Improving food safety and extending shelf life thanks to the X-ray technology

Evan XU

INDUSTRIAL &
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SOLUTIONS

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IBA in a nutshell

- Based in Belgium, listed on Euronext Brussels
- Focused on **particle accelerators**
- >**400 accelerators** worldwide
- 2017 sales of ~€300 million
- **1,500 people** worldwide, 40 nationalities
- 15 offices on 3 continents

IBA Main Activities

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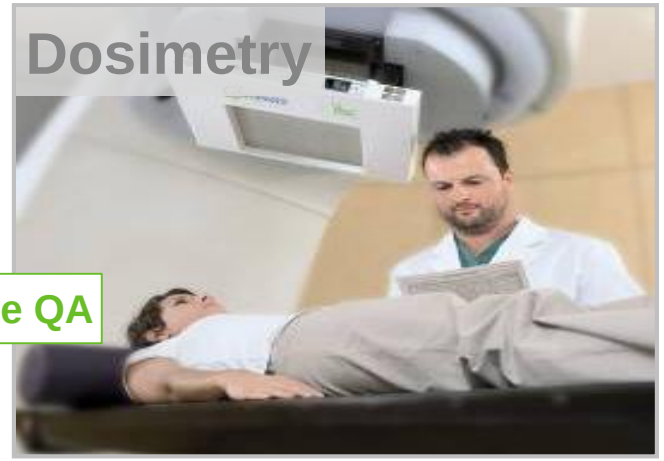
Cancer treatment

The Gulf International Cancer Centre, Abu Dhabi



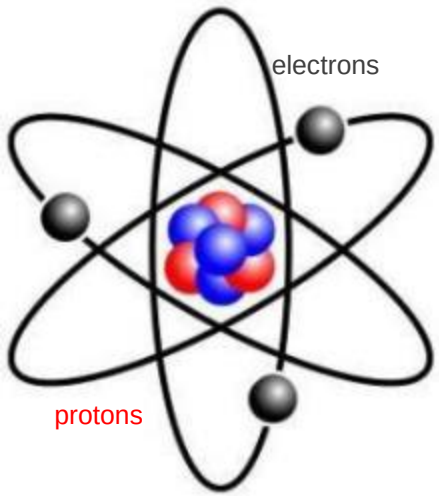
Patient and machine QA

Cancer diagnostic

Industrial applications

Industrial Particle Accelerators

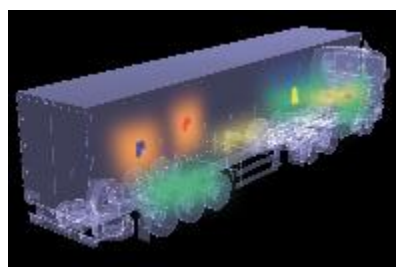
Atom



Particle Accelerators

Proton or electron acceleration

Product (and patients)



IBA Industrial - Installed Base

36
Rhodotron

200
Dynamitron

AM
16%

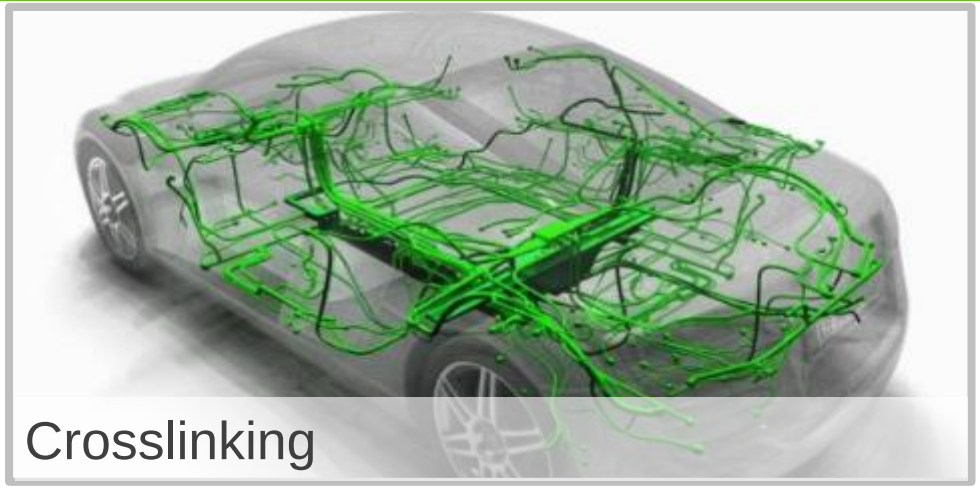
59%

EMEA
36%
29%

APAC
47%
12%

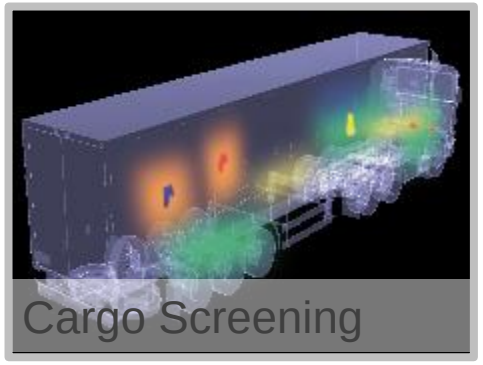
Irradiation applications


Sterilization


Crosslinking


Food


Gemstones


Cargo Screening


Mail Sanitization


Semiconductor Doping


Sterile Insect Technique

Food Irradiation

Food products: opportunities and challenges

Food irradiation is not new

1953 The U.S. Army develops starts irradiating fruits, vegetables, dairy products, fish and meats

1961 Canada approves the irradiation of potatoes

1964 The U.S. FDA approves the irradiation of potatoes, wheat and flour

1970 The NASA adopts irradiation to sterilize meat for astronauts to eat while in space

1983 Canada and the U.S. approve irradiation of spices

1983 Codex Alimentarius adopts a standard for the application of irradiation to food

1986 The U.S. approves the irradiation of fruits and vegetables up to 1kGy

1988 The FAO, WHO, IAEA, ITC and WTO adopt an international food irradiation trade agreement.

1990 The U.S. FDA approves the irradiation of poultry

1993 The American Medical Association (AMA) endorses food irradiation

1997 The U.S. FDA approves the irradiation of meat products

2000 Omaha Steaks starts irradiating all ground beef products

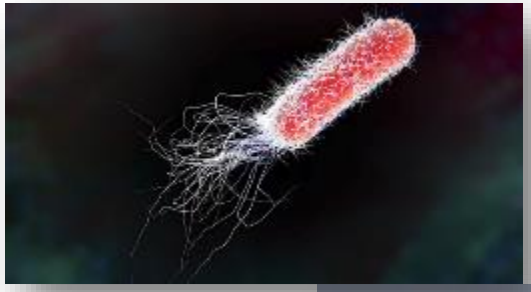
2005 The U.S. FDA approves irradiation of live mollusks

