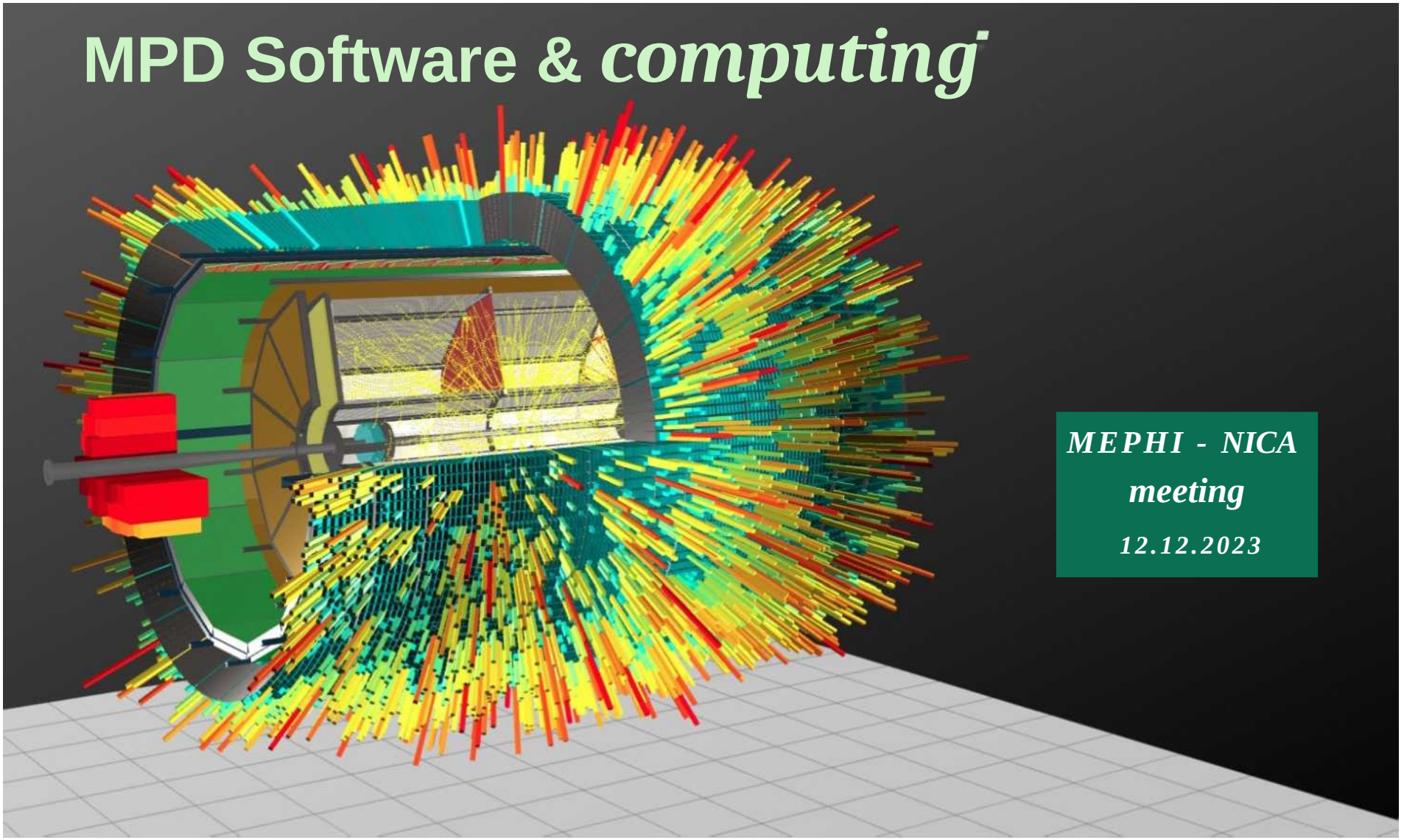
MPD Software & *computing*



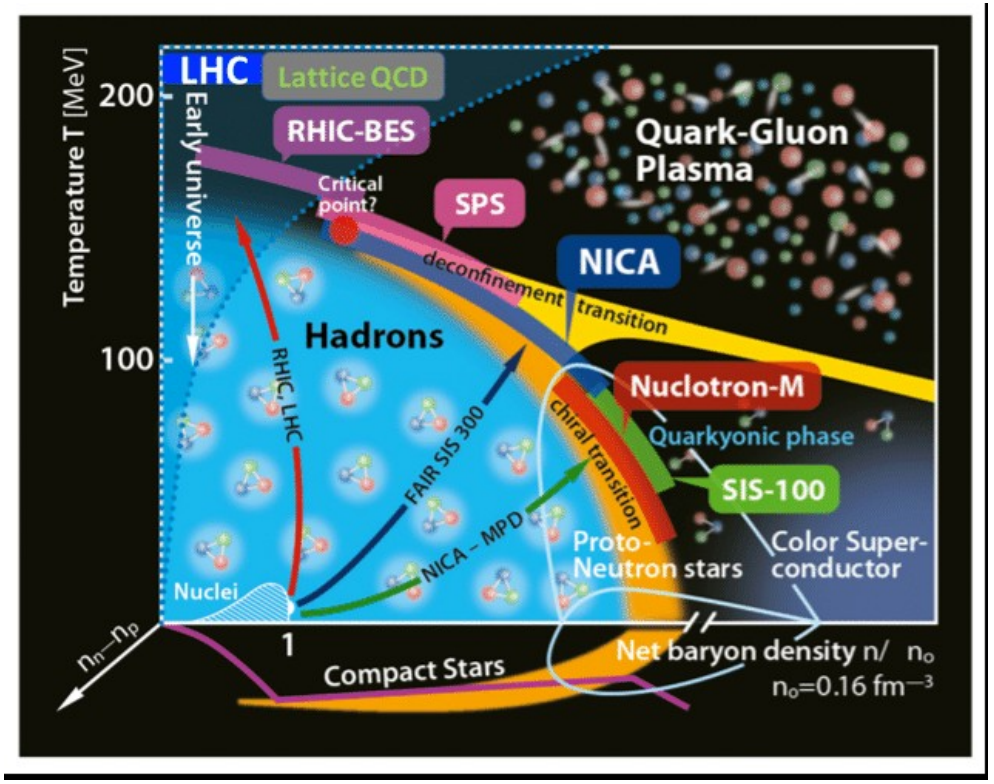
MEPHI - NICA meeting

12.12.2023

Rogachevsky Oleg
for MPD collaboration

rogachevsky@jinr.ru

Goal: QGP phase diagram



The collision of two heavy nuclei which approach and smash against each other with almost the speed of light. According to Einstein's theory of special relativity they look like thin pancakes. This "Little Bang" creates in the laboratory the primordial state of matter, called Quark-Gluon Plasma (QGP). The QGP expands like a fireball, cools and finally turns into ordinary matter, not unlike vapour turning into water

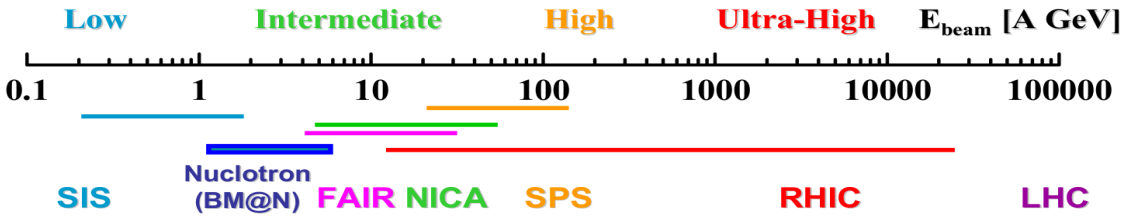
The thousands of particles produced will be recorded by detectors. The tracks that those particles leave in the detectors will be analysed by modern powerful software tools.

