Muon Detector R&D

Ilaria Vai per il gruppo di Pavia

Sistema muoni: geometria

7 layer in Barrel + 6 layer in Endcap

- Tecnologia “passata”: Glass-RPC
  - al limite della rate capability
- Nuova tecnologia: Triple-GEM

Cell size: 200 um

Digitizzazione: algoritmo di CLIC = i SimHit sono “mappati” secondo la geometria con possibilità di taglio temporale https://github.com/MuonColliderSoft/DDMarlinPandora/tree/DigiPavia3

```
<layer repeat="(int) YokeBarrel_layers" vis="YokeLayerVis">
    <slice material="Aluminium" thickness="0.1*cm" />
    <slice material="Air" thickness="0.5*cm" />
    <slice material="PCB" thickness="0.12*cm" />
    <slice material="Kapton" thickness="0.005*cm" />
    <slice material="Copper" thickness="0.0035*cm" />
    <slice material="GEMGasDefault" thickness="0.3*cm" sensitive="yes" vis="YokeSensorVis"/>
    <slice material="Copper" thickness="0.0005*cm" />
    <slice material="Kapton" thickness="0.005*cm" />
    <slice material="Copper" thickness="0.0005*cm" />
    <slice material="GEMGasDefault" thickness="0.1*cm" vis="YokeSensorVis"/>
    <slice material="Copper" thickness="0.0005*cm" />
    <slice material="Kapton" thickness="0.005*cm" />
    <slice material="Copper" thickness="0.0005*cm" />
    <slice material="GEMGasDefault" thickness="0.2*cm" vis="YokeSensorVis"/>
    <slice material="Copper" thickness="0.0005*cm" />
    <slice material="Kapton" thickness="0.005*cm" />
    <slice material="Copper" thickness="0.0005*cm" />
    <slice material="GEMGasDefault" thickness="0.1*cm" vis="YokeSensorVis"/>
    <slice material="Copper" thickness="0.0035*cm" />
    <slice material="PCB" thickness="0.32*cm" />
    <slice material="Air" thickness="1.13*cm" />
    <slice material="Aluminium" thickness="0.1*cm" />
    <slice material="Air" thickness="1.0*cm" />
    <slice material="Iron" thickness="24.4*cm" vis="YokeAbsorberVis" radiator="yes"/>
</layer>
```

Simulazione Picosec

Nella geometria c'è la descrizione di Picosec come possibile layer in endcap

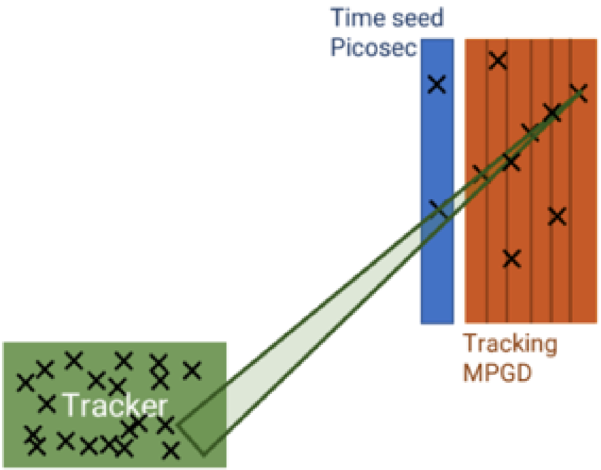
```
<layer repeat="1" vis="YokeEndcapLayerVis" rmin="YokeEndcap_inner_radius+YokeEndcapStep_dr">
    <slice material="Iron" thickness="19.7*cm"  vis="YokeAbsorberVis" radiator="yes"/>
    <slice material="Aluminium" thickness="0.1*cm" />
    <slice material="Air" thickness="0.2*cm" />
    <slice material="Radiator" thickness="0.3*cm" />
    <slice material="Photocathode" thickness="0.000002*cm" />
    <slice material="PCSupport" thickness="0.000001*cm" />
    <slice material="PicosecGasDefault" thickness="0.02*cm" sensitive="yes" vis="YokeSensorVis"/>
    <slice material="Mesh" thickness="0.0008*cm" />
    <slice material="PicosecGasDefault" thickness="0.0128*cm" vis="YokeSensorVis"/>
    <slice material="Copper" thickness="0.0035*cm" />
    <slice material="PCB" thickness="0.32*cm" />
    <slice material="Air" thickness="0.2*cm" />
    <slice material="Aluminium" thickness="0.1*cm" />
</layer>
```

