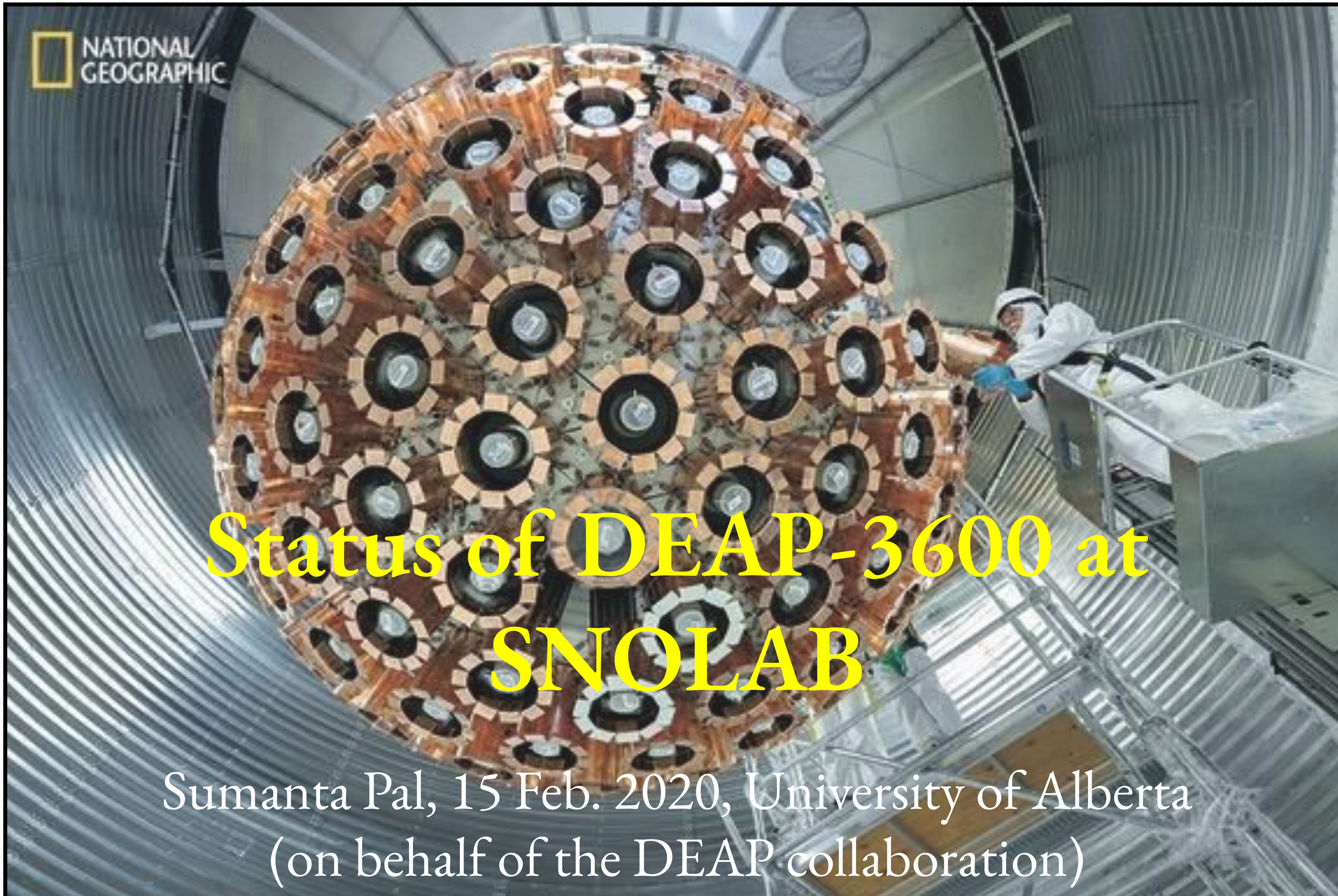


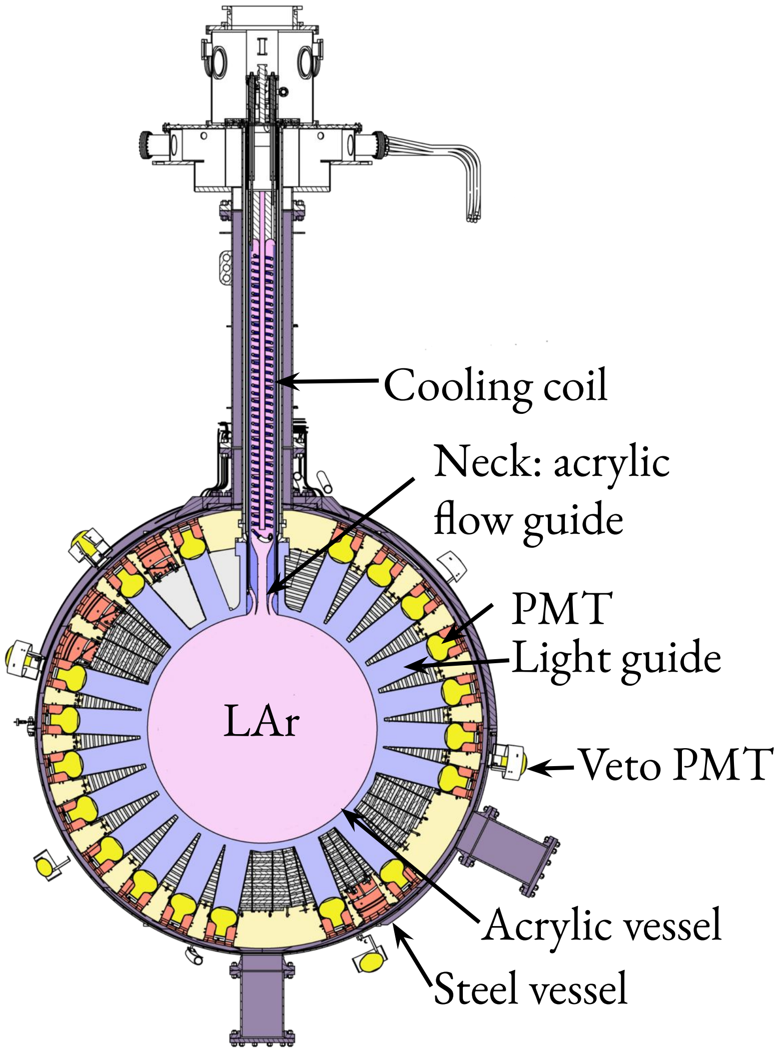
Status of DEAP-3600 at SNOLAB

Sumanta Pal, 15 Feb. 2020, University of Alberta
(on behalf of the DEAP collaboration)

DEAP 3600

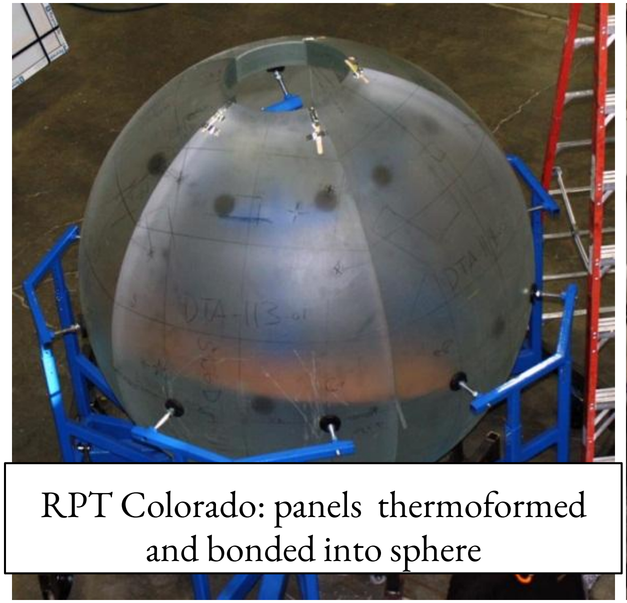
UNIVERSITY OF ALBERTA

Brief description of the DEAP-3600 detector



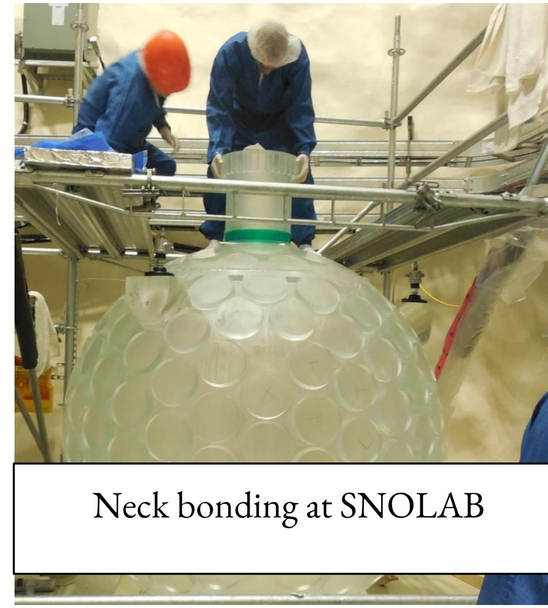
- Single phase liquid argon detector with ~3.3 tonne (3279 kg) target in sealed ultraclean Acrylic Vessel (AV) (**Diameter: 170 cm**).
- Vessel is "resurfaced" in-situ to remove deposited Rn daughters after construction.
- In-situ vacuum evaporated TPB wavelength shifter (**128 nm → 420 nm**) [JINST 12 P04017 (2017)].
- Bonded 50 cm long light guides + polyethylene shielding against neutrons.
- 255 Hamamatsu R5912 HQE PMTs 8-inch (32% QE, 75% coverage).
- PE detected(light yield): (6.1± 0.4) PE/keV$_{ee}$.
- Position resolution: 30 - 45 mm.

