

DarkSide Experiment Status Update

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For DarkSide collaboration,
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Outline

- DarkSide program (DS-10, DS-50 and DS-G2)
- Dark matter detection in DarkSide
- Backgrounds
- Scaling to ton-size liquid argon TPC for WIMP detection
 - Depleted argon
 - Active background subtraction with veto detectors
 - Material selection
 - Calibration
- Schedule and sensitivity

Darkside Collaboration

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

Institute for High Energy Physics – Beijing, China

Joint Institute for Nuclear Research – Dubna, Russia

Lomonosov Moscow State University, Russia

Princeton University, USA

RRC Kurchatov Institute – Moscow, Russia

St. Petersburg Nuclear Physics Institute – Gatchina, Russia

Temple University – PA, USA

University of Arkansas, USA

University of California, Los Angeles, USA

University of Houston, USA

University of Massachusetts at Amherst, USA

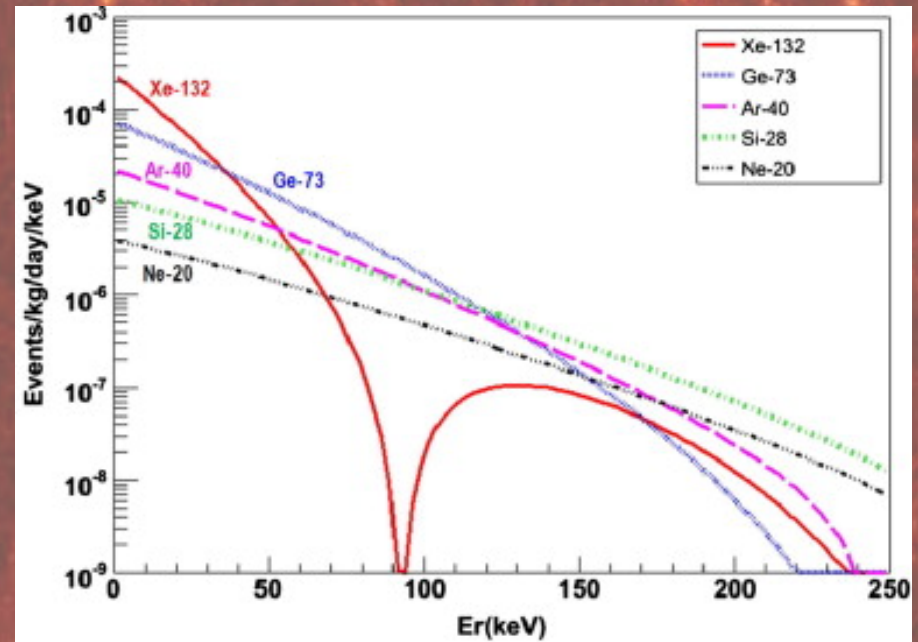
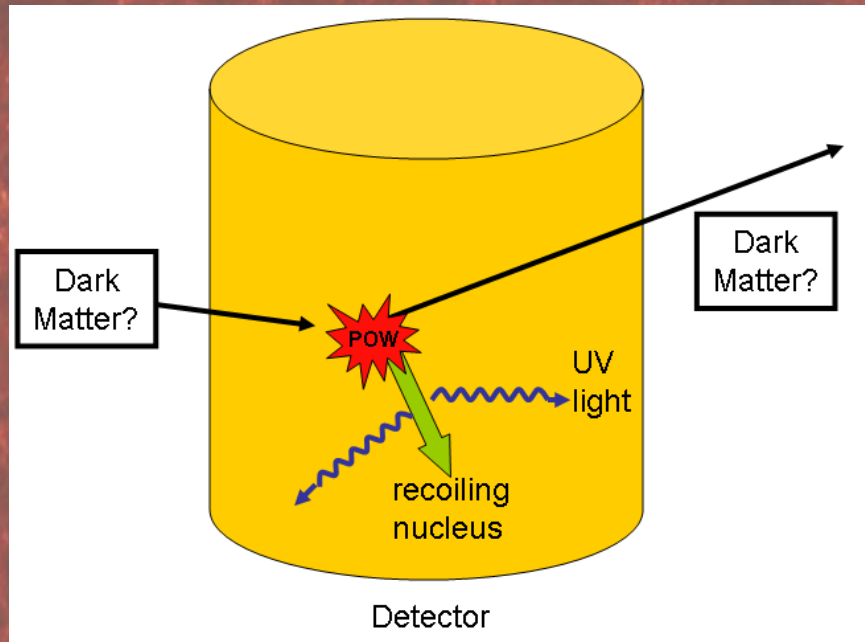
University of Hawaii, USA

