Silicon Tracker R&D for $\sqrt{S}$ =10 TeV MuC Detector

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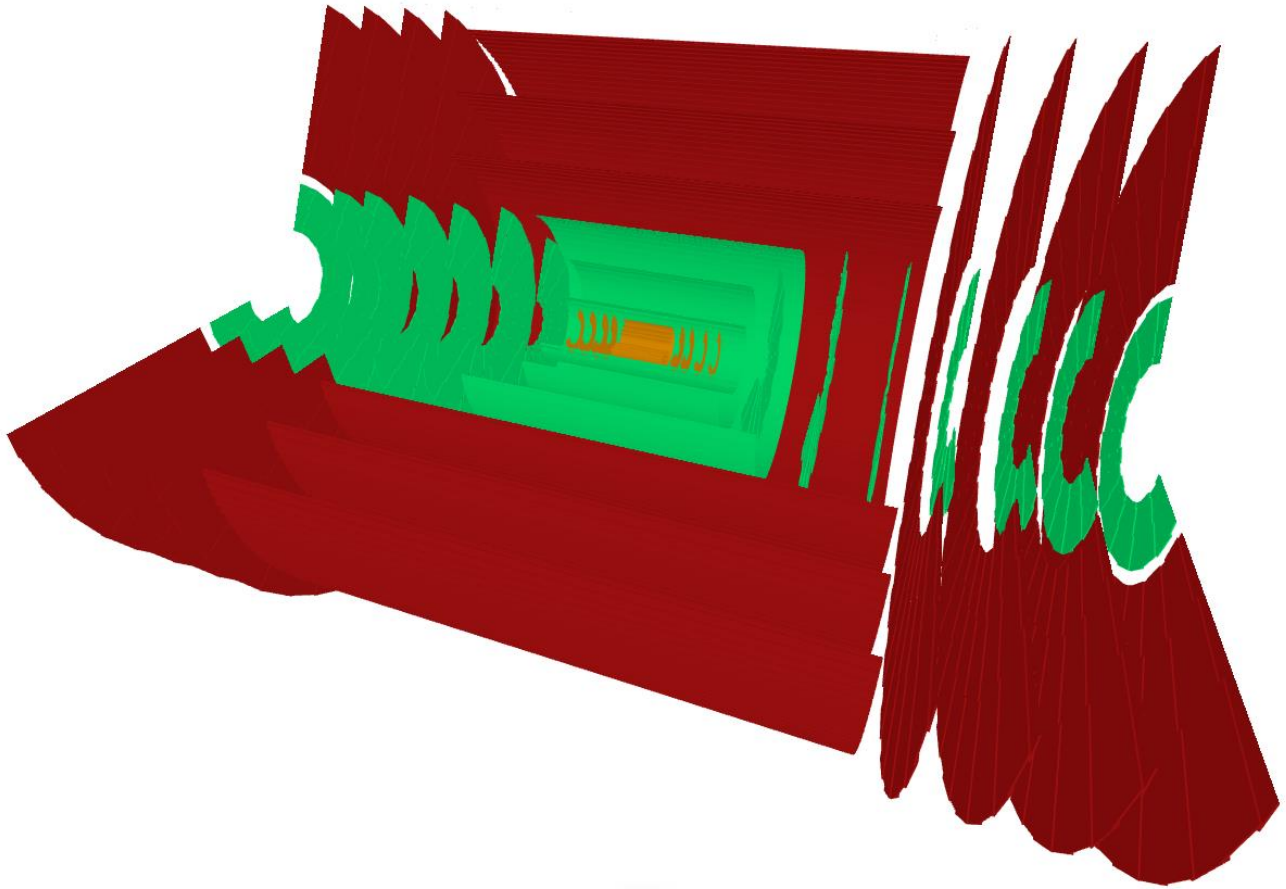
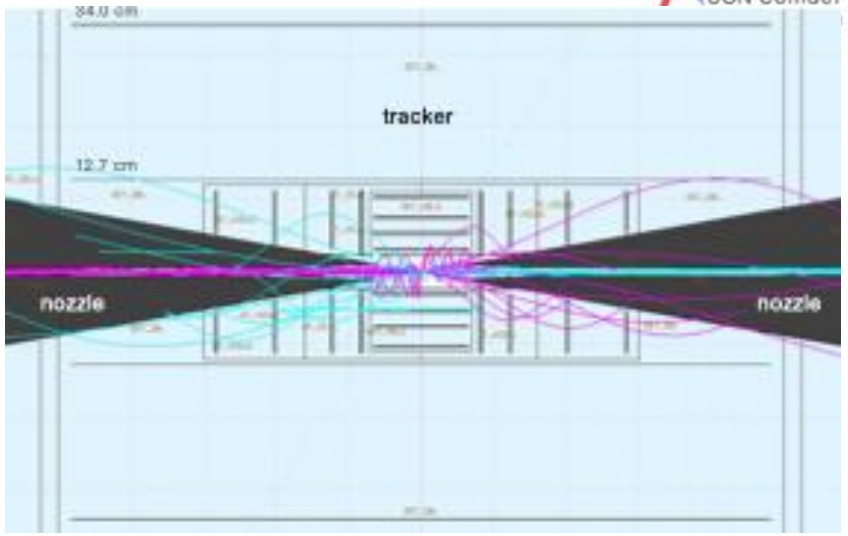


