UNCLASSIFIED

cy.4

CENTRAL RESEARCH LIBRARY
DOCUMENT COLLECTION

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES
3 4456 0361233 9

ORNL-2454
Physics and Mathematics

BREMSSTRAHLUNG SPECTRA IN NaI AND AIR

C. D. Zerby
H. S. Moran

CENTRAL RESEARCH LIBRARY
DOCUMENT COLLECTION
LIBRARY LOAN COPY
DO NOT TRANSFER TO ANOTHER PERSON
If you wish someone else to see this document, send in name with document and the library will arrange a loan.

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
Division of Union Carbide Corporation
UCC
POST OFFICE BOX X · OAK RIDGE, TENNESSEE

UNCLASSIFIED

RIV P. 41, 158

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

UNCLASSIFIED

ORNL-2454

Copy No._____

Contract No. W-7405-eng-26

APPLIED NUCLEAR PHYSICS DIVISION

BREMSSTRAHLUNG SPECTRA IN NaI AND AIR

C. D. Zerby and H. S. Moran

DATE ISSUED

FEB 25 1958

OAK RIDGE NATIONAL LABORATORY
Operated by
UNION CARBIDE NUCLEAR COMPANY
Post Office Box X
Oak Ridge, Tennessee

UNCLASSIFIED

3 4456 0361233 9

ORNL-2454
Physics and Mathematics
TID-4500 (13th ed. Rev.)

INTERNAL DISTRIBUTION

1. C. E. Center
2. Biology Library
3. Health Physics Library
4-5. Central Research Library
6. Reactor Experimental Engineering Library
7-26. Laboratory Records Department
27. Laboratory Records, ORNL R.C.
28. A. M. Weinberg
29. L. B. Emlet (K-25)
30. J. P. Murray (Y-12)
31. J. A. Swartout
32. E. H. Taylor
33. E. D. Shipley
34. A. H. Snell
35. M. L. Nelson
36. W. H. Jordan
37. R. A. Charpie
38. S. C. Lind
39. F. L. Culler
40. A. Hollaender
41. J. H. Frye, Jr.
42. M. T. Kelley
43. J. L. Fowler
44. R. S. Livingston
45. K. Z. Morgan
46. T. A. Lincoln
47. A. S. Householder
48. C. P. Keim
49. C. S. Harrill
50. C. E. Winters
51. D. S. Billington
52. D. W. Cardwell
53. D. Phillips
54. A. J. Miller
55. E. P. Blizard
56. M. J. Skinner
57. R. B. Murray
58. R. R. Dickison
59. J. A. Harvey
60. A. Simon
61. J. J. Pinajian
62. F. C. Maienschein
63. F. L. Friedman (consultant)
64. H. Goldstein (consultant)
65. H. Hurwitz, Jr. (consultant)
66. L. W. Nordheim (consultant)
67. R. R. Wilson (consultant)
68. C. D. Zerby
69. H. S. Moran
70. ORNL - Y-12 Technical Library, Document Reference Section

EXTERNAL DISTRIBUTION

71. R. F. Bacher, California Institute of Technology
72. Division of Research and Development, AEC, ORO
73-552. Given distribution as shown in TID-4500 (13th ed. Rev.) under Physics and Mathematics category

Abstract

Calculations of the Bremsstrahlung spectra resulting from electrons slowing down in NaI and air were made and are presented in graphical form.

Introduction

In most practical problems dealing with the distribution of radiation in materials the effects of secondary radiation are usually of little importance. In some cases, however, secondary radiation such as Bremsstrahlung radiation can be of considerable importance. This report provides some information on the energy spectra of Bremsstrahlung radiation resulting from the degradation of electrons.

The equations to determine the Bremsstrahlung spectrum in an arbitrary medium containing as many as three different elements were coded for calculation on the ORACLE at Oak Ridge National Laboratory. A description of the operation of this code is given in Appendix A. The following sections describe the equations used and the limitations of the code. The results of some calculations using sodium iodide and air are given in Figs. 1 and 2.

Method of Calculation

Electrons essentially lose energy by two separate mechanisms in the process of slowing down. Inelastic collisions with the bound electrons of the medium is the predominant method of degradation at low energy while at higher energies, radiative collisions with the electric fields of the nuclei and electrons becomes the most important method. For lead the electron energy loss per unit length of travel as a result of inelastic collisions is equal to that for radiative collision at an approximate electron energy of 18 $m_o c^2$ while for lower Z materials the equality occurs at higher energies. For water the equality occurs at approximately 220 $m_o c^2$.[1] It was assumed in these calculations that the initial energy of the electron was sufficiently small so the energy loss as a result of radiative collisions was negligible in comparison to the loss resulting from inelastic collisions.

The energy loss per cm path length (stopping power) for an electron making ionization collisions is given by the equation[2]

---

1. W. Heitler, The Quantum Theory of Radiation, 3rd ed., p. 252, Oxford Press, 1954.

2. H. A. Bethe and J. Ashkin, "Passage of Radiation through Matter," Experimental Nuclear Physics, Ed. E. Segré, p. 254, John Wiley and Sons, Inc., New York, 1953.

