WG6 intercomparison on voxel phantoms

The European Radiation Dosimetry Group, EURADOS, is organizing an intercomparison study on the usage of the ICRP/ICRU voxel reference computational phantoms together with radiation transport codes. Voluntary participants are invited to solve specific tasks and provide solutions to the organizers before an agreed deadline. The tasks to be solved are of practical interest in occupational, environmental and medical dosimetry. The aim of this training activity is to investigate if the phantoms have been correctly implemented in the radiation transport codes, to give participants the opportunity to check their own calculations against quality-assured master solutions, and to improve their approach, if needed.

The tasks to be solved consider a variety of exposure scenarios (occupational, environmental, and medical) and radiation types (photons, electrons, neutrons). More specifically, these are:

- Photon point source AP at 125 cm from the bottom and 100 cm from the chest: The aim is to calculate organ absorbed doses for both reference computational phantoms and the effective dose for 10 GBq of Co-60 and ten minutes exposure time.
- Neutron point source AP at 125 cm from the bottom and 100 cm from the chest: The aim is to calculate organ absorbed doses for both reference computational phantoms and the effective dose for a 1 minute exposure to a 1 GBq source of 10 keV neutrons.
- Am-241 ground contamination: The contamination is assumed to be contained within a disc of radius 2 m, with the anthropomorphic phantom standing at its center. The activity is deposited on the surface of the ground only, and a uniform contamination is assumed. The aim is to calculate organ absorbed dose rates for both reference computational phantoms, as well as the effective dose rate.
- Immersion in a radionuclide source homogeneously distributed inside a room: The anthropomorphic phantom is located at the center of a confined room filled with N-16 contaminated air. The aim is to calculate organ equivalent dose rates per activity concentration [in $(Sv\ s^{-1})/(Bq\ m^{-3})$].
- Typical x-ray examinations: The aim of this exercise is to calculate organ absorbed dose conversion coefficients for the male and female reference computational phantom for two typical x-ray examinations (chest p.a. and abdomen a.p.).
- Internal dosimetry: The aims of this exercise are to evaluate (1) absorbed fractions and specific absorbed fractions of energy in specified “target” organs for (1a) monoenergetic photons and (1b) monoenergetic electrons emitted in specific “source” organs of both phantoms, and (2) S-values for the same source and target organ combinations for specific radionuclides.

Each of the tasks is supervised by two or three members of EURADOS WG6. One person is responsible for providing a master solution, the correctness of which has been ascertained by second/third calculations by the other members responsible for the task.

Each interested participant can solve one or several of the problems, according to his/her knowledge, interest, and time to be devoted to the participation. The participants should provide their solutions to the person responsible for each specific task by the specified deadline. The solutions will be evaluated, and feedback to the participants will be provided; direct contact between responsible persons and participants will aim to resolve potential mistakes. All participants will receive a final report that will contain a detailed analysis of the results of the task in which they contributed. All results will be presented anonymously in that report. Depending on the attention received, the number of participants, and the complexity of problems encountered during the exercise, one or more journal publications co-authored by the task setters and the task solvers may result from the exercise.

The deadline for submitting solutions is 30th September 2018.

General remarks :

- The reference computational phantoms should be used as described in ICRP Publication 110 with the organ and tissue masses given there; separate blood content (not explicitly segmented) should not be added to the organ and tissue masses.
- An exception are the lungs which comprise the following organ identification numbers: 96 (left lung, blood), 97 (left lung, tissue), 98 (right lung, blood), and 99 (right lung, tissue). This definition follows Annexes C and D of ICRP Publication 110.
- For red bone marrow and endosteum (bone surface) dosimetry, the method proposed in ICRP Publication 116 is recommended; i.e., usage of dose response functions or dose enhancement factors. The bone dosimetry method should be stated explicitly, and any bone dosimetry method deviating from ICRP Publication 116 should be explained in detail.
- For many of the tasks, templates will be provided in which the solutions should be filled in a pre-defined format to facilitate the evaluation process.

Co-60 point source exercise

The aim of this exercise is to calculate the organ absorbed doses for RCP-AM and RCP-AF as well as the effective dose for a Co-60 point source.

Source description:

An isotropic Co-60 point source is placed in front of the reference voxel phantom (Fig. 1). The point source is at 125 cm from the bottom of the phantom and at 100 cm from the chest. Only the gamma emission of Co-60 is considered (see Annex 1). The configuration is surrounded by vacuum.

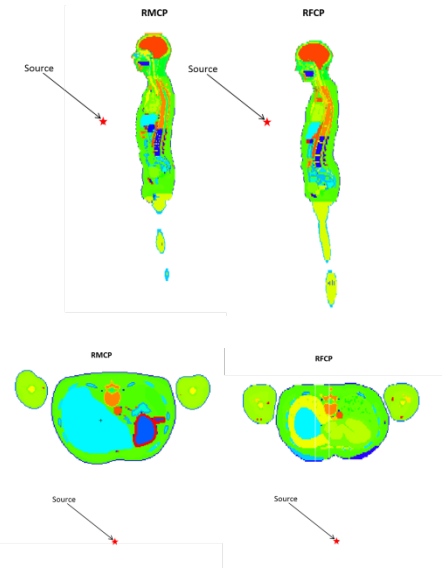


Fig 1. Illustration of the position of the Co-60 point source (not to scale)

Calculations:

- For RCP-AM, calculate the organ absorbed doses for 10 GBq of Co-60 and a 10 minute exposure time for the following organs: red bone marrow, colon, lungs, stomach, breast, gonads, liver, oesophagus, brain and skin.
- For RCP-AF, calculate the organ absorbed doses for 10 GBq of Co-60 and a 10 minute exposure time for the following organs: red bone marrow, colon, lungs, stomach, breast, ovaries, liver, oesophagus, brain and skin.
- Finally, calculate the effective dose (as specified in ICRP 116 and ICRP 103) for 10 GBq of Co-60 and a 10 minute exposure time.

Solutions should be sent to Christelle Huet, IRSN: christelle.huet@irsn.fr

Template to be used: "Template for Co-60pointsource.xlsx"

Neutron point source exercise

The aim of this exercise is to calculate organ absorbed doses for the RCP-AM and RCP-AF, as well as the effective dose, from a neutron source exposure. To simplify the calculations, a highly contrived scenario is considered that features an isotropic point source emitting just monoenergetic neutrons.

Source description:

A neutron point source is placed in front of the reference voxel phantom, located 125 cm from the soles of its feet and 100 cm from the surface of the chest (Fig. 1). The source is assumed to emit 10 keV neutrons isotropically, with an activity of 1 GBq. The configuration is surrounded by vacuum.

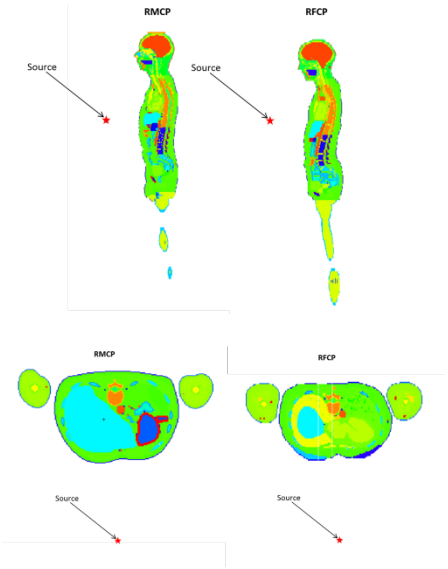


Fig 2. Schematic illustration of the position of the neutron point source relative to the phantom (*not to scale*)

Calculations:

- For the RCP-AM, calculate the organ absorbed doses from a 1 minute exposure for the: red bone marrow, stomach, small intestine, testes, liver, brain and skin.
- For the RCP-AF, calculate the organ absorbed doses from a 1 minute exposure for the: red bone marrow, stomach, small intestine, ovaries, liver, brain and skin.
- Finally, calculate the effective dose from a 1 minute exposure.

Participants should use radiation and tissue weighting factors from ICRP 103, and bone dose enhancement factors from ICRP 116, to calculate the quantities equivalent dose and effective dose.

Solutions should be sent to Jonathan Eakins, PHE: jonathan.eakins@phe.gov.uk

Template to be used: "Template for Neutron Point Source.xlsx"

Am-241 ground contamination exercise

The aim of this exercise is to calculate organ absorbed dose rates for the RCP-AM and RCP-AF, as well as the effective dose rate, for a simplified scenario representing ground contaminated by Am-241.

Geometry description:

For simplicity, the Am-241 is taken to be a monoenergetic source of 60 keV photons. The contamination is assumed to be contained within a disc of radius 2 m, with the anthropomorphic phantom standing at its centre, and is deposited on the surface of the ground only. The photons are emitted isotropically (4π solid angle) from this planar surface. A uniform ground contamination is assumed, with an emission rate of 10^6 photons per cm^2 per second. The ground is concrete of depth 0.5 m, density 2.3 g/cm^3, and composition as defined in Table 1. The configuration is surrounded by vacuum, and is illustrated in Fig. 1.

