Istituto Nazionale di Fisica Nucleare

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Connecting Russian and European Measures for Large-scale Research Infrastructures

The C+RWELL for the SCT detector

WP5.4 status report - July 9th 2021

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INFN LNF-DDG

Cremlin+ → low X0 cylindrical μ-RWELL

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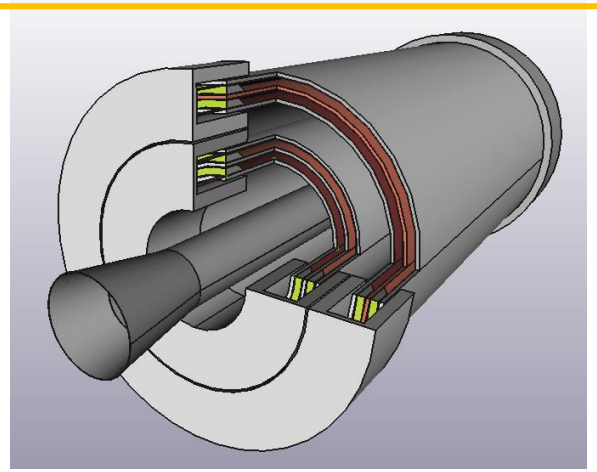
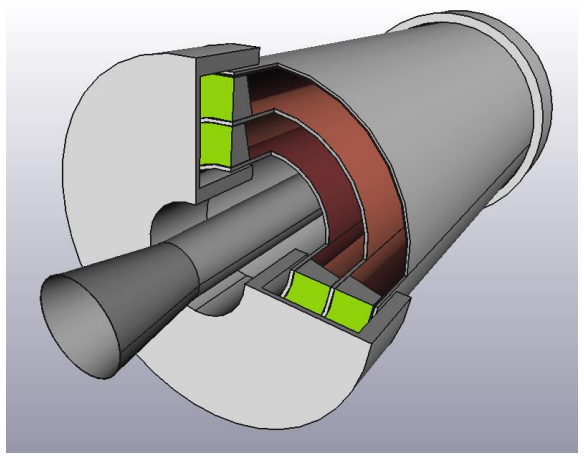
- The **goal** is the development of a **cylindrical modular μ-RWELL** as **inner tracker** for the **SCT detector**
- The **two schemes** under study are both based on a **B2B layout** (a **double radial TPC – with a central cathode**), characterized by **low material budget** and **modular roof-tile shaped active device**

"2 - B2B small drift gap" cylindrical detector



micro-TPC readout mode allowing **space resolution** of O(**100 μm**) for **inclined tracks** (on the radial view)

"1 - B2B large drift gap" cylindrical detector



- **N.2 small gap B2B C+layers → 1.72% X0**
- 2 × 1 cm gas gap/B2B device
- 4 cm global sampling gas

- **N.1 large gap B2B C+layers→ 0.86% X0**
- 2 × 1 cm gas gap/B2B device
- 10 cm global sampling gas

1.46 % X0 ←

Further **material budget reduction** by using:
- **high module FR4**
- **low resistivity DLC cathode**
- **aluminum Faraday-Cage/shielding**

