

Time-of-Flight system in SpdRoot: Protvino and Tsinghua

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SPD S&C meeting
26.10.2021

The purpose of the report

- Adding in SpdRoot TOF geometry options from Protvino and from Tsinghua
- The comparison of geometries

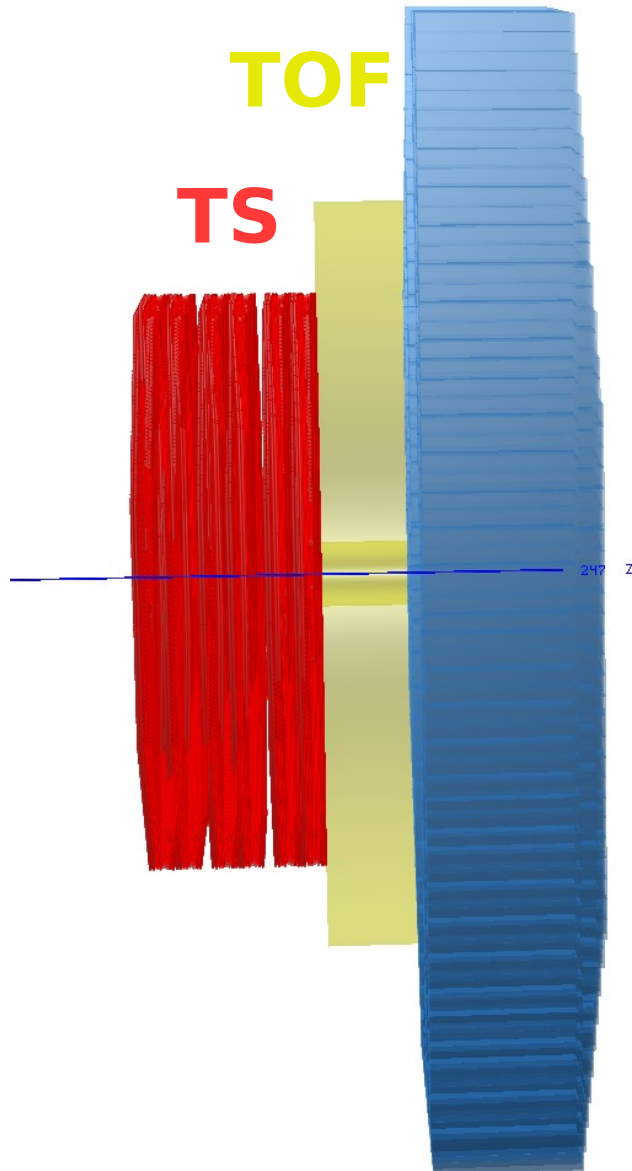
TOF system in SpdRoot

End-cap

ECAL

TOF

TS



Barrel

TS

TOF

Magnet



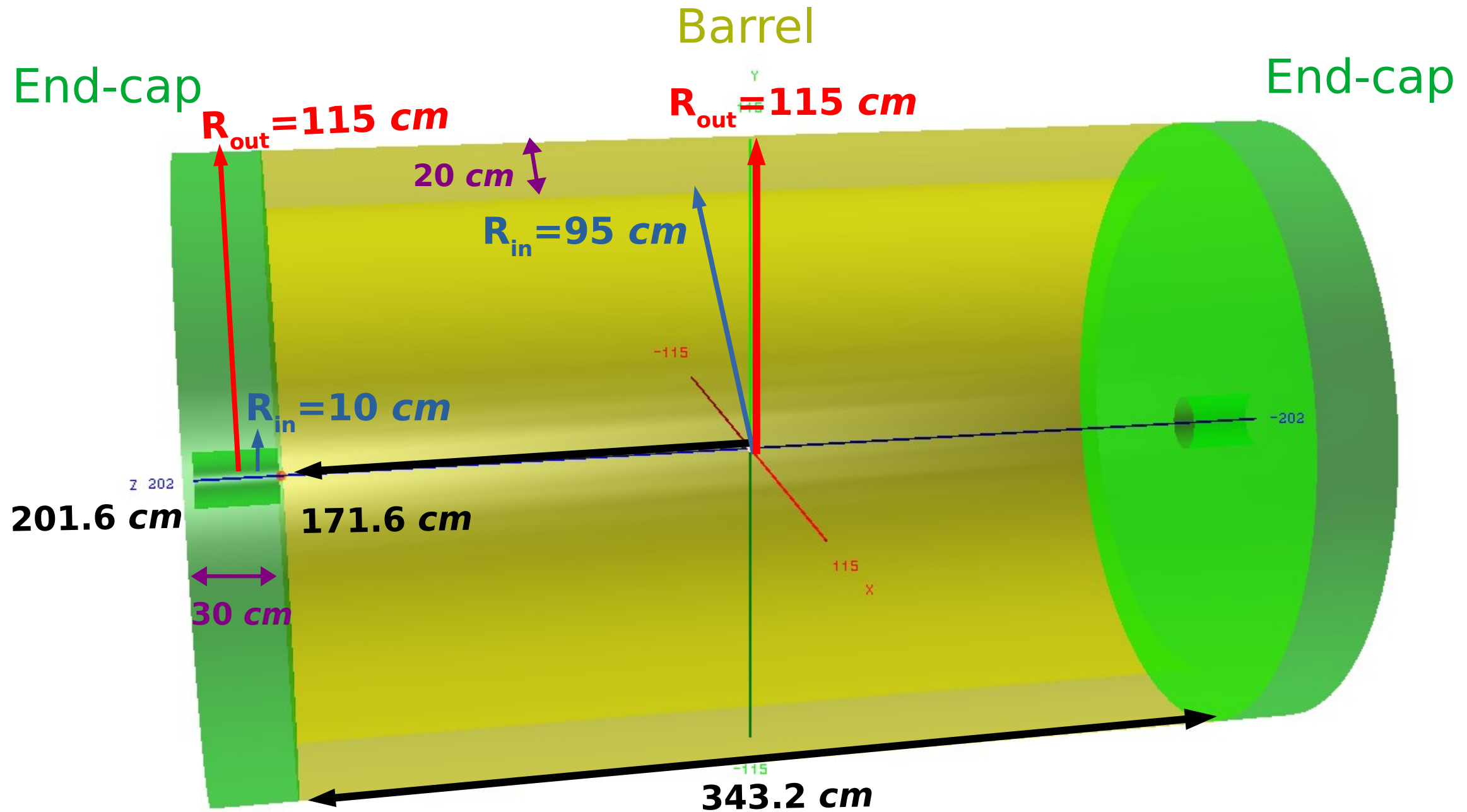
TOF system in SpdRoot: Simple geometry

spdroot/common/SpdCommonGeoMapper.cxx

```
65  /*===== TIME-OF-FLIGHT SYSTEM (BARREL) =====*/
66
67  Int_t      SpdCommonGeoMapper::theTofBDefGeoType      = 1;
68  TString    SpdCommonGeoMapper::theTofBBaseMaterial    = "air";
69  Double_t   SpdCommonGeoMapper::theTofBLength         = 343.2; // cm
70  Double_t   SpdCommonGeoMapper::theTofBSize           = 115.; // cm
71  Double_t   SpdCommonGeoMapper::theTofBWidth          = 20.; // cm
72
73  /*===== TIME-OF-FLIGHT SYSTEM (ENDCAPS) =====*/
74
75  Int_t      SpdCommonGeoMapper::theTofECDefGeoType     = 1;
76  TString    SpdCommonGeoMapper::theTofECBaseMaterial   = "air";
77  Double_t   SpdCommonGeoMapper::theTofECThickness      = 30.; // cm
78  Double_t   SpdCommonGeoMapper::theTofECSize           = 115.; // cm
79  Double_t   SpdCommonGeoMapper::theTofECWidth          = 105.; // cm
80  Double_t   SpdCommonGeoMapper::theTofECMinDist        = 171.6; // cm
81
```

TOF system in SpdRoot: Simple geometry

TOF cylinders in SpdRoot are placed all available space between detectors



Actual SPD sizes on 20.10.2021

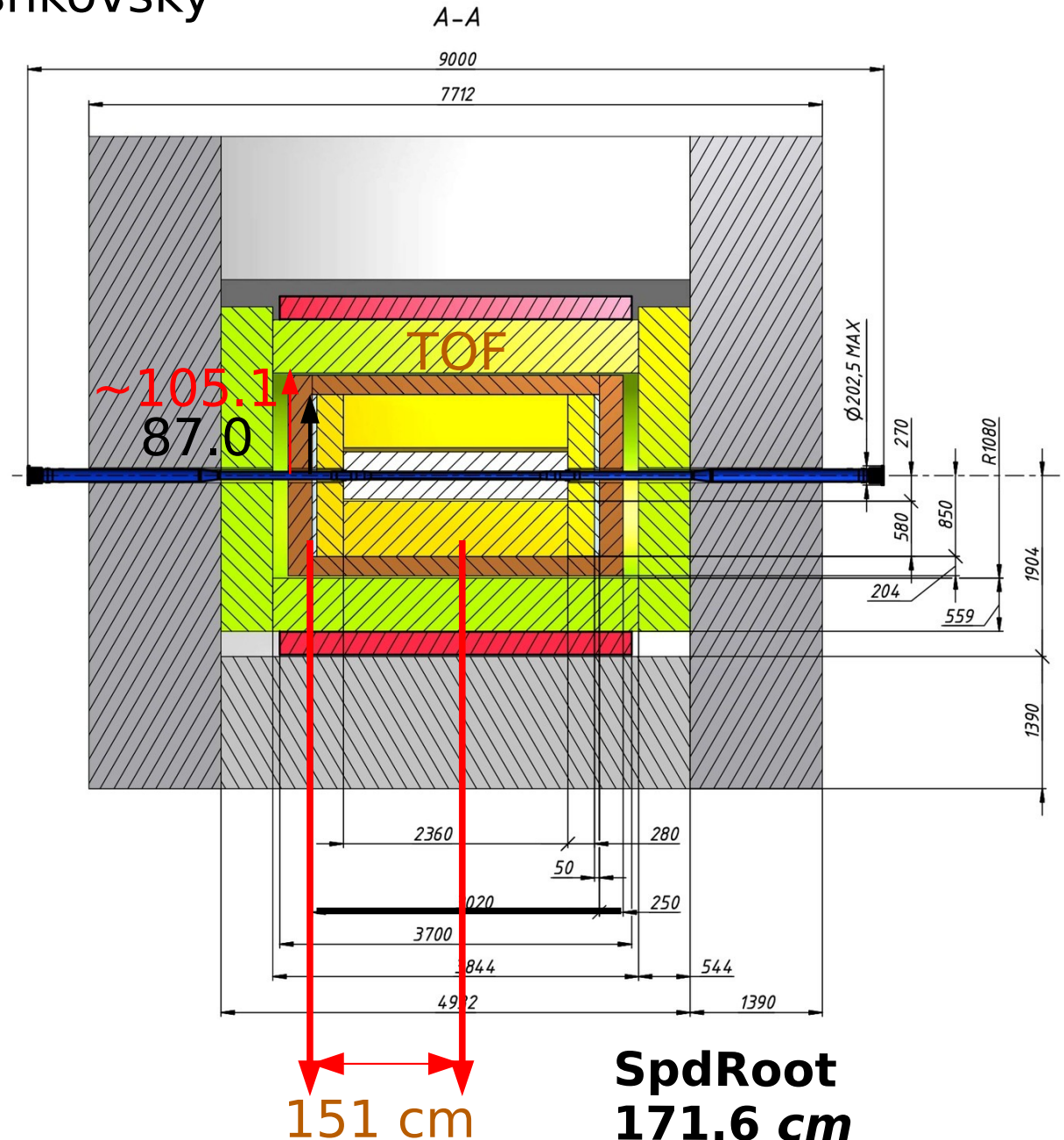
From Ivan Moshkovsky

Table — Radial sizes of SPD layers

№	Layer	Y, mm		
		ΔR	R min/max	Ø min/max
1	Beampipe	64	0/64	0/128
2	VD	186	64/250	128/500
3	Gap 1	20/42	-	-
4	TS	580	270/850	540/1700
5	Gap 2	20	-	-
6	TOF	181	870/1051	1740/2102
7	Gap 3	10/31	-	-
8	Ecal	564	1080/1644	2160/3288
9	Gap 4	20	-	-
10	Magnet	220	1664/1884	3328/3768
11	Gap 5	20/176	-	-
12	RS	1390	1904/3294	3808/6588

