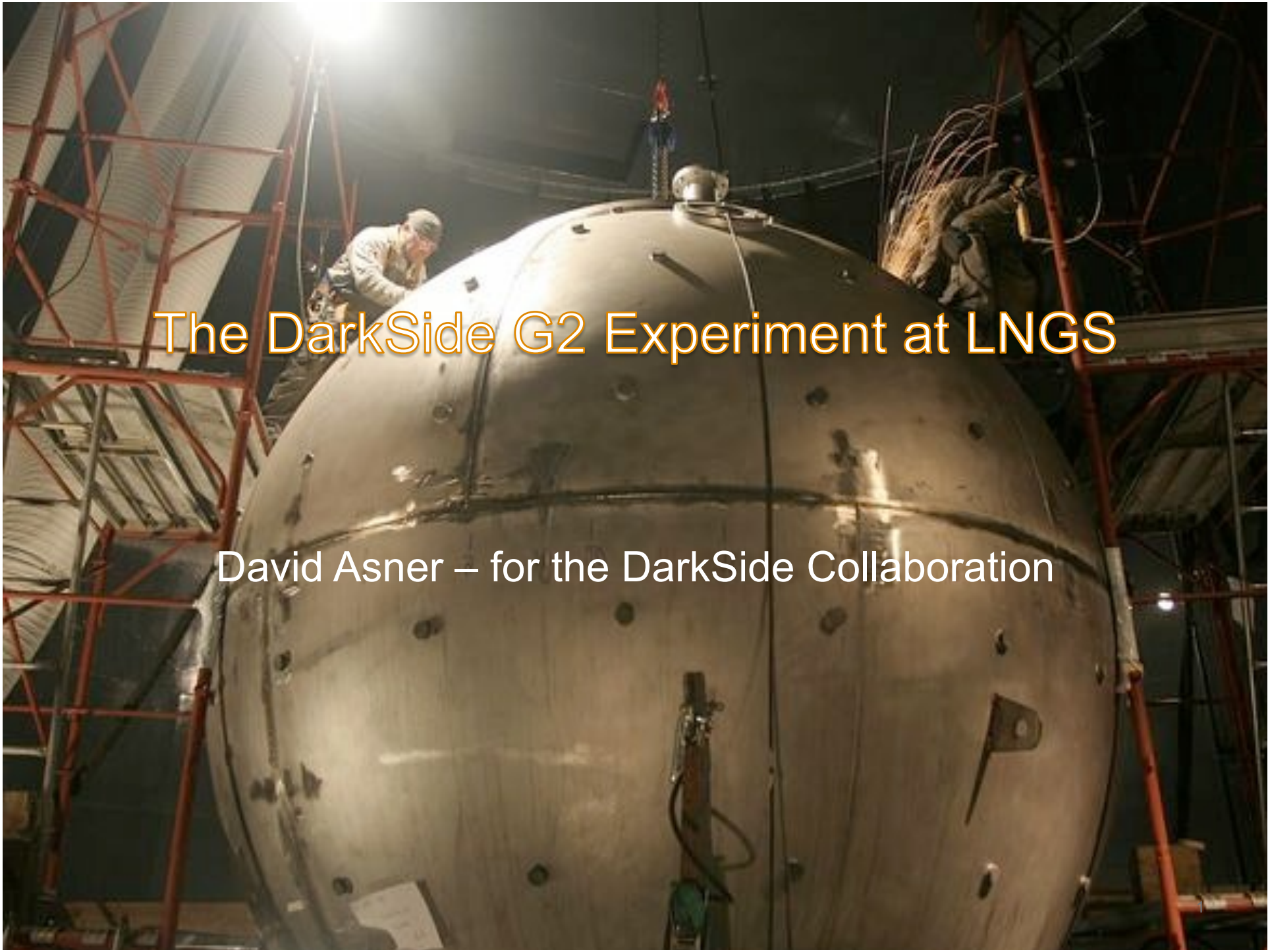

The DarkSide G2 Experiment at LNGS

David Asner – for the DarkSide Collaboration

DarkSide Collaboration supported by NSF, DOE, INFN, and other agencies

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- USA
  - Augustana College
  - Black Hills State University
  - University of Chicago
  - University of Hawaii
  - University of Houston
  - University of Massachusetts
  - **Princeton University**
  - Temple University
  - UC Davis
  - UCLA
  - Virginia Tech
  - BNL, **FNAL**, LLNL, PNNL, SLAC

