Searching for Planck-mass dark matter in direct detection experiments

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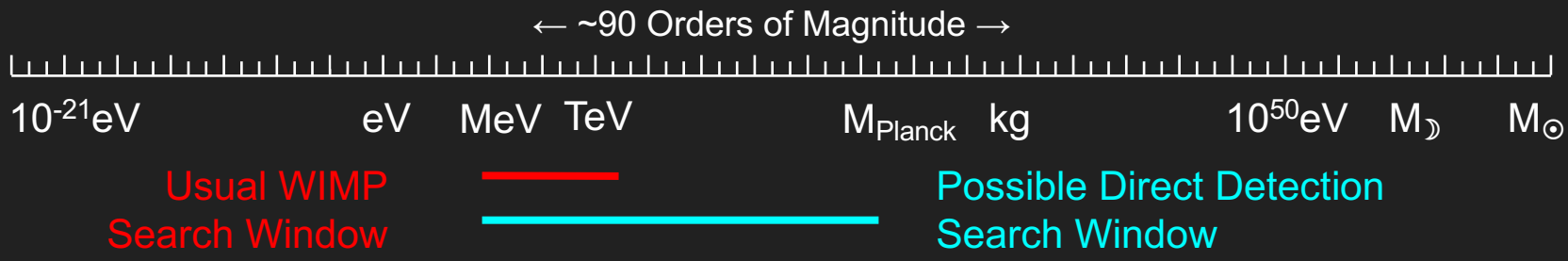
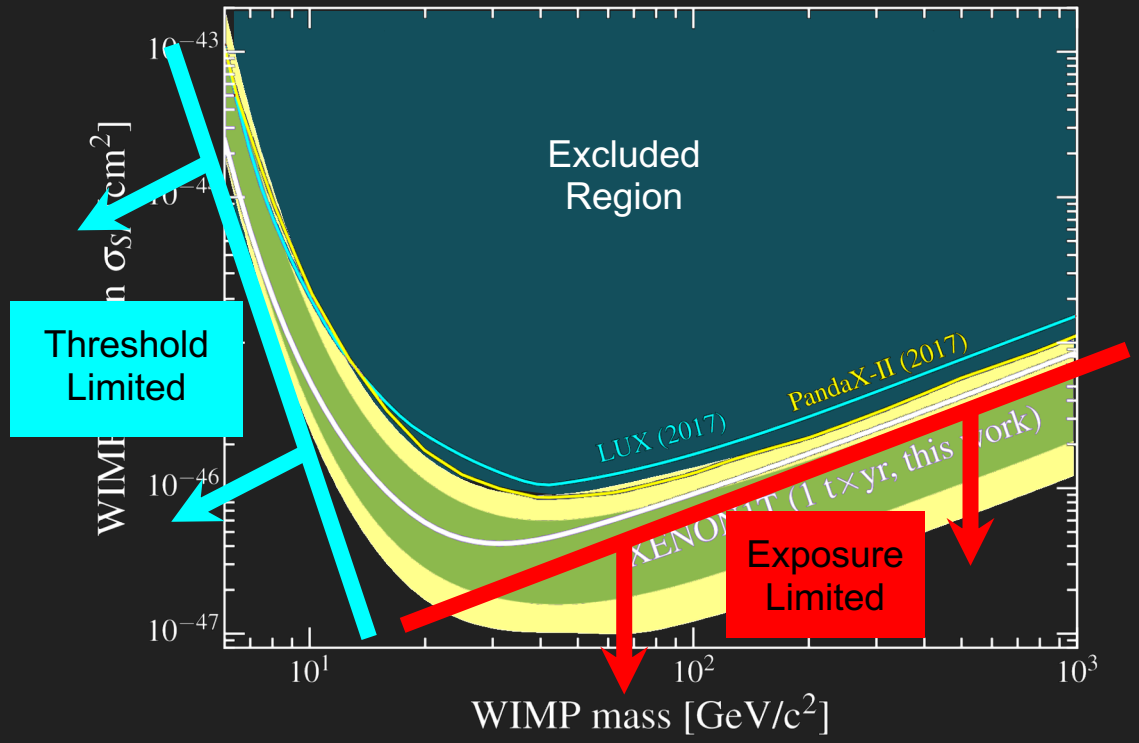
Motivation

Local DM ρ = 0.3 GeV/cm^3



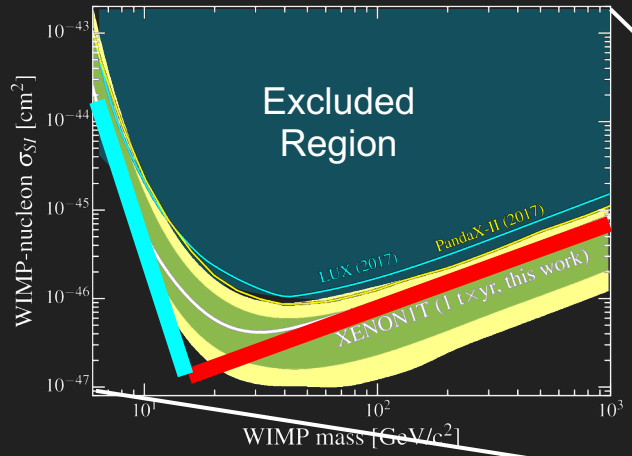
- WIMPs: abundant, but interact rarely (single-scatter nuclear recoils)
- WIMPzillas, composite DMs, PBHs, Q-balls…
- Multiply Interacting Massive Particles (**MIMPs**): sparse, but interact frequently, even multiple times as they pass through the DM detector
- At high DM mass: $\sin\theta = m_N/m_\chi \approx 0$, $E_{loss} \ll \frac{1}{2} m_\chi v^2$

