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SNOLAB Workshop, 26 August 2010

# DarkSide-50 Status Report

# DarkSide Program

- Experimental program aimed at developing 2-phase dark matter detectors based on depleted argon
- Staged approach, with 50 kg and ton-scale detectors ($10^{-45}$ $cm^2$ and $10^{-46}$ $cm^2$ target sensitivities)
- Develop technology for MAX
  - Multi-ton DAr/Xe TPCs in DUSEL ($<10^{-47}$ $cm^2$ target sensitivities)

# DarkSide-50

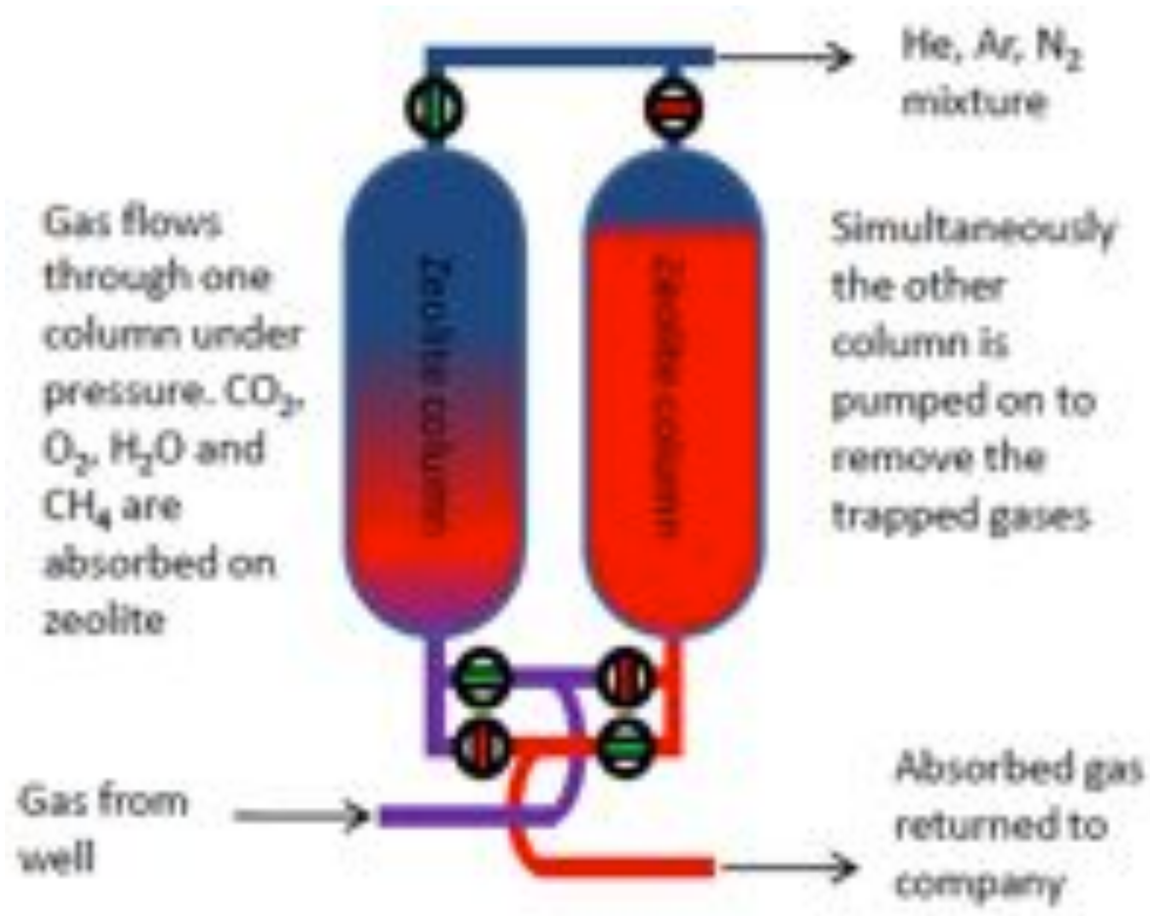
- 50kg DAr TPC
  - $10^{-45}$ cm$^2$ target sensitivity
- Demonstrate three key technologies
  - Naturally depleted argon
  - QUPID photodetectors
  - Liquid scintillator neutron veto

# Depleted Argon

- $CO_2$ from Kinder Morgan Doe Canyon Complex (Cortez, CO) contains ~600 ppm Argon
  - Wells produce 3 tons/day of Ar (mostly not collected)
  - $^{39}Ar$ content at least a factor of 25 reduced compared to atmospheric

