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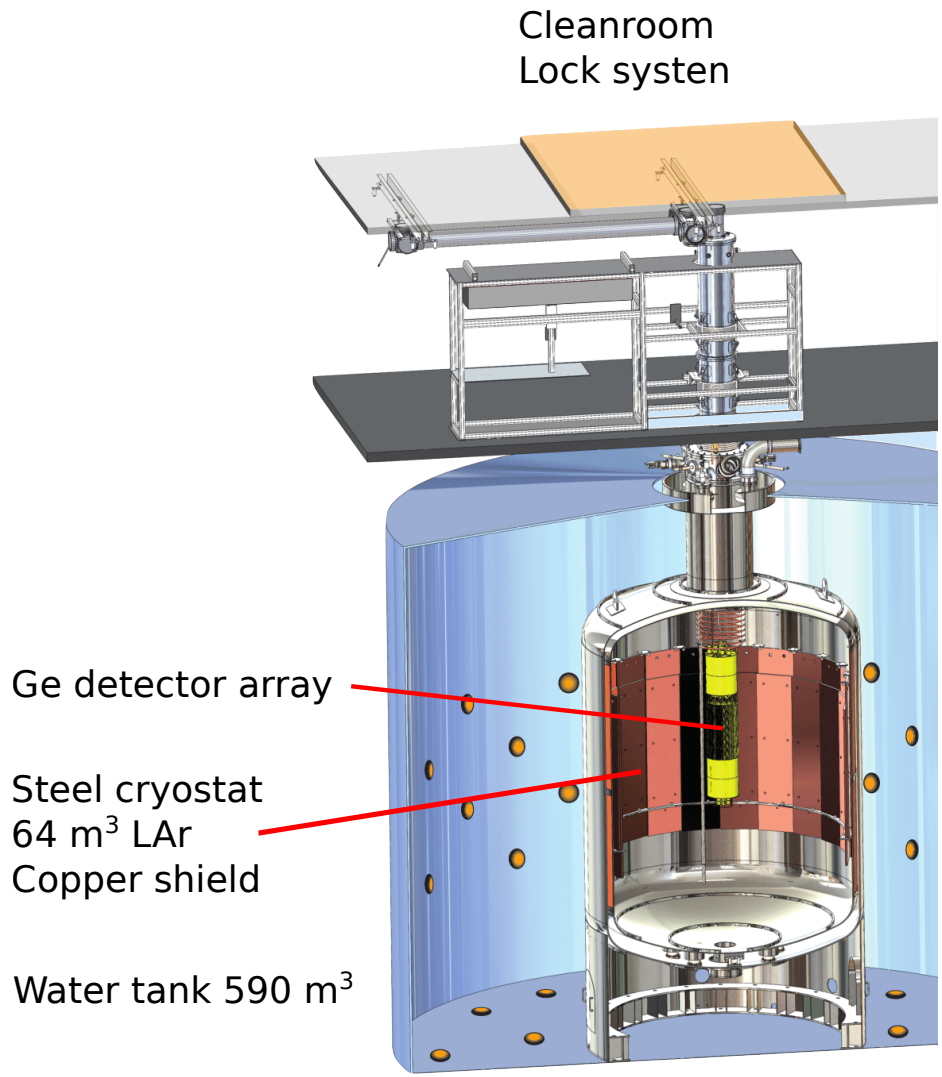
Physik-Institut

Prospects for keV-DM searches with the GERDA experiment

Roman Hiller for the GERDA collaboration

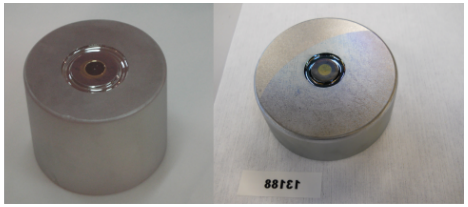
GERDA concept

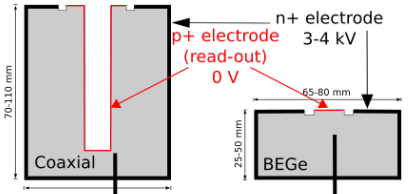
- Enriched ^{76}Ge detectors
- Cryostat /w liquid argon
- Innermost active shielding via LAr scintillation
- Wavelength shifting + PMT, SiPM
- Passive shielding
- WCD as μ veto

