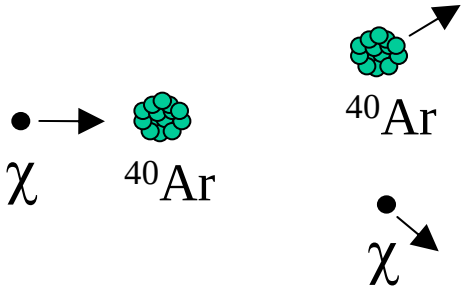
DEAP/CLEAN Experiment at SNOLAB

- Dark Matter Search with Argon
- Detector Backgrounds
- DEAP-1 Status
- 3600 kg Detector Status

DEAP-1 installation at SNOLAB (December 2007)

Mark Boulay
Queen's University

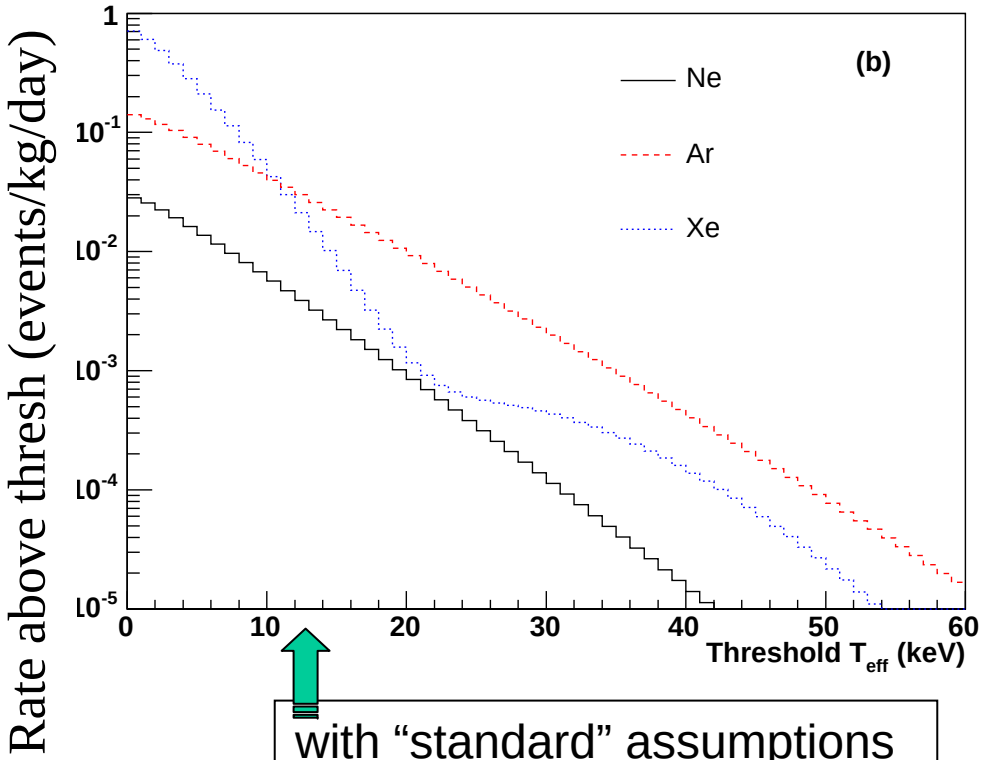
Argon as a target medium for direct WIMP detection



Rate ~ A^2F (coherent)

No. nucleons form factor

Less loss of coherence for lighter nuclei, argon can provide useful information even with relatively high energy threshold

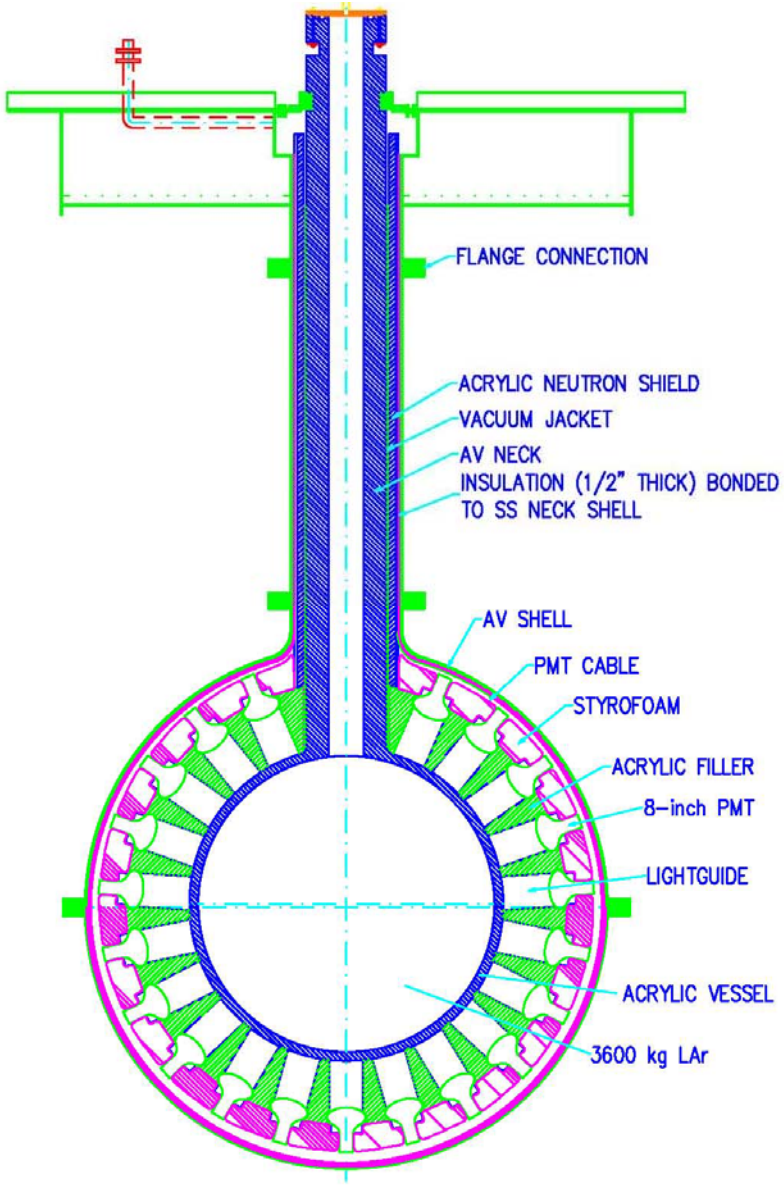


with "standard" assumptions about the WIMP halo and distribution and for a 100 GeV WIMP

