



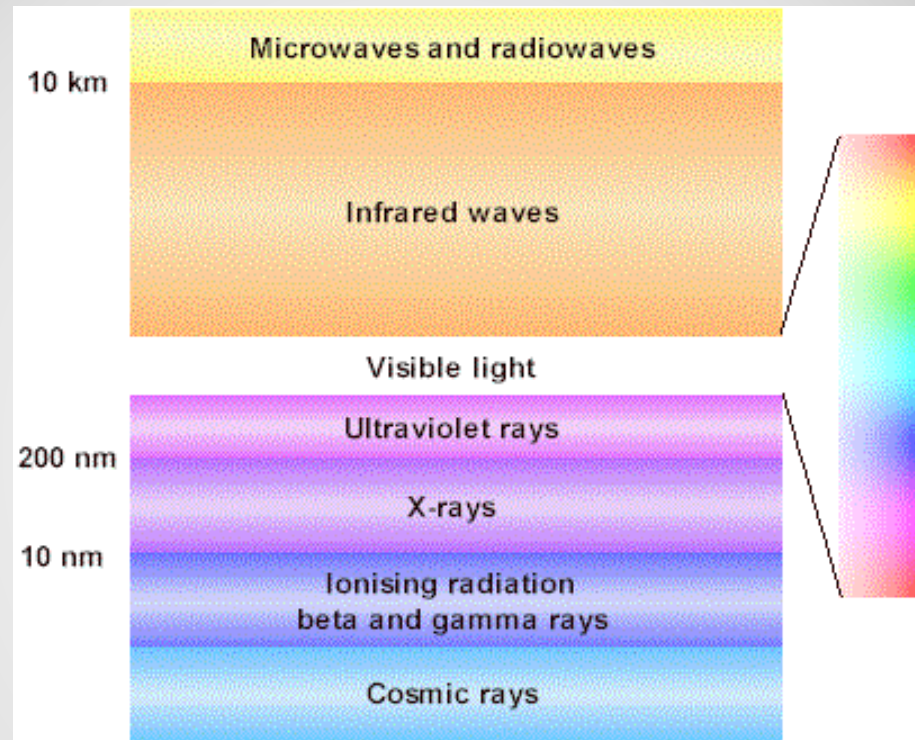
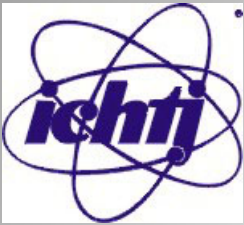
Erasmus+

**“Joint innovative training and teaching/learning program in
enhant and transfer knowledge of application of ionizing radiation in materials processing”**

Gamma irradiators

Andrzej G. Chmielewski

**Training /learning course – 2nd week at URCA
Reims, France
September 12-16, 2016**



Electromagnetic radiation



$$E = h\nu$$

frequency of radiation, sometimes written as f
giving expression $E = hf$.

Quantum energy
of a photon.

$h = \text{Planck's constant} = 6.626 \times 10^{-34} \text{ Joule}\cdot\text{sec} = 4.136 \times 10^{-15} \text{ eV}\cdot\text{s}$

Quantum energy

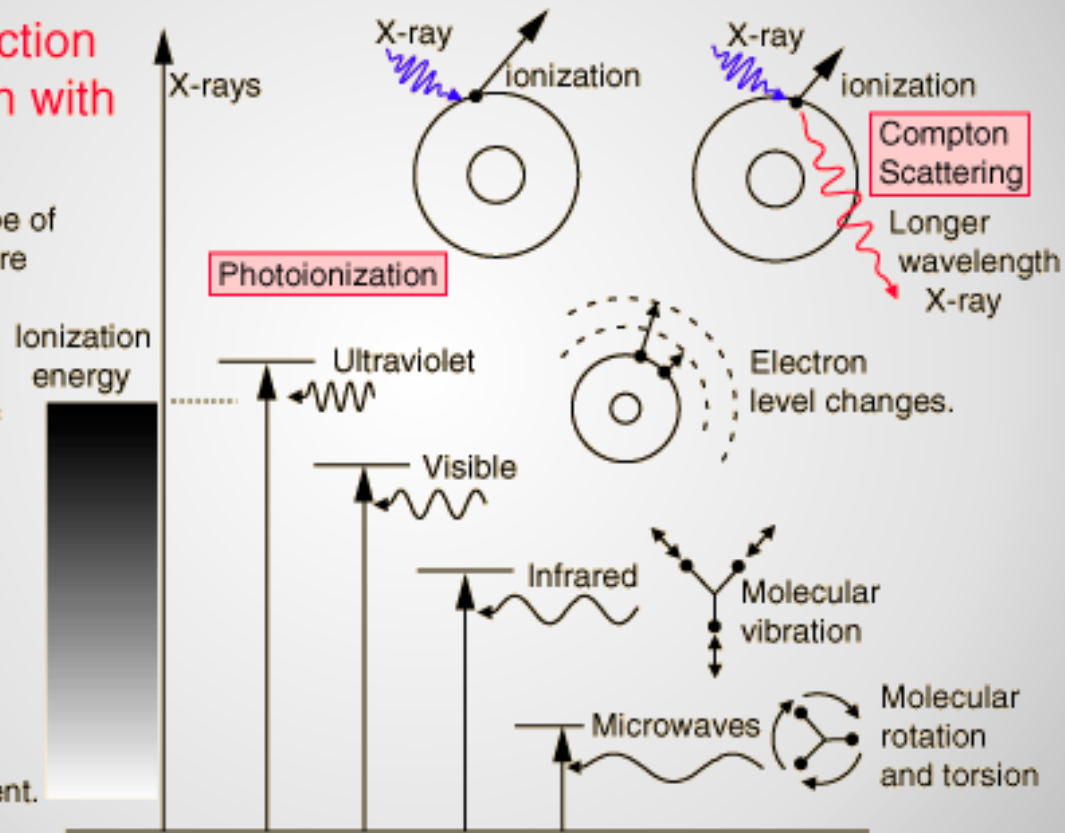


The interaction of radiation with matter.

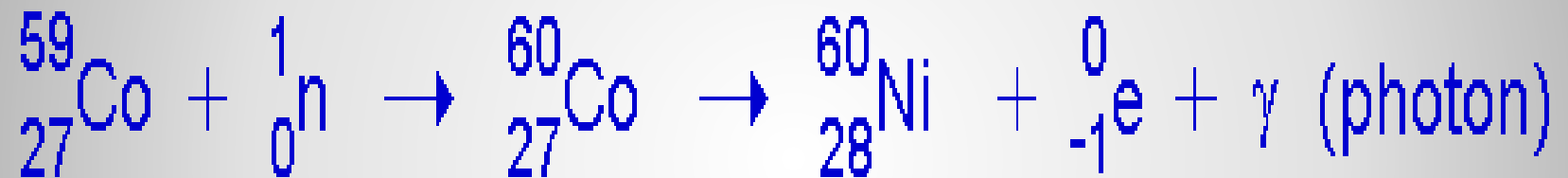
Click on any type of radiation for more information.

Large number of available energy states, strongly absorbed.

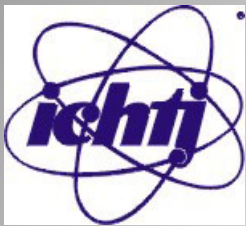
Small number of available states, almost transparent.



Interaction with the matter



Production of Cobalt-60

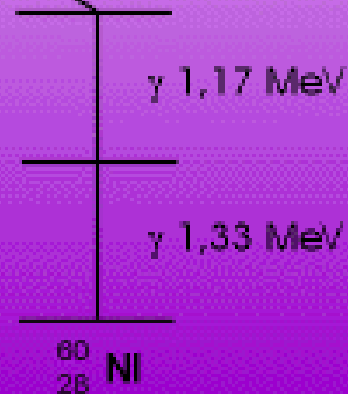


Radionuklid-Quellen

Zerfallschema

${}_{27}^{60}\text{Co}$ 5,26 a (Halbwertszeit)

β 0,31 MeV



${}^{60}\text{Cobalt}$

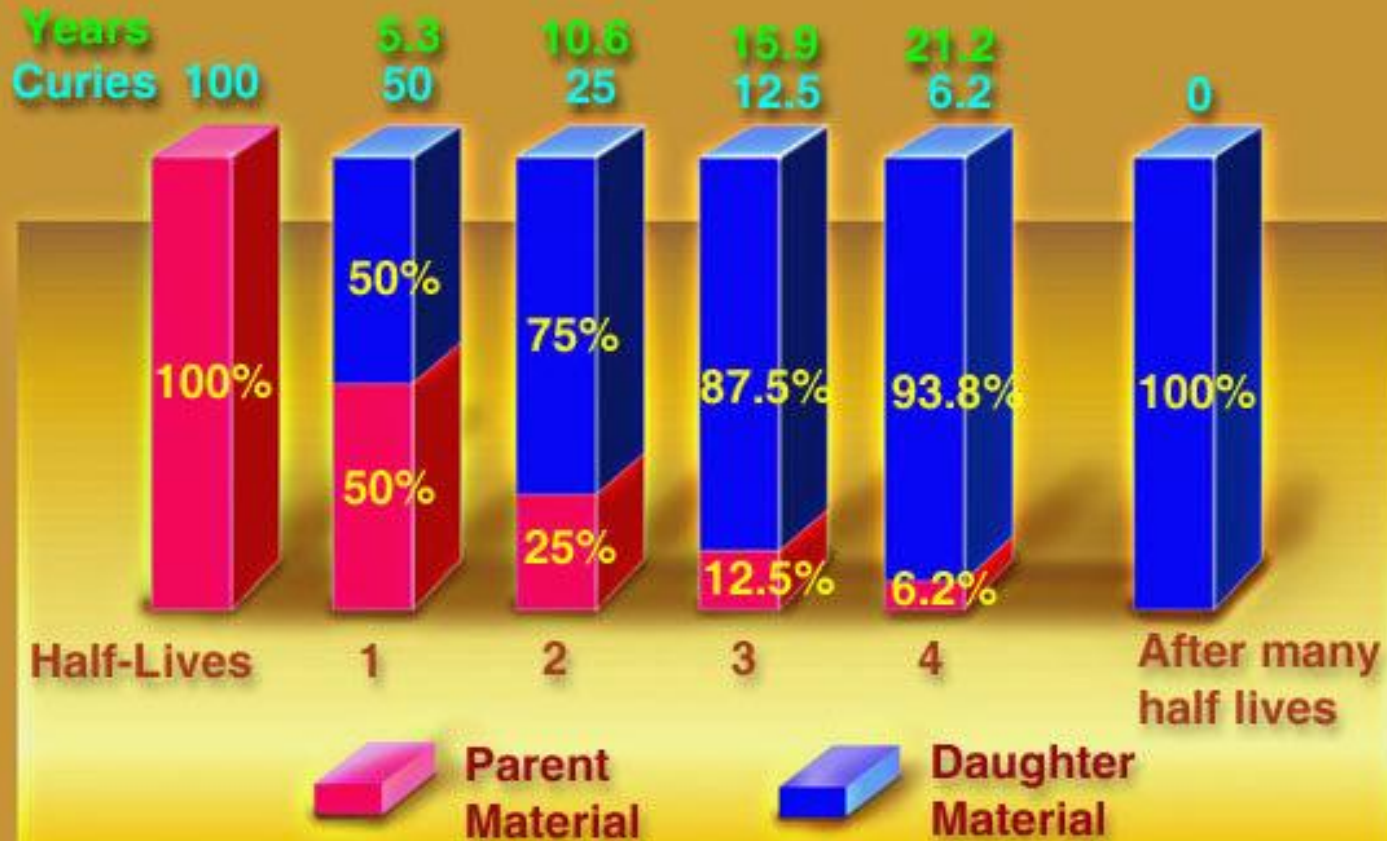
Herstellung: Durch die Bestrahlung von ${}^{59}\text{Co}$ mit thermischen Neutronen im Kernreaktor

