Some Liquid Argon Work at FNAL

Started with Detector-Materials Qualification for long-drift (> 2m) Liquid Argon TPC

now encompasses

- **Material Tests, purging, and H_20 studies (*)**
- **TPC electronics development**
- **ArgoNeut Expt– 0.25 ton in NuMI (few GeV) Neutrino Beam**
- **MicroBooNE Expt -200 tonne (75 fiducial) approved for Booster Neutrino Beam**
- **LBNE (Long Baseline Neutrino Expt (at DUSEL)) – 20 kT LArTPC**
- **Depleted Argon Distillation Column (*)**

Acknowledge enormous contribution of ICARUS and other European programs

Technical Issues for Multi-ton Argon detector for Dark Matter:

Chemical purity of Argon to allow electron drift (10's ppt O2 equivalent)

Chemical purity of Argon to allow light propagation

HV feedthroughs (>100 kV) in Argon gas***)***

TPC design

Data Acquisition

Cryogenics (and associated safety issues)

Detector Materials Qualification

Shielding from environment radiation

Radio-purity of detector materials

Technical Issues for Multi-ton Argon detector:

Chemical purity of Argon to allow electron drift (10's ppt O2 equivalent), ***(neutrino and DM)***

Chemical purity of Argon to allow light propagation (*DM*)

HV feedthroughs (>100 kV) in Argon gas ***(neutrino and DM)***

TPC design ***(neutrino and DM)***

Data Acquisition ***(neutrino and DM)***

Cryogenics (and associated safety issues) ***(neutrino and DM)***

Detector Materials Qualification ***(neutrino and DM)***

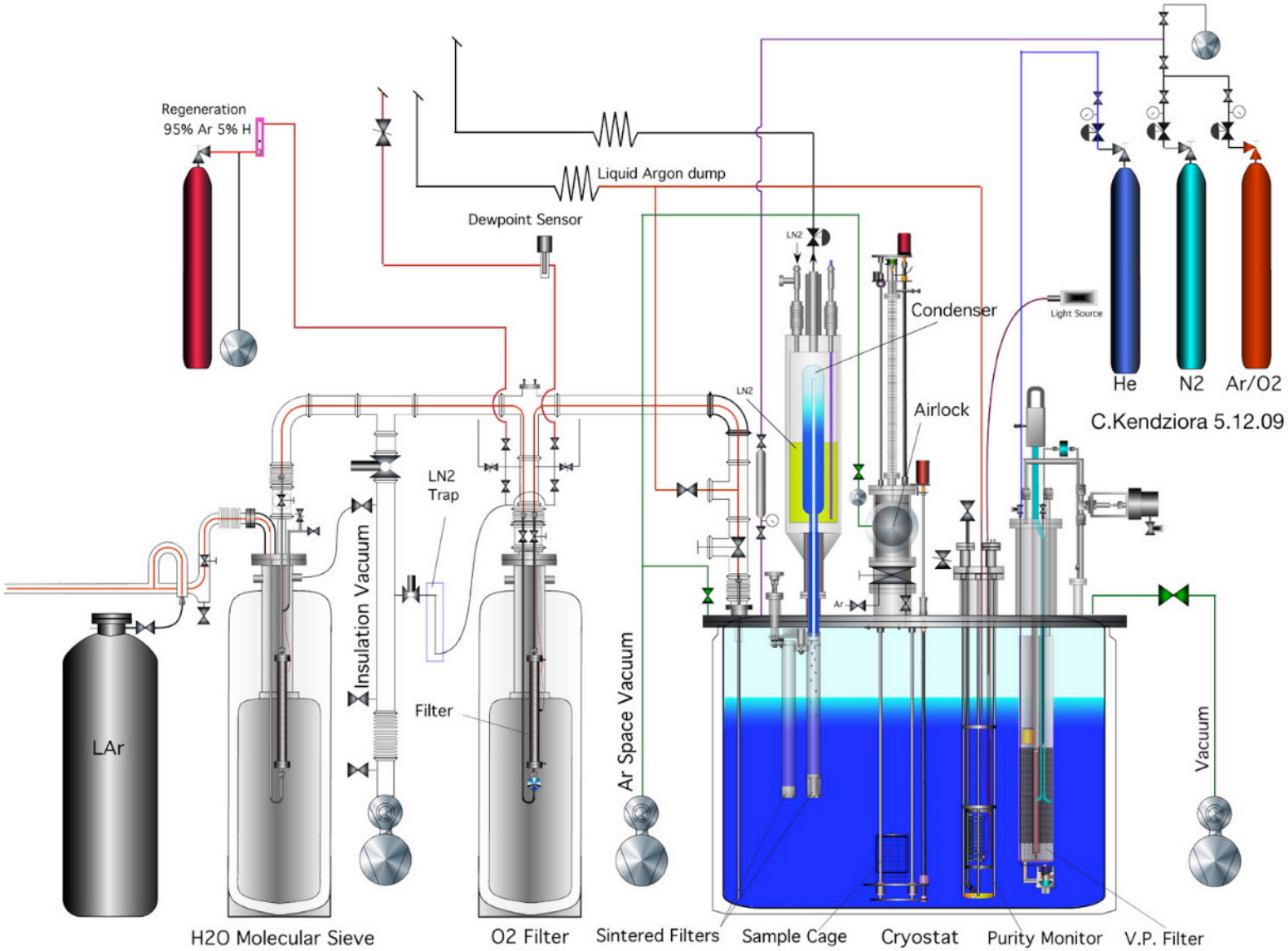
Shielding from environment radiation *(DM)*

