



Development of new Event Display and auxiliary software for BM@N experiment

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the MIPT team for the BM@N collaboration



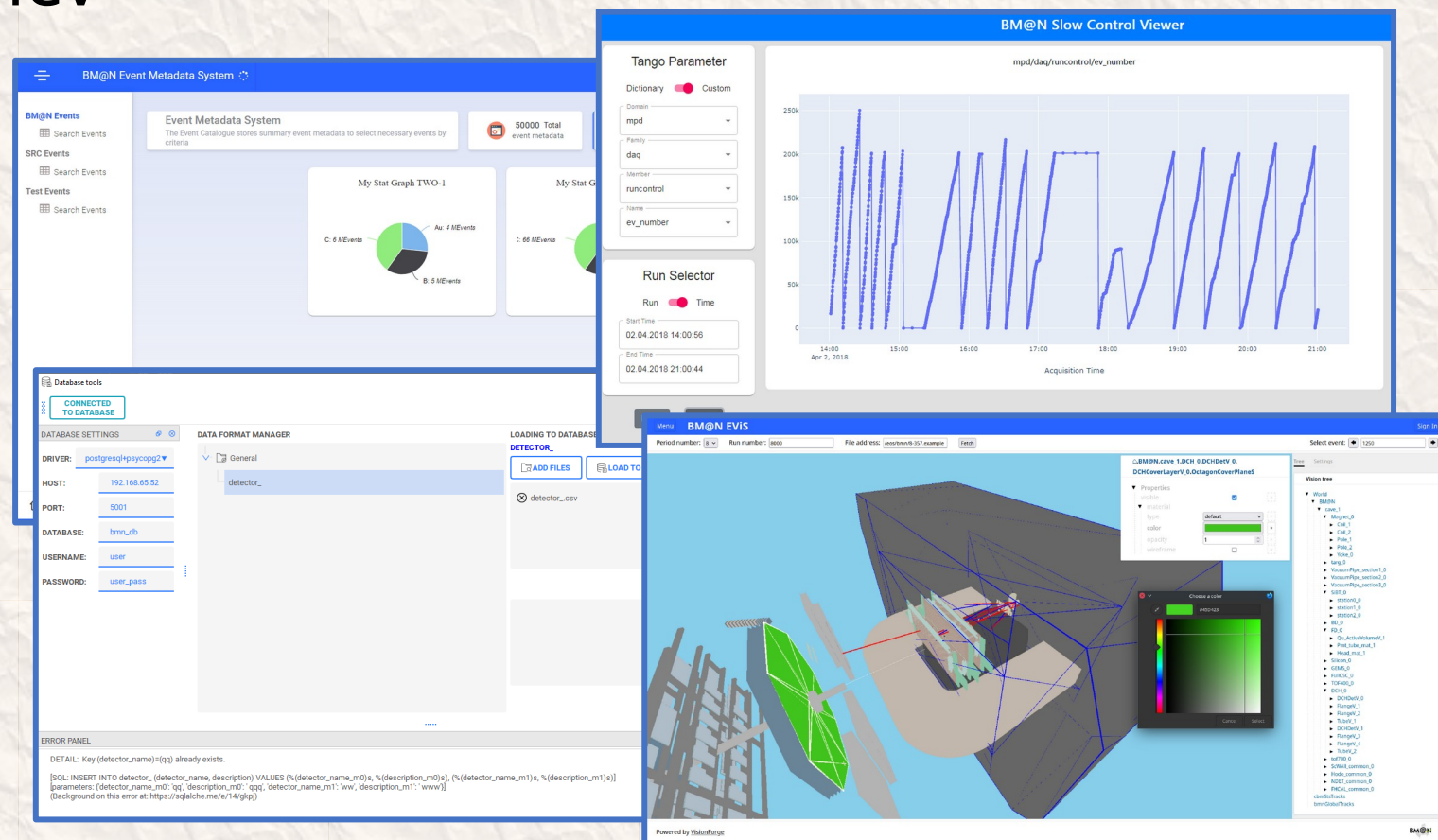


MIPT Software for BM@N – Team

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Team members:

- P. Klimai
- A. Nozik
- I. Dunaev (student 6y)
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- V. Kaplenko (student 6y)
- A. Degtyarev (PhD st. 2y)





