Computing environment for the Super-Charm-Tau factory detector

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on behalh of the SCTau collaboration

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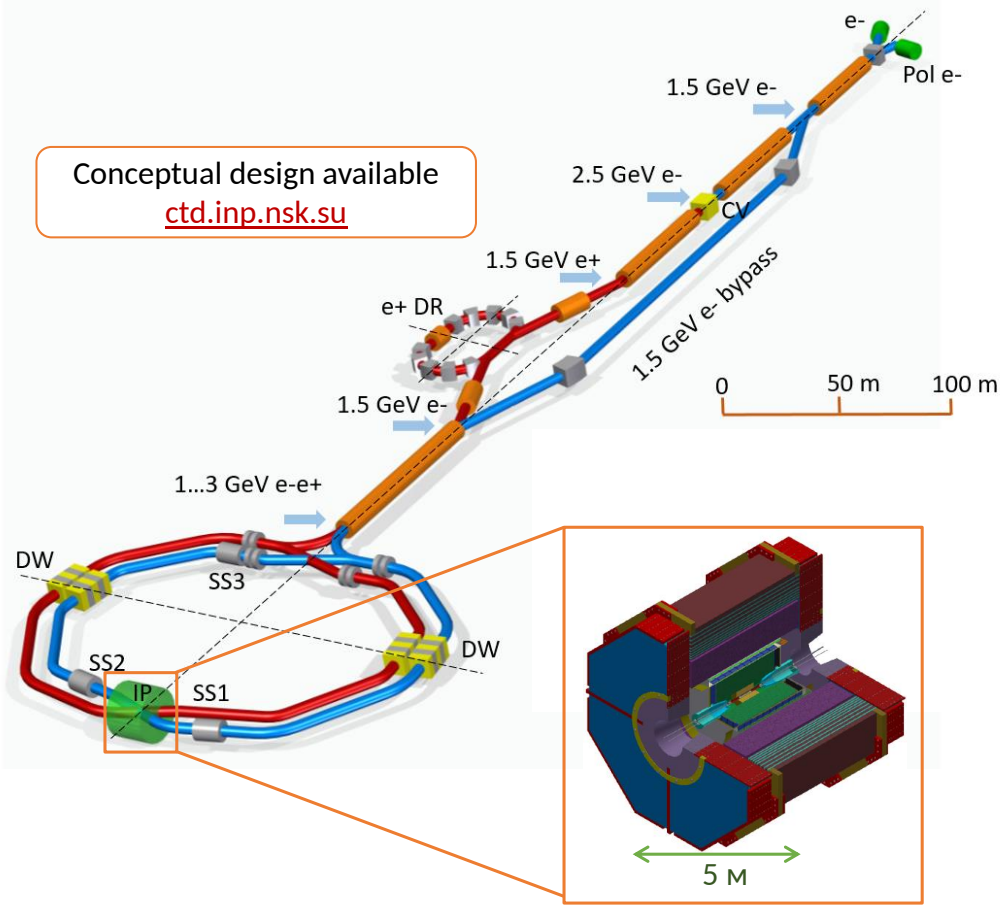
SCT Experiment overview

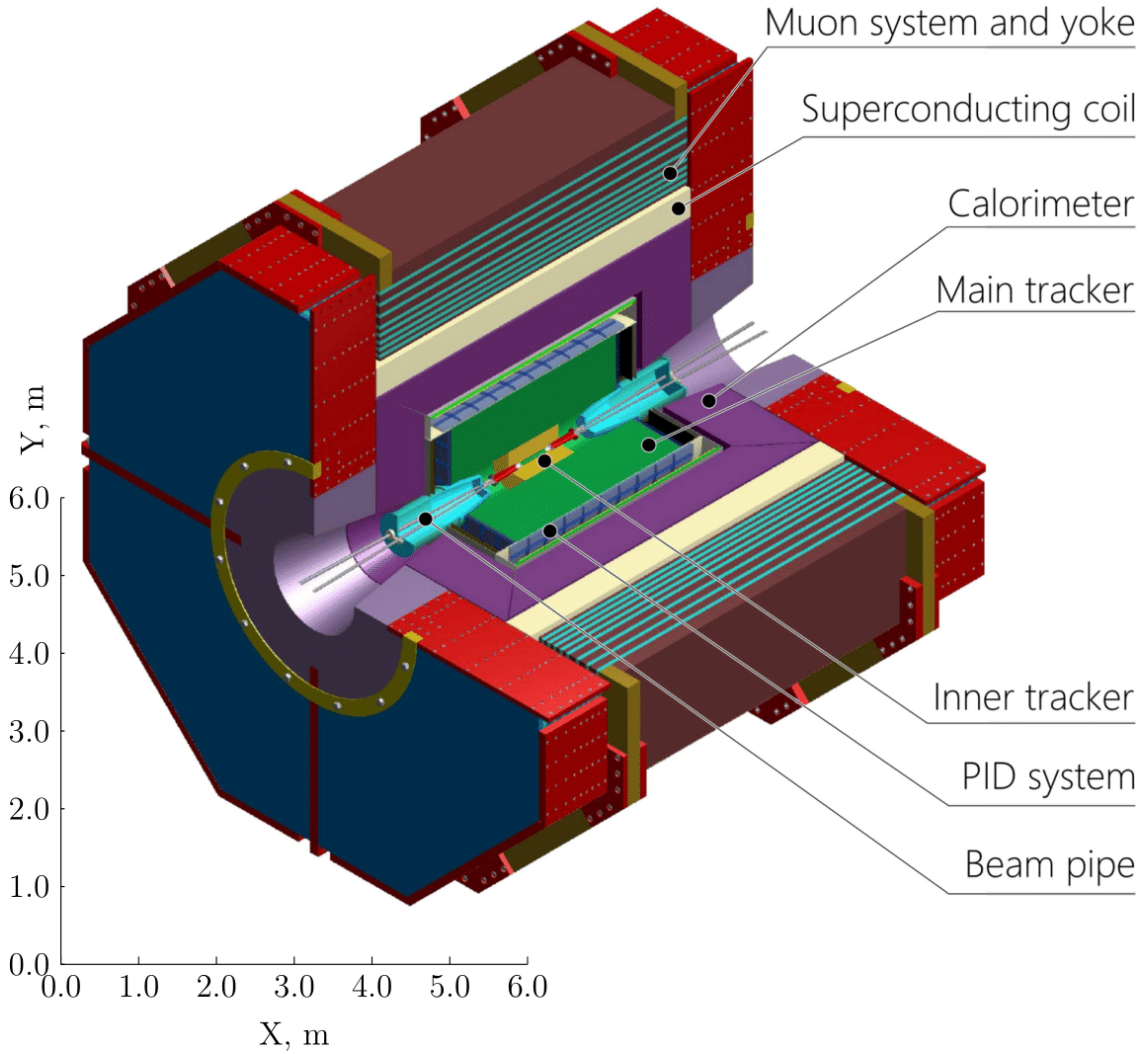
- Precision experiments with tau lepton and charmed hadrons, and search for BSM phenomena
- Electron-positron collider
  - Beam energy varying between 1.5 and 3.5 GeV
  - Luminosity $\mathcal{L} = 10^{35} cm{-}2s{-}1$ @ 2 GeV
  - Longitudinal polarization of the e^- beams
- Universal particle detector
  - Tracking system
  - Crystal electromagnetic calorimeter
  - Particle identification system



