INTERNATIONAL NUCLEAR ATLANTIC CONFERENCE
INAC 2019 – XIV ENAN

Radiation Technology for Science and Industry

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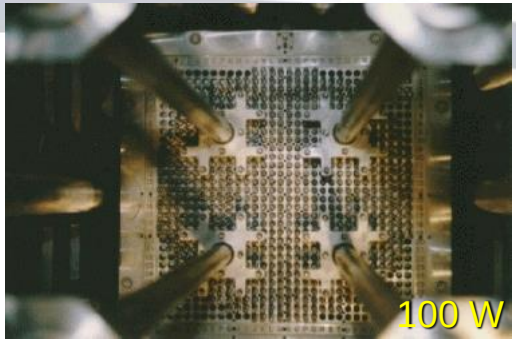
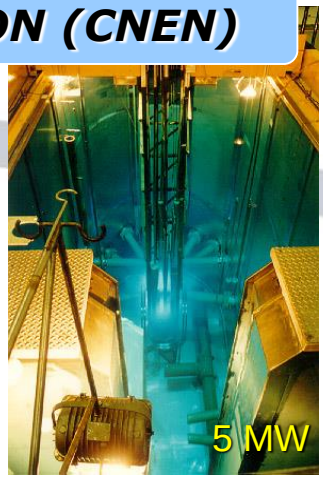
Nacional Nuclear Energy Commission
Nuclear and Energy Research Institute
IPEN-CNEN/SP

22/10/2019

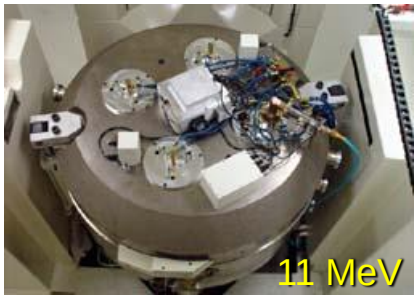
NATIONAL NUCLEAR ENERGY COMMISSION (CNEN)

☞ 4 R&D NUCLEAR REACTORS:
- ✓ 100 W - 5 MW





☞ 6 CYCLOTRONS:
- ✓ Siemens (11 MeV)
- ✓ IBA (18/9 MeV, 30 MeV)
- ✓ TCC (24 MeV)
- ✓ GE (18 MeV)



☞ 2 ELECTRON BEAM ACCELERATORS
- ✓ RDI (1.5 MeV)

☞ 5 GAMMA IRRADIATORS
- ✓ Multipurpose (2 MCi)
- ✓ Gammacell (12 kCi)
- ✓ Panoramics (5 kCi, 60 kCi)

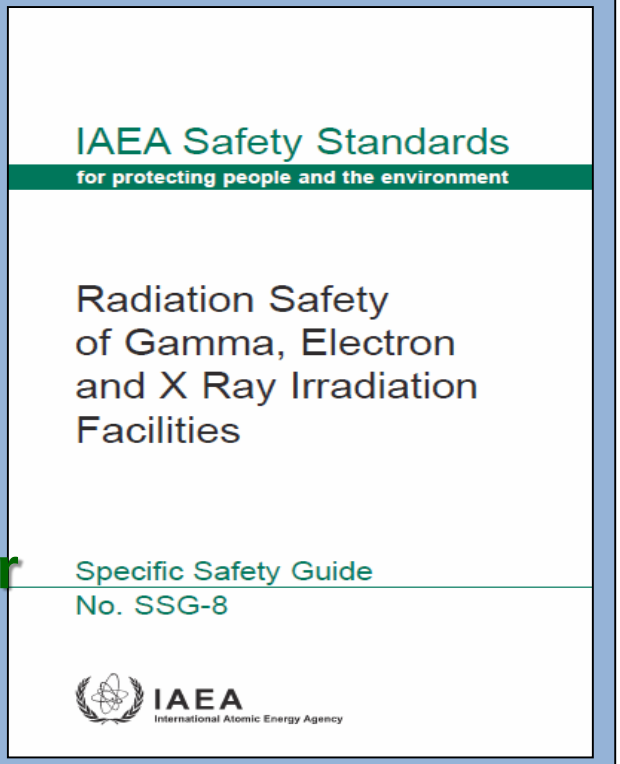
Source: CNEN

Safety Design, Construction and Operation

1. International Basic Safety Standards (BSS)
   - Protection against Ionizing Radiation
   - Safety of Radiation Sources

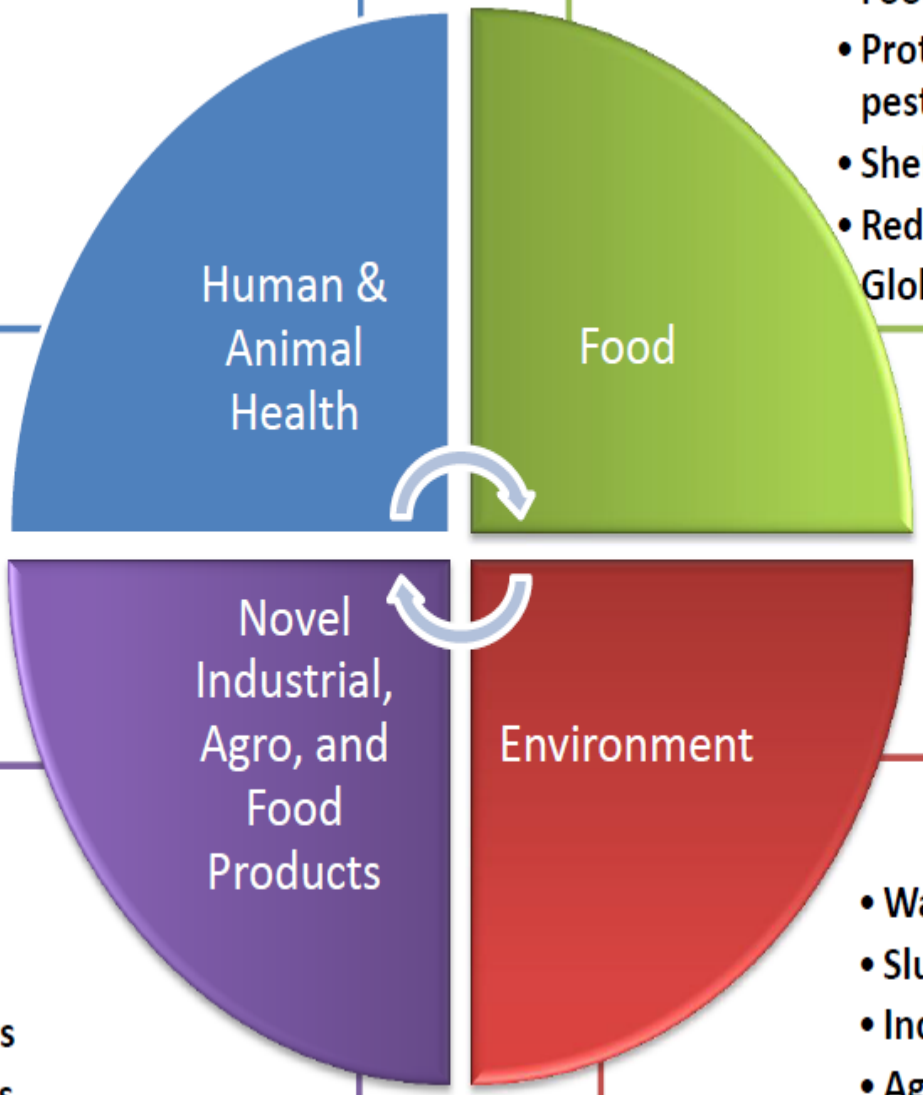
2. IAEA Safety Standards and Lessons Learned from Accidents in Industrial Irradiation Facilities

