Outline re: Fermilab Involvement in DarkSide

Background of Fermilab Involvement in non-accelerator Particle Physics (1 slide)

History of liquid argon work at Fermilab and synergies between Dark Matter and Neutrino liquid argon (3 slides)

Existing Facilities for liquid argon work. (3 slides)

DarkSide-50 approval as E-1000 (1 slide)

Organization and general expertise at Fermilab relevant to DarkSide (Mechanical, Electrical/Electronics, DAQ) (2 slides)

DarkSide Status per Fermilab Center for Particle Astrophysics (1 slide)

Request for support for Fermilab participation in DarkSide-50 (2 slides)

From Fermilab PAC re DarkSide 50– 12/2009

The Committee reviewed the DarkSide proposal to develop a 50-kg 2-phase liquid-argon WIMP detector which measures both the far UV scintillation light and the ionization produced by particle interactions. This approach promises to achieve very high background rejection with the combined use of scintillation pulse shape information and the ratio of scintillation light to ionization. The program is based on two promising developments: the possibility of obtaining underground argon depleted in ^{39}Ar, and the use of QUartz Photon Intensifying Detectors (QUPIDs), an innovative hybrid phototube with extremely low radioactive background. The proponents also propose a borated liquid scintillator shield inside a water gamma shield, to efficiently detect neutrons from fission, or alpha-n from the remaining U/Th contamination of internal components and the surrounding rock, and from muon interactions. These innovative approaches may enable sensitivity gains beyond WARP and ArDM, reaching 10^{-45} cm^2 per nucleon in a three-year exposure. This will be competitive and complementary to CDMS, EDELWEISS, and the liquid xenon detectors (Xenon 100, LUX, and XMASS)

The Committee enthusiastically recommends Stage I approval for this interesting experiment. The Committee recommends that the team address two questions: Is 50 kg the optimal size for such a detector at this stage, and what are the advantages and drawbacks of each of the SNOLAB and Gran Sasso sites?

From Fermilab Director – 12/2009

Dear Cristiano,

Thank you for the proposals on the search for dark matter using depleted-argon detectors, first using a 50 kg detector (DarkSide, which we have designated P-1000) and, secondly, in preparation for a larger detector at DUSEL (MAX, the R&D for which we have designated P-1001). I also thank you for your presentation at the recent Physics Advisory Committee (PAC) meeting, and the responses to the PAC's questions. In response to my charge, the PAC wrote the attached comments.

I share the PAC's enthusiasm for the depleted argon approach to search for dark matter, and accept the recommendation that P-1000 receive Stage I approval. I hereby grant that approval, and wish you the best of luck in your search for dark matter. In taking the next steps toward Stage II approval, including the preparation of a Memorandum of Understanding between the Laboratory and the DarkSide experiment (E-1000), it will be important to answer the questions posed by the PAC.

It would be great to detect dark matter in a DarkSide detector! Failing that, dark matter might appear in a larger depleted-argon detector at DUSEL, and we will attempt to provide some Laboratory resources to make progress on the design of MAX. We have designated this effort separately as P-1001. You should discuss the most important needs for the preliminary engineering of MAX with appropriate Division Heads and the Fermilab Center for Particle Astrophysics. Formal approval will depend on arriving at a plan in which Fermilab can provide the requested resources.

Good luck!

Sincerely,

Piermaria Oddone

Dan Bauer (deputy head Fermilab Center for Particle Astrophysics) report to the Fermilab PAC 12/2010

We believe that we articulated a coherent FCPA strategy at the non-accelerator review, with participation in three technologies that have the best intrinsic background discrimination. The review panel also recommended that we take a larger role in coordinating the dark matter community, and we are exploring ways to do that.

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three = solid-state (CDMS), bubble-chamber (COUPP), noble liquid (DarkSide)

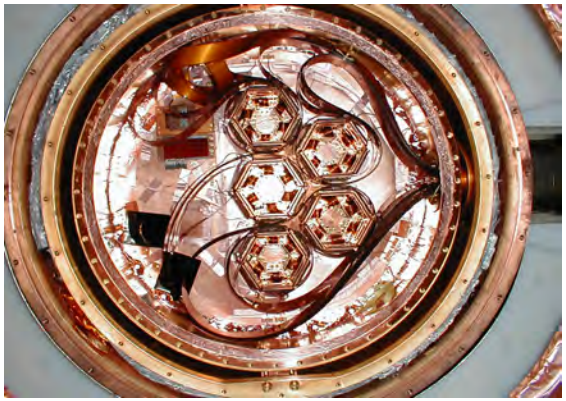
The Dark Matter Program at Fermilab

Dan Bauer, Fermilab

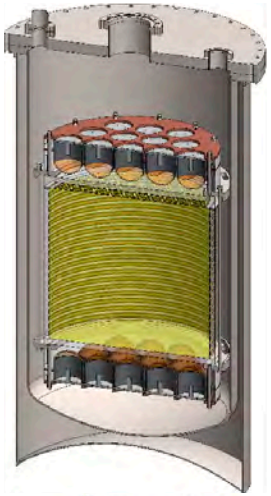
DOE Non-Accelerator Review, September 29, 2010

COUPP

CDMS



DarkSide



Fermilab

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Dan Bauer, Fermilab, DOE KA13 Review

Work on Liquid Argon originally for massive detectors for high energy (GeV) Neutrino physics.