Radio-purity of detector materials *(DM)*

Clean Argon Source, Materials Test System, and Electronics Test System at PAB

Develop purification, check detector materials, TPC for electronics development

Schematic of Materials Test Stand



Materials Test Stand

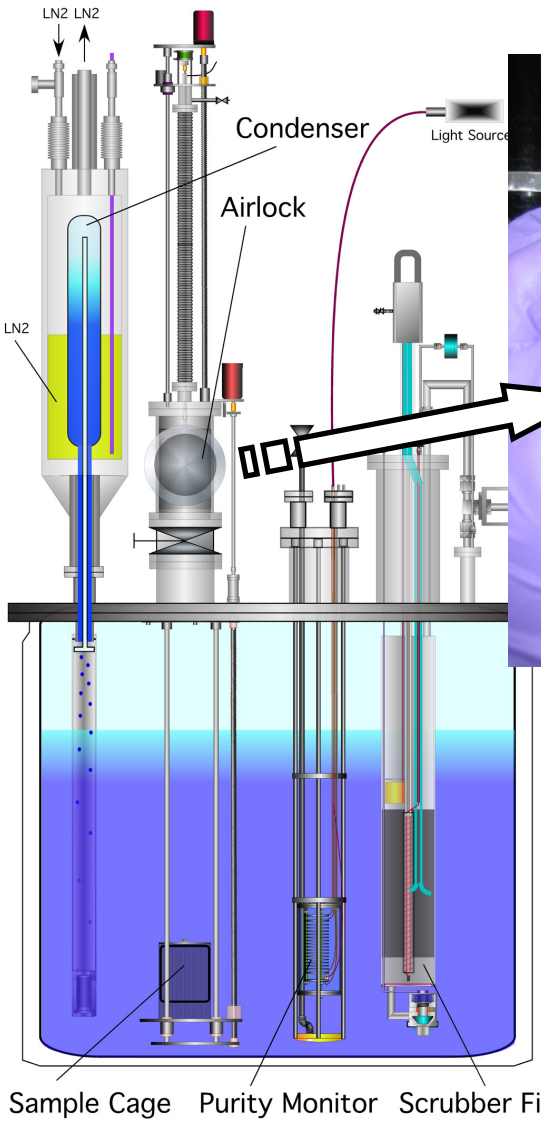
Features of Materials Test Stand

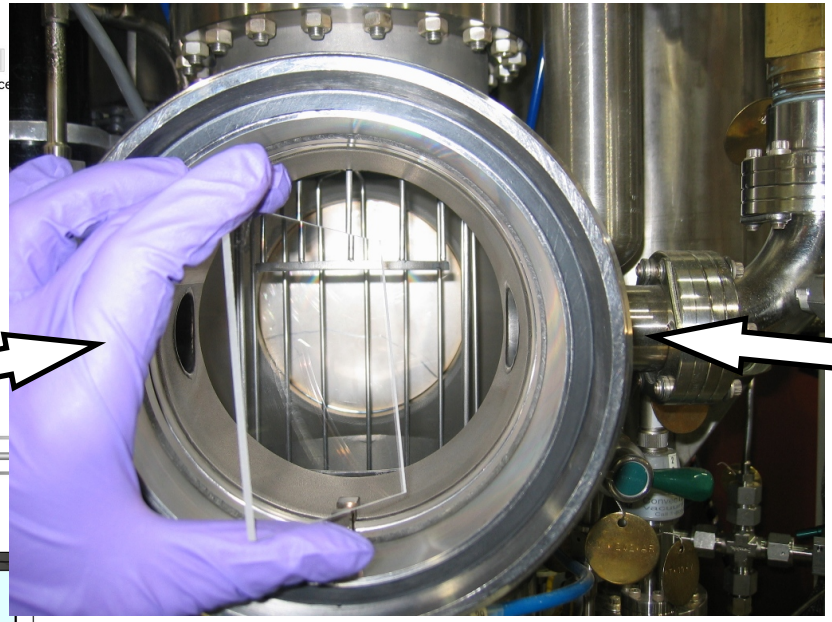
- Can insert materials into known clean argon
- Can insert materials after purging only or after pumping on them.
- Can position materials into liquid and into ullage with range of temperatures.
- Can insert known amounts of contaminant gases
- Nitrogen-based condenser can maintain liquid for long (weeks) studies
- Internal filter-pump can remove contamination introduced by materials – 2hr cycle
- Sample points at Argon Source, after single-pass filters, in cryostat gas and liquid

Measurement Features of Materials Test Stand

- Measure electron drift lifetime with ICARUS style purity monitor
- Measure Oxygen (0.3 ppb sensitivity) with oxygen meter (Delta-F & Tiger Optics)
- Measure H20 in gas (0.3 ppb sensitivity) with water meter (Tiger Optics)
- Cryogenic data, Lifetime Data, analytic instrumentation data in single data-base

