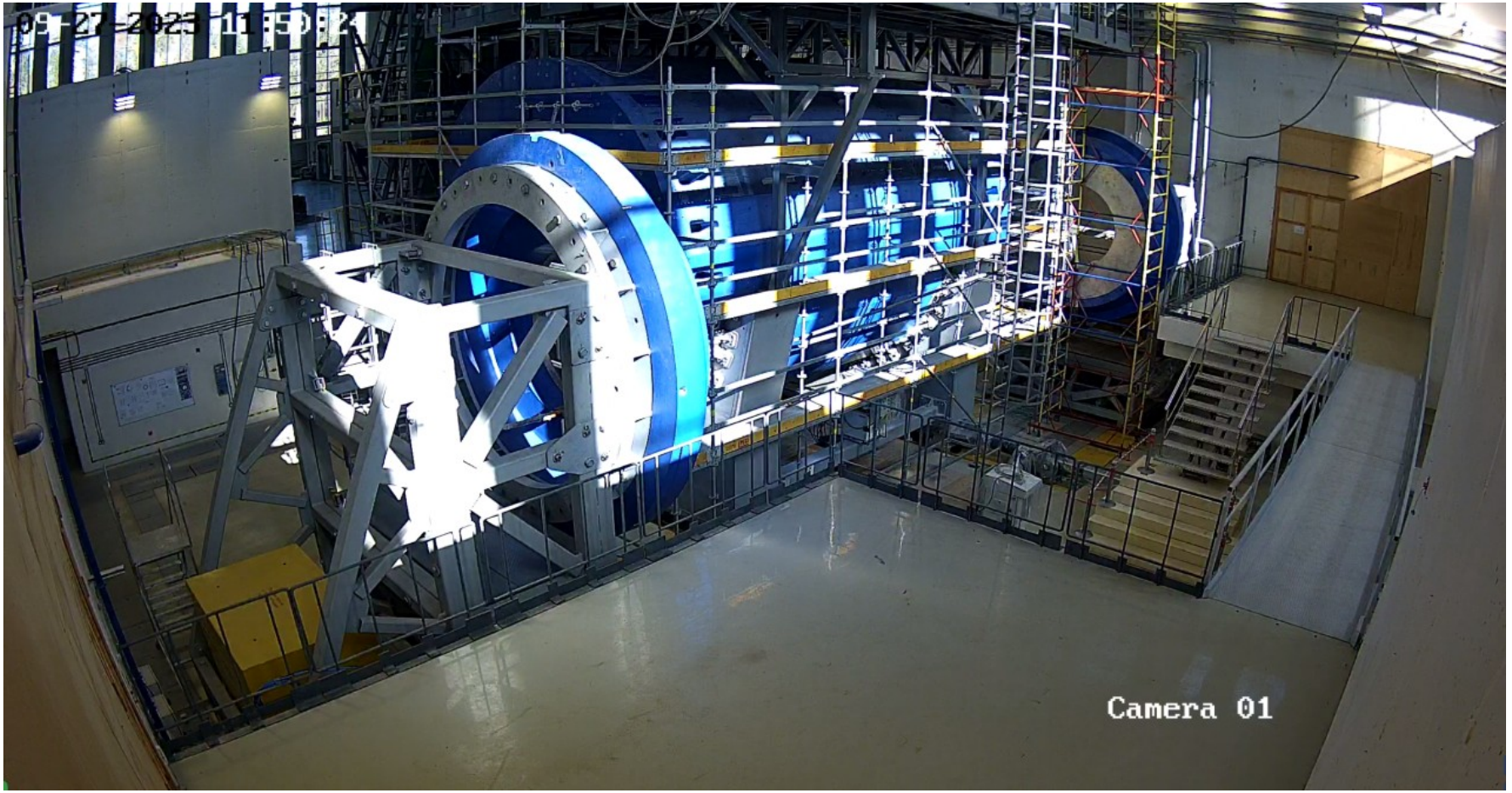
MPD computing

ROGACHEVSKY Oleg for MPD
JINR

April 12 2024
Dubna

MPD in place



Nuclotron based Ion Collider fAcility

Beams – p,d(h)..$^{197}Au^{79+}$

Collision energy √s= **4 - 11** GeV/u , **12 - 27** (p)

