The C+RWELL for the SCT detector

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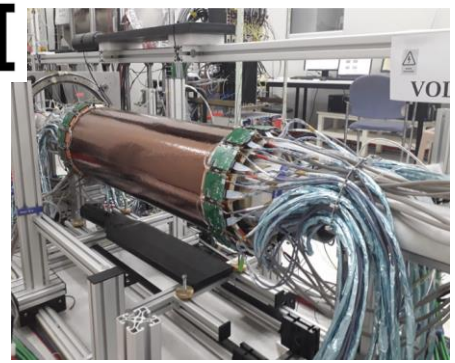
Inner tracker based on C+RWELL

The goal is the development of an ultra-light Cylindrical μ-RWELL (C+RWELL) as inner tracker for the SCT detector

The INFN (Ferrara & LNF) teams have long been involved in the R&D, design and manufacture of MPGDs for HEP experiments:

- planar GEM for the muon apparatus at LHCb
- C-GEM detectors as IT for the KLOE2- experiment (LNF) and for the upgrade of the BESIII-IT (Ferrara)



The μ-RWELL technology

The device is composed of two elements:

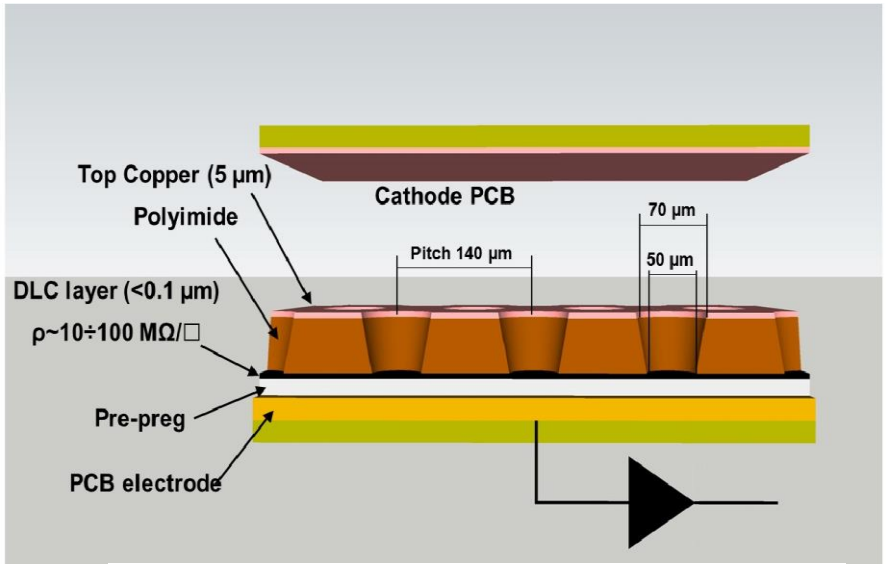
- μ-RWELL_PCB
- drift/cathode PCB defining the gas gap

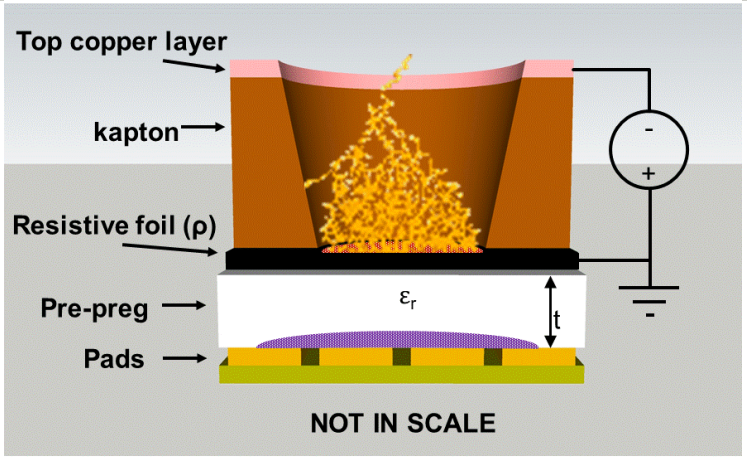
μ-RWELL_PCB = amplification-stage ⊕ resistive stage ⊕ readout PCB

large area & flexible geometry (i.e. cylindrical shape)

- The "WELL" acts as a multiplication channel for the ionization produced in the gas of the drift gap
- The charge induced on the resistive layer is spread with a time constant, τ ~ ρ×C

$$C = \varepsilon_0 \times \varepsilon_r \times \frac{S}{t} \cong 50\ pF/m$$ *(pitch-width 0,4 mm)*



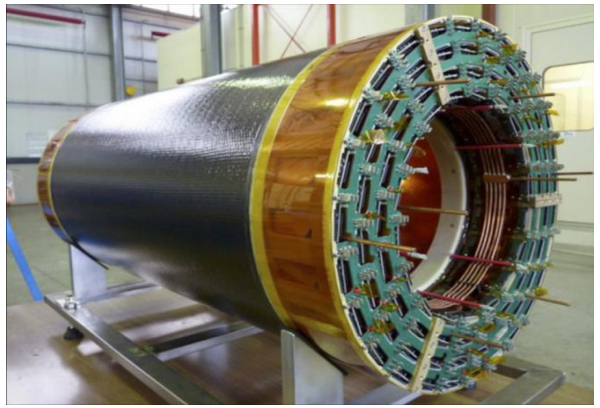


The μ-RWELL detector: a compact spark-protected single amplification-Stage MPGD, G. Bencivenni, et al., 2015 JINST 10 P02008.

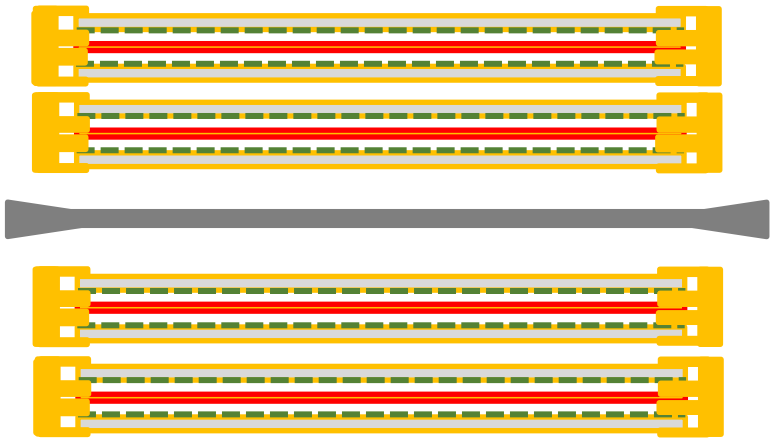
Possible layouts

preliminary

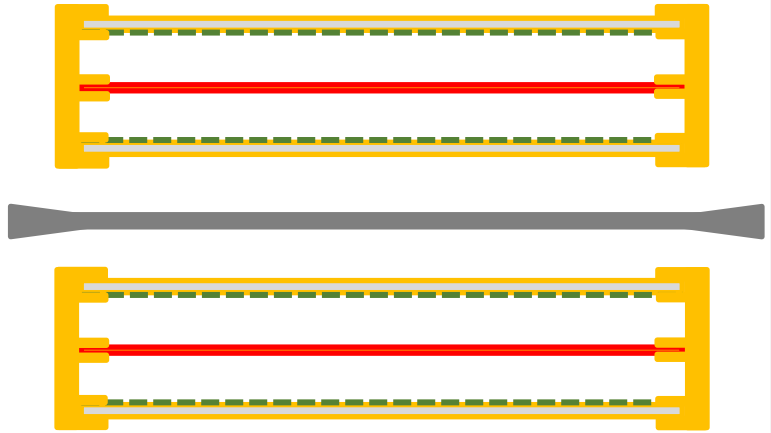
- N. 4 independent C+layers → 1.9÷2.5% X0
- 1 cm gas gap/layer
- 4 cm global sampling gas



