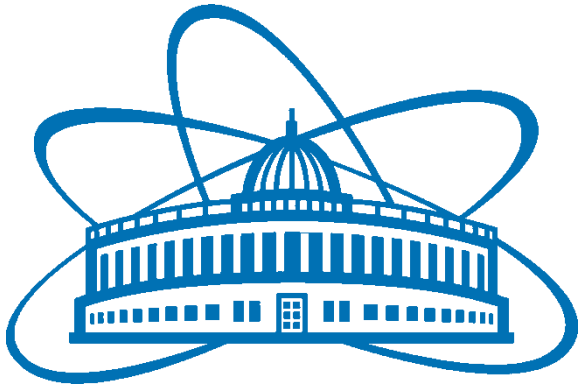
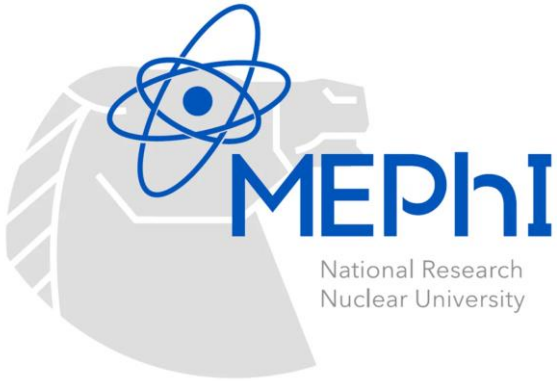




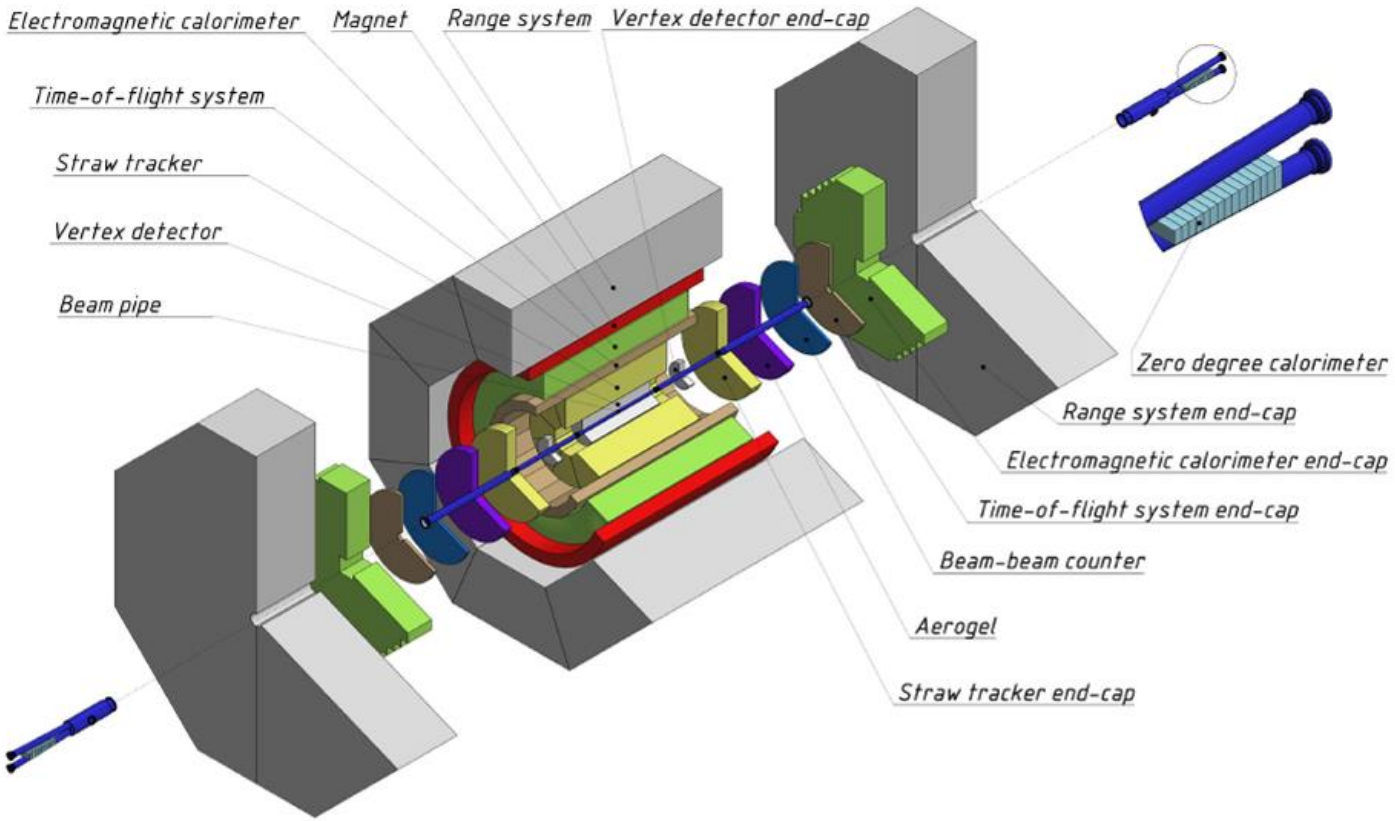
Status of the SPD Range System Implementation in Sampo