Detector overview

Requirements:

- Trigger rate up to 300 kHz
- $10^4 cm^{-2} s^{-1}$ tracks at $R \leq 20$ cm
- $\sigma_p/p \leq 0.4\%$ at 1 GeV/c
- Good π^0/γ separation, $E_\gamma = 10 - 3000$ MeV, $\sigma_E \leq 1.8\%$ at 1 GeV
- Dedicated PID system
  - $\frac{dE}{dx} < 7\%$,
  - μ/π separation up to 1.5 GeV/c,
  - π/K separation up to 3.0 GeV/c.
- Minimal CP detection asymmetry



Computing infrastructure for the project

- The immediate goal is to design the detector
  - need the simulation
  - need hardware to run it
- The existing BINP/General Computing Facility is available
  - local computing farm of about 2k CPU cores
  - various storage systems
  - service VM servers (about 100 CPU cores)
  - IB/10GbE/40GbE local interconnects
  - access to remote resources

. . . also shared with other groups

Resources available via BINP/GCF

- Computing resources of the Novosibirsk Scientific Center
  - NUSC & SSCC supercomputers
    - ★ mostly GPU, but still several thousands of CPUs
  - 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

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We have enough computing resources for the present stage of the detector project

Software for the project

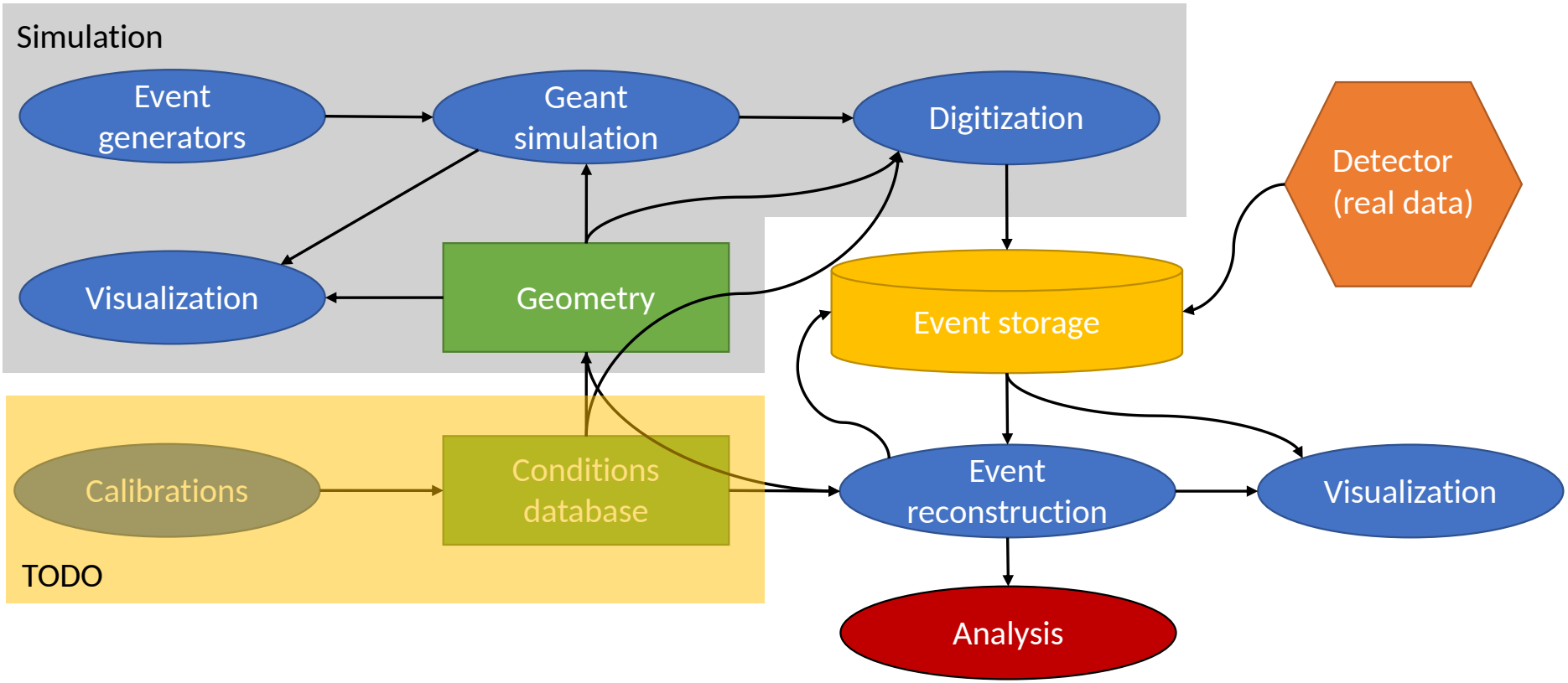
A HEP software framework

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



All software for our detector is impemented in framework named Aurora

The Aurora framework

- Based on Gaudi
- Uses conventional and recently emerged HEP software tools:
  - ROOT, Geant4
  - DD4Hep (Key4HEP)
- When possible we reuse peaces of 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, GCC9 + Python2&3

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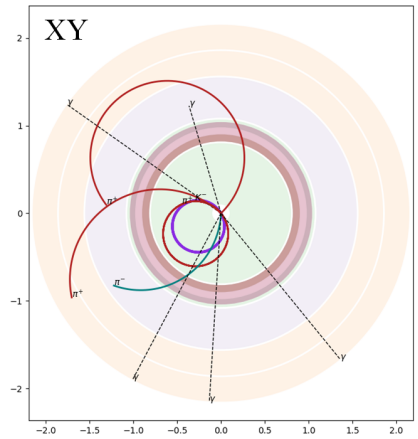
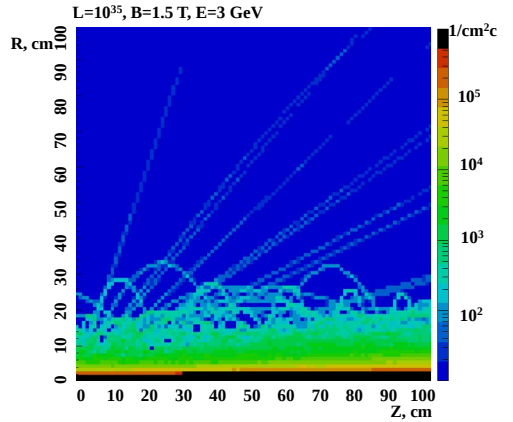
Standalone studies

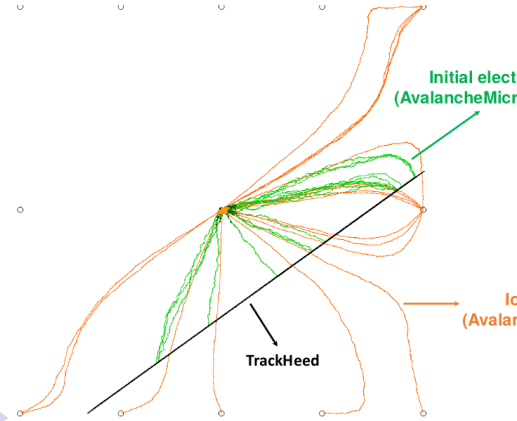
- Parametric simulation tool for quick estimations of the detector response



- Background simulations with Fluka
  e^+e^- flux is presented
  $L = 10^{35}$, $B = 1.5\,T$, $E = 3\,GeV$

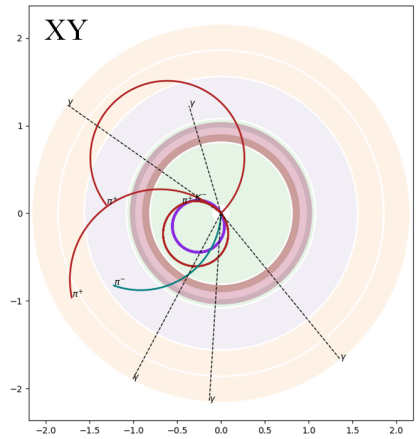


- Gas mixture studies and electric field simulations with Garfield for TPC and DC
  electrons and ions drift lines presented



Standalone studies

- Parametric simulation tool for quick estimations of the detector response, **now incorporated into the framework**



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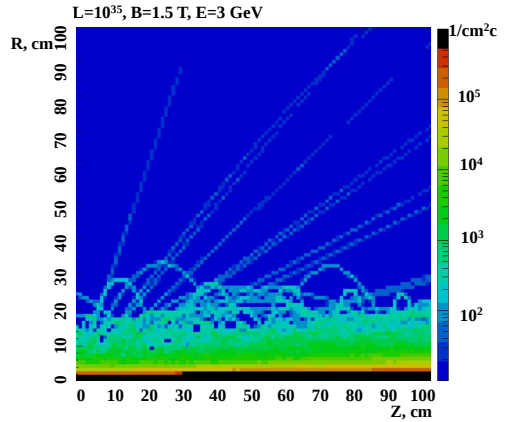

