Irradiation studies for the Mu3e Tile detector

(T96.3 DPG, Heidelberg 2022)

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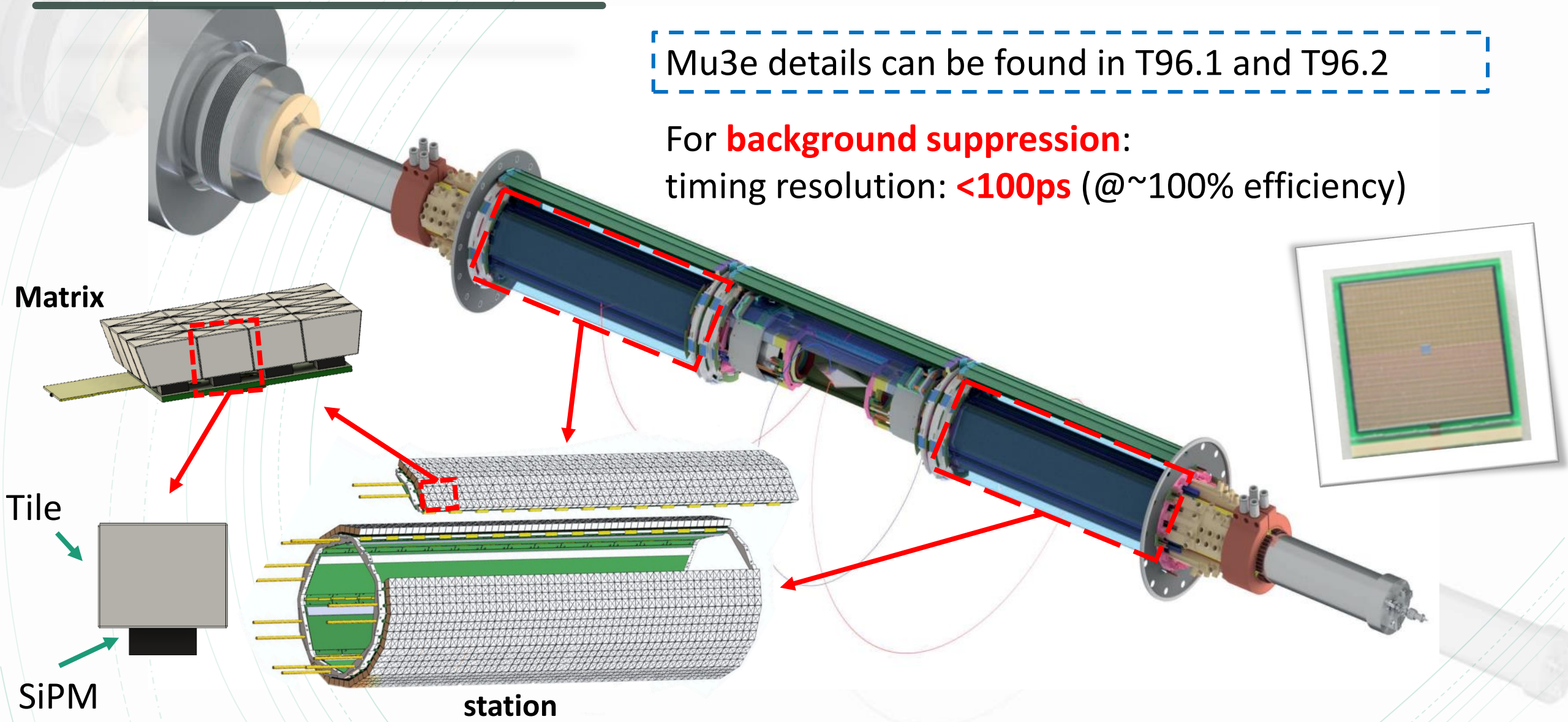
Introduction of Mu3e

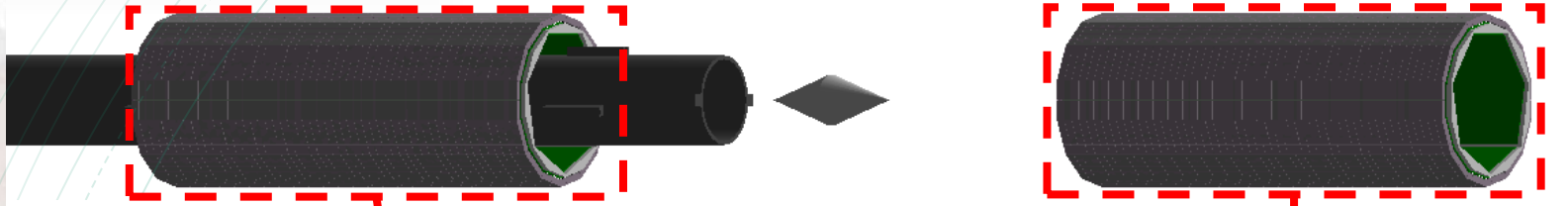
Mu3e details can be found in T96.1 and T96.2

For **background suppression**:
timing resolution: **<100ps** (@~100% efficiency)

