Geometry update for inner tracker detectors of the BM@N setup for RUN-7 and the next run configurations

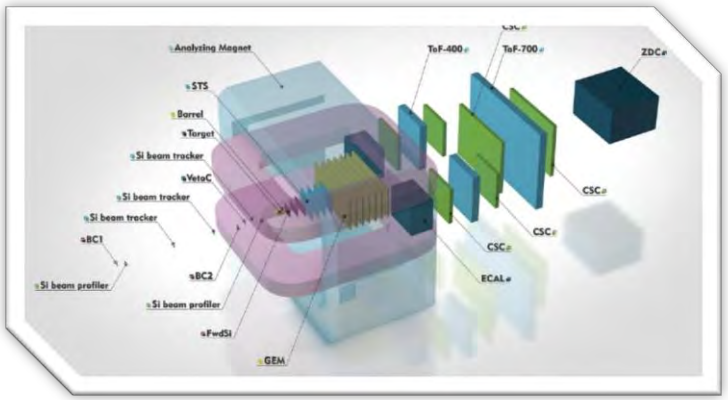
Baranov Dmitry

The reported study was funded by RFBR,
project number 18-02-40102

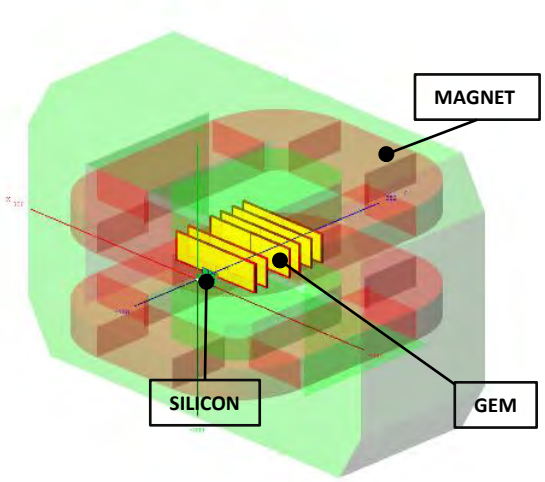
Introduction

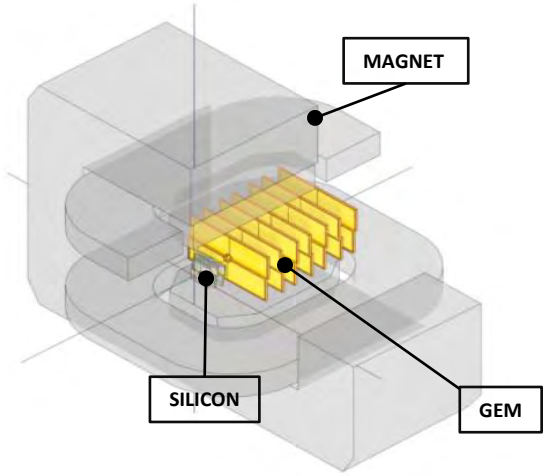
Talk topics:

- ❑ Geometry update for the inner tracker detectors (GEM and SILICON) of the BM@N setup for the following runs:
  - RUN-7 (2018)
  - the next run (2021-2022)
- ❑ Calculation of material budget for these configurations



The common view of the BM@N experimental setup





Geometry design of the BM@N inner tracker for the RUN-7 (left) and the next run (right)

Detailed geometry creation

- The detailed ROOT geometry was created for the following configurations:
  - GEM RUN-7 (Spring 2018)
  - GEM RUN SRC (Spring 2018)
  - GEM Future Configuration (2020-2021)
  - Forward SILICON Future Configuration (2020-2021)

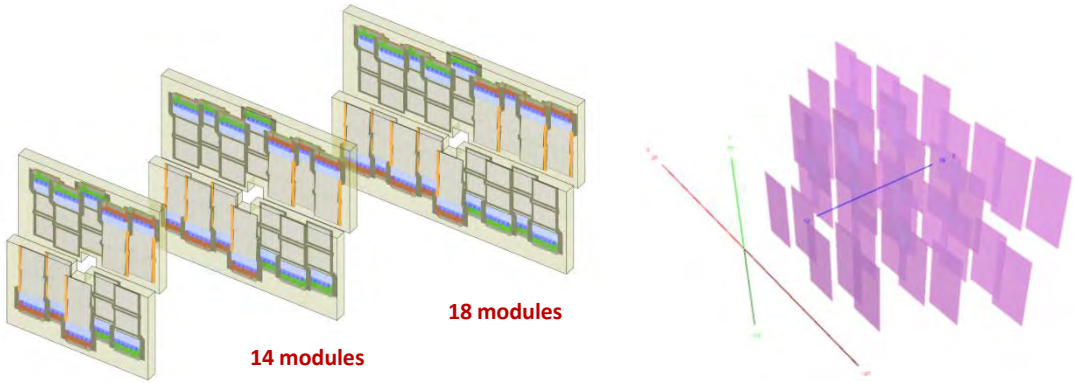
- The design of these detector has a lot of supporting elements, such as frames, electronics and others. It influences the detector efficiency.

- There are two versions of the ROOT geometry (simplified and detailed) for each configuration.

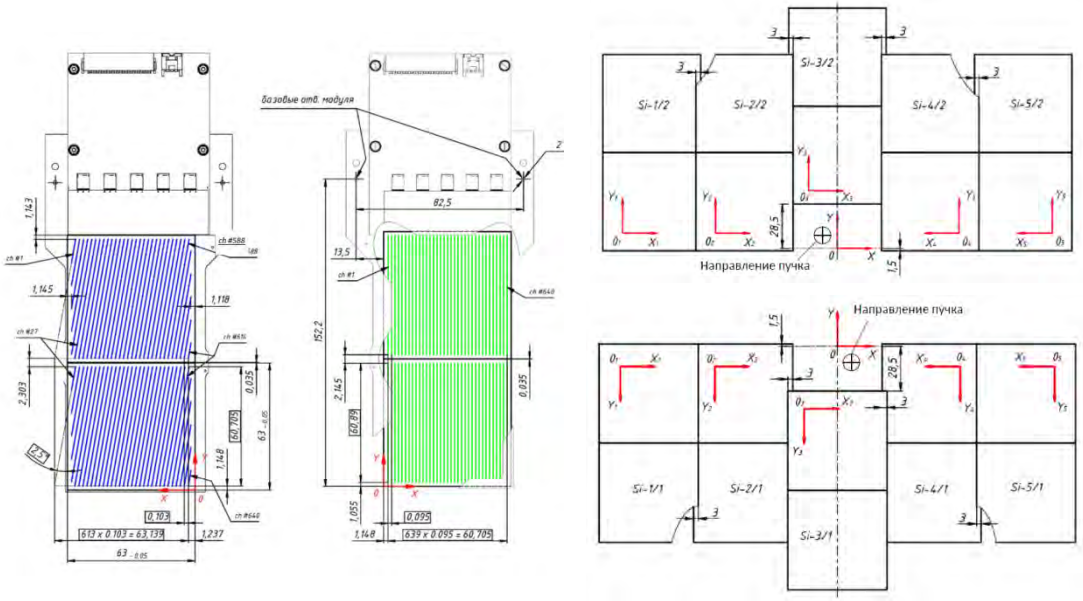
Forward Silicon Detector

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).

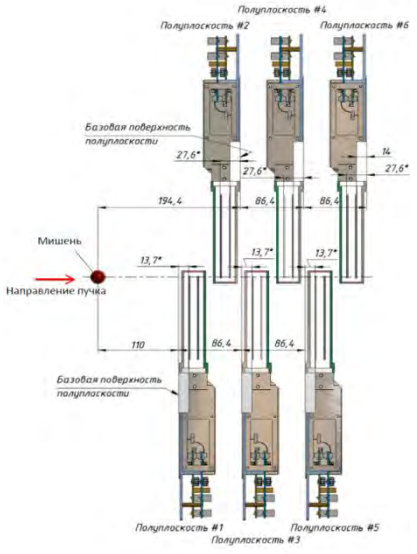
At the moment we have complete ROOT geometry for this detector in the BMNROOT repository for using it in simulation and reconstruction procedures.