Main Projects Summary

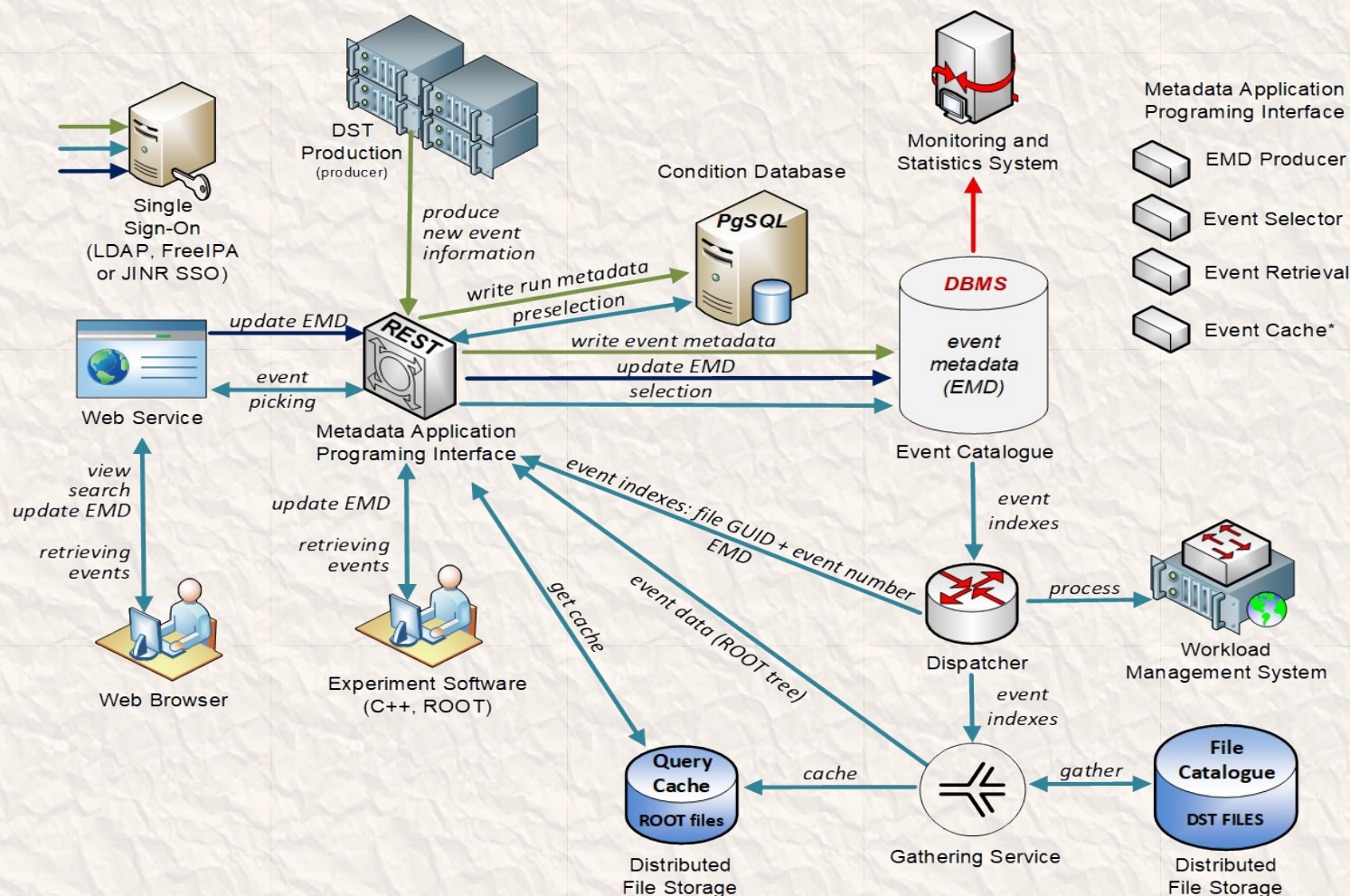
Project	URL
Event Metadata System	https://git.jinr.ru/nica_db/emd https://git.jinr.ru/pklimai/ems-deploy
Next-generation Event Display	https://git.jinr.ru/nica-visualization/visionforge https://git.jinr.ru/nica-visualization/visapi https://git.jinr.ru/nica-visualization/evis
Monitoring Service	https://git.jinr.ru/nica-computing/mon-service-deploy
REST API and Web interface for slow control system	https://git.jinr.ru/nica_db/tango_web https://git.jinr.ru/nica_db/tango-rest



Event Metadata System (an update)



BM@N Event Metadata System



Event Metadata System

- Event Catalogue based on PostgreSQL
- Integration with BM@N Condition database
- REST API and Web UI based on Kotlin Multiplatform
- Configurable to support different metadata
- ROOT macro to fill the catalogue
- Automatic deployment
- High Availability solution
- Statistics collection and display
- Monitoring

For more details:

