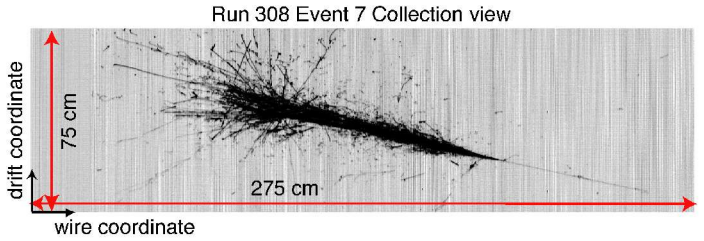
B.T.Fleming
FNAL Director's Review, LAr
June 3, 2008

Summary

- Physics using LarTPCs
- US program in the context of Worldwide R&D program
- Features of the US staged program presented here

Liquid Argon TPC detectors for neutrino oscillation physics



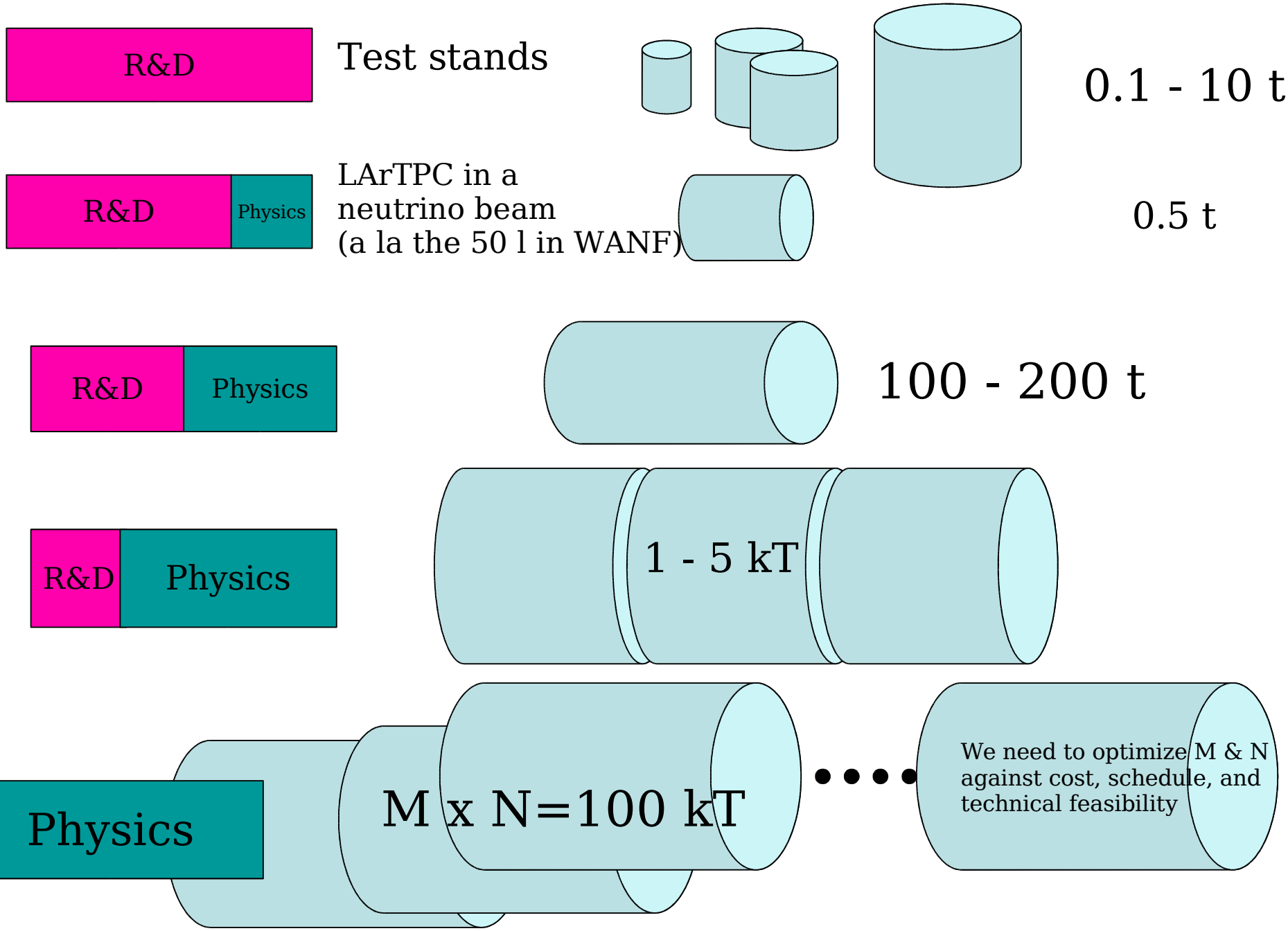
Unique Detectors
⇒ precision measurements in neutrino physics
⇒ appear scalable to large volumes

Neutrino oscillation physics: 3-4 times more sensitive than WC detectors.
(Differentiate π°s vs e's using topology and dE/dx)
ν_e appearance is difficult. Need powerful LAr detectors.....

