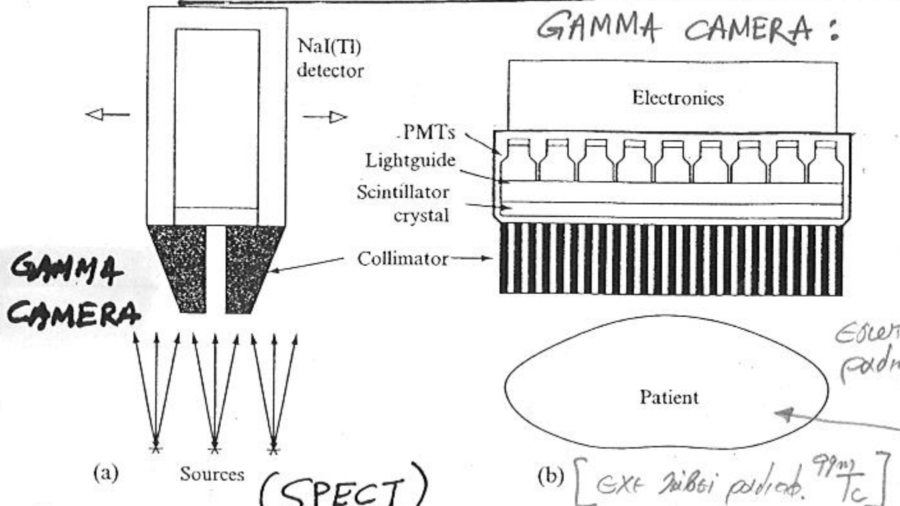
ΠΥΡΗΝΙΚΗ ΙΑΤΡΙΚΗ : ΔΙΑΓΝΩΣΤΙΚΕΣ ΜΕΘΟΔΟΙ :

GAMMA CAMERA :



(SPECT)

Figure 9.2 Principle of γ-ray imaging. In (a), a single, collimated scintillation detector is scanned across a distribution of γ-ray sources. In (b) is shown a schematic view of a gamma camera consisting of a multichannel collimator in front of a large piece of scintillator material, which is viewed through a lightguide with an array of photomultiplier tubes (PMTs).

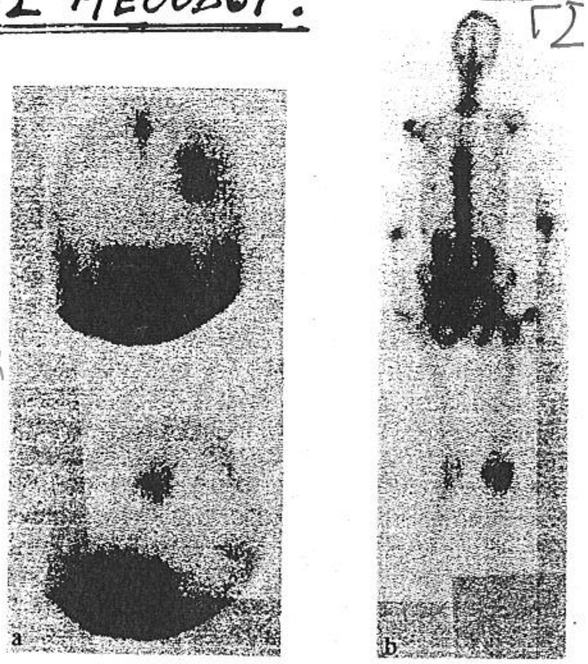
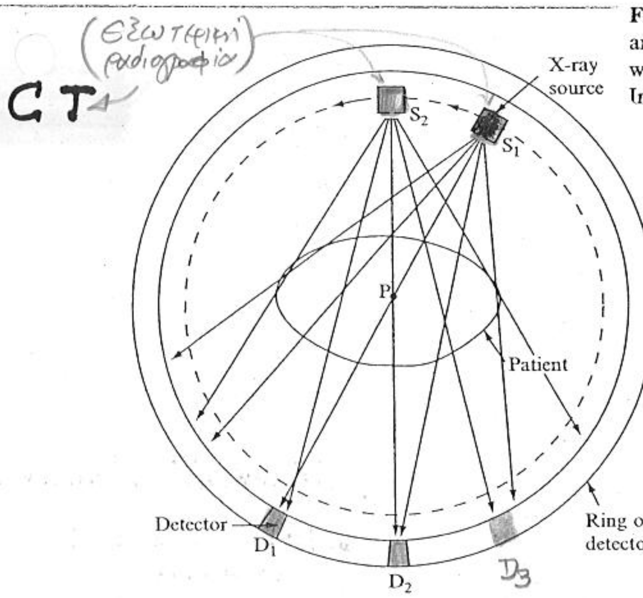


