



The DarkSide-50

Liquid Argon TPC

Direct WIMP search

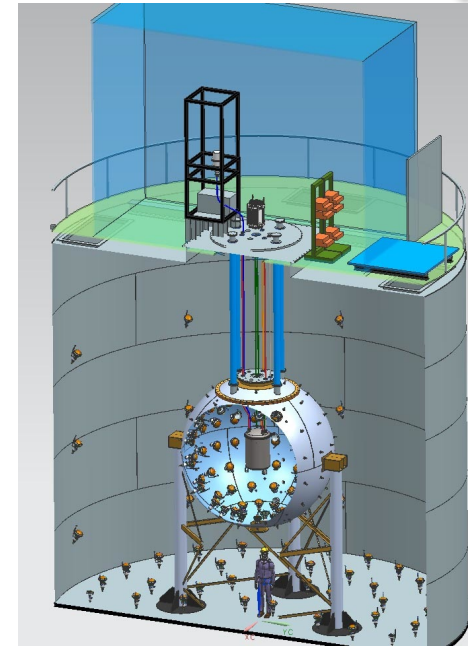
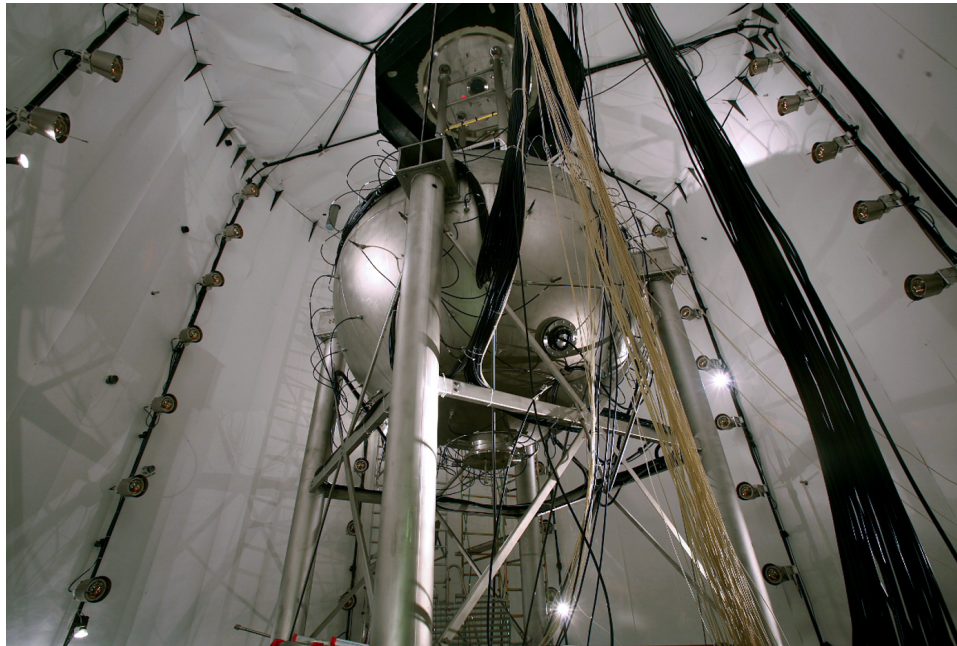
Yury Suvorov (UCLA)
on behalf of the DarkSide collaboration

ICPPA 2015, October 8th, MEPhI, Moscow

DM Direct Search Strategy

3800 m.w.e

- Deep underground location at LNGS, Italy.
- Active muon shielding (ultra-pure water).
- Active neutron shielding (borated scintillator -> high n capture rate).
- Two phase time projection chamber (scintillation + ionization).
- Low radioactivity Underground Argon.



Water Cherenkov Detector

Stainless Steel Tank (Borexino CTF)

Cylinder with $d=11$ m and $h=10$ m:

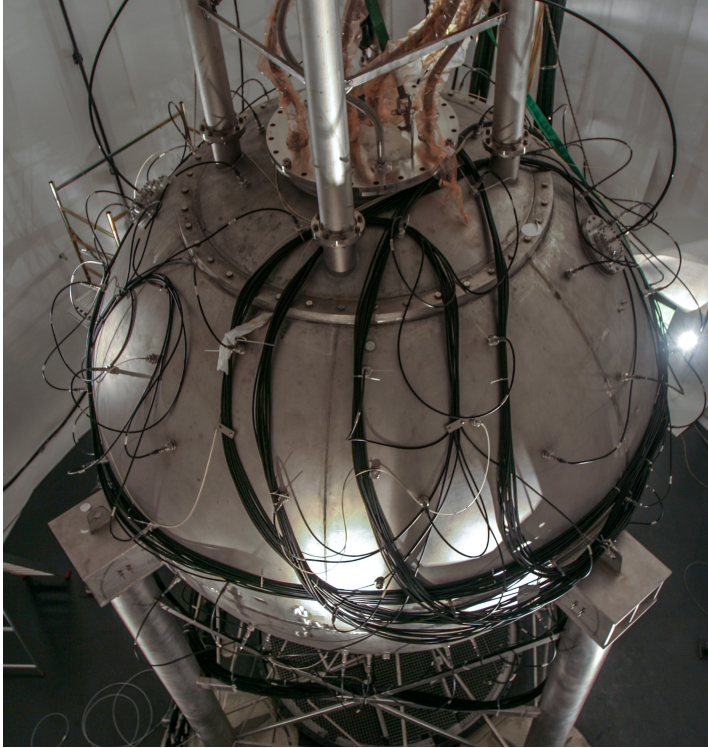
- Filled with 1000 t of High Purity Water.
- 3 m of shielding against external gammas, neutrons and cosmic muons.
- Equipped with 80 8" PMTs: 56 on the side and 24 on the bottom (27% quantum efficiency at 420 nm).
- Covered with reflector to improve light collection (laminated sandwich of Tyvek-polyethylene-Tyvek 1082D).



