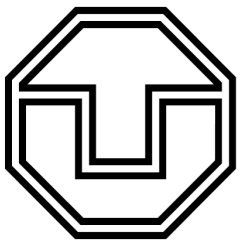
Measuring optical properties of LAr in GERDA



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Outline

Improving accuracy of MC benchmarks

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- Further background reduction via LAr veto
- Geometry of LAr veto not fixed yet (HK18.2)
- MC studies to find most promising setup
- Attenuation length (λ_{Att}) and light yield (LY) are input parameters for MC simulations (Geant4/MaGe)

Precise measurements of λ_{Att} and LY would lead to more accurate benchmarks

Impurities influence optical properties

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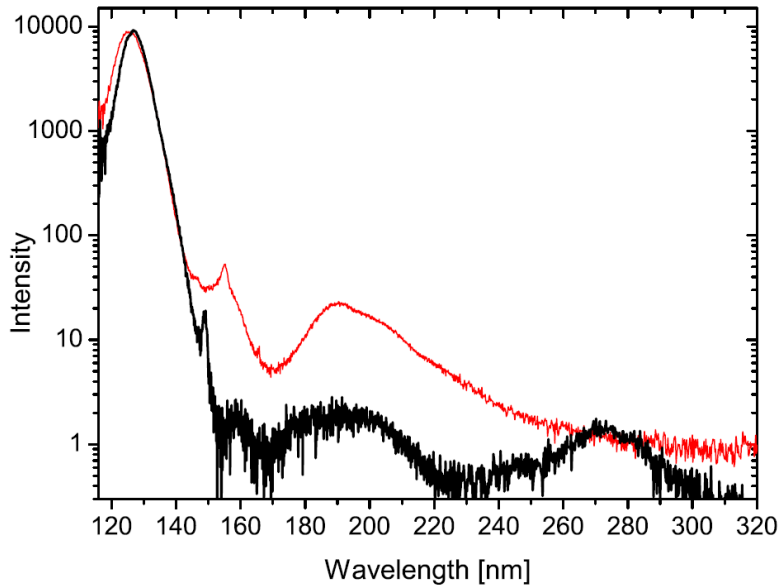
Pure LAr:

- Emission peak at $\lambda = 128.6\,\mathrm{nm}$[1]
- Attenuation length $\lambda_{\mathrm{Att}} = 66 \pm 3\,\mathrm{cm}$[2]
- Light yield
  - Alphas: $\sim 37.000\,\gamma\mathrm{s}/\mathrm{MeV}$[3]
  - Betas: $\sim 41.000\,\gamma\mathrm{s}/\mathrm{MeV}$[3]



Emission spectrum of gaseous (red) and liquid (black) Argon.[1]

Contaminated LAr:

- λ_{Att} depends on impurities: e.g. N_2, O_2,Xe
- Light yield supressed due to non-radiative de-excitation

[1] T. Heindl et al (2010) [2] N. Ishida et al (1997) [3] T. Doke et al (2002)

Radioactive source as only light source

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Problems:

- In-situ measurements necessary
- No commercial light source satisfies our needs:
  1. Emission at 128 nm
  2. Deployable in GERDA:
     - Operates at 87 K
     - Small enough to pass the glove box

Solution:

- Use scintillation light produced by radioactive source

Source Candidates

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Alpha Sources:

Isotope	$T_{1/2}$	BR [%]	Q-Value [keV]
^{148}Gd	74.6 y	100	3271.21
^{210}Po	138.4 d	$\approx$ 100	5304.38
		0.00122	4516.58

Beta Source:

Isotope	$T_{1/2}$	BR [%]	Q-Value [keV]
^{90}Sr	28.79 y	100	546.0

http://ie.lbl.gov/education/isotopes.htm

Gadolinium source looks promising

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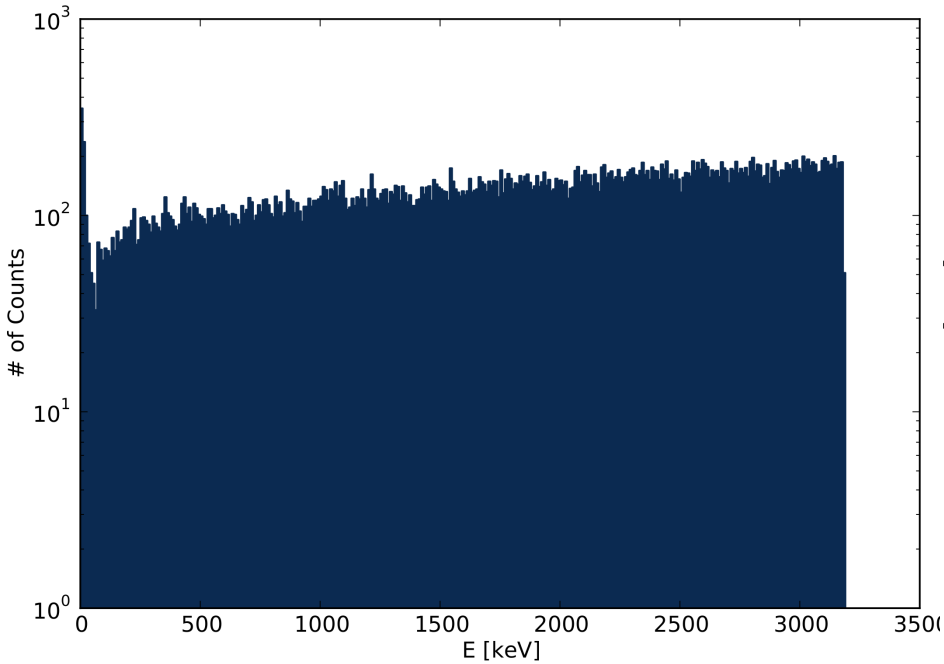
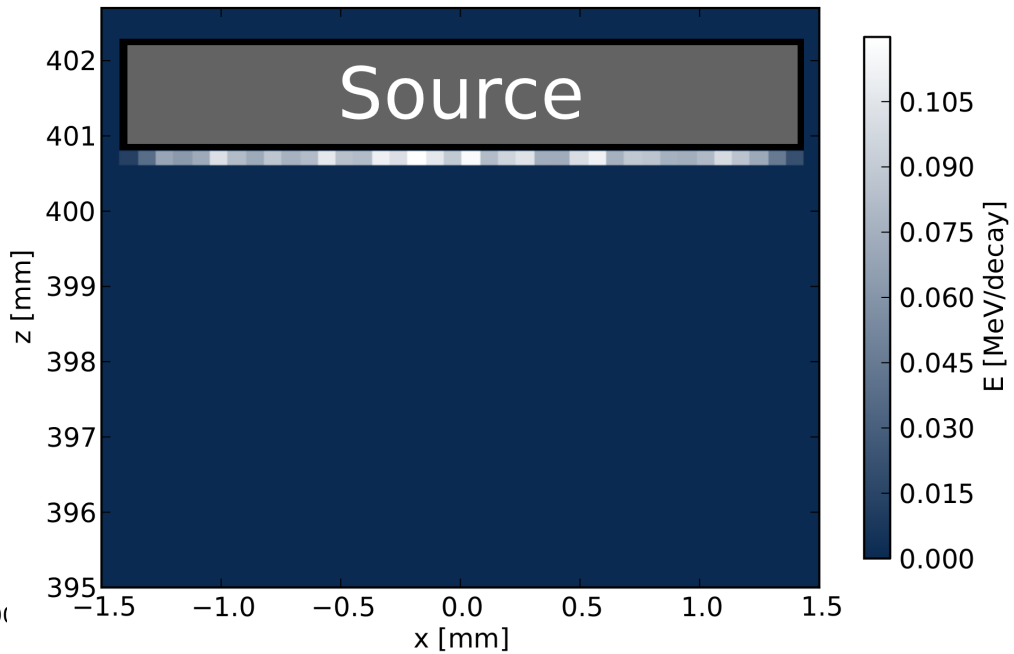
Energy spectrum



