TG10 Status Report

L. Pandola

INFN, Laboratori Nazionali del Gran Sasso

for the TG10 Task Group

Gerda Collaboration Meeting, Padova

March 11th-13th, 2009

Outlook of TG10 activities

The main activities currently carried on by the TG10 group are:

➢ **Monte Carlo Campaign 2 (MCC2)** [LNGS, MPPMU, Tübingen, Zürich] for the estimate of a realistic background spectrum for GERDA. Simulations are based on MaGe.

Major effort within TG10.

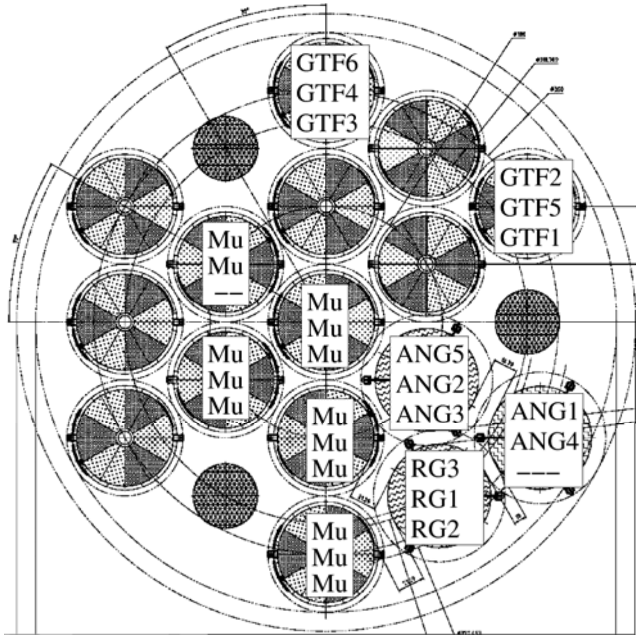
➢ **Dedicated simulations** [LNGS, Tübingen, INR] for specific background sources (e.g. ^{222}Rn emanation in the cryostat, Cherenkov μ veto, external γ-rays), also in coordination with other TGs.

➢ **Pulse shape simulation** [MPPMU], including comparison with experimental data with Munich prototypes.

Reminder of MCC2

- Get expectation of full energy spectrum of both phases of GERDA

- Array set up, crystals:
  - 6 x GTF (natural Ge)
  - 5 x ANG + 3 x RG (enr. Ge)
  - 14 x segmented (enr. Ge) [Phase II]



- Various physics processes contributing to the energy spectrum are simulated using MaGe (Geant4)
- **Main contributions** of energy depositions in Crystals:
  - Contamination of materials
  - Neutrons-induced
  - Muon-induced

From MaGe n-tuples to energy spectrum

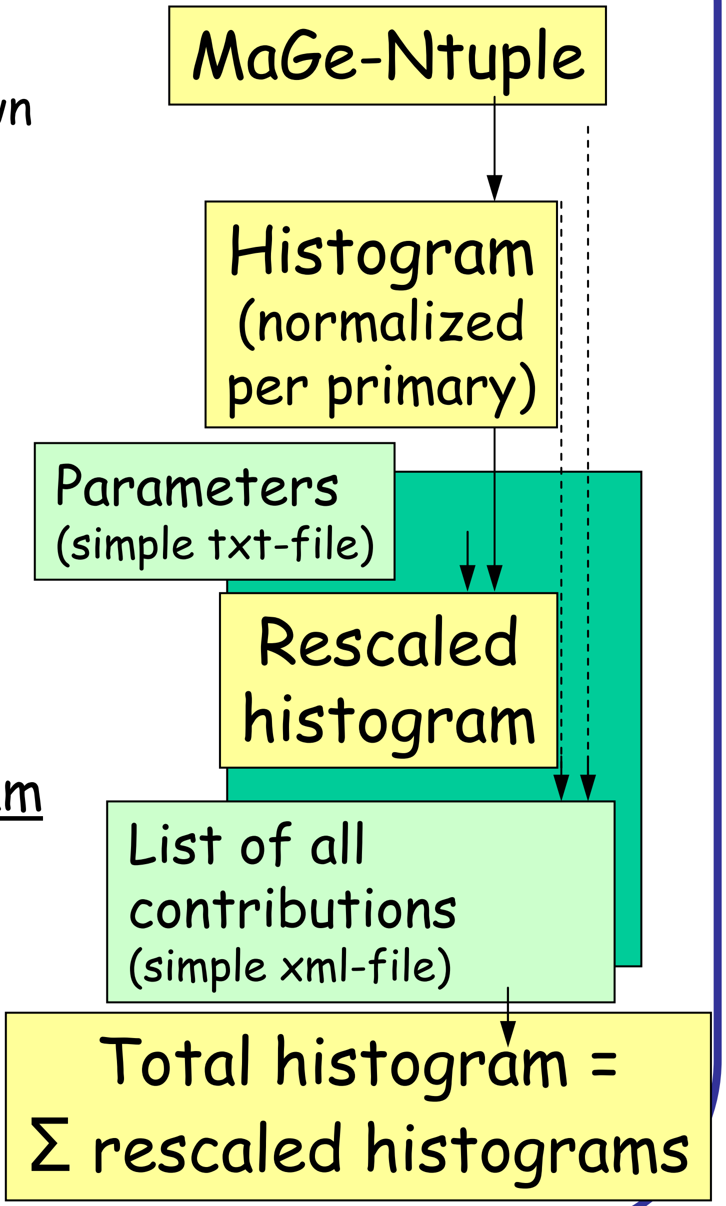
Many contributions have to be considered:
- each volume (cable,holder,screw,etc) has its own set of background sources
- some volumes may be grouped, but still: **very long list of contributions**

