

# **High Precision Dose Delivery from Electron & X-ray Beam Lines**

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# Industrial Irradiation

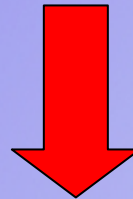
Product treatment using **ionizing radiation**

- **electrons ( $\beta$ ) of different energy**
- **Gamma ( $\gamma$ )- radiation from radioactive decay (Co-60)**
- **X-rays from conversion of electrons in a target**

# Sterilisation

SAL (Sterility Assurance Level)  
 $10^{-6}$  Sterilisation

**$D_{10}$  -Wert**

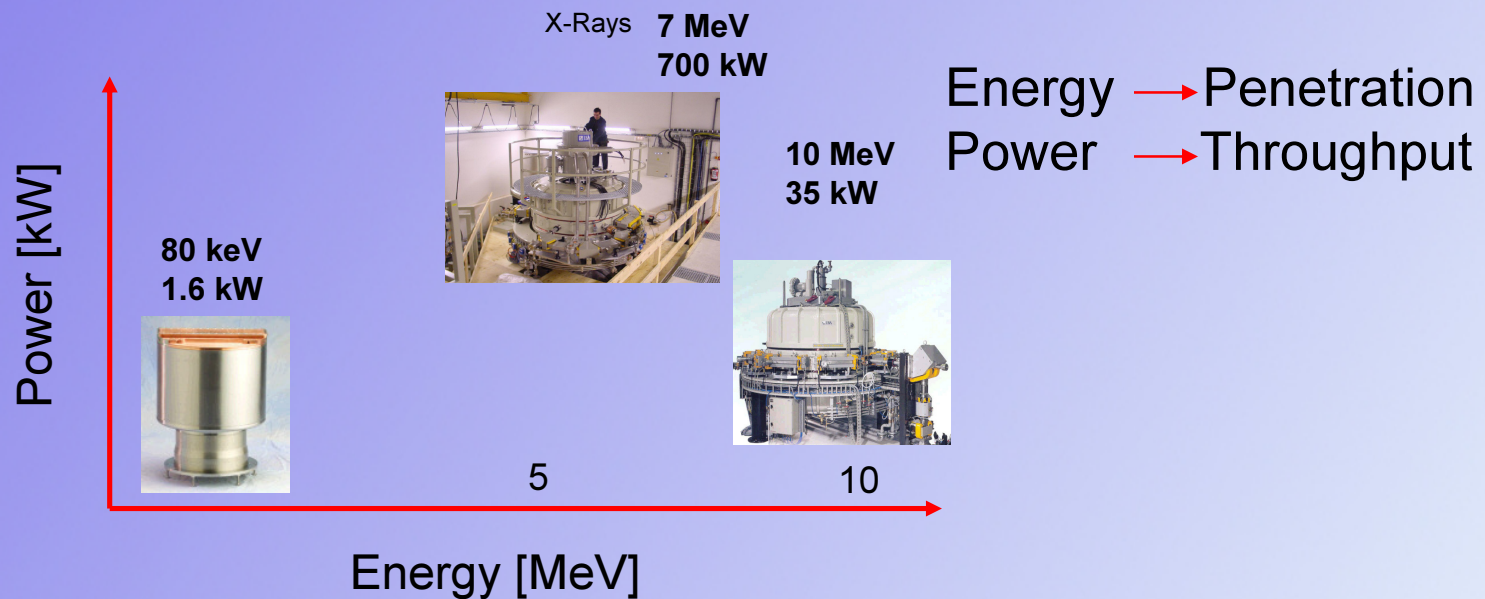


Effects on  
microorganisms

Deposition of ionising radiation  
(Energy Dose  $D = dE/dm$ )  
measured in Gy = [J/kg]

