μRWELL R&D plans for 2021

Marco Poli Lener
On behalf of WP7 group

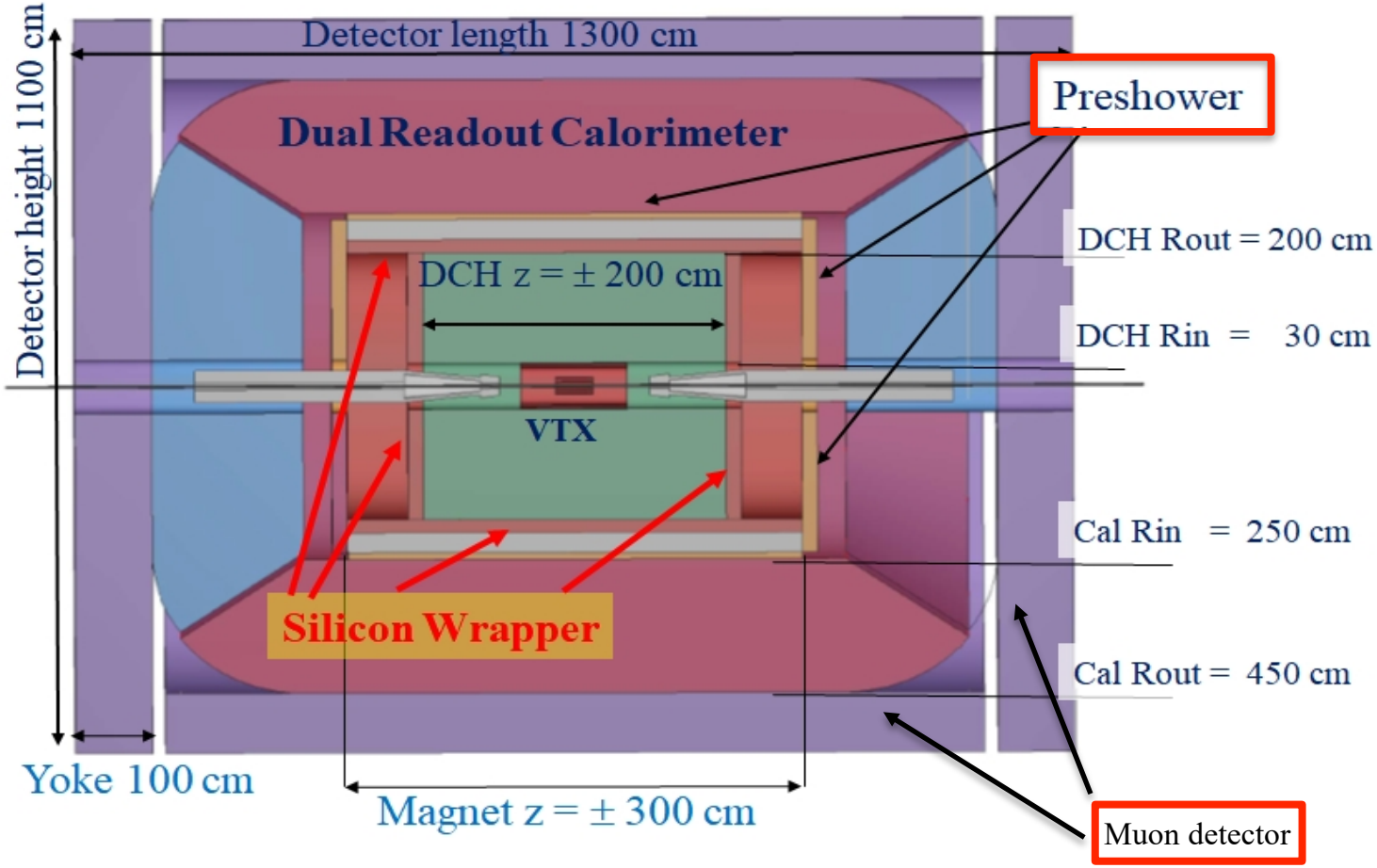
INFN BO, FE, LNF, TO

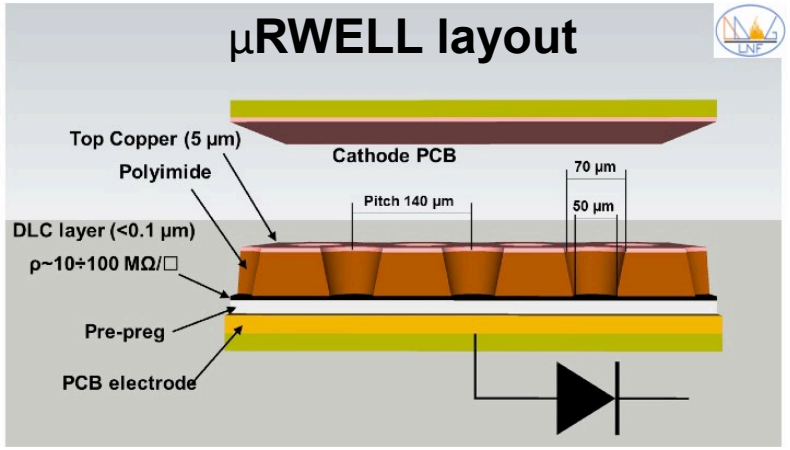
Gruppi coinvolti nei progetti Eu:

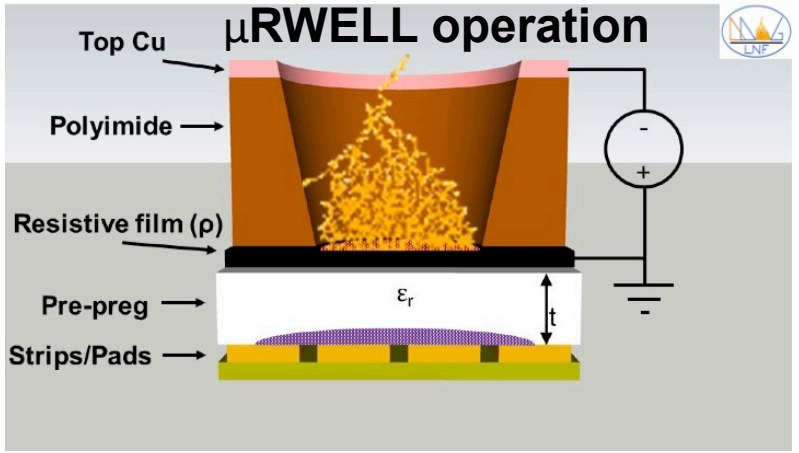
- CREMLIN+ → R&D for a full cylindrical μRWELL – Inner tracker for the Super c-tauFactory – Novosibirsk
- AIDAInnova → TT of the μRWELL technology to ELTOS, development of new tracking algorithms

IDEA detector layout

IDEA detector is a general purpose detector designed for experiments at future e^+e^- colliders (FCCee and CepC).







Preshower detector and the Muon system are designed with the µRWELL technology

IDEA Muon detector dimensions

Barrel

R [mm]	Length [mm]	Thickness [mm]	pixel size [mm]	area [cm²]	# of channels
2460	±2480	20	0.4×500	768K	384K

Endcap

