Is there any “LSND anomaly”?

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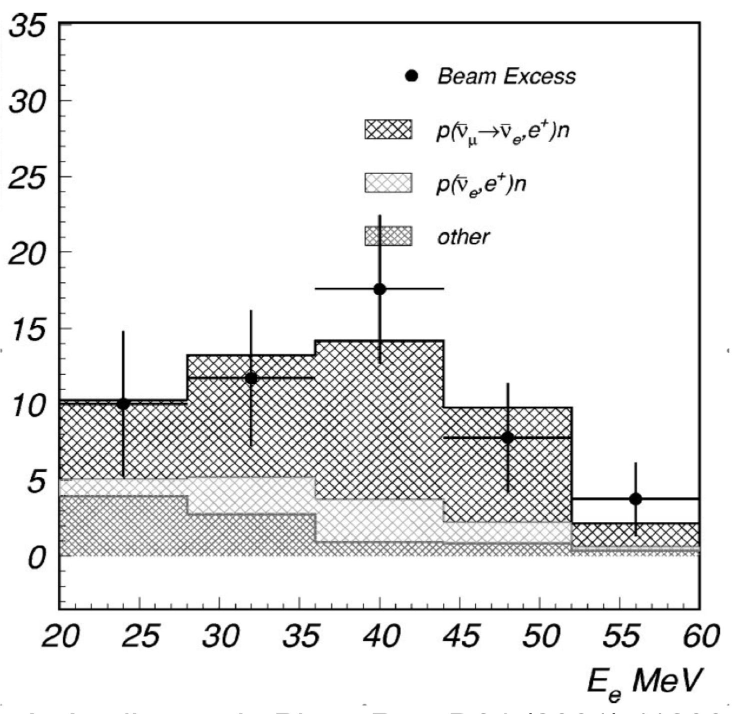
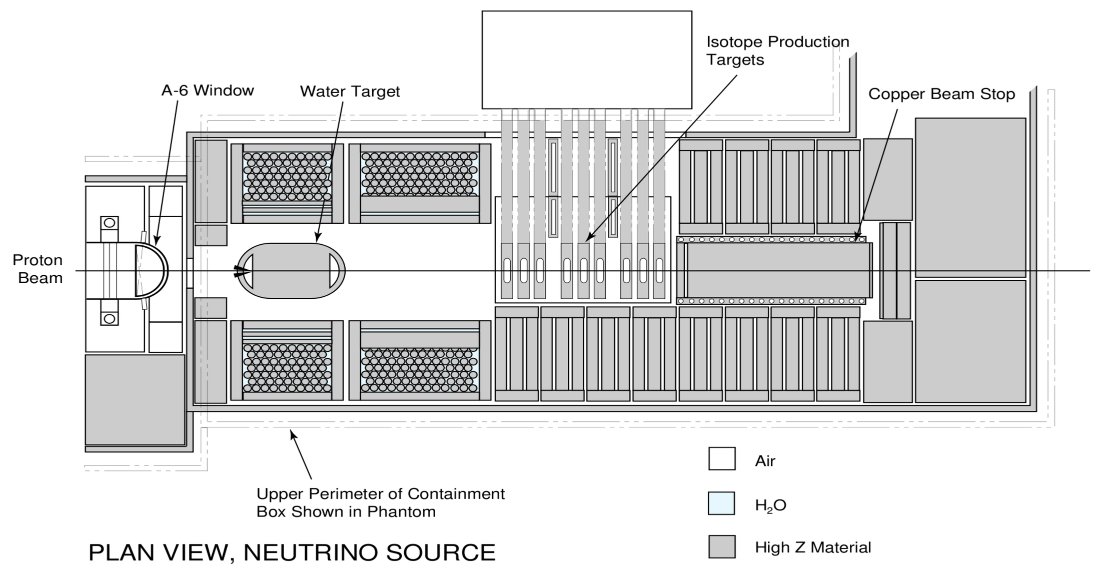
The LSND anomaly



