Orthoplastics
A VIANT COMPANY
science making a material difference

VIANT
WE'RE IN IT FOR LIFE.

HIGHLY CROSSLINKED UHMWPE, HIGH POWER X-RAY VS GAMMA

Mark Allen

Orthoplastics
A VIANT COMPANY
science making a material difference

DISCLOSURES

NONE

Orthoplastics
A VIANT COMPANY
science making a material difference

VIANT INC

- **24 locations worldwide** (US, Mexico, Costa Rica, Puerto Rico, Europe and Asia)
- **6,000** employees worldwide, **280+ engineers**

+10 facilities
+2,200 employees * +80 engineers

- **2.1M sq. ft.** total assembly and manufacturing capacity **~325,000 sq. ft.** clean room (Class 7 & 8) & white room

+670K sq. ft.

- **Expanded and strengthened network** through the acquisition of **world class capabilities** of Vention DMS , Coastal Life Technologies and Integer AS&O

Integer AS&O contributions

Plastics Processing Solutions

DEPTH & BREADTH IN PLASTICS & MEDICAL TECHNOLOGIES

- **450** processing machines (3 – 1000 tons) for injection molding, elastomers, blow molding, extrusion processes

Medical Device Solutions

EXPERTS IN FINISHED DEVICE MANUFACTURING & ASSEMBLY

- Packaging and assembly services
- Sterilization services
- Logistics management services

Orthoplastics

LEADING SUPPLIER OF IMPLANTABLE GRADE PLASTICS

- UHMWPE manufacturing, component machining, direct compression molding, crosslinked polyethylene

Advanced Surgical & Orthopedics

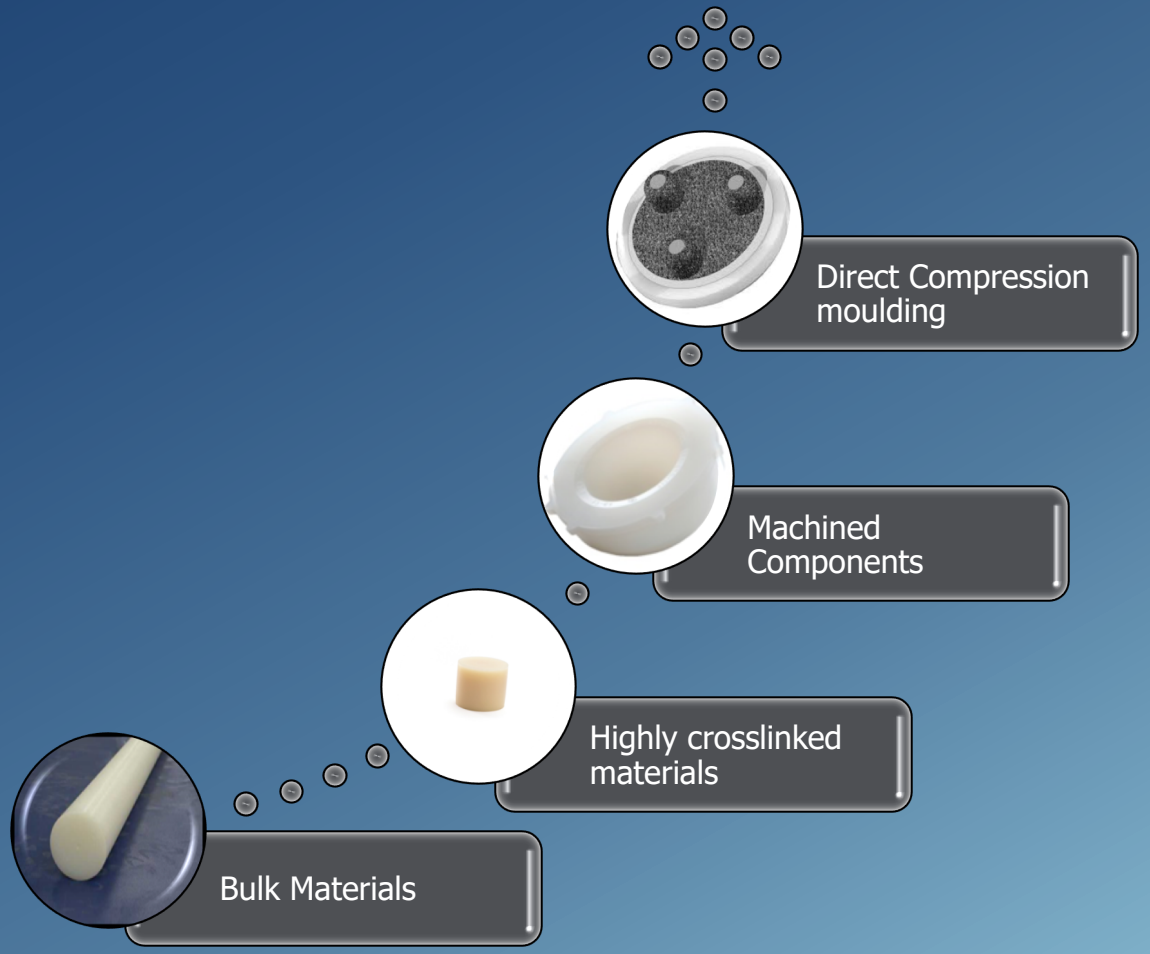
FULLY INTEGRATED MANUFACTURING SOLUTIONS WITH CORE DESIGN EXPERTISE

- **425** milling, turning, Swiss, EDM, and laser precision machining centers
- **30M ft** medical grade metal tubing produced annually

