Muon background simulations for GERDA

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GERDA simulations

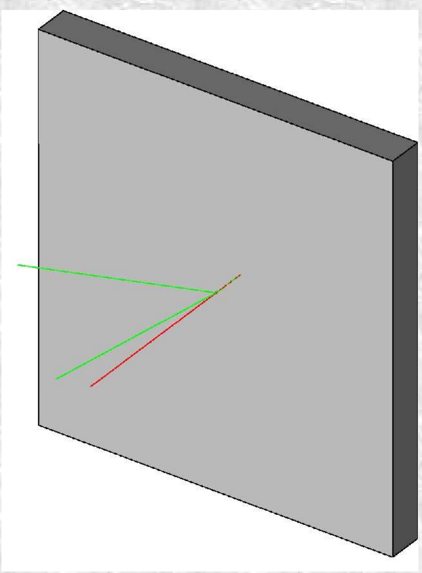
- MaGe – a GEANT4-based simulation framework
- Abstract set of interfaces for Majorana and GERDA experiments
- Share common parts like generator, physics, processes, materials, management etc.
- Individual geometry and output definition
- GERDA geometry already implemented

What about the physics list?

- In GEANT4, physics processes have to be selected individually by the user
- official lists available,
  but unfortunately not for our use-case
- My selection (originally for dark matter searches) in cooperation with H.-P. Wellisch of the GEANT4 Hadronic Physics Working Group:
  - QGSP_GN physics list
  - MuNuclear interaction for muon DIS above 1 GeV
  - BIC (or BERT) for n, p below 10 GeV
  - neutron_hp models for n below 20 MeV

Verification of my physics list

- Comparison of neutron production simulations with existing FLUKA simulations (H. Wulandari, PhD thesis, TU Munich 2003; M. Bauer et al., IDM2004 proceedings)
- Similar tests also carried out by H. M. Araujo et al. (hep-ex/0411026)



results in units of 10^{-5} n/μ/(g/cm^2)

Material	QGSP_GN + NHP + BIC	QGSP_GN + NHP + BERT	FLUKA
Copper	76.8	90.3	135.6
Lead	281.6	268.9	421.0
LNGS concrete	33.4	36.9	35.1
LNGS rock	36.9	31.4	40.4
PE	21.6	21.1	26.1

Differences between the physics lists

Most processes and models are the same

$\Rightarrow$GERDA physics list mostly equivalent

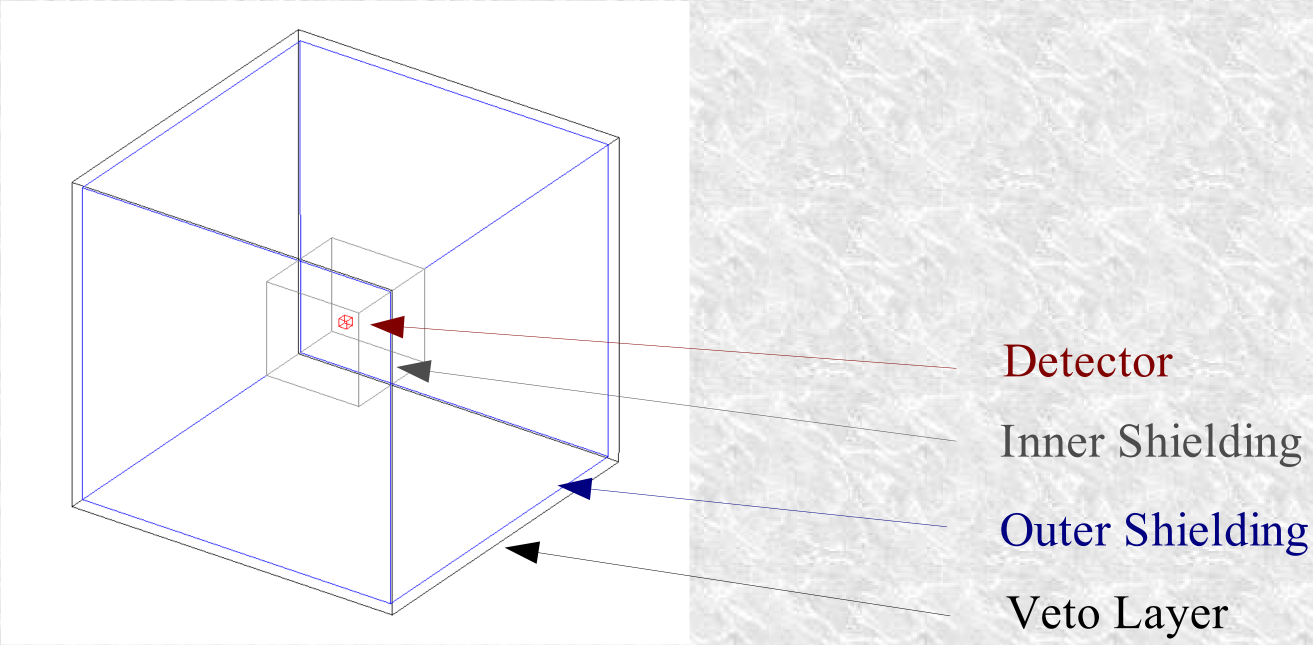
Main differences:

	My list	Official GERDA list
BERT/BIC	X	-
Muon DIS	MuNuclear	MuonNucleus
LE-EM	-	X (optional)
Resonances	X	-

Future: Combine these two physics lists into one

A Simple Toy Geometry

- Added a simple toy geometry to MaGe:



- Sizes and materials selectable by macro

MaGe „toy geometry“ results

- Cross-check for background simulations from LNGS group

Volume	Material	Dimensions
Detector	Enriched Ge	25 x 25 x 25 cm^3
Inner Shielding	Liquid Nitrogen	3 x 3 x 3 m^3
Outer Shielding	Water	10 x 10 x 10 m^3
Veto Layer	Plastic Scintillator	10.04 x 10.04 x 10.04 m^3

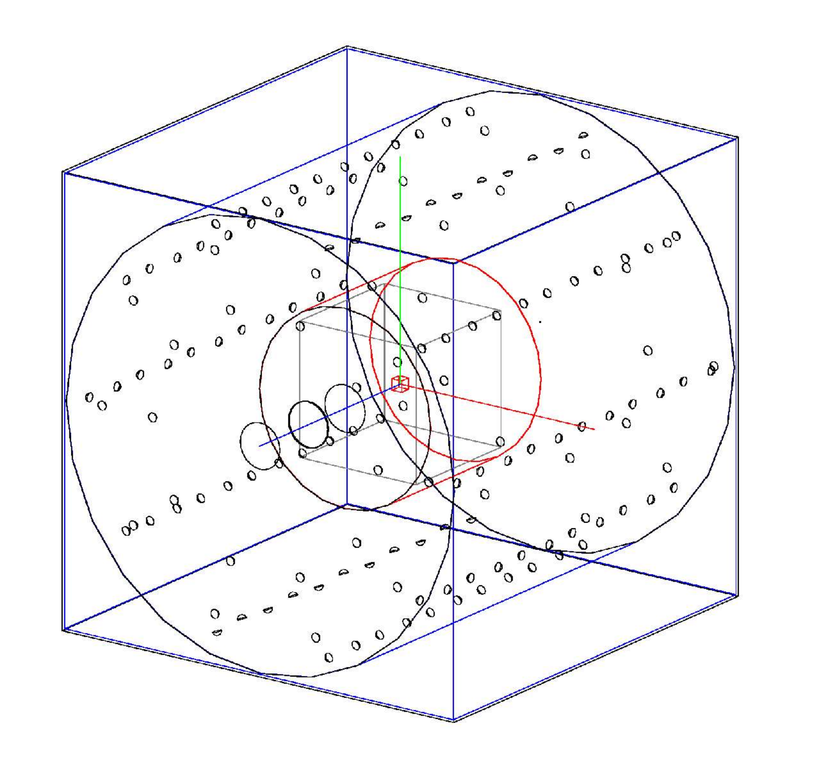
- Results (background index in counts/(keV kg yr)):

	LNGS simulations	Tübingen simulations	
		G4 6.2.p02 / 64-bit	G4 7.0.p01 / 32-bit
No cut	$3.3 * 10^{-3}$	$3.0 * 10^{-3}$	$7.8 * 10^{-4}$
Anticoincidence	$1.0 * 10^{-3}$	$1.0 * 10^{-3}$	$4.1 * 10^{-4}$
Top muon veto		$2.2 * 10^{-3}$	$5.5 * 10^{-4}$
Anticoinc + top	$4.4 * 10^{-4}$	$7.4 * 10^{-4}$	$2.6 * 10^{-4}$

(see also GSTR-05-003)

