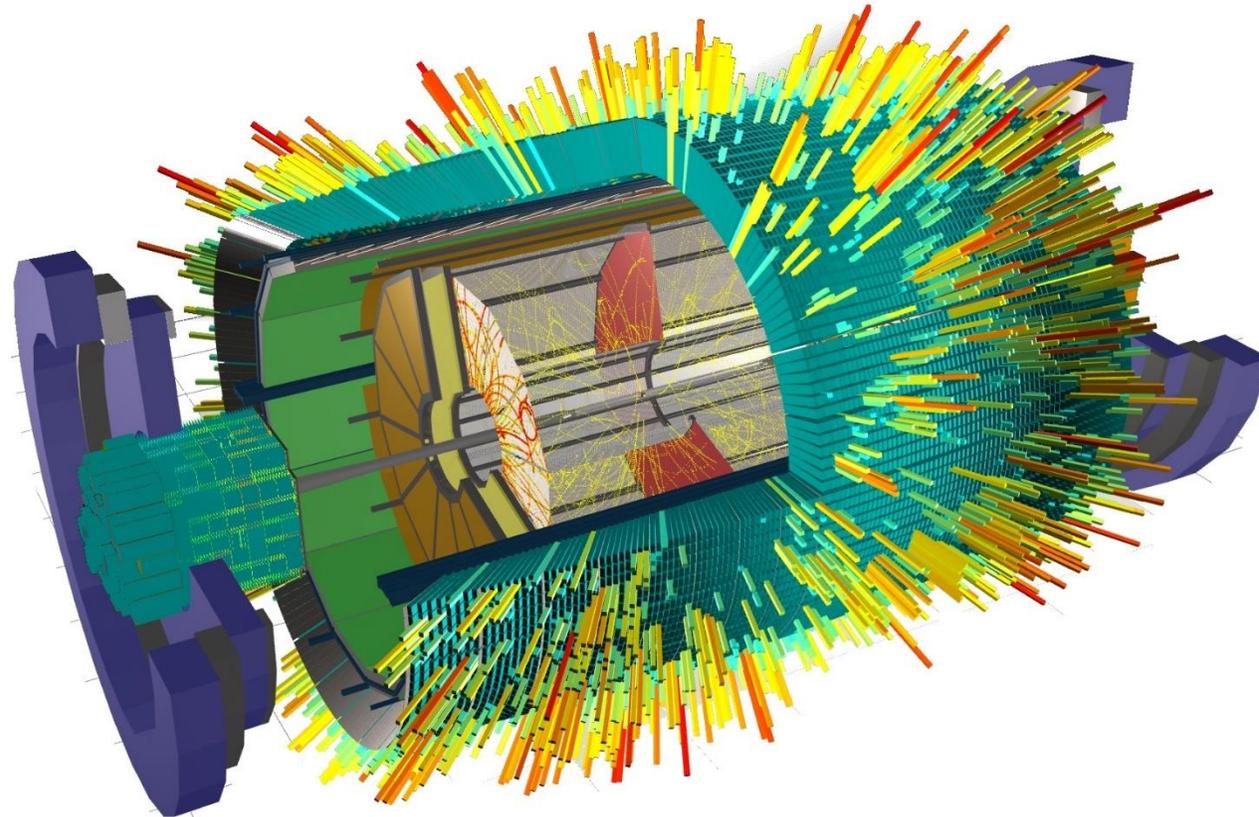


Software & Computing for MPD Experiment at NICA Collider

HNATIC Slavomir

on behalf of MPD Software Development & Computing Team



OUTLINE

- MPD Software & Computing Ecosystem – The Big Picture
- MPDRoot Framework
- Mass Production & Computing
- Software Development Best Practices
- Online Visualization of MPD experiment
- Reconstruction Enhancement Toolkit
- Current Development Focus

THE BIG PICTURE

NICADIST

- separate build system
- dependencies handling

CVMFS

- software distribution
- unified environment

Project Management & Support/User Interaction

GITLAB

- codebase
- CI
- testing

SUPPORT

- helpdesk
- telegram channel

WEBSITE

- howtos
- docs
- general info

RECONSTRUCTION ENHANCEMENT

TDD ENVIRONMENT

- jupyter-lab
- jsroot
- container

QA

- engine
- gallery

MPDRoot

ANALYSIS

SIMULATION

RECONSTRUCTION

Mass Production

PWG REQUESTS
HANDLING

DIRAC
INTERWARE

Computing Infrastructure

(MICC & friends)

