Probing Dark Matter–Electron Scattering via HPGe Detectors from the CDEX-10 Experiment

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DM-electron paradigm

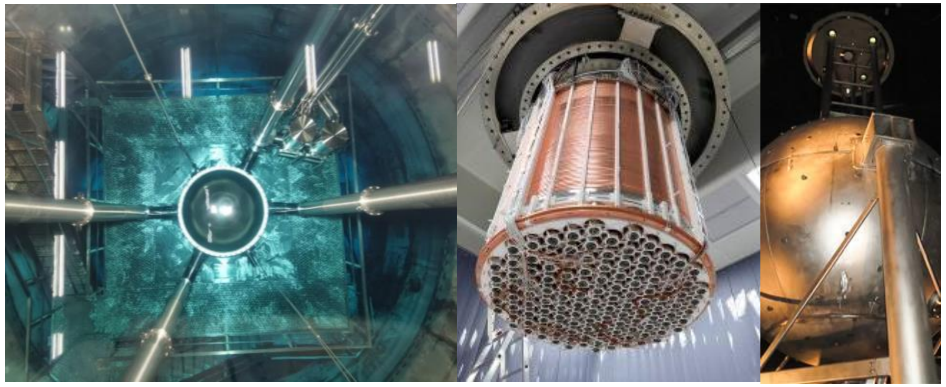
- Previously DM detection experiments mostly focus on **DM-nuclei(χ-N)** interactions.
- Recently a **DM-electron (χ-e)** scattering paradigm has drawn much attention. This physics channel proves to be successful in further lowering the m_χ reach.

Solid state detectors

SENSEI, DAMIC, EDELWEISS

Liquid scintillators

XENON, PandaX and Darkside



The m_χ is now pushed down to ~1 MeV.

Count rate for the target

The total rate can be written as, where $f_{i\to f}$ is the crystal form factor:

$$R_{i\to f} = \frac{1}{\rho_T}\frac{\rho_\chi}{m_\chi}\int d^3v f_\chi(\mathbf{v})\overline{\Gamma}_{i\to f}, \qquad (1)$$

$$\overline{\Gamma}_{i\to f} = \frac{4\pi}{16V m_e^2 m_\chi^2} \int \frac{d^3q}{(2\pi)^3}\overline{|\mathcal{M}(\mathbf{q})|^2} g(\mathbf{q},\omega)|f_{i\to f}(\mathbf{q})|^2\delta(E_f - E_i - \omega_\mathbf{q}), \qquad (2)$$

$$f_{i\to f} = \int d^3x e^{i\mathbf{q}\cdot\mathbf{x}}\psi_f^*(\mathbf{x})\psi_i(\mathbf{x}), \qquad (3)$$

$$\mathcal{M}(\mathbf{q}) = \mathcal{M}(q_0)\mathcal{F}_{med}(q_0/q)(f_e/f_e^0)$$

$\mathcal{F}_{med}(q_0/q) = 1$	Heavy mediator
$\mathcal{F}_{med}(q_0/q) = (q_0/q)^2$	Light mediator
f_e/f_e^0	Screening factor

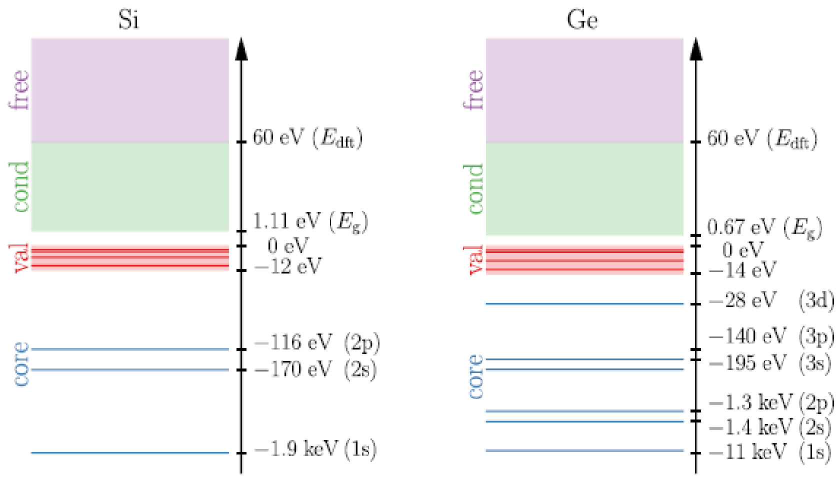
Noble gas target: atoms are considered as isolated (simple)
Crystal targets(Ge/Si): many-body system (complicated)