For each elementary contribution:

- ntuple of deposited energies produced by MaGe
- apply smearing to each energy deposition
- create standard histograms normalized per primary particle

Obtain individual contribution to energy spectrum by rescaling of normalized histogram
- needs **parameters**, e.g. start/end date of data taking, crystal masses, isotope fractions, contaminations, etc

Framework for clear book-keeping necessary:
- one **common parameter set** for all histograms
- better overview to list of all contributions



Features of the framework

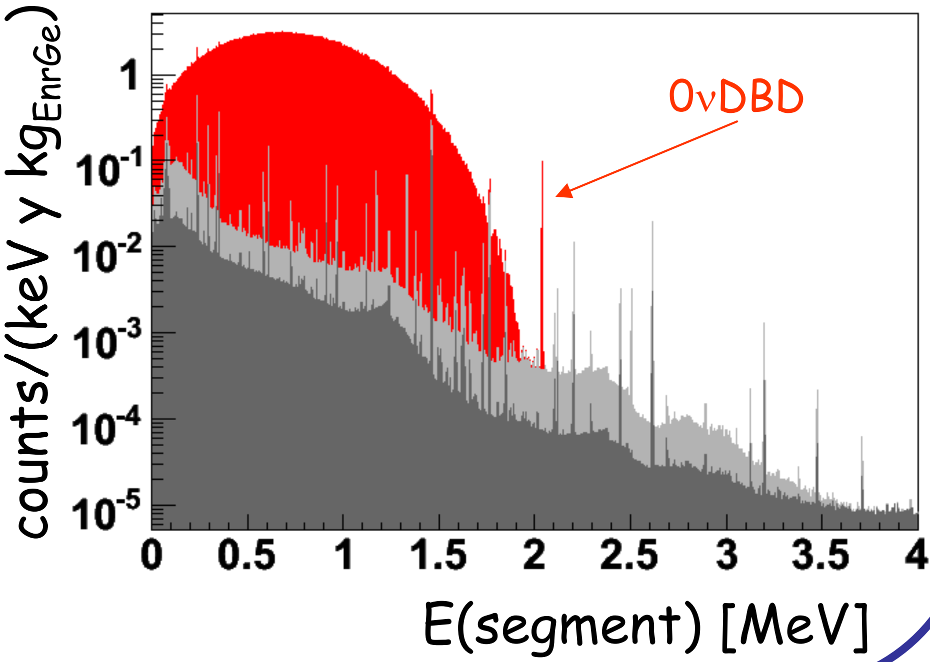
• Two input files *parameters.txt* and *BGList.xml* define the resulting energy spectrum

• **simple editing** of the two input files to play around with contributions and parameter values (e.g. change contamination of one item)

Example: Contributions from Holders (Phase II)

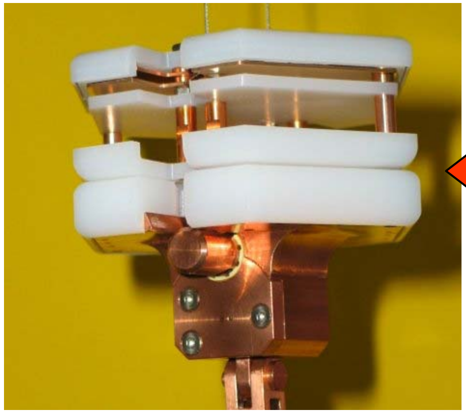
Includes:

- 2νDBD and 0νDBD in 28 crystals ($T_{1/2}$ = $1.74 \cdot 10^{21}$ and $1.2 \cdot 10^{25}$ y)
- All copper parts of all 28 holders. **Upper Limits** for ^{232}Th, ^{238}U, ^{40}K, ^{60}Co
- All teflon parts of all 28 holders. **Central Values** for ^{232}Th, ^{238}U, ^{40}K (if positive identification!)



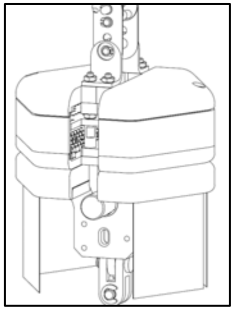
Features of the framework

Example: Contribution from Matrix (Phase II):



The 28 detectors are held in 10 strings

10 x



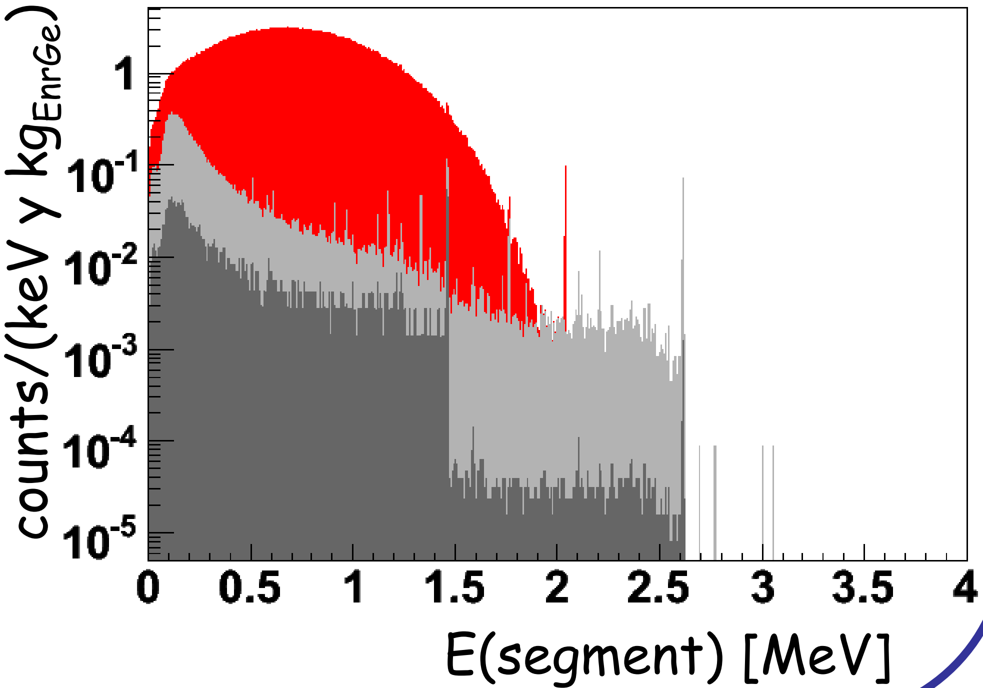
On top of each string: Cables, contact pins, PreAmps, etc.