- Flat energy spectrum

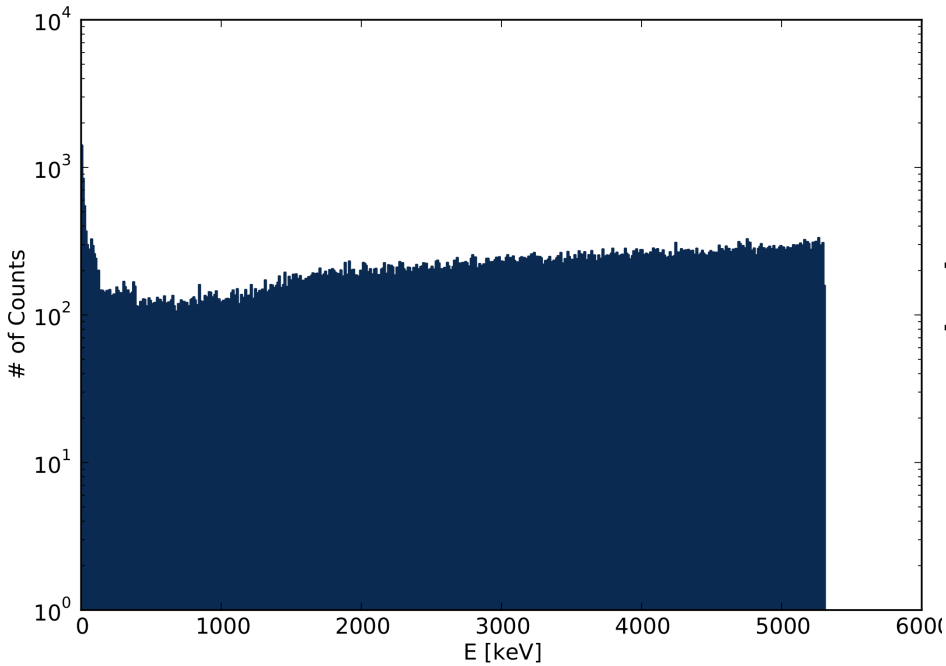
Position of E_{Dep}



- Localized energy deposition

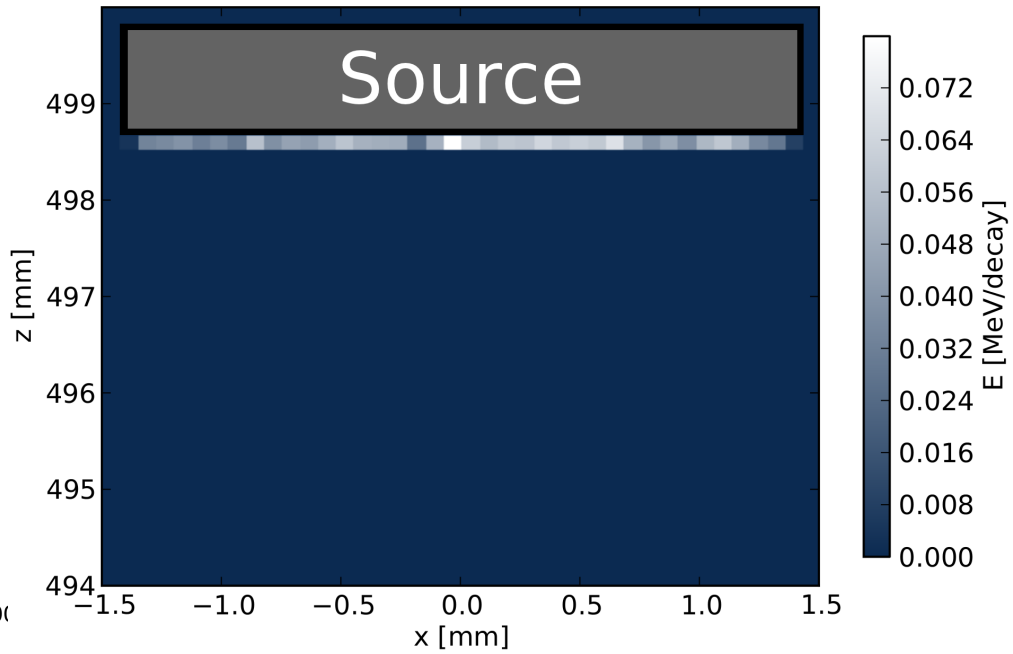
Polonium source looks promising

Energy spectrum



- Flat energy spectrum