Alexandr Osetrov

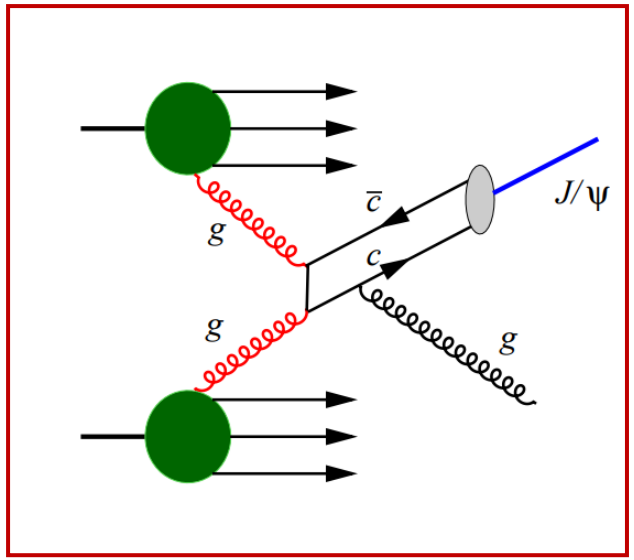
The XXth Workshop on High Energy Spin Physics, Dubna 2026

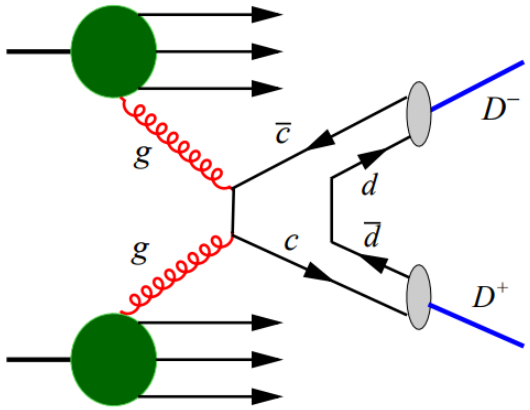
SPD EXPERIMENT

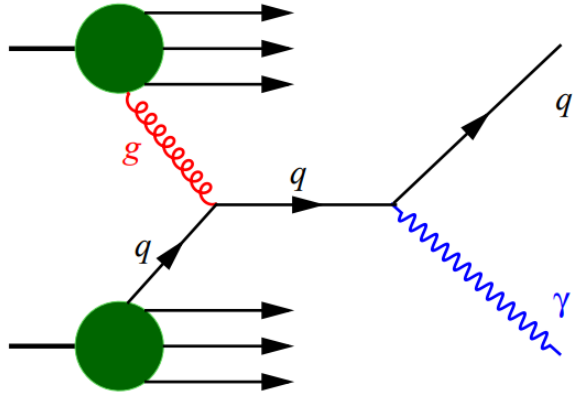
The goal of the experiment is to study the polarised and unpolarised gluon structure of the proton and deuteron, as well as other spin phenomena, in collisions of polarized p-p, d-d, and p-d beams at √s = 27 GeV and a luminosity on the order of 10^{32} cm^{-2} s^{-1}.



PROBES OF NUCLEON GLUON STRUCTURE @ SPD







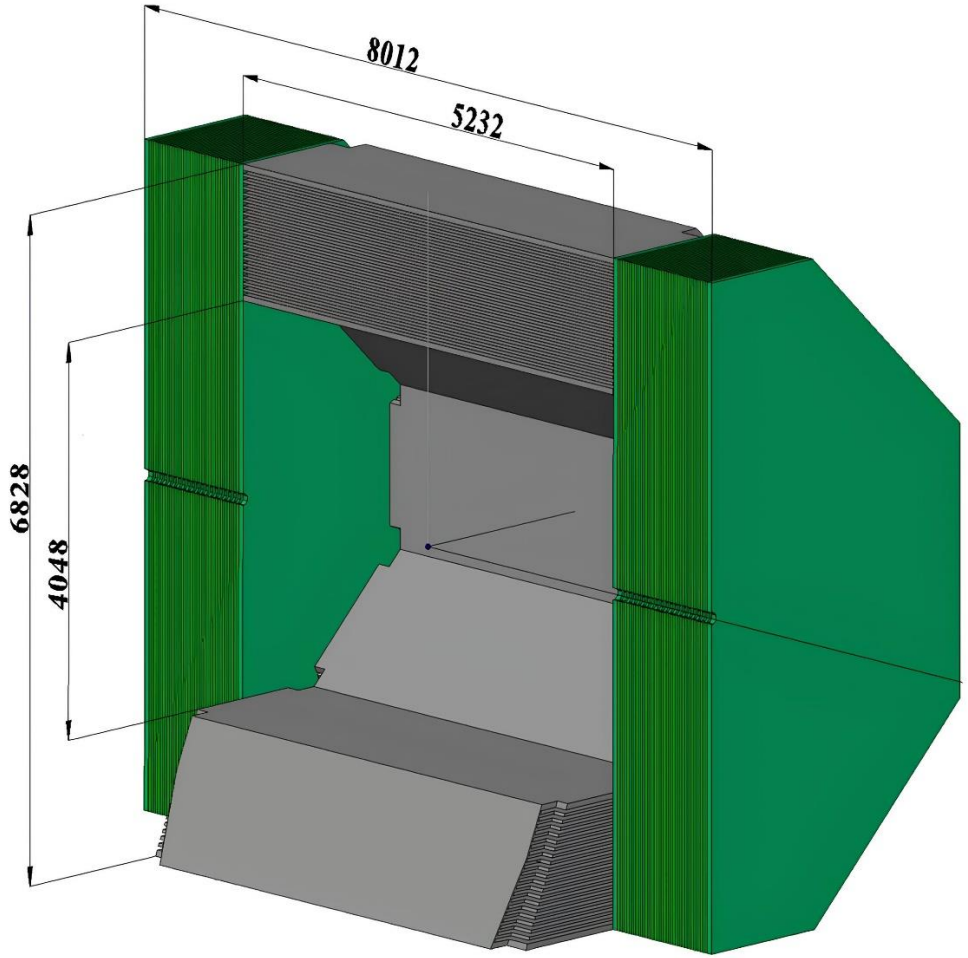
- The Range System plays the crucial role for physics with charmonium at SPD.
- RS is the only subsystem capable of registering neutrons, which is especially important for the first phase of the experiment.