The challenge is to infer the properties of the QGP state of matter by studying the different particles that arrive in the detectors.

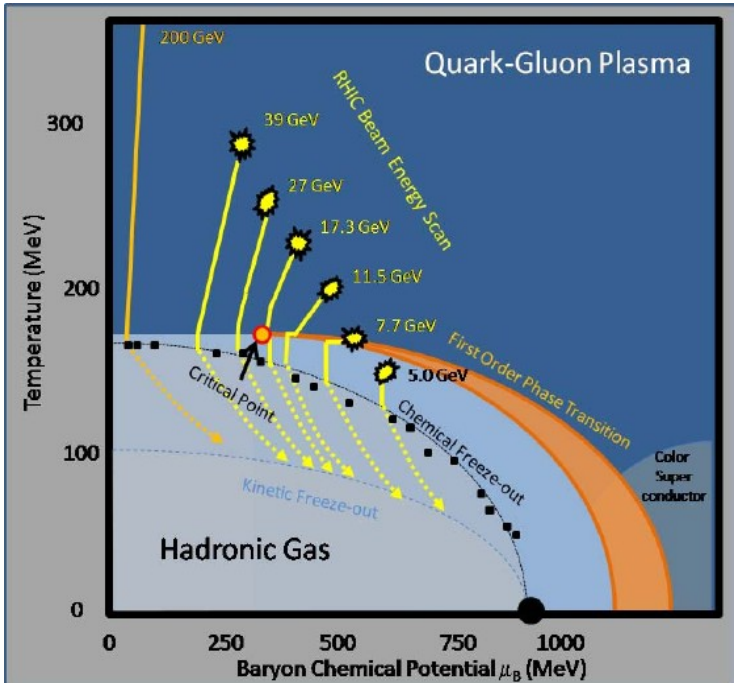
Current & future HIC experiments

Facility	SPS	RHIC BES II	Nuclotron-M	NICA	SIS/100	LHC
Laboratory	CERN Geneva	BNL Brookhaven	JINR Dubna	JINR Dubna	FAIR GSI Darmstadt	CERN Geneva
Experiment	NA61 SHINE	STAR PHENIX	BM@N	MPD	CBM	ALICE ATLAS, CMS LHCb
Start of data taking	2011	2010	2015	2025	2025	2009
$\sqrt{s_{NN}}$ (GeV)	4.9 – 17.3	7.7 – 200	< 3.5	4 - 11	2.3 – 4.5	up to 14000
Physics	CP & OD	CP & OD	HDM	OD & HDM	OD & CP	PDM

CP — critical point
OD — onset of deconfinement, 1st order phase transition
HDM — hadrons in dense matter
PDM — properties of deconfined matter



STAR Beam Energy Scan (2005)



BES-Short-v8.3_0

Experimental Study of the QCD Phase Diagram and Search for the Critical Point: Selected Arguments for the Run-10 Beam Energy Scan at RHIC

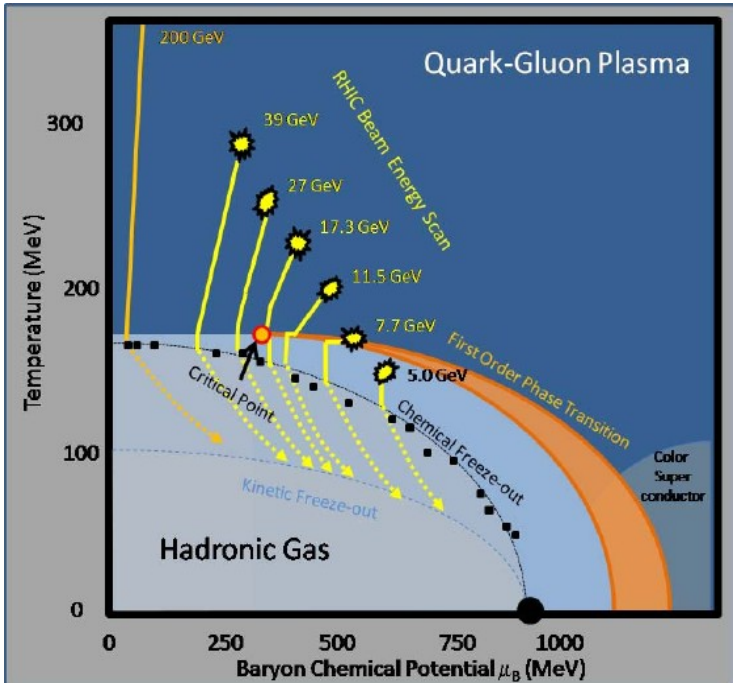
The STAR Collaboration (B. I. Abelev et al.)

Introduction & Summary

We present an overview of the main ideas that have emerged from discussions within STAR for the Beam Energy Scan (BES). The formulation of this concise and abridged document is facilitated by the existence of a much longer and more comprehensive companion document entitled Experimental Exploration of the QCD Phase Diagram: Search for the Critical Point [1].:

A search for turn-off of new phenomena already established at higher RHIC energies; QGP signatures are the most obvious example, but we define this category more broadly. If our current understanding of RHIC physics and these signatures is correct, **a turn-off must be observed in several signatures, and such corroboration is an essential part of the "unfinished business" of QGP discovery.**

STAR BES I program



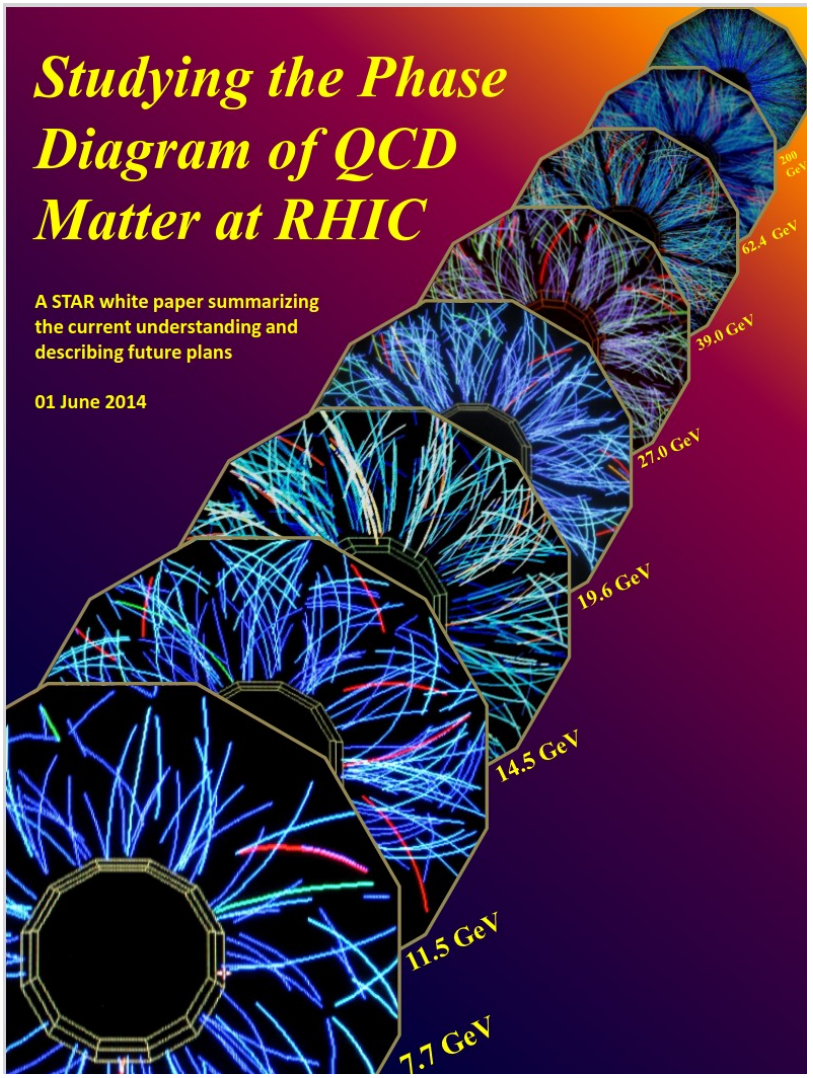
I

$\sqrt{s_{NN}}$ (GeV)	μ_B (MeV)	MinBias Events (10^6)	Time (weeks)	Year
7.7	420	4.3	4	2010
11.5	315	11.7	2	2010
14.5	**260**	**24.0**	**3**	**2014**
19.6	205	35.8	1.5	2011
27.0	155	70.4	1	2011
39.0	115	130.4	2	2010
62.4	70	67.3	1.5	2010

