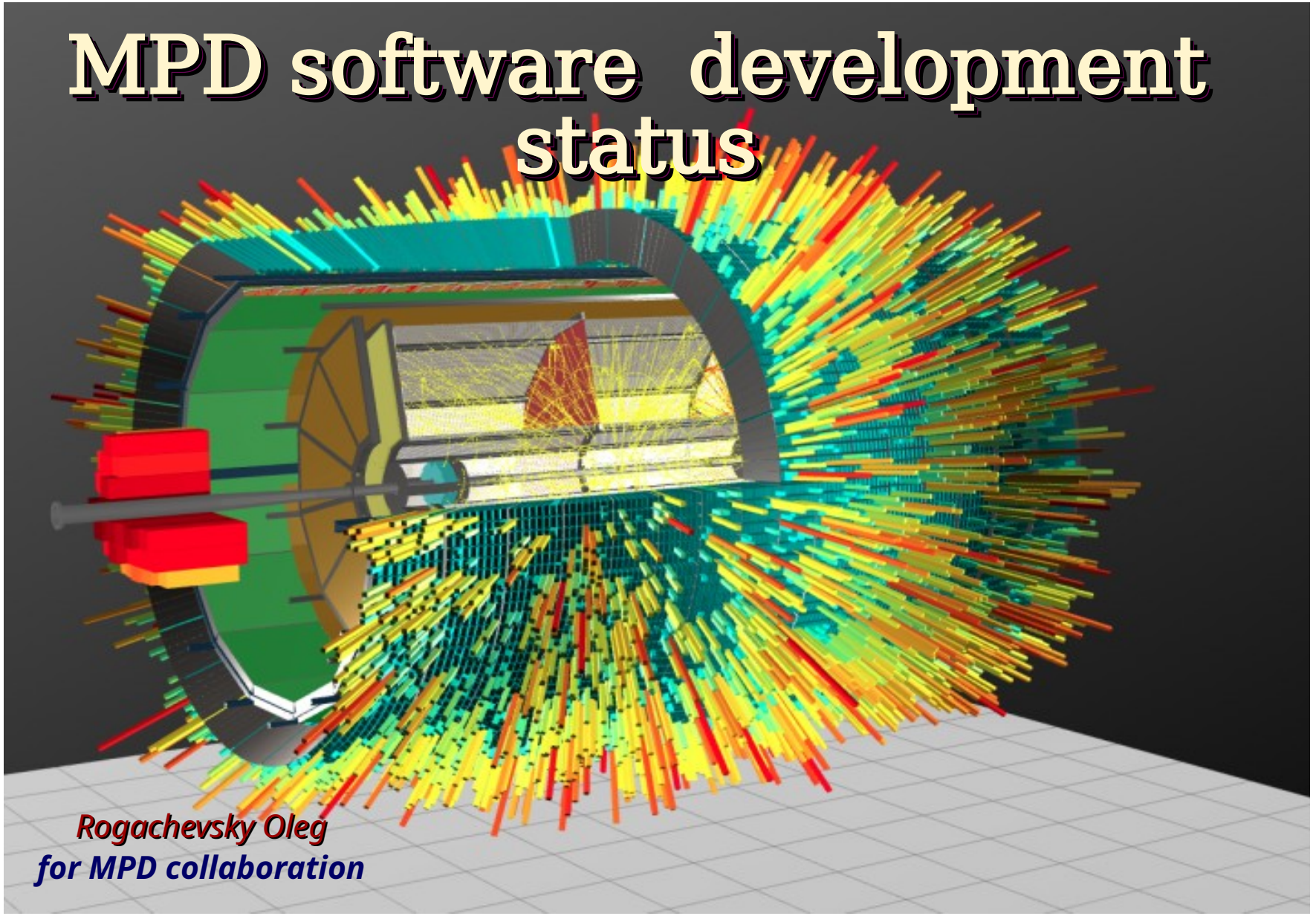
MPD software development status



Rogachevsky Oleg
for MPD collaboration

MpdRoot development

Software group:

Oleg Rogachevsky
This report

Slavomir Hnatic
Progress of ACTS implementation in MPDRoot

Alexander Krylov
MPD DST event viewer

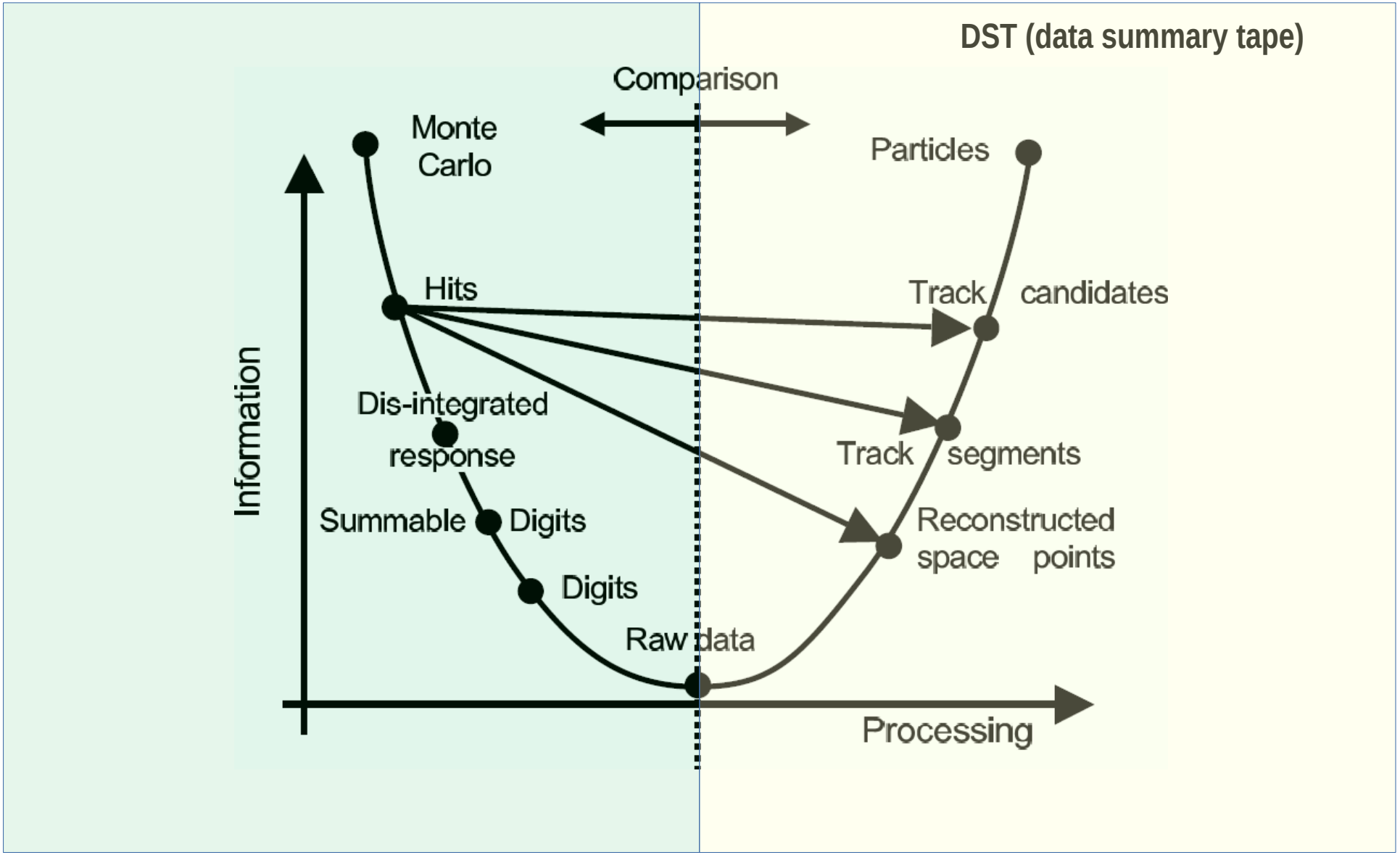
Victor Krylov

Alexander Bychkov

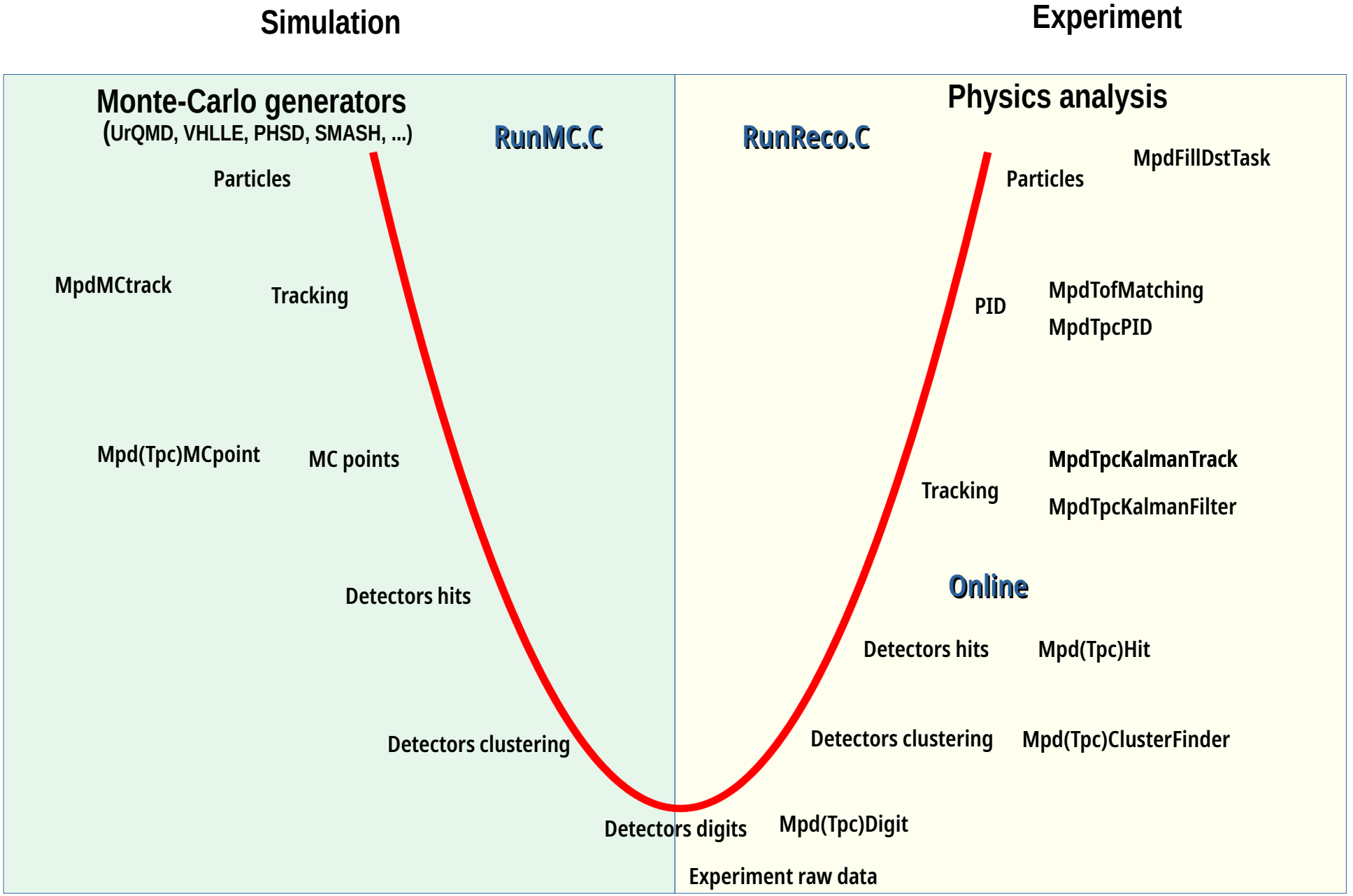
Jan Busa

Valentin Kuzmin

Standard HEP experiments software groups ~ several dozens of people

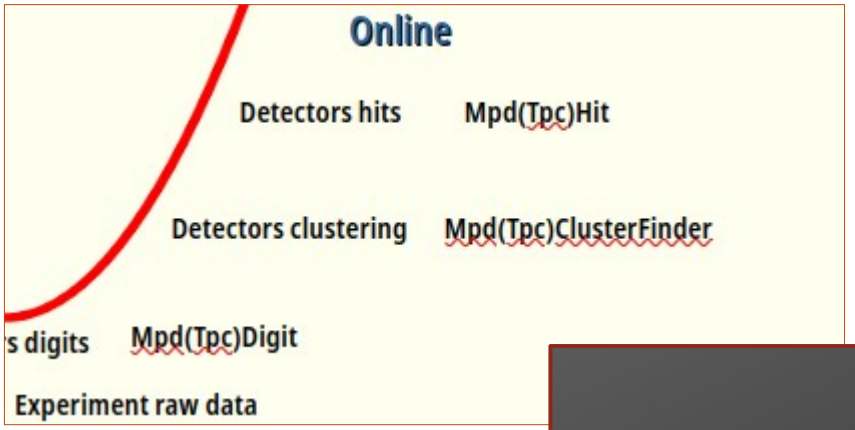

Simulation
Experiment
DST (data summary tape)
Comparison
Monte Carlo
Particles
Hits
Track candidates
Dis-integrated response
Track segments
Summable Digits
Reconstructed space points
Digits
Raw data
Information
Processing