→ **0,75 % X0**

Cremlin+ → the C+RWELL prototype

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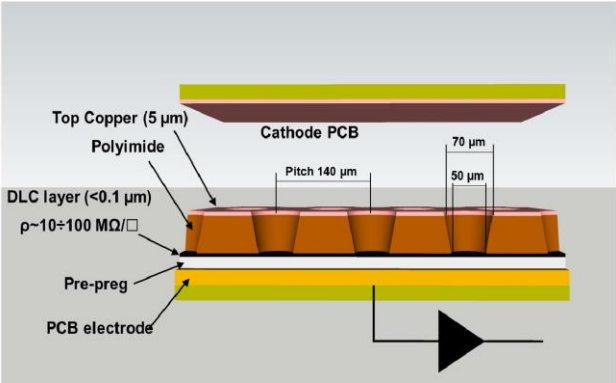
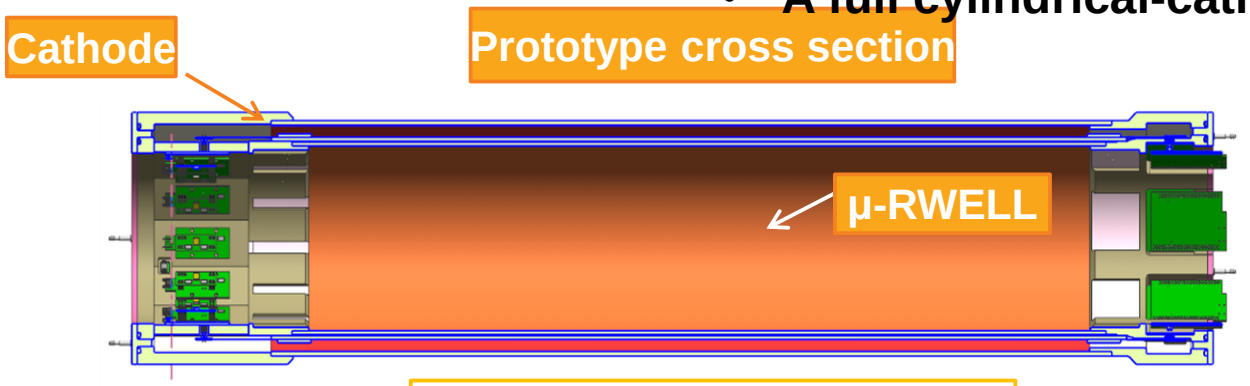
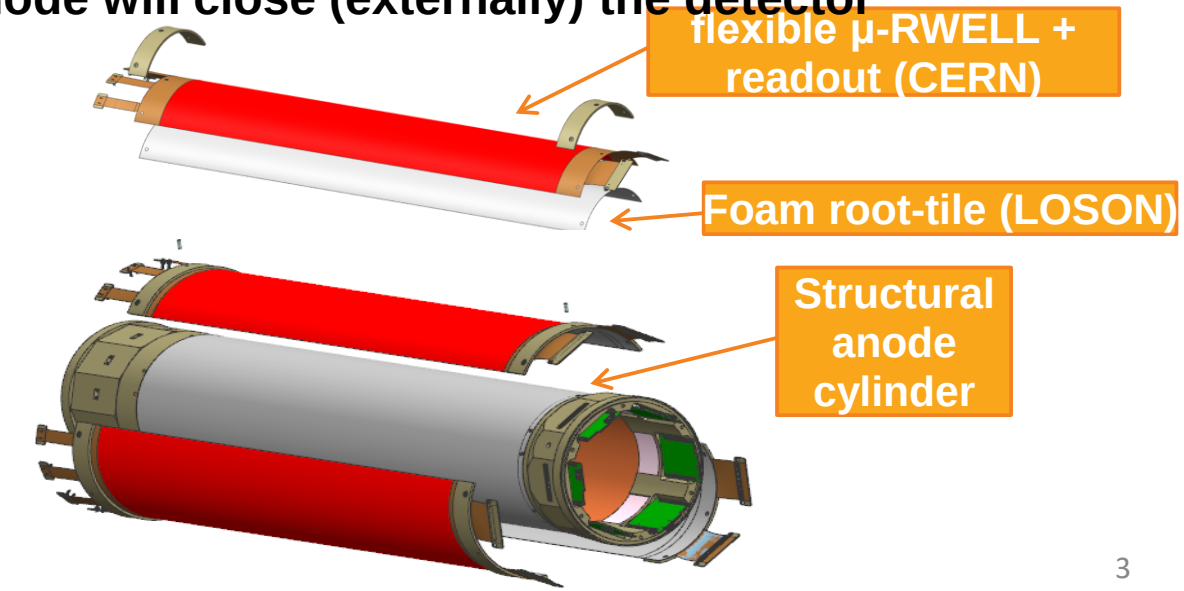
To validate the concept we are designing a single-layer small drift-gap (1 cm) C+RWELL prototype



- From standard **micro-RWELL technology on rigid PCB supports** we are developing a **full flexible detector tile**
- **Three of such flexible detector tiles** will be **glued** on **composite/foam roof-tiles**, then mounted on the **anode cylindrical support**
- **A full cylindrical-cathode will close (externally) the detector**





