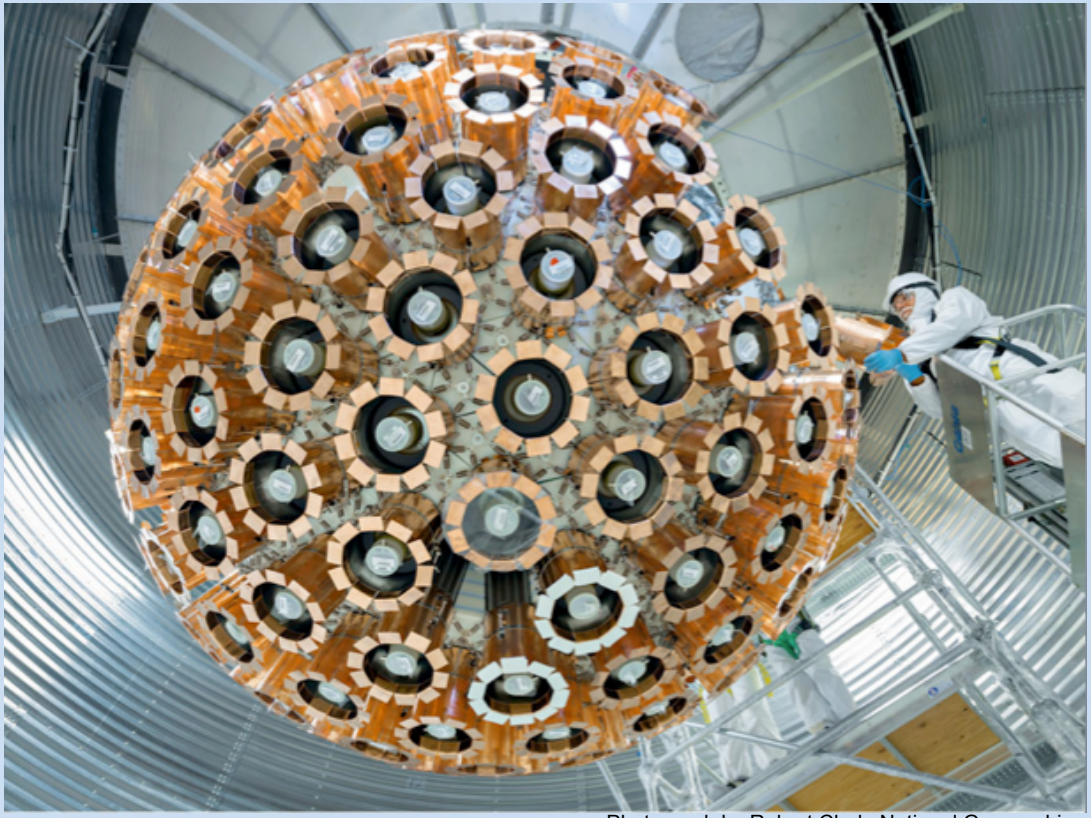


Photograph by Robert Clark, National Geographic

The DEAP 3600 Experiment

Tom Sonley

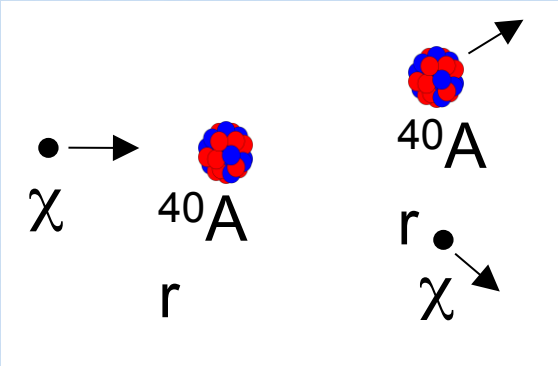
Queen's University

for the DEAP-3600 Collaboration

April 13, 2015

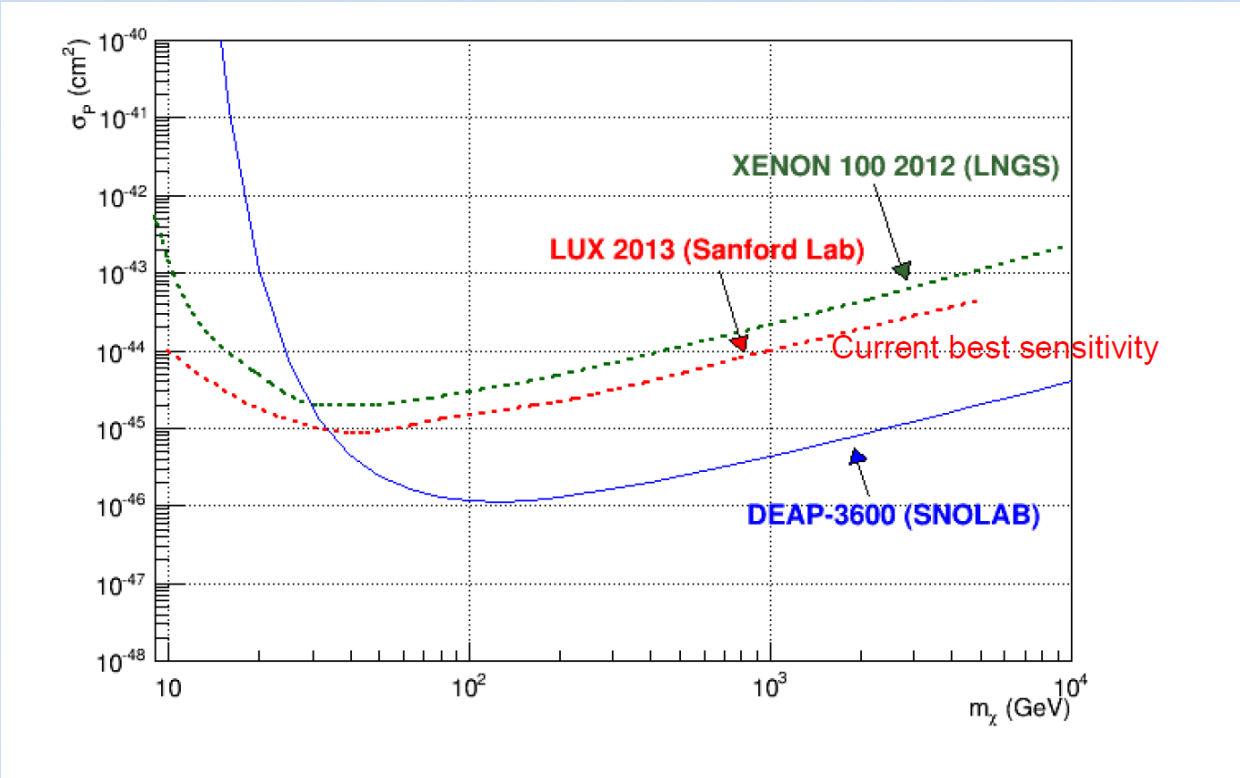
APS April Meeting

Single-Phase Liquid Argon as a Dark Matter Target

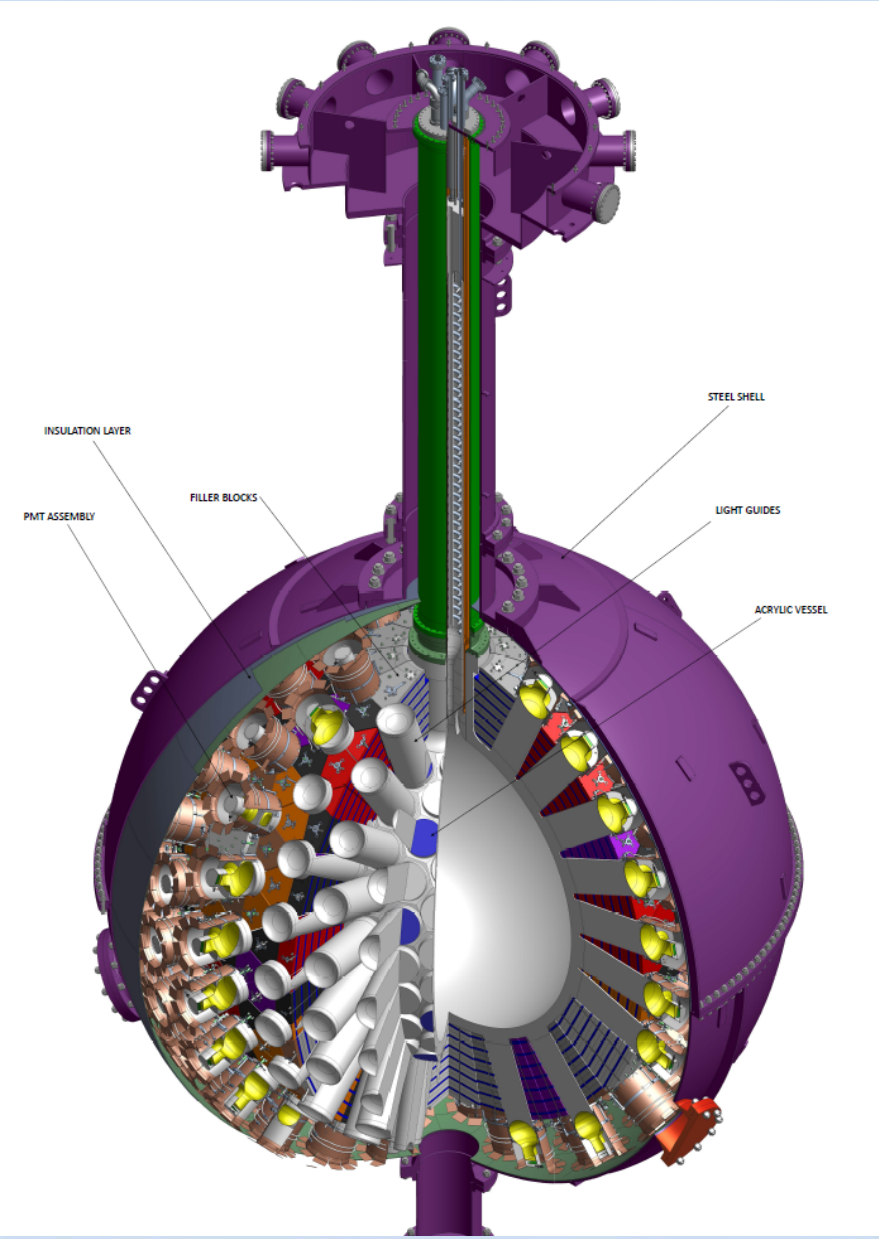


- Scattered argon nucleus with 10's of keV is detected by scintillation in liquid argon
- Well-separated singlet and triplet lifetimes in argon allow for good pulse-shape discrimination (PSD) of β's and γ's using only scintillation time information
  - projected to 10^{-10} at 20 keV_{ee}
  - see Astroparticle Physics 25, 179 (2006) and arxiv/0904.2930
- Very large target masses possible
  - UV scintillation photons have low absorption in argon
  - No electron drift requirements
- 1000 kg fiducial mass, 3-year run allows 10^{-46} cm^2 sensitivity with around 15keV_{ee} (60 keV_{recoil}) threshold

Projected Spin-Independent Sensitivity



- 1000 kg fiducial volume (3600 kg target)
- 60 keV$_{recoil}$ threshold
- Less than 1 background event in 3 years of livetime
- 8×10^{-47} cm^2 projected sensitivity using depleted argon



The DEAP 3600 Detector

3600 kg argon target (1000 kg fiducial) in sealed ultraclean Acrylic Vessel

Vessel is "resurfaced" in situ to remove Rn daughters deposited during construction

