DEAP underground in Canada

Ben Smith for the DEAP-3600 collaboration
SUSY 2015
25th August 2015

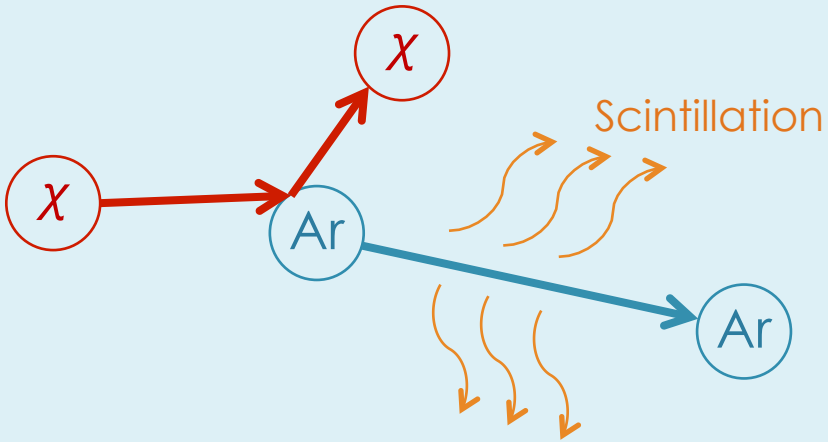
- Principle and detector design
- Construction progress
- Commissioning
- Sensitivity and outlook

DEAP-3600

- Searching for WIMPs
- Based at SNOLAB in Sudbury, Ontario
- Collaborators from CAN, UK and MEX

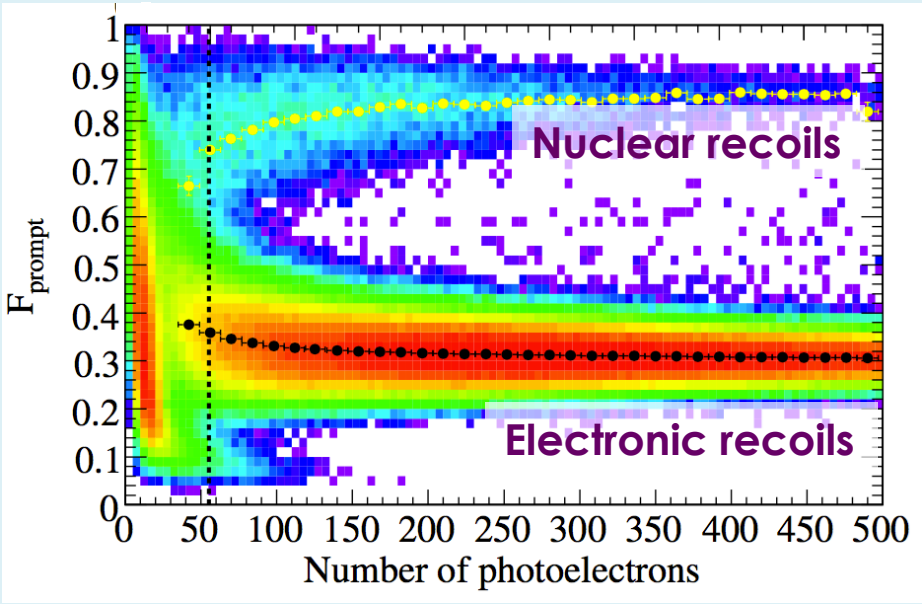
Detection principle – scintillation

- WIMP scatters off argon nucleus
- Recoil creates excited Ar_2 dimers
- Dimer decay produces UV scintillation light
  - Singlet and triplet states have different lifetimes (7ns / 1500ns)