$${}_{27}^{59}\text{Co} (n, \gamma) {}_{27}^{60}\text{Co}$$

Radiation gamma Co - 60



Cobalt 60 - Half Life 5.3 years



Courtesy of Digital Research & Development



$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$$
$$100 \text{ kCi} = 100\,000 \text{ Ci} = 3.7 \times 10^{15} \text{ Bq} = 3.7 \text{ PBq}$$

| Factor | Prefix | Symbol |
|------------|--------|--------|
| 10^{15} | peta | P |
| 10^{12} | tera | T |
| 10^9 | giga | G |
| 10^6 | mega | M |
| 10^3 | kilo | k |
| 10^{-1} | deci | d |
| 10^{-2} | centi | c |
| 10^{-3} | milli | m |
| 10^{-6} | micro | μ |
| 10^{-9} | nano | n |
| 10^{-12} | pico | p |

Activity



| Characteristic | Gamma | electron |
|---|--|---------------------------------------|
| Energy | 1.17 and 1.33 MeV | 0.2-10 MeV |
| Power | 1.48 kW/100 kCi | 4-400 kW/unit |
| Dose rate | Low (kGy/h) | High (kGy/s) |
| Maintenance | Replenishment of Co-60 source, decay 1%/month | Replacement of electronic parts |
| Penetration | High (43 cm in water) | Low (0.35 cm/MeV) |
| Energy utilization efficiency | Low ($\approx 40\%$) | High ($\approx 90\%$) |
| Product thickness (assume product density 0.5 gcm^{-3}) | 80-100 cm | 8-10 cm (double sided irradiation) |

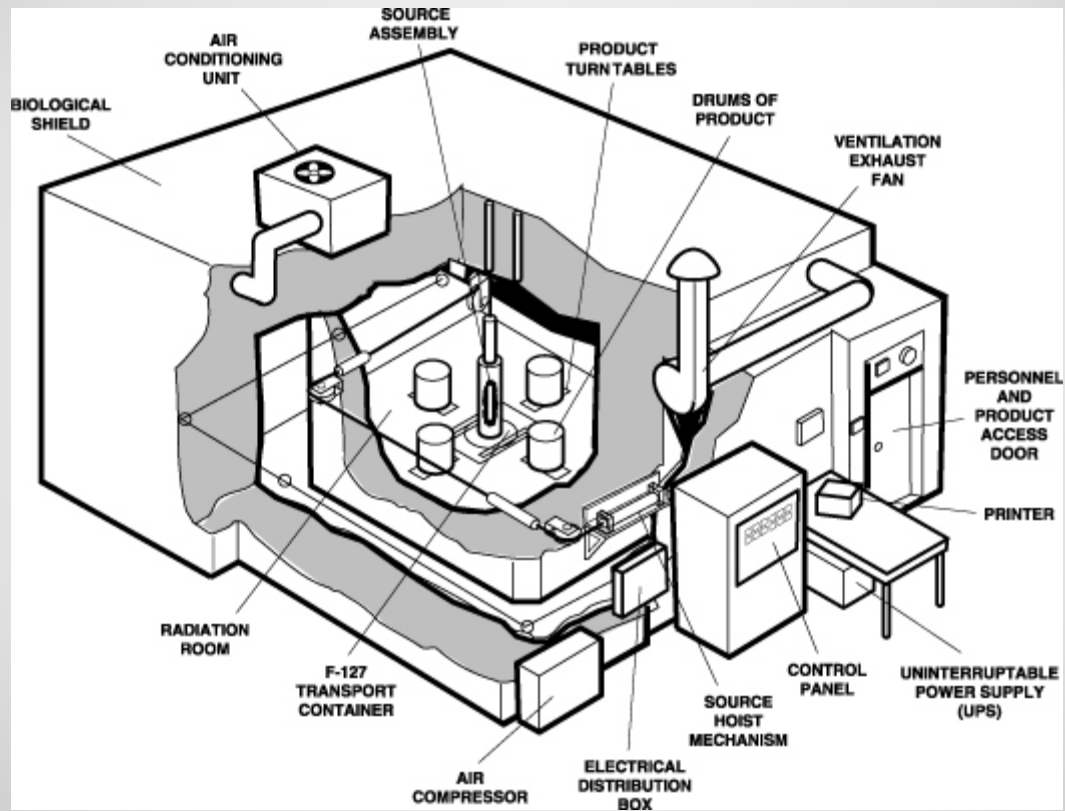
Comparison between gamma and electron irradiators.