TPB wavelength shifter deposited on inner surface

255 Hamamatsu R5912 HQE PMTs (8-inch, 32% QE, 75% coverage)

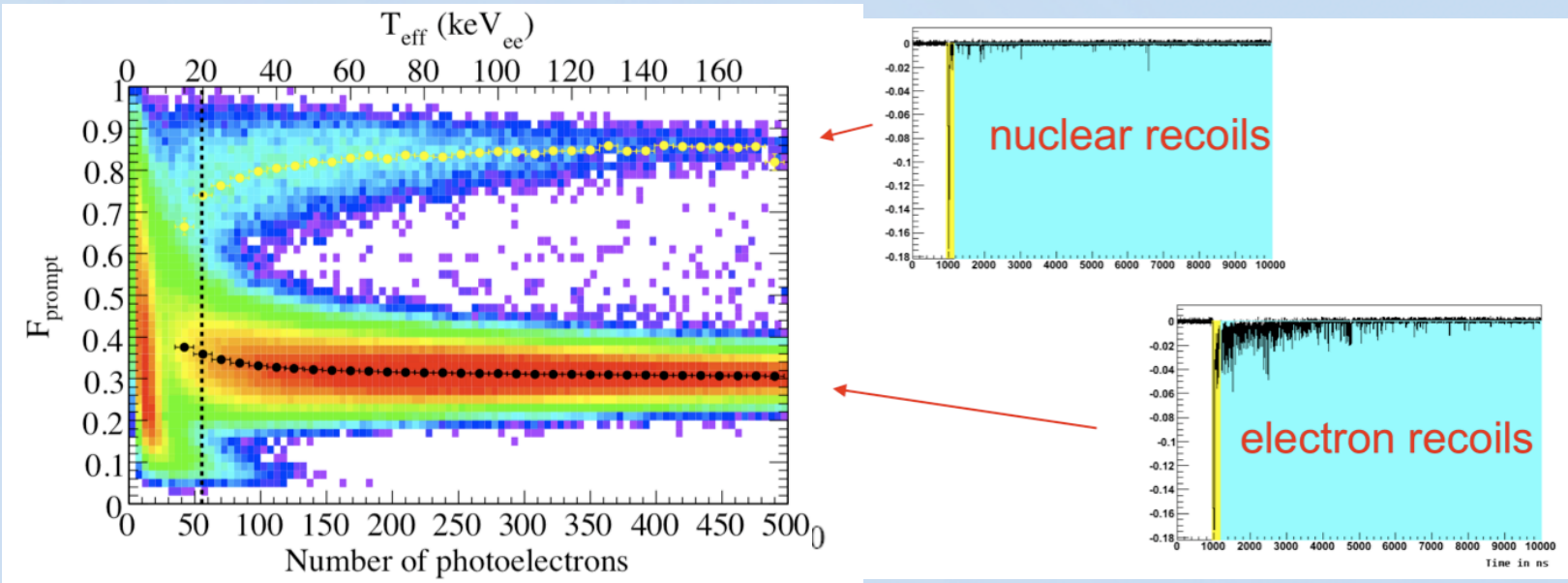
50 cm acrylic light guides + PE shielding moderate neutrons from PMTs

Detector in 8 m water shield at SNOLAB

Background Sources

- Betas and Gammas
  - ^{39}Ar in natural argon will produce ~10^9 events in energy window
  - Pulse Shape Discrimination will provide >10^{-9} suppression

Pulse Shape Discrimination



$$F_{prompt} = \frac{\text{Charge in first 150 ns}}{\text{Charge in first 10 μs}}$$

See: arXiv:0904.2930 and Astroparticle Physics 62, 178-194 (2015), arXiv:1211.0909

Background Sources

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  - PMT neutrons will be attenuated by acrylic
  - Clean acrylic used to minimize (α, n) reactions

