The DarkSide Program Giuliana Fiorillo March 18, 2014

The physics case

• WIMPs are still excellent candidates for particle dark matter properties, such as its mass and cross section

- WIMP masses: I GeV 100 TeV and cross sections: 10-40 10-50 cm²
- If a WIMP is discovered by a ton or multi-ton scale experiment, we must measure the recoil spectrum with high statistics, to extract WIMP
 - Dark matter identification: one of the highest science priorities!



WIMP masses and scattering cross sections

Example for theoretical predictions from supersymmetry



, 26 Feb 2014 DM@UCLA Roszkowsk



Available parameter space for WIMPs





Interaction rates for elastic scattering Recoil rate after integrative enne Akit Alisteibulic XC







A scalable technology for direct WIMP search: 2-phase low background argon TPC







technical prototype no DM goal



The DarkSide program at LNGS

DarkSide-50

sensitivity 10^{-45} cm²

DarkSide-G2



sensitivity 10^{-47} cm^2



DarkSide a null background strategy

 Time Projection Chamber (identify nuclear recoils from WIMPs) \Rightarrow Pulse Shape Discrimination of Primary Scintillation, SI (rejects β/γ , ~10⁷) \rightarrow Ionization: Scintillation Ratio, S2/S1 (rejects β/γ , ~10²) \Rightarrow 3D reconstruction of interactions (rejects γ and surface bkgs) \rightarrow Underground argon (avoid event pile-up from ³⁹Ar) Active Neutron Veto (identify neutrons with high efficiency in a compact volume) Water Cherenkov Muon Veto (identify muons to reject events induced by cosmogenic neutrons) Screen and select all detector materials for minimum radioactivity



Radon-free clean assembly room $\leq 5 \text{ mBq/m}^3 \text{ in } > 100 \text{ m}^3$ (CRH)

μ veto and n passive shield 1000 ton water Cherenkov 80 8" PMTs (WT - Borexino CTF)

neutron veto (LSV) 30 ton borated liquid scintillator (50%PC +50%TMB +PPO) 110 8" PMTs

> WIMP LAr detector 150 kg of UAr < 6.5mBq/kg (DS-50 TPC)

DarkSide-50

All facilities sized to house DarkSide-G2





DarkSide-50 Status

- with atmospheric argon target
- for GI- and G2-scale study of betas' rejection
- ³⁹Ar events in \sim 3 yrs DarkSide-50 with underground argon)
 - Results presented at DM2014 for full set of data

 - exposure

TPC, neutron veto, muon veto commissioned; physics run started end of October 2013

Largest fraction of November 2013-January 2014 dedicated to improvements of DAQ and data handling and processing, with the goal to permit large collection of ³⁹Ar decays

• As of February 20 already collected 3×10^{7 39}Ar events in 6.5 live days (equivalent to

Analysis still under development: S2/S1 cut and and x-y reconstruction cut require insitu calibrations due to S2 disuniformity and will not be presented or discussed

Detector is background free (even without S2/S1 and x-y cuts) over 280 kg×day



280 kg×day Exposure





DarkSide-50 Expected Sensitivity







DarkSide-50 Prospects

- online data reduction
 - Live time now >90%, aiming to reach >95% soon!
 - 44 kg fiducial in a 50 kg target
 - **1,365 kg×day** exposure as of Mar 18, 2014 (44 kg × 31 days)
 - (20|4))
 - **181301 (2012))**

Data collection restarted February 22 with smart FPGA-based trigger for

• LUX: 10,030 kg×day (85 days × 118 kg, Phys. Rev. Lett. 112, 091303

• XENON-100: 7,650 kg×day (225 days × 34 kg, Phys. Rev. Lett. 109,

• CDMS+Edelweiss: 614 kg×day (Phys. Rev. D 84, 011102(R) (2011))



DarkSide-50 Exposure





DarkSide-50 Prospects

- in high ¹⁴C
- with underground argon)
- July 2014: in-situ calibrations
- August 2014: switch to underground argon

March-April 2014: exchange TMB - one of two components of scintillator was produced with 10% carbon from methanol, resulting

• May-June 2014: ³⁹Ar spike to collect G2-sized statistical sample (equivalent to substantial fraction of planned 5 yrs DarkSide-G2







G2 Exposure (5 Years)



DarkSide-G2 Expected Sensitivity









DarkSide-G2



DS-G2 projected sensitivity



18 tonne-year exposure, E_r=55-240 keV_r [120-500 PE], 70% acceptance for NR