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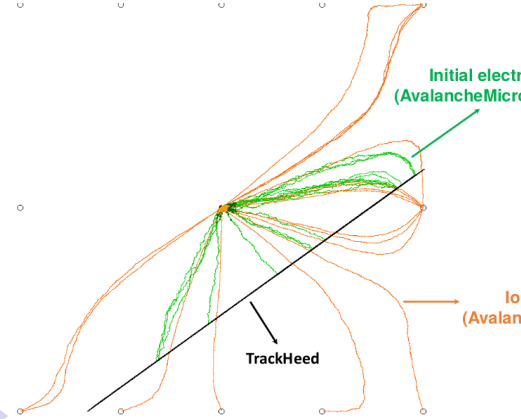
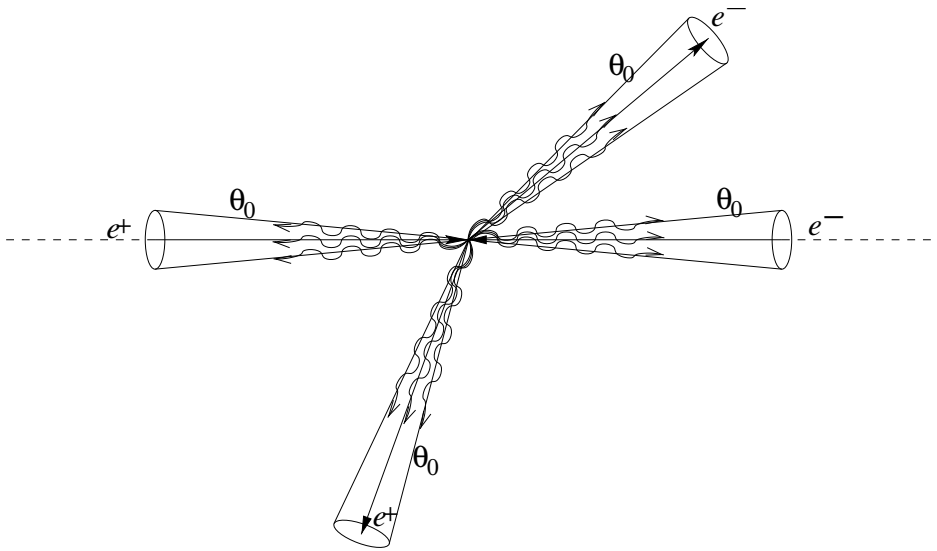


Event Generators

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...



arXiv:hep-ph/0504233

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
- Geometry testing tools for CI

  (overlaps, material scans. . .)

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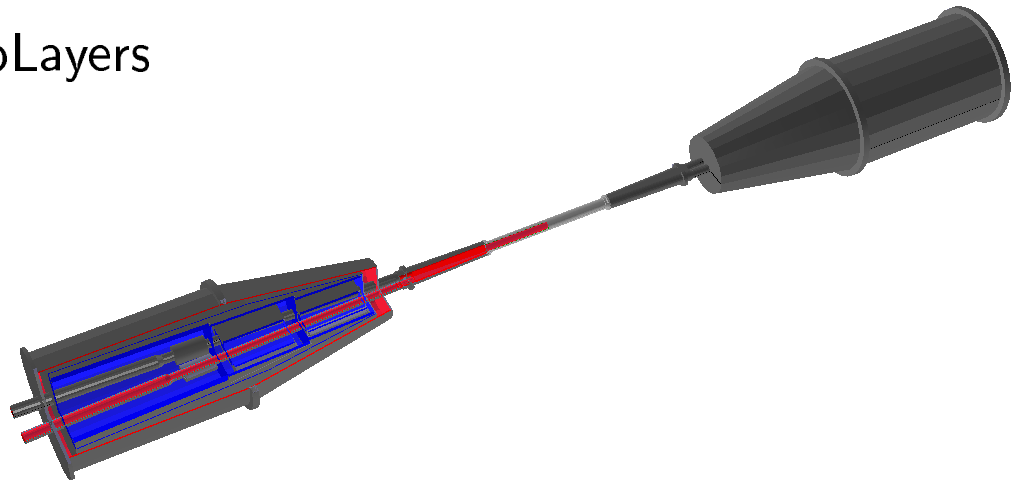

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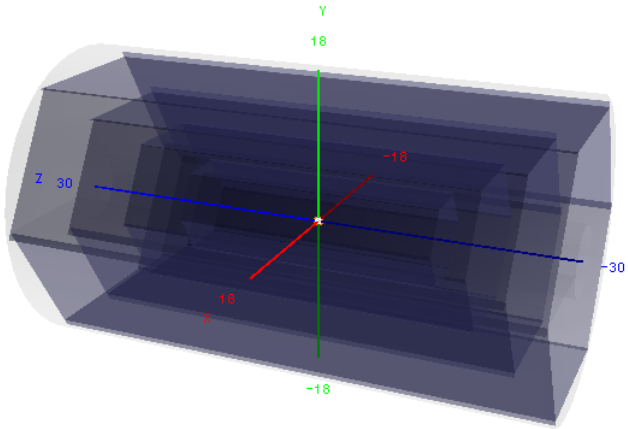

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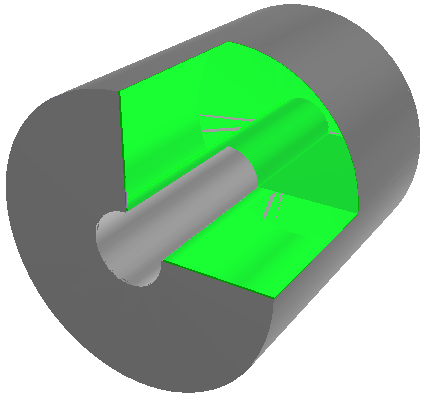

