Figure 20: Event view for run 5177, event 729, selected by selection II. The plots on the left show the event view in all three wire planes. A large gap of unresponsive wires is present in the U plane (see 20c). The plots on the right show the three-dimensional reconstructed image projected onto each wire plane. Comparing the reconstructed tracks to the wire plane views on the left it can be seen that the reconstruction successfully bridges gaps of unresponsive wires. The track reconstruction algorithm shown is pandoraNuPMA. All figures have the same scale (indicated by the white bar in the bottom left) and aspect ratio.
Outline

Topology-based measurements from the past year

- $\nu_\mu$ CC inclusive
- Charged particle multiplicity
- $\nu_\mu$ CC $\pi^0$
- $\nu_\mu$ CC 2p
- $\nu_\mu$ CC Np
- NC elastic
- $\nu_e$ CC inclusive
MicroBooNE goals

- Two main physics goals:
  - MiniBooNE low-energy excess
    - More on that in following talk, by Ivan
  - Cross section measurements
    - Lack of $\nu$–Ar data at low-energy
    - Ar target: same as DUNE, short-baseline program

“The precise measurement of neutrino properties and interactions is among the highest priorities in fundamental particle physics.”

-NuSTEC White Paper
MicroBooNE detector

- Liquid-argon time-projection chamber
  - 85 ton in active volume
  - 3 wire planes with 8256 wires
    - 3 mm wire pitch
- 32 PMTs of 20 cm diameter
  - Trigger and start of drift time
- Cosmic ray tagger (CRT) surrounding cryostat
  - Surface detector
MicroBooNE detector

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- 32 PMTs of 20 cm diameter
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  - Surface detector

Figure 1: The design of CRT planes as part of the MicroBooNE detector. Simulation of cosmic rays crossing the CRT, the brown lines represent possible cosmic ray trajectories. There are four CRT planes: top plane, bottom plane, pipe side plane and feedthrough side plane. The beam direction is along the $z$ axis.

2.1 CRT planes
The MicroBooNE CRT consists of four planes: the top plane, the bottom plane, the feedthrough side plane, and the pipe side plane. The top plane, shown in figure 2, is located 5.4 m above the TPC. The bottom plane is located 1.4 m under the TPC. Figure 3 shows the visible sides of the feedthrough side plane and the pipe side plane. The feedthrough side (beam right) plane is located 1.4 m from the side where TPC feedthroughs are installed. The pipe side (beam left) plane is located 1.4 m from the opposite TPC side. Each of the planes is composed of two layers of modules overlapping with perpendicular scintillator bar orientation. We describe details of each plane's construction in section 4.

2.2 CRT modules
The scintillating modules were designed and fabricated by the Laboratory for High Energy Physics (LHEP) at the University of Bern. After a quality inspection and a specification test, modules were shipped to Fermilab to be installed at LArTF where the MicroBooNE LArTPC is located. More details of the construction and performance of modules can be found in Ref. [5]. Here, we summarize the most important design aspects.

*Cosmic rays simulated with the cosmic-ray shower library CRY, https://nuclear.llnl.gov/simulation/main.html.*
BNB flux

- $\nu_e$ content less than 1% of total flux
- Run 5 just started
- CRT installed during run 2
- Blinded $\nu_e$ data for analysis of low-energy excess
  - 95% of data is blinded
NuMI flux

- Beam operates in two modes
- Greater relative content of $\nu_e$ – ~5% of total flux
- Data is not blinded

https://microboone-exp.fnal.gov/public/approved_plots/Beam.html
$\nu_\mu$ CC inclusive

Run 5326 Event 900, March 6\textsuperscript{th}, 2016
\( \nu_\mu \) CC inclusive

- \( \sigma(\nu_\mu + \text{Ar} \rightarrow \mu + X) \)
  - Looking for a muon at a vertex
- First double differential cross section
  - As function of muon momentum and angle wrt beam
- Complete angular coverage
- Tension with Genie v2 in forward region (along beam)
  - Data favours Genie v3