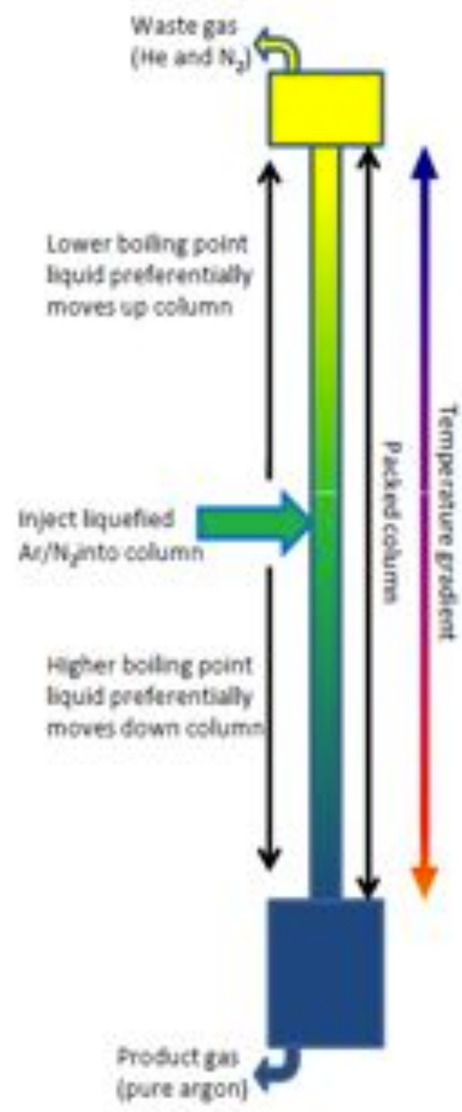
# Collecting Depleted Argon

- Gas from well:
  - 96% - $CO_2$
  - 2.4% - $N_2$
  - 5,700 ppm – CH4
  - 4,300 pmm – He
  - 2,100 ppm – other hydrocarbons
  - 1,000 ppm – H2O
- Output gas:
  - 70% - N2
  - 27.5% - He
  - 2.5% - Ar
- 26 kg of argon collected so far



# Purifying Depleted Argon

- Continuous flow cryogenic distillation
  - 2 cm diameter x 320 cm long packed column
  - 40 theoretical stages
- Theoretical performance:
  - 99.9999% pure argon
  - 5 kg / day
- Assembled at Fermilab



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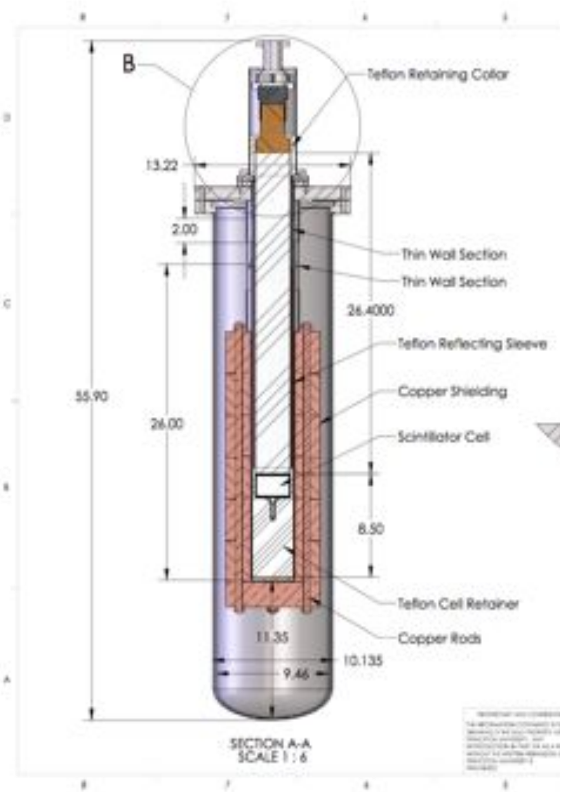
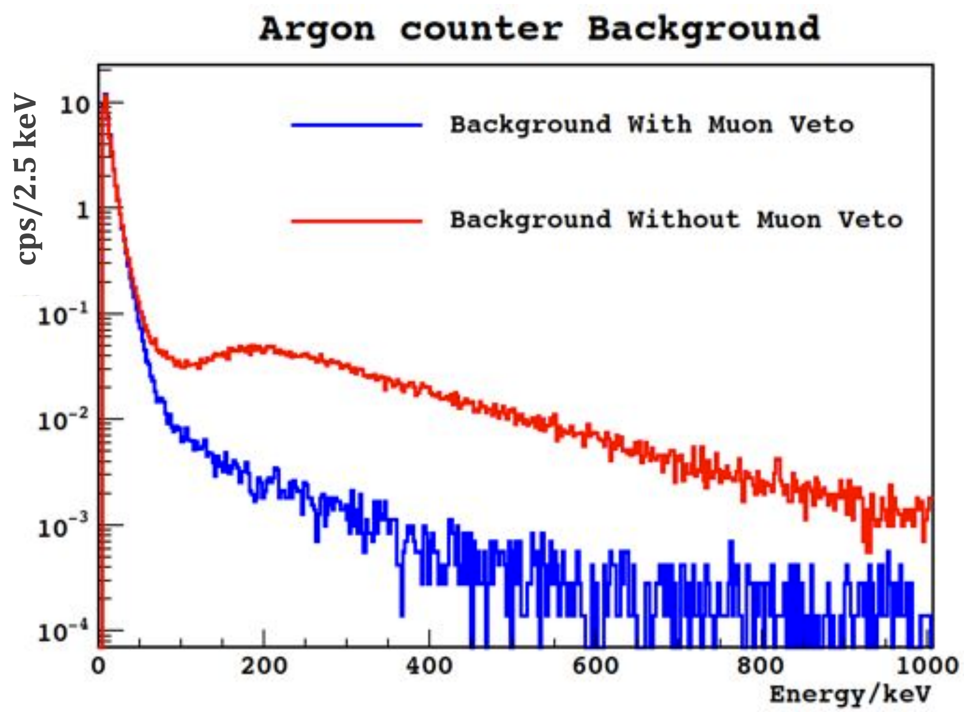
# Depleted Argon Counting

