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# Target Studies for Muon Production



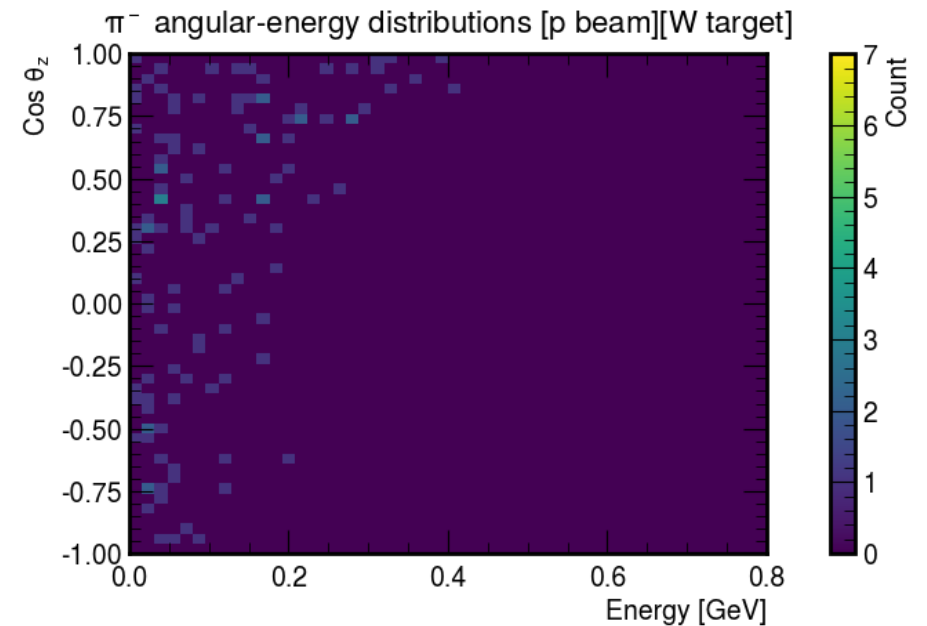
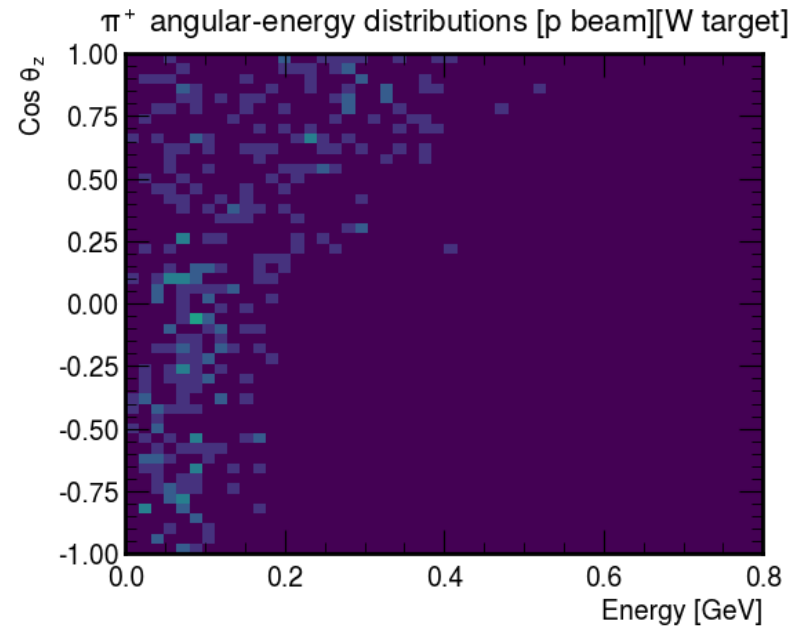
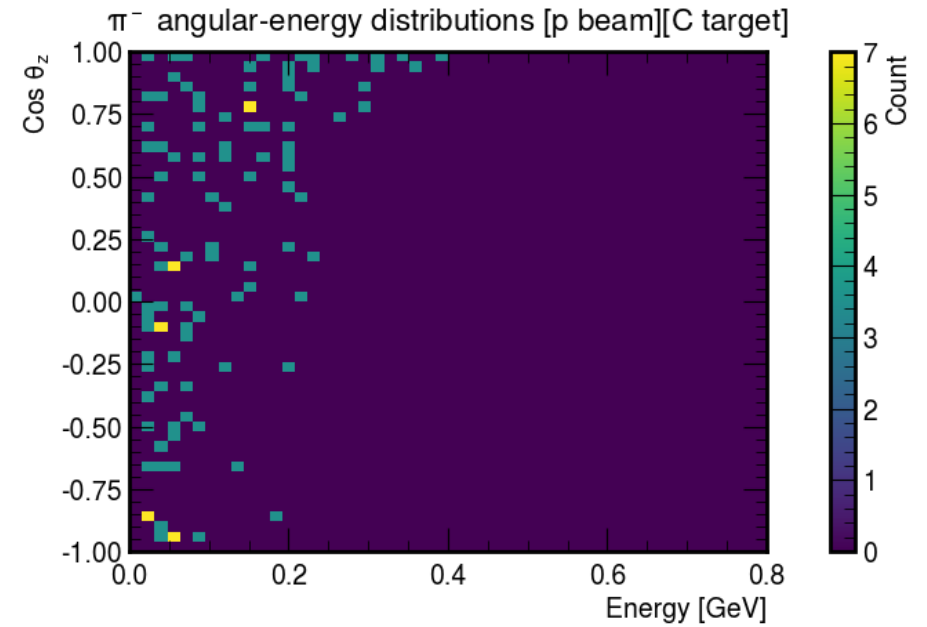
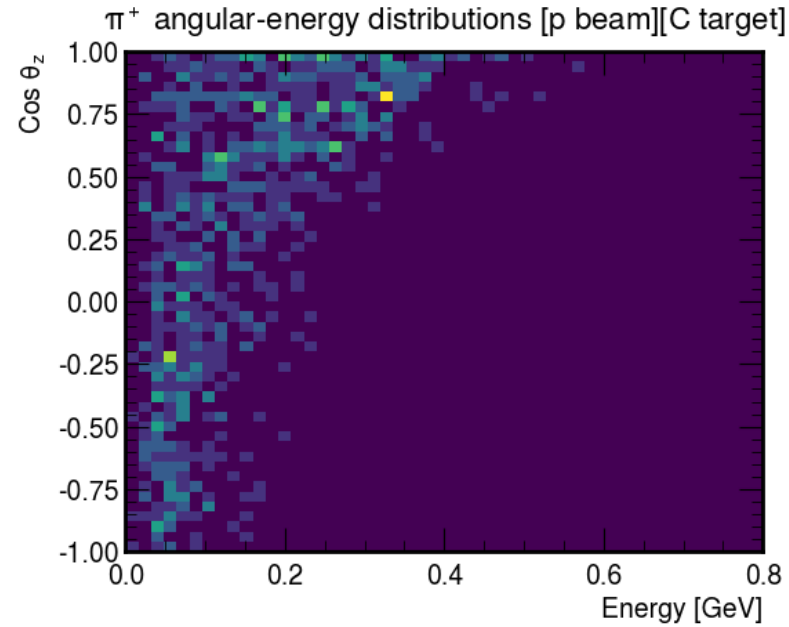
3/17/2025

