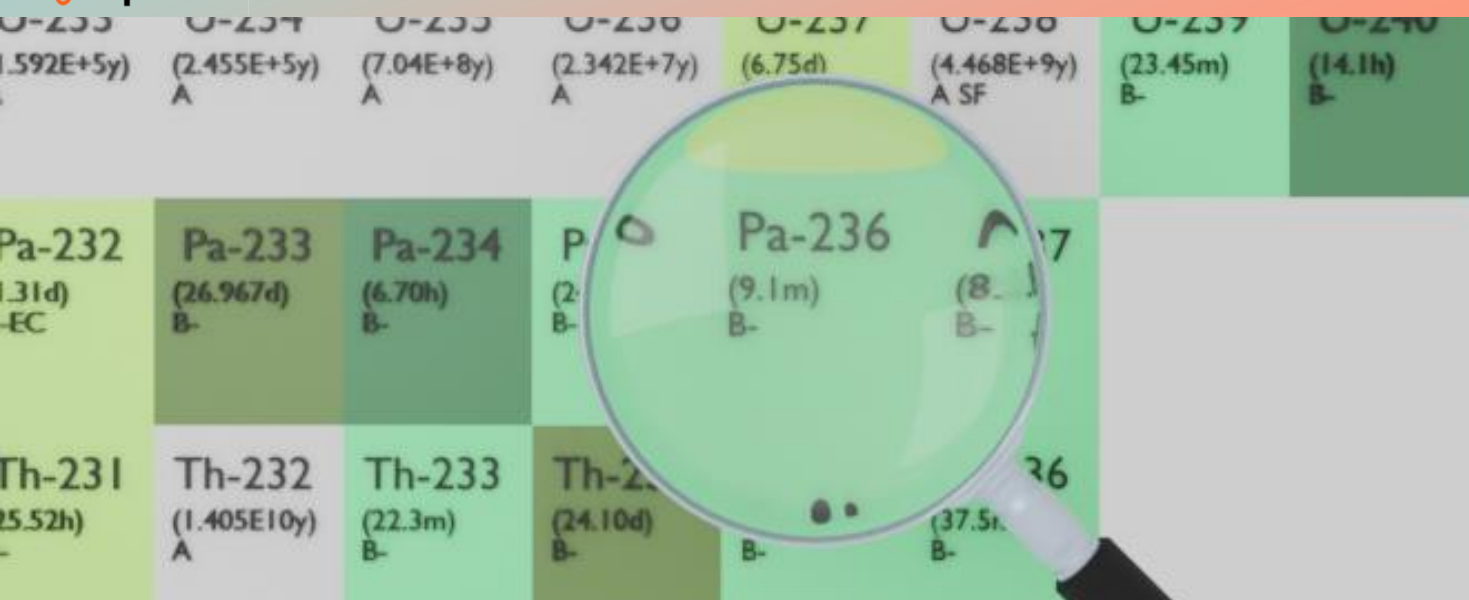




# PROTACTINIUM-236

## SUMMARY DATA

### GENERAL

### CLASSIFICATION

Isotope: Pa-236  
Atomic number (Z): 91  
Mass number (A): 236  
Neutron number (N): 145

### RADIOACTIVE DECAY

Decay modes:  $\beta^-$   
Half-life: 9.1 [m]  
Decay constant:  $1.2695 \times 10^{-3}$  [1/s]  
Daughters: U-236 (100.0%)  
Radioactive daughters: U-236

### DOSIMETRIC CONSTANTS

Mean alpha energy: 0.0 [MeV]  
Mean electron energy: 0.80492 [MeV]  
Mean photon energy: 0.91478 [MeV]  
Air kerma rate constant,  $\Gamma_{10}$ :  $3.870 \times 10^{-17}$  [Gy  $\cdot$  m<sup>2</sup>/Bq  $\cdot$  s]  
Air kerma coefficient,  $K_{\text{air}}$ :  $3.870 \times 10^{-17}$  [Gy  $\cdot$  m<sup>2</sup>/Bq  $\cdot$  s]  
Equilibrium dose constant for weakly-penetrating radiations ( $\alpha$  and/or electrons),  $\Delta_{\text{wp}}$ :  $1.290 \times 10^{-13}$  [Gy  $\cdot$  kg/Bq  $\cdot$  s]  
Equilibrium dose constant for alphas,  $\Delta_{\alpha}$ : 0.000e+00 [Gy  $\cdot$  kg/Bq  $\cdot$  s]

