Muon detector for a Muon Collider

C. Aimè[1,2], S. Calzaferri[2], M. Casarsa[3], D. Fiorina[2], C. Riccardi[1,2], P. Salvini[1,2], I. Vai[2,4], N. Valle[1,2], P. Vitulo[1,2]
on behalf of the Muon Collider Physics and Detector working group
[1]Università degli Studi di Pavia, [2]INFN-Pavia, [3]INFN-Trieste, [4]Università degli Studi di Bergamo

- M. Casarsa' s talk
Detector design for a multi-TeV muon collider
- D. Paesani' s poster
CRILIN: a semi-homogeneus Crystal Calorimeter for a future Muon Collider
- A. Stamerra' s talk
Design and simulation of a MPGD-based hadronic calorimeter for Muon Collider

Why a Muon Collider

A Muon Collider is a unique possibility for combining high energy and luminosity of hadron machines with very precise measurements of lepton colliders [1].

It offers a novel unprecedented physics program.

Parameter	Target value		
E_{cm}	3 TeV	10 TeV	14 TeV
$\mathcal{L}$	1.8 10^{34} cm^{-2} s^{-1}	20 10^{34} cm^{-2} s^{-1}	40 10^{34} cm^{-2} s^{-1}
$N_{mu/bunch}$	2.2 10^{12}	1.8 10^{12}	1.8 10^{12}

Tab 1. Tentative target parameters for a muon collider at different energies [2].

Muon Collider detector

The first version of the Muon Collider detector (Fig. 1) is largely based on the CLICdet geometry [3] with significant changes in the Tracking Detector.

Muon system

The iron yoke plates are instrumented with:

- 7 layers of detectors in the barrel
- 6 layers in the endcap.

The technology implemented by CLIC is Glass Resistive Plate Chamber (GRPC) with 3x3 cm² cells.

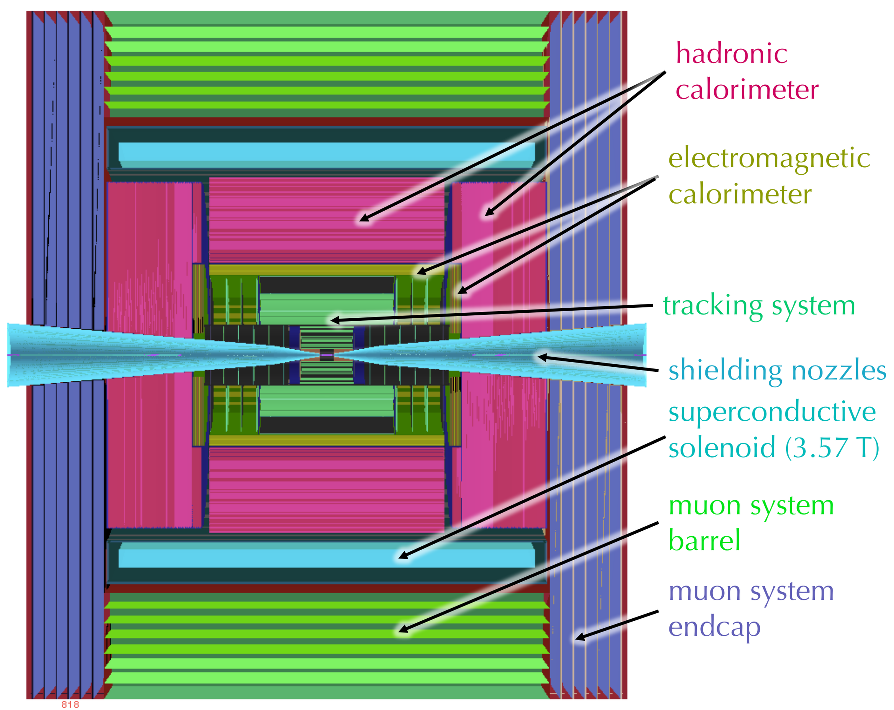

Fig 1. Muon Collider detector geometry [4].