US is ~1/2 the collaboration

- Italy
  - **INFN LNGS**
  - Gran Sasso Science Institute
  - INFN and Università degli Studi
    - Genova, Milano, Napoli, Perugia, Roma 3
- Russia
  - Joint Institute for Nuclear Research
  - SINP, Lomonosov Moscow SU
  - NRC Kurchatov Institute
  - St. Petersburg NPI
- France
  - Universite de Strasbourg
  - APC Universitè Paris 7 Diderot
- Poland - Jagiellonian University
- Ukraine – Institute for Nuclear Research
- China - IHEP

DarkSide in LNGS Hall C

DArKSIDE STRATEGY

Multi-stage program searching for dark matter direct interactions in low-background detectors deployed at Gran Sasso underground lab.

DArKSIDE STRATEGY

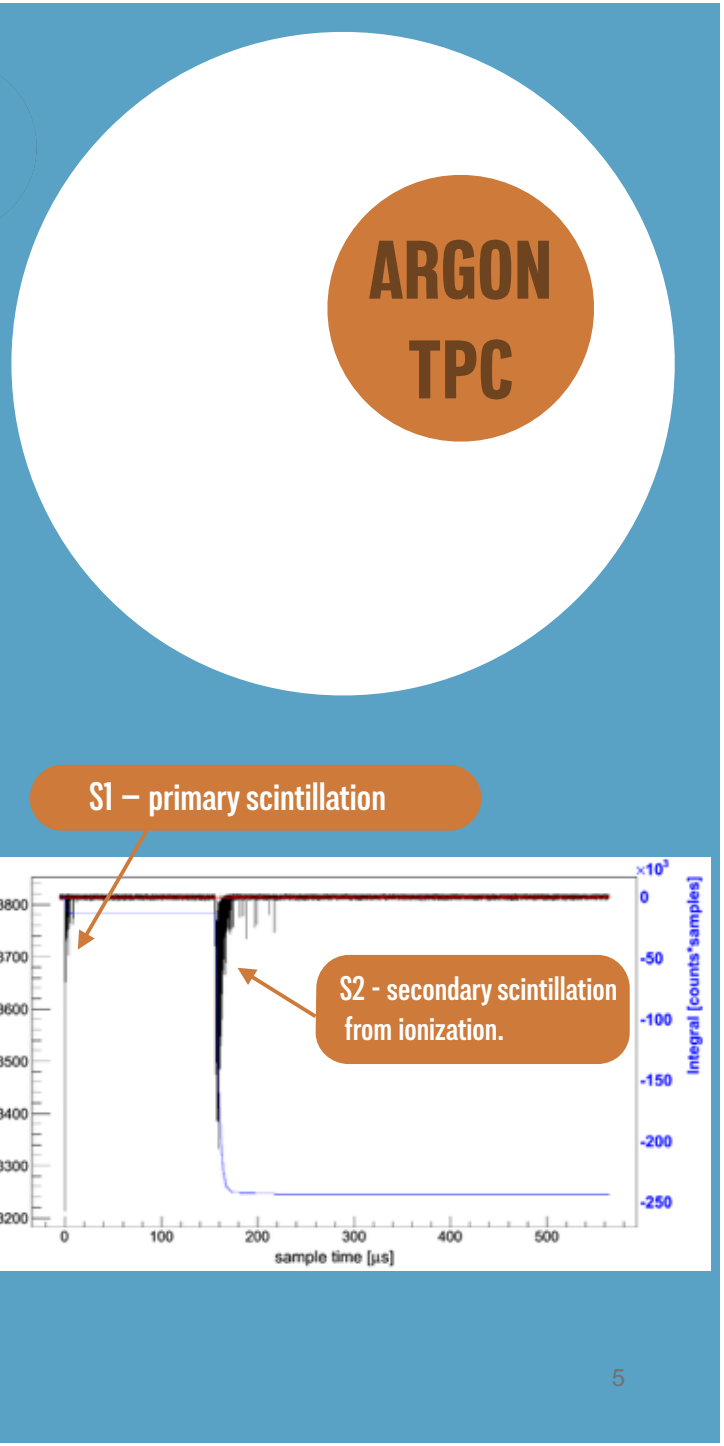
Multi-stage program searching for dark matter direct interactions in low-background detectors deployed at Gran Sasso underground lab.