- supercomputer
- clusters
- storage systems

MPD assembly

TPC installation: Oct/Nov 2024

Commissioning: Jan/Feb 2025

ONLINE EVENT DISPLAY

- experiment visualization
- slow control

DATA STORAGE & RETRIEVAL

DETECTOR CALIBRATION

- alignment
- noise level
- digitalization delay

MPDROOT FRAMEWORK

INSTALLATION

<https://mpdroot.jinr.ru/running-mpdroot-on-local-machine-using-cvmfs/>

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 Z1
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 38
[sudo] password for user:
INSTALLATION SUCCESSFUL
[user@fedora ~]$ toolbox enter c7-nica-dev
```

USERS

```
●[user@toolbox [c7-nica-dev] ~]$ module add mpdroot
```

DEVELOPERS

```
●[user@toolbox [c7-nica-dev] ~]$ module add mpddev
●[user@toolbox [c7-nica-dev] ~]$ git clone -b dev --recursive git@git.jinr.ru:nica/mpdroot.git
```

ENVIRONMENT & DEPENDENCIES

- the environment & dependencies for the same mpdroot or mpddev versions is **identical**
- no compatibility issues by definition

RELEASES

- release schedule: every 3 months
- “module add mpdroot” loads latest mpdroot/v23.06.23
- old releases can be loaded using specifier
- every release is coupled to its own dependency tree

