Status and Prospects of the MiniCLEAN Dark Matter Experiment

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Pulse-Shape Discrimination in LAr

- Noble liquids have singlet and triplet excited states
- For argon and neon, decay times for these states are different and long enough to provide discrimination between electronic and nuclear recoils
- Electronic recoils result in creation of more triplet states so more late light
- Data shows discrimination of $10^{-10}$ achievable, demonstrated $10^{-9}$
Overarching Goals of MiniCLEAN

Technical Proof-of-Principle
We aim to demonstrate all salient features of a $4\pi$ single-phase detector using, interchangeably, targets of LAr and LNe.

Analysis Philosophy
Using our experiences from SNO, SK etc … we aim to develop a robust analysis program where all detector parameters and response to signal and backgrounds are over-constrained through simulation and calibration.

Dark Matter Search
Perform a search for WIMP dark matter with a sensitivity competitive and complementary to next generation experiments with order 100 kg fiducial mass.

Future
MiniCLEAN serves as a prototype to a full-scale (~50T) CLEAN to be located at DUSEL in South Dakota.
Conceptually Simple Detector

- Sphere of argon or neon serves as target for WIMPs
- Scintillation light from recoils at 80-128 nm
- Converted to visible by wavelength shifter on acrylic
- Light guide brings visible light to photomultiplier tube where signal recorded
Conceptually Simple Detector

- Noble Elements scintillate in extreme ultraviolet (EUV)
- Essentially no fast, sensitive, big and cheap photon detectors are directly sensitive to EUV
- Characterizing WLS behavior is very important

<table>
<thead>
<tr>
<th>EUV Light</th>
<th>WLS</th>
<th>Visible Light</th>
<th>Charge</th>
</tr>
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<tbody>
<tr>
<td>Argon/Neon</td>
<td>TPB</td>
<td>Acrylic/Ar/Ne</td>
<td>PMT</td>
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</table>

![Diagram showing the interaction of EUV light with various materials and their corresponding wavelength transmittance graphs.](image)

![Graph showing scintillation probability density and transmittance against wavelength for different substances.](image)
MiniCLEAN Conceptual Design

Not Shown: Magnetic Compensation, Process Systems, Cable Bundles

Tank 18' dia. x 25' tall
47,600 gallons

~1.5m water top & sides
~3.5m water bottom
MiniCLEAN Conceptual Design

Calibration Port

Optical Module

Outer Vessel

Inner Vessel

Stand

LAr/LNe

163 cm
Inner Vessel

• Inner Vessel is being machined at Winchester Precision Technologies in Winchester, NH
Optical Cassettes

- Fabricating prototype parts
- Dedicated test setup to benchmark simulations and perform engineering tests
Simulations and Backgrounds

- Particular attention to backgrounds from:
  - $^{39}$Ar in argon target (Pulse shape discrimination)
  - Fast neutrons from PMT glass (Shielding, tagging)
  - Radon plate-out on WLS surface (Assembly, tagging)
- Full detector simulation in RAT
- Model of signals and background in multiple variables
Calibrations

- Calibration program designed to completely verify a positive signal in the same detector using enriched argon and neon targets.
The DEAP and CLEAN Family of Detectors

DEAP-0:
Initial R&D detector

DEAP-1:
7 kg LAr
2 warm PMTs
At SNOLab 2008

DEAP-3600:
3600 kg LAr (1000 kg fiducial mass)
255 warm PMTs
At SNOLAB mid-2013

picoCLEAN:
Initial R&D detector

microCLEAN:
4 kg LAr or LNe
2 cold PMTs
surface tests at Yale

MiniCLEAN:
500 kg LAr or LNe (150 kg fiducial mass)
92 cold PMTs
At SNOLAB mid-2012

50-tonne LNe/LAr Detector:
pp-solar ν, supernova ν, dark matter <10^{-46} cm^2
At DUSEL or SNOLAB ~2017?
MiniCLEAN Sensitivity

![Graph showing WIMP-nucleon cross section vs. WIMP mass for various experiments.]

- Events / 10 kg / yr
- Events / 100 kg / yr
- Events / 1000 kg / yr
MiniCLEAN Schedule

- Assembly begins in September (IV ready in December)
- Commissioning starts July 2012
- First liquid argon run starts by end of 2012
Longer Term Plans

- Single-phase detectors are easily scaleable to larger sizes
- CLEAN detector would be 10-50 tons capable of argon and neon target
- Allows for both a dark matter search and precision measurement of pp solar neutrinos
- Build on experience with MiniCLEAN and DEAP-3600
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Questions?

MiniCLEAN Shield Tank
Courtesy F. Duncan