A. Aguilar et al., Phys. Rev. D64 (2001) 112007

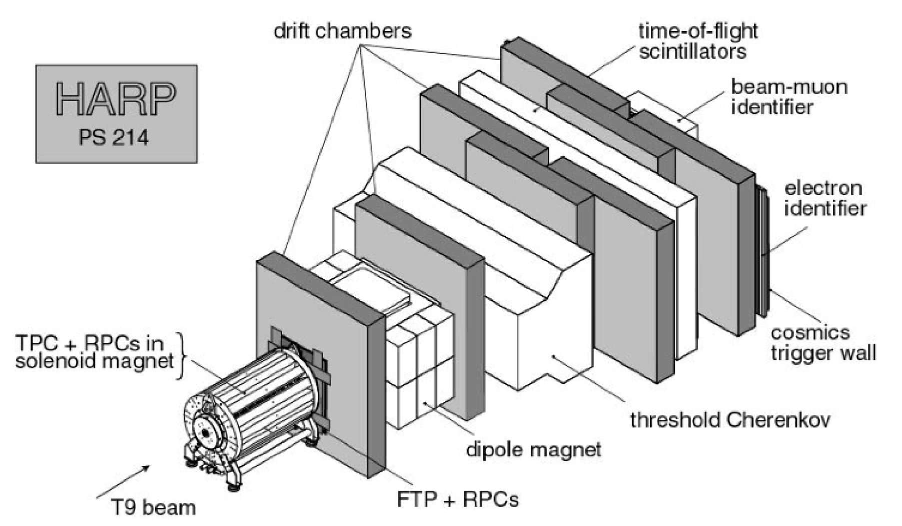
The LSND experiment reported an anomalous 3.8 σ excess of $\bar{\nu}_e$, interpreted as $\bar{\nu}_\mu \to \bar{\nu}_e$ oscillation with $\Delta m^2 \approx 1$ eV^2. This result has, until today, not been confirmed by other experiments. One explanation of the LSND signal is an underestimate of π^- production by 800 MeV protons in the calculation of the background neutrino flux in the LSND analysis. The HARP experiment measured pion production with a 1.5 GeV/c proton beam impinging on various target materials, including water and copper. The HARP measurements, together with pion production data from other experiments, were used to cross-check the calculation of the background of LSND's signal.

