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ArgonCube

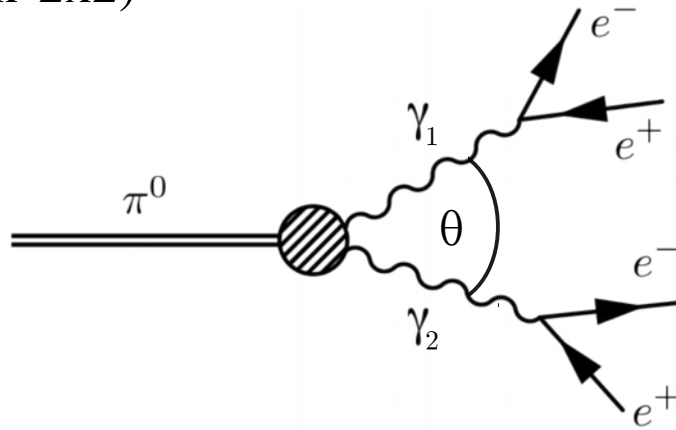
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π^0 studies with ArgonCube 2x2 in NuMI

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Motivation

Calibrating electron energy scale using $\pi^0 \rightarrow \gamma + \gamma$ events
(which are contained in 2x2)



Total π^0 energy goes into showers (back-to-back γ 's in CM frame)
→ Angle between γ 's allows for π^0 kinetic energy reconstruction:

$$|\vec{p}_{\pi^0}| = m_{\pi^0} \cdot \sqrt{\frac{2}{((1-\alpha^2) \cdot (1-\cos(\theta)))}}$$

$$\alpha = \frac{|E_{\gamma_1} - E_{\gamma_2}|}{E_{\gamma_1} + E_{\gamma_2}}$$

Simulation Tools

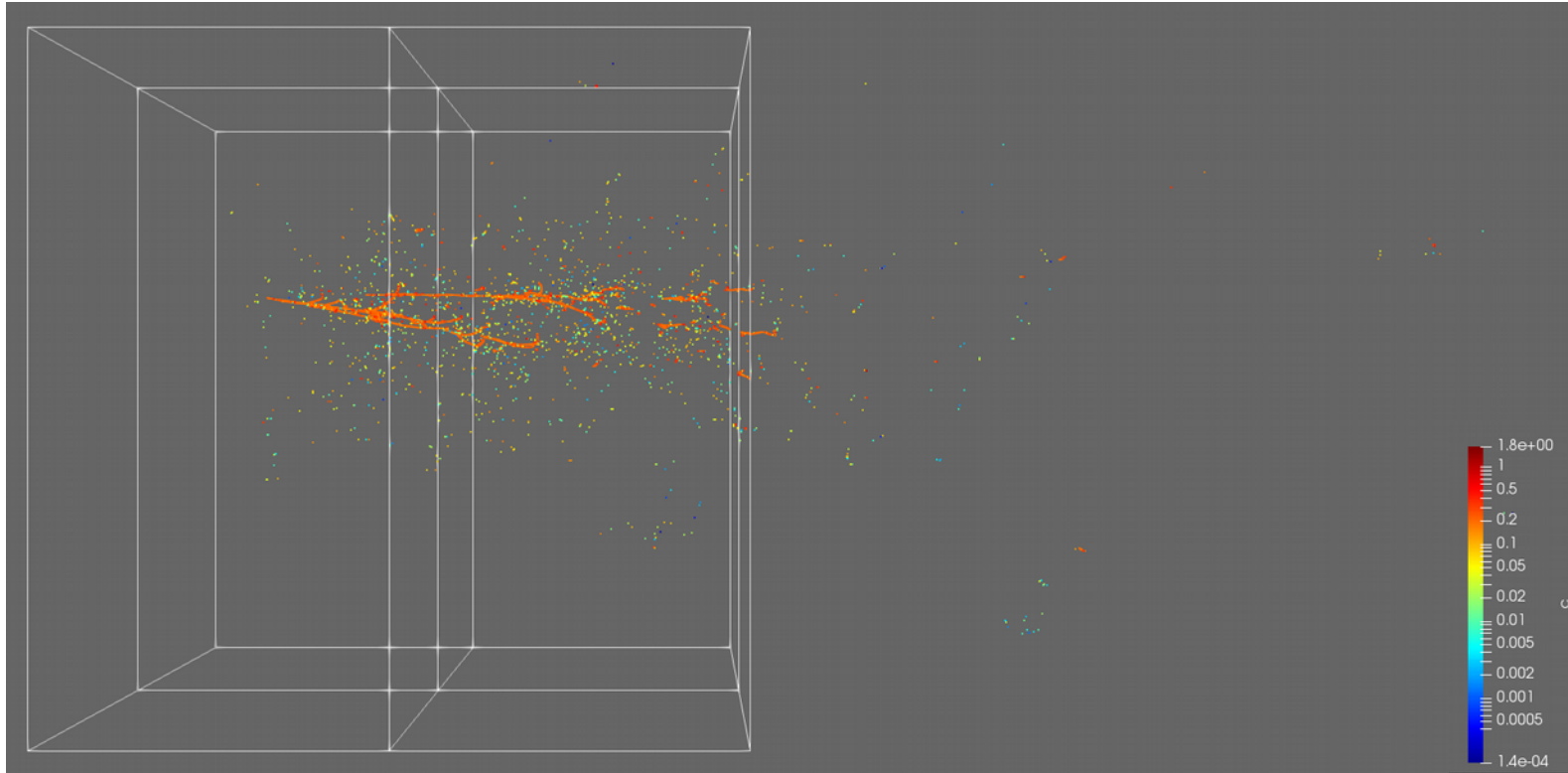
C. Marshall provided ROOT files with simulated ν_μ interactions in argon (used D. Dwyer's [argonbox](#))

