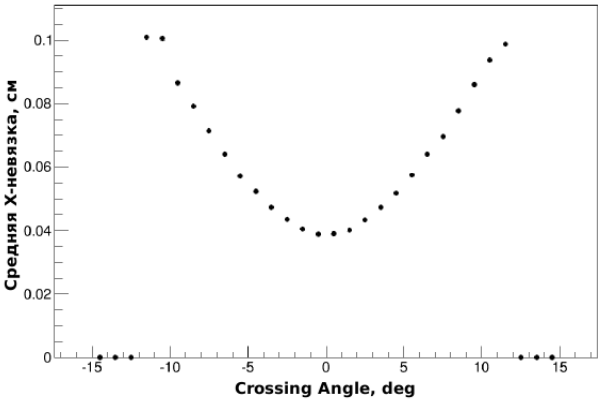


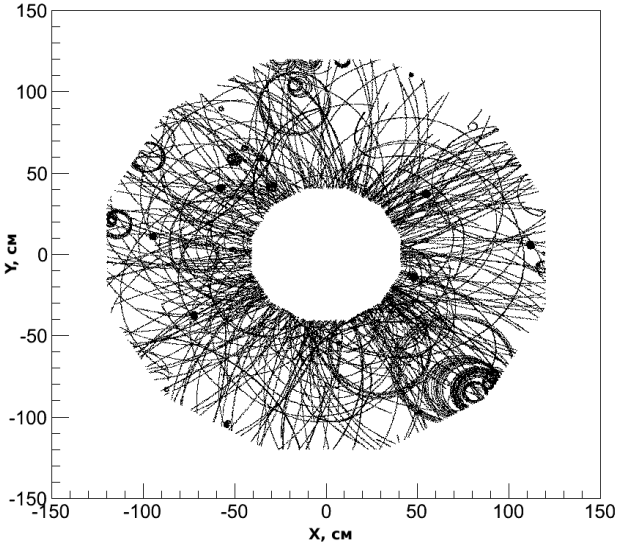
Clustering in MPD TPC

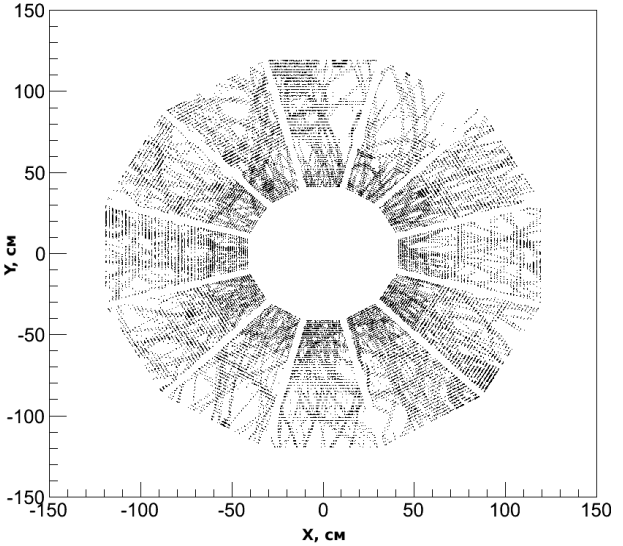
The hit reconstruction algorithm contains the following main steps:

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.



