Lepton Pair Production and Summary of Detector Calibration

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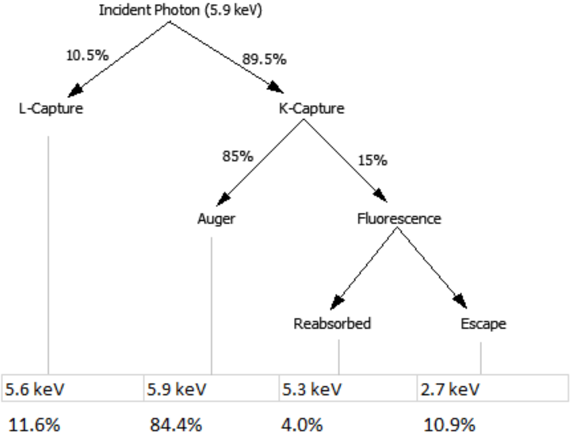
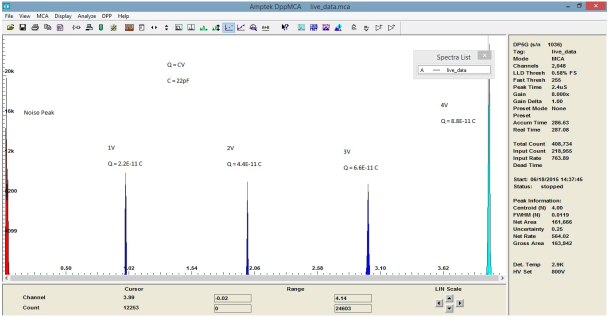
Argon x-ray Absorption

A 5.9 keV photon can ionize an argon atom in a number of different ways. The argon atom can then de-excite in multiple ways, each of which will effect the total amount of the photon energy absorbed by the detector.

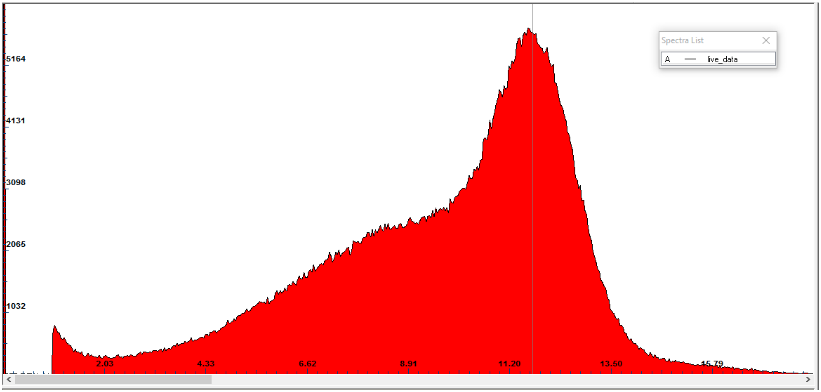


Calibrating the Amptek ADC



The Amptek DP5-G ADC was calibrated using a square pulse of known voltage in series with a 22pF capacitor. From this, the charge is determined.

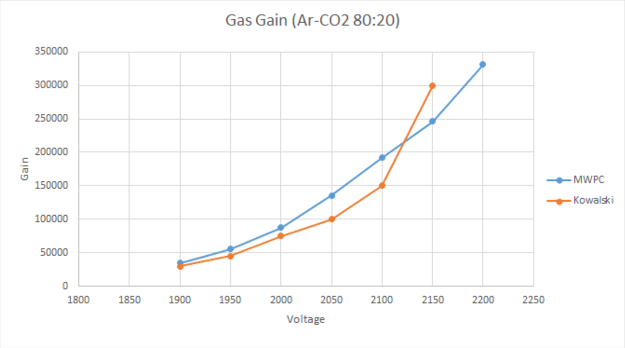
Ar-CO_2 80:20 Spectrum



Histogram taken at 2200V.