- Have built and are operating a "low background detector" to attempt to measure the residual $^{39}Ar$ content




# Depleted Argon Counting

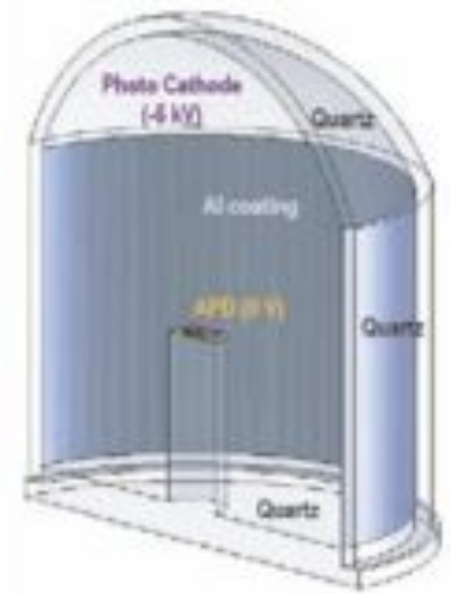
- At Princeton, background in the $^{39}Ar$ region is 0.3 cps after muon veto
- Estimate sensitivity of about a factor of 100 $^{39}Ar$ reduction on surface, maybe a factor of 1000 at a shallow underground site

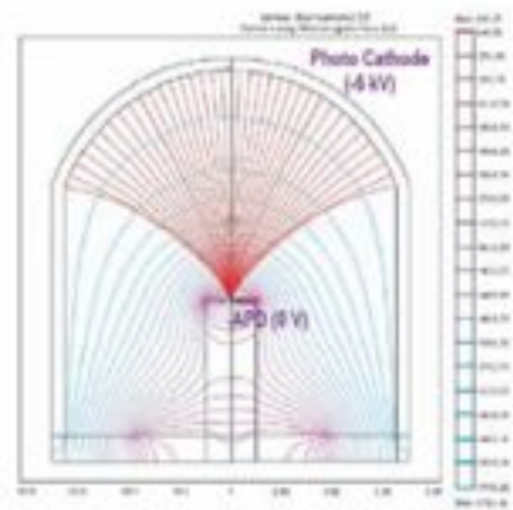


# Quartz Photon Intensifying Detectors (QUPIDs)

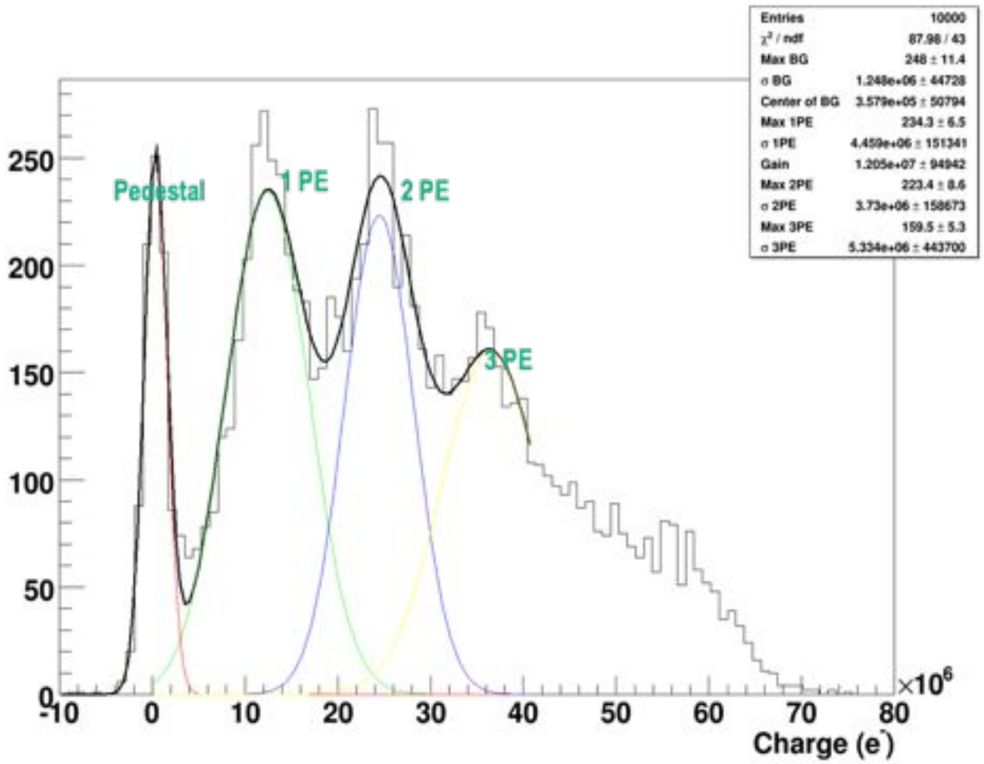
- Developed by Hamamatsu and our UCLA collaborators
  - Will be used for both DarkSide and Xenon
- Fused silica construction except for APD
- Bialkali-LT photocathode allows low temperature operation

| | Radioactivity | | | | |
|---|---|---|---|---|---|
| | $^{238}$U [mBq] | $^{232}$Th [mBq] | $^{40}$K [mBq] | $^{60}$Co [mBq] | Neutrons [$n$/yr] |
| 3" QUPID | <0.49 | <0.40 | <2.40 | <0.21 | <0.05 |



