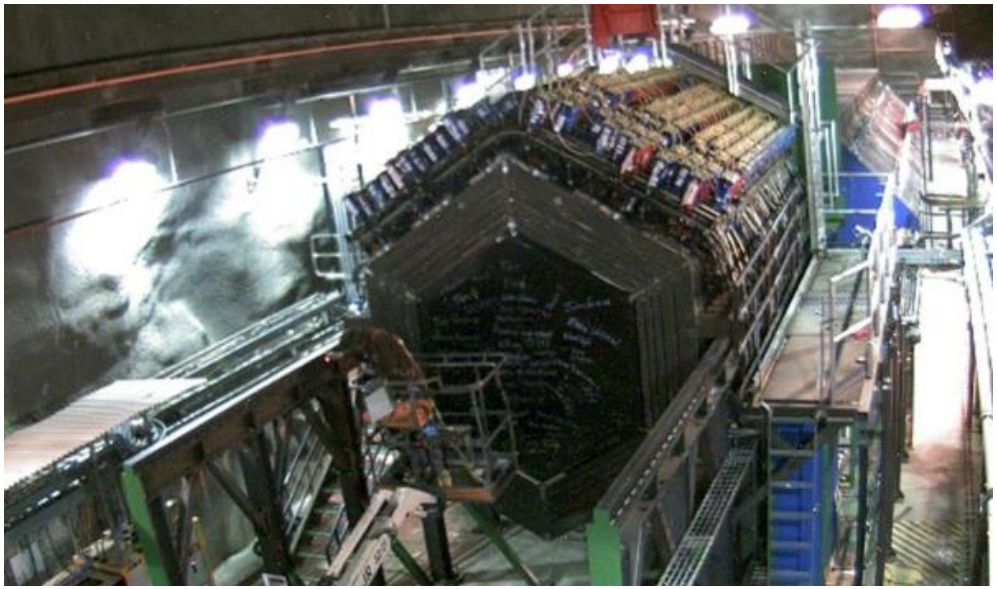
QuarkNet

# MINERvA Masterclass (Abbreviated)



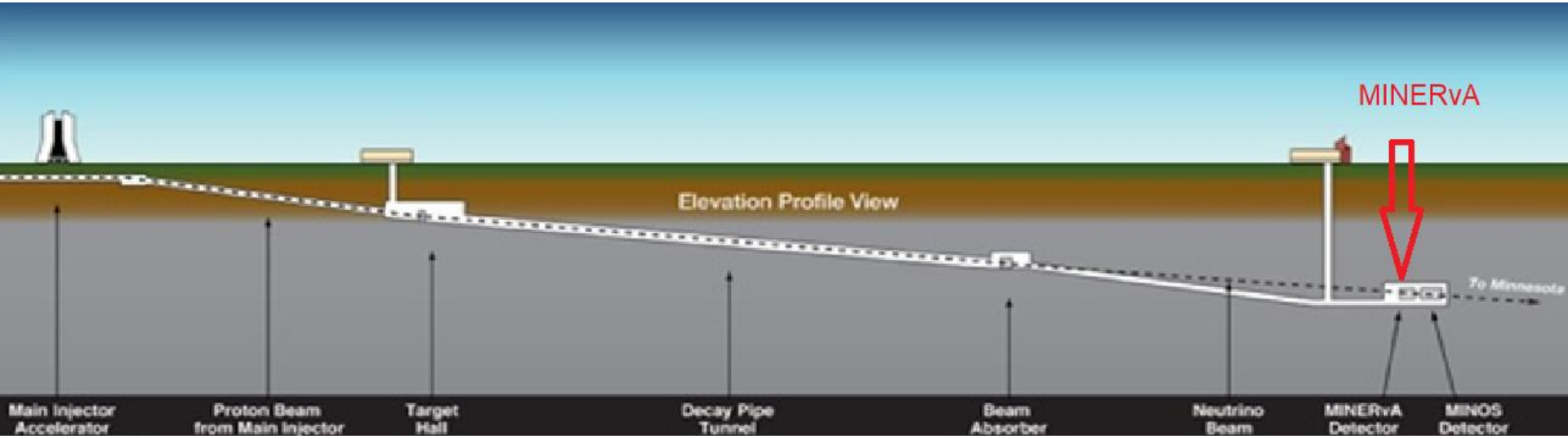
MINERvA

INTERNATIONAL MASTERCLASSES
hands on particle physics

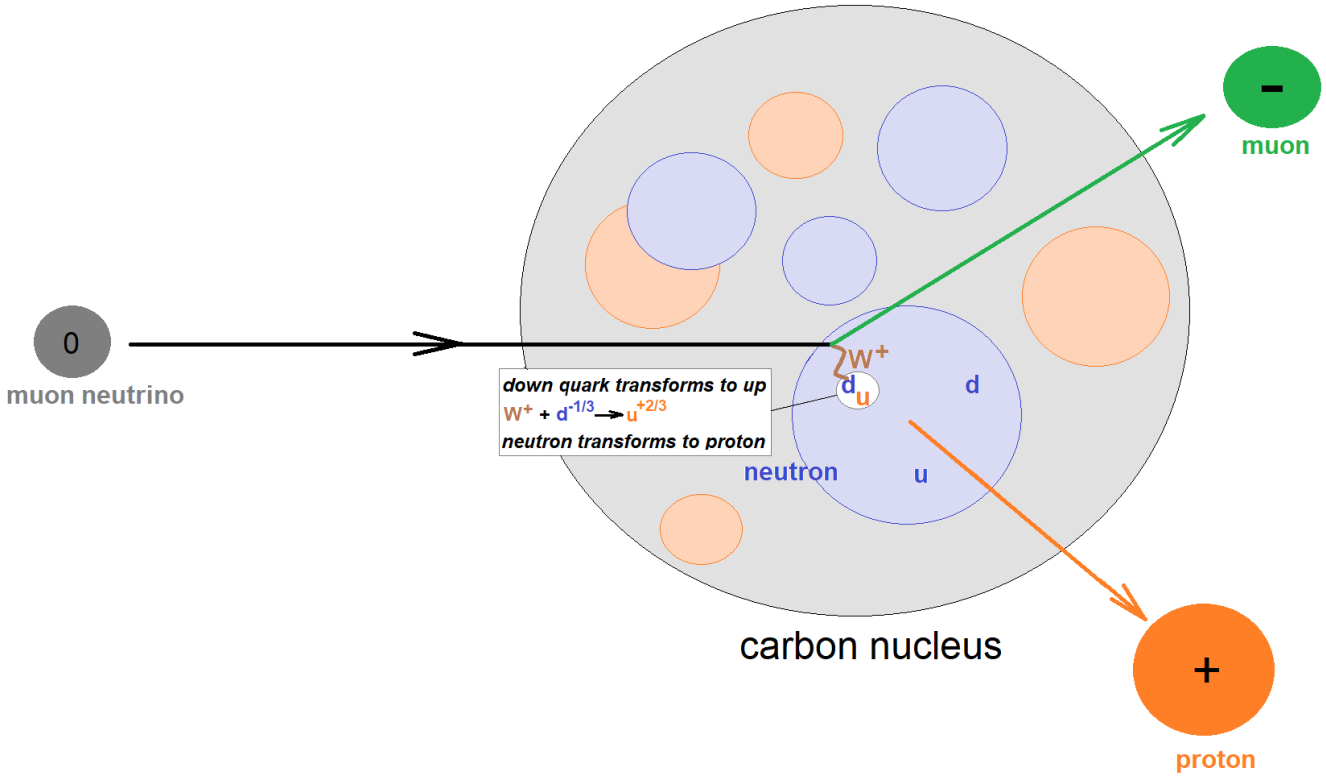
NSF

Fermilab

# The MINERvA Detector



# The Interaction




A muon neutrino interacts with a carbon nucleus. The interaction results in a muon and a proton that are ejected from the nucleus. **What happens to the momentum initially carried by the muon neutrino?**