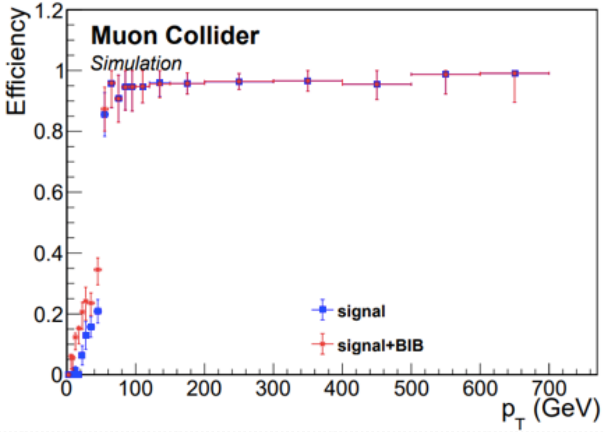
Da investigare: trattamento di optical photons dalle PhysicsList di Geant

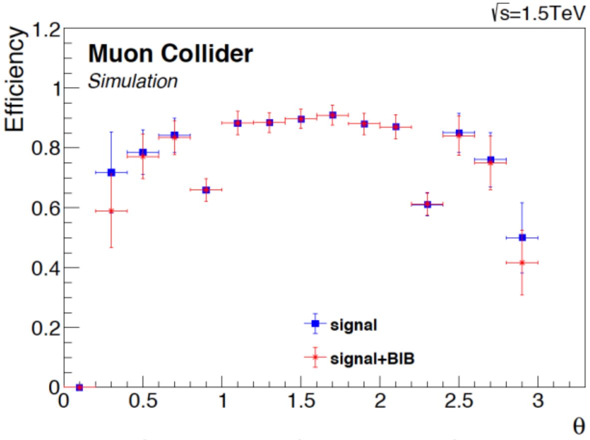
Ricostruzione

Sviluppo di un processore per algoritmo di ricostruzione standalone
https://github.com/MuonColliderSoft/MuonProcessorPV/blob/main/src/MuonRecoStandAlone.cc

- Creazione di cluster di hit nel sistema a muoni
  - cono con apertura angolare ΔR (valore selezionato= 0.02)
- Possibilità di estensione "all'indietro" per individuare una ROI nel tracker e filtrare gli hit
  - gli hit filtrati possono essere usati dagli algoritmi di tracking (test: Conformal Tracking)





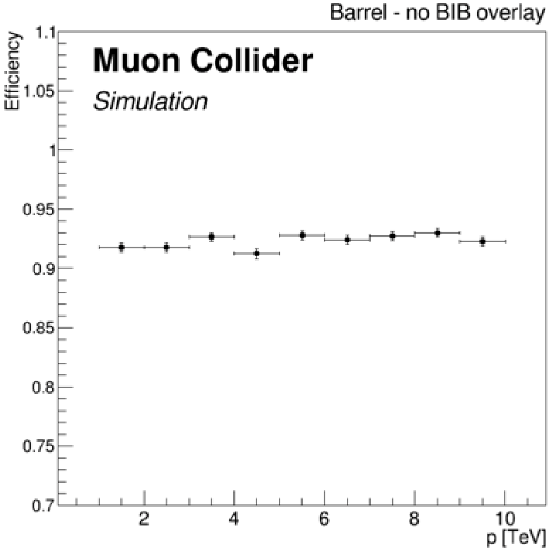


Geometria: Glass-RPC

Canale: HZ → 6 muoni √s=1.5 TeV

Algoritmo: Standalone + Conformal Tracking

Efficienza = frazione di muoni generati cui corrisponde una traccia in un cono di apertura 0.01



