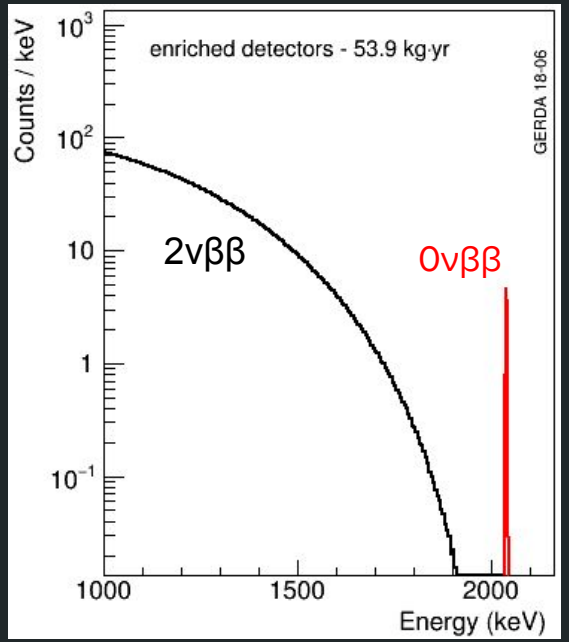
New results from GERDA

Matteo Agostini for the GERDA collaboration

Technical University of Munich (TUM)

ICHEP 2018, July 4-11 2018, Seoul, South Korea

GERDA approach



Search for 0νββ decay of ^{76}Ge:

$$^{76}Ge \rightarrow {}^{76}Se + 2e^-$$

- ➢ $\Delta L = 2$ → beyond Standard Model physics
- ➢ Majorana mass or other L-violating physics

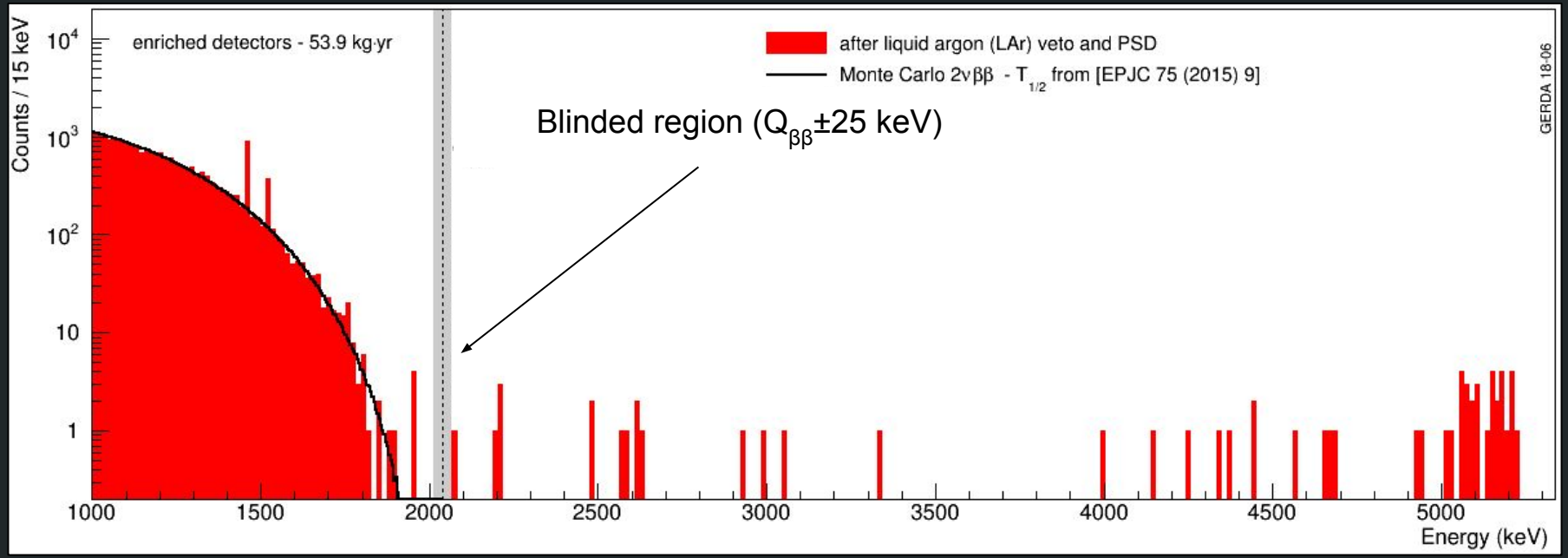
High purity Ge detectors (87% ^{76}Ge):

- source = detector → high efficiency
- radio-pure → no intrinsic background
- high density → e^- absorbed in 1-2 mm
- semiconductor → $\Delta E < 0.1\%$ at $Q_{\beta\beta}$

0νββ signature:

- ➢ point-like energy deposition in detector bulk volume
- ➢ sharp energy peak at 2039 keV (FWHM = 3-4 keV)

GERDA Strategy: High Resolution & Background Free



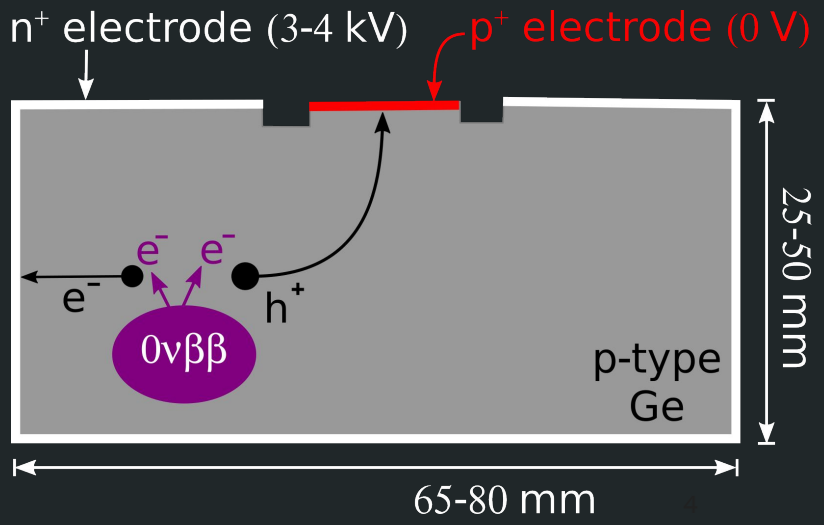
Background expectation in $Q_{\beta\beta}\pm2\sigma$ → <0.2 counts

The Ge Detectors

HPGe detector signals:

- ➢ signal induced by drift of electron-hole clusters
- ➢ time-projection chamber
- ➢ identification of events with multiple energy depositions
- ➢ identification of events on the surface

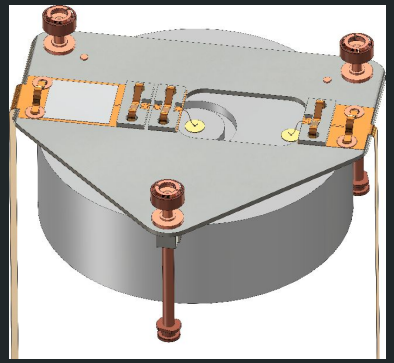
Signal/Background Discrimination!