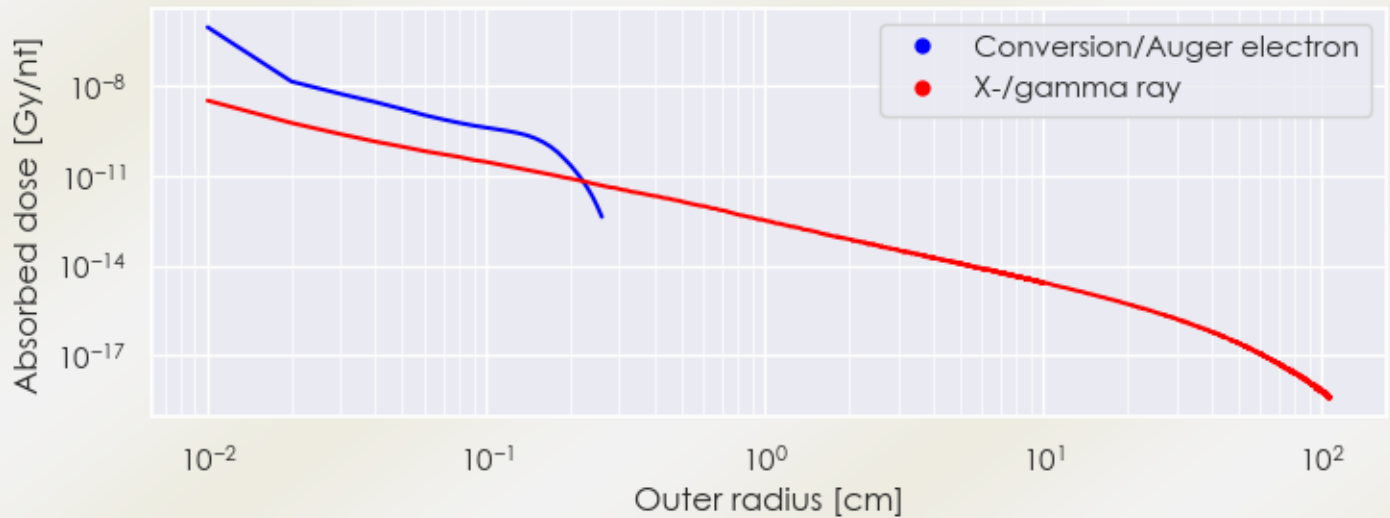
Equilibrium dose constant for betas/electrons,  $\Delta_{\beta, \beta^+, e^-}$ :  $1.290 \times 10^{-13}$  [Gy·kg/Bq·s]

Equilibrium dose constant for photons,  $\Delta_p$ :  $1.466 \times 10^{-13}$  [Gy·kg/Bq·s]

## DOSE POINT KERNELS (PLOT)

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

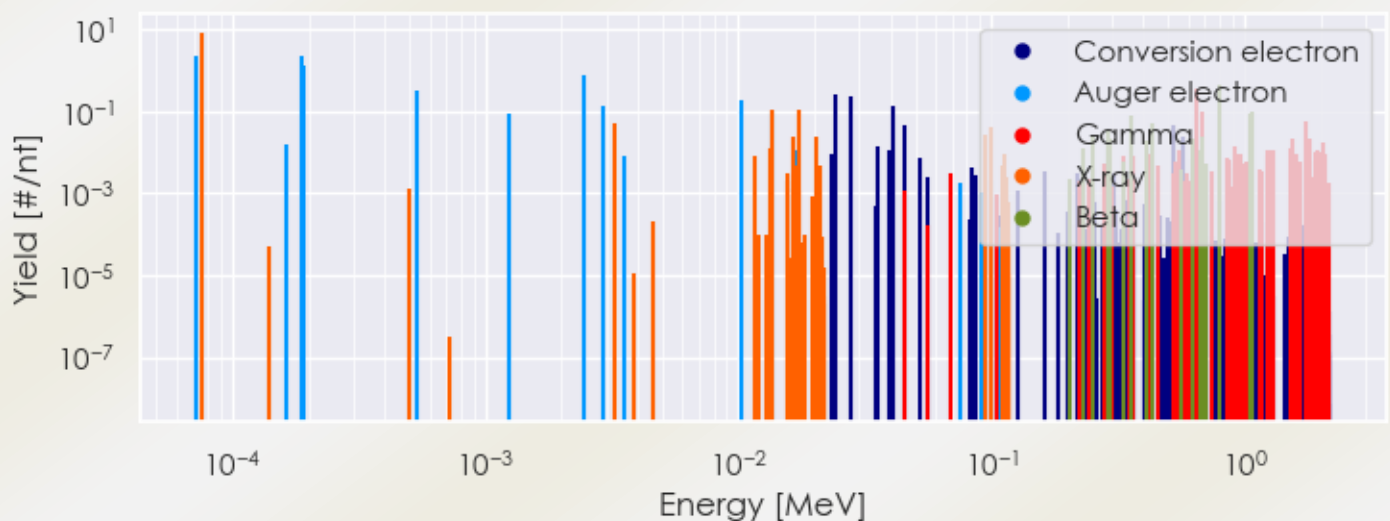
Note: Bins are spaced every 0.1 mm until a radius of 10 cm, and every 1 mm until a radius of 2 m.