UNCLASSIFIED
2-01-059-275

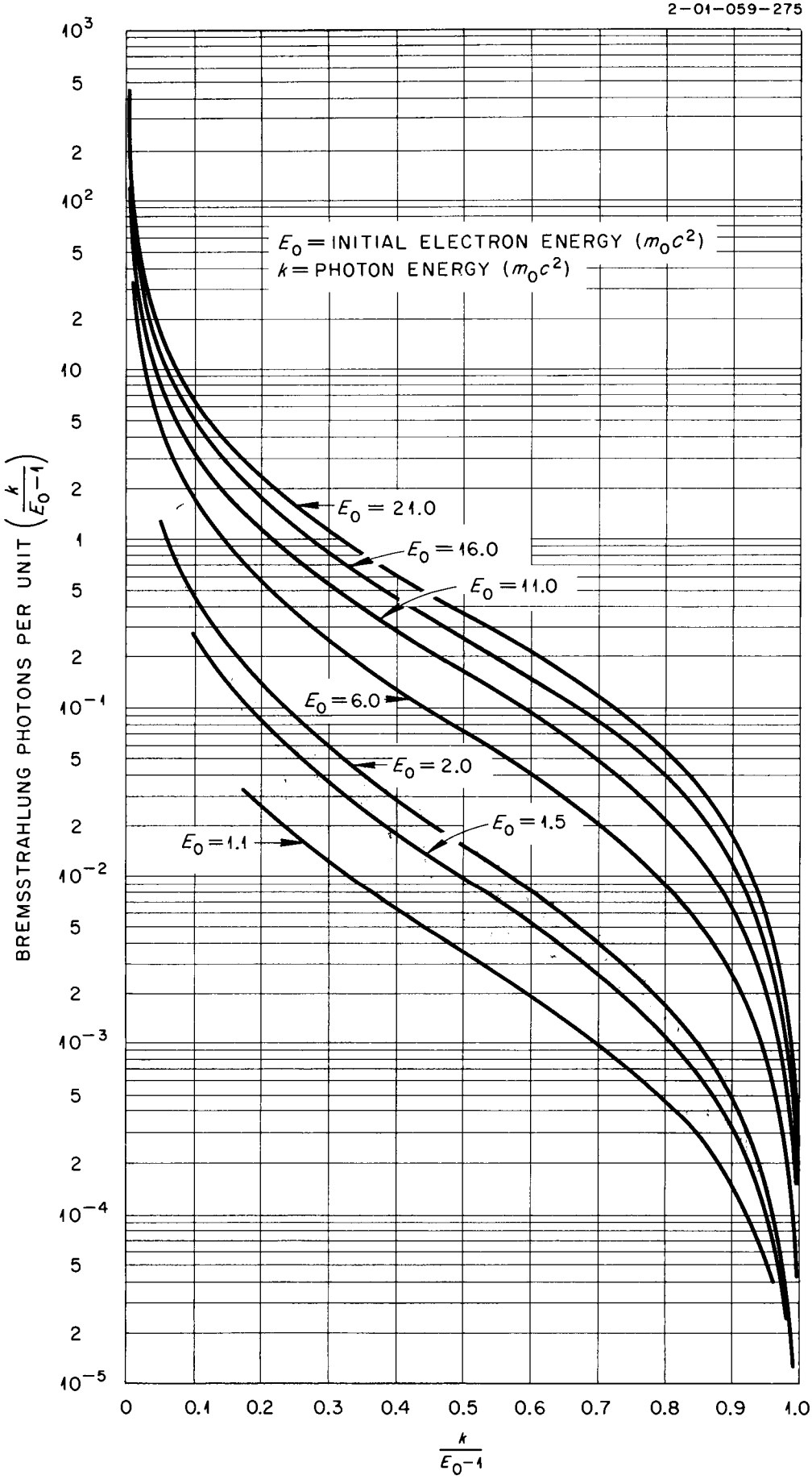

Fig. 1. Bremsstrahlung Spectrum in NaI.