Simulation @ Experiment chain

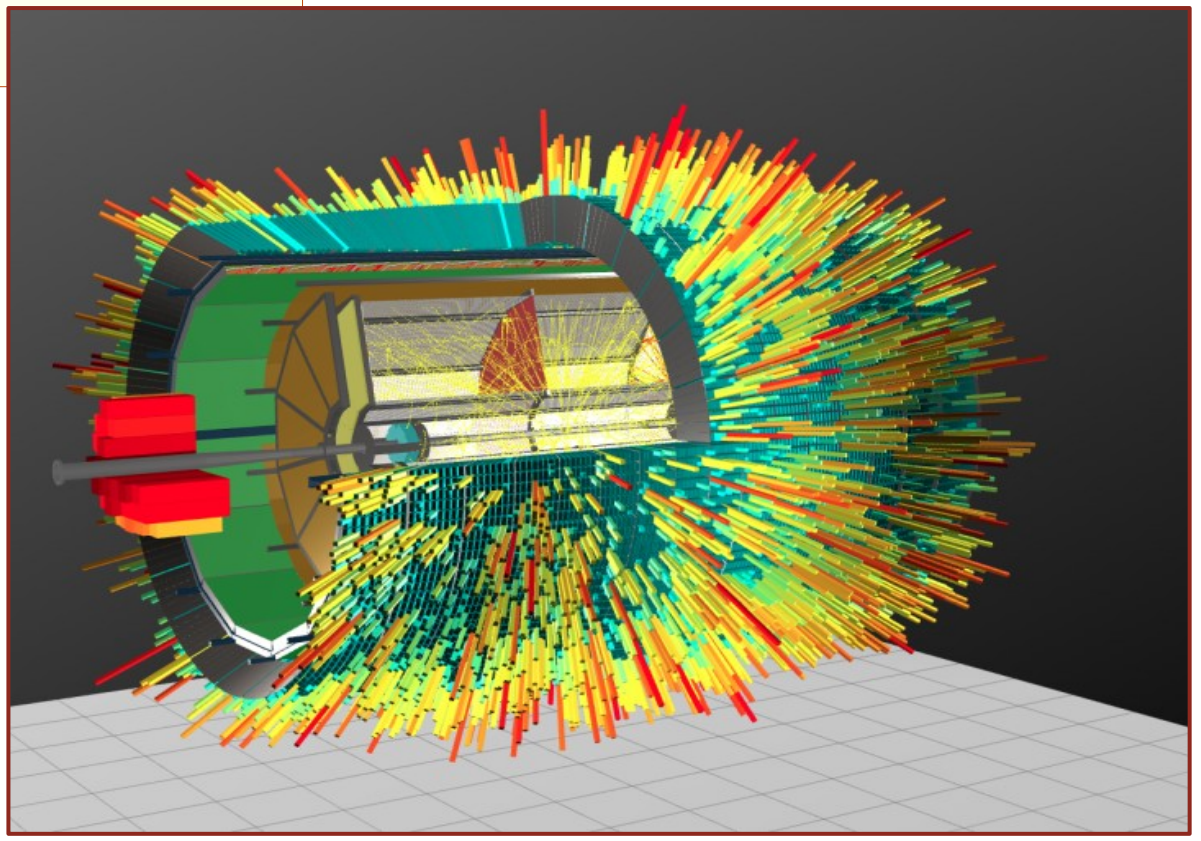


Event display for experiment

Alexander Krylov, Victor Krylov



Experiment raw data



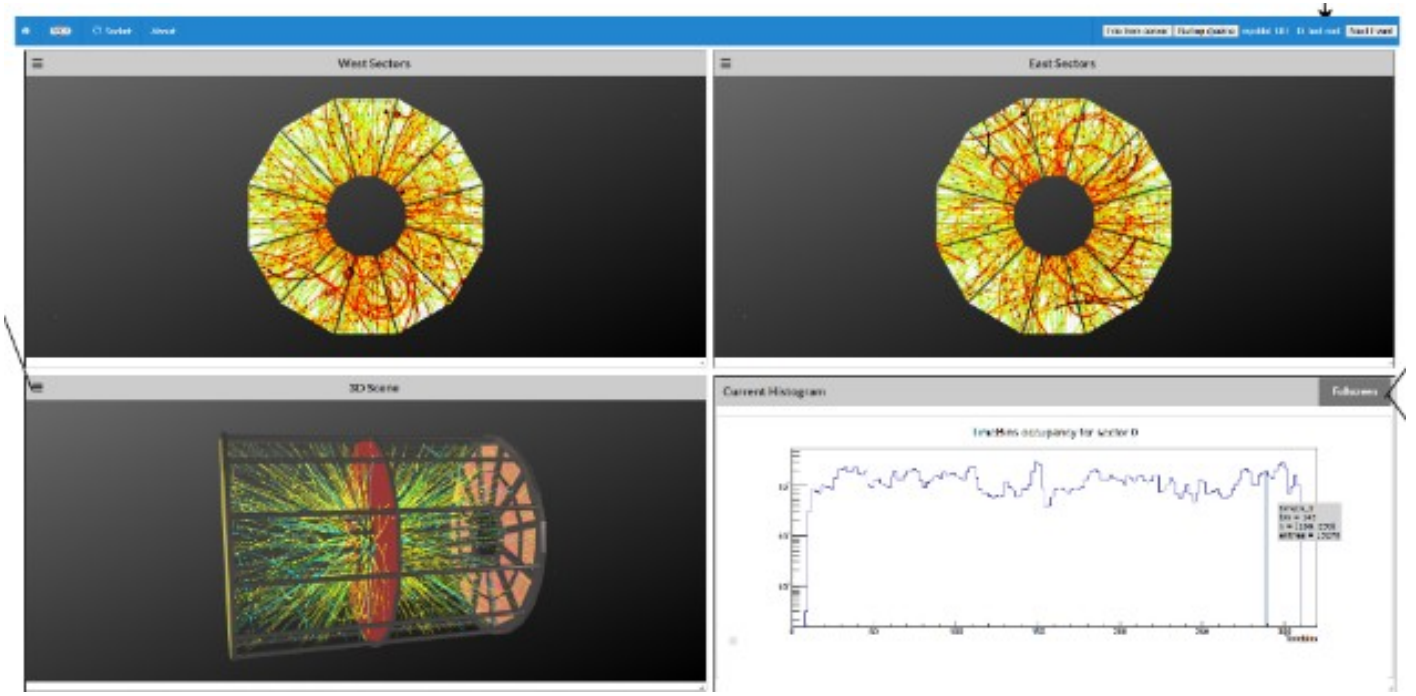
Event viewer for offline analysis

Alexander Krylov

Physics analysis

Particles — MpdFillDstTask

MonteCarlo (Experiment) **dst data**



Online QA hists for TPC

- Inner pads ADC distribution per sector – 24 histograms
- Outer pads ADC distribution per sector – 24 histograms
- Inner pads ADC distribution per timebucket – 24 histograms (per each sector)
- Outer pads ADC distribution per timebucket – 24 histograms (per each sector)
- Inner pads ADC distribution for current event – 24 histograms (per each sector)
- Outer pads ADC distribution for current event – 24 histograms (per each sector)
- General clusters information – 6 histograms

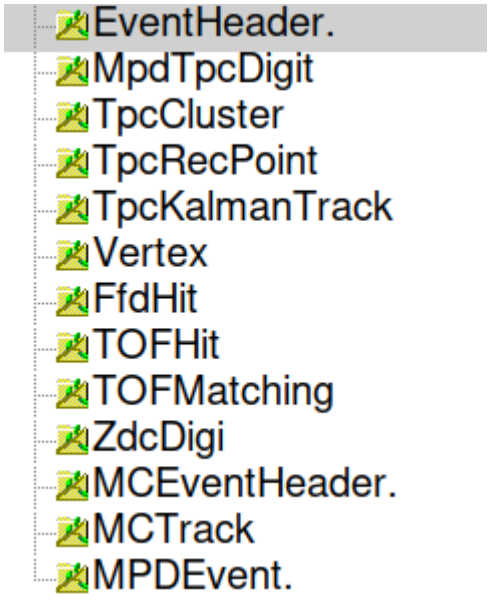
Total number of TPC QA histograms – 150

MPD DST output

runReco.C

MpdFillDstTask *fillDST = new MpdFillDstTask(qaObject, "MpdDst task");

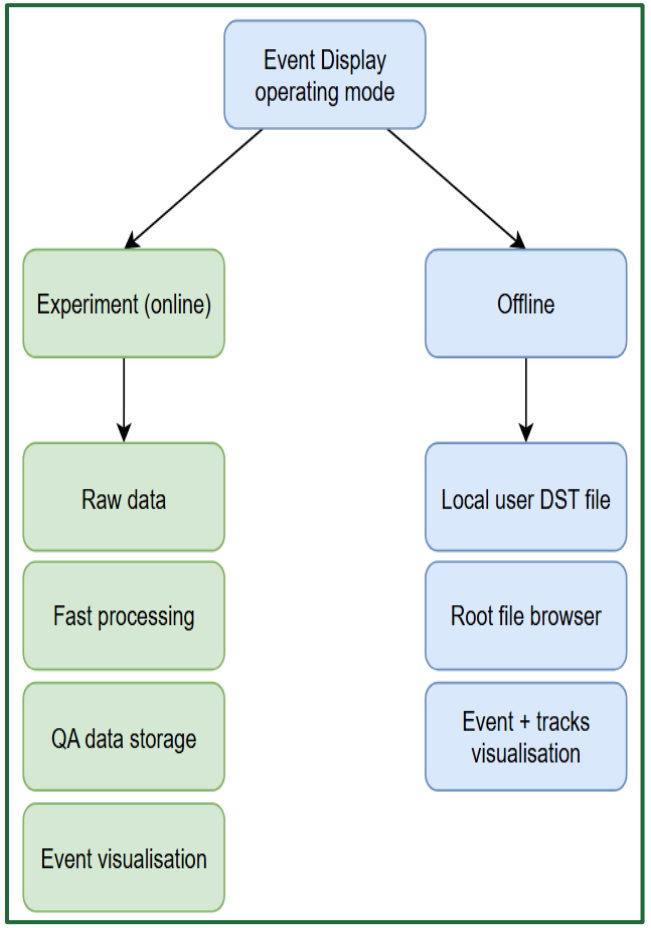
MpdMiniDstFillTask *miniDst = new MpdMiniDstFillTask(*kalman, outFile);



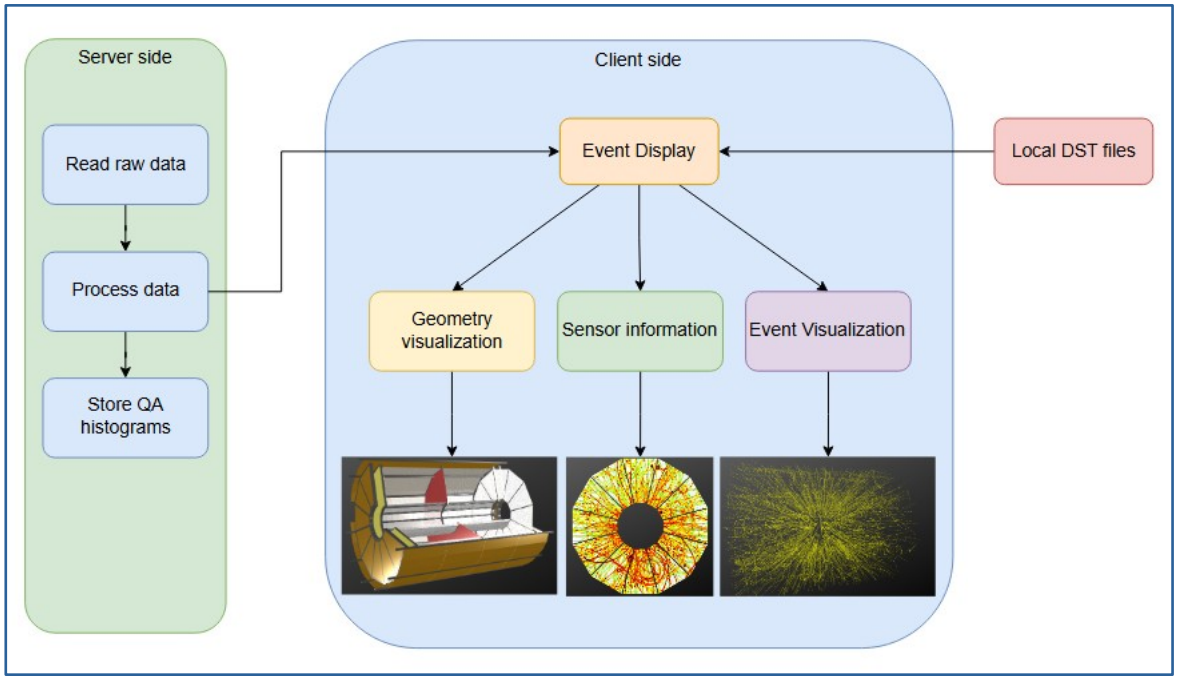
MCEventHeader		
MCTrack		**Monte-Carlo**
MPDEvent		
EventHeader		
TpcKalmanTrack		**reconstruction**
Vertex		
MpdTpcDigit	tpc/	
TpcCluster	tpc/	
TpcRecPoint	tpc/	
FfdHit	ffd/	**detectors**
TOFHit	tof/	
TOFMatching	tof/	
ZdcDigi	zdc/	