Cerenkov light simulation

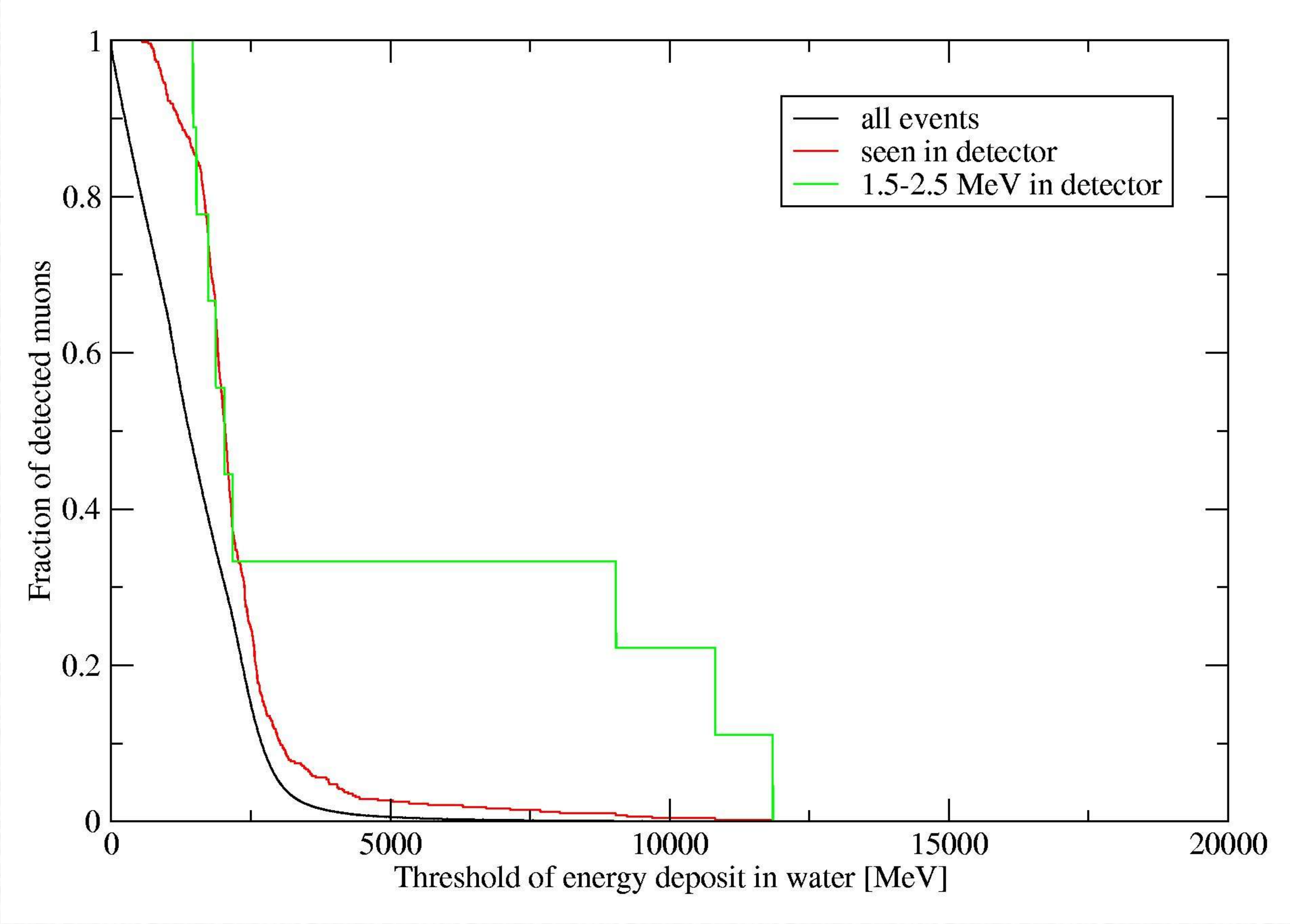
- Added by A. Klimenko during a visit in Tübingen
- Cerenkov and optical photon processes as well as 150 photomultipliers (with fixed positions) and neck