Virginia Tech, USA

DarkSide Program

- DarkSide utilizes liquid argon TPC to search for WIMP detection.
- Three stage program:
 - DarkSide-10, a prototype detector – 10 kg of liquid Ar
 - operating now underground at LNGS
 - demonstrated sufficient light yield in the liquid argon TPC at level of 9 p.e./keVee [reference]
 - DarkSide-50, a low background, 50 kg detector
 - DarkSide's first WIMP search (sensitivity at the level of $\sim 2 \times 10^{-45} \text{ cm}^2$ for 100 GeV WIMPs at 90% C.L.);
 - currently under construction;
 - DarkSide-G2 (second generation), a multi-ton detector with an active mass of 3.3 tons,
 - WIMP sensitivity at the level of $2 \times 10^{-47} \text{ cm}^2$;
 - currently in the R&D phase with goal of producing a detector capable of 5 years zero background running.

Direct Detection of WIMPs in DarkSide

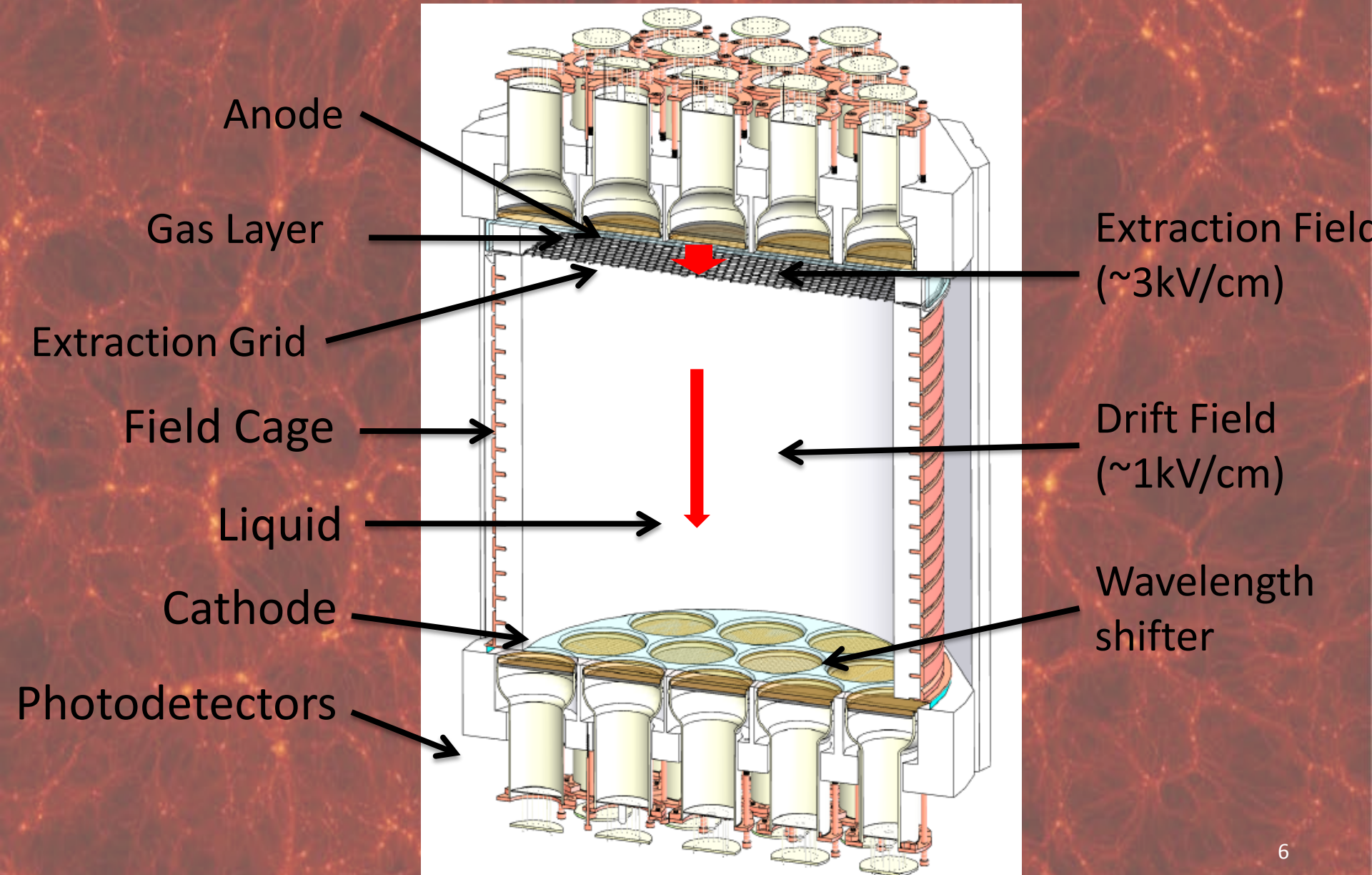


WIMPs elastically scatter from the nucleus that recoils ($E < 100$ keV)

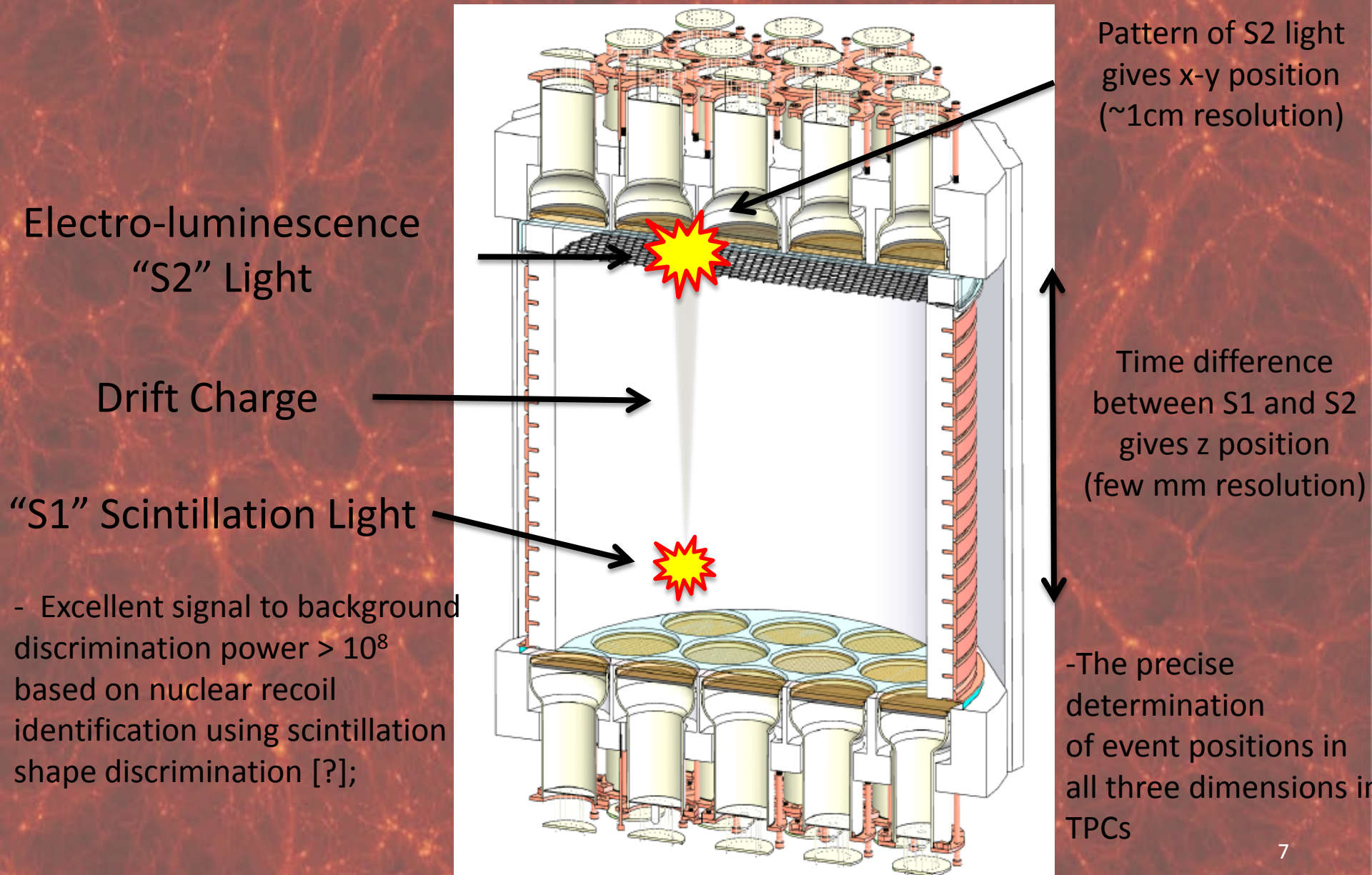
For standard WIMPs (~ 100 GeV WIMPs interaction c-s $\sim 10^{-44} - 10^{-55}$ cm² per nucleon)

