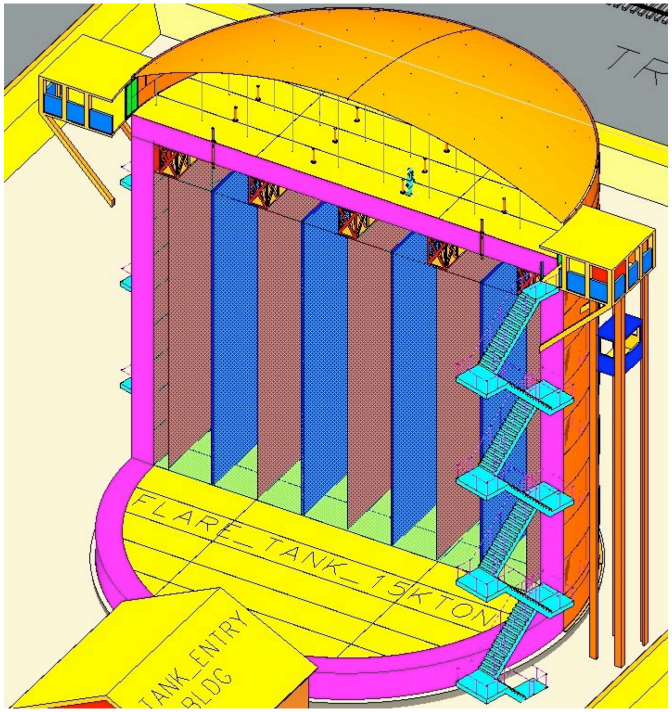
Fermilab Work for Liquid Argon TPC:

aimed at Large Detectors for Long Baseline Neutrino Physics

technical issues:



argon purity (without evacuation)

electronics (large capacitance detector)

TPC design (large area)

light collection

DAQ, reconstruction, analysis

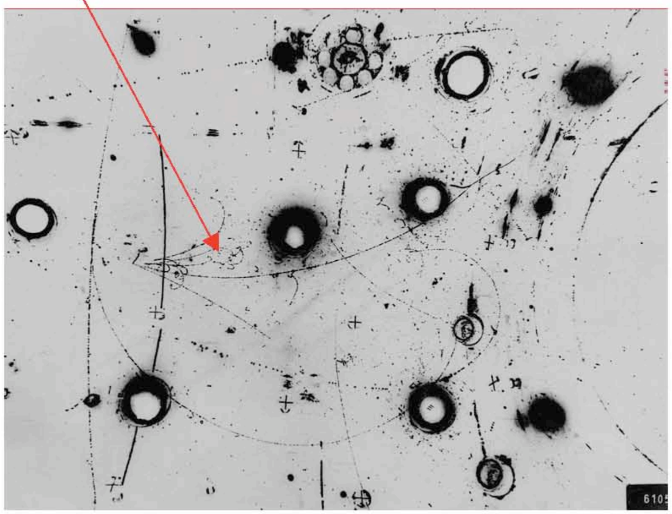
cosmic background (surface detector)

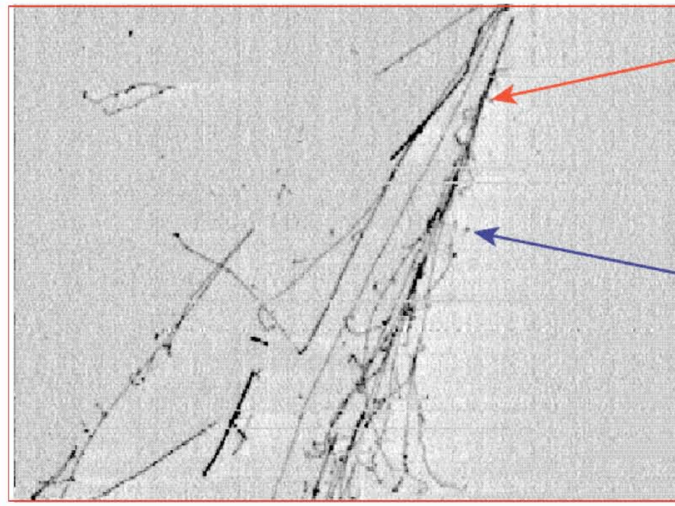
Thirty years of progress........

LAr is a cheap liquid (≈1CHF/litre), vastly produced by industry

Bubble diameter ≈ 3 mm (diffraction limited)

Gargamelle bubble chamber ICARUS electronic chamber





"Bubble" size ≈ 3 x 3 x 0.2 mm^3

Energy deposition measured for each point

40 cm

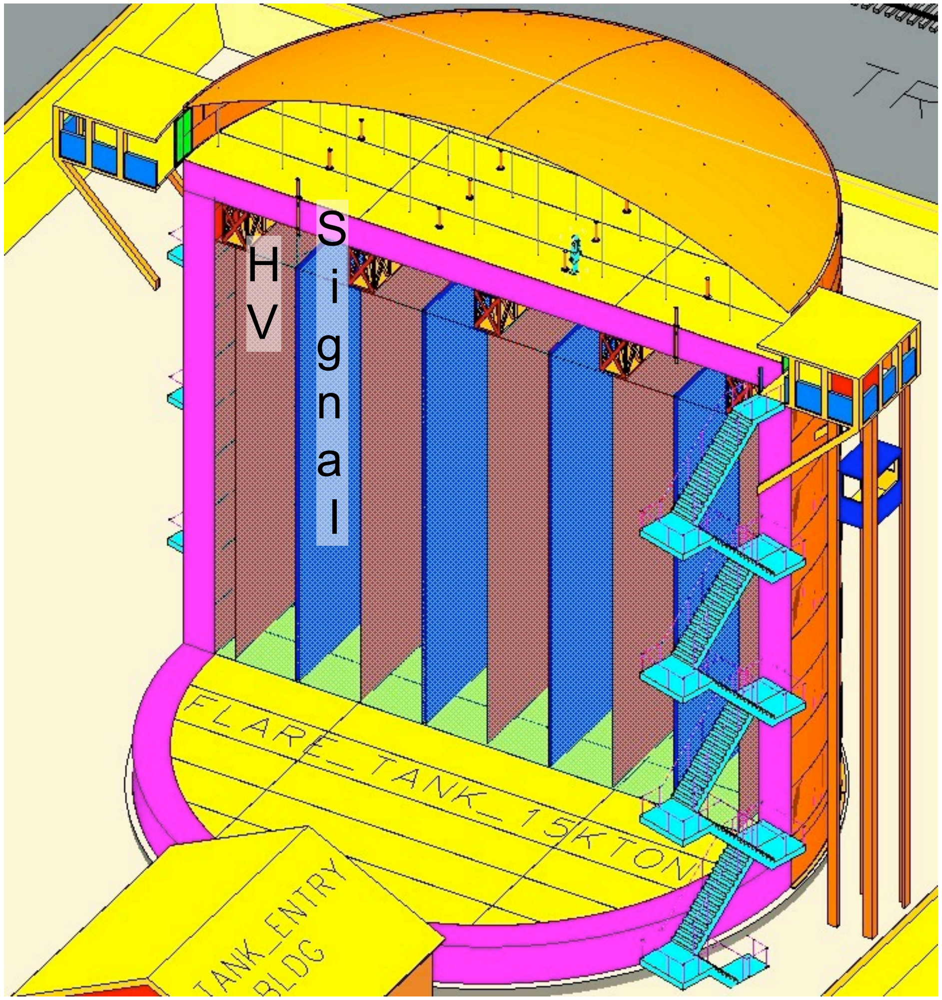
Drift

Medium	*Heavy freon*	
Sensitive mass	3.0	ton
Density	1.5	g/cm^3
Radiation length	11.0	cm
Collision length	49.5	cm
dE/dx	2.3	MeV/cm

