Goldhaber Experiment: neutrino helicity

$$^{152m}Eu + e^- \rightarrow {}^{152}Sm^* + \nu_e$$

K-Schale

$$\downarrow$$

$$^{152}Sm + \gamma$$

Idea: measure neutrino helicity
via photon polarization of Sm* decay

$J = 0^+$ ——————— ^{152}Eu

K-capture

$J = 1^-$ ——————— $^{152}Sm^* + \nu_e$

γ (960 keV)

$J = 0^+$ ——————— ^{152}Sm

ν_e

^{152}Eu-Source

Electromagnet
[γ-polarization]

γ $\quad$ γ

Blei
Abschirmung

γ $\quad$ γ

Sm$_2$O$_3$ ring
scatterer

NaI counter
[Photon counter]
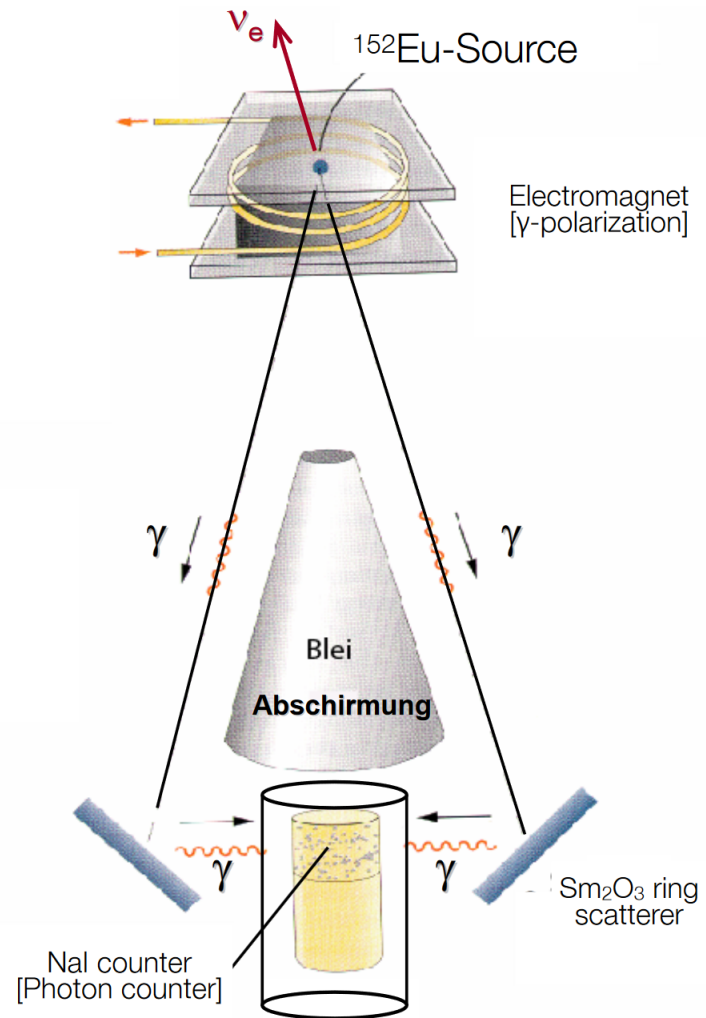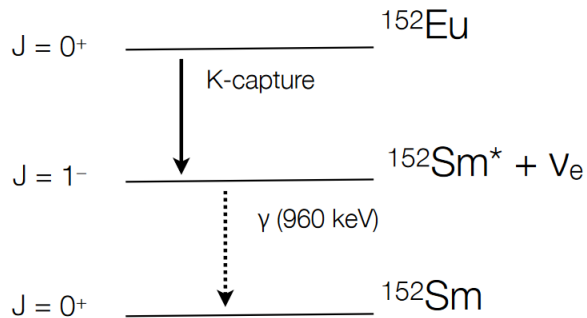
Goldhaber Experiment: neutrino helicity
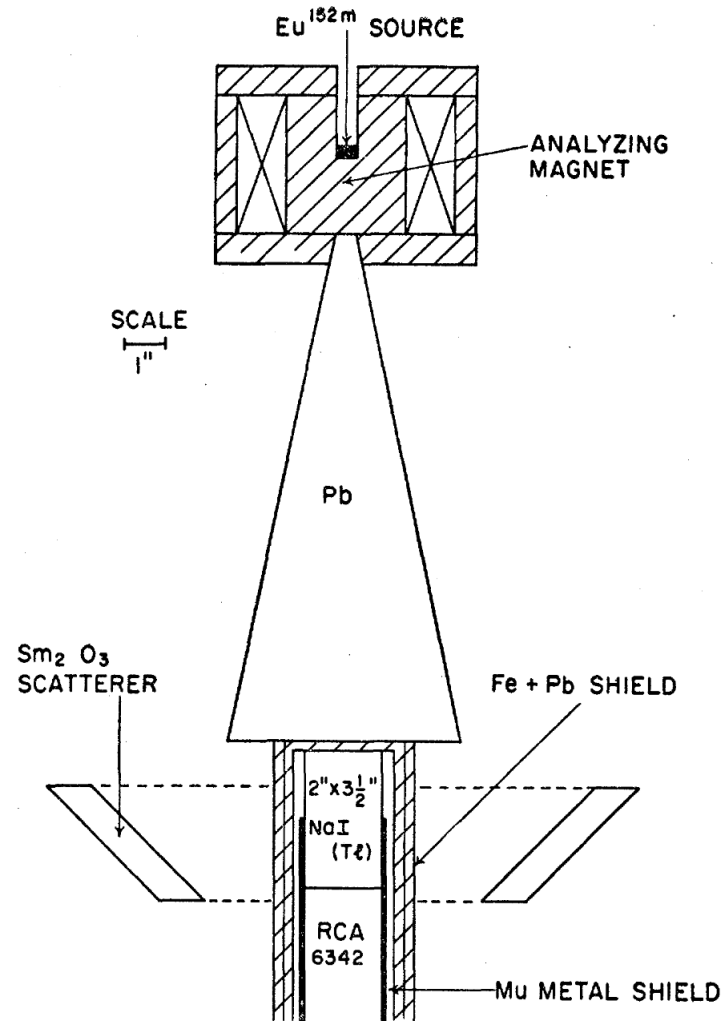
Goldhaber Experiment: neutrino helicity

