Radon-Induced Backgrounds: Alpha-gamma background

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DUNE Backgrounds Mitigation Strategies Workshop

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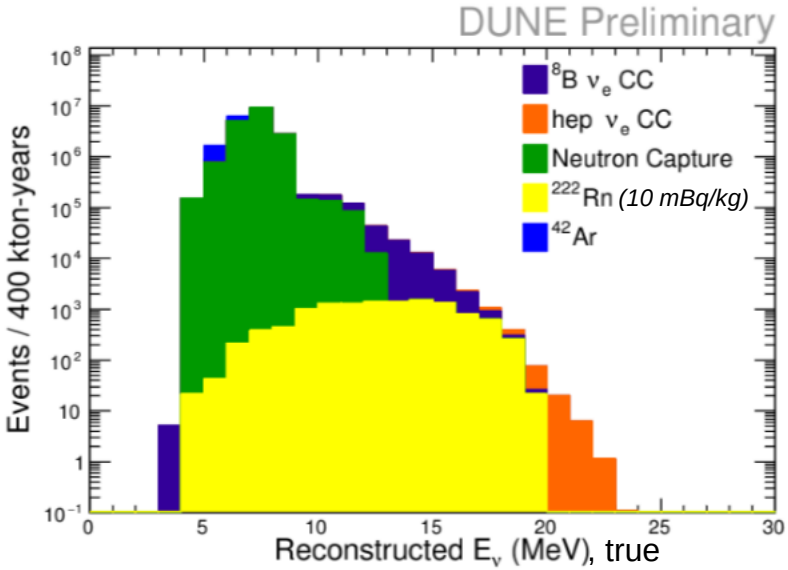
Ensure we maximise our potential

The Task Force may also **comment** on whether ***more stringent requirements*** on these background levels would allow DUNE to pursue other physics topics such as ***solar neutrino measurements***.



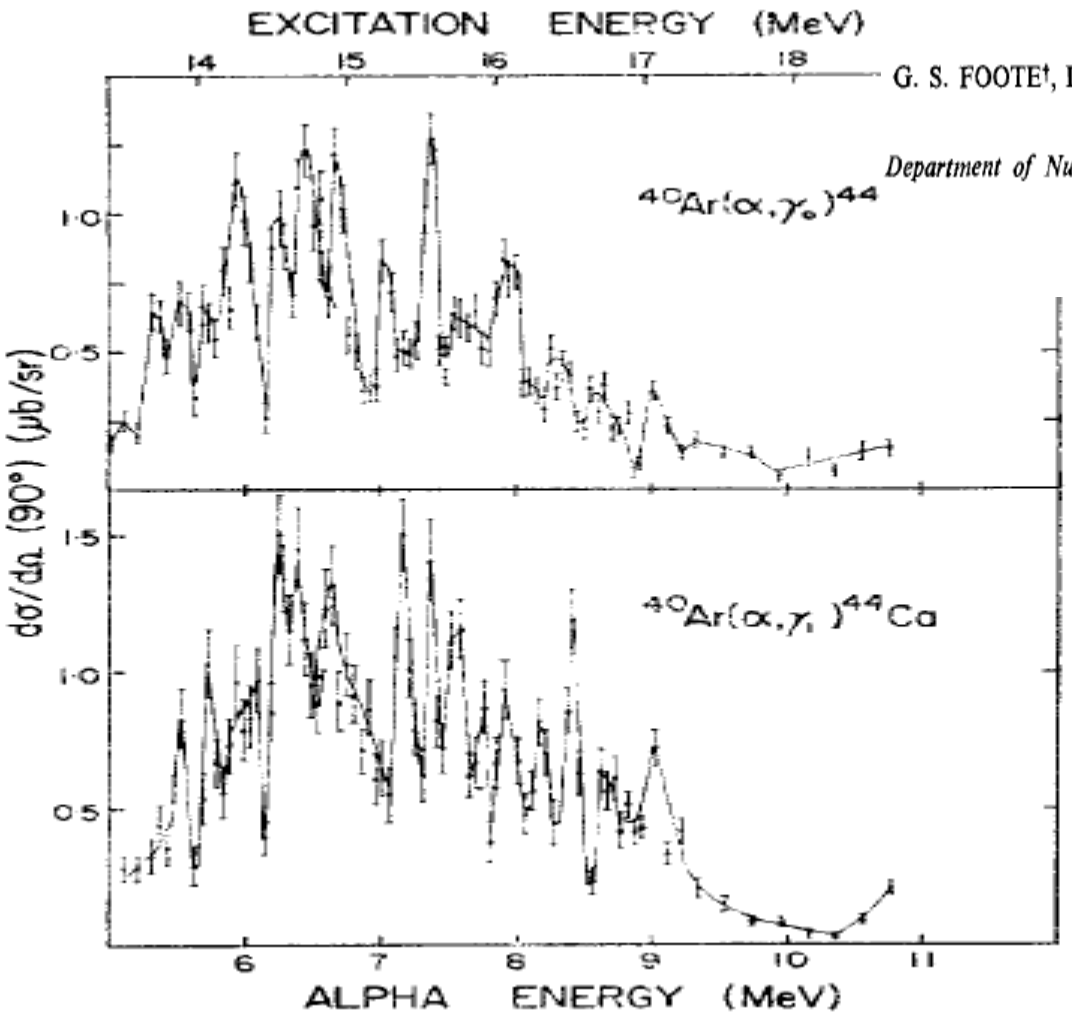
David Rivera *is studying the effect of lowering the DAQ trigger in order to keep the radiologic data volume reasonable.*

https://indico.fnal.gov/event/20144/session/19/contribution/271/material/slides/0.pdf