Two-Phase Time Projection Chamber

- *Detect scintillation and ionization channels (S1 and S2).*
- *Provides 3 tools for identifying nuclear recoils (NR) among the overwhelming electron recoil (ER) background.*
  - *Pulse Shape Discrimination (based on S1)*
  - *Ratio of ionization/scintillation (based on S1 and S2)*
  - *3D reconstruction (based on S2)*

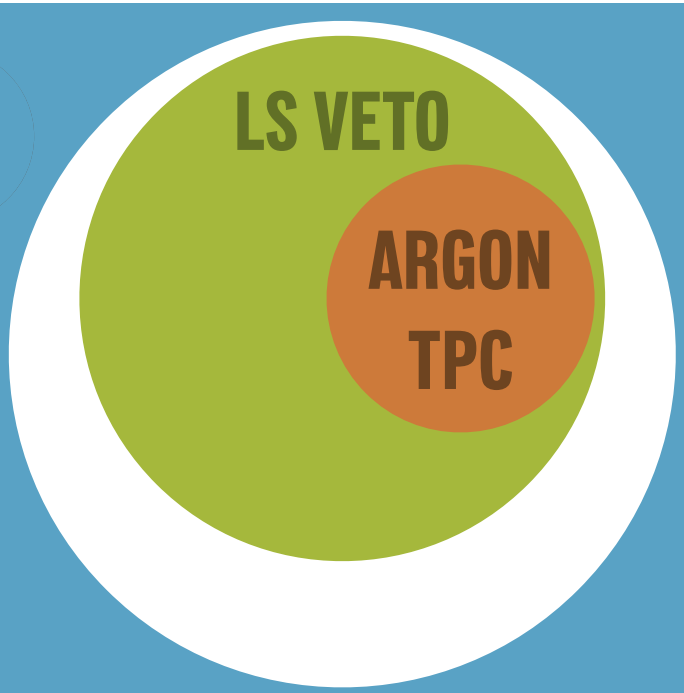
Low-Radioactivity Underground Argon (UAr)

- *<6.5 mBq/kg of ^{39}Ar, <1/154 of atmospheric argon (AAr)*



DArKSIDE STRATEGY

Multi-stage program searching for dark matter direct interactions in low-background detectors deployed at Gran Sasso underground lab.