Results in ~ 10 -100 events/ton/yr

DarkSide detector - 2-phase argon TPC

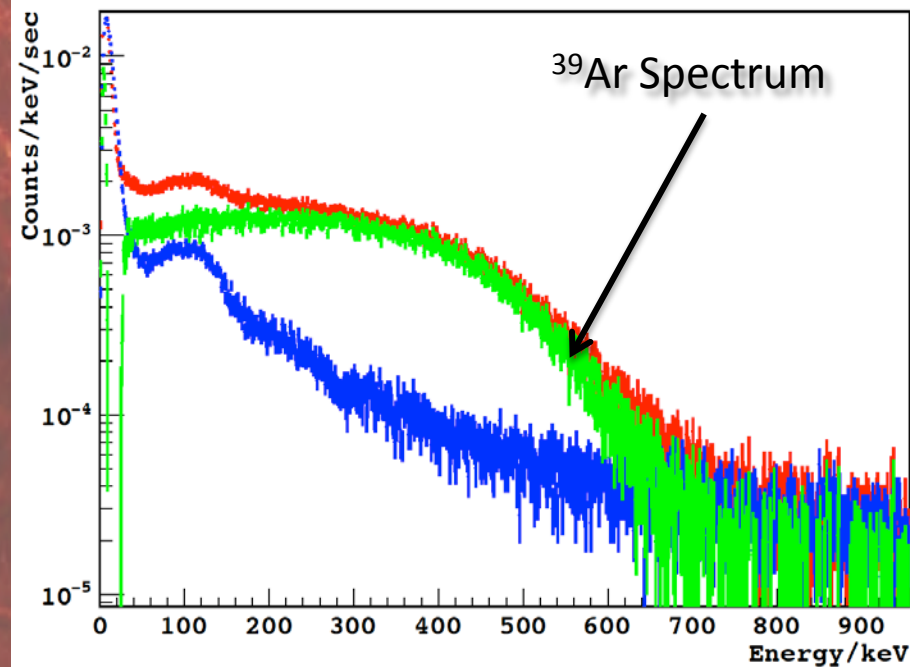


Dark matter signal in DarkSide

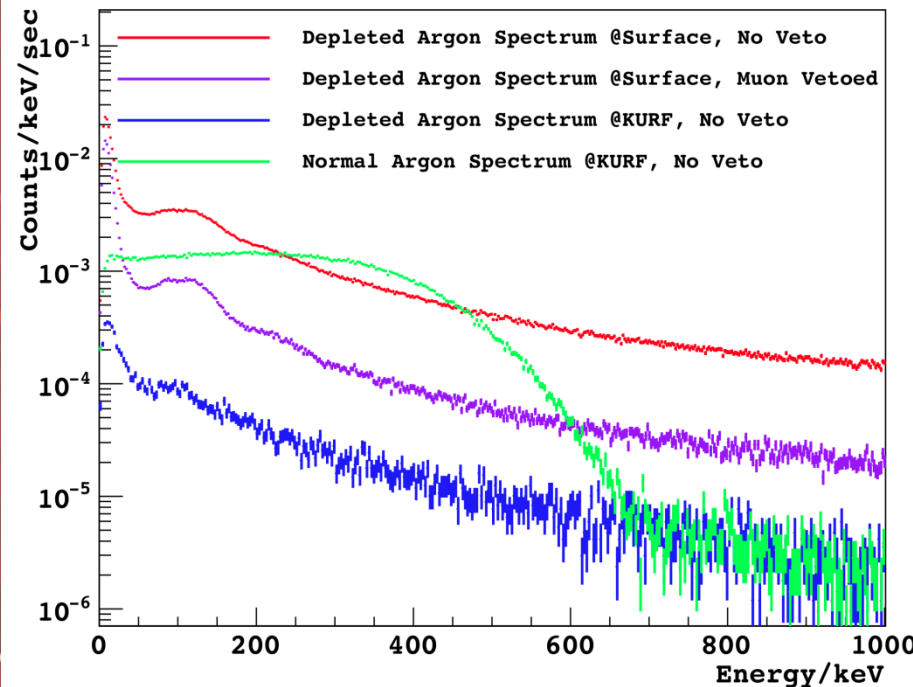


Argon as a target for dark matter detection

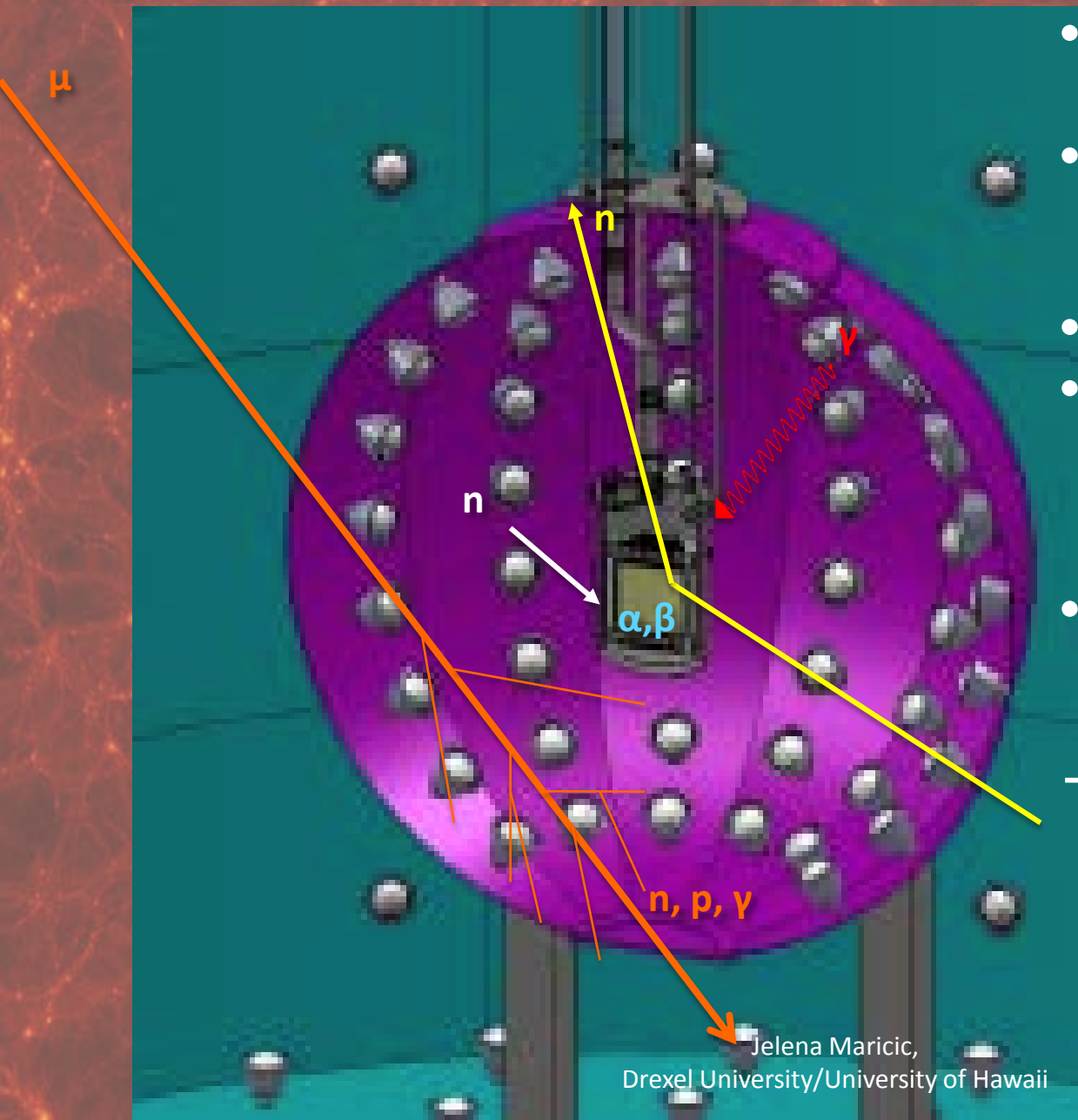
- Excellent scintillator: $\sim 40,000$ photons/MeV and very transparent to its own scintillation light
- Relatively abundant (1% in atmosphere) and easy to purify
- Possible scaling to multi-ton detectors: need to suppress ^{39}Ar
 - Underground argon $< 0.65\%$ of ^{39}Ar compared to atmospheric argon
 - DarkSide collaboration successfully demonstrated purity and extraction capability of underground argon
- Very powerful rejection capability for electron recoil background



