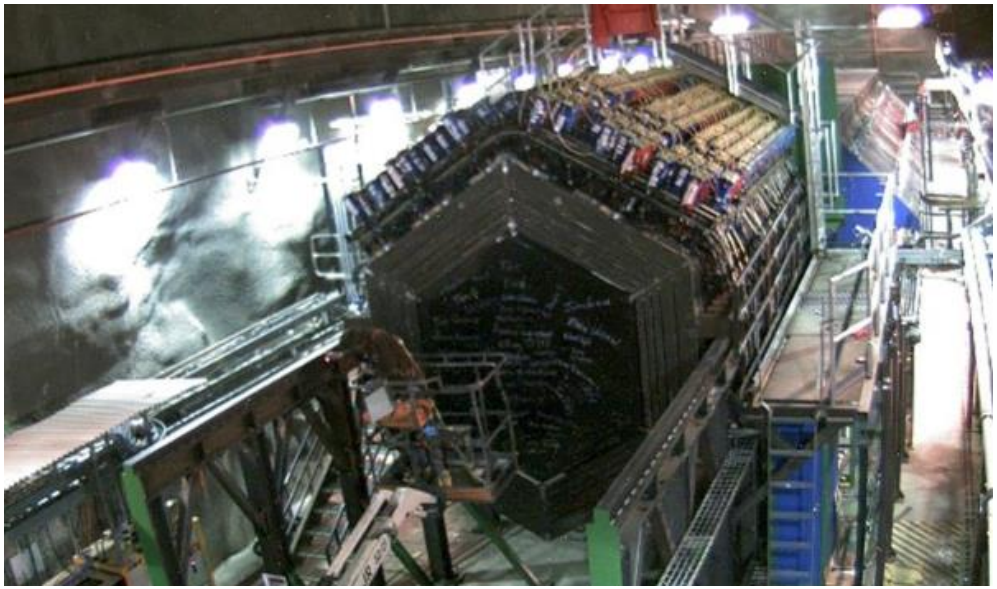
QuarkNet

MINERvA Masterclass Start-up



MINERvA

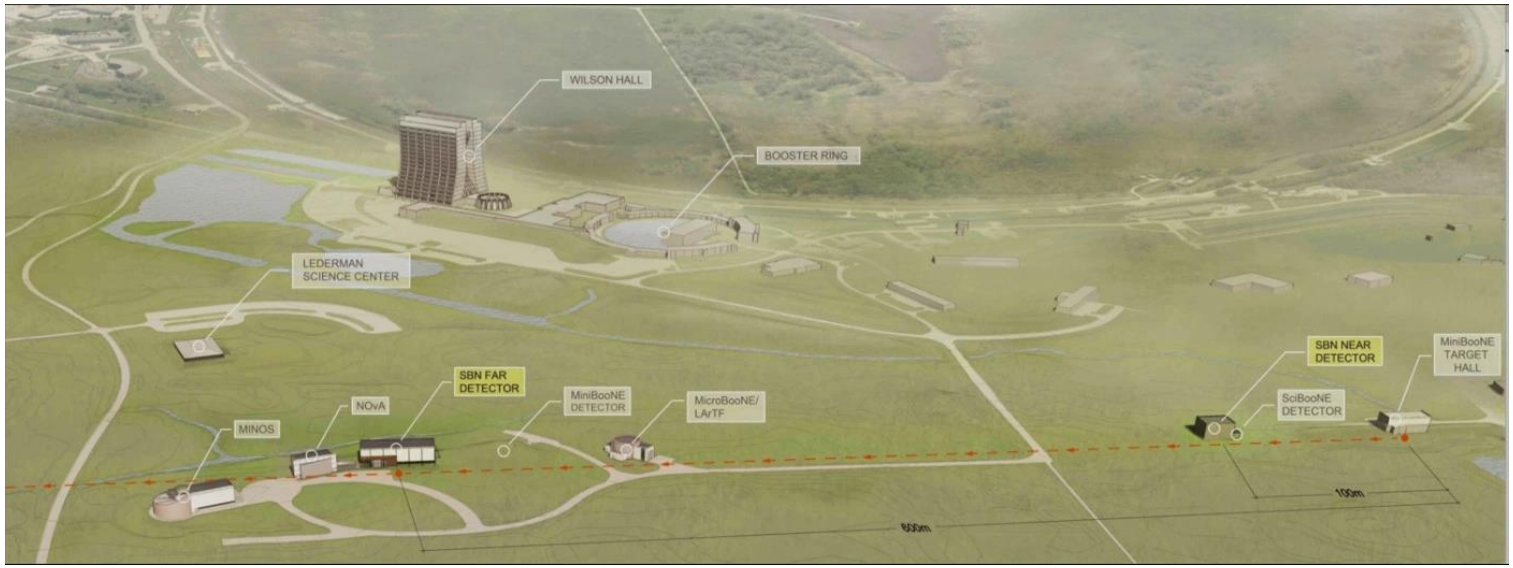
INTERNATIONAL MASTERCLASSES
hands on particle physics

