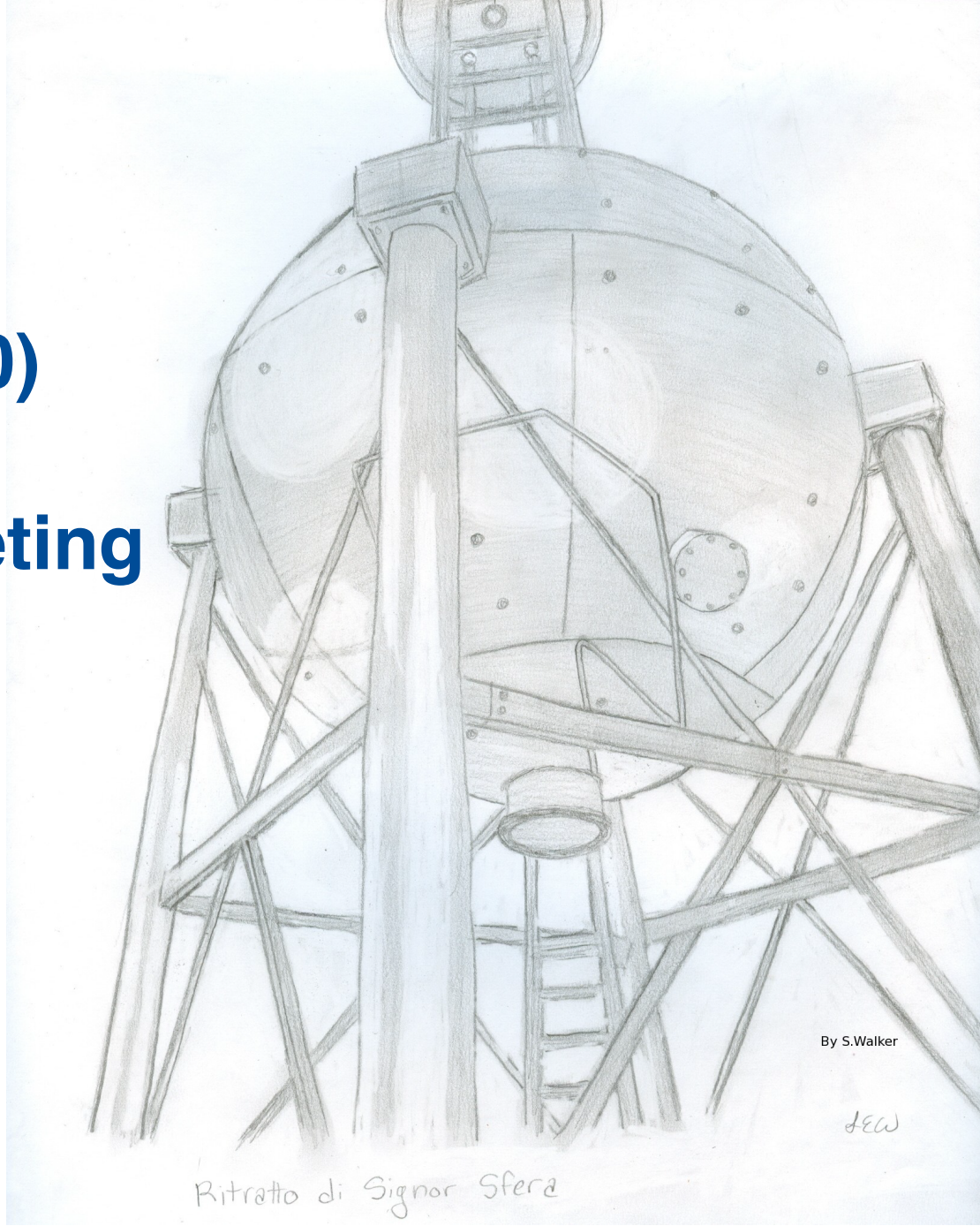
Fermilab

DarkSide-50 (E1000) report to All Experimenters Meeting



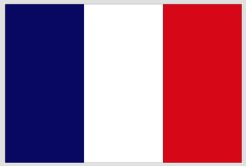
Stephen Pordes

All Experimenters Meeting

Feb 9 2015

The DarkSide Collaboration

IHEP



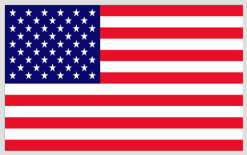
APC, Université Paris Diderot
IPHC, Université de Strasbourg

INFN LNGS & GSSI
INFN & Università Genova
INFN & Università Milano
INFN & Università Federico II Napoli
INFN & Università Perugia
INFN & Università Roma Tre
INFN & Università Cagliari

