What is the aim of DarkSide (E-1000)?

Who are DarkSide?

What is the design of DarkSide and why?

What is Fermilab involvement in DarkSide?

What is status and schedule of DarkSide?

A.O.B.

http://darkside.lngs.infn.it/

DarkSide: Direct Search for WIMP Dark Matter using liquid argon as target.

- DS-50 - 50 kg active, 33 kg fiducial

  sensitivity 2×10^{-45} cm^2 in 3 yr run.

  Funded by DOE, INFN, NSF

- DS-G2 - 5 tonnes total, 3.3 tonnes fiducial

  sensitivity 2×10^{-47} cm^2 in 3 yr run

  R&D funded by NSF (NSF DCL, May 1 2012)

  R&D requested to DOE (G2 FOA, Jul 6 2012)

DarkSide Collaboration

China, Italy, Poland, Russia, Ukraine, UK, & U.S.

Augustana College (SD), USA
Black Hills State University, USA
Fermilab, USA
IHEP, Beijing, China
INFN Laboratori Nazionali del Gran Sasso, Italy
INFN and Università degli Studi Genova, Italy
INFN and Università degli Studi Milano, Italy
INFN and Università degli Studi Napoli, Italy
INFN and Università degli Studi Perugia, Italy
INFN and Università degli Studi Roma 3, Italy
Institute for Nuclear Research, Kiev, Ukraine
Jagellonian University, Poland
Joint Institute for Nuclear Research, Russia
Princeton University, USA
RRC Kurchatov Institute, Russia
St. Petersburg Nuclear Physics Institute, Russia
Temple University, USA
University of Arkansas, USA
University College London, London, UK
University of California, Los Angeles, USA
University of Hawaii, USA
University of Houston, USA
University of Massachusetts at Amherst, USA
Virginia Tech, USA

Direct Detection Requirements

- Low energy nuclear recoils (< 100 keV)
- Low rate (~ few events/ton/yr for 10^{-47} cm^2)

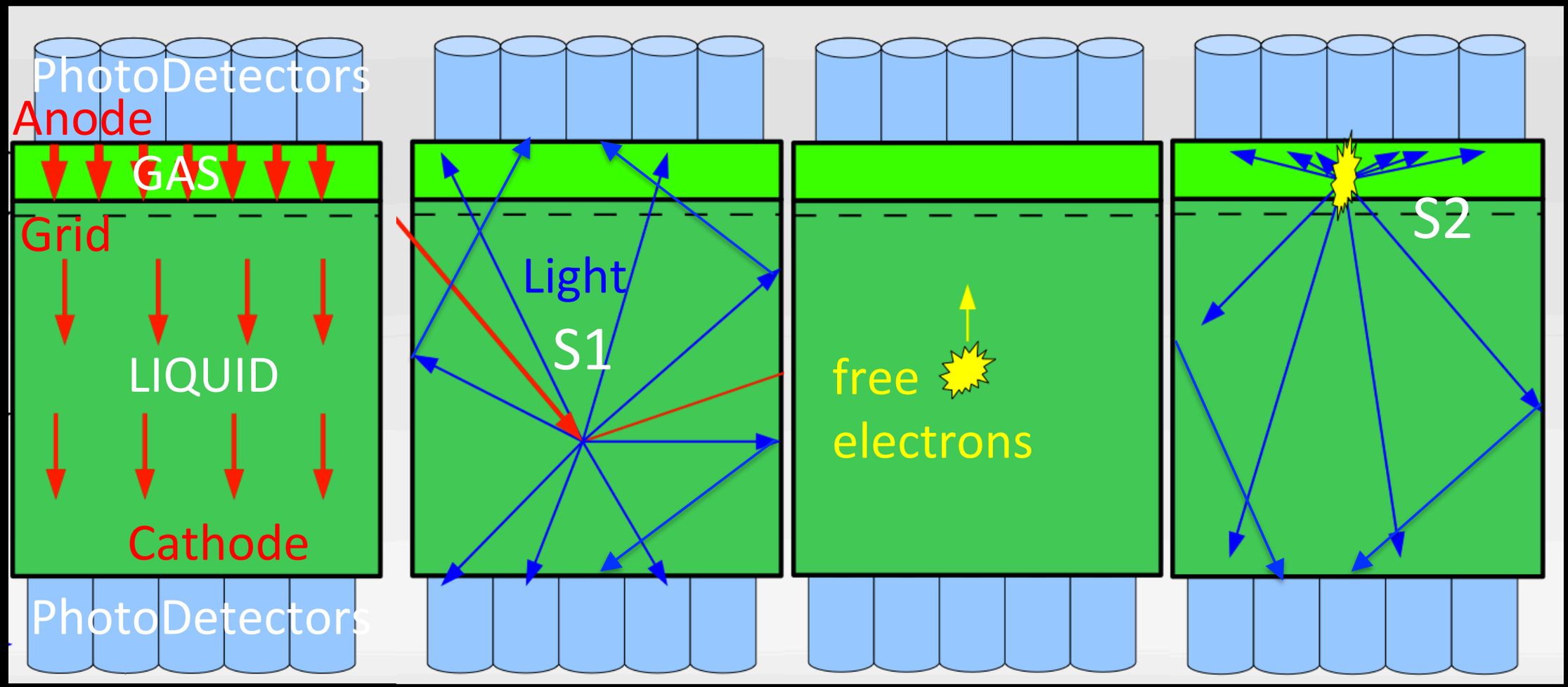
⇒ Maximize detector sensitivity (light yield)

⇒ Background avoidance, rejection, measurement

Detector designed for unambiguous discovery

Two-phase Argon TPC Schematic

Argon produces scintillation light and allows long (meters) free electron drift.



Liquid Phase;
Gas Pocket above;
Electric Field in both.
~ 1kV/cm (Liquid),
few kV/cm (gas)

WIMP interacts;
Nucleus Recoils
Argon produces
light and free
electrons.

Electrons drift up
in liquid and
……..
are extracted
by field of ~3 kV/cm

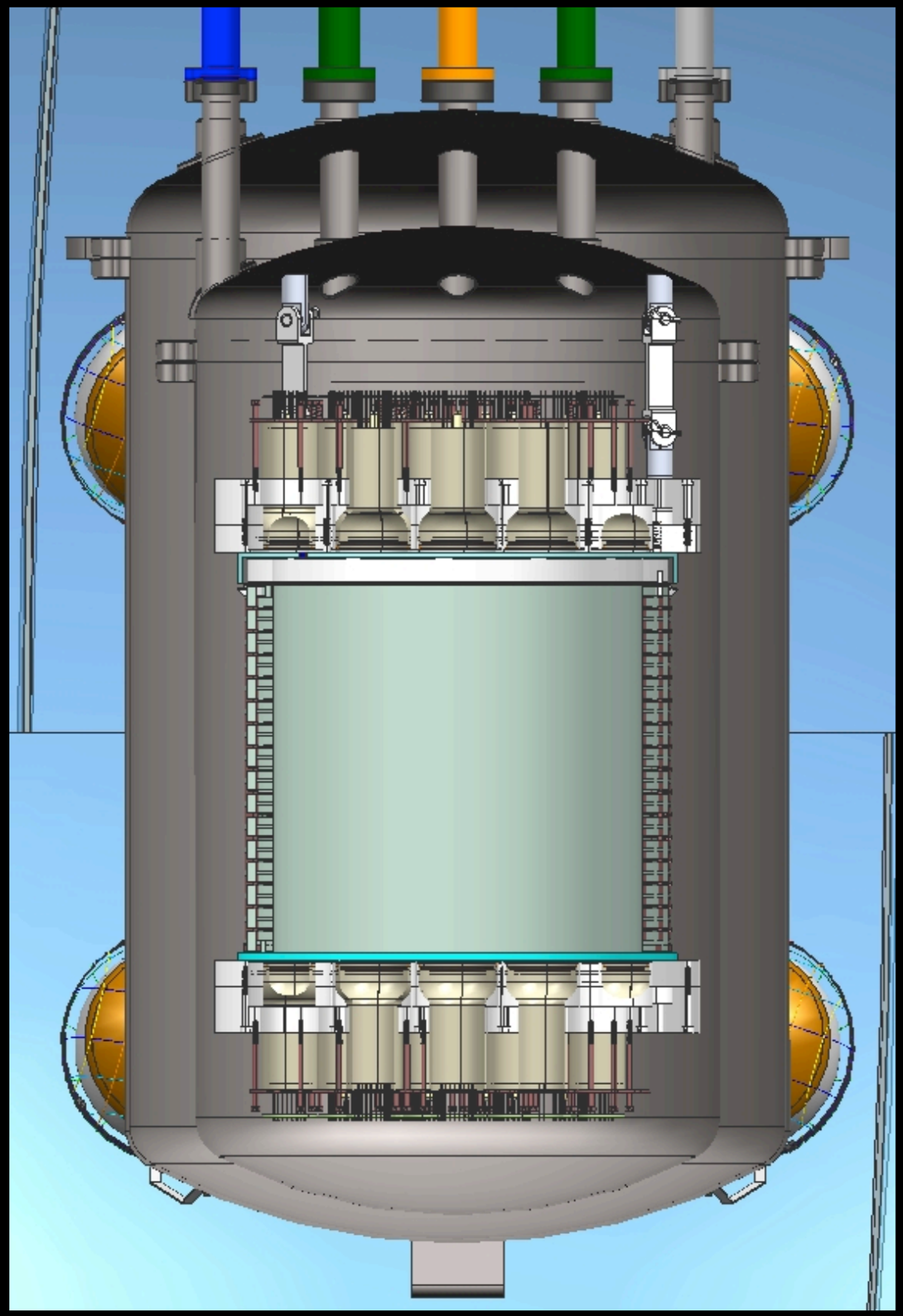
into gas region
where they produce
secondary
fluorescence (S2),
proportional to
number of e's.

