Computing & Software for the Super-Charm-Tau factory detector project

Andrey Sukharev

Budker Institute of Nuclear Physics, Novosibirsk, Russia

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BINP

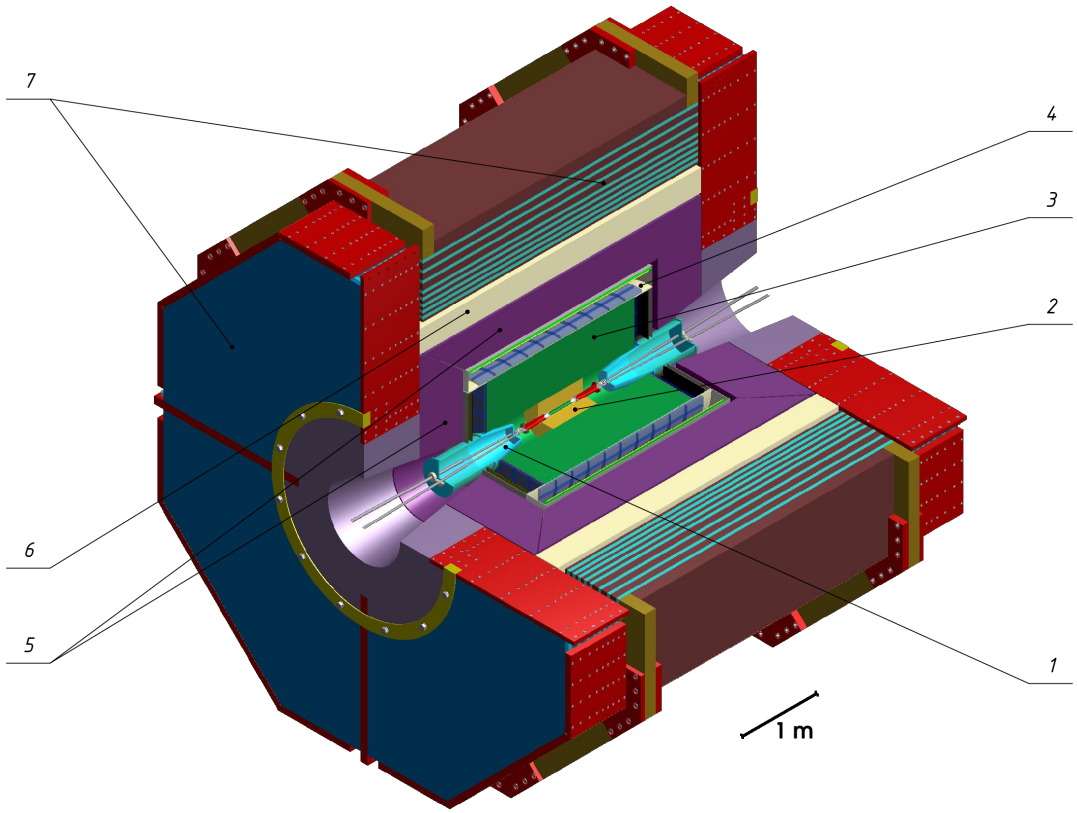
CREMLIN PLUS
Connecting Russian and European Measures for Large-scale Research Infrastructures

AFAD 2021

Detector overview

Requirements:

- Occupancy 300 kHz
- Good energy and momentum resolution
- High detection efficiency of soft tracks
- Best possible π/K and π/μ separations
- Minimal CP detection asymmetry



	subsystem	options		subsystem	options
1	Beam pipe	beryllium	**2**	Inner tracker	TPC, cGEM, Si-strip
3	Main tracker	drift chamber	**4**	PID system	FARICH, ASHIPH
5	Calorimeter	CsI, LYSO, LXe	**6**	Magnet	thin coil?
7	Muon system	Scintillators, RPC, ...			