Background in the Tracker at $\sqrt{S}$ =10 TeV

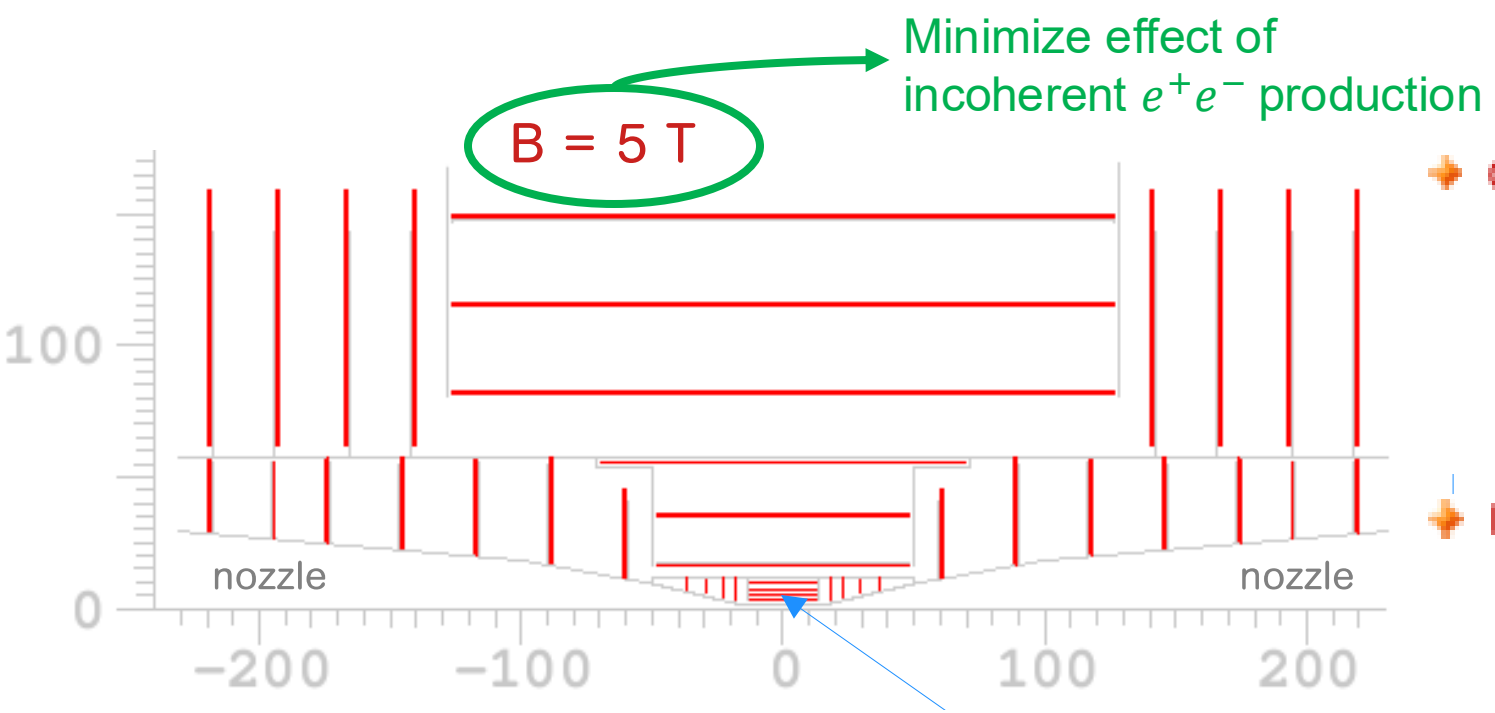
10 TeV	BIB	IPP
Photons	9.9E+07	4.0E+06
Neutron	1.1E+08	1.3E+05
e+/e-	1.2E+06	2.1E+05

