WG2: Forward Charm Production

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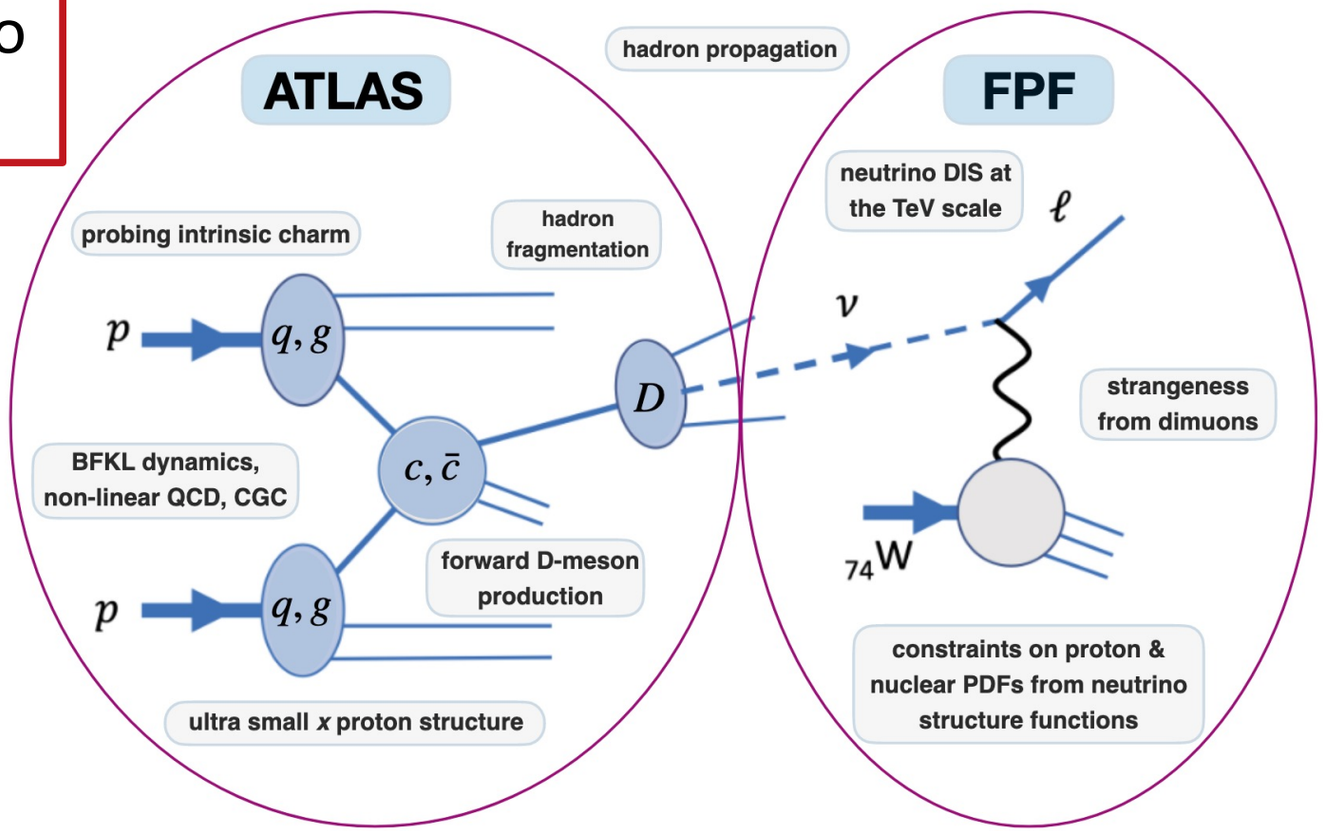
5th Forward Physics Facility Meeting