UNCLASSIFIED
2-01-059-276

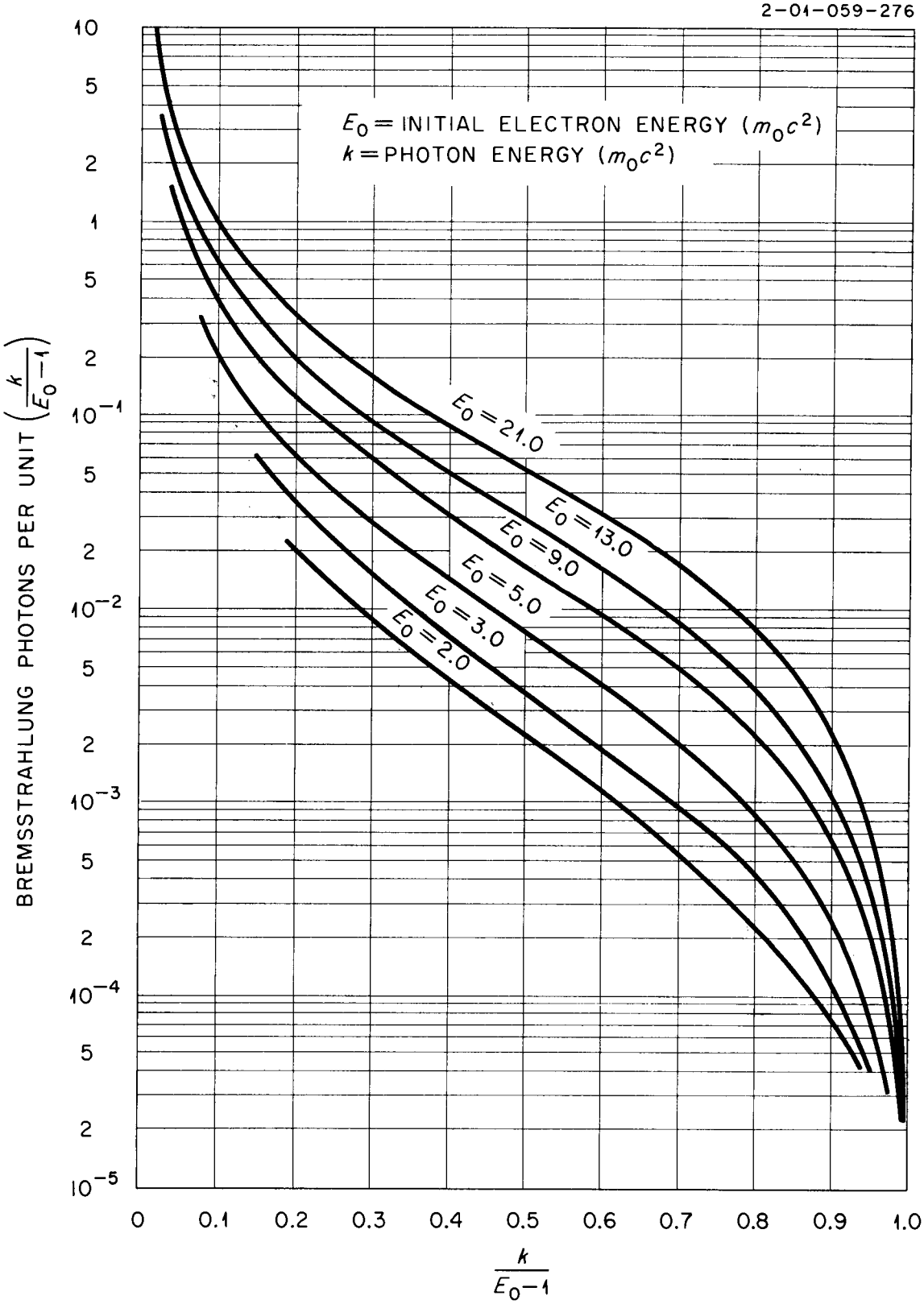

Fig. 2. Bremsstrahlung Spectrum in Air.

$$(1) \qquad -\frac{dE}{dx} = \frac{2\pi r_o^2 N Z}{\beta^2}\left[\ln\frac{\beta^2(E-1)}{2I^2(1-\beta^2)} - \left(2\sqrt{1-\beta^2} - 1 + \beta^2\right)\ln 2 + 1 - \beta^2 + 1/8\left(1-\sqrt{1-\beta^2}\right)^2\right]$$

where

E = total relativistic electron energy $(m_o c^2)$,
I = mean excitation potential $(m_o c^2)$,
$\beta^2 = (v/c)^2 = (E^2-1)/E^2$,
r_o = classical electron radius (cm),
N = atomic density (cm^{-3}),
Z = charge number.

It was assumed that for compounds the stopping power is additive for the compound elements. This is approximately true, however, since some slight discrepancies should be expected as a result of the deformation of the electron wave functions of the atom in the compound with a resulting slight change of the ionization potential. It is expected this change will be negligible in most cases.

A list of mean excitation potentials for various elements[3] is given in Table 1 for reference.

The Born approximation cross section for the production of light (Bremsstrahlung radiation) by an electron in the field of a nucleus without screening is given by[4]

$$(2) \qquad \Phi^a(E,k) = \frac{r_o^2 Z^2}{137}\,\frac{N}{k}\,\frac{P_1}{P}\left\{\frac{4}{3} - 2EE_1\frac{P_1^2+P^2}{P_1^2P^2} + \left(\frac{\epsilon E_1}{P^3} + \frac{\epsilon_1 E}{P_1^3} - \frac{\epsilon_1\epsilon}{PP_1}\right) + L\left[\frac{8}{3}\,\frac{EE_1}{PP_1} + \frac{k^2}{P^3P_1^3}\left(E^2E_1^2 + P^2P_1^2\right) + \frac{k}{2PP_1}\left(\frac{EE_1+P^2}{P^3}\,\epsilon - \frac{EE_1+P_1^2}{P_1^3}\,\epsilon_1 + \frac{2kEE_1}{P_1^2P^2}\right)\right]\right\}$$

where the following relations are used in Eq. (2):

---

3. Ibid, pg. 203.
4. W. Heitler, op. cit., pg. 245.

Table 1. Mean Excitation Potentials[a]

Z	Element	I (ev)	$\frac{I}{Z}$
1	H	15.6	15.6
3	Li	34.0	11.3
4	Be	60.4	15.1
6	C	76.4	12.7
13	Al	150	11.5
26	Fe	241	9.3
29	Cu	276	9.5
47	Ag	418	8.9
50	Sn	463	9.2
74	W	655	9.2
82	Pb	705	8.6
92	U	811	8.8

a. Taken from H. A. Bethe and J. A. Ashkin, "Passage of Radiation Through Matter," Experimental Nuclear Physics, Ed., E. Segré, p. 203, John Wiley and Sons, Inc., New York, 1953.

(3) $$L = 2\ln\left(\frac{EE_1 + PP_1 - 1}{k}\right) ,$$

$$\epsilon = 2\ln (E + P),$$

$$\epsilon_1 = 2\ln (E_1 + P_1),$$

$$E_1 = E - k,$$

$$P^2 = E^2 - 1,$$

$$P_1^2 = E_1^2 - 1 .$$

With the use of Eqs. 3, Eq. 2 is simply a function of E and k where E has the same definition as in Eq. 1 and k is the photon energy expressed in units of $m_o c^2$. The quantity $\Phi^a(E,k)dk$ is the electron cross section (cm^{-1}) for producing a photon in the interval k to k + dk.

