

Mu3e Online Event Selection on GPU

Chen Xie¹⁾ for the Mu3e collaboration²⁾

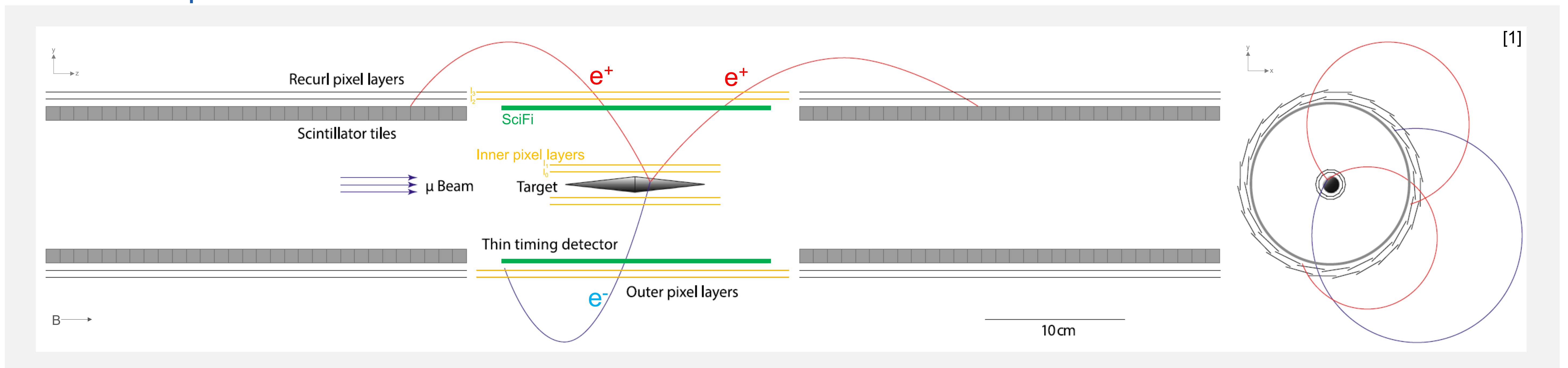
1) Institute for Particle Physics and Astrophysics, ETH Zürich;

2) Paul Scherrer Institute (PSI), University of Bristol, Université de Genève, Universität Heidelberg, KIT Karlsruhe, University of Liverpool, UCL London, JGU Mainz, University of Oxford, ETH Zürich, Uni Zürich