Dan Pershey *has carefully studied the solar neutrino sensitivities as function of the background.*

https://indico.fnal.gov/event/20144/session/19/contribution/269/material/slides/0.pdf

40Ar(alpha, gamma) Background



ALPHA CAPTURE TO THE GIANT DIPOLE RESONANCES OF ^{42}Ca, ^{44}Ca AND ^{52}Cr

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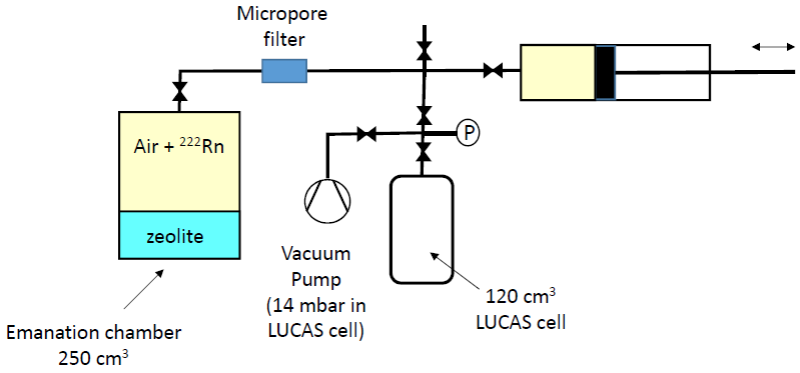
-> Plan to measure at Notre Dame (or Spain)
together with (α,n) cross section

Internal Backgrounds: Radon Emanation into LAr from Filter Materials

Jose Busto (CPPM Marseille)



	Zeolite	Cu Getter
Mass	71.5 g (20Bq/kg)	76.5g (2Bq/kg)
Ra in emanation chamber	1.44 Bq	0.153 Bq
Rn in Lucas cell	40.1 Bq/m3	20 Bq/m3
Rn in emanation chamber	0.01 Bq/m3	0.0052 Bq/m3
Ration Rn in air chamber	0.7 %	3.4 %

=> 0.55 mHz/kg alpha-ray activity in our LAr corresponding to a Rn-222 level of only 0.14 mBq/kg

This would already meet our Recommendation!

=> 0.1 mBq/kg goal of Rn-222 in LAr seems feasible (especially with further cold suppression)!

Plans for unique cold emanation measurement into Ar

⇒ Asks for extensive emanation assays of "2nd order" components
(e.g. large cables @ Sheffield?)

Impact of Radon Requirement in LAr

If I assume the old superseded radon requirement of 10 mBq/kg (since May I proposed 1 mBq/kg)
then we might have 140,000 Bq of Rn-222 uniformly dissolved in 14,000 tons of LAr.
Each Rn-222 decay can give us 4 alpha's making it 560,000 * 10 kton / 14 kton = about 400,000 alpha/sec in our fiducial volume, so far so good.

15 MeV gamma-ray production from 40Ar(alpha, gamma):
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In one day we'll get then 3.5e10 alpha decays in 10 kton LAr (with 1.4 g/cm^3 and atomic weight of Ar being 40 u).
If I assume a total cross section of 10 microbarn for 40Ar(alpha, gamma) with 30% upper and lower uncertainty
then I can expect 10e-6 * 10^-24 cm^2 * 3.5e10 * 2.1e22/cm^3 * 0.002 cm = about 15 gammas / day or 2x10^-4 gammas / sec
which corresponds to about 20% of our daily solar neutrino rate from boron-8. (1.5 γ's / day @ 1 mBq/kg)

7 MeV average alpha energy and 5 MeV cut-off gives about 20 micrometer effective alpha range.

15 MeV gamma-ray production from 40Ar(alpha, gamma):
0.75 microbarn dsigma/dOmega under 60 degree *4Pi = about 10 microbarn total cross section for 40Ar(alpha, gamma)

[~12 MeV gamma-ray from 38Ar (alpha,gamma):
4 microbarn dsigma/dOmega under 60 degree *4Pi =
about 50 microbarn total cross section for 38Ar(alpha, gamma) with abundance of 0.0629% and negligible]

Neutron production from 40Ar(alpha, neutron):
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If I assume a cross section for 40Ar(alpha, neutron) of 33 mbarn (with factor 3 upper and lower uncertainty)
then I can expect 33e-3 * 10^-24 cm^2 * 3.5e10 * 2.1e22/cm^3 * 0.002 cm = about 5x10^4 neutrons / day or 0.6 neutron / sec

(0.06 neutrons / sec @ 1 mBq/kg)

(compared to Vitaly's 14kt calculation: 0.16 neutrons / sec @ 1 mBq/kg)