<table>
<thead>
<tr>
<th>experiment</th>
<th>measurement</th>
<th>target</th>
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<tr>
<td>ArgoNeuT</td>
<td>( \nu_\mu ) CC [4,5], ( \bar{\nu}_\mu ) CC [5]</td>
<td>Ar</td>
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<td>MINER(\nu)A</td>
<td>( \nu_\mu ) CC [6,7,8], ( \nu_\mu ) CC [7], ( \nu_\mu/\bar{\nu}_\mu ) CC [9]</td>
<td>CH, C/CH, Fe/CH, Pb/CH</td>
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<td>NOMAD</td>
<td>( \nu_\mu ) CC [10]</td>
<td>Fe</td>
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<td>SciBooNE</td>
<td>( \nu_\mu ) CC [12]</td>
<td>CH</td>
</tr>
<tr>
<td>T2K</td>
<td>( \nu_\mu ) CC [13,14,15], ( \nu_\nu ) CC [16,17]</td>
<td>CH, H(2)O, Fe</td>
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PDG (Neutrino Cross Section Measurements Review)

MicroBooNE Preliminary

\[
\frac{d\sigma}{d\cos(\theta_{\mu})} \text{[10}^{-38} \text{cm}^2]\]

\[
\frac{d\sigma}{dp_{\mu}^{\text{eco}}} \text{[10}^{-38} \text{cm}^2/\text{GeV]}\]

MicroBooNE Preliminary

\[
\frac{d\sigma}{dp_{\mu}^{\text{eco}}} \text{[cm}^2/\text{degree}/\text{Ar]}\]

νμ CC inclusive: differential

FIG. 2. The presented analysis has full angular coverage and uses predictions from the models described above within uncertainties. The data (black) are compared to a GENIE v3 prediction (blue), a GENIE v2.12.2 + Emp. MEC prediction (green), a microboone_info@fnal.gov prediction (red), as described in the text. The vertical bars show statistical and systematic uncertainties.

-1.00 ≤ cos(θµ reco) < -0.50
MicroBooNE 1.6 × 10^{20} POT

0.27 ≤ cos(θµ reco) < 0.45

0.76 ≤ cos(θµ reco) < 0.86

0.86 ≤ cos(θµ reco) < 0.94

0.94 ≤ cos(θµ reco) ≤ 1.00

In summary, we have reported the first double-differential charged current inclusive cross section on argon. The data (black) are compared to various predictions, as shown in the comparison with various predictions.
$\nu_\mu$ CC inclusive: integrated

- Integrated cross section
  - $\sigma = 0.693 \pm 0.010$ (stat) $\pm 0.165$ (syst) $\times 10^{-38}$ cm$^2$

- Detector response is the dominant uncertainty
  - Expected to be lower in new MicroBooNE data reprocessing

Source of uncertainty | Relative uncertainty [%]
--- | ---
Beam flux | 12.4
Cross section modeling | 3.9
Detector response | 16.2
Dirt background | 10.9
Cosmic ray background | 4.2
MC statistics | 0.2
Statistics | 1.4
Total | 23.8

Calorimetric energy reconstruction can be validated on stopping muons for which a range-based energy measurement is also obtainable. This data-driven comparison, performed using a sample of tagged stopping muons, shows agreement at the 3% level. The calorimetric energy reconstruction procedure applied to muons for this sample is identical to that applied to photons, giving confidence in the energy-scale calibration. While the same ion recombination model is used, the implementation of corrections to account for this effect is different for showers, and discussed in detail in the next section.

We assess an uncertainty in the energy scale calibration for this work of 3% for charge deposited collinear to the collection-plane wire-pitch direction, noting that additional angular-dependent biases can impact the energy reconstruction of showers in particular.
$\nu_\mu$ CC $\pi^0$

- First measurement of this type!
- Pion production is important contribution for DUNE

- Require only a single shower
  - Cross-checked with $\pi^0$ mass

“First demonstration of automated EM particle three-dimensional reconstruction in LArTPC data.”