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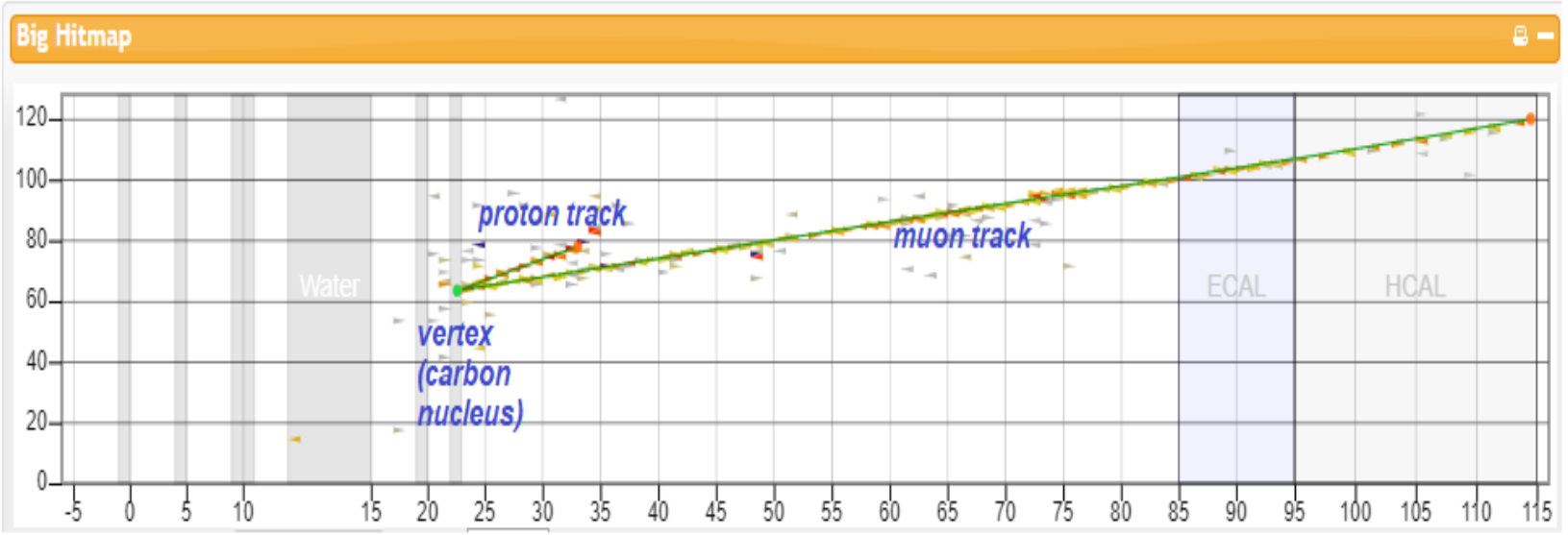
# Measurement