Position of E_{Dep}



- Localized energy deposition

Strontium source doesn't look feasible

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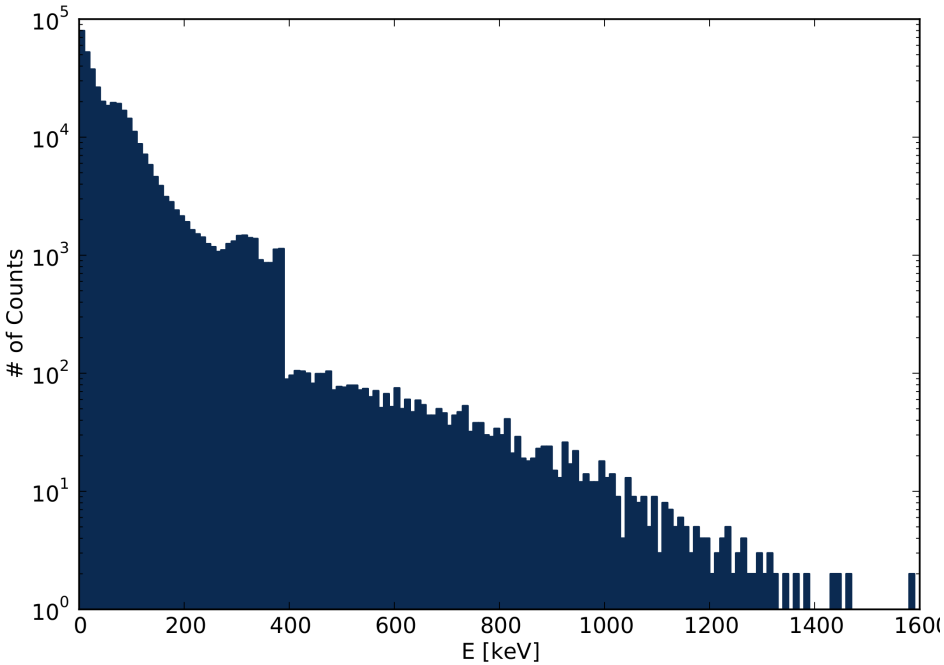
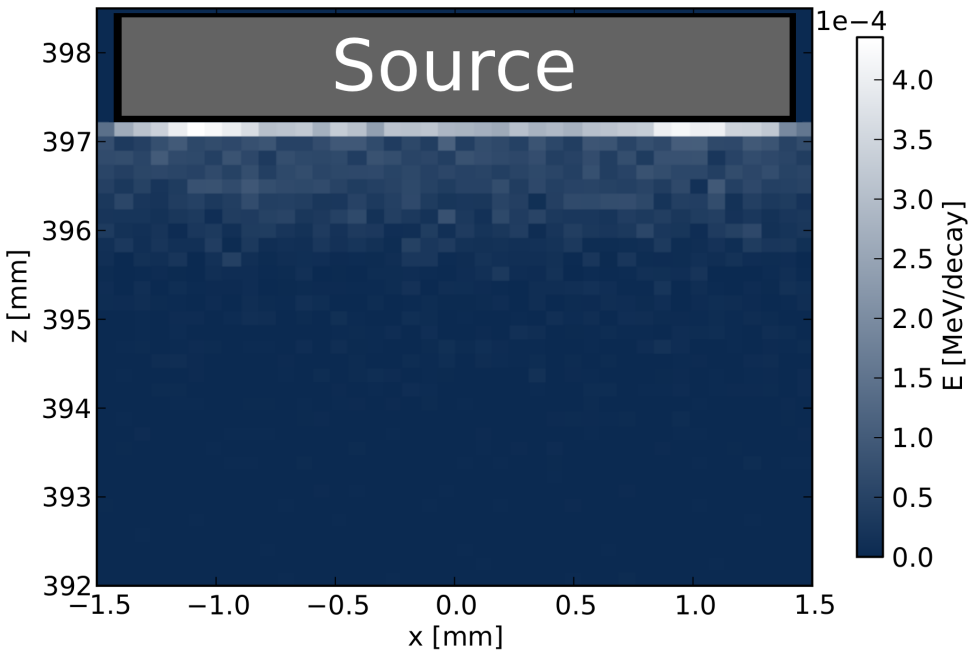
Energy spectrum



