TRIUMF

Canada's national laboratory
for particle and nuclear physics
and accelerator-based science

DEAP-3600 Dark Matter Search

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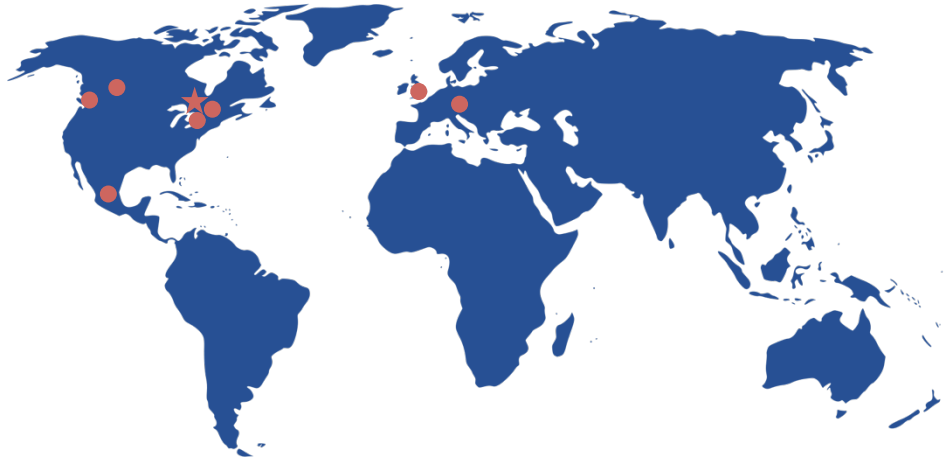
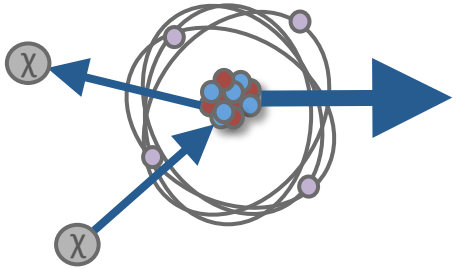
21 February 2017 – Lake Louise Winter Institute

DEAP collaboration

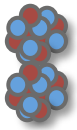
- 60 members from Canada, UK, Mexico, Germany
- Experiment based at SNOLAB in Sudbury, ON
- Looking to directly detect WIMPs using scintillation of liquid argon (LAr)



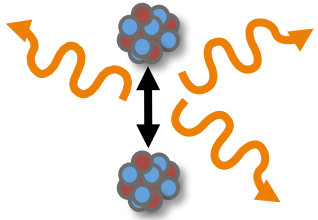
DEAP detection principle



Nuclear or electronic recoil…

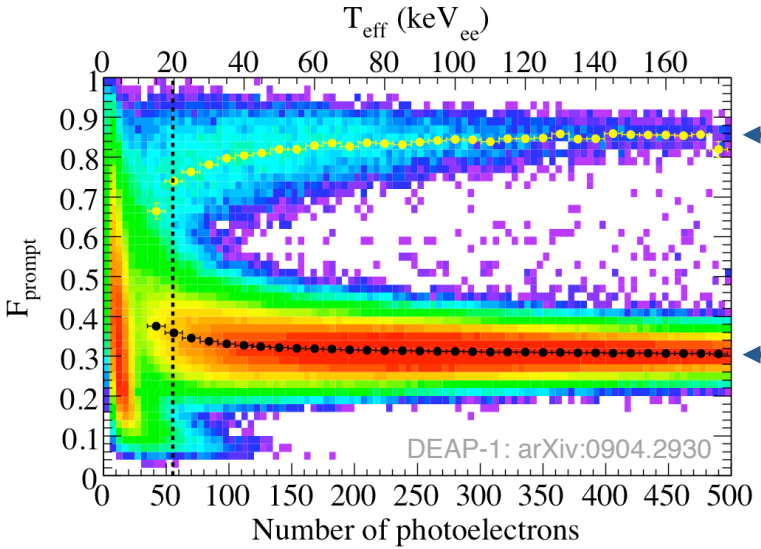


creates excimers…



which scintillate on decay

- WIMPs cause nuclear recoils
- Distinguish nuclear and electronic recoils using *promptness* of the light



