This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004761

Machine Learning for (resistive) MPGDs

G. Cibinetto (INFN Ferrara)

Aidainnova Annual Meeting – Valencia, Apr. 24-27, 2023

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The task in a nutshell

- Goal: use M.L. algorithms to improve tracking performance and PID capability to (resistive) MPGDs
  - Possible application pre-shower of the IDEA detector at FCC_{ee}

Aidainnova 4-year program

1. simulation of the μ-RWELL resistive layer
2. use of Machine Learning for cluster selection and track finding
3. track cleaning and refinement
4. application to IDEA framework

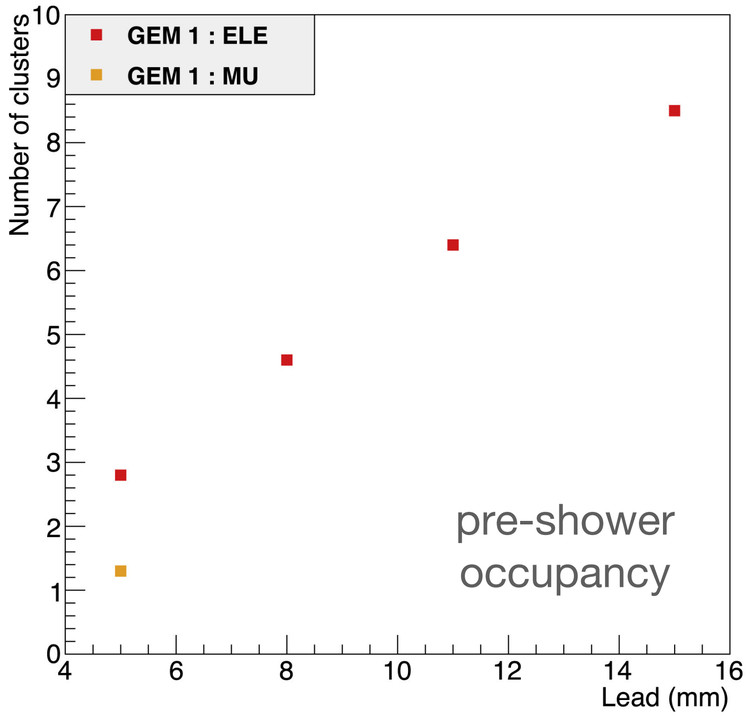
- Groups involved: INFN Bologna, Ferrara, Frascati and Turin
- Strong interplay with tasks
  - **7.3** design and industrialization of large area microRWELL detectors (we receive input from there)
  - **11.2** design of an ASIC chip dedicated to microRWELL readout (input from our simulations)
- Synergy with Eurizon European project

Features of resistive MPGDs

- The resistive layer
  - acts as high voltage spark protection
  - affects the coupling of the strip/pad readout, hence the reconstruction
- E.g., resistive MicroMegas, microRWELL

- microRWELL detectors have been proposed for
  - LHCb muon upgrade
  - Super tau-charm factories
  - JLAB, EIC
  - IDEA @ FCC_{ee} muon and pre-shower systems