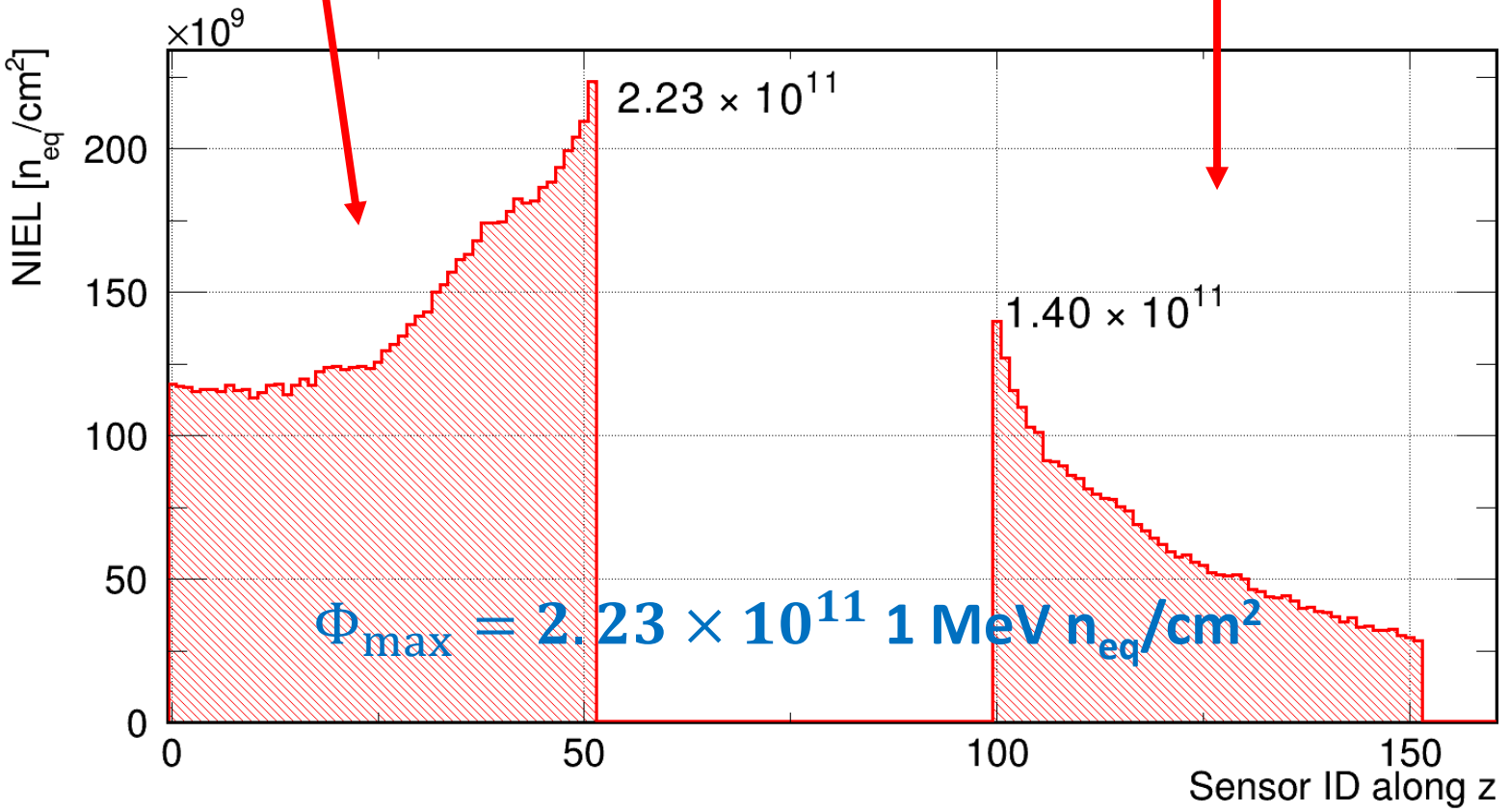


Irradiation in Mu3e Tile detector

Muon beam

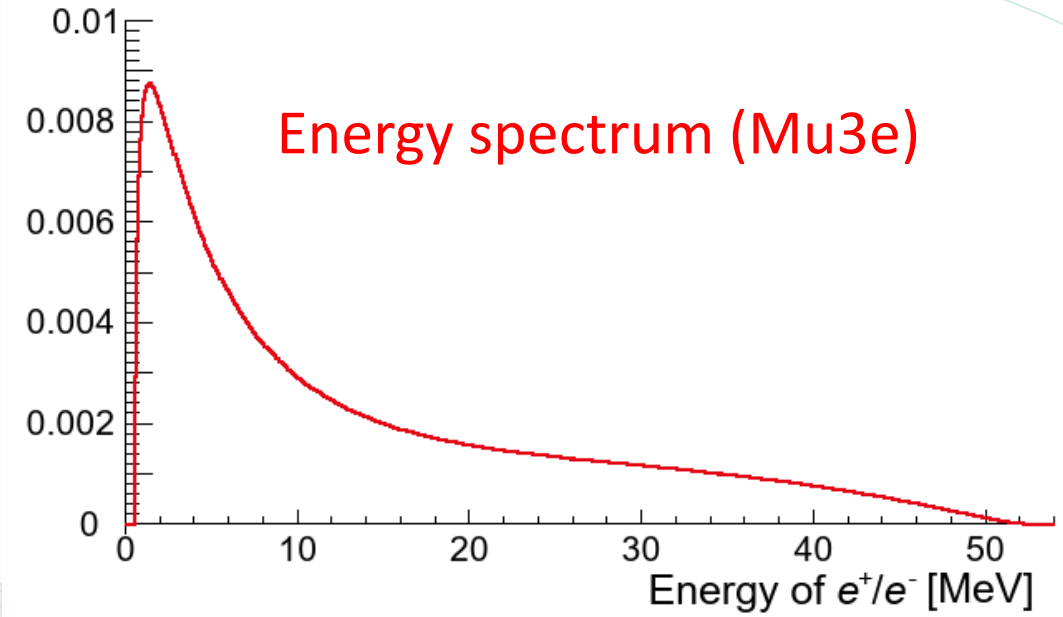


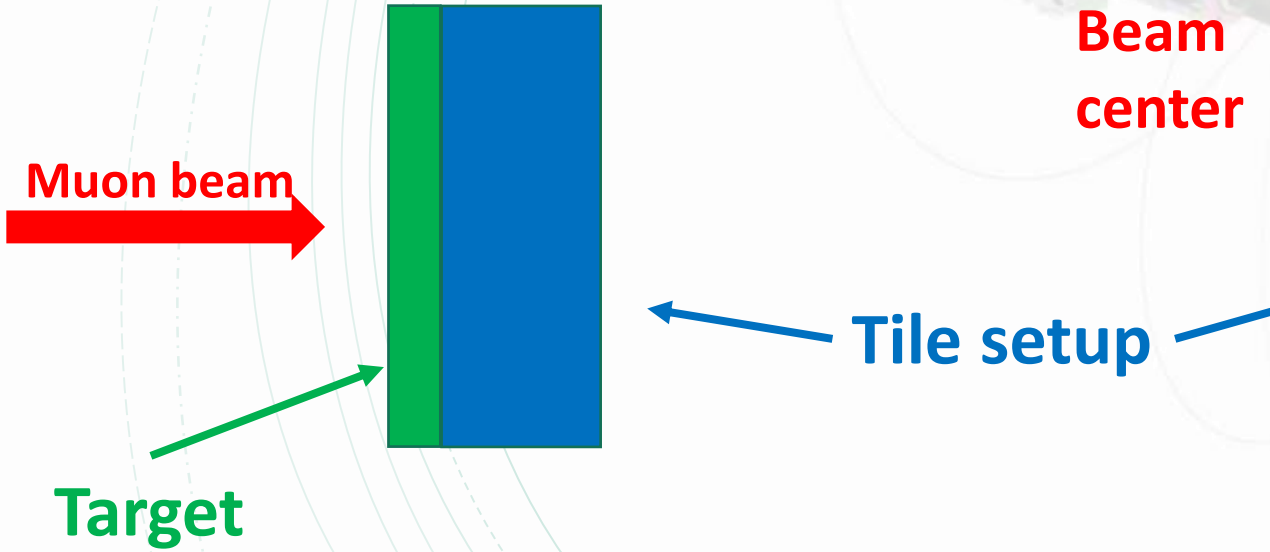
GEANT4 simulation

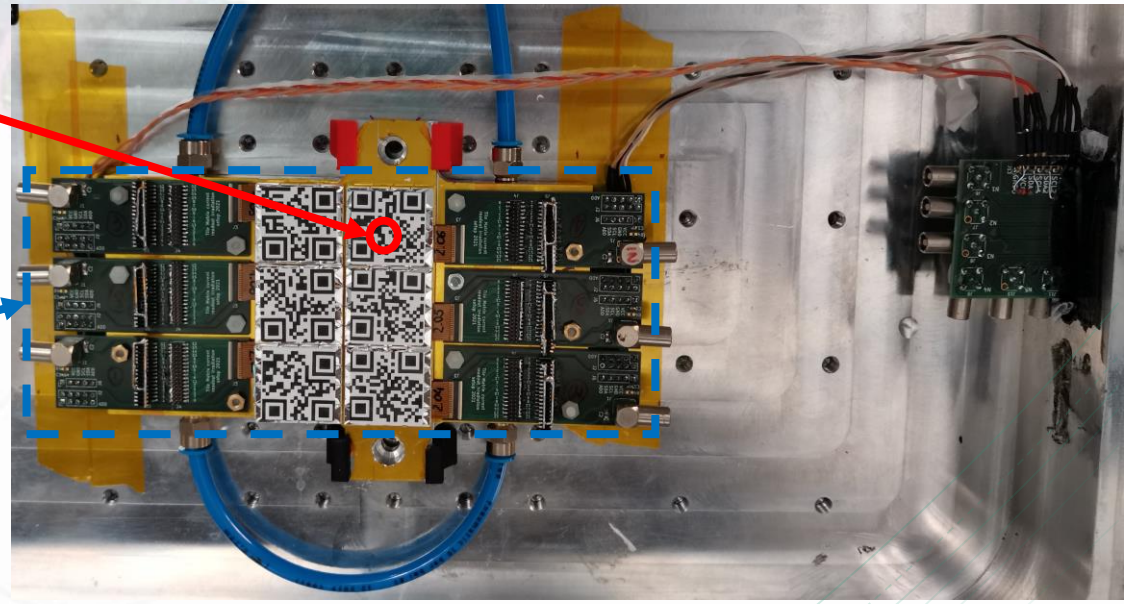


Testbeam setup

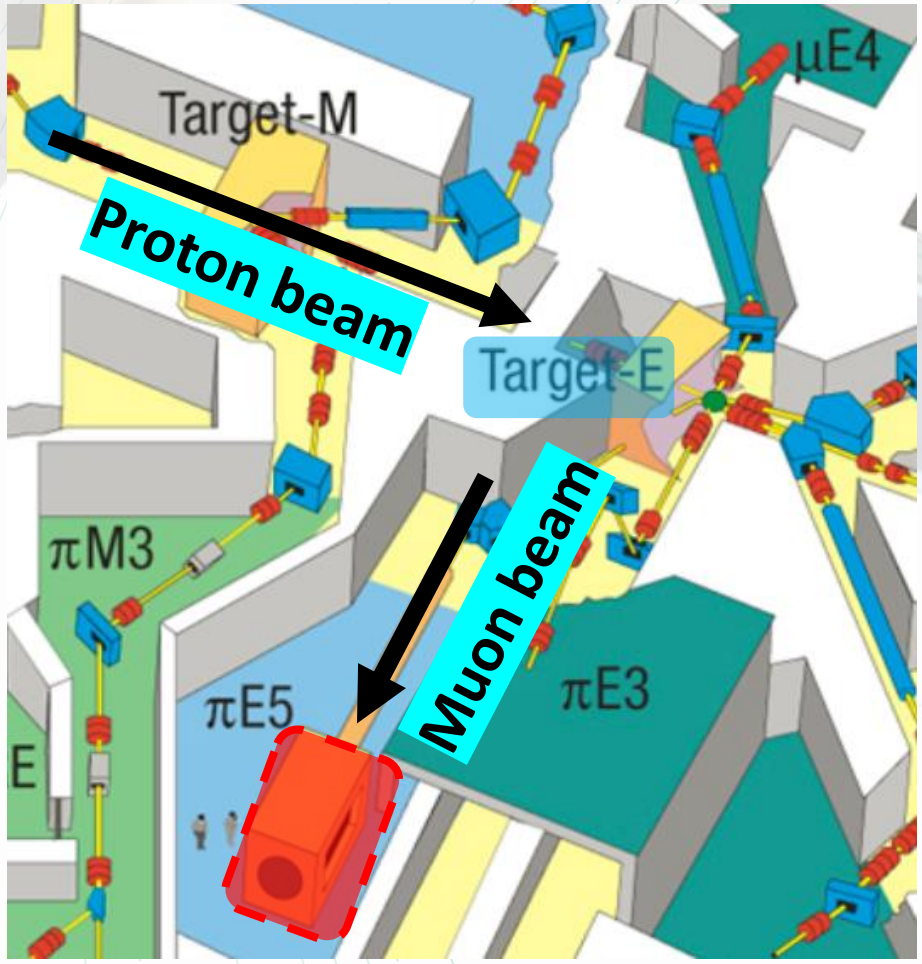
- Period: 3 week in **April** 2021
