How we improve dating using muon tomography ? The case of **slow muons or μ-capture.**

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- Previously I have shown how a precise measurement of the overburden will improve dating.

https://agenda.infn.it/event/42364/

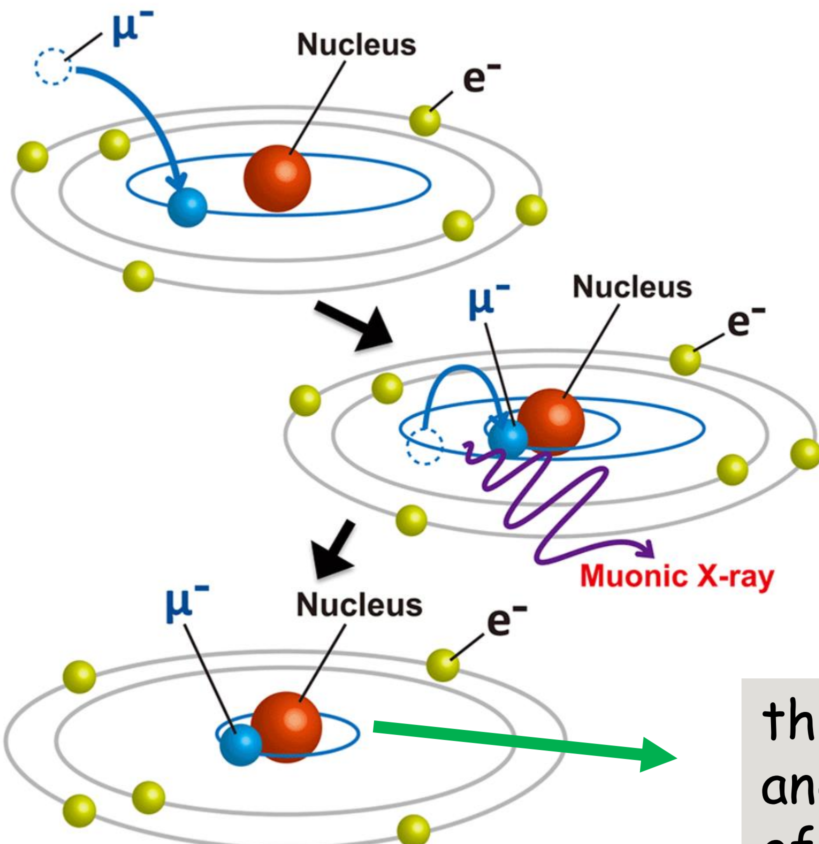
- I have also shown that the P-value for **fast muons** can be improved using a flux measurement in the cave …a flux measurement will allow a better determination of the post–burial component and a better determination of the MAX age.

https://agenda.infn.it/event/42981/

- In addition I have indicated that a measurement of the neutron flux at the surface might improve the MIN age via an improved knowledge of the inherited Be/Al ratio

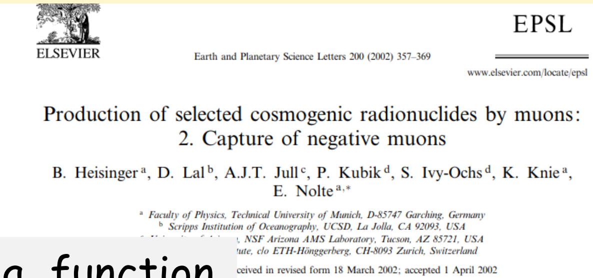
Today I will discuss the case of slow muons

Slow muons or muon capture…what is the process?



the muon collapse into the nucleus and the excess energy leads to loss of nucleons and cosmogenic nuclides are produced (among others)

To discuss the case of slow muons I follow the approach of Heisinger et al.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Earth and Planetary Science Letters 200 (2002) 357–369

www.elsevier.com/locate/epsl

Production of selected cosmogenic radionuclides by muons: 2. Capture of negative muons