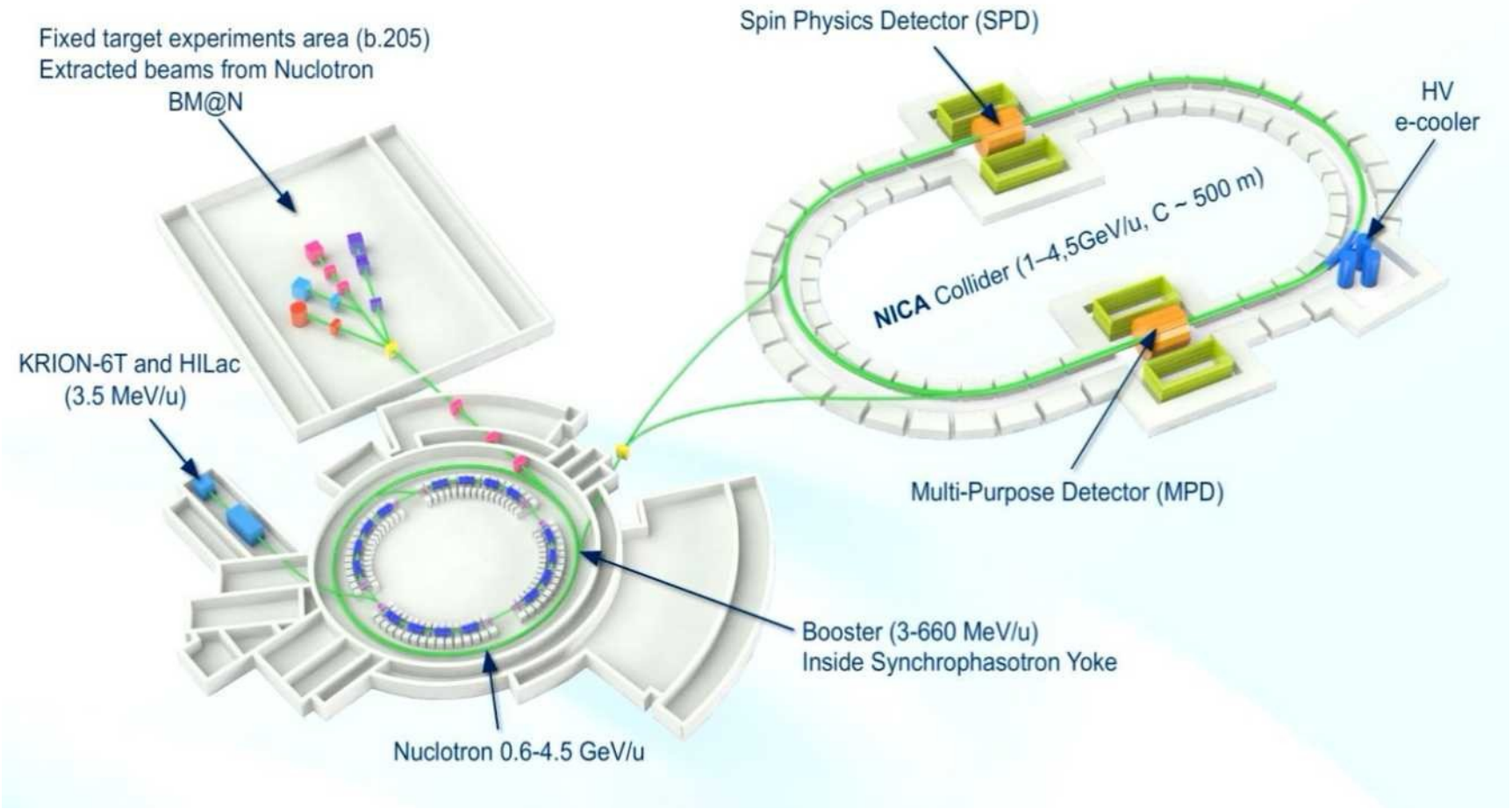
Beam energy (fixed target) - **1-6** GeV/u

Luminosity: 10^{27} $cm^{-2}s^{-1}$(Au), 10^{32} (p)

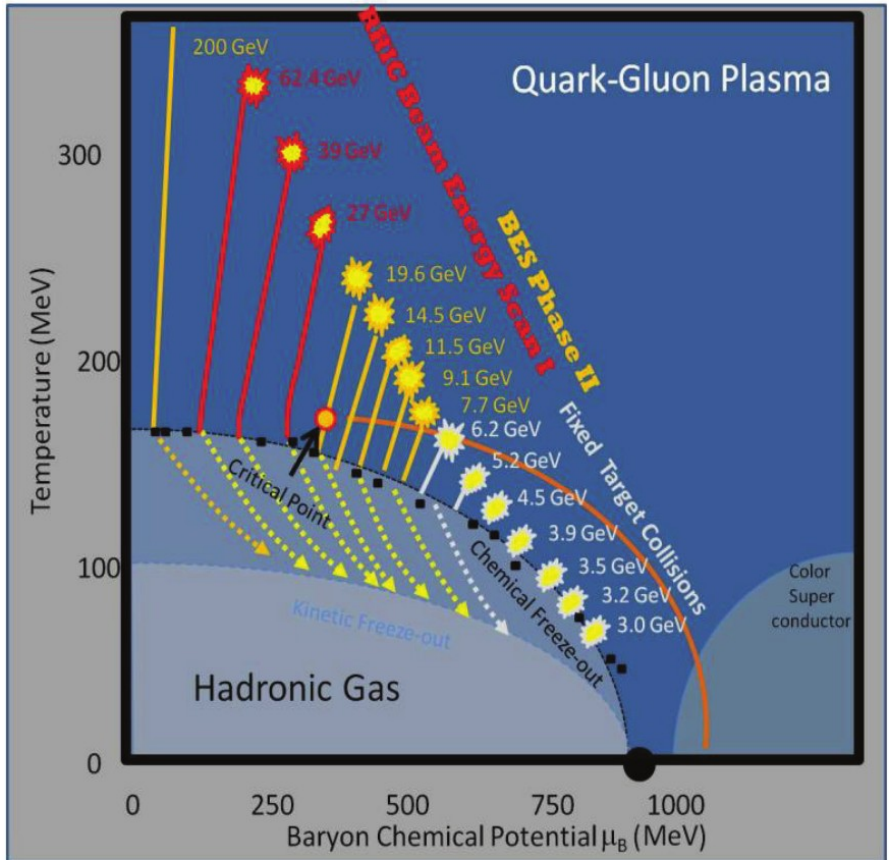
Experiments:

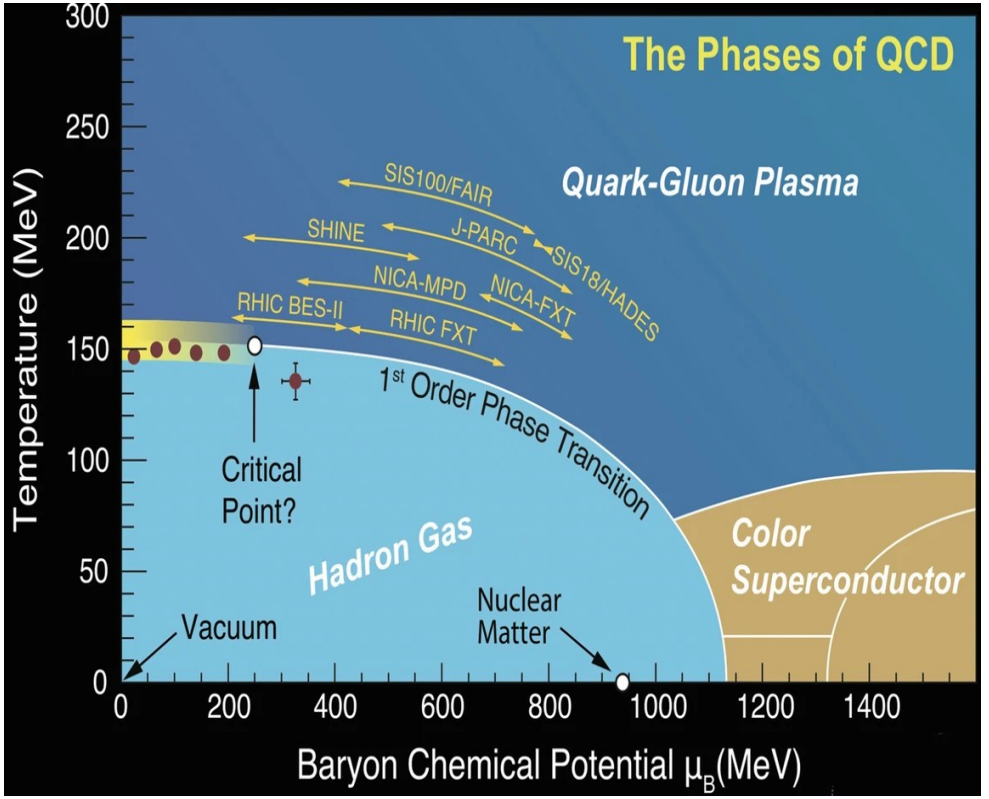
2 Interaction points – **MPD** and SPD

Fixed target experiment **BM@N**



QCD phase diagram @ NICA energies





QGP signatures

The particular observables that STAR has identified as the essential drivers of our run plan are:

Constituent-quark-number scaling of v_2 , indicating partonic degrees of freedom;
Hadron suppression in central collisions as characterized by the ratio R_{CP} ;
Untriggered pair correlations in the space of pair separation in azimuth and pseudorapidity, which elucidate the ridge phenomenon;
Local parity violation in strong interactions, an emerging and important RHIC discovery in its own right, is generally believed to require deconfinement, and thus also is expected to turn-off at lower energies.