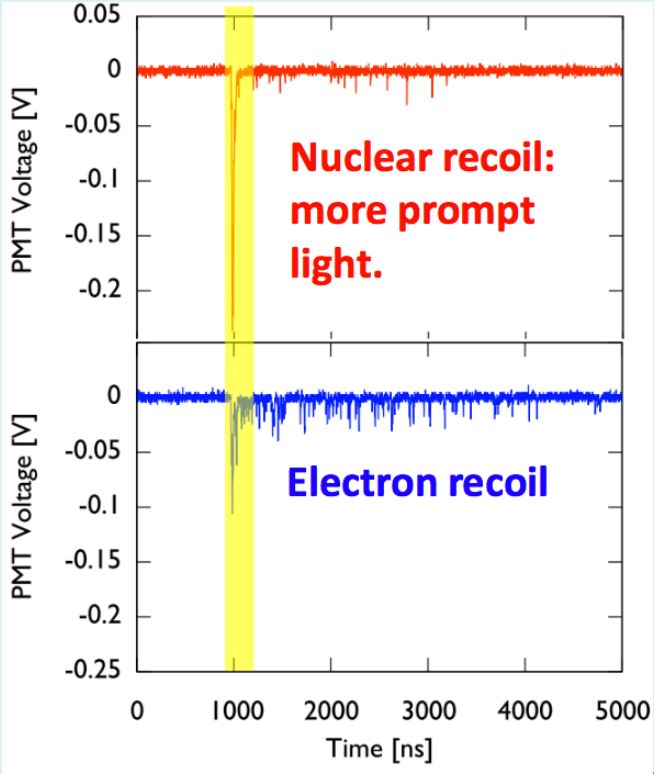


Pulse shape discrimination

- WIMP: nuclear recoil. β decay: electron recoil
- Nuclear recoils create more singlet states – more prompt light!
- Distinguish using pulse shape



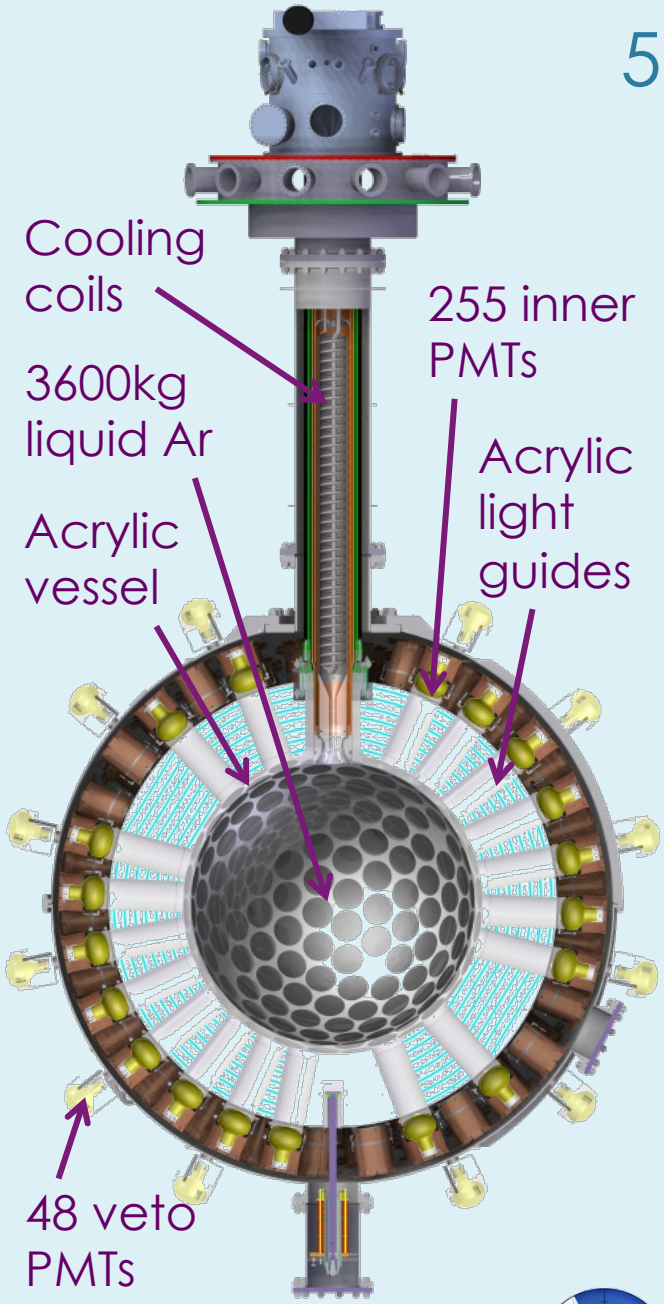
DEAP-1 data, arXiv:0904.2930



Detector design

- 3600kg LAr, 1000kg fiducial
- Acrylic vessel 85cm radius
- Surrounded by water shield