MODELING OF RS IN SPD OFFLINE SOFTWARE (SAMPO)

- Geometrical model of the SPD Range System within the SPDGeoModel environment.
- Implementation of the data structure and algorithm for creating RSMCHit in the Sampo environment.
- Implementation of the data structures and algorithm for creating RSDigis in the Sampo environment.
- Development and validation of algorithms for reco-hits clustering and track reconstruction.
- Development of methods and criteria for muon identification.
- Evaluation of the system’s muon PID capability and tuning the simulation to the real data.
- Validation the system performance for neutron reconstruction.

RANGE SYSTEM

- RS consists of an eight-module barrel and two endcaps.
- Mini Drift Tube (MDT) detectors and readout electronics are placed in the gaps between the layers.
- It’s main goal - muon identification in the presence of a significant hadronic background and hadron energy estimation (coarse hadronic calorimetry).

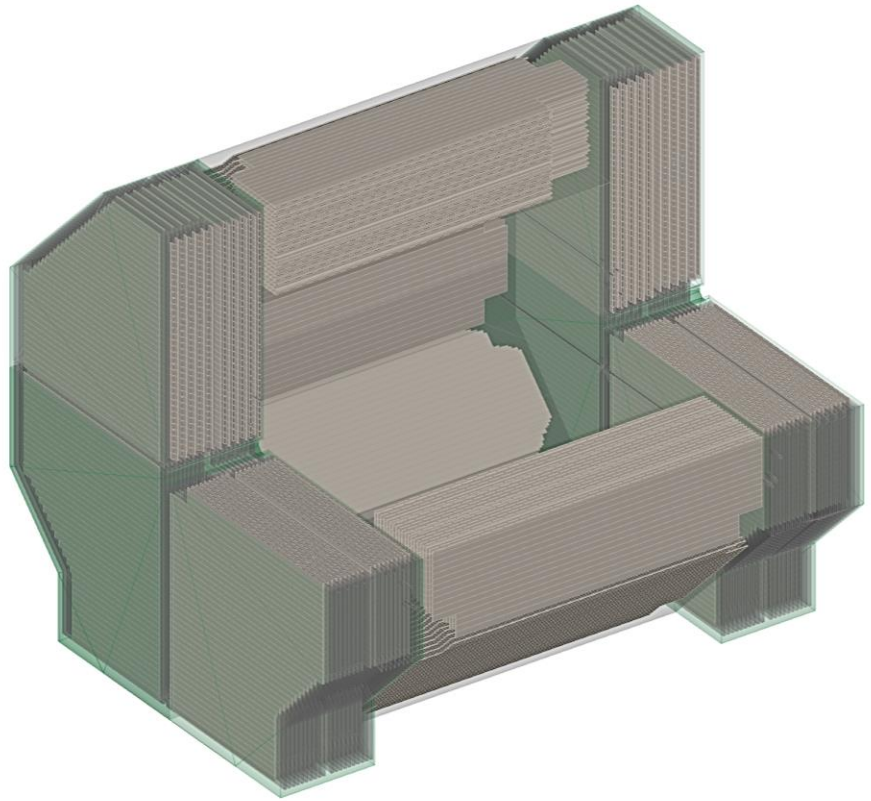


RS GEOMETRY

The geometric model of the Range System was created using the SPDGeoModel software package for subsequent use in the Sampo package.

- **SPDGeoMode**l project is aimed to create SPD detector geometry description. SPDGeoModel based on GeoModel cern which is a user-friendly C++ toolkit and suite for HEP Detector Description with minimal dependencies.
- **Sampo** is aimed to serve as applied software for SPD experiment. It will be used for generation, simulation and reconstruction tasks.

The model is a tree of nested volumes in such a way that a strict and unique path can be traced to each sensitive volume, starting from the world volume.



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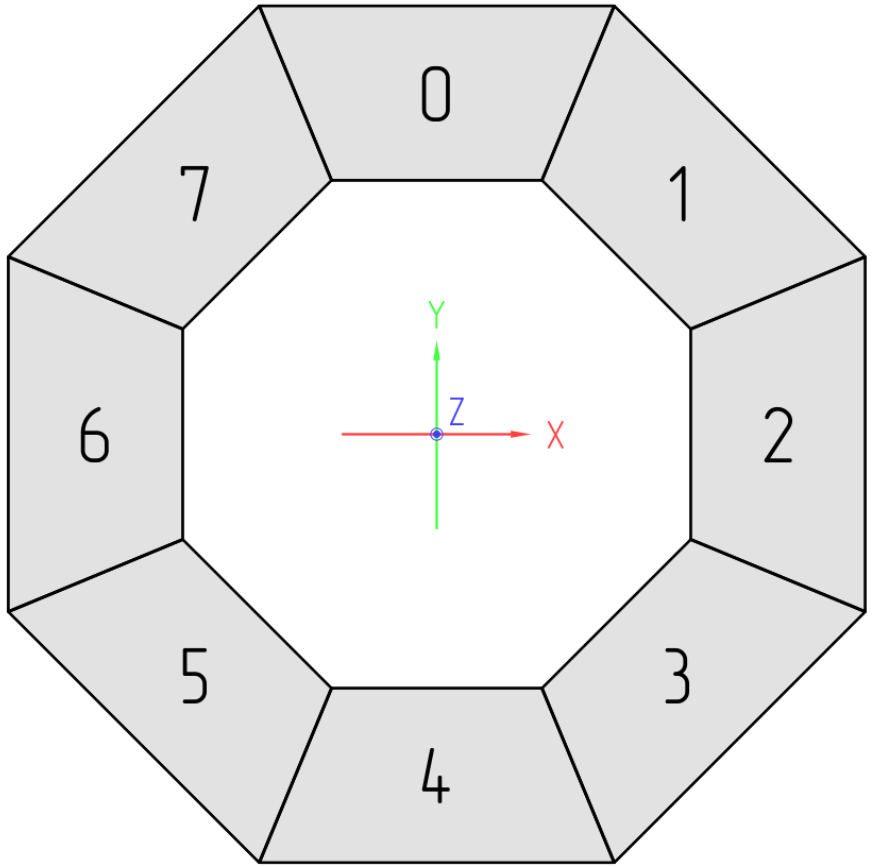