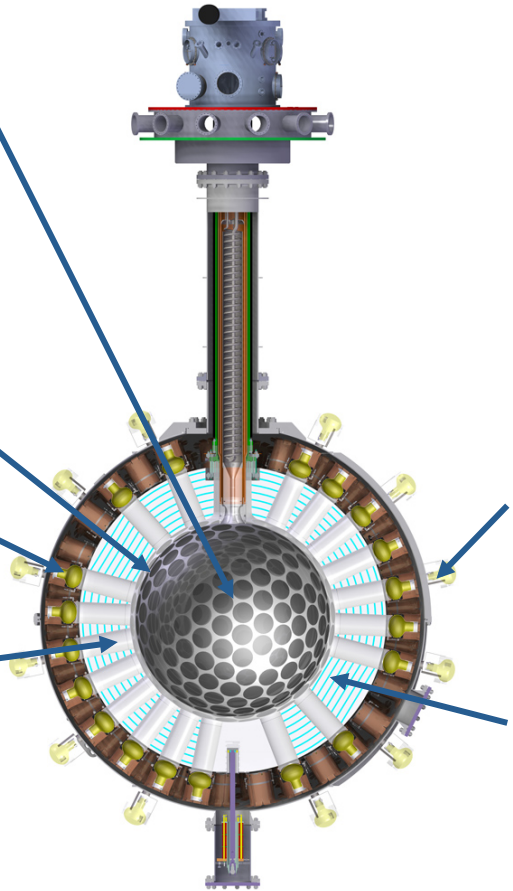
Background challenges

- Electronic recoils
  - ^{39}Ar beta decays; 1Bq/kg of natural Ar
    - Need 10^{10} rejection based on time profile of light
    - Lots of data to process
- Other things causing nuclear recoils
  - Indistinguishable from WIMP interactions
  - Main concern from radon daughter chain
    - Great effort to produce a "clean" detector

DEAP-3600 detector

Acrylic vessel
- 1.7m diameter
- Mfg. in low-radon air
- Inner surface removed in-situ, then coated with wavelength-shifter

LAr



2km of Ontario rock (not shown)

Water tank (not shown)

