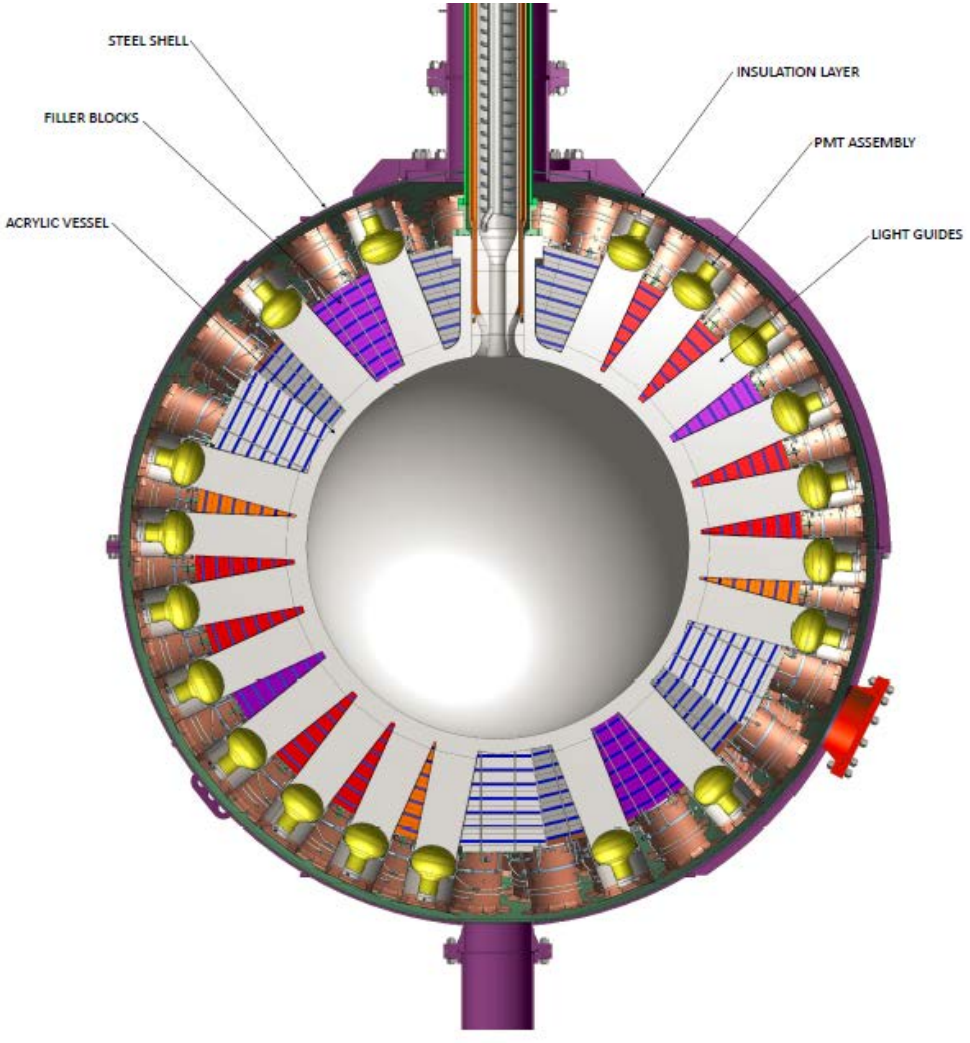
Dark-matter Experiment using Argon Pulse Shape Discrimination