2007 First legal shipment of Indian mangoes to U.S

2008 U.S. FDA approves irradiation of spinach and leafy greens for pathogen reduction

Food irradiation applications

1. Decontamination
2. Disinfestation
3. Extension of shelf life
4. Inhibition of sprouting



1. Decontamination

- **Spices, vegetable seasonings and herbs**

+ Flavor Color Aroma

- Problem: often heavily contaminated by micro-organisms

Solution: Irradiation

*** Cold process (Flavor & Aroma)**
*** No residue (Safety, Environment, Regulations)**
*** Widely approved**
*** High dose**

1. Decontamination

5 common food-borne bacteria you'd like to avoid!

- **E. Coli, Salmonella enteritis, Campylobacter, Listeria monocytogene, Clostridium botulinum…**

- **Can be found in:**
  - **Vegetables**
  - **Poultry**
  - **Fish & seafood**
  - **Meat**

2. Disinfestation

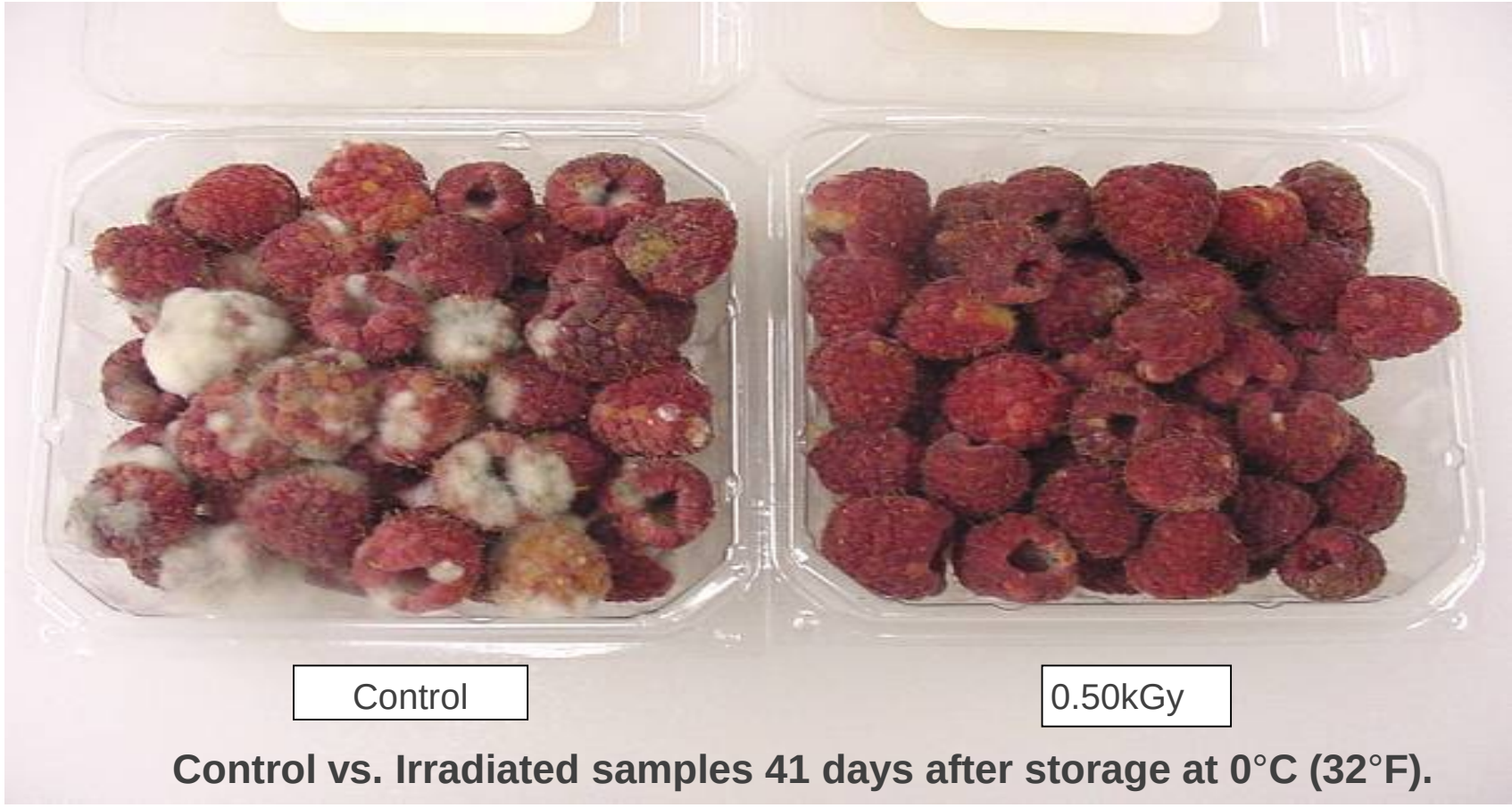
Grains, pulses, cereals, …

2. Disinfestation

- **Main problem in preservation of grains, pulses, cereals, coffee beans, dry fruits, flowers, …etc is insect infestation**
  - **Beetles, moths, weevils, fruit flies, …**

- **Solution: Irradiation**
  - **High throughput**
  - **Cost effective**
  - **No residue (Safety, Environment, Regulations)**

3. Extended Shelf-life



Control vs. Irradiated samples 41 days after storage at 0°C (32°F).

