MINERνA in 10 Minutes

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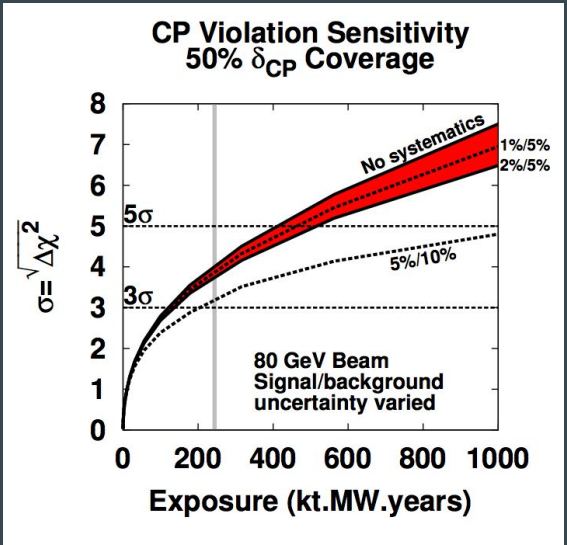
On behalf of the MINERνA Collaboration

New Perspectives 2016 - Fermilab

Motivating MINERvA: Challenges of Precision Era Neutrino Experiments



LBNE Estimate
Assuming 100 kT.MW.years
M Bass NuInt 2014

PRL 116, 181801 (2016) PHYSICAL REVIEW LETTERS week ending 6 MAY 2016

Measurement of Muon Antineutrino Oscillations with an Accelerator-Produced Off-Axis Beam

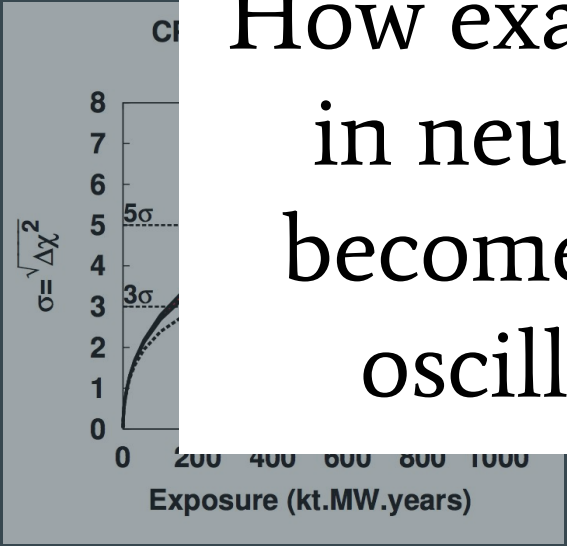
TABLE IV. Percentage change in the number of one-ring μ-like events before the oscillation fit from 1σ systematic parameter variations, assuming the oscillation parameters listed in Table III and that the antineutrino and neutrino oscillation parameters are identical.

Source of uncertainty (number of parameters)	$\delta n_{SK}^{exp}/n_{SK}^{exp}(\%)$
ND280-unconstrained cross section (6)	10.0
Flux and ND280-constrained cross section (31)	3.4
Super-Kamiokande detector systematics (6)	3.8
Pion FSI and reinteractions (6)	2.1
Total (49)	11.6

T2K publication

Motivating MINERvA:
Challenges of Precision Era Neutrino Experiments

How exactly does uncertainty in neutrino cross sections become a systematic for an oscillation experiment?



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week ending
6 MAY 2016

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(%)

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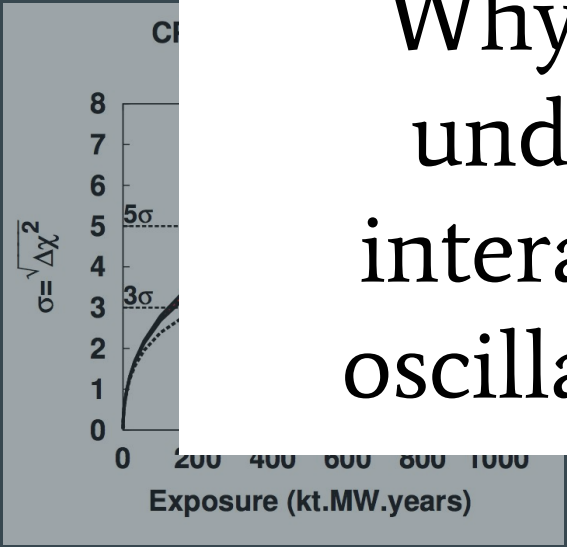
Motivating MINERvA:
Challenges of Precision Era Neutrino Experiments

Why don't we *already* understand neutrino interactions relevant to oscillation experiments?



