Bremsstrahlung radiation:

 describes the scattering of electrons off coulombic potentials and by symmetry, e⁺e⁻ pair-production by scattered photons:



- the dominant energy loss mechanisms for high-energy electrons (~10MeV) and photons, comprises the irreducible QED background for DarkLight
- can be measured straightforwardly by treating positrons as signal events

Pair production processes:

- (Doublet) Nuclear field scattering / Bethe Heitler (1934):
 - QM-derived quadruply differential cross section, $\sim Z^2$
 - Born approximation valid for $2\pi\alpha Z < \beta$

$$rac{d^4\sigma_A}{d\epsilon_+d heta_-d heta_+d\phi} = Z^2 rac{lpha^3}{2\pi\omega^3 ec Q^4} |F_A(ec Q^2) - f_{at}(ec Q^2)|^2 |T|^2$$
 Korchin, PrimEx at JLab

• Can integrate over angles to obtain positron energy distribution:

$$\frac{d\sigma_A}{d\epsilon_+} = \int \frac{d^4\sigma_A}{d\epsilon_+ d\theta_- d\theta_+ d\phi} \,\mathrm{d}\theta_+ \,\mathrm{d}\theta_- \,\mathrm{d}\phi = Z^2 \frac{\alpha^3}{m_e^2 \omega^3} [(\epsilon_+^2 + \epsilon_-^2)(\phi_1 - \frac{4}{3}\log Z - 4f) + \frac{2}{3}\epsilon_+\epsilon_-(\phi_2 - \frac{4}{3}\log Z - 4f)]$$

• (Triplet) Atomic field scattering:

• Scales ~Z

$$\frac{d^4\sigma_e}{d\epsilon_+d\theta_-d\theta_+d\phi} = Z \frac{\alpha^3}{2\pi\omega^3 \vec{Q^4}} H(\vec{Q^2}) |T|^2$$



Photon Total Cross Section v. Energy

- at energies greater than ~1MeV, $K_{nuc} > K_{e}$
- At 30MeV, K_{nuc} > K_e ~ O(10)
- for carbon, **K**_{nuc} ≅ 300mb

PDG, Particles Through Matter

Estimated positron signal rates using a 1µm C target:

- Bethe-Heitler is forward-peaked for relativistic electrons → use 20° spectrometer to measure positrons
 - angular acceptance approximately 3 msr
- Zeroth order: isotropic phase space $\leftrightarrow d\Omega = \Omega^* (.003/4\pi)$
 - Total pair production cross section at 30MeV ≅300mb / 137 = 2*10⁻²⁷ cm²
 - Luminosity at $150\mu A = 9*10^{33} e-C cm^{-2}s^{-1}$
 - Expect \leq 4.3 kHz signal
- First order: simulate 1E9 events in Mainz
 - Differential cross section $\approx 1.2 \times 10^{-32} \text{ cm}^2$
 - Total signal rate within acceptance at 20° ≅ 130 Hz

Checklist:

- Obtain more accurate Bethe-Heitler momentum and angular dependencies:
 - Possibly nontrivial screening corrections for the pair-production cross sections
 - Perform Geant simulations incorporating the actual DarkLight setup & geometry
- Quantify background processes:
 - Deflected electrons managing to reach the positron GEMs ? (from Cameron's Monte Carlo)