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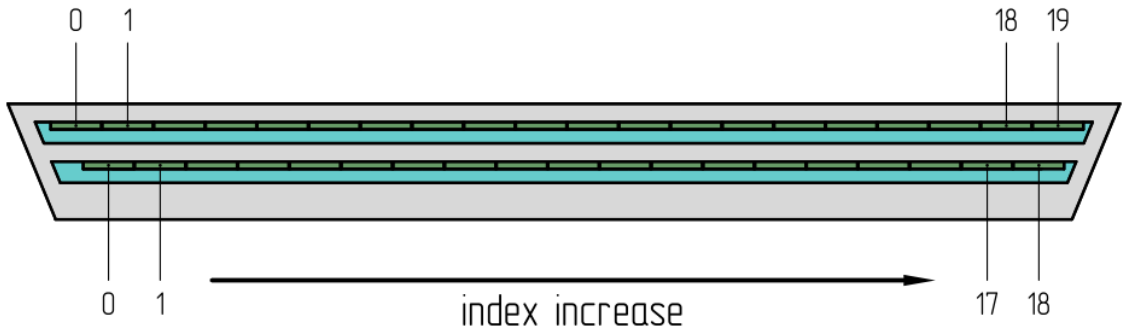

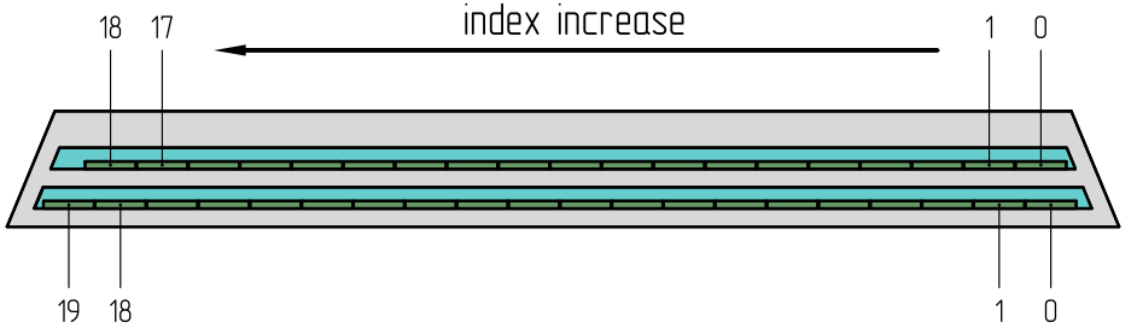

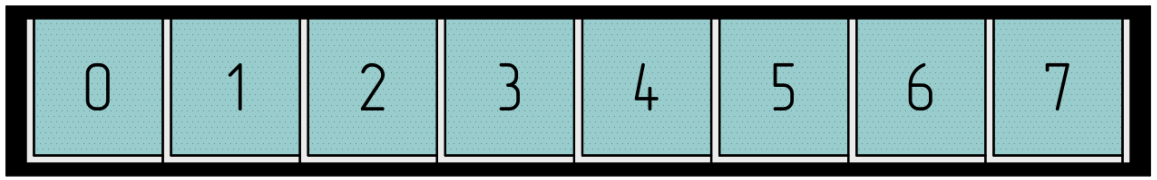

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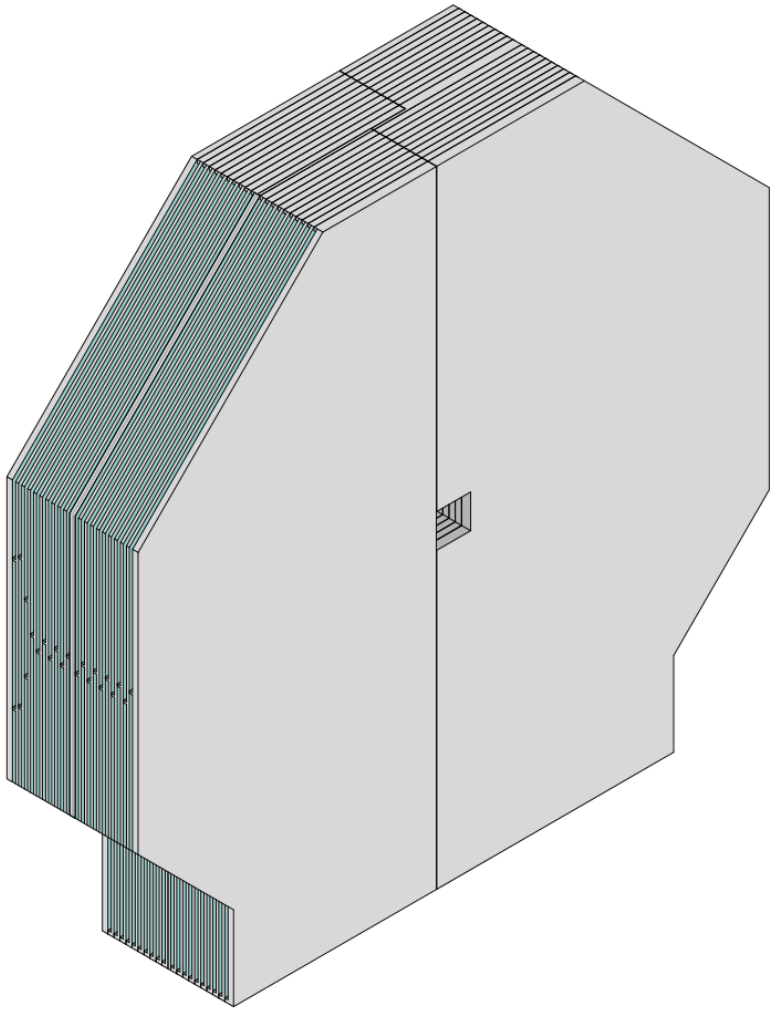

