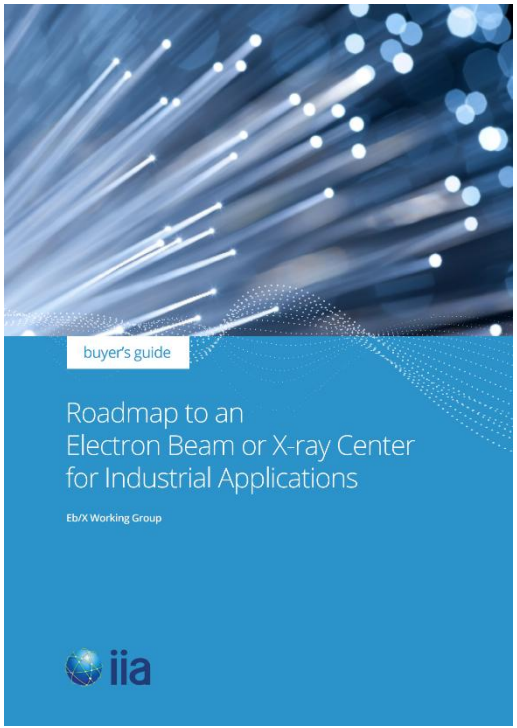
Roadmap to an Electron Beam or X-ray Center for Industrial Applications



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Introduction

Many New-Comers experience lack of easily accessible information on

- what E-beam and X-ray could do for their process
- unbiased technology comparison
- where to find unbiased advice
- available suppliers for key systems
- how to perform a feasibility analysis and establish a bankable business plan for a technology new to them

As a result:

- their project gets delayed,
- does not get off the ground,
- becomes too expensive for their purpose,
- lacks financing

➔ Need an easy-to-follow Roadmap without too much technological detail

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Purpose

- Enable EB/X-ray project developers, prospective buyers or users of EB/X-ray technologies, and investors in such projects to perform an effective feasibility and business plan analysis.
- It shall enable them to find supplier-independent information, identify other players than the market leading EB/X-ray solution providers.
- Refer to - instead of Duplicate - available Information

Primary Target Markets

- Medical Device Sterilization / Combination Products / Pharmaceutical Sterilization / Consumer products (e.g. >10 kGy sterilization dose); production integrated as well as external service centers
- Phytosanitary Treatment for Quarantine control, Import/Export, bio security (e.g. ≤ 1 kGy, fruit and vegetables)
- Food Irradiation (e.g. dried fruit, spices, pet foods, meat products)
- Polymer irradiation with high energy beams
  - using tray based conveyors, such as tubing, granular
  - using strand based product handling, such as wire & cable

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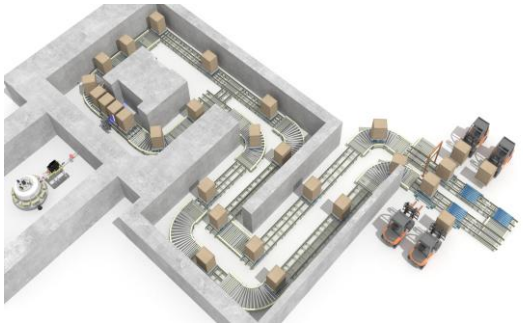
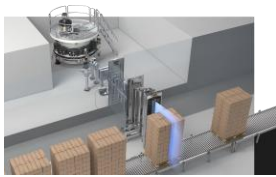
Ready to Cut the Ribbon on your new E-Beam or X-ray facility?

- Enlarging the capacity in a growing market
- Transition to E-beam / X-ray
- Phase-Out of chemical processes
- Meet regulatory requirements
  - Bio-security
  - Sterility
  - Radioactive material transport
- Supply chain issues





