



# **Status report on the DarkSide-50 WIMP search project**

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for the DarkSide collaboration

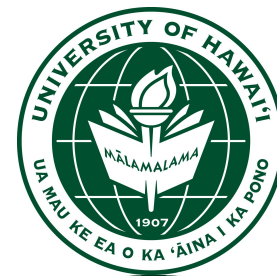
9<sup>th</sup> Patras workshop on Axions, WIMPs and WISPs  
Mainz, June, 23-28 2013



# Outline



- WIMP search with a LAr TPC
- DarkSide 50 structure
- DS50 construction status
- DS50 TPC commissioning
- Schedule
- Summary & Outlook: DS-G2

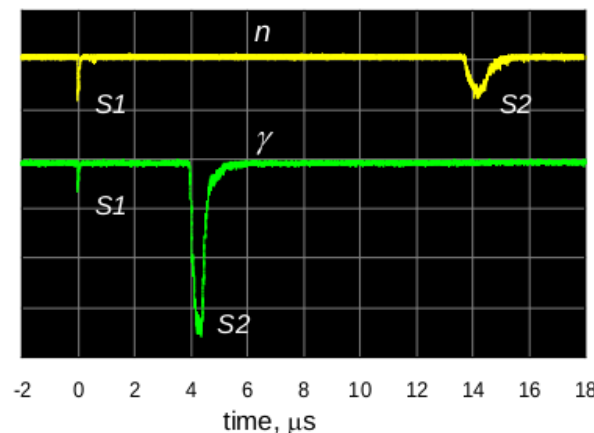
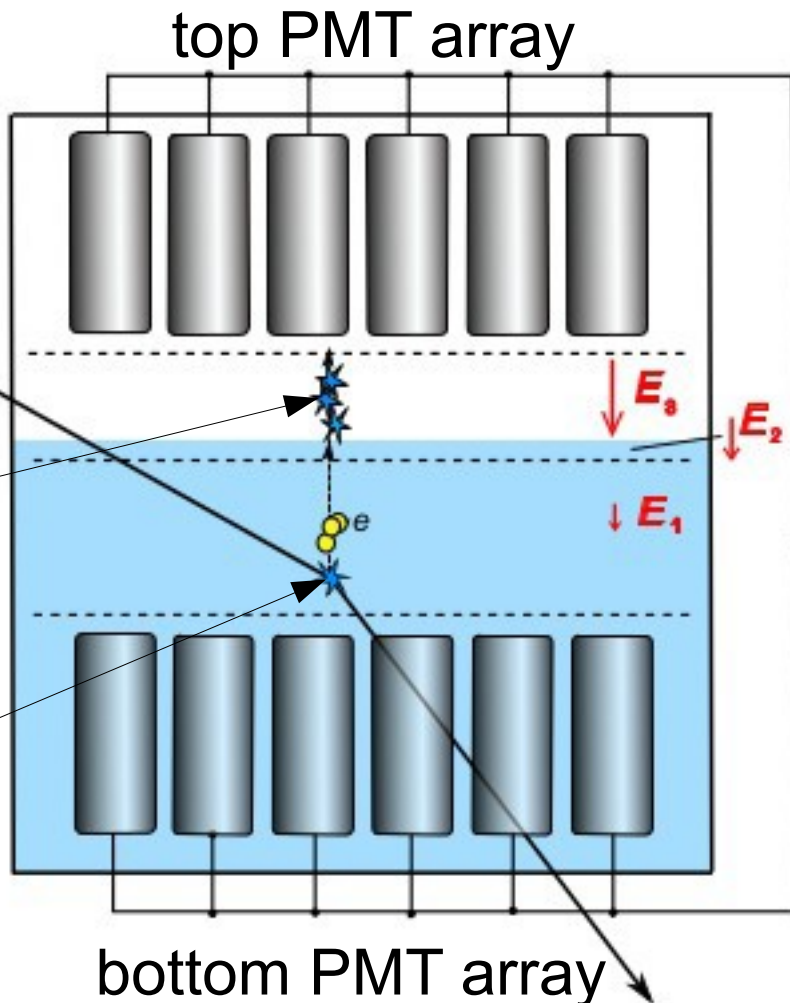


# Dual phase TPC

- signal: WIMP
- BG:
  - neutron
  - e<sup>-</sup>/γ

ionization signal (S2) in gas phase

primary scintillation signal (S1) in liquid



S1/S2:  
n vs. e<sup>-</sup>/γ-discrimination

source: Chepel/Araujo, arxiv:1207.2292

june 27, 2013

DarkSide 50

p. 3



# Why a LAr-TPC?



- scintillator with excellent light yield  
-> low energy threshold + PSD
- little intrinsic background, when using  $^{39}\text{Ar}$ -depleted underground argon (depl. factor  $>150$ )
- self-shielding & homogeneous & eff. purification
- background discrimination capabilities



# Why a LAr-TPC?



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- little intrinsic background, when using  $^{39}\text{Ar}$ -depleted underground argon (depl. factor  $>150$ )
- self-shielding & homogeneous & eff. purification
- background discrimination capabilities:
  - $\beta/\gamma$ -discrimination based on S1/S2-ratio
  - readout of S1 and S2 signals gives excellent position reconstruction -> reject surface events
  - PSD on primary scintillation signal ( $\beta/\gamma$  discr.)



# Neutron Backgrounds



- radiogenic (from ( $\alpha, n$ ) or spontaneous fission of detector material))
- cosmogenic

## Fighting n Backgrounds

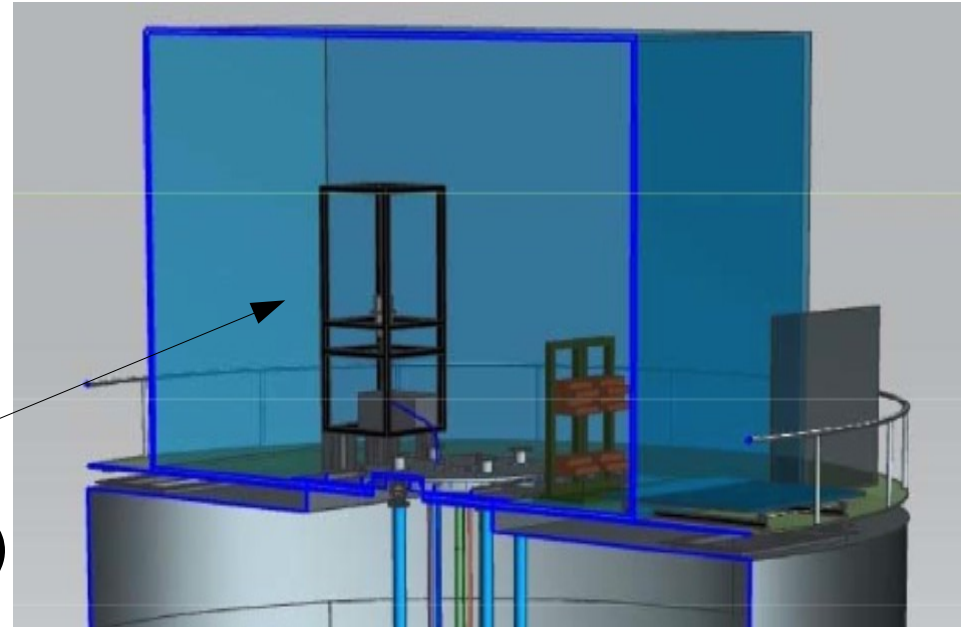
- passive: Gran Sasso, water Cherenkov veto
- material screening
- active: liquid scintillator neutron veto