DarkSide
Aim at zero-background technology

- Pulse Shape Discrimination (PSD) of Primary Scintillation, S1,
  (rejects e/gamma) (unique to Argon - atomic physics of Argon dimer)
- Ionization:Scintillation Ratio, S2/S1 (rejects e/gamma - not unique to Argon)
- Sub-cm Spatial Resolution (identify surface bkgs) (advantage of two-phase)
- Underground argon (avoid event pile-up from ^{39}Ar)
- Neutron Veto (identify neutrons with high efficiency in finite volume)
- Water shield (identify muons and avoid cosmogenic neutrons)
- Screen and select all detector materials for minimum radioactivity

DS-50 LAr detector,
within a neutron veto,
within a muon veto,
under a mountain

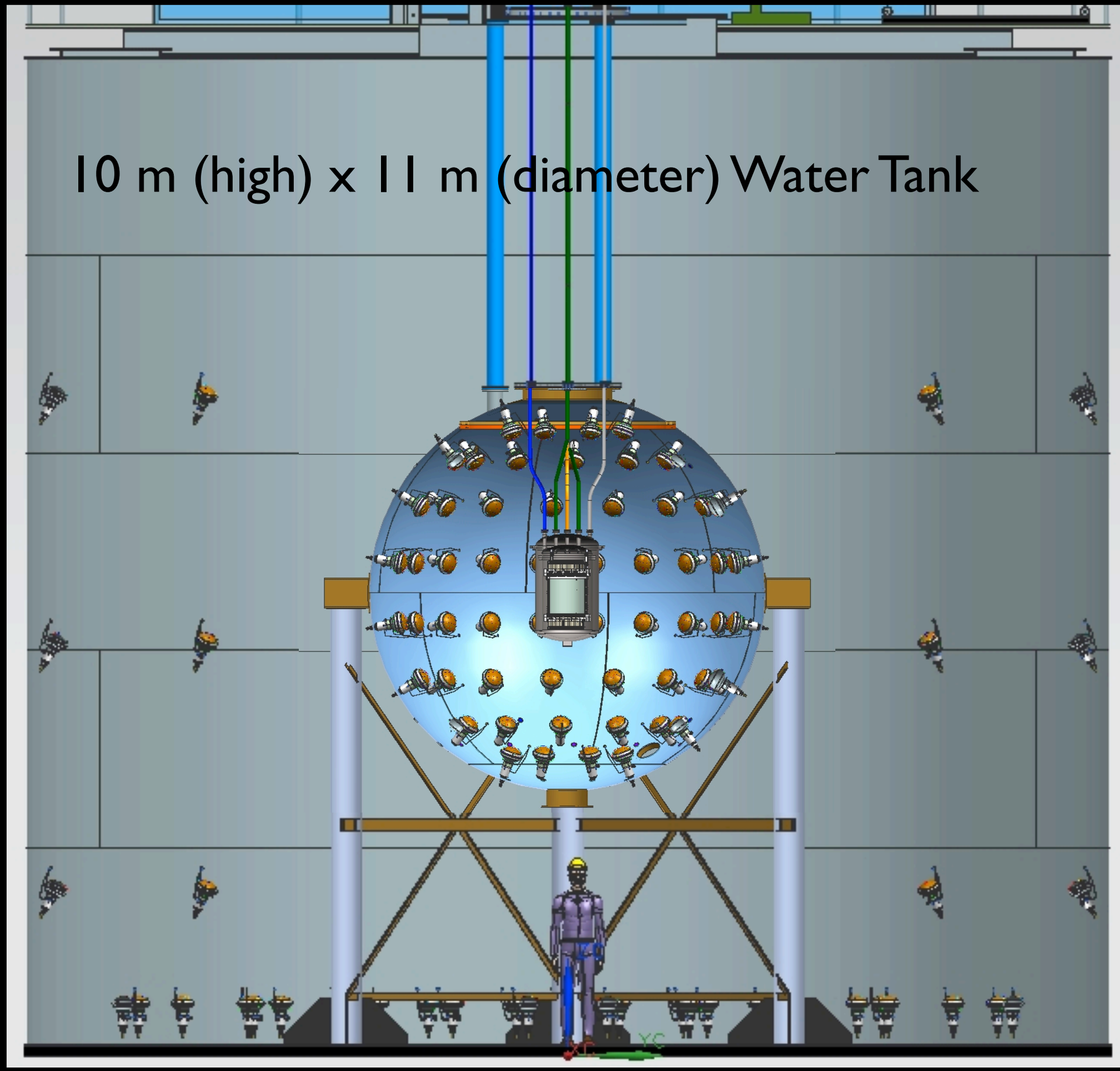
both the vetoes are sized
for DS-G2



Liquid Argon TPC & Cryostat

Liquid Scintillator Neutron Veto

10 m (high) x 11 m (diameter) Water Tank

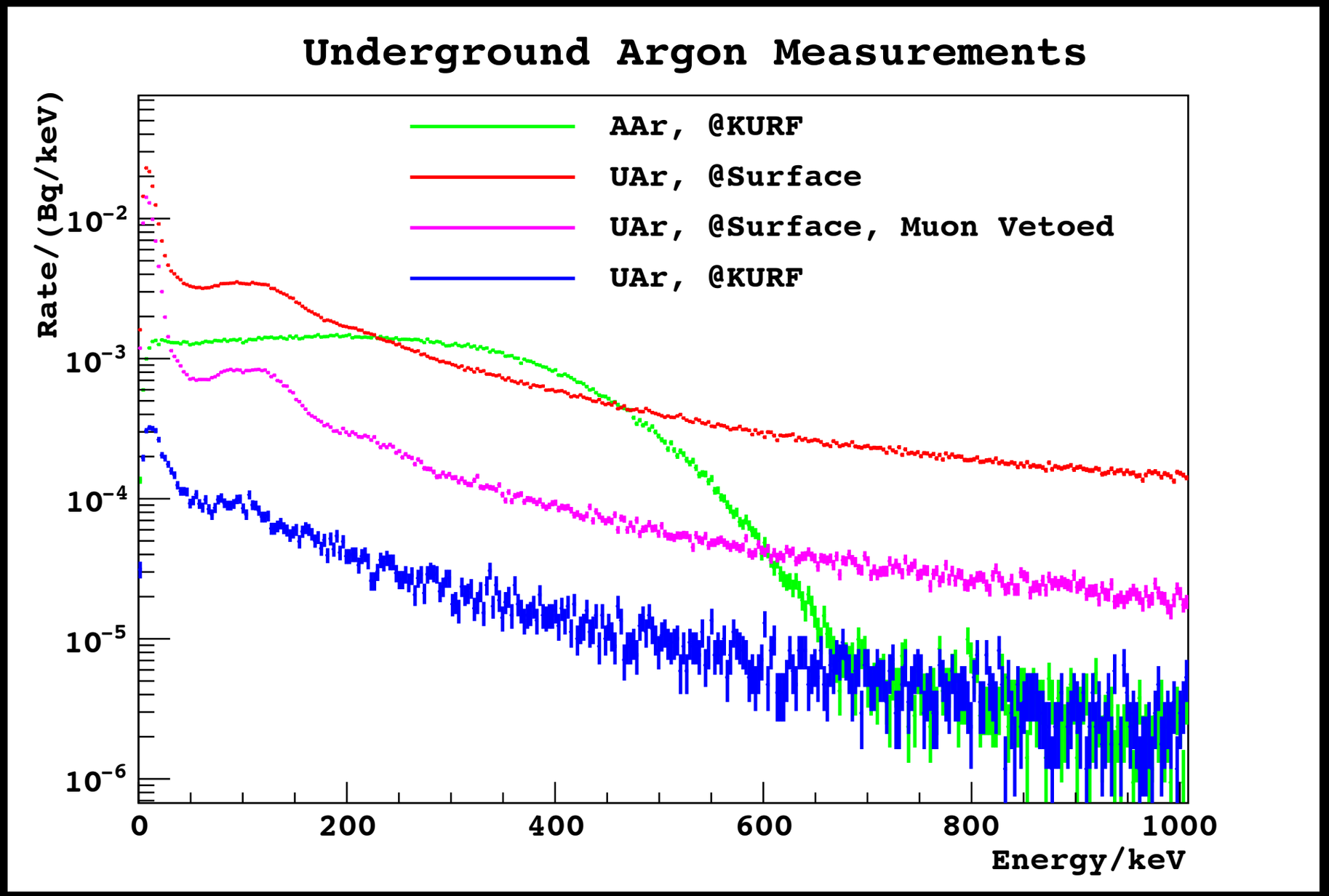


DS-50 Project Funding

- NSF: $6M in construction costs plus in kind contributions (Borexino infrastructure)
- DOE: slightly less than $2M in construction funds
- INFN: $2M in construction costs foreseen (still waiting for $760k) plus in-kind contributions (CTF and BX infrastructure)

Fermilab Participation in DS-50:

- Underground Argon Purification (PPD-ME & DDO *with Princeton)*
- Argon handling system (PPD-ME & DDO *with Princeton & UCLA*)
- TPC Data Acquisition System (SCD-NTL *with LNGS*)
- Trigger (PPD/EE)
- PMT Bases (PPD/EE)
- Project management & DOE funds co-ordination
- Data Storage (SCD-NTL) (& analysis) (under discussion in exp.)
- Source insertion mechanism (PPD-ME & DDO - proposed)



- <6.5 mBq/kg (cf 1 Bq/kg in atmospheric Argon - factor 150)
- 125 of 150 kg collected (Princeton operation), stable extraction at 0.4 kg/day

Cryogenic Distillation Column

Assembled, commissioned and operated at the Proton Assembly Building
(removes N2 and He from Ar,N2,He mix)

Princeton-Fermilab collaboration

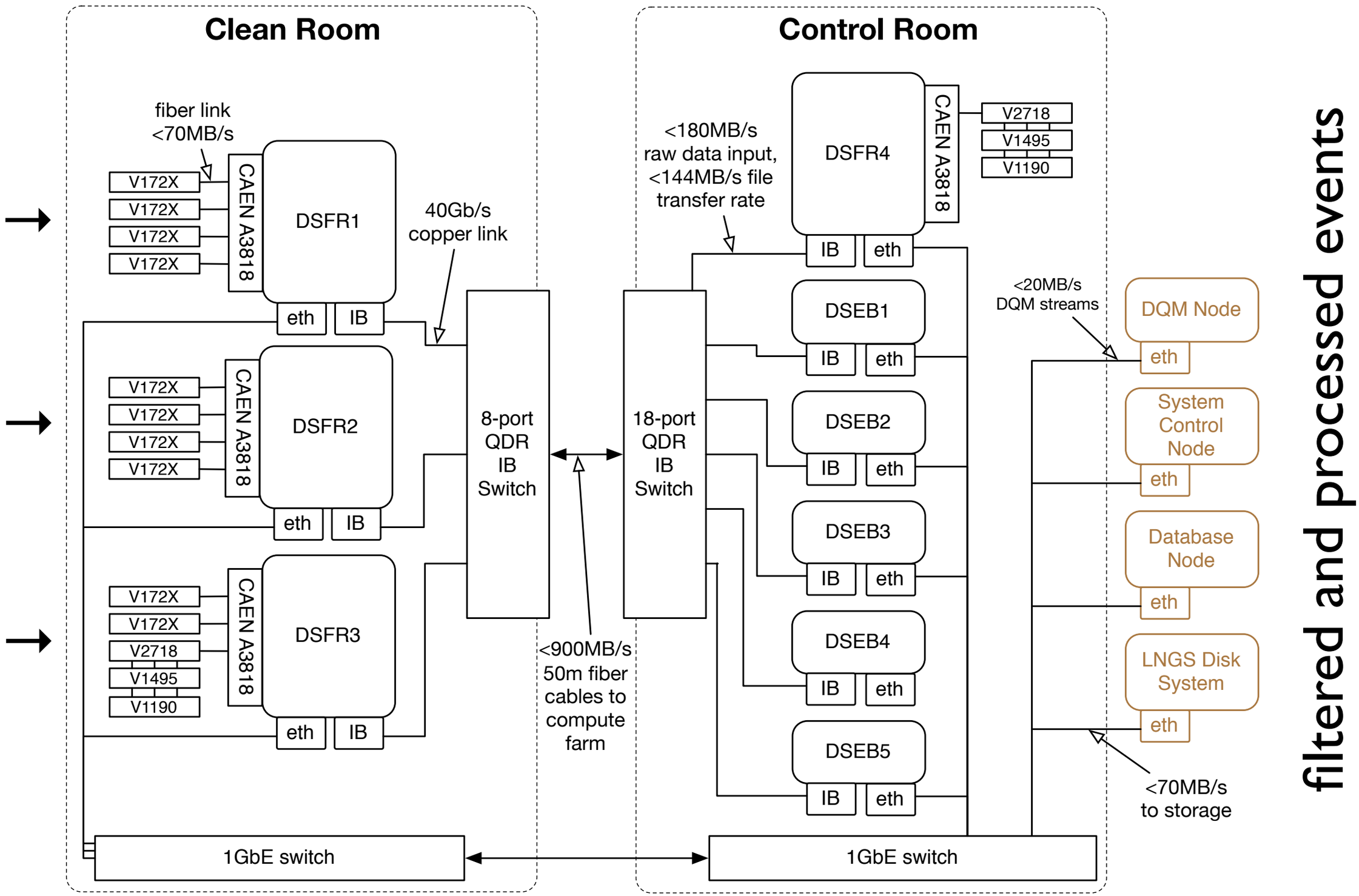
Argon handling system - leaving PAB, and in clean room at LNGS

DS-50 TPC DAQ Architecture

`Fragment Receiving'