87.0 - ~105.1 cm

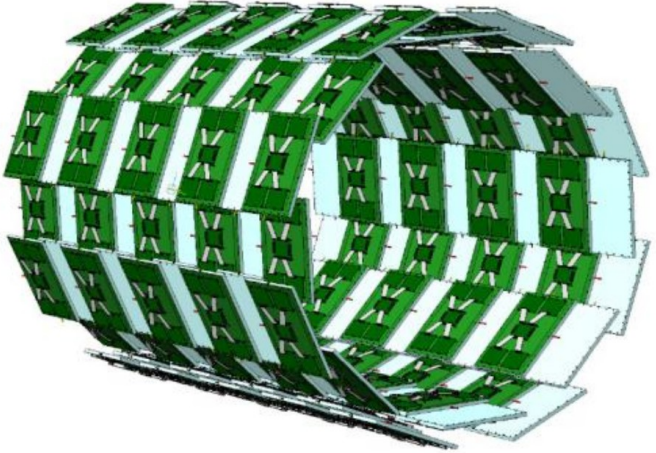
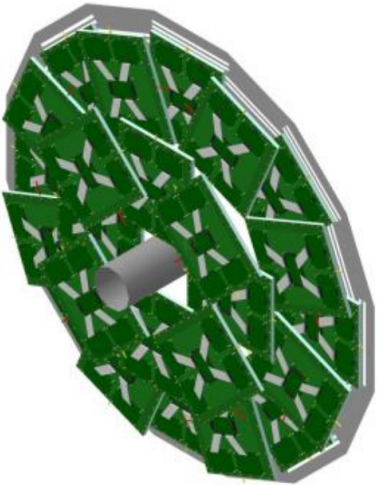
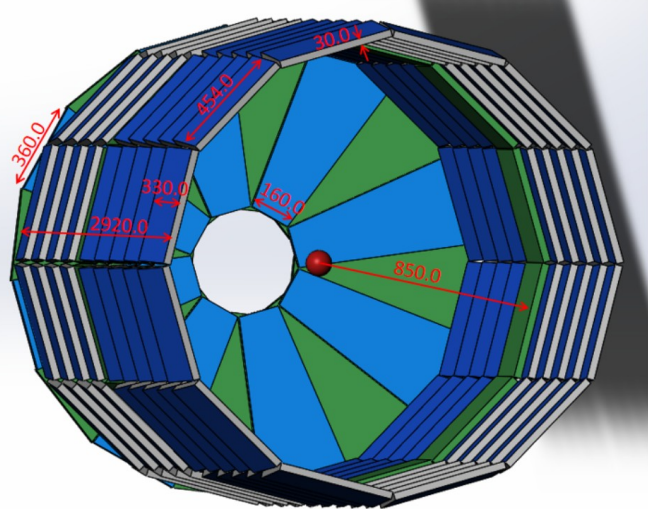
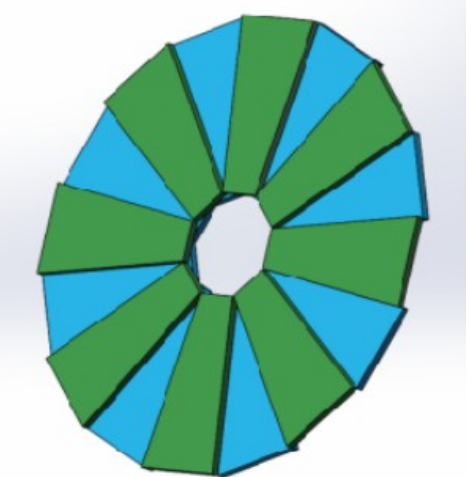
SpdRoot
95 - 115 cm



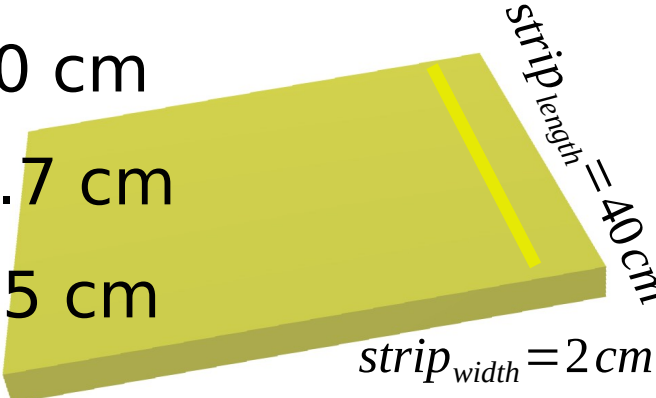
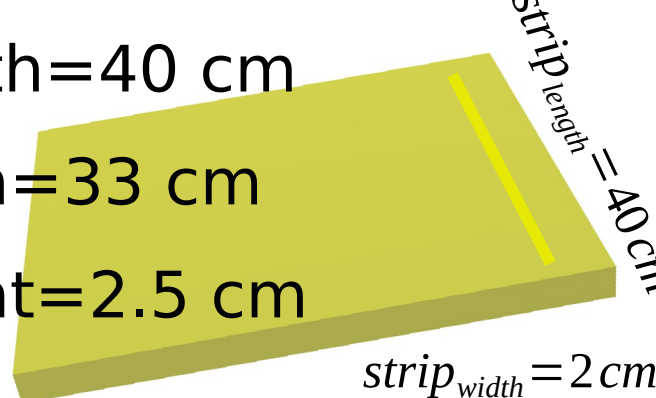
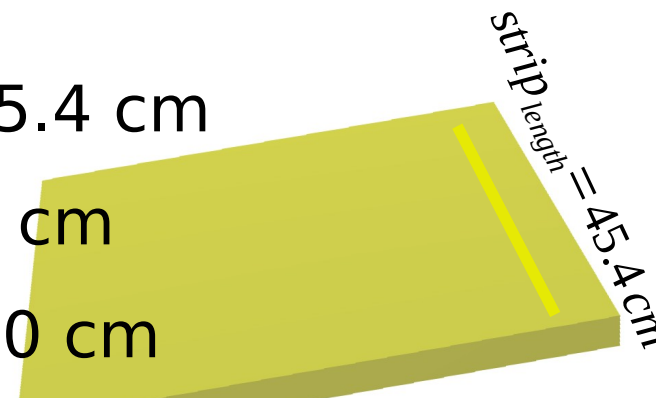
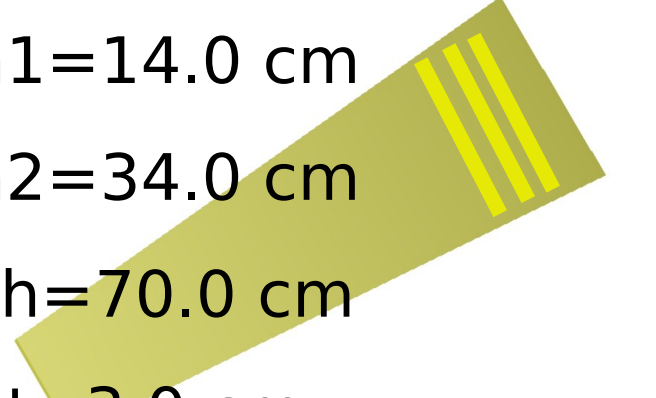
151 cm

SpdRoot
171.6 cm

TOF system: Tsinghua and Protvino

geometry	Barrel	End-cap
Protvino		
Tsinghua		

TOF system: Tsinghua and Protvino

Module active area	Barrel	End-cap
<p>Protvino</p>	<p>Length=40 cm Width=33.7 cm Height=2.5 cm</p>  <p>strip_{length} = 40 cm strip_{width} = 2 cm</p>	<p>Length=40 cm Width=33 cm Height=2.5 cm</p>  <p>strip_{length} = 40 cm strip_{width} = 2 cm</p>
<p>Tsinghua</p>	<p>Length=45.4 cm Width=33 cm Height=3.0 cm</p>  <p>strip_{length} = 45.4 cm strip_{width} = 1 cm</p>	<p>Width1=14.0 cm Width2=34.0 cm Length=70.0 cm Height=3.0 cm</p>  <p>strip_{width} = 1 cm</p>