# DS50 structure

Gran Sasso (passive sh.)

radon-free clean room  
( $\lesssim 30 \text{ mBq/m}^3$  in  $>100 \text{ m}^3$  CRH)



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# DS50 structure

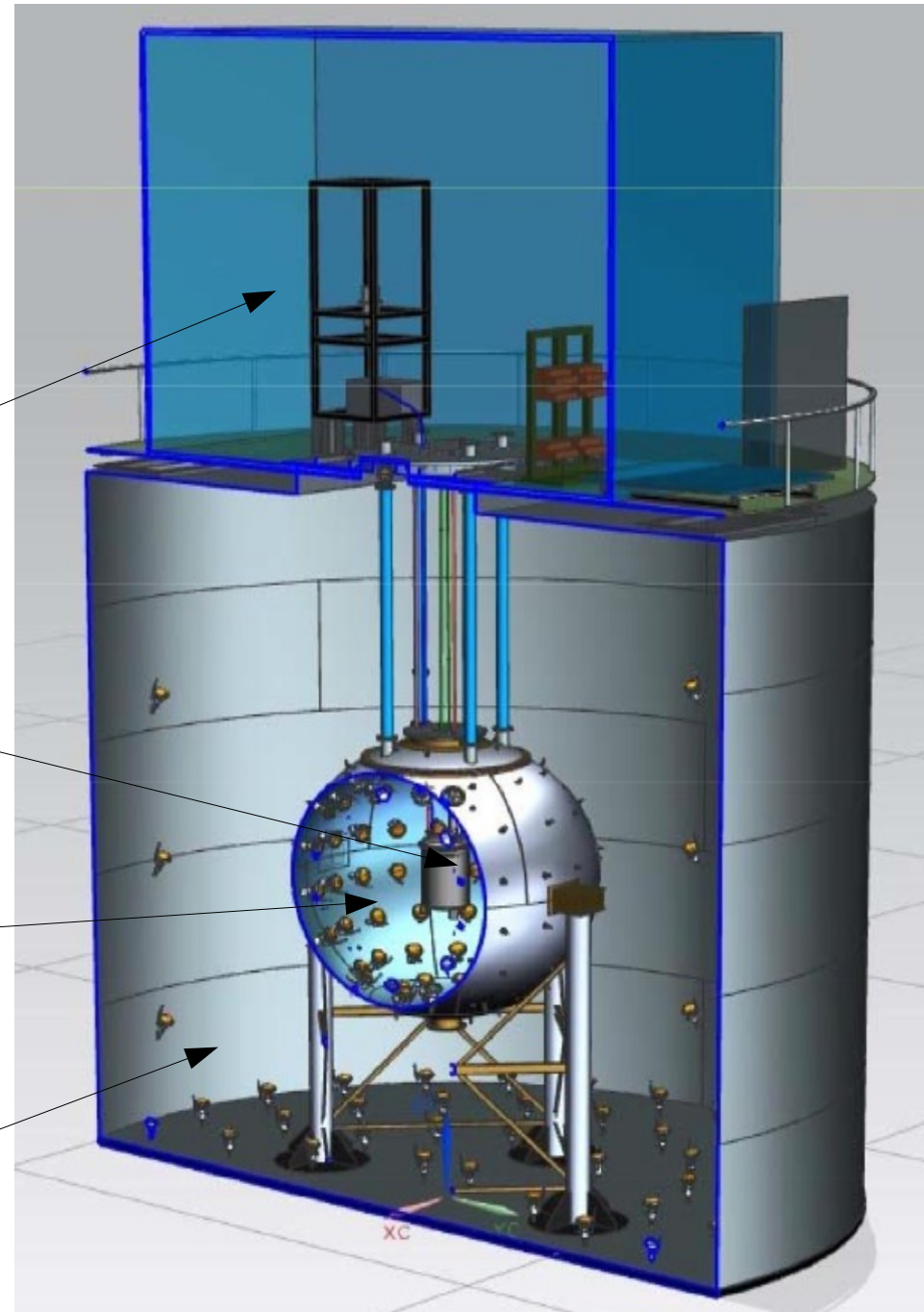
Gran Sasso (passive sh.)

radon-free clean room (CRH)

LAr TPC (Inner Detector)

borated liquid scintillator  
neutron veto (active BG  
measurement)

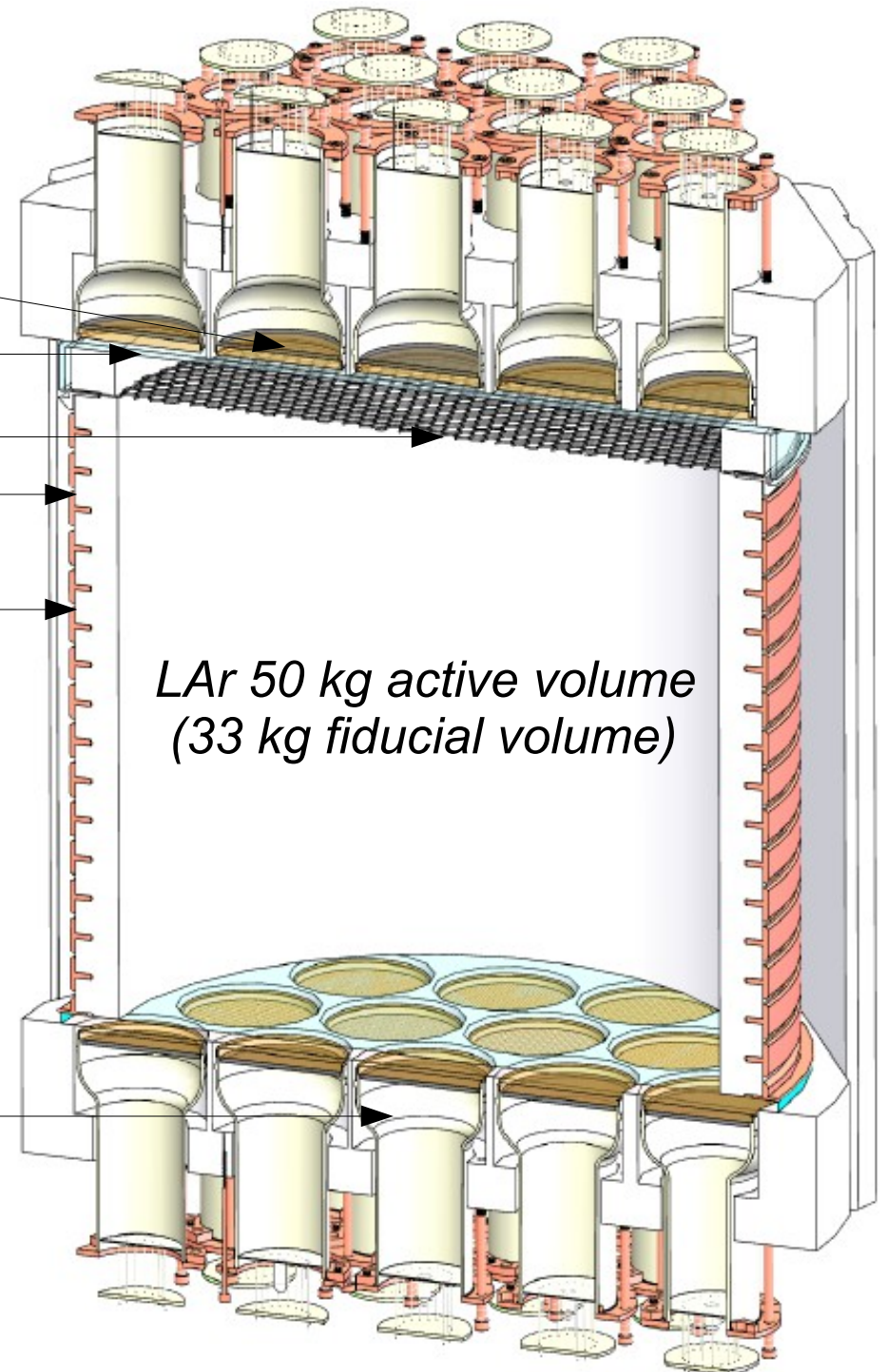
water Cherenkov muon veto  
(Borexino CTF, passive)