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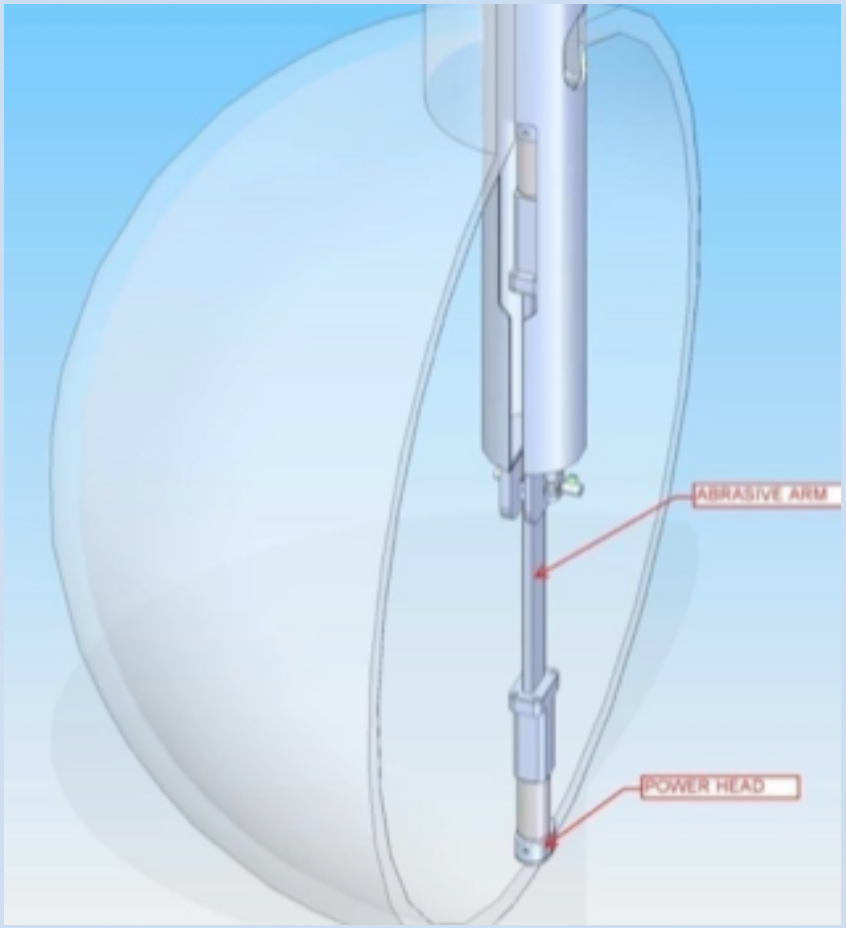
  - PMT neutrons will be attenuated by acrylic
  - Clean acrylic used to minimize (α, n) reactions
- Surface Alphas
  - Position reconstruction should reduce by ~350 times
  - Inner surface must be sanded

