

First search for neutrino-induced charm hadrons with FASER's emulsion detector at the LHC

Simon Thor on behalf of the FASER collaboration



Abstract

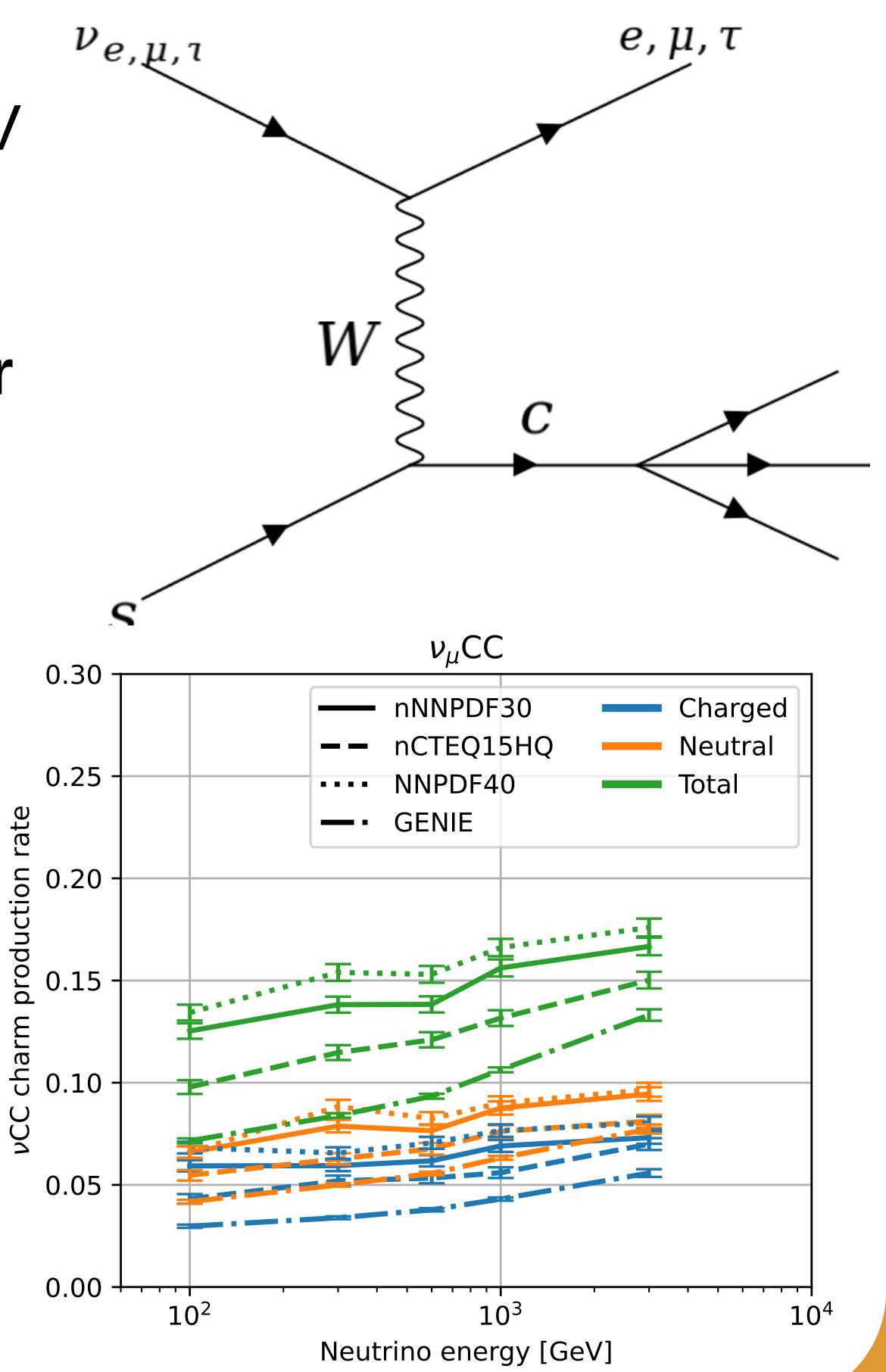
FASER is an experiment located 480 m from the ATLAS collision point, with an emulsion-tungsten based subdetector called FASERv.