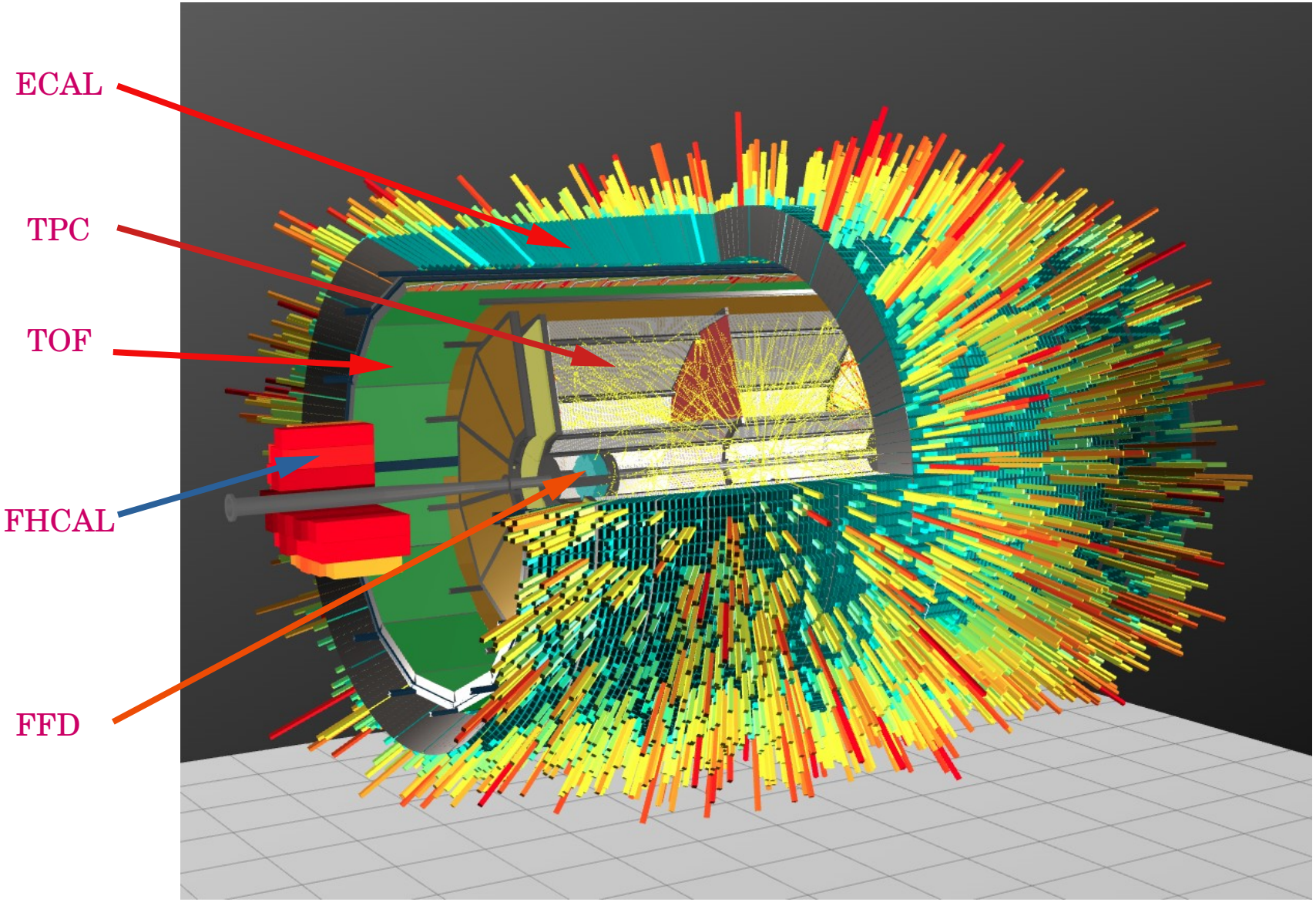
A search for signatures of a phase transition and a critical point. The particular observables that we have identified as the essential drivers of our run plan are:

Elliptic & directed flow for charged particles and for identified protons and pions, which have been identified by many theorists as highly promising indicators of a “softest point” in the nuclear equation of state;
Azimuthally-sensitive femtoscopy, which adds to the standard HBT observables by allowing the tilt angle of the ellipsoid-like particle source in coordinate space to be measured; these measurements hold promise for identifying a softest point, and complements the momentum-space information revealed by flow measurements, and
Fluctuation measures, indicated by large jumps in the baryon, charge and strangeness susceptibilities, as a function of system temperature – the most obvious expected manifestation of critical phenomena.

STAR data BES II program

$\sqrt{s_{NN}}$ (GeV)	Beam Energy (GeV/nucleon)	Collider or Fixed Target	$y_{center\ of\ mass}$	μ_B (MeV)	Run Time (days)	No. Events Collected (Request)	Date Collected
200	100	C	0	25	2.0	138 M (140 M)	Run-19
27	13.5	C	0	156	24	555 M (700 M)	Run-18
19.6	9.8	C	0	206	36	582 M (400 M)	Run-19
17.3	8.65	C	0	230	14	256 M (250 M)	Run-21
14.6	7.3	C	0	262	60	324 M (310 M)	Run-19
13.7	100	FXT	2.69	276	0.5	52 M (50 M)	Run-21
11.5	5.75	C	0	316	54	235 M (230 M)	Run-20
11.5	70	FXT	2.51	316	0.5	50 M (50 M)	Run-21
9.2	4.59	C	0	372	102	162 M (160 M)	Run-20+20b
9.2	44.5	FXT	2.28	372	0.5	50 M (50 M)	Run-21
7.7	3.85	C	0	420	90	100 M (100 M)	Run-21
7.7	31.2	FXT	2.10	420	0.5+1.0+ scattered	50 M + 112 M + 100 M (100 M)	Run-19+20+21
7.2	26.5	FXT	2.02	443	2+Parasitic with CEC	155 M + 317 M	Run-18+20
6.2	19.5	FXT	1.87	487	1.4	118 M (100 M)	Run-20
5.2	13.5	FXT	1.68	541	1.0	103 M (100 M)	Run-20
4.5	9.8	FXT	1.52	589	0.9	108 M (100 M)	Run-20
3.9	7.3	FXT	1.37	633	1.1	117 M (100 M)	Run-20
3.5	5.75	FXT	1.25	666	0.9	116 M (100 M)	Run-20
3.2	4.59	FXT	1.13	699	2.0	200 M (200 M)	Run-19
3.0	3.85	FXT	1.05	721	4.6	259 M -> 2B(100 M -> 2B)	Run-18+21