Liquid Scintillator Veto

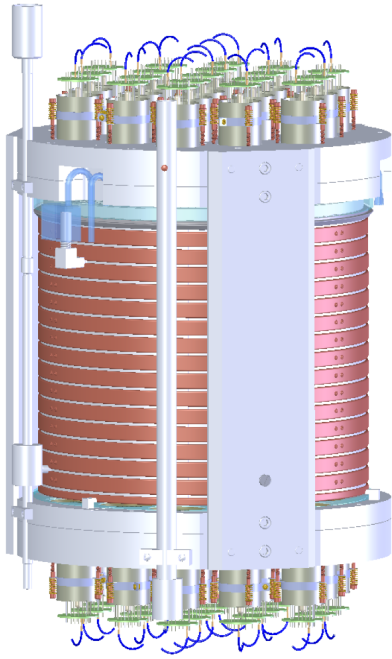
Stainless Steel Sphere (4 m diameter)

Filled with 30 t of boron loaded liquid scintillator

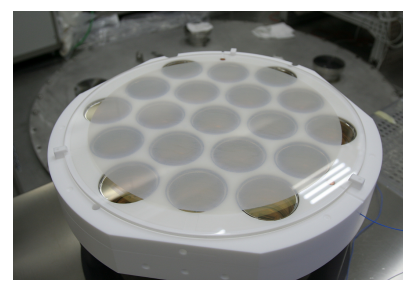
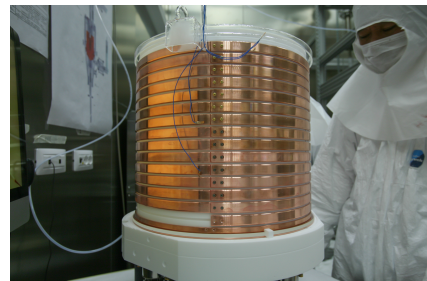
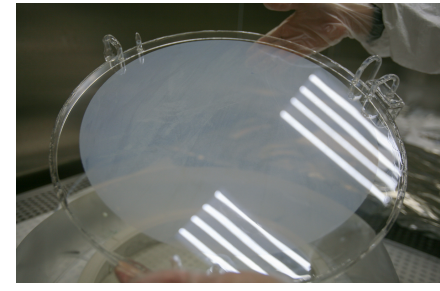
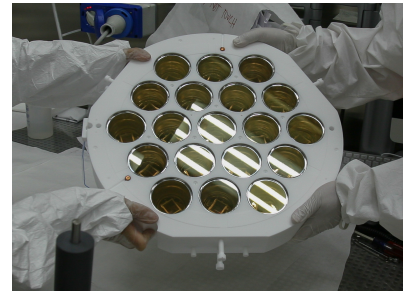
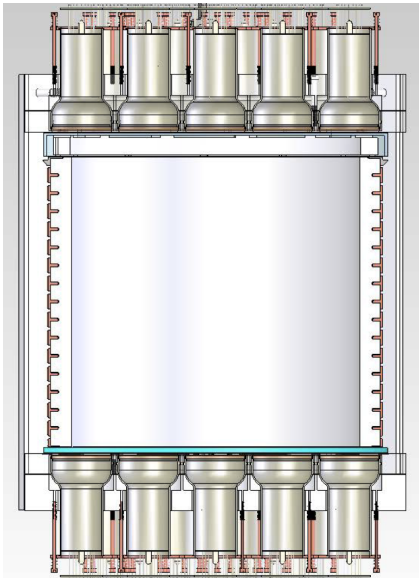


- Gives 1.5 m of active shielding against gammas and neutrons.
- Equipped with 110 8" PMTs.
- Covered with Lumirror 188 E6SR reflective film for light collection.

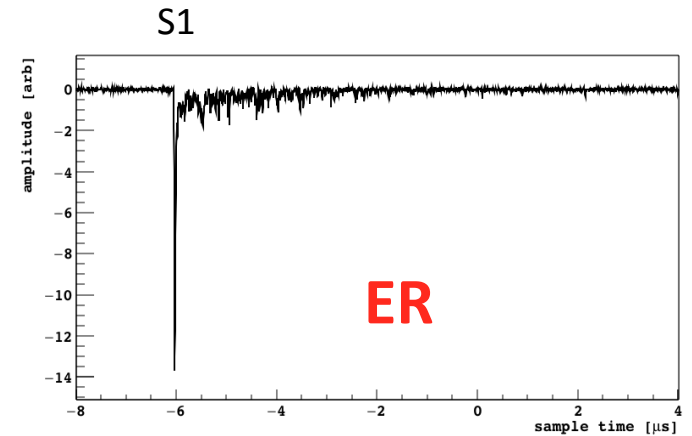
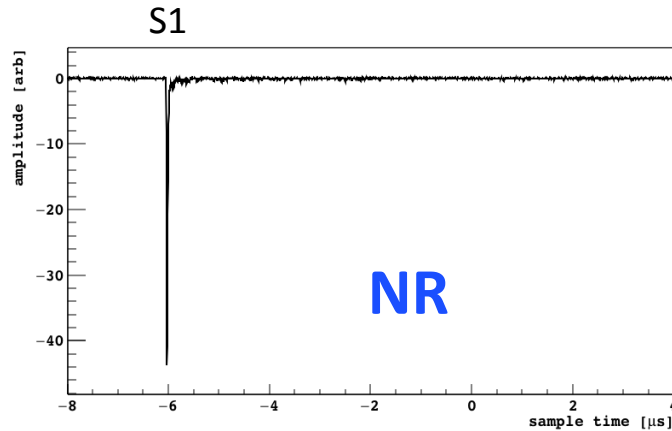
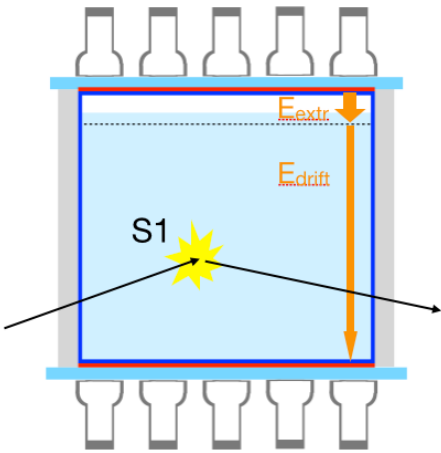
Two Phase Time Projection Chamber