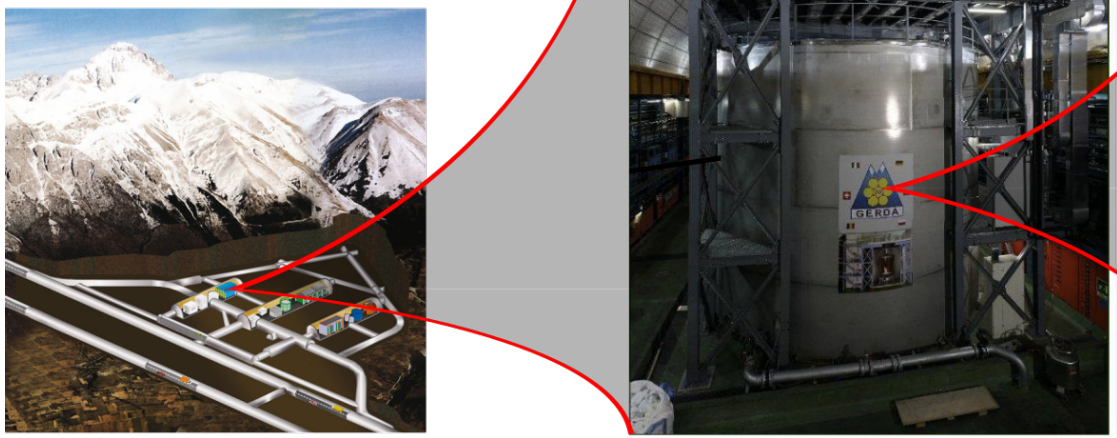


GERDA experiment

- LNGS, Italy, 3500 m.w.e.
- 7 enriched + 3 natural coaxial type det.
- since Dec. 2015: Phase II
  - added 30 enriched BEGe type det.
    $\rightarrow \sim$36 kg total
  - LAr veto







Eur. Phys. J. C 73 (2013) 2330

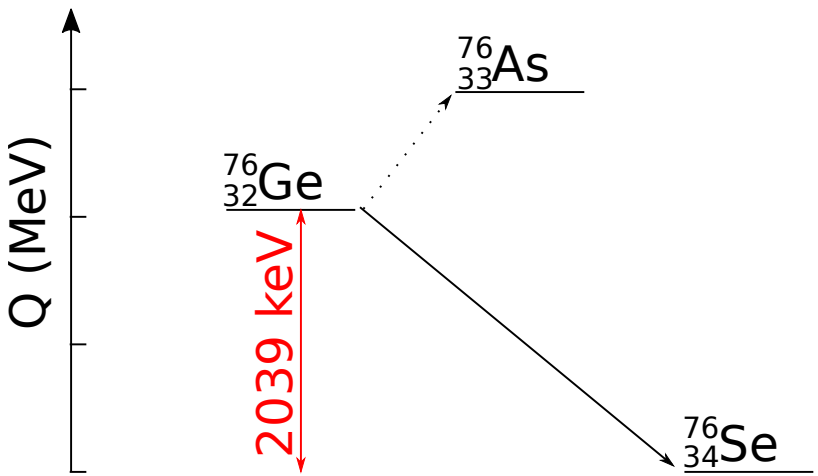
$0\nu\beta\beta$ - the main mission

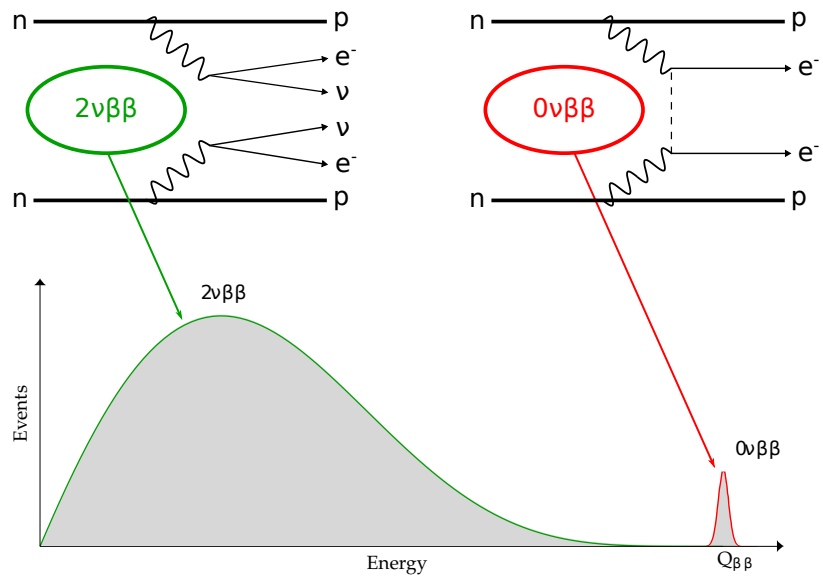
- Search for lepton number violation and study ν properties
- $\mathcal{O}(10)$ candidate isotopes with forbidden β-decay but allowed $2\nu\beta\beta$
- $2\nu\beta\beta$ in ^{76}Ge

$$T_{1/2} = 1.926 \pm 0.095 \times 10^{21}\ \mathrm{yr}$$

Eur. Phys. J. C 75 (2015) 416

- $0\nu\beta\beta$ signature = peak at endpoint of $2\nu\beta\beta$ spectrum



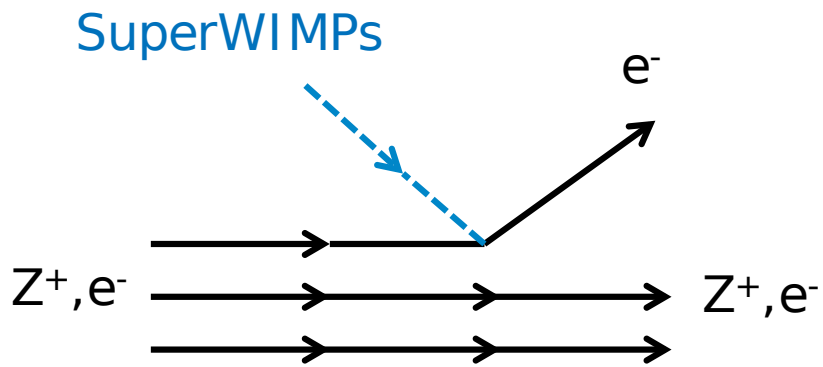


keV Dark Matter

- Sub-GeV DM via "super weak" coupling $\rightarrow$ Super-WIMP
- Well studied (hardly detectable) fermions (sterile ν, gravitino)
- Bosons in some cases detectable via axio-electric effect

