Comment on "^{37}Ar as a calibration source for solar neutrino detectors"

M. Skalsey
Randall Laboratory of Physics, University of Michigan, Ann Arbor, Michigan 48109
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A recent proposal to use ^{37}Ar electron capture decay as a neutrino calibration source for solar neutrino detectors neglected the internal bremsstrahlung radiation accompanying ^{37}Ar decay. Safety considerations require that MCi-type ^{37}Ar sources include sufficient shielding to reduce the flux of bremsstrahlung photons.

A recent Rapid Communication[1] proposes the use of ^{37}Ar sources in the MCi regime for the calibration of solar neutrino detectors. One of the major topics of that article is the safety aspects involved in the handling of such high-intensity radioactive sources. Clearly, electron capture decays with no accompanying nuclear gamma rays, e.g., ^{37}Ar, are the preferable type of neutrino sources for calibration purposes. However, the major source of gamma-ray radiation from ^{37}Ar decay, internal bremsstrahlung, was not mentioned in Ref. 1. The purpose of this Comment is to analyze the effects of the bremsstrahlung photons on the safety aspects of the ^{37}Ar neutrino calibration source.

Classically, internal bremsstrahlung accompanying electron capture can be thought of as the electromagnetic radiation emitted by the orbital electron as it accelerates and falls into the nucleus. More rigorous analyses[2] of the internal bremsstrahlung process give the photon yield and the photon energy spectrum. For our purpose here, the yield of bremsstrahlung photons, N_γ, relative to the number of K captures, N_0, is given by

$$\frac{N_\gamma}{N_0}=\frac{\alpha}{12\pi}\left[\frac{W_0}{m_0c^2}\right]^2 ,$$

where α is the fine structure constant, W_0 is the upper energy limit of the bremsstrahlung photons, and m_0 is the electron rest mass.[2] For ^{37}Ar decay, W_0 is 811 keV and hence N_γ/N_0 is 5×10^{-4}. While this is apparently a very small yield of photons, a 1 MCi ^{37}Ar source provides 500 Ci of γ rays.

The energy spectrum of the internal bremsstrahlung photons from ^{37}Ar decay is shown in Fig. 5 of Ref. 3. The photon energy spectrum is a roughly bell-shaped curve that peaks near 250 keV and goes to zero at energies of W_0 and zero. Clearly, a γ-ray shield surrounding the 1 MCi ^{37}Ar source will be required for safety in the handling and transportation. The dose rate for this source when unshielded would be 91 rem/hr at a distance of 1 m.[4] Using a 10-cm-thick Pb shield would reduce the dose rate to about 0.4 mrem/hr at the same distance. The handling and transportation of MCi-type ^{37}Ar sources would necessitate shielding of approximately the magnitude described above.

In conclusion, the recent proposal[1] to use MCi ^{37}Ar sources for the calibration of solar neutrino detectors omitted discussion of the internal bremsstrahlung photon background accompanying the electron capture decay of ^{37}Ar. Consideration of the internal bremsstrahlung radiation leads to the requirement of significantly more shielding than envisioned in Ref. 1. However, the shielding is certainly feasible to implement and would result in negligible attenuation of the neutrinos.

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[1] W. C. Haxton, Phys. Rev. C **38**, 2474 (1988).
[2] See, e.g., B. G. Pettersson, in *Alpha-, Beta-, and Gamma-Ray Spectroscopy*, edited by K. Siegbahn (North-Holland, Amsterdam, 1965), Vol. II, p. 1574.
[3] P. C. Martin and R. J. Glauber, Phys. Rev. **109**, 1307 (1958).
[4] J. B. Marion and F. C. Young, *Nuclear Reaction Analysis* (North-Holland, Amsterdam, 1968), p. 98.