Fabrice Retière on behalf of the DEAP collaboration

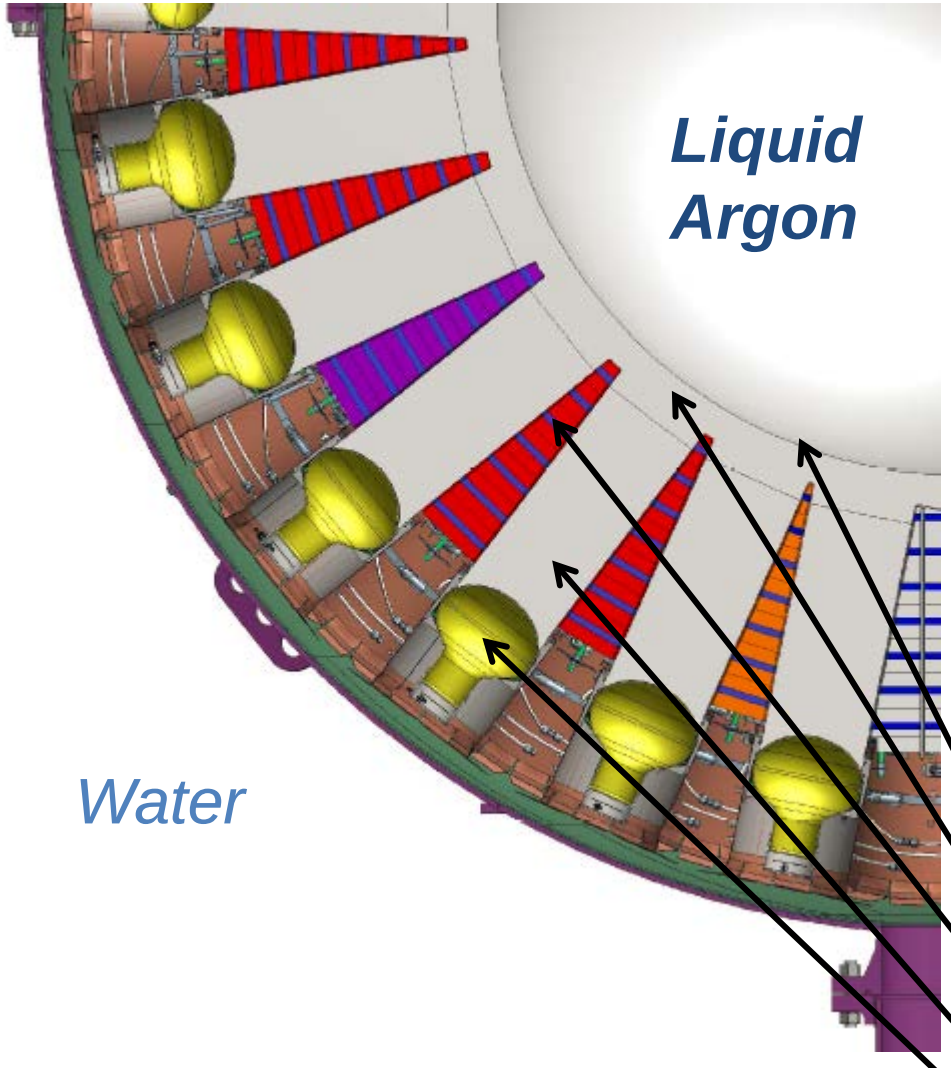
TRIUMF

DEAP-3600 concept



- **3.6 tonnes of liquid Argon**
  - Enclosed in 85 cm radius acrylic ball
  - 1 tonne fiducial
    - Excluding surface events
- **Scintillation only**
  - Aka single phase
  - Light viewed by 255 photo-multiplier tubes

Neutron background mitigation

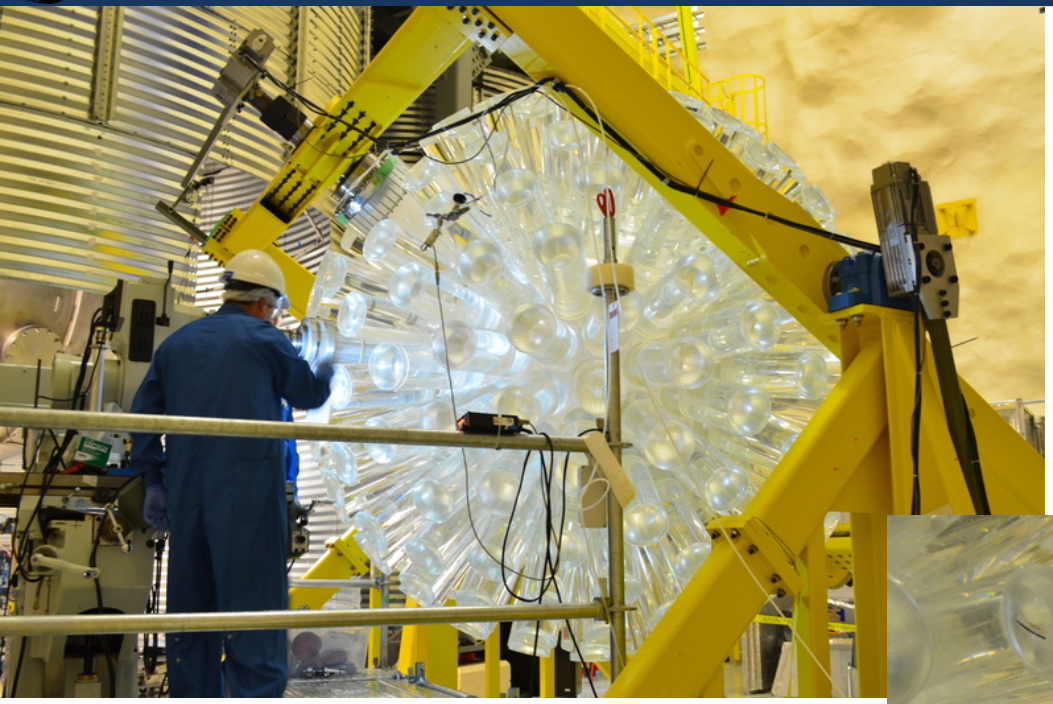


- **Sited at SNOLAB**
  - 6000 meter water equivalent
- **Inside a water tank**
- **~50cm of light guide acrylic and filler blocks**
- **Ultra-low radioactivity acrylic**