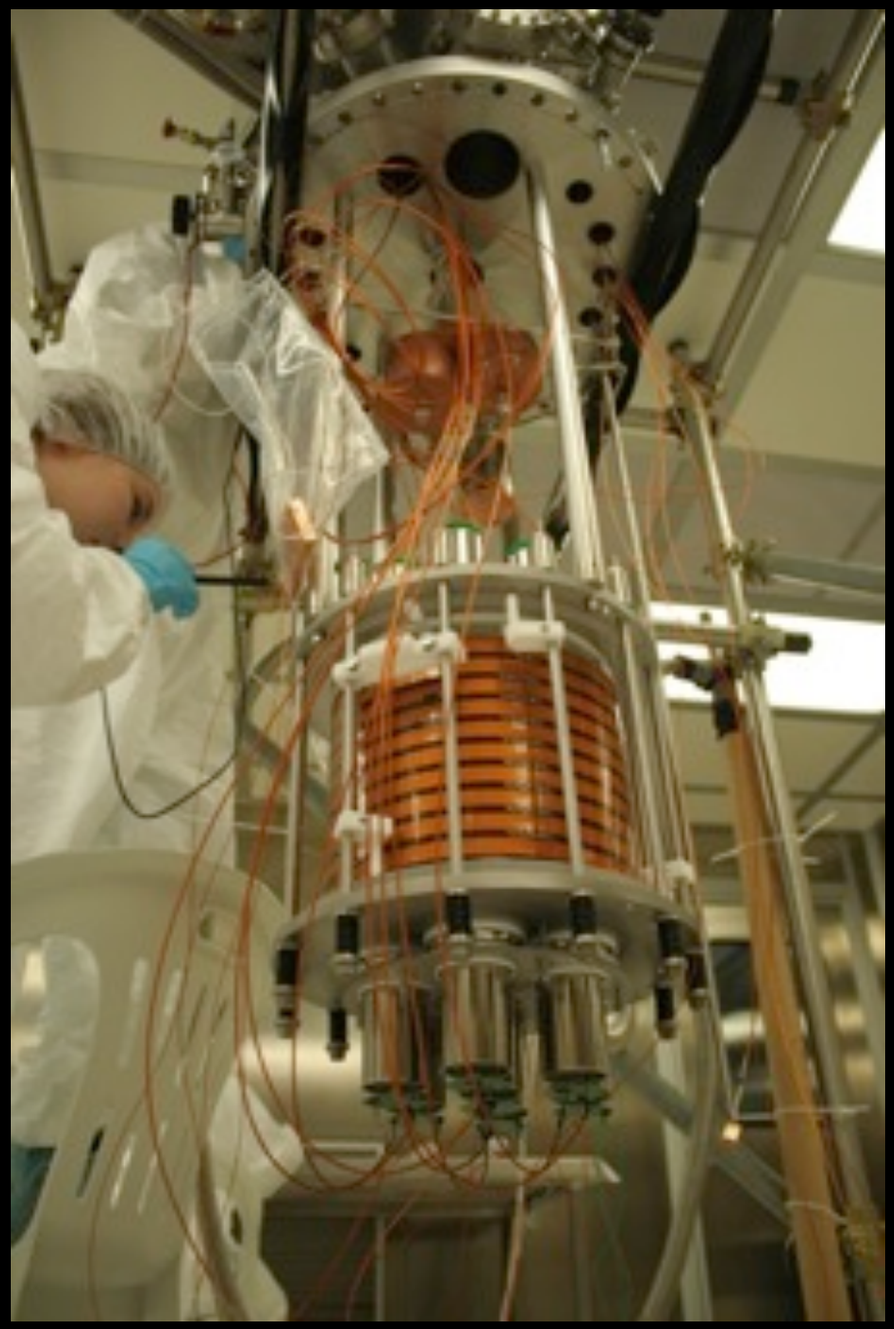
`Event Building'