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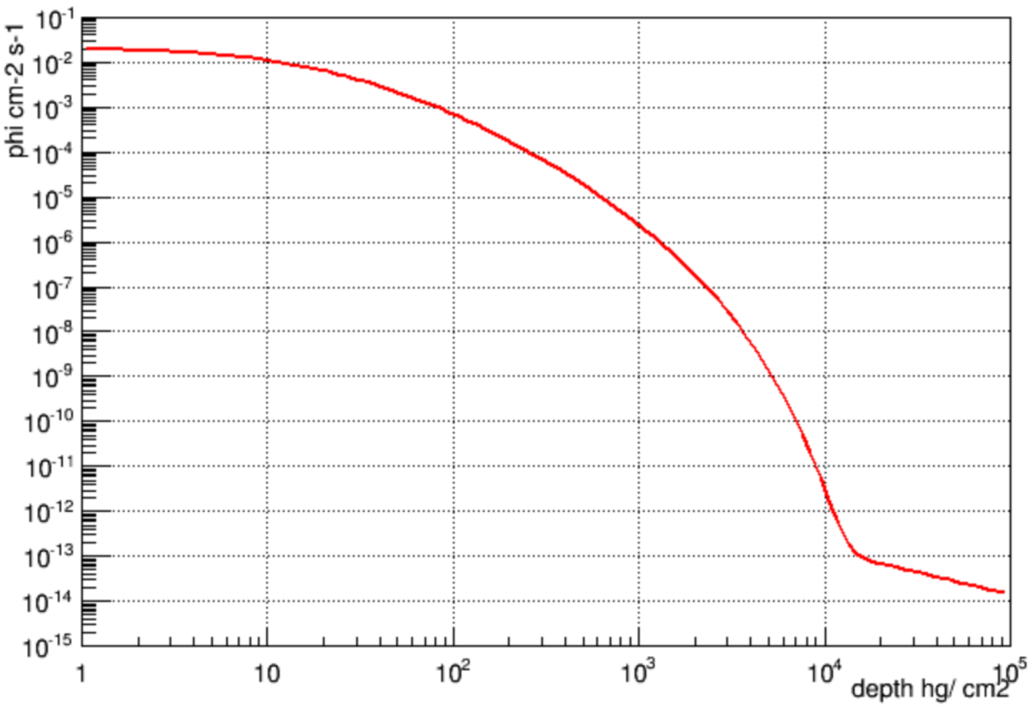
First step is to determine the stopping rate

The stopping rate is the derivate of the negative muon flux as a function of h after integration over the horizontal angles



$$R_{\mu^-}(h) = \frac{\mathrm{d}}{\mathrm{d}h}\left(\Phi_{v}(h)\cdot\frac{2\pi}{n(h)+1}\cdot f_{\mu^-}\right)$$

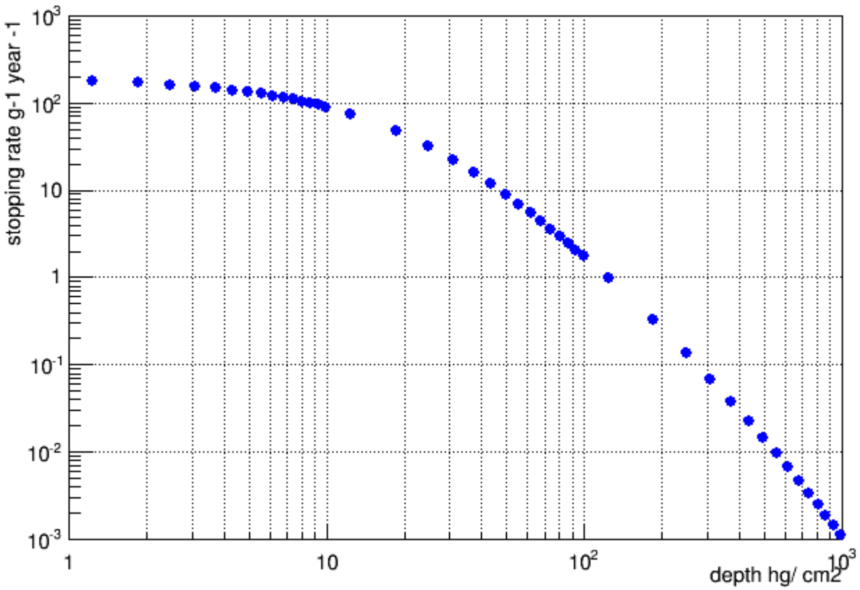
$$\Phi_{v}(h) = \frac{258.5}{(h+210)\cdot([h+10]^{1.66}+75)} e^{-5.5\times 10^{-4}\cdot h}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}\ \mathrm{sr}^{-1}$$