255 inner PMTs

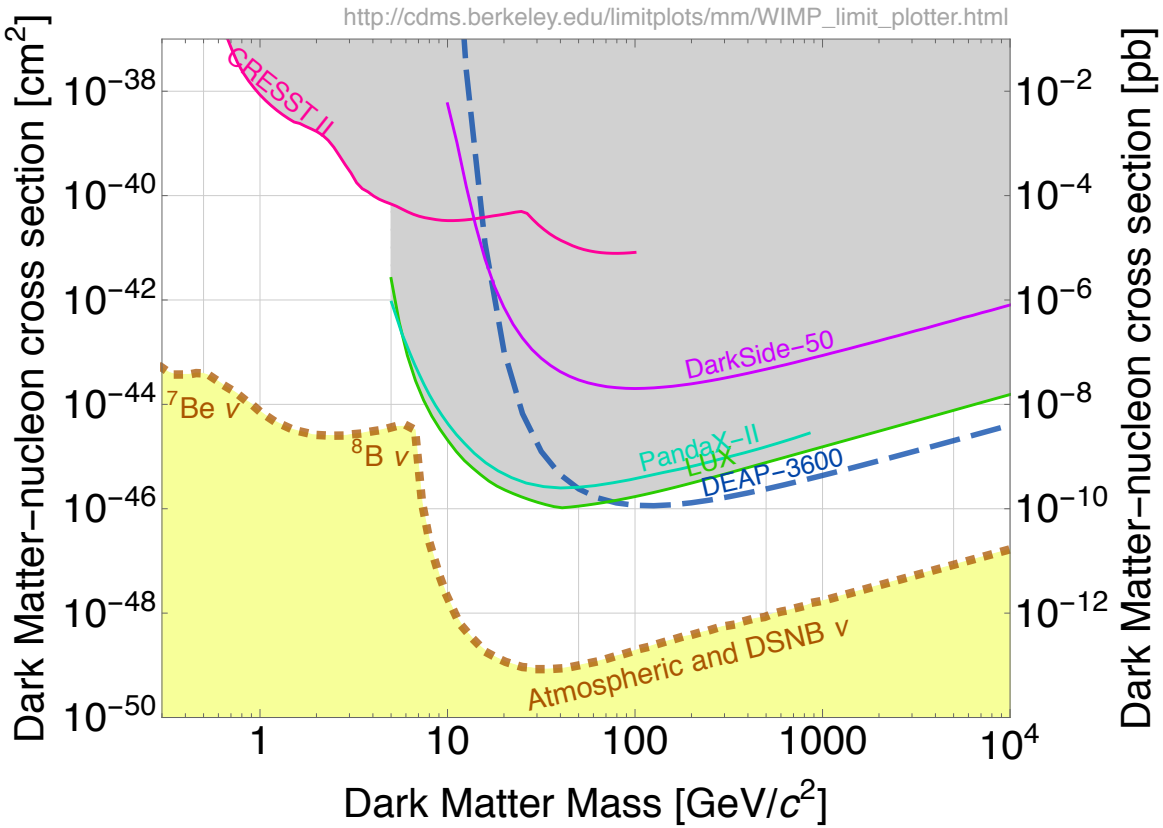
48 muon veto PMTs

Acrylic light guides
- PMTs run warmer
- Moderate neutrons from radioactive glass

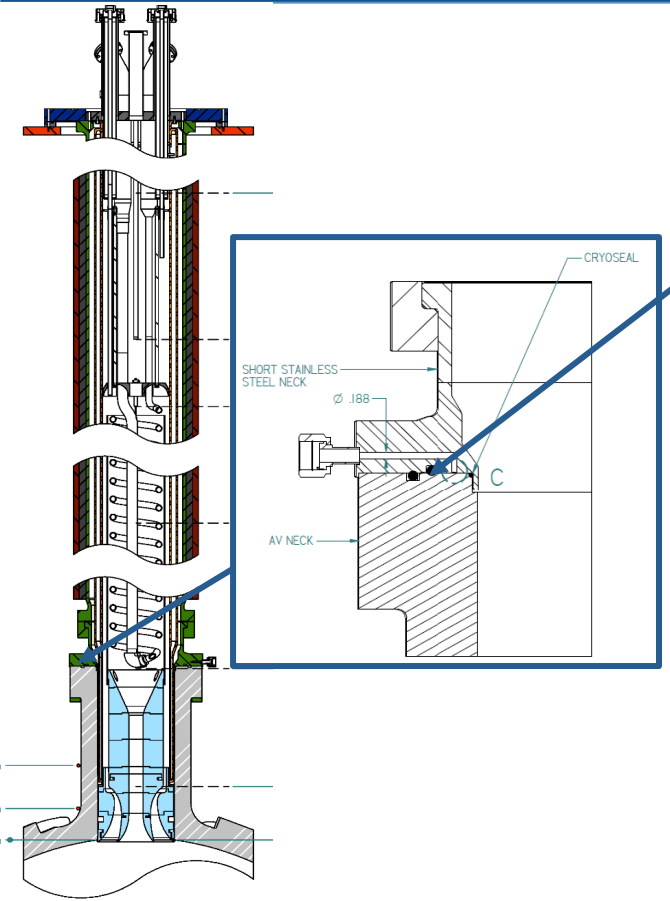
Filler blocks
- Neutron moderation

Expected sensitivity after 3 years

Background source	Leakage events (design goal)
Neutrons	< 0.2
Surface α	< 0.2
β mis-ID	< 0.2
Total	**< 0.6**

