IDEA Muon Detector Simulation

first studies and plans

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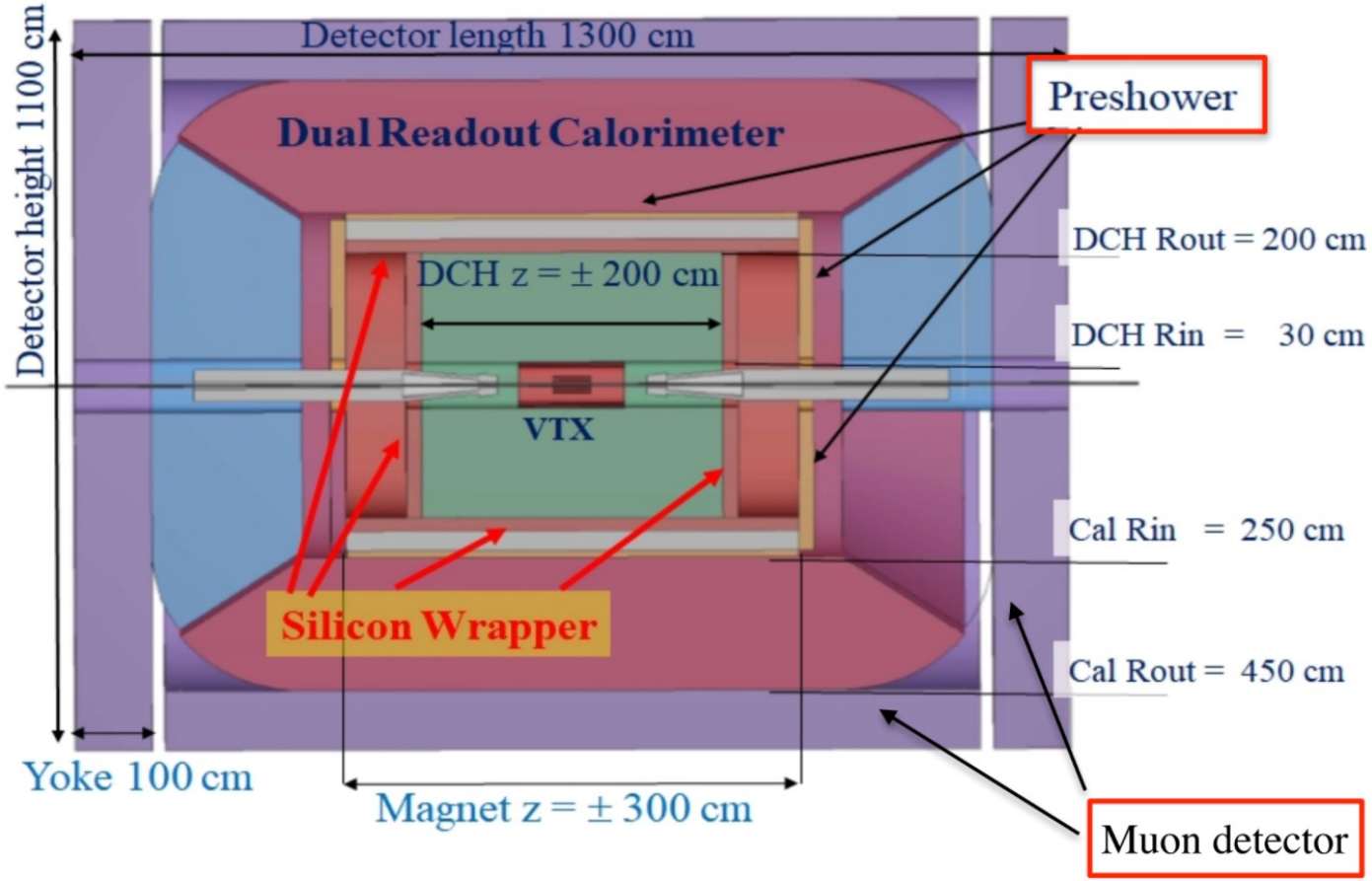
OUTLOOK