Projected pulse shape discrimination (PSD) in argon allows threshold of approx. 20 keV_{ee} (60 keV_r)

1000 kg argon target allows 10^{-46} cm^2 sensitivity (SI) with 20-40 keV_{ee} window

DEAP/CLEAN-3600 detector



85 cm radius acrylic sphere contains 3600 kg LAr
(55 cm, 1000 kg fiducial)

266 8" PMTs (warm)

50 cm acrylic light guides and fillers for neutron shielding (from PMTs)

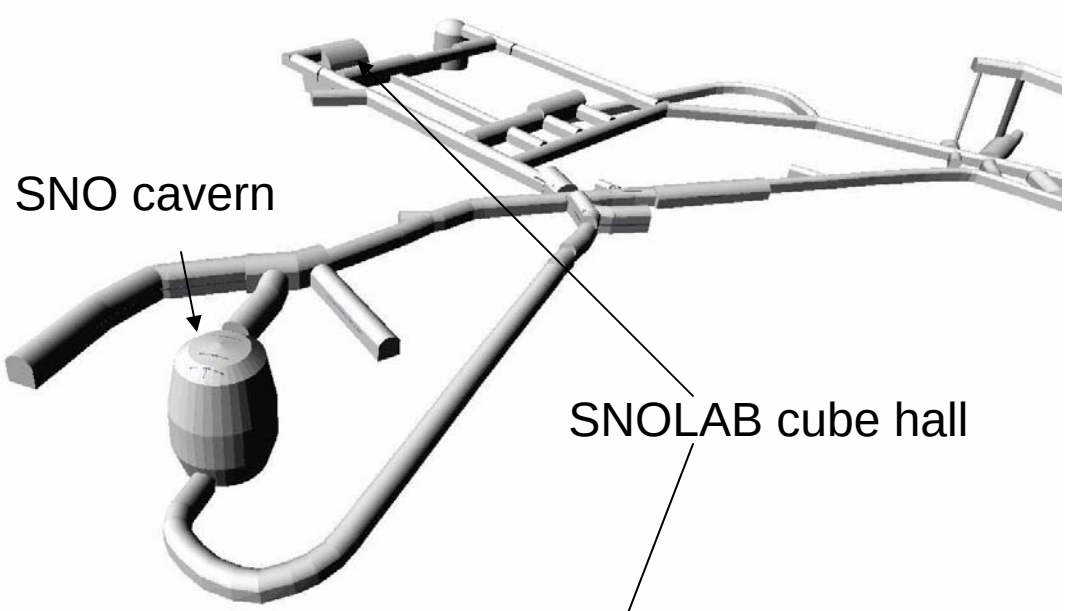
Only LAr, acrylic, and WLS (10 g) inside of neutron shield

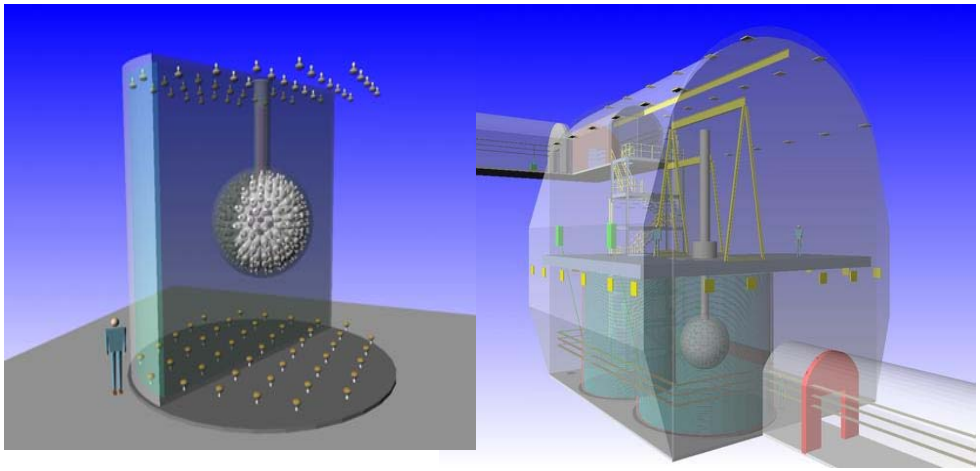
8.5 m diameter water shielding tank

DEAP/CLEAN 3600 construction activities will begin at SNOLAB 2008

Approved by SNOLAB/EAC for experimental space

Support deck steelwork and shield tank construction in 2008





DEAP&CLEAN International Collaboration

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DEAP/CLEAN collaborators currently working jointly on projects to be sited at SNOLAB

DEAP-1:

- 7 kg prototype experiment
- run at Queen's for demonstration of PSD
- installed underground at SNOLAB 2007 for continued PSD and background studies, DM search

DEAP/CLEAN-3600:

- 3600 kg experiment targeting DM with LAr
- Cyogenic Acrylic Vessel (AV) for radon mitigation
- Primary emphasis of Canadian collaborators in short term

miniCLEAN:

- 360 kg experiment targeting DM with LAr and prototyping neon for particle astrophysics
- Modular design, assembly in glove box for radon mitigation
- primary emphasis of US collaborators in short term

