Monte–Carlo based studies for the COBRA Experiment

Estimated Muon Background for the R&D Set–up

Nadine Heidrich

University of Hamburg

29. February 2012

Outline

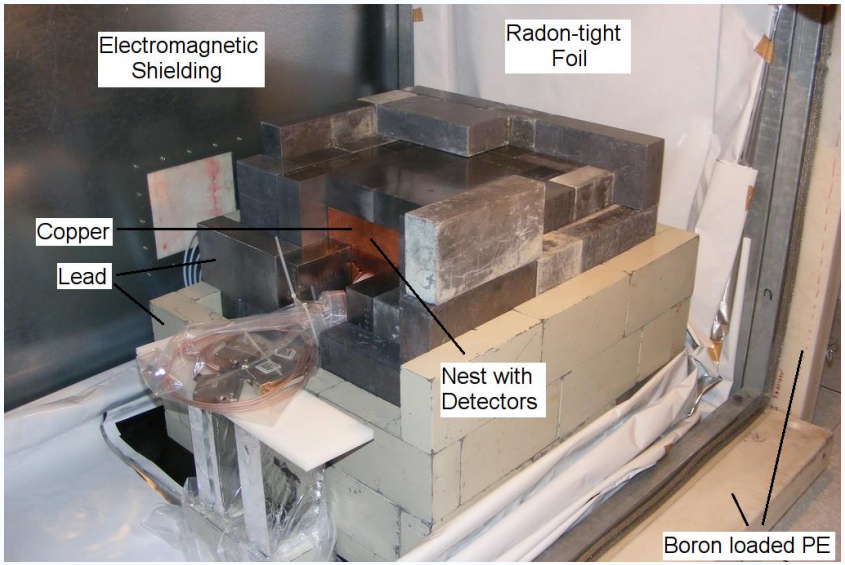
1. Introduction to the R&D set–up at LNGS
2. Muon background in general
3. Explanation of the Monte Carlo simulations
4. Calculation of background rates
5. Conclusion & Outlook

Introduction to the R&D Set–up at LNGS

Activities in 2011:

- Move into the Heidelberg–Moskow hut in spring 2011
  - Update of the complete passive shielding
- R&D set–up at LNGS can house 64 1 cm^3 CPG detectors
- Since late summer 2011 16 detectors are running
  - With new FADC readout
  - Full 64 array will be installed soon
    $\rightarrow$ Next 16 detectors will be installed in March/April 2012

Introduction to the R&D Set–up at LNGS



Shielding:

- High purity copper
- 2t lead
  $\rightarrow$ inner layer: ultra low background lead
- Radon–tight foil and Nitrogen flushing
- EMI shielding
- 7 cm boron loaded PE

Muon Background in general

Background: muons

- Component of cosmic radiation
- Flux reduced due to the overburden in the underground laboritory (LNGS: 3400 mwe)
  $\rightarrow \sim 2.58 - 3.22 \cdot 10^{-8}\,\mu/\mathrm{s/cm^2}$