DST Event viewer vs event display

Features

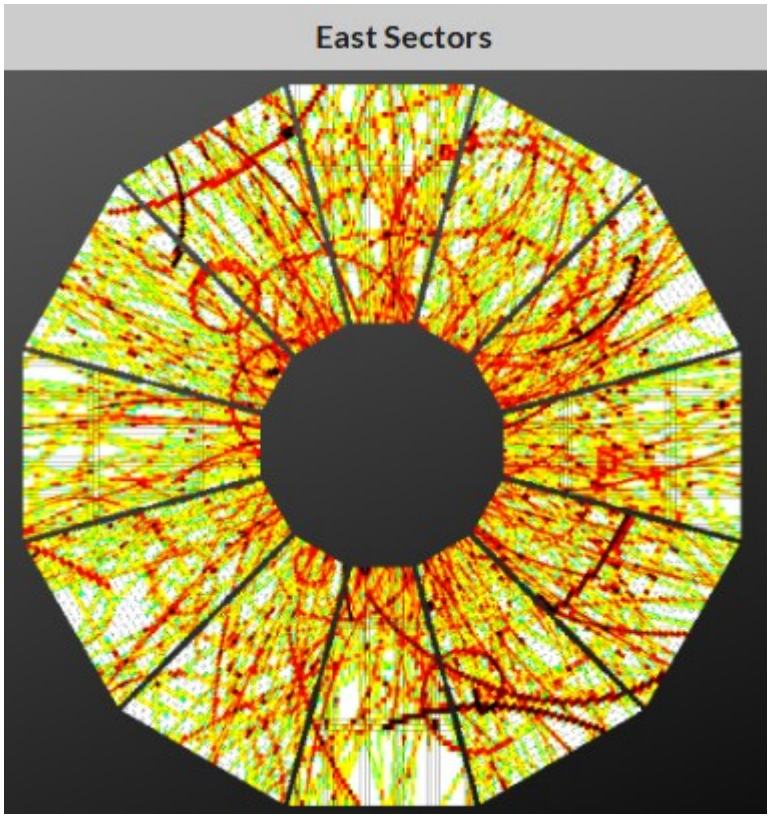


Advantages

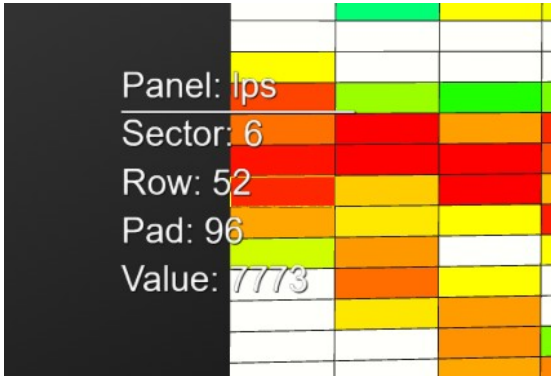


Event viewer TPC info

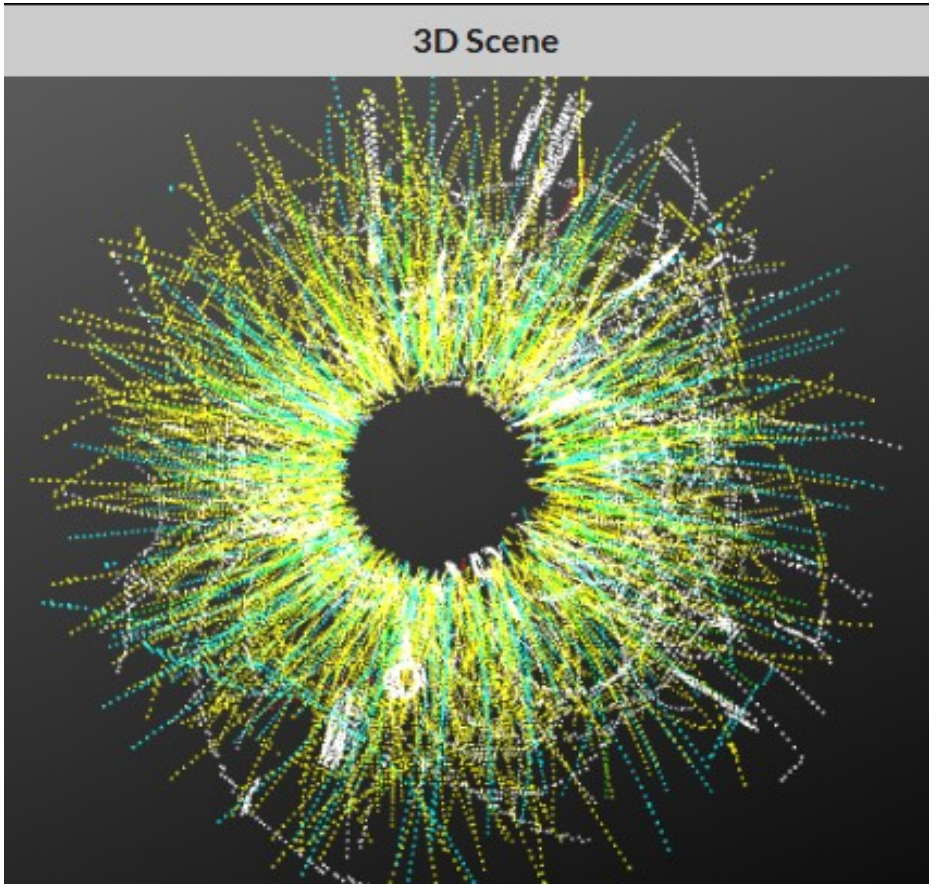
Alexander Krylov



TPC hits + ADC



TPC hits + MC tracks PID



Updates in release v25.03.25

Hnatic S., Busa J.

MOST IMPORTANT CHANGES

New features

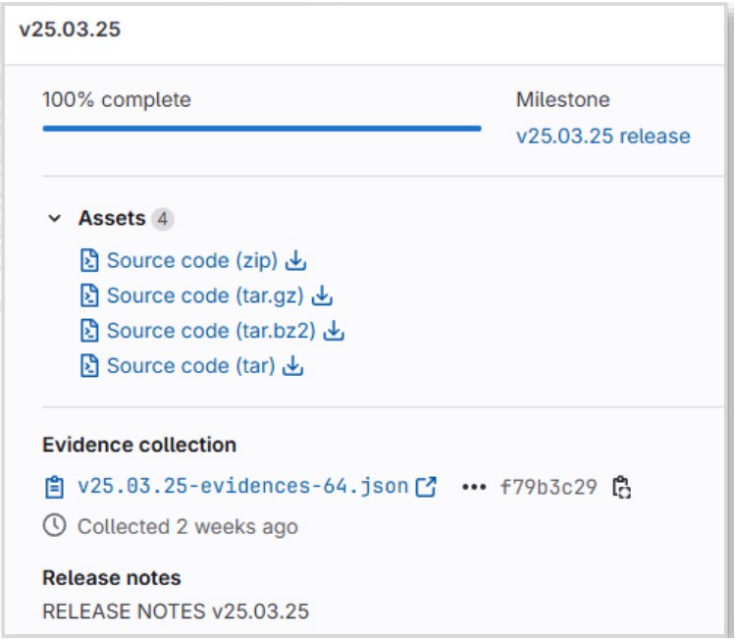
- Analysis updates (physicists)
- ACTS v40, v38.1, v38.1-ckf ports
- ACTS port refactorings, adjustments, fixes, custom patches

Latest dependencies

- ROOT 6.32.06
- GCC 13.2.0
- Boost 1.83.0
- FairRoot 18.6.10
- GEANT4 .... 11.2.1
- Python 3.12.4
- GSL 2.8
- Fedora 41

DETAILED INFO in RELEASE NOTES

git.jinr.ru/nica/mpdroot/-/releases

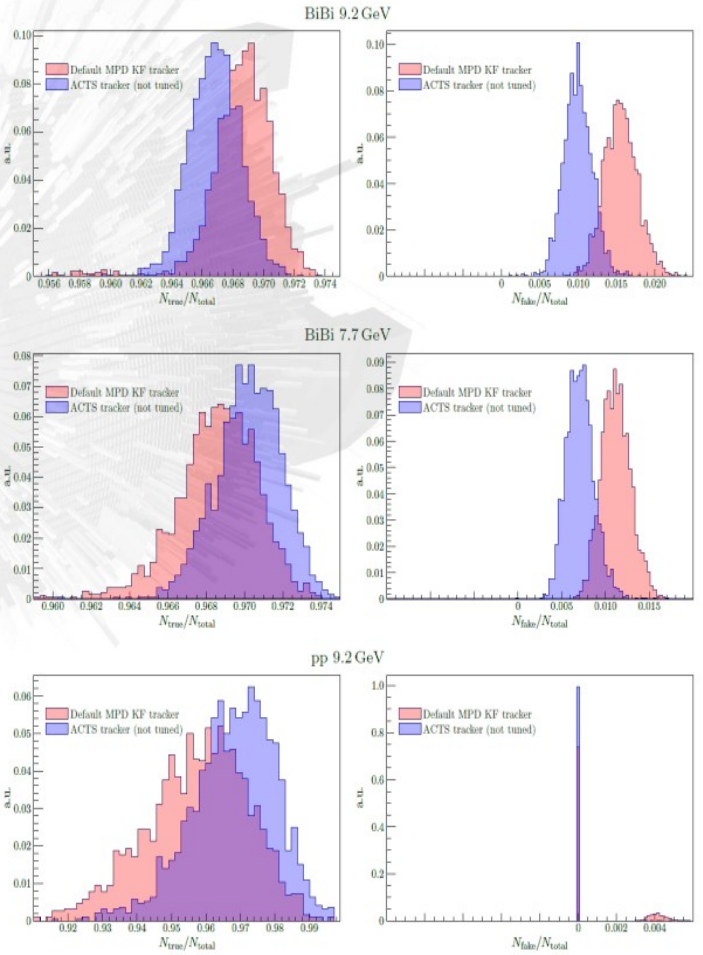


ACTS tracking implementation

Slavomir Hnatic, MLIT JINR

- MLEM clustering; ACTS v36.0.0
- 200000 events (2000 runs, 100 events per run)
- 9 minimum hits per track
- P_t > 0.1 GeV

	Default tracker		ACTS tracker	
	true rate	fake rate	true rate	fake rate
BiBi 9.2 GeV	$\mu = 0.9686$ $\sigma = 0.00212$	$\mu = 0.01544$ $\sigma = 0.002012$	$\mu = 0.9668$ $\sigma = 0.001724$	$\mu = 0.00999$ $\sigma = 0.00189$
BiBi 7.7 GeV	$\mu = 0.9686$ $\sigma = 0.002107$	$\mu = 0.01122$ $\sigma = 0.001664$	$\mu = 0.9702$ $\sigma = 0.001772$	$\mu = 0.00713$ $\sigma = 0.001612$
pp 9.2 GeV	$\mu = 0.958$ $\sigma = 0.01426$	$\mu = 0.00128$ $\sigma = 0.002337$	$\mu = 0.968$ $\sigma = 0.00212$	$\mu = 2.5 \cdot 10^{-5}$ $\sigma = 3.5 \cdot 10^{-4}$



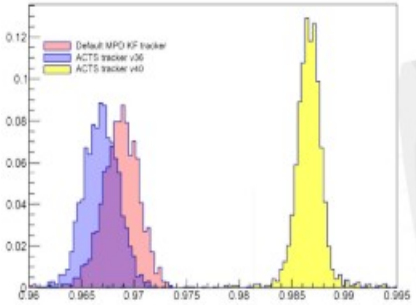
"Implementation of ACTS into MPDRoot"
S. Hnatic, J. Busa Jr., A. Bychkov, A. Krylov, V. Krylov, A. Moshkin, O.Rogachevsky

MMCP '24 Proceedings, PEPAN

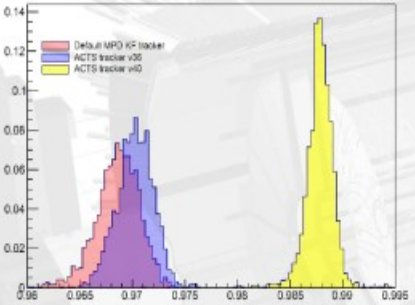
ACTS progress in MPD

CKF enhancements: better efficiency, far less fakes

Efficiency

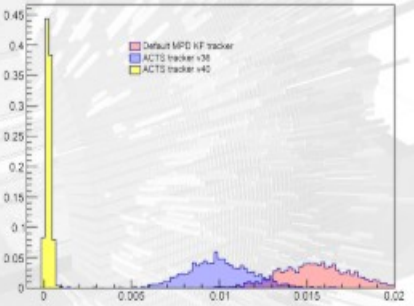


BiBi 9.2 GeV

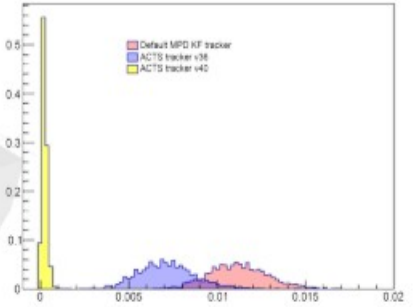


BiBi 7.7 GeV

Fake rate



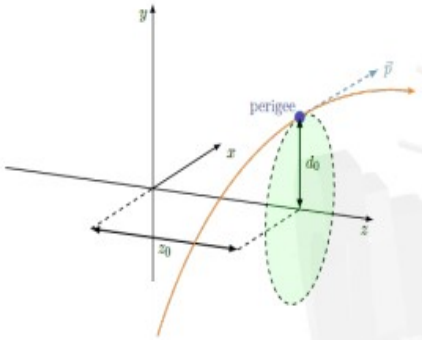
BiBi 9.2 GeV



BiBi 7.7 GeV

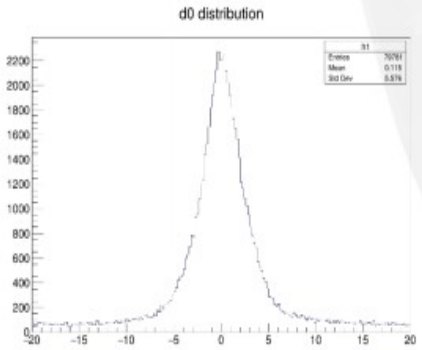
	Default tracker		ACTS tracker v36.0.0		ACTS tracker v40.0.0	
	true rate	fake rate	true rate	fake rate	true rate	fake rate
BiBi 9.2 GeV	$\mu = 0.9686$ $\sigma = 0.00212$	$\mu = 0.01544$ $\sigma = 0.002012$	$\mu = 0.9668$ $\sigma = 0.001724$	$\mu = 0.00999$ $\sigma = 0.00189$	$\mu = 0.9866$ $\sigma = 0.001779$	$\mu = 0.00026$ $\sigma = 0.000172$
BiBi 7.7 GeV	$\mu = 0.9686$ $\sigma = 0.002107$	$\mu = 0.01122$ $\sigma = 0.001664$	$\mu = 0.9702$ $\sigma = 0.001772$	$\mu = 0.00713$ $\sigma = 0.001612$	$\mu = 0.9878$ $\sigma = 0.001427$	$\mu = 0.000225$ $\sigma = 0.000168$