R_{in} [mm]	R_{out} [mm]	z [mm]	Thickness [mm]	pixel size [mm]	area [cm²]	# of channels
248	2440	±2460	20	0.4×500	370K	185K

Tiles: 50x50 cm² with X-Y readout
Strip Length: 50 cm
Strip pitch: 0.4 mm
Input FEE capacity (Cap_{inp})~ 70 pF

$$C = \varepsilon_0 \times \varepsilon_r \times \frac{S_{strip}}{t} \approx 36\,pF \times S(cm^2)$$

IDEA's Pre-Shower detector would have in total:

- ~ **330 m² total**
- ~ **1.5 M channel in total**

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

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
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µRwell	454	5220	±4880	20		1.5×500	1.7M	227K
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IDEA's Muon detector would have in total:

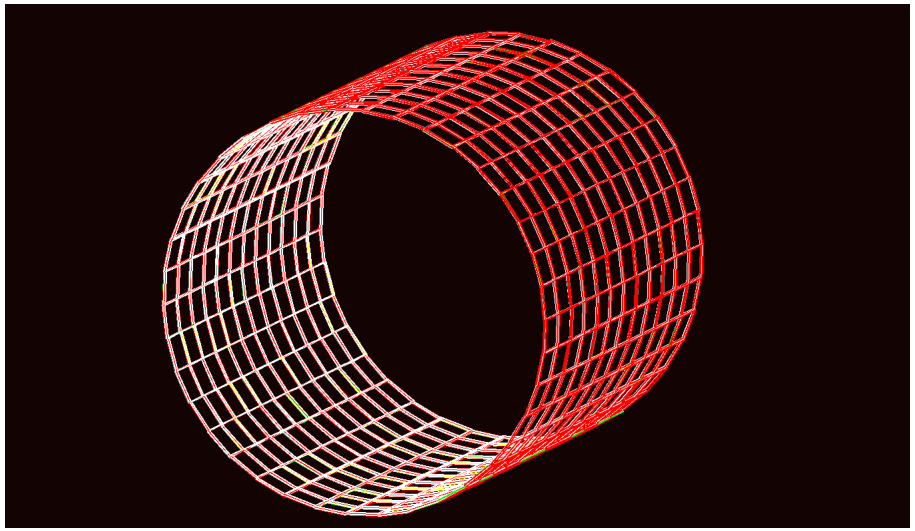
- ~ **4000 m² total**
- ~ **5 M channel in total**

