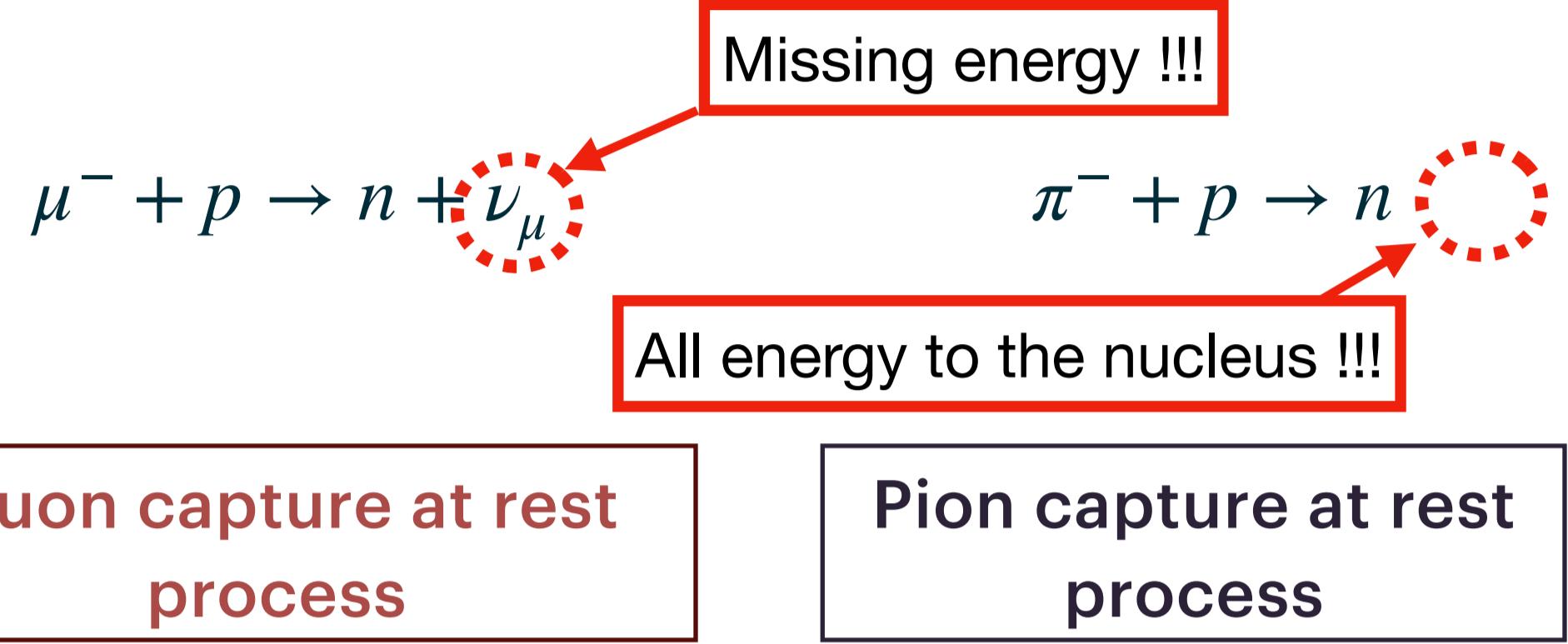
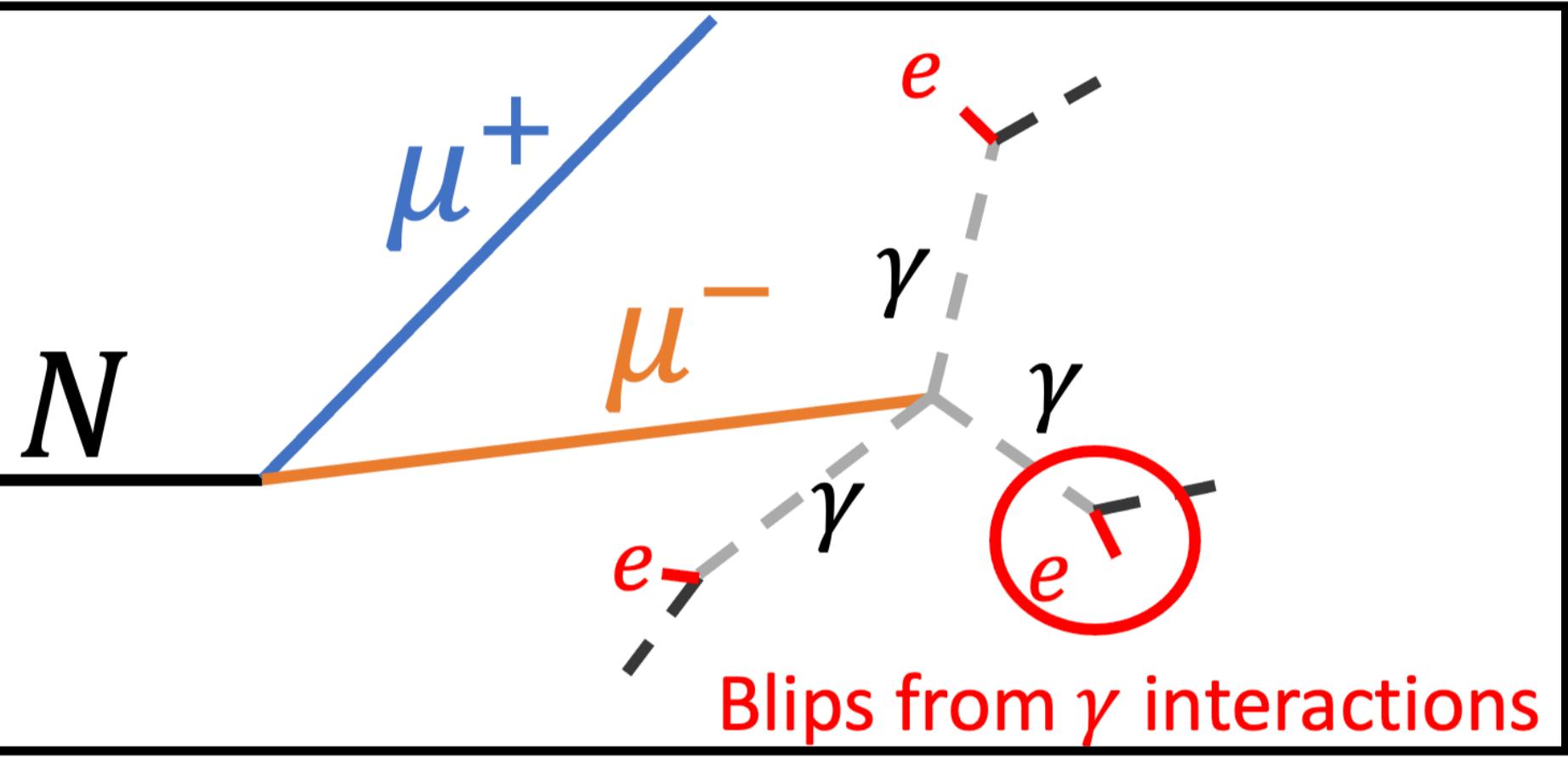