$$n(h) = 3.21 - 0.297\cdot\ln(h+42) + 1.21\times 10^{-3}\ h$$

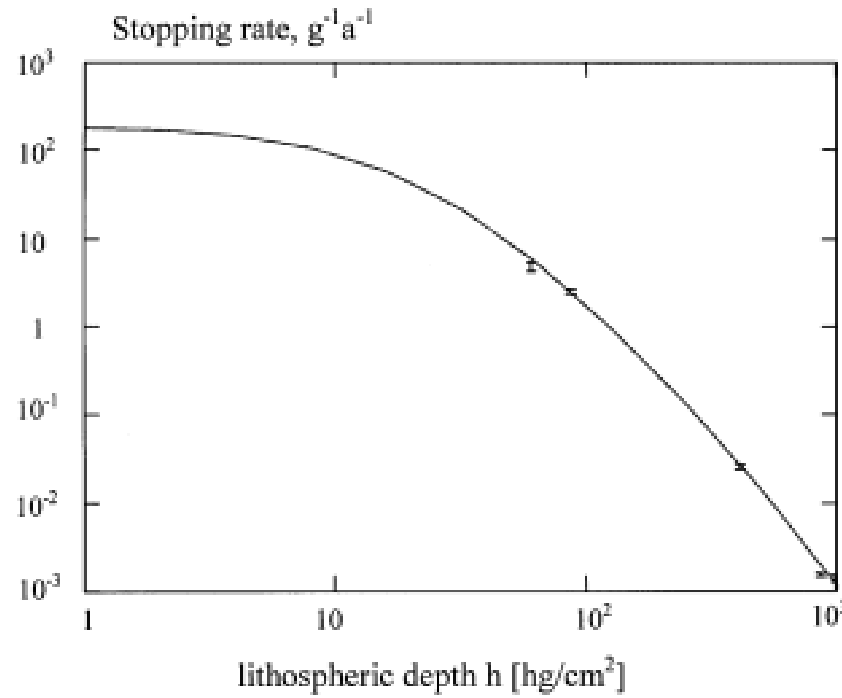
$$f_{\mu^-}(h) = \frac{1}{K_{\mu}+1} \qquad K_{\mu} = 1.268,$$

I have used the formulae on the previous page to calculate the stopping range….obviously I have calculated the derivate just numerically and not analytical

my calculations



Heisinger et al



Also the value at 0 agree i.e. 190 g^{-1} $year^{-1}$

Next step is to calculate the P_{10} value for capture of negative muons… in this case we don't talk about cross section but probability for capture..