*Ruaa Alharthy*

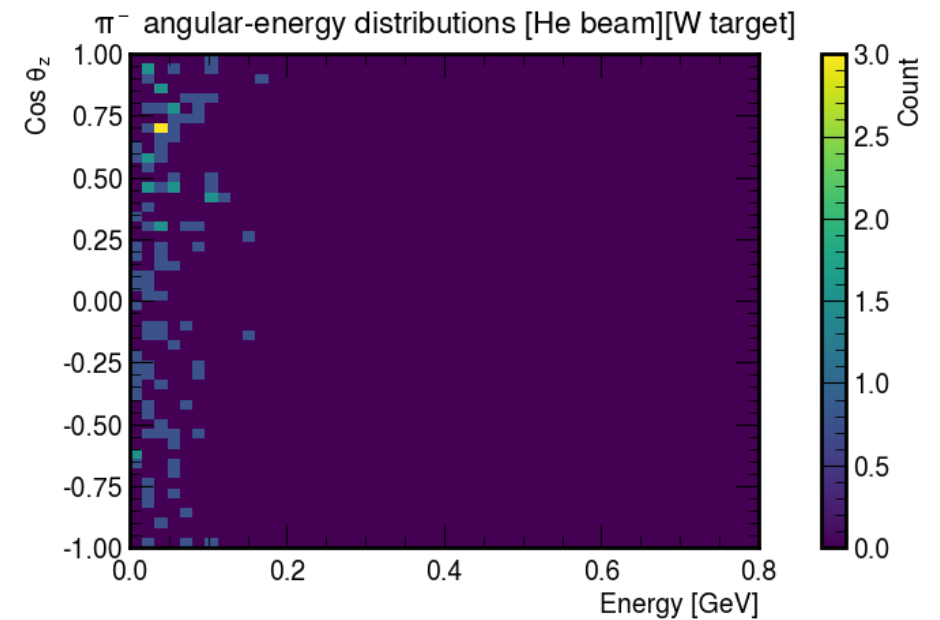
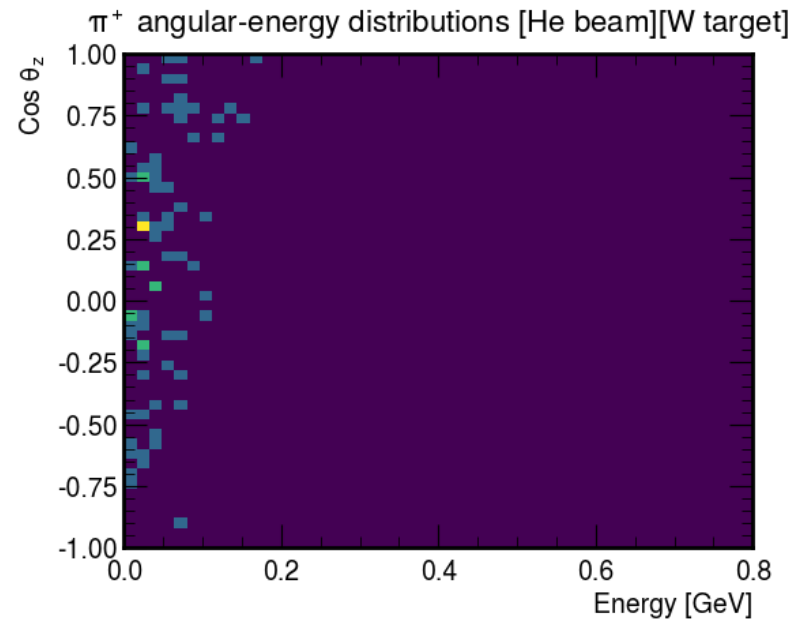