NSF

Fermilab

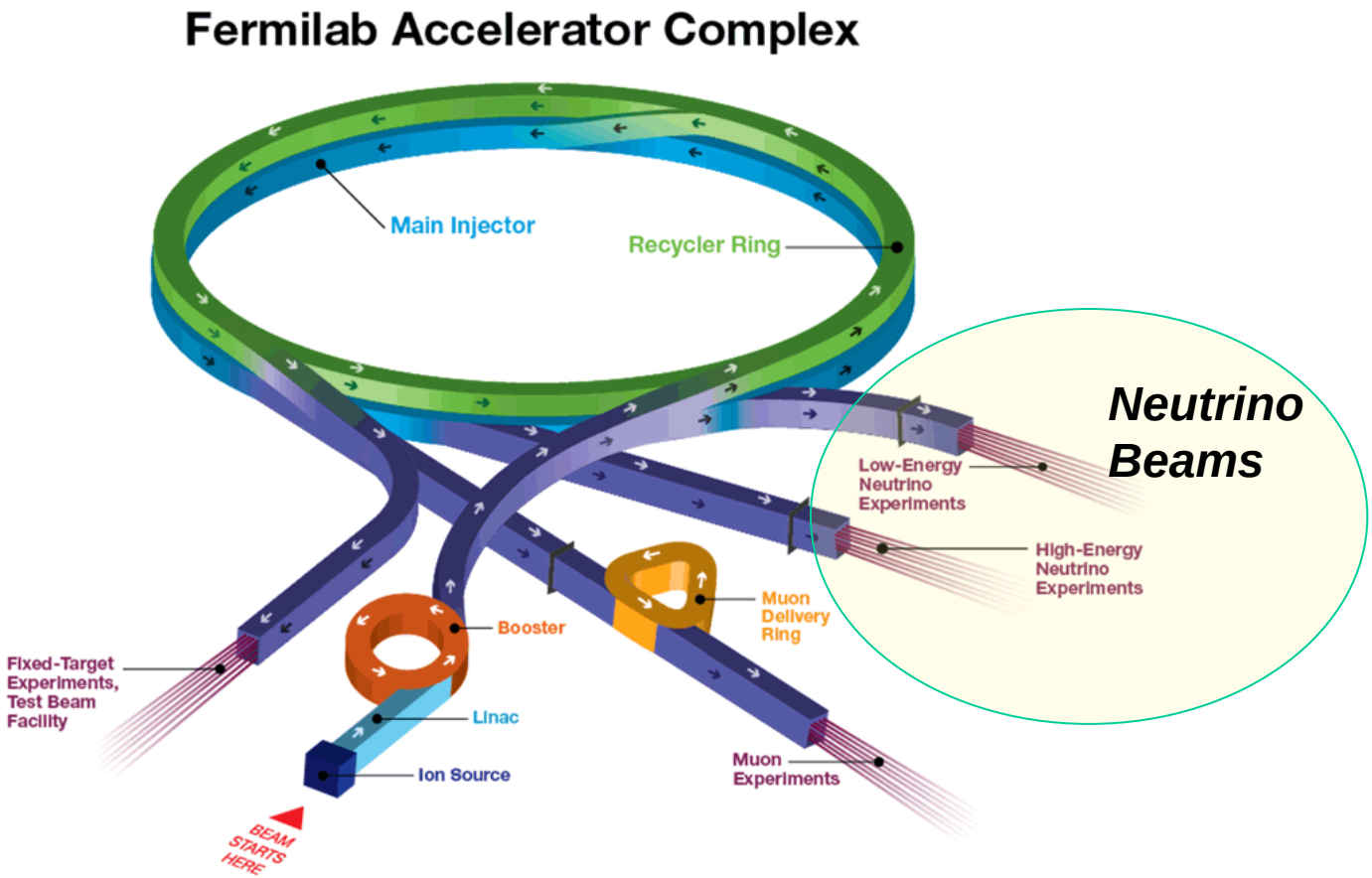
QuarkNet

Fermilab

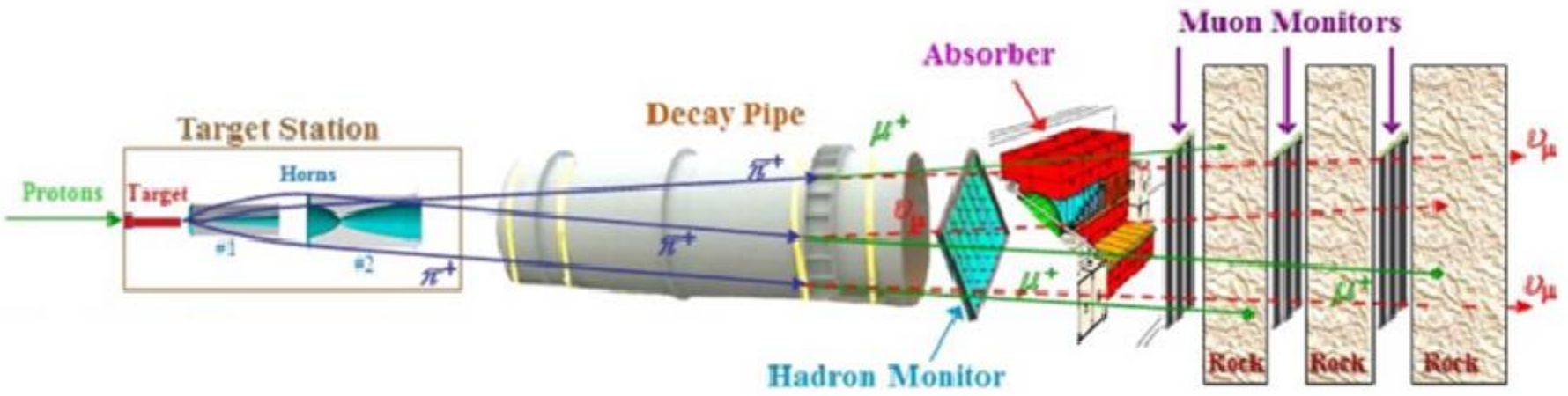


The Fermi National Accelerator Laboratory (Femilab) is the place to be to study neutrinos. The short- and long-baseline programs investigate all sorts of neutrino behaviors and shed light on the nature of the universe.