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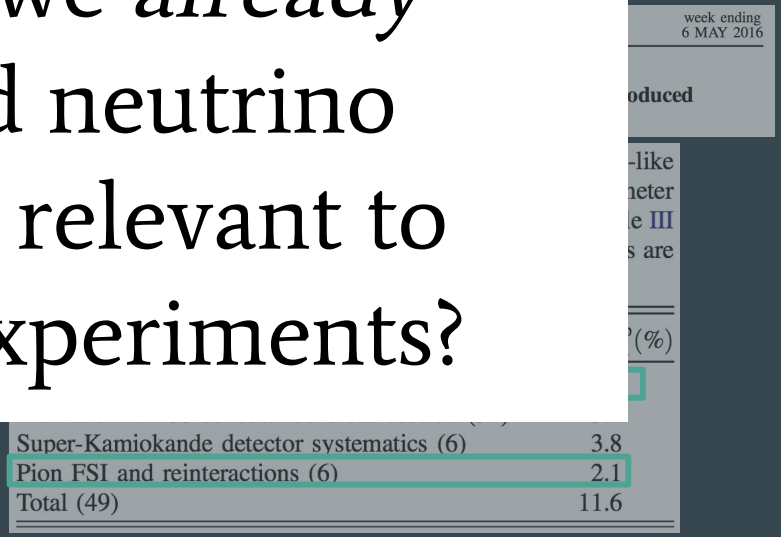

week ending
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Super-Kamiokande detector systematics (6)	3.8
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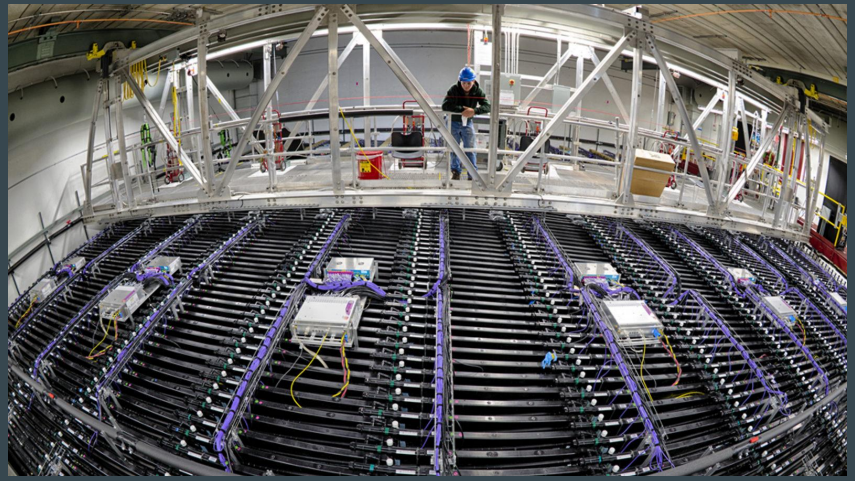
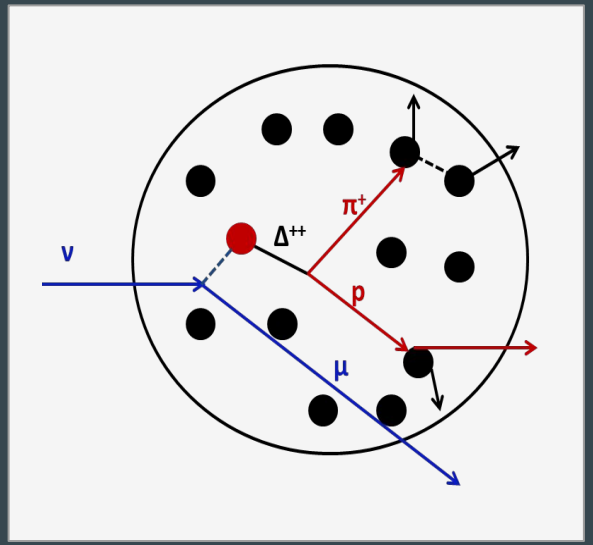
Neutrino-Nuclei Interactions Can Be Tricky