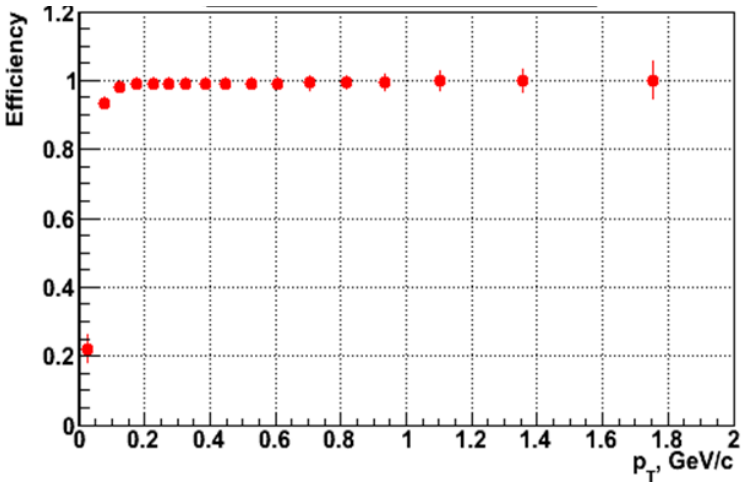




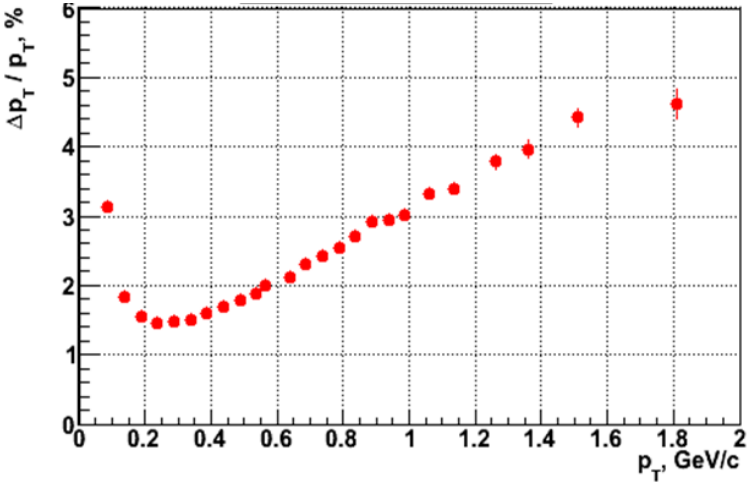


Tracking in MPD TPC

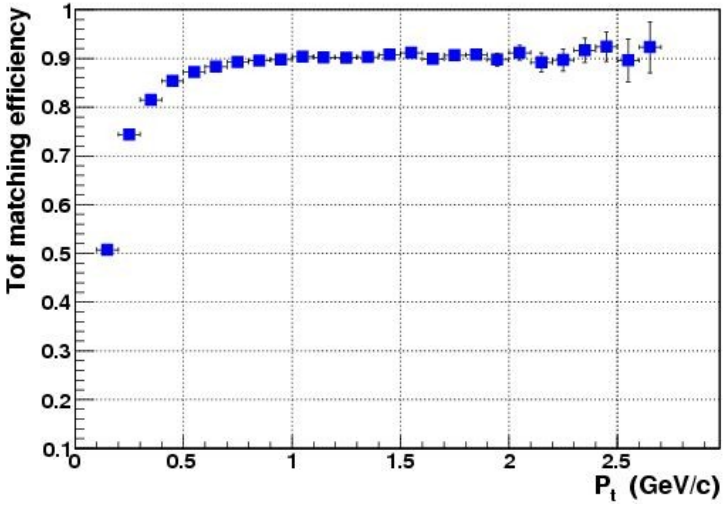
TPC tracking efficiency



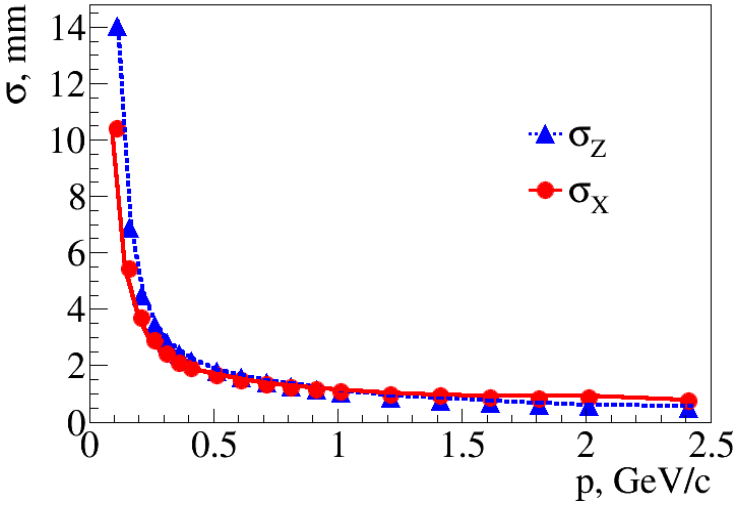
Momentum resolution



Efficiency of TOF matching

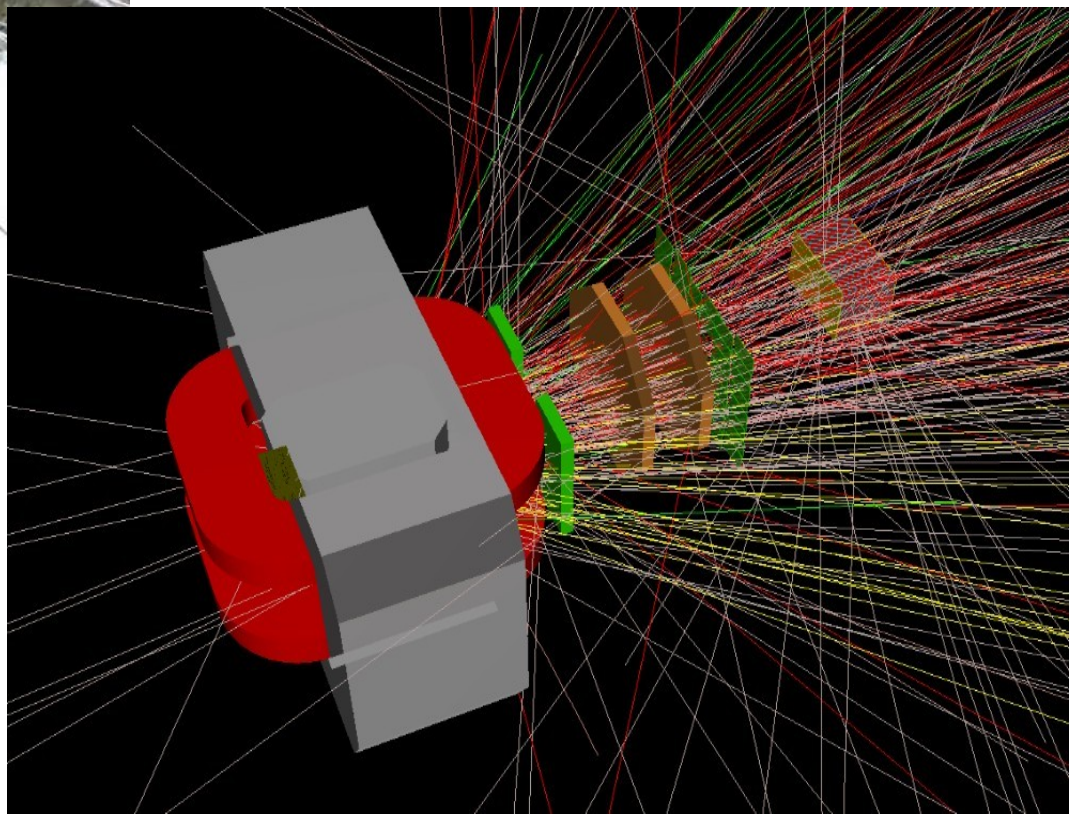


