A Standard Model explanation for the excess of electron-like events in MiniBooNE

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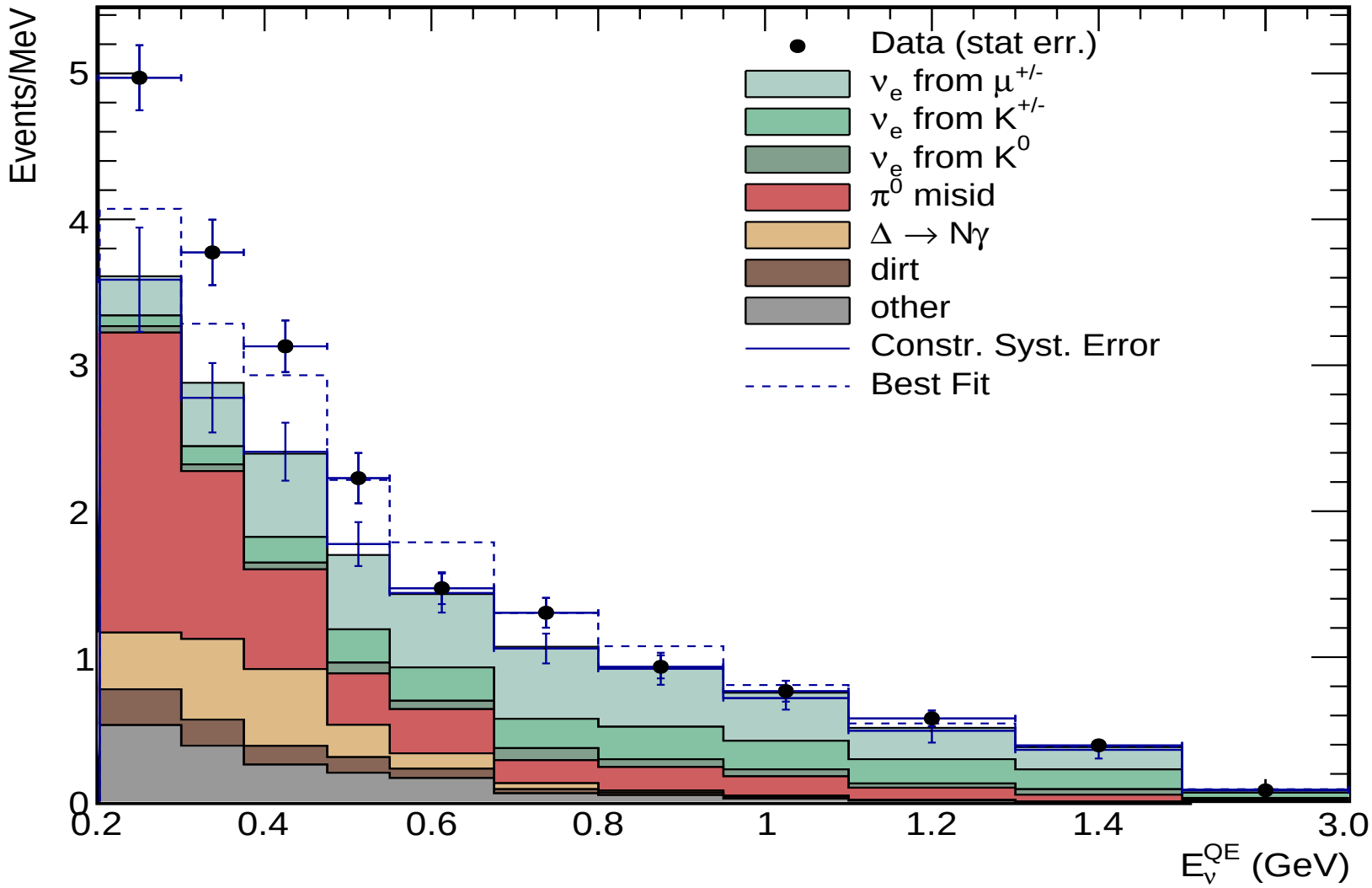
- MiniBooNE/LSND anomaly: $\nu_\mu \to \nu_e$ oscillations?
- excess of electron-like events,
- 200-500MeV
- Δ resonance region