A. ^{152}Eu undergoes K-capture:

^{152}Eu e^- → Sm* $[J^P = 1^-]$ ν_e

In principle two possible spin configurations exist

Sm* ν_R RH

Sm* ν_L LH
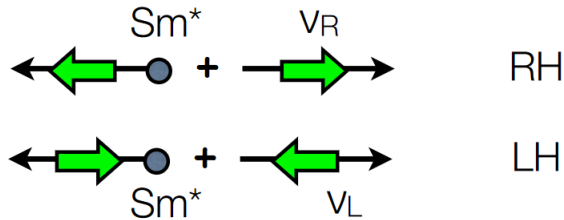
Goldhaber Experiment shows that only configuration "LH" does occur.

ν_e
^{152}Eu-Source
Electromagnet [γ-polarization]
γ   γ
Blei
Abschirmung
γ   γ
Sm$_2$O$_3$ ring scatterer
NaI counter [Photon counter]
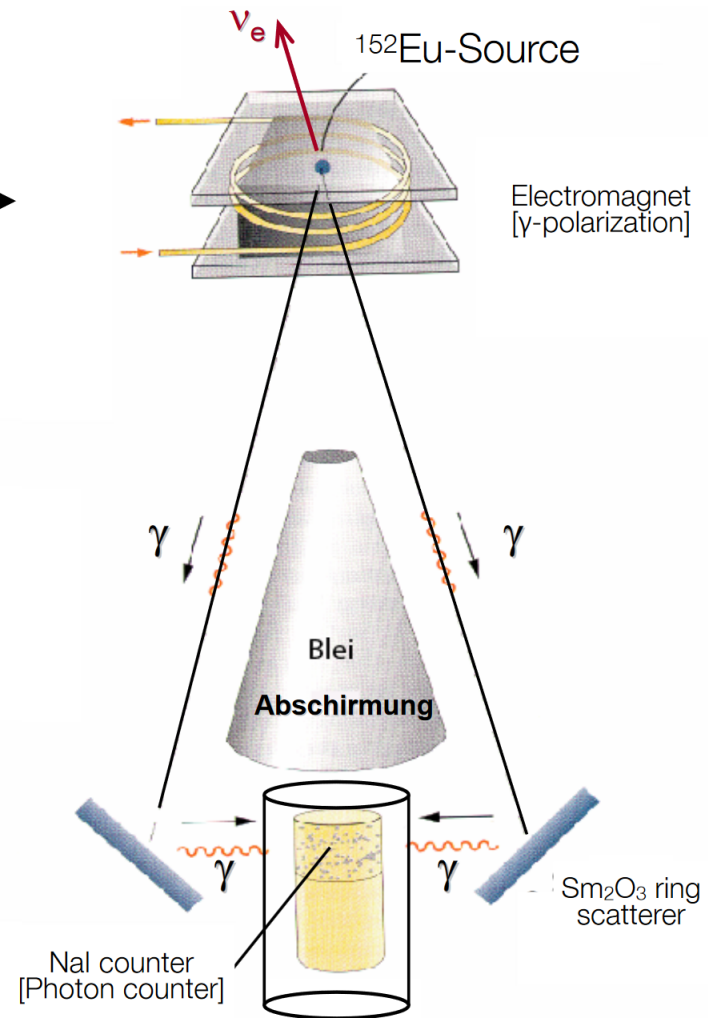
Goldhaber Experiment: neutrino helicity