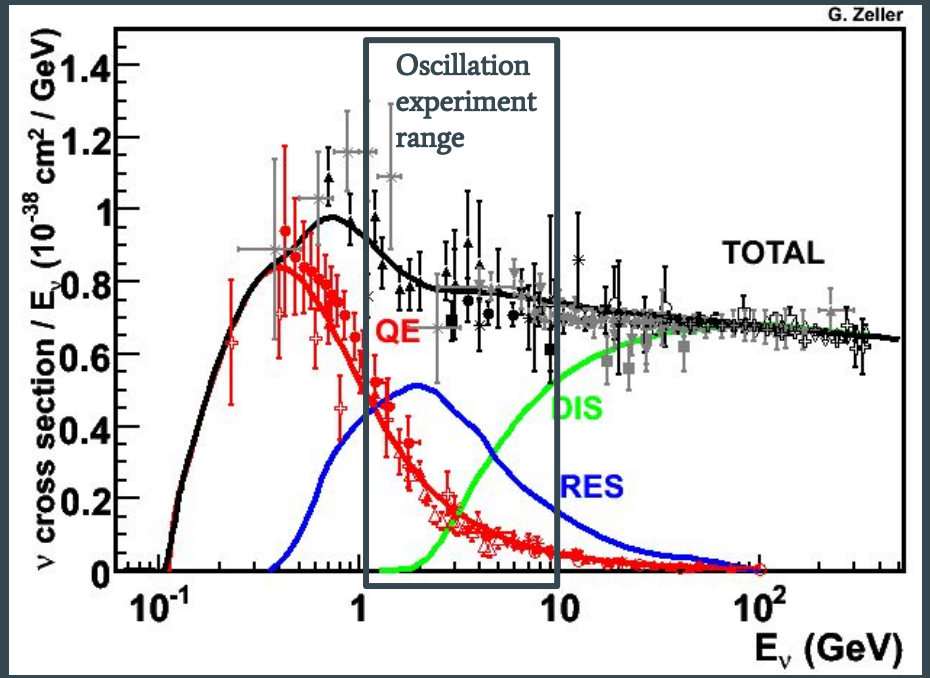


Oscillation experiments use heavy nuclei. NOvA uses a carbon-based mineral oil.



Re-interactions within the nucleus can fool reconstruction – making it hard to determine both E_ν and the interaction channel.

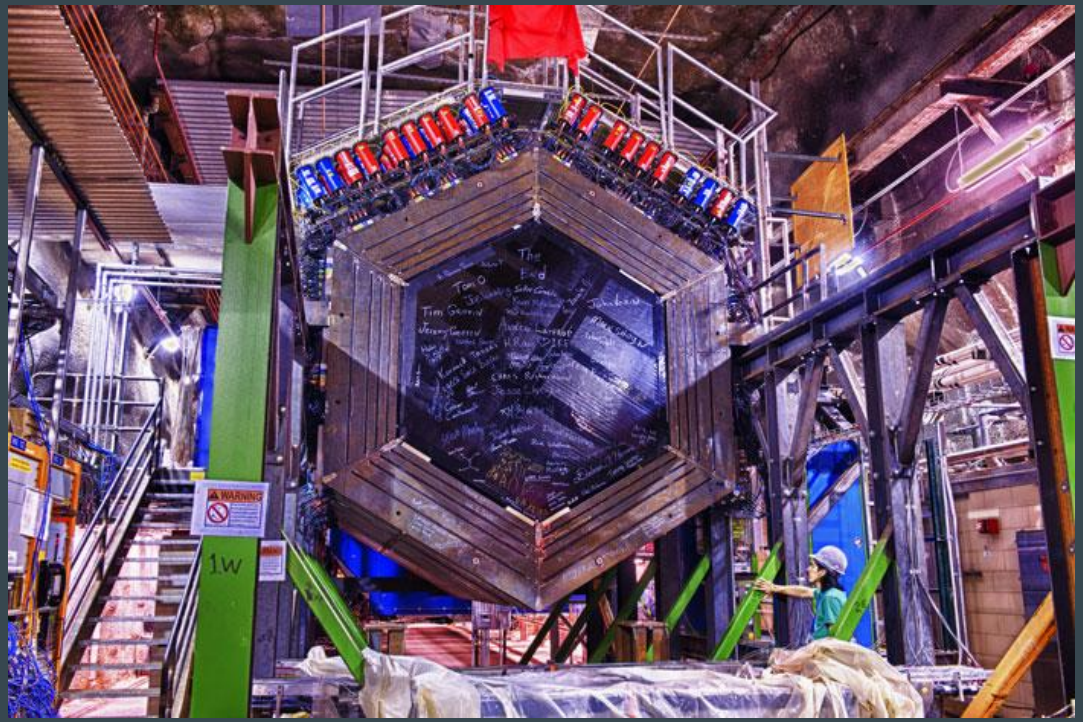
Another Complication: Energy Region



See: J.A. Formaggio, G.P. Zeller, Rev. Mod. Phys. 84, 1307 (2012)

- Oscillation experiments operate in the few GeV region, where many interactions channels are active.
- Event generators have difficulty describing scattering at these energies.
- Oscillation experiments need improved models/generators to achieve their physics goals!