Funded as Generic R & D

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

now encompasses

Lab studies:

Material tests, purging of large volume cryostat, filtration, and contaminant studies,

TPC readout electronics development with small (50 liter, 50 cm drift TPC)

Beam studies:

ArgoNeut Expt– 0.25 ton in NuMI (few GeV) Neutrino Beam (taken data)

ν – experiments:

MicroBooNE Expt -200 ton (75 fiducial) (E-974) to take data in 2013

Long Baseline Neutrino Experiment (LBNE) aimed at DUSEL

Dark Matter:

DarkSide - 50 (E-1000)

Depleted Argon Distillation Column

Acknowledge fundamental contribution of ICARUS and other European programs

Technical Issues for Multi-ton Argon Dark Matter detector:

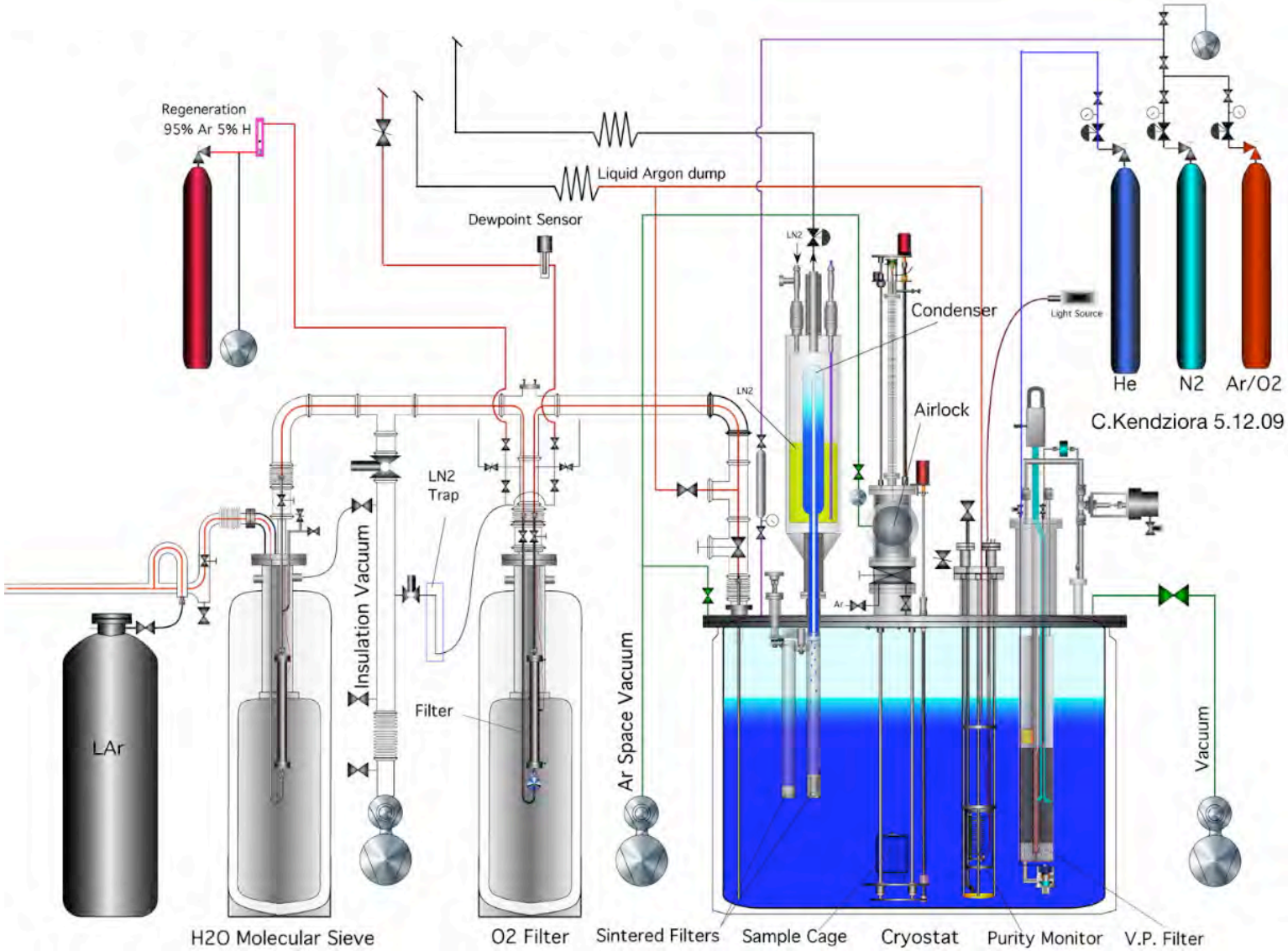
- Chemical purity to allow electron drift (10's ppt O2 equivalent),
- Chemical purity to allow light propagation
- Radio purity of Argon
- HV feedthroughs (>100 kV) in Argon gas
- TPC design
- Light Detection
- Data Acquisition
- Cryogenics (and associated safety issues)
- Detector Materials Qualification
- Shielding from environment radiation
- Radio-purity of detector materials