Prototype size

- external diameter ≈20cm
- global length ≈ 100cm

Task sharing

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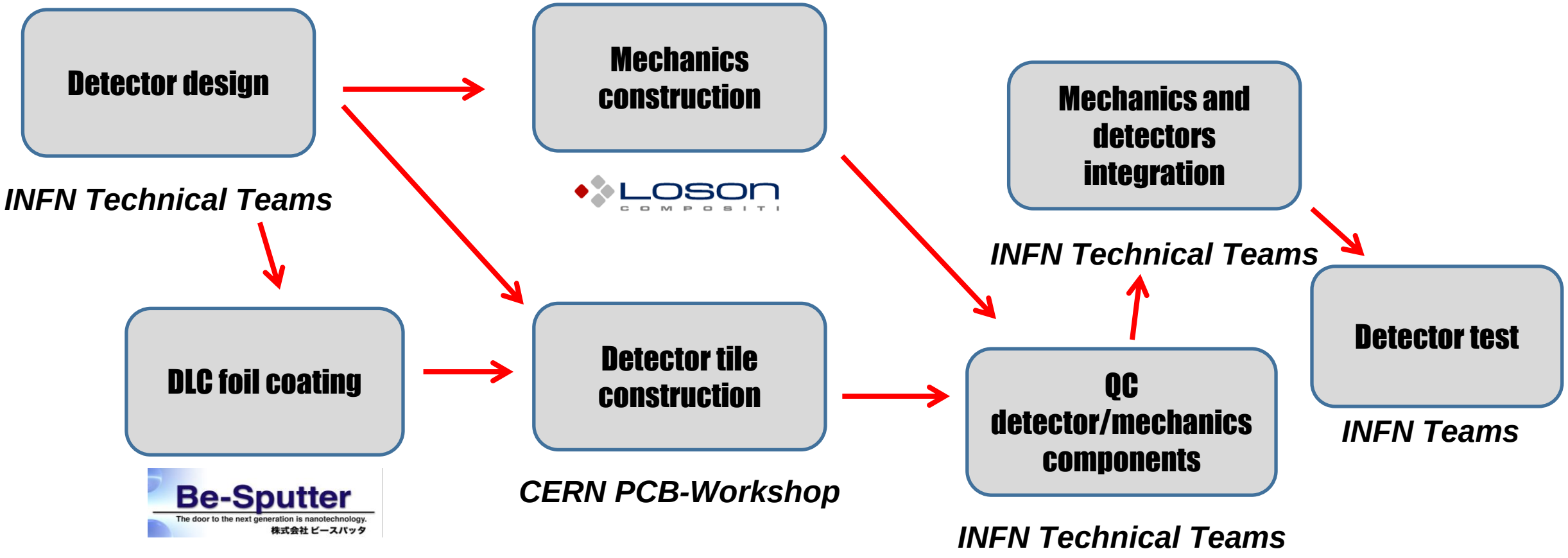

Cremlin+ → the C+RWELL progress (I)

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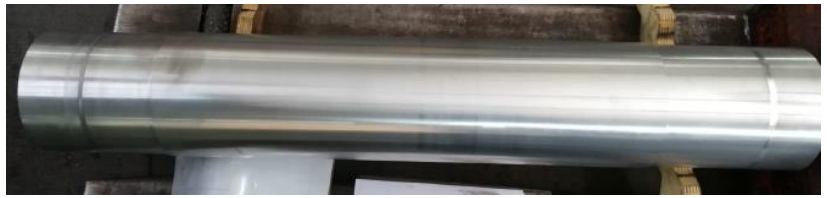
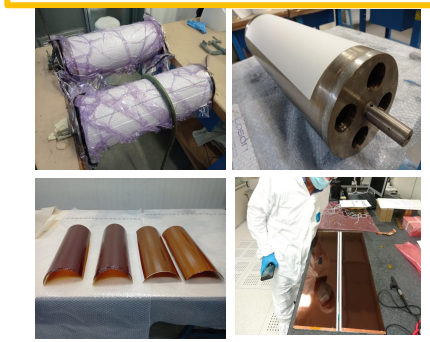
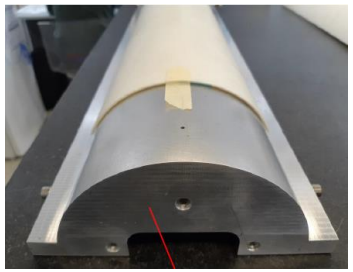
The **design** of the prototype has been **completely revised and finalized**

- Orders of **flex-detector tiles** (CERN – Rui) done → delivery by the end of **July 2021**
- Orders of **mechanics/tools** (anode/cathode, end-caps, plugs, tiles) done → **construction in progress (@LOSON):**
- **anode mould** → end of **July 2021**
- **cathode mould** → end of **July 2021**
- **end-caps/plugs in peek** → **15 Sept. 2021**
- **tiles (still) under test** → end of **July 2021**
- **HV, signal interface boards** → end of **July 2021**
- **Detector assembly** → **Oct – Dec 2021**







Cremlin+ → the C+RWELL progress (II)