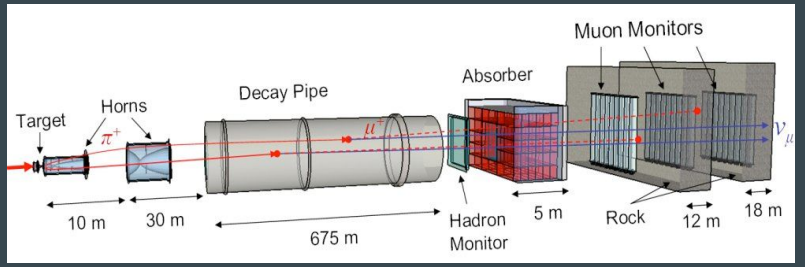
Enter: MINERvA

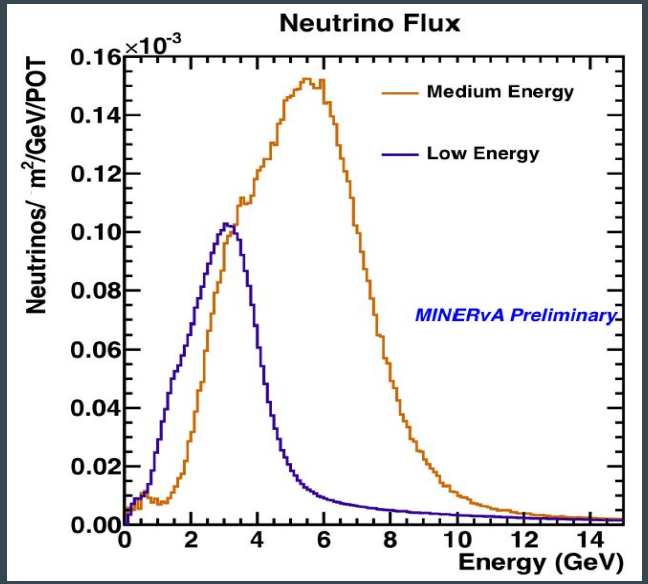


- Dedicated neutrino-nucleus scattering experiment
- Goals
  - Aiding oscillation experiments
  - Probing the nucleus purely through the weak force
- Only experiment measuring A-dependence of ν interactions

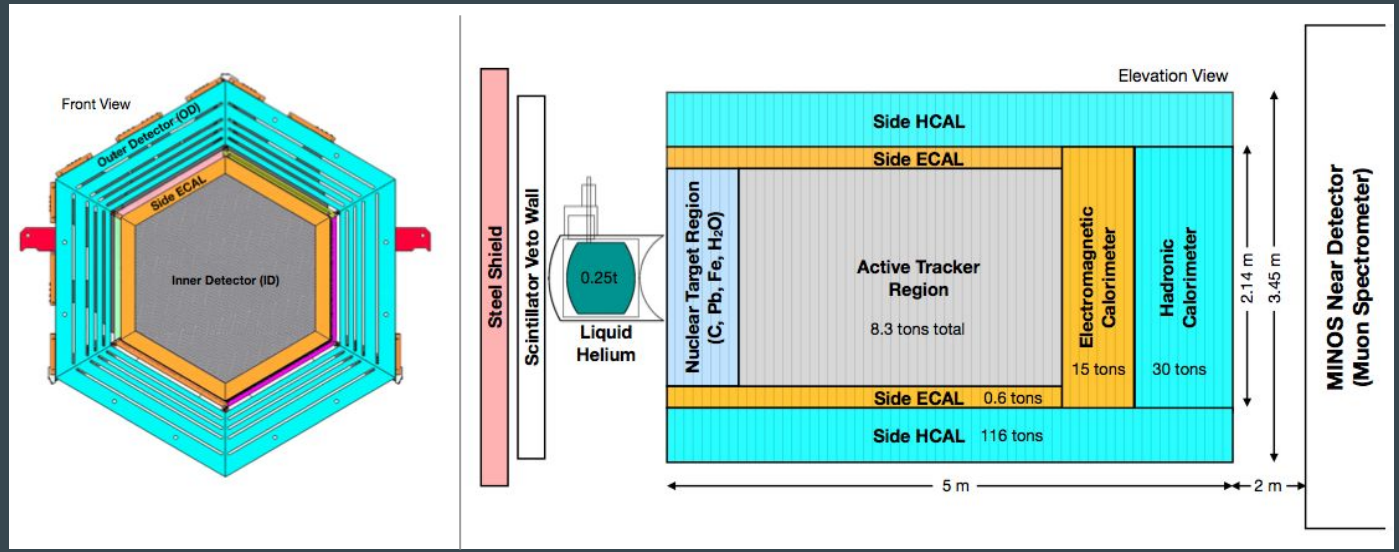
The NuMI Beam

- MINERvA is located just upstream of the MINOS near detector, in the NuMI beamline
- NuMI **low-energy** data collected from 2010-2012:
  - anti-neutrino: 1.09×10^{20} POT
  - neutrino: 3.18×10^{20} POT
- Now running in neutrino mode, **medium-energy** configuration:
  - Already have **$9\text{x}10^{20}$ POT**!
- Anti-neutrino mode is next!





The MINERvA Detector



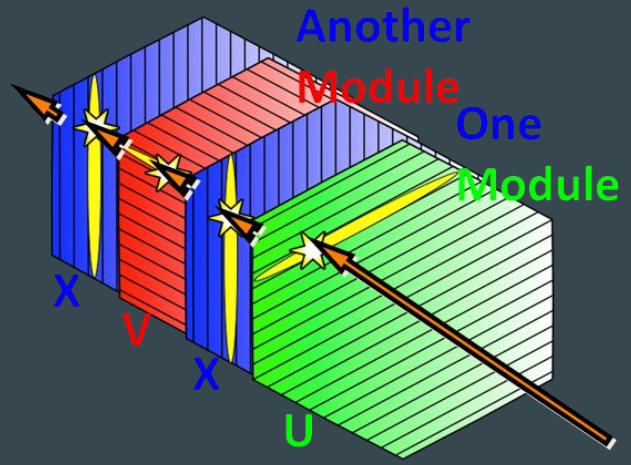
120 “modules” stacked along the beam direction