IDEA slice Test Beam results
NIM A958 (2020) 162088

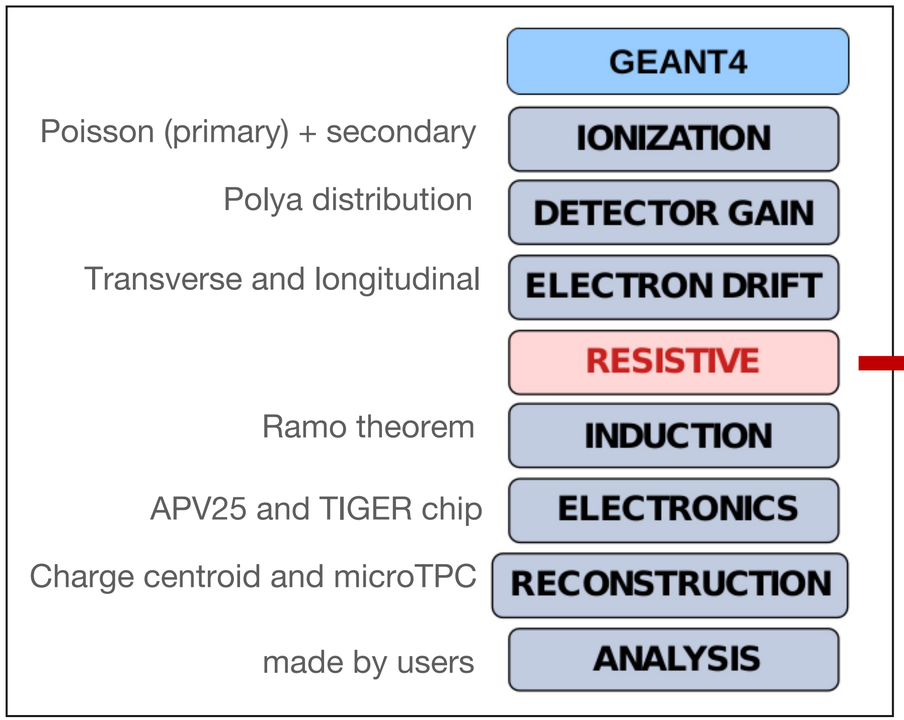


Simulation of resistive MPGDs

Simulation based on Parsifal toolkit originally developed for BESIII triple-GEM detectors

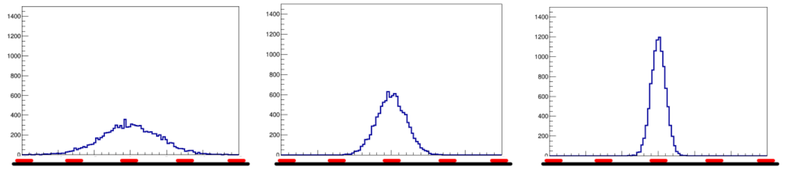
- fast, accurate and complete parametric simulation

PARSIFAL: a toolkit for triple-GEM parametrized simulation
arXiv:2005.04452 submitted to Computer Physics Communications



Charge distribution example

low resistivity



high resistivity

$$
\begin{aligned}
Q(t) &= \int_{x_1}^{x_2} \rho(x,t)\mathrm{d}x \\
&= \frac{q}{\sqrt{2\pi}\left[\sigma_0\left(1+\frac{t-t_0}{\tau}\right)\right]} \int_{x_1}^{x_2} \exp\left[-\frac{(x-x_0)^2}{2\sigma_0^2\left(1+\frac{t-t_0}{\tau}\right)^2}\right] \Theta\left(t-t_0\right)\mathrm{d}x \\
&= \frac{q}{2}\left[\mathrm{erf}\left(\frac{x_2-x_0}{\sqrt{2}\sigma_0\left(1+\frac{t-t_0}{\tau}\right)}\right) - \mathrm{erf}\left(\frac{x_1-x_0}{\sqrt{2}\sigma_0\left(1+\frac{t-t_0}{\tau}\right)}\right)\right] \Theta\left(t-t_0\right)
\end{aligned}
$$

M.S. Dixit, A. Rankin - NIMA Volume 566, Issue 2, (2006)