- N.2 small gap B2B C+layers → 1.5÷1.9% X0
- 2 × 1 cm gas gap/B2B device
- 4 cm global sampling gas



- N.1 large gap B2B C+layers → 0.75÷0.95% X0
- 2 × 5 cm gas gap/B2B device
- 10 cm global sampling gas



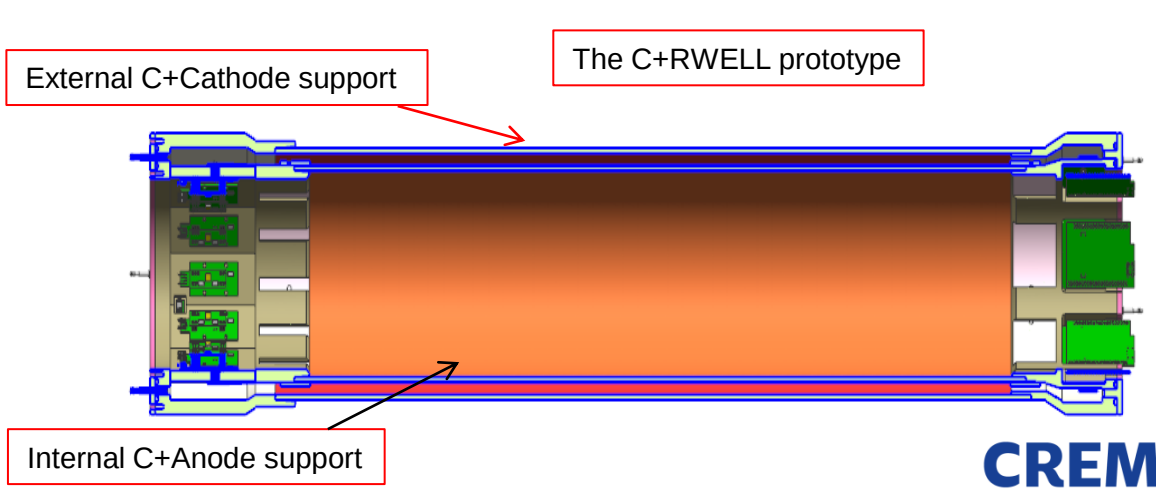
Operation of large gas gap radial TPC to be verified

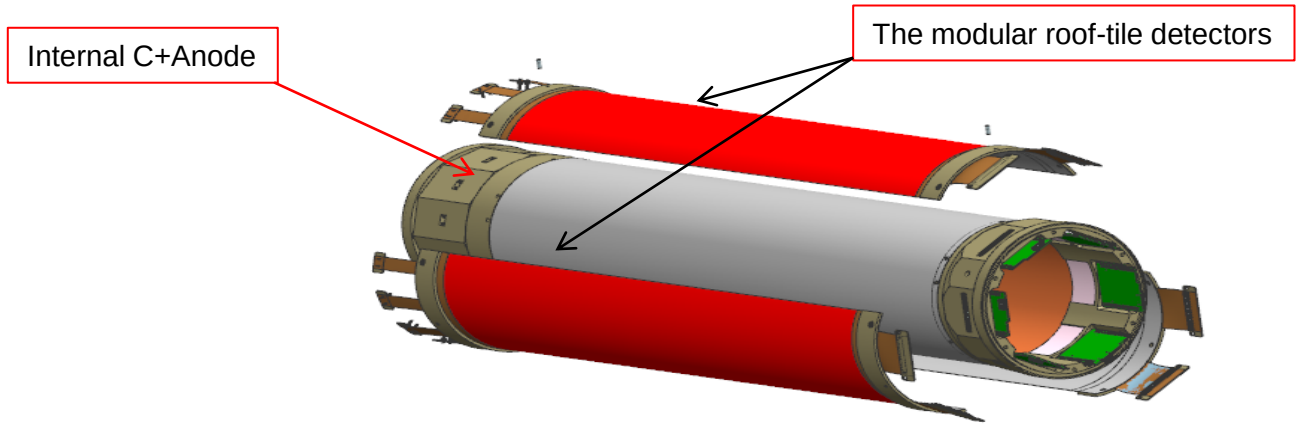
Material budget estimated taking into account different material choices for the mechanics, cathode and faraday cage.
All these layouts require the design, construction and test of a C+RWELL prototype.
The prototype under discussion is based on the innovative concept of the **modular roof-tile shaped detector.**

A Radial Time Projection Chamber for α detection in CLAS at Jlab, R. Dupré et al., 10.1016/j.nima.2018.04.052

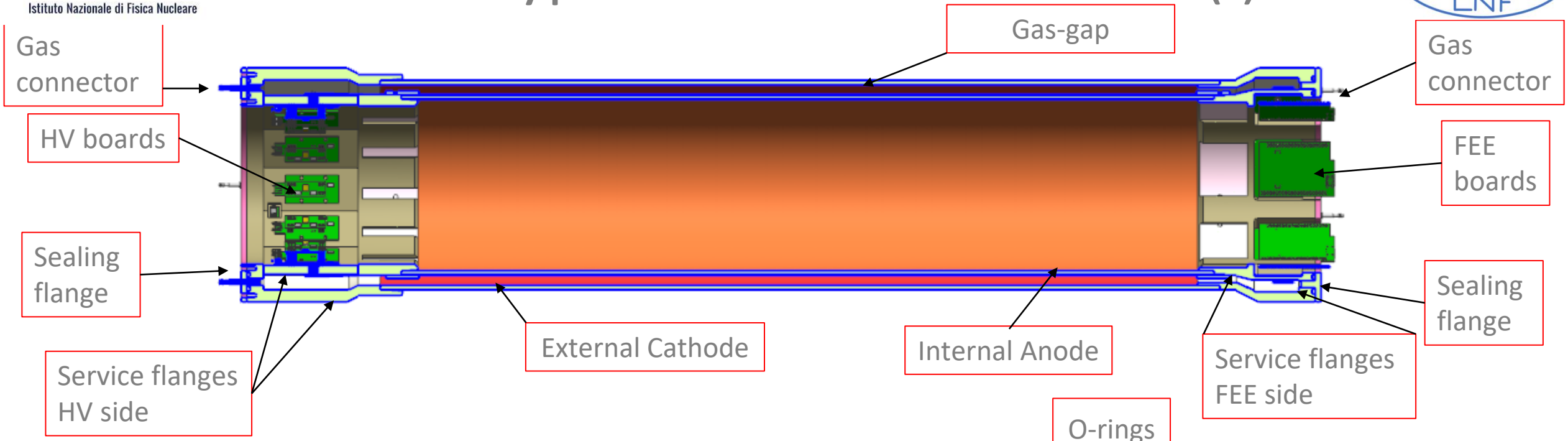
The modular C+RWELL prototype

- The idea is to design a “*modular*” & “*opening detector*”
- The *basic component* of this layout, besides the *ultra-light opening cylindrical structure* (*acting as gas envelope, detector & fee support*), is the **modular roof-tile shaped detector**
- The main advantage of such a *layout* is that in case of *failure of part* of the detector, it is possible to *open the structure* and *replace only the damaged module.* All *modular roof-tile detectors* are identical
- The **modular roof-tile detectors** are assembled on the *anode cylindrical structure*
- The *cylindrical mechanics* is realized as two concentric composite cylinders: one for the *cathode (external*) the other for the *anode (internal)*

