

DEAP-3600

Direct Dark Matter detector with single phase liquid argon

Simon JM Peeters

on behalf of the DEAP collaboration

University of Sussex

S.J.M.Peeters@sussex.ac.uk

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Outline

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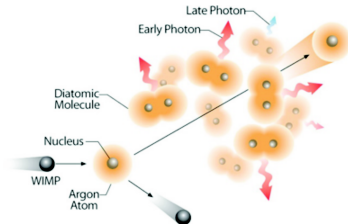


The DEAP collaboration

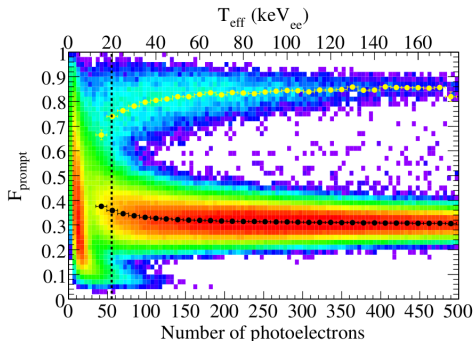
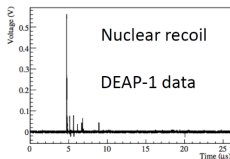
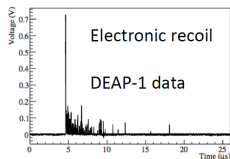
70 collaborators from UK and Canada



Scintillation of argon

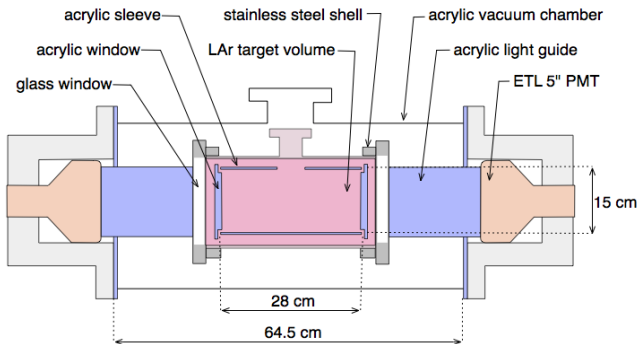


- Light (128 nm) is produced with the dissociation of Ar_2^* .
- Two molecular states of Ar_2^* ; singlet and triplet, with **very** different lifetimes: 7 ns vs. $1.5 \mu\text{s}$.
- 1,1,4,4-Tetraphenyl-1,3-butadiene (TPB) used to shift the light to the easier to detect 420 nm.



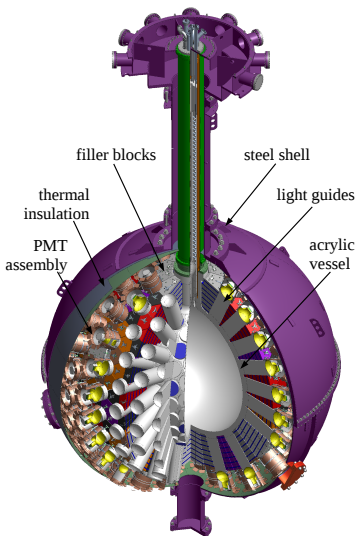
DEAP development program

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



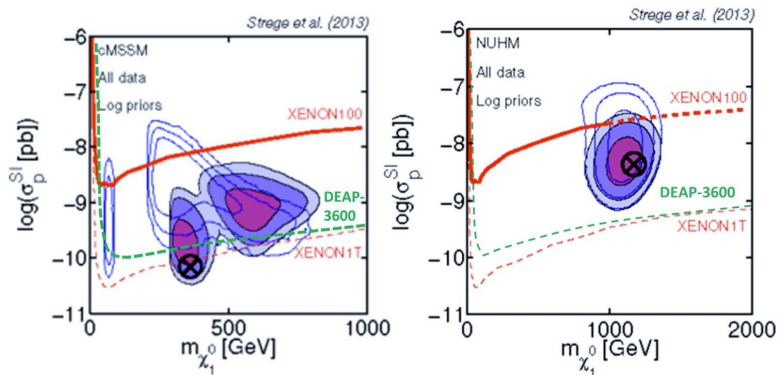
- Contains 3600 kg argon target (1000 kg fiducial) sealed in an ultra-clean acrylic vessel.
- The acrylic vessel is “resurfaced” in-situ to remove deposited Rn daughters after construction.
- TPB is then deposited in a clean, vacuum environment.
- Array of 255 Hamamatsu R5912 HQE PMTs: 8”, 32% QE, 75% 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 α	< 100 μ Bq/m ²
Neutrons in fiducial volume	< 2 pBq/kg
β/γ events (after PSD)	< 2 pBq/kg
Total backgrounds	< 0.3 events in 3 tonne-year

