Time-of-Flight System based on a MRPC in SpdRoot

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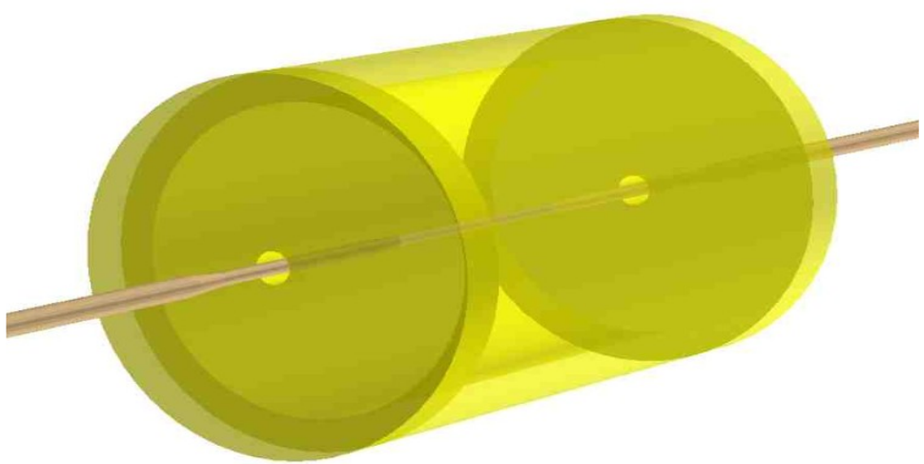
JINR, Dubna

Physics & MC meeting
6.10.2021

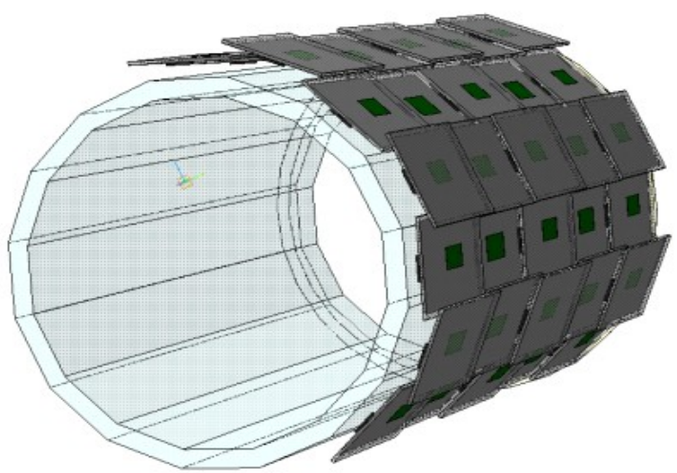
The purpose of the report

- To create a new version of the TOF system geometry based on a MRPC module in SpdRoot

TOF System
simple geometry



TOF System
based on a MRPC

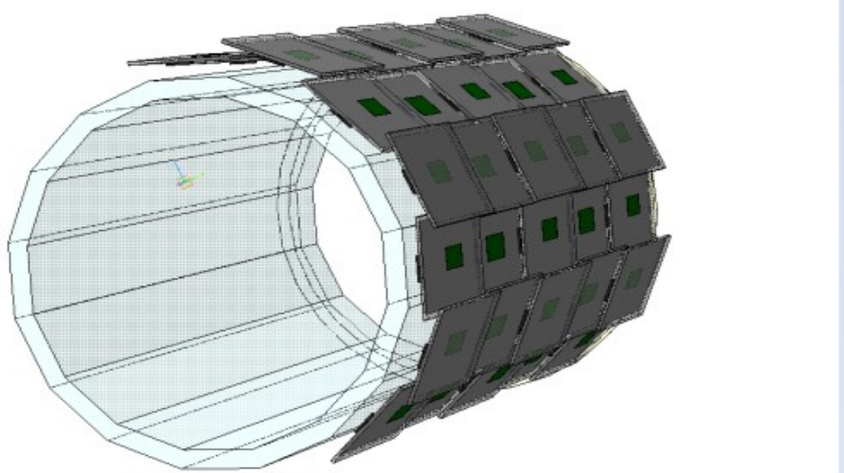


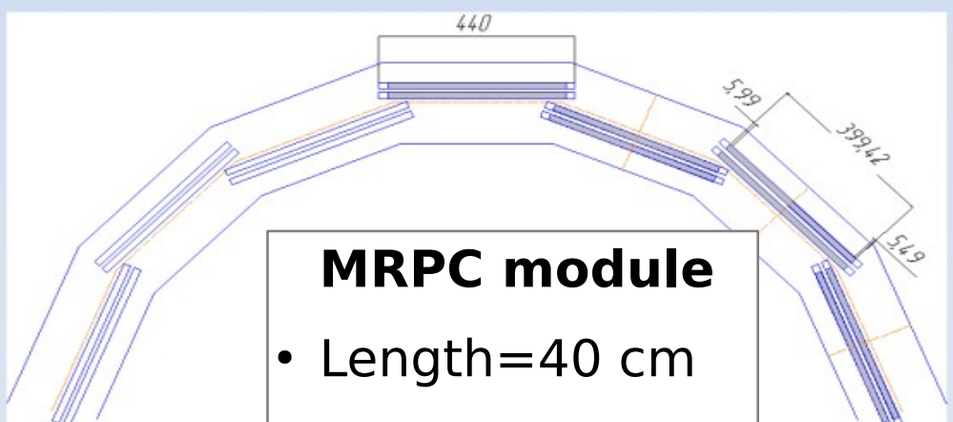
TOF-system based on the MRPC

From talk A. Semak on SPD collaboration meeting (June 10, 2021)
«*MRPC prototype chambers for TOF*»
(*https://indico.jinr.ru/event/2152/contributions/12962/attachments/10207/16610/Status_8jun2021.pdf*)

Our vision of the TOF system

- SPD TOF system could be designed with MRPC modules.
- We suggest using of 0.25 mm gas gap MRPC.
- Each MRPC consist of 10 gaps made of 0.33 mm glass.
- 16 read-out strips of 20 x 410 mm^2 size. Strip pitch is 21 mm.
- MRPCs active area is ~337 x 400 mm^2.
- The ToF distance of ~1m lead to the requirement of ≈30ps time resolution.





MRPC module

- Length=40 cm
- Width=33 cm
- Height=2.5 cm

SPD collaboration meeting 10.06.2021

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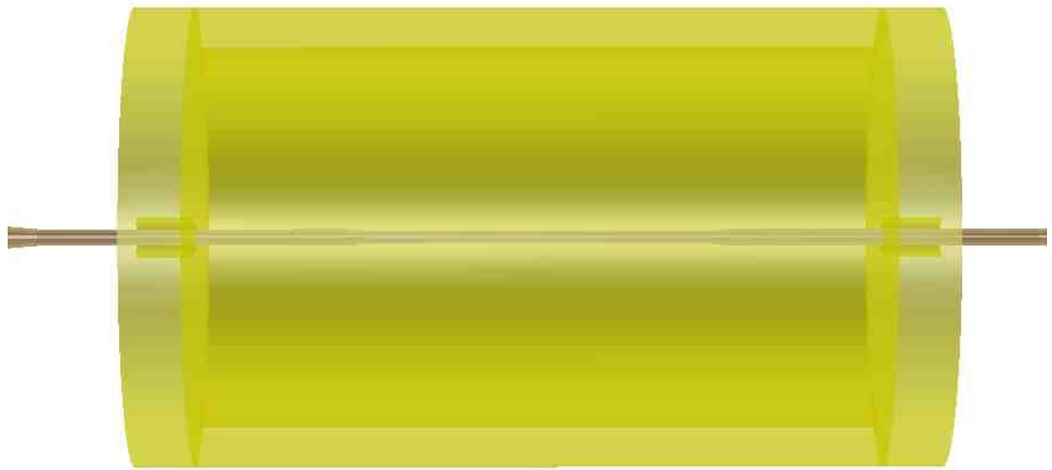
Simple geometry

Thanks Artur for first desciption TOF in SpdRoot
(git clone -b artur_dev https://git.jinr.ru/nica/spdroot.git)

Endcap

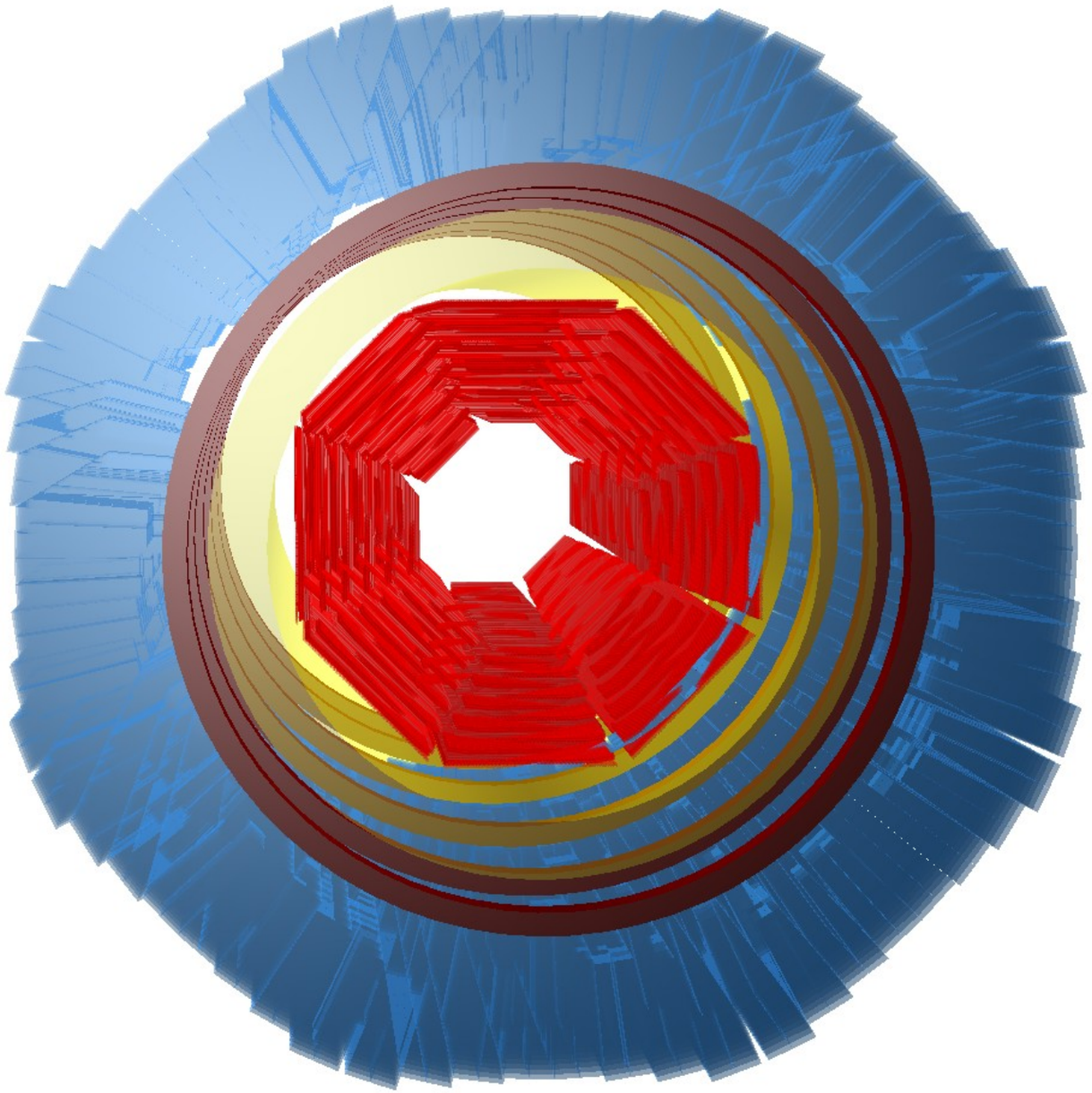
Shape: cylinder
Material: air
Thickness: 30 *cm*
R_min: 10 *cm*
R_max: 115 *cm*
***Distance from the center of set-up to endcap`s wall along the Z axis**:* 171.6 *cm*