→ From this files: Produced π^0 trees with relevant informations



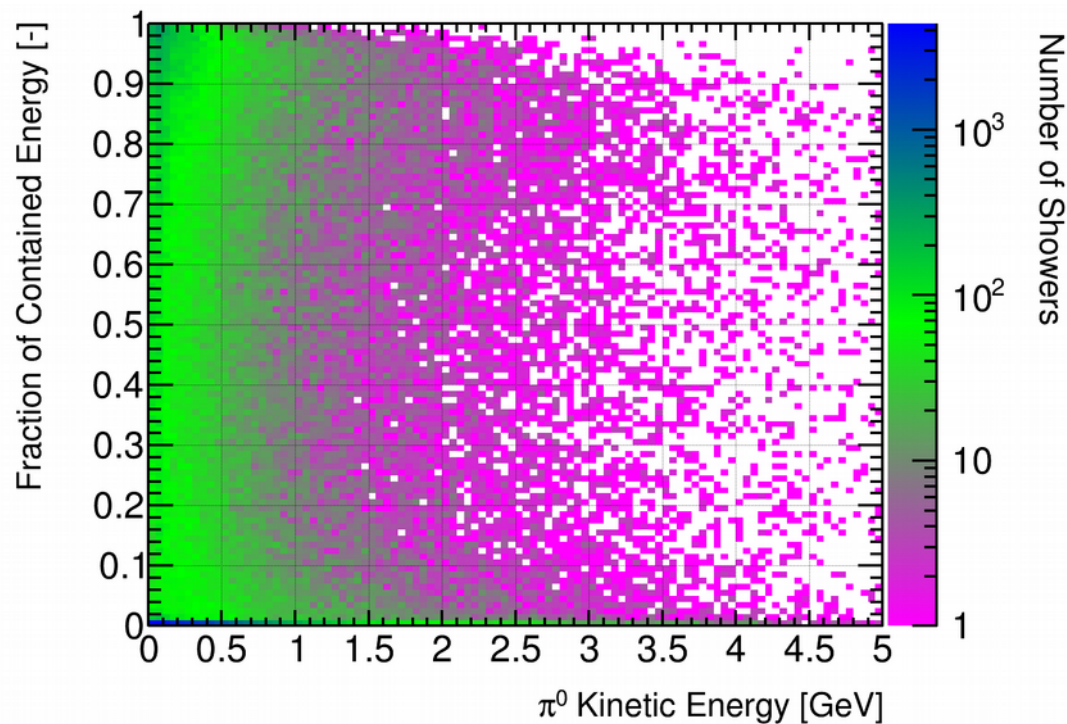
Contained π^0 induced Shower

Contained: If Shower's fraction of contained energy > 0.9



Energy Containment of π^0