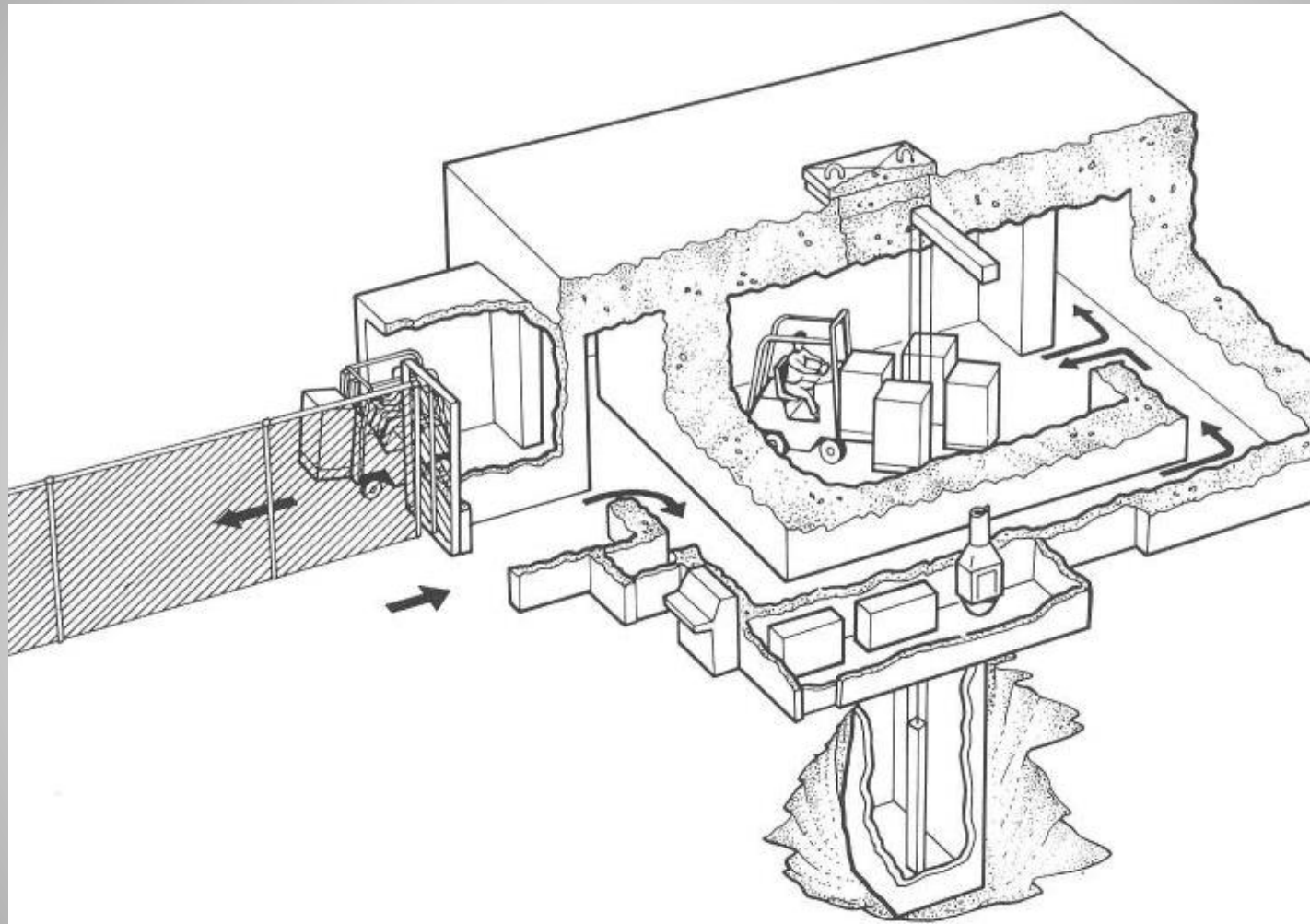
Gammacell



Laboratory unit



Panoramic irradiator



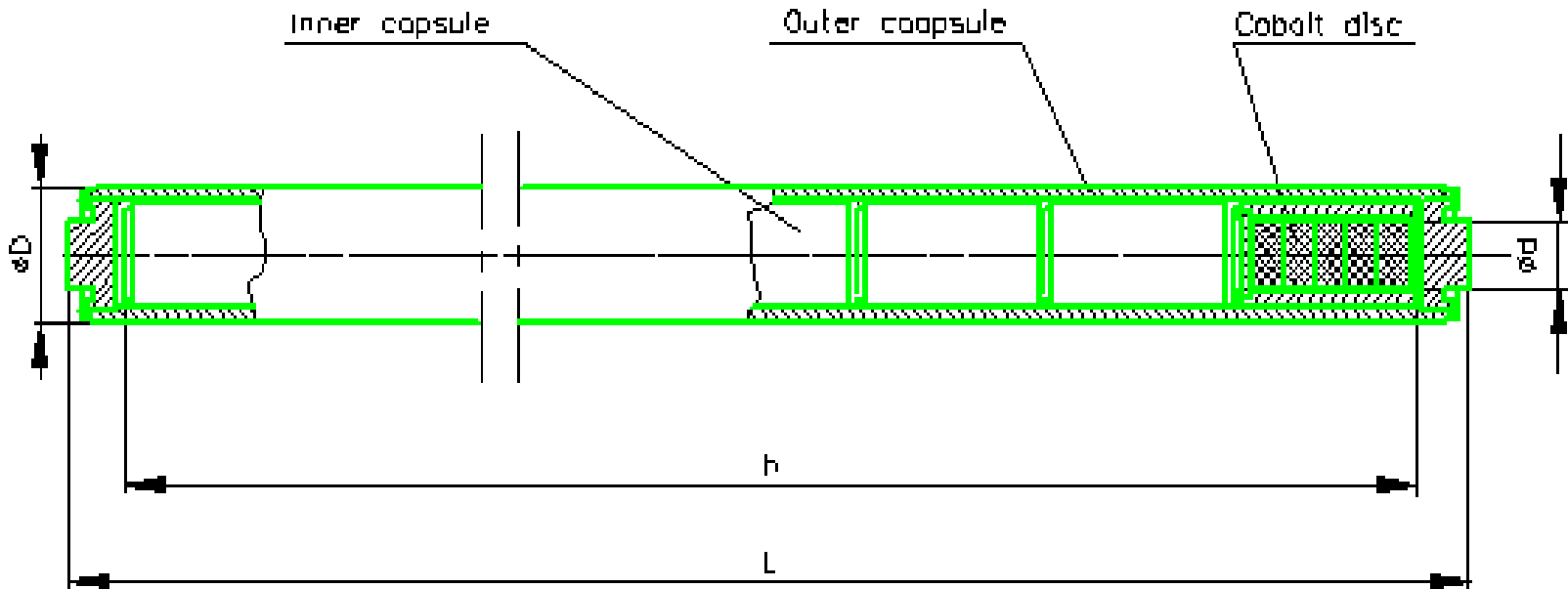
Batch irradiator

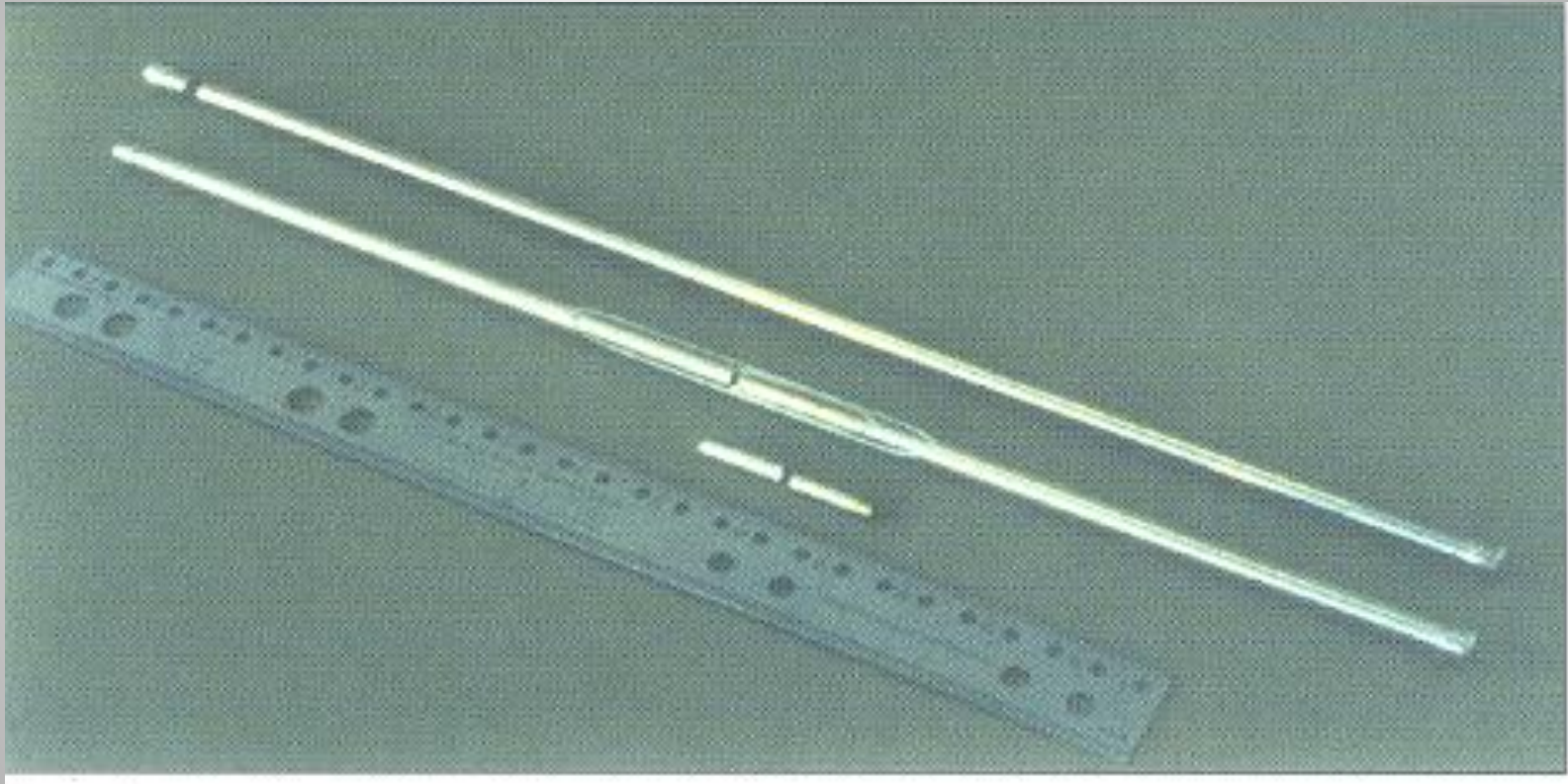


Co-60 Pencil

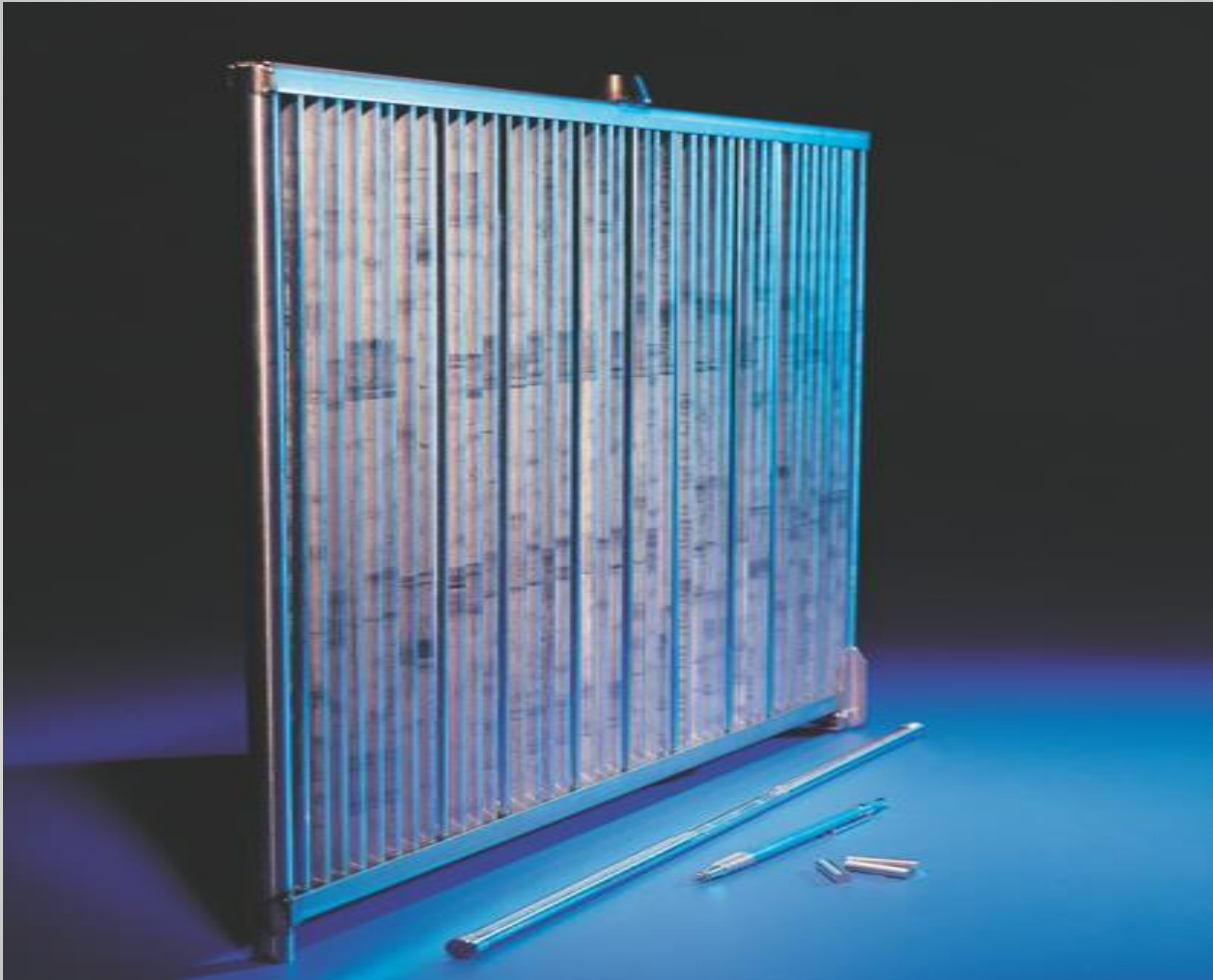
Cobalt metal double encapsulated in stainless steel (KO-33 or KO-36) and sealed by argon arc welding.