Technical Issues for Multi-ton Argon Dark Matter detector:

- Chemical purity to allow electron drift (10's ppt O2 equivalent), ***(ν and DM)***
- Chemical purity to allow light propagation ***(ν and DM)***
- Radio purity of Argon (*DM)*
- HV feedthroughs (>100 kV) in Argon gas ***(ν and DM)***
- TPC design ***(ν and DM)***
- Light Detection ***(ν and DM)***
- Data Acquisition ***(ν and DM)***
- Cryogenics (and associated safety issues) ***(ν and DM)***
- Detector Materials Qualification ***(ν and DM)***
- Shielding from environment radiation (*DM)*
- Radio-purity of detector materials (*DM)*

Liquid Argon Development Area in Proton Assembly Building
Argon
Argon
Cu Filter (O2)
Materials
Test System
Zeolite Filter (H2O)
TPC & Electronics
Test System
Argon Supply
ARGON

Schematic of Materials Test Stand



Features of Materials Test Stand

One-pass source of clean (< 50 ppt O2 equivalent)

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

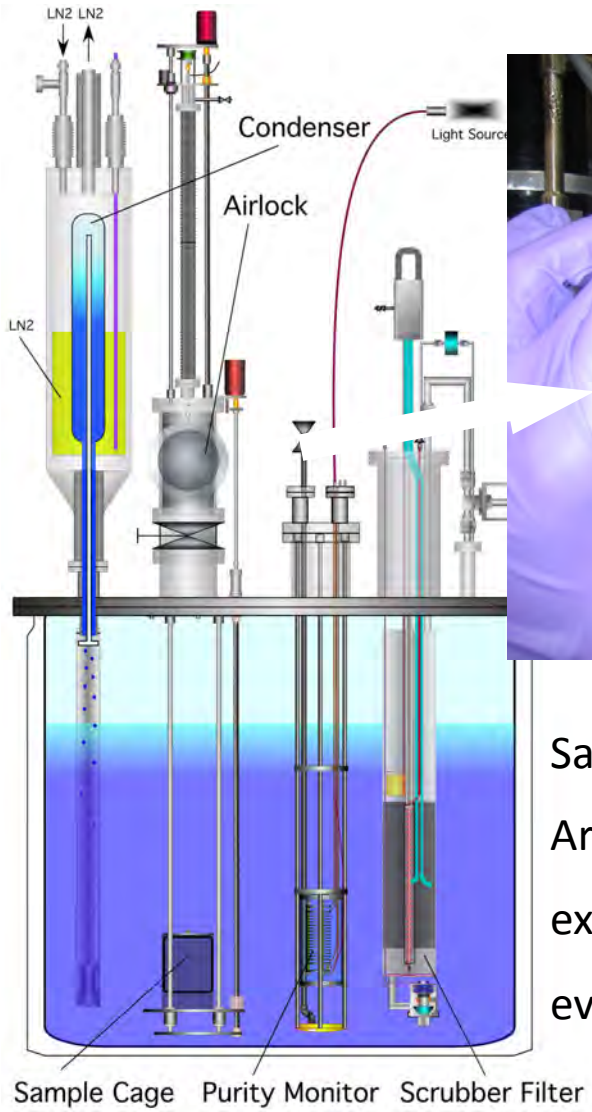
Measure electron drift lifetime with ICARUS style purity monitor

Measure Oxygen (~1 ppb sensitivity) with oxygen meters (Delta-F & Tiger Optics)

Measure H20 in gas (~1 ppb sensitivity) with water meter (Tiger Optics)

Cryogenic data, Lifetime Data, analytic instrumentation data in single data-base.