Barrel



Shape: cylinder
Material: air
Length: 343.2 *cm*
Thickness: 20 *cm*
R_min: 95 *cm*
R_max: 115 *cm*

Simple geometry: Barrel



TS

TOF system

Magnet

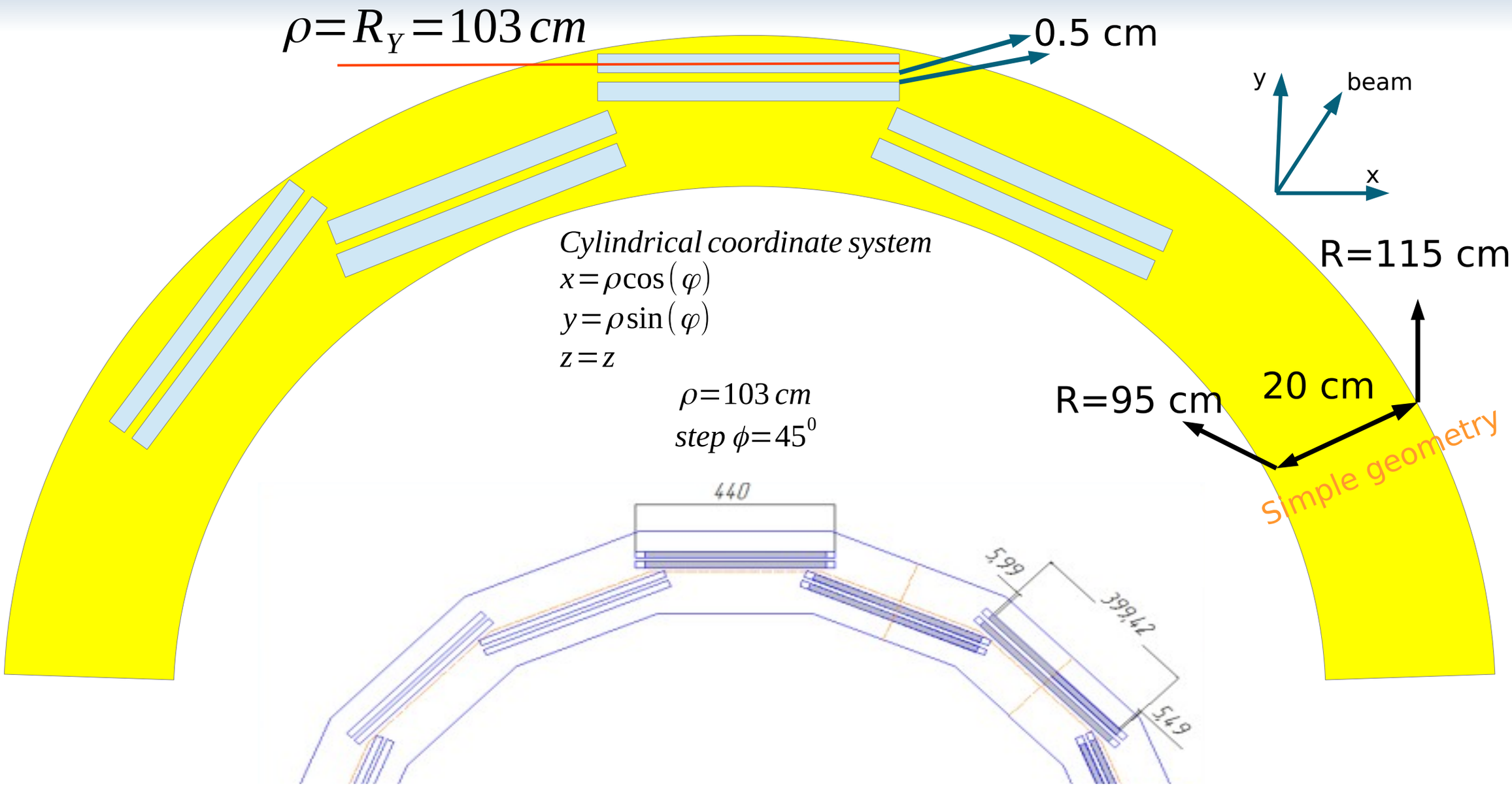
ECAL

MRPC module

MRPC module

- Length=40 cm
- Width=33 cm
- Height=2.5 cm

MRPC geometry: Barrel



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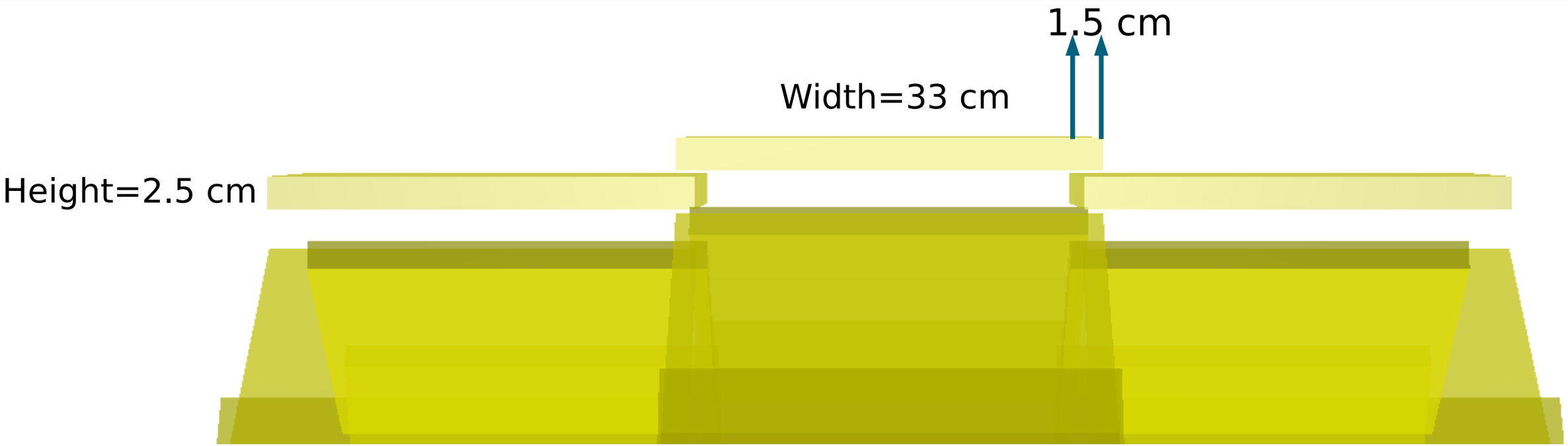
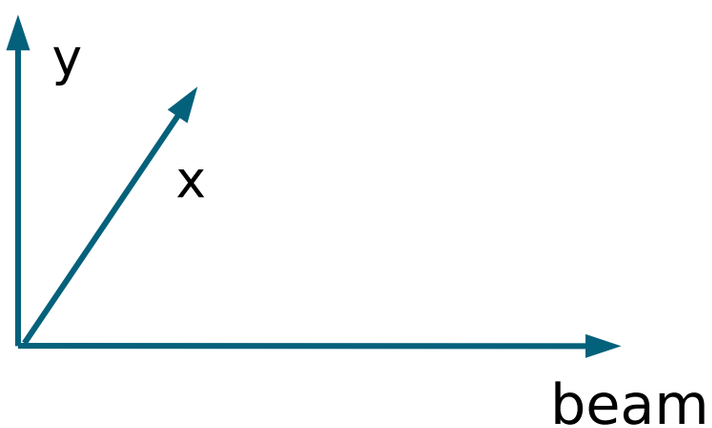
«*MRPC prototype chambers for TOF*»