CoS-43 HH CoS-44 HH CoS-45 HH





Sources



Rack



cobalt-60 slug

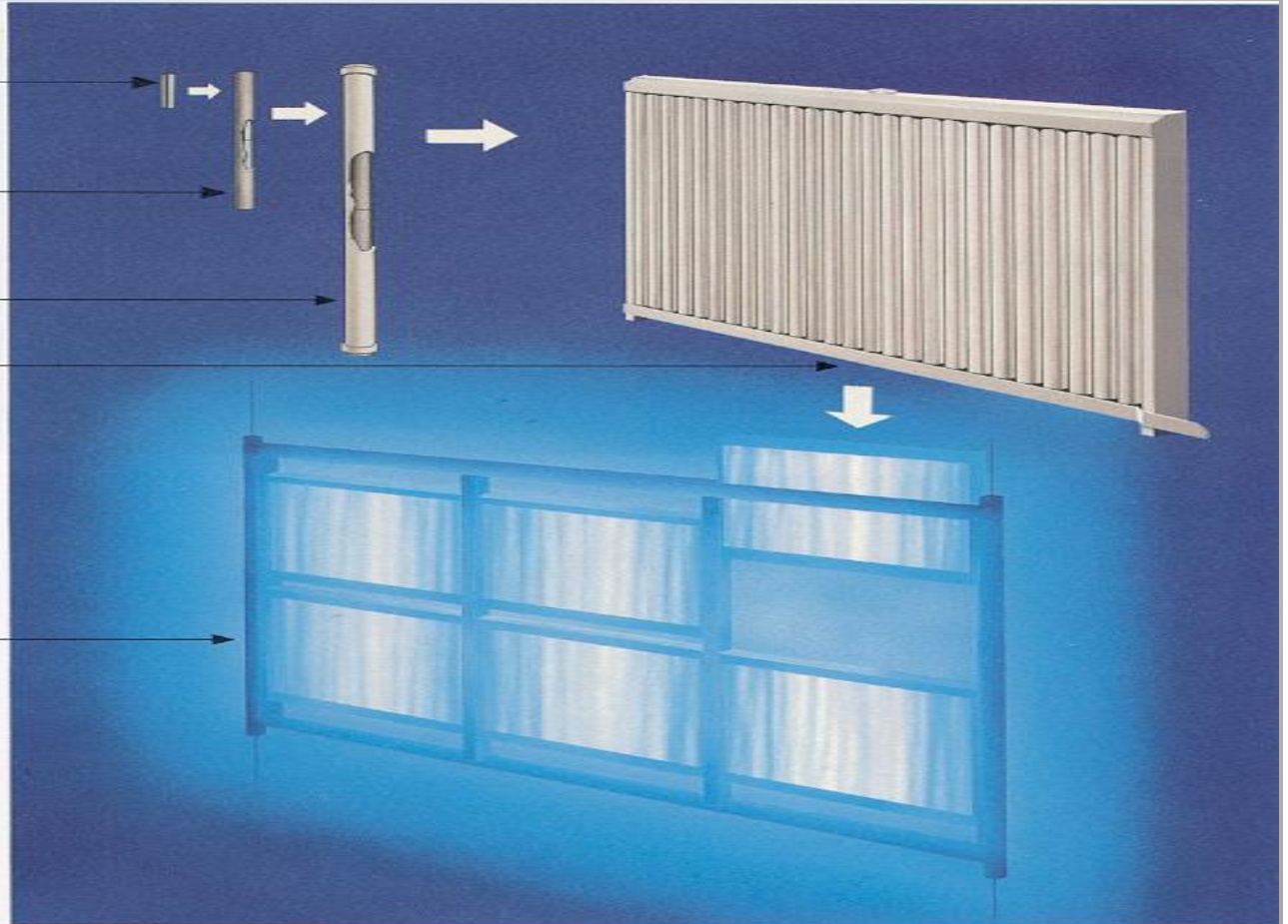
cobalt-60 source element
(an inner capsule containing slugs of cobalt-60)

source pencil
(contains 2 source elements)

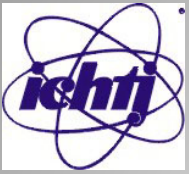
source module
(contains up to 48 source pencils)

source rack
(contains modules in different configurations, depending on irradiator design)

COBALT-60 SOURCES FOR INDUSTRIAL USE



Rack

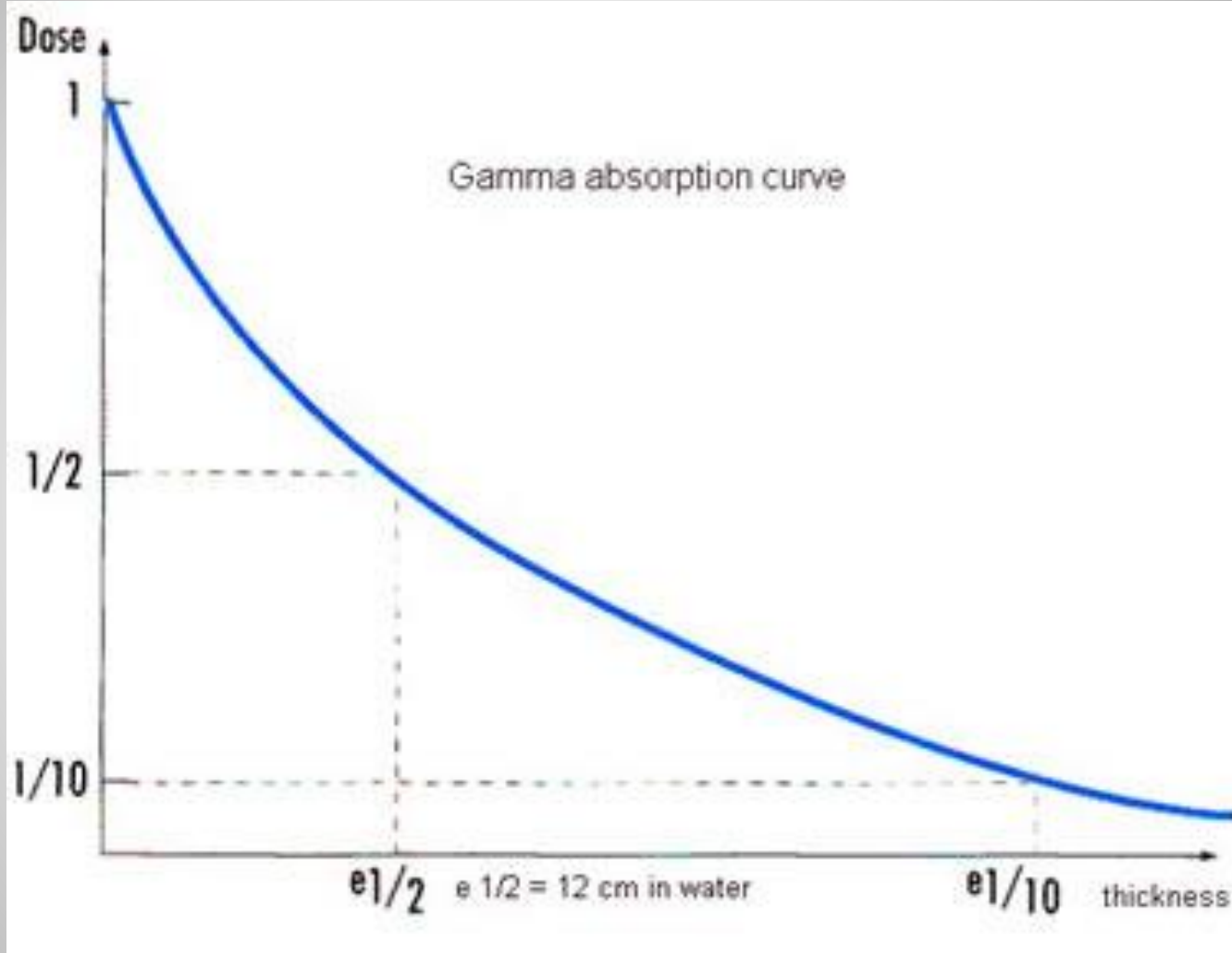
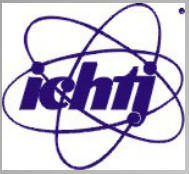


Source unloading

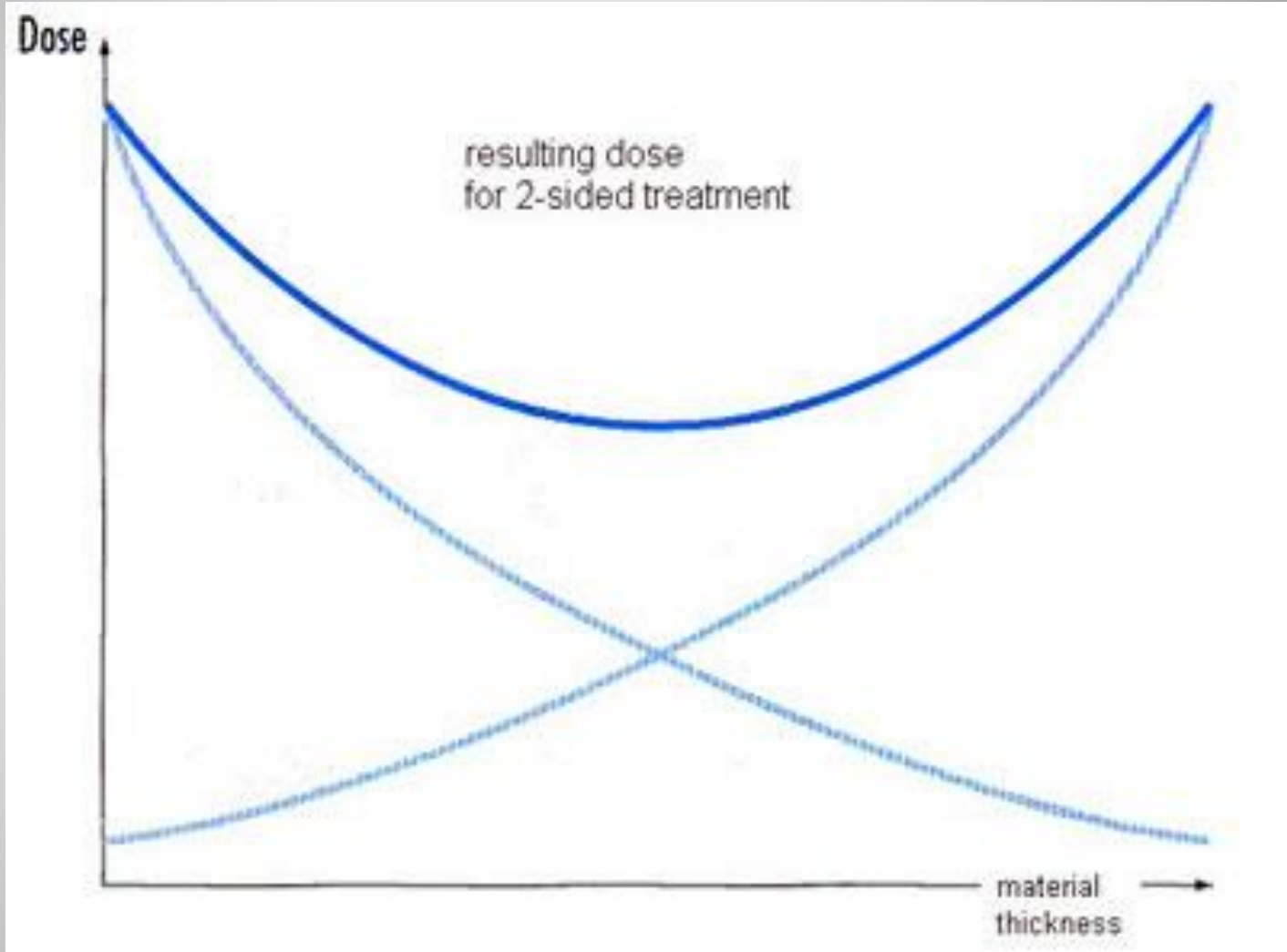
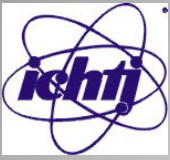