```
●[slavomir@toolbox [c7-nica-dev] ~]$ module add mpdroot/
mpdroot/latest          mpdroot/v22.06.22-1      mpdroot/v23.03.23-1
mpdroot/latest-release  mpdroot/v22.09.22-1      mpdroot/v23.03.23_vhll-1
mpdroot/v22.04.22-1      mpdroot/v22.12.22-1      mpdroot/v23.06.23-1
●[slavomir@toolbox [c7-nica-dev] ~]$ module add mpdroot/v22.04.22-1
●[slavomir@toolbox [c7-nica-dev] ~]$ module list
Currently Loaded Modulefiles:
 1) BASE/1.0                               15) lzma/v5.2.3-2          29) generators/v1.0-4
 2) pythia6/428-alice2-3                   16) boost/v1.75.0-4       30) postgresql/REL_14_2-1
 3) GCC-Toolchain/v10.2.0-alice2-2         17) HepMC/HEPMC_02_06_10-3 31) fmt/8.1.1-1
 4) AliEn-Runtime/v2-19-le-2              18) pythia/v8243-alicela-4 32) protobuf/v3.15.8-3
 5) FreeType/v2.10.1-4                    19) GSL/v1.16-2           33) eigen3/3.4.0-2
 6) GEANT4/v11.0.1-alice1-1               20) libxml2/v2.9.3-2       34) asio/v1.19.1-3
 7) lhpadf/v6.2.1-alice2-4                21) XRootD/v5.4.2-alice1-1 35) asiofi/v0.5.1-3
 8) zlib/v1.2.8-2                          22) ROOT/v6-24-06-1       36) FairLogger/v1.11.0-1