3. Extended Shelf-life

Fruits, vegetables, meat, poultry, fish and seafood

Spoilage micro-organisms (ex.: Pseudomonas, Botrytis,…)

- **Example:**
  - **Papayas: from 15 days to 4 months**
  - **Strawberries: from 5 days to 3 weeks**
  - **Onions: from 30 days to 4 months**
  - **Garlic: from 3 months to 12 months**
  - **Rice: from 3-18 months to 4 years**

4. Inhibition of Sprouting

4. Inhibition of Sprouting

- **Storage of onion bulbs, garlic, ginger, potatoes and other sprouting plant food over many months can be problematic .**
  - **Refrigeration in subtropical and tropical regions: $$$**
  - **Chemical residues (inhibitors as Propham, Chloropropham, Maleic hydrazide,…)**

- **Solution: Irradiation**
  - **Very low doses (0.10 kGy)**
  - **Allow storage at higher temperature (10-15°C)**
  - **Authorized and used for 40 years+ (Canada, Japan, China, India…)**

Absorbed dose

- Absorbed dose (in Gray) is the quantity of radiating energy absorbed per unit of mass of a specified product

- Typical dose ranges
  - Phytosanitary Irradiation 100 – 400 Gy
  - Pathogen Reduction (Meat and Poultry) 1 500 Gy
  - Spice Sanitation 6 000 Gy
  - Medical Device Sterilization 25 000 Gy
  - Food Sterilization (NASA) 45 000 Gy

- Dose limits vary per product
  - Min dose depends on target resistance (insect,bacteria)
  - Max dose depends on host product tolerance to radiation

Clearance database:

Explanations for Codes : 1. Delay ripening/physiological growth, 2. Disinfestation, 3. Microbial control, 4. Quarantine treatment, 5. Shelf-life extension, 6. Sprouting inhibition 7. Trichina/parasite control, 8. Sterile meals for hospital patients, 9. Sterilization, 10. Unstated.

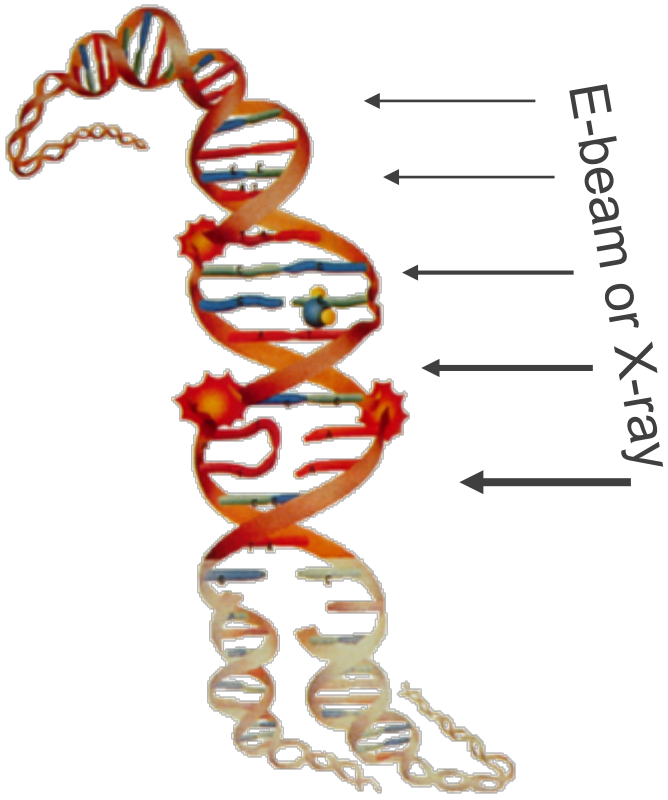
>>Refer to the Explanatory Notes and * * <<

Product	Code	Type of Clearance	Date	Dose Max (kGy)
DATES	2	UNCONDITIONAL	06.04.98	0.75
CHICKEN	3	UNCONDITIONAL	06.04.98	4.00
CHICKEN PRODUCTS	3,5	UNCONDITIONAL	06.04.98	4.00
FIGS (DRIED)	2	UNCONDITIONAL	06.04.98	0.75
FISH	3,5	UNCONDITIONAL	02.05.01	3.00
FISH (FROZEN)	3	UNCONDITIONAL	02.05.01	6.00
FISH (DRIED)	2	UNCONDITIONAL	02.05.01	1.00
GARLIC	6	UNCONDITIONAL	06.04.98	0.15
GINGER	6	UNCONDITIONAL	06.04.98	0.15
LEGUMES	2	UNCONDITIONAL	02.05.01	1.00
MANGO	1,2	UNCONDITIONAL	06.04.98	0.75

Clearance database (2)

MEAT	3,5	UNCONDITIONAL	06.04.98	4.00
MEAT PRODUCTS	3,5	UNCONDITIONAL	06.04.98	4.00
ONIONS	6	UNCONDITIONAL	09.08.94	0.09
PORK	3,5	UNCONDITIONAL	06.04.98	4.00
POTATO	6	UNCONDITIONAL	09.08.94	0.15
PULSES	2	UNCONDITIONAL	02.05.01	1.00
RAISINS	2	UNCONDITIONAL	06.04.98	0.75
RICE	2	UNCONDITIONAL	06.04.98	1.00
SEAFOOD	3,5	UNCONDITIONAL	02.05.01	3.00
SEAFOOD (FROZEN)	3	UNCONDITIONAL	02.05.01	6.00
SEAFOOD (DRIED)	2	UNCONDITIONAL	02.05.01	1.00
SHELLFISH	3,5	UNCONDITIONAL	02.05.01	3.00
SHELLFISH (FROZEN)	3	UNCONDITIONAL	02.05.01	6.00
SHRIMP	3,5	UNCONDITIONAL	02.05.01	3.00
SHRIMP (FROZEN)	3	UNCONDITIONAL	02.05.01	6.00
SHRIMP (DRIED)	2	UNCONDITIONAL	02.05.01	1.00
SPICES	3	UNCONDITIONAL	09.08.94	14.00
WHEAT FLOUR	2	UNCONDITIONAL	06.04.98	1.00
WHEAT PRODUCTS	2	UNCONDITIONAL	06.04.98	1.00

