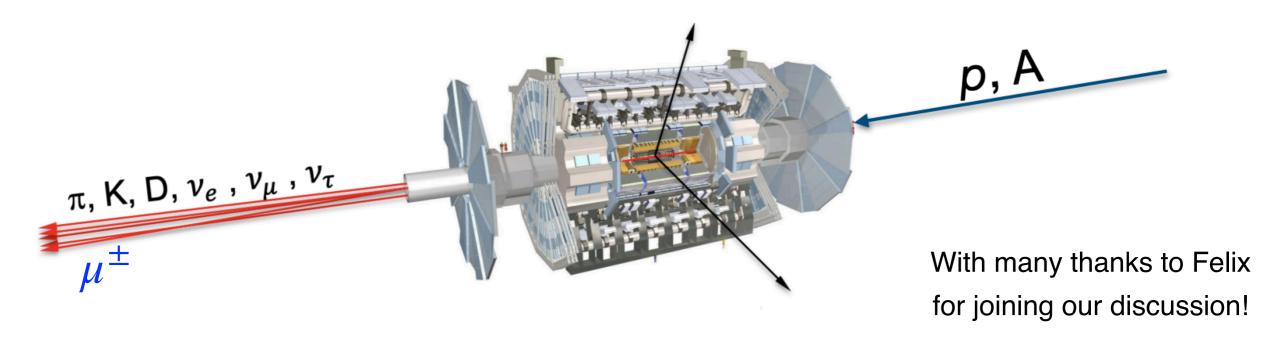




Kick-off meeting of the Nikhef FASER group

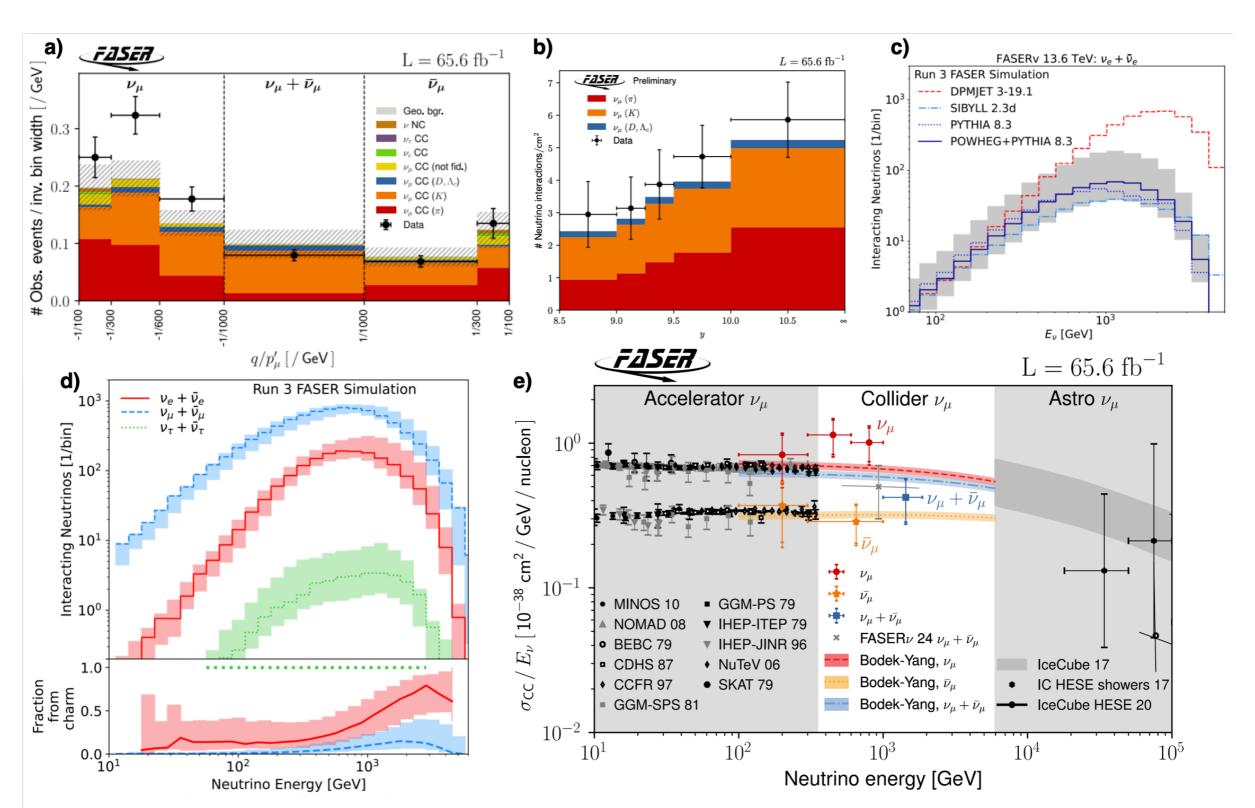
Lydia Brenner & Juan Rojo



9th October 2025

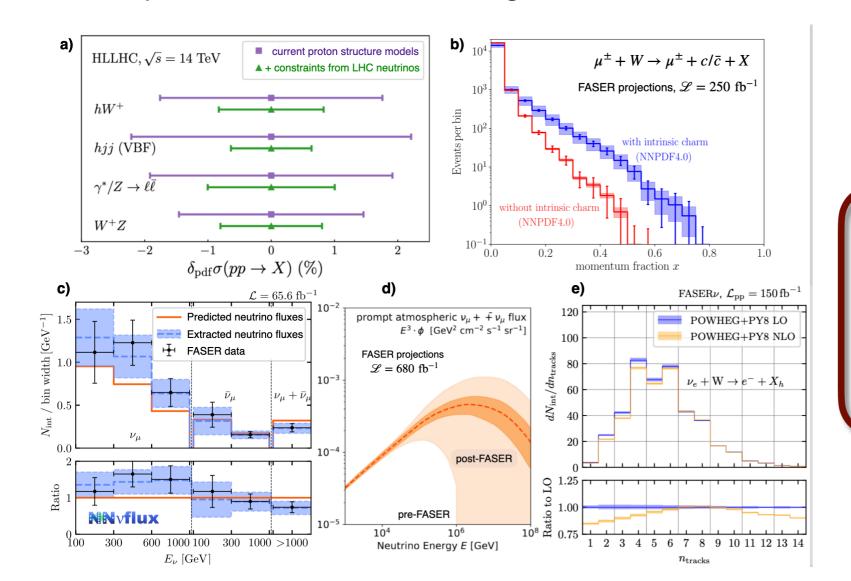
Overview of FASER neutrino analyses

- Flux measurements differential in energy and rapidity from electronic detector
- Cross-section measurements differential in energy from electronic and emulsion detectors



State of the art

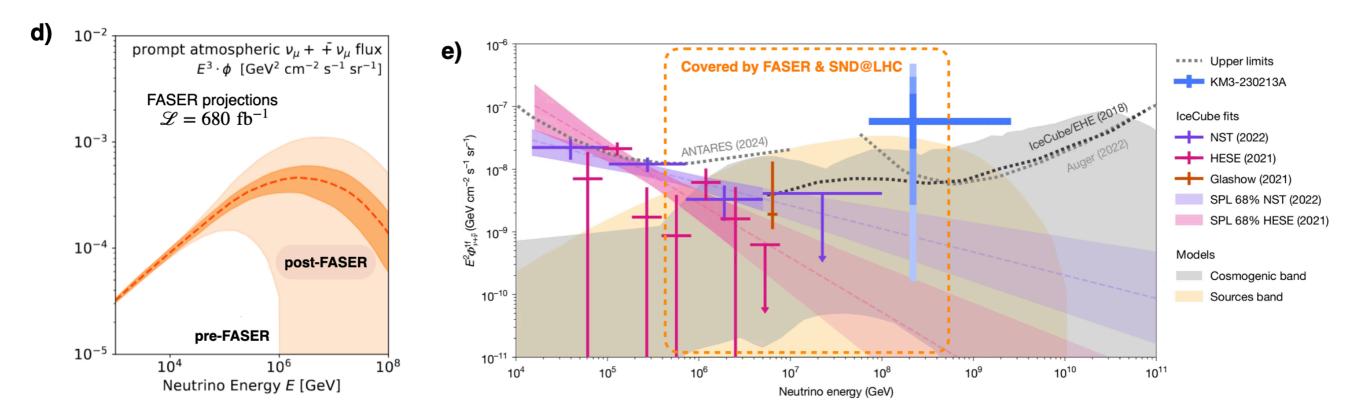
- Several results from the group and other colleagues provide the foundations for the next steps
- Demonstrated impact of muon and neutrino DIS for proton structure studies but now the measurements and the corresponding interpretation need to be carried out
- Demonstrated potential of flux measurements to constrain small-x QCD, proton structure, and MC generators: now apply to high-stats measurements with the electronic and emulsion detectors
- Developed a NLO+LL Monte Carlo generator tailored to muon and neutrino DIS at FASER



Challenge now is moving from projections to actual interpretations of FASER data based on global analyses