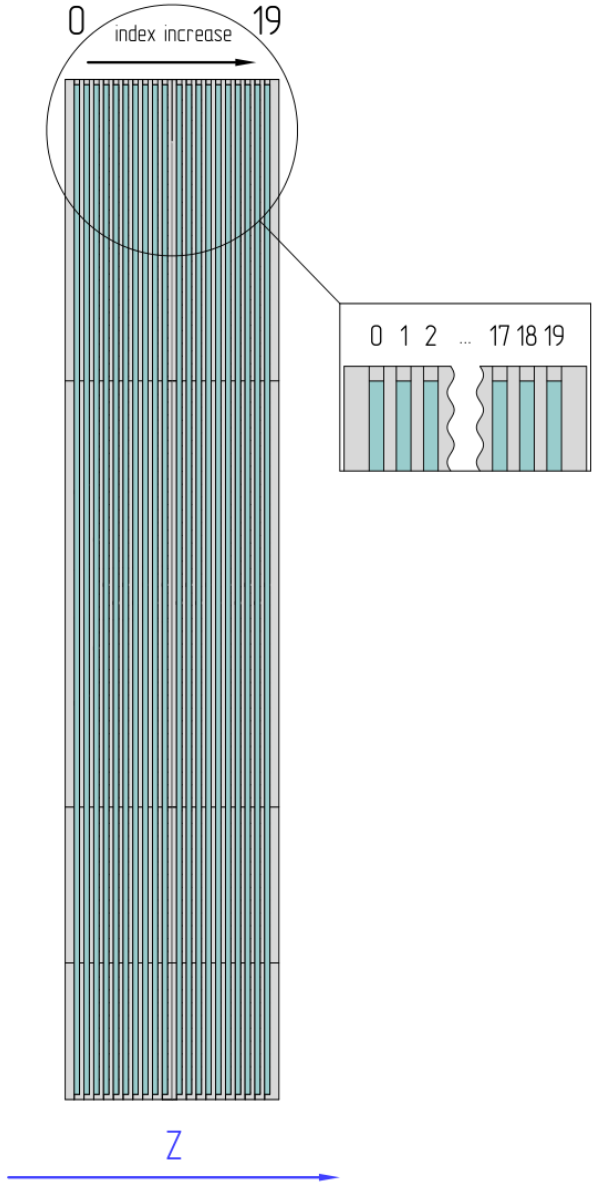

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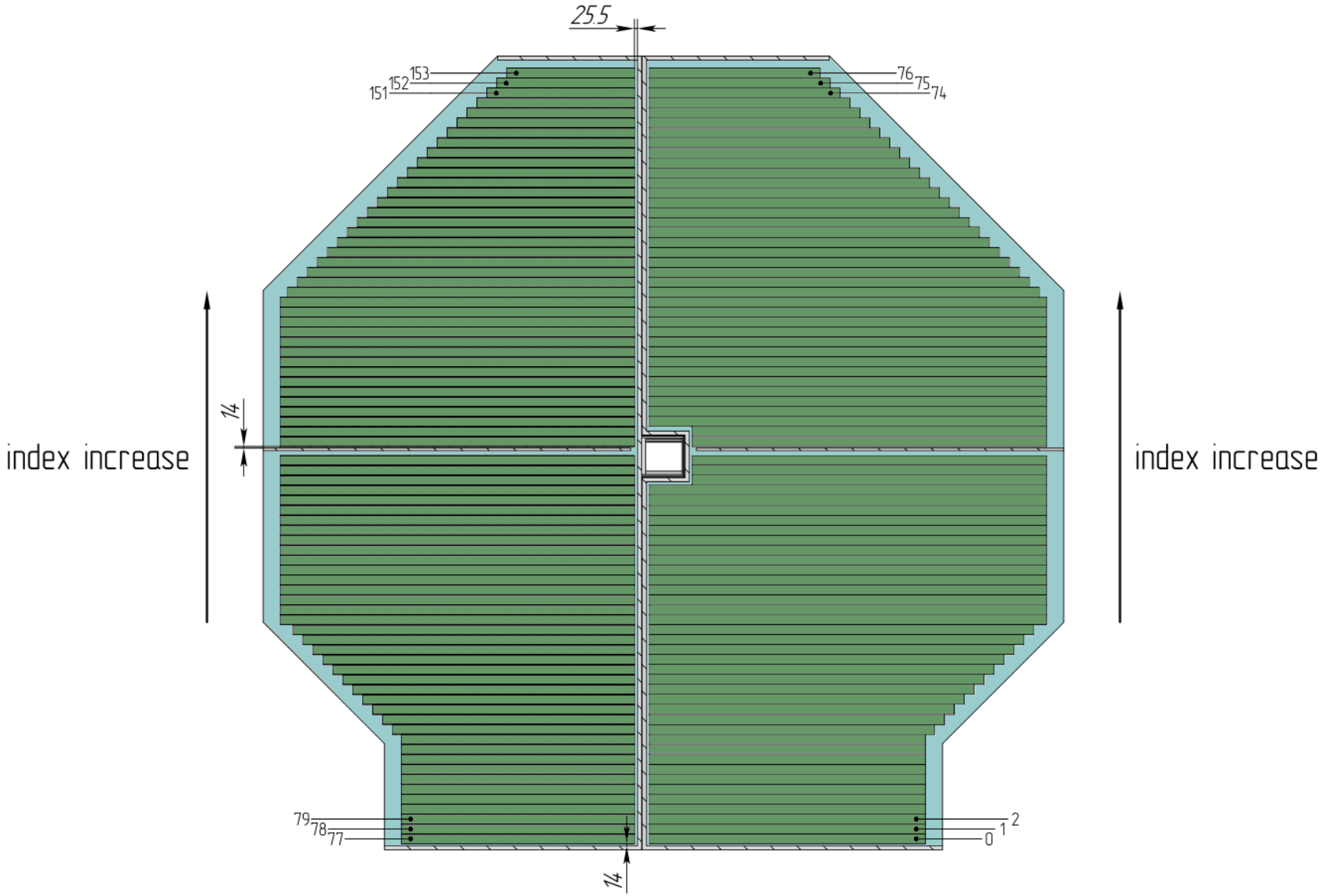
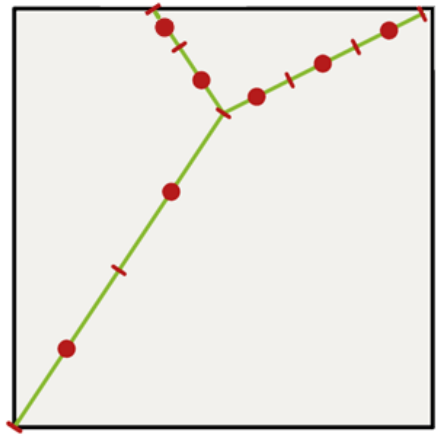