DBD in 28 crystals

All materials:
copper, commercial copper screws, teflon, iglidur, murtfeldt contact pins (Pogo pins) with ^{232}Th, ^{238}U, ^{40}K, ^{60}Co contamination values

upper limits

central values (for isotopes with **positive detection**!)

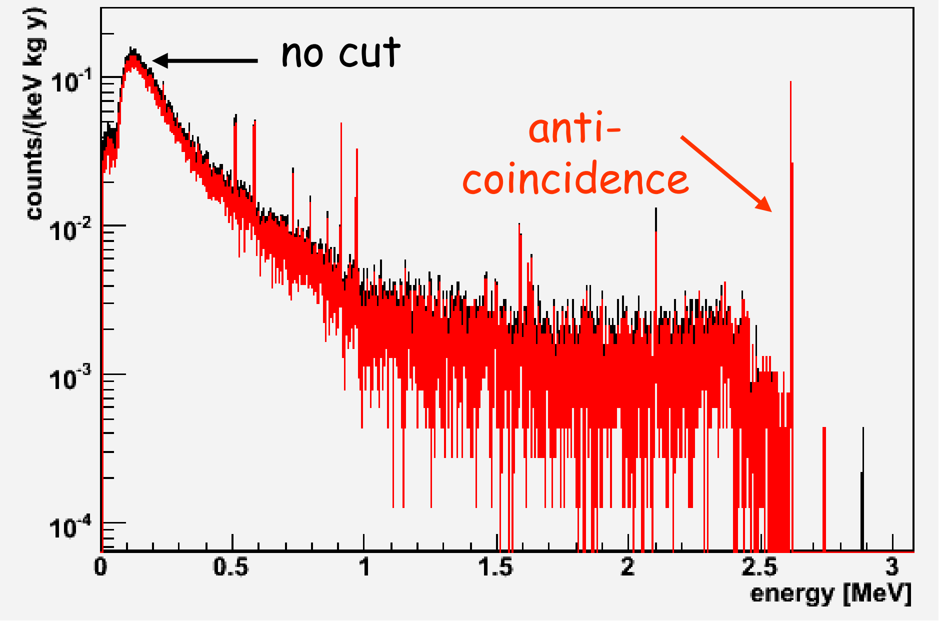


Coordination with TG3 & TG11

PCBs to be used for Phase I are under definition and optimization → also **material screening** ongoing

Monte Carlo simulations (Phase I array in MCC2, 5 strings) to determine the maximum tolerable activity and/or the minimum distance to the crystal array.

8 ^{enr}Ge crystals + 6 GTF crystals (anti-coincidence only)



For boards placed 30 cm above the uppermost crystal in each string and 0.5 mBq/piece in ^{232}Th

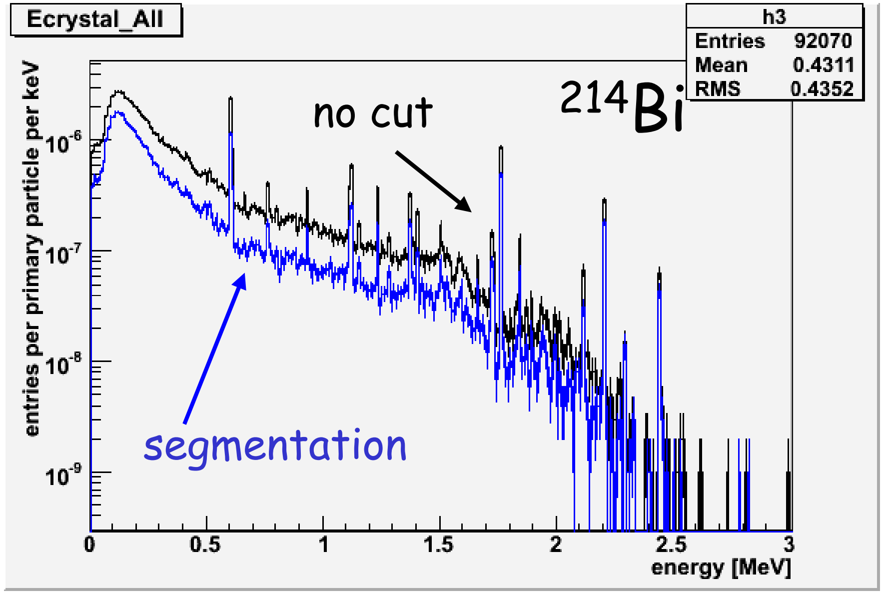
→ **$1.2 \cdot 10^{-3}$ cts/(keV·kg·y)** at $Q_{\beta\beta}$ (can be reduced by ~25% by crystal anti-coincidence)

