

K^+ production at MINERvA

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FNAL New Perspectives
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Why study K^+ production?



Background in searches for $p \rightarrow K^+ \bar{\nu}$

p



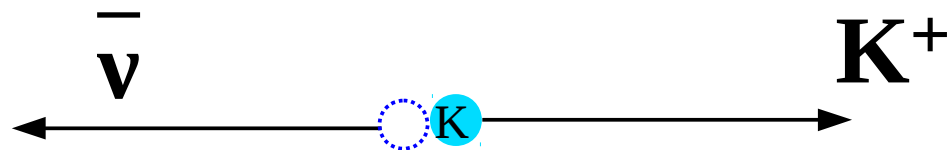


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$$p_K = 339 \text{ MeV}/c$$

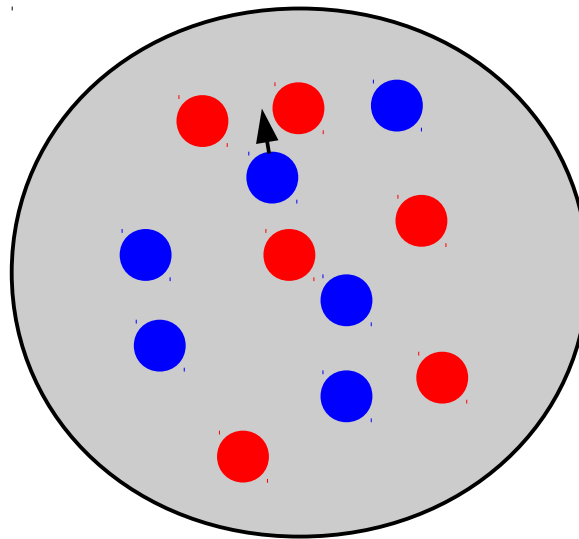


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Why study K^+ production?



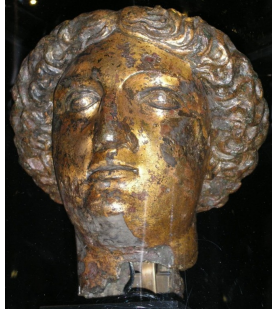
Background in searches for $p \rightarrow K^+ \bar{\nu}$



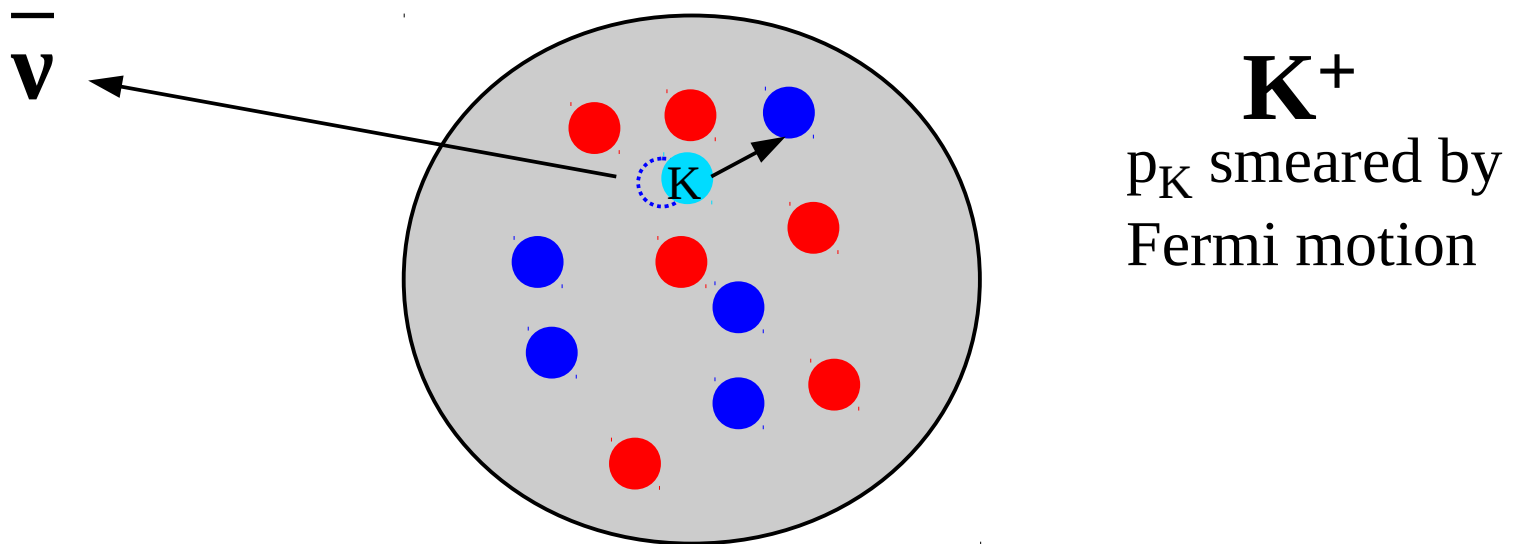


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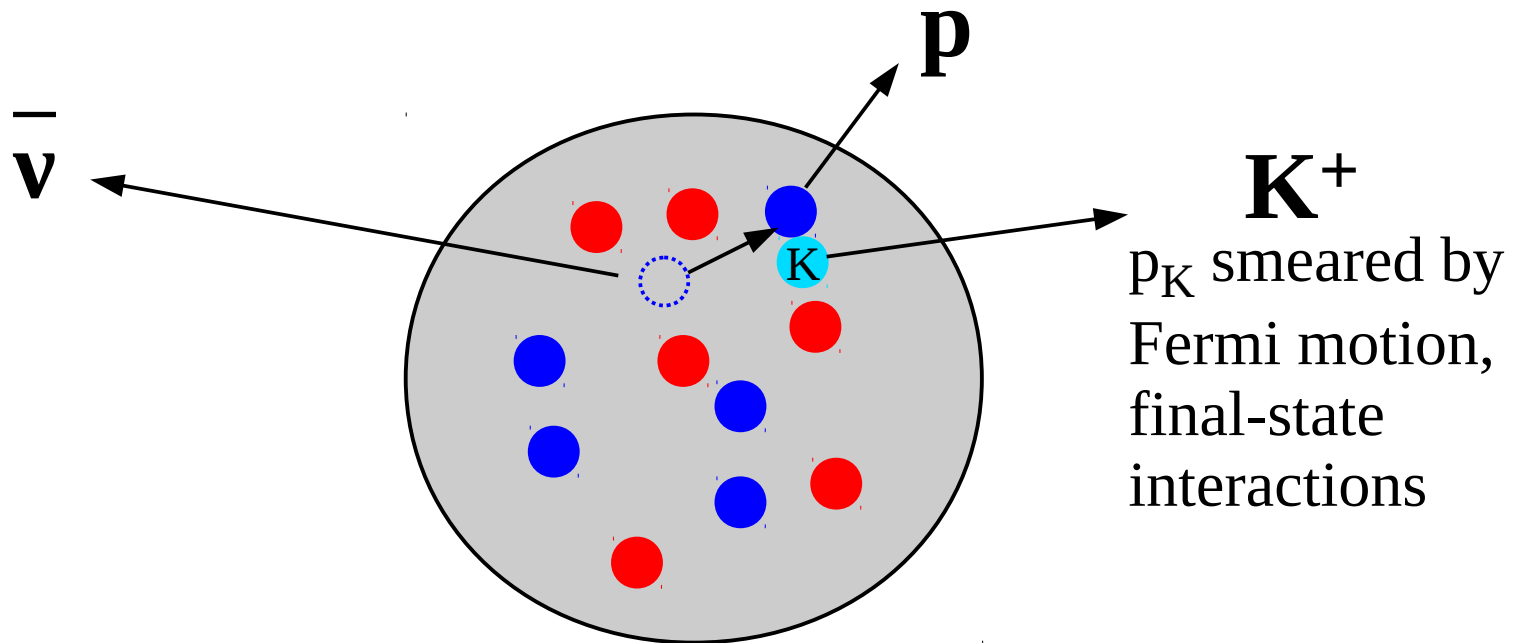


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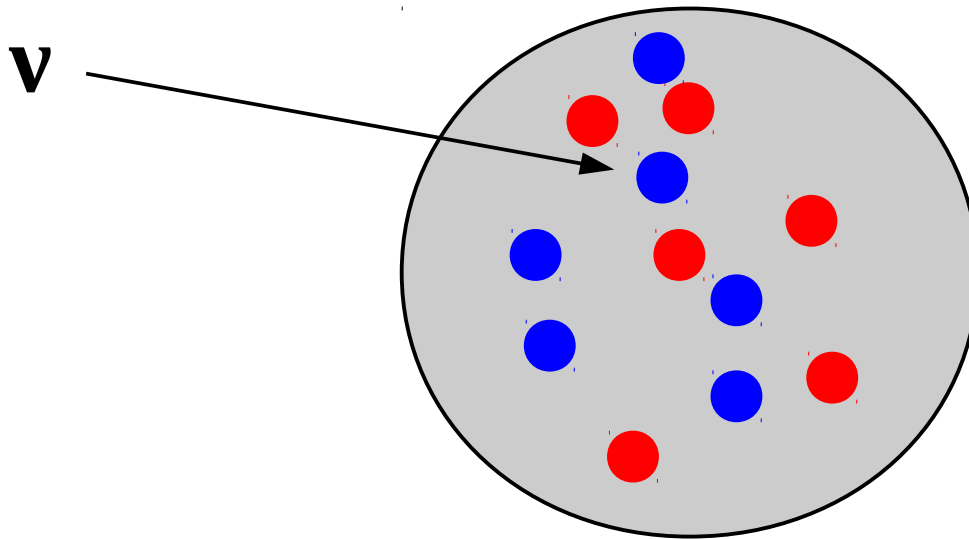


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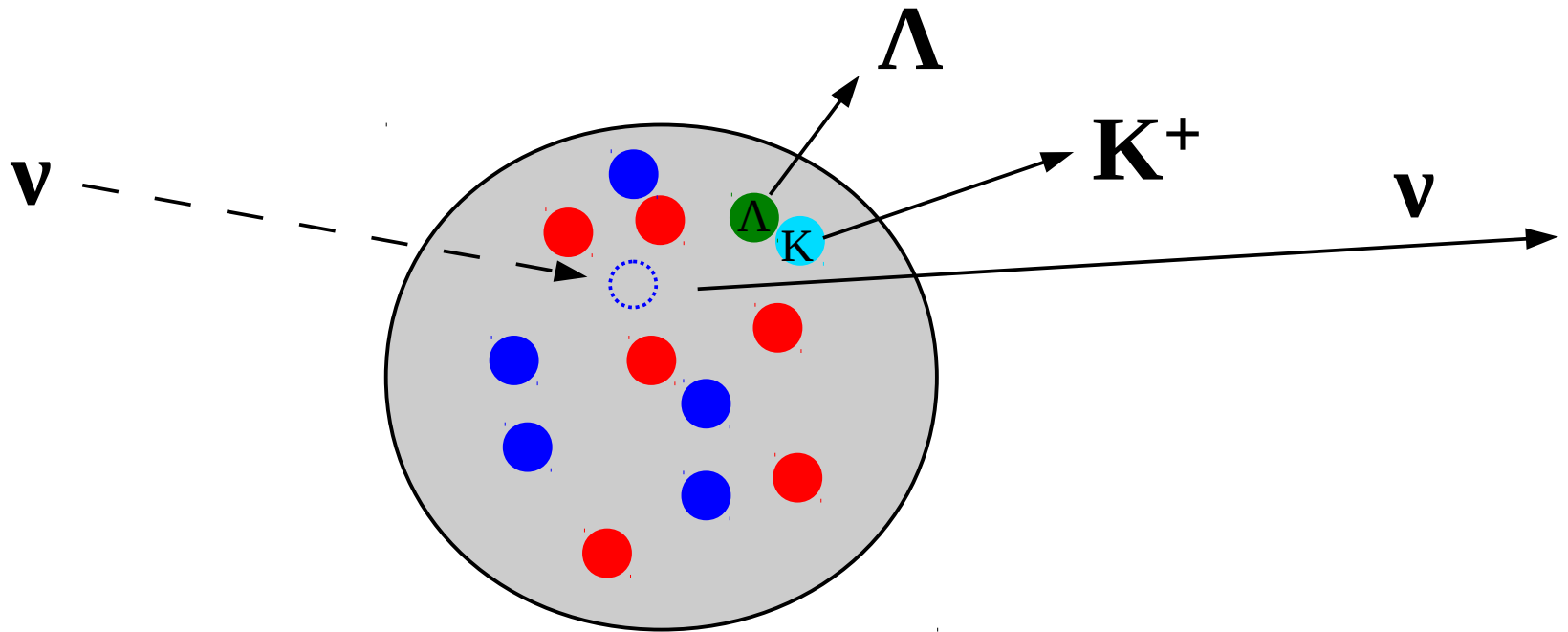