Jagiellonian University

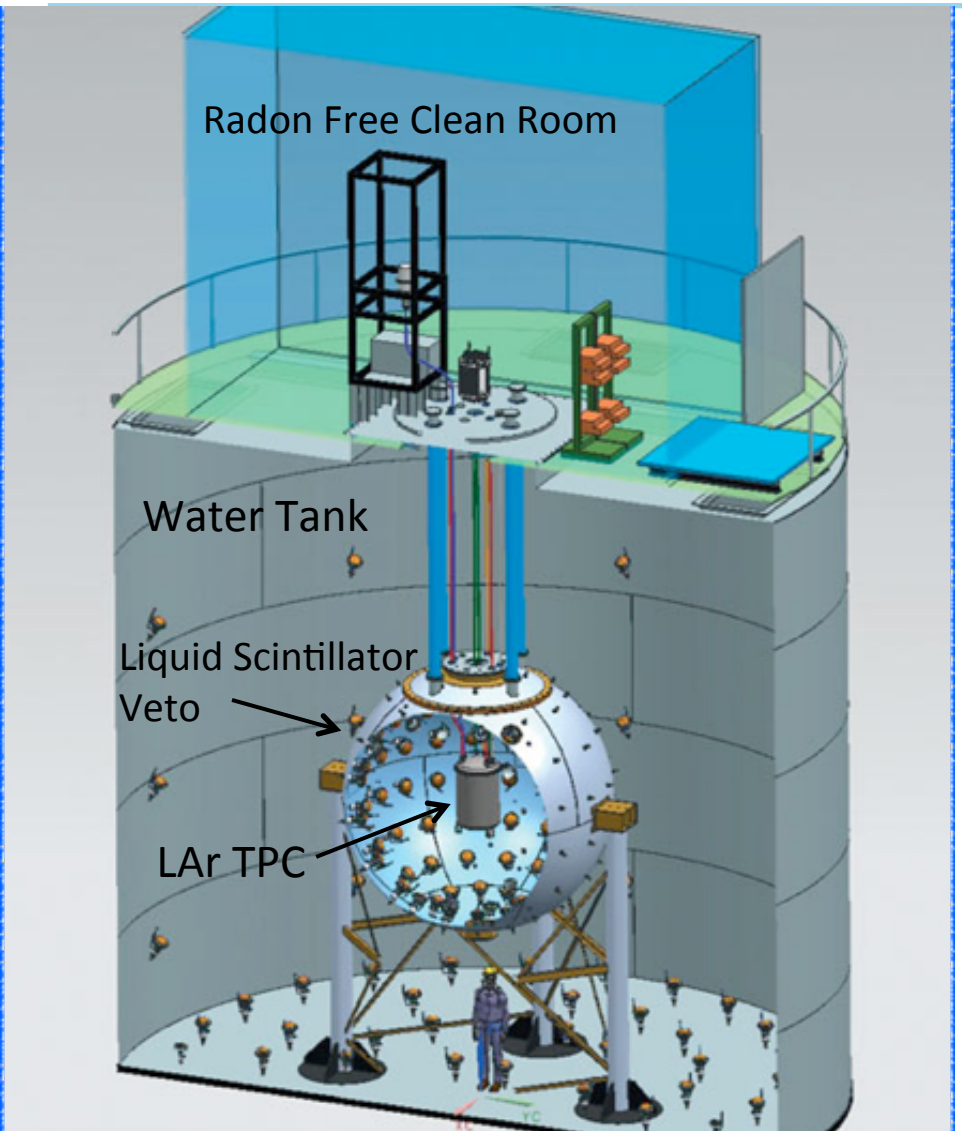
KINR, NAS Ukraine

Joint Institute for Nuclear Research – Dubna
Lomonosov Moscow State University
Kurchatov Institute – Moscow
Saint Petersburg Nuclear Physics Institute



Augustana (SD)
Black Hills State
Fermilab
PNNL
Princeton
SLAC
Temple University
University of Arkansas
UCLA
University of Chicago
University of Hawaii
University of Houston
University of Massachusetts
Virginia Tech

DarkSide-50 at LNGS Apparatus Schematic



LAr 2-phase TPC (50kg active, 150 kg total) 38 PMTs

Liquid Scintillator Veto
4 m sphere (30 tons) 110 PMTs

Water Cerenkov Veto
11m ϕ 10 m high (1 kt) 80 PMTs

3000 m.w.e overburden

2×10^{-45} cm^2 @ 0.1 t-yr exposure

Fermilab

Fermilab Technical Responsibilities in DarkSide-50

• DS-50 Argon system	C. Kendziora (PPD-MED)
• Underground Argon Purification	(H.Back*) (PAB)
• Trigger for TPC & Global Trigger	B. Baldin (PPD-EED)
• Data Acquisition (artdaq)	K. Biery (SCD)
• Offline framework (art)	art group (SCD)
• Data Transfer from Italy	CCD
• SAM, Fermigrid, OSG, Fife	Ken Herner (SCD)

* Princeton University

Fermilab

Activities since last report to AEM (June 2013)

- **Produced first paper on dark matter search**
- **Replaced biological based TMB (300 kHz 14C rate in veto) with oil based TMB**
- **Performed neutron and gamma calibrations of the TPC and veto**
- **Shipped ~140 kg of purified, underground (low-radioactivity) argon(UAr) to LNGS in preparation for fill in March.**

=> Period of intense activity to fill with UAr in March.

Fermilab

Activities to be able to insert Underground Argon (UAr)

- Installation and commissioning of final gettering system
- Connection between gettering system and DarkSide system
- Completion of Argon Recovery System – Cryocooler water lines, high-pressure compressor, gas-lines

  all argon and nitrogen piping to Helium leak-check standards
- Recovery system test (with atmospheric argon)
- Getter system test

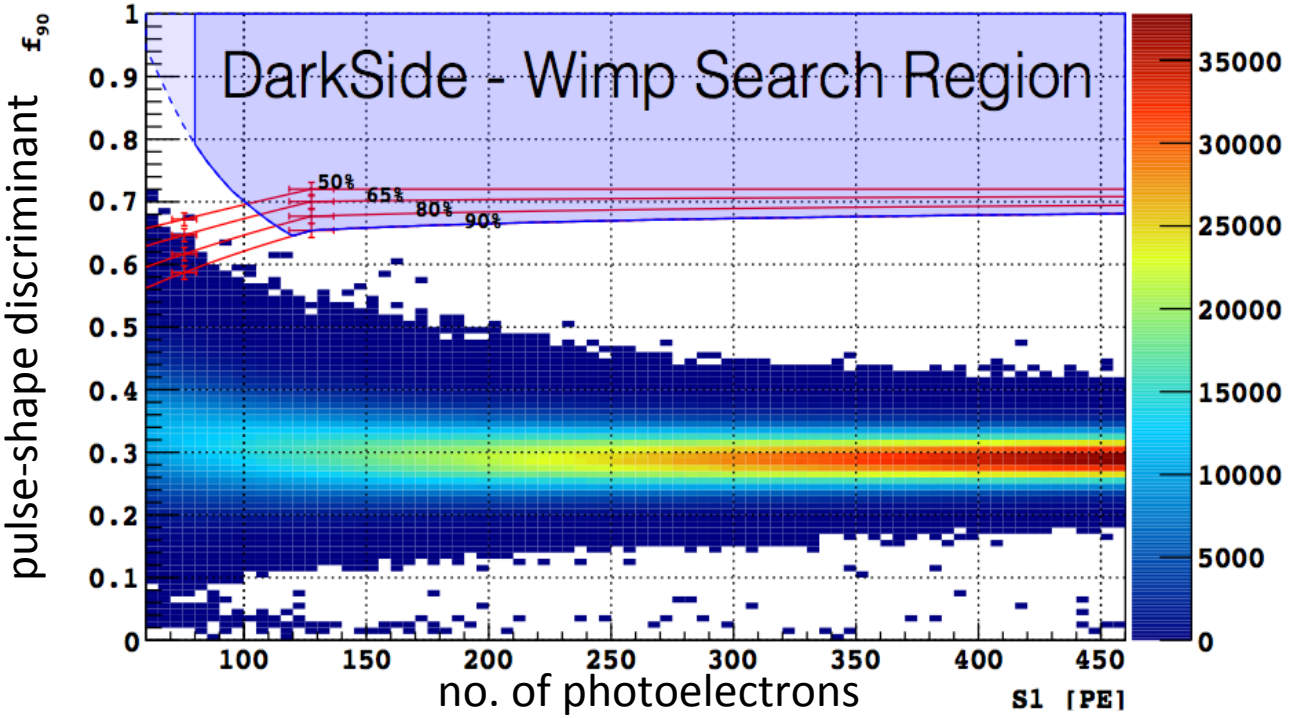
=> Empty DarkSide-50 mid-March

=> Fill with UAr 1 week later

=> Report to LNGS Scientific Committee 4-28-15

First DarkSide Result

- 1400 kg-days background free exposure with atmospheric argon
- equivalent to 0.6 tonne-yrs with underground argon
- **establishes rejection against electromagnetic backgrounds for t-yr exposures**



