CC COHERENT PION PRODUCTION AT MINERνA

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New Perspectives
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Outline

CC Coherent Pion Production – What & Why

Previous Measurements

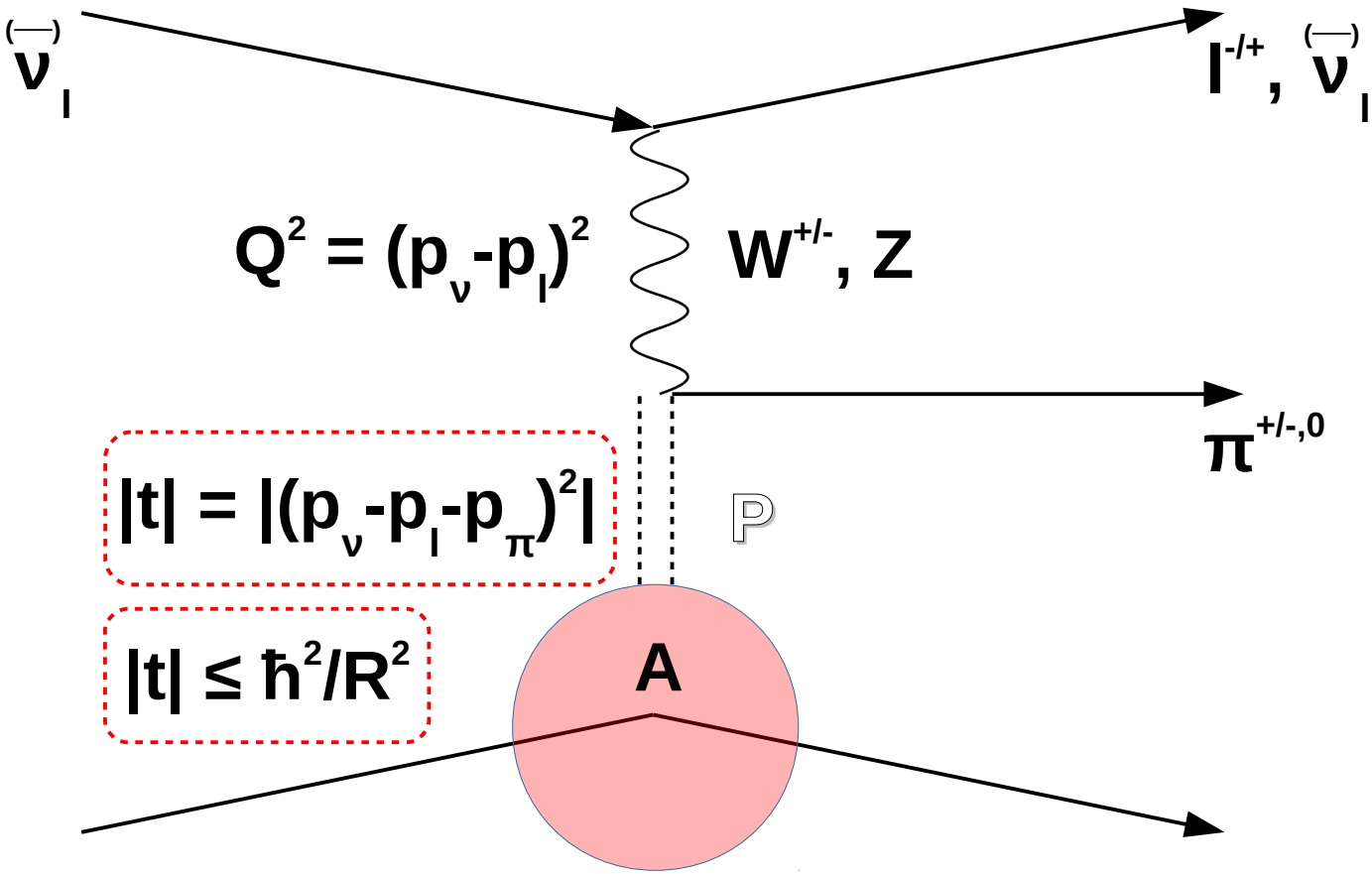
MINERvA's Measurement
- **-Low Energy**
- **-Upcoming in Medium Energy**

Discussion

CC Coherent Pion Production
What & Why

Coherent π Reactions

In General



The Theory: PCAC

From Adler's Theorem: $\nu+\alpha \rightarrow l+\beta$

- **Negligible lepton mass ($m_l << E_\nu$)**
- **Outgoing lepton parallel to incoming ν**

→ **$Q^2 = 0$**

Conserved in strong interactions

Not conserved in strong interactions

→ **Scattering amplitude of the interaction only depends on the divergence of h_V and h_A**

→ **$\sigma(\nu_\mu A) \rightarrow \sigma(\pi A)$**

The Theory: The Models

In reality Q2 > 0
So we need to extrapolate

↓

-Rein-Sehgal
-Berger-Sehgal
-Microscopic Coherent

Importance

But why are these harmless and shy interactions, so important?

Eν>~10GeV

- **Since before ν oscillations** ⟹ **Studying the weak axial vector current (test models like PCAC).**

Eν<~10GeV

- **After ν oscillations** ⟹ **Important background and source of systematic uncertainties.**