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

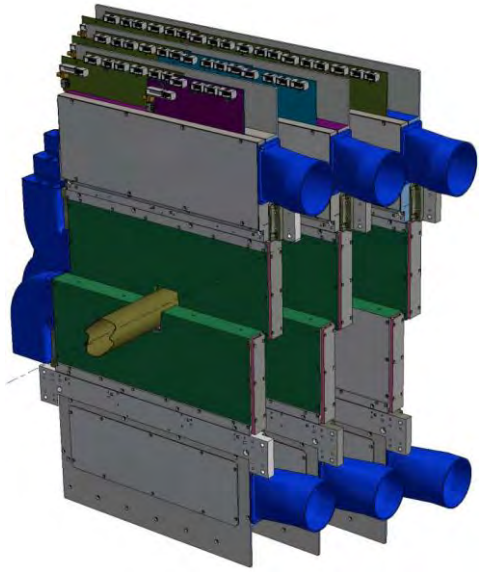


Schemes of a single Si-module (left) and their composition in the first station (right) (E. Zubarev)

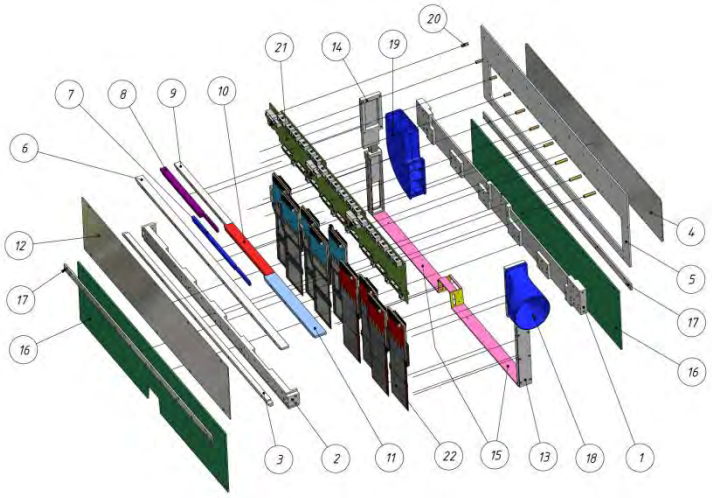


Scheme of the Forward Si detector (E. Zubarev)

Forward Silicon Detector



Full assembly of Forward Silicon detector



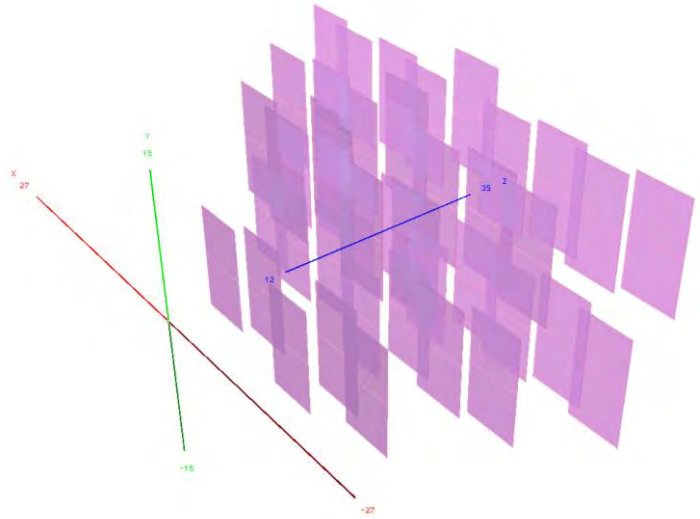
Parts of one half-plane of Forward Silicon Detector

Scheme of one half-plane: front and side views

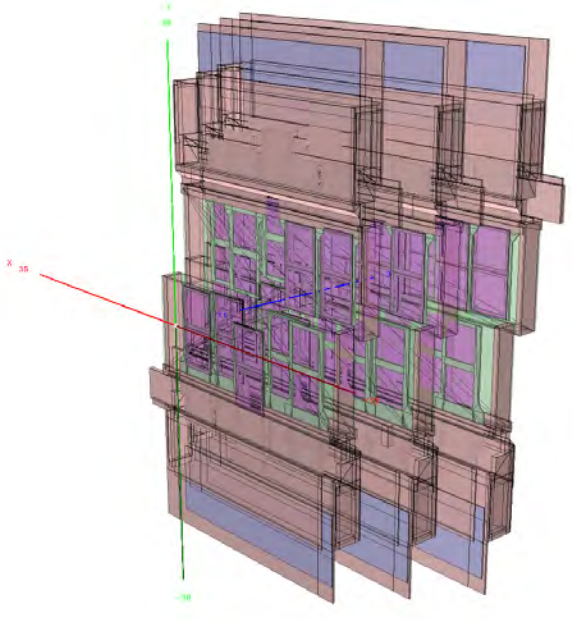
	Описание	Материал	Размер вдоль пучка	
1	Базовая планка	Алюминиевый сплав	8…14 мм	Вне чувствительной зоны Si-сенсоров
2	Планка	Алюминиевый сплав	6…12 мм	Вне чувствительной зоны Si-сенсоров
3	Планка	Алюминиевый сплав	10 мм	Вне чувствительной зоны Si-сенсоров
4	Пластина	Алюминиевый сплав	1.5 мм	Вне чувствительной зоны Si-сенсоров
5	Пластина	Алюминиевый сплав	3 мм	Вне чувствительной зоны Si-сенсоров
6…11	Рейки	Алюминиевый сплав	Суммарная толщина	Вне чувствительной зоны Si-сенсоров
12	Пластина	Алюминиевый сплав	1.5 мм	Вне чувствительной зоны Si-сенсоров
13	Боковая стенка экрана	Алюминиевый сплав	27 мм	Вне чувствительной зоны Si-сенсоров
14	Боковая стенка экрана	Алюминиевый сплав	27 мм	Вне чувствительной зоны Si-сенсоров
15	Горизонтальная стенка экрана	Пенопласт	27 мм	В чувствительной зоне Si-сенсоров
16	Лицевая стенка экрана	Пенопласт	3 мм	В чувствительной зоне Si-сенсоров
17	Планка экрана	Алюминиевый сплав	3 мм	Вне чувствительной зоны Si-сенсоров
18…19	Тонкостенный патрубок	Пластик АБС	Стенка - 2 мм	Вне чувствительной зоны Si-сенсоров
20	Втулки крепления плат электроники	Латунь	25 мм	Вне чувствительной зоны Si-сенсоров
21	Платы электроники	Стеклотекстолит	2 мм + компоненты	Вне чувствительной зоны Si-сенсоров
22	Модули Si-сенсоров и электроники			