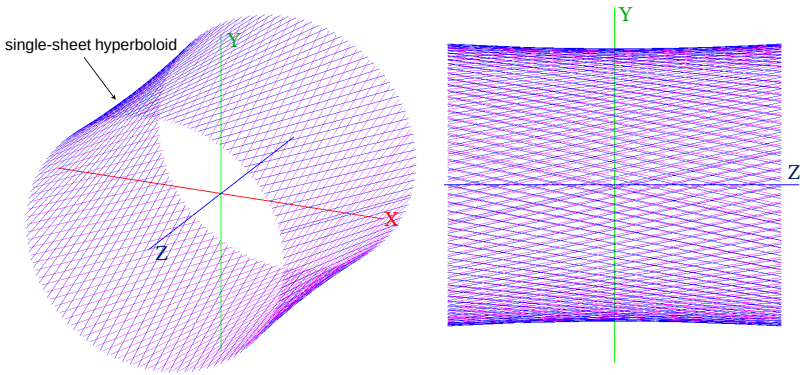

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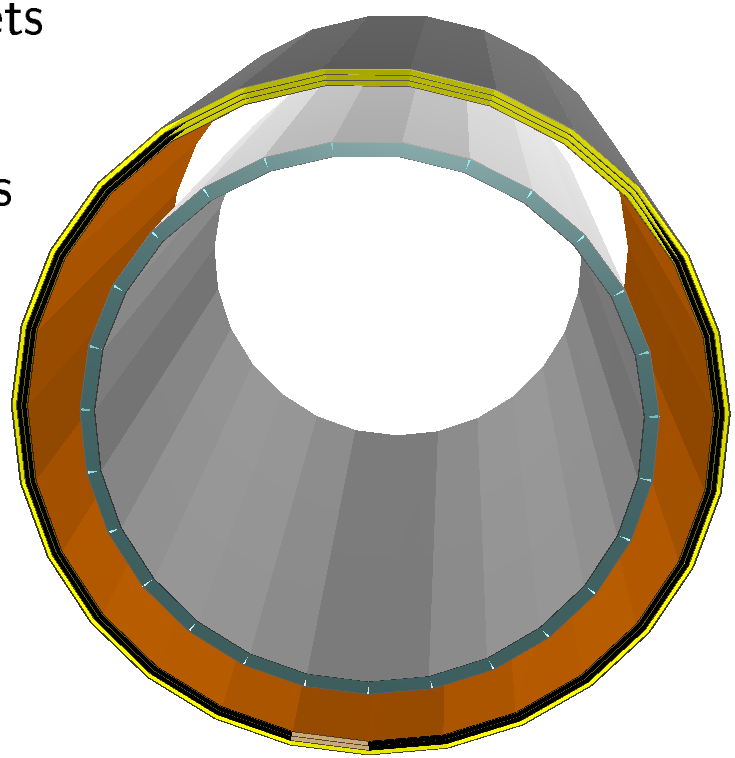

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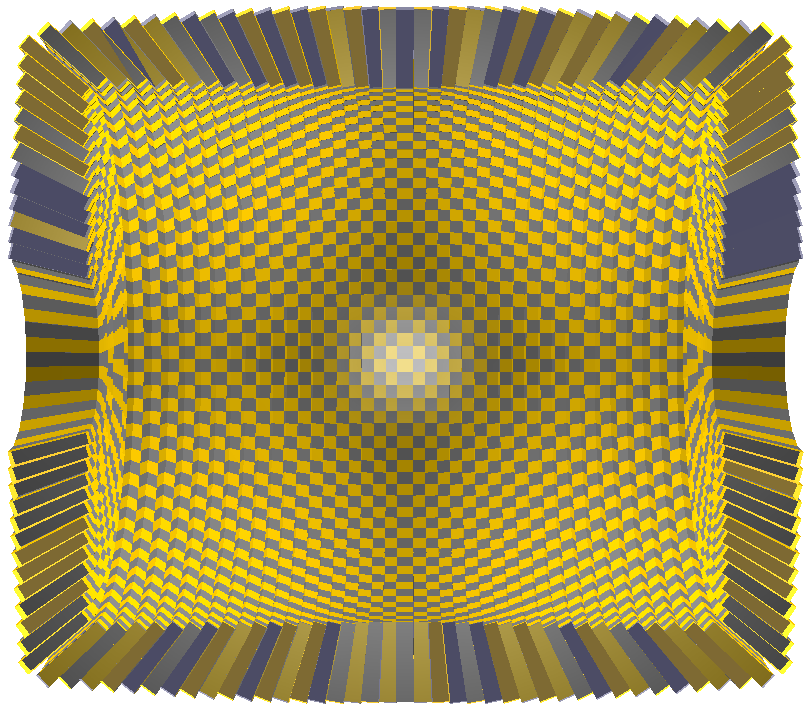