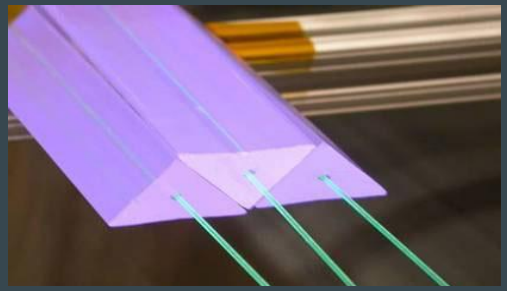
Central region is finely segmented scintillator tracker

~32k plastic scintillator strip channels total

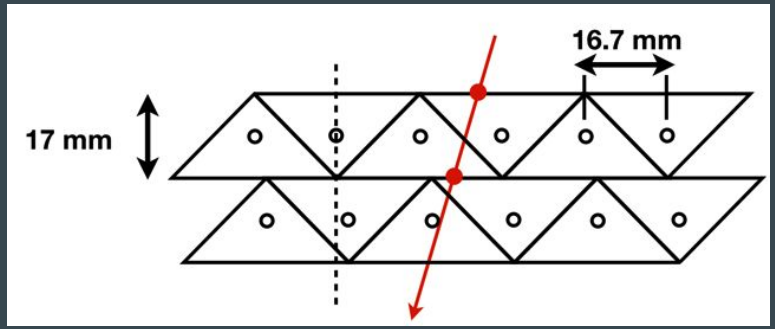
MINERvA Detector Technology

Hexagonal planes in three orientations (0°, ±60°) provide 3D track reconstruction.