Sources of backgrounds for WIMP search

We want WIMP search sensitive to <1 event/year/1000 kg

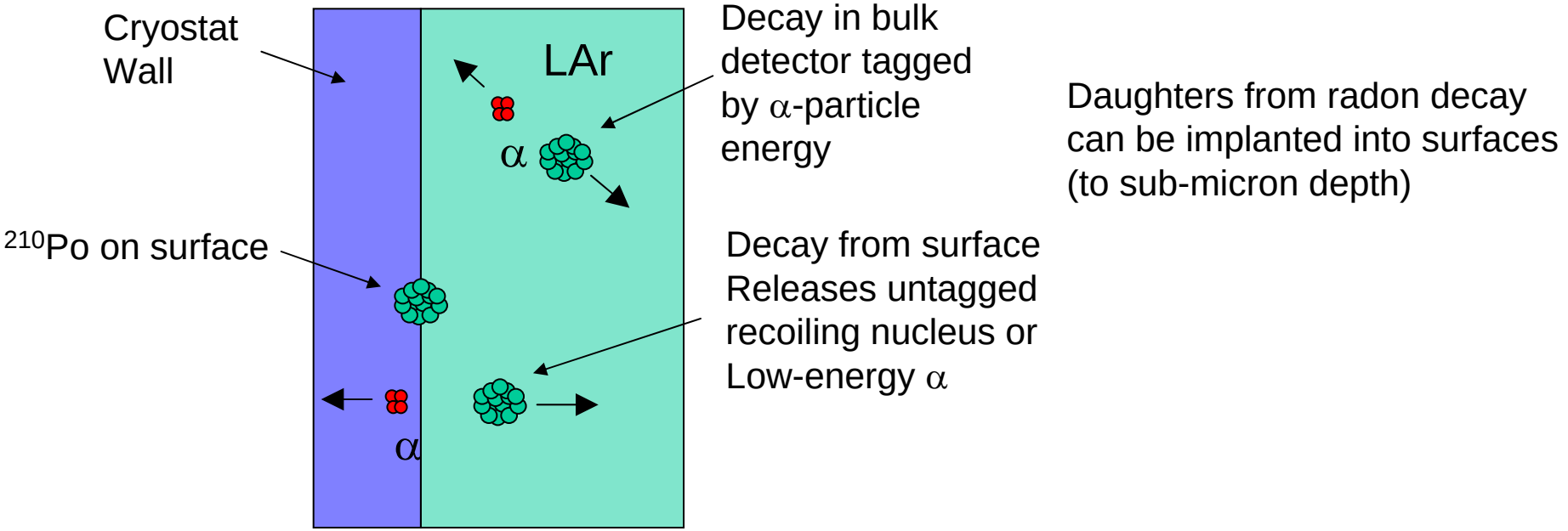
⇨ need to reduce backgrounds to that level

1. β/γ events. Use singlet/triplet time distribution in LAr to discriminate β/γ from nuclear recoils

2. neutron-induced nuclear recoils

   Need to suppress all potential neutron sources!

3. surface contamination



Backgrounds in DEAP/CLEAN-3600

1. $\beta-\gamma$'s (dominated by ^{39}Ar β-decays)
   argon from atmospheric source — 10^9 per year
   x20 depleted argon (UG source) — 6×10^7 per year

   (removed with PSD
   - -model projection for 10^9 events
   - -demonstrated for 6×10^7 events)

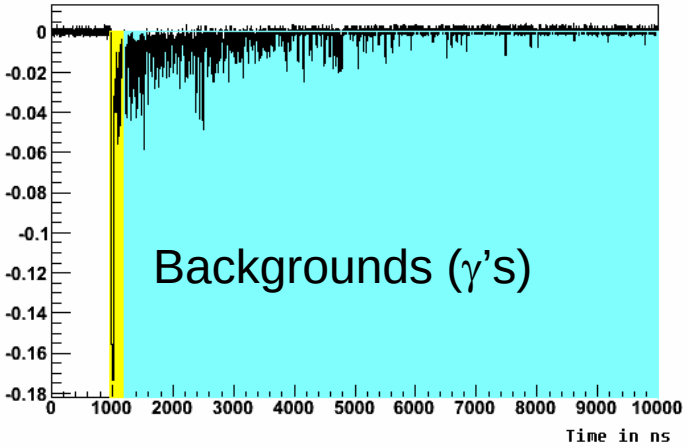
2. Nuclear recoils from neutrons

μ-induced	<<1	@ SNOLAB with 2 km rock shield
(α,n) from rock	<<1	8.5m H_2O shield tank
(α,n) from PMTs	< 1	50cm acrylic LGs
(α,n) from acrylic	<<1	ppt acrylic

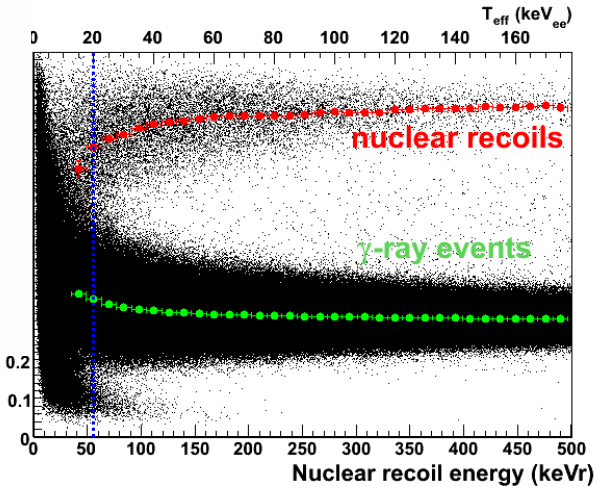
3. Surface contamination
   Requirement of < 1 event/m^2/day from surfaces, background removed with position reconstruction (σ=10 cm @ 20 keV)

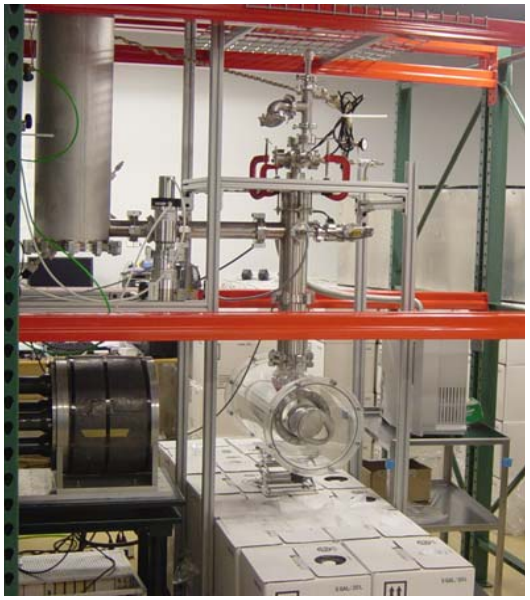
   Need intrinsically clean surface material (~10 ppt) and need to remove deposited radon daughter activity