Primary vertex resolution



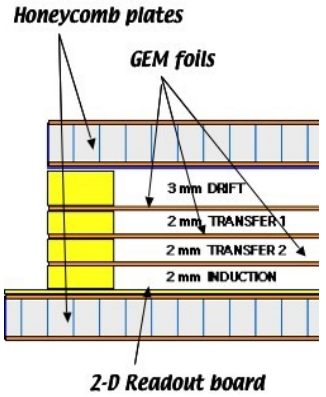
BM@N

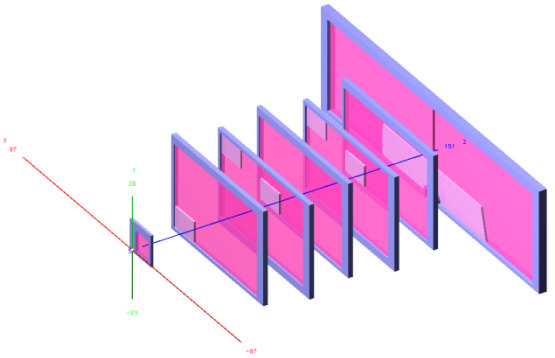
AuAu E_{beam} = 4 GeV



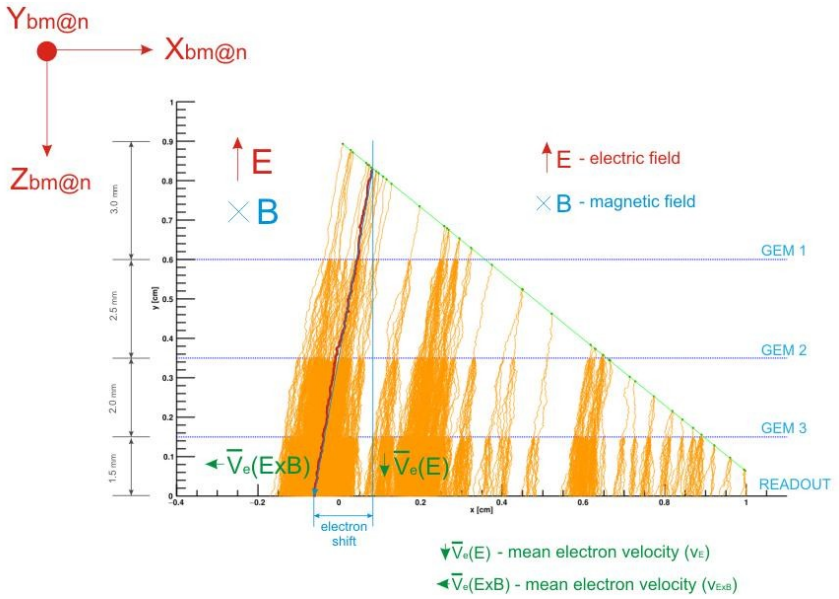
Clustering in GEM

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

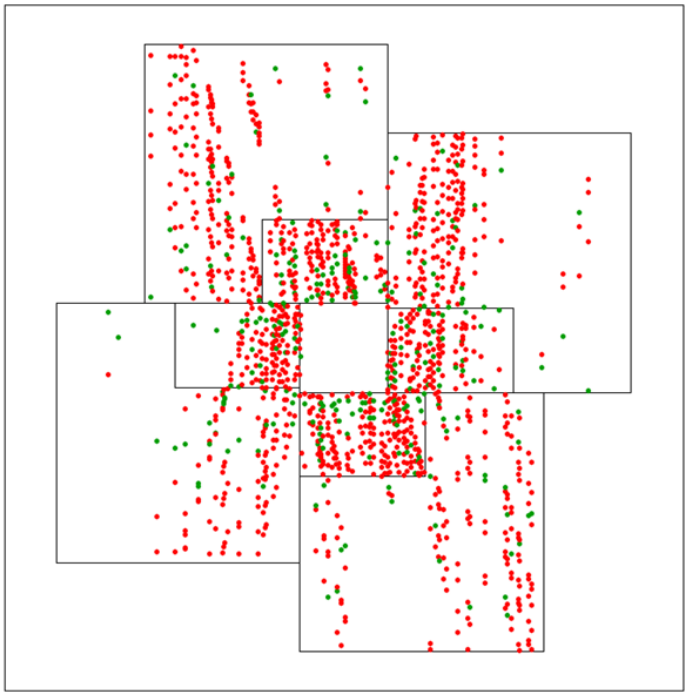




Station 0 (what is it)