3. Safety Standards of the National Nuclear Energy Commission (CNEN) - Brazil



Source: IPEN-CNEN/SP

GAMMA RAYS AND ELECTRON BEAM TECHNOLOGY APPLICATIONS



- Vaccines
- Blood sterilization
- Pediatric Cancer diets
- Tissue transplantation
- Artificial Tissues
- Novel Biotherapeutics

- Food Pasteurization
- Protection against insects/ pests –Global trade
- Shelf-life extension
- Reducing food waste

Global Food Security

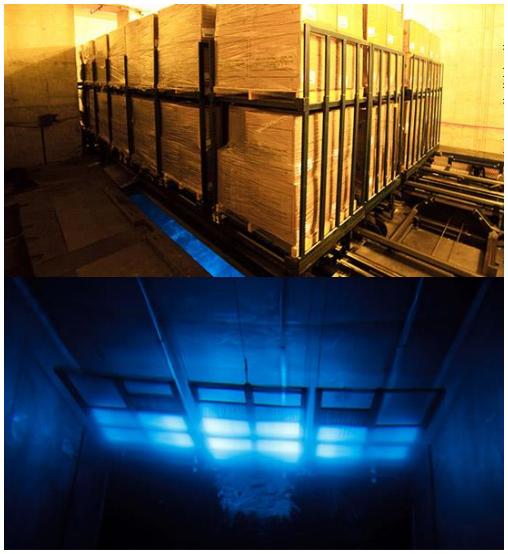
- Bioplastics
- Seed Enhancement
- Functionalized polymers
- Immobilized biofactories

- Water Reuse
- Sludge disinfection
- Industrial waste treatment
- Agriculture waste treatment

***Source*: Texas A&M University**

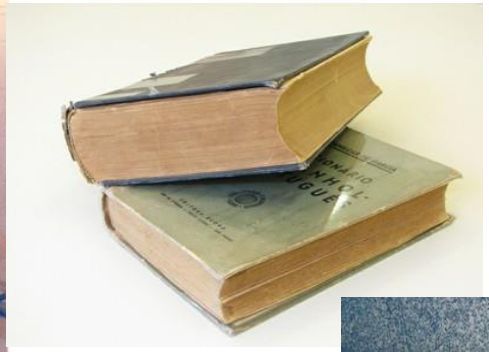
PALLET GAMMA IRRADIATOR

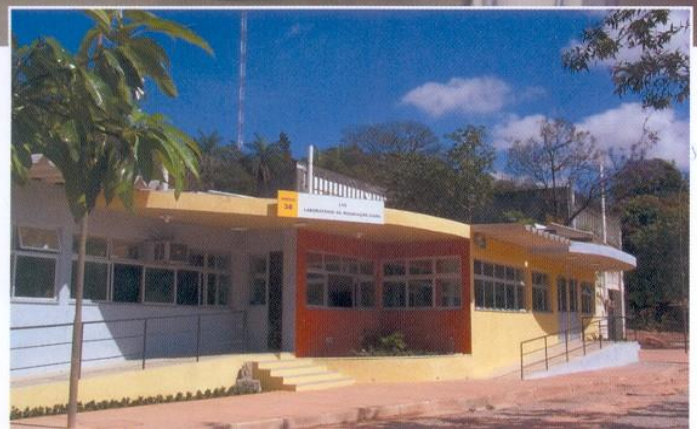
Brazilian Technology (3MCi)



***Source*: Sterigenics**

PANORAMIC GAMMA IRRADIATOR

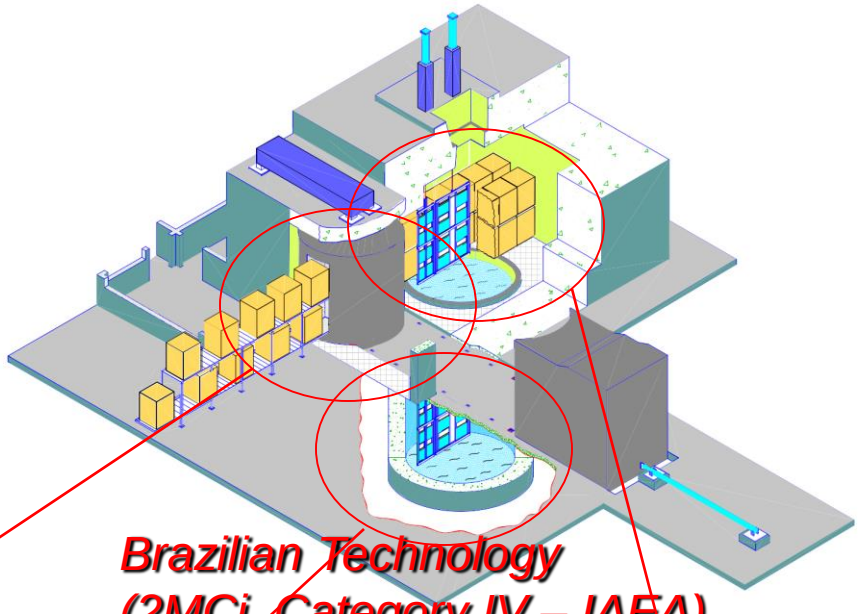




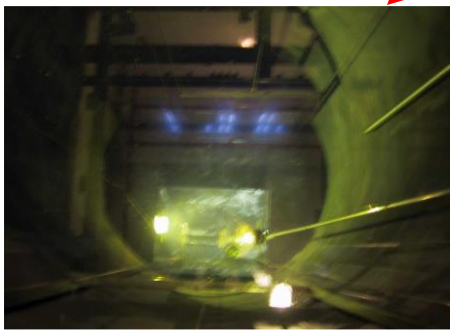
MDS Nordion/Canada
(Category II – AIEA)

***Source*: CDTN-CNEN/MG**

MULTIPURPOSE GAMMA IRRADIATOR



Brazilian Technology
(2MCi, Category IV – IAEA)



DUR / Efficiency:
1,33 / 11,6% (0,09g/cm^3)
2,08 / 36,6% (0,49g/cm^3)

Source: IPEN-CNEN/SP

RADIATION PROCESSING OF CULTURAL HERITAGE

Routine operations (semi-industrial scale)

- **Disinfestation and disinfection of cultural objects (books, furniture, sculptures and paintings)**