## Motivation

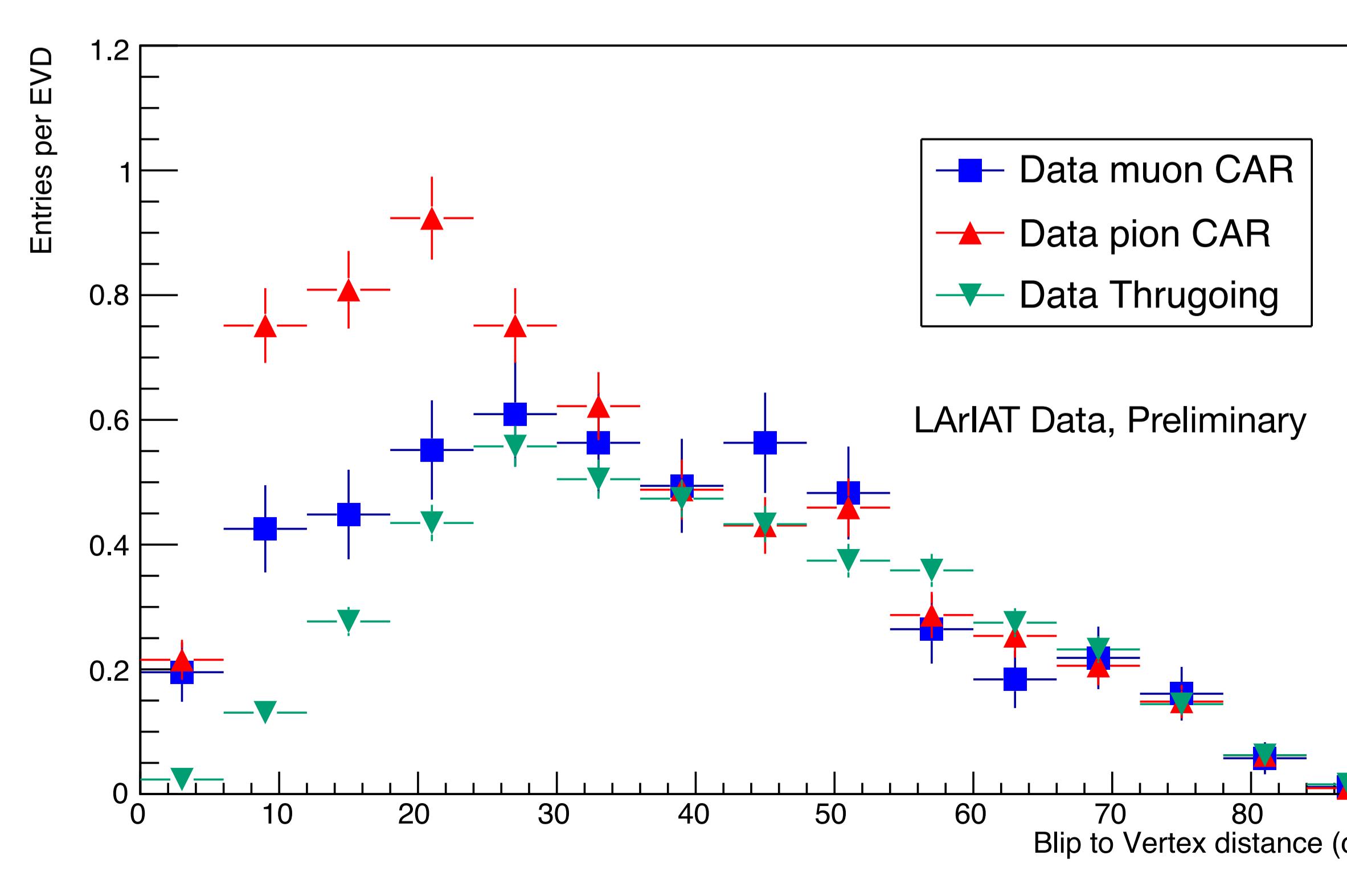
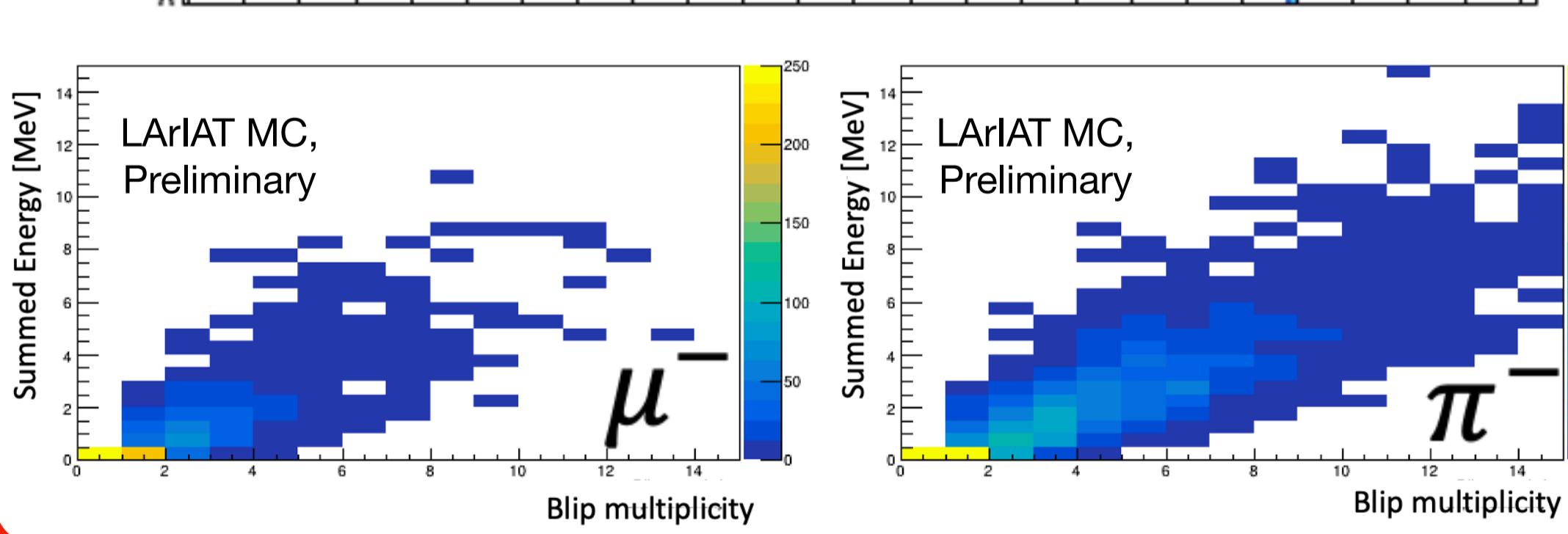
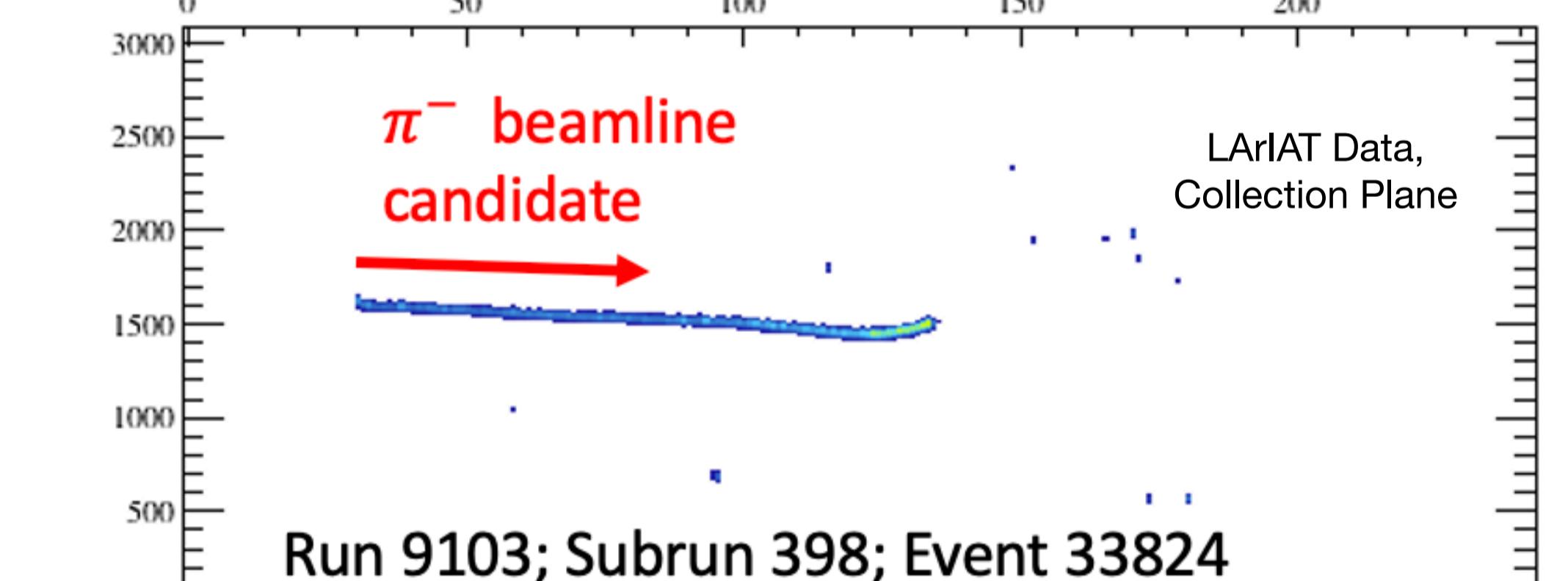
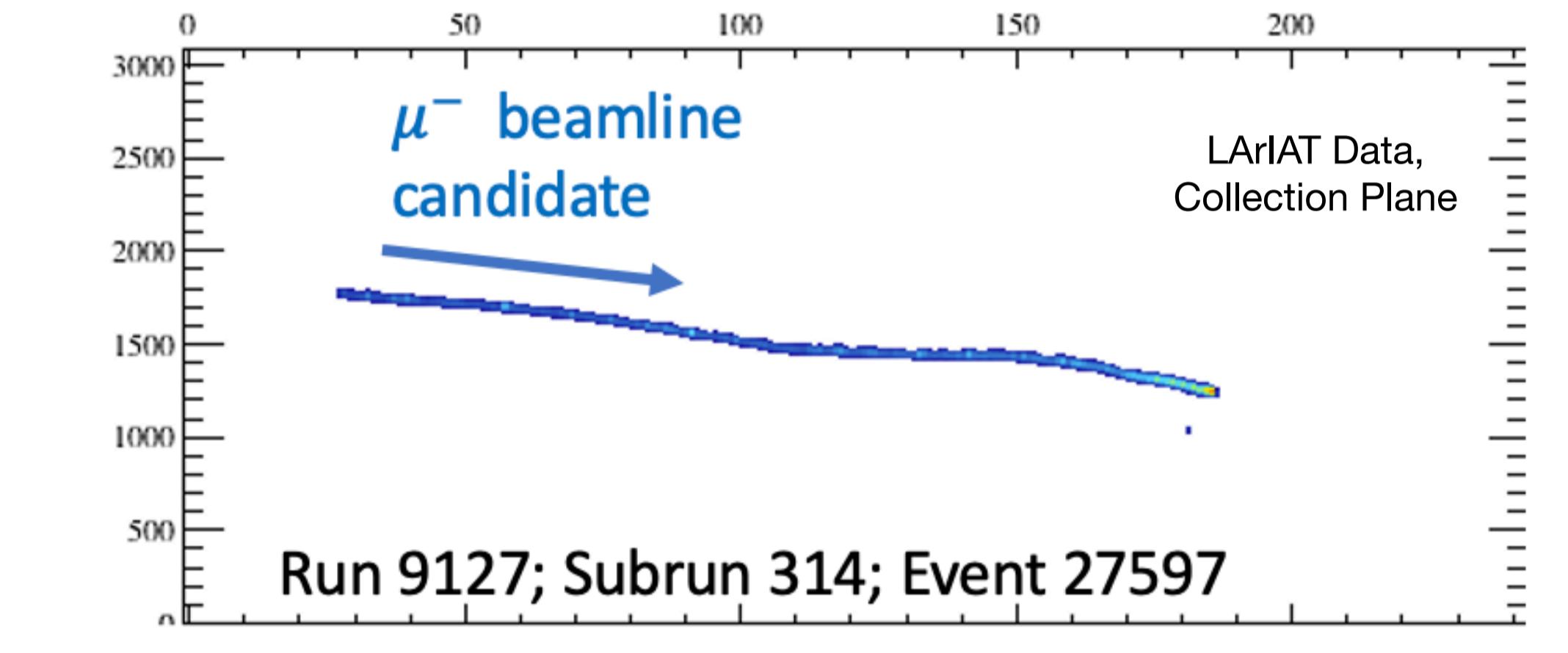
- DUNE (Deep Underground Neutrino Experiment) will be the largest neutrino LArTPC in the world.
- Identification of mu/pi would improve the understanding of BSM events, like decay of heavy neutral leptons with unusual topologies as final state with  $\mu^+\mu^-/\pi^+\pi^-$  [2]. This is *difficult* using standard track-based dE/dx methods due to the similar masses and energy deposition profiles in argon.