Estimating Electron Elastic Scattering

https://digital.library.unt.edu/ark:/67531/metadc865143/



Carbon

		C (6) (RARNS/								(RARNS/ST	TERADIAN)	
	RUTH	HOTT	RUTH	MOTT	RUTH	HOTT	RU7H	MOTT	RUTI	MOTT	RUTH	HOTT
DEG	8-0F-0	WEV	5.05.	INFU	7.05-	ANEW	1.0	F. AAUFU				
	8.2538+07	2665+07	5-6795+07	5-6875+07	3 2475407	2.2030	107 1 7075.	AT I BOOK	1.52.	DOMEN	2.0E+C	JONEV
2	5.1595+06	1715-06	3.5505.06	3.5585+04	2 0305404	3.6755		I. BUUE	A.045E+09	A*101E+00	5.553F+06	5.563E+06
3	1.0105+06	0225.06	7.0145.05	7.0355+05	A ALLEADE	2.033E	106 2 11-E-	1.1202.	00 5.0H3E+05	5.698E+05	3.471E+05	3.4802+05
	1.2765405	2385405	2.2205405	2.2385+05	1 3705405	E		09 2.220E+	1.123E+05	1.127E+05	6.859E+04	6.882E+04
	6.3885+04	4085+04	4.3000.004	4.4001404	2 5105404	1.6746	-05 1.0242.	0. 7.051E.	3.554E+04	3.5685+04	2.171F+04	2.1802.04
	2.0215.004	0315+04	1. 301 6404	1. 3085.404	7 0545403	C.SPEE	1,3046.	04 1.395E+	.028E+03	7.0616+03	+*583E+03	4.313E+03
10	8.2955+03	3345+03	5.7076.03	5.7345+03	3 3445403	7.993E	103 1 001E.	03 4.4222.4	2.227E+03	2.238E+03	1.360F+03	1.367E+03
15	1 6495-03	4535.03	1.1356.43	1.1975.03	5.2042403	3.2772	-03 1.000E.	03 1.01 E+	9,138E+02	9.178F+02	5.581E+02	5.605E+02
20	5 3645+02	2405-02	3.6225.63	3 6075-03	3 0315402	0.cdeE	-02 3.5702.	02 3. 5422.	1.017E+02	1.8176+05	1.110E+02	1.110E+02
30	1.0675+02	0435402	7. 1305-01	7.1545.401	2.0/12-02	S.OVOE	-02 1.1.000.	02 1.138E+	5.799E+01	5.754E+01	3.542F+01	3.513E+01
45	2 3325+01	0745+01	1.5346-01	1 4155-01	14/2-01	*.07*E	-01 2.3222.	01 2.240E+	1.175E+01	1.134F+01	7.177E+00	6.916E+00
	7 ASAFAAA	5875.000	E. 3405-00	1.4405.001	0,7812-00	H.000E	+00 +,858E+	00 4, 340E+	00 2.+59E+CO	5*500E+00	1.502E+00	1.343E+00
25	7 4855-00	SARE	3.3046.00	4.400E.400	3.0132-00	2.40'E	+00 1.007E+	00 1.357E+0	00 8.436E+01	6.769F-01	5.153E-01	4.107E-01
	1 0155400	3005-00	1 3175.00	1.0120+00	1.3/13-00	4. 443E	-01 1.507E-	01 5,354E-	01 3.839E+01	5.645E-01	2.345E-01	1.594E-01
		3475-01	5,517E+00	3 6305-01	7.533E-01	4.05*2	-01 •,108E-	01 2.446E-	2,109E-01	1.187E-01	1.288E-01	7.103E-02
	6.50VE-01	20/2-01	3+0356-01	5.0145-01	3. 348E-01	1.334E	-01 1.852E-	01 6.533E-	9.374E-02	2.959E-02	5.725E-02	1.7098-02
150	3. 3975-01	5125-01	3.7832-01	1.1/52-01	2.16JE-01	5.157E	-02 1.197E-	01 2,140E-	02 6.057E-02	A.014E-03	3.700F-02	4.095E-03