MRPC geometry: Barrel

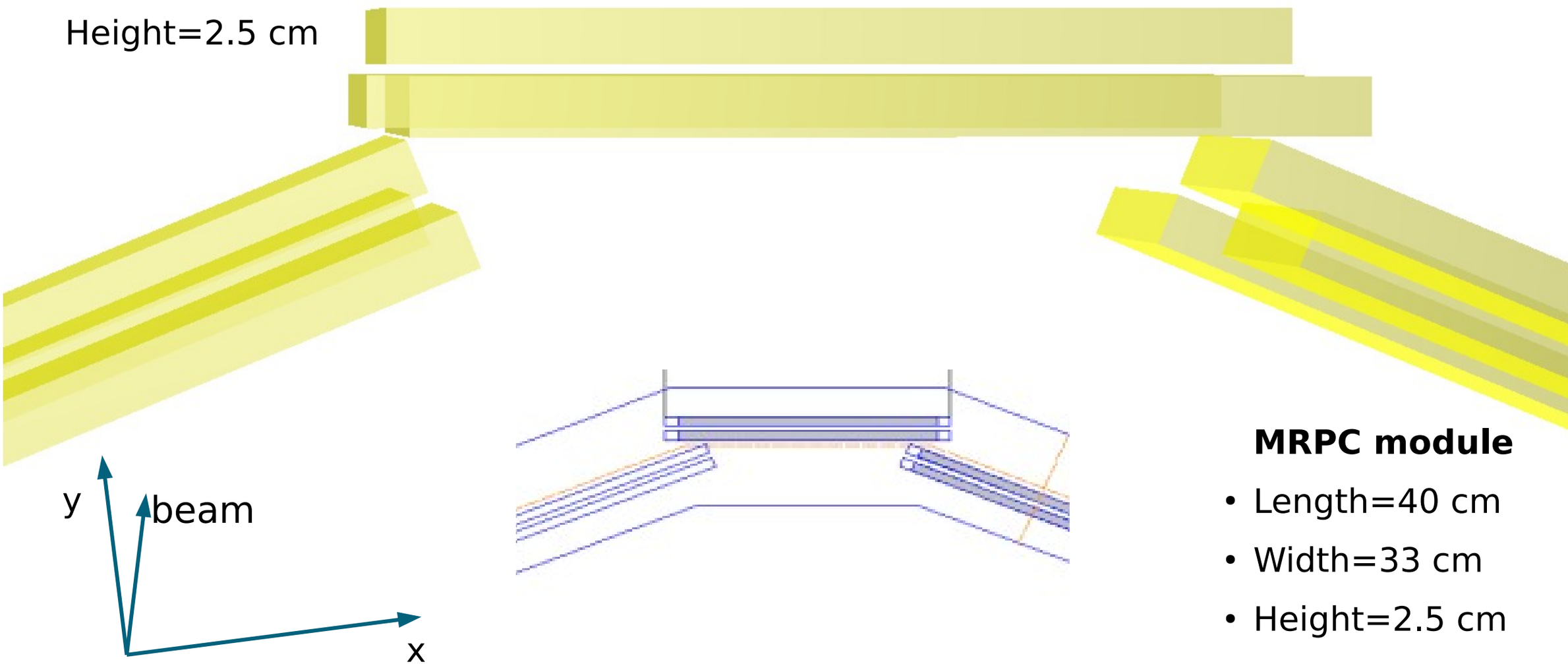




MRPC module

- Length=40 cm
- Width=33 cm
- Height=2.5 cm

MRPC geometry: Barrel

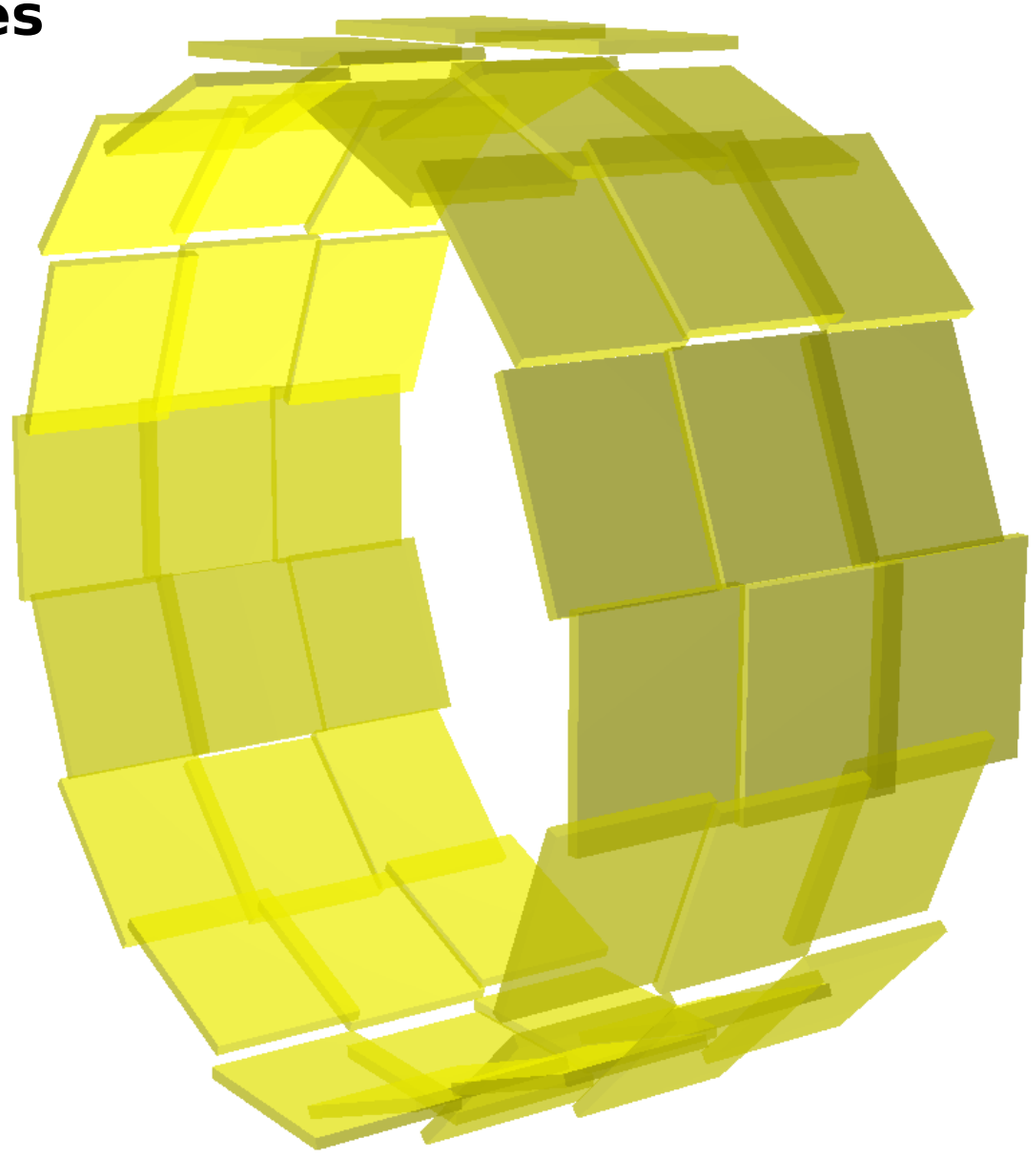


MRPC module

- Length=40 cm
- Width=33 cm
- Height=2.5 cm

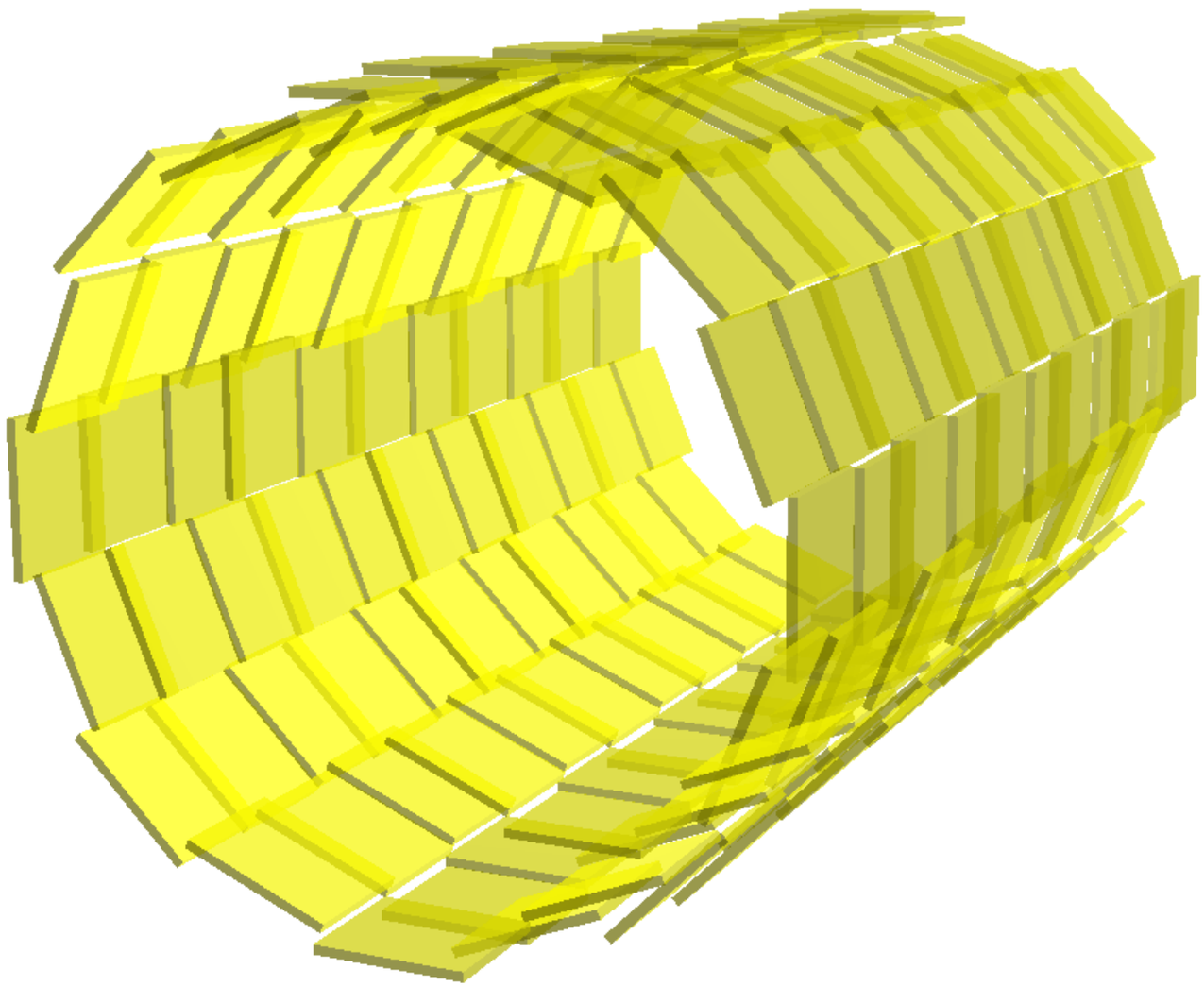
MRPC geometry: Barrel

