Question(s) to MicroBooNE

"The PAC is interested in hearing more about the size optimization of MicroBooNE. Could you achieve your R&D goals with a smaller detector? How does the physics reach change with a smaller detector?"

MicroBooNE's size was optimized by considering its combination of R&D goals, physics goals and practical considerations.

1) Combining R&D and physics is unusual – but it is what makes MicroBooNE a better experiment

2) Specifics on size optimization for R&D, physics, and practical reasons.

Question 1:

Not just that we CAN do both R&D and physics in the same experiment, but that its the combination of goals that make the experiment particularly attractive...

- From the physics perspective:

Addressing a difficult physics question with the low energy excess – a question that cannot be addressed with conventional detectors (MiniBooNE, SciBooNE, ND280, ...) this is the only cost effective technology that can do the physics.

→ Need the technology and the size to do the physics

- From the R&D perspective:

Physics R&D: For a newer technology, you need a fully contained set of interactions (and physics result!) to vet the technique overall and the details of the detector.

A running detector and physics analysis of real data provides the best way to understand detector strengths and shortcomings

Hardware R&D: need a detector that tests all systems of a complete experiment

Question 1 cont.

- From the practical perspective:

With multiple goals, we bring together a group of people interested in a variety of different things.

Most importantly, bring together people who are great at R&D but want to do physics as well. Without the physics program, the R&D program will suffer in people (would lose at least ½ of this collaboration, eg: university funding tied to physics output) and therefore in time.

Wide range of physics goals (low energy excess, unique low energy precision cross sections, cross sections for PX and beyond). PhD output/dollar is high!

From the cost perspective, it has been very difficult to justify an expensive pure R&D program. The physics case helps to justify the size of the program.

MicroBooNE is a good experiment **because** it is a combination of R&D and physics

Question 2

Specifics of size optimization:

- transverse size set by R&D goals
- length/overall volume set by physics goals

Size optimization for R&D goals:

1) Characterize the detector strengths and shortcomings using data:
   - e/gamma showers: contained in ~1 x1 x2 m
   - vertex containment for neutrino interactions (not including muons) 2x2x2 m
   - Full scale drift for interactions: 2-3m transverse size
   - statistically large sample of complete set of neutrino interactions

↓

Note: Measure and understand a complete set of neutrino interactions:

- e/gamma showers, topology of NCπ° events, range out 1-2 GeV muons to test MS momentum measurements, measure wide class of resonant and DIS background events, do full test of analysis chain (does not presently exist!)

- need to fully contain these events and have sizable event samples: necessitates a MicroBooNE sized detector both for containment and event sample.

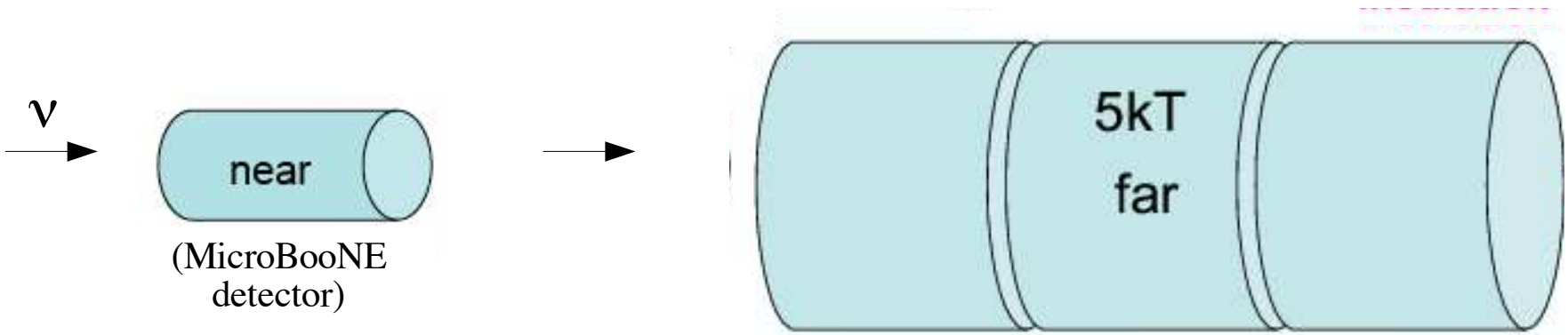
Question 2 cont.