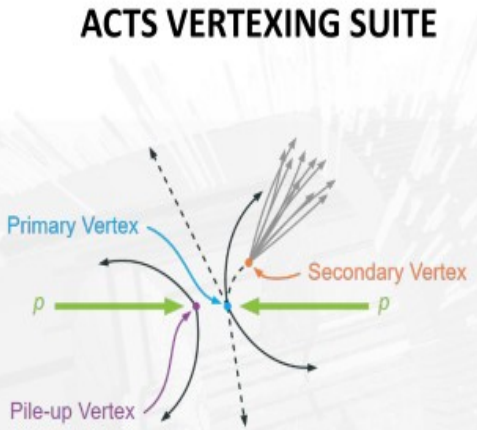
MPD Vertex with ACTS

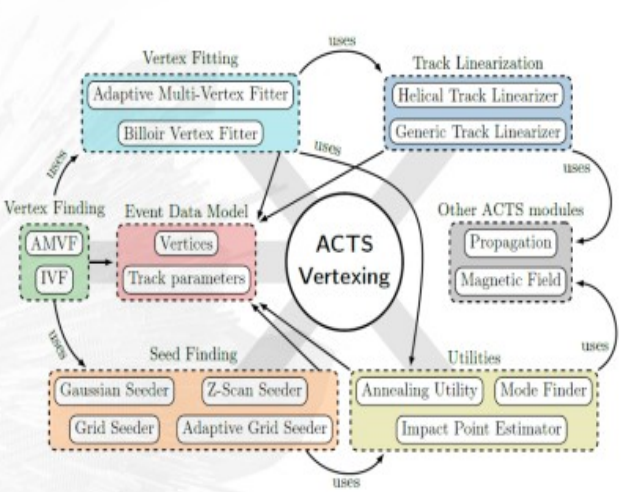


PERIGEE TRACK PARAMETRIZATION

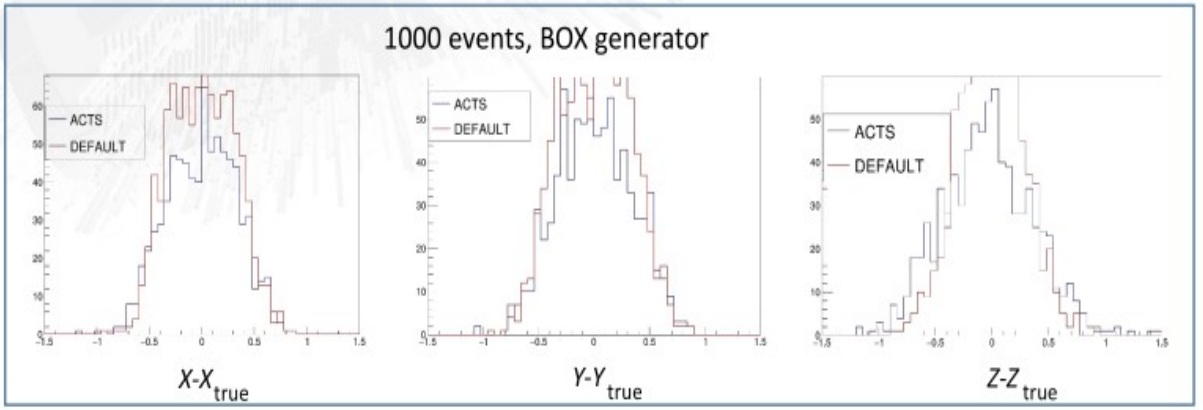
Track selection: |d_0| < 2mm



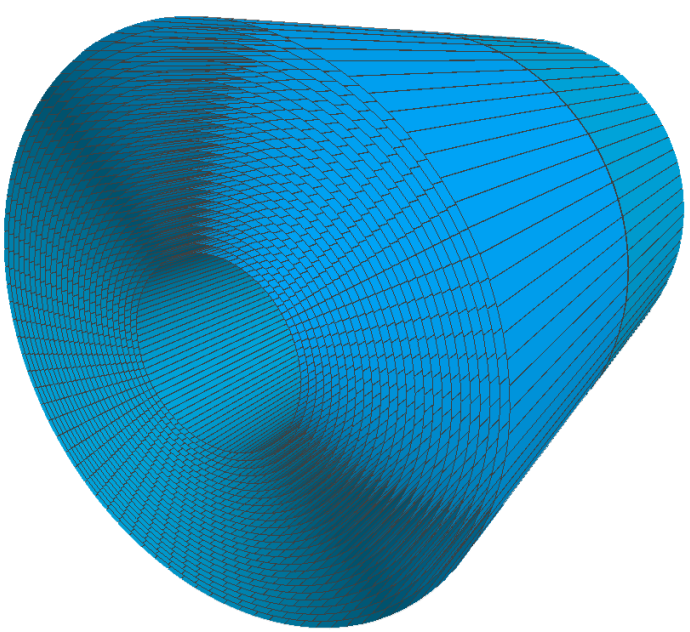


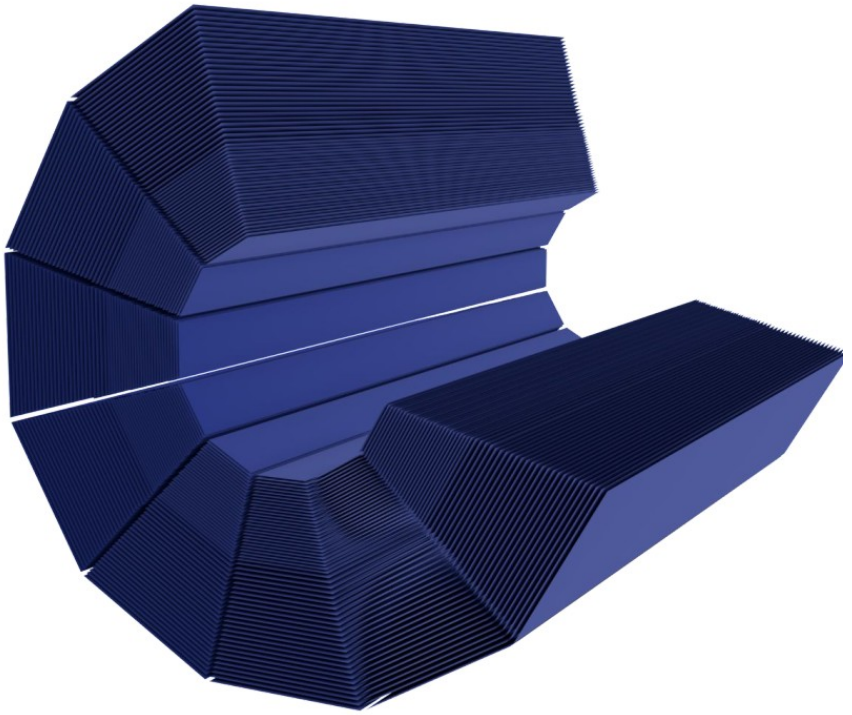


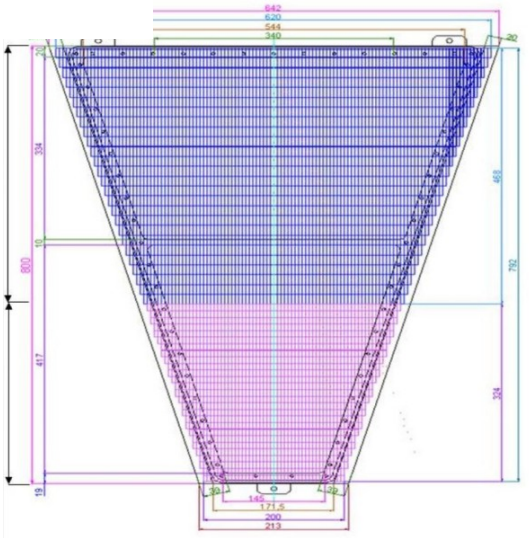
- many tunable parameters, to be fine tuned yet



