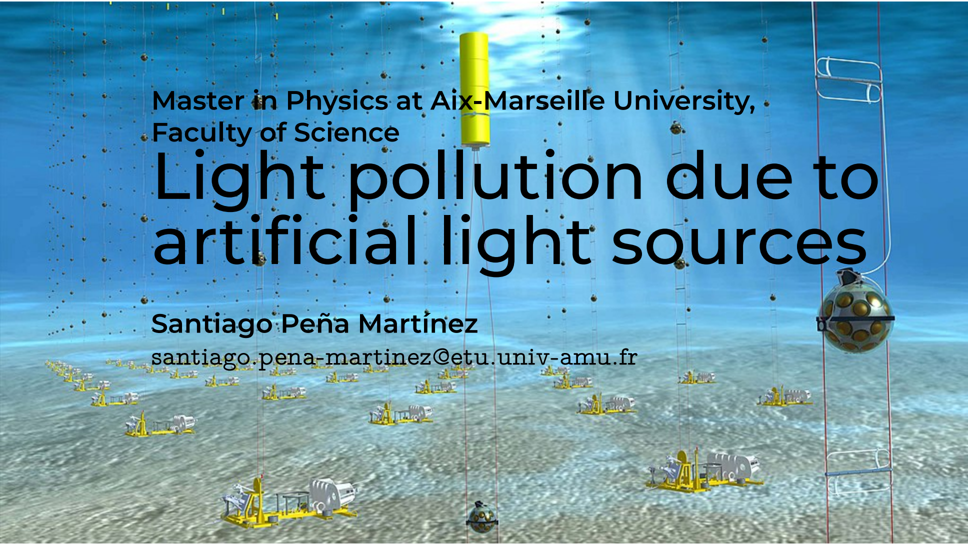

Master in Physics at Aix-Marseille University, Faculty of Science

Light pollution due to artificial light sources

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Aix✳Marseille université

January 5, 2021

Contents

KM3NeT as a neutrino telescope

New research infrastructure

- Discovery and subsequent observation high-energy neutrino sources in the universe

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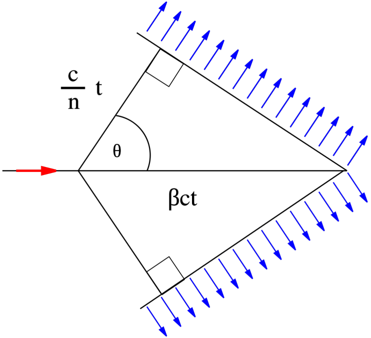
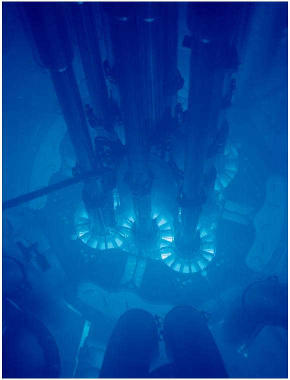
KM3NeT as a neutrino telescope

New research infrastructure

- Discovery and subsequent observation high-energy neutrino sources in the universe
- Measurement of neutrino mass hierarchy
- Joint research with earth and sea sciences

Detection mechanism





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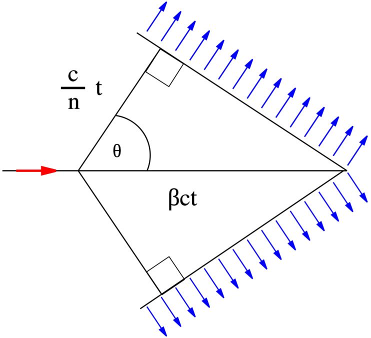
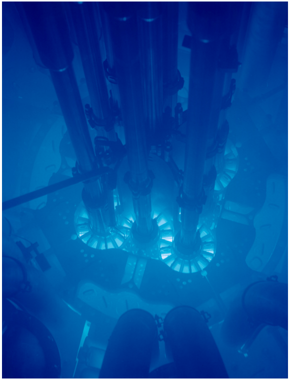
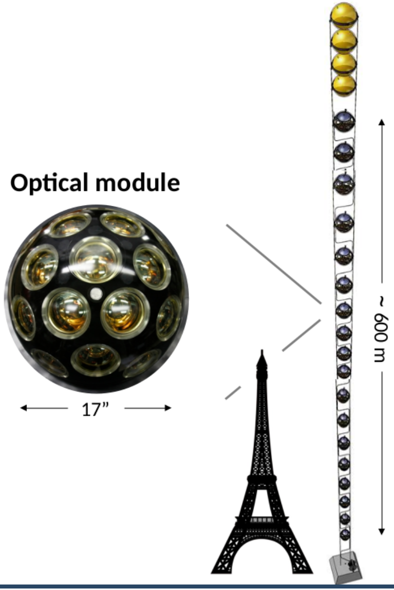




