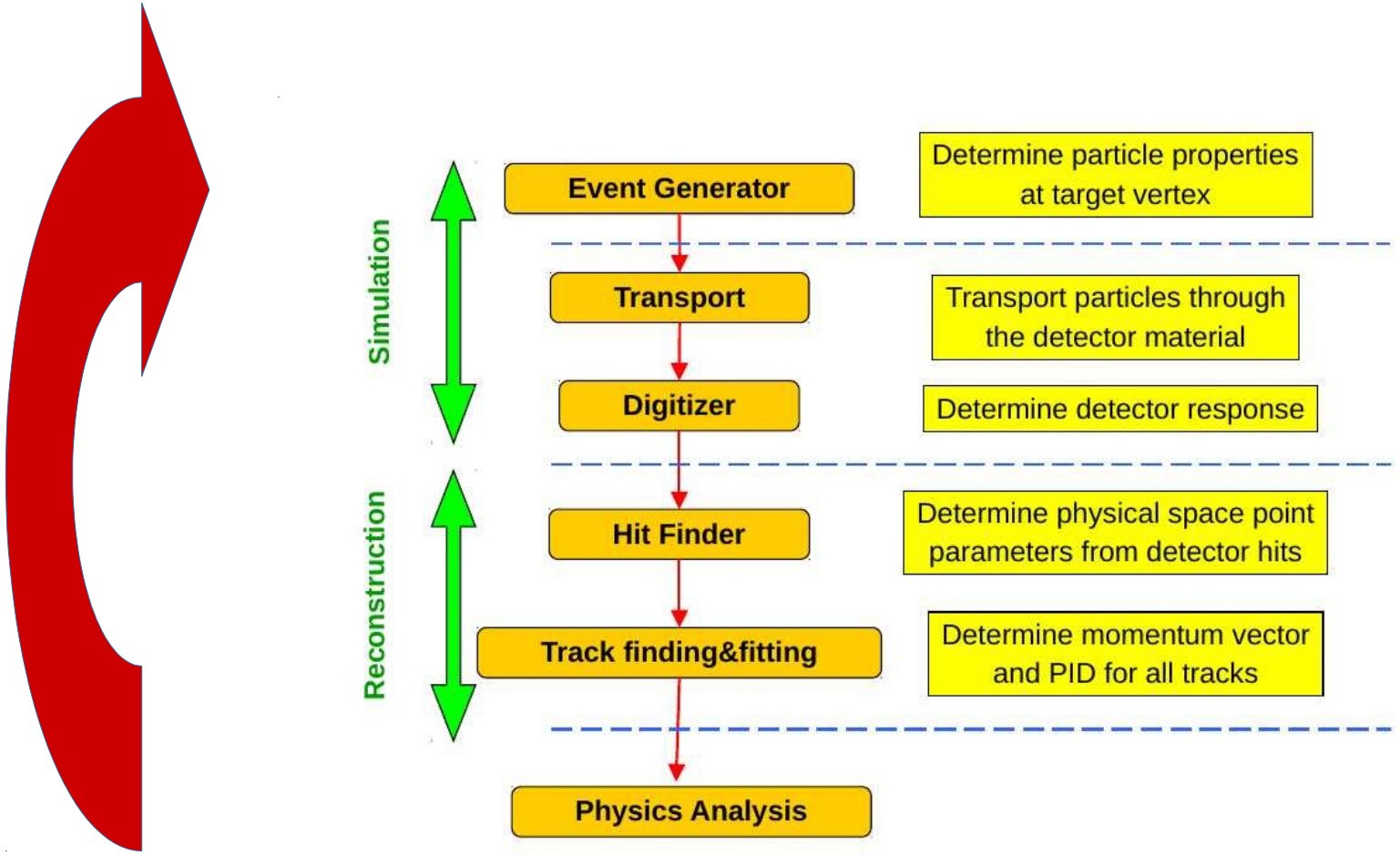
Offline software development for the NICA experiments: MpdRoot and others

2-nd CM of the NICA collaboration

HEP experiments data flow

Experiment software development is a key task
for the whole experiment life.

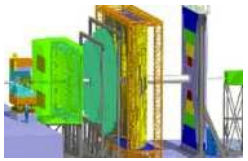


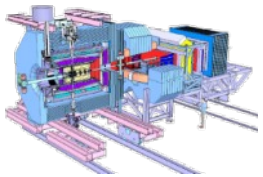
FairRoot family

Start testing the VMC concept for CBM

2004

First Release of CbmRoot

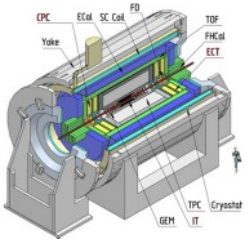




Panda decided to join → oct.
FairRoot: base package for experiments

2006

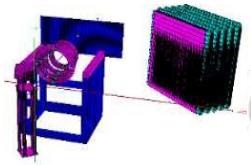
MPD@NICA started with FairRoot

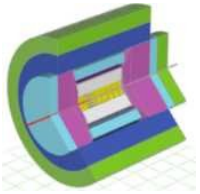


R3B joined

2010

ASYEOS joined

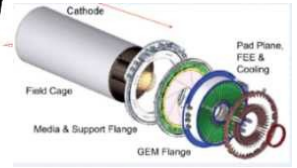


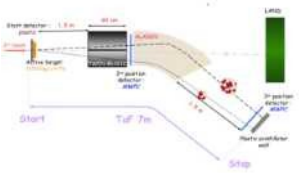


EIC (Electron Ion Collider BNL)

2011

GEM-TPC separated from PANDA branch



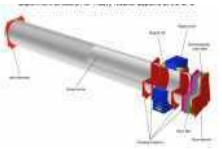


SOFIA (Studies On Fission with Aladin)

2012

ENSAR-ROOT
Collection of modules used by structural nuclear physics exp.

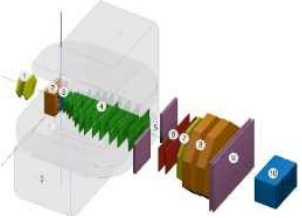
2013

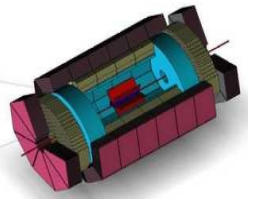


SHIP (Search for Hidden Particles)

201

BM@N@NICA started with FairRoot

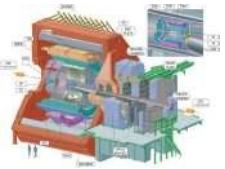




SPD@NICA joined

2015

ALICE
FAIR



FairRoot

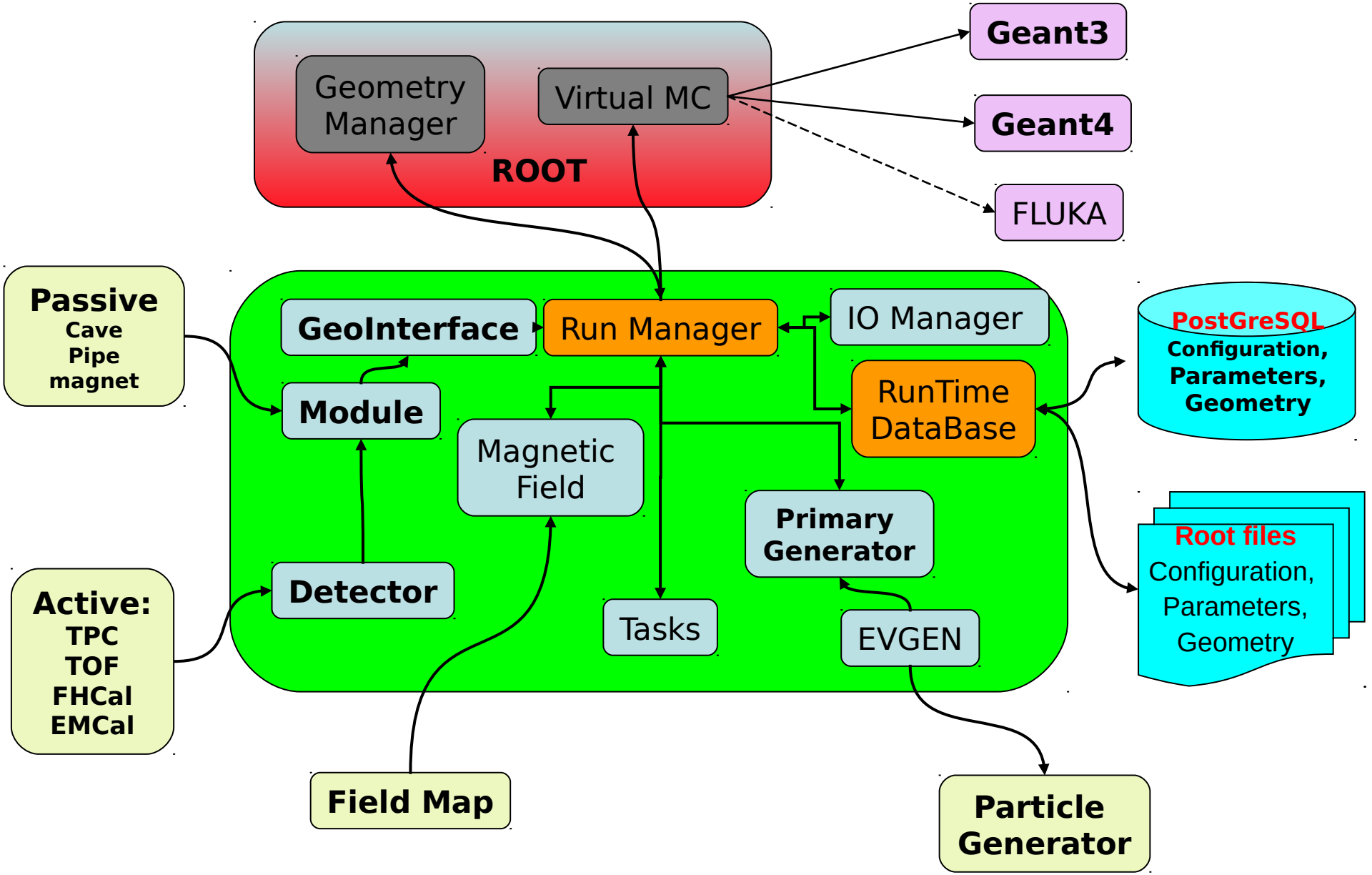
https://fairroot.gsi.de/

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.