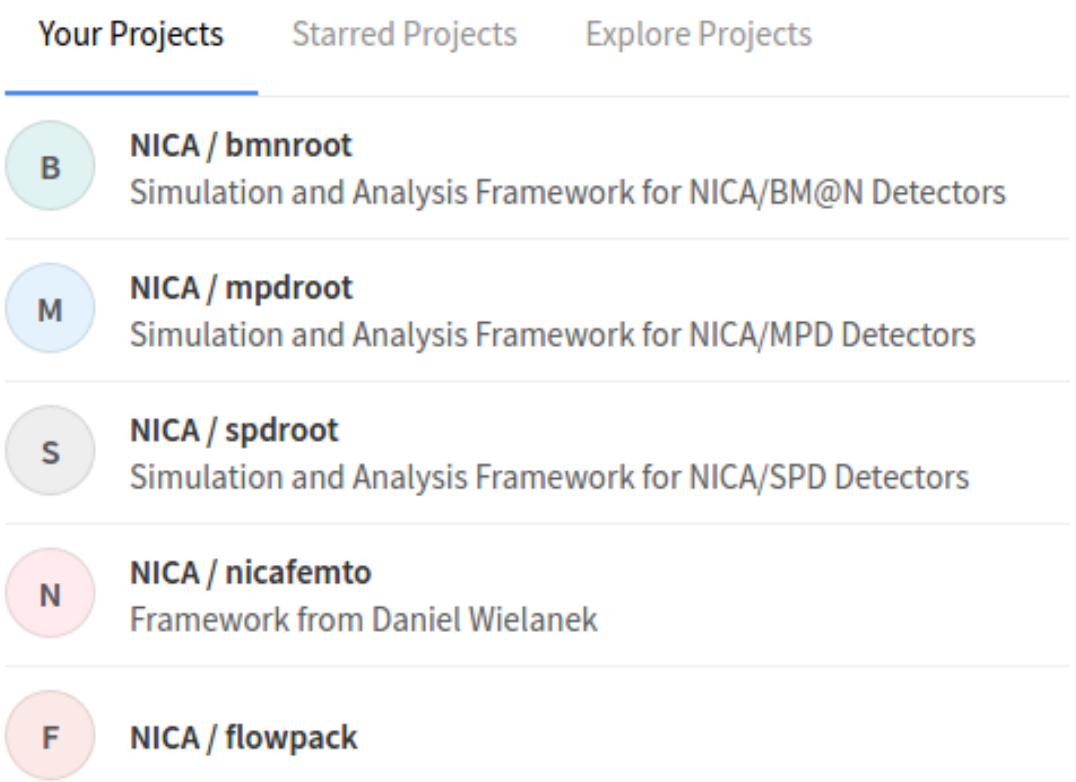


electron avalanches in the BM@N GEM chamber



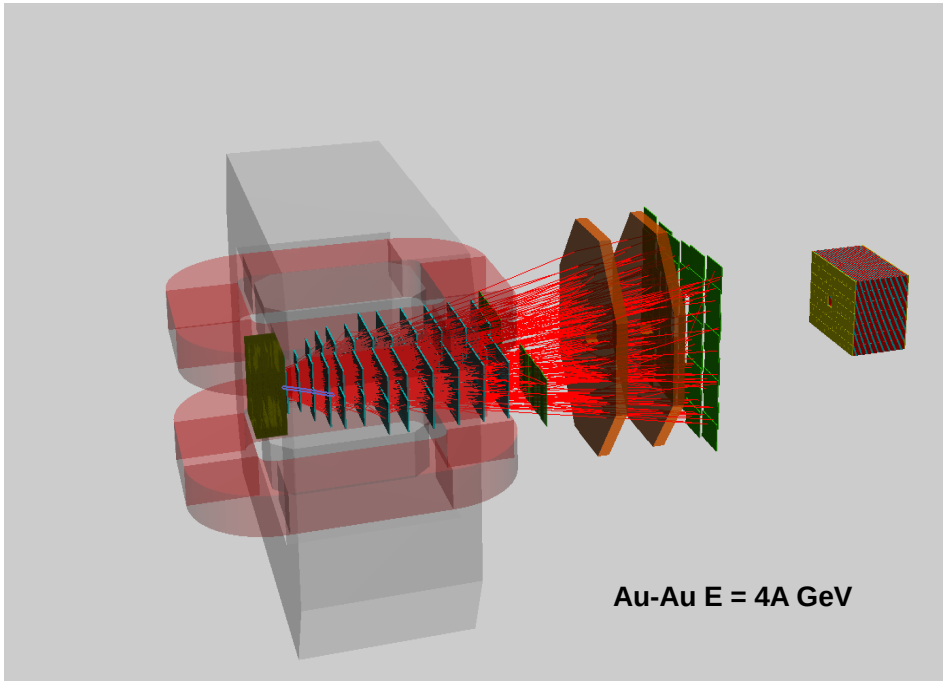
GIT repository for the NICA experiments

https://git.jinr.ru/



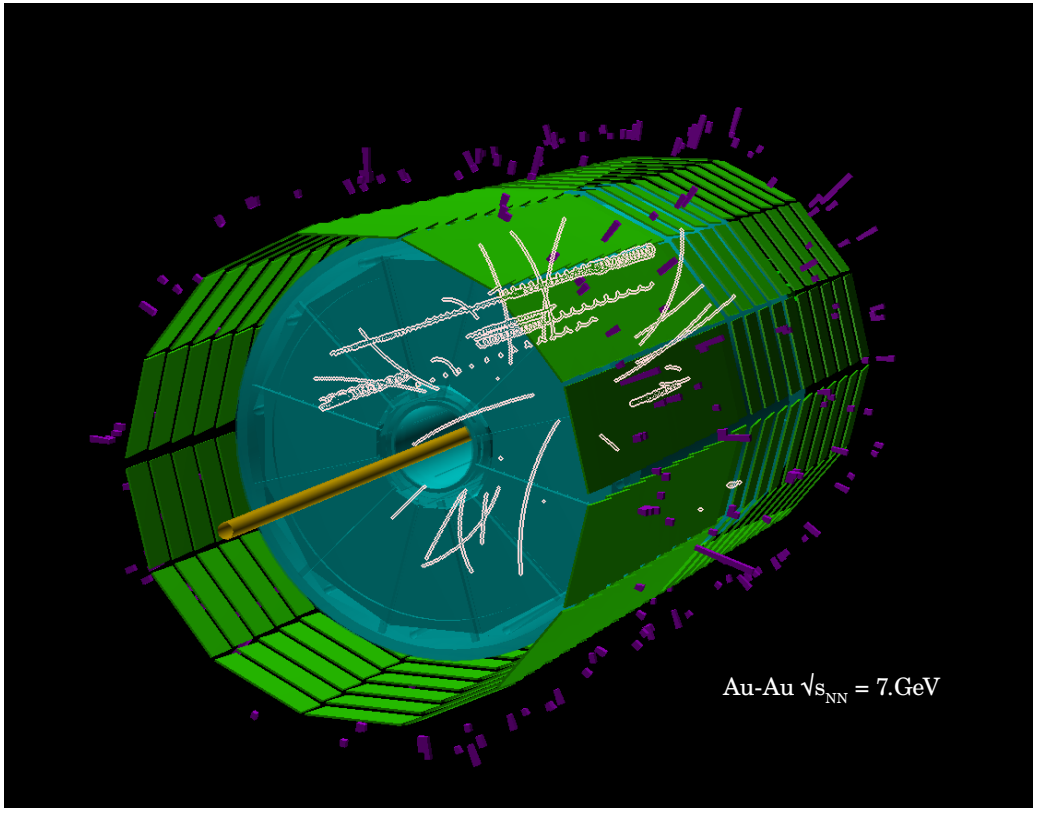
Event Displays for the NICA experiments

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

raw data processing
event reconstruction
physical analysis

BmnRoot / MpdRoot

reading and
changing data

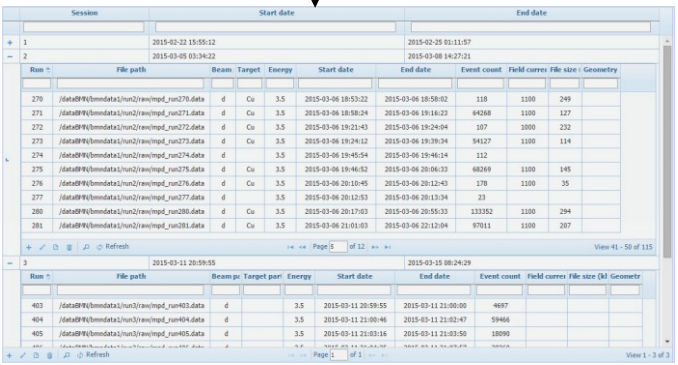
users

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

ROOT

unified database

PHP



UniDbTango interface

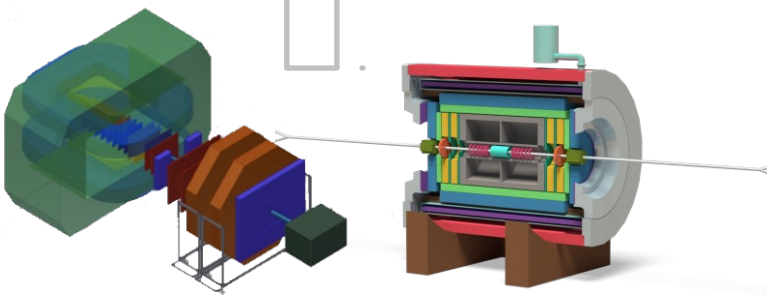