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<thead>
<tr>
<th>Experiment</th>
<th>CC</th>
<th>NC</th>
<th>Target</th>
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<td>NC [53]</td>
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<td>K2K</td>
<td>CC [54,55]</td>
<td>CC [56], NC [57]</td>
<td>CH, H$_2$O</td>
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<td>CC [58,59,60]</td>
<td>CC [59,61,62], NC [63]</td>
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<td>CC [66], NC [67,68]</td>
<td>CH$_2$</td>
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<td>MINOS</td>
<td>NC [69]</td>
<td>Fe</td>
<td></td>
</tr>
<tr>
<td>NOMAD</td>
<td>NC [70]</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>SciBooNE</td>
<td>CC [71]</td>
<td>NC [72,73]</td>
<td>CH</td>
</tr>
<tr>
<td>T2K</td>
<td>CC [74,75]</td>
<td>-</td>
<td>CH, H$_2$O</td>
</tr>
</tbody>
</table>

MicroBooNE

**Data:** Mean $128 \pm 5$ MeV/c$^2$

- Neutrino Induced $\pi^0$
- Charge Exchange $\pi^0$
- Cosmic (data)
- Other

Phys. Rev. D 99, 091102(R)
\( \nu_\mu \, \text{CC} \, \pi^0 \)

- Good agreement with models, in particular for the scaling wrt lighter nuclei

\[ \sigma = 1.9 \pm 0.2 \, \text{(stat)} \pm 0.6 \, \text{(syst)} \times 10^{-38} \, \text{cm}^2 \]

- 31% systematic uncertainty

\[ (\sigma_\phi (10^{-38} \, \text{cm}^2 / \text{D}), \text{Deuterium}) \]

\[ (\sigma_\phi (10^{-38} \, \text{cm}^2 / \text{CH}_2), \text{Carbon}) \]

\[ (\sigma_\phi (10^{-38} \, \text{cm}^2 / \text{Ar}), \text{Argon}) \]
Sebastien Prince

The observed CPMD and inclusive observed kinematic distributions have several desirable attributes. The $\sigma_{CC,n}$ are all large up to $n \lesssim 4$ at the neutrino energies (see Sect. 3); therefore only modest event statistics are required. Only minimal kinematic properties of the final state are imposed (the track definition implies an effective minimum kinetic energy), and complexities associated with particle identification and photon reconstruction are avoided. At the same time, the observed quantities reveal much of the power of the LArTPC in identifying and characterizing complex neutrino interactions. The observed CPMD and associated kinematic distribution ratios will have reduced sensitivity to systematic normalization uncertainties associated with flux and efficiency compared to absolute cross section measurements.

Ad is a disadvantage of the observed CPMD and other kinematic quantities is their lack of portability. One must have access to the full MicroBooNE simulation suite to use the $O_n$ to test other models.

The MicroBooNE detector and the booster neutrino beam

The MicroBooNE detector is a LArTPC installed on the Fermilab BNB. It is a high-resolution surface detector designed to accurately identify neutrino interactions [4]. It began collecting neutrino beam data in October of 2015. Figure 1 shows an image of a high multiplicity event from MicroBooNE data.

The MicroBooNE TPC (Fig. 2) has an active mass of about 85 tons (85 mg) of liquid argon. It is 10.4 meters long in the beam direction, 2.3 m tall, and 2.6 m in the electron drift direction. Electrons require 2.3 ms to drift across the full width of the TPC from cathode (at $-70$ kV) to anode (at $\sim 0$ kV). Events are read out to the anode wire planes with 3 mm spacing between wires. Drifting electrons pass through the first two wire planes, which are oriented at $\pm 60^\circ$ relative to vertical, producing bipolar induction signals. The third wire plane, the collection plane, has its wires oriented vertically and collects the charge of the drifting electrons in the form of a unipolar signal. The MicroBooNE readout electronics allow for measurement of both the time and charge created by drifting electrons on each wire. The amplified, shaped waveforms from 8256 wires from induction and collection planes are digitized at 2 MHz using 12-bit ADCs. A data acquisition system reads out a window consisting of 9600 recorded samples (4.8 ms) for all wires, then noise-filtered and deconvolved utilizing offline software algorithms. Reconstruction algorithms are then used on these output waveforms to reconstruct the times and amplitudes of charge depositions (hits) on the wires from particle-induced ionization in the TPC bulk.

While all three anode planes are used for track reconstruction, the collection plane provides the best signal-to-noise performance and charge resolution. The analysis presented here excludes regions of the detector that have non-functional collection plane channels ($\sim 10\%$). It also imposes requirements on the minimum number of collection plane hits-current pulses processed through noise filtering [22], deconvolution, and calibration-associated with the reconstructed...