Download tabulated dose point kernel file here: [www.mirdsoft.org/products/MIRDspecs/Pa-236 DPK.csv](http://www.mirdsoft.org/products/MIRDspecs/Pa-236 DPK.csv)

## SUMMARY SPECTRA (PLOT)

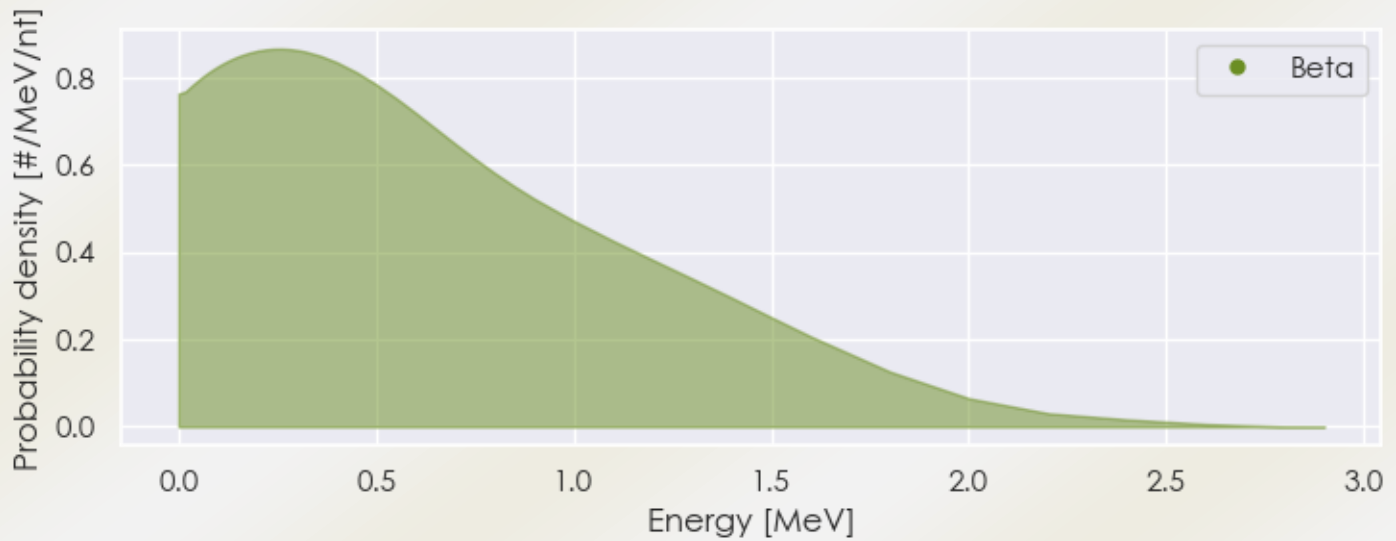
Spectra source: **ICRP Publication 107: Nuclear Decay Data for Dosimetric Calculations. Ann. ICRP 2008, 38 (3).**