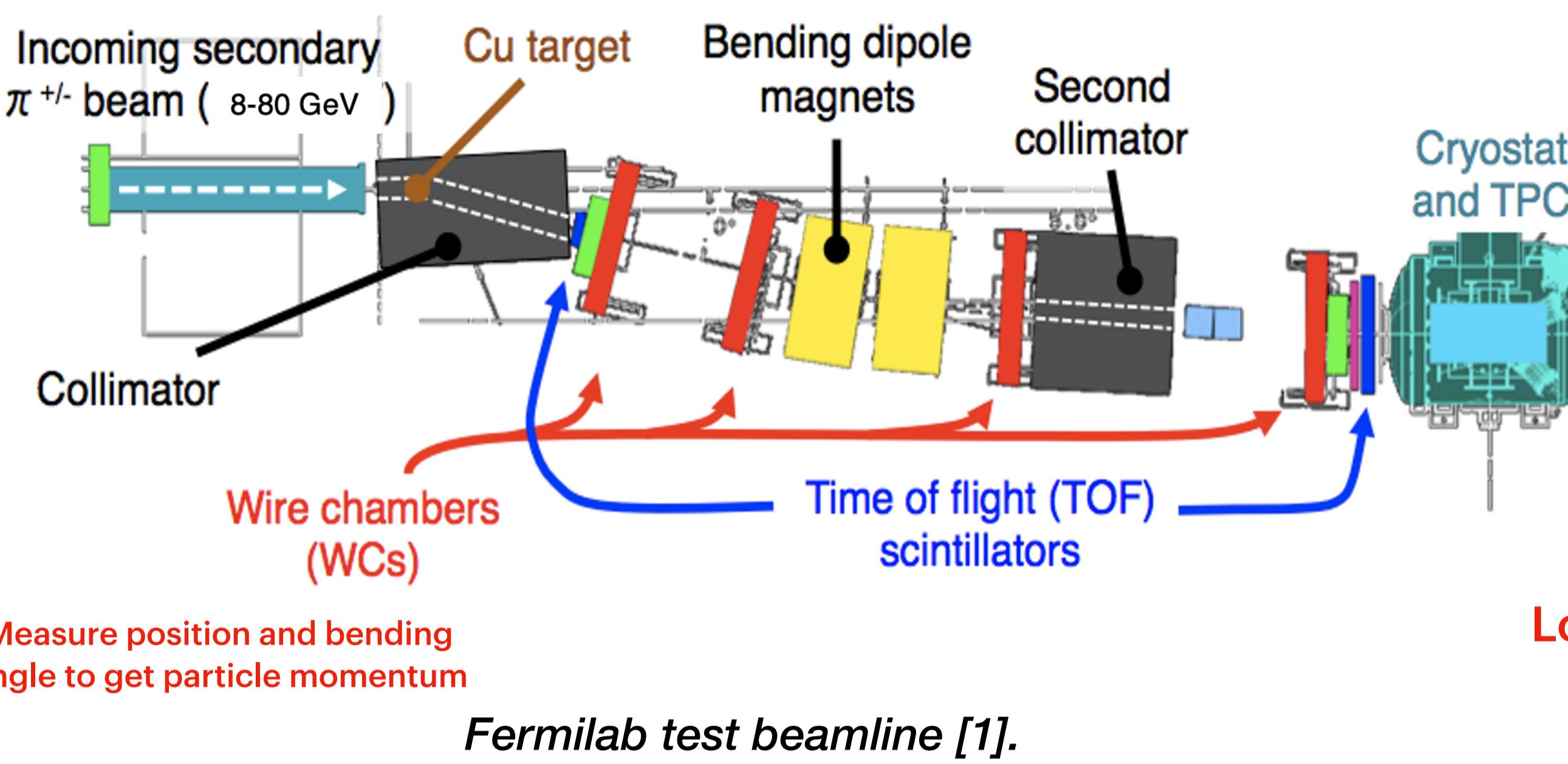
- Reconstruction of gammas from nuclear capture (**Blips**) can help with this!



