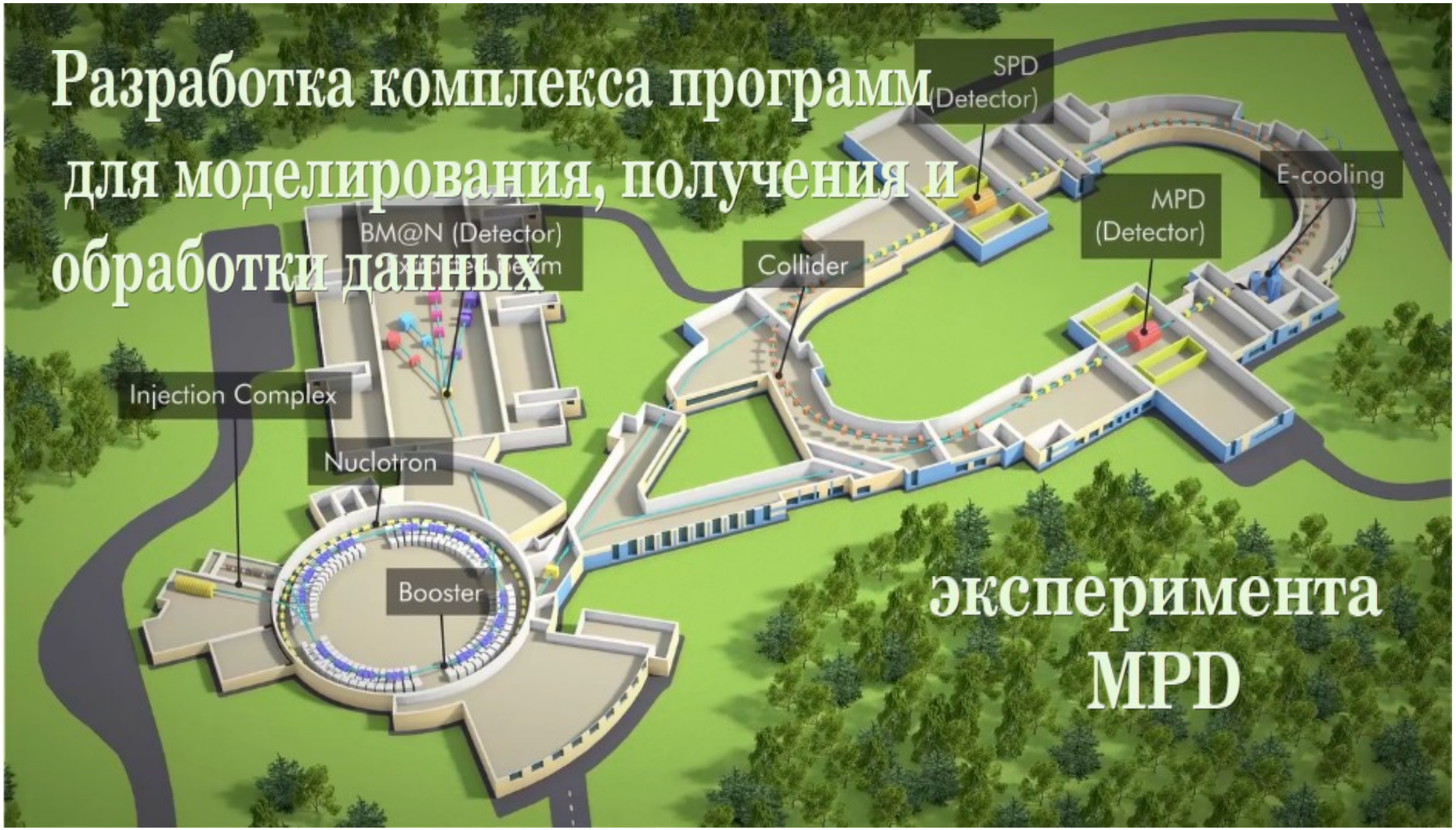
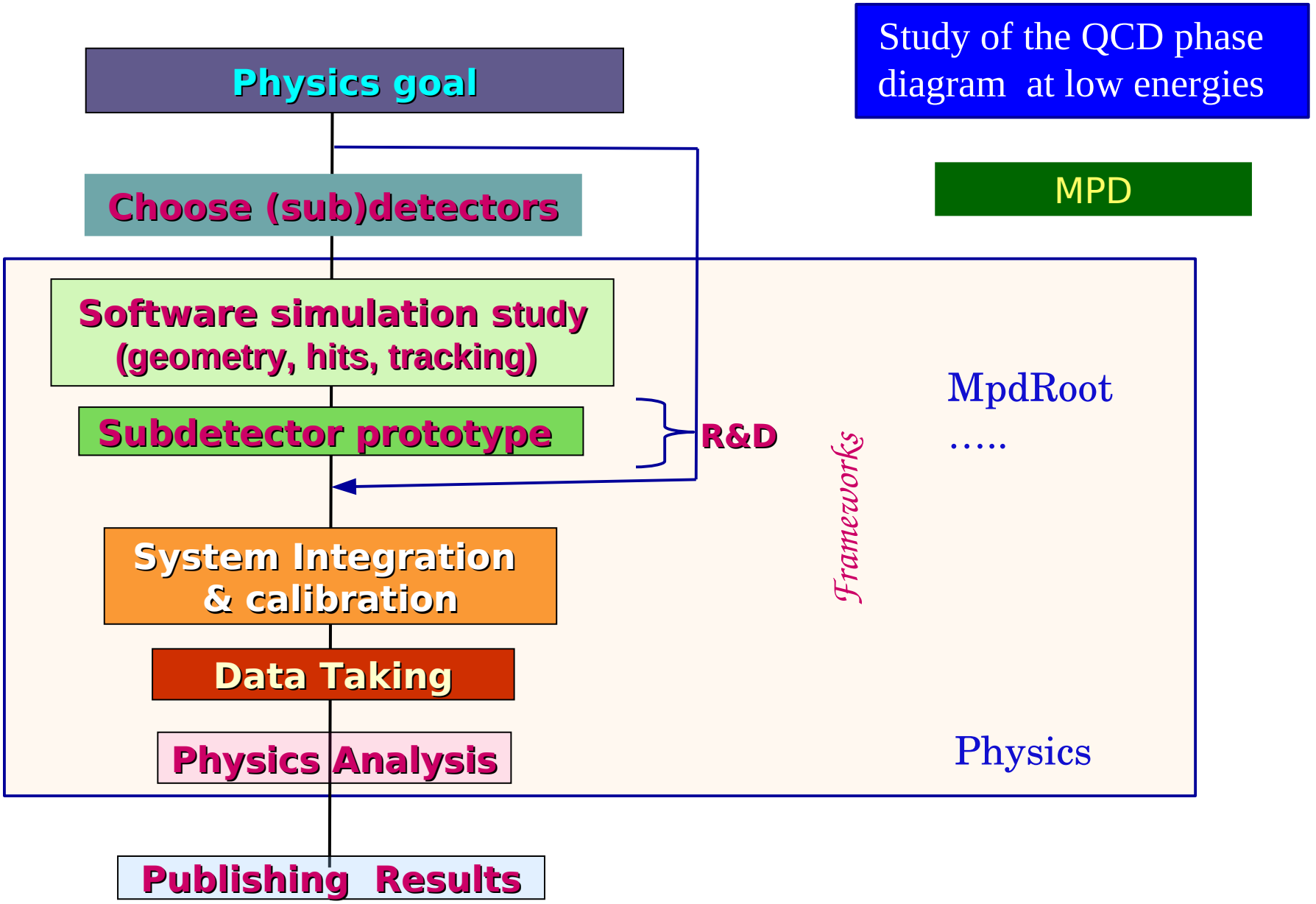


ROGACHEVSKY Oleg
MPD collaboration

IT school
October 19 2023
Dubna

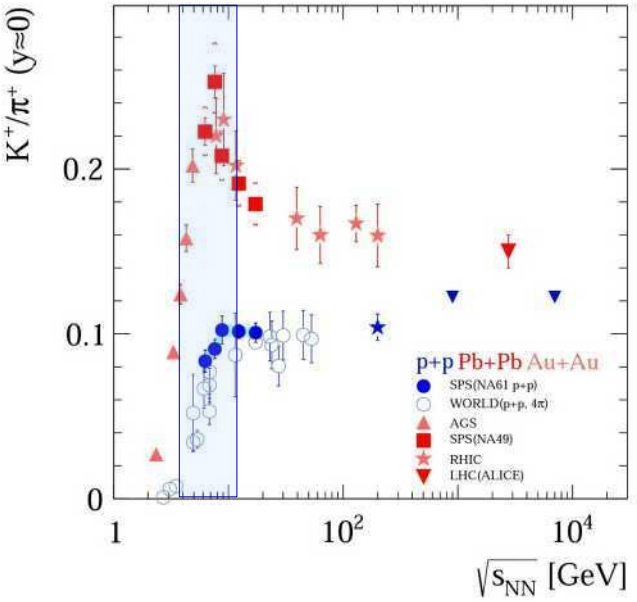
Outline of the HEP experiments

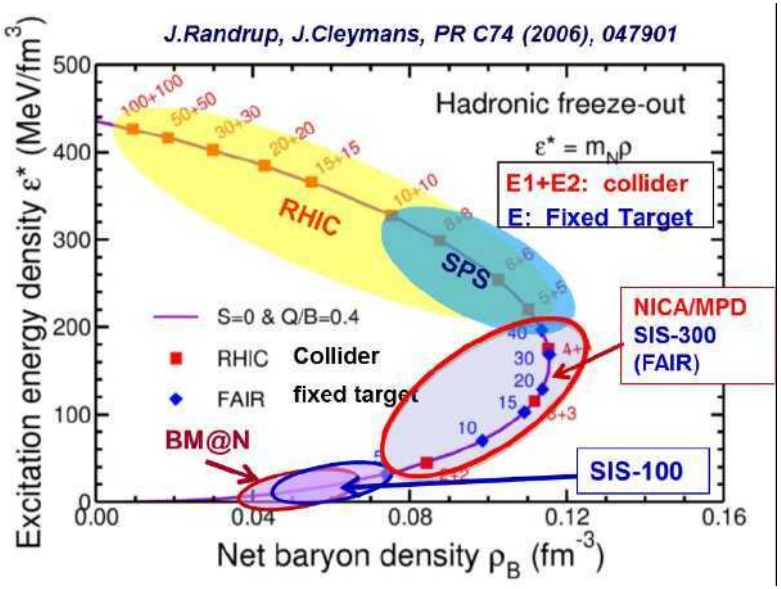


NICA advantagies

J. Cleymans
MPD collaboration Meeting April, 2018

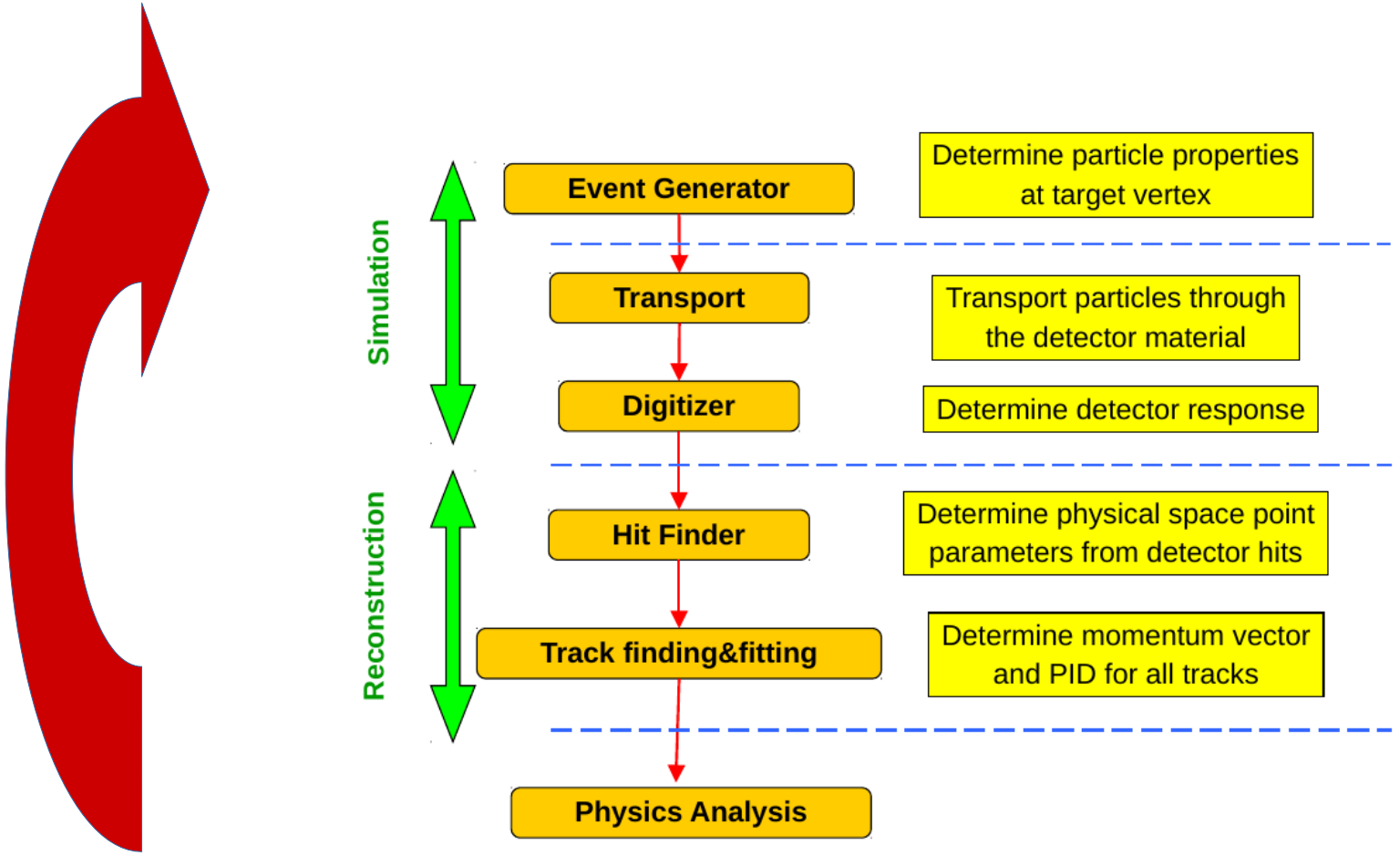
- ✔ Maximum in K^+/π^+ ratio is in the NICA energy region,
- ✔ Maximum in Λ/π ratio is in the NICA energy region,
- ✔ Maximum in the net baryon density is in the NICA energy region,
- ✔ Transition from a baryon dominated system to a meson dominated one happens in the NICA energy region.