GOAL:

- **Fast/Full Simulation of pre-shower & Muon apparatus**
- Reduction of the number of FEE channels without increse the Cap_{inp} → optimazation of the surface resistivity of the µRWELLresistive layer
- Cost reduction of FEE channels→ custom-made ASIC (TIGER)

Status and Plans for the IDEA's Pre-Shower and Muon Detector Simulations

Current status of the detector description



Pre-Shower

- General description of a μRWELL detector element implemented in Geant4 (by G. Morello & E. Fontanesi)
- Full barrel geometry implemented
- Preliminary studies to define the endcap geometry
- No implementation of sensitive volumes
- Everything in a standalone code https://github.com/elfontan/IDEA

Muon detector

- work just started (INFN Ferrara)

Provide a description of the geometry of muon detector and pre-shower

Simplified geometry → only the big volumes, to avoid chasing any modifications to the detection modules

Fine details (e.g., dead spaces, modularity) will be handled at reconstruction level

The description will include a simple implementation of the return yoke of the solenoid

The description will be done within the official IDEA framework

First with Geant4 directly (by end of July) using EDM4HEP as output

Later ported to DD4HEP

The Pre-Shower description must be also ported inside the official framework

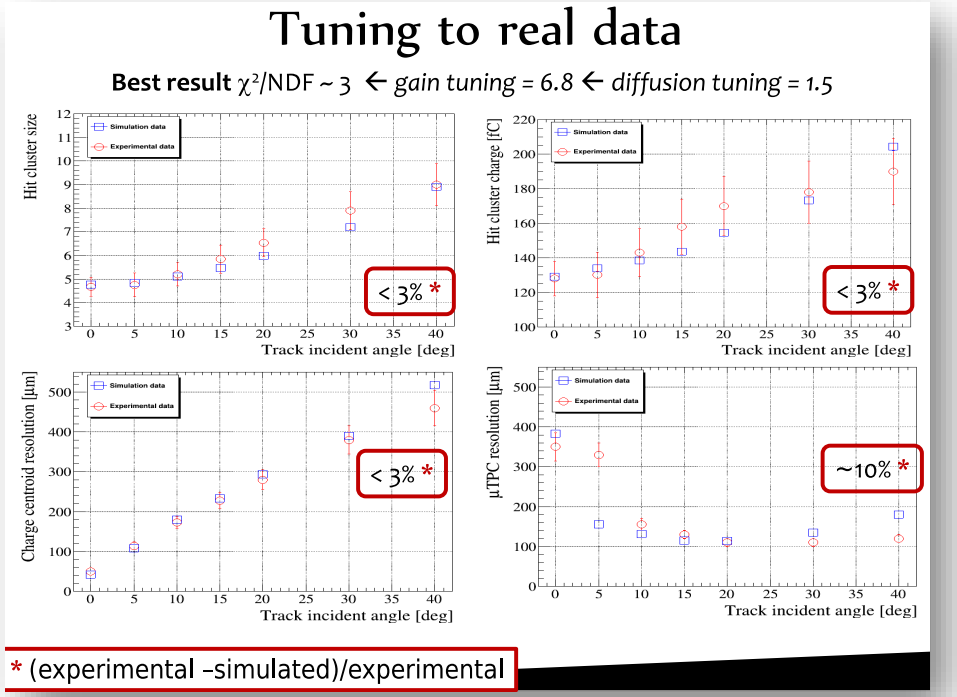
Resources identified within the muon and pre-shower group

Simulation and Machine Learning development

For triple-GEM, a parametric simulation which includes diffusion, transparency, gain, induction and readout electronics was developed

Tuning to test beam data → both charge and time readout for CoG and uTPC cluster reconstruction

Goal I: extend the simulation to μRWELL (synergy with Cremlinplus)
Goal II: develop general purpose Machine Learning tracking algorithms for MPGDs