The Setup

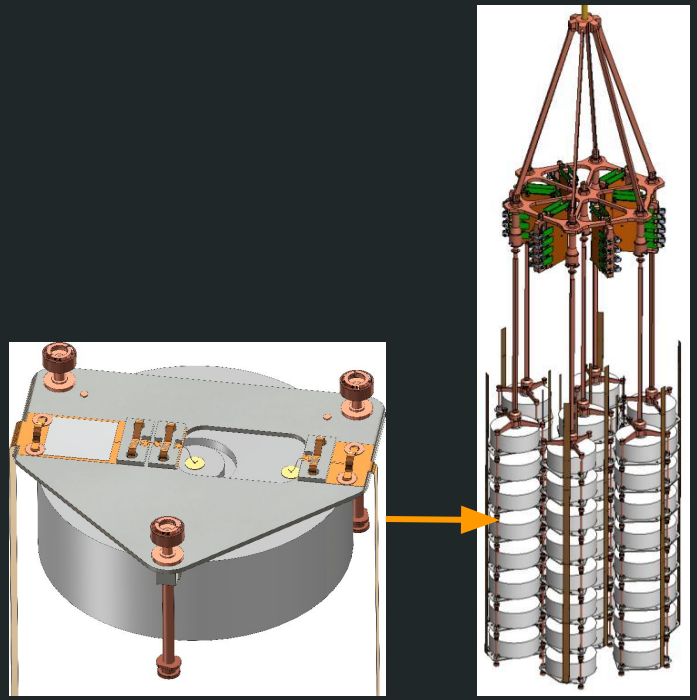
Detectors mounting:

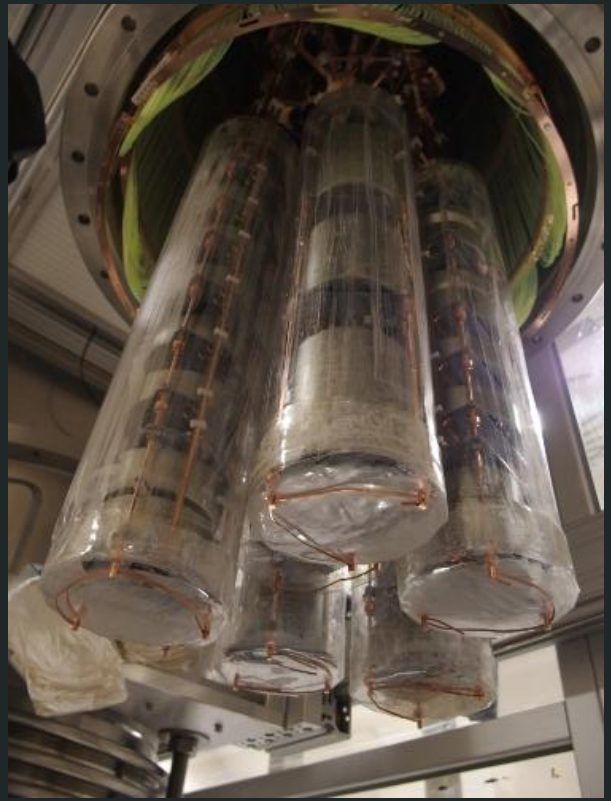
- low mass holders
- contacting with wire bonding



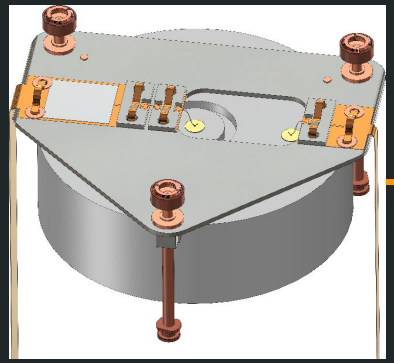
The Setup

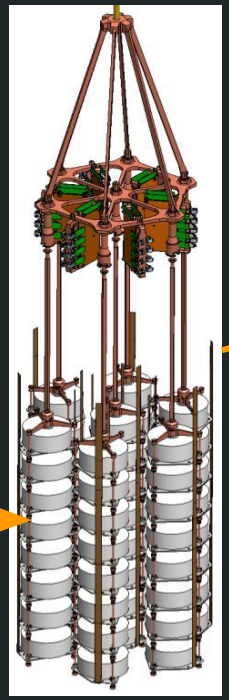
- Array deployed in Dec 2015
- 7 strings
- 40 detectors
- 7 enriched Coax (15.6 kg)
- 30 enriched BEGe (20 kg)
- 3 natural Coax (7.6 kg)

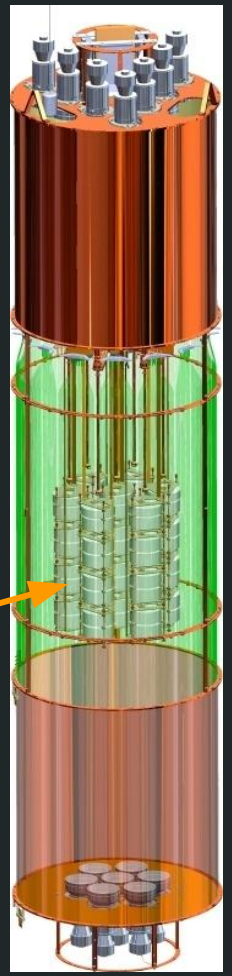


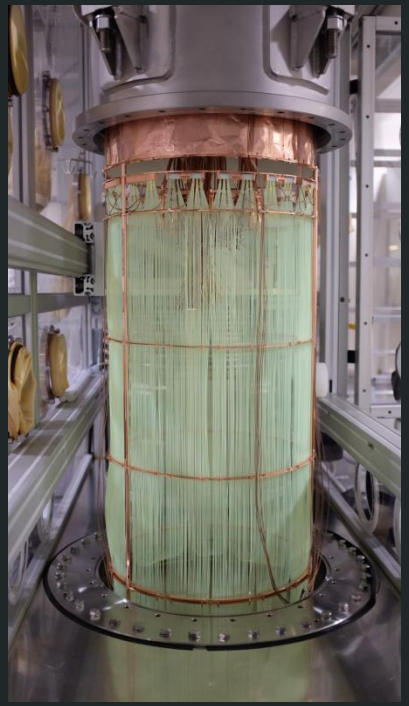


The Setup





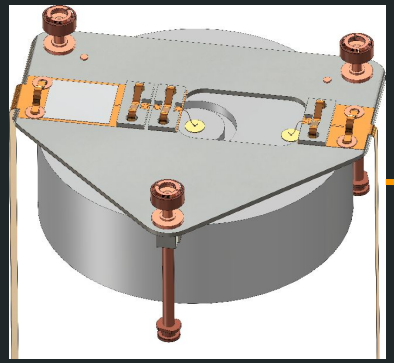


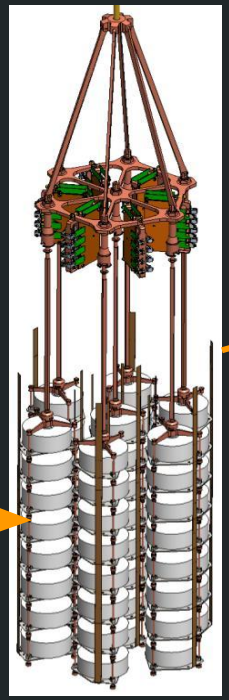


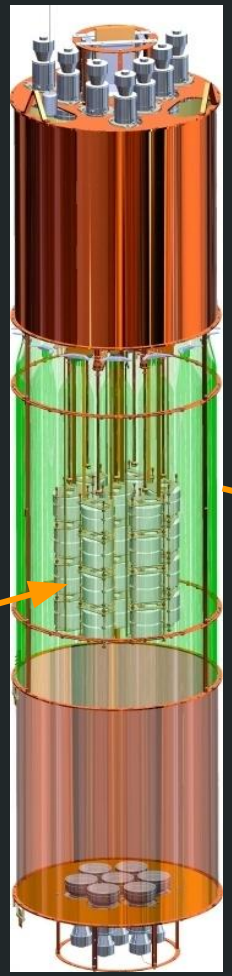
LAr scintillation detection:

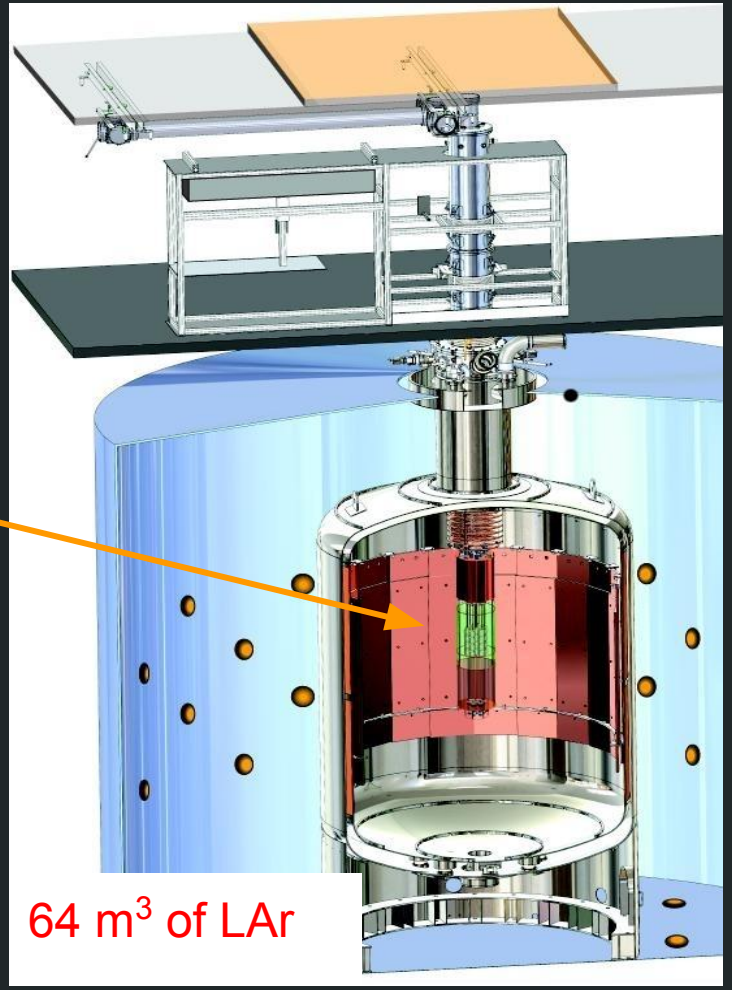
- 16 PMTs (9 top / 7 btm)
- ~1 km fibers with WLS + 90 SiPMs
- nylon mini-shroud around each string coated with WLS