Detector construction pictures at different stages



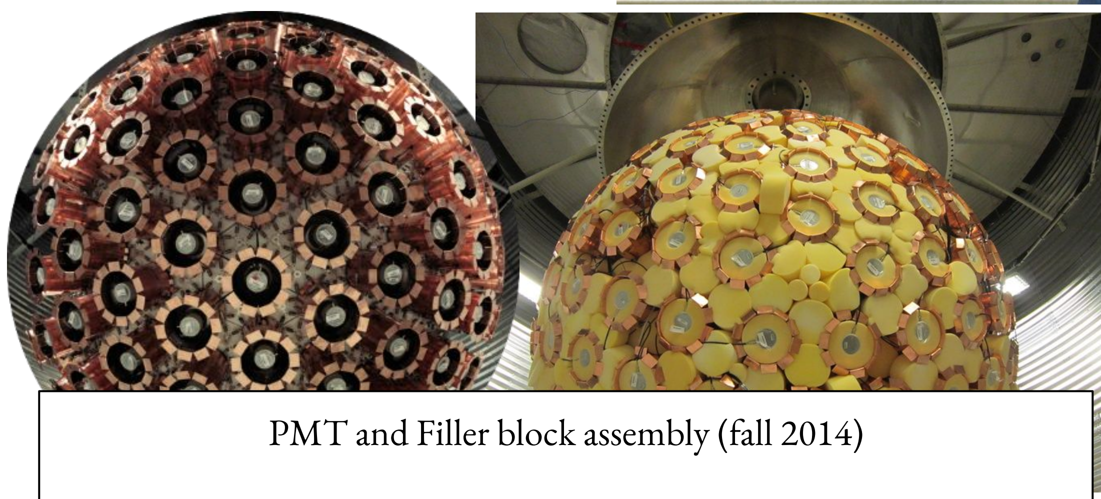
RPT Colorado: panels thermoformed and bonded into sphere

Machined at Univ. of Alberta (2011-12)



