Rn requirements for outer veto AAr

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Materials Call

The outer veto as a neutron source

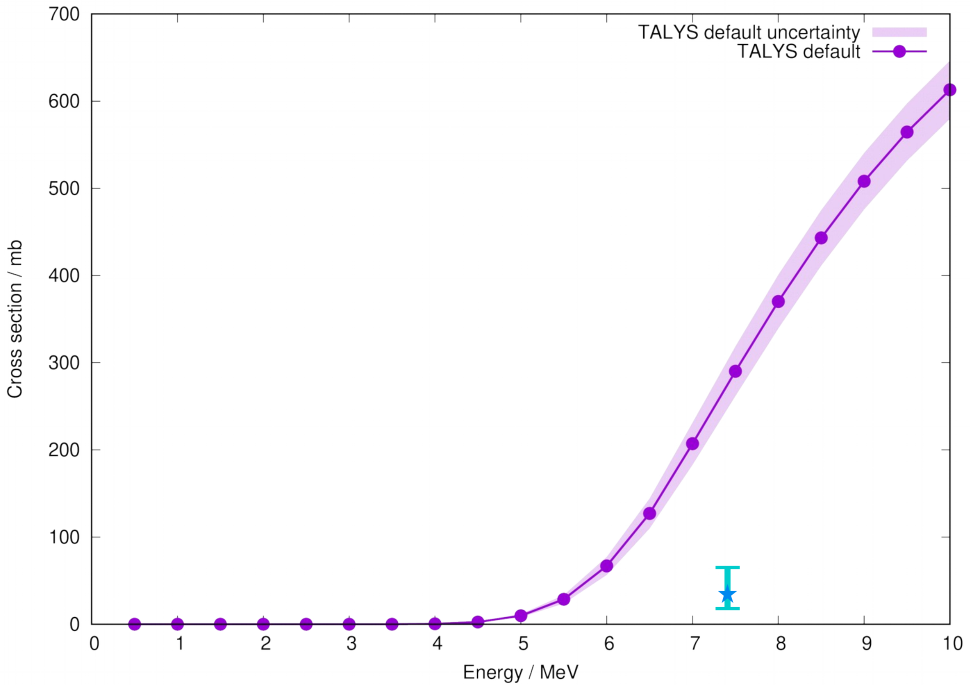
- The (α,n) yield of ^{nat}Ar for…
  - ^{220}Rn decay chain: 2.5×10^{-5} n/s/Bq
  - ^{222}Rn decay chain: 1.4×10^{-5} n/s/Bq
- For ~700 tonnes of AAr, 1 Bq/kg → 700 kBq
  - From ^{220}Rn: 9.8 n/s
  - From ^{222}Rn: 17.5 n/s
- P(TPC background | AAr neutron) ~ 2.6×10^{-8}
  - g4ds simulations from Paolo
- Therefore, the background rate from (α,n) backgrounds from Rn in AAr
  - From ^{220}Rn: 80 evts/(10 yrs)/Bq
  - From ^{222}Rn: 143 evts/(10 yrs)/Bq

Requirements on AAr purity

- Total neutron background from all components is 0.09928 evts/(10 yr)
  - Most subdominant sources contribute 10^{-3}-10^{-4} evts/(10 yr) – reasonable to aim for this range, as well
  - From Vicente's spreadsheet
- Therefore, for AAr neutrons to be negligible, we need
  - A_{222Rn}: <1.2 μBq/kg or <12.4 μBq/kg
  - A_{220Rn}: <0.7 μBq/kg or <7.0 μBq/kg
- For reference:
  - DEAP had… ^{222}Rn: 0.15 μBq/kg , ^{220}Rn: 0.004 μBq/kg
  - DS-50 had…^{222}Rn: 2.12 μBq/kg
- DEAP took **very** extensive measures to minimize Rn levels (as did DS-50), though this would indicate that the target Rn levels are likely achievable, with some wiggle room to be higher than DEAP, given that we are conscious of Rn contamination

How well do we know the ^{40}Ar(α,n) yield?

- There currently exists one measurement of the (α,n) cross section on ^{40}Ar, at 7.4 MeV
  - Author measures 33 mb
  - No uncertainty analysis is presented beyond a guess that the measurement may be in error by "as much as a factor of 2"
- Clearly TALYS and the single measurement do not agree, so the (α,n) yield must be very uncertain
  - Until better measurements can be made, it is prudent for us to err on the side of caution and assume the highest cross section



Plot by Holger Kluck using TASMAS to vary TALYS "default" uncertainties, defined so that on average, bands cover data/model uncertainties over all reactions

What about (α,n) in other volumes?

- For $^{40}Ar(\alpha,n)^{43}Ca$ w/ 5.5 MeV α (lowest in ^{222}Rn chain) minimum ^{43}Ca recoil energy is 202 keV, just above WIMP ROI
  - If α attenuates before capture, its energy is easier to see than ^{43}Ca recoil
  - Additional signal from recoiling nucleus: *e.g.* $^{218}Po \rightarrow \alpha + {}^{214}Pb$ (103 keV)
    - ^{214}Pb recoil quenched more heavily than ^{40}Ar, 103 keV_{Pb}~30 keV_{Ar} (or 5 keV_{ee})
    - J. Xu et al. "First measurement of surface nuclear recoil background for argon dark matter searches", PRD 96, 6 (2017): 061101
- It will be harder to see these NR signals in the neutron veto
  - For 8 MeV α's, TALYS predicts that 96% of decays will go to an excited state of ^{43}Ca, and so the de-excitation γ's would give a veto signal
  - May help in inner veto, but hard to say…warrants further investigation

END