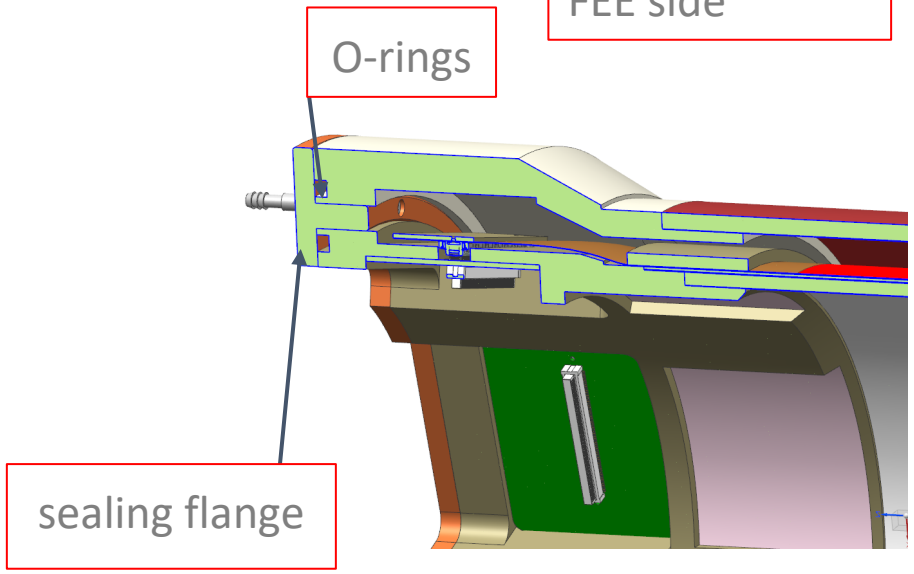




Prototype Mechanics Overview (I)

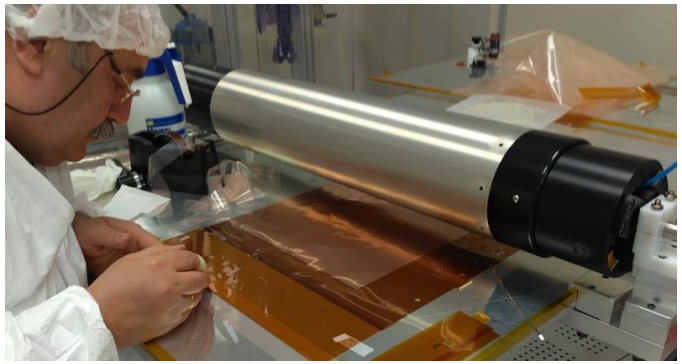


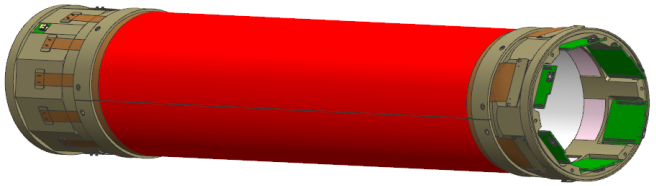
- The support structure consists of two concentric cylinders made of composite material
- Two *service flanges* are glued with the respective cylinders
- The *two cylinders* are then closed with two *sealing-flanges* coupled with the *service flanges through O-rings and screws*



Prototype Mechanics Overview (II)

- For the construction of the 1st prototype of the C+RWELL we decided to exploit *two of the cylindrical molds used for the construction of the Layer1 of the BESIII-CGEM.*
- This choice *define the overall dimension* of the *support structure* and the *detector prototype.*





Global Detector
- Length : 1011 mm
- External Diameter : 210 mm

Drift Gap : 7 ÷ 9 mm **(*)**
Active length: 675 mm

Anode Cylinder
- Thickness : 4.2 mm
- Internal diameter : 153.8 mm
- External diameter : 162.2 mm

Cathode Cylinder
- Thickness : 4 mm
- Internal diameter : 180 mm
- External diameter : 188 mm

(*) depending on the thickness of the roof-tile support

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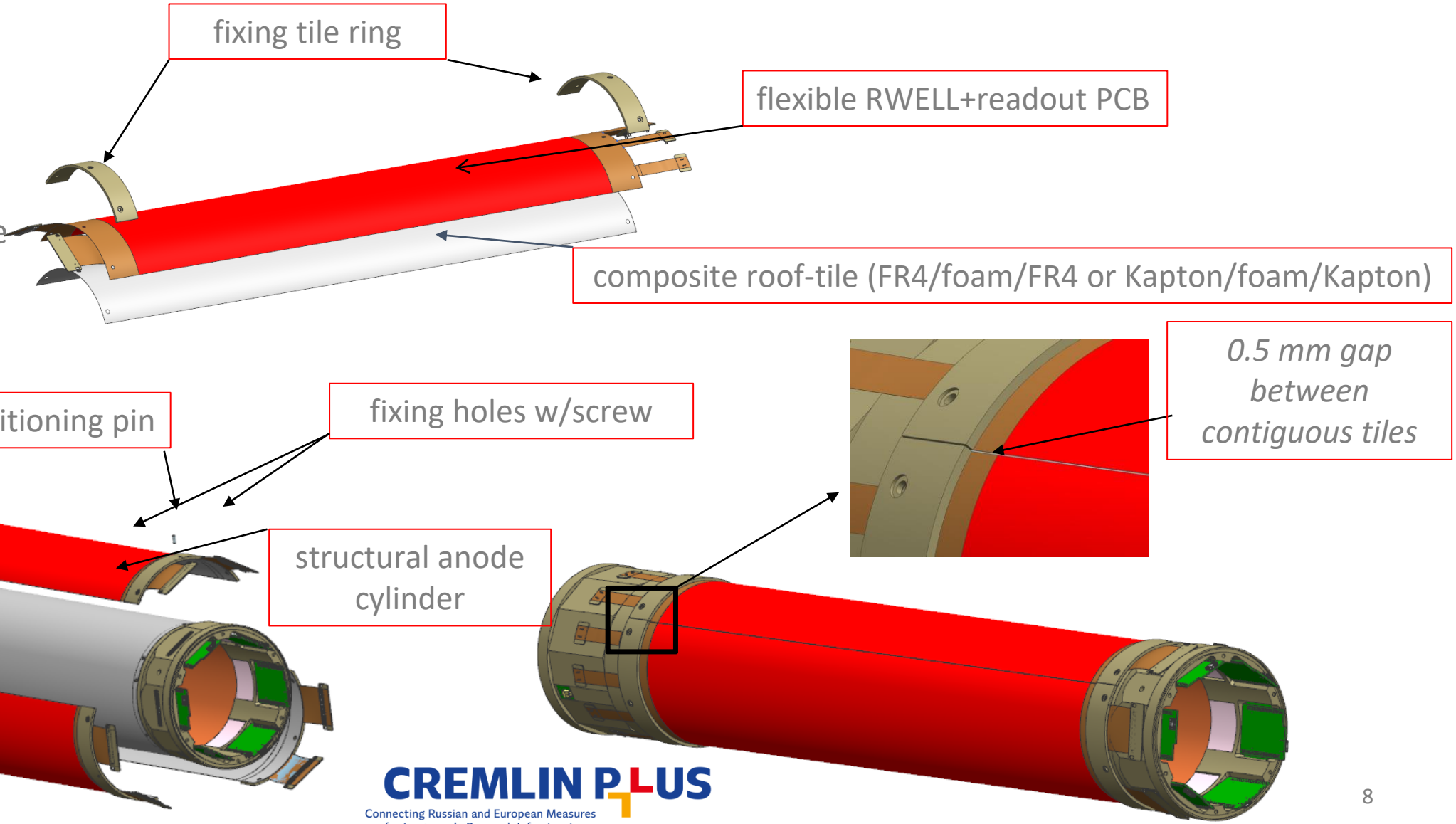
Modular roof-tile detector (I)