The Usual WIMP Space

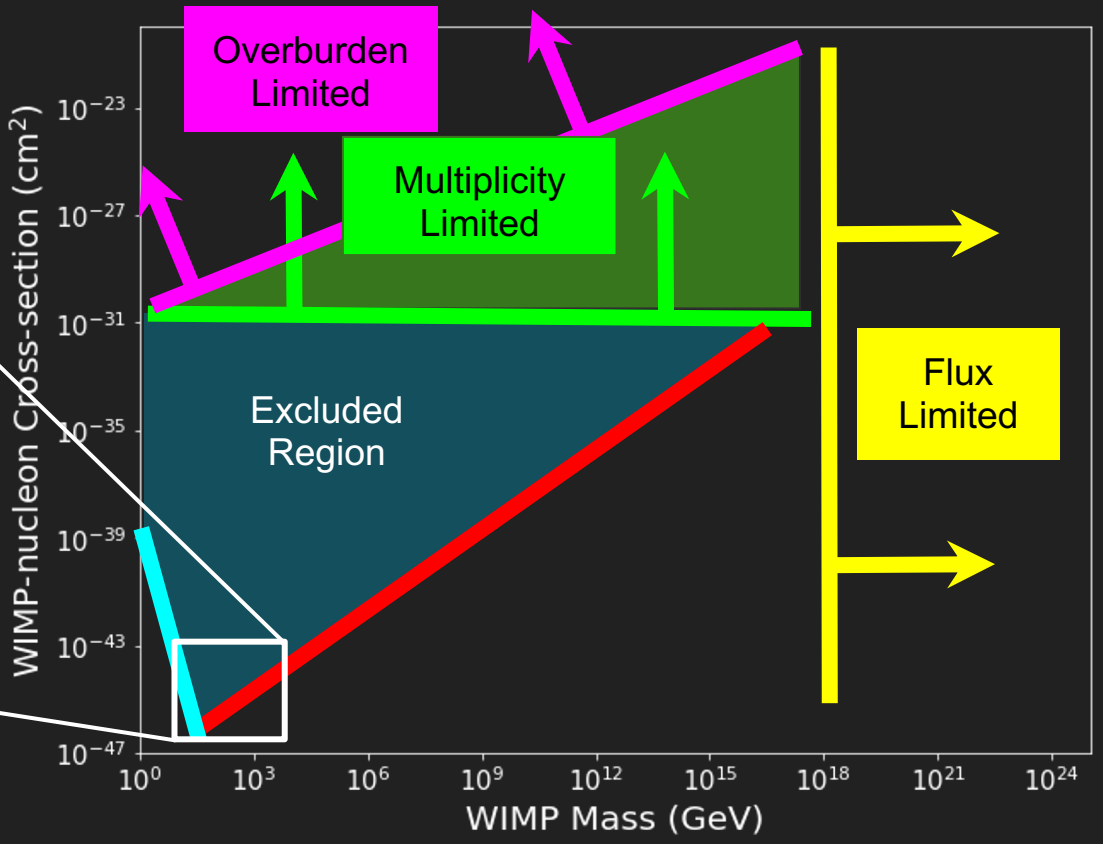


XENON, (2019)
1805.12962

A Wider Picture

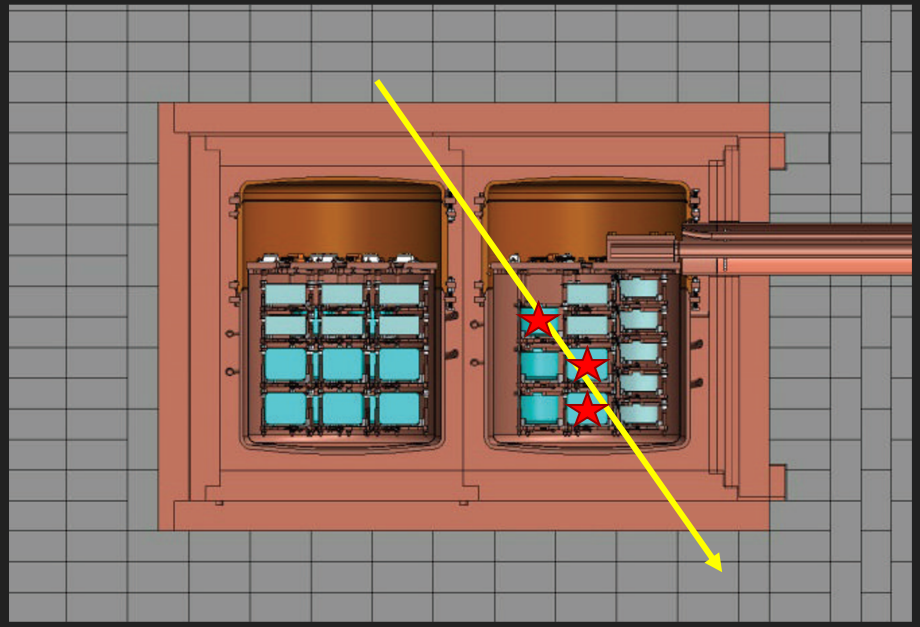


Bramante et al.,(2018)
1803.08044



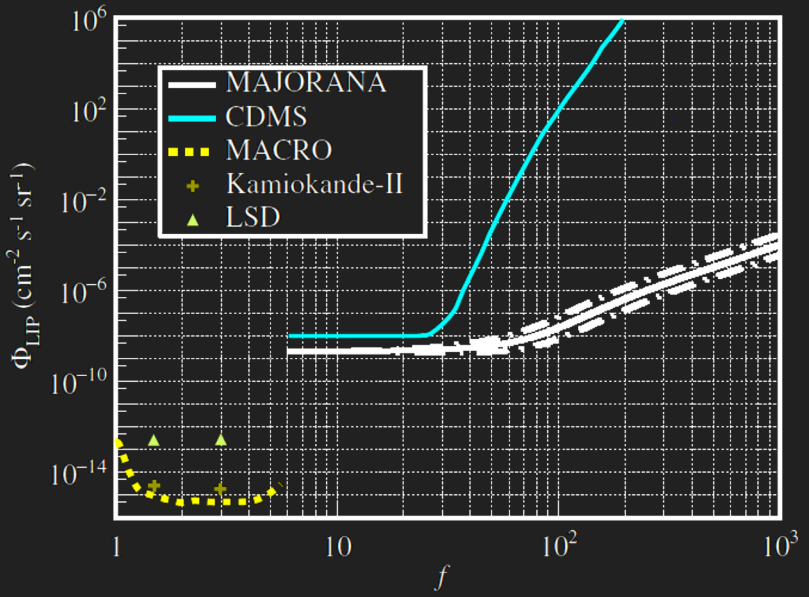
XENON, (2019)
1805.12962