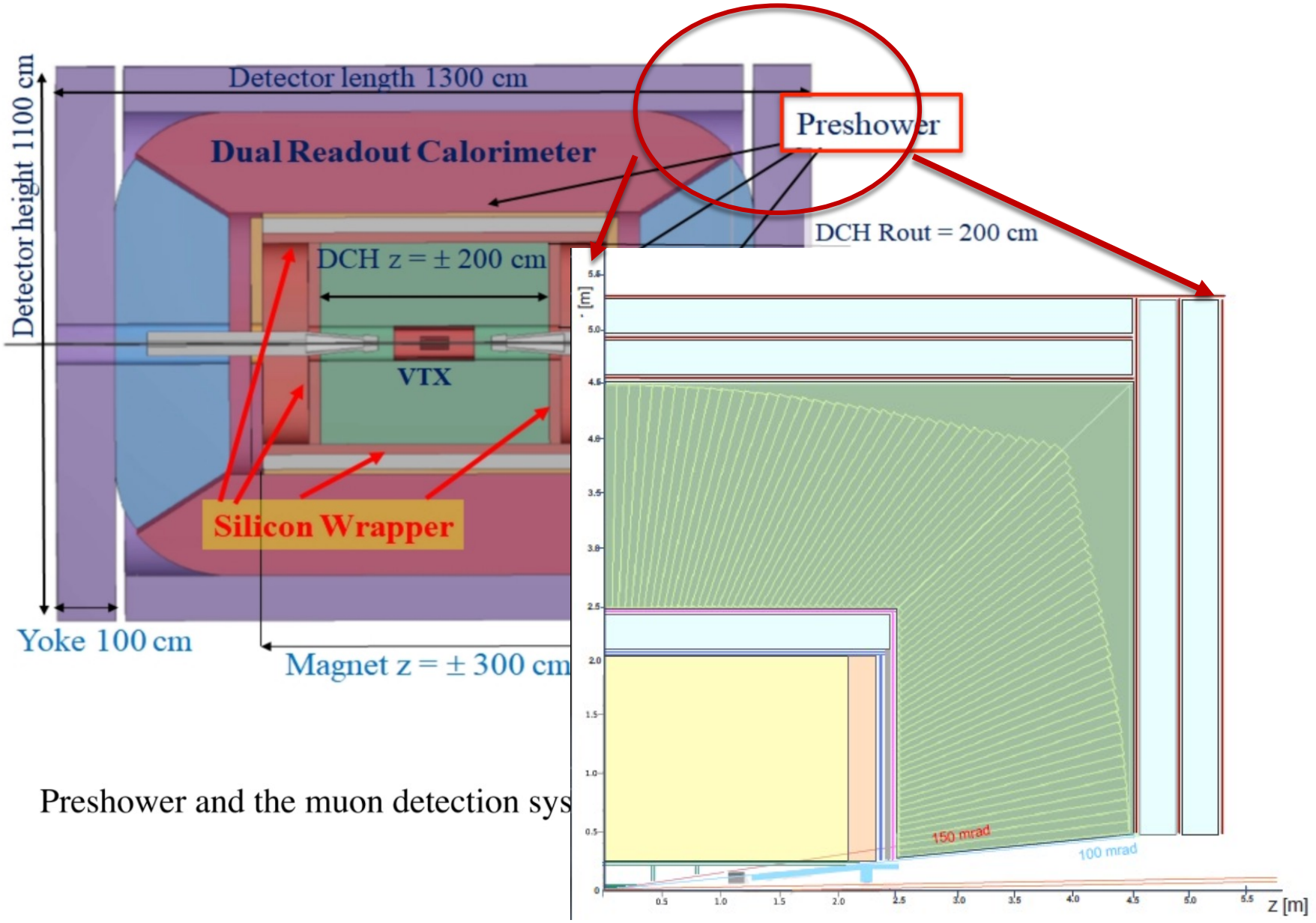
- Muon detector simulation with GEANT4
  - Muon detector dimensions
    - high, length, layer numbers
    - μRWELL stratification
      - Materials construction
- Standalone simulation implemented
- Conclusion and Plans