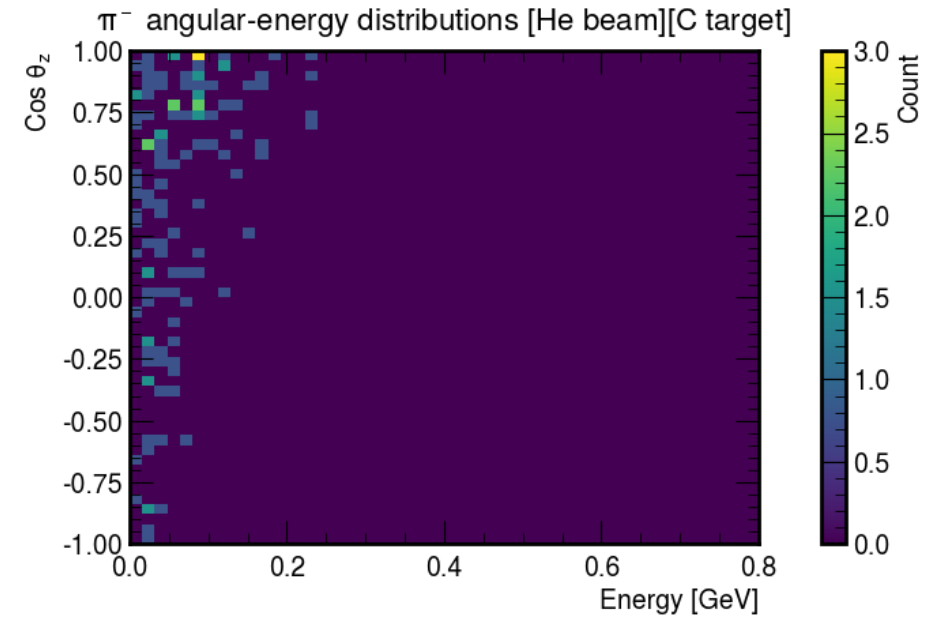
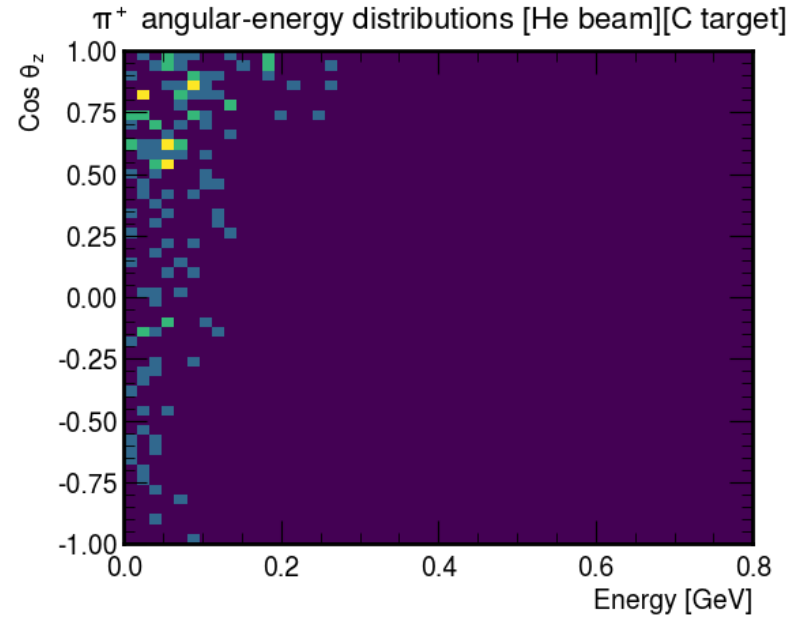
Shielding Module.  
Target heads



