Optimization of Bremsstrahlung X-ray Converters for Radiation Processing

Thomas Kroc, PhD

IMRP 2024

6 November 2024

FERMILAB-SLIDES-24-0260-ETD

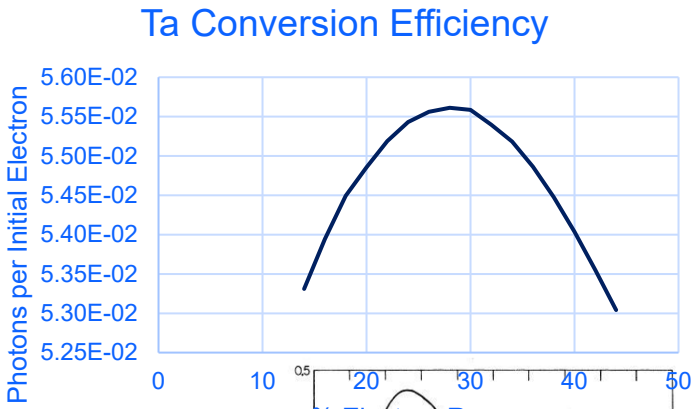
Maximizing the Physics of Bremsstrahlung

Squeezing everything we can out of $$j(v,\nu) = \frac{8\pi}{3\sqrt{3}} \frac{Z^2 \bar{e}^6 n_i}{c^3 m_e^2 v} g_{ff}(v,\nu)$$

• Optimal Bremsstrahlung Converter Thickness

- Current practice uses 40% of electron range
- Appears to be based on work by Berger 1965-1970
- Using unnamed monte carlo program
- Does 30% give higher yield?

  MCNP 6.2



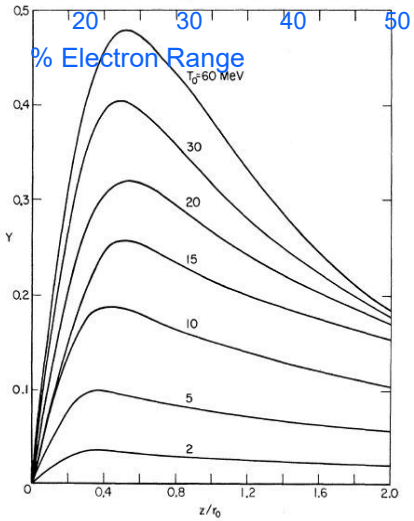
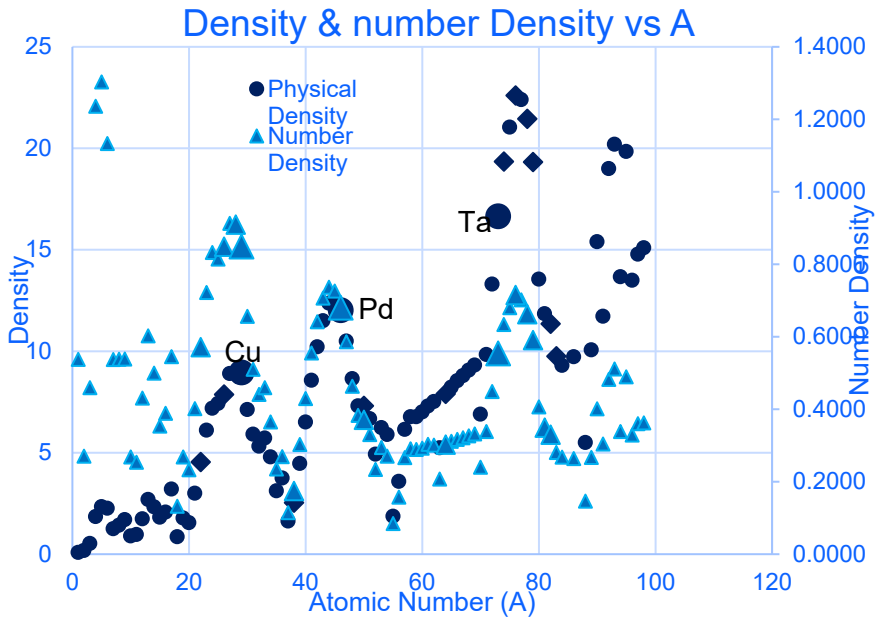


FIG. 3. Bremsstrahlung efficiency for monoenergetic electron beams incident perpendicularly on tungsten targets.