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


Geant3
Geant4
FLUKA
Geometry Manager
Virtual MC
ROOT
Passive
Cave
Pipe
magnet
GeoInterface
Run Manager
IO Manager
Module
RunTime DataBase
Magnetic Field
Primary Generator
Detector
Tasks
EVGEN
Active:
TPC
TOF
FHCal
EMCal
Field Map
Particle Generator
PostGreSQL
Configuration, Parameters, Geometry
Root files
Configuration, Parameters, Geometry

External packages

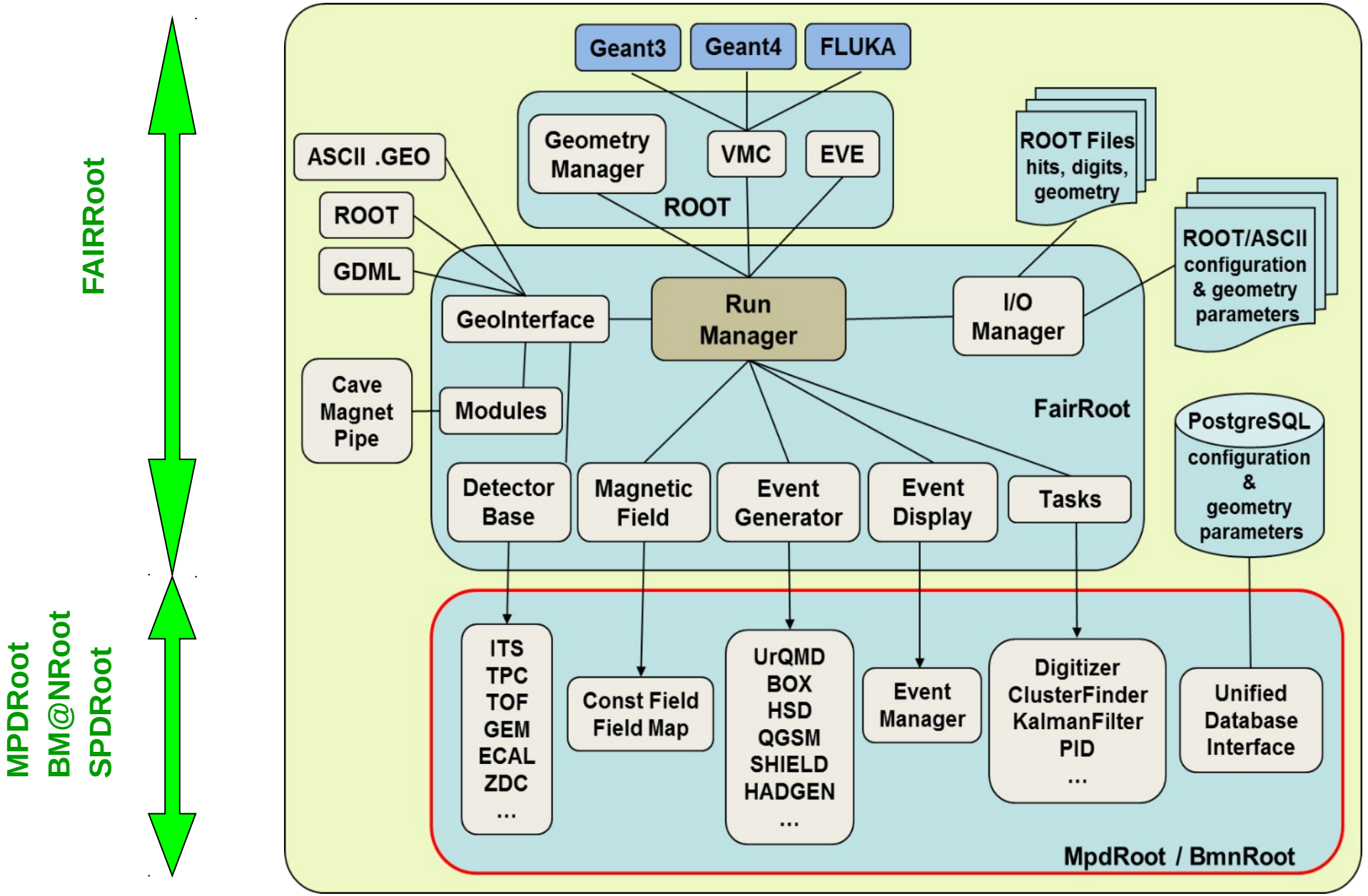
Releases update every half a year

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

+ Python support

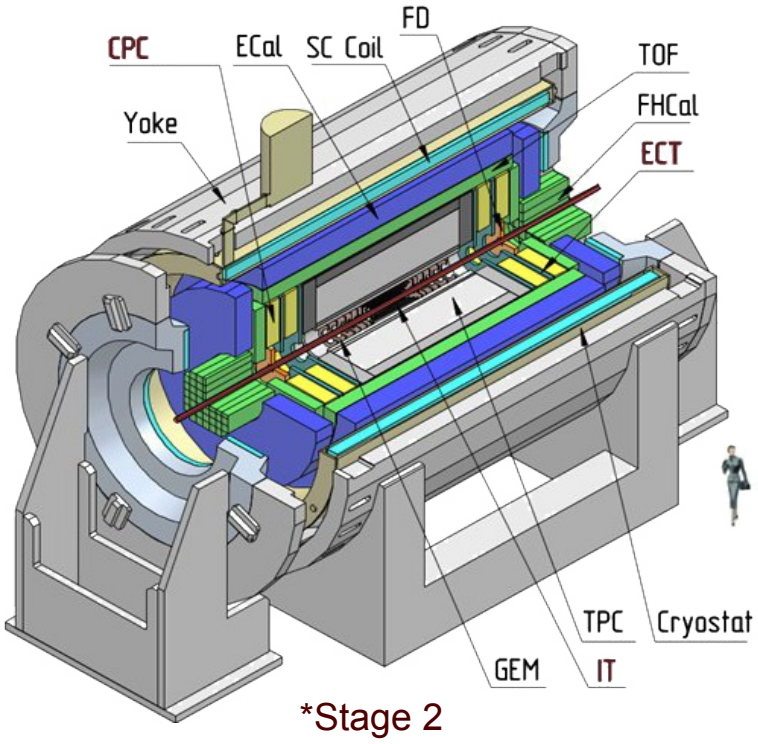
MPD/BM@N/SPDRoot design



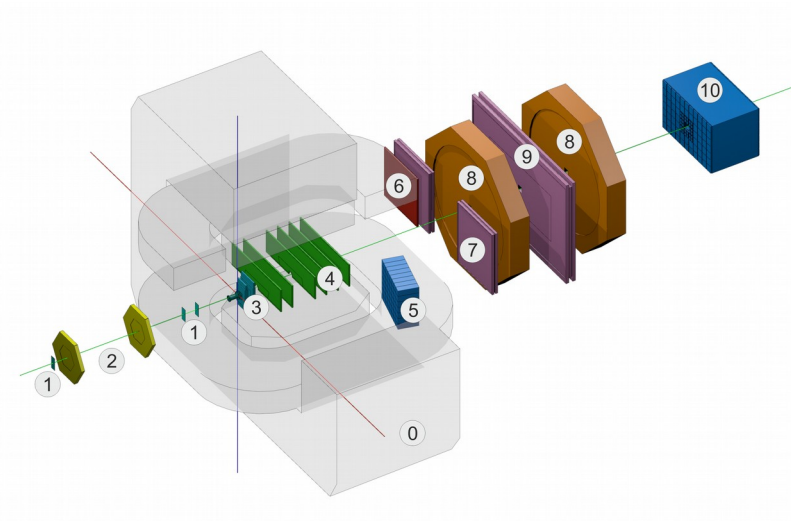
NICA HIC experiments frameworks

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



0 Analyzing magnet
1 Trigger detectors
2 MWPC (Multi-Wire Proportional Chamber)
3 ST (Silicon Tracker)
4 GEM (Gas Electron Multiplier)
5 ECAL (Electromagnetic Calorimeter)
6 CSC (Cathode Strip Chamber)
7 TOF1 (Time-Of-Flight detector)
8 DCH (Drift Chamber)
9 TOF2 (Time-Of-Flight detector)
10 ZDC (Zero-Degree Calorimeter)