In this poster, the results from the first ever search for charm hadrons produced from neutrino interactions at the TeV energy range are presented. The results were obtained by analyzing a FASERv module that was used for data-taking in 2022, which was exposed to 9.5/fb of proton-proton collisions, with 40 neutrino candidates observed.

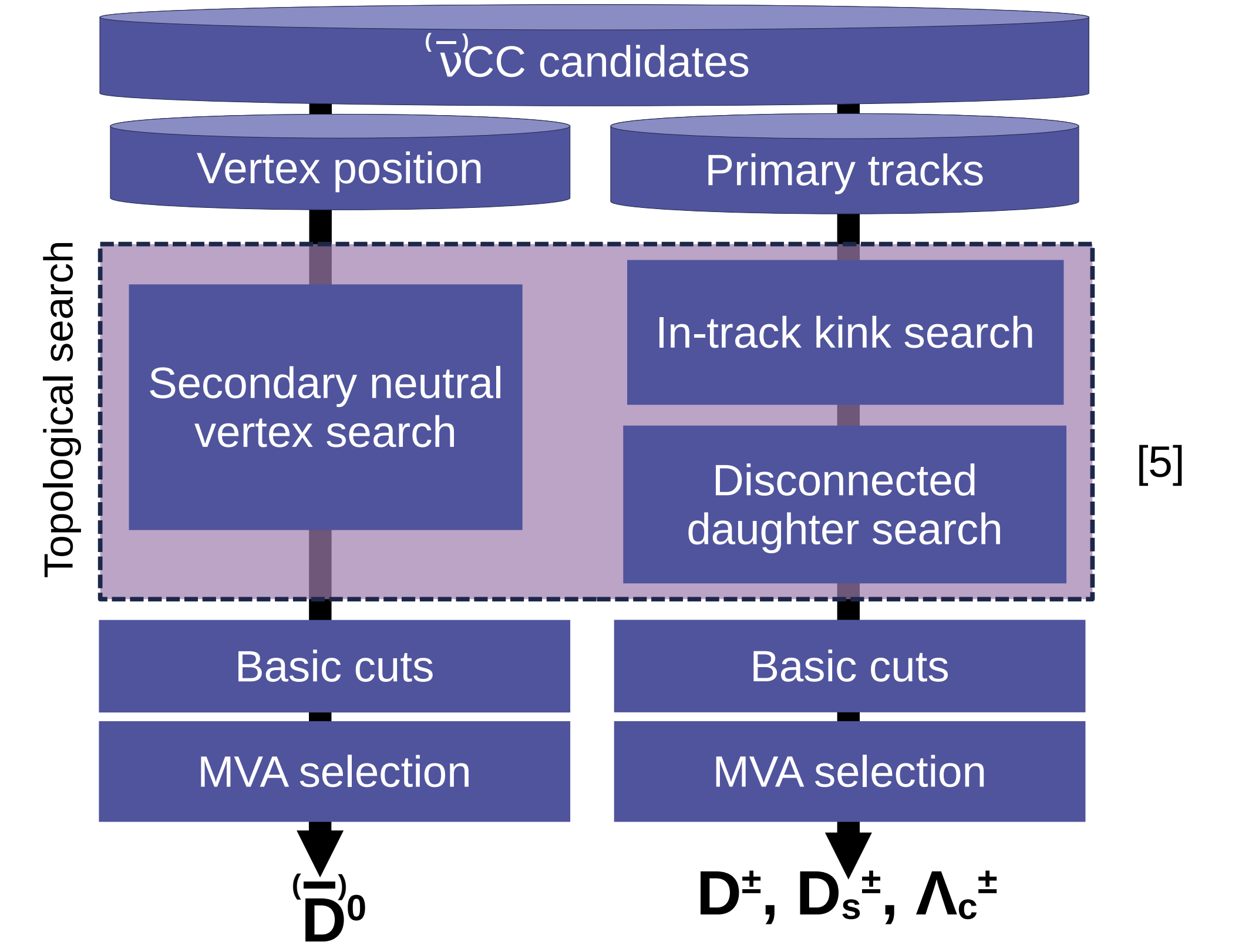
The method, background sources and selection criteria, and the results of this search of charm hadrons are presented. This is an important milestone for short-lived particle searches from neutrino interactions.