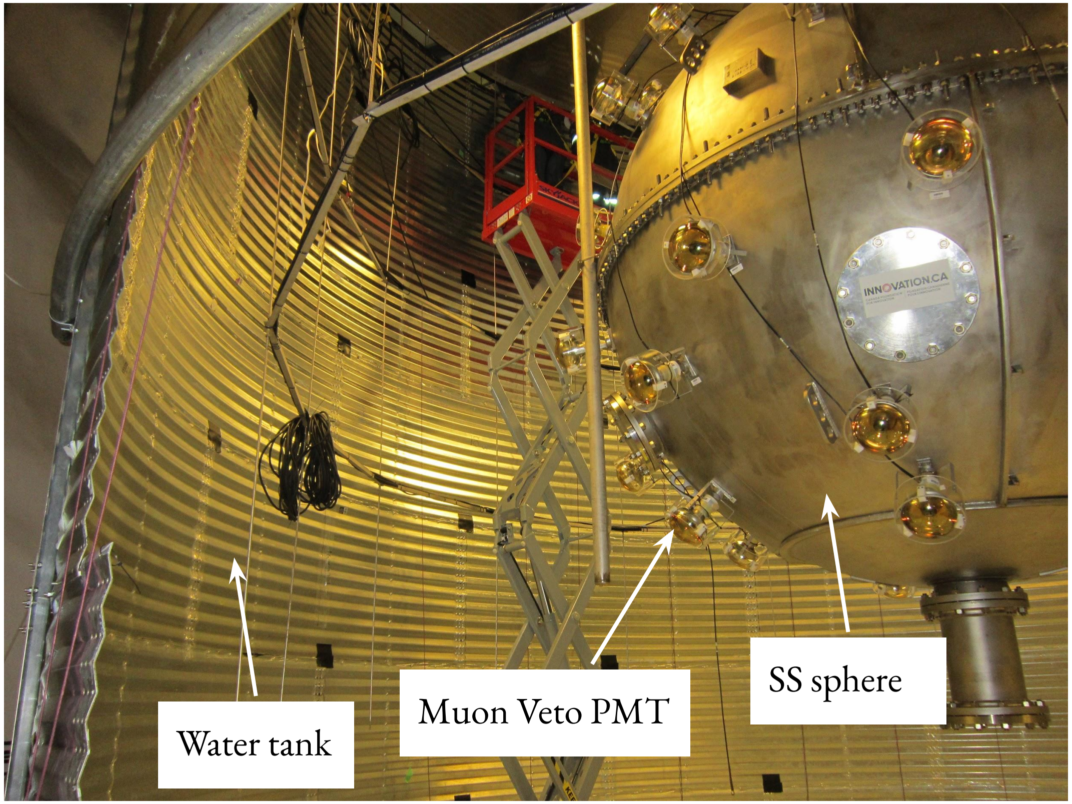
Neck bonding at SNOLAB

Light guides bonded & annealed in radon reduced air oven



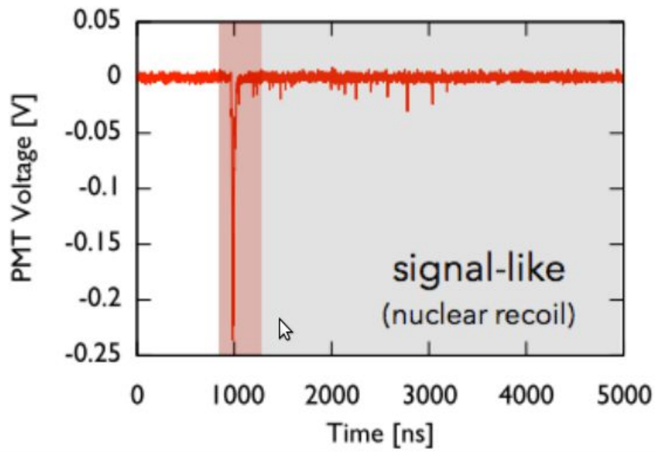
PMT and Filler block assembly (fall 2014)

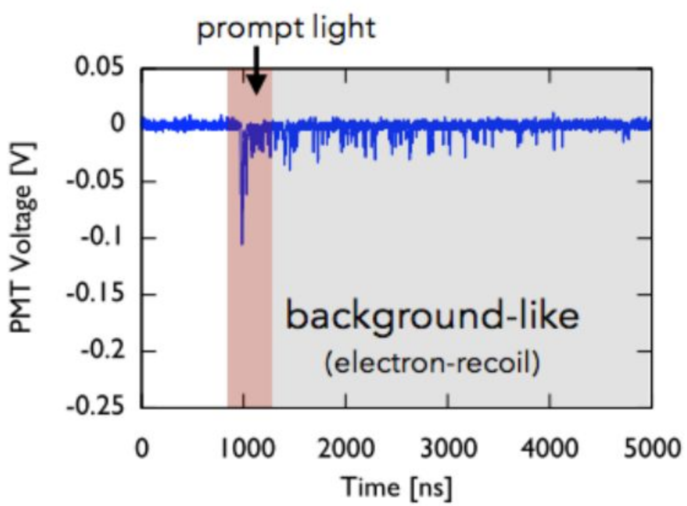
Detector construction pictures at different stages

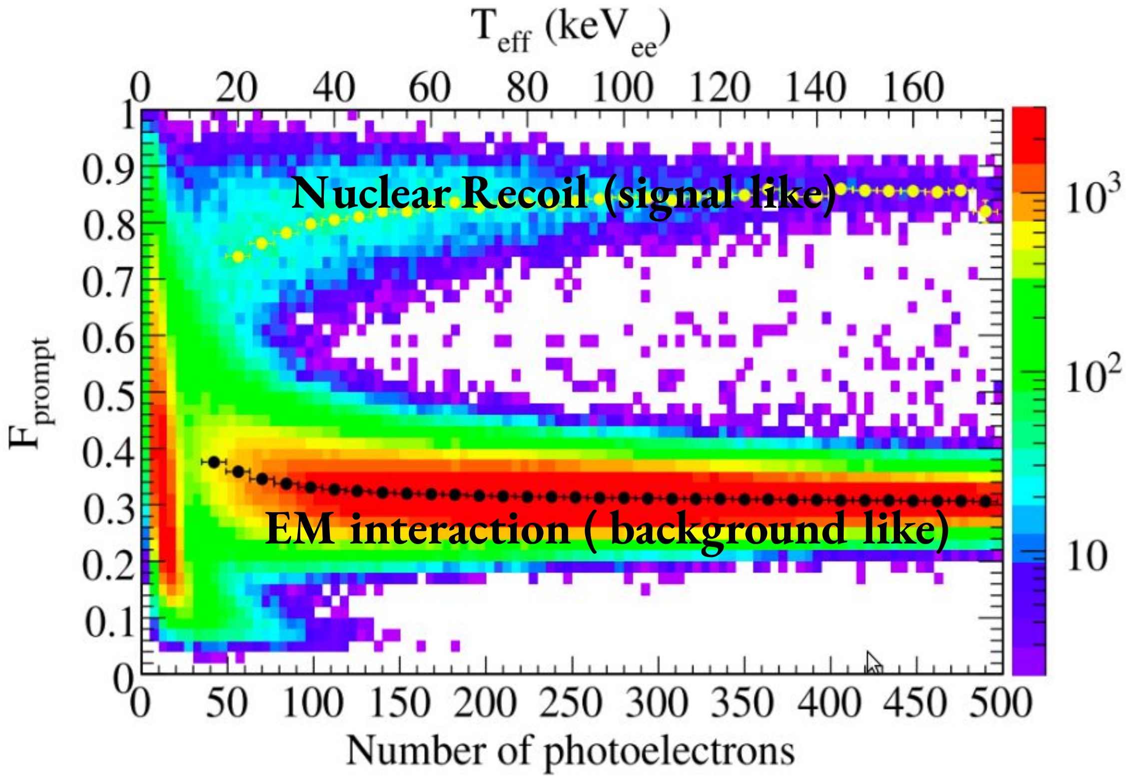


- The detector is contained in a Stainless Steel (SS) sphere.
- This SS sphere is submerged into a 7.8 m high and 7.8 m diameter wide water tank to suppress neutron and gamma backgrounds from the cavern.

