Heavy Dark Matter Search in XENON1T

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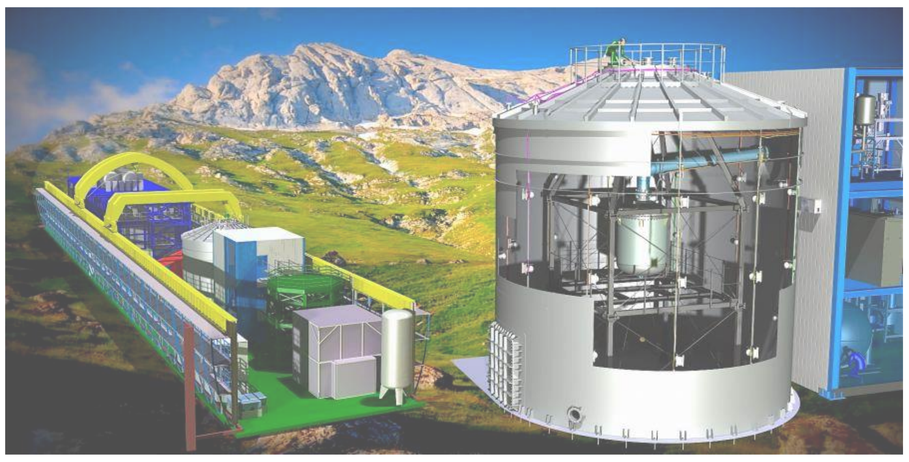
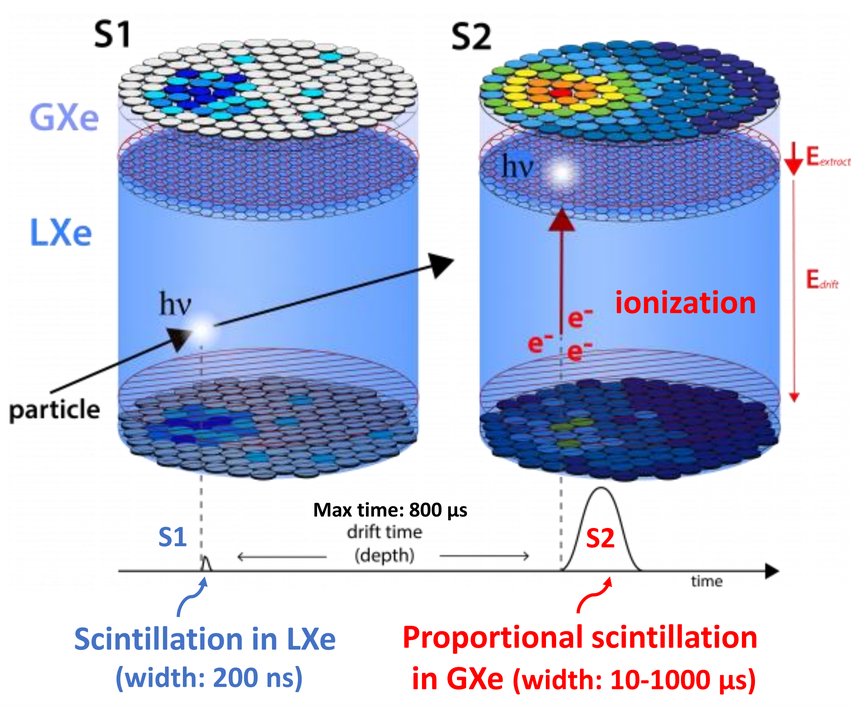
on behalf of the XENON collaboration

XENON1T experiment and WIMP search



XENON1T use a dual phase time projection chamber (TPC) filled with 3.2 tonne of ultra-pure liquid xenon (LXe) located at INFN Laboratori Nazionali del Gran Sasso under 3600 m water-equivalent overburden.



