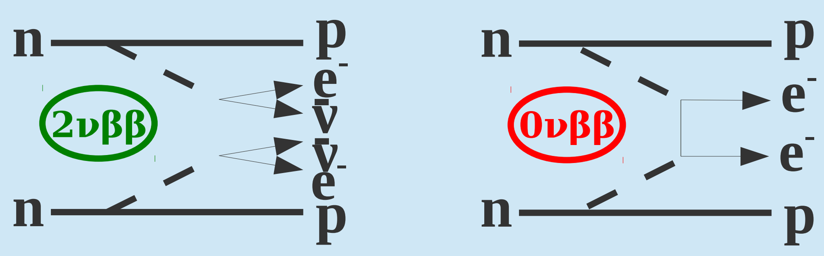
Keeping the background low

The GERDA Phase II detectors

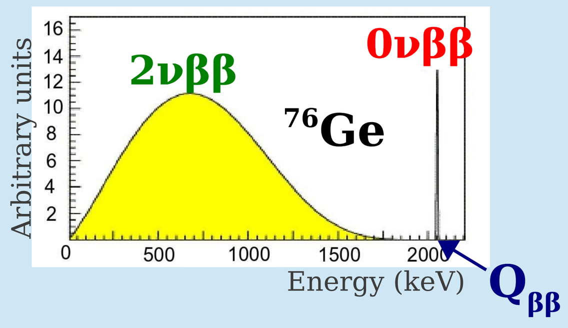
S. Hemmer for the GERDA collaboration
Università di Padova and INFN Padova