Boron-loaded organic liquid scintillator detector

- *30 tonnes: 50% PC and 50% TMB*
- *Readout by 110 low-radioactivity PMTs*

Passive shield against neutrons and gammas

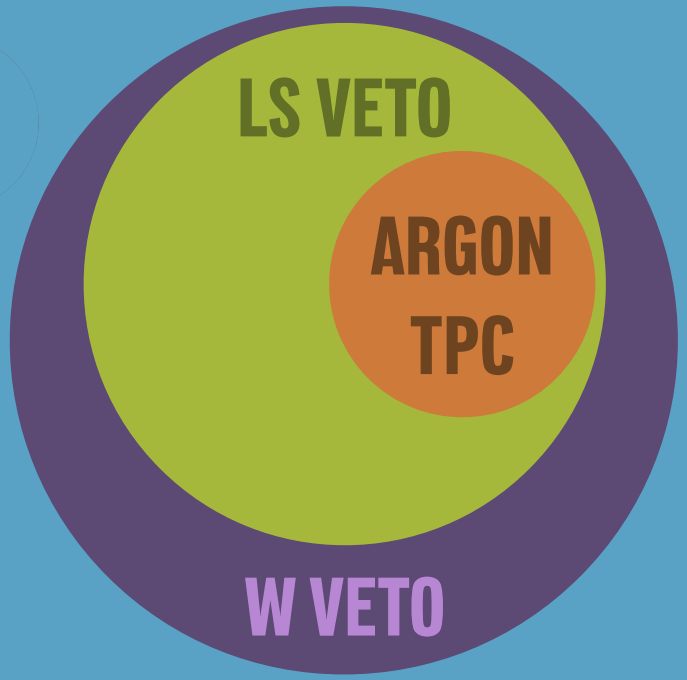
Efficient tagging of neutrons through n-capture

- *Emitted gamma+alpha (94%) and alpha (6%)*

Designed to host DS-50 and DS-G2

DArKSIDE STRATEGY

Multi-stage program searching for dark matter direct interactions in low-background detectors deployed at Gran Sasso underground lab.



