Development of Machine Learning Algorithms for MPGDs

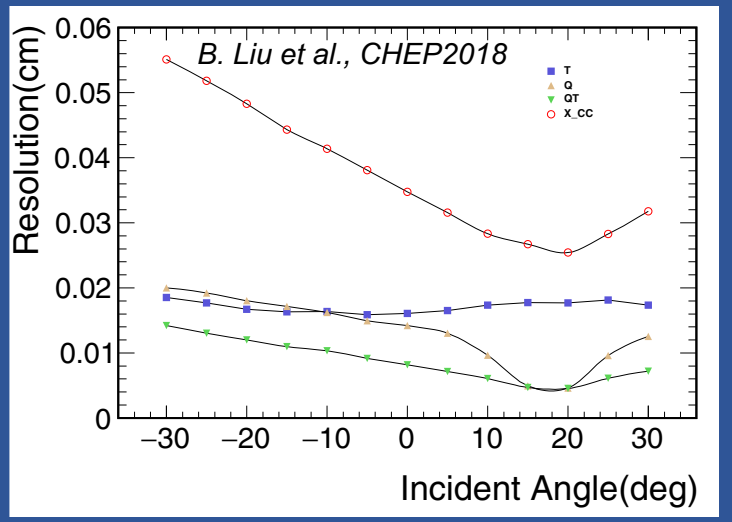
G. Cibinetto (INFN Ferrara)

on behalf of the 12.4.MPGD task group

StayWell General Meeting – June 21-22, 2022

The idea underneath the task

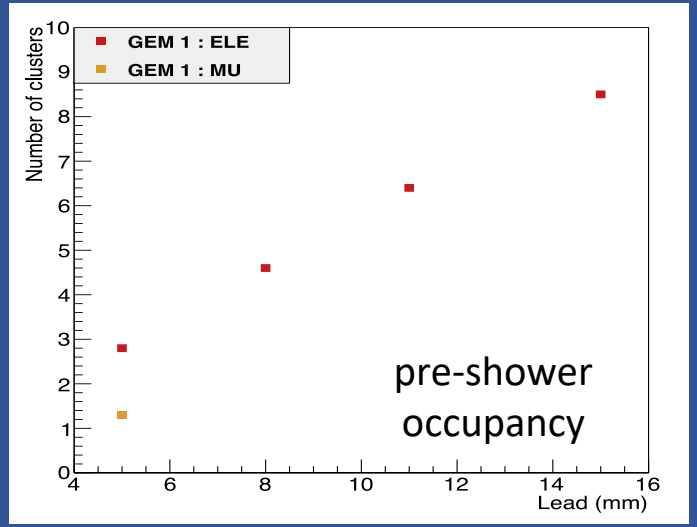
- MPDGs are gaseous detectors with high spatial resolution, good radiation tolerance, ideal for tracking in large-background environment
- MPGDs are widely used in experiments and planned for many upgrades
- Resistive MPGDs offer spark protection important for operational stability
- Charge centroid and microTPC algorithms guarantee tracking performance over a wide range of particle incident angles and external magnetic field
- Nevertheless, the performance of traditional algorithms are limited by the presence of high background
- Machine Learning approach can be used to overcome these limitations



MPGDs → resistive MPGDs → micro-Resistive Well (μ-RWELL)

- Proposed for
  - LHCb muon upgrade
  - Super tau-charm factories
  - JLAB, EIC
  - IDEA @ FCC_ee pre-shower and muon system

IDEA slice Test Beam results
NIM A958 (2020) 162088



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General description of the task

synergy with
Task 7.3 and 11.2

- Timeline and task: 4 years
  - First year: uRWELL simulation → implementation of resistive layer and tuning to test beam data
  - Second year: development of cluster selection and track finding based on simulation
  - Third year: track cleaning and refinement
  - Fourth year: application to IDEA detector pre-shower and muon → optimization

- Deliverables
  1. A scientific paper describing the performed activity and the results.
  2. An open-source software suite for training and testing ML algorithms with MPGD data and simulations.