11.		1.9156-01	3+E4+E+01	8.4492-02	1.88-6-01	3.368E	-05 1'0+SE-	01 1.197E-	DS 214E-05	3.4275-03	3.2511-05	1.3426-03
DEA	3.05.00	WEV	A. 05.4	ONEN							10.0	
	2.7245+06	7305+06	1.6335406	1.6765+04	1 4785444	DOMEN		E+OOMEV	1.0E+	OTHEN	1.5E+0	INEV
ż	1.7036+05	7075+05	1.0145+05	1.0176+05	A 7385+06	1.0802	-00 J. 190E.	05 5. / DOL .	2.926E+05	5.431E+02	1.340E+05	1.3426+05
3	3.3655+04	376E+04	2-0045-004	2.0116.04	1 3315 .04	0.1956	104 J. 578E+	04 3.000E.	1.0546.04	1.834F+04	8.378F+03	A.400E+03
	1.0655+04		6.3435 .03	6.3686+03	A 2145+03	1.3102	103 2.3505.	03 7,1346+	3.014E.03	3.026E+03	1.655F+03	1.661E+03
	2.106E+03	116E+03	1.2545+03	1.2605403	8 3315403	*****	+03 L.C.SUE+	03 2.2342+0	1.1	1.1486.03	2*538E+05	2*500E+05
	6.672E+02	. 705E+02	3.9746+02	3.9935+02	2 6405+02	3.6535	+02 1.410FA	02	7 1475.02	2.273E+02	1.036F+02	1.041E+02
10	2.738E+02	2.750E+02	1.6316+02	1-638E+02	1.0635+02	1.0BAF	+02 5.785C		2 9415-01	7.2016+01	3.283F .01	3.5485.01
15	5.443E+01 1	442E+01	3.2426.01	3.2415.01	2 153F+01	2.1635	-01 1.150F.	01 1 15054	E 8445.00	F. 953F.001	1.3478.01	1.3536+01
20	1.730E+01 1	.723E+01	1.035E+01	1.026E+01	6.874E+00	A.A:AF	+00 3.6716+	00 3.639F+	1 8445+00	5.000E.00	2.07HE+00	2.6/72+00
30	3.521E+00	.3895+00	2-0975+00	2.0175.00	1.3035+00	1.3405	+00 7.430E-	01 7 154C-	7010-01	1.450F.00	0.548E-01	8.4712-01
45	7.3665-01 (567E+01	4-387E-01	3.9065-01	2.9145-01	2.5030	-01 1.5576-	01 1 284F-	7 91 25-02	3.0305-01	1.7326-01	1.0052-01
60	2.5286-01	2.003E-02	1.505E-01	1.190E-01	1.000E-01	7.895F	-02 5.341F-	02 4.211F-	2 2.7155-02	3.1300-02	1. 2445-02	3.2010-02
75	1.1586-01	7.739E+02	6.851E-02	4.589E-02	4.551E-02	3-041F	-02 2.4316-	02 1.621F-	1.2365-02	8.2305-03	5.4505-43	3 7475-03
	6.3192-02 1	\$422E-02	3.7645-02	2.0235-02	2.5005-02	1. 3196	-02 1.1355-	A2 7.1245-	A 7075-02	3 4145-03	3 :00546-03	3.10/2-03
120	2.809E-02 1	959E-03	1.673E-02	4.636E-03	1.111E-02	3-0455	-03 5.9356-	A 1.609F-	3 3 6175-03	0.1765-04	1 3035-03	1.0532-03
150	1.8155-02 1	.666E-03	1.081E-02	9.078F-04	7.180F-03	5.7.7E	-04 3.8355-	03 2.0275-	1 0405-01	1 4470-04	8 0305-04	3. TUYE-04
179	1.580E-02 3	3.373E-04	9.4115-03	1-220E-04	6.252E-03	5.446F	-05 3.3305-	A3 1.5785-	1 6075-03	1.1450-04	7 7725-04	0.0192-05
