Range in the document

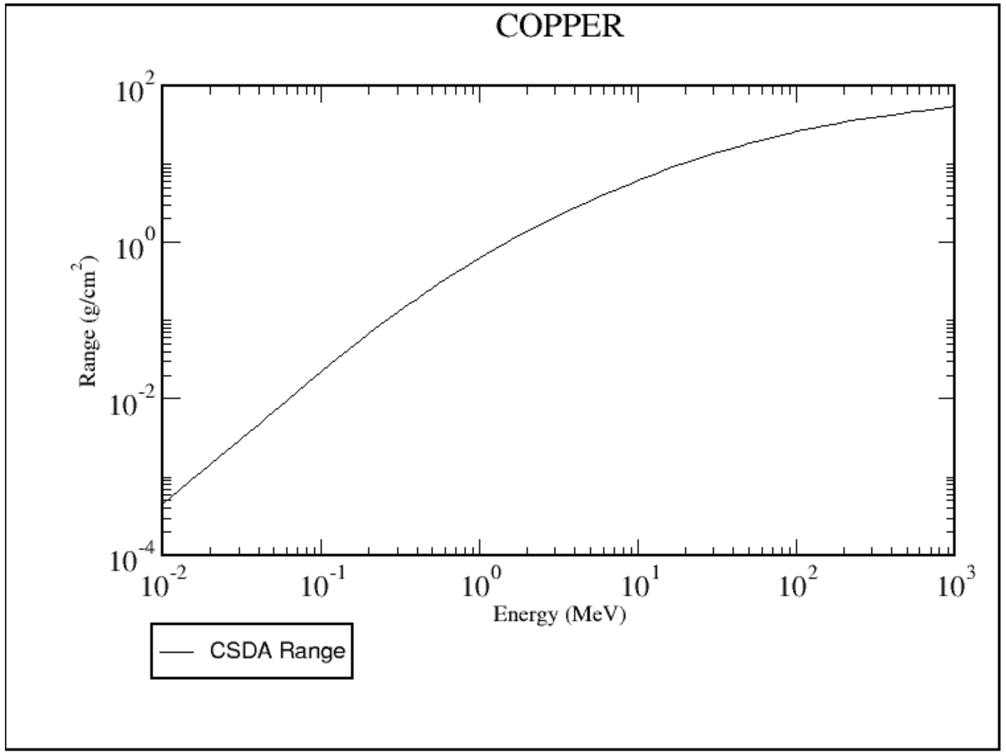
- L.S. Erhardt, D. Deptuck, J.P. Harrison, Transition-edge microcalorimeter for tritium beta decay, *Nuclear Instruments and Methods in Physics Research A,* 444 (2000) 92-95

- 18.6 keV electron range in Cu: 1.1 μm

- 191 keV tritium deposition(range) in Cu: 1.2 μm

Electron range - ESTAR database

- Copper



Kinetic Energy(keV)	Collision SP(MeV cm²/g)	Radiative SP(MeV cm²/g)	Total SP(MeV cm²/g)	CSDA Range(g/cm²)	Radiation Yield	Density Effect Parameter
17.50	8.874	1.366×10^{-2}	8.887	1.170×10^{-3}	7.972×10^{-4}	2.304×10^{-3}
20.00	8.066	1.399×10^{-2}	8.080	1.465×10^{-3}	9.019×10^{-4}	2.683×10^{-3}