Three identical flexible tile detectors are glued on *composite roof tiles*, then mounted on the anode cylindrical support.



Modular roof-tile detector (II)

Roof tile detector prototype (1D – readout)

Roof tile detector (1-D)

Strips (1-D)
- Number : 256 X
- Pitch : 660 um
- Width : 560 um

Tails
- n. 2 for signals
- n. 4 for HV

HV sectors : 4

Global size
- Length : 890 mm
- width: 169.2 mm

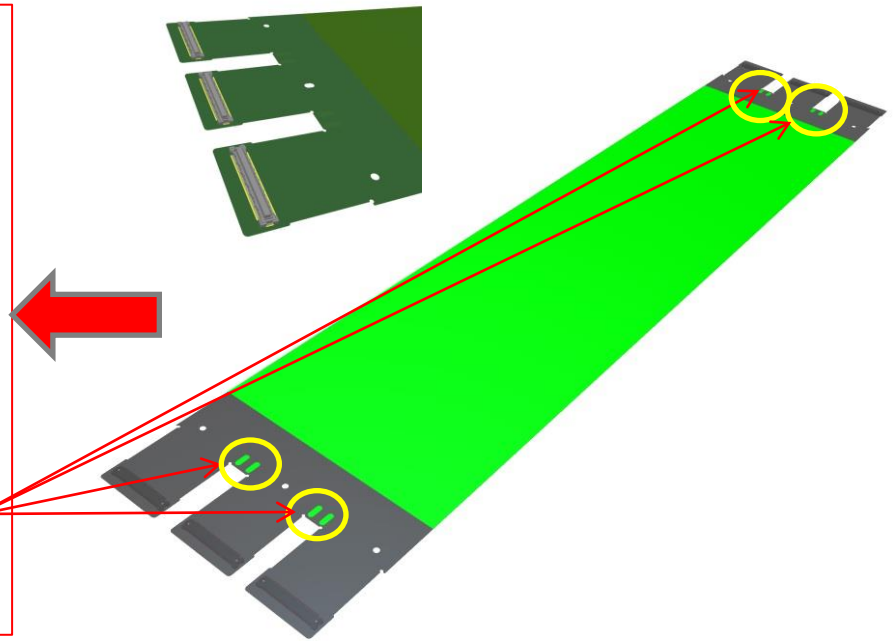
Active area
- Length : 675 mm
- width : 168.96 mm

Roof tile detector (2-D)

Strips (2-D)
- Number : 256 X + 512 V
- Pitch : 660 um
- Width : 560 um

Tails
- n. 6 for signals (3 each side)
- n. 4 for HV (routing to be solved)

HV sectors : 4

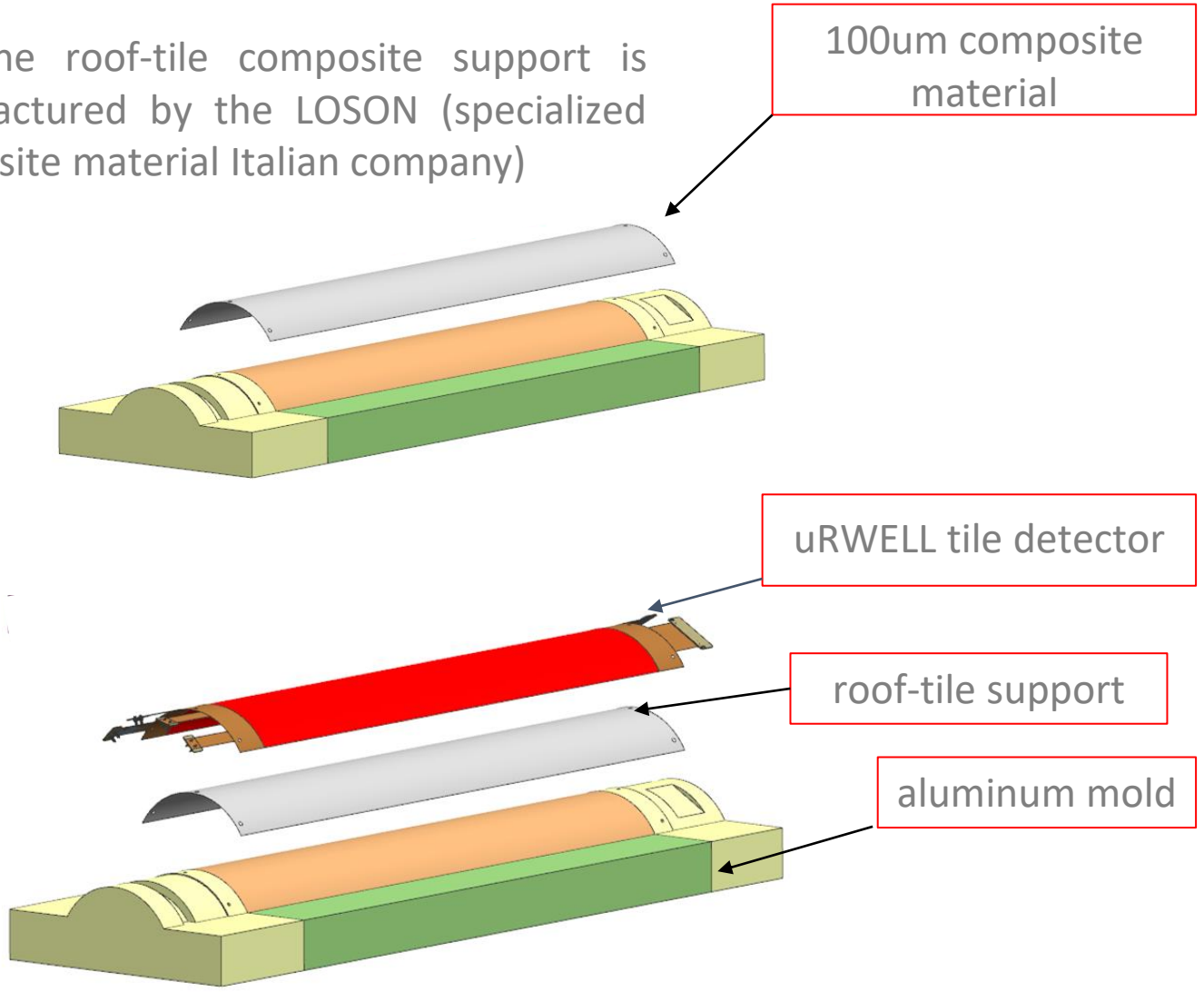


Roof-tile detector manufacturing (I)