# Radiation Sources

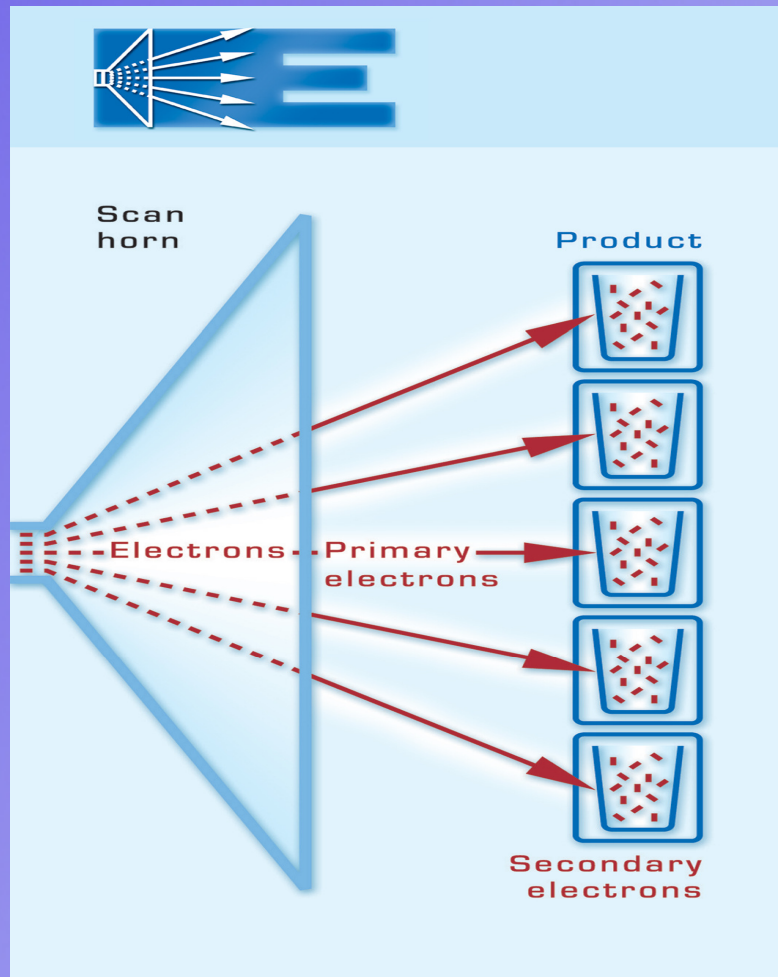
- Electrons of different energy
- X-rays (from Bremsstrahlung)



# Electron Beam

## Customer Requirements for doses:

- Routine doses (doses set to sterilizes products)
  - Repeatability, very tight
  - Small  $D_{\max} - D_{\min}$  Value
  - Trend to lower doses 25 kGy -> 15 kGy
  
- Verification Dose Audits
  - Very low doses ( because of low bioburden)
  - Precise dose delivery (within 10%)