- **PTFE cylinder 2.5 cm-thick:** (36 x 36) cm => 46 kg (37 kg fiducial). All inner surfaces are coated with wavelength shifter TPB (Tetraphenil Butadiene).
- **38 3" Hamamatsu PMTs** R11065, 19(top) + 19(bottom);
- **Field shaping copper rings:** $E_{\text{drift}} = 200\text{V/cm}$, $E_{\text{extrac}} \approx 2.8\text{kV/cm}$.
- **The grid:** hexagonal mesh with 95% optical transparency at normal incidence.
- **Cathode & Anode:** Indium Tin Oxide transparent layers (15 nm) on the fused silica windows, TPB coating.
- **Fused silica diving bell** for the 1 cm gas pocket.

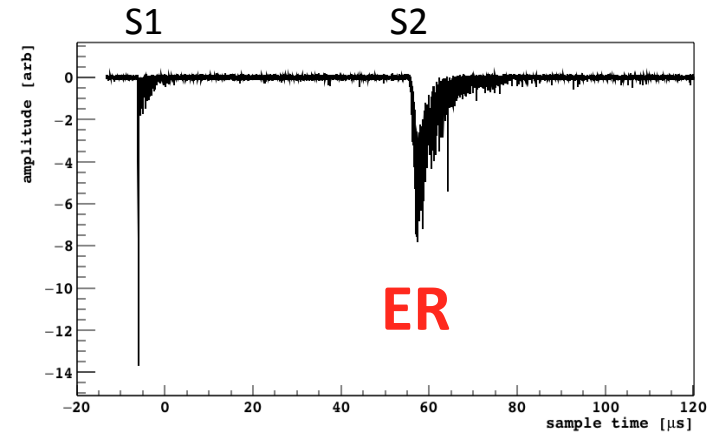
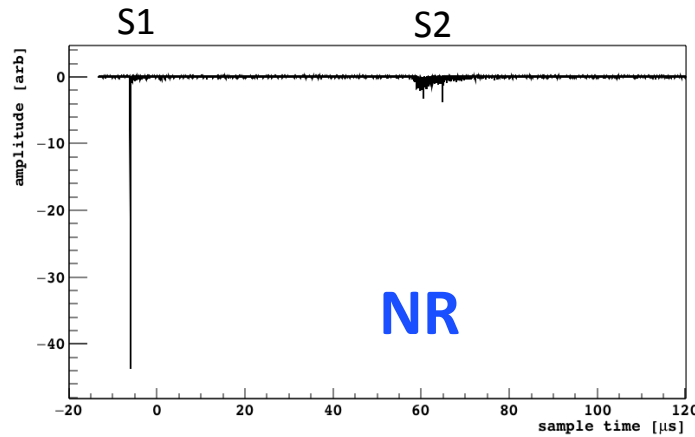
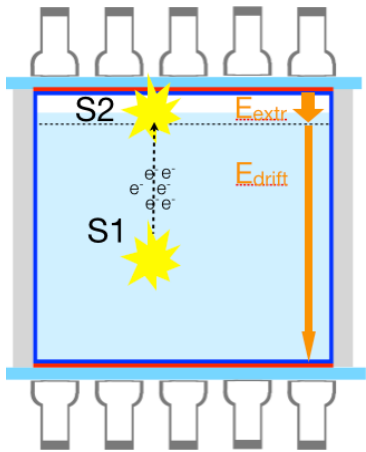


TPC Detection Principle



- Z position from drift time (maximum drift time is 376 μs).
- XY position is determined by the top PMT array with S2.

→ 3D positioning



PSD (temporal pulse shape of S1 (first 90 ns - f_{90})) provides discrimination between NR & ER)
3D localization and S2/S1 discrimination for background rejection

Atmospheric Argon Run

DarkSide-50 took data with Atmospheric Argon starting from October 2013. In total, it collected 53.8 live-days of usable data (47.1 d after all cuts), giving an exposure of (1422 ± 67) kg days.

TPC:

- Primary source of background is ^{39}Ar (rate ~ 1 Bq/kg; 1.5×10^7 events).
- Internal L.Y. calibrations with ^{39}Ar & $^{83\text{m}}\text{Kr}$.
- Electron drift lifetime > 5 ms (compared with max drift time of $376 \mu\text{s}$).