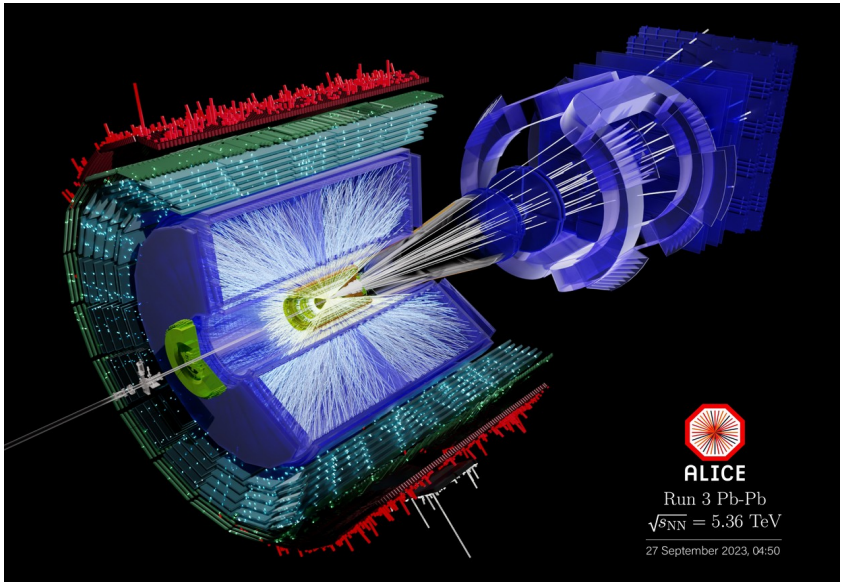
HEP experiments data flow

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

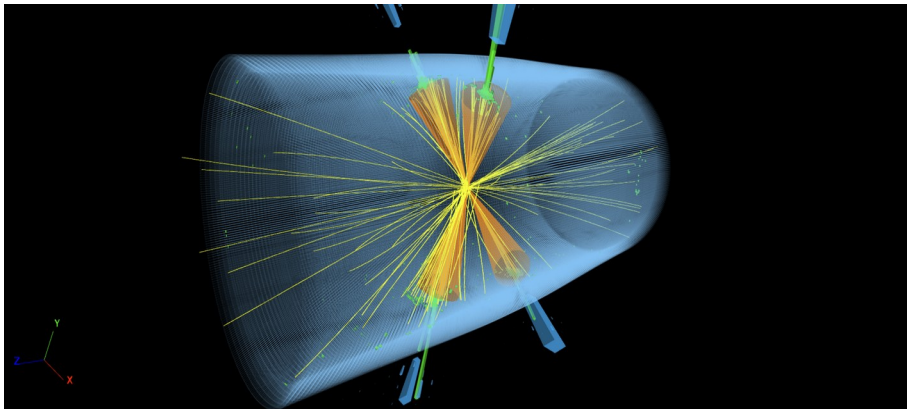


Frameworks: CERN experiments

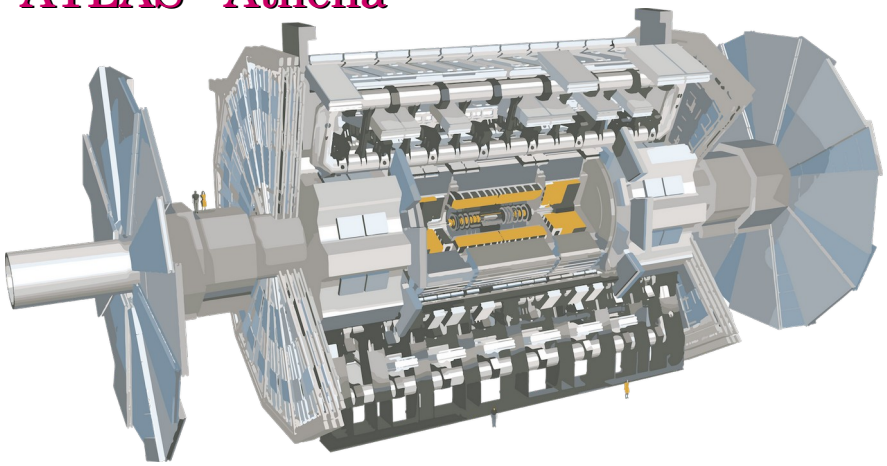
ALICE aliroot



CMS cmssw



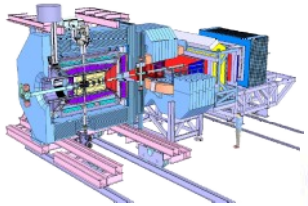
ATLAS Athena

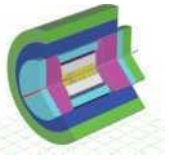


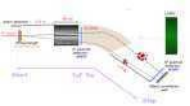
https://gaudi.web.cern.ch/gaudi/

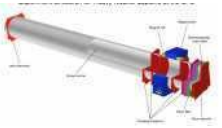
- LHCb Computing
- ATLAS Athena framework
- HARP Gaudino framework
- Fermi (previously GLAST)
- MINERvA
- BESIII BOSS framework
- LBNE (Long Baseline Neutrino Detector, WCD group), see also GARPI project
- Key4hep (common software for FCC, CLIC/ILC and CEPC)

FairRoot based frameworks









2004 Start testing the VMC concept for CBM

2006 Panda decided to join FairRoot: same base package for different experiments

2010 R3B joined

2011 EIC (Electron Ion Collider BNL) EICRoot

2012 SOFIA (Studies On Fission with Aladin)

2014 SHIP - Search for HIdden Particles

2017 SPDRoot

2004 First Release of CbmRoot

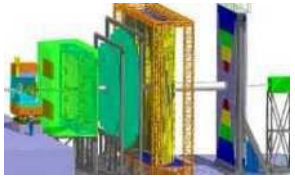
2006 MPD (NICA) start using FairRoot

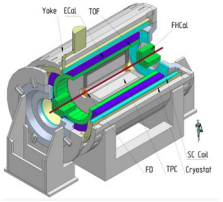
2010 ASYEOS joined (ASYEOSRoot)

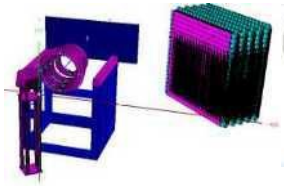
2011 GEM-TPC seperated from PANDA branch (FOPIRoot)

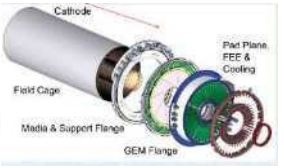
2013 ENSAR-ROOT Collection of modules used by structural nuclear phsyics exp.

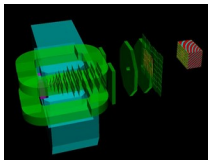
2016 BMNRoot



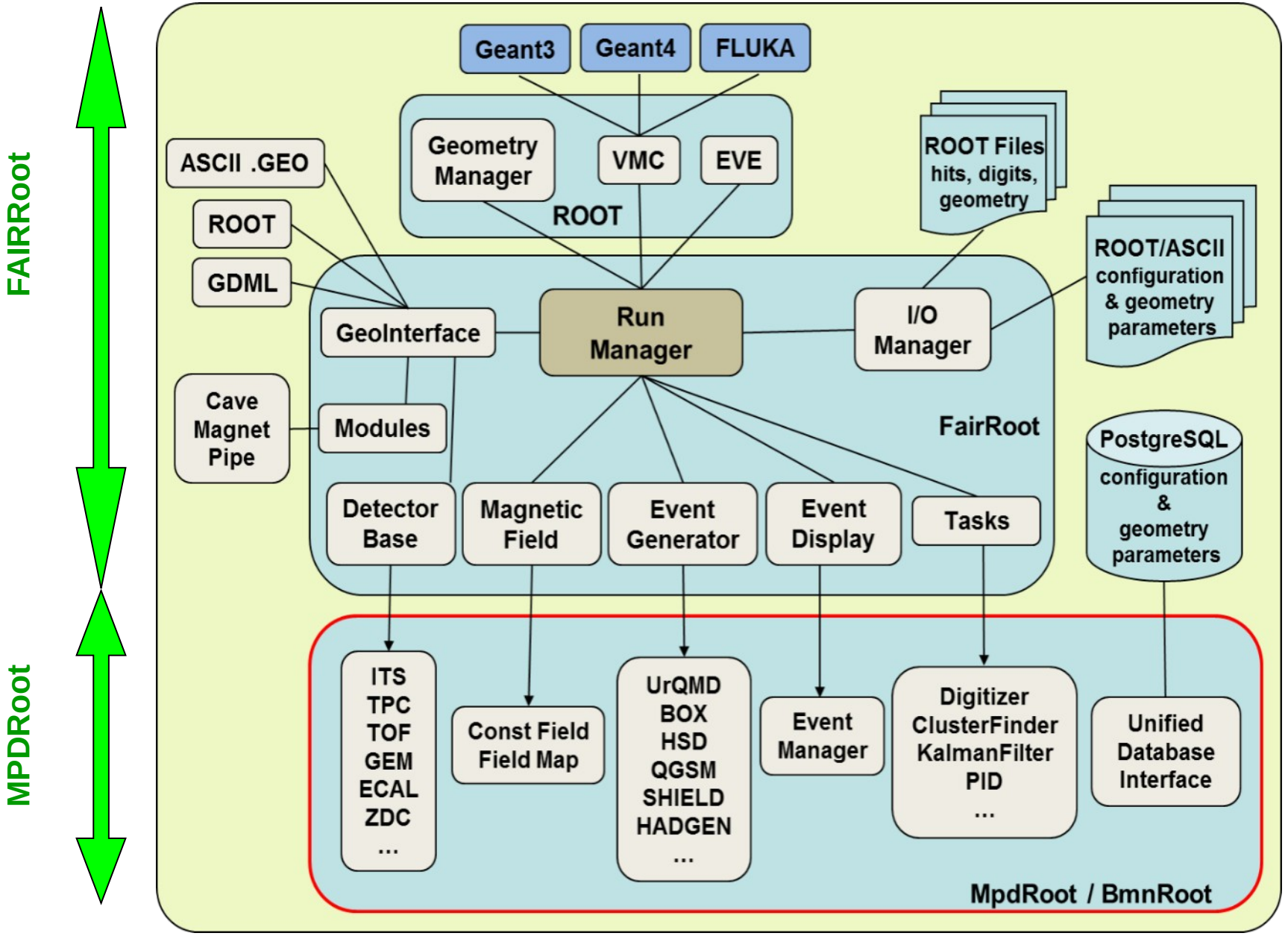






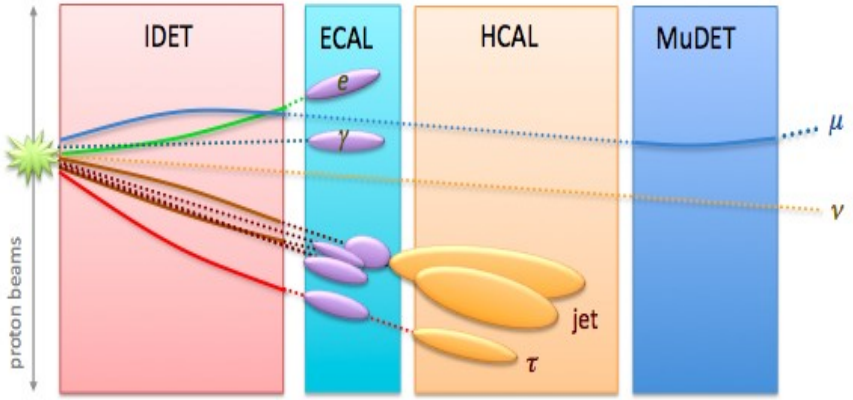


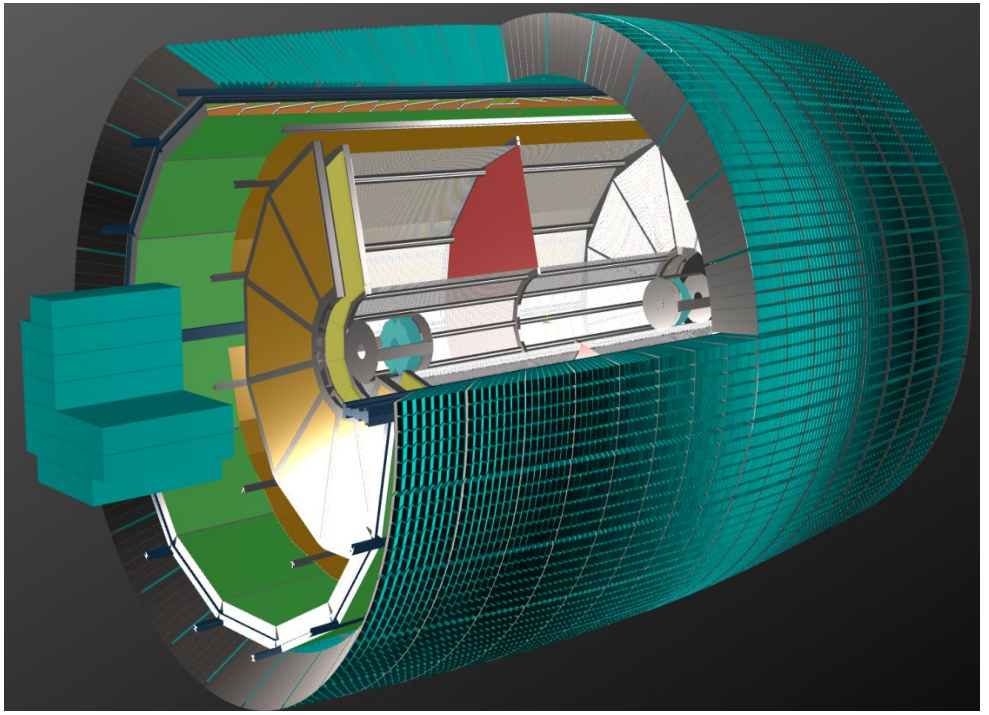
MPDroot design



Common tasks in HEP experiments

- Detector reconstruction
  - Tracking
    - finding path of charged particles through the detector
  - Calorimeter reconstruction
    - finding energy deposits in calorimeters from charged and neutral particles
- Combined reconstruction
- Particle identification
- Calibrations and alignments applied at nearly every step