When the electron screening of the nucleus is taken into account and Eq. 2 is reduced to the relativistic case $E \gg m_o c^2$ one arrives at the equation[5]

(4) $$\Phi^b(E,k) = \frac{r_o^2 Z^2 N}{137} \frac{4}{k} \left\{ \left[1 + \left(\frac{E - k}{E}\right)^2\right] \left[\frac{\phi_1(\gamma)}{4} - 1/3 \ln Z\right] - 2/3 \left(\frac{E - k}{E}\right) \left[\frac{\phi_2(\gamma)}{4} - 1/3 \ln Z\right] \right\}$$

where γ is given by[6]

(5) $$\gamma = 100 \frac{k}{E(E - k)Z^{1/3}}$$

---

5. H. A. Bethe and J. Ashkin, op. cit., pg. 260.

6. Ibid, pg. 259

The functions $\phi_1(\gamma)$ and $\phi_2(\gamma)$ are presented graphically by Bethe and Ashkin;[7] however, they are well represented with less than 0.3 per cent error by the empirical relations

(6) $$\phi_1(\gamma) = 5.089\, e^{-0.6587\gamma} + 15.661\, e^{-0.0481\gamma}$$

(7) $$\phi_2(\gamma) = \phi_1(\gamma) - 0.595\, e^{-3.04\gamma} .$$

The quantity γ measures the effect of screening. For $\gamma \gg 1$ the screening can be neglected; however, for $\gamma = 0$ the screening is complete. Although Bethe and Ashkin give a series of equations similar to Eq. 4 valid for various ranges of γ, the use of Eqs. 6 and 7 in Eq. 4 makes it valid for all values of γ.

The cross section relation for the production of Bremsstrahlung radiation, Eq. 2, was derived using the Born approximation which means it is not valid for high Z materials and for low initial or final energy of the colliding electron because of the improper form of the electron wave function. Equations 2 or 4 also neglect the production of light from collisions with atomic electrons; however, this last effect is proportional to Z whereas the production from collisions with the nucleus goes as Z^2. This means the production from the atomic electrons is negligible for high Z materials.

With the use of Eqs. 1, 2, and 4 the total Bremsstrahlung spectrum from an electron slowing down in a compound is given by

(8) $$K(E_o,k_o) = \int_{k_o}^{E_o-1} dk \left[\int_{k+1}^{g} \frac{\sum_j \Phi_j^a(E,k)dE}{\sum_j \left(-\frac{dE}{dx}\right)_j} + \int_{g}^{E_o} \frac{\sum_j \Phi_j^b(E,k)dE}{\sum_j \left(-\frac{dE}{dx}\right)_j} \right]$$

Here $K(E_o,k_o)$ is defined to be the total number of photons produced by an electron of initial energy E_o in the photon energy interval k_o to $E_o - 1$. The upper limit of the photon energy interval, $E_o - 1$, is the

7. Ibid, pg. 262.

maximum photon energy possible. The subscript j refers to the jth element of the compound. The intermediate limit, g, of the integral in the square brackets was chosen to have the value g = 3 or

(9) $$g = \frac{k}{2} + \frac{1}{2}\sqrt{k^2 + \frac{400k}{6Z^{1/3}}}$$

depending on which was the greater. The choice was made to use Eq. 2, which applies at all electron energies, when E was below 3 or in those cases when screening was not important. Equation 9 is derived from Eq. 5 with γ set equal to 6 and represents the maximum electron energy before screening becomes important. When $E_o \leq g$ the second integral in the curly brackets of Eq. 8 disappears resulting in the equation

(10) $$K(E_o,k) = \int_k^{E_o-1} dk \int_{k+1}^{E_o} \frac{\sum_j \Phi_j^a(E,k)dE}{\sum_j \left(-\frac{dE}{dx}\right)_j} ,$$

however, for E_o and k + 1 greater than g Eq. 8 reduces to

(11) $$K(E_o,k) = \int_k^{E_o-1} dk \int_{k+1}^{E_o} \frac{\sum_j \Phi_j^b(E,k)dE}{\sum_j \left(-\frac{dE}{dx}\right)_j}$$

In summary, it should be made clear that the use of Eq. 8 is restricted to intermediate Z materials. From the effect of the Z alone, it seems likely that $Z > 10$ the errors should be less than 10 per cent; however, the intermediate range of Z would have a much smaller error. The initial energy E_o should be restricted below the point where the energy loss as a result of radiative collisions equals the energy loss for inelastic collisions. The inequality the initial energy must satisfy is given roughly by

(12) $$E_o < \frac{1600}{Z}$$

There are two errors in Eq. 8 which could not be avoided. The use of the Born approximation for the cross section means the high energy end of the Bremsstrahlung spectrum will be slightly in error. The other error comes in by way of Eq. 2 which does not include screening. The last error has its most serious effect on the low energy spectrum which is overestimated by Eq. 8.

Results of Some Calculations

Calculations for the Bremsstrahlung spectrum in NaI and air were performed and are given in Figs. 1 and 2. The constants for each calculation are given in Tables 2 and 3.

For convenience, Figs. 1 and 2 present the number of photons per unit $\left(\frac{k}{E_o - 1}\right)$ as a function of $\frac{k}{E_o - 1}$. The integral under these curves represents the total number of photons released.

Table 2. Constants for NaI

Density 3.677 g/cm^3

	Na	I
Z	11	53
N $(\frac{\text{atoms}}{\text{cm}^3})$	1.47726×10^{22}	1.47726×10^{22}
I (ev)	129.3	466.4

Table 3. Constants for Air

	O	N
Z	8	7
N $(\frac{\text{atoms}}{\text{cm}^3})$	1.06598×10^{19}	3.9658×10^{19}
I (ev)	97	87

APPENDIX A

Oracle Code for Bremsstrahlung Spectrum in Various Media

As displayed below, this program allows the slowing-down medium to consist of one, two, or three elements. The computation is performed throughout in 8-32 floating point arithmetic. The double integration is executed numerically by Gauss' Method, with a mesh of six by six.[1]

For a given medium, the input data is in two parts, both on paper tape in packed decimal, as follows:

Part I - Medium Parameters:

1. $N_1 \cdot 10^{-24}$, atomic density of Element No. 1, (atoms/cm^3) x 10^{-24}.
2. $N_2 \cdot 10^{-24}$, atomic density of Element No. 2, (atoms/cm^3) x 10^{-24}.
3. $N_3 \cdot 10^{-24}$, atomic density of Element No. 3, (atoms/cm^3) x 10^{-24}.
4. Z_1, atomic number of Element No. 1.
5. Z_2, atomic number of Element No. 2.
6. Z_3, atomic number of Element No. 3.
7. I_1, Ionization potential of Element No. 1, electron volts.
8. I_2, Ionization potential of Element No. 2, electron volts.
9. I_3, Ionization potential of Element No. 3, electron volts.
10. Single space.