LSV:

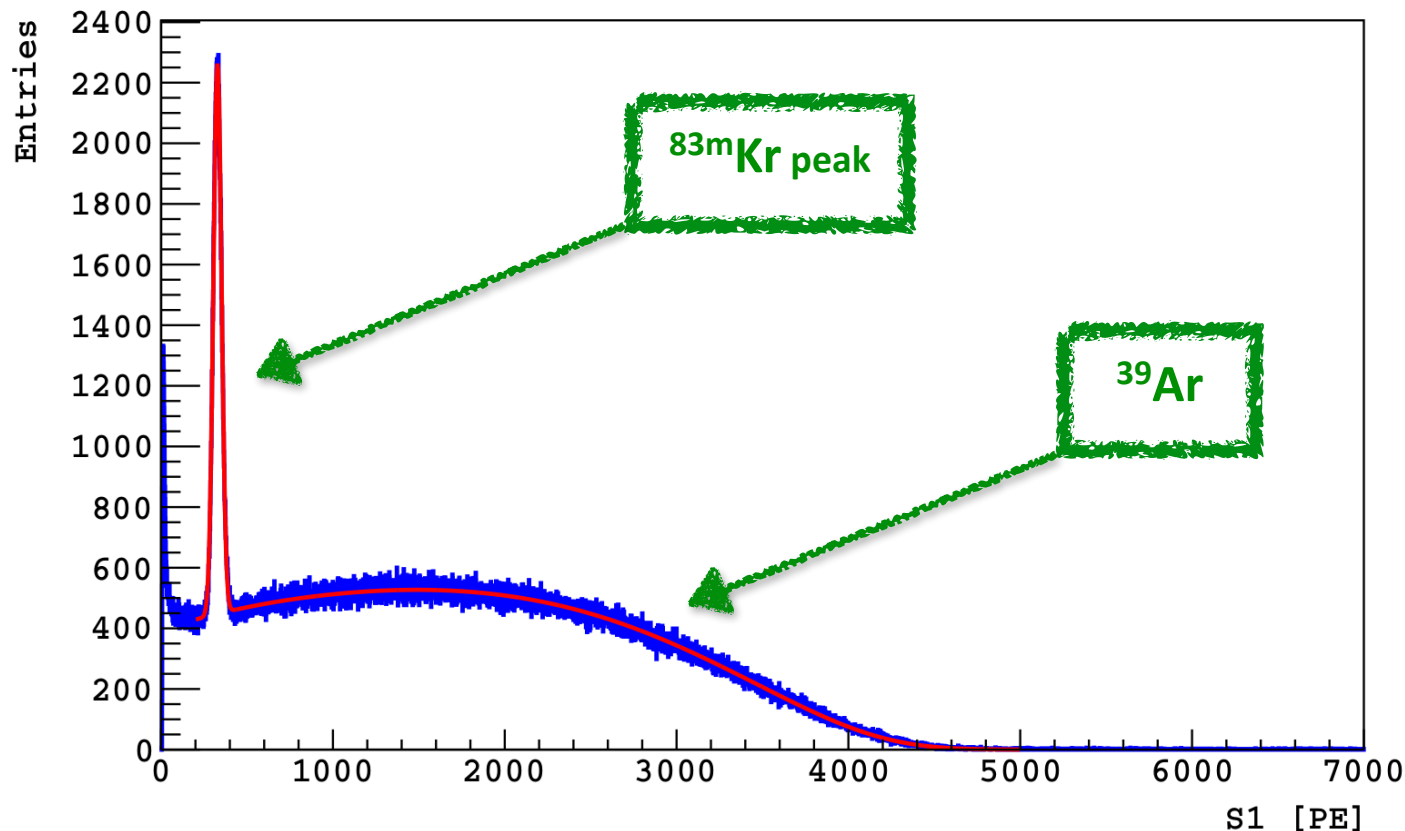
- ^{14}C rate initially ~ 150 kBq. Reduced to 0.3 kBq after refurbishing the TMB (TMB: 50% \rightarrow 5%, PPO: 2.5 g/l \rightarrow 1.4 g/l).
- External calibration done with CALIS.

<http://arxiv.org/pdf/1410.0653.pdf>

AAr Calibrations

Two sources of information to determine the TPC L.Y.:

- ^{39}Ar (565 keV endpoint) present in the AAr and the $^{83\text{m}}\text{Kr}$ source (half life of 1.83 h, decay energy of 41.5 keV_{ee}) located in the Ar gas panel.
- Recirculated Ar gas gets enriched with Kr, liquefied and then sent to the detector.



Determined light yield:
(7.0±0.3) PE/keV @ 200 V/cm And **(7.9±0.4) PE/keV @ null field.**