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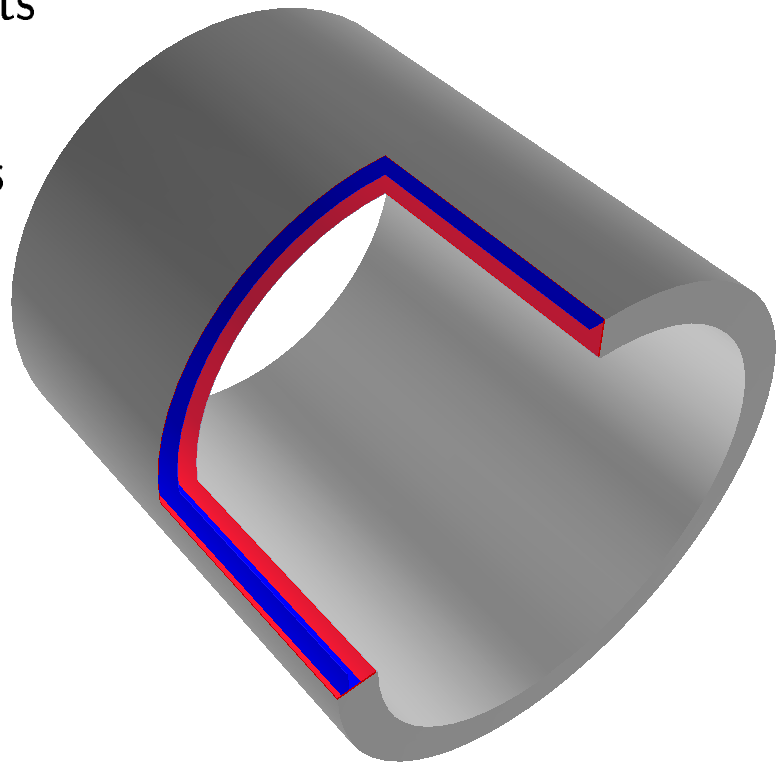

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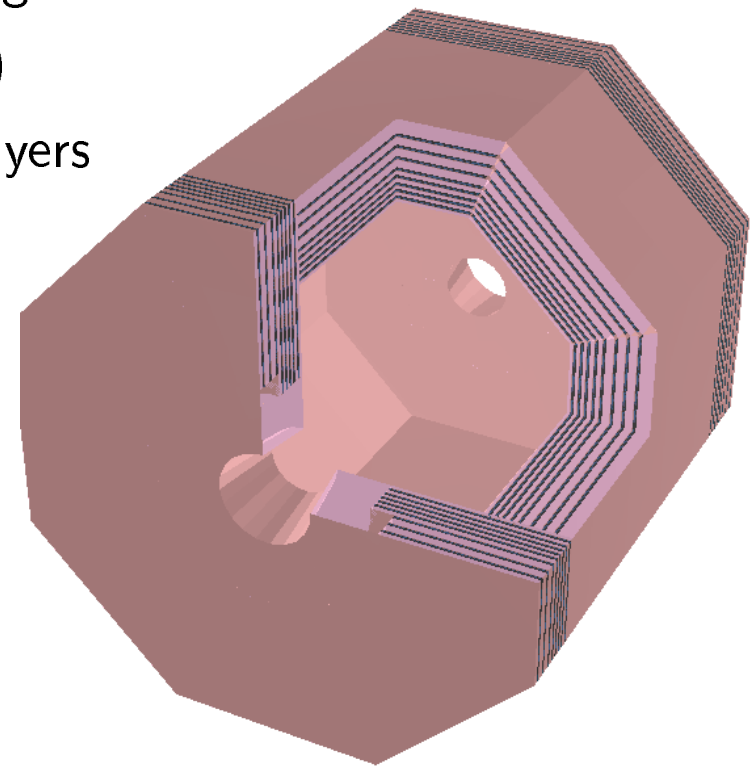

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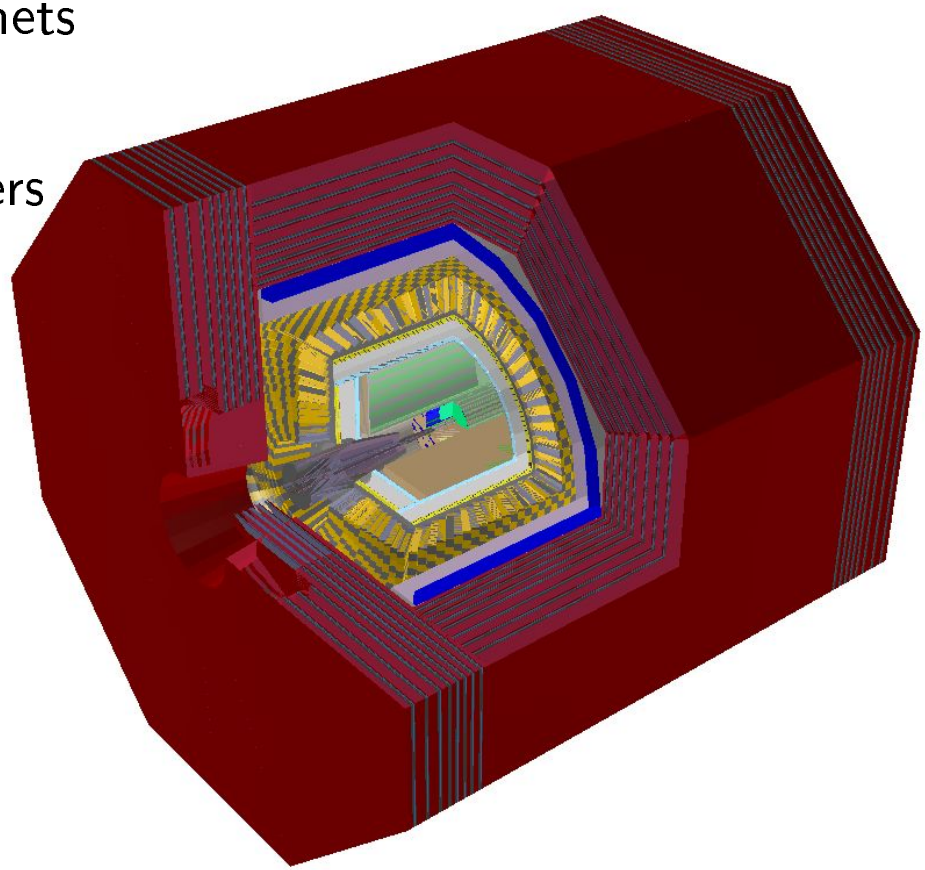
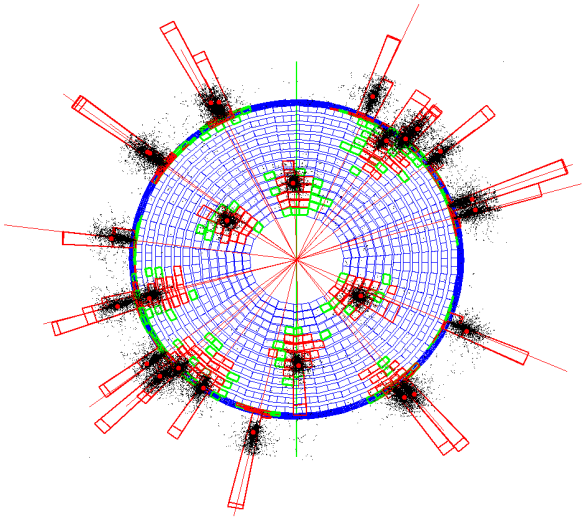