Medium	*Liquid Argon*	
Sensitive mass	Many ktons	
Density	1.4	g/cm^3
Radiation length	14.0	cm
Collision length	54.8	cm
dE/dx	2.1	MeV/cm

FermilabOct. 2005 *Slide# : 13*

The Large Liquid Argon TPC: Sketch



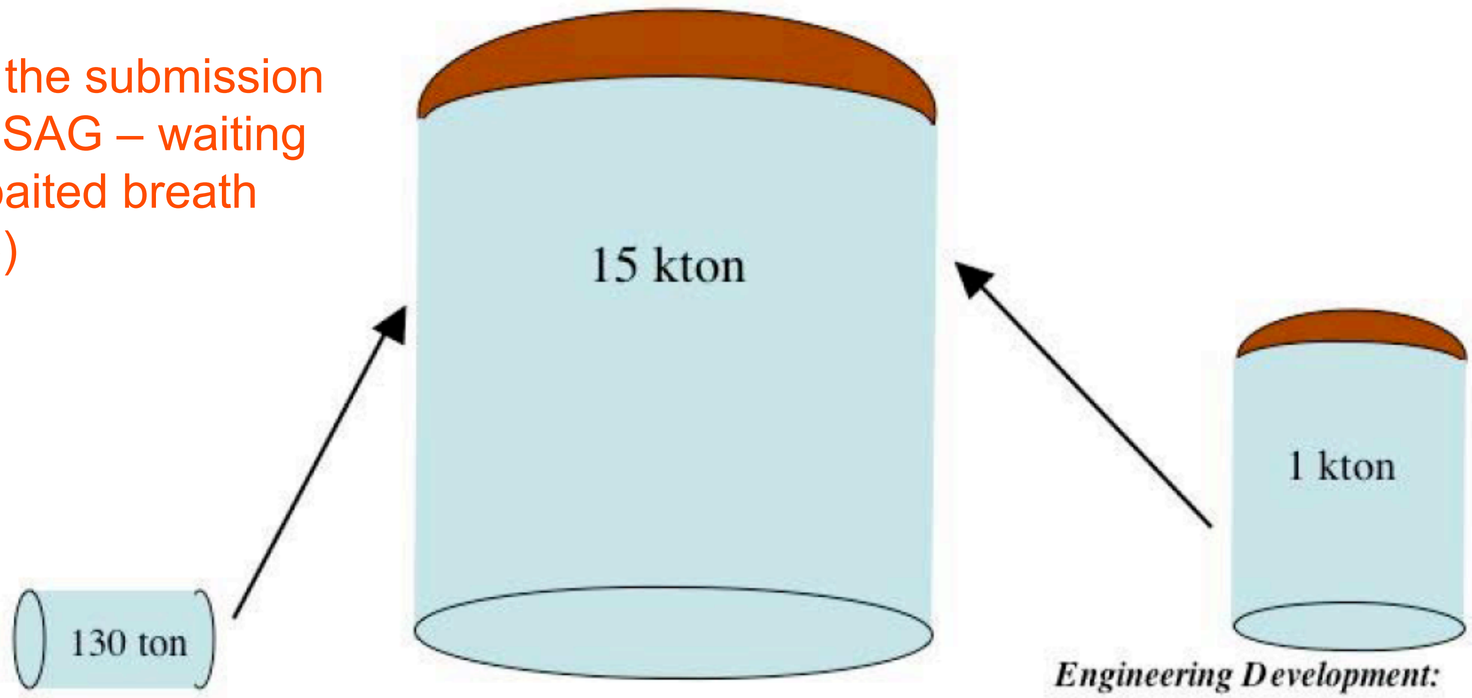
A large size, low rate, fully active, high efficiency, fine spatial resolution, imaging detector of relatively low cost. (5mm wire spacing, 3 meter drift)

Perfect for neutrino work (esp. off axis), but also for other uses (proton decay, super nova neutrino detection, and double beta decay)

But note that it is not a fully proven technology, if it is to be based on an LNG tank design.

NuMI Liquid Argon TPC Overview

From the submission to NUSAG – waiting with baited breath (2005)



Physics Development *using* ***existing*** *technology*
Record **complete neutrino interactions**: (ν_e & ν_μ)
Establish **Physics Collaboration**
Develop **Event Identification**,
Develop **Reconstruction**,
Develop **Analysis**,
Establish successful **Technology transfer**

Engineering Development:
Construction of Tank
Argon Purity
Mechanical Integrity of TPC
Readout S/N
Microphonics due to Argon Flow

Technical Setups

Purity Monitor Development | Materials Tests | 5 m Drift Demonstration | Long Wires Tests | Electronics Development

Immediate Synergies with Dark Matter Argon experiments:

argon purity (chemical)
(drift-lifetime (oxygen), light output (nitrogen))
cryogenics of argon handling

Argon Purity (chemical)

1) achieving purity (long electron drift times)

2) measuring purity (oxygen, nitrogen)

3) avoiding contamination by detector materials

Electron drift-velocity at 500V/cm is 1.5 m/ms. 1ppb Oxygen equivalent gives a drift-lifetime of 0.3 milliseconds.

For 3 m drift, want ~10 ms => 30 ppt

1) home-made, single-pass filtration system (buy supplies), copper on aluminum (oxygen),zeolite (water) - filters regenerated in place

2) Purity monitor (developed by ICARUS) for oxygen, photometric technique for Nitrogen based on Tevatron device.

3) Materials Test System for … testing materials without evacuation

Motivation for Materials Test System (MTS):

test all materials that will go into the cryostat to ensure they do not contaminate the argon long-term.