Description of the parts

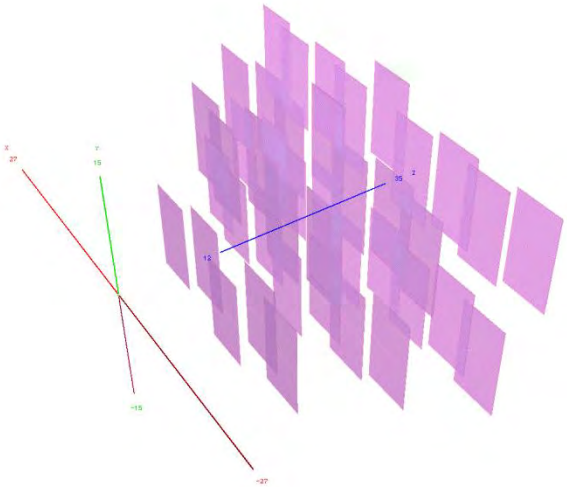
Forward Silicon Detector: ROOT geometry

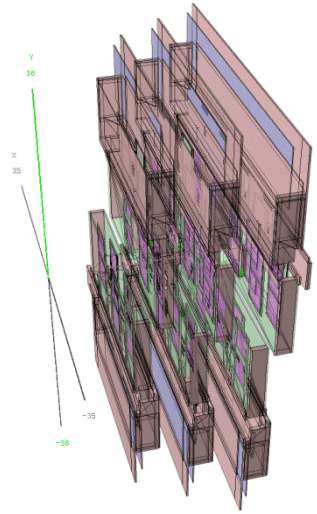


***Simplified ROOT geometry**: only sensitive planes composed of basic silicon-modules*

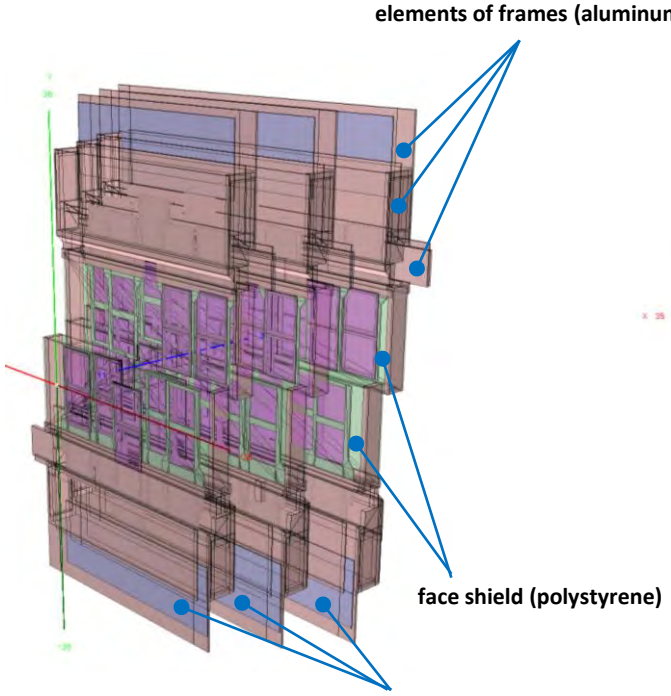


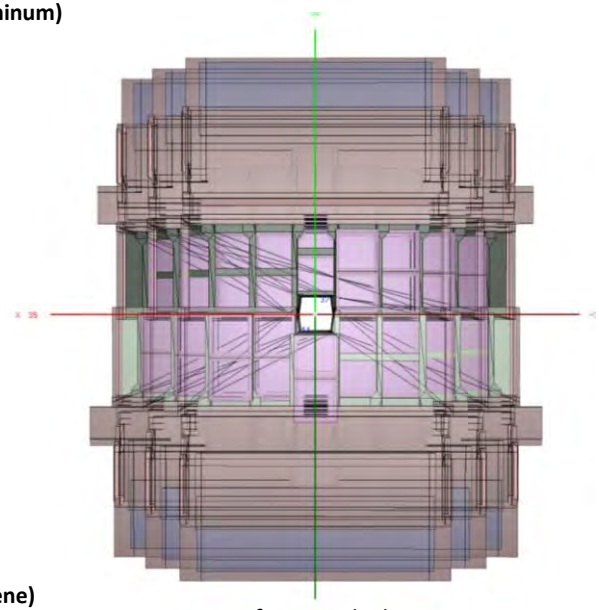
***Detailed ROOT geometry**: sensitive planes and supporting elements (passive volumes)*



