

Adding NA61 Kaon production data to PPFX

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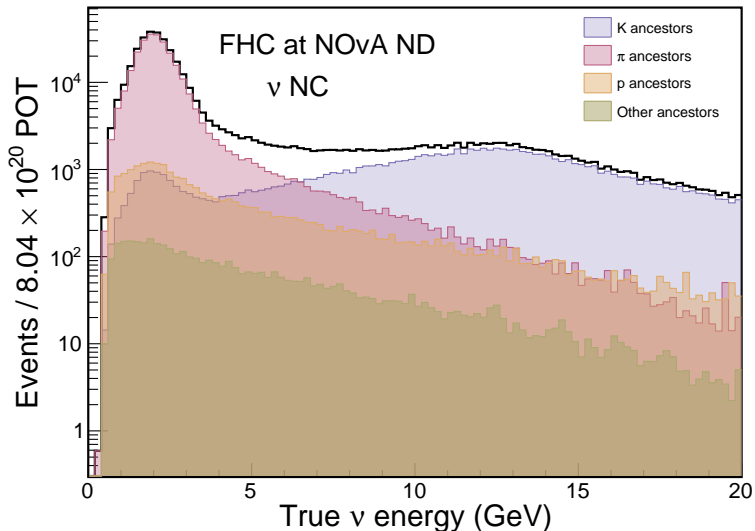
University of Sussex
NOvA & DUNE PPFX meeting



- ▶ In the **standard NOvA 3 flavour analysis** neutrinos from kaons make up only a small portion of the total neutrino selection
- ▶ Plus the beam uncertainty has minimal impact thanks to the extrapolation from ND to FD
- ▶ In the **sterile neutrino search** we want to include sterile oscillation in the ND → can't use extrapolation method
 - ▶ Bigger influence of the beam uncertainty(ies)
- ▶ We look mostly at NC events which have higher contribution from neutrinos from kaons
- ▶ We want to include higher energies (up to 20 GeV)
 - ▶ Even more neutrinos from kaons

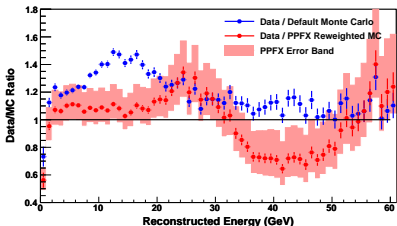
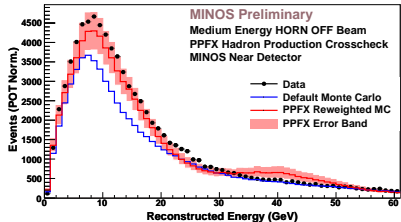
Neutrinos from kaons @ NOvA ND for NC selection

Simulation



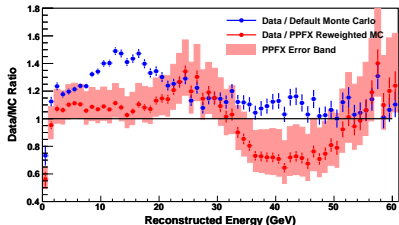
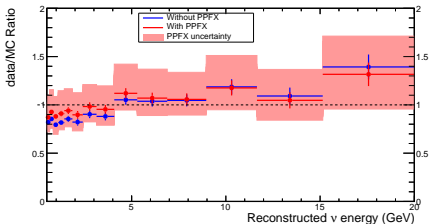
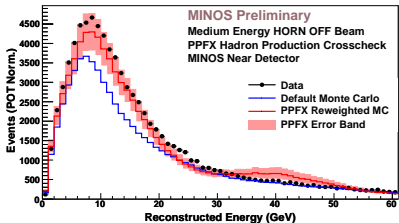
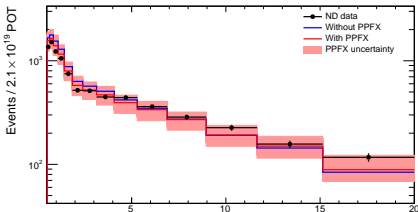
Motivation

- ▶ Results from MINOS indicate the PPFX might miscorrect the "kaon region" by up to 30%
- ▶ We know that we don't have enough data for kaons in PPFX, and we believe this is behind the discrepancy
- ▶ We **add 30% systematic uncertainty for all neutrinos from kaons** on top of the PPFX systematic just to be sure
- ▶ Beam systematic uncertainty (PPFX+Kaon) is the highest overall systematic in the current sterile neutrino search!