- Proton decay searches: sensitive to $p \rightarrow \nu k$
- Supernova

These are great detectors!

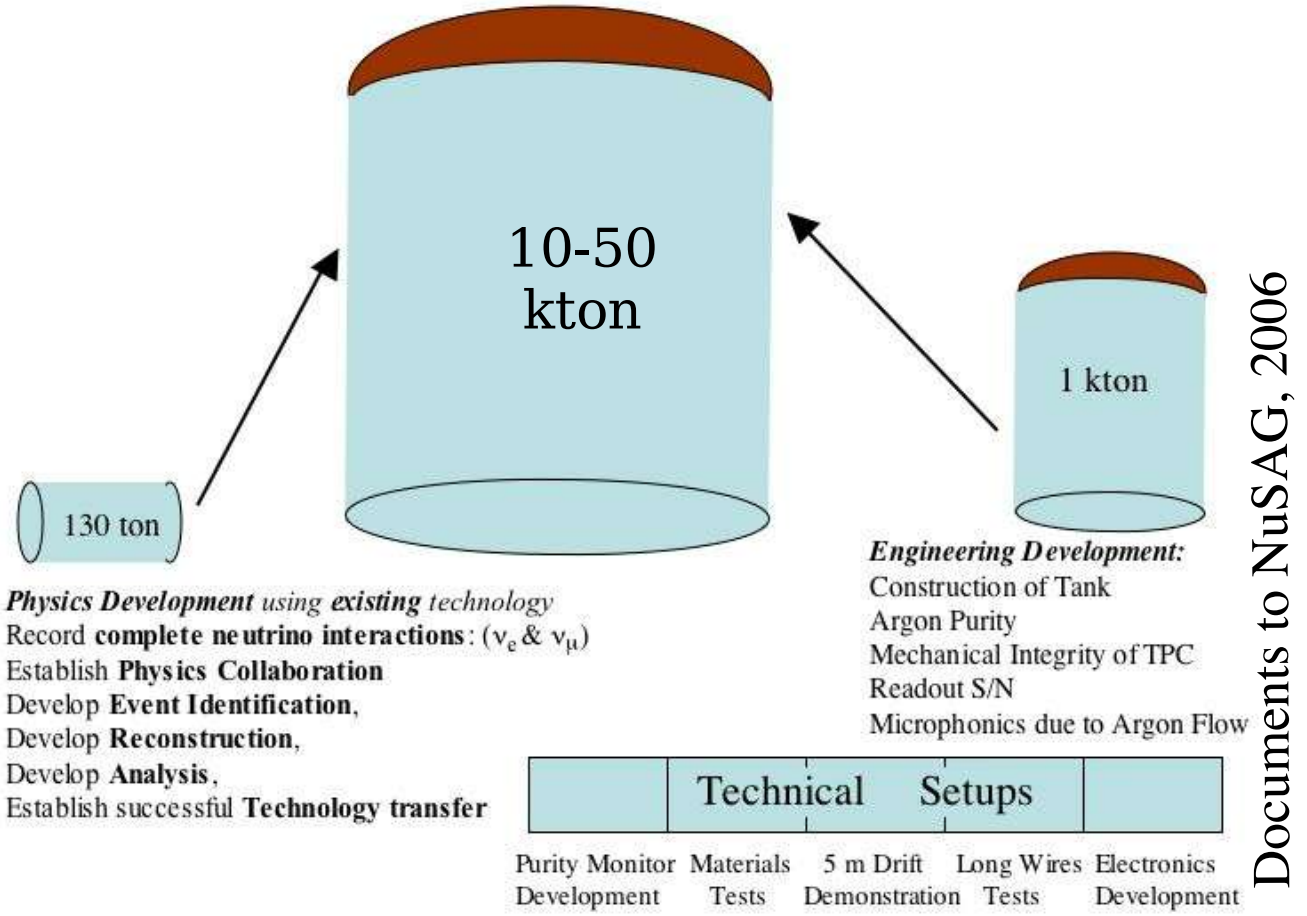
Evolution of a Liquid Argon Physics Program



From Project X workshop Series LAr working group

Staged approach towards
massive (100kton) detectors for CP Violation physics

- Address R&D goals at the appropriate size/stage
- Combine physics with R&D
  - Timely program
  - Grow collaborations
- Appropriate steps in time, size, and cost

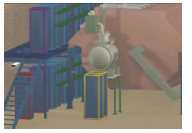


One of the four top level recommendations from the NuSAG report, 2007:

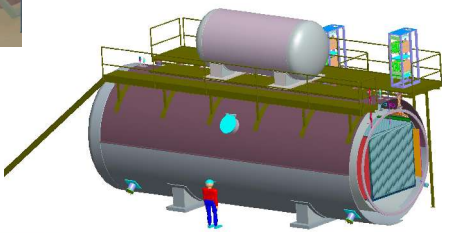
"A phased program with milestones and using technology suitable for a 50-100kton detector is recommended for the liquid argon detector option. Upon completion of the existing R&D project to achieve purity sufficient for long drift times, to design low noise electronics, and to qualify materials, construction of a test module that could be exposed to a neutrino beam is recommended"

Evolution of the Liquid Argon Physics Program

Yale TPC
Luke & Bo
R&D
Program underway



ArgoNeuT
R&D
Physics
Spring 2008



microBooNE
R&D
Physics
Data : 2011

near
5kT
far
R&D
Physics
Data : ~2015-2016

M x N = 100 kT
Physics !!!
Data 20??

From Project X workshop Series LAr working group

Recommendations from the Report of the P5 Panel to HEPAP, May 29, 2008

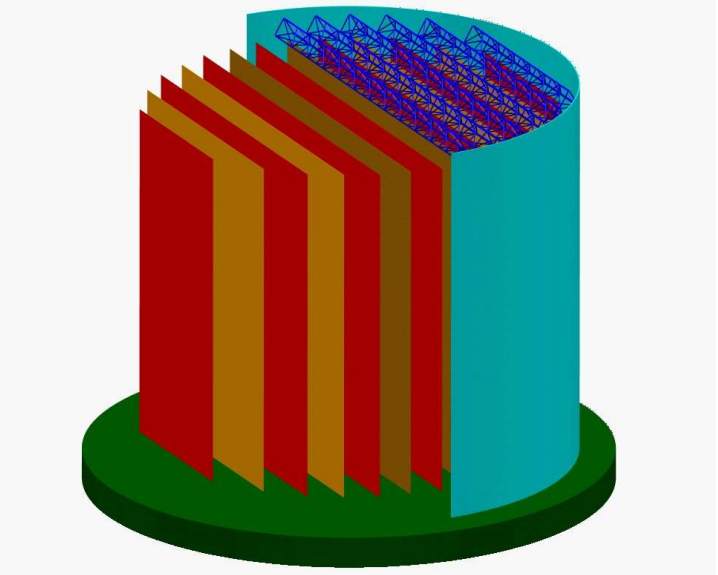
The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL laboratory and a high-intensity neutrino source at Fermilab

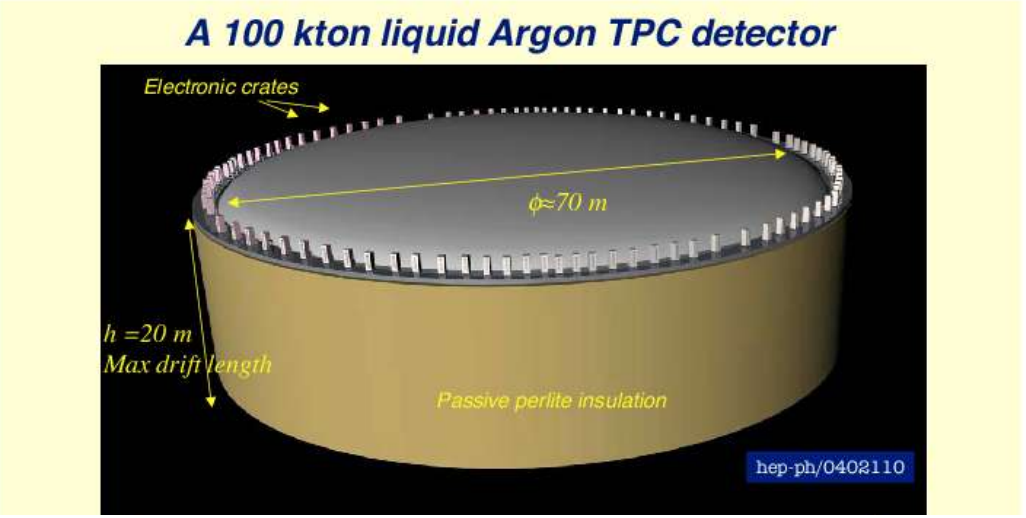
The panel recommends proceeding now with an R&D program to design a multi-megawatt proton source at Fermilab and a neutrino beamline to DUSEL and recommends carrying out R&D in the technology for a large detector at DUSEL.

The panel recommends support for a vigorous R&D program on liquid argon detectors and water Cerenkov detectors in any funding scenario considered by the panel. The panel recommends designing the detector in a fashion that allows an evolving capability to measure neutrino oscillations and to search for proton decays and supernovae neutrinos.