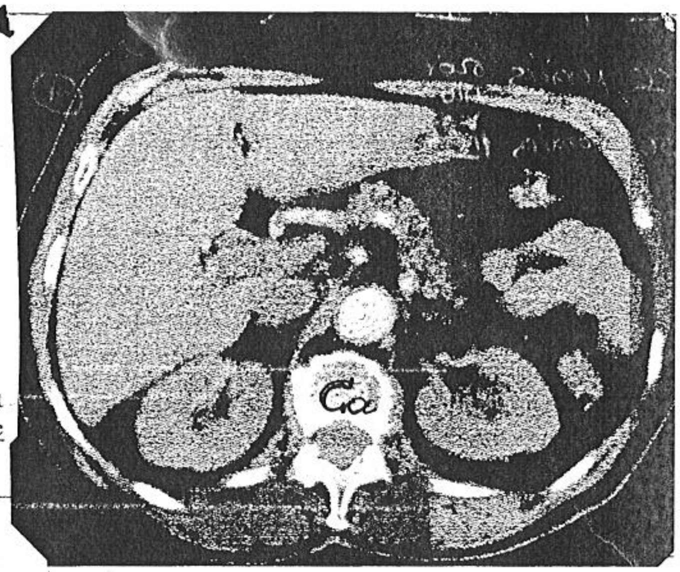
Figure 9.3 Gamma-camera images of (a) a human brain (upper: rear view; lower: side view) and (b) a human skeleton. The radioisotope $^{99}Tc^m$ was carried selectively to tumour sites, which are revealed as dark areas on the images Courtesy H. Sharma, Manchester Royal Infirmary, Manchester.

CT



igure Schematic view of a CT scanner. A source emits a fan of X-rays and those that ass t igh the patient are recorded in an outer ring of detectors. Scans at different angles are btained by rotating the X-ray source about the patient.

Figure 9.6 X-ray CT image of a section through a human trunk. Bone is indicated by the ligl areas where attenuation is relatively high compared with that of soft tissue.



PET

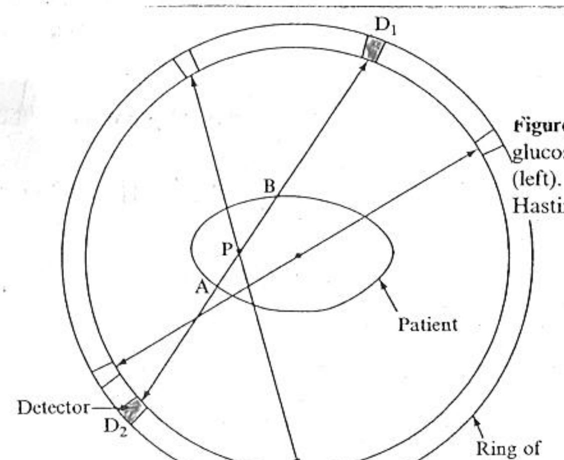
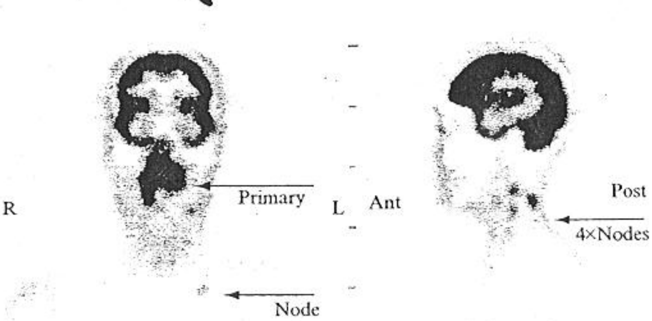


Figure 9.7 Schematic arrangement for performing positron emission tomography. Each positron, from a β^+ emitter inside the patient, results in two 511-keV γ rays emitted in opposite directions. These may trigger two detectors in the ring simultaneously. For example, detectors D_1 and D_2 will record coincident γ rays from β^+ emitters distributed along the line segment AB through the patient. The coincident count rate, therefore, is a measure of the line integral of the β^+ source distribution along AB. Other detector pairs measure different line integrals through the patient.