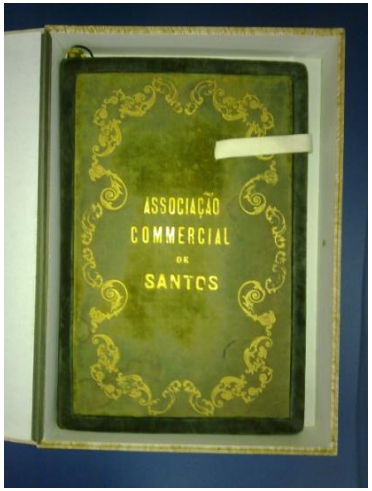


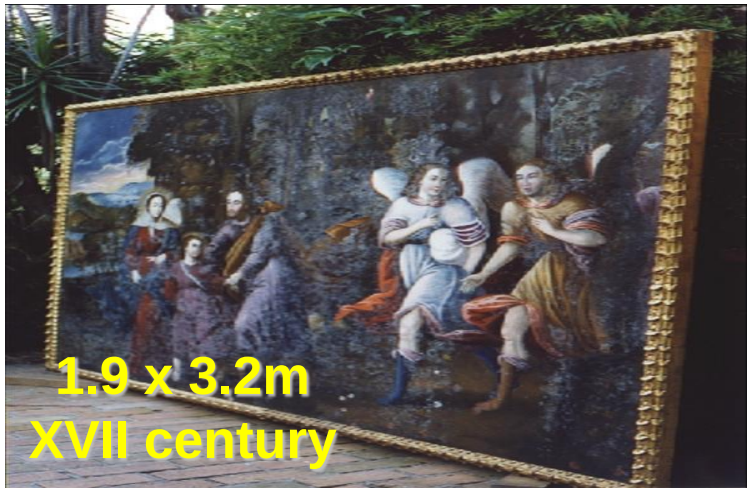


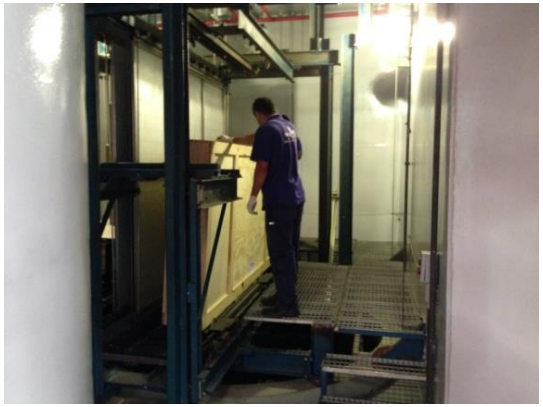

Source: IPEN-CNEN/SP

RADIATION PROCESSING OF CULTURAL HERITAGE

Extraordinary cultural objects irradiations





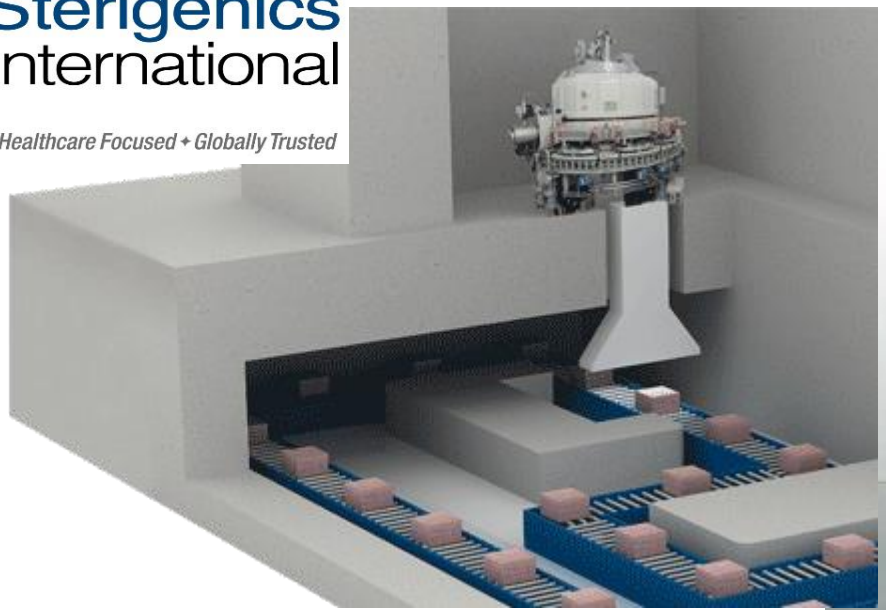


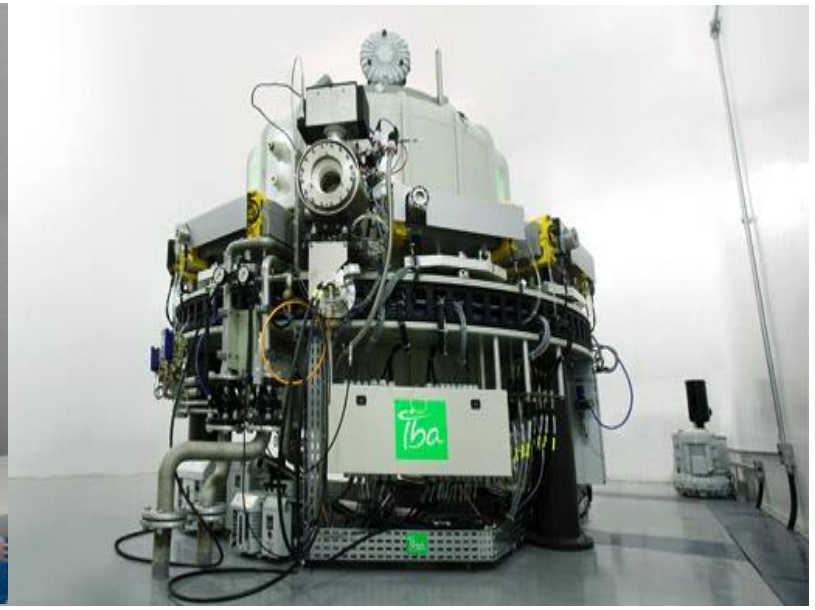
Source: IPEN-CNEN/SP

RHODOTRON TT200 (100 KW)

