The MicroBooNE Experiment

A liquid-argon TPC for neutrino physics

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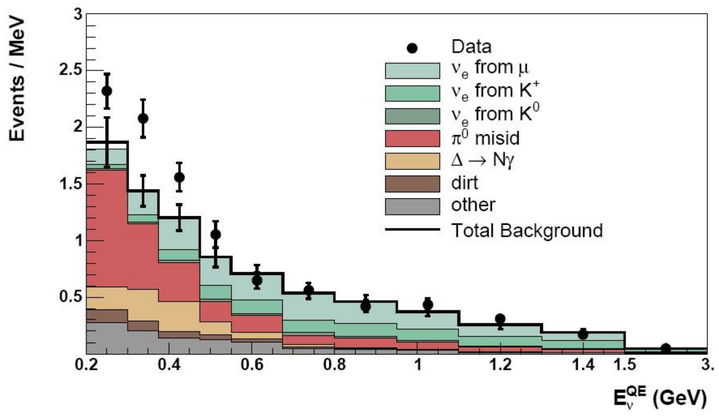
Motivation

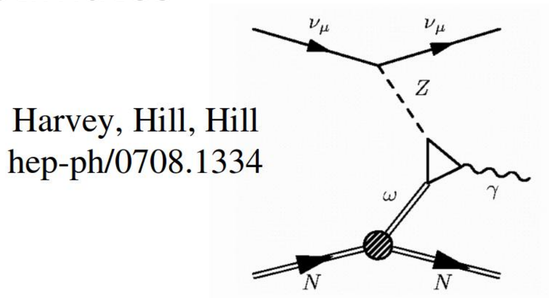
To understand the nature of the MiniBooNE low-*E* excess



Electron-like events in ν_μ beam above calculated backgrounds but not consistent with $\nu_\mu \rightarrow \nu_e$ oscillations

Possible SM origin

Additional γ's due to axial anomaly not considered in the background estimates



MiniBooNE cannot distinguish between electrons and γ→e^+e^- conversions

Liquid-Ar TPC

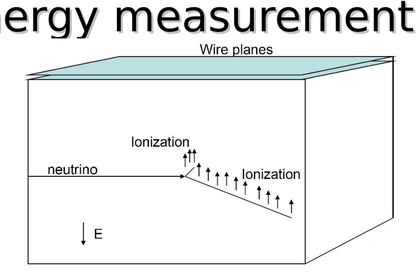
Why liquid argon?

	He	Ne	Ar	Kr	Xe	Water
Boiling Point [K] @ 1atm	4.2	27.1	87.3	120.0	165.0	373
Density [g/cm³]	0.125	1.2	1.4	2.4	3.0	1
Radiation Length [cm]	755.2	24.0	14.0	4.9	2.8	36.1
Scintillation [γ/MeV]	19,000	30,000	40,000	25,000	42,000	
dE/dx [MeV/cm]	0.24	1.4	2.1	3.0	3.8	1.9
Scintillation λ [nm]	80	78	128	150	175	

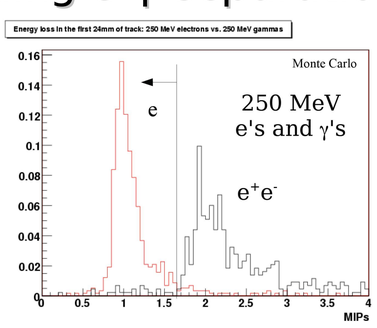
High density, small radiation length, high scintillation yield, inexpensive

Time-Projection Chamber

Three wire planes plus drift time provide 3D track reconstruction and energy measurement