soft particles and mostly out of time w.r.t. the bunch crossing.



- Relatively high-energy (few hundred MeV) $e^{\pm}$, enter detector at the IP in time with the bunch crossing;
- Affects mainly vertex detector and inner tracker layers;
- High solenoidal B field helps in confining them in the innermost region close to the beampipe.

Tracker configuration for $\sqrt{S}$ =10 TeV

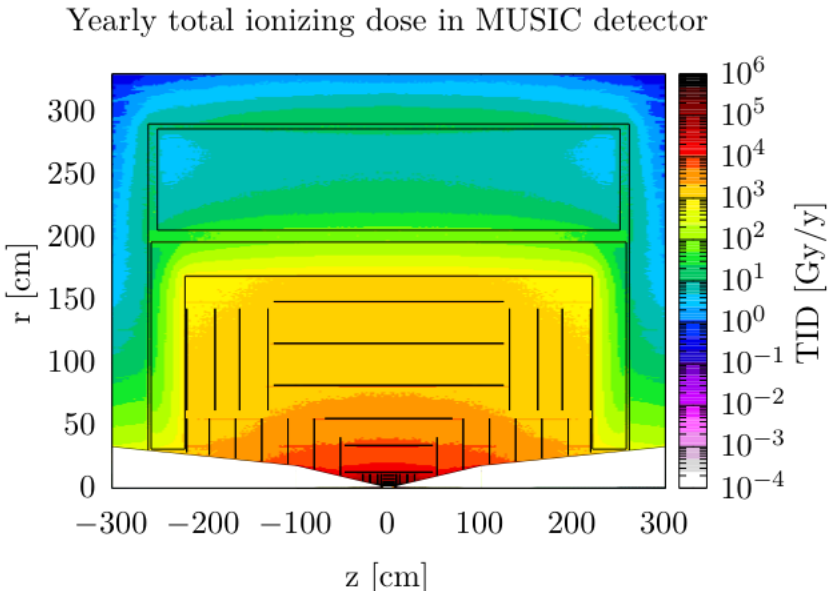


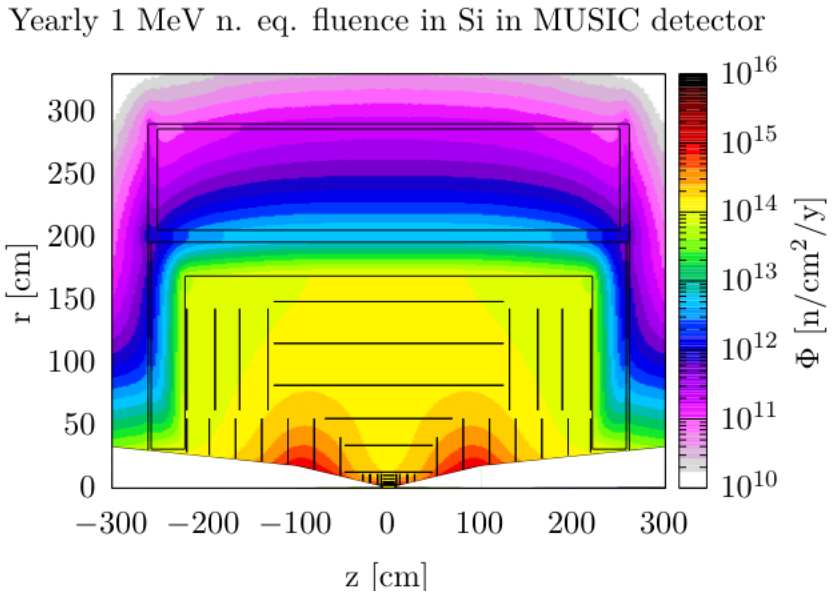
- Vertex Detector
  - 5 barrel layers at R = 2.9 - 10.1 cm and 4 + 4 endcap disks at $|z|$ = 18.0 - 36.6 cm
  - 25 x 25 μm^2 pixel Si sensors
  - timing with σ_t = 30 ps

- Outer Tracker
  - 3 barrel layers at 81.9 - 148.6 cm and 4 + 4 endcap disks at $|z|$ = 141.0 - 219.0 cm
  - 50 µm x 1 mm macropixel Si sensors
  - timing with σ_t = 60 ps

- Inner Tracker
  - 3 barrel layers at R = 16.1 - 55.4 cm and 7 + 7 endcap disks at $|z|$ = 60.7 - 219.0 cm
  - 50 µm x 1 mm macropixel Si sensors
  - timing with σ_t = 60 ps

