MPDG-based calorimeter for future colliders

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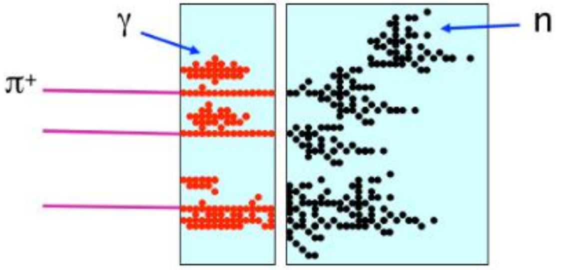
INFN Workshop on Future Detectors

Bari, 19 Ottobre 2022

Particle-Flow Calorimetry

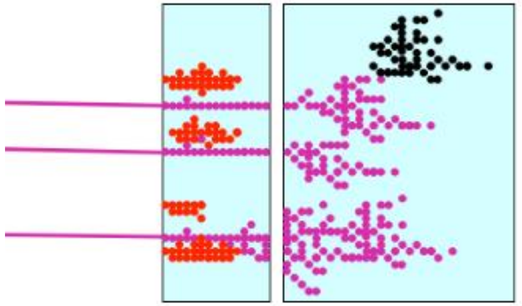
Future high-energy lepton colliders require optimal jet energy resolution: $\sigma_E / E < 3.5\%$



$E_{JET} = E_{ECAL} + E_{HCAL}$

Traditional calorimetric approach

- Jet-energy is measured as a whole
- Measured from ECAL + HCAL
- ~ 70 % of jet energy measured in HCAL with poor resolution (<60%)



$E_{JET} = E_{TRACK} + E_{\gamma} + E_n$

PFlow calorimetric approach

- Reconstruct individual particles of the jets
- Exploiting the most accurate subdetector system
- ~ 10 % of jet-energy carried by long-lived neutral hadrons is measured in HCAL

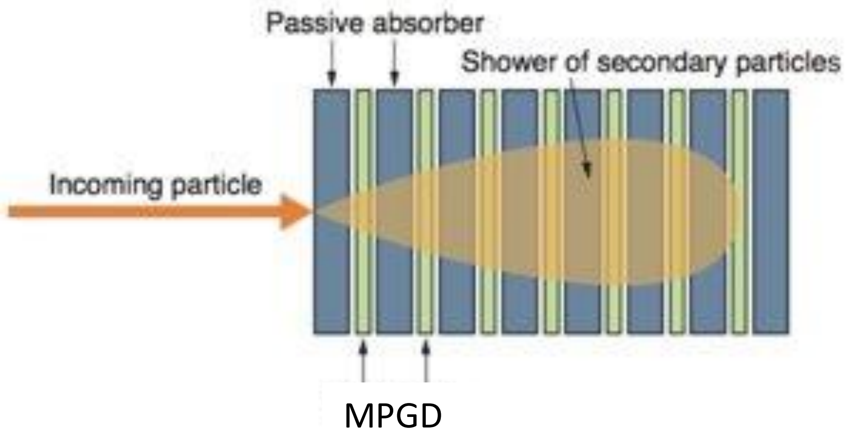
HCal requirements**:** longitudinal and transverse **fine granularity** to separate neutral hadrons from nearby charged particles

J. Marshall, M. Thomson
arXiv:1308.4537

Proposal: MPGD-based HCAL

The **CALICE collaboration**[*] already proposed the use of gas detectors (RPCs, GEMs and Micromegas) as active layers for hadron calorimetry to implement **digital** and **semi-digital** readout options.

MPGD-based HCAL layout

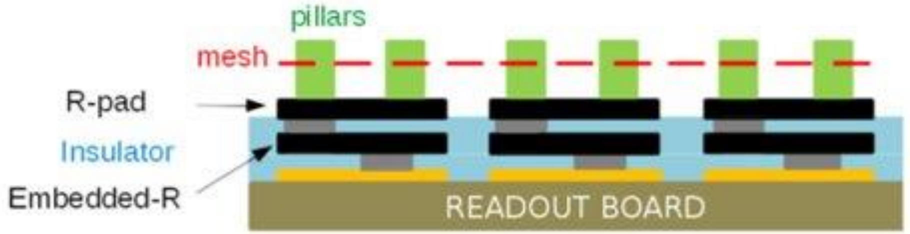


Micro Pattern Gas Detectors (MPGD) based HCAL

- High rate capability (up to 10 MHz/cm^2)
- Allow high granularity
- Flexible space resolution (> 60 μm)
- Time resolution of the order of tens of ns
- Low cost to instrument large area
- Use of environmental-friendly gas mixtures

- **μRWell** and resistive **Micromegas** as best candidates to mitigate effects due to discharge in the gas