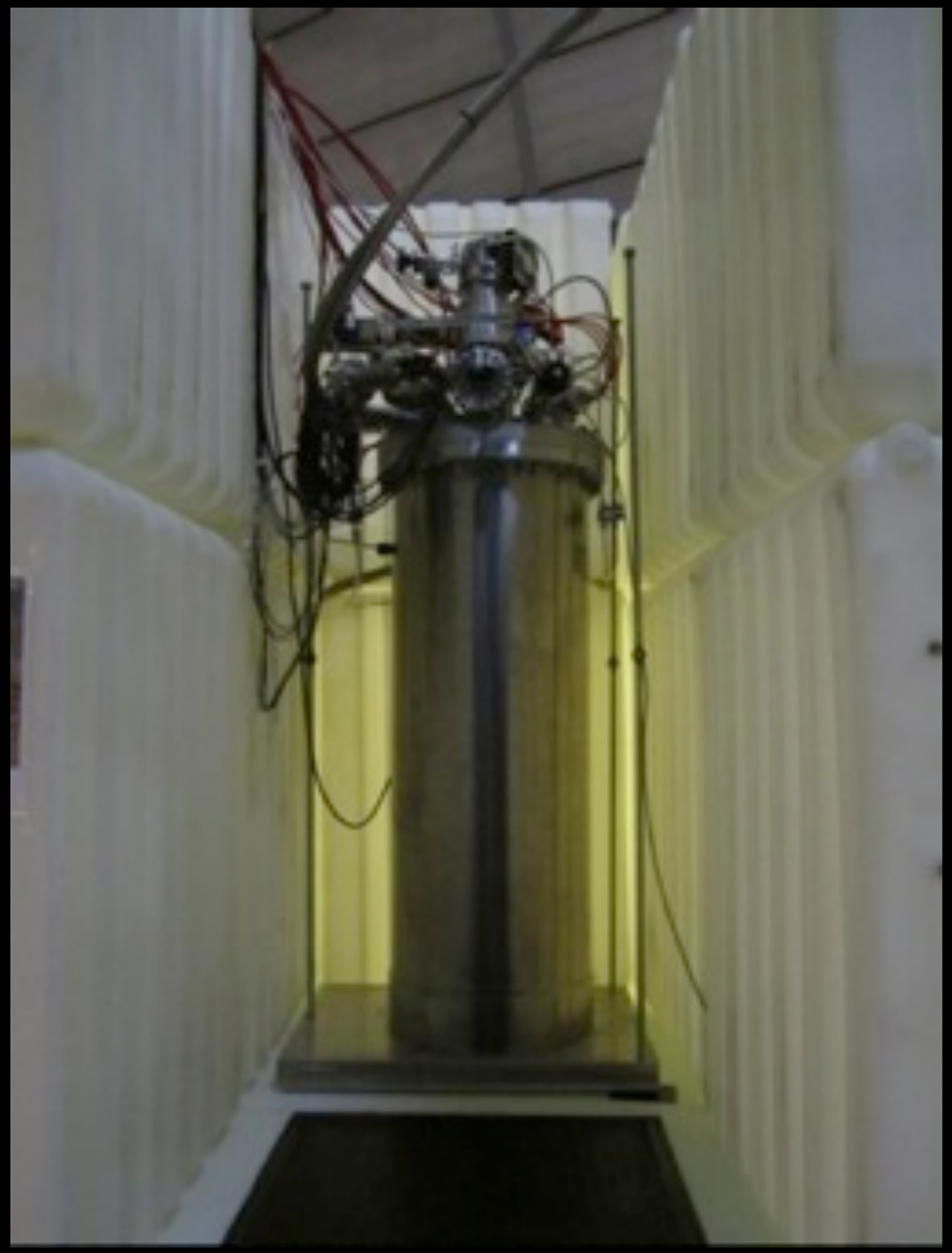
analog signals



filtered and processed events

Test System: DS-10 at LNGS

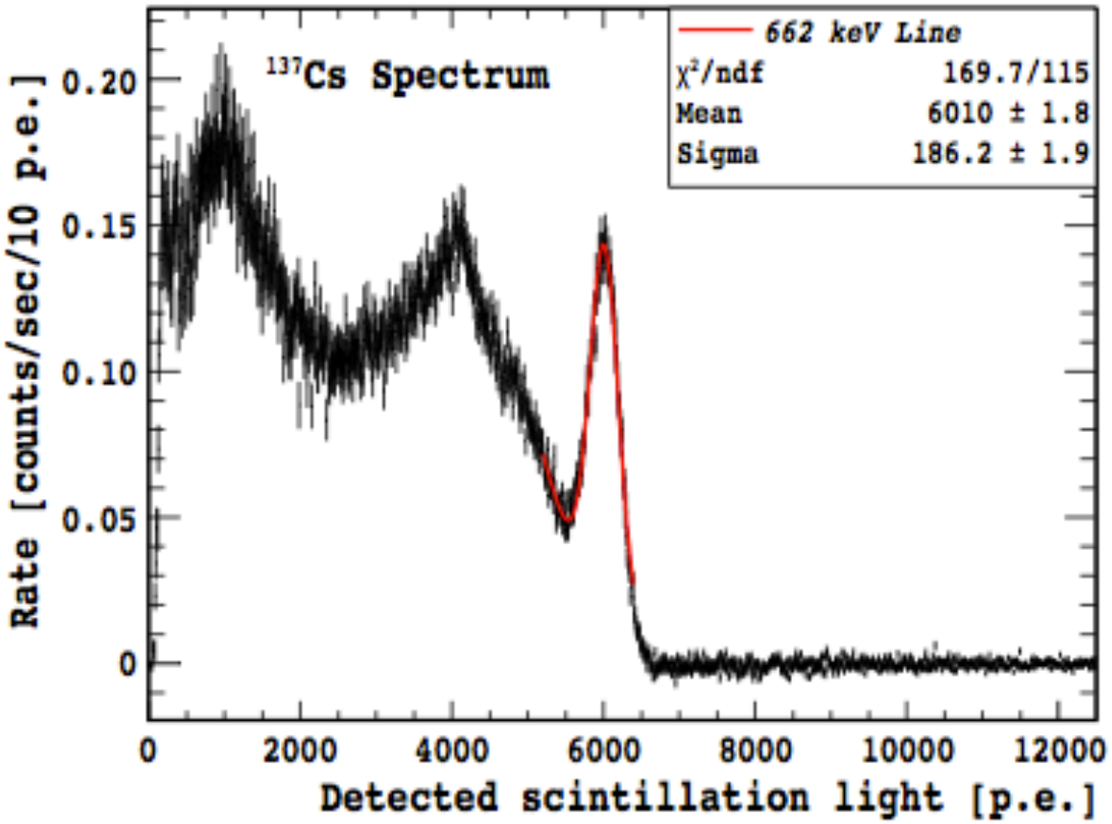


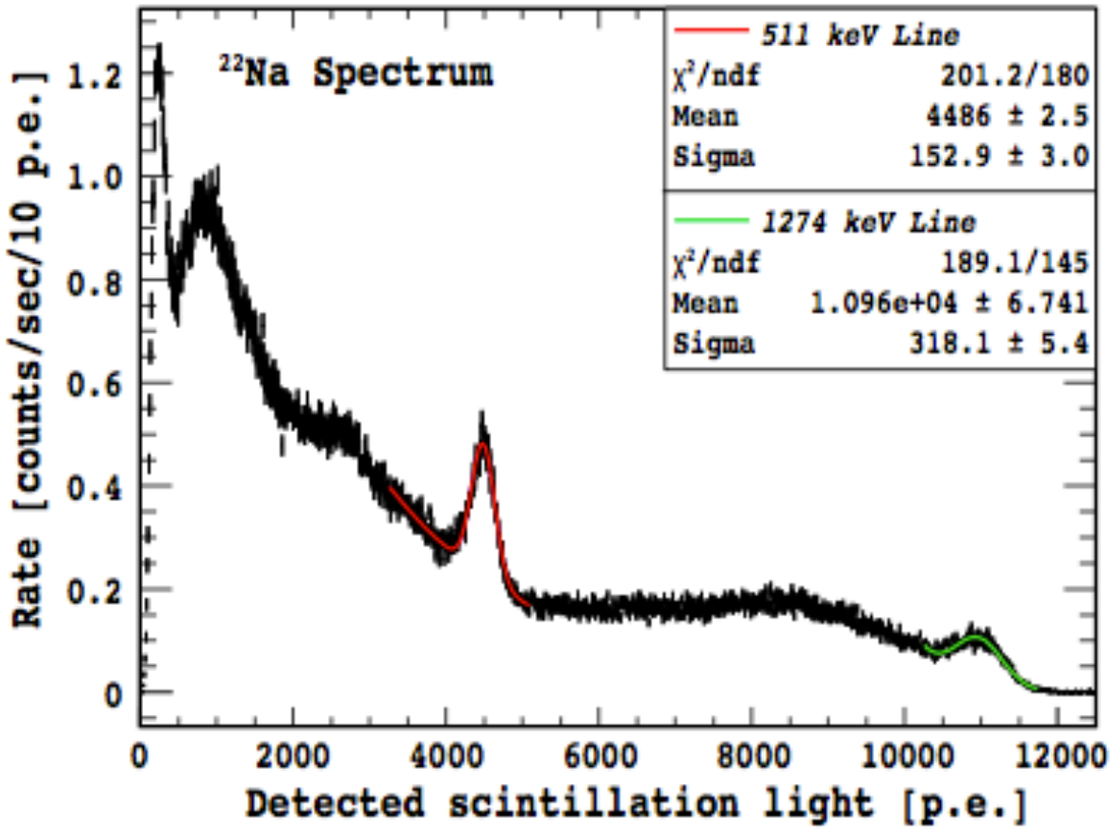


DarkSide-10 Activities and Results

- Compare performance of different reflectors for light collection
- Perform long-term test of HHV system
- Test detector calibration scheme and help refine calibration strategy
- Test of front-end amplifier for DS-50 TPC (ongoing)

DarkSide-10



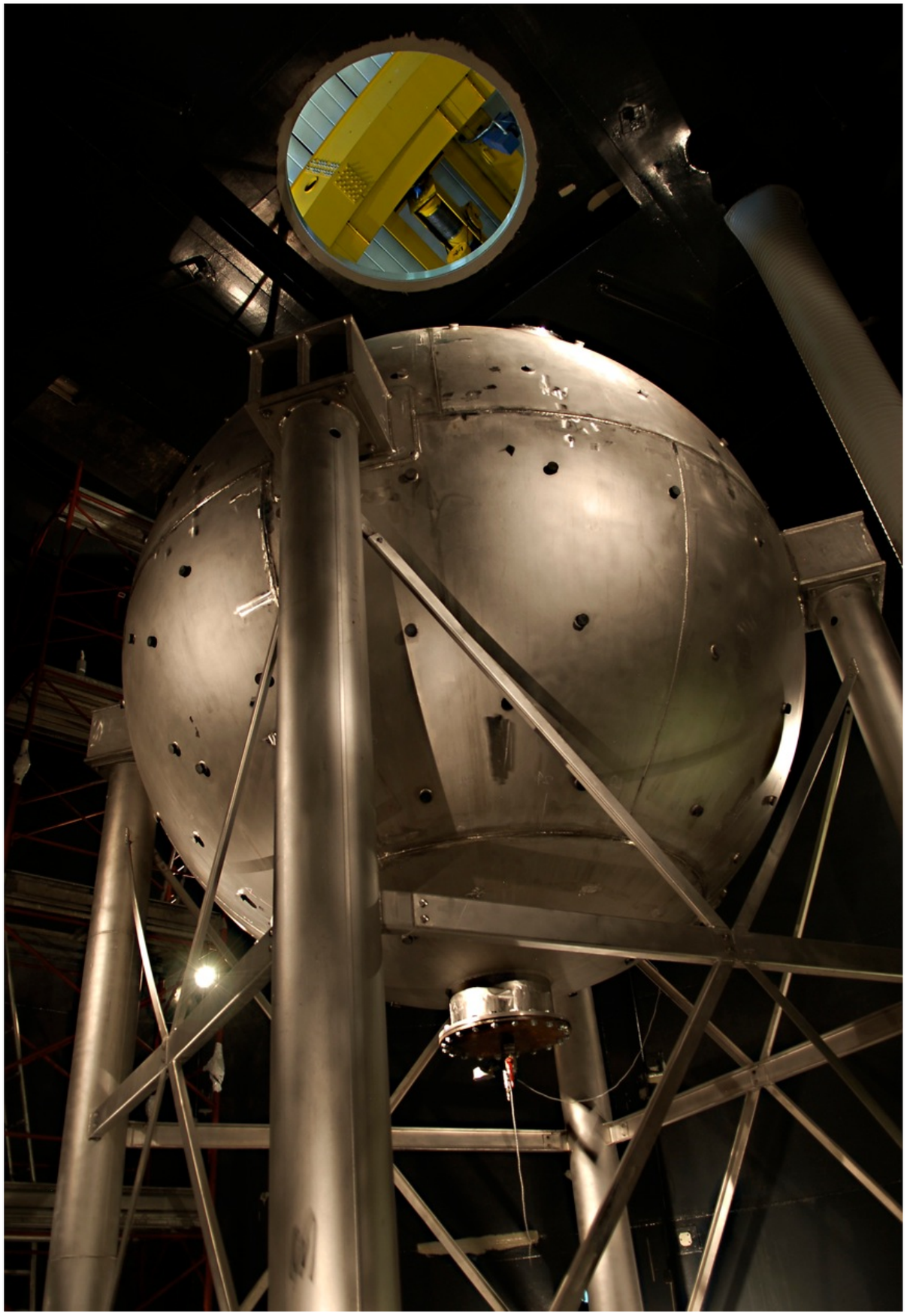


LY=8.9 pe/keV$_{ee}$ - outstanding

due to new PMTs and effective TPB coating

Report from LNGS

- Counting Test Facility of Borexino drained March 2012
- Liquid Scintillator Vessel build and completed May 2012
- Radon abatement system (230 m^3/hr, reduction factor>10,000, <1 mBq/m^3) delivered and commissioned September 2012
- Radon-suppressed clean room CR1 for precision cleaning and evaporation of wavelength shifter completed September 2012
- Liquid scintillator and water loop completed and precision cleaned by September 2012
- Radon-suppressed clean room CRH for assembly (on top of CTF, 5 tons crane, direct access to liquid scintillator vessel) expected by end of 2012