1 row = 16 modules

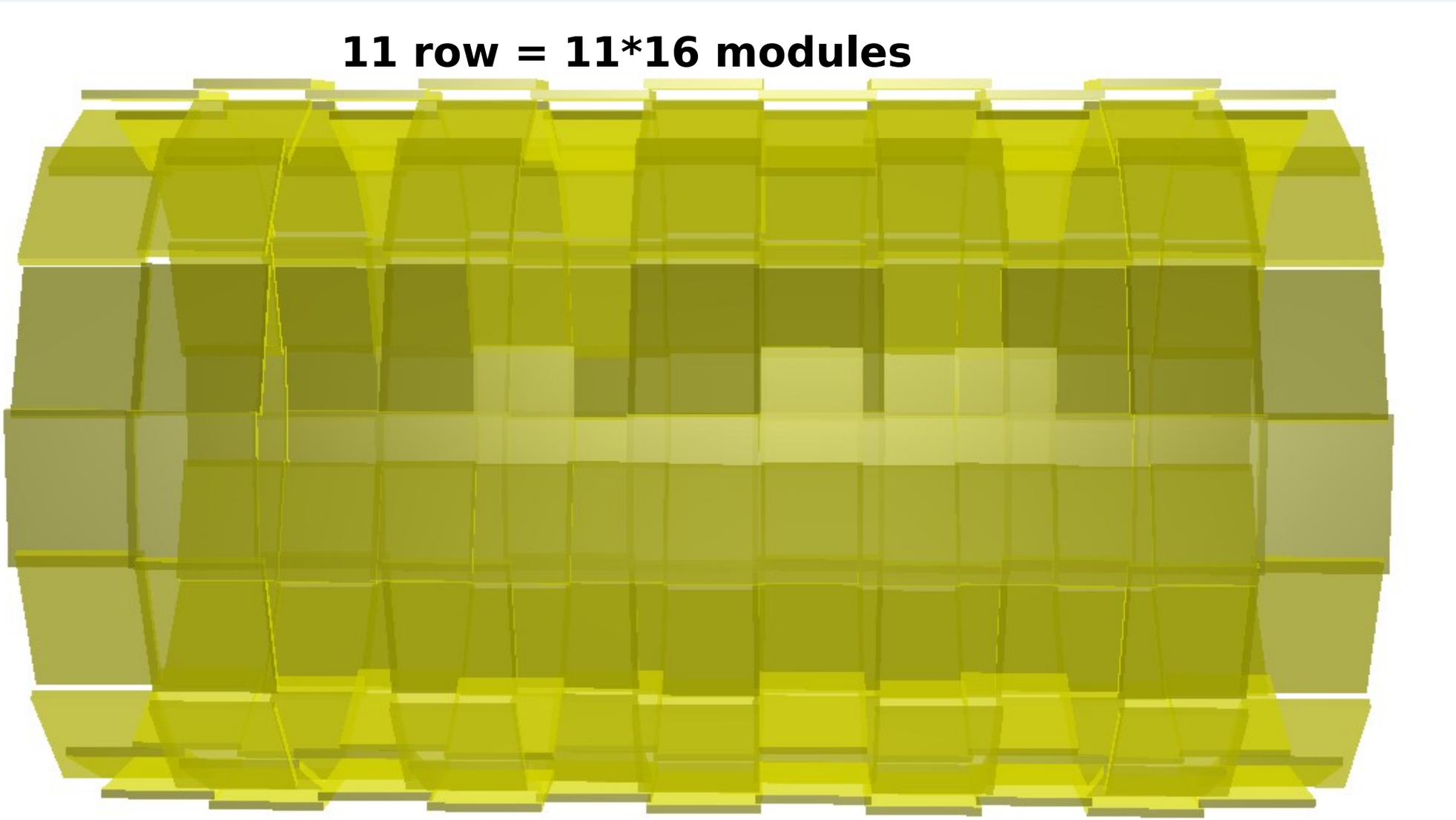


MRPC geometry: Barrel

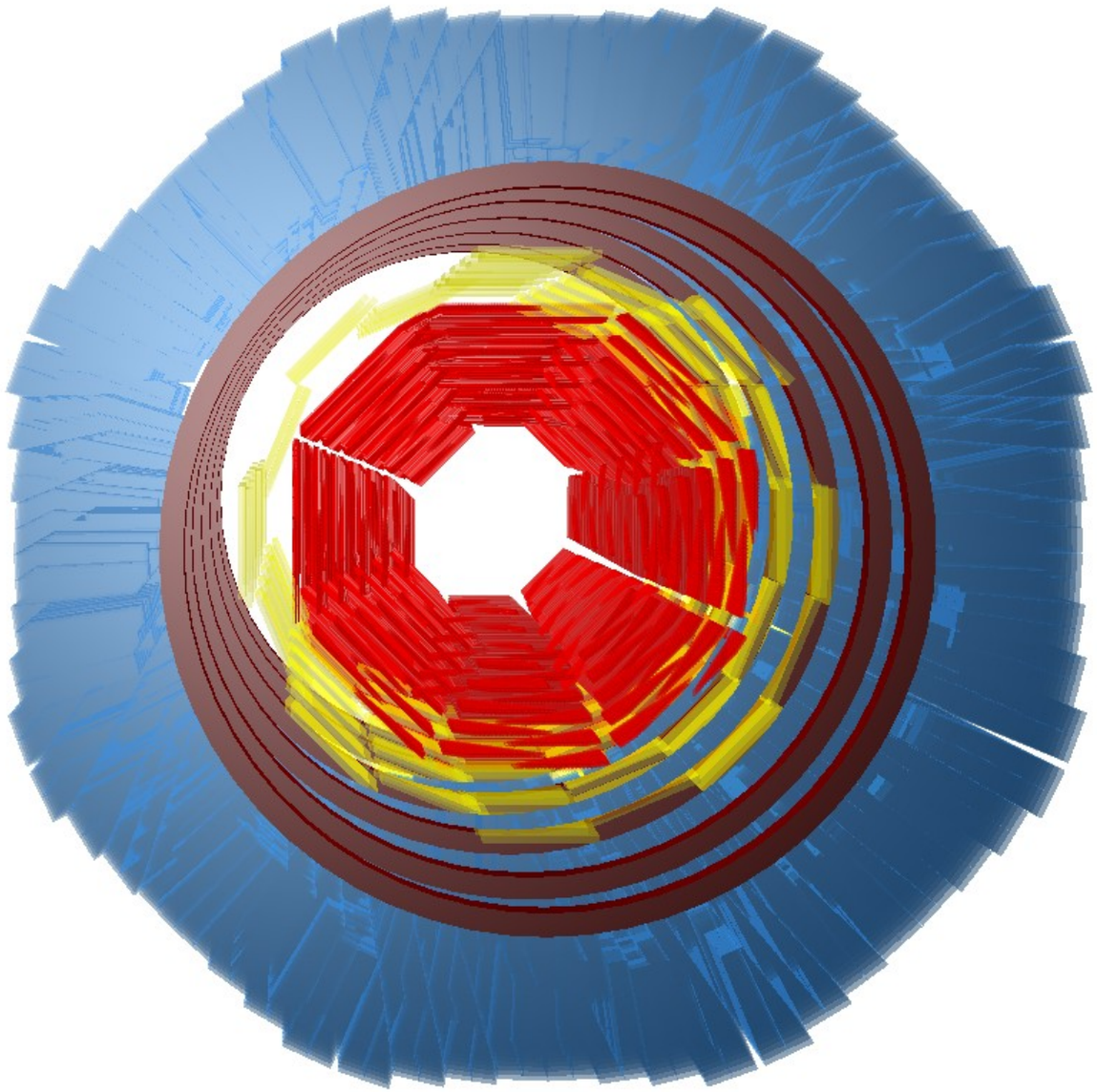
11 row = 11*16 modules



MRPC geometry: Barrel



MRPC geometry : Barrel



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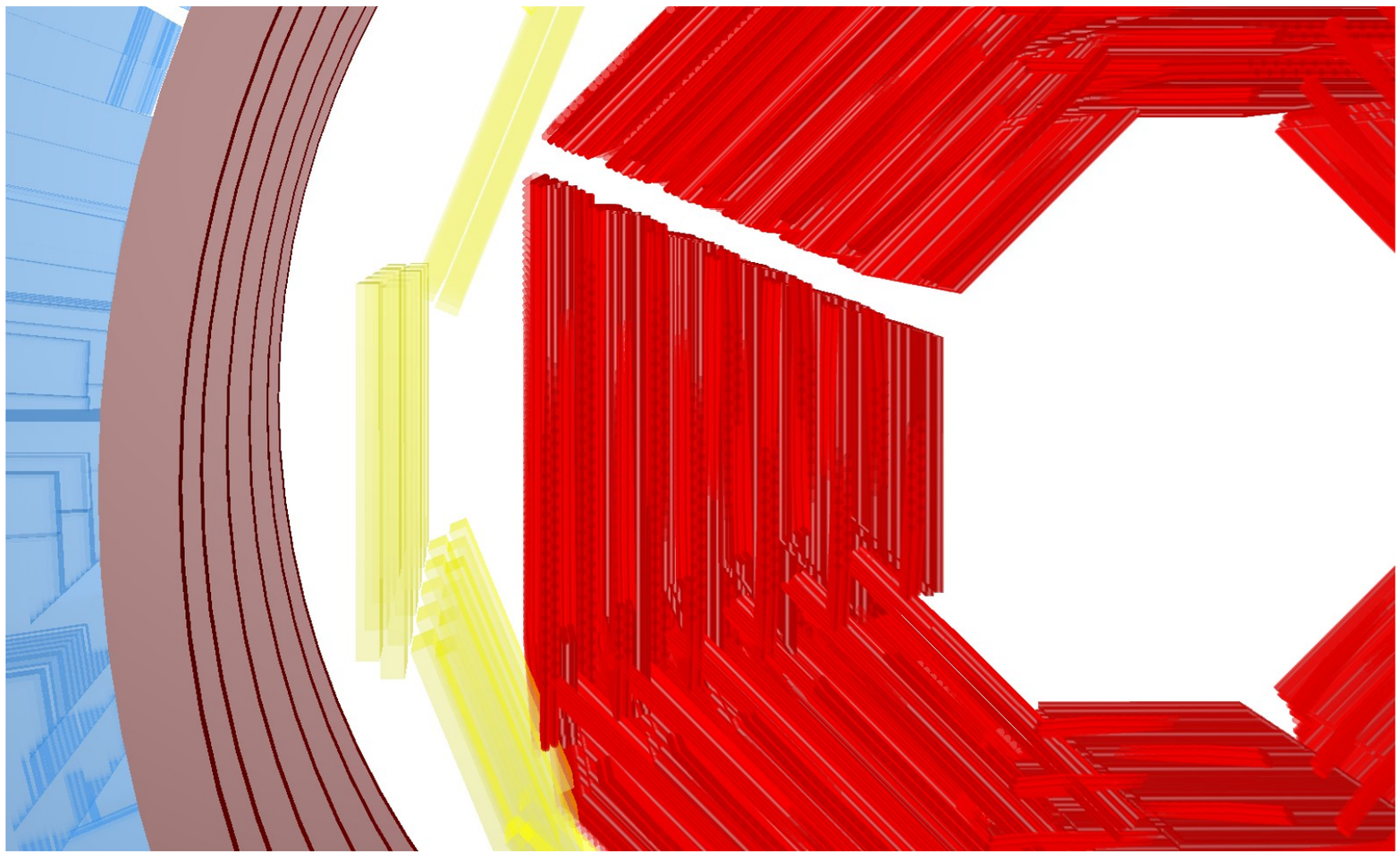
MRPC geometry : Barrel