Orthoplastics

A VIANT COMPANY

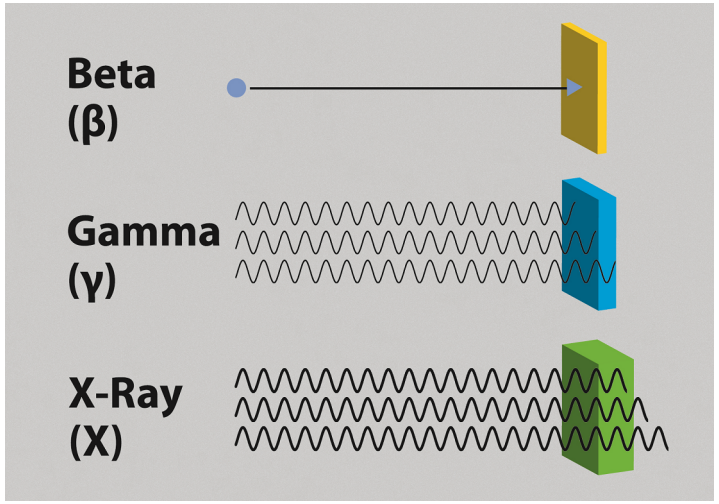
science making a material difference



STERILISATION AND CROSSLINKING METHODS

Gamma:

- First commercial irradiator installed in 1963 in New Jersey,
- Well established for sterilisation of Medical Devices, Pharmaceuticals and UHMWPE for orthopaedics.

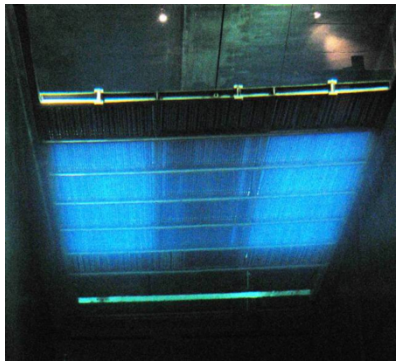


E-Beam:

- Commercially available for over 50 years
- Worldwide several hundred units in use
- Energies up to 5 MV mostly used for crosslinking
- Energies above 5 MeV to 10 MeV mostly used for sterilisation

X-Ray:

- Commercially developed in **Switzerland** around 2010, the first large scale pallet irradiator available
- Venlo, **Netherlands**: new X-ray system for pallets planned to be in service from early 2020
- Northborough, **US:** Expansion with a new X-ray system in planning status
- **Malysia:** Expansion with a new X-ray system in planning status



Orthoplastics
A VIANT COMPANY
science making a material difference

STERIS

Applied Sterilization Technologies Segment

Enhanced Geographic Coverage to Serve Global Customers

LOCATIONS (59)

- GAMMA (29)
- ETHYLENE OXIDE (EO) (23)
- ELECTRON BEAM (16)
- LABORATORIES (13)
- X-RAY (1)
- ION BEAM (1)

STERIS

GAMMA PROCESSING

In excess of 200 large-scale commercial gamma irradiators are in operation in about 50 countries, which can irradiate more than 400 million cubic feet of product annually.

Approximately half is sterilization of medical-related products and the other half is sterilization/disinfection/disinfestation of other products.

- 4-5 Cobalt 60 supplier globally
- Cobalt 60 supply only increasing at 6% per year
- Cobalt 60 prices increasing dramatically, supply and demand.
- Stable and reliable due to the use of an isotope source and the simplicity of the product handling system. Actual operational experience has demonstrated **~95% uptime**

GAMMA CROSSLINKING - CONSIDERATIONS

- Cobalt-60 is radioactive material, which will require appropriate management at the end of the life of the Source
- Availability and willingness of nuclear reactors that are capable of producing Cobalt-60
- New facility build dictated by a highly regulated world surround handling and management of radioactive sources.
- Operating costs
- Validation timelines
- Environmental lobby
- Marcoule France announced in 2010 – online 2015 with limited volume ramp timeline
- 100,000 pallets p/a full ramp
- Global supply interruption (Malaysia incident)

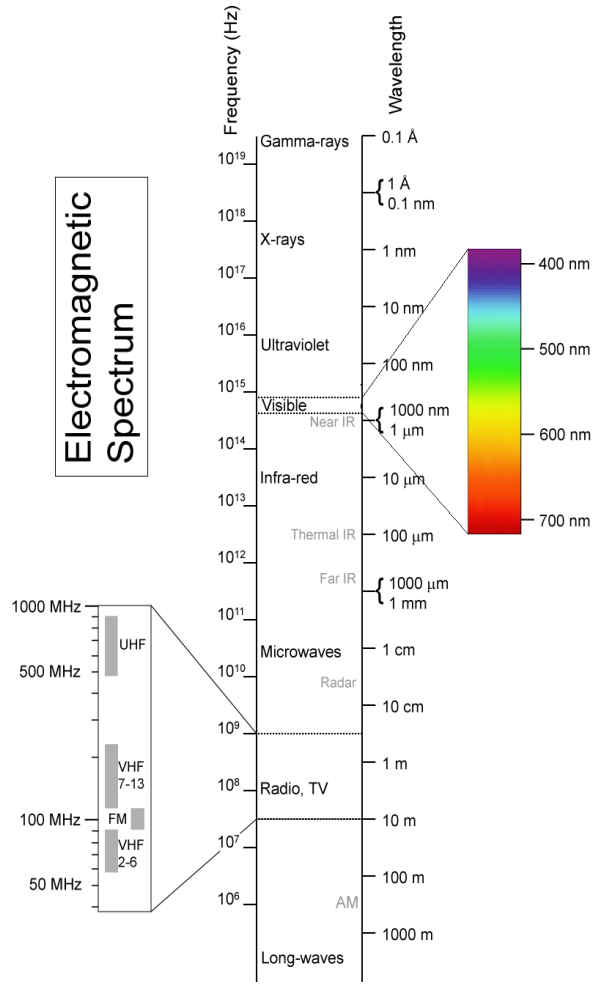
- Gas Plasma cessation
- Eto environmental issues