Insertion of a material sample into the airlock (argonlock) basket

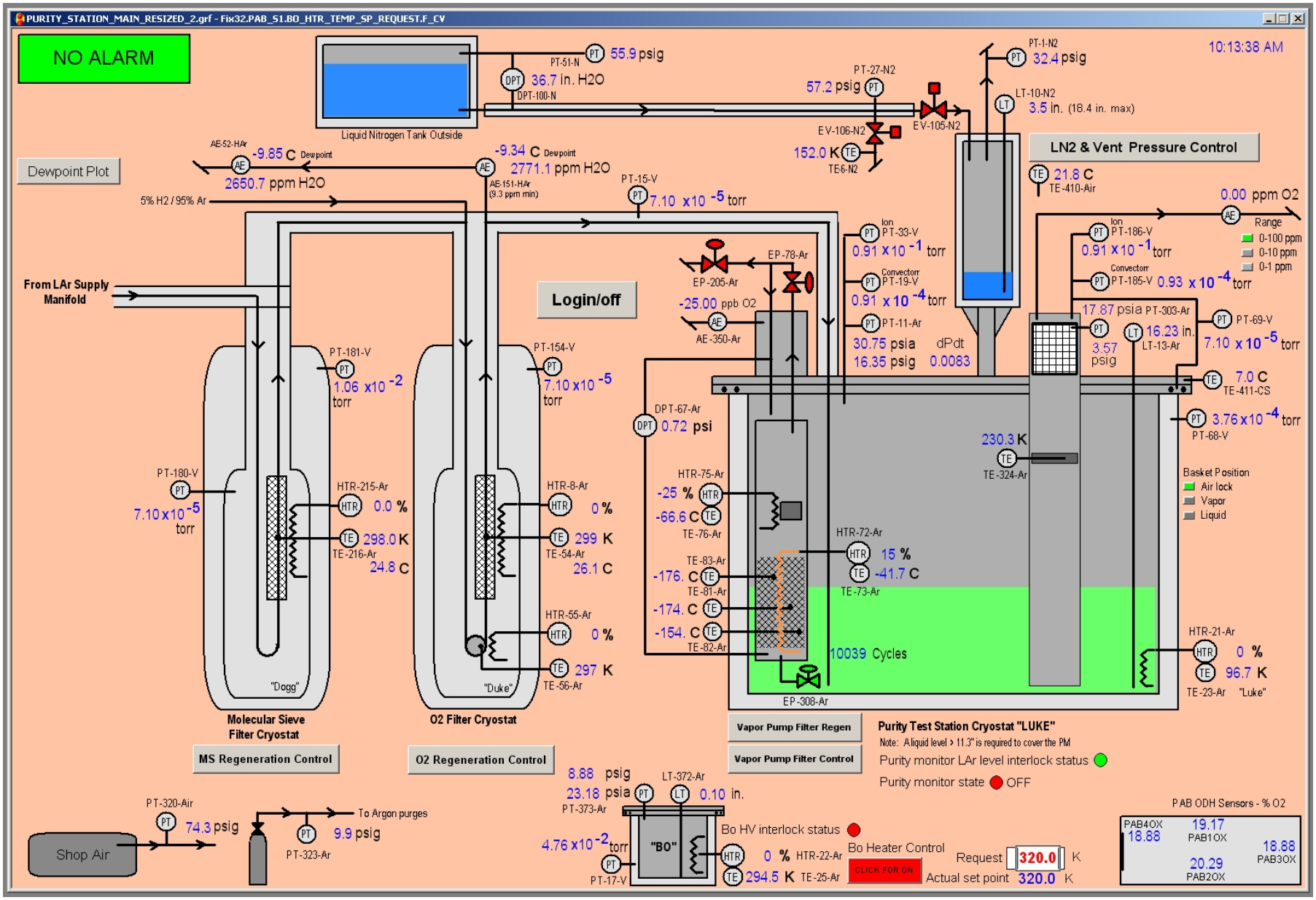




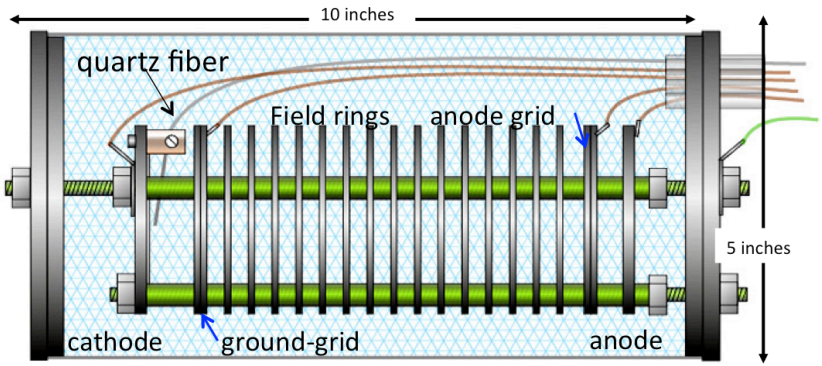
Sample volume 10 cm x 10 cm x 10 cm

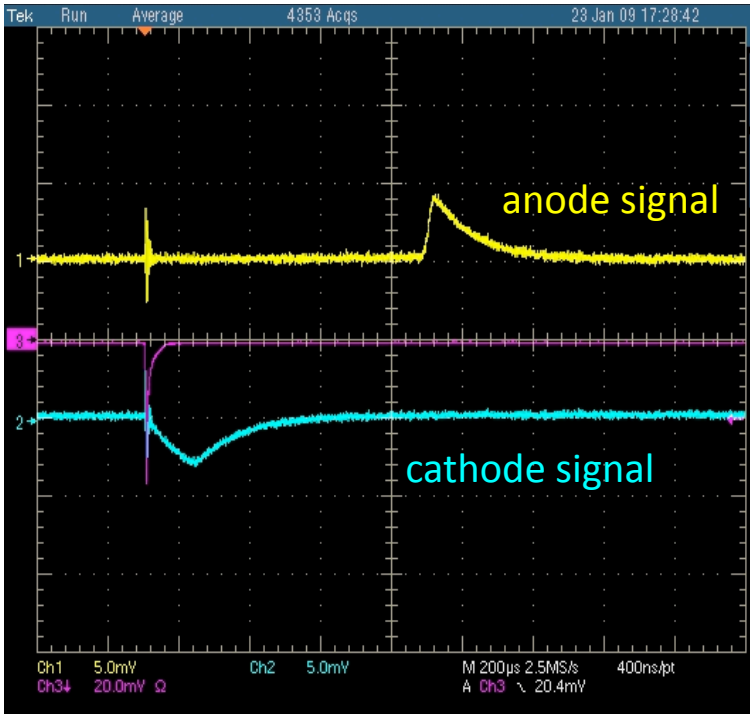
Argonlock can be purged with external argon, cryostat argon, and/or evacuated

Cryogenics Control Screen

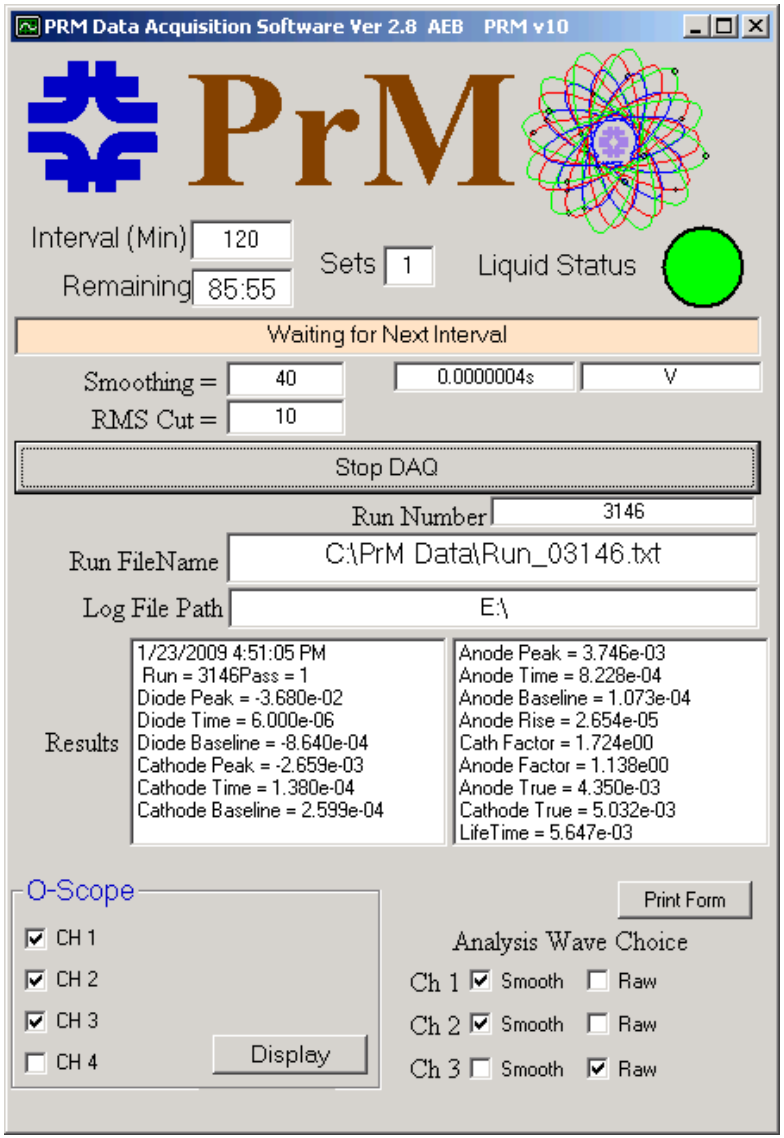


Electron Drift Lifetime Monitor



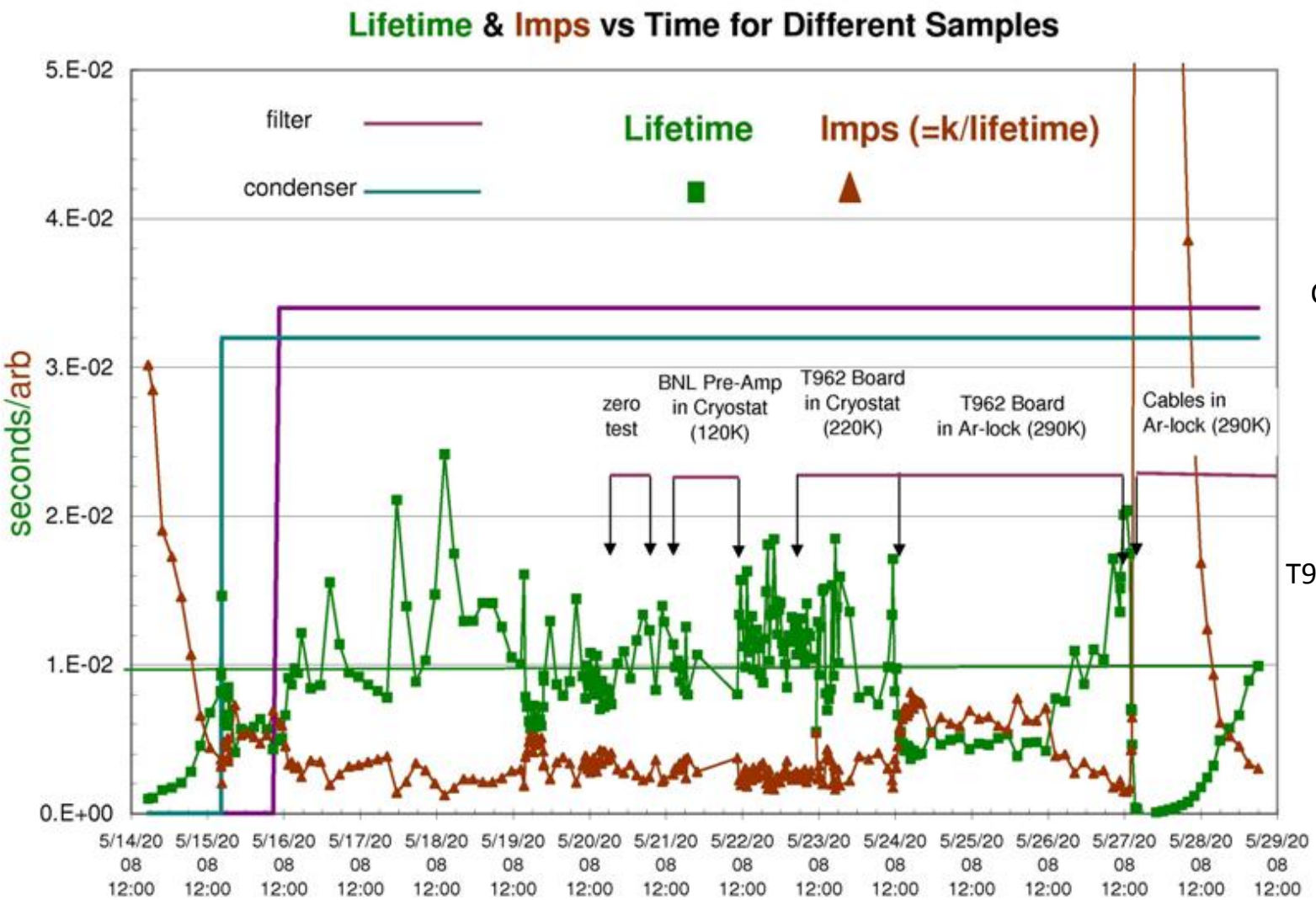


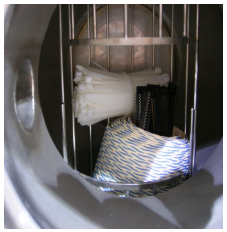
PrM scope signal



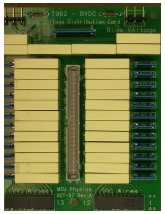
PrM automation software

An example set of measurements with the Materials Test System





Cables & Cable ties



T962 Decoupling Board

Cold pre-amp

Learning how to do what has been done by others

(cryogenics, purification, purity monitoring - all are now designed & built in the US)