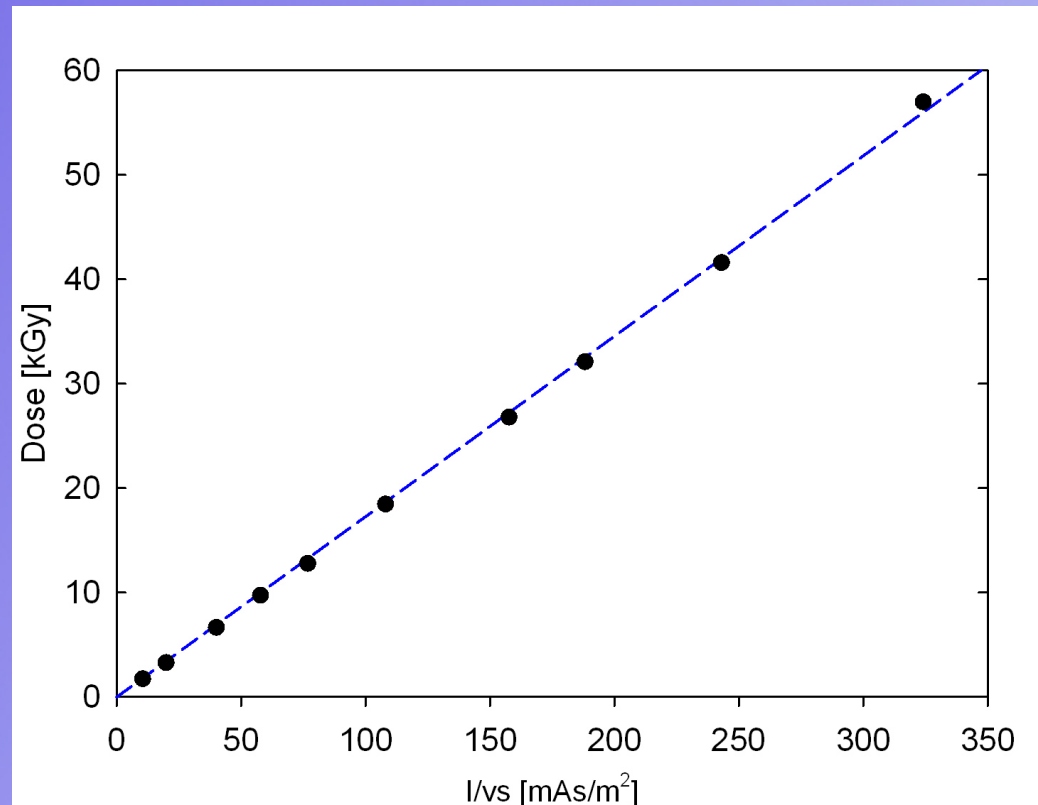


## Mediscan, Austria:

- Irradiation Service Provider
  - Consultancy in Radiation Processing
  - Established 1995
  - 2 TT-100 10 MeV 35 kW
- Second Unit:
- Additional 6.6 MeV X-ray

# Electron beam

## ■ Surface Dose



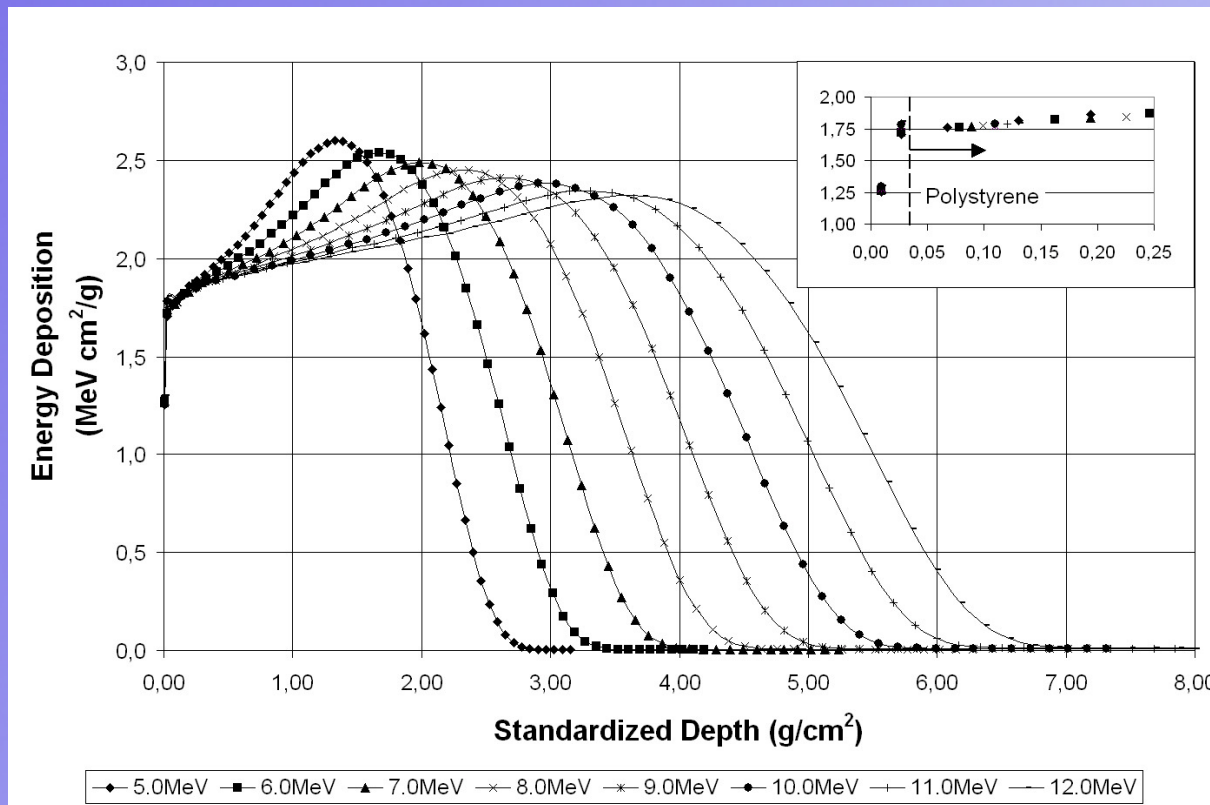
Dose defining  
parameter:

$$D = k \cdot I/v \cdot s$$

k process constant

# Electron beam

- Dose in Product



## Depth-Dose Curve

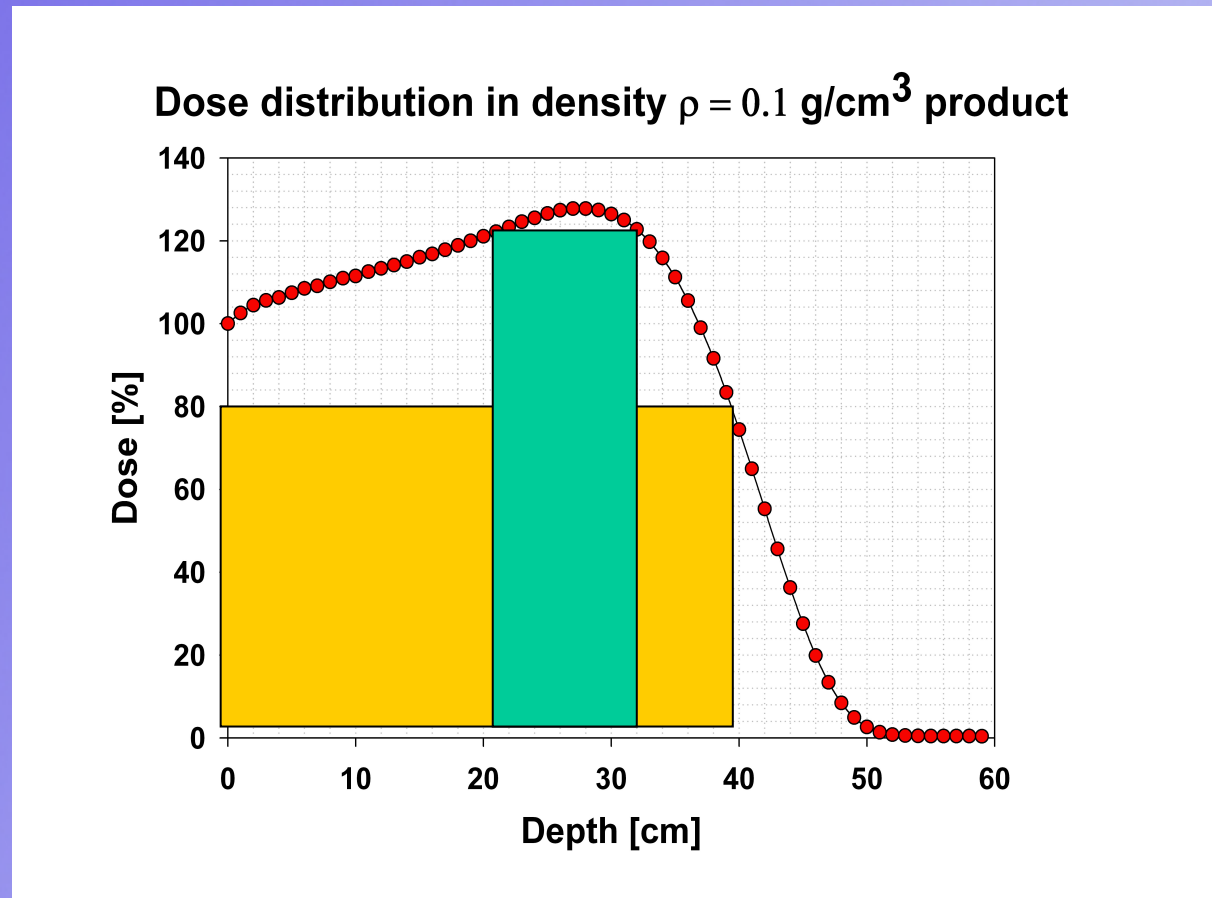