Lightly Ionizing Particle limits from MAJORANA



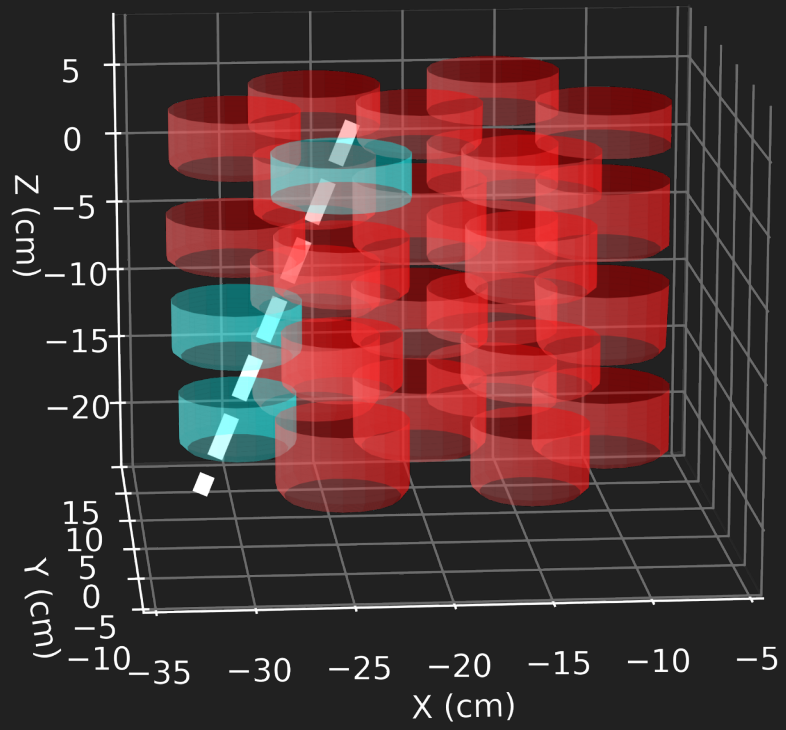
MAJORANA, (2014)
1412.5682

Zero candidate events found with
a detector coincidence of N=4-6



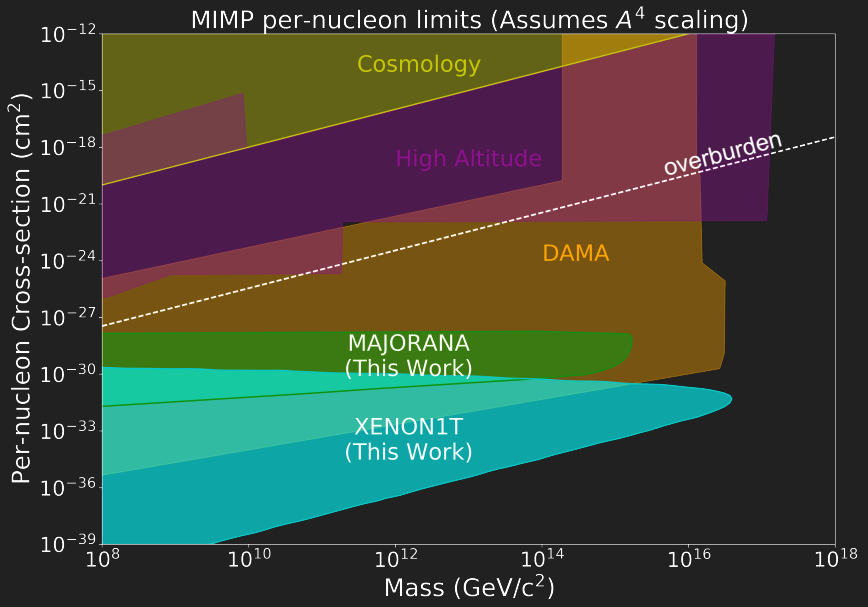
MAJORANA, (2018)