Sterigenics International

Science Driven + Healthcare Focused + Globally Trusted





Sterilized Medical Devices: 135.000 m³/year

***Source*: Sterigenics**

ELECTRON BEAM TECHNOLOGY APPLICATIONS

no Peroxides
less energy

better properties
less / no additives

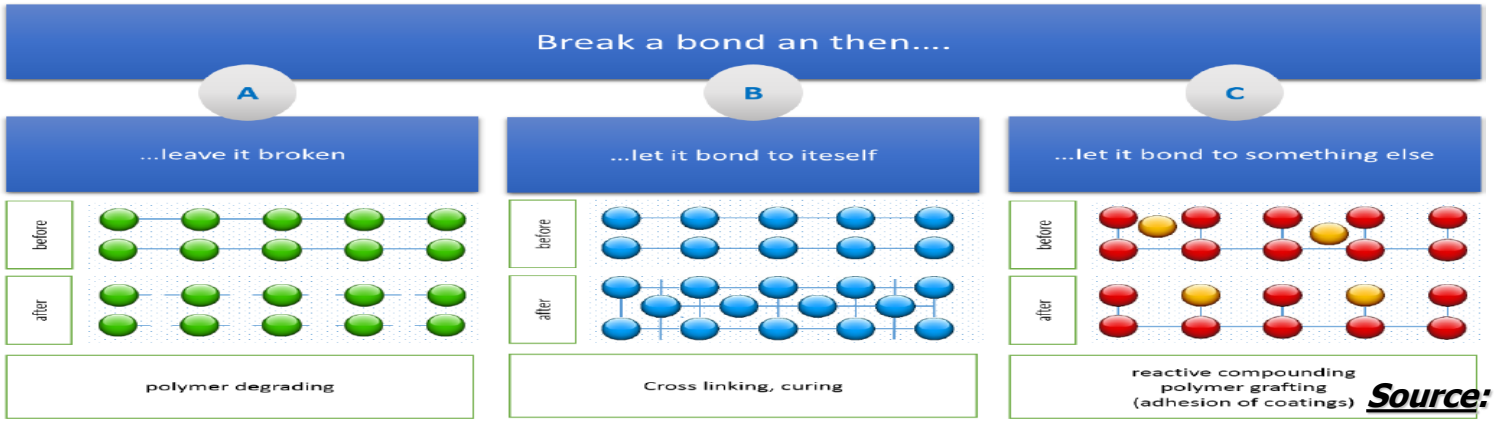
no UV-Initiators
less energy

better properties

no chemicals
less energy

no chemicals

processability
less material

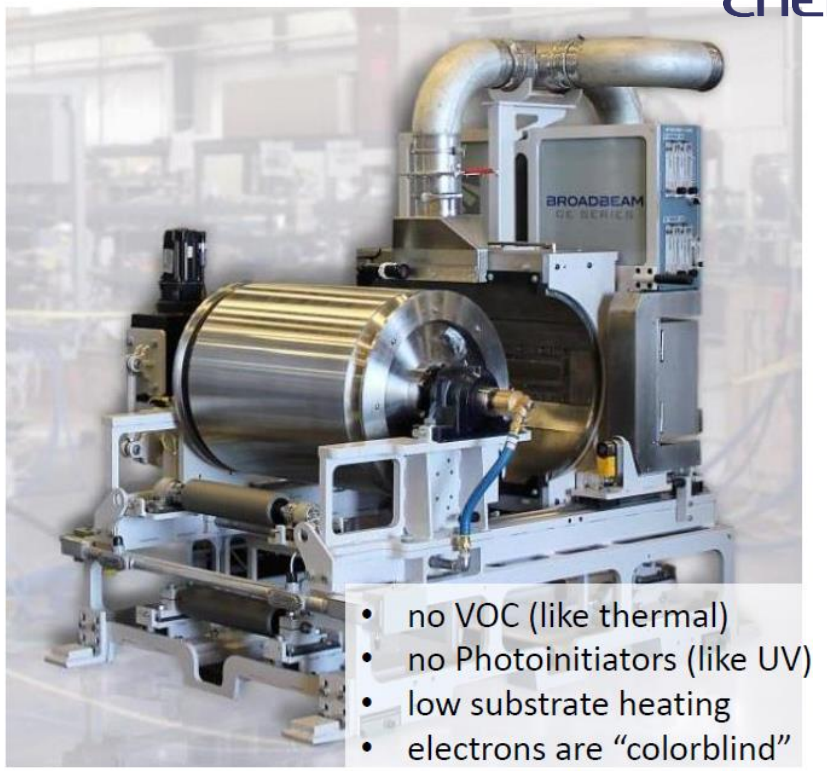


Source: COMET Ebeam

E-BEAM PRINTING AND CURING

RadTech South America

- **Integrated shield roll design**
  - With sealed e-beam Emitter
- **Features**
  - Energy: **80kV to 180kV**
  - Web width: **360mm**
  - Web speed **90m/min at 25kGy**
- **Applications**
  - Pilot / development lines
  - Narrow web printing presses
  - Presses for shrink sleeve labels



e⁵

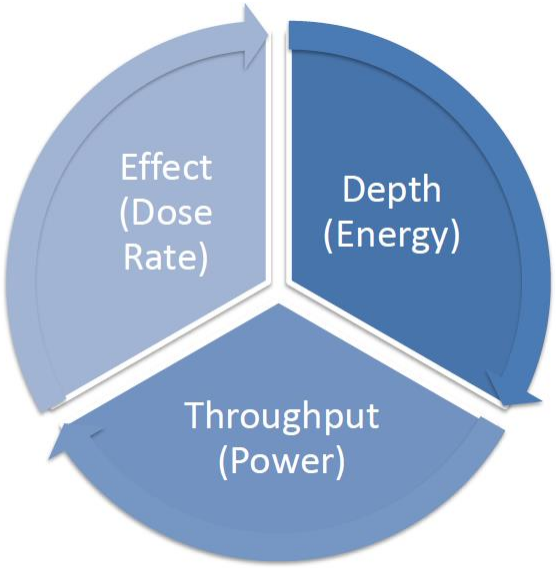
efficient

enabling

economical

energy savings

environmental friendly



- no VOC (like thermal)
- no Photoinitiators (like UV)
- low substrate heating
- electrons are "colorblind"
- higher speed

***Sources*: RadTech and COMET Ebeam**

HEAT SHRINKABLE TUBES IRRADIATION

SEMICONDUCTORS IRRADIATION and POLYMER DEGRADATION

***Source*: IAEA and IPEN-CNEN/SP**

BEAM TECHNOLOGY FOR POLLUTION CONTROL

Flue gas Purification

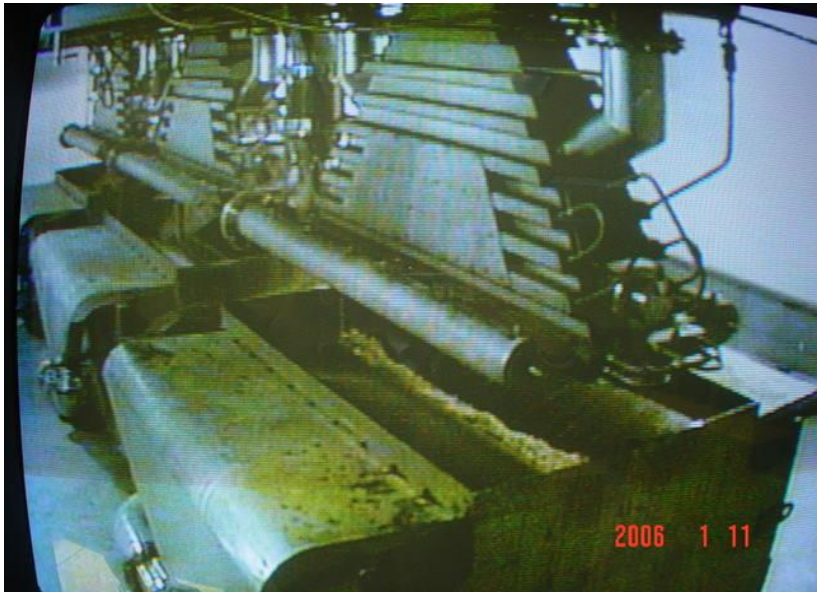
Wastewater Treatment

Sludge Hygienization

	Flue Gas Purification	Wastewater Treatment	Sludge Hygenization
Contaminants to clear	SO_2, NO_X, (Dioxin)	Complex COD, BOD, other	Disinfection of microorganism
Cleaning process	Simple	Limitation in depth Combined with others	Limitation in depth Handling system
Competition with other processes	Superiority proved in commercial plant	Complicate to analyze	Many advantages over chemical processes
Technology	Fully developed	Laboratory to pilot scale	Laboratory to pilot scale
Economies	Proved through pilot & commercial plant	Complicate to analyze	Complicate to analyze
By-product	Useful for fertilizer	Wastewater (less toxic) Reuse	Useful for fertilizer or soil treatment

Source: EB-Tech

WASTEWATER TREATMENT PLANT BY E-BEAM Dyeing Industrial Complex/KOREA (10,000 m³/day)