Effects of Radiation on living cells



- Product is exposed to a **controlled** amount of **ionizing energy**.
- Radiation damages DNA -> living cell will be **unable to reproduce.**

Benefits of Food Irradiation

- The **nutritional value** of the food is preserved (WHO)
- **Reduction of global food spoilage** (estimated at 25% of global production)
- Radiation is a **cold process**
- Number of Parasites can be reduced substantially
- Insects are eliminated
- **No chemicals harmful to human health and the environment**
- **Bulk and packed products** ready for consumers can be treated

Regulations

- More than **60 countries** authorize food irradiation
  - Authorized food varies widely per country

- **Labeling**
  - Irradiated foodstuff containing irradiated ingredient(s) must be labeled

Quoted Statement from Experts

FOOD IRRADIATION *Update*

Published by Ronald F. Eustice and sponsored by GRAY*STAR Inc. **October 2017**

Food Irradiation Update is published monthly by Ronald F. Eustice, a food quality & safety assurance consultant based in Tucson, Arizona. **He can be reached at: reustice@gmail.com and at 612.202.1016**

There is growing interest in using irradiation as a tool to improve the safety of seafood.

Bonamar® Corporation, a leading U.S. seafood company, has partnered with Gateway America to innovate food safety by launching the first nationally marketed line of ES (Extended Safety) crab meat products to the food industry

IN THIS ISSUE

Featured Article: Florida crab supplier Bonamar moves westward with new partnership

MYTH of the MONTH: Talk is Cheap!

SAVE THE DATE: INTERNATIONAL IRRADIATION FORUM.

Also in the News: ESTABLISHMENT OF MULTIPURPOSE IRRADIATION FACILITY IN TANZANIA

Also in the News: Vietnam Mangoes cleared for US market USA

Also in the News: Darwin, Australia Mangoes Reach USA

ADDITIONAL RESOURCES

INTERNAL USE ONLY

Myth: Irradiation makes food radioactive!

Irradiation (gamma, e-beam, X-ray)

DOES NOT

make products radioactive

Myths: Food irradiation replaces GMP

- Food irradiation is not the silver bullet
- Additional step to food safety
- It must be integrated
- It is always better if the bio burden is low

Myth: Irradiation is expensive !

- An irradiator is designed to work 24/7/365
- Additional cost from US$ 0.01/kg
- Go for the low dose!
- Cost of recall?
- Liability?
- Impact of brand?
- What if people got sick or died?

Myth: Irradiated food taste bad!

- Protein degradation may induce bad smell
- Fatty acids may affect the taste

- It’s all about DOSE !

Myth: All foods should be irradiated !

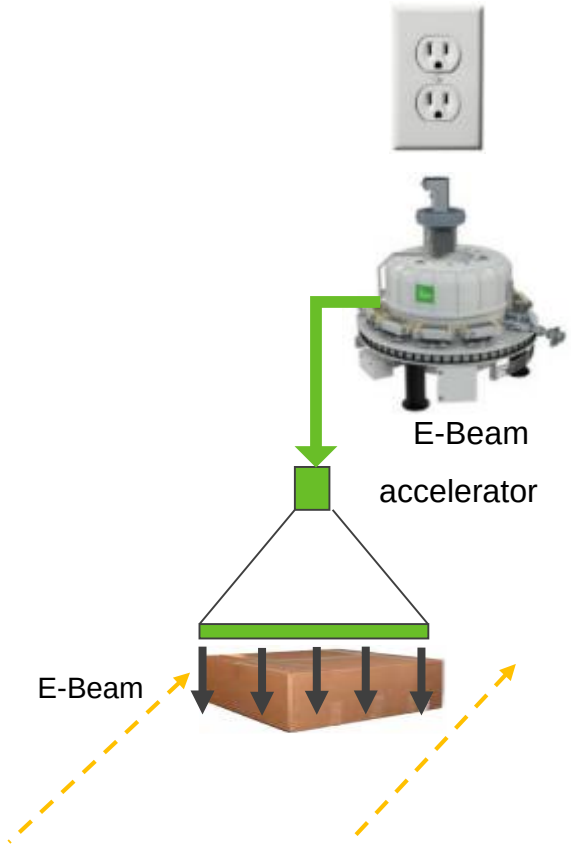
- Other technologies may sometimes be more appropriate like heat
  - Example: Spinach
    - Consumed raw □Irradiation
    - Heat for canned