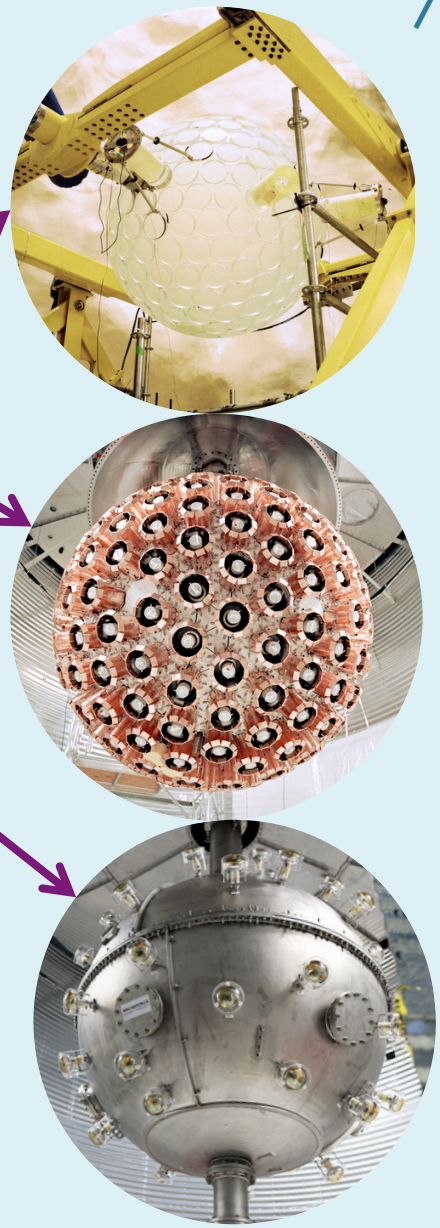
- 2km underground in active nickel mine
  - "A day at SNOLAB" – highly recommended! https://goo.gl/mgxwfi



Construction progress

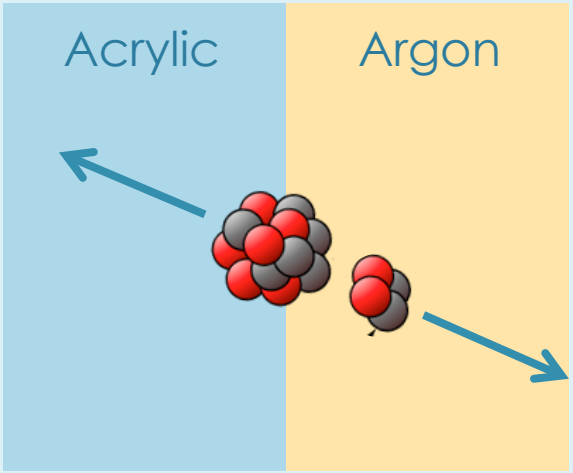
Recent milestones

- Acrylic Vessel completed Nov 2013
- Inner detector instrumented Jun 2014
- AV **resurfacing** complete Nov 2014
- Steel shell and veto PMTs Apr 2015
- **Wavelength-shifter** deposited Jun 2015
- Water tank completed Jul 2015
- Laserball **calibration** data Jul 2015