The manufacturing of the detector unit is performed in three steps

1 - CERN produces standard PLANAR uRWELL tile detector, based on kapton (flexible) components: (1-D) PCB readout embedded with DLCed-RWELL amplification stage

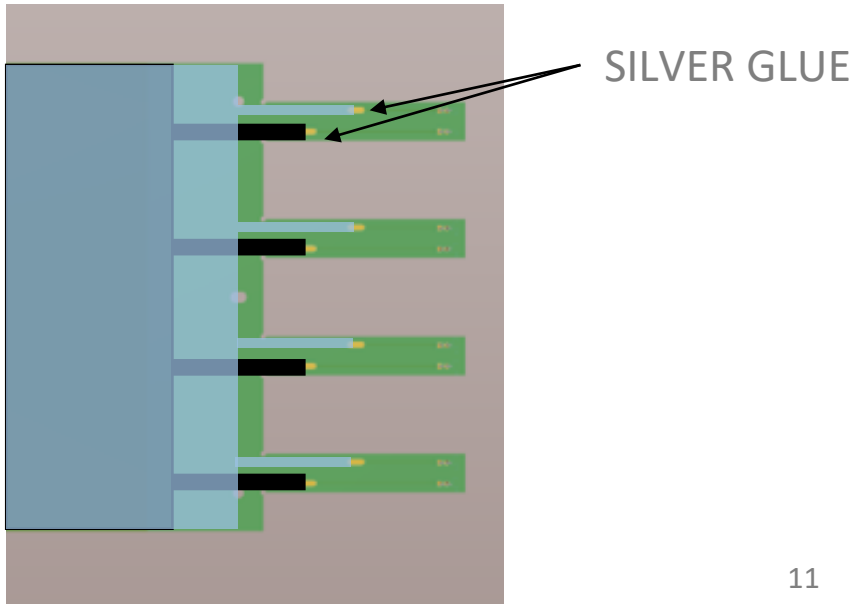
2 - The roof-tile composite support is manufactured by the LOSON (specialized composite material Italian company)



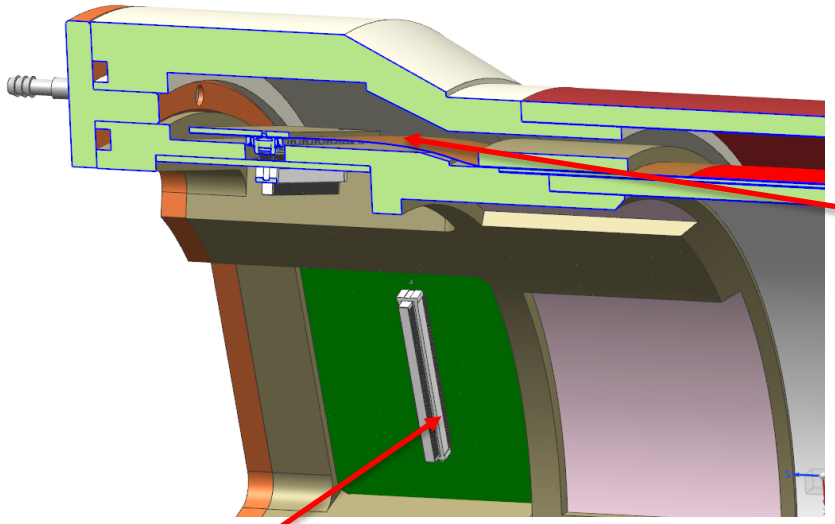
3 - with the vacuum-bag procedure the uRWELL tile detector is glued with the roof-tile support at INFN

HV and ground connections

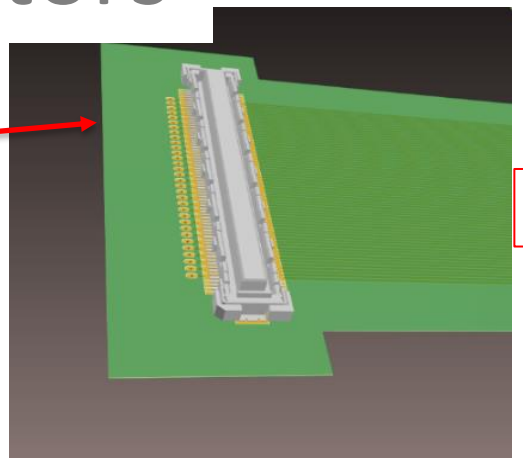
DLC (ground) and RWELL (HV) amplification tails are connected to the metallic pads patterned on the readout PCB by means silver glue



Signal Connectors



TAIL
w/stiffner

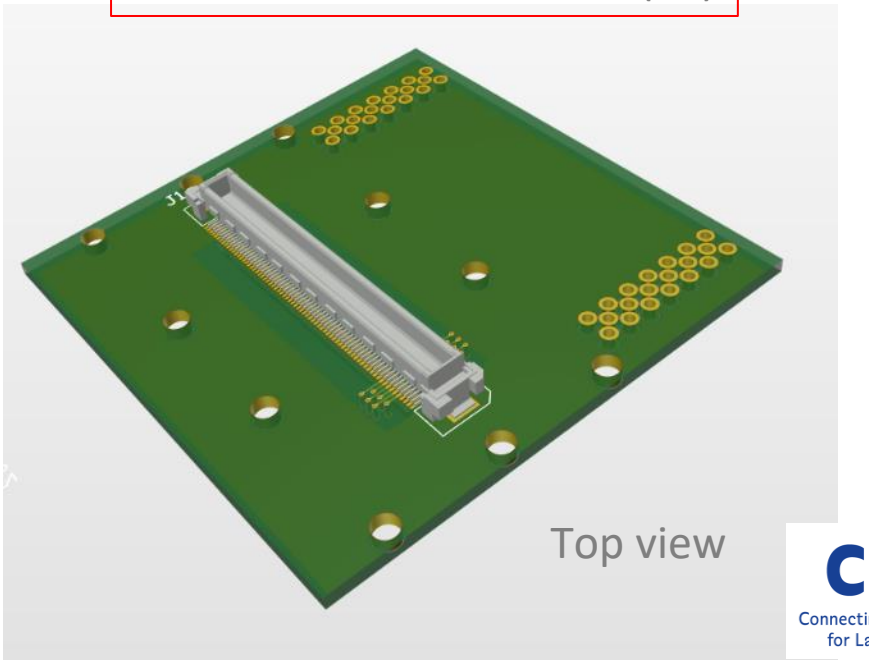


HIROSE - FX10A-144S-SV)

Board interface (external to detector)