Density function theory (QEdark package) realized valence and conduction transition rate calculation.
Still a problem for HPGe detectors (160 eV threshold)

EXCEED-DM

For states above 60 eV, electrons are considered "**free**" and are modeled as plane waves

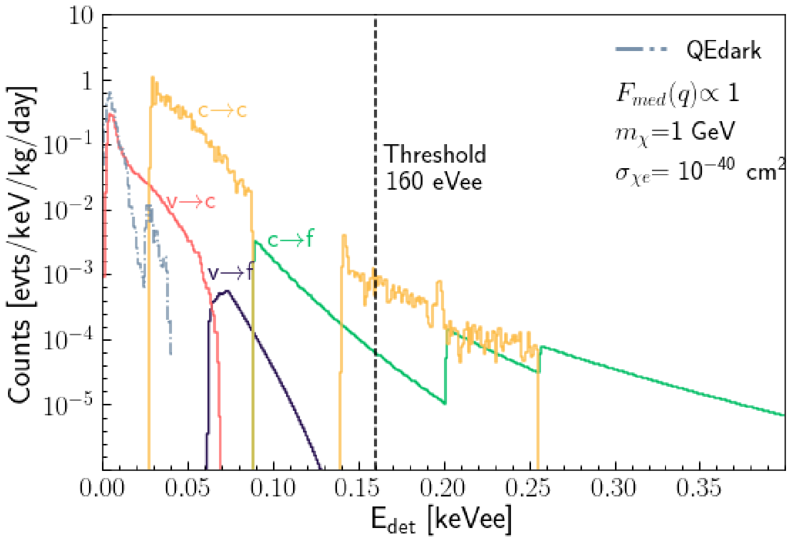
For core states a semianalytic method is utilized. They are modeled as "**core**" electrons