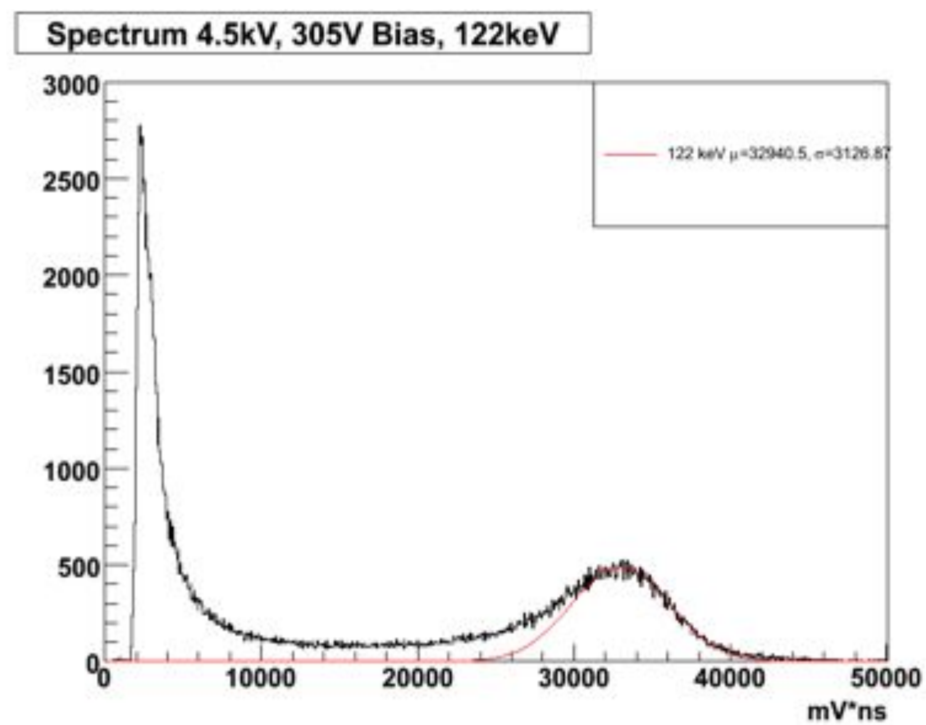



# QUPID Data




Hamamatsu Data

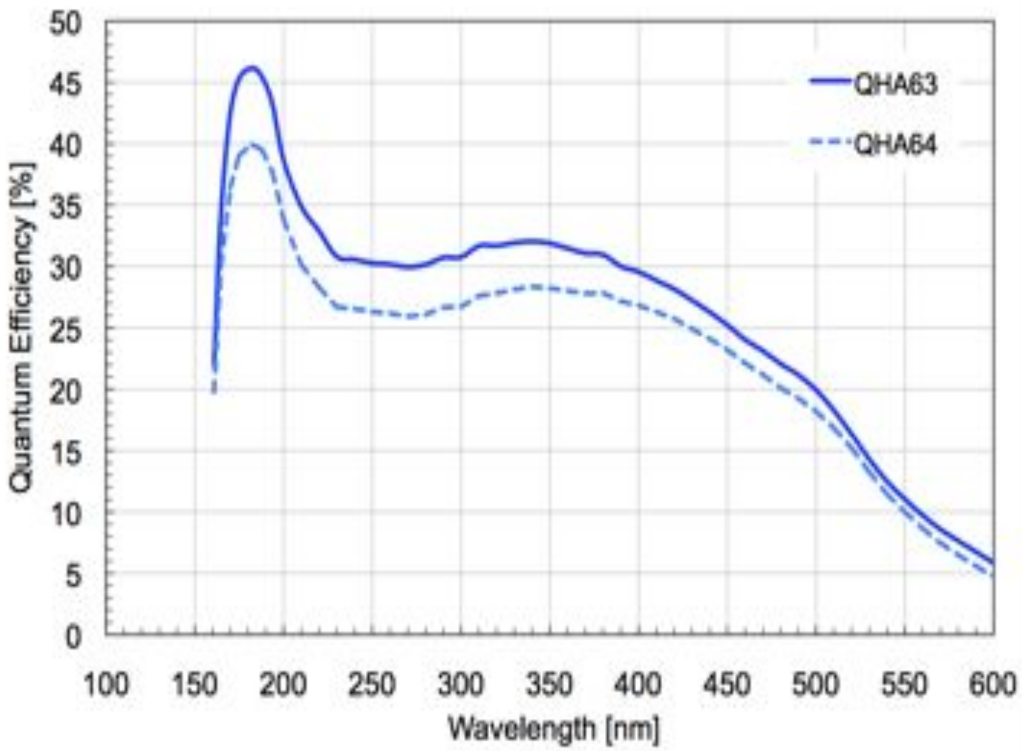
$^{57}$Co in liquid xenon




[Data from a development version QUPID with fairly low Q.E. at UCLA]

# QUPID Quantum Efficiency

- Optimizing photocathode for xenon (178 nm) has achieved >45% Q.E.
  - Optimization for Ar + WLS to begin in October