Process	Neutrino Mode	Antineutrino Mode
ν_μ & $\bar{\nu}_\mu$ CCQE	73.7 ± 19.3	12.9 ± 4.3
NC π^0	501.5 ± 65.4	112.3 ± 11.5
NC $\Delta \to N\gamma$	172.5 ± 24.1	34.7 ± 5.4
External Events	75.2 ± 10.9	15.3 ± 2.8
Other ν_μ & $\bar{\nu}_\mu$	89.6 ± 22.9	22.3 ± 3.5
ν_e & $\bar{\nu}_e$ from $\mu^\pm$ Decay	425.3 ± 100.2	91.4 ± 27.6
ν_e & $\bar{\nu}_e$ from $K^\pm$ Decay	192.2 ± 41.9	51.2 ± 11.0
ν_e & $\bar{\nu}_e$ from K^0_L Decay	54.5 ± 20.5	51.4 ± 18.0
Other ν_e & $\bar{\nu}_e$	6.0 ± 3.2	6.7 ± 6.0
Unconstrained Bkgd.	1590.6 ± 176.9	398.2 ± 49.7
Constrained Bkgd.	1577.8 ± 85.2	398.7 ± 28.6
Total Data	1959	478
Excess	381.2 ± 85.2	79.3 ± 28.6
0.26% (LSND) $\nu_\mu \to \nu_e$	463.1	100.0


Events/MeV
0
1
2
3
4
5
0.2
0.4
0.6
0.8
1
1.2
1.4
3.0
E_ν^{QE} (GeV)
Data (stat err.)
ν_e from $\mu^{+/-}$
ν_e from $K^{+/-}$
ν_e from K^0
π^0 misid
$\Delta \rightarrow N\gamma$
dirt
other
Constr. Syst. Error
Best Fit

$$Br(\Delta^{+/0} \to p/n + \gamma) = (5.5 - 6.5)10^{-3}$$

$$Br(\Delta^{+/0} \to p/n + \pi^0) \simeq 2/3$$

Thus the probability to have produced a photon per produced π^0 is

$$\frac{\Gamma^{\gamma}(\Delta^{+/0})}{\Gamma^{\pi^0}(\Delta^{+/0})} \simeq (8.25 - 9.75)10^{-3}$$

A2 collaboration at the Mainz MAMI accelerator
photon beam has a very well known energy, flux and polarisation
enrange 40-1603 MeV

$$\gamma + A \rightarrow$$

A is nucleon/nucleus

B. Krusche
Photoproduction of mesons from nuclei: In-medium properties of hadrons, Prog. Part. Nucl. Phys. **55**, 46 (2005)