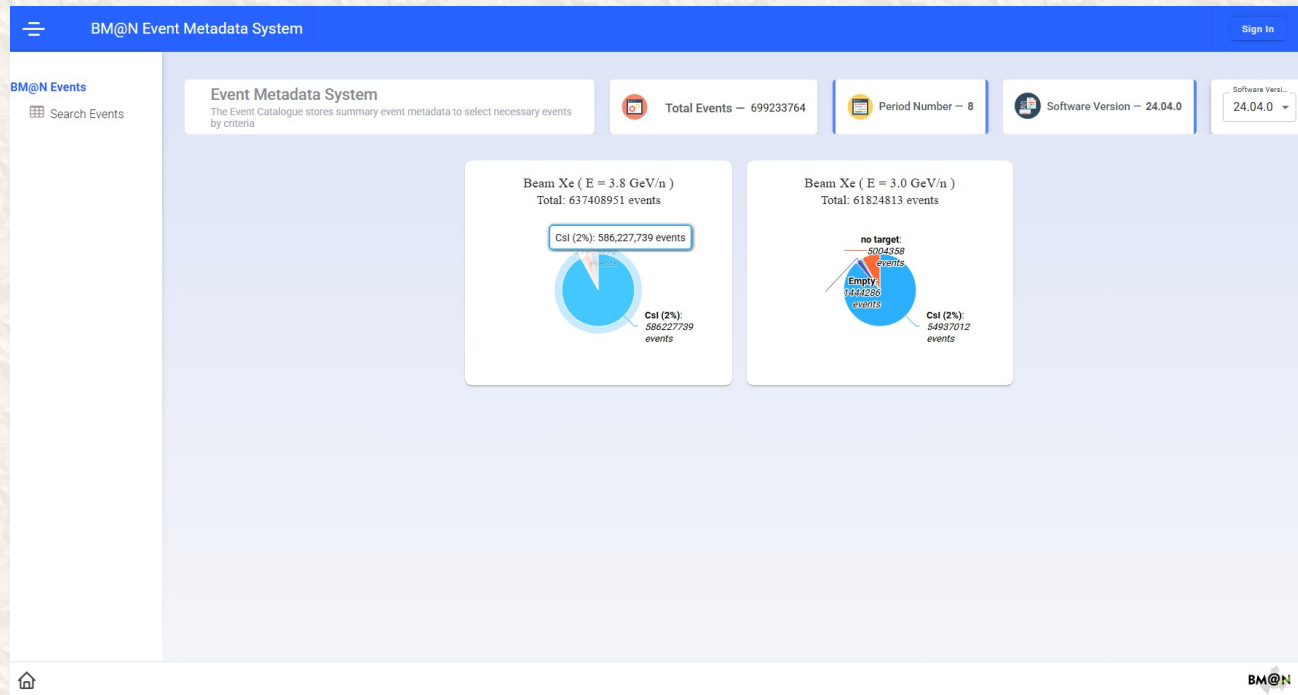
E. Alexandrov, I. Alexandrov, A. Chebotov, A. Degtyarev, I. Filozova, K. Gertsenberger,

P. Klimai and A. Yakovlev, "Implementation of the Event Metadata System for physics analysis in the NICA experiments", J. Phys.: Conf. Ser. 2438, 012046 (2023).



Recent Progress for the EMS

- EMS progress
 - New version deployed at <https://bmn-event.jinr.int/> with about 700M records currently in it
 - Performance improved for bulk writing of new events
 - Improved error processing and display
 - Statistics collection script developed and included in the main repository





EMS Filtering Event Example

- Example obtaining events for run 6700, having 5+ tracks
 - Pipe symbol is used for ranges, so filter is to be specified as "5|"

BM@N Event Metadata System

BM@N Events

Search Events

BM@N Events

Software Version

Period Number

Run Number
6700

Beam Particle

Target Particle

Energy, GeV

Total track number
5|

Limit [dfft=100]

Offset

Filter Reset

Storage	File path	# Event	Software	Period	# Run	Total track number
ncx	/eos/nica/bmn/exp/dst/run8/2 721	24.04.0	8	6700	5	
ncx	/eos/nica/bmn/exp/dst/run8/2 994	24.04.0	8	6700	5	
ncx	/eos/nica/bmn/exp/dst/run8/2 1050	24.04.0	8	6700	6	
ncx	/eos/nica/bmn/exp/dst/run8/2 1056	24.04.0	8	6700	6	
ncx	/eos/nica/bmn/exp/dst/run8/2 1238	24.04.0	8	6700	5	
ncx	/eos/nica/bmn/exp/dst/run8/2 1301	24.04.0	8	6700	5	
ncx	/eos/nica/bmn/exp/dst/run8/2 1360	24.04.0	8	6700	13	
ncx	/eos/nica/bmn/exp/dst/run8/2 2269	24.04.0	8	6700	7	
ncx	/eos/nica/bmn/exp/dst/run8/2 2343	24.04.0	8	6700	5	
ncx	/eos/nica/bmn/exp/dst/run8/2 2555	24.04.0	8	6700	8	

Rows per page: 10 1-10 of 100



Development of Next-Generation Event Visualization Platform for BM@N (an update)



VisionForge Project Overview

VisionForge – platform for creating next-gen visualization systems

- Distributed dynamic system
 - Visualization model can be created on one node, transferred to another node and rendered there
 - Nodes can exchange **updates** to the model
 - Changing one element or attribute only requires sending this small change
- Performance and optimizations
 - BM@N geometry model includes more than 400 000 elements
 - Geometry can be defined as **prototype** that is used by a set of objects, in this case rendering is simplified – only required properties can be changed if needed