Beam-induced Background (BIB)

The main challenge of a Muon Collider arises from the BIB. It is mostly due to electrons and positrons from muon decay interacting with the machine [5].

In the muon system, the BIB is mainly composed of neutrons and photons with hits concentrated in a small region around the beam axis in the endcaps (Fig. 2).

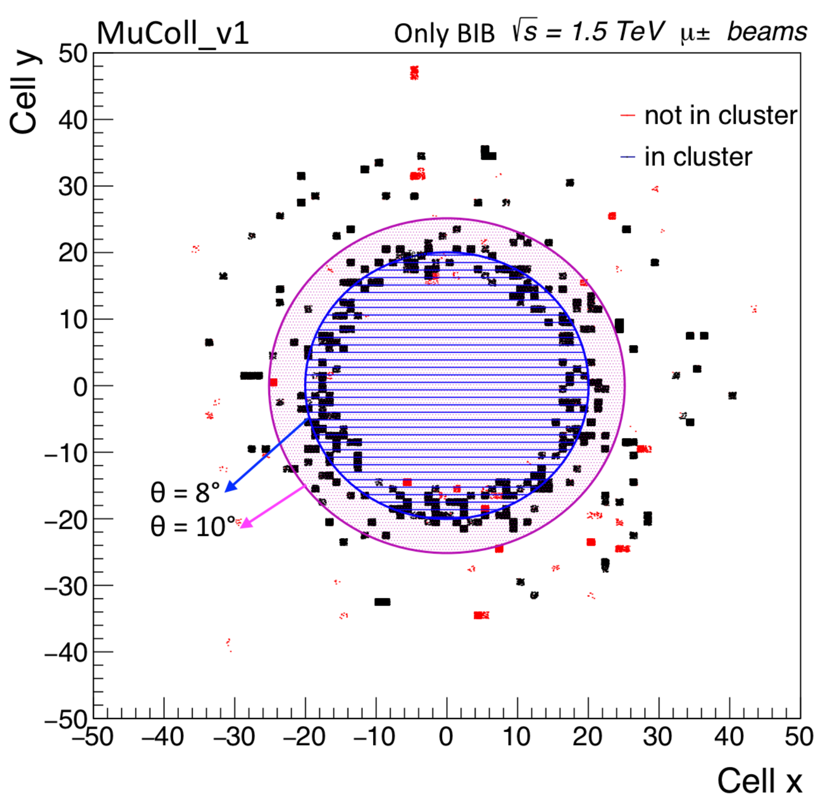

Fig 2. BIB hits distribution in the muon endcap.

BIB hit rate and sensitivity in the muon system

Sensitivity (Fig. 3) and hit rate (Fig. 4) of neutrons and photons from the BIB in the muon system have been estimated with a Geant4 stand-alone simulation [6].