Primary science goal:
Search for *single scattering* signal from Weakly Interacting Massive Particles (WIMPs)

Prompt and delayed pairing:
S1 (scintillation) + S2 (ionization)

3D position information and nuclear recoil (NR) vs. electronic recoil (ER) **discrimination** with S2/S1

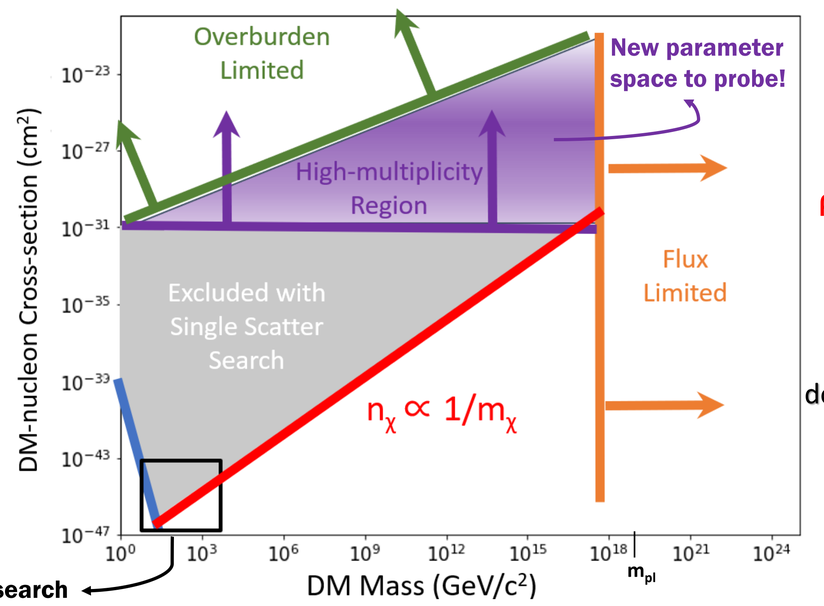
XENON1T WIMP result excluded **spin-independent elastic scatter** cross-section of **4.1×10^{-47} cm²** at 30 GeV/c² and 90% C.L.

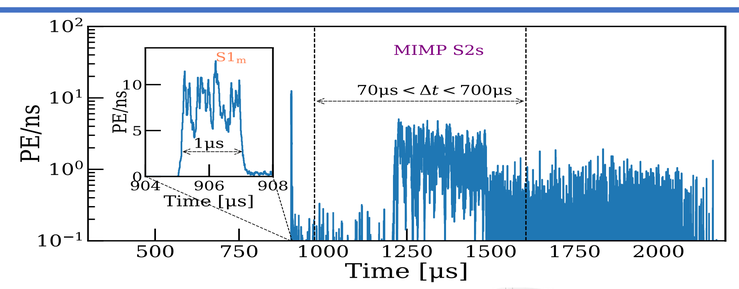
Extend dark matter search to Planck mass

Motivation: search for dark matter with a high mass up to the Planck scale.

Theories: Mechanisms like non-standard thermal freeze-out, thermal freeze-in, first-order phase transitions, and decays of heavy fields can form dark matter with a mass beyond the unitary bound.

Direct Production: too heavy to be produced at LHC.



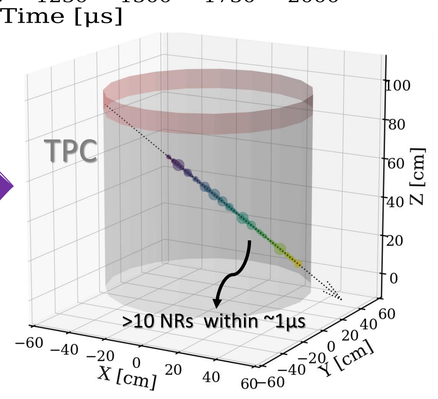


$\rho_\chi \approx 0.3$ GeV/c² cm⁻³

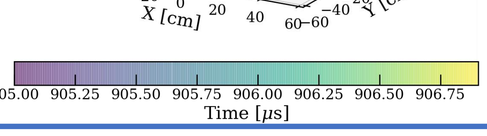
Total flux limit (1/m² · year)