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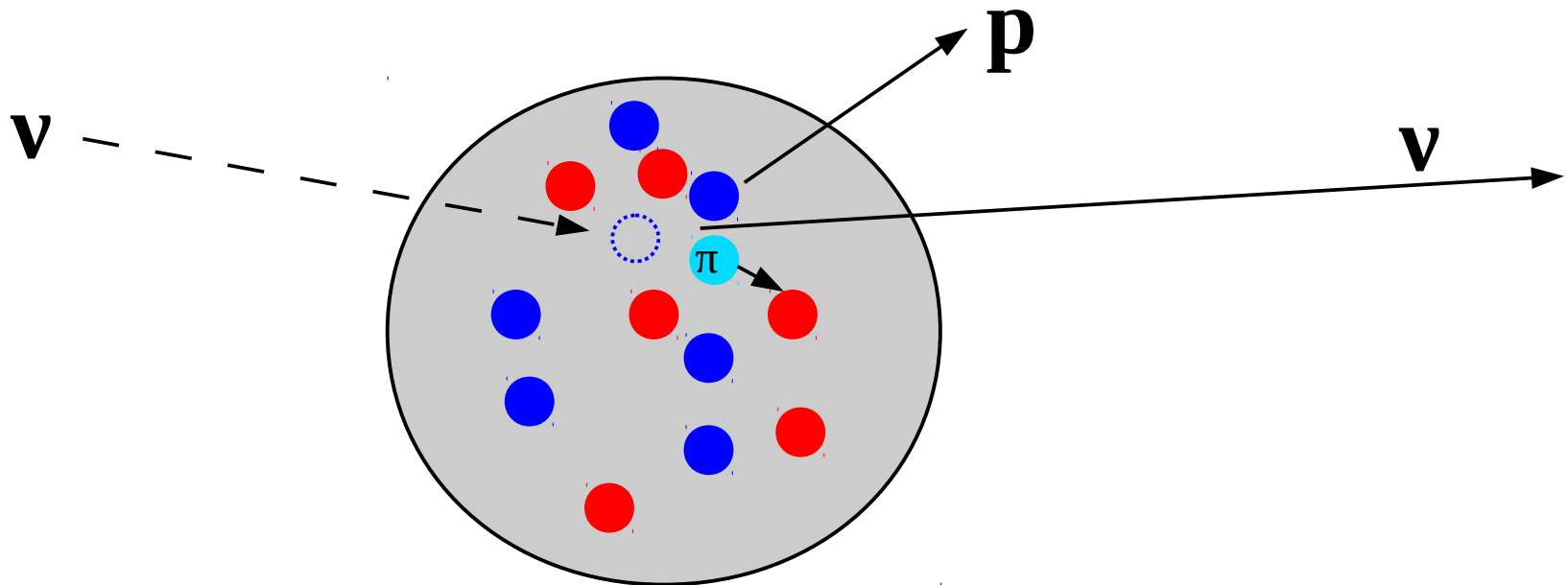




Final state interactions (FSI)



Kaons can be produced by pion interactions in the nucleus – we can't tell the difference in experiments

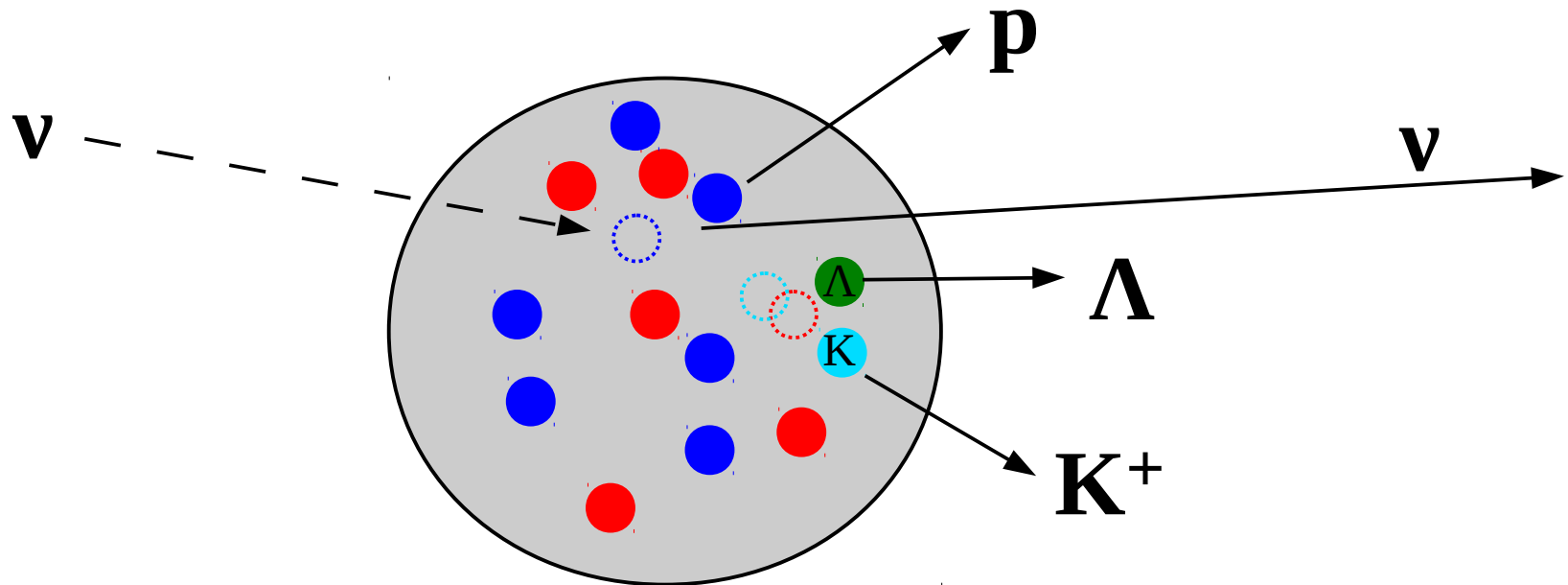




Final state interactions (FSI)

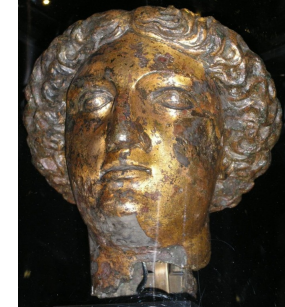


Kaons can be produced by pion interactions in the nucleus – we can't tell the difference in experiments

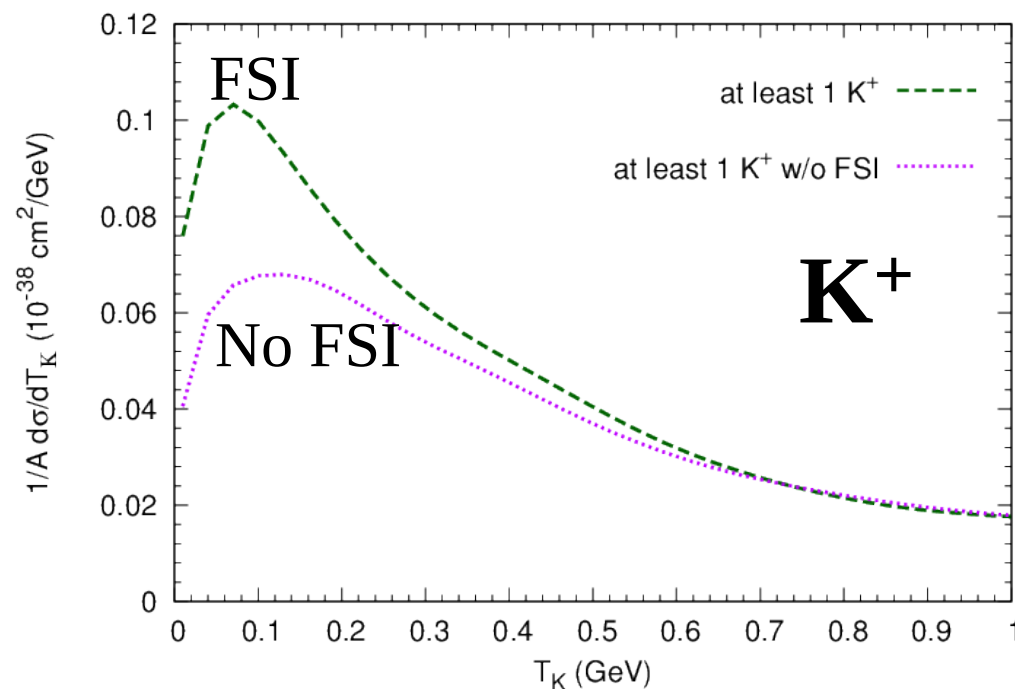
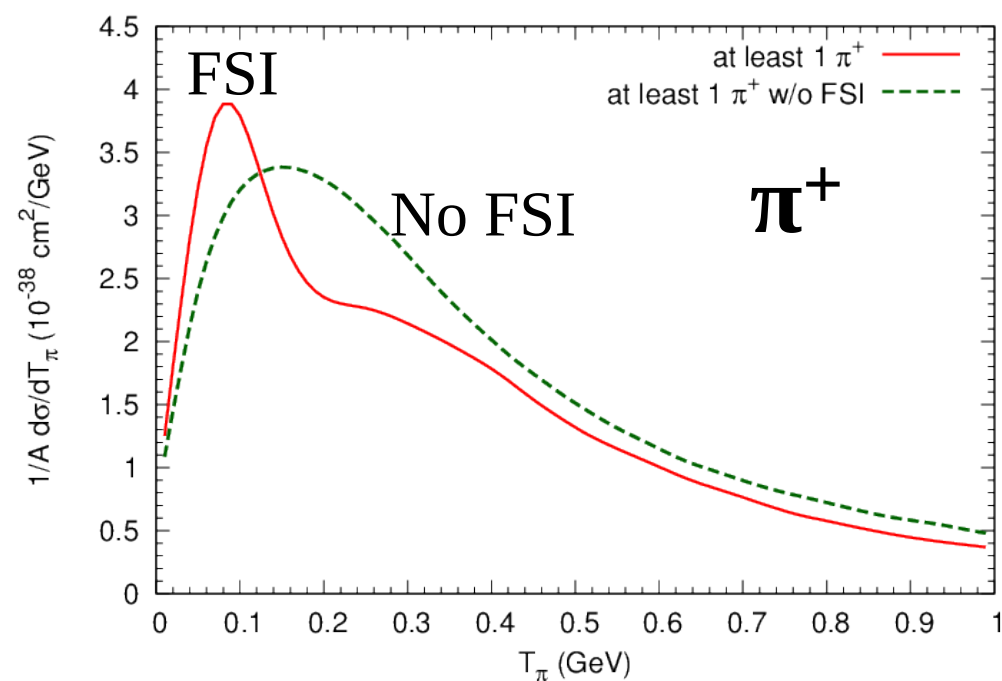




Why study K^+ production?