II

$\sqrt{s_{NN}}$ (GeV)	μ_B (MeV)	Needed Events (10^6)
7.7	420	100
9.1	370	160
11.5	315	230
14.5	**260**	**300**
19.6	205	400

STAR BES II program



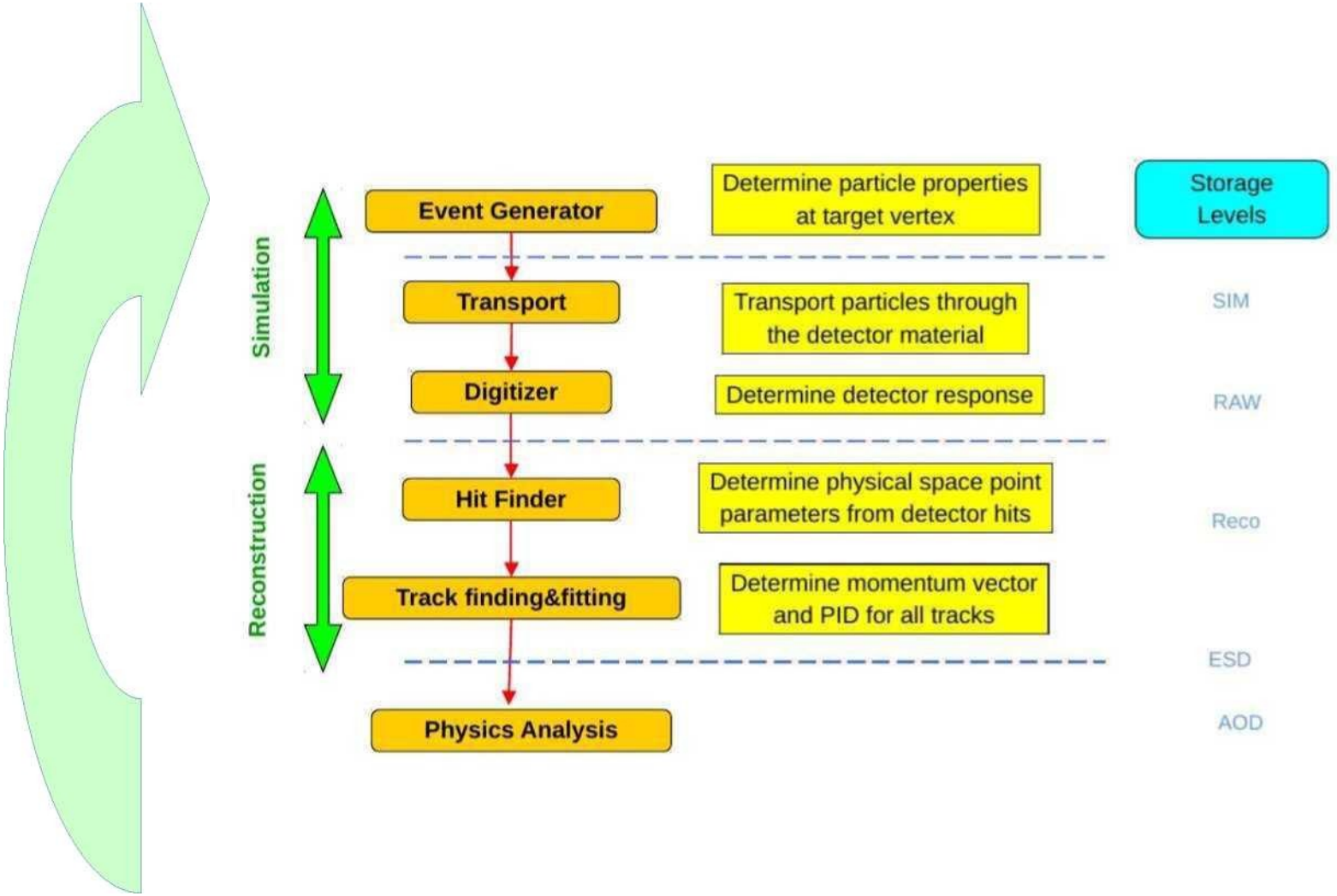
$\sqrt{s_{NN}}$ (GeV)	Beam Energy (GeV/nucleon)	Collider or Fixed Target	$y_{center\ of\ mass}$	μ_B (MeV)	Run Time (days)	No. Events Collected (Request)	Date Collected
200	100	C	0	25	2.0	138 M (140 M)	Run-19
27	13.5	C	0	156	24	555 M (700 M)	Run-18
19.6	9.8	C	0	206	36	582 M (400 M)	Run-19
17.3	8.65	C	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

Megaproject MPD/NICA

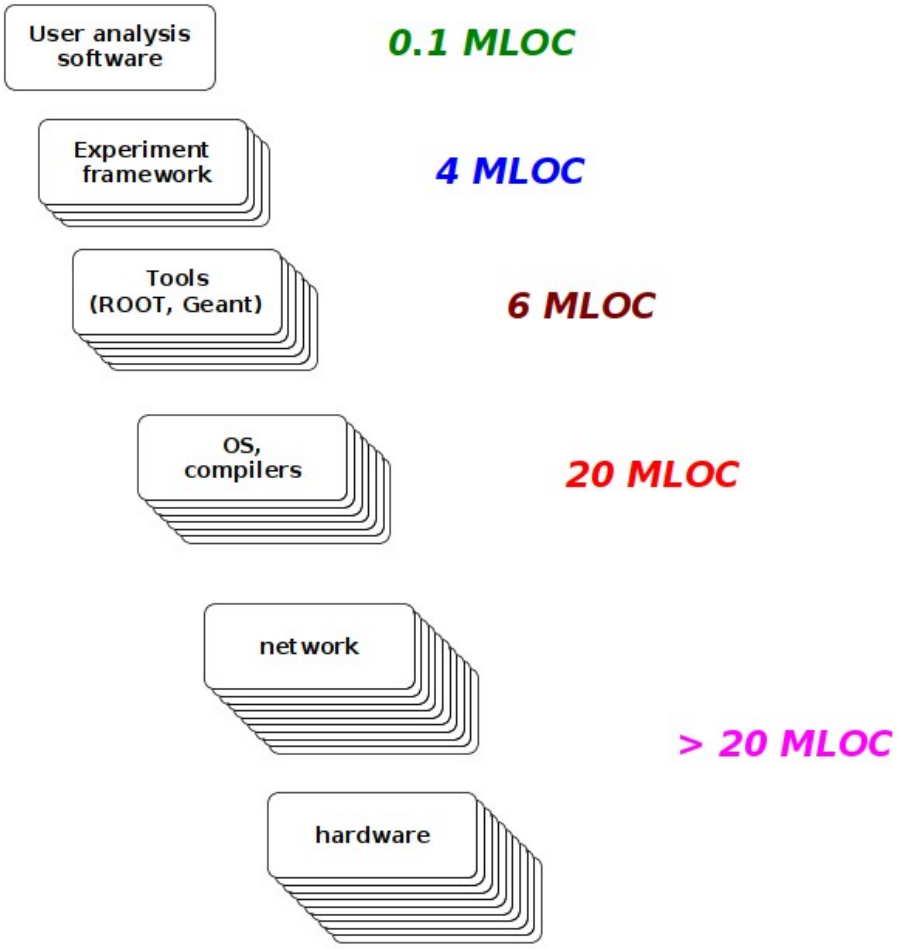
NICA collider

HEP experiments data flow

Simulation is the third way to scientific knowledge after **theory** and **experiment**