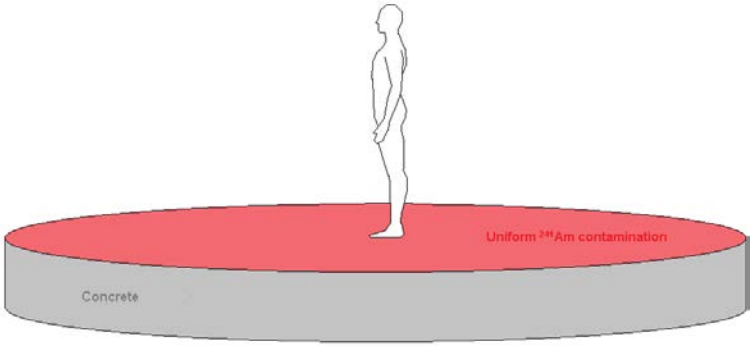


Fig 3. The phantom standing in vacuum on ground surface-contaminated by Am-241

Element (Z)	**1**	**6**	**8**	**11**	**12**
Mass Fraction	0.0221	0.002484	0.57493	0.015208	0.001266
Element (Z)	**13**	**14**	**19**	**20**	**26**
Mass Fraction	0.019953	0.304627	0.010045	0.042952	0.006435

Table 1. Atomic composition of the concrete by mass fraction

Calculations:

- For the RCP-AM, calculate the organ absorbed dose rates to the brain, lungs, small intestine, stomach and red bone marrow.
- For the RCP-AF, calculate the organ absorbed dose rates to the brain, lungs, small intestine, stomach and red bone marrow.
- Finally, calculate the effective dose rate from the contamination.

Participants should state clearly if they have chosen to use any dosimetry methods other than those recommended in ICRP 103 and ICRP 116.

Solutions should be sent to Jonathan Eakins, PHE: jonathan.eakins@phe.gov.uk

Template to be used: "Template for Ground Contamination.xlsx"

Calculation of the equivalent dose in organs and the effective dose due to immersion in a ^{16}N beta source uniformly distributed in air within a room

The aim of this exercise is to calculate the organ equivalent doses for RCP-AM and RCP-AF as well as the effective dose due to the immersion in a uniformly distributed ^{16}N beta source in air.

Source description:

The ICRP Adult Reference Phantom is standing within a 600 × 600 × 400 cm^3 large room with concrete walls, floor and ceiling 50 cm thick. The room is filled with air and the phantom is on the floor at the center of the room.

^{16}N properties[1,2]:

Half-life (s)	Decay mode	Yield	Mean energy (MeV)	Max. energy (MeV)	CSDA range in air for 10.4207 MeV electrons (m)
7.13 s	β^-	1.000	2.75615	10.42070	44.81

The beta energy spectrum is given in Annex 2.

Materials properties and composition[3]:

Material: Air, Dry (near sea level)
Density: 1.205x10^{-3} g/cm^3
Composition (mass fraction):
C: 0.000124
N: 0.755268
O: 0.231781
Ar: 0.012827

Material: Concrete, Ordinary
Density: 2.3 g/cm^3
Composition (mass fraction):
C: 0.002484
O: 0.574930
Na: 0.015208
Mg: 0.001266
Al: 0.019953
Si: 0.304627
K: 0.010045
Ca: 0.042951
Fe: 0.006435

[1] ICRP Publication 107. Nuclear Decay Data for Dosimetric Calculation. Ann ICRP (2008) 38(3) (DECDATA v2.7).

[2] M.J. Berger, J.S. Coursey, M.A. Zucker and J. Chang (2005). ESTAR, PSTAR, and ASTAR: Computer Programs for Calculating Stopping-Power and Range Tables for Electrons, Protons, and Helium Ions (version 1.2.3). [Online] Available: http://physics.nist.gov/Star [2017, January 16th]. National Institute of Standards and Technology, Gaithersburg, MD.

[3] J.H. Hubbell and S.M. Seltzer (2004). Tables of X-Ray Mass Attenuation Coefficients and Mass Energy-Absorption Coefficients (version 1.4). [Online] Available: http://physics.nist.gov/xaamdi [2017, January 16th]. National Institute of Standards and Technology, Gaithersburg, MD.

Reference ICRP materials and composition will be used for the ICRP Adult Reference Phantoms.

Quantities to be calculated:

- Organ equivalent dose rate per activity concentration [in (Sv s^{-1})/(Bq m^{-3})] for the organs identified in both ICRP Adult Reference Phantoms

- Effective dose rate per activity concentration [in (Sv s^{-1})/(Bq m^{-3})]

Solutions should be sent to José María Gómez-Ros, CIEMAT: jm.gomezros@ciemat.es

Template to be used: "Template for N-16 exercise.xlsx"

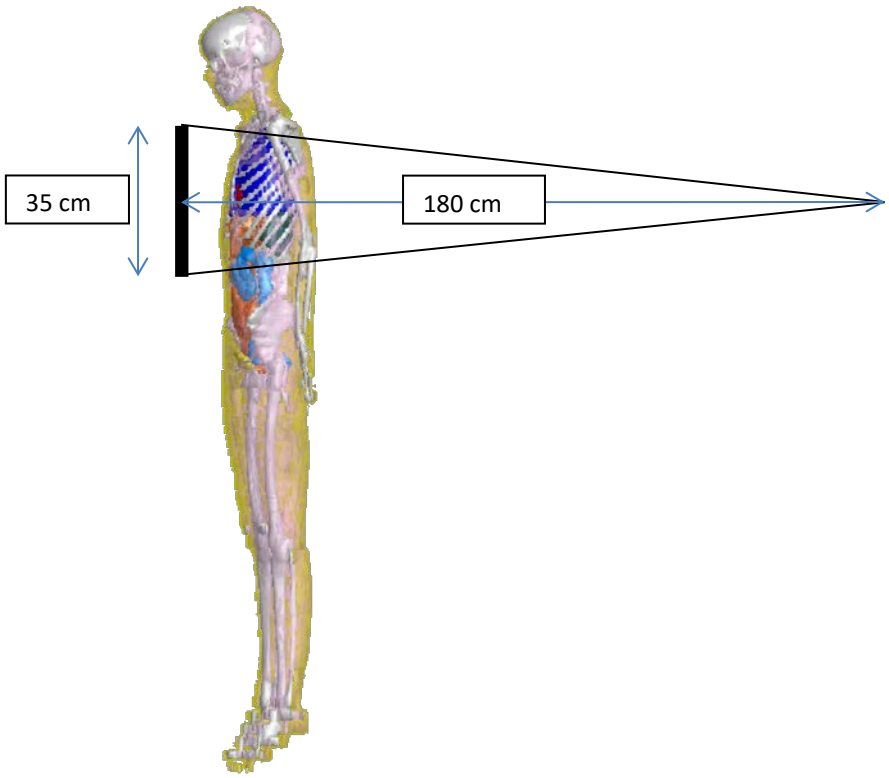
X-ray examinations exercise

The aim of this exercise is to calculate organ absorbed dose conversion coefficients for RCP-AM and RCP-AF for two typical x-ray examinations (chest PA and abdomen AP).

1) Chest PA examination:

Source description:

A divergent rectangular energy-spectral x-ray source (point source) is placed behind the reference voxel phantom and directed towards it, and an imaginary rectangular image receptor is placed in front of the phantom. The distance between the point source and the image receptor (focus-to-detector distance) is 180 cm, and the image receptor is 10 cm away from the exit skin (skin-to-detector distance = 10 cm). The field size at the detector is 35 cm x 35 cm. The field is to be centred in height between the top and bottom extensions and laterally between the left-most and right-most extensions of the phantom's lungs.



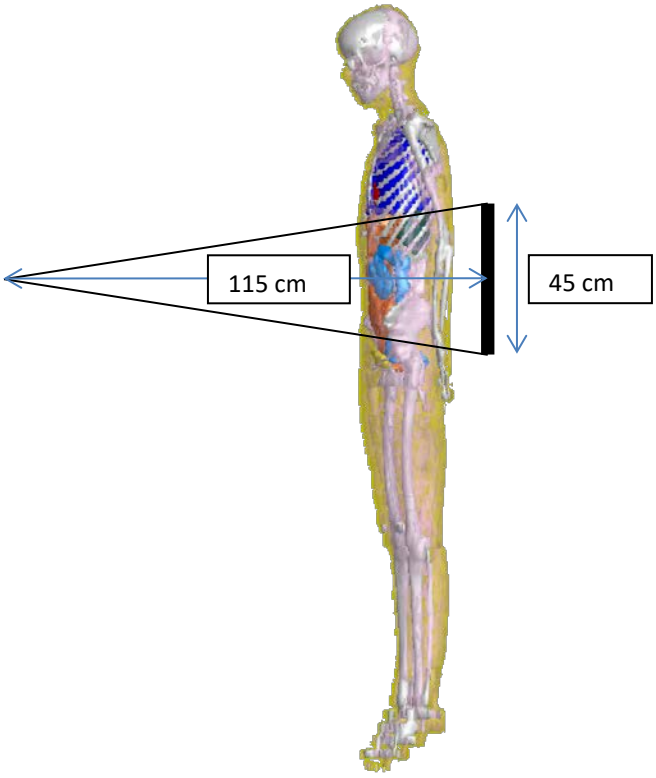
Calculations:

For both phantoms, calculate the organ absorbed doses normalized to (1) entrance air kerma free in air and to (2) kerma-area-product for the following organs: red bone marrow, lungs, stomach, breast, heart, oesophagus, and thyroid.