Pulse shape discrimination (PSD) in DEAP-3600







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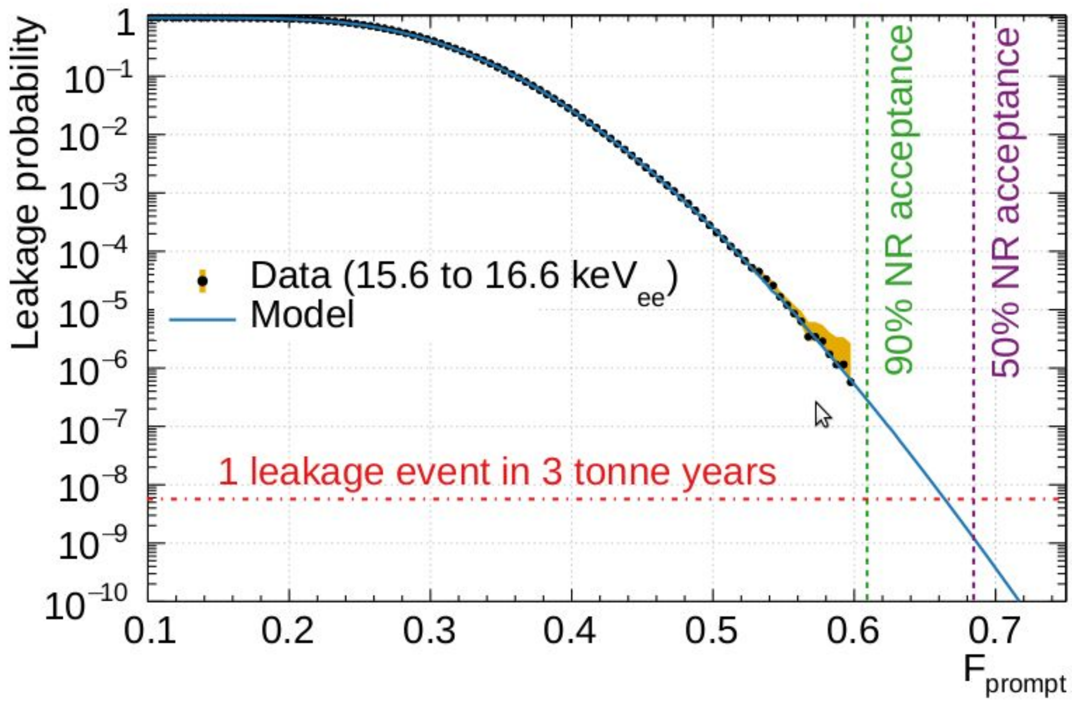
$$F_{\mathrm{prompt}} = \frac{\sum_{t=-28\ \mathrm{ns}}^{60\ \mathrm{ns}} PE(t)}{\sum_{t=-28\ \mathrm{ns}}^{10\ \mu s} PE(t)}$$

Pulse shape discrimination (PSD) in DEAP-3600

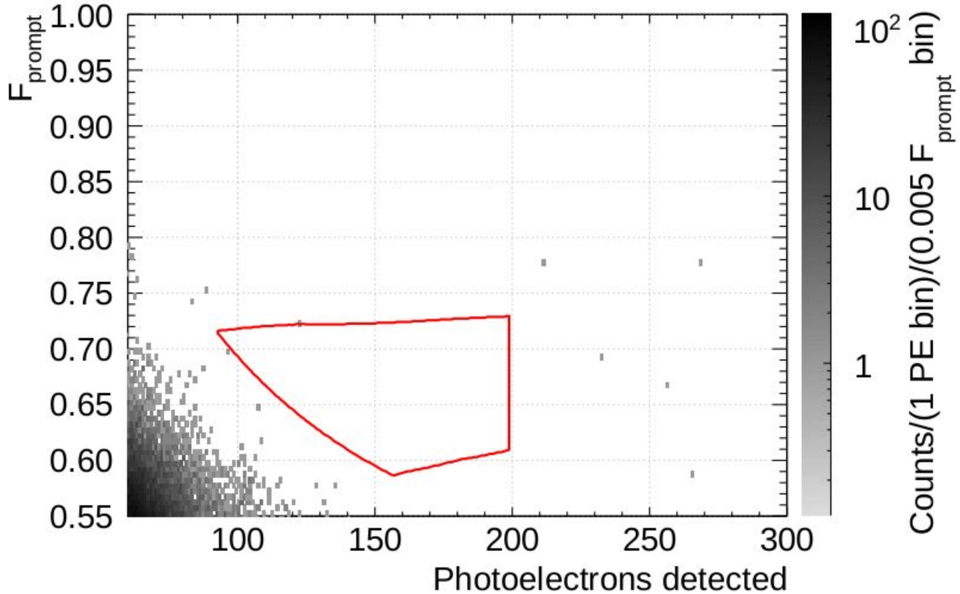


PRD 100 022004 2019 (arxiv:1902.04048)