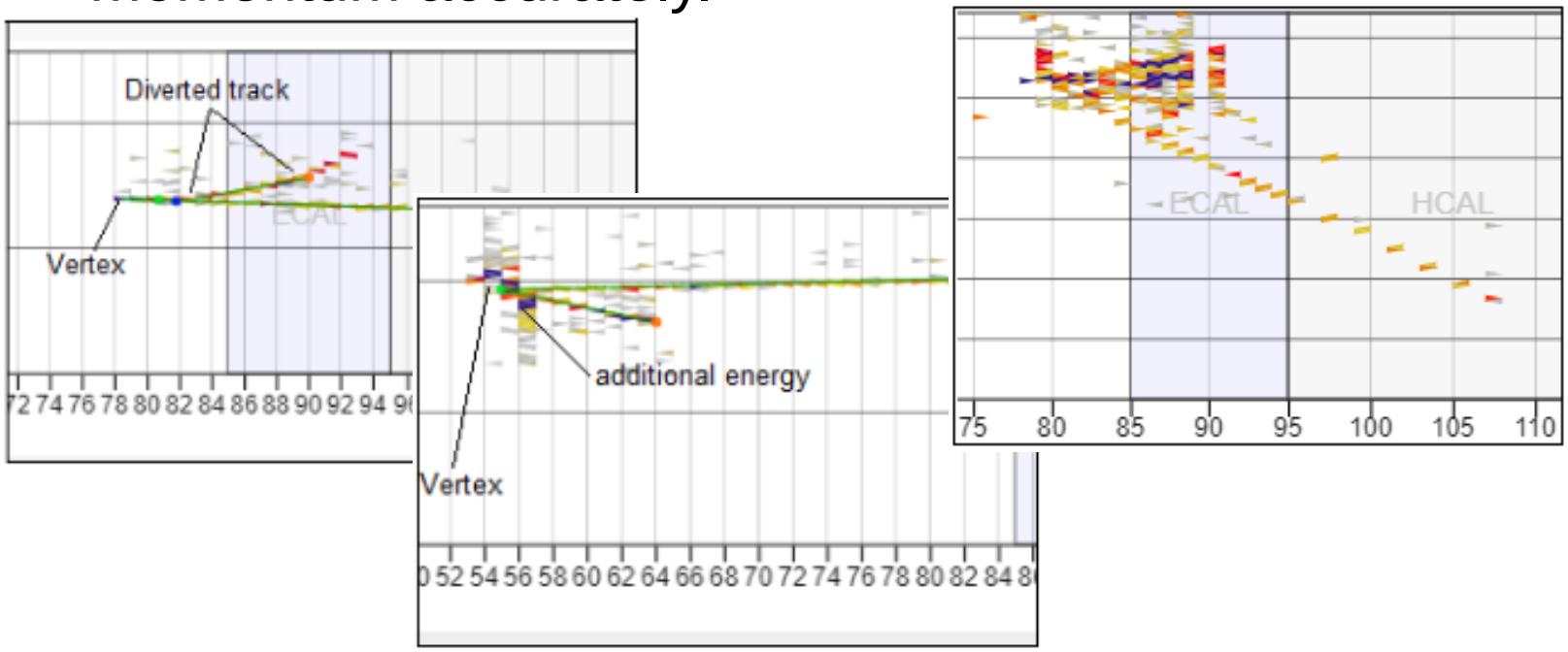

**Neutrino (no track) → proton + muon**

*MINERvA can measure the momentum of both the proton and muon.*

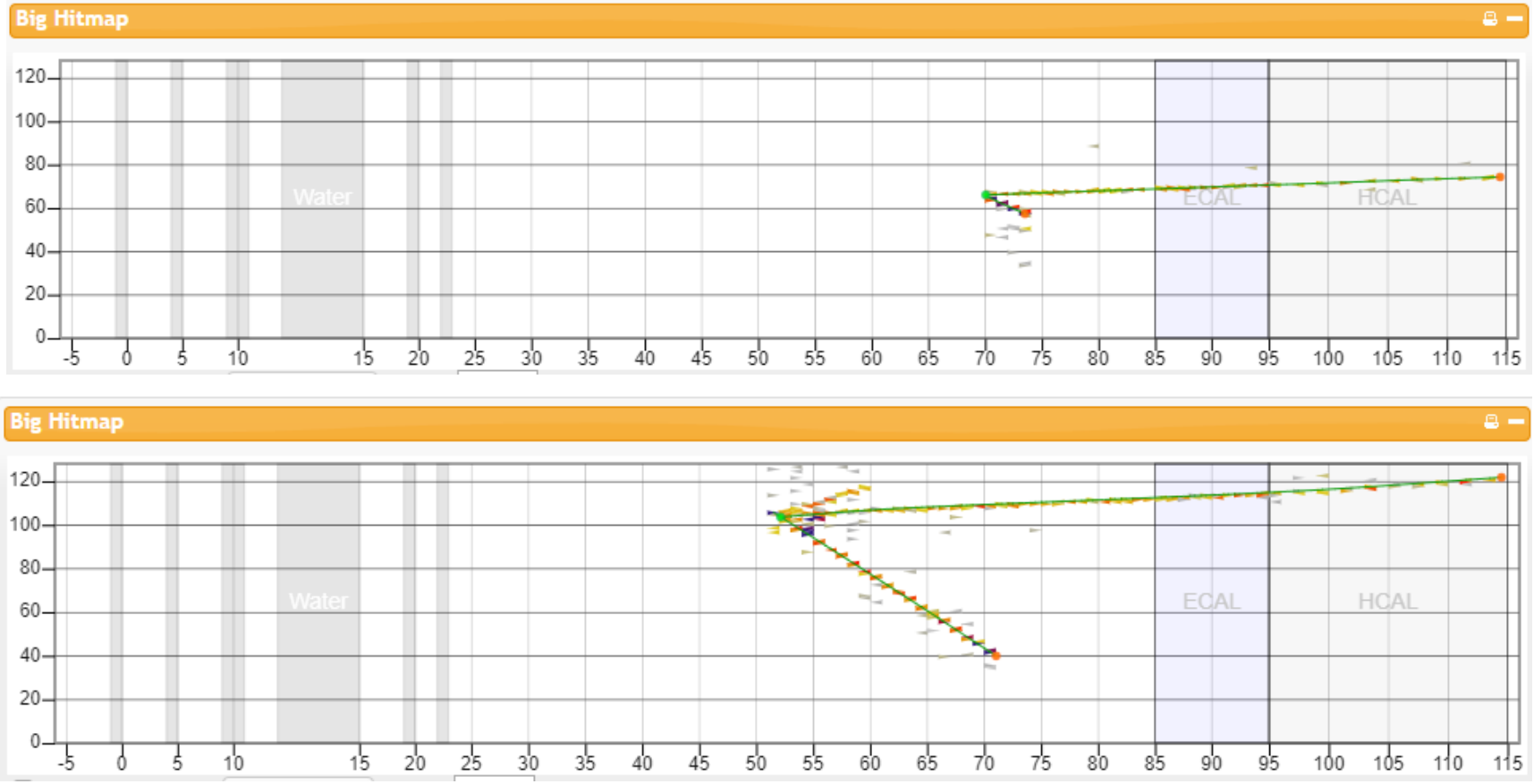
# Signal vs. Background

Background events:

- Do not fit signal paradigm of one short proton track, one long muon track, or
- Confound the ability of MINERvA to measure momentum accurately.