2) Abdomen AP examination:

Source description:

A divergent rectangular energy-spectral x-ray source (point source) is placed in front of the reference voxel phantom and directed towards it, and an imaginary rectangular image receptor is placed behind the phantom. The distance between the point source and the image receptor (focus-to-detector distance) is 115 cm, and the image receptor is 10 cm away from the exit skin (skin-to-detector distance = 10 cm). The field size at the detector is 35 cm (width) x 45 cm (height). The field is to be centred in height between the top of the liver and the bottom of the pelvic bone and laterally between the left-most and right-most extensions of the phantom's pelvic bone.



Calculations:

For both phantoms, calculate the organ absorbed doses normalized to (1) entrance air kerma free in air and to (2) kerma-area-product for the following organs: red bone marrow, liver, kidneys, pancreas, small intestine, colon, and bladder wall.

The x-ray energy spectra are provided in Annexes 3 and 4, respectively. The phantoms are surrounded by vacuum.

Solutions should be sent to Maria Zankl, HMGU: zankl@helmholtz-muenchen.de

Template to be used: "Template for x-ray examinations.xlsx"

Internal dosimetry exercise

The aim of this exercise is to calculate Absorbed Fractions (AF), Specific Absorbed Fractions (SAF) and S-values for specific source and target organs for RCP-AM and RCP-AF.

1) Monoenergetic photons:

   Source description:

   A volume source of monoenergetic photons is homogeneously distributed in specific organs (source organs) of the RCP-AM and RCP-AF phantoms. The source organs are: liver, thyroid, stomach contents and urinary bladder contents. The photon energies are: 0.01, 0.05, 0.1, 0.2, 0.5, 1.0, and 3.0 MeV.

   Calculations:
   For both phantoms, calculate (1) absorbed fractions and (2) specific absorbed fractions (in kg^{-1}) of the energy released in each source organ for the following "target" organs: liver, thyroid, stomach wall, urinary bladder wall, lungs, and red bone marrow.

2) Monoenergetic electrons:

   Source description:

   A volume source of monoenergetic electrons is homogeneously distributed in specific organs (source organs) of the RCP-AM and RCP-AF phantoms. The source organs are: liver, thyroid, stomach contents and urinary bladder contents. The electron energies are: 0.01, 0.05, 0.1, 0.2, 0.5, 1.0, and 3.0 MeV.

   Calculations:
   For both phantoms, calculate (1) absorbed fractions and (2) specific absorbed fractions (in kg^{-1}) of the energy released in each source organ for the following "target" organs: liver, thyroid, stomach wall, urinary bladder wall, lungs, and red bone marrow.

3) Specific radionuclides:

   Source description:

   A specific radionuclide is homogeneously distributed in specific organs (source organs) of the RCP-AM and RCP-AF phantoms. The source organs are: liver, thyroid, stomach contents and urinary bladder contents. The specific radionuclides are: F-18 and Tc-99m. The decay data are given in Annexes 5 and 6, respectively.

   Calculations:
   For both phantoms, calculate so-called S-values, i.e., the absorbed dose rate per unit activity, (in Gy $(Bq\ s)^{-1}$) of the energy released in each source organ for the following "target" organs: liver, thyroid, stomach wall, urinary bladder wall, lungs, and red bone marrow.

Since this task is rather extensive, also partial solutions are welcome (only one radiation type, or only part of the specified energies, only one or two source regions, …). Solutions should be sent to Maria Zankl, HMGU: zankl@helmholtz-muenchen.de

Template to be used: "Template for internal dosimetry.xlsx"

Annex 1: Co-60 Gamma Spectrum[4]

Photon Energy (MeV)	Yield
0.34714	7.5000E-05
0.82610	7.6000E-05
1.17323	9.9850E-01
1.33249	9.9983E-01
2.15857	1.2000E-05
2.50569	2.0000E-08

[4] ICRP Publication 107. Nuclear Decay Data for Dosimetric Calculation. Ann ICRP (2008) 38(3) (DECDATA v2.7).

Annex 2: N-16 Beta Spectrum[5]

The energy given is the lower energy of each bin.

Electron Energy (MeV)	P(E) (MeV^{-1})
0.000000000000000	0.0168600007892
9.99999974738E-05	0.0168600007892
0.000110000000859	0.0168600007892
0.000119999996969	0.0168600007892
0.000130000000354	0.0168600007892
0.000140000003739	0.0168600007892
0.000150000007125	0.0168600007892
0.000159999995958	0.0168600007892
0.000180000002729	0.0168699994683
0.000199999994948	0.0168699994683
0.000220000001718	0.0168699994683
0.000239999993937	0.0168699994683
0.000260000000708	0.0168699994683
0.000280000007479	0.0168699994683
0.000300000014249	0.0168699994683
0.000319999991916	0.0168699994683
0.000360000005458	0.0168699994683
0.000399999989895	0.0168699994683
0.000449999992270	0.0168699994683
0.000500000023749	0.0168699994683
0.000549999997020	0.0168699994683
0.000600000028498	0.0168800000101
0.000650000001770	0.0168800000101
0.000699999975041	0.0168800000101
0.000750000006519	0.0168800000101
0.000799999979790	0.0168900005519
0.000850000011269	0.0168900005519
0.00089999998454	0.0168900005519
0.00100000004750	0.0168999992311
0.00109999999404	0.0168999992311
0.00120000005700	0.0169099997729
0.00130000000354	0.0169300008565
0.00139999995008	0.0169399995357
0.00150000001304	0.0169500000775
0.00159999995958	0.0169699992985
0.00179999996908	0.0170099996030
0.00200000009499	0.0170600004494
0.00219999998808	0.0171199999750
0.00240000011399	0.0171799995005
0.00260000000708	0.0172400008887
0.00279999990016	0.0173099990934

[5] ICRP Publication 107. Nuclear Decay Data for Dosimetric Calculation. Ann ICRP (2008) 38(3) (DECDATA v2.7).

0.00300000002608	0.0173799991608
0.00319999991916	0.0174599997699
0.00359999993816	0.0176100004464
0.00400000018999	0.0177699998021
0.00449999980628	0.0179800000042
0.00499999988824	0.0181900002062
0.00549999997020	0.0184000004083
0.00600000005215	0.0186100006104
0.00650000013411	0.0188299994916
0.00700000021607	0.0190399996936
0.00749999983236	0.0192499998957
0.00800000037998	0.0194600000978
0.00850000046194	0.0196700002998
0.00899999961257	0.0198699999601
0.00999999977648	0.0202799998224
0.01099999994040	0.0206799991429
0.01200000010430	0.0210800003260
0.01300000026820	0.0214699991047
0.01400000043210	0.0218499992043
0.01499999966470	0.0222200006247
0.01600000076000	0.0225900001824
0.01799999922510	0.0233200006187
0.01999999955300	0.0240199994296
0.02199999988080	0.0247099995613
0.02400000020860	0.0253800004721
0.02600000053640	0.0260400008410
0.02800000086430	0.0266900006682
0.02999999932940	0.0273199994117
0.03200000151990	0.0279399994761
0.03599999845030	0.0291600003839
0.03999999910590	0.0303499996662
0.04500000178810	0.0317899994552
0.05000000074510	0.0331999994814
0.05499999970200	0.0345799997449
0.05999999865890	0.0359399989247
0.06499999761580	0.0372699983418
0.07000000029800	0.0385800004005
0.07500000298020	0.0398800000548
0.07999999821190	0.0411599986255
0.08500000089410	0.0424299985170
0.09000000357630	0.0436899997294
0.10000000149000	0.0461799986660
0.10999999940400	0.0486400015652
0.11999999731800	0.0510700009763
0.12999999523200	0.0534900017083
0.14000000059600	0.0558799989522
0.15000000596000	0.0582699999213
0.15999999642400	0.0606399998069
0.18000000715300	0.0653600022197
0.20000000298000	0.0700500011444
0.21999999880800	0.0747200027108
0.23999999463600	0.0793799981475

0.25999999046300	0.0840200036764
0.28000000119200	0.0886500030756
0.30000001192100	0.0932800024748
0.31999999284700	0.0978899970651
0.36000001430500	0.1071000024680
0.40000000596000	0.1162000000480
0.44999998807900	0.1274999976160
0.50000000000000	0.1386999934910
0.55000001192100	0.1495999991890
0.60000002384200	0.1604000031950
0.64999997615800	0.1709000021220
0.69999998807900	0.1811999976630
0.75000000000000	0.1912000030280
0.80000001192100	0.2008000016210
0.85000002384200	0.2100999951360
0.89999997615800	0.2190999984740
1.00000000000000	0.2358999997380
1.10000002384000	0.2509999871250
1.20000004768000	0.2646000087260
1.29999995232000	0.2766000032420
1.39999997616000	0.2869000136850
1.50000000000000	0.2958999872210
1.60000002384000	0.3034000098710
1.79999995232000	0.3122999966140
2.00000000000000	0.3125000000000
2.20000004768000	0.3041999936100
2.40000009537000	0.2879999876020
2.59999990463000	0.2649999856950
2.79999995232000	0.2363000065090
3.00000000000000	0.2039999961850
3.20000004768000	0.1699000000950
3.59999990463000	0.1045999974010
4.00000000000000	0.0548299998045
4.50000000000000	0.0419699996710
5.00000000000000	0.0422499999404
5.50000000000000	0.0418200008571
6.00000000000000	0.0406400002539
6.50000000000000	0.0386100001633
7.00000000000000	0.0355999991298
7.50000000000000	0.0315099991858
8.00000000000000	0.0263100005686
8.50000000000000	0.0201299991459
9.00000000000000	0.0133600002155
10.0000000000000	0.00171099998988
10.4207000732000	0.