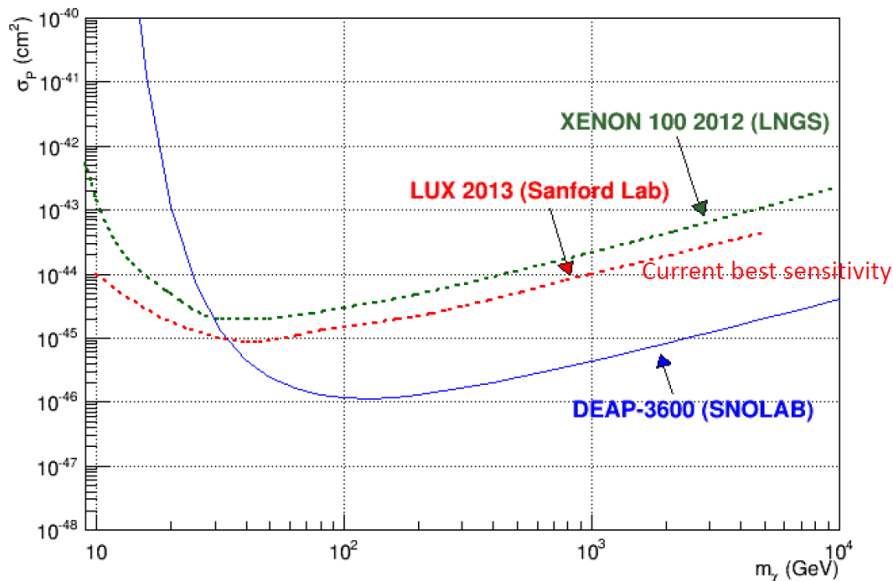
Physics reach

DEAP-3600 sensitive to SI DM interactions at 10^{-46} cm² 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.