Background suppression with PSD in DEAP-1

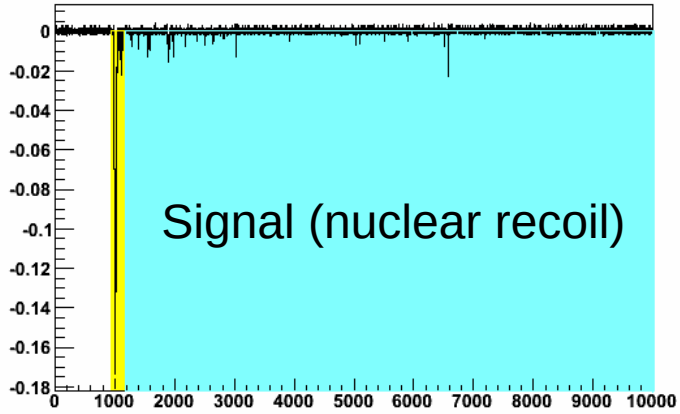


Yellow: Prompt light region
Blue: Late light region

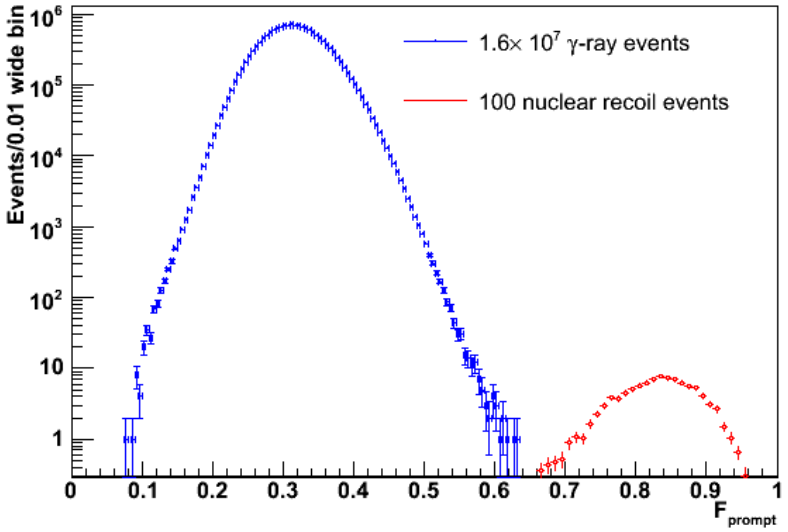




DEAP-1 at SNOLAB



$$F_{prompt} = \frac{PromptPE(150ns)}{TotalPE(9\mu s)}$$



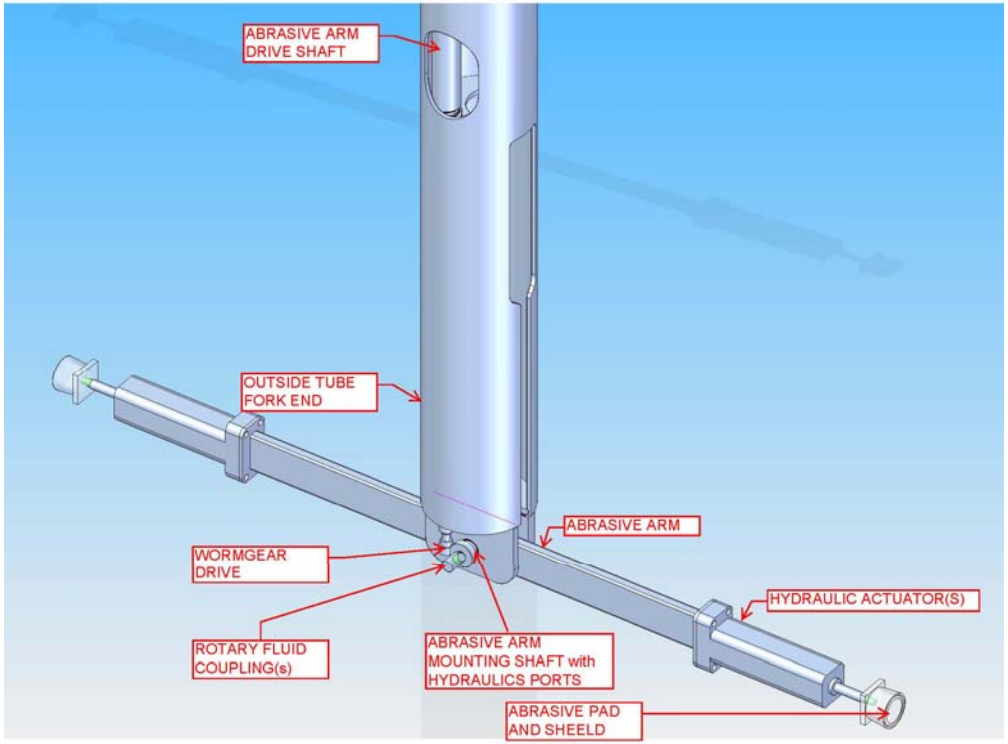
Background suppression better than 6×10^{-8}
120-240 pe

Acrylic Vessel Resurfacer for Implanted Radon Daughter Removal

Deployed through vessel neck/sealed glovebox in inert(radon-free) environment

Abrasive sanding pads will remove ~10 microns of acrylic from entire vessel in approx 24 hours, surfaces then as clean as bulk acrylic