TOF system: Tsinghua and Protvino

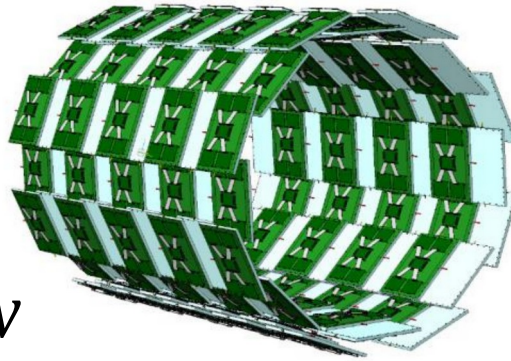
Number of modules

Barrel

End-cap

Protvino

$$16_m \times 9_{row}$$



number of readout strips
 $16_{strip} \times 144_{module} = 2304_{strip}$

144_m

$$24_m \times 2_{chamber}$$

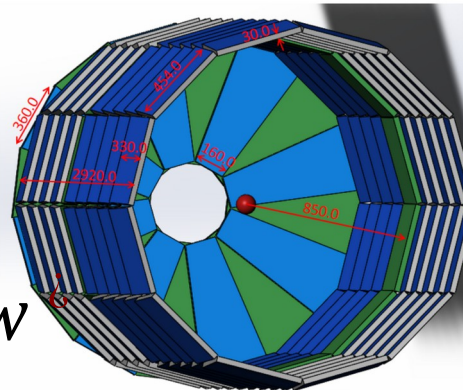


number of readout strips
 $16_{strip} \times 48_{module} = 768_{strip}$

48_m

Tsinghua

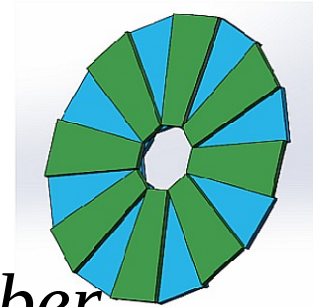
$$12_m \times 10_{row}$$



number of readout strips
 $24_{strip} \times 120_{module} = 2880_{strip}$

120_m

$$16_m \times 2_{chamber}$$

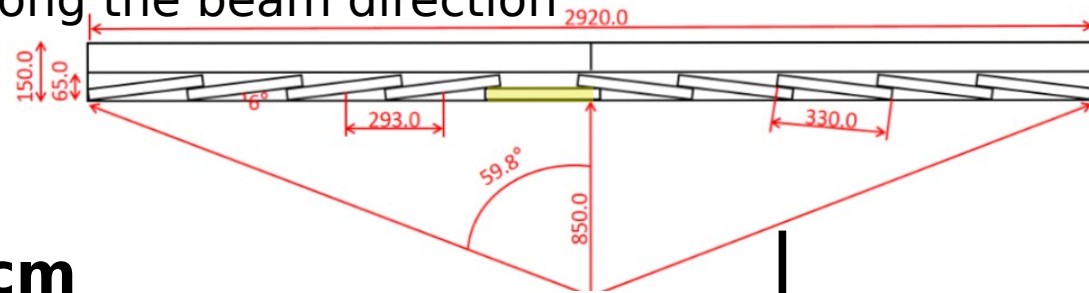


number of readout strips
 $48_{strip} \times 32_{module} = 1536_{strip}$

32_m

Tsinghua TOF system: Barrel

along the beam direction

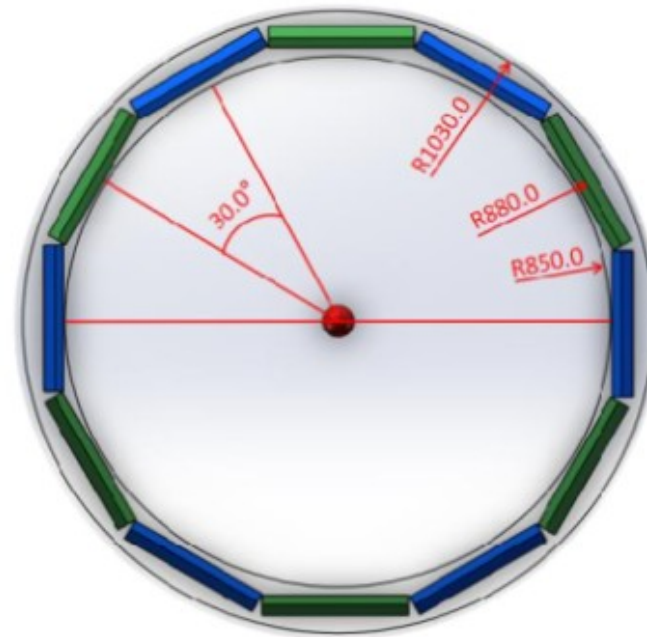
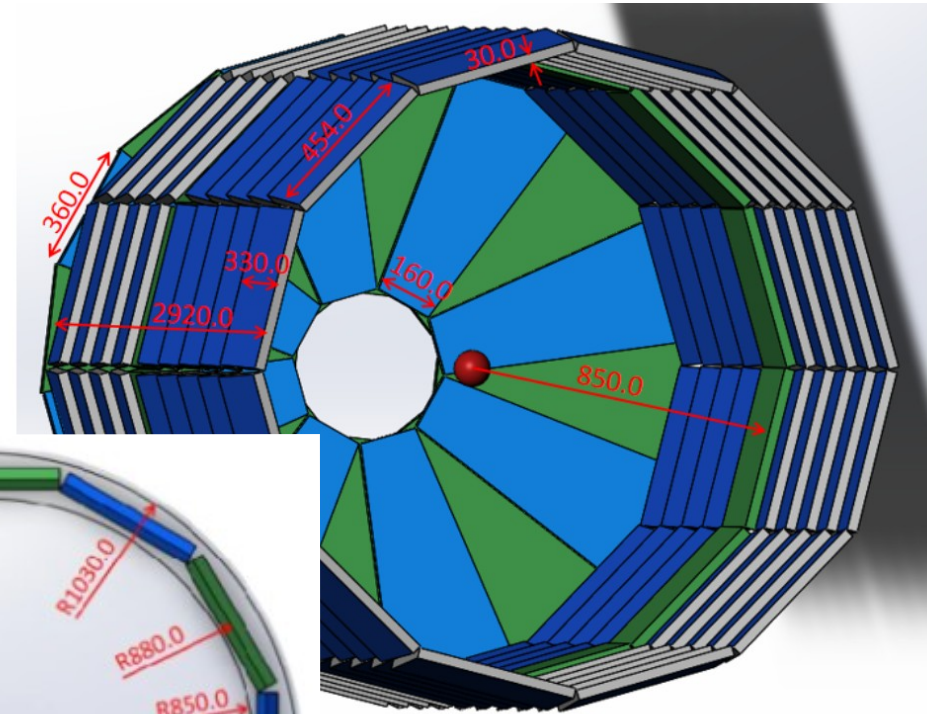
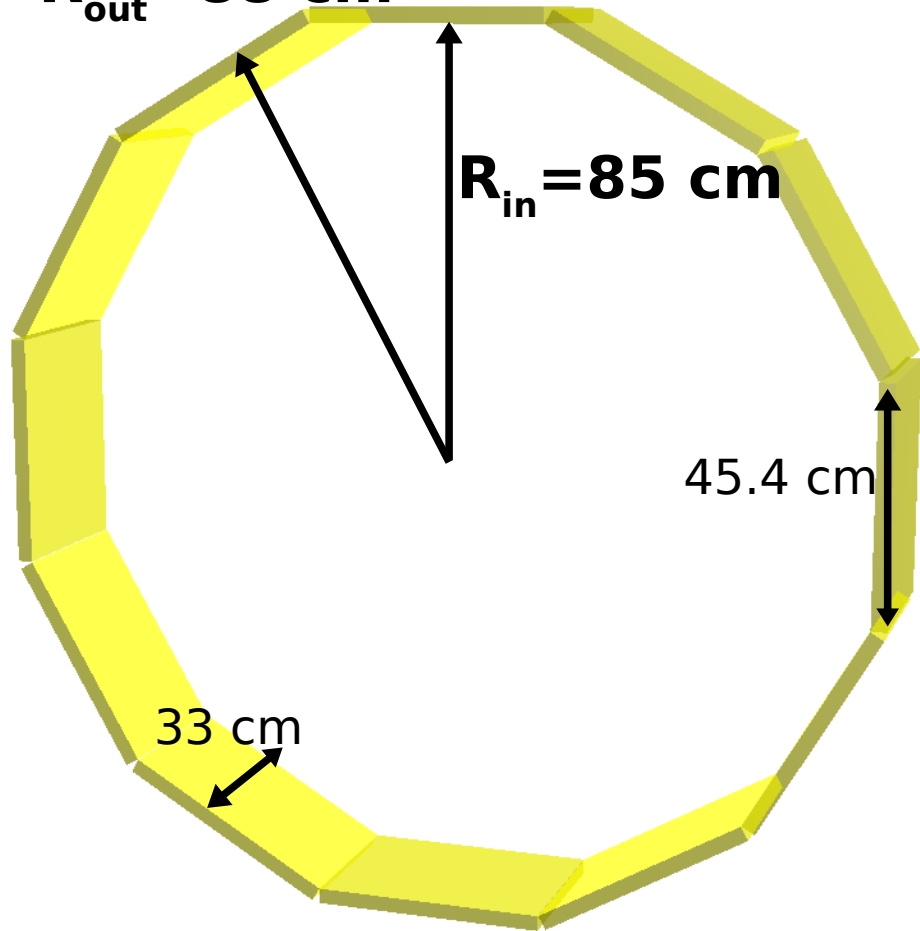


$R_{out} = 88 \text{ cm}$

$R_{in} = 85 \text{ cm}$

45.4 cm

33 cm

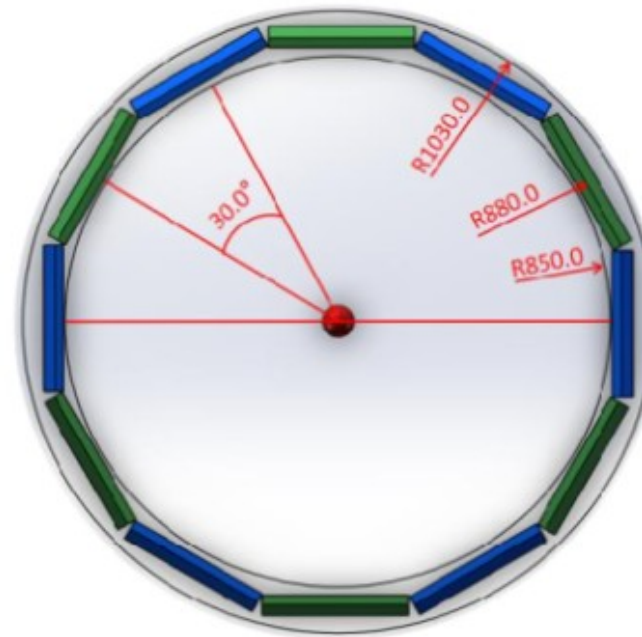
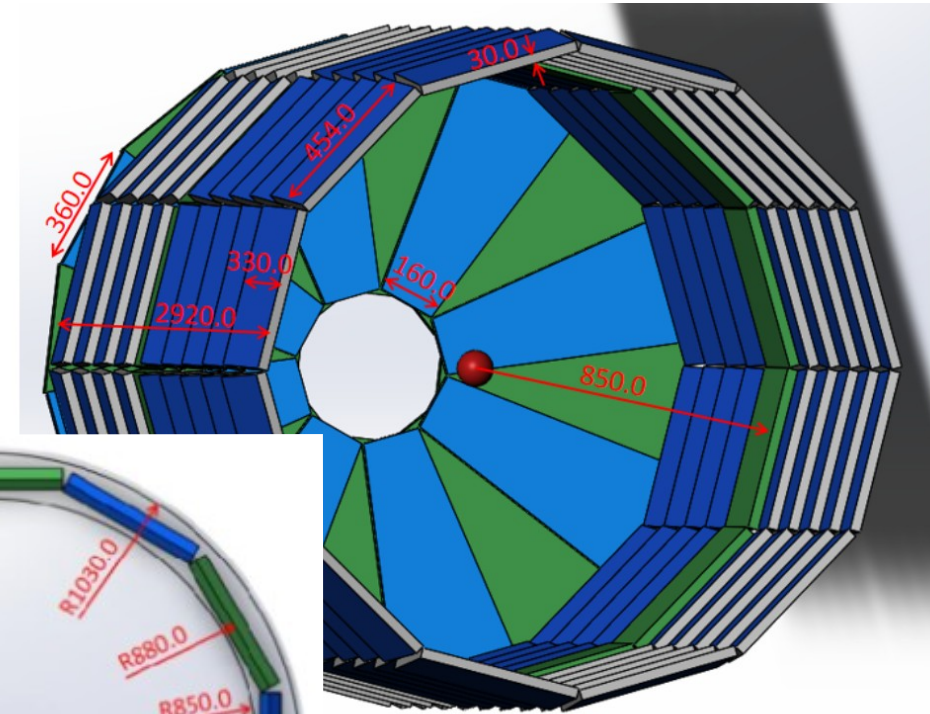
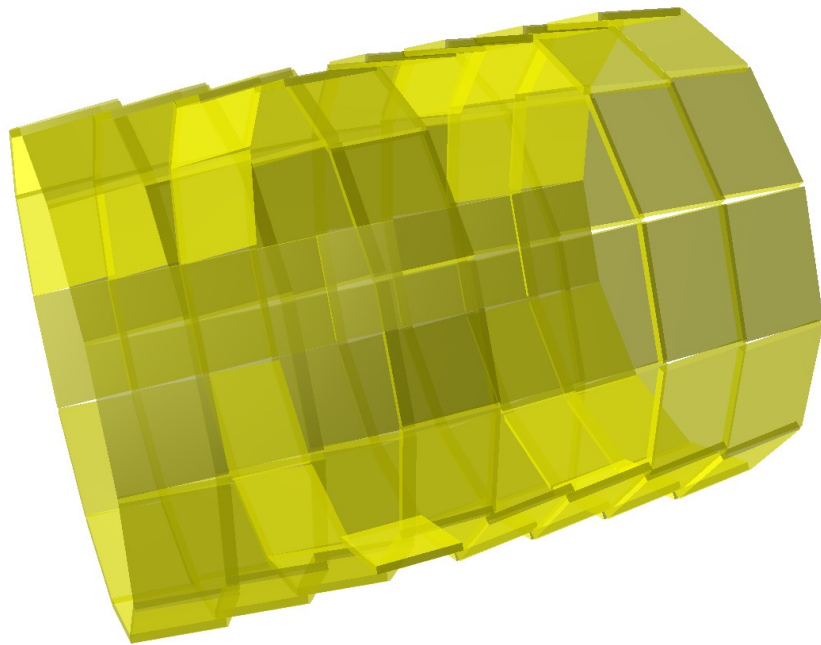
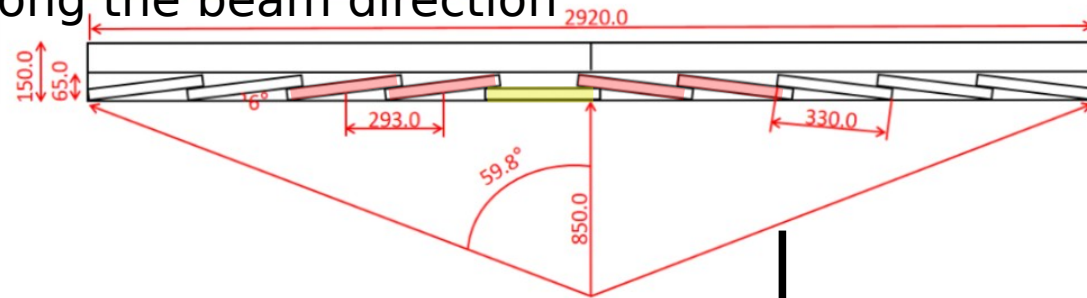