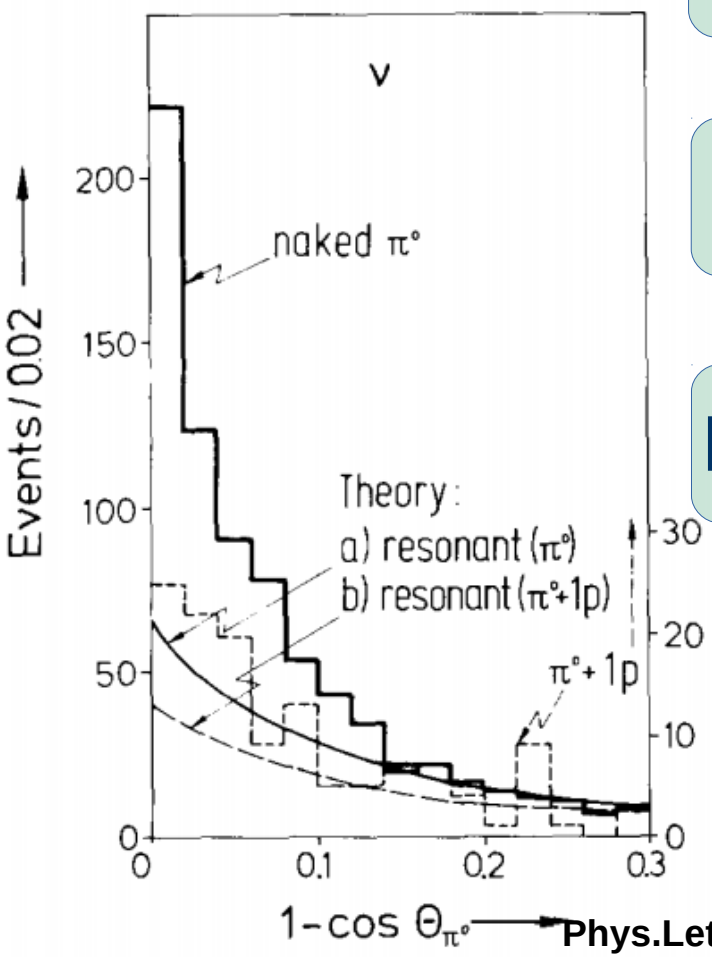
Previous Measurements

Evidence of Coherent π

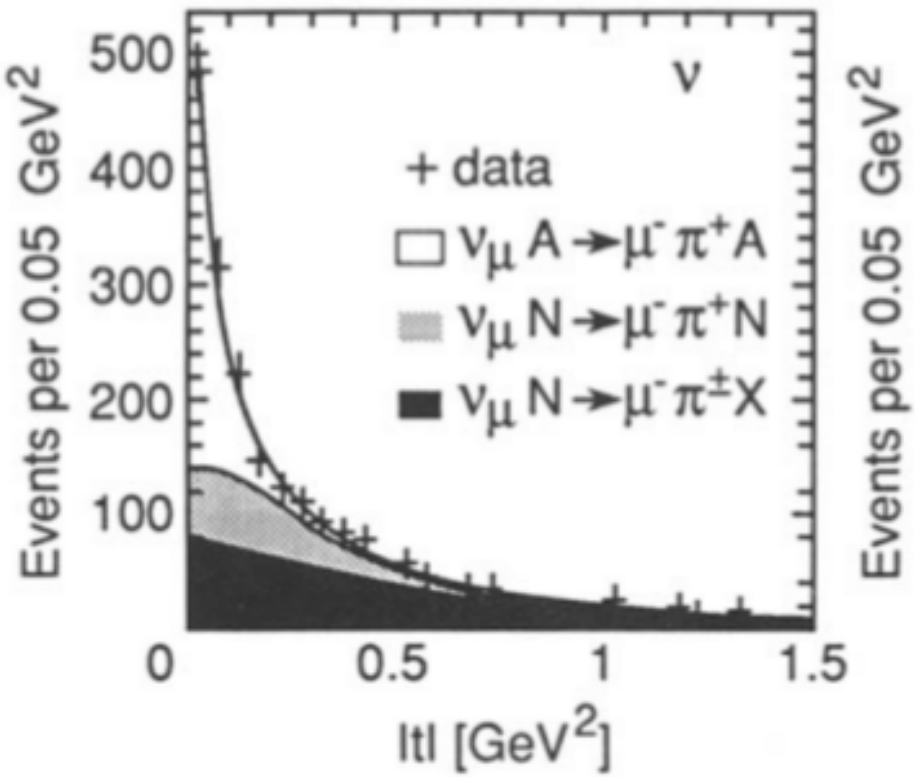
HE NC π^0

LE NC π^0

HE CC $\pi^{\pm}$



Phys.Lett. 125B (1983) 230-236



Physics Letters B 313 (1993) 267-275

Evidence of Coherent π

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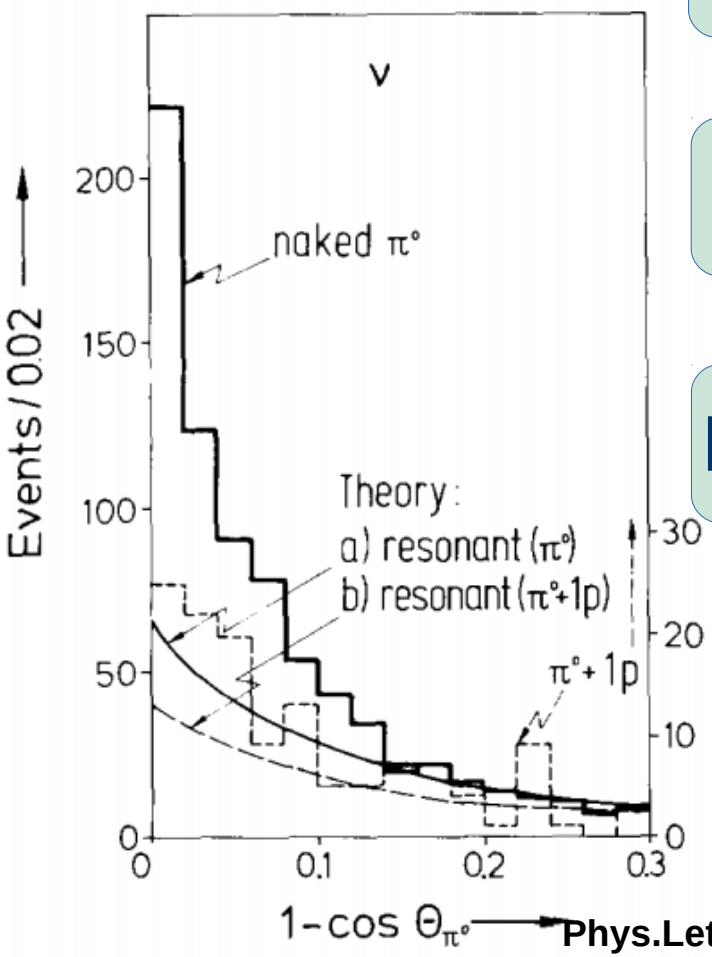

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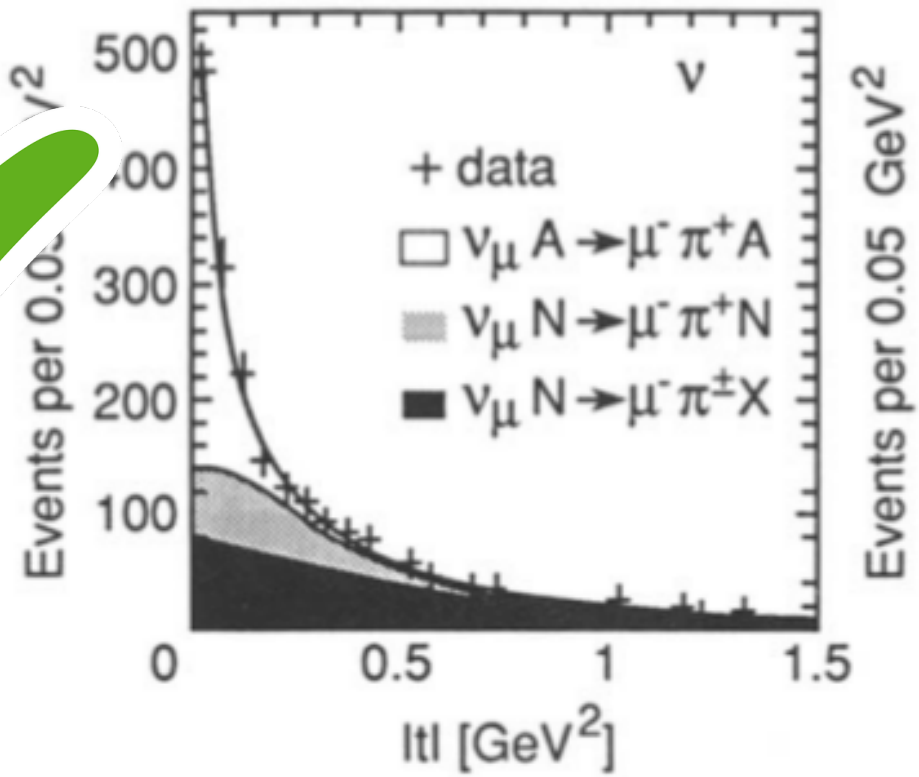

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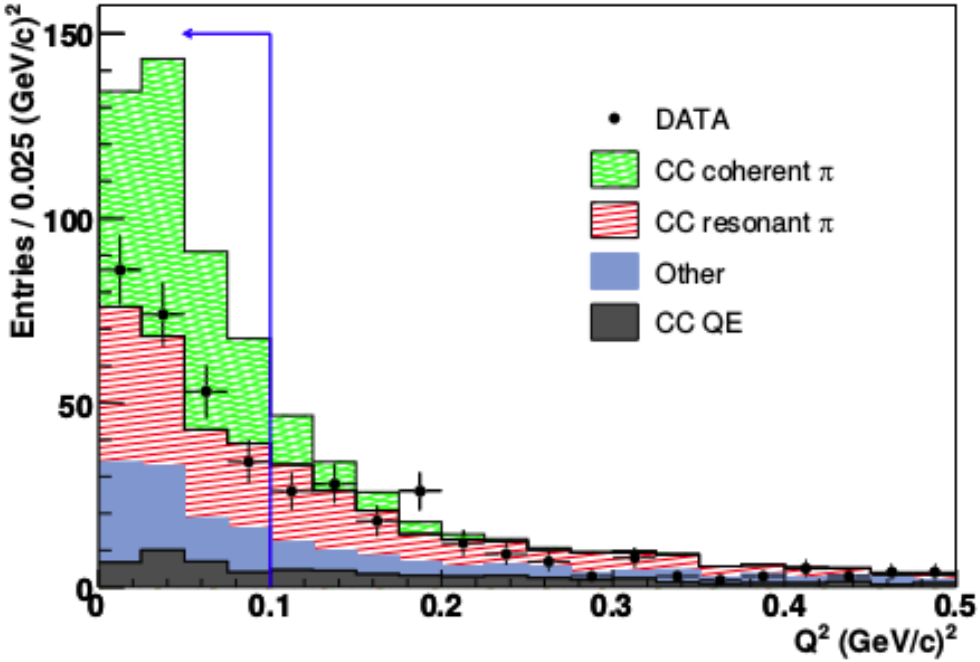
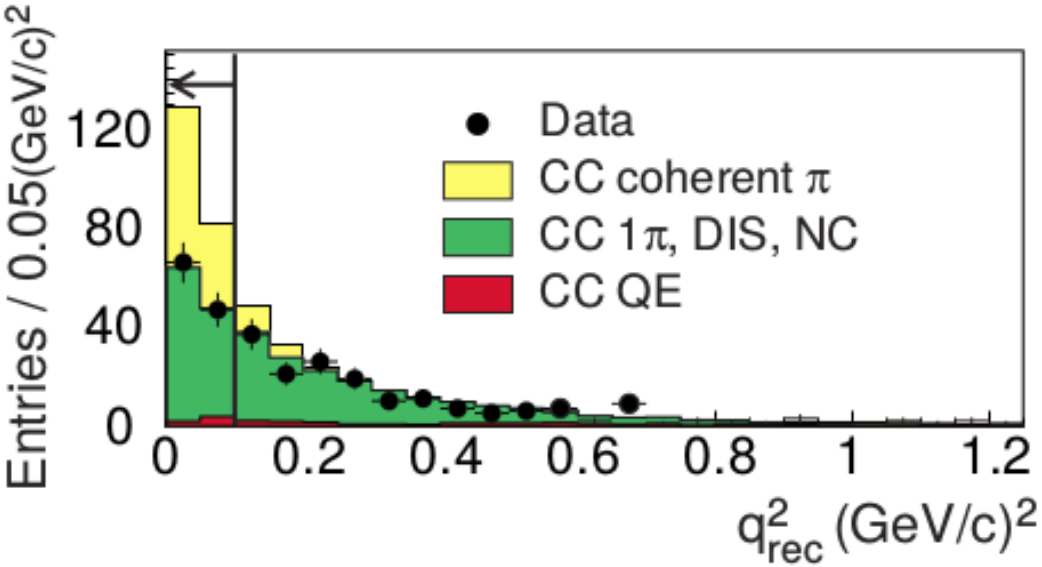
No Evidence of Coherent π