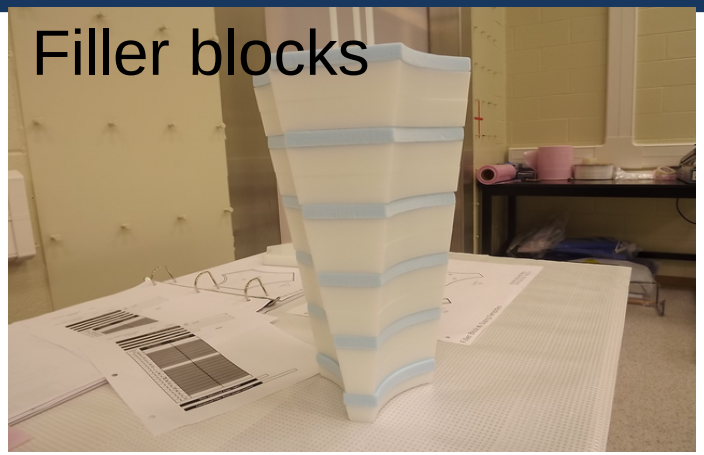
Acrylic work completed

- **Acrylic ball and light guide bars manufacturing by Reynolds Polymer**
  - Radiopurity control at each manufacturing steps
- **Stub machining at U. Alberta**
- **Light guide machining at TRIUMF**
- **Light guide bonding underground at SNOLAB**