MINOS Horn-Off PPFX X-check
→ big ($\approx 30\%$) discrepancy at the "Kaon" region

Horn-Off comparison



My results for NO ν A (left) do not show the same trend.
But we need to include sterile oscillations into the ND!!!

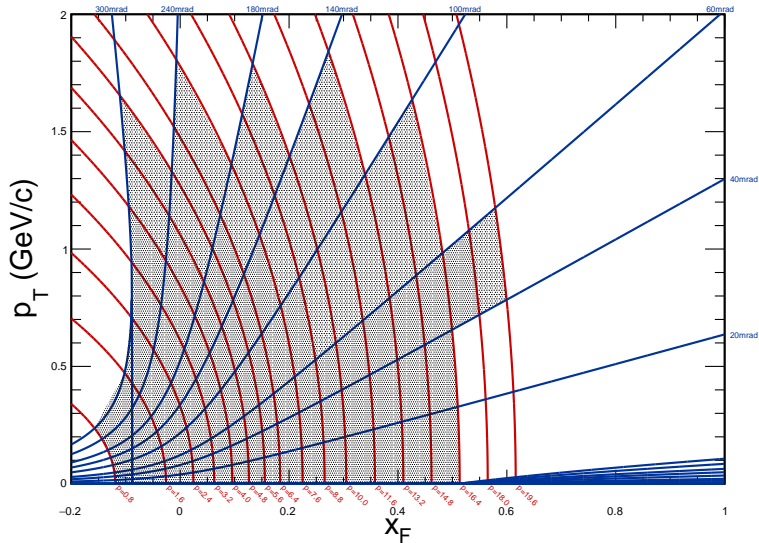
Adding NA61 Kaon production data

- ▶ I am going to focus on adding K production data from p-C interaction to the PPFX
- ▶ Currently we are using:
 - ▶ NA49 experiment's results for $pC \rightarrow K^\pm X$ @ 158GeV for $x_F < 0.2$
-low statistics
 - ▶ MIPP thin target ratios K/π @ 120GeV multiplied by NA49 results
- ▶ There are published results from 2015:
 - ▶ π^\pm , K^\pm , K_S^0 , Λ and p production in p-C at 31GeV
<https://arxiv.org/abs/1510.02703>
- ▶ But also yet unpublished results which will be very interesting for NOvA (and DUNE)
 - ▶ Hadron production from p-C @ 120GeV
 - ▶ NOvA-era NuMI replica target (collected in 2018)

NA61 data coverage

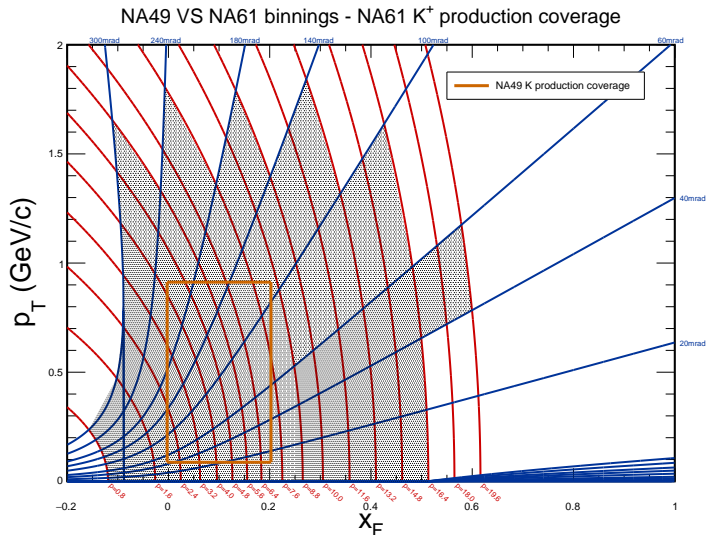
- ▶ NA61 uses different binning than NA49: (p, θ) VS (x_F, p_T)