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

Experiments info

http://mpd.jinr.ru/

NICA EXPERIMENTS

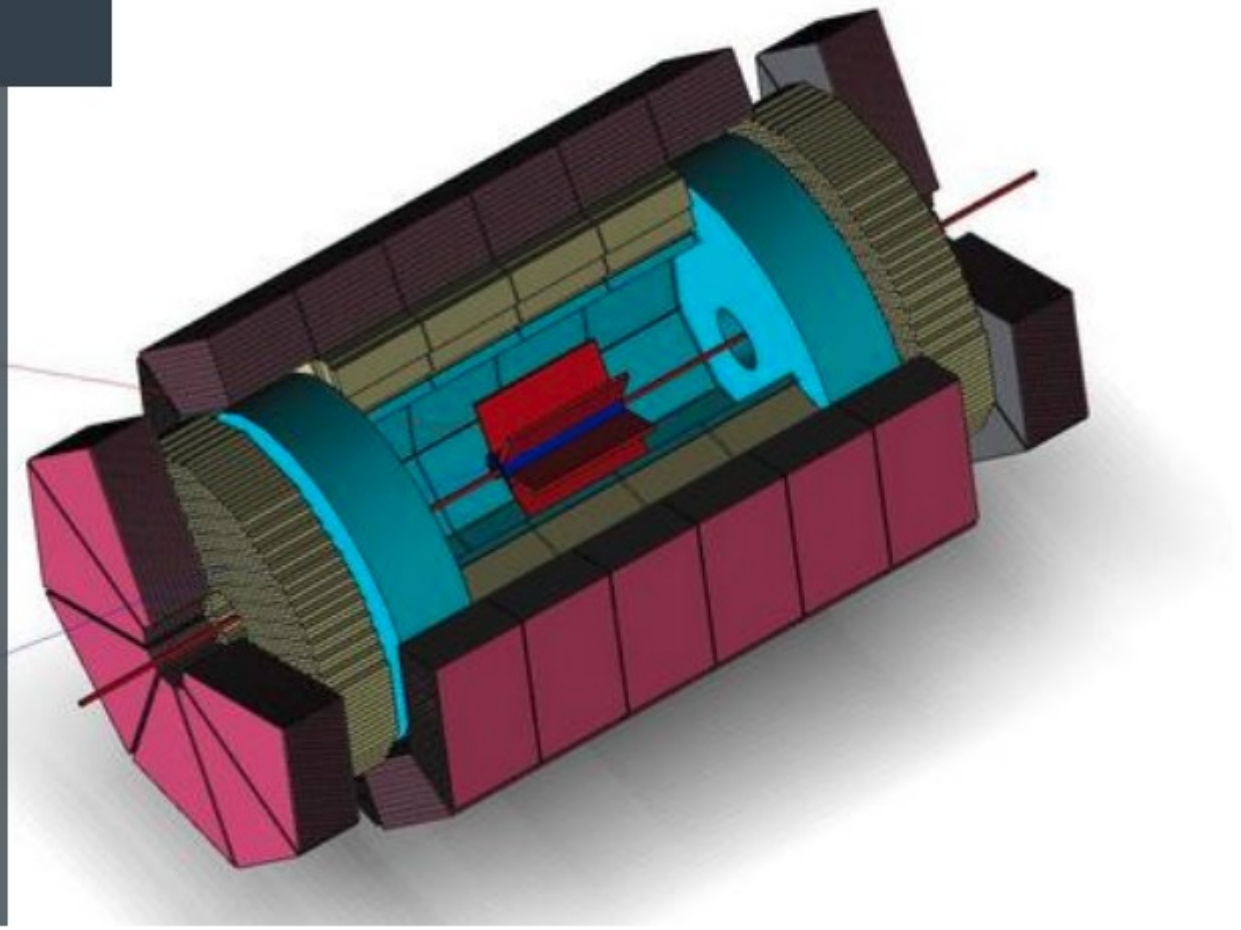
TECHNICAL WEBSITE

MAIN | DOCUMENTS | EXPERIMENTS | SOFTWARE | COMPUTING | FORUM | VIDYO

- BM@N
- MPD
- SPD

Spin Physics D (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 [...]



Experiments frameworks

http://mpd.jinr.ru/

NICA EXPERIMENTS

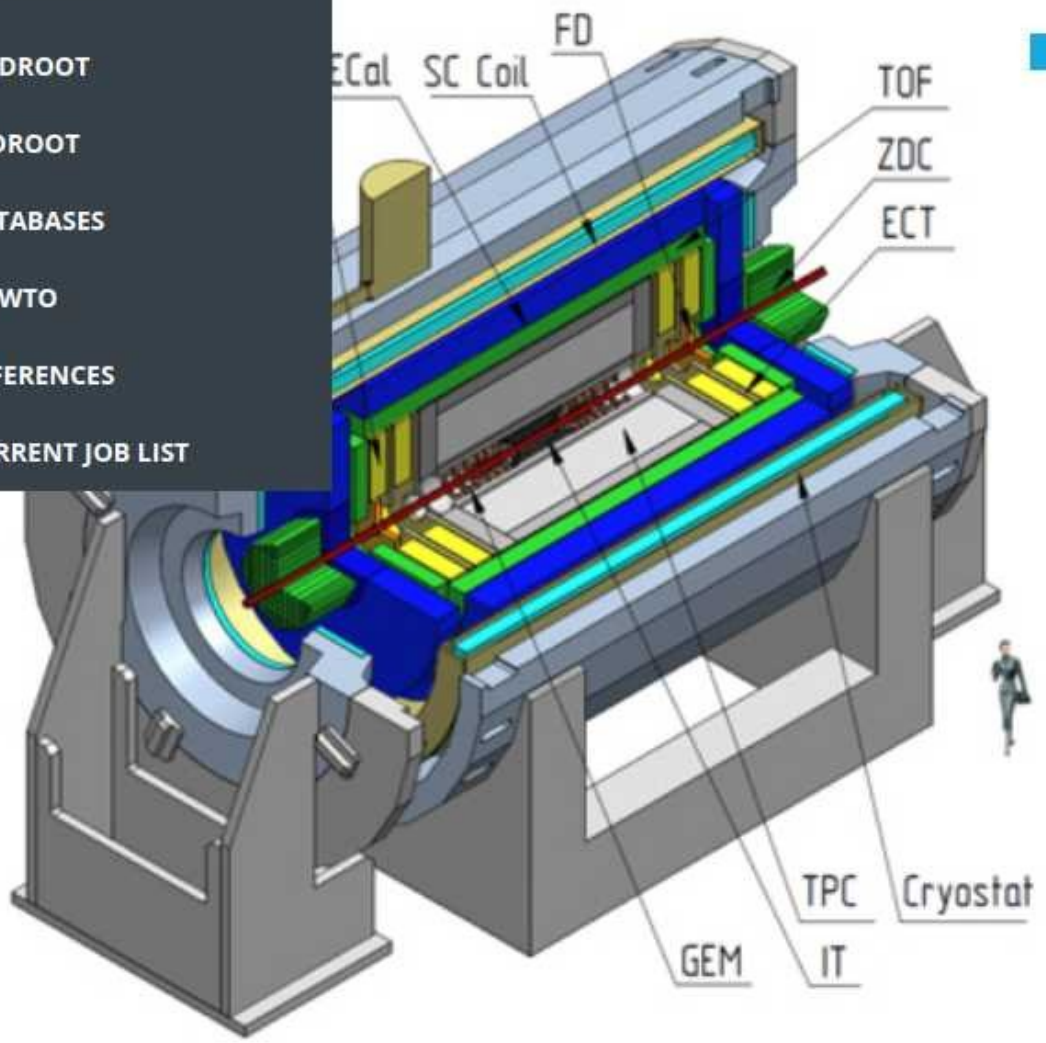
TECHNICAL WEBSITE

MAIN | DOCUMENTS | EXPERIMENTS | SOFTWARE | COMPUTING | FORUM | VIDYO

- BMNROOT
- MPDROOT
- SPDROOT
- DATABASES
- HOWTO
- REFERENCES
- CURRENT JOB LIST

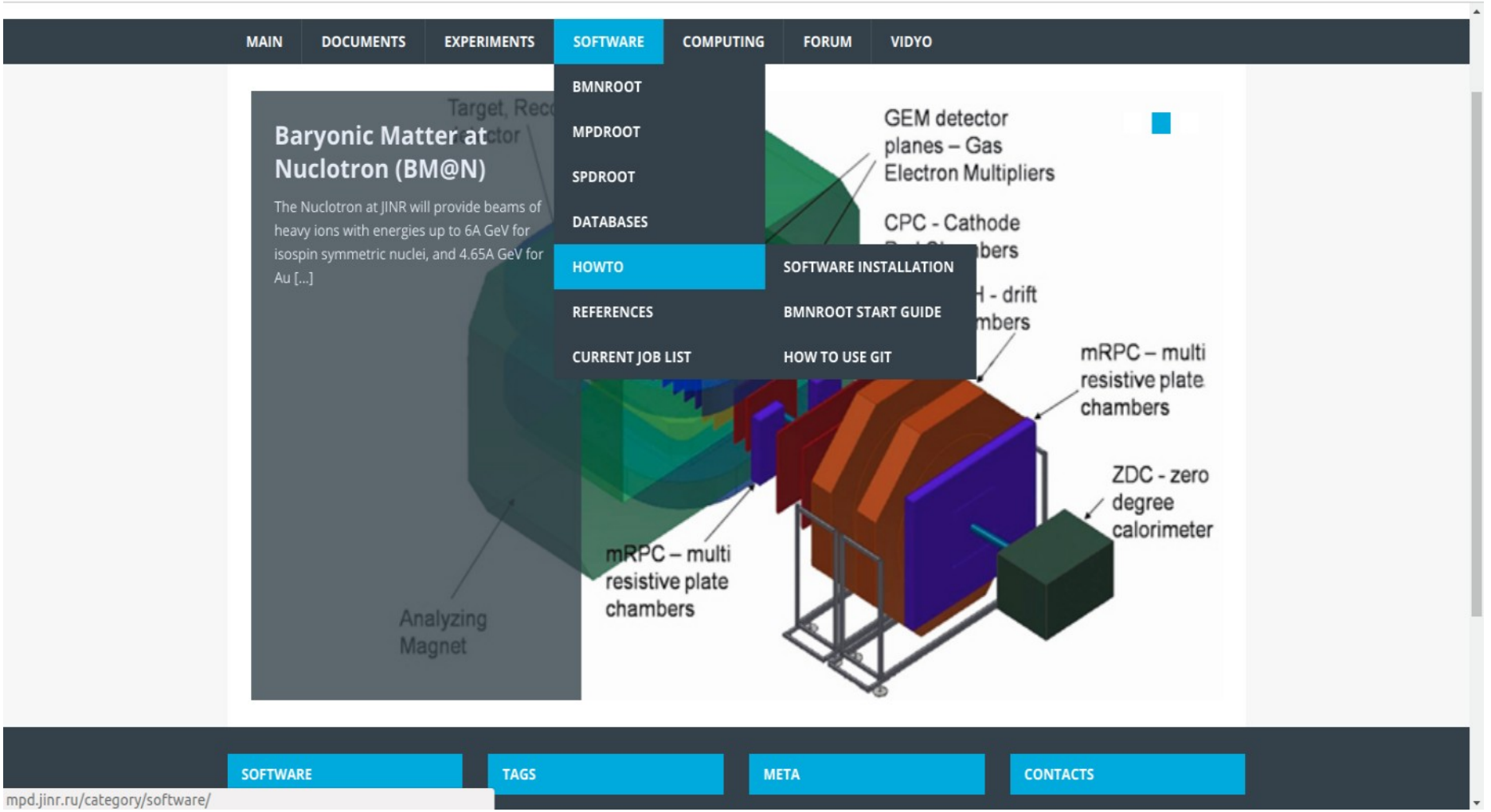
Multi Purpose Detector (MPD)