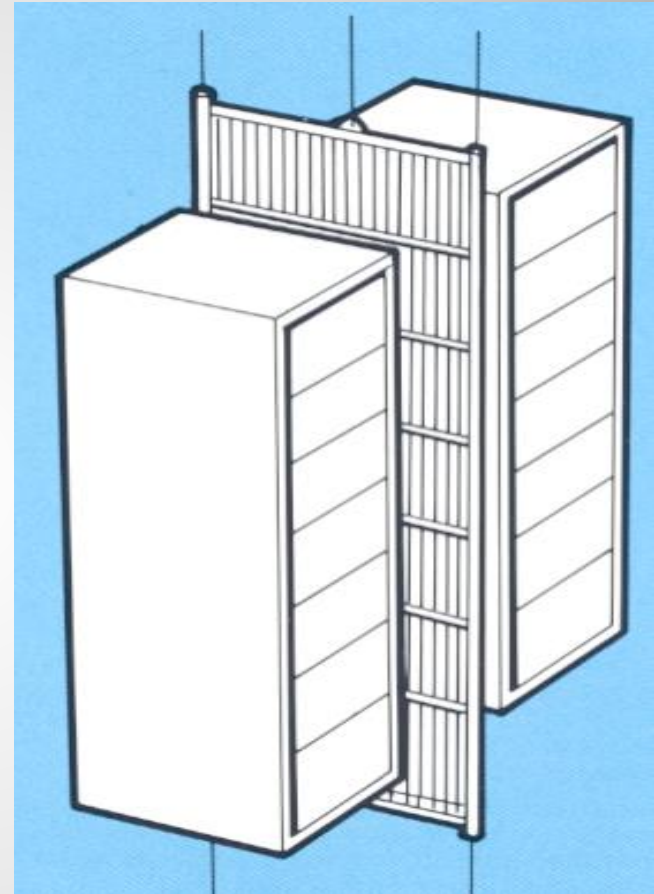
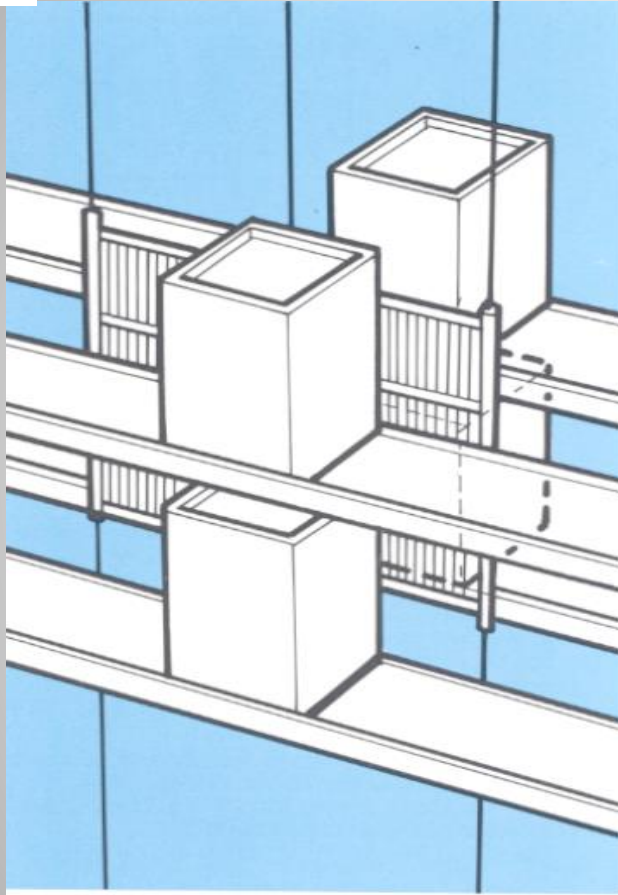
Source in store



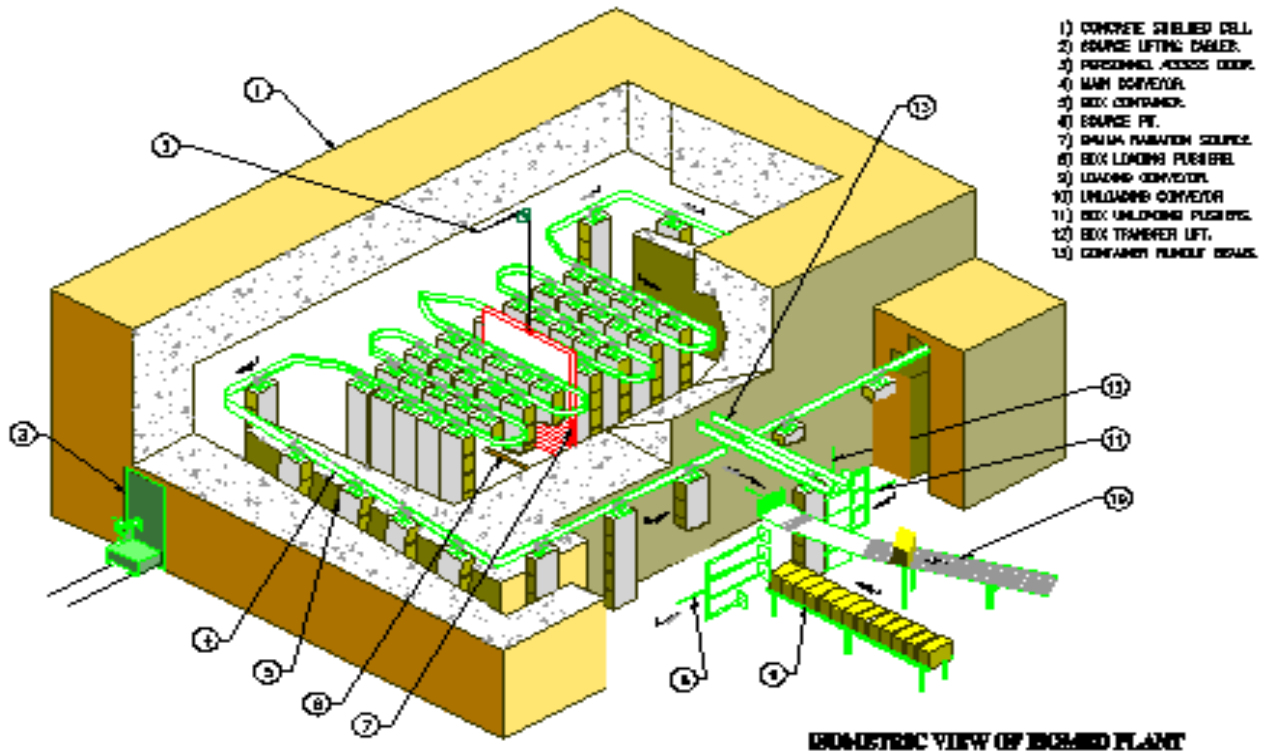
Radiation absorption



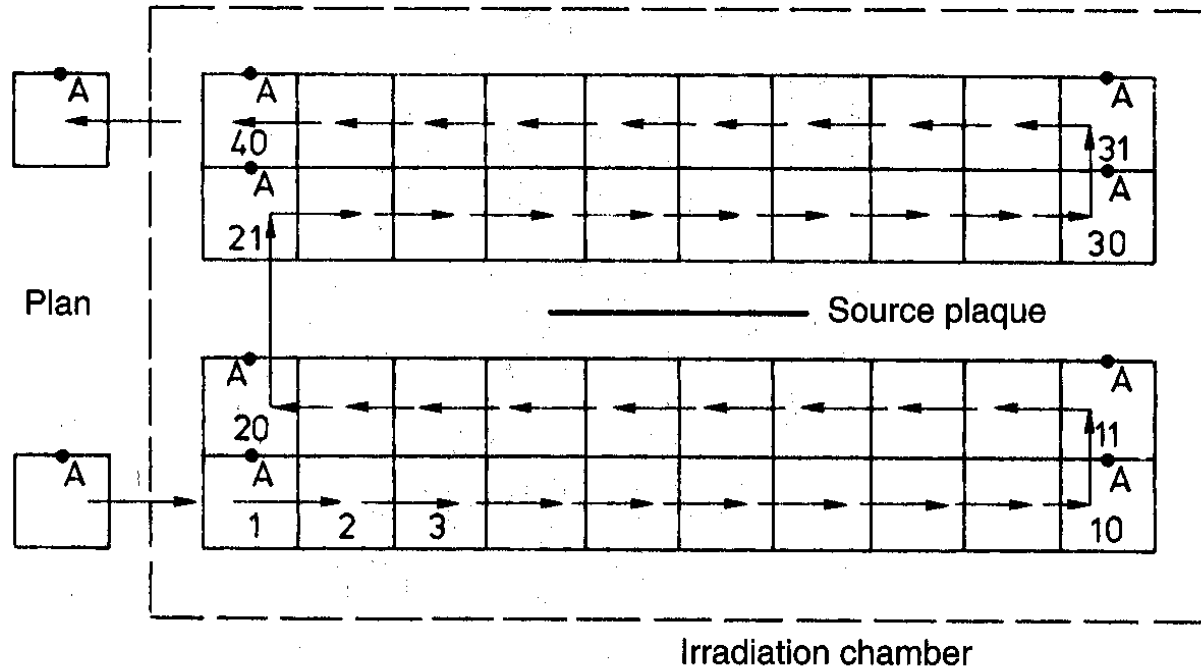
Double irradiation



Geometry (product - source)