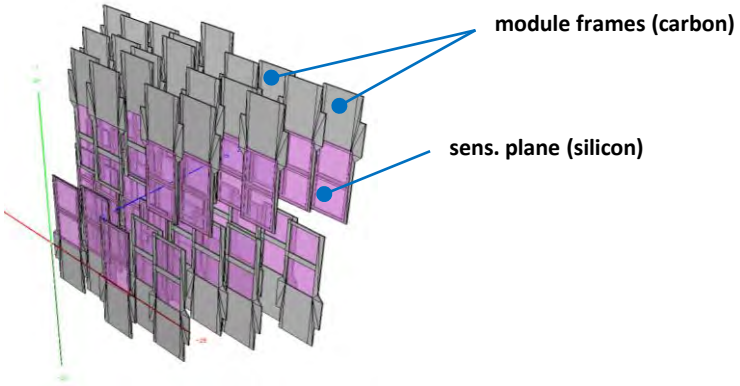


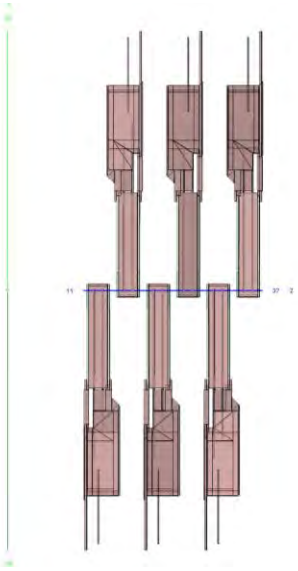
Forward Silicon Detector: ROOT geometry





Front view of Forward Silicon Detector



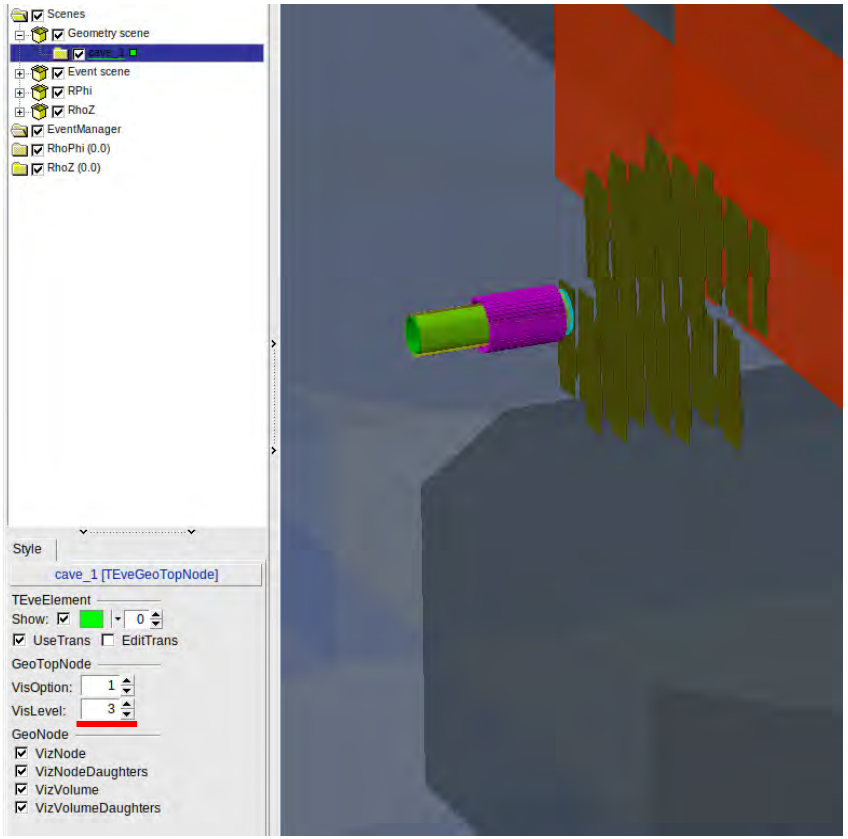


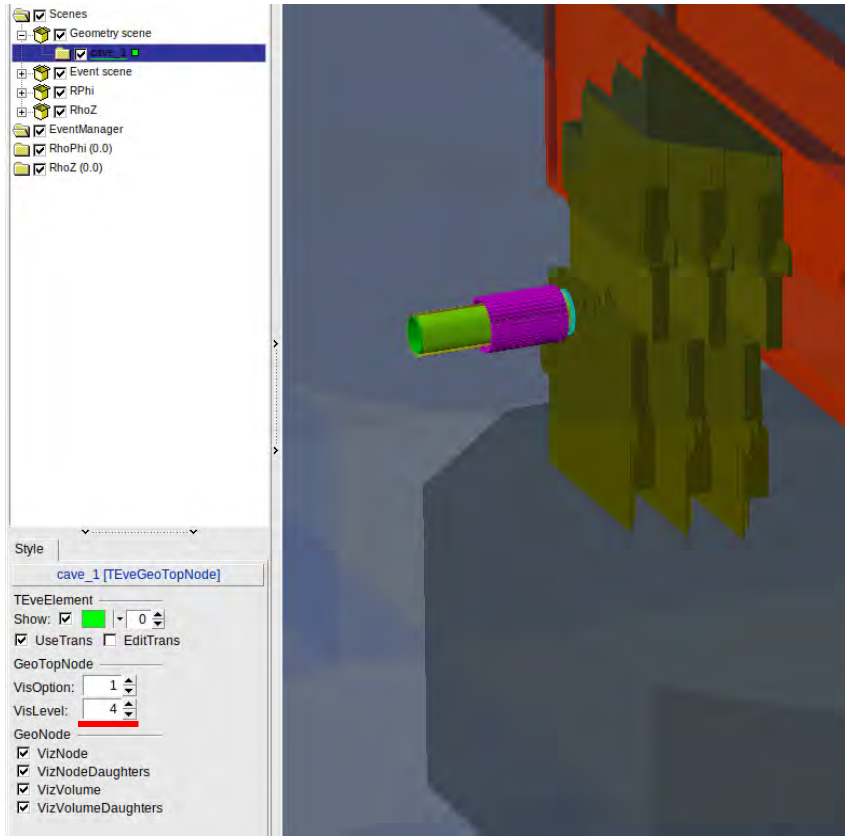
Side view of Forward Silicon Detector

passive elements in each SI-station

- moduleFrame2_station0_0
- module3_station0_0
- moduleFrame3_station0_0
- module4_station0_0
- moduleFrame4_station0_0
- module5_station0_0
- moduleFrame5_station0_0
- module6_station0_0
- moduleFrame6_station0_0
- module7_station0_0
- moduleFrame7_station0_0
- module8_station0_0
- moduleFrame8_station0_0
- module9_station0_0
- moduleFrame9_station0_0
- frames_station0_0
  - faceShildV_station0_0
  - faceShildV_station0_1
  - faceShildV_station0_2
  - faceShildV_station0_3
  - sideShieldV_station0_0
  - sideShieldV_station0_1
  - sideShieldV_station0_2
  - sideShieldV_station0_3
  - horizShieldV_station0_0
  - horizShieldV_station0_1
  - horizShieldV_station0_2
  - horizShieldV_station0_3
  - plankShieldV_station0_0
  - plankShieldV_station0_1
  - plankShieldV_station0_2
  - plankShieldV_station0_3
  - baseRailV_station0_0
  - baseRailV_station0_1
  - backRailV_station0_0
  - backRailV_station0_1
  - holdBackRailV_station0_0
  - holdBackRailV_station0_1
  - backPlaneV_station0_0
  - backPlaneV_station0_1
  - frontPlaneV_station0_0
  - frontPlaneV_station0_1
  - frontPlaneWithWindowV_station0_0
  - frontPlaneWithWindowV_station0_1
  - pcbV_station0_0
  - pcbV_station0_1
  - upperSideShieldV_station0_0
  - upperSideShieldV_station0_1
  - upperSideShieldV_station0_2
  - upperSideShieldV_station0_3
  - upperSideShieldCoverV_station0_0
  - upperSideShieldCoverV_station0_1
  - upperSideShieldCoverV_station0_2
  - upperSideShieldCoverV_station0_3
- station1_0
- station2_0

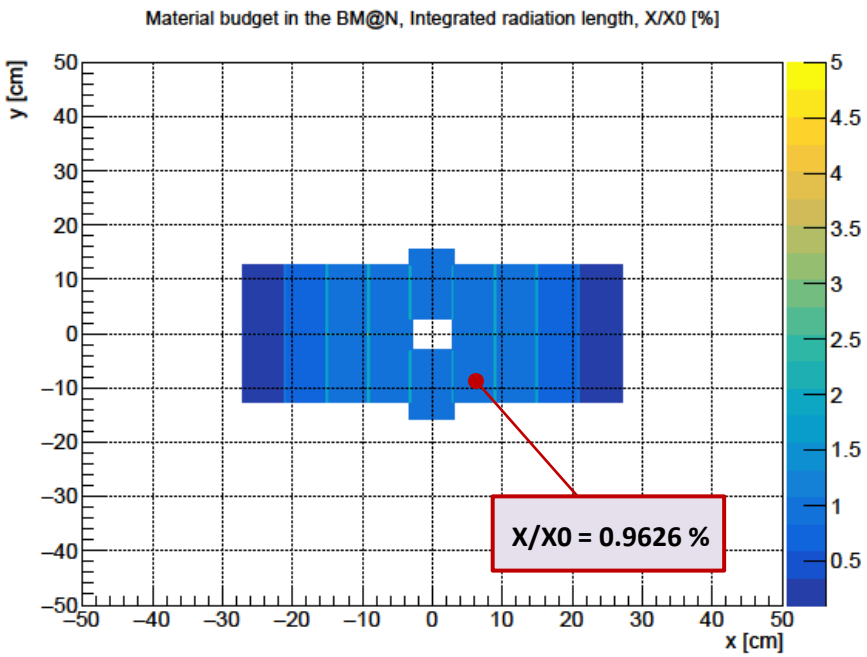
Forward Silicon Detector: ROOT geometry in EventDisplay

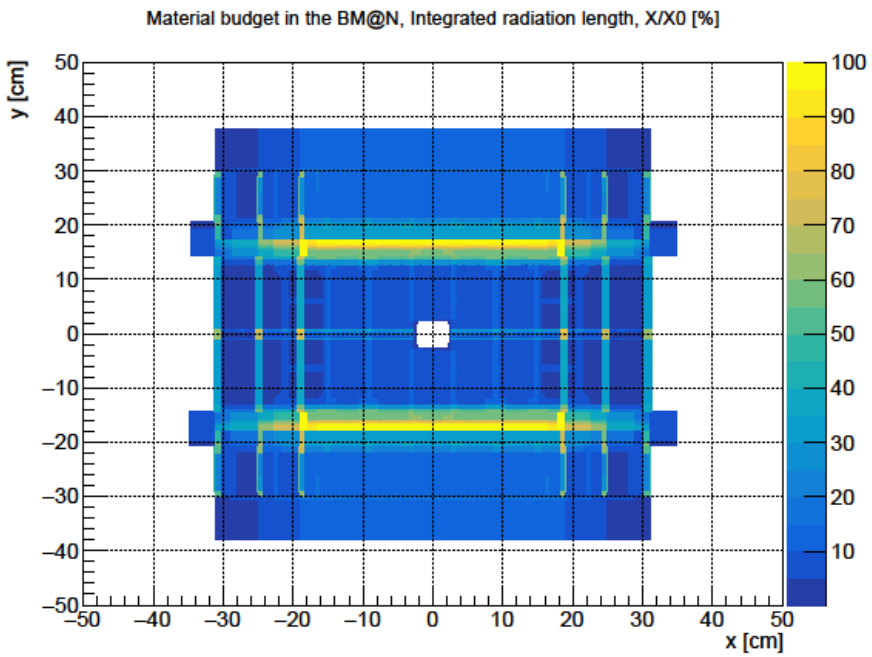




We can change the visualization level in EventDisplay to display
only modules *or* ***modules with passive elements***

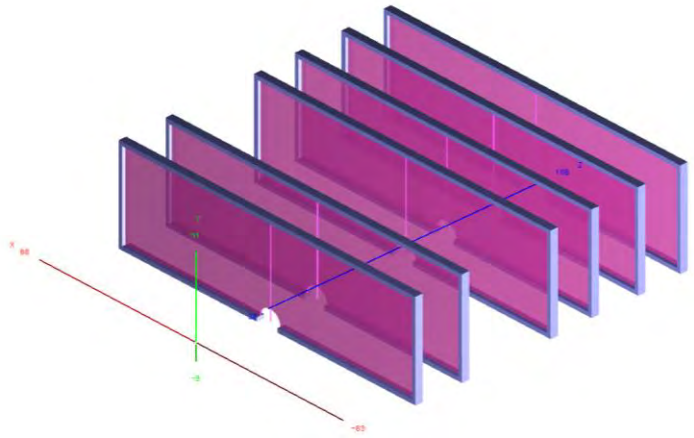
Forward Silicon Detector: material budget