1801.10145

MIMPrate Simulation in MAJORANA

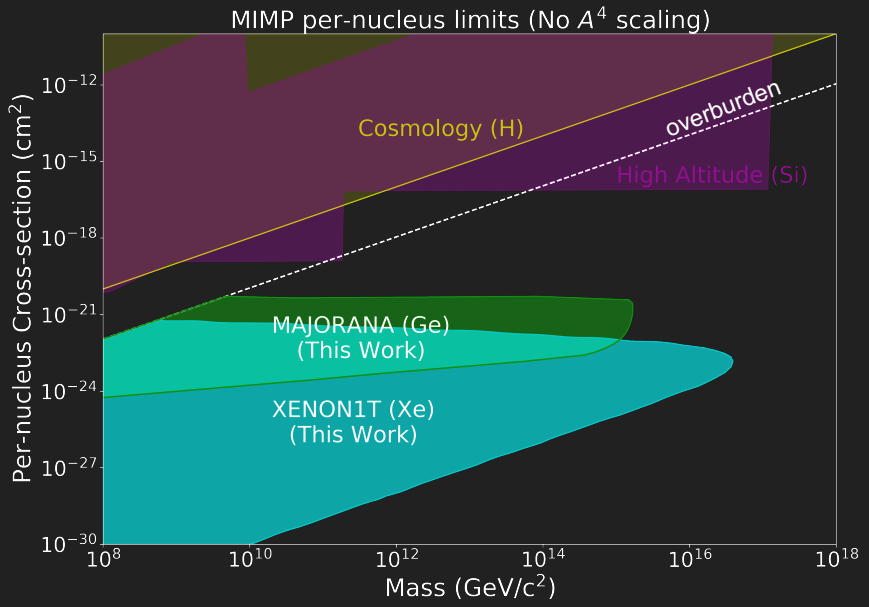


Clark, Li, et al. (2020)
2009.07909

Calculated limits from MIMPrate



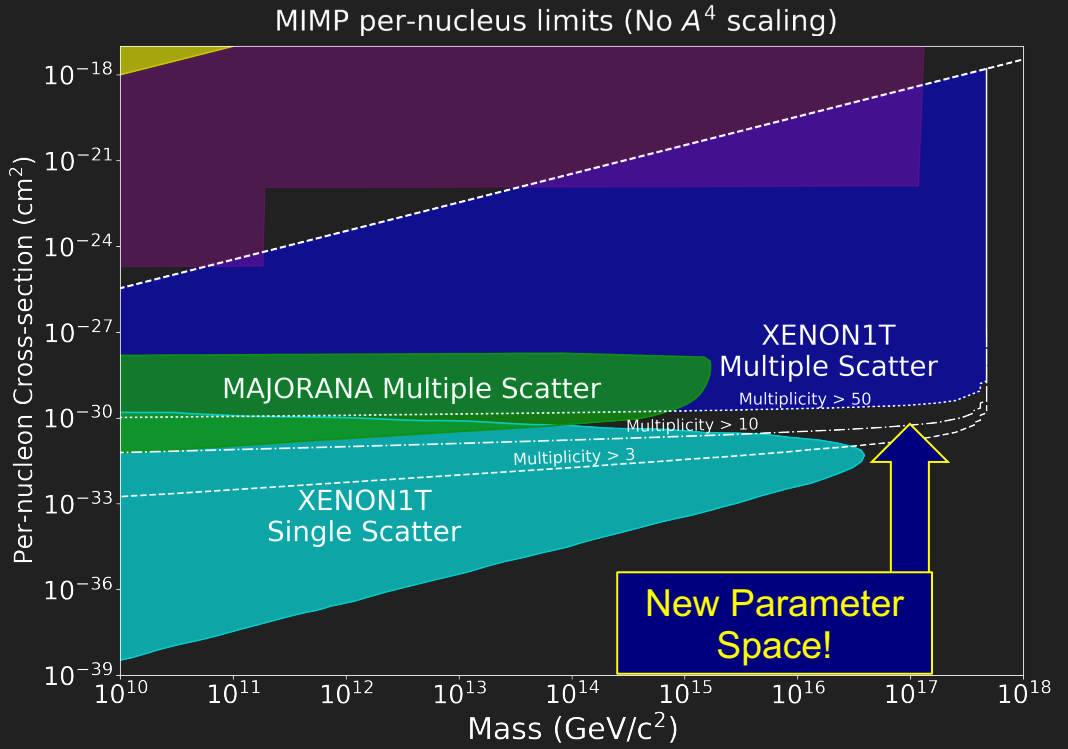
Clark, Li, et al. (2020)
2009.07909



Digman, et al. (2019)