Candidates:

- Pseudo-scalar Super-WIMPs (Axion-like particles)
- Vector Super-WIMPs (Hidden photon)



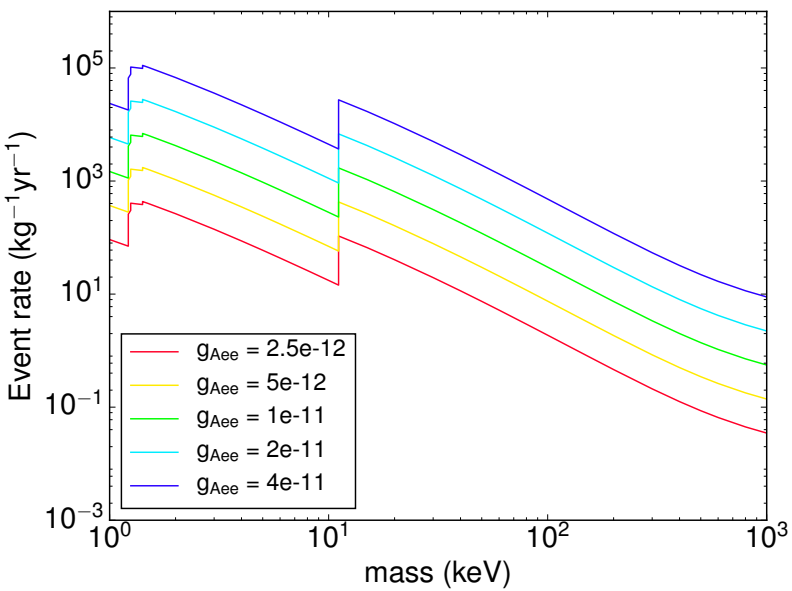
Pospelov et. al. Phys. Rev. D 78, 115012

Rates

- σ proportional to photoelectric effect σ_{pe}
- Using estimates of the local DM density, the expected rates are:

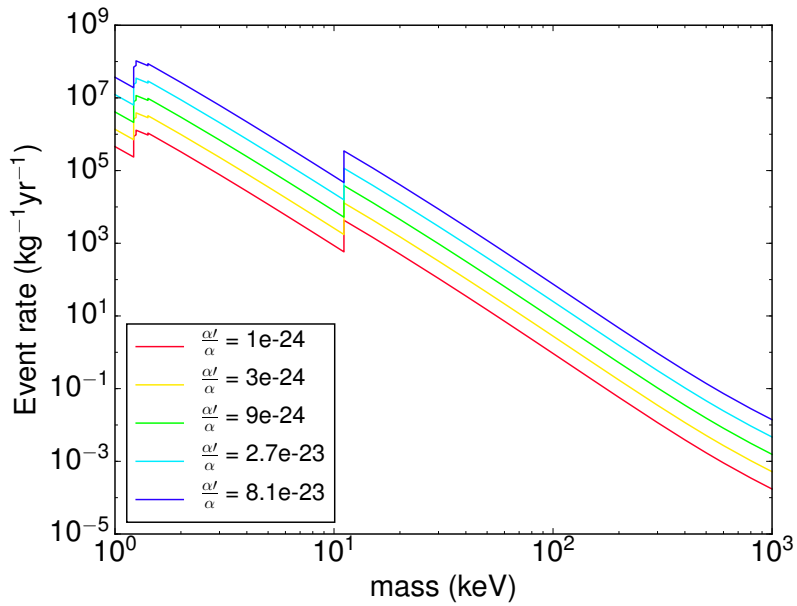
Pseudo-scalar

$$R \approx \frac{4.71\times10^{21}}{A} g_{Ae}^2 \left(\frac{m_A}{\mathrm{keV}}\right) \left(\frac{\sigma pe}{\mathrm{b}}\right) \mathrm{kg}^{-1}\ \mathrm{yr}^{-1}$$