The IDEA Detector



Preshower and the muon detection system are designed with the μRWELL technology

The IDEA Detector



Preshower and the muon detection sys

The Muon Detector: reference dimension

- Version 1: we simulate the barrel only
  - box with the following dimension
  - Only barrel (for beginning)

Barrel

Layer	R [mm]	Length [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm²]	# of channels
μRwell	4520	±4500	20		1.5×500	2.6M	341K
iron	4560	±4500	300	1.5			
μRwell	4880	±4500	20		1.5×500	2.8M	368K
iron	4920	±4500	300	1.5			
μRwell	5240	±5260	20		1.5×500	3.5M	462K

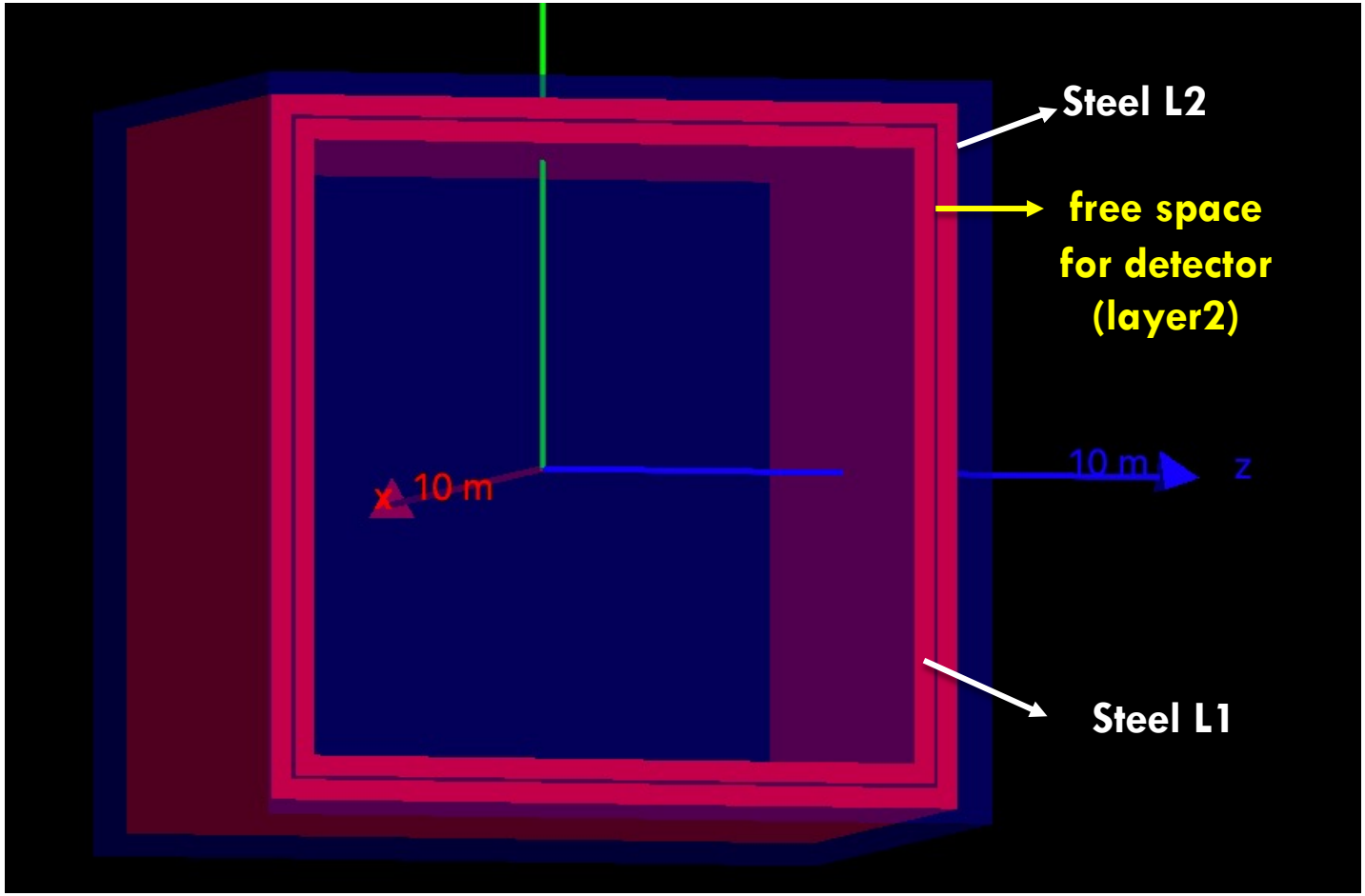
50x50 cm² strips 50 cm pitch 1.5 mm

Endcap

Disk	R_{in} [mm]	R_{out} [mm]	z [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm²]	# of channels
μRwell	454	5220	±4520	20		1.5×500	1.7M	227K
iron	454	5220	±4560	300	1.5			
μRwell	454	5220	±4880	20		1.5×500	1.7M	227K
iron	454	5220	±4920	300	1.5			
μRwell	454	5220	±5240	20		1.5×500	1.7M	227K

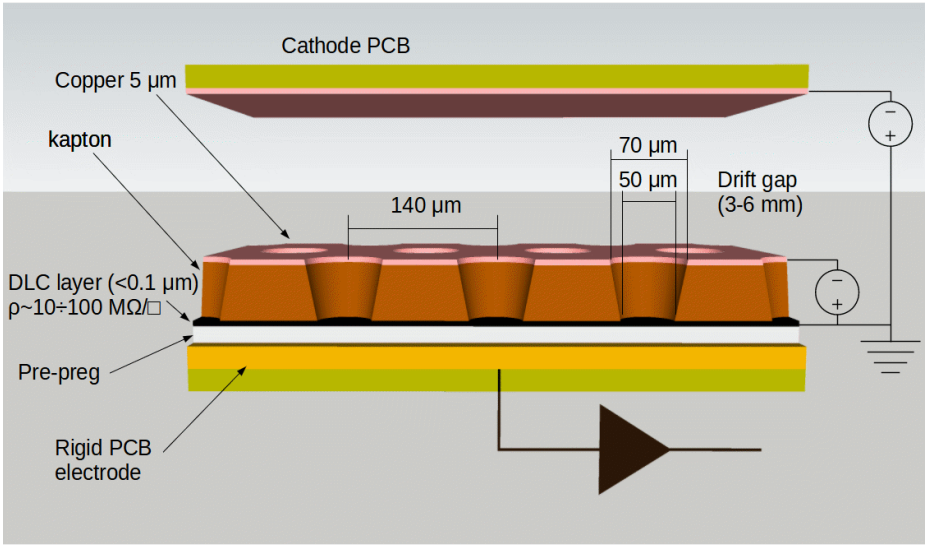
From G. Cibinetto talk on microRWELL-based IDEA subdetectors (14/10/2020)

