

Updated results for collider neutrino observations with the FASERν detector



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Abstract

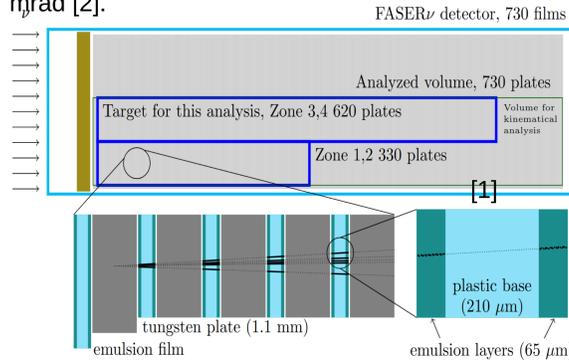
In 2024, the first neutrino candidates from FASERν were presented, including the first ever observation of collider electron neutrinos and cross section measurements at the TeV energy scale. These results were obtained by analyzing data from the second FASERν module that was used for data-taking in 2022, which was exposed to 9.5/fb of proton-proton collisions at a center-of-mass energy of 13.6 TeV. A subset of this module was analyzed, corresponding to a target mass of 128 kg. Updated statistics were presented in March 2025, with an approximately 2.5 times larger target volume. These updated results are presented here.

Prospects for upcoming analyses, specifically finding neutrino candidates in modules with higher track density, and searching for associated charm hadron production from neutrino interactions, are also discussed.

Detector

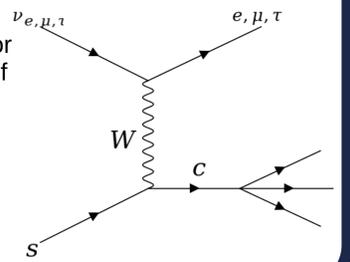
FASER (ForWard Search ExpeRiment) is located 480 m from the ATLAS collision point aligned with the beam collision axis. It is designed to detect neutrinos and feebly interacting particles produced in the forward region [1].

FASERν (target mass: 1.1 tonnes) is a subdetector of FASER consisting of interleaved tungsten plates and emulsion films. The tracks have a position resolution of 0.3 μm and angular resolution of 0.05 mrad [2].

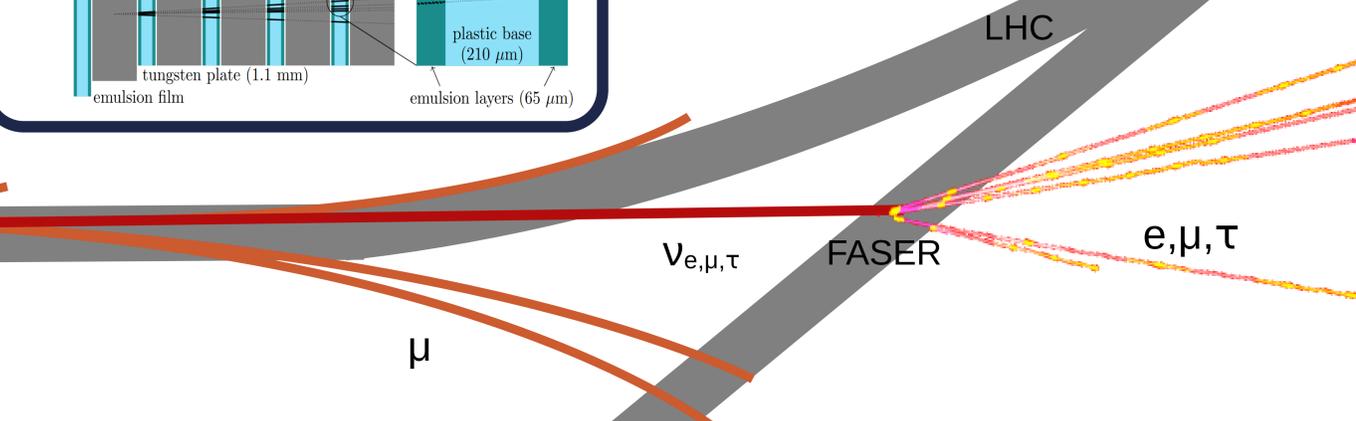
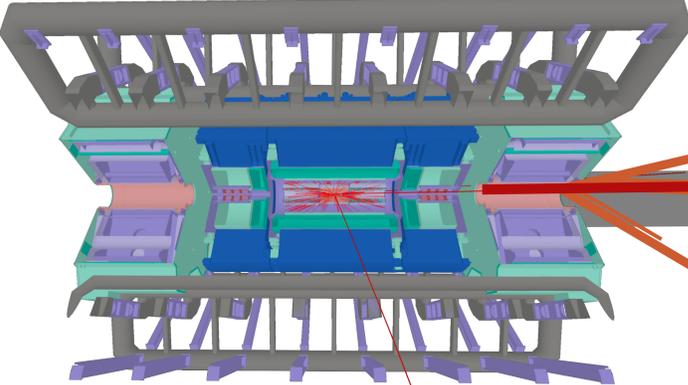