 9) libpng/v1.6.34-3                       23) VMC/v2-0-1            37) ZeroMQ/v4.3.3-3
10) sqlite/v3.15.0-3                      24) vgm/v5-0-1            38) FairMQ/v1.4.50-1
11) libffi/v3.2.1-3                       25) GEANT4_VMC/v6-1-1     39) FairRoot/v18.6.8-1
12) Python/v3.6.10-4                     26) GEANT3/v4-1-1         40) mpdroot/v22.04.22-1
13) OpenSSL/v1.1.1m-1                    27) simulation/v1.0-2
14) Python-modules/1.0-4                  28) ofi/v1.14.0-1
```

MASS PRODUCTION

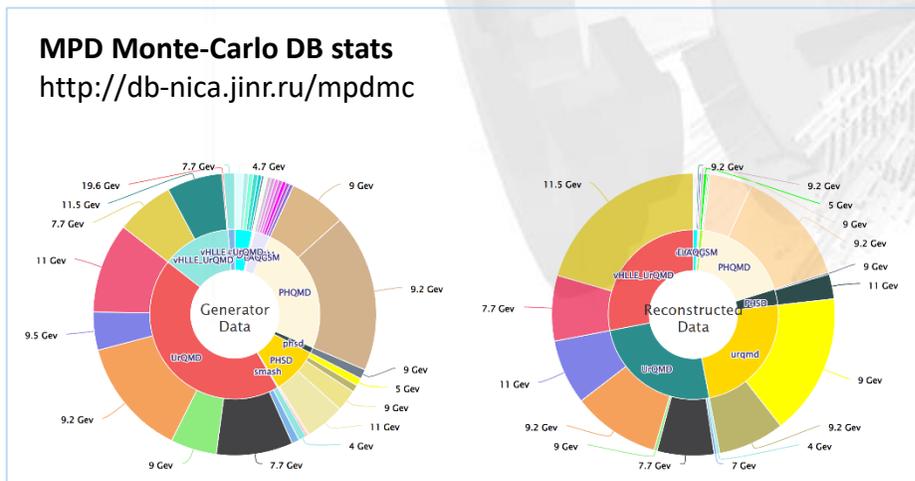
mpdforum.jinr.ru/c/mcprod/26

MPD

Do you want live notifications when people reply to your posts? [Enable Notifications](#)

Monte-Carlo productions ▾ Latest Unread (1) Top + New Topic

Topic	Replies	Views	Activity
¶ About the Monte-Carlo productions category	0	170	May '20
Request 32: Flow - vHLL+UrQMD, 23M BiBi @ 9.2 GeV	4	84	22d
Request 31: Femtoscopy-purpose, 50 M UrQMD BiBi@9.2 with freeze-out (second collaboration paper)	23	292	May 25
Mass production storage on NICA cluster	15	295	Jan 25
Request 29: General-purpose (hypernuclei), 20M PHQMD BiBi@9.2 (second collaboration paper)	2	148	Jan 6



