

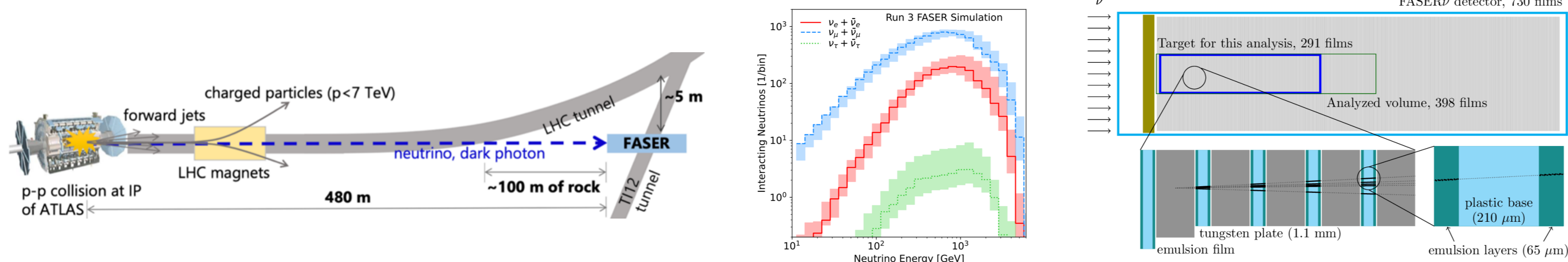
RECENT FASER RESULTS AND DEVELOPMENT OF NEUTRINO ENERGY RECONSTRUCTION FOR THE FASER ν DETECTOR

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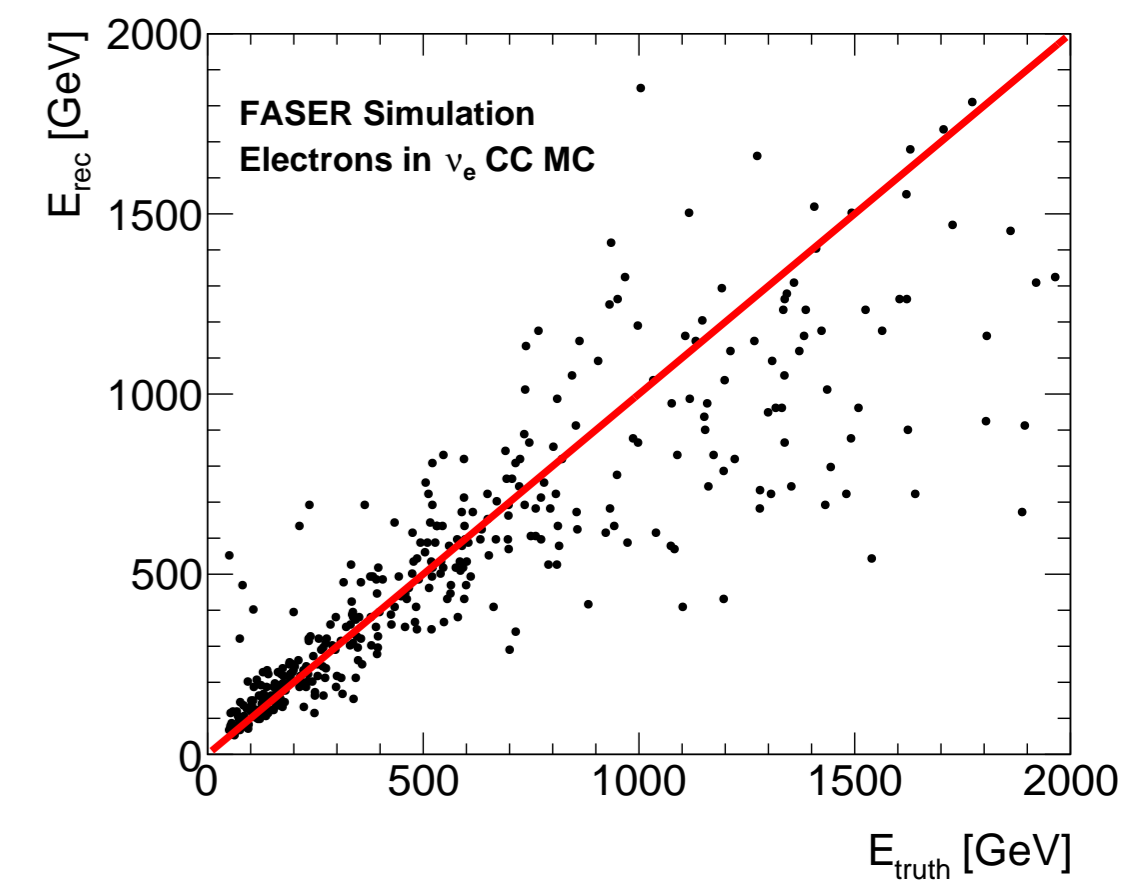
THE FORWARD SEARCH EXPERIMENT