The neutrino source at LANSCE



C. Athanassopoulos et al., NIM A 388 (1997) 149

The HARP detector and its performance



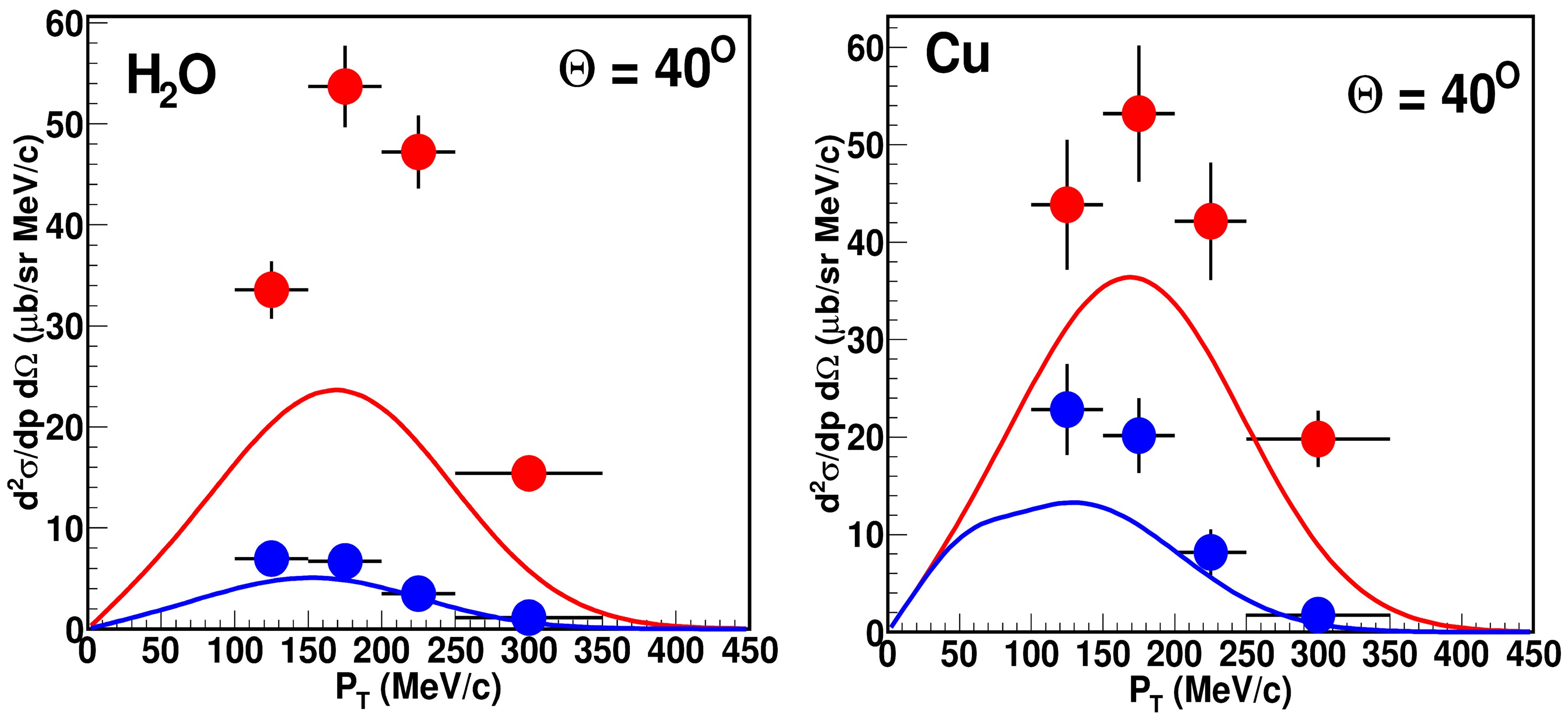
TPC:
NIM A588 (2008) 294-317
$\sigma(1/p_T) \approx 0.20$ (GeV/c)$^{-1}$
$\sigma(dE/dx)/(dE/dx) \approx 0.16$
$\sigma(\Theta) \approx 9$ mrad

RPCs:
NIM A578 (2007) 119-138
Efficiency ≈ 98%
σ(TOF) ≈ 175 ps

Good particle identification by combining d*E*/d*x* from TPC and TOF from RPCs

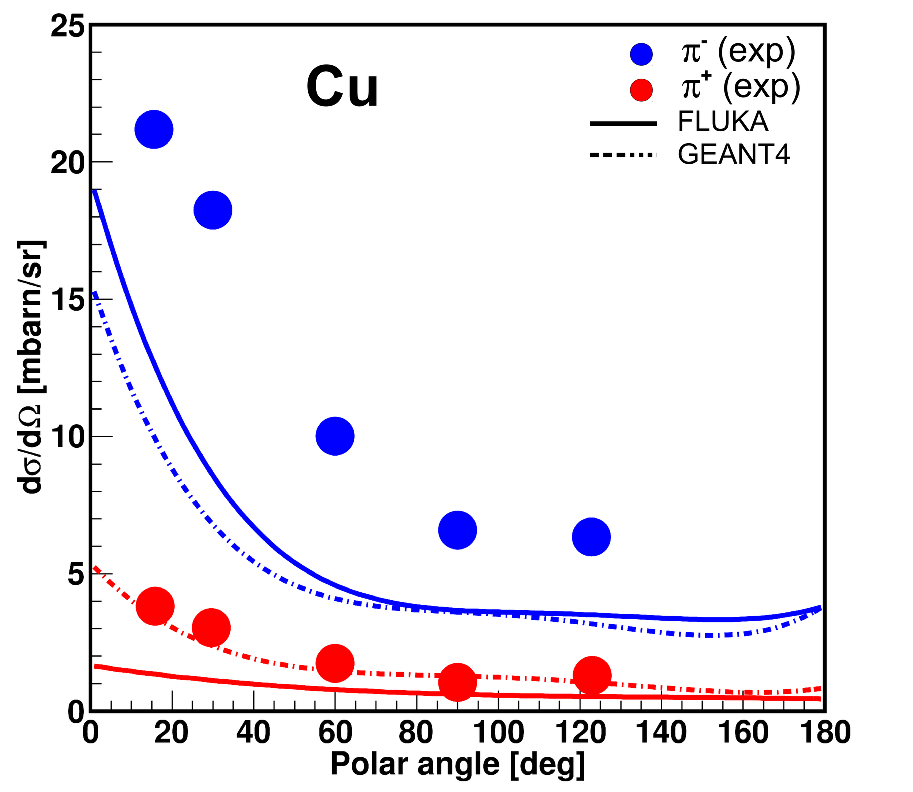
Pion production by 1.5 GeV/c protons (HARP-CDP)

