Geometry design for the BM@N detectors: status and preparation for the next runs

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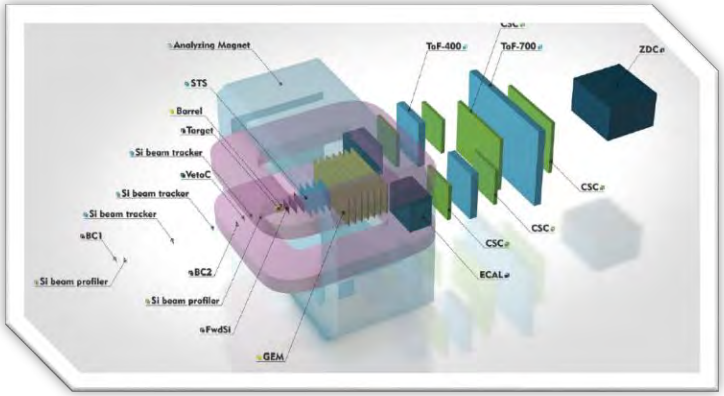
Introduction

Presentation topics:

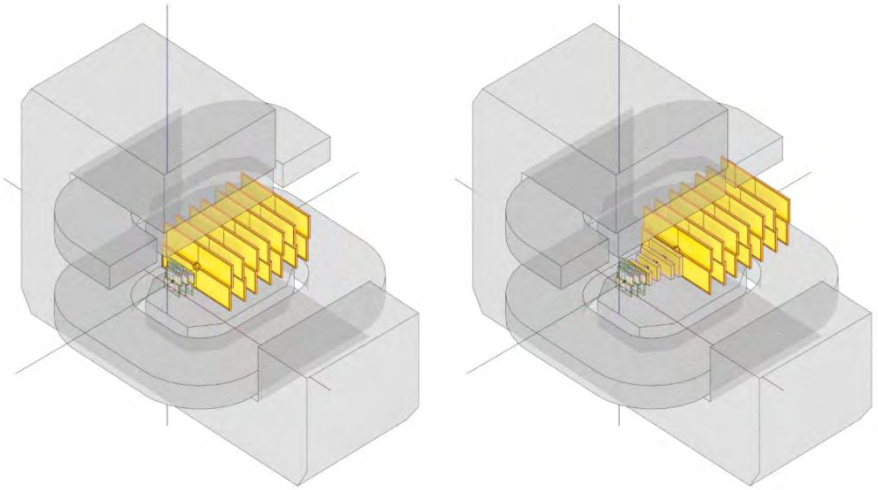
- ❑ Geometry for the inner tracker detectors for the next runs of the BM@N experiment in 2020-2022
- ❑ Features of creation and using the geometry in BMNROOT framework



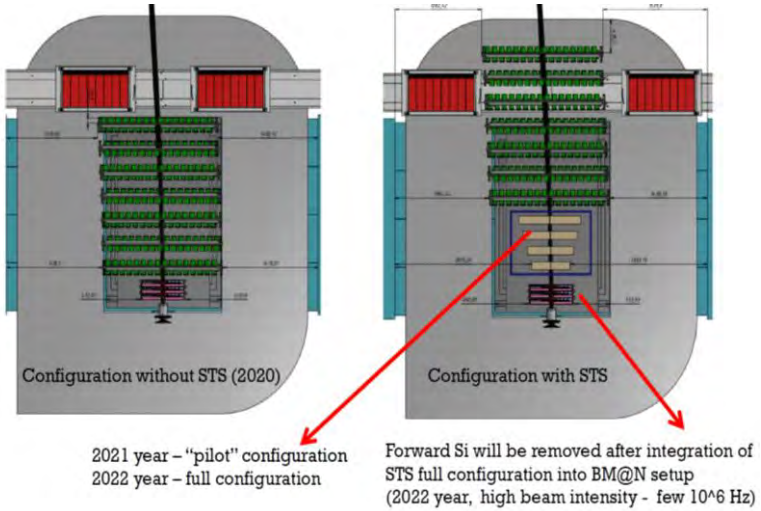
The common view of the BM@N experimental setup

Inner tracker configurations:

- **Forward Si [3 stations] + GEM [7 stations] (2020-2021)**
- **Forward Si [3 stations] + "pilot" STS [2 stations] + GEM [7 stations] (2021)**
- **Forward Si [3 stations] + STS [4 stations] + GEM [7 stations] (2022)**
- **STS [4 stations] + GEM [7 stations] (2022+)**



*Geometry design of the BM@N inner tracker detectors in two configurations: Left: **Forward Si** + **GEM** (2021) and Right: **Forward Si** + **STS** + **GEM** (2022)*

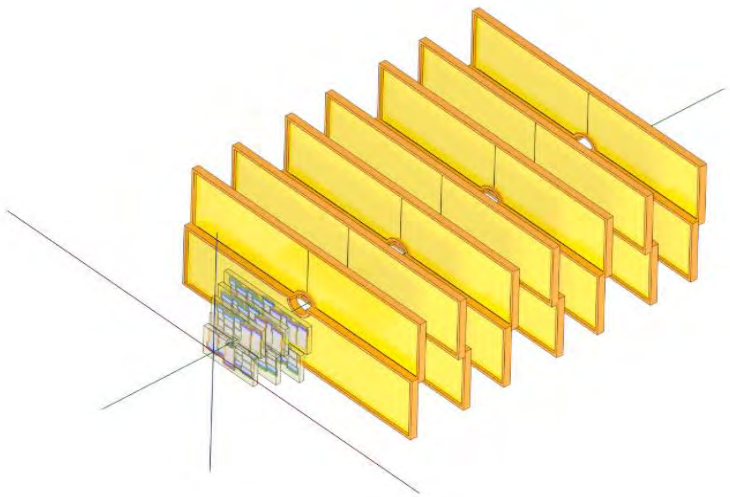


The geometry has been prepared in accordance with S. Piyadin's schemes presented by A. Maksymchuck at the 4th Collaboration Meeting of the BM@N experiment in October 2019

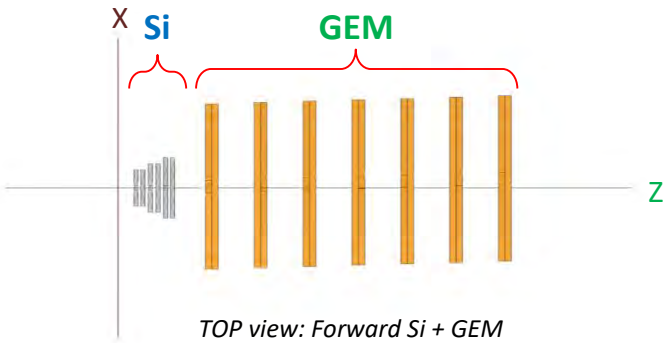
Central tracker configuration: Forward Si + GEM

Configuration of the central tracking system for the BM@N experiment in 2020-2021 is presented by two detectors: Forward Si and GEM

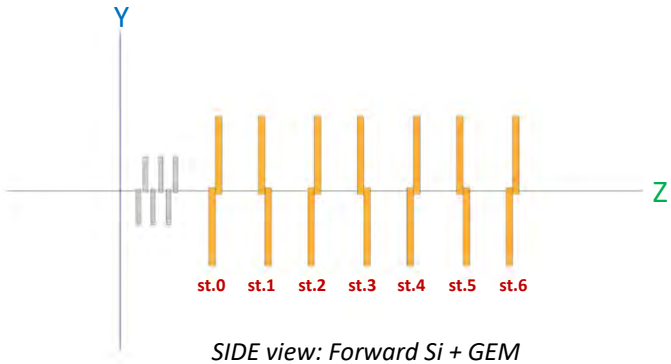
Forward Si: 3 stations (6 half-planes)
GEM: 7 stations (14 half-planes)



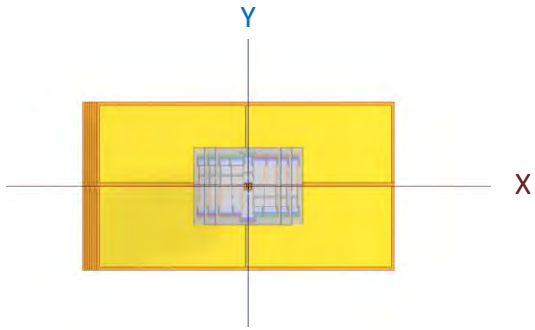
Configuration of the inner tracker of the BM@N experiment in 2020-2021: Forward Si + GEM