Figure 9.8 PET images of the human head and chest region. The patient ingested ^{18}F-labelled glucose before the PET scan. A primary tumour is shown in the nasal region in the front view (left). Several smaller tumours (nodes) are evident in the side view (right). Courtesy D. Hastings, Christie Hospital, Manchester.



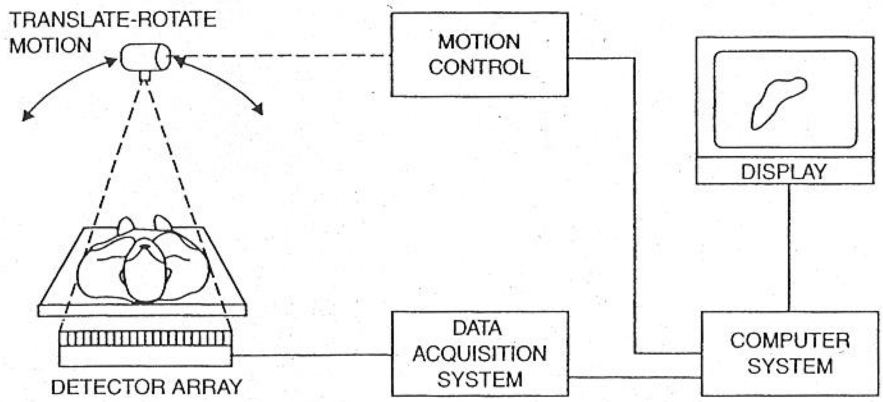


Figure 4.3 Schematic diagram of a CT system.

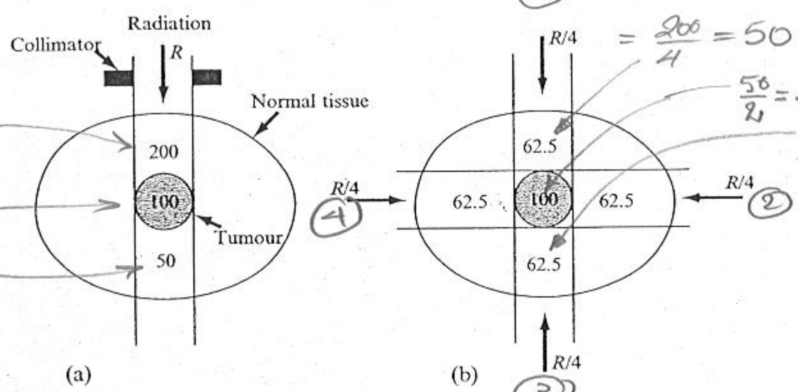


Figure 9.17 Effect of irradiating a tumour from different directions. In (a), an amount R of collimated radiation is directed from one direction only. The dose decreases approximately exponentially with depth of penetration and, therefore, is greater in front of the tumour than at the tumour itself. The numbers are for illustrative purposes only and indicate doses delivered to tissue before and beyond the tumour that are double or half that given to the tumour itself, which is arbitrarily set to be 100. In (b), radiation is delivered in four smaller amounts (R/4) from four different directions, as shown. The tumour receives the same dose as in (a), i.e. 100 units, but, although more tissue is exposed, its average dose is reduced to below that delivered to the tumour.

(Treatment planning)

Heavy-ion therapy (or Hadron-therapy)