Challenge for MTS:

Insert materials into clean argon without first putting the materials under vacuum. (Kiloton TPCs will not be evacuable)

Features of MTS:

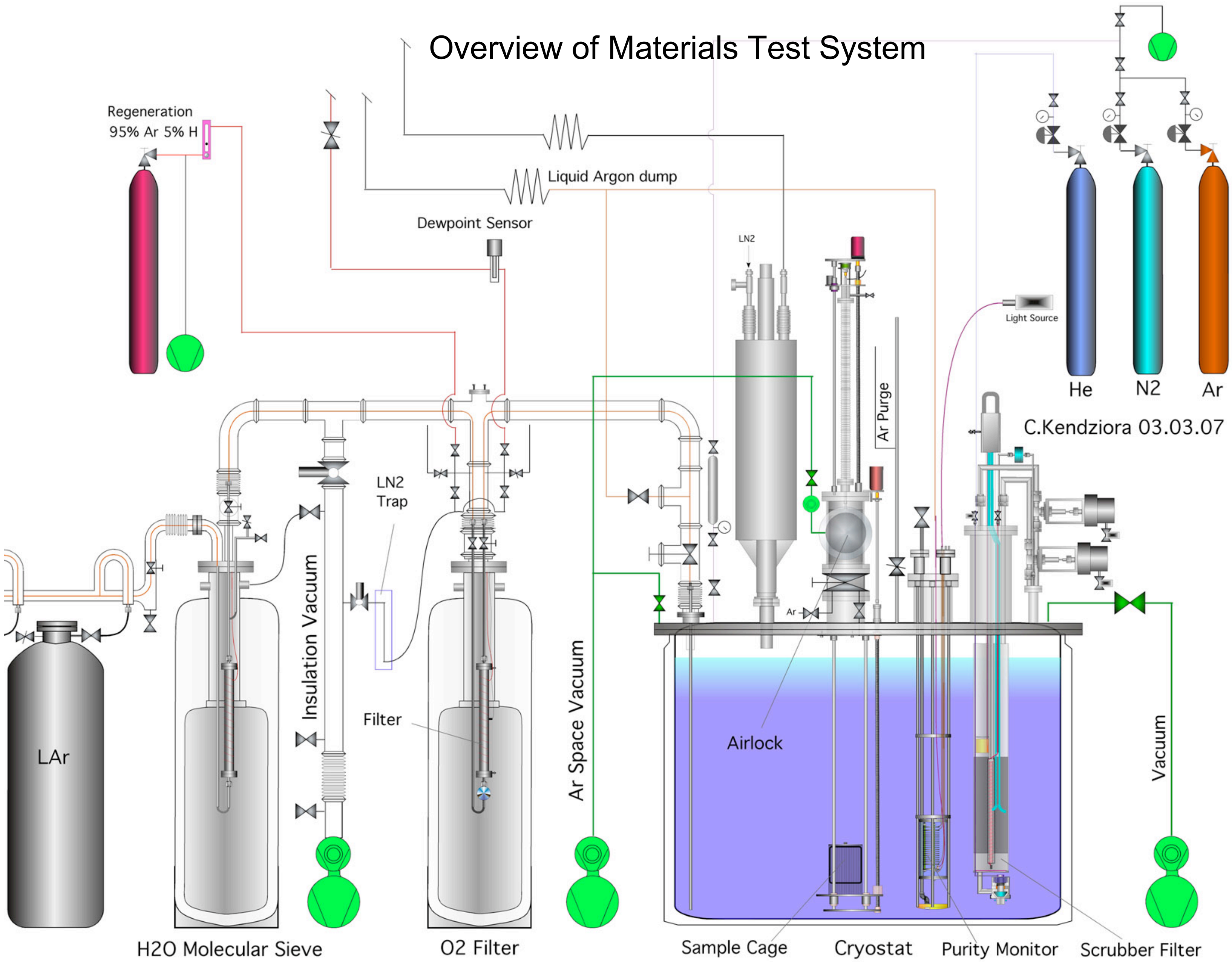
Single-pass fill system with oxygen (activated copper) and water (molecular sieve) regenerated in place.

Argon-lock plus drive and platform system to insert without evacuation;

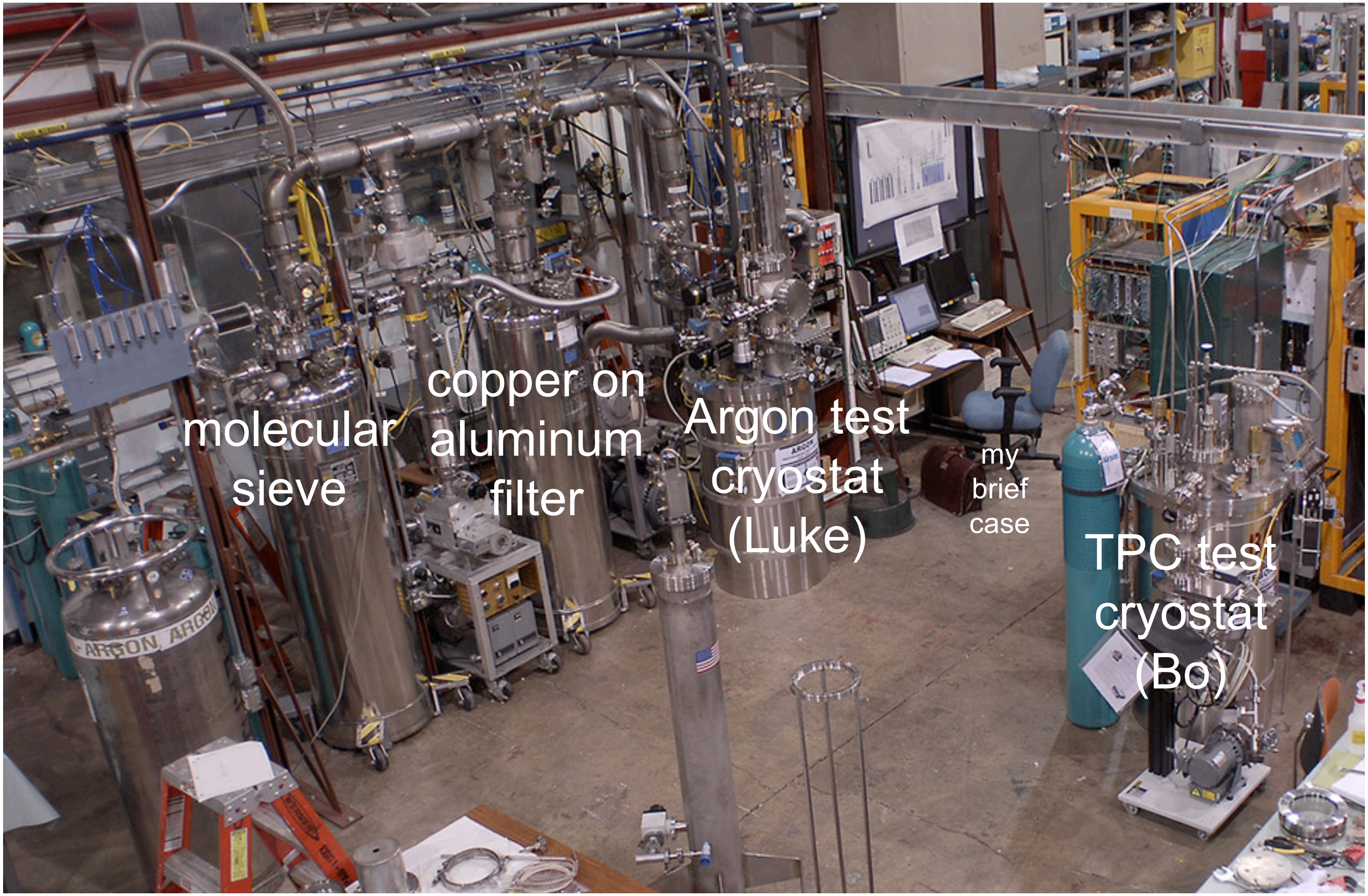
Internal filter-pump, gas-insertion line, gas-monitoring line,