Liquid Scintillator Vessel in Water tank

TPC Assembly - clean and radon-free room

Clean and radon-free room above water tank

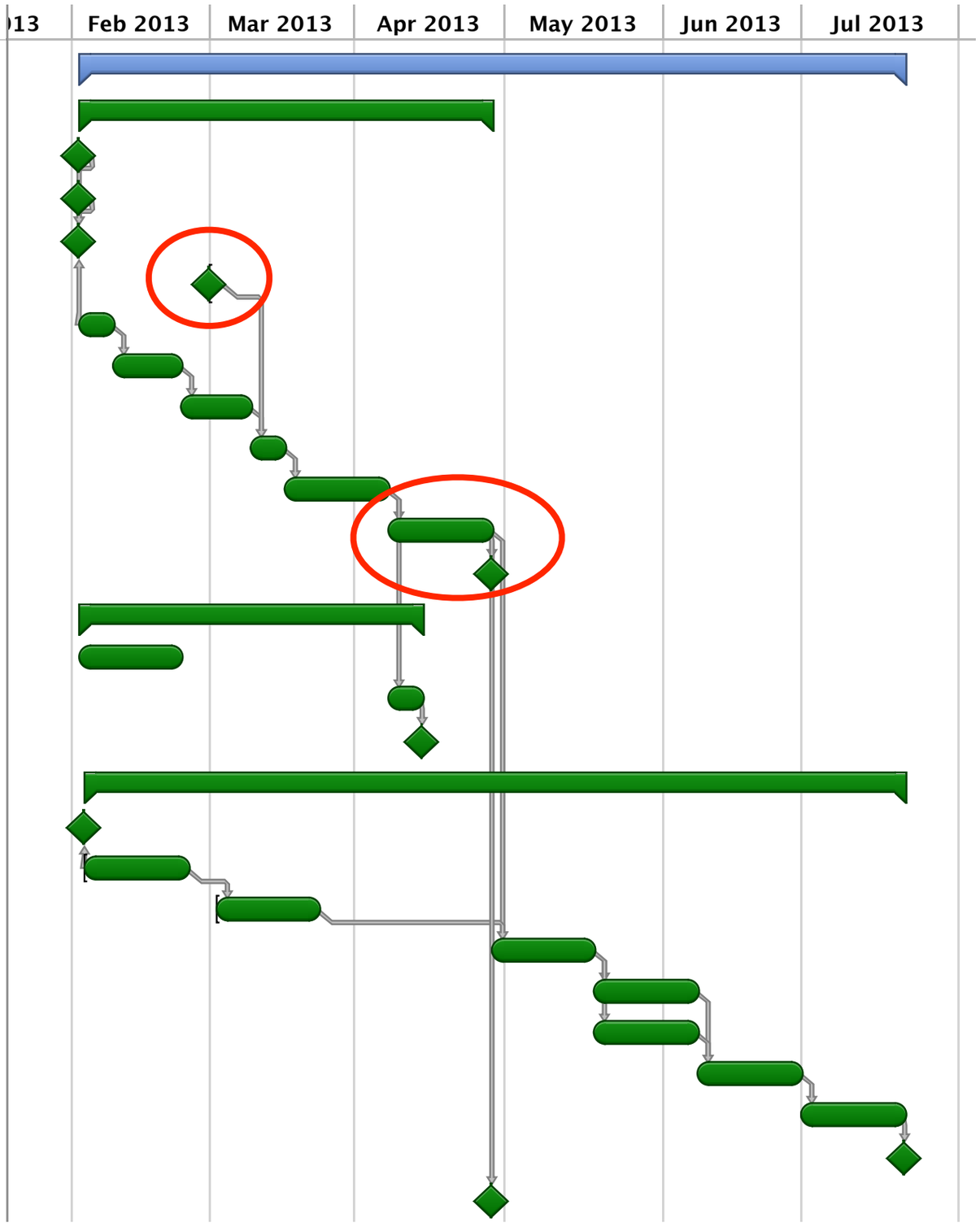
Recent Developments

- Granted NSF-DCL grant for R&D towards DS-G2
- Funding ($0.95M) of expansion of extraction plant (50 kg/day) granted in FY12 by NSF
- Completion of shields required for DS-50 & DS-G2 scheduled by December 2012