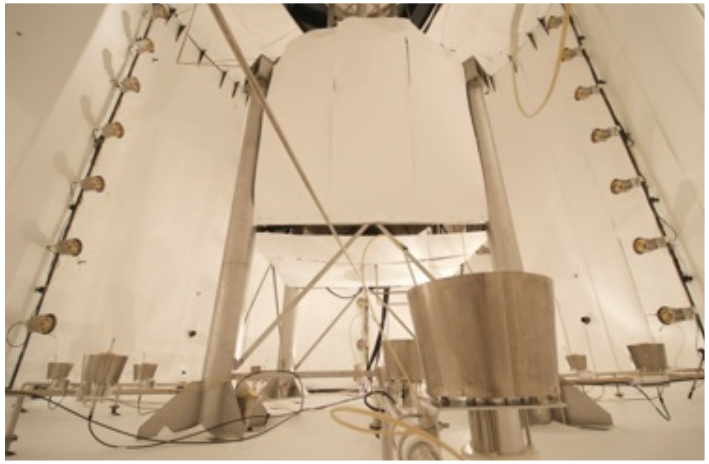
Water Cherenkov Muon detector

- *1000 tonnes of pure water*
- *Readout by 80 PMTs*

Passive shield against neutrons and gammas

Detects muons to tag cosmogenic-neutrons

Designed to host DS-50 and DS-G2



Status and Program of DarkSide-50
TPC active mass ~50kg Ar

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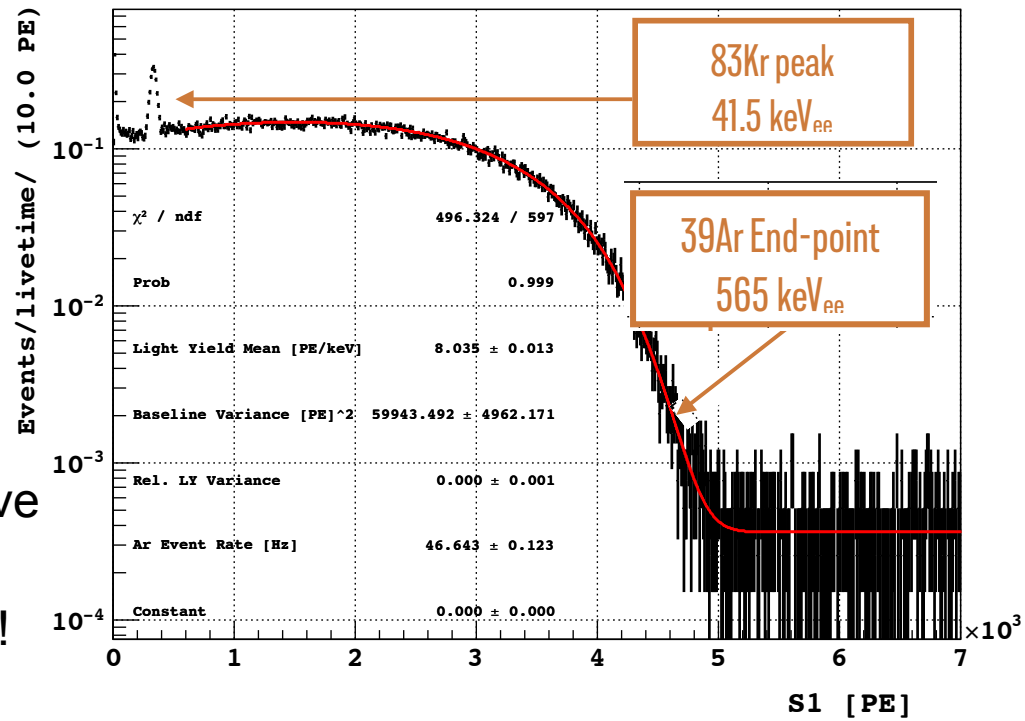
- October 2013
  - Begin DS-50 commissioning with Atmospheric Argon
- January 2014
  - Start of physics quality data run
- June 2014
  - Exposure of 5,150 kg*days
  - 3,150 kg*days with veto active with atmospheric argon
  - Stay tuned for physics result!
- Late CY 2014
  - First data runs with Underground Argon



^{39}Ar statistics collected equivalent to
>40 years of operation of DS-50 with U Ar
>0.6 years of operation of DS-G2 with U Ar