LE CC $\pi^{\pm}$



Phys.Rev. D78 (2008) 112004



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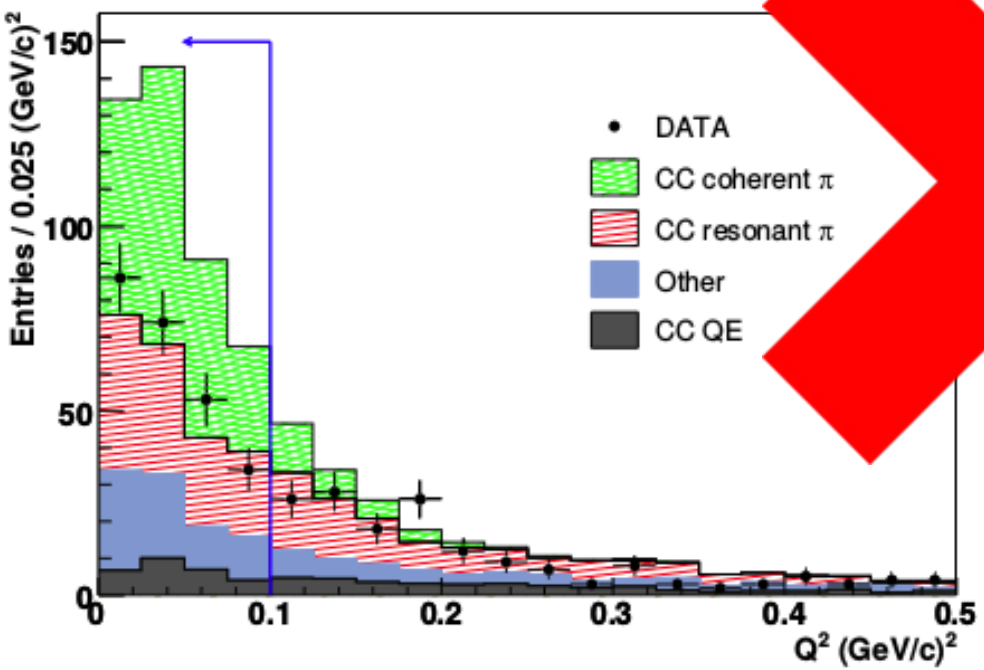

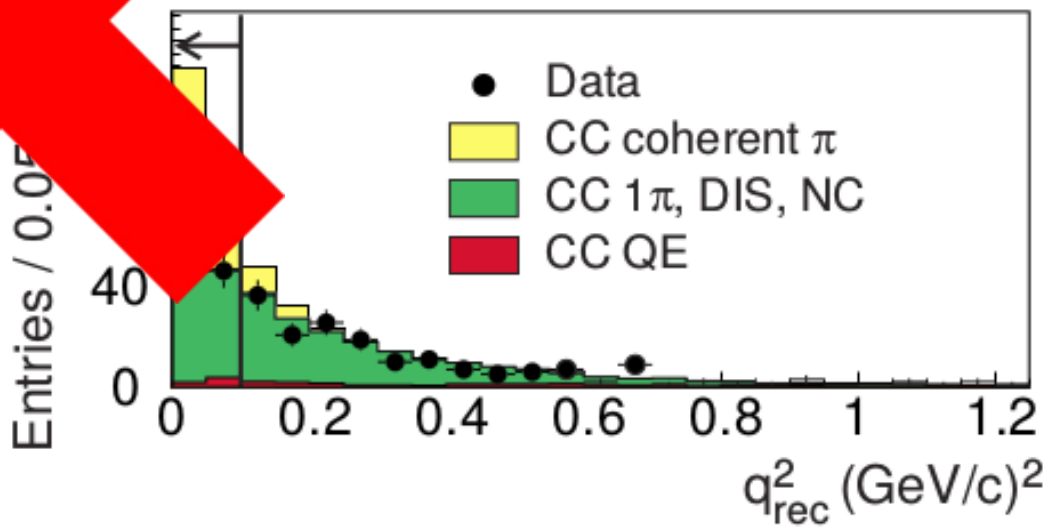

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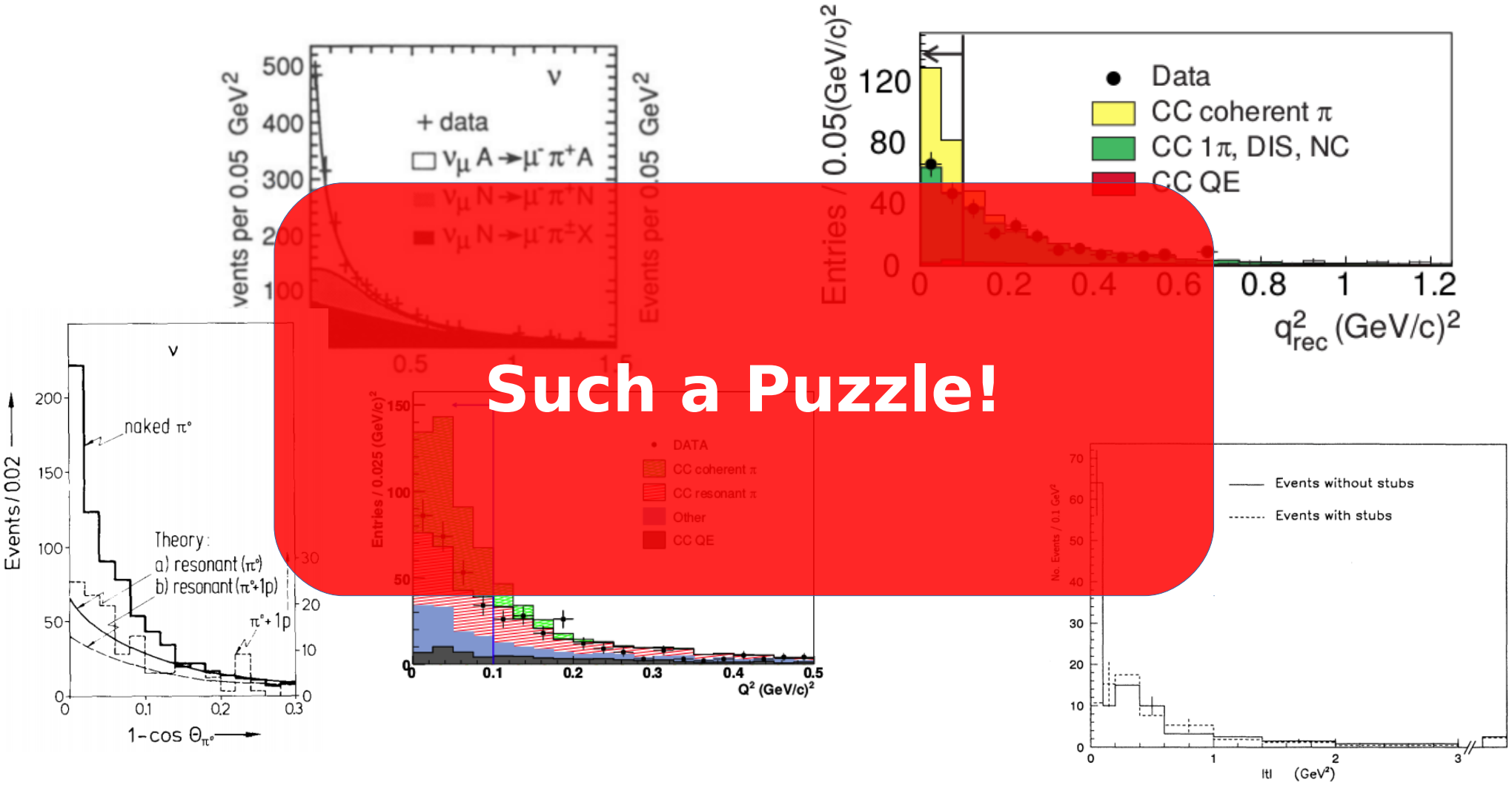
So Evidence?



Such a Puzzle!