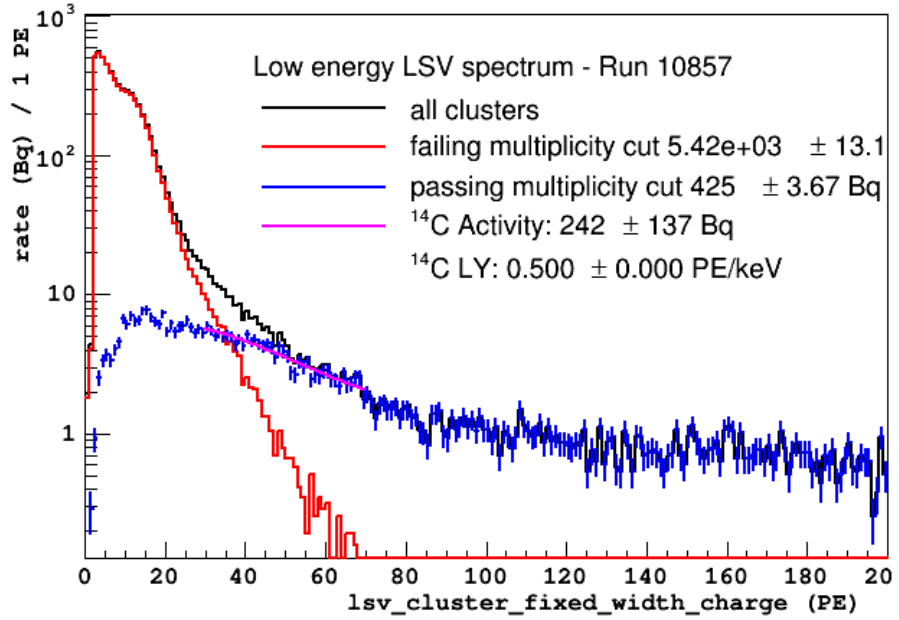
(E(keV) for electrons ~ S1/6, for nuclear recoils ~S1/2)

TMB Replacement in Liquid Scintillator ..

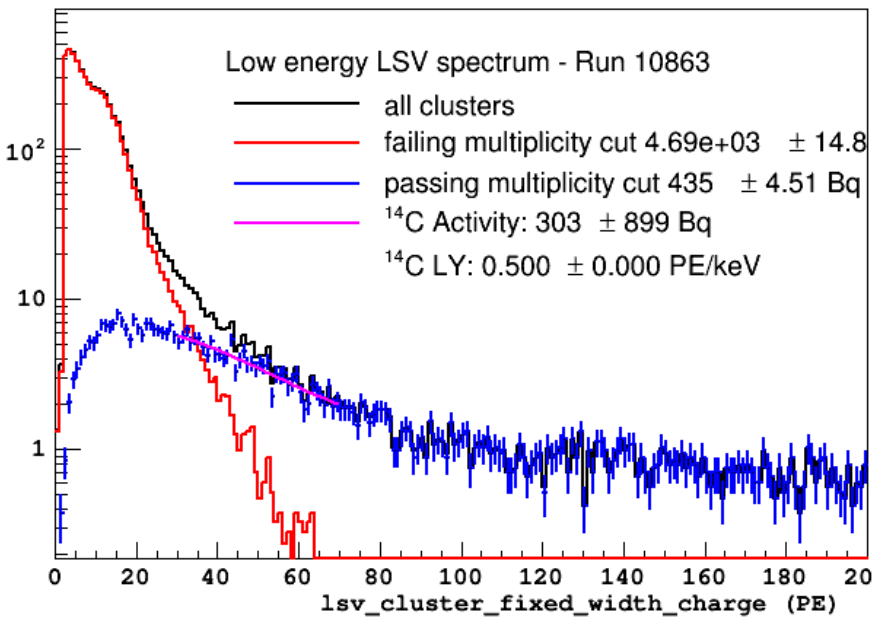
Replaced 15 tons of TMB with 13.5 tons PC and 1.5 tons new TMB

- Rate in veto does not change with addition of the new TMB.
- Dead time from any activity in scintillator veto, 100 us window ~ 20% (cf original 300 kHz rate from ^{14}C)