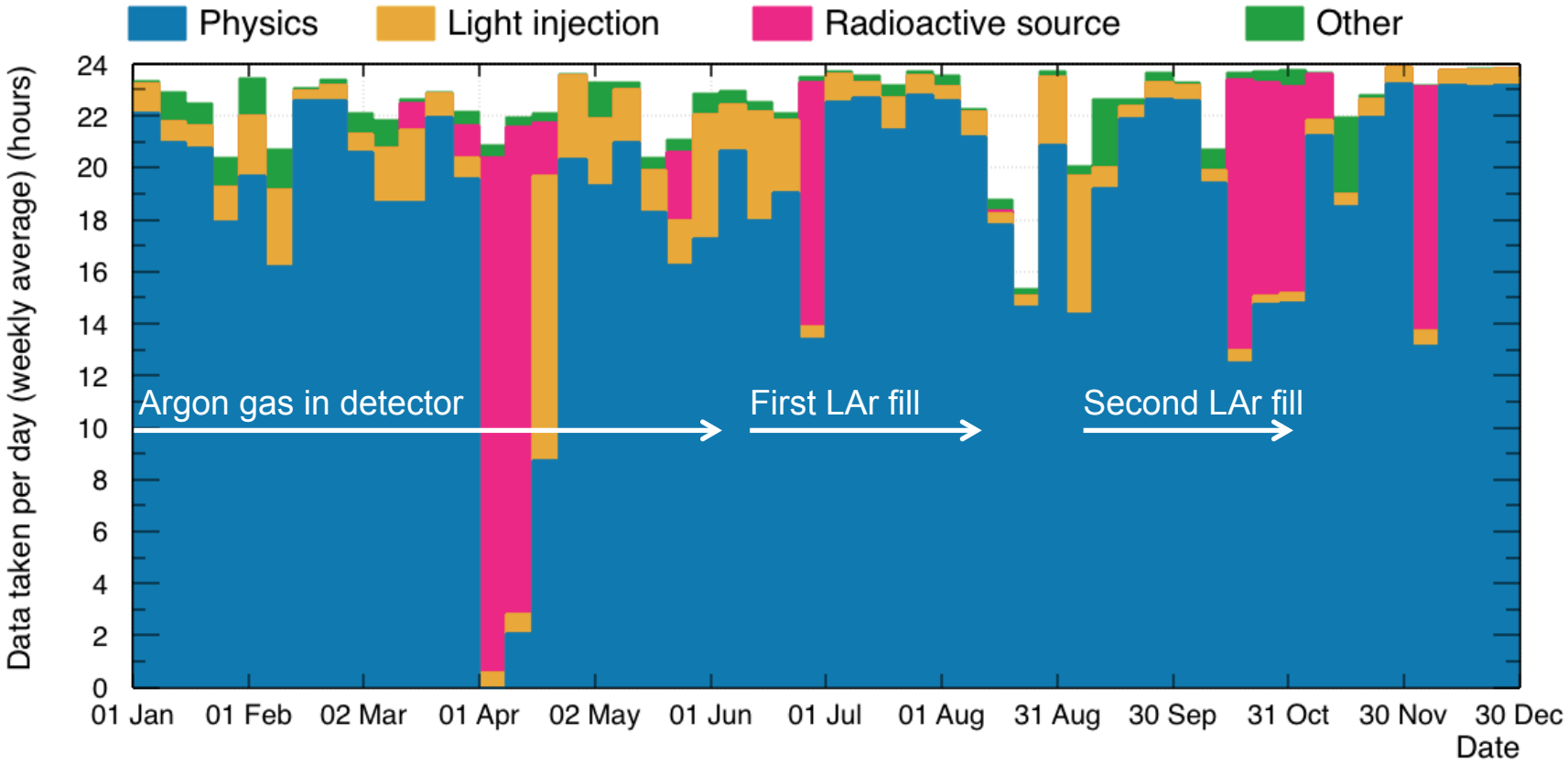


Neck filling incident – 17 August 2016



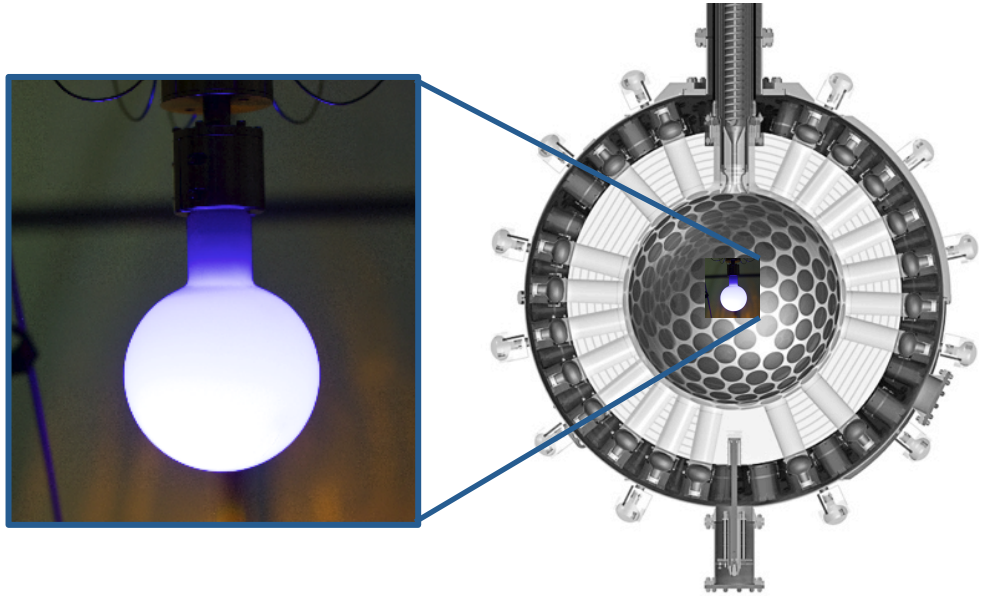
- LAr reached neck level
- Seal at acrylic-steel interface got too cold and failed
  - Clean Rn-scrubbed N_2 leaked into inner vessel
  - 100ppm level contamination of LAr
- Vessel was purged and re-filled
  - Currently running with 3260kg LAr (neck not filled)