Download tabulated summary spectra file here: [www.mirdsoft.org/products/MIRDspecs/Pa-236 Summary Spectrum.csv](http://www.mirdsoft.org/products/MIRDspecs/Pa-236 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-236 Beta Spectrum.csv](http://www.mirdsoft.org/products/MIRDspecs/Pa-236 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-236 Summary Spectrum.csv](http://www.mirdsoft.org/products/MIRDspecs/Pa-236 Summary Spectrum.csv)

| Energy [MeV] | Yield [# / nt] if > 0.01 | Radiation type |
|--------------|--------------------------|----------------|
| 7.55124e-05  | 8.610e+00                | X-ray          |
| 3.25799e-03  | 5.260e-02                | X-ray          |
| 1.34452e-02  | 1.305e-02                | X-ray          |
| 1.36268e-02  | 1.147e-01                | X-ray          |
| 1.64468e-02  | 2.405e-02                | X-ray          |
| 1.73072e-02  | 1.103e-01                | X-ray          |
| 2.02658e-02  | 2.499e-02                | X-ray          |
| 9.50660e-02  | 2.616e-02                | X-ray          |
| 9.89281e-02  | 4.186e-02                | X-ray          |
| 5.50600e-01  | 1.080e-02                | Gamma          |

|             |           |                |
|-------------|-----------|----------------|
| 6.42300e-01 | 3.700e-01 | Gamma          |
| 6.87500e-01 | 9.900e-02 | Gamma          |
| 9.17000e-01 | 1.370e-02 | Gamma          |
| 1.23490e+00 | 1.090e-02 | Gamma          |
| 1.28370e+00 | 1.140e-02 | Gamma          |
| 1.29160e+00 | 1.090e-02 | Gamma          |
| 1.51780e+00 | 1.250e-02 | Gamma          |
| 1.55960e+00 | 2.200e-02 | Gamma          |
| 1.76270e+00 | 6.000e-02 | Gamma          |
| 1.80780e+00 | 2.240e-02 | Gamma          |
| 1.92700e+00 | 1.020e-02 | Gamma          |
| 1.93410e+00 | 1.070e-02 | Gamma          |
| 1.97270e+00 | 1.020e-02 | Gamma          |
| 2.04130e+00 | 1.670e-02 | Gamma          |
| 2.29241e-01 | 1.202e-02 | Beta           |
| 2.53490e-01 | 2.605e-02 | Beta           |
| 2.91501e-01 | 1.804e-02 | Beta           |
| 2.92192e-01 | 3.307e-02 | Beta           |
| 2.94594e-01 | 2.104e-02 | Beta           |
| 3.55330e-01 | 8.216e-02 | Beta           |
| 4.10352e-01 | 1.904e-02 | Beta           |
| 4.32378e-01 | 5.110e-02 | Beta           |
| 6.26182e-01 | 2.204e-02 | Beta           |
| 6.75291e-01 | 1.102e-02 | Beta           |
| 6.83742e-01 | 2.305e-02 | Beta           |
| 7.97071e-01 | 4.709e-01 | Beta           |
| 1.06113e+00 | 9.018e-02 | Beta           |
| 1.07987e+00 | 1.002e-01 | Beta           |
| 7.21923e-05 | 2.318e+00 | Auger electron |
| 1.63076e-04 | 1.480e-02 | Auger electron |
| 1.86086e-04 | 2.271e+00 | Auger electron |
| 1.92358e-04 | 1.303e+00 | Auger electron |
| 5.37286e-04 | 3.330e-01 | Auger electron |
| 1.23559e-03 | 8.748e-02 | Auger electron |
| 2.44138e-03 | 7.502e-01 | Auger electron |
| 2.91333e-03 | 1.410e-01 | Auger electron |
| 1.02307e-02 | 1.898e-01 | Auger electron |
| 1.35588e-02 | 9.652e-02 | Auger electron |

|                    |           |                                     |
|--------------------|-----------|-------------------------------------|
| <b>1.69209e-02</b> | 1.156e-02 | <a href="#">Auger electron</a>      |
| <b>2.41980e-02</b> | 2.580e-01 | <a href="#">Conversion electron</a> |
| <b>2.80600e-02</b> | 2.273e-01 | <a href="#">Conversion electron</a> |
| <b>3.54560e-02</b> | 1.358e-02 | <a href="#">Conversion electron</a> |
| <b>3.93180e-02</b> | 1.127e-02 | <a href="#">Conversion electron</a> |
| <b>4.09524e-02</b> | 1.366e-01 | <a href="#">Conversion electron</a> |
| <b>4.52420e-02</b> | 4.806e-02 | <a href="#">Conversion electron</a> |
| <b>5.26190e-01</b> | 4.506e-02 | <a href="#">Conversion electron</a> |
| <b>5.71390e-01</b> | 2.495e-02 | <a href="#">Conversion electron</a> |

## 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](https://sites.snmmi.org/SNMML-MAIN/iCore/Store/StoreLayouts/Item_Detail.aspx?iProductCode=0-932004-80-6)