Implementation of resistive simulation

behavior of resistive electrode added to Parsifal toolkit

Aidainnova 4-year program

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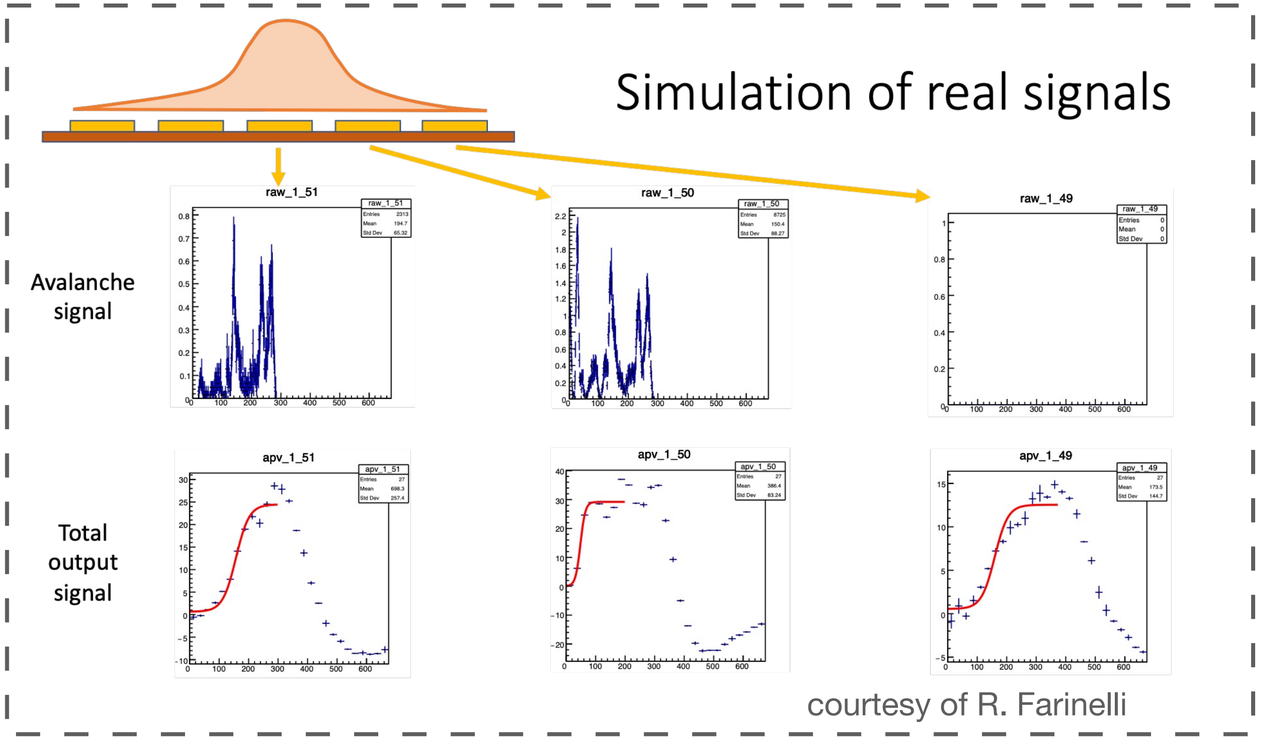
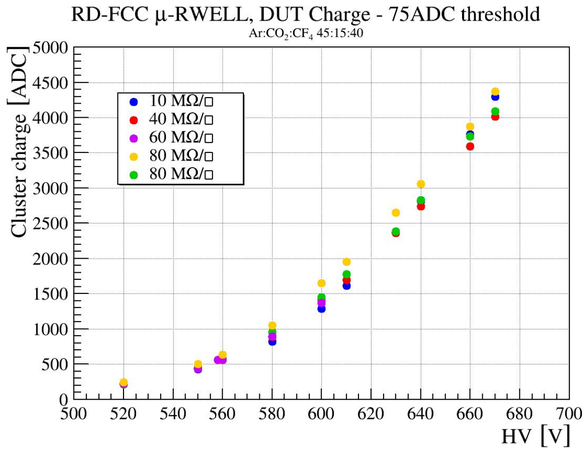