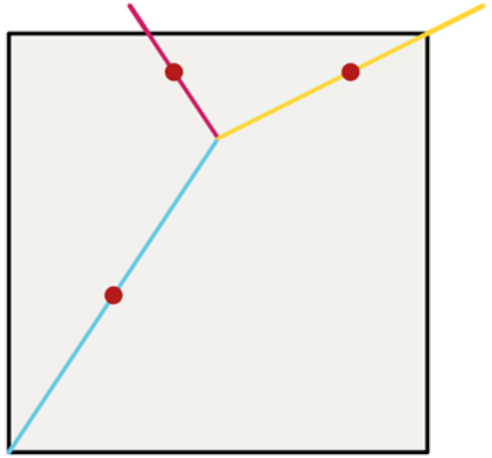
HITS PRODUCING

MCSteps



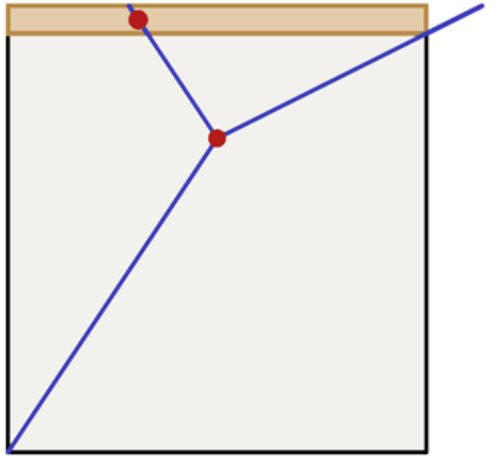
Several steps for each particle in one volume

RSMCHits



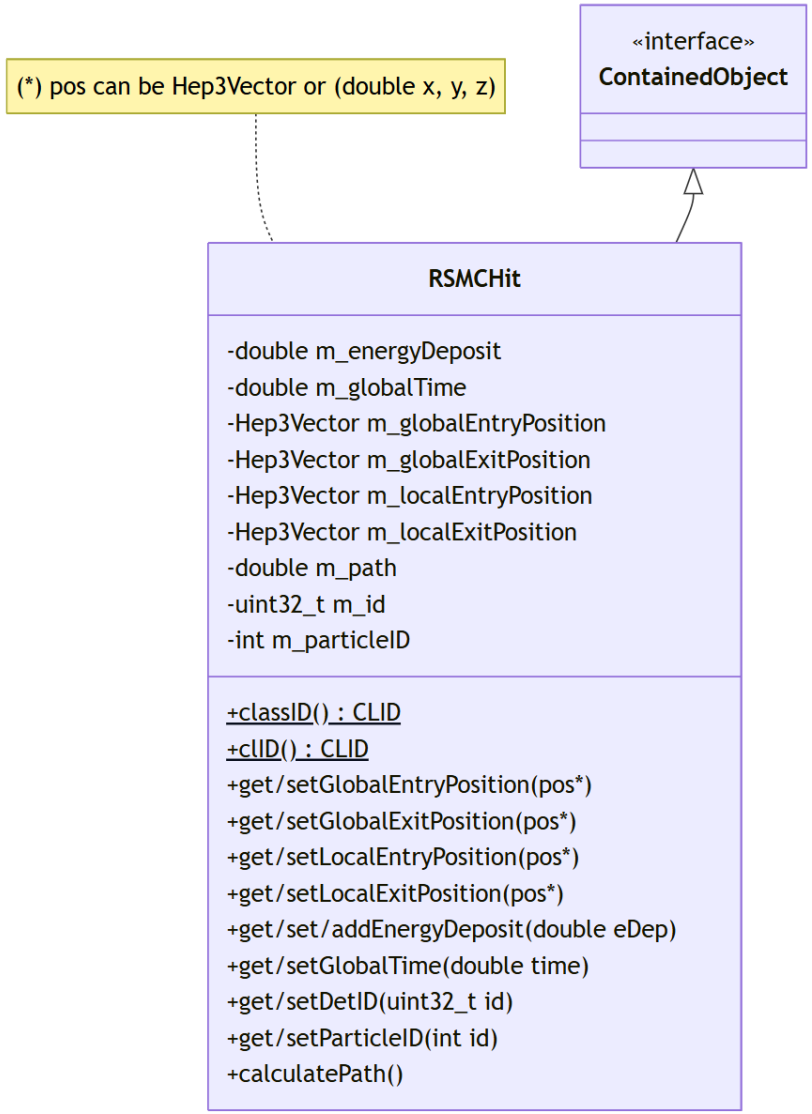
One hit for each particle in each volume