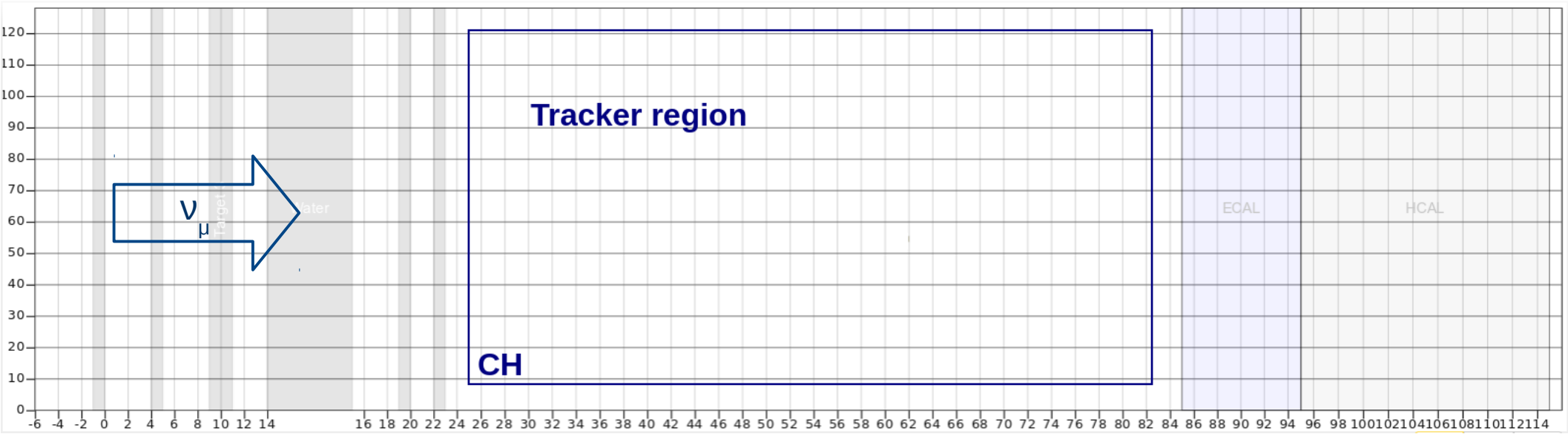
MINERνA’s Measurement

Low Energy Analysis

Beam & detector details

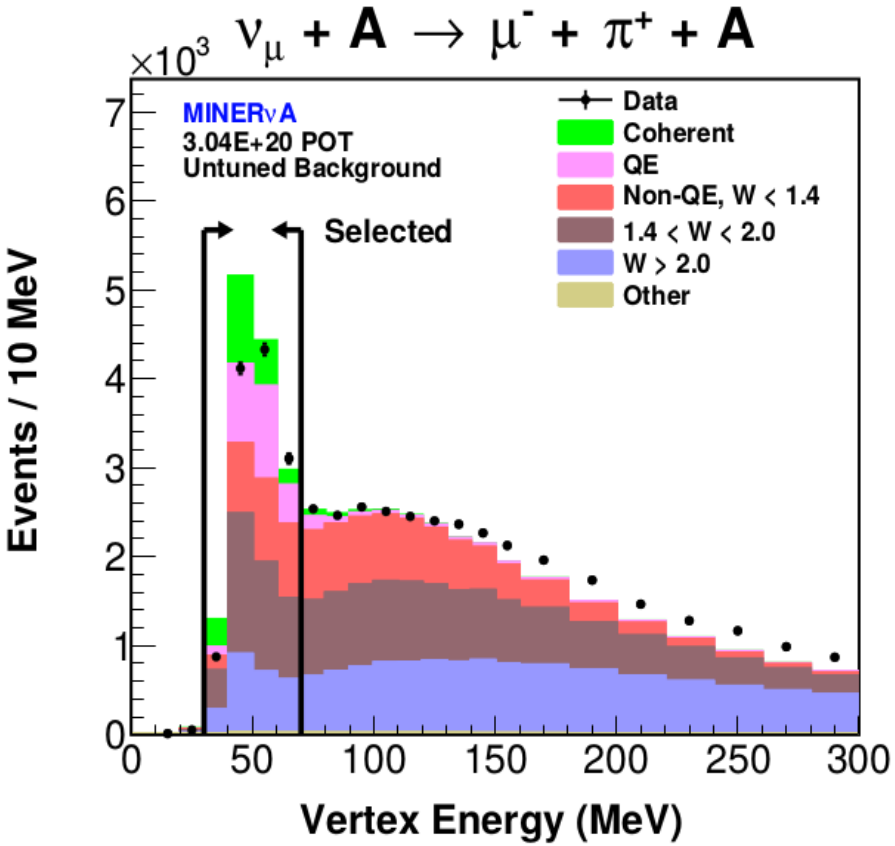
$<E_\nu>$=3.5GeV (both nu & anti-nu)

3.05(2.01)E20 POT for nu(anti-nu)



CC Coherent $\pi^{+/-}$ in LE, finally!

Solving the LE CC Coherent Puzzle !



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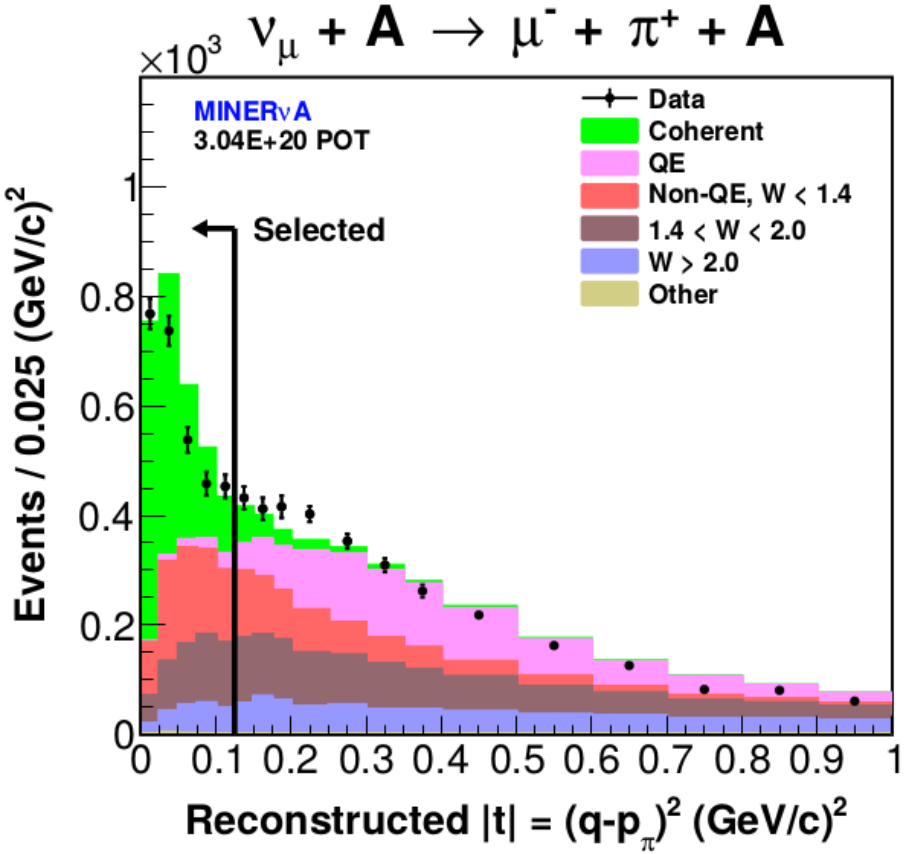
Aaron Mislivec.



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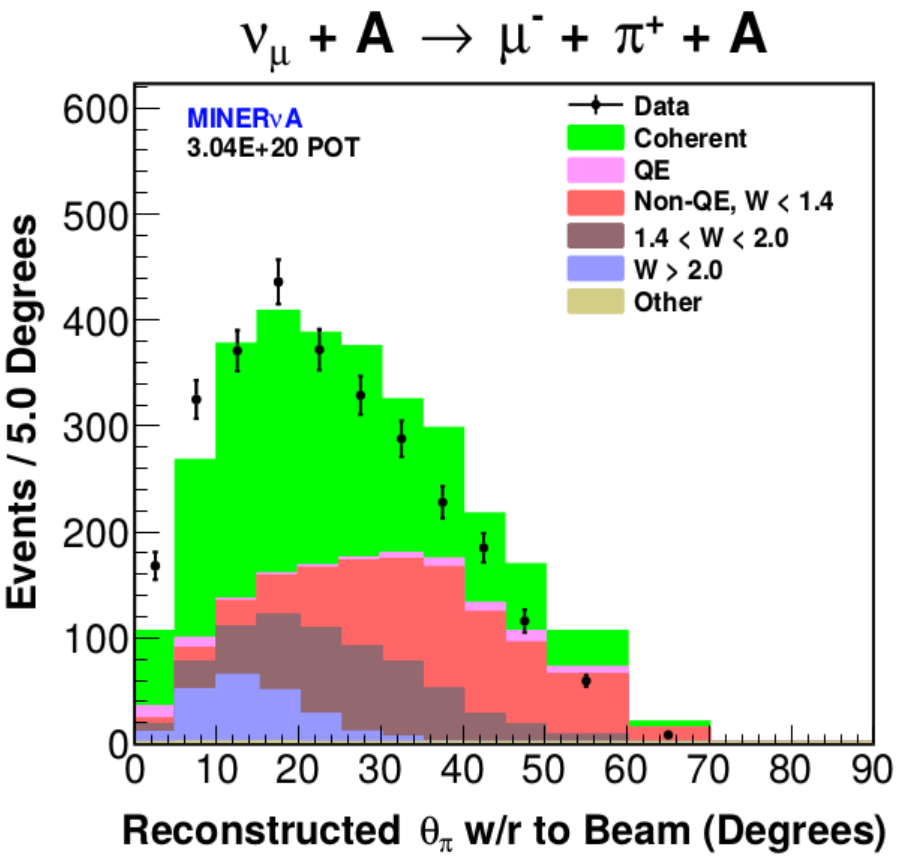
Sideband & selected sample