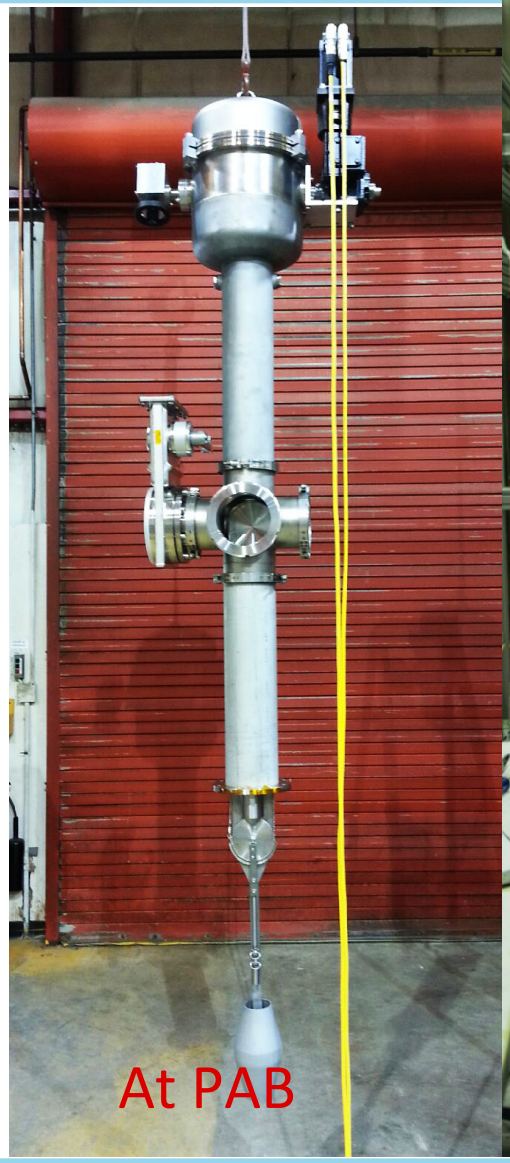
Rates after insertion of 0.5 t of TMB



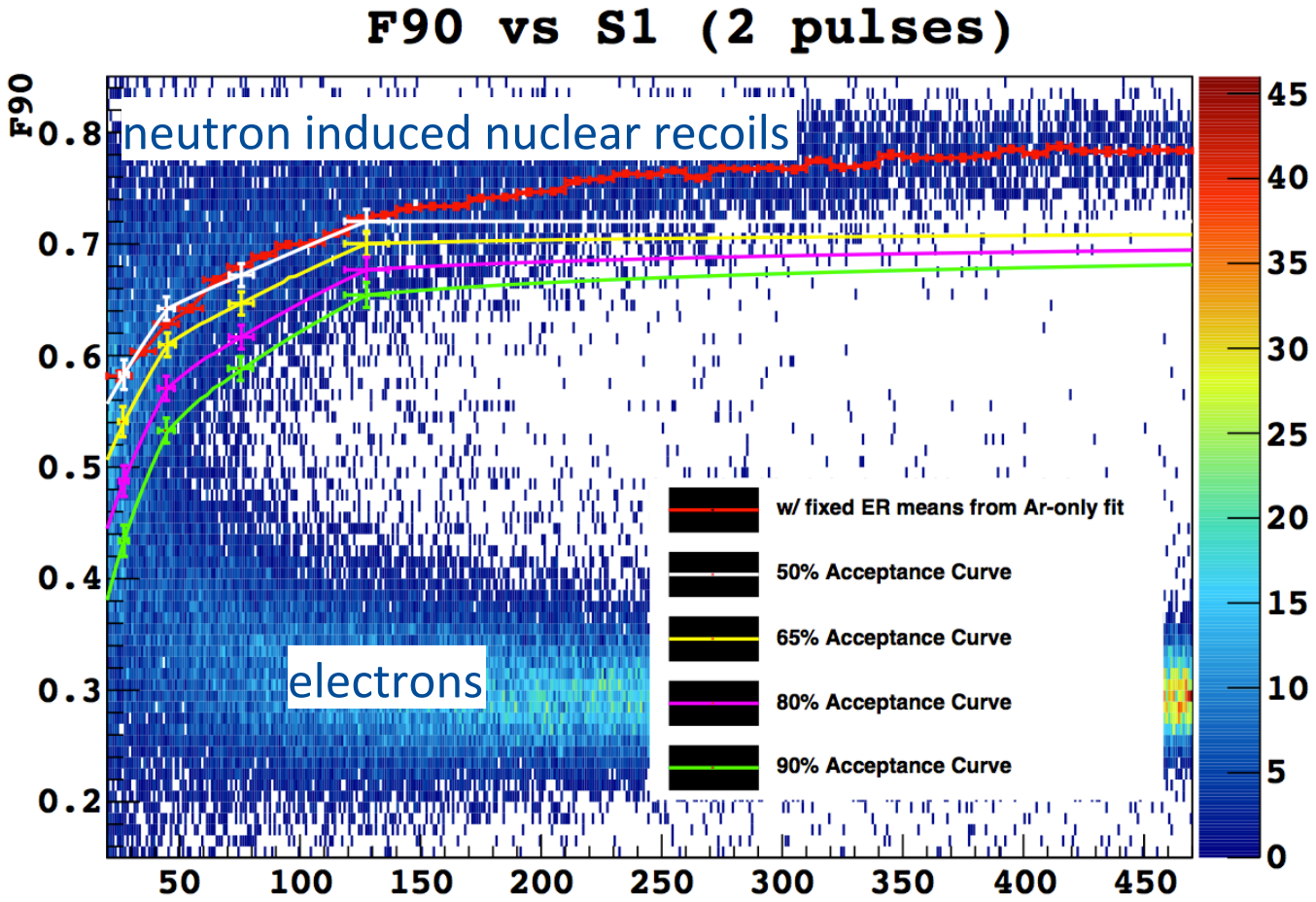
Rates after insertion of 1.5 t of TMB



Calibration System



Preliminary Neutron Calibration Data:



Red is 50% Nuclear Recoil acceptance contour measured in DarkSide-50; White is contour from SCENE data used in paper

Underground Argon:

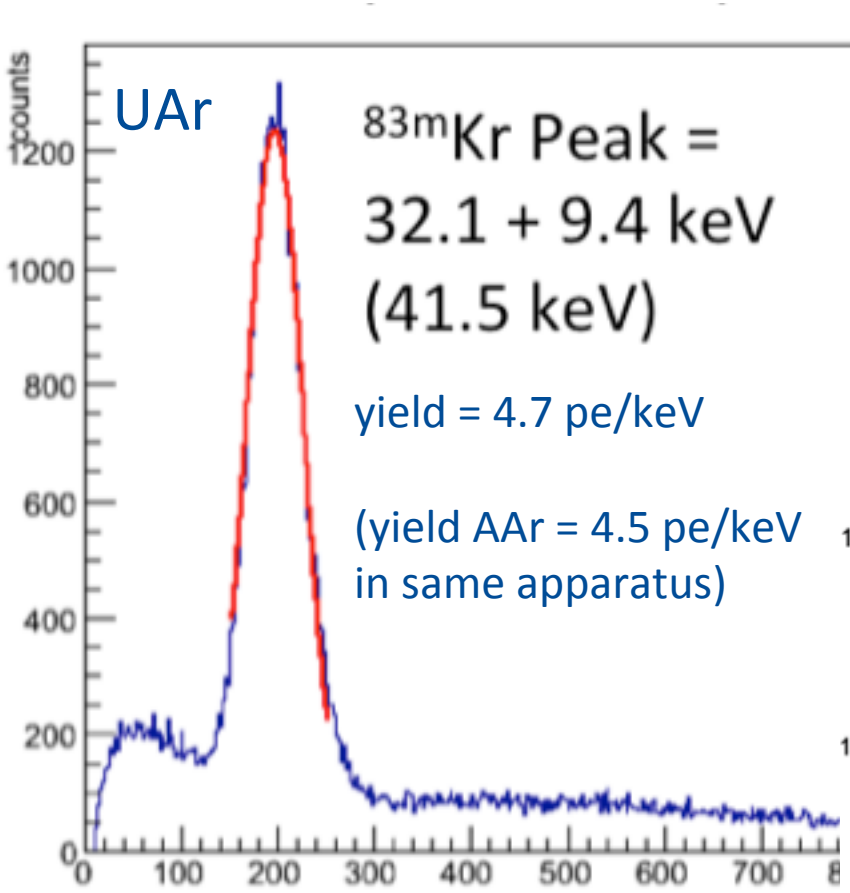
Nearing end of a long saga

- Need 153 +/-3 kg;
- have shipped (by boat) 141 kg (left PAB 12/19/14) to arrive LNGS ..
- will have another 15 kg by end February – ship by air to LNGS ..
- final `polishing' at LNGS using Fermilab-built gettering system
- LNGS Scientific Committee `expects' report at April 28 meeting ..

Validated that the purified argon is detector quality:

Underground Argon: tested at PAB in SCENE apparatus

Good light yield, good slow component lifetime, good drift (not shown)