Computing infrastructure for the project

- The immediate goal is to design the detector
  - need the simulation
  - . . . and where to run it
- Actual computing infrastructure is to be finalized as late as possible
  - outlined in the CDR
- The existing BINP/General Computing Facility is available
  - local computing farm of about 2k CPU cores
  - various storage subsystems
  - VM servers (about 100 CPU cores)
  - IB/10GbE/40GbE local interconnects
  - access to remote resources

. . . also shared with other groups

Local Resources at BINP/GCF

- Local computing farm
- BINP/GCF storage
- VM servers
- Centralized UPS solution is upcoming
- The computing environment based on Scientific Linux 7

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- Local computing farm $\rightarrow$ **improving**
  two EPYC 7702P installed recently, six EPYC 7352 to come this year, phasing out older machines
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  $\rightarrow$ **upgrading, moving from disk arrays to CEPH**
  $\sim$ 500 TB @ HDD + to be installed $\sim$ 50 TB @ SSD
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- The computing environment based on Scientific Linux 7
  $\rightarrow$ **migration to CentOS 8 suspended**

Resources available via BINP/GCF

- Computing resources of Novosibirsk Scientific Center
  - NUSC & SSCC supercomputers
    - ★ mostly GPU...
    - ★ ...but still several thousands CPU
    - ★ good experience of collaboration
  - ICT SB RAS storage
    - ★ $>$ 500 TB
  - ...connected with isolated 10GbE network (NSC/SCN)
- Dedicated network link to Moscow (KIAE)
  - 2 Gbps presently
  - direct access to LHCone network
- Intellectual resources of Novosibirsk Scientific Center
  - strong interdisciplinary cooperation

Offline computing infrastructure development

- Development of the simulation model of HPC system for the Super Charm-Tau factory
  - the goal is to estimate parameters and consider various options for computing farms and storage systems for the experiment
  - in cooperation with ICM&MG SB RAS
- Development of the offline data processing and analysis system based on the BioUML platform
  - in cooperation with ICG SB RAS
- Integration of the simulation model and the BioUML-based system

The prototype using container technologies is deployed at SSCC

The activity is supported by three-year RSF grant 19-72-20114

SCT Project at BINP/GCF

BINP/GCF provides the SCT detector project with

- general login servers,
- computing nodes & batch system,
- storage area,
- gitlab server,
- wiki & web servers,
- mail list,
- ...

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No lack of computing resources for the present stage of the detector project