Ricostruzione standalone con GEM

Geometria: GEM

Canale: single muon con momento tra 1 e 10 TeV

Algoritmo: Standalone

Efficienza =

- ➔ numeratore: eventi con un muone generato in accettanza (10°< θ<170°), almeno un hit nel sistema a muoni e almeno un cluster standalone
- ➔ denominatore: eventi con un muone in accettanza (10°< θ<170°), almeno un hit nel sistema a muoni

Tagli temporali con Picosec

$(\varepsilon_T - \varepsilon_{NT})/\varepsilon_{NT}$

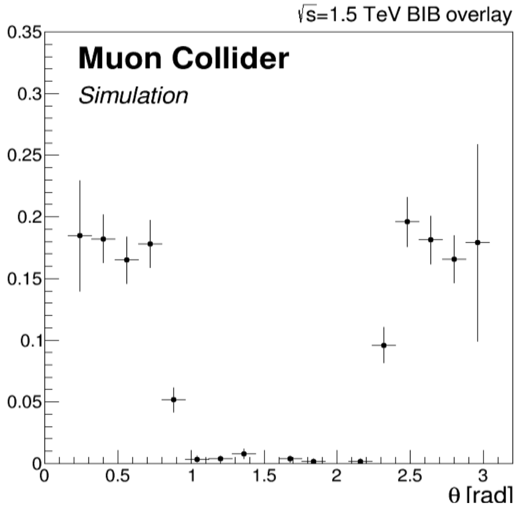
T = Timing cut (50 ps)

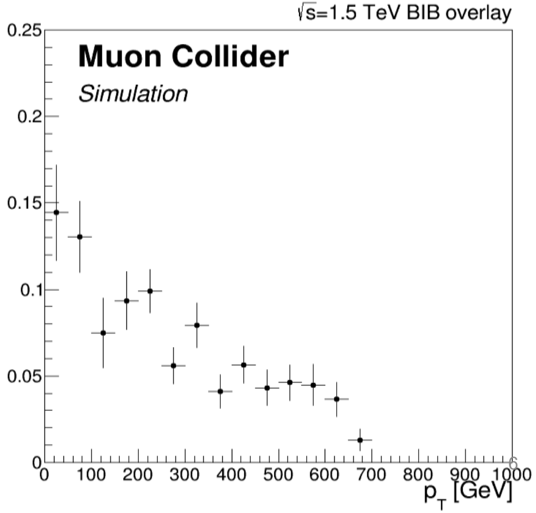
NT = No timing cut

Geometria: GEM+Picosec
Canale: single muon 1GeV-1TeV
Algoritmo: Standalone + Conformal Tracking

Efficienza ε=

- numeratore: eventi con un muone generato in accettanza (8°< θ<172°), almeno un hit nel sistema a muoni, almeno un cluster standalone e una traccia in dR=0.5
- denominatore: eventi con un muone generato in accettanza (8°< θ<172°), almeno un hit nel sistema a muoni, almeno un cluster standalone



