Muography toy studies with a Kasta like tumulus

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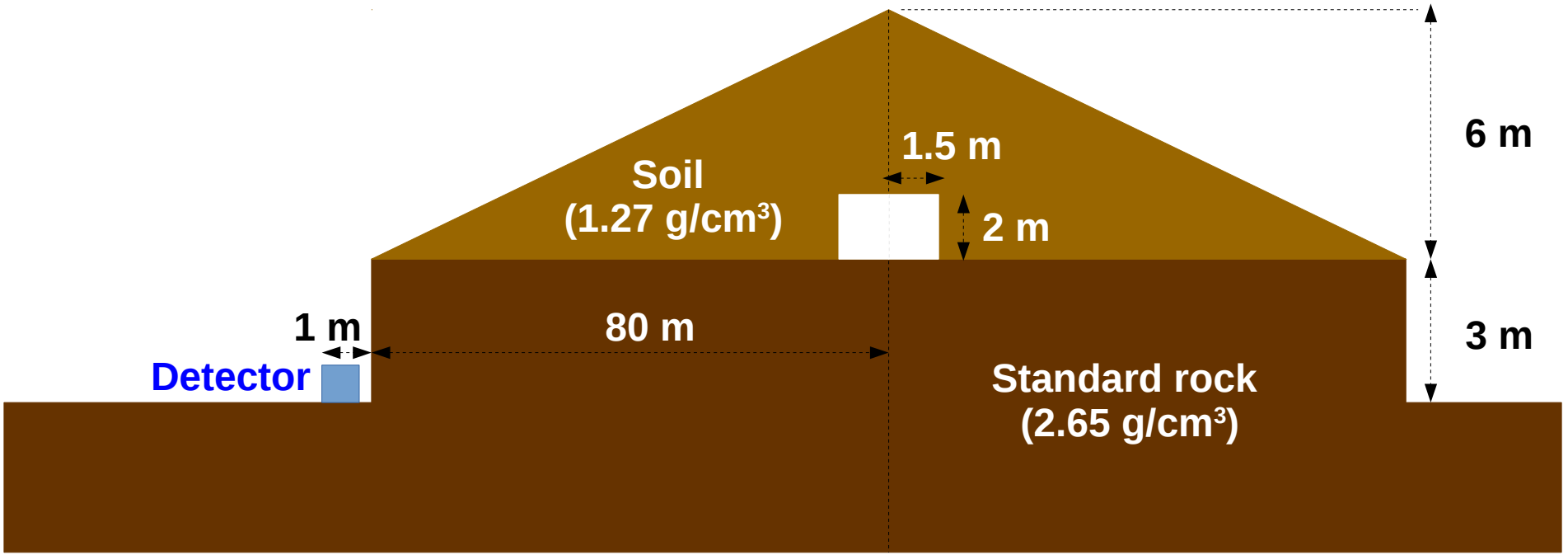
The toy model

- The tumulus is modelled by a cylindrical heavy basis with a lighter cone on-top.
- We look for a cylindrical 3x2 m² room/hole inside.
- An ideal detector is located at the side of the tumulus.