\( \nu_\mu + \text{Ar} \rightarrow \mu + X \)
- Consider tracks from vertex, including muon

Final state multiplicity measured across 26 kinematic distributions
- Indications that models overestimate the multiplicity
- Otherwise overall good agreement with models

\( \theta \) and \( \phi \) track passes or fails the PH and MCS tests:

Observations kinematic distributions

- Indications that GENIE overestimates the uncertainties with one another, and agree qualitatively with the predictions from three different GENIE predictions overlaid on data.

- No tuning or fitting has been performed to data. There are indications that GENIE overestimates the uncertainties with one another, and agree qualitatively with the predictions from three different GENIE predictions overlaid on data.

- Our fit to the distribution of the eight event categories in Fig. 19 provides samples with intermediate the multiplicity measured across 26 kinematic distributions.

- Indications that models overestimate the multiplicity
- Otherwise overall good agreement with models

- Indications that models overestimate the multiplicity
- Otherwise overall good agreement with models

\[ \text{Fig. 17 and 18} \]

\[ \text{Fig. 19} \]

\[ \text{Fig. 20} \]

\[ \text{Fig. 21} \]
On-beam data Event Displays

Here are presented some of the selected on-beam data events within the CC$^\pi_2P$ selection scheme and the last event shown corresponds to the selected four proton candidates event. Figures 27 and 28 are CC2Proton candidates, while Figure 29 shows an event that passes selection but upon visual inspection is suspected to be background. Figure 30 shows an event passing the CCNProton selection and containing 4 proton-candidate tracks. All figures correspond to on-beam data. All figures show collection plane only.

Figure 27: on-beam BNB data, $\nu_\mu$ CC with 2 proton candidates in the final state.
\( \nu_\mu \text{ CC } 2p \)

- \( \nu_\mu + \text{Ar} \rightarrow \mu + p + p \)
  - Exactly 2 protons, no pions
  - \( p_p > 300 \text{ MeV/c} \)

- Data seems to prefer Genie v3-like
  - No systematic uncertainties

\[ \cos \theta_{p1-p2} \]

\[ \cos \theta_{p1-p2} \]

---

### Table: PDG (Neutrino Cross Section Measurements Review)

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Measurement</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArgoNeT</td>
<td>2p [27]</td>
<td>Ar</td>
</tr>
<tr>
<td>K2k</td>
<td>( \frac{d\sigma}{dQ_2} ) [28]</td>
<td>H_2O</td>
</tr>
<tr>
<td>MINER(\nu)A</td>
<td>( \frac{d^2\sigma}{d\cos\theta_p} ) [29,30,31]</td>
<td>C, CH, Fe, Pb</td>
</tr>
<tr>
<td>MiniBooNE</td>
<td>( \frac{dT_{\mu\nu}}{d\theta_p} ) [23,24]</td>
<td>CH_2</td>
</tr>
<tr>
<td>NOMAD</td>
<td>( \sigma_{\mu} ) [37]</td>
<td>Fe</td>
</tr>
<tr>
<td>T2K</td>
<td>( \frac{d^2\sigma}{dL_{\mu\nu}} ) [26], ( \sigma(E_\nu) ) [38]</td>
<td>C</td>
</tr>
</tbody>
</table>

---

### Graphs:

**Genie v2 + MEC** vs. **Genie v3-like**

- **MicroBooNE preliminary, 4.411e19 POT, stats only**

**ArgeNeuT**

Figure 30: On-beam BNB data event passing the CCNProton selection with the longest track from the vertex being a muon track and 4 proton candidate tracks. This is the highest proton-multiplicity event in the current data sample.

$\nu_\mu$ CC Np
νμ CC Np

νμ + Ar → μ + N p
- N>0, no pions
- p_p > 300 MeV/c

6 kinematic distributions wrt leading proton and muon

Data seems to prefer Genie v3-like
- Especially in forward region

Model overestimates higher proton multiplicity
- Statistical uncertainty only

Figure 17: Area normalized distribution of proton multiplicity for the GENIE Default Model on the left, \(2/ndof = 42.7/4\) includes statistical uncertainty only. Right plot show a comparison of GENIE Default and GENIE Alternative models unit normalized with statistical uncertainty only.
NC elastic

BNB DATA : RUN 5515 EVENT 852
NC elastic

- $\nu_\mu + \text{Ar} \rightarrow \nu_\mu + p$
  - No vertex, only proton!
  - Used to investigate contribution of strange quark to proton spin

- Decent efficiency and good agreement with Genie
  - Statistical uncertainty only
  - Expect 1000 NC elastic events in full dataset

3.3 Remaining Backgrounds

The remaining backgrounds fall into four separate categories:
1. Neutral current background interactions in the TPC,
2. Charged current interactions in the TPC,
3. Neutrino interactions outside of the TPC,
4. Cosmic interactions in time with the beam.