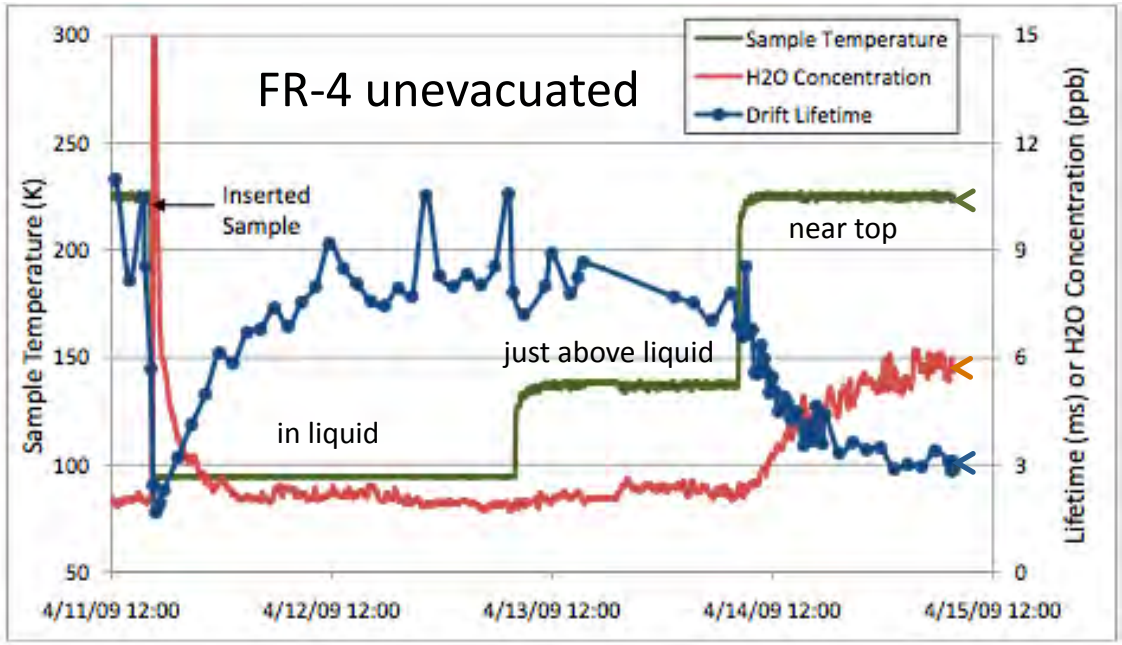
Insertion of a material sample into the airlock (argonlock) basket



Sample volume 10 cm x 10 cm x 10 cm

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

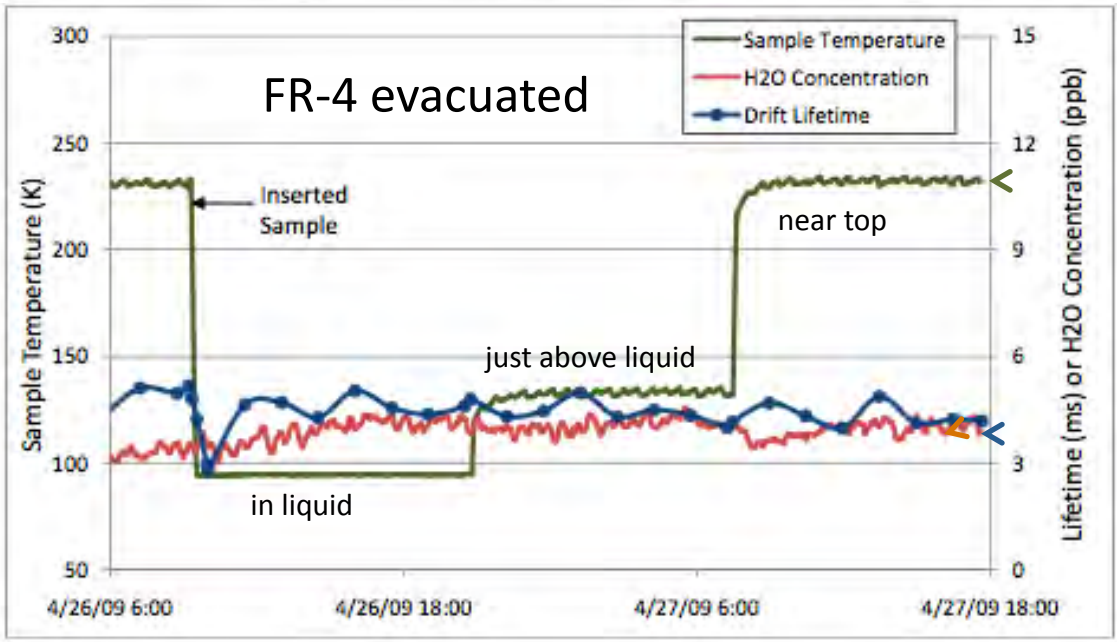
Data from Materials Test System



Sample Temperature

H20 concentration in vapor

Drift Lifetime



Sample Temperature

H20 concentration in vapor

Drift Lifetime

Primary Publications from Materials Test Stand ..