Procedure can be repeated in the event of accidental surface contamination



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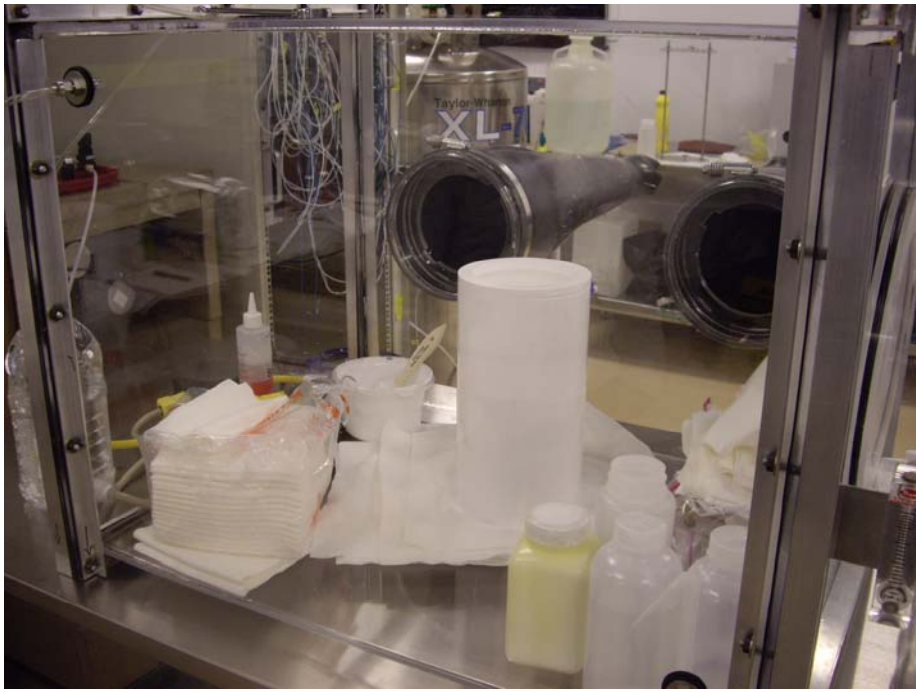
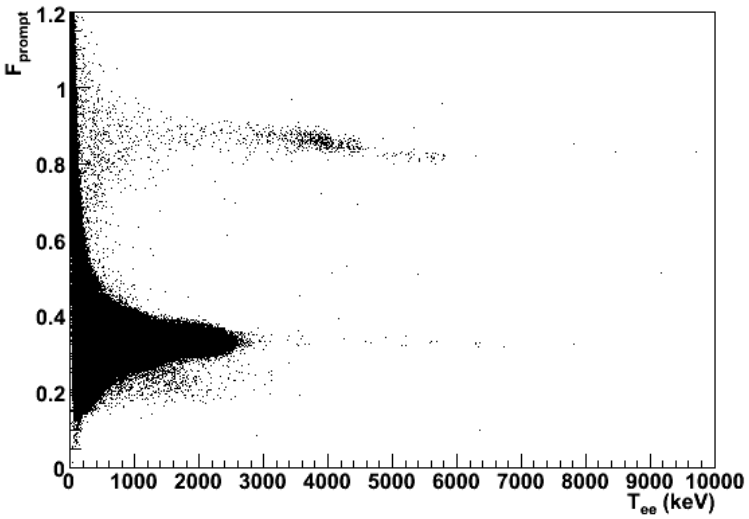
DEAP-1 glovebox at Queen's for low-radon chamber assembly



Resurfaced inner chamber now installed at SNOLAB

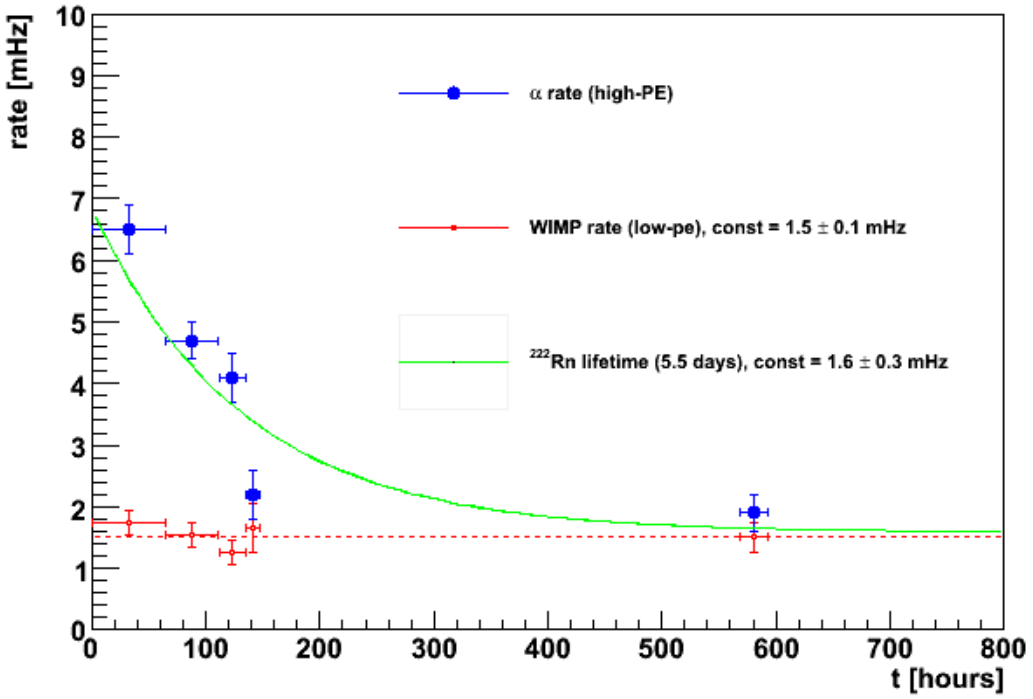
Backgrounds at SNOLAB will allow PSD demonstration to < 1e-9 in ~4 months