NEW

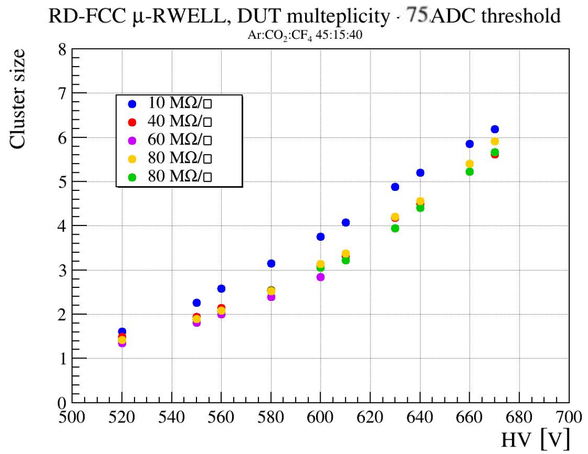
2021 test data analysis

- Preliminary results presented at VCI2022
- Final results ready to be published

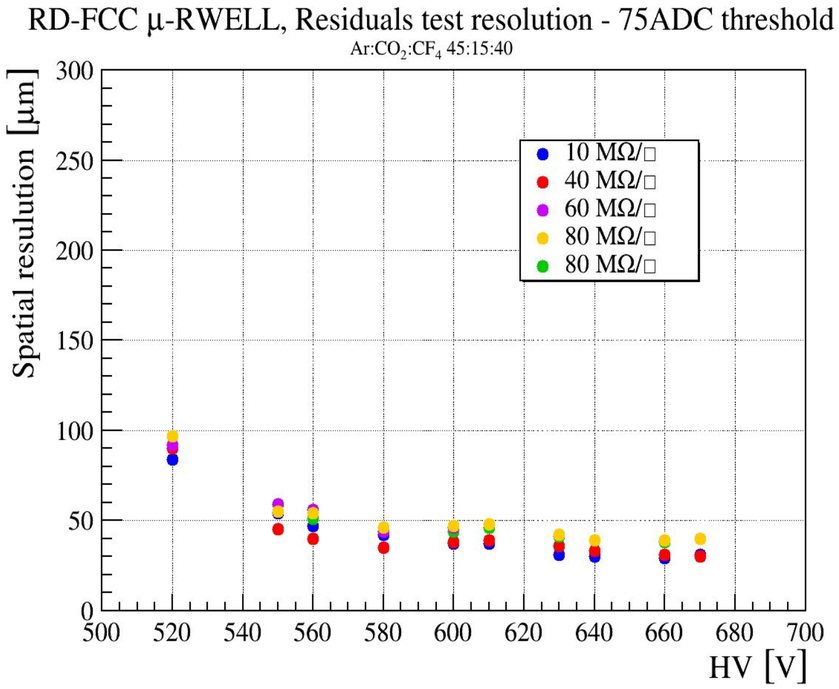
Cluster charge



Cluster multiplicity



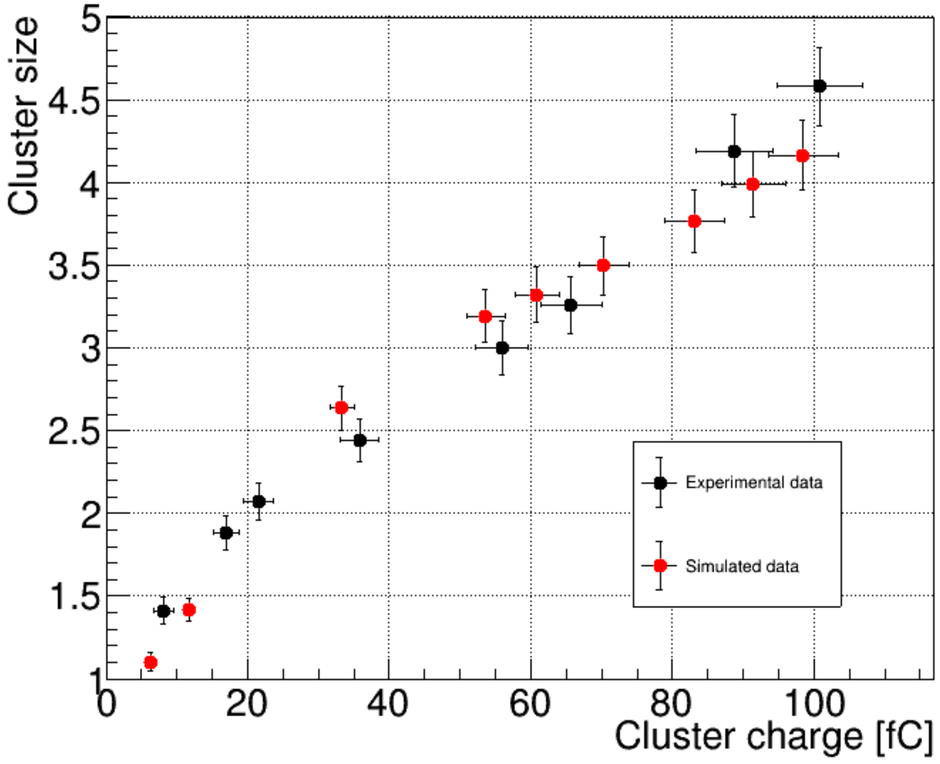
Spatial resolution