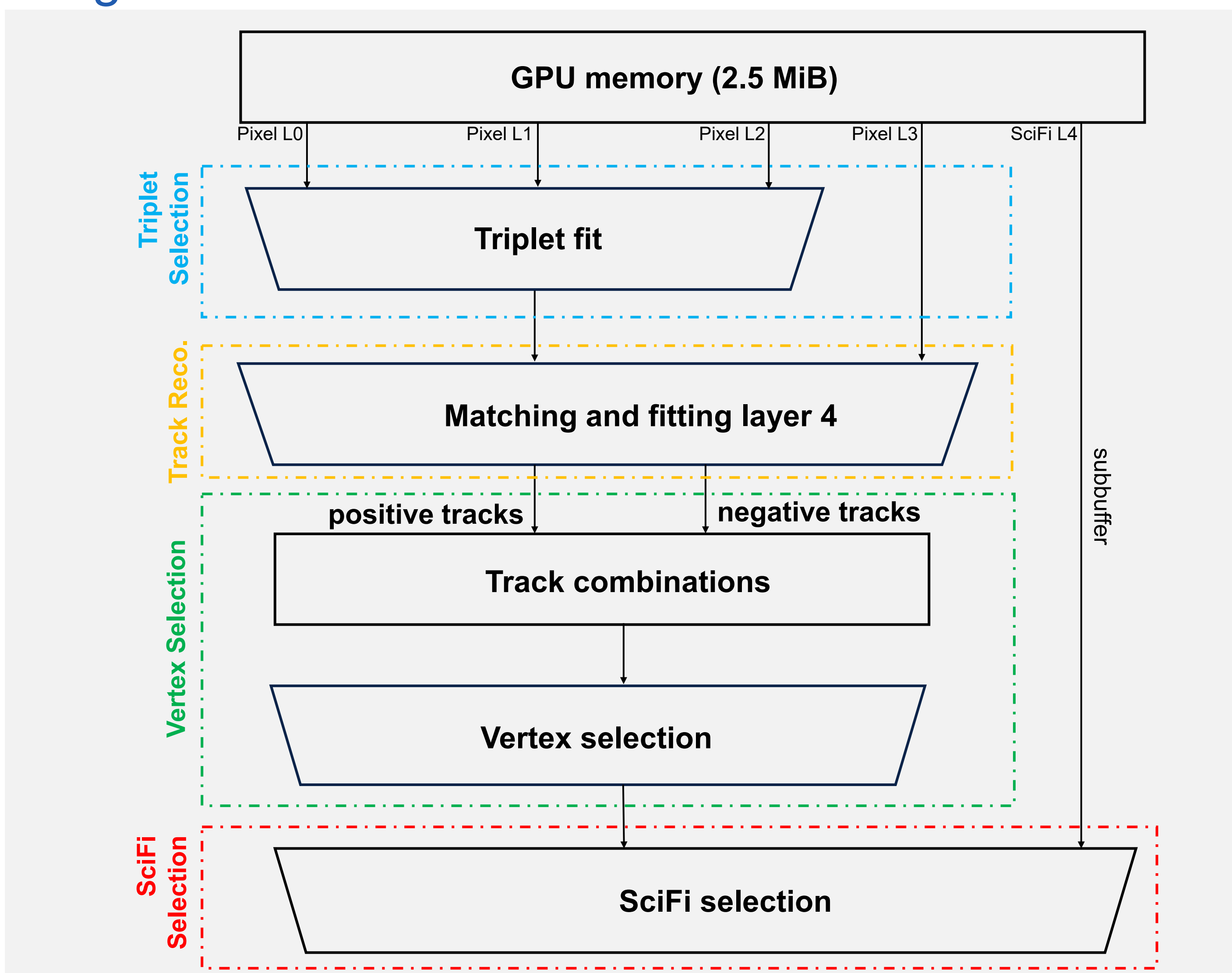
1 Introduction

The Mu3e experiment aims to search for the Charged Lepton Flavor Violation (cLFV) through the Standard Model (SM) forbidden decay $\mu^+ \rightarrow e^+ e^- e^+$, targeting a branching ratio sensitivity of 10^{-15} using the PSI $\pi E5$ beamline in Phase I. To cope with the exceptionally high muon rate of $10^8/s$ (equivalent to ~ 80 Gbps raw data rate), a triggerless, GPU-based online event selection algorithm is implemented to reconstruct the full kinematics of three tracks and their common vertex, enabling Mu3e signal identification and background suppression while reducing the data rate by two order of magnitude.