Background Subtracted



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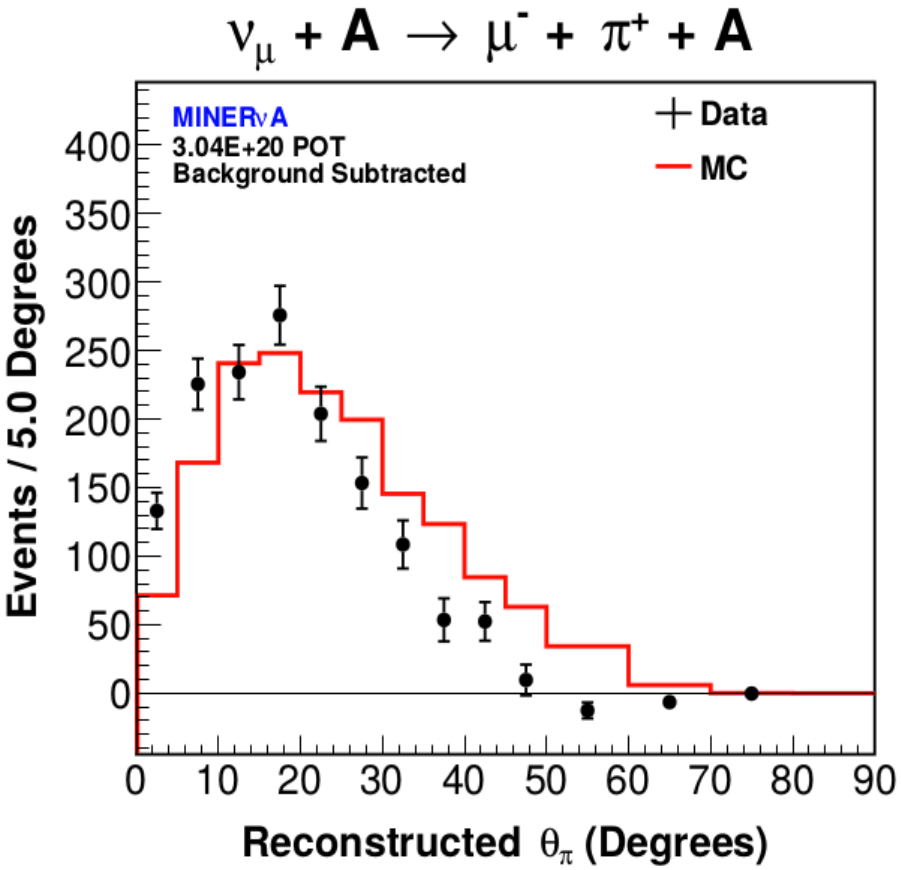

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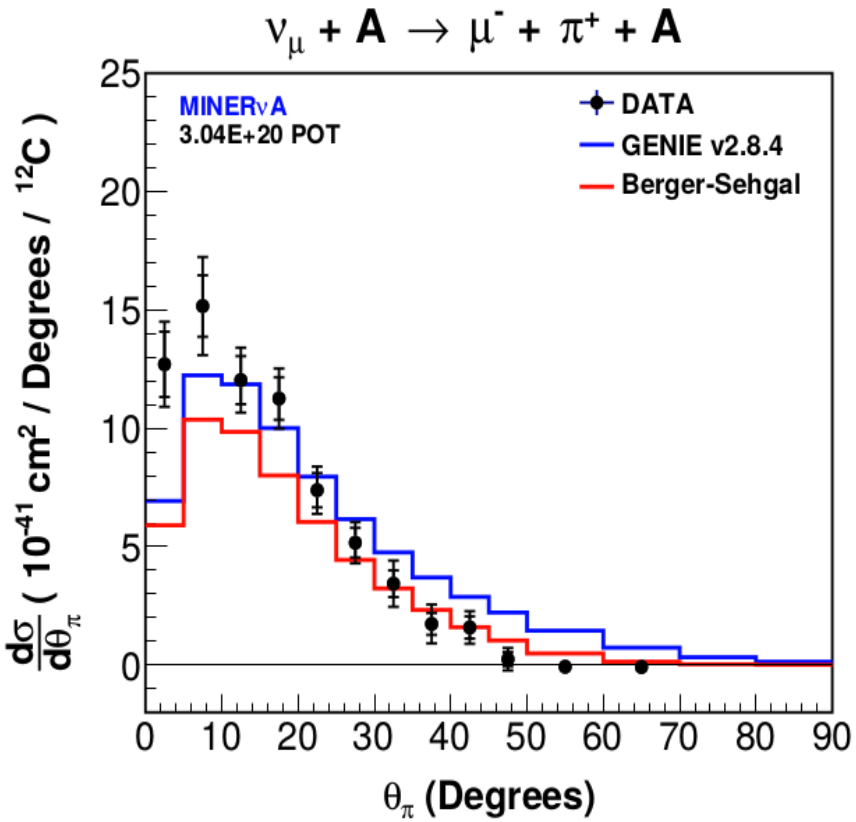
Cross Sections

E_π, θ_π, and Q_2 differential cross section were obtained. In general data is poorly reproduced by the models.



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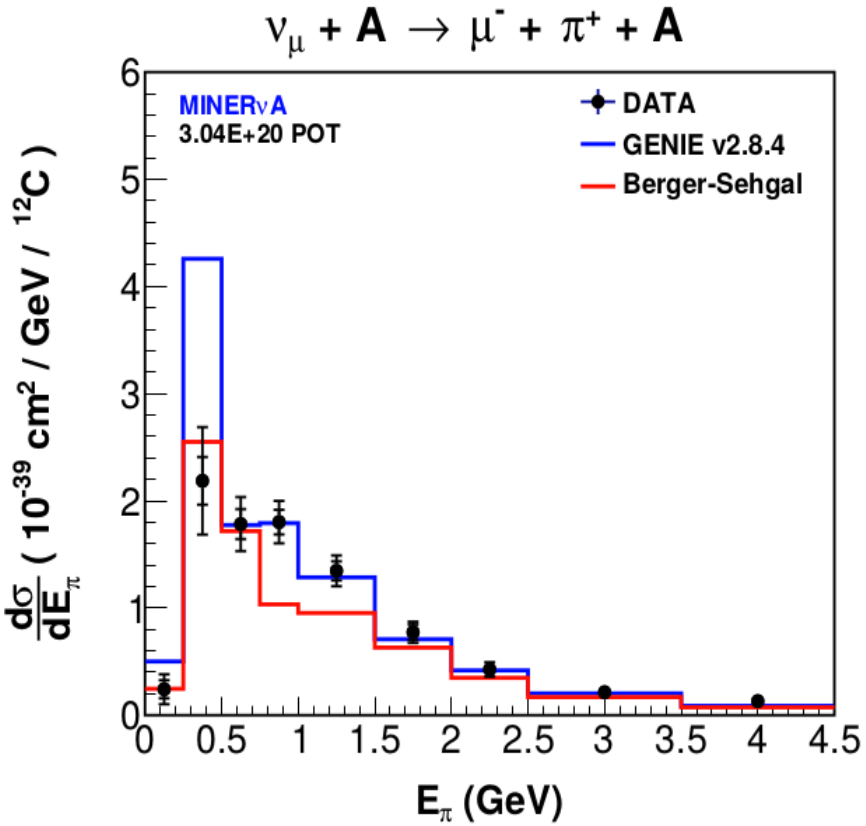

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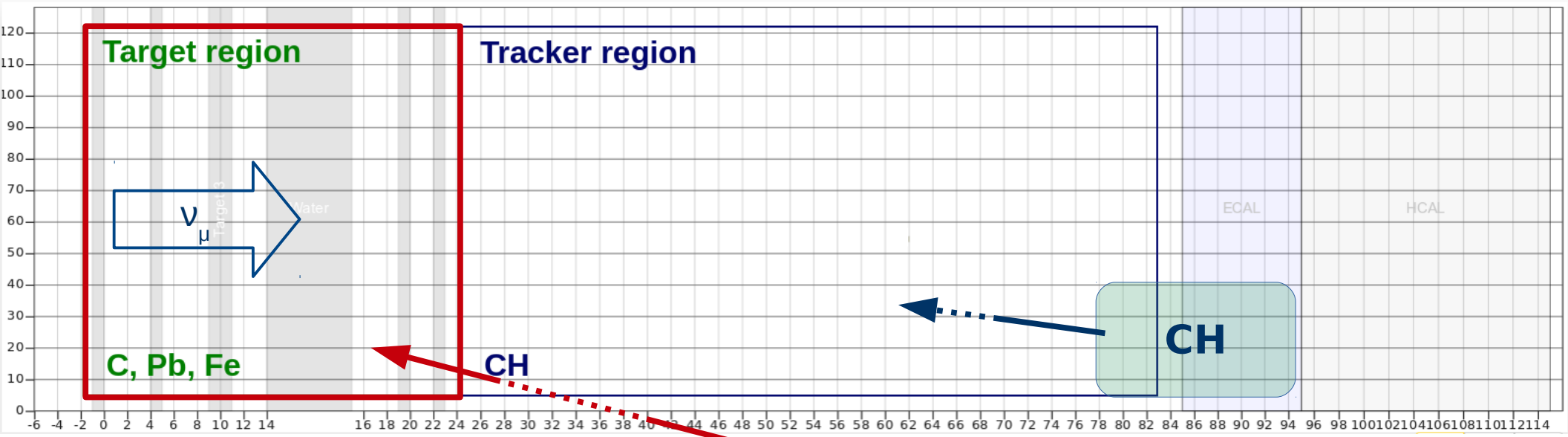
Medium Energy Analysis

Beam & detector details

$<E_\nu>$=6GeV (just nu so far, anti-nu is being taken)

12E20 POT (ν_μ beam)

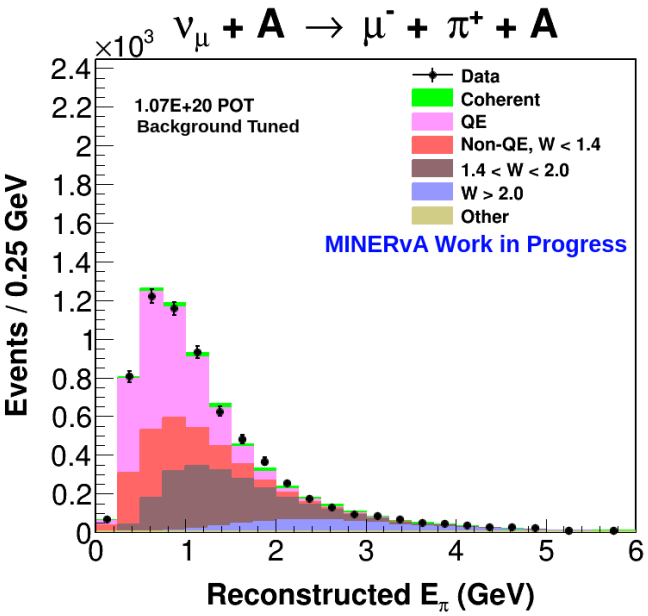


Looking for A-Dependence!

