The Mu3e scintillating fibre detector R&D

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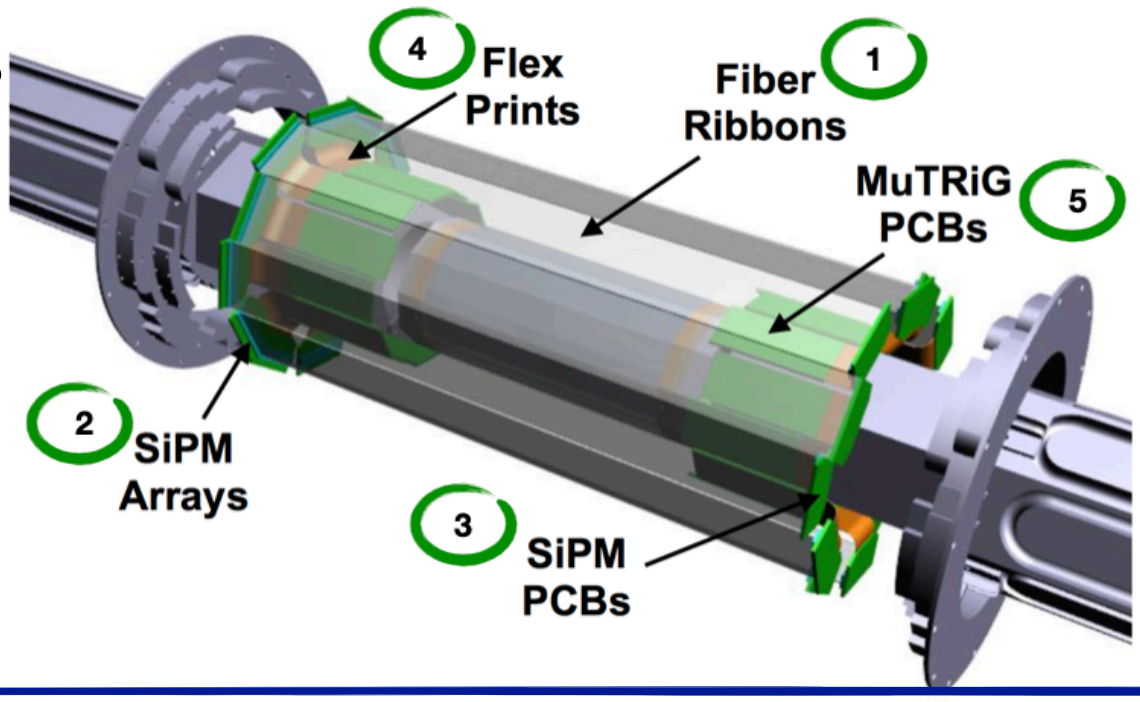
Goal

Detect m.i.p. with high efficiency, minimum amount of material for a sub ns time resolution with just few photoelectrons/fiber