Radiation damage in the detector at $\sqrt{S}$ =10 TeV



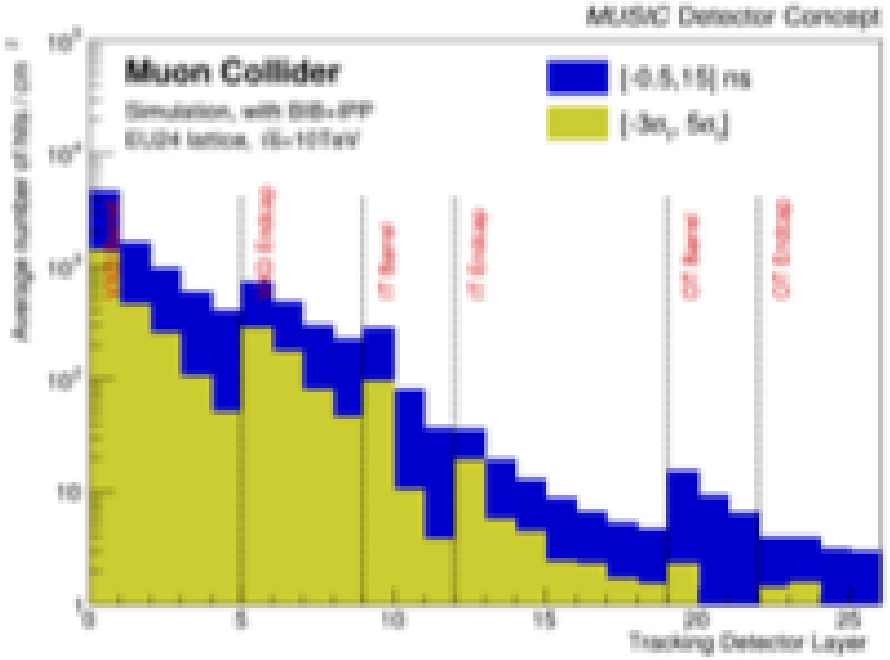


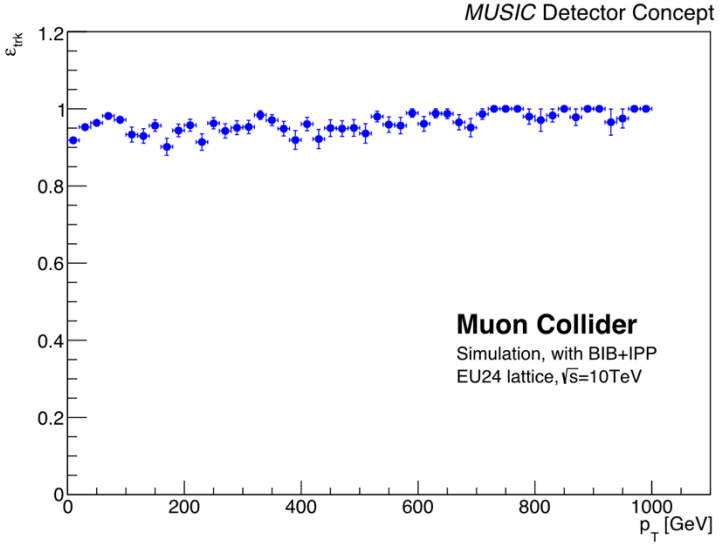
The muon collider: IMCC ESPPU submission

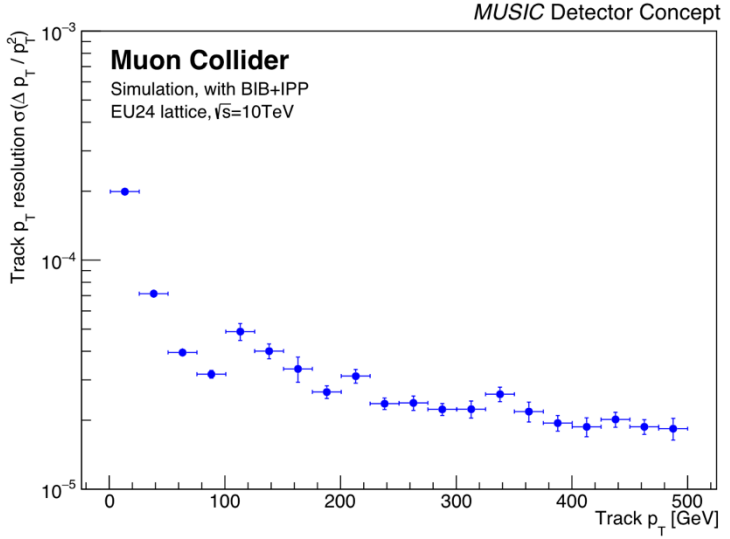
Table 3.2.1: Maximum values of the ionizing dose and the 1 MeV neutron-equivalent fluence (Si) for the two detector options. All values are