PostgreSQL
automatic backup

Web interface is required

Tango

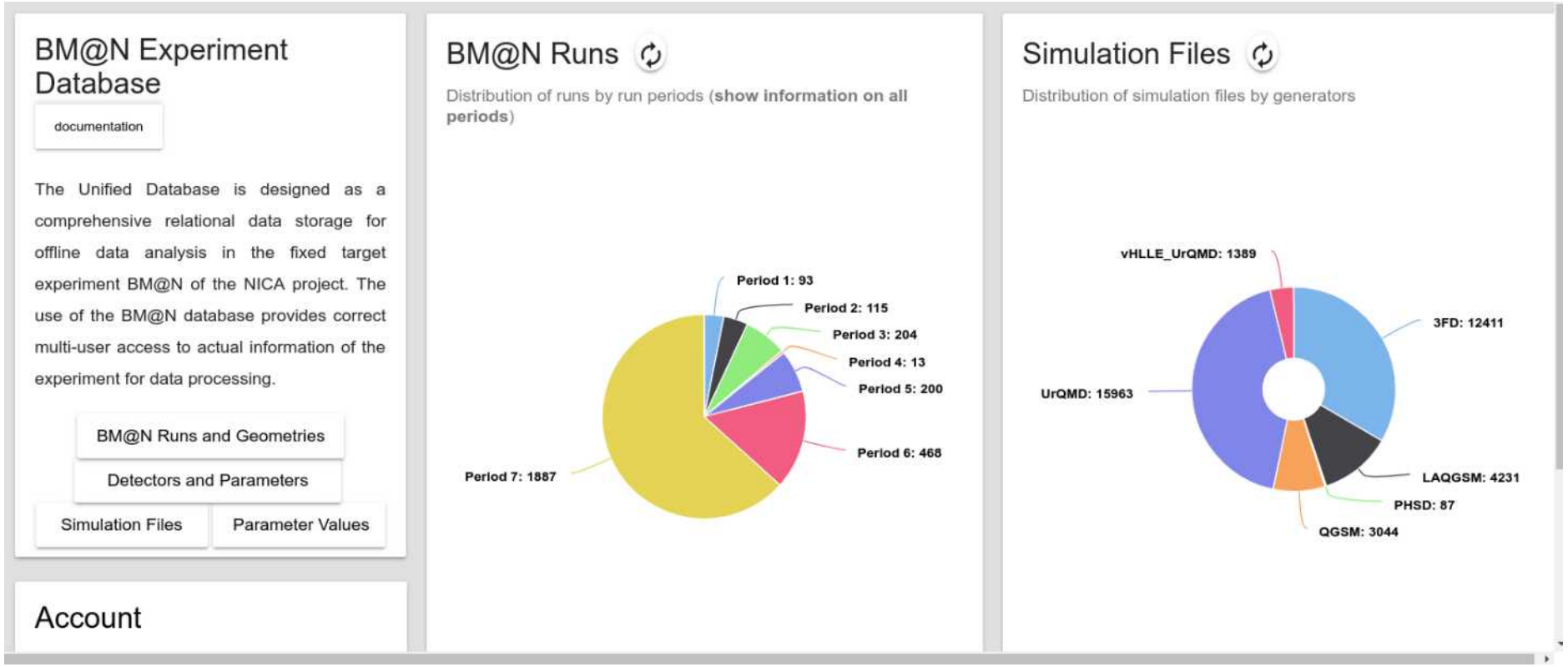
Slow Control System

configuration, calibration, parameter
and algorithm data



21

Database for events from MC generators & experiments



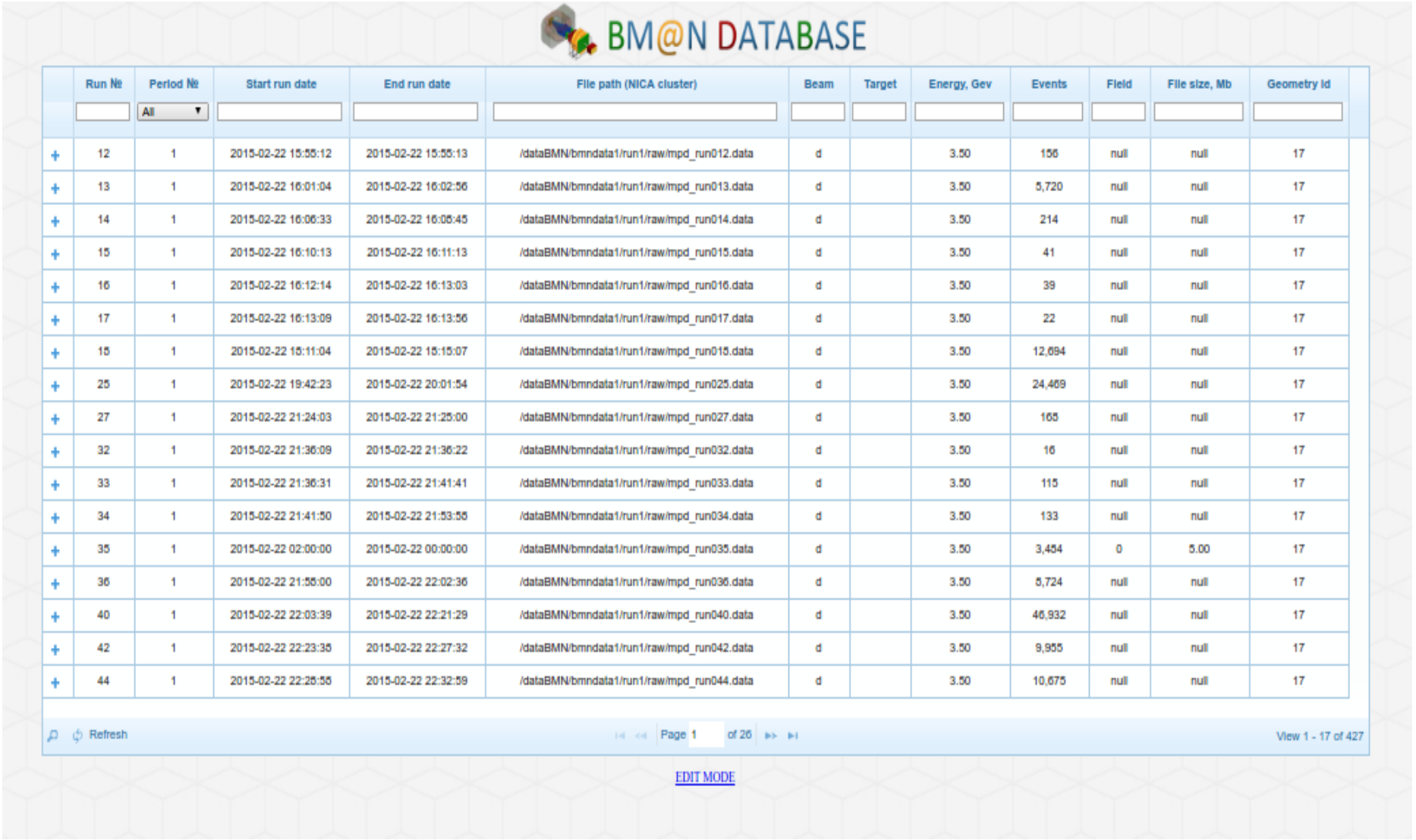
- ✔ UrQMD
- ✔ QGSM
- ✔ PHSD

- ✔ Hybrid UrQMD
- ✔ vHLLE_UrQMD
- ✔ 3FD(Theseus)

Exp. Data

- d + C,Al, Cu, Pb — E = 4 GeV, 3.5 GeV
- C + C, C_2H_4, 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



BM@N DATABASE

Run №	Period №	Start run date	End run date	File path (NICA cluster)	Beam	Target	Energy, Gev	Events	Field	File size, Mb	Geometry Id
	All										
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 22:23:35	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 — **Logged in as shift**

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

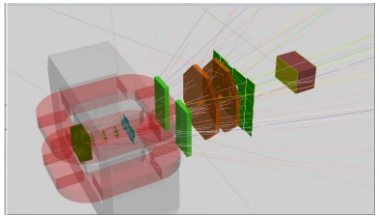
1 2 3 4 5 6 7 8 9 10 11 ... 106 > >>

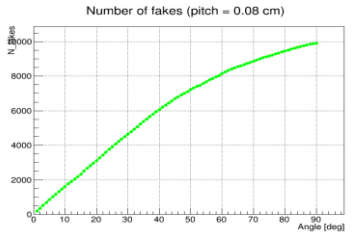
Date	Shift Leader	Type	№ Run	Trigger	DAQ Status	SP-41, A	SP-57, A	VKM2, A	Beam	Energy, GeV	Target	Comment
2018-03-07 08:14:09	Dryablov	New Run	2487 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 2x10^5 beam duration 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.