Particle ID through *dE/dx* including *e*-γ separation



Collaboration

- *Brookhaven Lab*: H. Chen, J. Farrell, F. Lanni, D. Lissauer, D. Makowiecji, J. Mead, V. Radeka, S. Rescia, J. Sondericker, C. Thorn, B. Yu
- *Columbia University*: L. Camilleri, C. Mariani, M. Shaevitz, B. Willis**
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- *Massachusetts Institute of Technology*: W. Barletta, L. Bugel, J. Conrad, C. Ignarra, B. Jones, G. Karagiorgi, T. Katori, H. Tanaka
- *Michigan State University*: C. Bromberg, D. Edmunds
- *Princeton University*: K. McDonald, C. Lu, Q. He
- *St. Marys*: P. Nienaber
- *University of California, Los Angelas*: H. Wang
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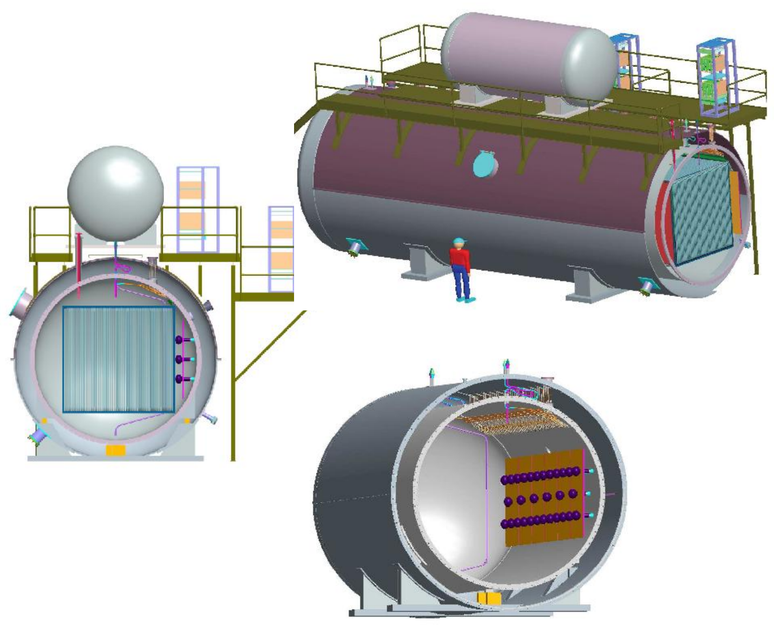
13 institutions
58 collaborators
NSF funded/DOE funded

*=Spokesperson, **=Deputy Spokesperson

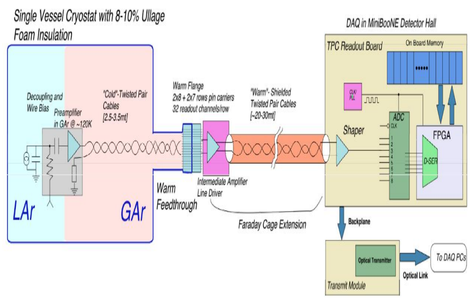
Detector Design



Y, U, V planes, 3-mm wire spacing
170 tons of LAr (70-ton FV)

Electronics

Significant R&D on cold electronics in liquid and gaseous argon

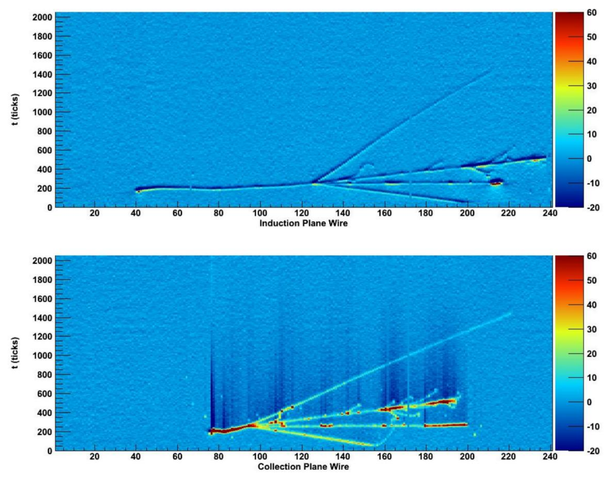


Triggering

30 Hamamatsu R5912-02 8" PMTs
Trigger efficiently on 40-MeV protons (to see NCE events at Q^2~0.08 GeV^2)
Expect 19 p.e. for a 5-MeV electron