TOP view: Forward Si + GEM



SIDE view: Forward Si + GEM

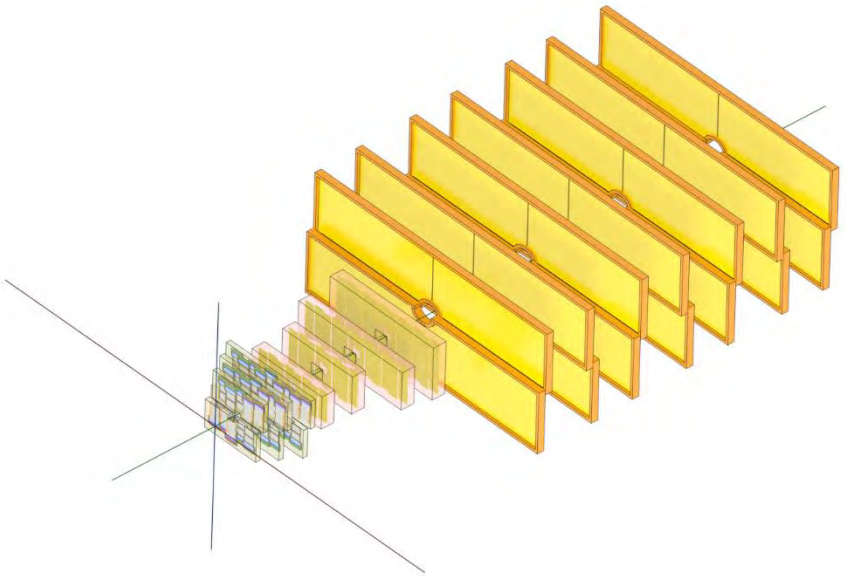


FRONT view: Forward Si + GEM

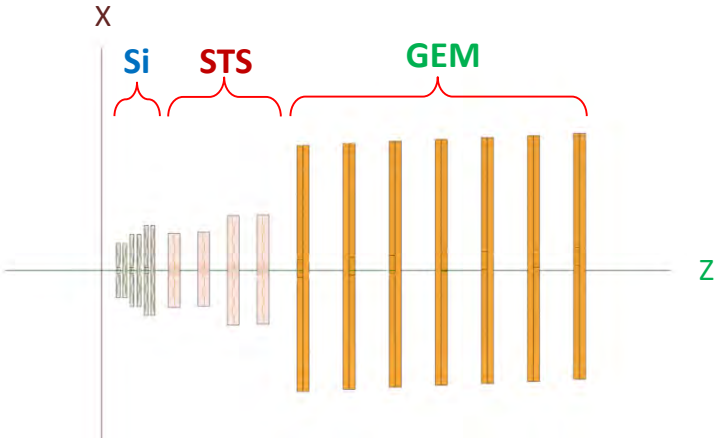
Central tracker configuration: Forward Si + STS + GEM

Configuration of the central tracking system for the BM@N experiment in 2022 is presented by three detectors: Forward Si, STS and GEM

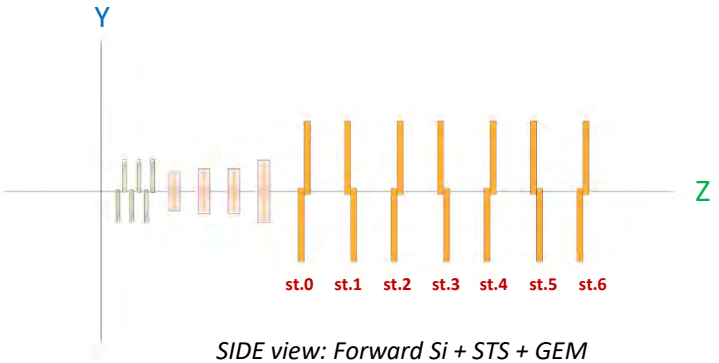
Forward Si: 3 stations (6 half-planes)
STS: 4 stations (4 planes)
GEM: 7 stations (14 half-planes)