Micromegas detector layout

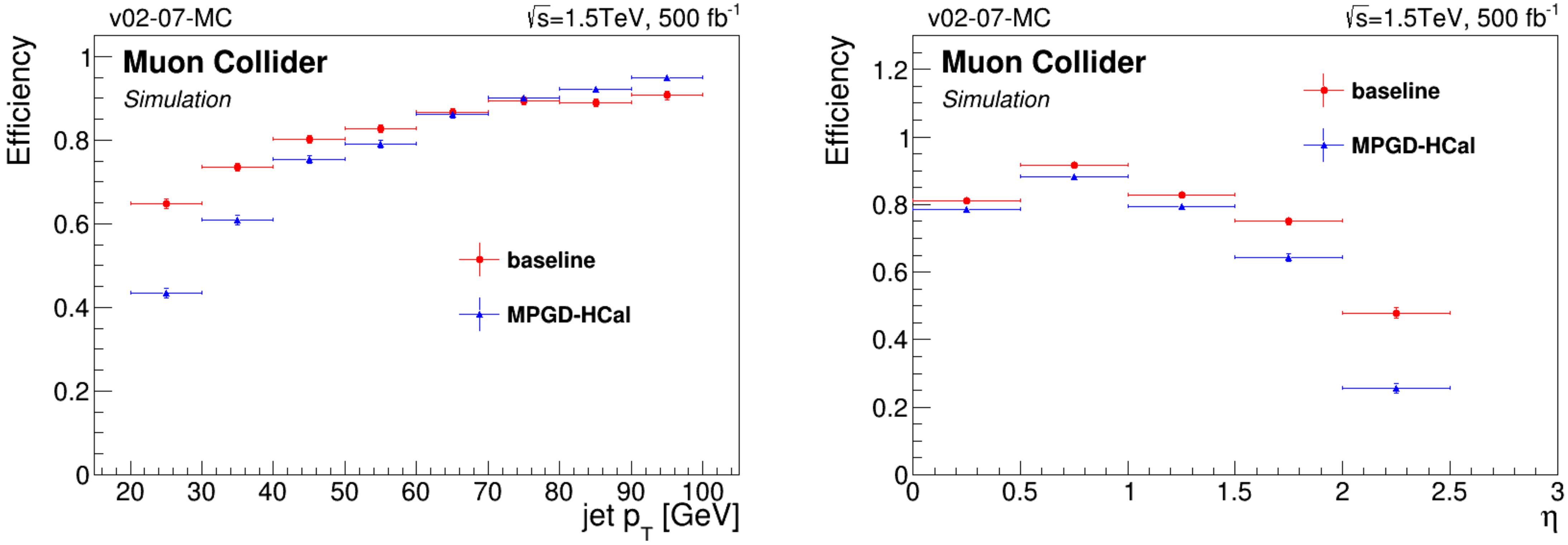


[*]arXiv:1901.08818

MPGD-based HCal at Muon Collider

Baseline: Scintillators + Steel

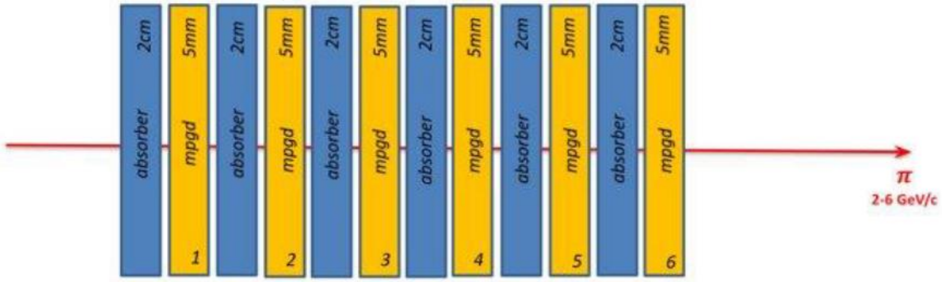
PRELIMINARY

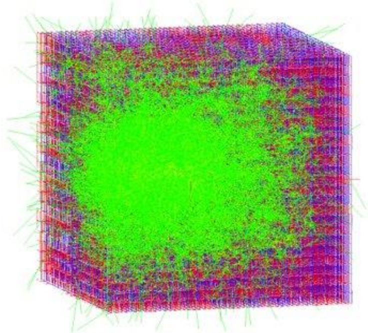


The jet reconstruction efficiency estimated with the MPGD-HCal is comparable to the baseline one.

MPGD-based HCal at Muon Collider – GEANT4 studies

Implemented geometry
- Layers of alternating
  - 2 cm of Steel (absorber)
  - 5 mm of Ar/CO2 (active gap)
- Granularity given by cell of 1x1 cm²