The Setup



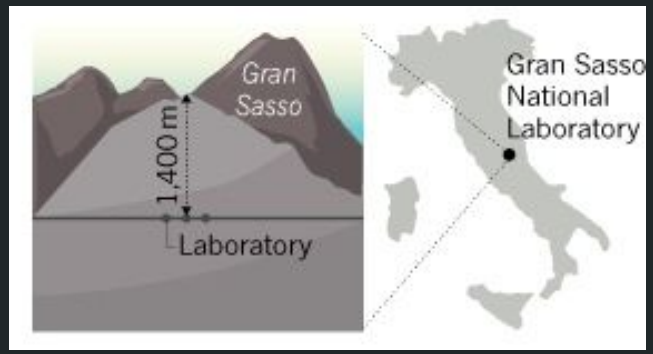


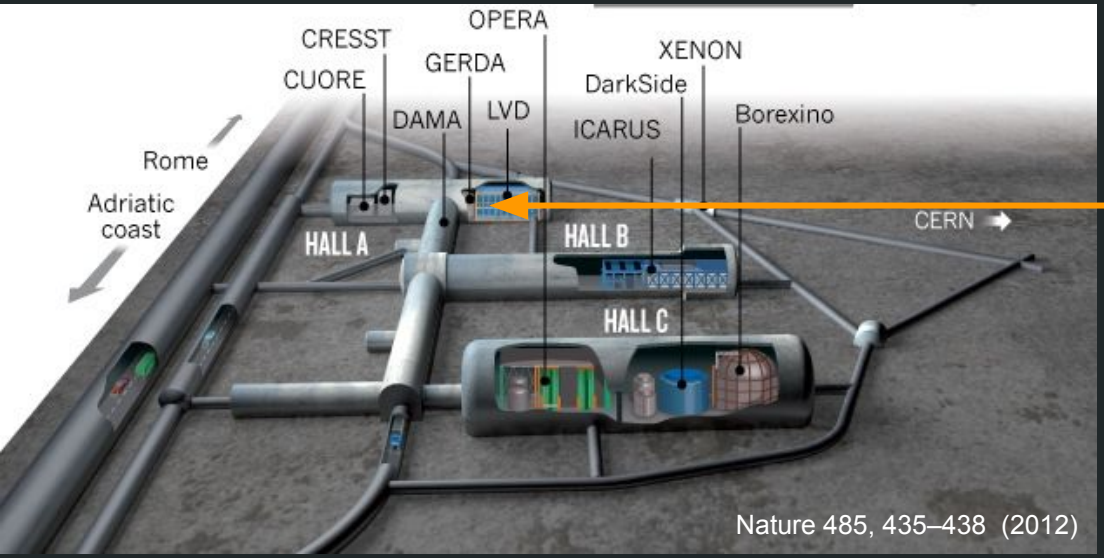




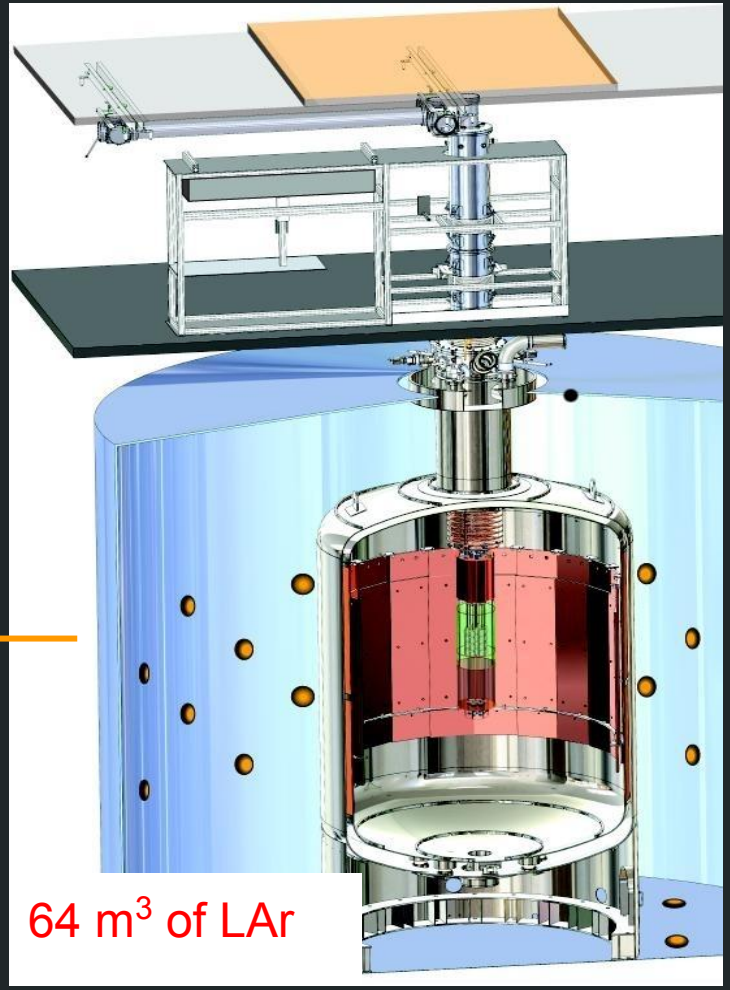
The Setup

LNGS (INFN)
3500 m.w.e.



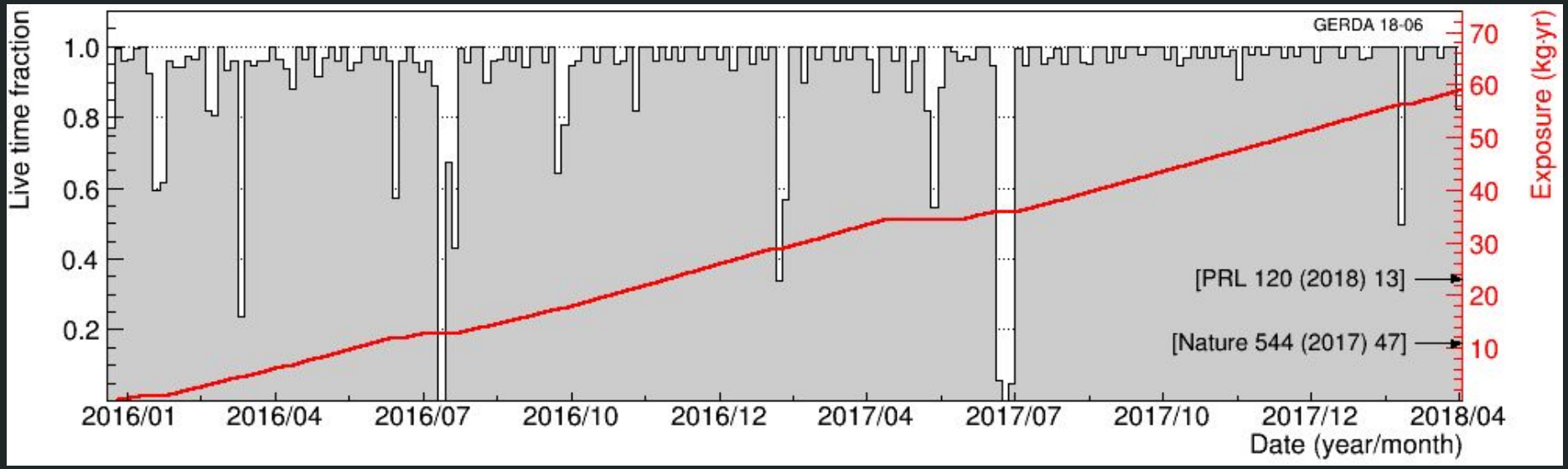


Nature 485, 435–438 (2012)



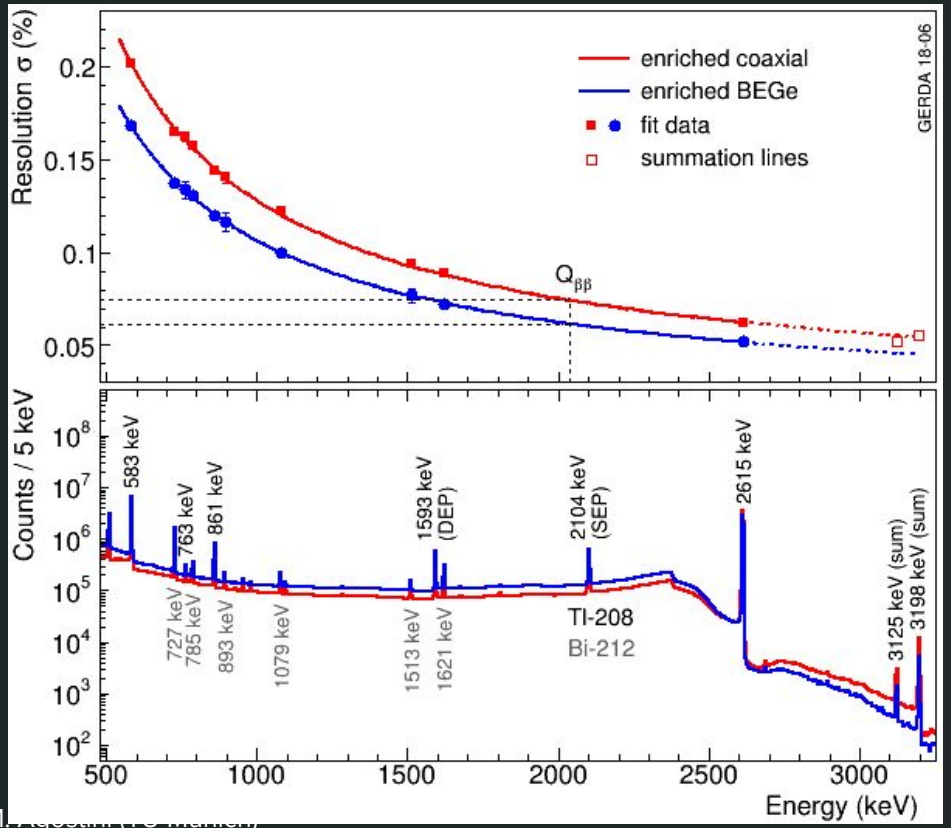
64 m^3 of LAr

Phase II Data taking

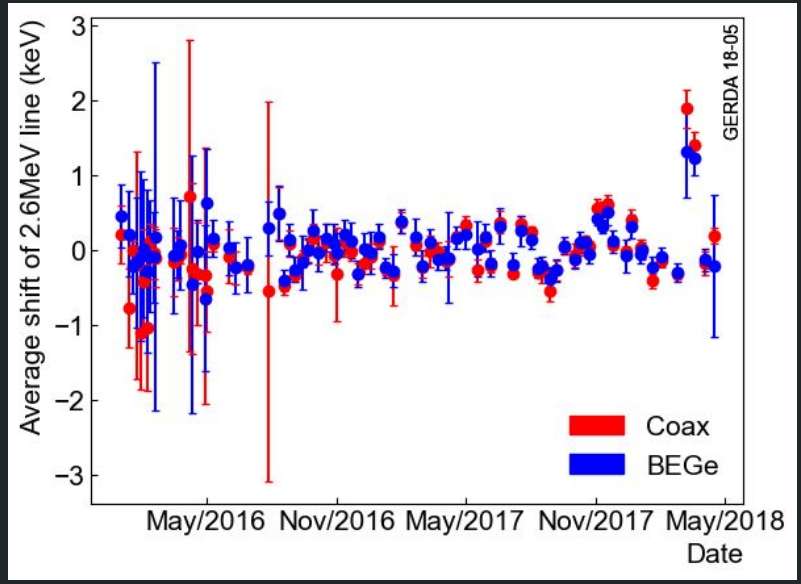


- Dec 2015 → Apr 2018: 835 d live time
- 93% duty cycle
- Phase II Exposure: 59 kg yr
- Phase I + Phase II: 82 kg yr