Resurfacing

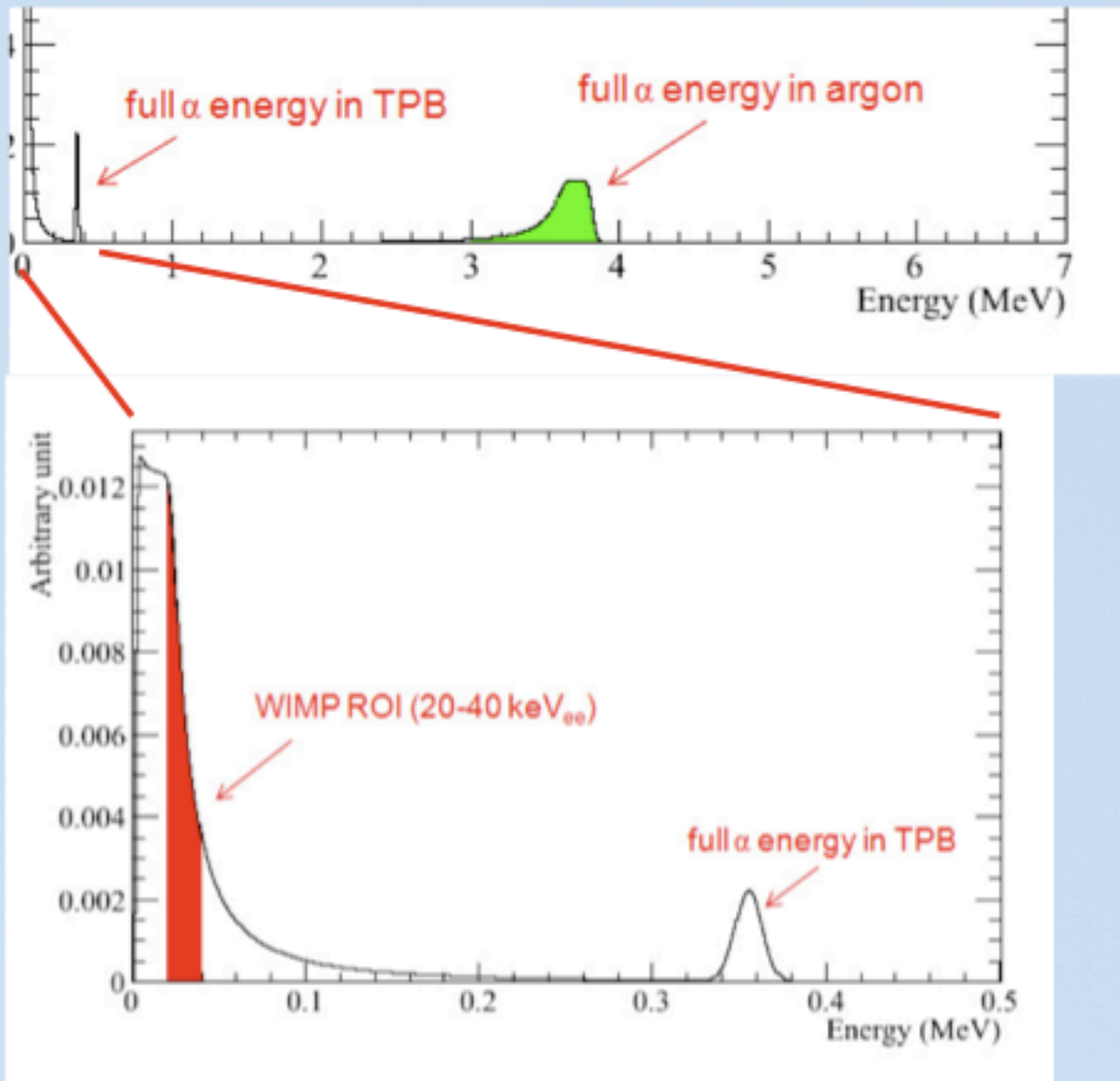


- Mechanical resurfacer removes ~1 mm of acrylic
- Debris flushed with ultrapure water
- Resurfacer made of clean, low emanation materials
- Deployed through sealed glove box

Bulk Alpha Limits

- Alpha scintillation in TPB produces 880 ± 210 photons/MeV
- Alphas that enter or leave the acrylic can produce WIMP-like events.
- Necessary TPB purity levels are difficult to measure, but are definitely achievable with distillation techniques

See NIM A: 635, 1 (2011), arXiv:1011.1012



Background Budget

Background	Raw No. Events in Energy ROI	Fiducial No. Events in Energy ROI
^{39}Ar β's (natural argon)	1.6×10^9	< 0.2
^{39}Ar β's (depleted argon)	8.0×10^7	< 0.01
Neutrons	30	< 0.2
Surface α's	150	< 0.2