Generator	PWG	Coll.	\sqrt{s}	# 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	-
vHLL+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)

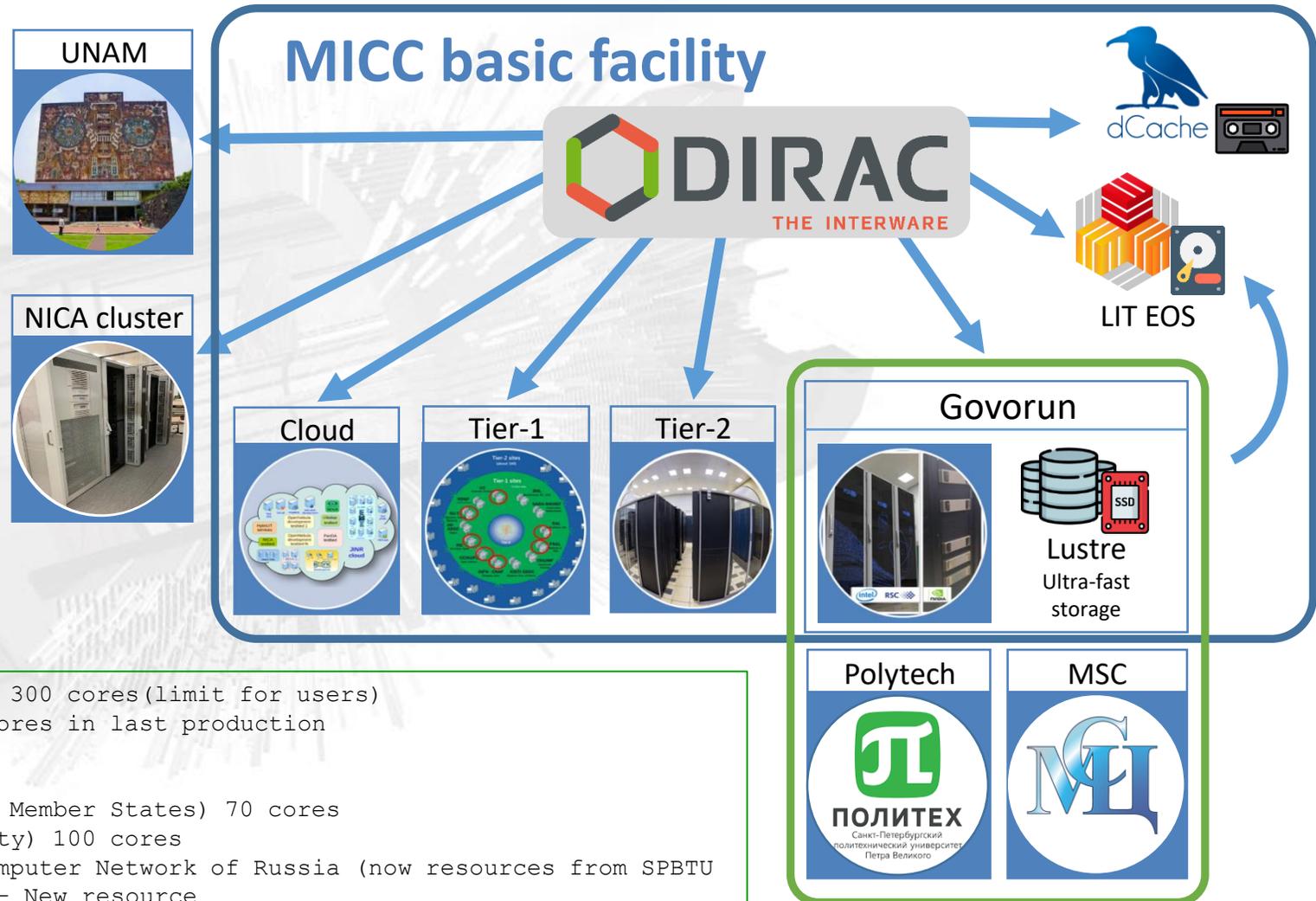
MPD COMPUTING

BASIC STATS

- 75% of DIRAC's computing workload
- uses all of the major computing resources
- max 3500 simultaneous jobs

More information:

Kutovskiy, N., Mitsyn, V., Moshkin, A. *et al.* Integration of Distributed Heterogeneous Computing Resources for the MPD Experiment with DIRAC Interware. *Phys. Part. Nuclei* **52**, 835–841 (2021)
 V. Korenkov *et al* 2023 *J. Phys.: Conf. Ser.* **2438** 012029



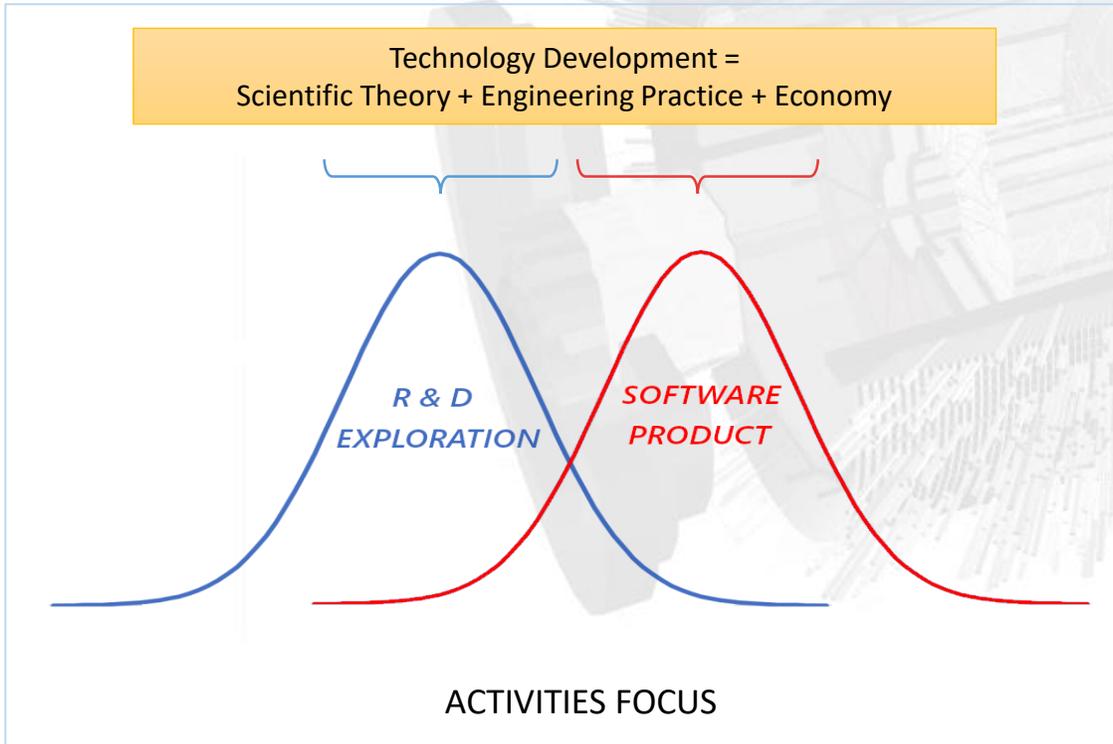
- NICA offline cluster 300 cores (limit for users)
 - GOVORUN up to 3260 cores in last production
 - Tier1 1400 cores
 - Tier2 1000 cores
 - Clouds (JINR and JINR Member States) 70 cores
 - UNAM (Mexico University) 100 cores
 - National Research Computer Network of Russia (now resources from SPBTU and JSCC) 672 cores – New resource
- Mass production storages integrated in Dirac File Catalog have size 2,3 PB.

SD BEST PRACTICES

SEPARATION OF CONCERNS

- thinking of software entity attributes in isolation, while keeping in mind, they're part of the whole