16 November 2022

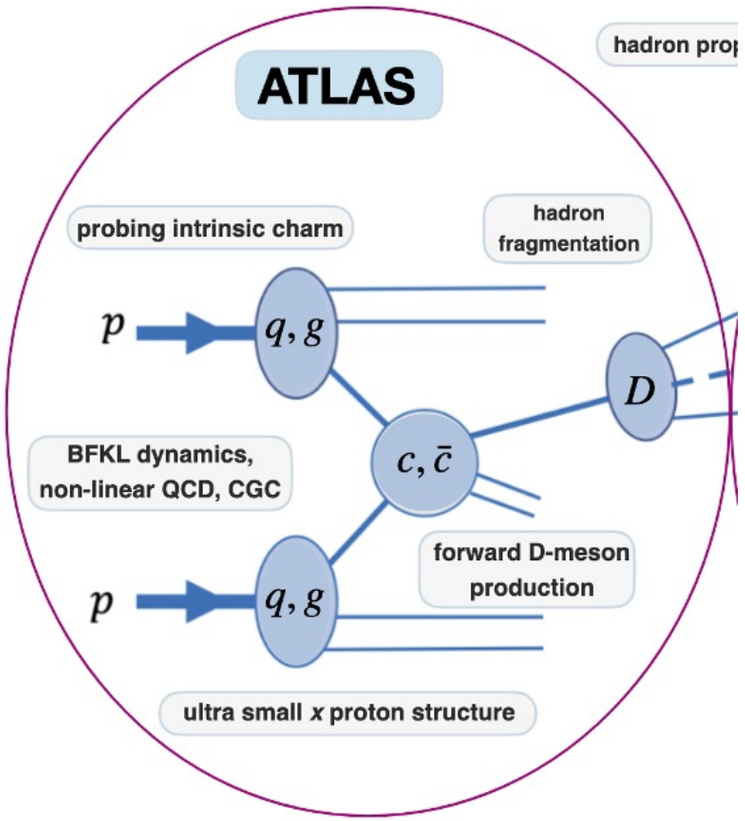
QCD in pp and νA collisions

1. Neutrino fluxes



2. Standard model neutrino interactions on nuclear targets

WG2 science



All things forward charm:

- prompt neutrino fluxes
- PDFs as they pertain to neutrino production through charm production and decay
- small-x gluons, BFKL/saturation
- potential links to prompt atmospheric neutrinos

Closely related to WG1

WG2 goals include

- Move to quantitative assessment with neutrino measurements (WG1), produce sets of FPF neutrino fluxes with different theory inputs (handling of small x, intrinsic charm, etc).
  - *Compare different predictions of neutrino fluxes from forward charm and unpack where the differences arise: production of charm, fragmentation, decay.*
- Project how measurements of other experiments could impact predictions of neutrino fluxes at the FPF.
- Articulate further the physics potential associated with measurements of FPF neutrino fluxes.

First examples: LHCb charm production @ 13 TeV and neutrino fluxes at FLArE

https://github.com/KlingFelix/ForwardCharm

- charm hadron distributions in pT and y from different groups/sources
- charm decays in rest frame using Pythia8 – all the same decays
- boost back to collider frame, pick neutrinos passing through detector cross section

Hadronic interaction models: Sibyll 2.3d, DPMJET 3.2019, Pythia 8, Pythia 8-BLC (string formation beyond leading color)-*Felix Kling*

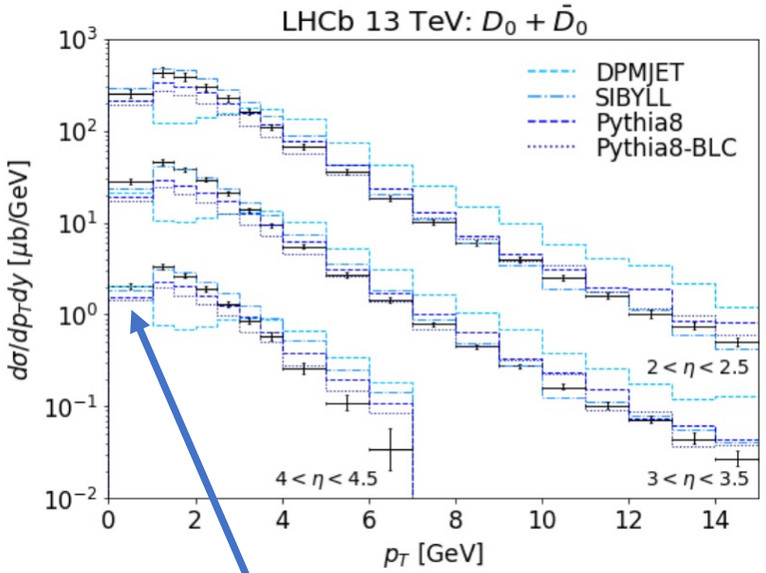
MC generators @LO: Pythia 8, Pythia 8-BLC, Herwig 7 – *Peter Reimitz*