Orthoplastics
A VIANT COMPANY
science making a material difference

TECHNOLOGY COMPARISON

Source	Electron Beam @ 10 MeV	Gamma Rays Co_{60}		X-Rays @ 7 MeV
Penetration	Limited: one side about 350 mm at density 0.1	Entire pallet	Entire tote	Entire **pallet**
Homogeneity (DUR)	Good to Average: ≈ 1.5 (one side) to 2.8 (double side treatment)	Good: (≈ 1.5 for pallets of 400 kg)	**Very good:** (≈ 1.3-1.5 for boxes)	**Very good**: (≈ 1.3 for pallets of 400 kg)
Typical Dose rate	**≈ 5 - 30'000 kGy/h** (part of a box under treatment)	**≈ 5 kGy/h** (≈ 20 pallets under treatment)		**≈ 500 kGy/h** (≈ 2 pallets under treatment)
ISO 11137	yes	yes		yes
Tolerance for inhomogeneity	Small, poor	good		**Very good**
Ozone impact	Low	High		Low (close to E-beam)
Heat development	Treatment room is cold Add. ≈ 5°C/10 kGy dose	Treatment room is ≈ 35°C Add. ≈ 5°C/10 kGy dose		Treatment room is cold Add. ≈ 5°C/10 kGy dose Max temp much lower than in Gamma

X-RAY COMMERCIAL USES



Medical
X-rays are widely used in medicine to reveal the architecture of the bone and other soft tissues.

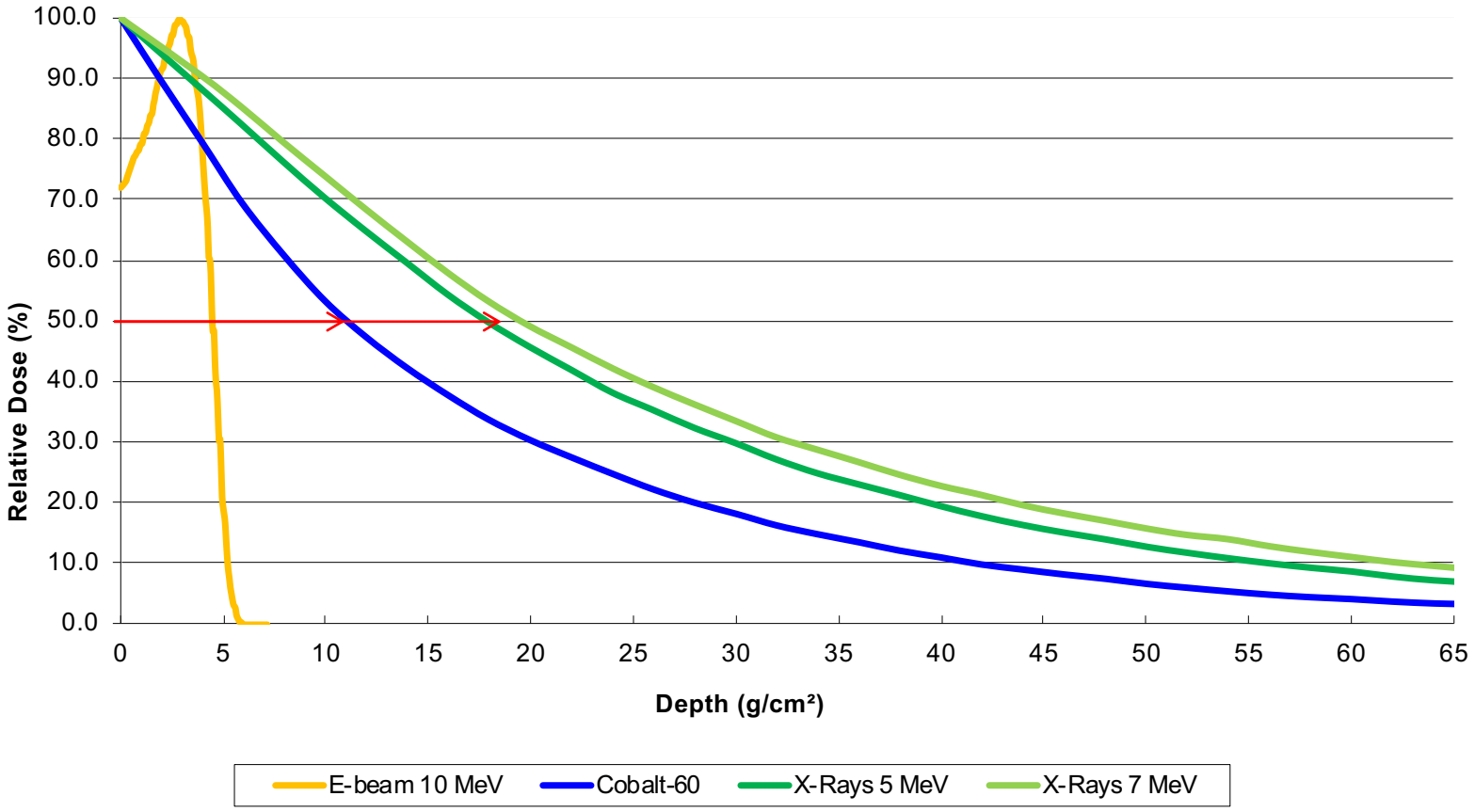
Airport Security
The use of X-rays in airports to examine for the illegal transit of goods.