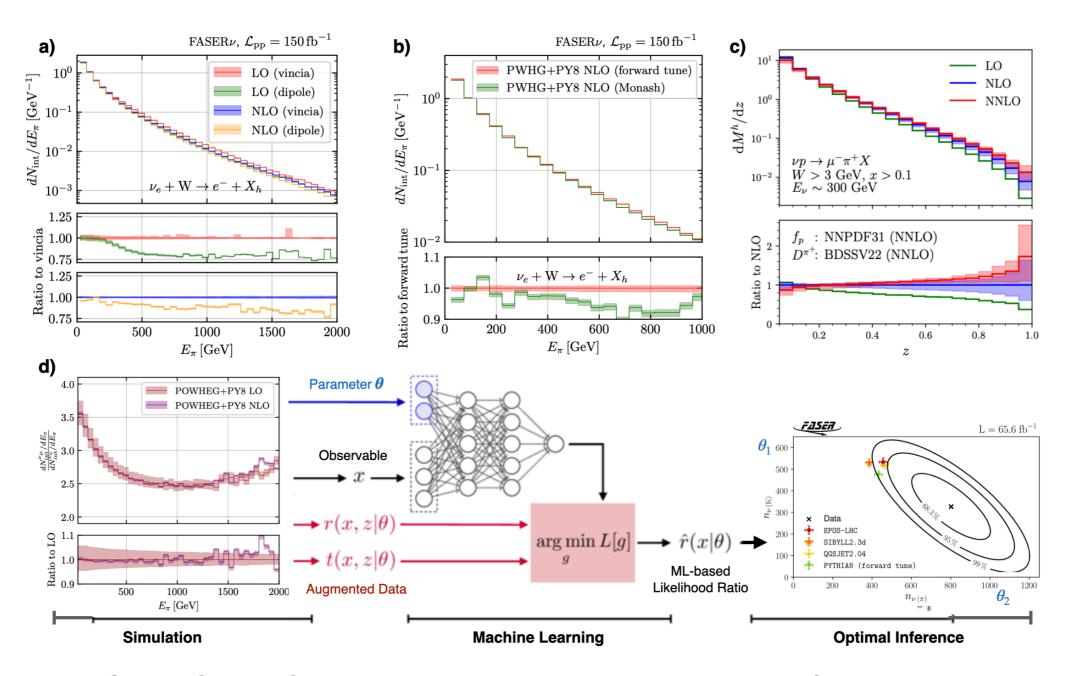
The Neutrino Telescope connection

Fig. 18 It is also high time to study implications of FASER for UHE neutrino telescope measurements



- Study implications of POWHEG simulations for UHE neutrino DIS up to 100 PeV, compare with simulation tools adopted by KM3NET and IceCube
- Revisit calculation of the prompt neutrino fluxes at the light of FASER, study implications for neutrino telescopes
- Need close collaboration with experimental colleagues in the interpretation of the FASER data

Progress in DIS modelling



- Integrate POWHEG in FASER pipeline, systematic benchmark with GENIE and other generators
- Benchmark with NNLO analytical calculations of SIDIS, study FASER potential to constrain light and heavy fragmentation functions
- Design detector-level multivariate observables at FASER with NSBI to achieve optimal sensitivity

List of possible projects (random order)

- Contribute to muon DIS measurement (simulations, theory interpretation, guidance)
- Ditto for neutrino DIS (goal: first measurement of neutrino structure functions at TeV energies)
- POWHEG simulations of final states with 100 PeV neutrinos
- Revisiting prompt neutrino flux calculations at the light of what FASER can provide
- ML-based observables at FASER for optimal sensitivity
- Benchmark POWHEG with GENIE and other MC DIS generators
- Secondary Power Power with NNLO SIDIS, quantify potential to constrain fragmentation functions
- Include muon and neutrino DIS data into NNPDF fits, study implications for HL-LHC
- Study in more detail the potential of muon DIS for PDF constraints, including to break down possible degeneracies with new physics signals
- Improve our modelling of systematic uncertainties in our projections
- Better generators of forward charm production (with charm in initial state, eventually move to NNLO)
- Consider the constraints also from SND@LHC
- Extend our NNnuFlux determination to the case of double differential (E,rapidity) measurements

To discuss today

- List possible projects, try to prioritise, distribute person power
- Align our theory-based activities with the priorities of FASER and its timeline to release new data
- Discuss what will be we doing as stand-alone theory activities and what will we be doing as members of the FASER collaboration
- Schedule for next meetings

WP1: A Data-Driven Extraction of the LHC Neutrino Fluxes

- Determination of the energy, rapidity, flavour, and parent hadron dependence of LHC neutrino fluxes
- Stress-testing QCD forward hadronic models
- Integrate constraints from FASER (on-axis, electronic & emission detectors) and SND@LHC (off-axis)

WP2: High-Resolution Probes of Small-x QCD with Forward Charm Production

- ₱ Differential charm production from neutrino fluxes
- Search for novel small-x phenomena through state-ofthe-art QCD calculations
- Laboratory-based validation of prompt flux predictions for neutrino telescopes

WP3: Proton Structure Boosted by LHC Neutrino and Muon Scattering Data

- Neutrino & muon DIS structure functions at LHC energies and integration in global PDF fits
- Theoretical predictions for Higgs and electroweak processes at the HL-LHC
- PDFs tailored to high-energy New Physics searches

WP4: Event Generation Neutrino DIS & Optimal Observables at FASER

- Precise Monte Carlo event generation for LHC neutrino DIS tuned to FASER & SND@LHC
- Neural Density Learning for optimal sensitivity
- PDF fits with unbinned detector-level FASER data