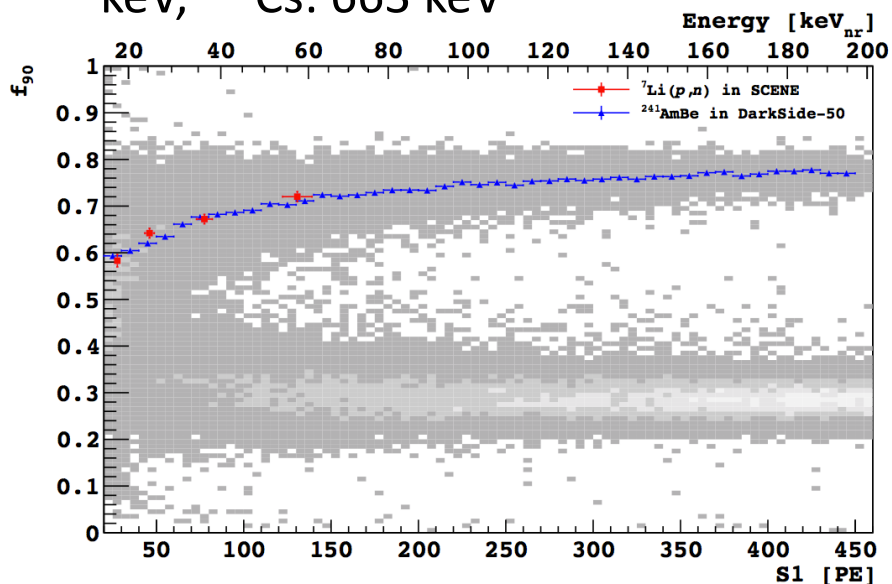
AAr CALibration Insertion System

CALIS to calibrate both detectors: LSV and TPC
(Sept, Oct-Dec 2014 & Feb 2015).

NR band study (crosscheck of **SCENE** data).

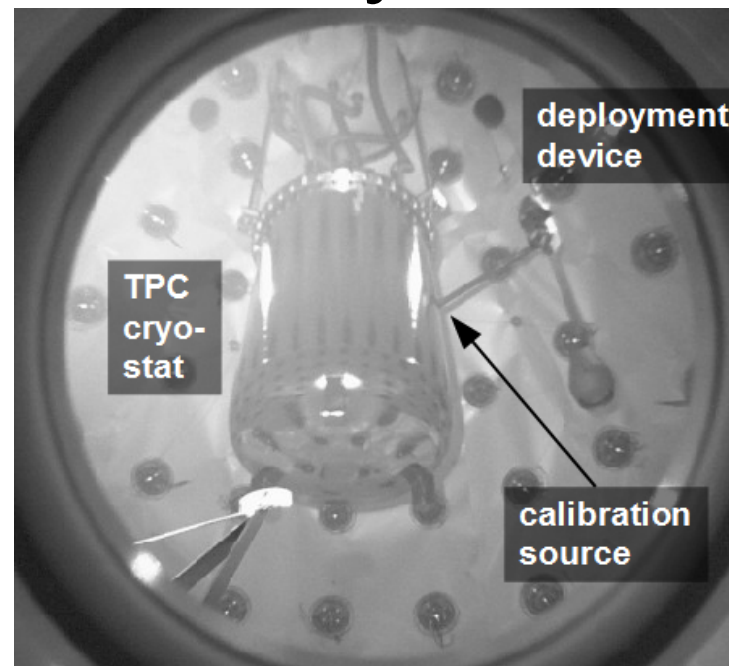
Deep test of the GEANT4 MC code.

- **Neutron source:** AmBe (w/o collimator)
- **Gamma sources:** ^{57}Co : 122 keV, ^{133}Ba : 356 keV, ^{137}Cs : 663 keV