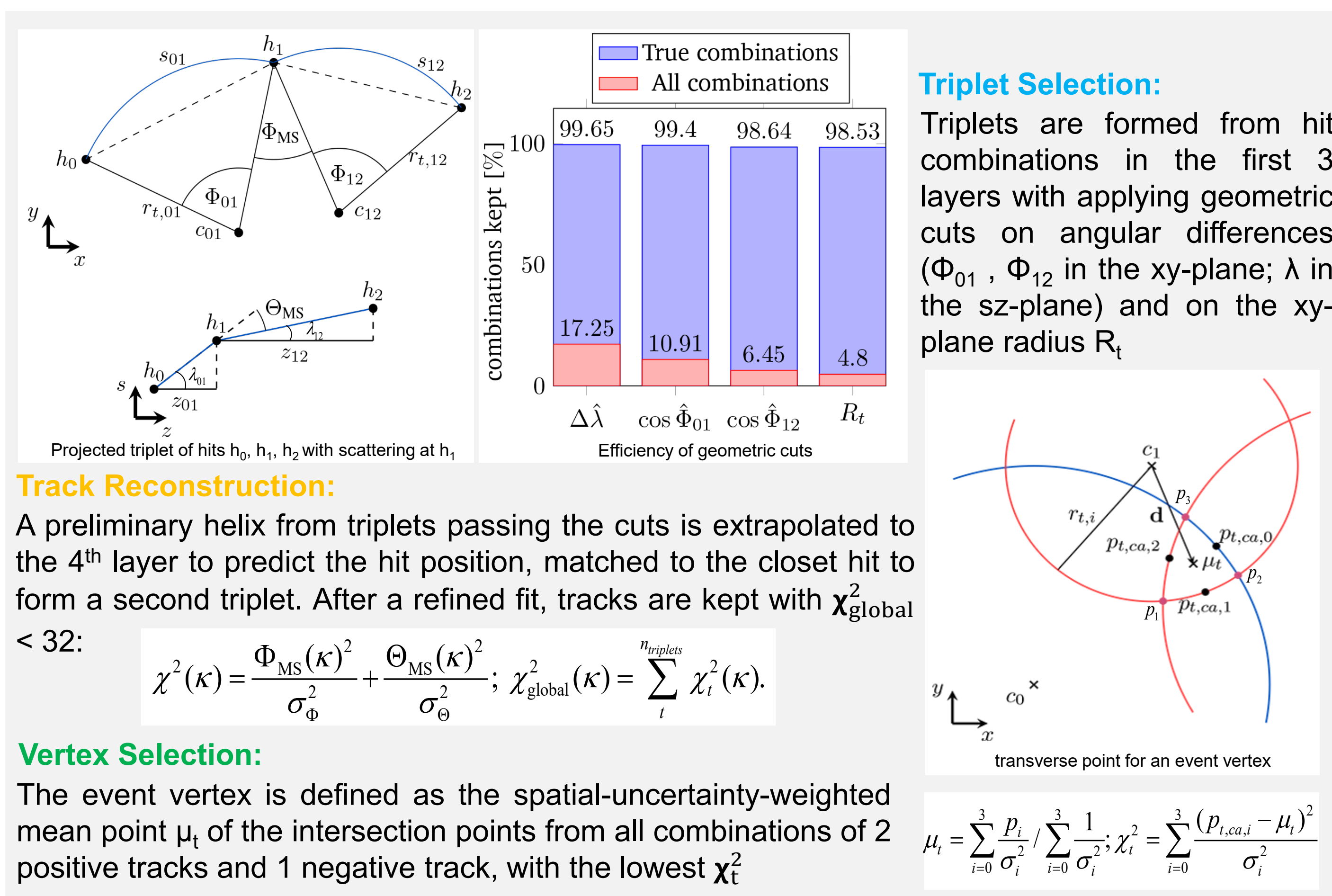
2 Mu3e Setup



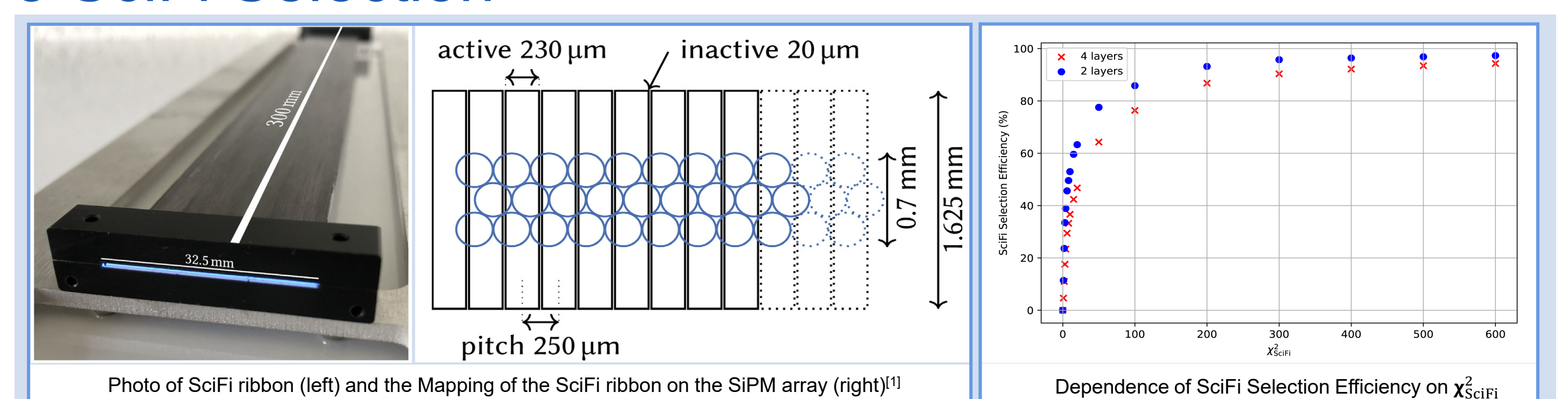
3 Algorithm Flowchart



4 Online Event Selection^[2,3]



5 SciFi Selection

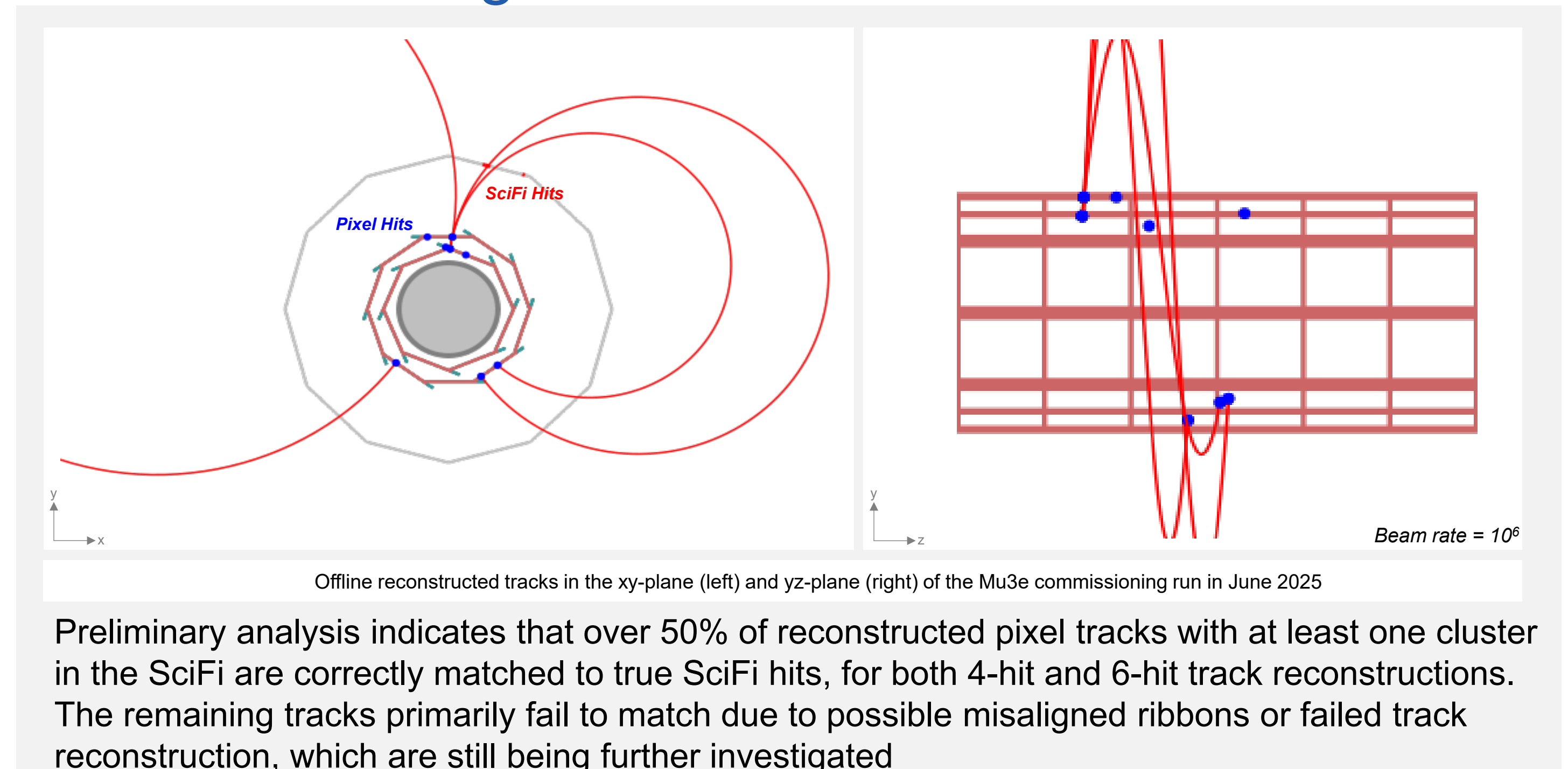


The scintillating fibre (SciFi) detector provides precise timing information with a resolution of 250 ps. Incorporating SciFi hits into the GPU-based online event selection allows tracks to be validated both spatially and in time.

Events with lower χ^2_{SciFi} tend to be accepted further by the SciFi selection after vertex selection, as χ^2_{SciFi} is correlated with the distance between the points of close approach (pca) on the SciFi and the three reconstructed tracks.

$$\chi^2_{\text{SciFi}} = \sum_{i=0}^3 \frac{|p_{t,ca,i} - \mu_{\text{SciFi}}|^2}{\sigma_{\text{SciFi}}^2}$$

6 Commissioning Run 2025



7. Conclusion

Monte-Carlo studies indicates that at the targeted muon rate of $10^8 \mu/s$ in Mu3e Phase I, more than 94% of the signal tracks are retained with a reconstruction accuracy of 97% while the data rate is reduced by a factor of 100^[2].

Meanwhile, SciFi selection has been incorporated into the online event selection and verified to run on the computing farm during Mu3e June beamtime; further validation is currently in progress.

References:

- [1] K. Arndt et al., "Technical design of the phase I Mu3e experiment", Nucl. Instrum. Methods. Phys., A 1014, 165679 (2021).
- [2] V. Henkys et al, "Online Event Selection for Mu3e using GPUs", ISPCD 2022, 17-24 (2022).
- [3] H. Augustin et al., "The Mu3e Data Acquisition", IEEE Trans. Nucl. Sci., 68, 1833-1840 (2021).