- Build-Up
- Steep Slope

Source : ISO/ASTM 51649



# Electron beam

- Dose in Product

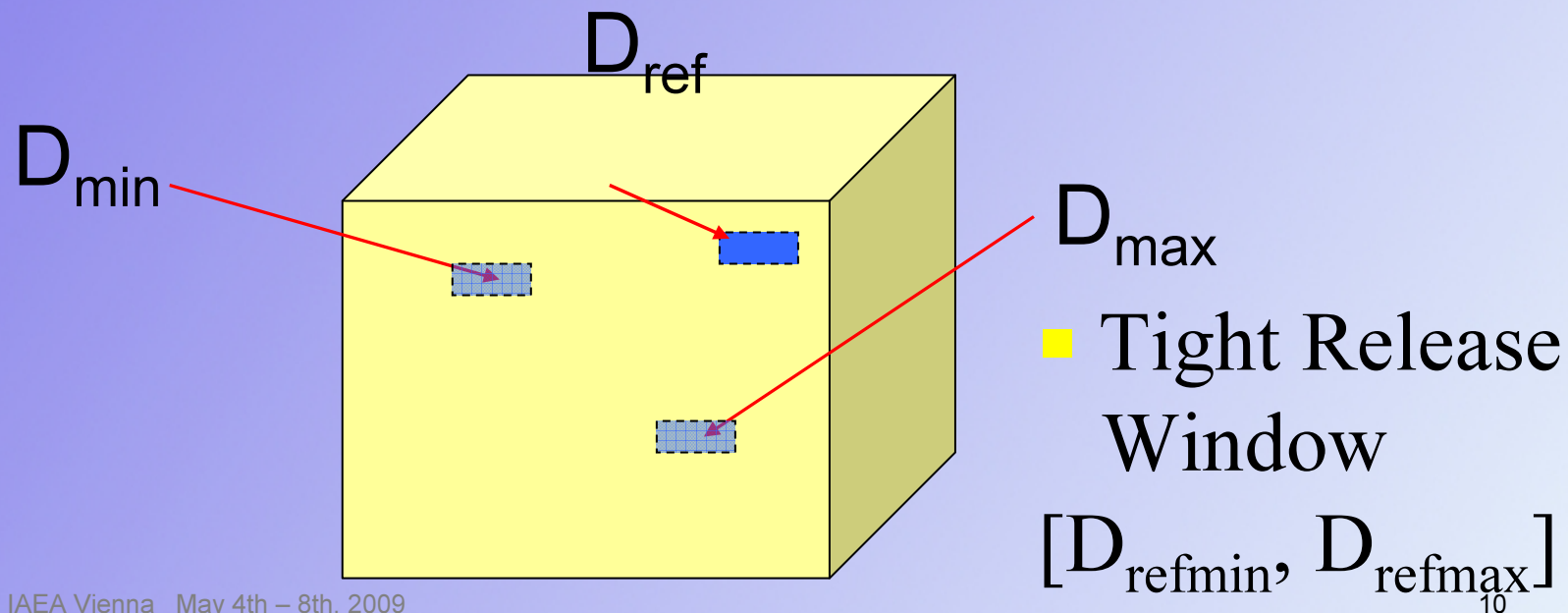