NA49 VS NA61 binnings - NA61 K^+ production coverage



NA61 data coverage - NA49 comparison

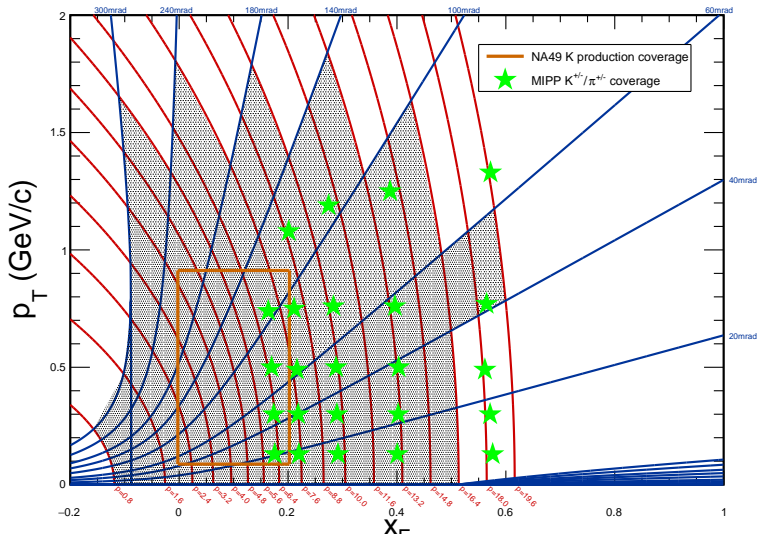
- ▶ There is much larger data coverage for "direct" kaon production XSec measurement



NA61 data coverage - NA49 and MIPP comparison

- ▶ MIPP extends the NA49 coverage, but this brings with it additional uncertainties

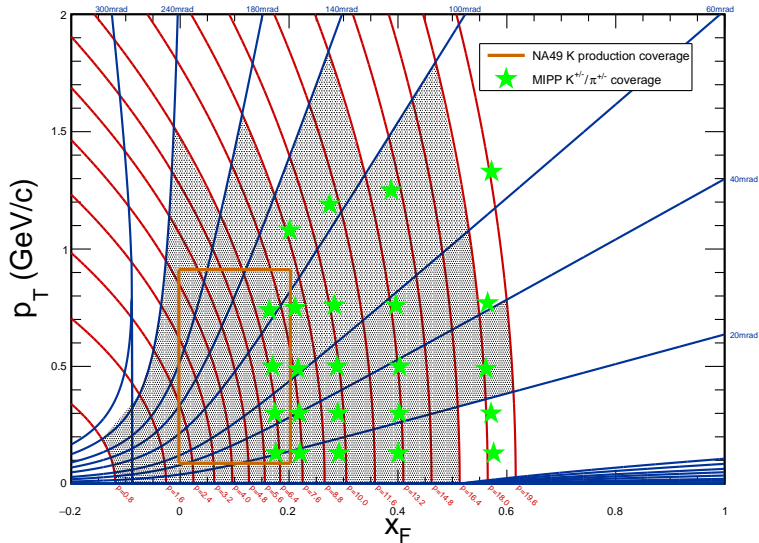
NA49 VS NA61 binnings - NA61 K^+ production coverage