Muon Background in general

Background: muons

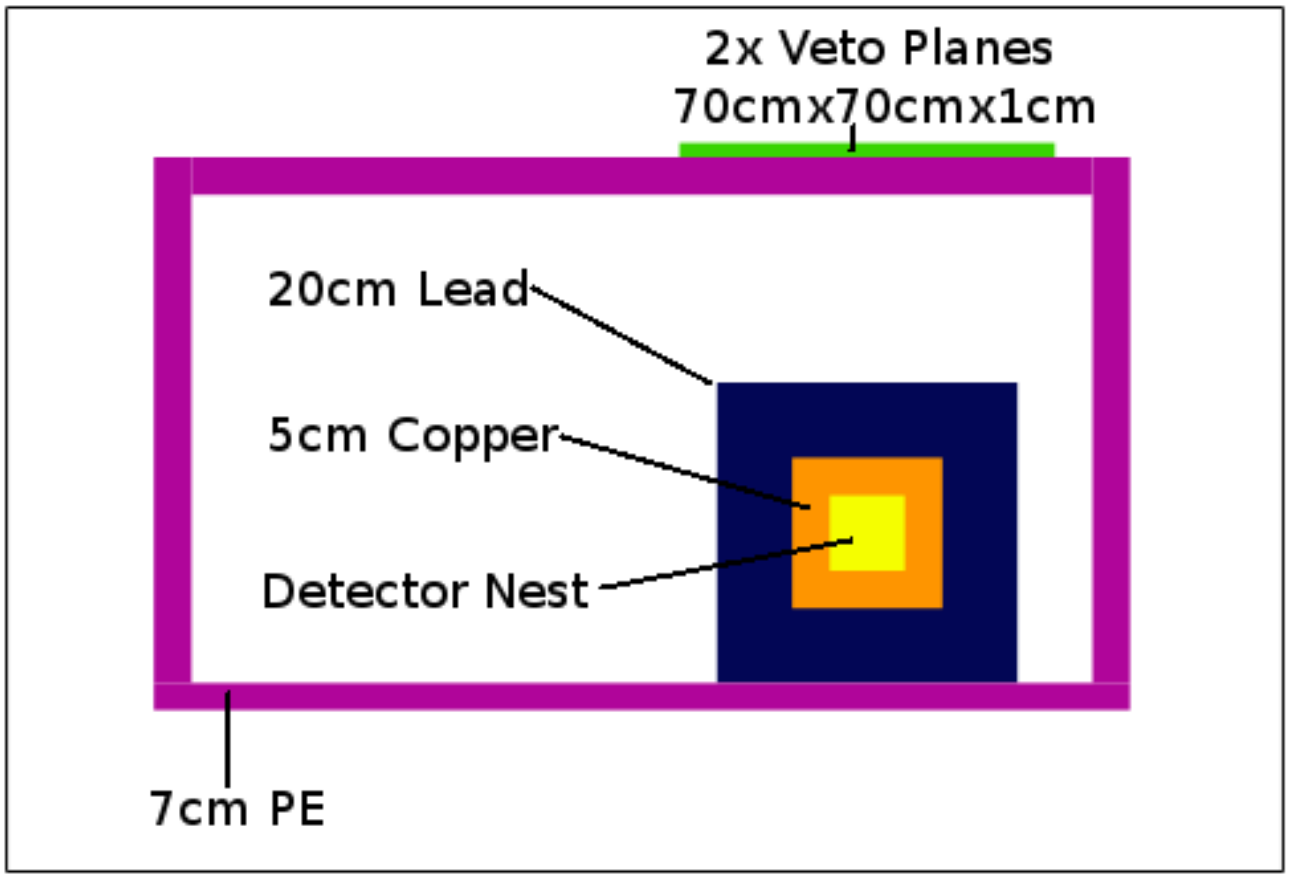
- Component of cosmic radiation
- Flux reduced due to the overburden in the underground laboritory (LNGS: 3400 mwe)
  $\rightarrow \sim 2.58 - 3.22 \cdot 10^{-8}\,\mu/s/cm^2$

Background: muon–induced

- Production of fast neutrons in the rock and in the shielding itself ($\rightarrow$ shielding, veto)
  $\rightarrow \sim 3 \cdot 10^{-9}$ neutrons/s/cm^2
  $\rightarrow$ Very hard energy spectrum ($\sim$ GeV)
- Cosmogenic radioactivity