- Goal: to investigate light, long-lived, weakly-interacting particles and TeV-scale neutrinos produced in the far-forward region of collisions at the ATLAS interaction point (IP1) $\sqrt{s} = 13.6$ TeV.
- Searches for BSM physics and studies high-energy neutrinos of all 3 flavours.
- FASER ν detector: 730 interleaved emulsion films and tungsten plates, resulting in a 1.1 tonne target mass.
- Number of expected events for 250 fb^{-1} : $\nu_e \sim 1700$, $\nu_\mu \sim 8500$, $\nu_\tau \sim 30$ (arXiv:2402.13318).



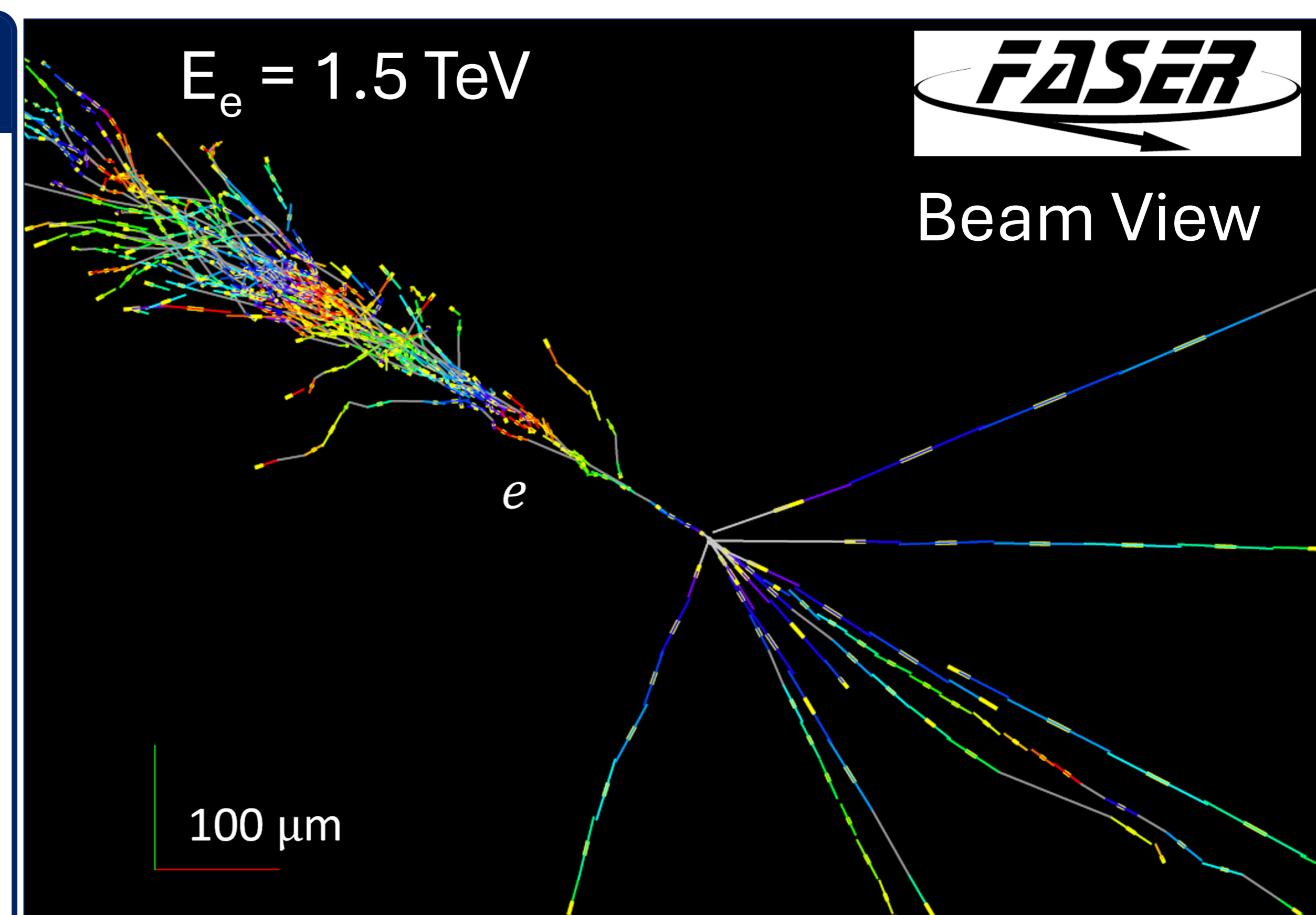
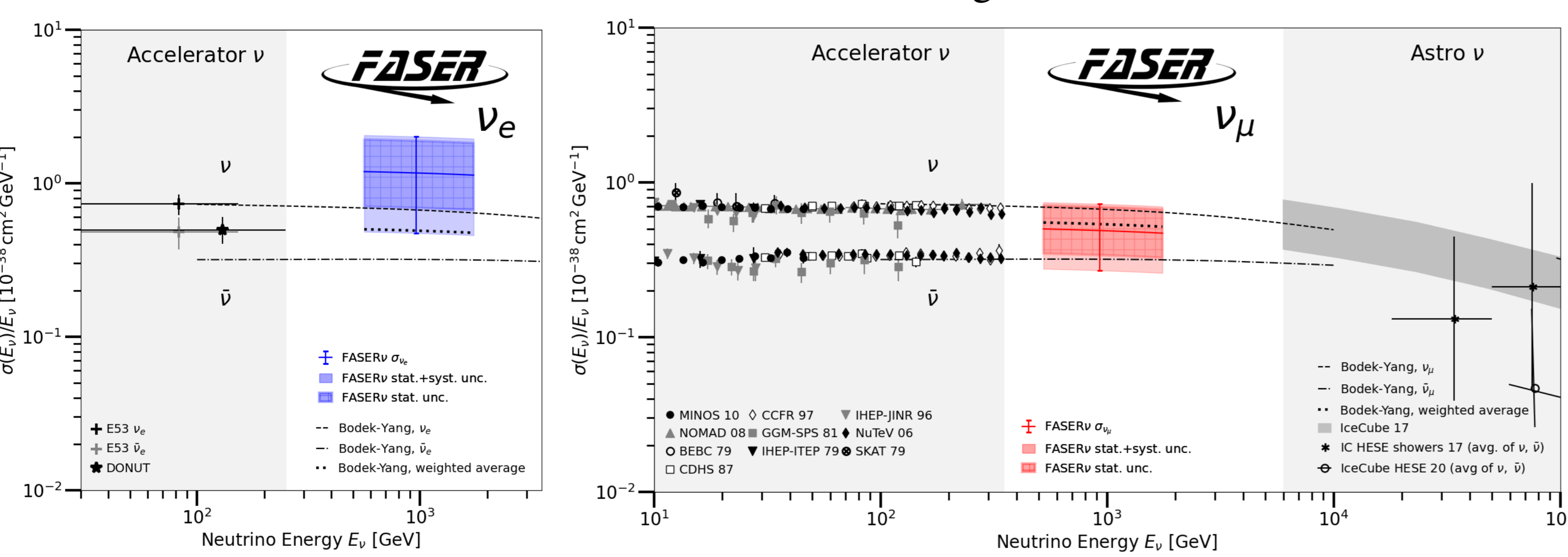
PERFORMANCE AND KINEMATIC MEASUREMENT

- Kinematic and topological variables are used for event ID and measurements: high position and angular resolution required.
- Achieved 300 nm position resolution, resulting in a 0.04 mrad angular resolution for a 1 cm track.
- Momentum measurement from Multiple Coulomb Scattering: $\Delta P/P$ at 200 GeV ~ 0.30 (see poster ID 387 by H. Fujimori).
- EM shower energy found using track multiplicity: $\Delta E/E$ at 200 GeV ~ 0.25 .