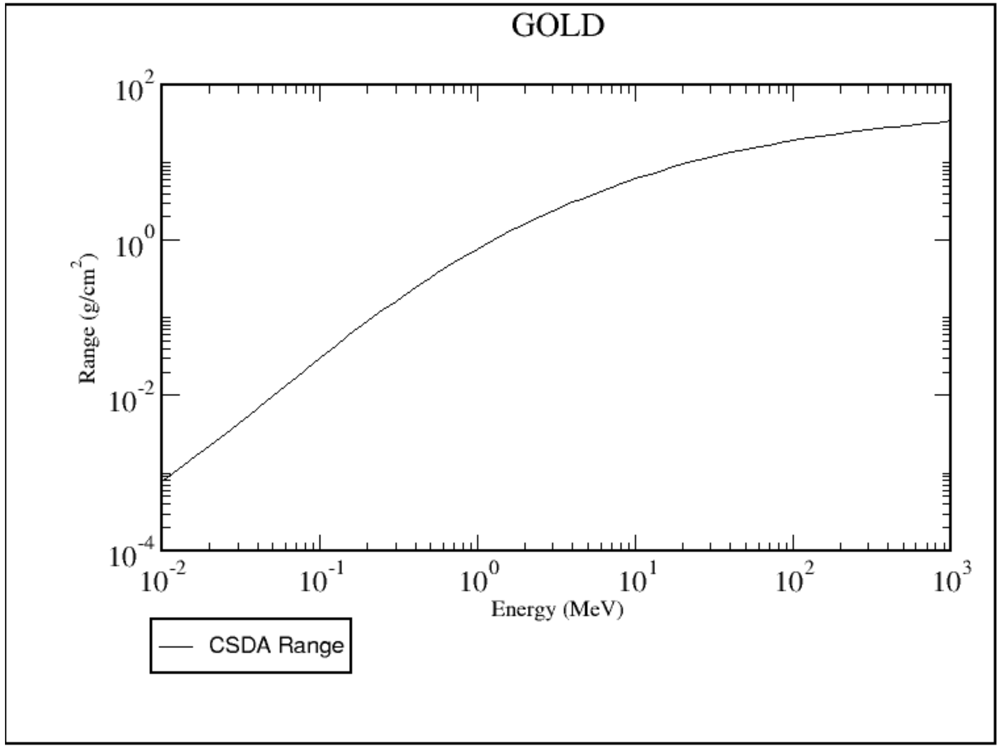
SP: Stopping power

Electron range - ESTAR database

- Copper
- Approximation:
  - Almost linear (in log scale) near 18.6 keV
  - Fit by [10,40] keV data
  - Get range≈$1.30 \text{ X } 10^{-3}$ g/cm^2
- Density=8.96 g/cm^3
- Range=1.45 μm (different from the document?!)

Electron range - ESTAR database

- Gold



Kinetic Energy(keV)	Collision SP(MeV cm²/g)	Radiative SP(MeV cm²/g)	Total SP(MeV cm²/g)	CSDA Range(g/cm²)	Radiation Yield	Density Effect Parameter
17.50	6.103	2.543×10^{-2}	6.128	1.839×10^{-3}	2.050×10^{-3}	1.131×10^{-3}
20.00	5.595	2.666×10^{-2}	5.621	2.266×10^{-3}	2.349×10^{-3}	1.323×10^{-3}

SP: Stopping power

Electron range - ESTAR database

- Gold

- Approximation:
  - Almost linear (in log scale) near 18.6 keV
  - Fit by [10,40] keV data
  - Get range≈2.02×10^{-3} g/cm^2

- Density=19.30 g/cm^3

- Range=1.05 μm

Electron range

- Copper vs. Gold

- 1.45 μm vs. 1.05 μm

- If we consider 1.1 μm of the paper is right and change the range value proportionally, gold range -> 0.80 μm

Tritium Deposition

- Given 1.2 μm of deposition on the copper foil on the paper
- Assume deposition depth=range
- Let’s consider the tritium particle as a heavy *charged* particle (so, may not correct)
- We can use the *Bragg-Kleeman* rule

Tritium Deposition

- The *Bragg-Kleeman* rule
- $\frac{R_1}{R_2} = \frac{\rho_2}{\rho_1}\frac{\sqrt{A_1}}{\sqrt{A_2}}$ (ρ: density, A: atomic number)