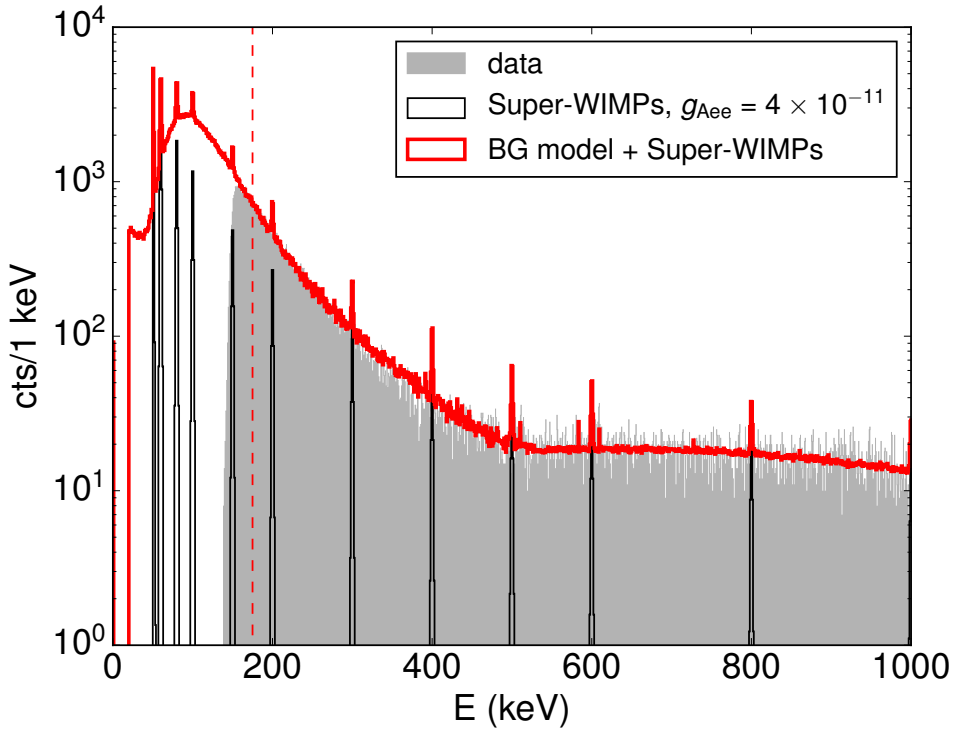
Vector

$$R \approx \frac{1.46\times10^{26}}{A} \frac{\alpha\prime}{\alpha} \left(\frac{\mathrm{keV}}{m_V}\right) \left(\frac{\sigma pe}{\mathrm{b}}\right) \mathrm{kg}^{-1}\ \mathrm{yr}^{-1}$$



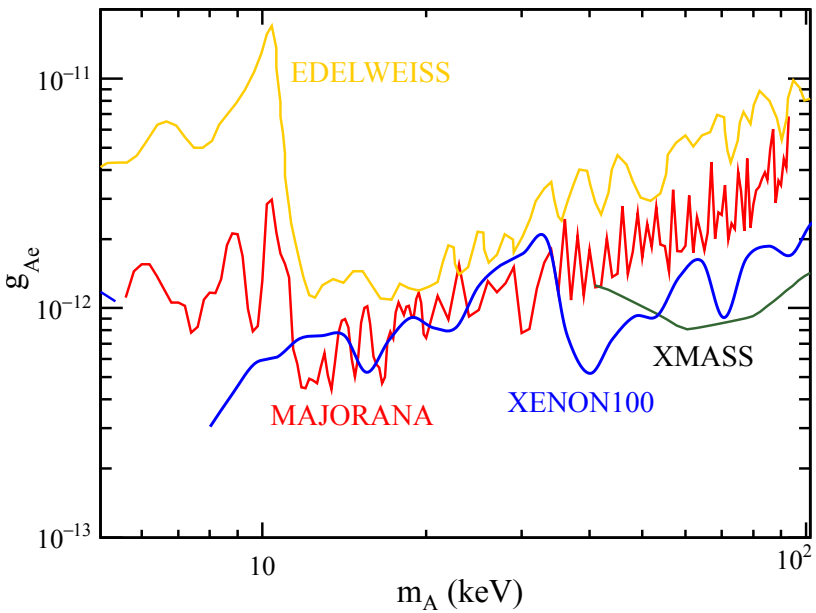
Signature

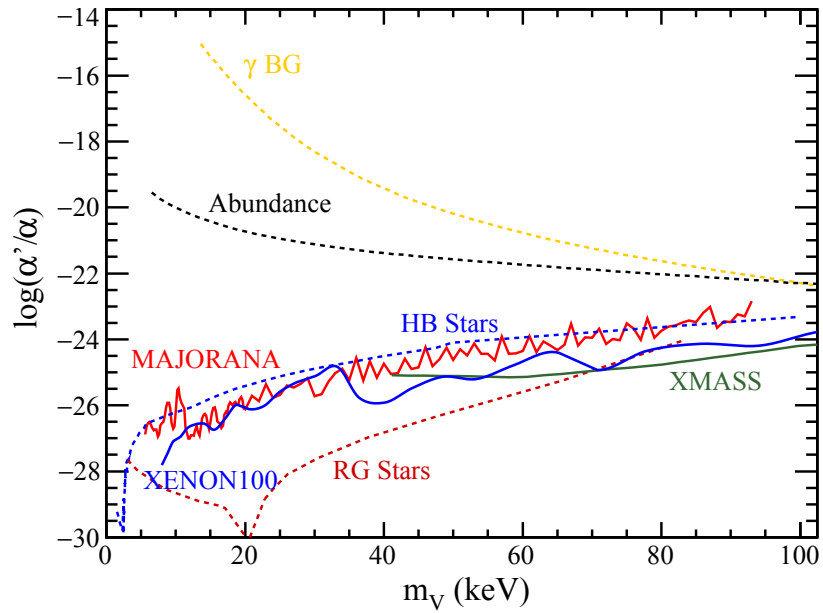
- Analogous to photoeffect: complete absorption in atom with emission of monoenergetic electron
- Peak of single-site events at the mass of the Super-WIMP



Existing limits

- limits in 10-100 keV region XMASS, XENON100, EDELWEISS, MAJORANA
- Several indirect constrains