Fermilab


Fermilab Accelerator Complex
Main Injector
Recycler Ring
Neutrino Beams
Low-Energy Neutrino Experiments
High-Energy Neutrino Experiments
Muon Delivery Ring
Booster
Fixed-Target Experiments, Test Beam Facility
Linac
Ion Source
Muon Experiments
BEAM STARTS HERE

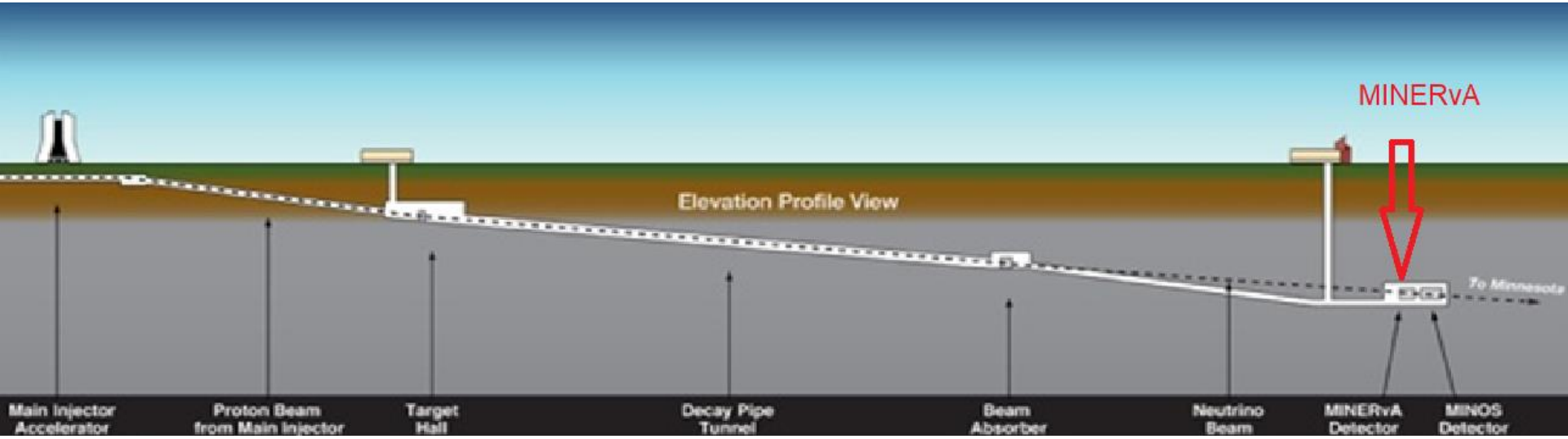
MINOS and MINERvA



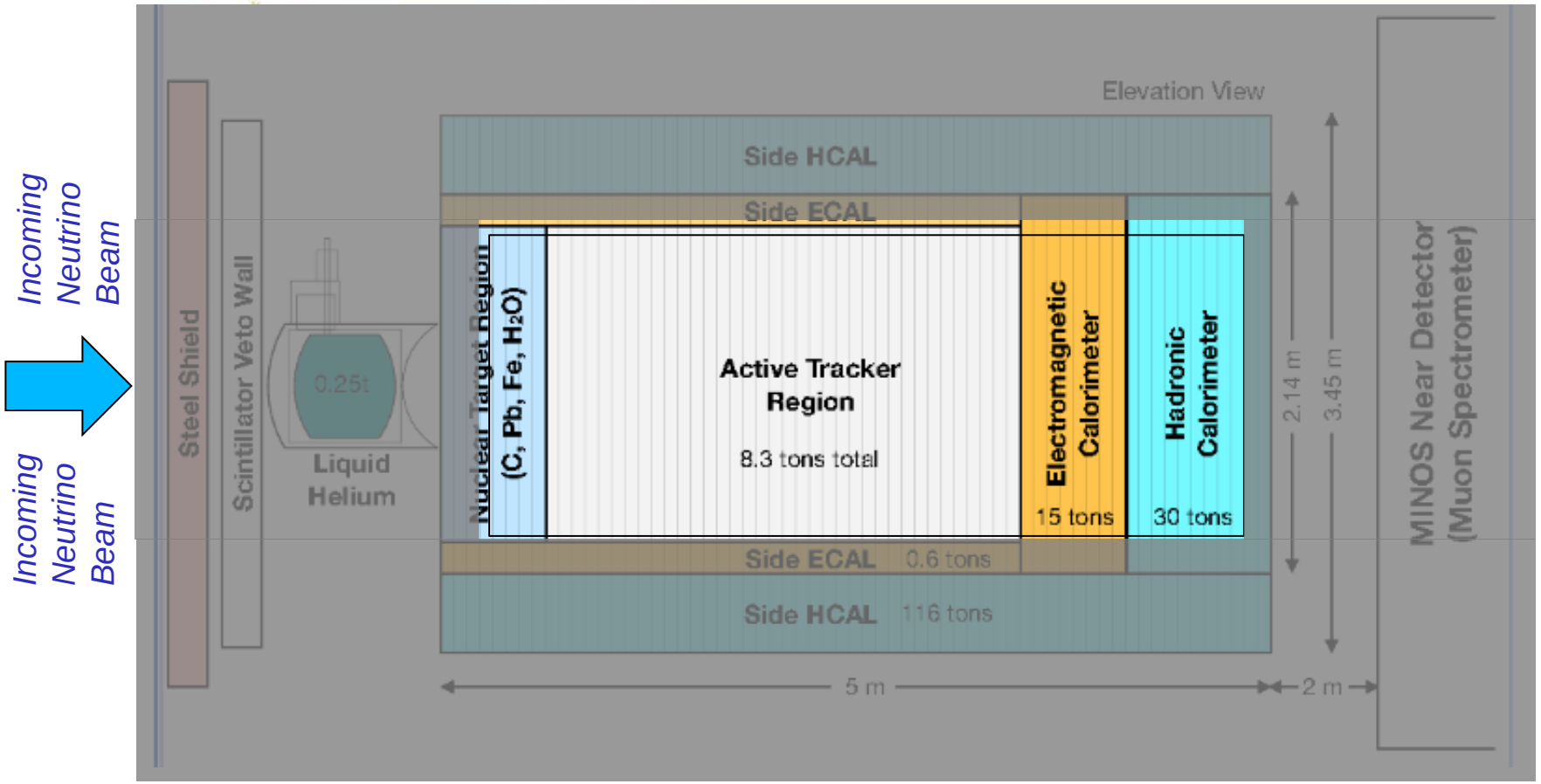
protons → target → pions → muons + neutrinos → neutrino beam