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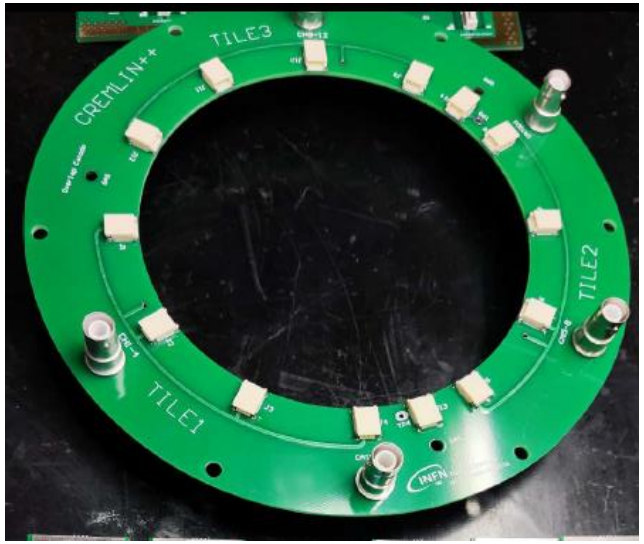
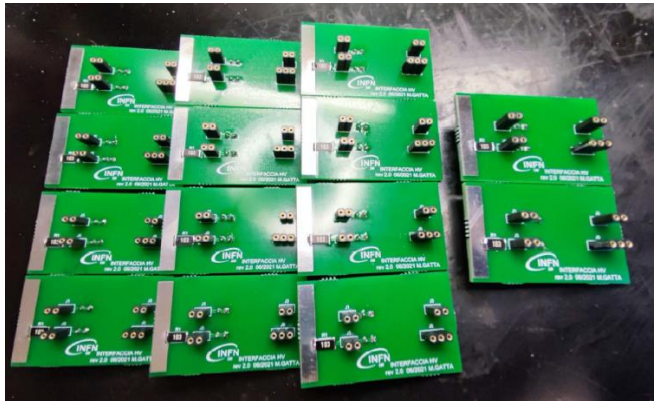
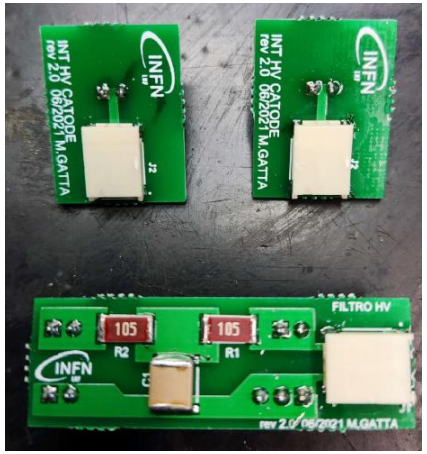
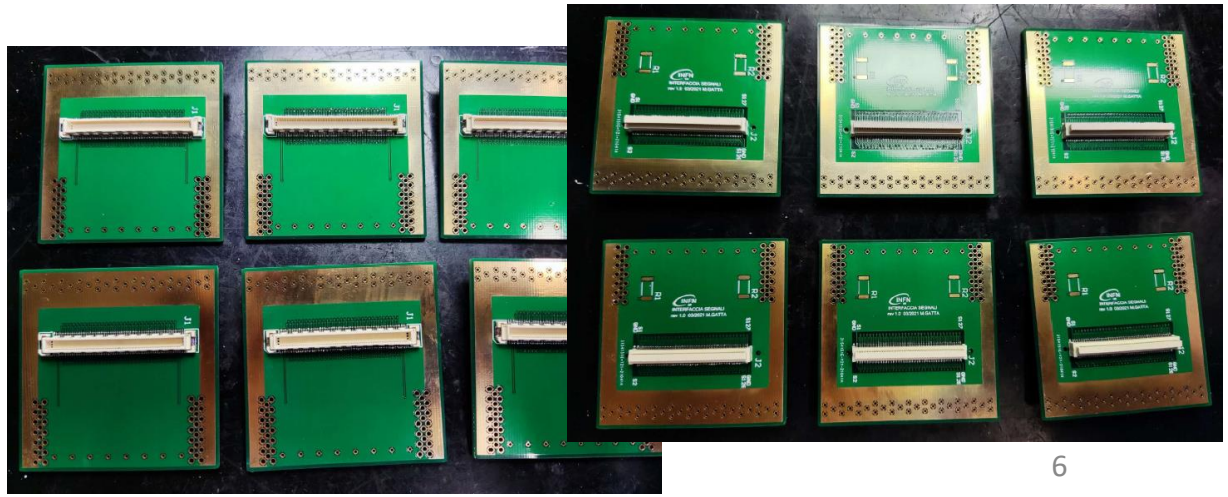
Boards assembly @ LNF (D. Di Bari)

- Signal Interface board, from HIROSE to PANASONIC
- HV board Interface
- HV Filter board
- HV distribution board









Detector Readout - 1D (present)

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Roof tile detector prototype (1D – readout)

signal side

HV side

Amplification/DLC stage circuit

Tile detector (1-D)

Strips (1-D)
- **Number : 256 X**
- Pitch : 0,680 mm
- Width : 0,200 mm

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

HV sectors : 4

Global size
- Length : 890 mm
- width: 175,8 mm

Active area
- Length : 600 mm
- width : 174,8 mm

DLC area: 620 × 175,8 mm

Detector Readout – 2D (future R&D)