MPD experiment 1-st stage

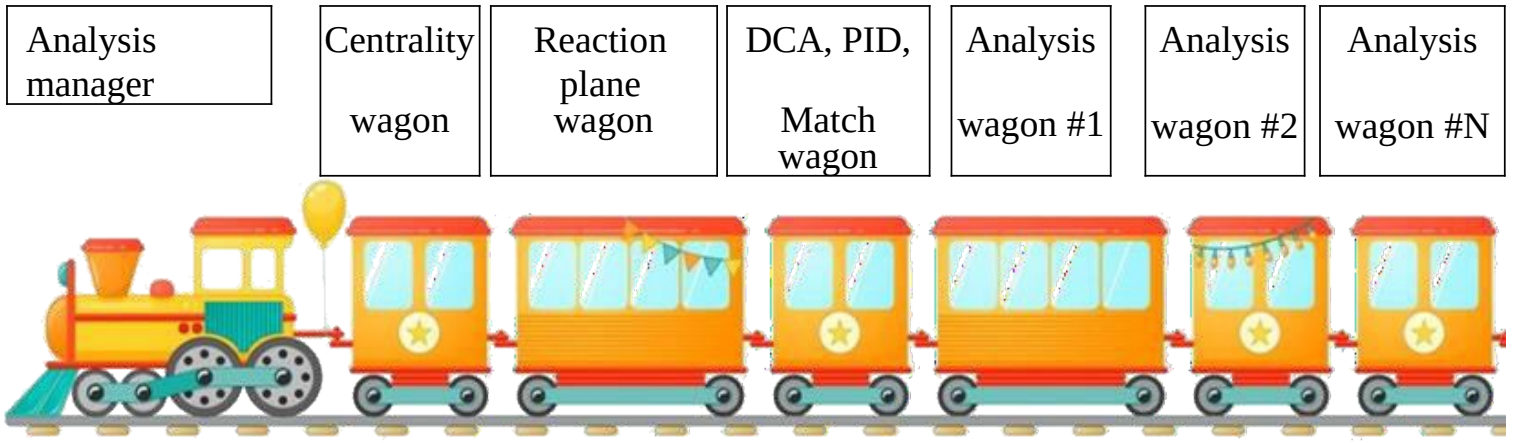


MC data set for MPD physics

Generator	PWG	Coll.		# of events (10^6)	Reconstruction
UrQMD	PWG4	AuAu	11	15	+
		BiBi	9	10	+
			9.46	10	+
			9.2	95	+
	PWG2	AuAu	11	10	+
	PWG3	AuAu	7.7	10	+
		BiBi	7.7	10	+
			9	15	+
		pp	9	10	+
		BiBi fix target	2.5	12	+
		BiBi fix target	3.0	12	+
		BiBi fix target	3.5	12	+
	PWG1	BiBi	9.2	61	+
DCM-SMM	PWG1	BiBi	9.2	1	+
PHQMD	PWG2	BiBi	8.8	15	+
			9.2	61	+
			2.4/3.0/4.5	10/10/2	-
vHLLE-UrQMD	PWG3	BiBi	11.5	15	+
		AuAu	11.5	15	+
		AuAu	7.7	20	+
		BiBi	9.2	48	+
Smash	PWG1	BiBi	9.46	10	+
		ArAr	4/7/9/11	20/20/20/20	-
		AuAu	4/7/9/11	20/20/20/22	-
		XeXe	4/7/9/11	20/20/20/20	-
		CC	4/7/9/11	20/20/20/20	-
		pp	4/7/9/11	50/50/50/50	-
JAM	PWG3	AuAu	3/3.3/3.5/3.8/4.0/4.2/4.5/5	40/40/40/40/40/40/40/40	
DCM-QGSM-SMM	PWG3	AuAu	4/9.2	5/5	+
		AgAg	4/9.2	5/5	+
		BiBi	4/9.2	5/6	+
PHSD		BiBi	9/9.2	25	+
Total				1367	523