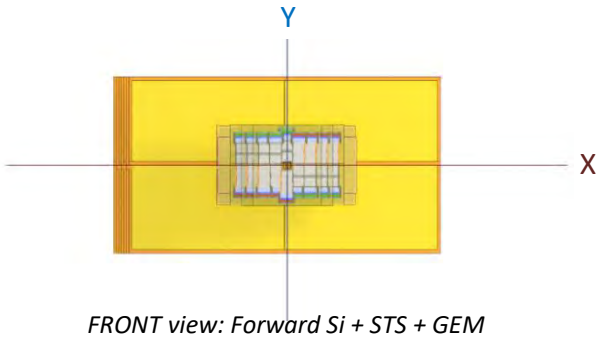
Configuration of the inner tracker of the BM@N experiment in 2022: Forward Si + STS + GEM



TOP view: Forward Si + STS + GEM



SIDE view: Forward Si + STS + GEM

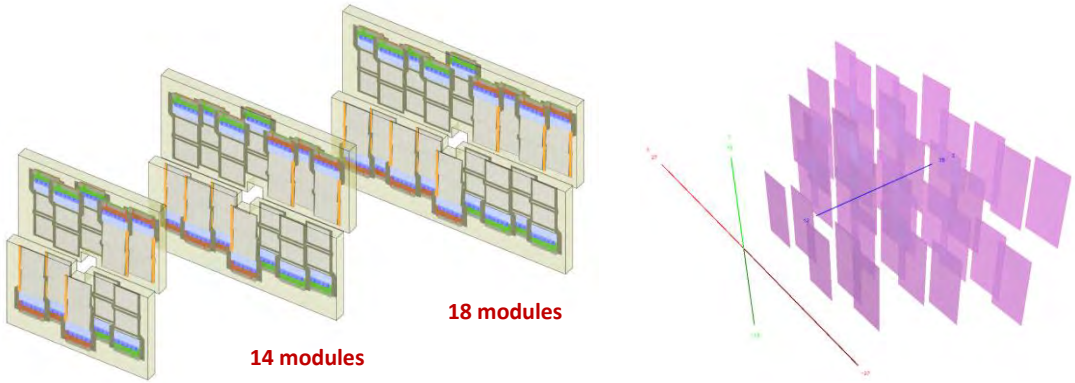


FRONT view: Forward Si + STS + GEM

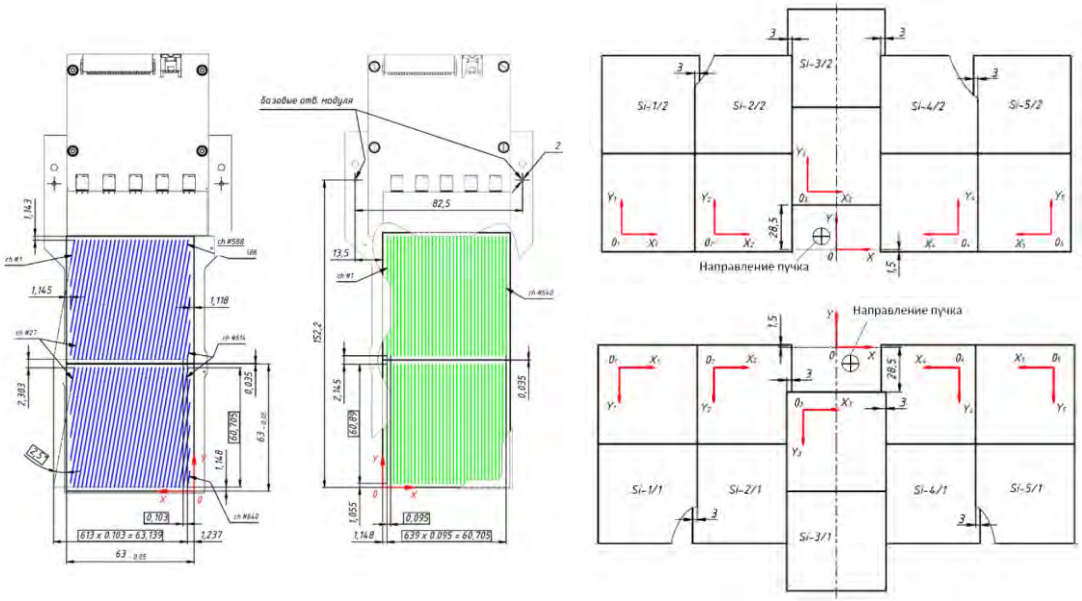
Geometry: Forward Si

Forward Si in our BM@N configuration is a silicon based semiconductor detector consisting of separate si-modules which are combined into stations of 10, 14 and 18 modules (42 modules in total).