DS-50 Schedule

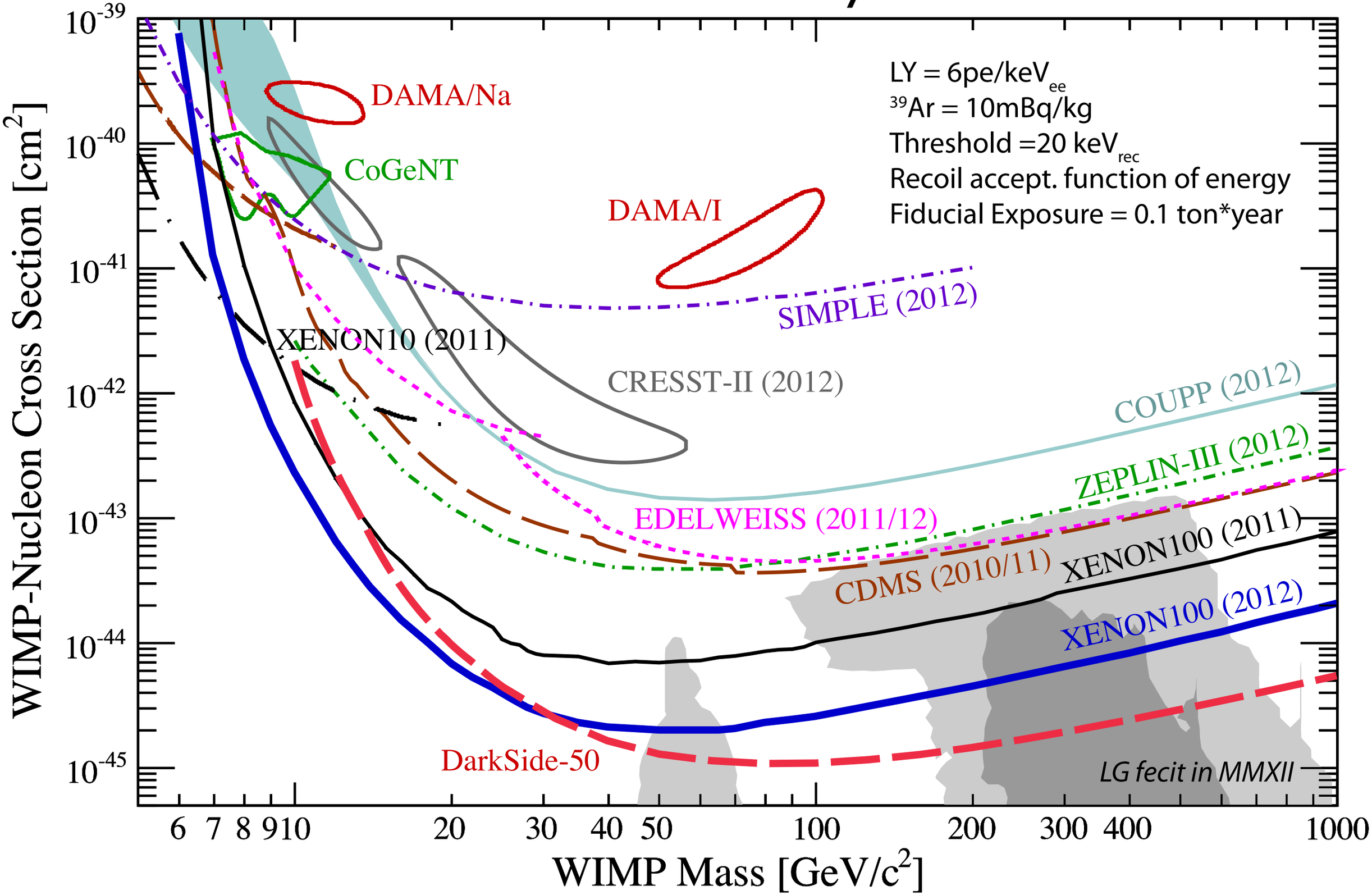
Title

- **1) DarkSide-50 Commissioning and Operations**
  - **1.1) TPC Commissioning**
    - *1.1.1) Installation of Inner Detector DAQ*
    - *1.1.2) Delivery of System Control*
    - *1.1.3) Start of TPC Commissioning in UAr cryostat*
    - *1.1.4) Completion of DAQ commissioning and debugging*
    - 1.1.5) Initial Checkout in Clean Room
    - 1.1.6) UAr cryostat/TPC insertion in LSV/CTF
    - 1.1.7) Prep work for first cool-down
    - 1.1.8) Cool-down and fill with atmospheric Ar
    - 1.1.9) Detector Checkout
    - 1.1.10) TPC Performance evaluation
    - *1.1.11) Completion of TPC Commissioning in LSV*
  - **1.2) Ar Supply & Recovery System Commissioning**
    - 1.2.1) Tests Ar Supply System @ LNGS
    - 1.2.2) Test of Ar Recovery System
    - *1.2.3) Completion of Ar Supply & Recovery System Commissioning*
  - **1.3) Outer Detectors Commissioning**
    - *1.3.1) Start of Outer Detectors Commissioning*
    - 1.3.2) Neutron Veto & Fluid handling system prep work
    - 1.3.3) Neutron Veto PMTs test with Optical Fibers in N2
    - 1.3.4) Fill LSV with Liquid Scintillator
    - 1.3.5) Neutron Veto PMTs test in Liquid Scintillator
    - 1.3.6) Muon Veto prep work and PMTs test
    - 1.3.7) Fill Water Tank with water
    - 1.3.8) Muon Veto PMTs test in water
    - *1.3.9) Completion of Outer Detectors Commissioning*
  - *1.4) Start of Physics Data*