Ability to put material in liquid, and in gas-phase at temperatures from 90K to 300K.

Overview of Materials Test System



Setup at the Proton Assembly Building (PAB)



The essentials of the MTS cryostat.

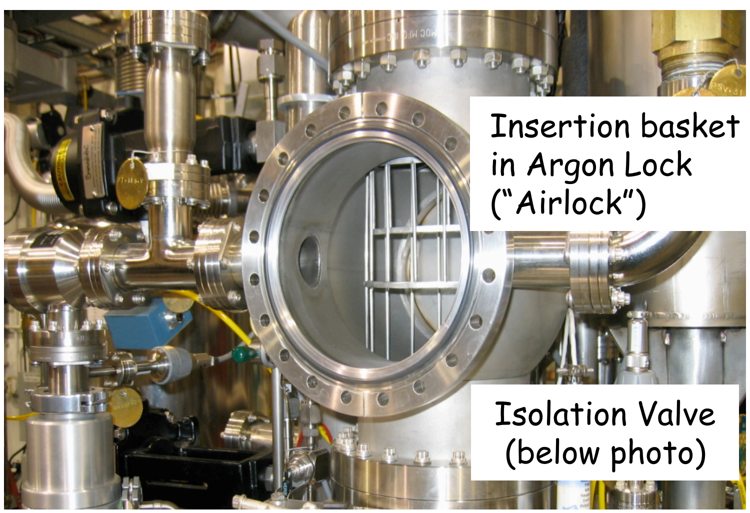
The main features are

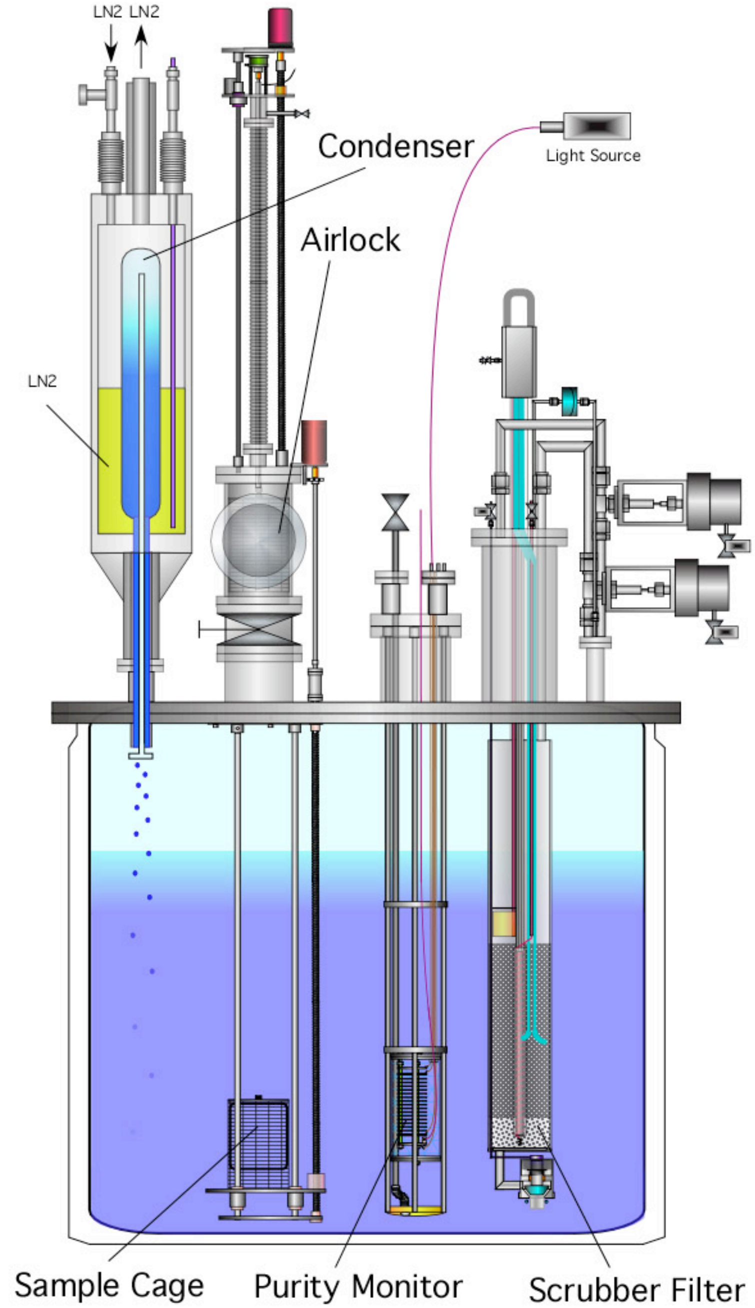
the condenser
(to maintain a closed system)

the sample insertion mechanism
(allows insertion of materials without evacuation)