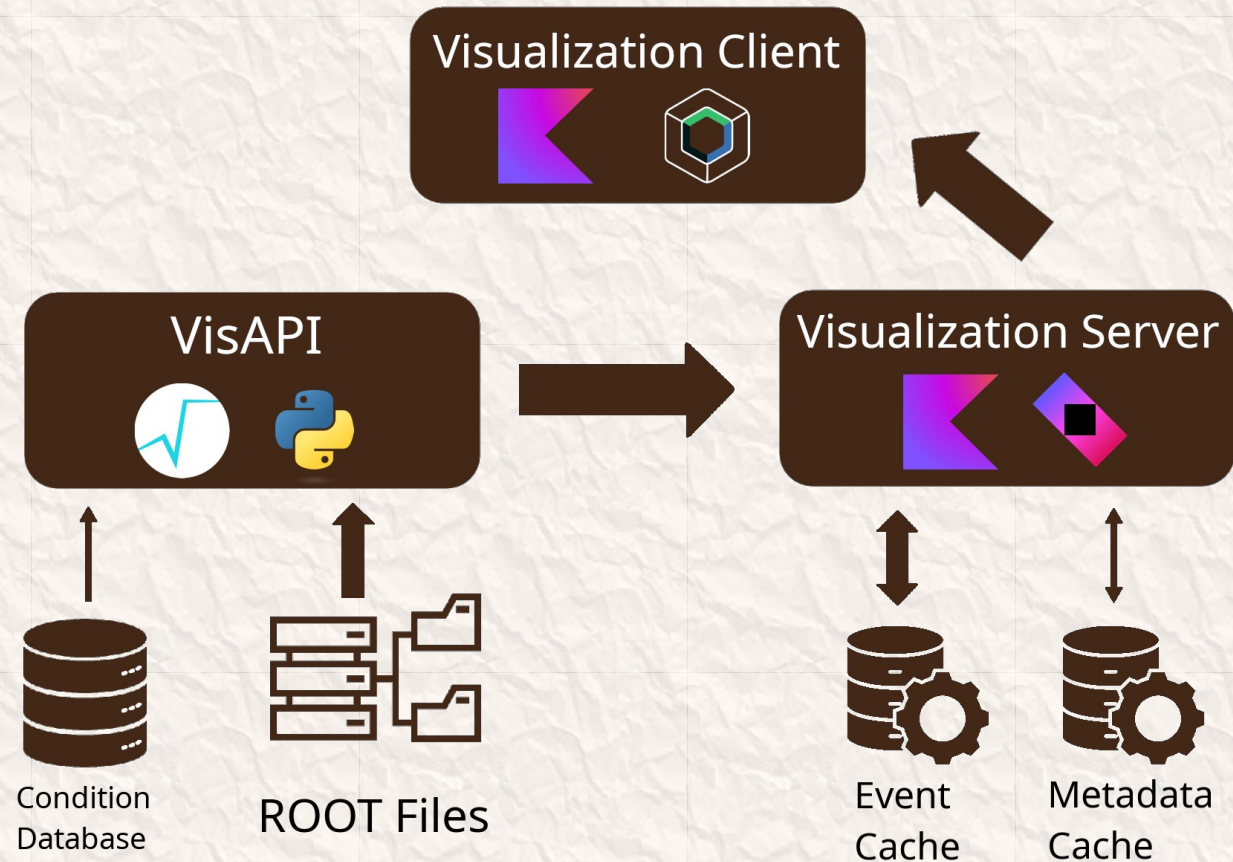
VisionForge Project Overview

See also:

- VisionForge project
 - sciprogramcenter.org/projects/visionforge
- VisionForge source code
 - git.sciprogramcenter.org/kscience/visionforge/src/branch/dev/
- Alexander Nozik — Unbearable lightness of data visualization in Kotlin full stack
 - https://www.youtube.com/watch?v=uT5j-xOXC3E&ab_channel=JPoint%2CJoker%20%26JUGru



System Architecture





Event latency problem

Method	D...	File	In...	Type	Transferred	Size	0 ms	1.28 s	2.56 s	3.84 s	5.12 s	6.40 s	7.68 s
GET		8000		e...	html	4.95 MB	4.95 MB						7806 ms
GET		1201?file=/eos/bmi		e...	html	118.53 kB	118.29 kB						7930 ms

- Each new event/geometry request takes a significant time to process (approximately 8 seconds in the test setup)
- In case of geometry, the main reason is the JSON format and the size of geometry objects themselves
- Events occupy much fewer space, but they take significantly more time to be extracted from ROOT files.
- Long event load latency is the main distraction for the user looking several sequential events



Event Cache

Simple caching algorithm (LRU with prefetching):

- Check if the requested event has previously been loaded (hit or miss);
 - If hit: return data from the cache;
 - If miss: send a request to the VisAPI, add results to the cache and return the data.
 - For prefetching: check neighbouring events as well and load them in case of misses;
- Disadvantages:
 - Multiple request to a single event produce multiple requests to the VisAPI (when serving several users);
 - With prefetching, multiple requests to sequential events may produce many requests to the VisAPI and block it (even when serving a single user)



Event Cache

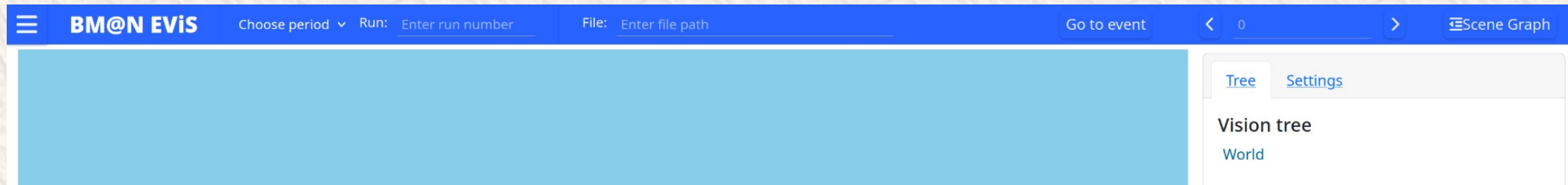
Event service uses an improved LRU cache with prefetching algorithm to reduce sequential event loading latency and improve user experience.