2) Appropriate size detector before making the jump to the 5kTon

	Scaling factor
ArgoNeuT (0.3 tons) -> 5,000 tons:	x 15,000
Potential test stand (2x2x2 ~ 20 tons) -> 5000 tons:	x 250
MicroBooNE (200 tons) -> 5000 tons:	x 25

MicroBooNE is the minimum size for:

- Demonstrating understanding of neutrino interactions over full scale drift
- Sizable overall volume for purity demonstration



(MicroBooNE is a good size for 5kTon near detector)

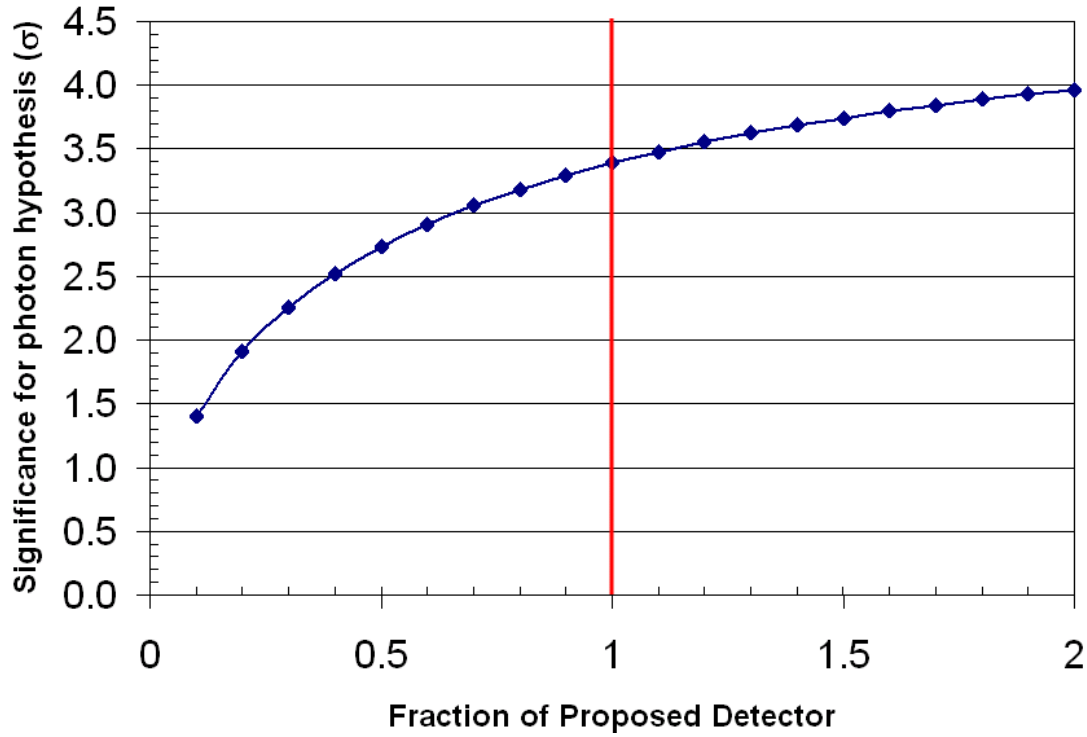
Question 2 cont.

Size optimization for physics goals:

- Low energy excess:
  - want to be at the location where we don't assume interpretation of the signal
  - statistics dictates size – particularly for interpreting signal as γs

Significance vs size for interpreting signal as γs

for electron interpretation, could go smaller for significance



- Cross sections: Need a set of fully contained events including muons from neutrino interactions. Could go closer to get large sample, costs are smaller, but not substantially. Can't take advantage of MiniBooNE enclosure and utilities.

Question 2 cont.