Fraction of Contained Energy $\stackrel{\text{def}}{=} \frac{\sum \text{Energy Deposits in } 2 \times 2 \text{ Active Volume}}{E_{\text{tot}} \text{ of } \pi^0}$

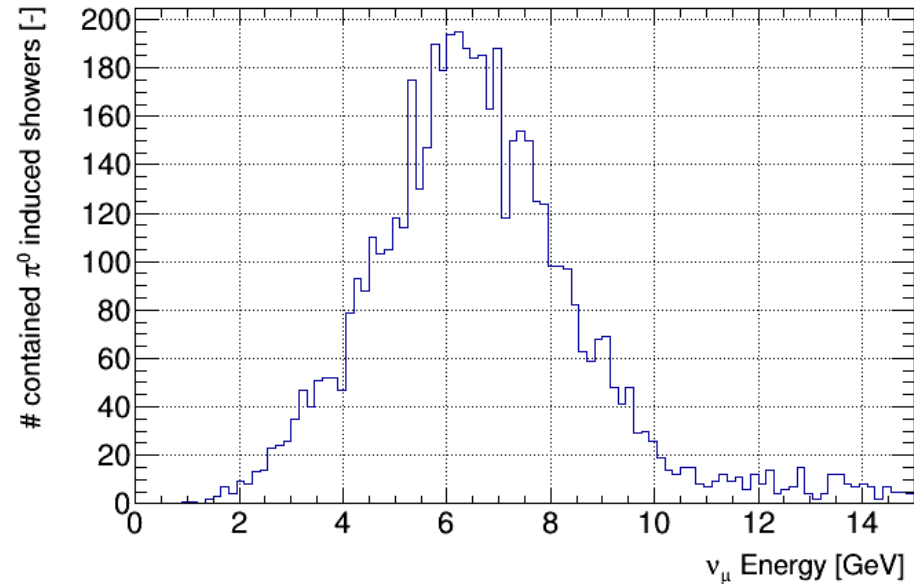
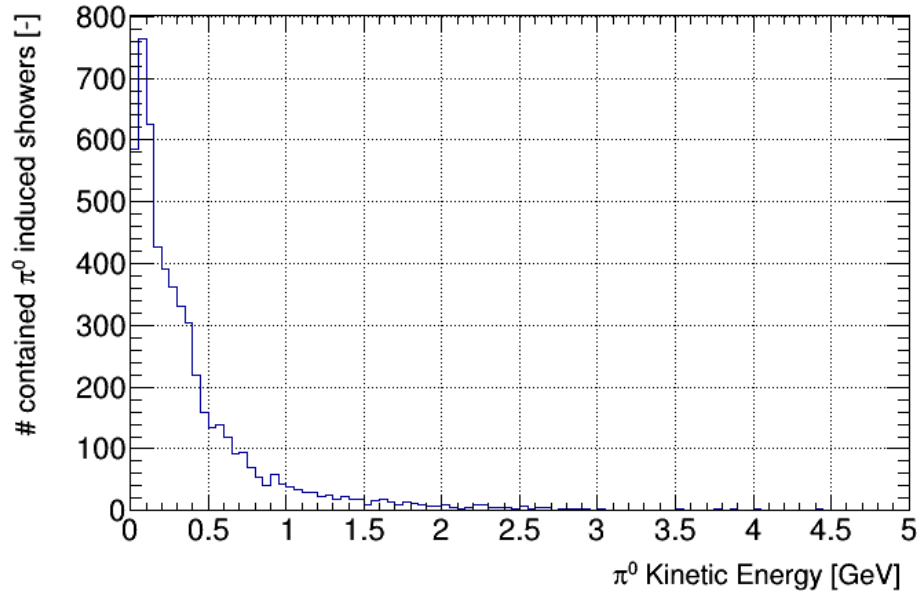