- Check if requested file has been loaded and its metadata are in the metadata cache;
 - Atomically:
 - Check if requested event is in the cache;
 - If it is missing, or if the user is close to a non-loaded event, a request to the VisAPI is sent (asynchronously);
 - If the request has been sent, deferred values are added to the cache;
 - At this point, a deferred object of the requested event is guaranteed to be present in the cache. Then the event object is awaited and returned.
-



Available for test now!

- Available online at <http://10.220.16.81:8080/>
- Example input:
 - Period number: **8**
 - Run number: **8000**
 - File address: **/home/lab/events/mpd_run_Top_8000_ev1_p8.root**
 - Select event: **1, 2, 3,...**
- Possible to build and run it on your own as well (source code available at git.jinr.ru/nica-visualization/evis)





Geometry, tracks, scene graph, tuning

BM@N EViS Period 8 Run: 7312 File: /eos/nica/bmn/exp/dst/run8/dev_vf_202301 Go to event 1202 Scene Graph

Geometry: BM@N_cave_1.Magnet_0.Coil_1

Properties

- visible: On
- material
 - type: default
 - color: [color picker]
 - opacity: 1
 - wireframe: Off

Vision tree

- World
 - Geometry
 - BM@N
 - cave_1
 - Magnet_0
 - Coil_1 (selected)
 - Coil_2
 - Pole_1
 - Pole_2
 - Yoke_0
 - targ_0
 - VacuumPipe_section1_0
 - VacuumPipe_section2_0
 - VacuumPipe_section3_0
 - SiBT_0
 - BD_0
 - FD_0
 - Silicon_0
 - GEMS_0
 - FullCSC_0
 - TOF400_0
 - DCH_0
 - tof700_0
 - ScWall_common_0
 - Hodo_common_0
 - NDET_common_0
 - FHCAL_common_0
 - Events
 - cbmStsTracks
 - bmGlobalTracks

Powered by VisionForge

BM@N



Available Features

- Visualization of geometry of the detector with a detail level of choice.
- Working with the scene: the ability to scale, shift and rotate the scene, section by plane.
- Saving scene configuration (JSON) to a file.
- Ability to show/hide geometric elements, set color, transparency. For a solid detector, we loaded from a prepared scheme (XML or JSON) to replace the default.
- Visualization of particle collision events: display of tracks and hits. The source is a ROOT file (ROOT) stored on a server.
- Event objects and detector geometry are presented as a hierarchical tree, with tracks grouped by particle type. When an object is selected in the tree, the object is highlighted, and vice versa, when an object is selected in the view, its properties are opened.



WIP Items

- Desktop application with a web UI based on the current client-server solution.
- Real time visualization solution: the present visualization solution using websockets to receive data for visualization and to update the data being visualized by web clients.
- Saving an image, saving scene parameters (without event or geometry data itself) to a file.
- Visualization hits and activated calorimeter towers. The source is either a file (initially ROOT), or a data stream from the socket for online monitoring.
- Selection of event objects with viewing of their properties, editing of color, visibility, marker, size/thickness. Selection/scrolling of transferred events in case of the source from a file.
- Filter of displayed event objects: particles by their code, energy range, only primary tracks. Show/hide separately simulated tracks/particles (before reconstruction), reconstructed tracks/particles
- Show general information: selected setup geometry, event number, number of events (if from file), number of displayed geometry objects.

Development of REST API and Web interfaces for slow control system



BM@N slow control system database

- Updated version of Tango slow control database uses PostgreSQL
- Convenient REST API and Web access is required

Language: English PostgreSQL » 10.18.86.81:5000 » hdb » public » Select: att_conf

Adminer 4.8.1

DB: hdb Schema: public

[SQL command](#) [Import](#) [Export](#) [Create table](#)

[select att_array_devboolean](#)
[select att_array_devdouble](#)
[select att_array_devencoded](#)
[select att_array_devenum](#)
[select att_array_devfloat](#)
[select att_array_devlong](#)
[select att_array_devlong64](#)
[select att_array_devshort](#)
[select att_array_devstate](#)
[select att_array_devstring](#)
[select att_array_devuchar](#)
[select att_array_devulong](#)
[select att_array_devulong64](#)
[select att_array_devushort](#)
[select att_conf](#)
[select att_conf_format](#)
[select att_conf_type](#)
[select att_conf_write](#)
[select att_error_desc](#)
[select att_history](#)
[select att_history_event](#)

Select: att_conf

[Select data](#) [Show structure](#) [Alter table](#) [New item](#)