1907.10618

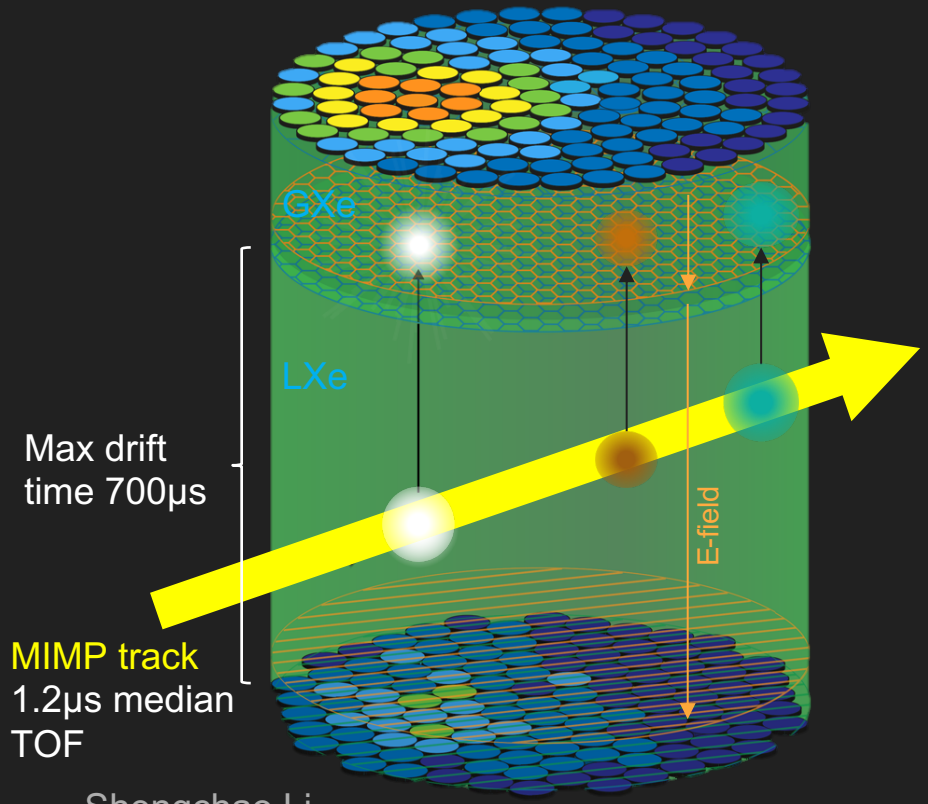
Sensitivity of a MIMP Analysis in XENON1T

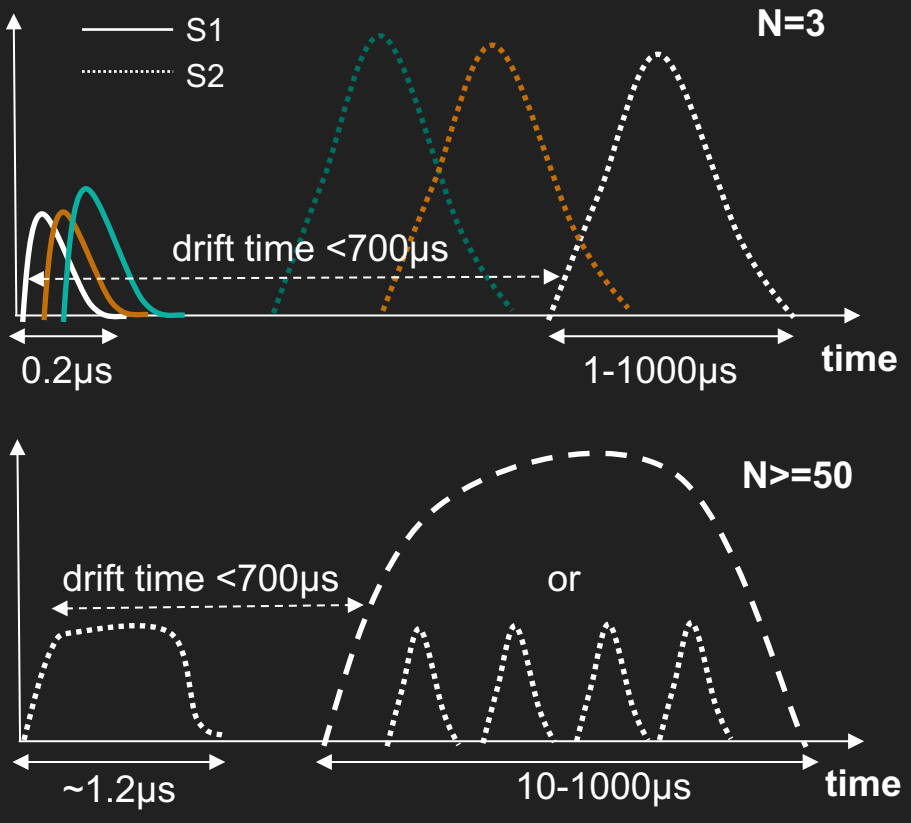
XENON1T could explore additional parameter space by looking for events with higher multiplicity (>50)