Wang Yi on SPD collaboration meeting (June 10, 2021)
 «Development of high resolution TOF system»

New geometry in SpdRoot

Tsinghua TOF system: Barrel

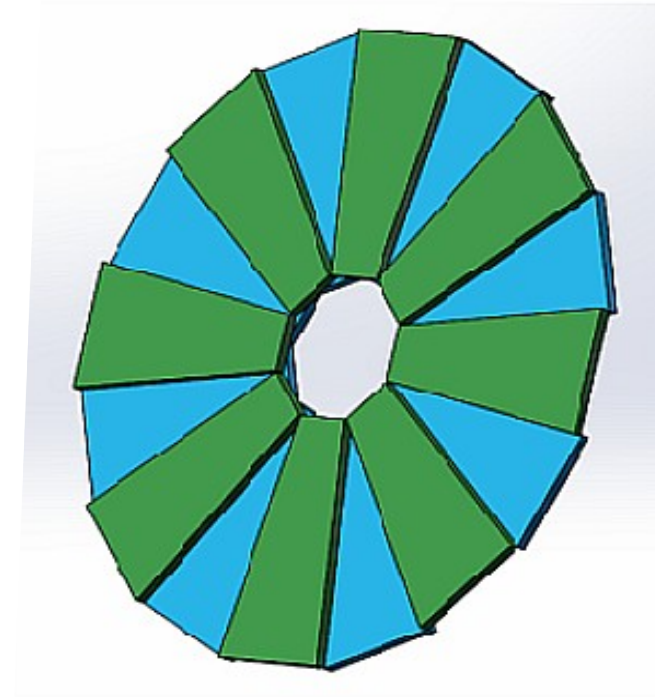
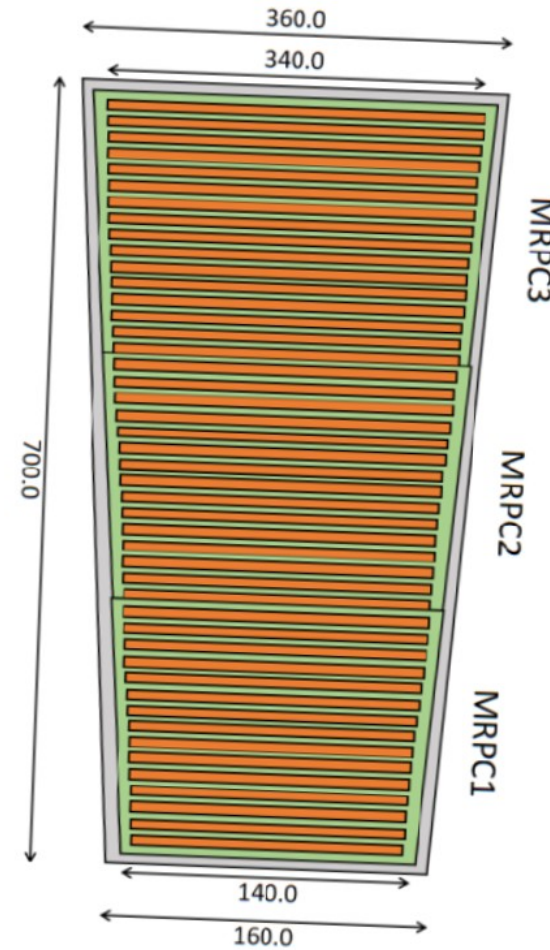
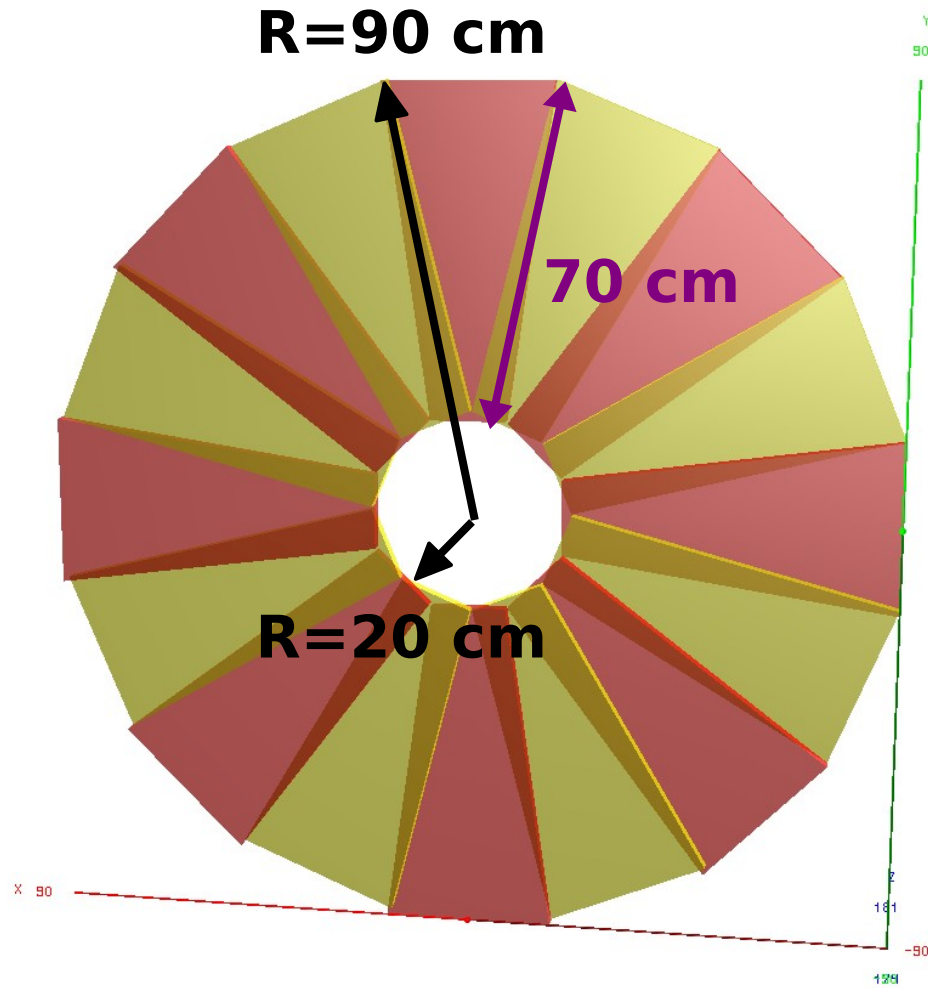
along the beam direction



New geometry in SpdRoot

Wang Yi on SPD collaboration meeting (June 10, 2021)
«Development of high resolution TOF system»

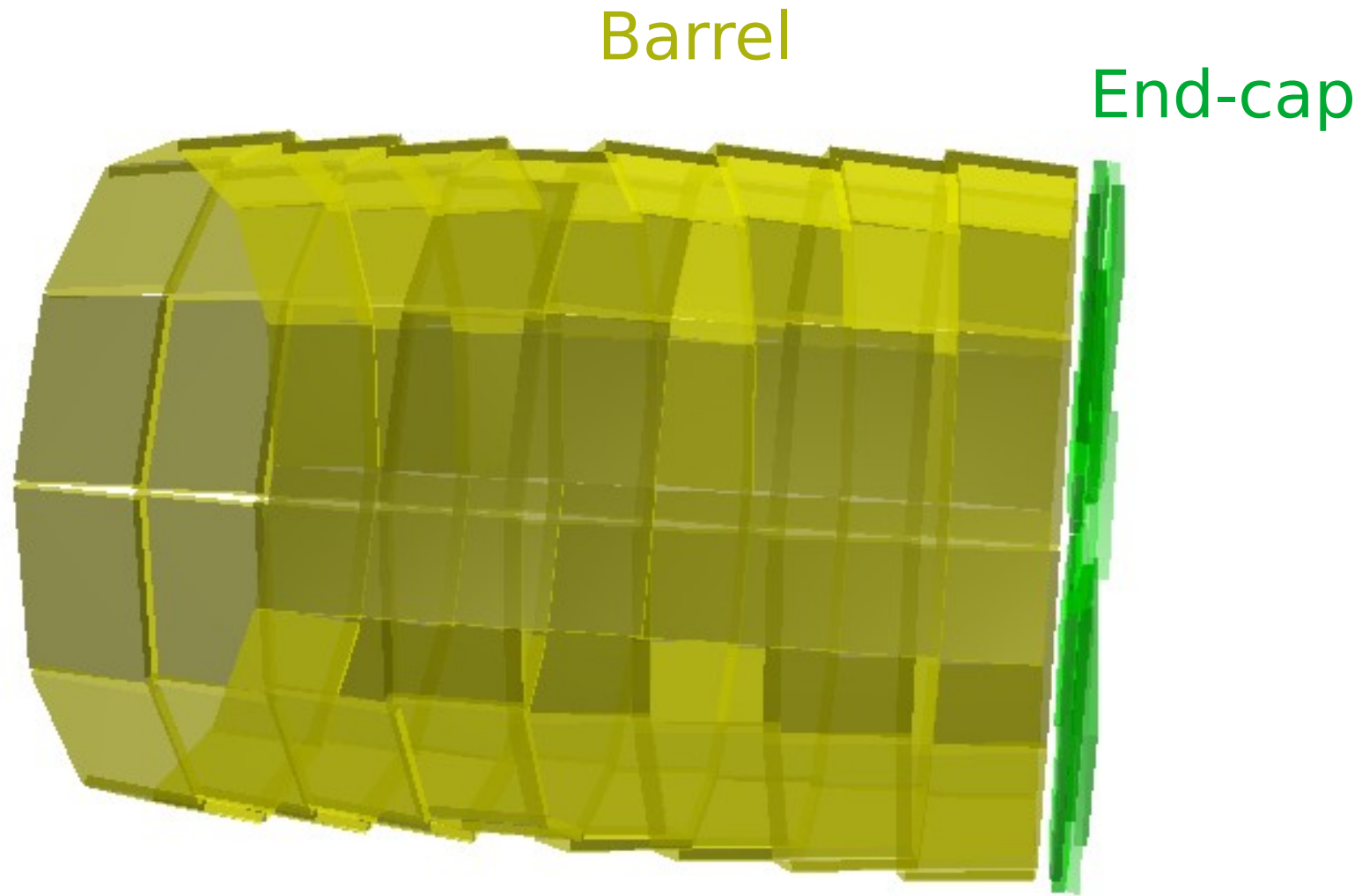
Tsinghua TOF system: End-cap



New geometry in SpdRoot

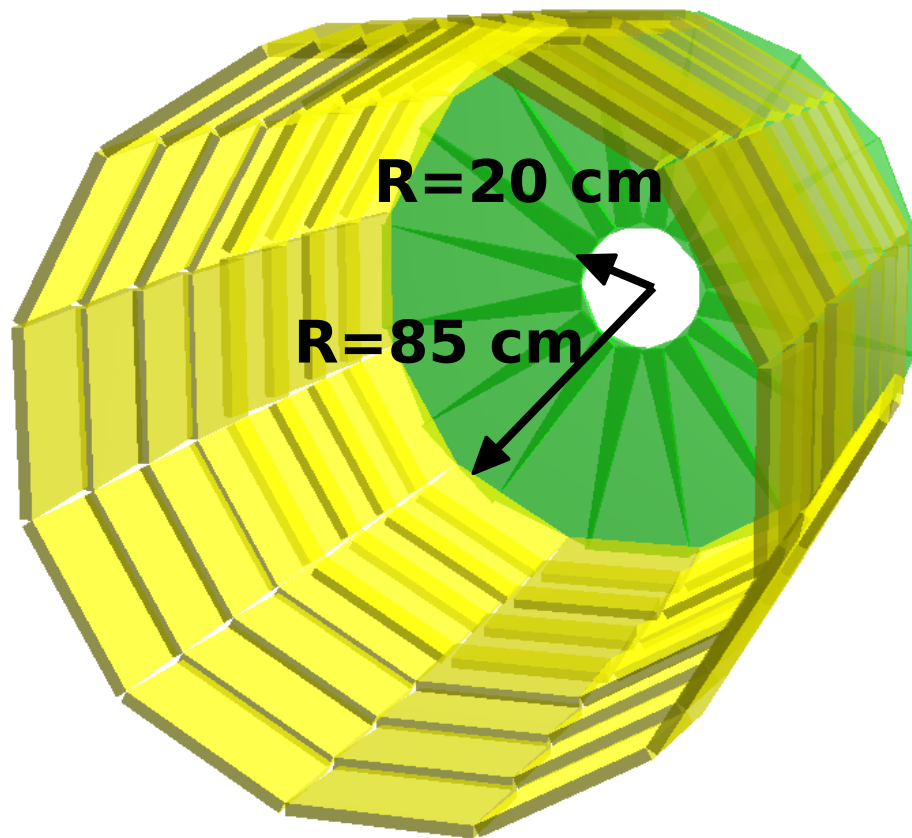
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Tsinghua TOF system: Barrel and End-cap