Cross-sections of the production of secondary π^+ (red points) and π^- (blue points) compared with the LSND parametrization (the red solid line refers to π^+, and the blue one to π^-).



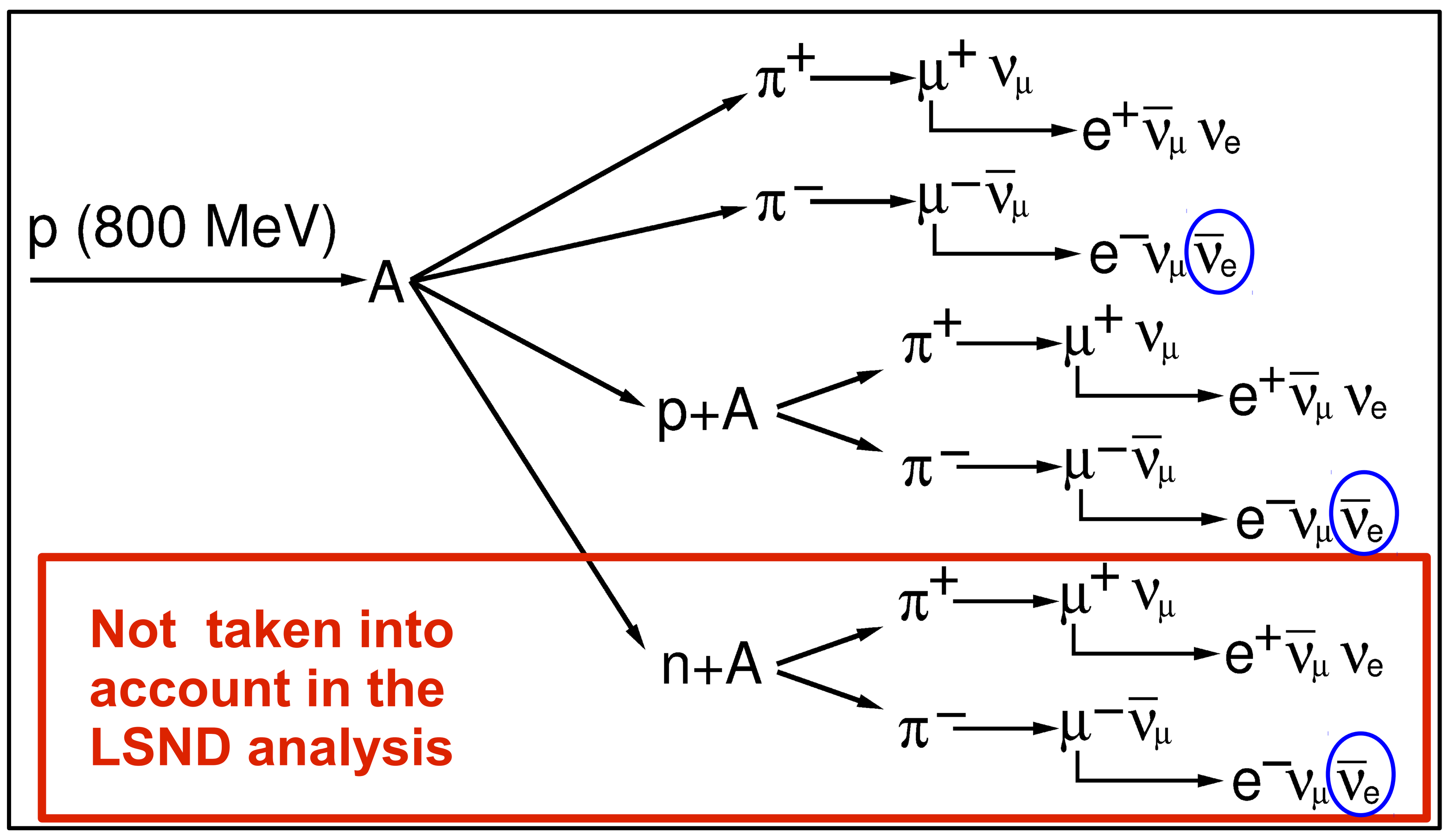
Pion production by 600 MeV neutrons

K.O. Oganesian, JETP 54 (1968) 1273



HARP-CDP simulation of the LSND $\bar{\nu}_e$ background:

- We “emulated” the LSND procedure of neutrino flux calculation to demonstrate understanding of the LSND geometry
- Two independent simulation programs
- Geant4 and FLUKA used to simulate hadron production
- HARP-CDP data used to tune pion production by protons
- Pion production by neutrons tuned according to *K.O. Oganesian, JETP 54 (1968) 1273*
- Neutron production by protons tuned according to *V.N. Baturin et al., JETP Lett., 30 (1979) 86*



Pion rates and neutrino flux from muon decays at rest

	LSND published (runs 1993-1995)	Our 'emulation' of the LSND procedure	Geant4 (default)	FLUKA (default)	Geant4 ⊕ exp. data		FLUKA ⊕ exp. data	
					w/o neutrons	with neutrons	w/o neutrons	with neutrons
π^+ [PoT^{-1}] π^- [PoT^{-1}]		0.107 – 0.159 0.026 – 0.051	0.200 0.040	0.212 0.045	0.196 0.037	0.203 0.072	0.206 0.035	0.214 0.071