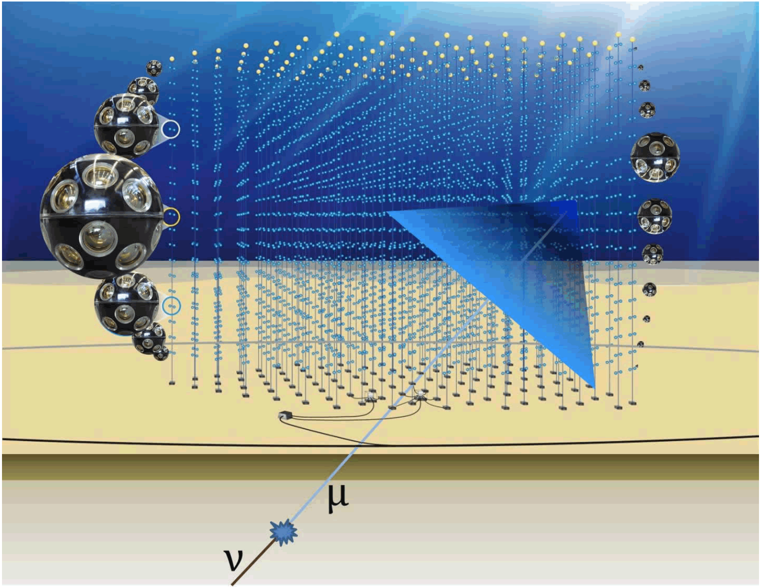
Cherenkov radiation

Electromagnetic radiation emitted when a charged particle passes through a dielectric medium at a speed greater than the phase velocity of light in that medium.

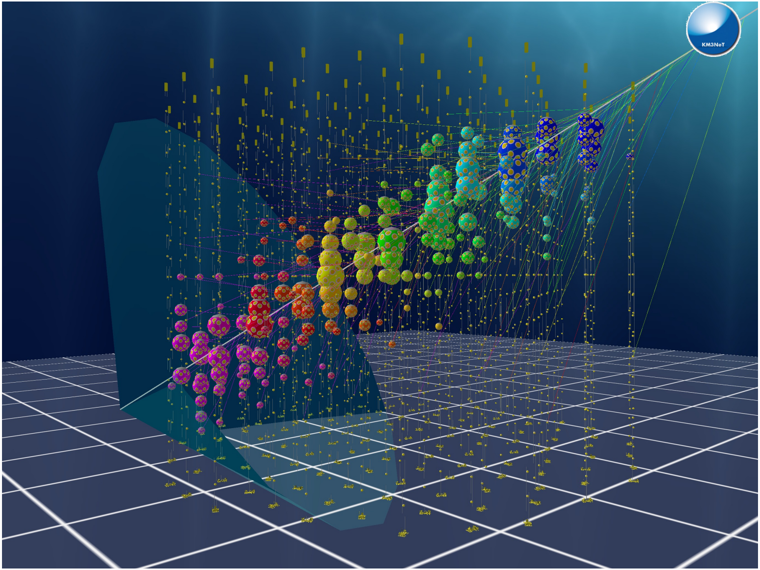
Design



Design



Several unknowns



Measuring the artifical light sources

A conversion between lumen and photons is needed.

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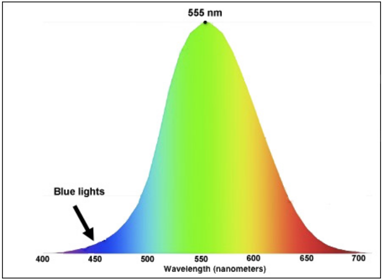

Conversion factor

1 lumen $= 4.11 * 10^{15}$ photons at $\lambda = 555nm$

Water parameters

From Rayleigh scattering theory we have

$$L_{sca}(\lambda) = \left(\frac{\lambda}{550nm}\right)^{4.32} \tag{1}$$

$$\frac{dp_{sca}}{d\Omega}(\beta) = \frac{1}{4\pi}\frac{3}{3+b}(1 + bcos^2\beta) \tag{2}$$

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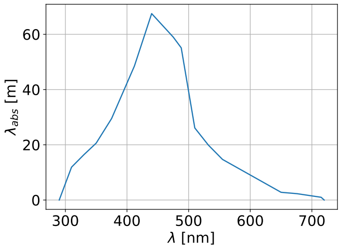
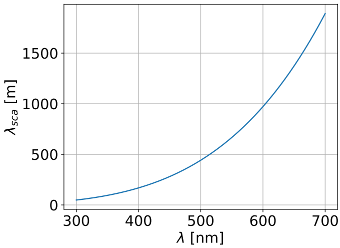
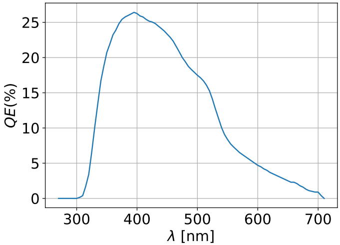


Water absorption length in salt water.