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



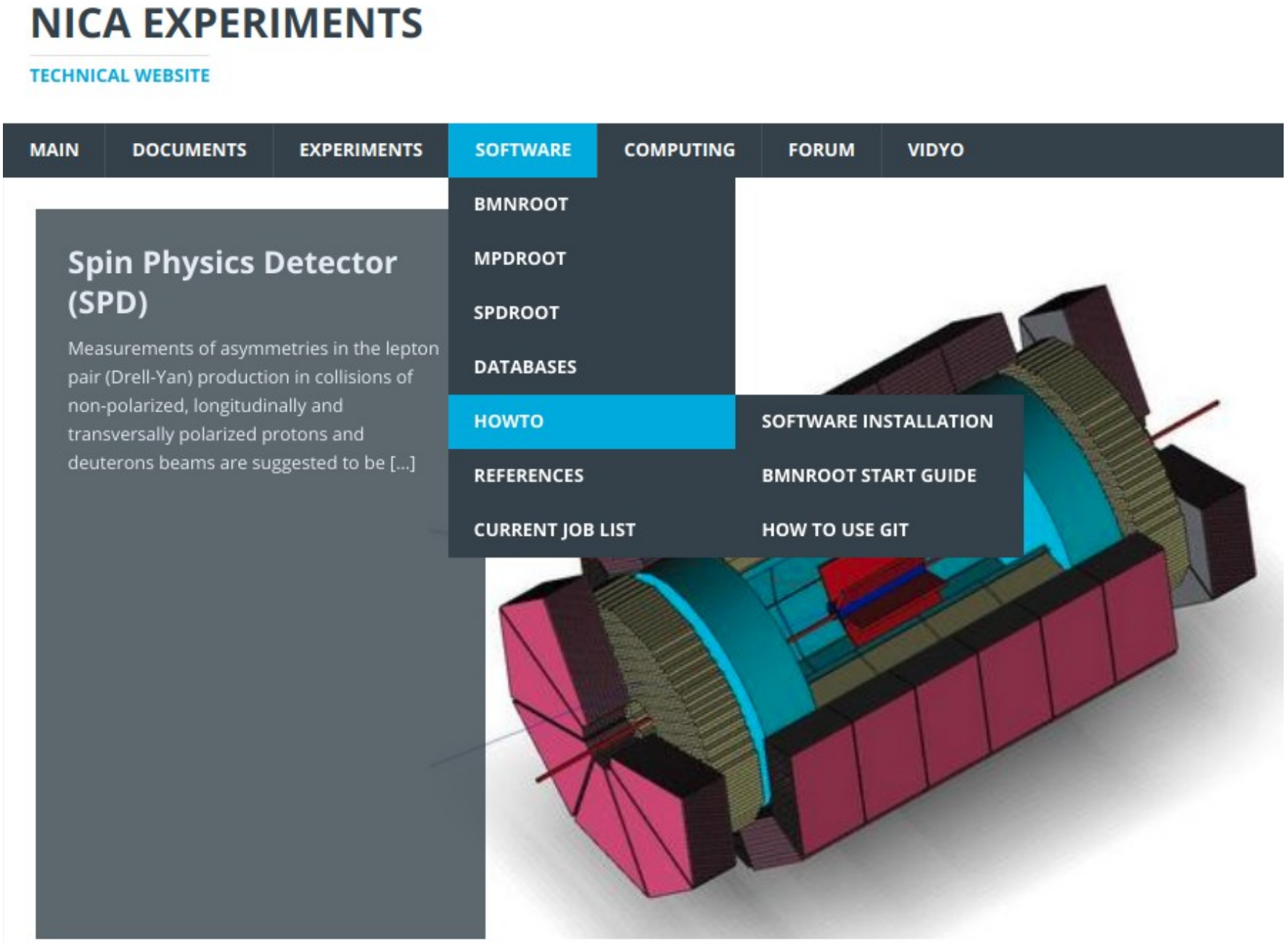
How to use

http://mpd.jinr.ru/



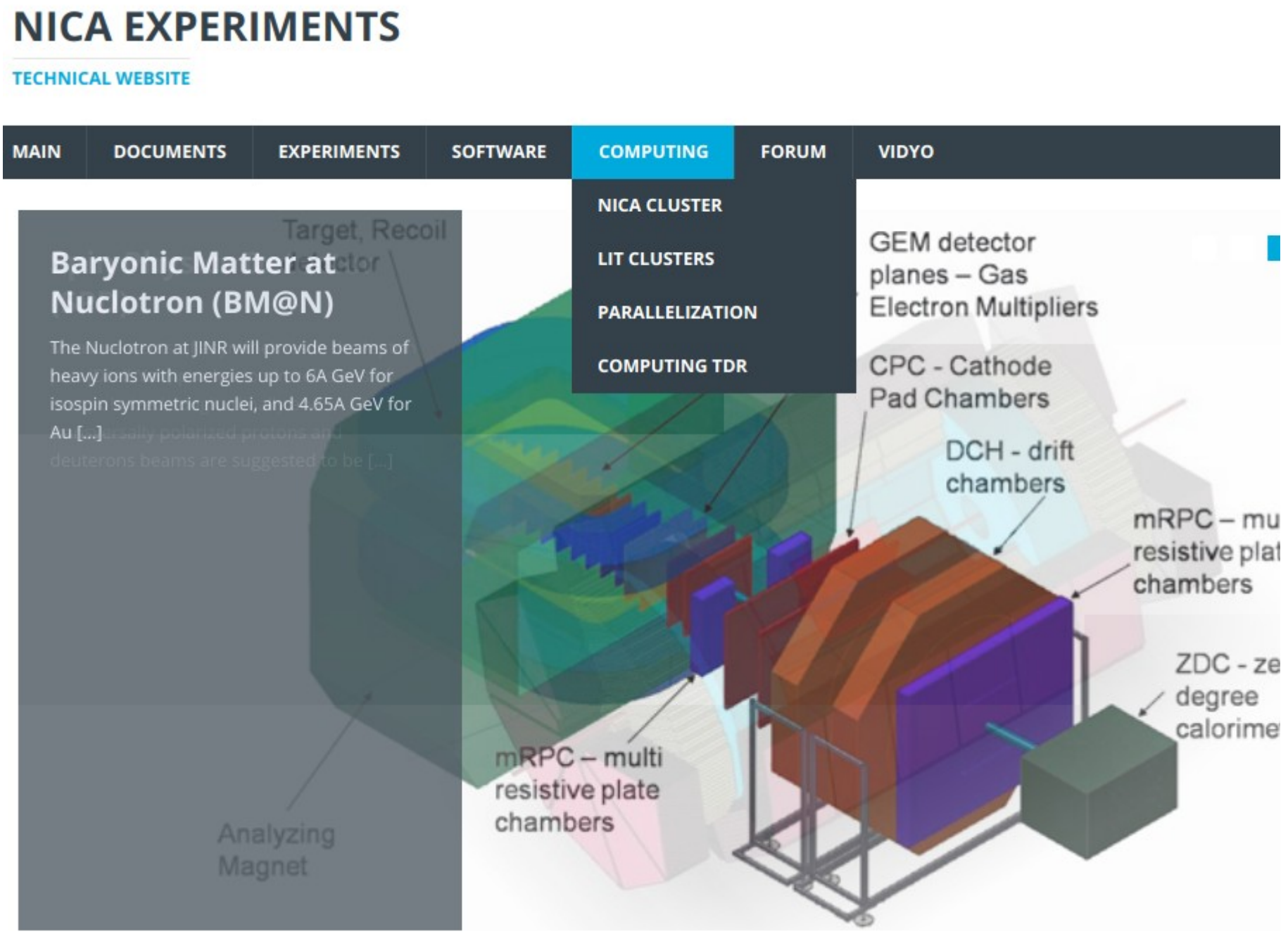
Software installation

http://mpd.jinr.ru/



Computing resources

http://mpd.jinr.ru/



MpdRoot & BmnRoot distributed computing

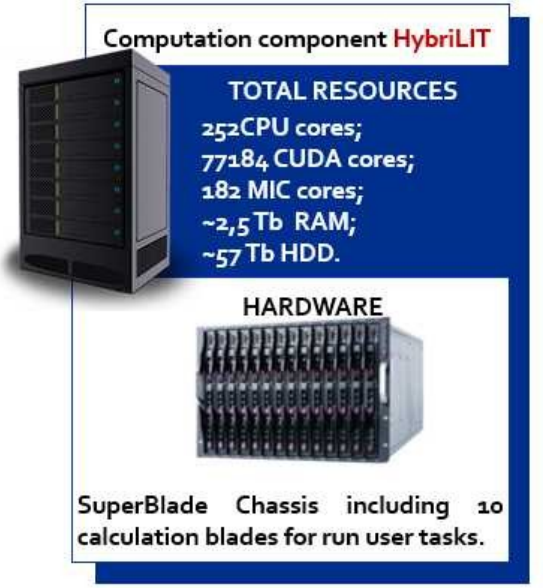
LHEP NICA Cluster

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. ~ 100 users

Distributed computing

NICA EXPERIMENTS

TECHNICAL WEBSITE

MAIN | DOCUMENTS | EXPERIMENTS | SOFTWARE | COMPUTING | FORUM | VIDYO

Batch Processing

If you have time-consuming tasks, many simple tasks or a lot of files to process, you can use *batch system* on distributed clusters, such as **HybriLIT** with SLURM, **NICA prototype cluster** with SGE or **MPD-Tier1** with Torque – to essentially accelerate your work.

If you know how to work with SLURM (SLURM on HybriLIT), Sun Grid Engine (user guide) and Torque systems (doc index), you can use ***sbatch*** or ***qsub*** command on the clusters to parallel data processing. Simple examples of user jobs for SLURM, SGE and Torque can be found in *'macro/mpd_scheduler/examples/batch'* directory in our software. Otherwise, MPD-Scheduler was developed to simplify running of user tasks in parallel.