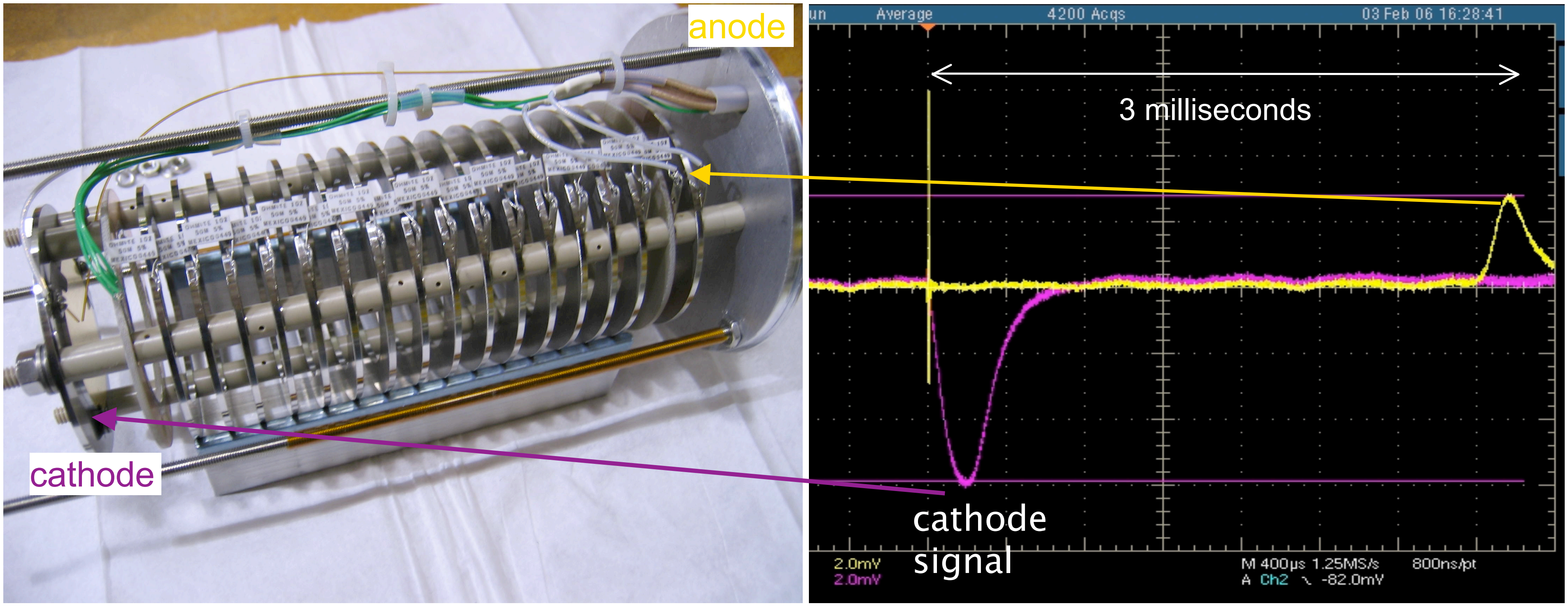
the lifetime monitor (PrM)
(to measure the electron drift-lifetime)

the filter pump (2 moving parts total)
(filled with zeolite and oxygen-filter material)





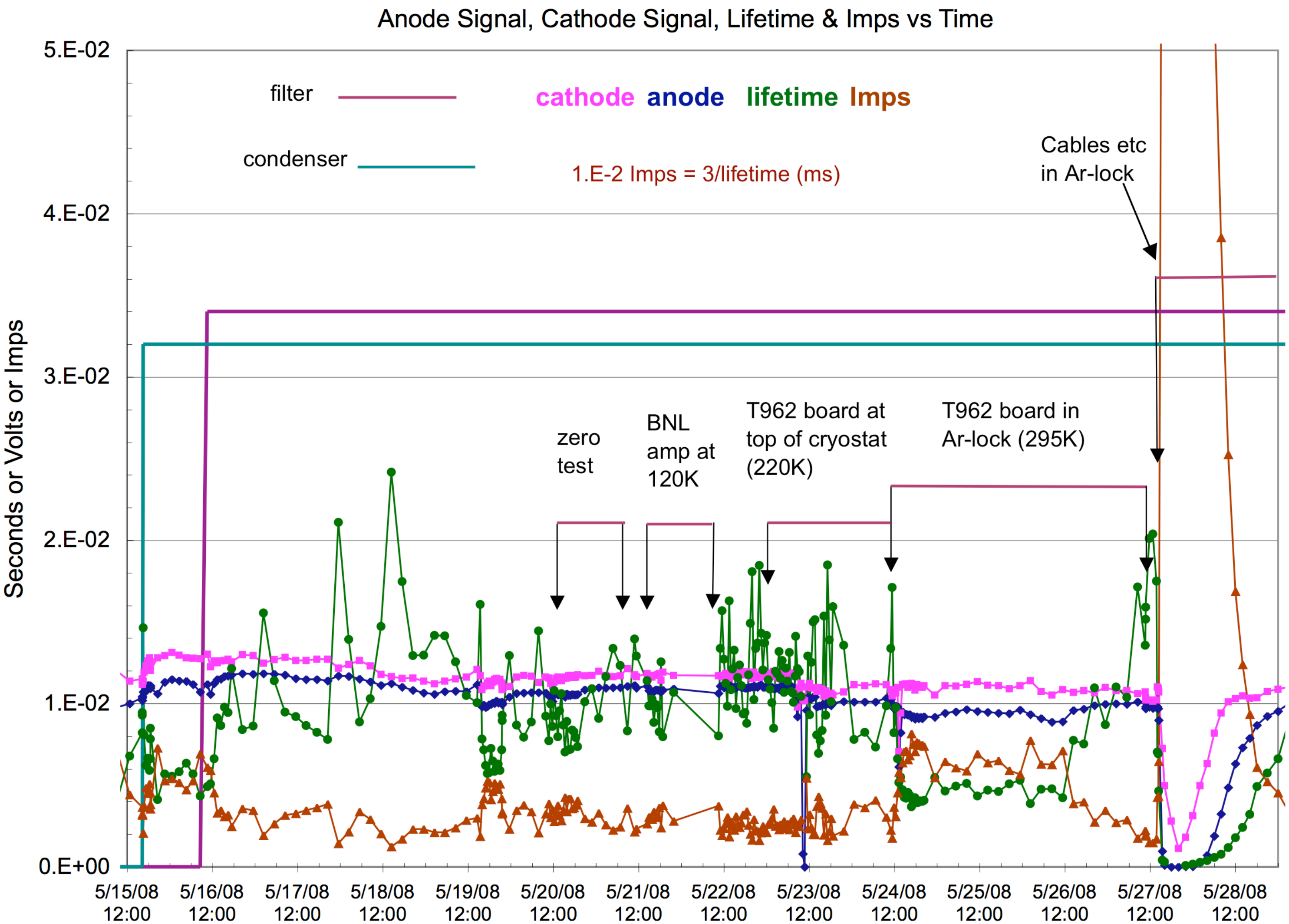
Drift lifetime Measurement (purity monitor)



(G. Carugno et al., NIM A292 (1990))

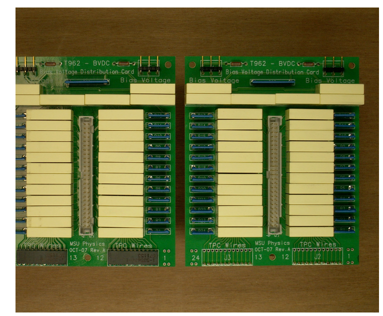
$Q_A/Q_C = e^{-t_{drift}/lifetime}$

Plot from on-going run where we have tested a BNL pre-amplifier, a T-962 blocking capacitor board and a mass of cable-ties and cable.