UAr

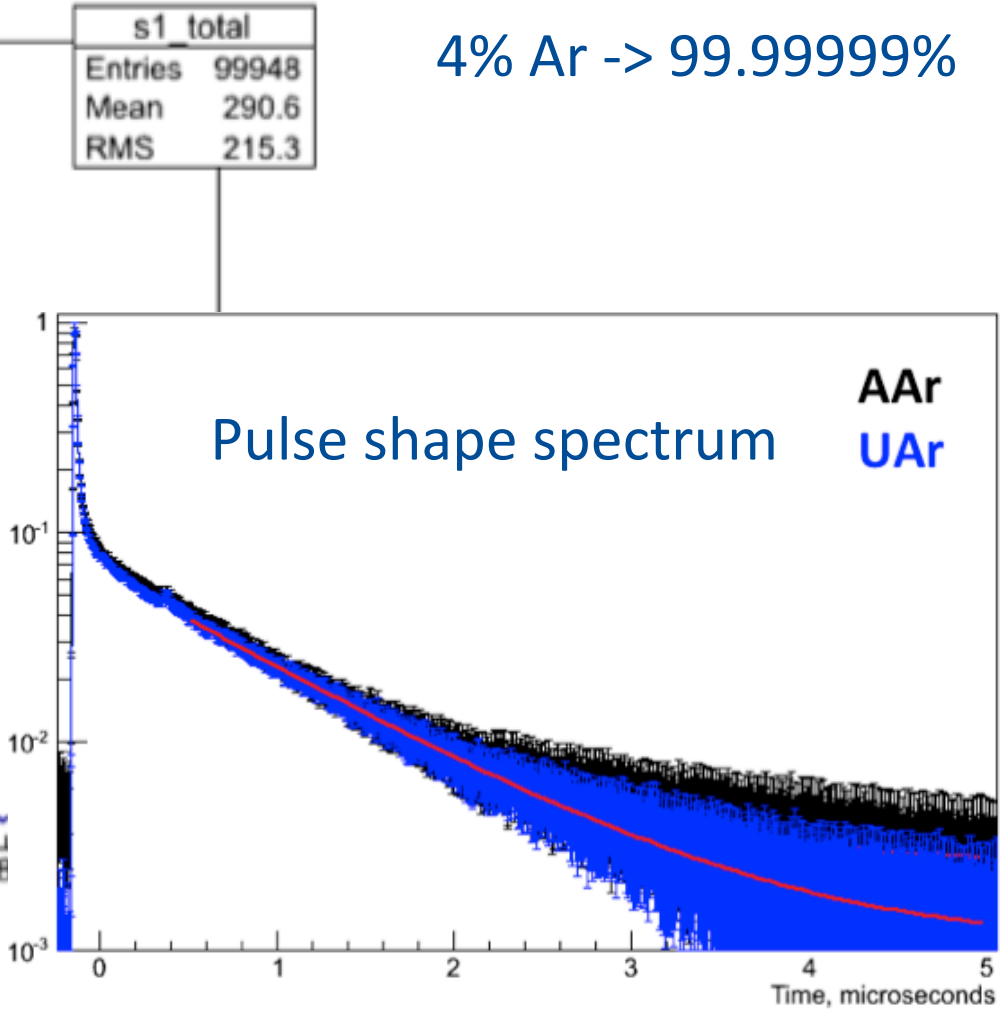
^{83m}Kr Peak =

32.1 + 9.4 keV

(41.5 keV)

yield = 4.7 pe/keV

(yield AAr = 4.5 pe/keV in same apparatus)



Pulse shape spectrum

4% Ar -> 99.99999%

work of Tom Alexander

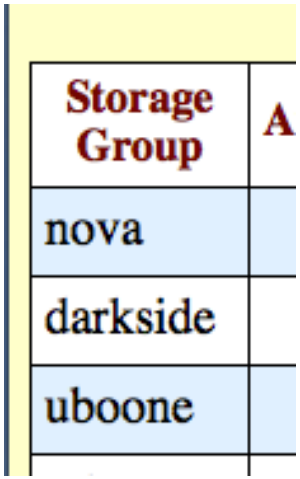
Fermilab

Computing Support – SCD & CCD

Fermilab plays essential role: base for all U.S. groups

Data transfer LNGS to FNAL – typically only a few hours behind
data will come from CNAF

Data storage – we are using ~ 550 TB, arranged smoothly



Storage Group	A
nova	
darkside	
uboone	

Processing – typically not a load at all. One huge MC took 250,000 cpu hours; do not expect a repeat.
Reprocessing entire data set takes ~100,000 cpu hours.
Data rate with UAr will be much lower (2 Hz cf 15 Hz now)

Summary of DarkSide-50 status

Demonstrated power of Argon to reject electromagnetic bacgrounds

Fixed the scintillator veto from radio-active TMB

Detector, DAQ, Data Transfer-Storage-Processing all working smoothly

First neutron and gamma calibration campaign completed

Going through final activities with atmospheric argon

Working hard with preparations for underground argon

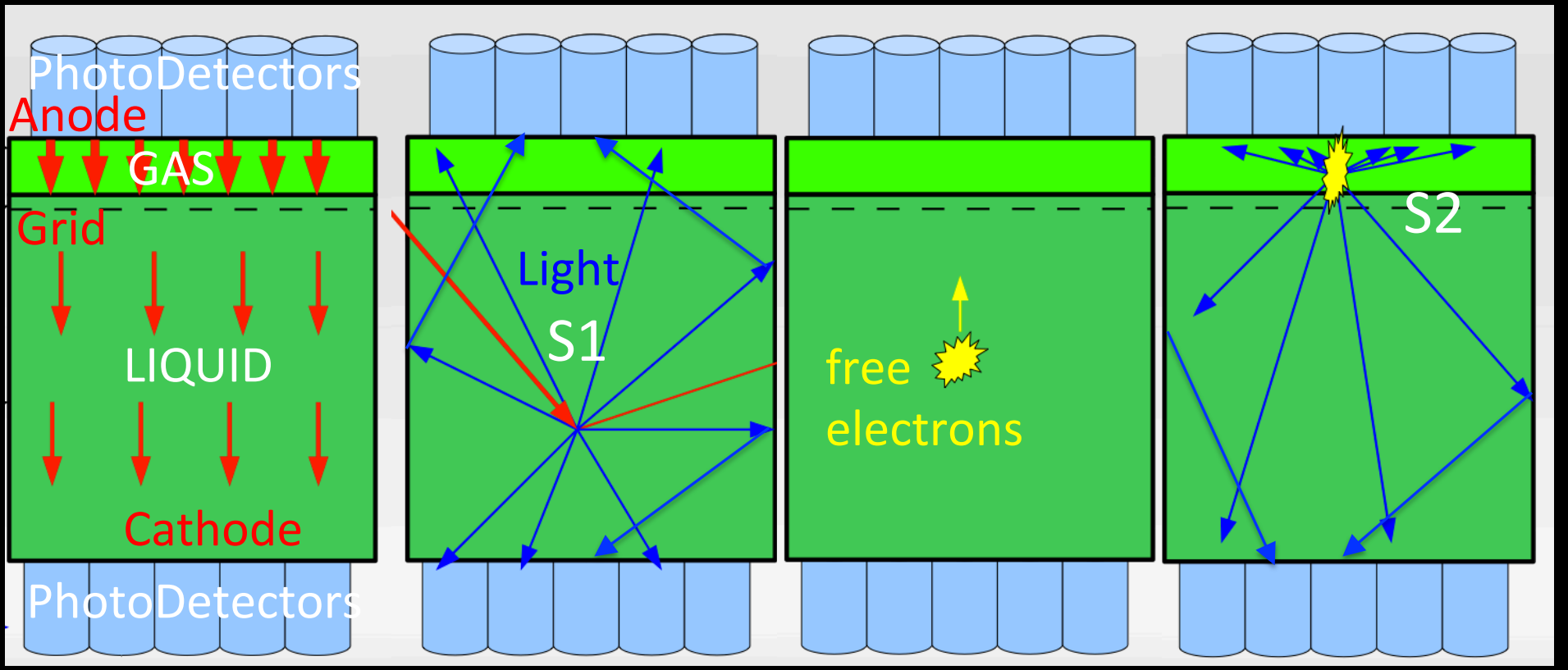
Fermilab support has been and is essential and much appreciated