Backups

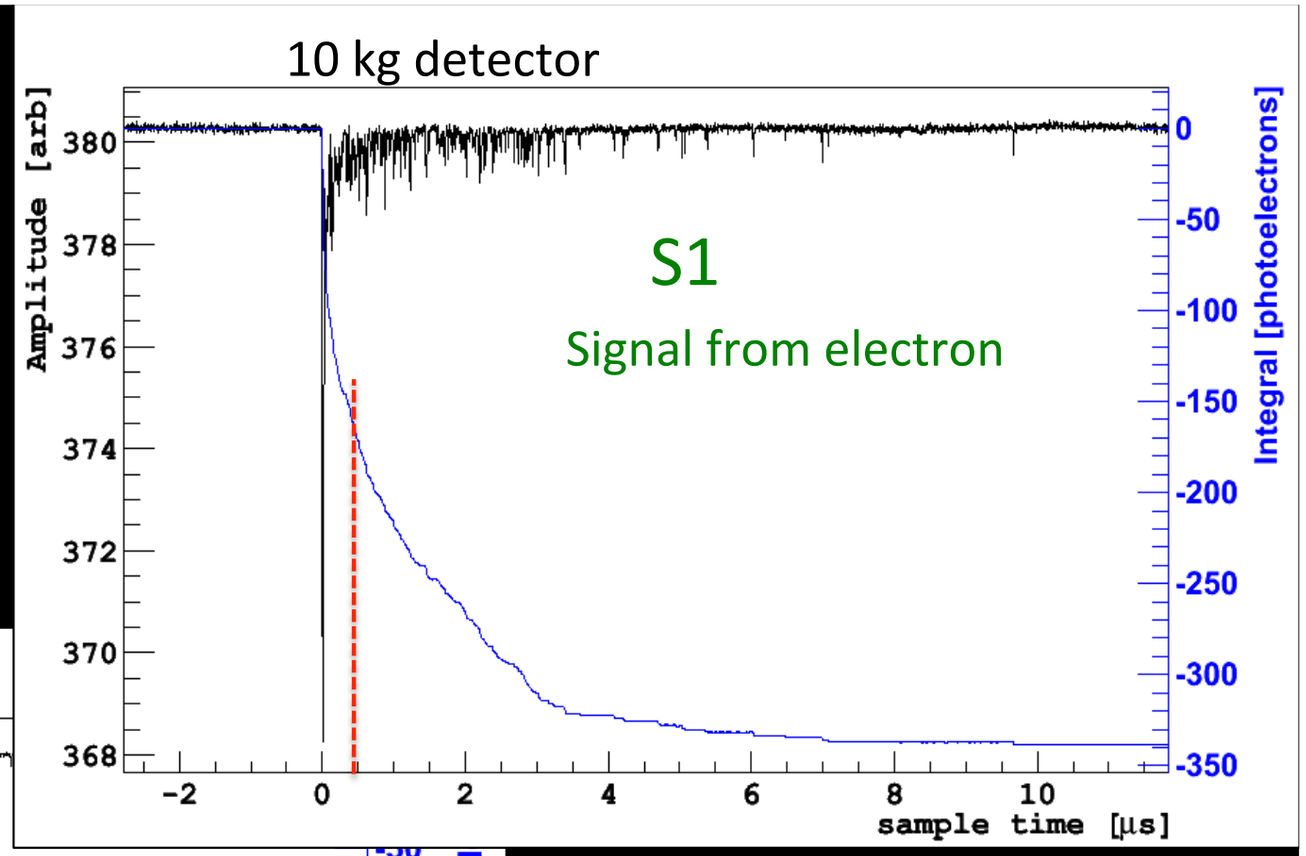
DarkSide-50 Sensitivity Plot

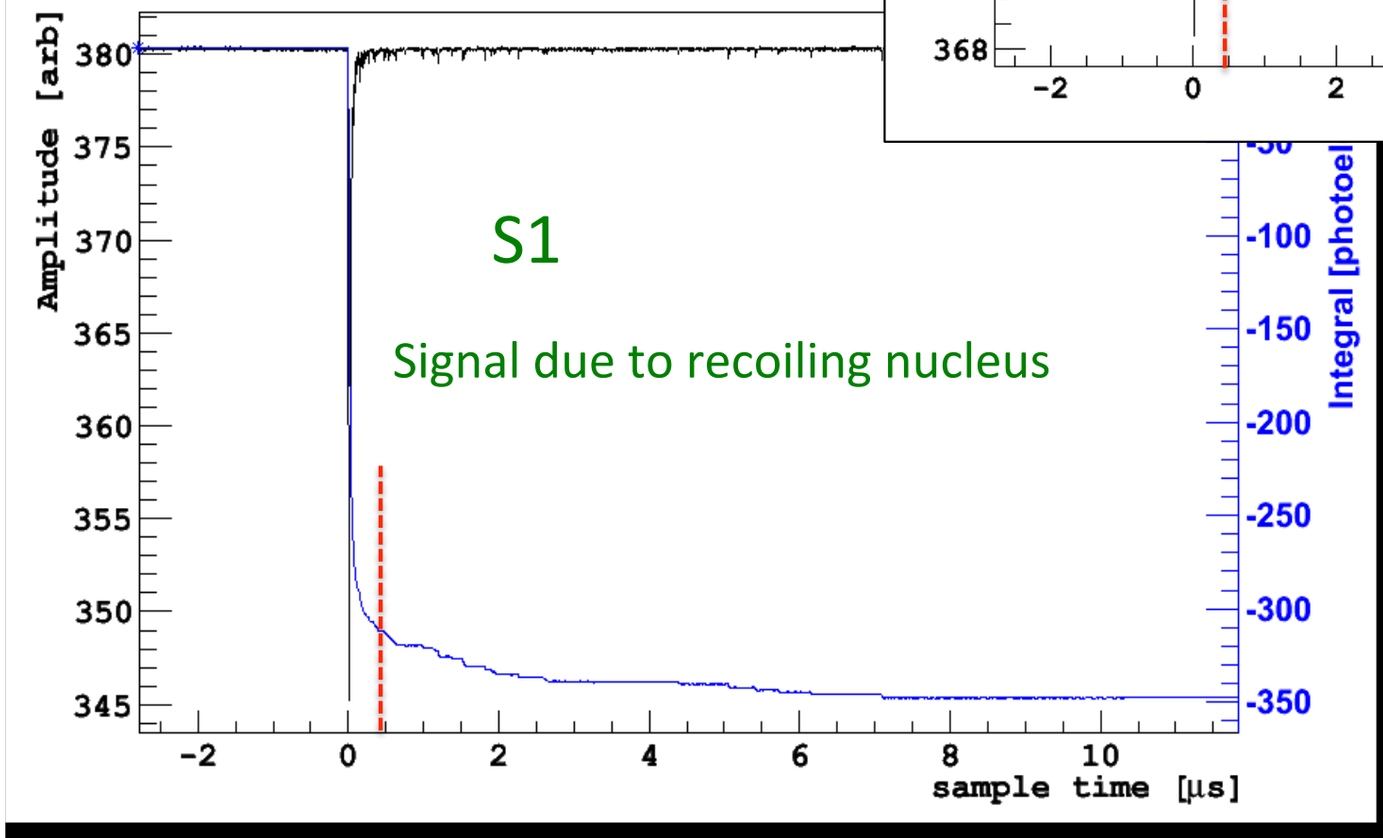


S1 signal shapes for

Electron event →

Nuclear recoil event ↓





Define **f90** =