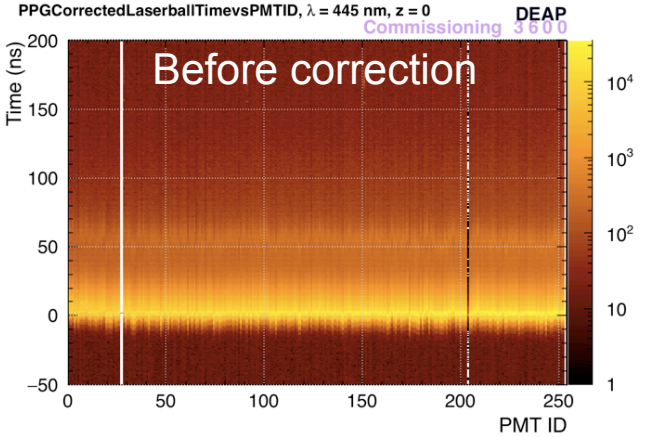
2016 data-taking timeline

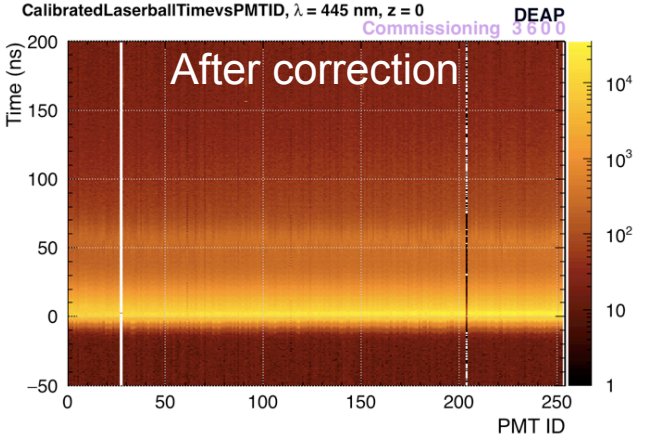


Calibration – laserball

- Deployed before filling with LAr
- Informs PMT efficiencies, optical model and timing offsets