Adjust TPC geometry for ACTS

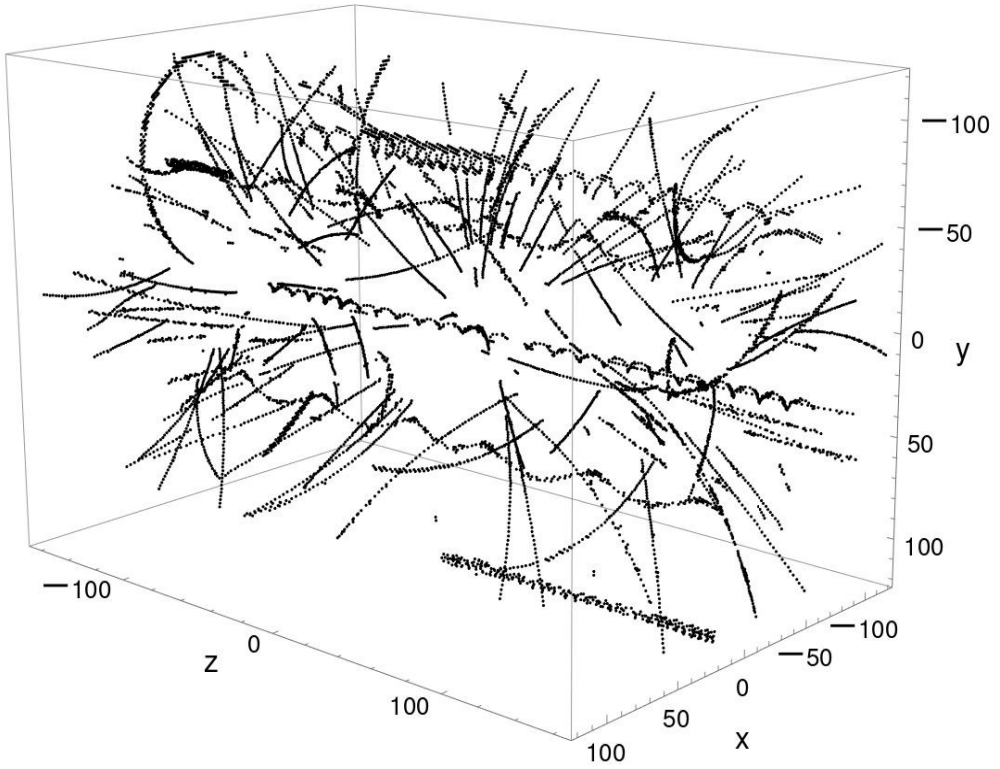


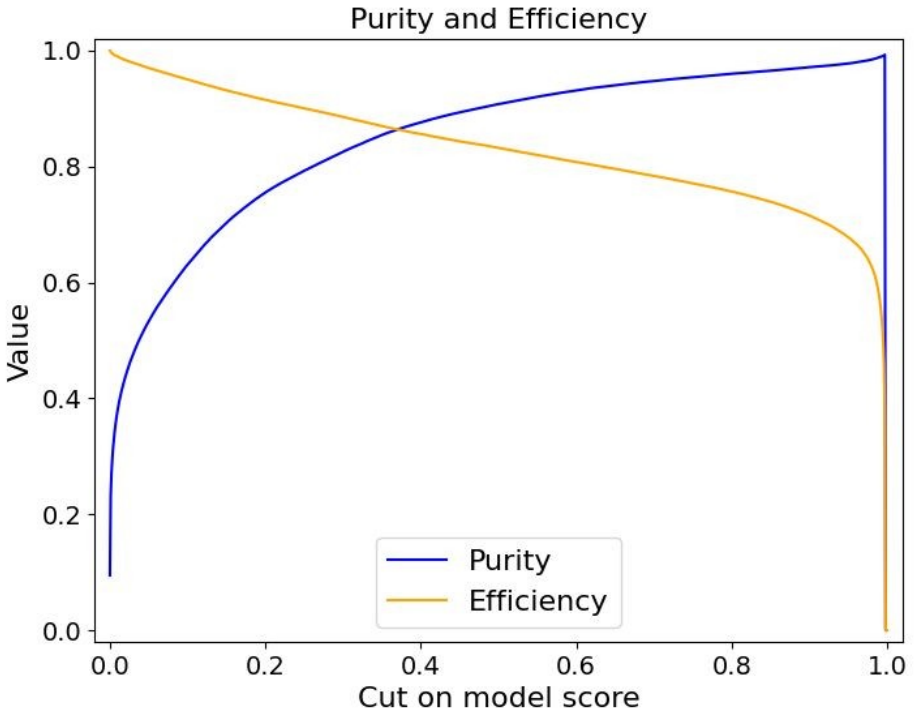




Tracking with Graph Neural Networks

Yauheni Talochka , MLIT JINR

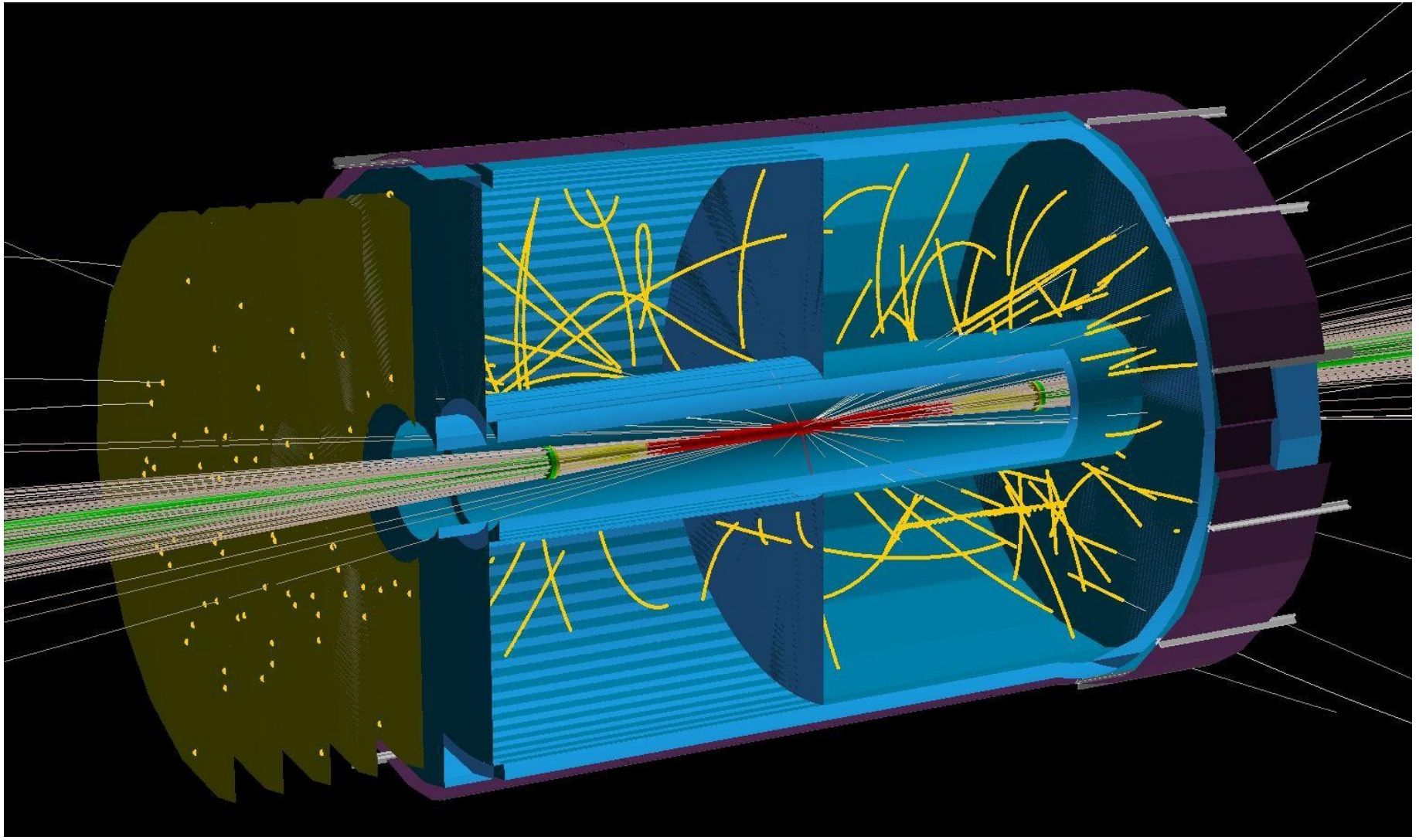




MPD AuAu √s = 11 GeV

Endcap tracking

Evgeny Kryshen, Nazar Burmasov,
PNPI



Refactoring

Refactoring is a disciplined technique for restructuring an existing body of code, altering its internal structure without changing its external behavior.

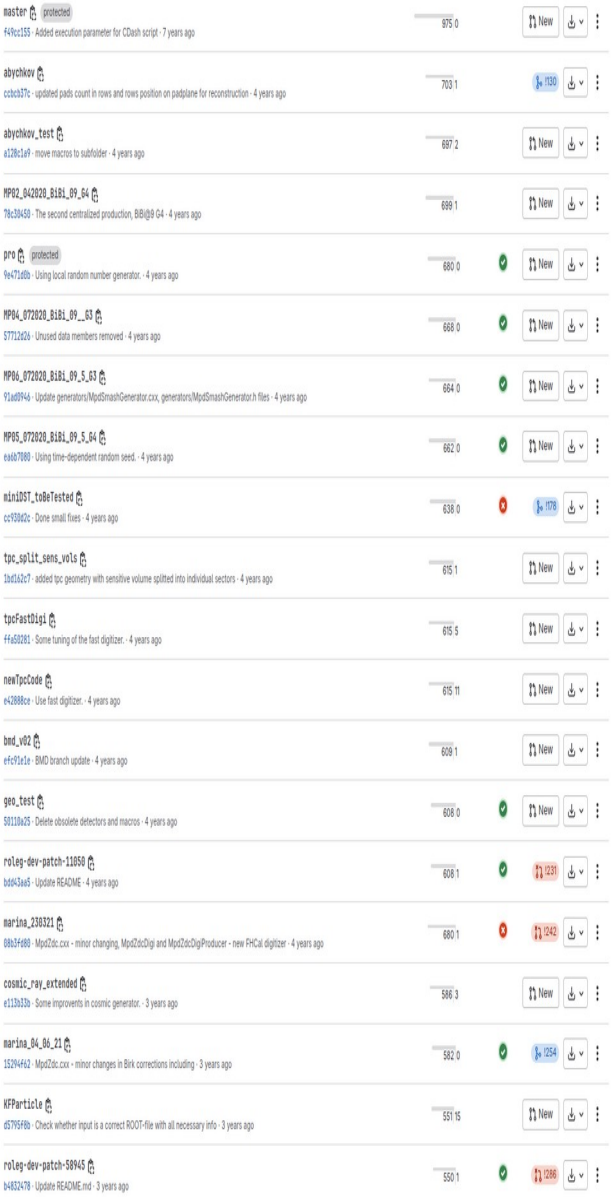
Refactoring

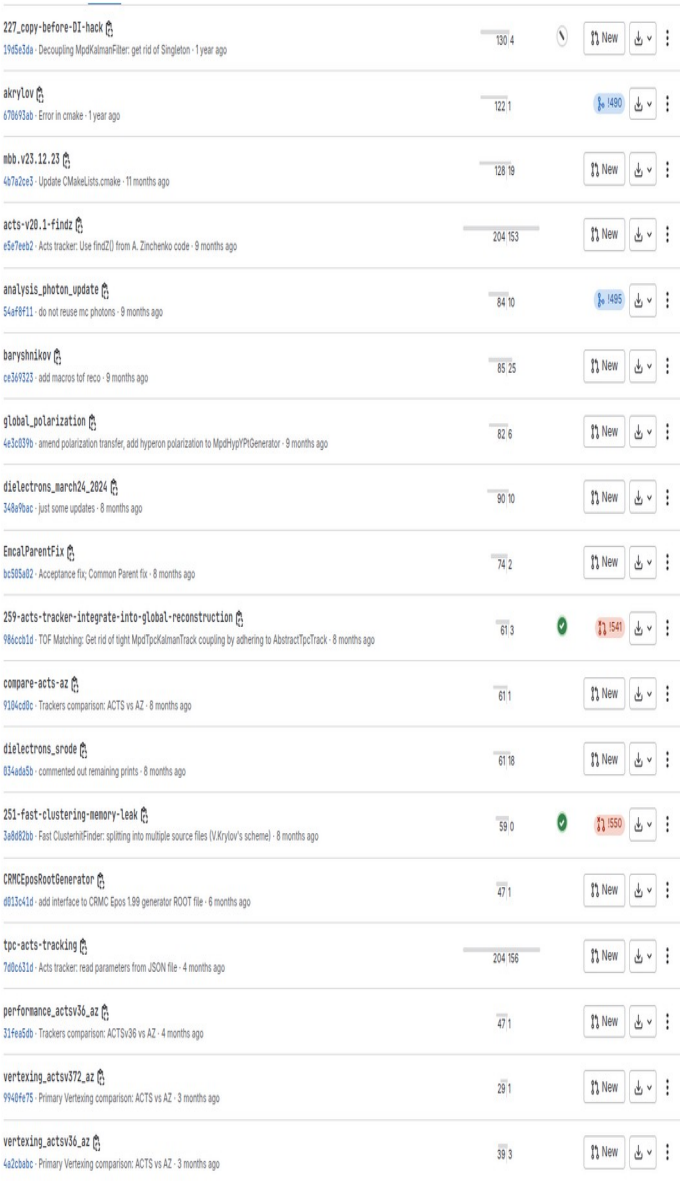
J.Busa -- MpdRoot refactoring (Version 0.1 – 2025. 01. 24)
https://indico.jinr.ru/event/5365/

Contents

1. Libraries Renaming
2. Library Merging
3. Directory Structure Change
4. Examples and Macros
5. Classes Renaming
6. Virtual Classes
7. Guard Rails
8. Removing cout, cerr
9. ClassImp
10. mpdPassive
11. CMake + New Library Versioning
12. MpdGeneratorType
13. Remove Dead Detectors
14. Copyright Notice

GIT status: 20 branches





GIT repository: too many root files

…..
3.1M ./input/field_sp41v1.root
7.5M ./input/TpcEDepParamsHeed.root
9.9M ./physics/dielectrons/macros/sim_Geo.root
9.9M ./physics/dielectrons/sim_Geo.root
9.9M ./physics/nuclei/macros/sim_Geo.root
9.9M ./physics/pairKK/macros/sim_Geo.root

Total root files size:
70 MB in 102 files from 347 MB

8.0K ./geometry/lusi_v1b.root
8.0K ./geometry/magnet_v5.root
8.0K ./geometry/pipe_v3.root
…
12K ./geometry/FFD_v6.root
12K ./geometry/pipe_v2.root
12K ./geometry/tof_v4.root
12K ./geometry/tof_v7.root
12K ./geometry/zdc_oldnames_7sect_v1_no_overlaps_w_pipe_magnet.root
12K ./geometry/zdc_oldnames_7sect_v1.root
12K ./geometry/zdc_oldnames_7sect_WITH_central_module_v1.root
12K ./physics/evPlaneFXT/macros/TrackRecEff_FXT.root
12K ./physics/pairKK/macros_FXT/TrackRecEff_FXT.root
16K ./geometry/FFD_v8.root
16K ./geometry/magnet_v6.root
16K ./geometry/magnet_v7.root
16K ./geometry/tpc_v7.root
20K ./geometry/tof_v8.root
…
2.2M ./geometry/emc_v2.root
2.8M ./geometry/emc_v3.root
2.9M ./geometry/emc_v4.root

Refactoring

Obsolete

```
tdaq
├── BmnEventMonitor.cxx
├── BmnEventMonitor.h
├── BmnEventPull.cxx
├── BmnEventPull.h
├── BmnTdaqSource.cxx
├── BmnTdaqSource.h
├── EventDLinkDef.h
├── Readme.MD
├── readRootFile.C
└── setup.sh
```

```
└── lheTrack
    ├── CMakeLists.txt
    └── legacy
        ├── lhe.h
        ├── MpdCellAutomat.cxx
        ├── MpdCellAutomat.h
        ├── MpdCellTrack.cxx
        ├── MpdCellTrack.h
        ├── MpdKfV0Fitter.cxx
        ├── MpdKfV0Fitter.h
        ├── MpdKinFitter.cxx
        ├── MpdKinFitter.h
        ├── MpdMotherFitterSimple.cxx
        ├── MpdMotherFitterSimple.h
        ├── MpdTpcTrackFollow2Sft.cxx
        ├── MpdTpcTrackFollow2Sft.h
        ├── MpdTrackFinderIts.cxx
        ├── MpdTrackFinderIts.h
        ├── MpdV0Cuts.cxx
        ├── MpdV0Cuts.h
        ├── MpdV0.cxx
        ├── MpdV0Finder.cxx
        ├── MpdV0Finder.h
        ├── MpdV0.h
        ├── README.md
        ├── TpcLheCMPoint.cxx
        ├── TpcLheCMPoint.h
        ├── TpcLheCMTrack.cxx
        ├── TpcLheCMTrack.h
        ├── TpcLheHit.cxx
        ├── TpcLheHit.h
        ├── TpcLheHitsMaker.cxx
        ├── TpcLheHitsMaker.h
        ├── TpcLhePoint.cxx
        ├── TpcLhePoint.h
        ├── TpcLheSegments.cxx
        ├── TpcLheSegments.h
        ├── TpcLheTrackCuts.cxx
        ├── TpcLheTrackCuts.h
        ├── TpcLheTrack.cxx
        ├── TpcLheTrackFinder.cxx
        ├── TpcLheTrackFinder.h
        ├── TpcLheTrackFitter.cxx
        ├── TpcLheTrackFitter.h
        └── TpcLheTrack.h
```

Refactoring

```
eventDisplay
├── CMakeLists.txt
├── config
│   ├── coloring.xsd
│   ├── eventDisplay.xml
│   └── eventPic.png
├── EventDisplayLinkDef.h
├── mpd
│   ├── EventMDLinkDef.h
│   ├── EventMLinkDef.h
│   ├── MpdEmcTowerDraw.cxx
│   ├── MpdEmcTowerDraw.h
│   ├── MpdGlobalTrackDraw.cxx
│   ├── MpdGlobalTrackDraw.h
│   ├── MpdZdcTowerDraw.cxx
│   └── MpdZdcTowerDraw.h
├── MpdBoxSet.cxx
├── MpdBoxSetDraw.cxx
├── MpdBoxSetDraw.h
├── MpdBoxSetEditor.cxx
├── MpdBoxSetEditor.h
├── MpdBoxSet.h
├── MpdEventManager.cxx
├── MpdEventManagerEditor.cxx
├── MpdEventManagerEditor.h
├── MpdEventManager.h
├── MpdHitDraw.cxx
├── MpdHitDraw.h
├── MpdHitPointSetDraw.cxx
├── MpdHitPointSetDraw.h
├── MpdMCPointDraw.cxx
├── MpdMCPointDraw.h
├── MpdMCStack.cxx
├── MpdMCStack.h
├── MpdMCTracks.cxx
├── MpdMCTracksEditor.cxx
├── MpdMCTracksEditor.h
├── MpdMCTracks.h
├── MpdPointSetDraw.cxx
├── MpdPointSetDraw.h
├── MpdWebScreenshots.cxx
├── MpdWebScreenshots.h
├── MpdXMLNode.cxx
├── MpdXMLNode.h
└── README.md
```

unstructured

```
chargeCorrelations
dielectrons
ebye
evCentrality
evFlowEP
evPID
evPlane
evPlaneFXT
femto
globalObs
globalPolarization
hyperons
mpdHadronSpectra
mpdPhysics
nicafemto
nuclei
pairGG
pairGLambda
pairKK
pairPiK
pairPiKs
pairPiLambda
pairPiPi
pairPK
photons
```

?

?