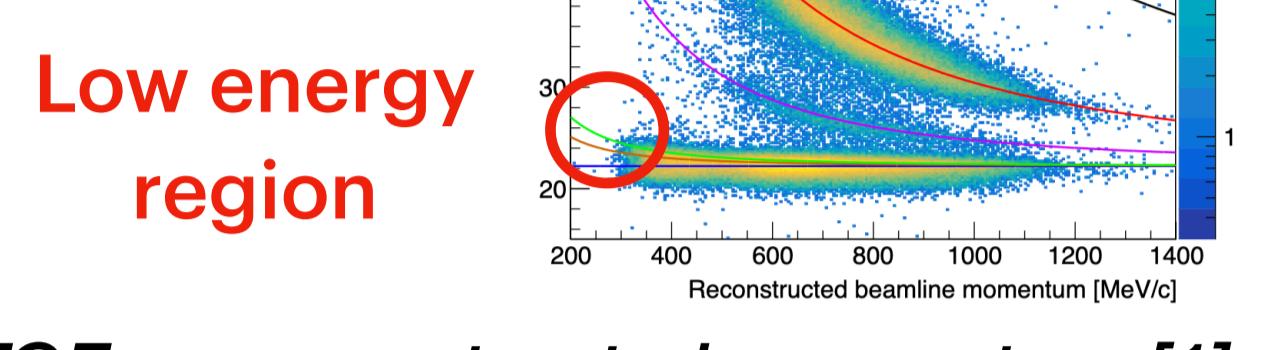
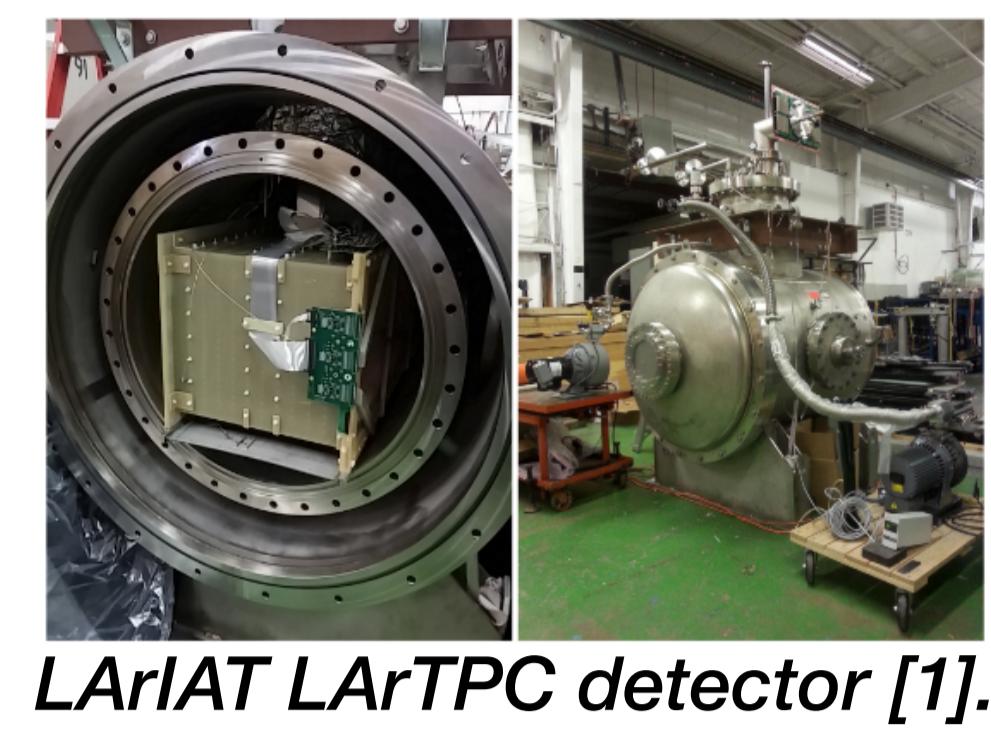
Unusual topologies  $\mu^+\mu^-/\pi^+\pi^-$  for BSM. Gammas produced by muon/pion capture, these gammas produce electrons (Blips) from induced interactions.