- The group is composed by INFN Bologna, Ferrara, LNF and Turin
  - mainly Riccardo Farinelli, Lia Lavezzi e Stefano Spataro

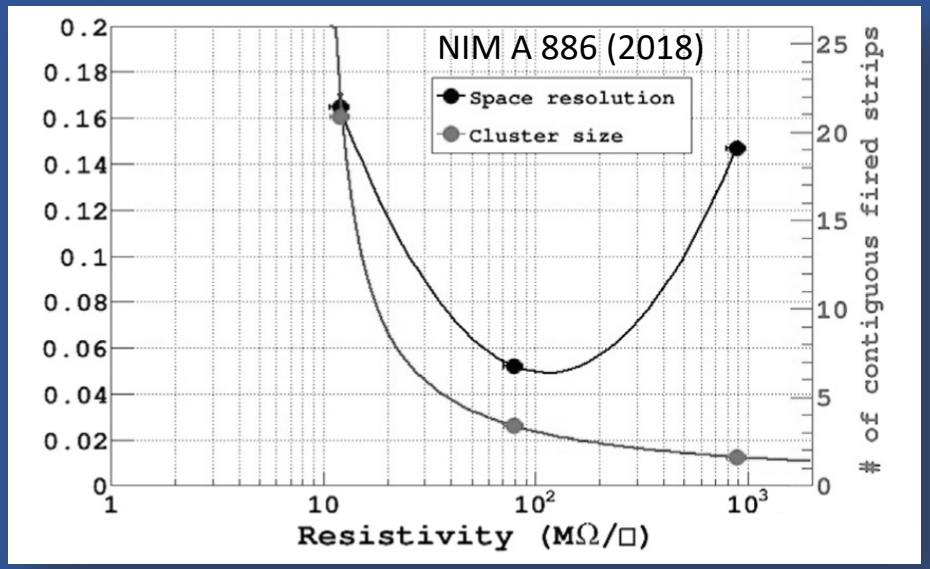
First year work flow

- Focuses on μ-RWELL simulation
  - Start from parametric simulation developed for the BESIII cylindrical GEM detector (GTS) → software framework available
  - First implementation of resistive layer → done
  - Tuning to test beam data → in progress
  - Add more features (e.g., inter-strip effects) → planned

μ-RWELL simulation

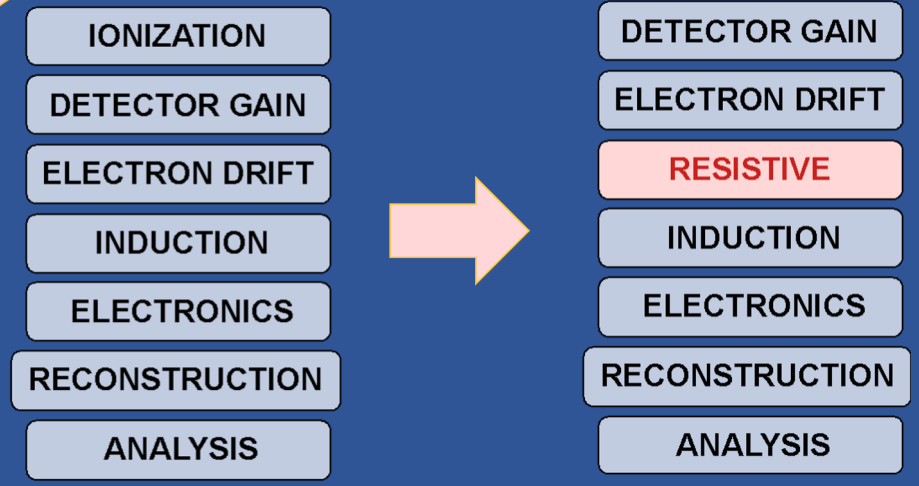
Resistive layer simulation – in progress

- Describe the charge dispersion which depends on the time constant determined by the DLC surface resistivity and the capacitance per unit area. Use the approach from *NIMA 566:281-285,2006*
- Simulation will be tuned with data from a test beam done at CERN in October 2021