MPD-Scheduler is a module of MpdRoot and BmnRoot software. It uses existing batch system (SLURM, SGE and Torque are supported) to distribute user jobs on the cluster and simplifies parallel job executing without knowledge of the batch systems. Jobs for distributed execution are described and passed to MPD-Scheduler as XML file:

```
$ mpd-scheduler my_job.xml
```

Example of MPD-Scheduler job:

```
<job name="reco_job">
   <macro path="$VMCWORKDIR/macro/mpd/reco.C" start_event="0"
count_event="1000" add_args="local">
    <file input="$VMCWORKDIR/macro/mpd/evetest1.root"
output="$VMCWORKDIR/macro/mpd/mpddst1.root"/>
    <file input="$VMCWORKDIR/macro/mpd/evetest2.root"
output="$VMCWORKDIR/macro/mpd/mpddst2.root"/>
    <file sim_input="energy=3,gen=urqmd"
```

NICA Experiments > All posts > Computing > Batch Processing

SEARCH ...

October 2018

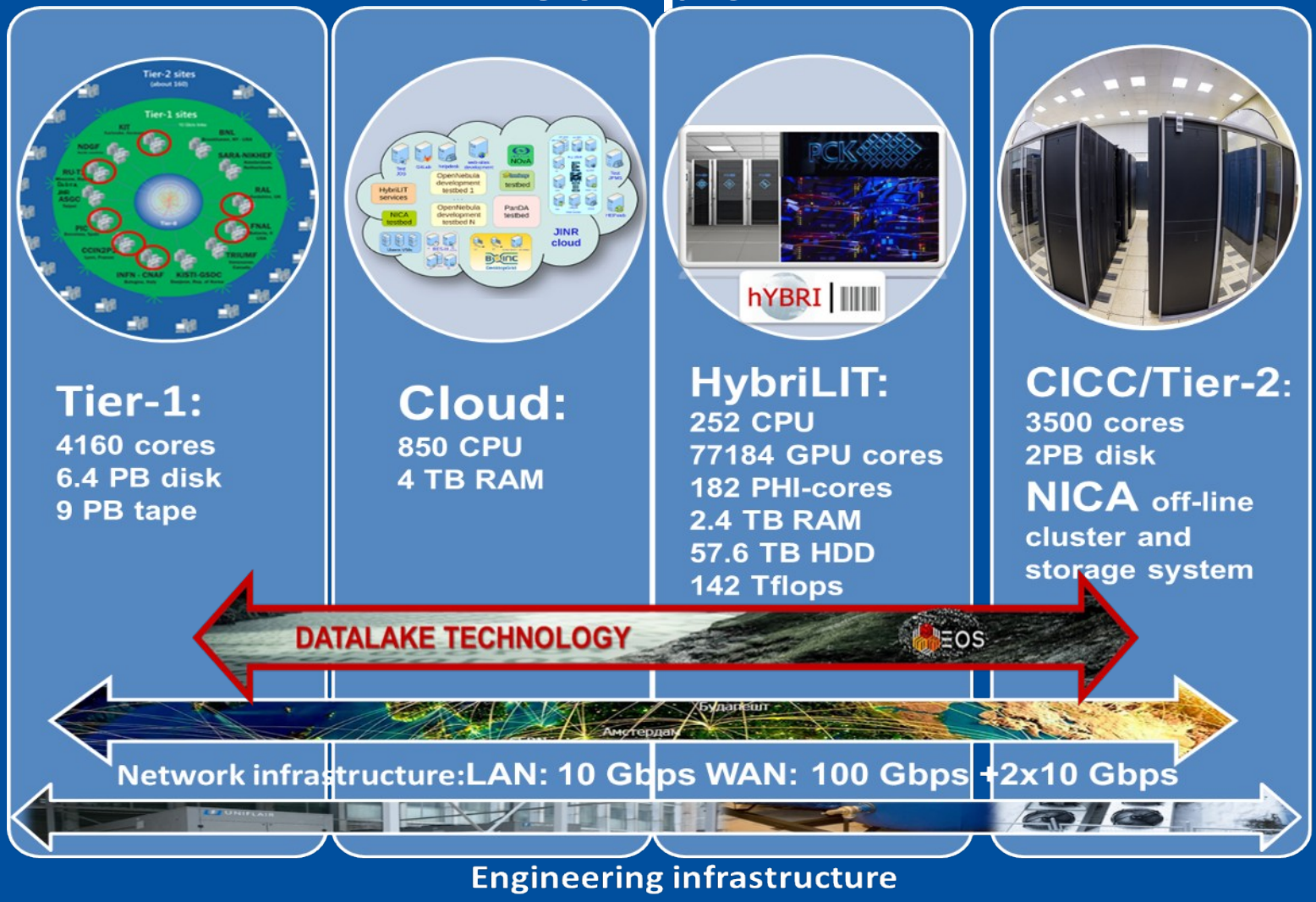
M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

« Apr

TAGS

BATCH | BMNROOT | GIT | GITLAB | HOWTO | INTERACTIVE | LIT FARM | MPDROOT | PROOF | ROOT | SCHEDULER

Multifunctional Information and Computing Complex



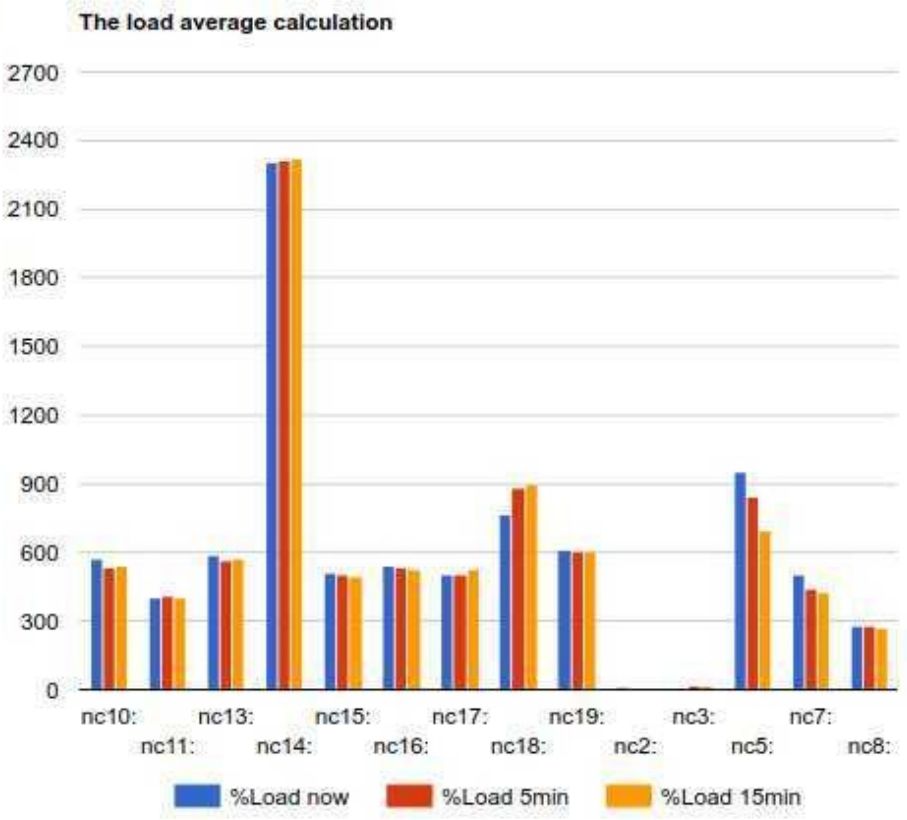
LIT IT-infrastructure is the one of JINR basic facilities