E.Dijkstra "On the role of scientific thought" (1974)



CORE INFLUENCES

- size / scaling
- structural complexity
- software defects
- uncertainty
- human variation
- synergy

SWEBOK v3 (2015, computer.org)

International ISO Standard

specifying the guide to

Software Engineering Body of Knowledge

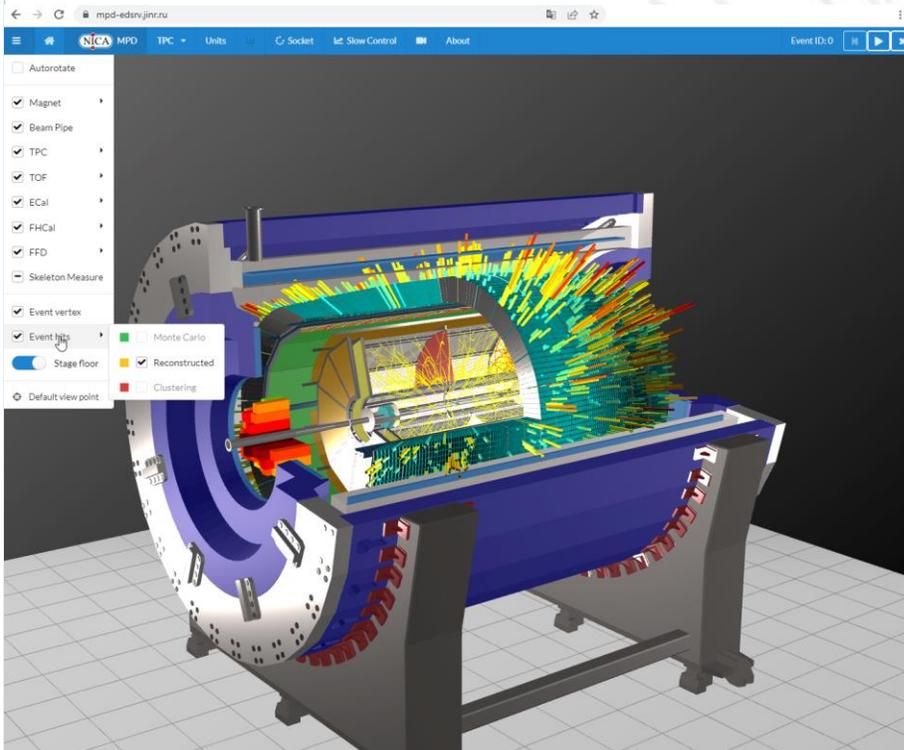
List of the most important things done on MPDRoot

- Complexity reduction
 - downscaling/separation:
 - build system, reconstruction/simulation engine, physics
 - codebase cleanup
- Code quality
 - code reviews, code influx control, formatting
 - interfaces, API
 - requirements modeling, acceptance TDD (in progress)
- Build redesign/unified environment
- Stable release schedule
- Support & Maintenance
 - service desk, website, telegram support chat

MPD EXPERIMENT VISUALIZATION

MPD EVENT DISPLAY

- <https://mpd-edsv.jinr.ru/>
- powerful feature-rich professional grade software for the visualization of MPD experiment



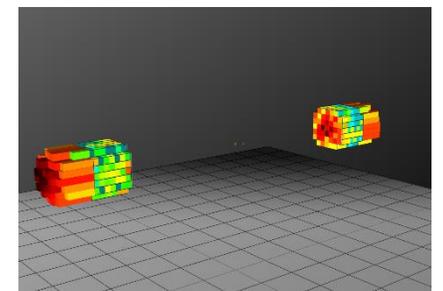
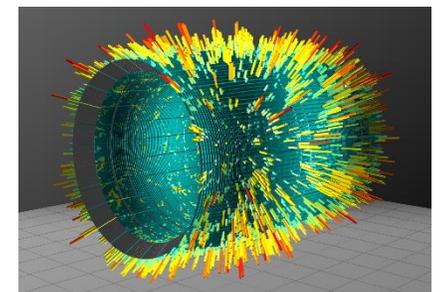
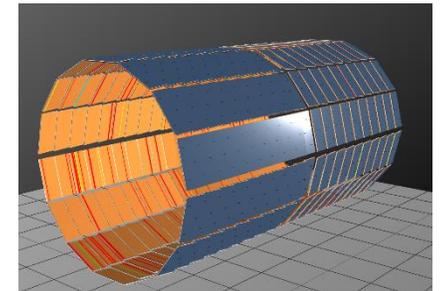
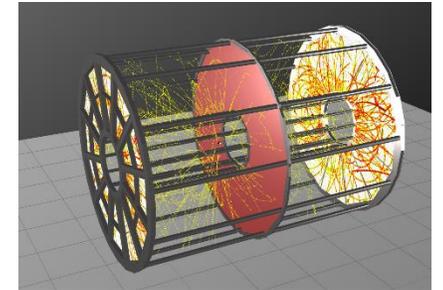