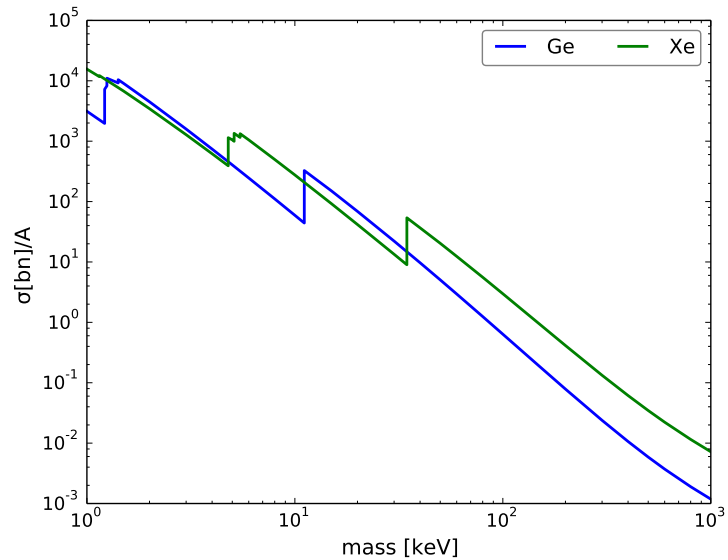


arXiv:1612.00886

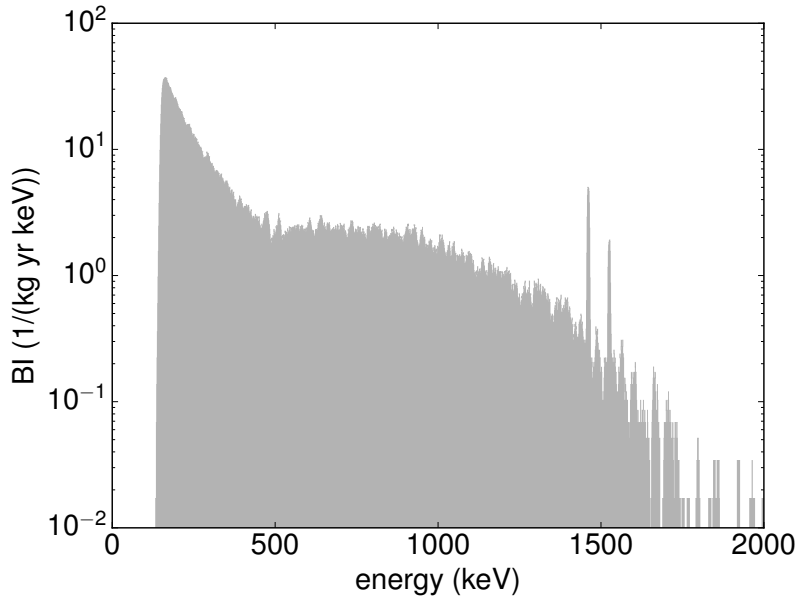
What about GERDA?

- Sensitivity $\sim \sqrt{\frac{M \cdot t}{\sigma_E \cdot BI}}$
- ...but GERDA has higher energy threshold 175 keV (DAQ)
- Cross section Ge and Xe similar
- ...but decreasing with energy
- However, no direct constrains above 145 keV

	$\frac{M \cdot t}{\text{kg yr}}$	$\frac{\text{BI}}{\text{kg yr keV}}$	$\frac{\text{FWHM}}{\text{keV}}$
GERDA	10	2-30	2-3
(175-1000 keV)	(100)	(/w LAr)	
XENON100	20	2	14
100 keV			