One directory

MPDroot deployment

Running MPDRoot locally using CVMFS

Questions? Click here

INSTALL CVMFS AND TOOLBOX
(Users and Developers)

Supported OS: Fedora, CentOS, AlmaLinux, Ubuntu 22.04, 20.04, Debian 11, 12, Manjaro 21
NOTE: If your OS is based on any of those, then pass it to nica-init script, for example
./nica-init.sh -d Ubuntu -v 20.04

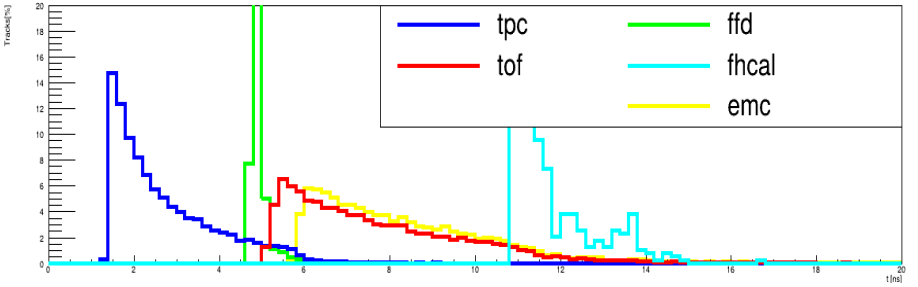
```
[user@fedora ~]$ wget -N https://git.jinr.ru/nica/nicadist/-/raw/master/scripts/nica-init.sh --no-check-certificate
--2021-12-02 00:00:00--  https://git.jinr.ru/nica/nicadist/-/raw/master/scripts/nica-init.sh
.....
.....
2021-12-02 00:00:02 (87.9 MB/s) - 'nica-init.sh' saved [10794/10794]

[user@fedora ~]$ chmod +x nica-init.sh && ./nica-init.sh
Installing toolbox on Fedora 39
[sudo] password for user:
.....
.....
Creating container a9-nica-dev ...
.....
.....
Installing cvmfs service as container ...
.....
.....
================================================

INSTALLATION SUCCESSFUL

How to use:

1. Enter toolbox container by:
   toolbox enter a9-nica-dev

2. Load MPDRoot environment as a user by:
   [user@toolbox ]$ module add mpdroot

   or MPDRoot environment as a developer by:
   [user@toolbox ]$ module add mpddev

================================================
[user@fedora ~]$
```

USERS

NOTE: If you are using CentOS 7 instead of "toolbox enter a9-nica-dev" command, type:
"source /cvmfs/nica.jinr.ru/sw/os/login.sh"

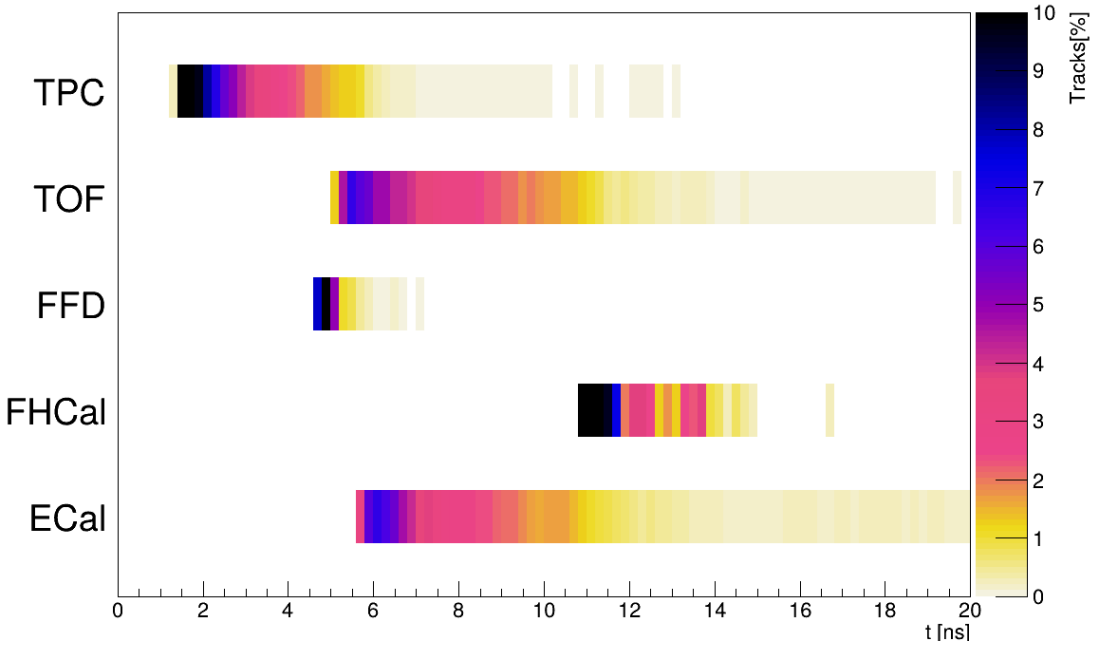
Trigger latency for data taking for MPD detectors

Alexander
Bychkov



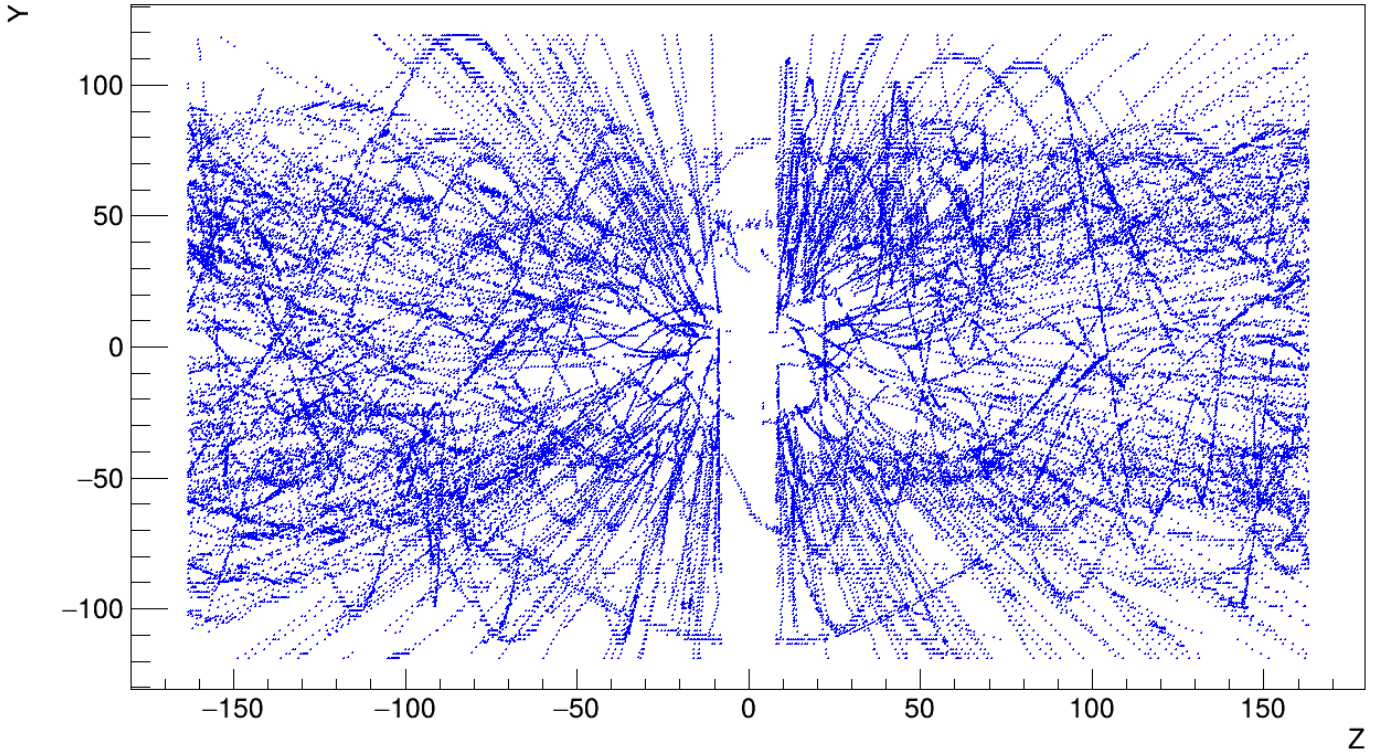
Collision point (0, 0, 0)

- 100 events from PHSD generator
- Reaching time for
  - Primary particles
  - π^0 gammas

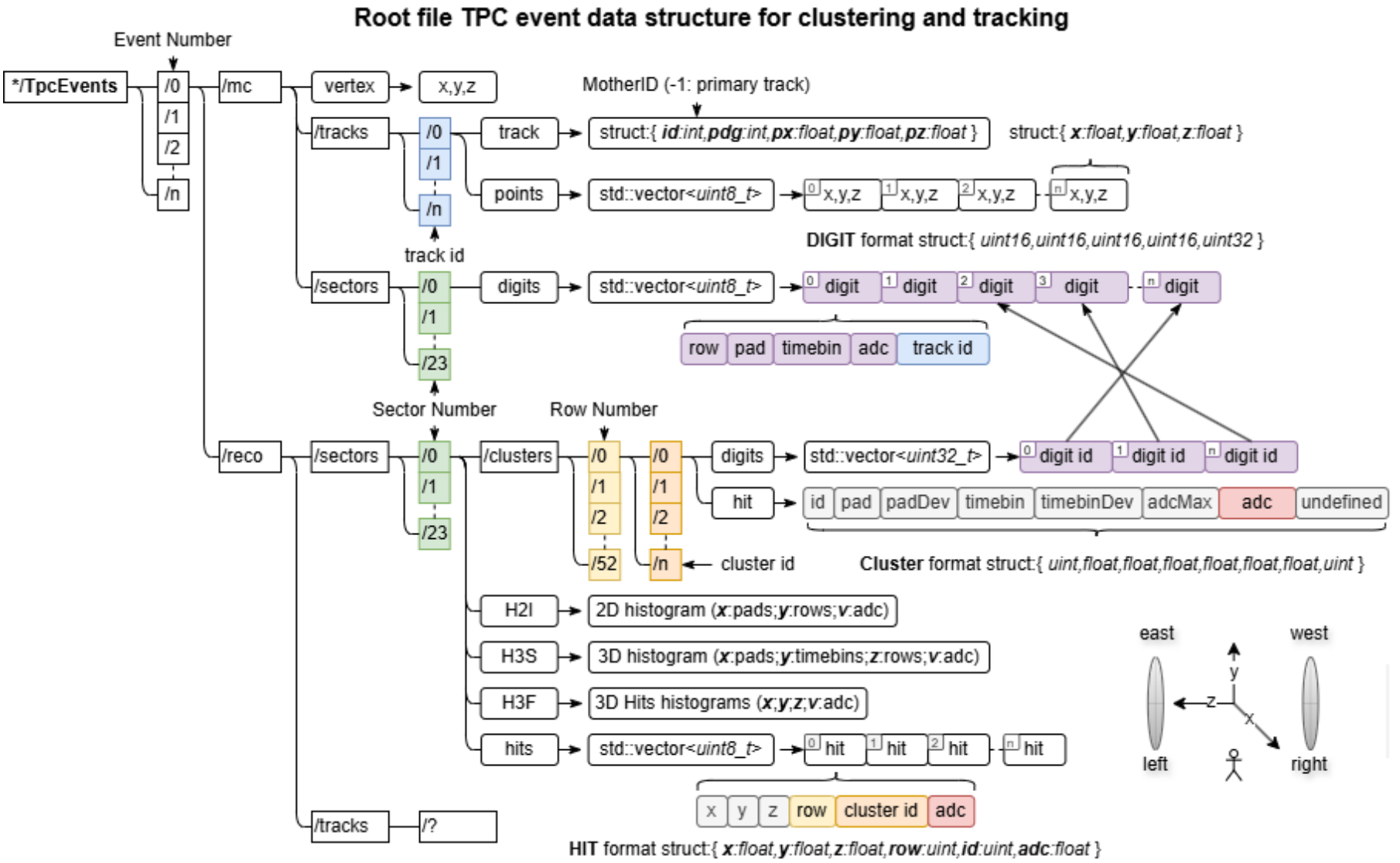


TPC data taking of events

- Collision point at (0, 0, 0)
- PHSD generator



Data file structure



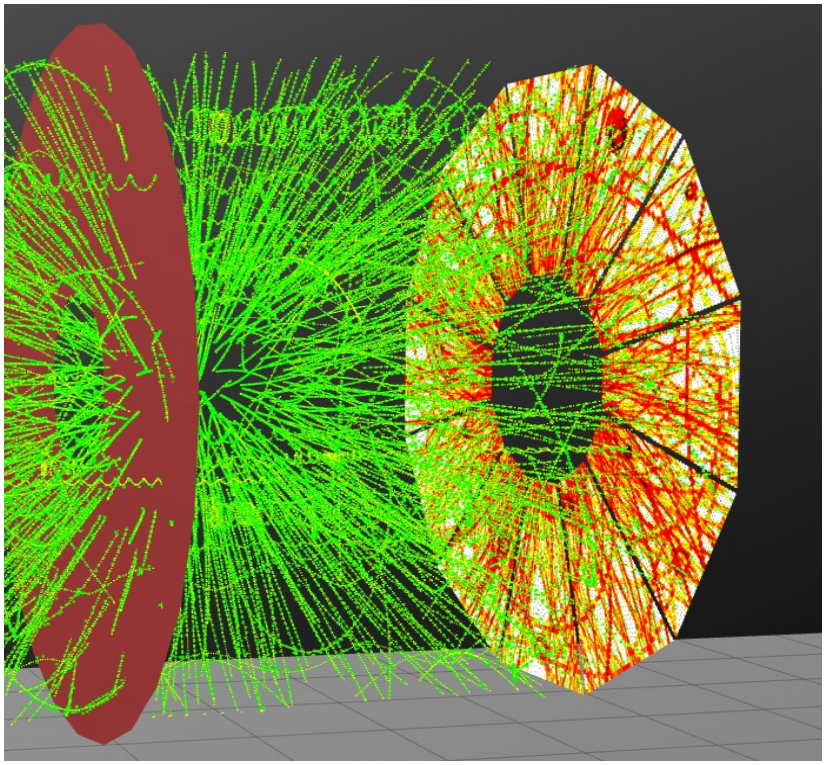
DAQ file structure for online clustering