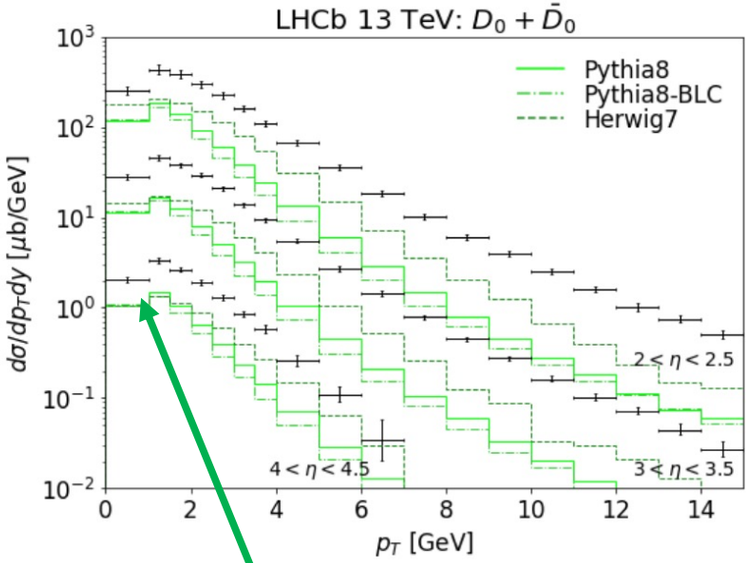
kt factorization with and without gluon saturation, with 2 fragmentation schemes (Peterson and BLC) – *Stasto, Bhattacharya, Kling, Sarcevic (in preparation)*

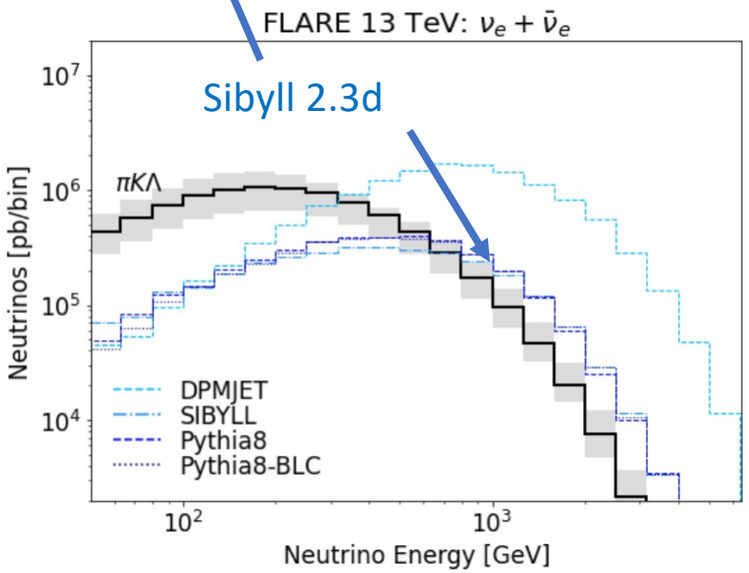
kt factorization with MRW unintegrated gluon uPDFs, hybrid, hybrid with KS-linear uPDFs, plus intrinsic charm,recombination – Maciula, Szczurek (arXiv2210.08890)

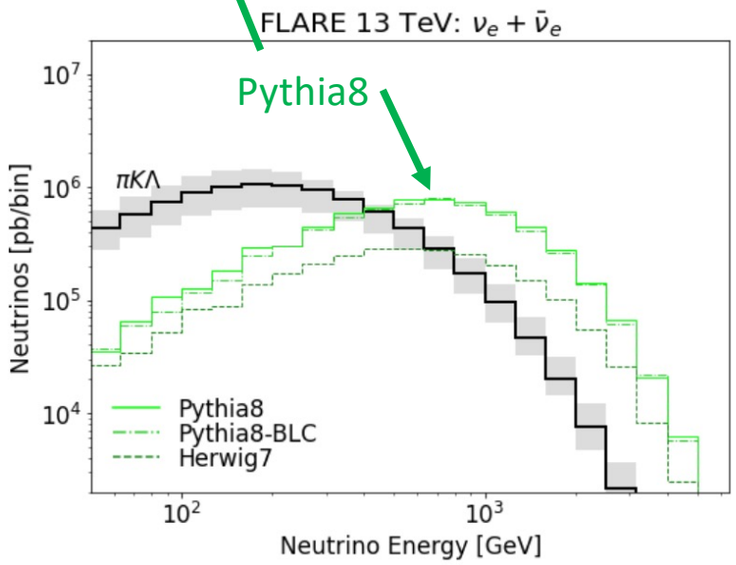
NLO collinear factorization, with 2 fragmentation schemes -- *Stasto, Bhattacharya, Kling, Sarcevic (in preparation)*

NLO collinear factorization, with kT smearing – *Jeong, Bai, Reno (similar to Bai, Diwan, Garzelli et al, 2112.11605,2203.07212)* also Keping Xie, et al.