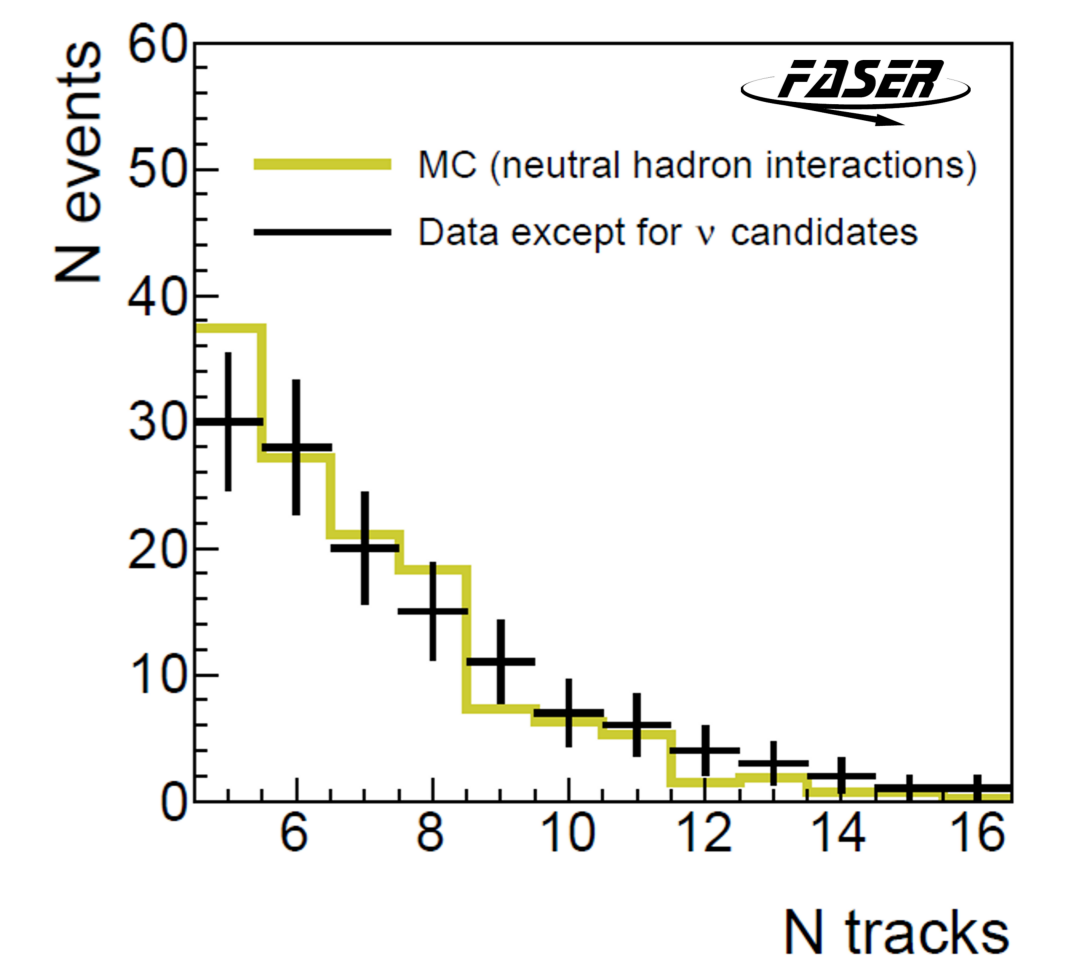
RESULTS FROM FASER ν : ν_μ AND ν_e AT THE LHC

- Dataset: 2nd 2022 module sub-volume: target mass = 128.6 kg, equivalent to 9.5 fb^{-1} , $\sim 1.7\%$ of the data collected to date.
- Selection criteria:
 - Vertex reconstruction: $N_{\text{charged}} \geq 5$; $N_{\tan\theta \leq 0.1} \geq 4$.
 - Lepton requirements: E_e or $p_\mu > 200$ GeV; $\tan\theta_e$ or $\tan\theta_\mu > 0.005$.
 - Back-to-back topology: $\Delta\phi > 90^\circ$.
- First observation of ν_e at the LHC - highest ν_e energy ever observed (arXiv:2403.12520).
- 4 ν_e and 8 ν_μ CC events were observed, corresponding to a significance of 5.2σ and 5.7σ respectively.
- First neutrino cross-section measurement in the TeV range.