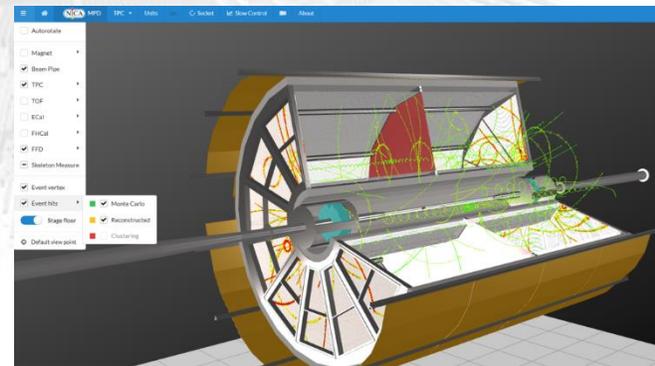
- superfast WebGL 3D-graphics technology at its core
- compatible with any web browser

More information:

V. Krylov, Modern Web Technologies for Data Visualization in HEP

FEATURES

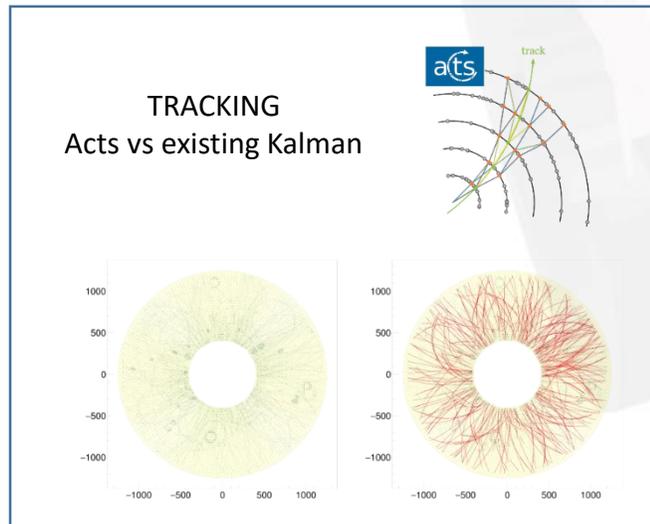
- modular interactive “on-click” geometry
- target online visualization capability 1 event per sec (once experiment running), currently played from root files
- fast TPC hit reconstruction
- MC tracks visualization
- reconstructed points/tracks
- comparison MC (or real) vs. reconstructed



RECONSTRUCTION ENHANCEMENT

QA / ACCEPTANCE TDD PARADIGM

- quality testing critical for overall project success
- requirements written in precise test case language
- QA gallery is a set of requirements
- API is a must
- multi-module multilevel quality comparison



QA / ATDD ENVIRONMENT

- Jupyter-Lab with JSRoot
- Custom code injection
- Cell structure with reprocess option
- Graphical output customized on demand
- Algo tuning to real experiment data

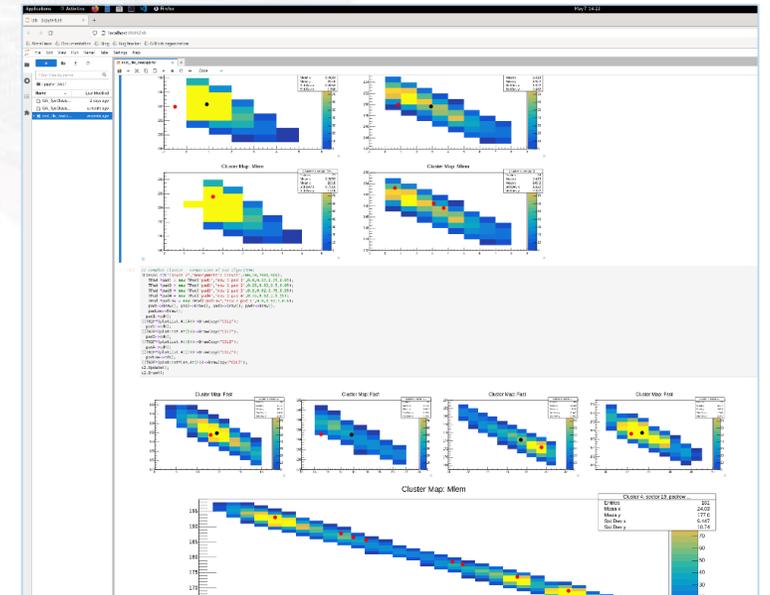
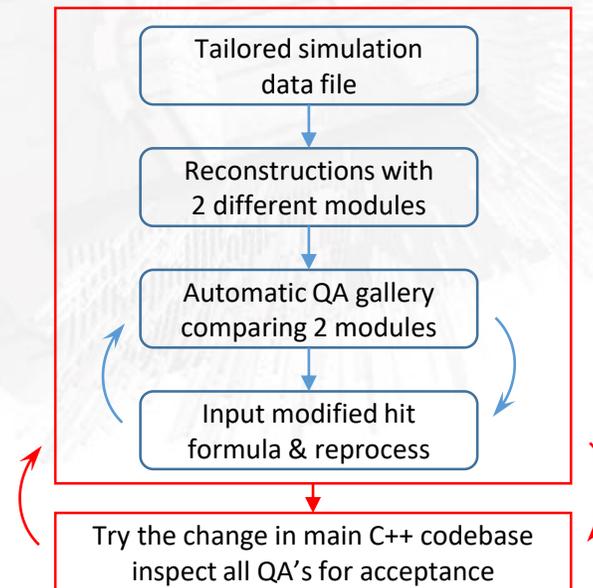
CLUSTERHITFINDER COMPARISON

- Mlem
- Fast

