

CYGNOSimulations update

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Summary of simulation activities

- **Background simulations** with GEANT4
 - ambient gamma/neutrons and shielding studies (Giulia)
 - internal background, radioactivity of the setup (Flavio, Giulia, Gianluca)
- **Signal simulations:** nuclear recoils with SRIM (Emanuele M., Davide)
- **Signal simulation with Geant4:** electron recoils (Flavio)
- **Digitization and MC analysis:** add diffusion and noise to produce images and apply reconstruction (Flavio, Fabrizio)
- **PMT simulation** (Francesco, Elisabetta)
- Study of feasibility of **solar neutrino measurements**, electron range in different gas mixtures (GSSI group)

Need to schedule regular meeting in order to coordinate, be updated of other's work and avoid overlap between groups → I'll circulate a doodle for this

Shielding studies

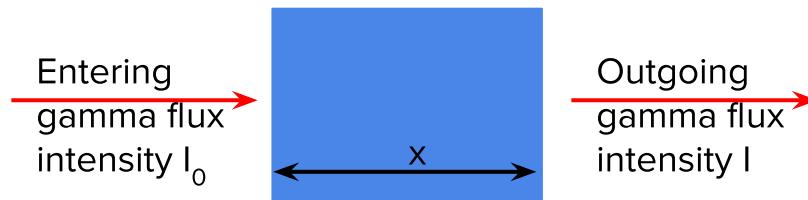
X-rays attenuation (rough calculation)

$$I/I_0 = \exp[-(\mu/\rho)x].$$

$$\mu/\rho = x^{-1} \ln(I_0/I)$$

ρ material density

$x=pt$ "mass thickness"



$$\mu/\rho = \sigma_{\text{tot}}/uA.$$

u = atomic mass unit

A = relative atomic mass

σ_{tot} is the total cross section

$$\sigma_{\text{tot}} = \sigma_{\text{pe}} + \sigma_{\text{coh}} + \sigma_{\text{incoh}} + \sigma_{\text{pair}} + \sigma_{\text{trip}} + \sigma_{\text{ph.n.}}$$

σ_{pe} atomic photoeffect xsec

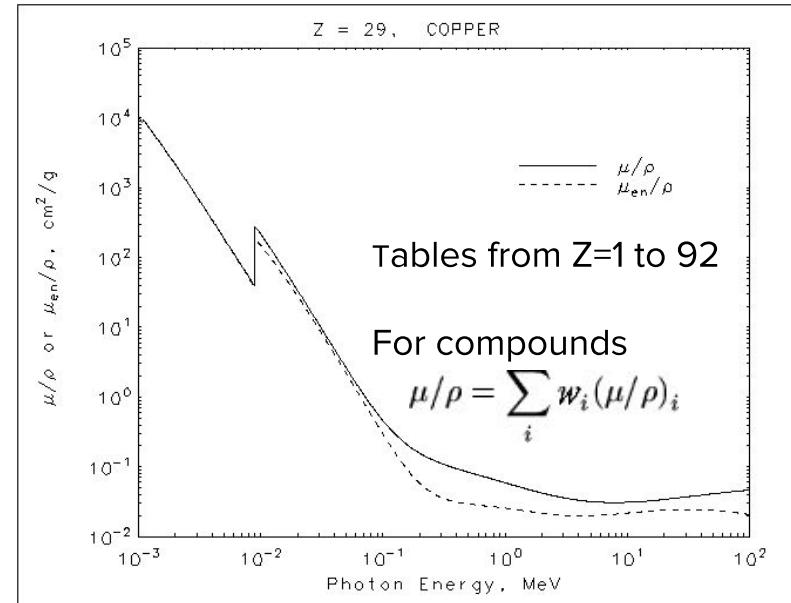
σ_{coh} and σ_{incoh} coherent (Rayleigh) and incoherent (Compton) scattering xsec

σ_{pair} and σ_{trip} e+e- production xsec in the fields of the nucleus and of the atomic electrons