Software for the project

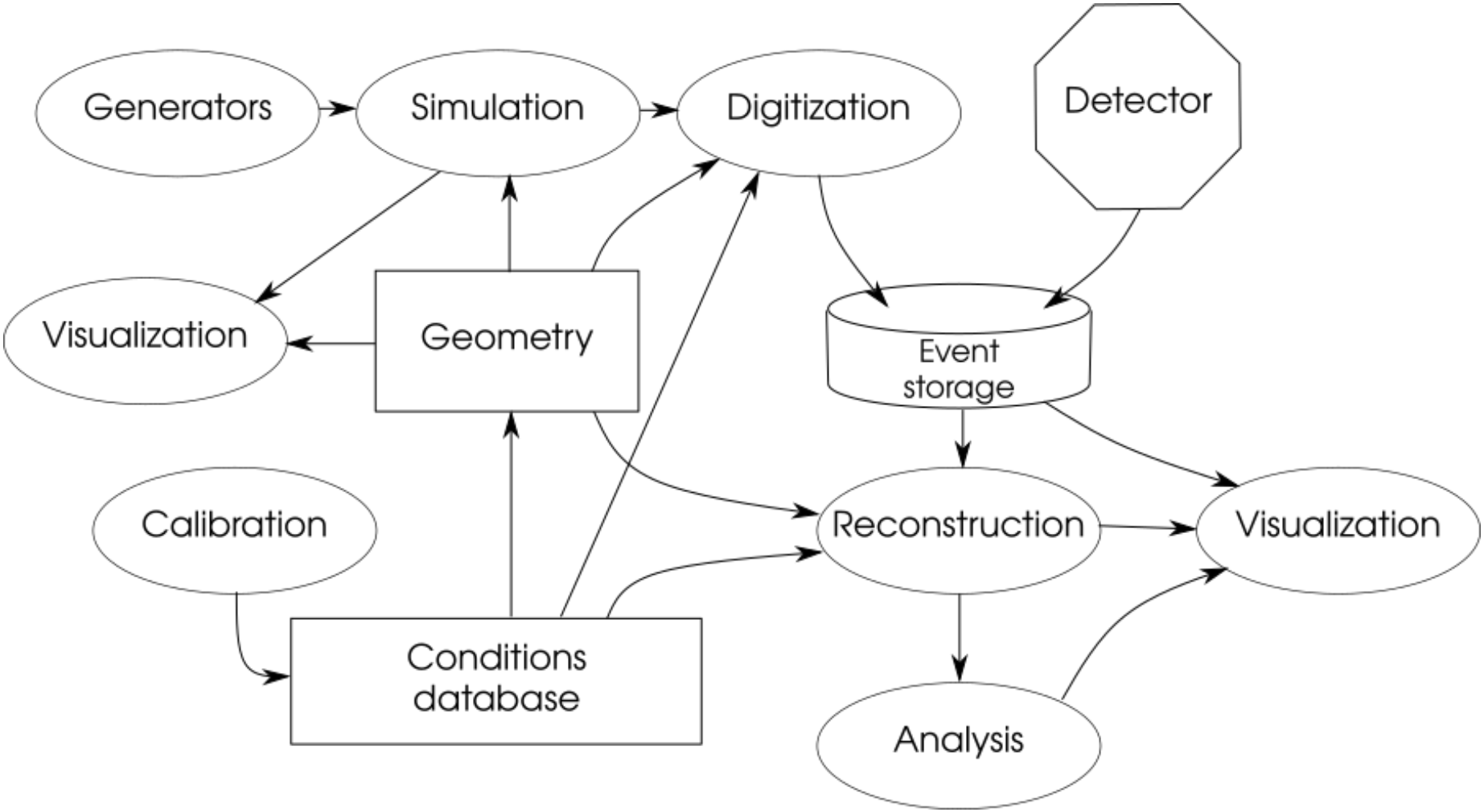
A HEP software framework

A typical HEP experiment requires complete stack of relevant software:

- event generators,
- parametric and full detector simulation,
- event reconstruction algorithms,
- online event interpretation for trigger decisions,
- event data model (EDM),
- I/O interface to conditions data base,
- I/O interface to data storage,
- offline data analysis algorithms,
- build system and release management software.

Software for the project

Framework elements and data flows



The Aurora framework

- Based on Gaudi
- Conventional and recently emerged HEP software tools:
  - ROOT, Geant4
  - DD4Hep (Key4HEP)
- Other experiments software
  - Belle II, ILC, FCCSW...
- Build & configuration system inspired by ATLAS Athena
- `lcgcmake` system to build external packages
- Nightly builds
- Standard computing environment is Scientific Linux 7 x86_64, GCC8 + Python2&3

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Standalone studies

- Parametric simulation tool for quick estimations of the detector response
- Background simulations with Fluka
- Gas mixture studies and electric field simulations with Garfield for TPC and DC
- CERN team develops TCP variant & adopts track finding algorithms from iLCSoft

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  $\rightarrow$ **now incorporating into the framework**
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  & adopts track finding algorithms from iLCSoft
  $\rightarrow$ **have a prototype, now incorporating into the framework**

Event Generators

The conventional set of event generators available

- Exclusive decays of hadrons and tau lepton
  - EvtGen, Tauola, PHOTOS, Pythia
- Inclusive generators for $e^+e^- \to$ hadrons
  - preliminary solution based on Pythia
- Generators for luminosity measurements and calibrations
  - MCGPJ, BabaYaga, BBBREM, KKMC...

Status of the software

Geometry in Aurora

- Subsystems implemented to the moment:
  - Beam pipe & final focus magnets
  - Inner tracker (three options)
  - Advanced DC with StereoLayers
  - Particle ID
  - Crystal calorimeter
  - Simplified s/c coil
  - Muon system & yoke
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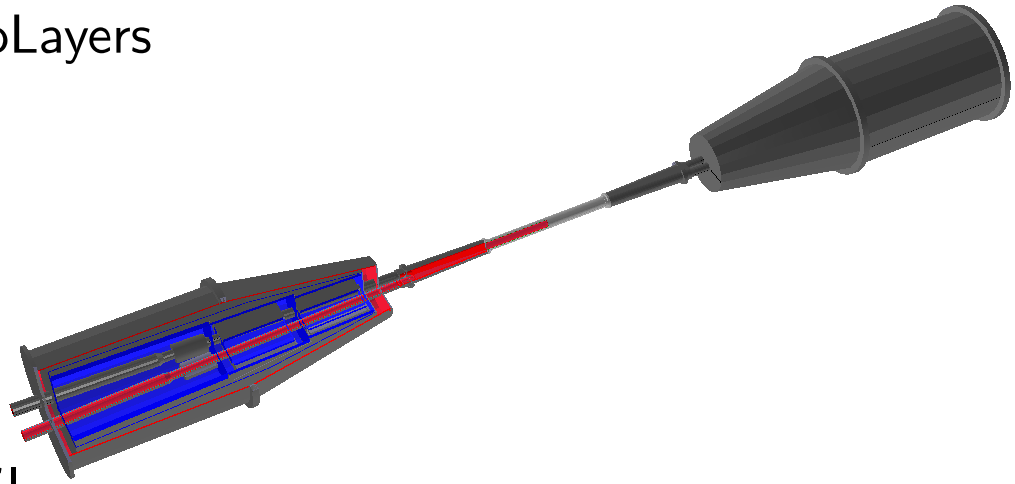