Software size hierarchy

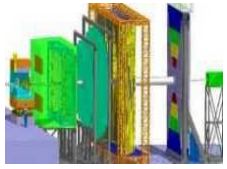


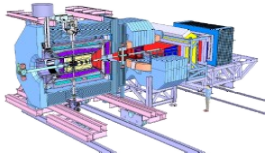
FairRoot based frameworks

Start testing the VMC concept for CBM

2004

First Release of CbmRoot



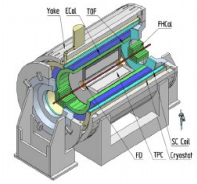


Panda decided to join FairRoot:

same base package for different experiments

2006

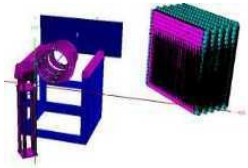
MPD (NICA) start using MPDRoot

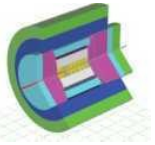


R3B joined

2010

ASYEOS joined (ASYEOSRoot)



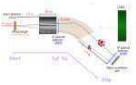


EIC (Electron Ion Collider BNL)

EICRoot

2011

GEM-TPC seperated from PANDA branch (FOPIRoot)



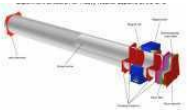
SOFIA (Studies On Fission with Aladin)

2012

ENSAR-ROOT

Collection of modules used by structural nuclear physics exp.

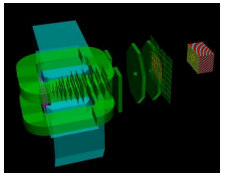
2013

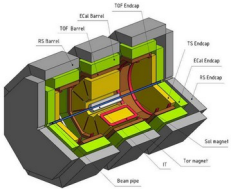


SHIP - Search for HIdden Particles

2014

BMNRoot



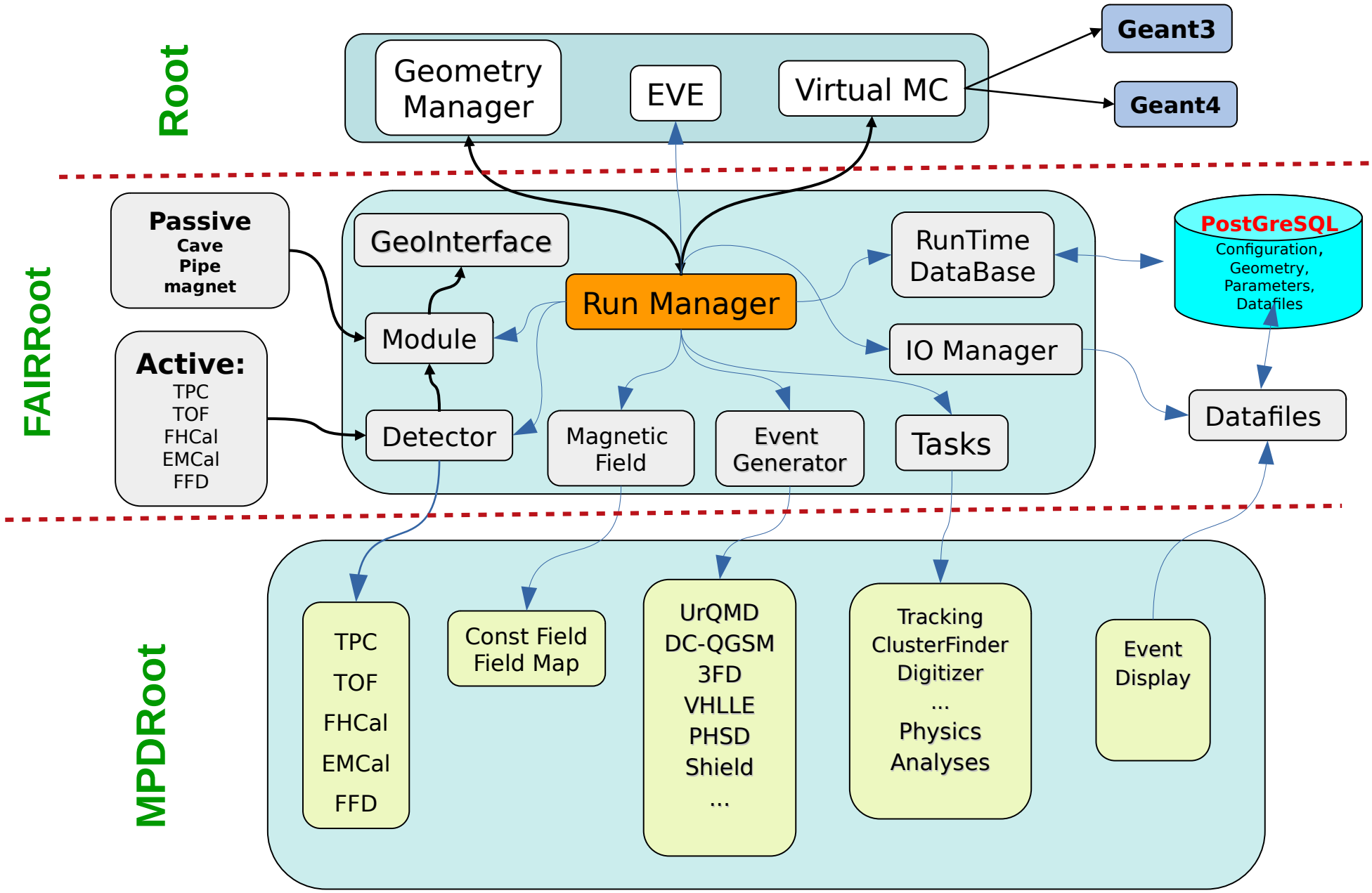


SPDRoot

2015

2016

MpdRoot structure



MPDroot development

SOFTWARE ENGINEERING

PRODUCT DEVELOPMENT

- R&D valid concepts integrated into whole
- Not in conflict with existing development
  - User/developer friendliness
  - Extensible
  - Maintainable
- Not requiring unmanageable (geeky) support
  - Compact, modular
- Follows SE principles & best practices

MPDROOT CODING RULES

Basic truths

1. It's harder to read the code, than to write it
2. Capability based approach being the most effect ve

Focus

- readability
- design
- general rules:

ht ps://mpdroot.jinr.ru/mpdroot-naimng-convent on/

Test-Driven Development (TDD)