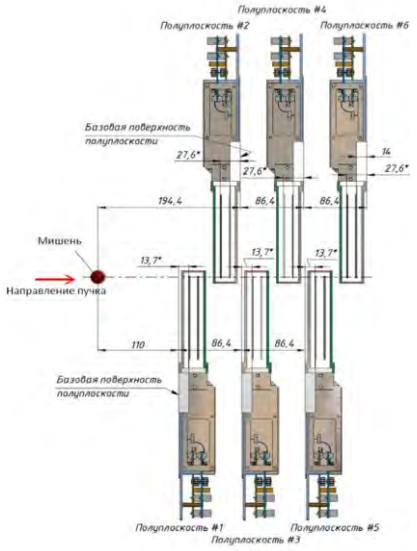
At the moment we have complete ROOT geometry for this detector in the BMNROOT repository for using it in simulation and reconstruction procedures.



Three stations of the Forward Si detector (left) and ROOT geometry of them for MC-simulation (right)



Schemes of a single Si-module (left) and their composition in the first station (right) (E. Zubarev)

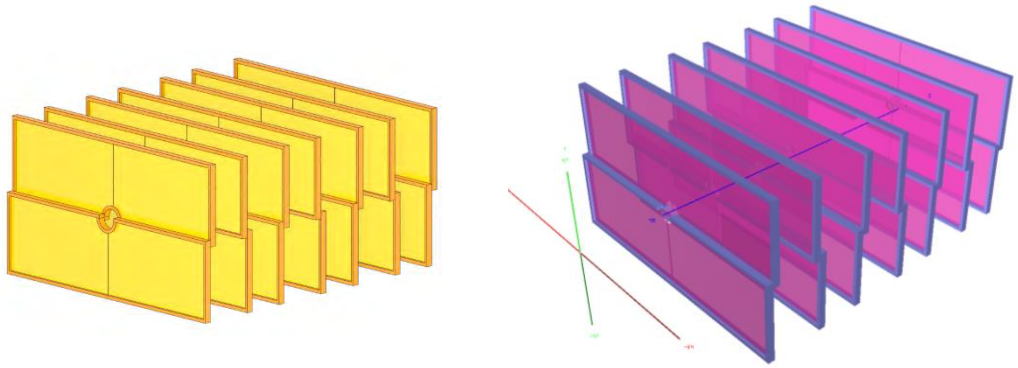


Scheme of the Forward Si detector (E. Zubarev)

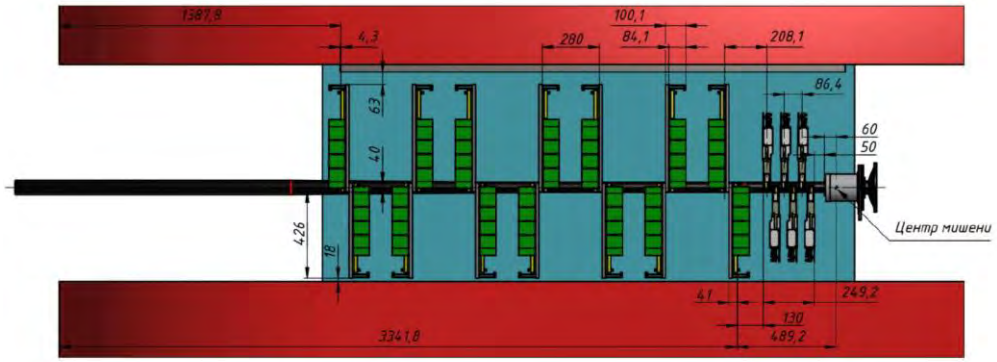
Geometry: GEM

GEM (Gas Electron Multiplier) is a gaseous detector with micro-strip readout.