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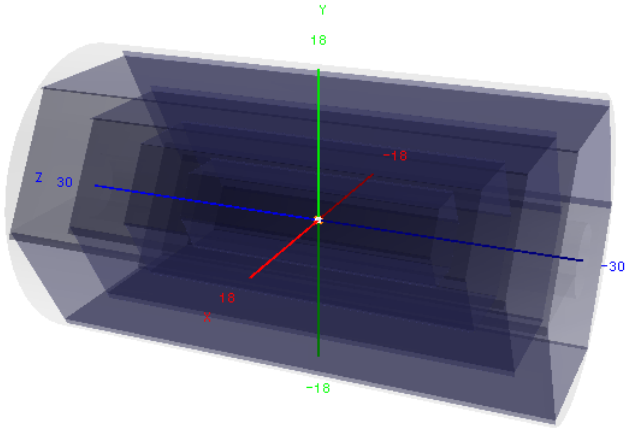

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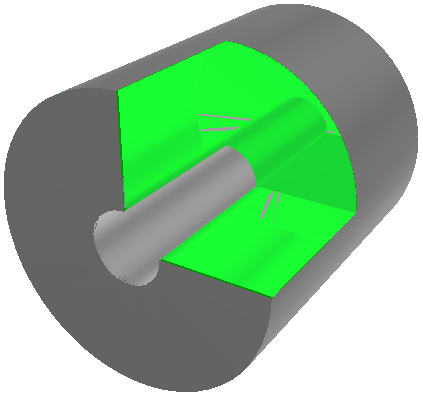

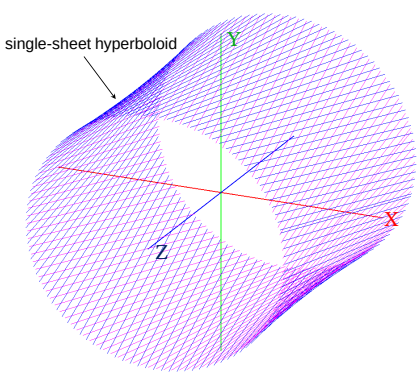

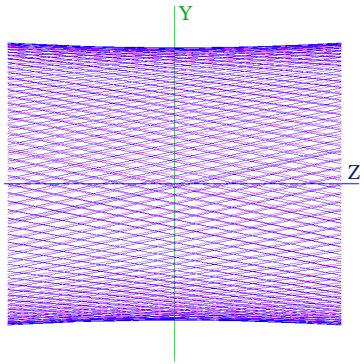

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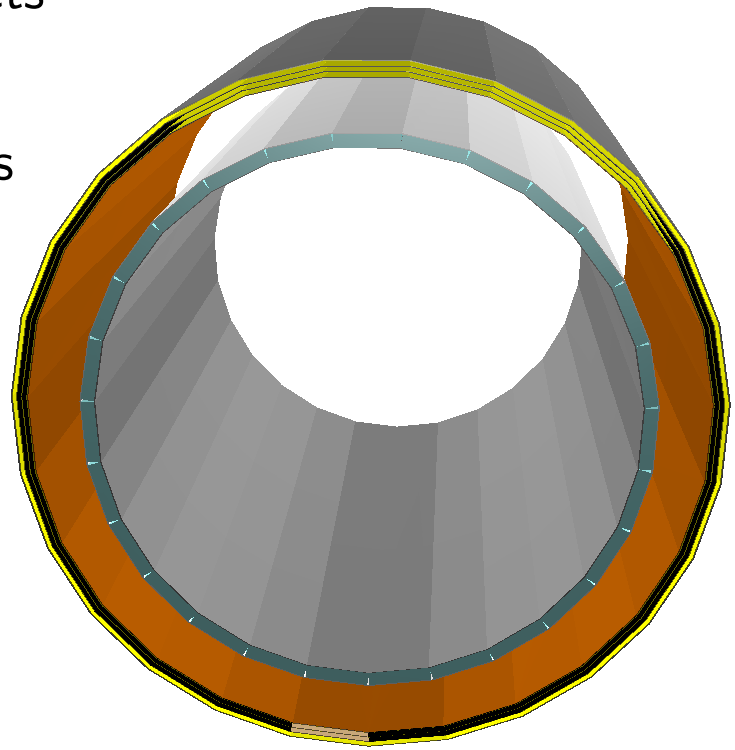