Sensitive to final-state interactions (FSI)



Theoretical prediction from GiBUU event generator

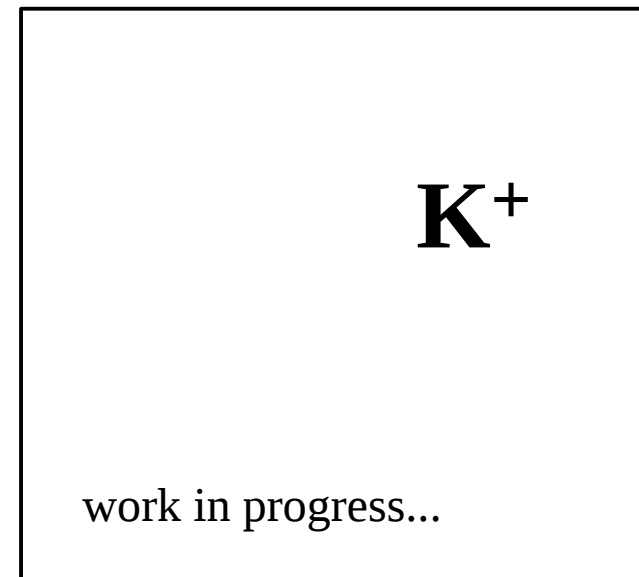
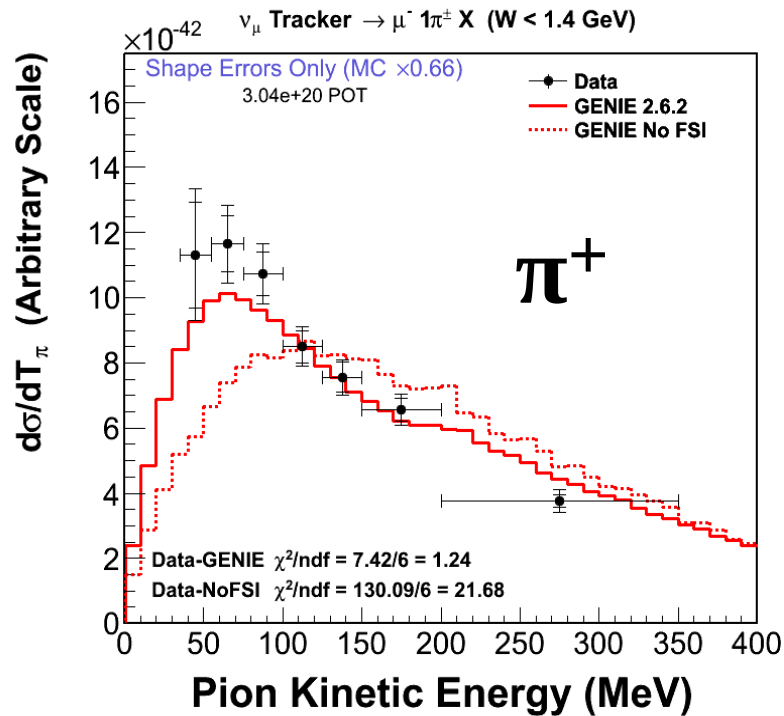
Mosel, Lalakulich, Gallmeister, Phys. Rev. D 89, 093003



Why study K^+ production?



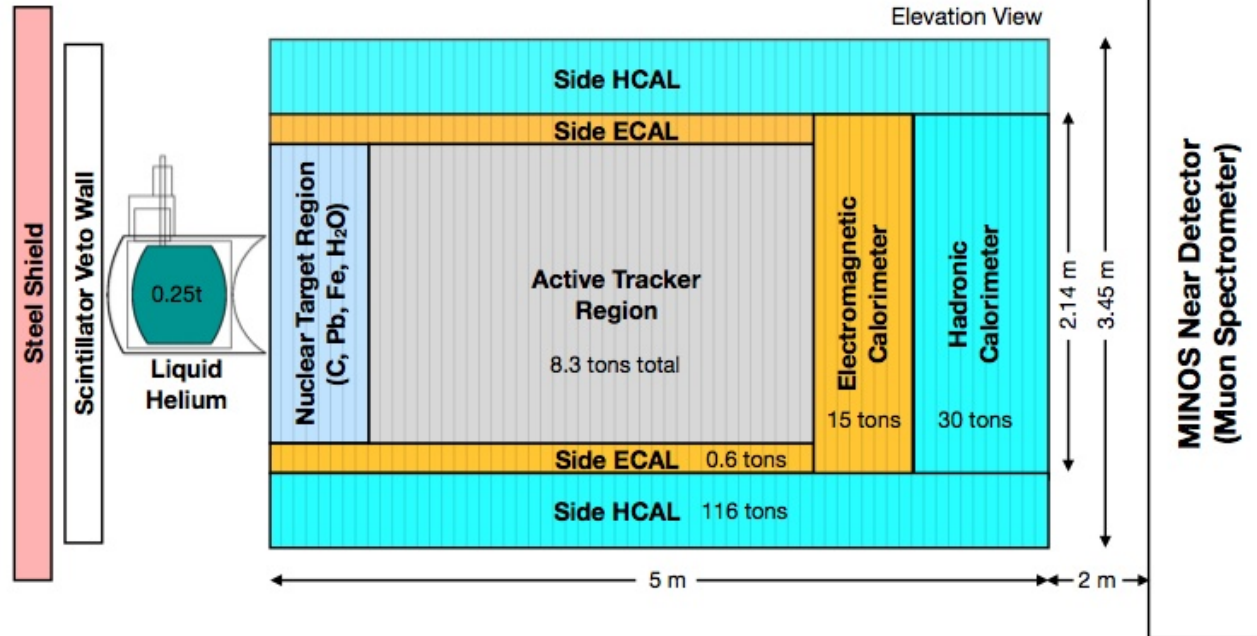
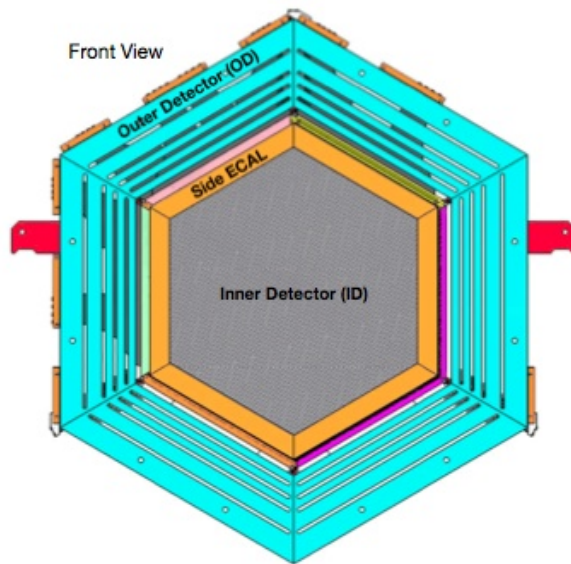
Sensitive to final-state interactions (FSI)



Data from MINERvA experiment



MINERvA detector



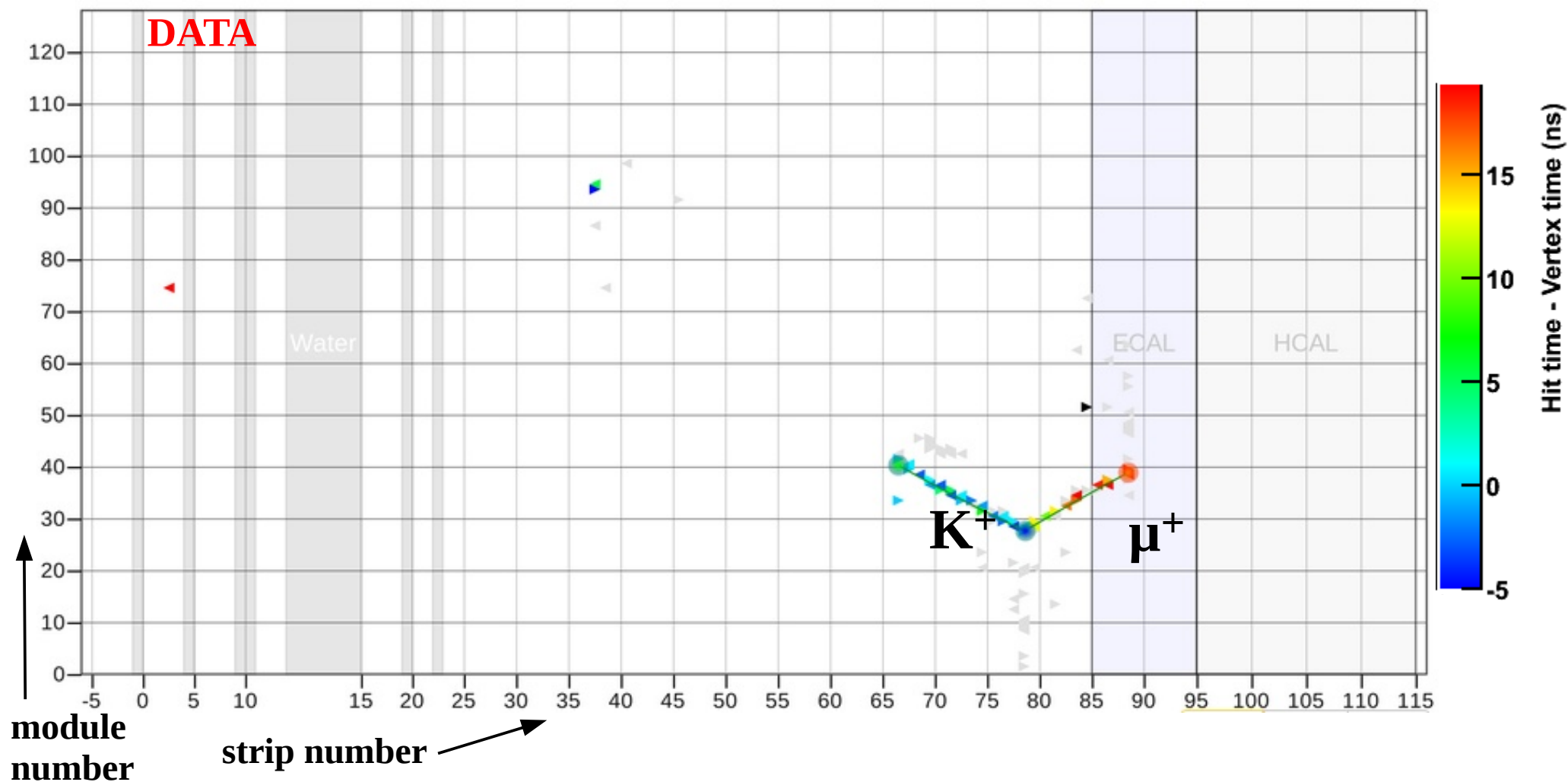


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“ K^+ + nothing”