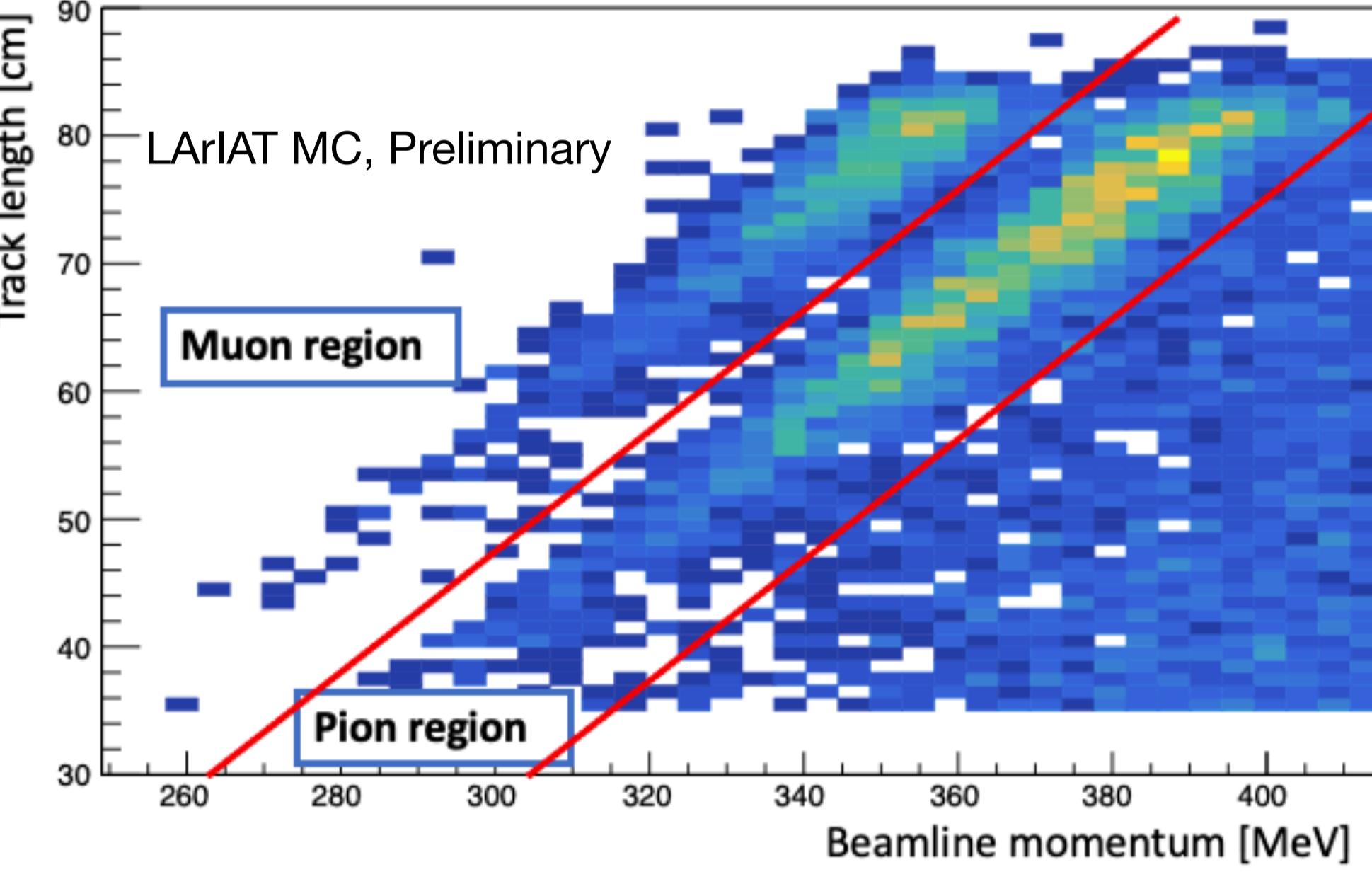
## Why LArIAT?



