GeMPI-Neo
A next generation screening station

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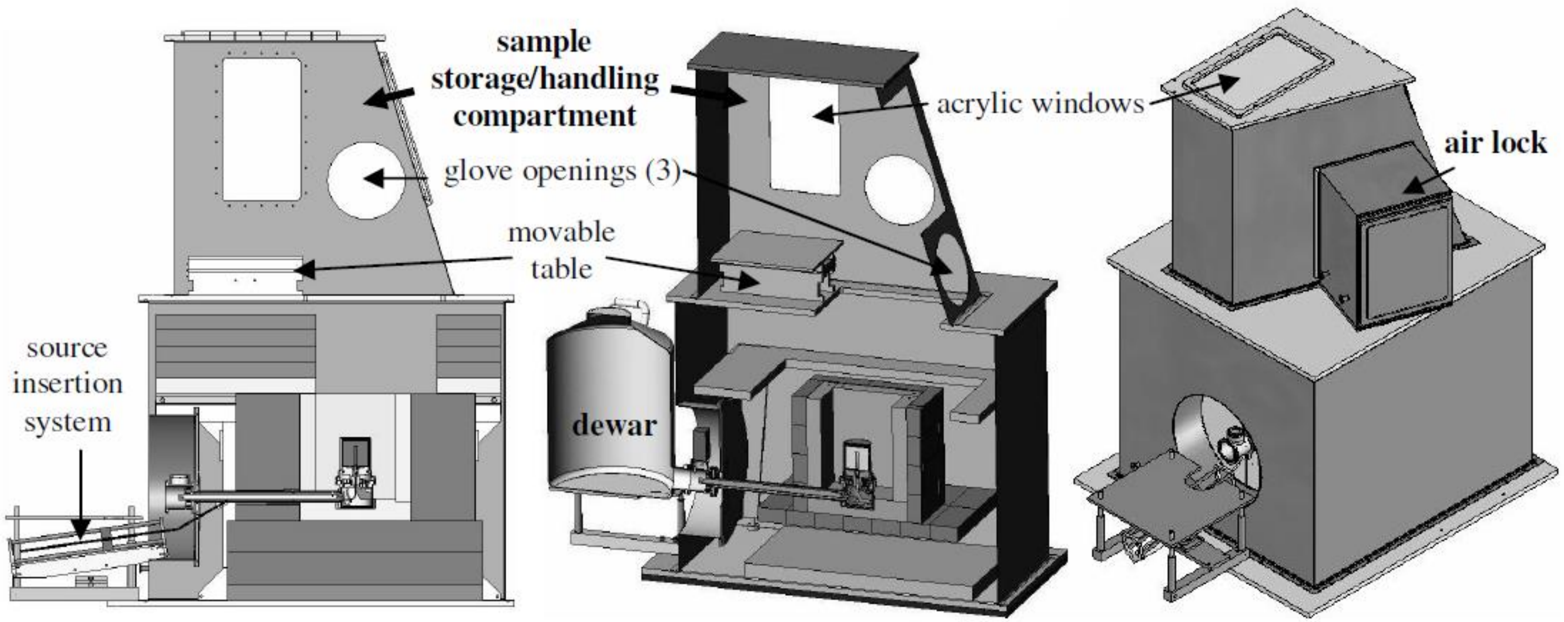
The GeMPI detectors

- 4 setups with highly sensitive Germanium spectrometers (active mass: 2.2 – 2.4 kg) (3* MPIK, 1* LNGS in close collaboration)
- Used for screening of materials for low background experiments
- Located at a depth of 3800 m w.e.
- Sensitivity for U and Th:

  ~ 10 µBq/kg

Basic detector design:

- 20 cm lead shield
- 5 cm copper shield
- Sample chamber flushed with Nitrogen gas
- Ge diode inside ultra low background copper cryostat



Background rate in low background material screening – a small comparison

Detector	Location	Background rate in 40 – 2700 keV [cts/d/kg]
GeMPI 1	LNGS, Italy	142 ± 1
GeMPI 2	LNGS, Italy	38 ± 1
GeMPI 3 **	LNGS, Italy	24 ± 1
GeMPI 4	LNGS, Italy	71 ± 1
GeOroel	Canfranc, Spain	103 ± 1 *
Gator	LNGS, Italy	65 ± 1
GeRysi	Canfranc, Spain	~ 38
GeMSE	Switzerland	164 ± 2 *
BUGS	Boulby Underground Laboratory, UK	90 ± 9
Ge02	Kamioka Observatory, Japan	~ 84