top view



2014-06-09

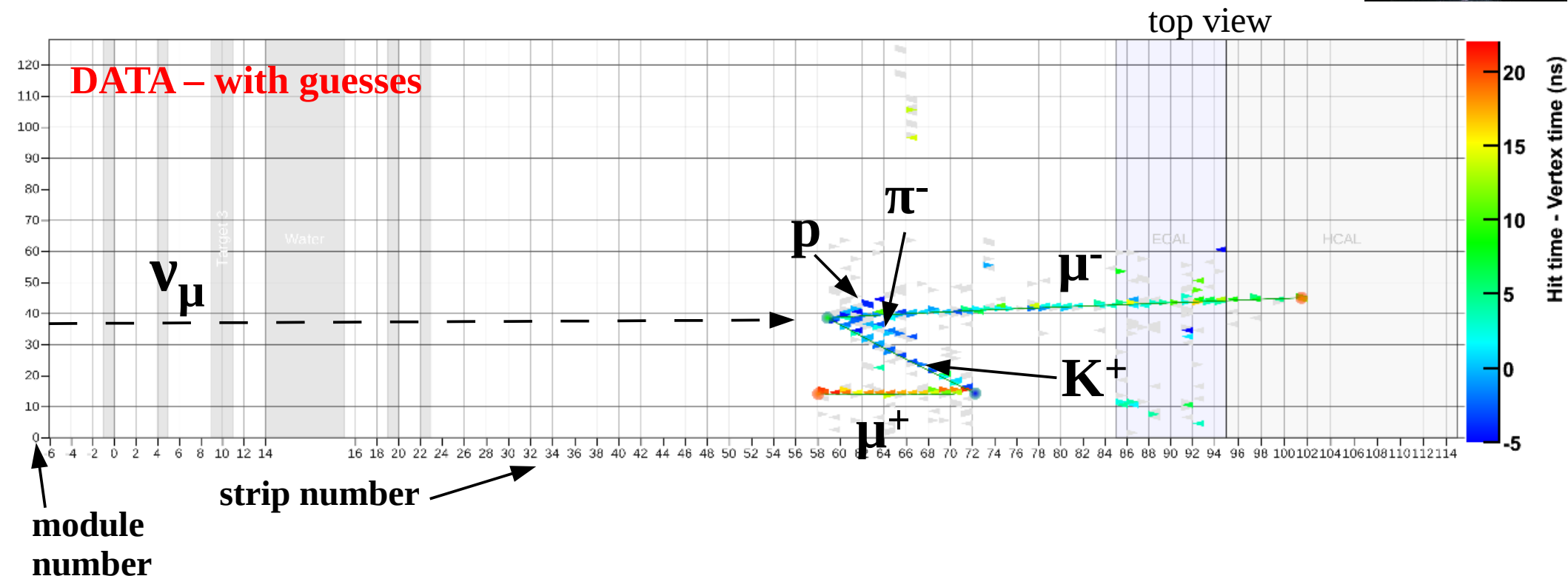
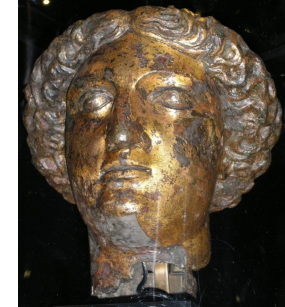
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K^+ event candidate