Depleted Argon Measurement



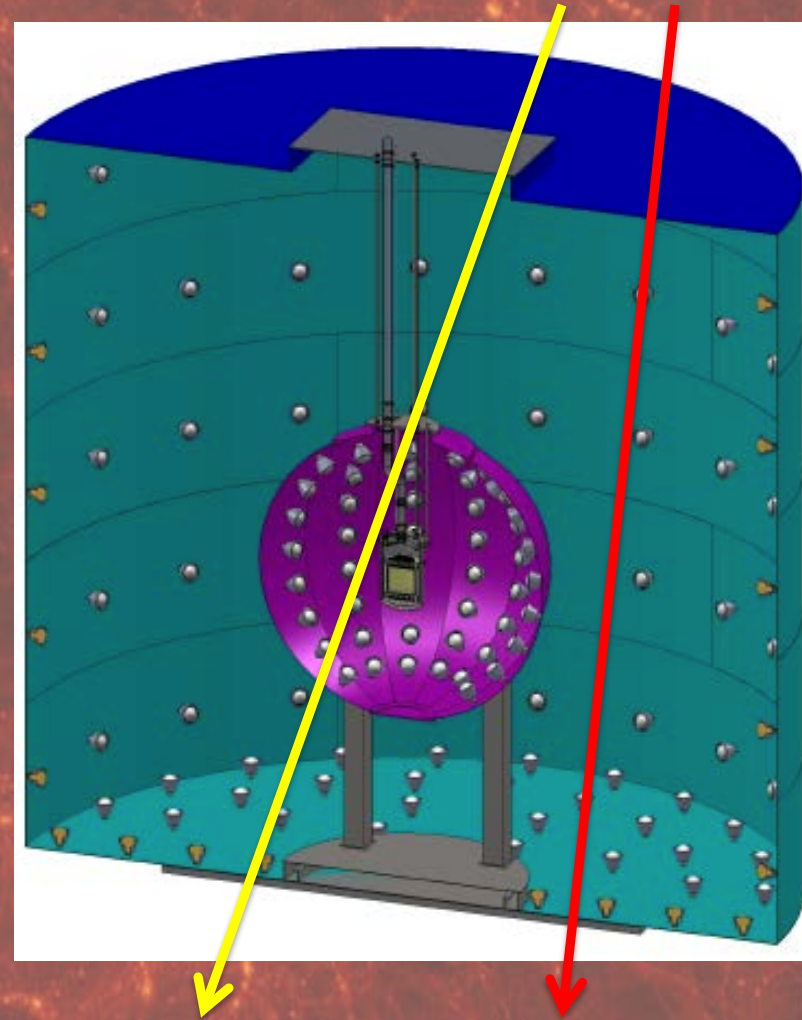
Background sources and suppression



- Internal Radioactivity
 ^{238}U , ^{232}Th , etc.
 - Gamma Rays
external and from shielding
 - Cosmic Muons
 - Radiogenic Neutrons
from spontaneous fission and (α, n) , externally and in shielding
 - Fast Neutrons
from muons in the shield and beyond
- *Radiopure materials (radioassay insitu, active background discrimination and calibration)*