⇒ Electron Beam: 1MeV, 400kW

Source: IAEA and EB-Tech

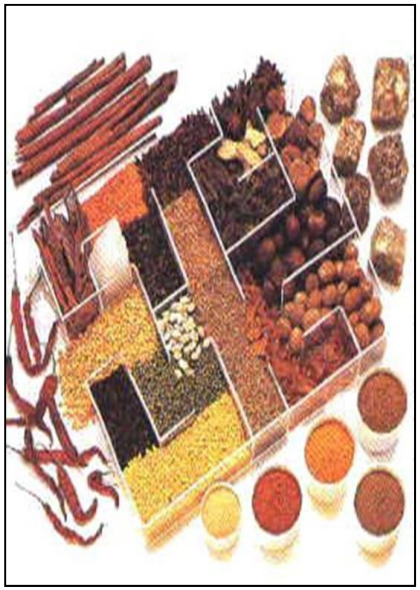
FOOD IRRADIATION

Current Production Volumes of Irradiated Food Stuffs

Region	Volumes (Metric tons)	Market Condition
USA	175,000	Flat
EU	198,000	Declining
Asia	450,000	Increasing

92% of food stuffs are treated with Cobalt-60. Only 8% is represented by E-beam

Latina America Caribbean > 100,000 tons



Spices

Medicinal herbs

Mango (Mexico)

Food industry are looking for EB or X-ray machines:

- Lower capital cost
- Reliable
- Simple enough to operate
- Lower cost of operation
- Compact enough to integrate in existing
- Production in-line or a packing house space