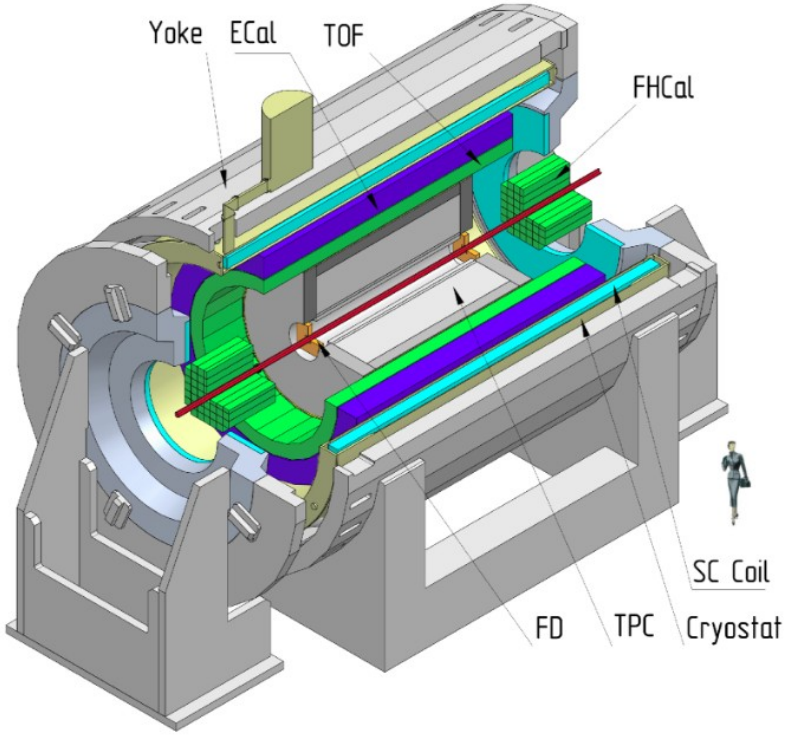


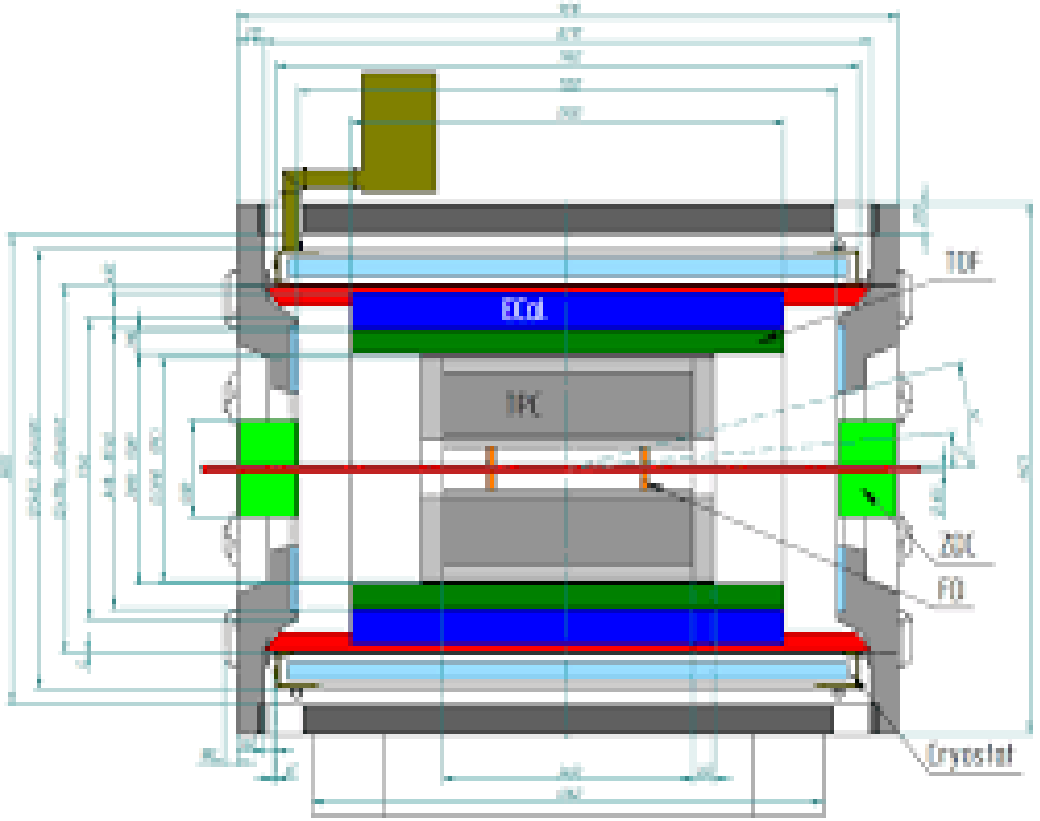


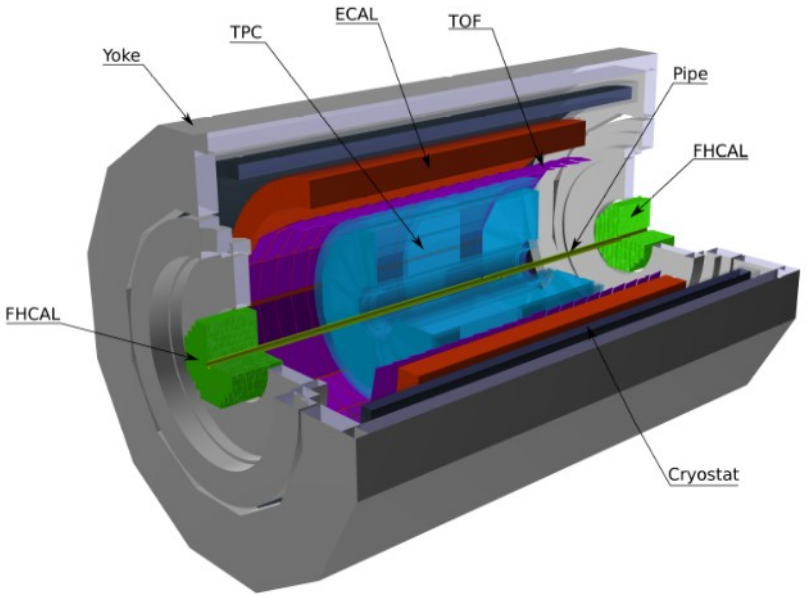
Programming tools

- C++
- Root
- GitLab git.jinr.ru
- Jupyter
- Javascript
- PostgreSQL
- Geant4
- Boost
- ...