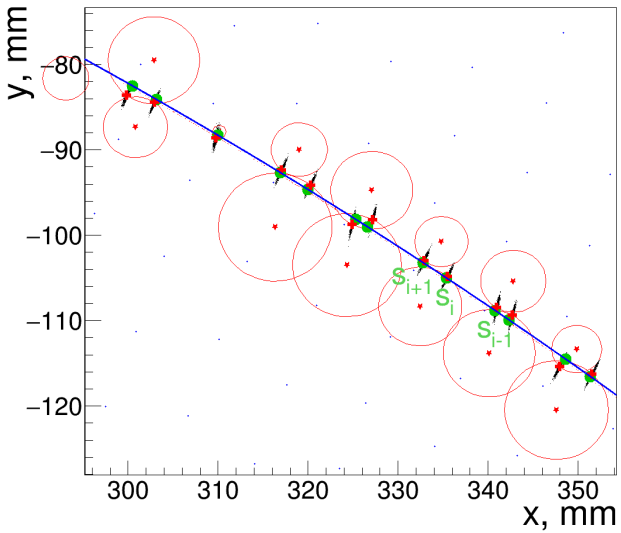
We have geometry for at least one option for each subsystem

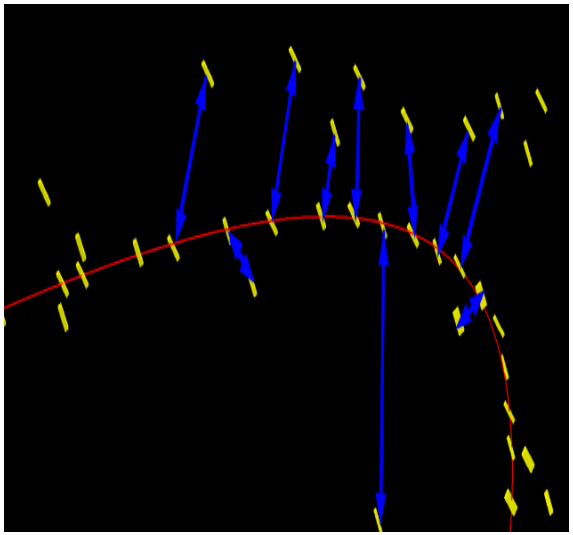
Status of the software

Digitization & Reconstruction

- Current focus of software development is Digitization
  - based on standalone studies
  - preliminary version is ready for several subsystems: Silicon Strip, Drift Chamber, Calorimeter, Moun system
- Reconstruction developped at individual subsystem level
  - Calorimeter and DC most advanced at the moment