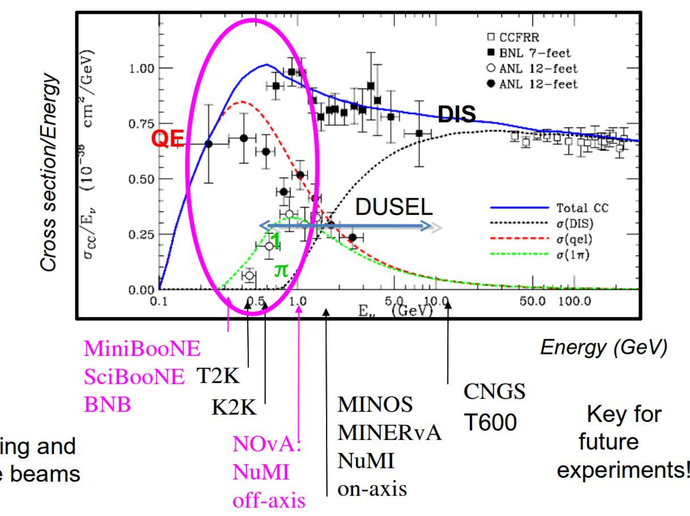
Prototype: ArgoNeut

170-L active volume, taking data since 2008 in the MINOS beam



Cross Sections

Expect significant contributions to cross-section measurements at low Q^2



Expected event rates

1-GeV neutrino beam, 6×10^{20} POT

	Nuance channel	Reaction	#interactions/6E20 POT 70 ton FV	% of total ν_μ
CCQE	1 (CC)	$\nu_\mu n \rightarrow \mu^- p$	52524	45.0
NCelastic	2 (NC)	$\nu_\mu N \rightarrow \nu_\mu N$	16945	14.5
Single pion resonant	3 (CC)	$\nu_\mu p \rightarrow \mu^- p\pi^+$	16124	13.8
	4 (CC)	$\nu_\mu n \rightarrow \mu^- p\pi^0$	6106	5.2
	5 (CC)	$\nu_\mu n \rightarrow \mu^- n\pi^+$	5833	5.0
	6 (NC)	$\nu_\mu p \rightarrow \nu_\mu p\pi^0$	2878	2.5
	7 (NC)	$\nu_\mu p \rightarrow \nu_\mu n\pi^+$	1819	1.6
	8 (NC)	$\nu_\mu n \rightarrow \nu_\mu n\pi^0$	3572	3.1
	9 (NC)	$\nu_\mu n \rightarrow \nu_\mu p\pi^-$	2368	2.0
DIS	91 (CC)	$\nu_\mu N \rightarrow \mu^- X$	1123	1.0
	92 (NC)	$\nu_\mu N \rightarrow \nu_\mu X$	410	0.4
Coherent/diffractive	96 (NC)	$\nu_\mu A \rightarrow \nu_\mu A\pi^0$	1479	1.3
	97 (CC)	$\nu_\mu A \rightarrow \mu^- A\pi^+$	2293	2.0
Subtotal			113474	97.3

	Nuance channel	Reaction	#interactions/6E20 POT 70 ton FV	% of total ν_e
CCQE	1 (CC)	$\nu_e n \rightarrow e^- p$	285	37.2
NCelastic	2 (NC)	$\nu_e N \rightarrow \nu_e N$	89	11.7
Single pion resonant	3 (CC)	$\nu_e p \rightarrow e^- p\pi^+$	110	14.4
	4 (CC)	$\nu_e n \rightarrow e^- p\pi^0$	48	6.3
	5 (CC)	$\nu_e n \rightarrow e^- n\pi^+$	53	6.9
	6 (NC)	$\nu_e p \rightarrow \nu_e p\pi^0$	19	2.5
	7 (NC)	$\nu_e p \rightarrow \nu_e n\pi^+$	13	1.7
	8 (NC)	$\nu_e n \rightarrow \nu_e n\pi^0$	24	3.1
	9 (NC)	$\nu_e n \rightarrow \nu_e p\pi^-$	17	2.2
DIS	91 (CC)	$\nu_e N \rightarrow e^- X$	26	3.4
	92 (NC)	$\nu_e N \rightarrow \nu_e X$	9	1.1
Coherent/diffractive	96 (NC)	$\nu_e A \rightarrow \nu_e A\pi^0$	9	1.1
	97 (CC)	$\nu_e A \rightarrow e^- A\pi^+$	17	2.2
Subtotal			719	93.9

Potential to measure Δ*s* via NC/CC ratio σ(*νp*→*νp*)/σ(*νn*→μ*p*)
Important for dark-matter searches

R&D for LBNE

Research on LAr purification, cold electronics
Demonstration of technology for future, larger-scale LAr TPC experiments at DUSEL and elsewhere

Roadmap