The technologies

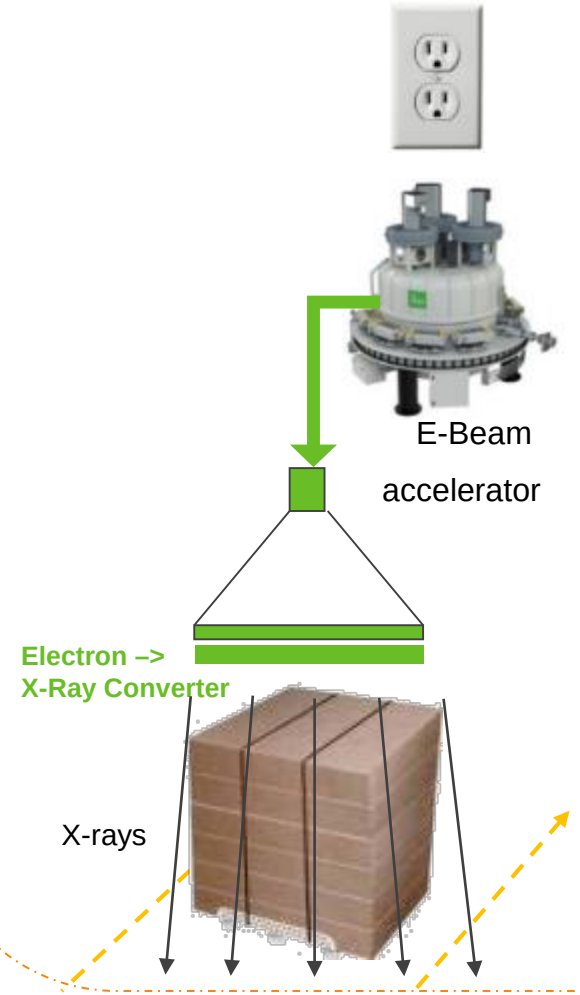
Irradiation Processing Comparison

Same technologies from a radiation point of view

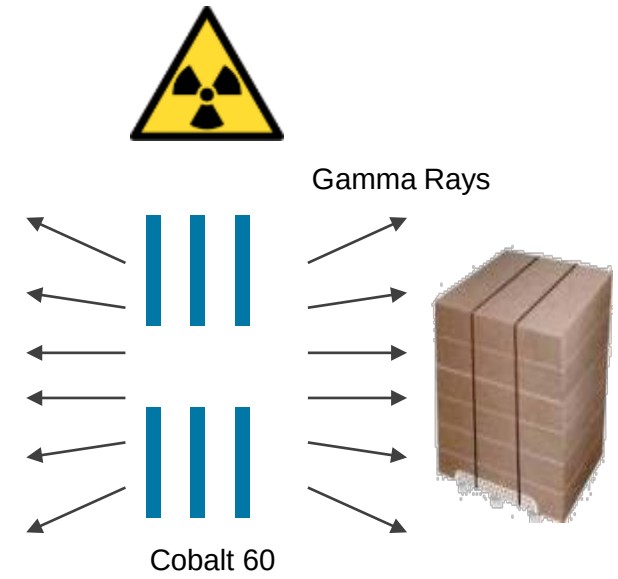
E-beam



X-ray



Gamma



E-beam vs X-ray : key differences

	E-beam	X-ray
Product Penetration	Low	**Very High**
Dose Uniformity Ratio	Average	**Excellent**
Dose Rate	**Very high**	Medium
Treatment Time	**Seconds**	Hours
Cost Efficiency	**Excellent**	Good