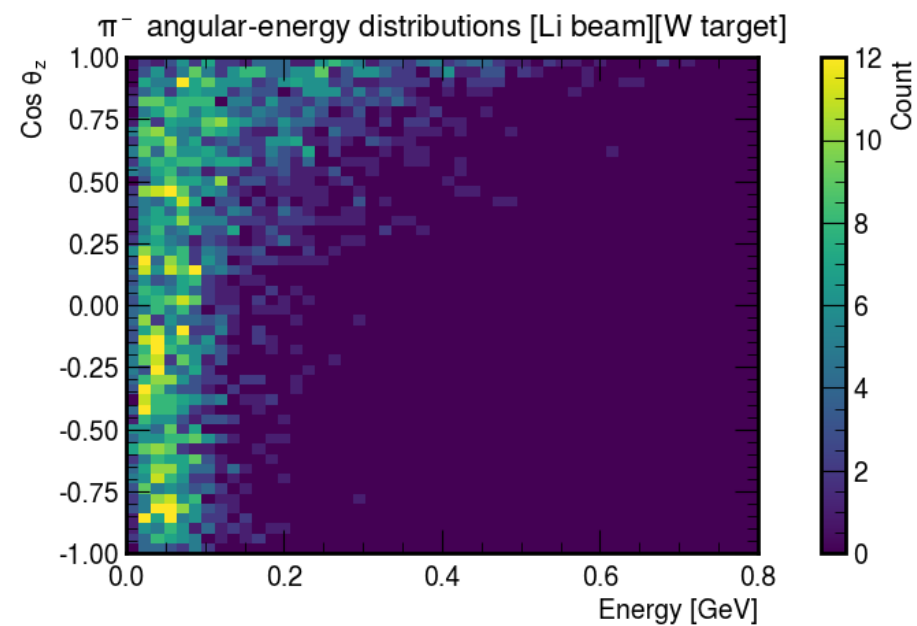
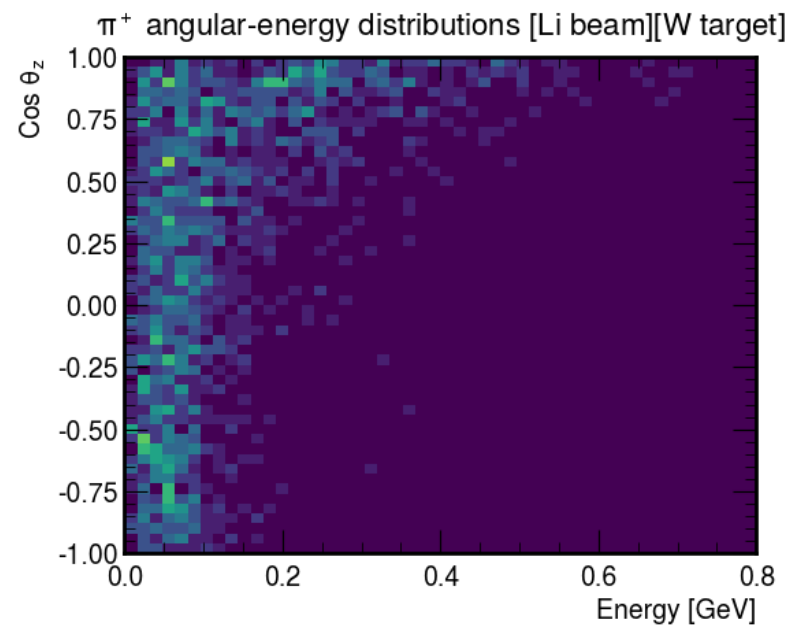
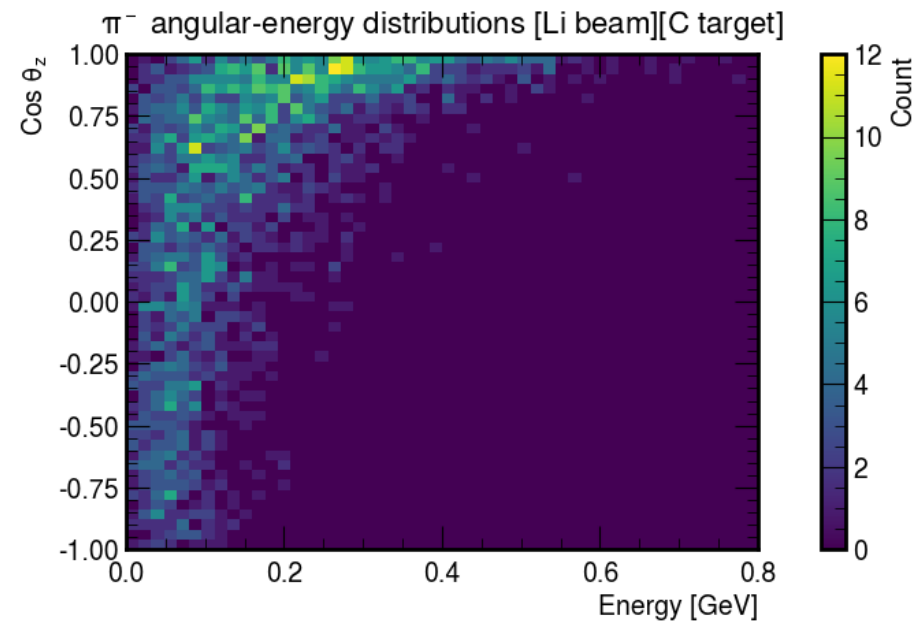
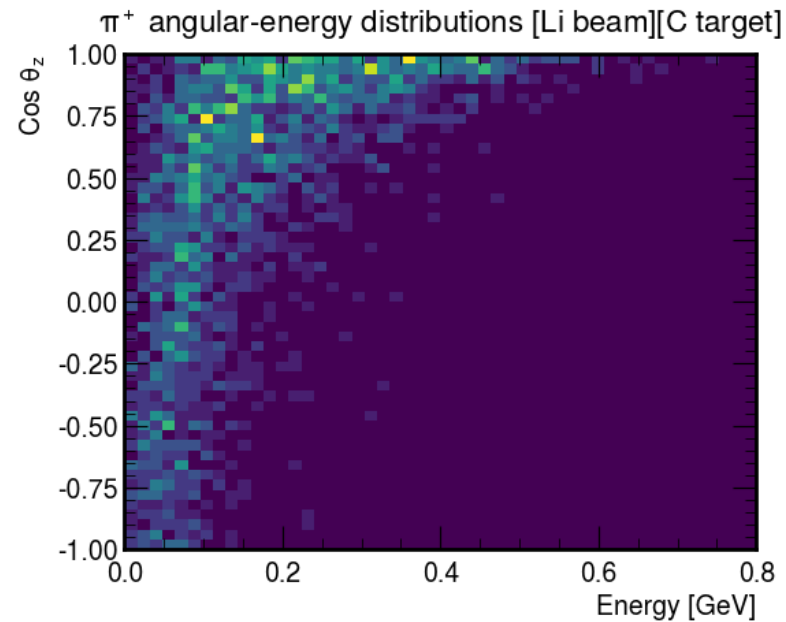
# Proton beam, $K = 0.8 \text{ GeV}$