$\sigma_{\text{ph.n.}}$ photonuclear cross section

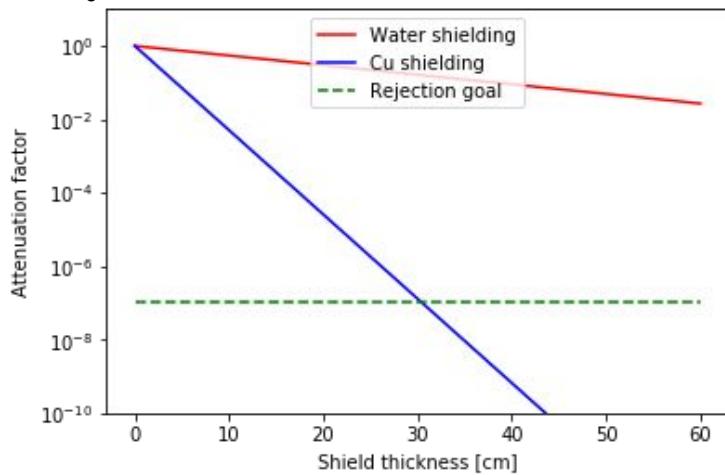
<https://physics.nist.gov/PhysRefData/XrayMassCoef/chap2.html>

<https://physics.nist.gov/PhysRefData/XrayMassCoef/tab3.html>



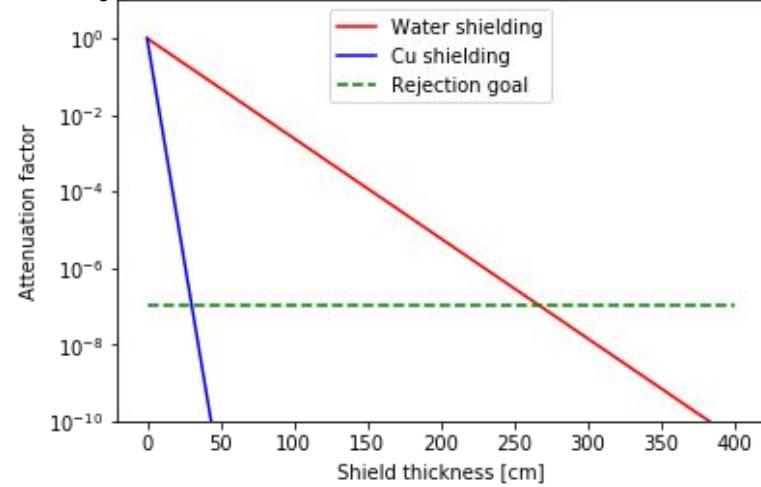
X-rays attenuation with Cu and water

I/I_0 attenuation vs thickness (1 MeV gamma)



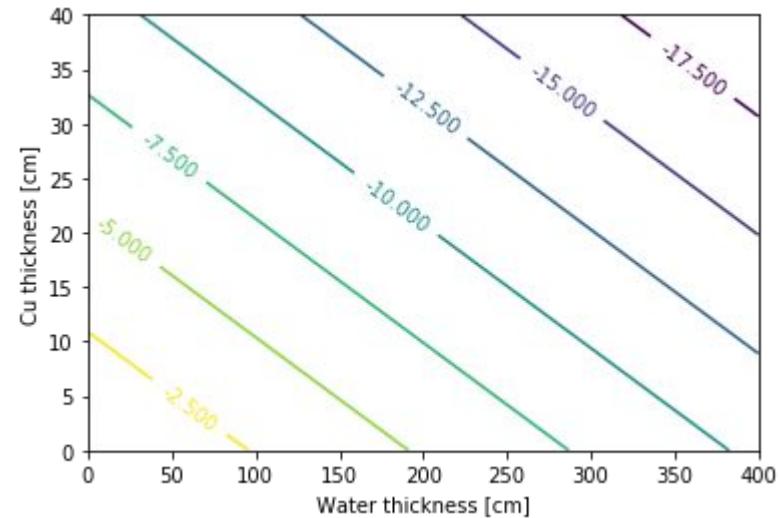
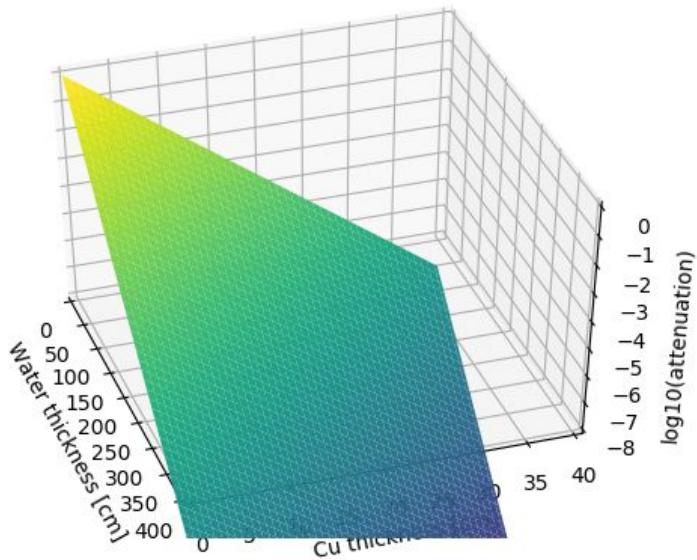
Shielding made of only copper gives an attenuation of 10^7 with thickness ~ 30 cm