Searching for neutrinoless double beta decay (0νββ) with the GERDA experiment

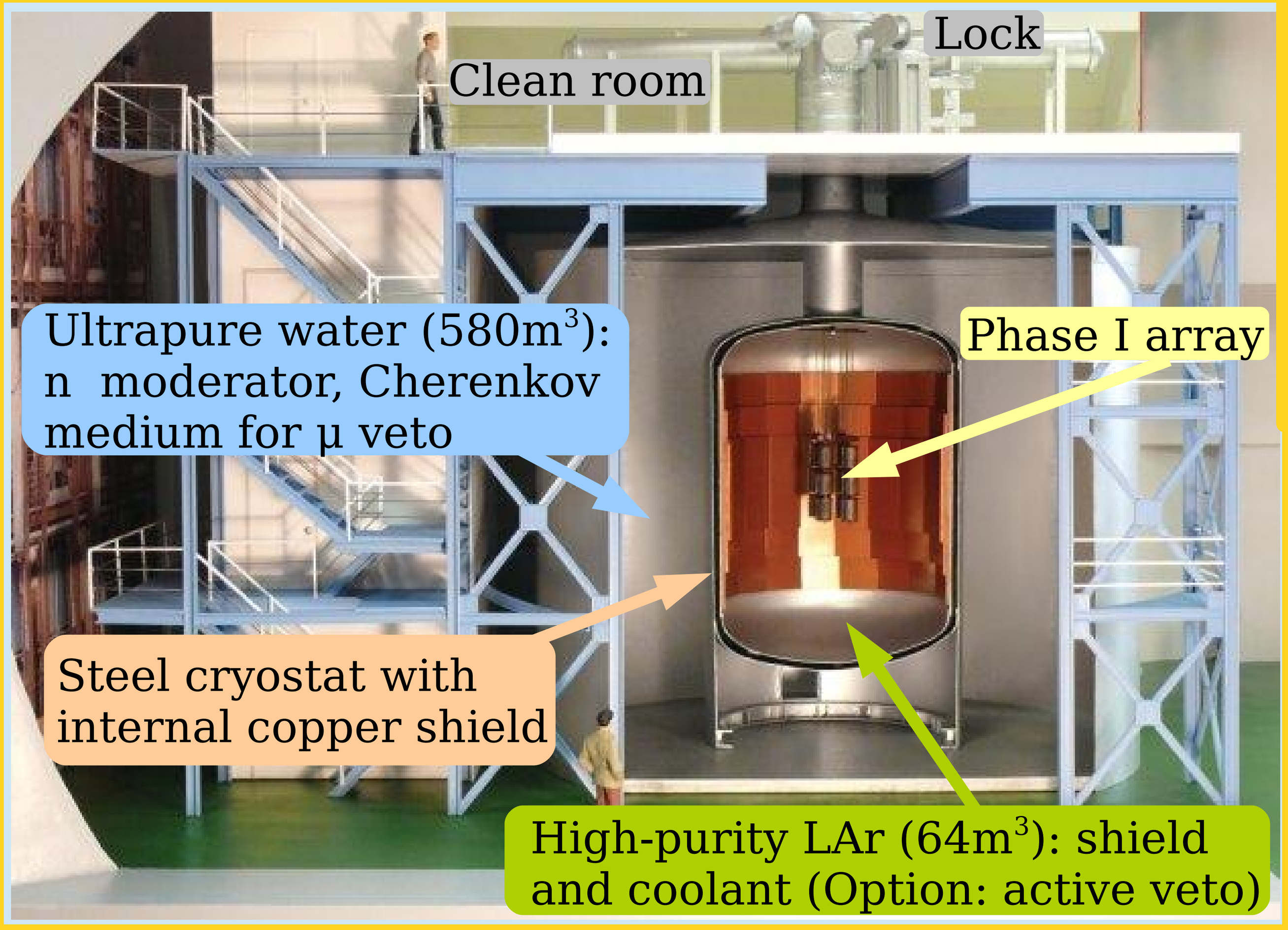


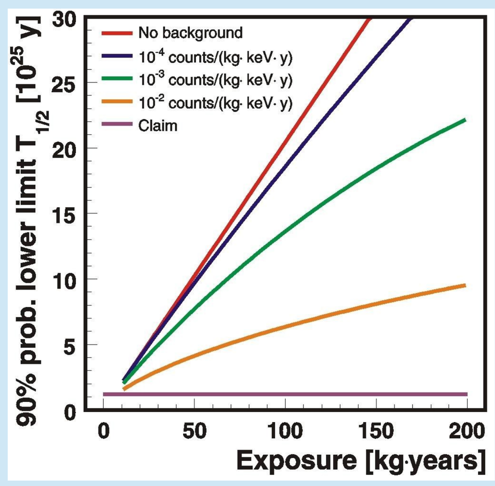
If 0νββ observed:

- Lepton number violation ΔL=2
- Neutrino has a Majorana mass term
- Sheds light on absolute neutrino mass scale
- Sheds light on neutrino mass hierarchy



GERDA Collab., Eur. Phys. J. C 73 (2013) 2330
GERDA Collab., J. Phys. G: Nucl. Part. Phys. 40 (2013) 035110



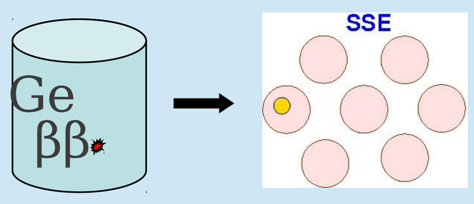


Background reduced by:

- GERDA situated in LNGS underground laboratories: suppression of cosmic ray muons by factor 10^6 by overlaying rock
- Graded shielding against ambient radiation
- Rigorous material selection
- Avoid exposure of detectors to cosmic radiation
- Anti-coincidence between detectors

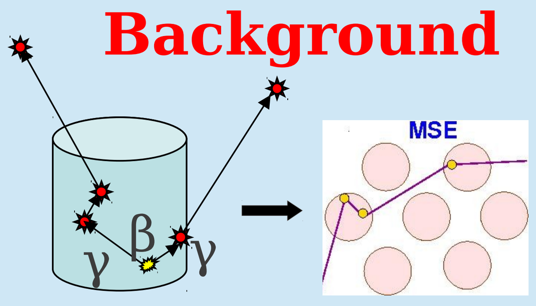
New detectors for GERDA Phase II: Broad Energy Germanium (BEGe) detectors for improved Pulse Shape Analysis (PSA)