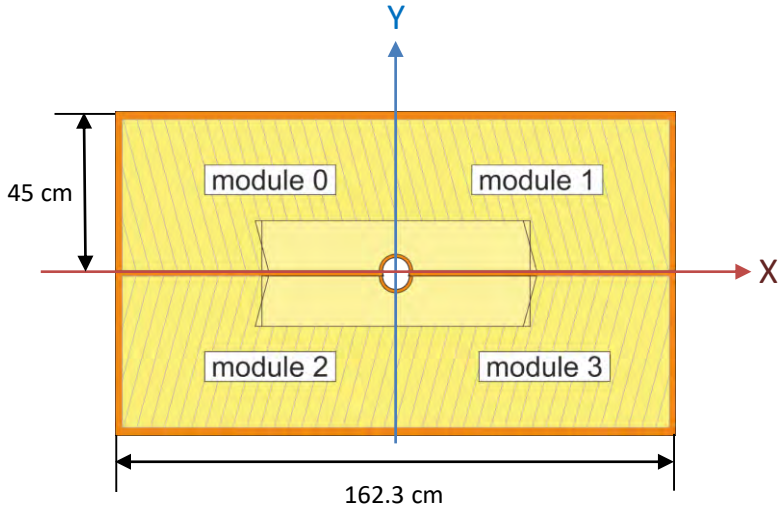
This detector has 7 stations in the configuration for the next BM@N runs in 2020-2022.



Seven stations of the GEM detector (left) and ROOT geometry of them for MC-simulation (right)



Scheme of GEM chambers composition (S. Piyadin)



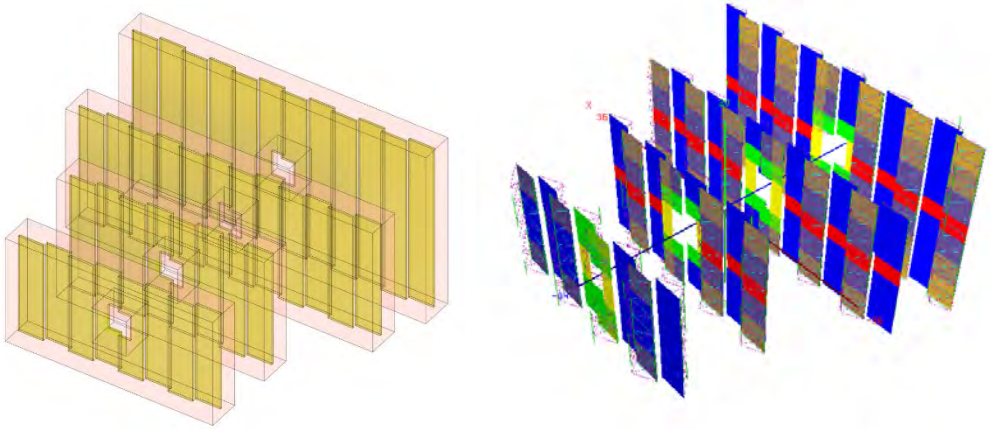
GEM station

Geometry: STS

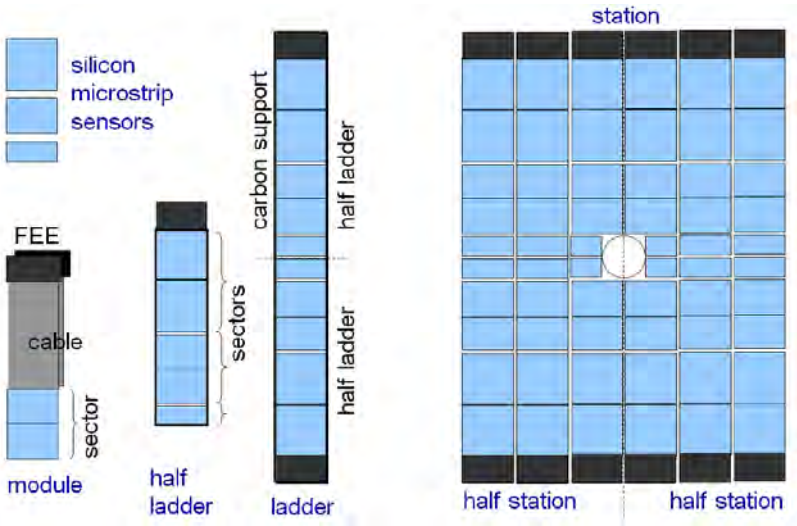
STS (Silicon Tracking System) consists of 4 stations for the BM@N configuration in 2022.