I/I_0 attenuation vs thickness (1 MeV gamma)



Shielding made of only water gives an attenuation of 10^7 with thickness ~ 270 cm

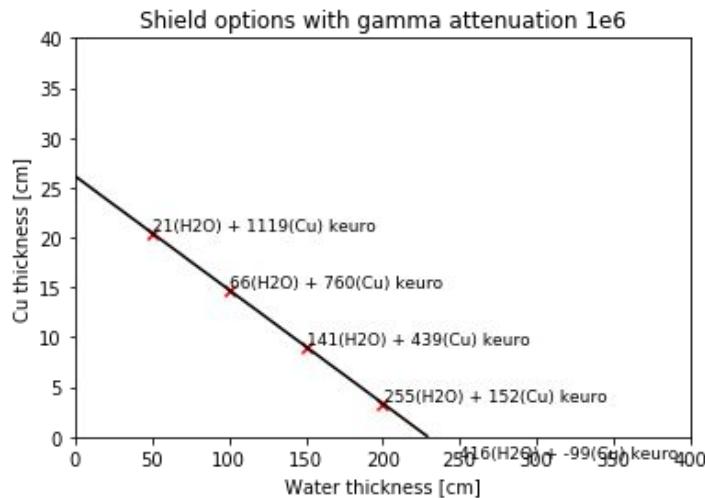
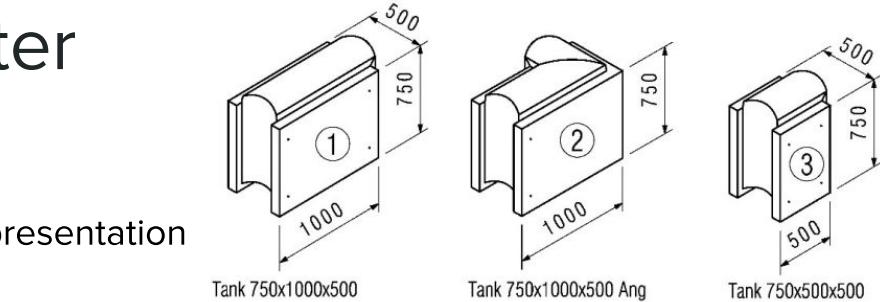
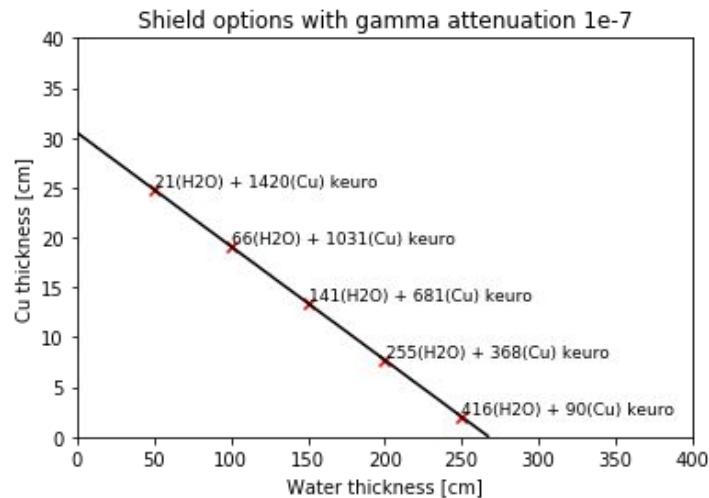
Combination of Cu + water



Cost optimization Cu + water

Assumptions:

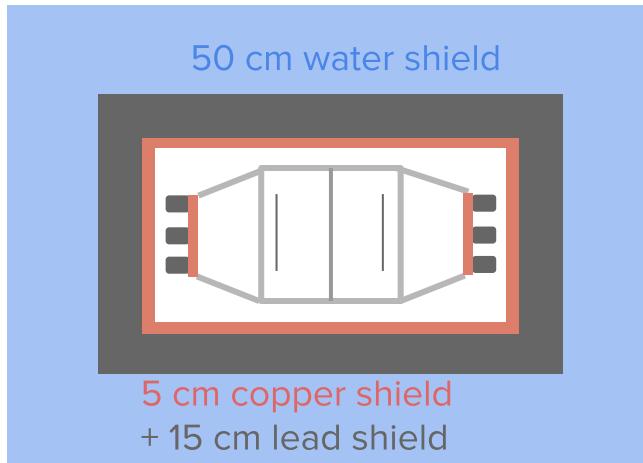
- Cost of copper: 25 euro/kg
- Cost of water: \sim 500 euro/tank from Cesidio presentation
($\rightarrow \sim$ 1.3 euro/kg)



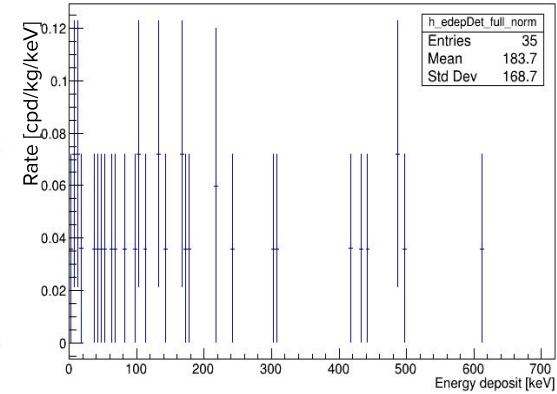
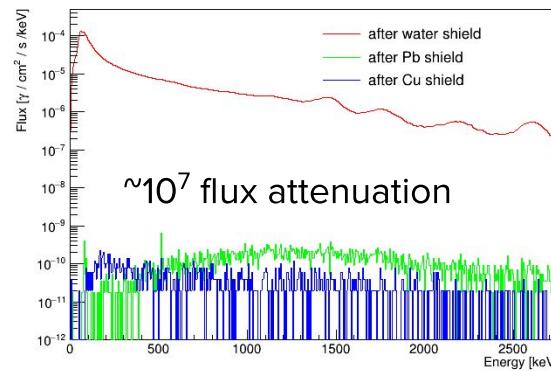
The Cu cost is significantly higher than water (also the modular option for water shielding), so the option with only 5 cm copper and 2-2.5 m water is the cheapest

Shielding option 1

50 cm water + 15 cm Pb + 5 cm Cu



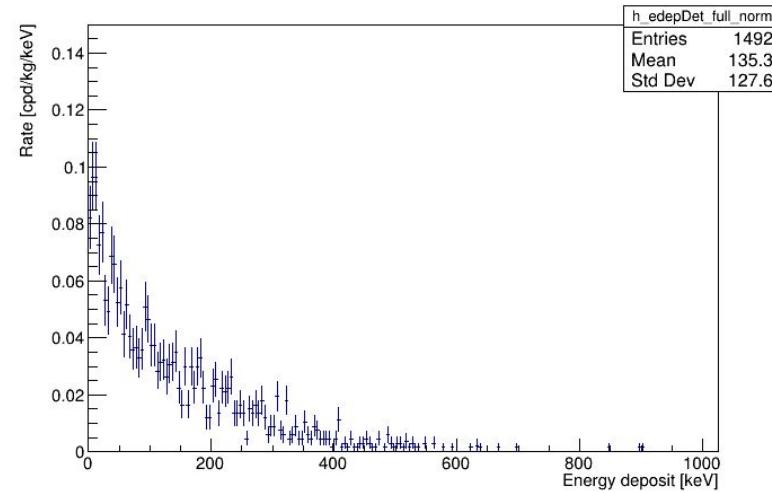
Gamma Flux entering outermost shield $0.56 \text{ cm}^{-1} \text{ s}^{-1}$
Gamma Flux after 50 cm water shield $0.019 \text{ cm}^{-1} \text{ s}^{-1}$
Gamma Flux after 20 cm Pb shield $3.2 \cdot 10^{-7} \text{ cm}^{-1} \text{ s}^{-1}$
Gamma Flux after 5 cm Cu shield $1.4 \cdot 10^{-7} \text{ cm}^{-1} \text{ s}^{-1}$



Rate [0-20] keV = $0.054 \text{ cpd/kg/keV} \rightarrow 630 \text{ cts/yr}$ in CYGNO detector

Shielding option 2

250 cm water + 5 cm Cu



Rate [0-20] keV = $8 \cdot 10^{-2}$ cpd/kg/keV $\rightarrow 10^3$ cts/yr in CYGNO detector