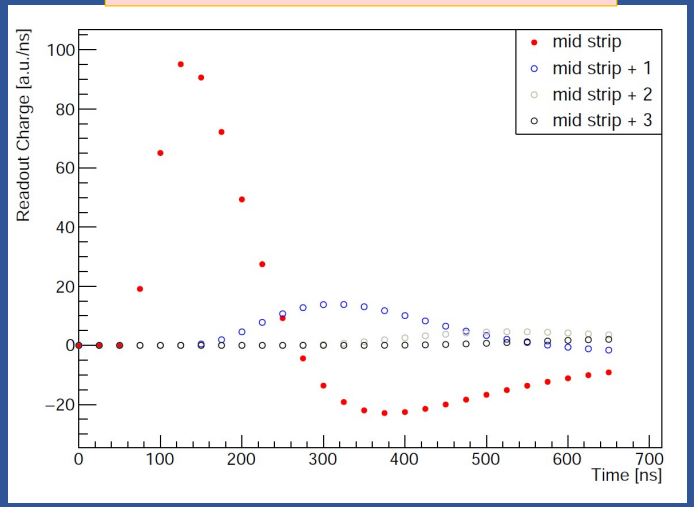


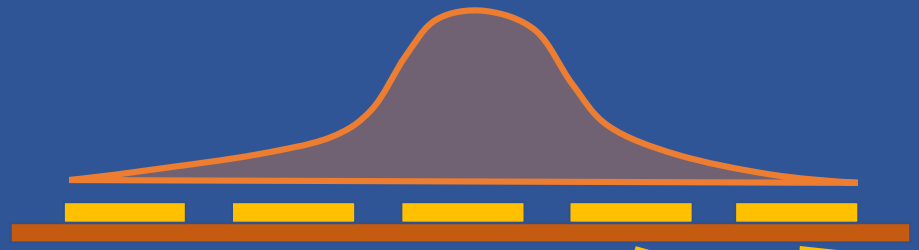
GTS software

EPJ Web of Conferences 245, 02025 (2020) CHEP 2019



Charge output from simulation

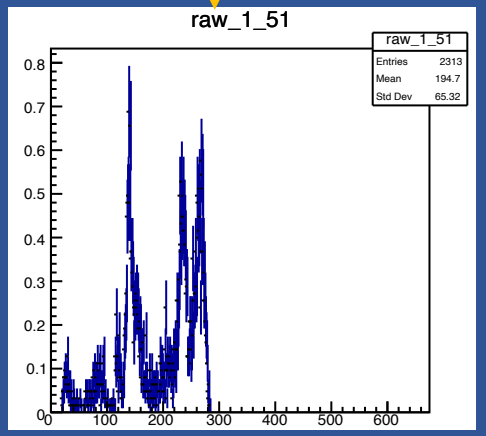


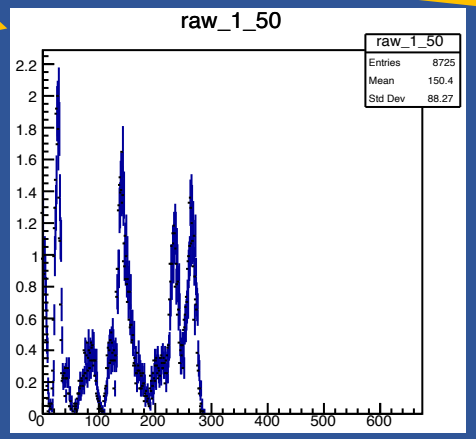


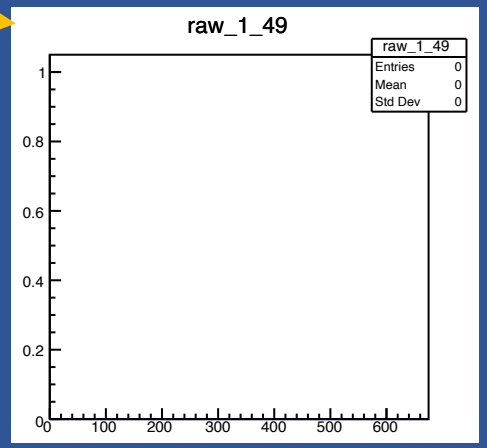
Simulation of real signals

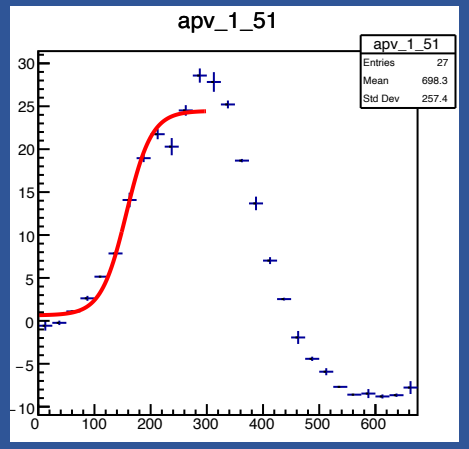
Avalanche signal

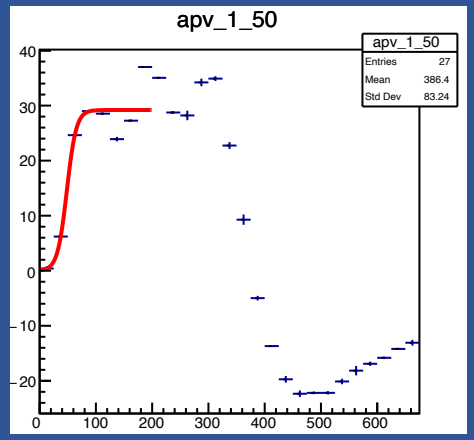
Total output signal

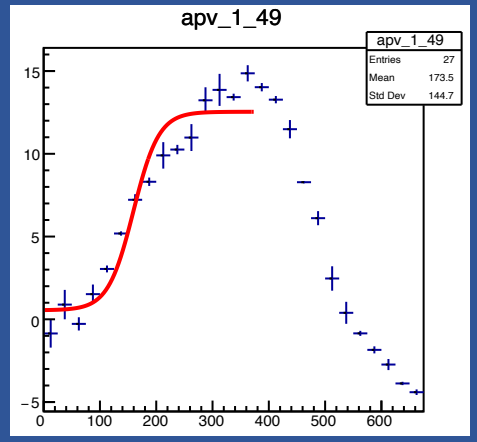






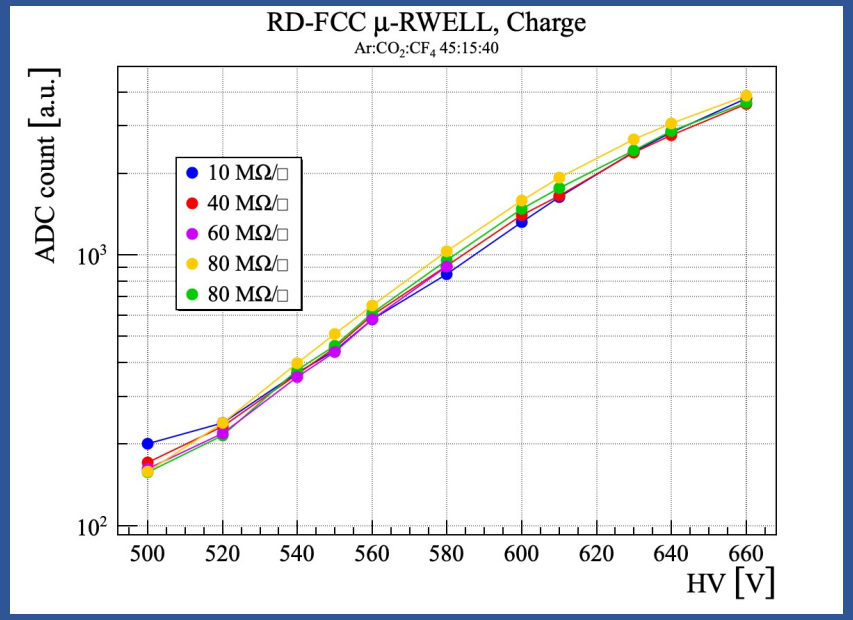


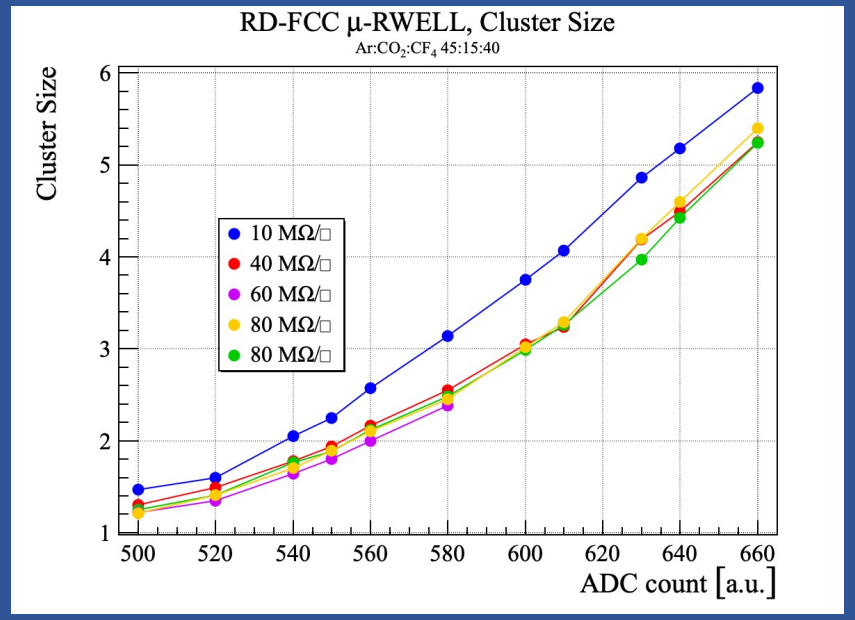




Preliminary TB results

- This is the input for the simulation tuning
- Presented @ VCI 2022