Source: L3

Final Remarks

- ✓ Rhodotron Duo (EB, X-ray)
- ✓ Mobiles E-Beam Accelerators

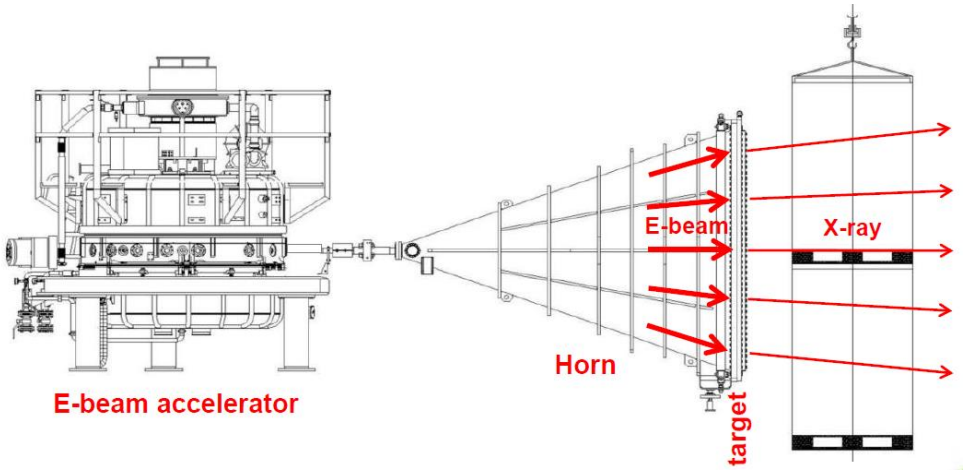
X-RAY CONFIGURATIONS

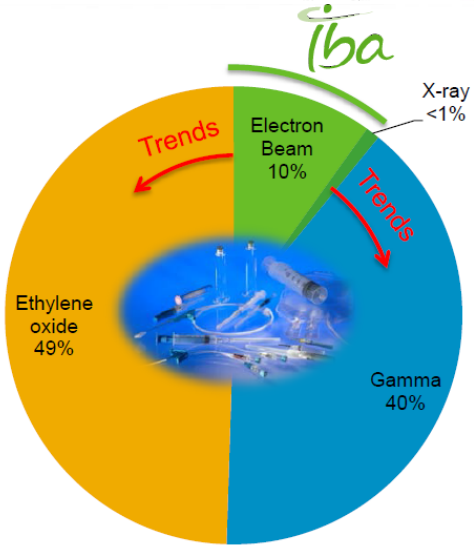
eXelis X-ray
5 or 7 MeV X-ray
Pallets

X-ray lateral irradiation

Rhodotron Duo
10 MeV E-beam
+ 5 or 7 MeV X-ray
Boxes

E-beam and X-ray top irradiation



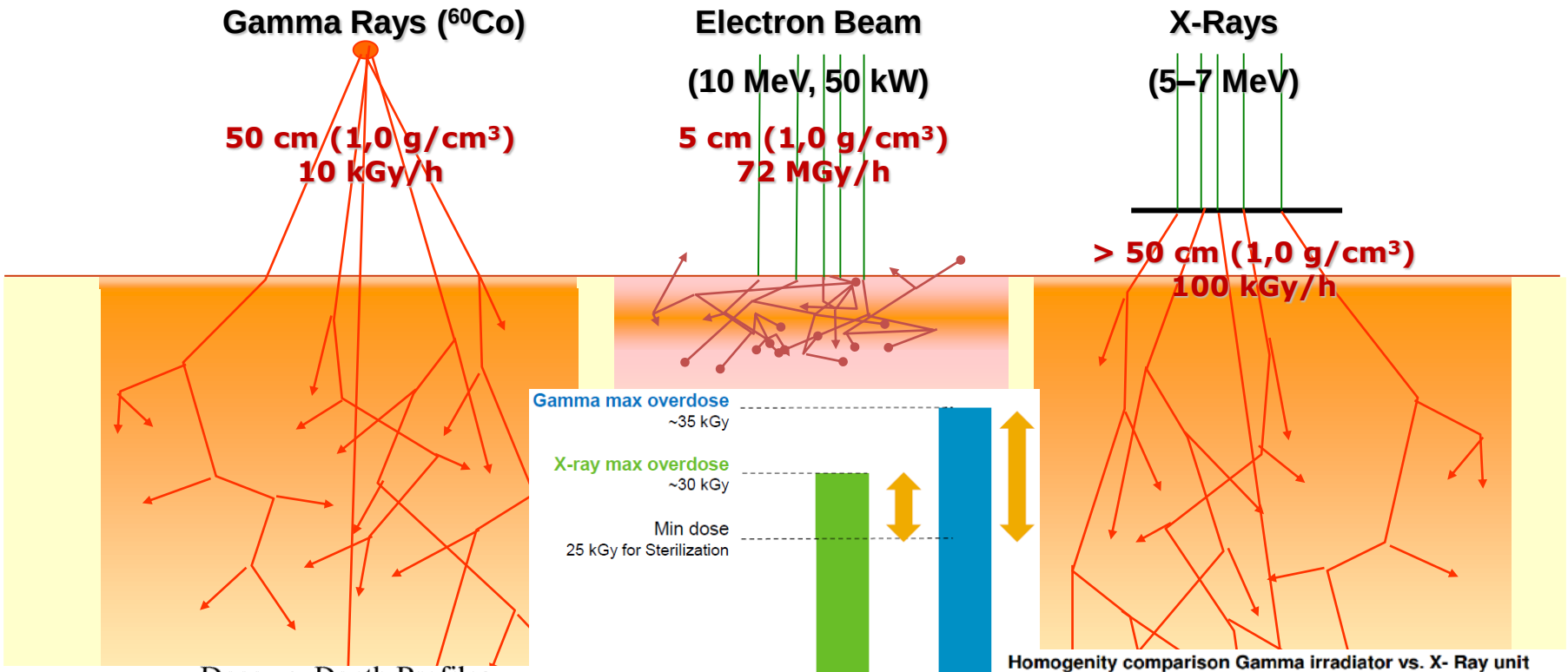


Volume of Sterilized Single Use Medical Devices

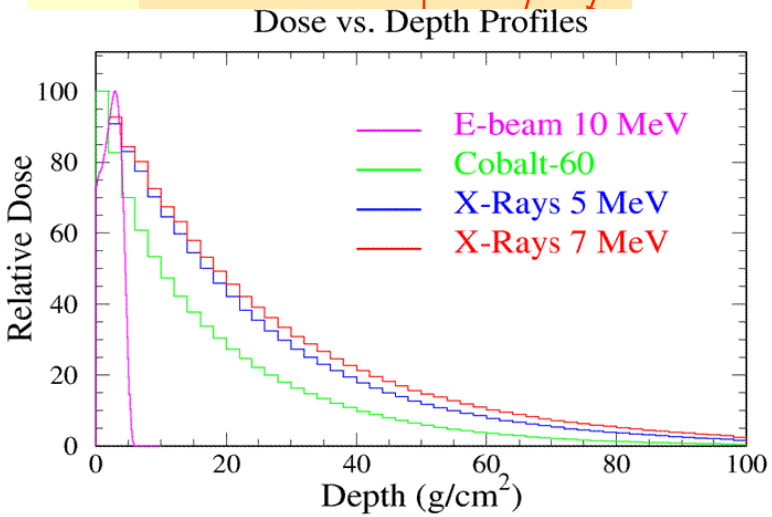
E-beam/X-ray market is **growing 1.5 to 2 times faster** compared with the global sterilization market

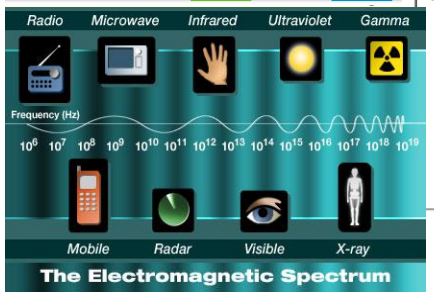
***Source*: IBA**

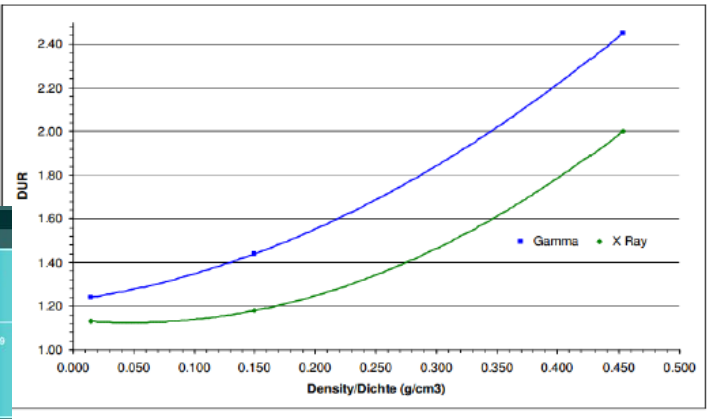
GAMMA RAYS, ELECTRON BEAM AND X-RAYS



Homogenity comparison Gamma irradiator vs. X- Ray unit







***Source*: IBA and IPEN-CNEN/SP**

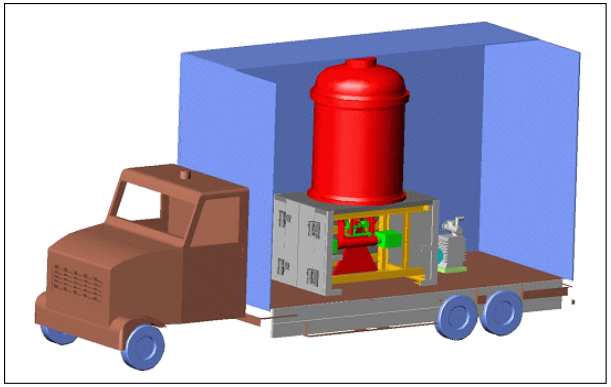
MOBILE ELECTRON BEAM ACCELERATOR

Laboratorial scale experiments (1~50m³/day)

Laboratorial scale experiments (1~10,000Nm³/h)

Pilot scale experiments (500~1,000m³/day)

- Cost
- Space
- Operation & Maintenance, other

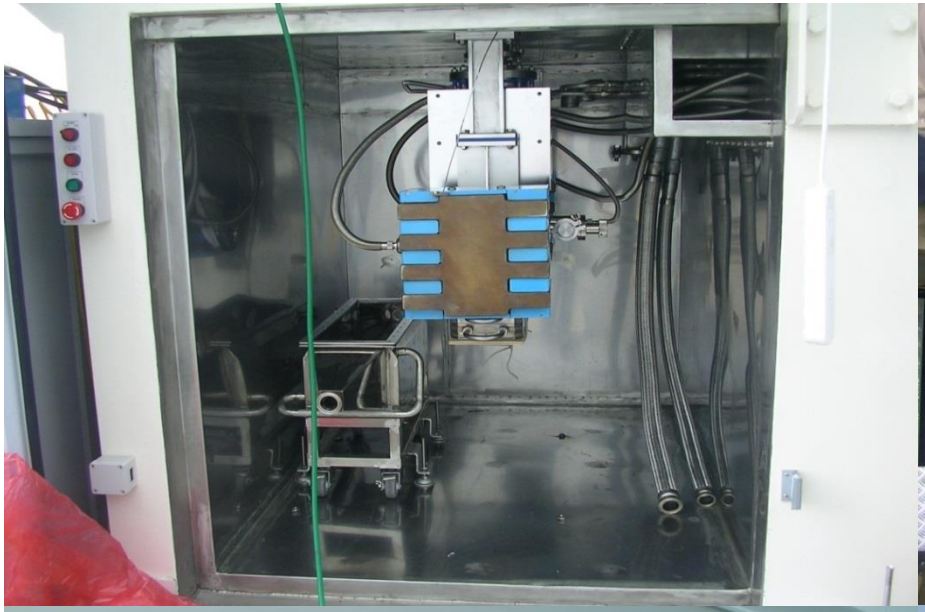


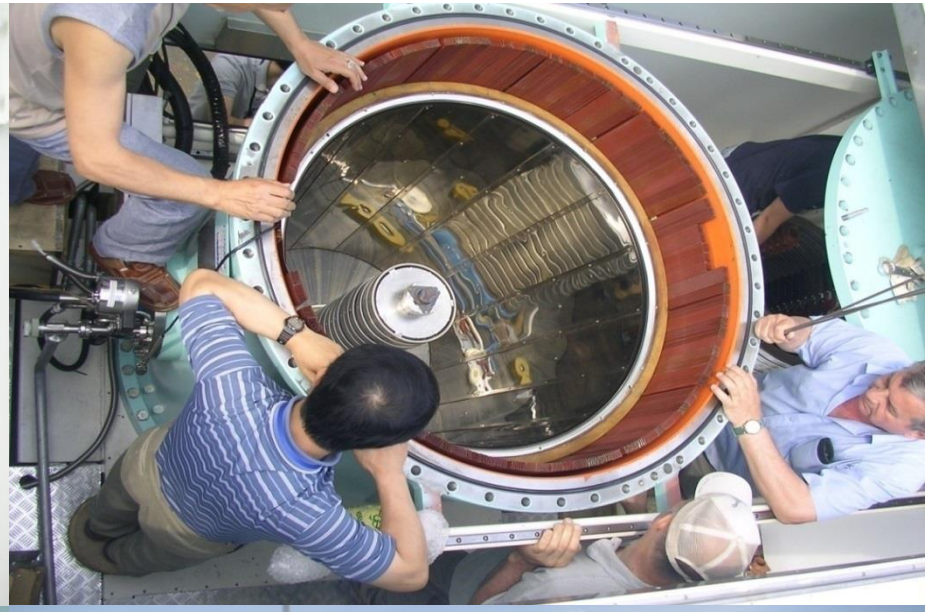
Industrial scale wastewater plant (10,000m³/day)