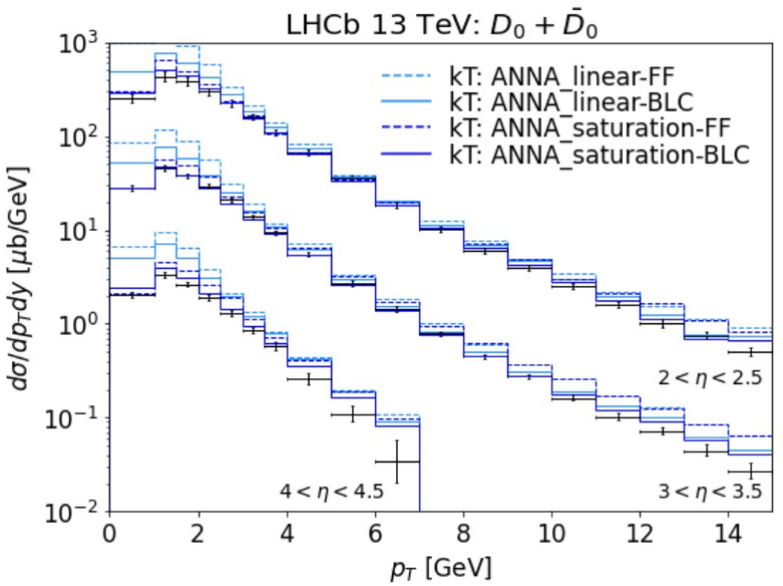
Monte Carlos

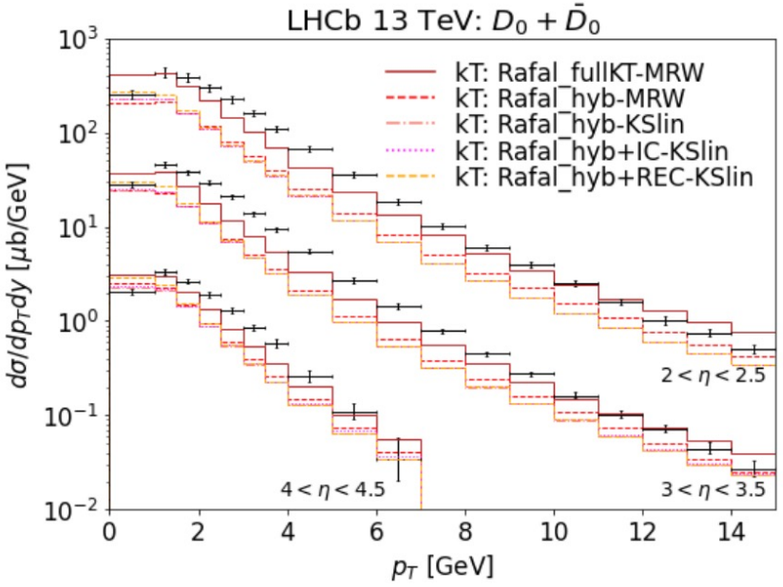
D^0 mesons

Except for Sibyl 2.3d, not tuned for charm production.
Green - LO

Electron neutrinos they produce.

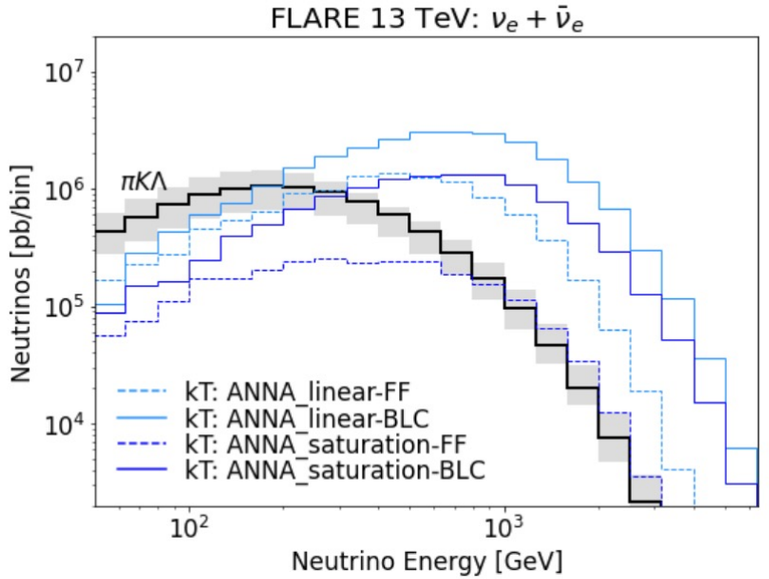
Pythia8 low for LHCb, high for neutrinos at FLArE.

