

# DEAP-3600

Direct Dark Matter detector with single phase liquid argon

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on behalf of the DEAP collaboration

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June 16, 2014

# Outline

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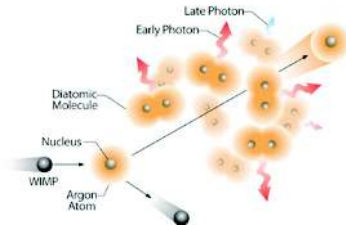


# The DEAP collaboration

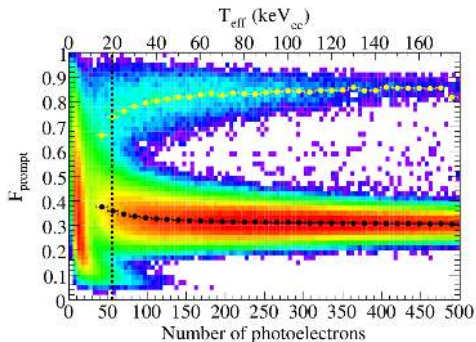
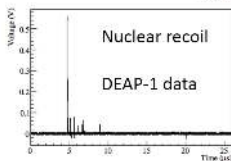
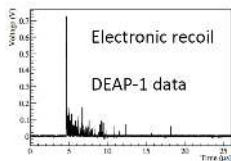
70 collaborators from UK and Canada



# Scintillation of argon

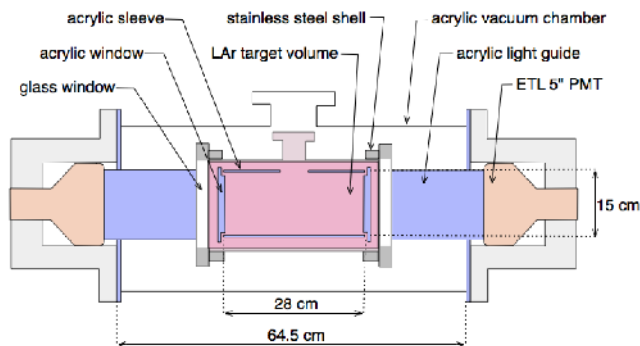


- Light (128 nm) is produced with the dissociation of  $\text{Ar}_2^*$ .
- Two molecular states of  $\text{Ar}_2^*$ ; singlet and triplet, with **very** different lifetimes: 7 ns vs. 1.5  $\mu\text{s}$ .
- 1,1,4,4-Tetraphenyl-1,3-butadiene (TPB) used to shift the light to the easier to detect 420 nm.



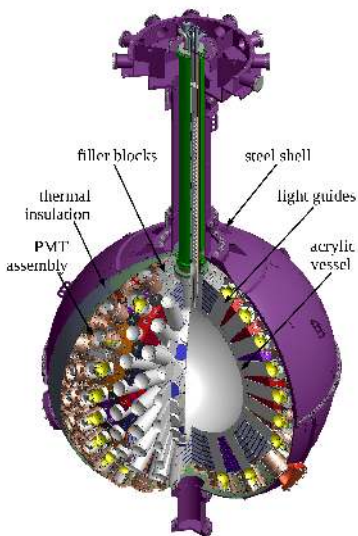
# DEAP development program

## DEAP-1: 7 kg LAr target in various configurations



*Significant radon reduction and backgrounds understanding gained, as well as confirmation of pulse shape discrimination. Two papers submitted to Astroparticle Physics.*