DEAP-1 underground data

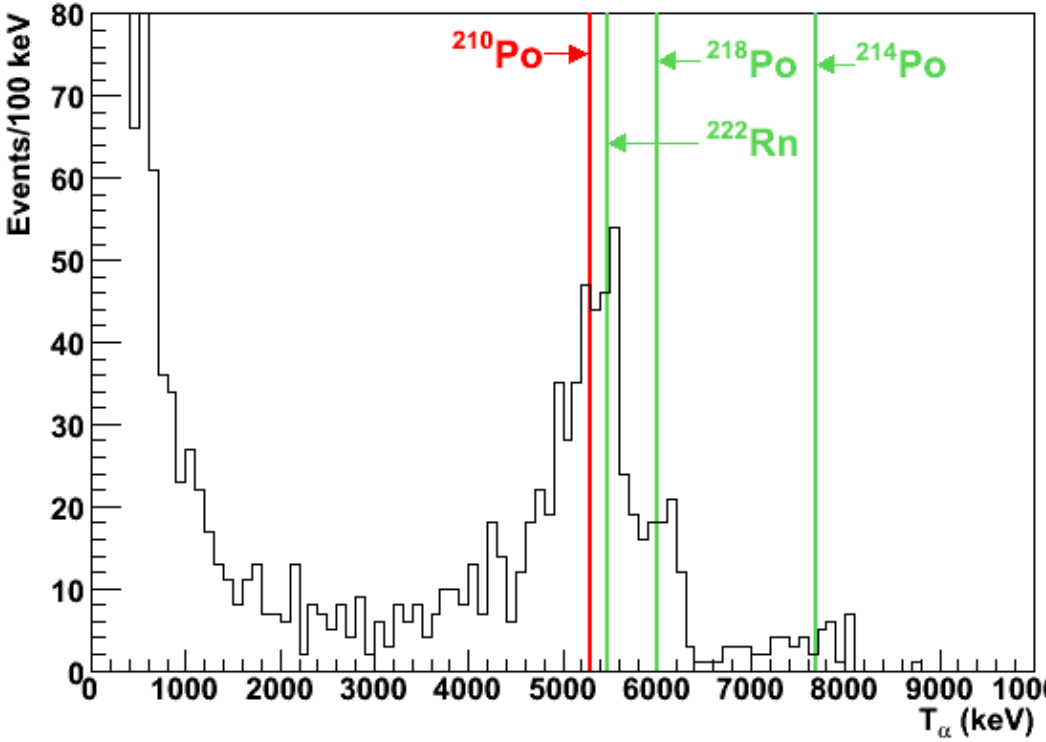


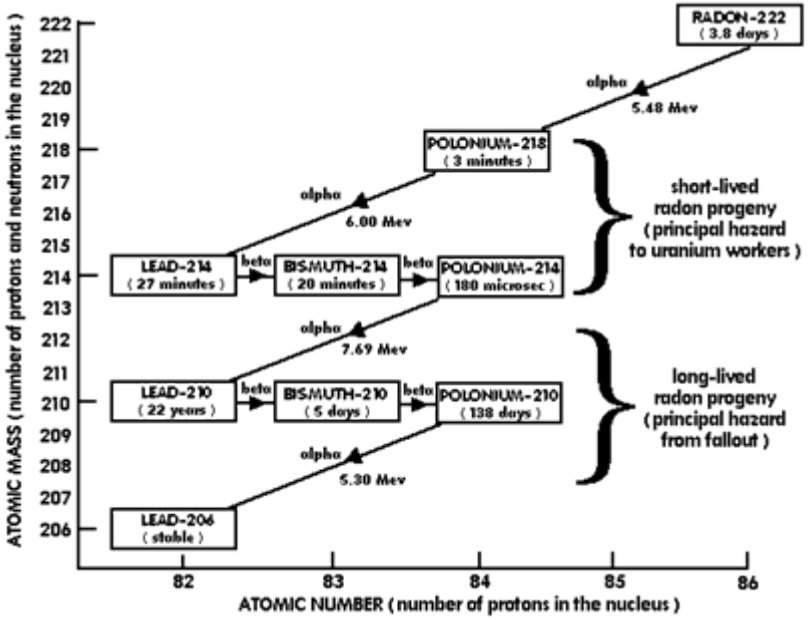
Low-PMT voltage runs to sample high-energy a events

Decay of ^{222}Rn after detector fill



DEAP-1 underground data





Consistent with ^{222}Rn and some embedded ^{210}Po

Need to further reduce contamination

Conclusions and Summary

Experimental goal is background-free dark matter search with sensitivity to SI WIMP-nucleon cross-section of 10^{-46} cm^2

Design for passive shielding and surface contamination removal:
AV+resurfacer, acrylic light guides,8.5 m shield tank

Completing engineering and physics optimization, acrylic bonding tests and other R&D, continued DEAP-1 operation at SNOLAB

Highest ratings from SNOLAB EAC for scientific priority and readiness, allocated space in the SNOLAB cube hall

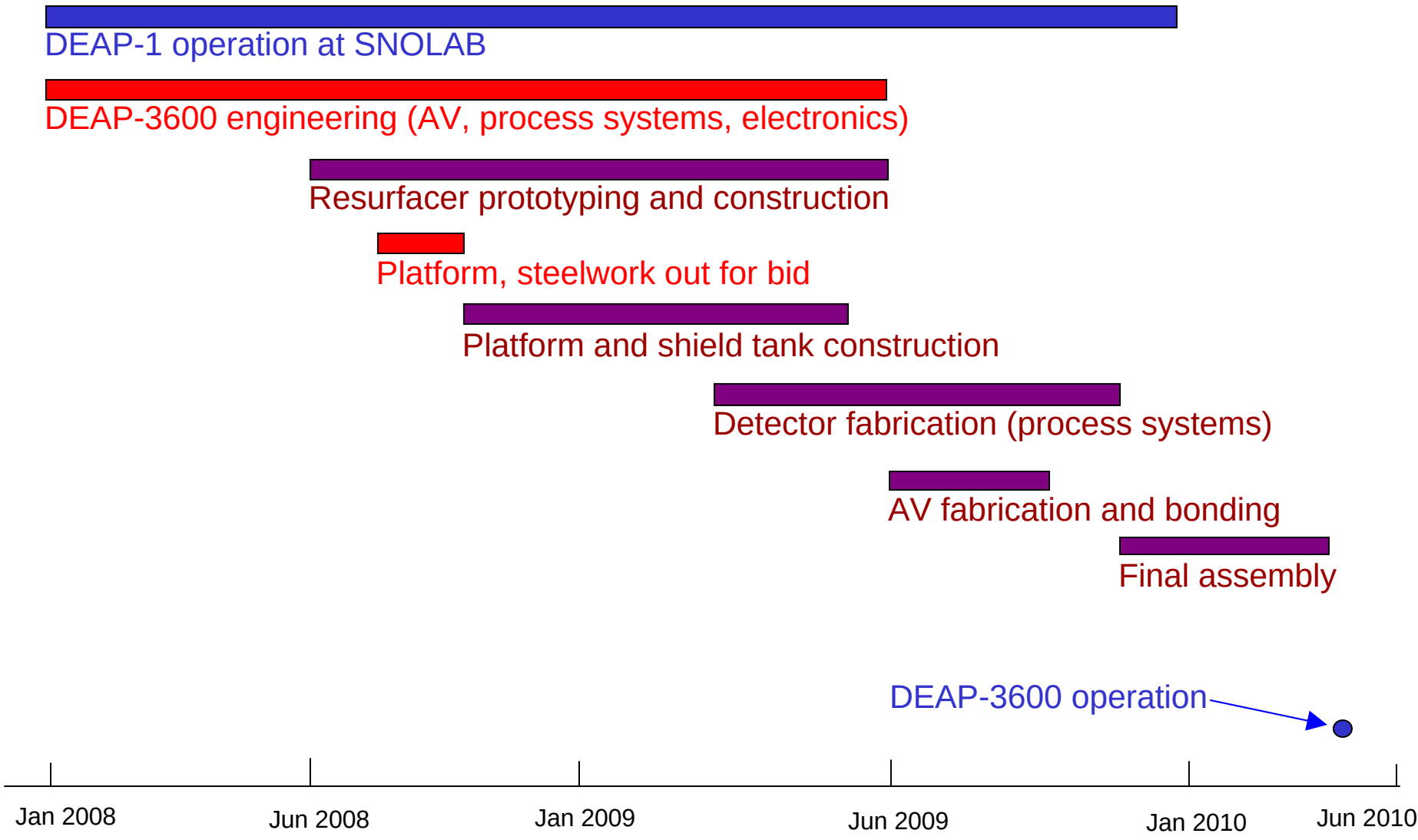
Installation begins 2008, data collection start 2010