$$\nu_\mu n \rightarrow \mu^- K^+ \Lambda$$

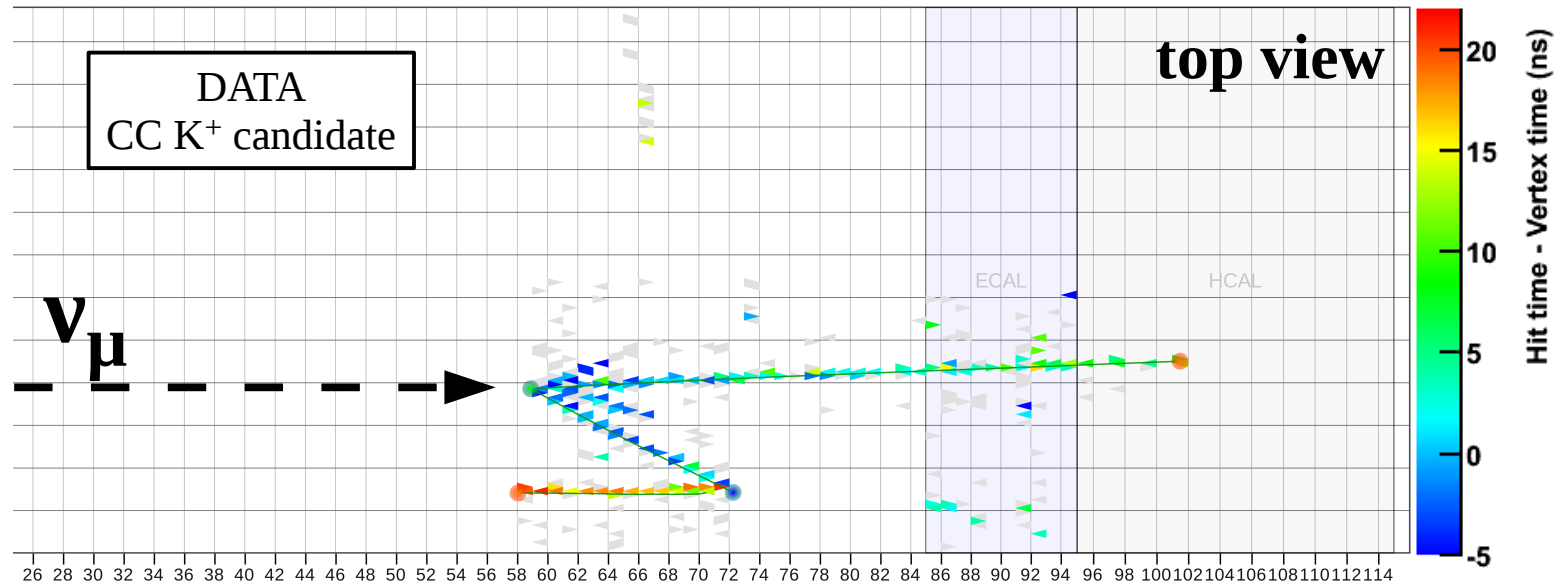
$$K^+ \rightarrow \mu^+ \nu_\mu$$

$$\Lambda \rightarrow p \pi^-$$

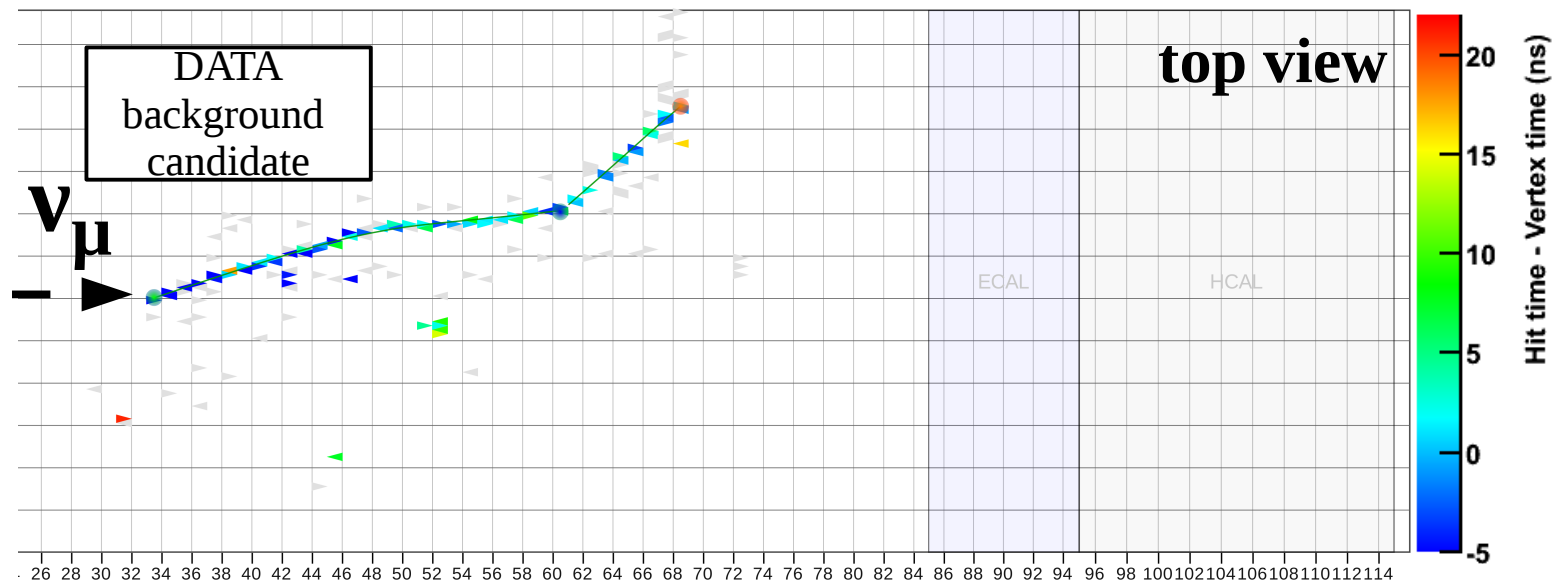


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Kinked track



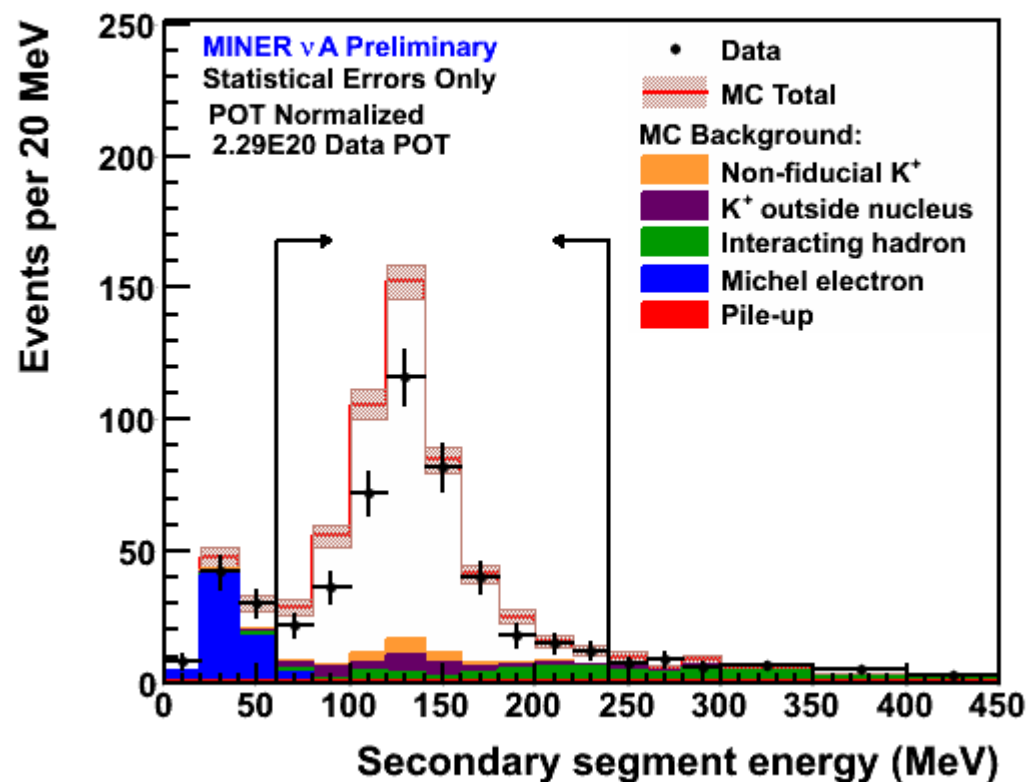
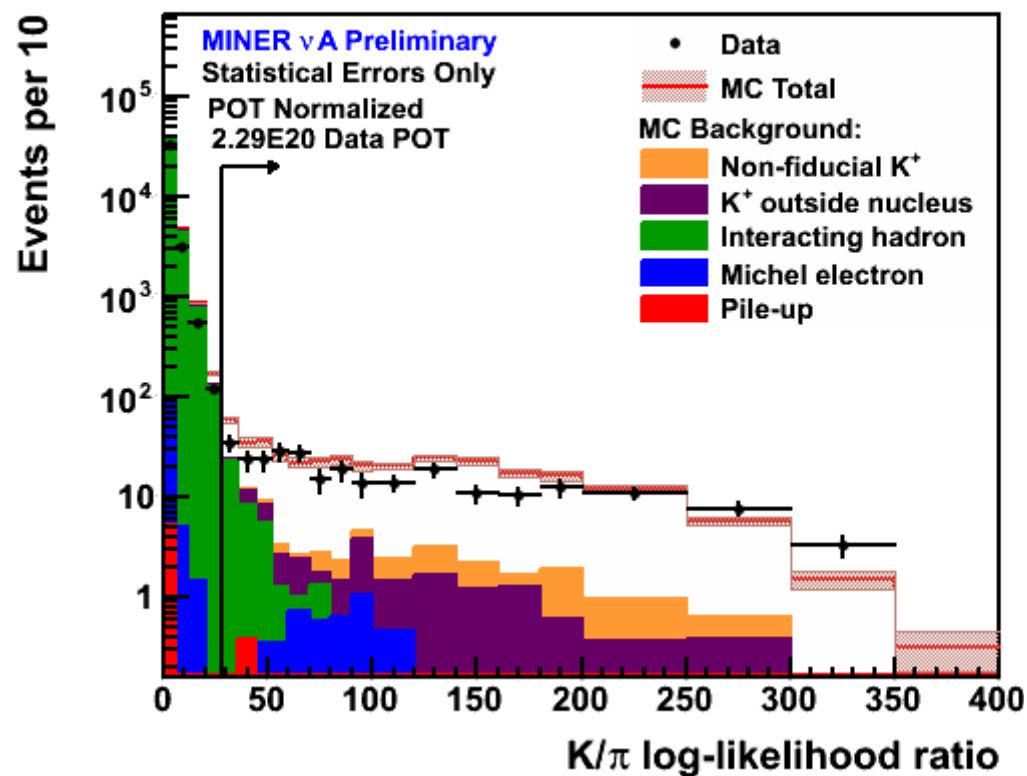
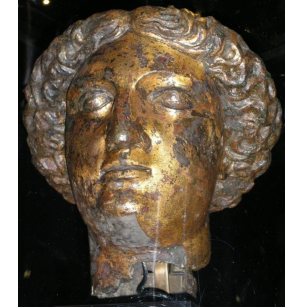
stopping kaon
at rest for ~ 17
ns at kink
point



interacting
pion (?)
does not stop
at kink point

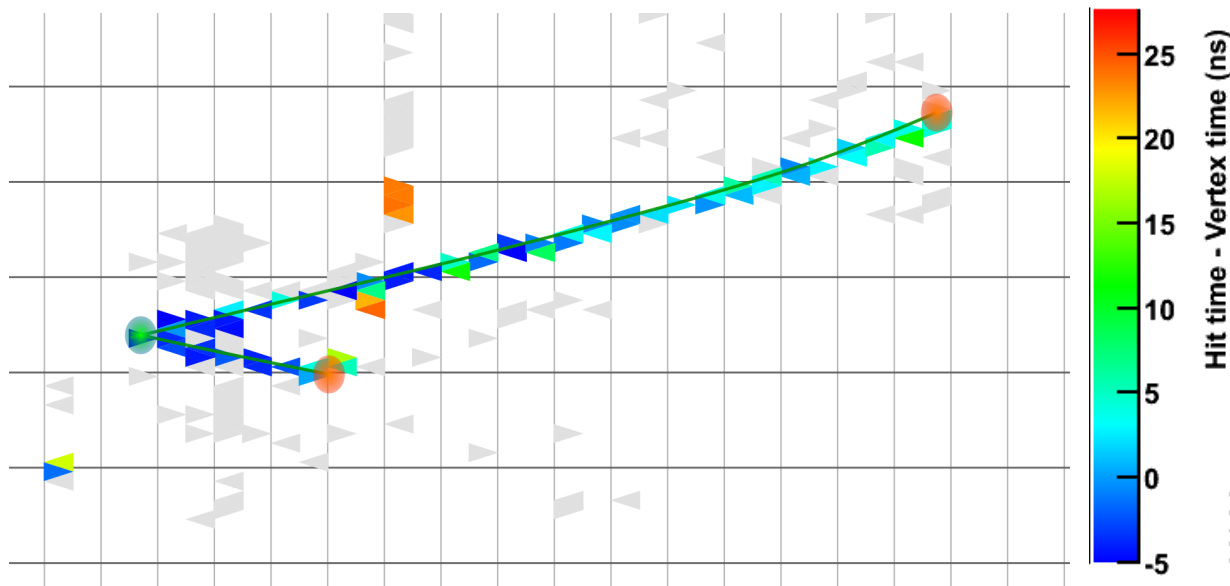


Selecting events



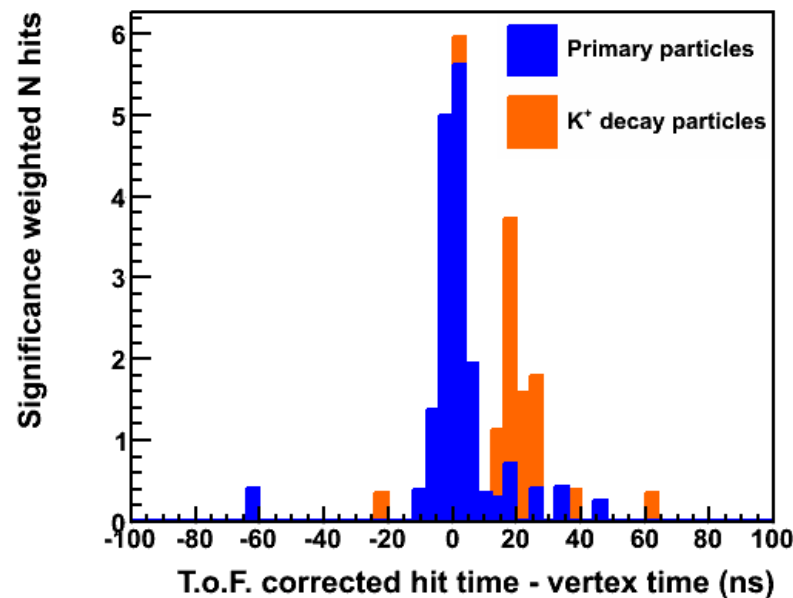


“Time sliver” selection



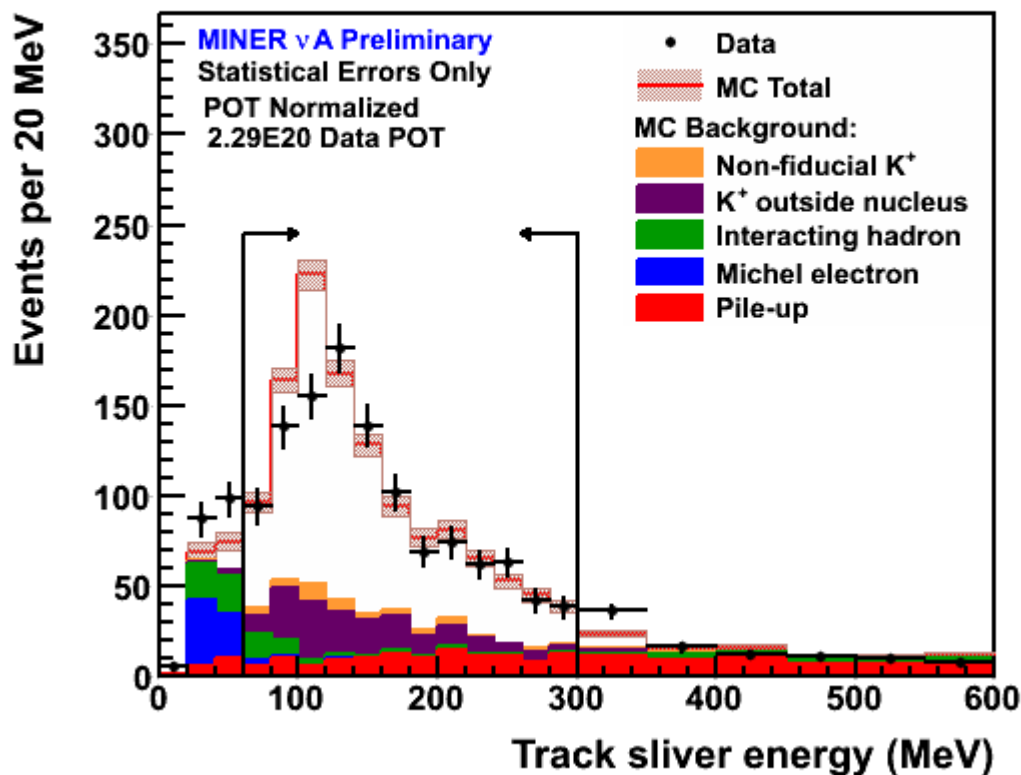
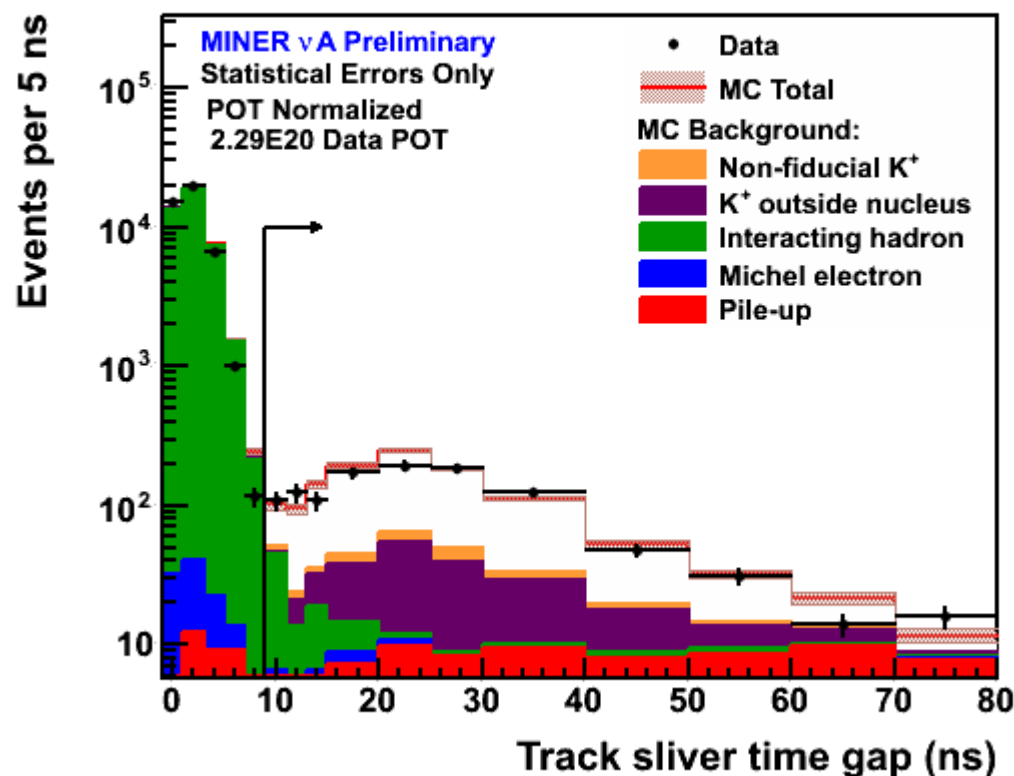
Look for hits clustered in time
in a narrow “time sliver” – like
the **orange** hits in this event