The basic functional unit of the STS detector is a module comprising silicon microstrip sensors. The modules are arranged on carbon support structures forming ladders.

- 1st station: 8 ladders
- 2nd station: 8 ladders
- 3rd station: 12 ladders
- 4th station: 12 ladders



Four stations of the STS detector (left) and ROOT geometry of them for MC-simulation (right)



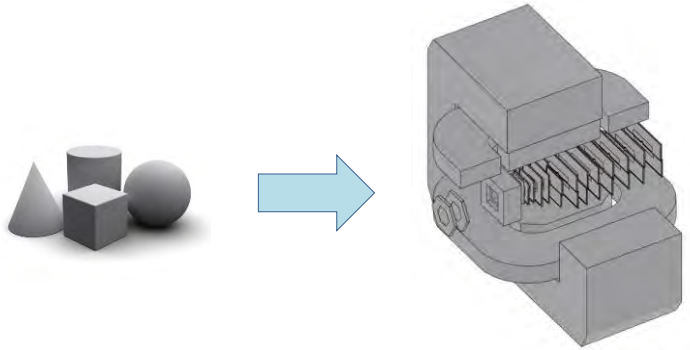
Structure of an STS station

The prepared geometry ROOT files for the STS detector are placed in the BMNROOT repository.

Geometry formats in BMNROOT

Detector geometry in BMNROOT can be defined with the following formats:

- **GEO** (ASCII files)
- **GDML** (Geometry Description Markup Language)
- **ROOT** (binary files)



Geometry for all detectors and passive objects is a composition of standard primitives and transformations for them

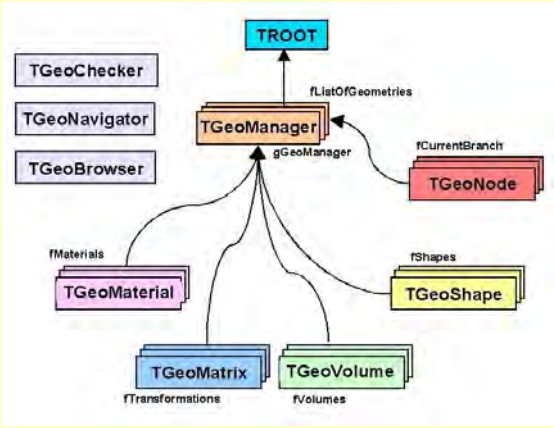
For detailed geometry description of the mentioned tracking detectors in the BMNROOT framework we use ROOT files.

```
Cave
BOX
Air

-1700.000000 -1500.000000 -300.000000
-1700.000000  1500.000000 -300.000000
 1700.000000  1500.000000 -300.000000
 1700.000000 -1500.000000 -300.000000
-1700.000000 -1500.000000  300.000000
-1700.000000  1500.000000  300.000000
 1700.000000  1500.000000  300.000000
 1700.000000 -1500.000000  300.000000

 320.000000 0.000000 8150.000000

 1.000000 0.000000 0.000000
 0.000000 1.000000 0.000000
 0.000000 0.000000 1.000000
```

GEO: example of geometry description for one box volume creation

```
<gdml>
  <define>
    ...
  </define>
  <materials>
    <material formula=" " name="Air" > ... </material>
      ...
  </materials>
  <solids>
    <box lunit="mm" name="Tracker" x="50" y="50" z="50"/>
  </solids>
  <structure>
    <volume name="World" >
      <materialref ref="Air" />
      <solidref ref="world" />
      <physvol>
        <volumeref ref="Tracker" />
        ...
      </physvol>
    </volume>
  </structure>
  <setup name="Default" version="1.0" >
    <world ref="World" />
  </setup>
</gdml>
```