Annex 3: X-ray spectrum 125 kV (chest radiograph)
The energy given is the middle energy of each bin.

Photon Energy (MeV)	Probability
0.014	0.00002
0.015	0.00007
0.016	0.00019
0.017	0.00042
0.018	0.00081
0.019	0.00139
0.020	0.00216
0.021	0.00310
0.022	0.00421
0.023	0.00545
0.024	0.00679
0.025	0.00819
0.026	0.00959
0.027	0.01097
0.028	0.01228
0.029	0.01351
0.030	0.01463
0.031	0.01548
0.032	0.01624
0.033	0.01687
0.034	0.01740
0.035	0.01782
0.036	0.01815
0.037	0.01838
0.038	0.01854
0.039	0.01861
0.040	0.01863
0.041	0.01852
0.042	0.01836
0.043	0.01817
0.044	0.01794
0.045	0.01770
0.046	0.01744
0.047	0.01715
0.048	0.01685
0.049	0.01655
0.050	0.01623
0.051	0.01588
0.052	0.01553
0.053	0.01519
0.054	0.01483
0.055	0.01449
0.056	0.01414
0.057	0.01381

0.058	0.04005
0.059	0.06016
0.060	0.01283
0.061	0.01250
0.062	0.01217
0.063	0.01186
0.064	0.01154
0.065	0.01125
0.066	0.01095
0.067	0.02715
0.068	0.01038
0.069	0.01450
0.070	0.00810
0.071	0.00761
0.072	0.00748
0.073	0.00735
0.074	0.00722
0.075	0.00709
0.076	0.00695
0.077	0.00681
0.078	0.00667
0.079	0.00654
0.080	0.00639
0.081	0.00625
0.082	0.00610
0.083	0.00596
0.084	0.00582
0.085	0.00566
0.086	0.00552
0.087	0.00537
0.088	0.00523
0.089	0.00508
0.090	0.00493
0.091	0.00478
0.092	0.00464
0.093	0.00449
0.094	0.00434
0.095	0.00420
0.096	0.00405
0.097	0.00390
0.098	0.00376
0.099	0.00361
0.100	0.00347
0.101	0.00332
0.102	0.00317
0.103	0.00303
0.104	0.00288
0.105	0.00274
0.106	0.00259
0.107	0.00245
0.108	0.00231
0.109	0.00217

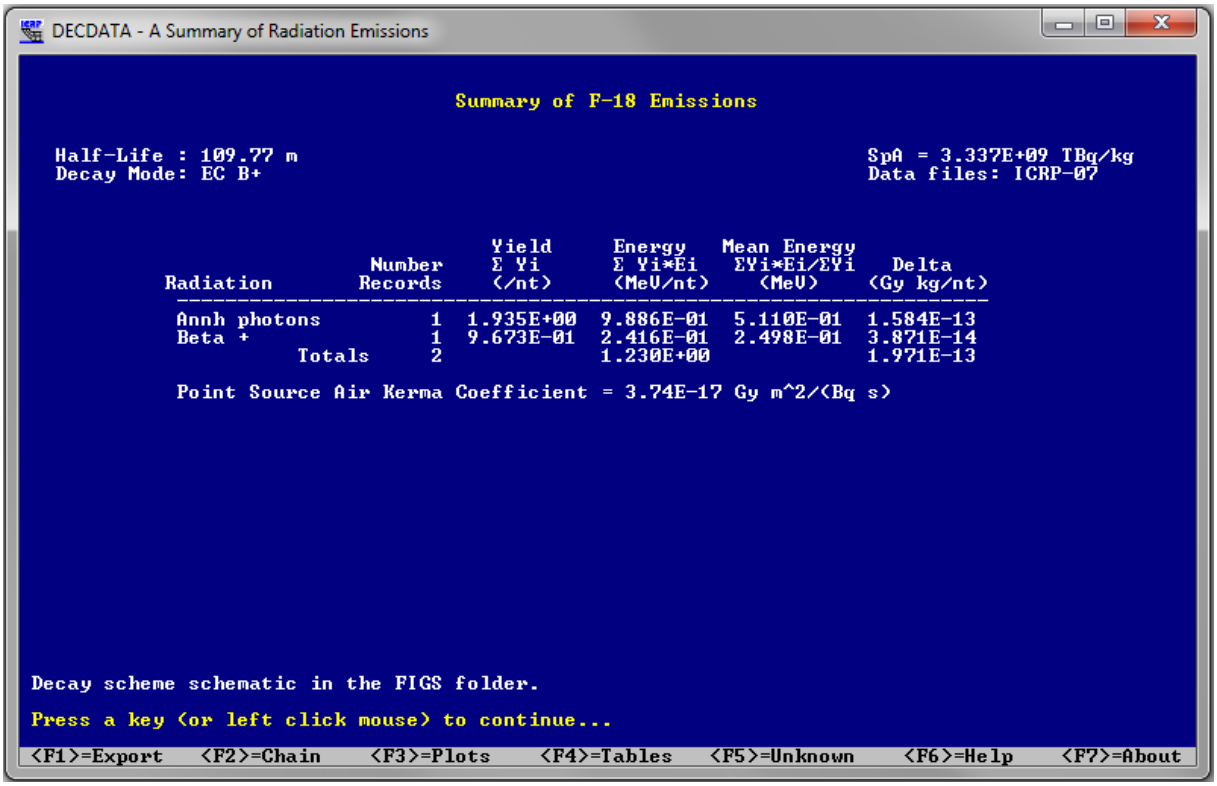
0.110	0.00202
0.111	0.00189
0.112	0.00174
0.113	0.00161
0.114	0.00146
0.115	0.00133
0.116	0.00119
0.117	0.00106
0.118	0.00092
0.119	0.00078
0.120	0.00066
0.121	0.00052
0.122	0.00038
0.123	0.00026
0.124	0.00002
0.125	0.00011

Annex 4: X-ray spectrum 90 kV (abdomen radiograph)
The energy given is the middle energy of each bin.

Photon Energy (MeV)	Probability
0.014	0.00005
0.015	0.00017
0.016	0.00045
0.017	0.00099
0.018	0.00187
0.019	0.00313
0.020	0.00474
0.021	0.00658
0.022	0.00861
0.023	0.01075
0.024	0.01291
0.025	0.01500
0.026	0.01696
0.027	0.01875
0.028	0.02035
0.029	0.02171
0.030	0.02287
0.031	0.02359
0.032	0.02414
0.033	0.02454
0.034	0.02478
0.035	0.02491
0.036	0.02491
0.037	0.02481
0.038	0.02465
0.039	0.02440
0.040	0.02408
0.041	0.02364
0.042	0.02316
0.043	0.02266
0.044	0.02214
0.045	0.02161
0.046	0.02107
0.047	0.02053
0.048	0.01997
0.049	0.01942
0.050	0.01886
0.051	0.01828
0.052	0.01770
0.053	0.01713
0.054	0.01657
0.055	0.01600
0.056	0.01546
0.057	0.01491

0.058	0.02607
0.059	0.03435
0.060	0.01333
0.061	0.01280
0.062	0.01227
0.063	0.01176
0.064	0.01125
0.065	0.01076
0.066	0.01026
0.067	0.01669
0.068	0.00930
0.069	0.01065
0.070	0.00781
0.071	0.00732
0.072	0.00694
0.073	0.00655
0.074	0.00617
0.075	0.00578
0.076	0.00539
0.077	0.00500
0.078	0.00461
0.079	0.00422
0.080	0.00384
0.081	0.00343
0.082	0.00305
0.083	0.00266
0.084	0.00228
0.085	0.00188
0.086	0.00151
0.087	0.00112
0.088	0.00075
0.089	0.00037
0.090	0.00002

