



PROTACTINIUM-228

SUMMARY DATA

GENERAL

CLASSIFICATION

Isotope: Pa-228
Atomic number (Z): 91
Mass number (A): 228
Neutron number (N): 137

RADIOACTIVE DECAY

Decay modes: α , β^+ , Electron capture
Half-life: 22.0 [h]
Decay constant: 8.7519×10^{-6} [1/s]
Daughters: Th-228 (98.0%), Ac-224 (2.0%)
Radioactive daughters: Th-228, Ac-224

DOSIMETRIC CONSTANTS

Mean alpha energy: 0.1216 [MeV]
Mean electron energy: 0.13196 [MeV]
Mean photon energy: 1.36942 [MeV]
Air kerma rate constant, Γ_{10} : 7.391×10^{-17} [Gy $\cdot$ m²/Bq $\cdot$ s]
Air kerma coefficient, K_{air} : 7.394×10^{-17} [Gy $\cdot$ m²/Bq $\cdot$ s]
Equilibrium dose constant for weakly-penetrating radiations (α and/or electrons), Δ_{wp} : 4.062×10^{-14} [Gy $\cdot$ kg/Bq $\cdot$ s]
Equilibrium dose constant for alphas, Δ_{α} : 1.948×10^{-14} [Gy $\cdot$ kg/Bq $\cdot$ s]

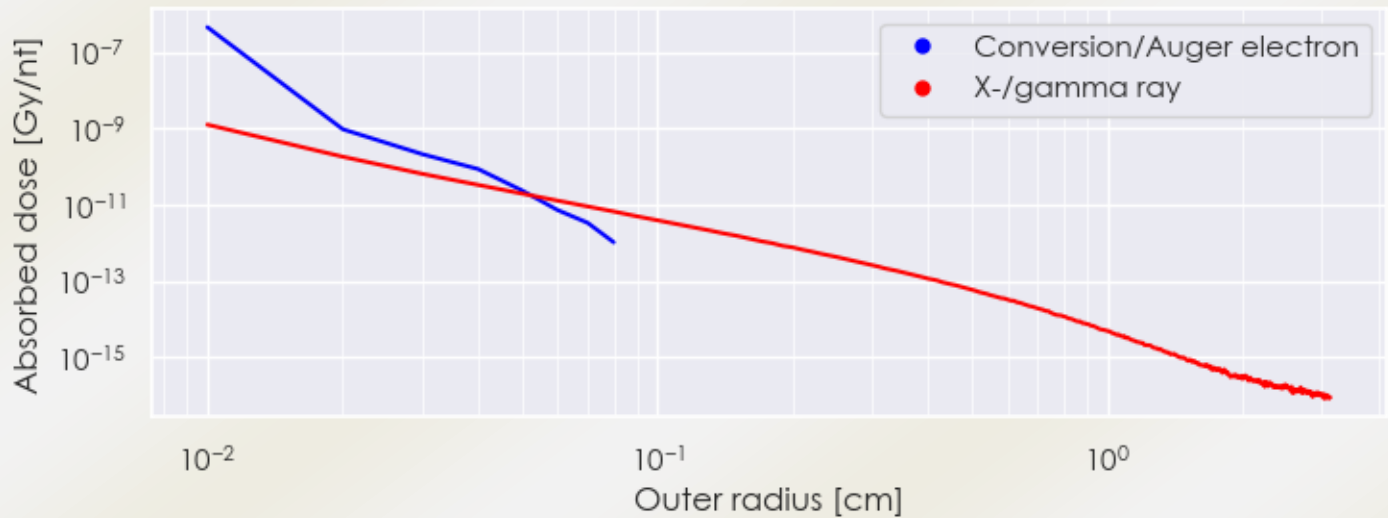
Equilibrium dose constant for betas/electrons, $\Delta_{\beta-, \beta+, e-}$: 2.114×10^{-14} [Gy·kg/Bq·s]

Equilibrium dose constant for photons, Δ_p : 2.194×10^{-13} [Gy·kg/Bq·s]

DOSE POINT KERNELS (PLOT)