Signal



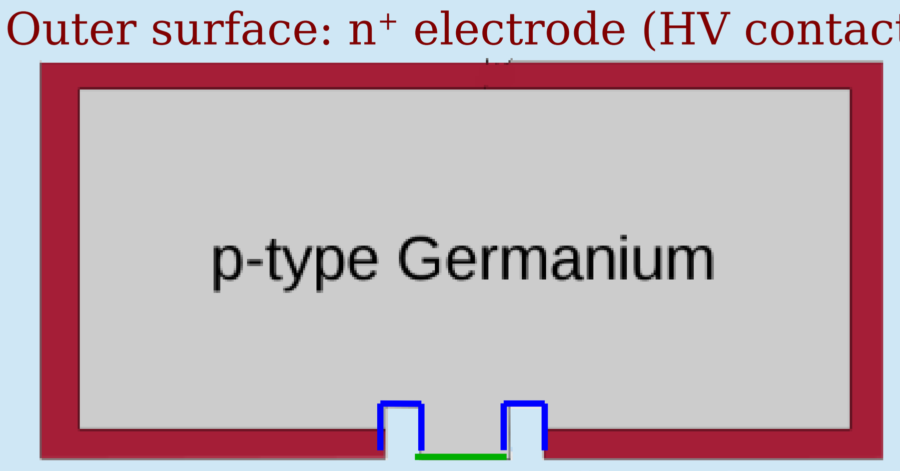
Point-like (single-site) energy deposition inside one Ge diode (Range: ~ 1mm)

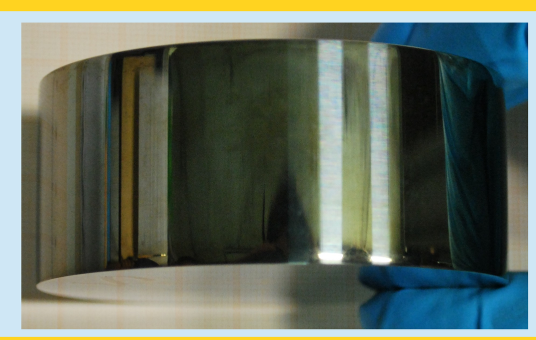
Background



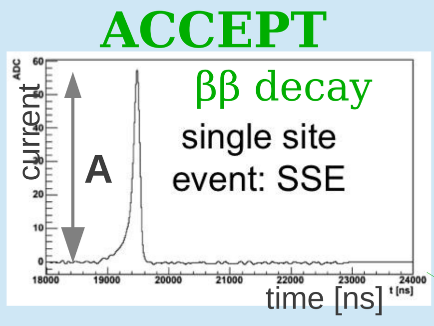
Multi-site energy deposition inside Ge diode (Compton scattering)

BEGe detector: strongly non-linear field allows improved PSA

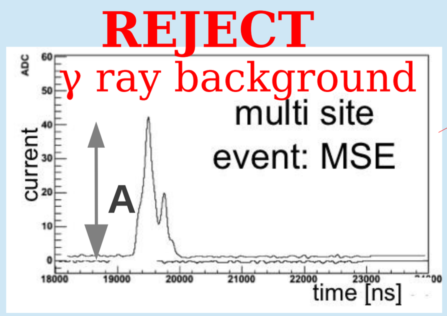


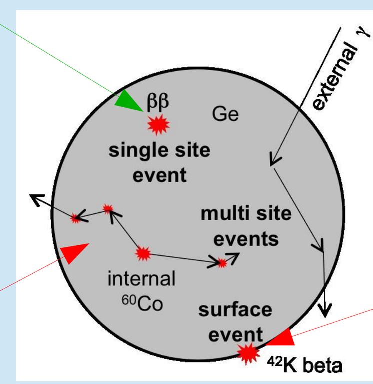


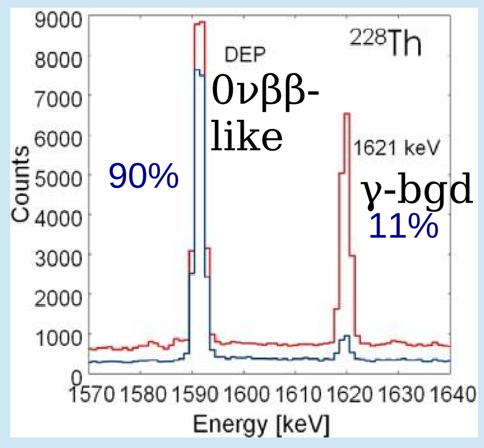
ACCEPT



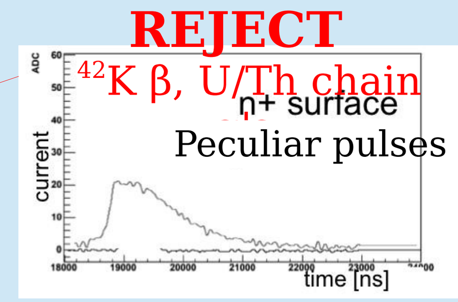
REJECT







REJECT



Selection of articles:
D. Budjas et al., JINST 4 (2009) P10007
M. Barnabé Heider et al., JINST 5 (2010) P10007
M. Agostini et al., JINST 6 (2011) P03005
M. Agostini et al. JINST 6 (2011) P04005