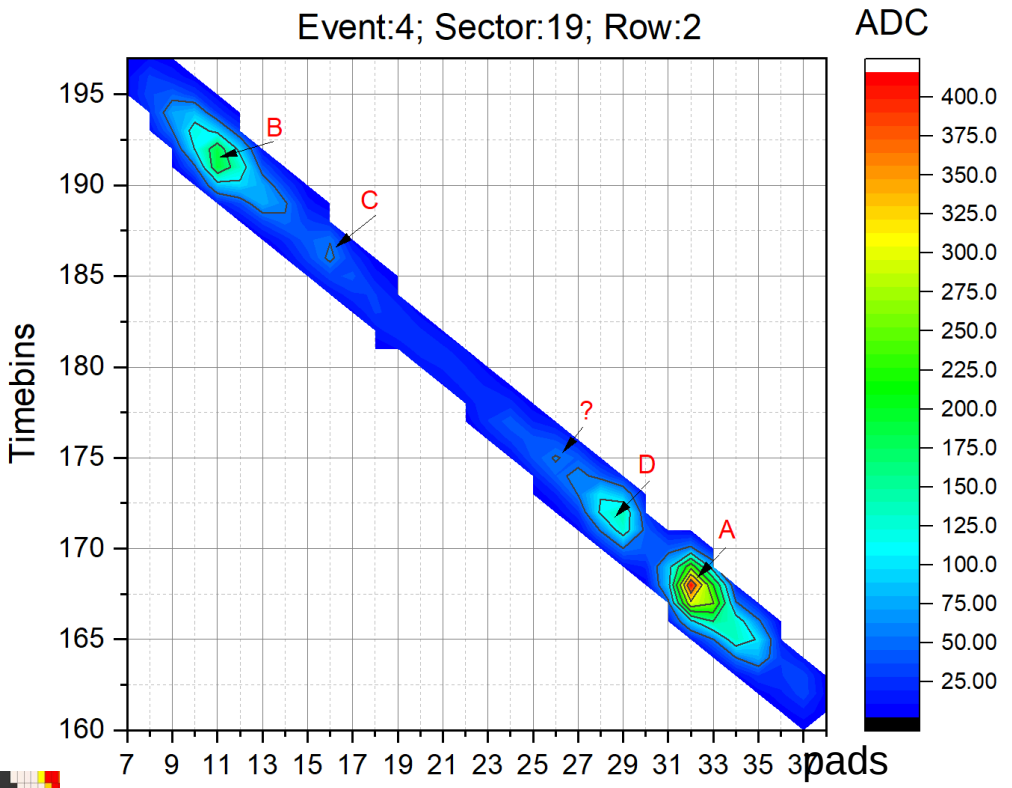
Tasks:

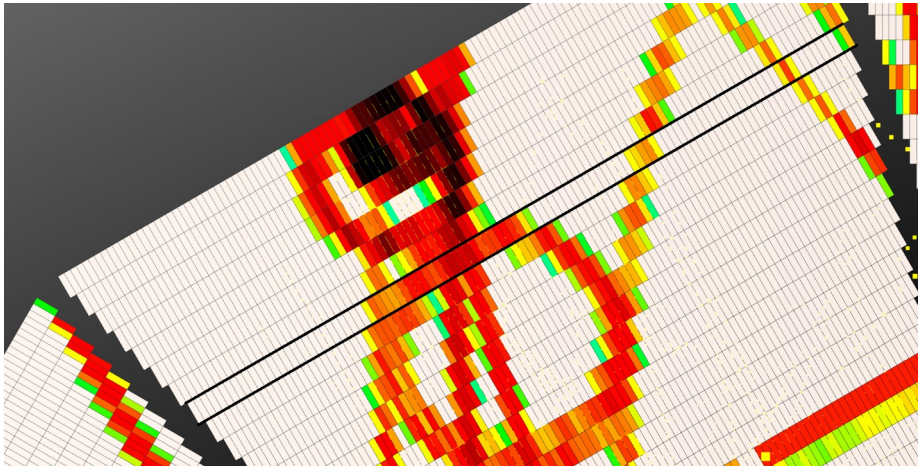
- Make the TPC clustering online and prepare it for 3D visualize by Event Display;
- Read input stream in the real experiment with data in SAMPA format;
- Parallelize TPC event processing;
- Decrease time for TPC clusteringfor event processing and rendering: <1 sec at the moment:
- Average time for TPC event processing: ~ 100 ms
- Maximum TPC event processing time: ~500 ms (depends on track multiplicity)

Online TPC clustering

Krylov V.