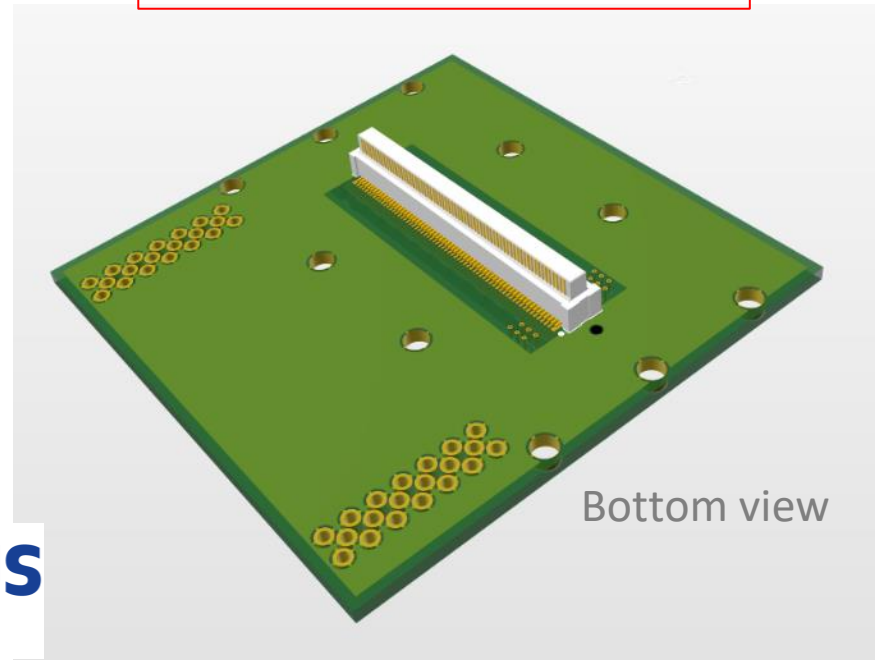
Signal Interface board connectors

HIROSE - FX10A-144P-SV1(83)



Top view

PANASONIC - AXK6SA3677YG



Bottom view

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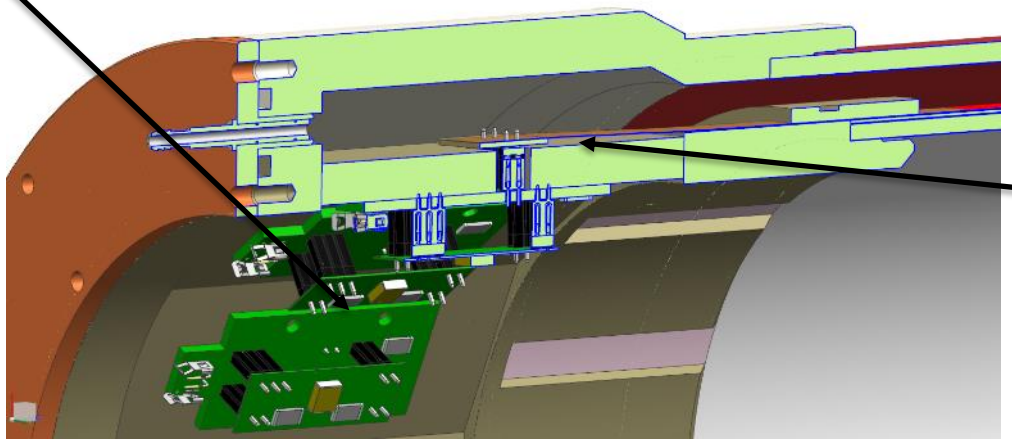
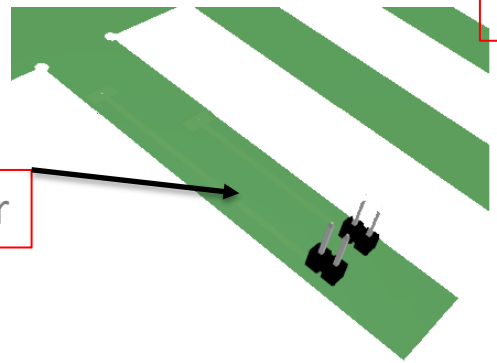
HV Connectors

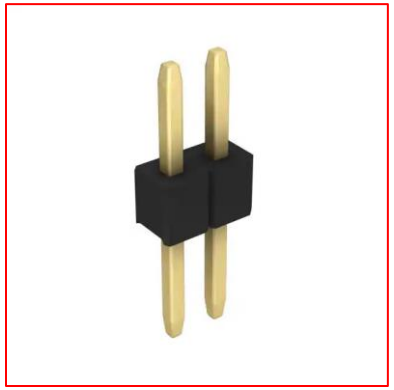
HV BOARD INTERFACE (external to detector)



TAIL w/stiffner

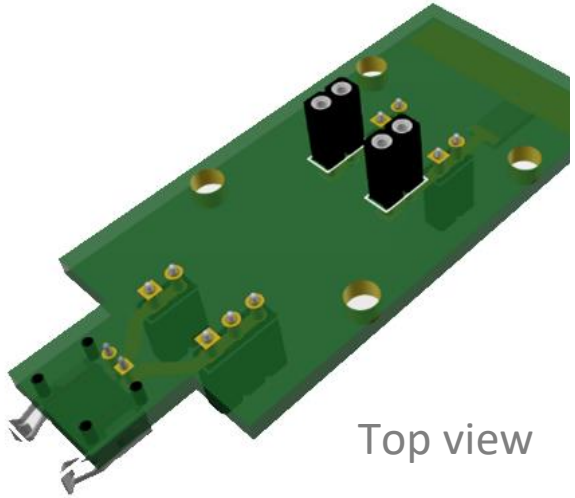


PRECIDIP 890-70-002-10-001101



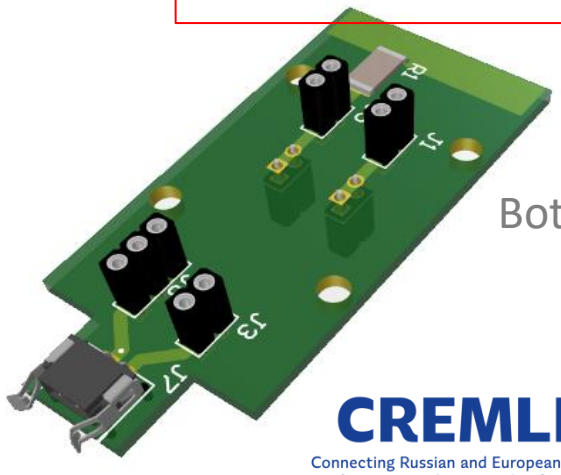
“HV board Interface”

PRECIDIP 801-87-002-10-001101)



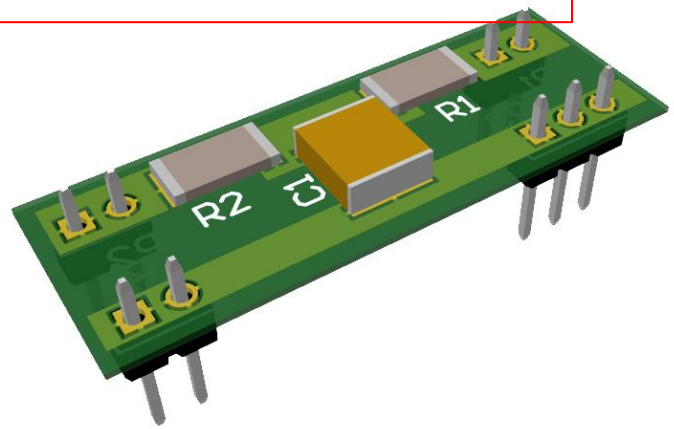
Top view

- PRECIDIP 801-87-002-10-001101
- PRECIDIP 801-87-003-10-001101
- HARWIN M80-8420242



Bottom view

HV FILTER
connected on the bottom of the HV board interface



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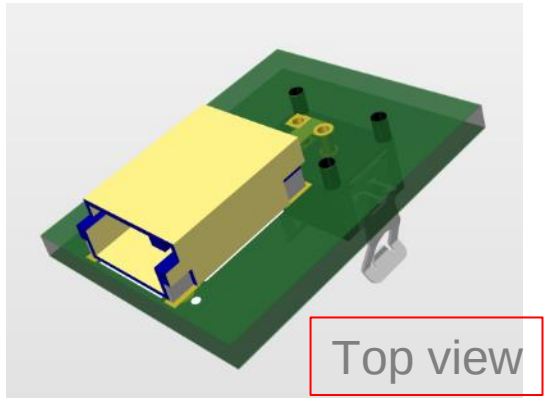
CATHODE HV Connectors