LArIAT: Liquid Argon In A Testbeam



## Muon and Pion selection

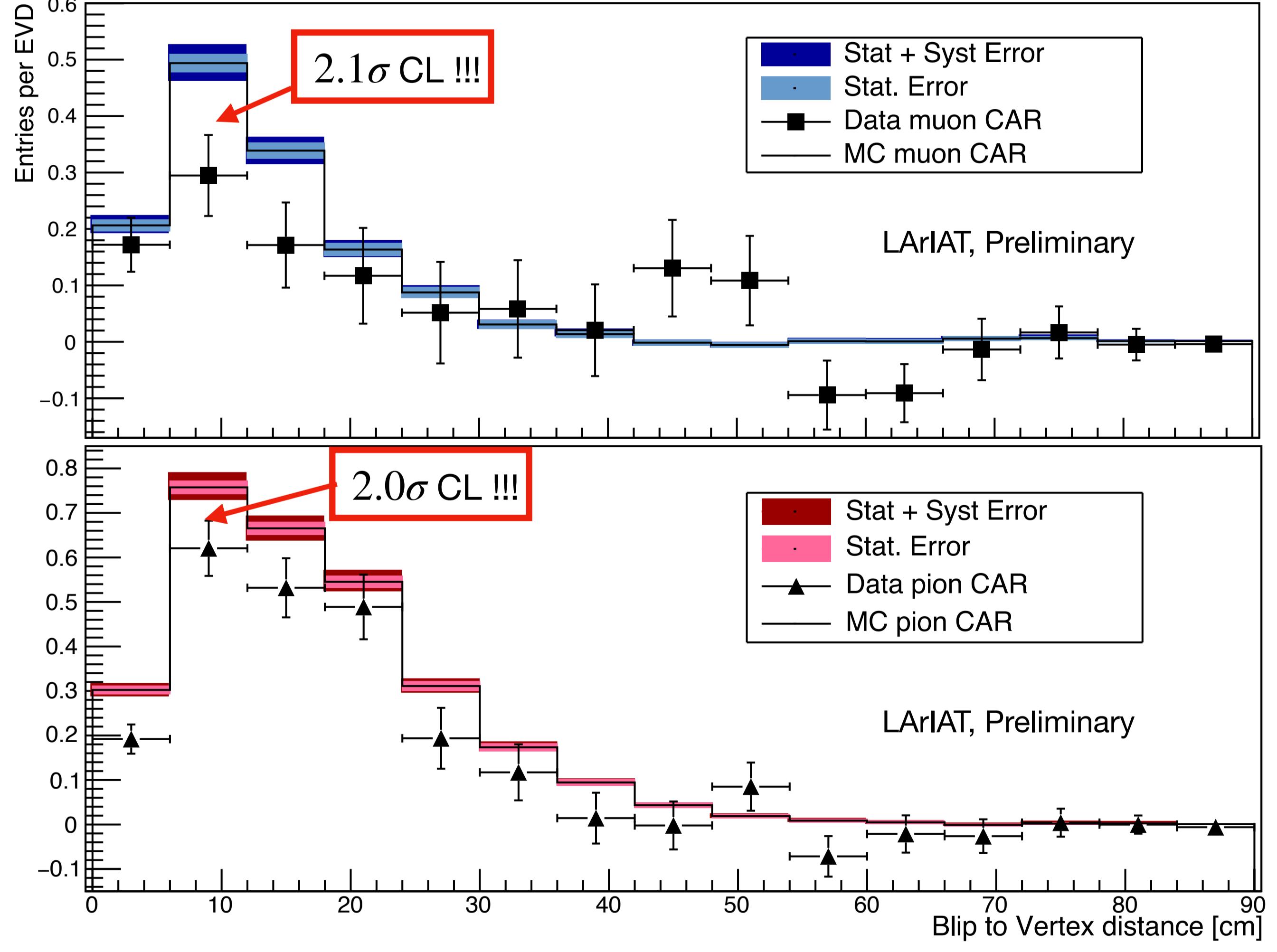


Using beam momentum and track stopping point inside of the TPC we separate stopping muons from stopping pions.

With a MC sample of 500k (G4 QGSP\_Bert\_HP Physics list) events a final selection of  
**2132 muon captured-at-rest events (79% purity)**  
**3931 pion captured-at-rest events (76% purity)**

Data has 87 muon captured at rest and 209 pion captured at rest candidates.

## Data-MC comparison



Dataset	Blips per EVD
Muon Data	$0.74 \pm 0.19$
Muon MC	$1.22 \pm 0.08$

Dataset	Blips per EVD
Pion Data	$1.86 \pm 0.17$
Pion MC	$2.34 \pm 0.09$

## Data based observations

- Muon Captured at rest to through-going  $4.2\sigma$  CL of statistical incompatibility
- Pion Captured at rest to through-going  $\gg 5\sigma$  CL of statistical incompatibility
- Muon to pion captured at rest  $3.6\sigma$  CL of statistical incompatibility

We have provided the first observation of the products of stopped pion and muon nuclear capture on argon, and have shown that capture products of the two particle types are clearly distinguishable from one another in neutrino LArTPC data  
(arXiv posting coming soon)

## References

[1] Acciari, R. et al. (2020). The Liquid Argon In A Testbeam (LArIAT) experiment. *Journal of Instrumentation*, 15(04), P04026.

[2] Abratenko, P. et al. (2022). Search for long-lived heavy neutral leptons and Higgs portal scalars decaying in the MicroBooNE detector. *American Physics Society, PhysRevD.106.092006*

## Acknowledgments

This document was prepared by the LArIAT Collaboration using the resources of the Fermi National Accelerator Laboratory (Fermilab), a U.S. Department of Energy, Office of Science, Office of High Energy Physics user facility. Fermilab is managed by Fermi Research Alliance, LLC (FRA), acting under Contract No. DE-AC02-07CH11359.