Tsinghua TOF system: Barrel and End-cap

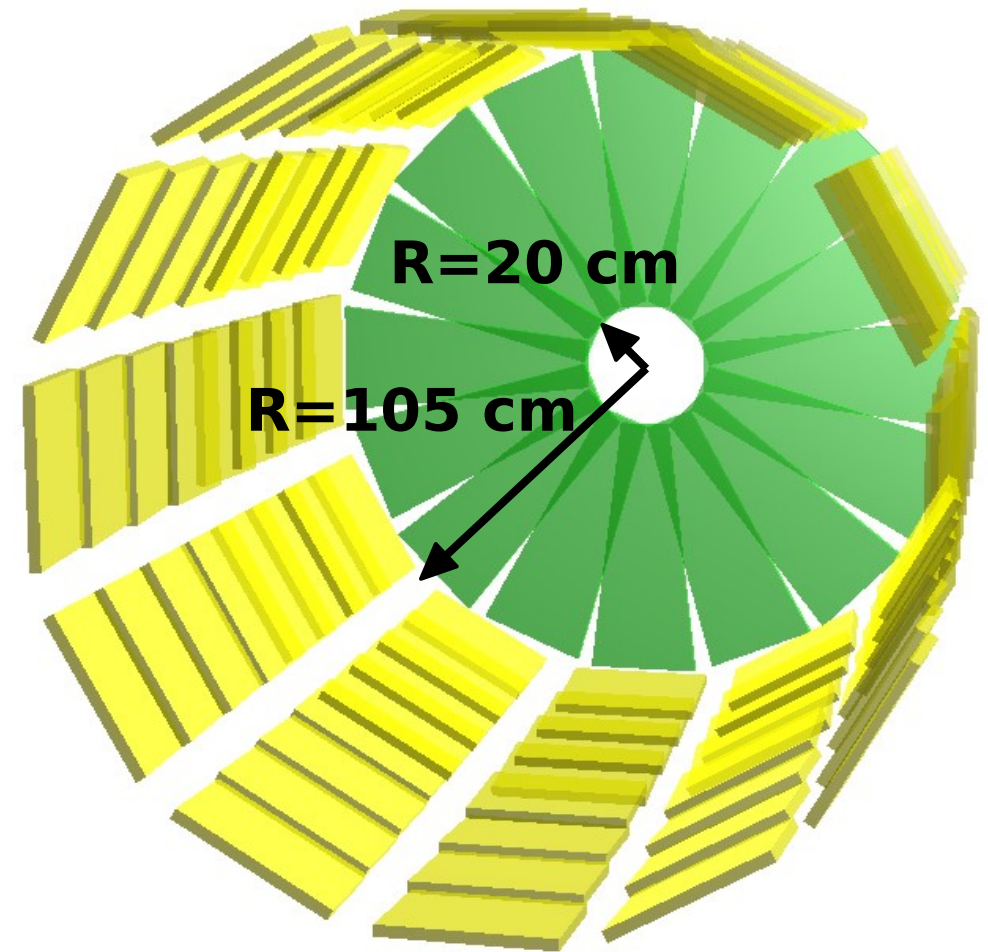
Proposal from Tsinghua



Module (Barrel)	Module (End-cap)
Length=45.4 cm	Width1=14.0 cm
Width=33 cm	Width2=34.0 cm
Height=3.0 cm	Length=70.0 cm
	Height=3.0 cm

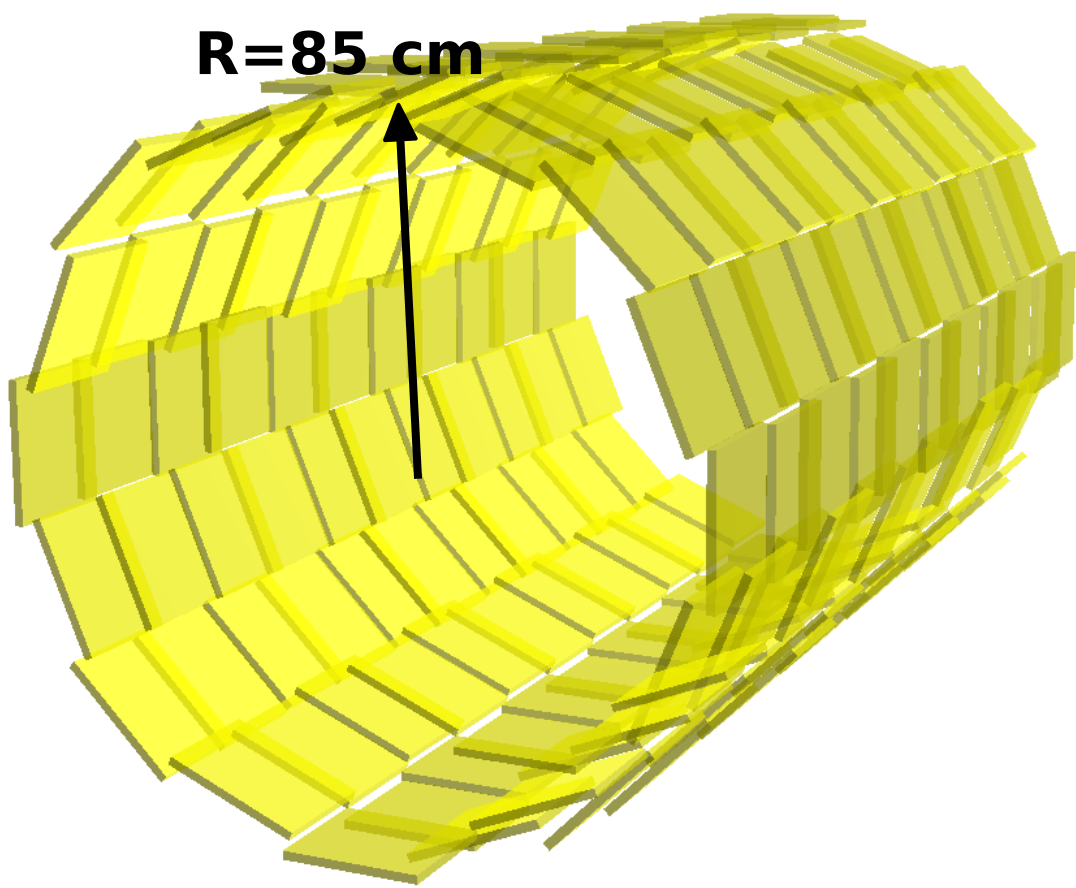
(95-115)

R=85 (proposal) → 105 as in SpdRoot

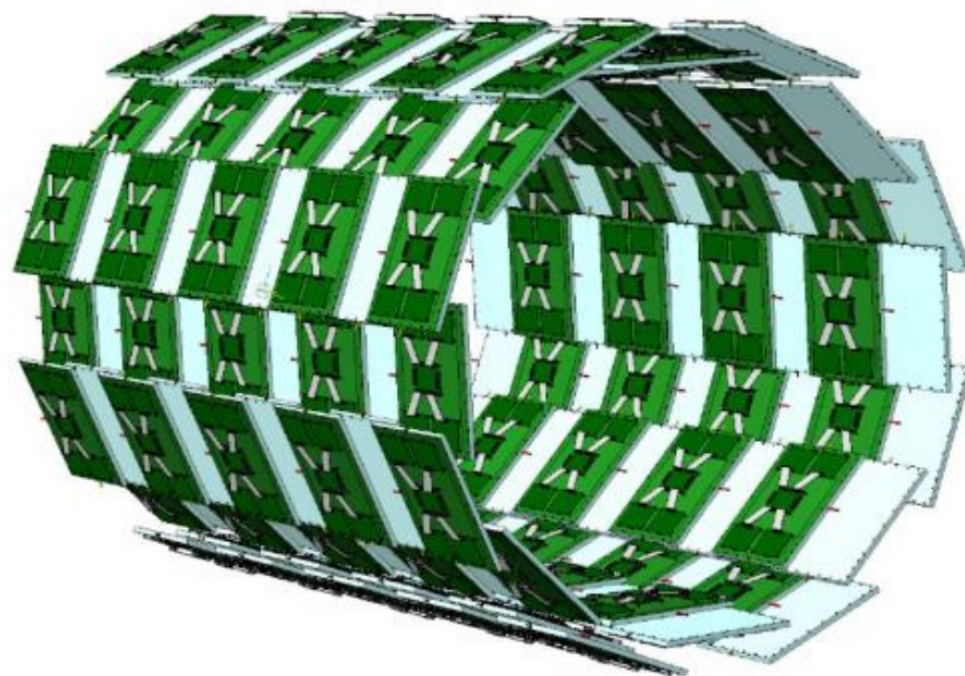
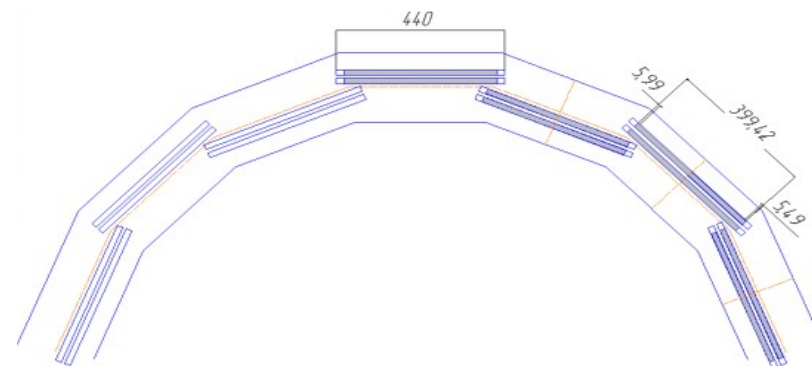