Background free exposure in 280 kg-days

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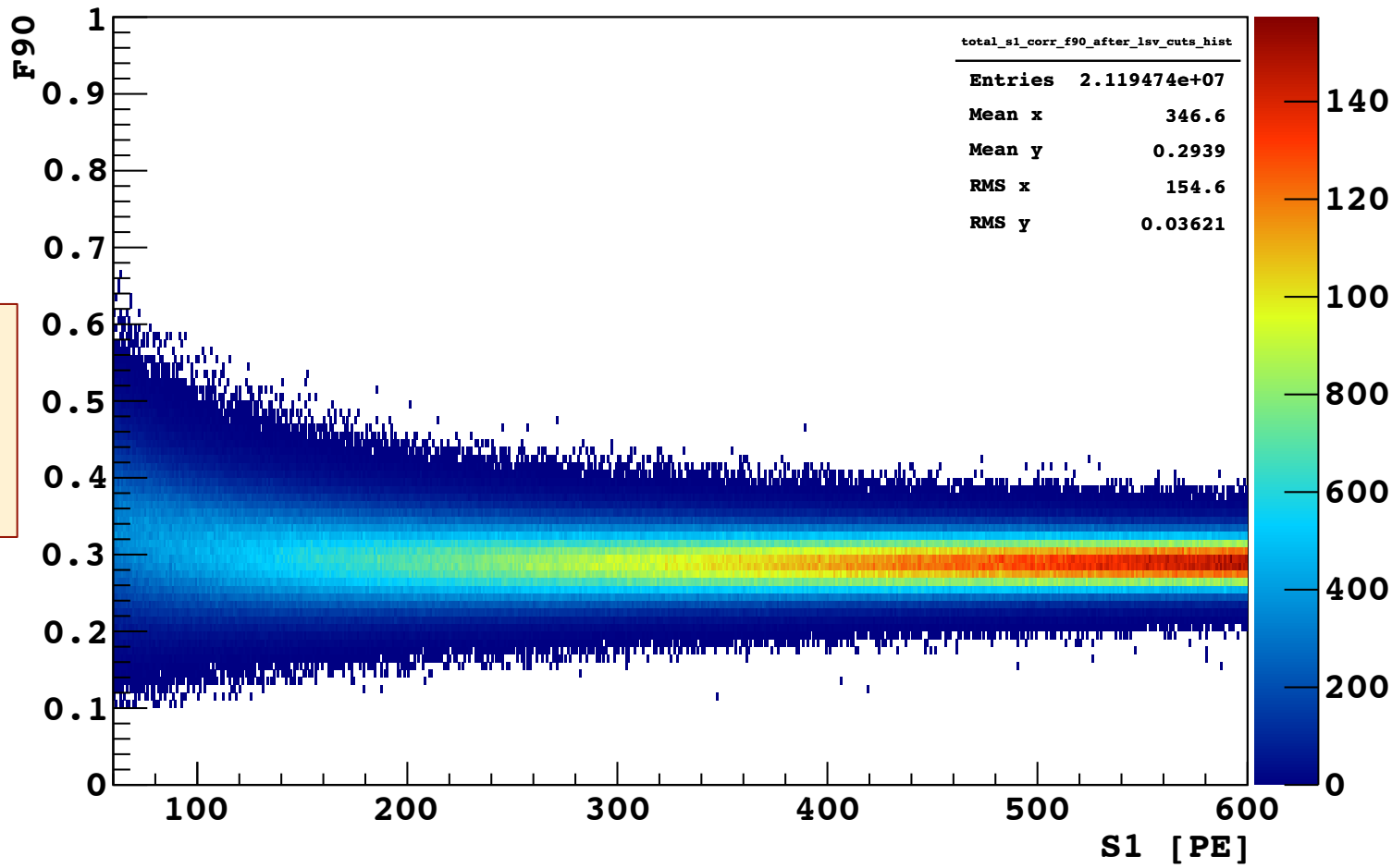
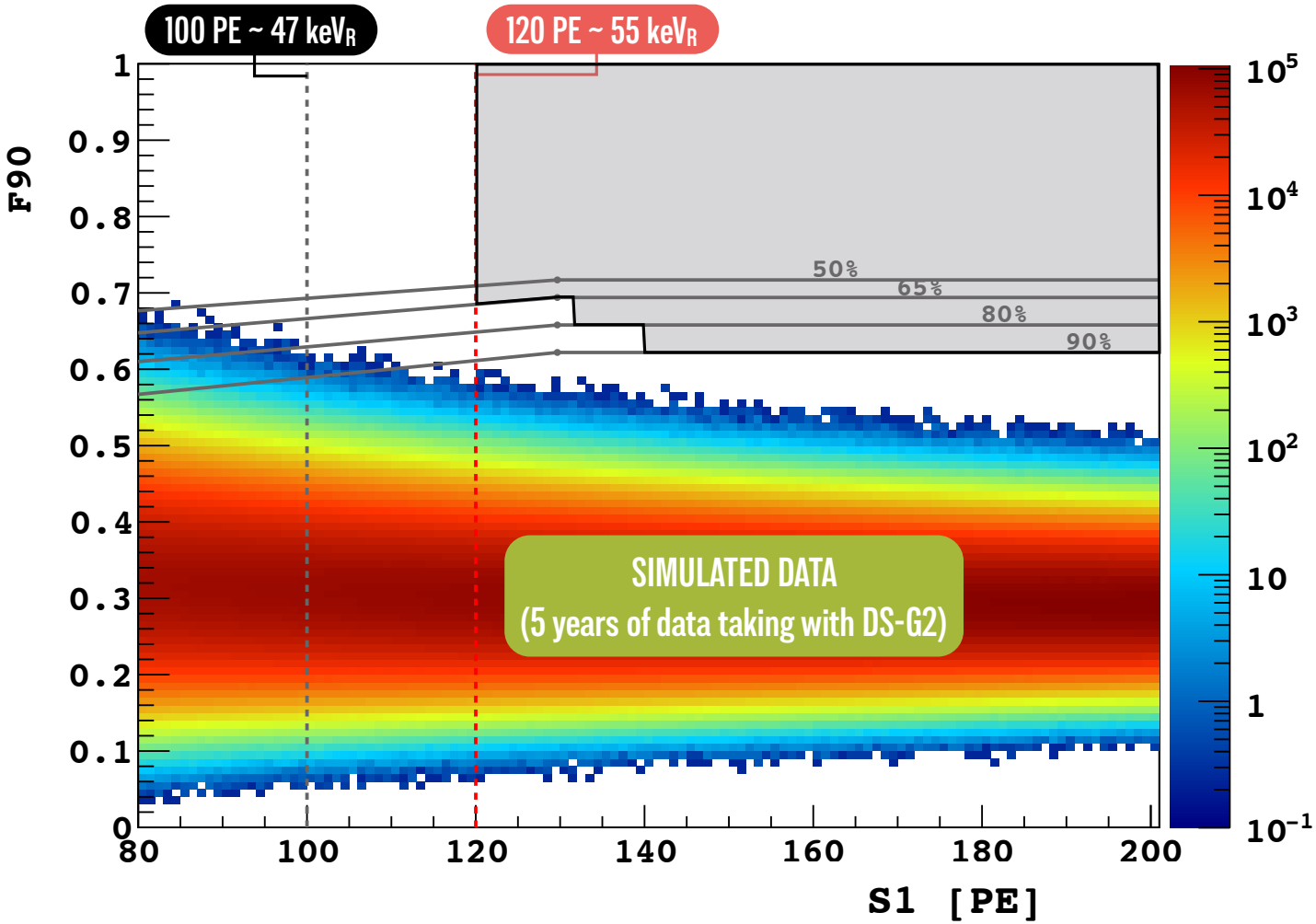
F90 – fraction of scintillation light detected in first 90 ns