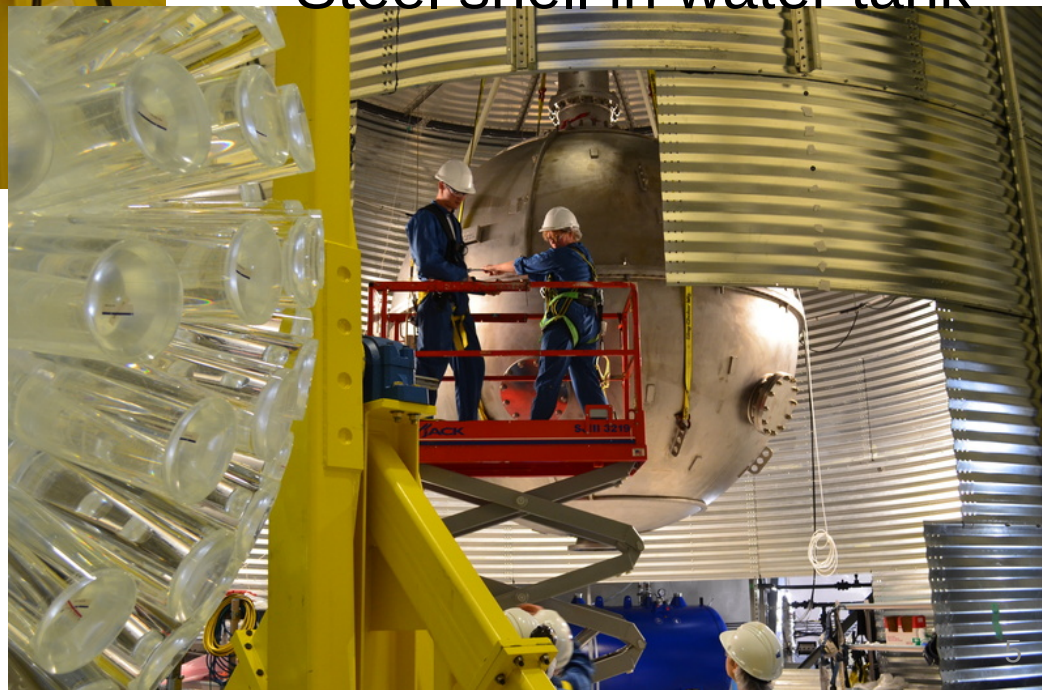
More shielding work in progress



Final touches to acrylic



Steel shell in water tank

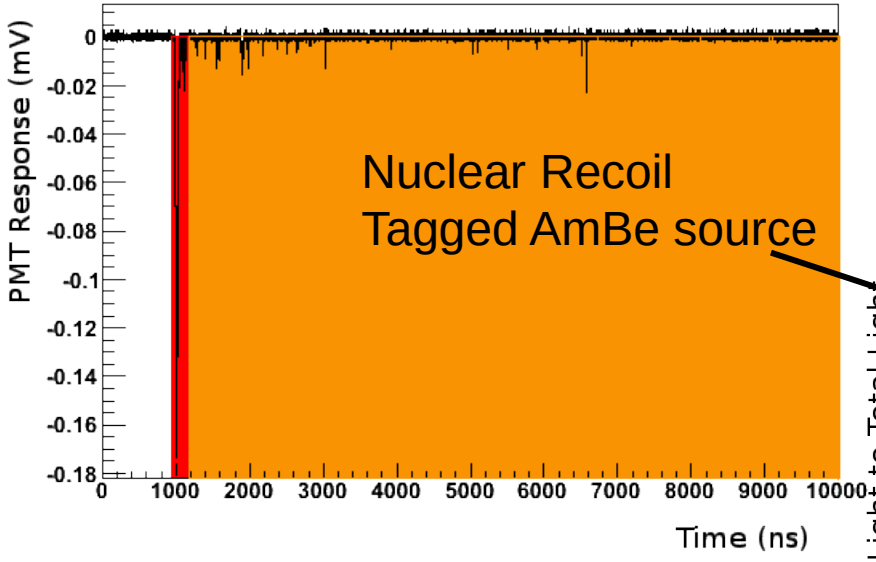


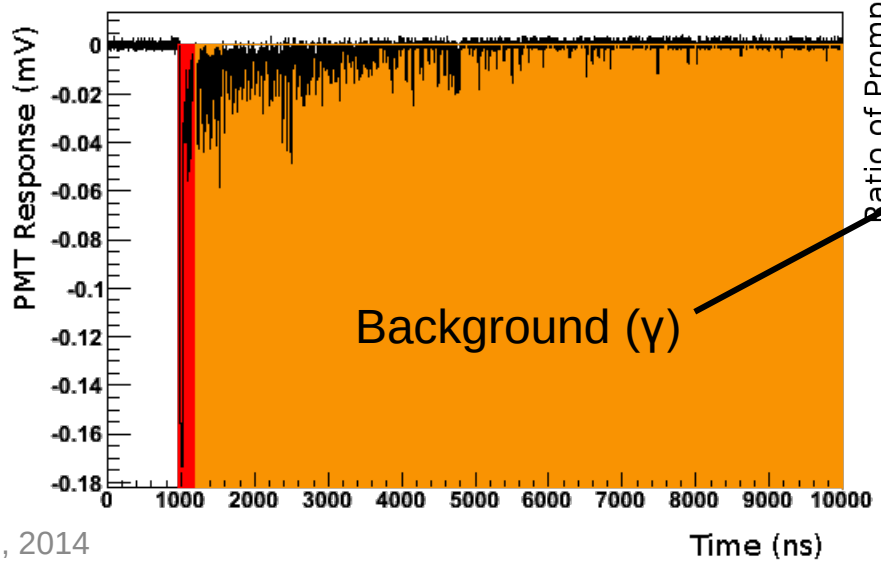
Current status

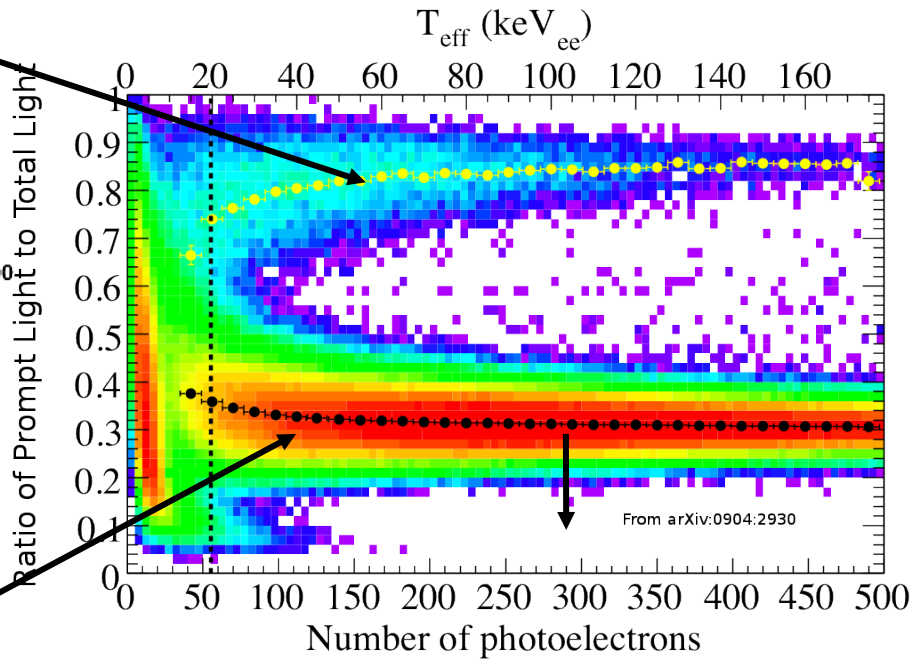
Light guide with reflectors

PMT and filler block assembly starting next week

Pulse shape discrimination concept

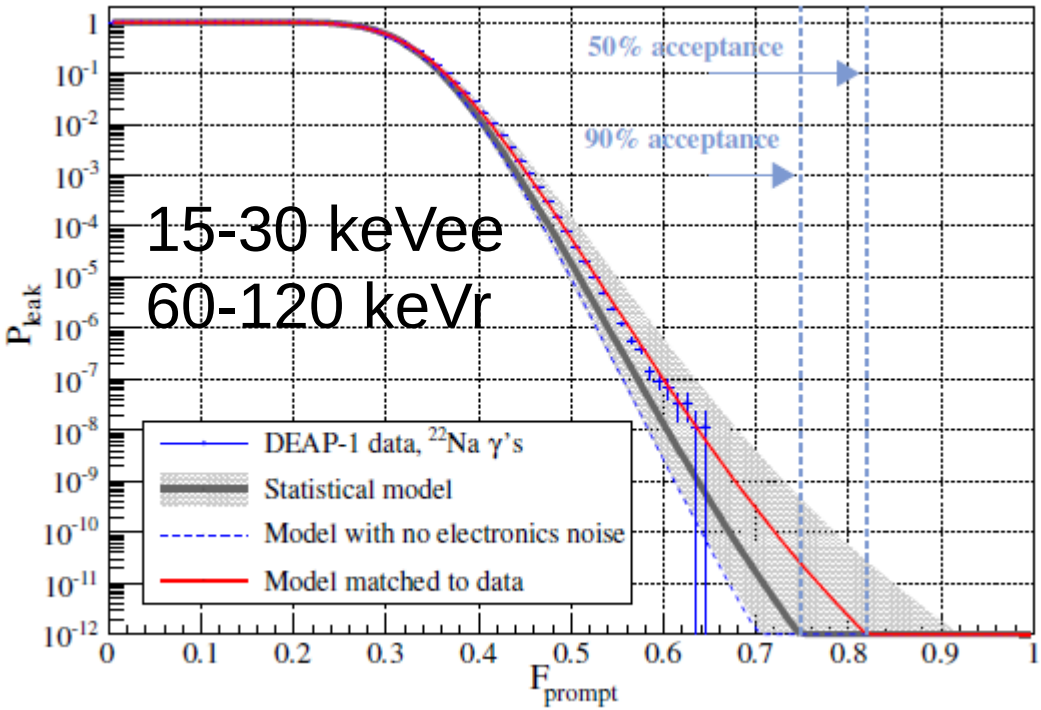




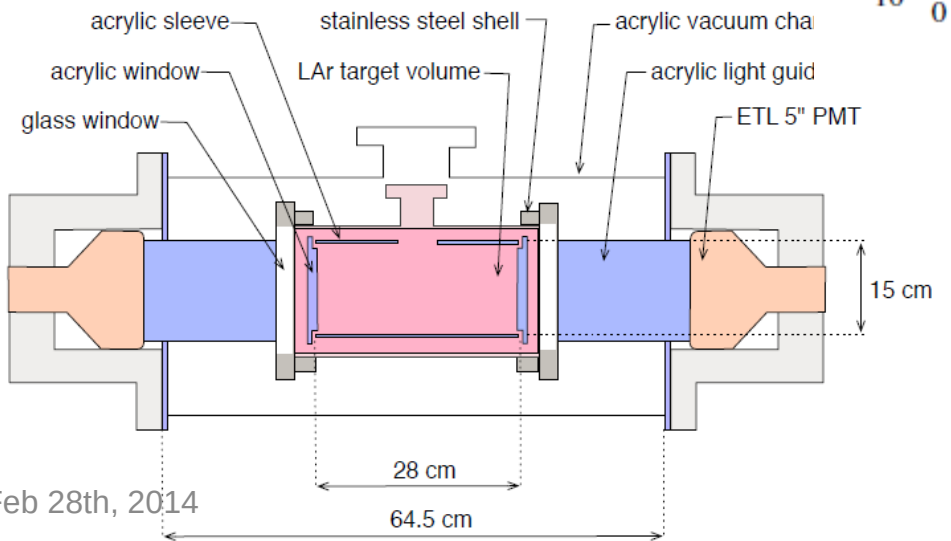


Expected PSD performances

- **Measured with DEAP-1 at SNOLAB**
  - Tagged ^{22}Na source



P-A Amaudruz et al.,
submitted to astro-particle physics