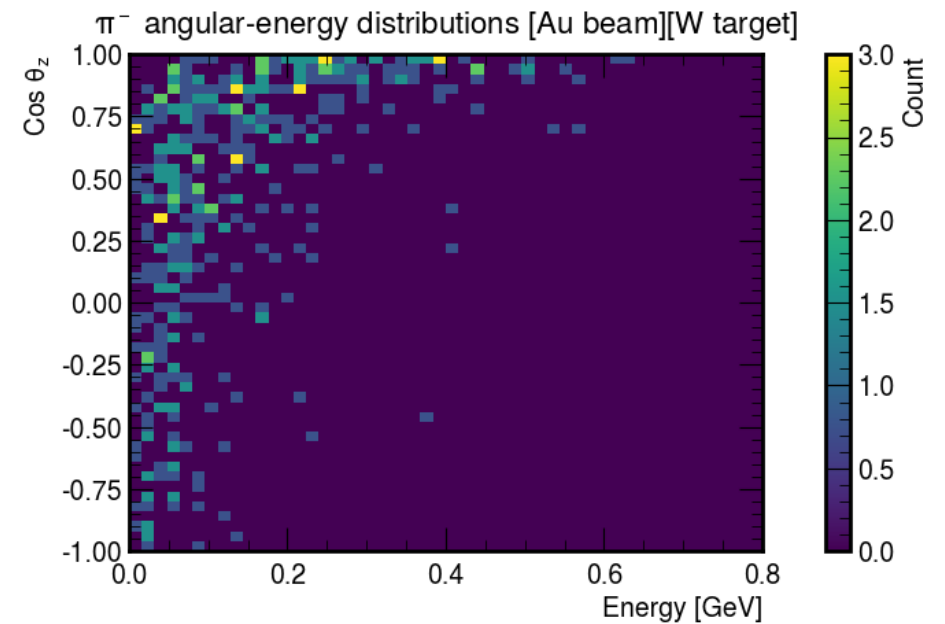
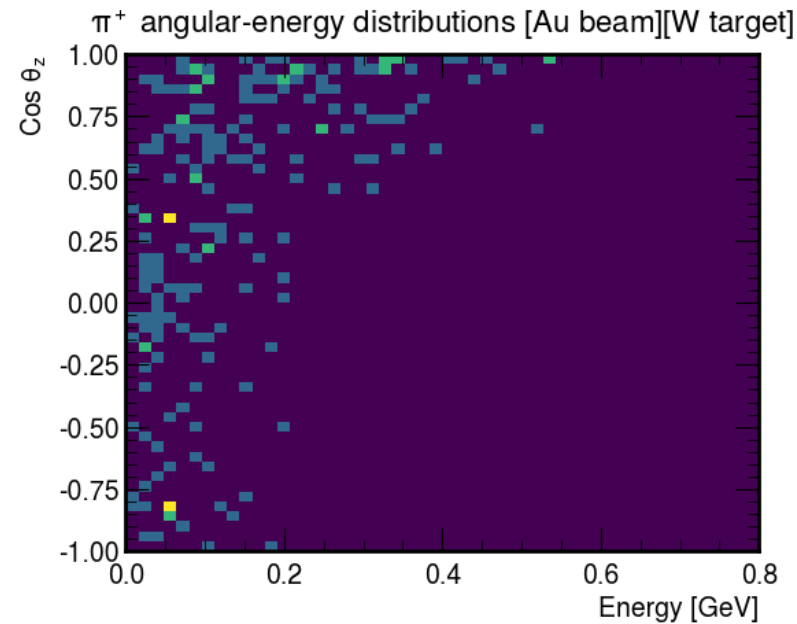
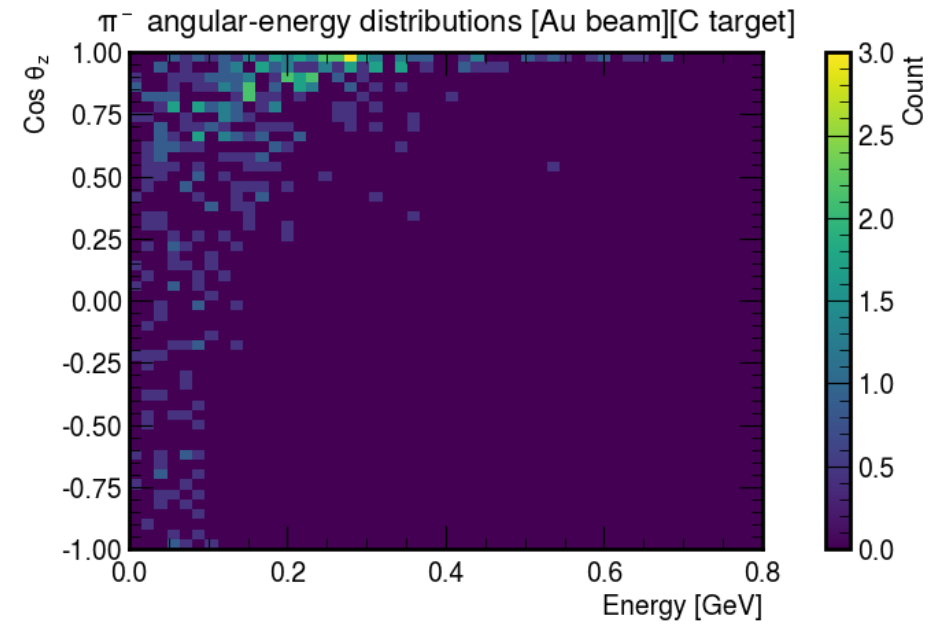
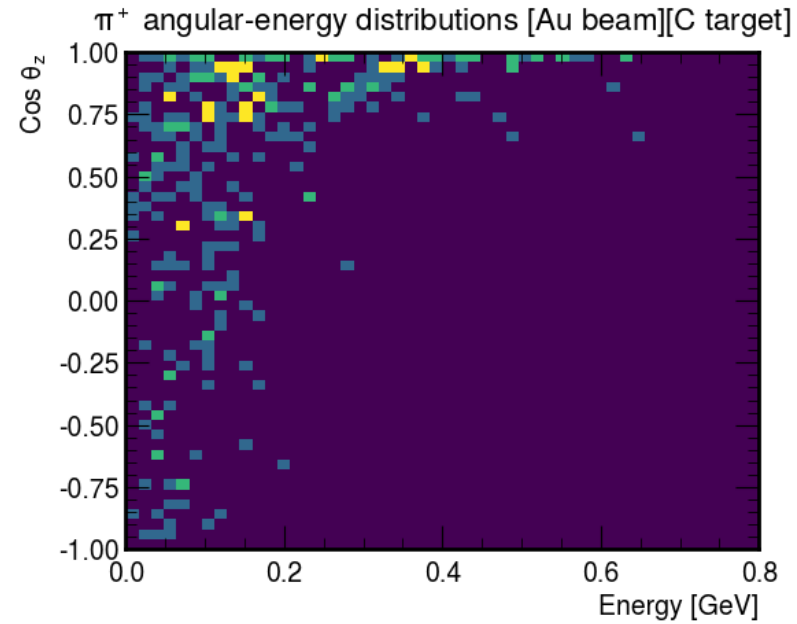
# Helium beam, K = 1.6 GeV