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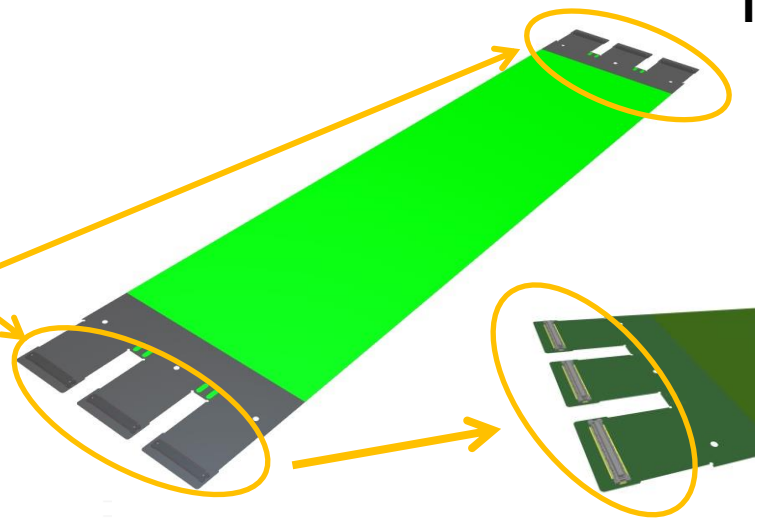
Very preliminary study

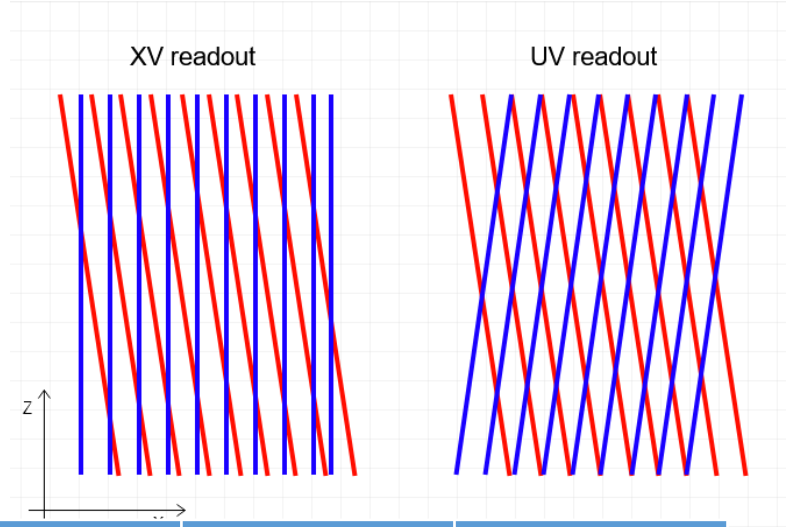
Constraint

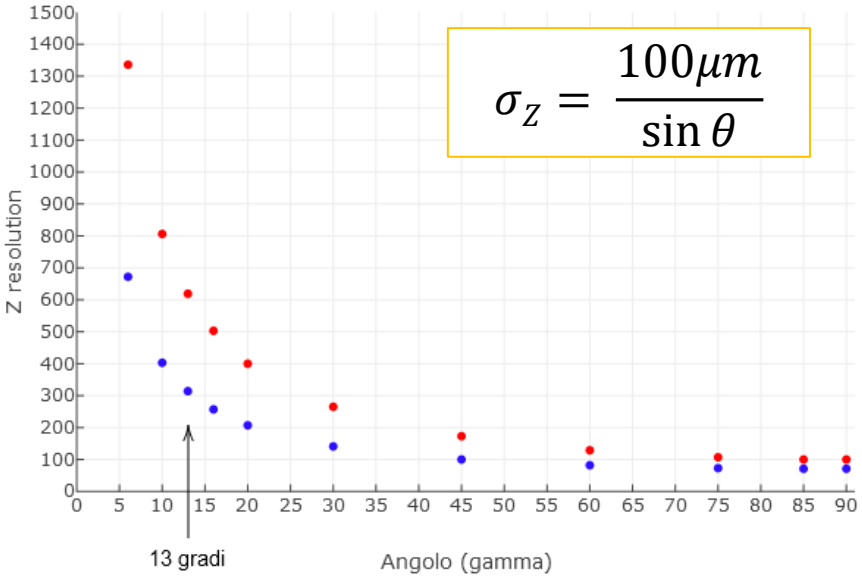
Signal maximum tails/connectors that can be placed on each readout-tile

- **n. 6** for signals (3 each side)
- **n. 4** for HV (corresponding to n.4 **HV sectors)**



Two 2-D options can be considered





$$\sigma_Z = \frac{100\mu m}{\sin\theta}$$

2D readout type	# APV/side	#chs/side	#strips/side	Strip/pitch
XV	3	384	128X, 256V	660um
UV	3	384	192U, 192V	857um

Assuming σ_X / $\sigma_{U\text{-}V}$ ~ 100 μm for the single view (X or U/V), the **Z-space resolution** depends on the stereo angle.
For prototype θ ~ **13°** : **for XV (σ_Z ~ 600 μm)** – while for **UV (σ_Z ~ 300 μm)**