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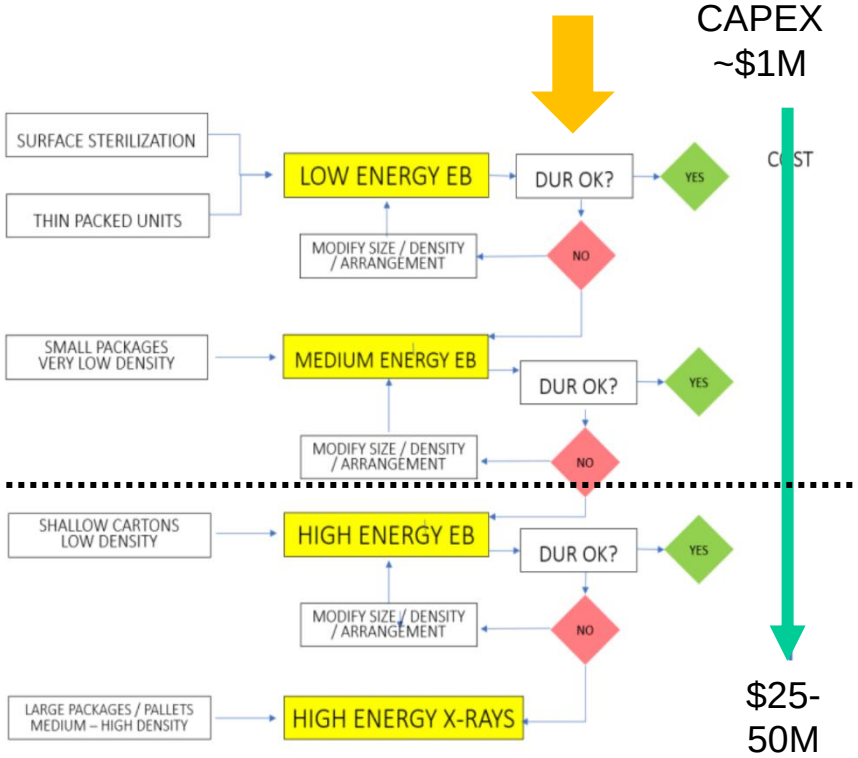
Process How to get There

You need to make some decisions

- What are your products?
- What is your packaging?
- What is your Dose Uniformity requirement – per product?
  - min Dose: process effectiveness
  - max acceptable Dose: Product integrity

➔ best fit Technology = DUR & Dose Limits

➔ But is this also the best fit for the budget?



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Phytosanitary Treatment / Sterilization

Electron Beam

- Treatment in boxes
- Best ROI – if it works with the product

X-ray

- Pallet integrity, no packaging changes
- Radiation on/off
- Best dose uniformity
- Scalable production
- Quick product change
- Very high electricity requirement

Gamma

- Pallet integrity, no packaging changes
- continuous production
- Simple operation
- Slower product changes
- Low electricity consumption, but Co-60 decay
- Co-60 availability and transport

Image Sources: iiA, Sterigenics, Steritec

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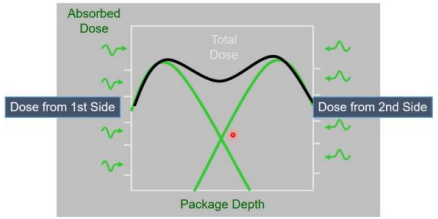
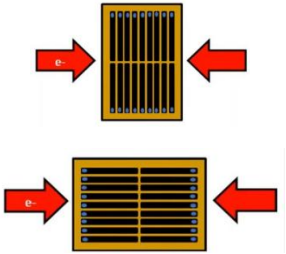
E-Beam: Dose Uniformity Ratio (DUR) & Product Qualification

- Typ. densities < 0.3g/cm² (10 MeV)
- packaging size, direction of beam
- arrangement inside the packaging
- often treatment from two sides
- Density differences within product are critical for e-beam.

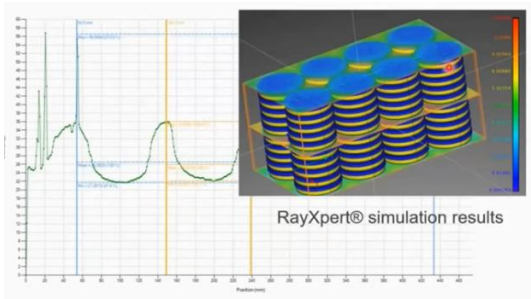
➔ for business & capacity planning

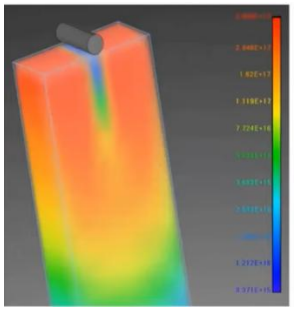
  - modelling
  - dose map
  - use expert support!