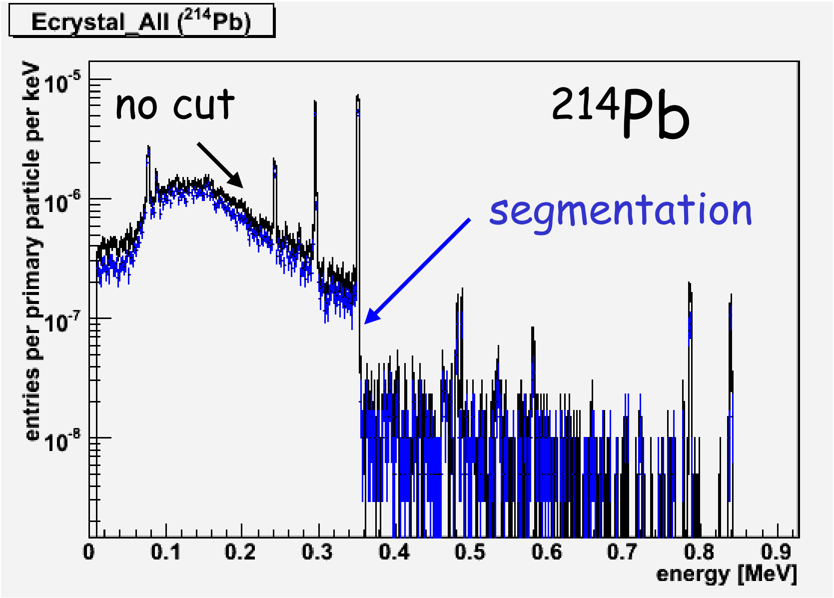
Background from ^{222}Rn in LAr

Recent measurements of the ^{222}Rn cryostat emanation, ~30 mBq, triggered a new Monte Carlo campaign for the background estimate → simulated the effect of ^{222}Rn daughters (^{214}Bi and ^{214}Pb) for the Phase I and Phase II arrays

MCC2 assumptions for threshold (10 keV core & segments), dead layer (0.8 mm for existing p-type detectors and negligible for n-type) and energy resolution: 2.5 keV FWHM at 1333 keV line.

Phase II array [uniform ^{222}Rn distribution]:

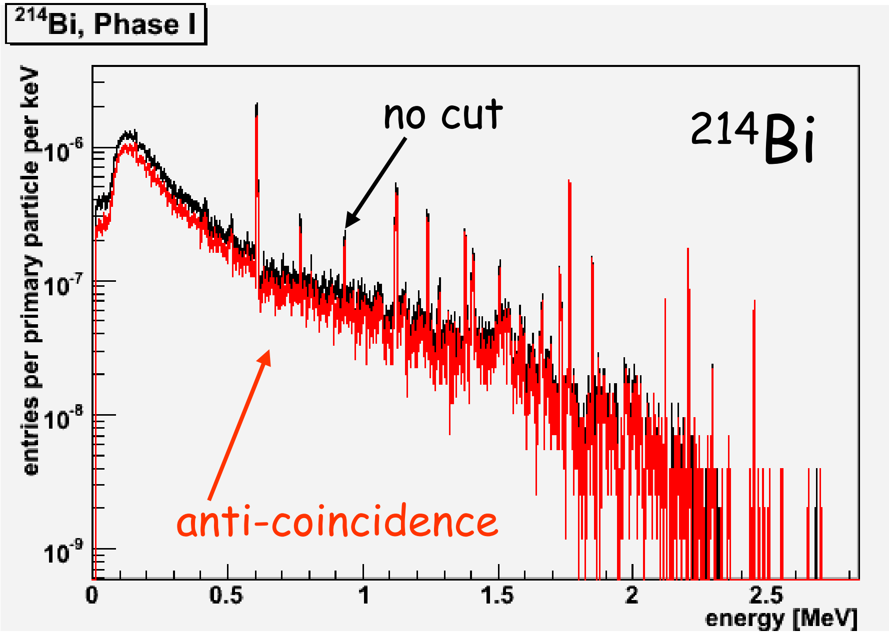




Segmentation cut: factor ~2 at $Q_{\beta\beta}$

Background from ^{222}Rn in LAr

Phase I array [uniform ^{222}Rn distribution]:



effect of the anti-coincidence is negligible (15% at $Q_{\beta\beta}$)

Uniform ^{222}Rn distribution in LAr is **not** a realistic assumption → convection concentrates ^{222}Rn close to detectors

Expected background for 30 mBq ^{222}Rn **uniformly** in LAr:

PhaseI → $4.0 \cdot 10^{-4}$ cts/(keV·kg·y) (no cut),

$3.5 \cdot 10^{-4}$ cts/(keV·kg·y) (anti-coincidence)