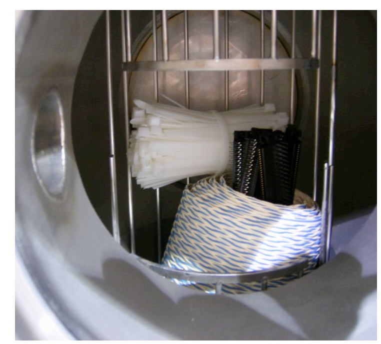


BNL pre-amp

T962 Capacitor Board



Cables & Cable-ties



Motivation for Bo:

Provide a system with signals from an actual TPC in LAr to test performance of front-end electronics (as developed at MSU and BNL).

Features of Bo:

Cylindrical TPC, 96 channels in 3 planes, with 50 cm drift and 24 cm diameter; separate purity monitor (PrM); there is space for electronics in the cryostat when we come to test `cold' electronics.

(TPC also has gold photocathode on cathode so it can act as its own PrM)

Present front-end electronics designed and built at Michigan State; MSU has provided DAQ, using DZero ADC and memory boards, and trigger.

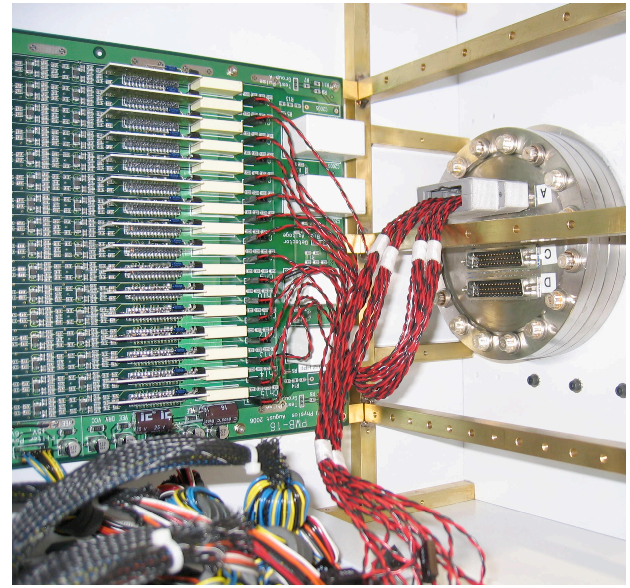
Present Challenge for Bo:

Resources to complete the cryogenics system while developing Luke. (Electronics from MSU have been ready for > 1 year).

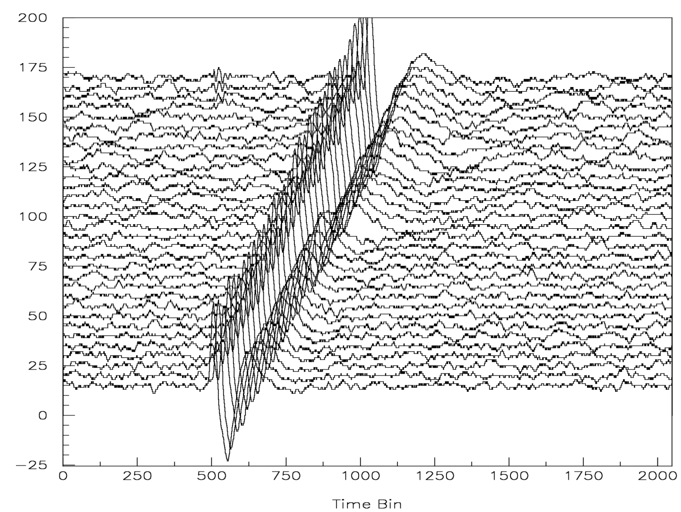
Development of local reconstruction and display software (may hear relevant stuff in ArgoNeut talk)

TPC being inserted into Bo:

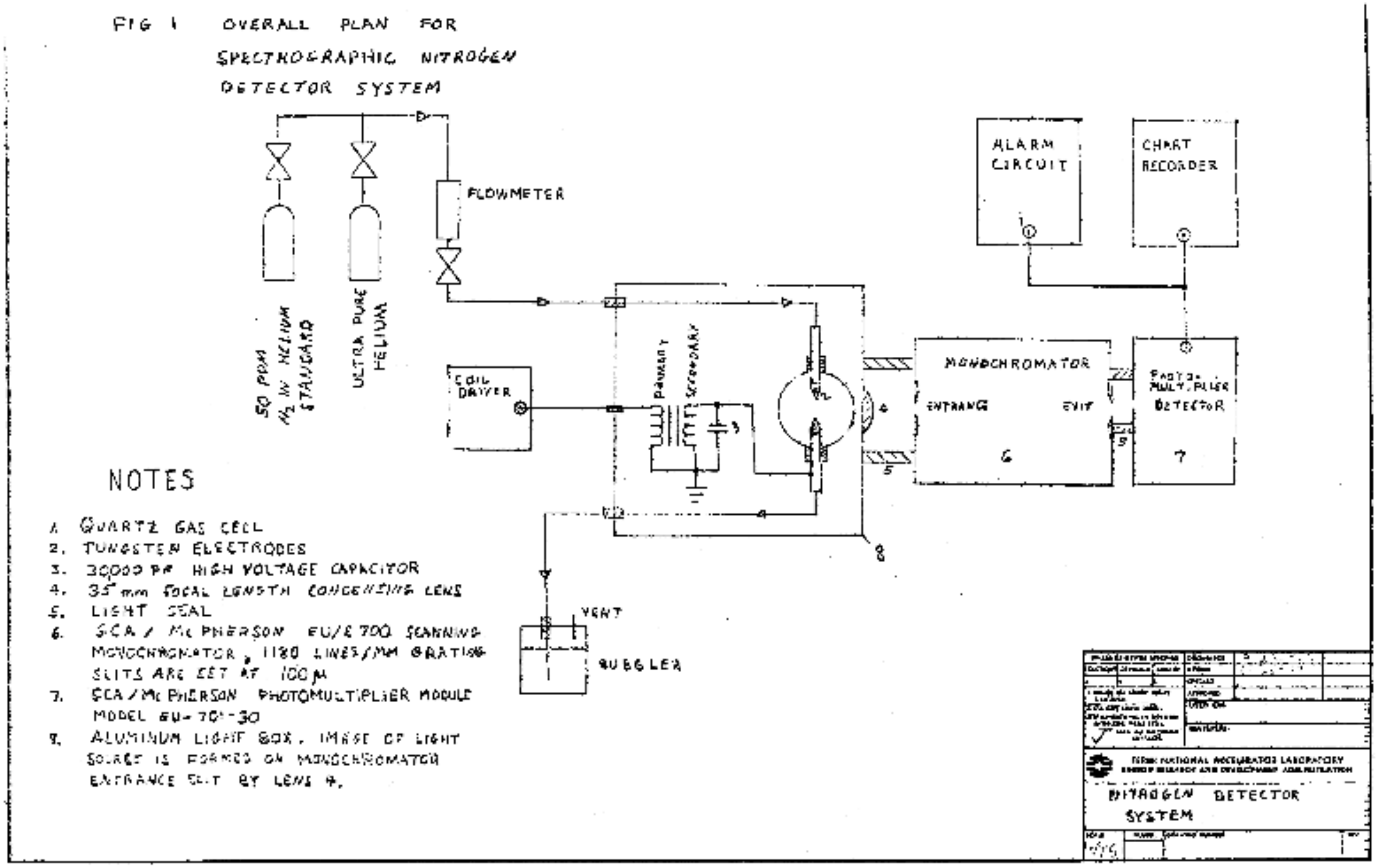
Electronics Installation (Michigan State)