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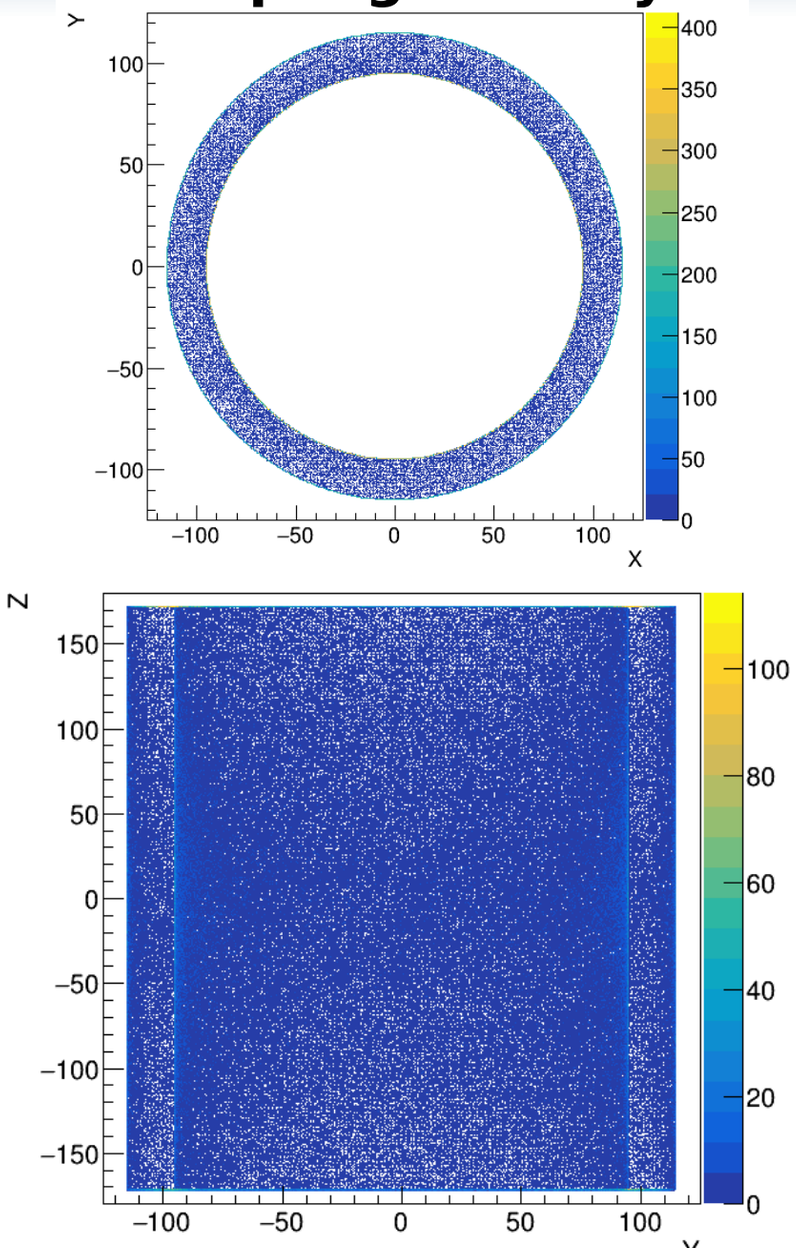
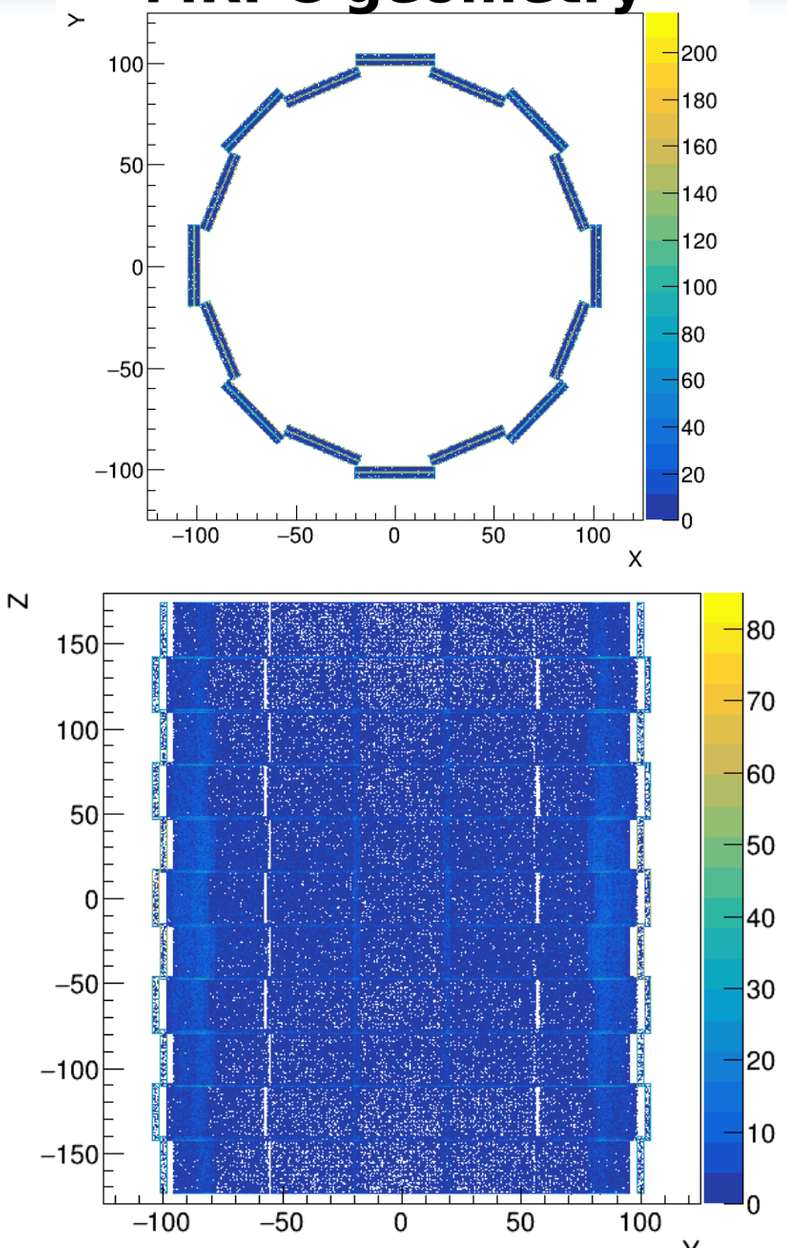
Hits from SpdRoot: Barrel