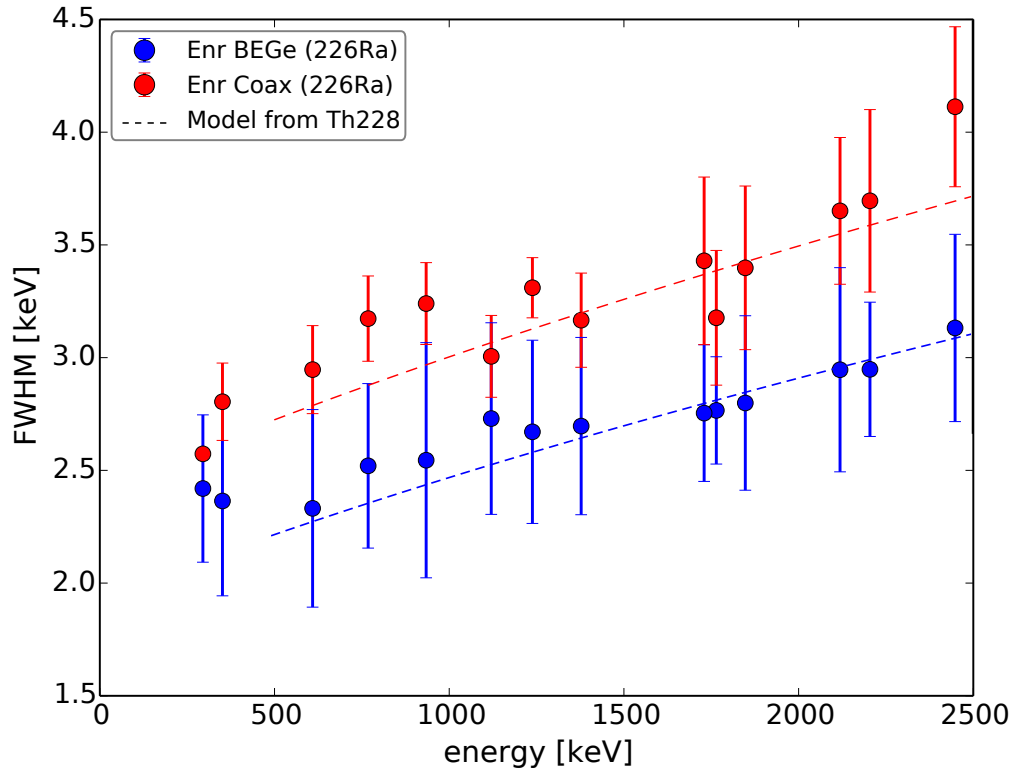


GERDA background index



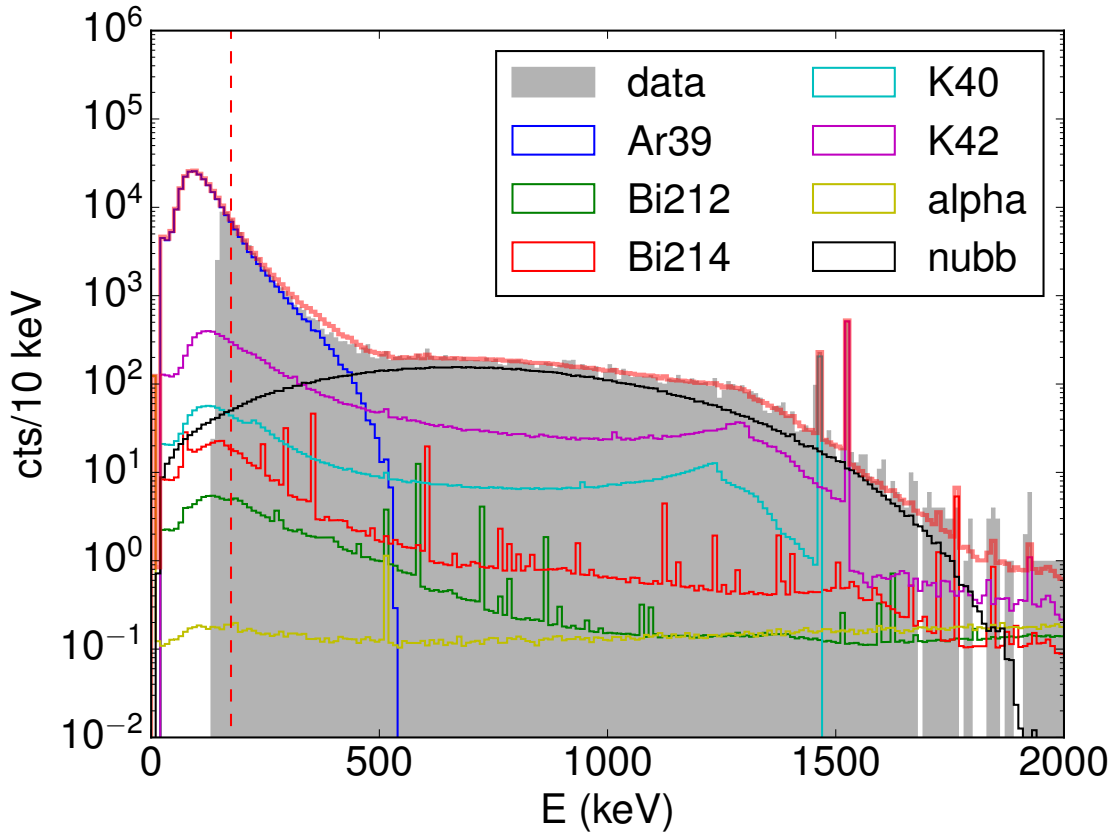
Energy reconstruction

- $\sim$ weekly calibrations with ^{228}Th sources
- DAQ threshold > 500 keV
- Special calibration campaign /w ^{226}Ra source also at < 500 keV