DUR  
Dose  
Uniformity  
Ratio

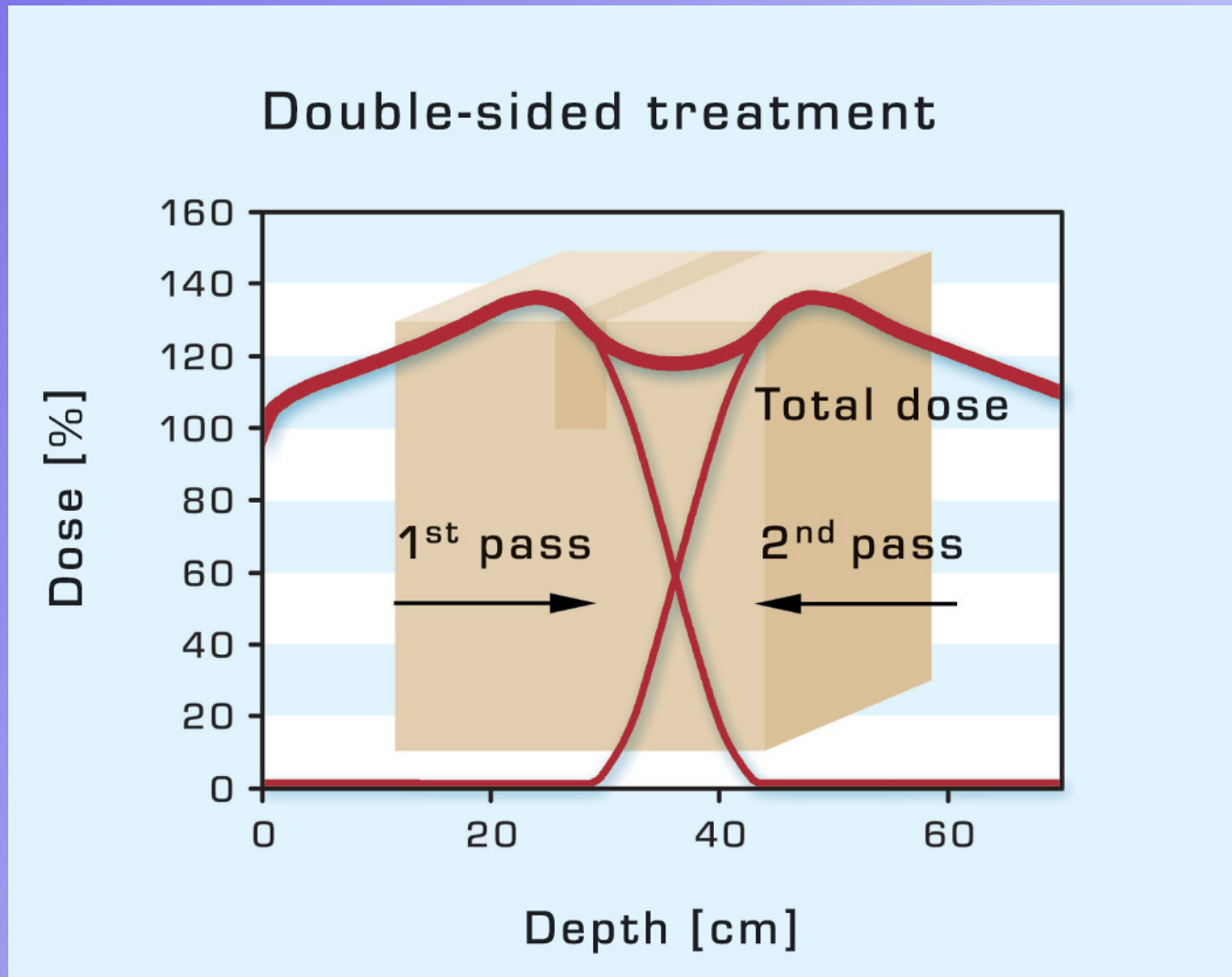
$$\text{DUR} = \frac{D_{\max}}{D_{\min}}$$