Why search for ν +charm?

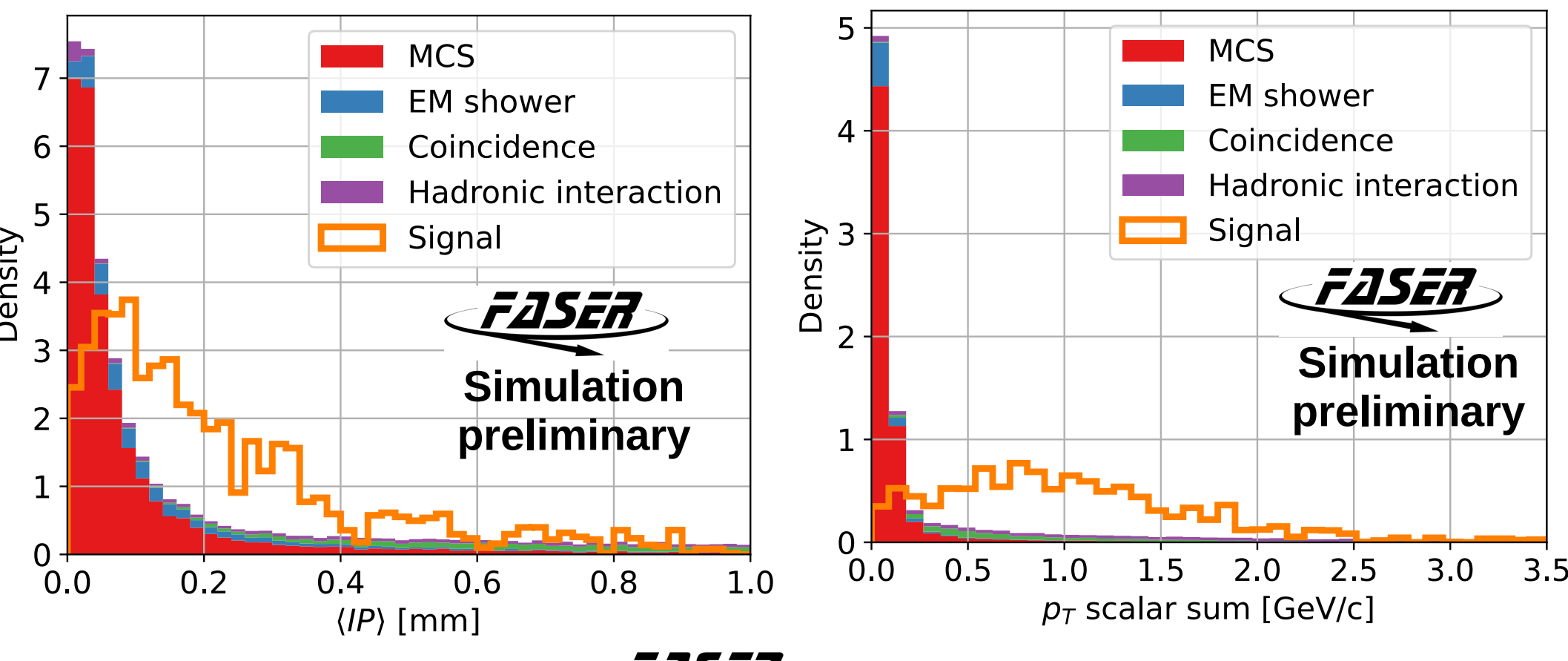
- LHC collider neutrinos have a unique energy range (100 GeV ~ 7 TeV)
- Charm hadron production has never been observed for ν_e interactions** → violation of lepton flavour universality?
- Measurements of strange PDFs → important for HL-LHC, FCC, and perturbative QCD [4]
- Intrinsic charm → is there a charm valence quark in the proton?
- Important proof of concept for ν_τ search → least understood SM particle!