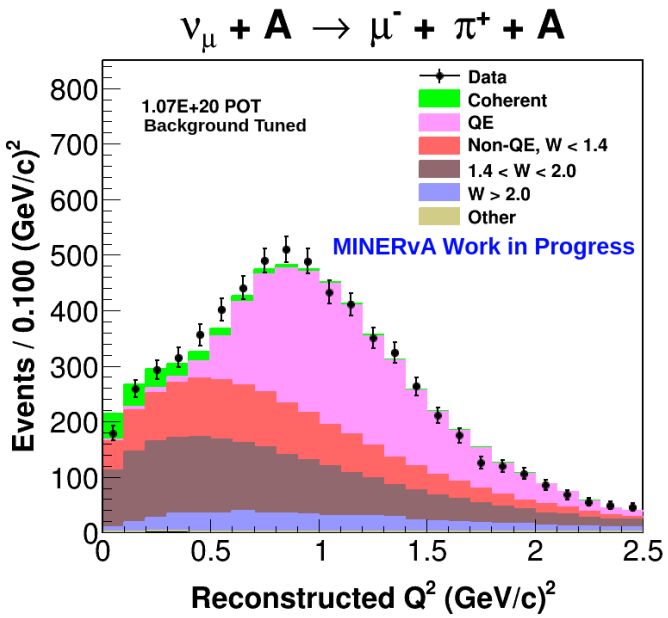
C, Pb & Fe

ME in the Tracker (CH)

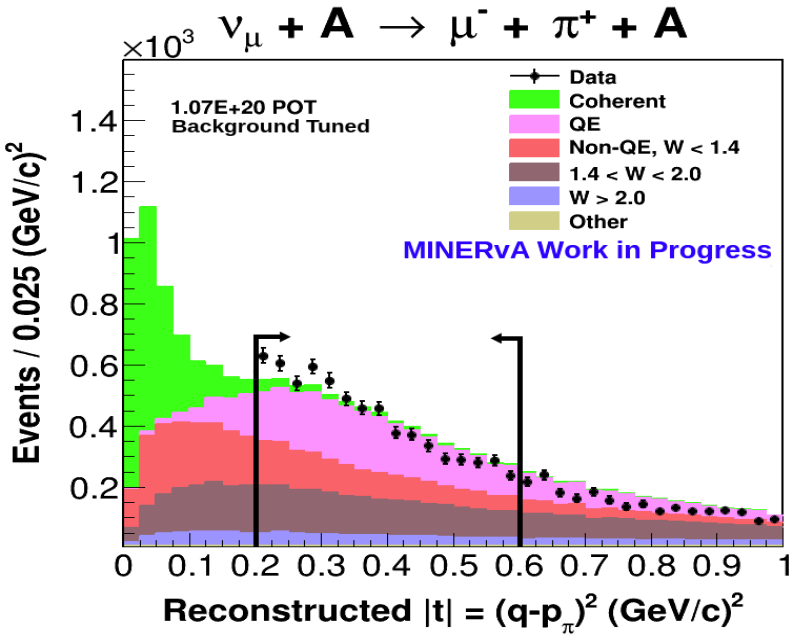
- **After the same basic cuts, and having tuned the background**



E_π tuned background



Q_2 tuned background



$|t|$ tuned background

ME in the Tracker (CH)

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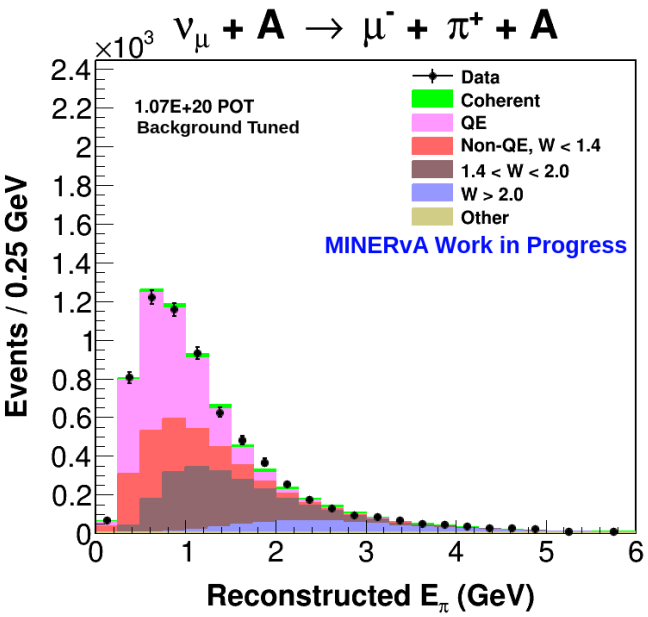
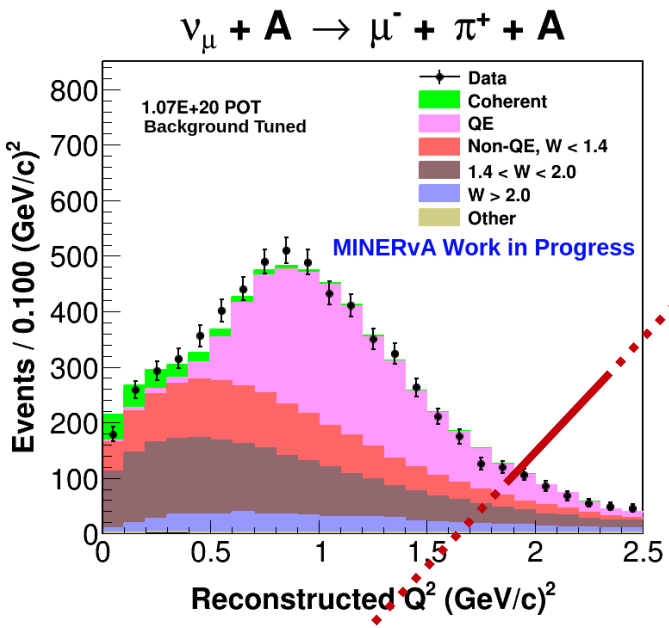
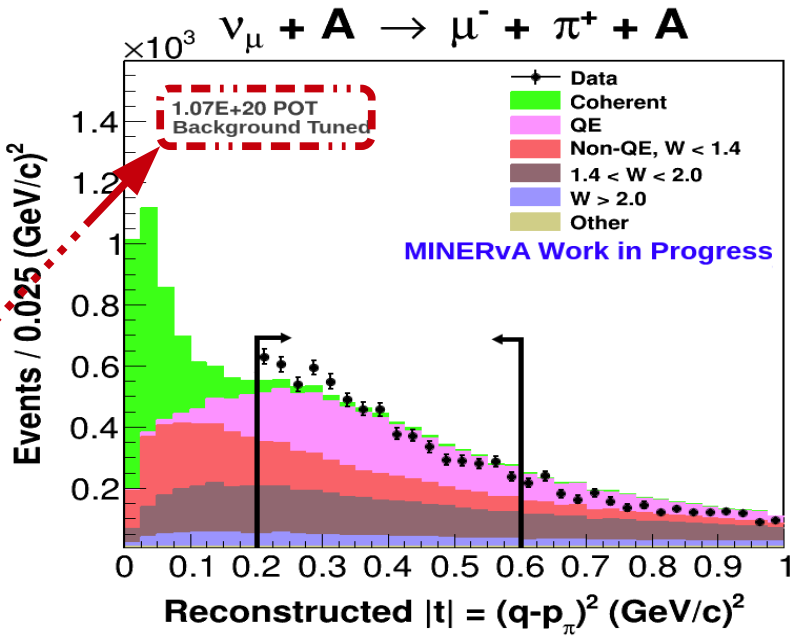