RSDigis



Only one digi per cell and one digi per strip

RSMCHit



What is stored in the hit:

- Energy deposit
- Timestamp
- Global & local entry & exit positions
- Particle's path in a cell
- Unique & non-unique id

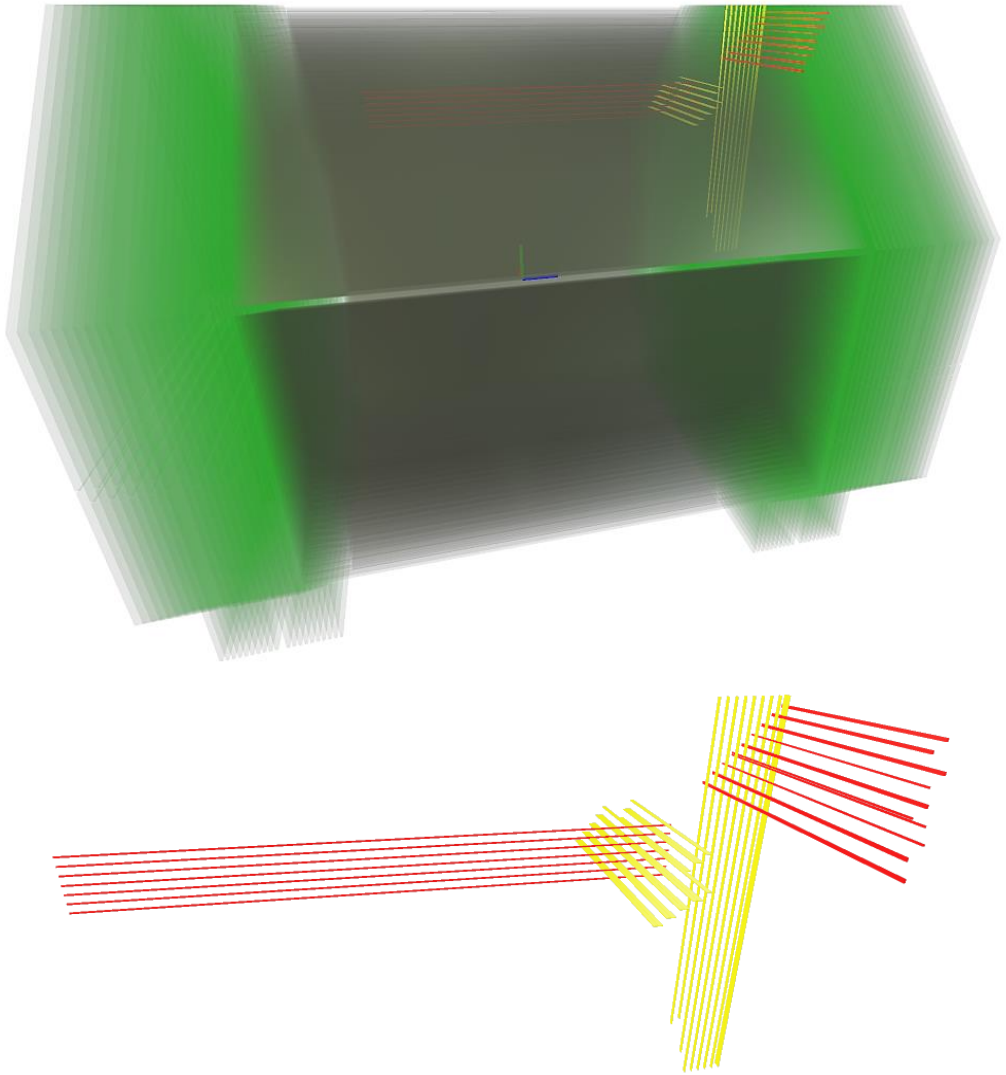
This is all the information needed to create RSDigi

RSDigi

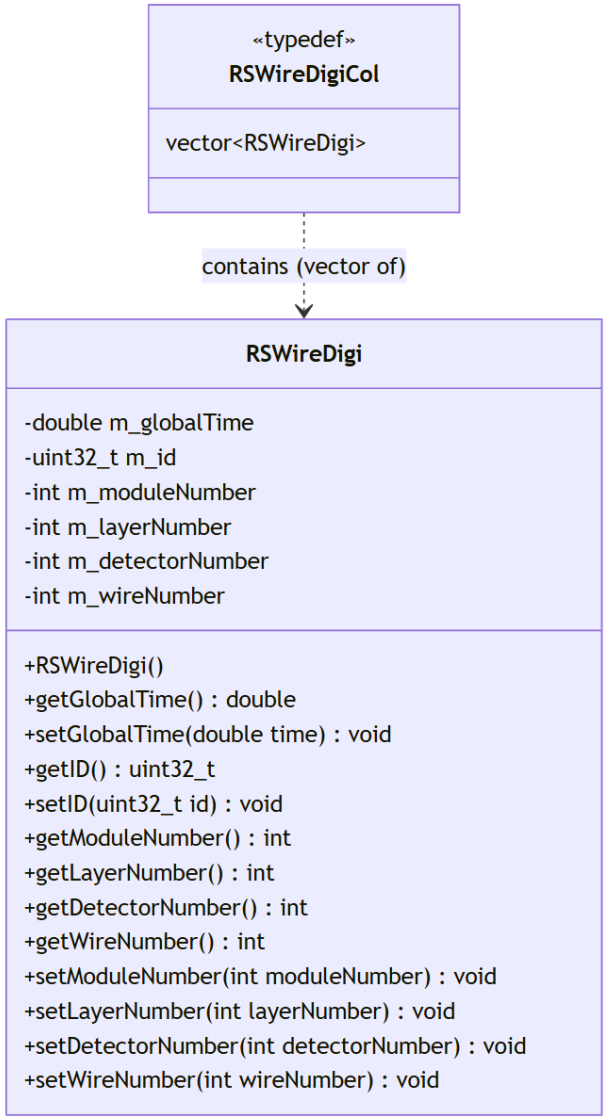
Digitalized hits (digis) simulate the real detector response in the experiment. They are divided into two types:

- **Wire digis**, shown in red in the figure, are responsible for triggered MDT detector cells and mark sensitive volumes.
- **Strip digis**, shown in yellow in the figure, are responsible for triggered strips, which, unlike cells, are not present in the geometric model as sensitive volumes.

RSDigis only indicate the fact of activation (strip/wire number & timestamp) in a specific area of the detector; they do not store information about the charge, energy deposit, or anything else.



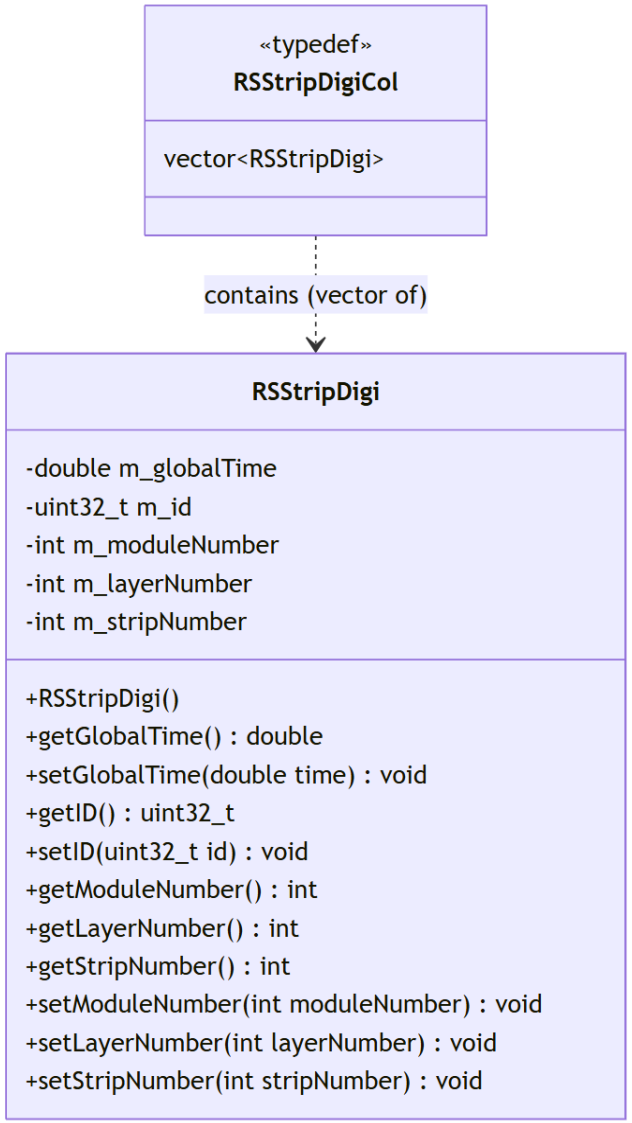
RSWireDigi



What is stored in the wire digi:

- 32-bit id indicating the position of the wire (cell) in the hierarchy of detector volumes
- The number of each volume in the geometric hierarchy of the system
- Timestamp

RSStripDigi



What is stored in the strip digi:

- 32-bit id indicating the position of the wire (cell) in the hierarchy of detector volumes
- The number of each volume in the geometric hierarchy of the system. Note that, unlike wire digi, the detector number is not stored here, since the strips are located above them.
- Timestamp

RSDigi FORMING

Currently, the empirical criteria for the "triggering" of the wire and strip are not definitive and require further refinement. The elements are activated according to the following principle:

- For a cell (wire) to be considered triggered, it must exceed a threshold of 0.2 keV energy deposit and a threshold of 2 mm for the particle's path within the cell. A detector dead time of 350 ns is also taken into account.
- A mandatory condition for the strip to be triggered is the firing of the cell beneath it, meaning the strip digi cannot appear "separated" from the wire. It is possible for multiple strips to fire above a single wire, depending on the distribution of the induced charge on the wire.

The criteria for digi formation will be refined once data from the range system prototype becomes available.

SUMMARY AND FUTURE PLANS

Implemented

- The geometric model of the RS in the SPDGeoModel environment has been created
- The data structure and algorithm for creating RSMCHit in the Sampo environment have been developed
- The data structures and algorithm for creating RSDigis in the Sampo environment have been developed

Future steps

- To develop and integrate the DBSCAN clustering algorithm into Sampo
- To develop and optimize the muon reconstruction algorithm

Backup slides

COPY NUMBER STRUCTURE

Sensitive volume names:

In the barrel:

“/SPD/RSBarrel/Module/BarrelMDTLayer/MDT/GasCell”

In endcaps:

“/SPD/RSEndcap/Module/EndcapMDTLayer/MDT/GasCell”