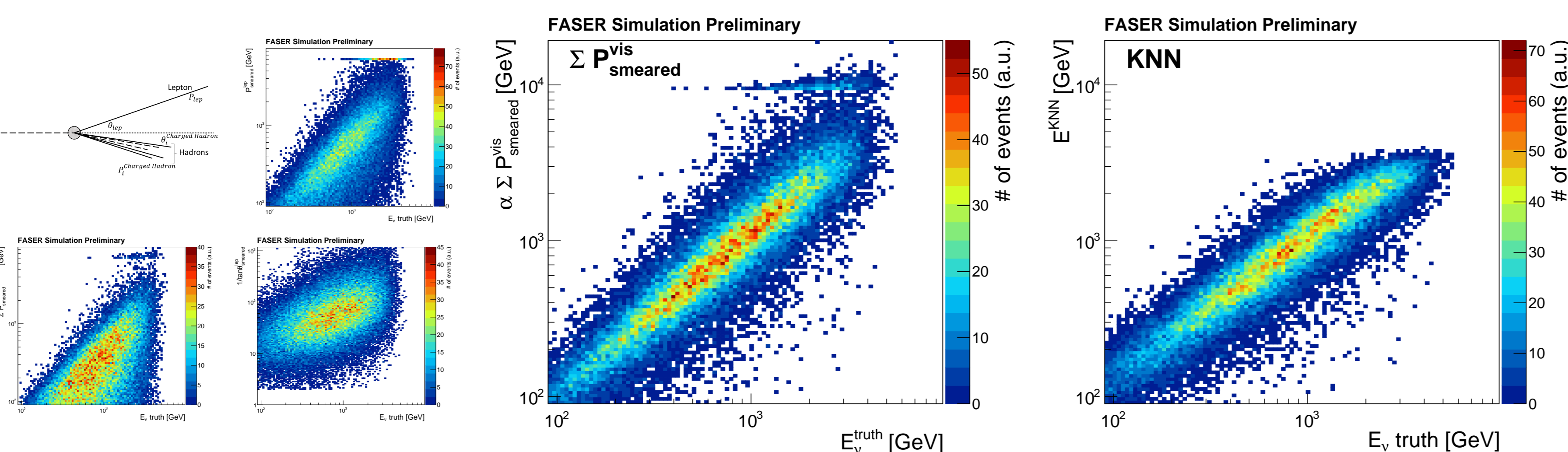
NEUTRAL HADRON STUDY

- Detected neutral vertices before high-energy lepton selection are dominated by neutral hadron interactions (K_S , K_L , n , \bar{n} , Λ , $\bar{\Lambda}$ interactions).
- Validation study: interactions occurring in 150 tungsten plates \rightarrow target mass = 68.2 kg.
- Expectation: 246 vertices.
- Data: 139 vertices detected \rightarrow lies within 50% uncertainty.



DEVELOPMENT OF NEUTRINO ENERGY RECONSTRUCTION

- To improve further cross-section measurements, neutrino energy reconstruction is needed.
- Dataset: truth level FASER GENIE simulation with smearing to emulate the effect of Multiple Coulomb Scattering in 100 emulsion films and tungsten plates.
- First estimate: sum of momenta of all charged particles, ΣP_{vis} , scaled by a factor $\langle\alpha\rangle \approx 1.35$, found by averaging $E_\nu^{truth} / \Sigma P_{vis}$ across all events.
- Two Multivariate Analysis techniques tested using ROOT TMVA: Boosted Decision Tree (BDT) and k-Nearest Neighbour (KNN), using $P_{smeared}^{lep}$, $\Sigma P_{smeared}^{ChargedHadrons}$ and $1/\tan\theta_{smeared}^{lep}$ as input variables.
- Energy resolution found in the 100 GeV - 1 TeV range as the *r.m.s.* ($\frac{E_{reco} - E_\nu^{truth}}{E_\nu^{truth}}$) for all methods.
- Application of ROOT TMVA methods improves resolution across the range to ~ 0.4 .



FASER Simulation Preliminary