Secondary μ^+ track
intersects another track
and is not
reconstructed





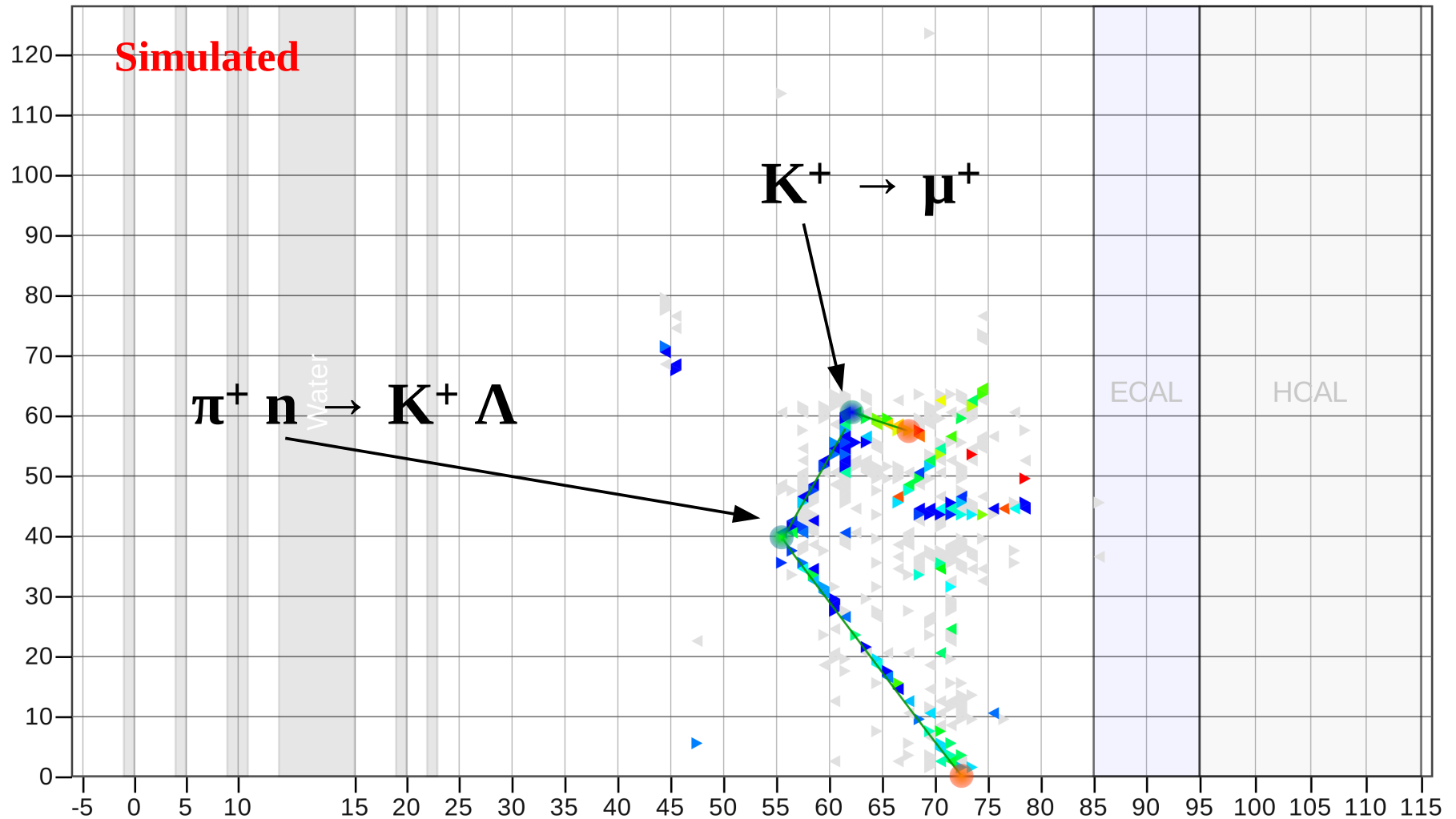
Selecting events





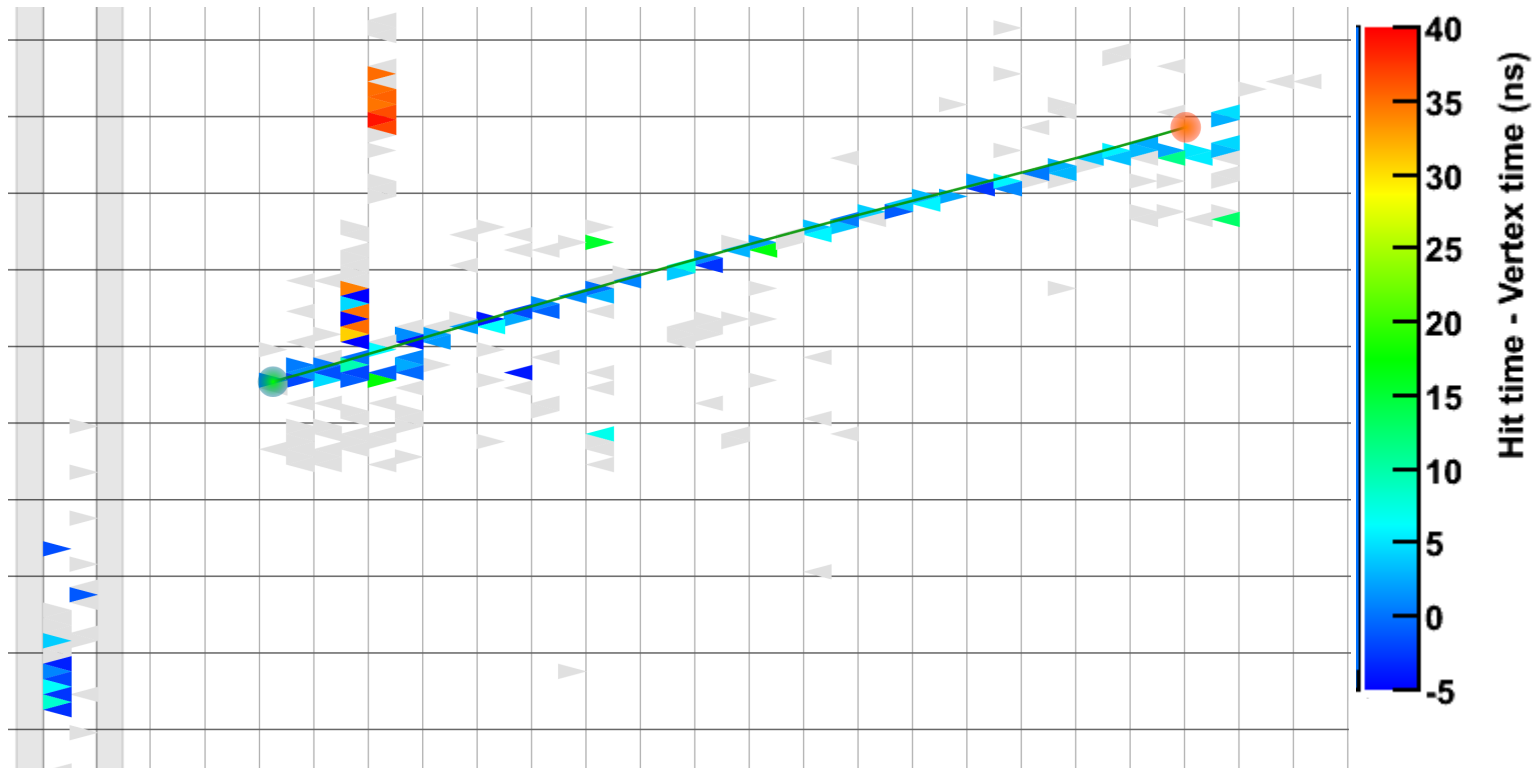
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“Outside nucleus” background





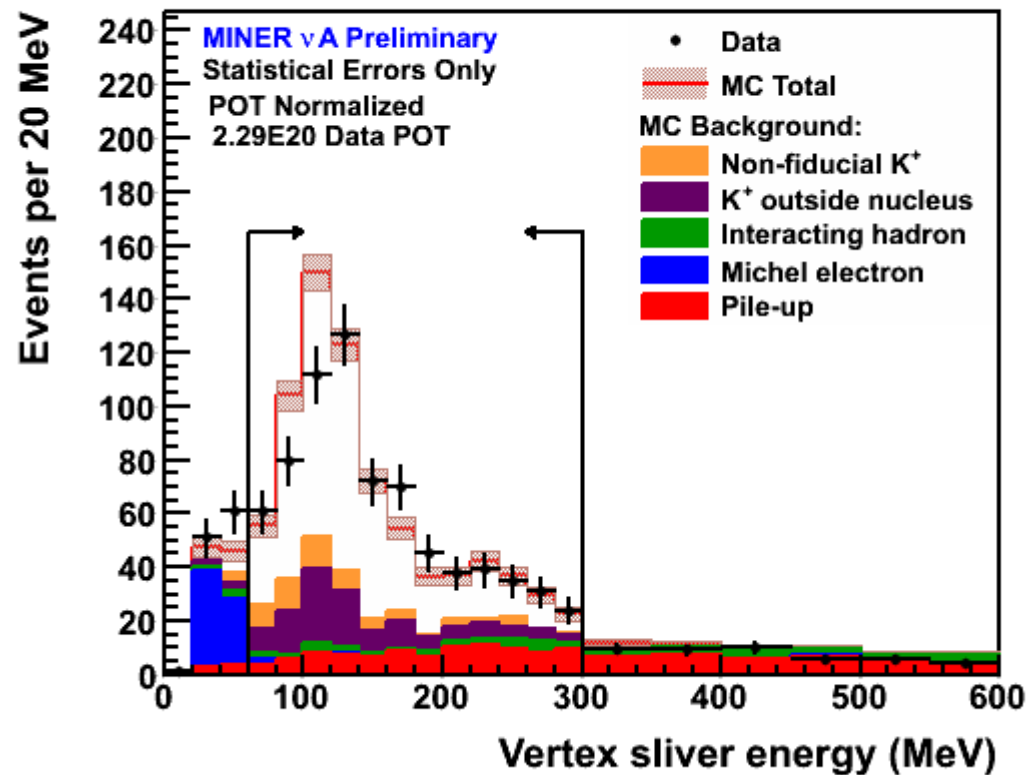
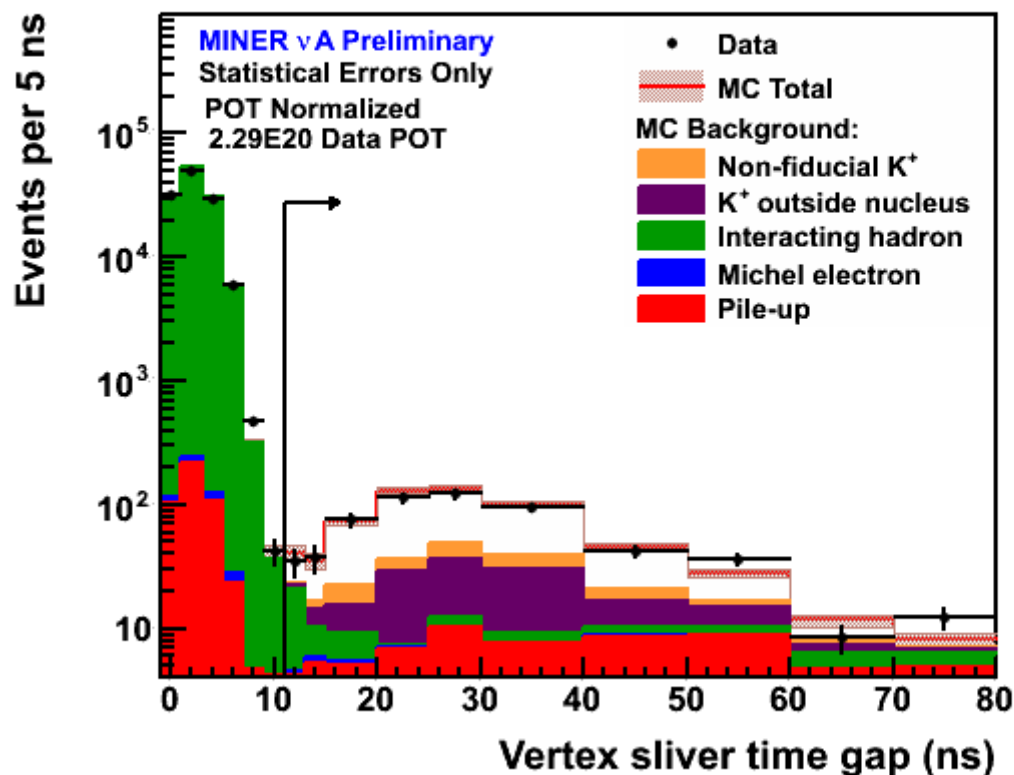
Soft kaons