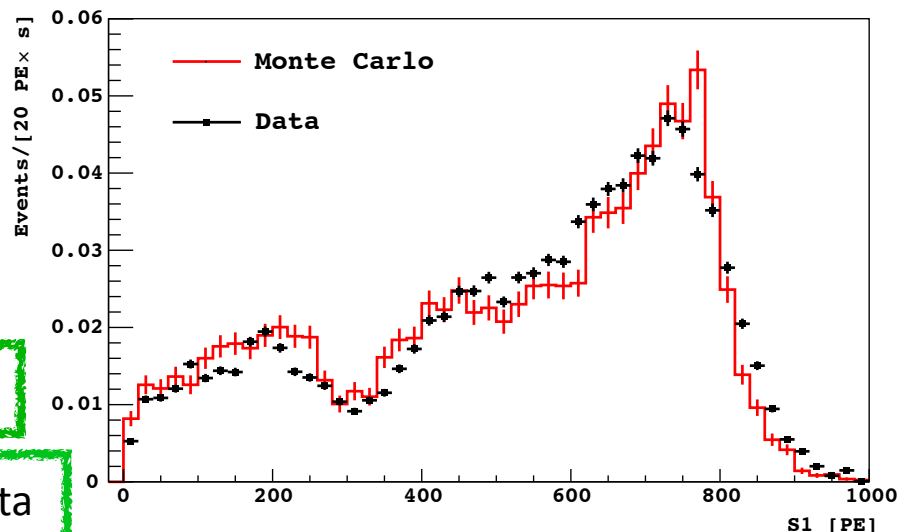


AmBe + MC: rad. n's detection efficiency $\sim 99.2\%$

L. Y. (0.54 ± 0.04) PE/keV based on ^{14}C and ^{60}Co data



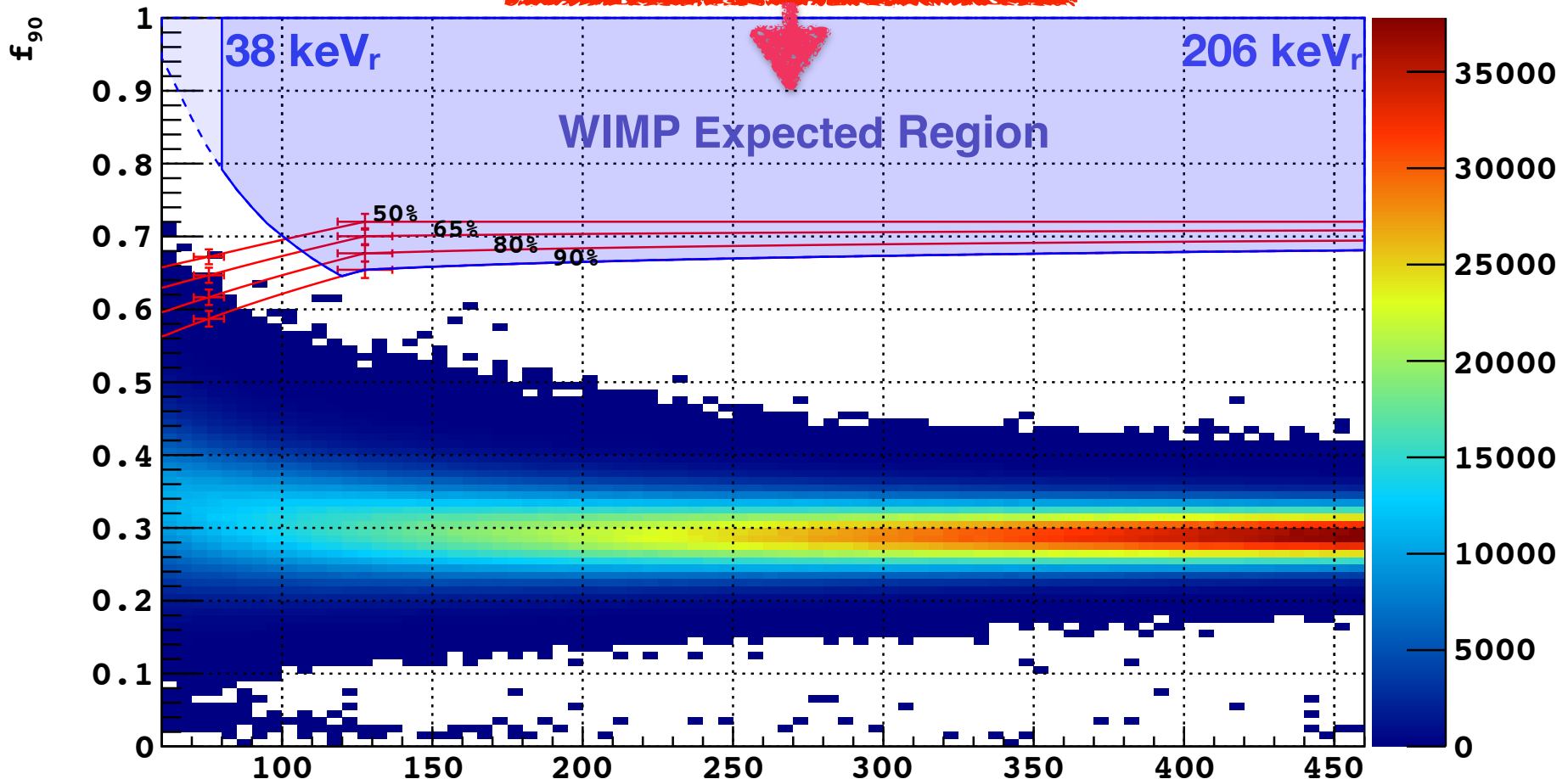
DATA-MC comparison: ^{57}Co source next to the cryostat



AAr First Results

The 47 live days. (1422 ± 67) kg day exposure. Single-hit interactions in TPC, no energy deposition in the veto. Equivalent to more than 20 yr exposure of DarkSide-50 with UAr.

No events in the WIMP region!



Underground Argon

- Extracted from the underground CO₂ wells in Cortez, CO. In situ enrichment from 400 ppm → 5%, since 2009.
- Shipment to Fermilab for main purification in the cryogenic distillation column to remove CO₂, O₂, N₂ and He (all <10 ppm).
- Shipment to Gran Sasso National Laboratory (LNGS), Italy.