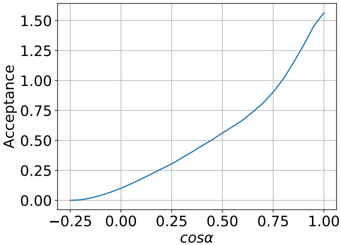


Water molecular Rayleigh scattering length.

PMT parameters

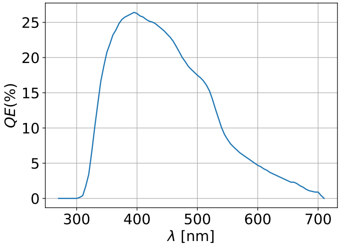


PMT quantum efficiency including glass and gel.



PMT angular acceptance.

PMT parameters



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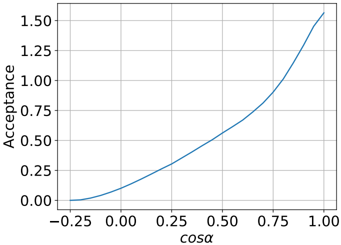
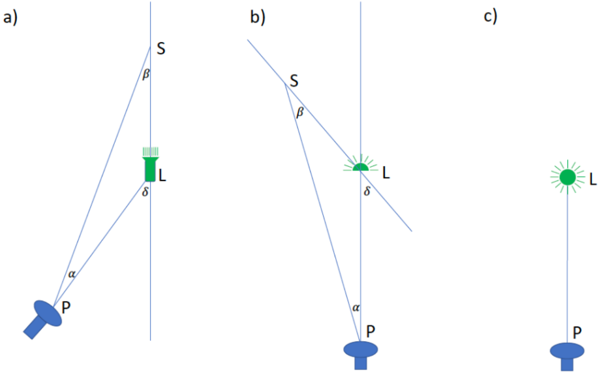


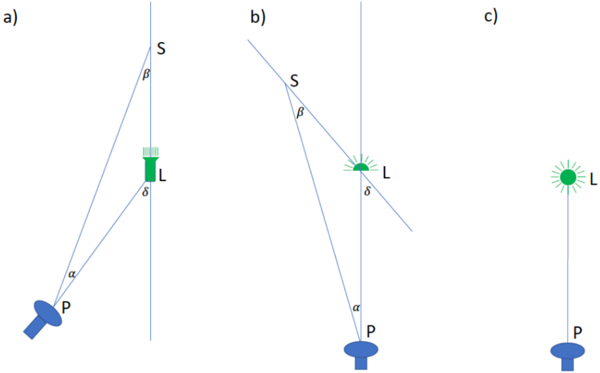
PMT angular acceptance.

Values taken from the oficial KM3NeT simulations.

Different setups



Different setups

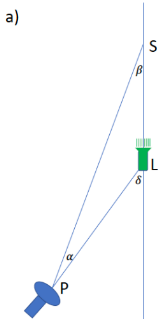


The corresponding scattering differential probability and absorption probability are given by:

$$\frac{dP_{sca}}{ds}(\lambda, s) = \frac{e^{-s/L_{sca}(\lambda)}}{L_{sca}(\lambda)}, \tag{3}$$

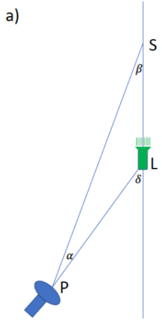
$$P_{abs}(\lambda, s+x) = e^{-(s+x)/L_{abs}(\lambda)}, \tag{4}$$

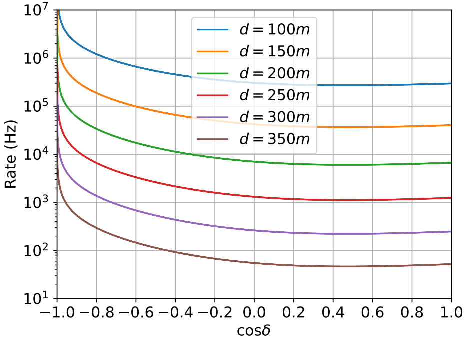
Setup a)



$$R(\lambda, d, \delta) = \Phi_0(\lambda) QE_{PMT}(\lambda) \int_0^{\infty \approx 500} ds P_{abs}(\lambda, s + x) \frac{dP_{sca}}{ds}(\lambda, s) P_{PMT}(\alpha) \frac{dp_{sca}}{d\Omega}(\beta) \frac{A_{PMT}}{x^2} \quad (5)$$