## DEAP-3600: design



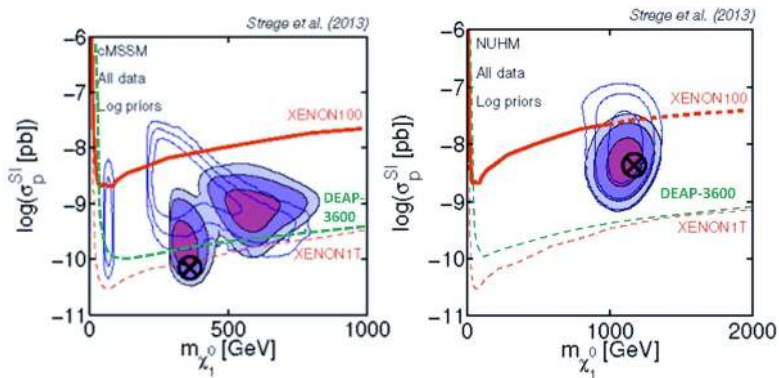
- Contains 3600 kg argon target (1000 kg fiducial) sealed in an ultra-clean acrylic vessel.
- The acrylic vessel is “resurfaced” in-situ to remove deposited Rn daughters after construction.
- TPB is then deposited in a clean, vacuum environment.
- Array of 255 Hamamatsu R5912 IIQE PMTs: 8”, 32% QE, 75% coverage
- Connected with 50 cm light guides plus PE shielding provide neutron moderation.
- Inside 8 m water shield at SNOLAB.

## DEAP-3600: basic parameters

Parameter	Value
Light yield	8 pe per keVee
Nuclear quenching factor	0.25
Analysis threshold	15 keVee (60 keVr)
Total argon mass (radius)	3600 kg (80 cm)
Fiducial mass (radius)	1000 kg (60 cm)
Position reconstruction resolution	< 6.5 cm
Background specification	Target
Radon in argon	< 1.4 nBq/kg
Surface $\alpha$	< 100 $\mu$ Bq/m <sup>2</sup>
Neutrons in fiducial volume	< 2 pBq/kg
$\beta/\gamma$ events (after PSD)	< 2 pBq/kg
<b>Total backgrounds</b>	<b>&lt; 0.3 events in 3 tonne-year</b>

# Physics reach

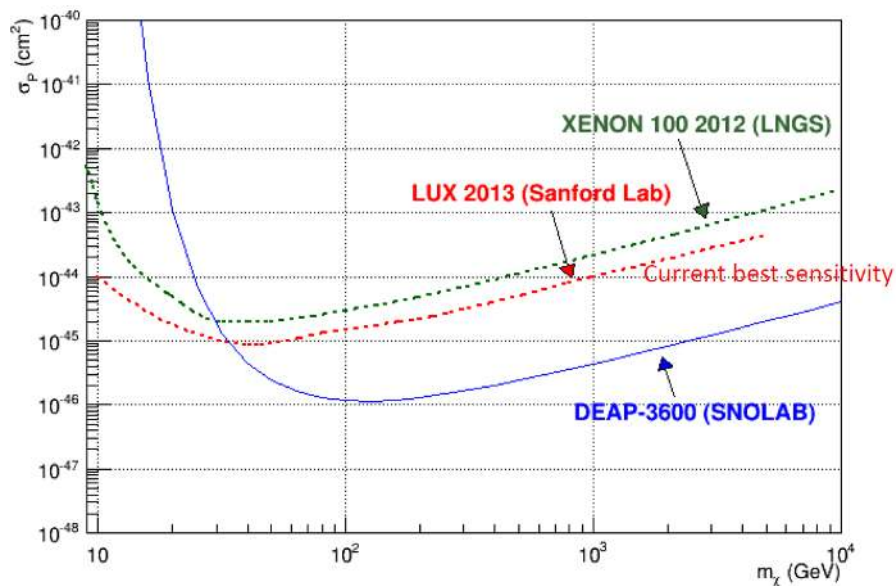
DEAP-3600 sensitive to SI DM interactions at  $10^{-46}$  cm<sup>2</sup> at 100 GeV.  
A factor of 23 improvement at high WIMP mass over current LUX leading result.



Adapted from: C. Strege et al. *Journal of Cosmology and Astroparticle Physics*, 4, 2013.