- EM/NR discrimination power: $\mathbf{4.1^{+2.1}_{-1.0}}$ **x 10^{-9}** for **90% NR acceptance** in the 15.6 - 32.9 keV$_{ee}$ range (the WIMP ROI).
- Average leakage probability in the WIMP ROI at 50% NR acceptance is 3.5×10^{-11}.

ROI data after all event selection criteria (231 live days)

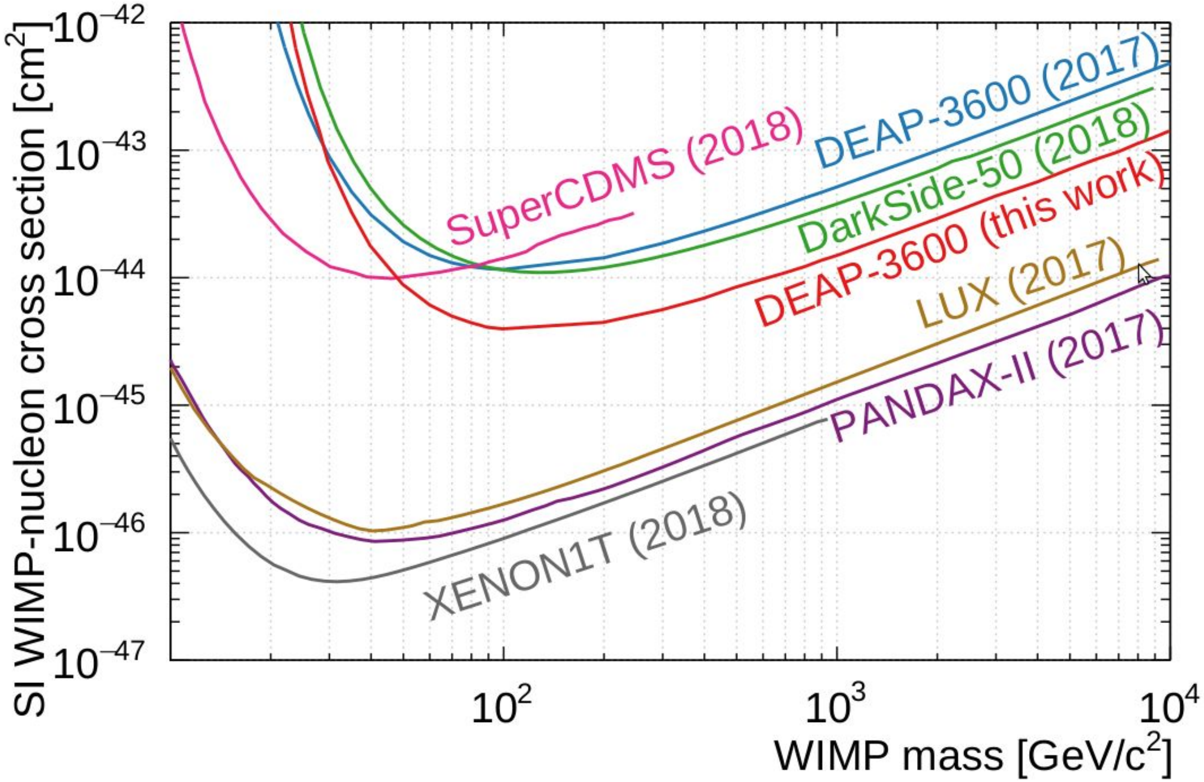
PRD 100 022004 2019 (arxiv)



- 231 live days after run selection and deadtime corrections. 824 kg fiducial mass.
- No background events are observed in the WIMP-ROI region.

- But this required several background rejection cuts, that decreased our acceptance.
- All events near the ROI are consistent with background expectation.
- Observed ‘unexpected background events’ at higher PE. Work is in progress to understand this background.

Dark Matter search results and sensitivity projections (758 tonne-day exposure taken over a period of 231 live days)



PRD 100 022004 2019 (arxiv)

DEAP-3600 latest published limit: **3.9 x 10^{-45} cm^2** at 100 GeV/c^2 (90% CL) 758 tonne-day (3 tonne x 231 live days) exposure.

Design sensitivity at this WIMP mass is **1.6 x 10^{-46} cm^2** with a 3 tonnes-year (3 tonne x 1 yr) exposure.