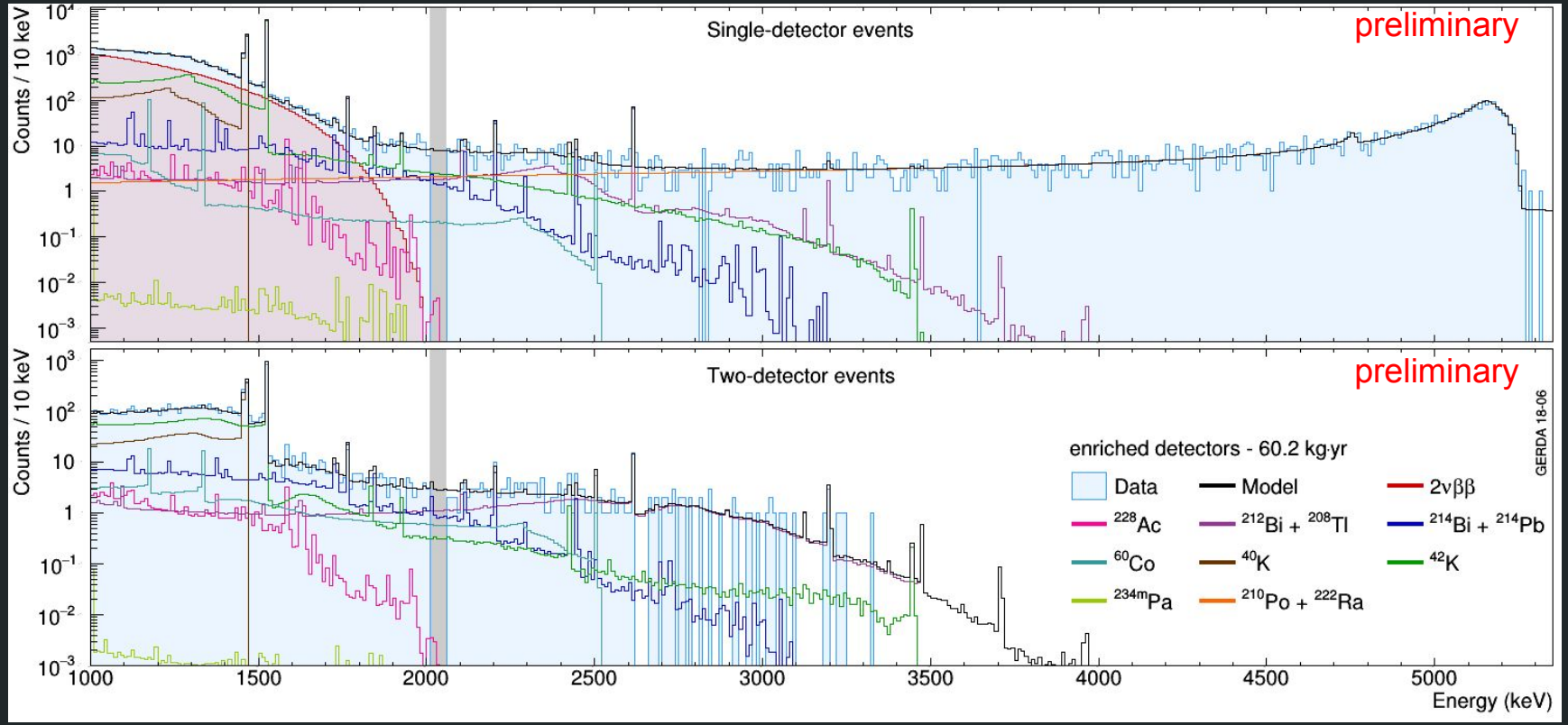
Energy Scale



- Weekly calibration with Th-228 sources
- Fluctuations between calibrations <1 keV
- Resolution at Qbb better than 0.1% (3-4 keV FWHM)