Decay vertex selection



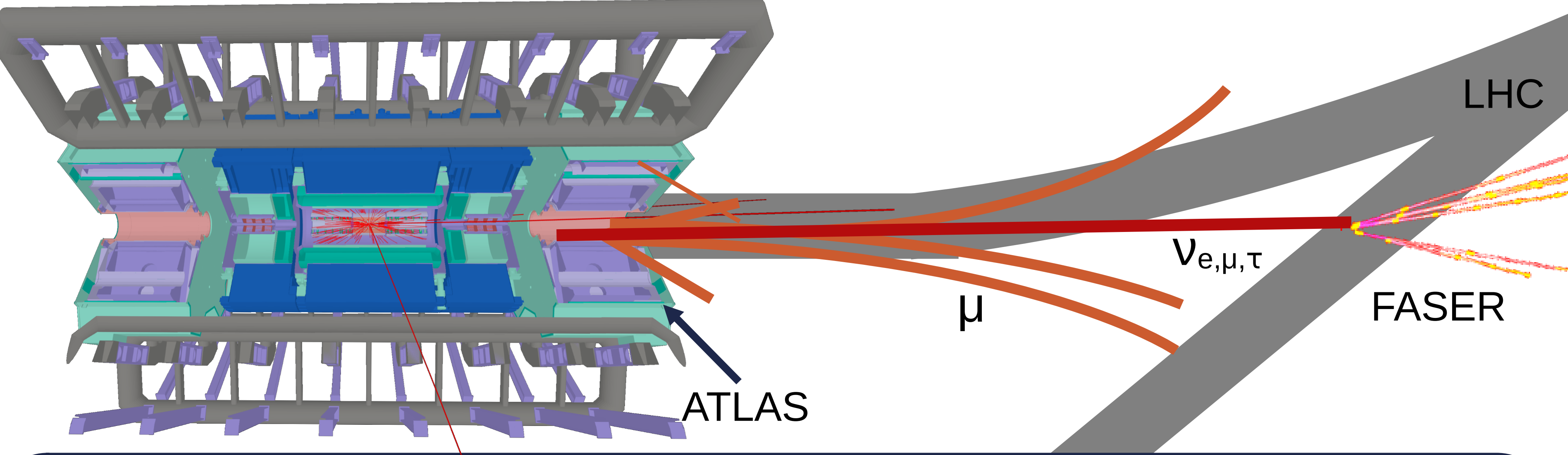
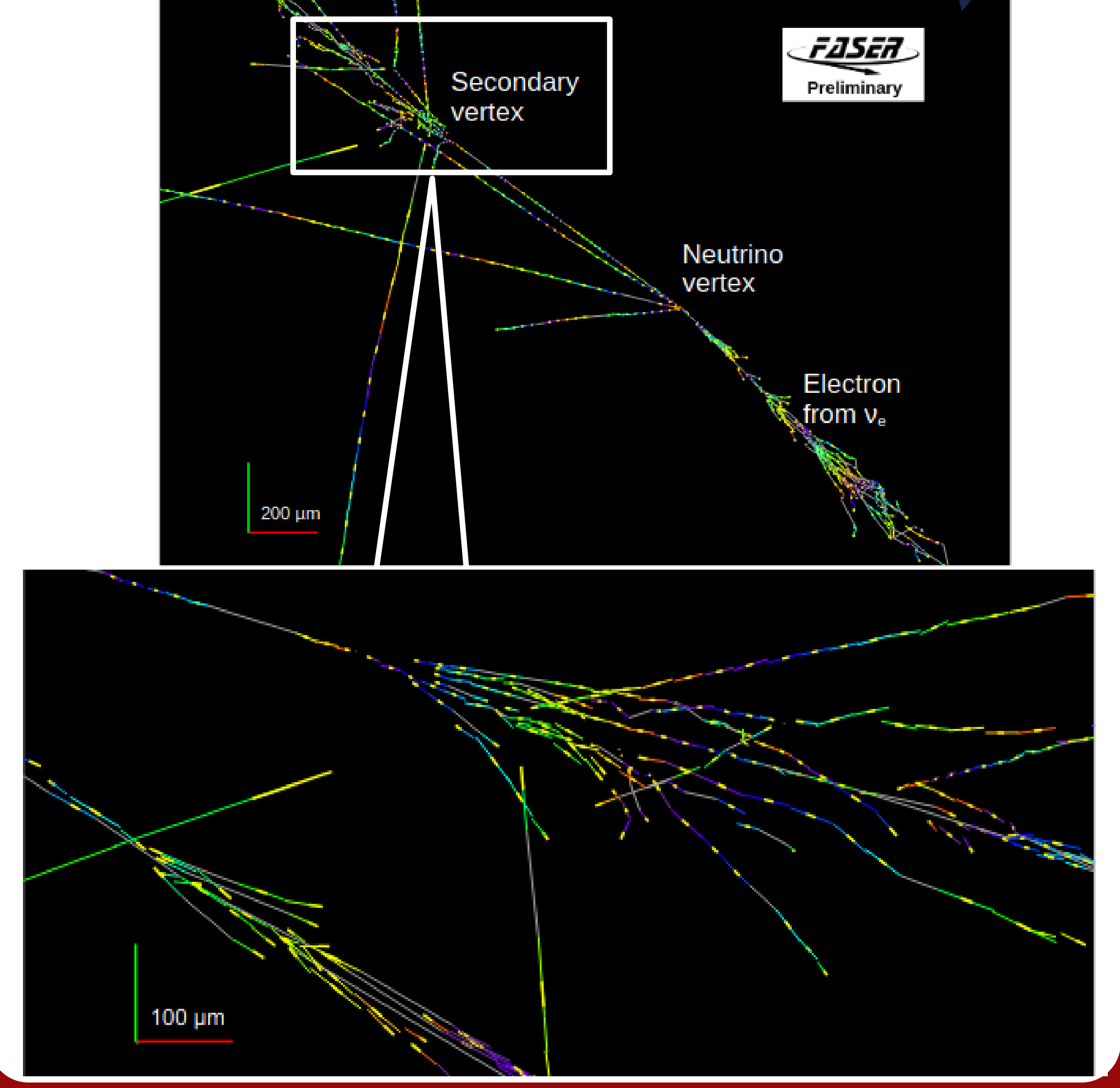
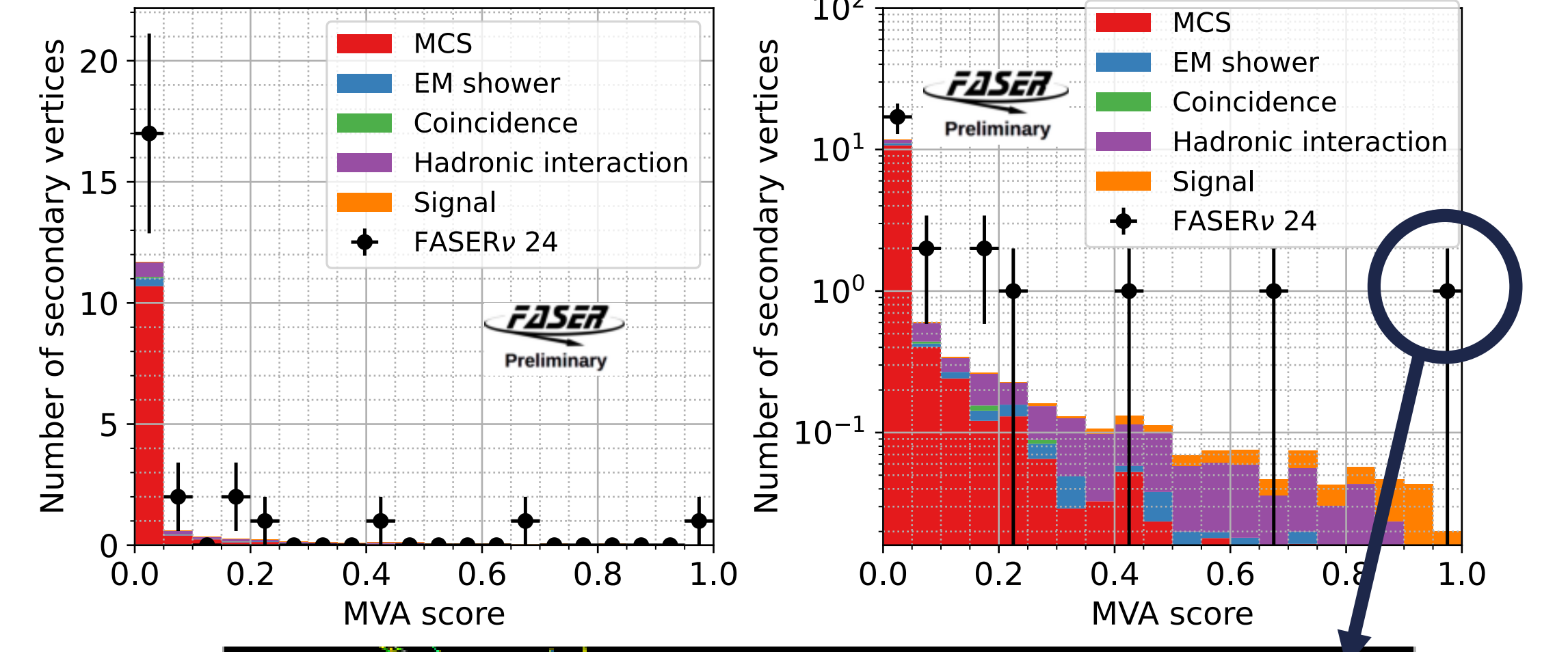
- Focus on **charged charm hadron search** for now
- 1) Search for kinks inside the primary track
- 2) Search for additional disconnected daughter tracks associated with the secondary vertex
- 3) Discriminate signal (charm decay) from background (hadronic interactions, EM showers, fake daughter tracks etc)
- 4) Mitigate modelling uncertainties by calculating Lorentz-invariant physical and kinematical parameters for each secondary vertex:
 - Transverse momentum, impact parameter, corrected mass, flight length / momentum etc.
- 5) Cuts on the physical/kinematical parameters (basic cuts)
 - Reduces background by a factor ~5: **4.9** → **1.1** background secondary vertices / ν_{CC} event
- 6) Classify remaining secondary vertices with an **interpretable machine learning model**