Background – radon decay

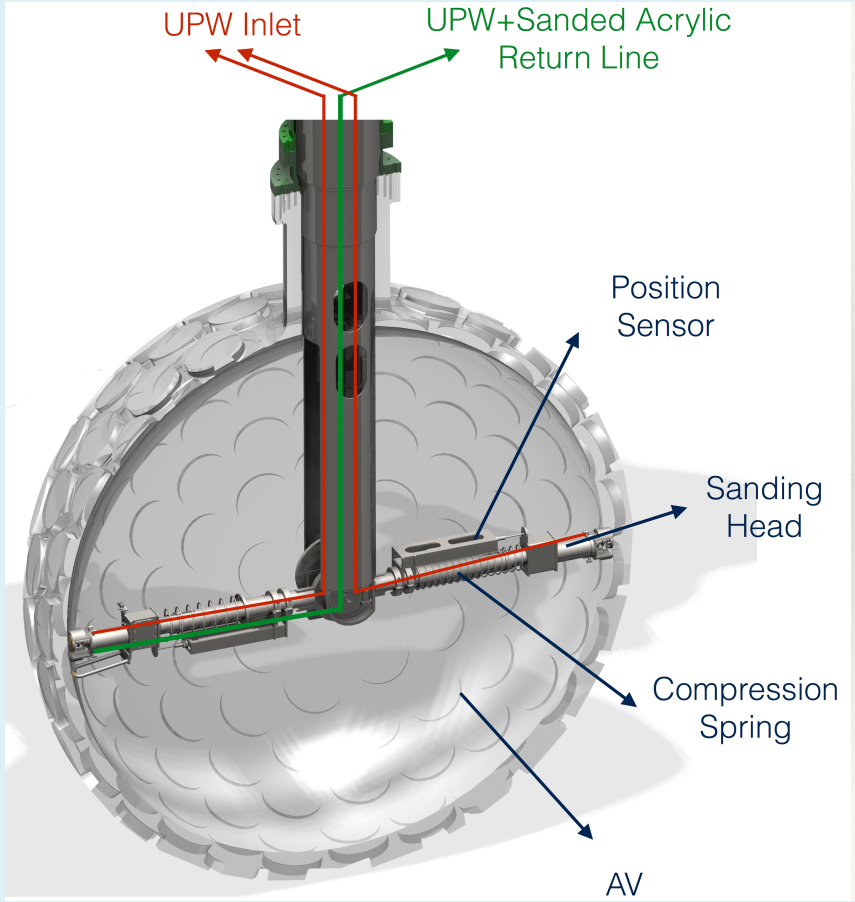
- ^{222}Rn … ^{210}Pb (τ = 22 years) … ^{210}Po
- ^{210}Po emits 5.3 MeV α – could mimic WIMP signal!
- Bulk acrylic is radon-free, but surfaces have been exposed to lab air



- Solution: sand off inside surface of acrylic vessel, and never expose it to air again

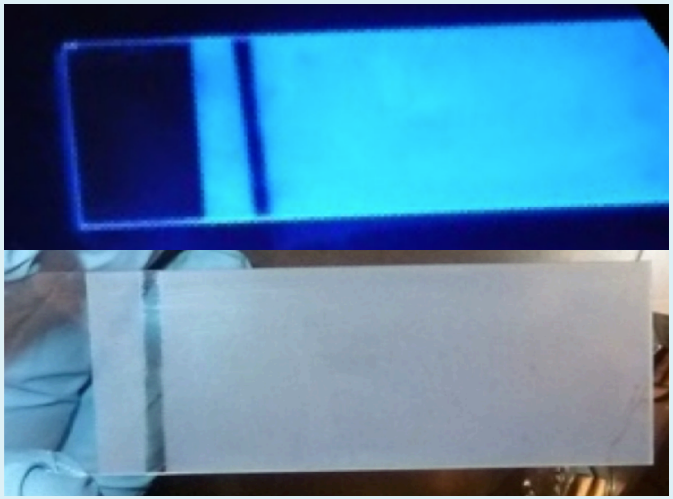
Resurfacer removes radon-laced acrylic

- Resurfacing robot sanded off inner acrylic
- Ran for 200 hours last fall
- Extracted without exposing vessel to air
- Purging with N_2 or at vacuum ever since



Wavelength-shifter

- PMTs aren't sensitive to UV scintillation light
- Vacuum-deposited 3μm of TPB wavelength-shifter over inner surface of acrylic vessel



TPB under UV and visible light

Evaporation source

Deployment tube

We're nearly ready!

- Construction to-do list
  - Fill veto tank with water
  - Prepare for liquid argon
    - Insert flow guides and cooling coils
    - Cool down detector with argon gas

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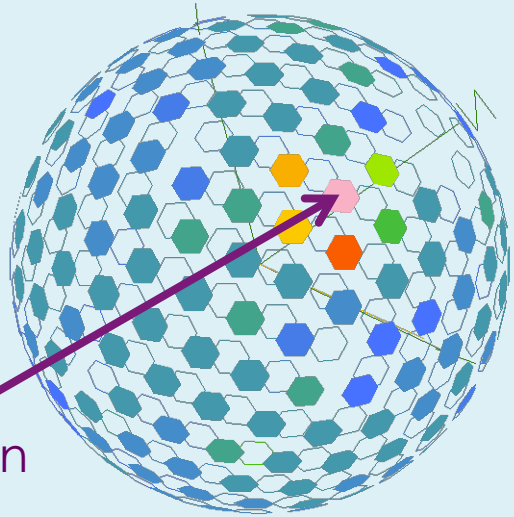
Commissioning