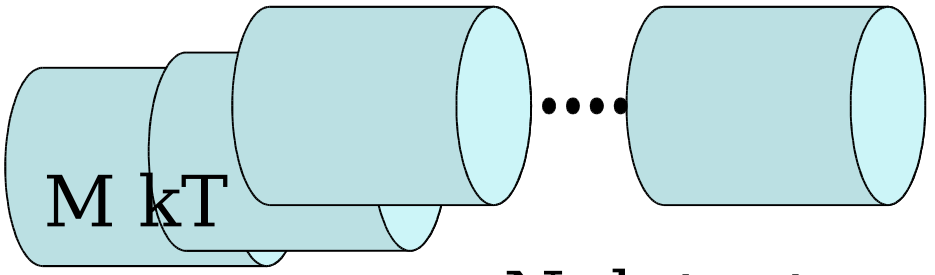
Possible designs for massive detectors:

LArTPC: Modularized drift regions in one large (10-50kton) tank (un-evacuated)



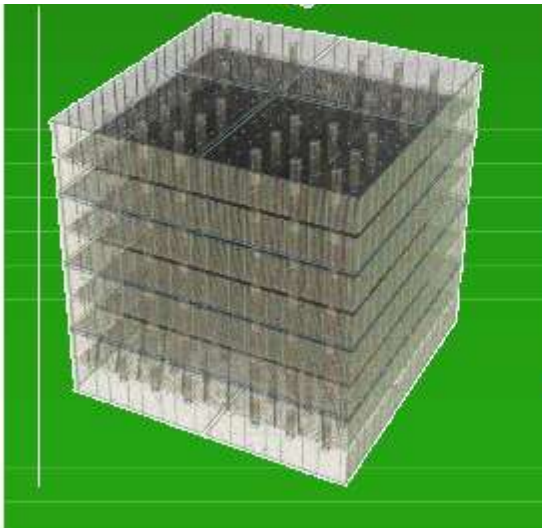


GLACIER: Combination of charge and light collection, single large drift area



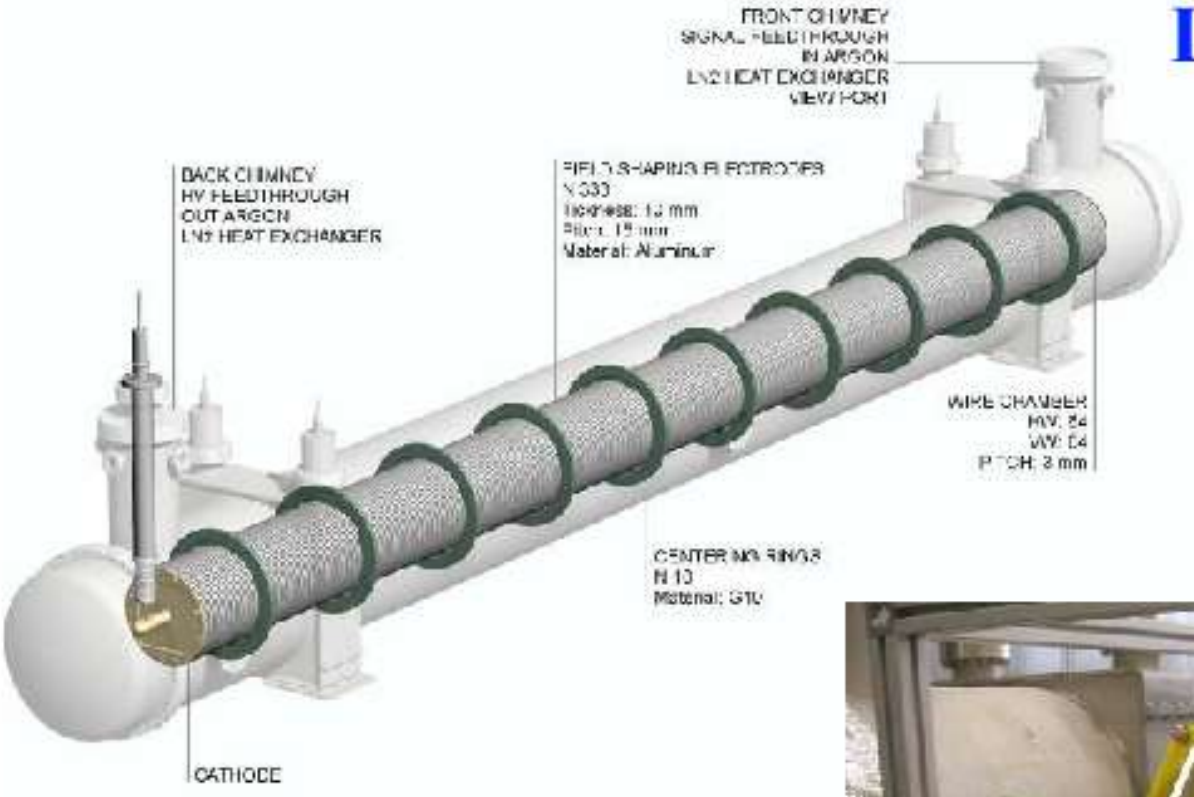
N detectors

M x N = 100



LAANDD: single module cubic evacuated vessel

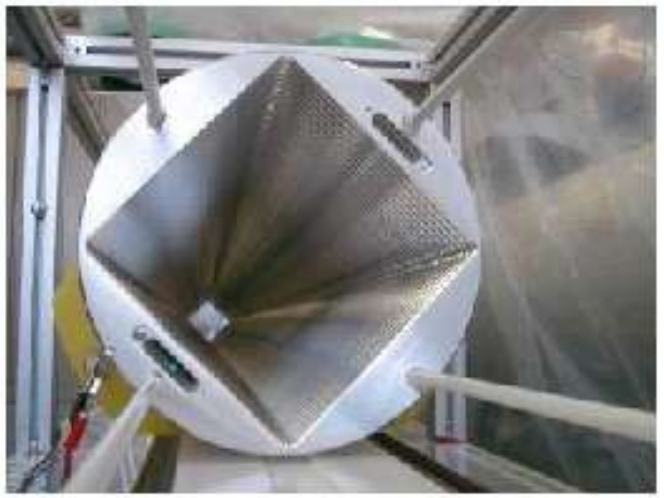
US/European LANDD effort



LANDD 5 m test @ CERN

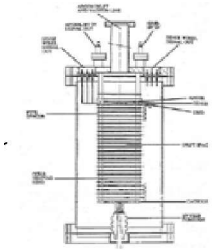
C. Cerri, D. Cline, F. Sergiampietri

Initial tests foreseen by summer '08



Similar evolution in European/ICARUS program

Test Stands →

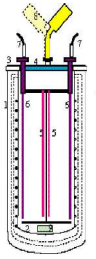


24 cm drift wires chamber

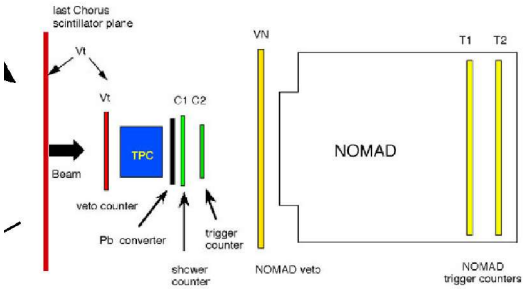
1987: First LAr TPC. Proof of principle. Measurements of TPC performances.