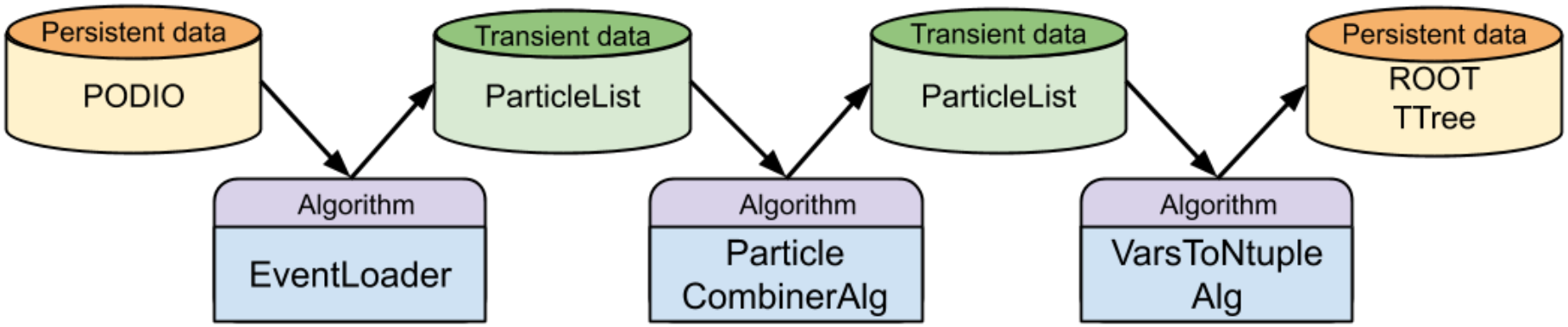




Status of the software

Data Analysis

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



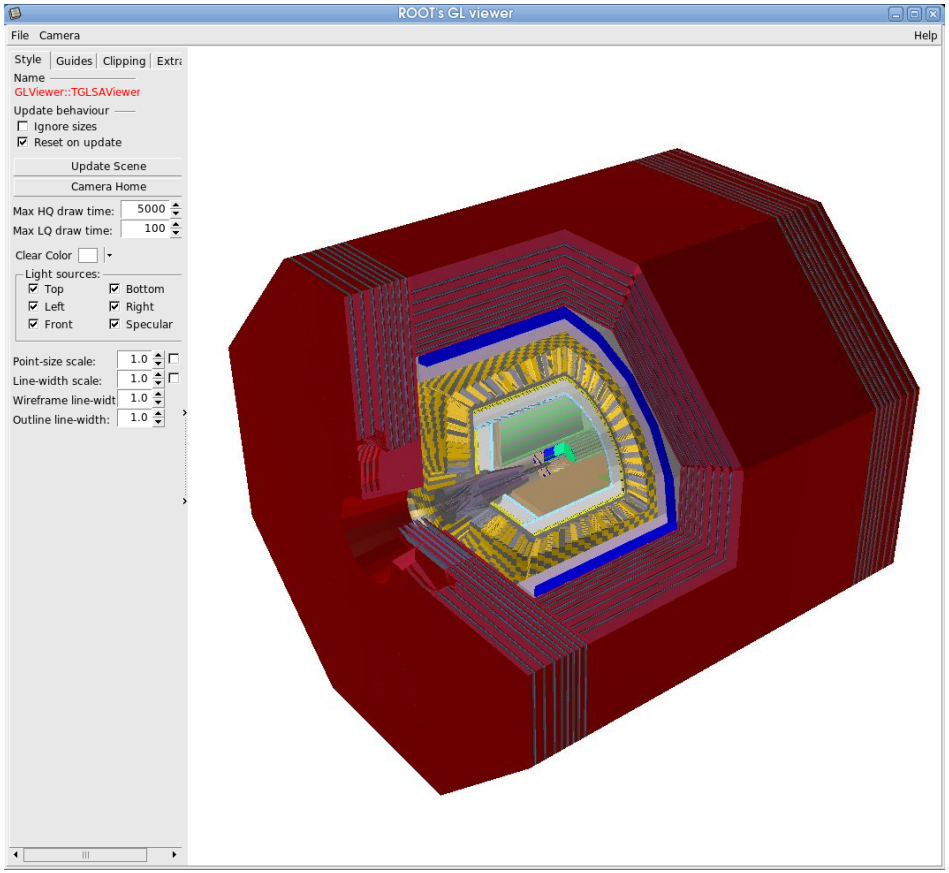
- final particles processing
- kinematic cuts

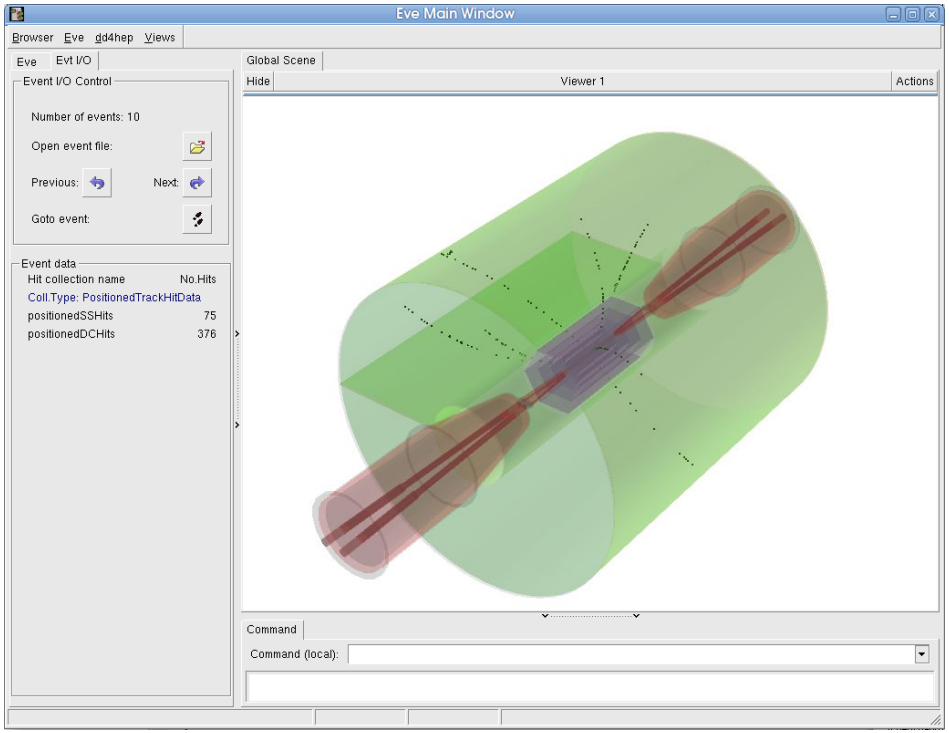
- reconstructuion of decayed particle
- kinematic cuts

- kinematic parameters calculation
- particle selection

Status of the software

Detector/Event Display





$\psi(4040) \rightarrow$ hadrons

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

Conclusions

The Aurora framework now contains all components minimally required at the present stage of the SCT detector project development:

- set of primary event generators,
- parameterized simulation,
- detector geometry (with at least basic description for all detector elements, and several options for some subsystems),
- full Geant4-based simulation,
- analysis and job configuration tools,
- test and service tools.

All described software is available as Aurora 1.0.1 release

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

This work was supported by RSF grant 19-72-20114

Thank you for your attention

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