e.g., for NaI:

1.	01 477 26 F01	N_1 = 0.0147726 x 10^{24} for Na.
2.	01 477 26 F01	N_2 = 0.0147726 x 10^{24} for I.
3.	00 000 00 000	N_3 = 0.
4.	01 100 00 002	Z_1 = 11 for Na.
5.	05 300 00 002	Z_2 = 53 for I.
6.	00 000 00 000	Z_3 = 0.
7.	01 293 00 003	I_1 = 129.3 ev for Na.
8.	04 664 00 003	I_2 = 466.4 ev for I.
9.	00 000 00 000	I_3 = 0.
10.	Single space.	

1. Coarser or finer meshes may be used accordingly as the interval in E_γ are smaller or larger, respectively.

Part II - Limits of integration and number of integrals. (Note Part II may consist of one or many sets of 5 words each, 1 set for each E_o). The total integral over E_γ extends frome some arbitrary lower limit, $E_{\gamma,lower}$, to a fixed upper limit, $E_o - 1$. This range is subdivided into N smaller intervals of width ΔE_γ. $E_{\gamma,lower}$, 2., below, represents the arbitrary lower limit of E_γ. $E_{\gamma,upper}$, 3., below, is equal to $E_{\gamma,lower} + \Delta E_\gamma$, and represents the upper limit of the first smaller interval of integration over E_γ. Warning: ΔE_γ should not exceed 0.2 $m_o c^2$ for the program as written. Larger values of ΔE_γ will require a finer mesh in subroutine 00 050, the 8-32 Gaussian double integration item. The 000 word of this subroutine is located in 2D5. Instructions for mesh changing may be found in the Appendix to ORNL Mathematics Panel Memorandum on the 3 8-32 Gaussian Integration Subroutines.

1. E_o, electron energy, in $m_o c^2$ units.
2. $E_{\gamma,lower}$, lower limit of E_γ, in $m_o c^2$ units.
3. $E_{\gamma,upper}$, upper limit of E_γ, in $m_o c^2$ units.
4. ΔE_γ, increment to both limits of E_γ, in $m_o c^2$ units.
5. N, the number, as a binary integer, of integrals to be computed at electon energy, E_o. i.e., $N = \dfrac{(E_o - 1) - E_{\gamma,lower}}{\Delta E_\gamma}$
6. Single space.

e.g. for $E_o = 2.0$

1.	02 000 00 001	$E_o = 2\ m_o c^2$.
2.	04 000 00 F01	$E_{\gamma,lower} = 0.04\ m_o c^2$.
3.	06 000 00 F01	$E_{\gamma,upper} = 0.06\ m_o c^2$.
4.	02 000 00 F01	$\Delta E_\gamma = 0.02\ m_o c^2$.
5.	00 000 00 030	No. of Integrals = 48 (dec.).
6.	Single space.	

Using the example input just described, the Oracle will read in Part I of the input and the first set of Part II, and then proceed to calculate the 48 (dec) integrals specified. Following the computation of each double integral, four words are punched on paper tape, in packed decimal, as follows:

1. E_o, as before
2. $E_{\gamma,lower}$, as before
3. $E_{\gamma,upper}$, as before
4. Value of double integral, units: number of photons in interval ($E_{\gamma,lower}$, $E_{\gamma,upper}$) per source electron of energy E_o.

e.g. , for the described input:

E_o	$E_{\gamma,lower}$	$E_{\gamma,upper}$	$\int\int$
02 000 00 001	04 000 00 F01	06 000 00 F01	01 291 11 F02
02 000 00 001	06 000 00 F01	08 000 00 F01	01 113 53 F02
	(44 sets omitted)		
02 000 00 001	09 600 00 000	09 800 00 000	01 297 85 F05
02 000 00 001	09 800 00 000	01 000 00 001	02 734 37 F06

Following the punching of the last four results above, the Oracle will proceed to read in the next set of limits, etc. from Part II of the input, and to calculate and punch as before. This process continues until no more input is availabe to the reader, which causes a stop on reader error in 3A8,L. To stop the program otherwise, the break-point switch may be turned on, causing a stop in 025,R, immediately following the punching a four word set of results. The fast memory may then be dumped on private magnetic tape, providing convenient re-entry at a future time by reading the program back into fast memory properly repositioning the input tape under the reader, and executing 43 025. Operating time averages about 0.7 minutes per integral over ΔE_γ, varying slightly with E_o.

Typical operating instructions would read:

1. Clear and set to 2048 memory.
2. Problem 316 code under reader: 90 7EF.
3. Input tape under reader: 43 000

Oracle will stop:

(a) When input is exhausted, 3A8,L.

(b) On break point in 025,R.