TOSHIBA MACHINE
110B16
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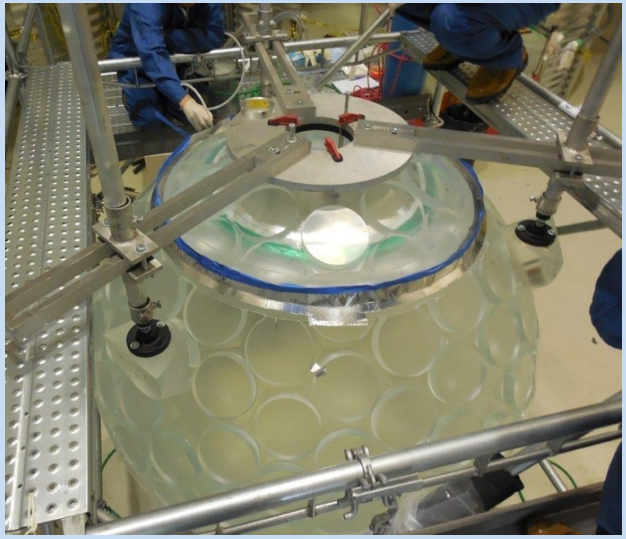
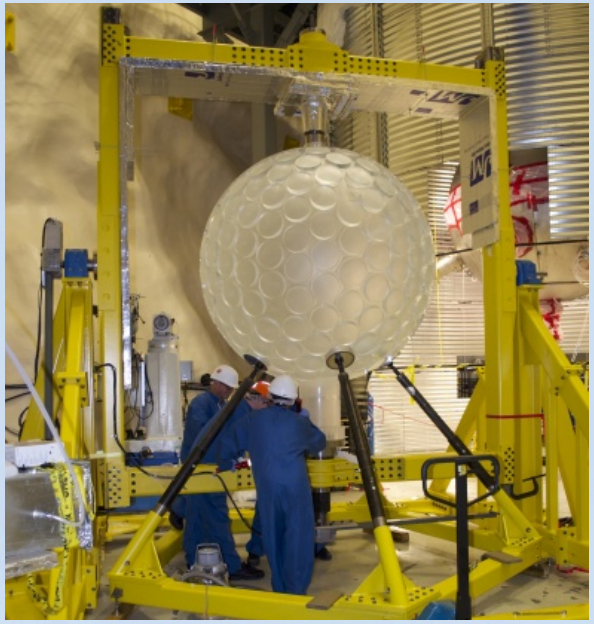
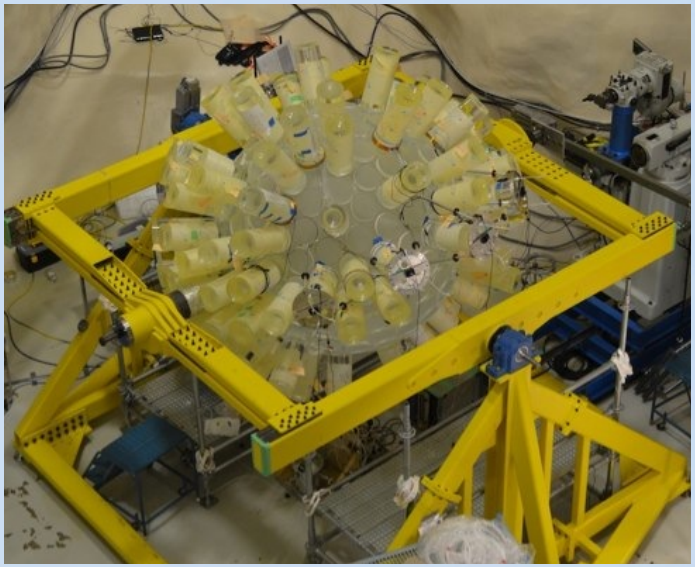
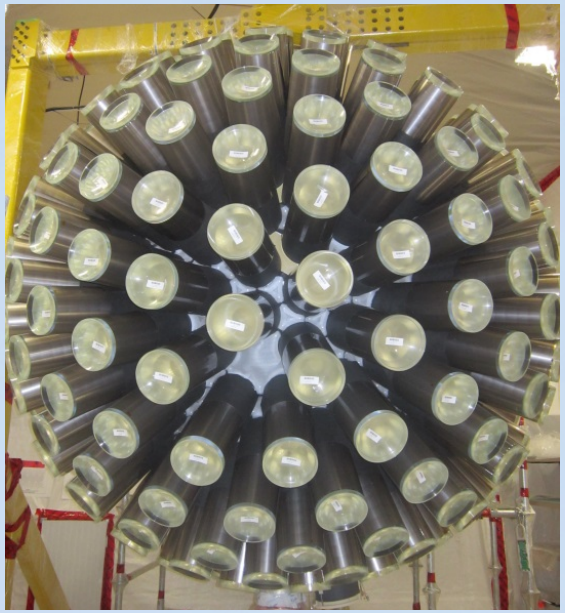
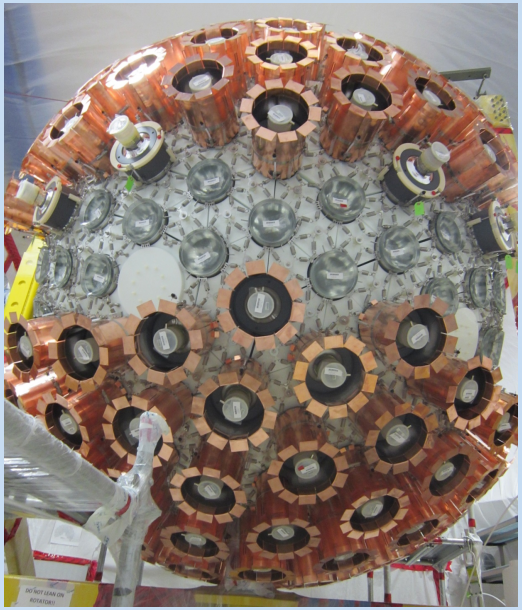