# Production Version QUPIDs

- First three production version QuPIDs have been delivered, are being evaluated
- Production of DarkSide QUPIDs could begin as early as the end of the year

| | Old Version (FY2009) | Production Version (FY2010) |
|---|---|---|
| Production Method | Vacuum Transfer | Exactly the same as PMT |
| Quartz Tip | No | Yes (for external vacuum pump) |
| Production Rate | 1 QUPID / 2 days | 6 QUPID / day (> 1,000 QUPID / year) |
| Cost | ~ $25,000 | < $7,000 |
| Photocathode | Bialkali (with Aluminum Pattern) | Bialkali-LT (Low Resistivity at Low Temperature) |
| APD diameter | 3 mm ϕ Front illuminated | 5 mm ϕ Back illuminated |
| No. of Leads | 5 | 4 (2 for APD, 2 for Getter) |
| 6 kV difference | at the bottom (no resistive layer) | on side (with resistive layer) |

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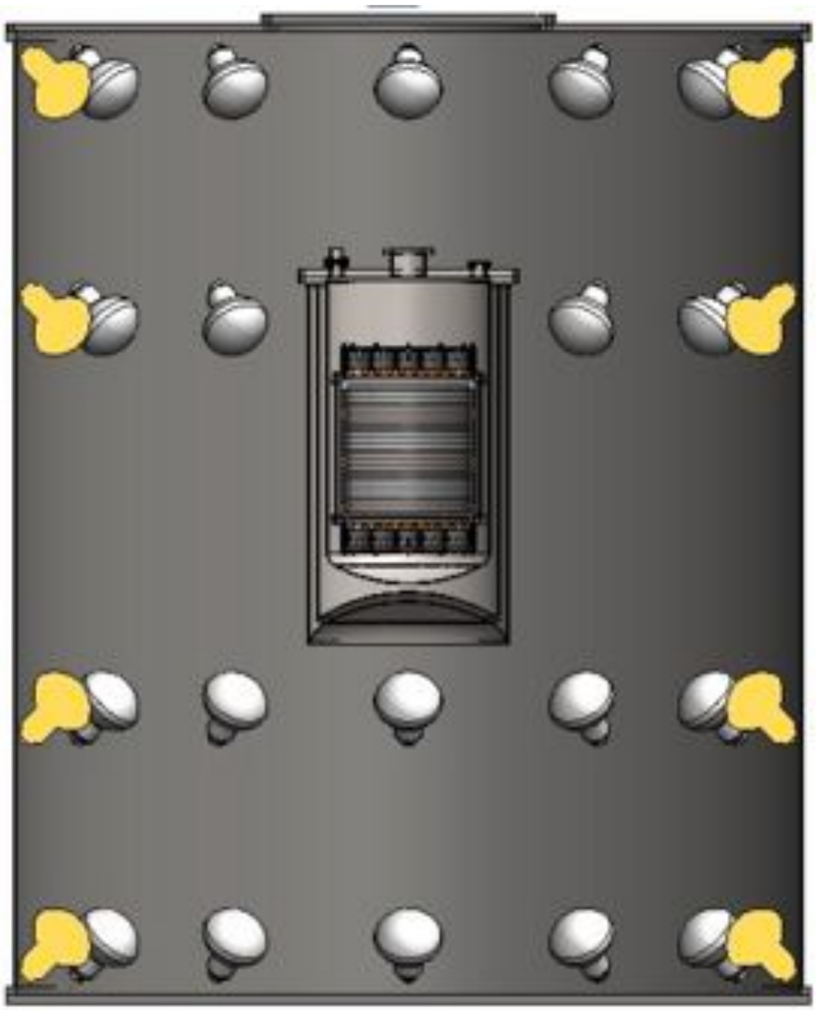
# Neutron Veto

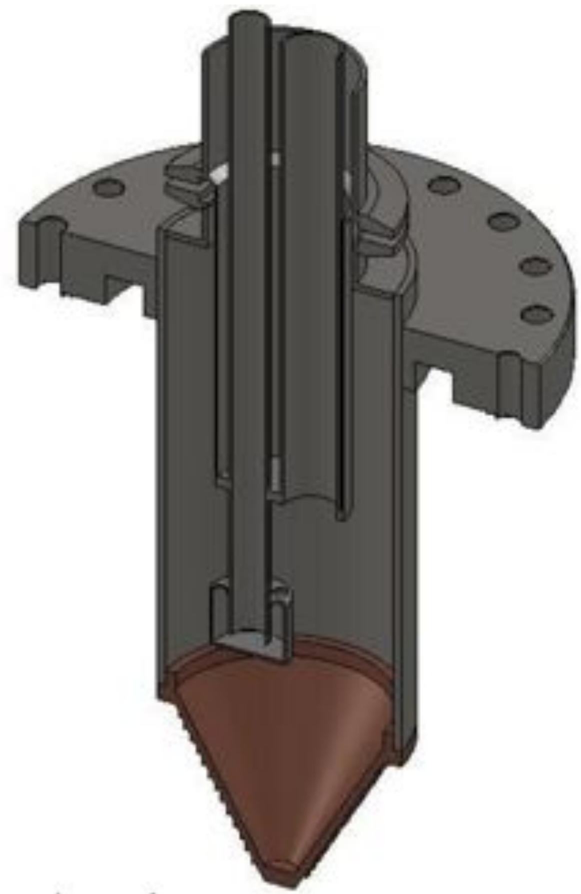
- DarkSide-50 will be deployed in a 1 m thick scintillator neutron veto
  - Expect >99.5% efficiency for radiogenic neutrons, >95% efficiency for cosmogenics
  - Demonstrate the veto technology and efficiency
- Demonstrate directly that a ton-scale experiment could operate background free
- Veto enables preliminary operation with R11065 PMTs if QUPIDs are delayed