ORACLE CODE -- PROBLEM 316

```
000  24000433a4 4007a40082 24002433a4 4008b4008b
     24004433a4 4008540086 24006433a4 4008940089
     940aa40000 24009430b2 87d207d7e7 2707e4a011
     2400c430b2 87e207e7e8 2707f4a011 2400f430b2
010  87f207f7e9 2408b5f766 240a85f764 240a95f765
     240855f762 240865f763 240aa5f7ea 24017431ca
     4301a00000 40762400a3 247ea22421 4b0025f7ea
     6001940000 2401d432d5 5f7eb40000 2401f433e1
020  4076640766 24021433e1 4076240763 24023433e1
     407eb407eb 24025438b2 7628089762 f638089763
     4301a00000 2402a4102a 2042714014 5102d9473d
     1b03c5402e 160094b427 94fff4102b 240865f763
030  240ad5f7ea 240132042c 5401343012 240a15f762
     240a25f763 240ae5f7ea 2401e20422 5f01e2401f
     204225f01f 240132042d 5401343012 2408f5f766
     240855f762 240865f763 240ad5f7ea 2401e22422
040  5f01e2401f 224225f01f 240132042e 5401343012
     240a15f762 240a25f763 240af5f7ea 2401e20422
     5f01e2401f 204225f01f 240132042d 5401343012
     240905f766 240855f762 240865f763 240ad5f7ea
050  2401e22422 5f01e2401f 224225f01f 240132042e
     5401343012 240a15f762 240a25f763 240b05f7ea
     2401e20422 5f01e2401f 204225f01f 240132042d
     5401343012 240915f766 240855f762 240865f763
060  240ad5f7ea 2401e22422 5f01e2401f 224225f01f
     240132042e 5401343012 240a15f762 240a25f763
     240b15f7ea 2401e20422 5f01e2401f 204225f01f
     240132042d 5401343012 2401e22422 5f01e2401f
070  224225f01f 2401322430 224302242f 5401300000
     0000000000 0000000000 007fffffff 01745c91d1
     0168b8f9b1 fd7fffffff 0000000000 0000000000
     0000000000 0000000000 0000000000 0000000000
080  0000000000 0000000000 0000000000 036487f23c
     26797e6b3c fc66666666 fc7ae147ae 0000000000
     0000000000 fa51eb851e fd66666666 0146666666
     015fffffff 017fffffff 035fffffff 0457fffff
090  047fffffff 0553fffff ff55554fbd 0358e392e1
     025fffffff 0742aaacd9 ff7fffffff 0763fffff
     03516c8b43 00abcd35a8 047d49ba5e fc9d7dbf48
     004c28f5c2 029eb851eb f97791514b 015555475a
0a0  0255555c52 017fffffff 0243333333 240a3430f4
     240a4430f8 240a5430fb 240a6430fe 0100000000
     0000000000 0000000000 0000000005 000000002d
     000000005f 00000000c3 000000001e 0000000050
```

0b0	0000000082	00000000b4	20427540b3	240b25f0f0
	510c316001	1b007540ba	1b004710b7	5f0f1240b2
	1c0207f0ec	5f0ed16000	240b21c020	7f0ee5f0ef
	240f1490d2	12002490d1	12001490e7	12001490c8
0c0	250ec430e2	600ec240ed	1b01f60428	1b0015f0b2
	4f0f2240b3	20427540b3	240f04a0b3	240b3540c8
	430b2270ee	480d5270ec	480c3250ec	230ee4b0cf
	240ec14001	5f0ec240ed	204215f0ed	240ec3a0ee
0d0	240ed220ef	430c2260ee	5f0ee270ec	4b0d6600ee
	240ef1b020	410c300000	270ee4a0c1	240ed220ef
	480dc5f0f1	240ec600ee	5f0ee7f0ec	240ef5f0ed
	260f1510de	220eb4a0c1	240ee14000	200ec4e0e2
0e0	1c029240ed	20421430c2	5f0ec270ec	480c3240ec
	120014f0c1	5f0ec240ed	224215f0ed	410e3240ed
	200ef5f0ed	600ec380ee	5f0ec410e2	0000000020
	0000000000	0000000000	0000000000	0000000000
0f0	0000000000	0000000000	4a0eb24420	410c300000
	20427540f7	240f5430b2	f3e807673e	430f400000
	20427540fa	247665f73e	430f800000	20427540fd
	240765f73e	430fb00000	2042754150	7f767400fe
100	24100431e3	24101430b2	f6640947dd	247dd12009
	4a111401ca	241054321e	24106430b2	7d827e77de
	07a27de7df	7d827e87e0	07b27e07e1	7d827e97e2
	07c27e27e3	7df87e17e4	7e487e37e5	fe5175873e
110	4315000000	2411143193	2411243151	24113430b2
	f77473e7e6	247e612009	4b11c400fe	241174321e
	24118430b2	7d827e77de	87a27de7df	4312300000
	247915f7d9	247925f7da	2476b5f7db	2407d5f7dc
120	2412043273	24121430b2	87a27fb7df	2707e4a12d
	24124430b2	f7f473e7e6	247e612009	4b130400fe
	241284321e	24129430b2	7d827e87e0	87b27e07e1
	4313700000	2412d430b2	fdf175873e	4315000000
130	247935f7d9	247945f7da	2476c5f7db	2407e5f7dc
	2413443273	24135430b2	87b27fb7e1	2707f4a141
	24138430b2	f80473e7e6	247e612009	4b145400fe
	2413c4321e	2413d430b2	7d827e97e2	87c27e27e3
140	4314c00000	24141430b2	7df87e17e4	fe4175873e
	4315000000	247955f7d9	247965f7da	2476d5f7db
	2407f5f7dc	2414943273	2414a430b2	87c27fb7e3
	2414c430b2	7df87e17e4	7e487e37e5	fe5175873e
150	430fe00000	2042754192	24152430b2	093176e771
	7718076772	8941772773	2707e4a160	24157430b2
	093176f771	7718076772	8941772774	2707f4a160
	2415c430b2	0931770771	7718076772	8941772775