Detector Readout – 2D optimization

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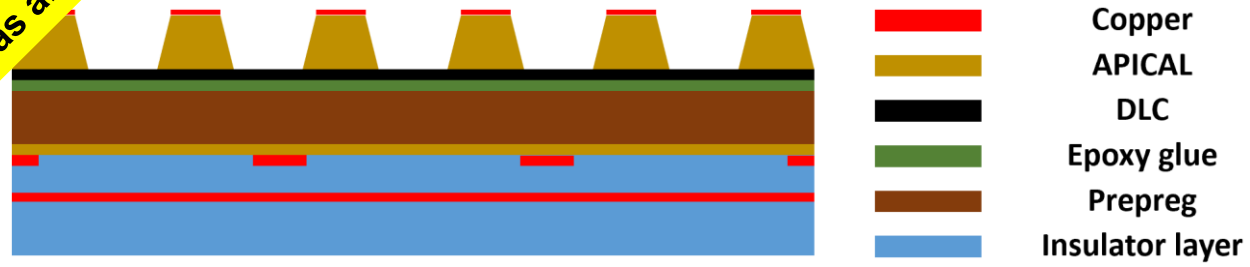
X-Y equal sharing + **signal collection** optimization → study by Zhou Yi (USTC) w/Rui (CERN)

just as an example

2D-strip μRWELL



X-Y equal sharing

Top strips: 60um (80)
Bottom strips: 350um (350)
Pitch: 400um (400)

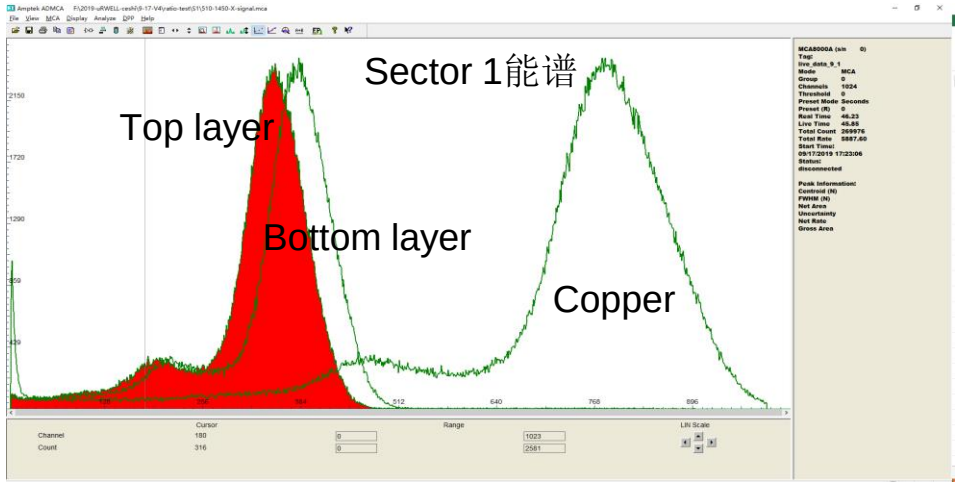
strip width geometry not good for us

Insulator layer between Top & Bottom readout strips: 25um (50)
DLC resistivity: R_{AB}=40MΩ

top/bottom thickness

Insulating layer between DLC and readout strip:
50um Prepreg+12um Kapton+10um epoxy glue

DLC-readout distance → *can be **reduced** down to **28um** (**for signal optimization**)*



	Top	Bottom	Copper	Bottom/Top	Copper/Bottom
Sector 1	354	386	785	1.09	2.03
Sector 2	322	358	698	1.11	1.95
Sector 3	329	375	771	1.14	2.06
Sector 4	336	374	728	1.11	1.95

DLC production

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DLC production @ Be-Sputter (Kyoto - Japan)

CERN-INFN joint DLC facility (C.I.D.) → MOU close to approval

NOW

Max foil size: 1 × 4.5 m^2

Be-Sputter
The door to the next generation is nanotechnology.
株式会社 ビースパッタ

NEAR FUTURE

Max foil size: 2 × 0.6 m^2

In operation within June 2022

Summary

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- The design of the prototype completed
- Orders started
- Construction of detector components in progress
- Electronics/HV boards delivered - components mounting started

<u>Next steps</u>

- Prototype assembly Dec. 2021
- FEE Integration + source/Cosmics/ Beam Test (tbd) ≥ 2022

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Thanks for the attention

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Deliverables & Milestones

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D5.2 - m24: Status report on R&D work on Inner Tracker for the SCT detector. This report is supposed to describe joint EU – Russia activities around inner tracker of the SCT detector

D5.7 - m44: Final report on R&D work on Inner Tracker for the SCT detector. This report is supposed to describe the advanced stage of activities of SCT collaboration related to inner tracker of the SCT detector, including the construction and test of prototype.