- Place: **PiE5** beam line at **PSI**
  - Radiation by **e^-/e^+** from Muon decay
  - **Exact beam line** for Mu3e
- Environment: water cooling @**13**℃





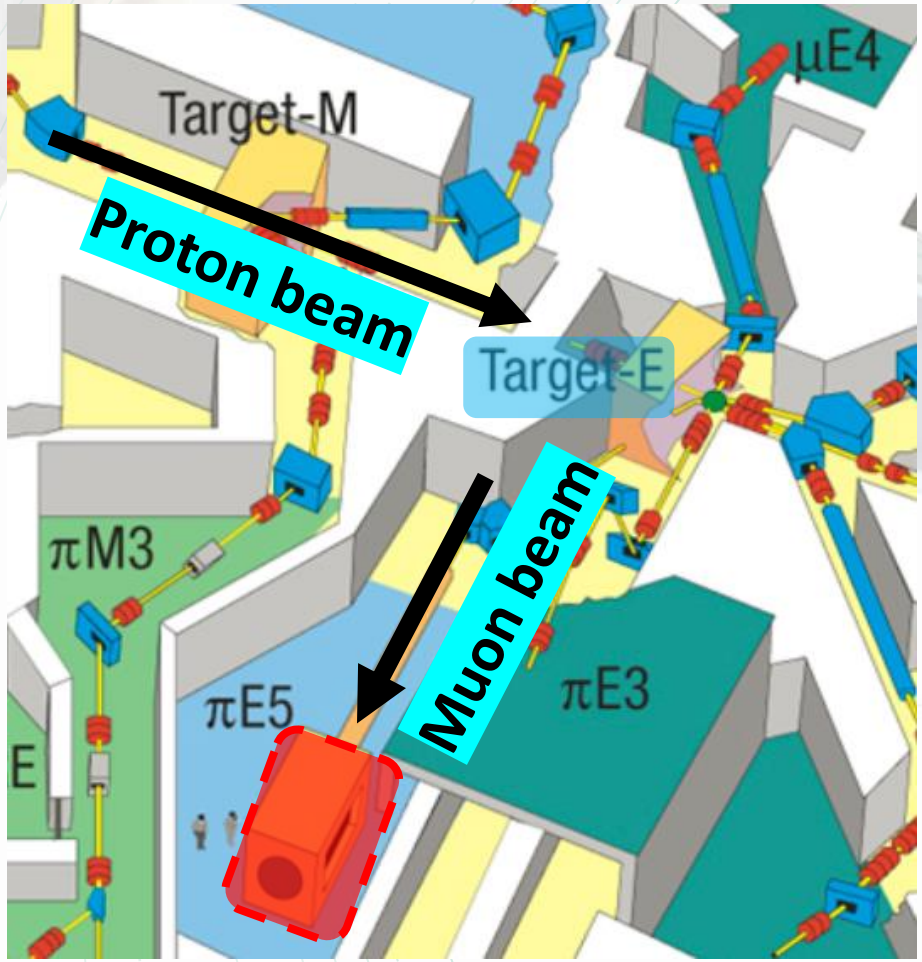


Beamline introduction



Beamline in PSI

Beamline introduction



Beamline in PSI

How much dose we got?