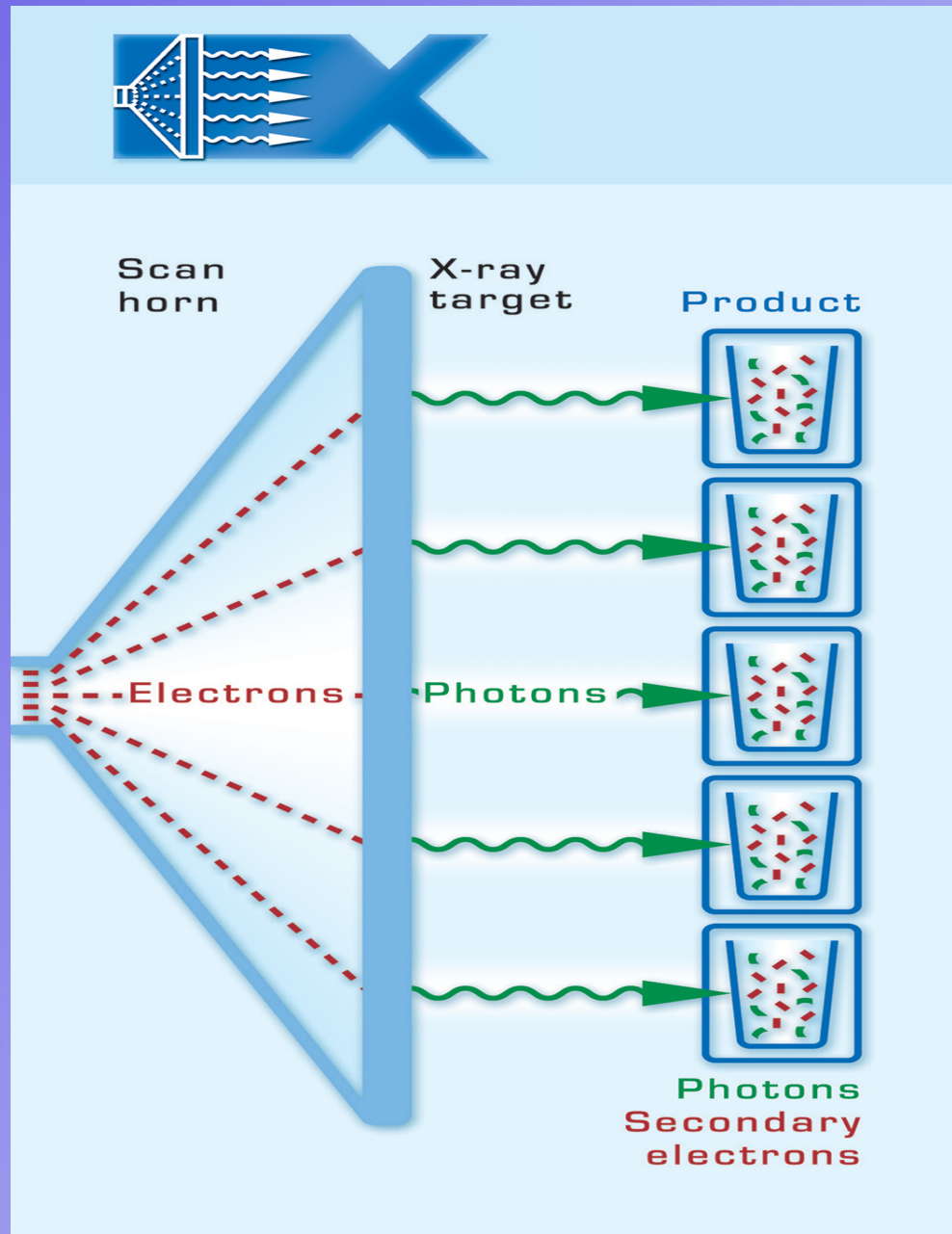
# Electron beam

- Use of special product carriers (build-up plates) to „shape“ dose distribution
- DUR = 1.1 achievable for some products
- Careful Product Qualification reduces process uncertainty and facilitates product release



# Electron beam

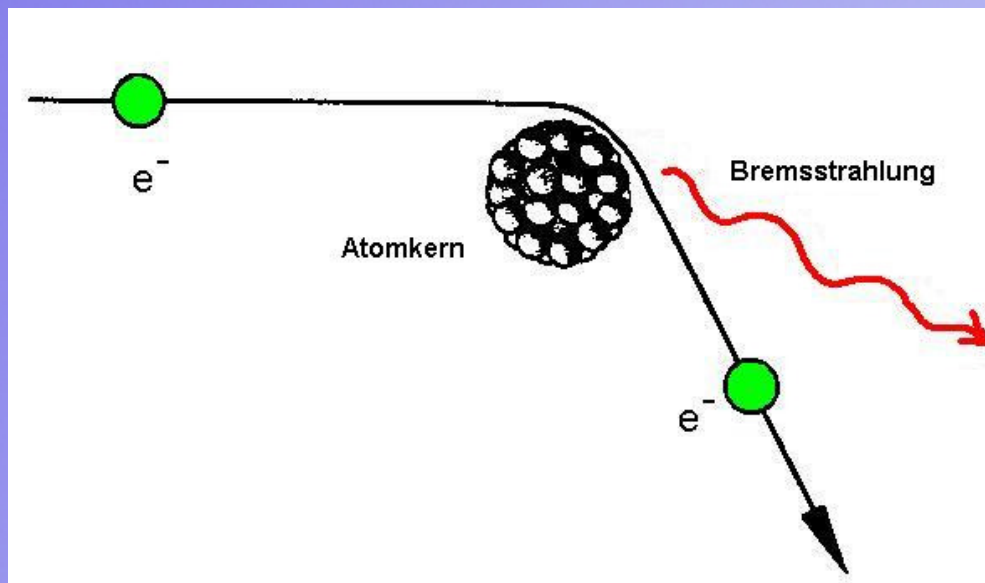




- Combination: Electron/Gamma
- High Penetration
- No Isotope !
- shorter dwell time