Clark, Li, et al. (2020)
2009.07909

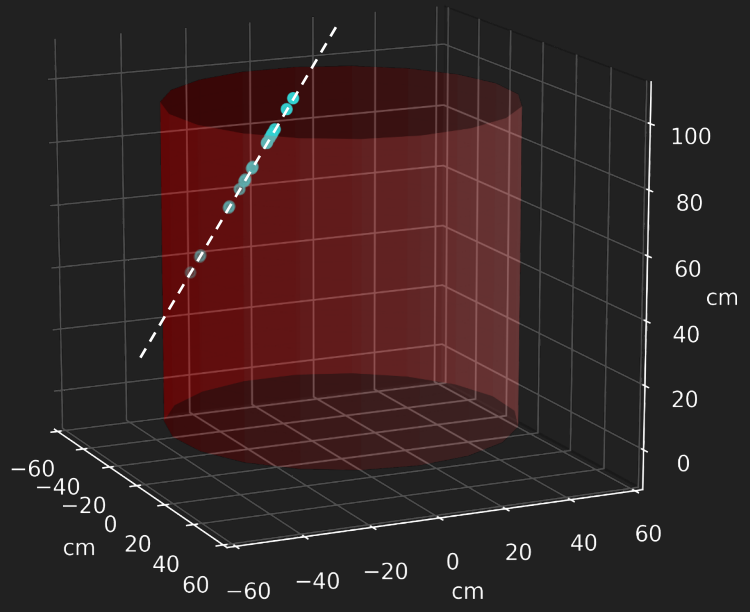
High Multiplicity MIMP in XENON1T



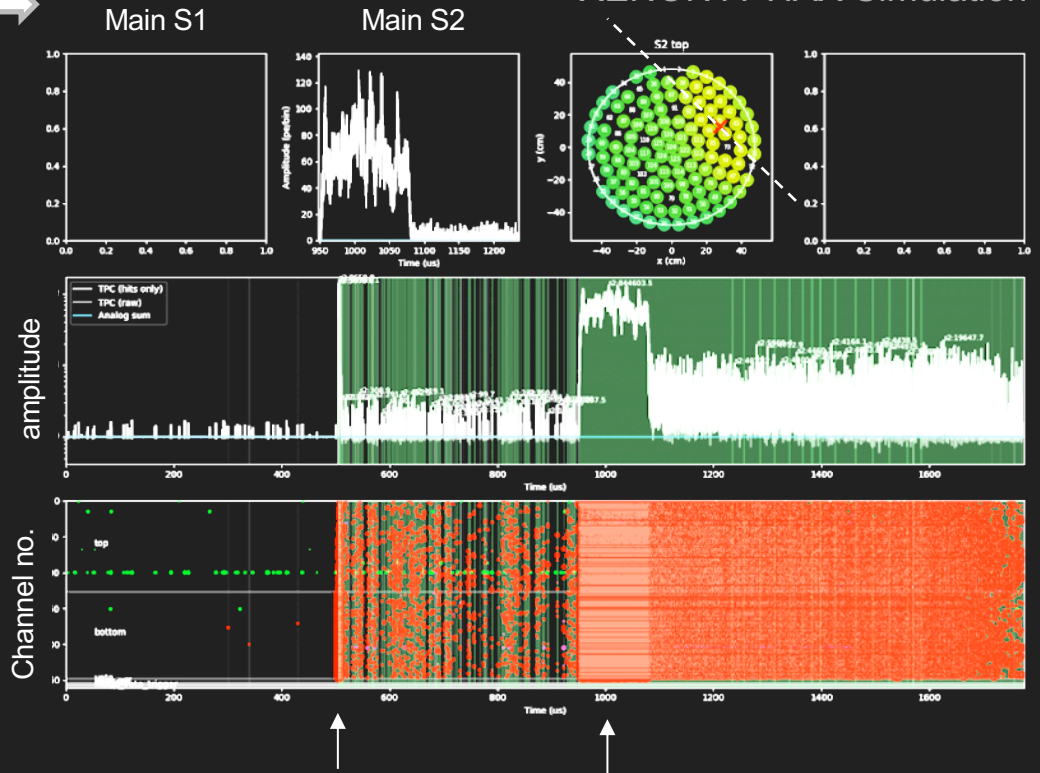


Complete Simulation of MIMP in XENON1T

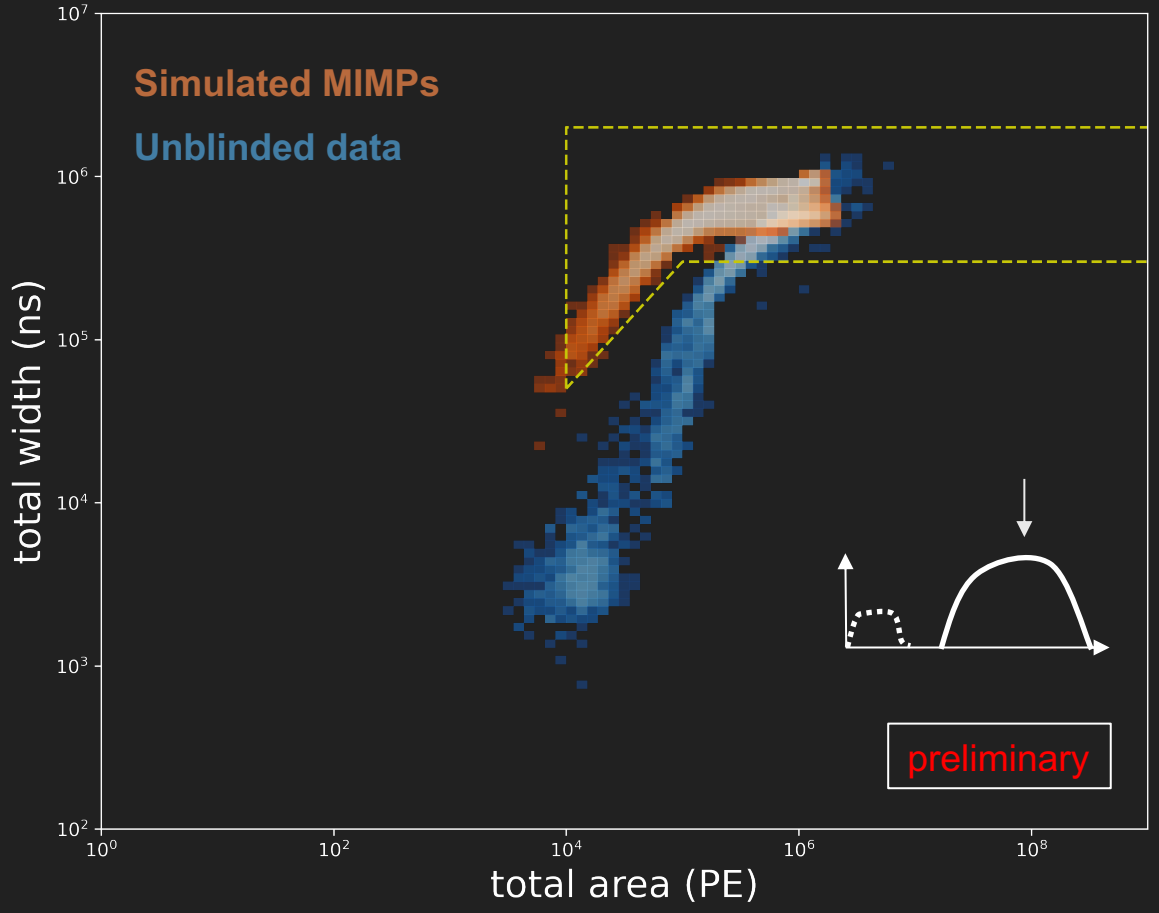