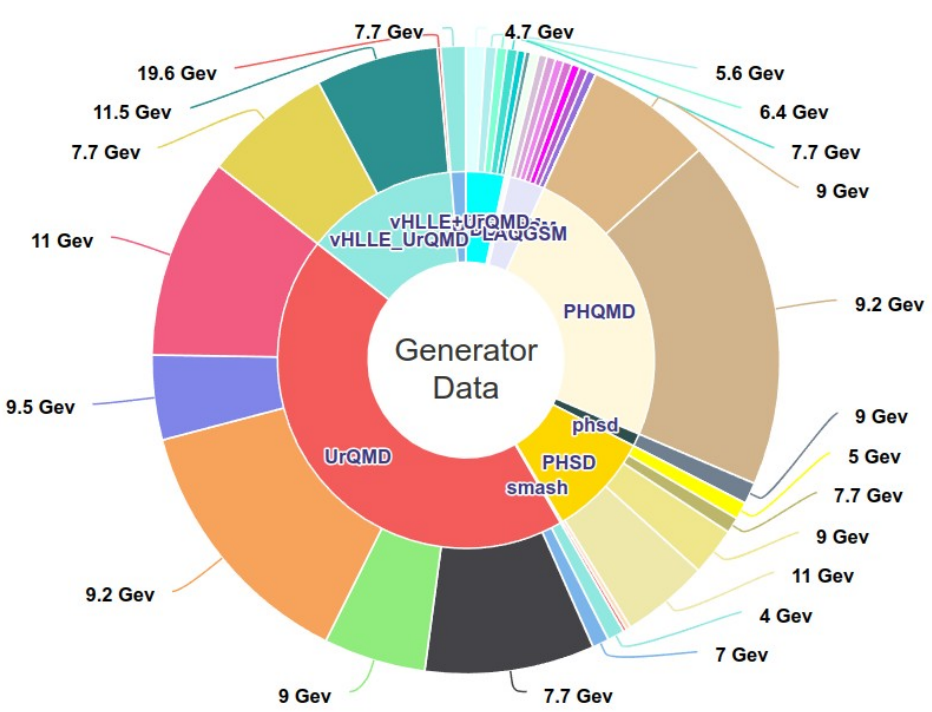
Handling the big data sets

- **Centralized Analysis Framework for access and analysis of data:**
  - ✓ **consistent approaches and results across collaboration, easier storage and sharing of codes and methods**
  - ✓ **reduced number of input/output operations for disks and databases, easier data storage on tapes**
- **Analysis manager reads event into memory and calls wagons one-by-one to modify and/or analyze data:**

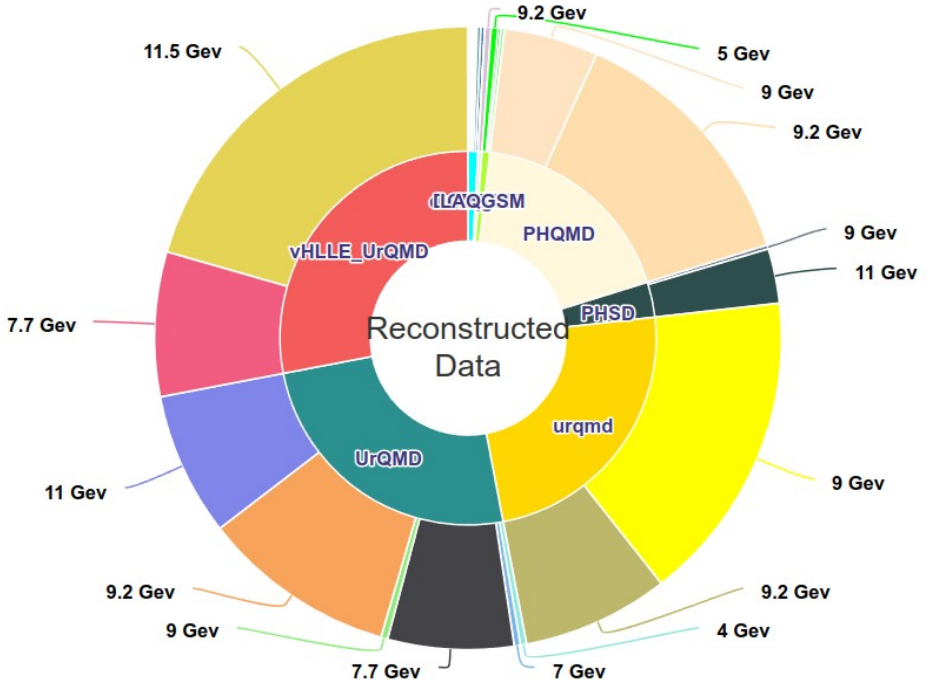


MPD data mass production

MC events
> 1300M



Reconstructed events
> 500M



ЛАБОРАТОРИЯ ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ имени М.Г. Мещерякова