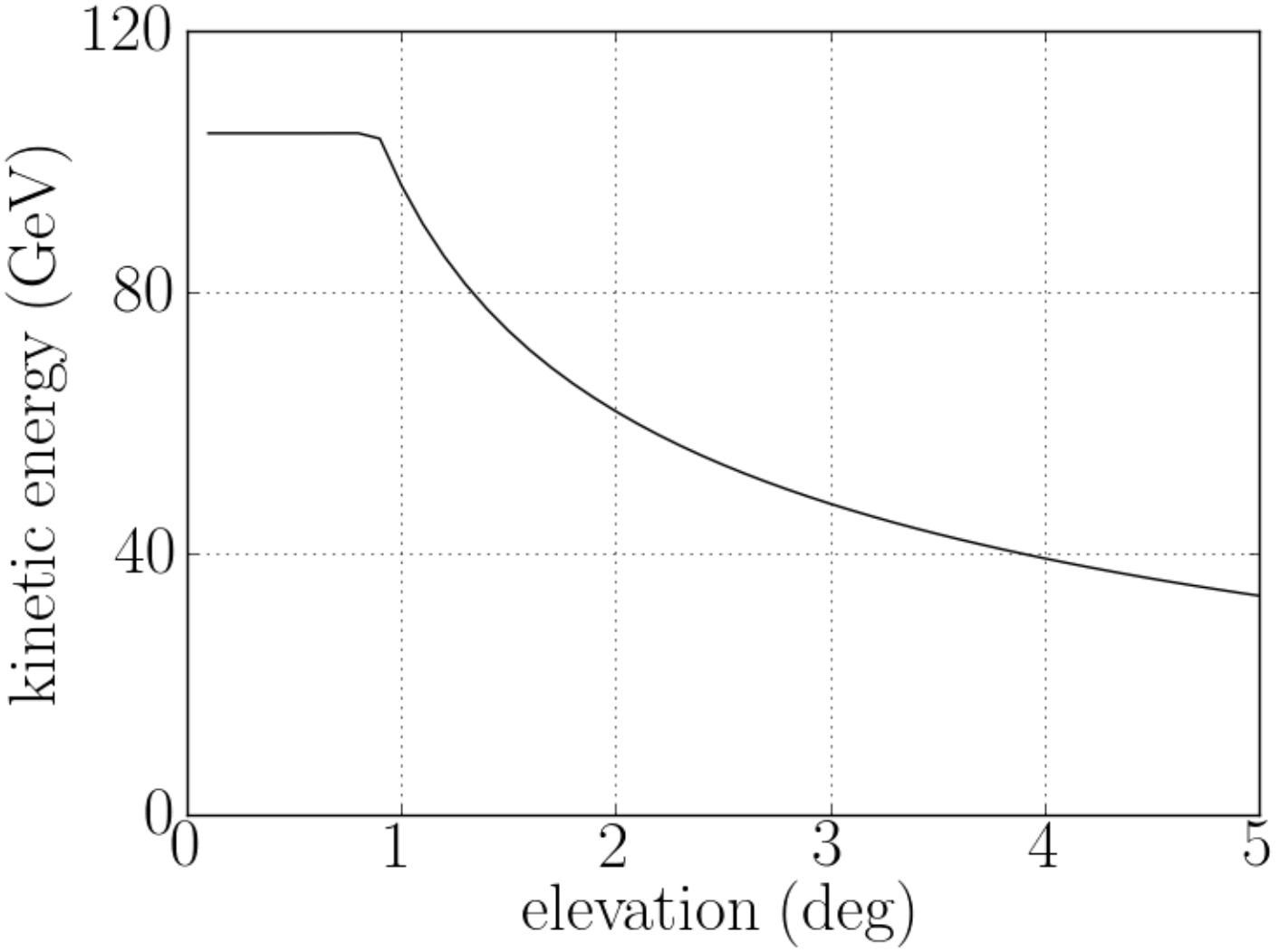


The toy Physics

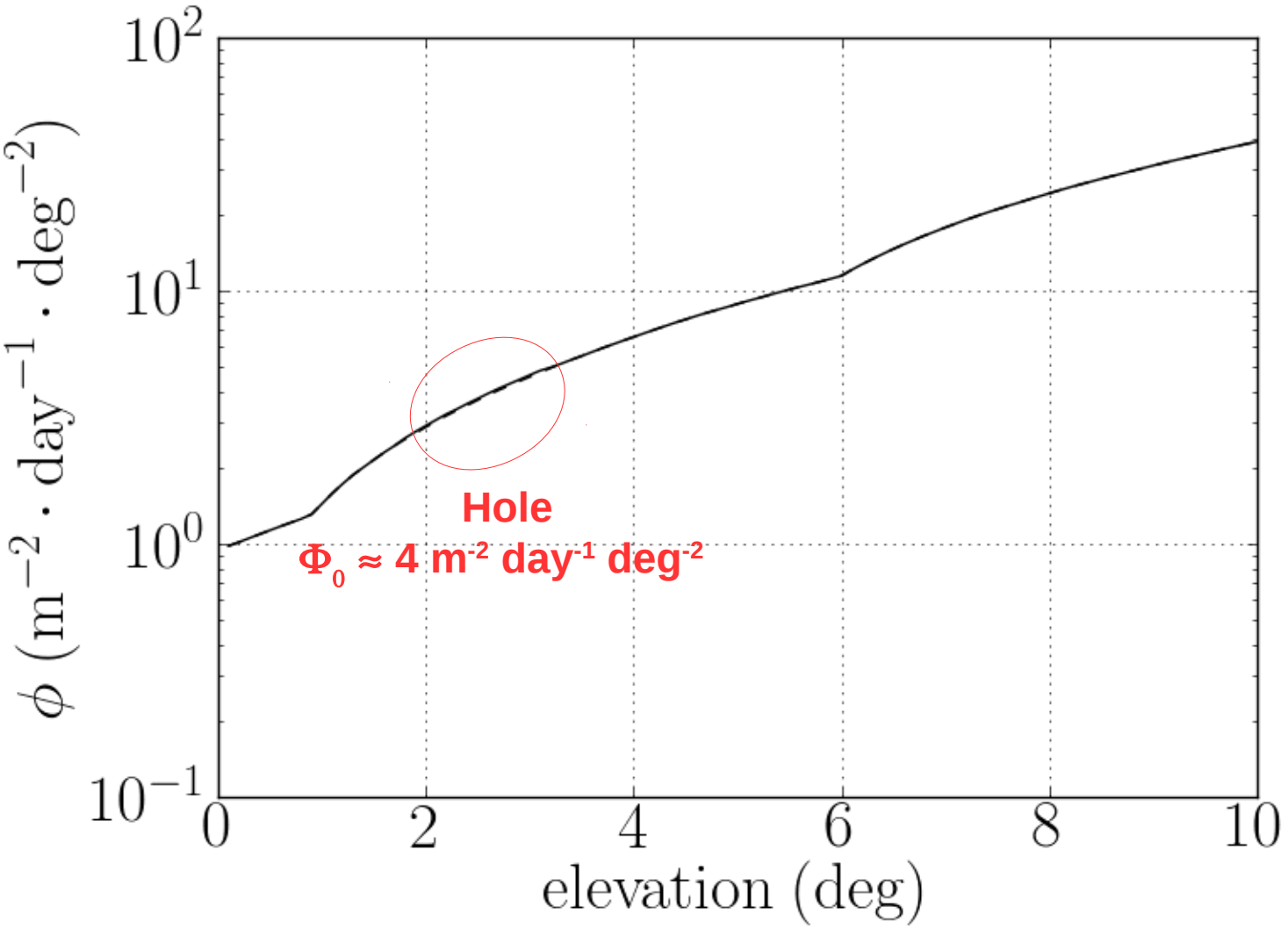
- Atmospheric muon flux from Chirkin (hep-ph/0407078). Good (5%, absolute scale) agreement with Tomuvol field measurements in [5;30] deg of elevation.
- Continuously Slowing Down Approximation (CSDA) for muons propagation. Accurate (~1%, systematics) estimate of the integrated density for X < 2 km·g·cm^{-3}.
- 1D simulation. Muons follow straight path lines: no scattering. OK for E_{mu} > 10 GeV. Background from low energy particles is not simulated.
- The required exposure, Σ (m^2·s), for statistical uncertainties to be reduced to ε percent of the transmitted flux, Φ_0, in a solid angle Ω, goes as:

$$\Sigma = \frac{1}{\Phi_0 \, \Omega \, \epsilon^2}$$

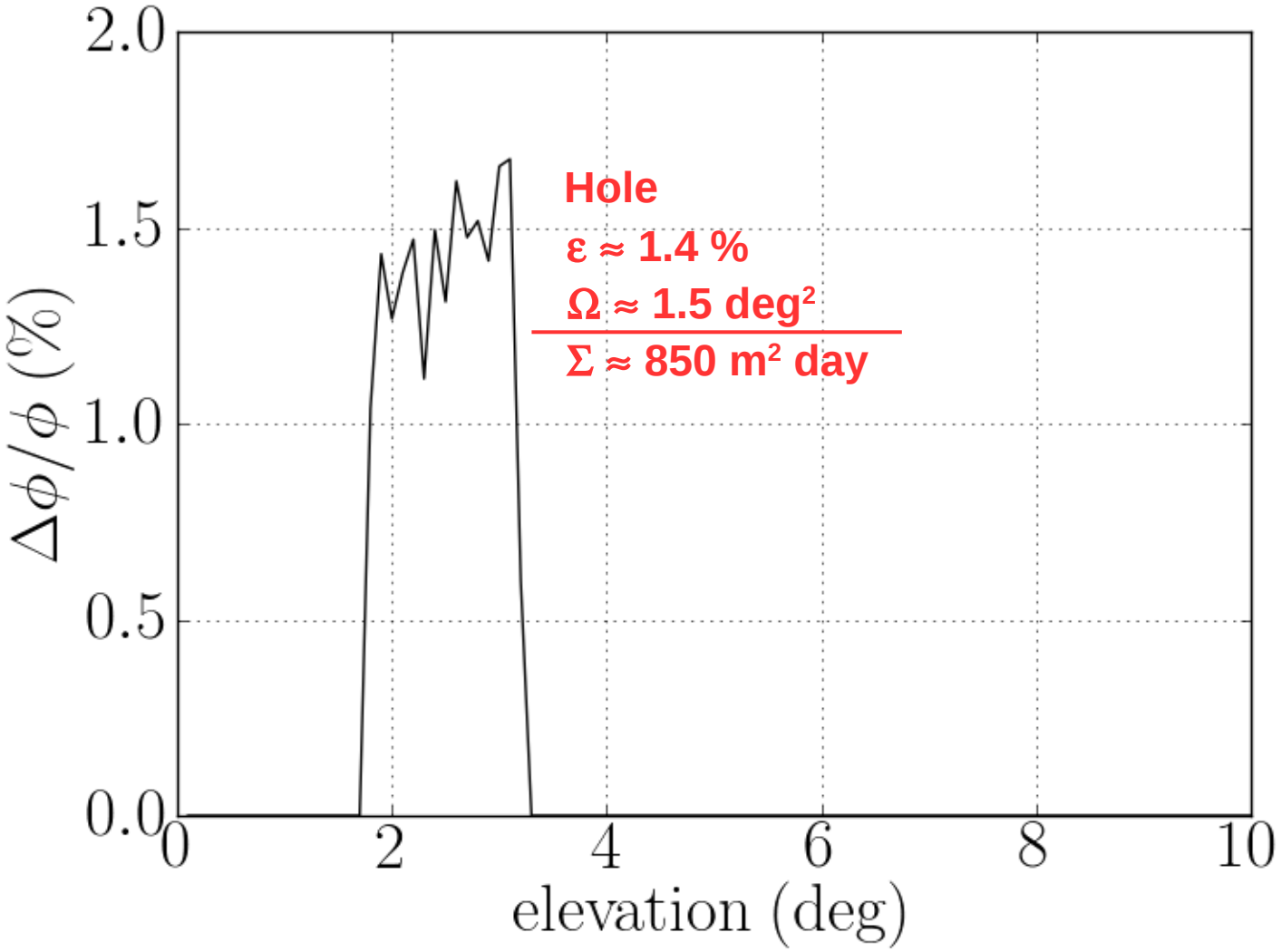
The CSDA kinetic threshold



The transmitted muon flux

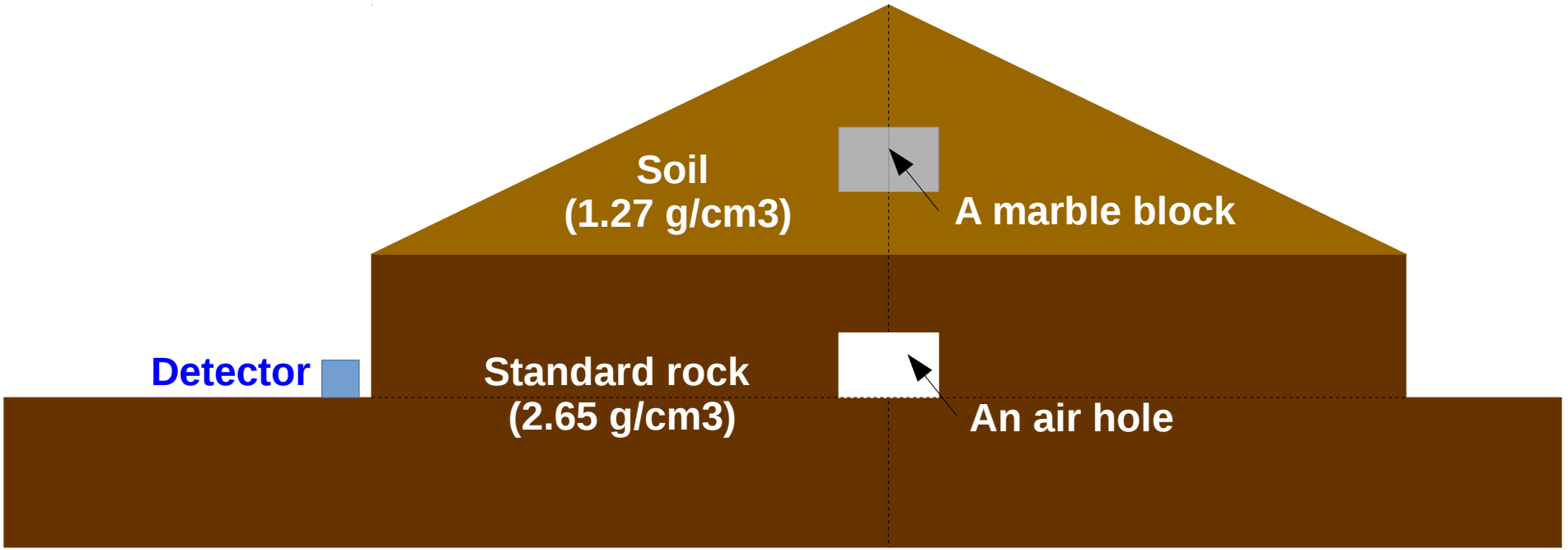


The flux variation

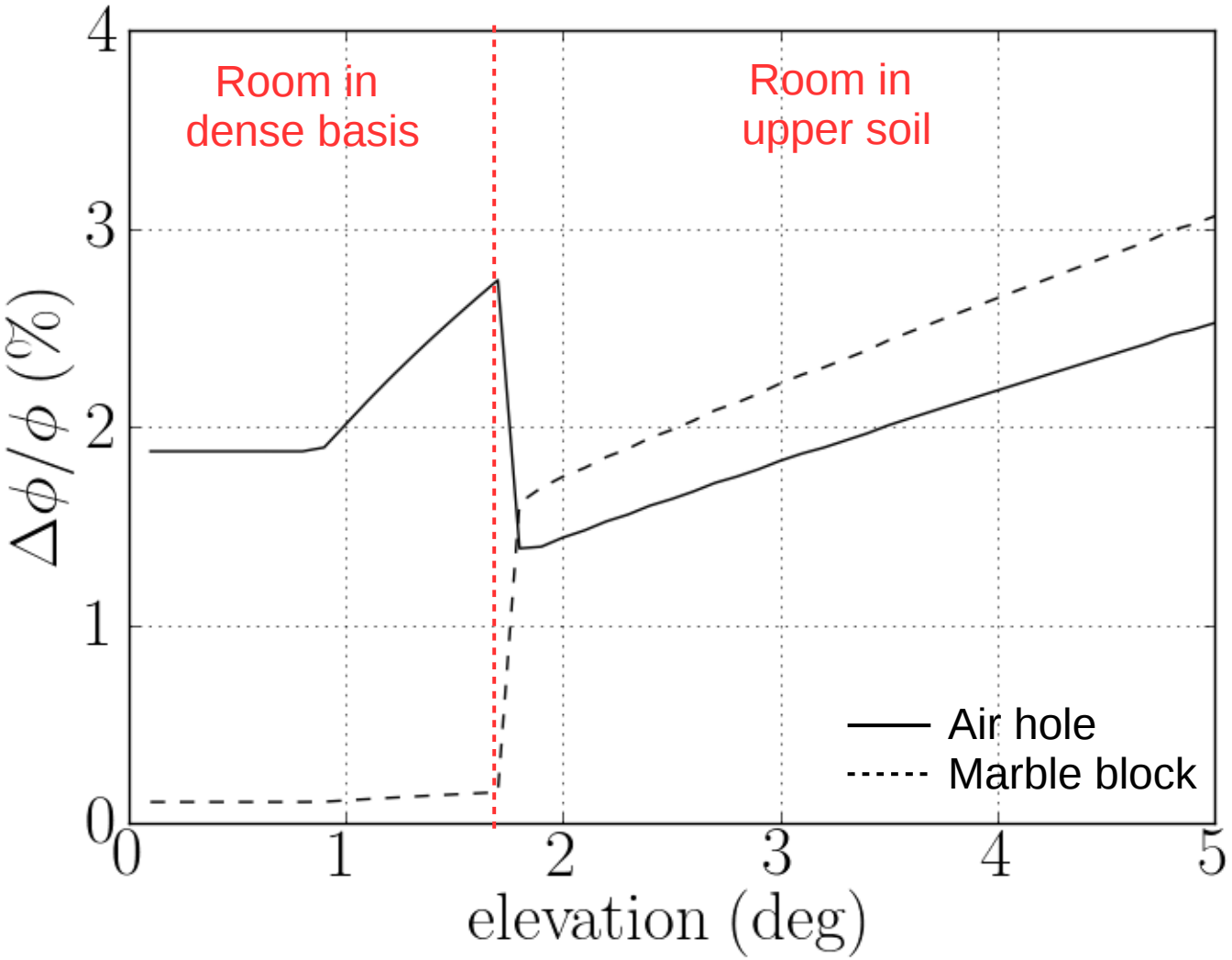


Variation of the toy model