1970 Berger & Seltzer "Bremsstrahlung and Photoneutrons from thick Tungsten and Tantalum targets" Physical Review C, (1970) Vol 2, #2, 621

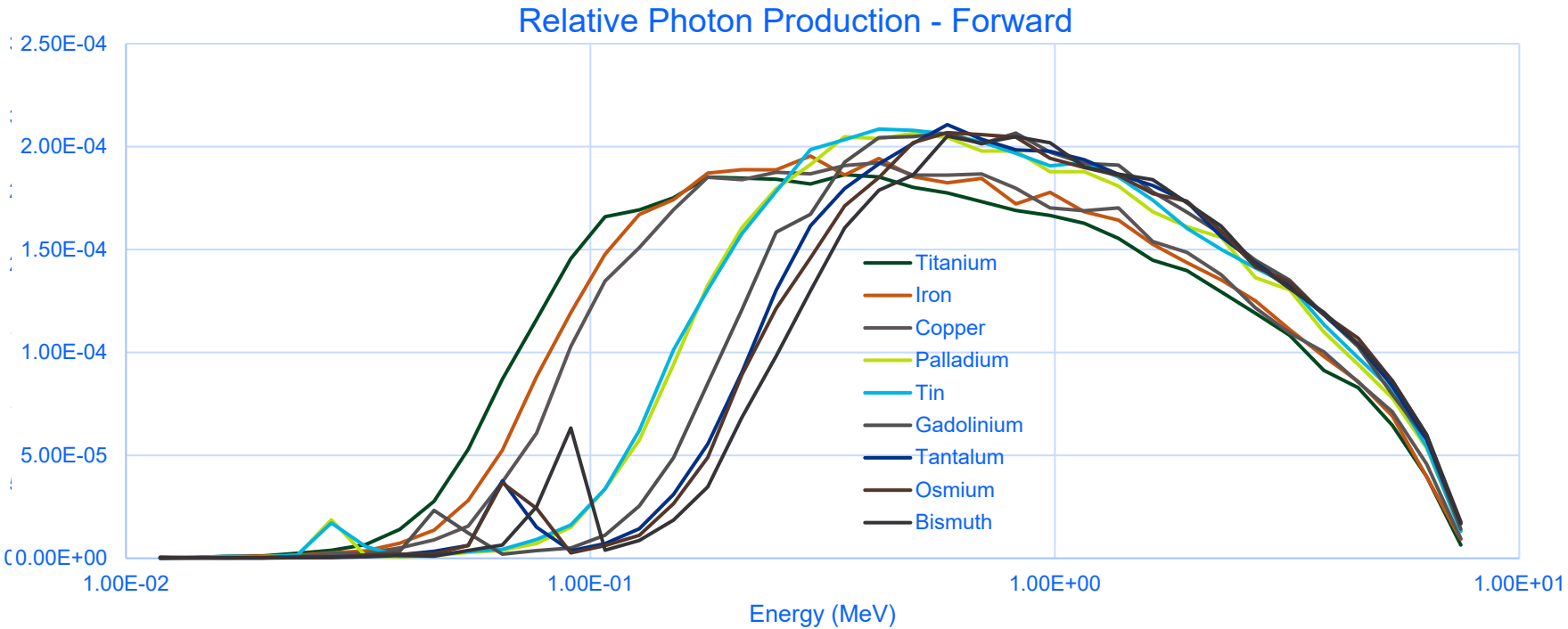
Fermilab

- Optimal Converter Material



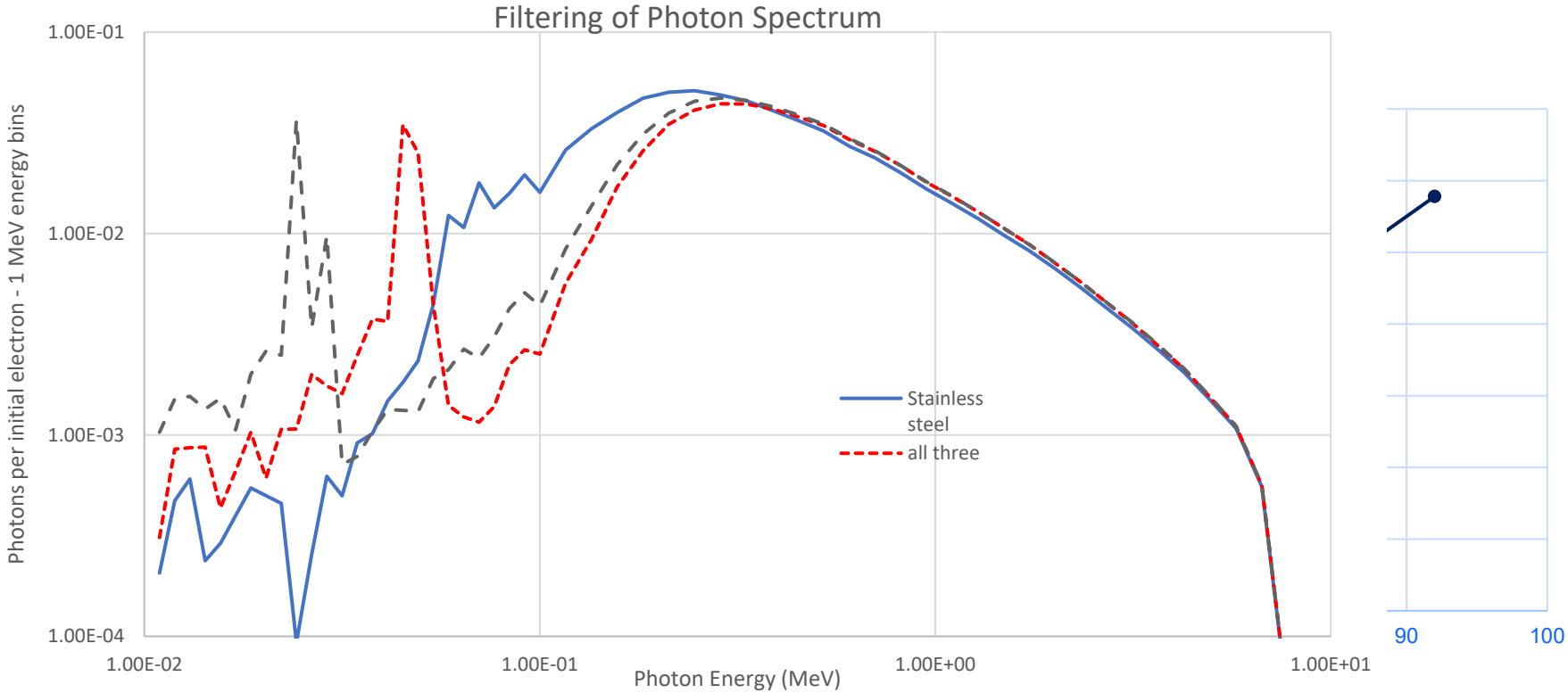
	Z	Physical Density – g/cc	Number Density - relative	Activation Threshold (MeV)
Ti	47.9	4.54	0.57	10.4
Fe	55.8	7.87	0.85	8.85
Cu	63.4	8.96	0.85	9.9
Pd	106.4	12.0	0.68	7.8
Sn	118.7	7.31	0.37	7.5
Gd	157.2	7.90	0.30	7.45
Ta	180.9	16.6	0.55	7.57
Os	190.2	22.6	0.72	5.7
Bi	209.0	9.75	0.28	7.46

- Optimal Converter Material



Fermilab

Improve DUR – remove electrons & LE photons from photon beam



Tantalum + water cooling + X (various thickness to maintain total attenuation)

Fermilab

Thank You

This work was produced by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics

Fermilab