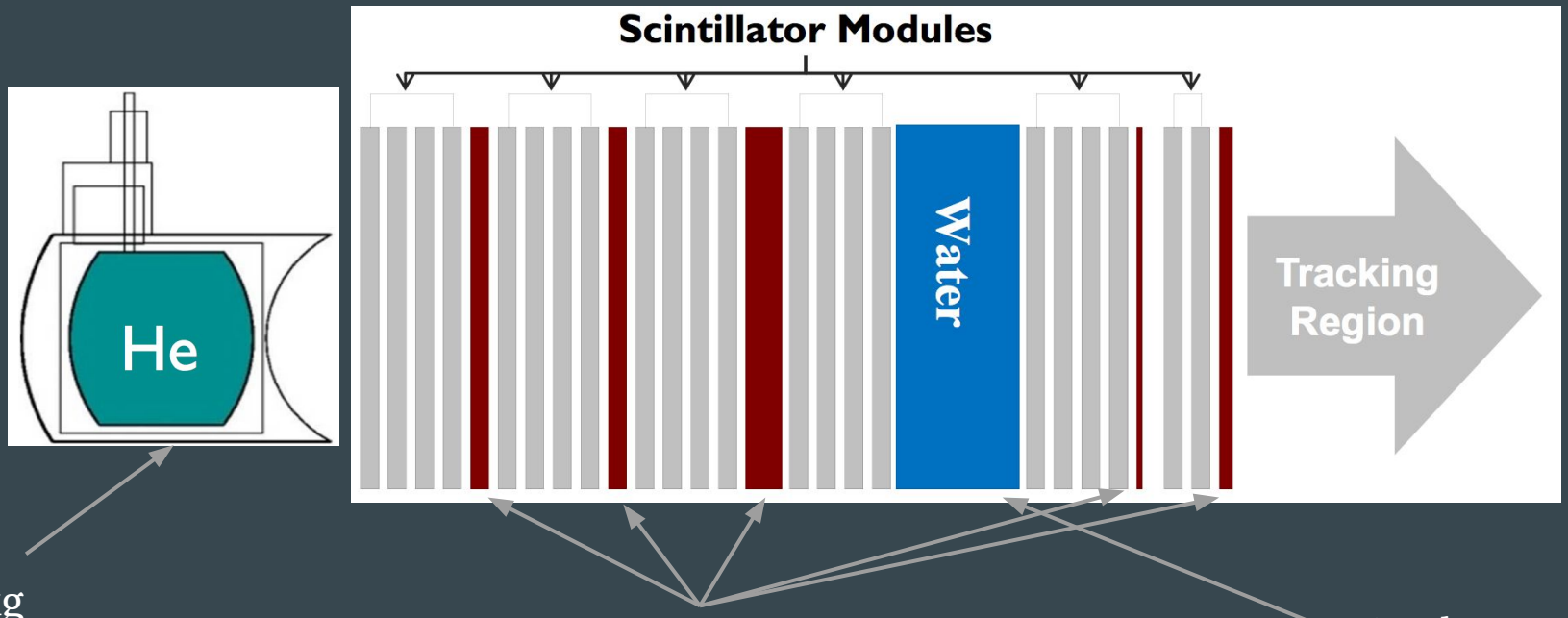




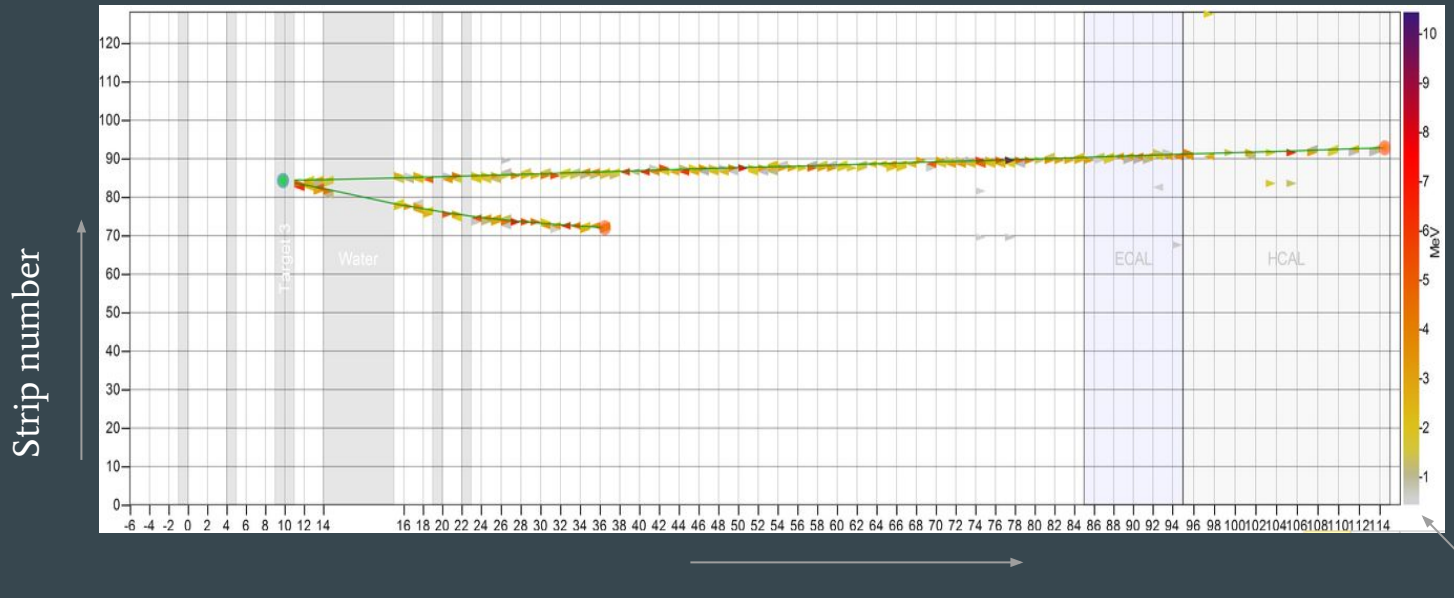
Planes of scintillator strips with wavelength shifting fibers.



