First results from the DEAP-3600 Experiment

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Outline

• Dark Matter
  • Direct Detection
• DEAP-1 prototype
  • DM detection in LAr
• DEAP-3600 detector
  • First Results
• Future DEAP-50T
  • Projected results

DEAP-3600 without steel casing [1]
Dark Matter

• Dark Matter constitutes **26.8%** of total universe
• Candidates:
  • Weakly Interacting Massive Particles
  • Axions
  • Sterile Neutrinos
  • And more!

![Pie chart showing the composition of the universe: 68.3% Dark Energy, 26.8% Dark Matter, 4.9% Visible Matter.](chart.png)
Dark Matter Direct Detection

• Direct Detection - elastic scattering on nuclei
  • Produces **Nuclear Recoil** (NR) O(10) keV
  • Detect recoil -> Directly detect Dark Matter!

- X → Nuclear Recoil (NR) → N
- Time
DEAP-1 Prototype

Dark Matter Experiment using Argon Pulse-shape discrimination

- 7kg Liquid Argon
  - Scintillator
- 2km Underground
- Purpose:
  - LAr Techniques
  - Backgrounds
DM Detection in LAr

- Biggest background
  - e\textsuperscript{-} recoil in \(\nu\) scattering

- Pulse Shape Discrimination

\[
F_{\text{prompt}} = \frac{\sum_{t_i \in (-28\text{ns},150\text{ns})} Q_i}{\sum_{t_i \in (-28\text{ns},10\mu\text{s})} Q_i}
\]

[2]
DM detection in LAr

• Americium Beryllium (AmBe) Source
  • Electronic + Nuclear

• 0.0 – 0.6 – Electronic
• 0.6 – 0.9 – Nuclear

• DEAP-1 conclusions
  • $e^-$ suppressed
  • Use $F_{\text{prompt}}$ for DM

[2]
DEAP-3600 Detector

- 3600kg Liquid Argon
  - First LAr > 1 tonne
- Acrylic Cryostat
  - LAr cryogenic
  - PMTs room temp
- Submerged in water
  - External $\mu$ veto
DEAP-3600 Calibration

- Region Of Interest
- Limits on #PE
  - Band crossing
  - Surface impurities
- Limits on $F_{\text{prompt}}$
  - 90% NR events

AmBe source
DEAP-3600 First Results

• Published 1st Aug 2017

• Data taken during filling
  • 4.44 Live days
  • 9.87 tonne days

• No events in ROI

• Leakage < 1.2 x 10^{-7}
  • Fraction of e^- in ROI
  • 10^4 stronger than Xe
DEAP-3600 First Results

Cross section $< 1.2 \times 10^{-44} \text{ cm}^2$ for 100 GeV WIMP (90% CL)

Leading Limit in LAr

[3]
Future - DEAP-50T

- Water Shield, 44ft diameter
- Steel Cryostat
- Acrylic Shielding
- 4400 PMTs
- Acrylic Vessel, 17ft diameter

- Single phase LAr
- Easily scaled up
- Large masses
- More exposure
- Impurities suppressed
- High cost
Future - DEAP-50T Projections

- Neutrino floor
  - Strong PSD in LAr
  - Low sensitivity to solar $\nu$
  - Neutrino floor lower

- Theoretical 100GeV limit
  - $\text{Xe} \sim 10^{-47} \text{ cm}^2$
  - $\text{Ar} \sim 10^{-48} \text{ cm}^2$

- No spin dependency
Summary

- DEAP-1 Prototype
  - Detection with LAr – **Pulse shape discrimination**

- DEAP-3600 detector
  - Design – First **>1 tonne** LAr detector
  - Cross section <\(1.2 \times 10^{-44} \text{ cm}^2\) for 100 GeV WIMP

- Future DEAP-50T
  - Projected cross section limit \(~ 10^{-48} \text{ cm}^2\)
Thank You
References