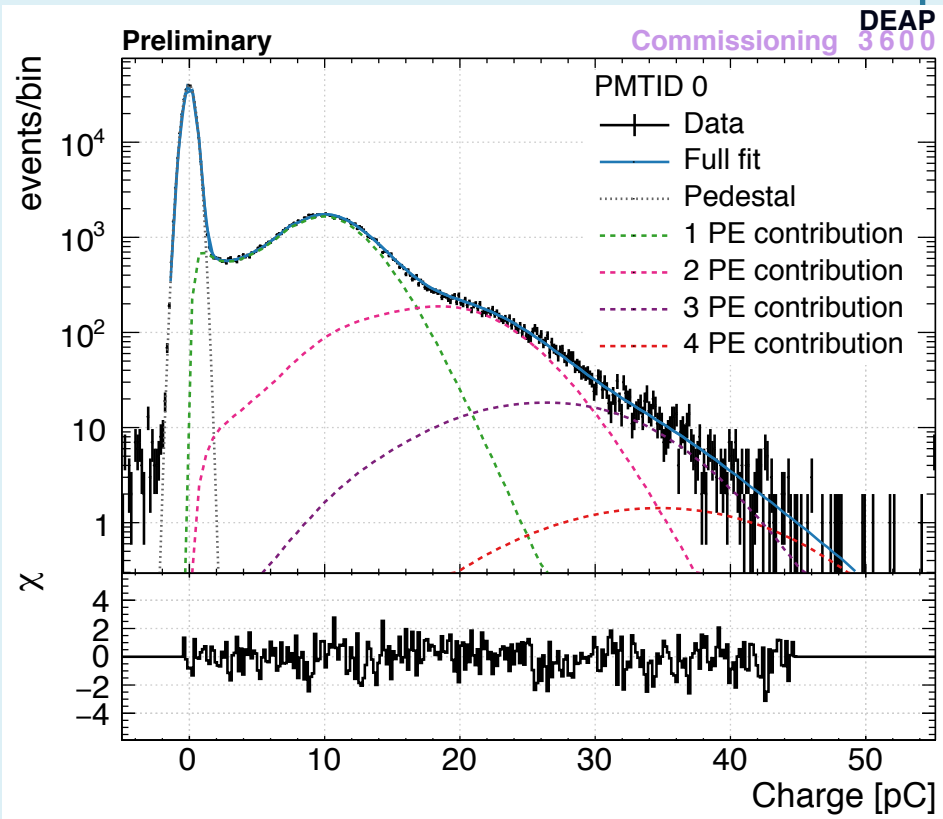
Lots of commissioning data

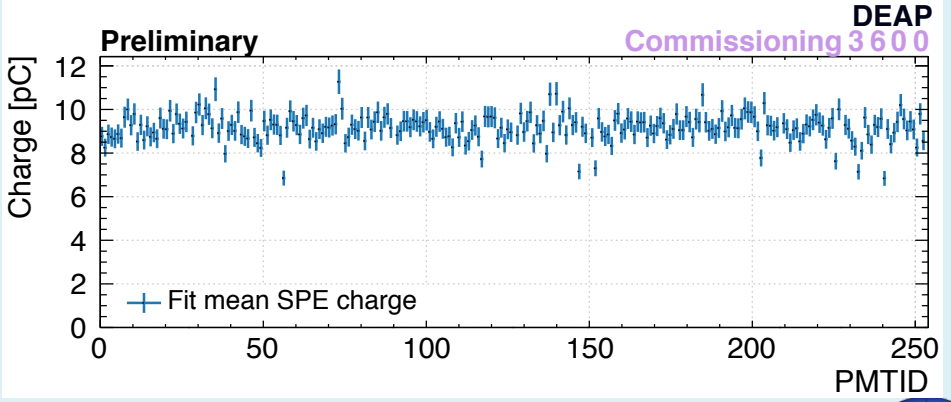
- We've been taking real data during construction
- Light injection using LEDs and fibres
  - Optical properties, PMT characterisation, effect of wavelength-shifter deposition…
- Light injection using laserball inside detector
  - Precise timing, optical properties…
- "Dark" data
  - Backgrounds, detector stability…

