TREX-DM
A search for low-mass WIMPS with mM

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Outline

What, Why and How .. Is TREX-DM
Past and current challenges
Prospects
TREX-DM

- Detector looking for low-mass WIMPs
- HP (up to 10 bar), symmetrical gas TPC
  - Active volume of 20L @ 10bar
    (~0.32 kg Ar or ~0.16 kg Ne)
- Shielding
  - 5cm copper + 20cm lead walls
  - Polyethylene ceiling + water
- Located at Laboratorio Subterráneo de Canfranc (LSC) (2400 m.w.e.)
Purpose and motivation

- Community interest shifted to low masses (< 10 GeV/c^2)

- Requisites:
  - Light nuclei as target
  - Very low energy threshold (< 1 keVee)
  - Low background level

1 event/kg/day
1 event/tonne/year
Why Gas TPC?

T-REX: merge MPGD-read TPC + low background techniques

TPCs for Rare-Event searches
- Target selection flexibility
- Low energy threshold
- Highly segmented readouts available
- Access to rich topological information

Micromegas
- Consolidated structures
- Microbulk flavour particularly interesting
  - Low intrinsic radioactivity
  - Good energy resolution
  - Low energy threshold
  - Topological information
  - Scaling-up

11th TPC Symposium  Theopisti Dafni  Paris, December 2023
Equipping TREX-DM with microbulk mM

- Biggest microbulk surface built
- Radioactivity Control in process
- Energy resolution
- Segmentation 512 channels: 256 X strips, 256 Y strips

Building TREX-DM with the new mM
What can TREX-DM do?

- Probe uncharted area
- Offer a new technology
- Change target
Data-taking at 4 bar, sealed mode
Connectivity issues with mM
Background level 2 orders higher than expected
\(^{222}\text{Rn}\) Contamination, reduced to 1 order

2018: Installation at LSC

2019-2021: Data taking with Ar & Ne

June 2022: New Micromegas

July 2023: Commissioning @LAB2500

Sep 2022-July 2023: Relocation tasks

Aug 2023 – present: Data-taking for comparison

Some issues came up

Site preparation (electrical, gas, crane, …)
Chamber transportation and installation
Lead shielding assembling
DAQ & SlowControl re-commissioning
Leak tests, High Voltage tests

…
So, currently...

<table>
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(dru = keV$^{-1}$ kg$^{-1}$ day$^{-1}$)
How can it be improved?

- Main Challenges to be addressed
  - Energy threshold
  - Background level
  - Gas composition
  - Operation stability
How can it be improved? (I)

- Main Challenges to be addressed
  - **Energy threshold**
    - preamplification volume (with a GEM?) factors would allow very low energy threshold (even single electron)
      - Big microbulk mM @1bar (x100)
      - Small microbulk mM @1-10bar (x100 to x10)

publication in preparation
How can it be improved? (Ib)

• Main Challenges to be addressed
  o Energy threshold
    • preamplification volume (with a GEM?)
      factors would allow very low energy threshold
      (even single electron)
      o Big microbulk mM @1bar (x100)
      o Small microbulk mM @1-10bar
        (x100 to x10)
    • Low-energy calibrations
      o $^{37}\text{Ar}$ (2.82 keV, 0.27 keV )
        • Used in XENON1T and NEWS-G

In a small setup @Saclay
How can it be improved? (Ic)

- Main Challenges to be addressed
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    - Preamplification volume (with a GEM?) factors would allow very low energy threshold (even single electron)
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  o **Background level**
    • Initially dominated by $^{222}$Rn, attributed to the purifiers
    • Switched from sealed mode to open loop:
      o 600dru to 100dru (dru = keV$^{-1}$ kg$^{-1}$ day$^{-1}$)
    • June 2022-now:
      o $^{222}$Rn progeny contamination on mylar cathode surface
      o Changing to a cleaner cathode estimate: 1-10dru

$^{222}$Rn
(3.82 d)

$^{218}$Po
(3.1 min)

$^{214}$Pb
(26.8 min)

$^{214}$Bi
(19.9 min)

$^{214}$Po
(1.64 × 10$^{4}$)

$^{210}$Pb
(22.3 y)

$^{210}$Bi
(5.01 d)

$^{210}$Po
(138 d)

$^{206}$Pb
(stable)
How can it be improved? (IIb)

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    - AlphaCAMM:
      - screening α surface contamination
      - Goal sensitivity: 100nBq/cm$^2$
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Exposure 0.32 kg y
How can it be improved? (III)

- Main Challenges to be addressed
  - Energy threshold
  - Background level
  - **Gas composition improvement**
    - Target change (Ne, Ar depleted)
    - Increasing presence of H
How can it be improved? (IIIb)

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<td>C   50</td>
<td>1</td>
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Exposure 0.32 kg y
How can it be improved? (IV)

- Main Challenges to be addressed
  - Background level
  - Energy threshold
  - Gas composition improvement
  - **Operation stability**
    - Gas quality
    - Noise
    - Voltage operations
    - Leak currents at detector connections
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<tr>
<td>D 50</td>
<td>0.1</td>
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Exposure 0.32 kg y

Exposure 1.6 kg y
Conclusions

- TREX-DM offers a technology that can be very sensitive to low-mass WIMPs
- Continuous R&D gives birth to ‘spin-off’ projects of great interest
- Despite the delay due to the relocation, TREX-DM continues data taking / near term roadmap towards competitive background level & threshold
TREX-DM

• Relevant publications:

  • Gaseous time projection chambers for rare event detection: Results from the T-REX project. II. Dark matter. *JCAP 01 (2016) 034*. Err: *JCAP 05(2016) E01*
  • Assessment of material radiopurity for Rare Event experiments using Micromegas. *JINST 8 (2013) C11012*
  • Radiopurity of Micromegas readout planes. *Astrop. Phys. 34 (2011) 354-359*
  • Development and performance of Microbulk Micromegas detectors, *2010 JINST 5 P02001*
  • Readout technologies for directional WIMP Dark Matter detection. *Phys. Rept. 662 (2016) 1-46*
  • Microbulk Micromegas in non-flammable mixtures of argon and neon at high pressure, *2022 JINST 17 P07032*
  • AlphaCAMM, a Micromegas-based camera for high-sensitivity screening of alpha surface contamination, *2022 JINST 17 P08035*