Size module as from proposal Wang

Protvino TOF system: Barrel

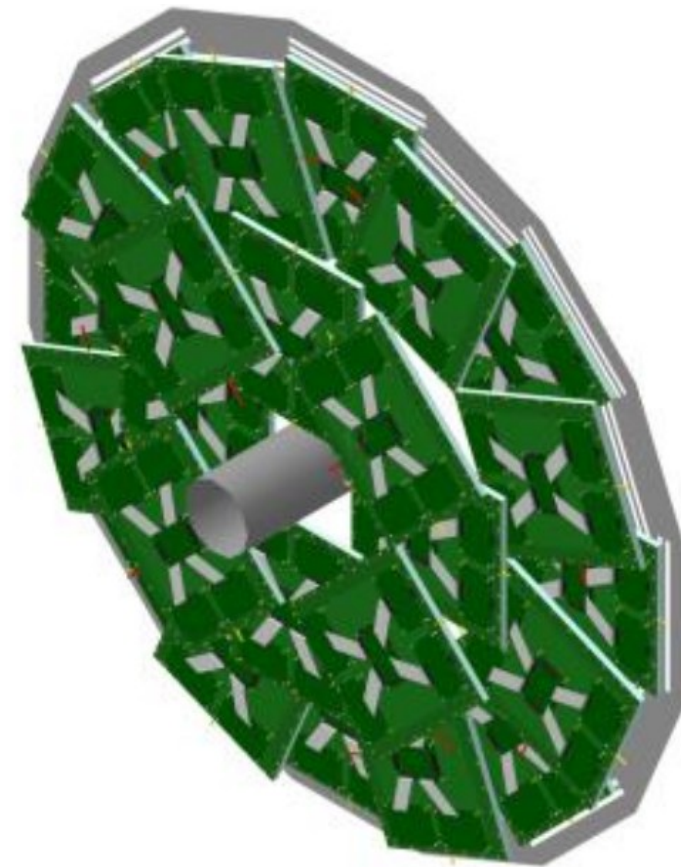
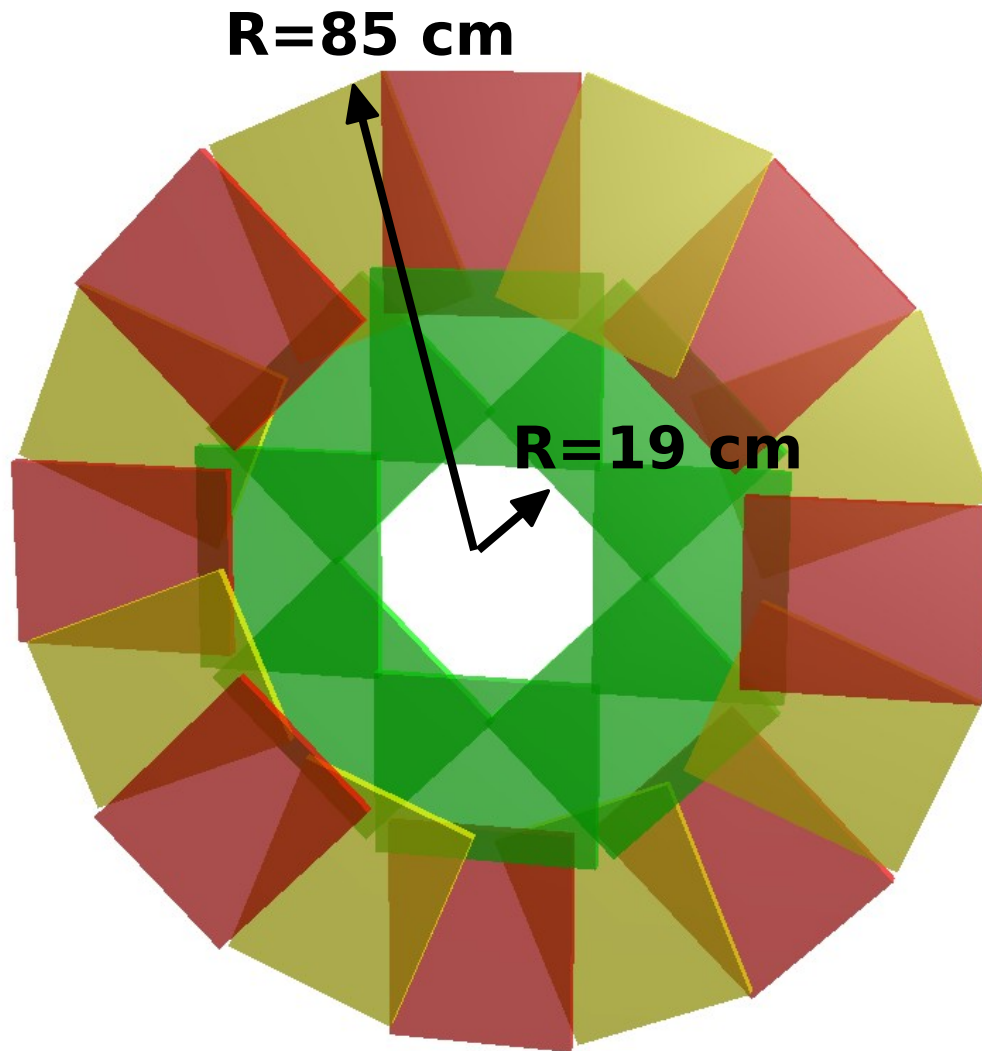


New geometry in SpdRoot



A. Semak on SPD collaboration meeting (June 10, 2021)
«MRPC prototype chambers for TOF»

Protvino TOF system: End-cap

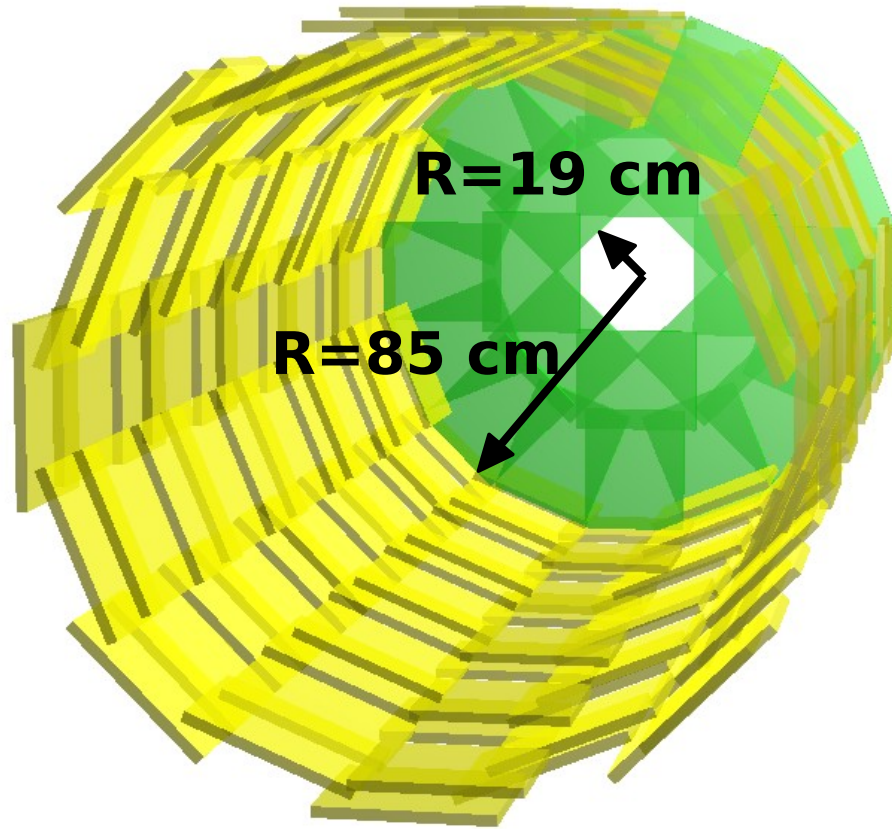


New geometry in SpdRoot

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«MRPC prototype chambers for TOF»

Protvino TOF system: Barrel and End-cap

Proposal from Protvino



module

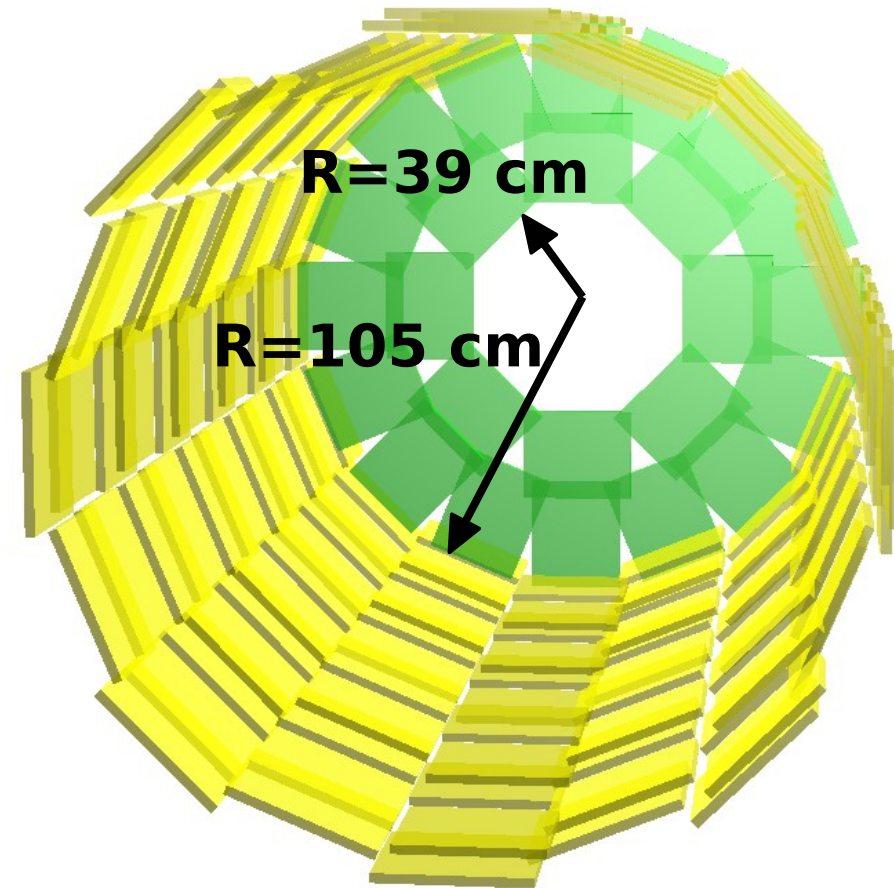
Length=40 cm

Width=33 cm

Height=2.5 cm

(95-115)

R=85 (proposal) → 105 in SpdRoot

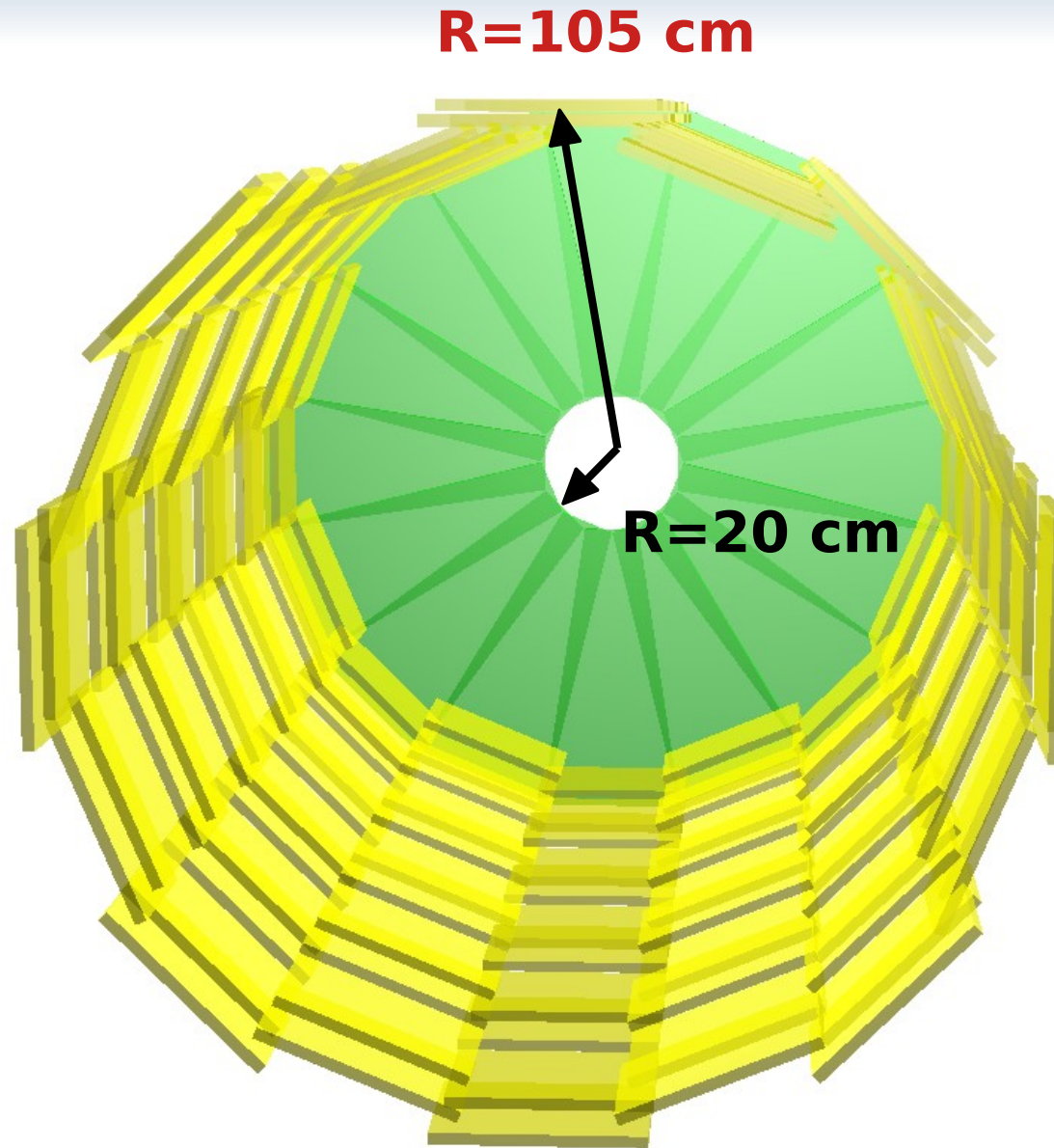


Size module as from

Protvino

Hybrid TOF system

$R=85 \rightarrow 105 \text{ cm}$



Barrel-module (Protvino)