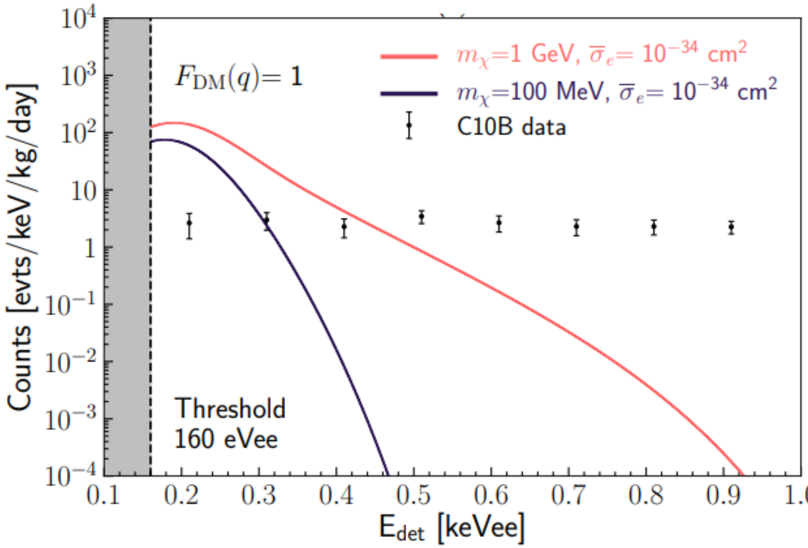


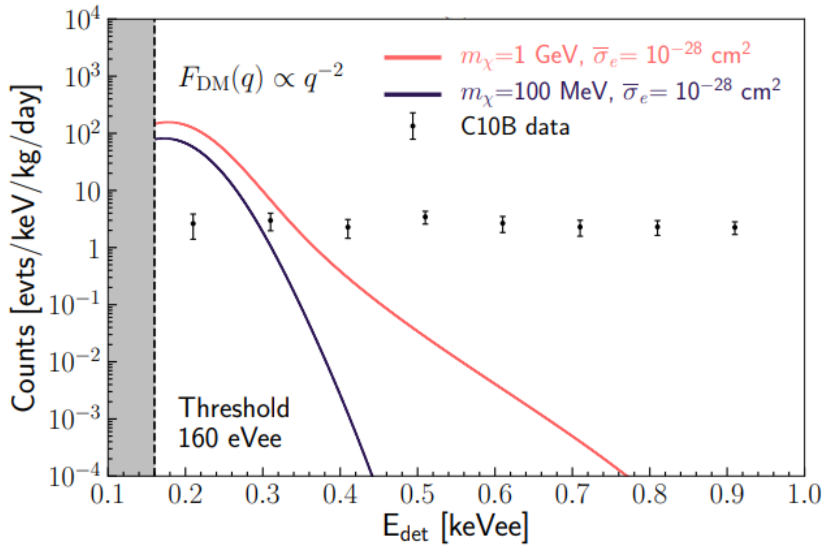
For **valence** and **conduction** band, **DFT** and **AE reconstruction** method is used.

QEdark package only take valence and conduction bands into account.
EXCEED-DM results are more complete and spectra can reach up to ~keV

Expected rate in HPGe detectors







C10B-Ge1 dataset

Exposure: 205.4 kg·day

Treatment: Pedestal noise cut, physics event selection, B/S discrimination, Known radioactive peaks are subtracted

Threshold: 160 eVee (signal efficiency 4.5%)

Resolution: $\sigma = 35.8 + 16.6 \times \sqrt{E}\,(\mathrm{eV})$

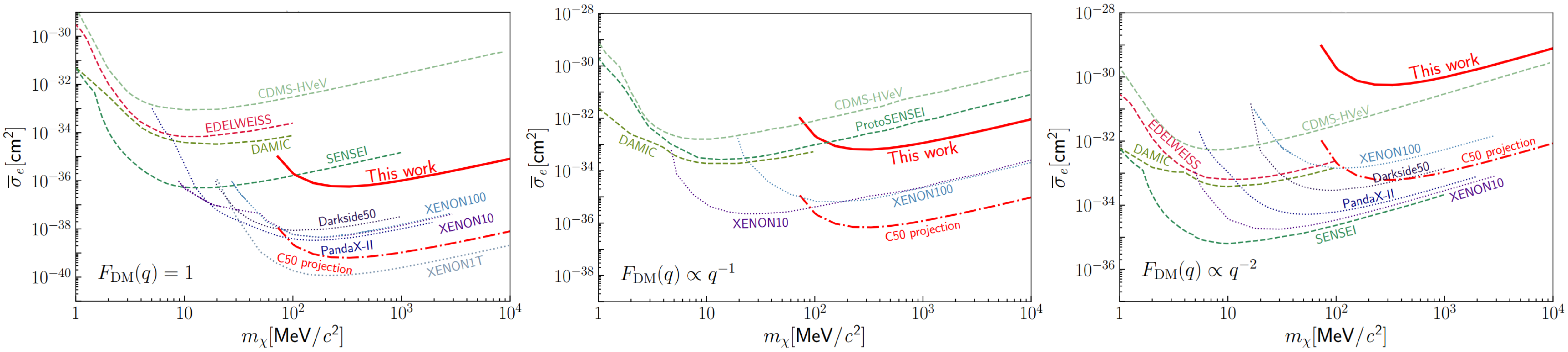
Can we see events with energy lower than the threshold?

Maybe. But not for sure!

All **<u>removed</u>** before analysis.

Exclusion line

- In the heavy mediator scenario, our result proves to be more stringent comparing with other solid state detector based experiments in high mass region of m_χ > 100 MeV.
- The first χ-e result from HPGe detectors.



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