Dedicated vs Combined Configurations

Dedicated E-beam
10 MeV Rhodotron
Boxes

Dedicated X-ray
5 or 7 MeV eXelis
Pallets

Combined E-beam & X-ray
Rhodotron DUO
Boxes

10 MeV E-beam
& **5 / 7 MeV X-ray**

Example of a treatment facility

The new TT50 Rhodotron : Designed for food irradiation

5, 7 or 10 MeV

E-beam or X-ray

~~**Economical Design**~~

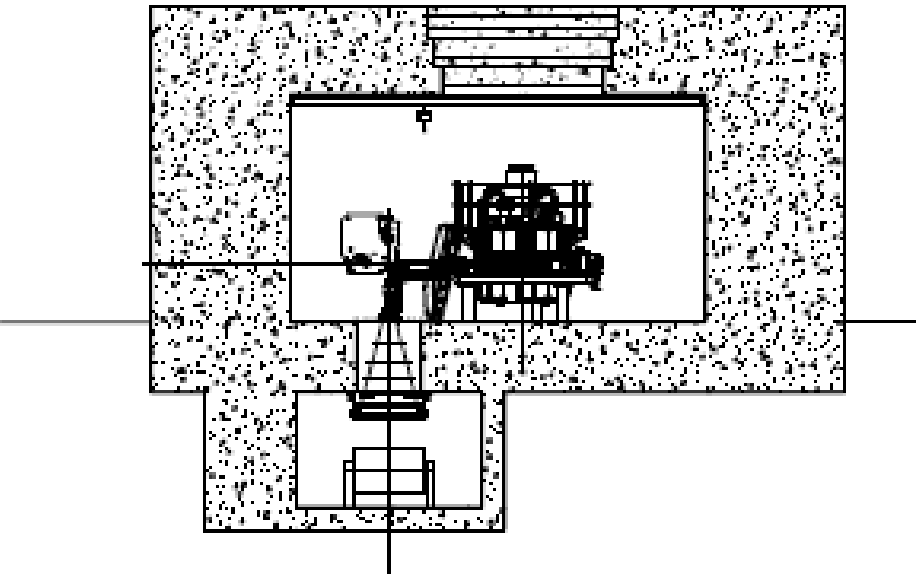
Up to 20 kW

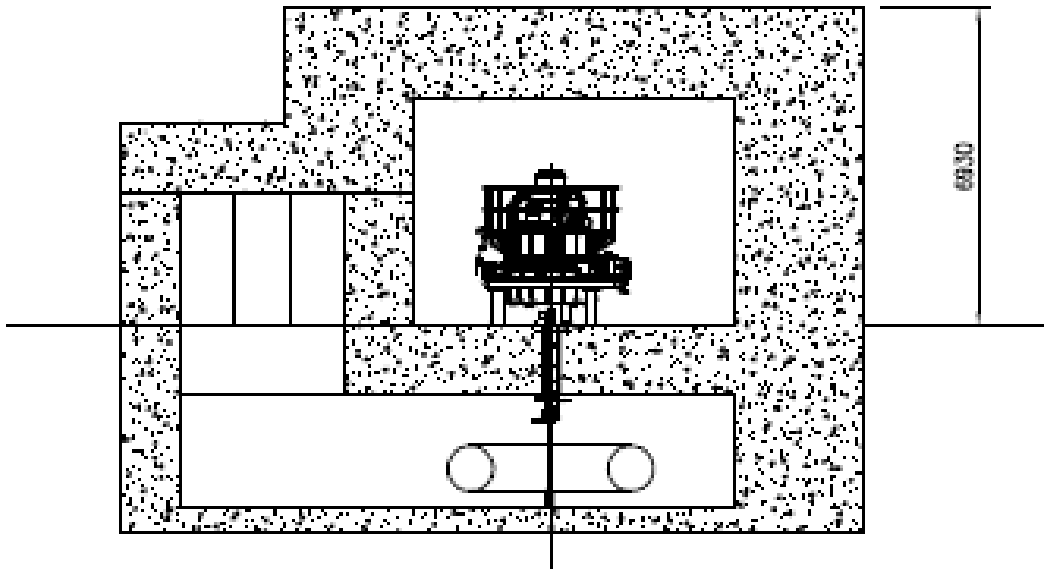
Small footprint

Transport and install frame

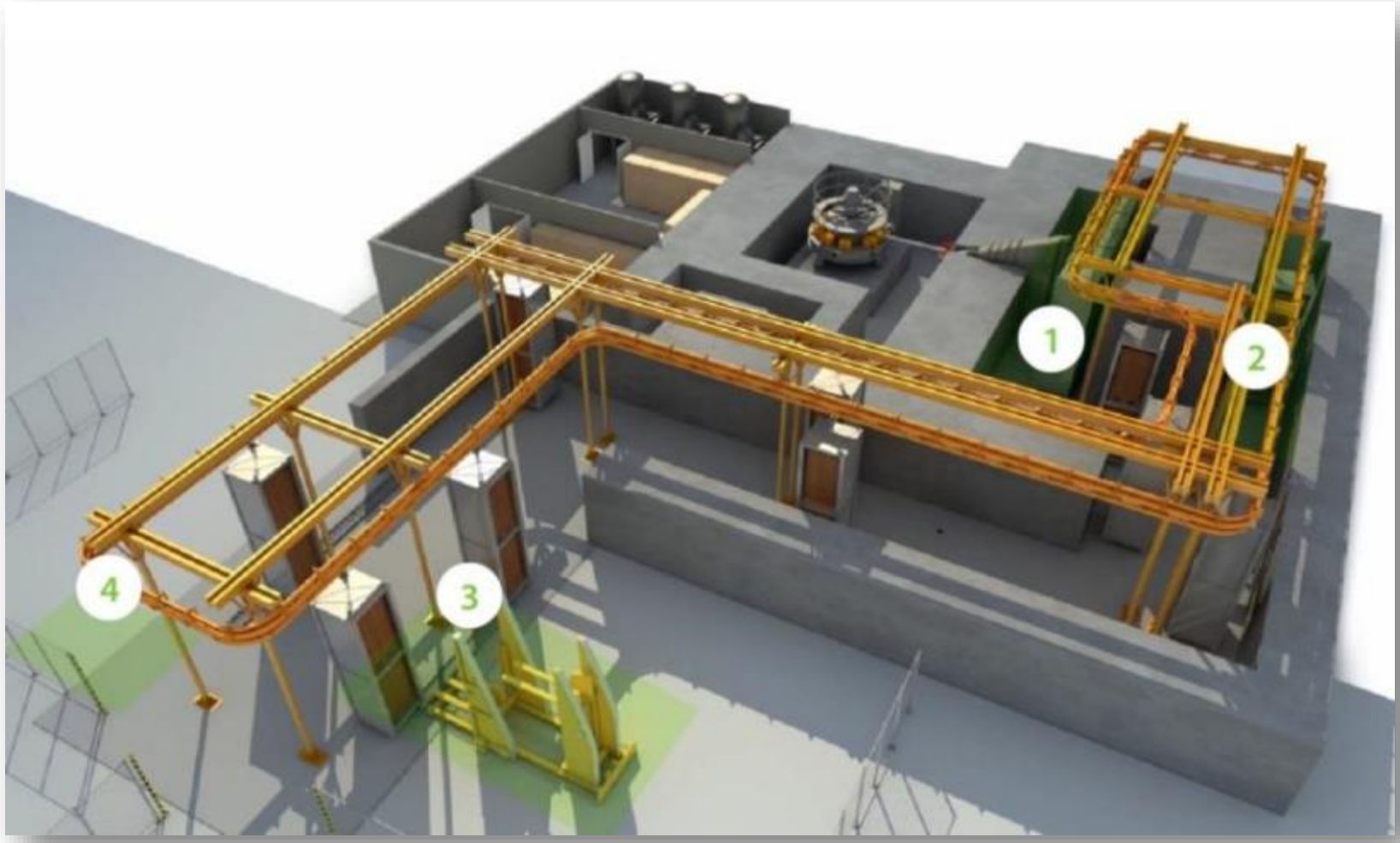
10 MeV E-beam for Food : Typical configurations