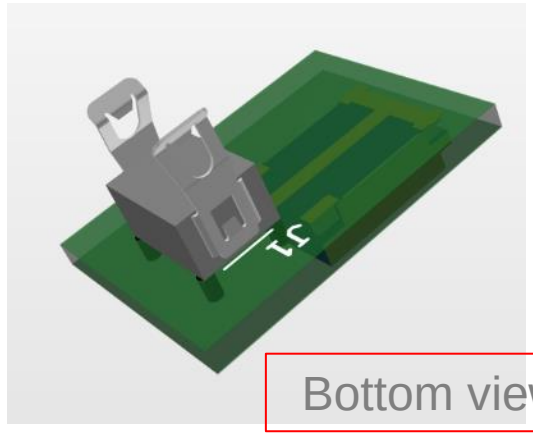
HV tail

INTERFACE HV CATHODE BOARD

HV Cable



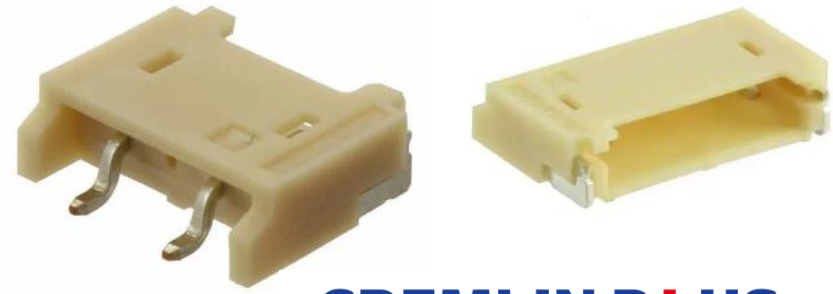
Top view



Bottom view

WIRE TO BOARD SOCKET
JST BHSR-02VS-1-BHS
SOCKET CONTACT
JST SBHS-002T-P0.5A

SM02B-BHSS-1-TB-BH



HARWIN M80-8820242

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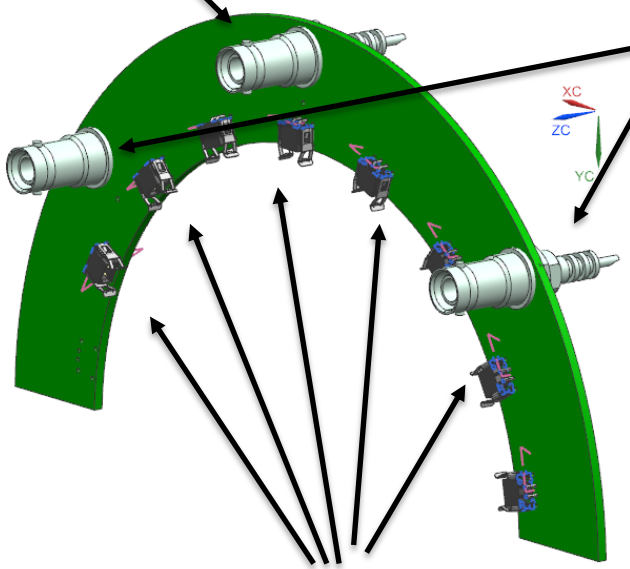
HV DISTRIBUTION - BOARD

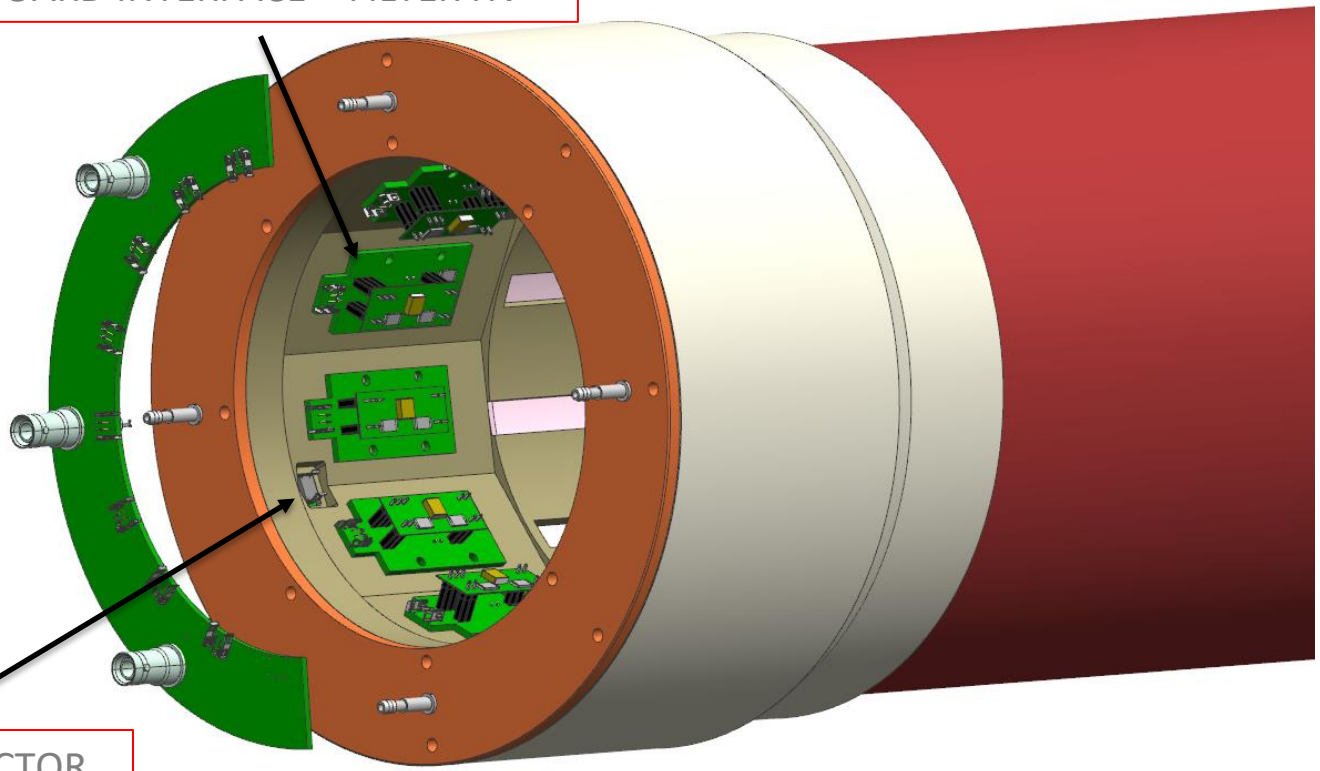
N° 2 SEMI-CIRCLE HV BOARD DISTRIBUTION

N° 2 SHV CATHODE CONNECTORS

N° 4 SHV ANODE CONNECTORS
3 HV SECTORS FOR EACH



HV BOARD INTERFACE + FILTER HV



JST CONNECTORS FOR RWELL AND CATHODE
HV DISTRIBUTION

HV CATHODE CONNECTOR

ANODE & CATHODE LAYERING (*preliminary*)