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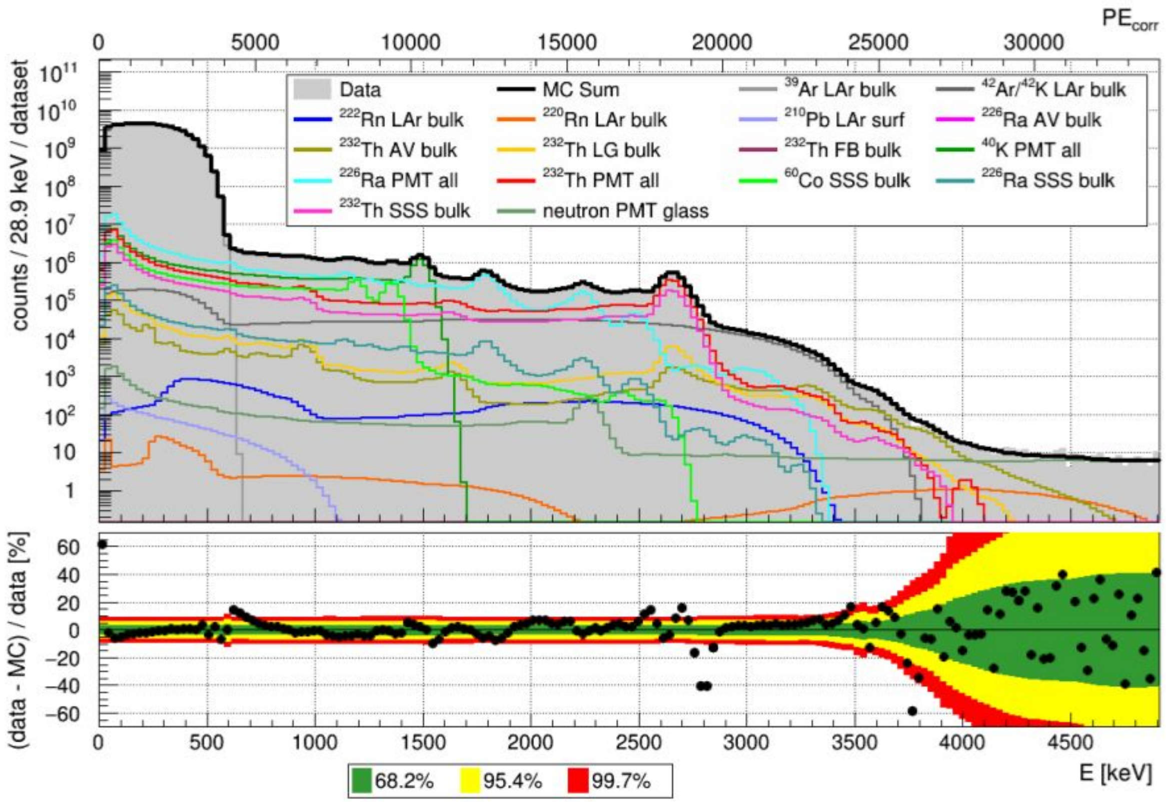
Electromagnetic backgrounds & ^{42}K activity

- Electromagnetic Backgrounds and Potassium-42 Activity in the DEAP-3600 Dark Matter Detector was published last year. [PRD 100 072009 (2019), arXiv:1905.05811]

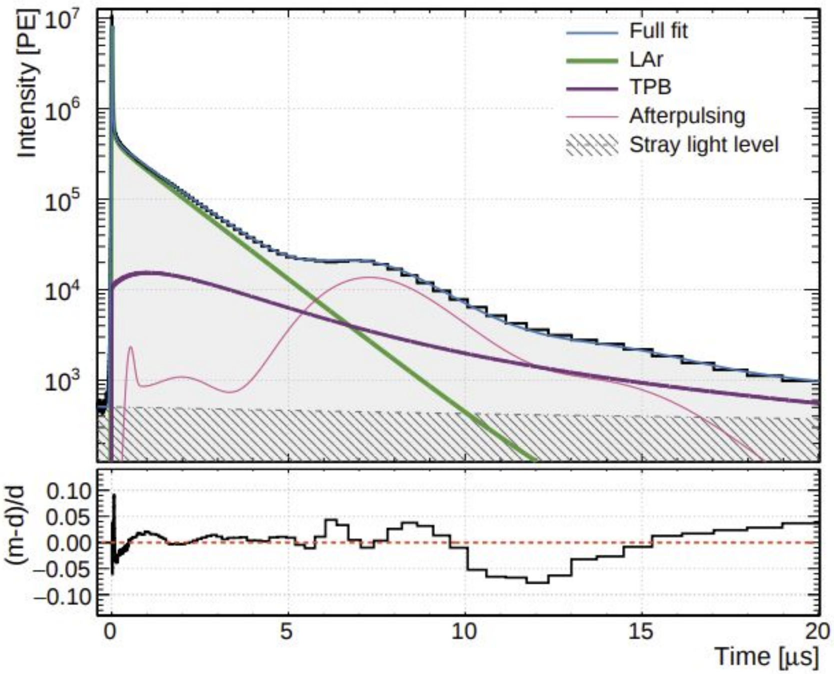


The energy spectrum of the ER data (shaded grey) with the fit result.