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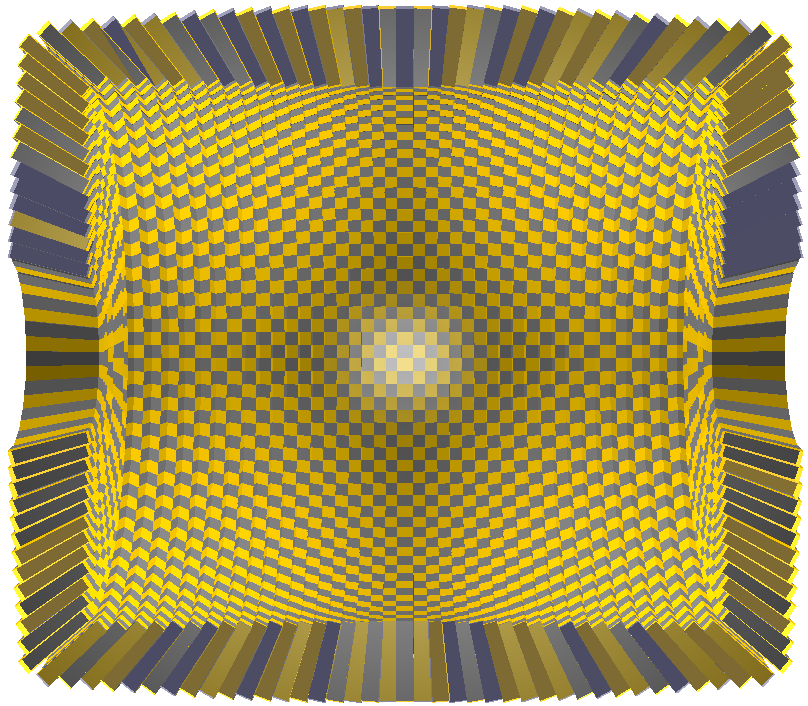

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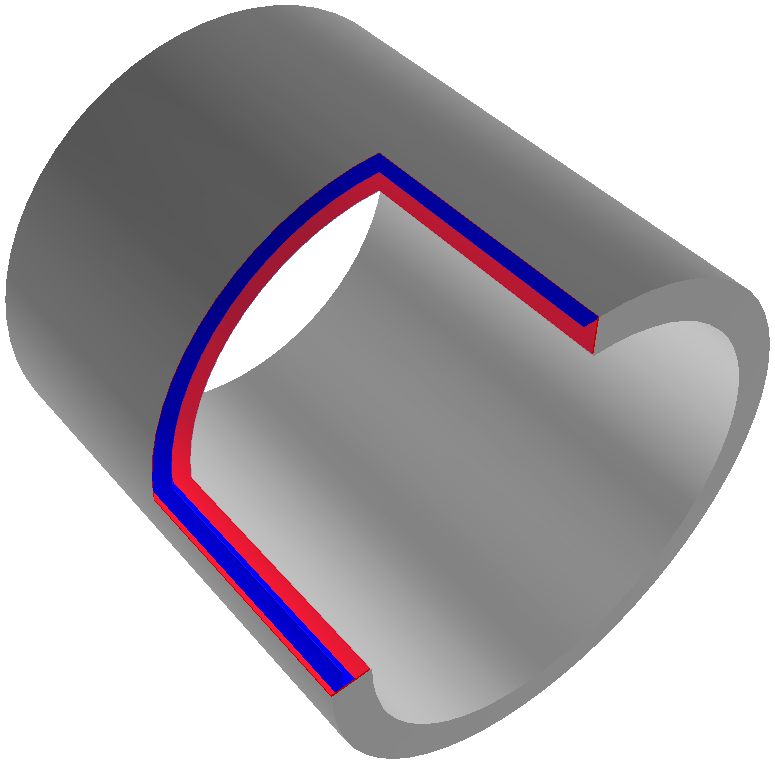