GDML: example of geometry description for one box volume creation



ROOT: scheme of the classes responsible for ROOT geometry

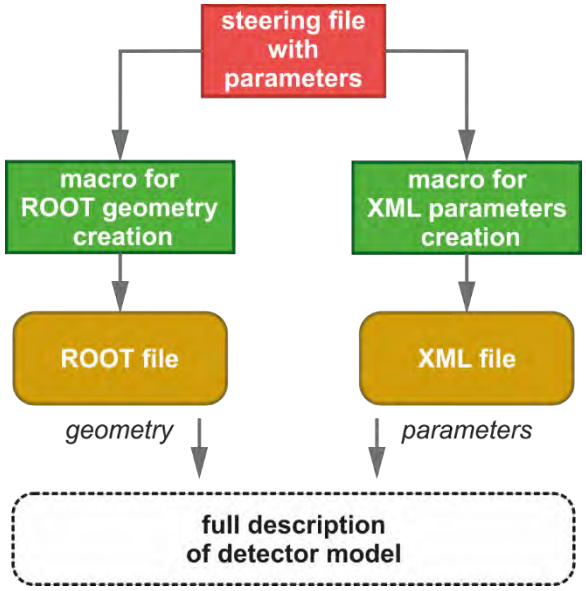
Description of detector model: the main stages and features

To create ROOT geometry for any detector or passive object we use a **macro** - a program written in the C++ language with an object oriented approach. The execution result of the macro is a ROOT file needed for MC-simulation.

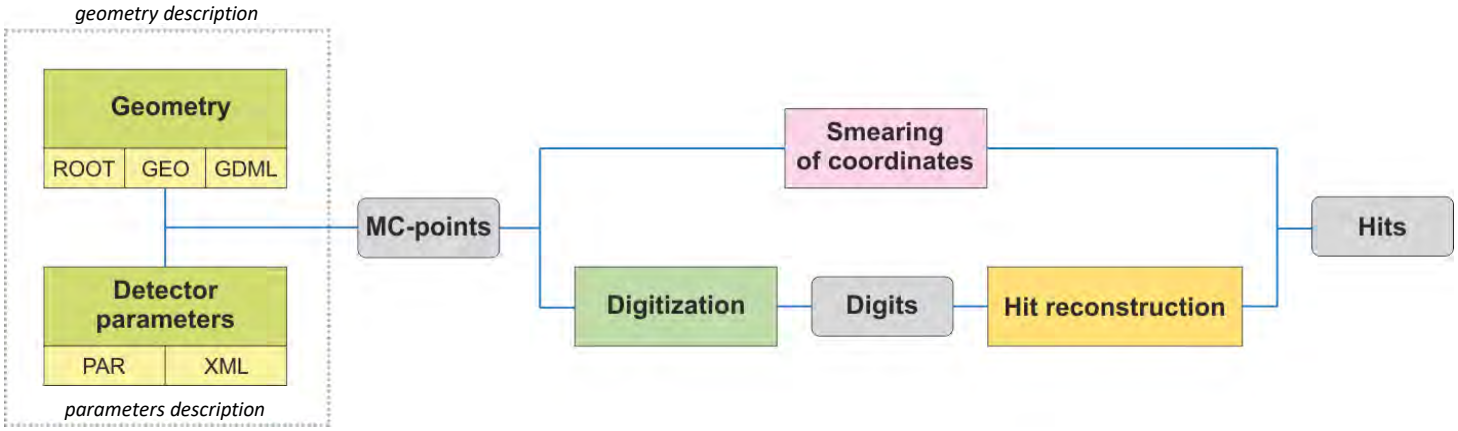
However, only the ROOT file is insufficient to describe detector parameters which are taken into account in realistic simulation and hit-reconstruction procedures. We need to have an auxiliary parameter file.

There are two ways to store the parameters:

- PAR file
- XML file *(more flexible and informative)*



Steps for the full description of some detector



Geometry creation with param. description is the primary stage for the next simulation (MC-points and digits) and hit reconstruction procedures.

Conclusion

Key points of the report:

- ☑ Geometry for two versions of the central tracker configuration for the BM@N runs in 2020-2022 has been prepared
- ☑ The brief overview of the key features and stages of geometry preparation for the next runs has been given

What is needed to do:

- ❑ Improve the geometry detail of the inner tracker detectors
- ❑ Add auxiliary tools for testing correctness of geometry at the stage of creation
- ❑ Others

Thank you for your attention…