1 2 3 4 5 6 7 8 9 10 11 ... 106 > >>

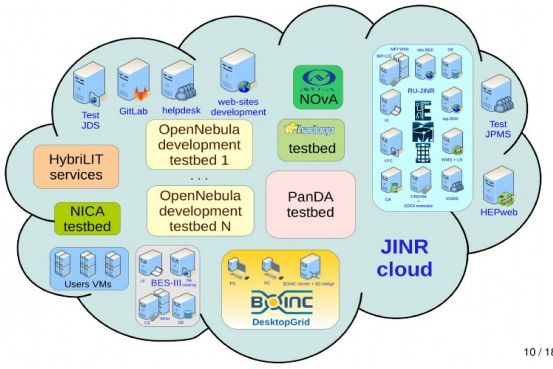
2018 - software team (contact e-mail: gertsen@jinr.ru)

MPD Run Control System

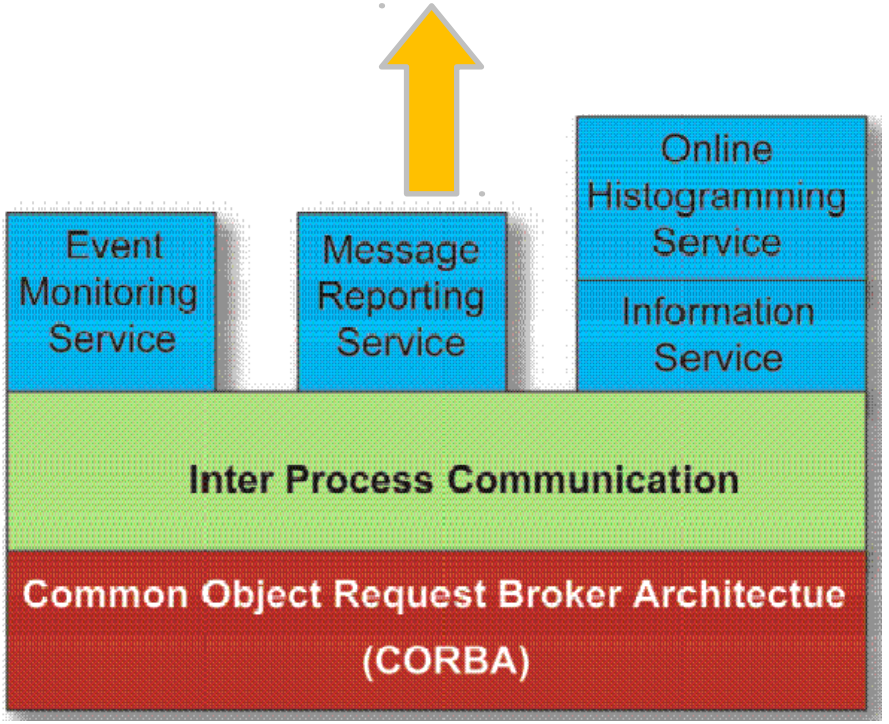




Displays		Analysis	Archiving	
Event Display	Information Monitors	Data Quality Monitoring	Monitoring Data Archiving	Archive Browser
Histogram Presenter	Web Monitoring			



first prototype is developed on LIT Virtual Machines



ATLAS TDAQ Online Components

Raw Event Builder

25

MpdRoot & BmnRoot distributed computing

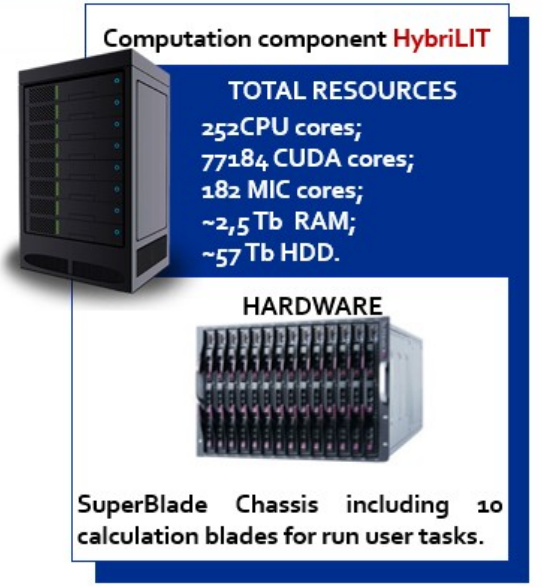
NICA Cluster prototype

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

LIT Tier1 (lxmpd-ui)

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

LIT HybriLIT (+SC "Govorun")