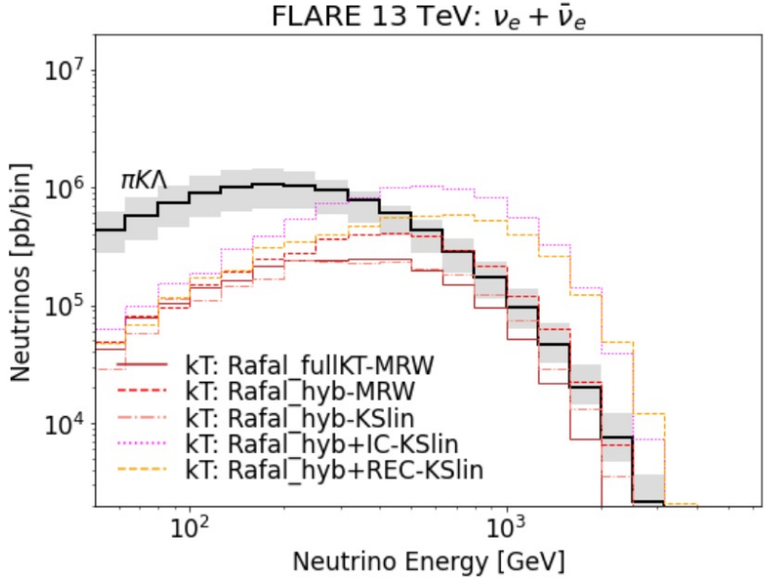




kT factorization

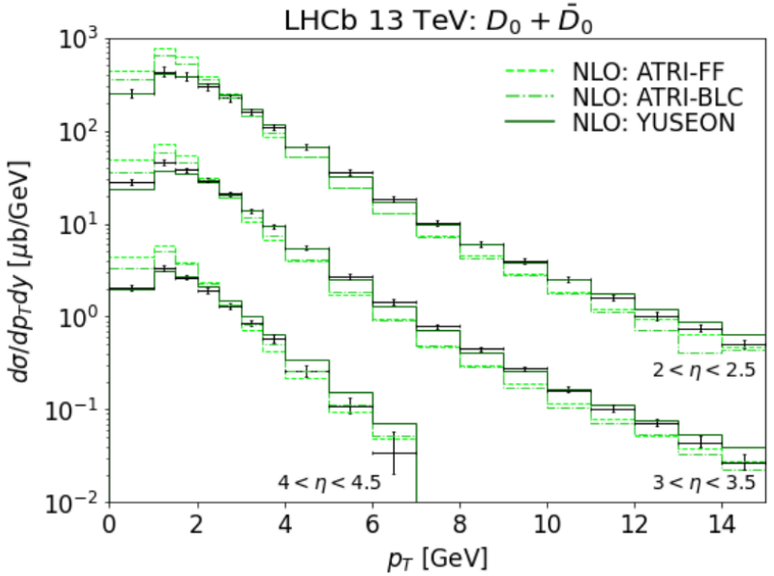
D^0 mesons





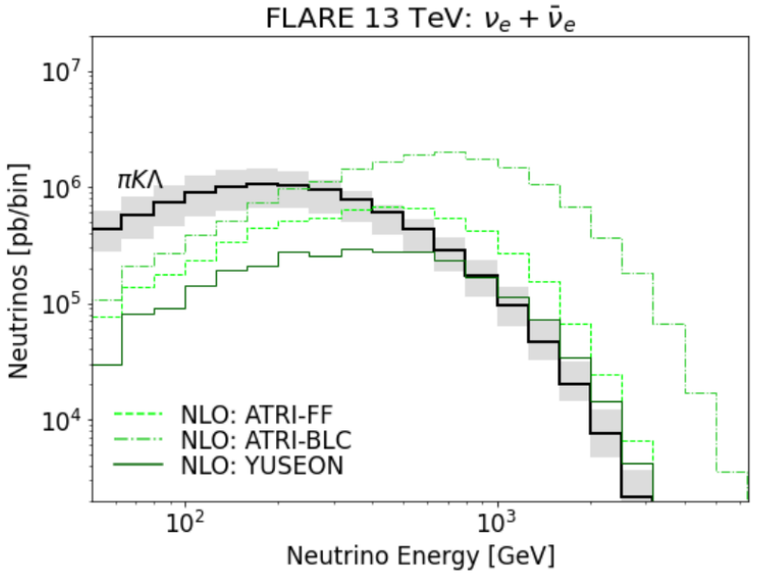
Electron neutrinos they produce.