Helicity of Neutrinos*

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(Received December 11, 1957)

A COMBINED analysis of circular polarization and resonant scattering of γ rays following orbital electron capture measures the helicity of the neutrino. We have carried out such a measurement with Eu^{152m}, which decays by orbital electron capture. If we assume the most plausible spin-parity assignment for this isomer compatible with its decay scheme,[1] 0−, we find that the neutrino is "left-handed," i.e., $\boldsymbol{\sigma}_\nu \cdot \hat{p}_\nu = -1$ (negative helicity).

$$\delta = (N_- - N_+)/\tfrac{1}{2}(N_- + N_+)$$

Region A: small effect
Region B: main signal, $+0.017 \pm 0.003$
Region C: no effect

From path through Fe, expect $\delta = \pm 0.025$
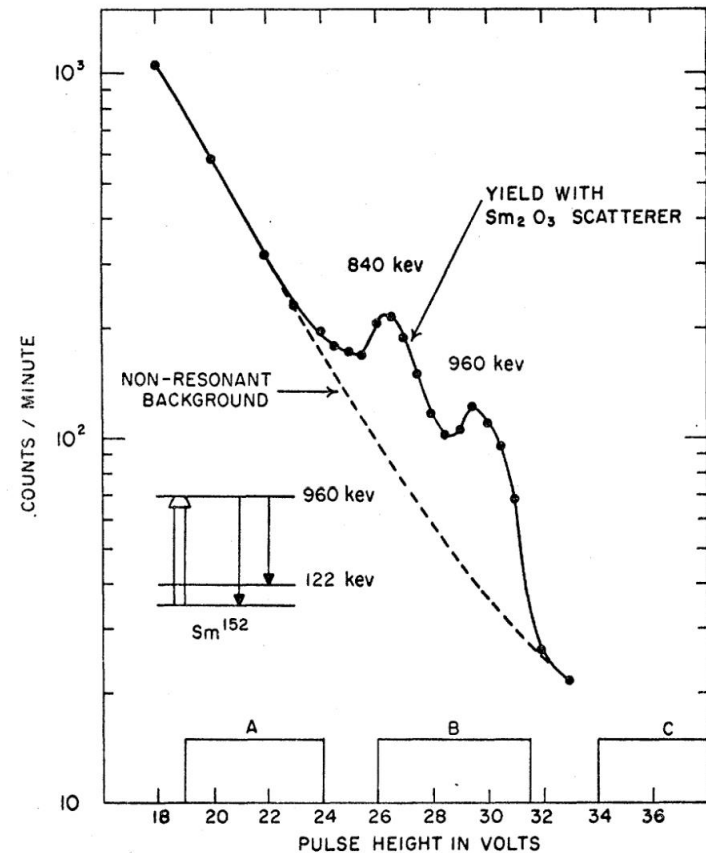for 100% polarization of 960keV gammas… where the sign indicates helicity

FIG. 2. Resonant-scattered γ rays of Eu^{152m}. Upper curve is taken with arrangement shown in Fig. 1 with unmagnetized iron. Lower curve shows nonresonant background (including natural background).