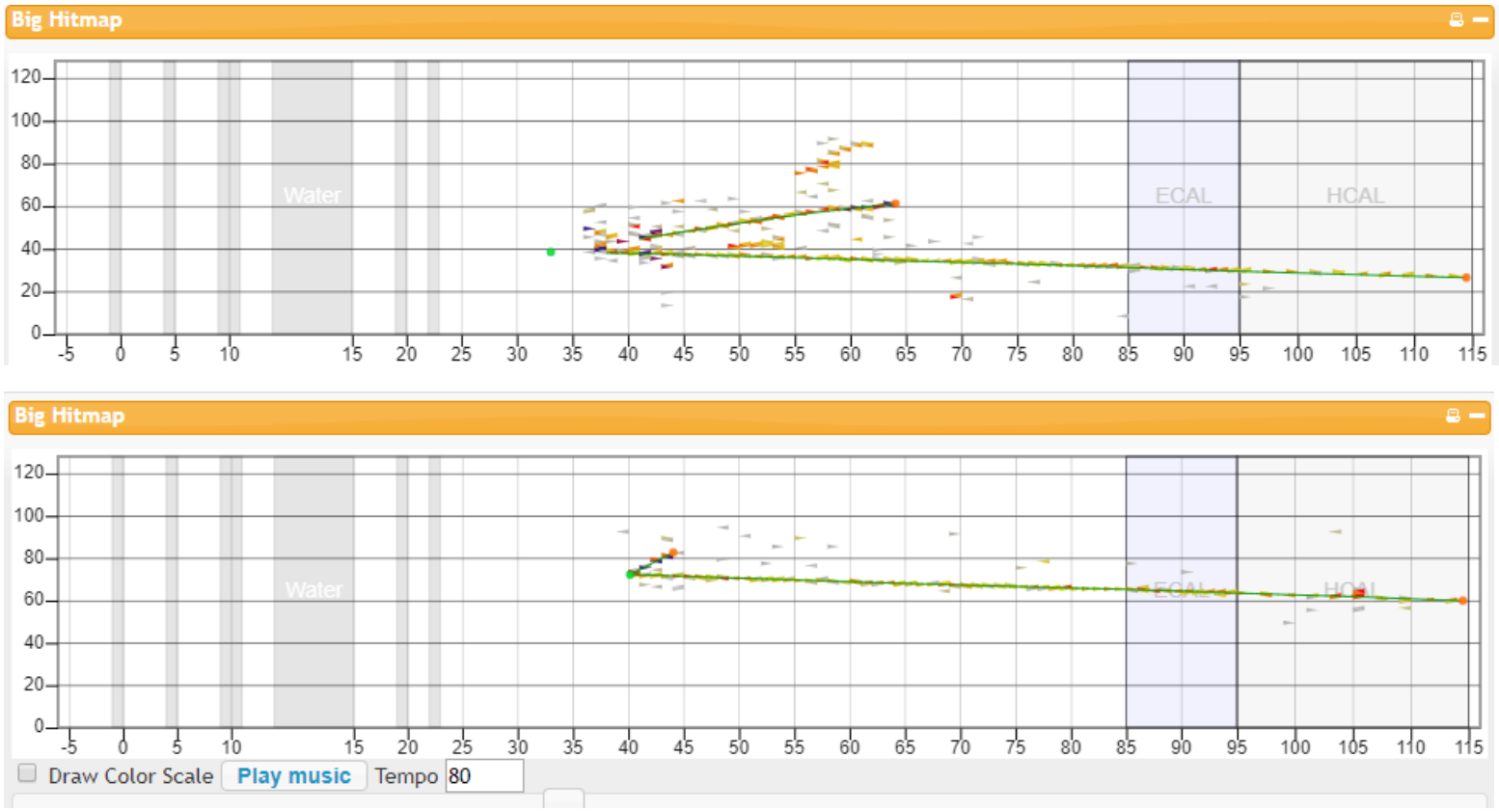


# Signal vs. Background



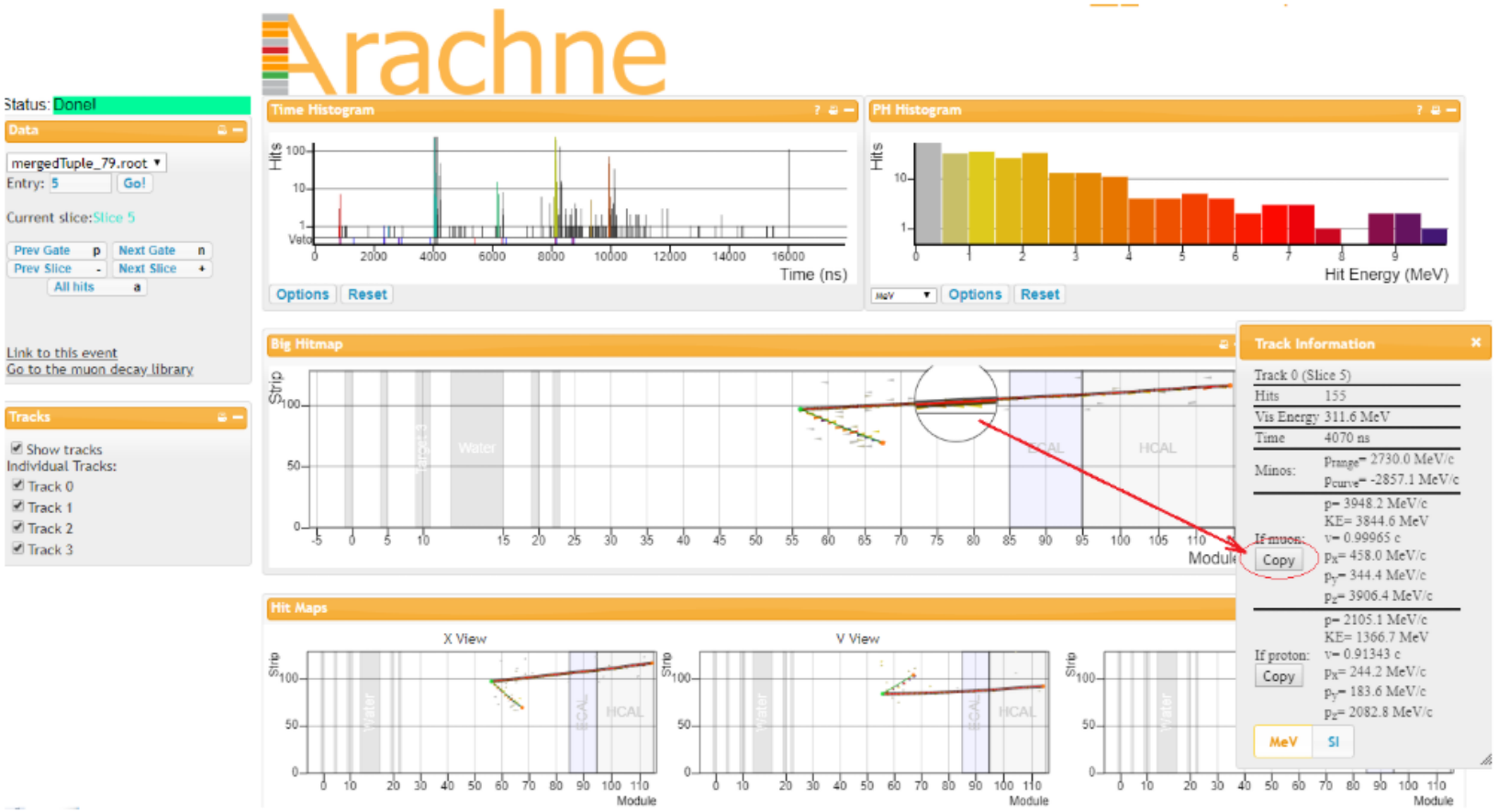

One of these is signal, one is background. Which is which? Why?

# Signal vs. Background




One of these is signal, one is background. Which is which? Why?