Demonstrated $6x10^{-8}$ β/γ rejection, sensitive to 10^{-9} at SNOLAB with 4 months of PSD data (120-240 pe, 40-80 keV_{ee})

DEAP-1 currently limited by surface α-contamination, working to reduce

EXTRA SLIDES

Schedule for DEAP-1 and DEAP/CLEAN-3600 at SNOLAB

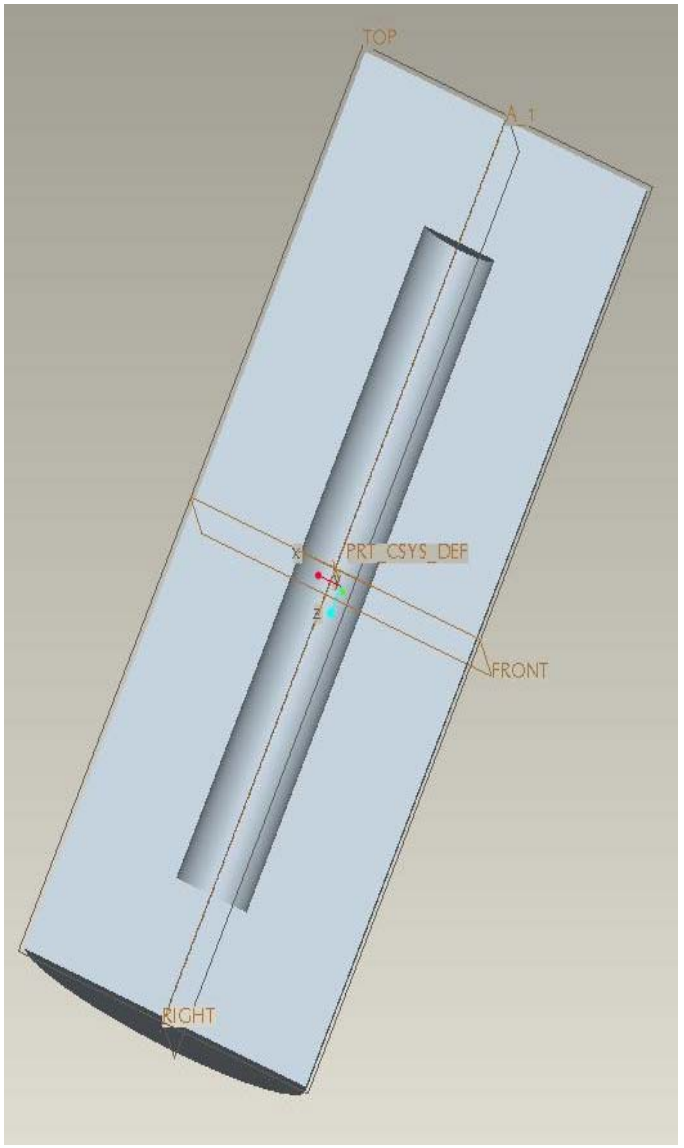


STUDY A: Thermal Stress on Test Cylinder (Queen's)

Boundary conditions:

- Temperature on inner surfaces fixed at -10°C
- Temperature on the outer surface fixed at -195.95°C (LN temp)

- Cut fixed for symmetry
- Points fixed at the top and bottom of structure to minimize constraints



FEA calculation for bond test (Alberta)