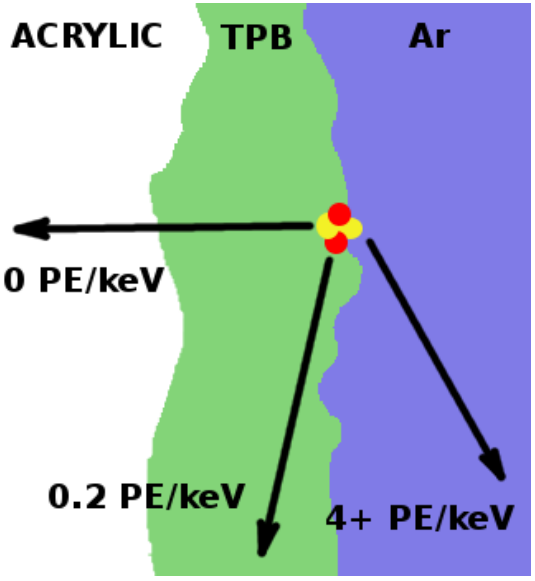


LAr scintillation to visible light TPB deposition

- **Coat inside of acrylic vessel with 1μm of TPB**
- **TPB shifts Argon 128nm light to blue light**
- **Deposition after resurfacing**
  - Source developed at Queens U.
  - Tested on 20” vessel

Radon and daughters

- **Radon Decay in LAr yields energy >> WIMP interaction**
- **Main issue Rn daughter decaying on surface**



http://arxiv.org/abs/1211.0909

- **Solutions:**
  - Minimize radon emanation with filters and a trap
  - AV resurfacing: shave a mm off the surface

Developed by Queen's U.