Details in related talk Saturday at LRT

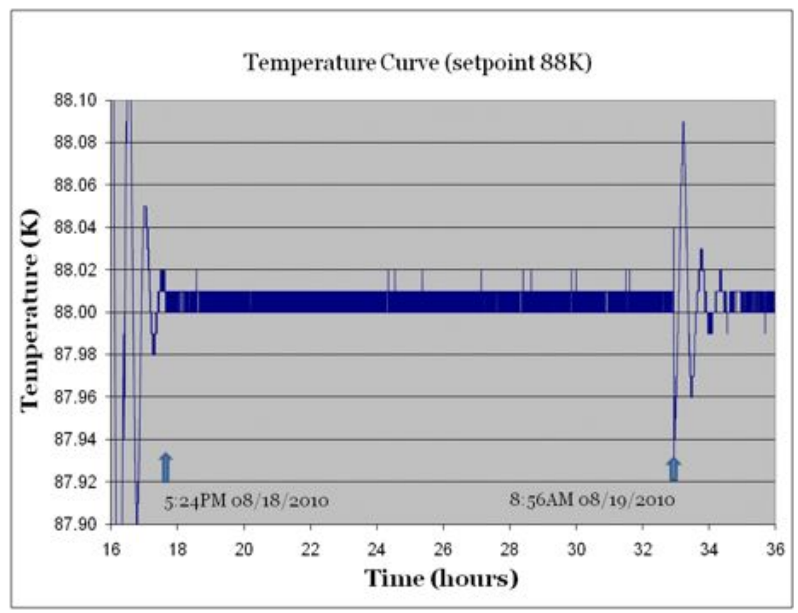
# “Remote” $LN_2$ Cryocooler

- $LN_2$ supplied by low pressure dewar/gravity feed
- Flow controlled by throttling boil-off gas
- Provide kW of cooling at liquid Ar temperatures (depending on size) but very little cooling when “off”
- Can be made from clean materials



# "Remote" $LN_2$ Cryocooler

- Small (~100W cold heads) tested at UCLA and Princeton
- Cold head temperature stable to a fraction of a degree
- Nitrogen delivery through 20' of vacuum jacketed flex line

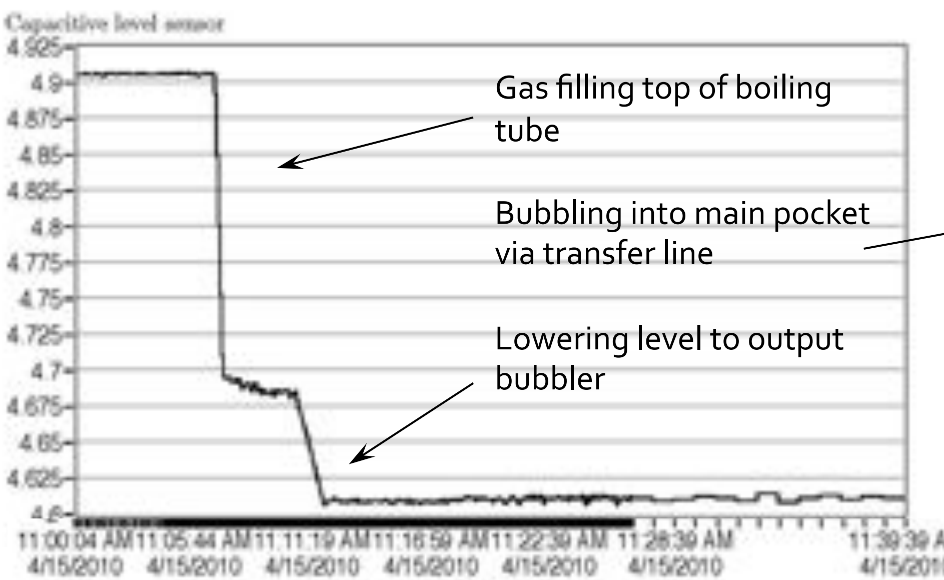


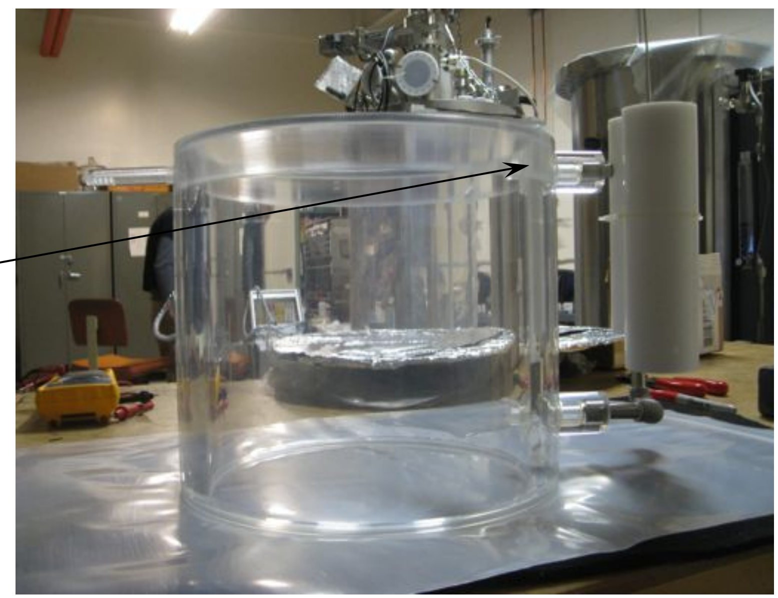
# 10 kg Prototype

- Test some critical aspects of the DarkSide design
  - Light yield
  - Control of gas layer
  - Charge drift and S2 light collection
  - Surface background rejection