Ousber Ht Finder

Preparatory work

- get rid of geometry si ngleton
- create invariant Base class for geometry

Create interface

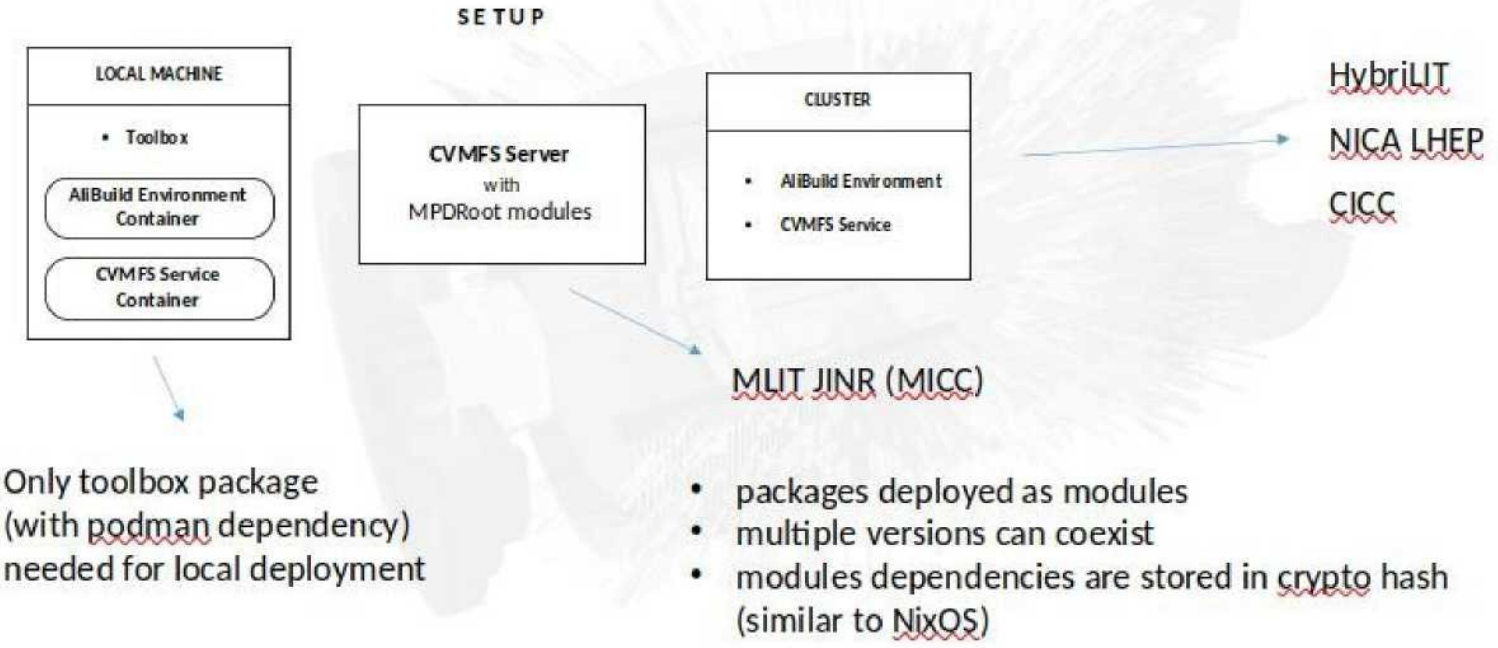
- i nherit ng from Fai rTask
- i nterface dependencies should be passed by inject bn
- cl usterhit finder units, candidates for pure vi rtual methods: findQusters, findHits

Implementaton

- current M lem algorithm to be adapted to i nterface (reconstruct on ident ty criterion)
  - new fast cl usterhit finder to be adapted to i nterface
  - both algorithms are standardized and testable on levels of:
    - implemented pure virtual methods
    - implemented interface
    - reconstruct on

MPD deployment

NEW DEPLOYMENT ARCHITECTURE

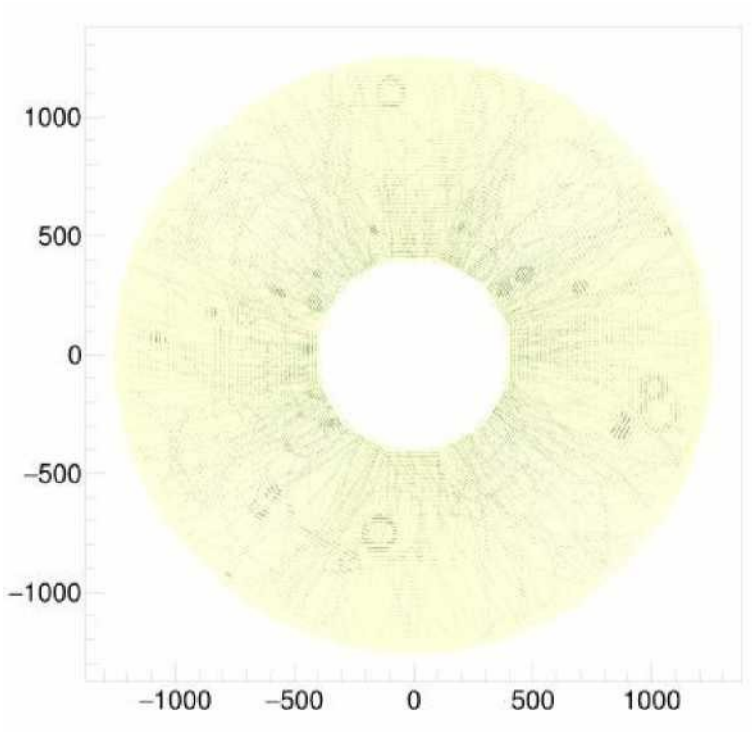


TPC tracking

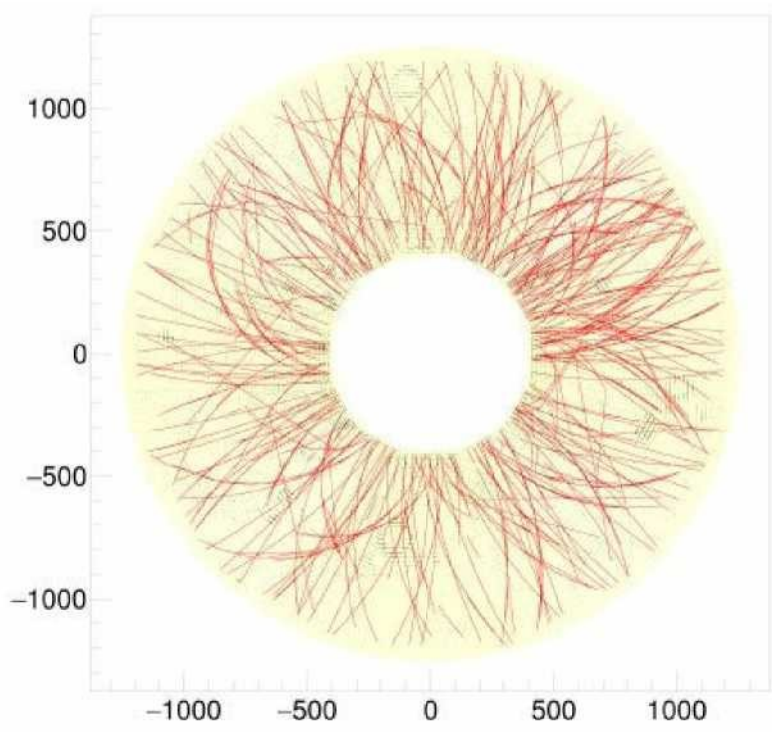
The A Common Tracking Software (Acts) project is an attempt to preserve and evolve the track reconstruction software of the LHC era towards HL-LHC and beyond.