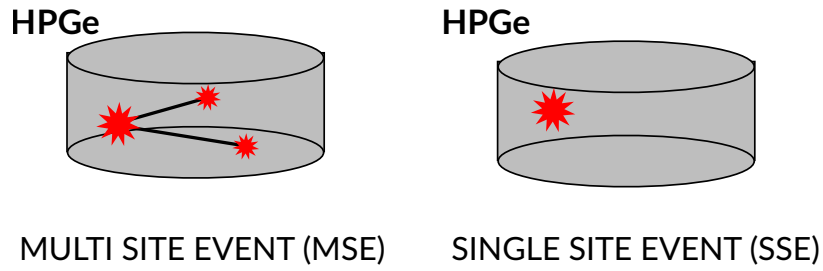
Background

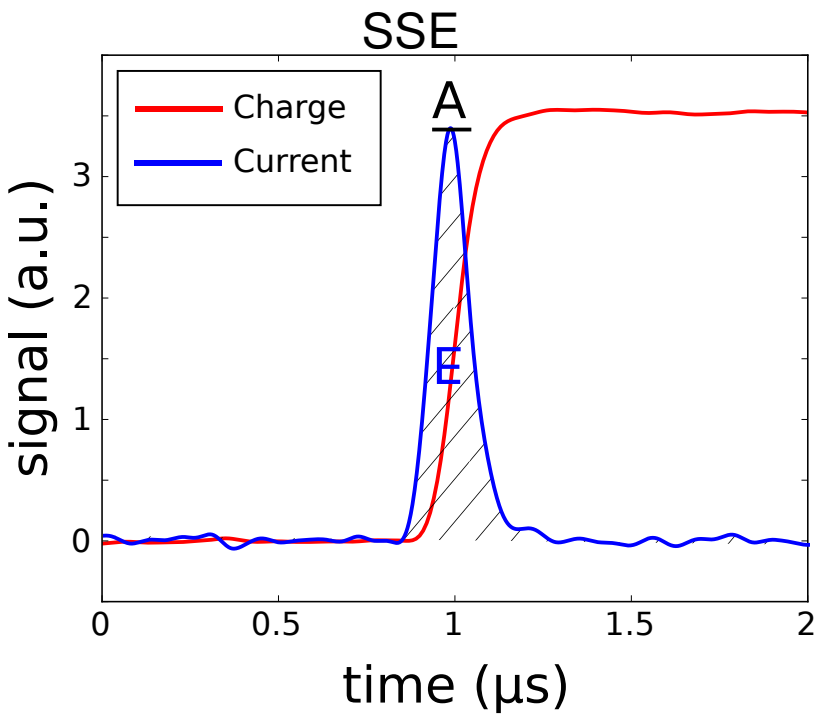
- MC Background model
- Main contributions < 1 MeV:
  - $2\nu\beta\beta$ (irreducible internal SSE)
  - ^{39}Ar (n-surface; LAr suppression factor$\sim$3-5, PSD?)

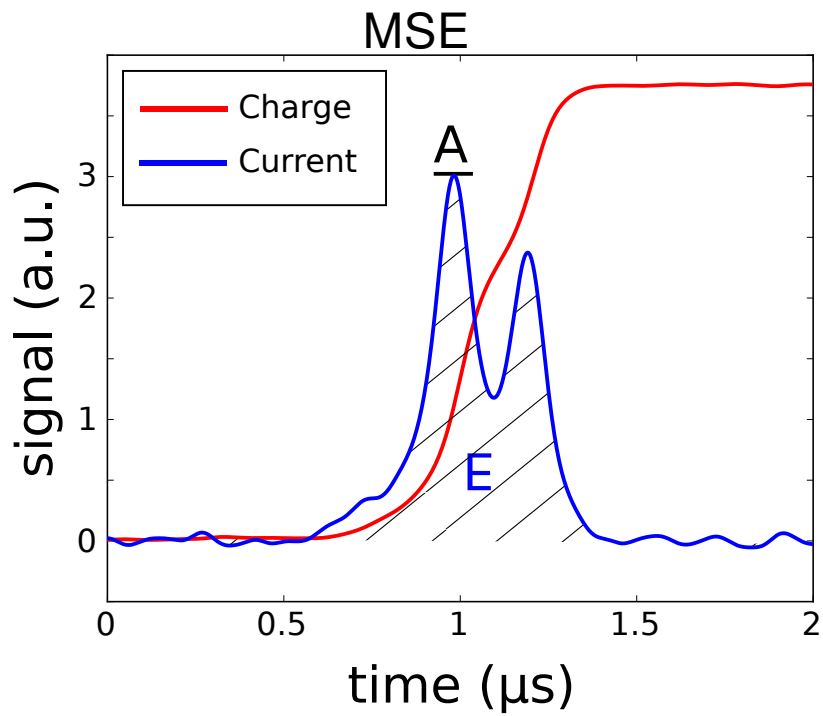


Background reduction - Pulse shape discrimination

- Discrimination of SSE/MSE, surface events
- Charge drift time → pulse shape
- Current trace amplitude/energy = amplitude/area

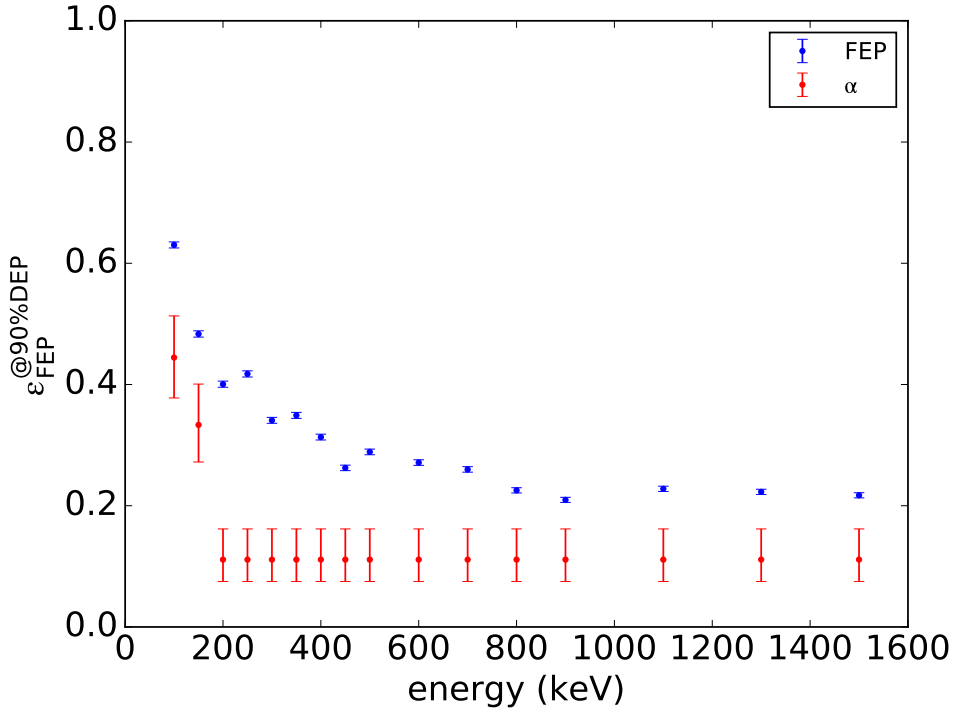






Background rejection

- A/E too sensitive to noise?
- Check by adding measured noise to signal traces
  $\rightarrow$ might be alright
- Alternative: compare pulse to template of SSE, ΔQt