Annex 5: F-18 Decay Data[6]



Beta+ spectrum (DECDATA)

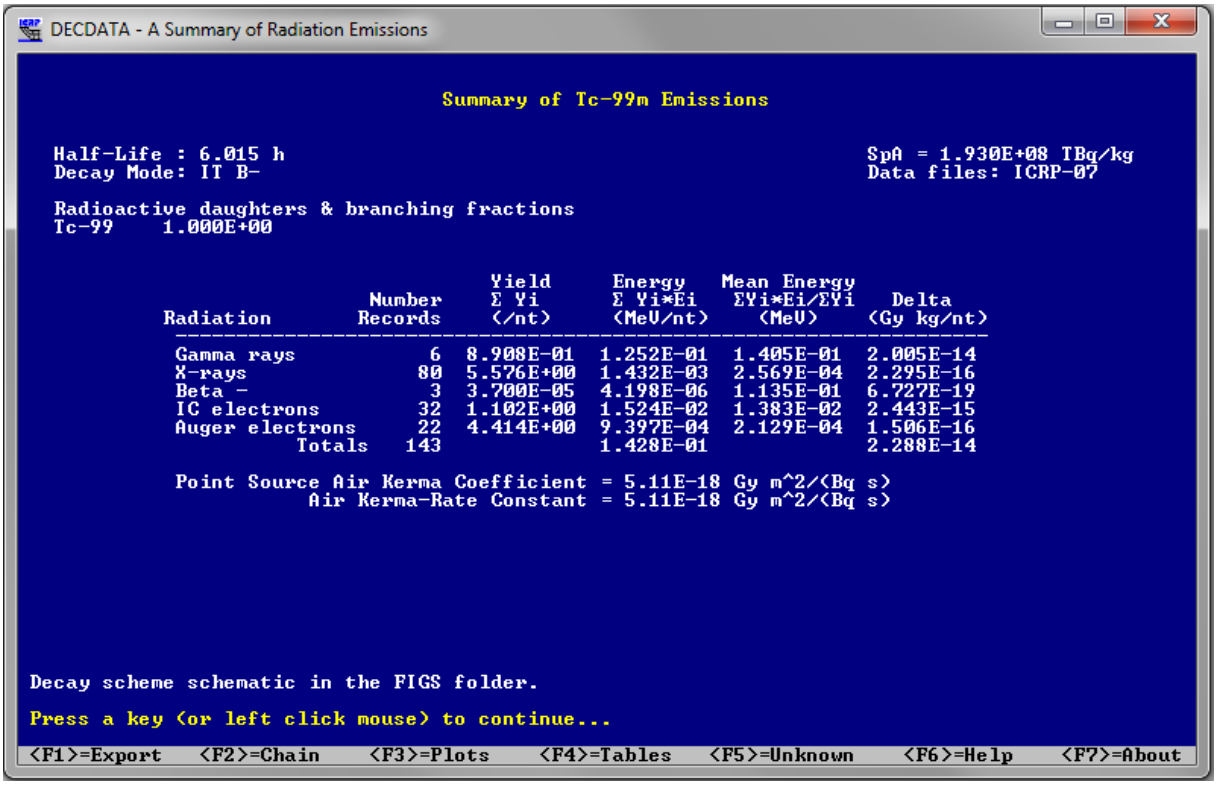
E(MeV)	P(E) dE
0.00000	0.000E+00
0.00010	1.781E-08
0.00011	4.220E-08
0.00012	8.955E-08
0.00013	1.739E-07
0.00014	3.142E-07
0.00015	5.345E-07
0.00016	8.643E-07
0.00018	1.998E-06
0.00020	4.060E-06
0.00022	7.472E-06
0.00024	1.272E-05
0.00026	2.034E-05
0.00028	3.090E-05
0.00030	4.499E-05
0.00032	6.322E-05
0.00036	1.145E-04
0.00040	1.893E-04
0.00045	3.230E-04
0.00050	5.090E-04
0.00055	7.551E-04
0.00060	1.068E-03
0.00065	1.455E-03

[6] ICRP Publication 107. Nuclear Decay Data for Dosimetric Calculation. Ann ICRP (2008) 38(3) (DECDATA v2.7).

0.00070 1.920E-03
0.00075 2.468E-03
0.00080 3.102E-03
0.00085 3.824E-03
0.00090 4.634E-03
0.00100 6.518E-03
0.00110 8.743E-03
0.00120 1.129E-02
0.00130 1.412E-02
0.00140 1.722E-02
0.00150 2.055E-02
0.00160 2.409E-02
0.00180 3.167E-02
0.00200 3.977E-02
0.00220 4.827E-02
0.00240 5.705E-02
0.00260 6.603E-02
0.00280 7.515E-02
0.00300 8.436E-02
0.00320 9.363E-02
0.00360 1.123E-01
0.00400 1.309E-01
0.00450 1.540E-01
0.00500 1.769E-01
0.00550 1.995E-01
0.00600 2.218E-01
0.00650 2.438E-01
0.00700 2.655E-01
0.00750 2.868E-01
0.00800 3.078E-01
0.00850 3.285E-01
0.00900 3.488E-01
0.01000 3.887E-01
0.01100 4.274E-01
0.01200 4.650E-01
0.01300 5.016E-01
0.01400 5.372E-01
0.01500 5.720E-01
0.01600 6.059E-01
0.01800 6.713E-01
0.02000 7.338E-01
0.02200 7.937E-01
0.02400 8.513E-01
0.02600 9.066E-01
0.02800 9.599E-01
0.03000 1.011E+00
0.03200 1.061E+00
0.03600 1.156E+00
0.04000 1.245E+00
0.04500 1.349E+00
0.05000 1.446E+00
0.05500 1.537E+00
0.06000 1.622E+00
0.06500 1.702E+00
0.07000 1.777E+00
0.07500 1.848E+00

0.08000 1.914E+00
0.08500 1.976E+00
0.09000 2.035E+00
0.10000 2.142E+00
0.11000 2.236E+00
0.12000 2.318E+00
0.13000 2.389E+00
0.14000 2.449E+00
0.15000 2.499E+00
0.16000 2.540E+00
0.18000 2.594E+00
0.20000 2.616E+00
0.22000 2.607E+00
0.24000 2.570E+00
0.26000 2.507E+00
0.28000 2.421E+00
0.30000 2.314E+00
0.32000 2.188E+00
0.36000 1.891E+00
0.40000 1.549E+00
0.45000 1.094E+00
0.50000 6.557E-01
0.55000 2.879E-01
0.60000 5.162E-02
0.63350 0.000E+00

Annex 6: Tc-99m Decay Data[7]




```
Output File OutPut\Tc-99m.RAD for Tc-99m
Tc-99m       6.015h       143
T1/2 = 6.015h Decay Mode: ITB-
Radiations of each type listed in increasing energy
Number of photon radiations: 86
Number of beta radiations: 3
Number of monoenergetic electron radiations: 54
ICODE  Y (/nt) E(MeV) Mnemonic
START RADIATION RECORDS
 2 5.49690E+00 7.87678E-06  X
 2 1.34360E-04 8.90978E-06  X
 2 9.07474E-06 3.31522E-05  X
 2 2.95618E-10 3.63497E-05  X
 2 2.19455E-10 1.20300E-04  X
 2 3.93222E-14 1.33100E-04  X
 2 2.90440E-07 2.24500E-04  X
 2 3.27065E-11 2.32100E-04  X
 2 6.90809E-04 2.53797E-04  X
 2 1.71356E-08 2.77874E-04  X
 2 1.93175E-06 3.44800E-04  X
 2 2.27624E-10 3.65200E-04  X
 2 3.90368E-04 2.14418E-03  X
 1 6.65489E-11 2.17260E-03  G
 2 1.69925E-06 2.23236E-03  X
 2 1.61107E-06 2.25265E-03  X
 2 1.04684E-04 2.26447E-03  X
```