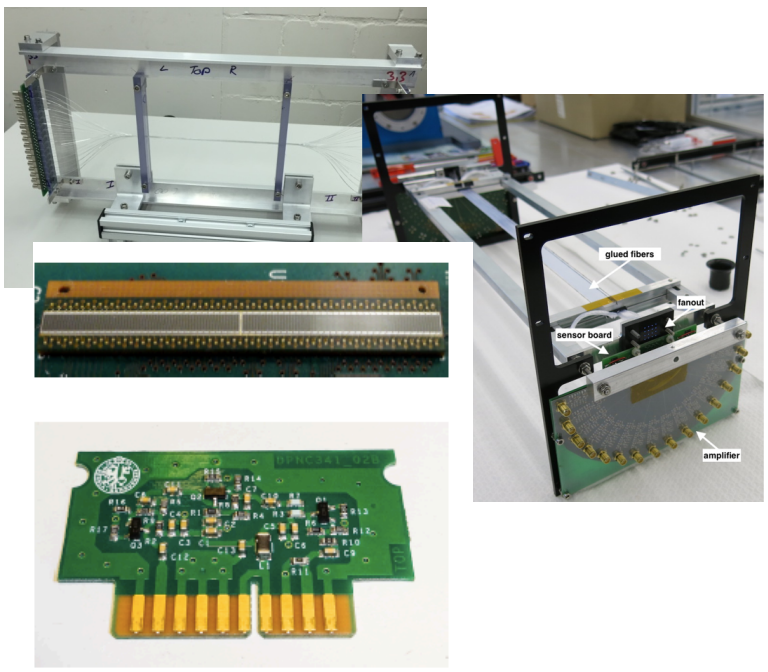
Requirements

- < 900 μm total thickness < 0.3 % X_0
- time resolution σ < 1 ns
- rate up to 250 KHz/fiber
- very tight space for cables, electronics and cooling



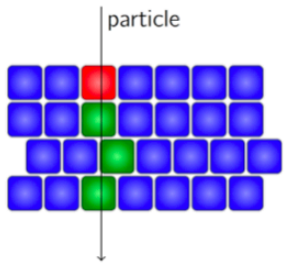
Parts

- cylindrical at ~ 6 cm (radius); length of 28-30 cm;
- 3 layers of multi-clad 250 μm fibers
- fibers grouped onto SiPM array
- MuTRiG readout

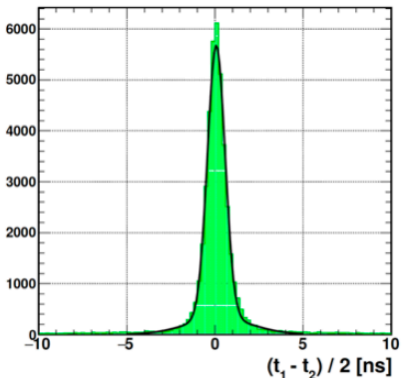


Detector prototypes

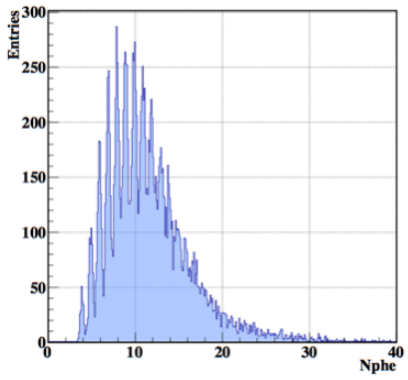
Trigger
offline selection:
hits in 3 layers
MC SQ BCF12 Saint-Gobain
Hamamatsu S13360-1350CS



3 layer time resolution O(550) ps

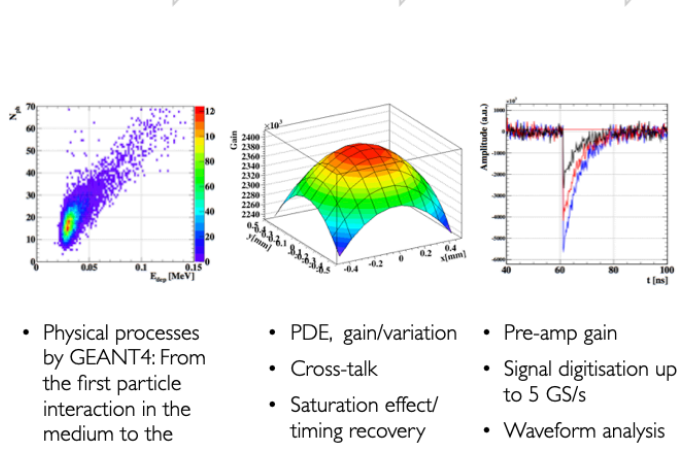


3 layer offline array charge collection (thr > 1.5 Nphe)