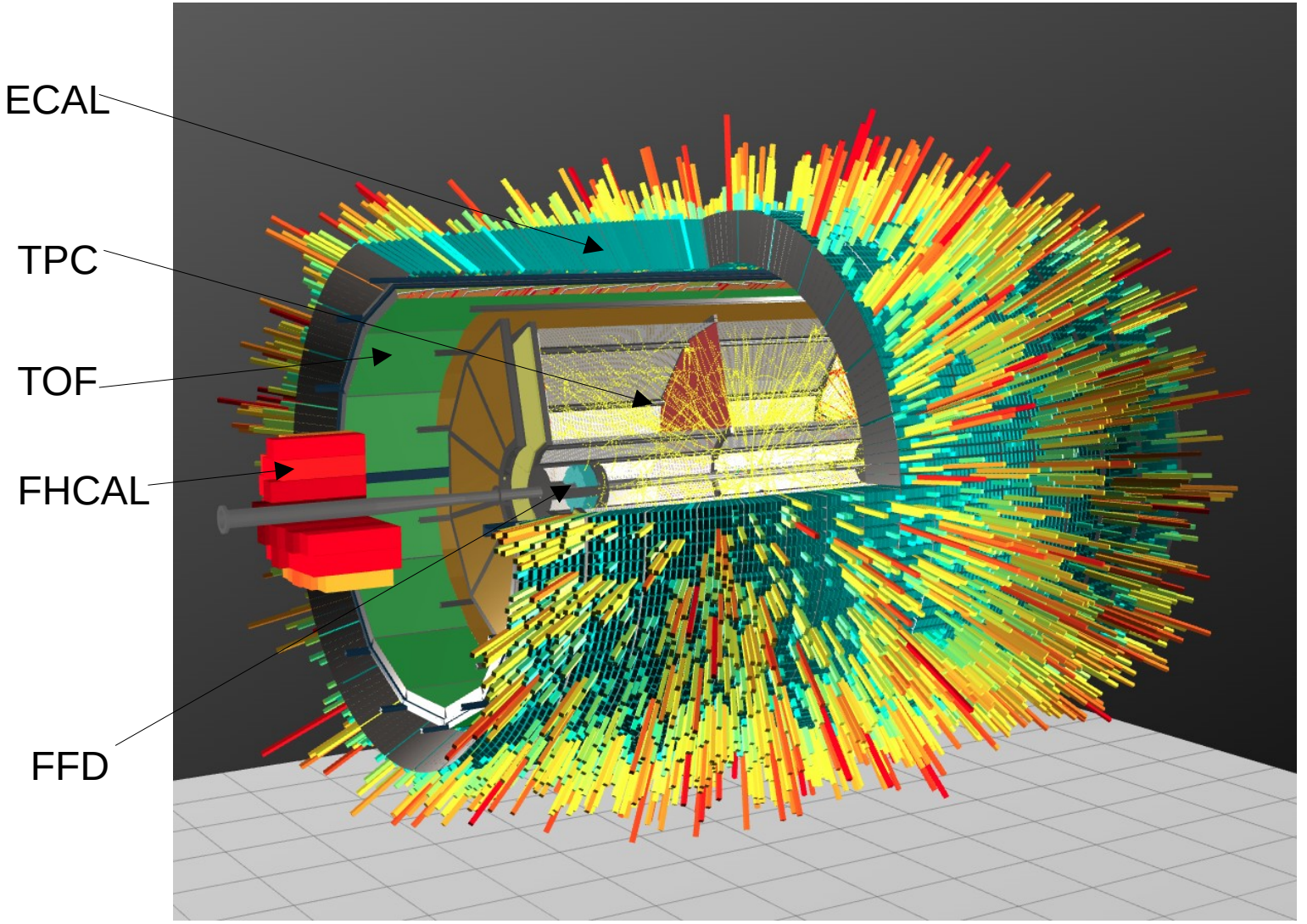
MPD geometry for simulation



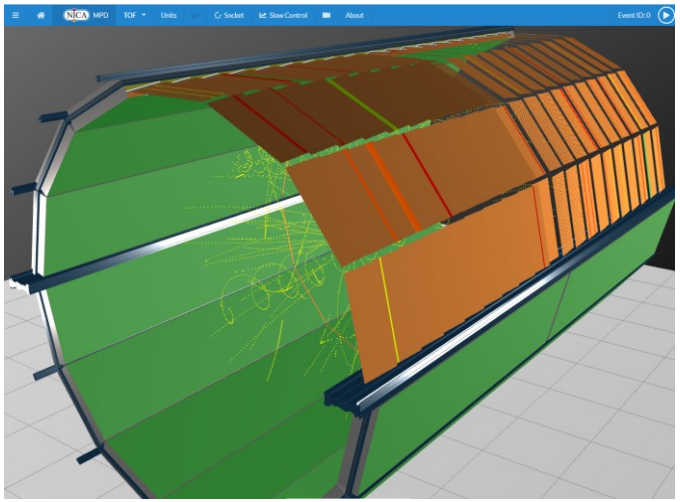




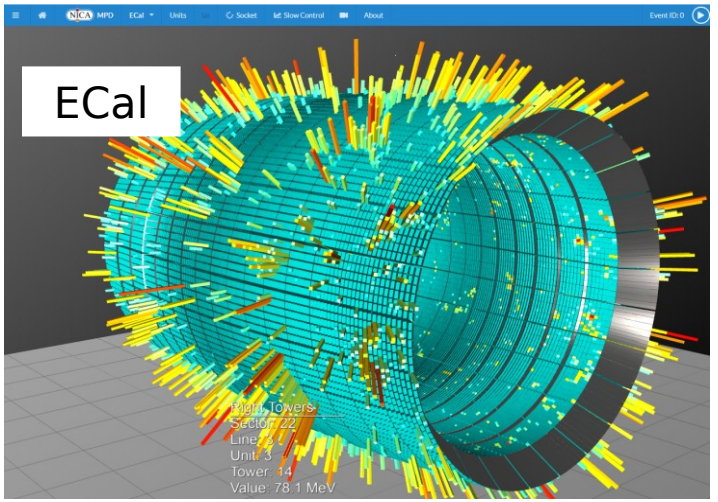
MPD eventdisplay

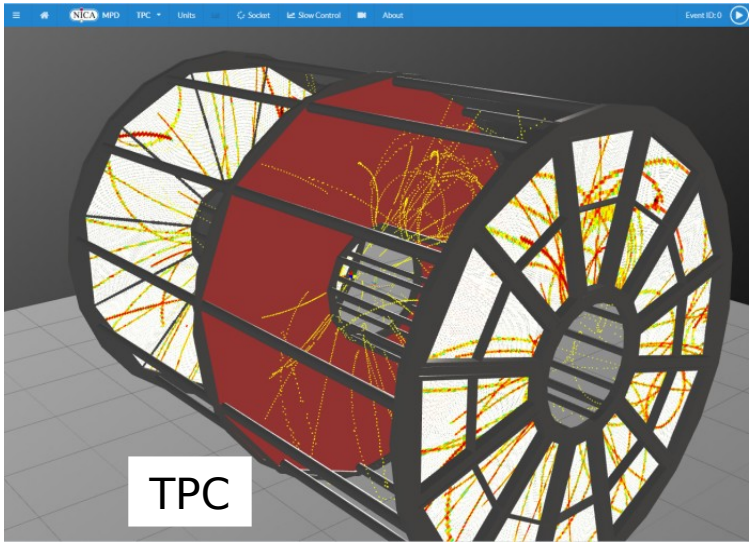


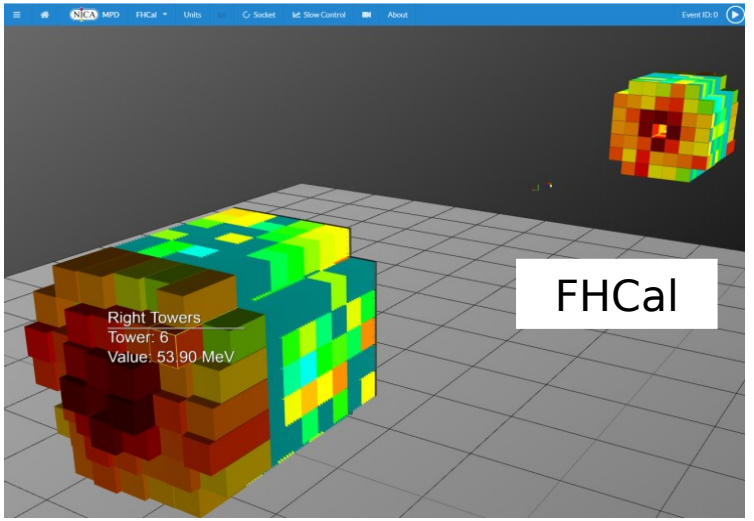
Detectors in event display



TOF

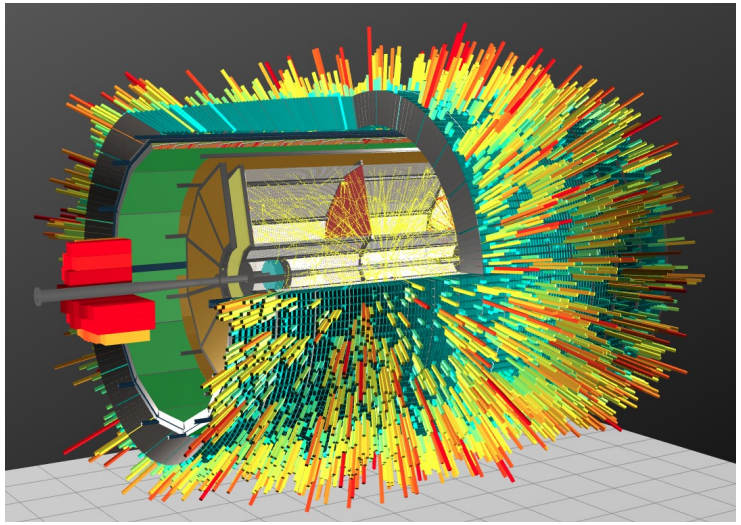






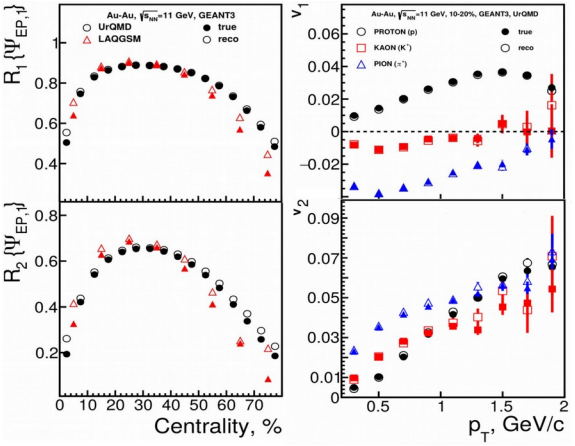
Event recontruction

Experiment

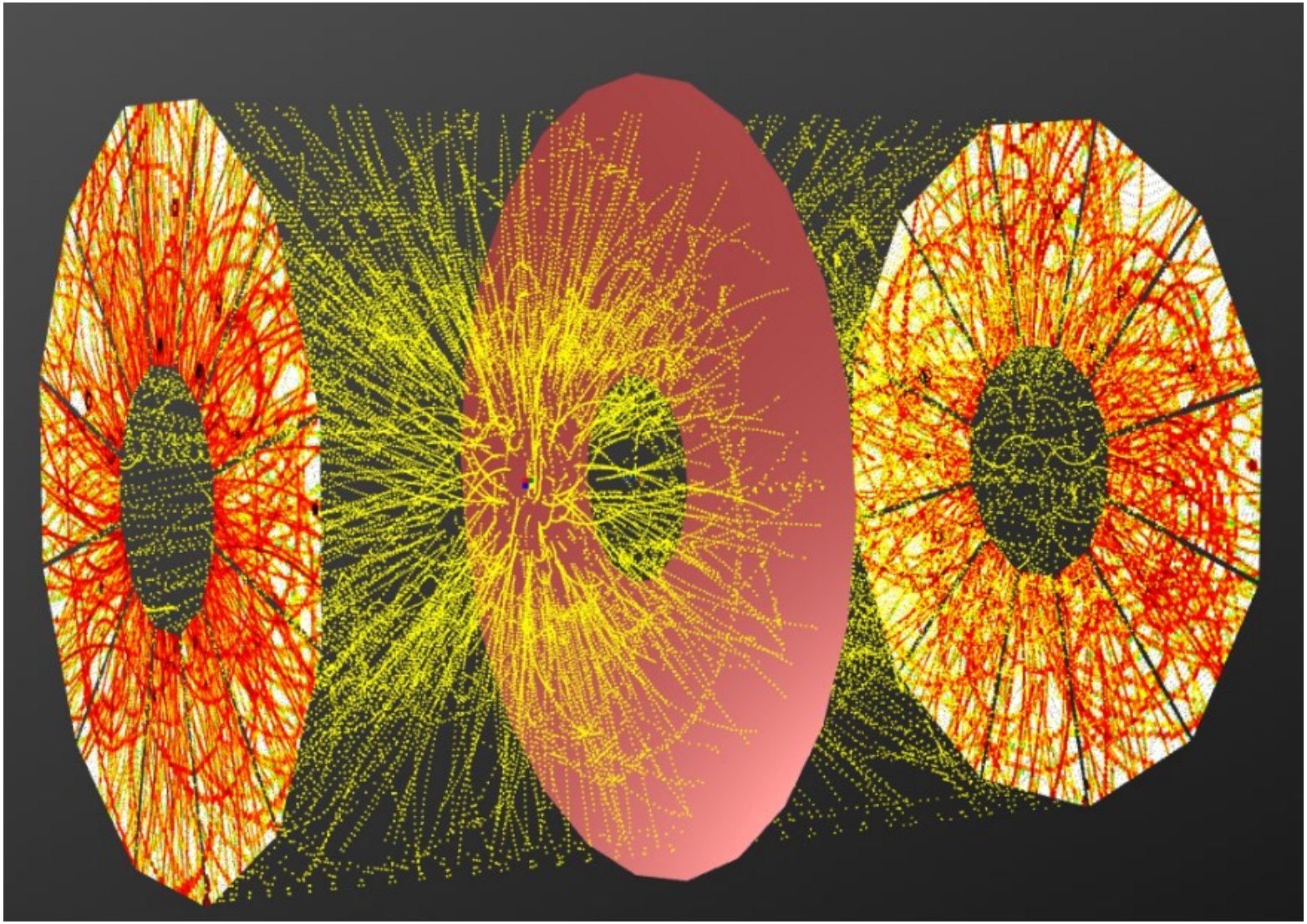


Reconstruction

Physics analysis



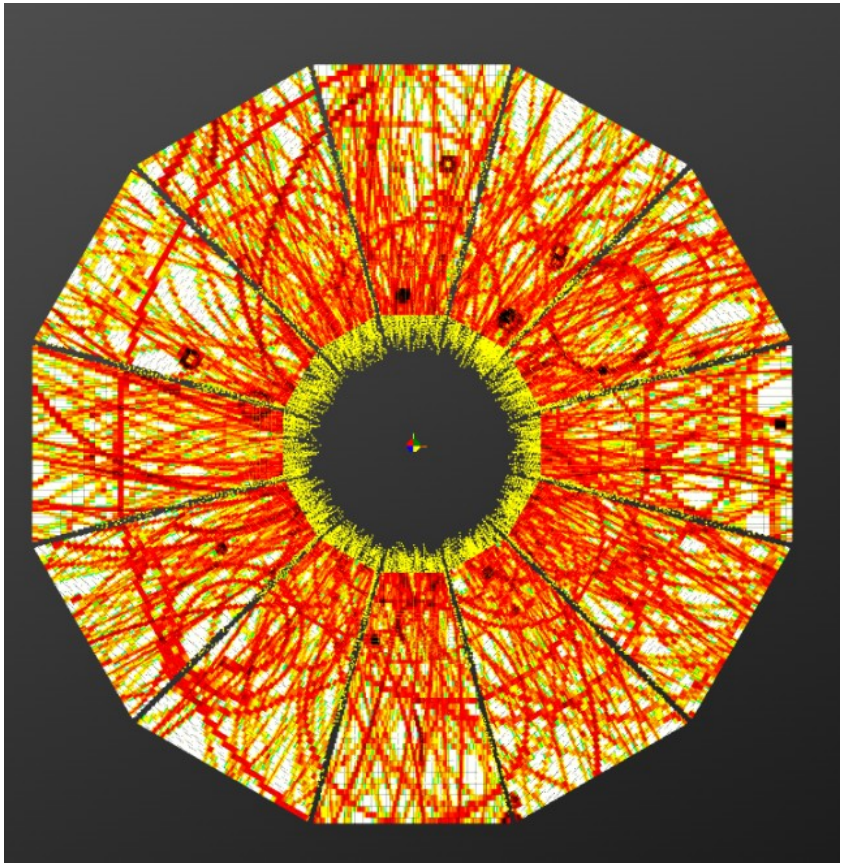
Tracking in MPD



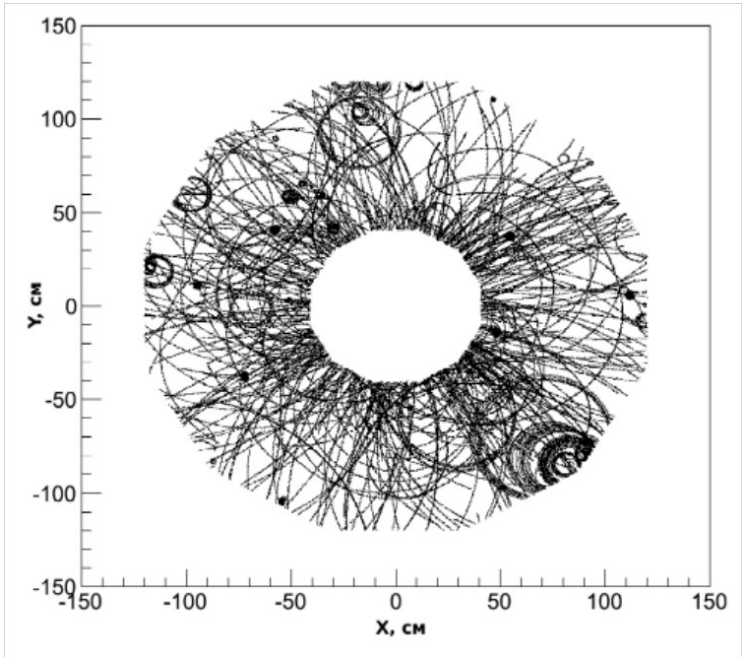
Clustering in MPD TPC

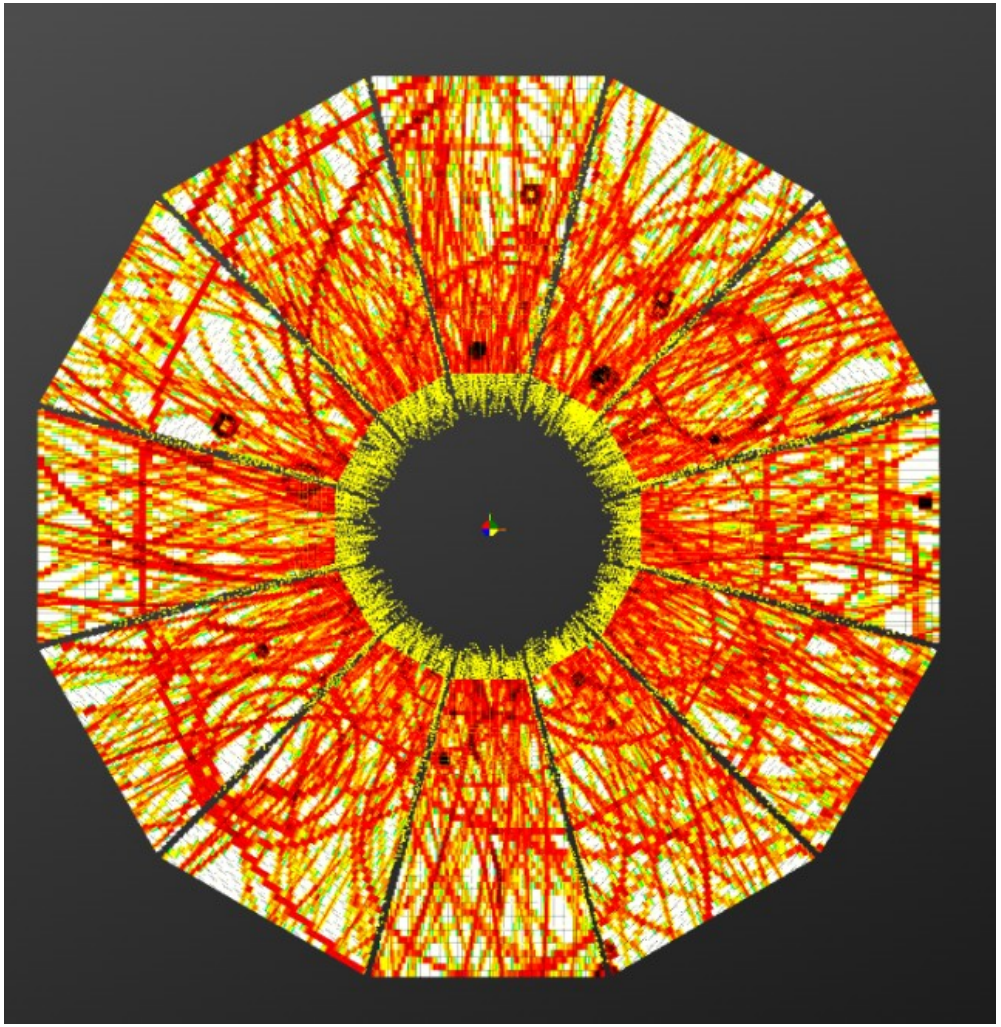
The hit reconstruction algorithm contains the following main steps:

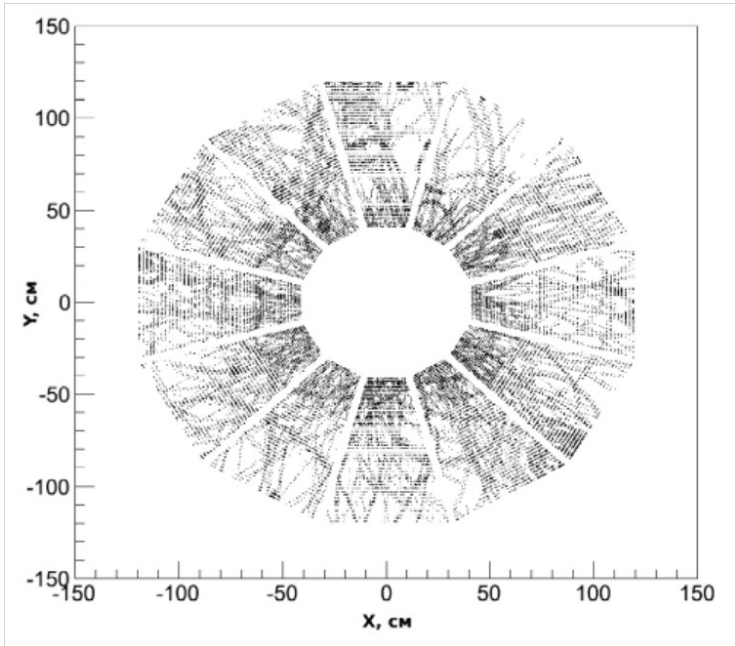