- Complex energy spectrum

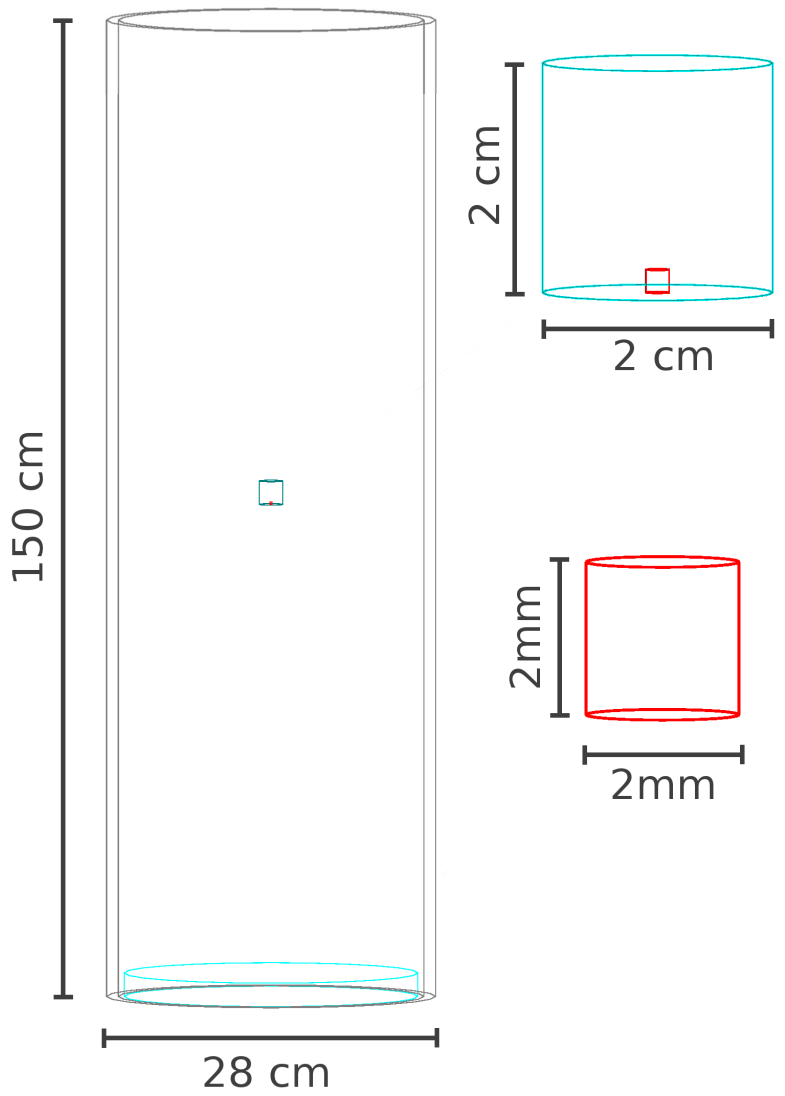
Position of E_{Dep}