[Select](#) [Search](#) [Sort](#) [Limit](#) [Text length](#) [Action](#)

SELECT * FROM "att_conf" WHERE "name" = 'temperature' LIMIT 10 (0.498 s) [Edit](#)

<input type="checkbox"/> Modify	att_conf_id	att_name	att_conf_type_id	att_conf_format_id	att_conf_write_id	table_name	cs_name	domain	family	member	name	ttd	hide
<input type="checkbox"/> edit	4	tango://bmn-sc-tangodb.he.jinr.ru:10000/bmn/env/pir230e_2/temperature	5	1	1	att_scalar_devdouble	bmn-sc-tangodb.he.jinr.ru:10000	bmn	env	pir230e_2	temperature	0	#
<input type="checkbox"/> edit	3876	tango://bmn-sc-tangodb.he.jinr.ru:10000/bmn/env/pir230e_3/temperature	5	1	1	att_scalar_devdouble	bmn-sc-tangodb.he.jinr.ru:10000	bmn	env	pir230e_3	temperature	0	#
<input type="checkbox"/> edit	2	tango://bmn-sc-tangodb.he.jinr.ru:10000/bmn/env/pir230e_1/temperature	5	1	1	att_scalar_devdouble	bmn-sc-tangodb.he.jinr.ru:10000	bmn	env	pir230e_1	temperature	0	#

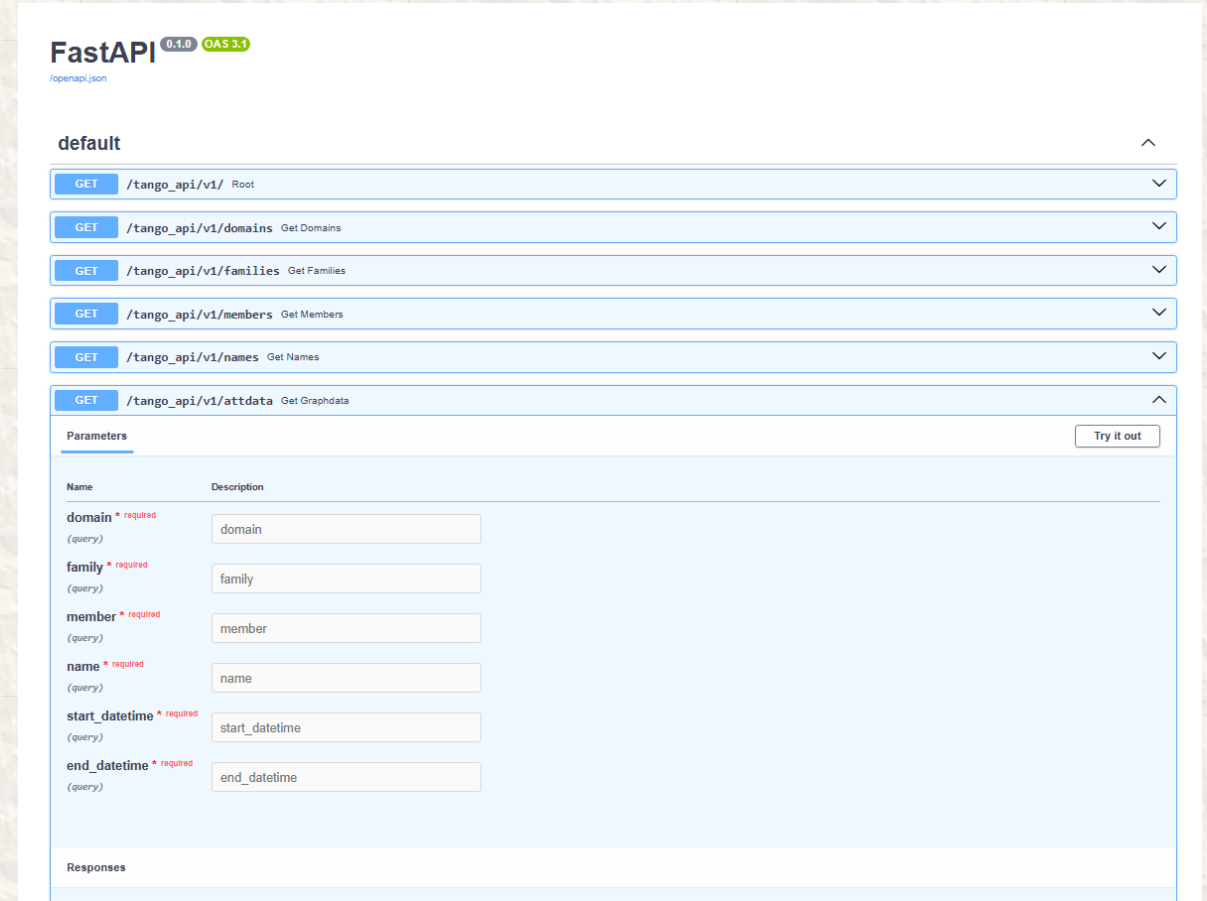
☐ Whole result ☐ 3 rows [Modify](#) [Save](#) [Selected \(0\)](#) [Edit](#) [Clone](#) [Delete](#) [Export \(3\)](#)