The Muon Detector: reference dimension

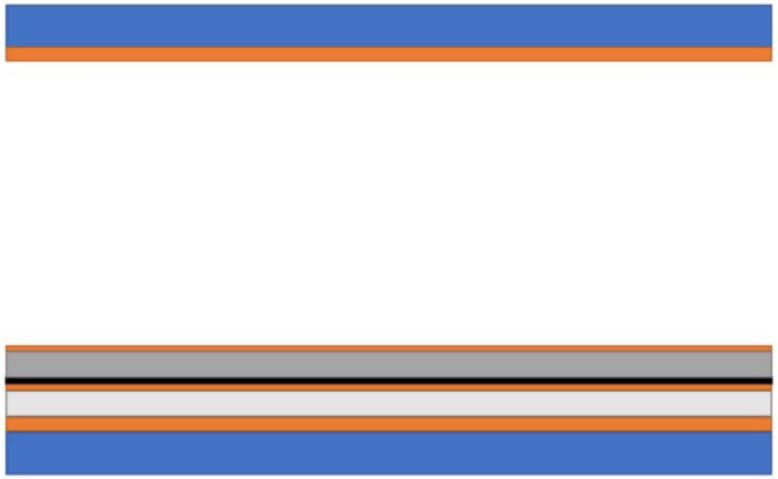


The µRWELL detector

- µRWELL: chatode, drift gap, µRWELL_PCB



µRWELL stratification



- see R. Farinelli and M. Poli Lener talks for more details on µRWELL concept
  - https://agenda.infn.it/event/28676/contributions/145373/attachments/87079/116206/General_Meeting_2021-12-15_urwell.pdf
  - https://agenda.infn.it/event/28676/contributions/145393/attachments/87090/116219/20211215_µRWELL_TB_Preliminary.pdf

The μRWELL stratification

*from E. Fontanesi PhD thesis

μ-RWELL component	Thickness of each layer	Material	
Cathode	1.6 mm	FR_4	
	35 μm	Copper	
Gas gap	6 mm	ArCO2CF4	
	5 μm	Copper	holes
	50 μm	Kapton	holes
	0.1 μm	DLC	
μ-RWELL + readout PCB	35 μm	Copper	Strips
	100 μm	Film glue (same DLC density)	
	35 μm	Copper	Strips
	1.6 μm	FR_4	

1.6 mm?

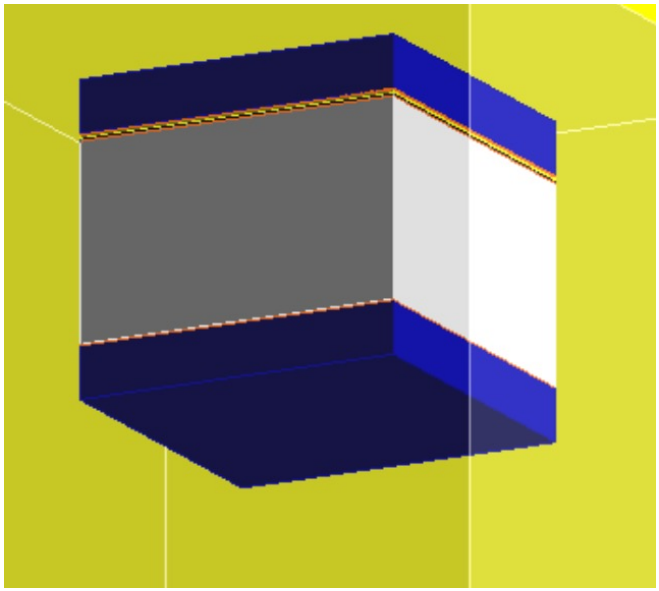
Holes and strips: effective density as first option

The μRWELL materials and implementation

- Goal: construction of a parametric code for simulation

```
G4double CStratification[numlayer]={1.6*mm,0.035*mm, 6*mm, 0.005*mm, 0.050*mm, 0.0001*mm, 0.035*mm, 0.1*mm, 0.035*mm, 1.6*mm};
G4Material* materials[numlayer]={m_FR4,m_Cu,m_gasDet,m_Cu,m_Kapton,m_DLC,m_Cu,m_DLC,m_Cu,m_FR4};
```

- Two function for steel layers and sensitive detectors
  - CreateSteelLayer(logicEnv, La, r1_steel, thickness_steel, checkOverlaps);
  - DetAssembly(logicEnv, mat, La, radius, CStratification[i],color[i], checkOverlaps);



The μRWELL materials and implementation

- ConstructMaterial();

- From G4NistManager:
  - m_Cu = nist->FindOrBuildMaterial("G4_Cu");
  - m_Kapton = nist->FindOrBuildMaterial("G4_KAPTON");
- DLC:

```
////DLC material (carbonio amorfo)
mat_name    = "DLC";
mat_density = 2.00*g/cm3;  ///should be checked (used for CGEM simulation)
n_element = 1;
m_DLC = new G4Material(mat_name,mat_density,n_element = 1);
m_DLC->AddMaterial(m_C , 1);  //fraction mass
```