hYBRI LIT/JINR

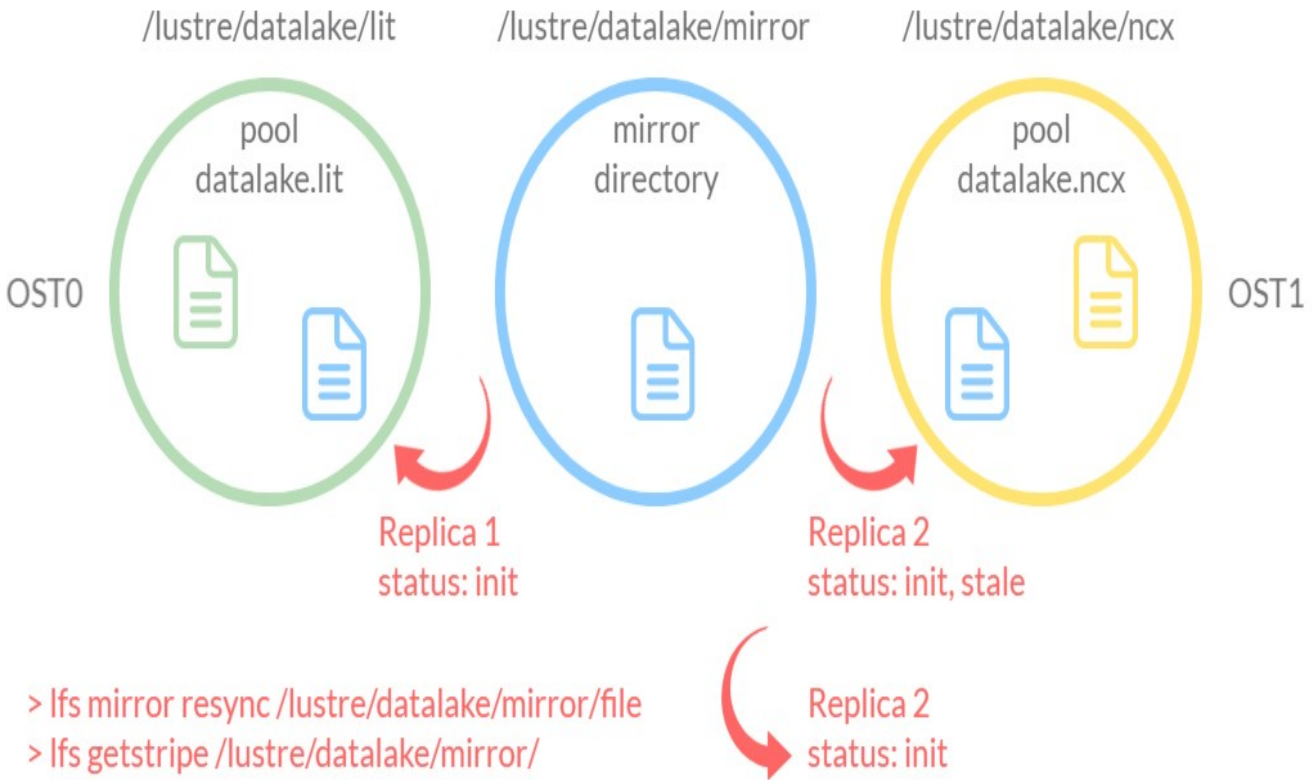
NICA

lustre

LHEP ЛФВЭ

Distributed system for processing and data storage for experiments at the Complex NICA

MLIT Team
Belyakov D.V., Dolbilov A.G., Kokorev A.A., Lyubimova M.A., Pelevanuk I.S., Podgainy D.V.



LHEP Team
Moshkin A.A., Rogachevsky O.V., Slepov I.P.

MLIT servers

2x
Dell PowerEdge R730xd

2x 160 TB, SAS

Motherboard	PowerEdge R730/R730xd System Board
Processor	2x Intel Xeon E5-2660 v4 @ 2.00 GHz
Memory	8x Micron DDR4 2400 MHz, 16 GB (128 GB)
RAID	Dell PERC H730P
Disk	2x Dell MFC6G (Samsung) SSD SAS, 400 GB (2x 400 GB) 16x HGST UltraStar HE10 SAS, 10TB (160 TB)
Network	Dell 99GTM (Intel X540-T2 2x 10 Gb/s + Intel I350 Dual Port 2x 1 Gb/s)
Power	2x 750W Redundant Power Supply