* In 100 – 2700 keV ** latest GeMPI to be built

Updates for GeMPI-Neo

Primary goal for update:
Increase of sensitivity

Increase of active volume

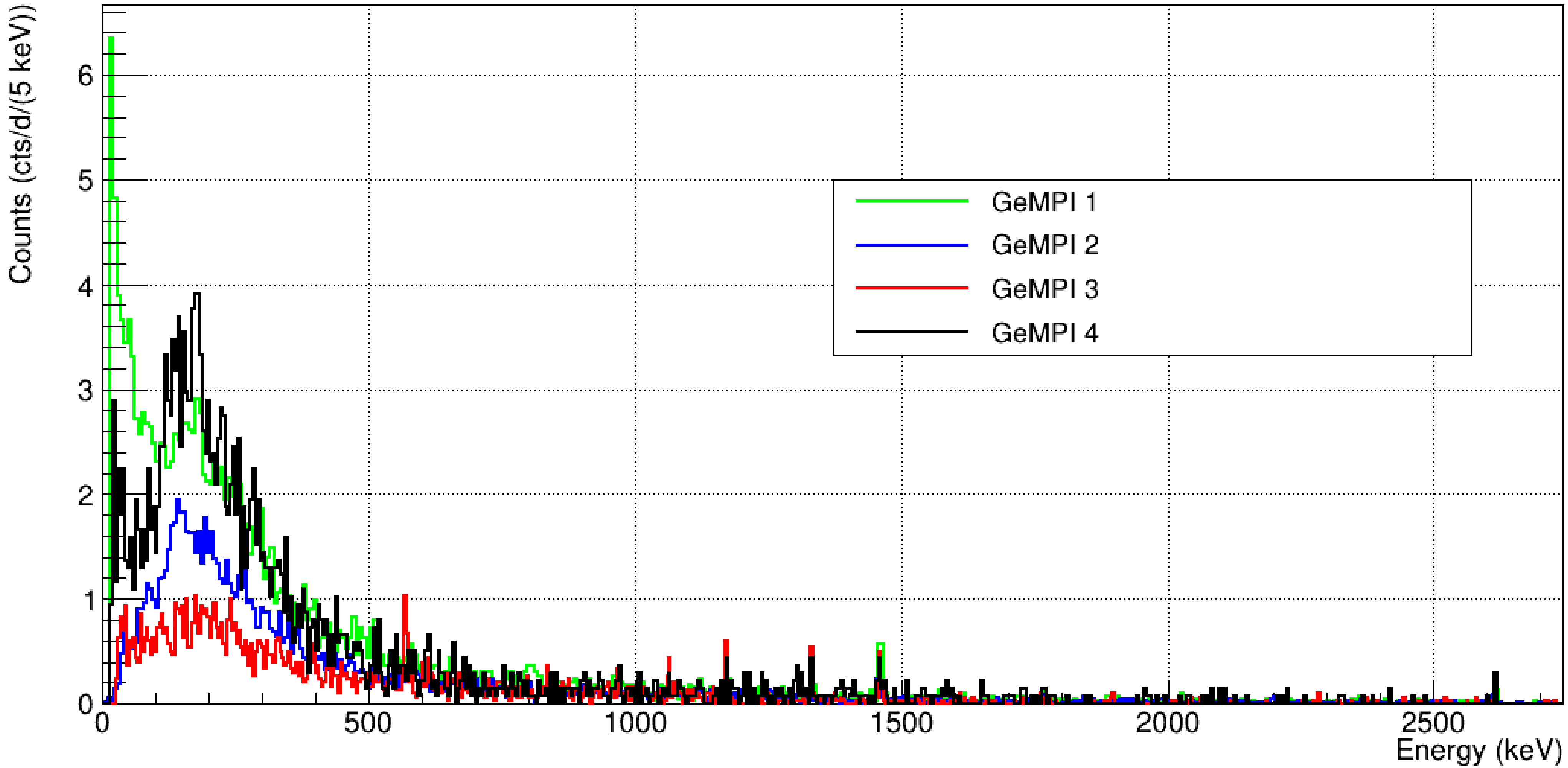
- Employ two Ge crystals

Decrease of background

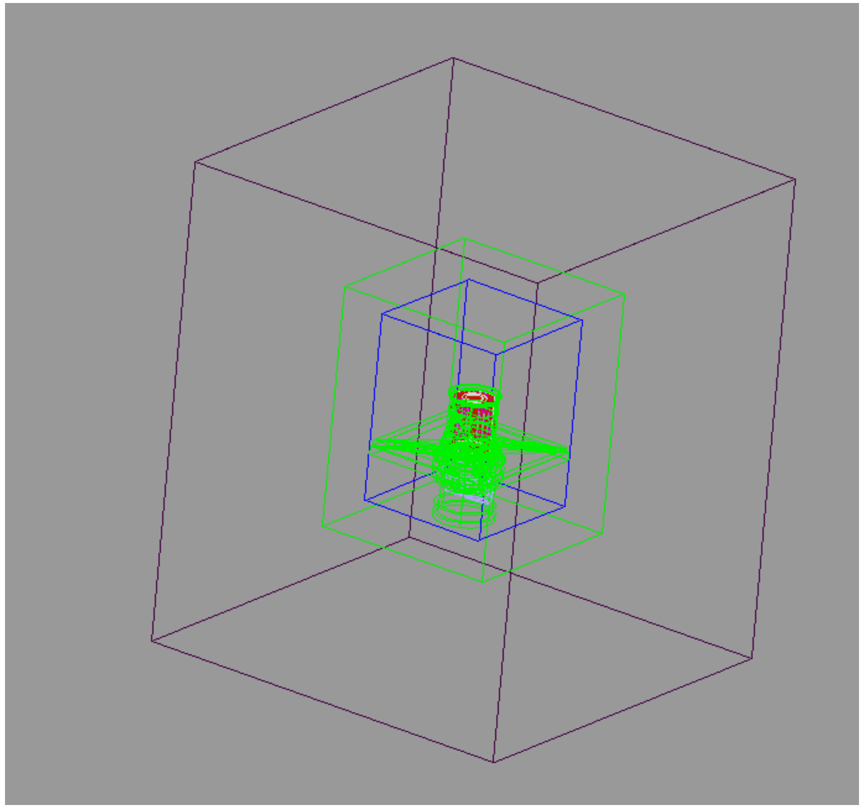
- Updated shield design
- Muon Veto?
- Neutron shielding?
- New setup of Pb layers?