MIMPrate Simulation



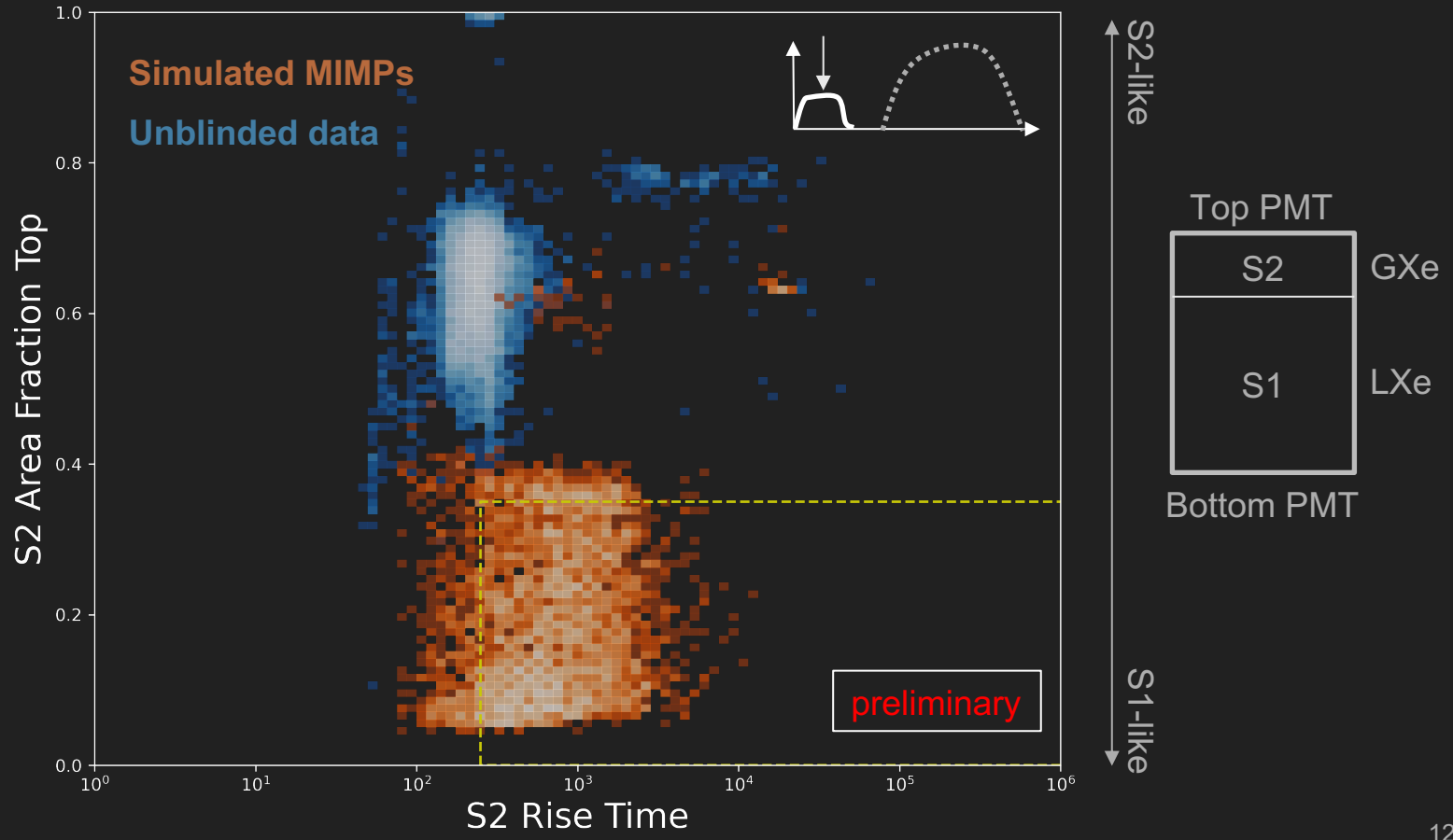
XENON1T HAX Simulation



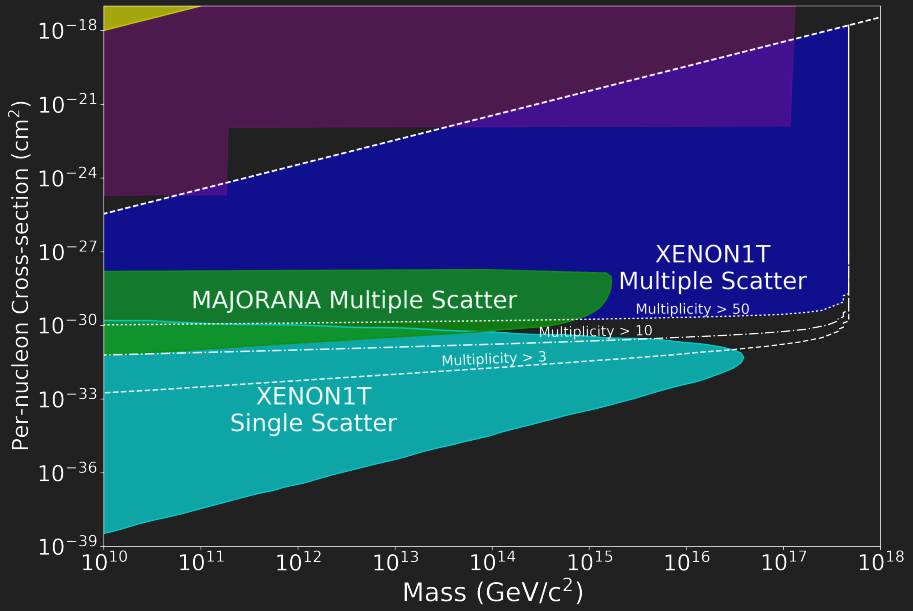
Total Area vs. Total Width of S2s



Rise edge vs. Area Fraction Top (AFT)



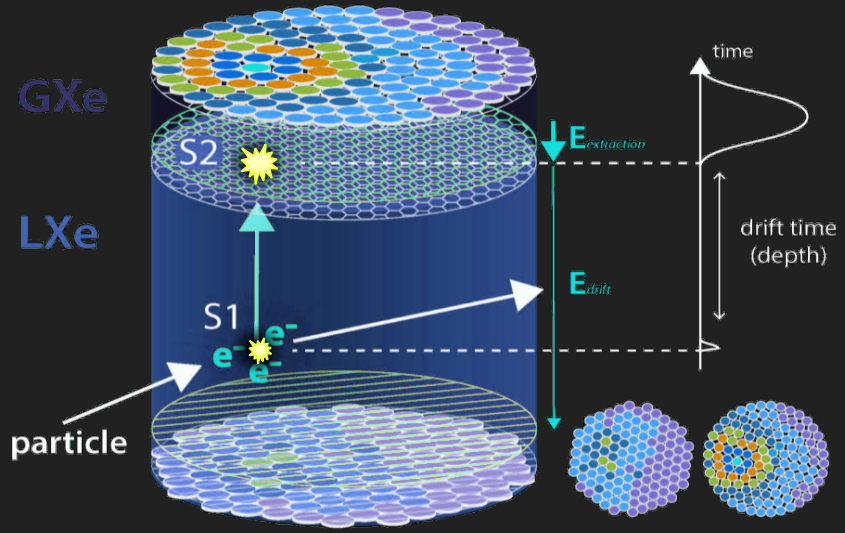
Conclusions