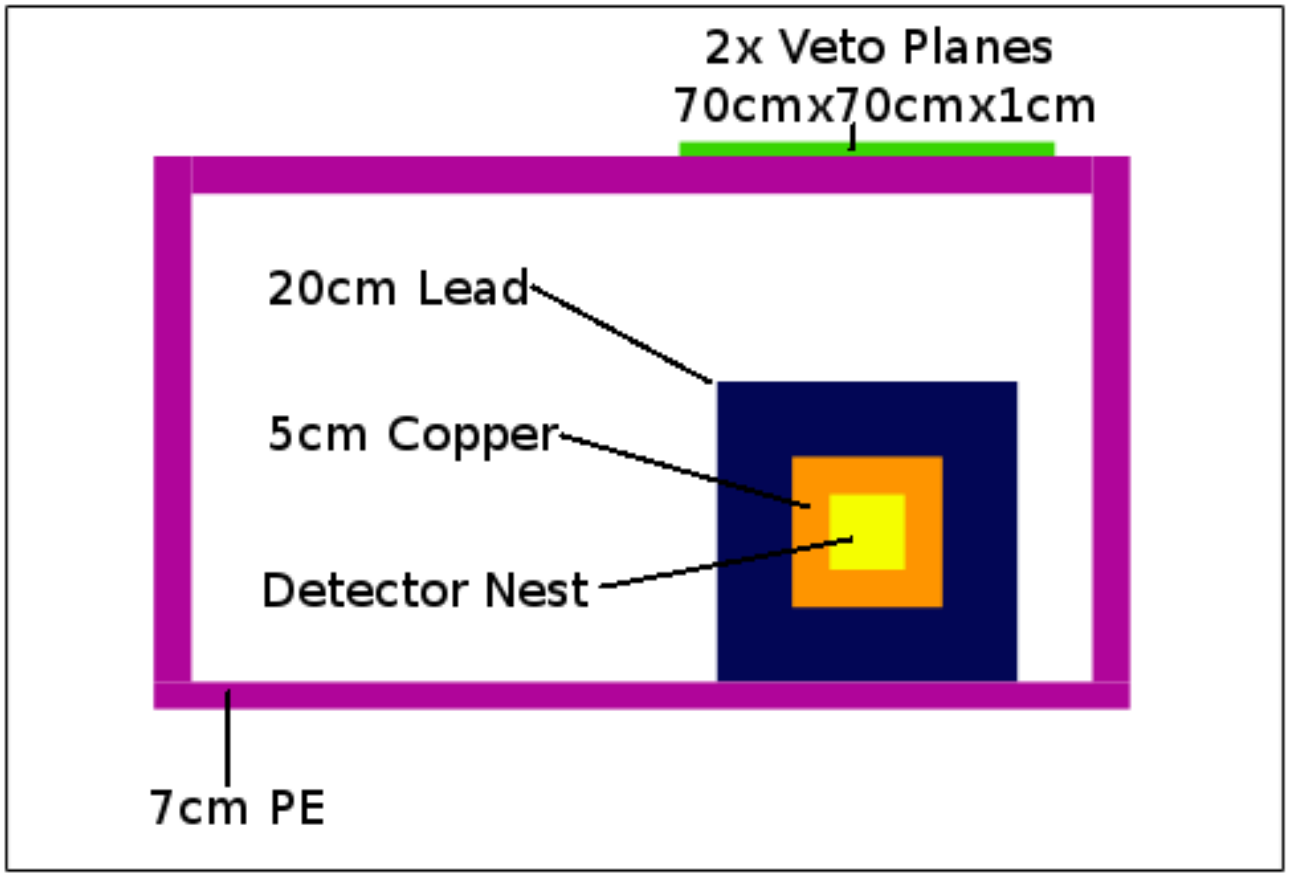
Explanation of the Monte Carlo Simulations

For the simulation Geant4 4.9 is used in combination with GDML for the R&D–geometry (EMI shielding not considered).



Explanation of the Monte Carlo Simulations

Muons are simulated on a cube surrounding the geometry with an energy and angular distribution.