- https://indico.cern.ch/event/1044975/contributions/4663799



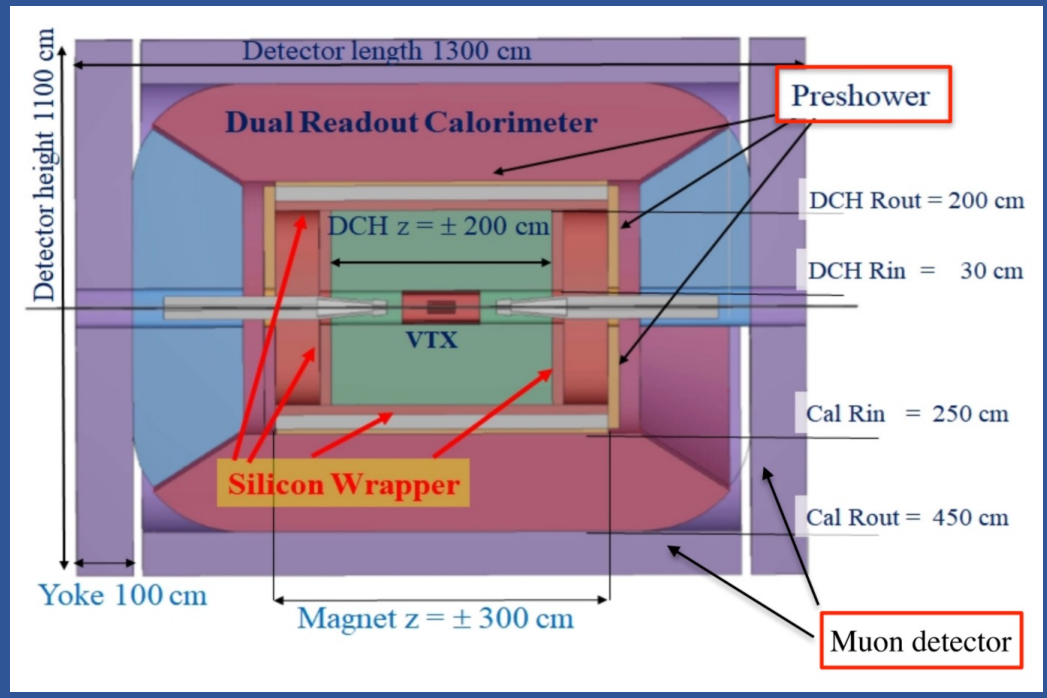


Next steps

- Complete Test Beam data analysis (in progress)
  - extract charge and time distributions as function of the detector resistivity
  - measure detector performance (efficiency and spatial resolution) at different resistivities
  - preliminary results presented at VCI conference
- Perform Simulation Tuning with TB data (fall 2022)
- Develop cluster reconstruction and track finding algorithms based on detector simulation (2022-23)
- Further Test Beam(s) are under consideration to study a bi-dimensional readout and to expand the resistivity scan

Next to next steps

- Later the ML algorithms will be tested on the IDEA pre-showers and muon detectors as case study
- GEANT4 implementations of the two systems is also ongoing



Impact of Covid-19 on the Task

- The pandemic situation has sowed down the activities on detector characterization
  - the prototypes arrived few days before the test beam → no time for gain equalization
  - some prototype were damaged therefore we don't have all the resistivity points we planned for
- We are catching up, but we still have few months of delay w.r.t. the original schedule
- Might expect some further delay IF additional test beam(s) and TB data analysis will be needed

Thanks