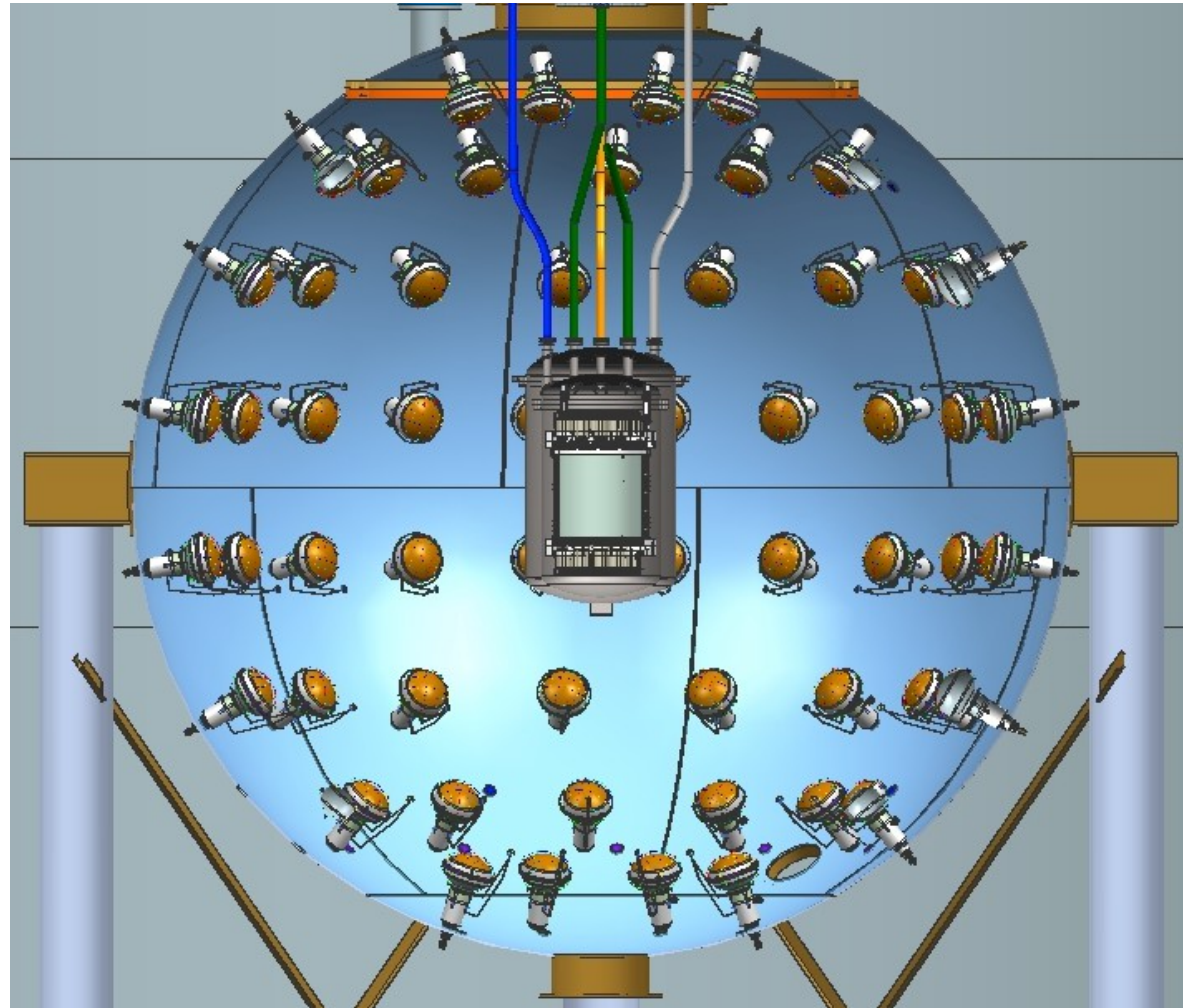
# DS50 LAr TPC

- 19 3" PMTs
  - TPB+ITO covered diving bell (anode window)
  - extraction grid
  - TPB coated PTFE (reflector)
  - copper field cage rings
- 
- ITO covered cathode window
  - 19 3" PMTs