GeMPI-Neo

Background of current GeMPIs



Updated shield design – MC simulations



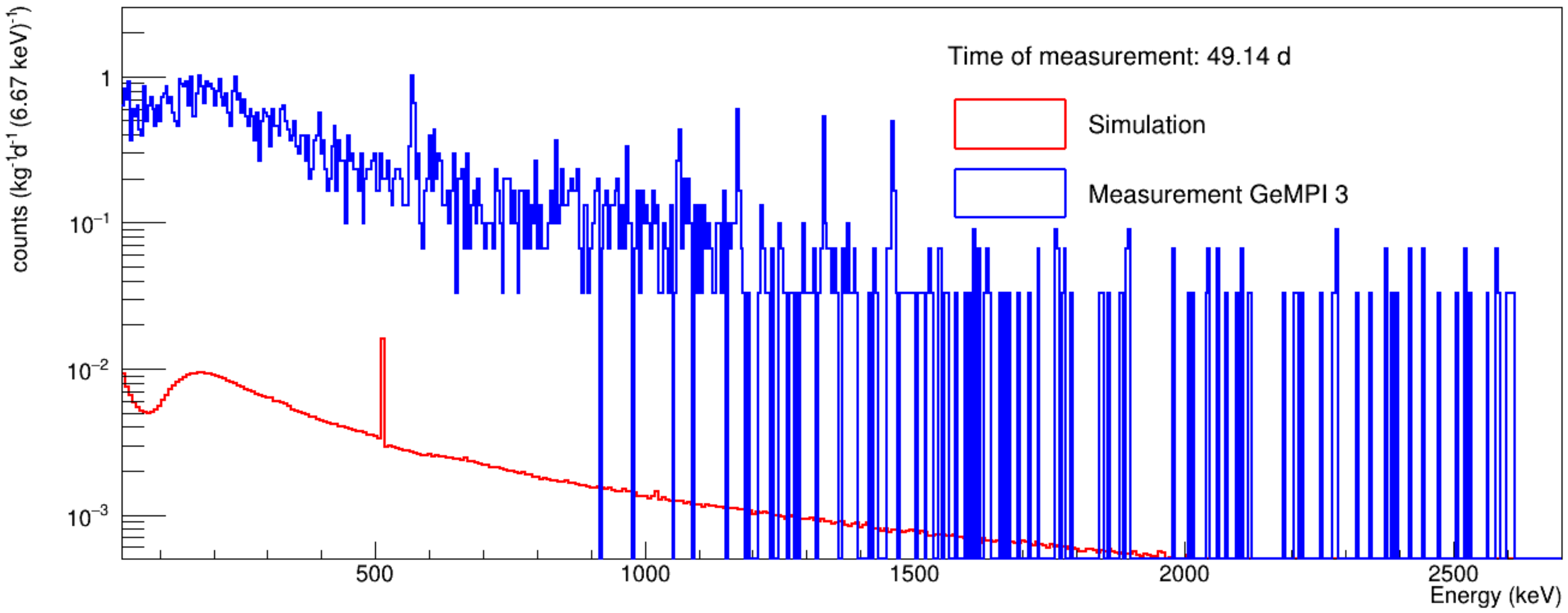
- **Goal**: Decomposition of full Bkg. Spectrum
  → find possible areas of improvement
- Use MaGe based on Geant4, developed for Majorana and Gerda experiment
- Major background sources to simulate:

  - Cosmic ray muons

  - Neutrons (muon-induced and from nat. radioactivity)

  - Contaminations of shielding materials (Th232, U238, Co60, K40, Pb210 ...)

Muon Veto for GeMPI-Neo?