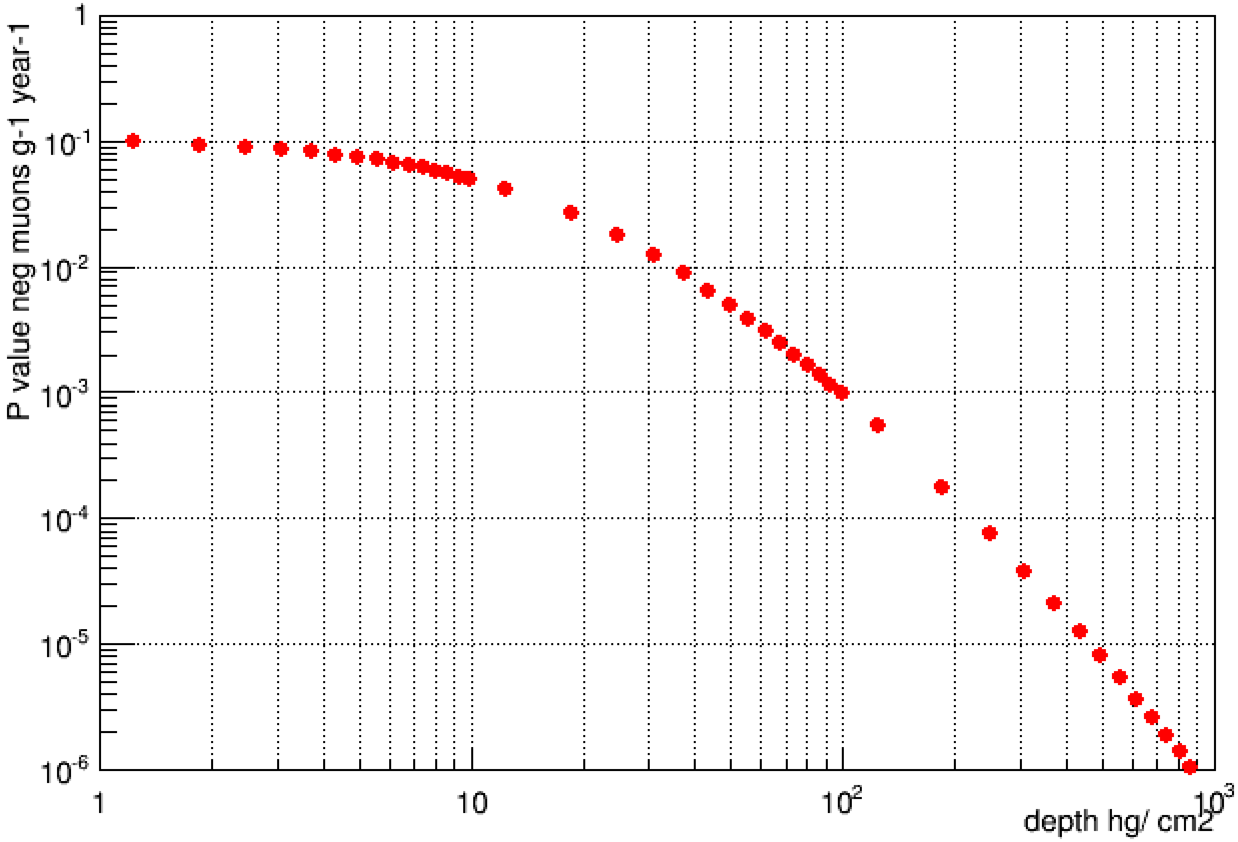
$$P_{\mu^-}(h) = R_{\mu^-}(h) \cdot f_C(Z_i) \cdot f_D(Z_i) \cdot f^*(^AZ)$$

f_C = chemical compound factor =0.704
(I don't know exactly what it is…no access to the ref)