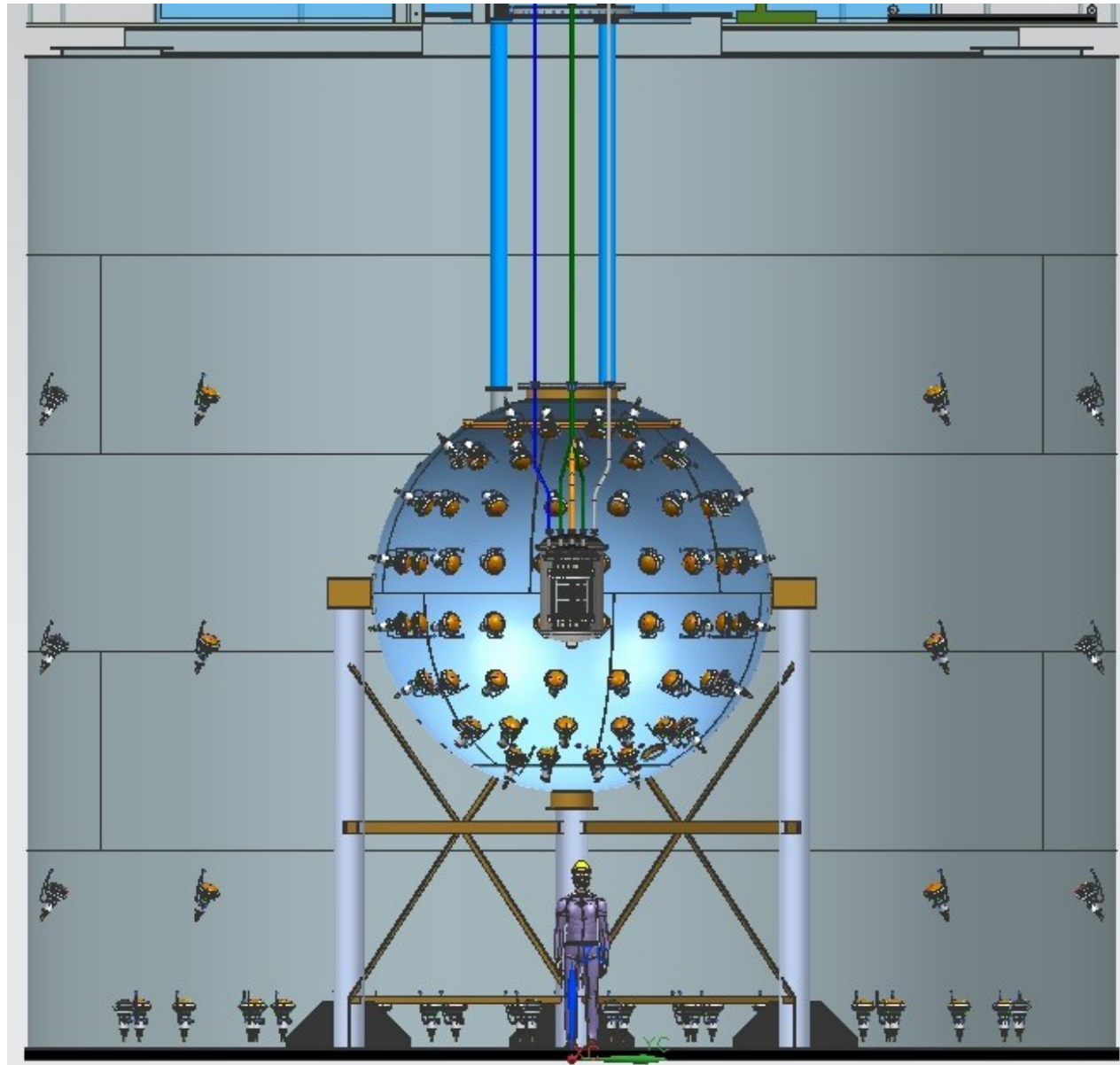
# Liquid scintillator neutron veto

- 4m diameter stainless steel sphere
- 110 8" PMTs
- 1:1 PC + TMB liquid scintillator + 3 g/l PPO
- borated scintillator: high efficiency for neutron captures (arxiv:1010.3609)
- allows to measure neutron BG in-situ with TPC-veto coincid.
- 4m sphere is ready to house the next generation DS-5000



# Water Cherenkov muon veto

- Borexino CTF tank (10 m height, 11 m diameter)
- filled with 1kt ultra-pure water
- observed by 80 upward facing PMTs
- muon veto
- passive shielding against external neutrons and gammas





# DS50 construction (June 2013)

## water Cherenkov veto:

- CTF veto tank (1kt water)
- Tyvek installed
- PMT installation imminent



# Neutron liquid scintillator veto



# Neutron liquid scintillator veto

- lumirror reflective foil installed
- 110 8" PMTs installed
- PMTs tested and successfully commissioned after installation





# TPC assembly & installation

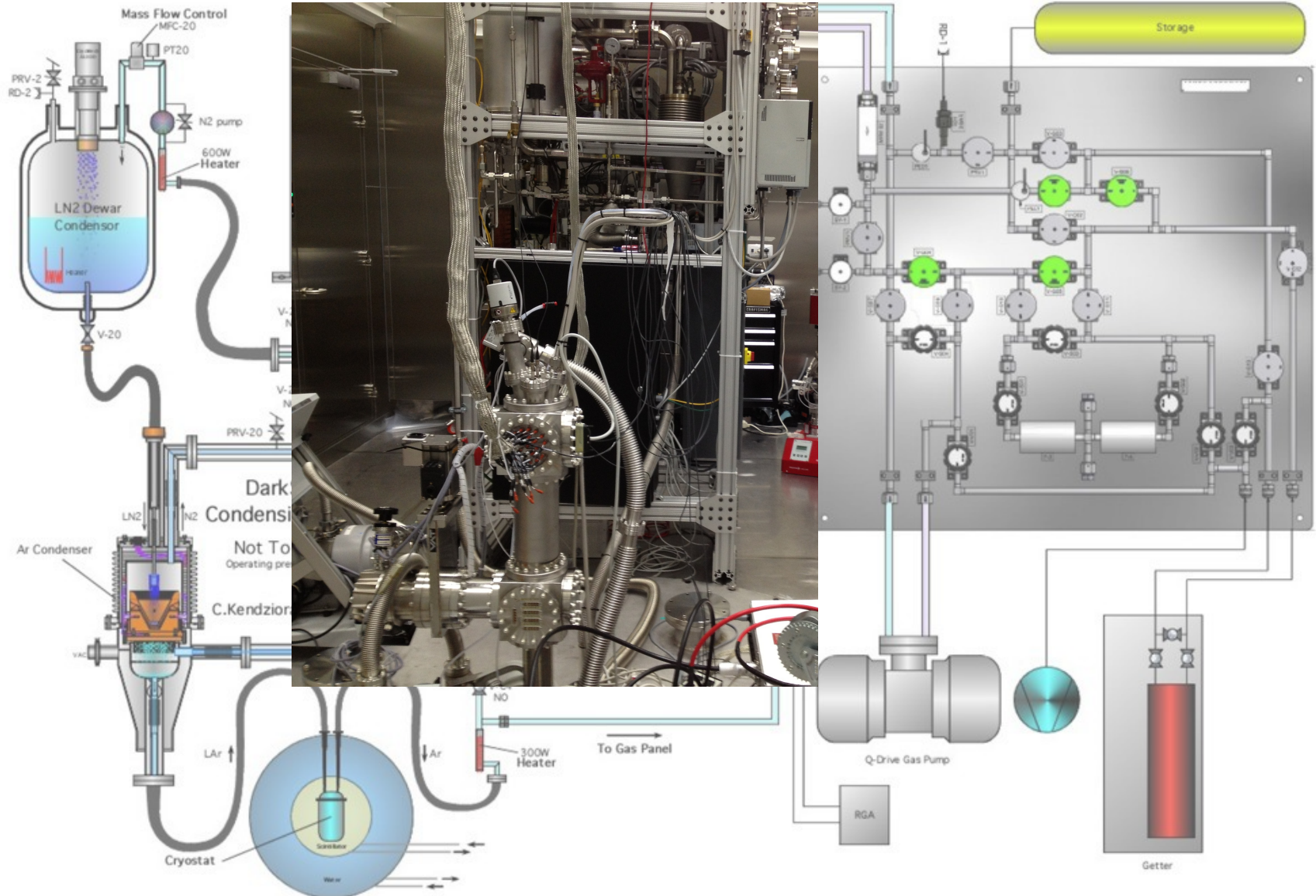
- successful assembly of the TPC in the radon-free clean room (CRH),
- installation in the cryostat and
- installation of the cryostat in the veto