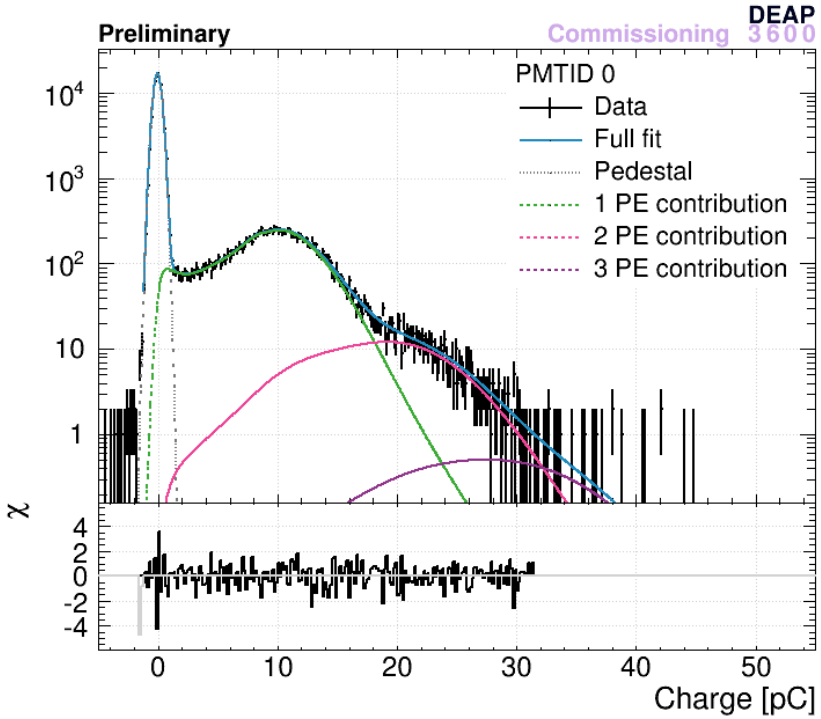




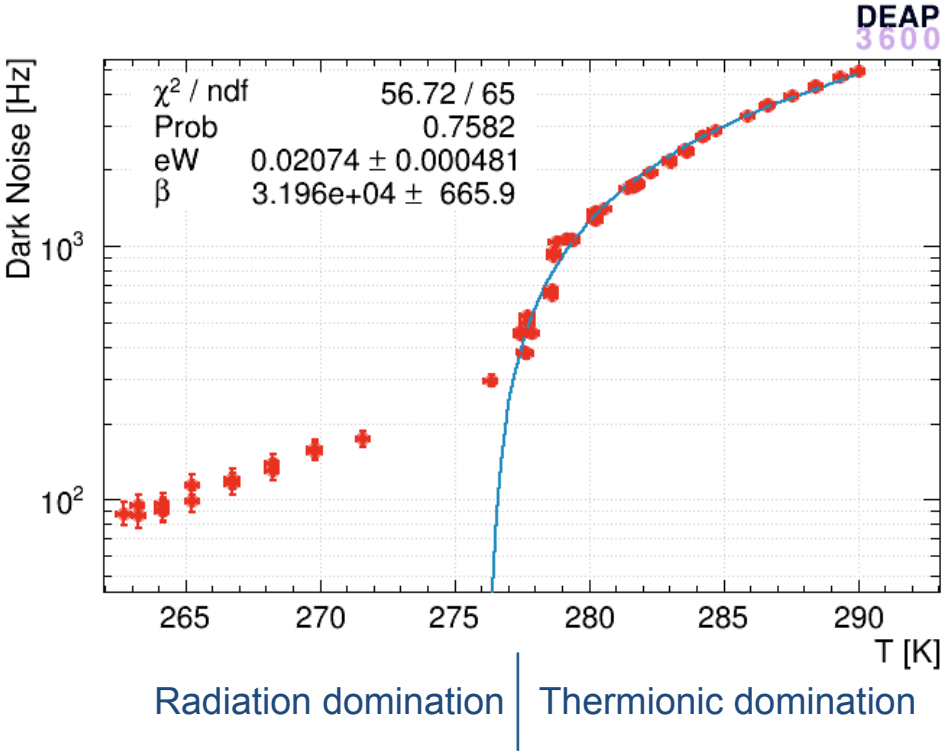


Calibration – LED light injection and dark noise

Single photo-electron charge calibration

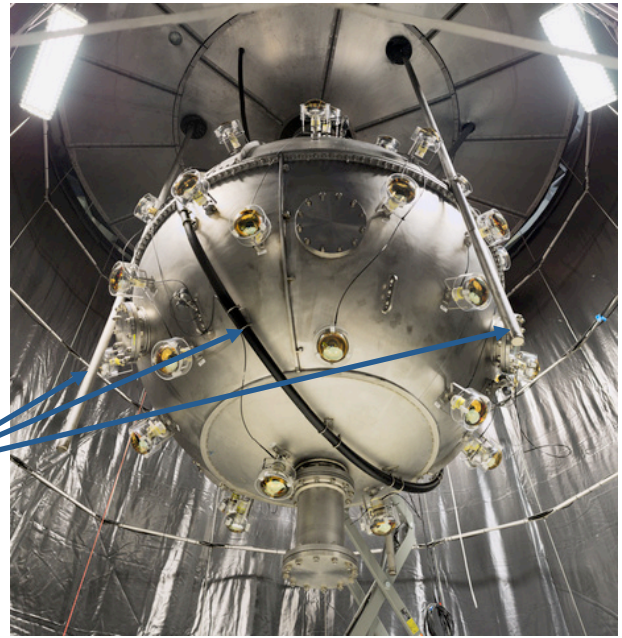