M4 – m42: Construction and test of the Inner Tracker (C-RWELL) prototype for SCT detector

Prototype mechanics

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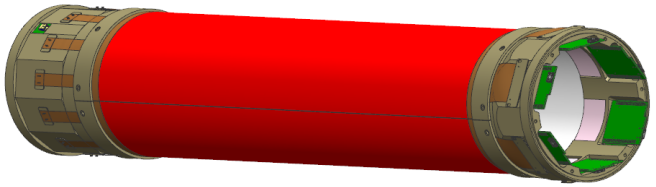
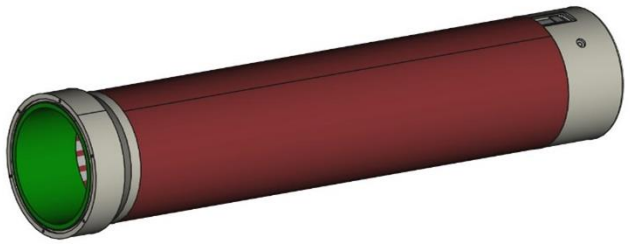
NEW molds/toolings have been designed and are under construction





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

Drift Gap: 10 mm
Active length: 600 mm

Anode Cylinder
- Thickness: 4.1 mm
- Internal diameter: 153.8 mm
- External diameter: 162.2 mm

Cathode Cylinder
- Thickness: 4 mm
- Internal diameter: 188.5 mm
- External diameter: 196.2 mm

Prototype material stacking

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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
	MILLIFOAM/honeycomb	800		1312,5	0,006
					0,193
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	50		28,6	0,017
					0,084
BARE Tile option				33,5	0,000
				19,3	0,000
	GLUE	25		33,5	0,007
	MILLIFOAM	3000		1312,5	0,023
				33,5	0,000
				19,3	0,000
					0,030
			Tot. Anode		0,373

CATODHE Dia-int=188.5mm; Dia-ext=196.25mm

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

Improvements are possible by using:

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

The material budget of the single layer option
→ from 0,606% to 0,488% X0

For the B2B (large gap – radial TPC) option
→ from 0,860% to 0,742% X0

Construction Tests (I)

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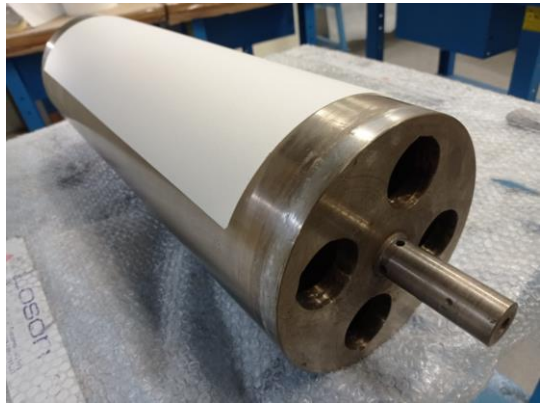
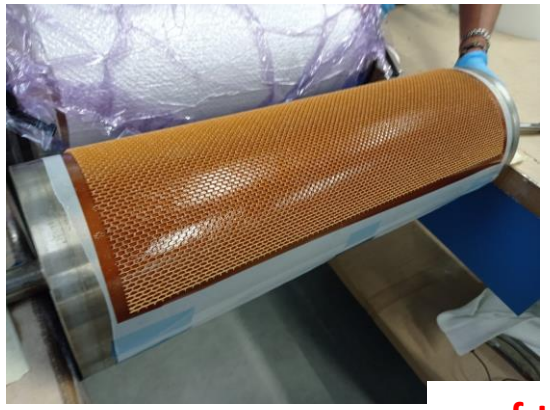
work done at LOSON





roof-tile tests

work done at CERN

detector mock-up tests

detector stacking

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

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Construction Tests (II)

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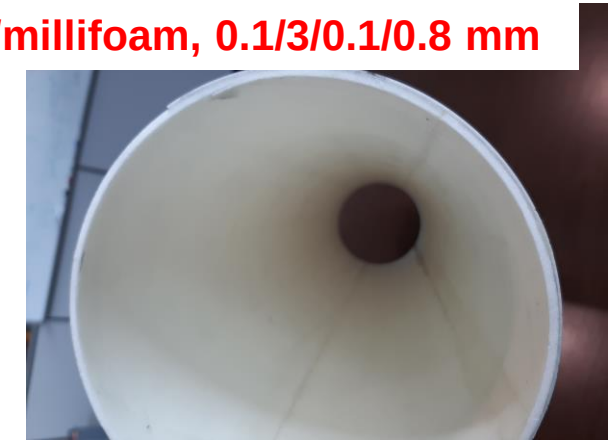
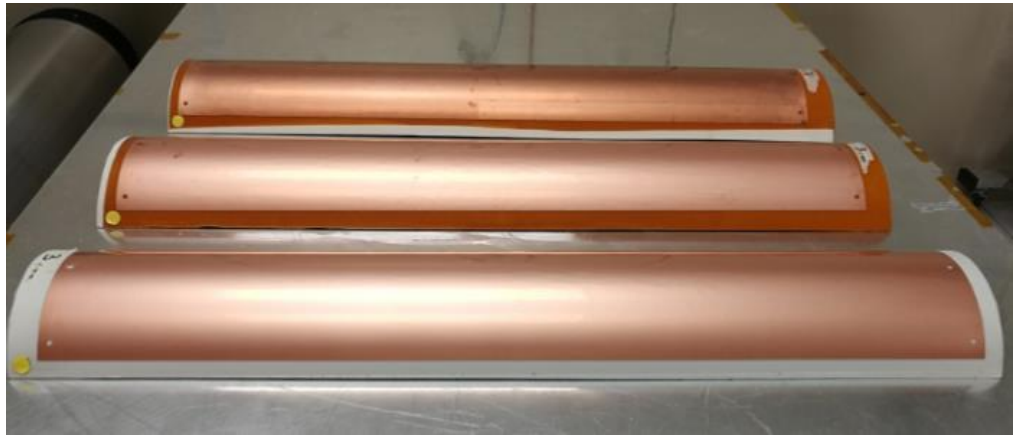
work done at LOSON