Dose point kernel source: **Graves, et al. Medical Physics. 2019 Nov.; 46(11):5284-5293.**

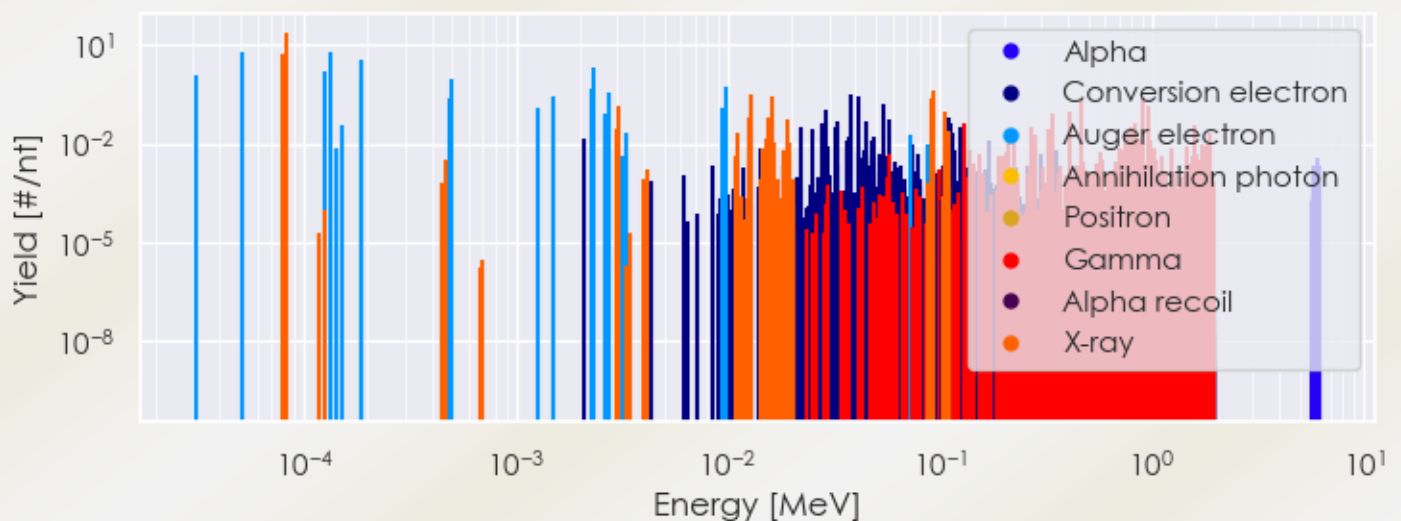
Note: Bins are spaced every 0.1 mm until a radius of 10 cm, and every 1 mm until a radius of 2 m.



Download tabulated dose point kernel file here: www.mirdsoft.org/products/MIRDspecs/Pa-228 DPK.csv

SUMMARY SPECTRA (PLOT)