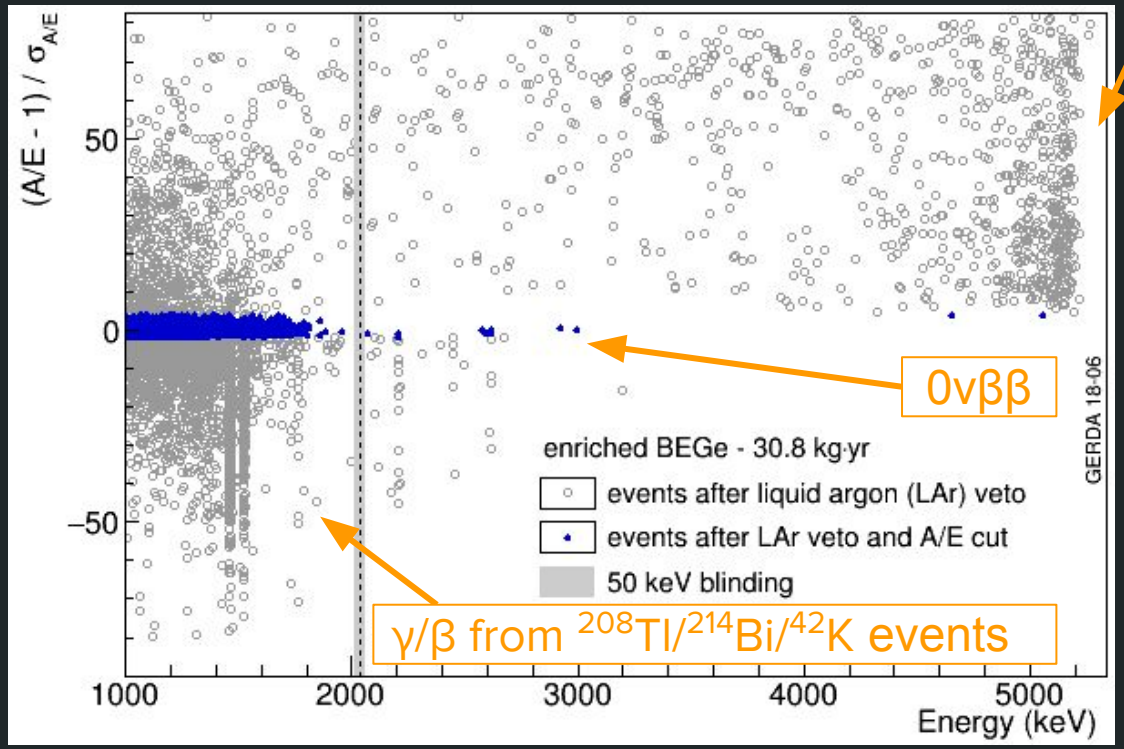


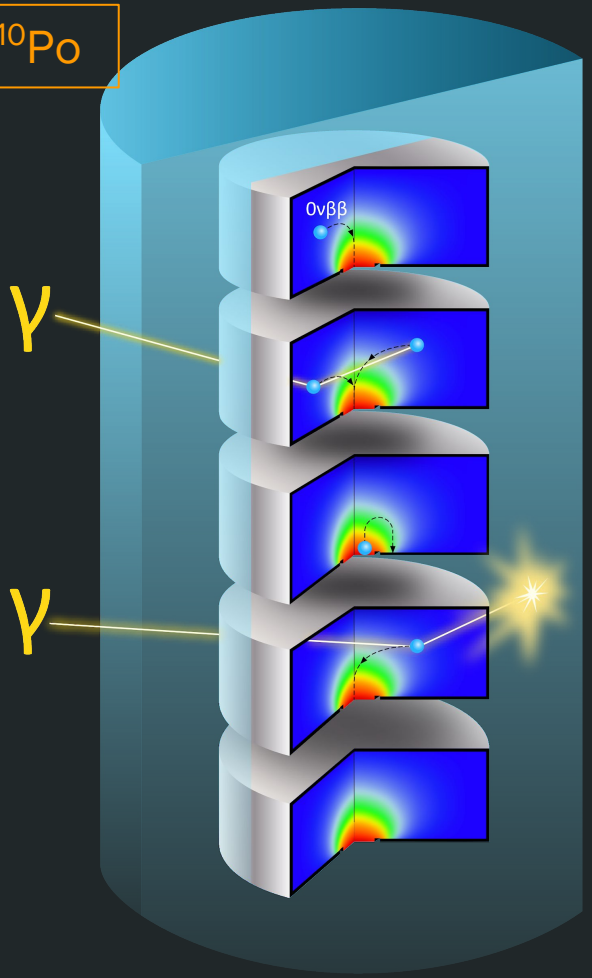
The Background before Analysis Cuts



Background at $Q_{\beta\beta}$: ➢ α from ^{210}Po ➢ γ from ^{208}Tl/^{214}Bi ➢ β from ^{42}K

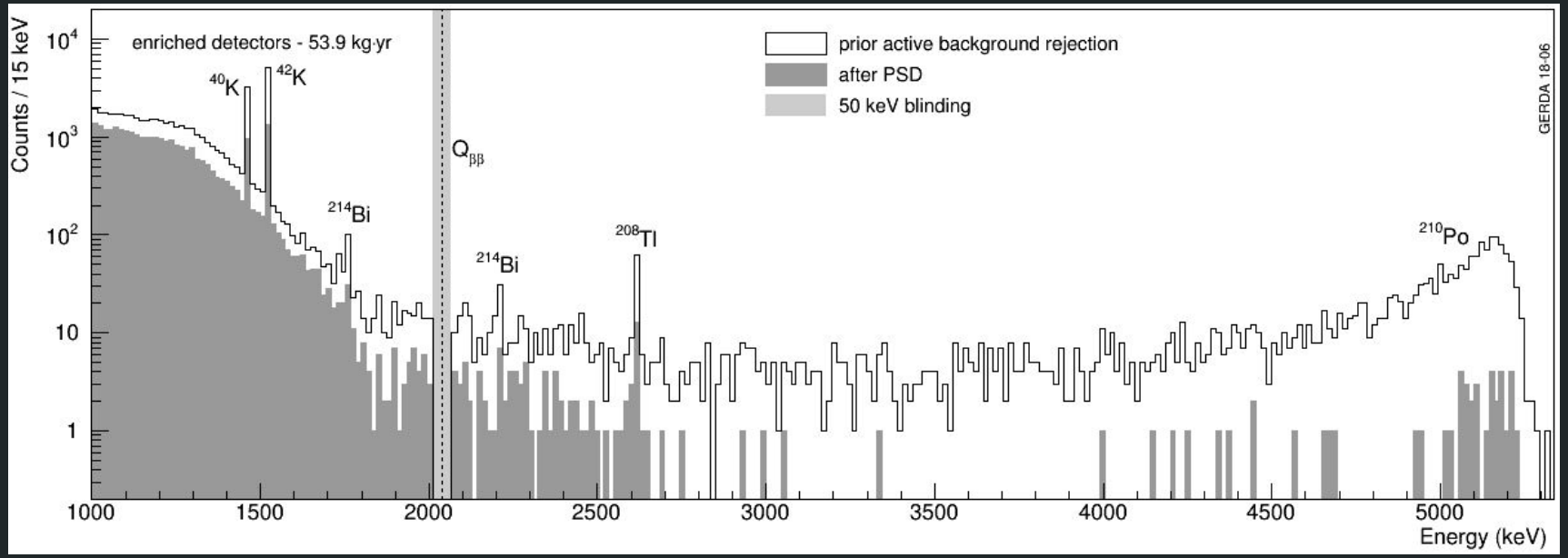
Pulse shape discrimination





0νββ efficiency → ε_{BEGe} = (87.6+2.5)% ε_{coax} = (71.2+4.3)%

Active background suppression - PSD



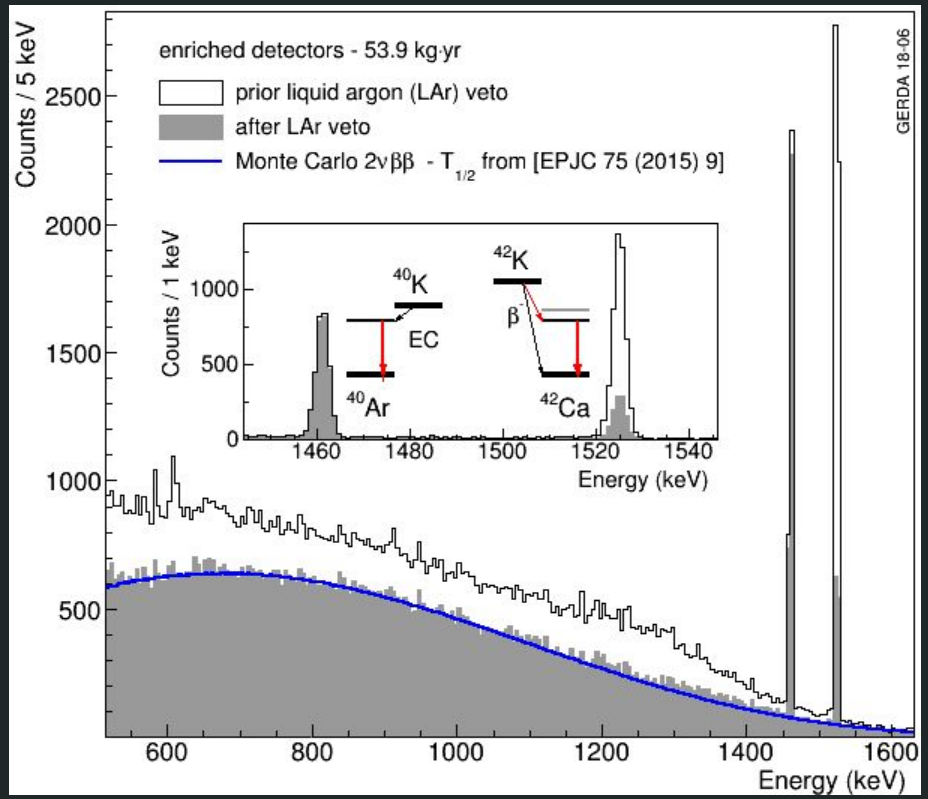
Expected suppression factors at $Q_{\beta\beta}$:

~ 100 for α from ^{210}Po

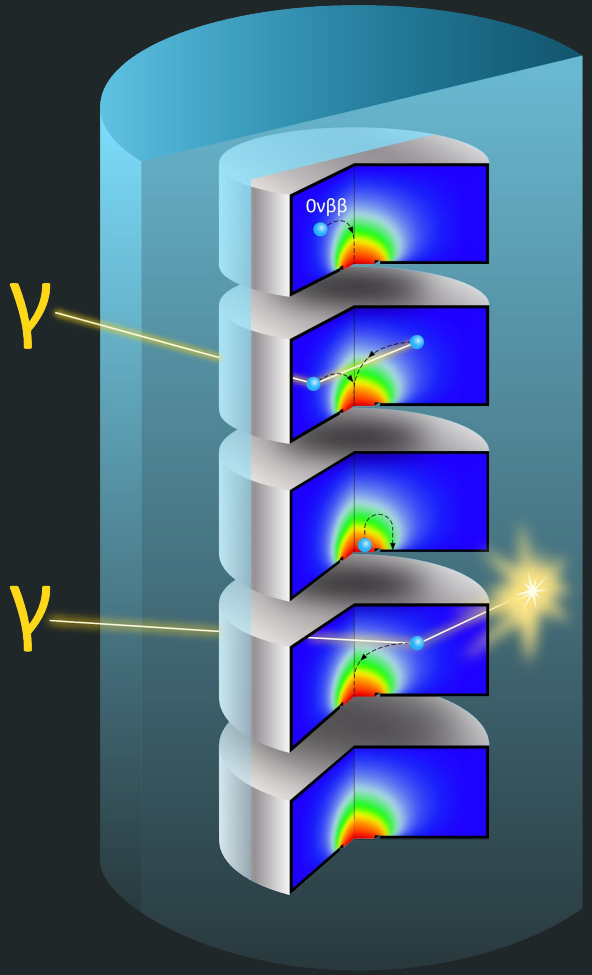
~ 2 for γ from ^{208}Tl/^{214}Bi

~ 100 for β from ^{42}K

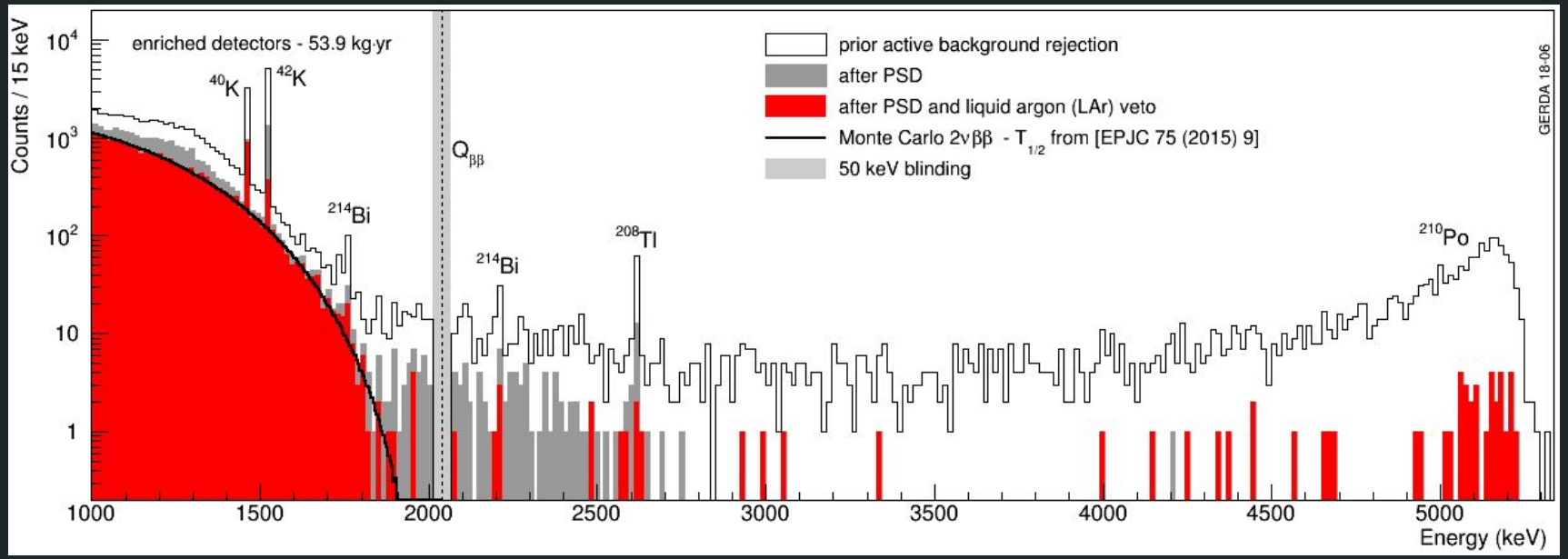
LAr scintillation anti-coincidence



Dead time
~2%



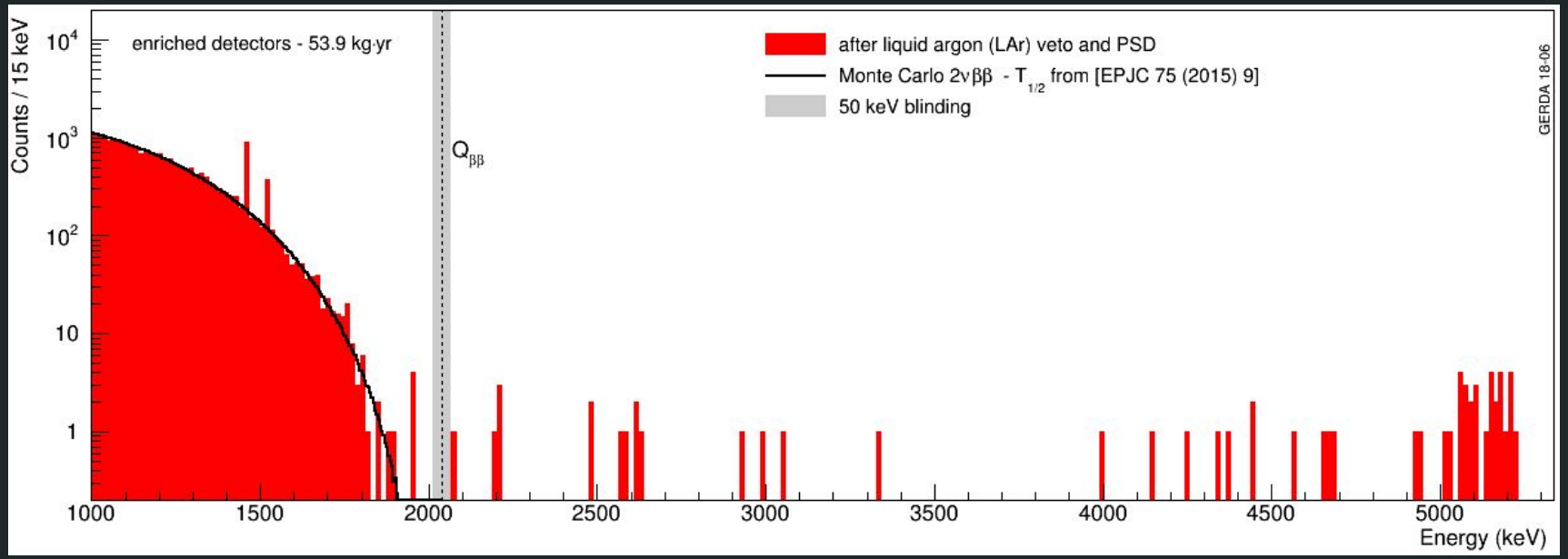
Active background suppression - LAr veto