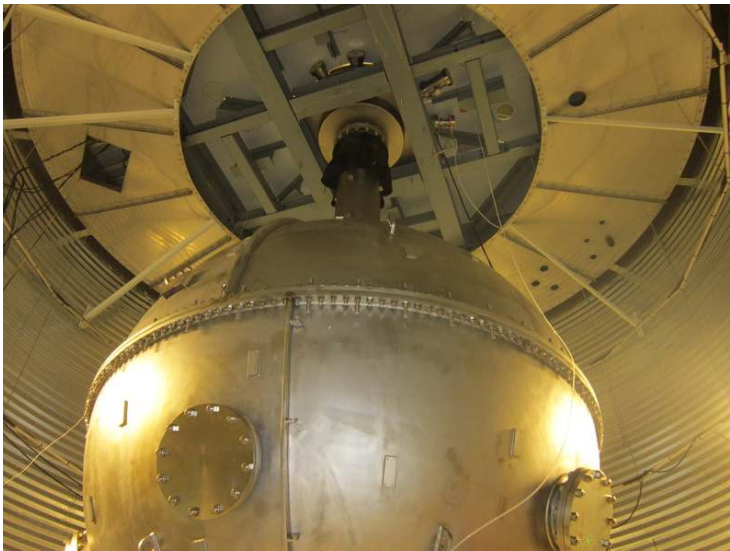
# DEAP-3600 projected sensitivity



# Cryocoolers



# Steel shell and watershield



# Acrylic production

Very tight control of the radiopurity (Chris Jillings, LRT2013)