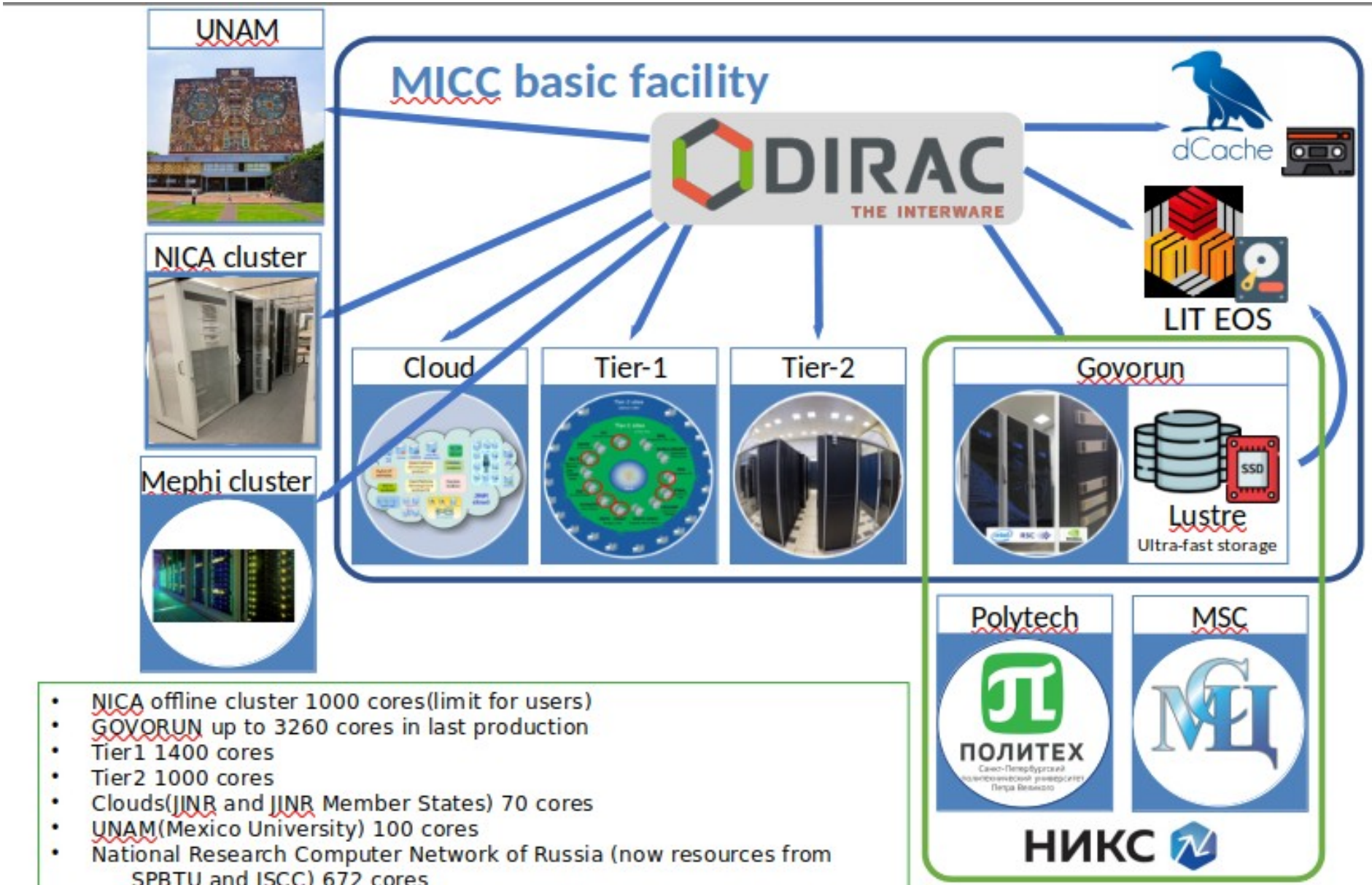
Data flow rates 100 Gbps

LHEP servers

2x
Supermicro SSG 1029P-NEL32R

2x 244.8 TB, NVMe (Rulers)

Motherboard	Supermicro X11DPS-RE
Processor	2x Intel Xeon Gold 6230R @ 2.10 GHz
Memory	12x Samsung DDR4 2993 MHz, 64 GB (768 GB)
Disk	2x Apacer SSD NVME m.2 , 512 GB (2x 512 GB) 16x Intel DC P4510 SSD NVME (Ruler), 15.3TB (244.8 TB)
Network	Intel X550-T Dual Port 2x NVidia (Mellanox MT27800) ConnectX-5 Dual Port 2x 100 Gb/s Ethernet
Power	2x 1600W Redundant Power Supply



- NICA offline cluster 1000 cores(limit for users)
- GOVORUN up to 3260 cores in last production
- Tier1 1400 cores
- Tier2 1000 cores
- Clouds(JINR and JINR Member States) 70 cores
- UNAM(Mexico University) 100 cores
- National Research Computer Network of Russia (now resources from SPBTU and JSCC) 672 cores

Mass production storages integrated in Dirac File Catalog have size 4,2 PB.

Software deployment

Problems with usual approach

- too much effort to prepare MPDRoot environment for regular users (physicist) - users tend to use same old version of MPDRoot for long time mixed versions of installed dependencies on users computers hard to keep track on dependencies
- projects on which MPDRoot depends are installed inside MPDRoot instead of being linked to
- macro directory contains users (non-general) macros as well as unsupported ones
- macros rely on variable $VMCWORKDIR shared across multiple FairRoot-based projects

New approach advantages

- any NICA project (BM@N, SPD) can join - one needs only to create proper recipe files
- if necessary, defaults can be fixed according to the project needs (e.g. each project can use different FairRoot version)
- it is easy to test build with upcommig versions of dependent projects
- it is easy to link multiple projects (split them to parts reusable by individual software packages)
- possibility of creating user specific tags

Resources for MPD
(Rough estimations)

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Total
$N_{\text{raw events}}$ $[10^6]$	100	150	165	181	200	220	240	266	292	322	355	2500
Storage space [PB]	1.2	1.7	1.9	2.1	2.4	2.5	2.8	3.1	3.4	3.7	4.1	29
CPU time [1000 years]	0.6	1.0	1.1	1.2	1.3	1.4	1.5	1.7	1.9	2.0	2.3	15.9

Event size = 1.5 MB(raw data) + 2*2.5 MB(DST data) + N_{gen}*2.5 MB(sim. Data)

Thanks For Attention