Estimation of PMT exposure in the phase II system test

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1 Cosmic Rays

The significant contribution from cosmic rays should result from the incident muon flux. The flux is $70\,\mathrm{m^{-2}s^{-1}str^{-1}}$ (PDG) incident directly downward with a $cos^2\theta$ profile. Integrating over all angles gives an incident flux of $345.4\,\mathrm{m^{-2}s^{-1}}$. The portion of our vessel inside the reflector wall has a cross-sectional area of $2.09\,\mathrm{m}^2$, so we then have a flux of $721.9\,\mathrm{s}^{-1}$.

Assuming all of these muons are minimum ionizing, they should deposit, on average, $\approx (2\,\mathrm{MeV}\frac{\mathrm{cm}^2}{\mathrm{g}})\rho$ per centimeter traveled in the detector (Tavernier). ρ here is the mass density. The distance between the reflector plate and the PMTs (during a grid test) is 28.4 cm and xenon at room temperature has a density of $0.016\,\frac{\mathrm{g}}{\mathrm{cm}^3}$. Assuming -for simplicity- that all of our muons go straight down (despite us knowing otherwise) each will deposit
$\approx 2\,\mathrm{MeV}\frac{\mathrm{cm}^2}{\mathrm{g}} \cdot 28.4\,\mathrm{cm} \cdot 0.016\,\frac{\mathrm{g}}{\mathrm{cm}^3} = 909\,\mathrm{keV}$.

If we don't have any electric field applied, all of this energy should end in the form of scintillation photons. The work function of xenon is 13.7 eV, so each muon should result in the creation of $\frac{909 \times 10^3}{13.7} = 66 \times 10^3$ photons. This would result in 47.6×10^3 photons/s from muons.

We have a detection efficiency of ≈ 0.015 (granted this is for light emitted in the S2 region), so our PMTs should be exposed to 710 photons/s as a collective, or 22.2 photons/s each (we have 32). Note that these should come in pulses, this is not our detection rate, but only the photon rate.

If we bias our grids, 2.3 cm of our previous SI28.4cm will create S2 light (maybe more will). If we assume a 50% chance for electron vs photon emission, then $\approx 0.5 * \frac{2.3}{28.4} = 0.04$ of the events will emit ≈ 500 photons instead of 1. So we would have $0.04 \cdot 22.2 \cdot 500 + 0.96 \cdot 22.2 \cdot 1 = 465$ photons/s.

2 Ground Radiation

I think Ryan knows a bit about this...

3 Grid Contribution

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4 Sparking

Could probably figure out how much energy could be released by a spark, though the location may be important.