160	24160430b2	f734767776	2477612009	4a18c40151
	24164430b2	095176e778	7782767779	767276777a
	f7a877977b	2416943286	4077b4077c	2416b430b2
	096277c77d	096276777e	f7e877d777	2707e4a192
170	24170430b2	f744767776	2477612009	4a18e40151
	24174430b2	095176f778	7782767779	f7a877977b
	2417843286	4077b4077c	2417a430b2	096277c77d
	f7e877d77f	2707f4a192	2417e430b2	7754767776
180	2477612009	4a19040151	24182430b2	0951770778
	7782767779	f7a877977b	2418643286	4077b4077c
	24188430b2	096277c77d	f7e877d780	4319200000
	240945f777	4316f00000	240945f77f	4317d00000
190	240945f780	4319200000	4315100000	20427541aa
	24194430b2	73e4767781	73e2781782	0972767783
	7831782784	f84176e785	2707e4a1a1	2419b430b2
	f84176f786	2707f4a1a1	2419e430b2	f841770787
1a0	431a140193	244215f797	2707e4a1a7	2479720421
	5f7972707f	4a1a724797	204215f797	241b95f1b4
	241ba5f1c7	2479722421	4b1935f797	241b420424
	5f1b420423	204225f1b5	2042320422	571b6241c7
1b0	2042520425	5f1c722421	511c640193	241b3430b2
	7852099788	785209b789	f85209d78a	601c9431bb
	241b8430b2	7842099788	f8f4790790	241bb4329a
	241c920427	1802840193	241be4329a	241c92042b
1c0	1802840193	241c14329a	241c2430b2	098278b78e
	09a278c78f	09c278d790	78e878f791	f914790792
	431a900000	407884078b	20427541e1	241cb43379
	4007d40768	2707e4a1d3	241ce43379	4007e40769
1d0	2707f4a1d3	241d143379	4007f4076a	241d3430b2
	092276876b	092276976c	892276a76d	601e2401ca
	241d84329a	2707e4a1e1	241e220427	18028401ca
	241dc4329a	2707f4a1e1	241e22042b	18028401ca
1e0	241e04329a	431ca00000	4076b4076e	204275421d
	241e4430b2	083207a759	759207d760	080208075b
	75b875b75c	884175c75d	241ea43379	4075d4075e
	241ec430b2	f60275e761	2707b4a208	241ef430b2
1f0	083207b759	759207e75a	081208175b	75b875b75c
	884175c75d	241f543379	4075d4075e	241f7430b2
	75a275e75f	75a8760760	f5f8761761	2707c4a208
	241fc430b2	083207c759	759207f75a	082208275b
200	75b875b75c	884175c75d	2420243379	4075d4075e
	24204430b2	75a275e75f	75a8760760	f5f8761761
	24208430b2	076173e747	7472747748	0772748749
	078274774a	076174874b	74b407674c	076174774d

210	74d407674e	f4c274e74f	2421243379	4074f40750
	24214430b2	7508749751	751474a752	7528079753
	7602753754	7618754755	0764748756	0761756757
	f572755758	431e300000	2042754436	2421f430b2
220	73e4767798	7982798799	f99407679a	2779a48271
	2422443286	4079a4079d	24226430b2	f9d279a79f
	2779f48271	24229430b2	73e273e79b	f9b407679c
	2422c43286	4079c4079e	2422e430b2	79e279c7a0
230	798273e7a1	79d279e7a2	7a187a27a3	7a340767a4
	fa417677a5	2423543379	407a5407a6	247a6200a7
	5f7a74021e	24239430b2	f3e879e7a8	2423b43379
	407a8407a9	247a9200a7	5f7aa4021e	2423f430b2
240	f98879d7ab	2424143379	407ab407ac	247ac200a7
	5f7ad247a1	200a75f7ae	24246430b2	79a879c7af
	79a279c7b0	7ae27af7b1	7b117b07b2	7aa27987b3
	7b317a07b4	7ad273e7b5	7b5179f7b6	7ad27aa7b7
250	7b717a27b8	7a117a27b9	0a027b97ba	7a127a17bb
	7bb87b07bc	76727677bd	79f27a07be	7bd17be7bf
	7bf27bc7c0	76717a27c1	7c120967c2	7a1879c7c3
	7c317a07c4	7c427aa7c5	7a1879a7c6	7c627ad7c7
260	7c7179f7c8	7ae27677c9	7c917b07ca	7c547c87cb
	7cb87ca7cc	7c227cc7cd	7ba87c07ce	7ce87cd7cf
	7a727cf7d0	09f47b27d1	7d187b47d2	7d287b67d3
	7d347b87d4	7d487d07d5	79d179e7d6	09e27d67d7
270	fd727d57d8	4343424420	5f7d843436	2042754285
	24274430b2	73e47677ec	7ec173e7ed	7ed27ed7ee
	07687ee7ef	43227d97f0	7f047db7f1	43327ed7f2
	43227da7f3	7f347db7f4	7dc27dc7f5	43127f57f6
280	7f617677f7	7ef27f17f8	7f227f47f9	7f847f97fa
	ff727fa7fb	4327300000	2042754288	2042754299
	6028674289	2428671298	160001c020	7f74620421
	1c0015f745	2474649299	7f74424744	4b2907f746
290	2474614001	204295f743	267463a743	7f74026743
	2274014001	4829620743	4129124745	607431b021
	150015f286	4328600000	20427542ce	7429c712cd
	2429a16000	1c0205f743	7f74125743	222d0492a4
2a0	24743482a2	604292442a	432cd24741	482d024420
	412cd25741	4c2a826429	5f74124743	2042a5f743
	4129e5f73f	2442a12001	20743482b0	5f74326743
	512af602d4	3973f5f73f	6073f24420	5f7431c000
2b0	432bd512b9	512bc602d4	3873f5f744	120011c001
	7f743602cf	3973f20743	5f73f4c2b8	247442042a
	5f74460744	244201b000	4d2a25f743	2473f12001
	607441b000	247414b2c1	2442a1d001	207435f743