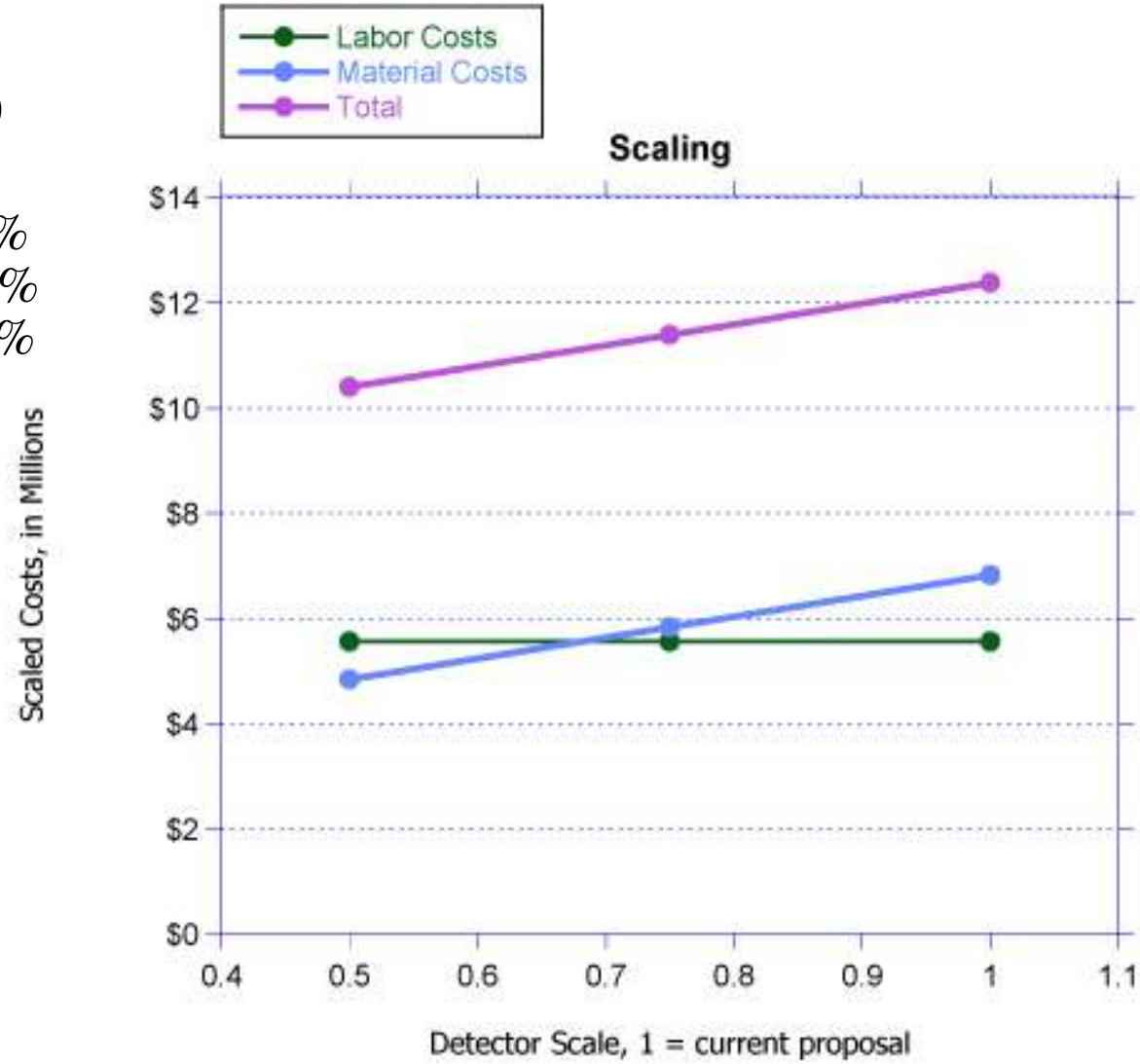
Practical Considerations: Cost savings modest

Estimated Scaling:

Example: detector size reduced by ½.
(Cost compared to original)

- Vessel: 50%
- Insulation (and LN2 system): 80%
- Cryogenics and purification: 100%
- Feedthroughs/inner detectors: 75%
- Electronics: 60%
- Installation materials: 100%
- Labor: 100%

Total costs are fully loaded with 50% contingency – $19M for detector proposed.



Conclusions:

Size is near optimal for the combination of R&D and physics goals given the practical constraints (lucky!)