Expected suppression factors at $Q_{\beta\beta}$: ~ 100 for γ from ^{208}Tl

~ 2 for γ from ^{214}Bi

Active background suppression - PSD & LAr veto



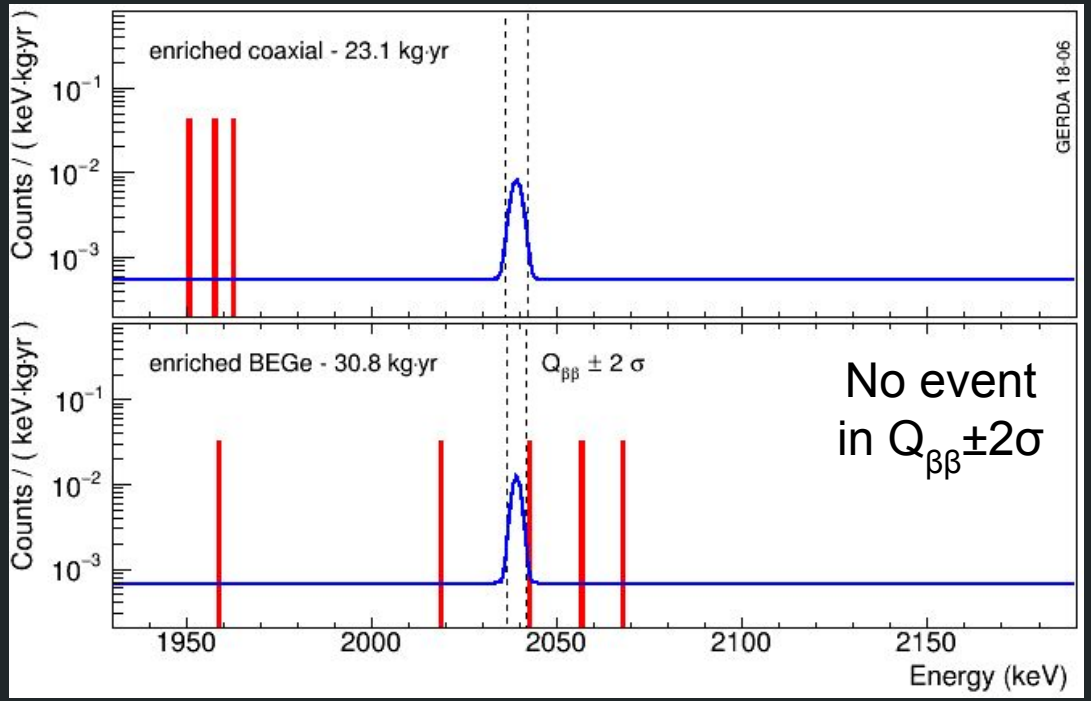
$BI_{BEGe} = 5.6\ ^{+3.4}_{-2.4}\ 10^{-4}$ cts / (keV kg yr) $BI_{coax} = 5.7\ ^{+4.1}_{-2.6}\ 10^{-4}$ cts / (keV kg yr)

Lowest background in the ROI!

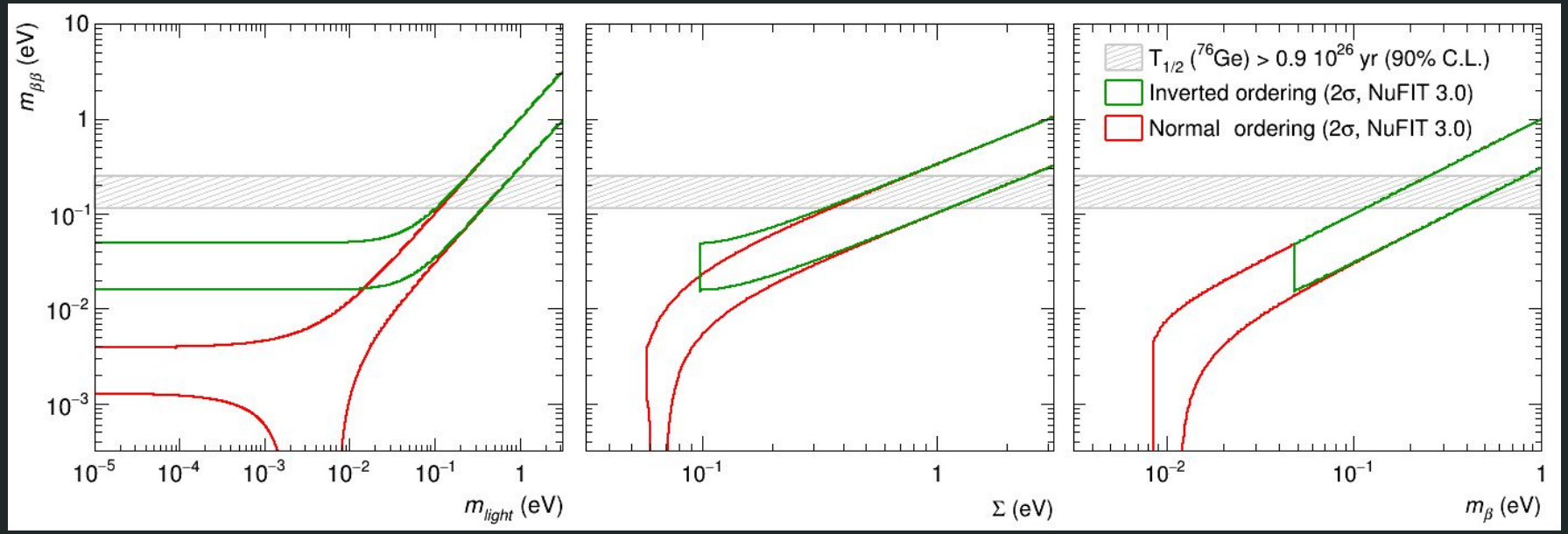
Statistical analysis

Phase I & II combined fit:

- ➢ frequentist unbinned likelihood
- ➢ simultaneous fit of 7 data sets
- ➢ best fit for **no 0νββ signal**
- ➢ $\mathbf{T^{0\nu}_{1/2} > 0.9\ 10^{26}\ yr}$ (90% C.L.)
- ➢ sensitivity $\mathbf{T^{0\nu}_{1/2} > 1.1\ 10^{26}\ yr}$
- ➢ $m_{bb} < (0.11 - 0.25)$ eV



Implications for neutrino physics



- ➢ Degenerate Majorana masses probed!
- ➢ Next target inverted ordering band
- ➢ 0νββ searches, cosmological surveys and direct mass measurements give complementary information!

Outlook

GERDA: high-resolution & background-free search for $0\nu\beta\beta$ in ^{76}Ge:

$BI = 6\ 10^{-4}$ cts / (keV kg yr)

$\Delta E < 0.1\%$ at $Q_{\beta\beta}$

GERDA probed $T_{1/2}$ values at the 10^{25} yr scale. Pioneering exploration of the 10^{26} yr scale!

GERDA keeps taking data. LEGEND-200 is in preparation to reach $T_{1/2}$ above 10^{27} yr