# Preliminary Run

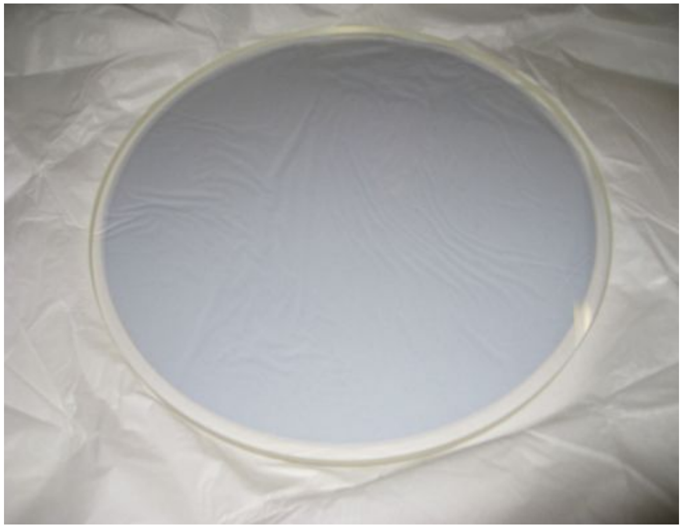
- No electric fields
- Light yield of 3-5 p.e./keV
- Successful production/maintenance of gas pocket



# Deployment II: Electric Field

- Install field cage, extraction grid and conducting ITO windows
- Affix weak alpha sources to vertical walls to study surface backgrounds
  - "Charge interruption" technique for surface background rejection



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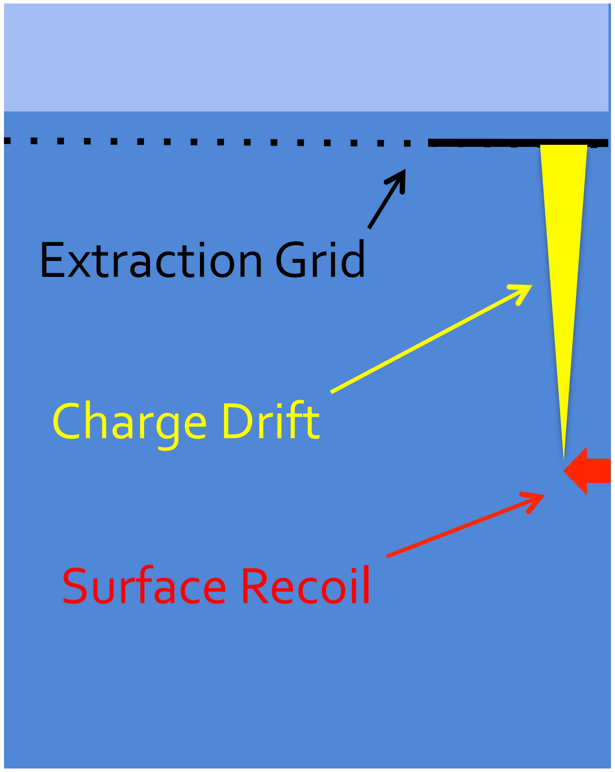