								US INDIGE	1.0912-03	4.10-2-00		4.1050-07
DEG	2.0E+01	NEV	3.0E+0	IMEV	4.0E+	DIMEV	5.0	E.OIMEV	7.0E.	OINEV	1.05+0	AMEN
1	7.6578+04 1	.670E+04	3.4502+04	3.4642+04	1.961E+04	1.964E	+04 1.261E+	04 1.263E+	6.472E+03	6.4835+03	3.1856+03	3.190E+03
2	4.787E+03 +	.799E+03	2.162E+03	2.167E.03	1.226E+03	1.229E	+03 7.885E+	02 7.905E .	4.046E+02	4.056F+02	1.9915+02	1.9966+02
3	9.457E+02 9	490E+02	4.271E+02	4.2862.02	2.422E+02	2.430E	.02 1.558E.	02 1.563E+	7.993E+01	A.021F+01	3.9345.01	3.947E+01
•	5.993E+02 3	.006E+02	1.3522+02	1.357E+02	7.6665+01	7.6975	•01 +.931E+	01 4.951E+	01 2.530E+01	2.5405+01	1.2455+01	1.2505.01
6	5.9192+01	5.947E+01	2.673E.01	2.686E+01	1,516E+01	1.573E	.01 9.750E.	00 9.796E+	00 5.003F+00	5.0275+00	2.4625+00	2.474E+00
	1.875E+01 1	.685E+01	8.470E+00	8.511E.00	4.803E.00	4.836E	.00 3.089E.	00 3.104E+	00 1.585E+00	1.5935.00	7.8015-01	7.839E-01
10	7.696E+00 1	728E+00	3.476E+00	3.4902+00	1.971E+00	1.979E	+00 1.26RE+	00 1.273E+	00 6.505F-01	6-5326-01	3.2015-01	3.2155-01
15	1.530E+00 1	+529E+00	6.909E-01	6.907E-01	3.918E-01	3.917E	-01 2.520E-	01 2.519E-	1.293E-01	1.2935-01	6.363F-02	6.362E-02
20	4.884E-01 4	.840E-01	2.206E-01	2.186E-01	1,251E-01	1.2.0E	-01 8.045E-	02 7.973E-	4.128E-02	4.091F-02	2.0315-02	2.0136-02
30	9.696E-05 4	514E-02	4.469E-02	4.297E-02	2.5346-02	2.437E	-02 1.630E-	02 1.567E-	8.364E-03	8.0415-03	4.116F-03	3.9576-03
	2.071E-02 1	-840E-02	9+351E-03	8.310E=03	5.303E-03	4.713E	-03 3.411E-	03 3.031E-0	3 1.750E-03	1.555E-03	8.6125-04	7.6546-04
60	7.105E-03	.590E-03	3.2098-03	55527E=03	1.820E-03	1.473E	-03 1.170E-	13 9.216E-	4 6.005E-04	4.729F-04	2.9555-04	2.327E-04
75	3.23JE-03	.152E-03	1.460E-03	9.715E-04	8,281E-04	5.509E	-04 5,326E-	04 3.543E-	4 2.733E-04	1.818F-04	1.3455-04	8.946E-05
90	1.776E-03 9	.442E-04	3+022E=04	4.263E-04	4.549E-04	2.417E	-04 2.926E-	04 1.555E-	4 1.501E-04	7.976E-05	7.38AF-05	3.9256-05
150	7.8942-04 2	-116E-04	3.565E=04	9.548E-05	50-3220'Z	5.413E	-05 1.300E-	04 3.401E-0	5 6.673E-05	1.7865-05	3.284F-05	8.788E-06
N 150	5.101E-04	.702E-05	2+304E-04	1.6652-05	1.306E-04	9.456E	-06 6,403E-	05 6.058E-	4.312E-05	3.106F-06	2.1228-05	1.528E-06
- 179	IE-04 3	.131E+07	2.006E-04	7.291E-08	1.137E-04	2.749E	-08 7.316E-	05 1.351E+	3.754E-05	5.055F-09	1.847F-05	1.9938-09