per year of operation (10 TeV) and include only the contribution of muon decay.

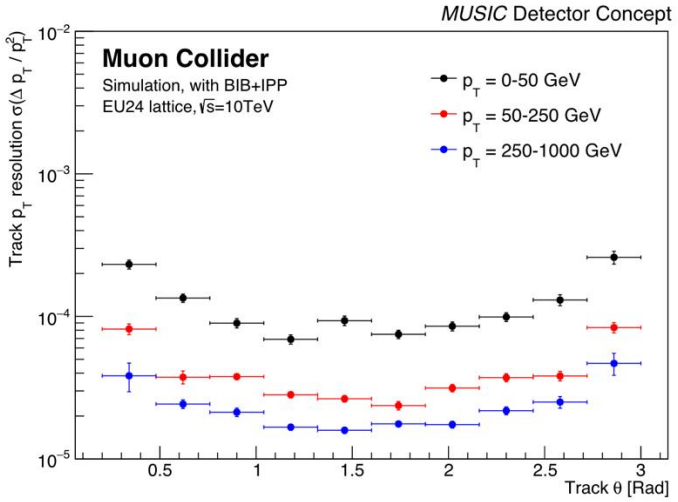
Component	Dose [kGy]		1 MeV neutron-equivalent fluence (Si) [10^{14} n/cm^2]	
	MAIA	MUSIC	MAIA	MUSIC
Vertex (barrel)	1000		2.3	
Vertex (endcaps)	2000		8	
Inner trackers (barrel)	70		4.5	4
Inner trackers (endcaps)	30		11.5	10
ECAL	0.58	1.4	0.15	1