A Regenerable Filter for Liquid Argon Purification.

A. Curioni[1], B. T. Fleming[1], W. Jaskierny [2], C. Kendziora[2], J. Krider[2], S. Pordes[2], M. Soderberg[1], J. Spitz[1], T. Tope[2], T. Wongjirad[1] ([1] Yale University, [2] Fermilab) Nucl.Instrum.Meth.A605:306-311,2009

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

R. Andrews, W. Jaskierny, H. Jostlein, C. Kendziora, S. Pordes, T. Tope, (Fermilab)

Nucl.Instrum.Meth.A608:251-258, 2009.

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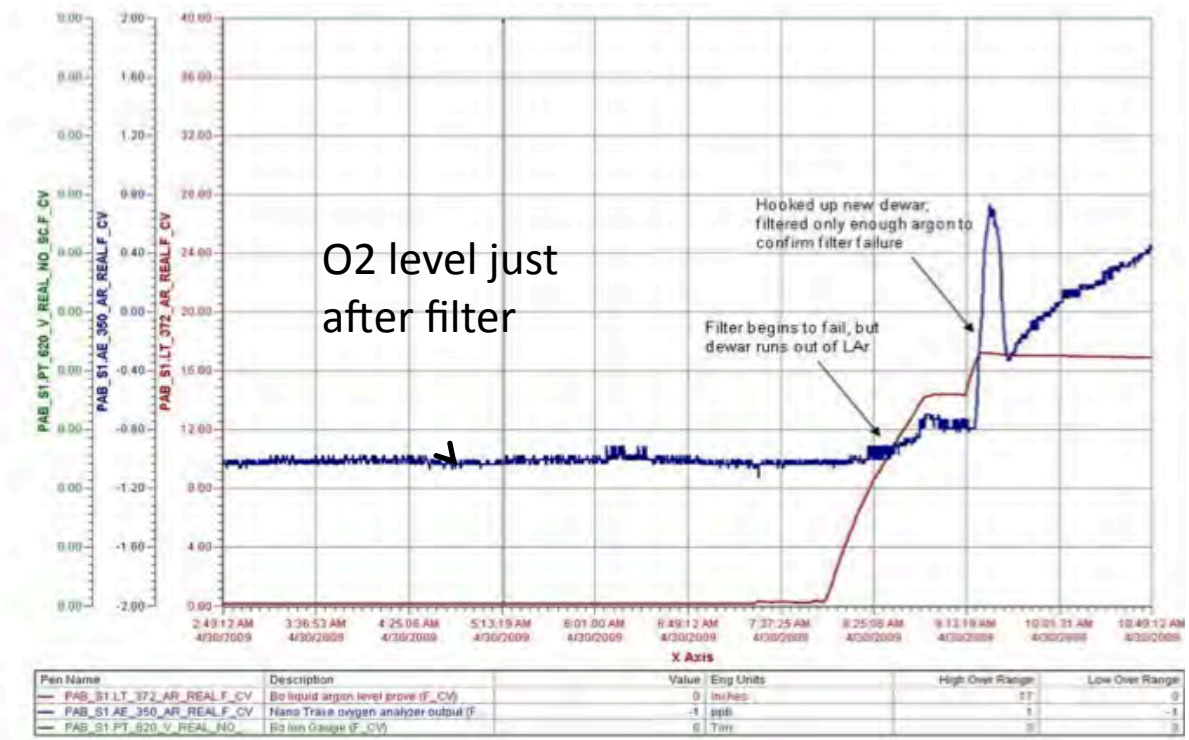
Filter Materials

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

We are interested in the capacity of filter materials before `breakthrough' at liquid argon temperature.