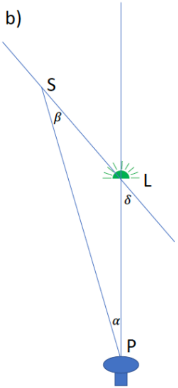
Setup a)





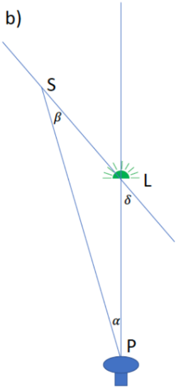
$$R(\lambda, d, \delta) = \Phi_0(\lambda) QE_{PMT}(\lambda) \int_0^{\infty \approx 500} ds P_{abs}(\lambda, s+x) \frac{dP_{sca}}{ds}(\lambda, s) P_{PMT}(\alpha) \frac{dp_{sca}}{d\Omega}(\beta) \frac{A_{PMT}}{x^2} \tag{5}$$

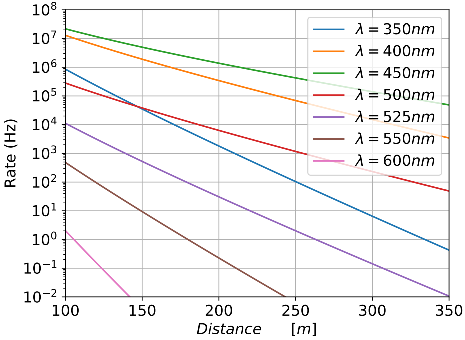
Setup b)



$$R(\lambda,d,\delta)=\Phi_0(\lambda)QE_{PMT}(\lambda)\int_0^{\infty\approx 500}\int_0^{\pi/2}dsd\delta P_{abs}(\lambda,s+x)$$
$$\frac{dP_{sca}}{ds}(\lambda,s)P_{PMT}(\alpha)\frac{dp_{sca}}{d\Omega}(\beta)\frac{A_{PMT}}{x^2} \quad (6)$$

Setup b)





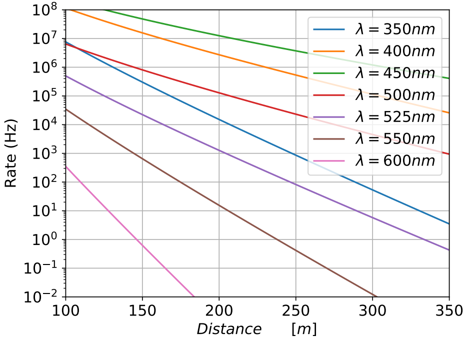
$$R(\lambda, d, \delta) = \Phi_0(\lambda) QE_{PMT}(\lambda) \int_0^{\infty \approx 500} \int_0^{\pi/2} ds d\delta P_{abs}(\lambda, s + x)$$

$$\frac{dP_{sca}}{ds}(\lambda, s) P_{PMT}(\alpha) \frac{dp_{sca}}{d\Omega}(\beta) \frac{A_{PMT}}{x^2} \quad (6)$$

Setup c)

$$R(\lambda, d) = \Phi_0(\lambda) QE_{PMT}(\lambda) P_{abs}(\lambda, d) P_{PMT}(0) \frac{A_{PMT}}{4\pi d^2}. \qquad (7)$$

c)

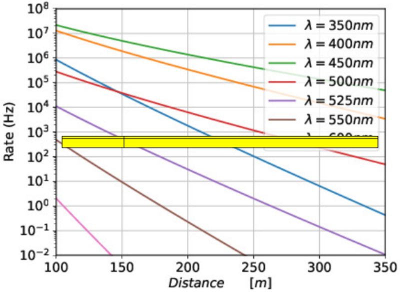


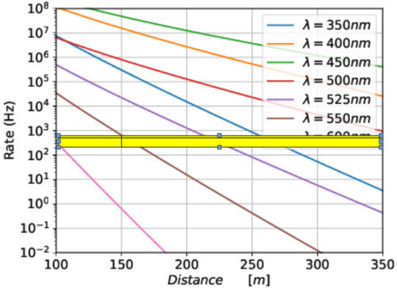
$$R(\lambda, d) = \Phi_0(\lambda) QE_{PMT}(\lambda) P_{abs}(\lambda, d) P_{PMT}(0) \frac{A_{PMT}}{4\pi d^2}. \qquad (7)$$

Lower limits wrap up

Background noise

Natural bioluminiscence and natural radiation from ^{40}K is $\sim 6-7kHz$





Next steps

- Multiple scattering.
- Mie theory for particle scattering.
- Montecarlo simluations for single photons.

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Thank you for your attention