Industrial scale EBFGT Plant (~600,000Nm³/h)

Source: EB-Tech

MOBILE ELECTRON BEAM ACCELERATOR





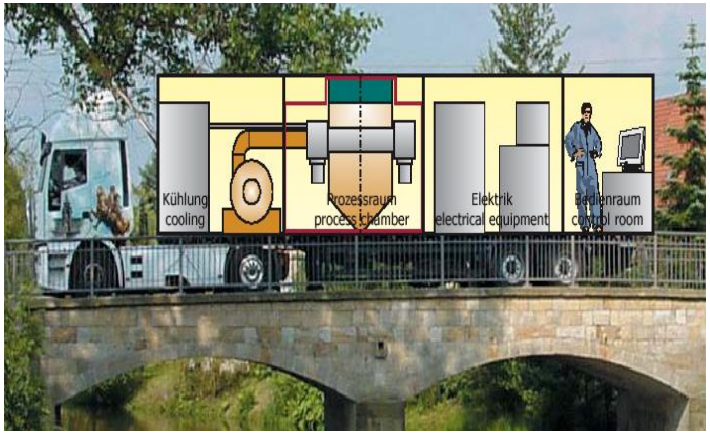
- Beam Energy: 0.4 ~ 0.7 MeV
- Beam Power: 20 kW
- Total weight: 40 tons

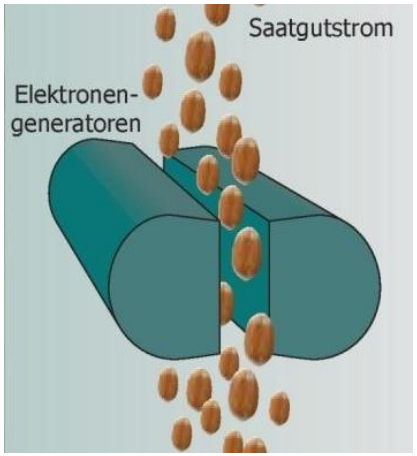
Source: EB-Tech

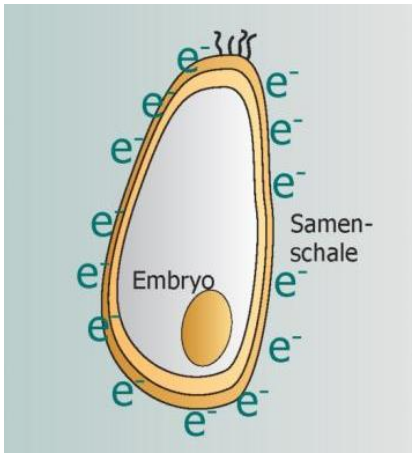
MOBILE E-BEAM IN FLUE GAS PURIFICATION FROM OIL-REFINERY IN SAUDI ARABIA

***Source*: EB-Tech**

ELECTRON TREATMENT OF SEED







IPEN

WORKSHOP ACCELERATED ELECTRONS FOR LIFE
06-07 November, 2017

- **Penetration of episperm by electrons with precise depth control**
- **Embryo keeps untouched**

- **Mobile treatment plant**
  - **Continuous treatment on air**
  - **Throughput: 30 t/h**
  - **2 line emitting sources (150keV/30kW)**

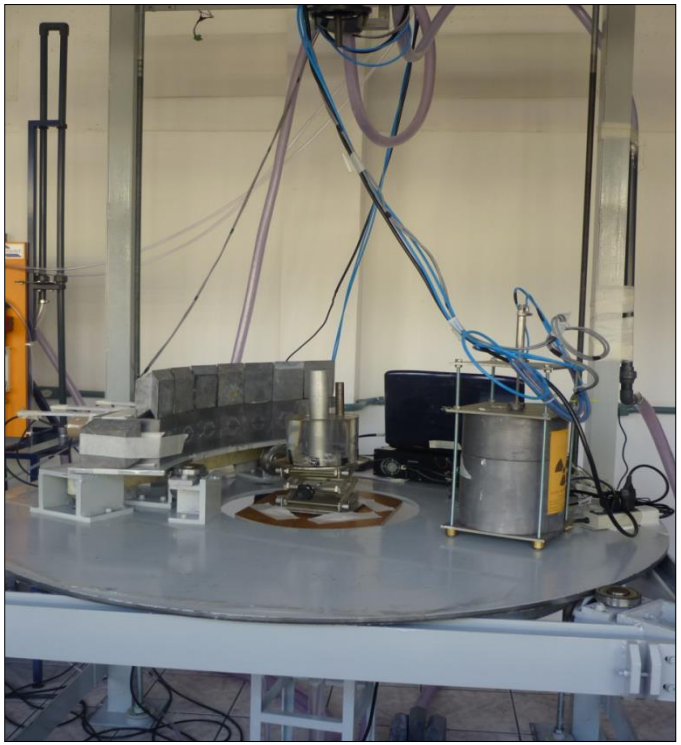
***Source*: Fraunhofer Institut-FEP (Seed-Health@fep.fraunhofer.de)**

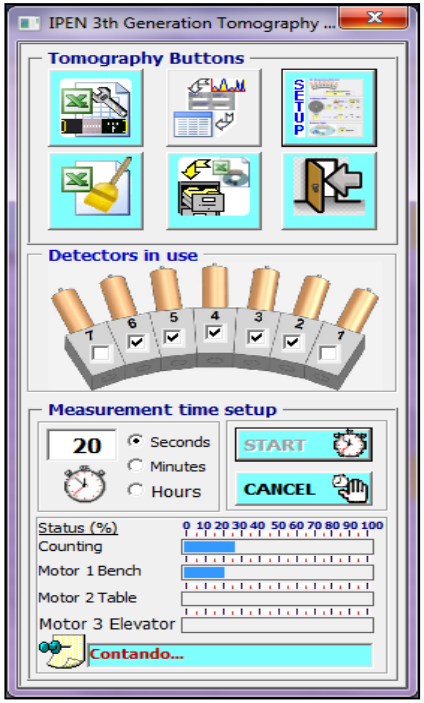
MOBILE UNIT WITH AN ELECTRON BEAM ACCELERATOR TO TREAT INDUSTRIAL EFFLUENTS FOR REUSE PURPOSES IN BRAZIL