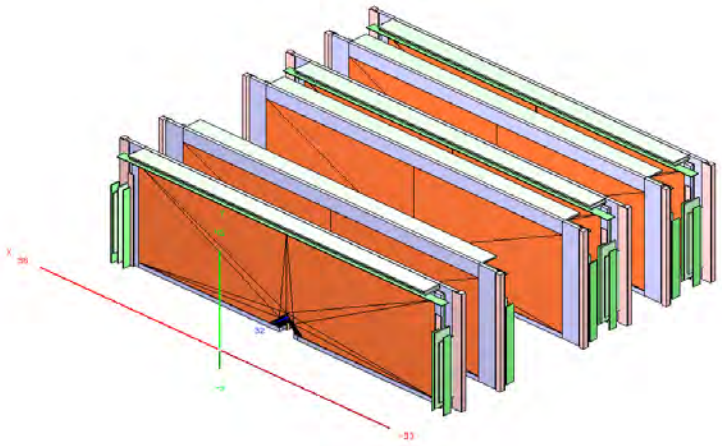


Material budget for the Forward Silicon Detector:
Left – simplified geometry (only sensitive planes), right – detailed geometry

GEM: configuration for RUN-7 (RunSpring2018)



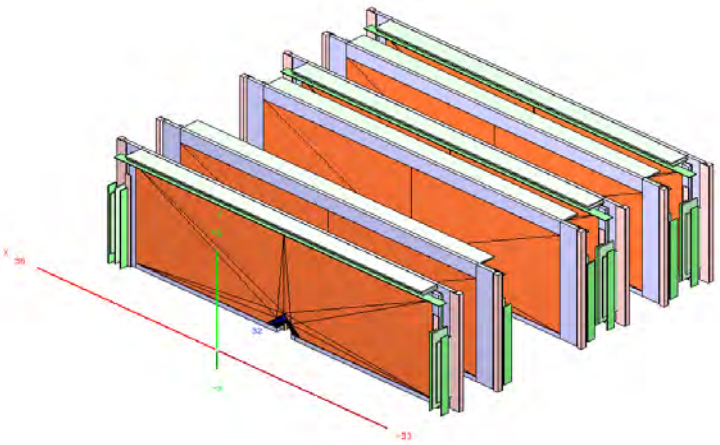
Simplified ROOT geometry of GEMs for RUN-7: only sensitive planes (as volumes filled with a gas mixture) and ordinary frames.
ROOT file: GEMS_RunSpring2018.root



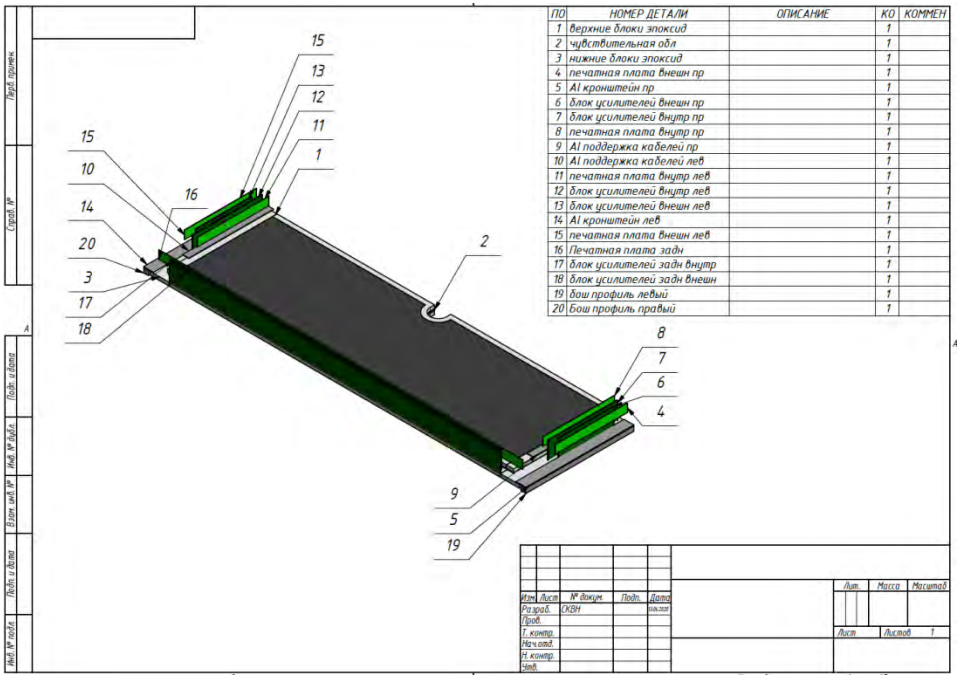
Detailed ROOT geometry of GEMs for RUN-7: passive elements (such as frames, electronics and material layers in sensitive areas) were added .
ROOT file: GEMS_RunSpring2018_detailed.root

To generate these ROOT files we have corresponding macros located inside the directory '**BMNROOT/macro/geometry**"

GEM: configuration for RUN-7 (RunSpring2018)

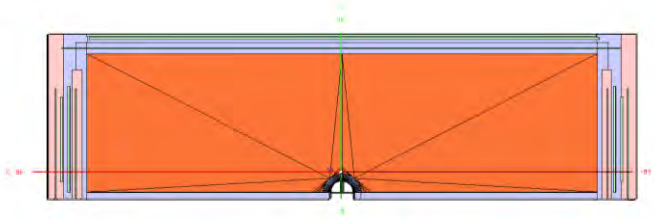


Detailed geometry of GEMs for RUN-7: common view

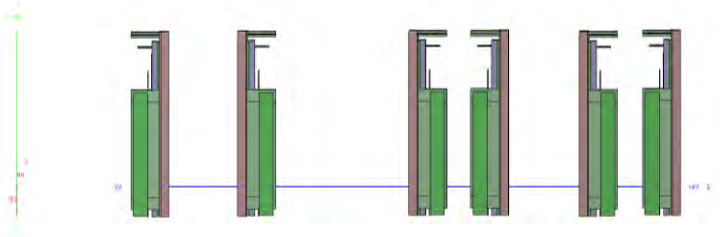


ПО	НОМЕР ДЕТАЛИ	ОПИСАНИЕ	КО	КОММЕН
1	верхние блоки эпоксид		1	
2	чувствительная обл		1	
3	нижние блоки эпоксид		1	
4	печатная плата внешн пр		1	
5	Al кронштейн пр		1	
6	блок усилителей внешн пр		1	
7	блок усилителей внутр пр		1	
8	печатная плата внутр пр		1	
9	Al поддержка кабелей пр		1	
10	Al поддержка кабелей лев		1	
11	печатная плата внутр лев		1	
12	блок усилителей внутр лев		1	
13	блок усилителей внешн лев		1	
14	Al кронштейн лев		1	
15	печатная плата внешн лев		1	
16	Печатная плата задн		1	
17	блок усилителей задн внутр		1	
18	блок усилителей задн внешн		1	
19	Бош профиль левый		1	
20	Бош профиль правый		1	

Detailed ROOT geometry have been prepared according to the schemes of half-planes provided by S. Piyadin (and others)

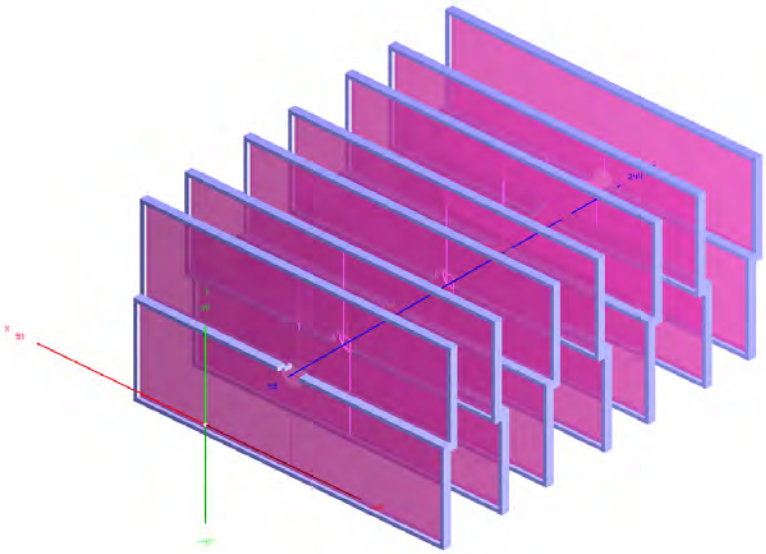


Detailed geometry of GEMs for RUN-7: front view (XY)