ABSTRACTION LEVELS

- Topbench.....Reconstruction
- Middle.....component....ClusterHitFinder
- Bottomunits.....Clustering, Topology, Hit extraction

Interactive workflow example



CURRENT DEVELOPMENT FOCUS

MASS PRODUCTION

- “custom tagged” software builds deployed to cvmfs

RECONSTRUCTION ENGINE

- QA toolkit / bringing Fast Cluster Finder accuracy to Mlem level

MPD VISUALIZATION

- Full chain visualization (generator -> geant4 -> hits -> tracks)

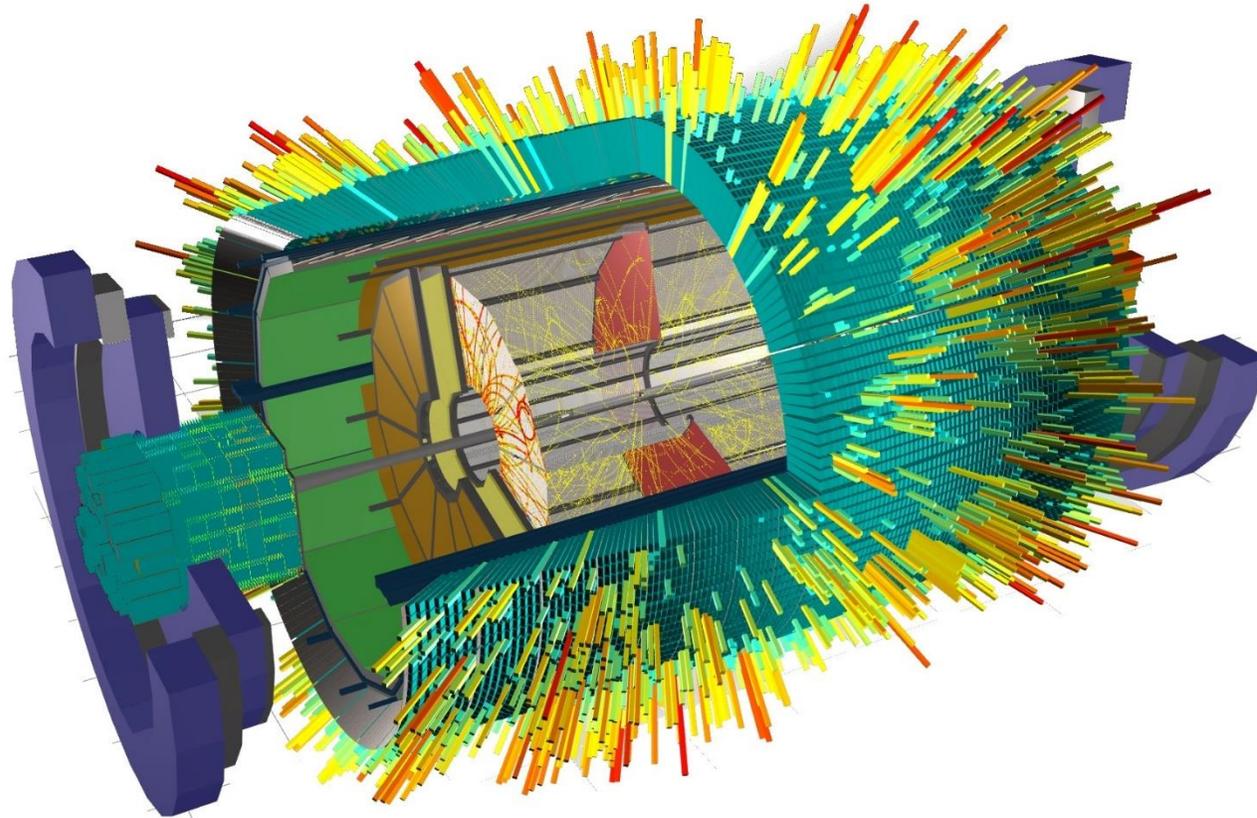
TRACKING

- porting ACTS to TPC API

BUILD

- migration to latest AL9 container, update to ROOT v6.28/04, FairRoot v18.8.1

Thank You !



MPD Software Development & Computing Team

<i>Rogachevsky O.</i>	Coordinator
<i>Krylov V., Krylov A.</i>	Online MPD Event Display
<i>Moshkin A., Pelevanyuk I.</i>	Mass Production
<i>Bychkov A.</i>	Detector Simulation
<i>Kuzmin V.</i>	Detector Alignment
<i>Podgainy D., Zuev M.</i>	Supercomputing
<i>Alexandrov E., Alexandrov I.</i>	Databases
<i>Balashov N.</i>	Gitlab Support
<i>Belyakov D.</i>	Network Infrastructure
<i>Belecky P., Kamkin A.</i>	Acts Tracker
<i>Busa J.</i>	Build System
<i>Hnatic S.</i>	Architecture