7

Carbon

	с (6)								(RARNS/STERADIAN)				
	RUTH	HOTT	RUTH	MOTT	RUTH	MO	TT	RUTH	MOTT	RUTI	MOTT	RUTH	HOTT
DEG	4.0E-0	INEV	5.05-0	IMEV	7.0F-			1.05.4	ONEV				
	8.2538+07	8.266F+07	5-6795+07	5-6875+07	3 2475407	2.20	35407	1 7975.07	BAACTAR	1.52.	DOMEN	2.0E+0	JONEV
2	5.1595+06	5 171F+06	3.5505.06	3.5585+04	2 0305404	3.67	SEAGE	1 1225.00	1.0002.07	A. 045E+09	A*101E+00	5.553F+06	5.563E.06
i	1 0105-06	1 0225-06	7 0145-05	7 0355.05	L.030E-00	2.03	JE-UB	1.1232+08	1.1202.00	5.0H3E+05	5.698E+05	3.471E+05	3.480E+05
	3 3765405	3 3385445	2 2205.05	2 2285.05	4.011E+05	·.02	-E-02	C+219E+05	5.550E+02	1.123E+05	1.127E+05	6.859E+04	6.882E+04
	3.2206-03	3.2382.05	2.2202.05	2.2202.00	1.270E-05	1.51	•E • 05	1.024E+04	7.051E+04	3.5542.04	3.5685+04	2.1715.04	2.180E+04
	0.300F.04	0.400F+04	3005-0-		5'210E+0+	2.57	2E+0+	1.389E+04	1.395E+04	7.028E+03	7.061E+03	4.293E+03	4.313E+03
	2.0211.00	2.031E+0+	1.391E+04	1.3982+04	7.954E+03	7.99	3E+03	4.401E+03	4.422E+03	2.227E+03	2.238E+03	1.360F+03	1.367E+03
30	8.542E+03	8,334E+03	5.707E+03	5.734E+C3	3.264E+03	3.27	9E+03	1.806E+03	1.814E+03	9,138E+02	9.17AF+02	5.581F+02	5.605F+02
15	1.0472+03	1.0932+03	1.135E+03	1.137E+03	6,488E+02	6.49	0E+02	3.590E+02	3.592E+02	1.817E+02	1.8175+02	1.110E+02	1.110E+02
20	20+2+05	20+36+22	3.655E+05	3.607E+02	2.071E+02	2.04	0E+05	1.146E+02	1.138E+02	5.799E+01	5.754F+01	3.5426.01	3.5135+01
30	1.067E+02	1.043E+02	7.339E+01	7.154E+01	4.197E+31	4.07	+E+01	2,322E+01	2.246E+01	1.175E+01	1.1345+01	7.1775.00	6.916F+00
45	2.232E+01	2.074E+01	1.536E+01	1.415E+01	8,781E+00	8.00	6E+00	4.858E+00	4.390E+00	2.4595+00	2.2065+00	1.5025+00	1 3435+00
60	7.650E+01	6.587E+30	5.2692+00	4.460E+00	3.013E+00	2.40	7E+00	1.6676+00	1.357E+00	A.436F-01	4.7495-01	5.1635-01	1.3432-00
75	3.485E+00	2.705E+00	2,398E+00	1.812E+00	1.37.5+00	9.94	SE-01	7.587E-01	5.354F-01	3.8305-01	2.6475-01	2. 2465-01	1 5045-01
	1.915E+00	1.309E+00	1,317E+00	8.632E-01	7.533E-01	4.65	4F-01	4.168F-01	2.446F-01	2 1005-01	1 1075-01	1 2005-01	1.3946-01
120	8.509E-01	4.267E-01	5.655E-01	2.679E-01	3.3485-01	1.31	95-01	1.8525-01	6.5335-02	G 3745-02	2 0505-02	1.204E-01	7.1032-02
150	5.4986-01	2.0126-01	3.783E-01	1.175E-01	2.1635-01	5.10	55-02	1-1975-01	3 1405-02	6 0675-02	5.4246-05	2.1526-05	1.1045-05
179	4.787E-01	1.512E-01	3.294E-01	8-449E-02	1.8845-01	3. 34	85702	1.0425-01	1 1075-02	5 2745-02	A.0146-03	3.1001-05	4.0952-03