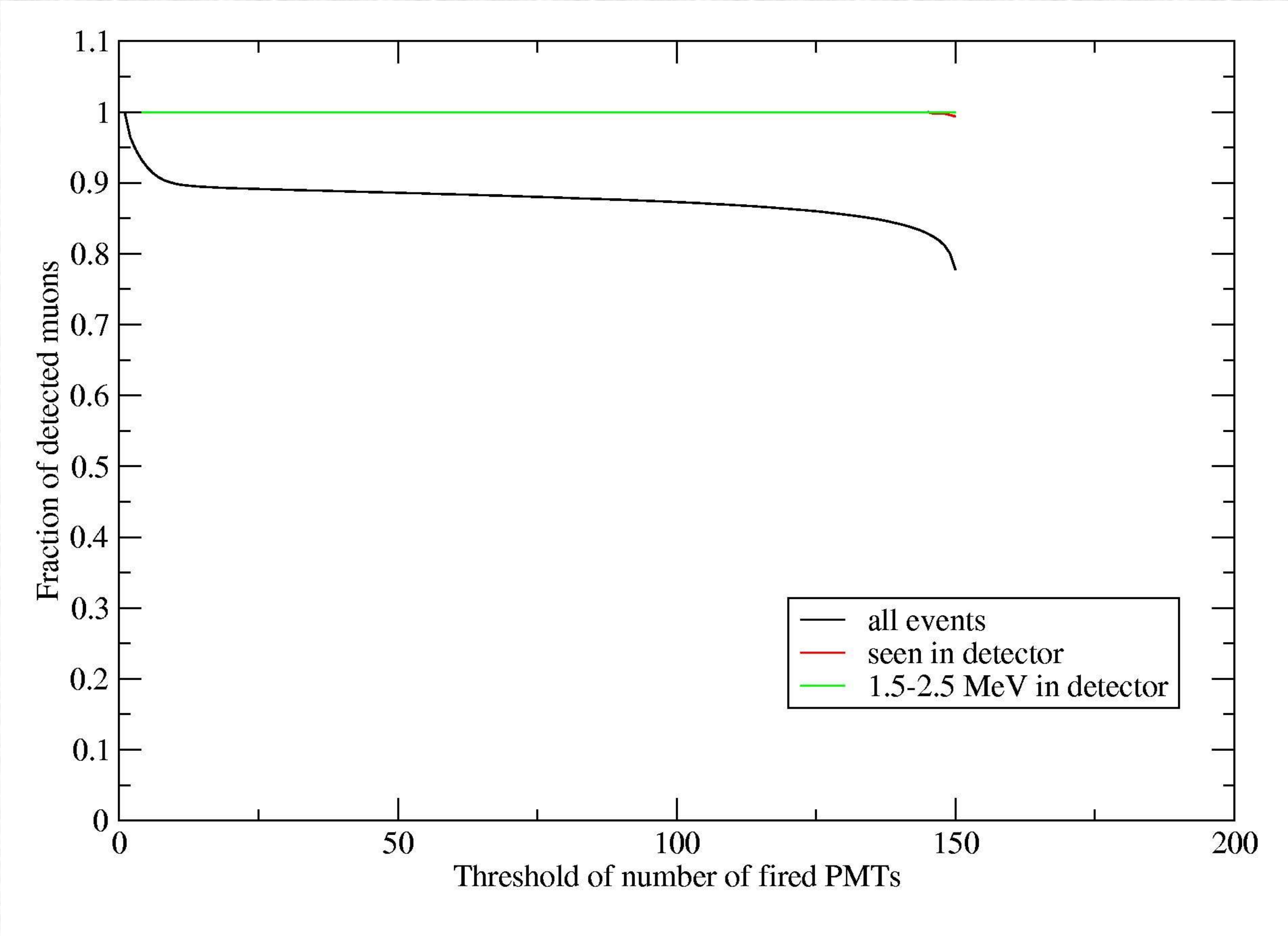
First results

Background index	Cerenkov	No Cerenkov	Air neck	LN2 neck	Water neck
Total [cts/(kg*yr)]	33.18	34.97	34.02	33.34	31.91
Per keV					
[cts/(kg*keV*yr)]					
1.5-2.5 MeV	6.22E-04	7.87E-04	1.13E-03	9.06E-04	8.37E-04
Anticoinc	2.07E-04	4.08E-04	1.53E-04	2.13E-04	3.35E-04
Top muon veto	2.77E-04	5.54E-04	8.70E-04	7.73E-04	6.69E-04
Statistics [muons]	2107522	5000000	2847807	5467424	2611613

Influence of threshold (1)



Influence of threshold (2)



Summary and Outlook

- Results almost independent of details of geometry and/or physics models used in the simulation
- Threshold of water Cerenkov veto can safely be set to a high value
- Cerenkov light studies in the full GERDA geometry in progress (see talk by M. Knapp)
- Future: Optimization of number and placement of PMTs
- Integration of these simulations into the official MaGe version