New stuff - our own filter systems,
material test systems,
the effect of H_20,

FERMILAB-TM-2384-E: efficiency of slow purging to remove atmosphere to ppm levels

A regenerable filter for liquid argon purification

A. Curioni [b], B.T. Fleming [b], W. Jaskierny [a], C. Kendziora [a], J. Krider [a], S. Pordes [a], M. Soderberg [b], J. Spitz [b,*], T. Tope [a], T. Wongjirad [b]

[a] Particle Physics Division, Fermi National Accelerator Laboratory, Chicago, IL, USA
[b] Department of Physics, Yale University, New Haven, CT, USA

NIM-A 605:306-311,2009.

A system to test the effect of materials on electron drift lifetime in liquid argon and the effect of water

R. Andrews, W. Jaskierny, H. Jöstlein, C. Kendziora, S. Pordes *, T. Tope

Particle Physics Division, Fermi National Accelerator Laboratory, Batavia, IL 60510, USA

NIM-A 608:251-258,2009.

Some Materials Tested

Material	Sample Surface Area (cm^2)	Effect of Material on Electron Drift Lifetime (LT)			Comments
		94 K liquid	≈120 K vapor	≈225 K Vapor	
Red-X Corona Dope[a]	100	None	None	LT Reduced from 8 to 1 ms; recovery observed.	H_2O concentration not monitored.
Deactivated Rosin Flux[b]	200	None	Not Tested	LT reduced from 8 to 1.5 ms recovery observed	H_2O concentration not monitored.
FR4	1000	None	Not Tested	LT reduced from 8 to <1 ms	Outgassed enough H_2O at 225 K to saturate sintered metal return.
Taconic[c]	600	None	Not Tested	LT reduced.	Sample outgases water at 225 K.
Hitachi BE 67G[d]	300	None	Not Tested	LT reduced; recovery observed	Sample outgases water at 225K; outgassing reduced over time.
TacPreg[e]	200	None	None	LT reduced; recovery observed	Sample outgases water at 225 K; outgassing reduced over time.
FR4, y-plane wire endpoint for uBooNE	225	None	None	LT reduced from 8 to 3 ms	Sample outgases water at 225 K.
FR4, y-plane wire endpoint for uBooNE	225	None	None	None	Sample was evacuated in airlock prior to testing
FR4, y-plane wire cover for uBooNE	225	None	None	None	Sample was evacuated in airlock prior to testing
Devcon 5-min epoxy	100	None	None	LT reduced from 10 to 6 ms; some recovery observed	Sample outgases water at 225 K.

– no effect on lifetime when material is in liquid

The effect of H20

Material	Sample Surface Area (cm^2)	Effect of Material on Electron Drift Lifetime (LT)			Comments
		94 K liquid	≈120 K vapor	≈225 K Vapor	
Red-X Corona Dope[a]	100	None	None	LT Reduced from 8 to 1 ms; recovery observed.	H_2O concentration not monitored.
Deactivated Rosin Flux[b]	200	None	Not Tested	LT reduced from 8 to 1.5 ms recovery observed	H_2O concentration not monitored.
FR4	1000	None	Not Tested	LT reduced from 8 to <1 ms	Outgassed enough H_2O at 225 K to saturate sintered metal return.
Taconic[c]	600	None	Not Tested	LT reduced.	Sample outgases water at 225 K.
Hitachi BE 67G[d]	300	None	Not Tested	LT reduced; recovery observed	Sample outgases water at 225K; outgassing reduced over time.
TacPreg[e]	200	None	None	LT reduced; recovery observed	Sample outgases water at 225 K; outgassing reduced over time.
FR4, y-plane wire endpoint for uBooNE	225	None	None	LT reduced from 8 to 3 ms	Sample outgases water at 225 K.
FR4, y-plane wire endpoint for uBooNE	225	None	None	None	Sample was evacuated in airlock prior to testing
FR4, y-plane wire cover for uBooNE	225	None	None	None	Sample was evacuated in airlock prior to testing
Devcon 5-min epoxy	100	None	None	LT reduced from 10 to 6 ms; some recovery observed	Sample outgases water at 225 K.

Lifetime deteriorates when `warm' materials out-gas water

The effect of H20

In general: Lifetime inversely proportional to H_20 concentration in gas

Constant of proportionality independent of material
– so H_20 is not just a marker and is probably the prime contaminant

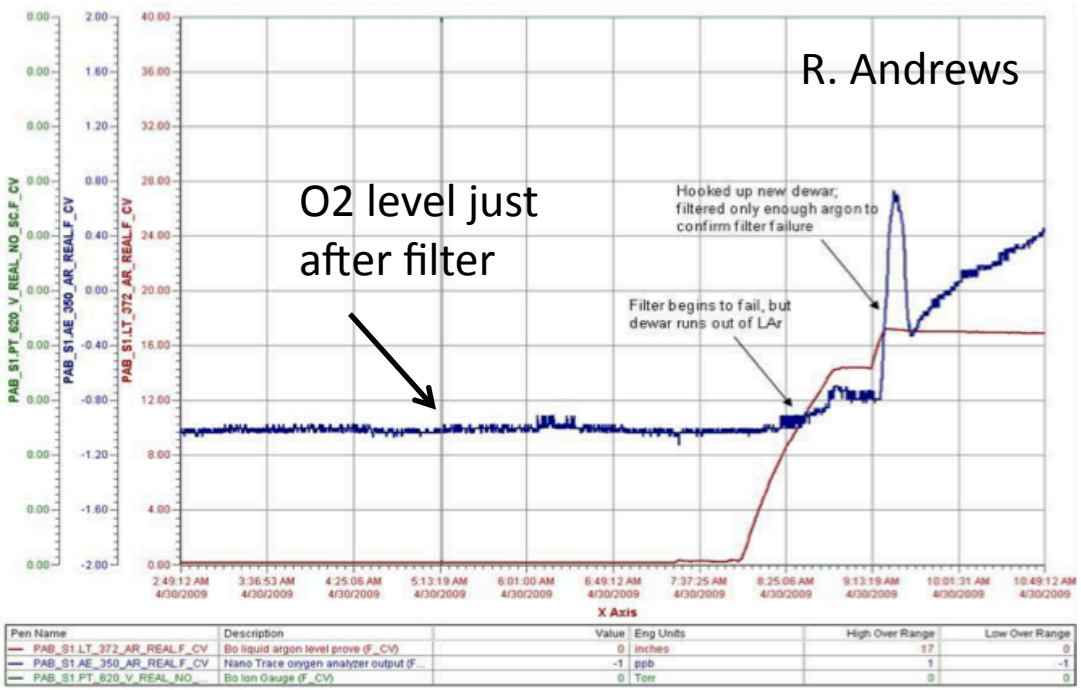
Calculations of effective concentration in liquid suggest H20 as bad 02