Six Years Effort! 155 kg produced

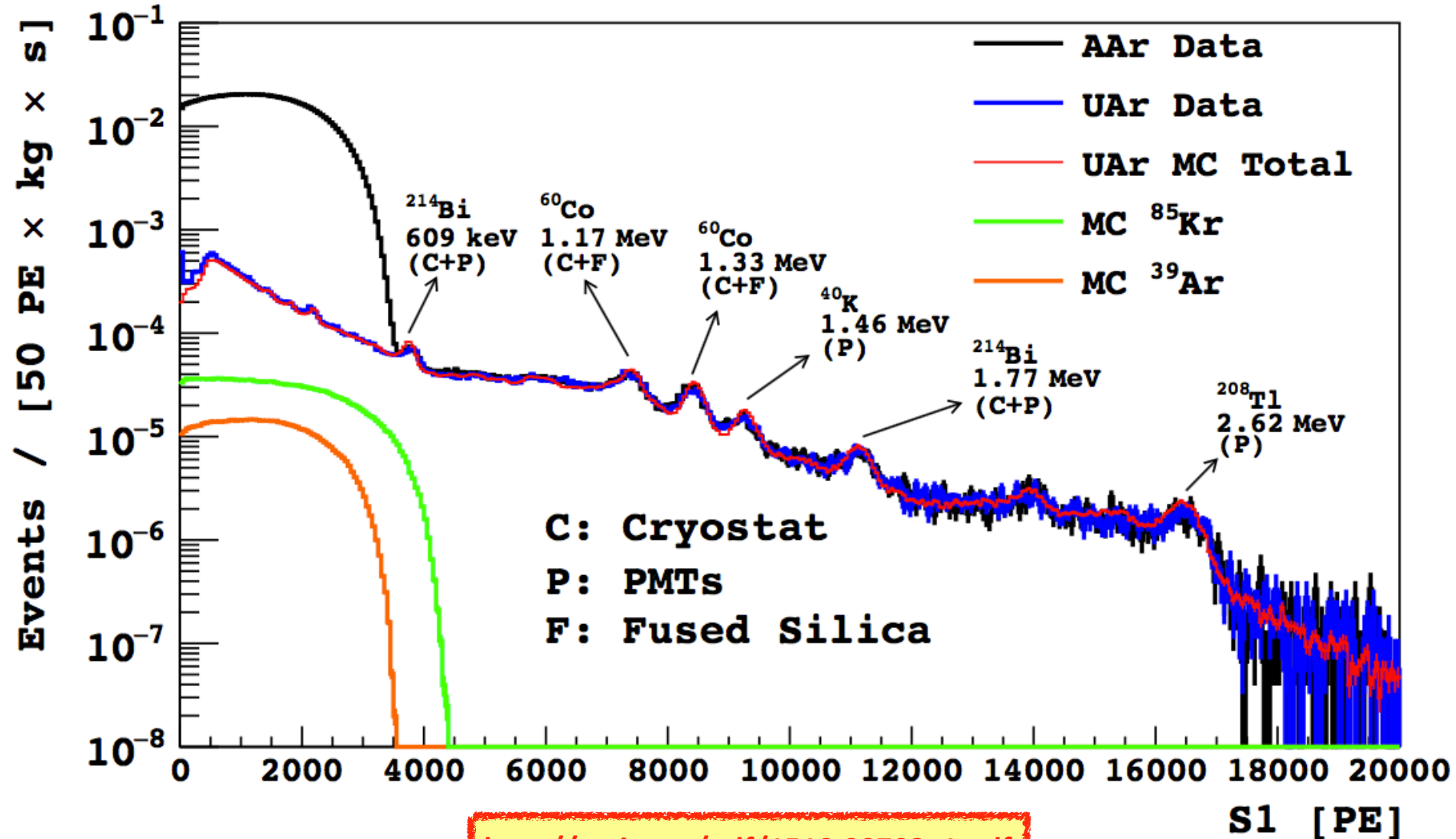


DS-50 was filled with UAr in April 2015.



UAr First results

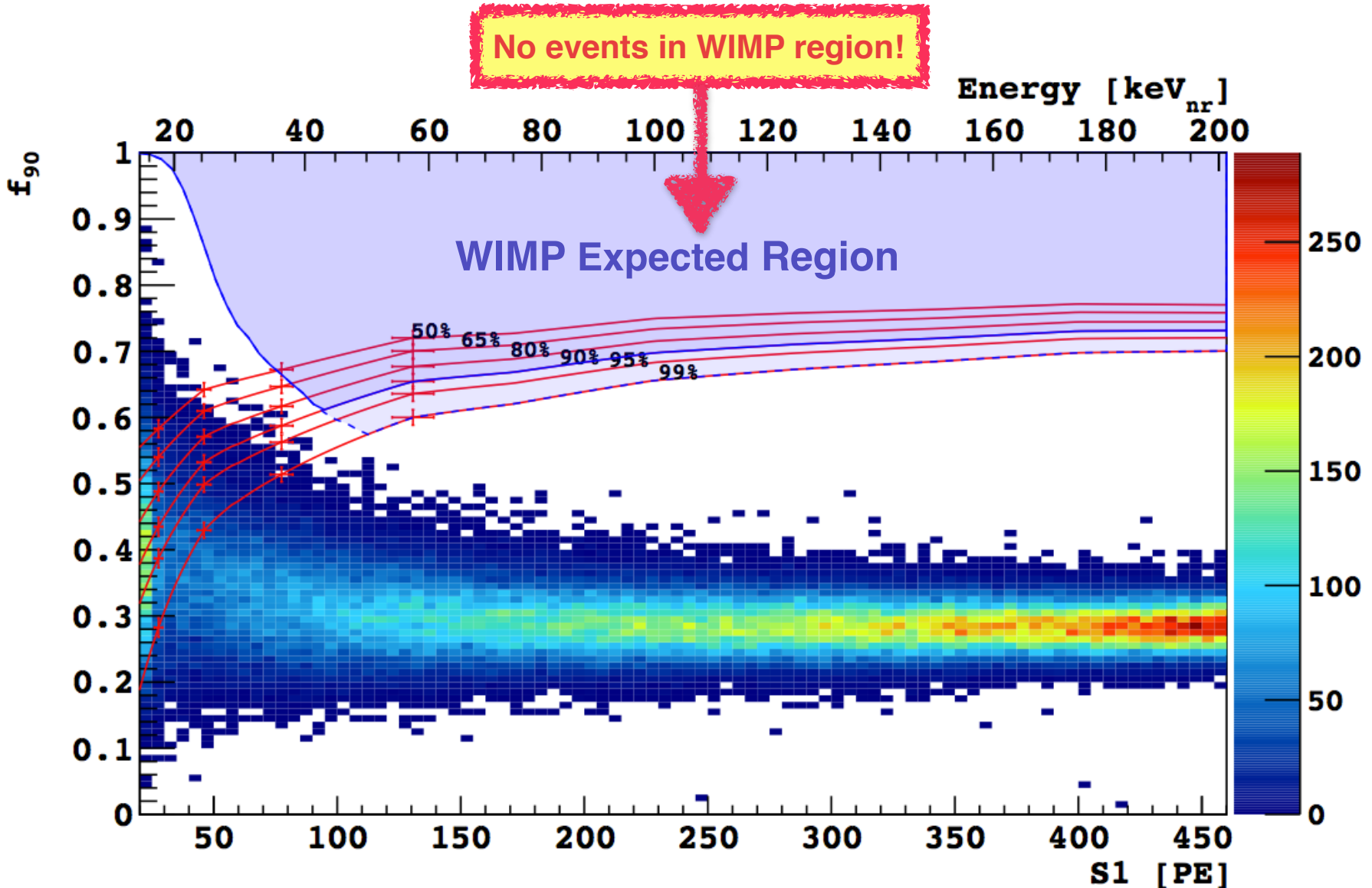
AAr vs UAr. Live-time-normalized S1 pulse integral spectra at zero field.
 ^{39}Ar reduction factor of $\sim 1400!$