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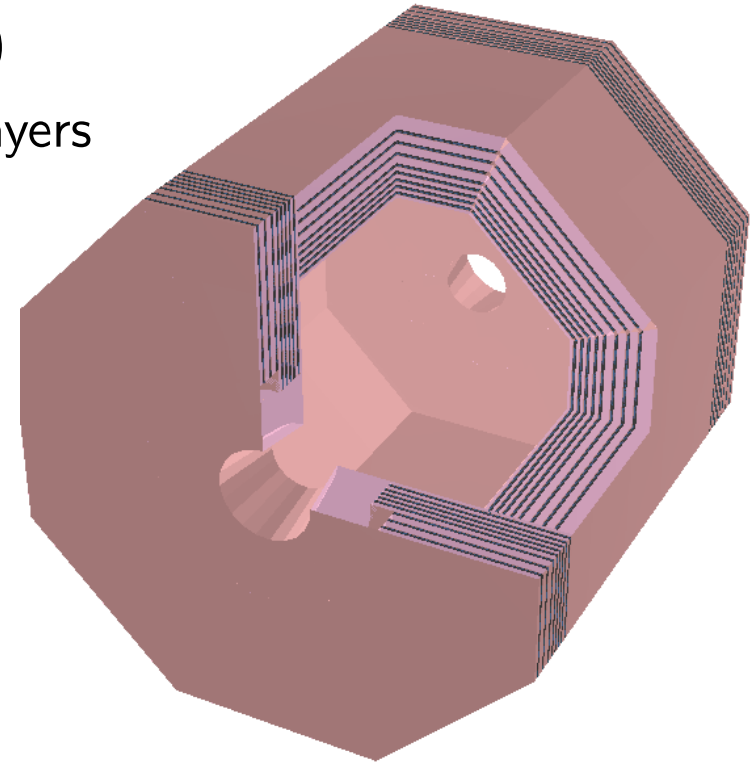

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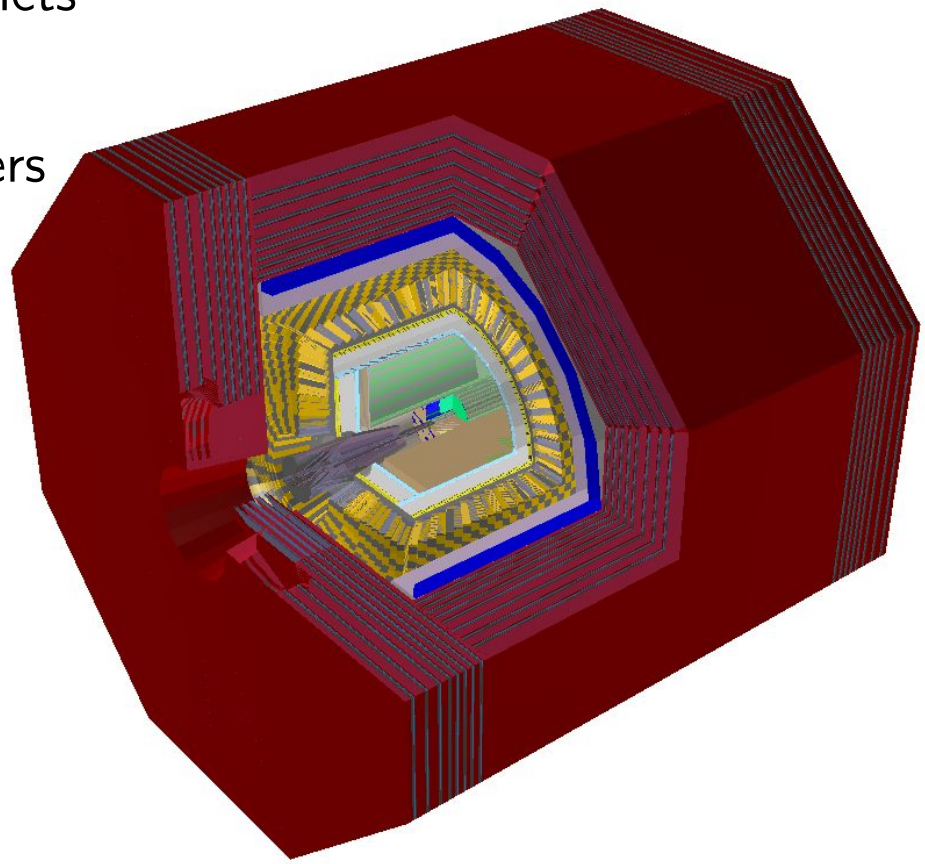