3 ton prototype

1991-1995: First demonstration of the LAr TPC on large masses. Measurement of the TPC performances. TMG doping.

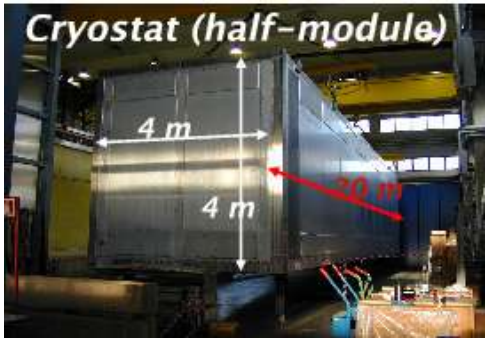


Seeing neutrino Interactions →



50 litres prototype
1.4 m drift chamber

1997-1999: Neutrino beam events measurements. Readout electronics optimization. MLPB development and study. 1.4 m drift test.

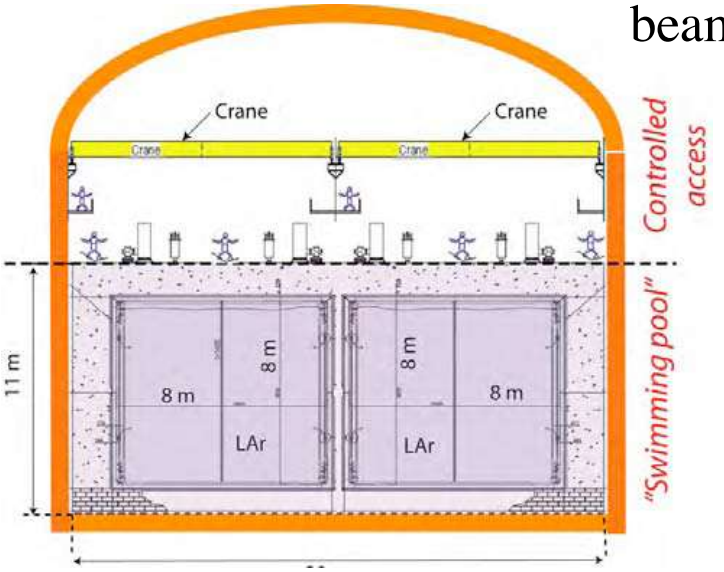


T600: data in '08
~2000 evts/yr, 17 GeV CNGS beam

Towards massive detectors →

SLICE:
slice of MODULAr
- 600 ton LArTPC
- low energy ν interactions
- prototype for MODULAr

similar program to MicroBooNE



MODULAr:
5kton modules

Similar evolution in European/T2K program

European/T2K program

From A. Marchionni's talk: NP08

GLACIER R&D

Charge readout with extraction from liquid phase & amplification in gas phase for long drifts