Video Options: *How to Make a Neutrino Beam (cartoon) OR How do You Make a Neutrino Beam? (Don Lincoln)*

The MINERvA Detector

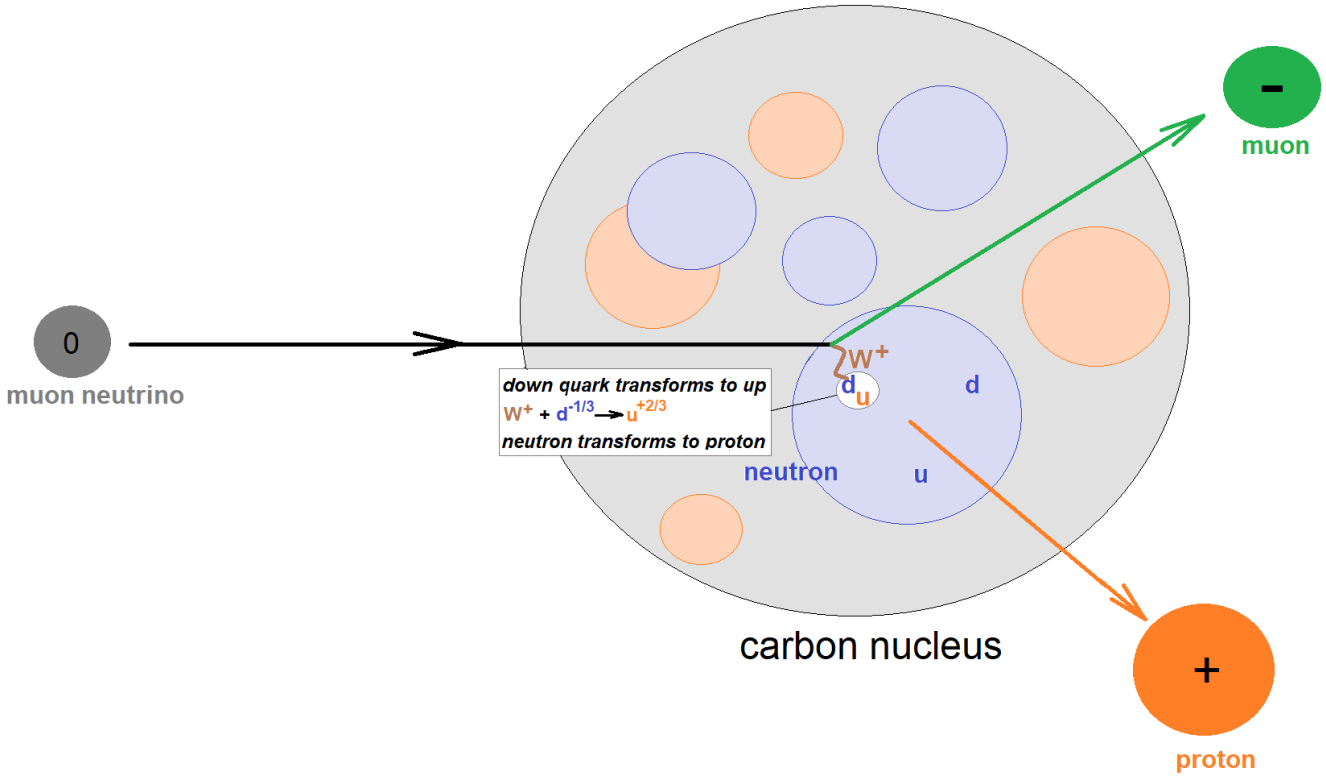


MINERvA – Our interaction zone



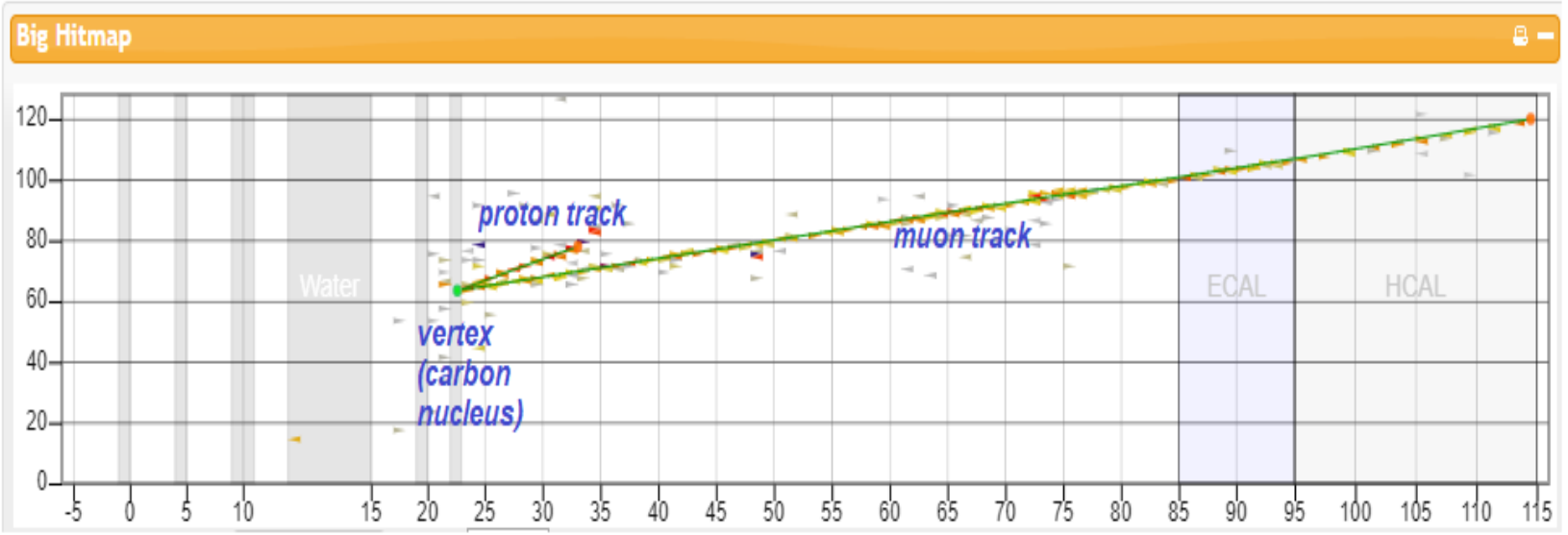
Muon neutrinos hit the carbon target. MINERvA measures the products of the interaction.