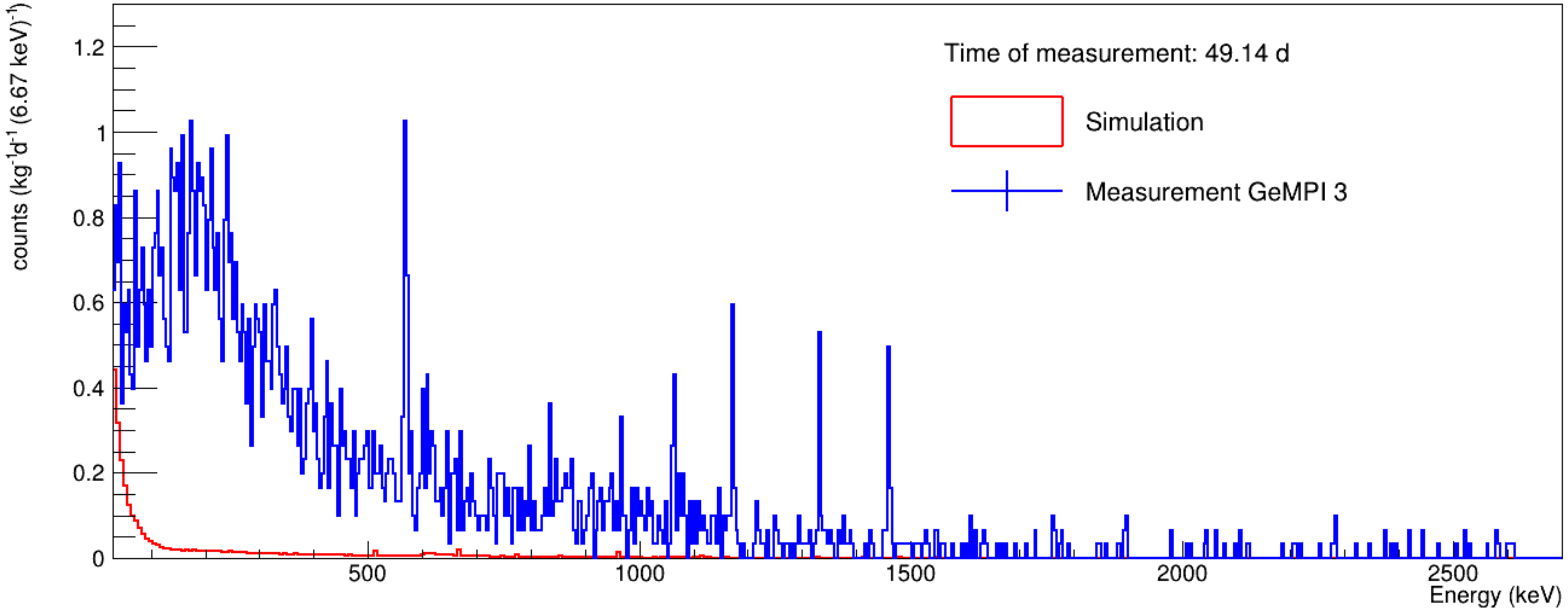


- Muons only contribute to a small part of the GeMPI background

→ Muon veto system in future GeMPI generations not necessary

Count rate from simulations [40, 2700] keV (cts/d/kg)	Percentage of total bkg. rate [GeMPI 3] (%)