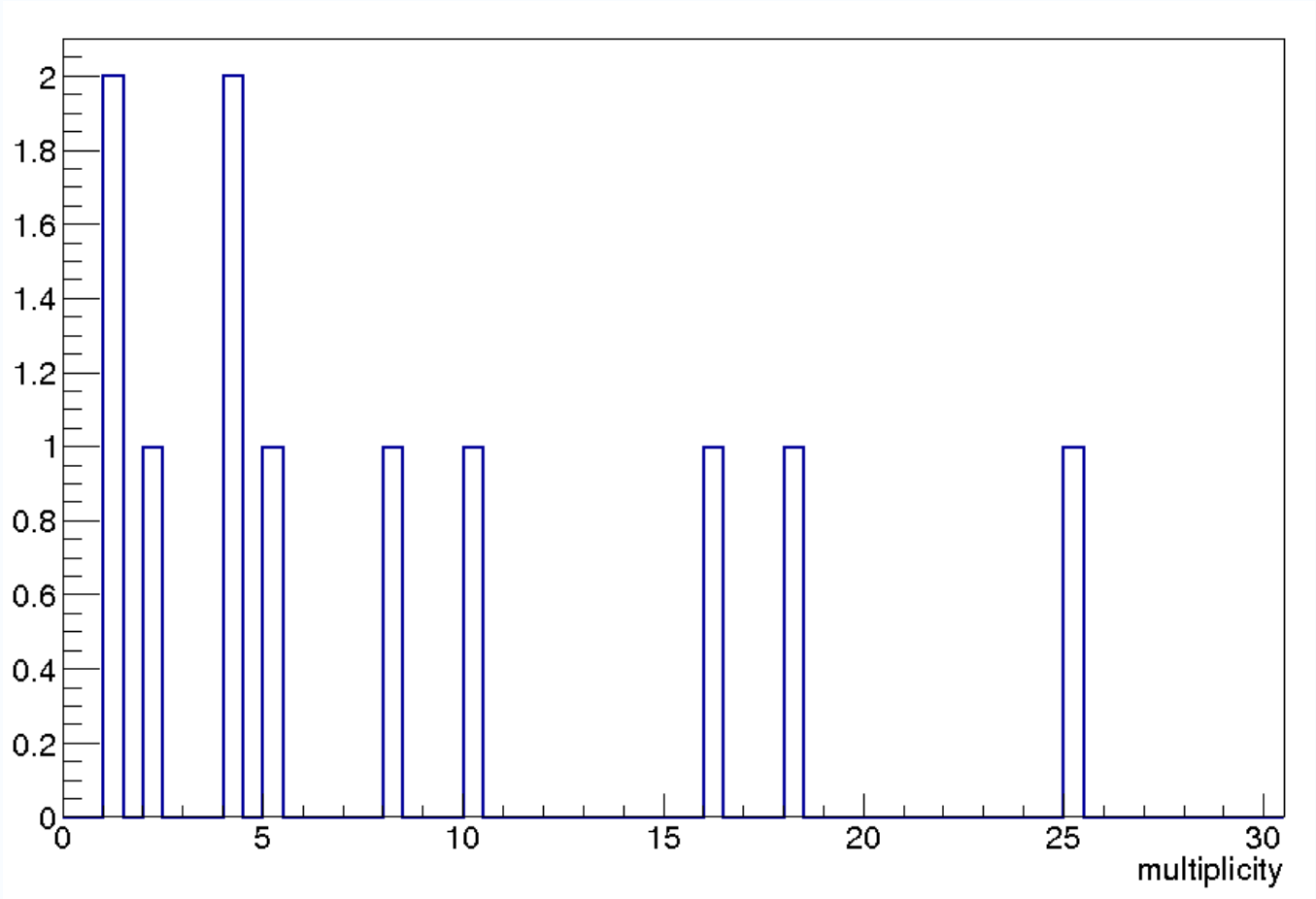


Background Rate: Muons

		Cut	**Events ROI** $(2.7 - 2.9\,\mathrm{MeV})$	**Background Rate** [counts/keV/yr/kg]
Muons	$\sim 10\,\mathrm{yr}$	without	11	$(1.6 \pm 0.5) \cdot 10^{-2}$ $(< 2.55 \cdot 10^{-2})$

Background Rate: Muons

Multiplicity in the ROI (2.7 – 2.9 MeV)
Only single–site events are considered!