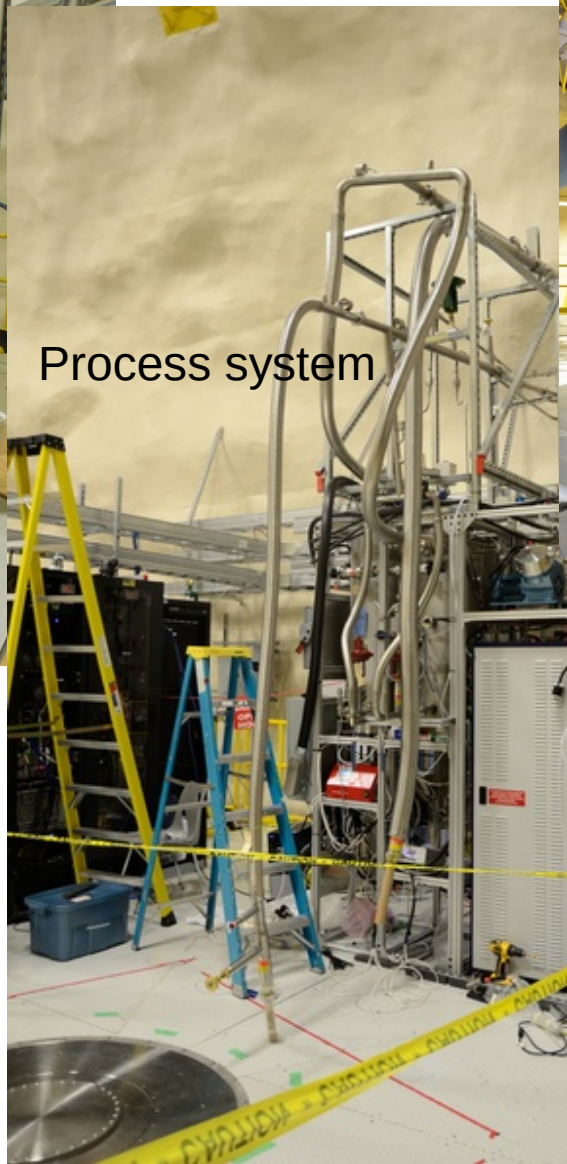
Projected backgrounds

Assuming 8PE per keV

Background	Rate/count	Mitigation
Neutron In 1t LAr	< 2 pBq/kg < 0.06 count/year	Shielding: 6000 mwe (SNOLAB), Active water shield, light guides and filler blocks Material selection
β & γ In 1t LAr	< 2 pBq/kg < 0.06 count/year	Pulse shape discrimination Material selection (for γ)
Radon In 1t LAr	< 1.4 nBq/kg < 44 count/year*	Material selection, SAES getter, cold charcoal radon trap ** High energy events, not in ROI*
Surface α In 1t LAr	< 0.2 mBq/m^2 < 0.6 count/year	Material selection (acrylic), sanding of AV (1mm removal), fiducialization.