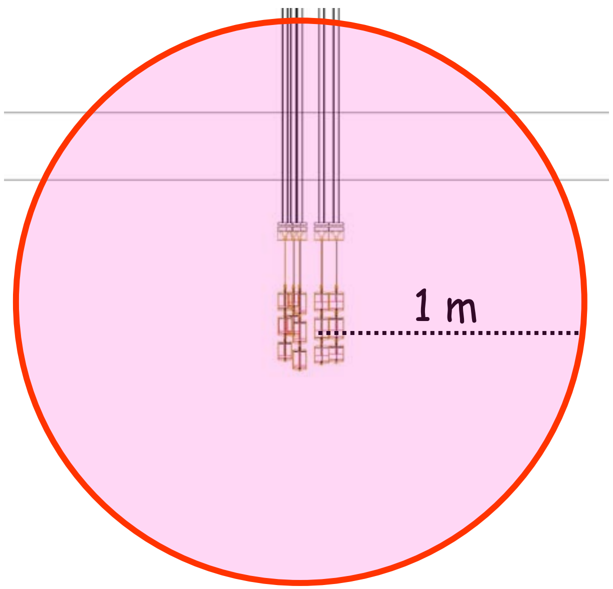
Phase II → $3.0 \cdot 10^{-4}$ cts/(keV·kg·y) (no cut),

$1.4 \cdot 10^{-4}$ cts/(keV·kg·y) (segment anti-coincidence)

Range of a few 10^{-4}

Background from ^{222}Rn in LAr

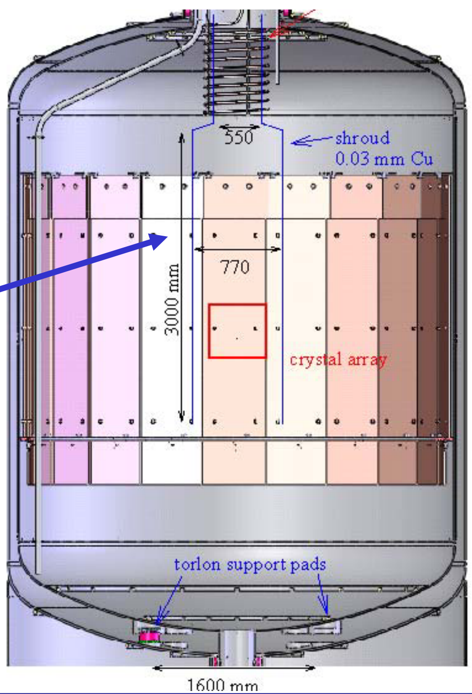
Study to evaluate the effect of ^{222}Rn close to the detectors → define the possibility to have a cylindrical shroud surrounding the crystals (GSTR-09-001). Simulations for Phase I.



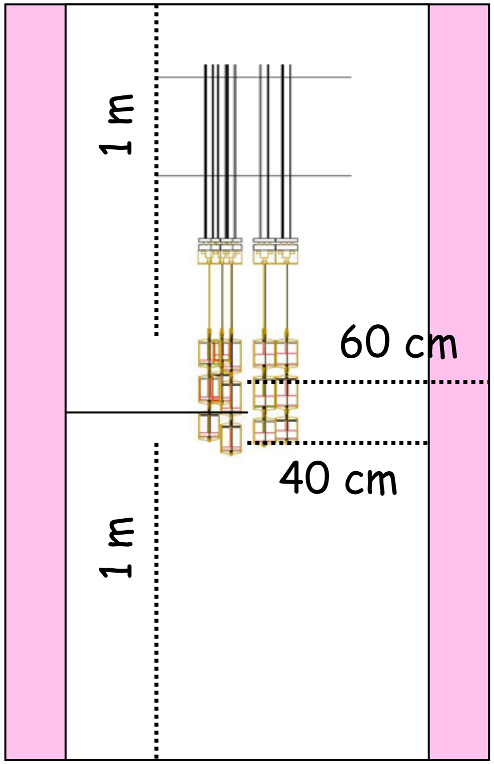
Convection concentrates ^{222}Rn in a cylinder of radius ~tens of cm centered in the array. Notice: if 30 mBq were concentrated in a sphere of r = 1 m around the crystal array → $5.0 \cdot 10^{-3}$ cts/(keV·kg·y)

definitely too large!

With the proposed shroud (30 μm Cu), ^{222}Rn would be re-directed within a cylindrical shell of inner radius ~40 cm and outer radius ~60 cm → decays > 40 cm from the crystals



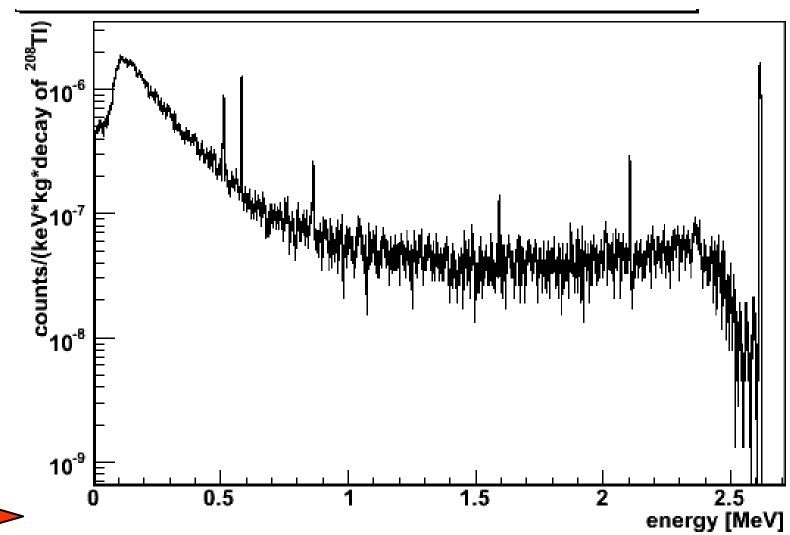
Background from ^{222}Rn in LAr



Simulated ^{214}Bi decays in a cylinder shell having radii 40 and 60 cm, and height ±1 m with respect to the crystal array (decays > 1 m do not contribute)