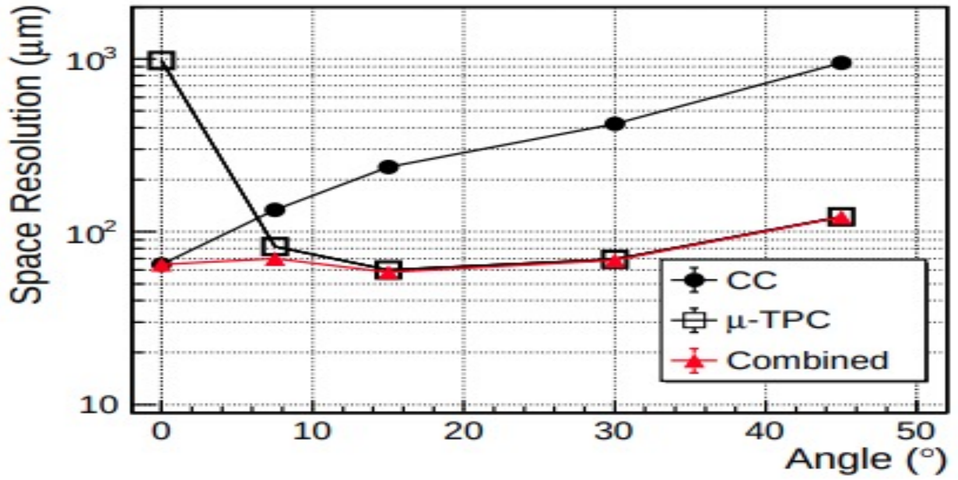


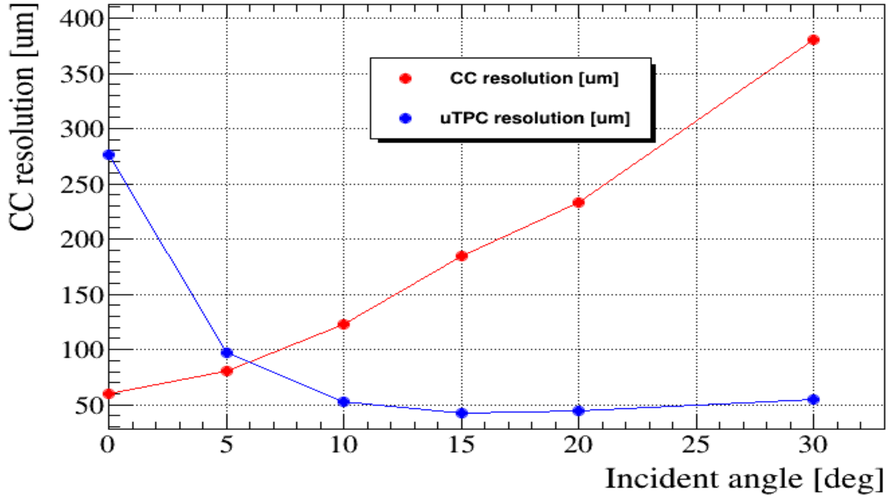
NEW

Simulation tuning with TB data

comparison data-simulation







Code available at https://github.com/Hilldar/PARSIFAL.git
Preliminary results presented at ACAT 2022
Final results will be presented at CHEP 2023

Cluster Reconstruction with M. L.