Industrial
X-rays reveal structural information about the material through which it passes or falls over.

It is also used to reveal stress related changes in building materials for bridges and aircrafts.

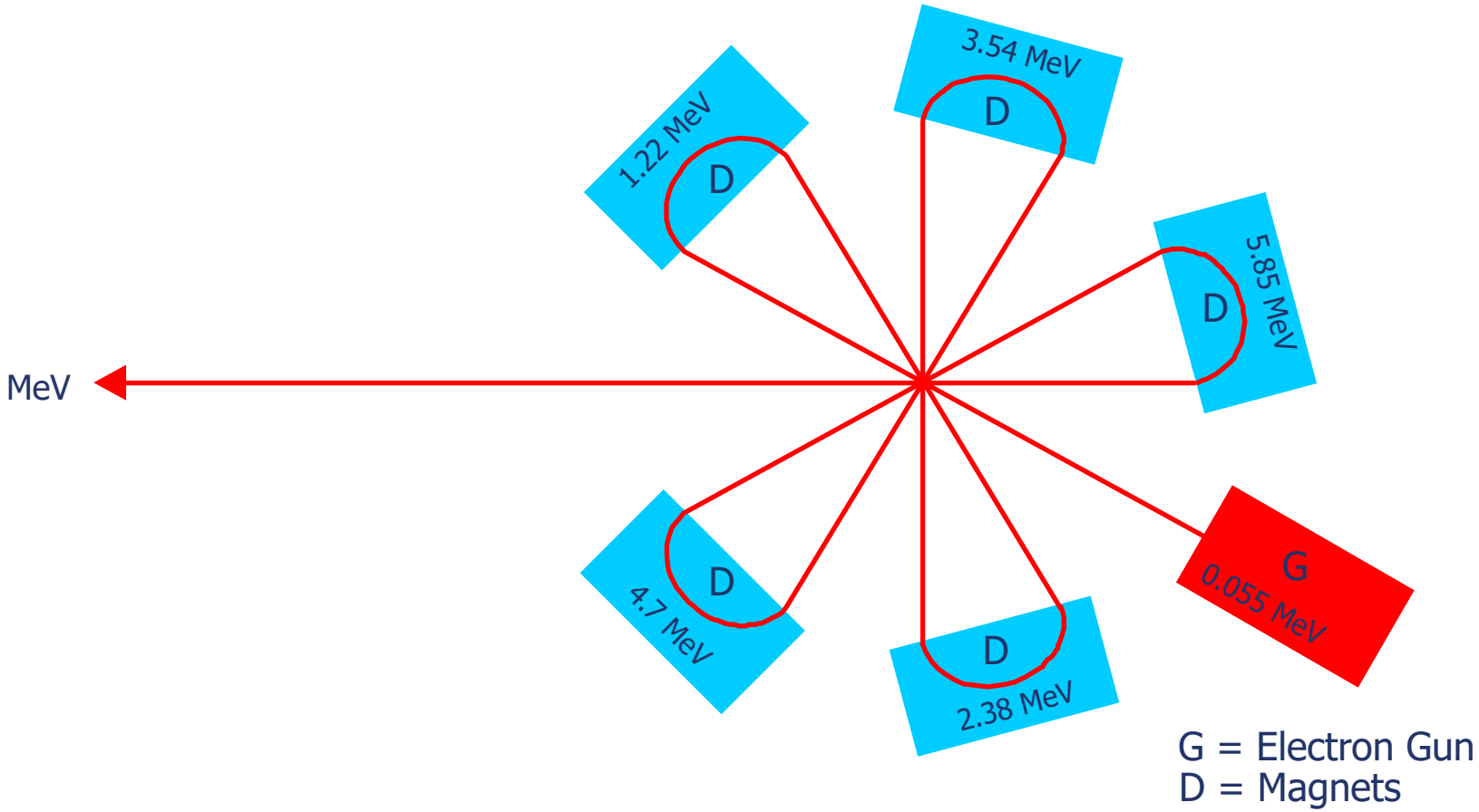
Orthoplastics
A VIANT COMPANY
science making a material difference