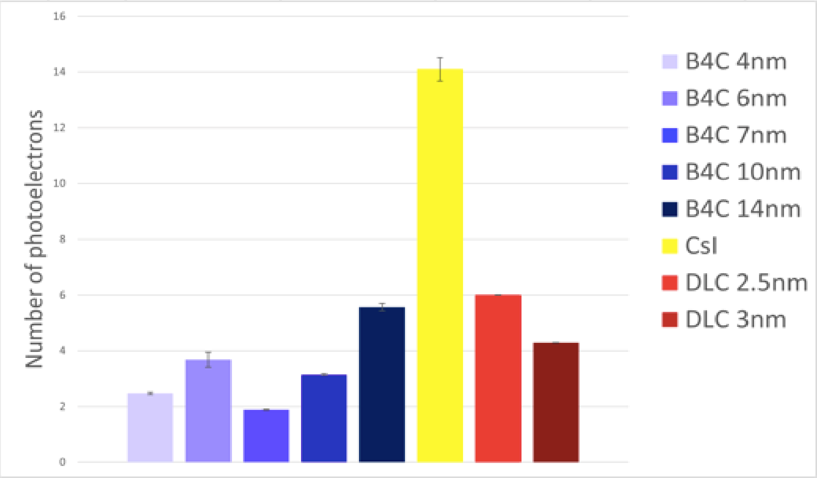


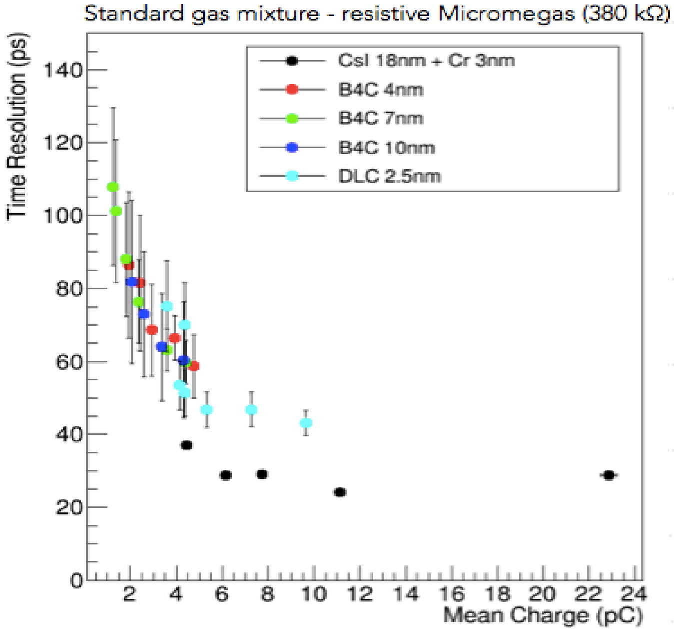
R&D single channel Picosec

Test beam:

- luglio 2023
- aprile 2024

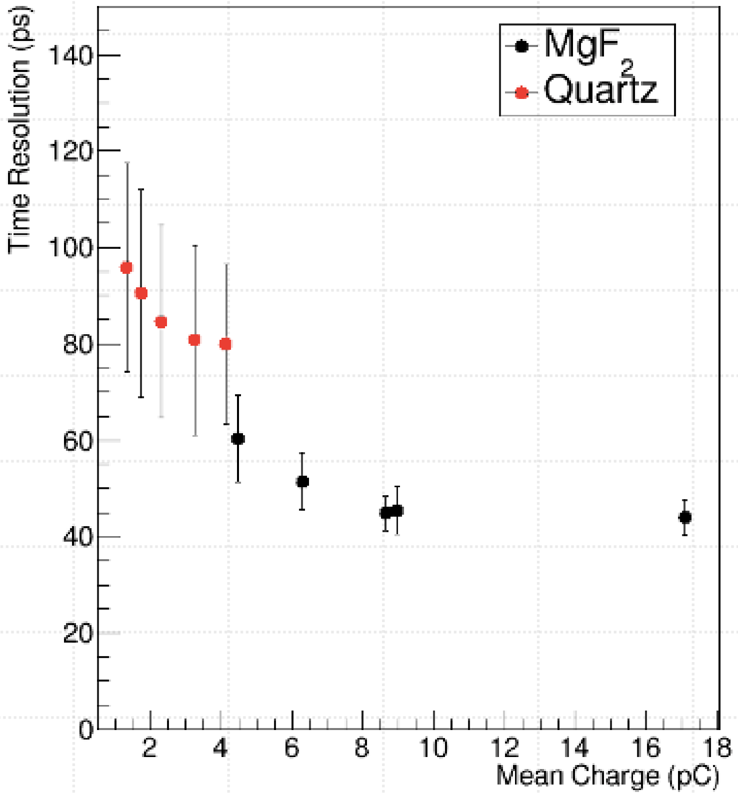
Fotocatodo





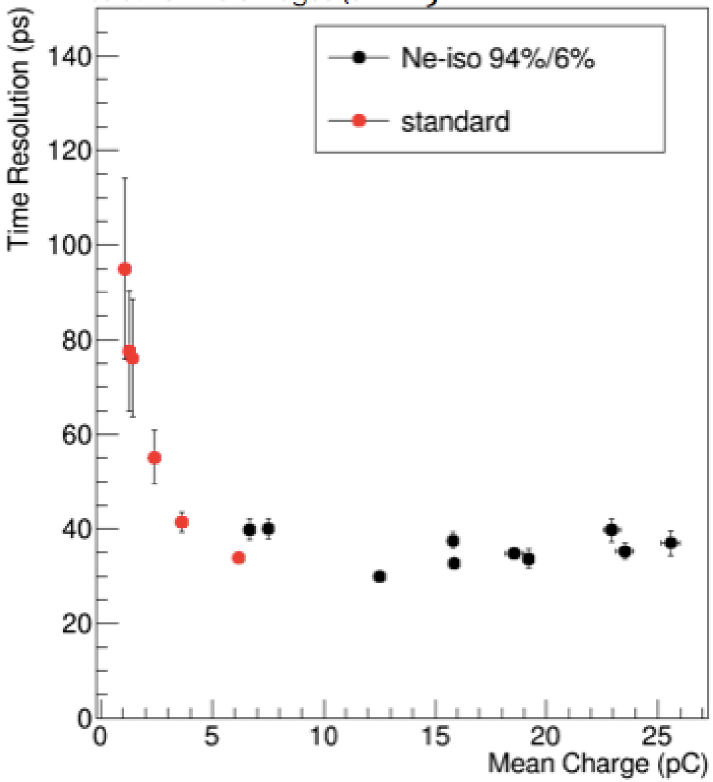
Radiatore

Photocathode: CsI 18 nm thick + 3 nm chromium layer



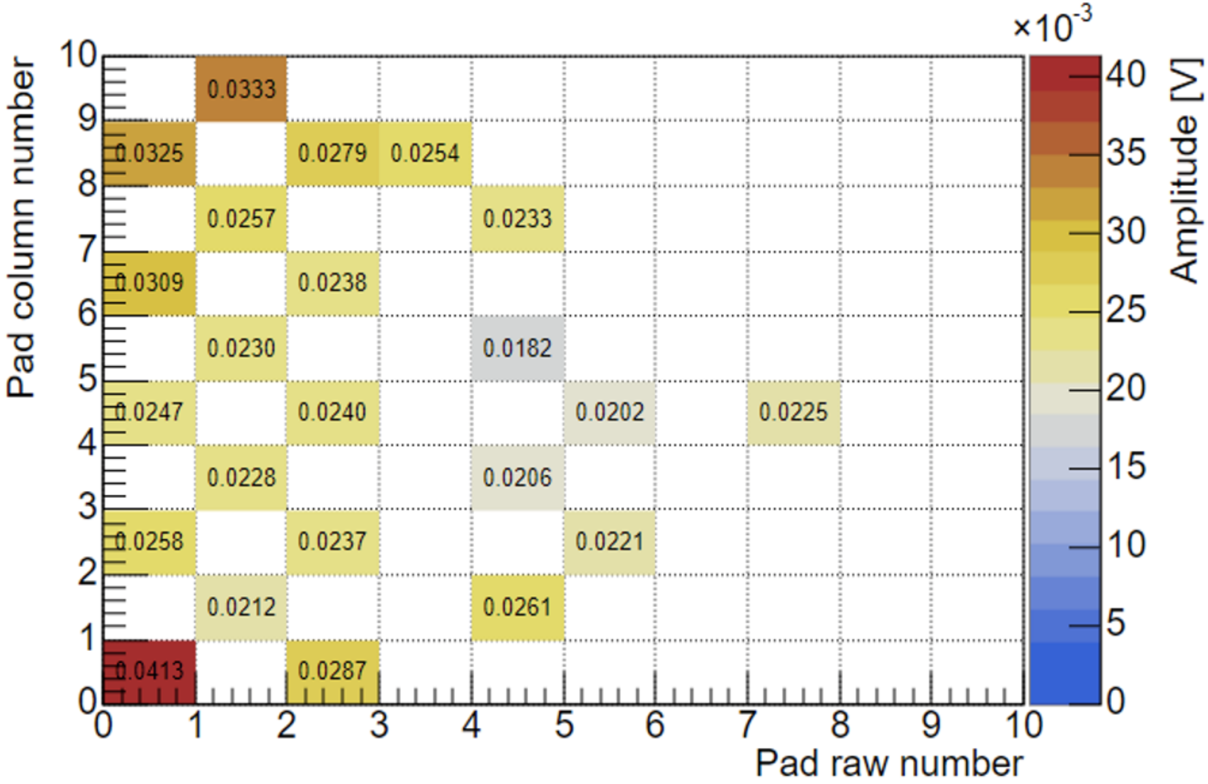
Miscela di gas

Photocathode: CsI 18 nm thick + 3 nm chromium layer – resistive Micromegas (82 MΩ)



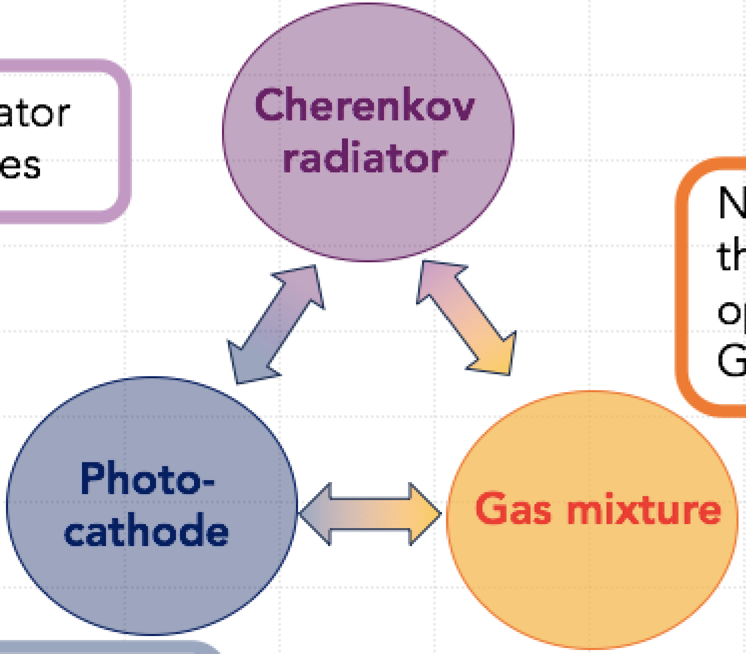
R&D multipad Picosec

Uniformità



Riassunto risultati R&D Picosec

MgF_2 is the best radiator among the tested ones



Ne/iC_4H_{10} 94/6 comparable to the standard but wider operating range , reduced GWP

CsI grants higher performance but DLC 2.5nm could be a good alternative

Piani per il 2025

Single channel

<u>Main focus: alternative gas mixture</u>

- Further tests with Ne/iC4H10 different ratios
- Test of mixture with new generation HFO + CO2
- Test of gas recirculation and recovery system

<u>Optimization of the radiator material</u>

- Test of new materials: UV Fused Silica Broadband window, CaF2

Multipad

<u>Main focus: scalability studies</u>

- Uniformity measurements
- Stack of 2 multipads with minimization of the dead space