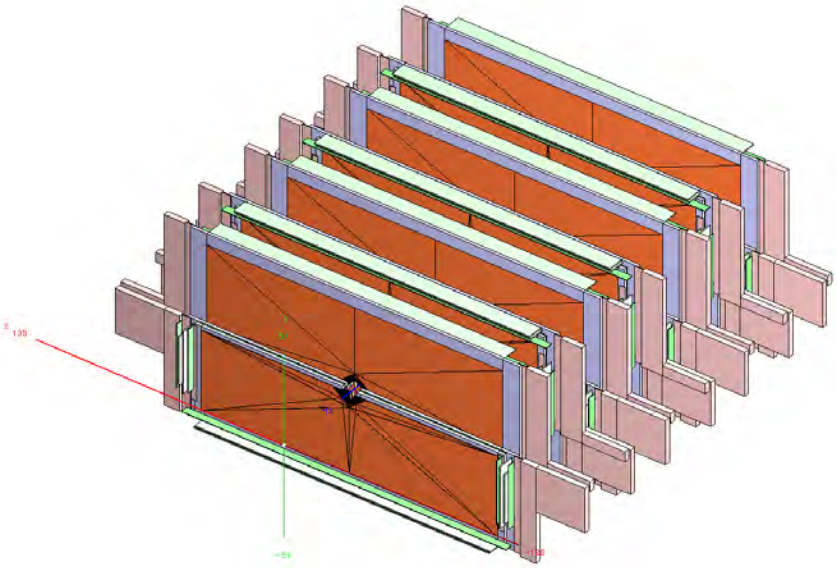


Detailed geometry of GEMs for RUN-7: side view (ZY)

GEM: configuration for the next run (FutureConfig2020)

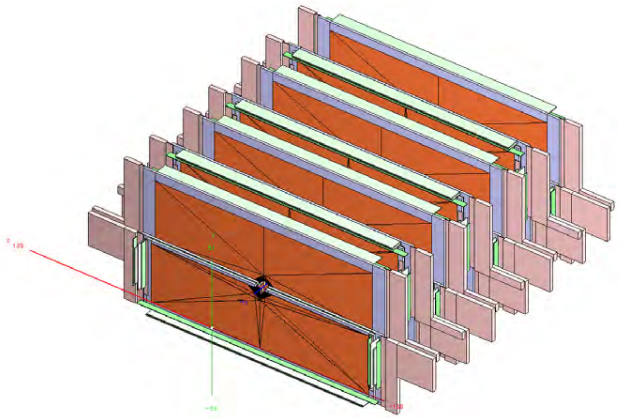


Simplified ROOT geometry of GEMs for the next run: only sensitive planes (as volumes filled with a gas mixture) and ordinary frames.
ROOT file: GEMS_FutureConfig2020.root

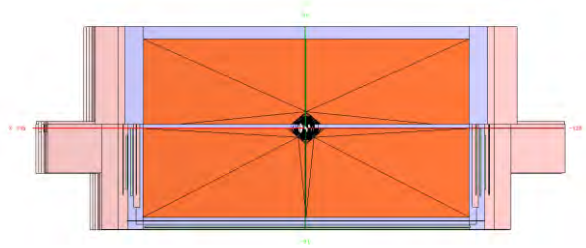


Detailed ROOT geometry of GEMs for the next run: passive elements (such as frames, electronics and material layers in sensitive areas) were added .
ROOT file: GEMS_FutureConfig2020_detailed.root

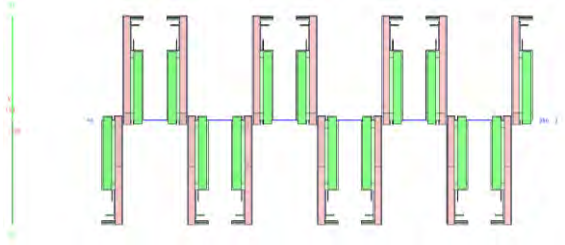
GEM: configuration for the next run (FutureConfig2020)



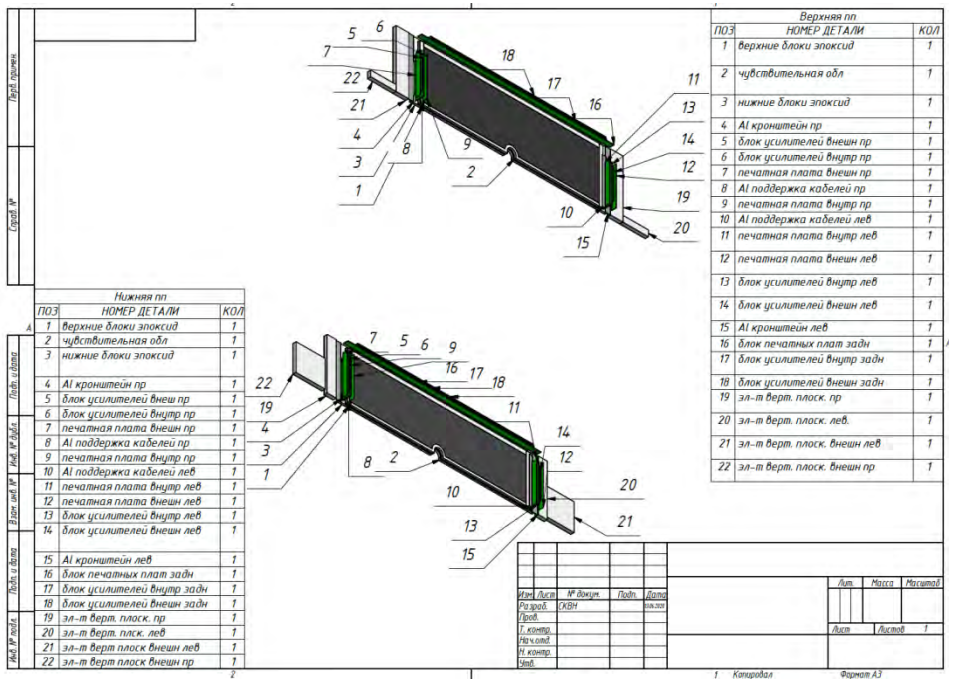
Detailed geometry of GEMs for the next run: common view



Detailed geometry of GEMs for the next run: front view (XY)



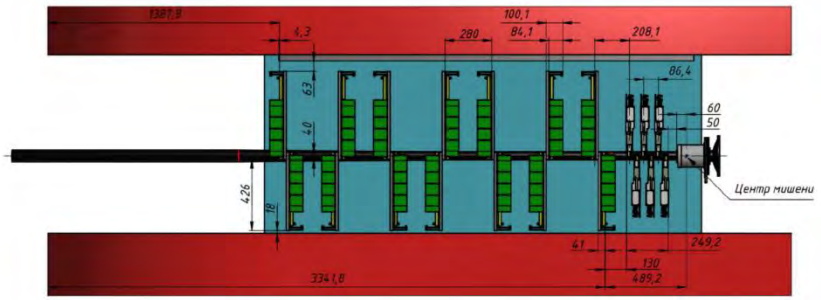
Detailed geometry of GEMs for the next run: side view (ZY)



Верхняя пл		
ПОЗ	НОМЕР ДЕТАЛИ	КОЛ
1	верхние блоки эпоксид	1
2	чувствительная обл	1
3	нижние блоки эпоксид	1
4	Al кронштейн пр	1
5	блок усилителей внешн пр	1
6	блок усилителей внутр пр	1
7	печатная плата внешн пр	1
8	Al поддержка кабелей пр	1
9	печатная плата внутр пр	1
10	Al поддержка кабелей лев	1
11	печатная плата внутр лев	1
12	печатная плата внешн лев	1
13	блок усилителей внутр лев	1
14	блок усилителей внешн лев	1
15	Al кронштейн лев	1
16	блок печатных плат задн	1
17	блок усилителей внутр задн	1
18	блок усилителей внешн задн	1
19	эл-т верт. плоск. пр	1
20	эл-т верт. плоск. лев.	1
21	эл-т верт. плоск. внешн лев	1
22	эл-т верт. плоск. внешн пр	1