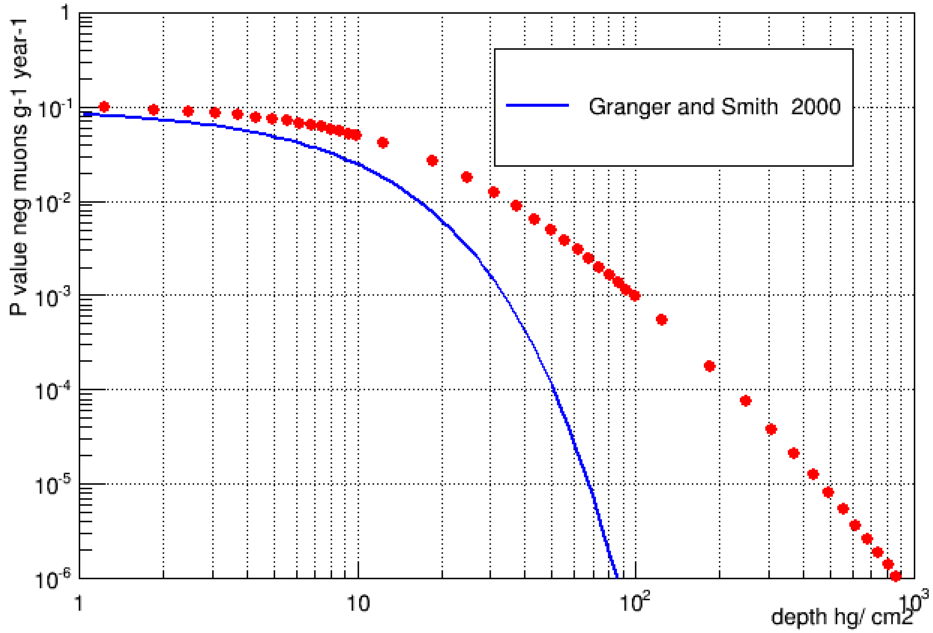
f_D= probability the muon does not decay in the K-shell before nuclear capture =0.1828

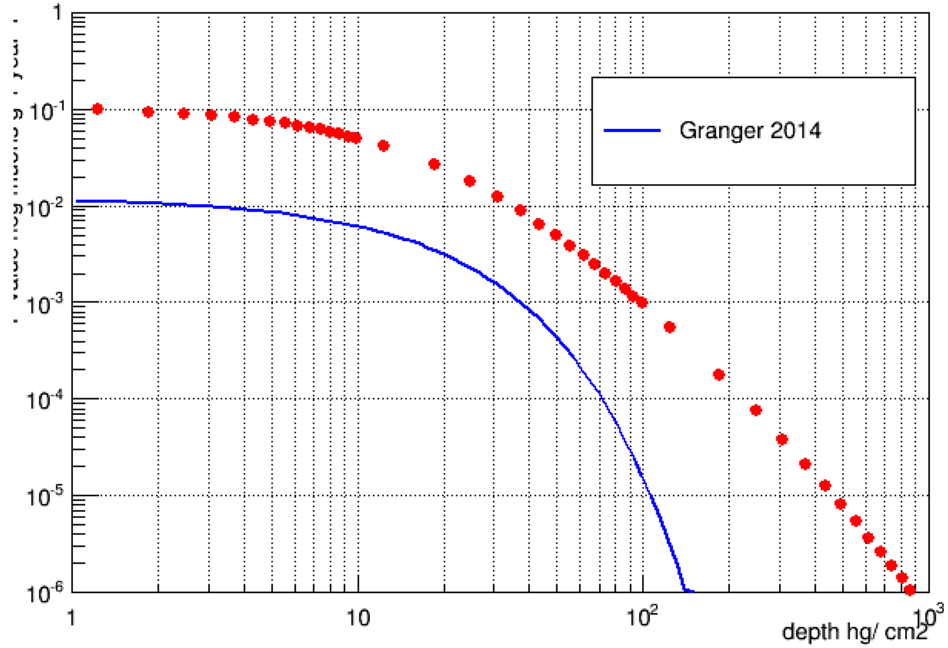
f* =the probability that Be^{10} is produced after μ-capture=0.43 %
(measure by Heisinger et al at Paul Scherrer institute.