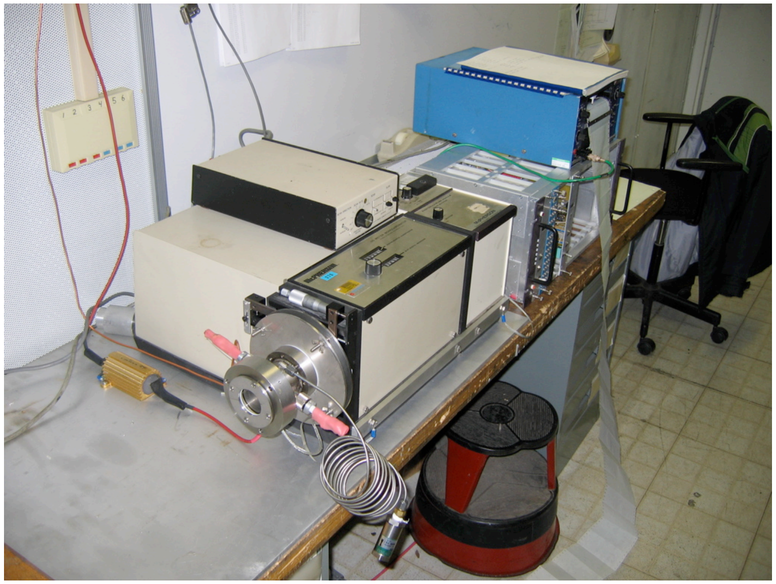
Response to Test Inputs and Noise Check



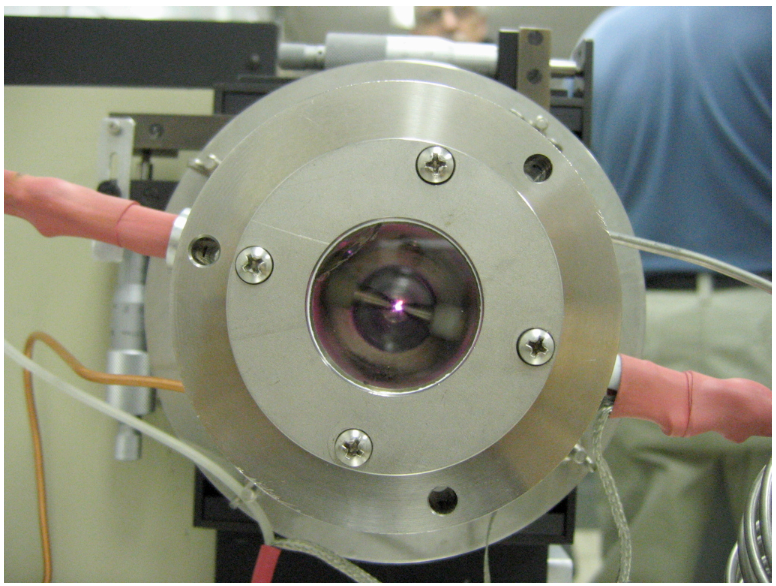
Nitrogen in Helium Measurement - R. Walker (1977)



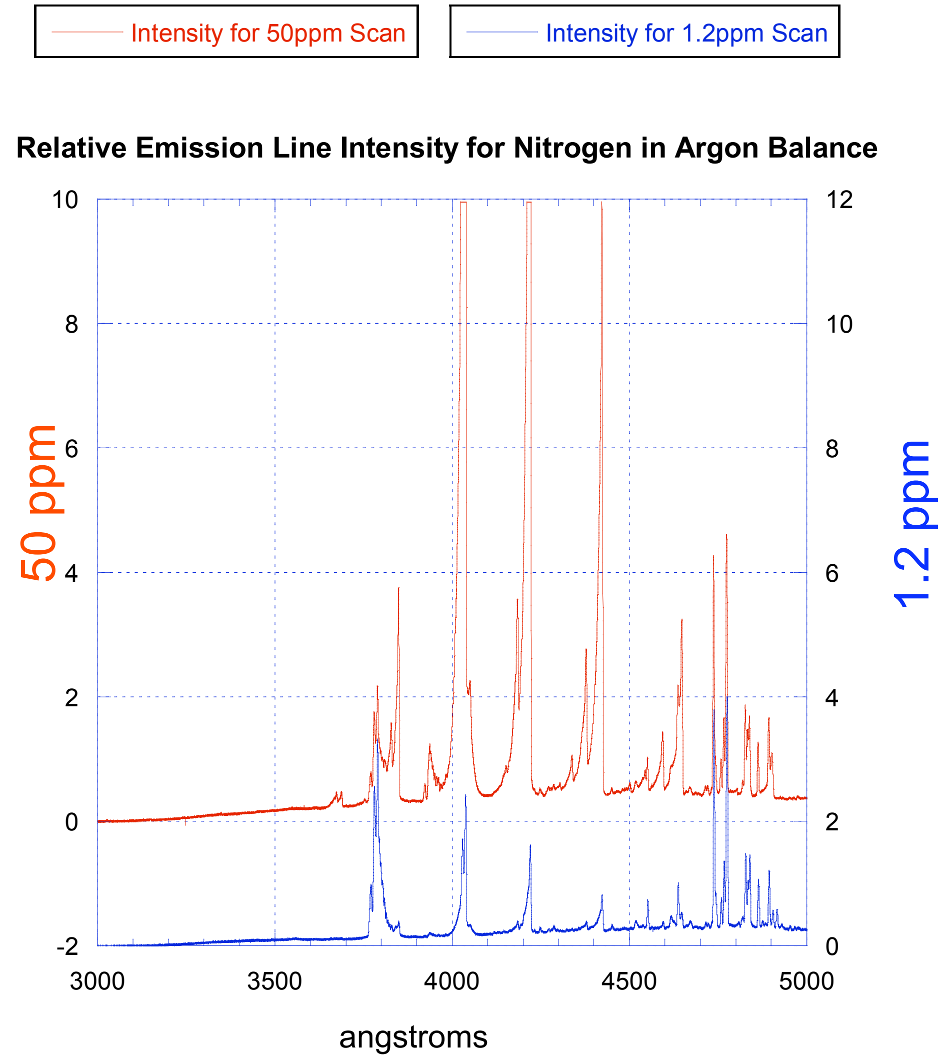
Nitrogen in Argon Measurement
(*based on Nitrogen in Helium for Tevatron)*



arc-cell, monochromator, PMT



the arc



Sensitive to ~ 0.2 ppm Nitrogen

Liquid Argon Purity Demonstration - LAPD
(D. Finley & R. Schmitt)

Industrial vessel, trucked in to site, foam insulation, TPC materials (no assembly), 20 tons Lar, lifetime monitors, flow meters, RTDs

M & S (only) cost $300,000 - requested funding from DOE R&D funds.