	1,00-C VI 3,300 VL 1,00-C VI 1,14/E-UC 3,C/02-02 3,422F+03 3,221F-02 1,342E-										1.3426-03		
DEG	3.0E+0	CHEV	4.0F+f	OMEV	5.0F.	ONE		7.05.	ONEN	1			
1	2.724E+06	2.729E+06	1.623E+06	1.6255+06	1.0785+06	1.00	05+06	5.75AFADE	E. 744EADE	2 9345.00	DIREV OF	1.56+0	INEV
2	1.703E+05	1.707E+05	1.014F+05	1.0175.05	6.738F+04	6.75	55+04	3.5985+04	3. 6085+04	1 8305.04	2.4315.05	1.3402.05	1.3422+05
3	3.3656+04	3.376E+04	2.004E +04	2.011E+04	1.3316+04	1.33	OF+04	7.1105.03	7.1345+03	3 6145404	1.0346.03	0.3/8F+03	H
4	1.065E+04	1.069E+04	6.343F +03	6.368F+03	4.214F+03	4.27	15+03	2.2505.03	2 2595-03	3.0142.03	3.0202.03	1.055F+03	1.0616.03
6	2.106E+03	2.116E+03	1.2545+03	1.2605403	8 3315403		IFAN7	4 4505+03	2.2372.03	1,1	1.1446.03	2.534E+05	2*500E+05
	6.6725+02	6. 705F +02	3.9746+02	3.9935+02	2 6405+02	3 65	35402	1 4105+02	A. ATTE-02	2.202E .02	2.273E+02	1.036F+02	1.041E+02
10	2.7385+02	2.750E+02	1.6315+62	1.63AF+02	1 0475+02	2.05	05+02	5.7855+02	1.41/2+02	1.16/E.01	7.201F+01	3.283F+01	3.548E+01
15	5.443E+01	5.442E+01	3.2425.01	3.2415.01	2 1635+01	3 16	35-01	1 1505-01	5.0100.01	2.7412+01	2.953F.01	1.347E+01	1.3532+01
20	1.7385+01	1.7235401	1.0355-01	1.0745+01	4 0745400	C.17	12401	1.1502-01	1.1502.01	5,5462+00	5.844E+00	2.07AE+00	5.0116+00
30	3.5215+00	3 3805400	2.0075.00	2.0175+05	1 3035400	0.01		3.0/12.00	3.0346.00	1.866E+00	1.850F.00	8.548E-01	8.471E-01
45	7. 3665-01	6.567F-01	4.3875-01	3.9065-01	2 0145-01	1.34	35-01	1.4392-01	7.15-5-01	3,7816-01	3.636F-01	1.732E-01	1.6655-01
60	2.5785-01	2 0035-01	1.5055-01	1.1005-01	2. 192-01	2.94	56-01	1.5576-01	1.30-2-01	1.4155-05	7.034E-02	3.0546-05	3.551E-05
75	1.1565-01	7.7305-02	6.8515-01	1.500E-02	A SELE-OI	1.84	15-0E	3.3412-02	+.clite-02	2. 1156-05	2.1395-02	1.244F-02	9.795E-03
	A 3105-02	1 4225-02	3 7445-02	3.0335-02	551E-02	3.04	16-05	231E-05	1.0216-05	1.534E-05	A.229F-03	5.6598-03	3.767E-03
180	2.8095-02	7 0505-07	3. 4736-02	2+0232-02	2.500E-02	1.33	96-05	1.335E-02	7.124E-03	6.787E-03	3.614E-03	3.1095-03	1.653E-03
180	1 8155-02	4445-03	1.0132-02	4.030E-03	1.1116-02	3.04	56-03	2.432E=03	1.004E-03	3.017E-03	A.126F-04	1.345E-03	3.709E-04
170	1.0100-02	2 2725-03	1.0016-02	9.0702-04	180E-03	5.14	1E-04	3.835E-03	5-9512-04	1,949E-03	1.447E-04	8.928F-04	6.519E-05