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?**

Measurement



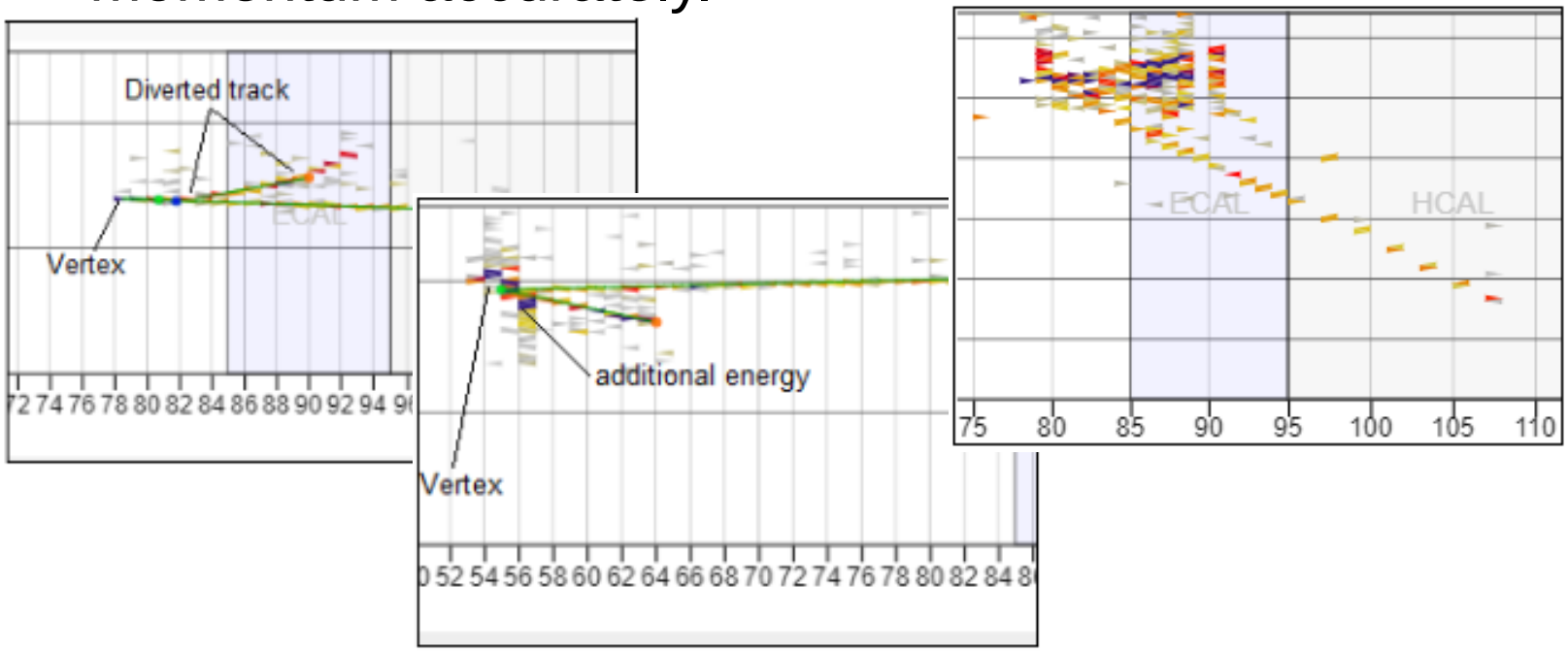
Neutrino (no track) → proton + muon

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

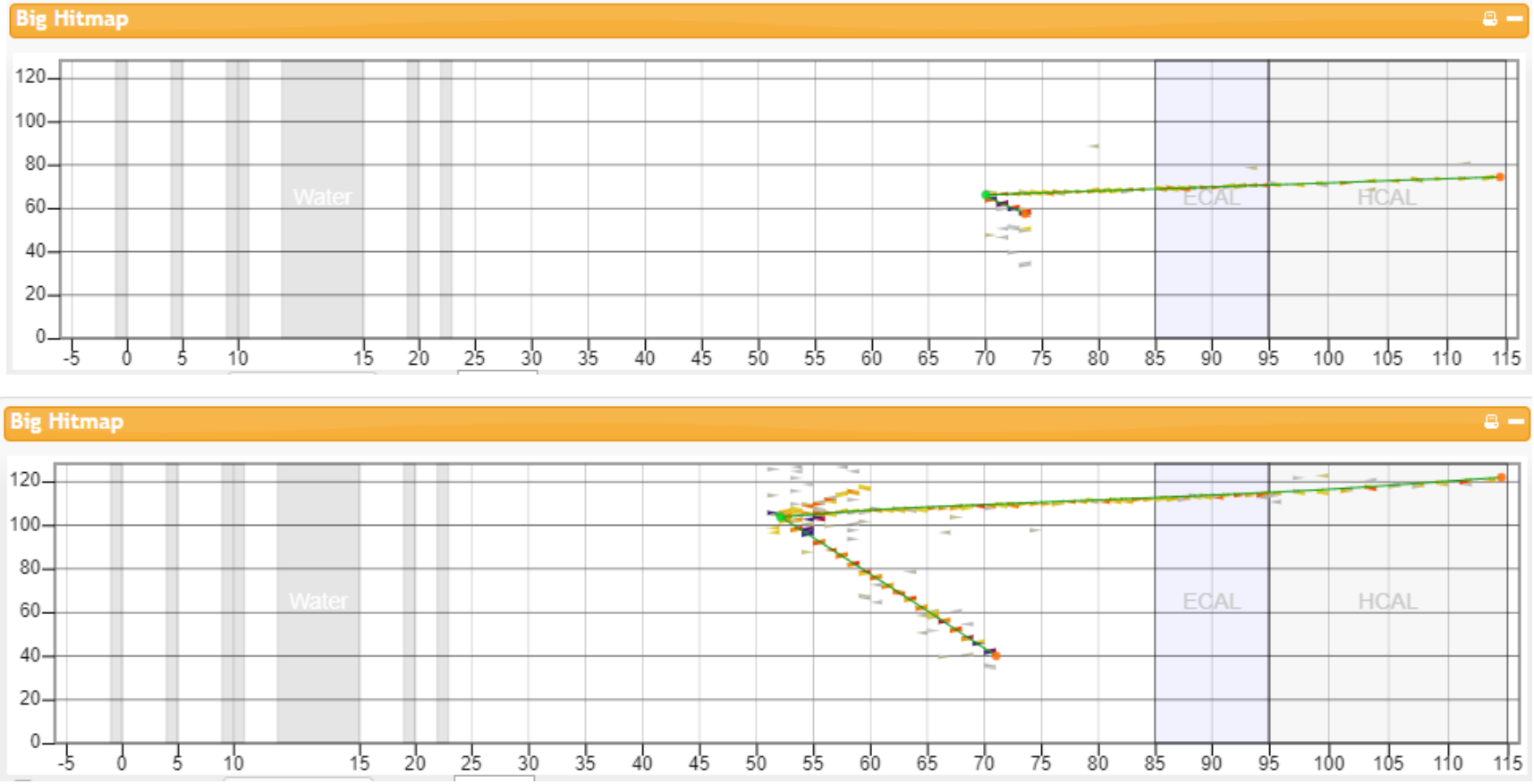
Signal vs. Background

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.