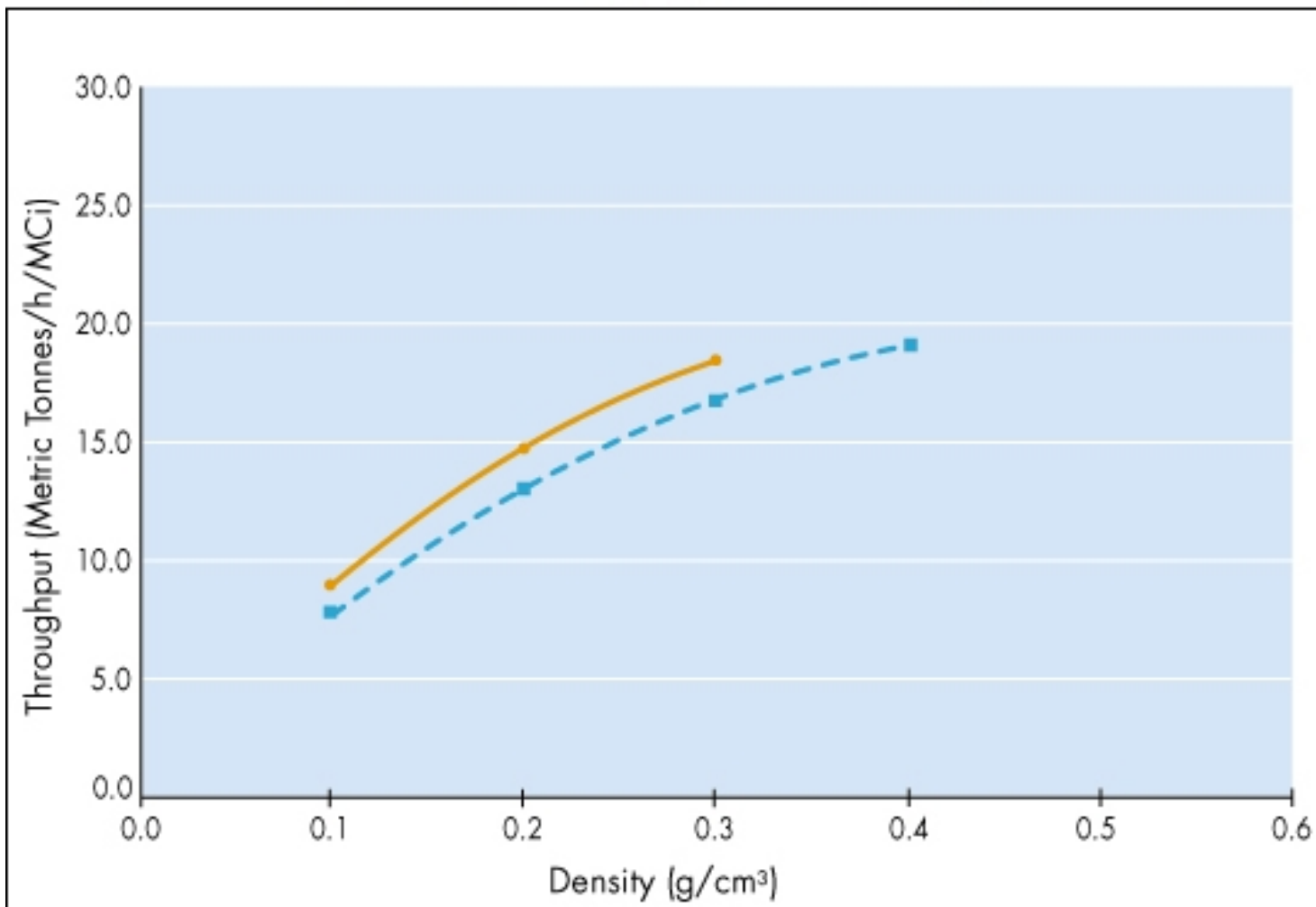
Product movement



Ruch produktu

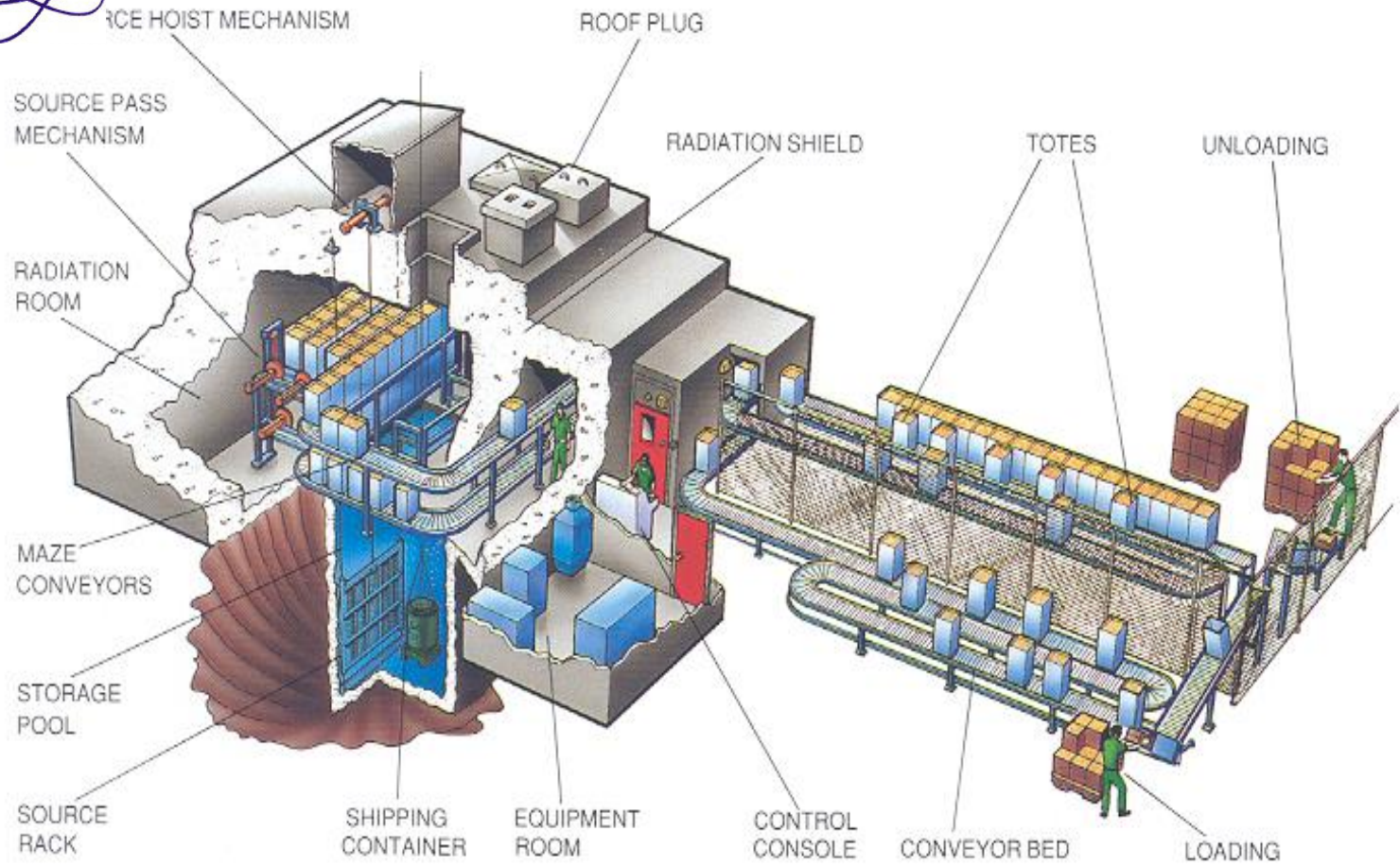


Mass Throughput at 1 kGy

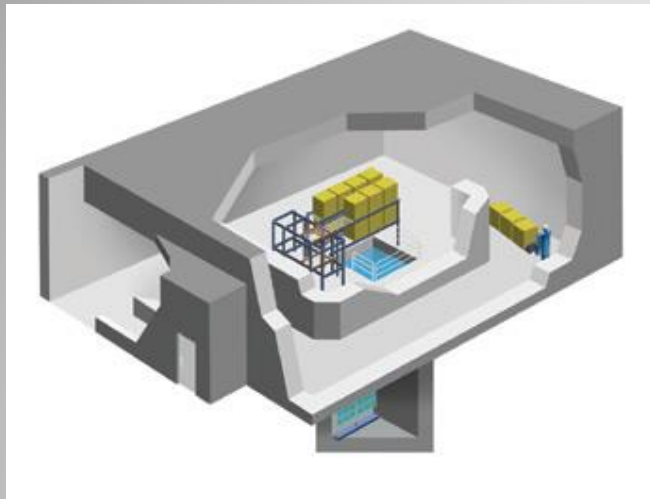


- JS-10000 hanging-tote irradiator
The JS-10000 hanging-tote irradiator provides large-scale manufacturers and gamma-processing service providers with the capacity to process high volumes of product-efficiently, effectively and reliably.
- JS-9500 and JS-9600 tote irradiators
Designed for small- to medium-sized manufacturers of products such as medical supplies, the JS-9500-and its larger-capacity alternative, the JS-9600-is a proven tote irradiator that treats diverse products in varied lots, regardless of packaging.

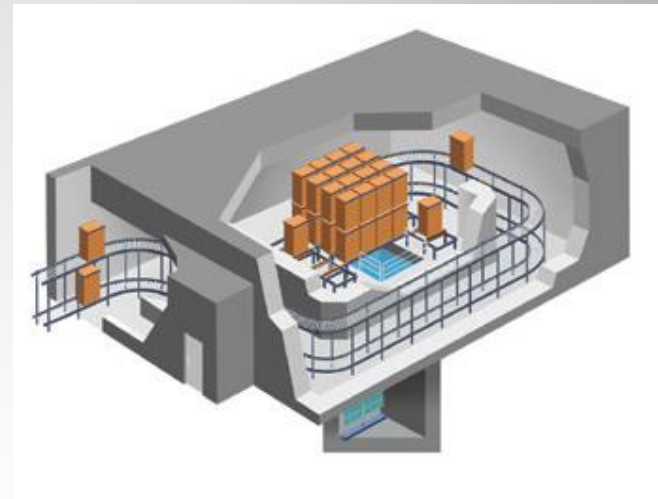
Gamma tote irradiators



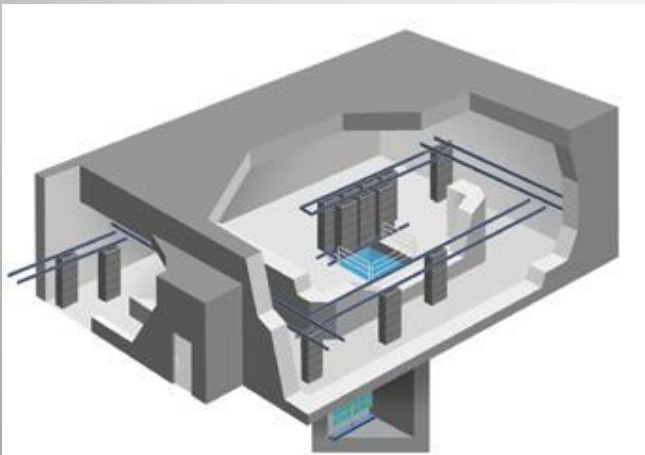
Industrial irradiator



Two-Pass Batch Tote



Four-Pass Automatic Tote



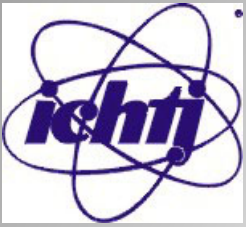
Two-Pass Automatic Carrier



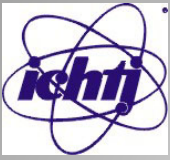
Automatic Pallet



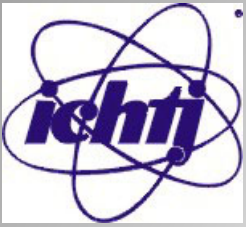
ISOMED



Palets uploading



Control room



Product uploading

Peru



Source of radiation Cobalt- 60

Irradiator storage Water

The maximal activity of an irradiator, Bq $3,7 \times 10^{15}$

The sizes of an irradiator, mm 1000×2000



- **Quadura™**

Quadura marks an exceptional advancement in food irradiation technology from MDN Nordion to help you grow your business and expand your markets. It delivers full-pallet processing, precise dose uniformity, maximum operational flexibility and efficiency and safe and effective product treatment.