1) Searching for extended clusters in (Pad-Time) for each pad raw.
2) Searching for peaks in time-profile for each pad in the found extended cluster.
3) Combining the neighboring peaks into resulting hits.



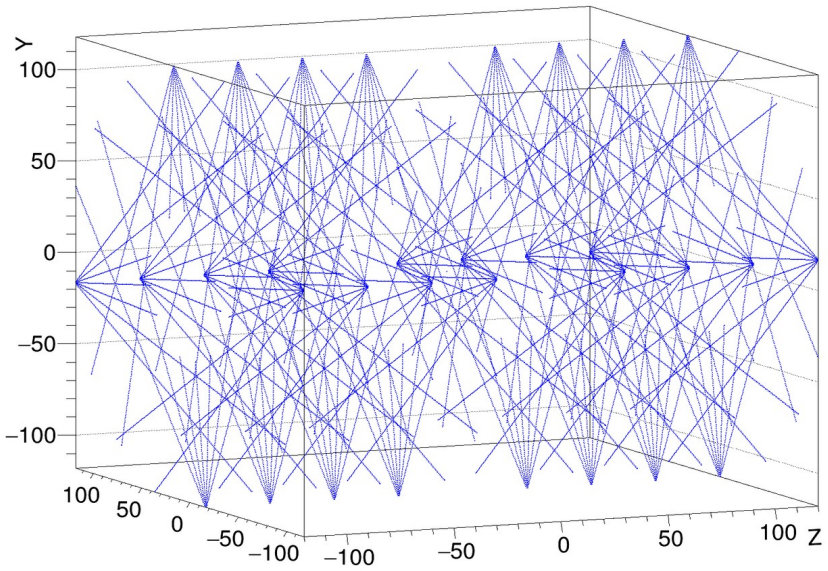
MPD TPC pad plane responces

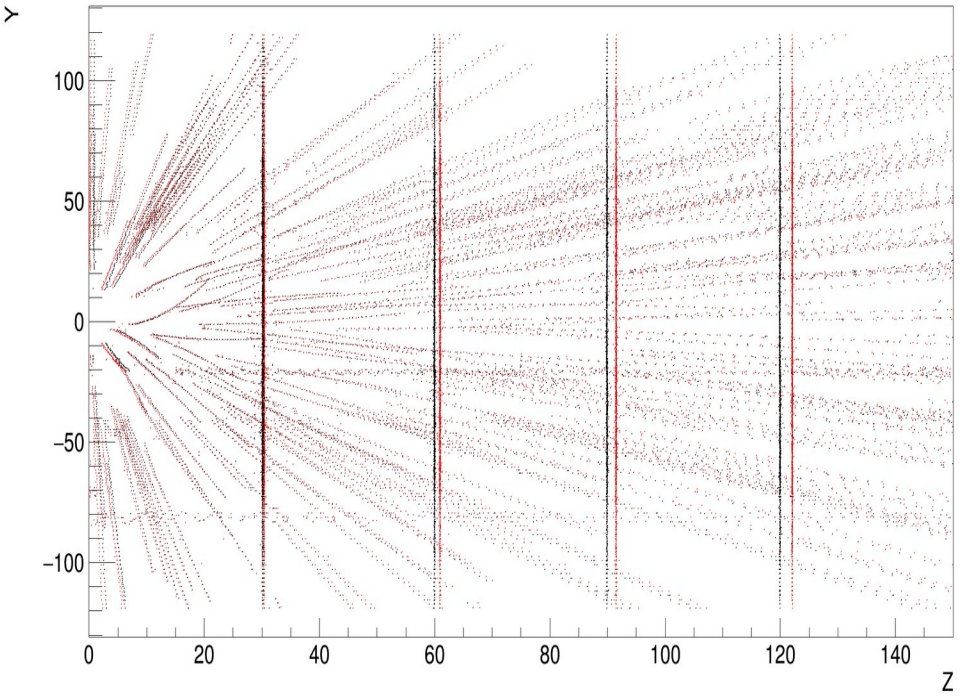






Drift time in TPC





Laser system

Two pulsed 130 mJ 5-7 ns Nd:YAG lasers
~1mm diameter
224 laser beams in total

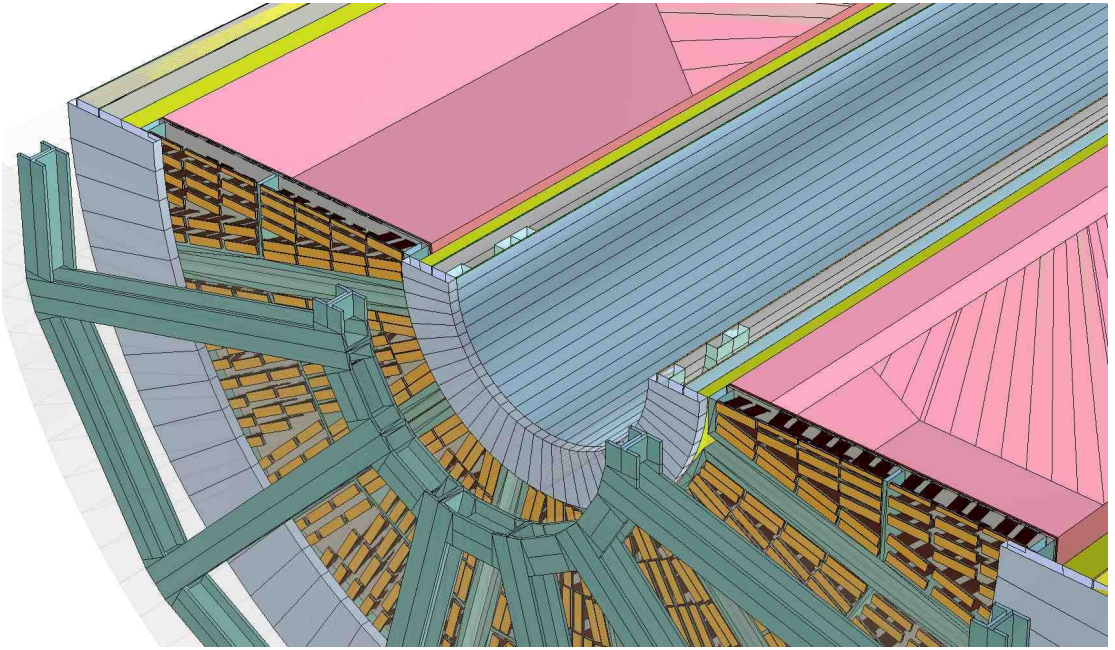
112 “tracks” in each half of the TPC

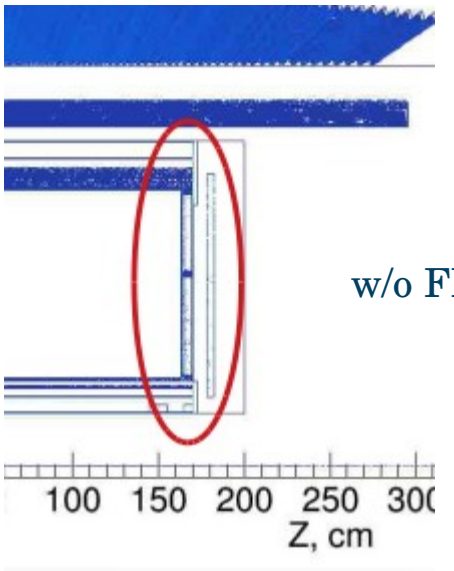
4 planes of laser beams, 300mm between planes
10 Hz impulses

Example correction

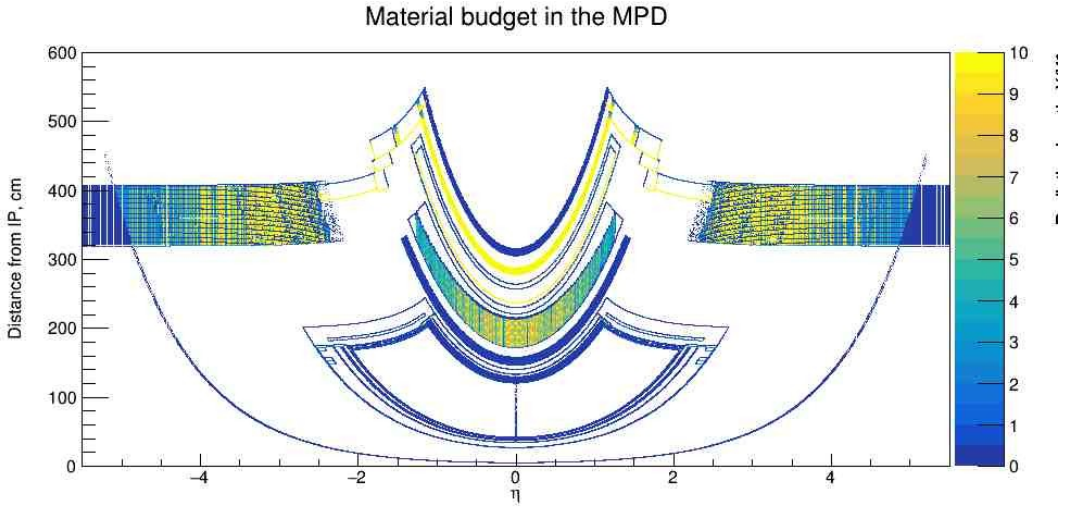
V_{drift} = 5.4 cm/μs $t_{trigger}$ = 545 ns