ν_μ, $\bar{\nu}_e$ DAR flux [PoT^{-1}cm^2]	0.65×10^{-12}	$(0.52 – 0.77) \times 10^{-12}$	0.90×10^{-12}	0.72×10^{-12}	0.88×10^{-12}	1.20×10^{-12}	0.70×10^{-12}	0.99×10^{-12}
$\bar{\nu}_\mu$, ν_e DAR flux [PoT^{-1}cm^2]	0.80×10^{-9}	$(0.75 – 1.20) \times 10^{-9}$	1.20×10^{-9}	1.40×10^{-9}	1.20×10^{-9}	1.30×10^{-9}	1.30×10^{-9}	1.40×10^{-9}

CONCLUSIONS: the background of LSND's “anomalous $\bar{\nu}_e$ signal” was underestimated by nearly a factor of two, and its systematic error was underestimated by at least a factor of two. The causes were too small pion production cross-sections by protons and the neglect of pion production by neutrons, which, unlike protons, predominantly produce π^- rather than π^+.

THE PUBLISHED 3.8 σ SIGNIFICANCE OF THE LSND SIGNAL IS LOST.

We are grateful to M. Sung for providing us with the LSND parametrization code

Geant4 refers to the Geant4 software (S.Agostinelli et al., NIM A506 (2003) 250-303; J. Allison et al., IEEE Trans. Nucl. Sci. 53 (2006) 270-278)
FLUKA refers to the FLUKA software (G.Battistoni et al, AIP Conf. Proc. 896, 31-49, (2007); A.Fasso et al.,CERN-2005-10 (2005), INFN/TC_05/11, SLAC-R-773)