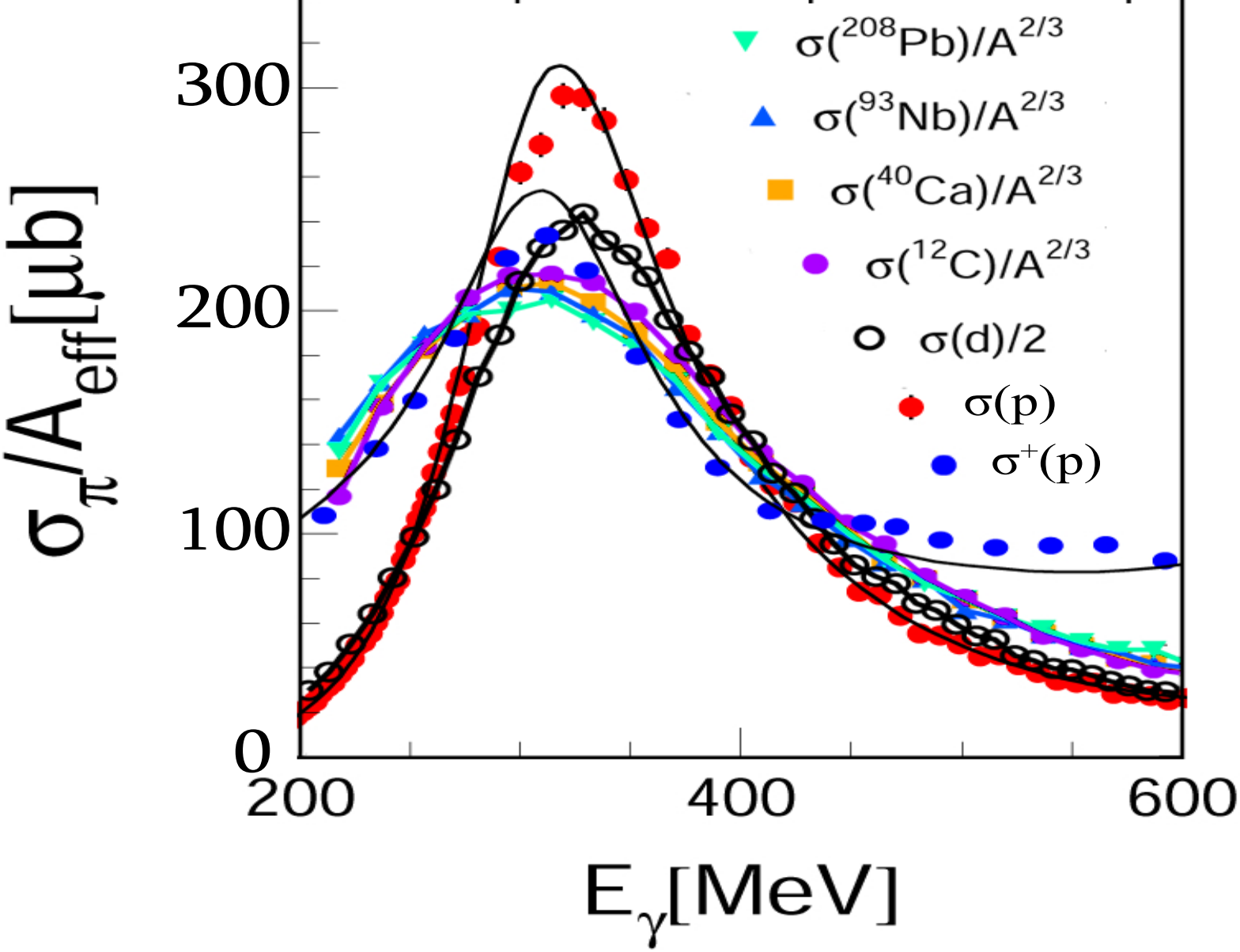


Figure: Inclusive π^0 production cross sections $\gamma + A \rightarrow \pi^0 + X$. A_{eff}=1 for proton, 2 for deuteron and $A^{2/3}$ for heavy nuclei. σ^+ is the cross section of $\gamma + p \rightarrow n\pi^+$ **Krusche**

According to the A2 collaboration the π^0 photo-production on nuclei scales as $A^{2/3}$

$$\sigma(\gamma + A \rightarrow 1\pi^0 + X) \propto A^{2/3}.$$

As it is well known the pion-nucleus interaction cross section is proportional to the surface area of the nucleus, $A^{2/3}$.
By contrast the total photon absorption cross section on the nucleus is proportional to its volume and scales as A . Meanwhile the photons created in Δ decays will leave the nucleus, and that cross section will be proportional to the atomic number of the nucleus,A, volume of the nucleus.
Thus we conclude that the ratio of photon to π^0 production via a Δ resonance in nuclei is proportional to $A^{1/3}$.
For MiniBooNE via NC on ^{12}C there will be about 2.3 times more photons than the naive estimation. Thus from CH_2 there will be at least twice more photons, reducing the significance of the excess of electron-like evens to just 2.2 σ (instead of 4.5 σ)

ICARUS experiment at FERMILAB,
there will be at least $40^{1/3} \simeq 3.4$ times more photons per π^0 than one may expect.

THANK YOU