[7] ICRP Publication 107. Nuclear Decay Data for Dosimetric Calculation. Ann ICRP (2008) 38(3) (DECDATA v2.7).

```
2 5.50352E-08 2.26467E-03  X
2 2.45387E-10 2.35665E-03  X
2 1.07173E-06 2.37296E-03  X
2 2.32221E-10 2.37941E-03  X
2 1.54869E-08 2.39778E-03  X
2 2.75184E-04 2.41059E-03  X
2 2.44299E-03 2.41453E-03  X
2 1.65365E-10 2.51250E-03  X
2 1.15088E-03 2.53088E-03  X
2 4.03225E-08 2.54417E-03  X
2 3.57799E-07 2.54865E-03  X
2 4.52904E-05 2.57716E-03  X
2 7.74132E-05 2.59745E-03  X
2 2.08567E-05 2.60175E-03  X
2 5.98209E-08 2.62800E-03  X
2 5.71273E-08 2.63105E-03  X
2 1.22192E-05 2.66952E-03  X
2 1.07818E-04 2.66984E-03  X
2 1.80436E-07 2.67727E-03  X
2 5.68732E-09 2.72184E-03  X
2 8.82499E-06 2.72205E-03  X
2 9.66017E-09 2.74460E-03  X
2 4.94423E-08 2.75134E-03  X
2 4.10851E-07 2.75539E-03  X
2 3.09230E-09 2.75656E-03  X
2 6.12413E-07 2.75933E-03  X
2 9.48772E-12 2.78451E-03  X
2 9.05156E-12 2.78804E-03  X
2 5.17415E-05 2.78982E-03  X
2 2.23765E-09 2.82955E-03  X
2 1.97421E-08 2.82992E-03  X
2 1.38898E-09 2.88966E-03  X
2 5.43540E-11 2.90937E-03  X
2 8.10029E-11 2.91385E-03  X
2 8.39363E-12 2.92114E-03  X
2 1.01425E-08 2.96264E-03  X
2 7.31257E-06 2.97280E-03  X
2 1.26121E-05 2.97585E-03  X
2 1.62259E-08 3.01433E-03  X
2 2.41385E-08 3.01462E-03  X
2 9.46856E-10 3.14970E-03  X
2 1.62341E-09 3.15323E-03  X
2 2.66490E-12 3.19474E-03  X
2 3.96784E-12 3.19511E-03  X
2 2.13522E-02 1.82141E-02  X
2 4.05945E-02 1.83344E-02  X
2 2.78672E-06 1.91152E-02  X
2 5.28700E-06 1.92483E-02  X
2 3.35728E-03 2.05668E-02  X
2 6.53385E-03 2.05871E-02  X
2 1.75138E-05 2.07450E-02  X
2 2.47192E-05 2.07489E-02  X
2 6.47724E-04 2.09624E-02  X
2 1.24477E-03 2.09655E-02  X
2 9.26637E-07 2.10040E-02  X
2 1.29314E-06 2.10042E-02  X
```

```
2 4.43641E-07 2.16049E-02  X
2 8.62826E-07 2.16277E-02  X
2 2.47831E-09 2.17925E-02  X
2 3.48692E-09 2.17969E-02  X
2 8.68846E-08 2.20328E-02  X
2 1.67276E-07 2.20364E-02  X
2 1.65139E-10 2.20778E-02  X
2 2.29722E-10 2.20782E-02  X
1 1.03629E-05 8.96000E-02  G
1 8.90567E-01 1.40511E-01  G
1 1.87019E-04 1.42630E-01  G
1 8.51000E-08 2.32800E-01  G
1 9.69400E-07 3.22400E-01  G
5 1.07767E-06 3.01202E-02 B-
5 2.59439E-05 1.02026E-01 B-
5 9.97843E-06 1.52232E-01 B-
7 2.46630E+00 2.96081E-05 AE
7 5.56845E-05 3.14686E-05 AE
7 2.07457E-02 1.06317E-04 AE
7 2.48421E-06 1.06836E-04 AE
7 7.08794E-01 1.14154E-04 AE
7 1.26607E-05 1.14712E-04 AE
7 1.08359E+00 2.06128E-04 AE
7 3.08584E-05 2.31830E-04 AE
7 8.95782E-03 2.46278E-04 AE
7 2.26426E-07 2.76769E-04 AE
6 8.62476E-01 1.74765E-03 IE
7 9.03225E-02 2.05392E-03 AE
7 1.21851E-05 2.15893E-03 AE
6 1.29615E-01 2.17260E-03 IE
7 1.40669E-02 2.33269E-03 AE
7 2.07551E-06 2.46807E-03 AE
7 6.35225E-04 2.64192E-03 AE
7 9.94305E-08 2.80378E-03 AE
7 1.47888E-02 1.54229E-02 AE
7 1.75768E-06 1.61570E-02 AE
7 5.58618E-03 1.78238E-02 AE
7 6.76249E-07 1.86981E-02 AE
7 5.08802E-04 2.02270E-02 AE
7 6.27073E-08 2.12417E-02 AE
6 1.21193E-05 6.75130E-02 IE
6 1.12588E-06 8.63961E-02 IE
6 7.30025E-07 8.66282E-02 IE
6 9.41100E-07 8.67613E-02 IE
6 5.29713E-07 8.91407E-02 IE
6 9.09894E-08 8.96000E-02 IE
6 8.91611E-02 1.19499E-01 IE
6 5.49755E-03 1.21618E-01 IE
6 9.89088E-03 1.37489E-01 IE
6 6.45845E-04 1.37713E-01 IE
6 3.37337E-04 1.37833E-01 IE
6 9.47718E-04 1.39608E-01 IE
6 1.97803E-04 1.39832E-01 IE
6 6.08417E-04 1.39952E-01 IE
6 1.99386E-03 1.40086E-01 IE
6 3.80172E-04 1.40511E-01 IE
```

```
 6 3.48073E-04 1.42205E-01 IE
 6 6.18371E-05 1.42630E-01 IE
 6 3.56835E-09 2.10713E-01 IE
 6 3.99451E-10 2.29596E-01 IE
 6 1.78907E-11 2.29828E-01 IE
 6 5.74493E-12 2.29961E-01 IE
 6 7.83144E-11 2.32341E-01 IE
 6 1.50450E-11 2.32800E-01 IE
 6 1.44207E-08 3.00313E-01 IE
 6 1.60478E-09 3.19196E-01 IE
 6 6.19962E-11 3.19428E-01 IE
 6 2.07627E-11 3.19561E-01 IE
 6 3.11662E-10 3.21941E-01 IE
 6 5.99387E-11 3.22400E-01 IE
END RADIATION RECORDS


Output File OutPut\Tc-99m.BET for Tc-99m
Tc-99m        100
Beta Spectrum for Tc-99m
Number of energy points: 100
E(MeV)  P(E) dE
START RADIATION RECORDS
0.00000 2.319E-04
0.00010 2.318E-04
0.00011 2.318E-04
0.00012 2.318E-04
0.00013 2.318E-04
0.00014 2.318E-04
0.00015 2.317E-04
0.00016 2.317E-04
0.00018 2.317E-04
0.00020 2.317E-04
0.00022 2.317E-04
0.00024 2.316E-04
0.00026 2.316E-04
0.00028 2.316E-04
0.00030 2.315E-04
0.00032 2.315E-04
0.00036 2.315E-04
0.00040 2.314E-04
0.00045 2.314E-04
0.00050 2.313E-04
0.00055 2.312E-04
0.00060 2.312E-04
0.00065 2.311E-04
0.00070 2.310E-04
0.00075 2.310E-04
0.00080 2.309E-04
0.00085 2.308E-04
0.00090 2.308E-04
0.00100 2.306E-04
0.00110 2.305E-04
0.00120 2.304E-04
0.00130 2.302E-04
0.00140 2.301E-04
```

0.00150 2.300E-04
0.00160 2.299E-04
0.00180 2.296E-04
0.00200 2.293E-04
0.00220 2.291E-04
0.00240 2.288E-04
0.00260 2.286E-04
0.00280 2.283E-04
0.00300 2.280E-04
0.00320 2.278E-04
0.00360 2.273E-04
0.00400 2.267E-04
0.00450 2.261E-04
0.00500 2.255E-04
0.00550 2.248E-04
0.00600 2.242E-04
0.00650 2.235E-04
0.00700 2.231E-04
0.00750 2.227E-04
0.00800 2.223E-04
0.00850 2.219E-04
0.00900 2.215E-04
0.01000 2.207E-04
0.01100 2.198E-04
0.01200 2.190E-04
0.01300 2.182E-04
0.01400 2.174E-04
0.01500 2.166E-04
0.01600 2.157E-04
0.01800 2.141E-04
0.02000 2.124E-04
0.02200 2.108E-04
0.02400 2.091E-04
0.02600 2.075E-04
0.02800 2.059E-04
0.03000 2.042E-04
0.03200 2.026E-04
0.03600 1.994E-04
0.04000 1.962E-04
0.04500 1.922E-04
0.05000 1.883E-04
0.05500 1.844E-04
0.06000 1.805E-04
0.06500 1.767E-04
0.07000 1.729E-04
0.07500 1.692E-04
0.08000 1.655E-04
0.08500 1.619E-04
0.09000 1.583E-04
0.10000 1.514E-04
0.11000 1.448E-04
0.12000 1.385E-04
0.13000 1.321E-04
0.14000 1.255E-04
0.15000 1.188E-04
0.16000 1.121E-04

0.18000 9.831E-05
0.20000 8.447E-05
0.22000 7.080E-05
0.24000 5.757E-05
0.26000 4.509E-05
0.28000 3.371E-05
0.30000 2.384E-05
0.32000 1.590E-05
0.36000 7.143E-06
0.40000 1.990E-06
0.43618 0.000E+00
END RADIATION RECORDS

Output File OutPut\Tc-99m.ACK for Tc-99m
Tc-99m 968
Auger/Coster-Kronig Spectrum for Tc-99m
Number of electrons: 968
START RADIATION RECORDS