Fermilab

FIN

Back-ups

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



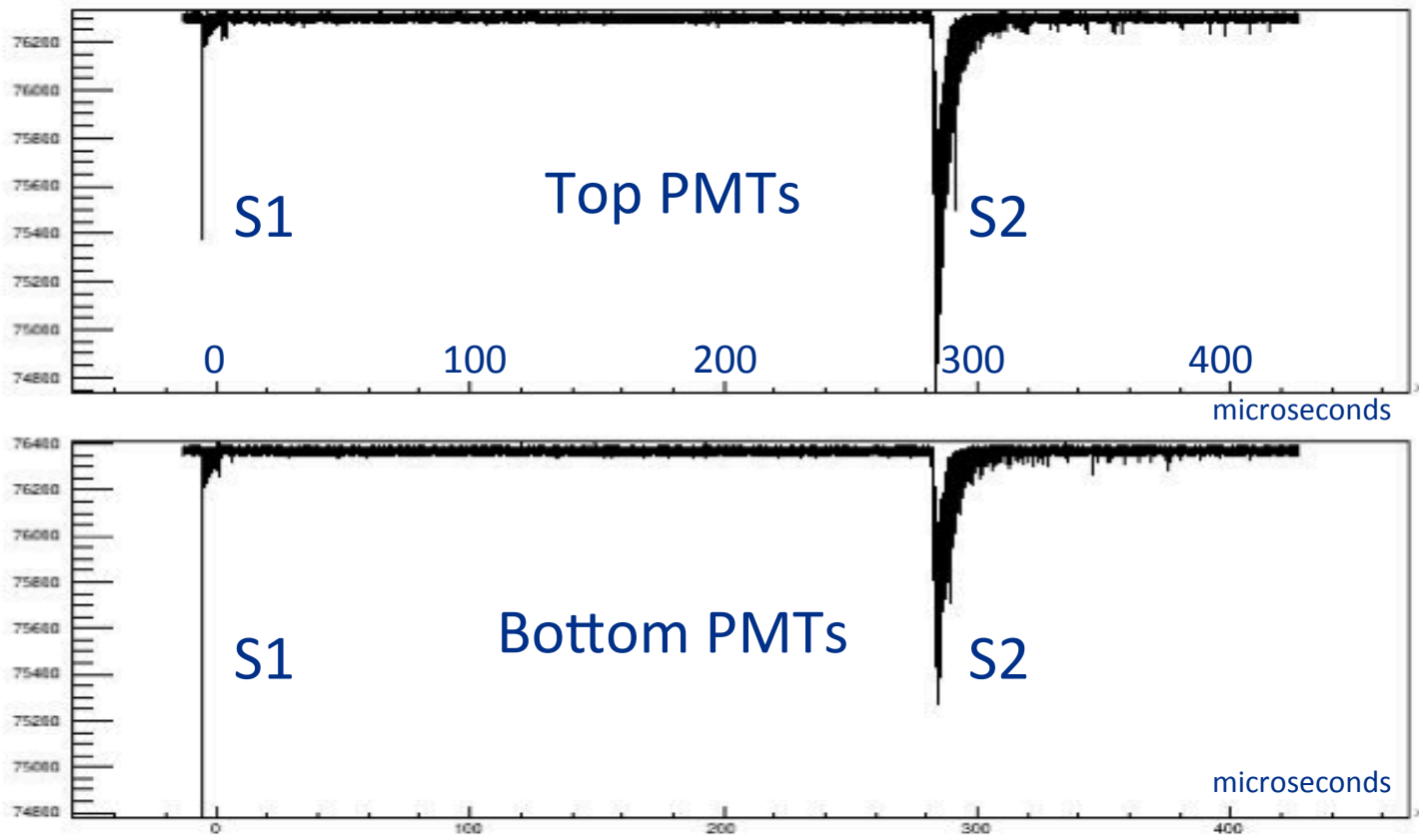
Liquid Phase;
Gas Pocket above;
Electric Field in both.
~ 1kV/cm (Liquid),
Few kV/cm (gas)

WIMP interacts;
Nucleus Recoils
Argon produces light and free electrons

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

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

Typical event waveform



Event data = 440 us x 38 x 250 MHz x 2 bytes ≈ 8.5 x 10^6 bytes ..

Event rate from 39Ar decay ~ 50 Bq; trigger rate in ROI ~ 15 Hz ..

DAQ readout rate ≈ 120 MB/s (fully live at this rate) – can go x 3 faster

Huffman compression factor ~ 5 => 25 MB/s to disk at LNGS, and dCache at FNAL

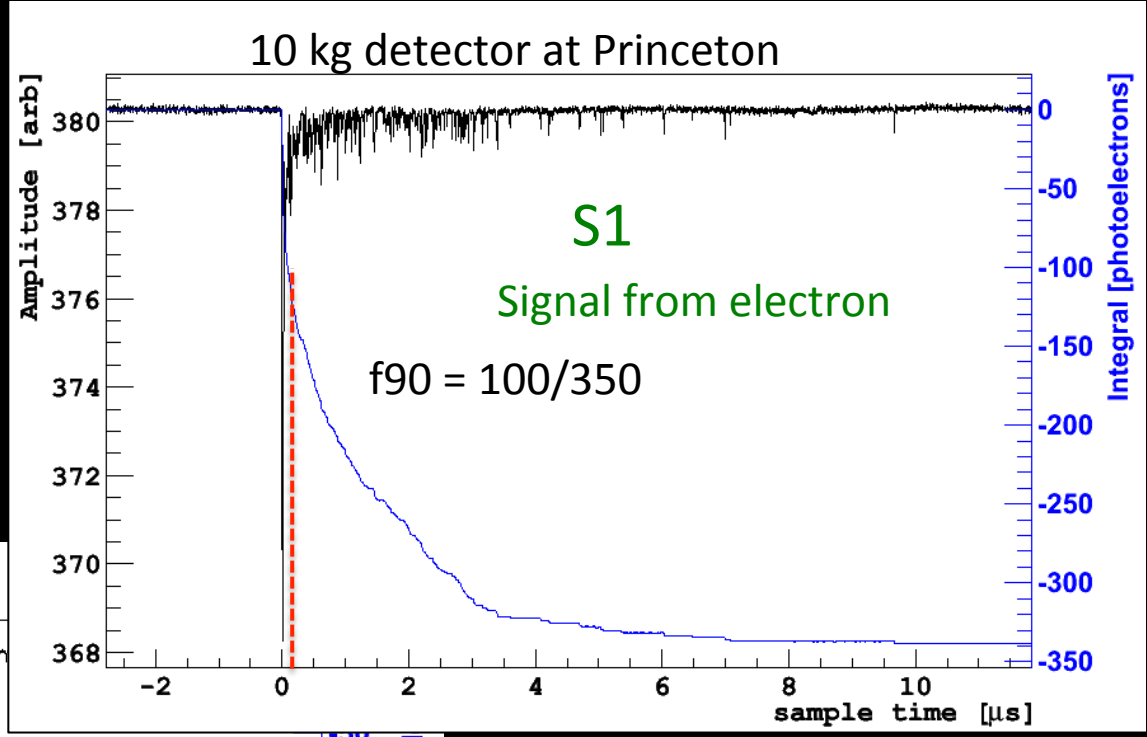
****** with underground (low-radioactivity) argon, trigger rate ~ 3 Hz or less *******