Stat: 120'000 ν_μ interactions

Active Volume = $(1.4\text{m})^3 \rightarrow$ No fiducialisation applied

Energy Spectra of Contained Showers

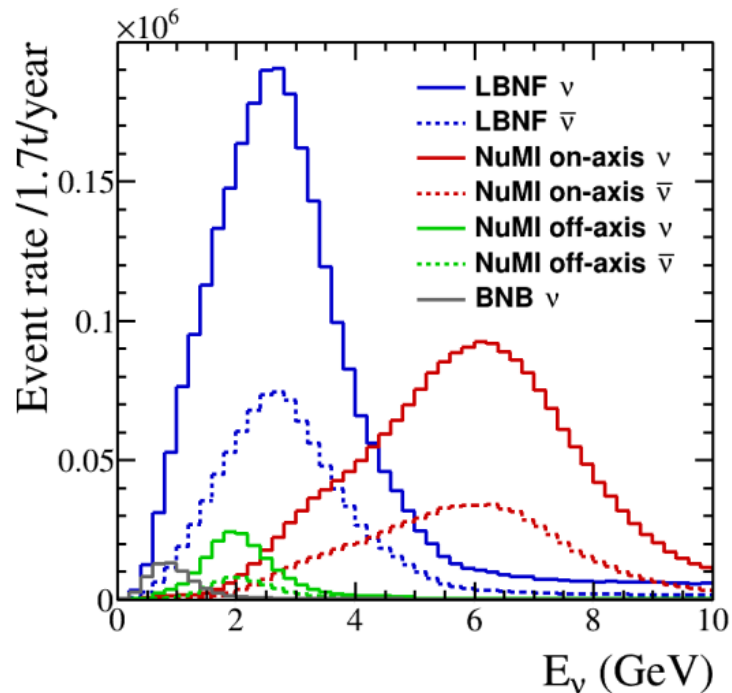
Contained: If Shower's fraction of contained energy > 0.9



Stat: 120'000 ν_μ interactions
Active Volume = $(1.4\text{m})^3$

Next: Expected rate of contained “ π^0 -showers” for 2x2 in NuMI

Event Rates in NuMI ND Hall



→ Determine expected event rate of π^0 induced showers which are contained in 2x2

D. Goeldi: π^0 pile-up study for the DUNE ND:

His approach: Using 3D space, Cylinder + Cone around EM showers

→ Will use this code to **reconstruct angle** between γ 's
and deposited energy for each shower

Machine Learning (working together with Kazu):

→ In order to **find π^0 induced showers in data**

Backup

$$\begin{aligned} \text{Fraction of contained energy} &\stackrel{\text{def}}{=} \frac{\text{total energy in 2x2}}{\text{total energy of } \pi^0} \\ &= \frac{\sum \text{Energy Deposits in 2x2} + \sum E_{tot} \text{ of particles remaining after shower}}{E_{tot} \text{ of } \pi^0} \end{aligned}$$

\geq

$$\frac{\sum \text{Energy Deposits in 2x2}}{E_{tot} \text{ of } \pi^0}$$

Lower limit for the energy containment

Note: Detector efficiency not taken into account