Y(/nt)	E(eV)	transition
6.57103E-05	3.34000E+00	M1 M4 M5
1.66012E-04	7.28000E+00	M1 M5 M5
7.71672E-08	9.83000E+00	M1 M2 N1
3.19642E-03	1.22200E+01	M2 M3 N4
6.44567E-04	1.23300E+01	M1 M2 N1
7.26819E-03	1.25100E+01	M2 M3 N5
5.69309E-08	1.36200E+01	M2 M3 N4
1.33075E-07	1.39800E+01	M2 M3 N5
8.01605E-04	1.41000E+01	M2 M3 O1
1.16677E-08	1.63900E+01	M2 M3 O1
3.64637E-02	1.81800E+01	N1 N2 N4
1.20735E-01	1.84700E+01	N1 N2 N5
8.44103E-07	1.88000E+01	N1 N2 N4
2.75618E-06	1.91600E+01	N1 N2 N5
4.33710E-03	2.00600E+01	N1 N2 O1
1.70751E-01	2.12300E+01	N1 N3 N4
1.77705E-01	2.15200E+01	N1 N3 N5
8.25057E-08	2.15700E+01	N1 N2 O1
4.14734E-06	2.23300E+01	N1 N3 N4
4.25936E-06	2.26900E+01	N1 N3 N5
7.38855E-03	2.31100E+01	N1 N3 O1
1.39621E-07	2.51000E+01	N1 N3 O1
2.48268E-02	3.04100E+01	N3 N4 N4
7.71772E-01	3.07000E+01	N3 N4 N5
4.48773E-01	3.09900E+01	N3 N5 N5
4.83879E-03	3.22900E+01	N3 N4 O1
6.05392E-07	3.23600E+01	N3 N4 N4
2.19930E-02	3.25800E+01	N3 N5 O1
1.26610E-07	3.26000E+01	M1 M3 N1
1.09070E-03	3.26200E+01	M1 M3 N1
1.72171E-05	3.27200E+01	N3 N4 N5
1.03275E-05	3.30800E+01	N3 N5 N5
8.67963E-02	3.34600E+01	N2 N4 N4
5.47870E-01	3.37500E+01	N2 N4 N5
1.69189E-02	3.40400E+01	N2 N5 N5
7.74675E-08	3.51300E+01	N3 N4 O1
1.03726E-02	3.53400E+01	N2 N4 O1

3.53490E-07 3.54900E+01 N3 N5 O1
1.41148E-03 3.56300E+01 N2 N5 O1
2.06613E-06 3.58900E+01 N2 N4 N4
1.18775E-05 3.62500E+01 N2 N4 N5
3.83803E-07 3.66100E+01 N2 N5 N5
7.52159E-08 3.77800E+01 M1 M2 N2
6.24008E-04 3.85800E+01 M1 M2 N2
1.67248E-07 3.86600E+01 N2 N4 O1
2.06990E-08 3.90200E+01 N2 N5 O1
1.49963E-07 4.13100E+01 M1 M2 N3
1.26295E-03 4.16300E+01 M1 M2 N3
5.60674E-04 4.44500E+01 L2 L3 N1
7.70236E-08 5.09600E+01 L2 L3 N1
1.15823E-03 5.88700E+01 M1 M3 N2
1.73056E-04 5.97100E+01 N1 N4 N4
8.05447E-03 6.00000E+01 N1 N4 N5
2.43539E-03 6.02900E+01 N1 N5 N5
1.36126E-07 6.05500E+01 M1 M3 N2
9.66986E-04 6.15900E+01 N1 N4 O1
1.71864E-03 6.18800E+01 N1 N5 O1
1.88302E-03 6.19200E+01 M1 M3 N3
5.41500E-09 6.38400E+01 N1 N4 N4
2.20612E-07 6.40800E+01 M1 M3 N3
2.23681E-07 6.42000E+01 N1 N4 N5
6.94497E-08 6.45600E+01 N1 N5 N5
2.21746E-08 6.66100E+01 N1 N4 O1
3.81888E-08 6.69700E+01 N1 N5 O1
5.75857E-07 7.06700E+01 L1 L3 M4
1.87520E-03 7.07000E+01 L2 L3 N2
6.99654E-04 7.37500E+01 L2 L3 N3
8.40121E-07 7.51500E+01 L1 L3 M5
5.30407E-03 7.77900E+01 L1 L3 M4
2.67454E-07 7.89100E+01 L2 L3 N2
2.48141E-04 8.01100E+01 M1 M2 N4
3.15441E-04 8.04000E+01 M1 M2 N5
7.62707E-03 8.17300E+01 L1 L3 M5
2.35918E-05 8.19900E+01 M1 M2 O1
1.56357E-02 8.20900E+01 M3 M4 N1
9.93225E-08 8.24400E+01 L2 L3 N3
2.67059E-07 8.26200E+01 M3 M4 N1
3.85161E-08 8.28200E+01 M1 M2 N4
4.96261E-08 8.31800E+01 M1 M2 N5
2.70457E-09 8.55900E+01 M1 M2 O1
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2.66742E-04 1.00400E+02 M1 M3 N4
4.07473E-04 1.00690E+02 M1 M3 N5
3.86924E-05 1.02280E+02 M1 M3 O1
4.23479E-02 1.02380E+02 M2 M4 N1
6.31533E-07 1.05390E+02 M2 M4 N1
4.04970E-08 1.05590E+02 M1 M3 N4
6.13428E-08 1.05950E+02 M1 M3 N5
7.06726E-03 1.06320E+02 M2 M5 N1
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1.06381E-07 1.09870E+02 M2 M5 N1