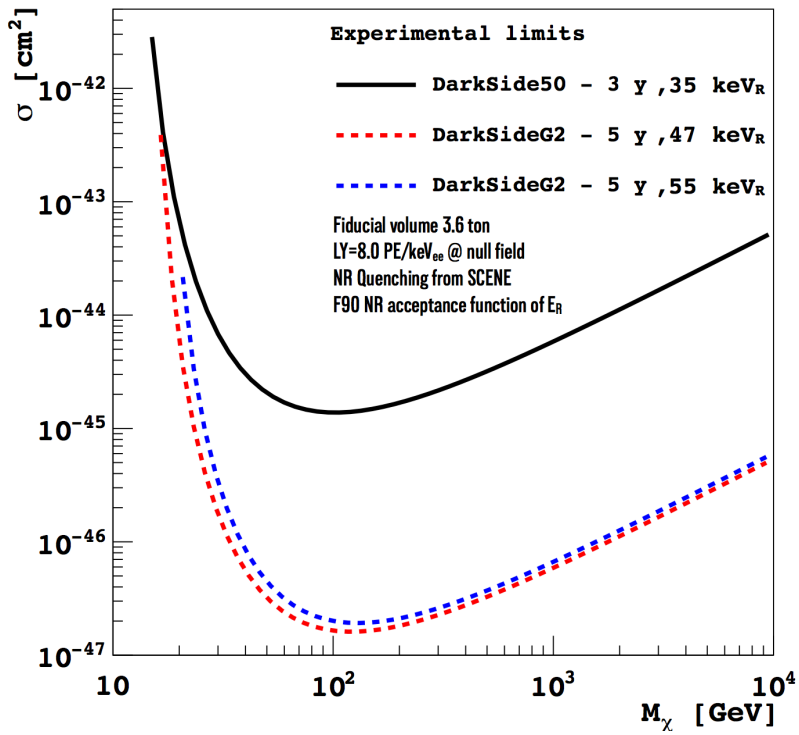


Selected only single-hit interactions in the TPC fiducial volume (44.1 kg) with no energy deposition in the veto