E-beam Bulk



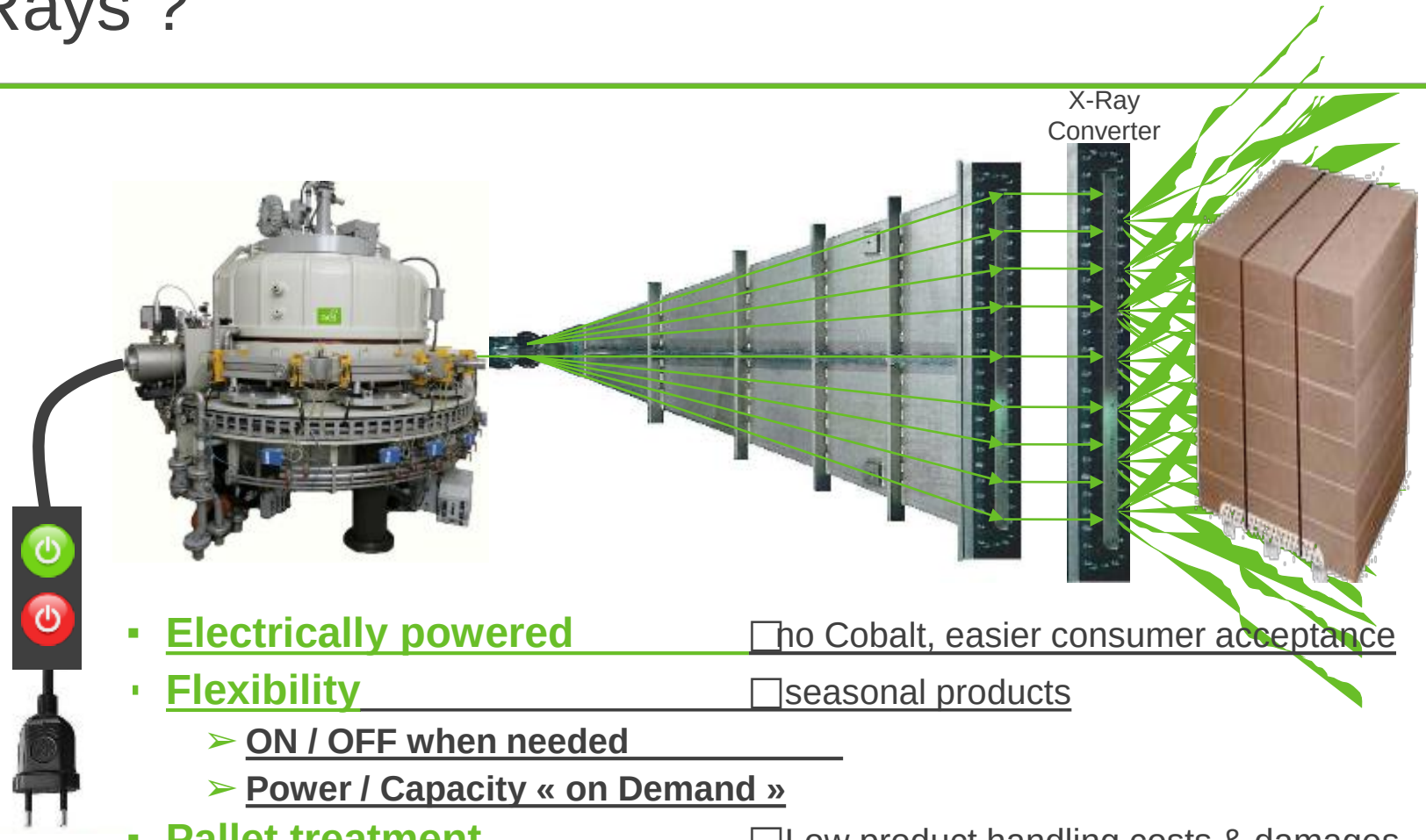


A Typical dedicated X-ray Center



http://www.iba-sterilization.com

Why X-Rays ?

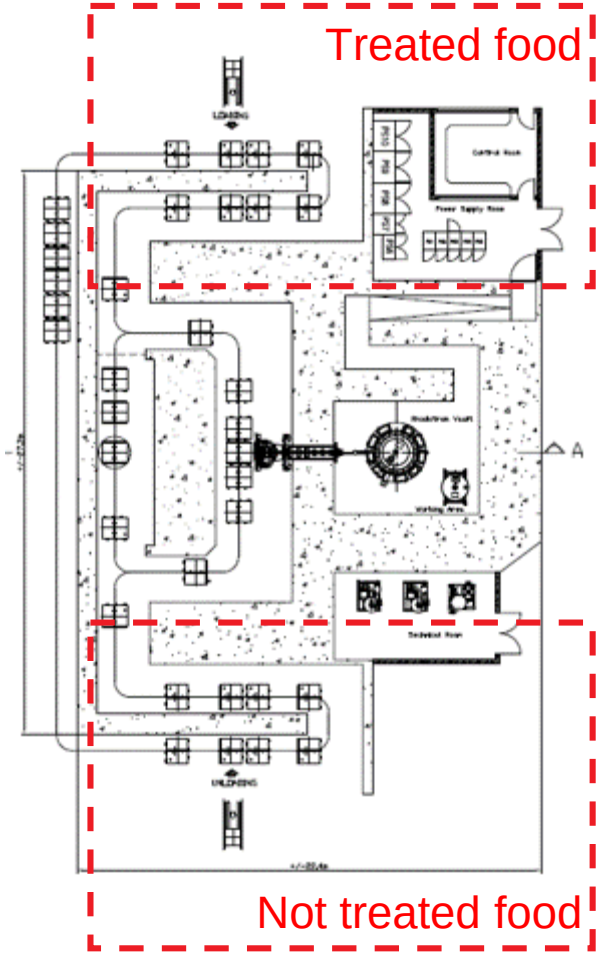


- **Electrically powered** → no Cobalt, easier consumer acceptance
- **Flexibility** → seasonal products
  - ➢ **ON / OFF when needed**
  - ➢ **Power / Capacity « on Demand »**
- **Pallet treatment** → Low product handling costs & damages
- **Excellent Dose Uniformity** → no overdosing
- **Short Treatment Time** → no refrigeration during treatment

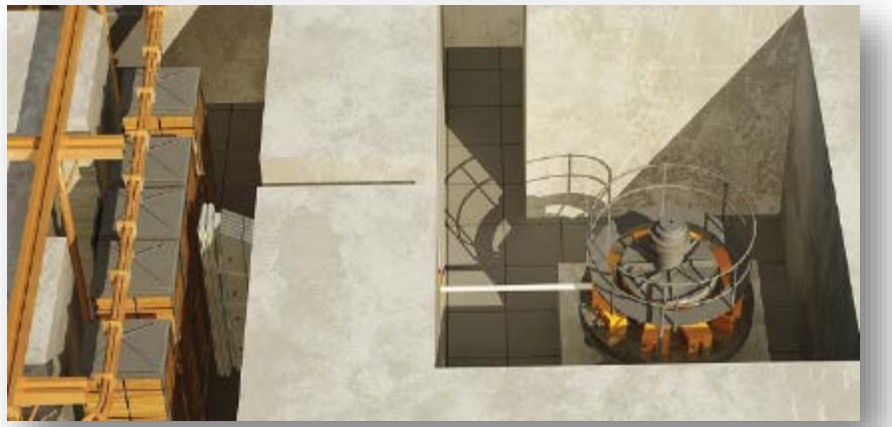
5 MeV X-ray for Food : Typical configurations

X-ray pallet

Seperate entry and exit



2 side irradiation



Typical performances

Power	30 □400 kW (@ 5 MeV)
Throughput	~270 kg / h / kW
DUR	~2.8 (full pallets)