Simple geometry

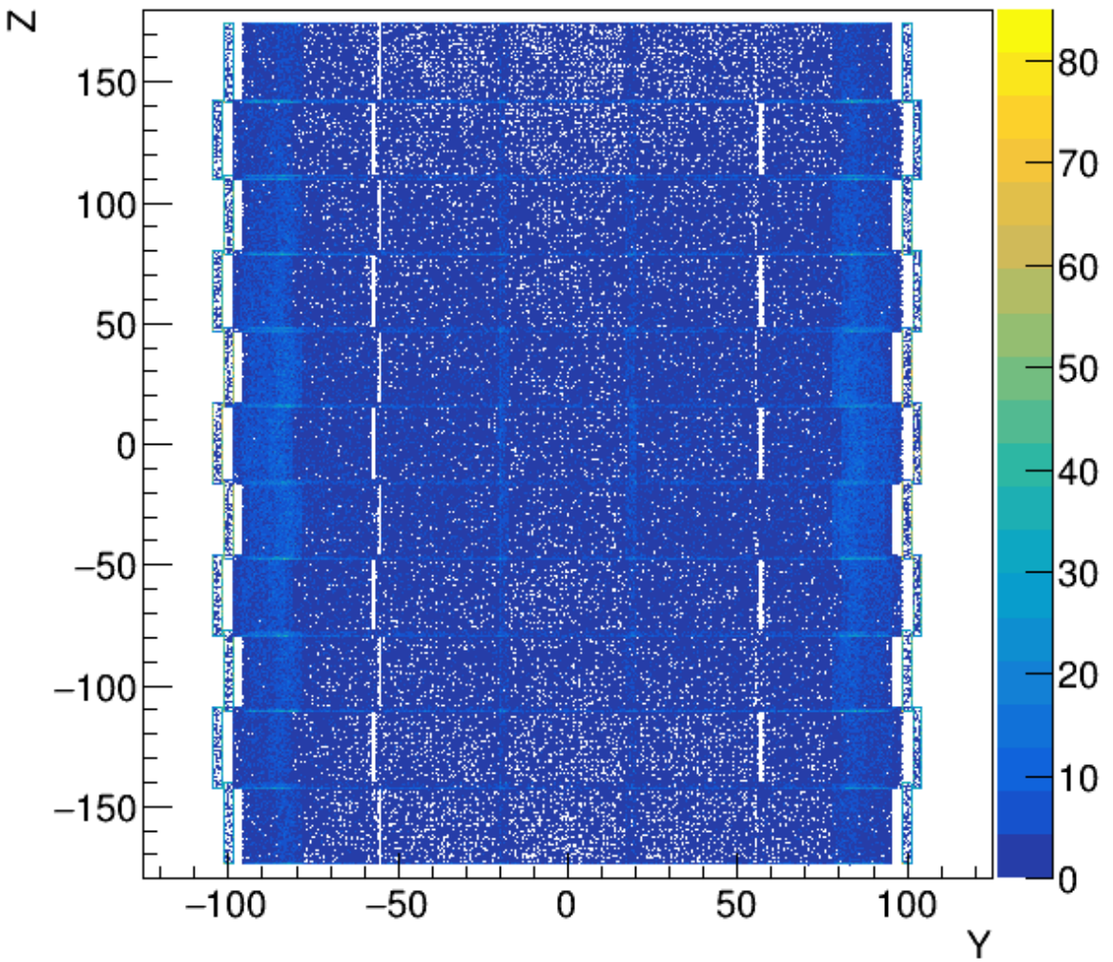


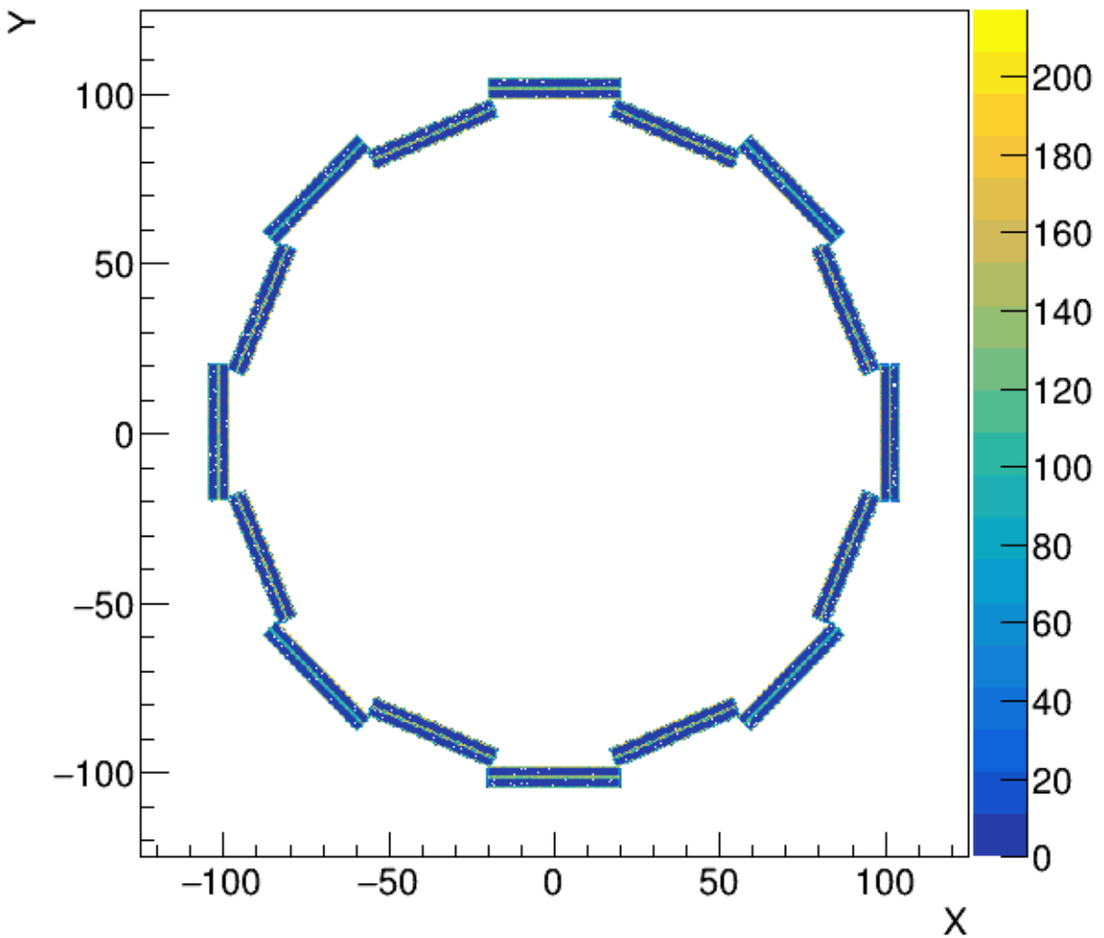
MRPC geometry



Minimum bias *pp* 27 *GeV* events were generated (SimuQslPy8.C)

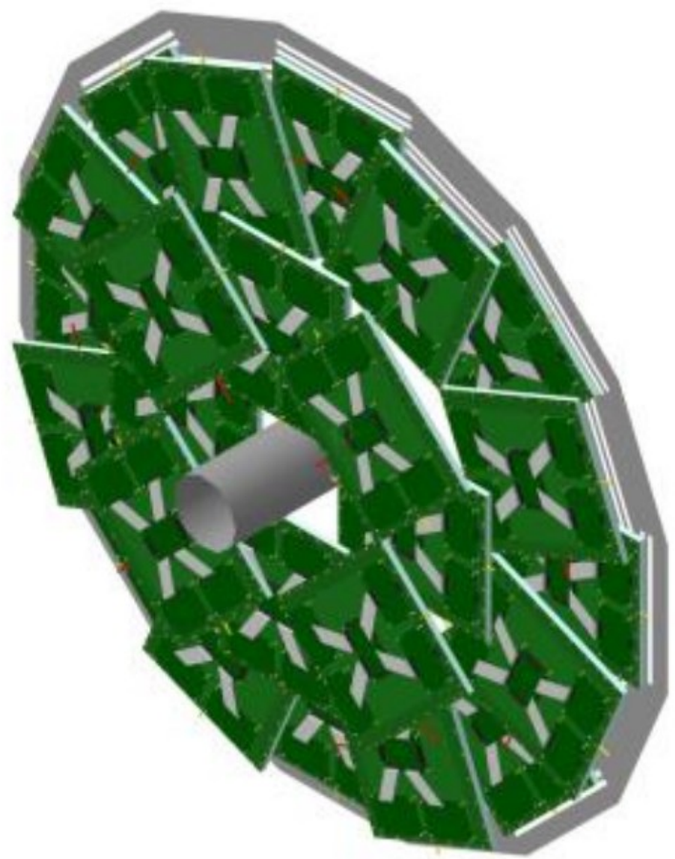
Hits from SpdRoot: Barrel





Construct TOF in SPD: End-cap

The TOF geometry of end-caps:
The article “*Time of Flight System for SPD*” by A.Semak, E.Ladygin, S.Nagorniy

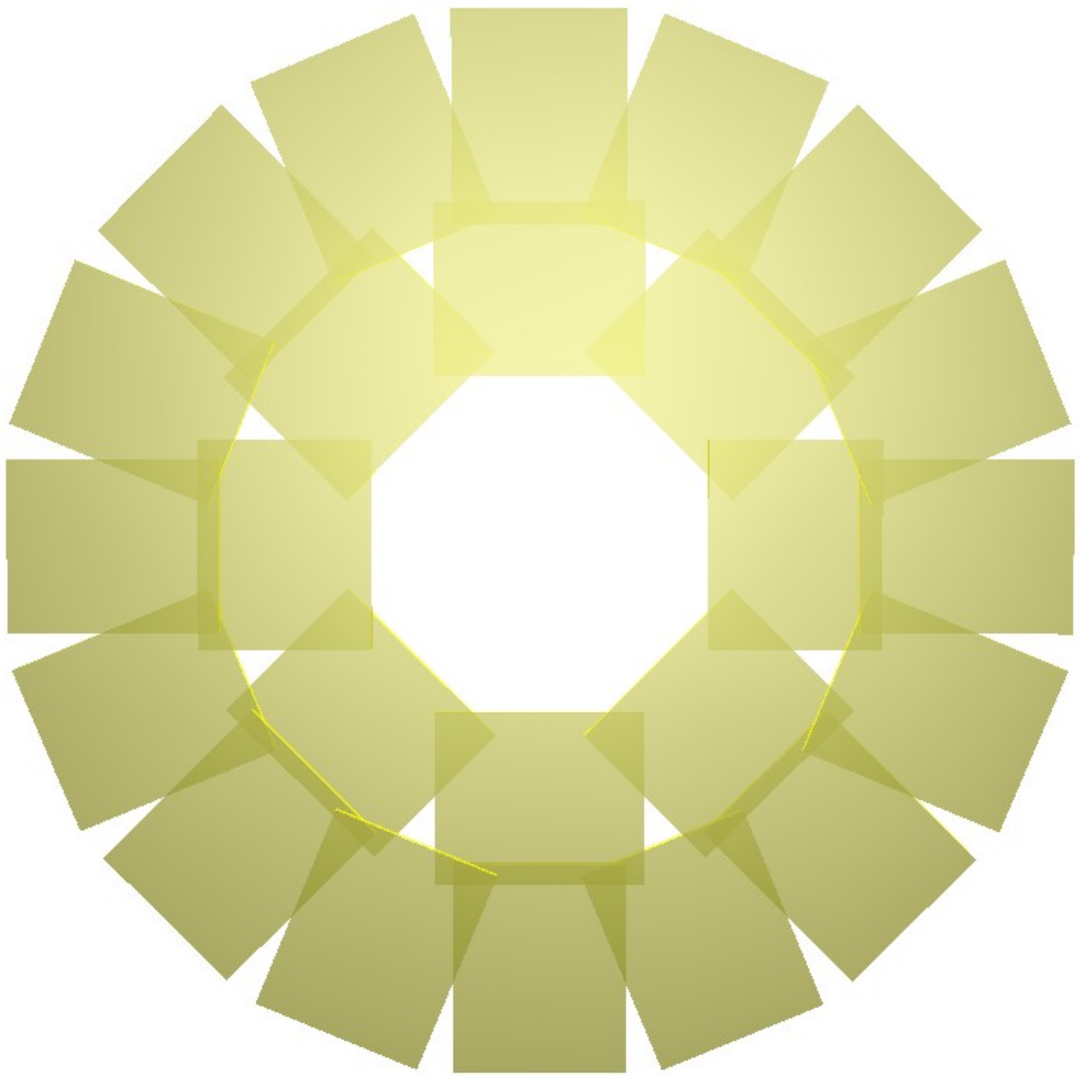


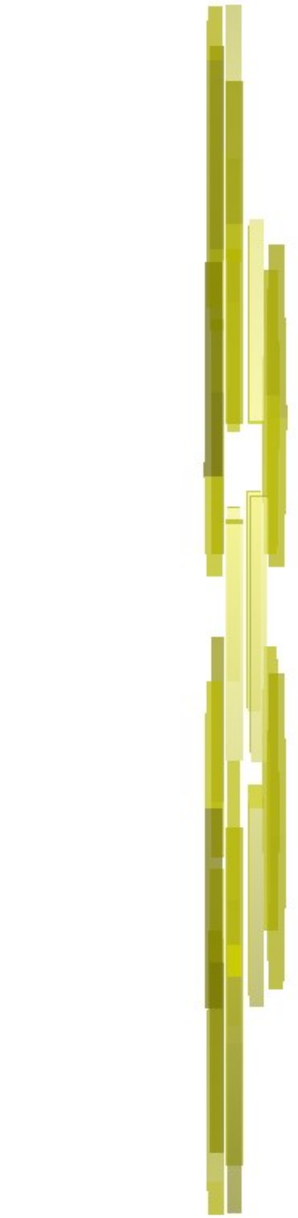
The TOF module as for barrel:
A. Semak on SPD collaboration meeting (June 10, 2021)
«*MRPC prototype chambers for TOF*»

MRPC module

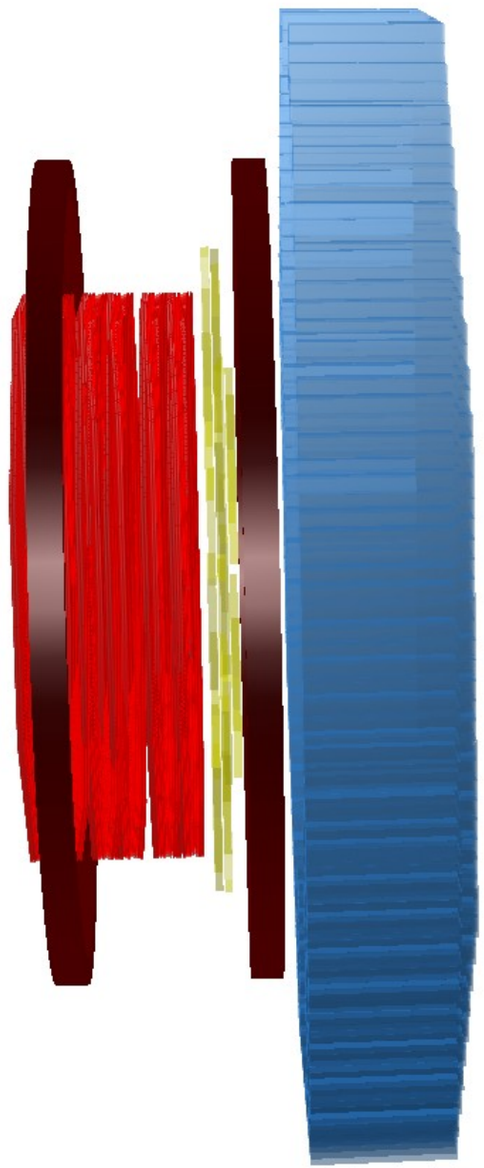
- Length=40 cm
- Width=33 cm
- Height=2.5 cm