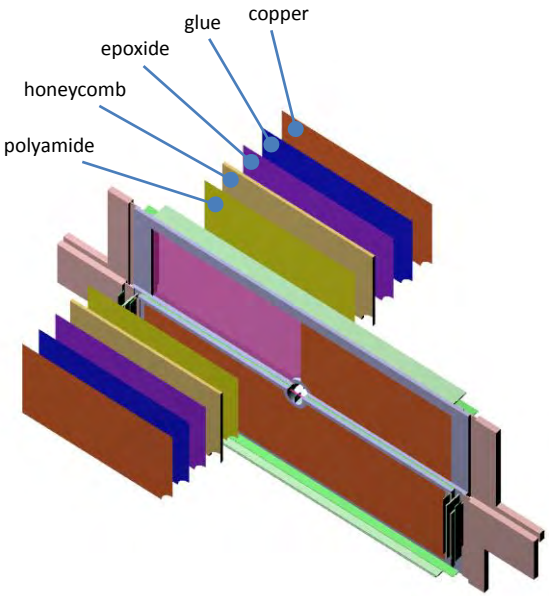
Нижняя пл		
ПОЗ	НОМЕР ДЕТАЛИ	КОЛ
1	верхние блоки эпоксид	1
2	чувствительная обл	1
3	нижние блоки эпоксид	1
4	Al кронштейн пр	1
5	блок усилителей внеш пр	1
6	блок усилителей внутр пр	1
7	печатная плата внешн пр	1
8	Al поддержка кабелей пр	1
9	печатная плата внутр пр	1
10	Al поддержка кабелей лев	1
11	печатная плата внутр лев	1
12	печатная плата внешн лев	1
13	блок усилителей внутр лев	1
14	блок усилителей внешн лев	1
15	Al кронштейн лев	1
16	блок печатных плат задн	1
17	блок усилителей внутр задн	1
18	блок усилителей внешн задн	1
19	эл-т верт. плоск. пр	1
20	эл-т верт. плск. лев	1
21	эл-т верт плоск внешн лев	1
22	эл-т верт плоск внешн пр	1

Detailed ROOT geometry have been prepared according to the schemes of *half-planes* provided by S. Piyadin (and others)



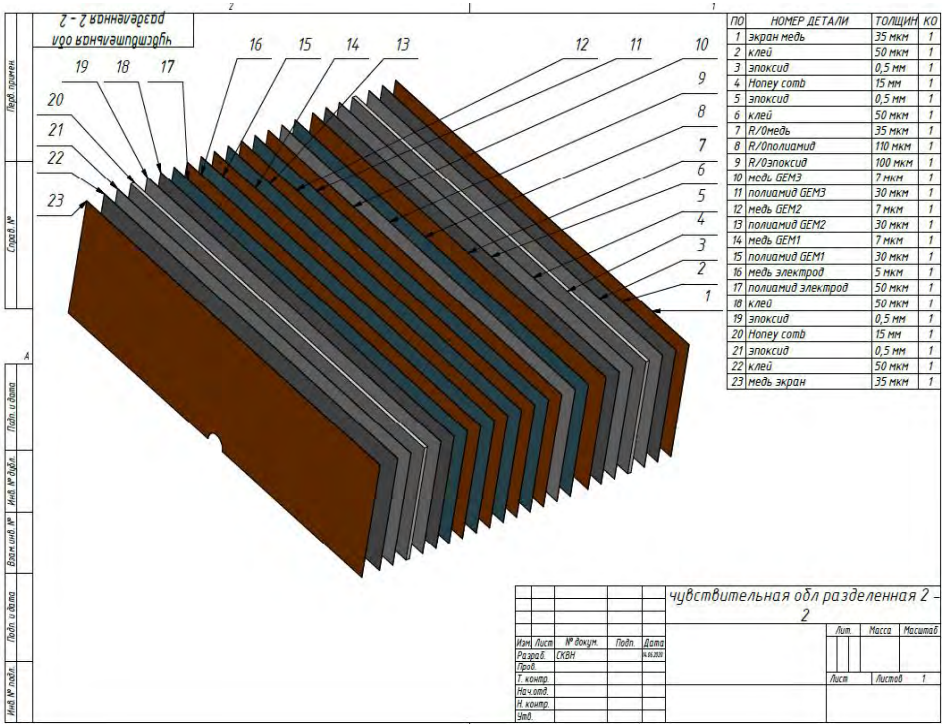
Scheme of GEM chambers composition (S. Piyadin)

GEM: structure of sensitive area



Besides frames and electronic elements, layers of materials in sensitive areas have been added to the detailed geometry.

The thickness of some layer is a summary thickness of all layers with the same material.



Layer structure of a sensitive area for one half-plane of GEM (S. Piyadin)

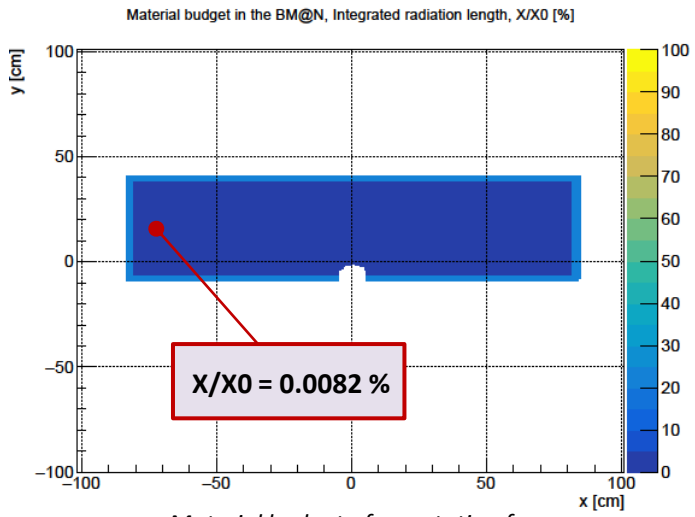
copper: 35µm + 35µm + 7µm + 7µm + 7µm + 5µm + 35µm = **131µm**
glue: 50µm + 50µm +50µm + 50µm = **200µm**
epoxide: 0.5mm + 0.5mm + 100µm + 0.5mm + 0.5mm = **2.1mm**
honeycomb: 15mm + 15mm = **30mm**
polyamide: 110µm + 30µm + 30µm + 30µm + 50µm = **250µm**

GEM: Material budget

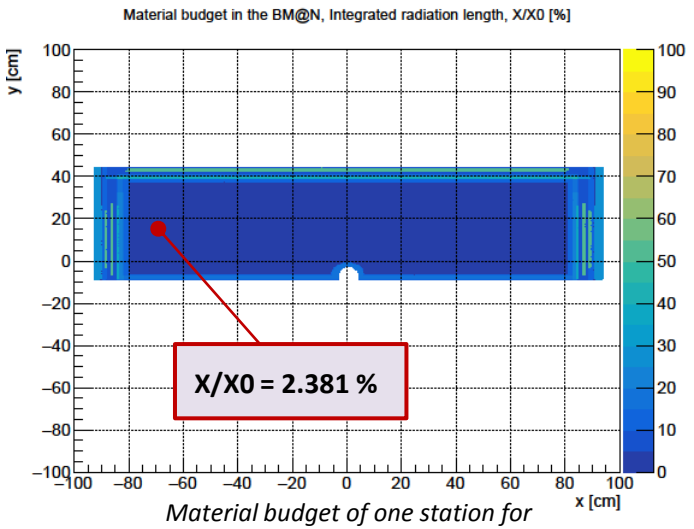
layer	material	density [g/cm-3]	thickness (X) [cm]	X0 [cm]	X/X0 [%]
gas	*ArCO2 (70/30)*	0.0019	0.9	10960.2	0.0082
copper	*copper*	8.96	0.0131	1.435	0.9129
glue	*acrylic glue*	1.25	0.02	32.1603	0.0622
epoxide	*polyurethane (high dens.)*	1.8	0.21	22.5351	0.9319
	polyurethane (medium dens.)	0.59	0.21	68.7512	0.3055
	polyurethane (low dens.)	0.25	0.1	162.253	0.1295
honeycomb	*nomex aramid honeycomb (kevlar chemical structure)*	0.048	3.0	755.397	0.3971
polyamide	*polyamide*	1.14	0.025	36.4052	0.0687