DOSE PENETRATION



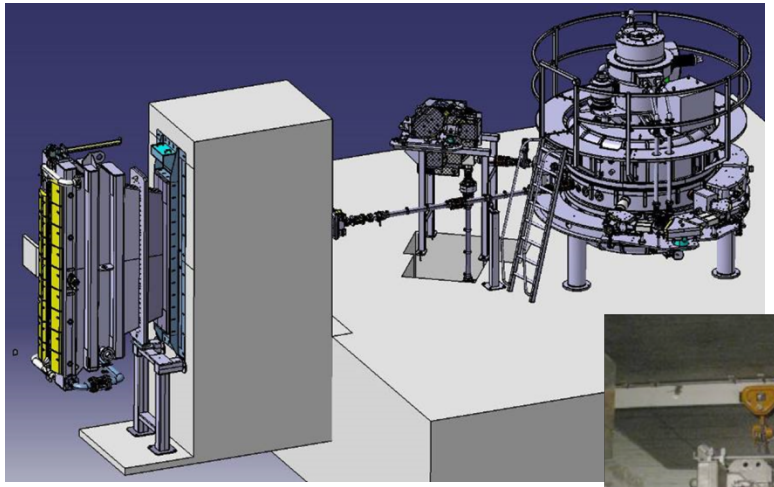
X-RAY

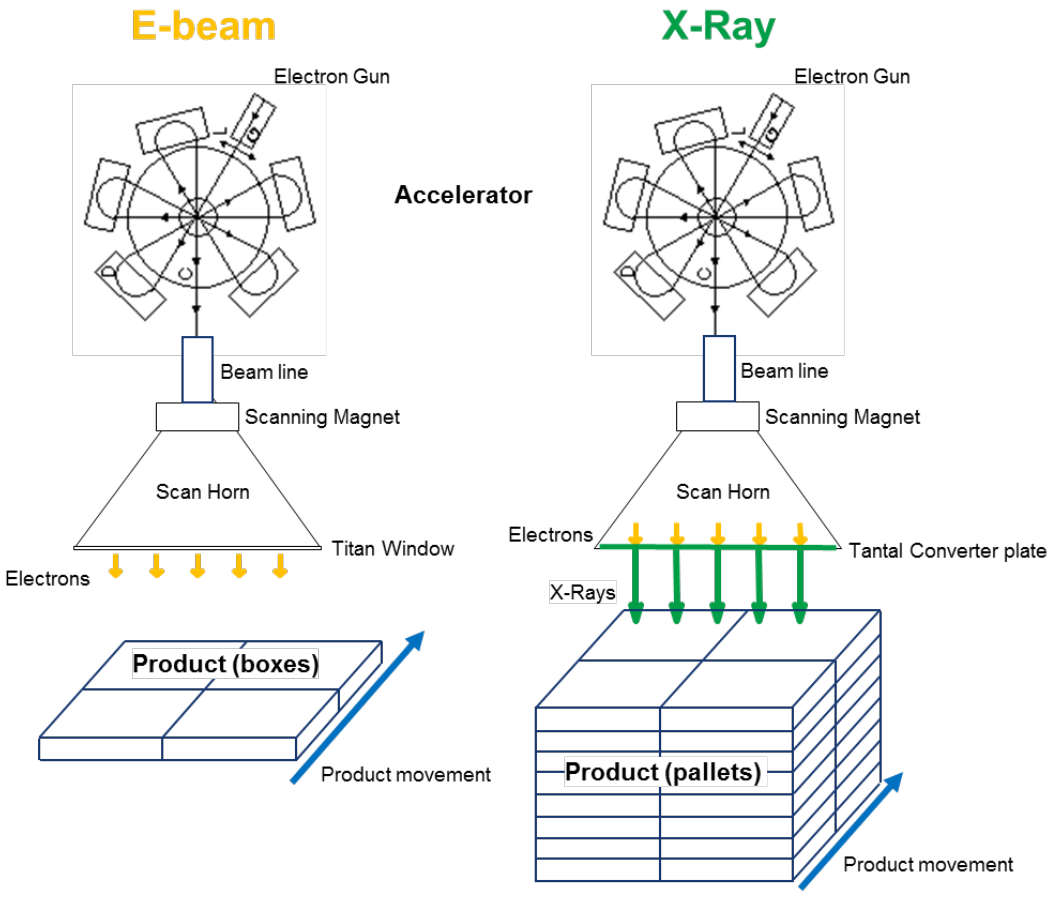
Interlocked redundant measure and control of both beam current and voltage
New electrons injected 107 Million times/s