Preliminary studies

Aidainnova 4-year program

1. simulation of the μ-RWELL resistive layer
2. use of Machine Learning for cluster selection and track finding
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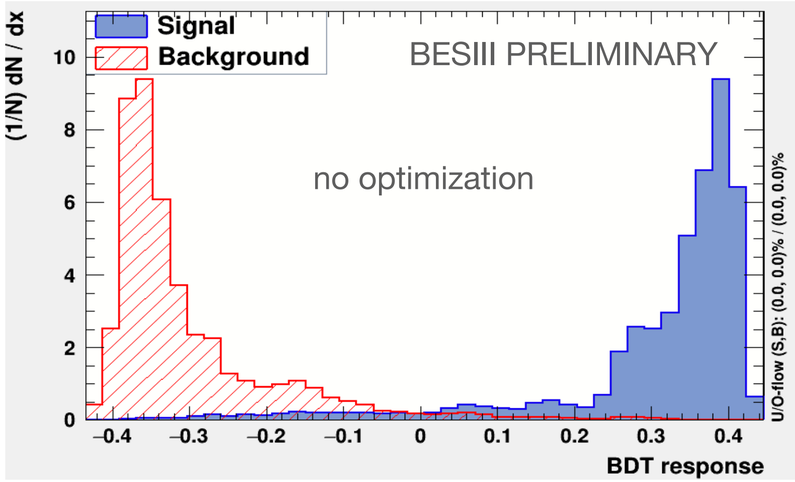
- Work in progress with real data from BESIII CGEM-IT