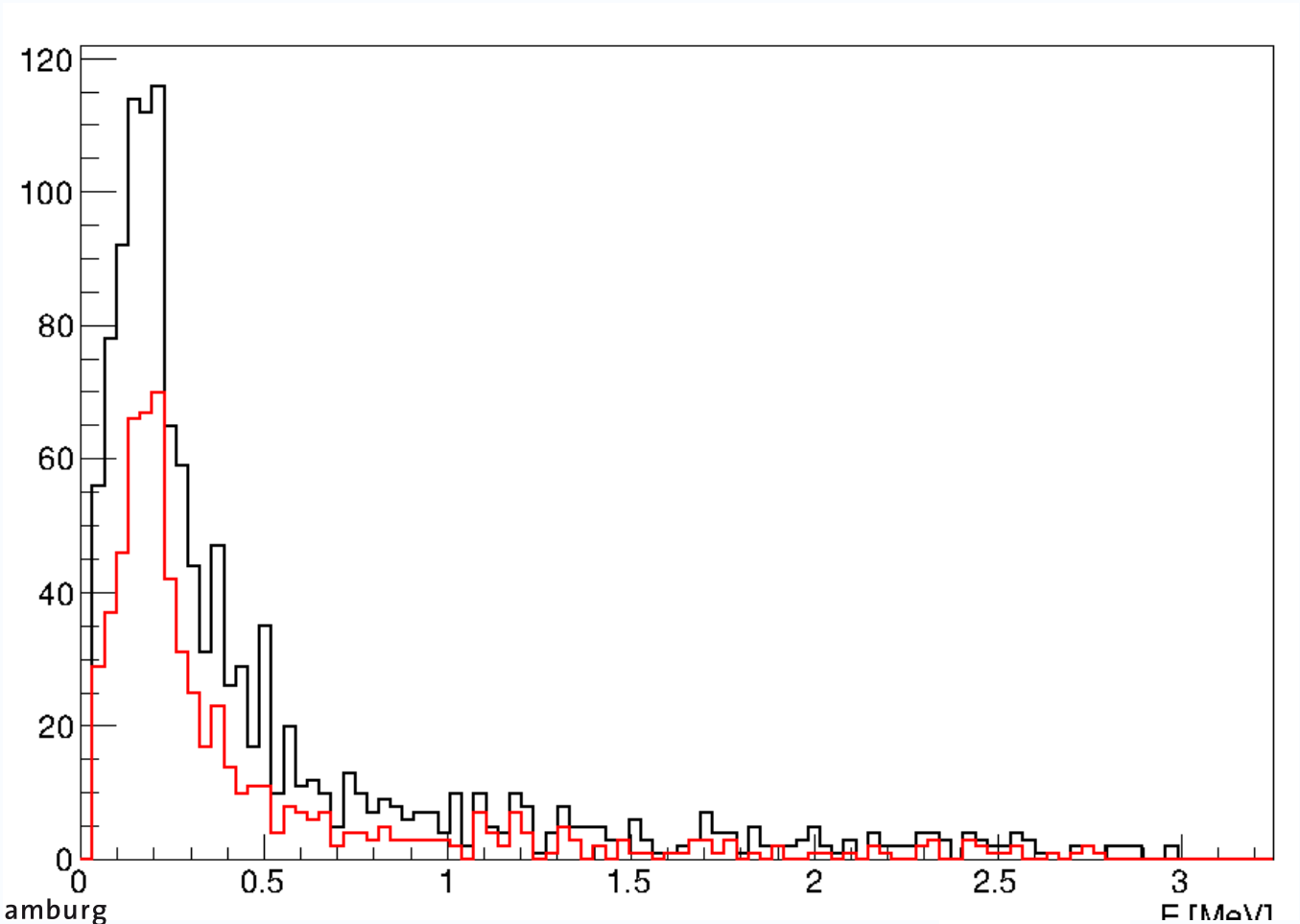
Background Rate: Muons

		Cut	Events ROI $(2.7 - 2.9\,\mathrm{MeV})$	Background Rate [counts/keV/yr/kg]
Muons	$\sim 10\,\mathrm{yr}$	without	11	$(1.6 \pm 0.5) \cdot 10^{-2}$ $(< 2.55 \cdot 10^{-2})$
		Multiplicity	2	$< 0.848 \cdot 10^{-2}$

Background Rate: Muons

Black: without cuts **Red:** time cut

Comparission between events detected in the vetos and in the detector itself $\rightarrow$ time cut