- **Centurion food irradiator**
A high-throughput food-irradiation system for temperature-sensitive products, Centurion achieves exceptional dose uniformity-protecting consumers from harmful microorganisms in food products

Gamma pallet irradiators

Compact, simple and versatile small-scale irradiators makes it possible to incorporate state-of-the-art batch-processing capabilities into almost any manufacturing facility.

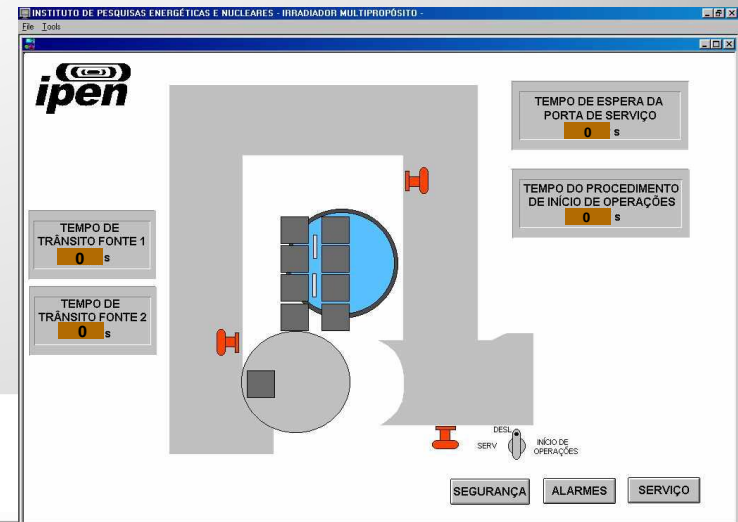
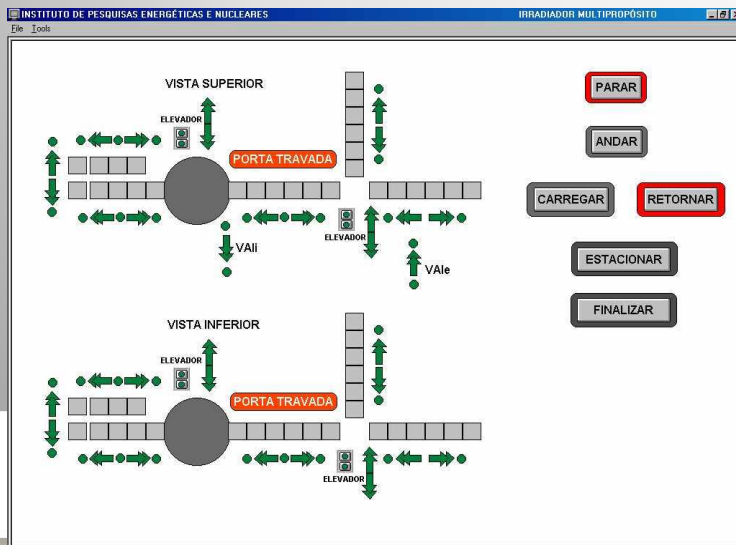
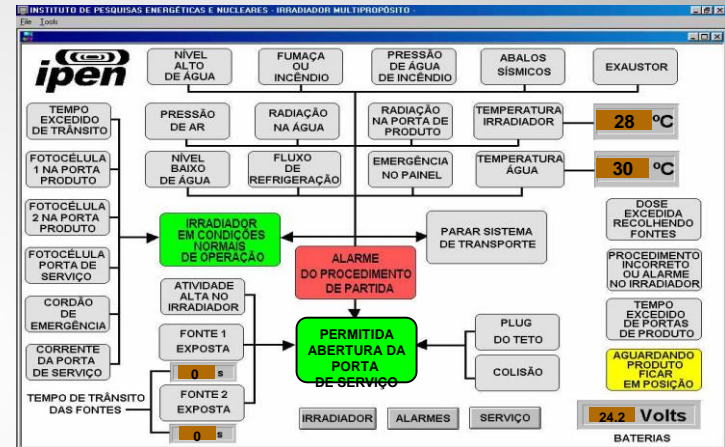
- **Brevion small-scale irradiator**
- **IPEN small-scale irradiator**

Mini gamma irradiators



Mini irradiator

Control panel



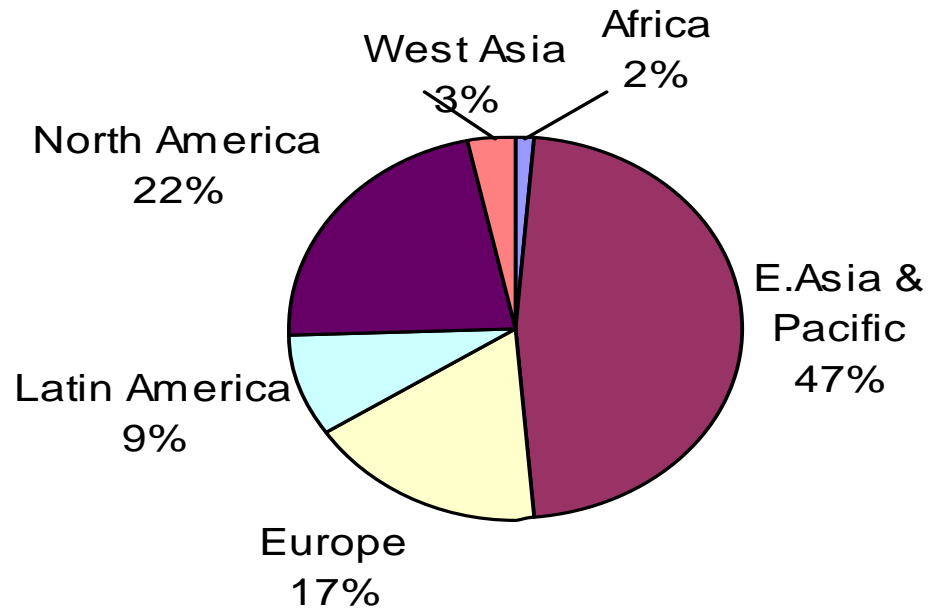


Type of source

- Source storage dry (10%) wet (90%)
- Source rack rectan. (86%) cylind. (10%)
- S.hoisting electr. (29%) pneum. (54%)
hydraulic (15%)
- Product transp. Pallets (11%) totes (35%)
carriers (50%)
- Oper.mode continuous (72%) batch (28%)