Filter Materials

We make and regenerate our own filters using material from BASF (originally Engelhard) for O2 and Molecular Sieve from Aldrich

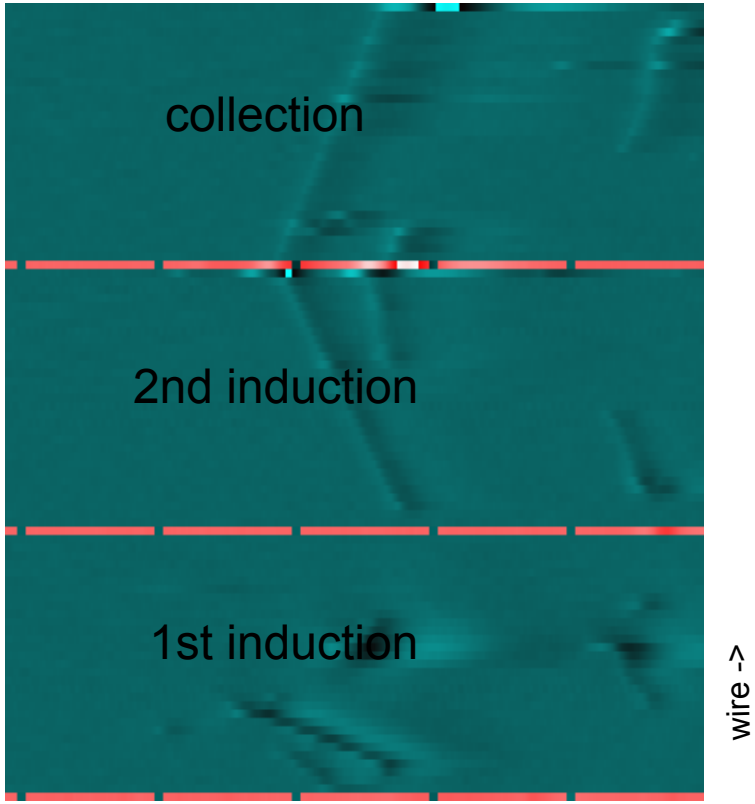
We have the capability to use other materials but have not pursued that yet.

We are interested in **the capacity of filter materials before `breakthrough'** - the capacity seems much much less than one would calculate from curves at room temperature.

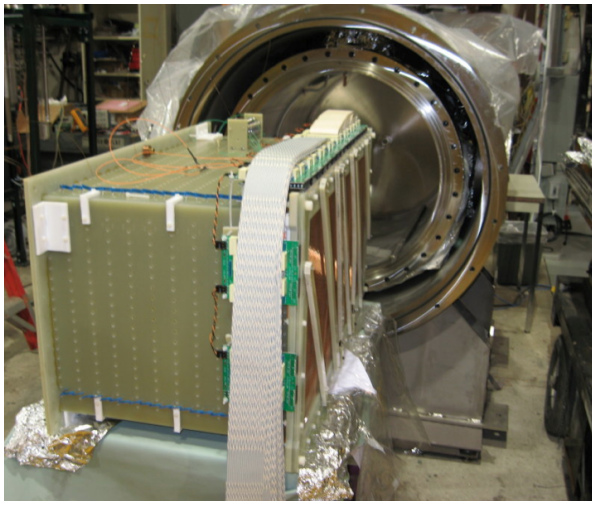


Plot of O2 level after ~ 0.5 g O2 through filter.
Note the `breakthrough' style of behavior.

TPC for electronics development



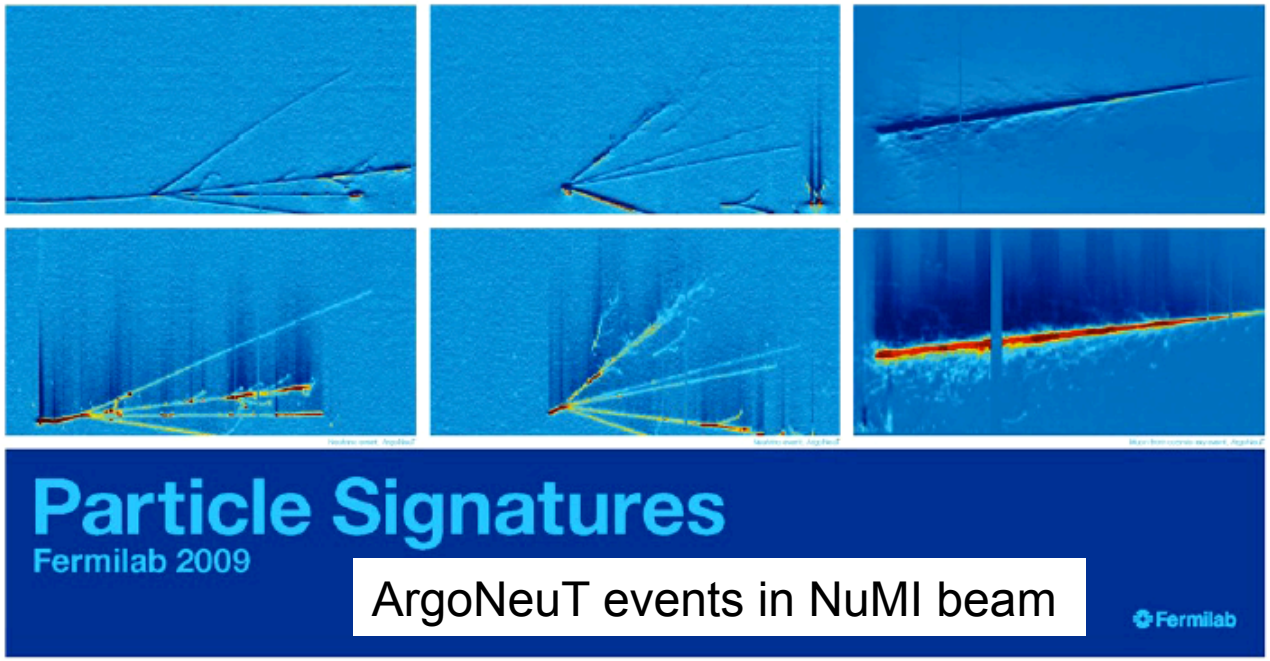
ArgoNeut



0.25 tonne LAr TPC in NuMI neutrino beam

10k anti-neutrino interactions in < 6 months

major ongoing effort in reconstruction software at LNGS & FNAL



ArgoNeuT events in NuMI beam

Liquid Argon Purity Demonstration - LAPD

Aim is to achieve long electron drift lifetime in an industrial vessel without evacuation.

All other LAr TPCs are evacuated before filling (eg ICARUS). Multi-kiloton detectors may not have evacuable cryostats.

Single wall, insulated, holds 30 tons.

Stage 1 vessel and instrumentation – this summer.