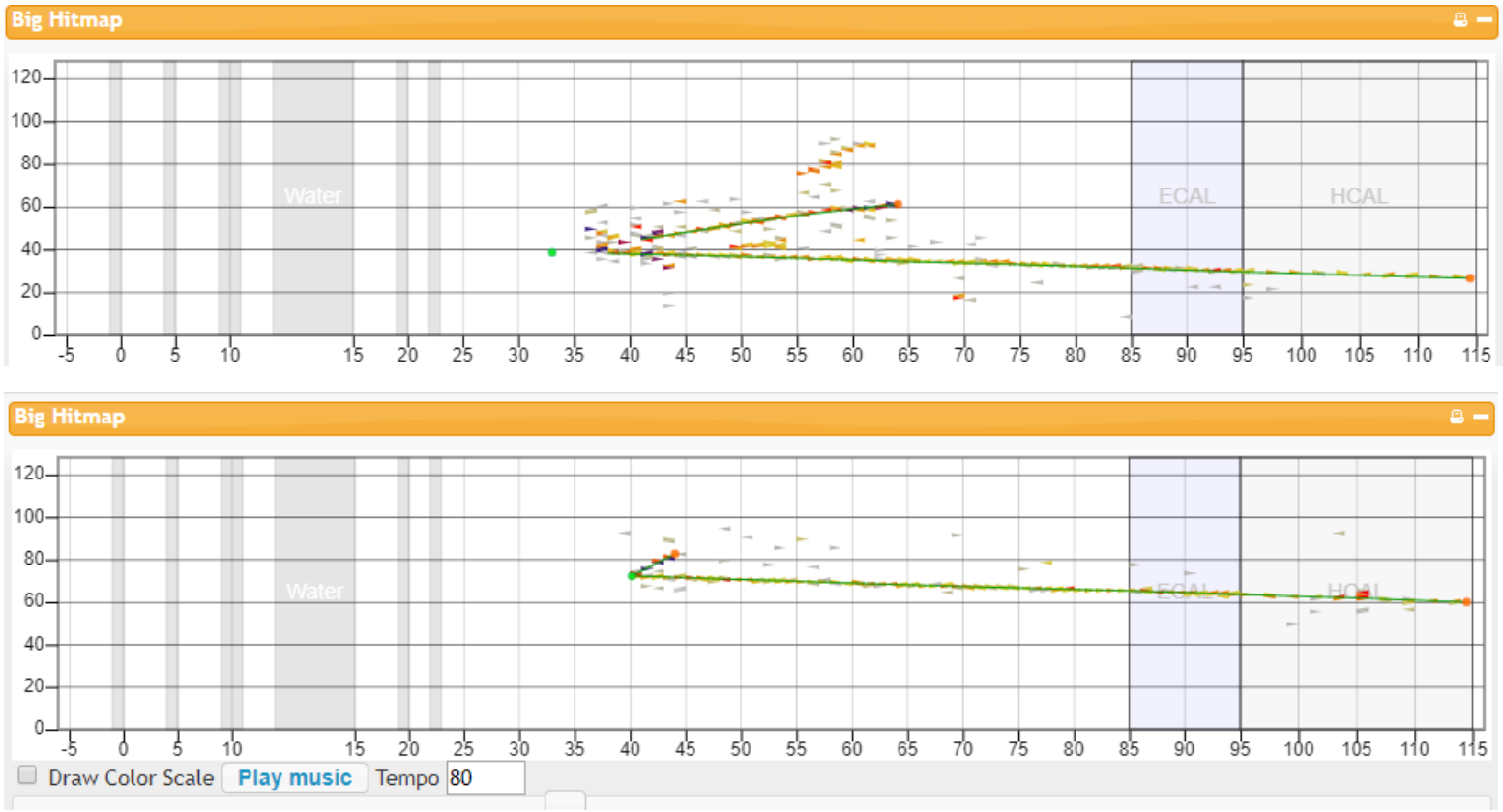


Signal vs. Background



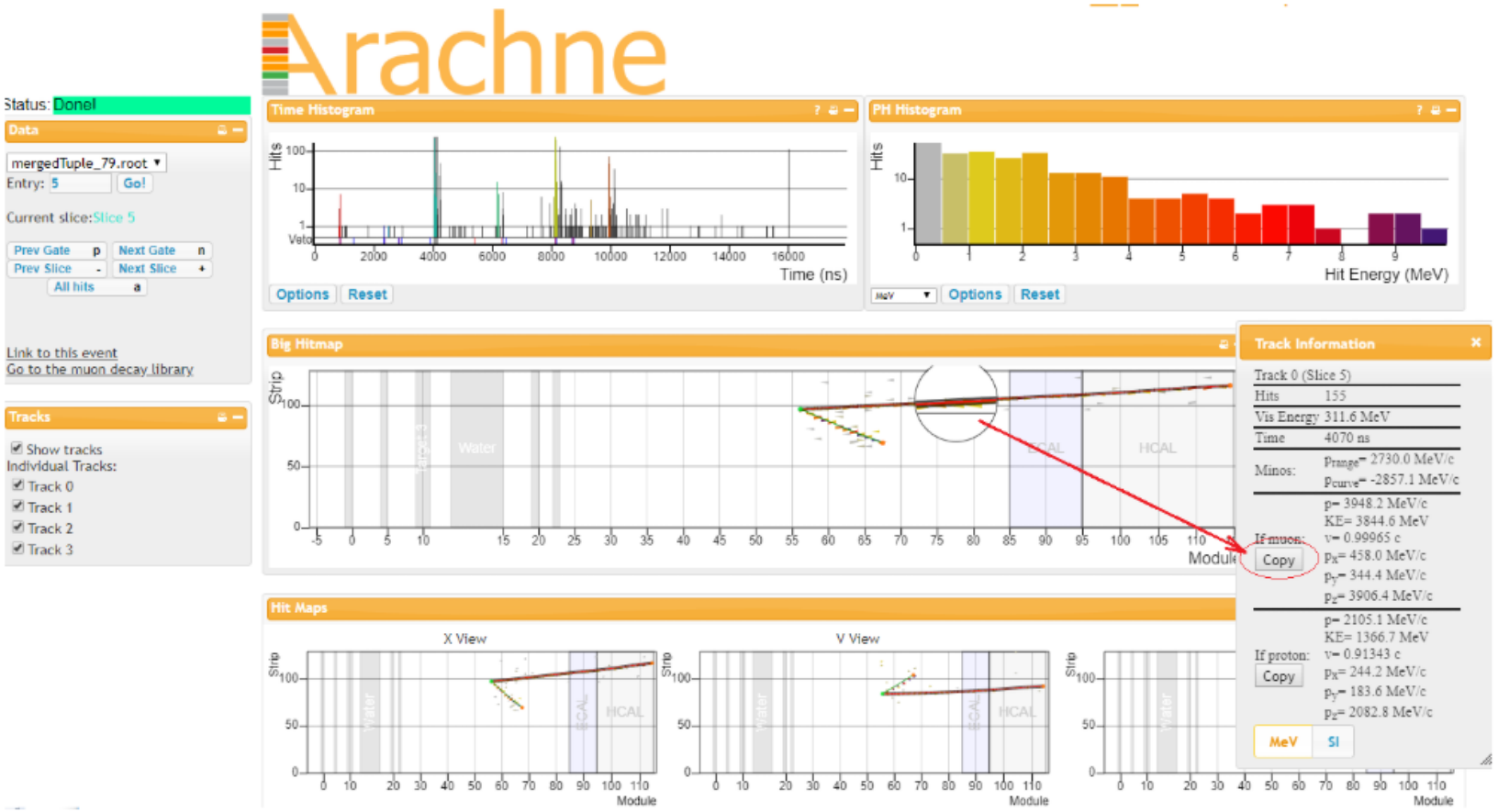
One of these is signal, one is background. Which is which? Why?

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?