The BEGe production and test chain: a logistical challenge

Fast neutrons in cosmic rays produce radio-isotopes in Germanium via spallation reactions (^{60}Co, ^{68}Ge)
Problem: Decays of cosmogenic radio-isotopes mimic signal events
Solution: Minimize exposure of Germanium to cosmic radiation by

- Underground storage
- Transport in shielded containers

Production of enriched $^{76}GeO_2$ at ECP Zelenogorsk, Russia

Crystal pulling and zone refinement at Canberra in Oak Ridge, USA

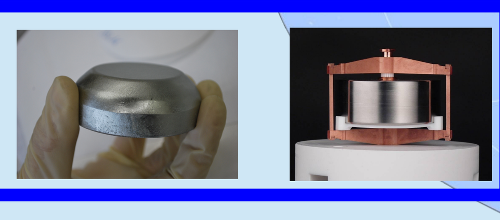
Underground storage in Cherokee Caverns, Knoxville

Water and steel shielding for transport

Metal reduction and zone refinement at PPM in Langelsheim, Germany

Underground storage in Rammelsberg Mining Museum

Diode production at Canberra in Olen, Belgium



Hades Experimental Research Of Intrinsic Crystal Appliances (HEROICA):
Detector characterization tests at HADES underground facility in Mol, Belgium

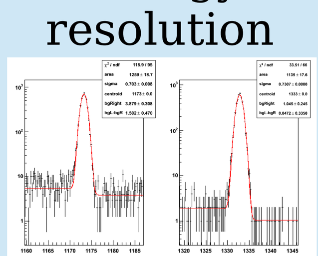
Automated scanning measurements of top and lateral surface with collimated ^{241}Am source:

- Charge collection efficiency
- Homogeneity of dead layer
- Position dependence of pulse shapes

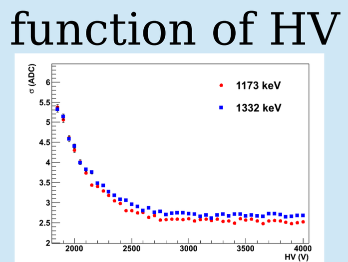
Fixed uncollimated sources:

- ^{60}Co: energy resolution, HV scan, active mass measurement
- ^{241}Am and ^{133}Ba: dead layer thickness
- ^{228}Th: PSA parameters

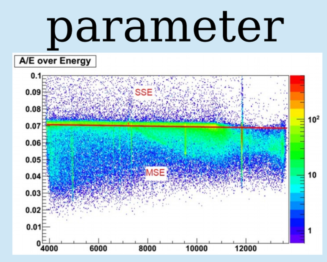
Energy resolution



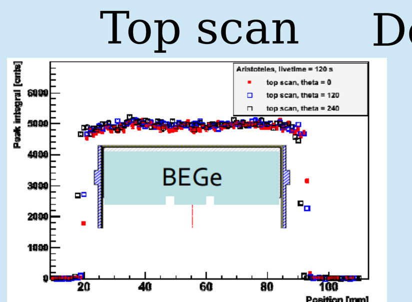
Resolution as function of HV



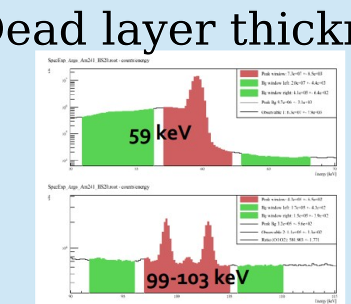
PSA parameter

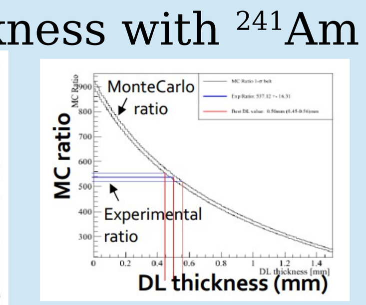


Top scan



Dead layer thickness with ^{241}Am





E. Andreotti et al., "HEROICA: an Underground Facility for the Fast Screening of Germanium Detectors" submitted to JINST (arXiv: 1302.4277)
D. Budjas et al., "Isotopically modified Ge detectors for GERDA: from production to operation" submitted to JINST