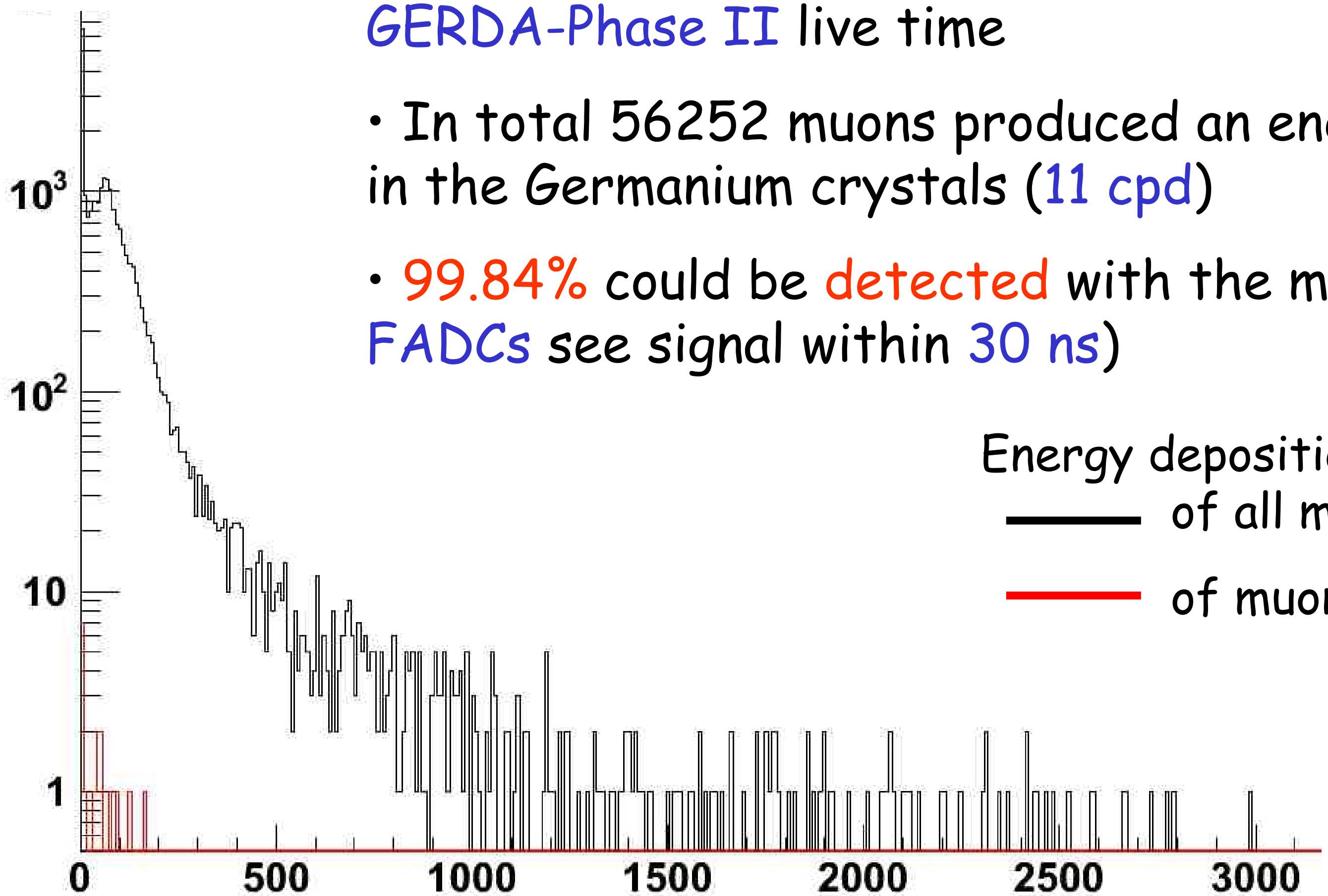
Assuming h=6 m for the convection layer → background at $Q_{\beta\beta} = 1.4\cdot10^{-4}$ cts/(keV·kg·y) for 30 mBq of ^{222}Rn → **acceptable!**

One also has to check for the background possibly induced by the Cu shroud because of ^{208}Tl contamination: for 20 μBq/kg in ^{232}Th contribution is $3\cdot10^{-5}$ cts/(keV·kg·y) → OK



Muon veto simulations

- Spectrum obtained from 14 years of simulated GERDA-Phase II live time
- In total 56252 muons produced an energy deposition in the Germanium crystals (11 cpd)
- 99.84% could be detected with the muon veto (3 FADCs see signal within 30 ns)



Efficiency: 99.56% with 4-fold FADC coincidence (30 ns)

Calculation of γ-ray background

Recalculated γ-ray background from stainless steel cryostat and external γ-rays (with the full geometry, including Cu layer) using the **home-made** fast simulation code developed by INR
→ cross check of results that will be obtained also with MaGe-MCC2

Simulated 2.6-MeV γ-rays from ^{208}Tl. Assumed ... Bq/kg in ^{232}Th from the cryostat stainless steel