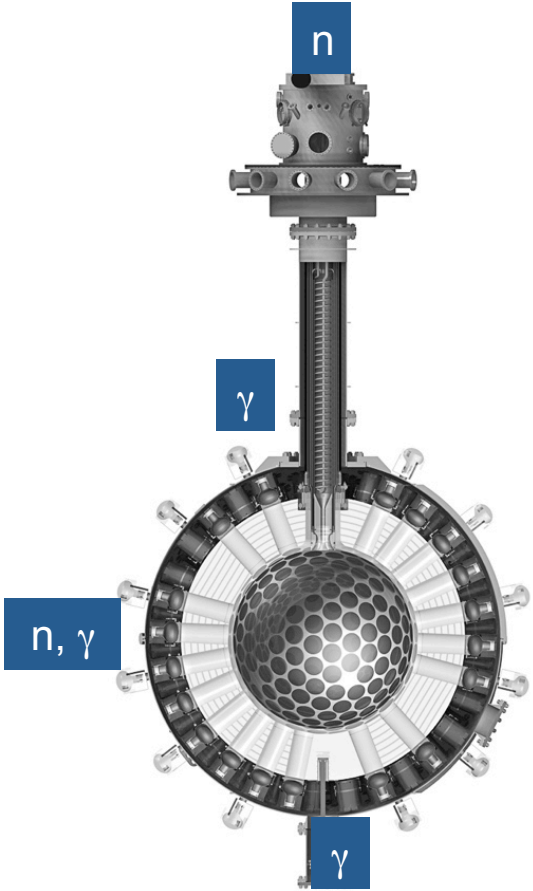
PMT noise rates as PMTs cool



Calibration – radioactive sources

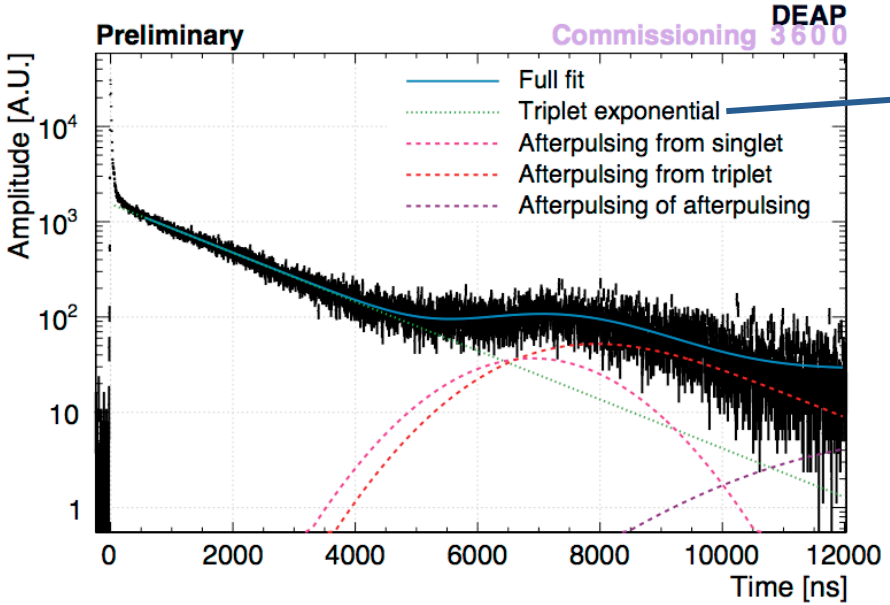
- Neutron and gamma sources deployed at multiple locations