<http://arxiv.org/pdf/1510.00702v1.pdf>

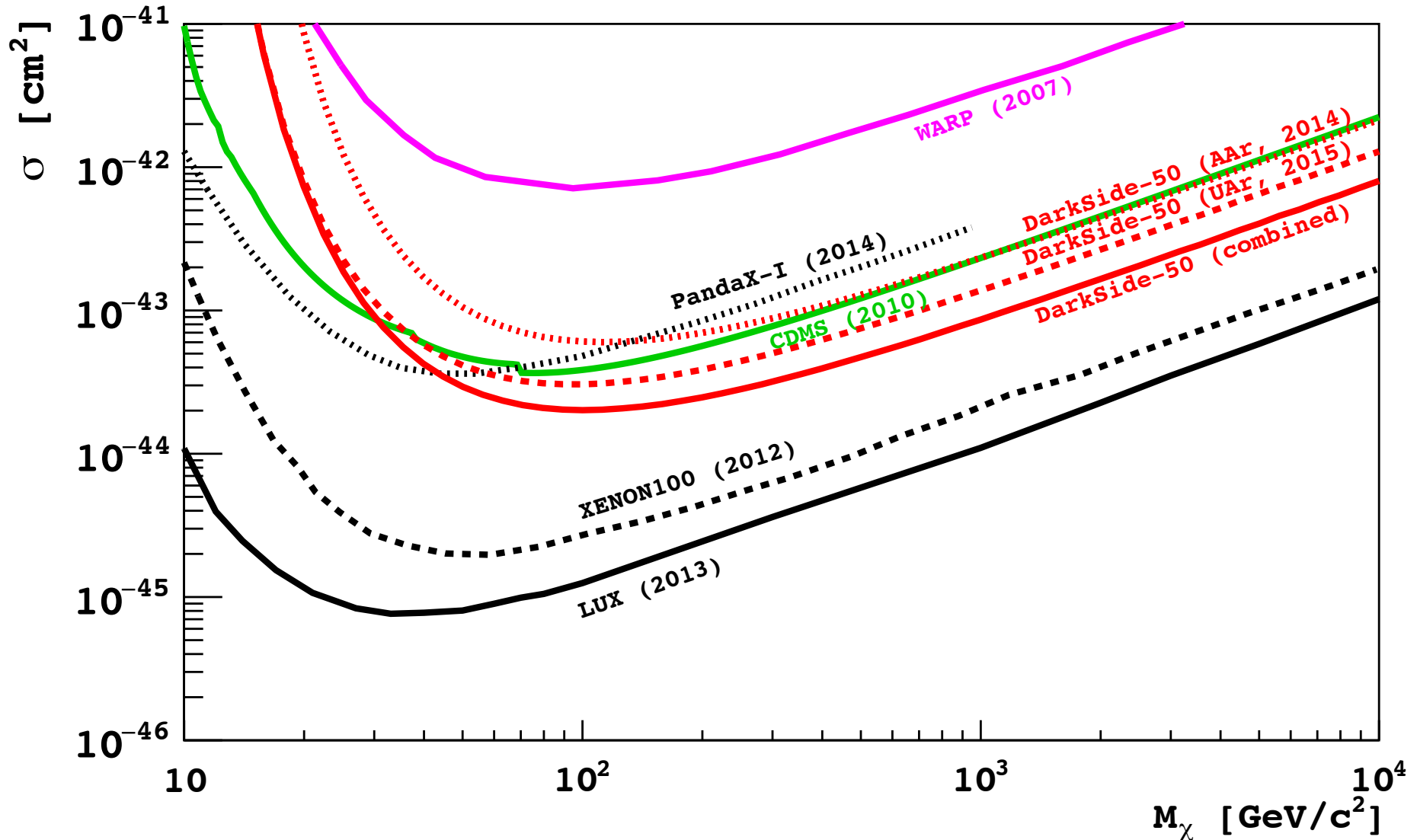
UAr First Results

71 live-days after all cuts. (2616±43) kg day exposure.
Single-hit interactions in the TPC, no energy deposition in the veto.



UAr First Results

Best limit to date with Argon target



DarkSide-50 milestones

October 2013:

All three detectors are assembled, commissioned and filled.
Cryostat is filled with AAr. Start of the AAr run.

June 2014:

End of WIMP search with AAr (1422 kg d exposure). First results.

October - December 2014:

Calibration campaign with CALIS.

January 2015:

LSV filled with new TMB. The ^{14}C rate is reduced from 150 kHz to 0.3 kHz.

April 2015:

Cryostat is filled with low radioactive UAr. Start of new WIMP search run.

October 2015:

First results with UAr, total exposure of 2616 kg d.

Thank You!