- -> $R_{\mathrm{Au}} = R_{\mathrm{Cu}}\frac{\rho_{\mathrm{Cu}}}{\rho_{\mathrm{Au}}}\frac{\sqrt{A_{\mathrm{Au}}}}{\sqrt{A_{\mathrm{Cu}}}} = 1.2\ \mu m \times \frac{8.96}{19.30}\frac{\sqrt{79}}{\sqrt{29}} \approx 0.92\ \mu m$

Conclusion

- Copper vs. Gold
- Electron: 1.45 μm vs. 1.05 μm (or 1.1 μm vs. 0.80 μm)
    - The range of the paper may be wrong
- Tritium: 1.2 μm vs. 0.92 μm

Reference

- ESTAR Database
  - http://physics.nist.gov/PhysRefData/Star/Text/ESTAR.html

- William R. Leo, *Techniques for Nuclear and Particle Physics Experiment A How-to Approach*, Springer-Verlag, Second Revised Edition

Data

- Copper

(required) Kinetic Energy (MeV)	Stopping Power (MeV cm^2/g)			CSDA Range (g/cm^2)	Radiation Yield	Density Effect Parameter
	Collision	Radiative	Total			
1.000E-02	1.318E+01	1.213E-02	1.319E+01	4.601E-04	4.701E-04	1.244E-03
1.250E-02	1.127E+01	1.277E-02	1.128E+01	6.658E-04	5.814E-04	1.585E-03
1.500E-02	9.904E+00	1.327E-02	9.917E+00	9.028E-04	6.904E-04	1.938E-03
1.750E-02	8.874E+00	1.366E-02	8.887E+00	1.170E-03	7.972E-04	2.304E-03
2.000E-02	8.066E+00	1.399E-02	8.080E+00	1.465E-03	9.019E-04	2.683E-03
2.500E-02	6.877E+00	1.449E-02	6.892E+00	2.138E-03	1.105E-03	3.481E-03
3.000E-02	6.040E+00	1.488E-02	6.055E+00	2.914E-03	1.301E-03	4.334E-03
3.500E-02	5.416E+00	1.518E-02	5.431E+00	3.788E-03	1.491E-03	5.247E-03
4.000E-02	4.931E+00	1.543E-02	4.947E+00	4.754E-03	1.674E-03	6.220E-03
4.500E-02	4.544E+00	1.564E-02	4.560E+00	5.808E-03	1.852E-03	7.259E-03
5.000E-02	4.226E+00	1.583E-02	4.242E+00	6.946E-03	2.025E-03	8.365E-03

Data

- Gold

(required) Kinetic Energy (MeV)	Stopping Power (MeV cm^2/g)			CSDA Range (g/cm^2)	Radiation Yield	Density Effect Parameter
	Collision	Radiative	Total			
1.000E-02	8.673E+00	2.036E-02	8.694E+00	7.919E-04	1.150E-03	6.025E-04
1.250E-02	7.562E+00	2.237E-02	7.585E+00	1.101E-03	1.449E-03	7.709E-04
1.500E-02	6.739E+00	2.402E-02	6.763E+00	1.450E-03	1.749E-03	9.470E-04
1.750E-02	6.103E+00	2.543E-02	6.128E+00	1.839E-03	2.050E-03	1.131E-03
2.000E-02	5.595E+00	2.666E-02	5.621E+00	2.266E-03	2.349E-03	1.323E-03
2.500E-02	4.832E+00	2.872E-02	4.861E+00	3.226E-03	2.945E-03	1.735E-03
3.000E-02	4.284E+00	3.043E-02	4.315E+00	4.320E-03	3.534E-03	2.183E-03
3.500E-02	3.870E+00	3.190E-02	3.902E+00	5.541E-03	4.117E-03	2.673E-03
4.000E-02	3.545E+00	3.321E-02	3.579E+00	6.881E-03	4.694E-03	3.208E-03
4.500E-02	3.283E+00	3.439E-02	3.318E+00	8.333E-03	5.264E-03	3.791E-03
5.000E-02	3.067E+00	3.547E-02	3.102E+00	9.893E-03	5.828E-03	4.427E-03