GEANT4: muon beam

No access to **muon beam** during the test

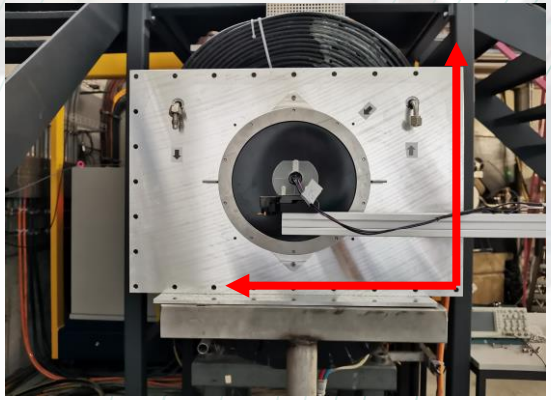
Proton beam
(during the test)

+

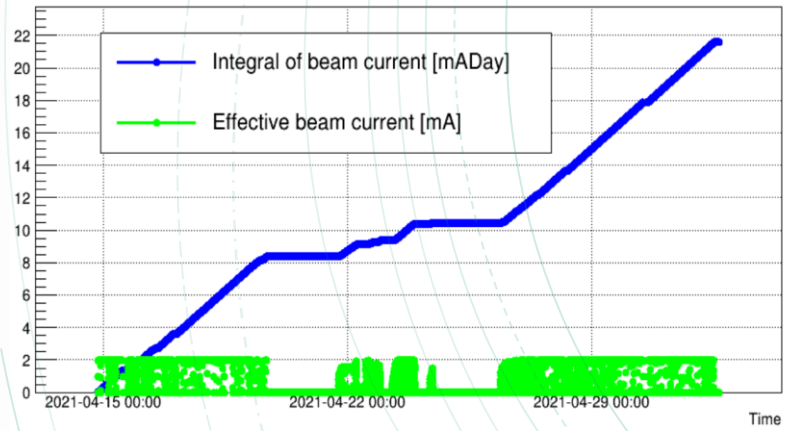
Coefficient:
Proton beam → **muon beam**
(before the test)

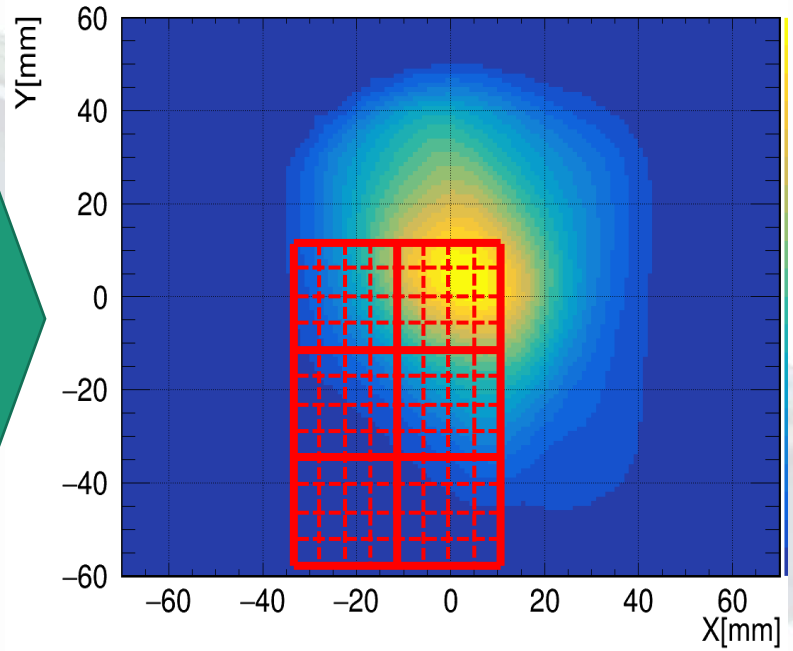
Dose estimation (testbeam)

Muon beam scan
(before irradiation)



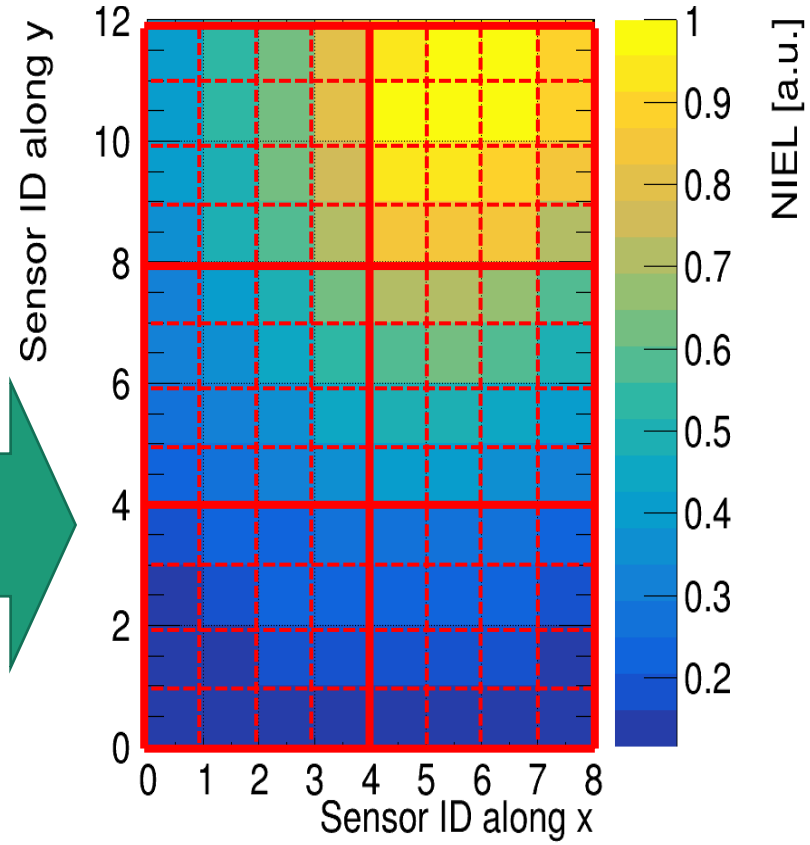
Proton beam log
(during irradiation)