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4.05917E-04 1.12520E+02 L2 L3 N5
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6.94205E-08 1.24310E+02 L2 L3 N5
1.35997E-07 1.25770E+02 M5 N1 N1
3.35258E-09 1.26720E+02 L2 L3 O1
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7.12755E-08 1.30250E+02 M4 N1 N1
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6.84403E-07 5.17280E+02 M1 N4 N4
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1.39090E-06 5.17860E+02 M1 N5 N5
4.06231E-06 5.19160E+02 M1 N4 O1
5.89473E-06 5.19450E+02 M1 N5 O1
1.38169E-10 5.55730E+02 M1 N4 N4
2.81439E-10 5.56090E+02 M1 N4 N5
2.73756E-10 5.56450E+02 M1 N5 N5
5.85919E-10 5.58500E+02 M1 N4 O1
8.46888E-10 5.58860E+02 M1 N5 O1
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4.77233E-05 1.73106E+03 L2 M1 M1
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4.59891E-03 1.80741E+03 L3 M2 M3
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4.88769E-09 1.87458E+03 L3 M2 M2
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6.08719E-07 1.89735E+03 L3 M2 M3
9.87921E-04 1.90742E+03 L2 M2 M2
1.46283E-07 1.91571E+03 L2 M1 M2
8.74399E-07 1.92012E+03 L3 M3 M3
3.23592E-03 1.92771E+03 L2 M2 M3
1.38942E-08 1.93848E+03 L2 M1 M3
8.73021E-05 1.94800E+03 L2 M3 M3
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9.82254E-03 1.98958E+03 L3 M3 M5
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4.57674E-07 2.03045E+03 L2 M2 M3
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2.53883E-03 1.53120E+04  K L1 L3
2.58896E-04 1.54162E+04  K L2 L2
5.75865E-03 1.55365E+04  K L2 L3
3.02623E-03 1.56568E+04  K L3 L3
1.80794E-07 1.56792E+04  K L1 L1
2.06117E-07 1.59113E+04  K L1 L2
3.01756E-07 1.60444E+04  K L1 L3
3.07753E-08 1.61434E+04  K L2 L2
6.81593E-07 1.62765E+04  K L2 L3
3.56635E-07 1.64096E+04  K L3 L3
4.89740E-04 1.74562E+04  K L1 M1
2.91053E-04 1.75444E+04  K L1 M2
4.32359E-04 1.75647E+04  K L1 M3
2.30785E-04 1.76807E+04  K L2 M1
2.41919E-05 1.77226E+04  K L1 M4
2.94379E-05 1.77265E+04  K L1 M5
8.04979E-05 1.77689E+04  K L2 M2
8.25777E-04 1.77892E+04  K L2 M3
3.42594E-04 1.78010E+04  K L3 M1
8.16937E-04 1.78892E+04  K L3 M2
8.87823E-04 1.79095E+04  K L3 M3
8.73478E-05 1.79138E+04  K L1 N1
4.58145E-05 1.79400E+04  K L1 N2
6.74921E-05 1.79430E+04  K L1 N3
3.12047E-05 1.79471E+04  K L2 M4
1.10093E-04 1.79510E+04  K L2 M5
1.39158E-06 1.79815E+04  K L1 N4
1.65916E-06 1.79818E+04  K L1 N5
4.38897E-06 1.79834E+04  K L1 O1
1.33749E-04 1.80674E+04  K L3 M4
1.26846E-04 1.80713E+04  K L3 M5
3.97689E-05 1.81382E+04  K L2 N1
1.25241E-05 1.81645E+04  K L2 N2
1.25559E-04 1.81675E+04  K L2 N3
1.76626E-06 1.82060E+04  K L2 N4
6.15501E-06 1.82063E+04  K L2 N5
1.98031E-06 1.82079E+04  K L2 O1
5.90898E-05 1.82585E+04  K L3 N1
1.24969E-04 1.82848E+04  K L3 N2
1.35570E-04 1.82878E+04  K L3 N3
5.96230E-08 1.83091E+04  K L1 M1
7.54645E-06 1.83263E+04  K L3 N4
7.11833E-06 1.83266E+04  K L3 N5
2.94376E-06 1.83282E+04  K L3 O1
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3.56714E-08 1.84010E+04  K L1 M2
5.21551E-08 1.84238E+04  K L1 M3
2.81788E-08 1.85412E+04  K L2 M1
2.98217E-09 1.85886E+04  K L1 M4
3.59229E-09 1.85930E+04  K L1 M5
9.68851E-09 1.86331E+04  K L2 M2
9.90526E-08 1.86559E+04  K L2 M3
4.10842E-08 1.86743E+04  K L3 M1
9.78813E-08 1.87662E+04  K L3 M2
1.06084E-07 1.87890E+04  K L3 M3
1.08650E-08 1.88010E+04  K L1 N1
3.82506E-09 1.88207E+04  K L2 M4
1.34381E-08 1.88252E+04  K L2 M5
5.77533E-09 1.88289E+04  K L1 N2
8.37368E-09 1.88324E+04  K L1 N3
2.13898E-10 1.88740E+04  K L1 N4
2.51649E-10 1.88743E+04  K L1 N5
5.28474E-10 1.88767E+04  K L1 O1
1.63004E-08 1.89538E+04  K L3 M4
1.54198E-08 1.89582E+04  K L3 M5
4.96402E-09 1.90331E+04  K L2 N1
1.54770E-09 1.90610E+04  K L2 N2
1.54711E-08 1.90645E+04  K L2 N3
2.70527E-10 1.91060E+04  K L2 N4
9.31124E-10 1.91064E+04  K L2 N5
2.39067E-10 1.91088E+04  K L2 O1
7.23515E-09 1.91662E+04  K L3 N1
1.53948E-08 1.91941E+04  K L3 N2
1.66412E-08 1.91976E+04  K L3 N3
1.14501E-09 1.92392E+04  K L3 N4
1.07584E-09 1.92395E+04  K L3 N5
3.46028E-10 1.92419E+04  K L3 O1
3.93931E-05 1.99452E+04  K M1 M1
3.97125E-05 2.00333E+04  K M1 M2
5.87146E-05 2.00536E+04  K M1 M3
5.99452E-06 2.01215E+04  K M2 M2
1.18714E-04 2.01418E+04  K M2 M3
6.52430E-05 2.01621E+04  K M3 M3
3.05075E-06 2.02116E+04  K M1 M4
3.63941E-06 2.02155E+04  K M1 M5
3.42552E-06 2.02998E+04  K M2 M4
1.24178E-05 2.03037E+04  K M2 M5
1.56280E-05 2.03200E+04  K M3 M4
1.44504E-05 2.03240E+04  K M3 M5
1.40233E-05 2.04027E+04  K M1 N1
6.26222E-06 2.04290E+04  K M1 N2
9.20584E-06 2.04320E+04  K M1 N3
1.60565E-07 2.04705E+04  K M1 N4
2.14080E-07 2.04708E+04  K M1 N5
6.95792E-07 2.04724E+04  K M1 O1
1.65915E-06 2.04819E+04  K M4 M5
4.32514E-07 2.04859E+04  K M5 M5
6.85094E-06 2.04909E+04  K M2 N1
1.01151E-05 2.05112E+04  K M3 N1
1.87330E-06 2.05172E+04  K M2 N2
1.80905E-05 2.05202E+04  K M2 N3
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1.81973E-05 2.05375E+04  K M3 N2
1.99091E-05 2.05405E+04  K M3 N3
2.14079E-07 2.05587E+04  K M2 N4
6.95788E-07 2.05590E+04  K M2 N5
3.21126E-07 2.05606E+04  K M2 O1
9.09852E-07 2.05790E+04  K M3 N4
8.02806E-07 2.05793E+04  K M3 N5
4.81682E-07 2.05809E+04  K M3 O1
5.35230E-07 2.06691E+04  K M4 N1
6.48789E-07 2.06731E+04  K M5 N1
4.81697E-07 2.06954E+04  K M4 N2
2.30160E-06 2.06984E+04  K M4 N3
1.83823E-06 2.06993E+04  K M5 N2
2.16248E-06 2.07024E+04  K M5 N3
1.07039E-07 2.07372E+04  K M4 N5
1.08124E-07 2.07409E+04  K M5 N4
5.40656E-08 2.07412E+04  K M5 N5
5.40656E-08 2.07427E+04  K M5 O1
1.25219E-06 2.08603E+04  K N1 N1
1.08879E-06 2.08865E+04  K N1 N2
1.63323E-06 2.08896E+04  K N1 N3
1.51824E-07 2.09128E+04  K N2 N2
2.63167E-06 2.09158E+04  K N2 N3
1.55590E-06 2.09189E+04  K N3 N3
5.44433E-08 2.09281E+04  K N1 N4
5.44433E-08 2.09284E+04  K N1 N5
1.08879E-07 2.09300E+04  K N1 O1
4.84453E-09 2.09389E+04  K M1 M1
5.06101E-08 2.09543E+04  K N2 N4
1.01213E-07 2.09546E+04  K N2 N5
5.06101E-08 2.09562E+04  K N2 O1
1.11132E-07 2.09574E+04  K N3 N4
1.11132E-07 2.09577E+04  K N3 N5
5.55698E-08 2.09593E+04  K N3 O1
4.92021E-09 2.10309E+04  K M1 M2
7.14721E-09 2.10537E+04  K M1 M3
7.29830E-10 2.11229E+04  K M2 M2
1.44204E-08 2.11457E+04  K M2 M3
7.90842E-09 2.11684E+04  K M3 M3
3.83792E-10 2.12184E+04  K M1 M4
4.52993E-10 2.12229E+04  K M1 M5
4.27824E-10 2.13104E+04  K M2 M4
1.52880E-09 2.13149E+04  K M2 M5
1.92527E-09 2.13332E+04  K M3 M4
1.78048E-09 2.13377E+04  K M3 M5
1.76167E-09 2.14308E+04  K M1 N1
7.99032E-10 2.14588E+04  K M1 N2
1.15136E-09 2.14623E+04  K M1 N3
2.07617E-10 2.15024E+04  K M4 M5
2.51660E-11 2.15038E+04  K M1 N4
3.14579E-11 2.15042E+04  K M1 N5
8.80828E-11 2.15066E+04  K M1 O1
5.16140E-11 2.15069E+04  K M5 M5
8.68243E-10 2.15228E+04  K M2 N1
1.25829E-09 2.15456E+04  K M3 N1
2.32795E-10 2.15508E+04  K M2 N2
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2.25870E-09 2.15543E+04  K M2 N3
2.27122E-09 2.15735E+04  K M3 N2
2.47892E-09 2.15770E+04  K M3 N3
3.14578E-11 2.15958E+04  K M2 N4
1.06958E-10 2.15962E+04  K M2 N5
4.40385E-11 2.15986E+04  K M2 O1
1.38414E-10 2.16186E+04  K M3 N4
1.25829E-10 2.16189E+04  K M3 N5
6.29155E-11 2.16213E+04  K M3 O1
6.92047E-11 2.17103E+04  K M4 N1
7.74204E-11 2.17148E+04  K M5 N1
6.29130E-11 2.17383E+04  K M4 N2
2.89398E-10 2.17418E+04  K M4 N3
2.38720E-10 2.17428E+04  K M5 N2
2.77421E-10 2.17463E+04  K M5 N3
1.25824E-11 2.17837E+04  K M4 N5
6.29130E-12 2.17861E+04  K M4 O1
1.29033E-11 2.17878E+04  K M5 N4
6.45172E-12 2.17882E+04  K M5 N5
6.45172E-12 2.17906E+04  K M5 O1
1.64196E-10 2.19227E+04  K N1 N1
1.44491E-10 2.19507E+04  K N1 N2
2.10174E-10 2.19542E+04  K N1 N3
1.80687E-11 2.19786E+04  K N2 N2
3.43304E-10 2.19822E+04  K N2 N3
1.96443E-10 2.19857E+04  K N3 N3
6.56781E-12 2.19957E+04  K N1 N4
6.56781E-12 2.19961E+04  K N1 N5
1.31355E-11 2.19985E+04  K N1 O1
6.02281E-12 2.20237E+04  K N2 N4
1.80687E-11 2.20240E+04  K N2 N5
6.02281E-12 2.20264E+04  K N2 O1
1.90107E-11 2.20272E+04  K N3 N4
1.90107E-11 2.20275E+04  K N3 N5
1.26734E-11 2.20300E+04  K N3 O1
END RADIATION RECORDS
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