Passive Target Region



A MINERvA Event

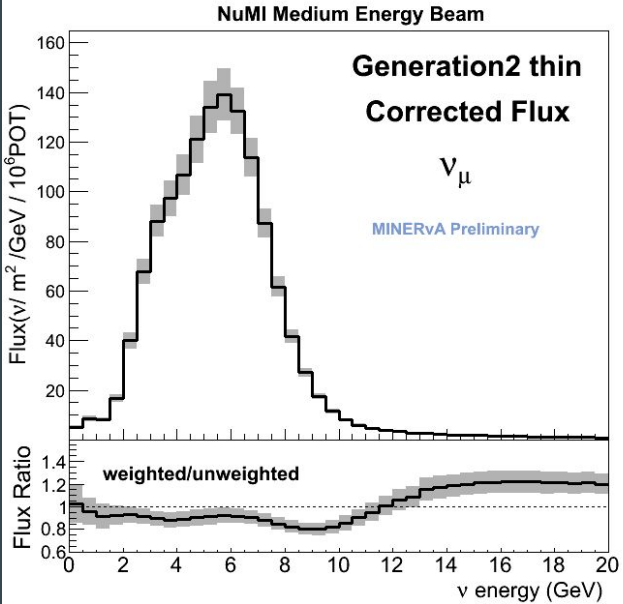


Two Track Event from
Lead Target

Recent Results from MINERvA

11 Published results and counting!

Neutrino Flux Predictions for the Low Energy NuMI Beam

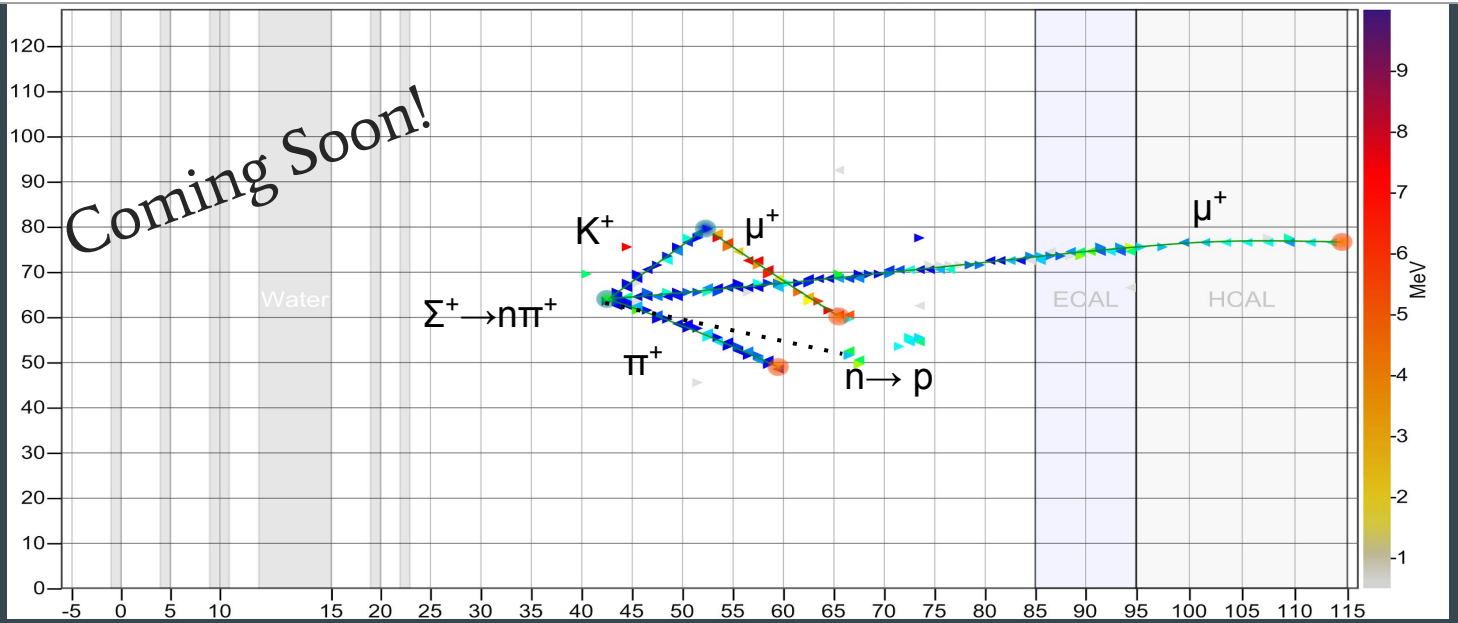


Coming Soon!

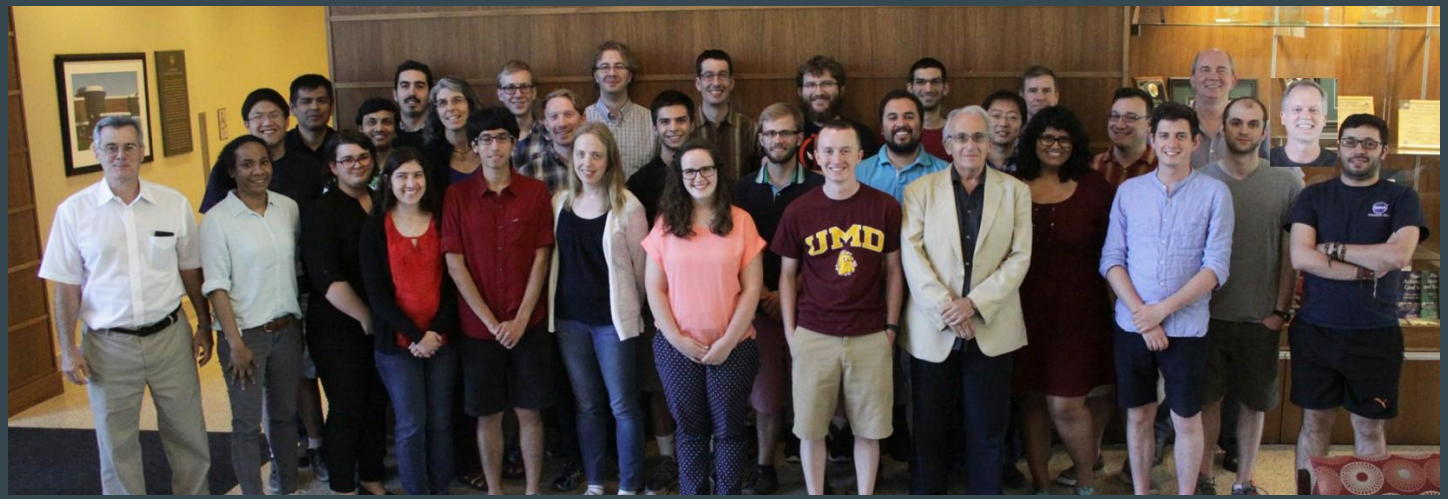
Recent Results from MINERvA

11 Published results and counting!

Measurement of K^+ production in charged-current ν_μ interactions



The MINERvA Collaboration

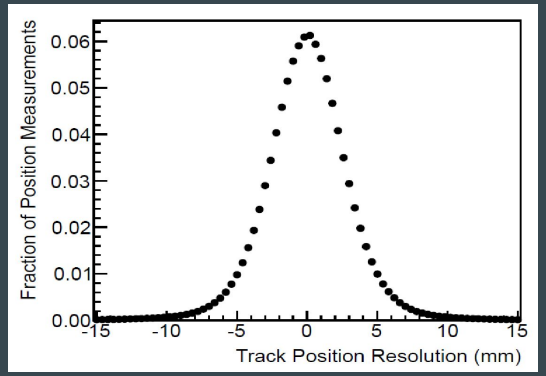


Don't Turn That Dial! Next Up:

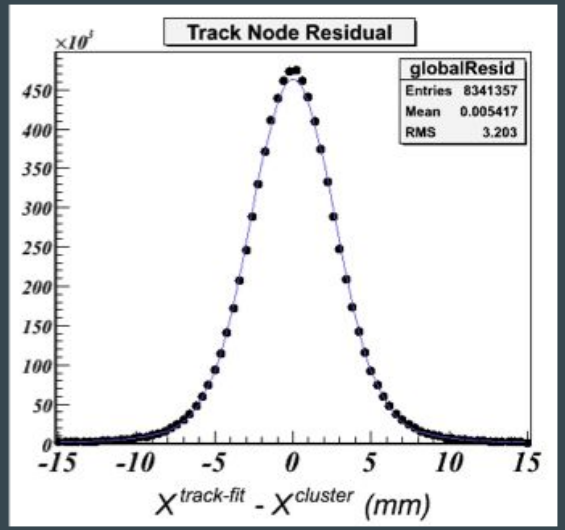
- Maya on "Deep Inelastic Scattering" in nuclear targets
- Noah on world's first neutrino scattering measurement on liquid helium.

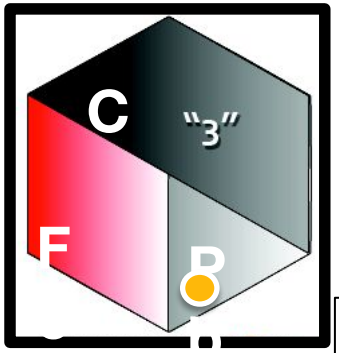
Backup

Tracking resolution



Forward-going track position resolution: ~3mm

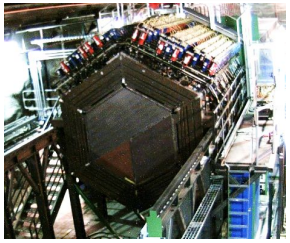


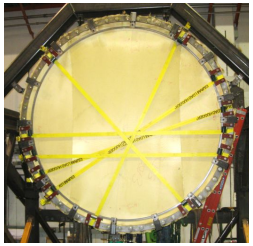


1" Fe / 1" Pb
323kg / 264kg

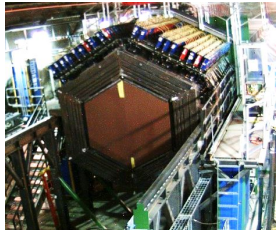
1" Pb / 1" Fe
266kg / 323kg

3" C / 1" Fe /
1" Pb
166kg /
169kg /
121kg

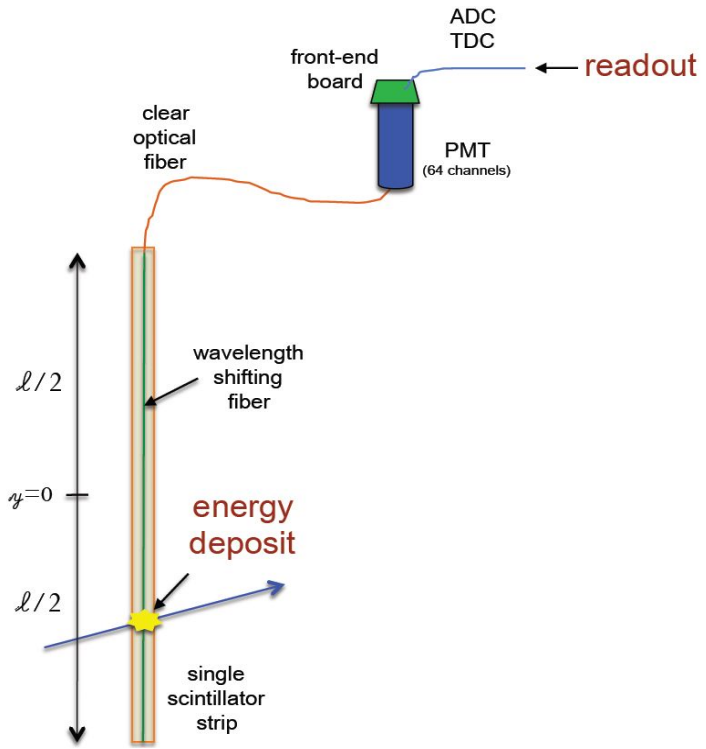




0.3" Pb
228kg



.5" Fe / .5" Pb
161kg/ 135kg


ADC
TDC
front-end
board
readout
clear
optical
fiber
PMT
(64 channels)
wavelength
shifting
fiber
$\ell/2$
$y=0$
energy
deposit
$\ell/2$
single
scintillator
strip