ArgonTube: 5 m drift test

Electronic racks

GAr

Charge readout plane

E ≈ 3 kV/cm

Extraction grid

E-field

LAr

E ≈ 1 kV/cm

Field shaping electrodes

Cathode (- HV)

UV & Cerenkov light readout photosensors

Greinacher voltage multiplier up to MV

Large area DUV sensitive photosensors

US efforts in context of worldwide efforts

- US efforts benefited greatly from worldwide R&D programs
- US has running and possible future neutrino beams: ideal for next generation LArTPCs
- Interaction between different R&D programs worldwide through workshops, conferences etc.
- Collaboration between INFN groups and US groups in particular is growing
  - INFN collaborators on the ArgoNeuT project
  - Possible collaboration on MicroBooNE project

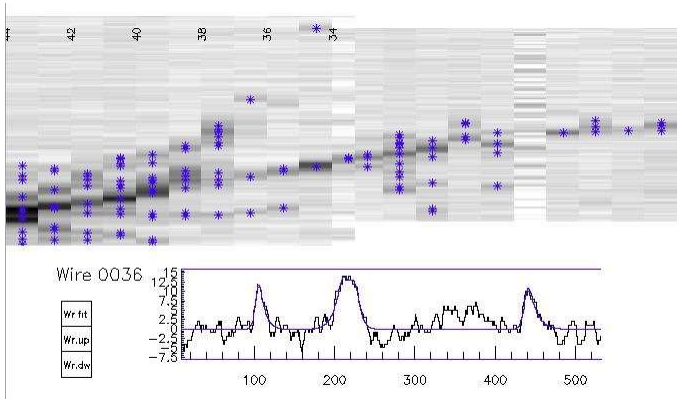
R&D

Test stands

-developing electronics components
-developing filtering techniques
  -Testing materials in Argon
  -Gaseous argon purge for purification
-developing Light Collection techniques
-technology transfer
-test e/γ separation

Good as "bench top" tests, but there are scale limitations....