Selection criteria	Fraction of $\bar{\nu}_{CC}$ interactions	MC signal	MC background	Data
ν vertex reconstructed	100%	40	-	-
Charged charm produced (truth)	3.8%	1.5	-	-
Visible charm decay	3.2%	1.3	-	-
Secondary vertex reconstructed	2.5%	0.9	194	234
Basic cuts	2.0%	0.8	43	59

First look at the data

- Partial unblinding of neutrino candidates published in 2024
- Data and MC mostly agree (slightly more secondary vertices in data)
- Charm candidate? → further investigation still needed**

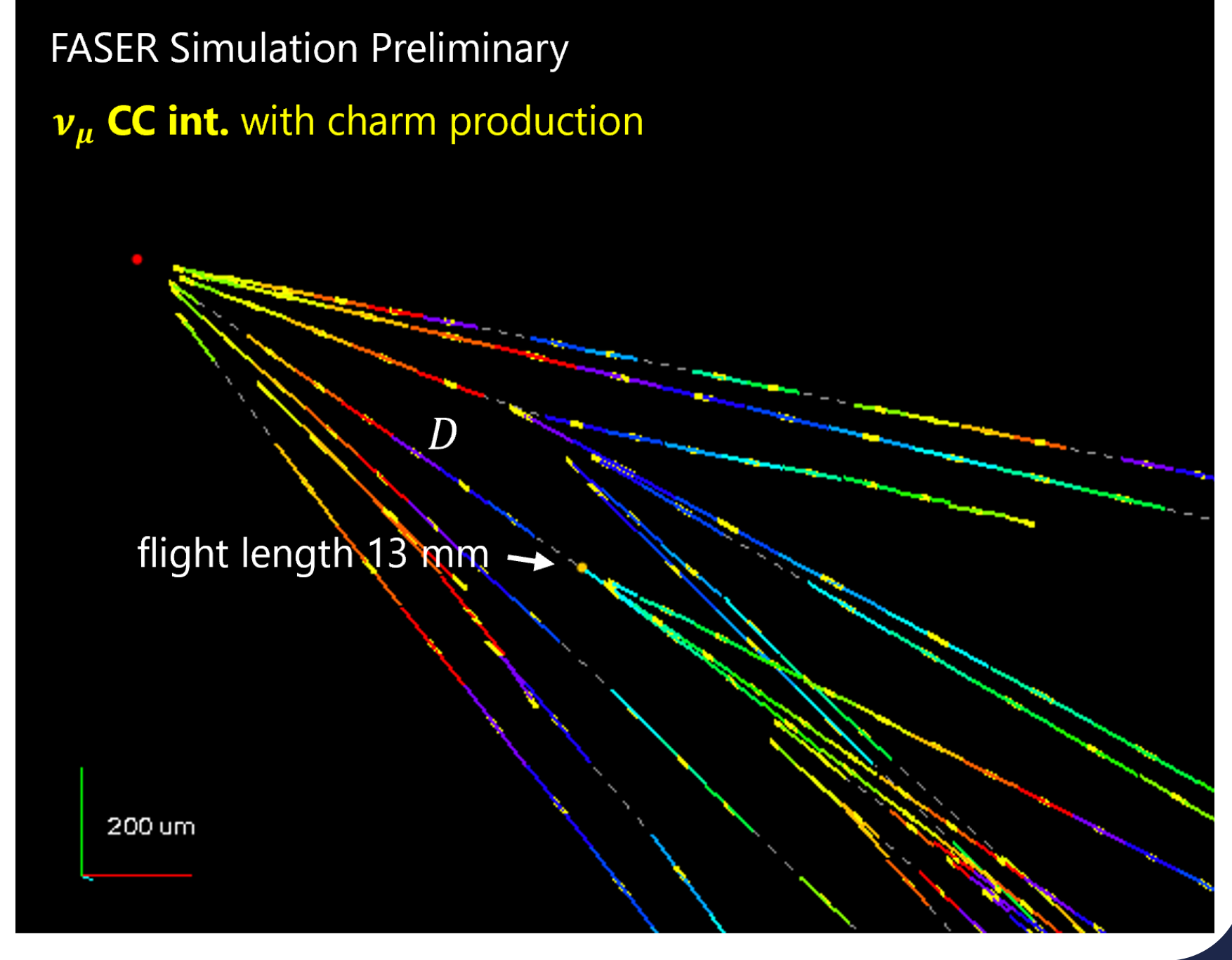
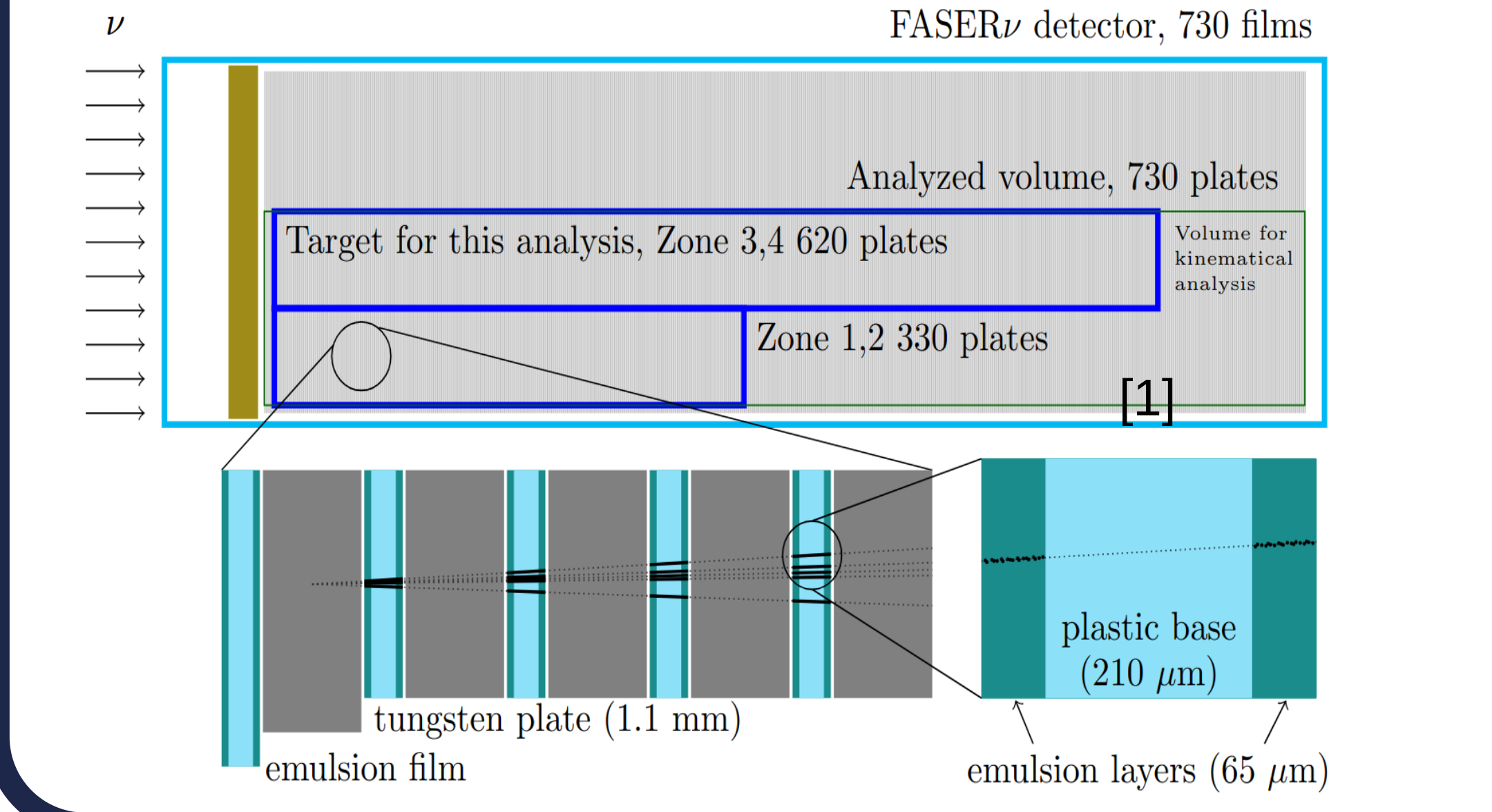