# Argon circulation & purification system





# TPC commissioning



- TPC commissioning since May 2013 with atmospheric argon
- goals: basic functional tests & first measurements of physics parameters of the TPC in a low shield environment (no neutron/ water veto)



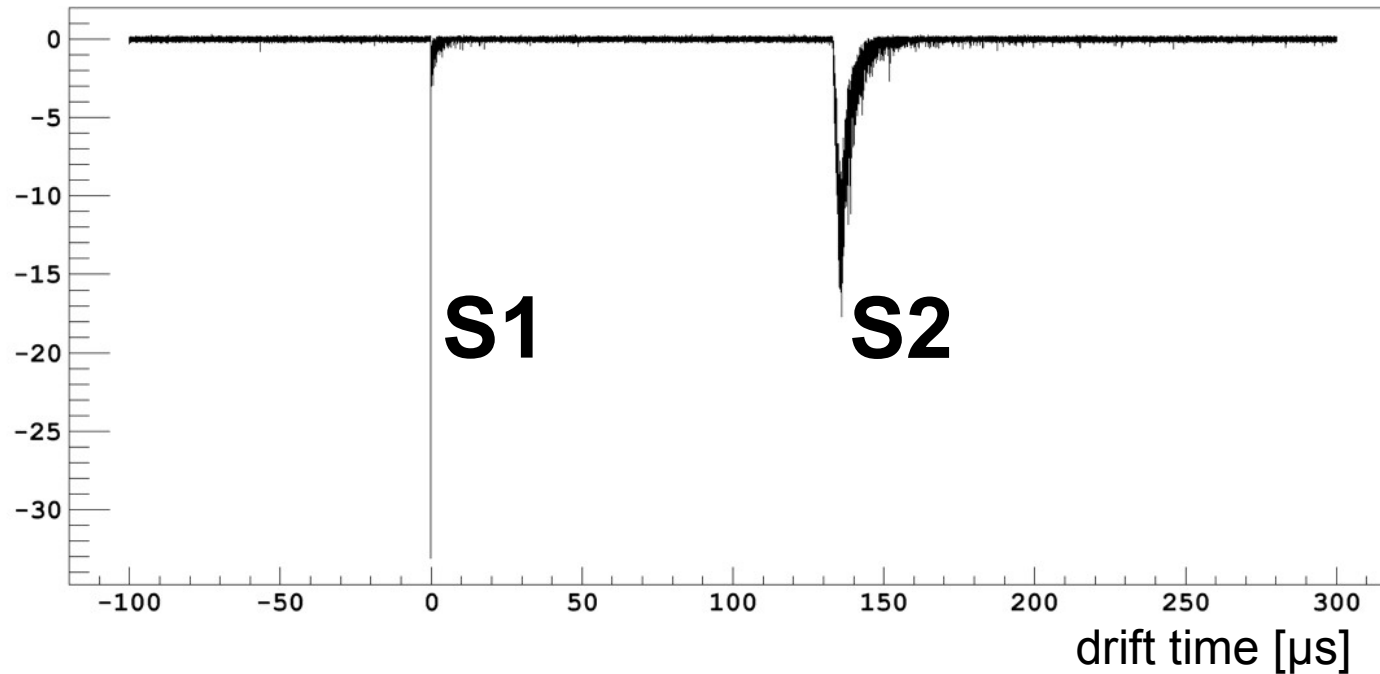
# TPC commissioning (a selection of topics)



- Argon recirculation & cryo system
- HHV (TPC high voltage)
- gas pocket
- electronics & DAQ:
  - PMT gain calibration (Laser)
- slow control
- [and many more]



# TPC commissioning (first light)



currently ongoing measurements of physics parameters, e.g.:

- LY
- electron lifetime
- background rates & spectra



# Schedule DS-50

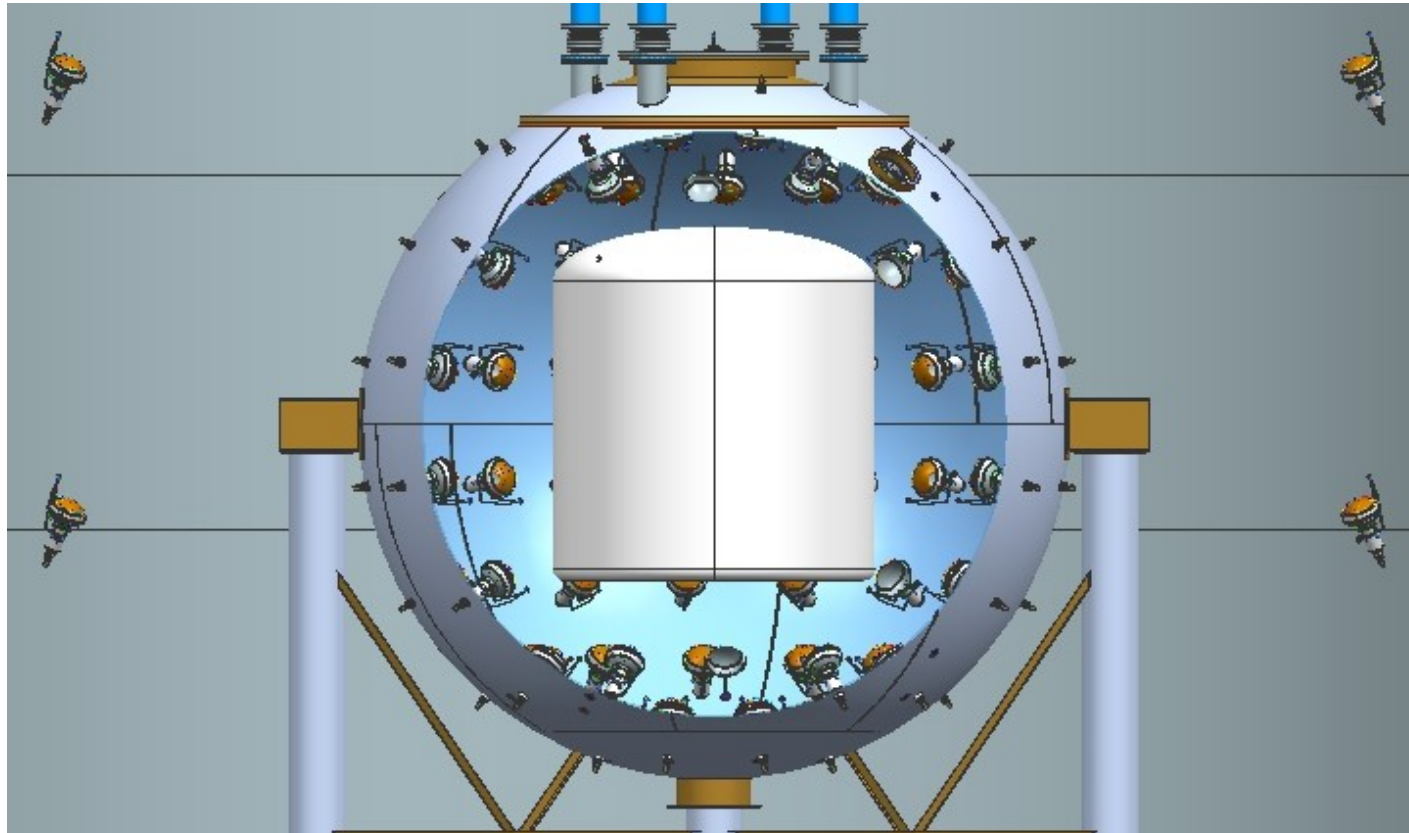


- finalizing of TPC commissioning: July 2013
- thereafter: filling with underground argon
- commissioning of neutron veto & water veto:  
Fall 2013
- first physics run in final configuration in  
**Fall 2013**