G = Electron Gun
D = Magnets

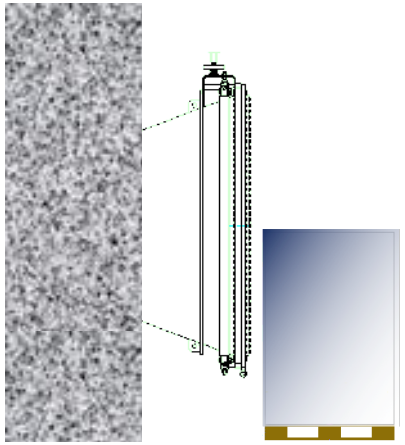
STERIS COMMERCIAL X-RAY





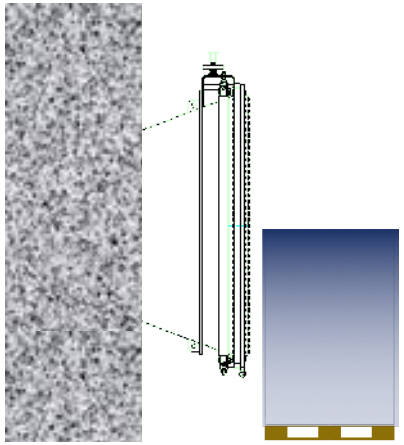
4 STEP X-RAY IRRADIATION

Orthoplastics
A VIANT COMPANY
science making a material difference



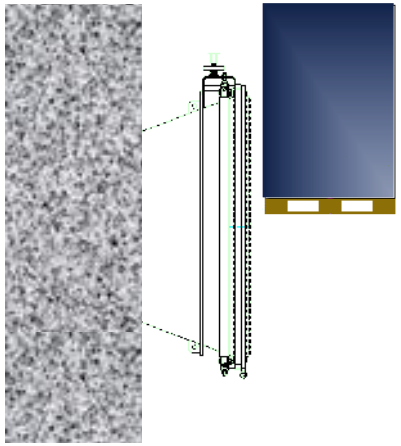
First pass

180 deg turn



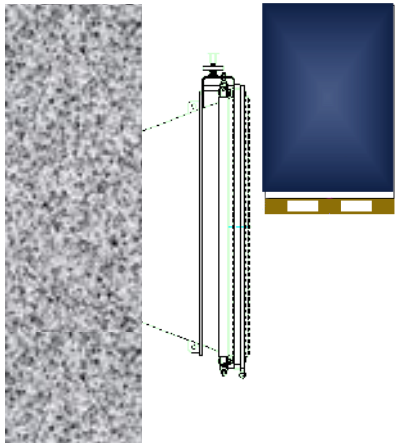
Second pass

Lift to upper level



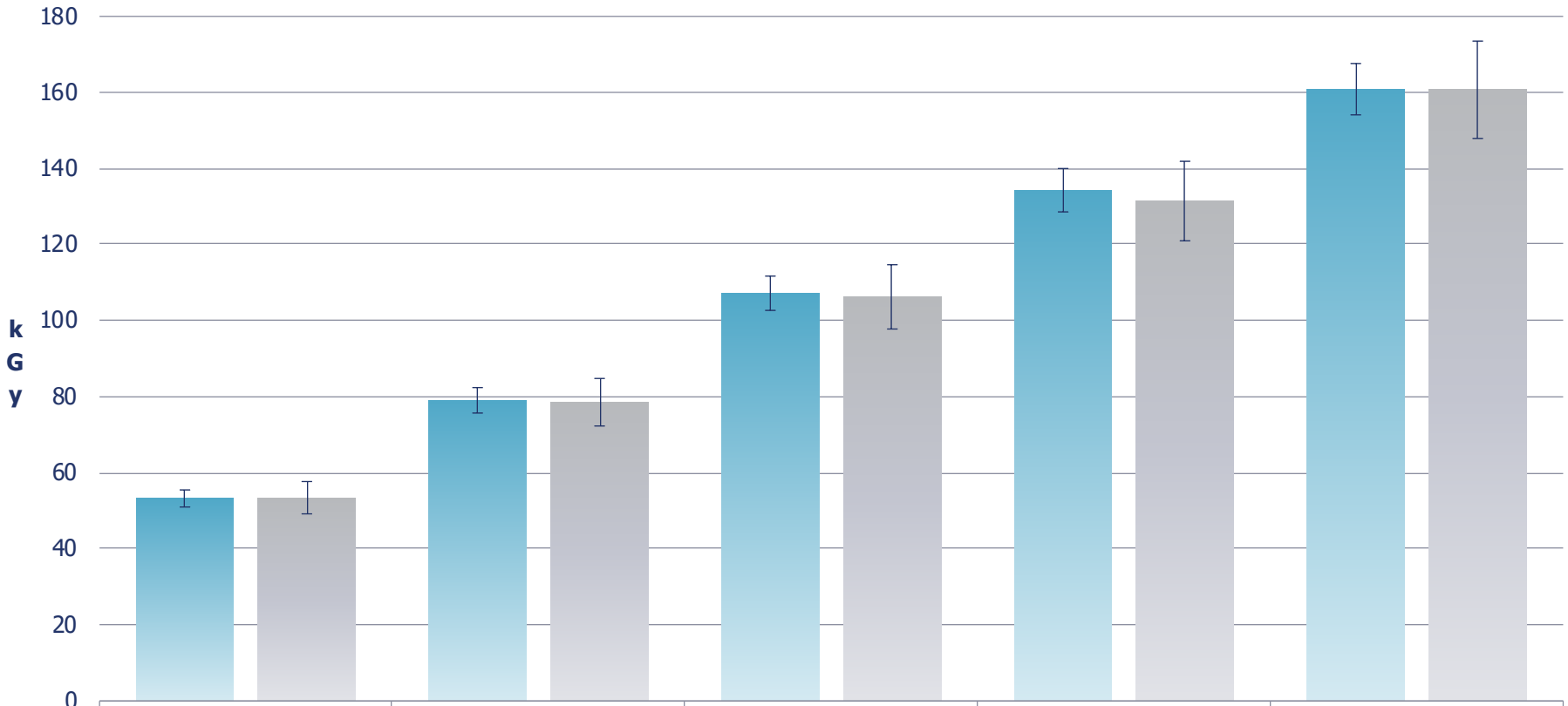
Third pass

180 deg turn



Fourth pass

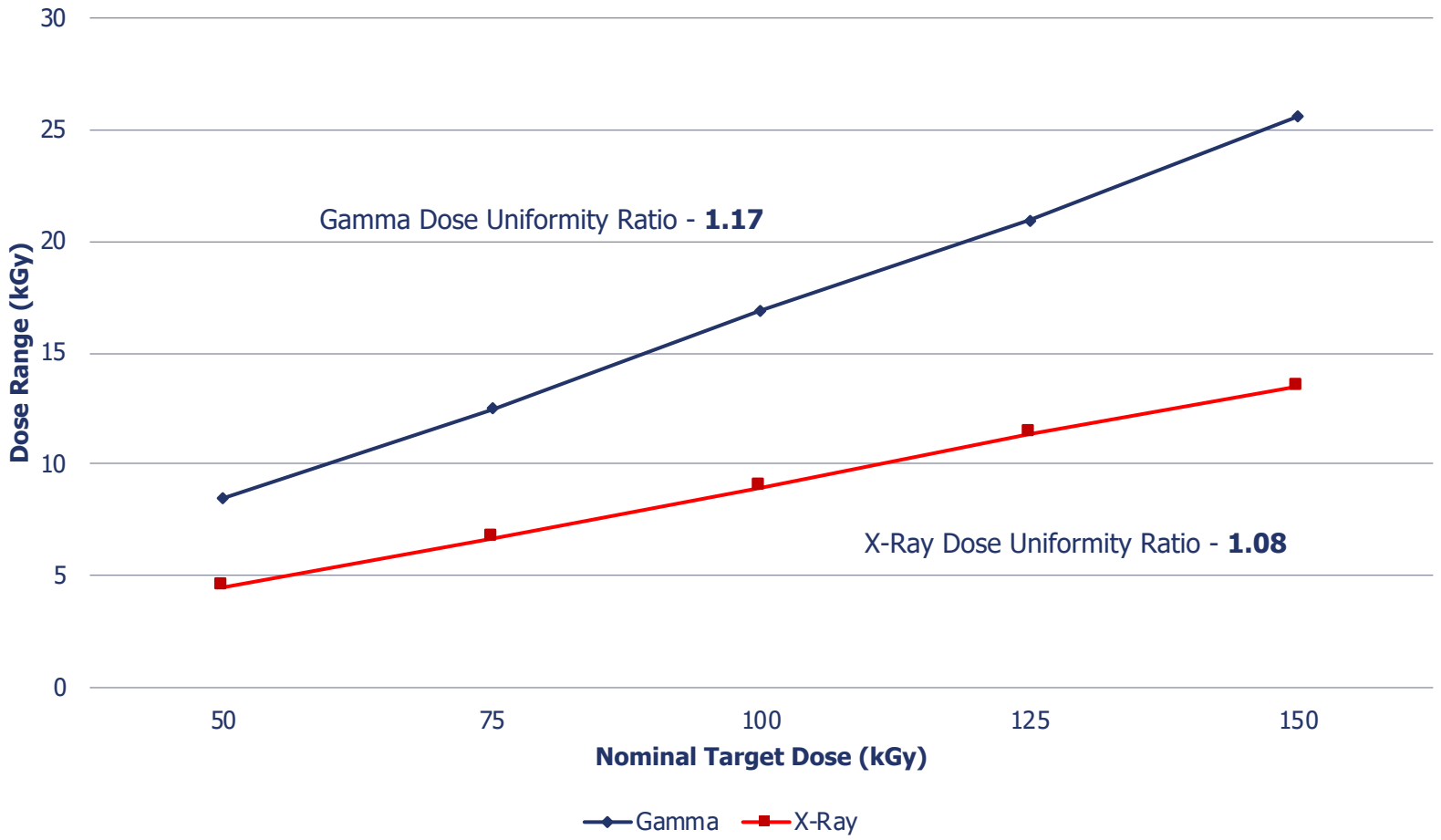
IRRADIATION DOSE DISTRIBUTION (KGY)



	50	75	100	125	150
X-Ray	53.25	79.05	107.2	134.3	160.85
Gamma	53.45	78.55	106.25	131.45	160.7

Orthoplastics
A VIANT COMPANY
science making a material difference

ACTUAL DOSE RANGE (kGy) AND D.U.R



X-RAY UNIT IN DÄNIKEN

- ✓Fast Turnaround time: Dwell time for 25 kGy minimal dose and density 0.15: 3 hours
- ✓Flexible Hold up: 20 to 30 pallets
- ✓Small Lap dose: 2.5 to 3.0 kGy surface dose for minimised overdosing
- ✓Equivalence to a Cobalt 60 pallet irradiator: 6 Mio Curie
- ✓Incremental dose, overlapping product concept
- ✓No significant influence of neighbour pallets: free product mixing allowed
- ✓Standard pallet dimensions of 80*120*195 or 100*120*195 cm
- ✓Pallet weights up to 999 kg
- ✓Minimized gap between pallets

X-RAY BASICS

- Evaluate the radiation sensitivity of microorganisms irradiated with Gamma and X-Rays through evaluation of their respective D10 values

Conclusion:

Statistical analysis show that the D10 values of the studied micro-organisms are not significantly different when treated with Gamma or X-Ray irradiators.

ISO 11137 asks for an evaluation of a potential activation of materials with X- Ray irradiation even if the risk of activation of product is very small and comparable with a 10 MeV E-Beam treatment.