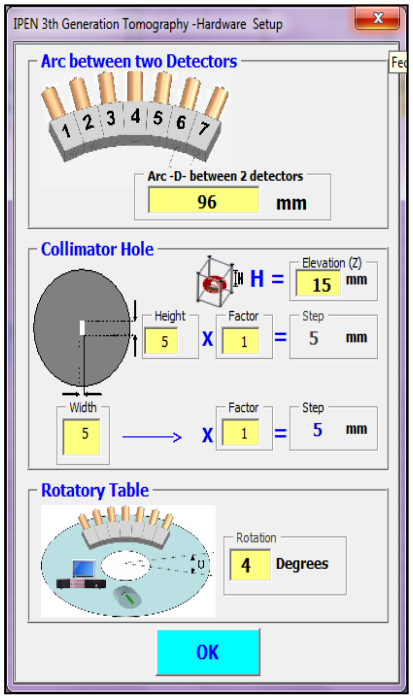
***Sources*: Truckvan, IPEN-CNEN/SP**

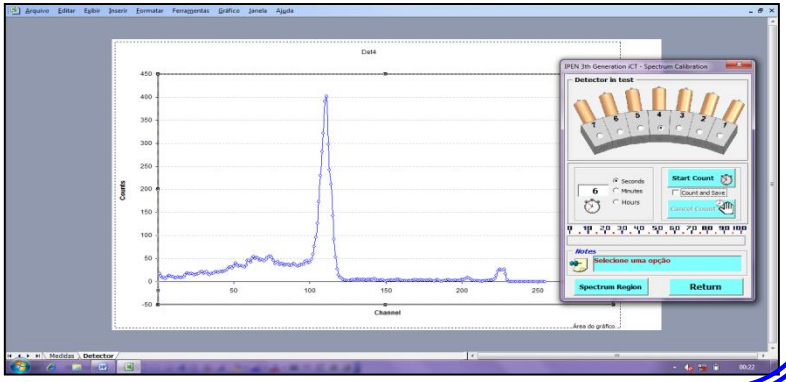
BRAZIL

THIRD-GENERATION INDUSTRIAL CT SCANNER





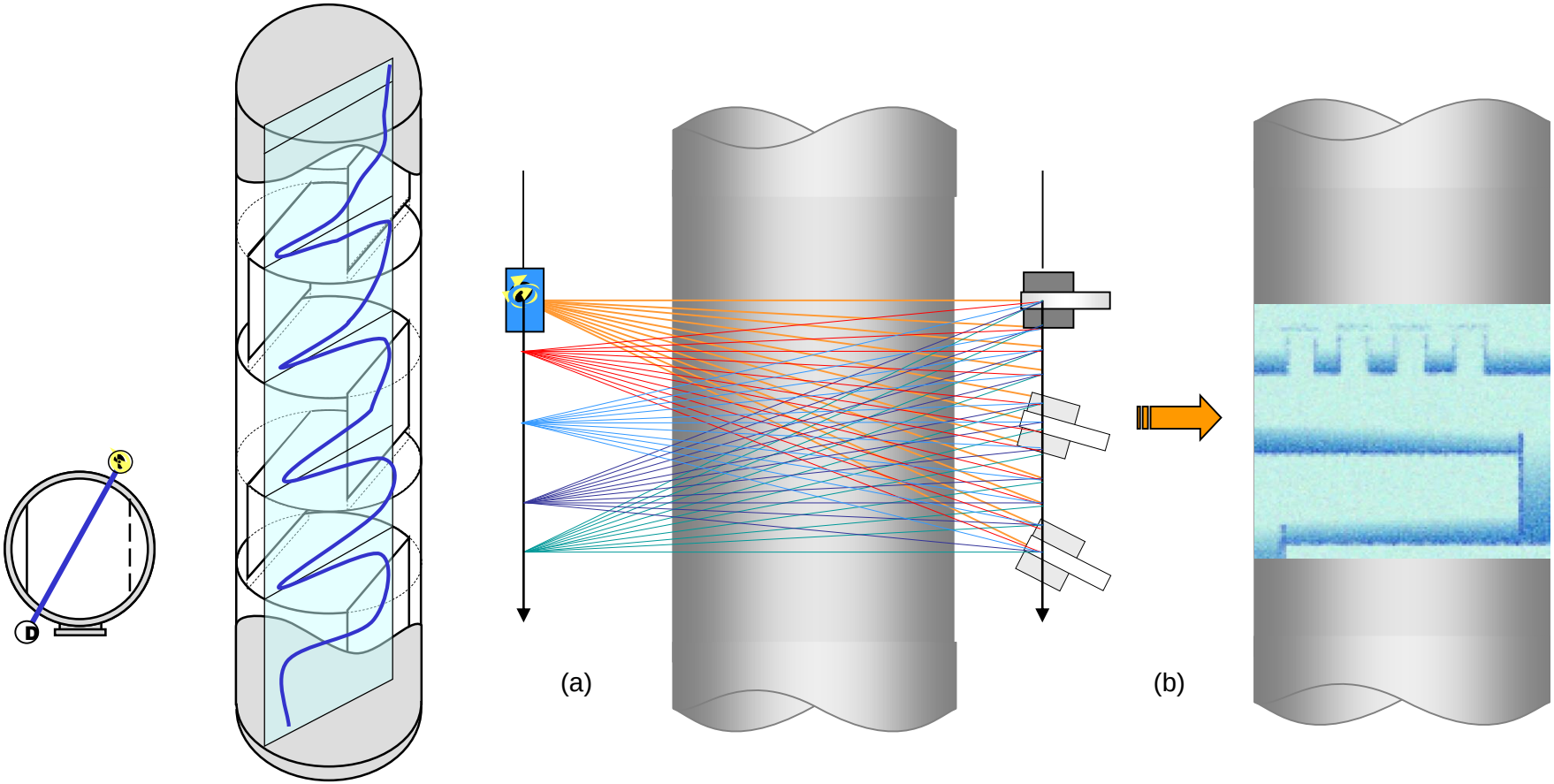




- ✓ **Dimension: ∅ = 1,500 mm (external)**
- ✓ **Columns: ∅ = 255 mm - 400 mm**
- ✓ **Detection system: 7 multi-detectors array (NaI(Tl), 2")**
- ✓ **Sources: ^{60}Co,^{137}Cs, ^{75}Se, ^{192}Ir (collimated in fan shaped planar beam)**
- ✓ **Stepping motors: 2 (rotation and translation movements)**

***Source*: IPEN/CNEN-SP**

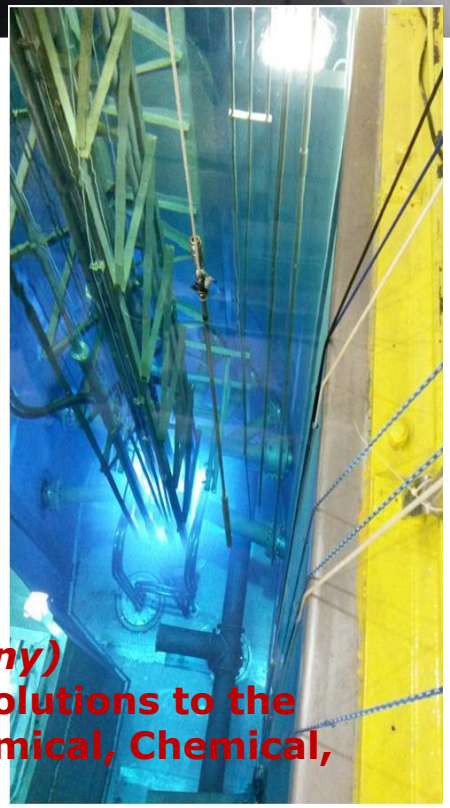
Imaging Technique Improved Gamma-Ray Absorption Scans



➢ Computed simulated column arrangement with resulting gamma ray profile and reconstructed tomographic image of a trayed column

Source: IPEN/CNEN-SP

DEVELOPMENT OF A IRRADIATION SYSTEM FOR PRODUCTION OF GASEOUS RADIOISOTOPES APPLIED IN INDUSTRIAL PROCESSES



PARTNERSHIP - TRACERCO (Worldwide Company)

Process diagnostics services and specialist measurement solutions to the world's process industries (Oil and Gas, Refineries, Petrochemical, Chemical, Consumer Fuels)

Benefits in Brazil: US$ 450 millions/year

***Source*: IPEN-CNEN/SP**


THANK YOU!
Source: Russian weather satellite Elektro-L