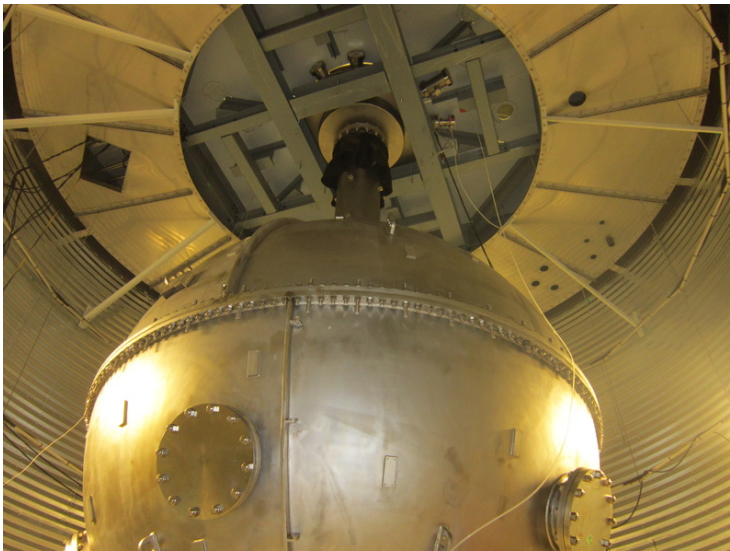
DEAP-3600 projected sensitivity



Cryocoolers



Steel shell and watershield



Acrylic production

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

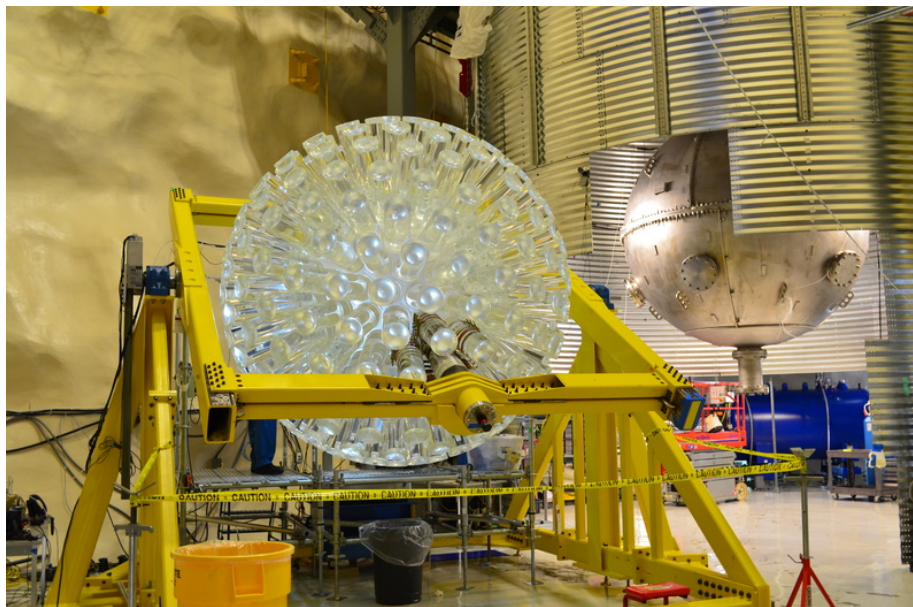


*Tight control of production at RPT
Asia*

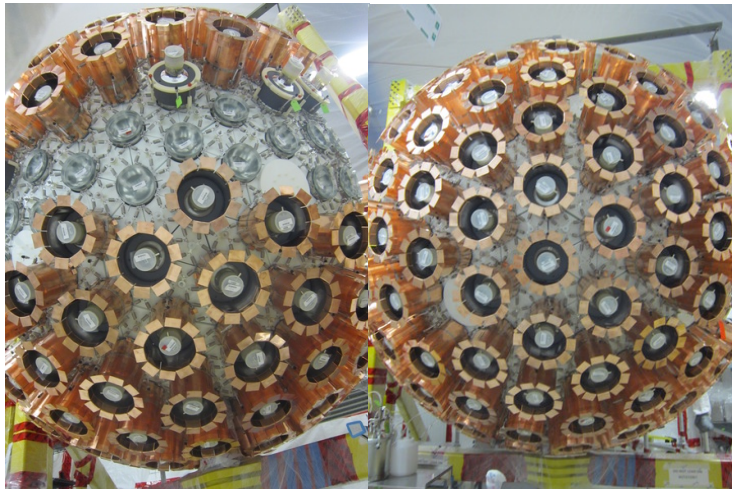


*Measurement required assay to
 10^{-20} g/g ^{210}Pb*

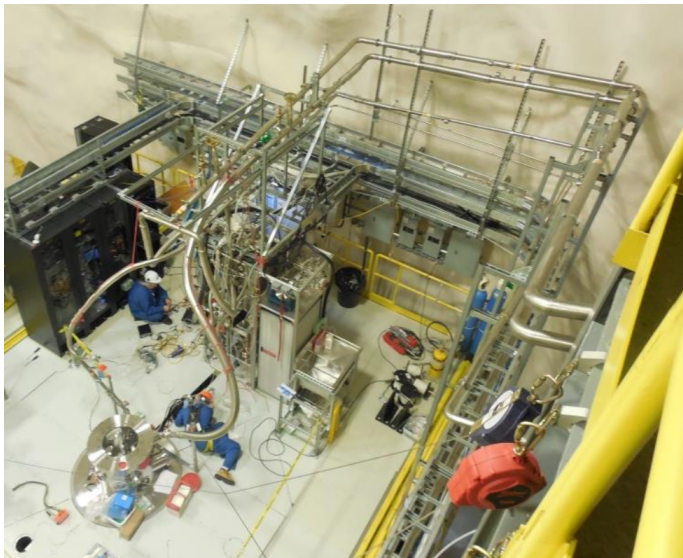
Lightguide bonding



PMT mounting and filler block assembly complete