single layer

ANODE Dia-int=153.8mm; Dia-ext=162mm

		Thikcness (um)		X0 (cm)	% X0
Cyl. Support Anode	Cu Ground FEE	3		1,43	0,021
	kapton	50		28,6	0,017
	glue	25		33,5	0,007
	FR4	100		19,3	0,052
	glue	25		33,5	0,007
	MILLIFOAM/honeycomb	3000		1312,5	0,023
	glue	25		33,5	0,007
	FR4	100		19,3	0,052
					0,187
Amplif.	Cu	3		1,43	0,021
	kapton	50		28,6	0,017
	DLC	0,1		12,1	0,000
	Pre-preg (106)	50		19,3	0,026
					0,064
Anode 2D	Cu	3		1,43	0,021
	kapton	50		28,6	0,017
	glue	25		33,5	0,007
	Cu	3		1,43	0,021
	kapton	25		28,6	0,009
					0,076
Tile BaseLine	Glue (KREMPEL)	25		33,5	0,007
	kapton	50		28,6	0,017
	Glue	25		33,5	0,007
	Honeycom	2000		1312,5	0,015
	Glue	25		33,5	0,007
	Kapton	50		28,6	0,017
					0,073
			Tot. Anode		0,400

CATODHE Dia-int=180mm; Dia-ext=188mm

Cyl Support + Cathode	Cu	3		1,43	0,021
	kapton	50		28,6	0,017
	glue	25		33,5	0,007
	FR4	100		19,3	0,052
	glue	25		33,5	0,007
	MILLIFOAM/honeycomb	3000		1312,5	0,023
	glue	25		33,5	0,007
	FR4	100		19,3	0,052
Far. Cage	glue	25		33,5	0,007
	kapton	50		28,6	0,017
	Cu Ground	3		1,43	0,021
					0,233

work in progress

In case of

- *high module FR4*
- *cathodes made of low resistivity DLC*
- *Faraday cage in Aluminum*

The material budget of the *single layer* option
→ *from 0,63% to 0,47% X0*

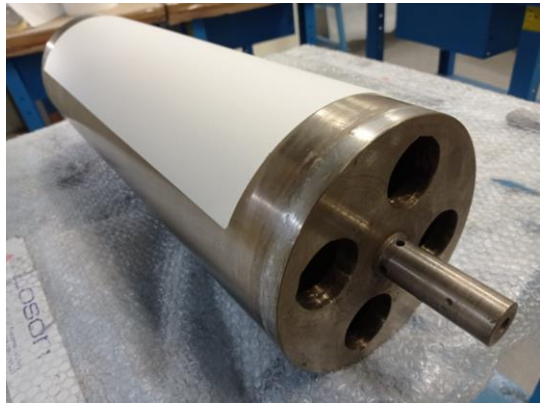
For the *B2B (large gap)* option
→ *from 0,93% to 0,75% X0*

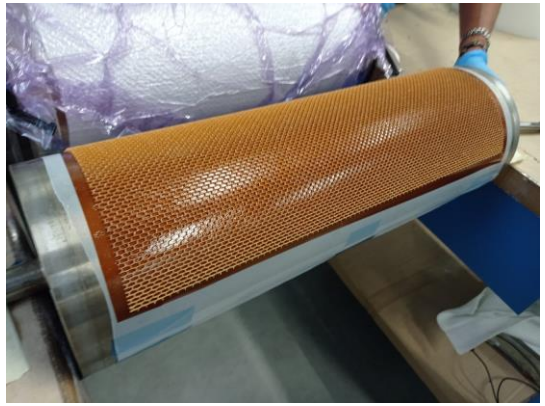
Task sharing & production sites

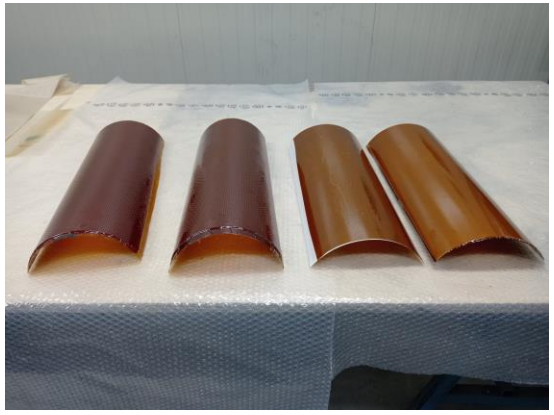
- The *design* of the detector is performed by our *INFN Technical Teams*
- The *mechanics* of the detector in composite material will be built by the *Italian Company LOSON*
- The *resistive amplification stage and the readout plane* of the C+RWELL will be produced by the *CERN PCB-Workshop*
- The sputtering of *Diamond Like Carbon* (DLC) for the resistive stage of the detector is done by the *Be-sputter in Japan*
- The *assembly* will be done at *LNF-Ferrara INFN sites*

Roof tile & detector mock-up tests

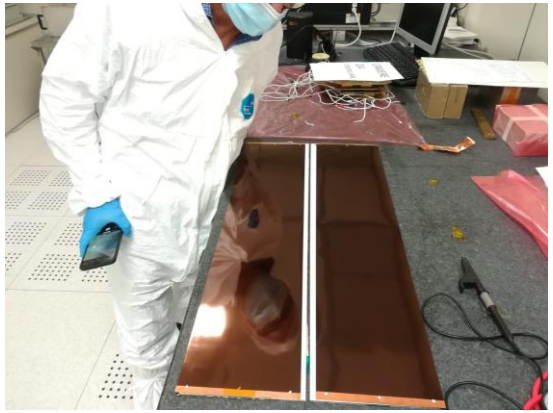
work done at LOSON







work done at CERN



detector layering

5 um Copper
50 um KAPTON
50 um prepreg 106
5 um Copper
50 um KAPTON

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Tentative program

The *design of the C+RWELL prototype* is in progress even though a global delay of few months due to COVID-19 has been accumulated

The *technical drawings of the prototype* have been already discussed with *Rui de Oliveira*

Tests of the first mechanical components of the prototype are in progress

Then the *project will be finalized*

Tentative timetable of the first period:

- Design of the mechanics, readout electrodes, amplification stage: **3 – 12/2020**
- Orders & procurement of the detector components **1 – 4/2021**
- Construction of the 1st prototype: **5 – 7/2021**
- Integration with front-end electronics + source test : **9 – 12/2021**
- Cosmic Ray & Beam test: **1 – 7/2022**

Summary

- An innovative C+RWELL based on new ideas (*modular & opening detector concepts*) is under development
- *Different layouts (B2B, large gap …) and materials* are under evaluation in order to *minimize the material budget* while optimizing the detector performance
- The design of the prototype is on going:
  - the technical drawings should be completed within Dec. 2020
  - the construction is foreseen within middle of 2021
  - extensive tests (*CR & test beam*) will follow
  - Taking into account the *versatile design of the detector,* the prototype can be recycled for *large gap layout testing*, just replacing the current cathode with a larger one

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Connecting Russian and European Measures for Large-scale Research Infrastructures

Thanks for the attention

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