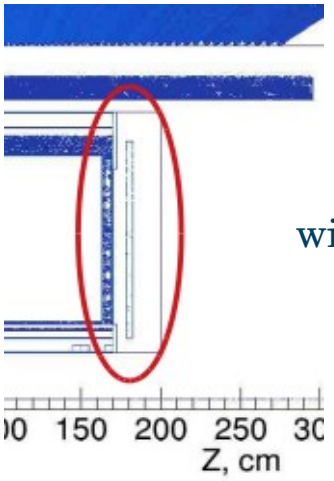
TPC endcap transparency





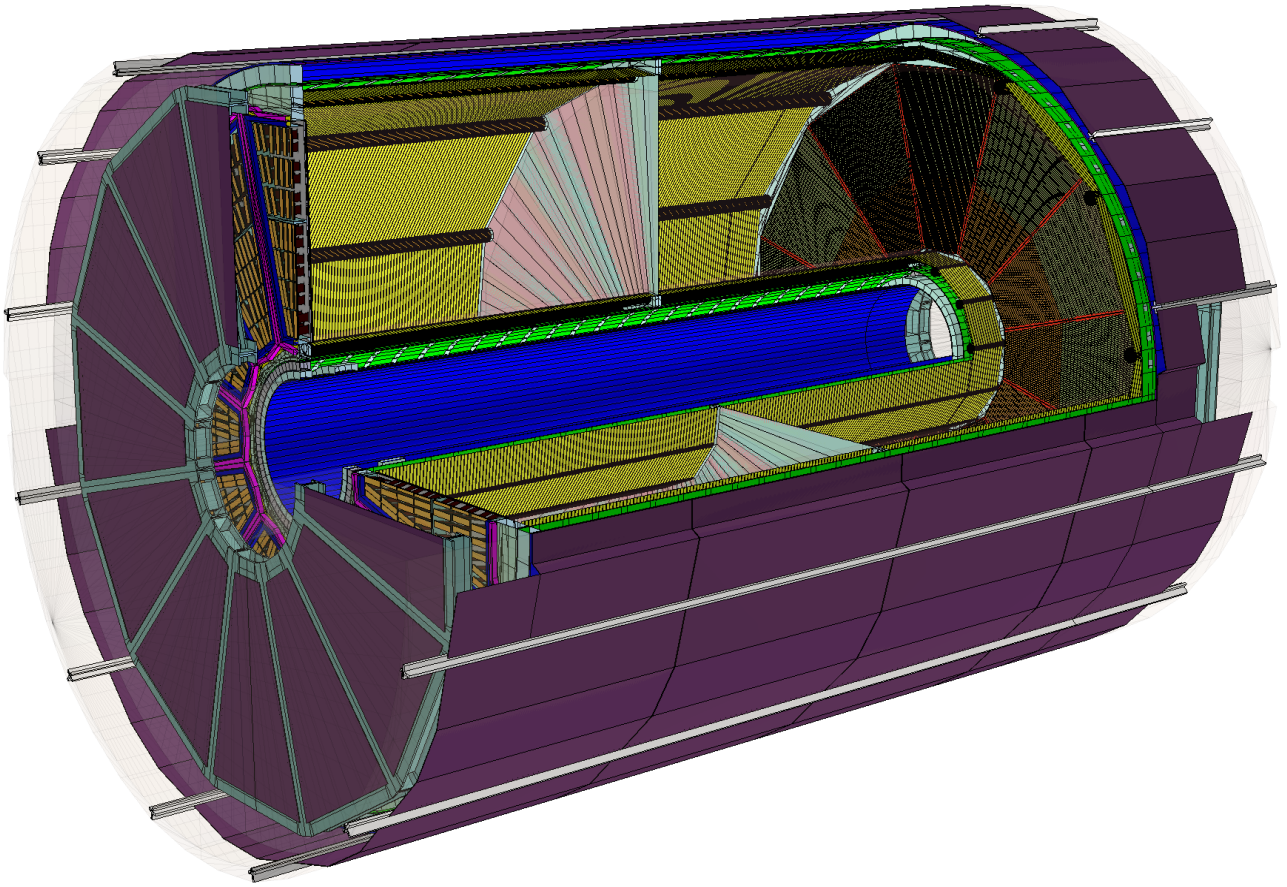
w/o FEE



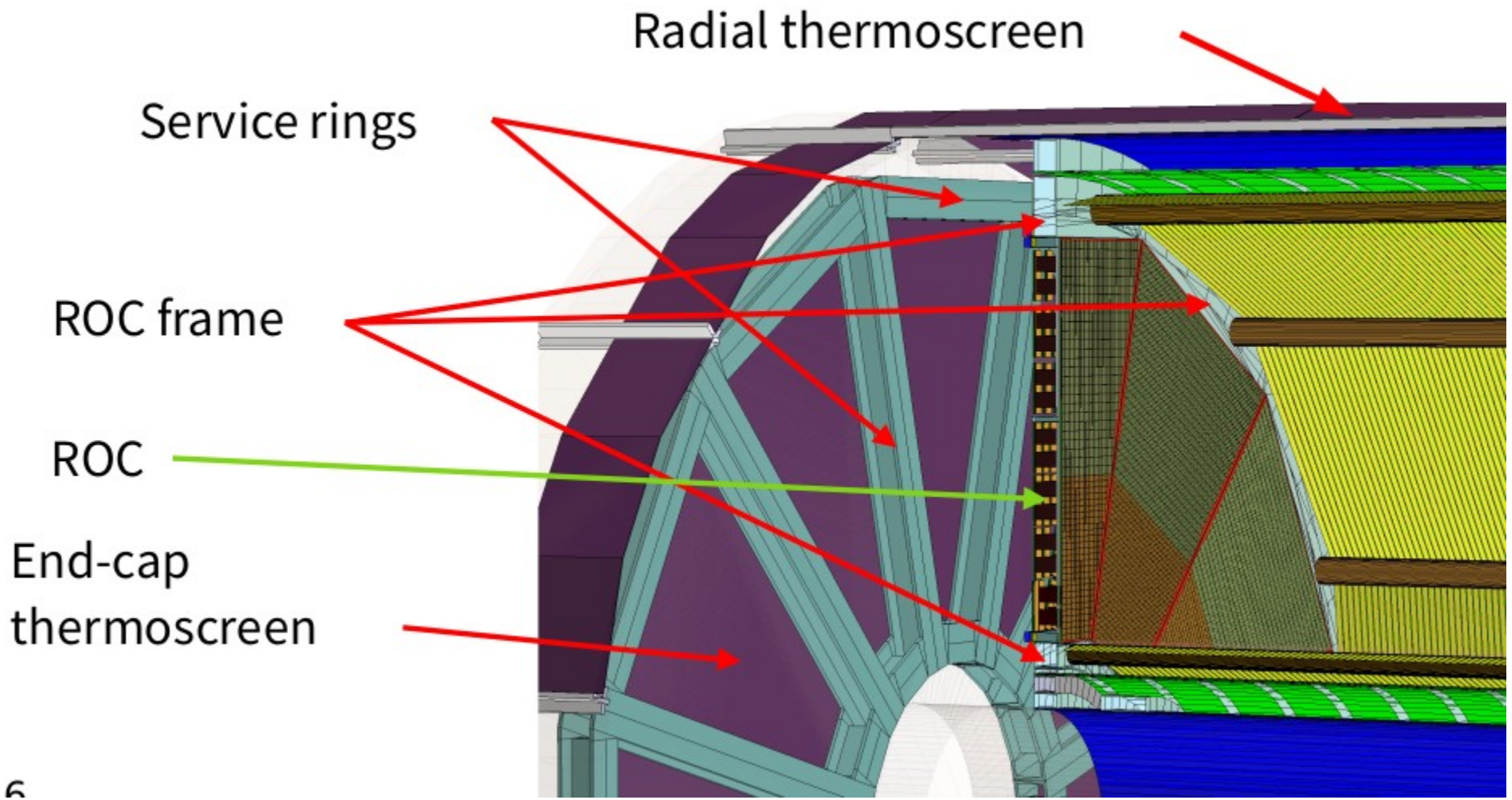


with FEE

Tracks distortions in barrel and endcap TPC parts



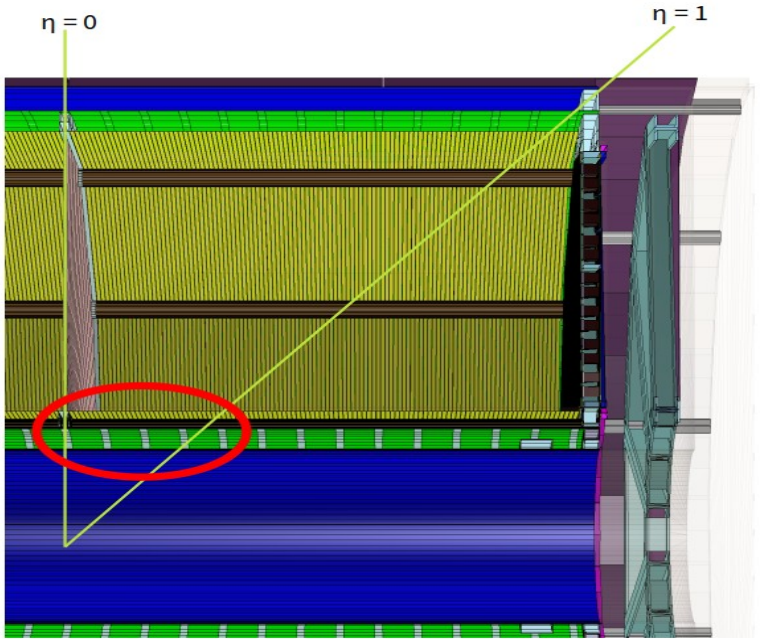
MPD Endcaps structure



Pseudorapidity dependence

P_0 = 900 MeV

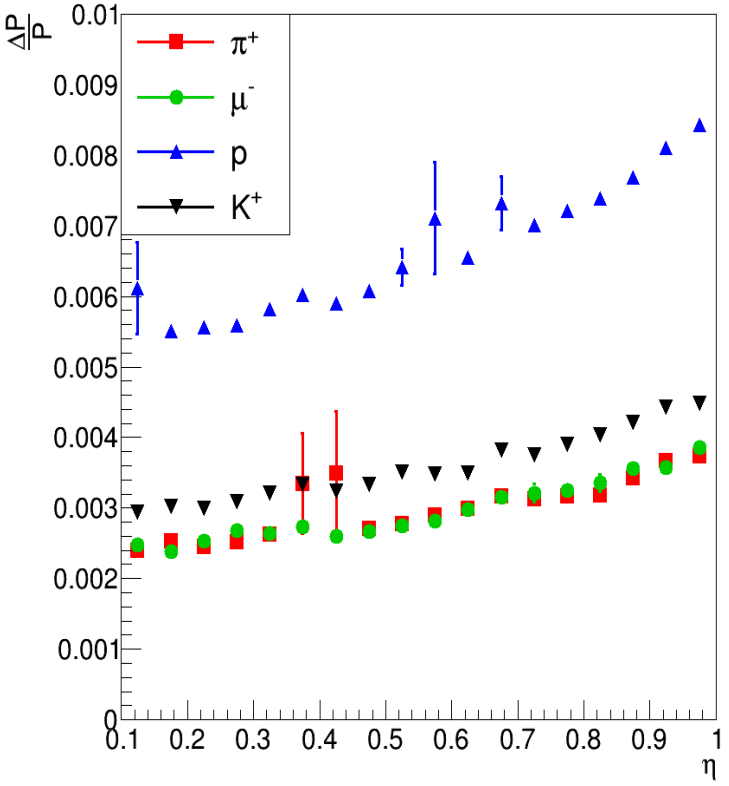
$\eta < 1$



TPC inner wals:
- Kevlar
- Tedlar
- N^2
- Al rings
- Kevlar

Field cage inner pins:
- Polypropylene

Field cage:
- Mylar film



Pseudorapidity dependence

P_0 = 900 MeV

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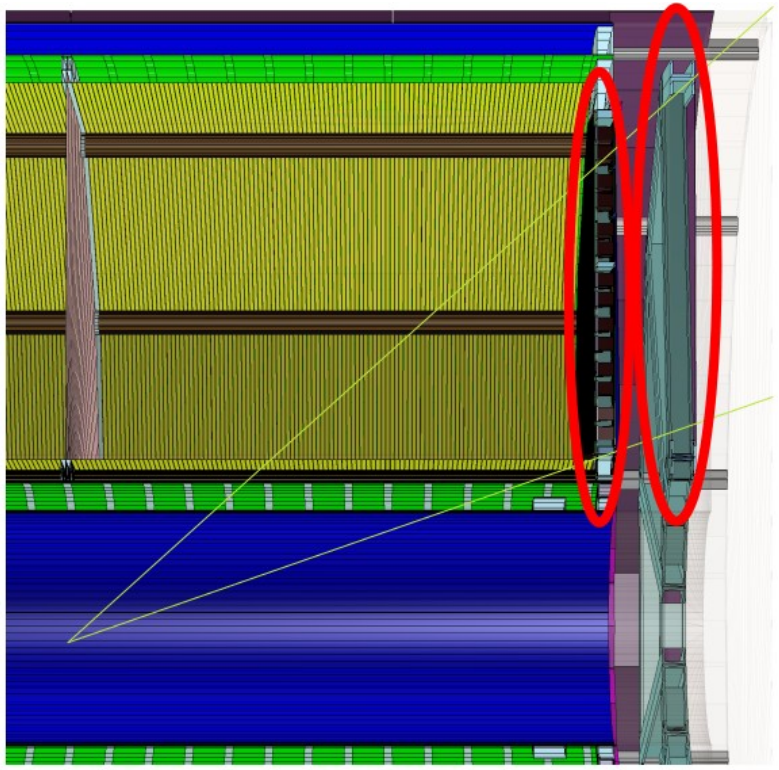
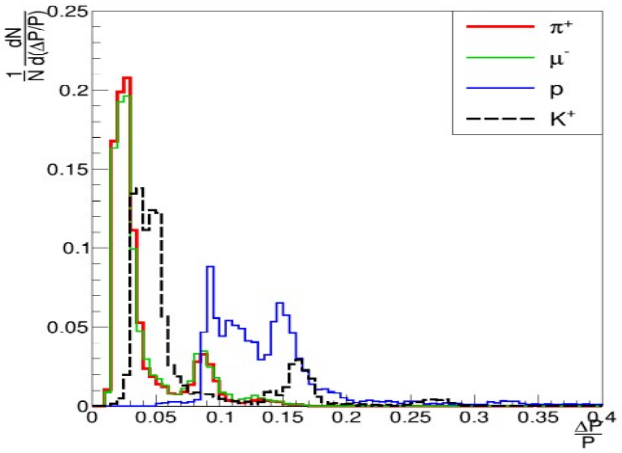
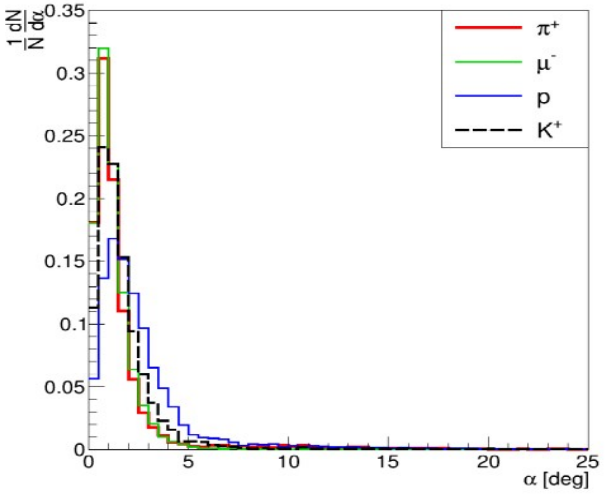