Stage 2 add detector materials

Stage 3? add real detector

LAPD Tank(in hall where upsilon (b-quark) was discovered in 1977)

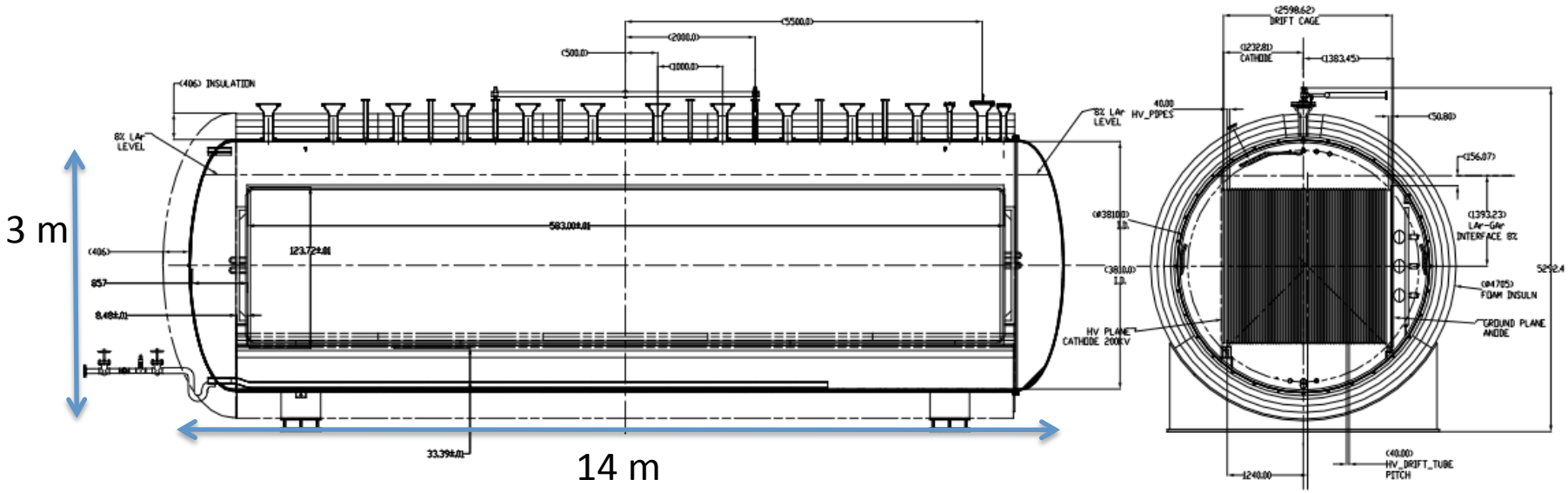
MicroBooNE

75 tons liquid argon fiducial in Booster (8 GeV) Neutrino Beam

Single-wall, Foam Insulated Evacuable Cryostat – 200 tons Liquid Argon

~ 9,000 Wire TPC – drift distance 2.6 m

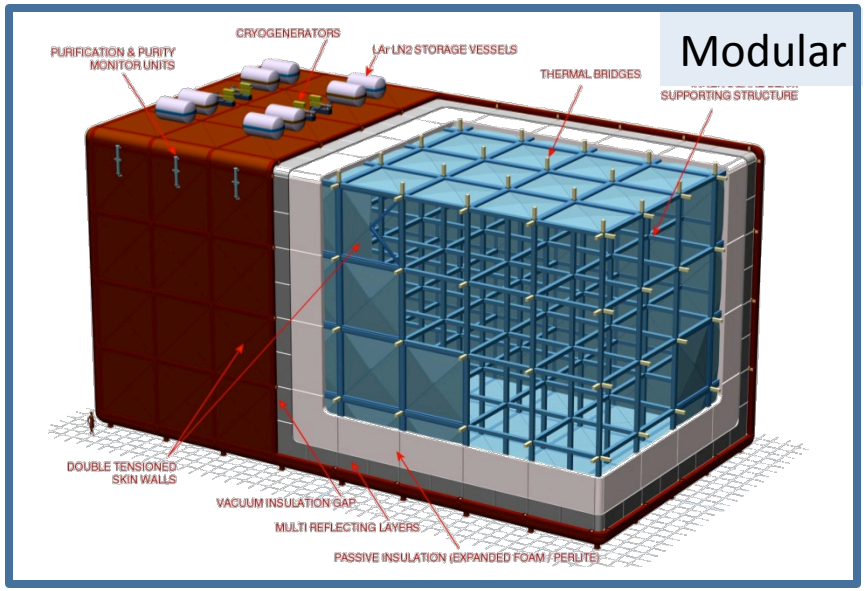
Investigate MiniBooNE anomaly (excess of low E events (< 300MeV)) and ν−Argon cross sections

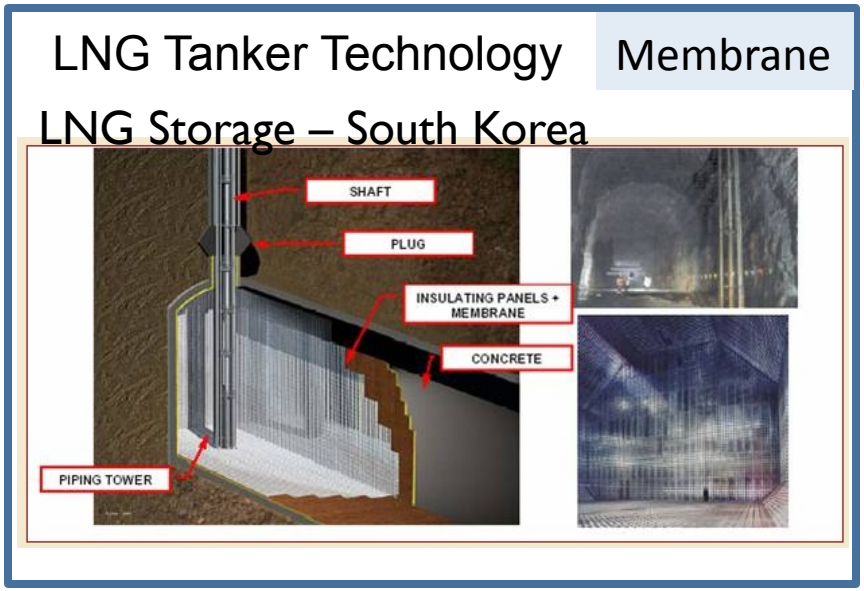


Technical R & D

- purging to purity (i.e. not evacuating)
- electronics in cryostat
- daq development
- event reconstruction & identification

Options for LBNE LAr Detector (DUSEL)





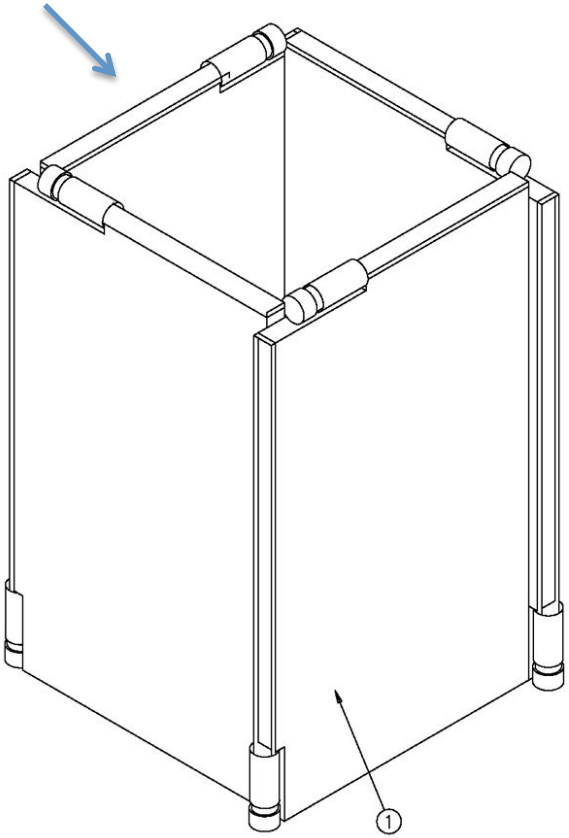
- Internal structural support
- Evacuation possible

- Externally supported by cavern walls
- Not evacuable

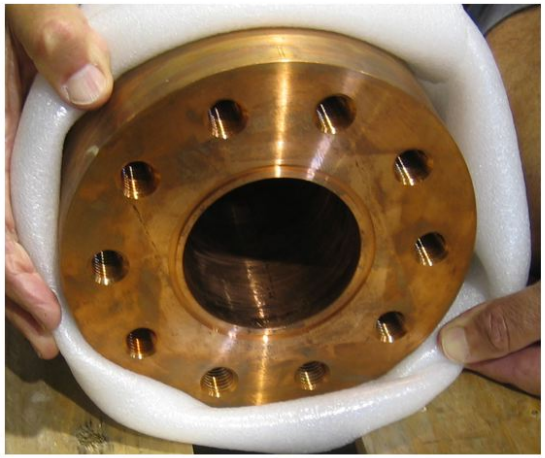
Choice will be based on cost and technical risk