Total of <0.6 events in ROI in 3 years for a spin-independent WIMP-nucleon cross section sensitivity of 10^{-46} cm^2 at 100GeV.

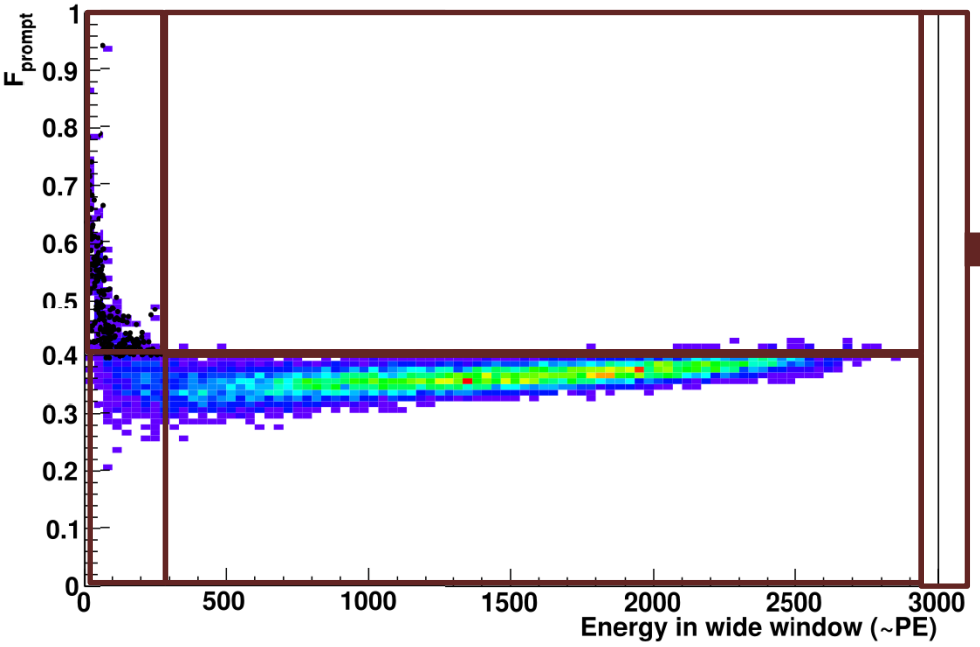
Other systems in place



A triggering challenge

- **Lots of ^{39}Ar**
  - 3.6 kHz expected in full volume
  - Everything else expected < mHz