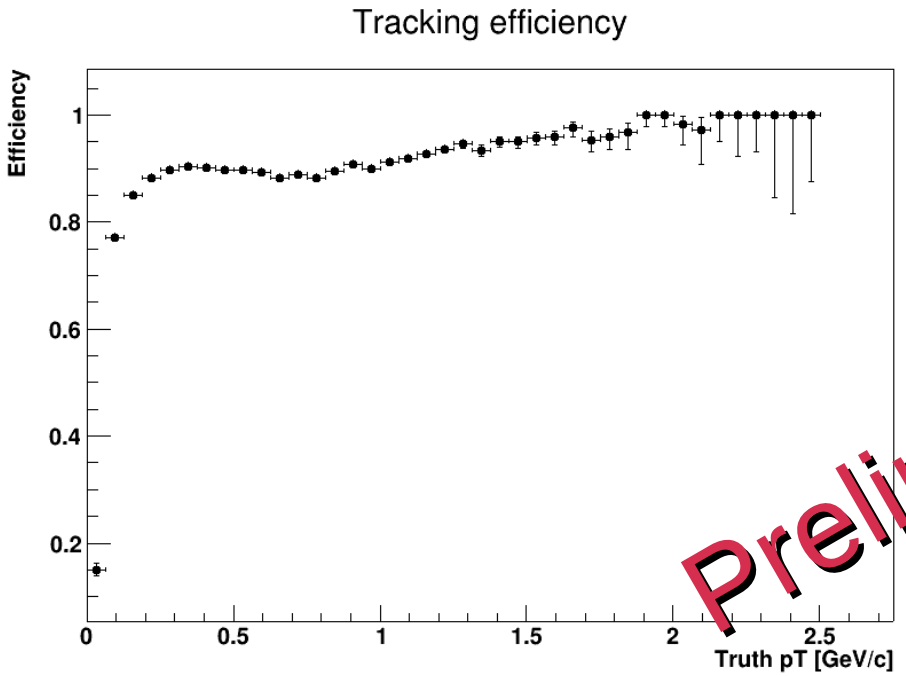
After end-cap flanges

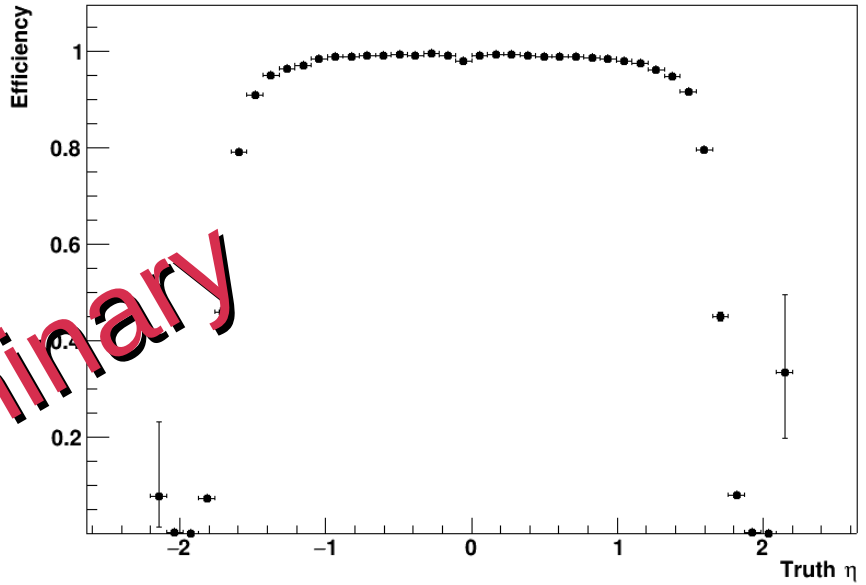




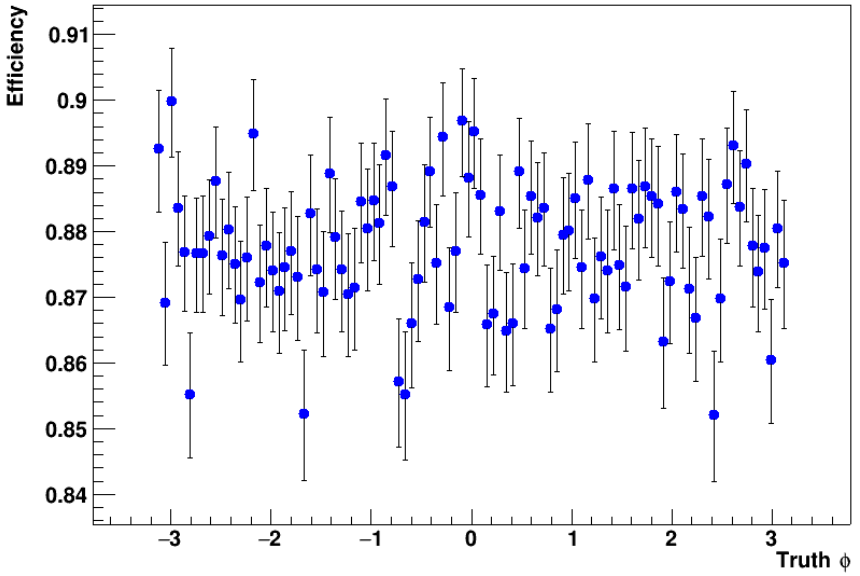
$$\alpha = \langle \vec{p}_{in}, \vec{p}_{out} \rangle$$

Tracks reconstruction with Acts

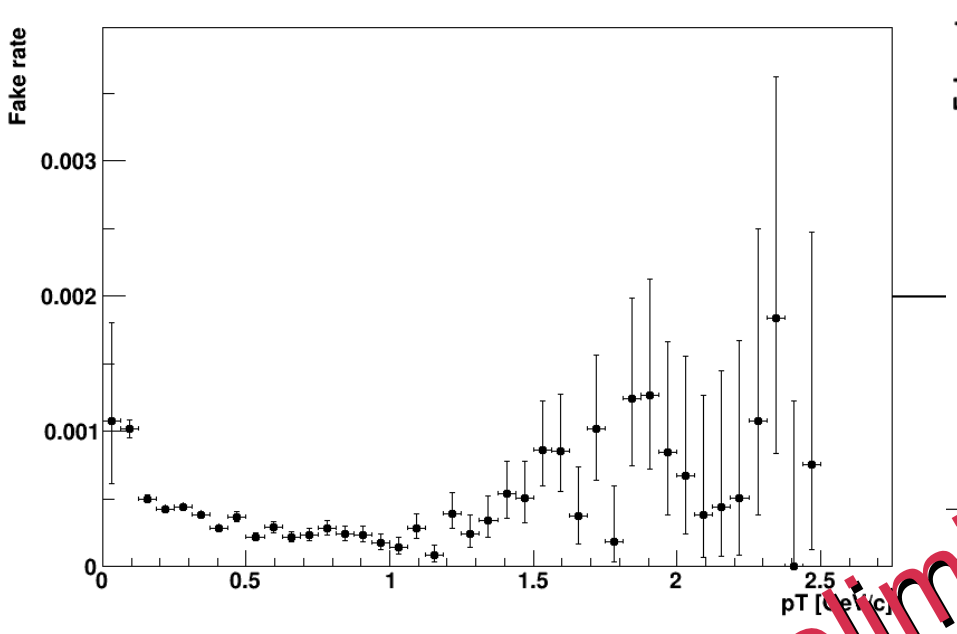


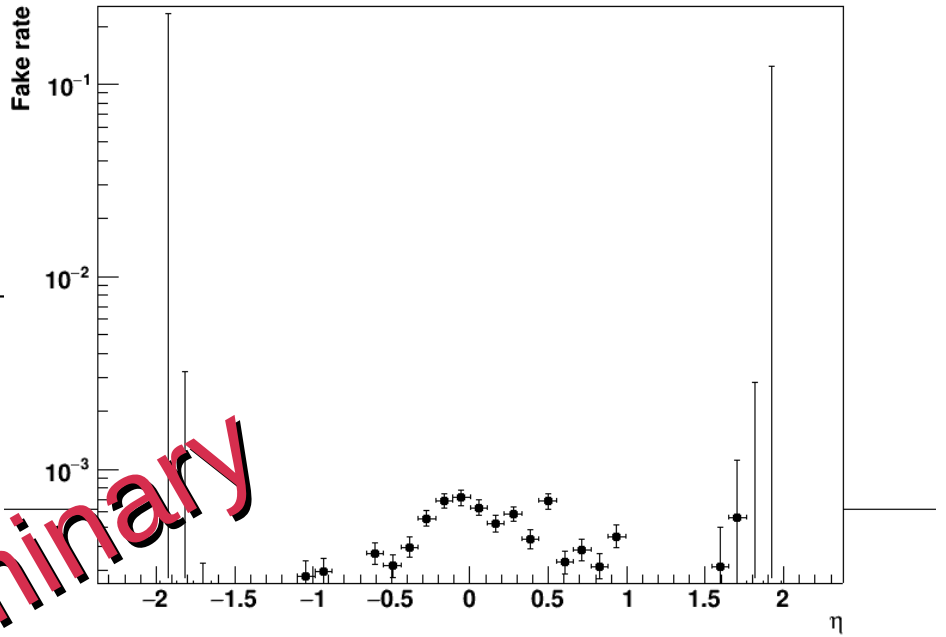


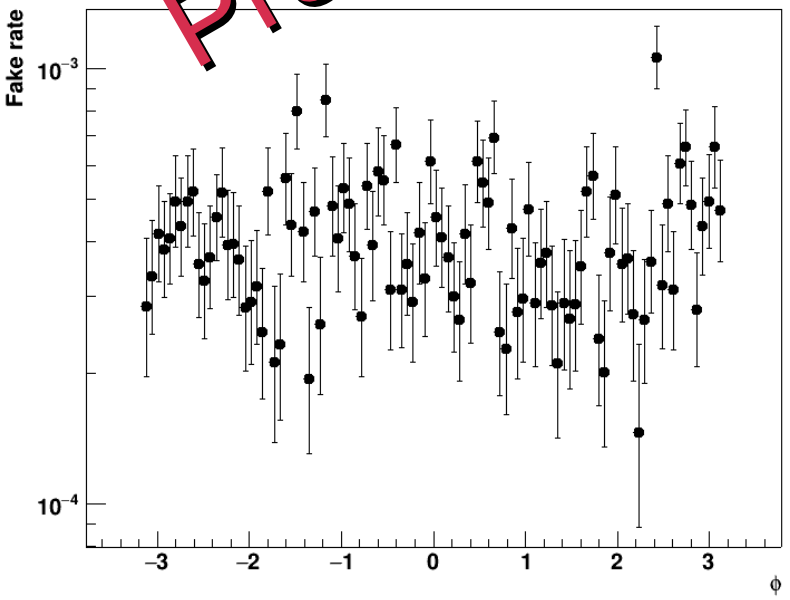
Preliminary



Fake tracks



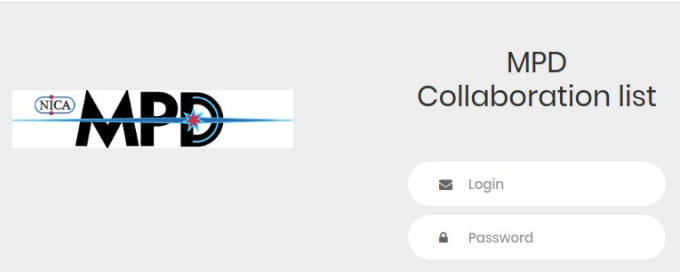


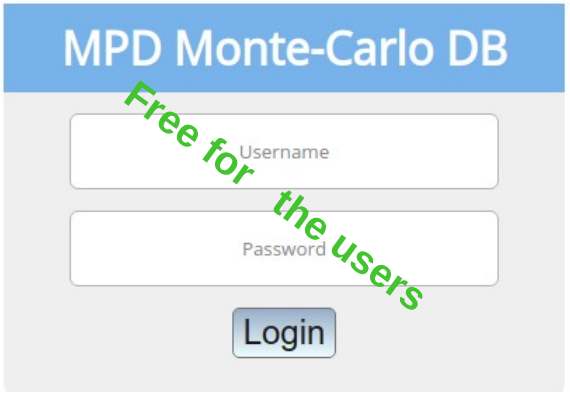


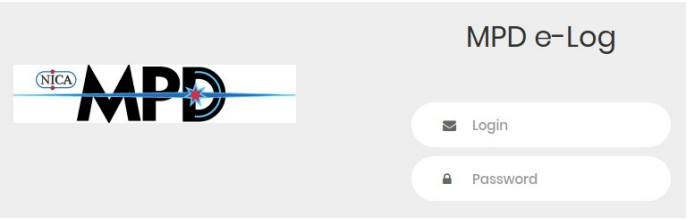
Preliminary

MPD databases

- ✔ List of MPD members & authors
- ✔ MC events mass productions
- ✔ LogBook for Experiment
- ✔ TPC DB
  - TPC geometry
  - TPC calibration
  - TPC alignment parameters
- ✔ TOF calibration
- ✔ ECAL instrumentation
- ✔ ....