# Darkside 5000



- R&D and engineering for ton-scale experiment "DS G2" with 5t liquid Argon (active volume) and a sensitivity of  $2 \cdot 10^{-47} \text{ cm}^2$
- reuse same neutron veto + water Cherenkov veto



# Summary: DS50 design goals



- WIMP search with LAr TPC using  $^{39}\text{Ar}$ -depleted underground argon
  - efficient passive veto of radiogenic neutrons and cosmogenic neutrons
  - material screening
  - *in-situ* measurement of remaining (radiogenic) neutron background using borated scintillator (TMB) as active neutron veto
- > *aim for zero-BG technology*



# Summary

- the DS50-TPC is being commissioned and first light has been seen in the TPC
- preliminary results show that the LAr-TPC is operating within specifications
- next steps involve filling of the neutron veto + water Cherenkov veto
- first physics run in **Fall 2013**
- sensitivity with 3 years of BG-free running of DS-50:

$$\sigma_{\text{spin-independent}} = 1 \cdot 10^{-45} \text{ cm}^2 (@ 100 \text{ GeV}/c^2 \text{ WIMP})$$

# The DarkSide collaboration



Augustana College, USA

APC Paris, France

Black Hills State University, USA

Fermilab, USA

IHEP, China

INFN Laboratori Nazionali del Gran Sasso, Italy

INFN and Università degli Studi Genova, Italy

INFN and Università degli Studi Milano, Italy

INFN and Università degli Studi Napoli, Italy

INFN and Università degli Studi Perugia, Italy

INFN and Università degli Studi Roma 3, Italy

IPHC Strasbourg, France

Jagiellonian University, Poland

Joint Institute for Nuclear Research, Russia

Princeton University, USA

RRC Kurchatov Institute, Russia

SLAC, USA