Active Veto Detectors

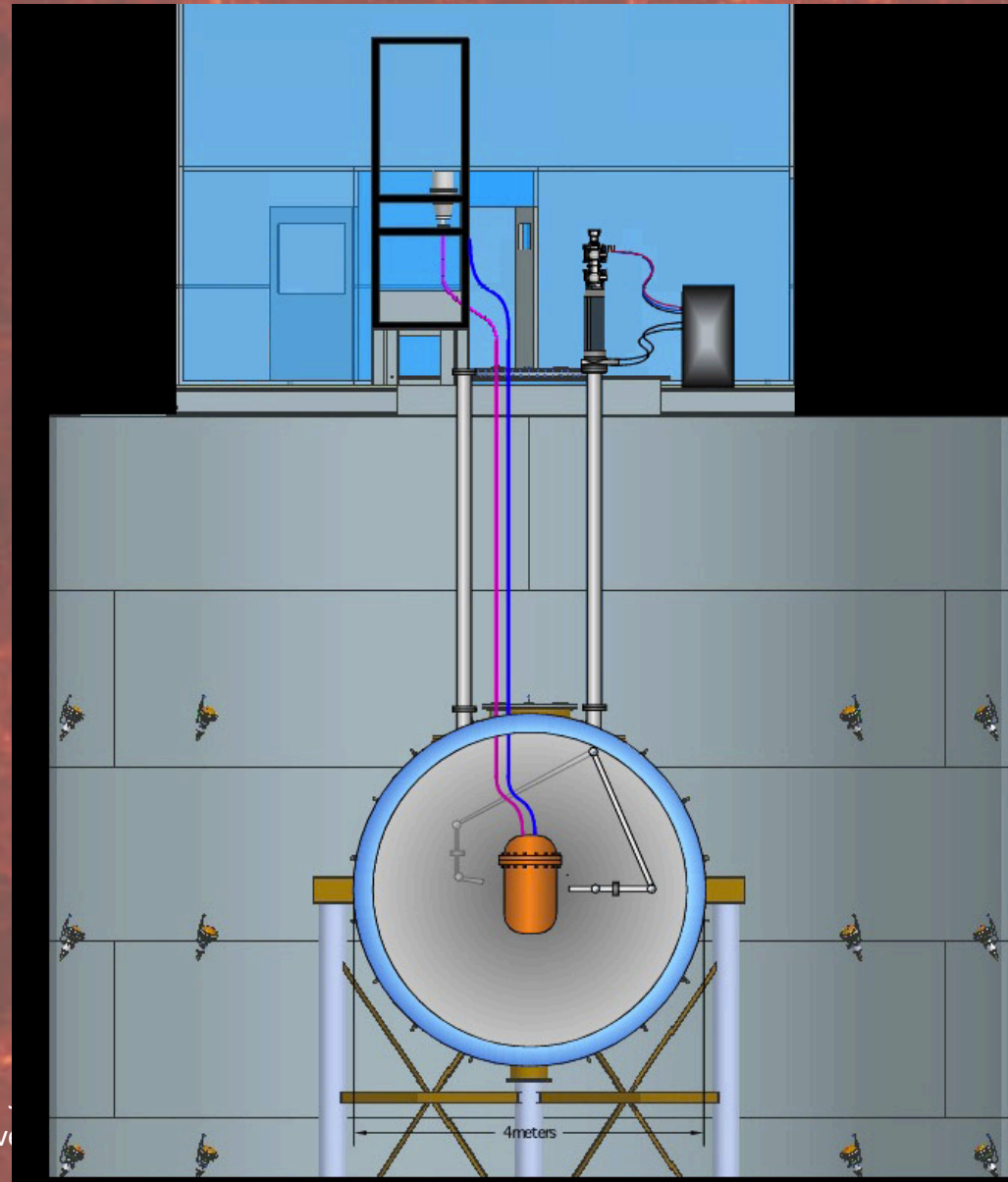
- Deploy DarkSide in the CTF in Gran Sasso
- Cryostat is surrounded with active neutron veto detector to identify neutrons from cosmic ray muons
- Neutron veto is filled with boronated liquid scintillator (Boron reduces capture time from $250\ \mu\text{s}$ to $2\ \mu\text{s}$)
- Water filled CTF, instrumented with PMTs successfully tags passing cosmic ray muons and act as passive neutron shield
- CTF tank + neutron veto reduce cosmogenic backgrounds by $\gg 10^3$