K^+ candidate is below tracking threshold, but can be identified by hits from its decay products



Selecting events



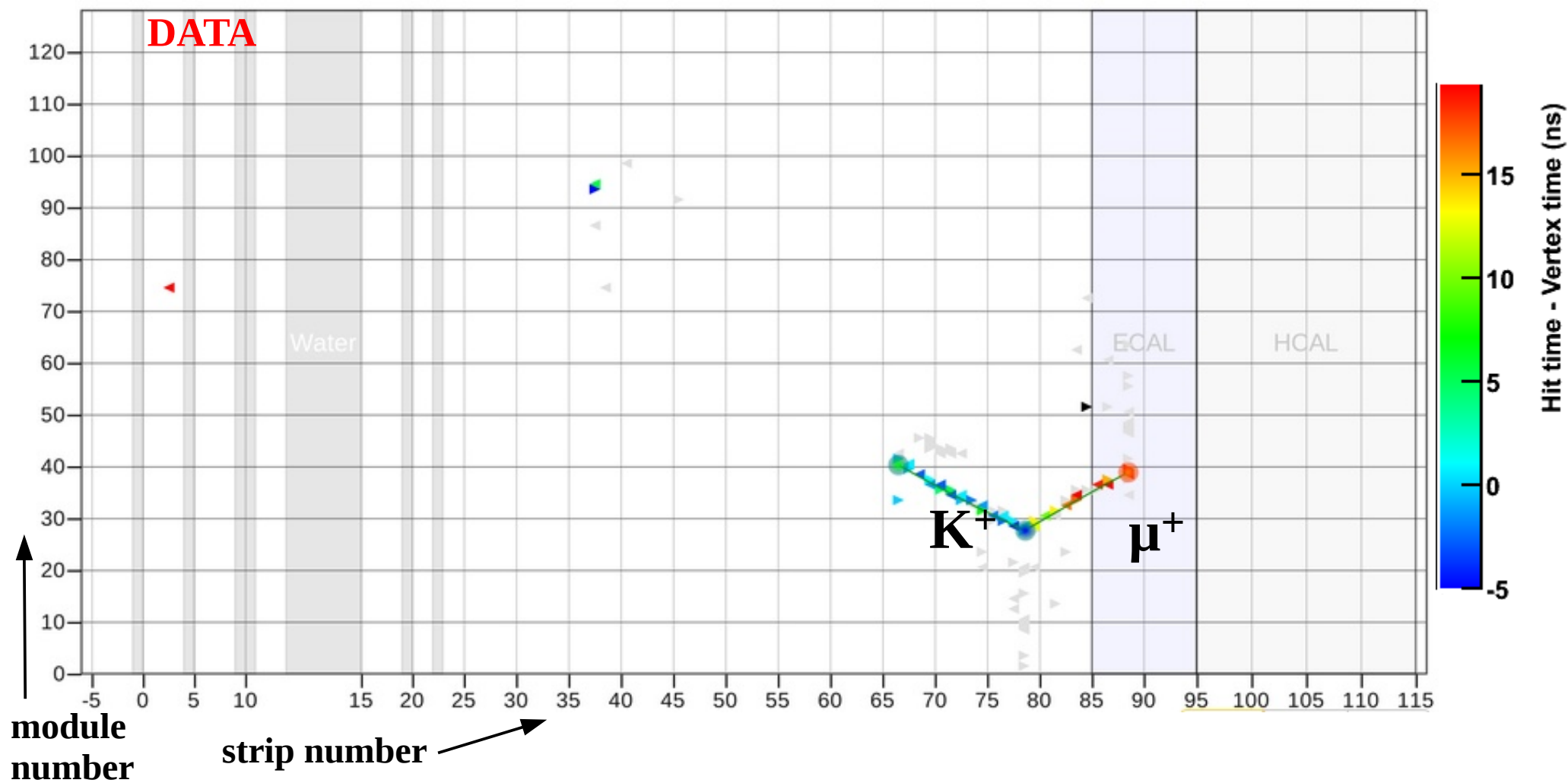


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$$\nu p \rightarrow K^+ ?$$



top view



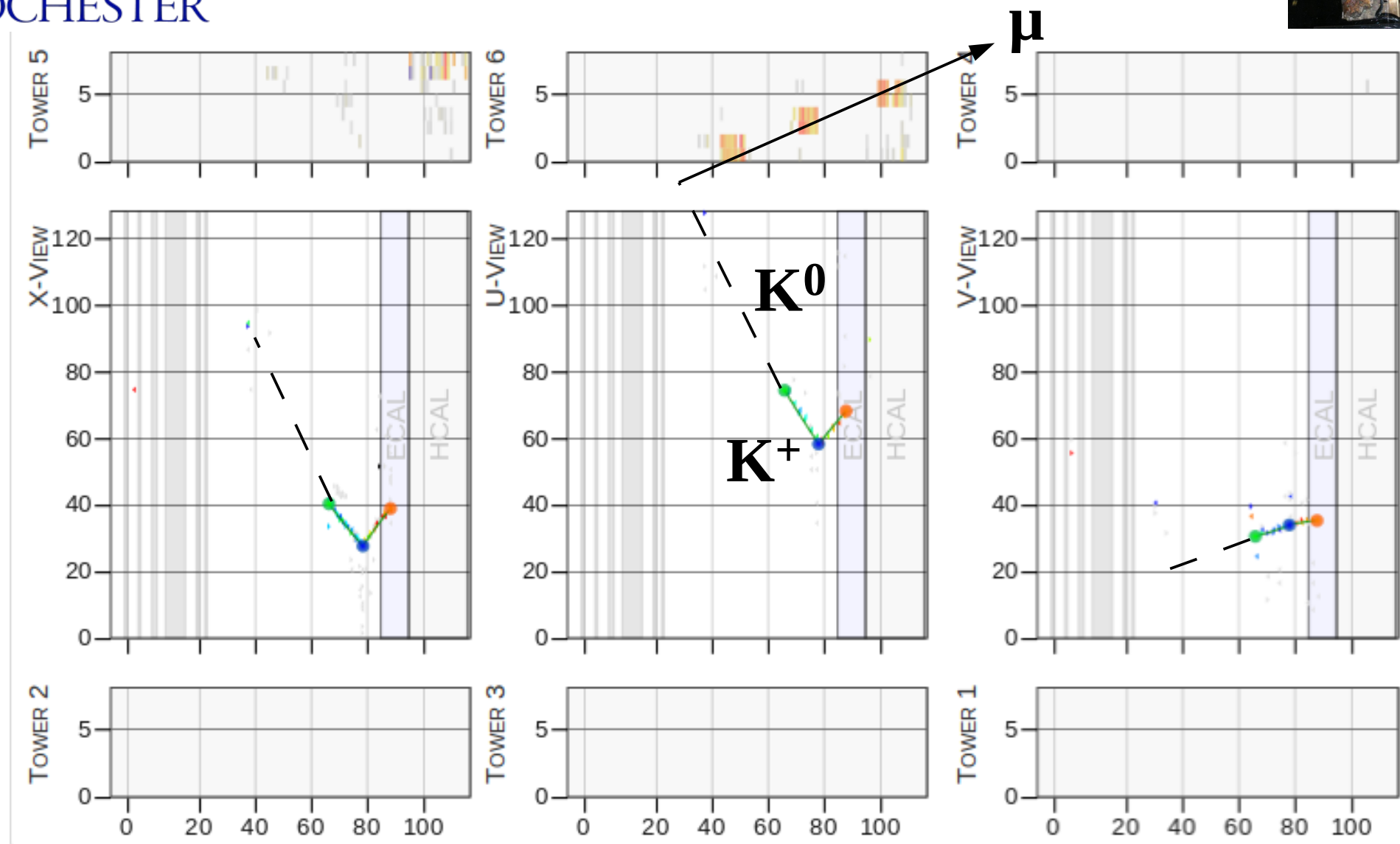
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No





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Recap



MINERvA uses timing information to identify K^+ events

Plan to measure neutral current K^+ production as a background constraint for proton decay searches