FASER

FASER (ForwArD Search ExpeRiment): located 480 m from the ATLAS collision point aligned with the beam collision axis. Designed to detect neutrinos and feebly interacting particles produced in the forward region [1]. First experiment to observe ν_e and ν_μ produced by a collider [3]

FASERv: subdetector of FASER consisting of interleaved tungsten plates and emulsion films.

- Position resolution: 0.3 μ m, angular resolution: 0.05 mrad [2]
- well-suited for short-lived particle decay searches



What's next?

- Full calculation of systematic uncertainties
- Further refinements to the secondary vertex search and selection
- Publication
- Neutral charm search
- Tau neutrino search

References

[1] Abreu, Hens, et al. "The FASER detector." Journal of Instrumentation 19.05 (2024): P05066.
 [2] FASER Collaboration. "Reconstruction and Performance Evaluation of FASER's Emulsion Detector at the LHC." arXiv preprint arXiv:2504.13008 (2025).
 [3] FASER Collaboration. "First Measurement of ν_e and ν_μ Interaction Cross Sections at the LHC with FASER's Emulsion Detector." Phys. Rev. Lett. 133 no. 2, (2024) 021802, arXiv:2403.12520 [hep-ex]
 [4] Anchordoqui, Luis A., et al. "The Forward Physics Facility at the Large Hadron Collider." arXiv preprint arXiv:2503.19010 (2025).
 [5] FASER Collaboration. "First search for neutrino-induced charm hadrons with FASER's emulsion detector at the LHC." https://cds.cern.ch/record/2956186.