Credit: iia buyers guide, Steris AST





Credit: IBA, AERIAL, TRAD RayXpert

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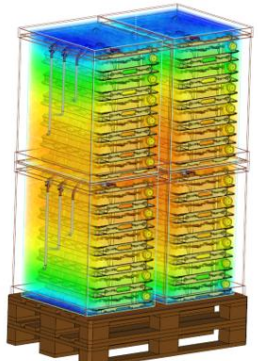
X-ray: Dose Uniformity Ratio (DUR) & Product Qualification

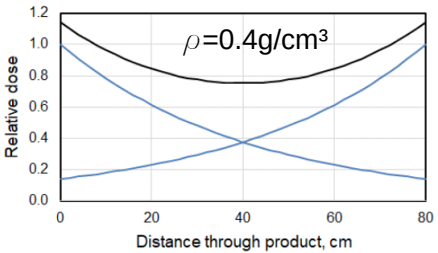
- pallet processing, DUR increase with ρ
- always treatment from two sides
- average density planning; also for high density fruits
- Production Capacity system dependent – no simple formula

➔ for business & capacity planning

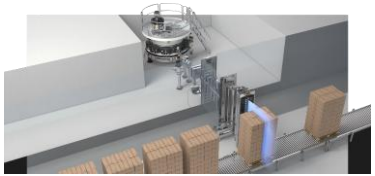
  - modelling for complex products
  - dose map
  - Experimental verification of throughput

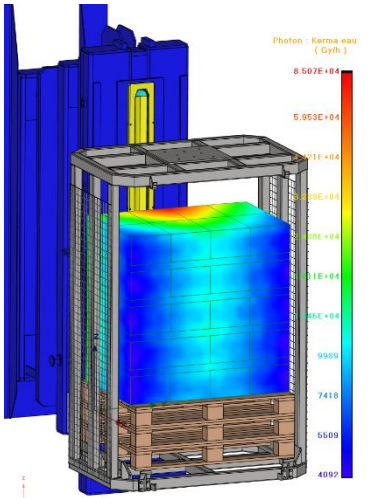
Complex Product
Two sided





Dose Rate Simulation





Credit: Irradiation Panel, IBA, TRAD (RayXpert)

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Optimize your Business Case

- Energy (MeV) – fit for the product
  - accelerator
  - Shield
- Power (kW) – fit for the next 5-10yrs
  - accelerator & building MEP
  - product handling system / automation
  - utility cost: electricity ~3x beam power
- X-ray instead of E-beam – a CAPEX step
- turnkey = project risk on vendor side $$$

➔ carefully review your product needs with experts

- Energy and Power – E-beam vs X-ray
- packaging & dose distribution optimization

➔ consider risk mitigation by experts on your side

System	Energy range	Shielding type	Shielding material	Shielding footprint	typ Project Cost
Low energy EB	< 300 keV	Self-shielded	steel, lead	up to 60m²	$100k - $1M
Low to Medium Energy EB	500 keV - 3 MeV				$500k - several $1M
Medium energy EB	2 - 8 MeV	self-shield or bunker	steel, lead, concrete	up to 200m²	several $1M
High energy EB	8-13 MeV	large bunker	concrete	400-500m²	> $10M
High energy X-ray	5– 7.5 MeV				> $25M

Constraints and Risks

- Op cost: Maintenance, staff, utilities
- Certification, Ramp-up, small batches/partial carriers
- customer requirements and inter-product compatibility
- community acceptance, radiation safety
- utility outages, supply chain, staffing

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Thank You!

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Credits & Source of Images:

- iia Buyers guide
- iia Roadmap
- IBA Webinar / AERIAL / TRAD (RayXpert)
- Steris AST
- LTXD
- IBA