We have geometry for at least one option for each subsystem

Status of the software

Digitization & Reconstruction

- most subsystems miss separate Digitization stage yet
  - integrated into reconstruction
  - based on standalone studies
  - sample module prepared for Silicon Strip
- 1st stage Reconstruction: individual subsystem level
  - in preparation by subsystem groups
  - Calorimeter and DC most advanced at the moment
- 2st stage Reconstruction: combining subsystems, PID...
- the Event Data Model is to be finalized

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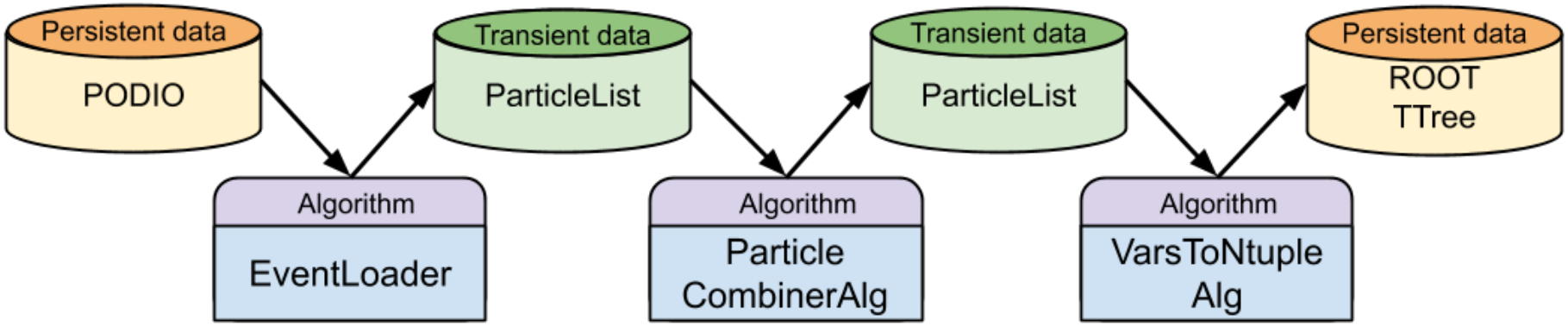
  $\rightarrow$ eventually re-basing to EDM4hep

Status of the software

Data Analysis

- Adopting Belle II recipes and solutions for analysis
- Base set of analysis algorithms ready:



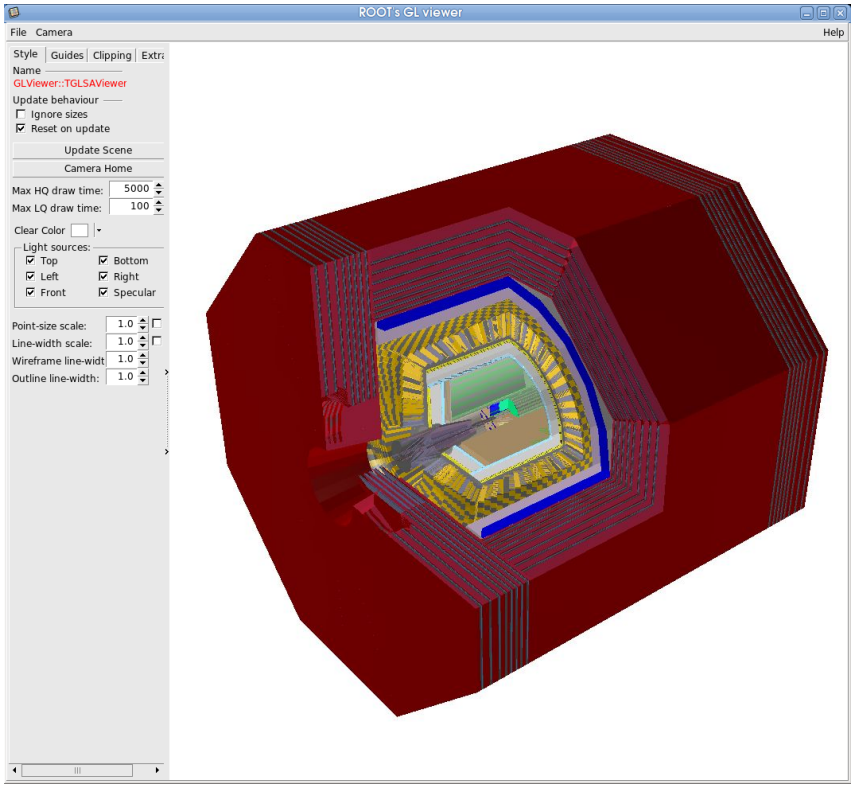
- final particles processing
- kinematic cuts