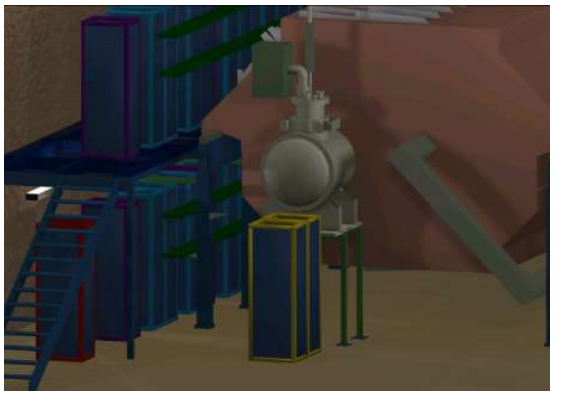
TPC at Yale



First tracks in US, April 2007

Materials Test at FNAL

Electronics Test Stands at FNAL and BNL

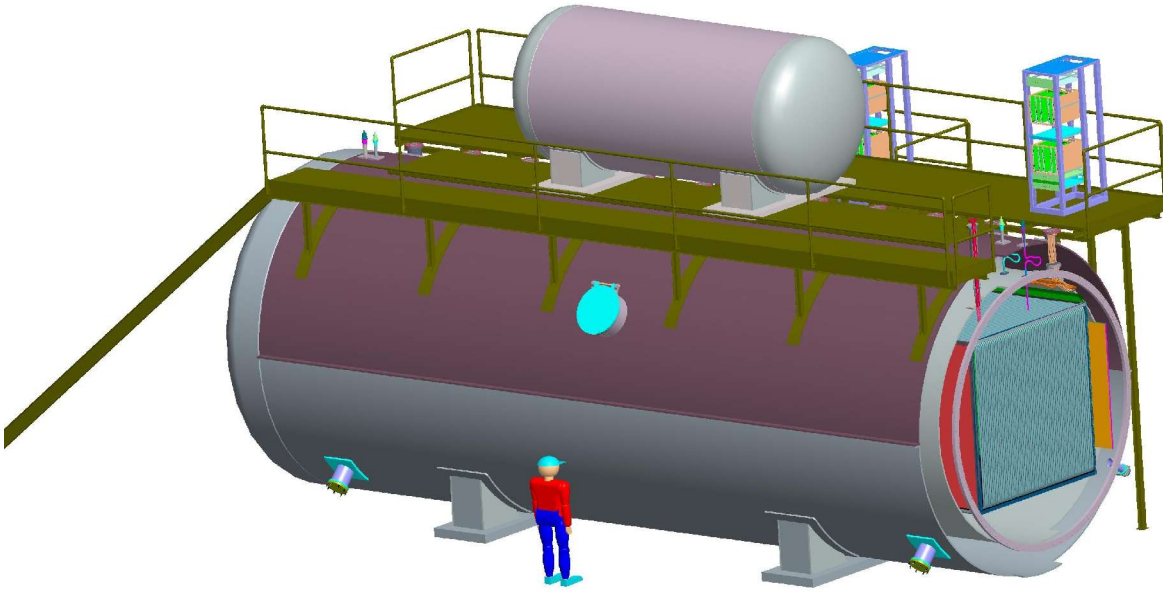


ArgoNeuT neutrino test stand underground

R&D | Physics

MicroBooNE: Full scale experiment physics results with a LArTPC detector

- **Purity in a non-evacuated vessel**
- **Full systems test of low noise electronics**
- Light Detection: data reduction, triggering
- Physics Development
  - See fully contained ν interactions
  - Simulation, reconstruction, analysis
  - Study surface running issues (cosmics)
- TPC and Vessel Design
- Value engineering

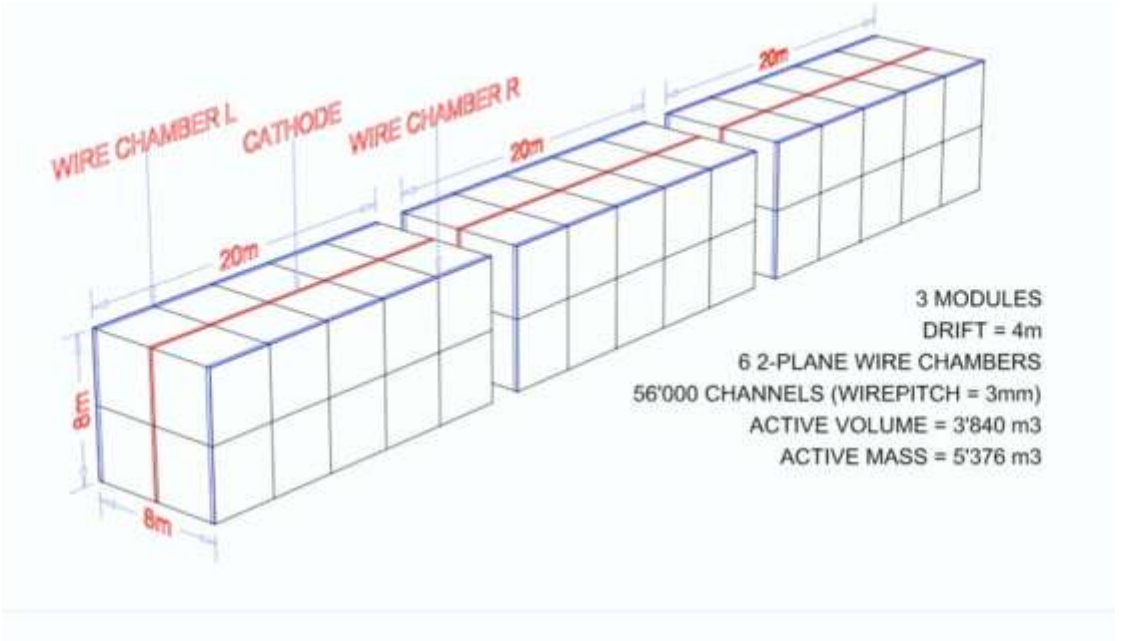


- Low energy neutrino interactions
  - Measure neutrino cross sections
  - Resolve MiniBooNE low energy excess
  - Physics R&D