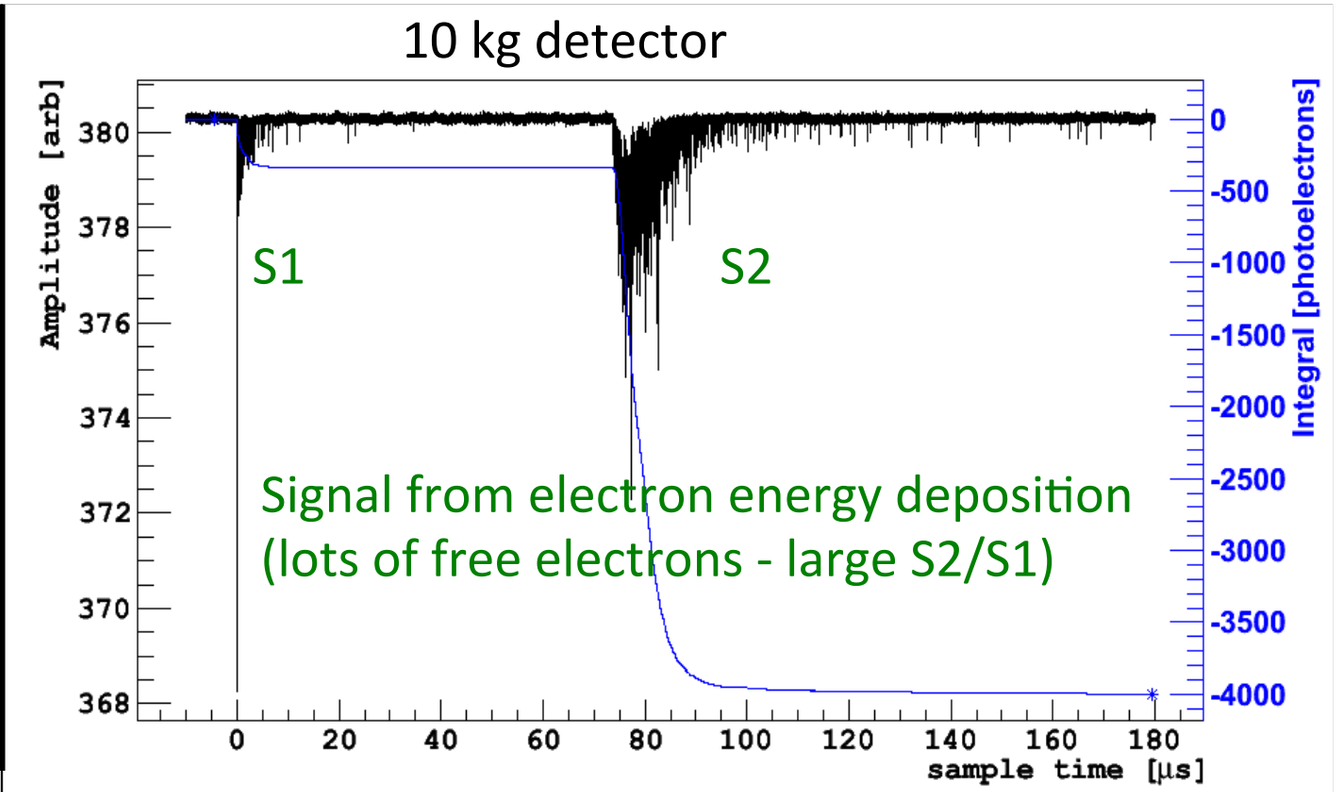
Fraction of integral in first 90 ns

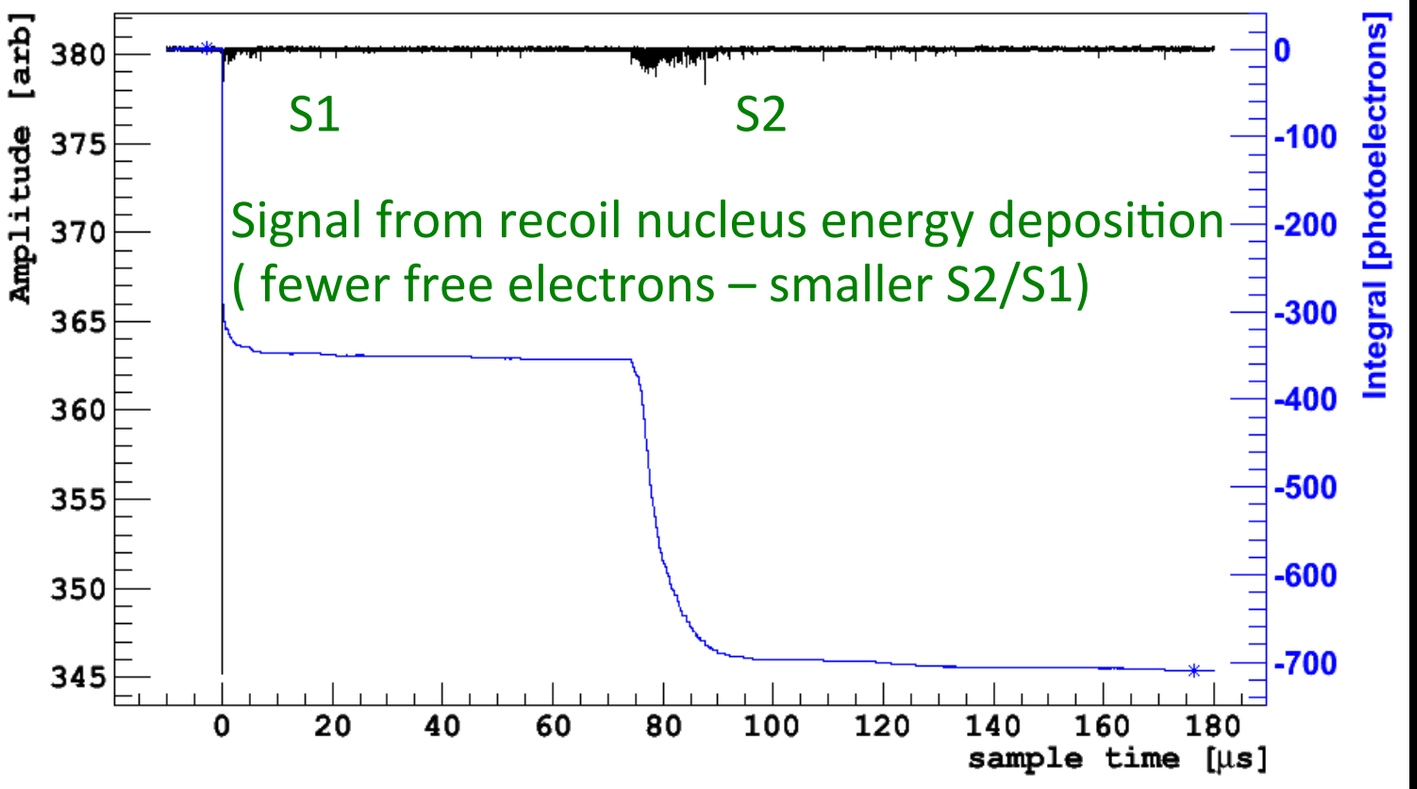
S1 & S2 signals

Electron event →

Nuclear recoil event

↓





Use **log(S2/S1)**
as discriminant