$\sqrt{S}$ =10 TeV Silicon tracker detector performance









- High level of spurious hits
- Current mitigation measures:
  - high granularity;
  - hit timing requirements;
  - optimized track finding algorithm

No detailed simulation of background effects in silicon detector

Already good performance.
Improvements expected with dedicated sensor and services design

Status of R&D activities

Already presented last year, we have been completely overwhelmed by the preparation of ESPPU document:

P. Andreetto et al., “Performance study of the MUSIC detector in √s = 10 TeV muon collisions”,: paper dedicated to the description of MUSIC detector performance obtained with detailed detector simulation including machine induced background.

P. Andreetto et al., “Sensitivity study on H→bb, H→WW*, and HH→bbbb cross sections and trilinear Higgs self-coupling with the MUSIC detector in √s = 10 TeV muon collision”: paper dedicated to the expected precision on the most important Higgs measurements, including detailed detector simulation and all backgrounds.

In progress with LBL colleagues:
Study of dedicate clustering algorithm with the current detector configuration, (no cooling, no services, etc.)
Updates after studies described in the next slides

Proposed R&D activities on MAPS

- Vertex barrel
  - Study background distributions in the sensors by using full silicon simulation: for example, evaluate sensor thickness, tradeoff between small sensor to minimize multiple scattering and secondary production and ”tick” sensor to contain the background.
  - Test beam activities:
    - study hits distribution in space coordinates and energy at test beams and compare to simulation
  - Combine above information to define granularity (trade off among background multiplicity, readout capacity, cooling system and services) and structure of the barrel

- Vertex, Inner and Outer barrel
  - Identify preliminary parameters of possible cooling and service system.
  - Vertex has high occupancy but crossing rate < 100 kHz.
  - Special attention to the first layer

Proposed R&D activities on MAPS cont'd

- Endcap disks, vertex, IT and OT
  - Study a configuration to maximize the coverage and occupancy. Exploit the experience of other experiments (ALICE).
  - Test beam activities: study hits distribution in space coordinates and energy at test beams and compare to simulation with different sensors orientation.
  - Identify preliminary parameters of a possible cooling and service system: high occupancy in the tracker but crossing rate < 100 kHz.

- Study a dedicate clustering algorithm that will depend on all the above detector, readout and services structure.

- Dedicated prototypes studies once specific requests will be identified

Anagrafica Padova

Andreetto Paolo	25
Awais Muhammad	50
Bertolin Alessandro	30
Calzolari Daniele	100
Ciarlantini Sabrina	30
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Lupato Anna	30
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Nguyen Xuan Tung	50
Palombini Leonardo	100
Qundomg Han	30
Zingaretti Alessandra	0
Zuliani Davide	20
Tot. FTE	5.55

Richieste per padova

Capitolo	Descrizione	Parziali (k€)		Rimuovi	Modifica	Totale (k€)	
		Richieste	SJ			Richieste	SJ
consumo	Premiale AdR progetto aMUSE	40.00	0.00			46	0
	Metabolismo di gruppo per piccole richieste per test beams	6.00	0.00				
missioni	7- Metabolismo + 6-Test beam silicio e calorimetro + 25-conferenze e workshops + 2.5-responsabilita'	40.50	0.00			40.5	0
inventario	Contributo per acquisto di una macchina bondatrice per attivita' di R&D comuni a FCC, MuC, CMS ed esperimenti di CSN3, cofinanziato DOE/CSN1/CSN3/Sez. PD - ANTICIPABILE	10.00	0.00			10	0
Totale						96.5	0

Missioni: usata la formula data da voi + responsabilità + richieste per test beam.

Inventario:

- richiesta di contributo per bonding machine di sezione fondamentale per design di prototipi, in collaborazione con Alice, EPIC, FCC-ee

R&D on silicon activities are supported also by a new MSCA-SE2024 project: NEMESIS, starting 2026. Travels to US and PSI are co-funded.