Here the result for the p_{10} value of slow muons

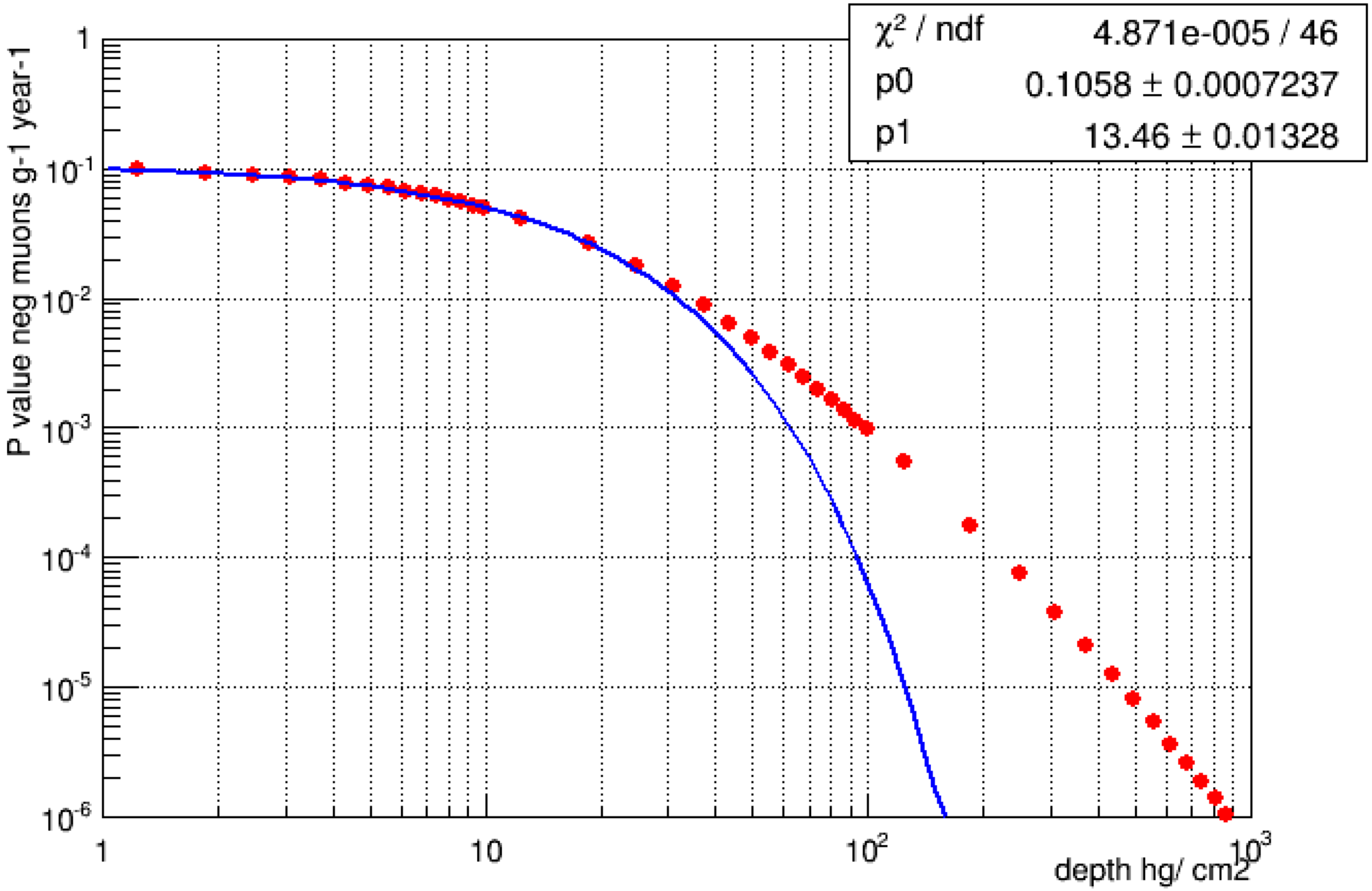


Now compare with results from core drills





Here I make my own exponential fit .....



with a length parameter of 13.5 hg/cm2 we have good description up to depth of 30-40 hg/cm2

Discussion what does these considerations bring…..

Also for slow muons or (rather muon capture) we have separated the capture probability and the stopping rate applying the Heisinger approach.

The question is how can we use this to improve the p-value for muon capture after having measured the muon flux in the cave?

In the case of fast muons it is straight forward as I showed in the previous presentation.

In the case of muon capture it is more indirect as we can not measure the derivative of the muon flux

However the measurement of the flux will allow us to see where we are on the «standard» paramerisation of the flux as a function of the the depth and then we take the derivative from the standard curve…

Thus I conclude that our flux measurement will also improve the p-value for slow muons

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