E_π tuned background

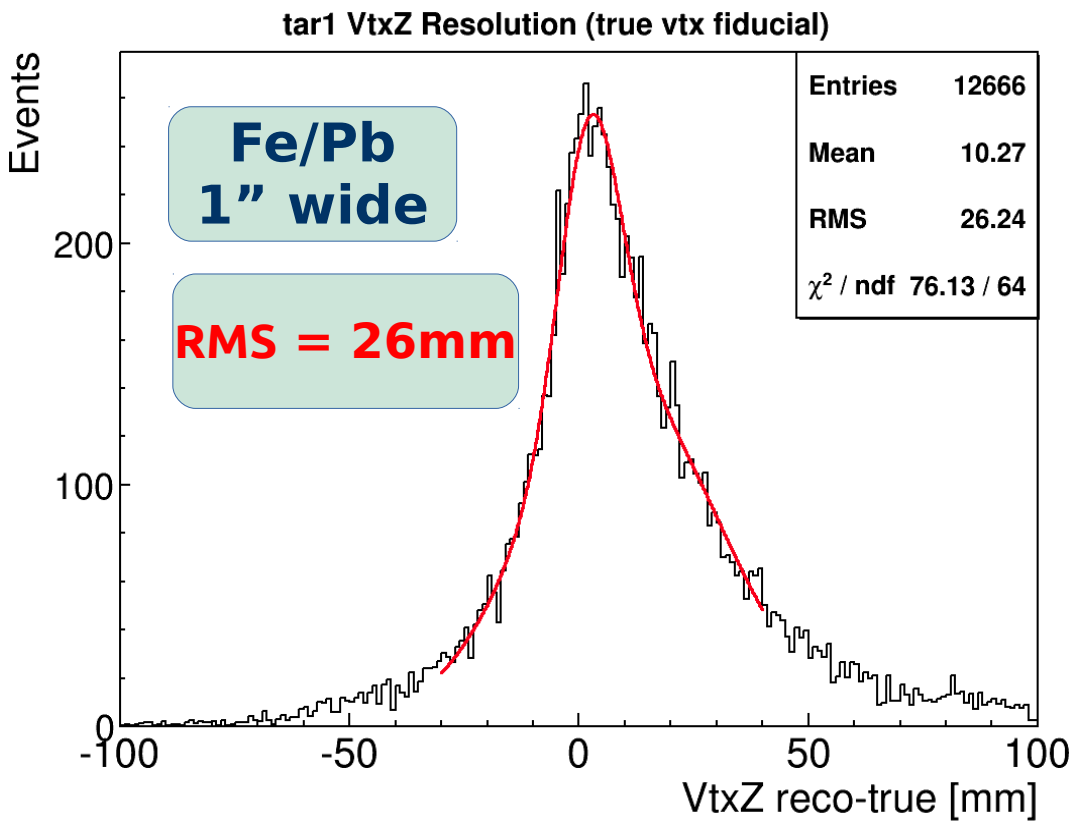
Q_2 tuned background

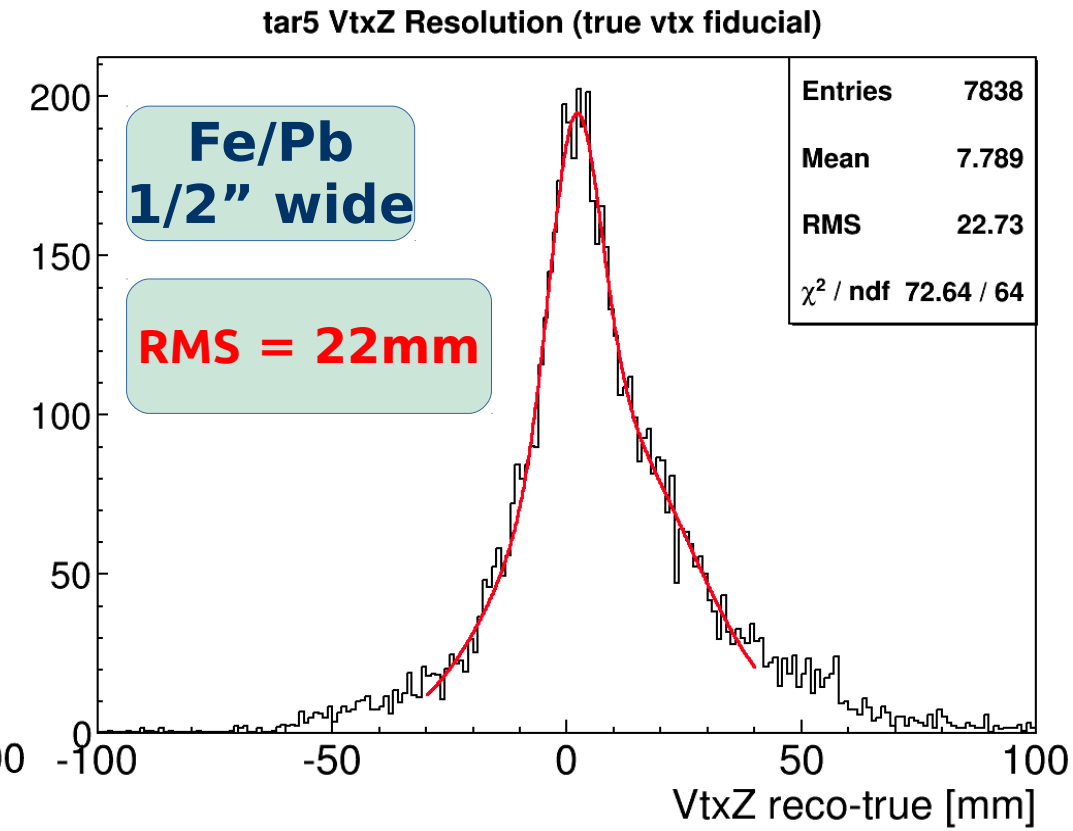
|t| tuned background

Just ~10% of the data!

Status in the Targets

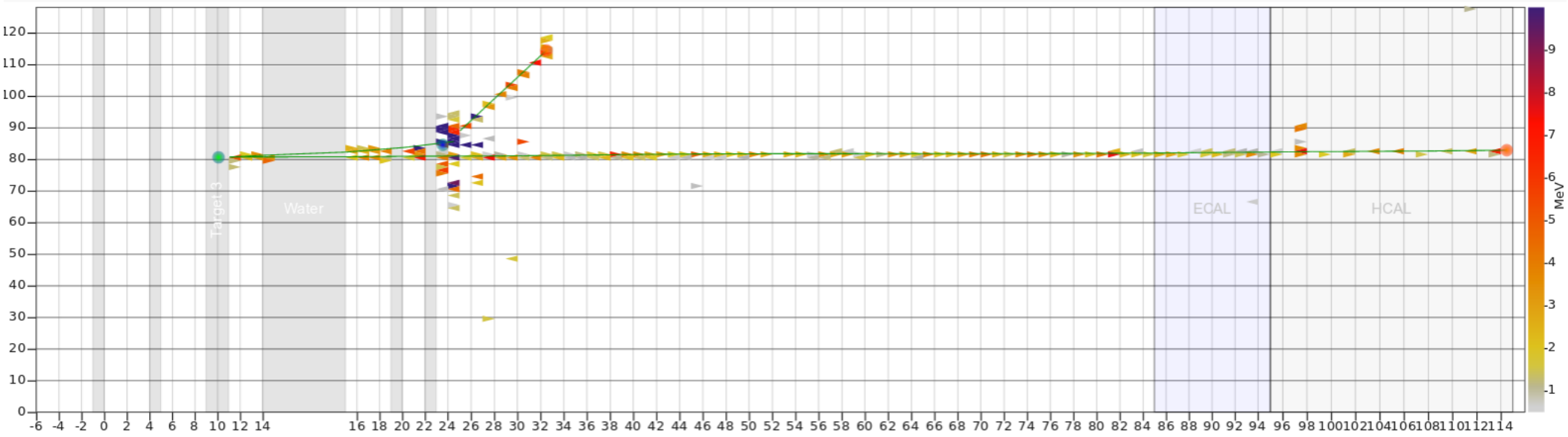
Most signal events have very small opening angles. A good vertex reconstruction is essential.





Candidate in the Targets

Coherent candidate from the passive target region



event

New Possibilities

Our New Collected Data will Allow Us to Do…

- **A-Dependence.**
  To get cross section measurements in all C, Fe and Pb targets, where even the theorists don't agree.

- **Low pi momentum reconstruction improvement.**
  To get a better measurement of the cross section at very low pion energies, important for low energy oscillation experiments.

Thanks!

Discussion

Questions?

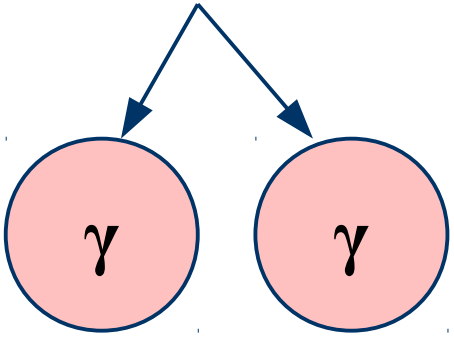
Backup

Coherent π Observables

Model Independent

- $\overset{(-)}{\nu}_l + A \rightarrow l^{-(+)} + \pi^{+(-)} + A$ CC

- $\overset{(-)}{\nu}_l + A \rightarrow \overset{(-)}{\nu}_l + \pi^0 + A$ NC



Assumptions on some kinematics variables

Model Dependent

NC Coherent Model Dependency

Why is NC Coherent pion production measurement, model dependent?