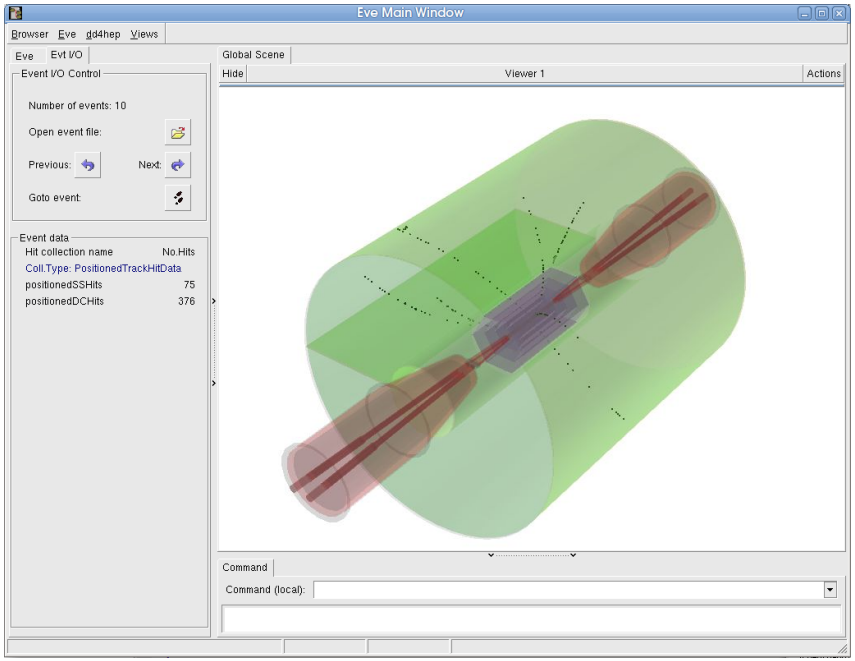
- reconstructuion of decayed particle
- kinematic cuts

- kinematic parameters calculation
- particle selection

Status of the software

Detector/Event Display





- Geometry display tool is ready
- Base Event display (DDEve-based) available, lots of things to improve

Conclusions

- There are sufficient computing resources for the SCT detector project at Budker INP
- Software for the project improves continuously
- The Aurora framework now contains all components minimally required at the present stage of the SCT detector project development:
  - set of primary event generators,
  - usable in analysis parameterized simulation,
  - detector geometry (with at least basic description for all detector elements, and several options for some subsystems),
  - full Geant4-based simulation,
  - sample digitization module,
  - reconstruction modules (from basic to really advanced, depending on subsystem),
  - analysis and job configuration tools,
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This allows us to announce the Aurora 1.0.0 release

Acknowledgments

We are grateful to the Belle II collaboration and to the FCCSW project for access to their software

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072 (the CREMLINplus project)

Thank you for attention

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Backup

Further software development

The nearest goals for the software development are:

- implementation of digitization modules for all subsystems
- further reconstruction improvements, including adoption of some high-level tools, i. e. track finding,
- improvement of detector and event visualization tools. The underlying DDEve has been not actively developed recently, so this is an area of possible backward contribution to DD4Hep
- distribution of the software via CvmFS