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



The Unified Database for offline data processing

raw data processing
event reconstruction
physical analysis

BmnRoot / MpdRoot

reading and
changing data

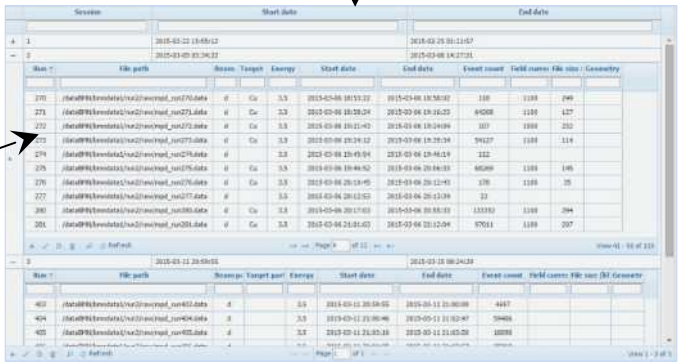
users

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

ROOT

unified database

PHP



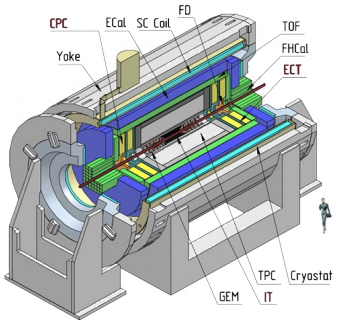
Web interface is required

UniDbTango interface

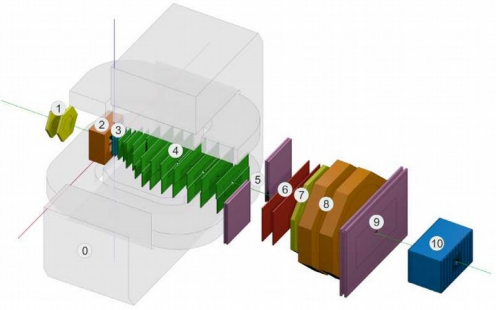
PostgreSQL
automatic backup

Tango

Slow Control System

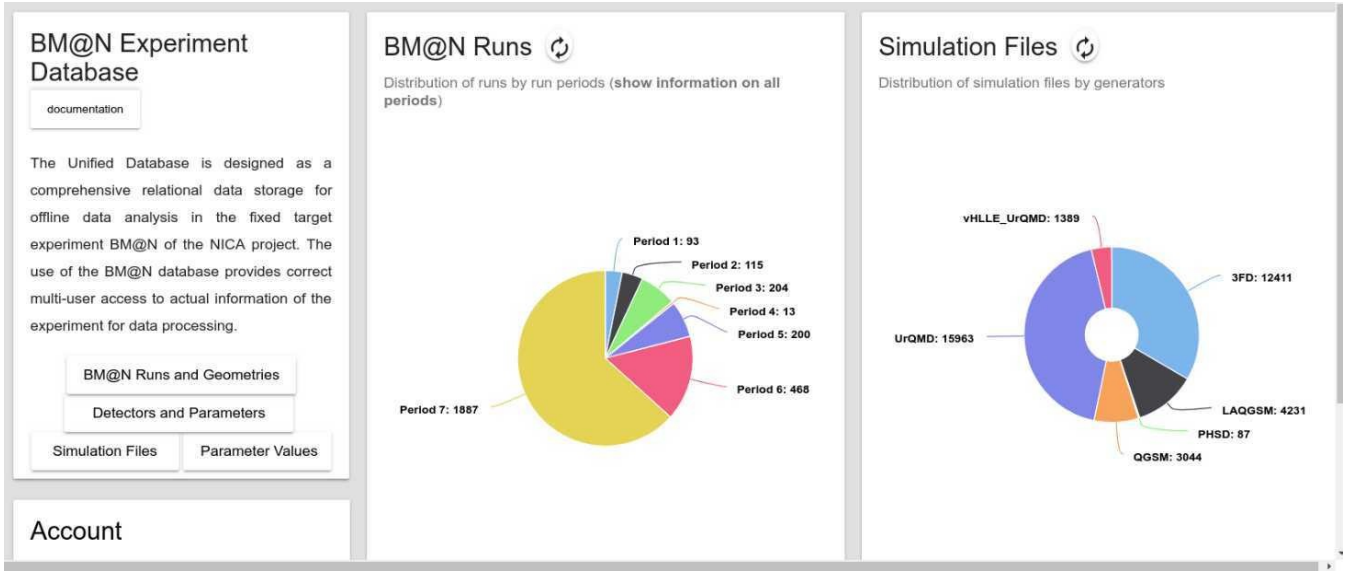


Configuration,
Calibration,
Parameter
and algorithm data



18

Database for events from MC generators & experiments

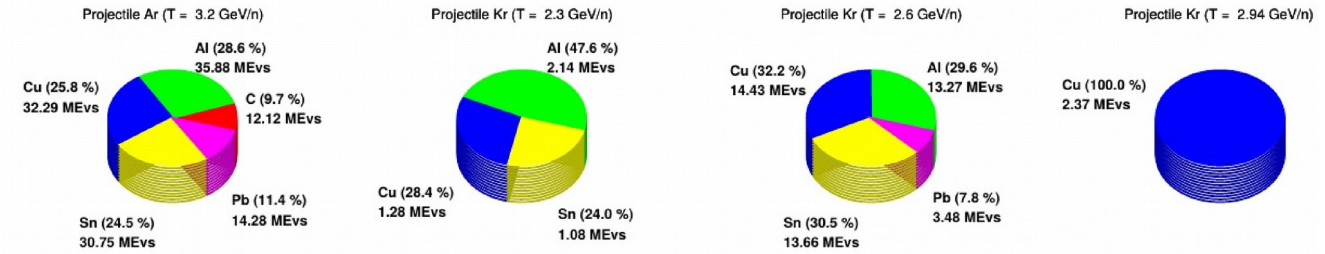


Exp. Data

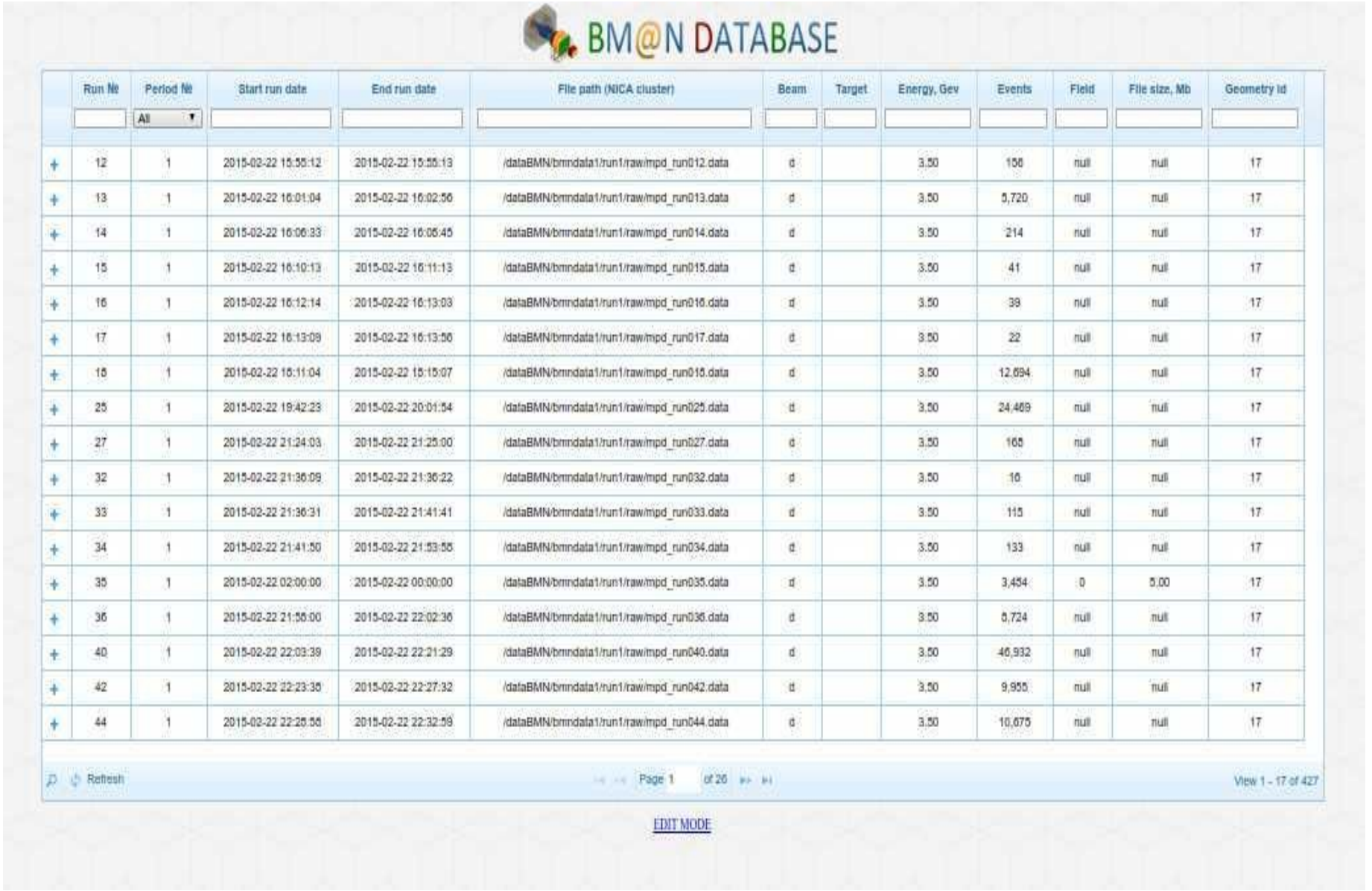
- ✔ UrQMD
- ✔ QGSM
- ✔ pHSD

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

- 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



Runs configuration databases



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 16:11:04	2015-02-22 16:15:07	/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 21:53:55	/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

BM@N 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 — Logo

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

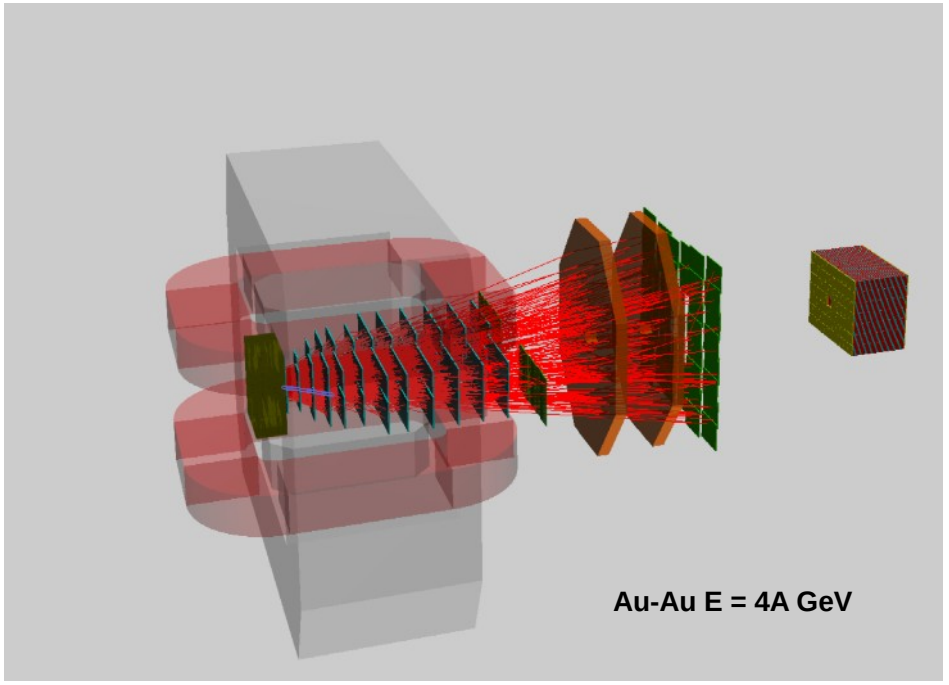
Date	Shift Leader	Type	№ Run	Trigger	DAQ Status	SP-41, A	SP-57, A	VKM2, A	Beam	Energy, GeV	Target	Comment
2018-03-07 08:14:09	Dryablov	New Run	2487 per.7	SRCT2 Full Trigger = IT & (X1 & Y1) & (X2 & Y2)	All in except ECal and CSC	1800	0	0	C	3.17	H2 (300 mm)	IT=BC1&BC2&VC&SRC(AND), beam 2x10^5 beam duration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