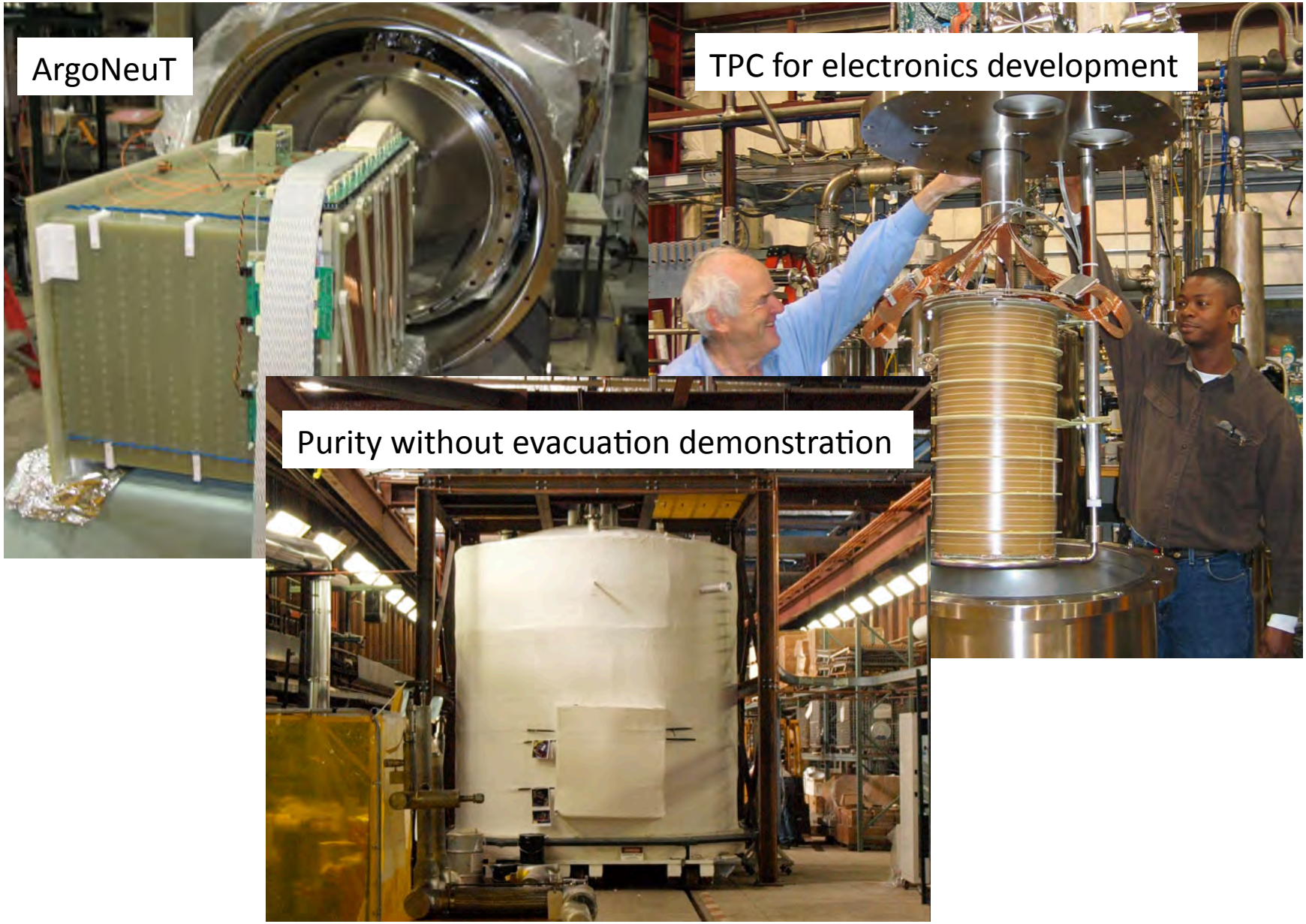
Other potential filter materials are on the market and will be evaluated.



Plot of O2 level after ~ 0.5 g O2 through filter.

~ 0.5 gm of O2 passed through the ~1 kg of filter before the `breakthrough'

Some Liquid Argon Activities



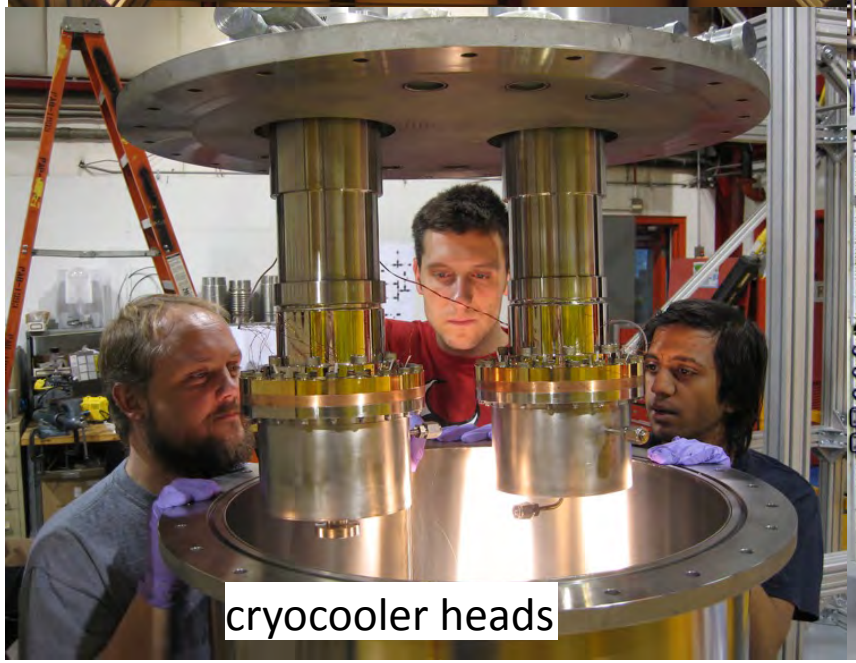
Princeton Distillation Column to separate depleted Argon from accompanying Nitrogen (and Helium)
Design capacity ~ 10 kg/day; Design purity ~ 99.999% Ar