0.8 ± 0.1	3.3 ± 0.6

Neutron shielding for GeMPI-Neo?

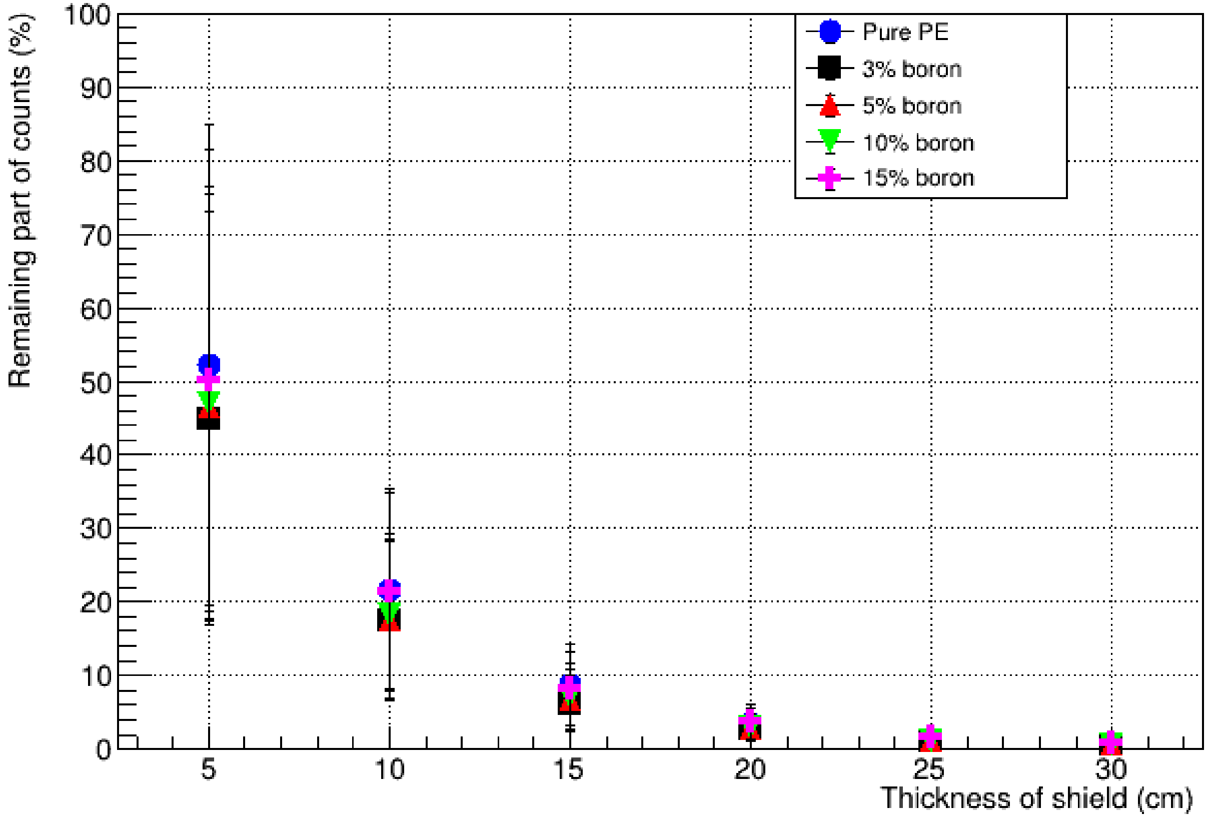


- Significant part of background spectrum
- Mainly neutrons from natural radioactivity in the surrounding rock