Phase I array (9 crystals), LAr filling, anti-coincidence

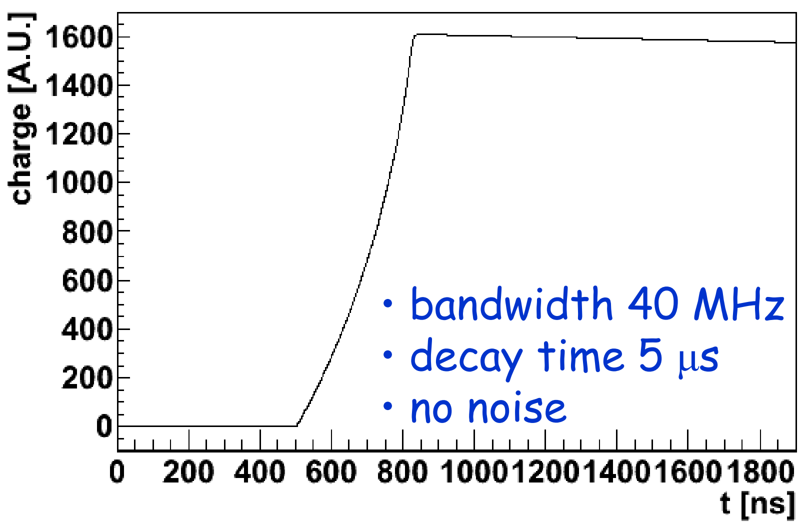
- cryostat: $1.2 \cdot 10^{-5}$ cts/(keV·kg·y) ± 20%
- external: $7.7 \cdot 10^{-6}$ cts/(keV·kg·y) ± 40%

Background mainly comes from sides (cylindrical part) and from the bottom

Validation of pulse shape simulation

Available a tool for **pulse shape simulation** (Munich) →
C++ based and fully interfaced with MaGe

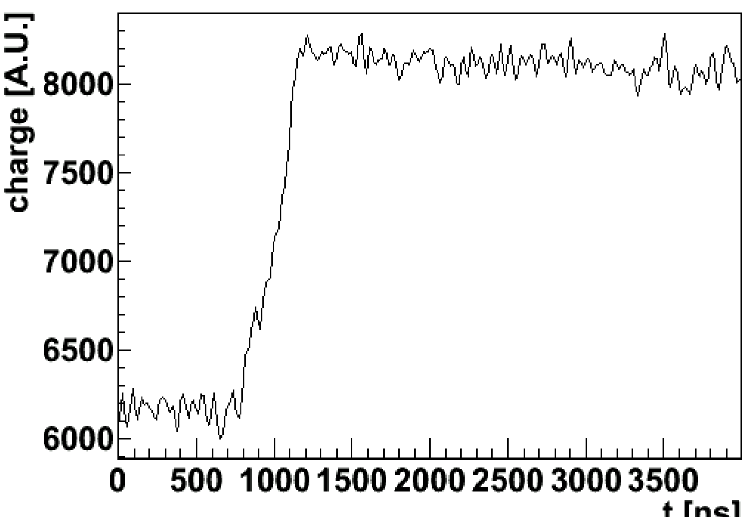
Simulated core pulse for Munich 18-segment prototype



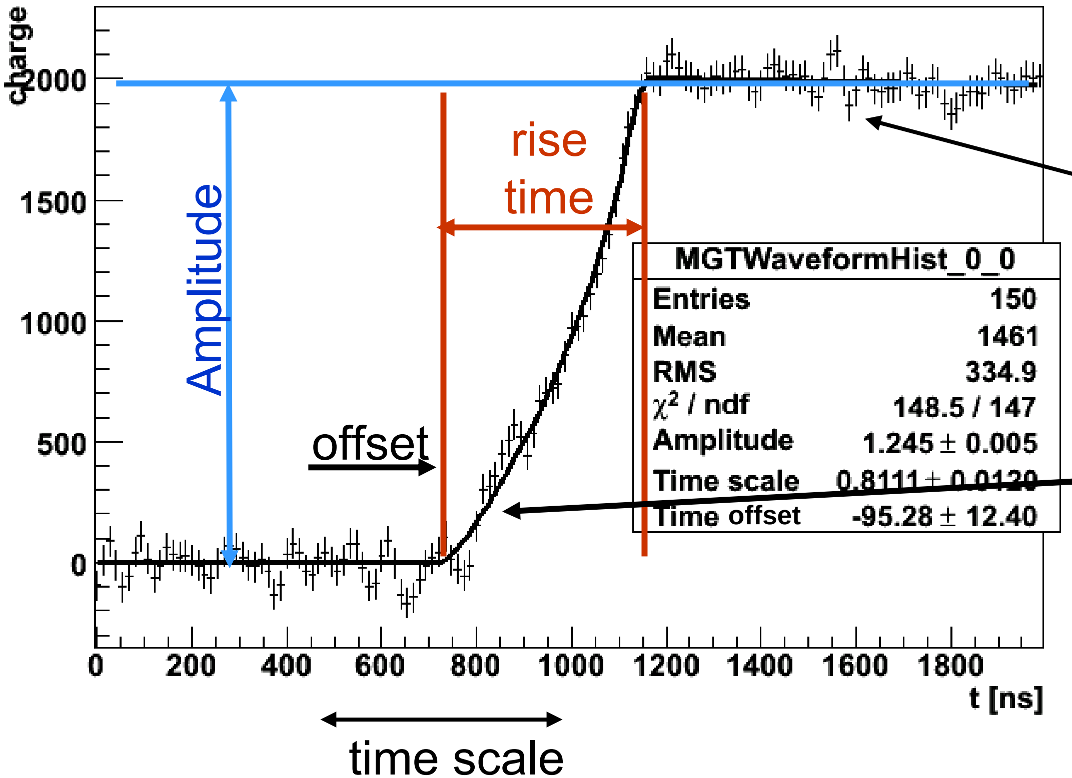
Understand the effects of physics (e.g. impurities, axis displacement) and of electronic chain (noise, etc.)