Plan to measure K^+ spectrum to study final-state interactions

Cross sections in 2015

Backup

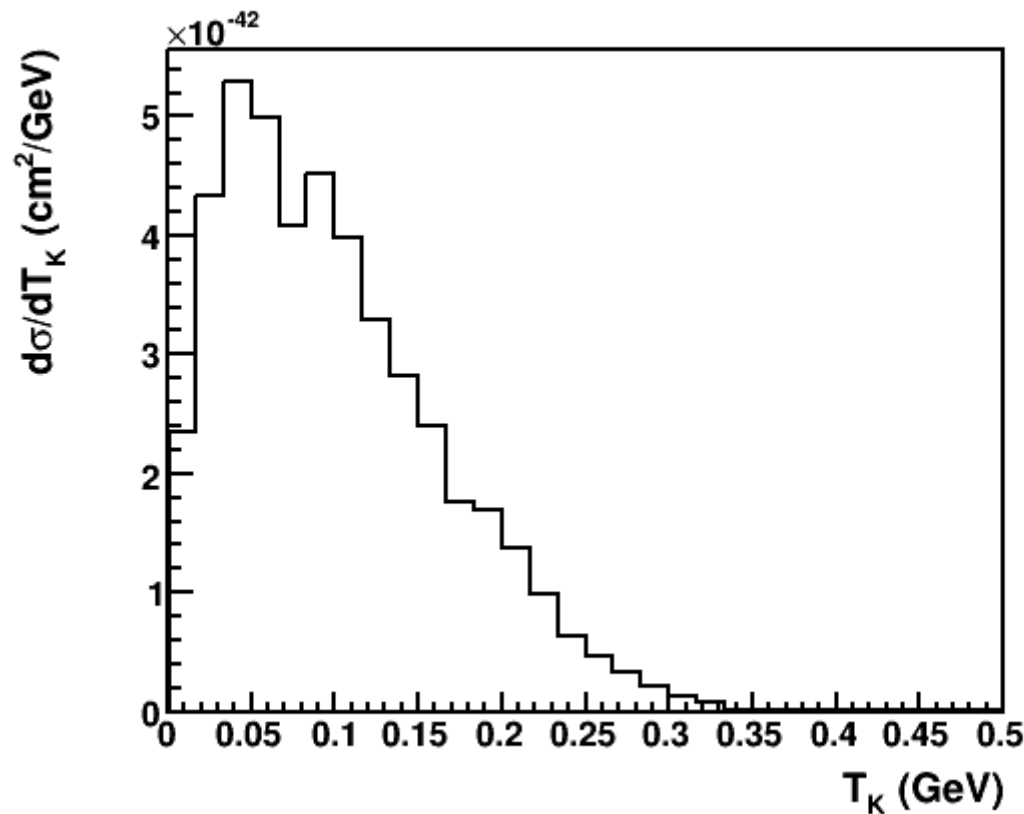




Single kaon production



1.0 GeV $\nu_\mu p \rightarrow \mu^- K^+ p$

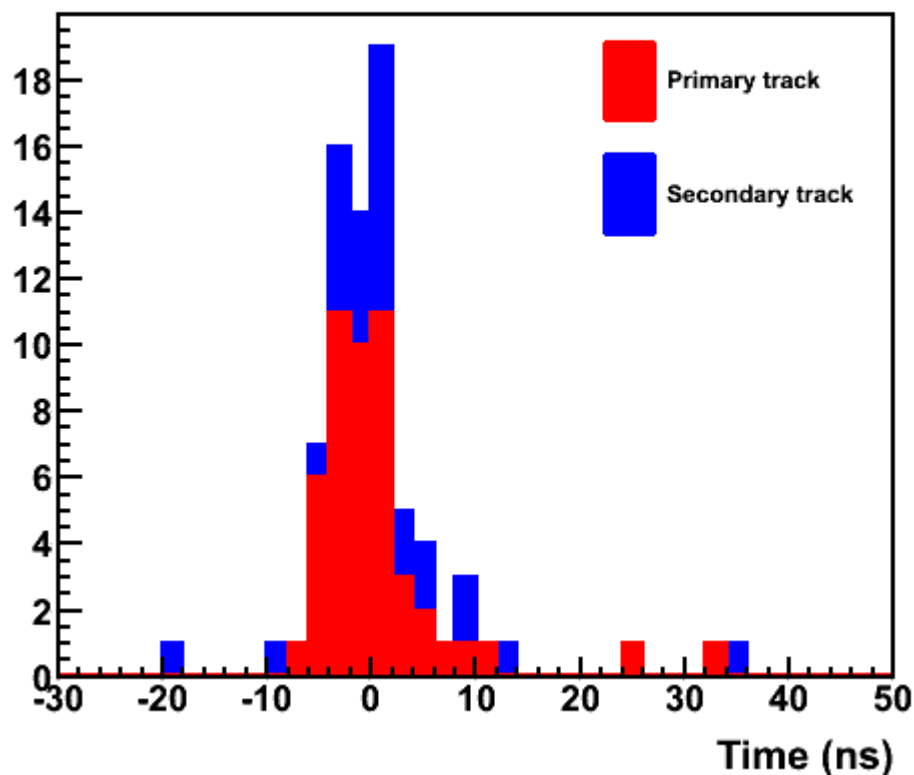


Work underway to add
Alam *et al.* model to
GENIE

Especially important at
low end of MINERvA
flux, but associated
production still dominates



Pion example histogram



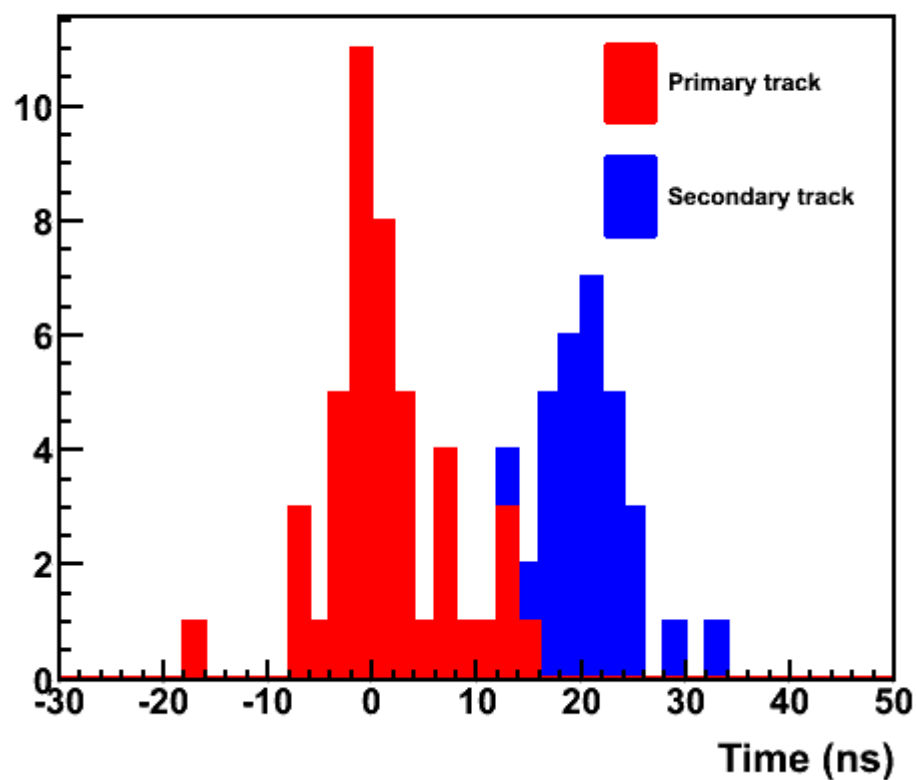
For pions, primary and secondary tracks are in-time

This distribution is just the typical time smearing for a pion track



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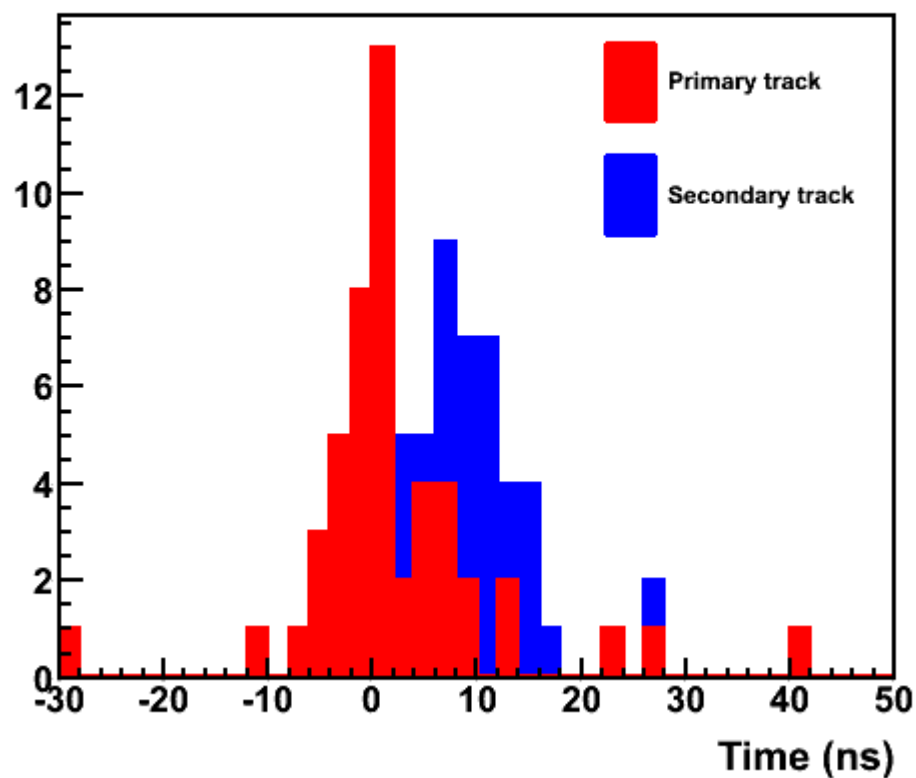
20 ns kaon



Kaon with 20 ns decay time



10 ns kaon

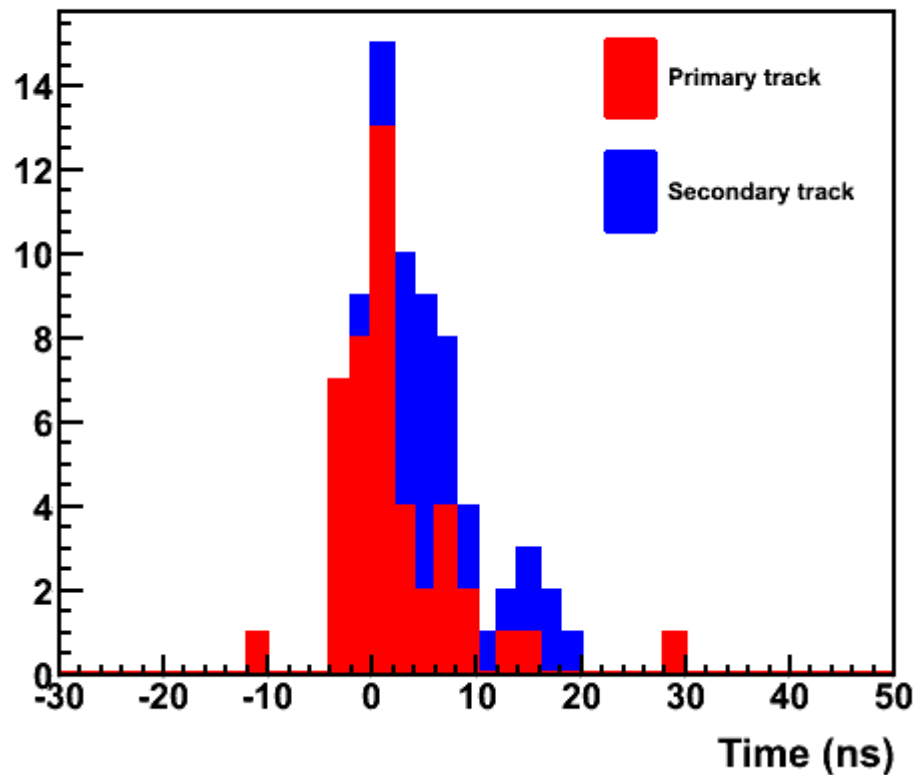


Kaon with 10 ns decay time

Starts to overlap with the primary



5 ns kaon



Kaon with 5 ns decay time

Large overlap with primary but still some separation – if you know which hits are which



Data overlay



Insert MC hits into data

Combine MC, data hits before running reconstruction

Reconstruction algorithms can be confused by “data overlay” hits