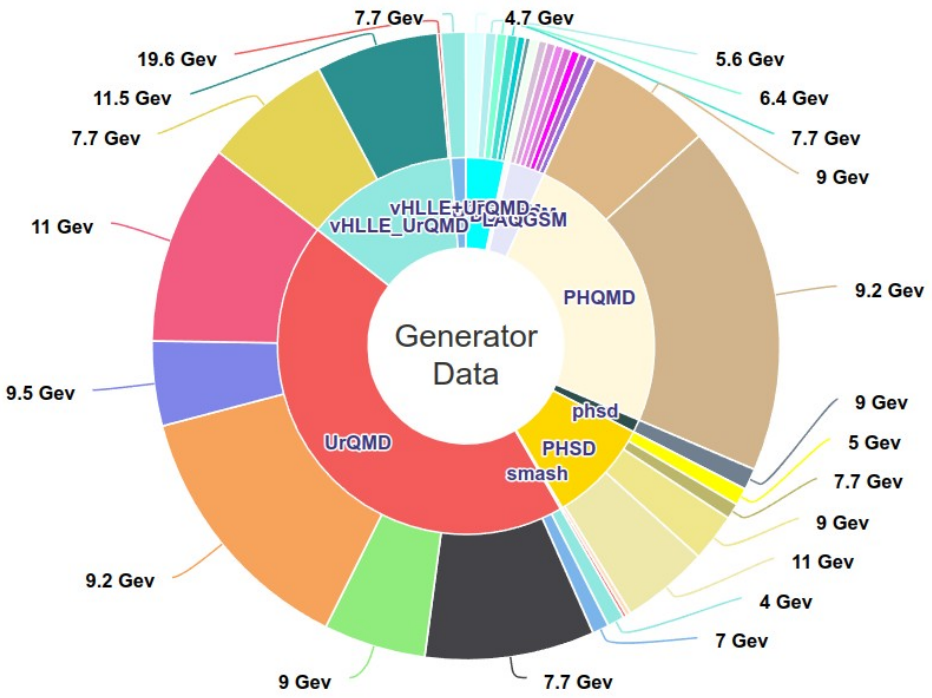




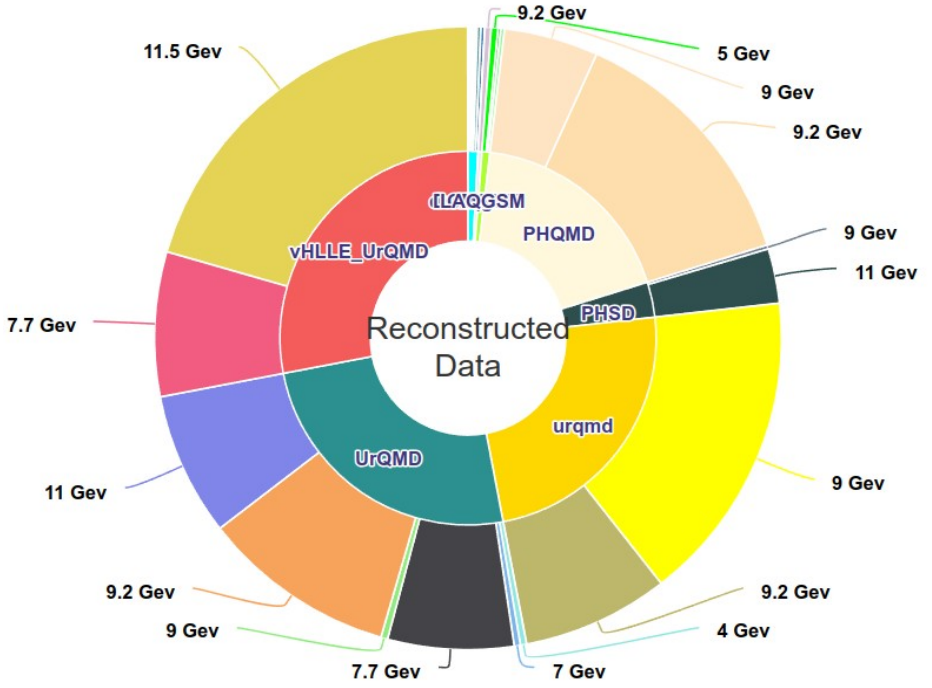


MPD MC data mass production

MC events
> 1300M



Reconstructed events
> 500M

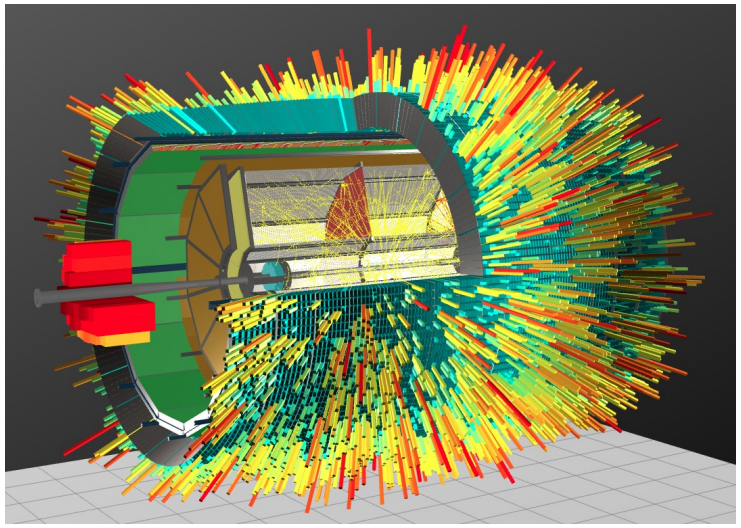


MC Data set for MPD

Generator	PWG	Coll.		# of events()	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	+
		BiBi fix target	2.5	12	+
		BiBi fix target	3.0	(12 underway)	+
		BiBi fix target	3.5	(12 underway)	+
	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	+
		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				1293(74 underway)	449(74 underway)

Software for physics analyses

Experiment

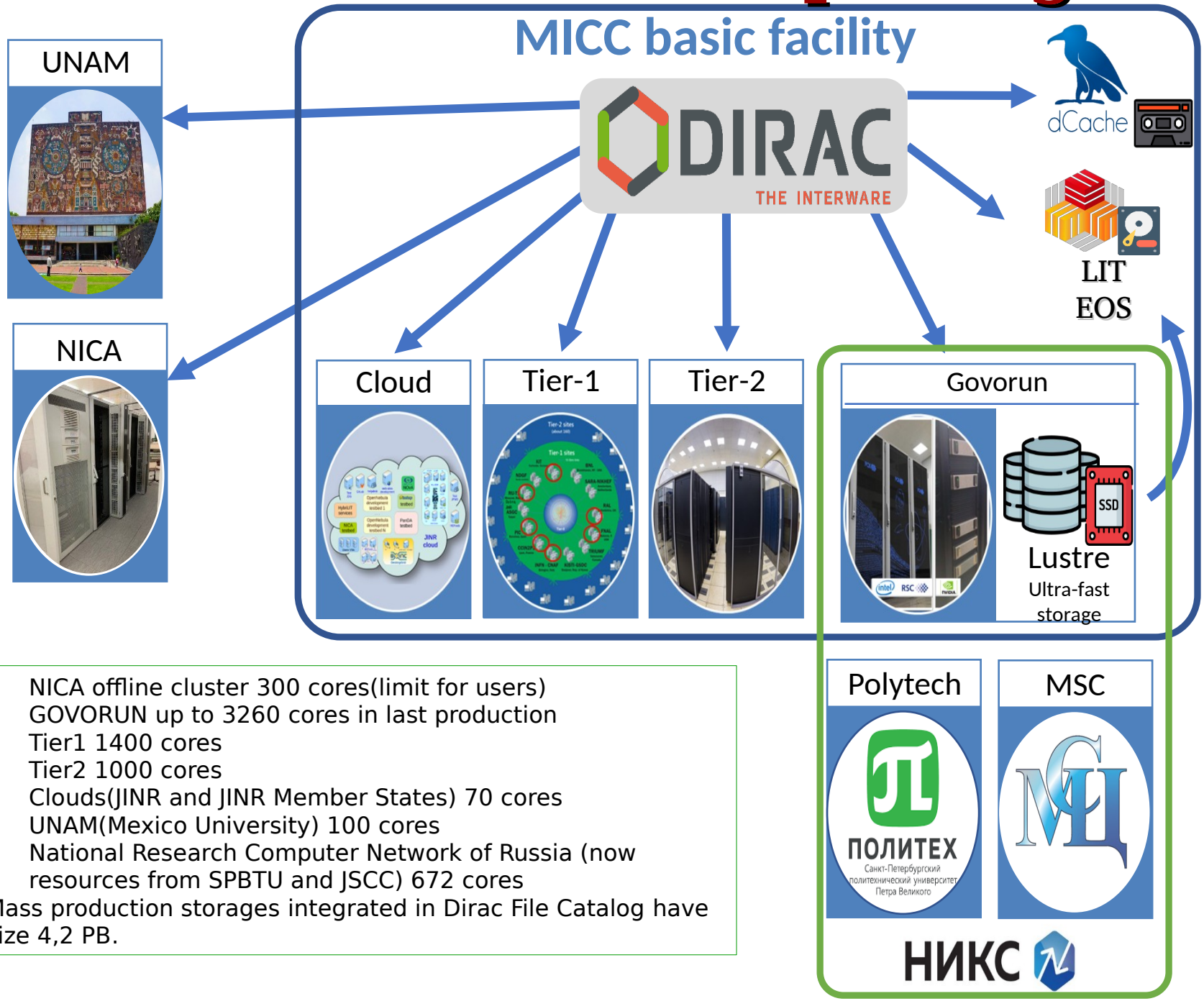


Reconstruction

Physics analyses

- Flow
- Femtoscopy
- Dileptons
- Stopping power
- Particles decay
- …

NICA distributed computing

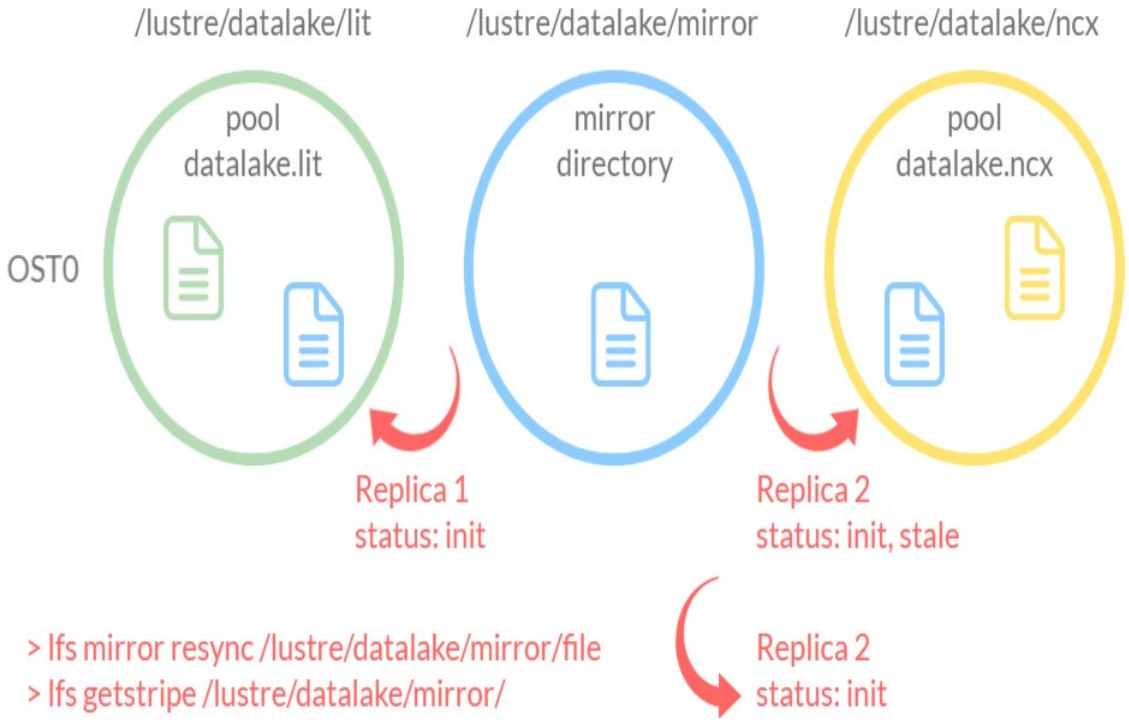


- NICA offline cluster 300 cores(limit for users)
- GOVORUN up to 3260 cores in last production
- Tier1 1400 cores
- Tier2 1000 cores
- Clouds(JINR and JINR Member States) 70 cores
- UNAM(Mexico University) 100 cores
- National Research Computer Network of Russia (now resources from SPBTU and JSCC) 672 cores

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

Data processing

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



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

Thank you for attention

to MPD