# Lithium beam, K = 2.4 GeV

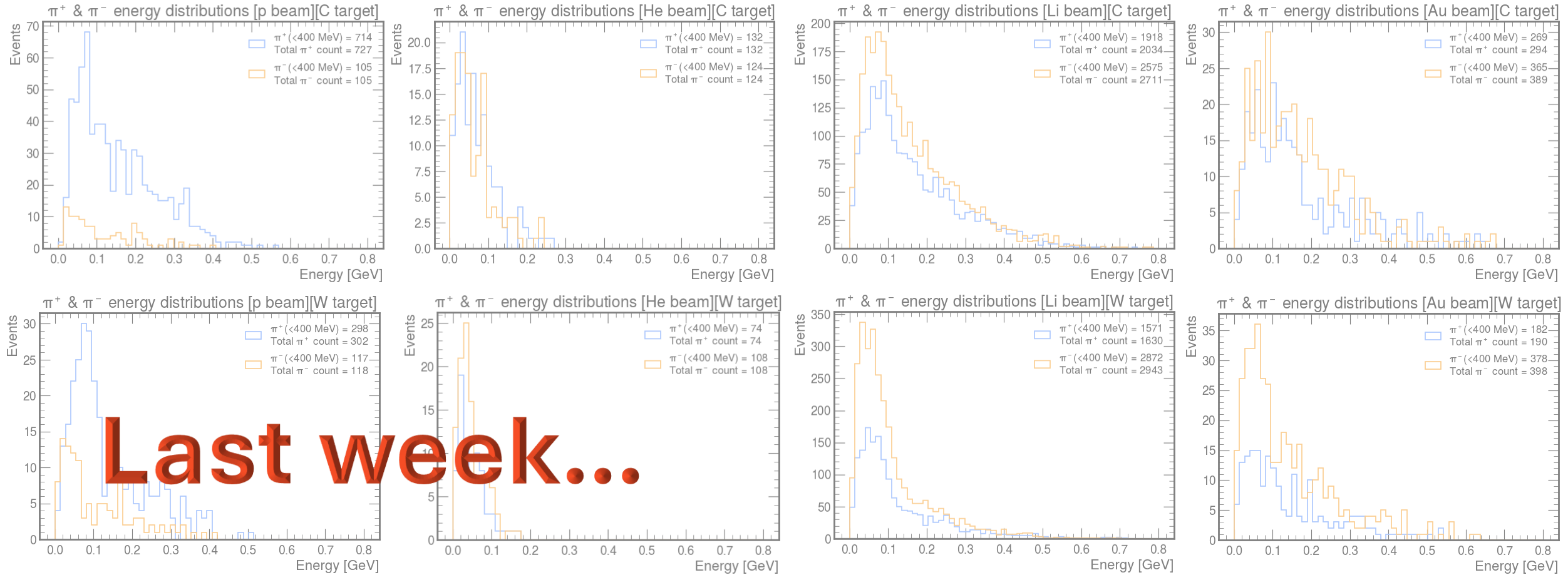


**Gold beam,  
K = 63.2  
GeV**



# Closer look at energy plots...

→ It's easier to see pi+ and pi- production yield patterns from energy plots



Last week...

# My attempt to justify the charged pion production pattern...

Beam	Energy [GeV]	Energy/nucleon
p	0.8	0.8
4-He	1.6	0.4
Li	2.4	0.34
Au	63.2	0.32

→ I am planning to run simulations with various energies for next week to see the effect of Energy/nucleon

# Last week...

Element	Protons	Neutrons	Ratio p/n
Carbon	6	6	1
4-He	2	2	1
Lithium	3	4	0.75
Tungsten	74	110	0.67
Gold	79	118	0.67

Beam	Target	Most common interaction
P	C	p-p
	W	p-n
4-He	C	p-p, p-n, n-n
	W	p-n, n-n
Li	C	p-n, n-n
	W	n-n
Au	C	p-n, n-n
	W	n-n

→ I thought of listing all the interactions and compute the cross-sections for producing pi+ vs pi-, but prof. Herndon investigated it and didn't find anything