NA61 data coverage - NA49 and MIPP comparison

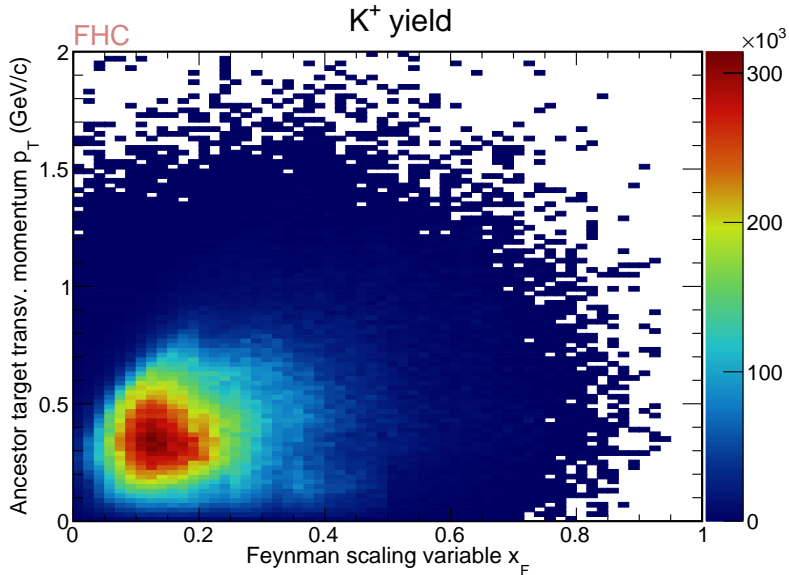
- ▶ Very similar results for K^- (but a bit different NA61 coverage)

NA49 VS NA61 binnings - NA61 K^- production coverage



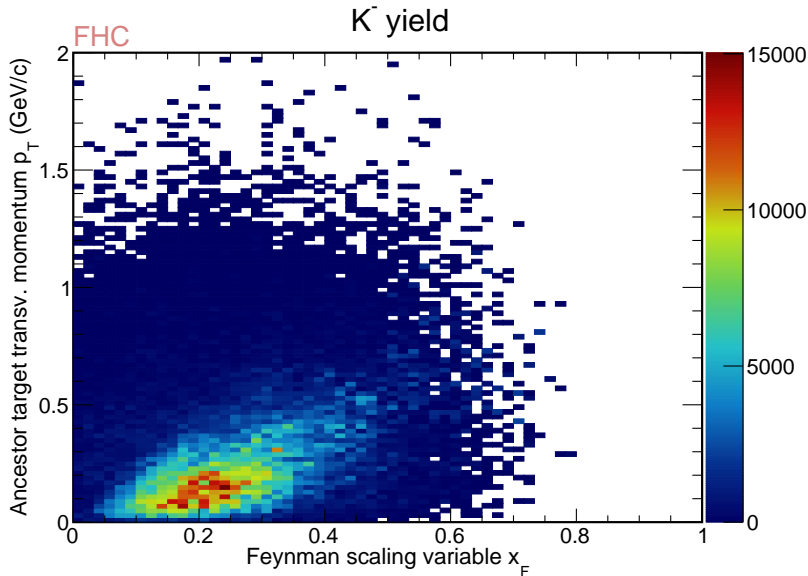
NOvA ND K^+ phase space

- ▶ Phase space for K^+ without any selection



NOvA ND K^- phase space

- ▶ Phase space for K^- without any selection



- ▶ Overlay the phase space plots with the coverage plots
- ▶ Comparison between NA61 and MC @ 31 GeV with G4HP
- ▶ Scale NA61 data at centers of bins and compare with NA49 / MIPP*NA49
- ▶ Figure out what is the best idea for the energy scaling and bin change
- ▶ Thanks to Antoni Aduszkiewicz and Leo for giving me proposals for how to deal with different binnings
 - ▶ Antoni proposes we don't try to change the NA61's binning, but instead compare it directly with MC in the same variables and change only the MC/data ratio

Backup