11.2	1.3005-02	3.3/30-04	4.4116-03	1.2205-0.	0,2528-03	5.44	0E-05	3.339E-03	1.578E-05	1,697E-03	4.1658-06	7.773F-04	9.1056-07
DEG	2.05+0	INFV	3.0540	1 MEU	A.0E.								
1	7.6576+04	7.6705.04	3.4585404	3.4645.404	I Galfage	1 0.		1 241Ecot	I DE DE LES	7.02.	DIMEV	1.05.0	J2MEV
2	4. 787E+03	7995.443	2.1625.443	3.1475.03	1 2545404	1.77	00000	1.2012-04	1.2032-04	0. •72E •03	6.483F+03	3,185E+03	3,190E+03
3	9 4575.02	9 A90F-02	4. 2715+03	A 3865.03	2 4035+03	1.22	46.03	1.0052.02	7.9052.02	4.046E+07	4.056F+02	1.991F+02	1.996E+02
	2 0035+02	3 006E.02	1 3535402	1 3675.02	C. SECANS		06.05	1.5586.05	1.5036+02	7.993E+01	A.021E+01	3,934E.01	3.947E+01
	5 0195-01	5 047E+01	2.6735.01	1.35/2.02	.0606.01	7.09	11 .01	4.931E+01	4.951E+01	2.530E+01	2.540F+01	1.245F+01	1.250E.01
	1 BTREANT	SALE - AL	2.0732.01	2.0002.001	1.9106.01	1.57	JE .01	4.750E+00	9.796E+00	5.003E+00	5.027F+00	2.462F+00	5.414E+00
10	7 6965400	7 7285-00	8.4702-00	8.5116.00		4.82	00 . TO	3.089E.00	3.104E+00	1.585E+00	1-5936+00	7.801E-01	7.839E-01
			3.4762.400	3.4405+00	1.9712.00	1.97	AE+00	3+508E+00	1.273E+00	6,505E-01	6.532F-01	3.501E-01	3,2156-01
20	1.5302-00		0. 404E-01	0.907E-01	3.918E-01	3.91	1E-01	2.520E-01	2.519E-01	1.503E-01	1.293E-01	6.363E-02	6.362E-02
-	0 0065-01	BIAE-07	C. CUGE-01	2. 100E-01	1,251E-01	1.24	0E-01	8.045E-02	7.973E-02	4.158E-05	4.091F-02	2.031F-02	2.013E-02
45	2 0716-02		4.404E=02	4.247E-02	2.034E-02	5.43	1E-02	1.630E-02	1.567E-02	8.364E-03	8.041E-03	4.116F-03	3.957E-03
60	7 1055-02	5 5065-02	9-301E-03	0. JIUE=03	5.303E-03	4.71	3E-03	3.411E-03	3.0316-03	1.750E-03	1.555E-03	8.612E-04	7.6546-04
75	3 2335-03	2 1525-03	J+204E=03	2.5272=03	1.820E-03	1.41	36-03	1.170E-03	4.510E-04	6.005E-04	4.729F-04	2.9555-04	2.327E-04
80	1 7765-03		1.4005-63	4. 11DE-04	0.281E-04	5.50	9E-04	3,326E-04	3.543E-04	2.733E-04	1.818F-04	1.3458-04	8.946E-05
120	7 8048-04	1145 04	0.0KKE=04	9.2032-04	4.54YE-04	5.41	1E-04	2.926E-04	1.555E-04	1.501E-04	7.976E-05	7.38AF-05	3.9256-05
180	6 1016-04	7005-05	3.3036=04	4.3485-05	5.055E-04	5.41	3E-05	1.300E-04	3.401E-05	6.673E-05	1.7865-05	3.284F-05	8.788E-06
12 170	- 101E-04	1.1022-05	2+3045-04	1+0032=05	1.306E-04	9.42	0E-06	6.403E-05	6.058E-06	4.312E-05	3.106F-06	2.1228-05	1.528E-06
114	-'eetf=0e	-131E+07	5.000E-04	1+501E=08	1,137E-04	2.74	9E-08	7.316E-05	1.351E+08	3.7546-05	5.055F-09	1.847F-05	1.9938-09