UrQMD AuAu
$\sqrt{s}$ = 9 GeV

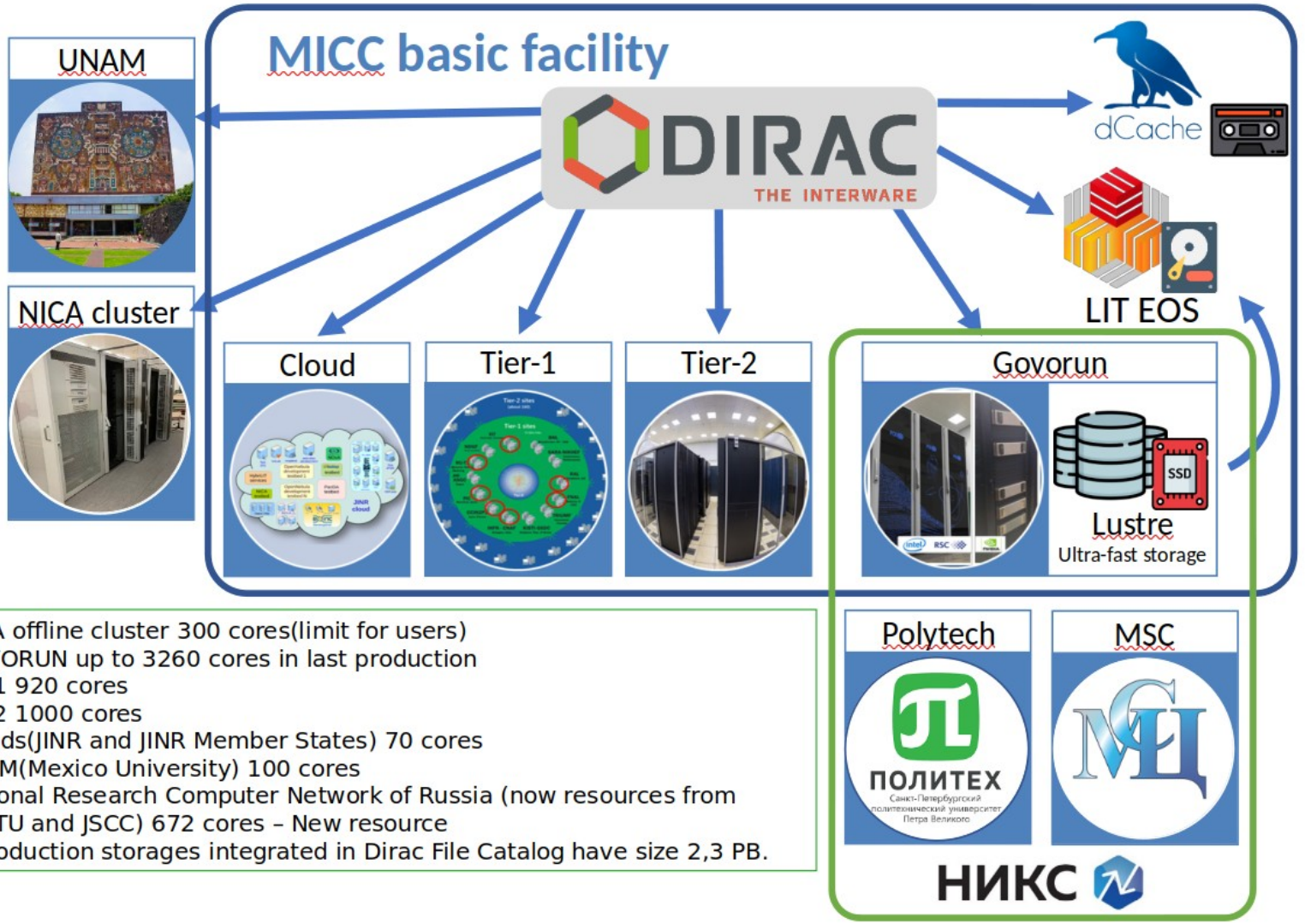
Hits



Tracks



Computing resources



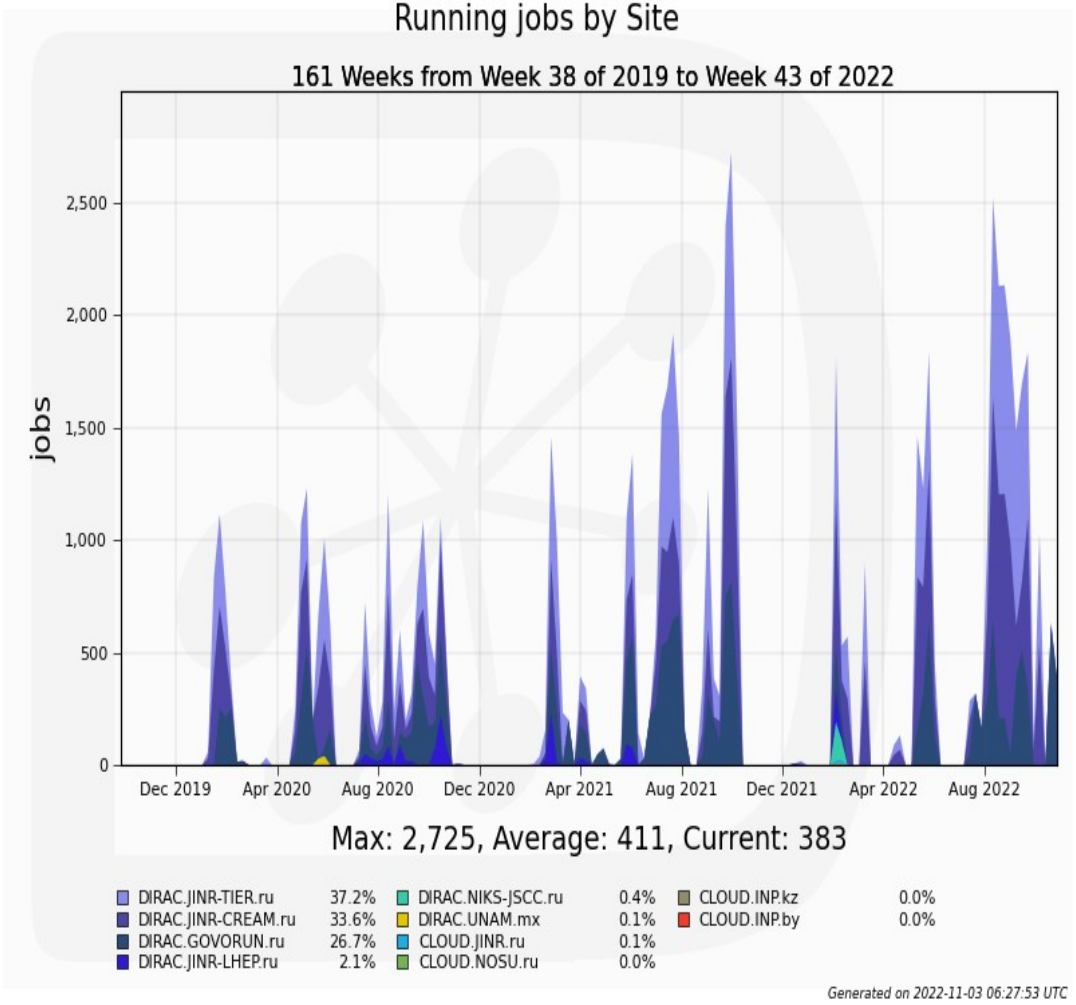
- NICA offline cluster 300 cores(limit for users)
- GOVORUN up to 3260 cores in last production
- Tier1 920 cores
- Tier2 1000 cores
- Clouds(JINR and JINR Member States) 70 cores
- UNAM(Mexico University) 100 cores
- National Research Computer Network of Russia (now resources from SPBTU and JSCC) 672 cores – New resource