Multiple-scatters dominate the high mass DM signal

DM tracks



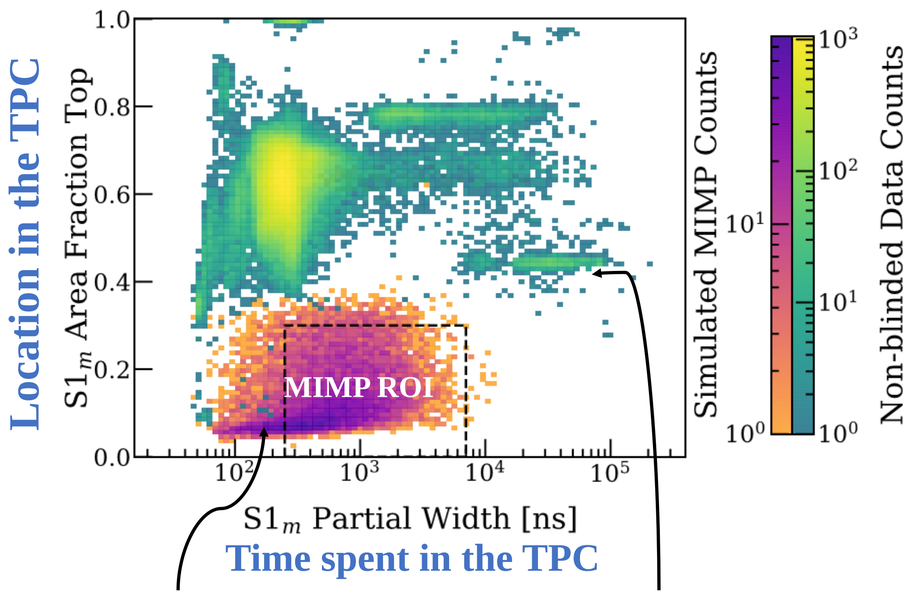
Less constraint from **overburden** due to higher momentum



Multiply Interacting Massive Particles **(MIMPs):**

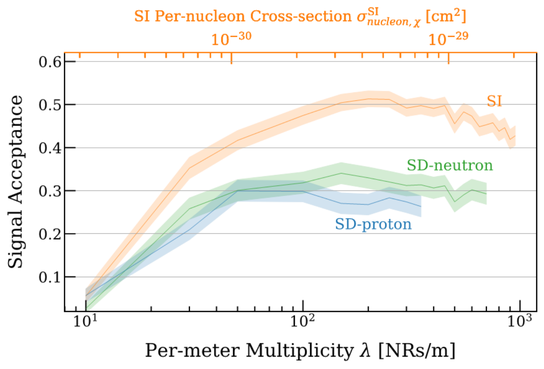
- *Multiple scattering* NRs due to high cross-section (SI DM-nucleon $\sigma > 10^{-31}$ cm²)
- For a $m_\chi > 10^{12}$GeV:
  - Co-linear track
  - Negligible energy loss
  - A^2 enhancement from kinematic μ_A^2/μ_N^2
- Energy transfer is still small (i.e., $kr_A \ll 1$)
  - Mainly s-wave scatter
  - A^2 enhancement from coherence

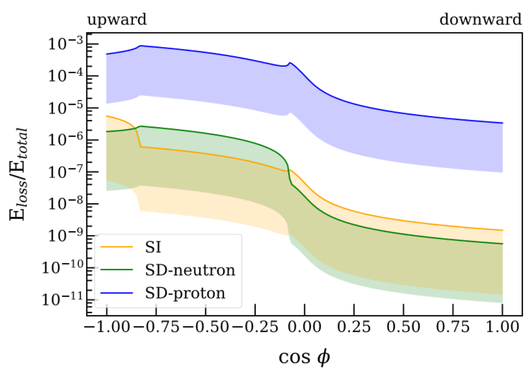
MIMP Search in XENON1T



Backgrounds: BiPo decay chain, detector artifacts, muons (99.5% veto)