MRPC geometry: Endcap





Simple geometry: Barrel



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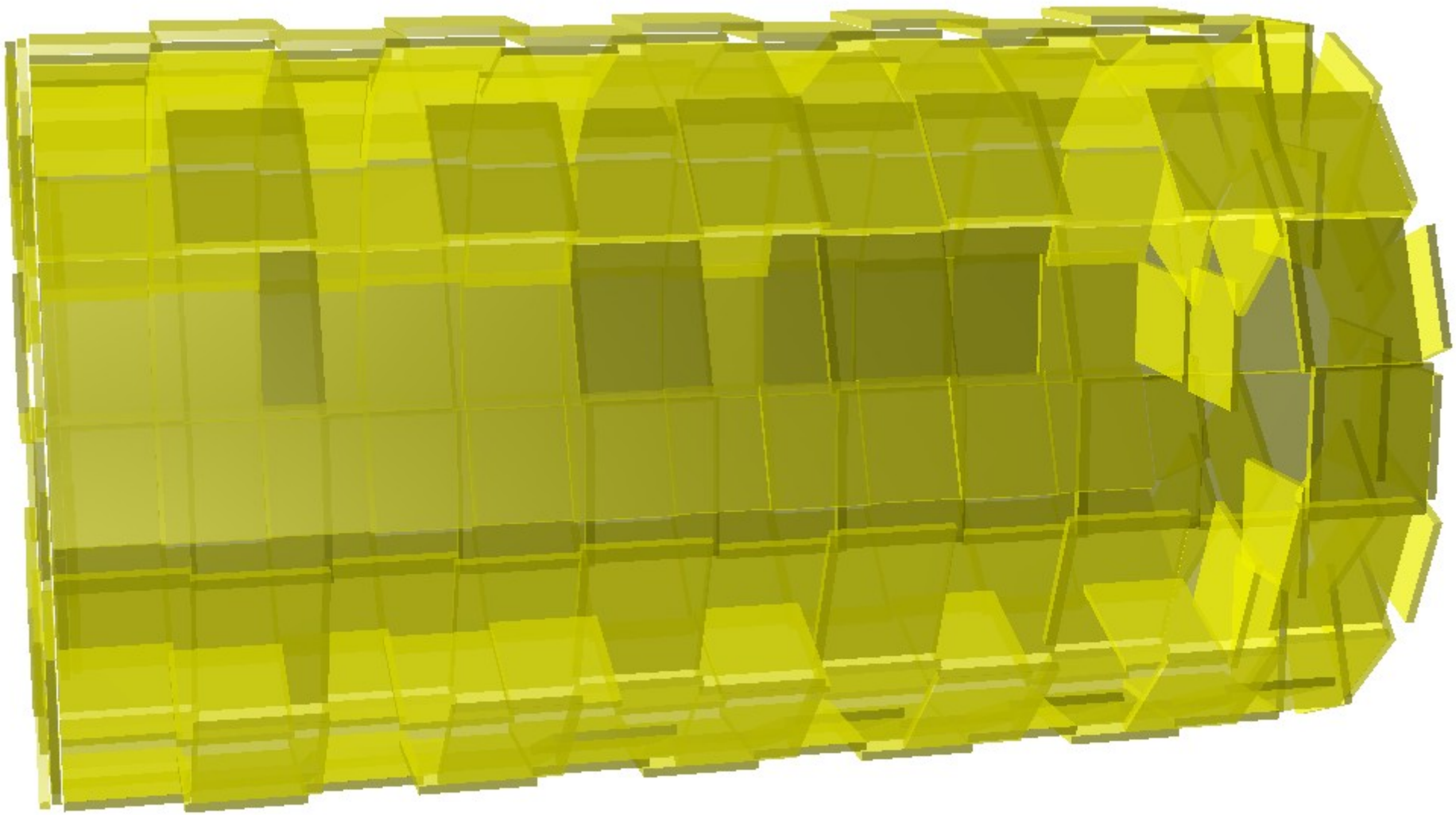
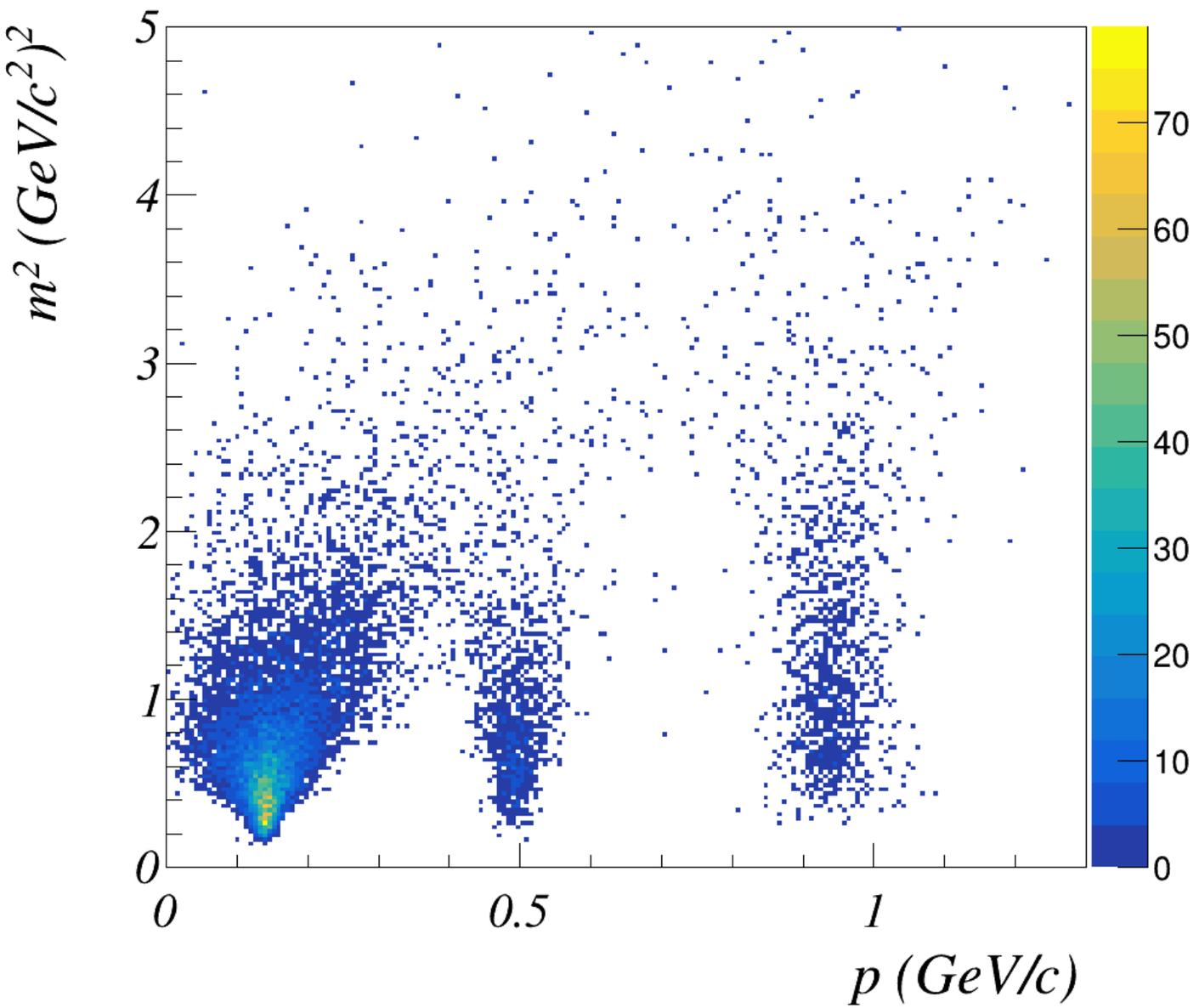
TOF-system based on the MRPC



Results with new geometry

Minimum bias *pp* 27 *GeV* events were generated (SimuQslPy8.C)