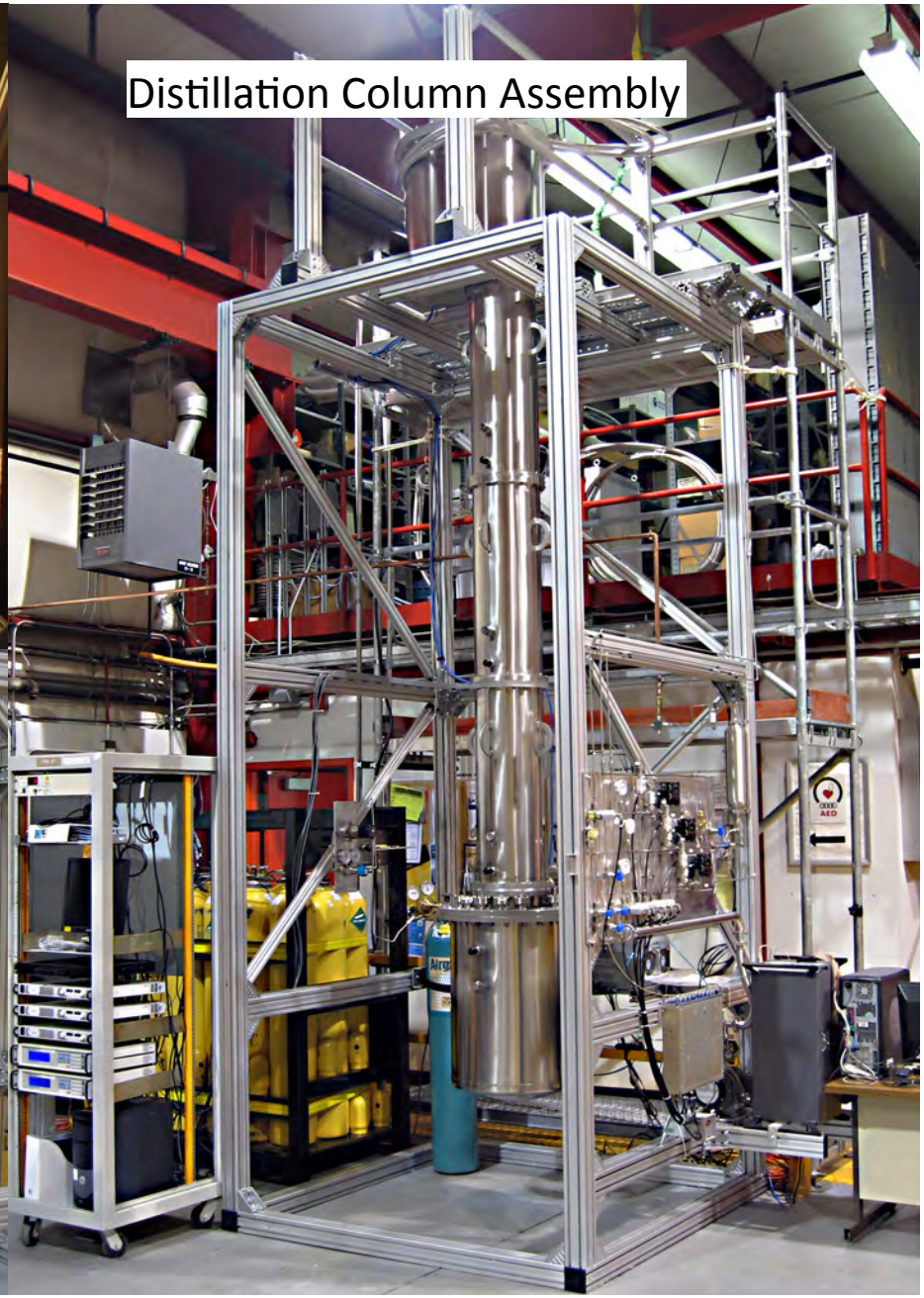
E-1000 (DarkSide) gets stage 1 approval at FNAL Nov 12 2009
Proposal from CG at end of November 20 2009 to build column at FNAL

Visit by Fermilab engineers to Princeton December 11 2009
Agreement by Fermilab to accept column December 28 2009
Pieces of column arrive Jan 11 2010