PSD Model for DS-G2 Extrapolation

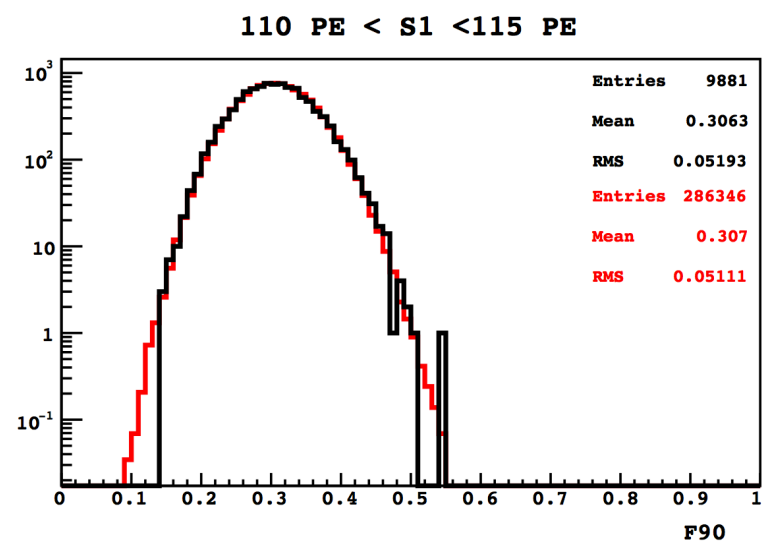


Projected Sensitivity of DS-50 and DS-G2



- Light yield as measured in DS-50
- PSD: based on F90 model
- Did not use S2/S1 rejection
- Fiducialization along z-axis only
- Neutron Recoil model from SCENE

- Excellent agreement between F90 model and DS-50 data



G3 Scalability & Pulse Shape Discrimination

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- **From P5 Report - Recommendation 20**: Support one or more third-generation (G3) direct detection experiments…
- Large monolithic detectors most likely to cost effectively scale to G3
- Advanced plans for construction of plant capable of producing 100 kg/day of underground argon for G2 (and G3) program
  - Underground argon offers opportunity for scaling to zero-background detectors of several tens of tons … with limited infrastructural costs planned for G2 experiment to serve also possible G3 needs
- Background rejection in general and discriminating against the electron-neutrino scattering in particular are vital as we approach sensitivity to the atmospheric neutrino signal
  - Pulse Shape Discrimination (PSD) in LAr permits rejection factor of beta/gamma >1 part in 10^8. PSD almost unavailable in LXe
  - Internal backgrounds critical for LXe (radon and daughters, ^{85}Kr, pp neutrinos) are not a concern for LAr
- Fully demonstrate zero-background condition in DS-G2 with ^{39}Ar spike run in DS-50 this summer

Opportunities for new University Groups

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- Opportunities in DarkSide-50 science
  - Vibrant efforts on data analysis, Monte Carlo efforts could benefit from additional collaborators
- Opportunities in DarkSide-G2 (WBS not frozen)

  Potential contributions for new groups include
  - Photosensor characterization
  - Cold preamplifiers for photosensors
  - Readout electronics (digitizers)
  - DAQ
  - Data handling and processing
  - Underground argon production and purification
  - Cryogenics systems upgrade

PNNL joined <1 year ago

Level 2 responsibility
For calibration
For materials and assay
Level 3 responsibility for U Ar

And engaged in DS-50 analysis

Contact: Cristian Galbiati galbiati@princeton.edu ; Stephen Pordes stephen@fnal.gov

Summary

- DS-50 commissioned and taking physics quality data
  - Includes veto systems (designed to host DS-G2)
  - Underground Ar run to start later this CY
- Demonstrated PSD performance to reject ^{39}Ar background in 2.6 years of DS-50
  - Stay tuned for results on performance >40 years of DS-50 (0.6 years of DS-G2)
- Spike with ^{39}Ar in Summer 2014 will allow to test PSD with full statistics of 5 years of DarkSide-G2
- Existing DarkSide-50 facilities at LNGS leveraged for fast deployment of G2 system
- Scalability and PSD background rejection make UAr a clear target choice for one of the two DM-G3 experiments advocated by P5
- Many opportunities for new University groups to contribute