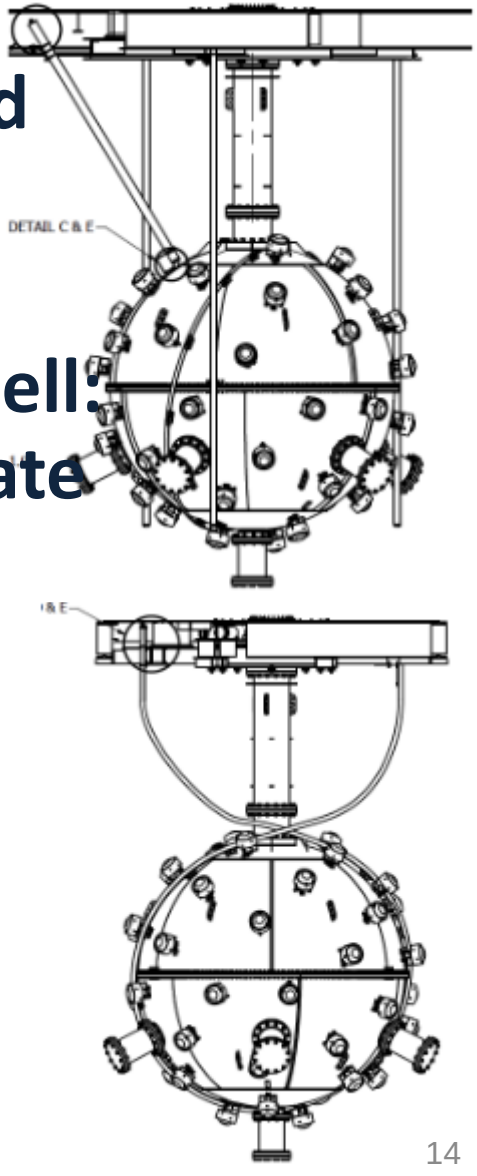
Simulation of online calculations



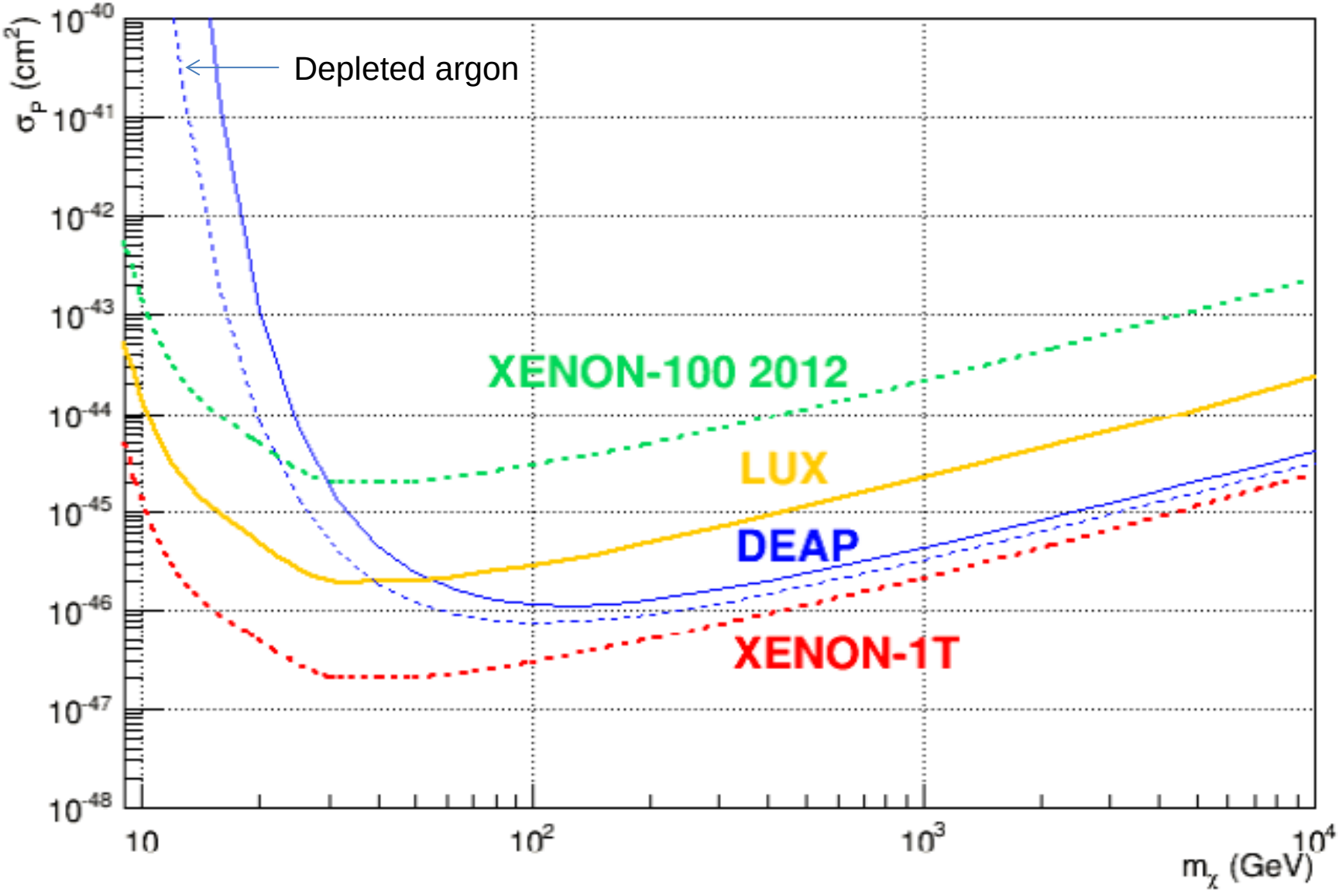
- **Two-tier online selection scheme**
  - FPGA-based decision using 22 digitized analog sums
    - Low energy window
  - Online charge/time (Q/t) calculation & energy + Fprompt calculation
    - Separate in 5 regions
- **Offline analysis using using waveform fragments and Q/t**

A calibration challenge

- **No internal sources used to avoid contamination**
  - Main calibration tool ^{39}Ar
- **Sources in tubes outside steel shell: need very hot sources to penetrate shielding**
  - 74MBq AmBe source for neutrons
    - 0.05Hz tagged neutron interactions
  - 0.37MBq ^{22}Na for gammas
    - 120 Hz tagged gamma interactions
- **Optical calibration**



First physics data in 2014
…Stay tuned



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