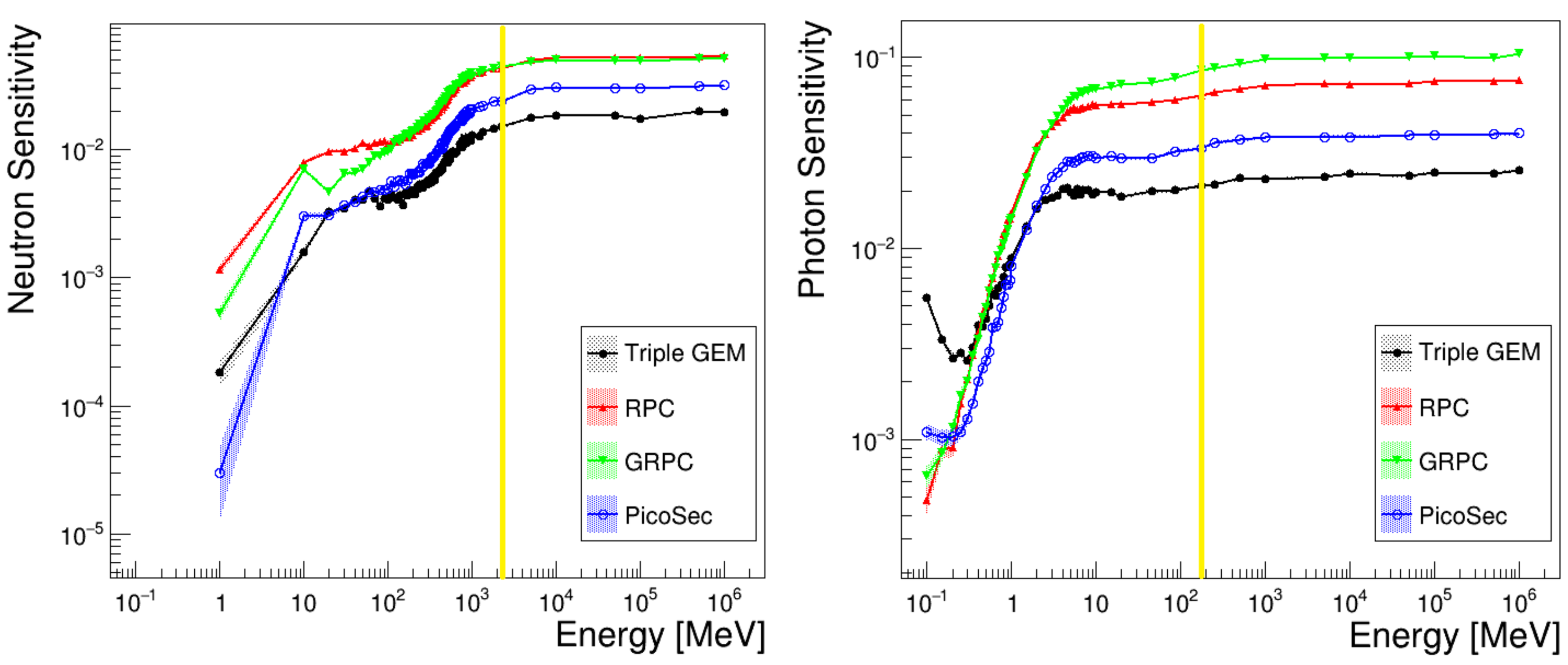

Fig 3. Neutron (left) and photons (right) sensitivity vs energy.