Range of predictions for kT factorization, many moving parts.



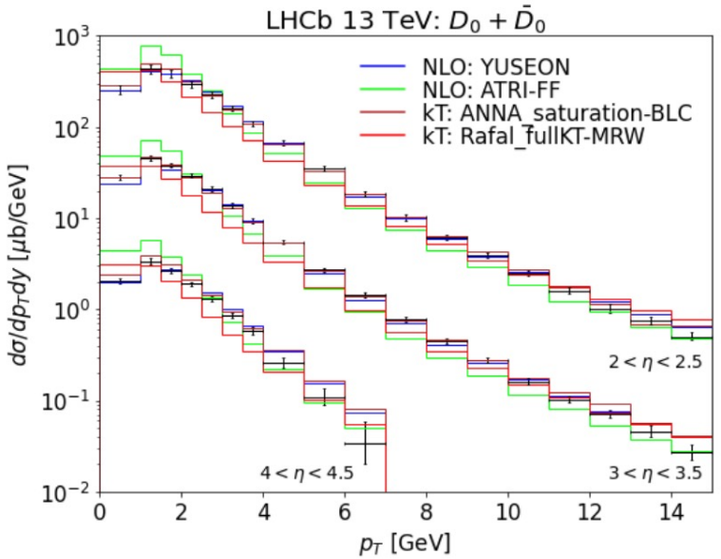
NLO QCD (+kT smearing for one)

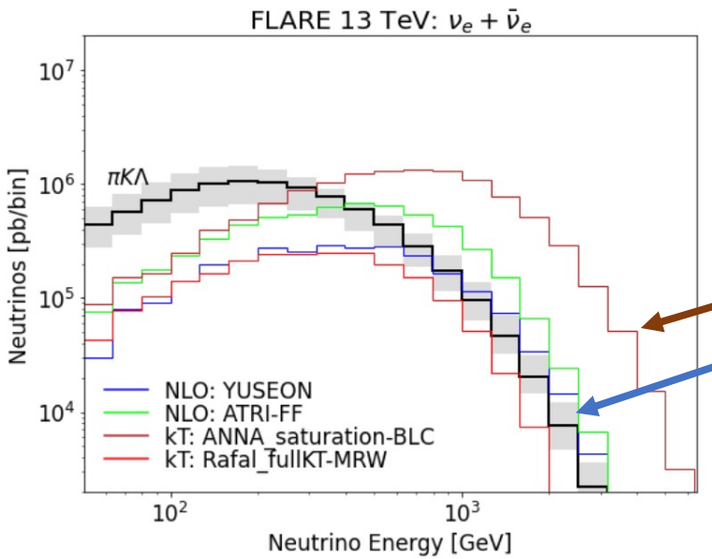
D^0 mesons



Electron neutrinos they produce.

LHCb → forward neutrinos not unique





Dark red and blue histograms almost the same for LHCb, much different at FLArE.

Investigating origins of differences and how to improve modeling.

CDR goals (partial overlap with WG1)

- Official set of FPF predictions for neutrino fluxes, make quantitative studies of the constraints that a flux measurement imposes on the charm production cross-section and on the small-x and large-x PDFs (in particular on the small-x gluon and the large-x intrinsic charm).
- Contribution of charm production and PDF choices to detailed simulation pipeline translating the impact of theory choices on the expected event rates at the FPF.
- Study of the implication of FPF measurements for high-energy astrophysics: prompt neutrino flux

Experiment-related questions

- What are the merits of different rapidity ranges and possibility of complementary coverage?
- Is there a role for detection at the FPF in coincidence with ATLAS?
- What detector capabilities are needed to study forward charm production (tau neutrinos? electron neutrinos? charge separation?)