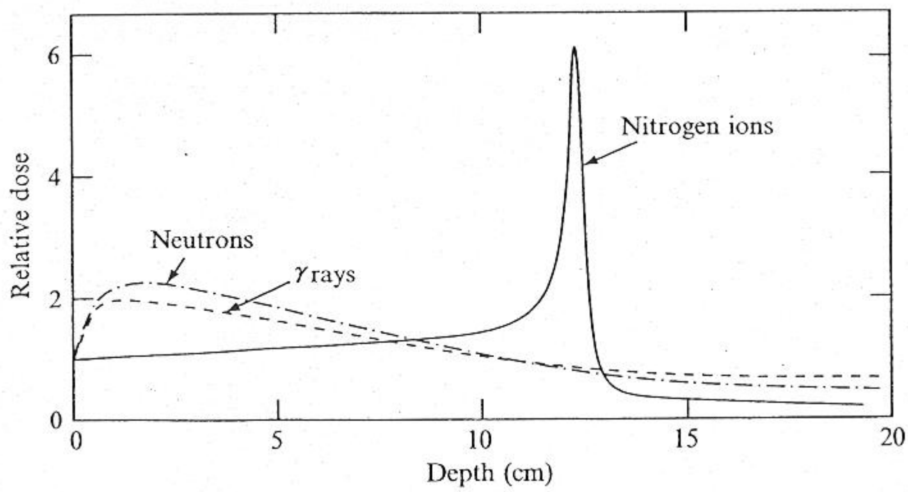


Figure 9.20 Composition of relative dose–depth distributions in tissue for ^{60}Co γ rays, neutrons and nitrogen ions. The doses delivered by neutrons and γ rays exhibit a mainly exponential decay with depth, whereas nitrogen ions have an inverted profile, typical of charged particles, with a high relative dose near the end of their range.

Κατηγορίες Πυρηνικών Αντιδραστήρων

(I) Αντιδραστήρες θερμικών νετρονίων (Thermal Reactors)

Α) Αντιδραστήρες κοινού H_2O (light water reactors)

1) Ερευνητικοί Αντιδραστήρες
P ~ 1 MW, παρέχουν μεγάλη ροή νετρονίων για ακτινοβολήσεις : ~10^{13} νετρόνια / cm^2 sec
Καύσιμο : μερικά kg εμπλουτισμένου U (20-90% σε ^{235}U) σε ράβδους ντυμένες με Zr ή Al. Όμως πυρήνα ~ 1 m^3 μέσα σε δεξαμενή νερού (moderator + coolant)

2) Αντιδραστήρες ισχύος (power reactors)
P ~ 1-3 GW. Συνήθεις τύποι :

BWR (Boiling Water Reactor)

PWR (Pressurized Water Reactors)

Β) Αντιδραστήρες Βαρέος Ύδατος (D_2O)

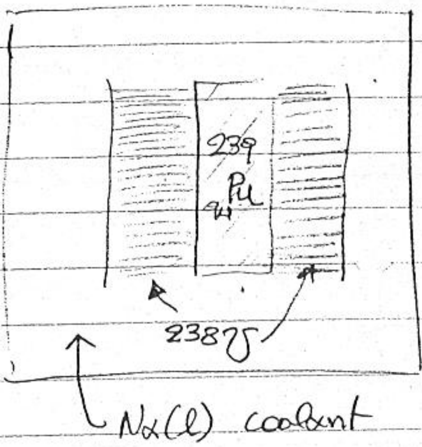
Χρησιμοποιείται D_2O για moderator. Το καύσιμο είναι φυσικό ουράνιο. Τύπος CANDU στον Καναδά

Γ) Αντιδραστήρες Γραφίτου

II) Αντιδραστήρες Ταχέων Νετρονίων

• Το καύσιμο υλικό είναι $^{238}_{92}U$ ή ^{232}Th. (fertile material)

• Αποτελούνται από κεντρικό φλοιό σχάσιμου υλικού (fissile Material) κυρίως $^{239}_{94}Pu$ (σε ~15% εμπλουτισμό)
Αυτός περιβάλλεται από το καύσιμο υλικό $^{238}_{92}U$ (ή ^{232}Th) και μετατρέπεται σε $^{239}_{94}Pu$ (ή $^{233}_{92}U$) από τα νετρόνια του κεντρικού πυρήνα



Η λειτουργία είναι τέτοια ώστε παράγεται περισσότερο ^{239}Pu απ' αυτό πού καταναλώνεται (για την περίπτωση ^{238}U)

Άρα στο τέλος του κύκλου καταναλώνεται το ^{238}U

Το ψυκτικό είναι υγρό Na (έχει πολύ καλές θερμικές και υδραυλικές ιδιότητες)
- Δεν επιβραδύνει τα νετρόνια
- Σημείο τήξεως 98°C, ζέσεως 882°C
- Χρησιμοποιείται σε (max) 550°C
- Προσοχή : εύφλεκτο στον αέρα και το νερό

Energy Amplifier

III) Σύστημα επιταχυντού - αντιδραστήρα : ADS (Accelerator Driven System)

• Το σύστημα λειτουργεί πάντα ως υποκρίσιμο $K<1$
$E_p \sim 1-2$ GeV, $i \sim 1-300$ mA