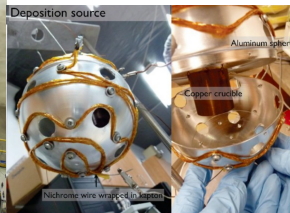
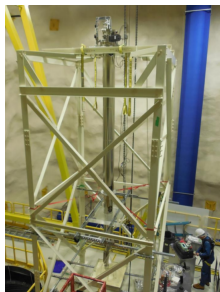
Cryogenic systems and electronics



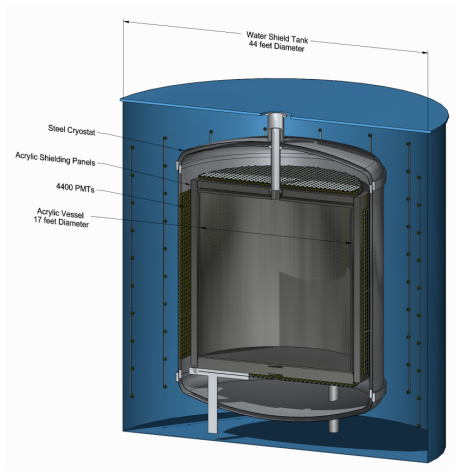
Next main items



- 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**



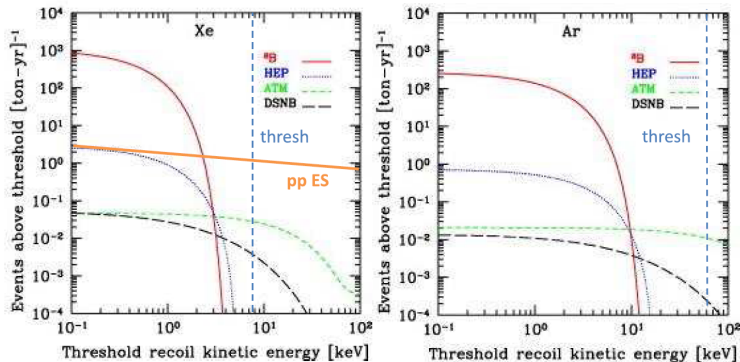
Going beyond DEAP-3600



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.

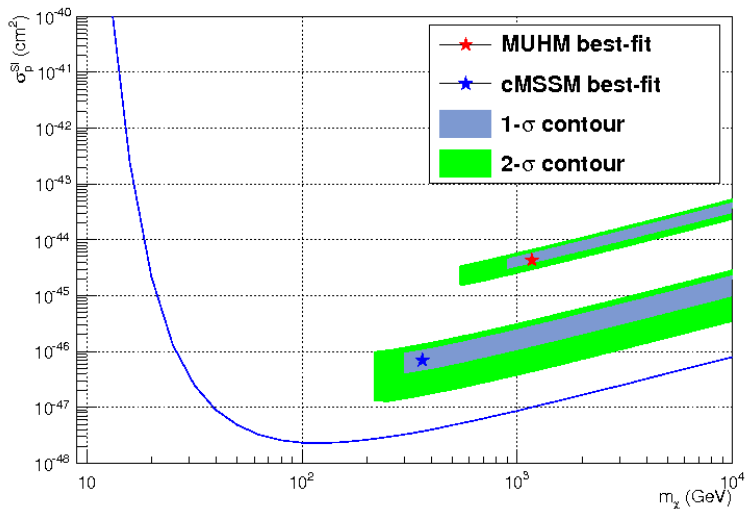
Neutrino backgrounds



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.