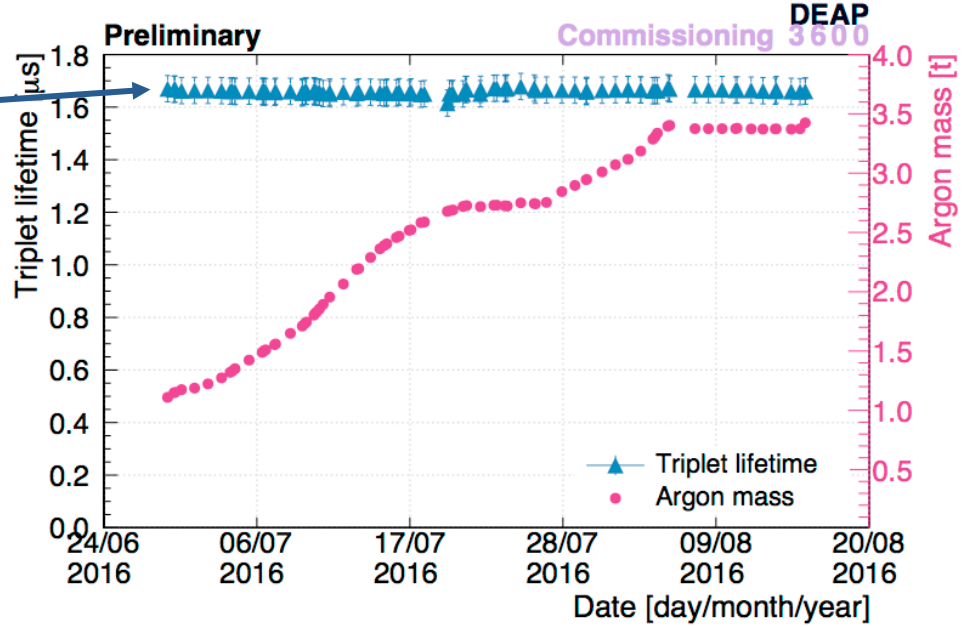


Physics data from first fill: ~116 tonne-days

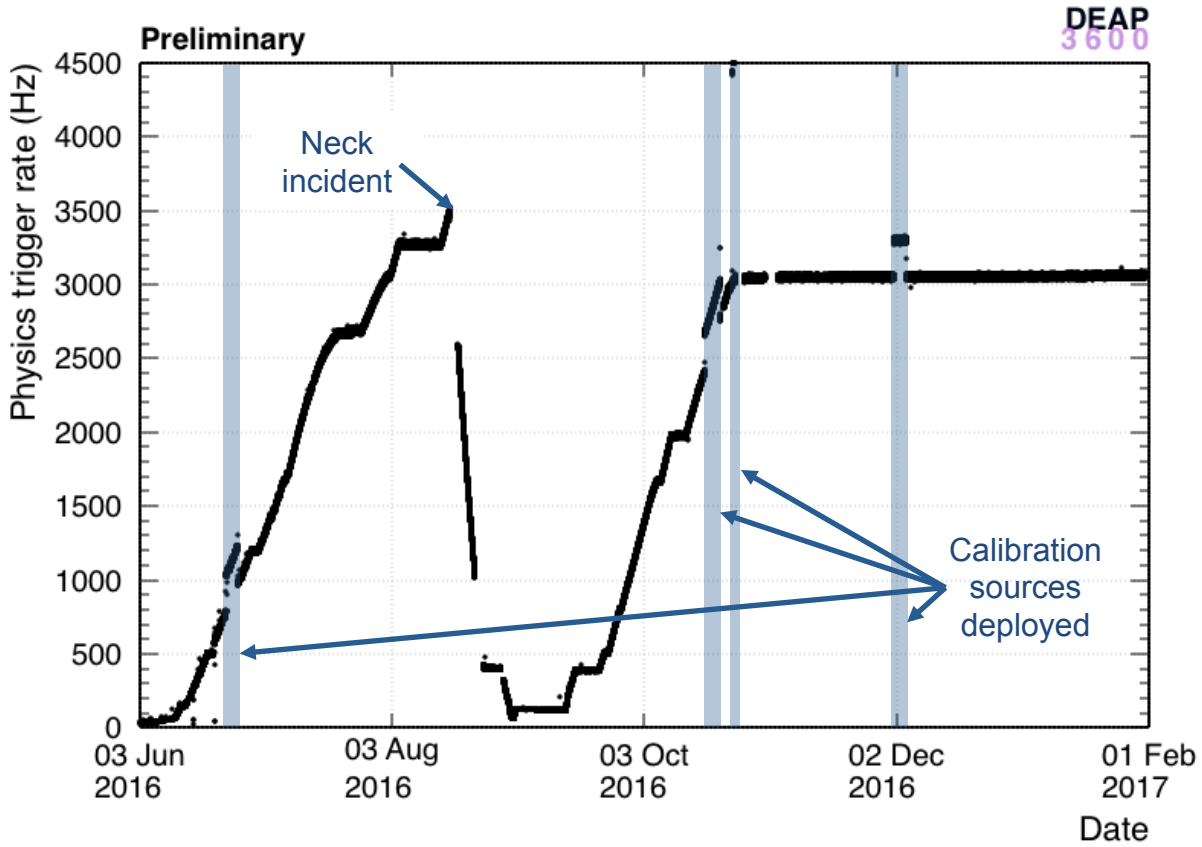
Average pulse shape of Ar39 beta decays



Triplet response as detector filled with LAr



Still taking data!



Summary

- Running stably with 3260kg LAr
  - Detailed detector paper soon
- Excellent characterisation of PMTs
  - PMT paper soon
- Background and WIMP search analysis on-going
  - Physics analysis paper soon