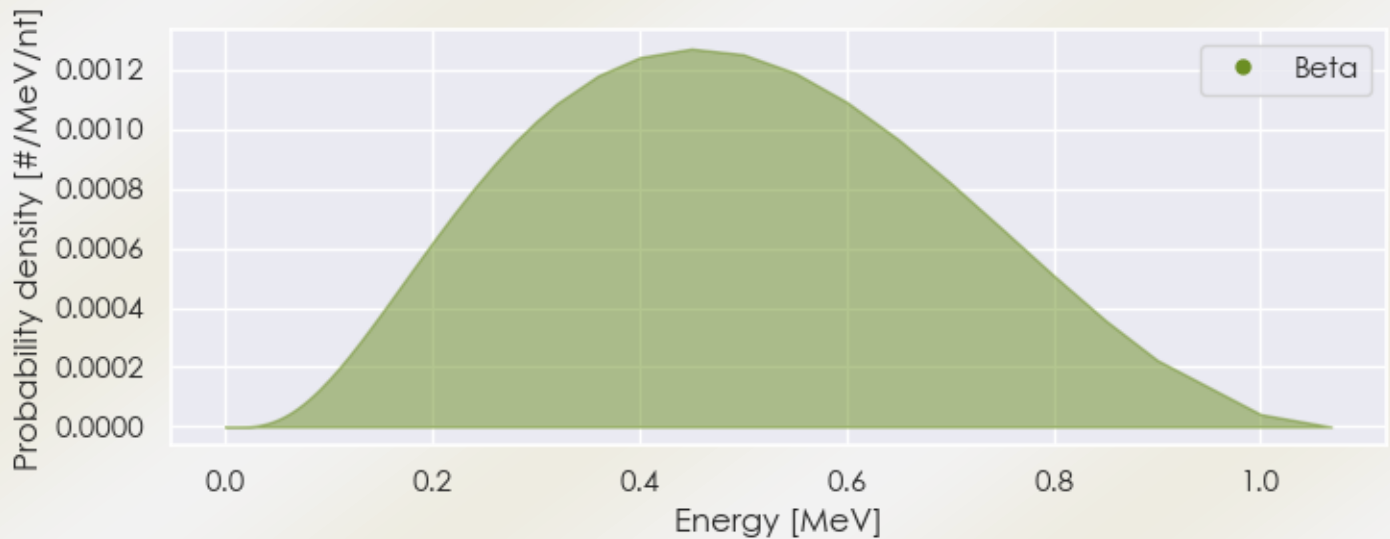
Spectra source: **ICRP Publication 107: Nuclear Decay Data for Dosimetric Calculations. Ann. ICRP 2008, 38 (3).**



Download tabulated summary spectra file here: www.mirdsoft.org/products/MIRDspecs/Pa-228 Summary Spectrum.csv

BETA SPECTRA (PLOT)

Spectra source: **ICRP Publication 107: Nuclear Decay Data for Dosimetric Calculations. Ann. ICRP 2008, 38 (3).**



Download tabulated beta spectra file here: www.mirdsoft.org/products/MIRDspecs/Pa-228 Beta Spectrum.csv

TABULATED DATA

SUMMARY SPECTRA (TABLE)

Spectra source: **ICRP Publication 107: Nuclear Decay Data for Dosimetric Calculations. Ann. ICRP 2008, 38 (3).**

Note: Radiations with yield < 0.01 are excluded from the table, but are available in the linked *.csv data.

Download tabulated summary spectra file here: www.mirdsoft.org/products/MIRDspecs/Pa-228 Summary Spectrum.csv

Energy [MeV]	Yield [# / nt] if > 0.01	Radiation type
7.95493e-05	5.408e+00	X-ray
8.22753e-05	2.362e+01	X-ray
2.97108e-03	2.833e-02	X-ray
3.06514e-03	1.309e-01	X-ray
1.11571e-02	2.015e-02	X-ray
1.26589e-02	6.516e-02	X-ray
1.28126e-02	3.358e-02	X-ray
1.29764e-02	2.951e-01	X-ray
1.52434e-02	1.335e-02	X-ray
1.56384e-02	6.097e-02	X-ray

1.56464e-02	1.217e-02	X-ray
1.57834e-02	2.879e-02	X-ray
1.62179e-02	1.114e-02	X-ray
1.62776e-02	2.539e-01	X-ray
1.64418e-02	1.115e-02	X-ray
1.90652e-02	5.644e-02	X-ray
1.96758e-02	1.052e-02	X-ray
9.03299e-02	2.431e-01	X-ray
9.37949e-02	3.929e-01	X-ray
1.05278e-01	4.504e-02	X-ray
1.06073e-01	8.784e-02	X-ray
1.08947e-01	1.117e-02	X-ray
1.09154e-01	2.245e-02	X-ray
1.29060e-01	4.255e-02	Gamma
2.09260e-01	2.449e-02	Gamma
2.23800e-01	1.238e-02	Gamma
2.70250e-01	3.156e-02	Gamma
2.82010e-01	1.732e-02	Gamma
3.27450e-01	2.886e-02	Gamma
3.28030e-01	2.793e-02	Gamma
3.32370e-01	1.955e-02	Gamma
3.38320e-01	7.634e-02	Gamma
3.40980e-01	1.909e-02	Gamma
4.09450e-01	9.310e-02	Gamma
4.63020e-01	2.085e-01	Gamma
7.55320e-01	1.825e-02	Gamma
7.72280e-01	2.346e-02	Gamma
7.94970e-01	3.203e-02	Gamma
8.30480e-01	2.700e-02	Gamma
8.35650e-01	3.975e-02	Gamma
8.40360e-01	1.480e-02	Gamma
8.70450e-01	1.480e-02	Gamma
9.04190e-01	2.467e-02	Gamma
9.11200e-01	2.300e-01	Gamma
9.64800e-01	1.136e-01	Gamma
9.68980e-01	1.387e-01	Gamma
9.76000e-01	1.248e-02	Gamma
1.58815e+00	3.463e-02	Gamma