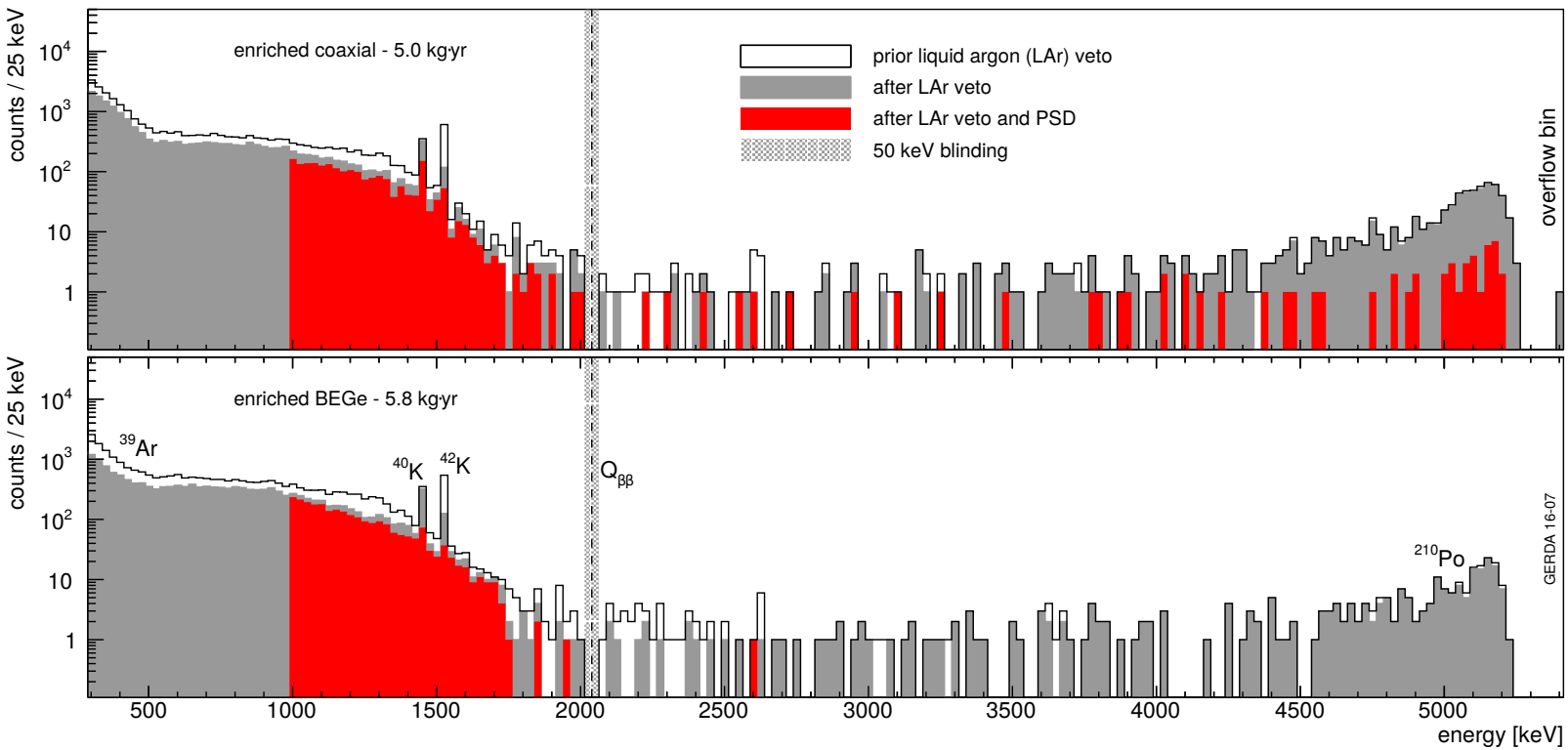
Conclusion

- Bosonic Super-WIMPs are a candidate for keV mass DM
- They can be detected via a peak signature
- GERDA performs well down to $\sim$ 175 keV (exposure, energy resolution, background)
- ... and consequently might be sensitive to Super-WIMPs at the lower end of its spectrum

Recent GERDA results

- Phase II 28.5 kg yr exposure
- background index BEGe 0.6×10^{-3} and coax 2.2×10^{-3} $\frac{\mathrm{cts}}{\mathrm{kgyrkeV}}$
- $<$ 1 background event in ROI at design exposure 100 kg yr

$$T_{1/2}^{0\nu} > 5.3 \times 10^{25}\,\mathrm{yr}(90\%\mathrm{C.L.})$$



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