Physics targets

- Can study tau neutrinos and anti-tau neutrinos → least studied Standard Model particle
- LHC collider neutrinos have a unique energy range (100 GeV ~ 7 TeV)
- Charm hadron production from neutrino interactions (~10% of all ν charged current interactions)
- Charm hadron production has never been observed for ν_e interactions → violation of lepton flavour universality?
- Measurements of strange PDFs → important for HL-LHC and FCC [3]
- Intrinsic charm



ATLAS

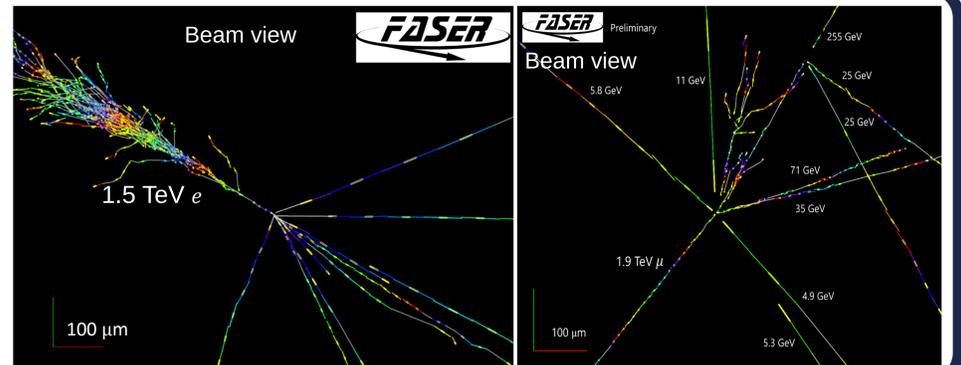


Finding ν in FASERν

- Can measure momentum of tracks using multiple Coulomb scattering, and energy of EM showers using the size of the shower ($\Delta E/E \approx 20\text{--}30\%$)
- Search for neutral vertices with [4]
 - At least five tracks
 - An associated high-momentum long track (μ) or EM shower (e)
- Back-to-back topology between the lepton and the other tracks coming from the neutral vertex

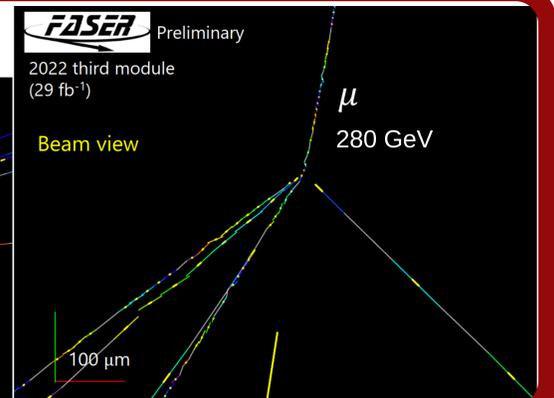
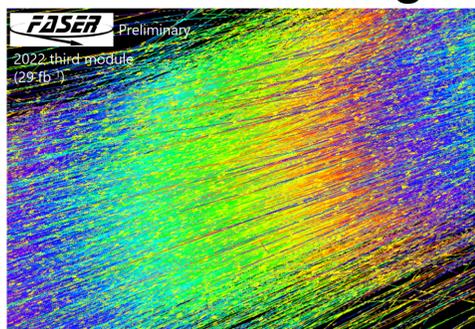
ν observations

- Analyzed roughly 1/2 of the second module from 2022 (F222)
- **25 ν observations** [5]
 - → 20 ν_μ, 5 ν_e CC
 - Highest energy ν_e ever observed
 - ν_μ with 1.9 TeV momentum