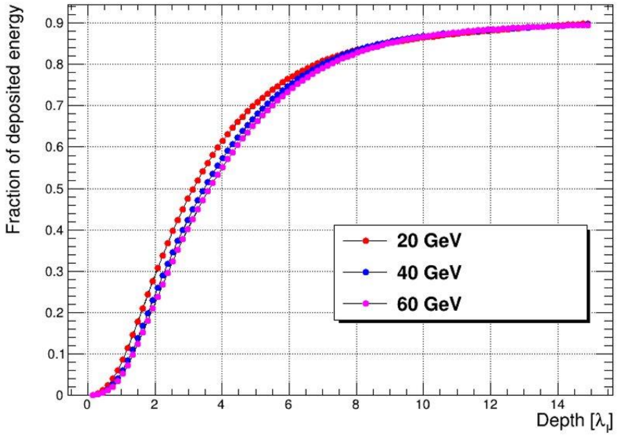




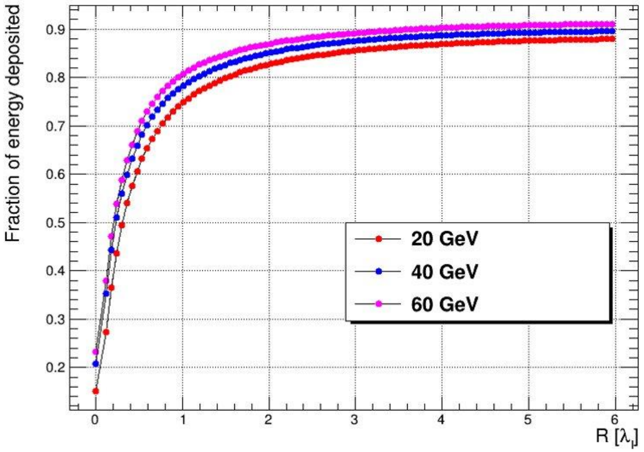
Digital readout simulated

PRELIMINARY

Shower longitudinal containment

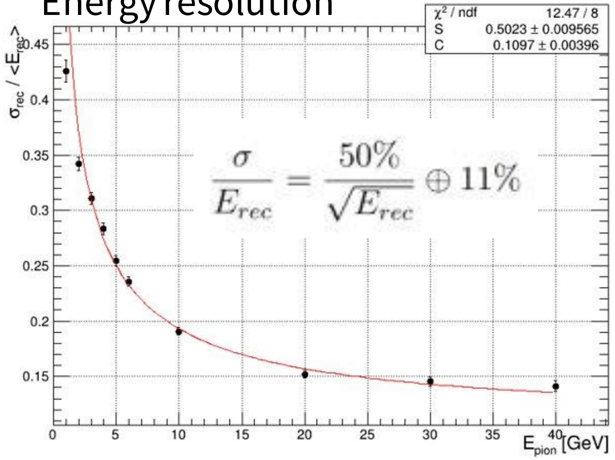


Shower lateral containment



90% shower **containment** in 14 $\boldsymbol{\lambda}_I$ depth and 3 $\boldsymbol{\lambda}_I$ radius

Energy resolution



HCAL Experimental Prototype

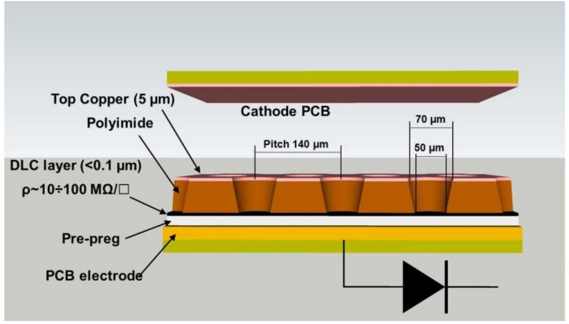
A small scale prototype exploiting last generation resistive MPGDs is under construction
GOAL: validate the simulations with test beam (MIPs with energies between 1 to 6 GeV)

- **6 active layers** made of state of the art resistive MPGDs
    - Resistive **µ-RWell** and **MicroMegas**
    - 20x20 cm^2 with 1 cm^2 pad size

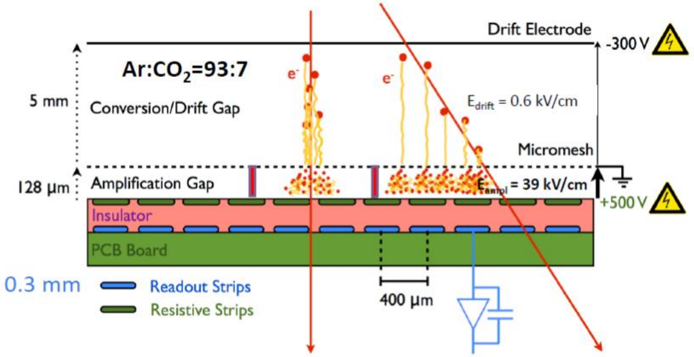
- For Read Out 32 channels **FATIC**(*) asic
    - for timing and charge measurements of the hits
    - It is possible to emulate semi-digital readout

- **Plans for the prototype**
    - Test Micromegas and µRWELL prototypes
    - Build HCal prototype
    - Test under beam irradiation

µ-RWell

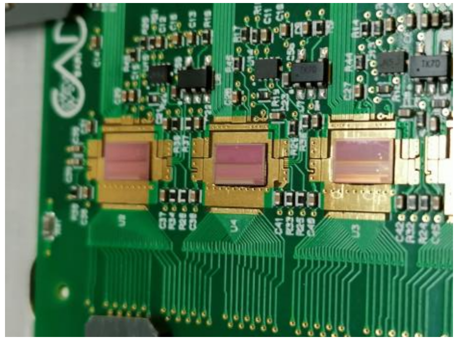


Resistive Micromegas



Stainless steel absorber

FATIC chips



(*)DOI: 10.1109/IWASI.2019.8791274