High Pressure Ionization Chamber for Depletion Measurement
(or invest in useful stuff)

at Princeton

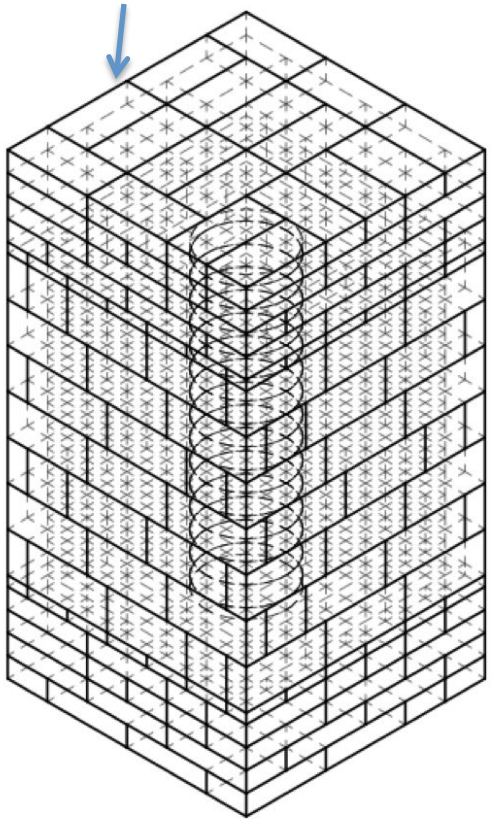


Ion Chamber Body



150 bar (0.15 kg)

used in light WIMP search



Muon veto, lead shield, and low-radioactivity copper, and running in NuMI tunnel needed to achieve < 0.01 Bq/kg

Martin, Martoff, Sonnenschein

Cryogenic Distillation Plant Rev. 7 - Saturday, February 20, 2010

Cryogenic Distillation Plant Rev. 7

C. Galbiati, Tristen C. Hohman, David Montanari

Physics Department
Princeton University

Saturday, February 20, 2010

Introduction

The report presents the design of a cryogenic distillation system capable of purifying a gas stream composed by 99% argon and 1% nitrogen (percentage by volume). The purpose is to treat the crude argon stream from underground wells, extracted and refined with the VPSA system and the charcoal traps in Cortez, CO. The goal is to reduce the nitrogen contamination below 1 ppm. The residual nitrogen contamination at the output of the cryogenic distillation system will be removed with hot getters.

Figure 1 shows the vapor pressure curves of argon and nitrogen, and Table 1 shows the boiling points of the two compounds in the gas mixture: argon and nitrogen.

The different boiling points of the two compounds address the possibility to perform a cryogenic distillation to remove nitrogen from the gas mixture.

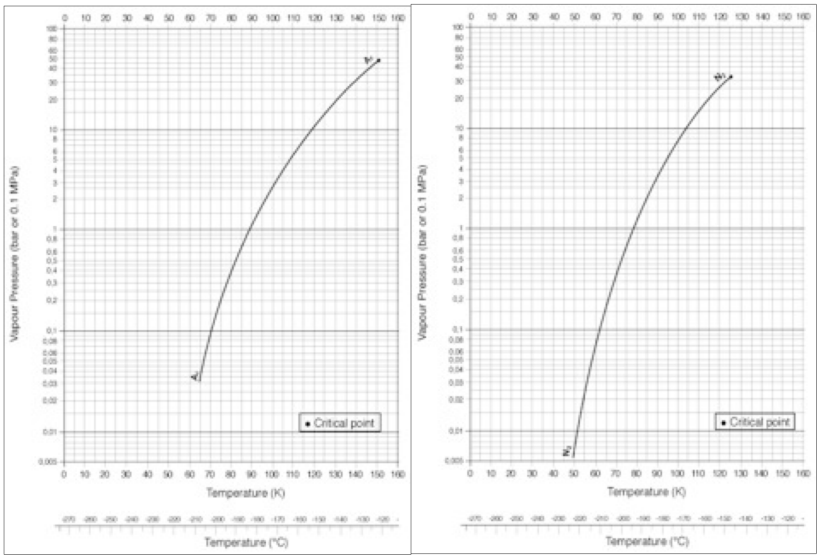
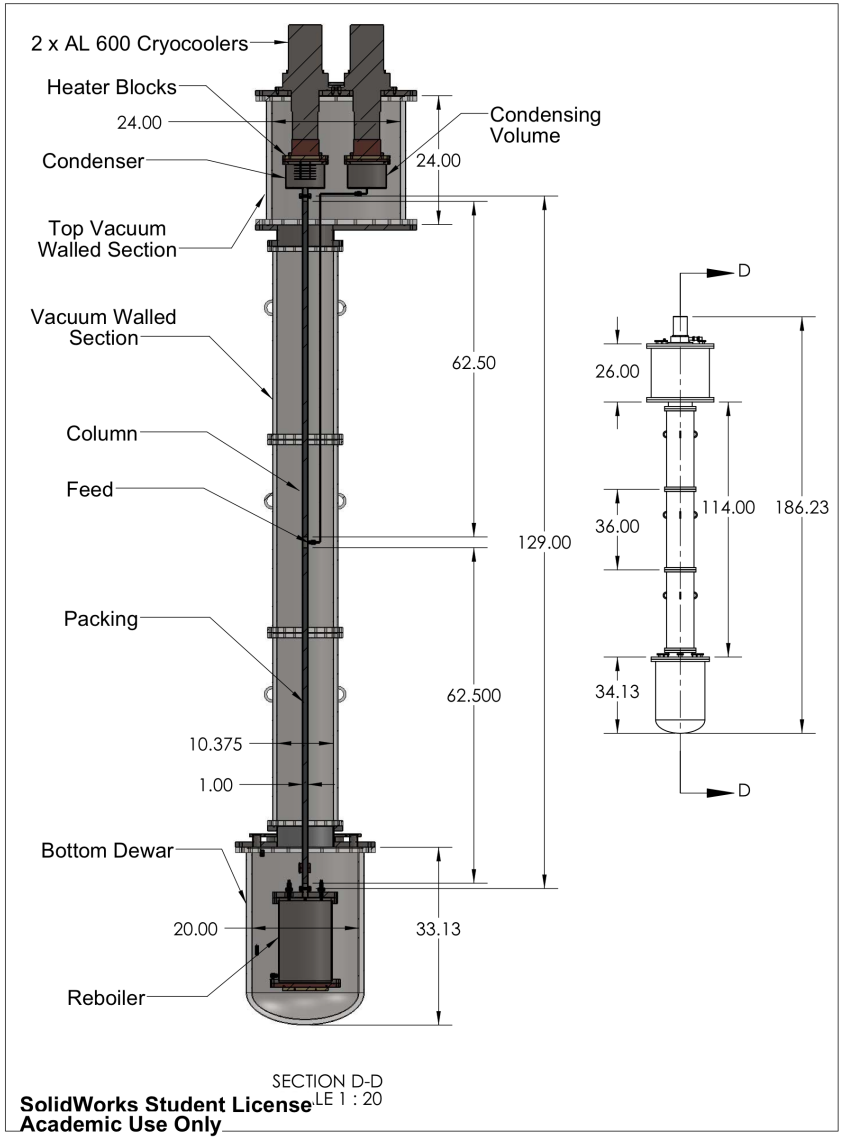


Figure 1 – Argon and Nitrogen vapor pressure curve



Princeton Distillation Column
to separate depleted Argon from accompanying Nitrogen (and Helium)