# Measure signal in Arachne



# Transfer to spreadsheet

| | merged | | Background | Zoo | Muon | | | | | Proton | | | | | Net |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tuple | Entry | (enter a 1) | (enter a 1) | KE (MeV) | v/c | px (MeV/c) | py (MeV/c) | pz (MeV/c) | KE (MeV) | v/c | px (MeV/c) | py (MeV/c) | pz (MeV/c) | px (Me |
| 154 | 78 | 38 | | | 2,468.00 | 0.99917 | 127.87 | -451.51 | 2,527.66 | 250.63 | 0.61 | 282.26 | 73.04 | 669.32 | |
| 155 | 78 | 39 | | | 4,180.98 | 0.9997 | -290.25 | 322.75 | 4,262.65 | 4,180.98 | 1 | -290.25 | 322.75 | 4,262.65 | |
| 156 | 78 | 40 | | | 2,783.10 | 0.99934 | -181.33 | -468.2 | 2,842.18 | 299.54 | 0.65 | 40.96 | 609.33 | 527.92 | |
| 157 | 78 | 41 | | | | | | | | | | | | | |
| 158 | 78 | 42 | | | 3,467.68 | 0.99957 | 311.9 | -624.25 | 3,502.30 | 1,219.51 | 0.9 | 169.69 | -339.63 | 1,905.48 | |
| 159 | 78 | 43 | | | 6,862.50 | 0.99989 | 579.99 | -95.45 | 6,941.86 | 330.54 | 0.67 | -61.04 | 308.27 | 794.1 | |
| 160 | 78 | 44 | | | 70.27 | 0.80069 | 56.54 | -31.5 | 124.52 | 158.34 | 0.52 | 228.67 | -127.41 | 503.58 | |
| 161 | 78 | 45 | | | 4,687.34 | 0.99976 | -602.76 | -335.44 | 4,741.27 | 158.34 | 0.52 | 228.67 | -127.41 | 503.58 | |
| 162 | 78 | 46 | | | 2,879.91 | 0.99938 | -369.07 | -127.86 | 2,957.39 | 1,286.94 | 0.91 | -249.61 | -86.47 | 2,000.18 | |
| 163 | 78 | 47 | | | 3,890.06 | 0.99965 | -295.93 | 433.85 | 3,959.00 | 1,397.32 | 0.92 | -158.47 | 232.33 | 2,120.09 | |
| 164 | 78 | 48 | | | 5,784.31 | 0.99984 | 370.25 | -586.18 | 5,847.42 | 169.58 | 0.53 | -246.29 | 271.65 | 460.9 | |
| 165 | 78 | 49 | | | 3,074.27 | 0.99945 | -228.59 | -303.83 | 3,154.71 | 1,432.36 | 0.92 | -156.6 | -208.15 | 2,161.23 | |
| 166 | 78 | 50 | | | 5,756.19 | 0.99984 | 326.56 | -411.38 | 5,836.67 | 5,784.31 | 1 | 370.25 | -586.18 | 5,847.42 | |
| 167 | | | | | | | | | | | | | | | |
| 168 | | | | | | | | | | | | | | | |
| 169 | | | | | | | | | | | | | | | |
| 170 | | | | | | | | | | | | | | | |
| 171 | 79 | 0 | | | | | | | | | | | | | |
| 172 | 79 | 1 | | | 125.64 | 0.89036 | 111.97 | -12.75 | 171.66 | 260.46 | 0.62 | 406.75 | -46.31 | 623.59 | |
| 173 | 79 | 2 | | | | | | | | | | | | | |
| 174 | 79 | 3 | | | 2,745.79 | 0.99932 | -396.07 | -157.98 | 2,816.76 | 1,493.81 | 0.92 | -311.93 | -124.42 | 2,218.35 | |
| 175 | 79 | 4 | | | 235.04 | 0.60049 | 337.93 | -438.13 | 435.93 | 235.04 | 0.6 | 337.93 | -438.13 | 435.93 | |
| 176 | 79 | 5 | | | 3,844.64 | 0.999646564 | 457.9591639 | 344.430018 | 3,906.44 | | | | | | |
| 177 | 79 | 6 | | | | | | | | | | | | | |
| 178 | 79 | 7 | | | | | | | | | | | | | |
| 179 | 79 | 8 | | | | | | | | | | | | | |
| 180 | 79 | 9 | | | | | | | | | | | | | |
| 181 | 79 | 10 | | | | | | | | | | | | | |
| 182 | 79 | 11 | | | | | | | | | | | | | |
| 183 | 79 | 12 | | | | | | | | | | | | | |
| 184 | 79 | 13 | | | | | | | | | | | | | |

mergedTuples1to25 | mergedTuples26to50 | Copy of mergedTuples51to100 | videocon plots