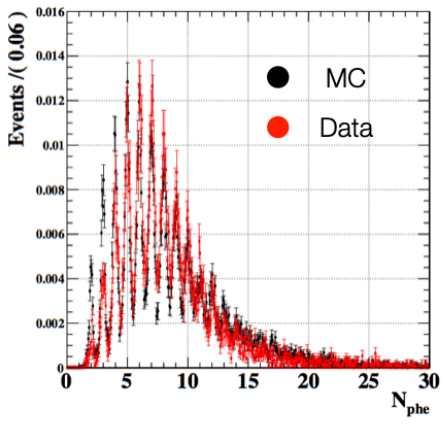


Addressed requirements with one of the prototypes

GEANT4 → MPPC → DAQ → Analysis: Data vs MC

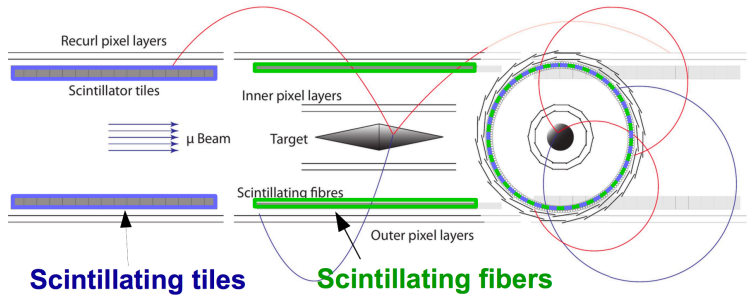


- Physical processes by GEANT4: From the first particle interaction in the medium to the photosensor
- PDE, gain/variation
- Cross-talk
- Saturation effect/ timing recovery
- Dark Counts
- Pre-amp gain
- Signal digitisation up to 5 GS/s
- Waveform analysis



From detailed MC to Data

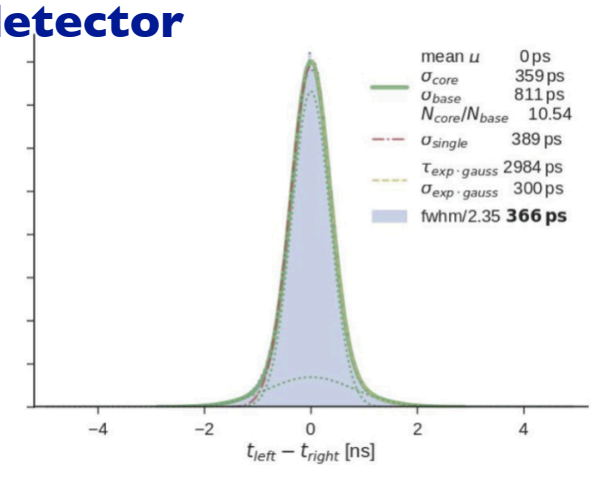
- The Mu3e experiment aims to search for $\mu^+ \rightarrow e^+ e^+ e^-$ with a sensitivity of ~10^{-15} (Phase I) up to down ~10^{-16} (Phase II).
- Previous upper limit BR($\mu^+ \rightarrow e^+ e^+ e^-$) ≤ 1 x 10^{-12} @90 C.L. by SINDRUM experiment)
- Observables (E_e, t_e, vertex) to characterize μ→ eee even
- Here the focus on precise timing measurement: Critical to reduce the accidental BGs



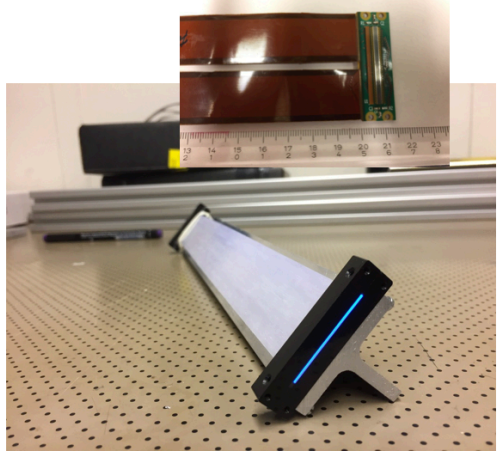
Ref. K. Arndt et al. The Mu3e collaboration. NIMA 1014 (2021)165679

The framework
The Mu3e experiment

Towards the final detector



SiPM Array: Hamamatsu S13552-HQR



Fibres: Kuraray SCSF78J

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