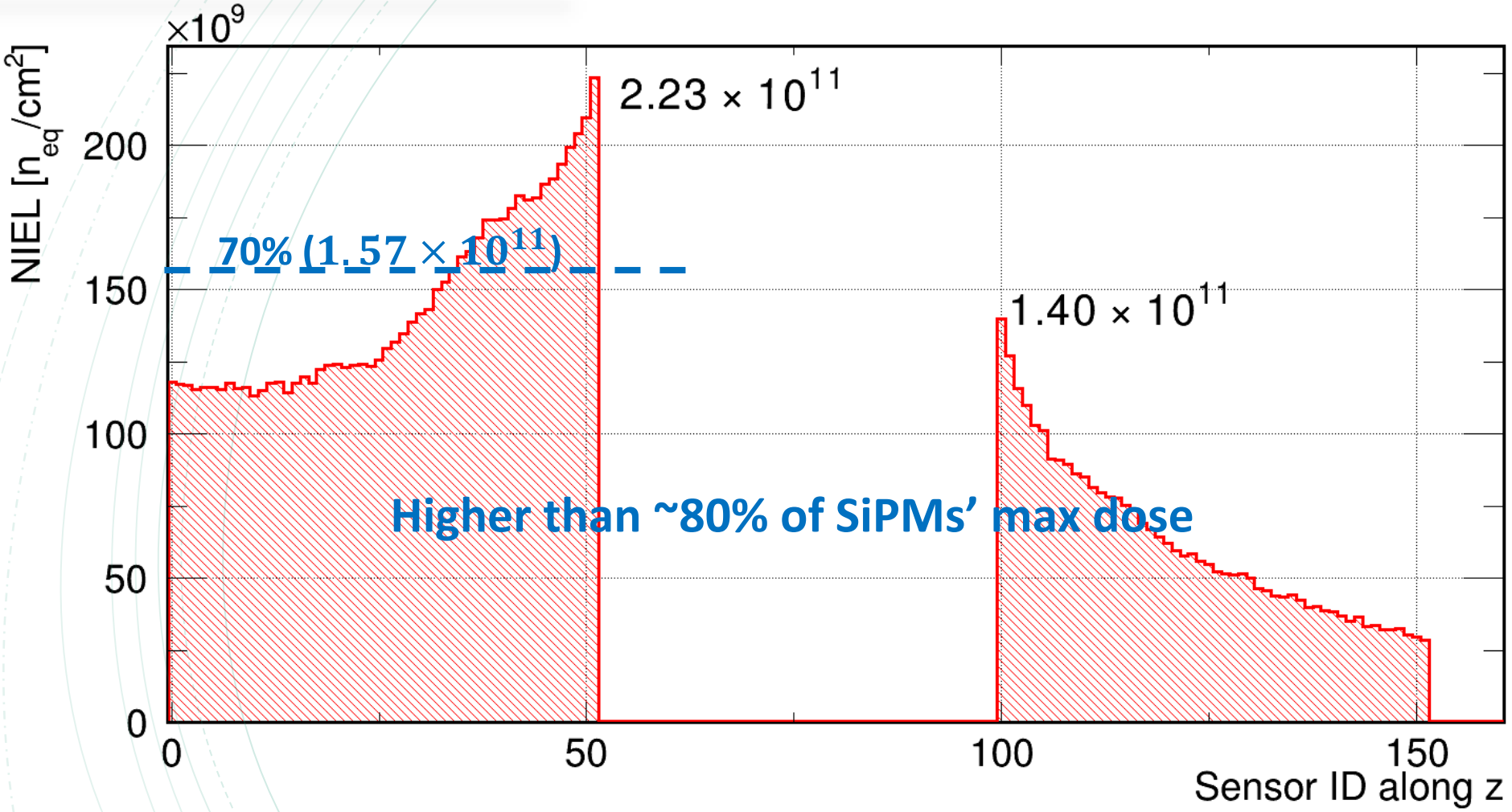
Muon Beam profile
(red: position of Tile SiPMs)

Max dose: $1.57 \times 10^{11} n_{eq}/cm^2$



Dose distribution (simulation)

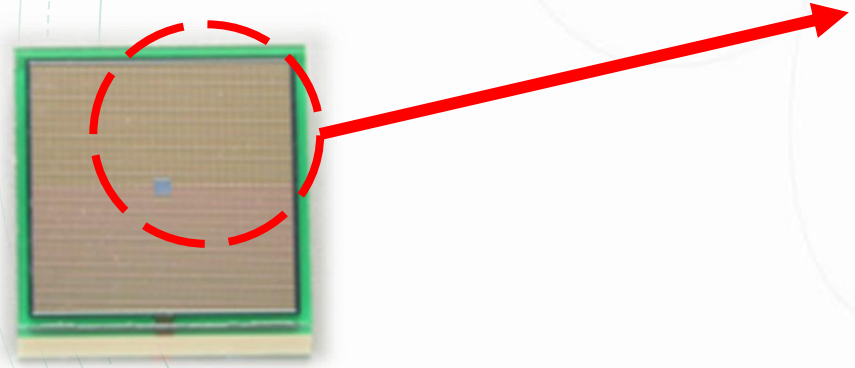
Dose estimation (testbeam)