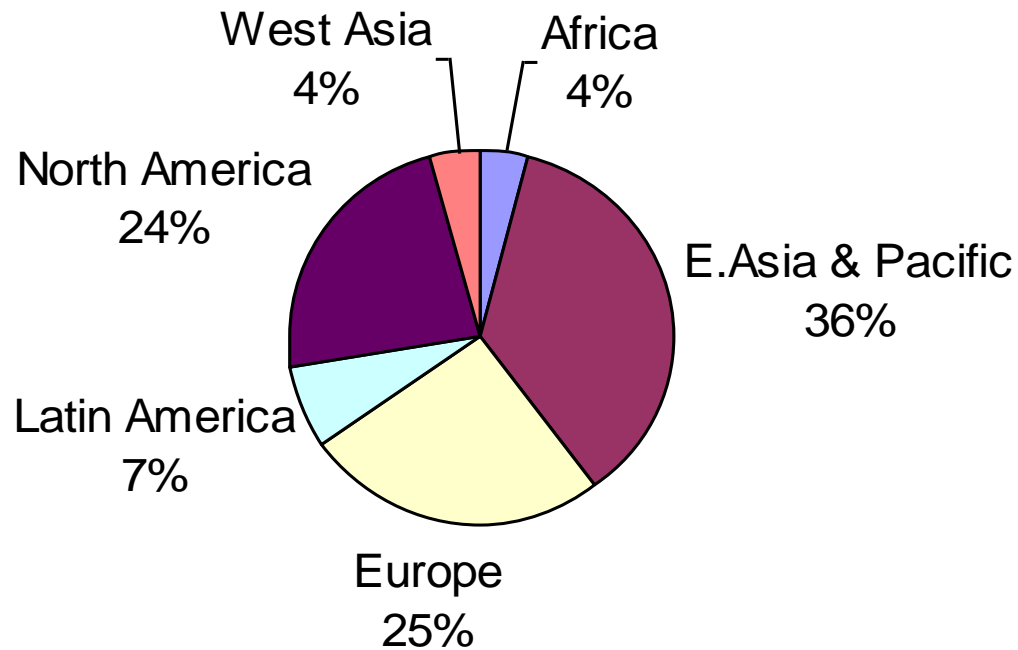


Growth of Industry since 1990



Growth by region

Regional distribution of irradiation units

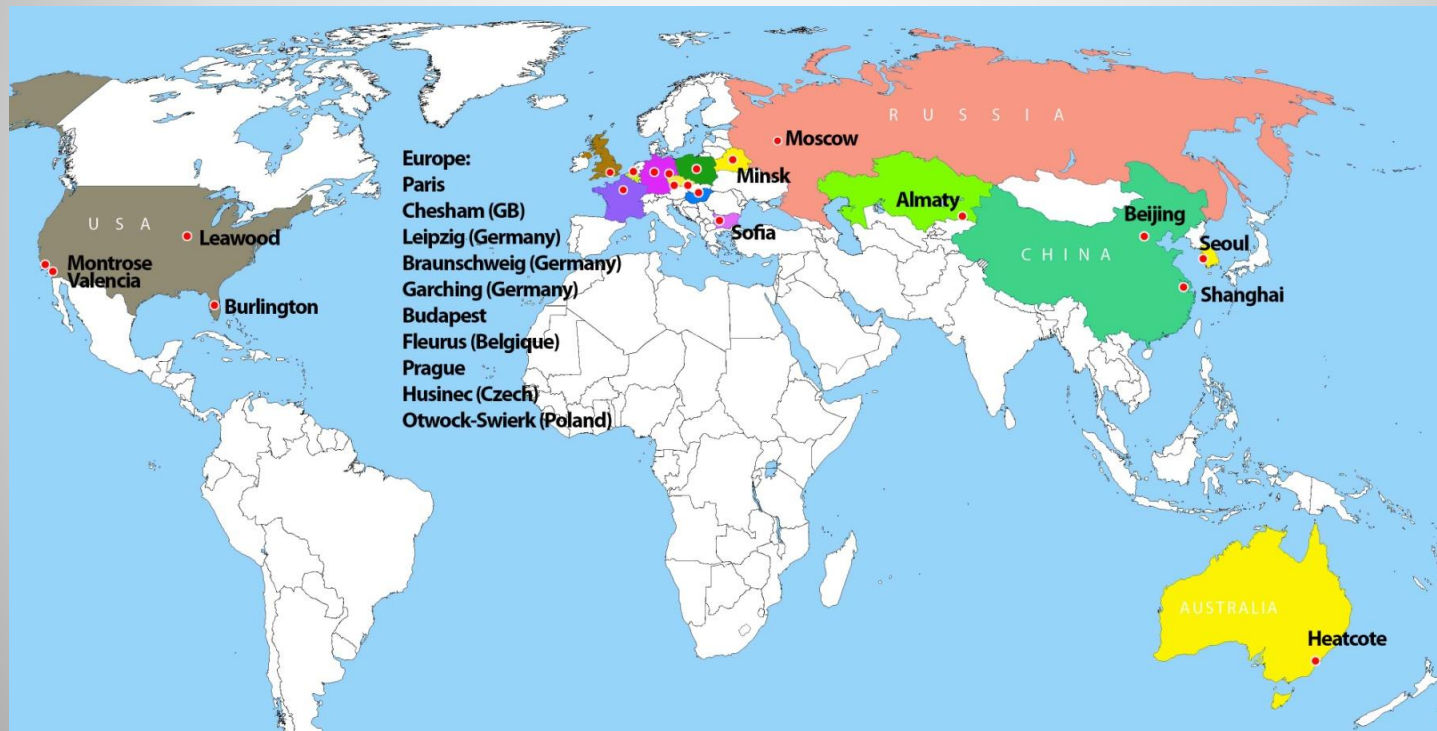


Regional distribution



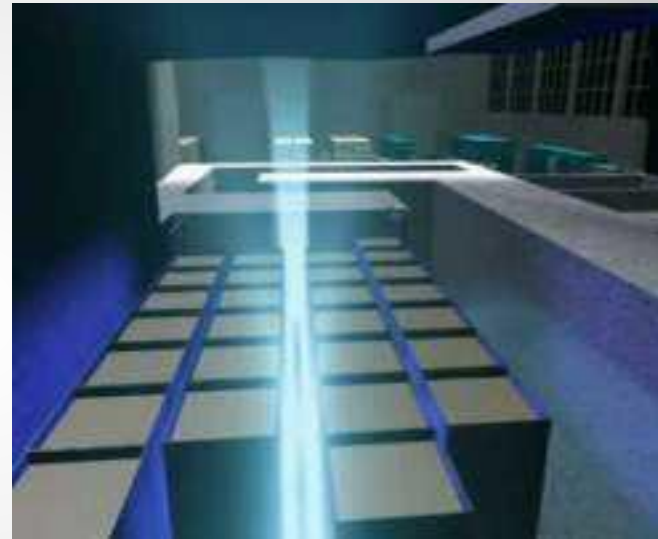
**All-Russian Scientific Research Institute of
Technical Physics and Automation (VNIITFA)**

Trans-Regional Izotop Association is authorized by Rosatom State Corporation





- This year Izotop Association has been implementing a field research project aimed at gamma irradiation sterilization in agriculture under the protocol agreed between Rosatom and Tatarstan government. Gamma sterilization of farm produce and livestock forage is one of our company's top priorities domestically

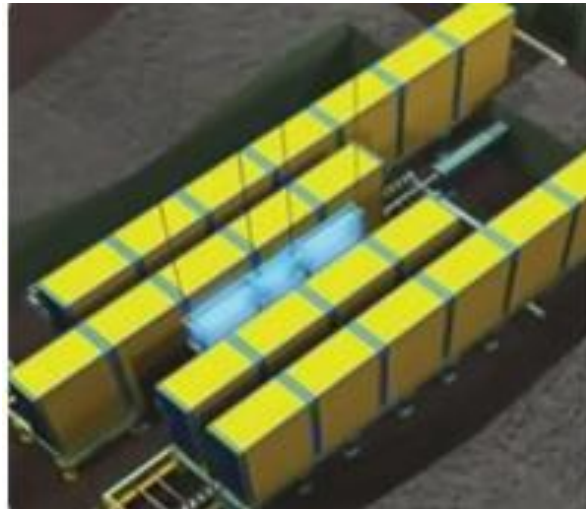


Institute of Isotopes Co., Ltd.

1121 Budapest, Konkoly Thege Miklós út 29-33.

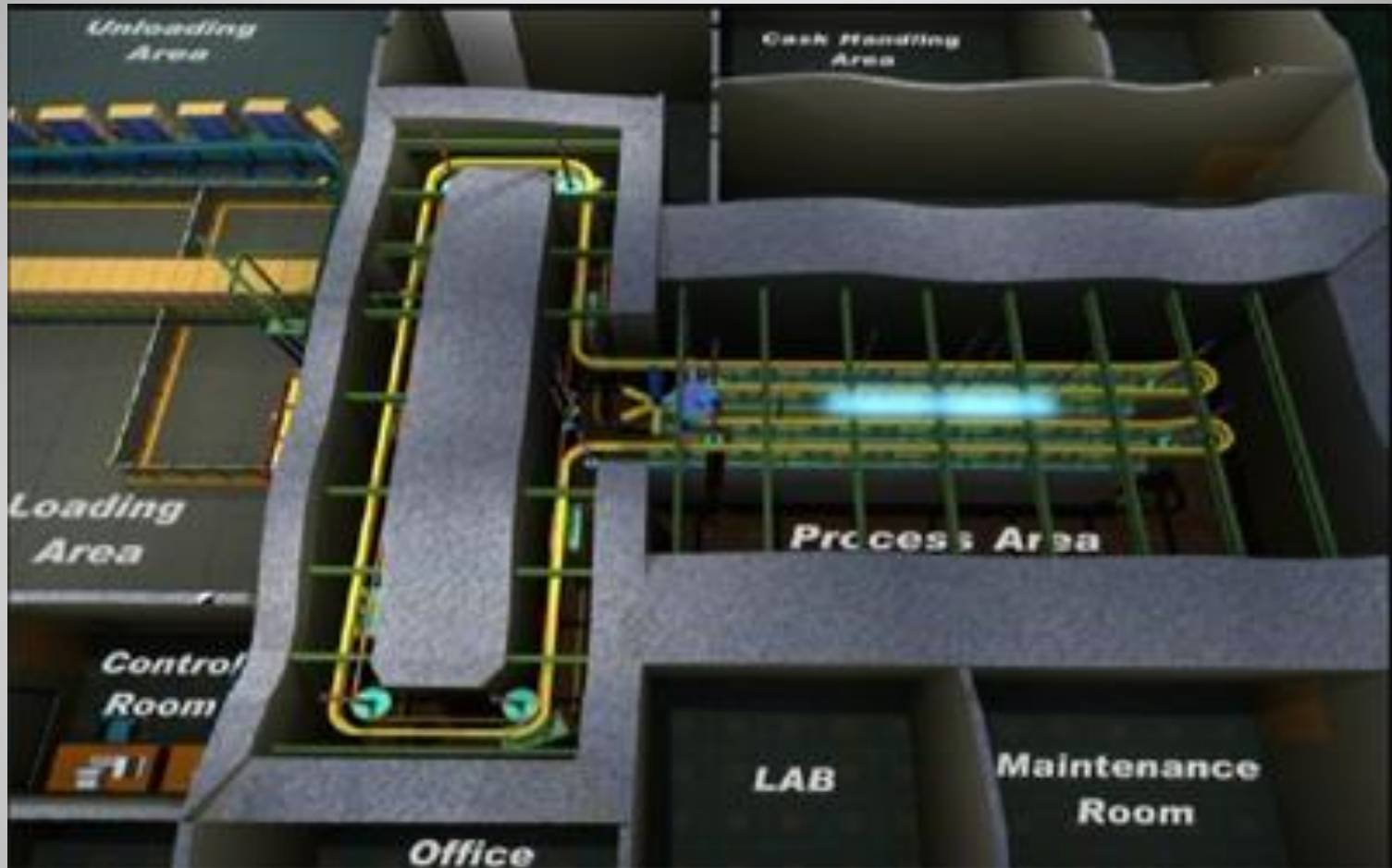


**SYMEC
ENGINEERS
(INDIA) PVT. LTD.**



- **The SYM-1 Model gamma Irradiation plant is a continuous, carrier type product overlap design plant which is optimized for medium to high dose products. This state of the art design can be also designed to also irradiate certain low dose products.**
- **Fully Automated PLC controlled Plant**
- **SCADA mimic for dose tracking, product box position etc**
- **Max Dose Range of 0.4 Kilo Gray – 25 Kilo Gray**
- **Max source strength: 3 Million curies**
- **Max Throughput : 66,000 Metric Tonnes /year**
- **Optional Split Source design for low dose irradiation**
- **Optional systems for automated/assisted loading and unloading of products**
- **Designed to Process Medical products, Pet food, spices, medicinal herbs and other high/ medium dose products**

SYM – 1 Carrier type continuous Gamma Irradiator



SYM – 1 Carrier type continuous Gamma Irradiator

- Service life of Co – 60 sources 20 years (RSL2089)
- Flat source rack
- Maximum total activity 74PBq(2 MCi)
- Product density 0.1 – 0.6 g/cm³
- Irradiation dose range 1 – 30 kGy
- DUR (1.2 for density up to 0.2 g/cm³, 1.87 for density up to 0.6 g/cm³)
- Aluminium tote boxes 1000 x 480 x 1500 mm
- Yield 32 boxes/hr (max) 187,400 m³/year

Hungaroster - Hungaroster.hu



- Consulting, planning
- Delivery
- Installation
- Commissioning

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