- **Given that we cannot measure |t|, the coherent sample is selected by means of the relation:**

$$E_\pi(1-\cos\theta_\pi)<1/R$$

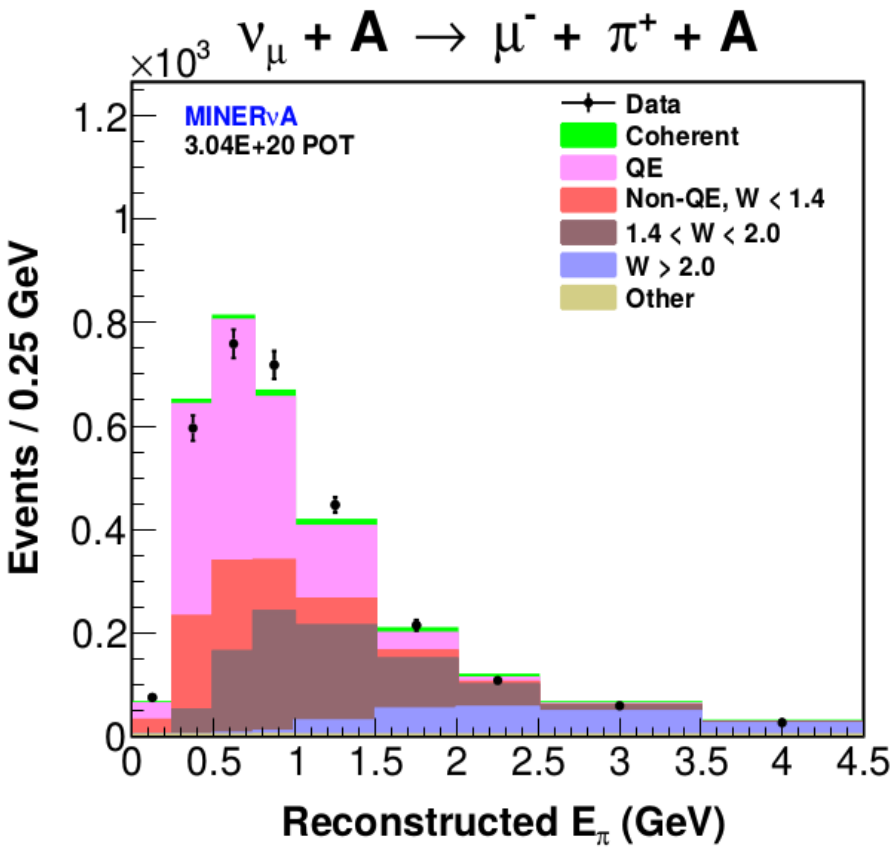
which comes from

$$|t|\leq \hbar^2/R^2$$

- **Restrictions to pion kinematics involve restrictions to the lepton kinematics as well**

Sideband & selected sample

Tuned distributions In LE



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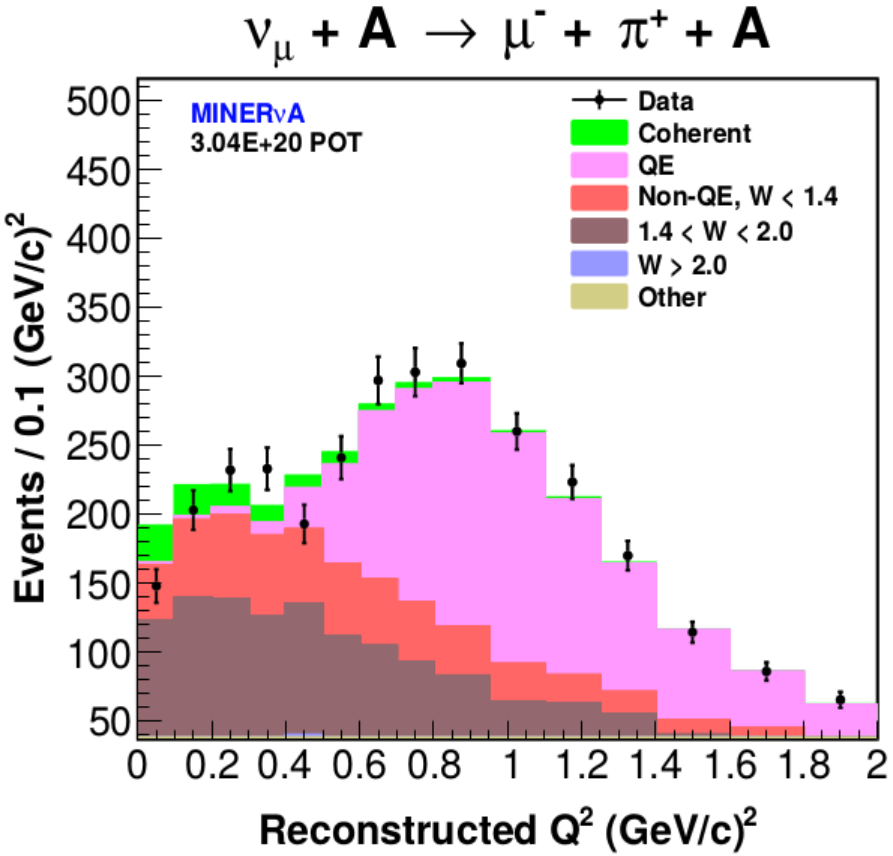

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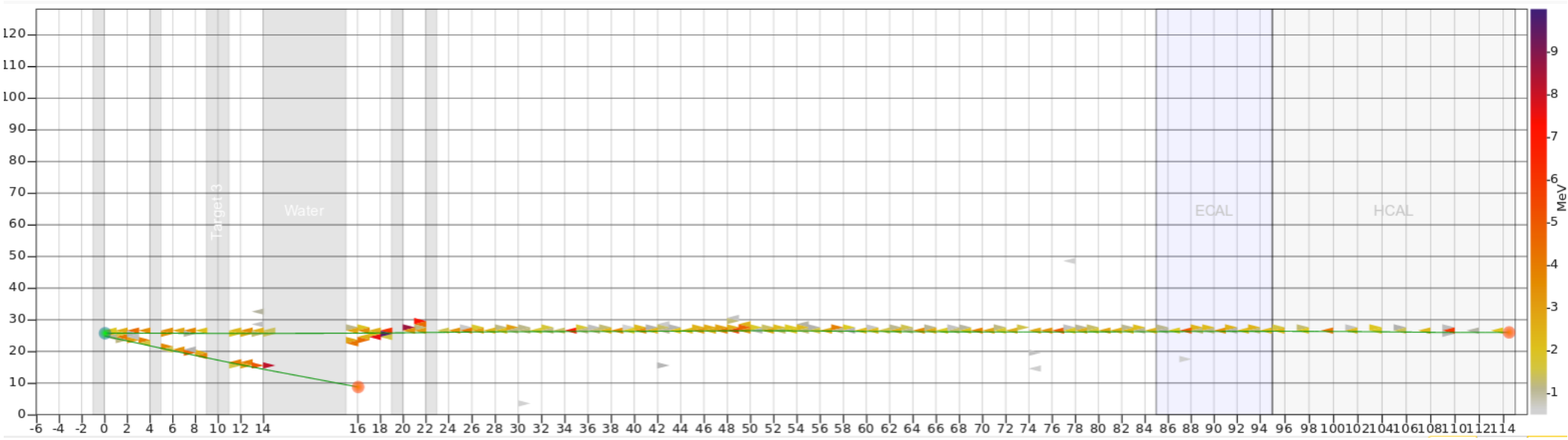
Backup

Other candidates



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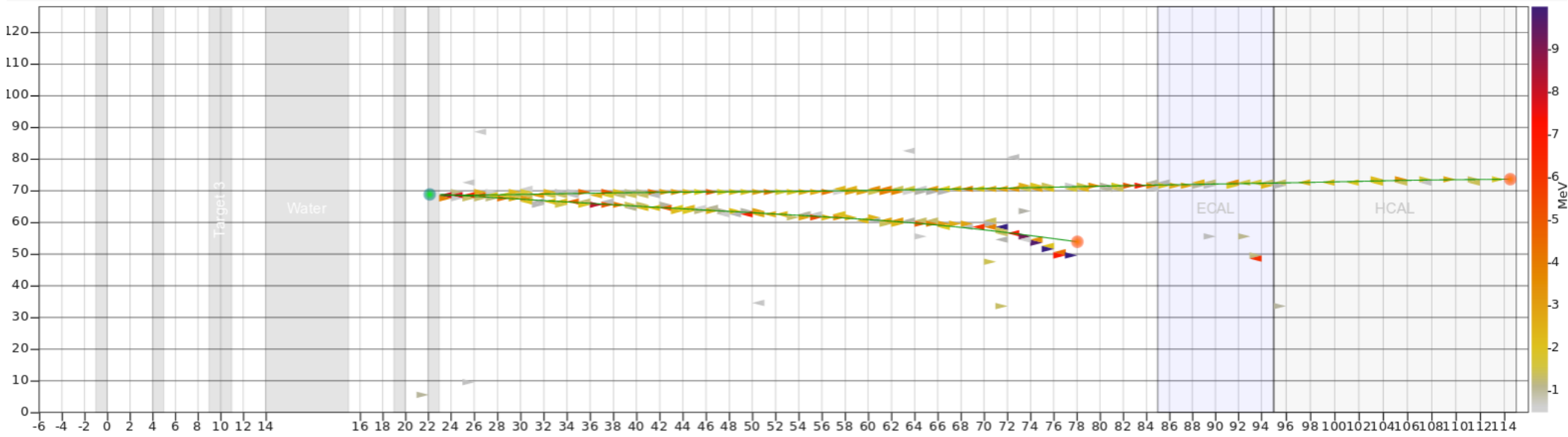
Other candidates



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