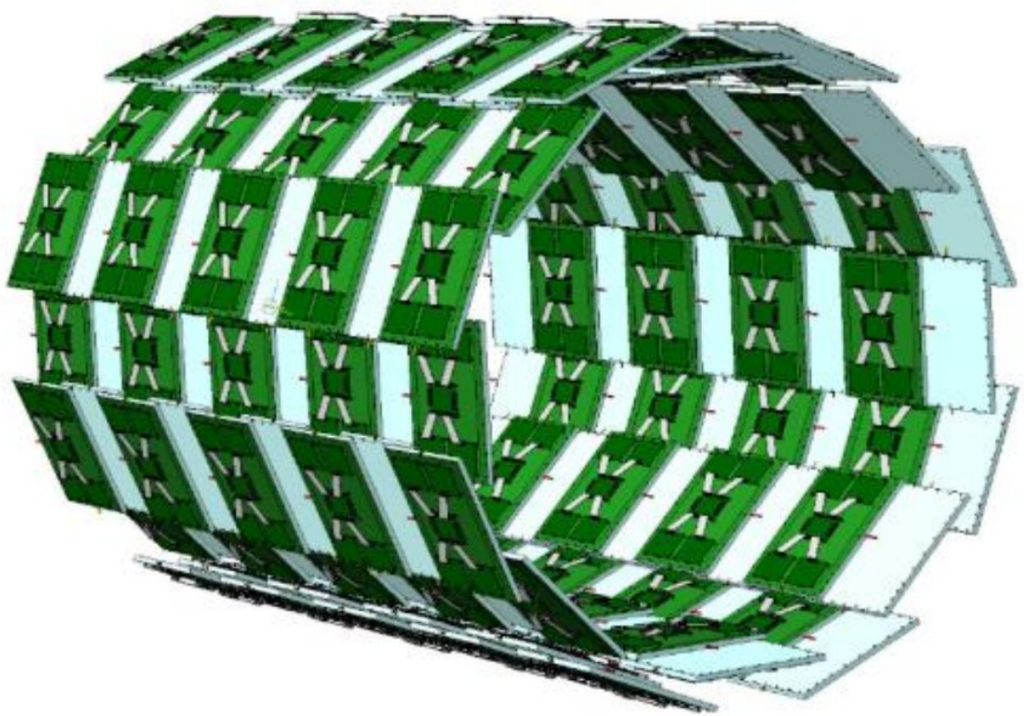
Conclusion

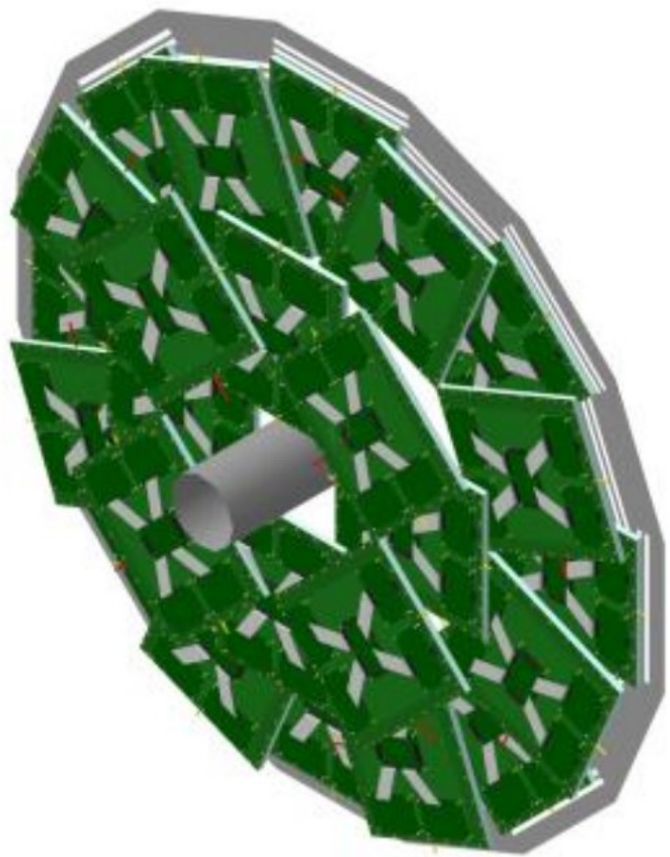
- New version of the TOF system geometry based on a MRPC module in SpdRoot was added
- Next step
  - Use size from nowadays design of TOF
  - To send code (or do merge request) on approval by Arthur

Backup

Construct TOF in SpdRoot

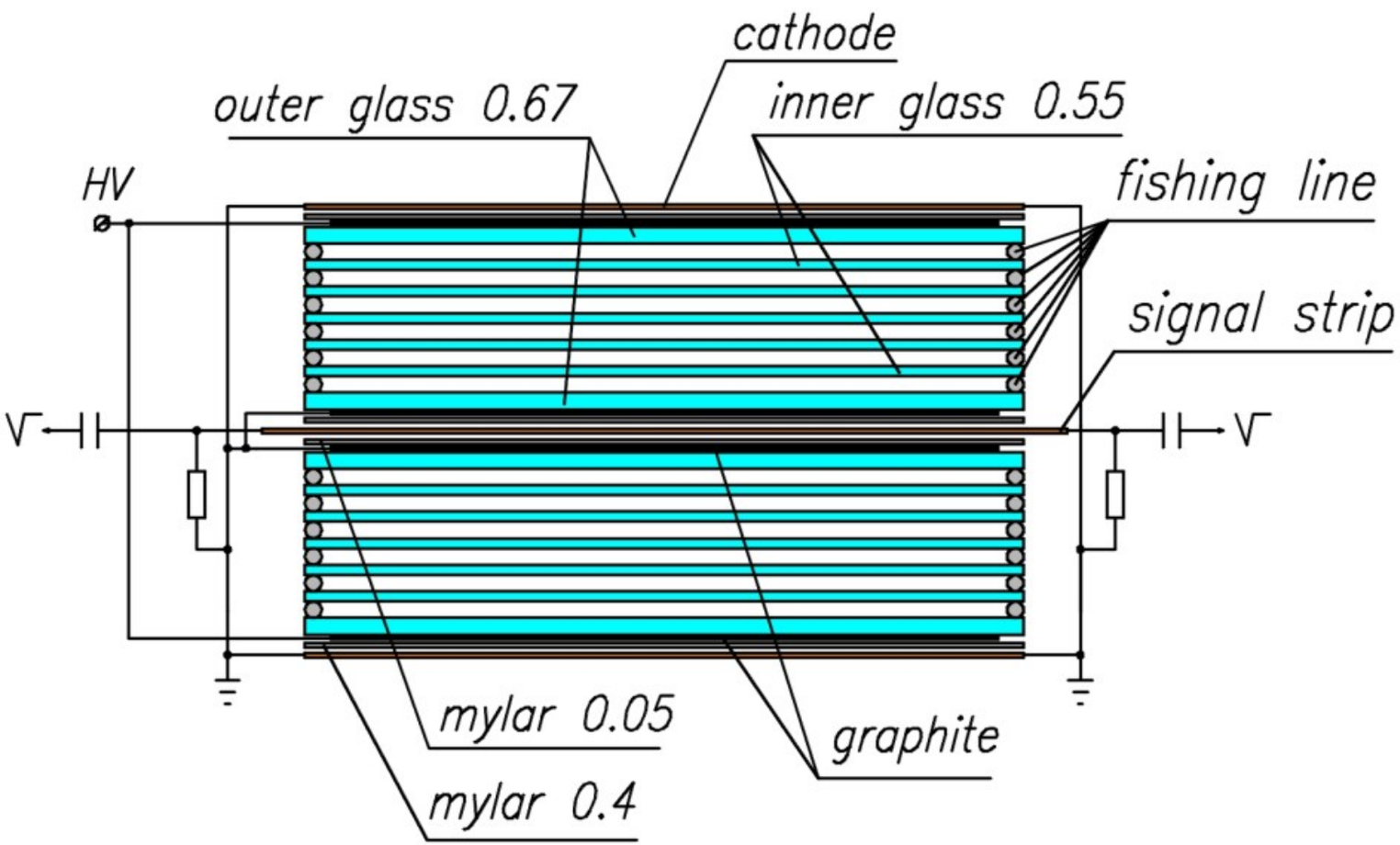
The TOF geometry from the article “*Time of Flight System for SPD*” by A.Semak, E.Ladygin, S.Nagorniy





MRPC module

Schematic view of the twelve-gap MRPC



Options of TOF system in SPD

SPD CDR
http://spd.jinr.ru/2102-00442/
page 93

MRPC **plastic scintillator**

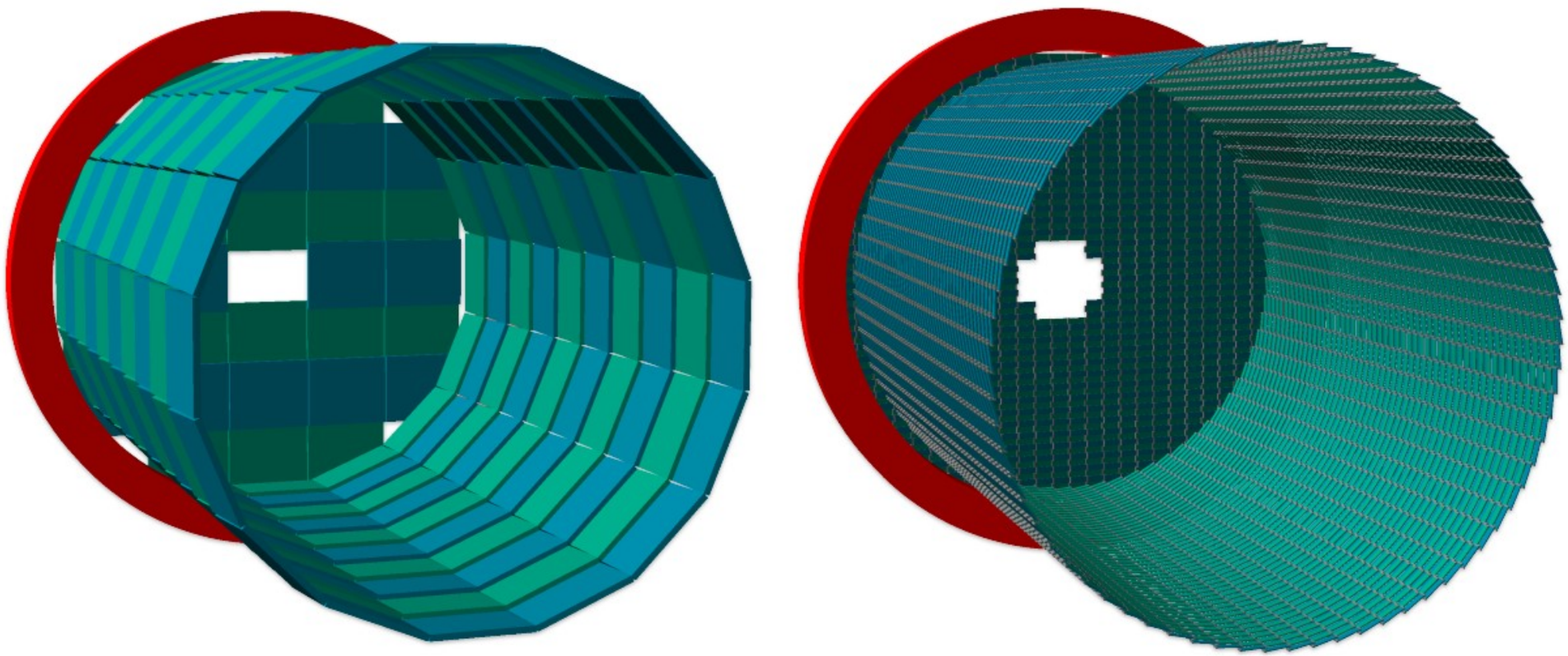


Figure 4.35: Two technologies are being considered for the time-of-flight system of SPD: the multigap Timing Resistive Plate Chamber, mRPC (left) and the plastic scintillator option (right). Barrel and one of two end-cap parts are shown for both options. One of six magnet coils limiting the volume of TOF is shown in red.

TOF in SPD SDR

SPD CDR
http://spd.jinr.ru/2102-00442/
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	MPRC	Plastic scintillator
Active area: barrel + 2×end-cap	$19.8\ m^2 + 2 \times 3.7\ m^2 = 27.1\ m^2$	
Area of readout element: pitch × length	strip $1.25\ cm \times 40\ cm = 50\ cm^2$	tile $2.9\ cm \times 9\ cm = 26.1\ cm^2$
Size of chamber or tile: W × L × H	chamber (24 strips) 33 cm × 40 cm × 2.5 cm	tile 3 cm × 9 cm × 0.5 cm
Number of chambers or tiles: barrel + 2×end-cap	chambers 160 + 2 × 30 = 220	tiles 7.3k + 2 × 1.4k = 10.1k
Number of DAQ channels	10.6k	20.2k

Table 4.8: Dimensions and numbers of the TOF elements for two technologies: mRPC and plastic scintillator.

The particle identification (PID) analysis with TOF

Mass of particle

$$m^2 = \frac{p^2}{c^2}\left[\frac{t^2 c^2}{L^2} - 1\right]$$

$$\sigma^2_{m^2} = 4m^4\left(\frac{\sigma_p}{p}\right)^2 + 4E^4\left(\frac{\sigma_t}{t}\right)^2 + 4E^4\left(\frac{\sigma_L}{L}\right)^2$$