MIMP signal: clustered S1s (**$S1_m$**) with a time scale around **1μs.**



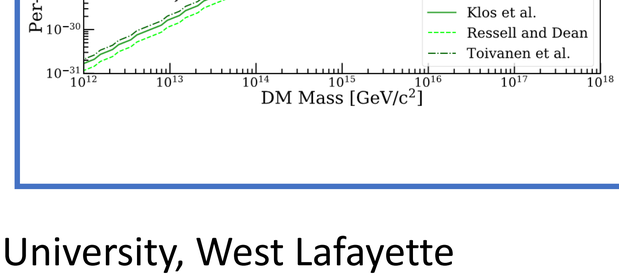


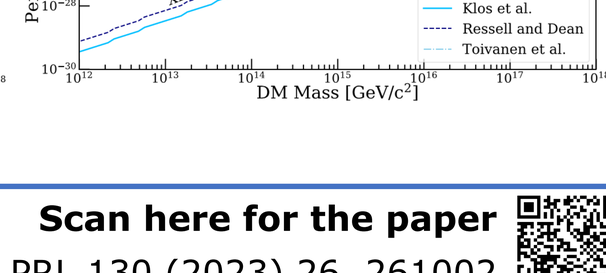
- Signal acceptance from Monte Carlo simulation.
- Both spin-independent (SI) and spin-dependent (SD) interactions simulated.
- Overburden effect modeled for MIMPs traveling through the Earth before reaching the TPC.
- Energy loss is less than 0.1% for the parameters space considered.

New SI and SD limits near Planck mass

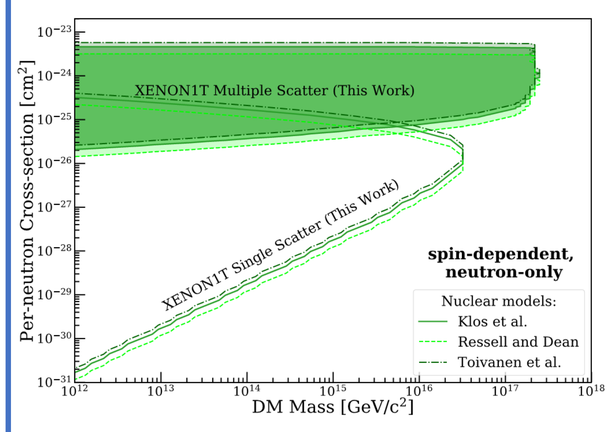
In the 188.7 m²×day of unblinded data, no MIMP candidates were found.

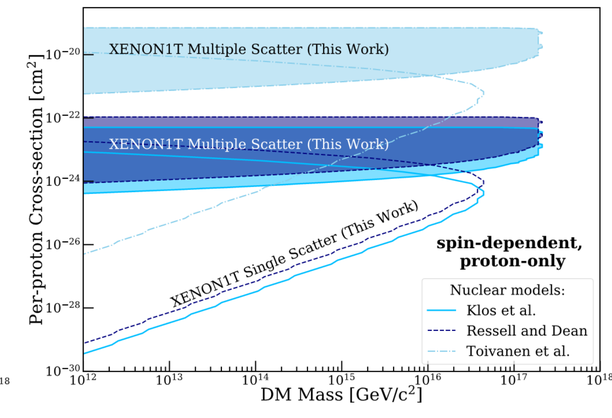
Spin-independent: $$\frac{d\sigma^{SI}_{A,\chi}}{dq^2} = \frac{\mu^2_{A,\chi}}{\mu^2_{nucleon,\chi}} A^2 |F_A(q)|^2 \sigma^{SI}_{nucleon,\chi}$$ (A⁴)





Spin-dependent: $$\frac{d\sigma^{SD}_{A,\chi}}{dq^2} = \frac{4}{3}\frac{\pi}{2J+1}\frac{\mu^2_{A,\chi}}{\mu^2_{n/p,\chi}} S_A^{a_0=1,a_1=\mp1}(q)\sigma^{SD}_{n/p,\chi}$$
(from ^{131}Xe and ^{129}Xe)





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Scan here for the paper
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