Length=40 $\rightarrow 44 \text{ cm}$

Width=33 cm

Height=2.5 cm

Geometry Barrel as from Protvino

End-cap-module (Tsinghua)

Width1=14.0 cm

Width2=34.0 $\rightarrow 42 \text{ cm}$

Length=70 $\rightarrow 85.0 \text{ cm}$

Height=3.0 cm

Geometry End-Cap as from Tsinghua

Comparison table

		Barrel	End-cap
<i>Protvino</i>	Size of chamber $W \times L \times H$ [cm]	$33_W \times 40_L \times 2.5_H$	$33_W \times 40_L \times 2.5_H$
	Number of chambers	$16_{module} \times 9_{row} = 144_{module}$	$24_{module} \times 2_{chamber} = 48_{module}$
	Width of strip [cm]	2	
	Number of strips	$16_{strip} \times 144_{module} = 2304_{strip}$	$16_{strip} \times 48_{module} = 768_{strip}$
<i>Tsinghua</i>	Size of chamber $W \times L \times H$ [cm]	$33_W \times 45.4_L \times 3_H$	$14_{W1} \times 34_{W2} \times 70_L \times 3_H$
	Number of chambers	$12_{module} \times 10_{row} = 120_{module}$	$16_{module} \times 2_{chamber} = 32_{module}$
	Width of strip [cm]	1	
	Number of strips	$24_{strip} \times 120_{module} = 2880_{strip}$	$48_{strip} \times 32_{module} = 1536_{strip}$
<i>Hybrid</i>	Size of chamber $W \times L \times H$ [cm]	$33_W \times 44_L \times 2.5_H$	$14_{W1} \times 42_{W2} \times 85_L \times 3_H$
	Number of chambers	$16_{module} \times 9_{row} = 144_{module}$	$16_{module} \times 2_{chamber} = 32_{module}$
	Width of strip [cm]	2	1
	Number of strips	$16_{strip} \times 144_{module} = 2304_{strip}$	$58_{strip} \times 32_{module} = 1536_{strip}$

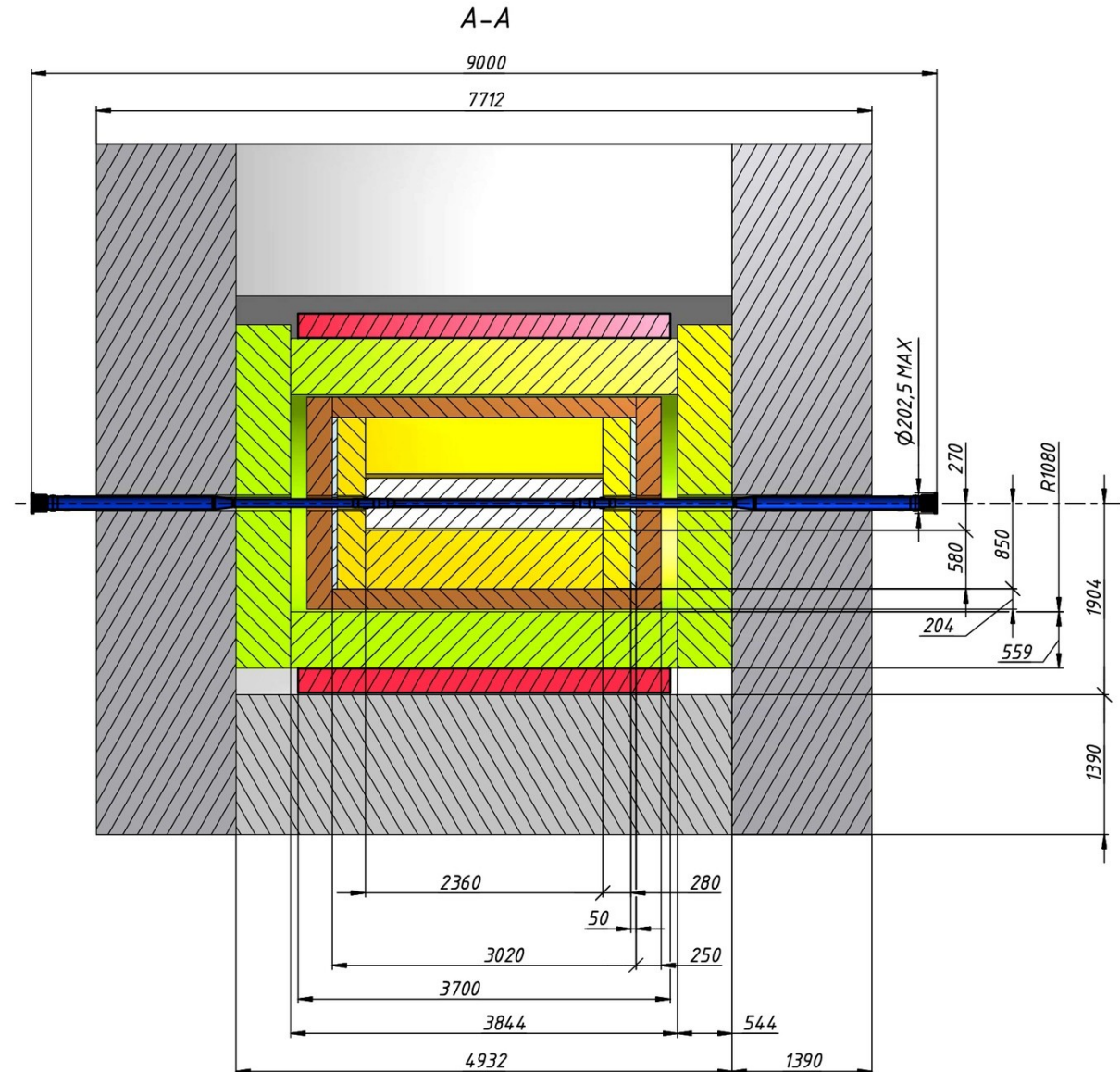
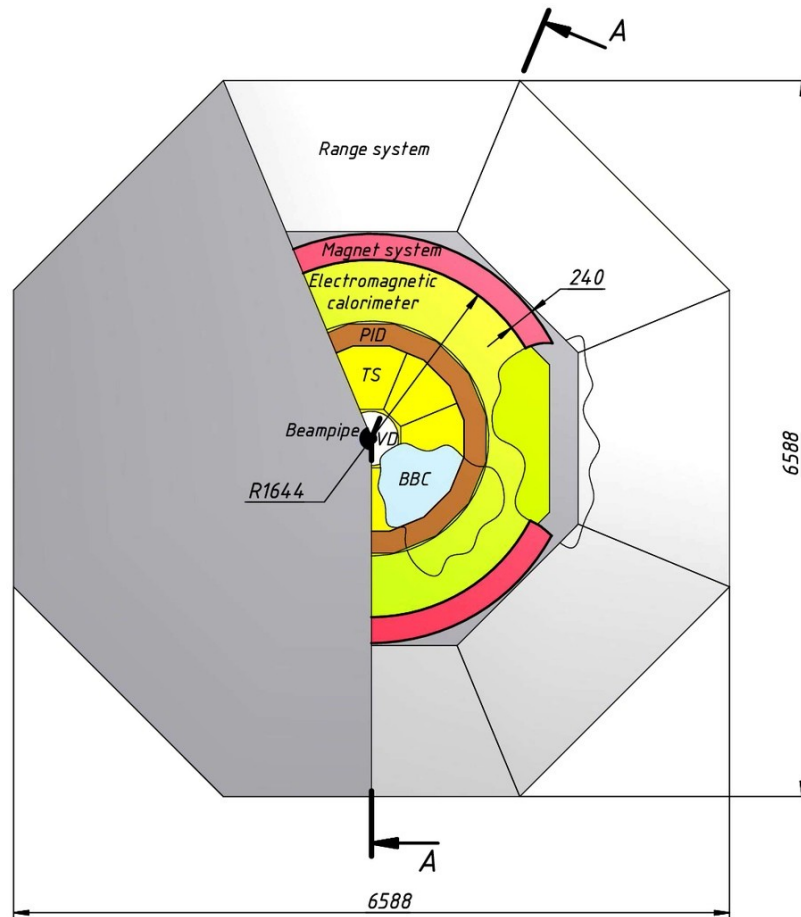
Conclusion

- Because of the change in the size of the SPD detector, possible TOF sizes from the proposal should be modified.
- Hybrid option of TOF system geometry consist of **Tsinghua End-cap** and **Protivino Barrel** was suggested