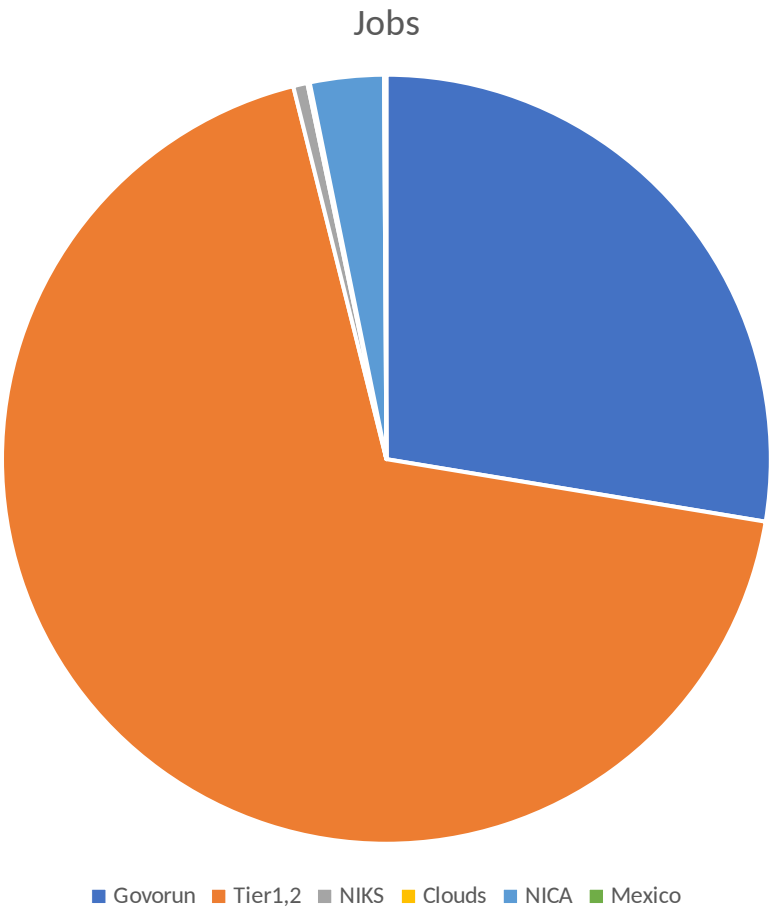
Mass production storages integrated in Dirac File Catalog have size 2,3 PB.

MC generators mass production

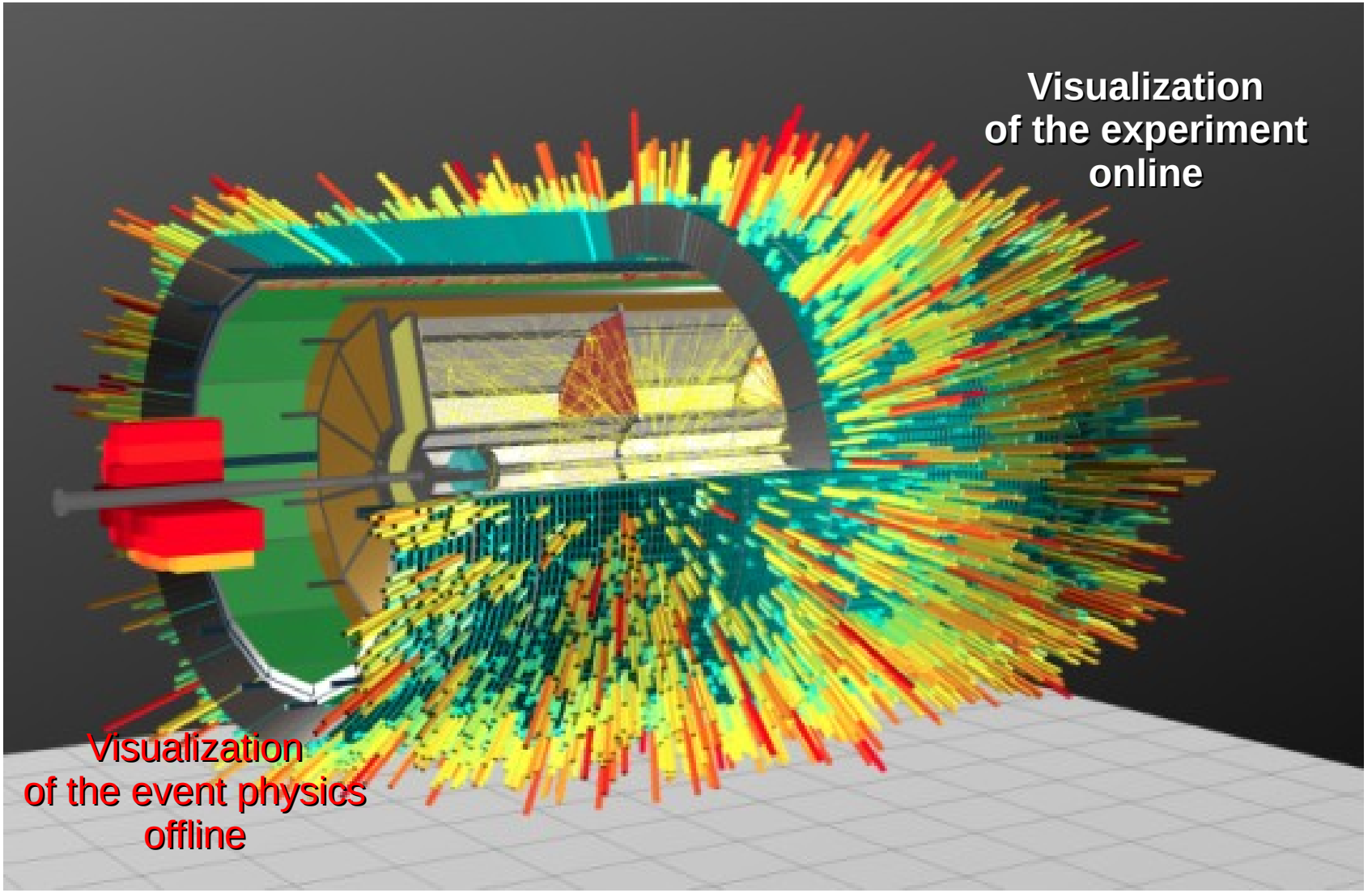
Generator	PWG	Coll.		# of events() 10^6	Reco
UrQMD	PWG4	AuAu	11	15	+
		BiBi	9	10	+
			9.46	10	+
			9.2	95	+
	PWG2	AuAu	11	10	+
	PWG3	AuAu	7.7	10	+
		BiBi	7.7	10	+
			9	15	+
		pp	9	10	+
	PWG1	BiBi	9.2	11(50 underway)	+
DCM-SMM	PWG1	BiBi	9.2	1	+
PHQMD	PWG2	BiBi	8.8	15	+
			9.2	61	+
			2.4/3.0/4.5	10/10/2	-
vHLLE-UrQMD	PWG3	BiBi	11.5	15	+
		AuAu	11.5	15	+
		AuAu	7.7	20	+
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				1233(50 underway)	389(50 underway)