[Import](#)



API Service Development

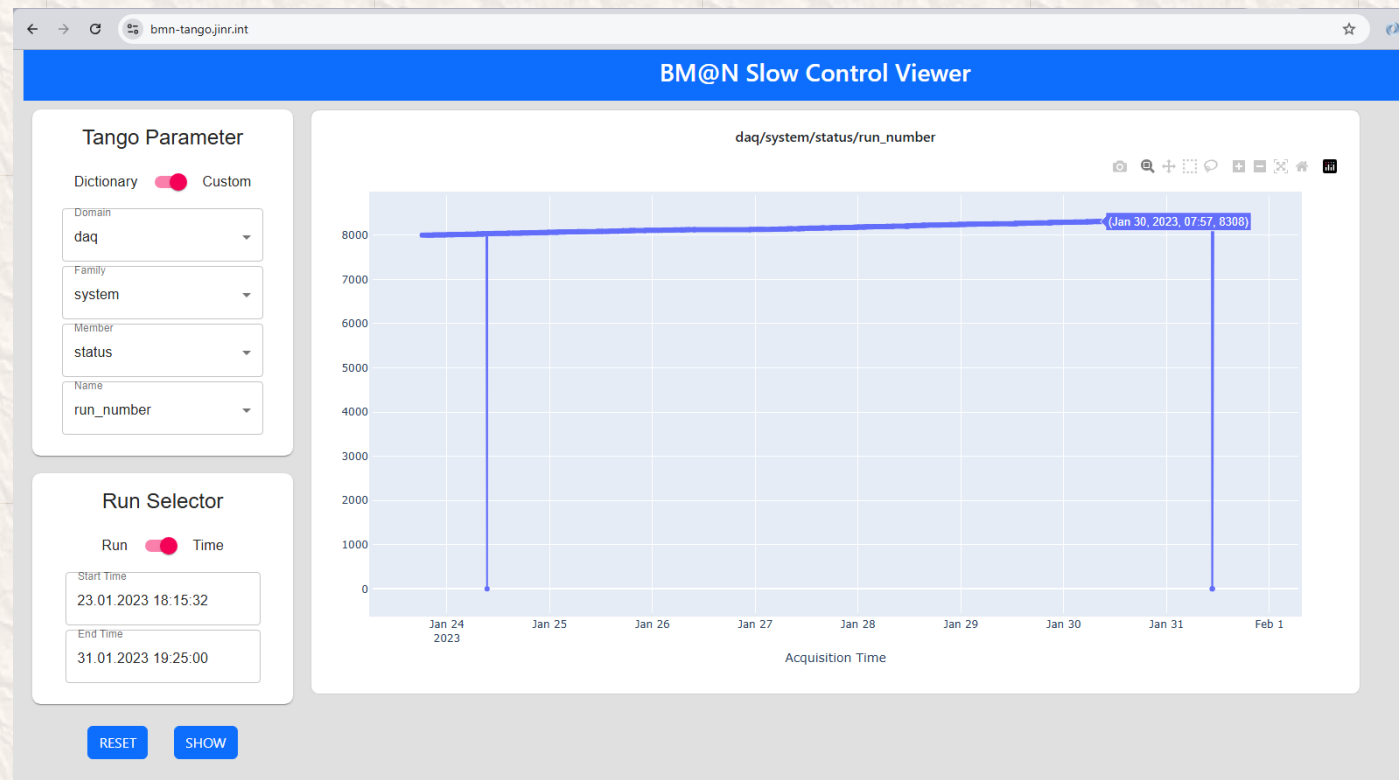
- REST API was developed
 - Using FastAPI framework
 - Deployed in JINR network
 - Used by Web interface (see next slide)
- Sources available at https://git.jinr.ru/nica_db/tango-rest





Web Interface Development

- Web-based viewer for SCS was updated to use the new API and, hence, the new database
- Available at <https://bmn-tango.jinr.int/>