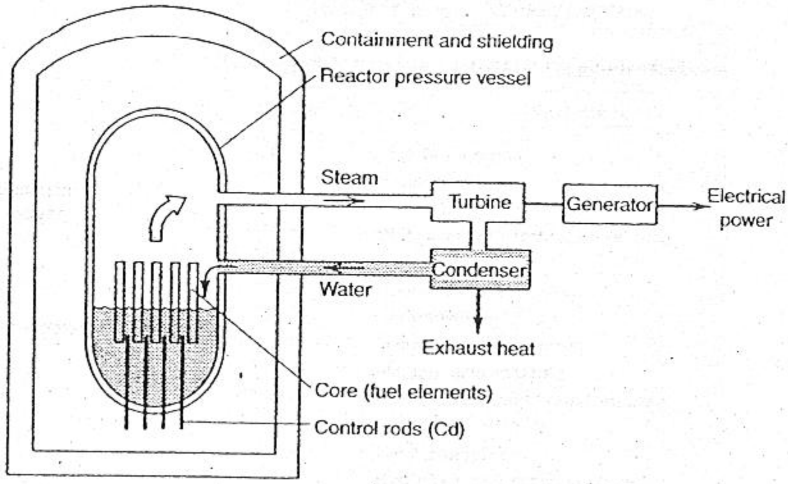
• Δέσμη πρωτονίων από επιταχυντή (κύκλοτρο ή LINAC) κτυπά στόχο π.χ. Pb και παράγει spallation neutrons :
$N \sim 30 \cdot E_p(GeV)$

• Τα νετρόνια αυτά προκαλούν σχάση του καυσίμου (π.χ. ^{232}Th) όπως στην περίπτωση των fast reactors

• Η ηλεκτρική ενέργεια που απαιτείται από τον επιταχυντή παρέχεται από τον αντιδραστήρα

Reactor types

Boiling Water Reactor (BWR)



PWR

Pressurized water Reactor

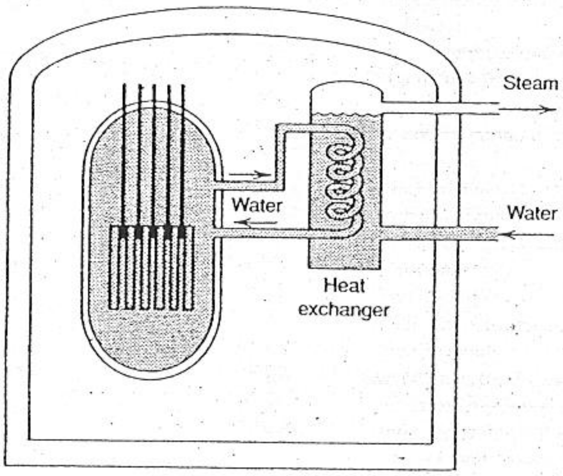


Figure 14.2 Schematic diagram of boiling water (top) and pressurized-water reactors (bottom). (From Krane, 1988.)

Accelerator - driven Reactor system: (ADS)

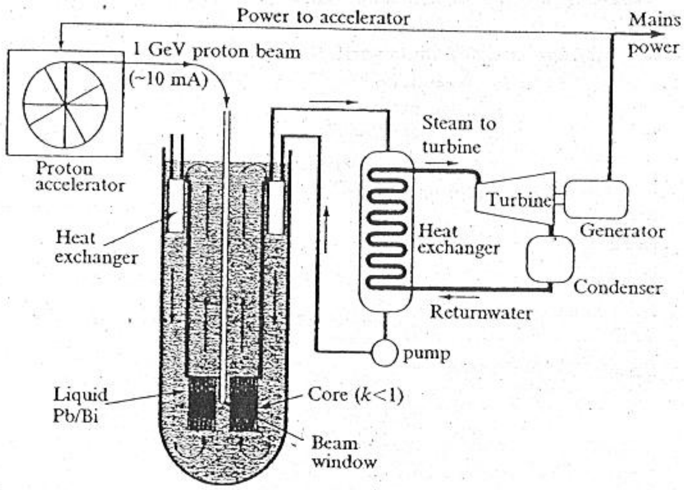


Figure 10.13 Schematic layout of a proposed accelerator-driven (hybrid) reactor. A proton beam from a cyclotron is injected down a long vertical beam pipe into a subcritical assembly containing thorium fuel. The core and the region where the beam emerges from the pipe through a specially designed window are cooled by convection in a liquid lead/bismuth mixture.