MPD computing 2019-2023 summary

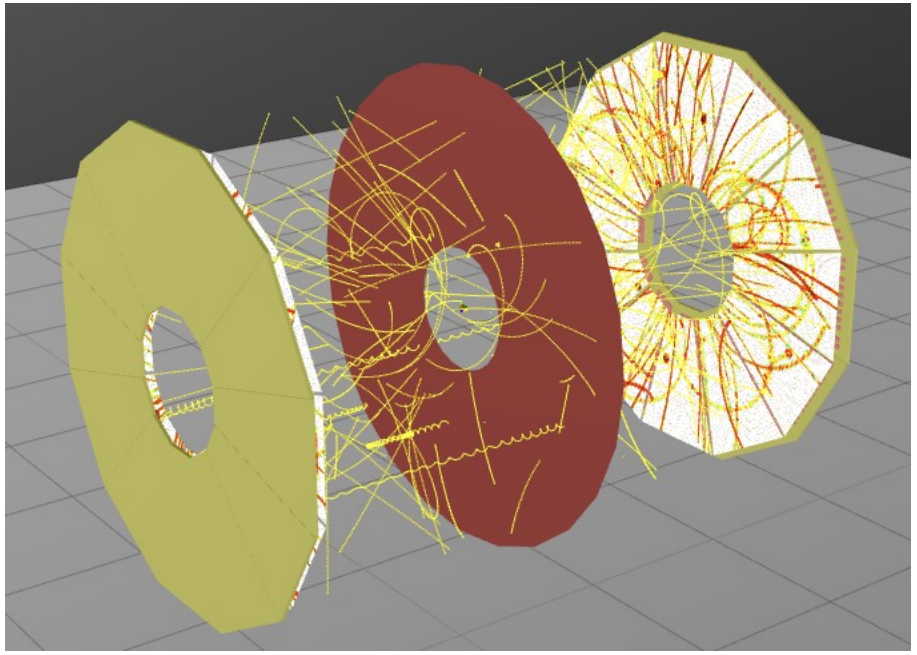


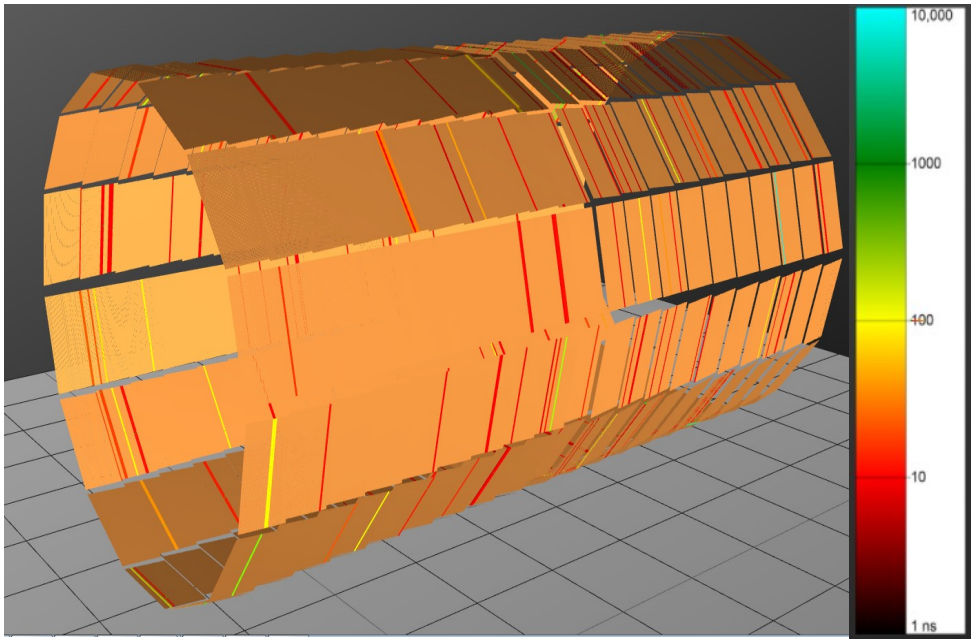


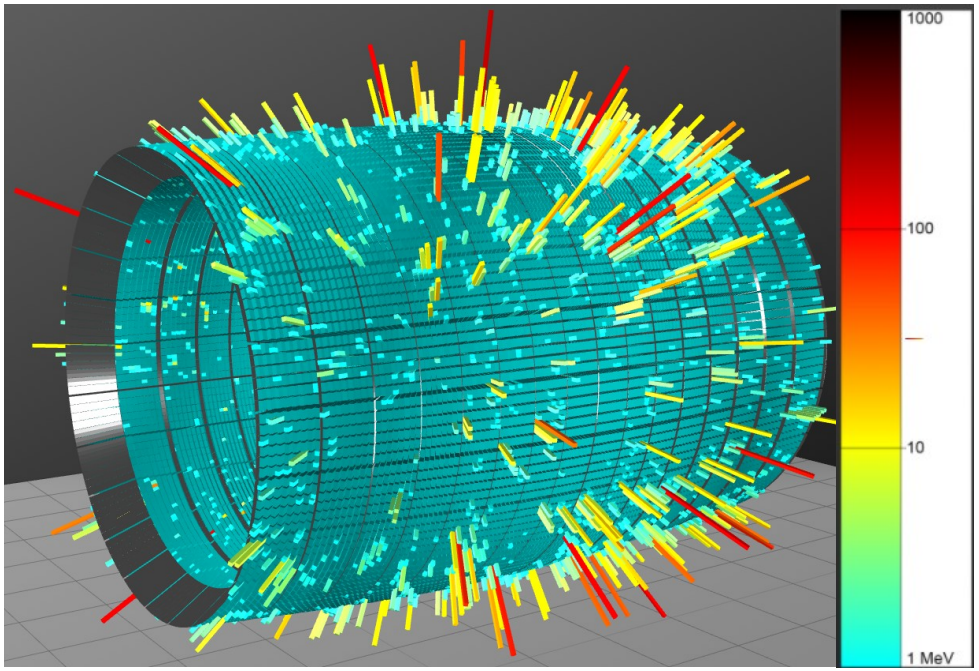
MPD EventDisplay

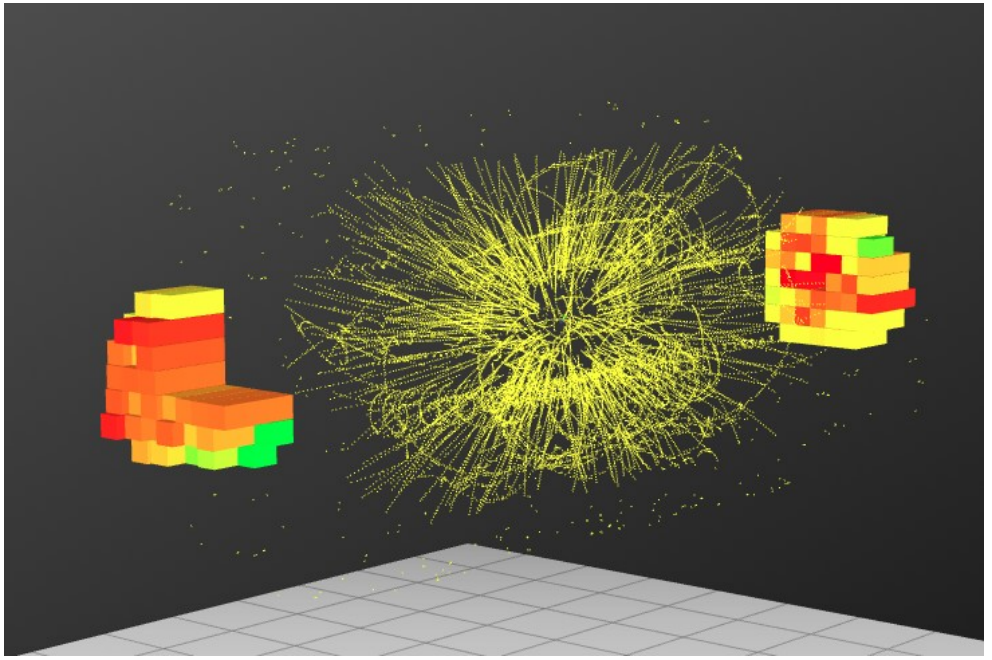


MPD EventDisplay: hits in detectors









Thanks for your attention