STUDY A

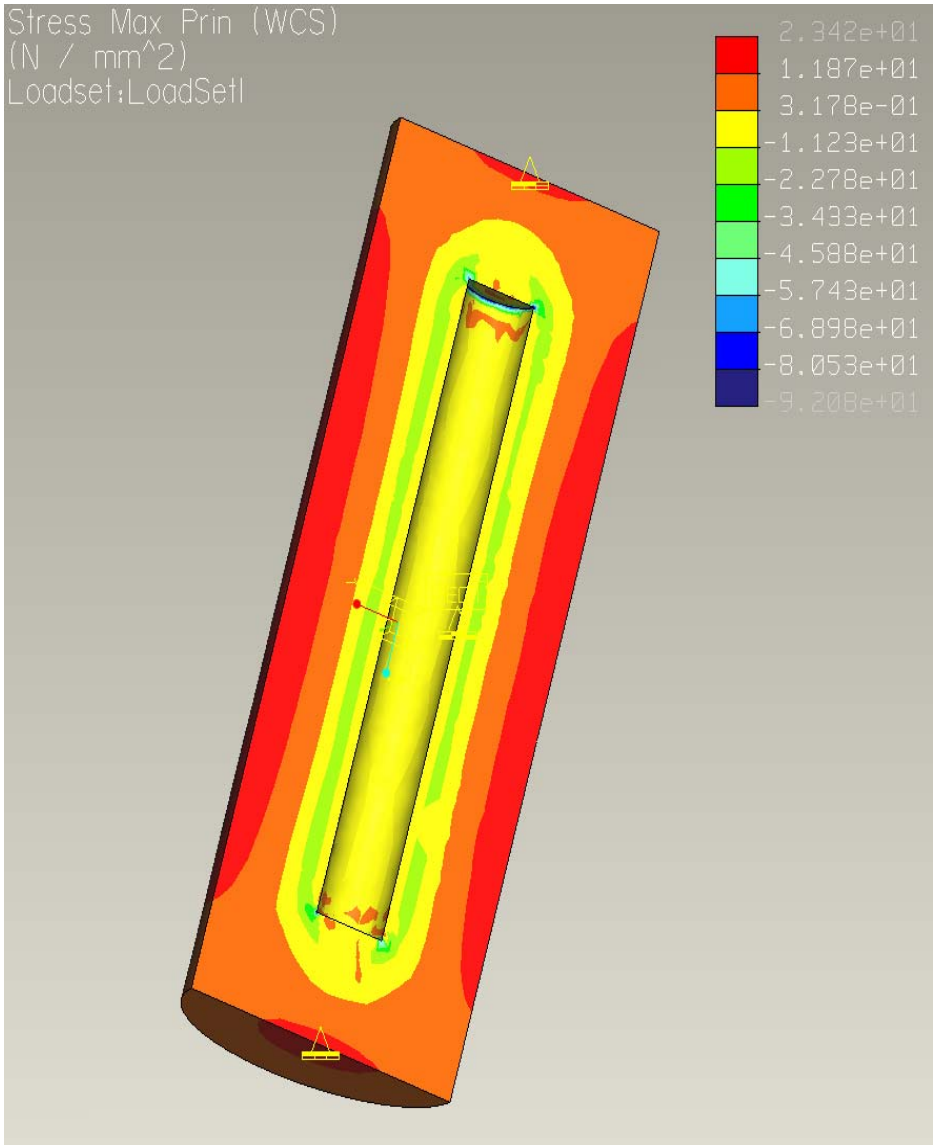
Max Principal Stresses

Max Tensile Stress in Test:
23.42 MPa

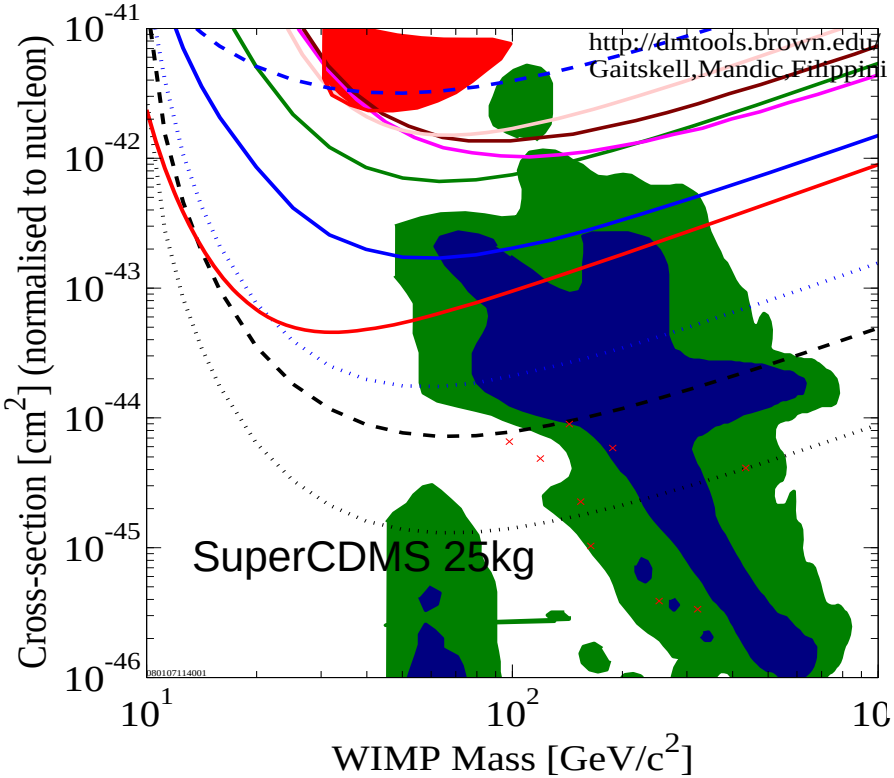
Breaking Strength:
75.8 MPa

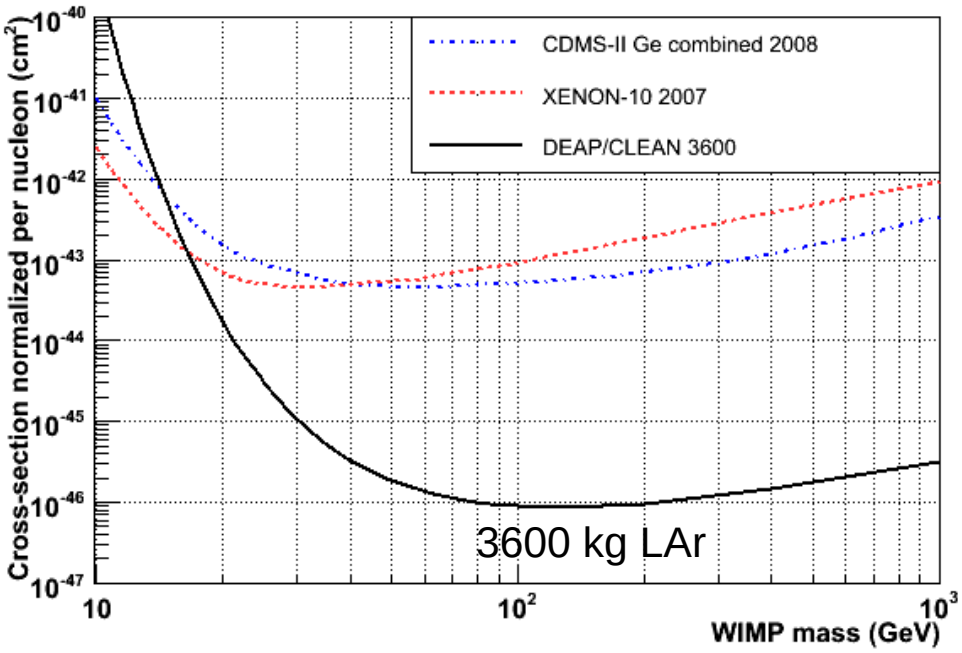
Max Compressive Stress in Test:
92.08 MPa

Allowable Compressive Stress:
137.9 MPa



FEA being used to finalize design
For 3600 Detector Acrylic Vessel





CDMS-II: ~50 kg-days (Ge)
XENON-10: ~300 kg-days (Xe)
DEAP/CLEAN: 1,000,000 kg-days (Ar)

20 keV threshold, without depletion of argon-39.