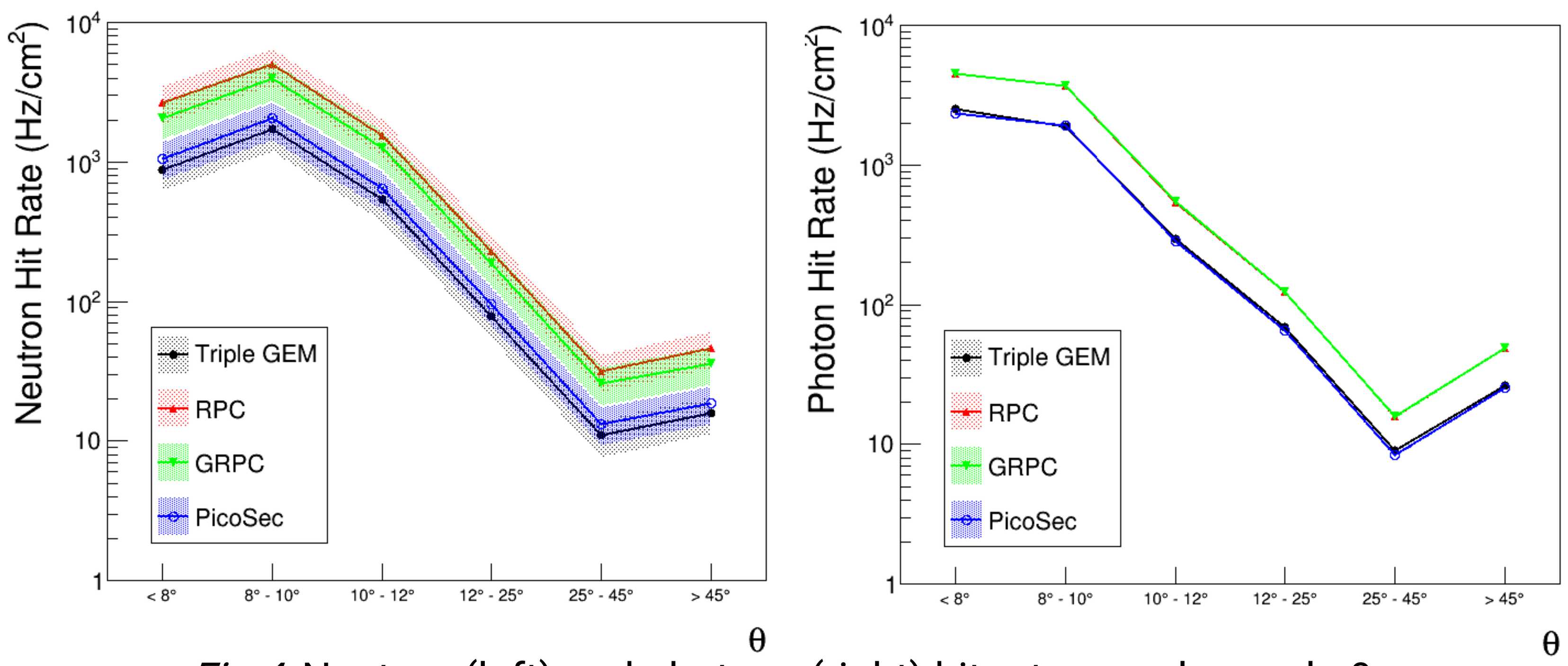

Fig 4. Neutron (left) and photons (right) hit rate vs polar angle θ.

Muon reconstruction performance

Since BIB occupancy in the muon system is very low, the development of a stand-alone muon object algorithm is ongoing. Preliminary results seeding the global muon track reconstruction with the stand-alone object are shown in Fig. 5. Muon hits are clustered inside a cone and then reconstructed hits in the tracker are filtered.

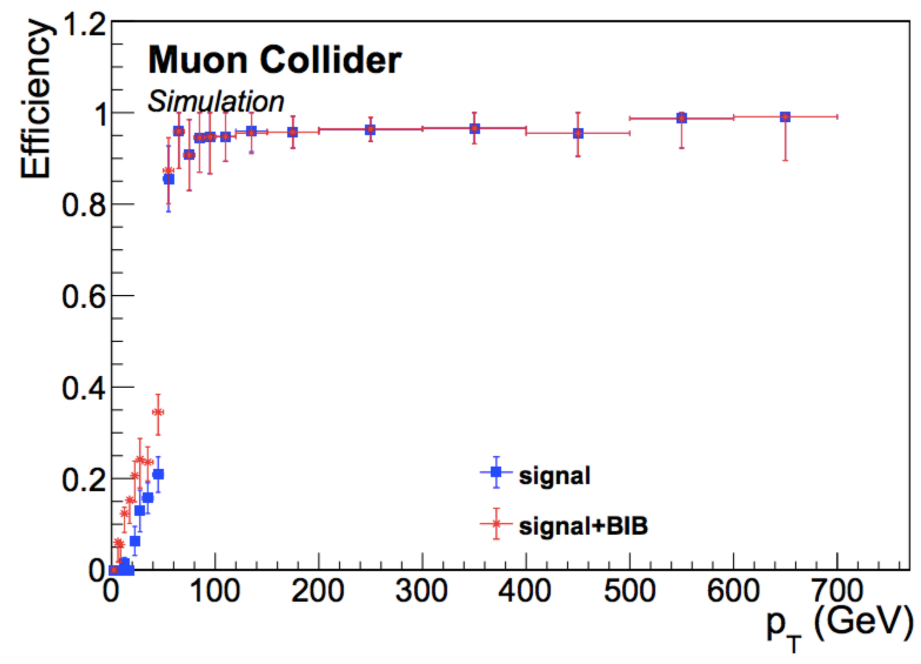

Fig 5. Muon reconstruction efficiency vs transverse momentum in a sample with multi-muons in the final state [4].

The drop of the curve at low p_T is mostly due to reconstruction inefficiency in the region between barrel and endcap and for tracks with a high curvature.