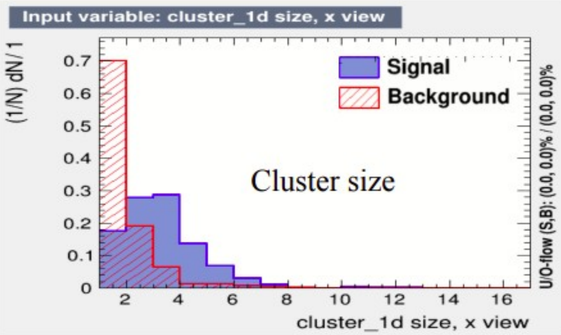
courtesy of L. Lavezzi

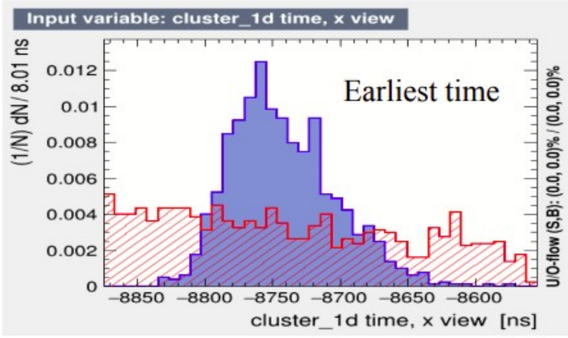
NEW

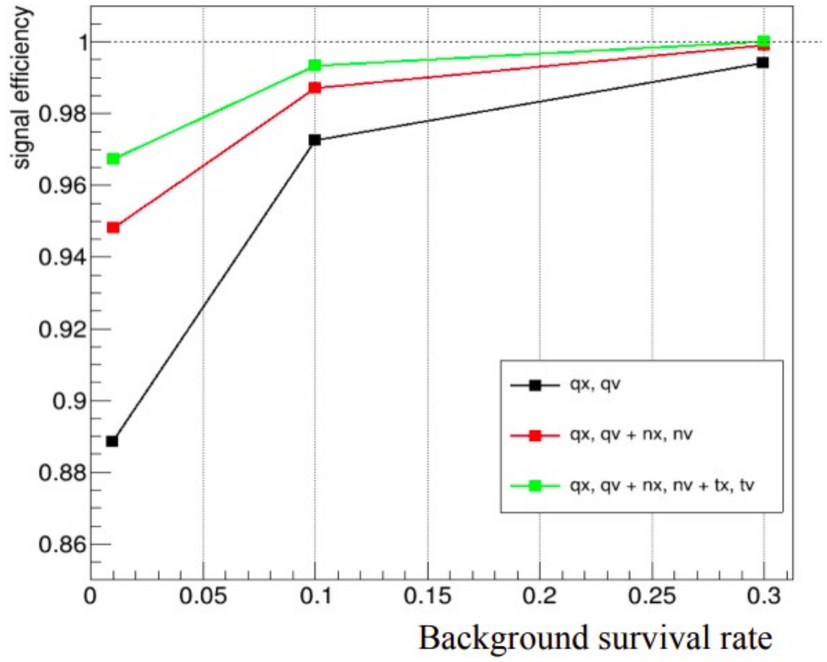
Cluster Reconstruction with M. L.

- Machine Learning to separate signal from noise at hit/cluster level (classification)
- Use TMVA, Boosted Decision Tree

  cluster 1d Charge x, v + cluster 1d size x, y + fastest hit in cluster 1d x, y







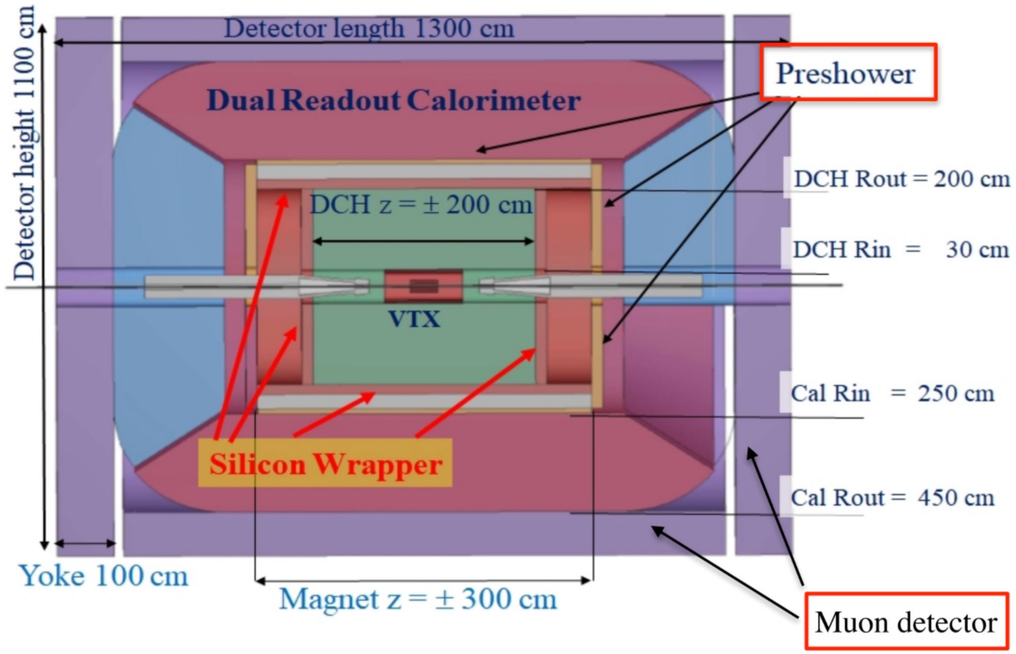
Update of last year progress slide

- Complete Test Beam data analysis (in progress) → **DONE**
- Perform Simulation Tuning with TB data (fall 2022) → **DONE**
- Develop cluster reconstruction algorithms based on detector simulation (2022-23) → **IN PROGRESS**
- Further Test Beam(s) are under consideration to study a bi-dimensional readout and to expand the resistivity scan → **PLANNED**

Beyond this year

- Later the ML algorithms will be tested on the IDEA pre-showers and muon detector as case study

- GEANT4 implementations of the two systems is also ongoing



Thanks for your attention