Ar-CO_2 80:20 Gas Gain

Voltage	Gain	Kowalski
1900	34691	30000
1950	55616	45000
2000	87555	75000
2050	135737	100000
2100	191905	150000
2150	245955	300000
2200	330947	



Multi-photon Exchange Pair Production

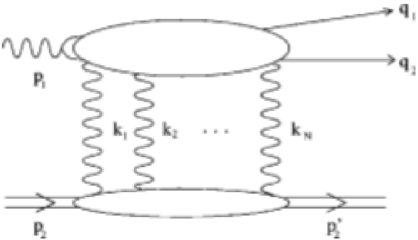


FIG. 1. A diagram with N photons, exchanged in the t channel. Diagrams of this type contribute to the leading asymptotic of lepton pair production by a high energy photon.

$$J_s(\mathbf{q}_1, \mathbf{q}_2) = \frac{i}{2\nu} \int \frac{\mathrm{d}^2 r_1 \mathrm{d}^2 r_2}{(2\pi)^2} \mathrm{e}^{-i(q_1 \cdot r_1 + q_2 \cdot r_2)} K_0(m|\mathbf{r}_1 - \mathbf{r}_2|)\nu[\mathrm{e}^{-i\nu\phi} - 1]$$

$$\mathbf{J}_T(\mathbf{q}_1, \mathbf{q}_2) = \frac{-1}{2\nu} \int \frac{\mathrm{d}^2 r_1 \mathrm{d}^2 r_2}{(2\pi)^2} \mathrm{e}^{-i(q_1 \cdot r_1 + q_2 \cdot r_2)} \frac{m(\mathbf{r}_1 - \mathbf{r}_2)}{2|\mathbf{r}_1 - \mathbf{r}_2|} K_1(m|\mathbf{r}_1 - \mathbf{r}_2|)[\mathrm{e}^{-i\nu\phi} - 1]$$

The result depends on the choice of form factor used for the atomic target. For a pure Coulomb field

$$\phi_C(\mathbf{r}_1, \mathbf{r}_2) = ln(\frac{\mathbf{r}_1^2}{\mathbf{r}_2^2}) \tag{1}$$

If atomic screening is included,

$$\phi_A(\mathbf{r}_1, \mathbf{r}_2) = 2\sum_{i=1}^{3} \alpha_i (K_0(\mu_i|\mathbf{r}_2|) - K_0(\mu_i|\mathbf{r}_1|)) \tag{2}$$

Including the nuclear form factor $F_N = -\frac{1}{6}q^2 < r^2 >_A$,

$$\phi(\mathbf{r}_1, \mathbf{r}_2) = \phi_A - \frac{1}{3} < r^2 >_A (\delta^{(2)}(\mathbf{r}_2) - \delta^{(2)}(\mathbf{r}_1)) \tag{3}$$

For the Coulomb case, J_S and $\mathbf{J}_T$ can be obtained analytically.

$$J_S(q_1,q_2)=\frac{|\Gamma(1-i\nu)|^2}{\mu^2 q^2}\left(\frac{\xi_1}{\xi_2}\right)^{-i\nu}$$
$$\times\left\{(\xi_1-\xi_2)F(z)-\frac{i\delta}{\nu}(\xi_1+\xi_2-1)F'(z)\right\}, \tag{40}$$

$$\mathbf{J}_T(q_1,q_2)=\frac{|\Gamma(1-i\nu)|^2}{\mu^2 q^2}\left(\frac{\xi_1}{\xi_2}\right)^{-i\nu}\left\{(\xi_1\mathbf{q}_1+\xi_2\mathbf{q}_2)F(z)\right.$$
$$\left.-\frac{i\delta}{\nu}(\xi_1\mathbf{q}_1-\xi_2\mathbf{q}_2)F'(z)\right\}, \tag{41}$$

where the function $F(z)$ reads

$$F(z)=F(i\nu,-i\nu;1;z). \tag{42}$$

References

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