- FR4:

```
mat_name    = "FR4";
mat_density = 1.97*g/cm3;  ///should be checked (used for CGEM simulation)
n_element = 2;
m_FR4 = new G4Material(mat_name, mat_density, n_element);
m_FR4->AddMaterial(m_FiberGlass,0.6);
m_FR4->AddMaterial(m_Epoxy,0.4);
```

The μRWELL materials and implementation

- ConstructMaterial();
- From G4NistManager:
  - m_Cu = nist->FindOrBuildMaterial("G4_Cu");
  - [illegible]KAPTON");
-

```
mat_name    = "FiberGlass";
mat_density = 1.99*g/cm3;
n_element = 4;
m_FiberGlass =  new G4Material(mat_name, mat_density, n_element);
m_FiberGlass -> AddMaterial(SiO2, 0.6);
m_FiberGlass -> AddMaterial(B2O3, 0.05);
m_FiberGlass -> AddMaterial(Al2O3, 0.13);
m_FiberGlass -> AddMaterial(CaO, 0.22);
```

```
mat_name    = "Epoxy";
mat_density = 1.2*g/cm3;
n_element = 2;
m_Epoxy =  new G4Material("epoxy", mat_density, n_element=2);
m_Epoxy->AddElement(elC, n_natoms=2);
m_Epoxy->AddElement(elH, n_natoms=2);
```

- FR4:

```
mat_name    = "FR4";
mat_density = 1.97*g/cm3;  ///should be checked (used for GEM simulation)
n_element = 2;
m_FR4 = new G4Material(mat_name, mat_density, n_element);
m_FR4->AddMaterial(m_FiberGlass,0.6);
m_FR4->AddMaterial(m_Epoxy,0.4);
```

The μRWELL materials and implementation

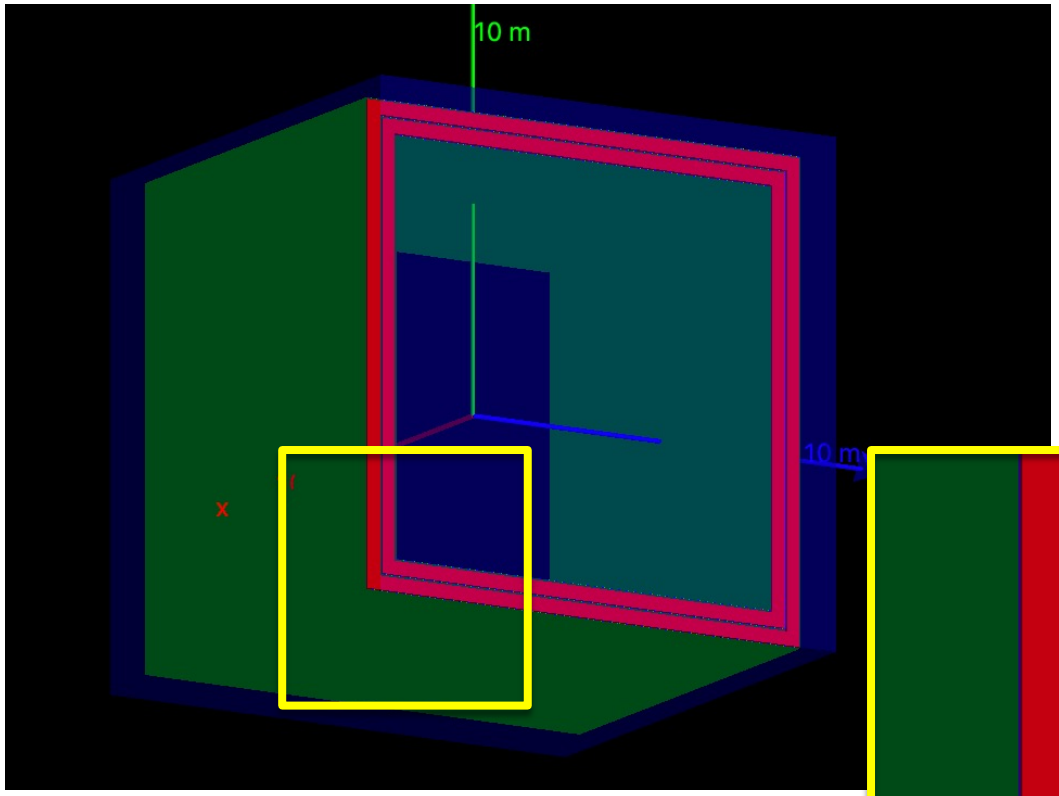
- ConstructMaterial();
- ArCO2CF4:

from G4NistManager

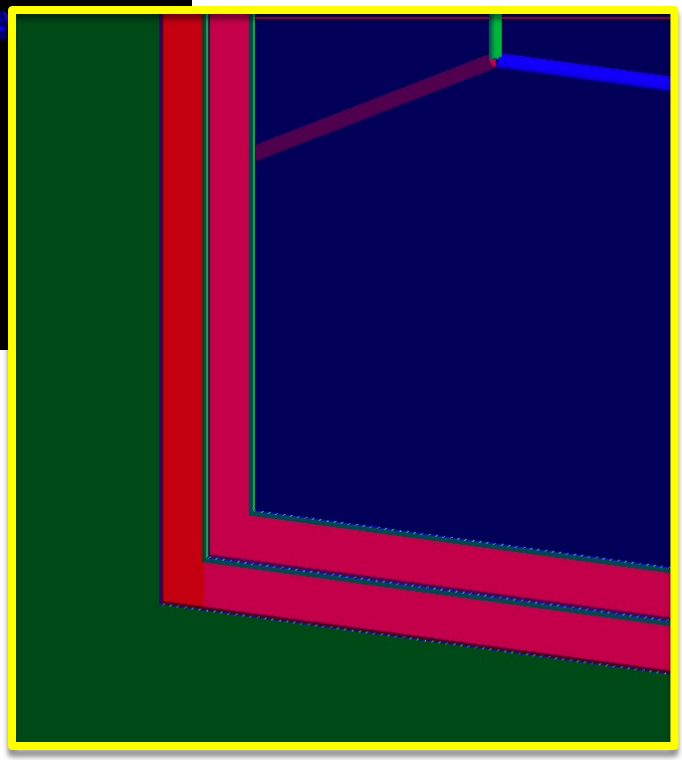
```
G4Material* _CO2 = nist->FindOrBuildMaterial("G4_CARBON_DIOXIDE");
mat_name = "CF4";
mat_density = 3.78*kg/m3;
n_element = 2;
G4Material* _CF4 = new G4Material(mat_name, mat_density, n_element = 2);
_CF4->AddElement(elC, n_natoms=1);
_CF4->AddElement(elF, n_natoms=4);
//build gas for the muon detector
mat_name    = "gasDet";
mat_density = 2.94*kg/m3;  ///should be checked (used for CGEM simulation)
n_element = 3;
m_gasDet = new G4Material(mat_name,mat_density,n_element = 3);
m_gasDet->AddElement(elAr, 0.295);  //fraction mass
m_gasDet->AddMaterial(_CO2, 0.109);  //fraction mass
m_gasDet->AddMaterial(_CF4, 0.596);  //fraction mass
```