→ Implement dedicated neutron shield GeMPI-Neo

Count rate from simulations [40, 2700] keV (cts/d/kg)	Percentage of total bkg. rate [GeMPI 3] (%)
3.1 ± 2.0	12.9 ± 8.2

The neutron shield

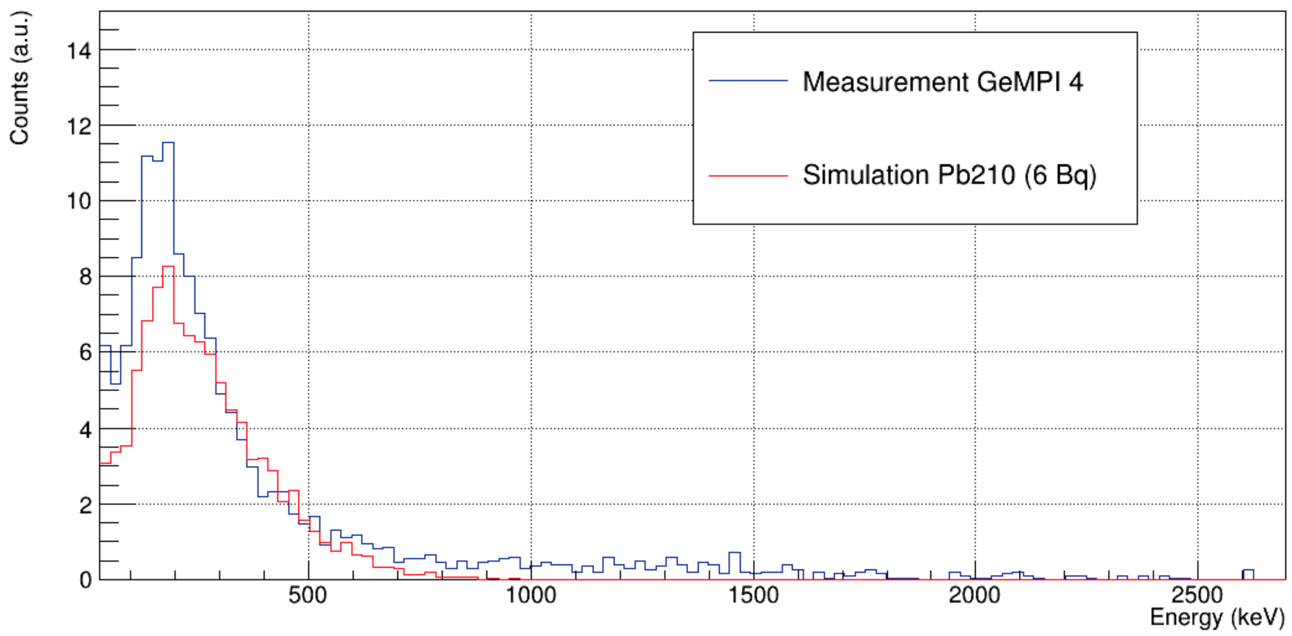


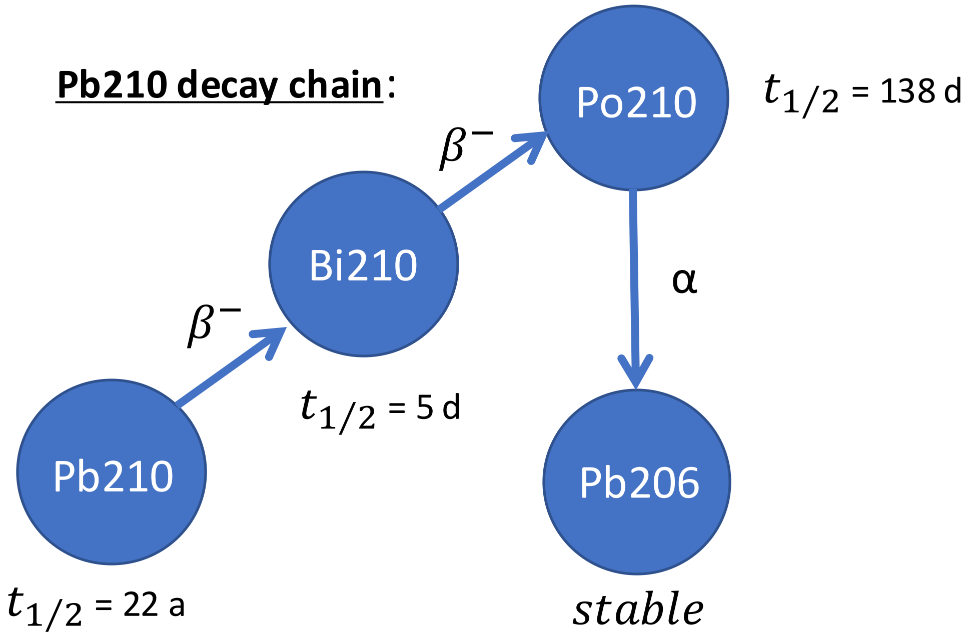
- Simulation of possible neutron shielding
- PE (or borated PE) as possible materials

RESULT:

- At 15 cm thickness: neutron contribution comparable to muon contribution
- No significant influence of boron content on effectiveness of shield