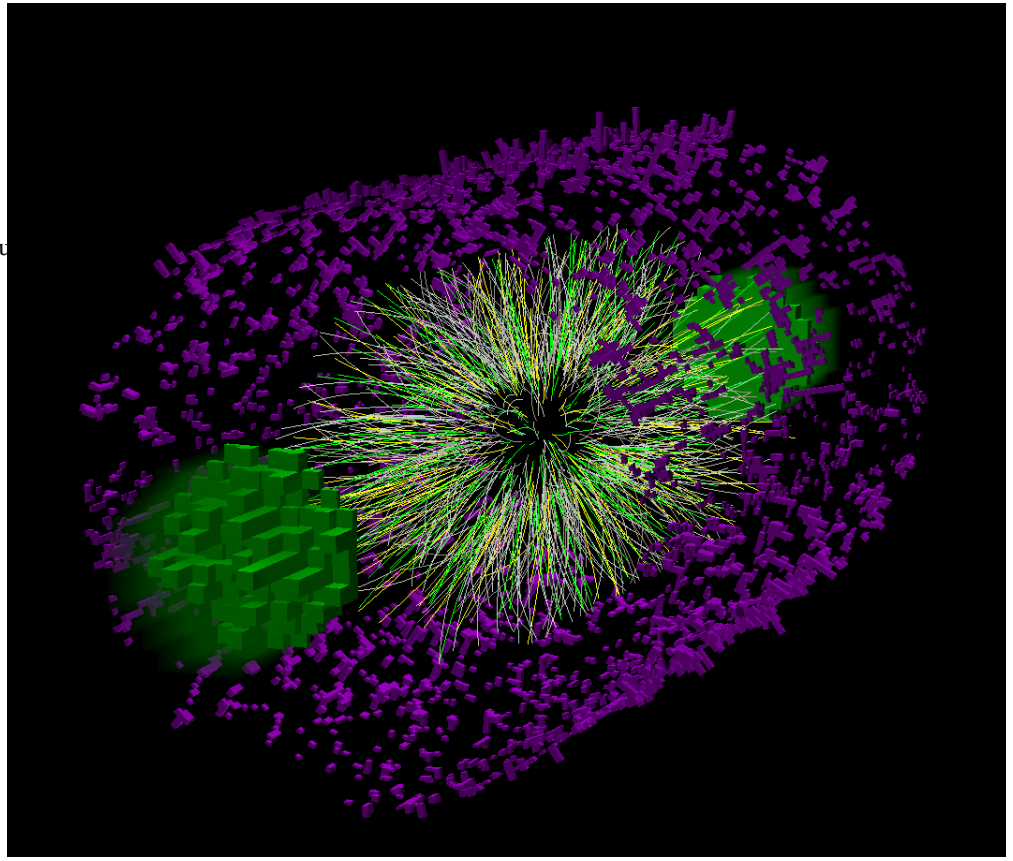
Event Display for the NICA experiments

based on EVE package



BM@N event :
Reco tracks

MPD event:
TPC reco tracks, FHCal and EMC towers
AuAu 11 GeV

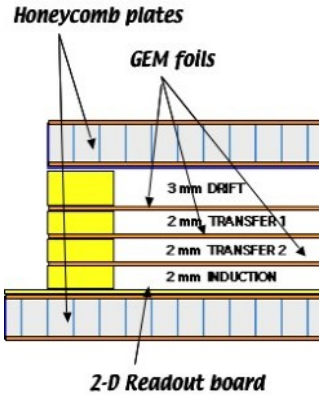


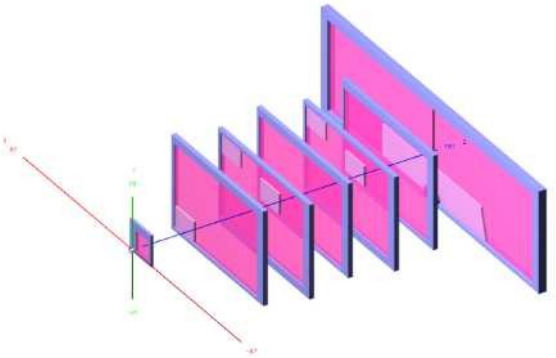
Clustering in GEM

- There are realistic hit finder in GEMs

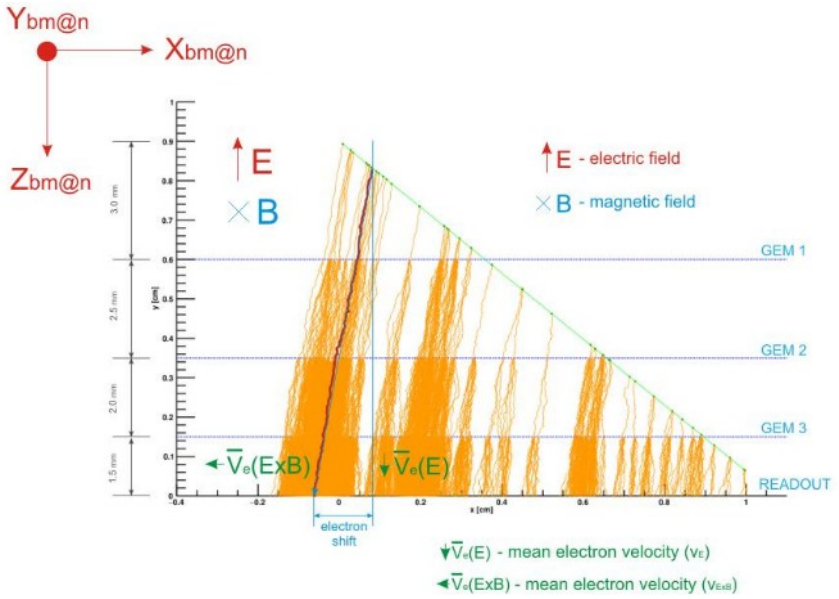
  (Garfield)

- For the GEM stations procedure of the fake hits production is implemented

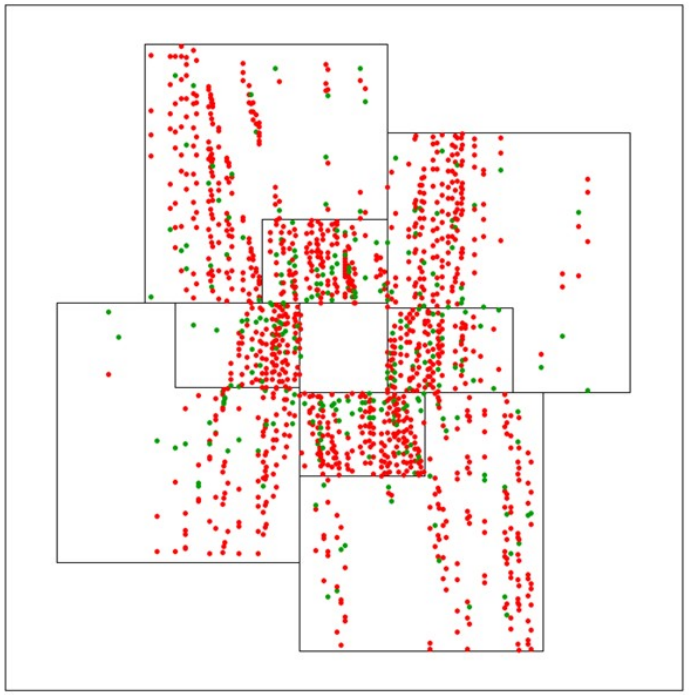




Station 0 (what is it)



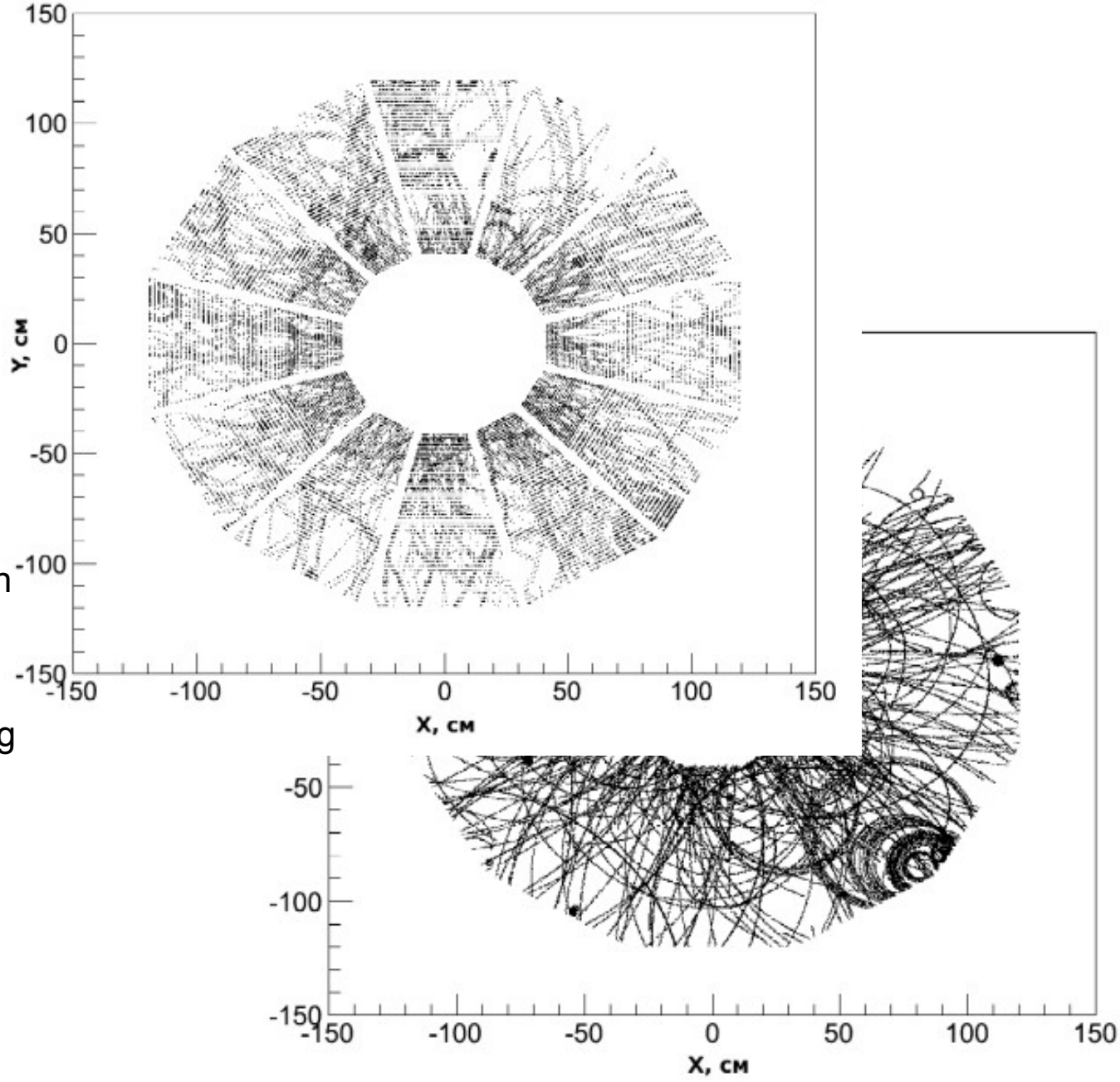
electron avalanches in the BM@N GEM chamber