Optimized for throughput

Rotating pallets

Typical performances

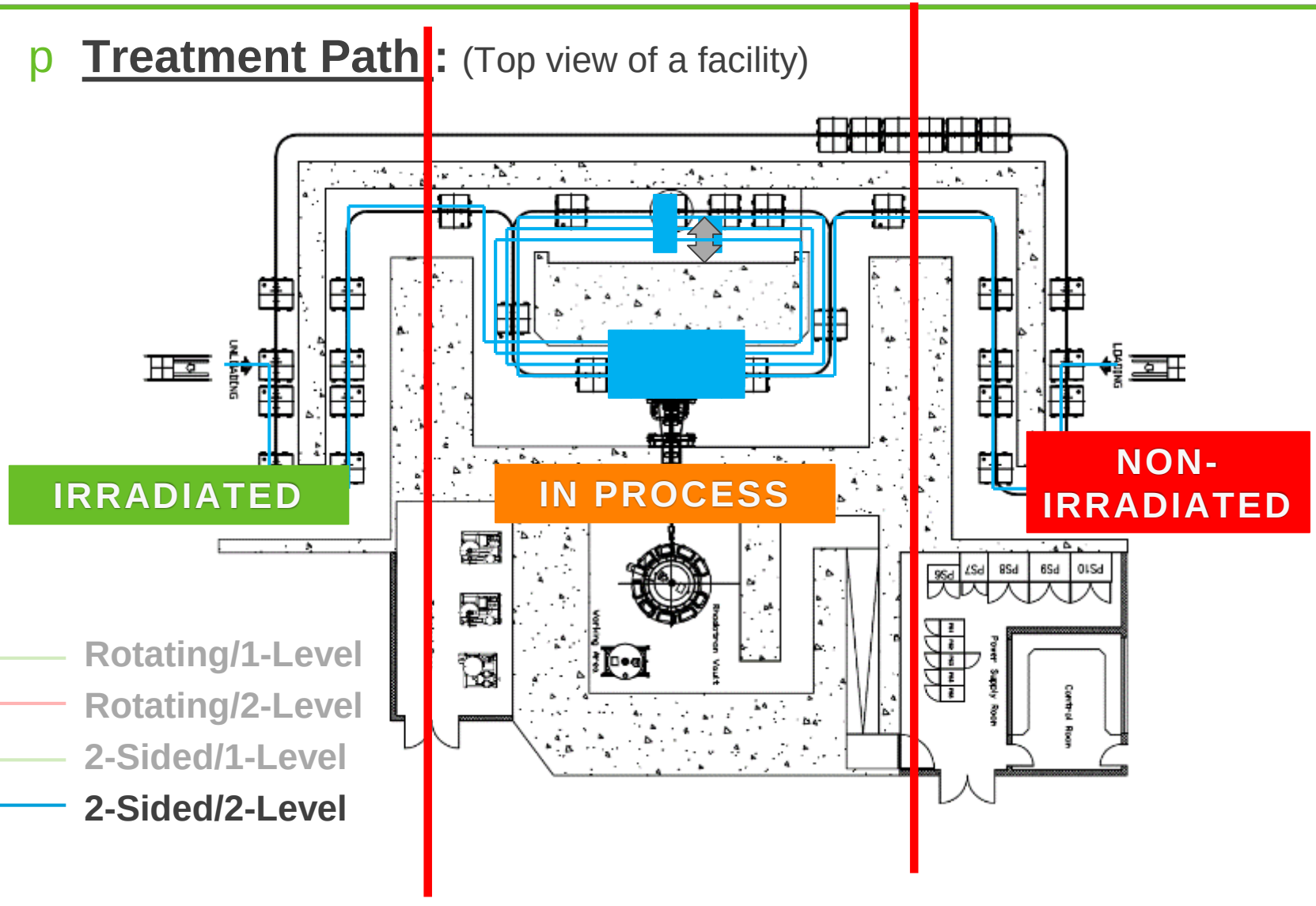
Power	30 □400 kW (@ 5 MeV)
Throughput	~200 kg / h / kW
DUR	~1.6 (full pallets)

Optimized for DUR

Assumptions: 0.4 gr/cc, 5 MeV X-ray, 2m³ pallets, 1 level

Treatment configuration

- **Treatment Path :** (Top view of a facility)



X-ray technology

- **X-Ray is the appropriate tool for Phytosanitary applications**
  - **Electricity Powered**
  - **Flexible**
  - **Pallet Treatment**
  - **Excellent DUR**
  - **Short Treatment Time**

- **Treatment Configuration is influenced by :**
  - **Density range**
  - **DUR** (Dmin required, Dmax allowed)

- **X-Ray Costs are driven by :**
  - **Volume**
  - **Seasonality**
  - **Electricity actual use**
  - **Electricity Cost** (night/days rate, peak consumption)

Example of fruits with high irradiation tolerance

Dragon fruit

Apples

Blueberries

Cherries

Peaches

Guava

Pomegranates

Longan

Grapes

Rambutan

Pitaya

Lychees

Mangoes

Papaya

Figs

Pallet X-ray process double side

- **Case study**
  - **Products :**
    - **ρ = 0.3 gr/cc ➔ Mangoes**
    - **ρ = 0.5 gr/cc ➔ Dates**
  - **Doses :**
    - **D = 400 Gy**
  - **Accelerator Power :**
    - **100 kW (14.3 mA @ 7 MeV)**
  - **Mangoes: 29 MT/h**
  - **Dates: 33 MT/h**
  - **Price ~ € 10/ MT**

Economics: examples

- **Fruits:**
  - **Large scale X-ray unit**
  - **Investment: US $ 6,000,000 to 8,000,000**
  - **Capacity 300,000 MT/Y**
  - **Dose 500 Gy (Phytosanitary & Extended shelf-life)**
  - **Cost US $ 3 to 5 per MT**

- **Potatoes/Onions**
  - **Medium size X-ray unit**
  - **Investment: US $ 4,000,000 to 6,000,000**
  - **Capacity 350,000 MT/Y**
  - **Dose 100 Gy**
  - **Cost US $ 2 to 4 per MT**

Conclusions

- Food irradiation is a cold treatment process for applications such as:
  - Phytosanitary
  - Sanitary
  - Shelf life extension
- Food irradiation has been used since the 60’s
- FDA, FAO, WHO, IAEA, ITC and WTO approve food irradiation
- E-beam and X-ray technologies are the ideal alternative to radioactive sources

Thank you!

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