St. Petersburg Nuclear Physics Institute, Russia

Moscow University, Russia

Institute for Theoretical and Experimental Physics, Russia

Institute of Nuclear Research, Ukraine

Temple University, USA

University College London, UK

University of Arkansas, USA

University of California at Los Angeles, USA

University of Chicago, USA

University of Hawaii, USA

University of Houston, USA

University of Massachusetts at Amherst, USA

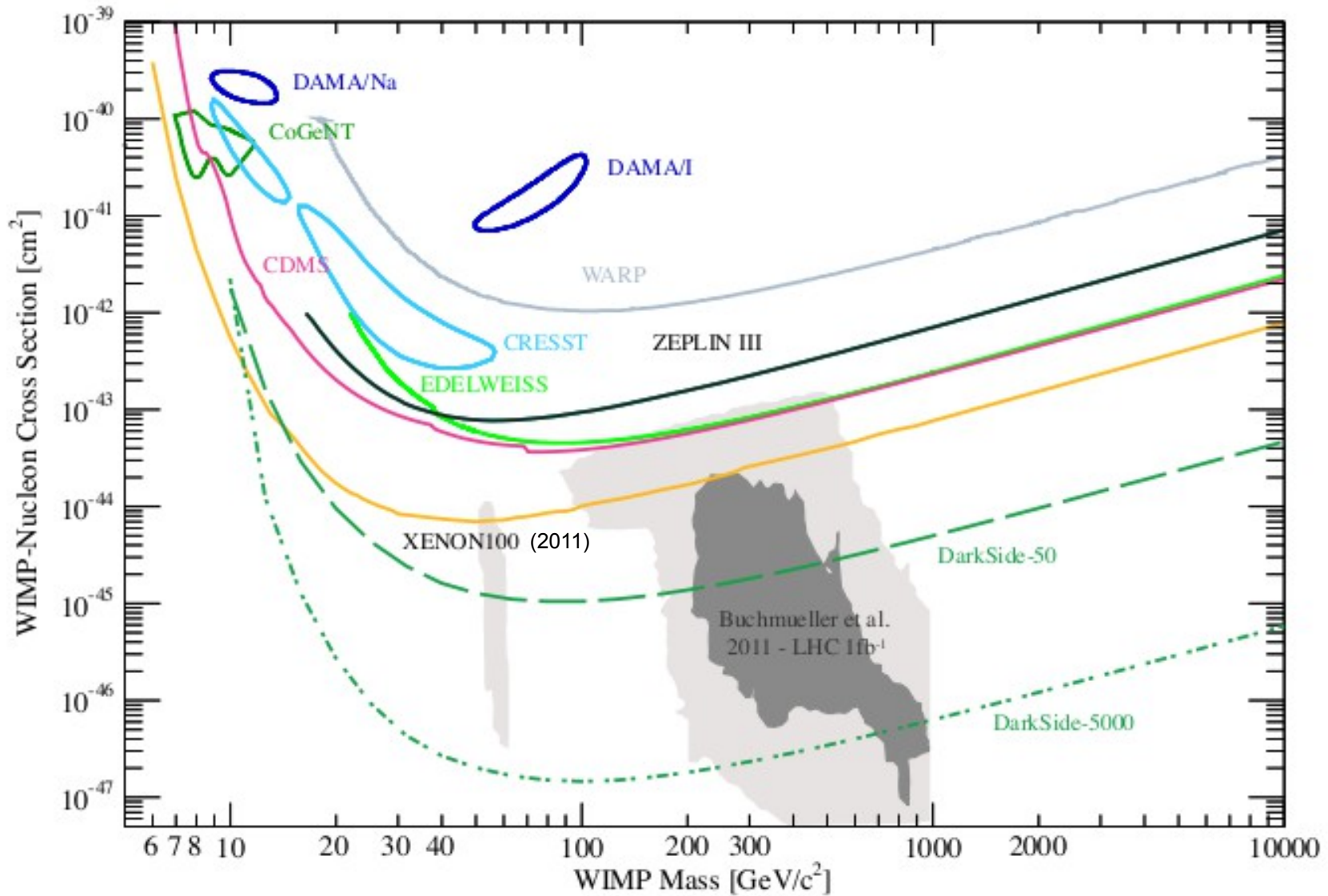
Virginia Tech, USA

University of Virginia, USA



# Backup

# Darkside WIMP search program



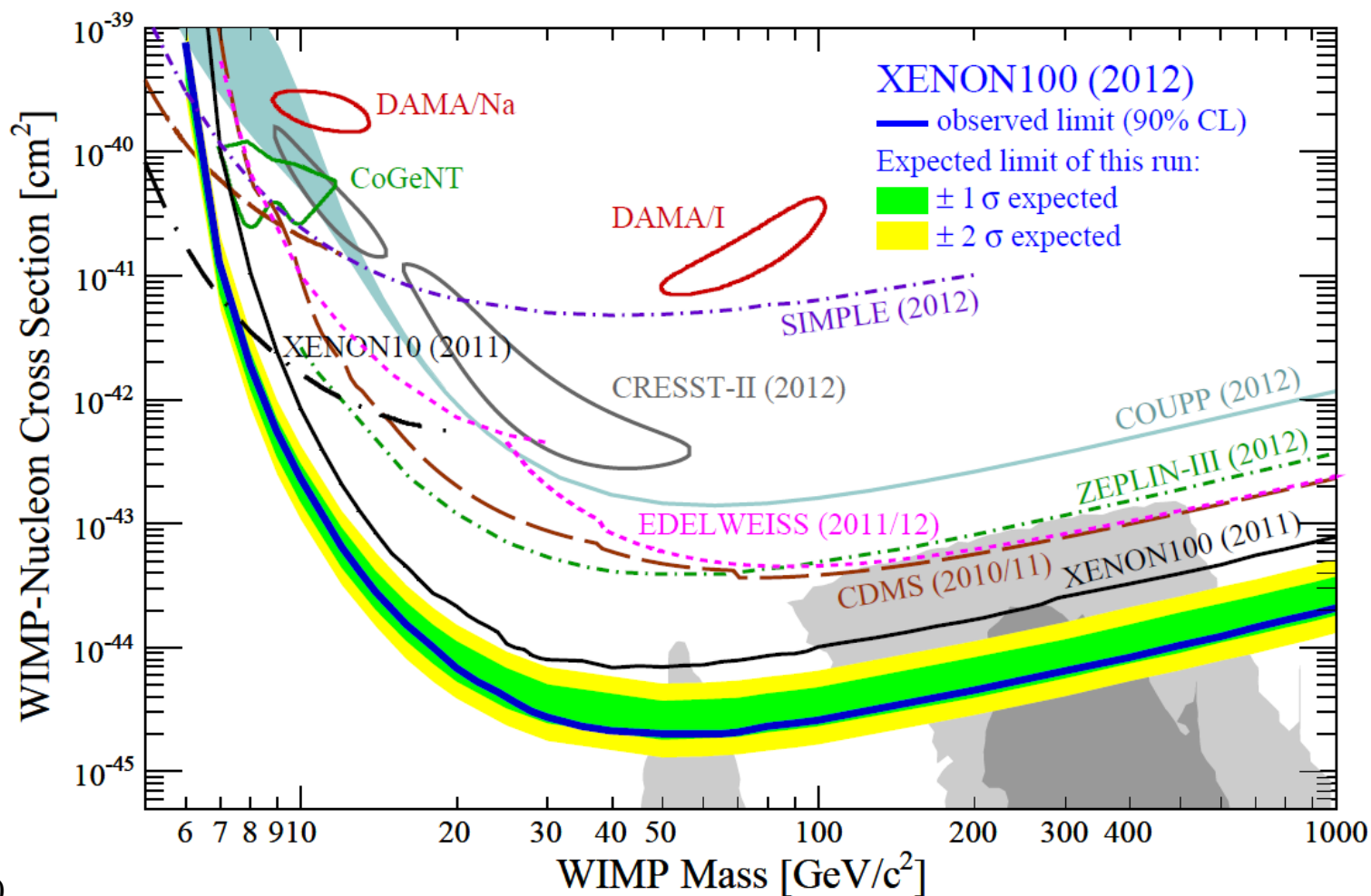




# sensitivity XENON100



- from <http://arxiv.org/abs/1207.5988>



# Darkside WIMP search program

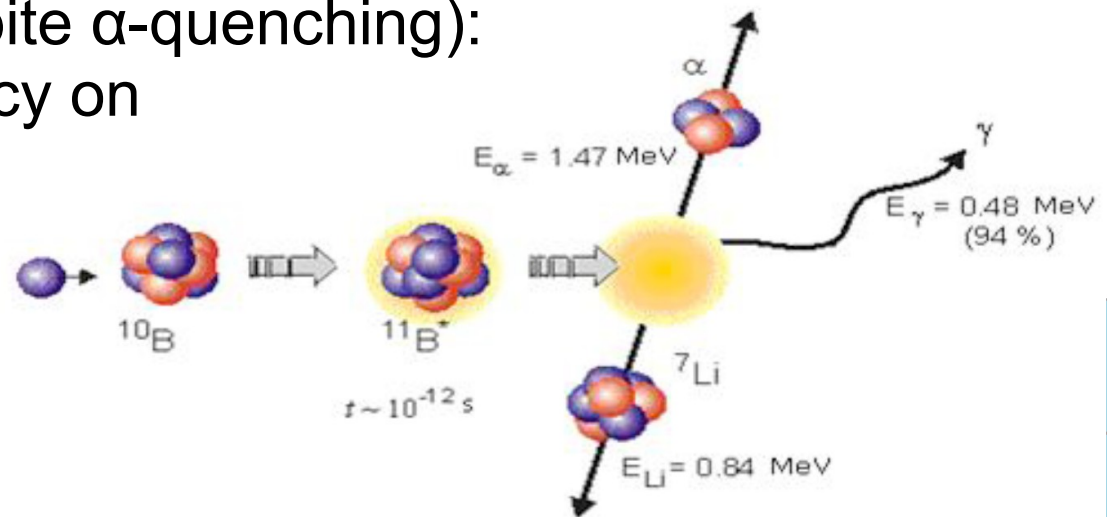
- DS10 prototype
  - not physics capable
  - measurement of record LY of 9 keVee/MeV for a  $^{137}\text{Cs}$  source (arxiv:1204.6218)
  - operated the HHV stably at required 36 keV for 8 months
  - study of pulse shape discrimination capabilities
  - sensitivity extrapolations for DS50 & tuning of MC



# borated liquid scintillator



- neutron veto scintillator:
  - 1:1 mixture of Trimethyl-borate (TMB) and pseudocumene (PC)
- TMB has 20 %  $^{10}\text{B}$ , which has very high neutron capture cross section (3837 b)
- small capture time constant (2.3 us) allows for vetoing with small incurred dead-time
- decay in  $^7\text{Li} + \alpha$  or  $^7\text{Li} + \alpha + \gamma$ , which can be detected directly with high efficiency (despite  $\alpha$ -quenching):
  - 99.5 % detection efficiency on radiogenic neutrons (arxiv:1010.3609)
- decay products produce 50-60 keVee  $E_{\text{vis}}$