Designed to test/demonstrate ability to achieve good lifetime within a year of receipt of go-ahead. Can also check flow and temperature distributions

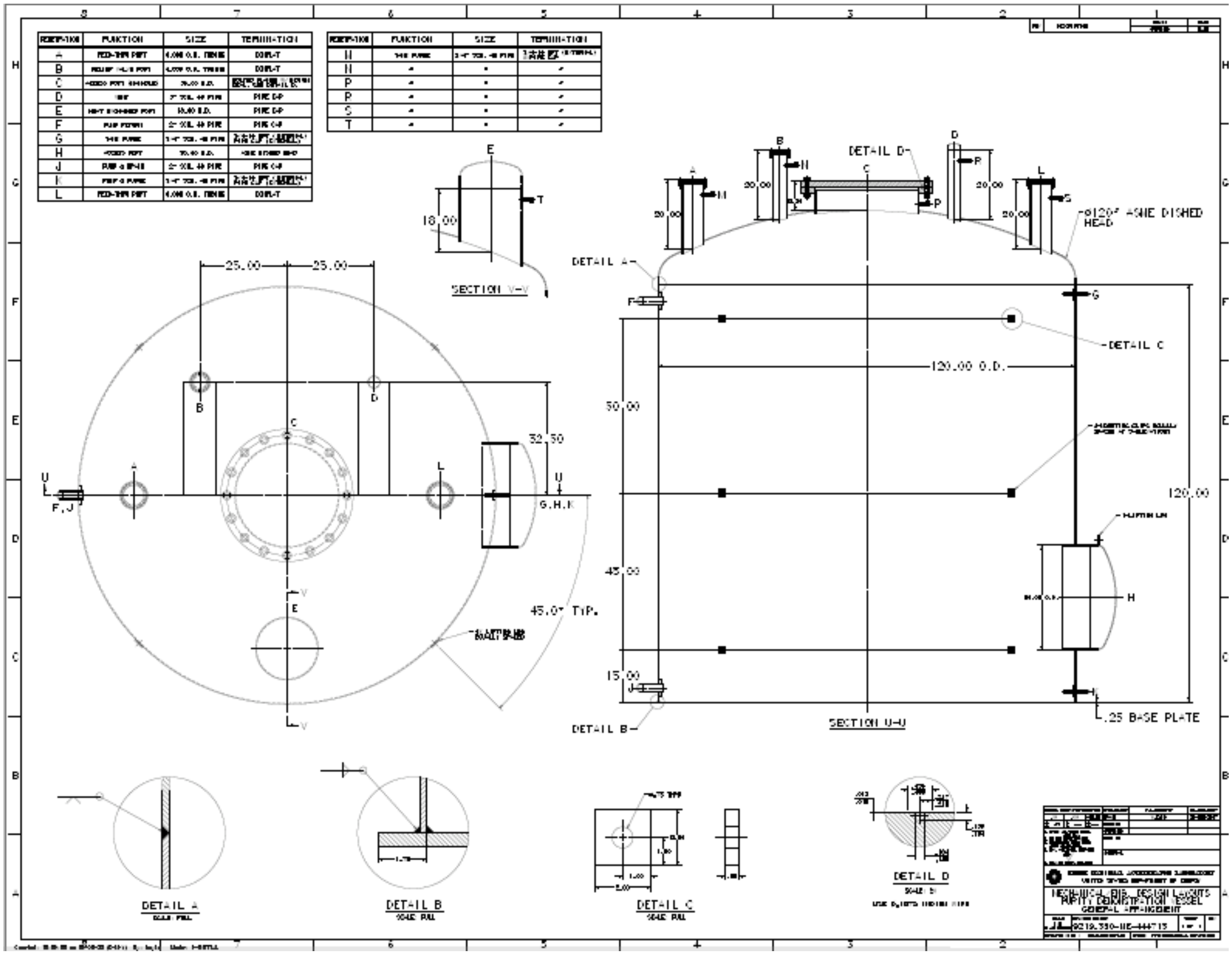
Speed is of the essence:

- if successful, provides encouragement for MicroBooNE test (with real detector and real events) and larger devices;
- if initial failure, provides some time to investigate and implement changes for MicroBooNE

DUSEL R&D Proposal, Liquid Argon Purity Demonstration

Program announcement title : **DUSEL R&D Proposals in FY2008**
http://www.science.doe.gov/hep/DUSELR&D.shtm
Name of laboratory : **Fermi National Accelerator Laboratory**
Name of principal investigator (PI) : **David Finley**
Position title of PI : **Scientist II, Fermilab**
Mailing address of PI : **M.S. 122, PO Box 500, Fermilab, Batavia, IL 60510**
Telephone of PI : **630-840-4620**
Fax number of PI : **630-840-3614**
Electronic mail address of PI : **finley@fnal.gov**
Name of official signing for laboratory* : **Pier Oddone**
Title of official : **Director of Fermilab**
Fax number of official : **630-840-2900**
Telephone of official : **630-840-3211**
Electronic mail address of official : **pjoddone@fnal.gov**
Requested funding : **One year of funds are requested totaling $334,950**
Use of human subjects in proposed project : **No**
Use of vertebrate animals in proposed project : **No**

Tank Design for Liquid Argon Purity Demonstration



Some context:

FNAL and Yale people are in contact with people in Europe (in and out of ICARUS) on purity and other issues.

Yale, MSU, FNAL and people from Italy are working on the 250 liter test TPC (ArgoNeut) to be placed in the NuMI beam at FNAL

A proposal (MicroBooNE) for a 200 ton TPC to go into the Booster Neutrino beam has been submitted by BNL, FNAL, MSU, UTA &Yale.

A LOI for a 5 kiloton detector LAr5 has been submitted. LAr5 is comparable in physics reach to NOvA and could complement it at Ash River or at Soudan, or go to DUSEL.