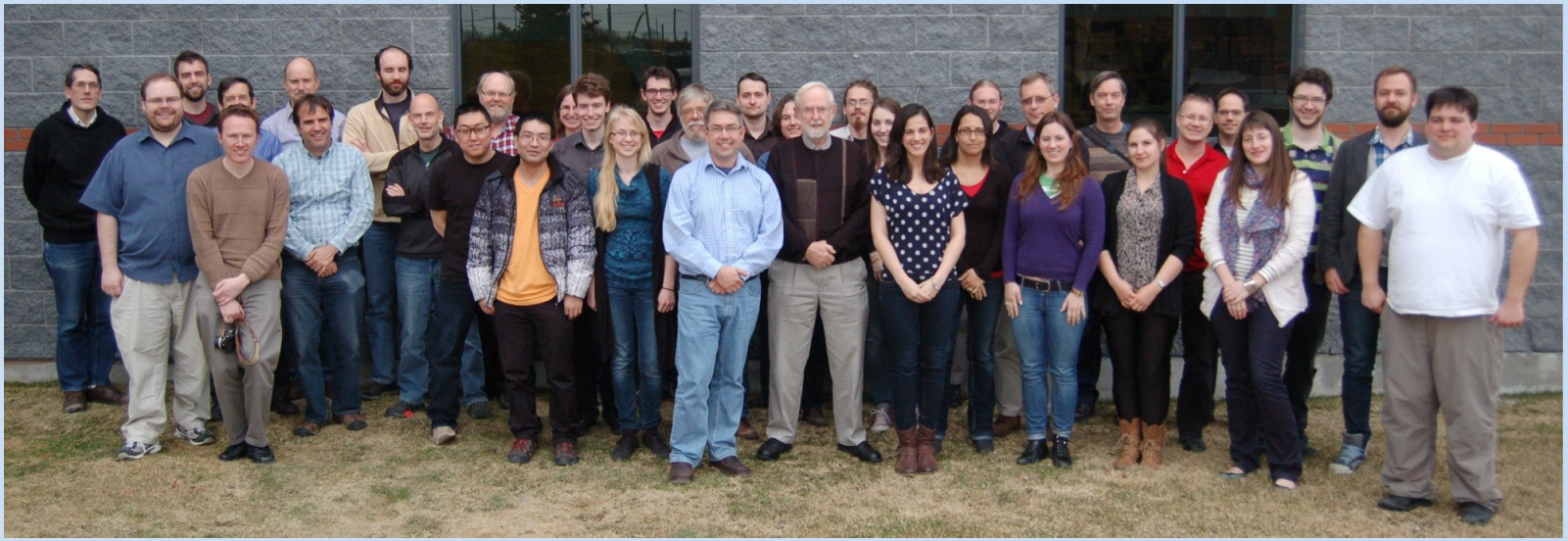





SKYJACK
SJ III 3219

Conclusions

- DEAP is designed to run for 3 years with a 1000 kg fiducial volume and less than 1 background event.
- Expected sensitivity is 10^{-46} cm^2 for spin-independent dark matter interactions
- All major components are installed
- Currently commissioning PMTs and Cryosystems
- First physics data: Summer 2015



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