Isospin:

$$I_3 = \frac{n_u - n_d}{2} = \frac{Z - N}{2}$$

Particle	$I_3$
p	+1/2
n	-1/2
4-He	0
Li	-1/2
Au	-19.5
C	0
W	-18



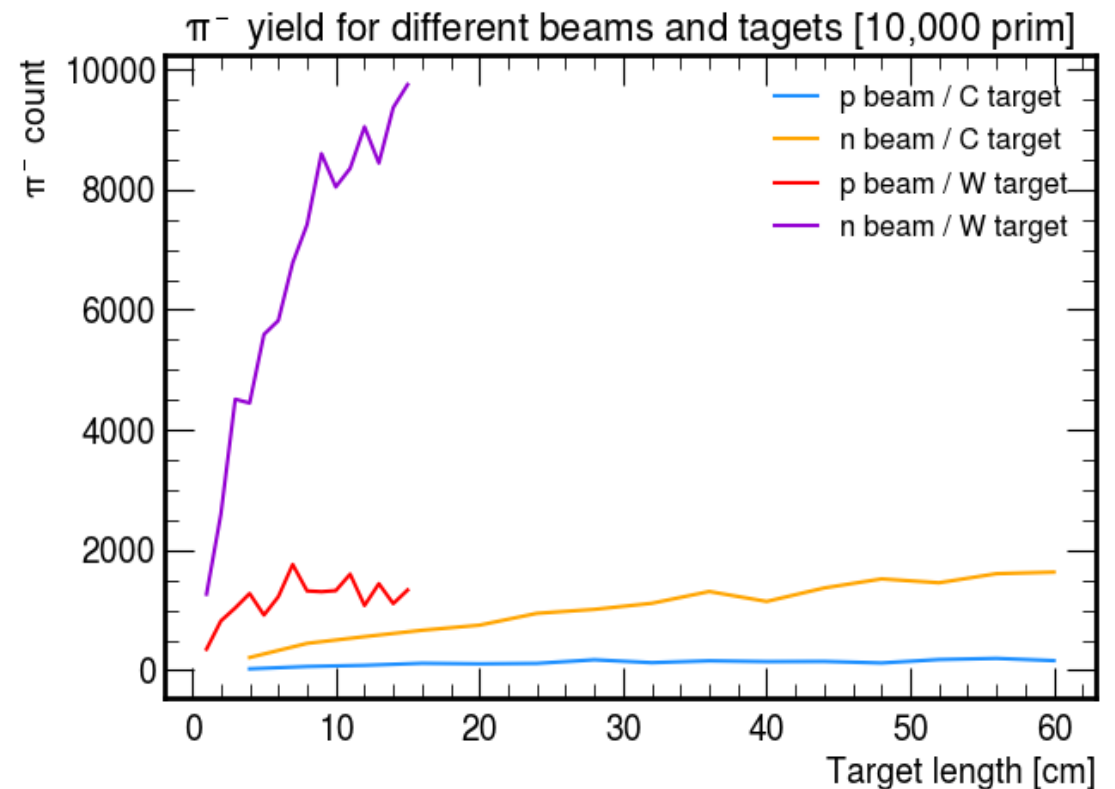
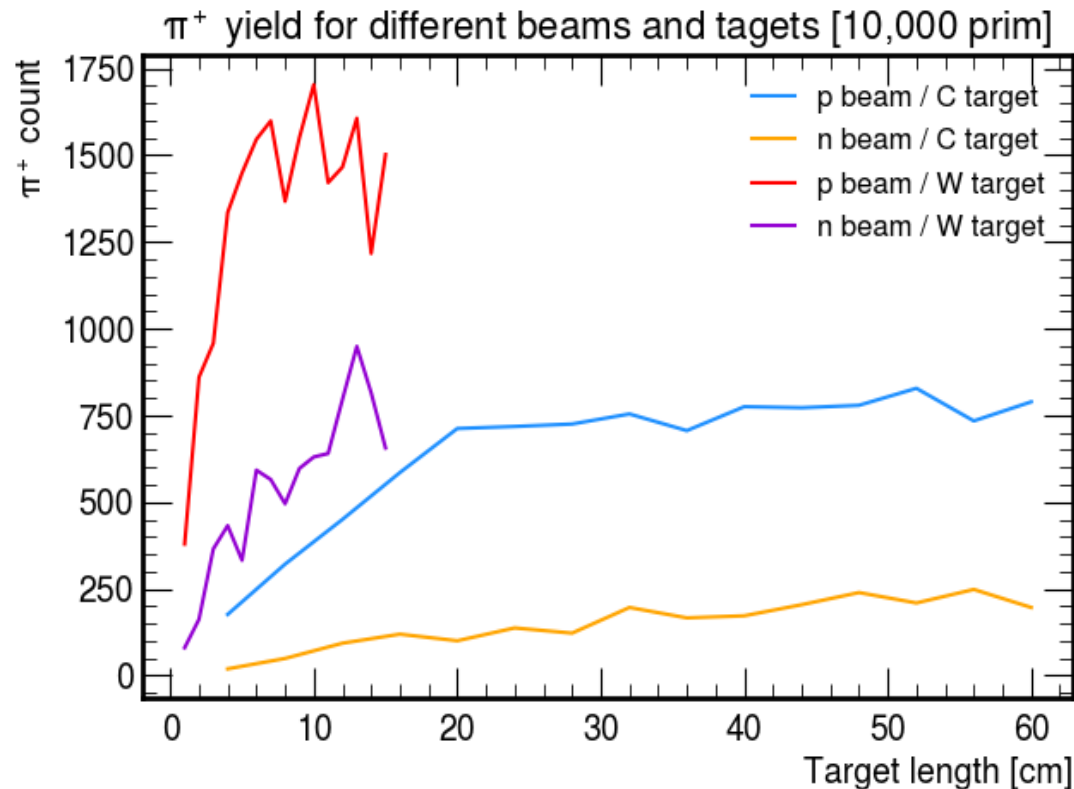
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# This week...