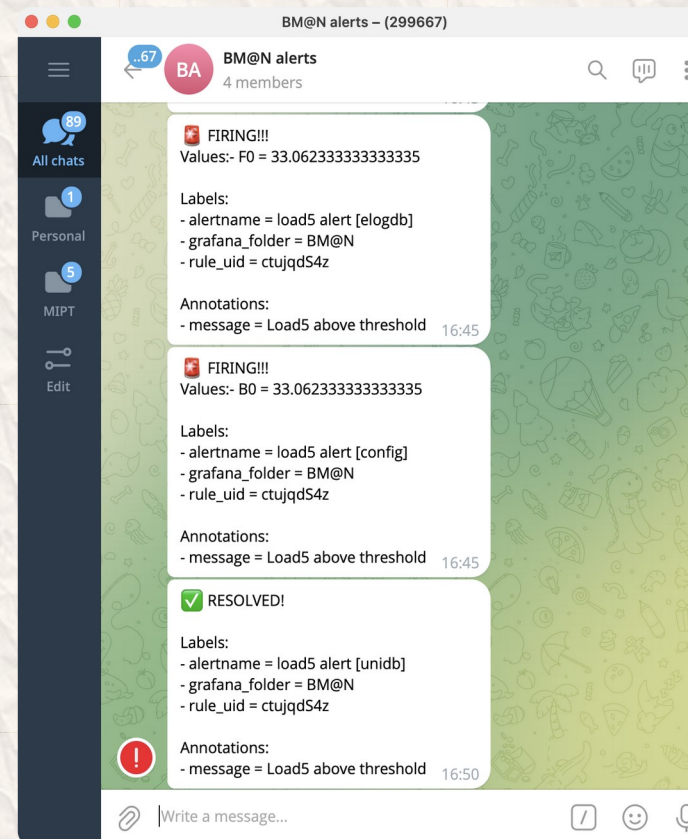


Monitoring Service (an update)



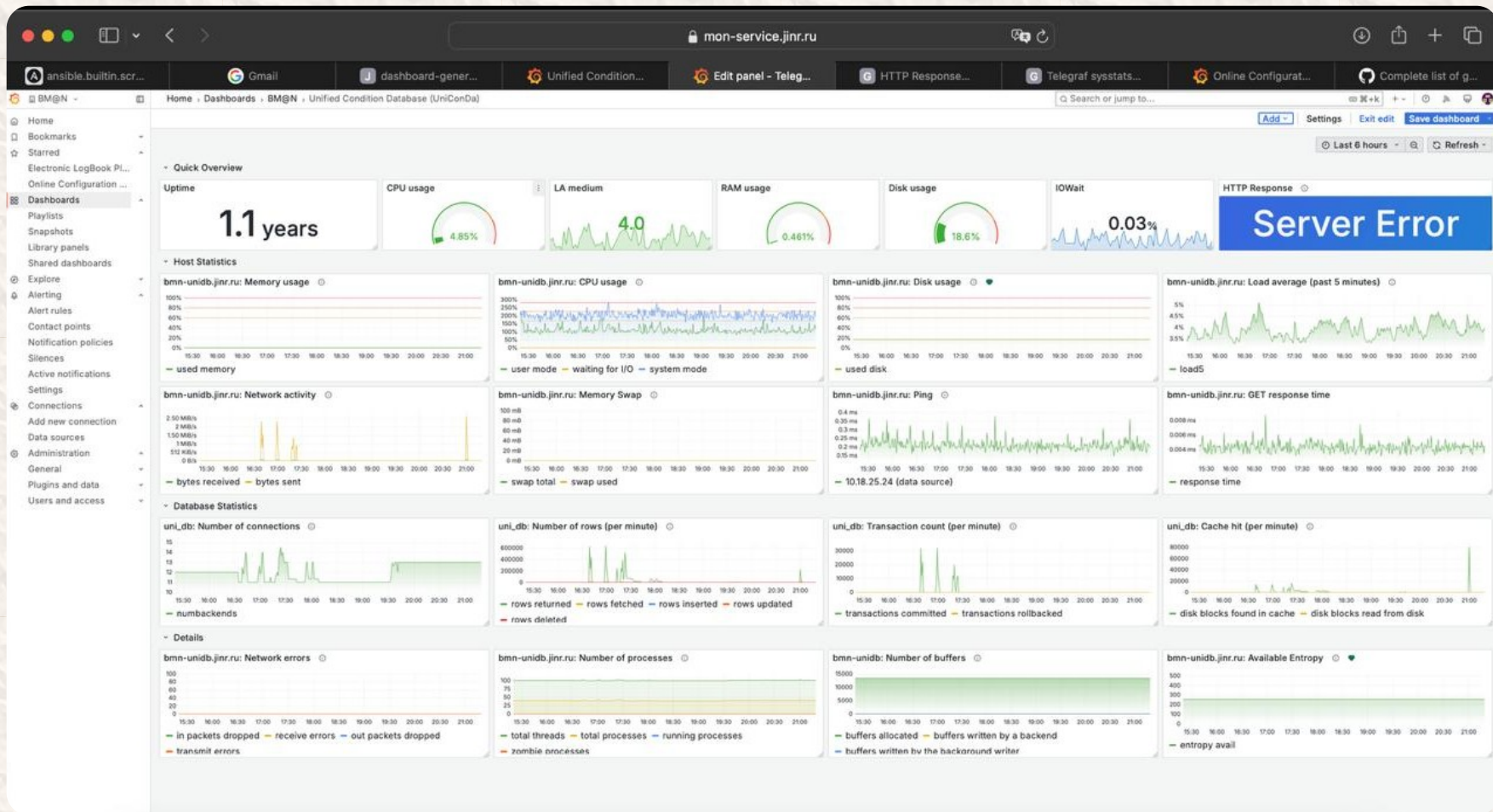
New and Planned Features

- Dashboard UI
 - Configurable Quick overview
 - Chart sorting
 - HTTP response code chart
- Telegram alerts formatting
 - [WIP] Quick alert summary
- Planned features
 - User Manual
 - Gateway Server, Log Collector Server, Keycloak and FreeIPA service healthchecks
 - Event Metadata system and other systems monitoring





New Dashboard UI





Thank You!