1

Εφαρμογές Ραδιοϊσοτόπων :

Ιατρικές Εφαρμογές

TABLE 4.5 Commonly Used Diagnostic Radionuclides

Nuclide	Application
^{11}C	PET brain scans
^{14}C	Radiolabeling
^{13}N	PET scans
^{15}O	PET scans of cerebral blood flow
^{18}F	PET brain scans
^{32}P	Bone disease diagnosis
^{33}P	Radiolabeling
^{35}S	Heart disease diagnosis
	Nucleic acid labeling
^{47}Ca	Cell function and bone formation
^{46}Sc	Blood flow studies
^{47}Sc	Cancer diagnosis
^{51}Cr	Red blood cell survival studies
	Intestinal blood loss
^{51}Mn	Myocardial localizing agent
^{52}Mn	PET scans
^{59}Fe	Bone marrow scanning
	Iron metabolism studies
^{57}Co	Scanning of various organs
^{58}Co	Tracer for pernicious anemia
^{64}Cu	PET scans
^{67}Cu	Cancer diagnosis
^{67}Ga	Tumor and inflammatory lesion imaging
^{68}Ga	Thrombosis and atherosclerous studies
^{72}Se	Brain imaging
^{75}Se	Protein studies
	Liver and pancreas imaging
$^{81}\text{Kr}^{m}$	Lung imaging
^{82}Rb	Myocardial localizing agent
^{85}Sr	Measurement of bone metabolism
$^{99}\text{Tc}^{m}$	Brain, heart, lung, thyroid, gall bladder, skin, lymph node, bone, liver, spleen, and kidney imaging
	Blood flow studies
^{109}Cd	Cancer detection
	Pediatric imaging
	Heart disease diagnostics
^{111}In	Detection of heart transplant rejections
	Imaging of abdominal infections
	Imaging of metastatic melanoma
^{123}I	Thyroid disorders
^{125}I	Osteoporosis detection
	Tracer for drugs
^{131}I	Thyroid disorders
	Brain biochemistry in disease
^{127}Xe	Lung imaging
	Neuroimaging for brain disorders
^{133}Xe	Lung ventilation studies
^{169}Yb	Gastrointestinal tract diagnosis
$^{191}\text{Ir}^{m}$	Cardiovascular angiography
$^{195}\text{Pt}^{m}$	Pharmacokinetic studies of antitumor agents

Βιομηχανικές Εφαρμογές

TABLE 4.4 Industrial Uses of Radionuclides

Nuclide	Application
^{3}H	Self-luminous aircraft and exit signs
	Luminous dials, gauges, wrist watches
	Luminous paint
^{24}Na	Location of pipeline leaks
	Oil well studies
^{46}Sc	Oil exploration tracer
^{55}Fe	Analysis of electroplating solutions
	Defense power source
^{60}Co	Surgical instrument and medicine sterilization
	Safety and reliability of oil burners
^{63}Ni	Detection of explosives
	Voltage regulators and current surge protectors
	Heat power source
^{85}Kr	Home appliance indicator lights
	Gauge thickness of various thin materials
	Measurement of dust and pollutant levels
^{90}Sr	Survey meters
^{109}Cd	XRF of metal alloys
^{124}Sb	Oil exploration tracer
^{126}Sb	Oil exploration tracer
^{131}I	Petroleum exploration
^{136}Cs	Oil exploration tracer
^{137}Cs	Measure and control liquid flow in pipes
	Measure of oil well plugging by sand
	Measure fill level of consumer products
^{140}Ba	Oil exploration tracer
^{147}Pm	Used in electric blanket thermostats
	Gauge thickness of thin materials
	Oil exploration tracer
^{151}Sm	Heat source
^{156}Eu	Oil exploration tracer
^{192}Ir	Pipeline, boiler and aircraft weld radiography
	Oil exploration tracer
^{198}Au	Oil exploration tracer
^{204}Tl	Thickness gauge
^{210}Po	Reduction of static charge
^{229}Th	Extend life of fluorescent lights
^{230}Th	Coloring and fluorescence in glazes and glass
^{232}Th	With W, electric arc welding rods
^{234}U	Natural color, brightness in dentures
^{235}U	Nuclear reactor fuel
	Fluorescent glassware, glazes, and wall tiles
^{238}Pu	Radioisotope thermal generator
^{241}Am	Smoke detectors
^{244}Cm	Analysis of pit mining and drilling slurries
^{252}Cf	Luggage inspection for explosives
	Soil moisture content