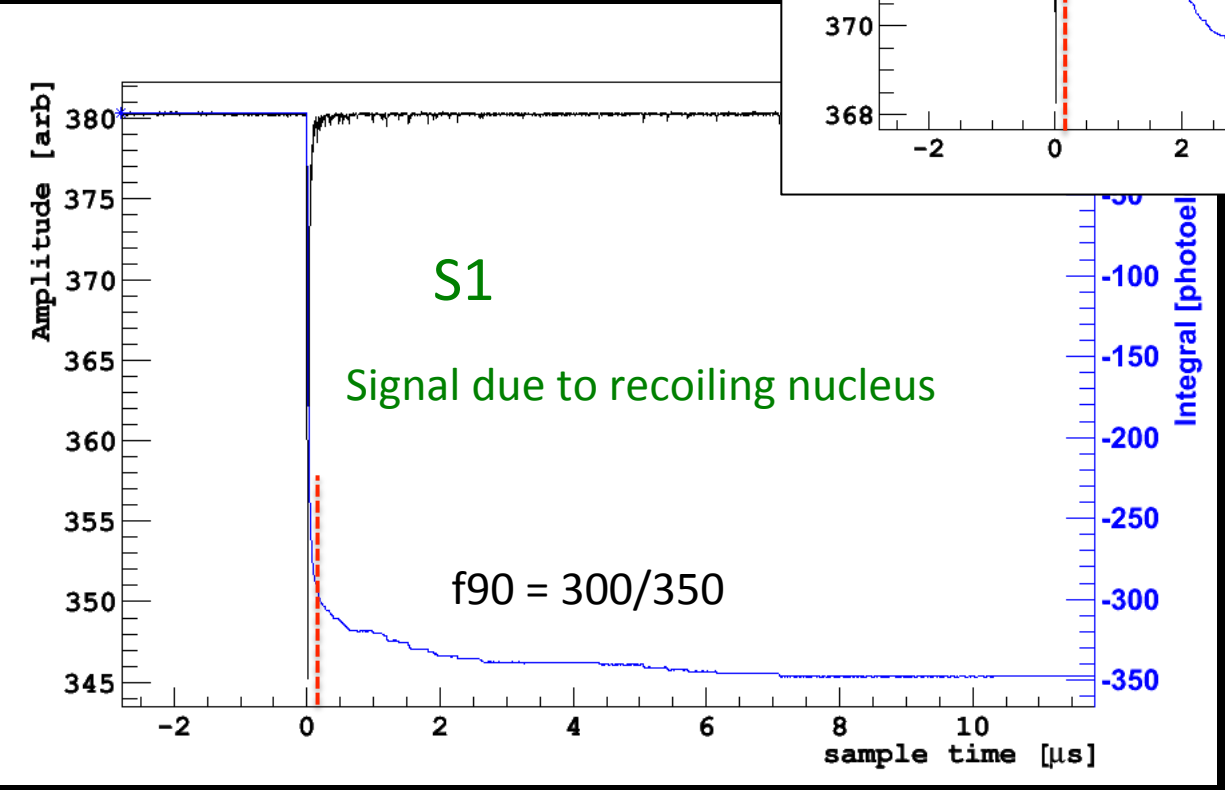
Fermilab

S1 signal shapes for

Electron event →

Nuclear recoil event ↓





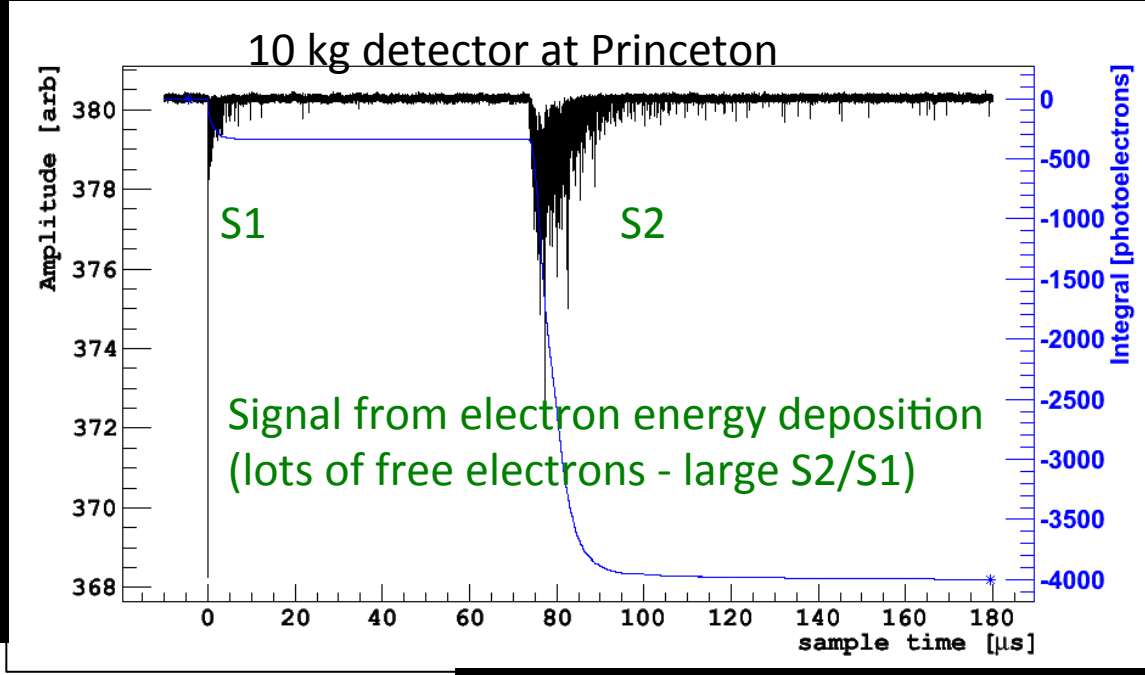
Define **f90** =

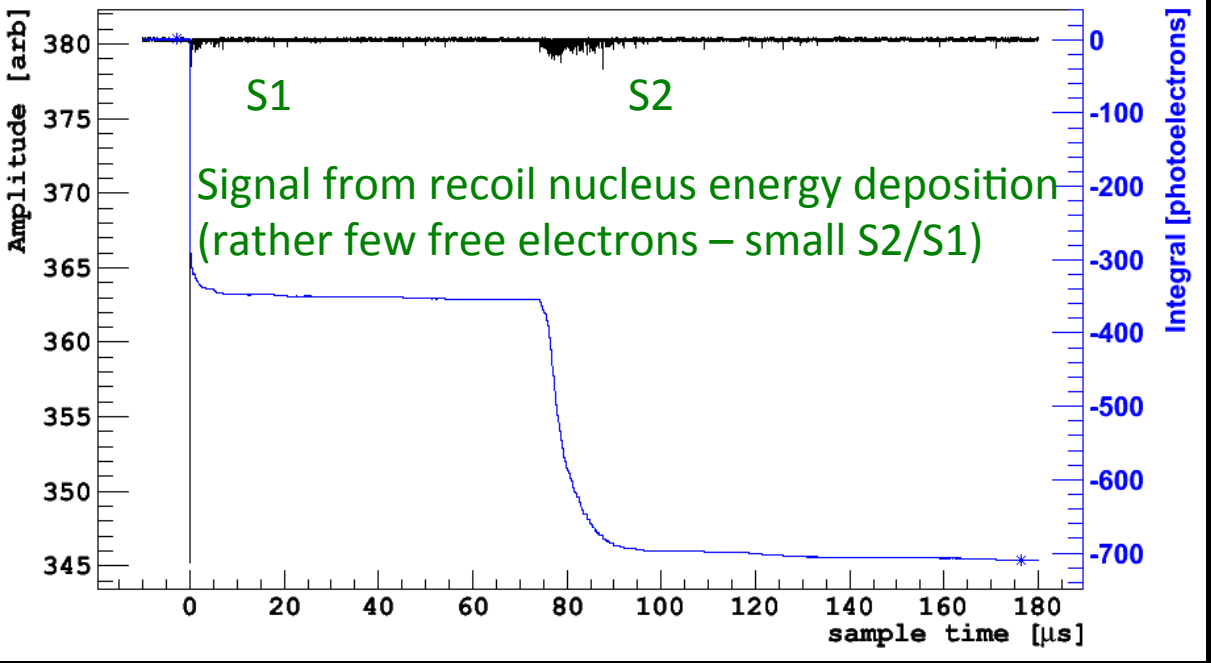
Fraction of integral in first 90 ns

S1 & S2 signals

Electron event →