Design capacity ~ some kg/day

Design purity ~ 99.999% Ar

E-1000 (DarkSide) gets stage 1 approval at FNAL Nov 12 2009

Proposal from CG at end of November 20 2009 to build column at FNAL

Visit by Fermilab engineers to Princeton December 11 2009

Agreement by Fermilab management to accept column December 28 2009

Pieces of column arrive Jan 11 2010

Status as 6/4/2010

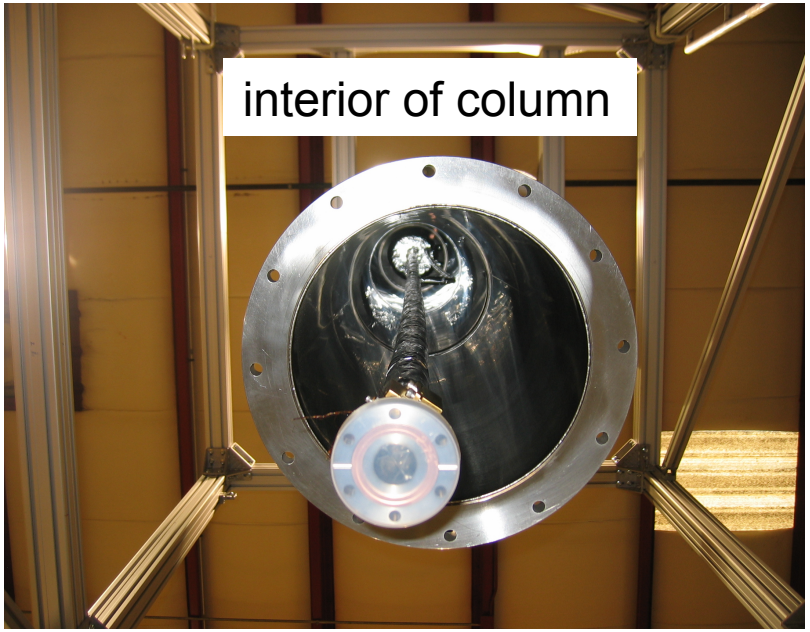
Column assembled and leak-tested.

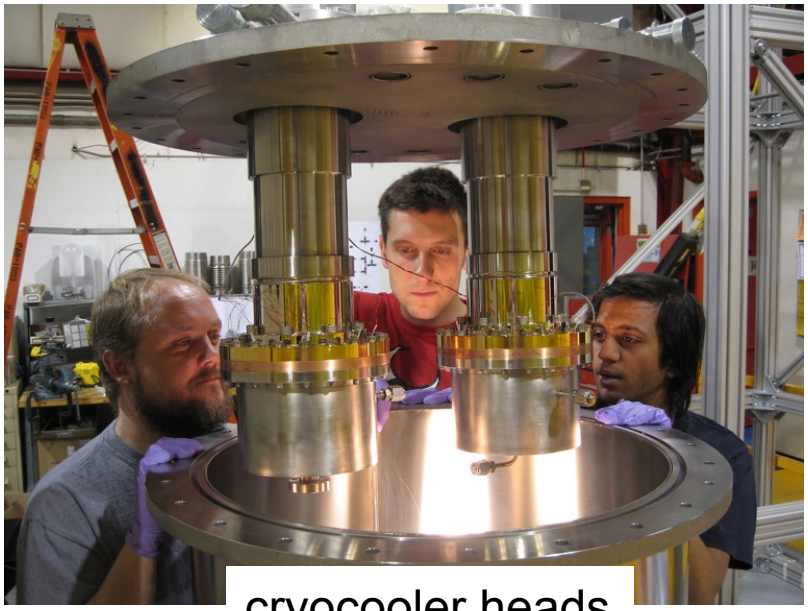
All wiring and basic instrumentation in place

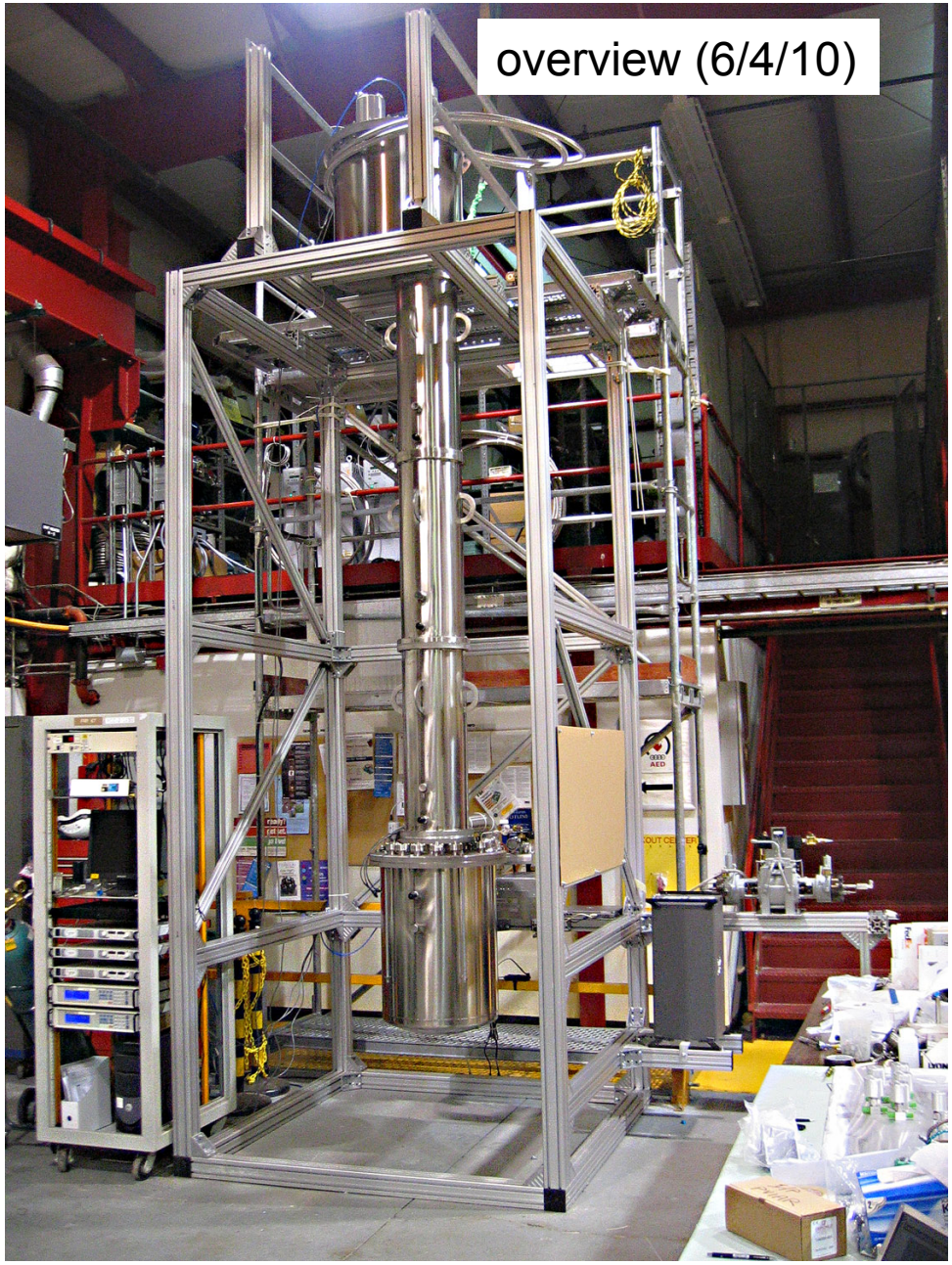
Gas system under assembly

Control software is being tested

Safety Review in preparation


interior of column


cryocooler heads


overview (6/4/10)

Active and exciting program in which DarkSide has a prominent place

FIN