new material

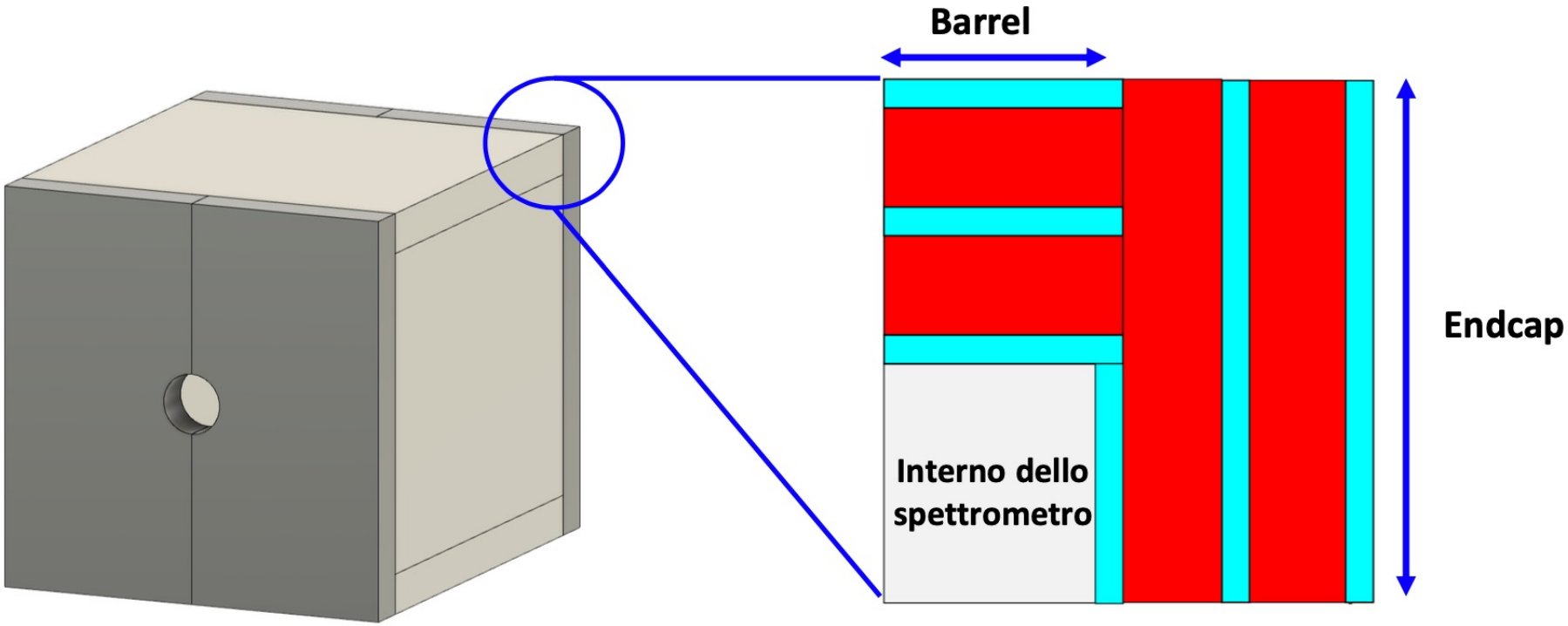
The μRWELL materials and implementation



- 2 layers of steel
- 3 layers of sensitive detector

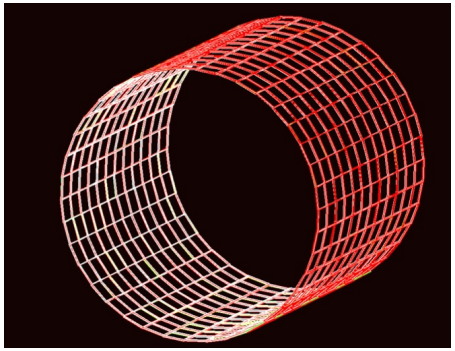


Muon Endcaps



first studies from S. Ghirelli

Plans and Conclusions



- Implementation study started
  - Standalone simulation done
  - Volume overlaps checked

- Start to study what was implemented on lxplus machines
  - reproduce the implemented geometry
  - change some parameters and try to understand the code already available
- Problematic found
  - difficult communication
  - a lot of time needed to understand the code → I have done several test, much more studies needed
  - I'm trying to arrange a meet with other people involved

- My deadline: barrel simulation by the end of Dec 2022

Thanks for your attention