Product Types already tested :

- Polymers (PP/PE/PS/ PVDF)
- Implants (Stainless Steel, Keramic-Al-Oxid, Ti-Al-Nb)
- Bones cement

Conclusion :

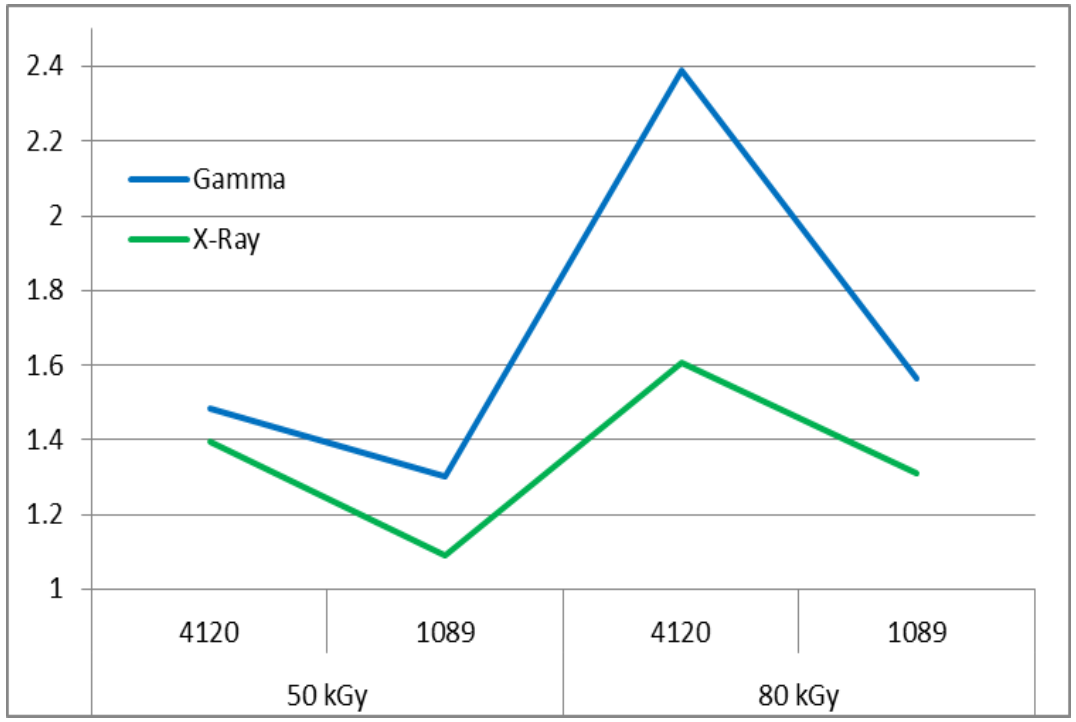
All product tested up to today has shown that they can be declared as non-activated by X-Ray confirmed by SUVA (according to Swiss law)

PRIMARY PACKAGING MATERIAL

Primary packaging material evaluated in both Gamma and X-Ray in the same treatment conditions.
As a test parameter we have chosen the SOI (surface oxidation index)

Much higher SOI with Gamma when compared to X-Ray after Time 60 and 120 days and aged with different temperatures and humidity:

Both methods are showing some recuperation, but X-Ray continues to show better values.



Conclusion: X-Ray shows lower oxidation values

GAMMA OR X-RAY STERILISATION PROCESS

Final Decision

FDA guidance and ISO11137 part 1, X-Ray sterilisation process is not affecting the device properties/specification or resulting in a lower SAL, then no 510(k) need be submitted. Before transferring the sterilisation process, to be on a safe side, the manufacturer shall contact ODE (FDA Office of Device Evaluation) to have approval, but:

Conclusion : there is no new submission required!

OVERVIEW

As a result:

- Reduced effects of ozone induced oxidation in the product
  - ✓ less yellowish for transparent products (ex. PP tubes)
  - ✓ less oxidation in high surface products (ex. blood filter, cotton and others; no risk of adhesion of toxic gas (ETO))
- Evidence of a much better dose usage for crosslinking application
- Lower Maximal Dose for sensitive products for given Minimal Dose (ex. Pharmaceuticals)
- Better Pallet usage for the same dose range compared to Gamma (more boxes on the pallet for the same pallet price!)
- Better acceptance for consumable customers (cosmetics a.o.)

Gamma	X-ray
Transportation of radioactive Cobalt sources: Licencing, shipping, installation, disposal	None
Cobalt Replenishment – lead time, PQ re-qualification, regulatory submission (s)	None
Perception: Decaying Radioactive sources	Electrical machine (Greener technology)
Price Control: minimal number of suitable suppliers	Electricity = commodity energy supply. Predictability on pricing

Orthoplastics
A VIANT COMPANY
science making a material difference

CONCLUSION

Dose Uniformity Ratio is lower for X-Ray processing

Dose Range is significantly lower with X-Ray

Attenuation is much lower in X-Ray due to the penetrative energy

Crosslinked UHMWPE properties are statistically equivalent to Gamma

The acceptance of X-Ray sterilisation for Class III devices has enhanced the viability of X-Ray as a crosslinking method

Conclusion:
Is X-Ray crosslinking the future for UHMWPE?

Orthoplastics
A VIANT COMPANY
science making a material difference

Orthoplastics
A MedPlast Company
science making a material difference

ORTHOPLASTICS

http://www.orthoplastics.com/

COMPONENT MANUFACTURE

http://www.orthoplasticsmachining.com/

DIRECT COMPRESSION MOULDING

http://www.orthoplastics.com/products/compression-moulding

THANK YOU

With thanks to,

Hervé Michel & Hans Hartmann STERIS AG

Julia Crabtree, and the orthoplastics technical team