Analysis of FASERν module with higher track density

- Successful track reconstruction of the third FASERν module from 2022
- **3x higher track density** compared to F222 (29 fb⁻¹ vs 9.5 fb⁻¹)
- Track density: ~800 000 tracks / cm²
- Muon neutrino candidate found
- Demonstrates that emulsion can be used to take large quantities of data, potentially more than 30 fb⁻¹ per module



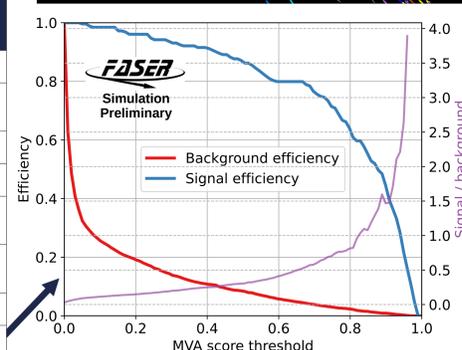
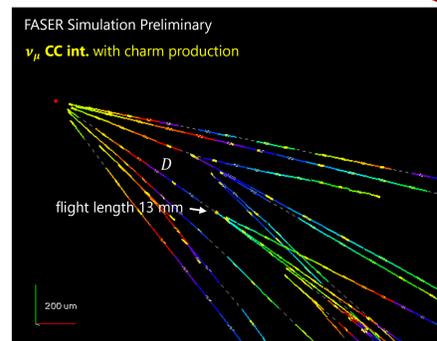
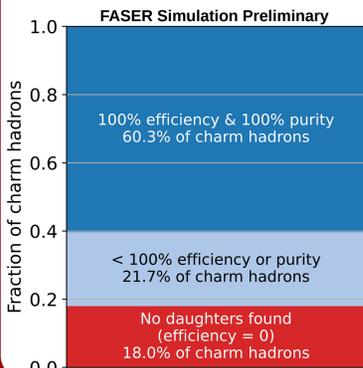
Charged charm search

Charm hadrons have short lifetimes

- To find charged charm hadrons ($D^\pm, D_s^\pm, \Lambda_c^\pm$), search for secondary vertices among the primary tracks from νCC interactions
- To find neutral charm (D^0), search for neutral secondary vertices close to the νCC vertex (not shown here, still under development)
- Discriminate background secondary vertices (mainly secondary interactions of hadrons) from signal (charm decay)

Preliminary results using MC

Selection criteria	Fraction of νCC interactions	Expected signal in F222 (prel.)	Expected background in F222 (prel.)
ν vertex reconstructed	100%	66	-
Charged charm produced (truth)	4.1%	2.7	-
Visible charm track	3.7%	2.5	-
Visible daughter track	3.4%	2.3	-
Charm track among primaries found by vertexing	3.3%	2.2	-
Secondary vertex reconstructed	2.7%	1.8	385
Physical parameter cuts	2.2%	1.4	49
MVA cut	1.6%	0.9	0.8



Outlook

- Analyze the rest of the F222 module (ongoing using automated tools)
- Continue development of neutral charm (D^0) search
- Additional improvements to charged charm search
- Unblinding + analysis of real data

References

- [1] Abreu, Hens, et al. "The FASER detector." *Journal of Instrumentation* 19.05 (2024): P05066.
- [2] Abraham, Roshan Mammen, et al. "Reconstruction and Performance Evaluation of FASER's Emulsion Detector at the LHC." *arXiv preprint arXiv:2504.13008* (2025).
- [3] Anchordoqui, Luis A., et al. "The Forward Physics Facility at the Large Hadron Collider." *arXiv preprint arXiv:2503.19010* (2025).
- [4] Collaboration, FASER, et al. "First Measurement of the $\nu_e e$ and $\nu_e \mu$ Interaction Cross Sections at the LHC with FASER's Emulsion Detector." *Physical Review Letters*, vol. 133, no. 2, July 2024, p. 021802. *arXiv.org*, <https://doi.org/10.1103/PhysRevLett.133.021802>.
- [5] Ariga, Akitaka, and Tomoko Ariga. Updated results of high-energy electron and muon neutrino interactions with FASER's emulsion detector at the LHC. No. CERN-FASER-CONF-2025-002. 2025.