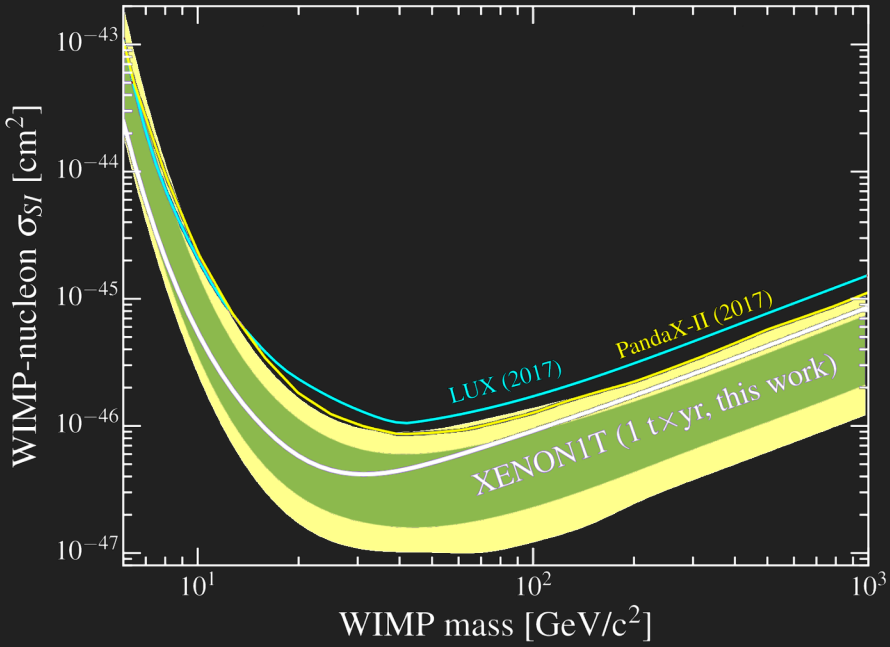


- New discover potential at high DM masses (MIMPs):
  - MAJORANA Multiple Scatter ✓
  - XENON1T Single Scatter ✓
  - XENON1T Multiple Scatter ⧗

backup

WIMP Search in Xenon1T





XENON, (2019)
1805.12962