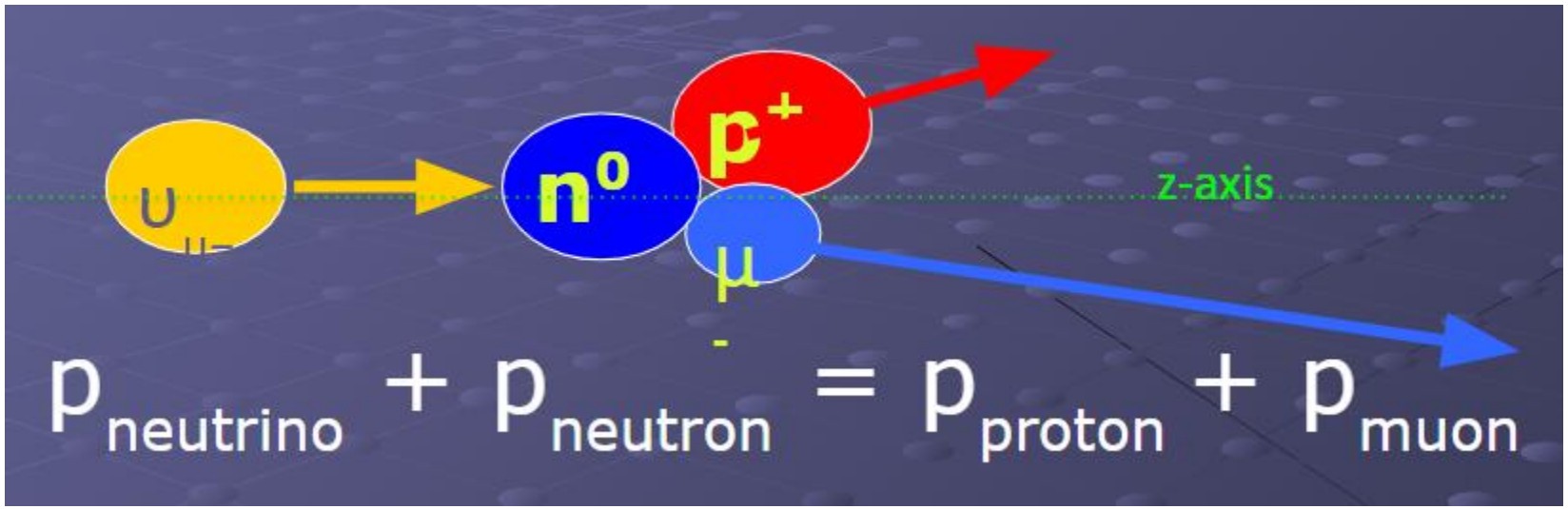
Conservation of Momentum

Initial momentum:

- p_ν all in z (beam) direction

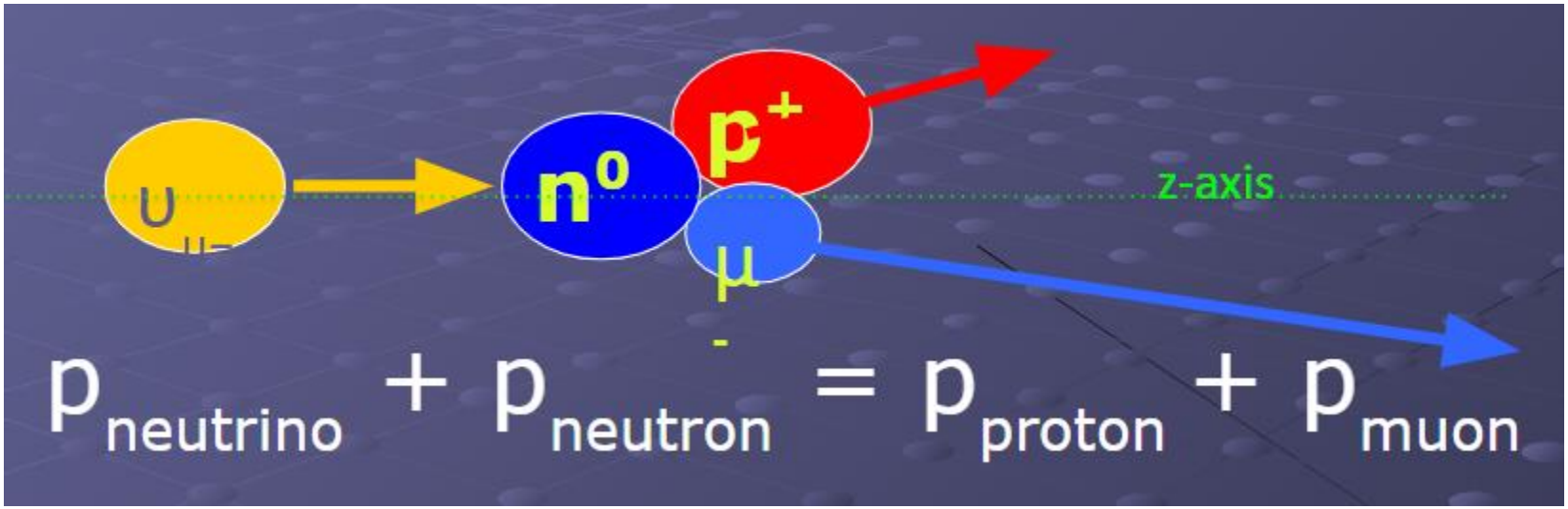
Final momentum:

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



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?



Keep in Mind. . .

"Science is nothing but developed perception, interpreted intent, common sense rounded out and minutely articulated." *George Santayana*

- Indirect observations and imaginative, critical, logical thinking can lead to reliable and valid inferences.

- Therefore: work together, think (sometimes outside the box), and be critical of each other's results to figure out what is happening.

Let's Analyze Events!

Make teams of two.

Practice.

Talk with physicists.

Find good $p^+ + \mu^-$ candidates.

Which events go to the spreadsheet?

Let's plot final p_x, p_y, and p_z.

Let's see what they mean!

Report! Rapport! Rejoice! Relax!