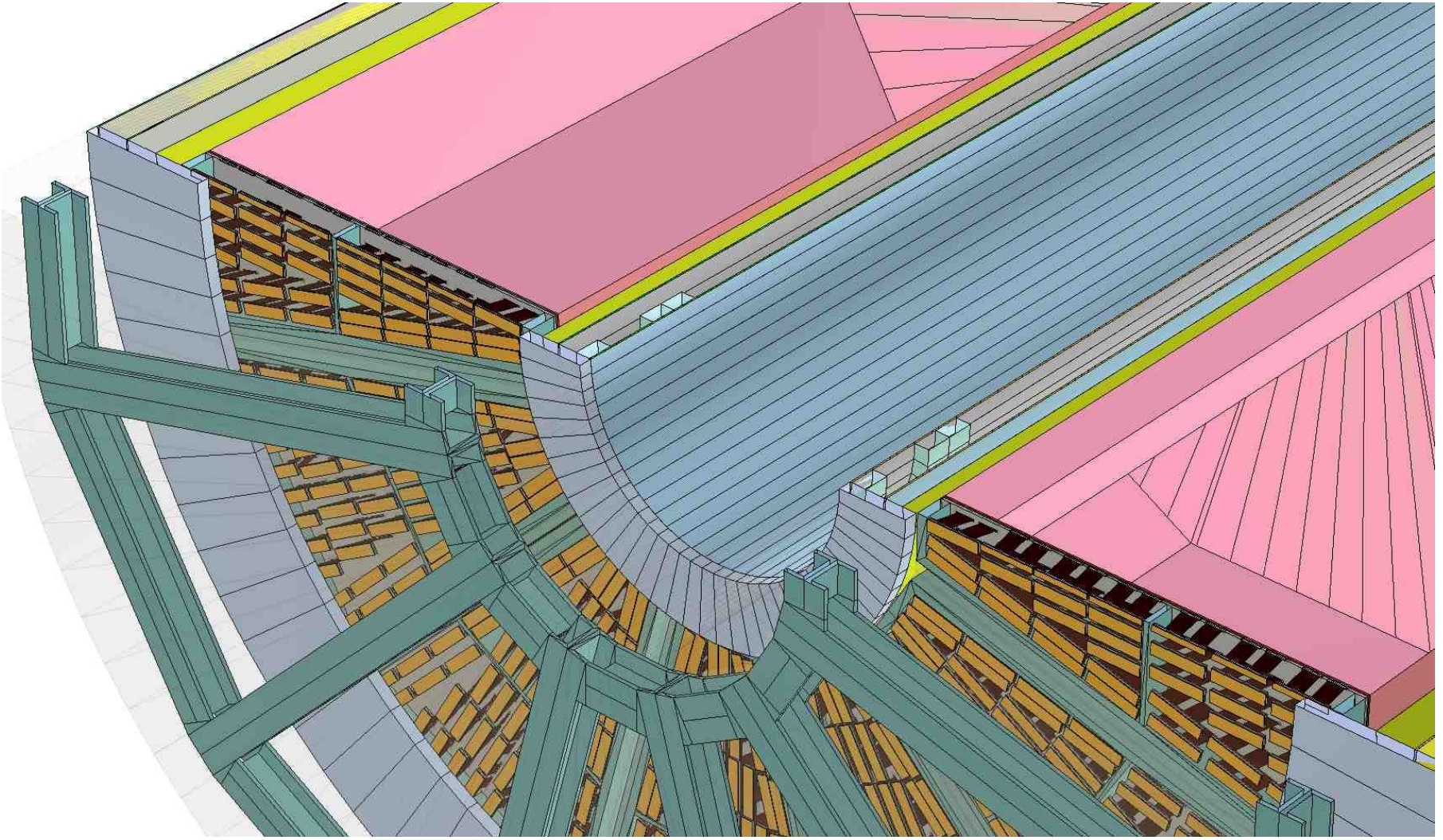
Realistic clustering in MPD TPC

The hit reconstruction algorithm contains the following main steps:

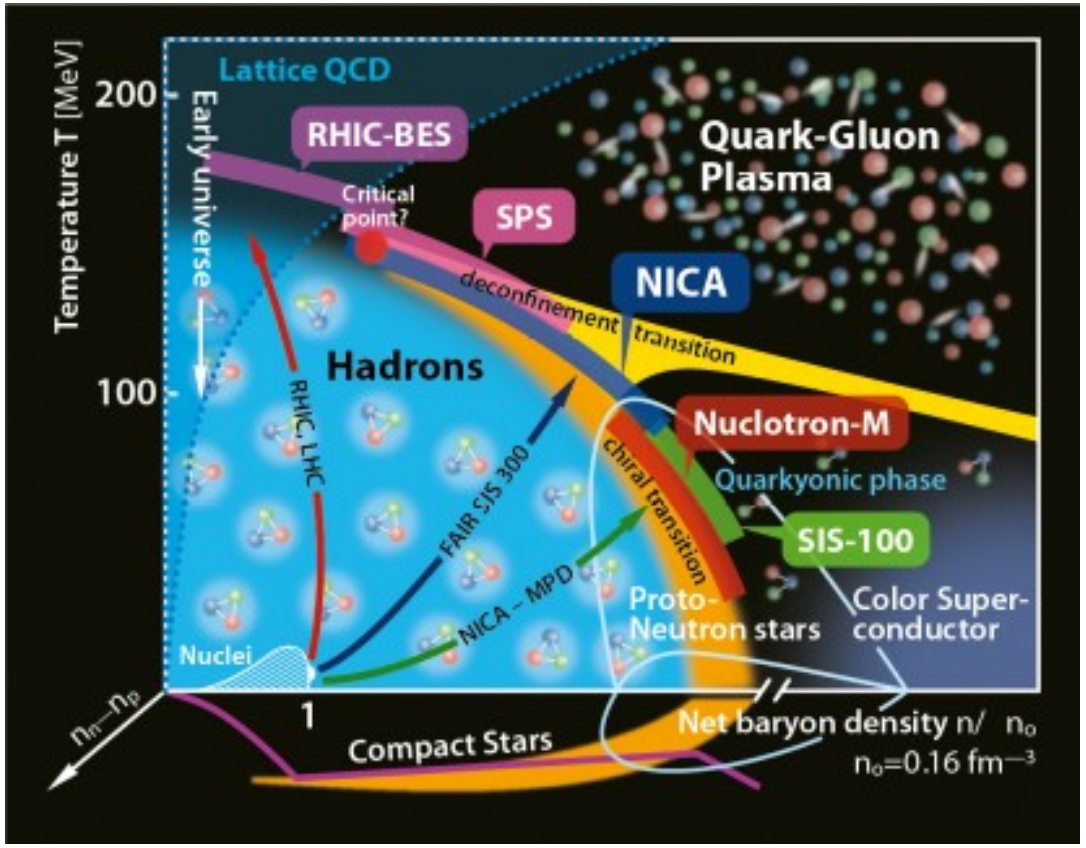
1) Searching for extended clusters in (Pad-Time) for each pad raw.
2) Searching for peaks in time-profile for each pad in the found extended cluster.
3) Combining the neighboring peaks into resulting hits.

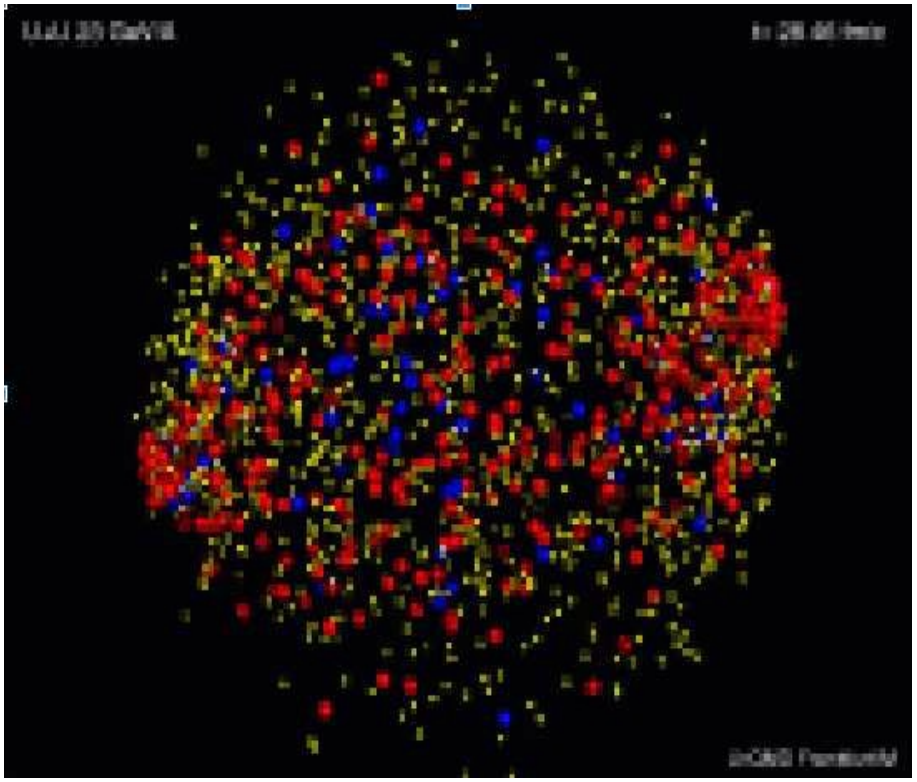


Towards realistic TPC geometry



Physics analyses





Simulations

Hot NICA topics for HPC

- Physical generators
  Monte-Carlo simulations with different physics input

- Detectors simulation
  detailed detector description with realistic detector response
- Tracks reconstruction
  high efficiency for finding tracks with different methods
  (deep learning & etc.) ~ 1000 tracks in event

- BigData analysis
  > 10^{10} events, 1min/ev, ~2 years on our today resources
  Multicore & multithreads computing
  BigPanDA & GRID
  Clouds and cloud services

NICA center

Thank for your attention