Alternative technological solutions

Fig. 4 points out that RPC and GRPC are already at the limit of their current rate capability. Classical MPGDs, such as GEMs, are characterized by an excellent spatial resolution but do not match the demanding request on the timing resolution (below 1 ns).
New generation MPGDs, e.g Picosec, are promising solutions [7].

Possible muon system design: heterogeneous detector, composed of layers of different technologies to optimize the timing and tracking performance.

PICOSEC

Picosec detector, designed by the RD-51 PICOSEC collaboration [8], is a standard Micromegas with a reduced drift gap (Fig. 6). Particles pass through a Cherenkov radiator and produce photons converted by a photocathode before entering the drift region. Preliminary results show a time resolution of sub-25 ps.

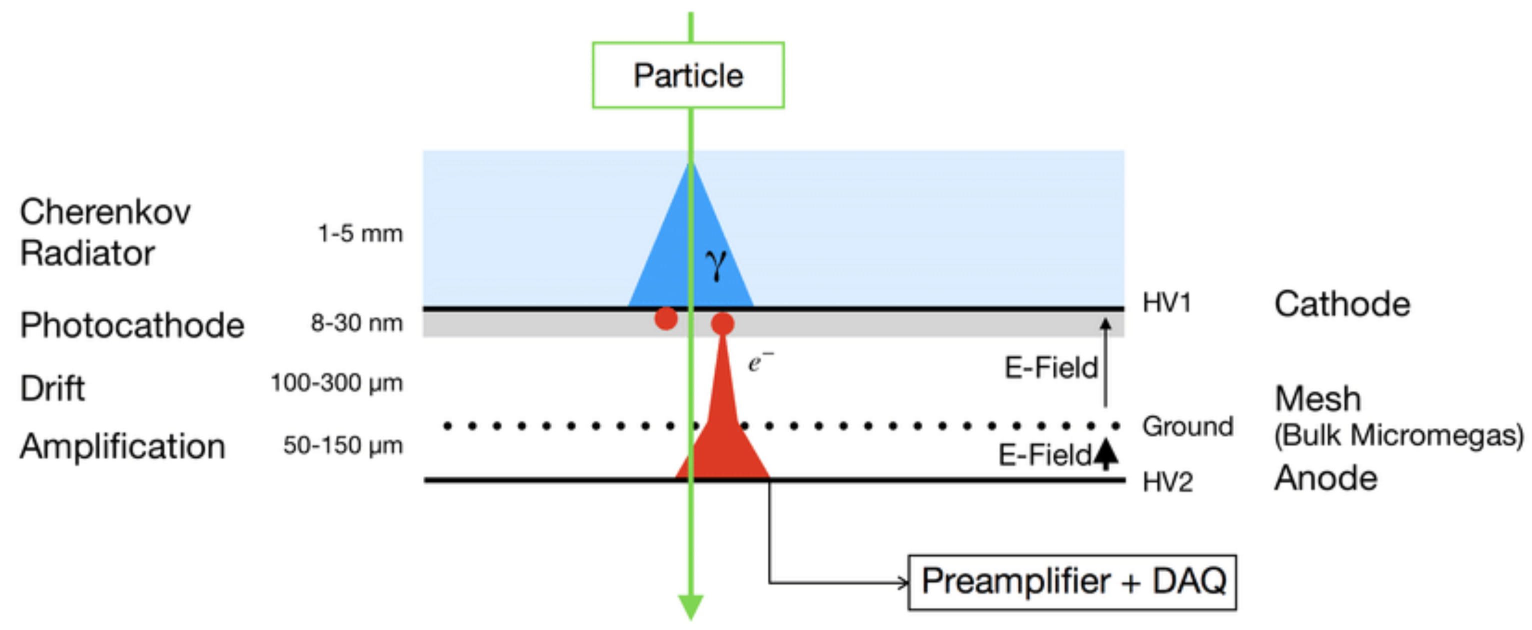

Fig 6. PICOSEC MicroMegas detector.

References

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Contact: chiara.aime01@universitadipavia.it