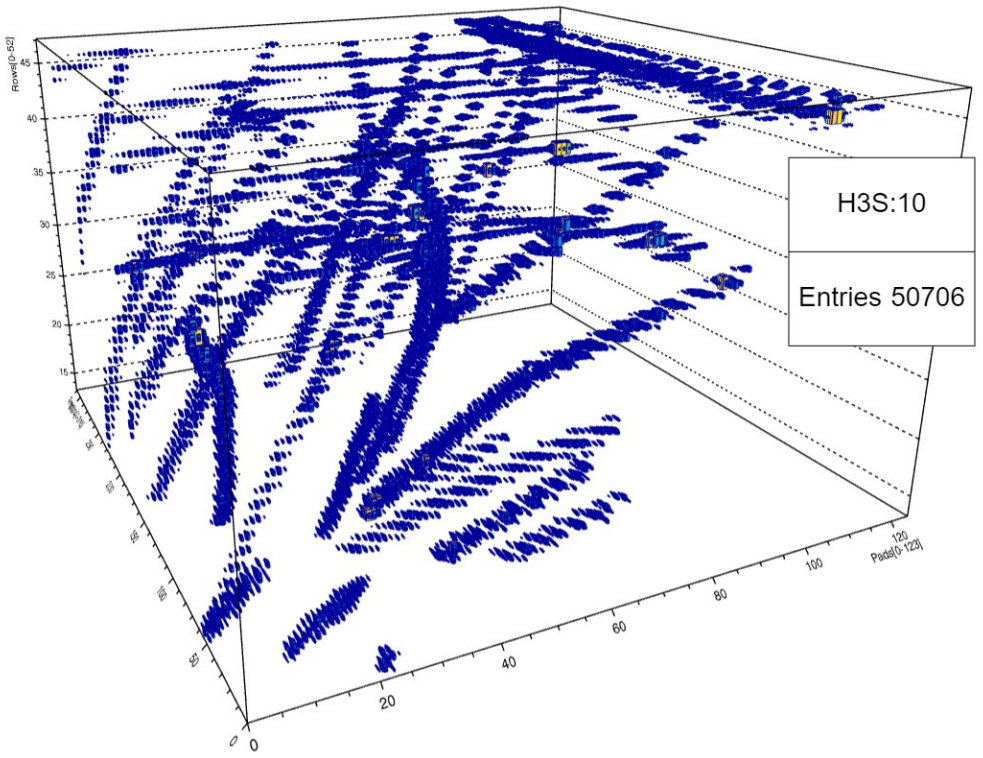


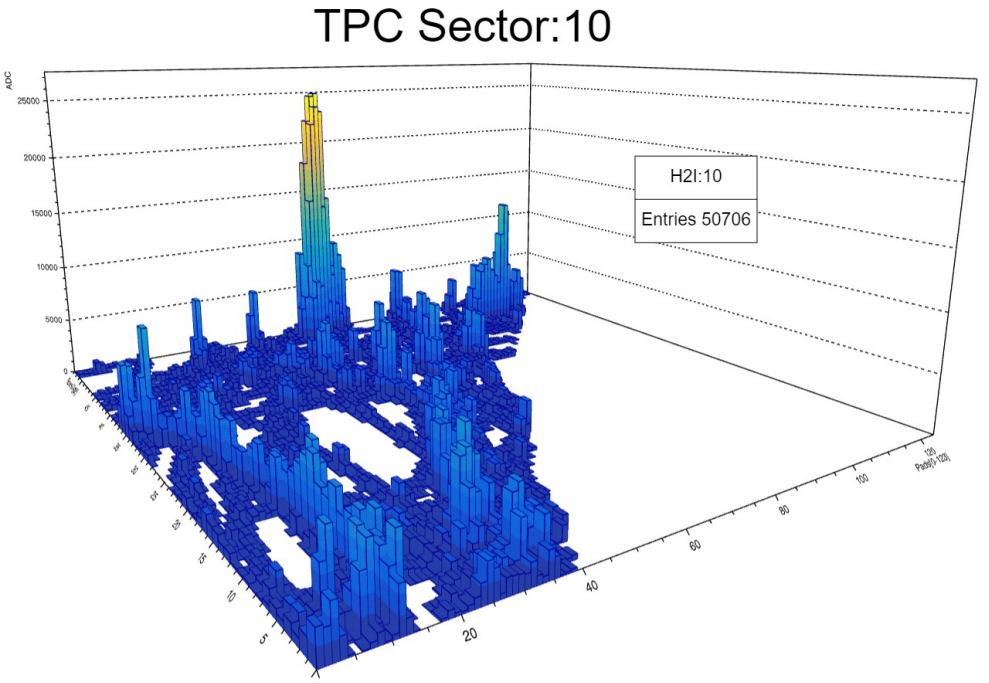




Data structure

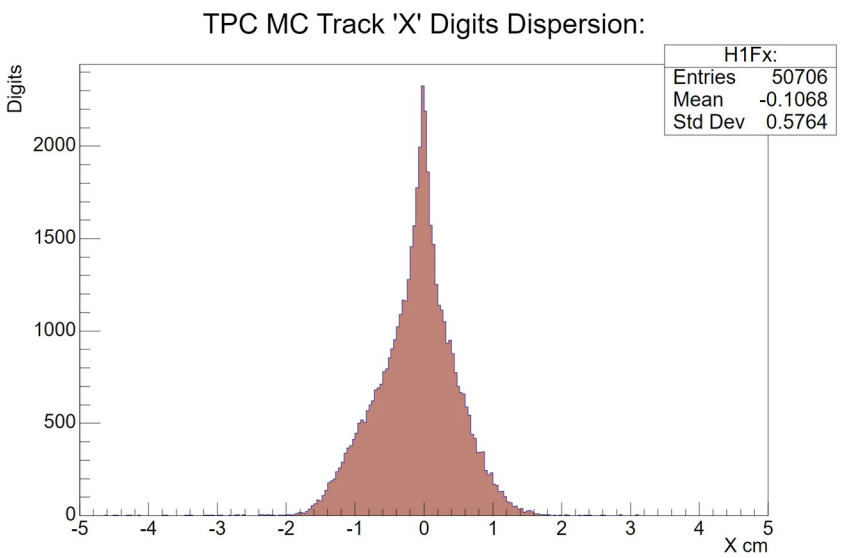
Sector digits

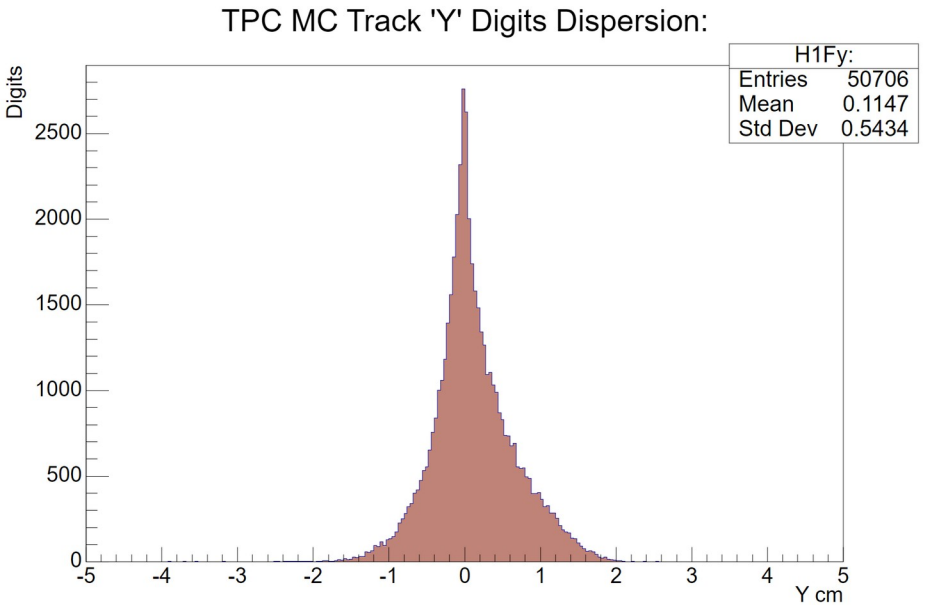


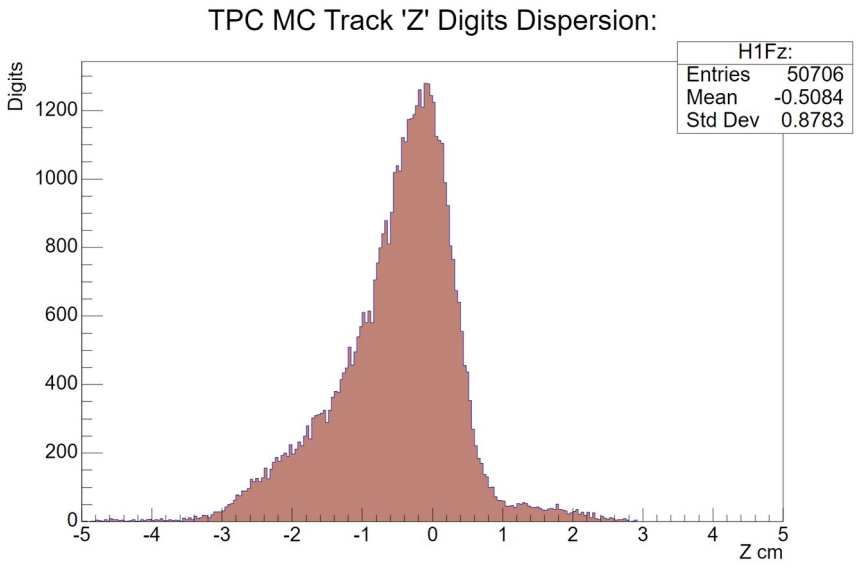


Data structure

Sector digits distribution

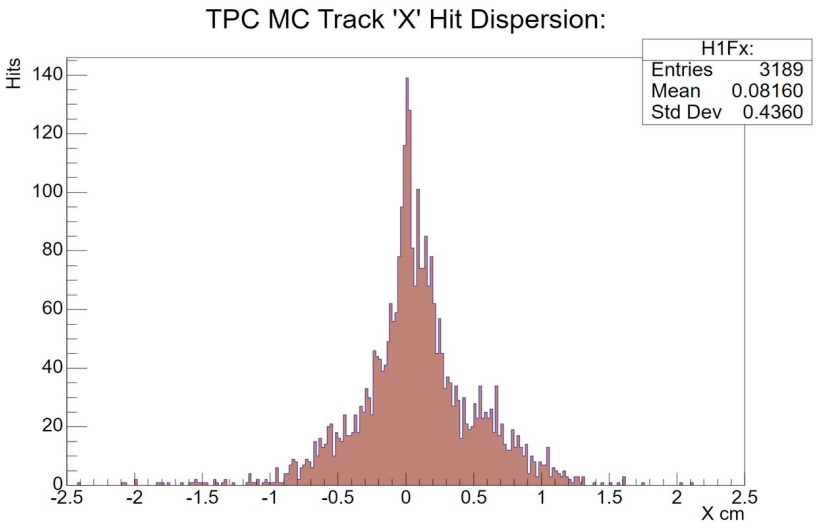


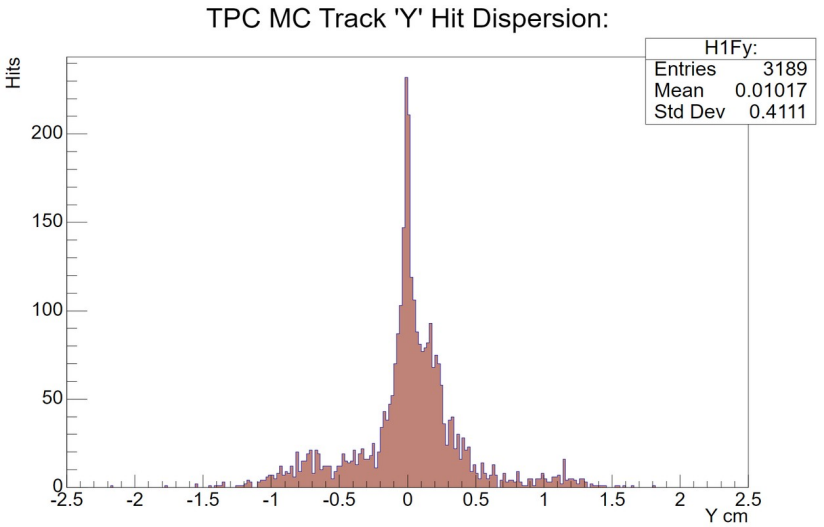


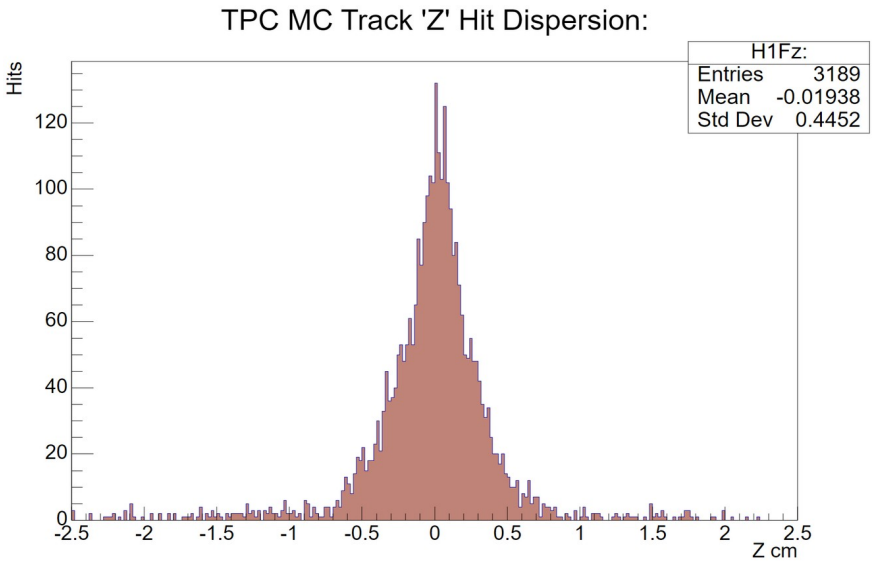


Data structure

Sector hits distribution







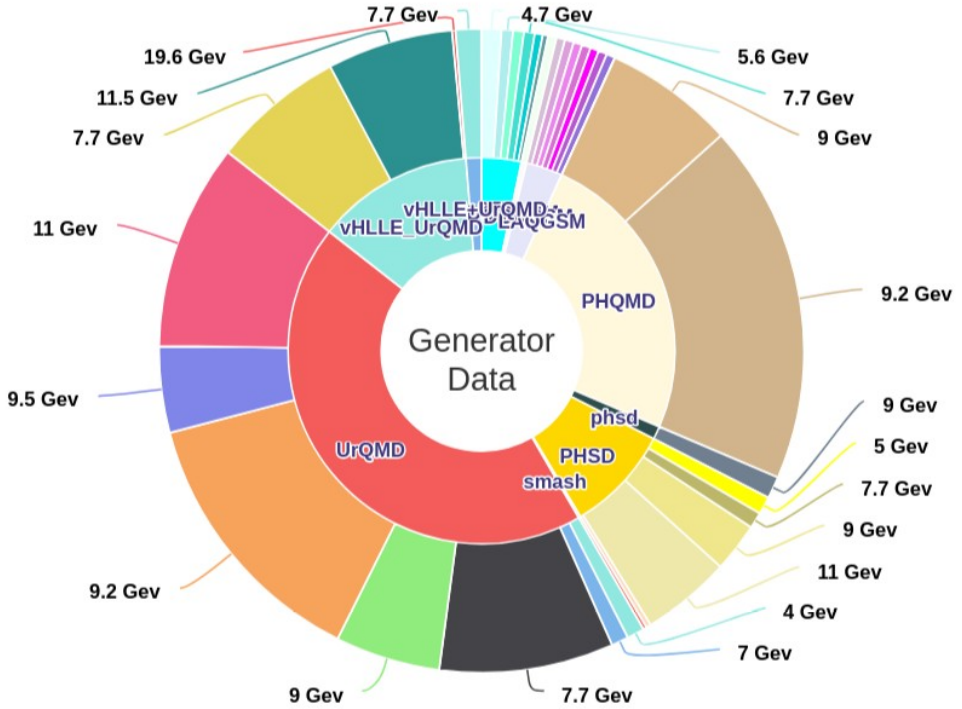
MC data for MPD physics group

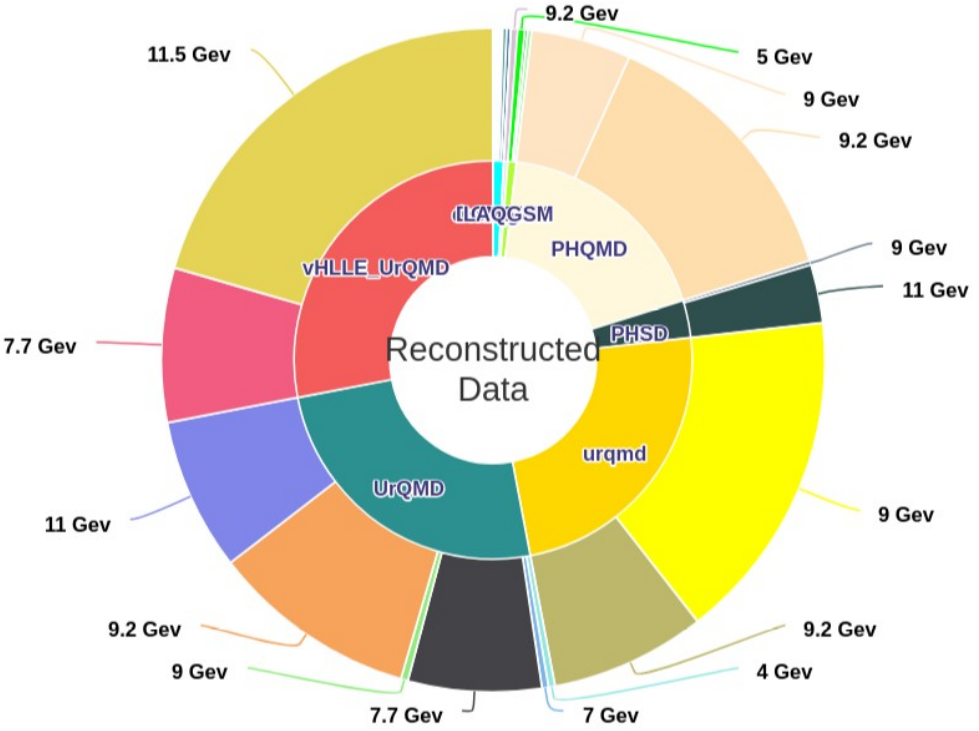
Generator	PWG	Coll.		# of events()	Reco
UrQMD	PWG4	AuAu	11	15	+
		BiBi	9	10	+
			9.46	10	+
			9.2	95	+
	PWG2	AuAu	11	10	+
	PWG3	AuAu	7.7	10	+
		BiBi	7.7	10	+
			9	15	+
		pp	9	10	+
		BiBi fix target	2.5	12	+
		BiBi fix target	3.0	12	+
		BiBi fix target	3.5	12	+
		XeW fix target	2.5	15	+
		XeXe fix target	2.5	15	+
	PWG1	BiBi	9.2	76	+
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				1412	568

1.7 PB

MPD mass production database

http://db-nica.jinr.ru/mpdmc/stat.php





All production data stored in Dirac File Catalog

Mass production data

Adding wagon for hadron spectra analysis

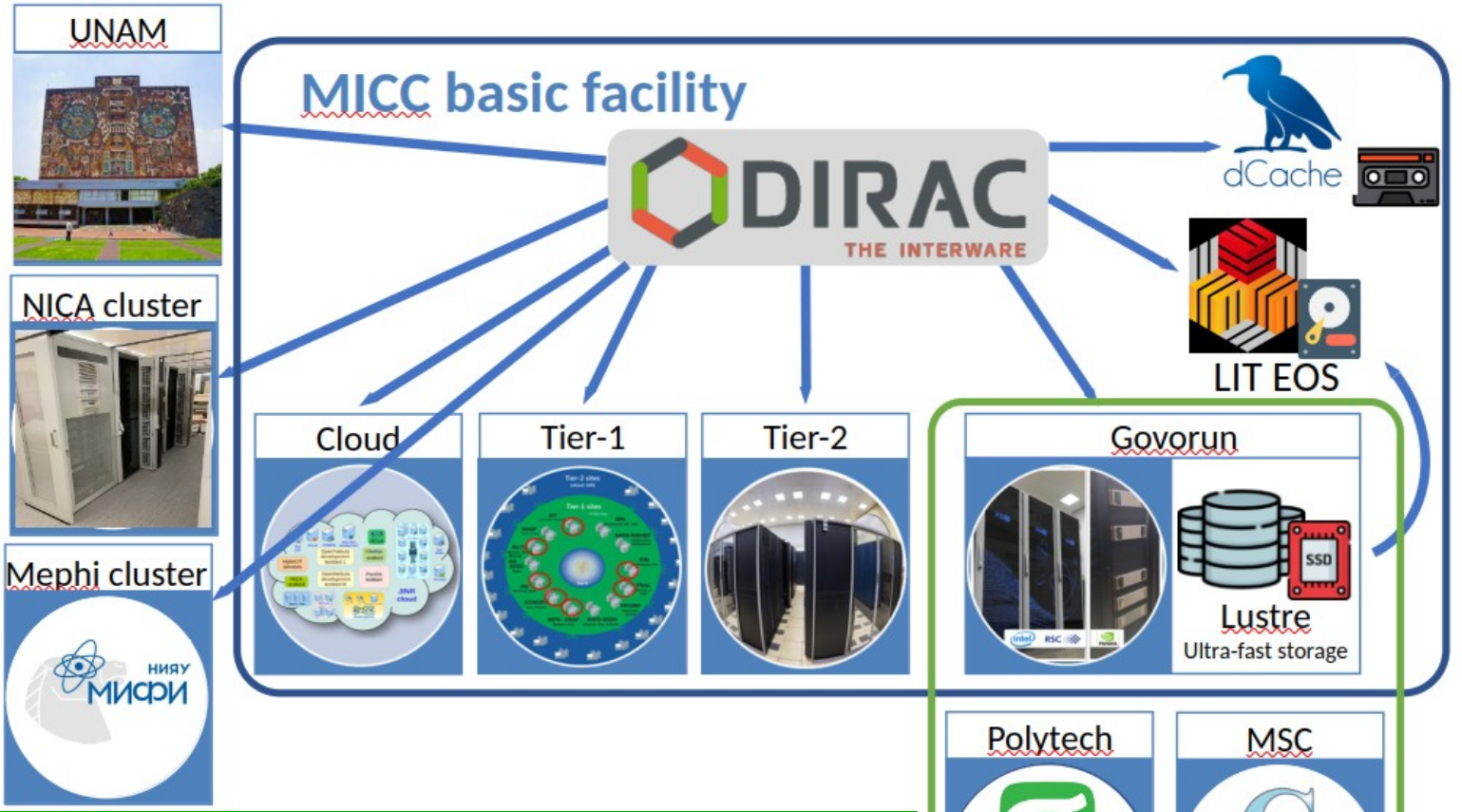
Natalia kolomoyets

- 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:

• Analysis manager	• Centrality • wagon	• Reaction plane • wagon	• DCA, PID, • Match wagon	• Analysis • wagon #1	• Analysis • wagon #2	• Analysis • wagon #N

- All productions for physical analyses of simulated data already have been done.

Computing resourses for MPD



- 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 9,2 PB.

Thanks for your attention