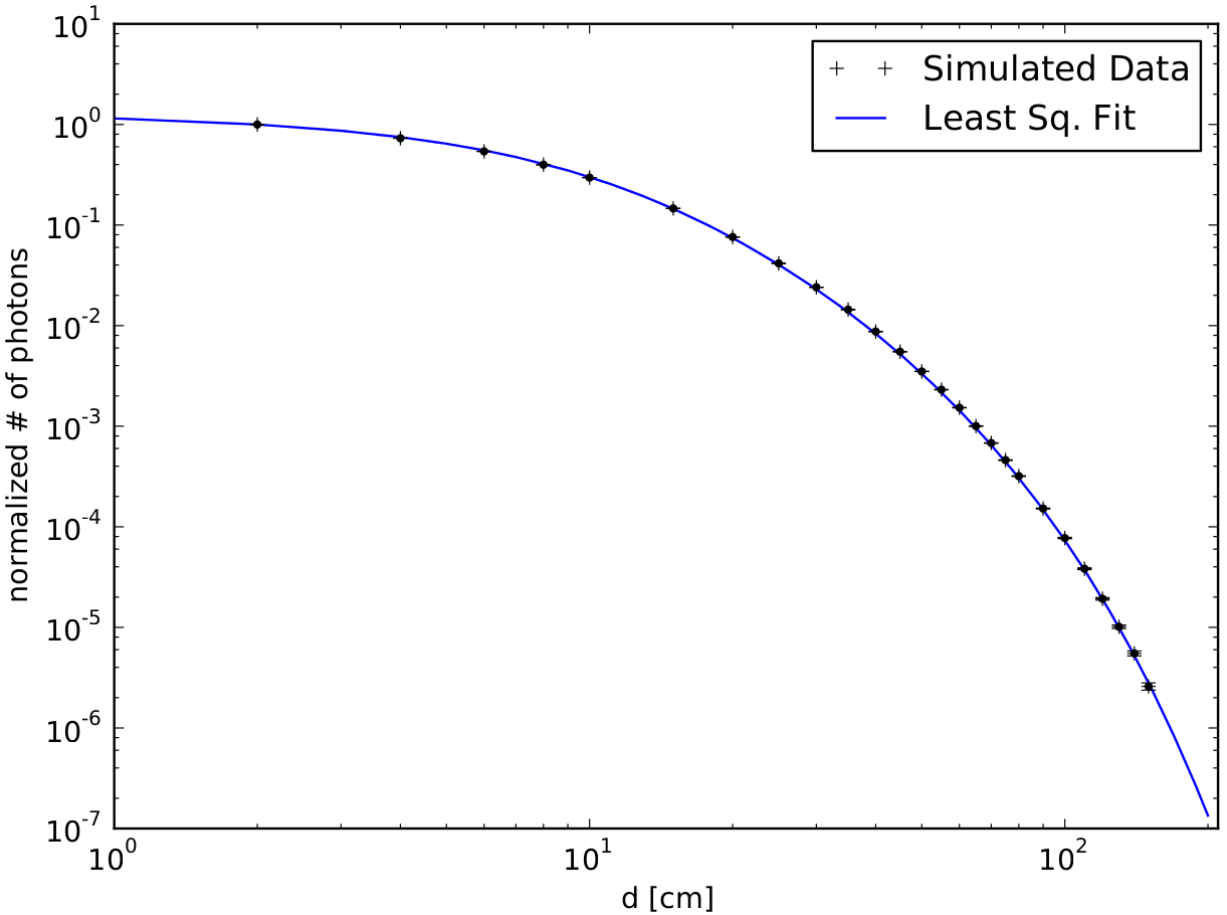
- Wide area of energy deposition

Can λ_{Att} really be measured?