Material contaminations: Pb210





	GeMPI 1	GeMPI 2	GeMPI 3	GeMPI 4
Pb210 Cont. (Bq/kg)	~6	~3	~1.7	~6
Contr. to Bkg. [40, 2700] keV (cts/d/kg)	45 ± 4	23 ± 2	13 ± 1	45 ± 4
Percentage of total bkg. rate (%)	63 ± 5	60 ± 5	54 ± 4	69 ± 6

Material contaminations: Pb210

- Pb210 in lead shield is biggest contributor to background despite copper shield

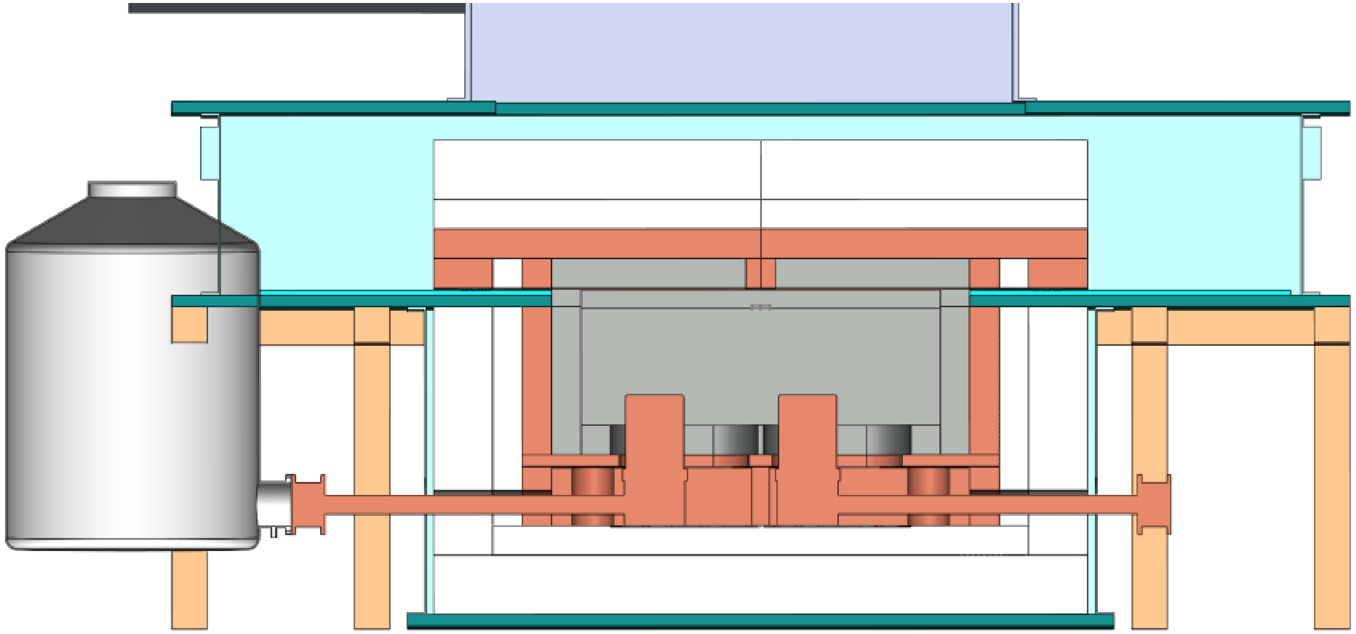
→ need different shield design to reduce contribution