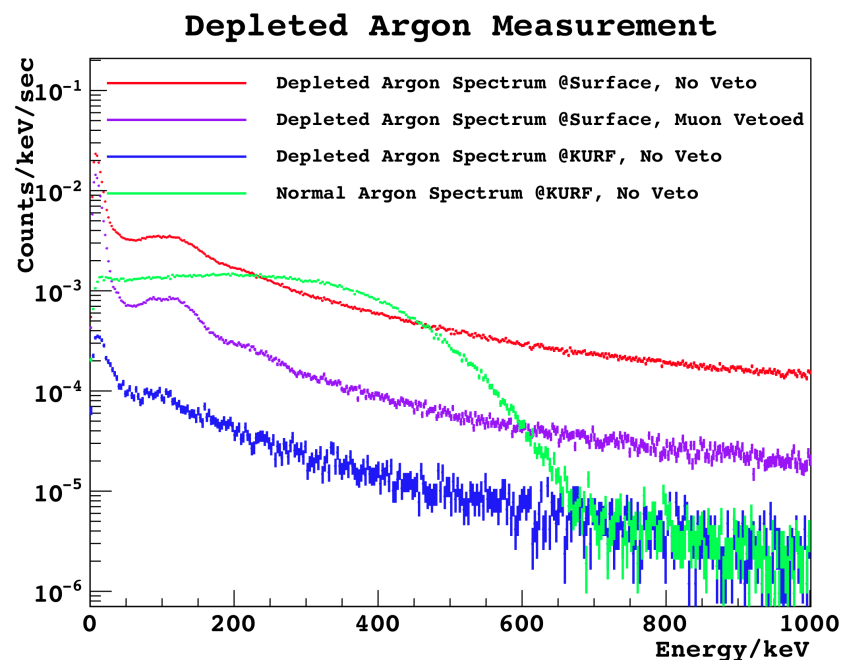




# Underground argon



- $^{39}\text{Ar}$  ( $\beta$ -emitter with half-life 269 y, end-point 0.56 MeV)
- atmospheric argon: 1 Bq/kg  $\rightarrow$  event pile up for ton-scale experiments
- limitation at low energies where PSD becomes less powerful
- (mostly) produced through cosmic rays
- underground argon has  $> 150x$  less  $^{39}\text{Ar}$  (as measured)







# Underground argon



- all UAr necessary for DS50 extracted (150 kg)
- distillation column for UAr: [arxiv:1204.6061](https://arxiv.org/abs/1204.6061)





# DarkSide 50



## Dimensions

- Active volume diameter 35.6 cm
- Active volume height 35.6 cm
- Gas pocket height 1.0 cm
- LAr above grid 0.5 cm
- TPC full height 69.0 cm

## Masses

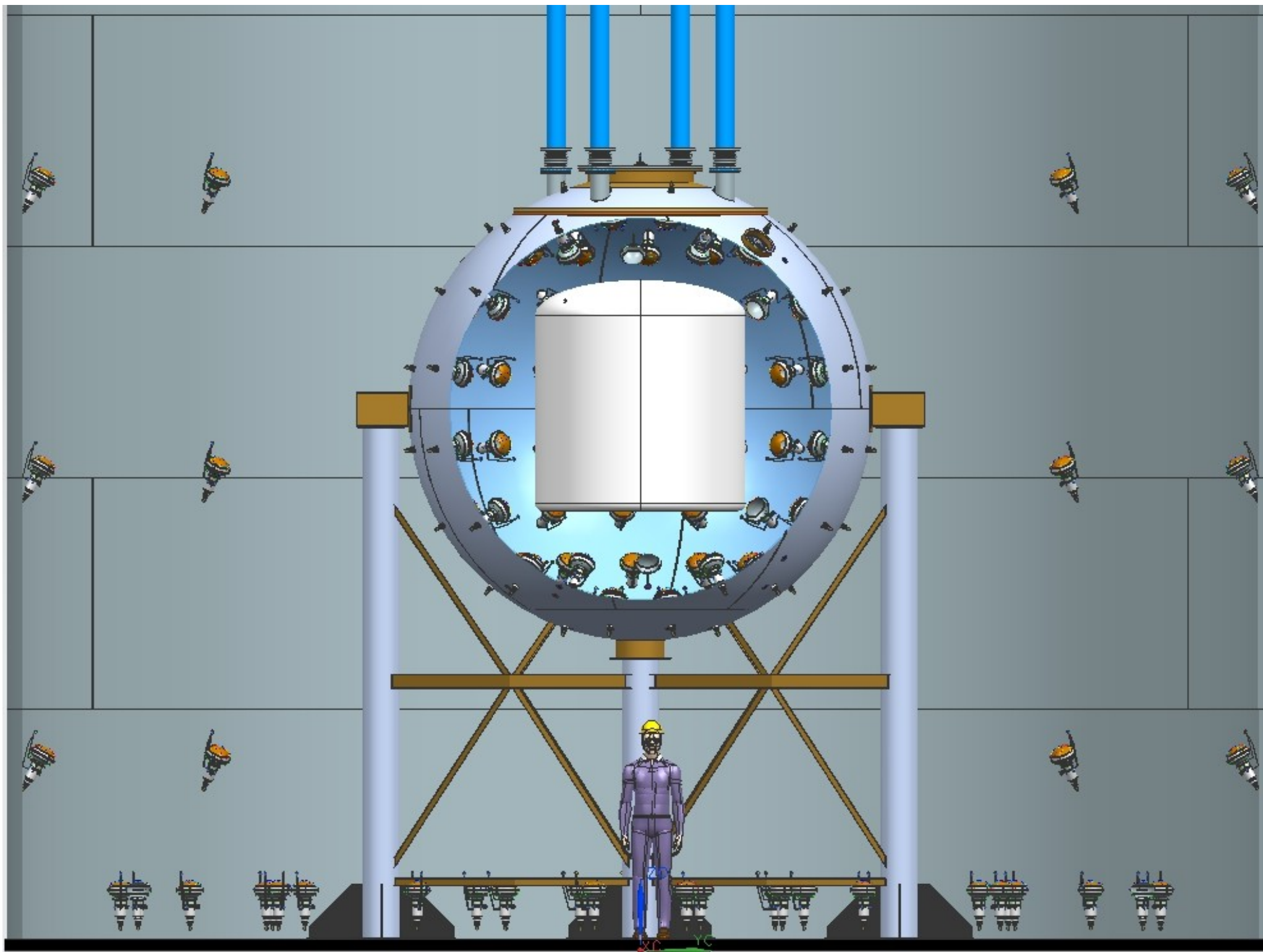
- Active LAr 49.4 kg
- Total LAr ~145 kg
- Main PTFE reflector 22.8 kg
- Total PTFE 59.2 kg
- Total fused silica 3.5 kg
- Copper field cage rings 23.5 kg
- 38 R11065 PMTs 7.9 kg

## Other parameters

- Recirculation rate (min)\* 15 slpm  
(max)\* 40 slpm  
=4.1 kg/h
- Drift field (typical) 1.0 kV/cm
- Extraction field (typ) 3.8 kV/cm
- Electroluminescent field 5.7 kV/cm
- Grid potential -7.6 kV
- Cathode potential -43.2 kV
- Photocathode coverage ~20%  
of top and bottom ~60%

\* Estimate







# DarkSide 5000