Green, yellow, and red belts denote 1, 2, and 3 sigma, confidence respectively.

Modelling LAr pulse shape

- A detailed analysis of liquid argon pulse shape in DEAP-3600 has been performed [arXiv: 2001.09855 (submitted to European Physics Journal C)].
- Understanding the pulse shape so well is important as we use this knowledge to remove afterpulsing, which can weaken the PSD.
- The model considers
  - LAr scintillation physics (include so-called intermediate component)
  - Time response of the TPB wavelength shifter
  - PMT response
  - The model is fit to pulse-shapes of 160 µs length and describes the observed pulse shape to better than 11% across this time range.



Ongoing activities

- Current published WIMP-search sensitivity from cut-and-count analysis. Expected to increase sensitivity using multivariate analysis.
- Detector reconfiguration work is ongoing; it will be done this year.
- Run the detector in full design sensitivity in 2021-2022.
- Search for admixture of background events and to identify the feature of them that can be used to find and cut them (different models are getting explored).
- Simulation work is also in progress to understand Cherenkov related backgrounds in the detector and to identify them in data.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US University of Sussex
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TUM
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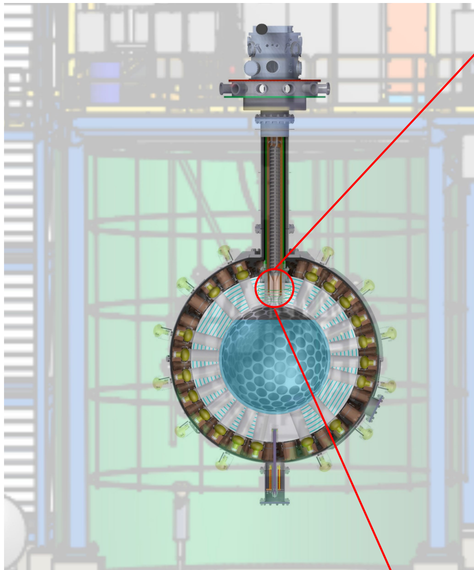
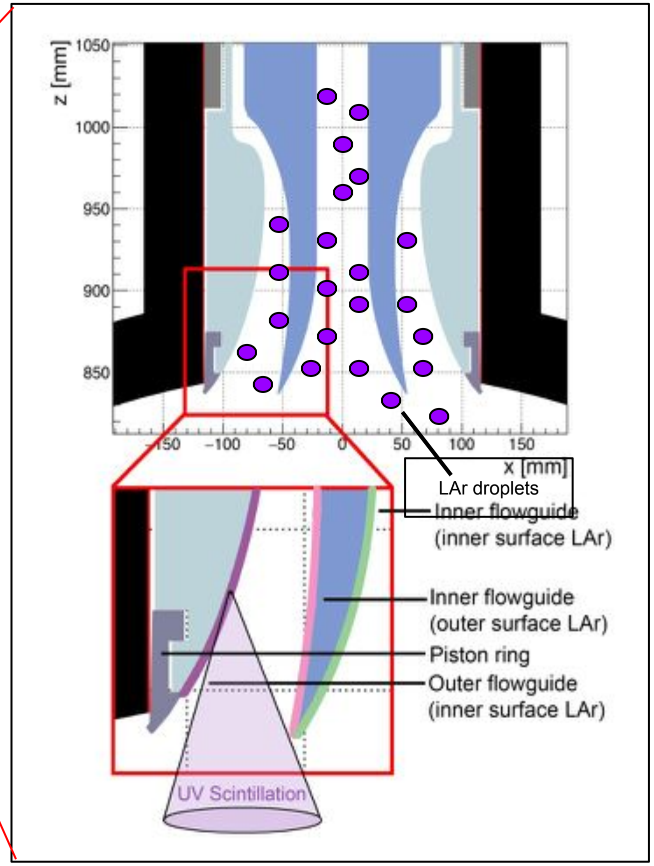
The DEAP Collaboration: 80+ researches in Canada, Germany, Italy, Mexico, Russia, Spain, UK, and USA

Backup



Schematic of the DEAP detector



A zoomed view of the neck of the DEAP detector

- The neck region has a turbulent mixture of gaseous and liquid argon.
- A 50 micron LAr film was assumed on the flowguides to simulate scintillation light of alphas coming from ^{210}Po on neck flowguides.
- Simulating a variation on this model, like a mist (LAr bubbles entrained in argon gas vapour), to understand an observed excess events at high PE.