Table: properties of material layers in the sensitive area of GEM chambers

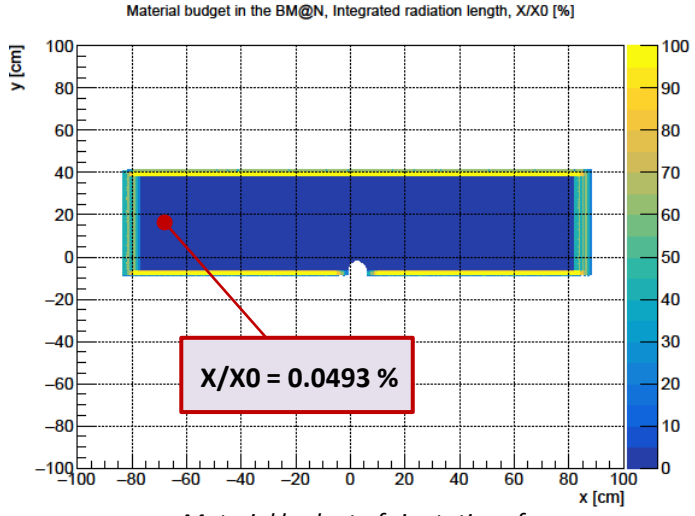
Material budget: GEM configuration for RUN-7



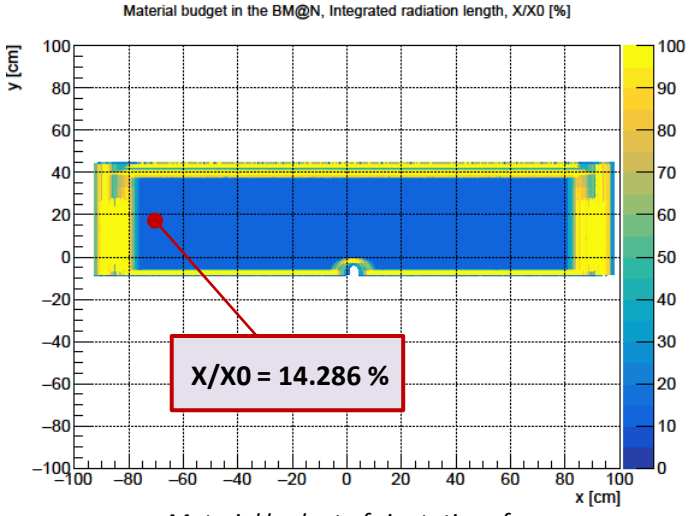
Material budget of one station for tracks parallel to Z axis (simplified geometry)



Material budget of one station for tracks parallel to Z axis (detailed geometry)

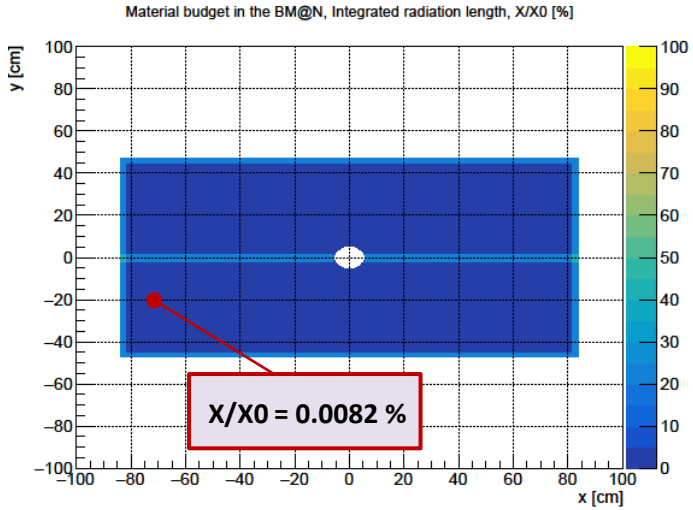


Material budget of six stations for tracks parallel to Z axis (simplified geometry)

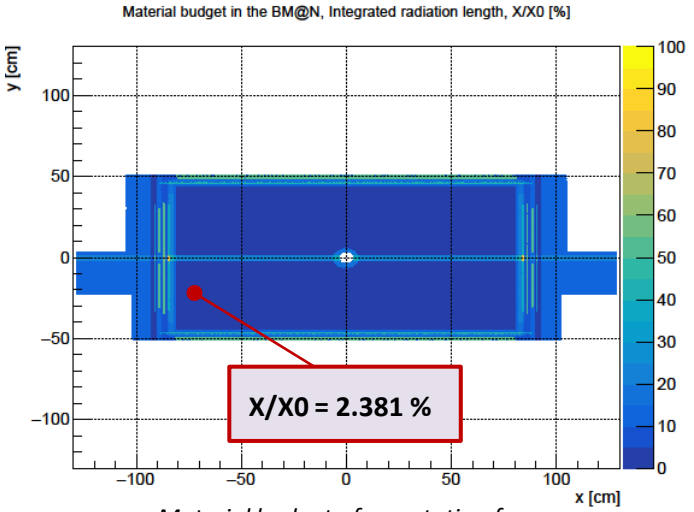


Material budget of six stations for tracks parallel to Z axis (detailed geometry)

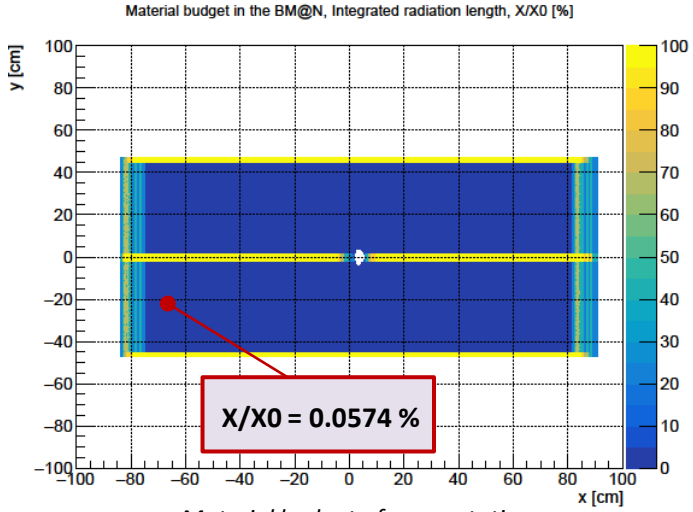
Material budget: GEM configuration for the next run (FutureConfig2020)



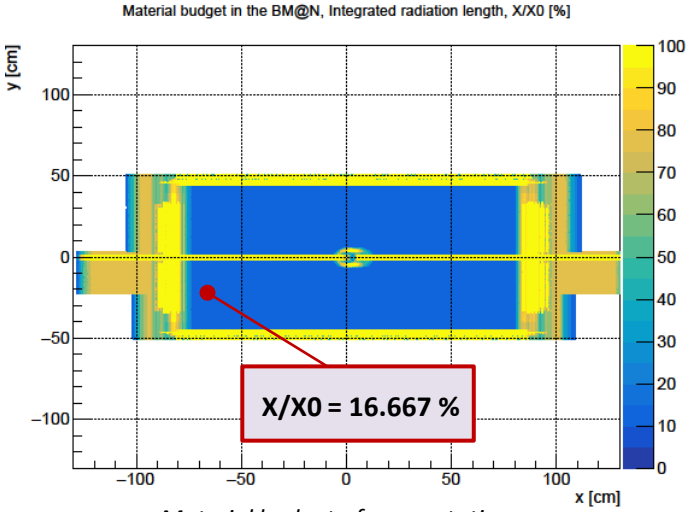
Material budget of one station for tracks parallel to Z axis (simplified geometry)



Material budget of one station for tracks parallel to Z axis (detailed geometry)



Material budget of seven stations for tracks parallel to Z axis (simplified geometry)



Material budget of seven stations for tracks parallel to Z axis (detailed geometry)

Summary

- ✓ The detailed geometry for the inner tracker detectors (GEM and SILICON) of the BM@N setup was prepared for the following runs:
  - RUN-7 (2018)
  - the next run (2021-2022)
- ✓ The material budget distribution for each configuration was calculated

Thank you for your attention…