# Darkside Collaboration, 2009

Augustana College

Black Hill State University

Fermilab

Princeton University

Temple University

University of California, Los Angeles

University of Houston

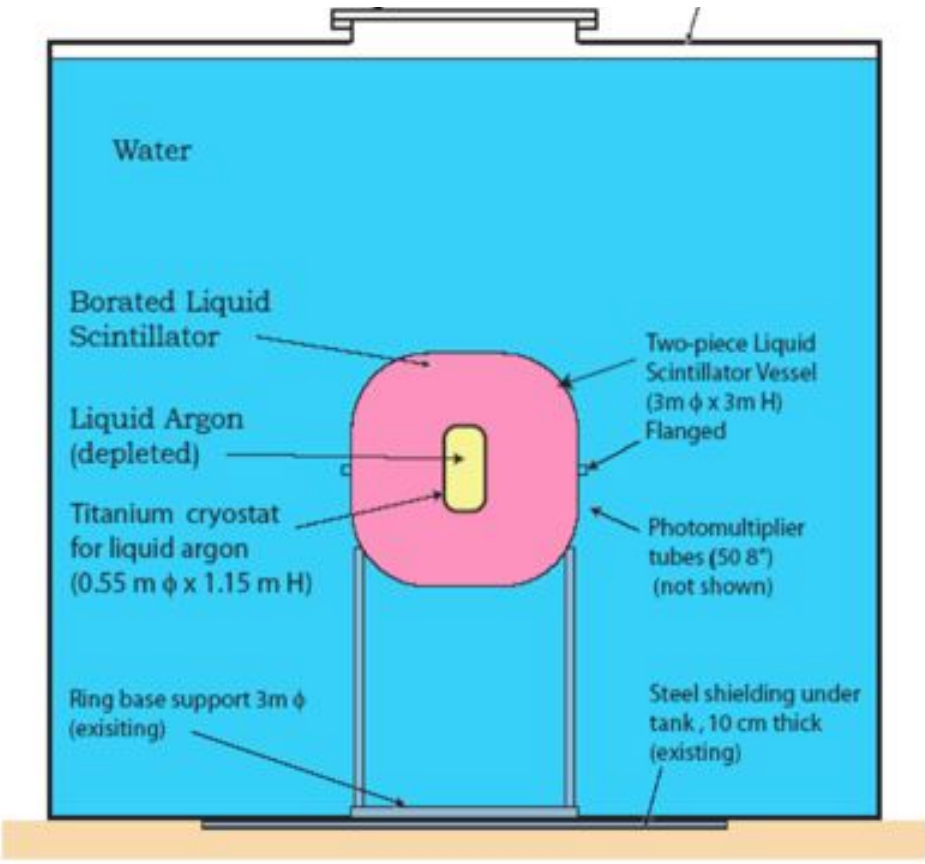
University of Massachusetts at Amherst

# Darkside Collaboration, 2010

Augustana College – SD, USA
Black Hill State University – SD, USA
Fermilab – Il, USA
INFN Laboratori Nazionali del Gran Sasso – Assergi, Italy
INFN and Università degli Studi Genova, Italy
INFN and Università degli Studi Milano, Italy
INFN and Università degli Studi Naples, Italy
INFN and Università degli Studi Perugia, Italy
Joint Institute for Nuclear Research – Dubna, Russia
Princeton University, USA
RRC Kurchatov Institute – Moscow, Russia
St. Petersburg Nuclear Physics Institute – Gatchina, Russia
Temple University – PA, USA
University of California, Los Angeles, USA
University of Houston, USA
University of Massachusetts at Amherst, USA

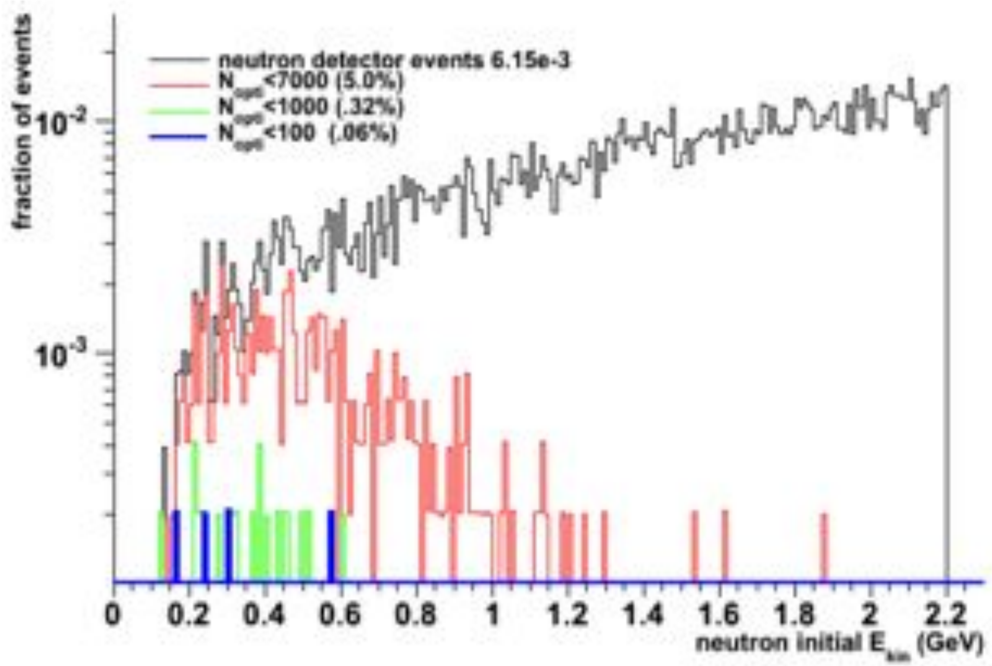
# CTF at LNGS

- Increased Borexino collaboration involvement opens the possibility of deploying DarkSide-50 in the Counting Test Facility water tank
  - Water suppresses the higher cosmogenic backgrounds at LNGS



# Cosmogenic Backgrounds in CTF

- Simulations suggest that CTF water tank + scintillator veto suppress cosmogenic backgrounds to ~0.3 / T•yr
  - Perhaps even further
    - Simulated only single neutrons
    - High energy neutrons can produce Cerenkov particles in water as well
- A ton-scale experiment is possible in the CTF!



# Possible DarkSide Program at LNGS

- Deploy DarkSide-50 in 3 m diameter neutron veto
  - Could operate outside of CTF until Borexino purification campaign is completed, if necessary
  - Move into CTF tank for 50 kg "best physics run"
- Upgrade directly to a ton-scale experiment
  - Re-use veto tank and infrastructure

# Conclusions

- DarkSide is making good progress on all technical fronts
  - Re-deployment of 10 kg prototype in a few weeks
    - Finalize our design decisions for DarkSide-50
- Hope to have first physics detector operational in late 2010 or 2011