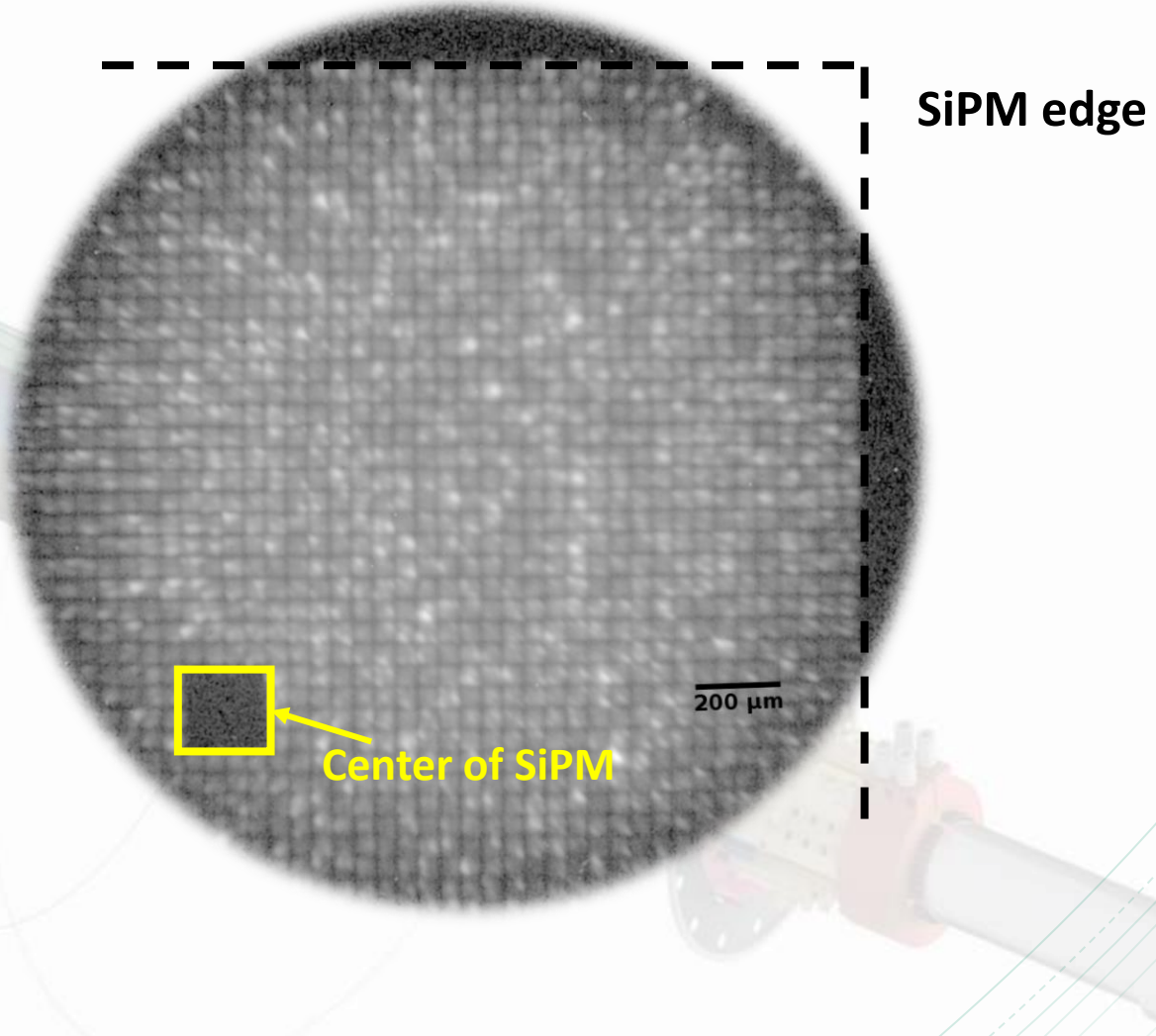


Direct look of damage distribution

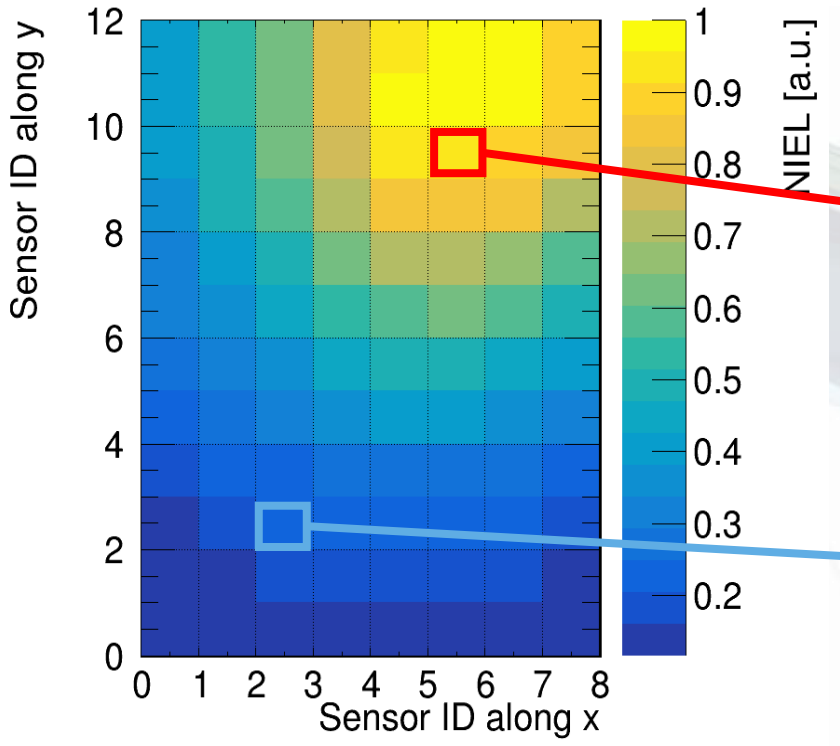
Photons from SiPM avalanche:

- Low noise camera: SXVR-H18 (T: -15°C)
- Scope lens amplification :X10
- SiPM: (HV=58V; cool with water @5°C)
- Hot-spots are uniformly distributed