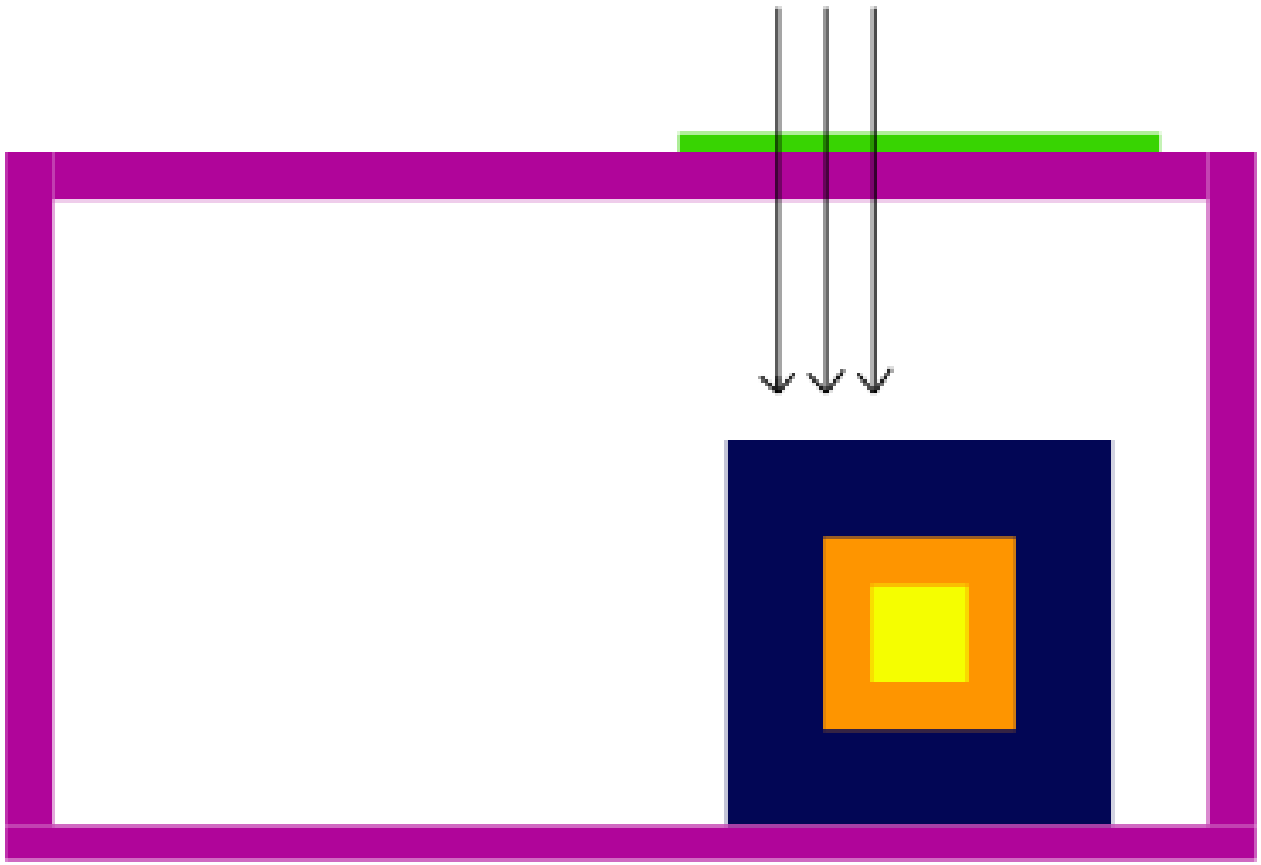


Background Rate: Muons

	Cut	Events ROI ($2.7 - 2.9\,\mathrm{MeV}$)	Background Rate [counts/keV/yr/kg]
Muons $\sim 10\,\mathrm{yr}$	without	11	$(1.6 \pm 0.5) \cdot 10^{-2}$ $(< 2.55 \cdot 10^{-2})$
	Multiplicity	2	$< 0.848 \cdot 10^{-2}$
	Time	1	$< 0.625 \cdot 10^{-2}$

Background Rate: Muons

Special cases: Muons are simulated as point sources with direction (0,0,-1) in different distances (x–axis) from the dectector
$\rightarrow$ Muons are not passing the detector chamber



Background Rate: Muons

Distance	**Events ROI** $(2.7 - 2.9\,\mathrm{MeV})$	**Events ROI** Multiplicity
Lead (25 cm)	0	0
Lead/Copper (35 cm)	9	1
Copper/Chamber (39 cm)	56	1

Background Rate: Muons

Distance	**Events ROI** $(2.7 - 2.9\,\mathrm{MeV})$	**Events ROI** Multiplicity
Lead (25 cm)	0	0
Lead/Copper (35 cm)	9	1
Copper/Chamber (39 cm)	56	1

$\rightarrow$ Same time cut: 0 events remain

Conclusion & Outlook

Conclusion

- Background from muons can be reduced due to multiplicity and time cuts
- **But:** remains in the order 10^{-2} counts/kg/keV/yr

Conclusion & Outlook

Conclusion

- Background from muons can be reduced due to multiplicity and time cuts
- **But:** remains in the order 10^{-2} counts/kg/keV/yr

Outlook

- Test veto within the shielding (between PE and Pb)