PMT calibration

- Shine LEDs through fibres to inject light
- Excellent fit to charge spectrum using Polya function







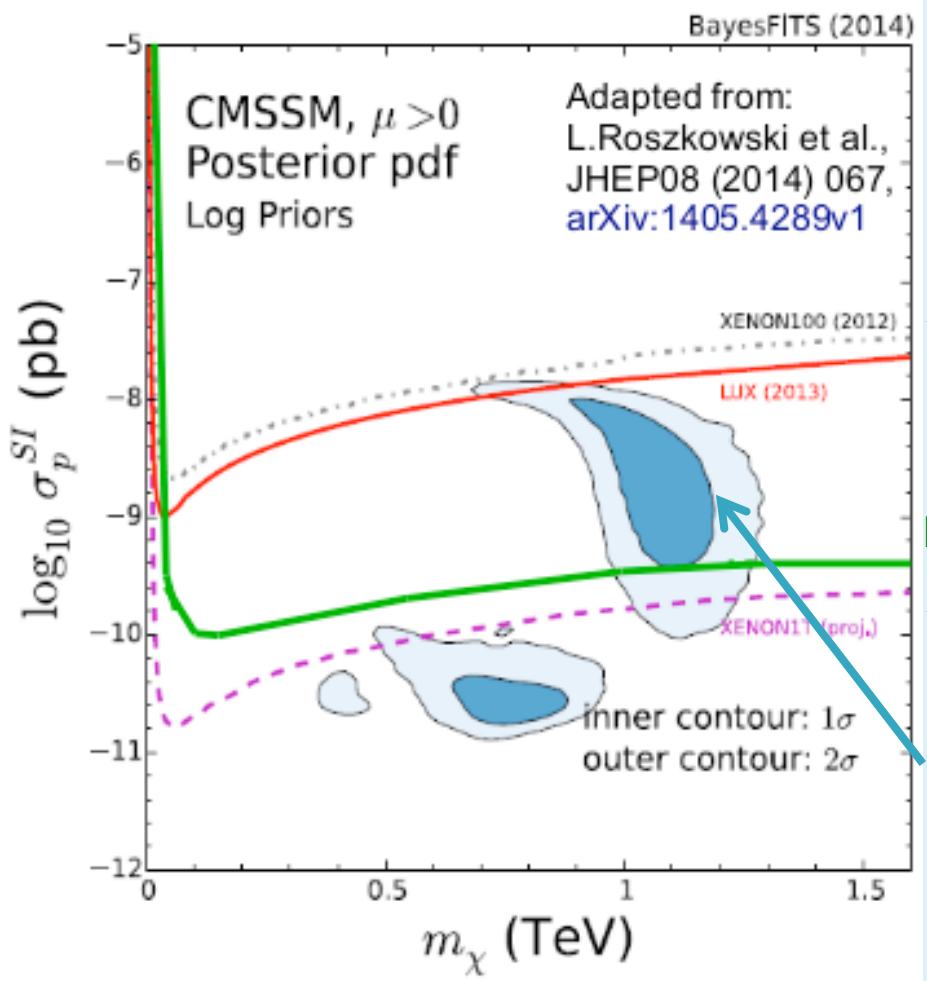
Sensitivity and outlook

Dominant backgrounds

- Expected events for 3 years of data-taking

Background type	Mitigated by	Events passing **energy** cut	Events passing **energy**, **position** & **pulse shape** cuts
Neutrons (nuclear recoil)	Water tank, filler blocks	30	< 0.2
Surface α (nuclear recoil)	Material choice, resurfacing	150	< 0.2
^{39}Ar β (electron recoil)	Pulse shape discrimination	1.6×10^9	< 0.2

Expected sensitivity



XENON100 (2012)

LUX(2013)

DEAP-3600 (expected)

XENON1T (expected)

CMSSM scan based on ATLAS+LUX data

Summary

- Huge construction progress made in the last year
- Lots of commissioning data taken to understand optics, PMTs etc
- Very close to taking liquid argon data
- Expect first results early next year