Necessary to **validate** the pulse shape simulation against experimental data

Real core pulse from the same detector



Fit of a simulated pulse on a real one



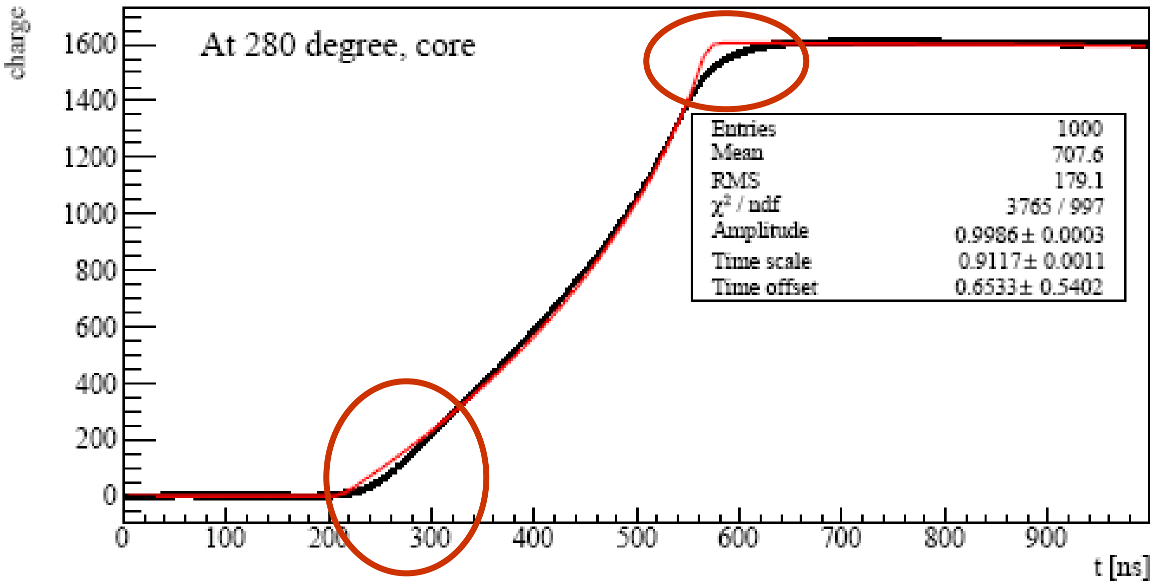
Real pulse:
- dots with error bars
- error is set according to noise fluctuations

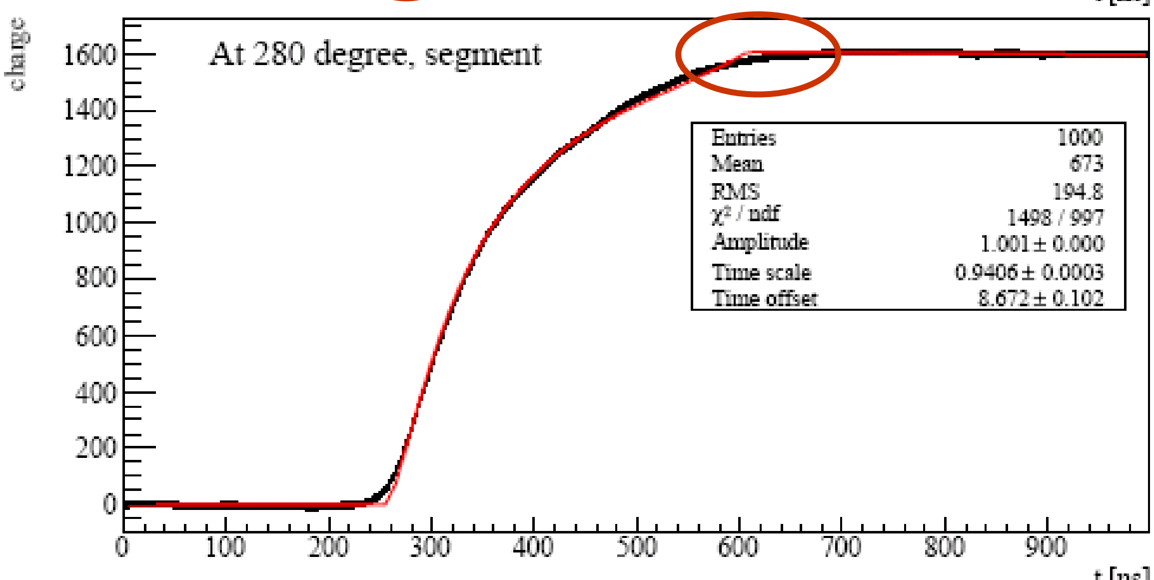
Simulated pulse:
- smooth line

3 free parameters in the fit: amplitude, time scale, time offset

Results are in **good agreement**. To have better clue (especially on fine structures): **average real pulses** to cancel the effect of noise

Fit simulated pulses to averaged pulses





Red: simulated

Black: data

Bad χ^2 of the fit especially close to the segment boundaries → need to understand and **refine** the model for simulation (impurity effects?)

Conclusions

The **activity** of the Monte Carlo Working Group on simulations and background studies continues **regularly**

The **main effort** at the moment is the Monte Carlo Campaign 2 (**MCC2**), aiming to estimate a realistic background spectrum from GERDA → prepare **machinery** and tools for **combining** parameters and simulations in a consistent way (a lot of work!)

Other Monte Carlo studies are ongoing on **dedicated issues** (also with other codes than MaGe): ^{222}Rn emanation, μ veto, γ-rays from cryostat and walls

Activity for the development and **validation** of **pulse shape simulation is going on**. It is interfaced to with MaGe, to have the full simulation chain