- Ran simulations for a 0.8 GeV proton beam and a 0.8 GeV neutron beam.
- The neutron beam simulations are not meant to emulate reality, but are used to learn about charged pion yield that result from different nuclear interactions inside the target.
- The motivation is to find a good justification for the discrepancy in amounts of charged pions that escape the target.
- To achieve this, I was working on a more robust code to extract pion and muon production information (instead of recording only the particles that have escaped the target) from Fluka simulation. I want to say that I have something that is more robust than what I had before. However, its robustness depends on the fact that there is no magnetic in the simulation setup.
- Here, I chose to run simulations for different target lengths ranging from  $0.1 \lambda_I$  to  $1.5 \lambda_I$  for graphite and tungsten
  - Tungsten: 1 – 15 cm (15 simulations/beam)
  - Graphite: 4 – 60 cm (15 simulations/beam)

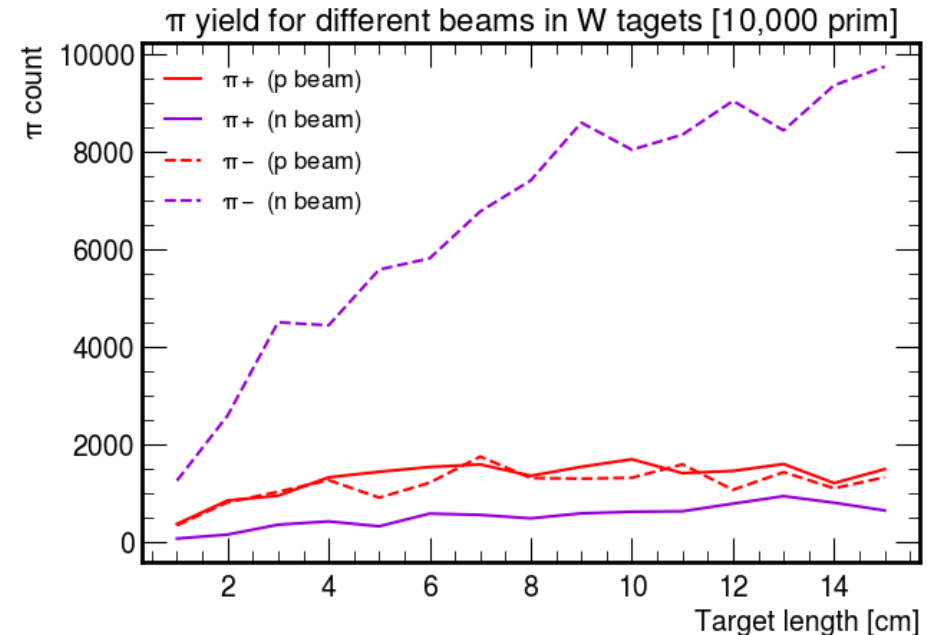
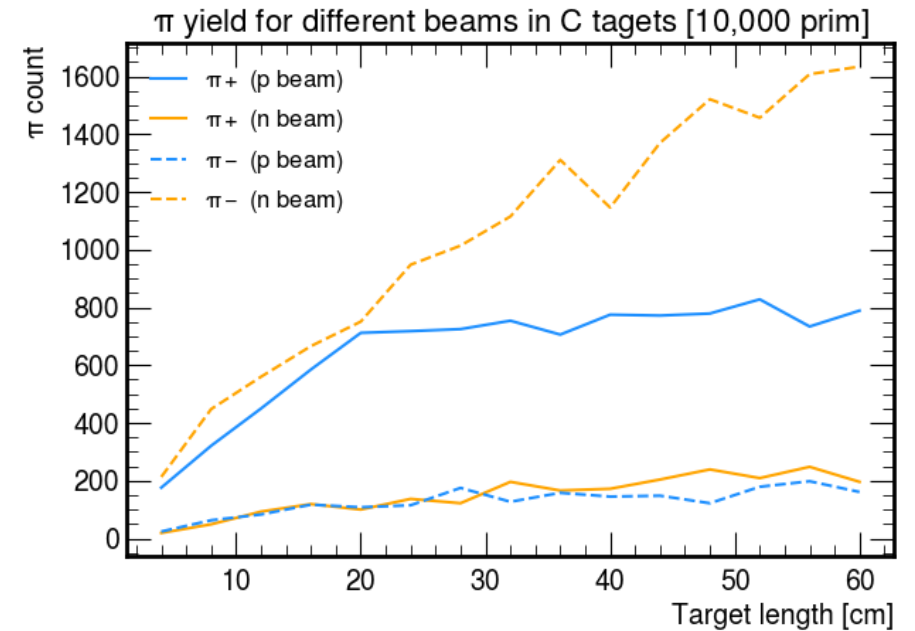
# $\pi^+$ VS $\pi^-$

→ When we compare charged pion production from a proton beam vs a neutron beam, we find that protons result in the creation of more  $\pi^+$  than neutrons and neutrons produce more  $\pi^-$  than protons in both materials.



# $\pi^+$ VS $\pi^-$

- Solid lines represent  $\pi^+$ , and dashed lines represent  $\pi^-$ .
- The graphs show the total pions produced inside the targets of different lengths and materials.
- As expected, we see higher pion yield inside the tungsten target.
- Also, confirming my predictions from last week, neutrinos produce more  $\pi^+$  than  $\pi^-$ .
- I suspect that the main nuclear interactions that are happening inside the target produce only one charged pion.



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