Backup

Actual SPD sizes on 20.10.2021

From Ivan Moshkovsky



Actual SPD sizes on 20.10.2021

From Ivan Moshkovsky

Picture – Slice of the SPD

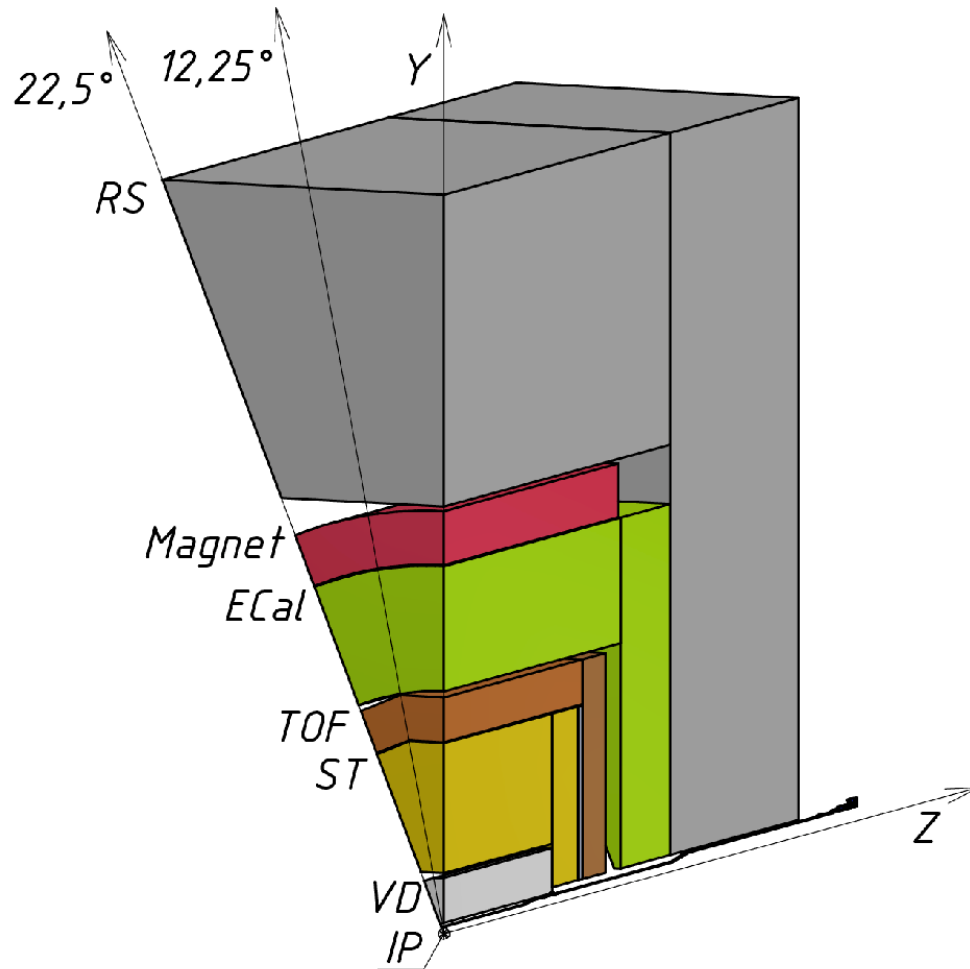


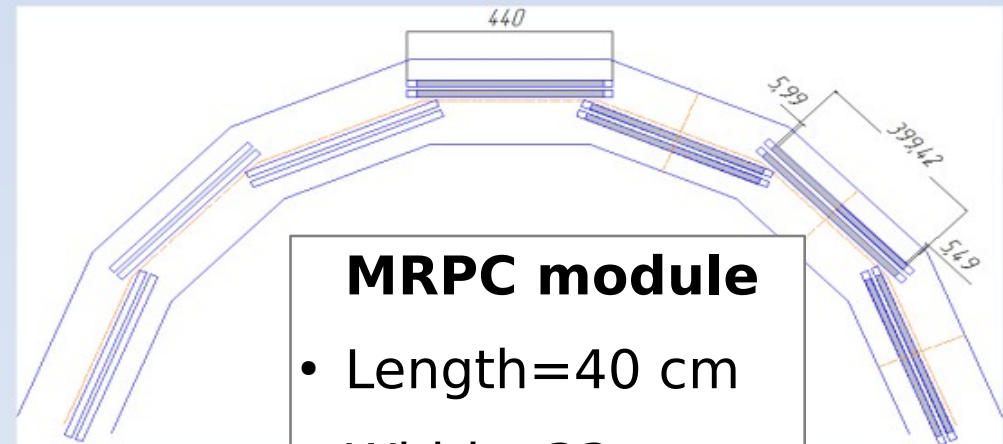
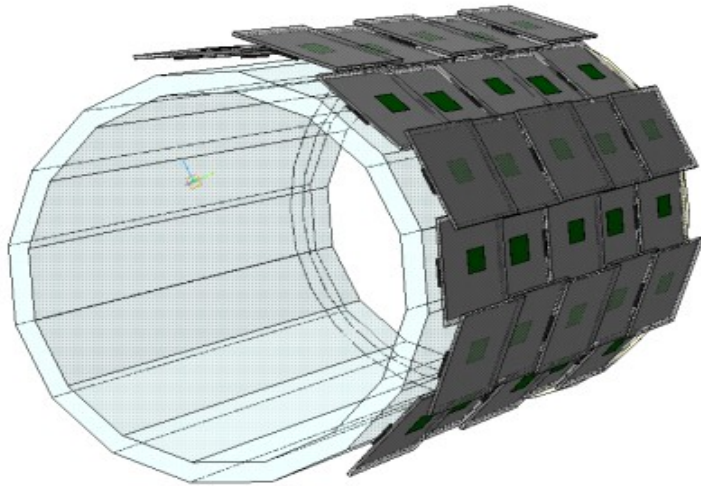
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10	Magnet	220	1664/1884	3328/3768
11	Gap 5	20/176	-	-
12	RS	1390	1904/3294	3808/6588

Protvino

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 mm² size. Strip pitch is 21 mm.
- MRPCs active area is ~337 x 400 mm².
- The ToF distance of ~1m lead to the requirement of ≈ 30 ps time resolution.



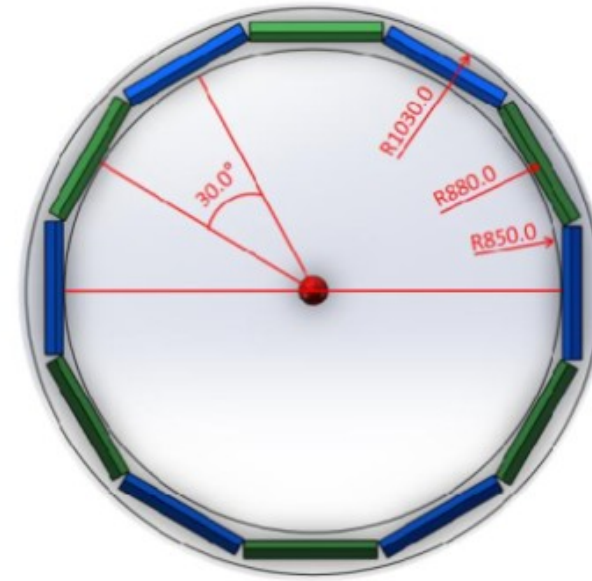
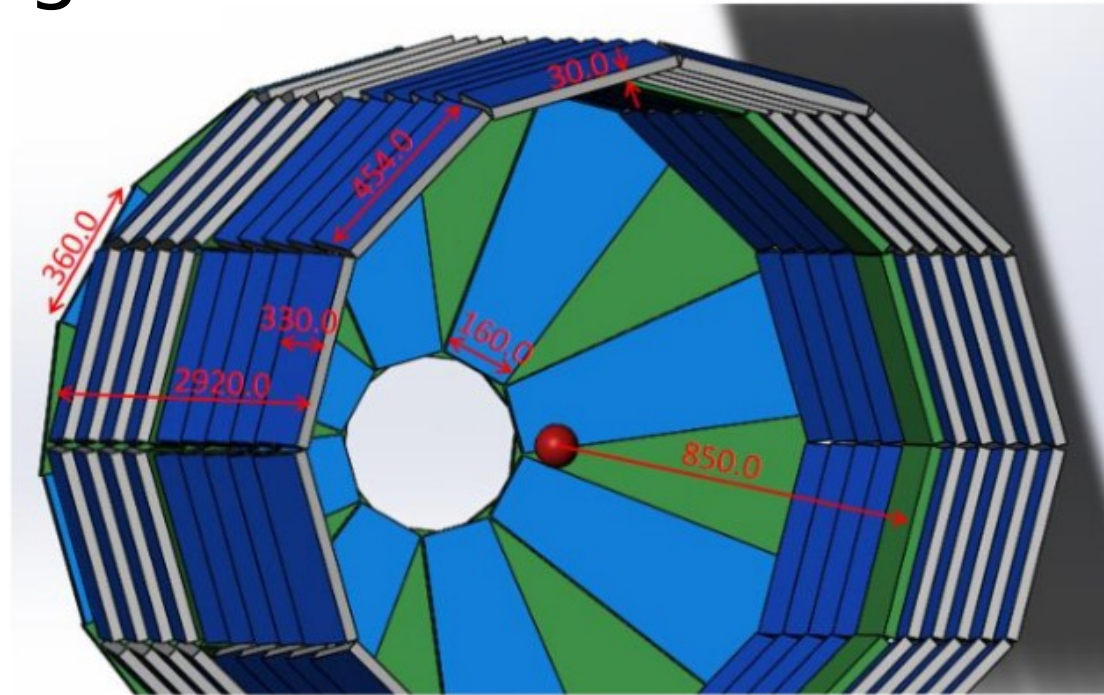
MRPC module

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

TOF system: Barrel

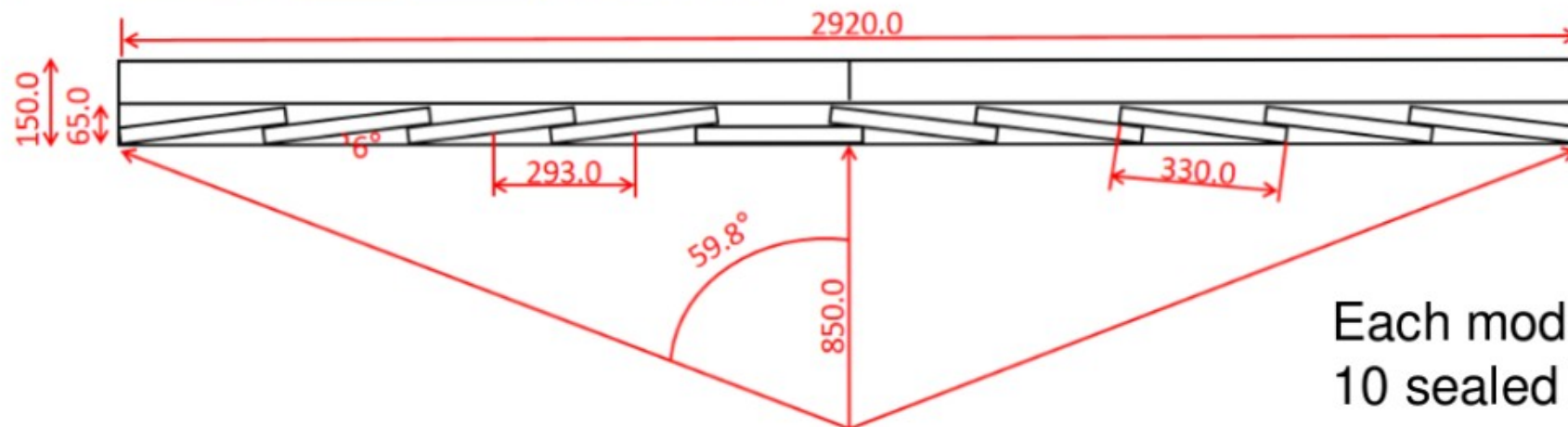
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Tsinghua



12 module for
one circle

Figure 1.1 Main sizes of the TOF barrel in ϕ direction.



Each module consists of
10 sealed MRPC

TOF system: End-cap

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Tsinghua

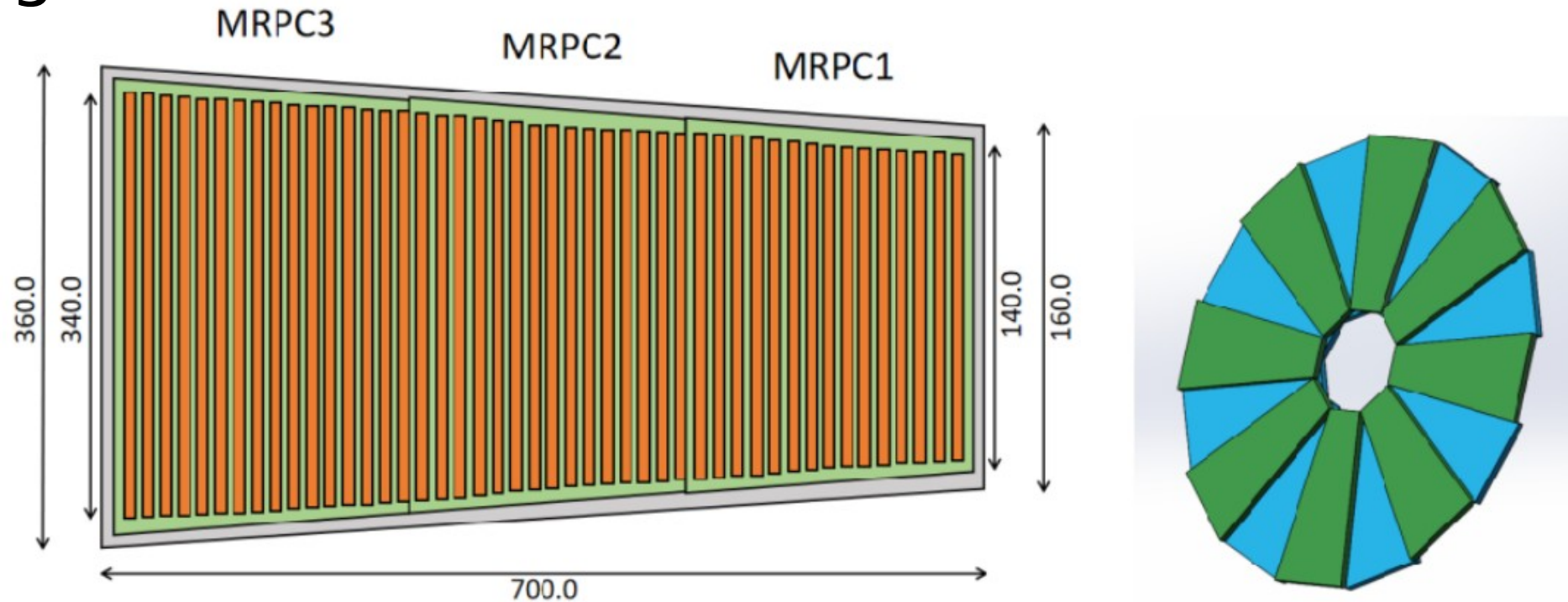


Figure 1.3 Arrangement of MRPCs inside the box in the End-cap.

eTOF consists of 16 modules and each module consists of 3 sealed MRPC.