Combination of physics and R&D

Detector scale set by technical challenges, Physics, and Physics R&D questions

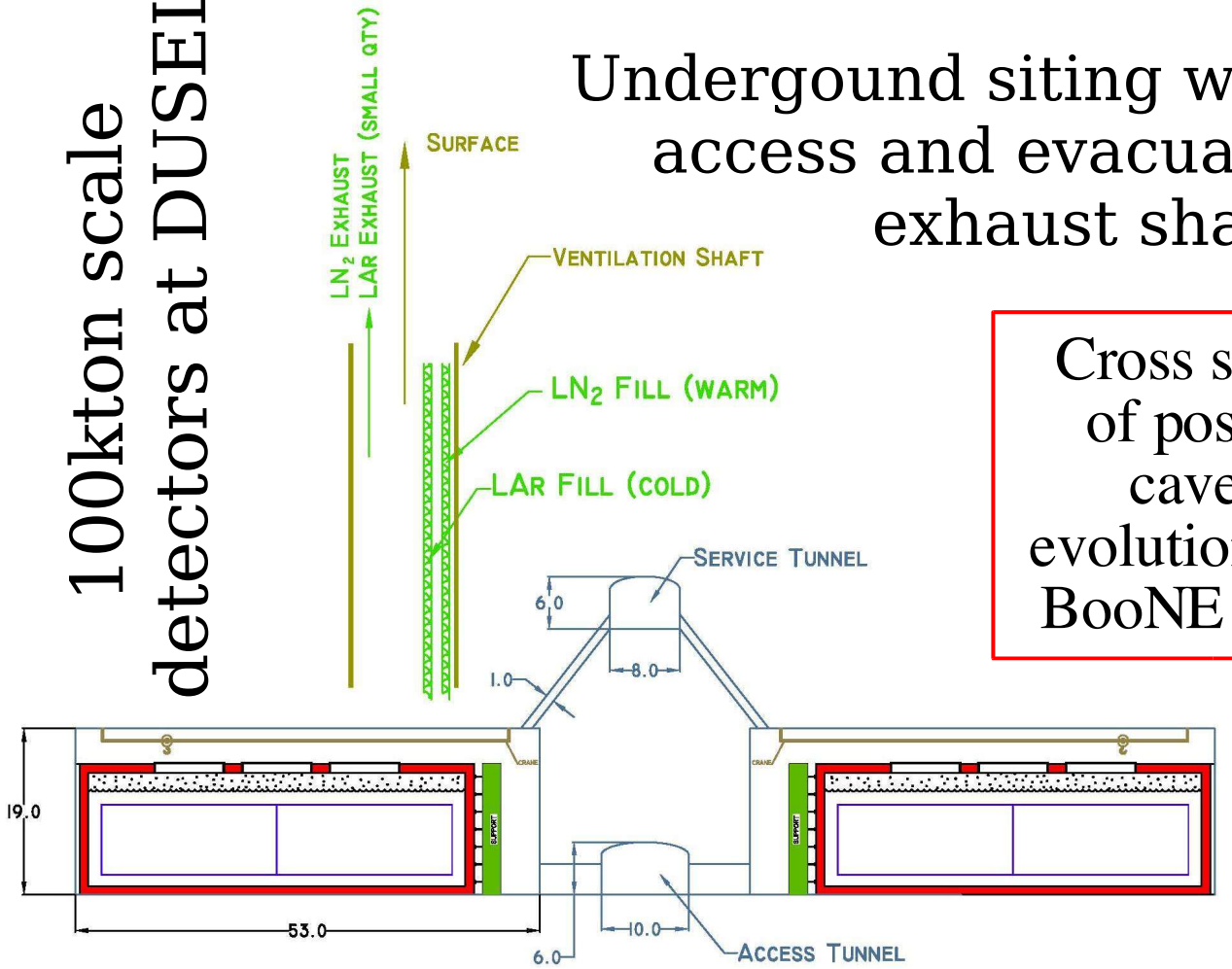
Possible design for LAr5



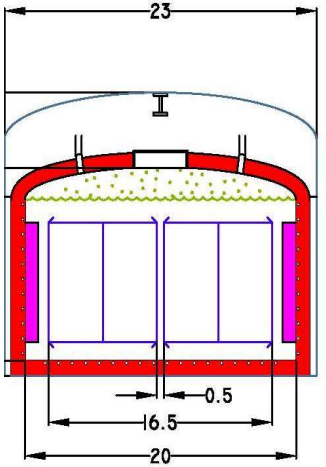
- ***Searches for CP Violation and Nucleon Decay***
- ***Implementation of CMOS electronics and multiplexing***
- ***Vessel design and construction***
- ***Underground siting:***
  - ***Construction and Installation***
  - ***Argon fill***
  - ***Safety considerations***

100kton scale detectors at DUSEL

Underground siting with service cavern, access and evacuation tunnel, and exhaust shaft shown



Cross section of possible cavern: evolution of m-BooNE design



Design considerations for 10kton scale detector:

- Implementation of cold electronics and multiplexing: μ-BooNE Phase 2 R&D
- Vessel, TPC and light collection design: evolution of μ-BooNE design
- Purification in non-evacuatable vessel: test stands, μ-BooNE, LAr5
- Underground siting considerations: Experience on LAr5

μBooNE - Construction	2009-2011
*****	
Agree on a Strawman Layout	2008-2010
Caverns design & excavation plan	2009-2011
Start excavation of the caverns	2012-2015
Finalize the design of 5 k-ton	2012
5 k-ton Construction	2012 -2017
20-30 k-ton: 1st det.Construction	2015-2020
2nd det. Construction	2017-2022
3rd det. Construction	2019-2023
4th det. Construction	2020-2024

The test stand program combined with the MicroBooNE experiment and the concepts for LAr5 and beyond are the necessary next steps in this staged approach.

MicroBooNE is the critical path for this R&D program. A timely start will put the program on the path to success.