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

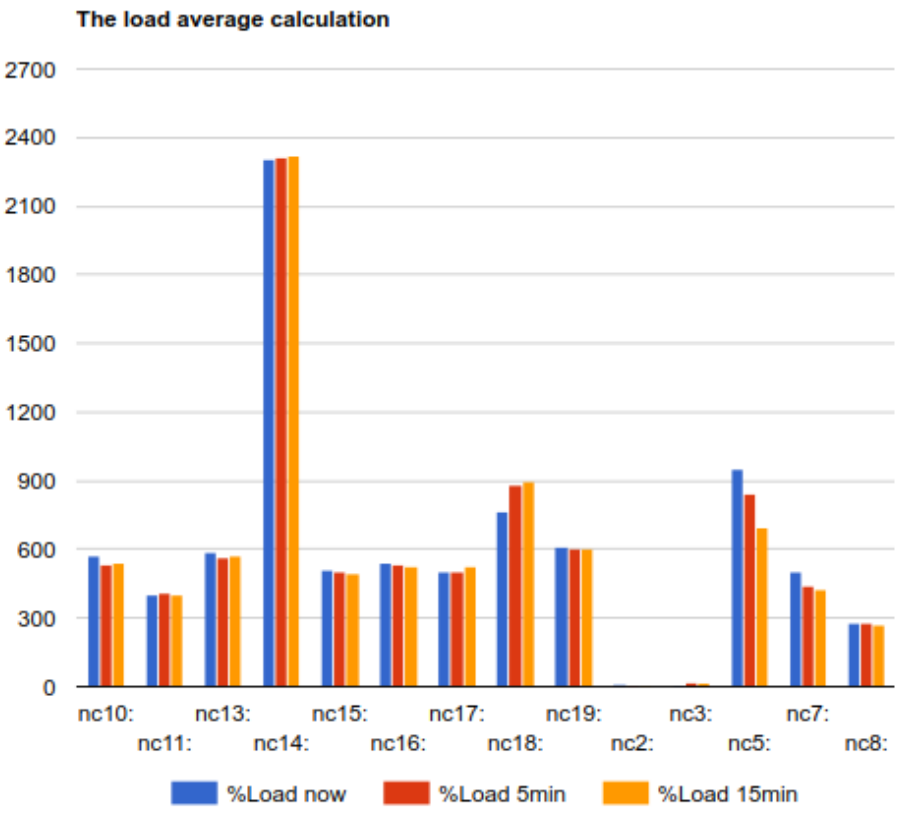
All external packages for MpdRoot & BmnRoot are installed & configured. MpdRoot & BmnRoot is taken from GIT repository. ~ 60 users

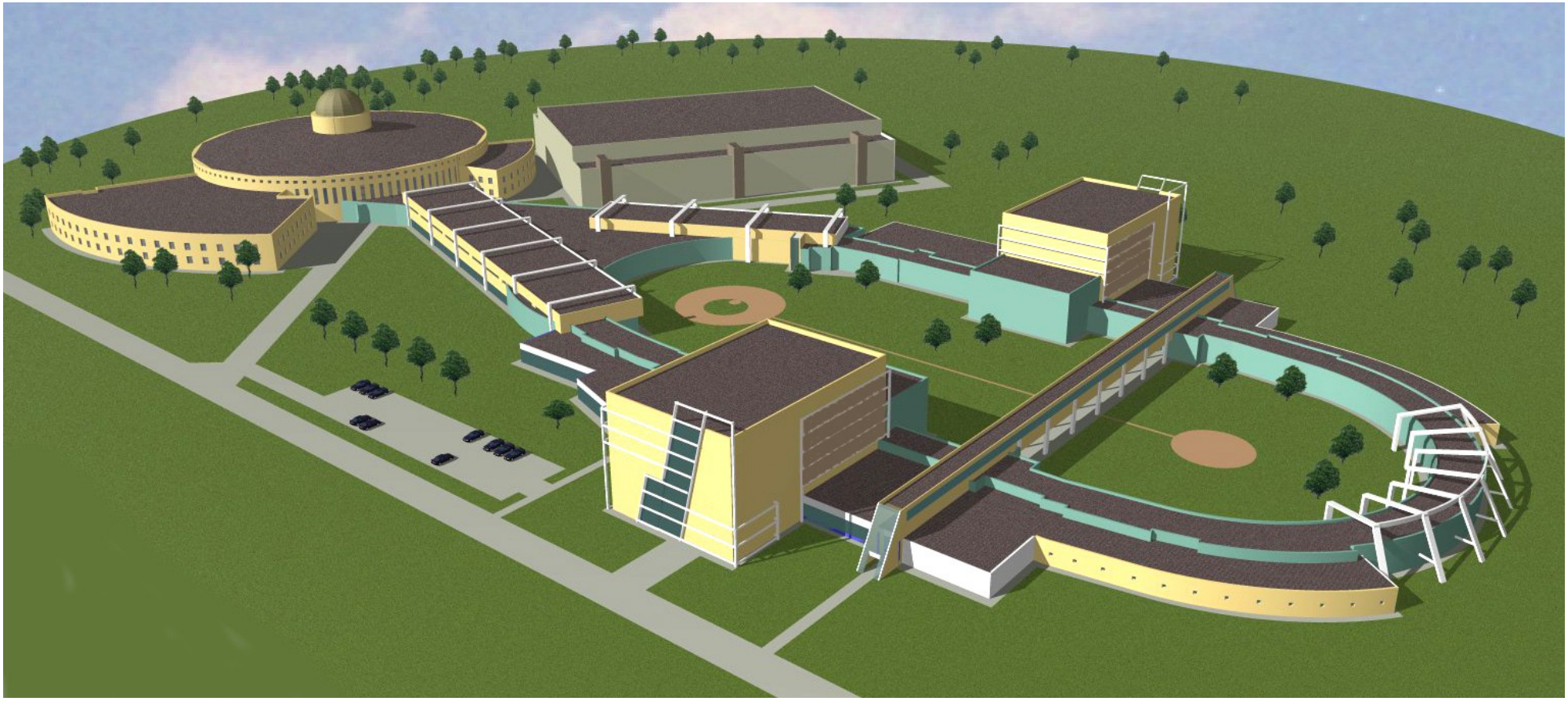
Computing resources: LHEP

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