R. Farinelli and L. Lavezzi, RD51 coll. Meeting - Oct 2019

Resistive simulation – in progress: describe the charge dispersion at the anode which depends on the time constant determined by the DLC surface resistivity and the capacitance per unit area (*Nucl.Instrum.Meth.A566:281-285,2006).*

The **simulated spatial and temporal charge evolution** will be convoluted to the intrinsic rise-time of the detector and the electronics shaping time effects and then compared with **results from test beam (slide 9)**

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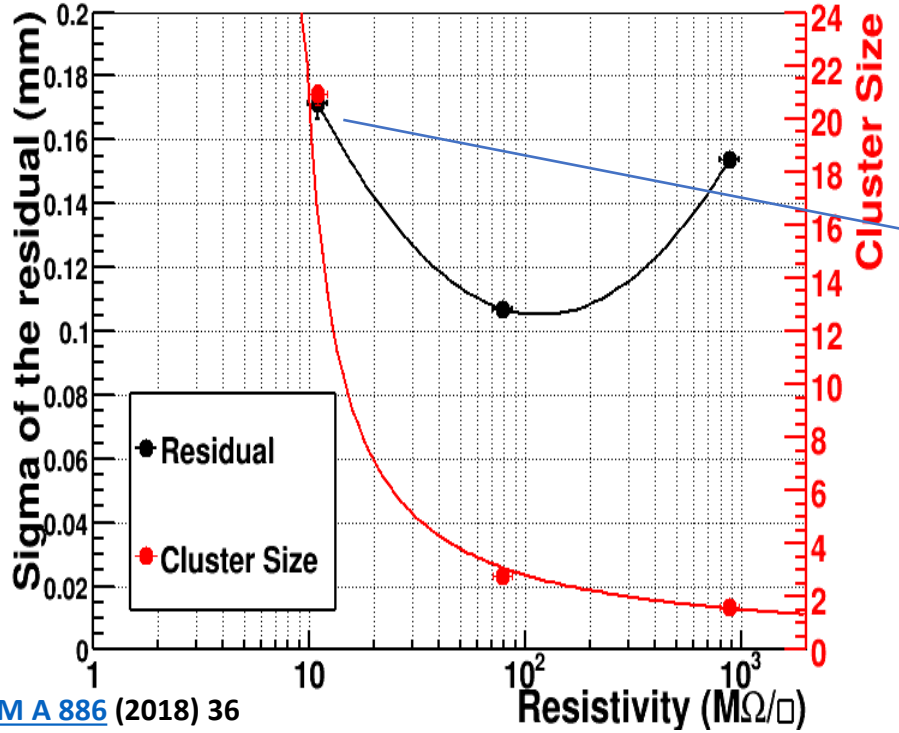
Space resolution with μRWELL: orthogonal tracks