Column ready for final safety sign-off and commissioning in early 2011

interior of column


cryocooler heads


Distillation Column Assembly

Areas of Fermilab Technical Competence relevant to DarkSide

Mechanical Engineering

Cryogenic Engineering and controls

Project Engineering

Front-end electronics

HV feed-throughs

Data-acquisition

exploit and leverage synergies with high energy program

and also with Dark Matter Program

COUPP – *synthetic silica vessel*

CDMS - *low background materials, neutron veto*

Specific Fermilab Areas of Contribution to DarkSide-50

Project Engineering and Integration (appropriate personnel)

Veto systems PMTs (local interest and resources available)

Data Acquisition (modern `trigger-less' DAQ well-matched to physics of signal and background detection)

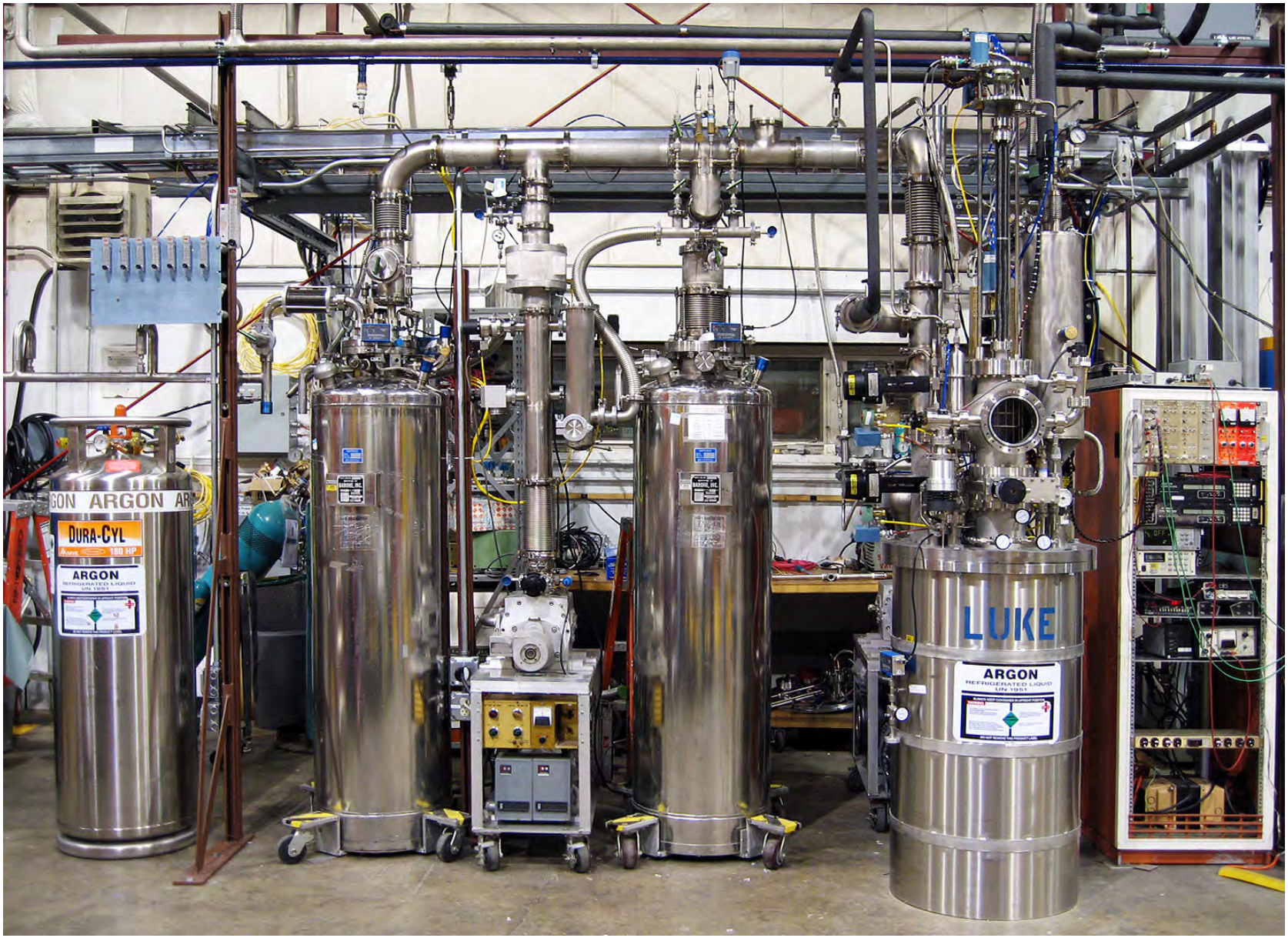
Expect to provide consultation on

Cryogenics

Purification

High Voltage Feed-throughs

Funding Slide to be constructed

FIN ..

Materials Test Stand