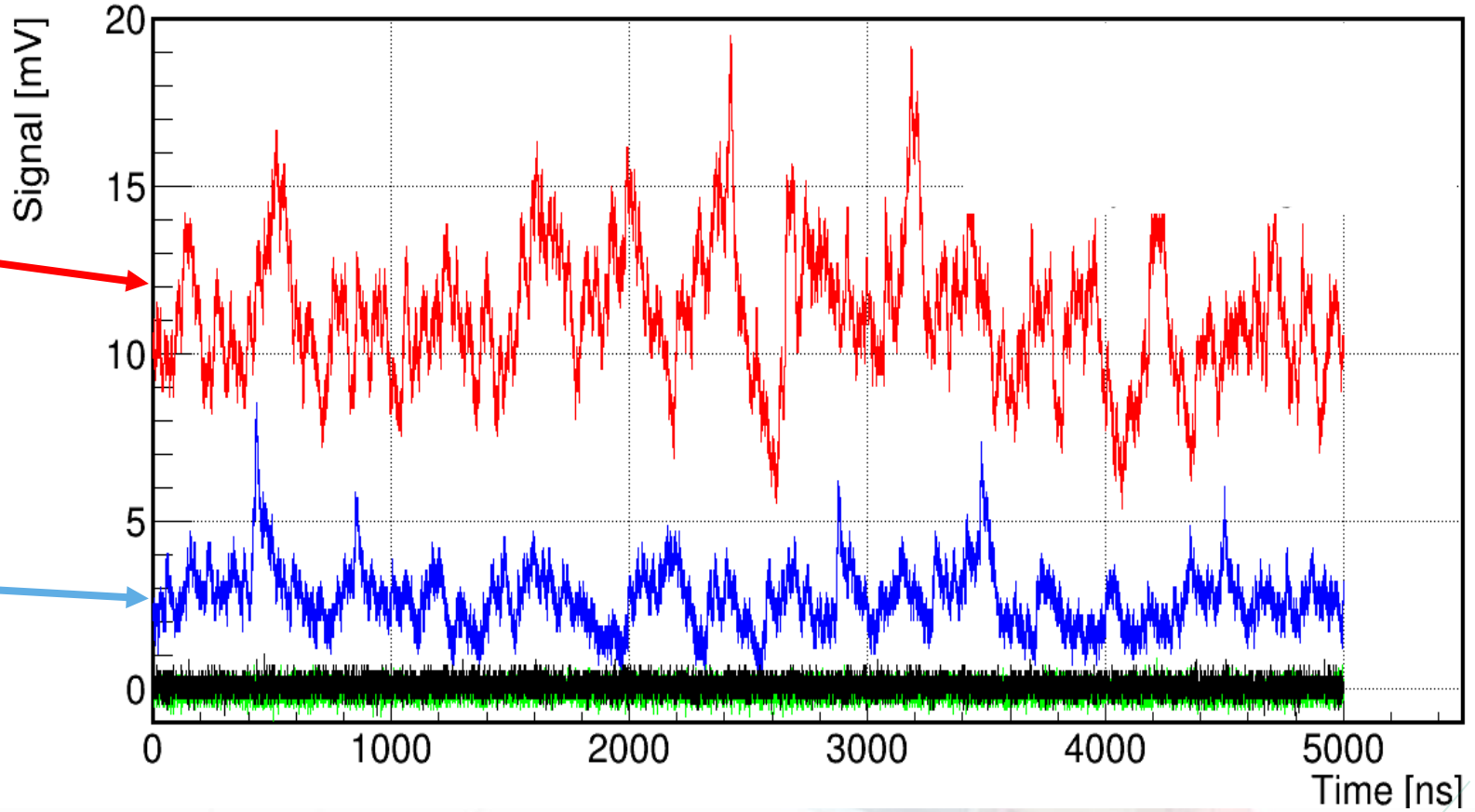




Dark signal measurement



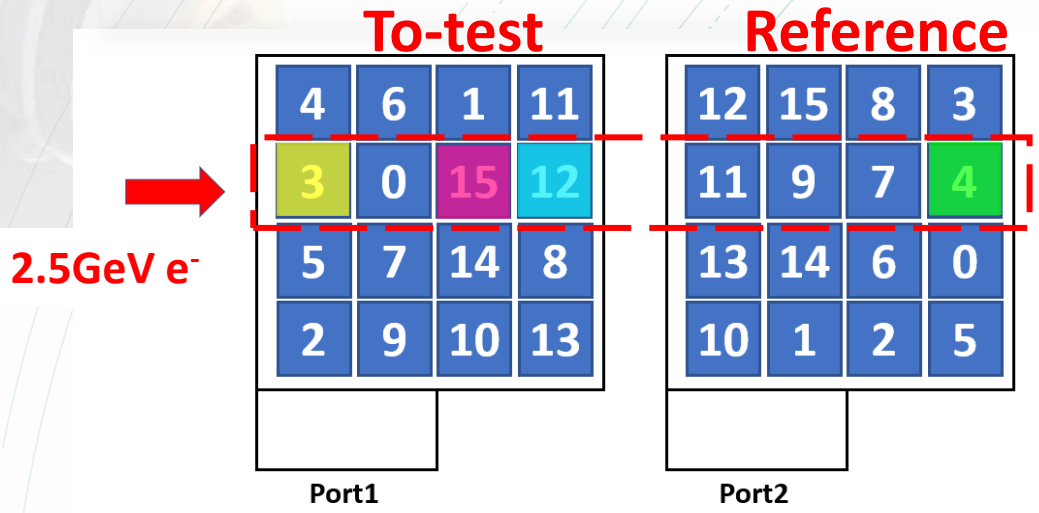
Dose distribution

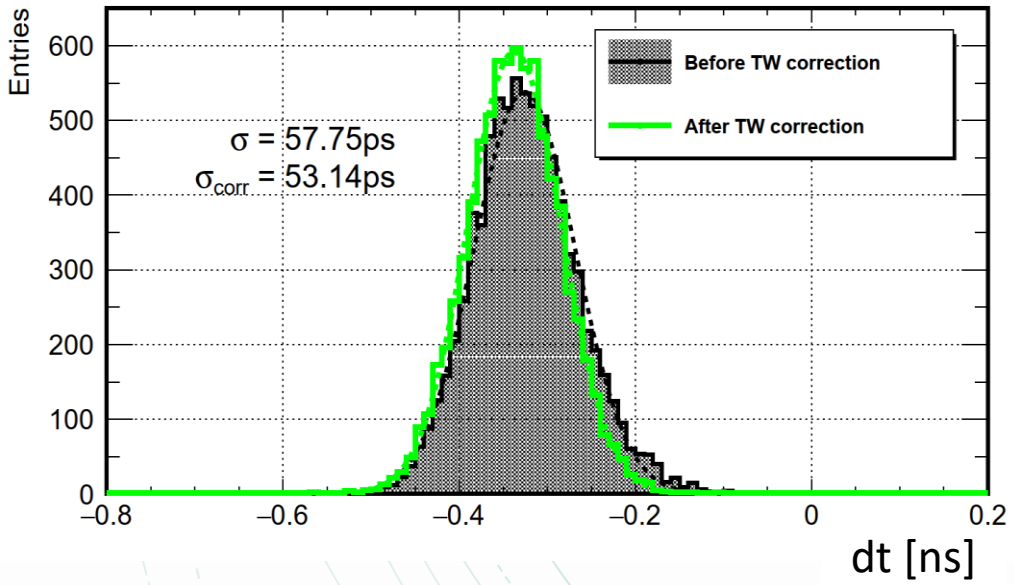


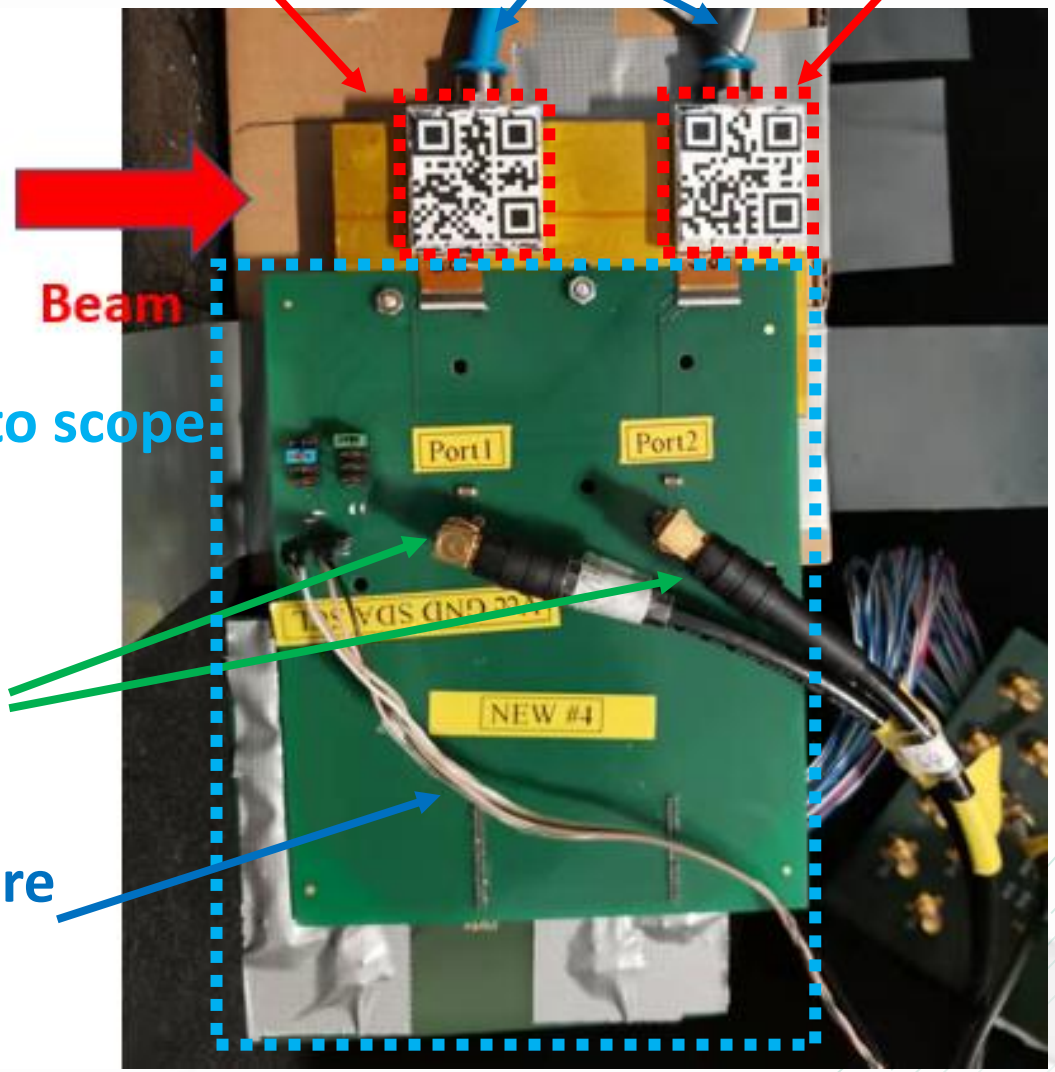
Black: background

green: new matrix **w/o irradiation**

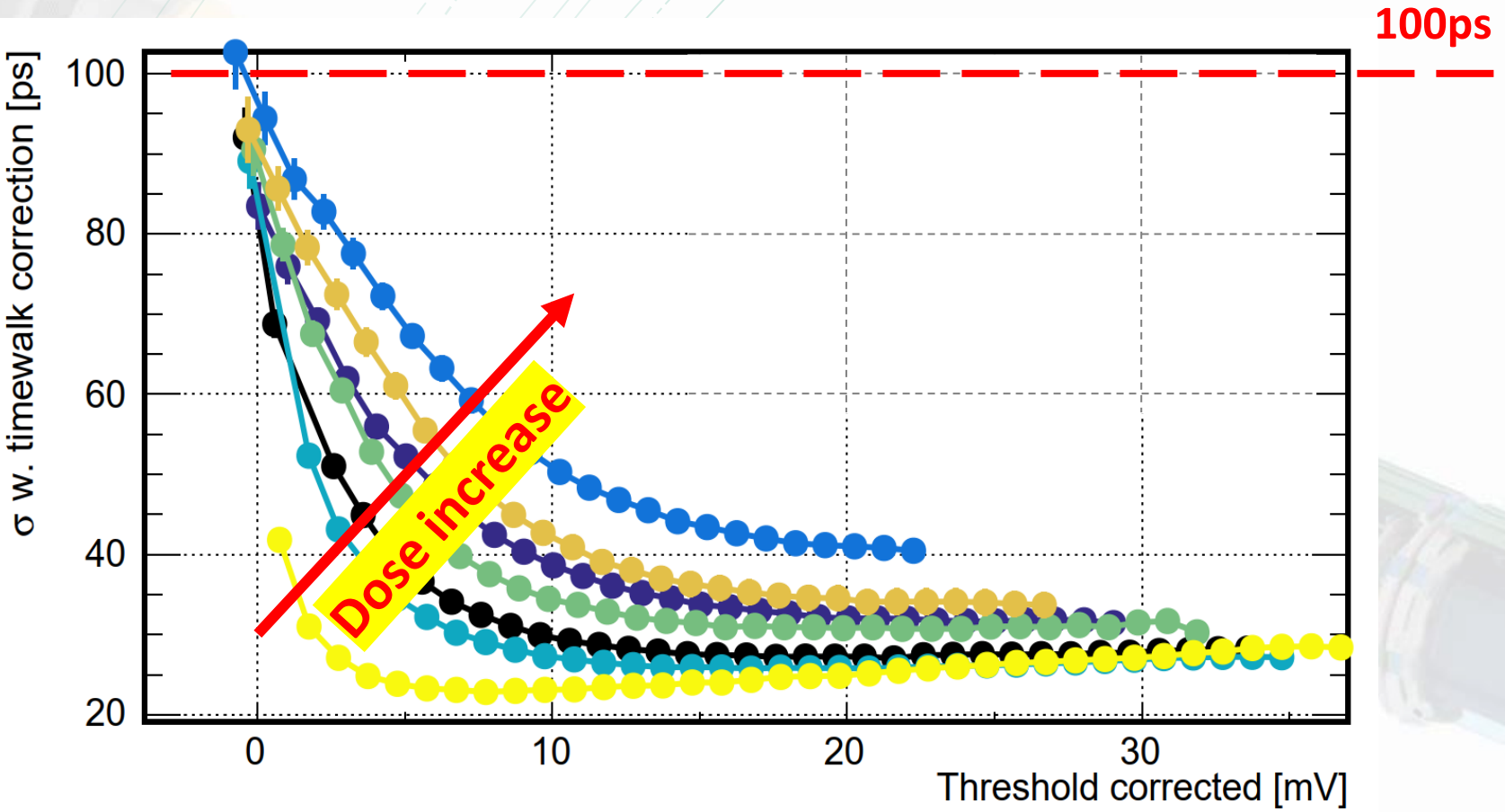
Testbeam and timing analysis







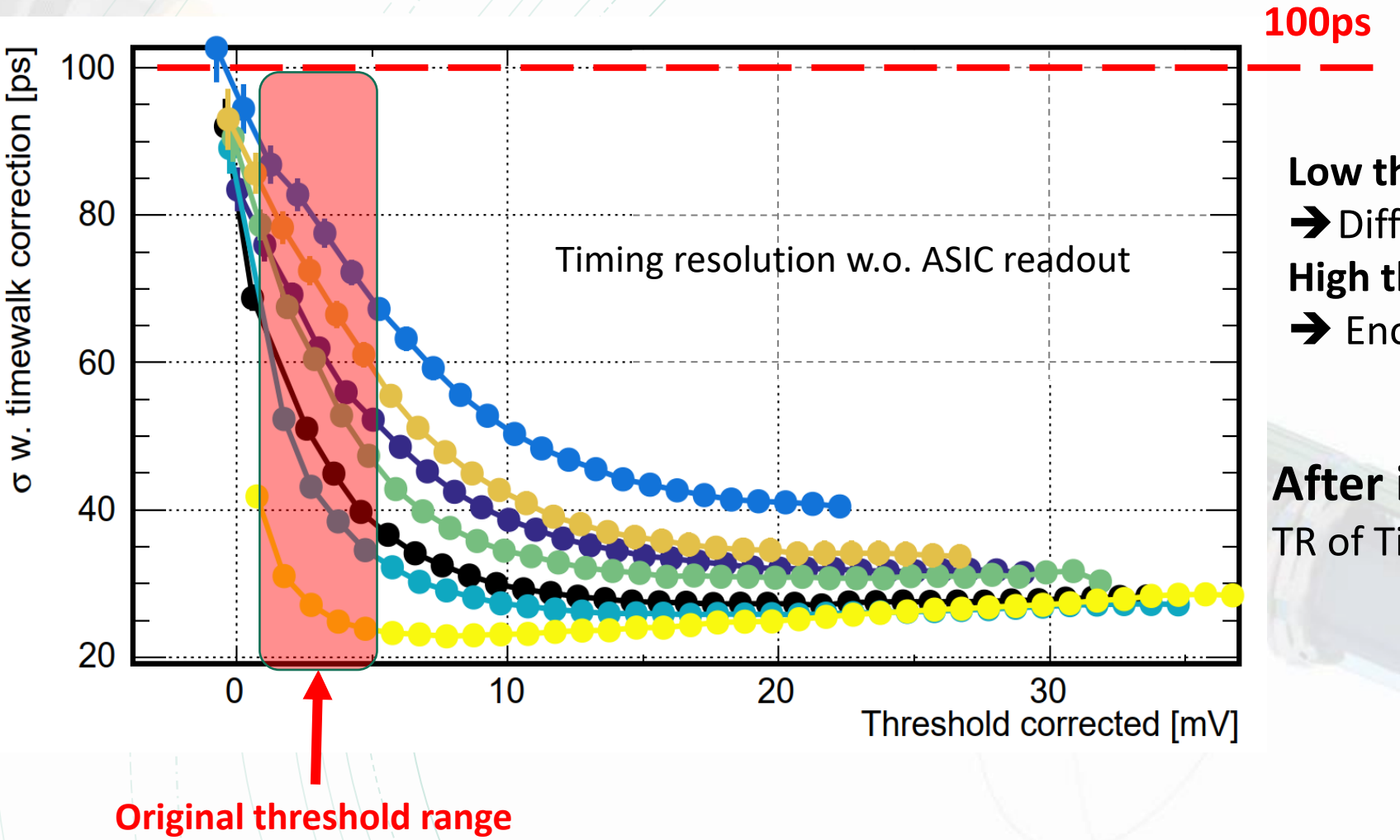
Timing analysis



Timing resolution(**TR**):

- **@low threshold**: dominated by **signal fluctuation**
- **@high threshold**: dominated **by photon statistic uncertainty**

Timing analysis



Low threshold:

➔ Difficult to fulfill the requirement

High threshold:

➔ Enough margin for uncertainty from ASIC

After irradiation:

TR of Tile Detector will fulfill the requirement.

Summary

Mu3e Tile detector:

- **Irradiation** study is a very **interesting and important** topic.
- The results shows that after **irradiation** TR will still **fulfill the requirement.**

Thanks for you time and attention!!