Nuclear recoil event ↓

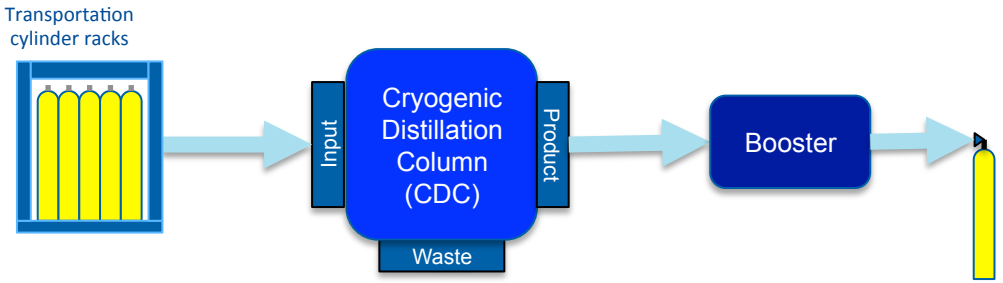




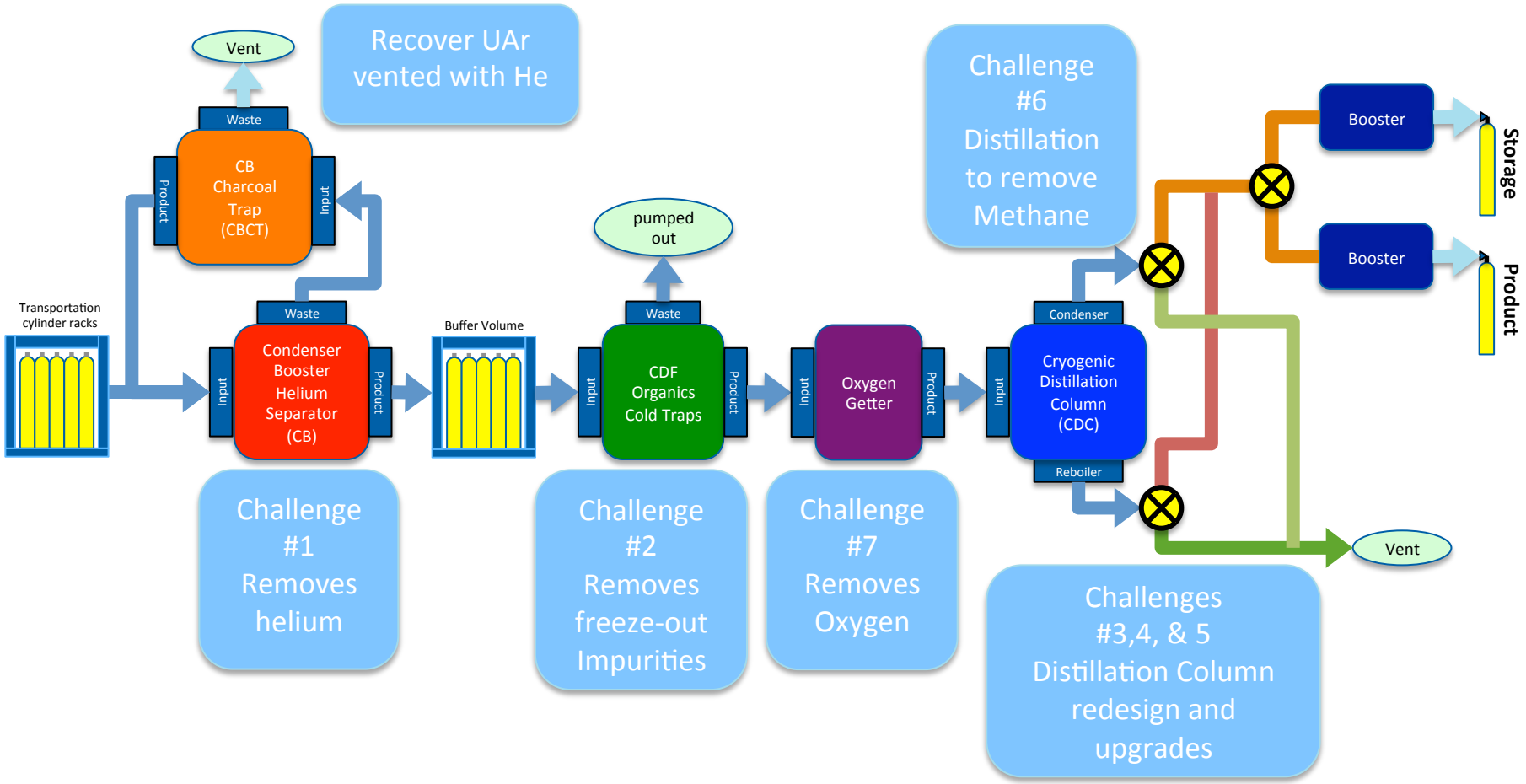
Use **log(S2/S1)**
as discriminant

Underground Argon Purification at FNAL

original system design



Underground Argon Purification: Final System Schematic



work of Henning Back (Princeton)