- Estimation of background from other sources
  $\rightarrow$ radioactive, cosmogenic,...
- Estimation of background for the large scale set–up

Conclusion & Outlook

Conclusion

- Background from muons can be reduced due to multiplicity and time cuts
- **But:** remains in the order 10^{-2} counts/kg/keV/yr

Outlook

- Test veto within the shielding (between PE and Pb)
- Estimation of background from other sources
  $\rightarrow$ radioactive, cosmogenic,...
- Estimation of background for the large scale set–up

Thank you for your attention!

Backup Slides

Background Rate: Muons

Consideration of the two veto planes:

	Time: 1. Event [ns]	**Time: 2. Event** [ns]
Detector	5.486	4.995

Background Rate: Muons

Consideration of the two veto planes:

	Time: 1. Event [ns]	**Time: 2. Event** [ns]
Detector	5.486	4.995

T first events in the veto: $\Delta T \sim 2\,\text{ns}$

Background Rate: Muons

Consideration of the two veto planes:

	Time: 1. Event [ns]	**Time: 2. Event** [ns]
Detector	5.486	4.995

T first events in the veto: $\Delta T \sim 2\,\text{ns}$
Distance Source–Veto: $0.57\,\text{m} \rightarrow \Delta T = 1.9\,\text{ns}$
Size of set–up (Z–axis): $1.1\,\text{m} \rightarrow \Delta T = 3.6\,\text{ns}$
$\rightarrow$ Cut at 5 ns in the detector: 1 event remain