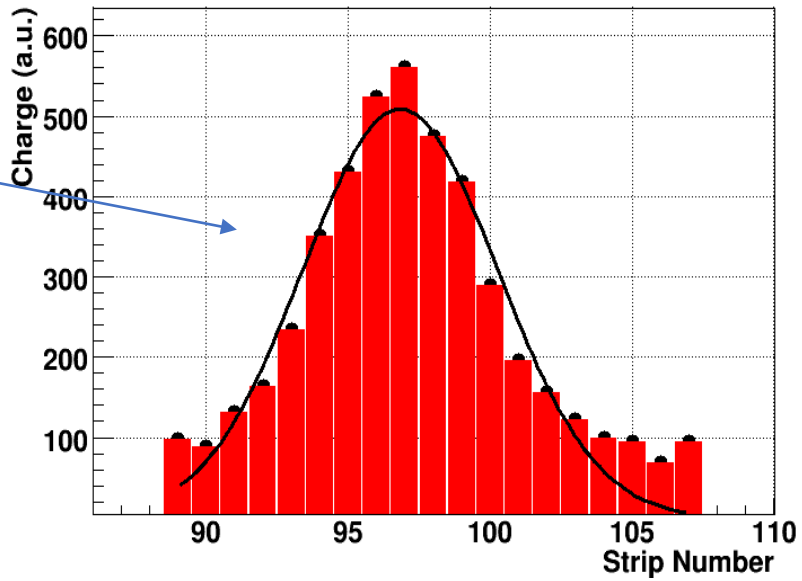
Centroid analisys

APV & 400 um strip pitch & Cinp=15 pF



G. Bencivenni et al., NIM A 886 (2018) 36

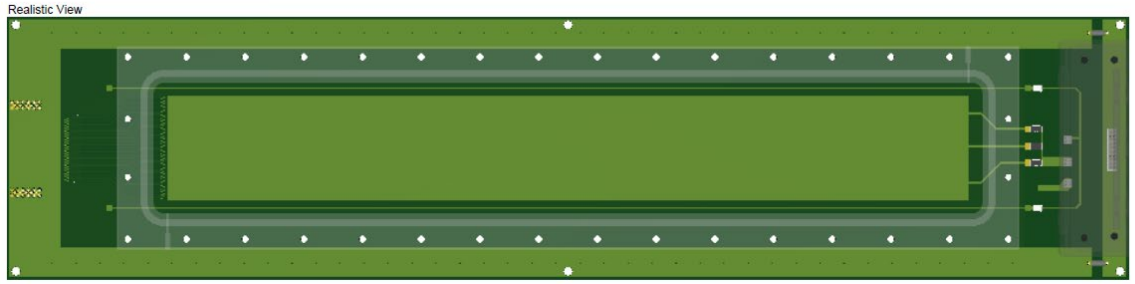
Charge collected by the APV on the strip readout (resistivity 10 MΩ/□)



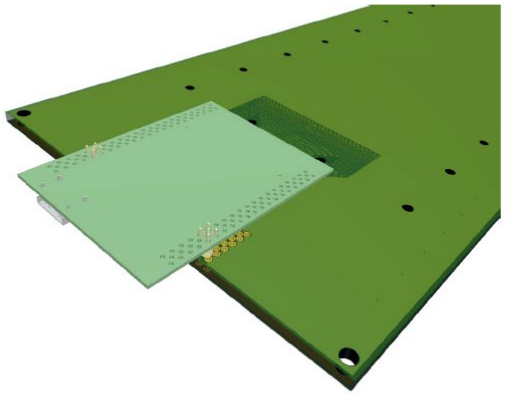
R&D 2021 plan: measurement of the space resolution as a function of the detector surface resistivity for different pitch - pre-shower p=0.4 mm muon p=1 mm -

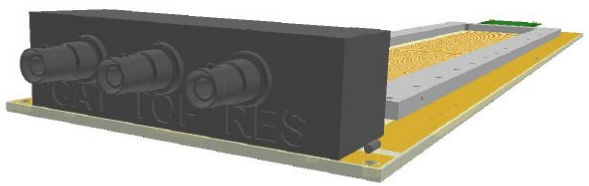
R&D status

- Pre-shower:
  - design → completed pitch strip 0.4 mm
  - DLC foils with different resistivity 10, 30 50, 70, >100 MΩ/sq
    → <u>available from URANIA & LHCb stock (to be restored urgently – 5 k€)</u>
  - order completed
  - production will be concluded by the end of July 2021

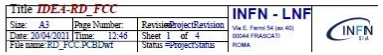


- Muon:
  - design → completed with pitch 0.8, 1.2 mm
  - DLC foils with different resistivity, 10, 20, 30 MΩ/sq
    → will be delivered in few weeks
  - order on going
  - production will be concluded in 8 weeks