Rate Estimate (Carbon)

- $E_0 = 30 \text{ MeV}$
- Scattering angle = 30°
- Differential cross section = 6.2 x 10⁻² barns/steradian = 6.2 x 10⁻²⁶ cm²/sr
- Electron current = 9 x 10¹⁴ electrons/sec (150 microamps)
- 1 micron thick C foil = $0.22 \text{ mg/cm}^2 = 0.22 \text{ x} 6 \text{ x} 10^{20}/12 \text{ Ta-atoms/cm}^2 = 1 \text{ x} 10^{19} \text{ C-atoms/cm}^2$
- Luminosity = $9 \times 10^{14} \times 1 \times 10^{19} \text{ e-C/cm}^2/\text{s} = 9 \times 10^{33} \text{ e-C/cm}^2/\text{s}$
- Elastic scattering rate = $6.2 \times 10^{-26} \times 9 \times 10^{33}$ /s/sr = 5×10^{8} Hz/sr
- For solid angle of 3 msr, elastic rate is 1.5 MHz.

Rate Estimate (Tantalum)

- E₀ = 30 MeV
- Scattering angle = 30°
- Differential cross section = 8.9 barns/steradian = 8.9 x 10 -24 cm²/sr
- Electron current = 9 x 10¹⁴ electrons/sec (150 microamps)
- 1 micron thick Ta foil = 1.67 mg/cm² = $1.67 \times 6 \times 10^{20}/181$ Taatoms/cm² = 5.5×10^{18} Ta-atoms/cm²
- Luminosity = $9 \times 10^{14} \times 5.5 \times 10^{18} \text{ e-Ta/cm}^2/\text{s} = 5 \times 10^{33} \text{ e-Ta/cm}^2/\text{s}$
- Elastic scattering rate = $8.9 \times 10^{-24} \times 5 \times 10^{33}$ /s/sr = 5×10^{10} Hz/sr
- For solid angle of 3 msr, elastic rate is 150 MHz.

Rate Estimate (Carbon)

- E₀ = 30 MeV
- Scattering angle = 45°
- Differential cross section = 8.3 x 10⁻³ barns/steradian = 8.3 x 10⁻²⁷ cm²/sr
- Electron current = 9 x 10¹⁴ electrons/sec (150 microamps)
- 1 micron thick C foil = 0.22 mg/cm² = 0.22 x 6 x 10²⁰/12 C-atoms/cm² = 1 x 10¹⁹ C-atoms/cm²
- Luminosity = $9 \times 10^{14} \times 1 \times 10^{19} \text{ e-C/cm}^2/\text{s} = 9 \times 10^{33} \text{ e-C/cm}^2/\text{s}$
- Elastic scattering rate = $8.3 \times 10^{-27} \times 9 \times 10^{33}$ /s/sr = 7.4×10^{7} Hz/sr
- For solid angle of 3 msr, elastic rate is 0.2 MHz.

Rate Estimate (Tantalum)

- $E_0 = 30 \text{ MeV}$
- Scattering angle = 45°
- Differential cross section = 2.2 barns/steradian = 2.2 x 10⁻²⁴ cm²/sr
- Electron current = 9 x 10¹⁴ electrons/sec (150 microamps)
- 1 micron thick Ta foil = 1.67 mg/cm² = $1.67 \times 6 \times 10^{20}/181$ Taatoms/cm² = 5.5×10^{18} Ta-atoms/cm²
- Luminosity = $9 \times 10^{14} \times 5.5 \times 10^{18} \text{ e-Ta/cm}^2/\text{s} = 5 \times 10^{33} \text{ e-Ta/cm}^2/\text{s}$
- Elastic scattering rate = $2.2 \times 10^{-24} \times 5 \times 10^{33}$ /s/sr = 1.2×10^{10} Hz/sr
- For solid angle of 3 msr, elastic rate is 36 MHz.