*Tight control of production at RPT  
Asia*

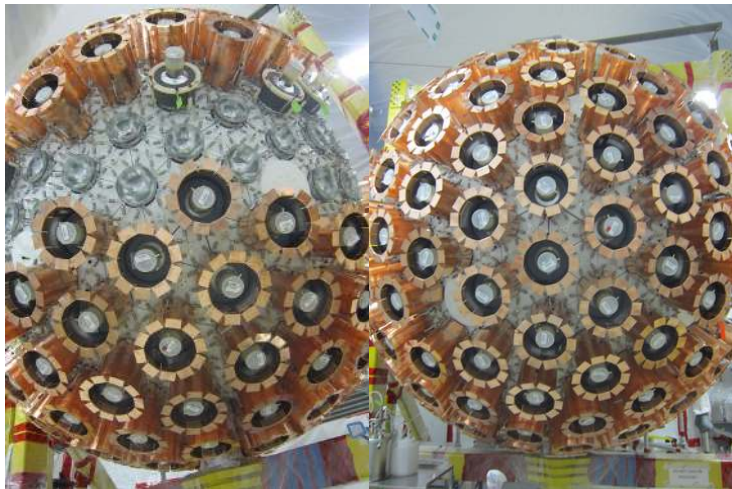


*Measurement required assay to  
 $10^{-20}$  g/g  $^{210}\text{Pb}$*

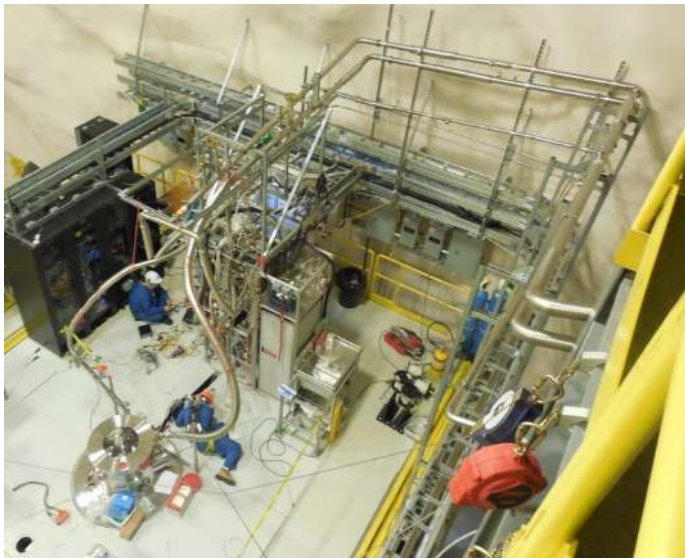
# Lightguide bonding



# PMT mounting and filler block assembly complete



# Cryogenic systems and electronics



## Next main items

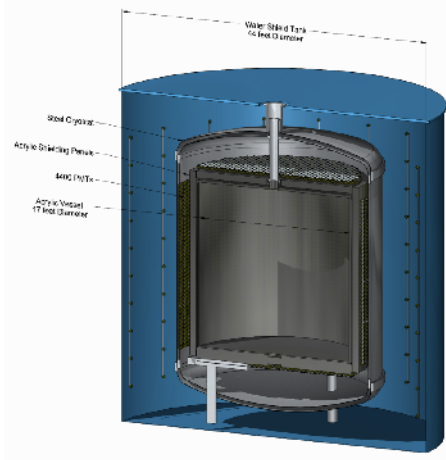


- Moving of the acrylic vessel into the steel shell
- Resurfacing of the inside of the acrylic vessel
- Application of the TPB onto the acrylic vessel
- **First data expected this fall**





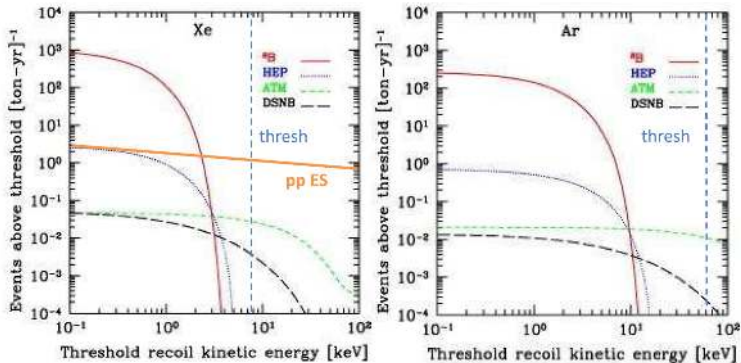
# Going beyond DEAP-3600



*Basic design concept*

- Single-phase DAR, 50 tonnes fiducial mass
- Large inner vessel: Initial discussion with Reynolds polymers are very encouraging.
- Surrounded by 12" clear, ultra-low background acrylic panels
- Large double-walled cryostat with immersed in water shield.
- **Planned location: SNOLAB cryopit.**

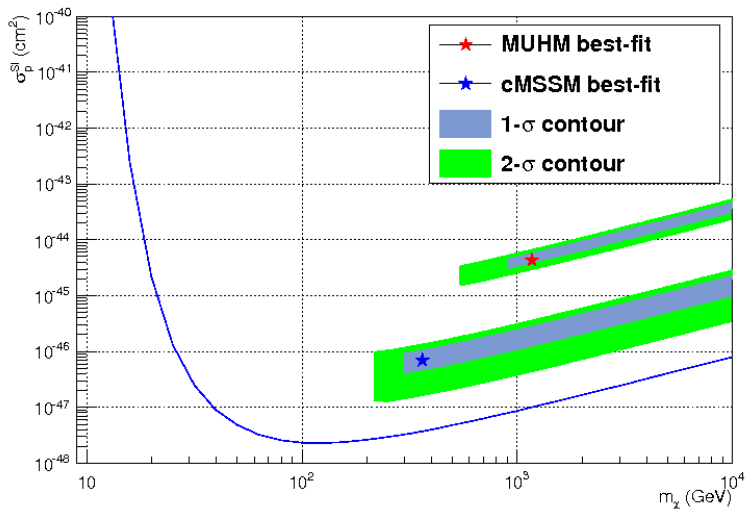
# Neutrino backgrounds



*Neutrino backgrounds for Ar and Xe, adapted from L.E. Strigari, ArXiv:0903.3630.*

**The ultimate background is coherent scattering of atmospheric neutrinos.**

# Expected sensitivity



# Conclusions

- single-phase liquid argon is a very **exciting and promising technique** for expanding the direct detection of Dark Matter searches with **great discovery potential**.
- DEAP-3600 is will be taking data *this fall* and expected to improve the current SI DM limit by a factor of 23.
- Proposal being developed for the 50-tonne follow-up, with ultimate sensitivity dictated by atmospheric neutrinos.