- Simulations show that Pb210 in first two cm of the lead shield have the biggest impact

→ Replace first two cm of lead shield with extremely pure lead

Layer	Percentage of total Pb210 contribution coming from layer (%)
0 – 1 cm	85 ± 4
1 – 2 cm	11 ± 1
2 – 3 cm	3 ± 1
3 – 4 cm	< 1
4 – 5 cm	< 1

New shield design



- Major improvements:

  - 15 cm neutron shield implemented in walls of new STELLA laboratory in LNGS

  - New innermost 2 cm layer of roman lead

  - Include second Germanium crystal to double sensitivity

  - Both cryostats can be moved to adjust for sample geometry

Goals for background rate and sensitivity

Ideal scenario:

GeMPI 3 has rate of 24 counts/d/kg in ROI

Neutron shield ↓

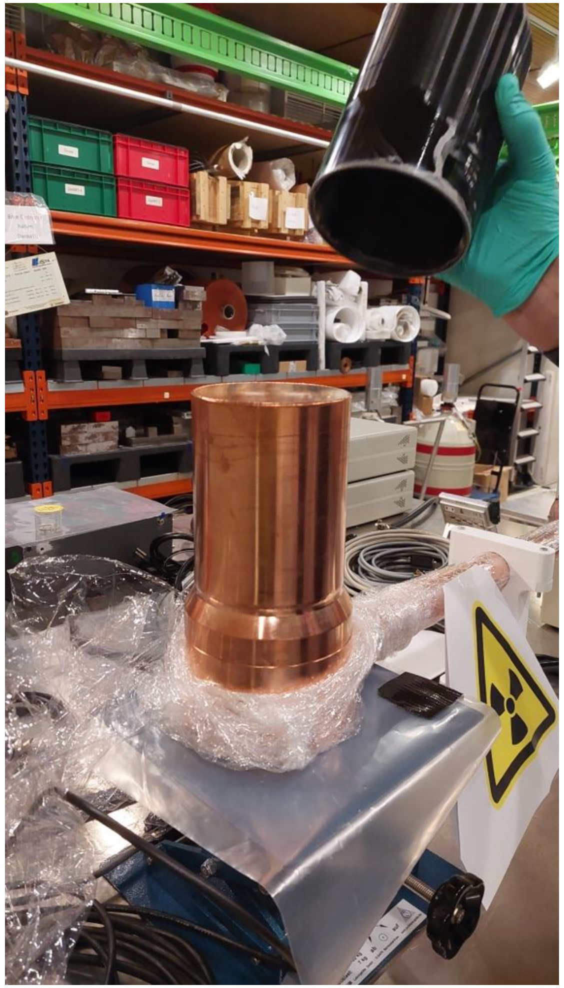
21 counts/d/kg

New Pb shield setup ↓ ← Assuming 0.5 Bg/kg of Pb210 for new inner layer and 10 Bg/kg in outer layer

12 counts/d/kg

Current status

- Materials are all at MPIK
- Test setup being built at MPIK
  Uses dummy detectors to test moving mechanism
- Refurbished underground aged crystals (in new cryostats) perform well
- Installation at LNGS soon, followed by commissioning



Summary and Outlook

- **Simulation of background components of GeMPI shield:**

  - Pb210 in lead shield is main background source (~60%)
  - Muon contributions are very small (1% – 3%)
  - Neutrons contribute up to 15%

- **Consequences for GeMPI-Neo:**

  - 2 cm inner layer of very pure lead to reduce impact of Pb210 in outer lead
  - 15 cm neutron shield integrated in the walls of the laboratory
  - no muon veto necessary
  - Background count rate of 15 cts/d/kg between 40 keV and 2700 keV seems feasible (GeMPI 3: 24 +- 1 cts/d/kg)

  - Addiditionally a second Ge crystal will be included in the next GeMPI detector

- **Current status:**

  - New crystals perform well
  - Test setup being built at MPIK