prototype of the structural cylinder sandwich: FR4/millifoam/FR4/millifoam, 0.1/3/0.1/0.8 mm





Integration test at INFN

Quality checks

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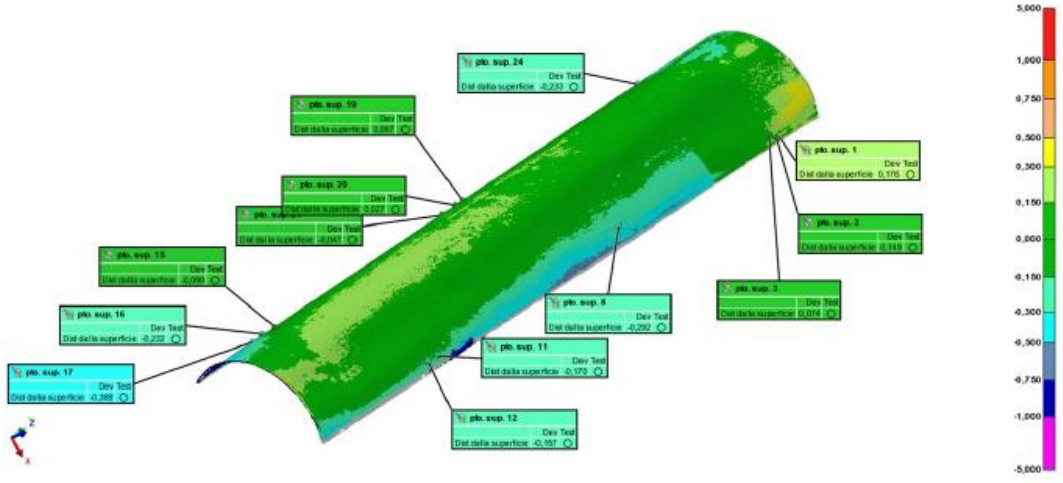
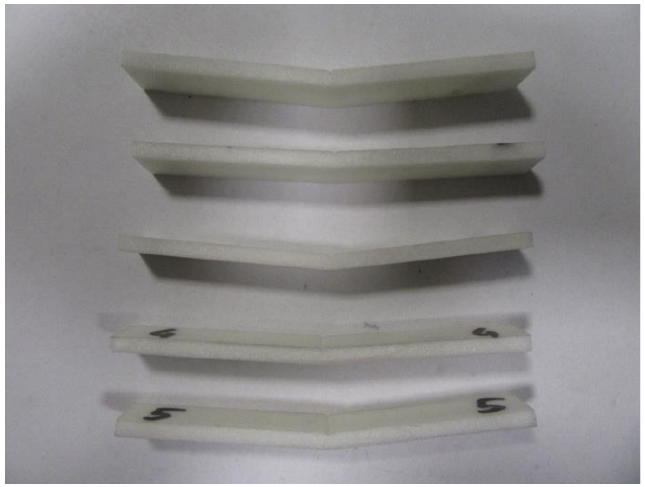


- Tile–prototypes have been measured with a Laser arm, before and after fake-detectors gluing
- The comparison between before and after fake-detector gluing shows max differences **well inside 0.1 mm** (*shape precision*)
- Structural tests of the composite material used for the cylindrical support has been recently performed



Identificativo provino	d mm	b mm	t mm	c mm	S mm	E_{mod} GPa	F_s^{ult} N/mm²	σ N/mm²	Dettagli sulla rottura
SANDWICH PANNEL 1	3,20	11,29	0,100	3,00	64	1,42	0,233	74,4	CGC
SANDWICH PANNEL 2	3,19	10,37	0,100	2,99	64	1,40	0,237	76,0	CGC
SANDWICH PANNEL 3	3,20	10,02	0,100	3,00	64	1,48	0,257	82,4	CGC
SANDWICH PANNEL 4	3,20	10,76	0,100	3,00	64	1,42	0,234	74,9	CGC
SANDWICH PANNEL 5	3,19	9,92	0,100	2,99	64	1,44	0,206	66,0	CGC

1,4 GPa