1.88713e+00	2.234e-02	Gamma
3.10492e-05	1.236e+00	Auger electron
5.13393e-05	5.690e+00	Auger electron
1.25573e-04	1.462e+00	Auger electron
1.32767e-04	6.292e+00	Auger electron
1.50462e-04	3.620e-02	Auger electron
1.86634e-04	8.106e-01	Auger electron
1.88062e-04	3.581e+00	Auger electron
4.82508e-04	2.302e-01	Auger electron
4.96674e-04	9.288e-01	Auger electron
1.27095e-03	1.180e-01	Auger electron
1.50945e-03	2.782e-01	Auger electron
2.09500e-03	1.331e-02	Conversion electron
2.26356e-03	4.676e-01	Auger electron
2.31895e-03	2.056e+00	Auger electron
2.65629e-03	7.764e-02	Auger electron
2.73391e-03	3.533e-01	Auger electron
3.31404e-03	2.054e-02	Auger electron
9.46745e-03	1.153e-01	Auger electron
9.81490e-03	5.420e-01	Auger electron
1.24919e-02	5.659e-02	Auger electron
1.29437e-02	2.699e-01	Auger electron
1.61070e-02	3.172e-02	Auger electron
1.89500e-02	1.115e-02	Conversion electron
2.19370e-02	3.037e-02	Conversion electron
2.52170e-02	2.848e-02	Conversion electron
2.78400e-02	3.943e-02	Conversion electron
2.87520e-02	1.087e-01	Conversion electron
3.22520e-02	3.002e-02	Conversion electron
3.27170e-02	4.652e-02	Conversion electron
3.62170e-02	1.235e-02	Conversion electron
3.71961e-02	1.627e-02	Conversion electron
3.72820e-02	1.028e-02	Conversion electron
3.79800e-02	3.116e-01	Conversion electron
4.14450e-02	2.644e-01	Conversion electron
4.46961e-02	4.609e-02	Conversion electron
4.81961e-02	1.257e-02	Conversion electron
4.86000e-02	1.647e-02	Conversion electron

5.37238e-02	1.612e-01	Conversion electron
5.77600e-02	5.566e-02	Conversion electron
7.18676e-02	1.744e-02	Auger electron
1.09280e-01	6.470e-02	Conversion electron
1.12745e-01	4.104e-02	Conversion electron
1.13690e-01	1.973e-02	Conversion electron
1.25024e-01	3.032e-02	Conversion electron
1.29060e-01	1.053e-02	Conversion electron
1.71900e-01	1.214e-02	Conversion electron

USEFUL LINKS

Isotope decay characteristics are periodically updated as better measurements can be made - changes that may not be reflected on this page. Please see useful links:

National Nuclear Data Center (NNDC): <https://www.nndc.bnl.gov/nudat3/mird/>

International Atomic Energy Agency (IAEA) Livechart: <https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html>

REFERENCE LINKS

ICRP Report 107: <https://www.icrp.org/publication.asp?id=ICRP%20Publication%20107>

Graves et al. Dose Point Kernels: <https://doi.org/10.1002/mp.13789>

MIRD Decay Schemes 2nd Edition: https://sites.snmmi.org/SNMML-MAIN/iCore/Store/StoreLayouts/Item_Detail.aspx?iProductCode=0-932004-80-6