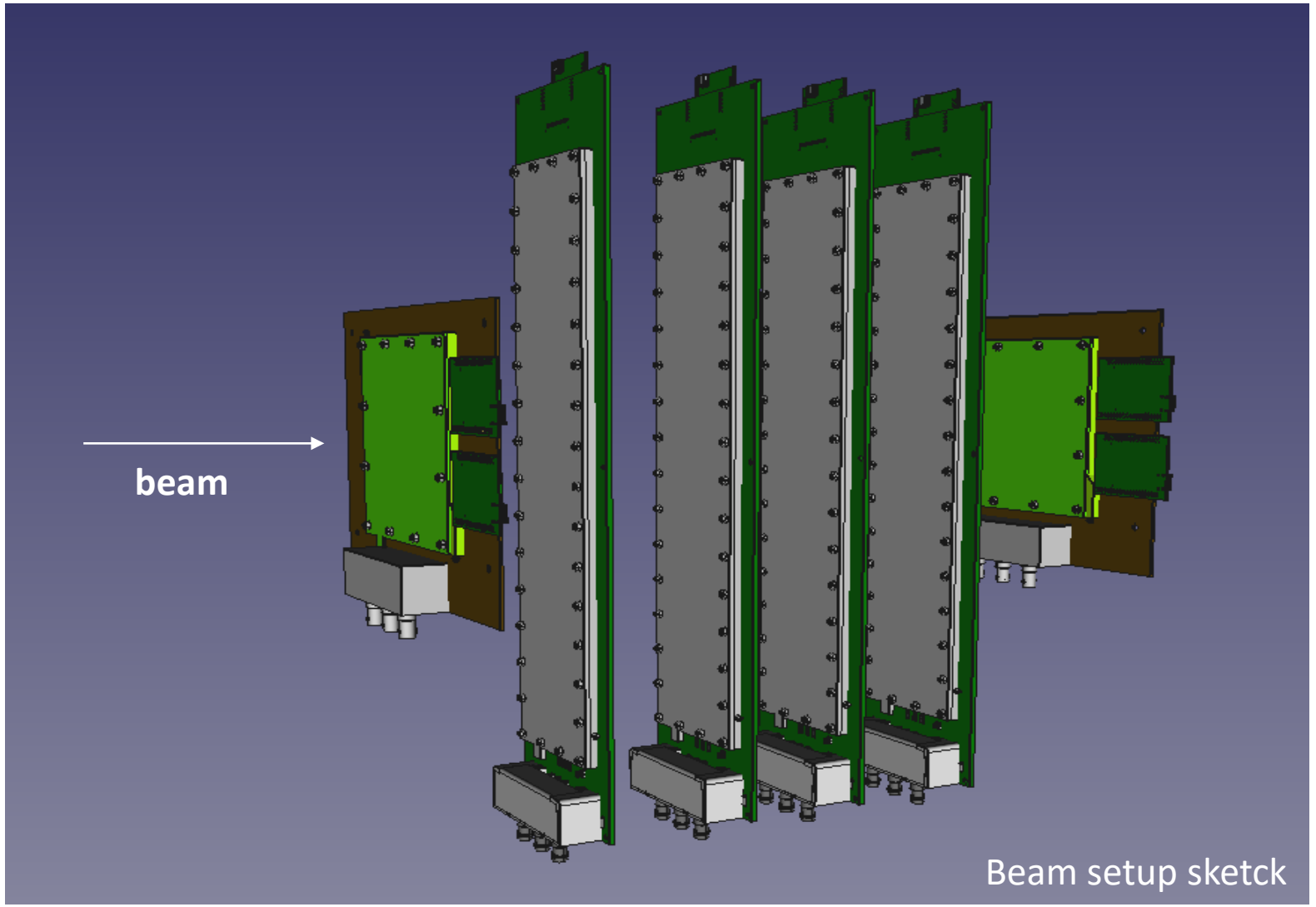


Cathodes and frames order to be done (Eltos, Meroni & Longoni)



Test beam @ CERN

20th October → 3rd November 2021 (2 weeks) @ SPS-H8C



TB results will validate the simulation studies

Collaboration tasks

- Detector design → LNF
- Detector assembly & characterization→ LNF
- XY Trackers → LNF
- Mechanics for the TB → Fe, Bo
- APV electronics + flat cables → Bo
- SRS+PC acquisition → Fe
- Card for the T0 → LNF
- Trigger (scint., tile, NIM modules, CRATE) → Fe
- HV system + boards, cables + DAQ → LNF
- PC for DAQ → Fe (laptop)
- Gas pipe, pressure reducer, column flowmeters , T-p-RH probe → LNF
- Gas bottle pre-mix order @ CERN → Bo
- Material Transport → LNF

Richieste ulteriori 2021

Richieste:

- sblocco missioni sj (LNF= 5k€, Bo= 5k€, Fe= 5k€, To=5k€)
- spese per supporto meccanico per realizzazione setup (Bo): 2k€
- spese per trasporto (LNF): 2k€
- spese per bombola pre-mix gas @ CERN (Bo): 0.5 k€
- DLC da restituire a URANIA e LHCb: 5 k€

2022-2024 plans of WP7

Very preliminary program:

- Define the best resistivity of the DLC for both μRWELL fundamental tiles
  - Build 50x50 cm^2 prototypes for preshower and muon system
    - Both prototypes with bi-dimensional readout
  - Develop a custom-made ASIC for the μRWELLs, with the experience obtained from the TIGER
  - Optimise the engineering mass construction process together with industry (Eltos)
  - Develop a new reconstruction algorithm, ML-based, to improve the resolution for tracks impinging at an angle far from 90^0
- Test and validate μRWELL prototypes in the lab with cosmic rays
- Test and validate μRWELL prototypes with custom-made electronics in test beams