The first category, NC backgrounds in the TPC, include NC elastic interactions with a neutron (35%), NC elastic interactions with a correlated neutron-proton pair (35%), NC resonant interactions (25%), and NC DIS interactions (4%). The last two, resonant and DIS, are mainly due to tracks being mis-reconstructed.

---

Figure 3: Neutral current elastic selection efficiency as a function of true four-momentum transfer for a logistic regression score cut of 0.8. The uncertainties are statistical only.

Figure 4: NC elastic event selection given a logistic regression score cut of 0.8 as a function of reconstructed negative four-momentum transfer. The top plot shows the signal and itemized backgrounds compared to the BNB $5 \times 10^{19}$ POT data in black. The bottom plot shows the ratio of BNB $5 \times 10^{19}$ POT data to BNB MC with cosmic overlay and off-beam data. In both plots the uncertainties are statistical only.
A proof of technique for extracting the inclusive NuMI flux-weighted $\nu_e + \bar{\nu}_e$ charged current cross section using data in the near future. This selection has been used to isolate approximately 100 signal events in data, making this the largest sample of $\nu_e$ events in Argon to-date.

This appendix presents several event displays for NuMI On-Beam data events which have passed the event selection explained above.

Figure 13 demonstrates the selection's ability to find $\nu_e/\bar{\nu}_e$ candidate events in data, which mirror an expected topology of a single track and single shower interaction. The color scale shows different levels of charge deposition which can be calorimetrically reconstructed for both track-like and shower-like objects.

Figure 14 shows a 2.2 GeV shower with a length up to 1.5 meters, that is nicely resolved in the detector. This is within the expected energy range for events being measured by DUNE.
ν_e CC inclusive

- \( \sigma(\nu_e/\bar{\nu}_e + \text{Ar} \rightarrow e^\pm + X) \)
  - Using NuMI unblind data to measure ν_e cross section

- Automated selection
  - About 100 signal events, largest sample in argon

- Succeeded to extract via reconstruction the input cross section (closure)
  - \( \sigma_{\text{MC}} = 4.83 \pm 0.69 \text{ (stat)} \pm 1.20 \text{ (sys)} \times 10^{-39} \text{ cm}^2 \)

- Shower angle wrt to detector long axis peak closer to 40° than 0°
  - Neutrinos going upward since NuMI target underground by several meters

Figure 11: (Area normalised, MicroBooNE Coordinates) Leading shower for events which pass all selection cuts. The distribution is peaked in roughly the region expected based on the NuMI o-axis prediction. Forward-going showers appear favoured over backwards-going showers.

7 Monte Carlo Cross Section Closure Test

This section presents the method used to calculate the flux integrated Monte Carlo ν_e+ν_e CC cross section on argon. This calculation uses Monte Carlo events, but hopes to demonstrate the method and expected sensitivity of a future cross section measurement using data. For exclusively a flux-integrated cross section the calculation is relatively simple. Using the Equation 1, one can calculate the cross section:

\[ \sigma = \frac{N_B}{N_{\text{Target}}} \cdot \frac{1}{\nu_{\nu_e}} \]

where \( N \) is the total number of selected events, \( B \) the number of selected background events, \( \varepsilon \) the signal selection efficiency, \( N_{\text{Target}} \) the number of target nucleons and \( \nu_{\nu_e} \) the integrated NuMI ν_e+ν_e flux POT-scaled flux.
Future measurements

- CC $\pi^\pm$
- NC $\pi^0$
- NC $\gamma$
- CC $\mu$ (0p)
- Transverse variables
- CC $K^\pm$
- Kaon decays at rest
- ...
- And updates of previous ones with complete dataset
Take-home messages

- MicroBooNE's first published cross-section measurements
  - $\nu_\mu$ CC inclusive (first double differential in argon)
  - $\nu_\mu$ CC $\pi^0$ (first in argon)

- Preliminary results for several other channels public

- These measurements help constrain model uncertainties
  - Data prefers Genie v3 over v2
  - Useful for DUNE
  - Useful for short-baseline oscillation search (next talk!)
Interaction processes

![Graph showing cross section versus energy](image)

- **Cross section** $\frac{\nu}{E_\nu}$ in units of $10^{-38}$ cm$^2$/GeV.
- **Energy range**: $10^{-1}$ to $10^2$ GeV.
- **Contributions**:
  - **QE** (quasielastic), **DIS** (deep inelastic scattering), and **RES** (resonance).
- **Data points** and model predictions.