- Run simulations with known λ_{Att} and LY
- Simulated setup as shown
  - Cylindrical shield
  - Movable source
  - PMT at the bottom
  - ^{39}Ar background
- Check whether correct λ_{Att} can be retrieved from data



Excellent results without background



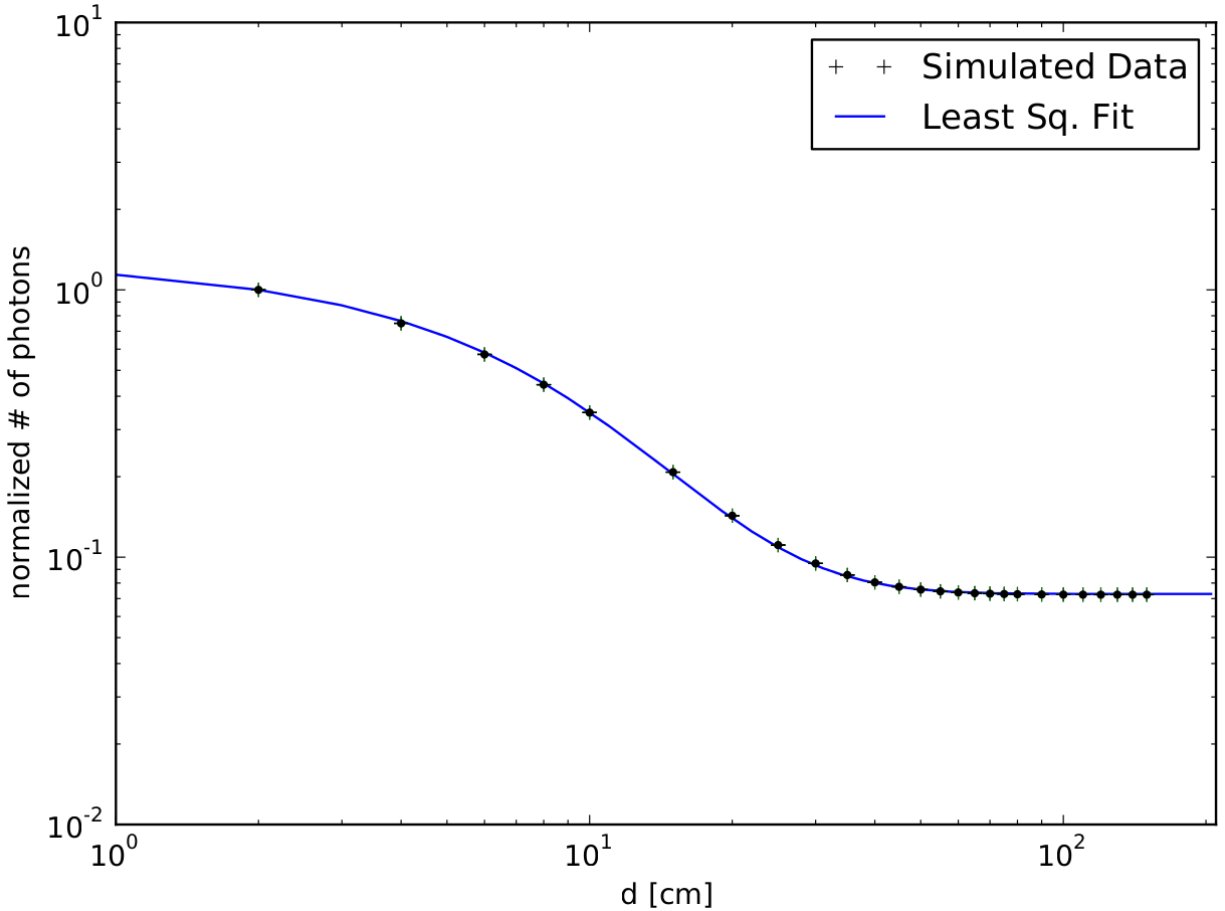
Input λ_{Att}
20 cm

Source Act.
37 kBq

Background Act.
0 Bq

Fitted λ_{Att}
20.31 ± 0.21 cm

Good results with ^{39}Ar background



Input λ_{Att}
20 cm

Source Act.
37 kBq

Background Act.
153 Bq

Fitted λ_{Att}
19.64 ± 0.27 cm

Simulations indicate feasible setup

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- Include systematics, mainly positioning
- Check commercial Polonium sources for contaminations
  - ^{210}Pb content would rule a ^{210}Po source out
- Setup feasible to yield any information regarding the LY?
  Known problems: Quantum efficiency of WLS, PMT, etc.
- Build small test stand