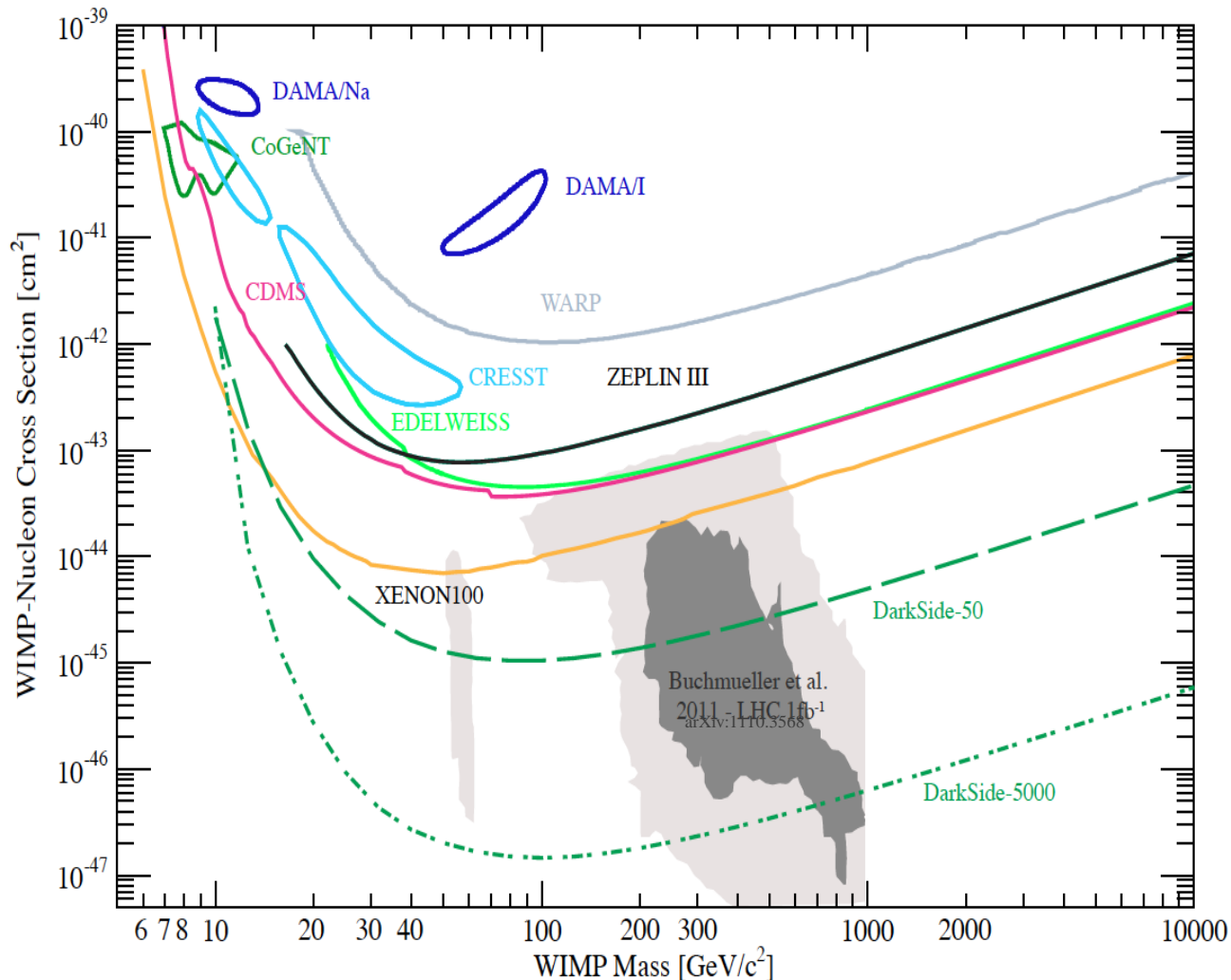
Active veto detectors designed to accommodate DarkSide-G2 10

Calibration

- The target and neutron veto will be actively calibrated using a combination of internal distributed ($^{83\text{m}}\text{Kr}$), external point sources (neutron and gamma sources) and neutron gun deployed in the neutron veto region.
- Point sources and neutron gun will be deployed using calibration insertion system.
- 6-axis articulated arm system for 360° coverage



Sensitivity and Timeline



- DarkSide-10 continues to operate- valuable experience with 2-phase operation, background level measurements
- DarkSide-50 to be deployed by the end of 2012
 - Reach 10^{-45} cm² in 3 years background free operation
- DarkSide-G2 (~3.3 ton)
 - up to 10^{-47} cm² and will utilize the same active shielding as DarkSide-50
 - R&D to reach 5 years of background free running