2c0	392d3412c3	267435f743	120011c001	392d25f744
	262d15f746	247441c027	3b7461b028	224265f745
	247462042a	4a2cc5f746	6074438745	412c500000
	6074524743	1b0205f29a	4329a00000	3700000000
2d0	0000000006	0000000011	58b90bfbe9	a746f40417
	5c551d94ae	2042754340	1b028542dc	512f320427
	542dd512f6	20427542e0	5132620427	542f85130d
	242d55f365	242d55f366	242de430b2	b66436536f
2e0	242d55f375	263754b2e4	2433920342	5f339412eb
	5f36924375	512e62642a	402d512000	2042a5f36a
	2436f220a7	5f36f24369	2042a5f369	4b2e816000
	7f37116000	7f37326341	5f36c402d5	242ef430b2
2f0	345236f378	b78836573e	2473e5f377	242f3412d5
	2473e5f367	243775f73e	242f6412d5	2473e5f368
	242d55f376	242f9430b2	b684367370	263764b2fe
	2431f20342	5f31f41305	5f36b24376	51300402d5
300	2642a12000	2042a5f36d	24370220a7	5f3702436b
	2042a5f36b	4b30216000	7f37216000	7f37426341
	5f36e402d5	24309430b2	3452370378	b78836773e
	60377402d5	2430d412d5	2430e430b2	355273e378
310	b788374374	2430a20424	5c30a2430f	204245c30f
	2436e2042a	5f36e4b309	2430a22343	5f30a2430f
	223435f30f	24319430b2	3702374378	3788372372
	b678370367	2436d2042a	5f36d49306	4131f2431f
320	203425f31f	24321430b2	b684367370	413062431f
	223425f31f	243775f73e	24326412d5	24327430b2
	73e2372378	3552378378	b788373373	242f020424
	5c2f024329	204245c329	2436c2042a	5f36c4b2ef
330	242f022343	5f2f024329	223435f329	24333430b2
	36f2373378	3788371371	b6f8365365	2436a2042a
	5f36a492ec	4133924339	203425f339	2433b430b2
	b66436536f	412ec24339	223425f339	402d524371
340	432d500000	0000000006	0000400000	0060000000
	0010001000	fc4526b630	fe56bafb4d	ff6174ed30
	004f458968	006a51412d	007bad949d	ff5bf46a33
	ff73d6a14d	004614af5a	005205cae6	005d50259a
350	00678b48ce	0070588bbb	007766806a	007c73eacc
	007f52584d	fd57b7d808	fe5c5aded6	fe77c93526
	fe77c93526	fe5c5aded6	fd57b7d808	fd5d7e31e0
	fd60ffaba0	fd60ffaba0	fd5d7e31e0	fd569baeed
360	fd4c97d86f	fc7f9ebcaf	fc61713b9e	fb7f7ec68b
	fa6f376ad3	0000000000	0000000000	0000000000
	0000000000	0000000000	0000000000	0000000000
	0000000000	0000000000	0000000000	0000000000

370	0000000000	0000000000	0000000000	0000000000
	0000000000	0000000000	0000000000	0000000000
	0000000000	204275437b	20427543a0	603797437c
	243797139f	5874516009	777457f743	1c00220429
380	5f74120426	1b0013b741	7f7417f746	397411c002
	5f74424421	203a153743	6074439746	5f7461c027
	3b7437f742	277424a38c	207415f741	2474343385
	277455f744	48394243a2	5f74460745	383a35f745
390	1b0014f394	5f74524744	224215f744	2474543390
	2474451395	247411c000	207454d39c	5f74516021
	4c39f24745	160014d3a0	5f74524744	224215f744
	4139814001	5f74524744	2042160745	1c0087f379
3a0	4337924744	4139e00002	0000000007	58b90bfbff
	20427543a6	20427543d9	243a4513dc	14014513d7
	9473e433a9	2773e483d7	1b01c1200c	5f73f7f73e
	1a00424420	1b0045f740	1200220740	120015f740
3b0	244201b004	207405f740	2473e4a3b4	267405f740
	60740383e0	1b00220421	5f7411b028	1000120426
	5f73e6073e	393df5f73e	2642714010	5f73d2673e
	5f7401c027	3b73d1a001	1c0012473d	204217f73e
3c0	4a3c25f73d	38740413bc	2473f16004	7f7427f740
	180247f743	207425f742	2474020421	5f740223dd
	4a3cc24742	1600220742	160015f742	24743433c4
	60742383de	1b00a5f742	2473f4a3d0	267425f742
3d0	607423873e	1b0014f3d5	5f74224741	224215f741
	24742433d1	1c02924741	1b01f60428	1b0015f3a4
	243d7223dc	4a3a4243d7	204215f3d7	433a800000
	1b0015f000	0000000009	44b82fa09b	58b90bfbe9
3e0	6a4d3c25e6	20427543e3	2042754417	243e1543e5
	160145441a	243e11c020	7f73d1c028	3841e20421
	5f73c1b028	1000120426	5f73f6073f	3941f5f73f
	2642714010	5f7402673f	5f7411c027	3b7401a001
3f0	1c00124740	204217f73f	4a3f45f740	38741413ee
	6073f3973f	5f74160741	397415f73f	6073f3973d
	5f73d12002	2073d12001	4d3fc5f73d	2473c22421
	5f73c2473d	493fe60420	433ff60428	2573d2041d
400	4e4042473c	204215f73c	2442910002	1a0184340a
	5f73d2641b	5f73f2573d	140022173d	1a00410001
	5f73d2473f	204214b405	2473c4b40c	244204140c
	244281b004	7f73f16000	7f7412573c	2241c49412
410	5f73c24741	204215f741	4140e2473f	1200420741
	120042173c	5f74184741	243e52241a	4a3e1243e5
	20427543e5	433e500000	240001c020	0000000006
	000000000a	00000431be	268826a13f	49aec6eed6
420	0000000000	0000000001	0000001000	0000001001
	0010000000	0010000001	8000000000	0000100001
	ffffffffff	4000000000	0000000001	0000200002
	0000600006	0000800008	0000900009	0000d0000d
430	0002000020	fb7791533e	ff40000000	0055555555
	24434430b2	fd817677d8	4300000000	