# What do we know?

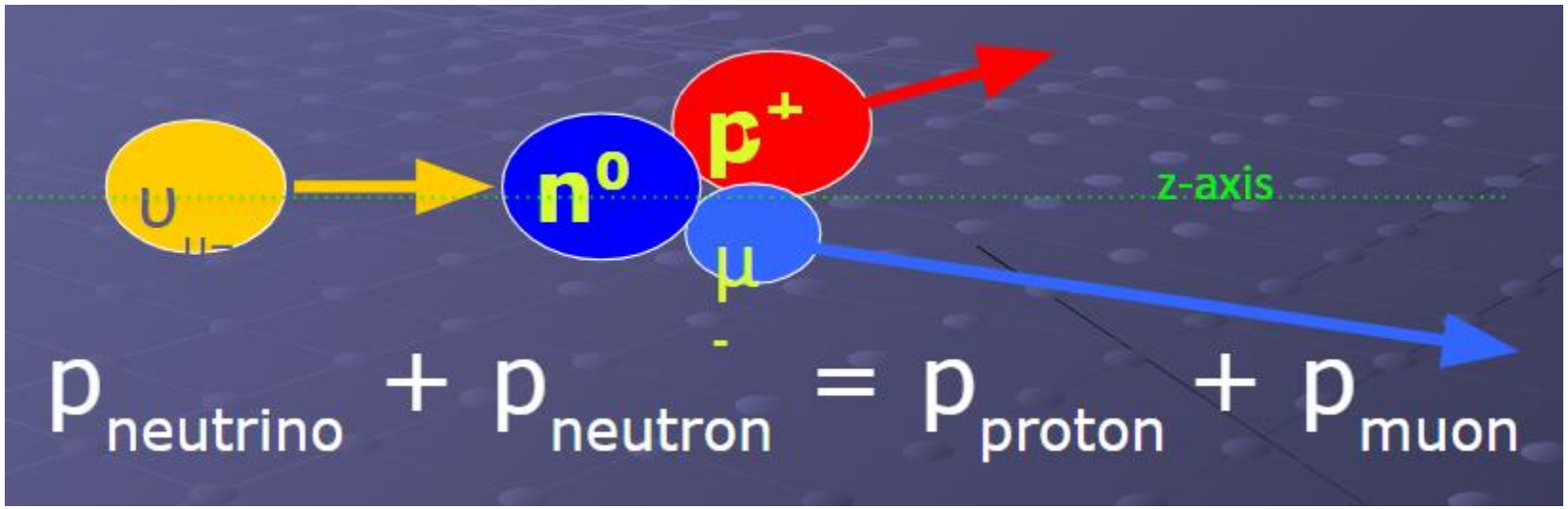
**Conservation of Momentum**

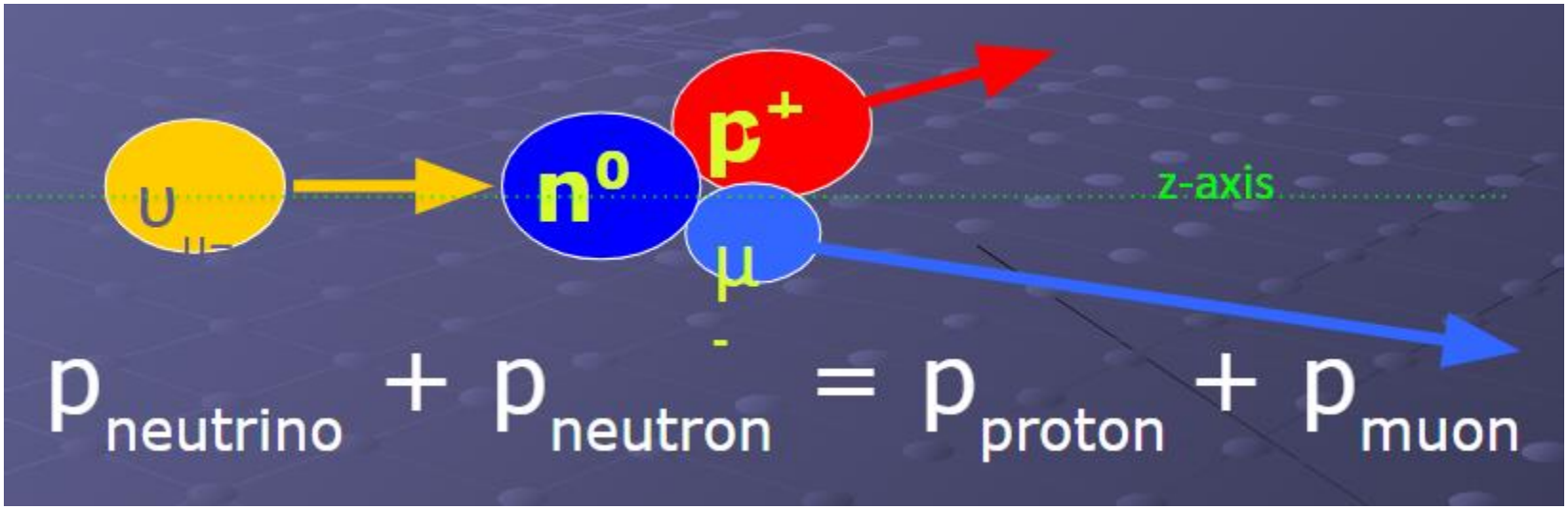
Initial momentum:

- $p_\nu$ all in z (beam) direction

Final momentum:

- $p_z = p_{zp} + p_{z\mu}$
- $p_x = p_{xp} + p_{x\mu}$
- $p_y = p_{yp} + p_{y\mu}$



# What will we investigate?

- If we measure final $p_x$ , $p_y$ , and $p_z$ for many events in MINERvA, what do we get? Why?
- What does this imply?