---

**Caption**: This graph illustrates the variation of neutrino cross section with energy. It is divided into contributions from quasielastic (QE), deep inelastic scattering (DIS), and resonance (RES) interactions. The cross section is normalized to the energy, $E_\nu$, and is plotted on a logarithmic scale for both axes.

---

**Rev. Mod. Phys., Vol. 84, No. 3, July–September 2012**

---

**Note**: The graph includes data from various experiments and predictions, emphasizing the transitions between different interaction processes as energy changes.
Two models available: hA and hN

FIG. 2. The hadronic shower produced in the initial interaction must still traverse the dense nuclear matter and is then subject to Final State Interactions (FSI) before appearing in the detector. These FSI include nucleon-nucleon interactions as well as pion-nucleon interactions as illustrated. Figure from Tomasz Golan.

It cannot be stressed enough that the incident neutrino energy is not a priori known. This situation differs dramatically from electron or muon scattering studies where the amounts of energy and momentum that are transferred to the nucleus is known precisely on event-by-event basis. For neutrino nucleus scattering the incoming neutrino energy and initially produced hadronic particles, which have been subject to the above mentioned nuclear effects, can only be estimated from what is observed in the detector. Since it is the initial neutrino energy spectrum as well as signal and background topologies that have to be used in the extraction of oscillation parameters, the strong dependence of the unbiased extraction of neutrino-oscillation parameters on neutrino-interaction physics can best be summarized by noting that the energy and configuration of interactions observed in experimental detectors are, aside from detector effects, the convolution of the energy-dependent neutrino flux, the energy-dependent neutrino-nucleon cross section, and these significant energy-dependent nuclear effects.

Practically, experimenters combine information about the energy dependence of all exclusive cross sections as well as nuclear effects into a nuclear model. This model along with the best estimate of the spectrum of incoming neutrino energies then enters the Monte Carlo predictions of target nucleus response and topology of final states and is a critical component of oscillation analyses.

To illustrate how oscillation experiments depend on this nuclear model, consider the following illustrative conceptual outline of a two-detector, long-baseline oscillation analysis:

1. Reconstruct the observed event topology and energy (final state particles identification and their momenta) in the near detector (ND).
2. Use the nuclear model to take the reconstructed event topology and energy back through the nucleus to infer the neutrino interaction energy $E_{\text{nd}} \Rightarrow E_{\text{nd}}$.
3. Using information on geometric differences between near and far detector fluxes and perturbed via an oscillation hypothesis, project the resulting initial interaction neutrino energy spectrum $(E_{\text{nd}} \Rightarrow E_{\text{nd}})$, into the predicted spectrum $0 (E_{\text{fd}} \Rightarrow E_{\text{fd}})$ at the far detector.
Figure 3.26: Neutrino fluxes for the reference focusing system operating in neutrino mode (left) and antineutrino mode (right), generated with a 120-GeV primary proton beam.
Model differences

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<tr>
<th>Model element</th>
<th>GENIE Default</th>
<th>GENIE Alternative</th>
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<td>Nuclear Model</td>
<td>Bodek-Ritchie Fermi Gas</td>
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<td>Nieves</td>
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<td>Meson-Exchange Current</td>
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<td>FSI</td>
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<th>Reaction type</th>
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<th>GENIE Alternative</th>
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<td>Meson Ex-change Current</td>
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## Event rate

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<td><strong>CC – RES</strong></td>
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<td>702</td>
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<td><strong>CC – DIS</strong></td>
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<td>1.3</td>
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<tr>
<td><strong>CC - COH</strong></td>
<td>740</td>
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<td>502</td>
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https://microboone-exp.fnal.gov/public/approved_plots/Cross_Section.html