Technical Associates’ Model ~ LiveOne
(Radiation Monitor for Live Small Animals)

Test data indicate Gamma efficiency on the order of 0.9%, measured with Cs-137, 662 KeV Gammas.

**I-123**

- **Gammas:** 159 KeV (87%)
- **Betas:** 127 KeV (13%)
- **Total Maximum Energy:** + c.a. 11 (Auger) at 0.05 – 0.5 KeV
- **Half Life:** 13.2 hours

The detailed decay mechanism is electron capture to form an excited state of the nearly-stable nuclide Tellurium-123 (Its Half Life is so long that it is considered stable for all practical purposes). This excited state of Te-123 produced is not the metastable nuclear isomer Te-123m (the decay of I-123 does not involve enough energy to produce Te-123m).

It is a lower-energy nuclear isomer of Te-123 that immediately Gamma decays to ground state Te-123 at the energies noted, or else (13% of the time) decays by internal conversion electron emission (127 keV). This is followed by an average of 11 Auger electrons emitted at very low energies (50-500 eV).

The latter decay channel also produces ground-state Te-123. Because of the internal conversion decay channel, I-123 is not an absolutely pure Gamma-emitter, although it is sometimes clinically assumed to be one.

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**Iodine-123 Decay Scheme**
IODINE ISOTOPES & Nuclear Medicine

I-123 ~ I-124 ~ I-125 ~ I-129 ~ I-131

I-124
Gammas: 511 KeV (26%) (from Positron emission)
2.74 MeV, 2.29 MeV, 1.5 MeV, 600 KeV, and others.
74% of decays are by electron capture, resulting in various Gamma emissions.

Betas Total Available Energy: 3.22 MeV
Half Life: 4.2 Days

Iodine-124 is a neutron-rich isotope of Iodine with a half-life of 4.18 days. Its modes of decay are: 74.4% electron capture, 25.6% positron emission. I-124 decays to Te-124.

I-124 can be made by numerous nuclear reactions via a cyclotron. The most common starting material used is Te-124.

I-124 as an iodide salt can be used to directly image the thyroid using Positron Emission Tomography (PET). I-124 can also be used as a PET radiotracer with a usefully longer half-life compared with Fluorine-18. In this use, the nuclide is chemically bonded to a pharmaceutical to form a Positron-emitting radiopharmaceutical, and injected into the body, where again it is imaged by PET scan.

I-125
Gammas: 35.5 KeV (7%), 27 KeV (8%), 31 KeV (<2%),
27 – 32 KeV (1%)

Betas: As many as 21 per decay event (Auger)

Maximum Energies: 0.05 – 0.5 KeV
Half Life: 59 days
Half-Value Layer: 0.025 mm Pb

The detailed decay mechanism is electron capture to form the nearly-stable nuclide Tellurium-125. This is followed by Gamma decay at 35.5 KeV energies noted, or else internal conversion electron emission, followed by an average of 21 Auger electrons emitted at very low energies (50-500 KeV).

The internal conversion and Auger electrons from the radioisotope have been found in one study to do little cellular damage, unless the radionuclide is incorporated chemically directly into cellular DNA. This procedure is not the case for present radiopharmaceuticals using I-125 as the radioactive label nuclide.
IODINE ISOTOPES & Nuclear Medicine

I-129
Gammas: After Beta decay to Xe-129, c.a. 40 KeV residual energy. No data on emission.
Betas: 190.8 KeV (maximum)
Half life: 15,700,000 years

Iodine-129 is a rare long-lived radio-isotope of Iodine. I-129 is called a cosmogenic nuclide, because it is created by energetic cosmic rays impacting matter in a cosmic fission reaction, called spallation.

It is also created artificially in nuclear fission reactions and naturally in nature by spontaneous uranium decay. Significant quantities of I-129 were released into the atmosphere during the Above Ground Atomic Bomb Testing in the 1950s and 1960s.

I-129 is not used in Nuclear Medicine.

I-131
Gammas: 364 KeV (81%), 637 KeV (7%)
Betas: 606 KeV (90%), 334 KeV (7.25%)
Maximum Mean Energy: c.a. 1/5th
Half Life: 8 days

Iodine-131 decays with a half-life of 8.02 days with Beta and Gamma emissions. This nuclide of Iodine atom has 78 neutrons in nucleus. In comparison the stable nuclide I-127 has 74 neutrons. Upon decaying, I-131 transforms into Xe-131:

The primary emissions of I-131 decay are 364 KeV Gamma rays (81% abundance) and Beta particles with a maximal energy of 606 KeV (89% abundance).

The Beta particles, due to their high mean energy (190 KeV; 606 Kev is the maximum, but a typical Beta-decay spectrum has a tissue penetration of 0.6 to 2 mm.

Iodine-131 Decay Scheme
Some Comments on Nuclear Medicine & Iodine Therapy
(Courtesy Wikipedia article on I-125)

Iodine-125 (\(^{125}\text{I}\)) is a radioisotope of Iodine which has uses in biological assays, nuclear medicine imaging and in radiation therapy as brachytherapy to treat prostate cancer and brain tumors. It is the second longest-lived radioisotope of Iodine, after Iodine-129.

Its half-life is around 59 days and it decays by electron capture to an excited state of Tellurium-125. This state is not the metastable Te-125m, but rather a lower energy state that decays immediately by Gamma decay with a maximum energy of 35 KeV.

Some of the excess energy of the excited Te-125 may be internally converted ejected electrons (also at 35 KeV), or to X-rays (from electron bremsstrahlung), and includes a total of 21 Auger electrons, which are produced at the low energies of 50 to 500 electron volts.\(^1\) Eventually, stable nonradioactive ground-state Te-125 is produced, as the final decay product.

The internal conversion and Auger electrons cause little damage outside the cell which contains the isotope atom. The X-rays and Gamma rays are of low enough energy to deliver a higher radiation dose selectively to nearby tissues, in "permanent" brachytherapy where the isotope capsules are left in place (I-125 competes with Palladium-103 in such uses).\(^2\)

Because of its relatively long Half Life, and emission of low-energy photons which nevertheless activate Gamma-counter crystal detectors, I-125 is the preferred isotope for tagging antibodies in radioimmunoassay and other Gamma-counting procedures involving proteins outside the body.

The same properties of the isotope make it useful for brachytherapy (as noted), and for certain nuclear medicine scanning procedures, in which it is attached to proteins (albumin or fibrinogen), and where a longer Half-Life than provided by I-123 is required, in order to follow the isotope during the several days of test.

Iodine-125 has been sometimes been used in scanning/imaging the thyroid, but Iodine-123 is preferred for this purpose, due to better radiation penetration and shorter Half Life (13 hours).

For radiotherapy killing of tissues that absorb Iodine (such as the thyroid) or that absorb an Iodine-containing radiopharmaceutical, the Beta-emitter Iodine-131 is the preferred isotope; Iodine-125 is used therapeutically (to kill tissue) only in brachytherapy.
Iodine-131 ($^{131}\text{I}$)

Airborne plume deposits of radiation contamination on pasture results in contaminated feed ingested by cows. Concentrations of Cs-134, Cs-137, Sr-89 and Sr-90 may result in doses through the milk pathway, the I-131 dose will probably be larger than that of each of the other nuclides.

http://emilms.fema.gov/IS0303/assets/RAAC%20Lesson%209%20Summary.pdf