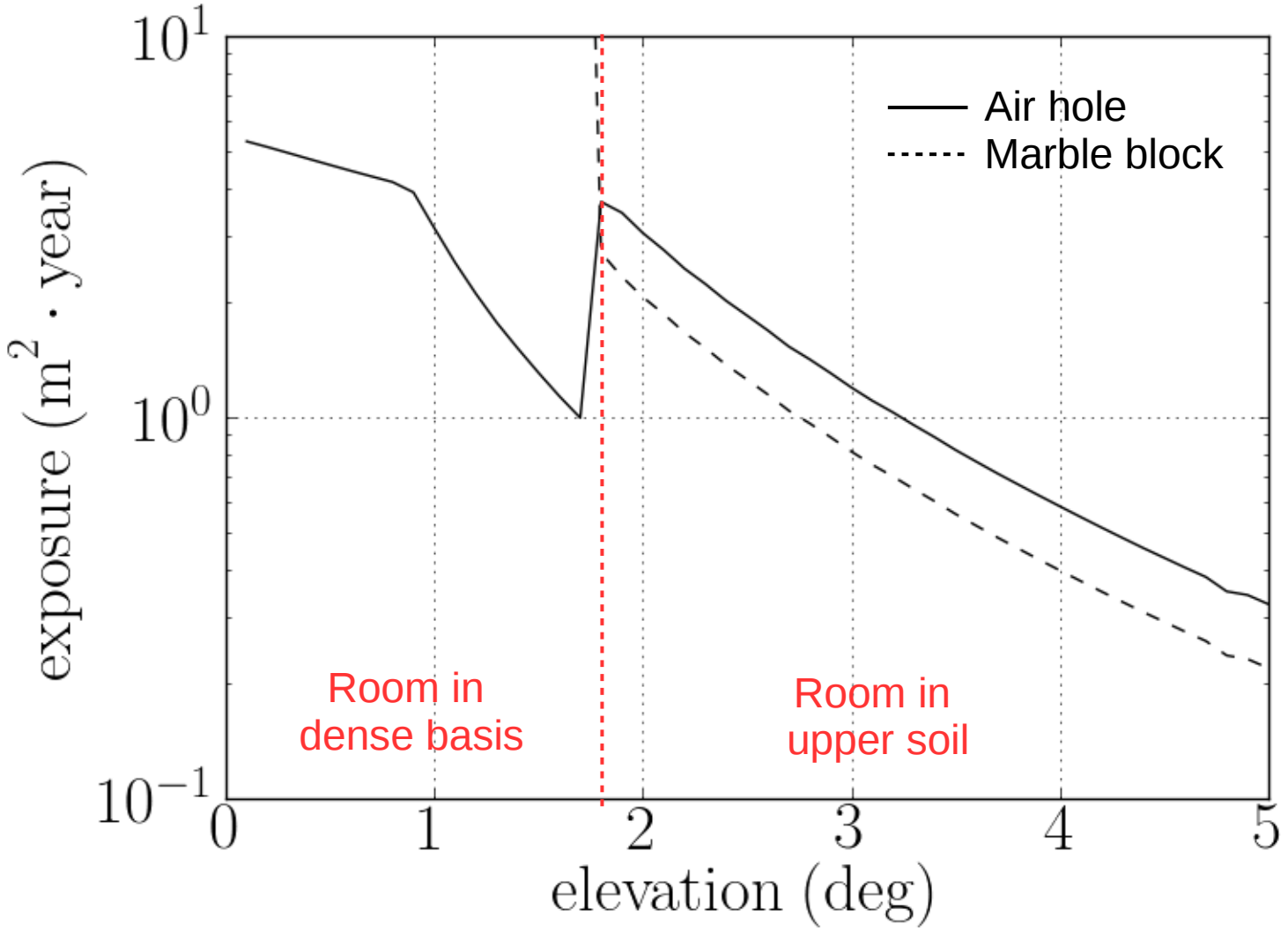
- The room can be a air hole or a marble block (2.8 g/cm^3). It can be located at various heights, though still centered.



The flux variation as the room elevation



The required exposure as the room elevation



Conclusion and outlooks

- Detecting a 1% variation of the transmitted muon flux, over 1 deg^2, is challenging due to the low statistic (~a few muons per day per m^2). But, not out of reach: requires 10 m^2 effective area and a very good control over the background (<0.3%).

- The flux variation, ε, induced by a “default” is the leading parameter (squared dependency). Therefore, the detector location plays a critical role. We considered a worst case here: detecting a small room from the outside. Detecting a long corridor perpendicular to the detector (ε~10%), or a room above the detector from inside the tumulus, is much easier.