# X-Ray System:

Generation of high energetic (X-rays) by stopping of electrons in a target (Converter): Tungsten, Tantalum

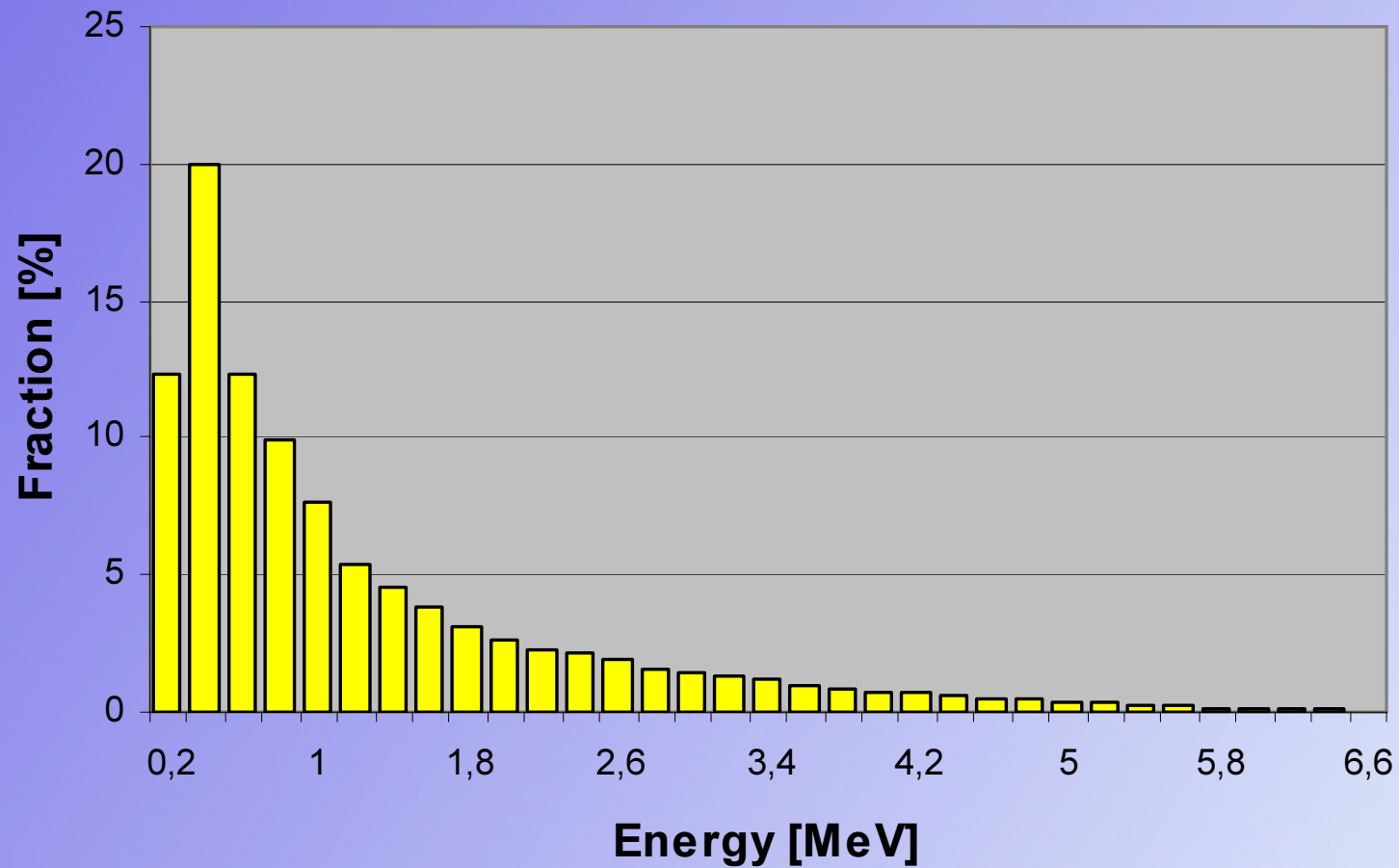


- High Z-Material

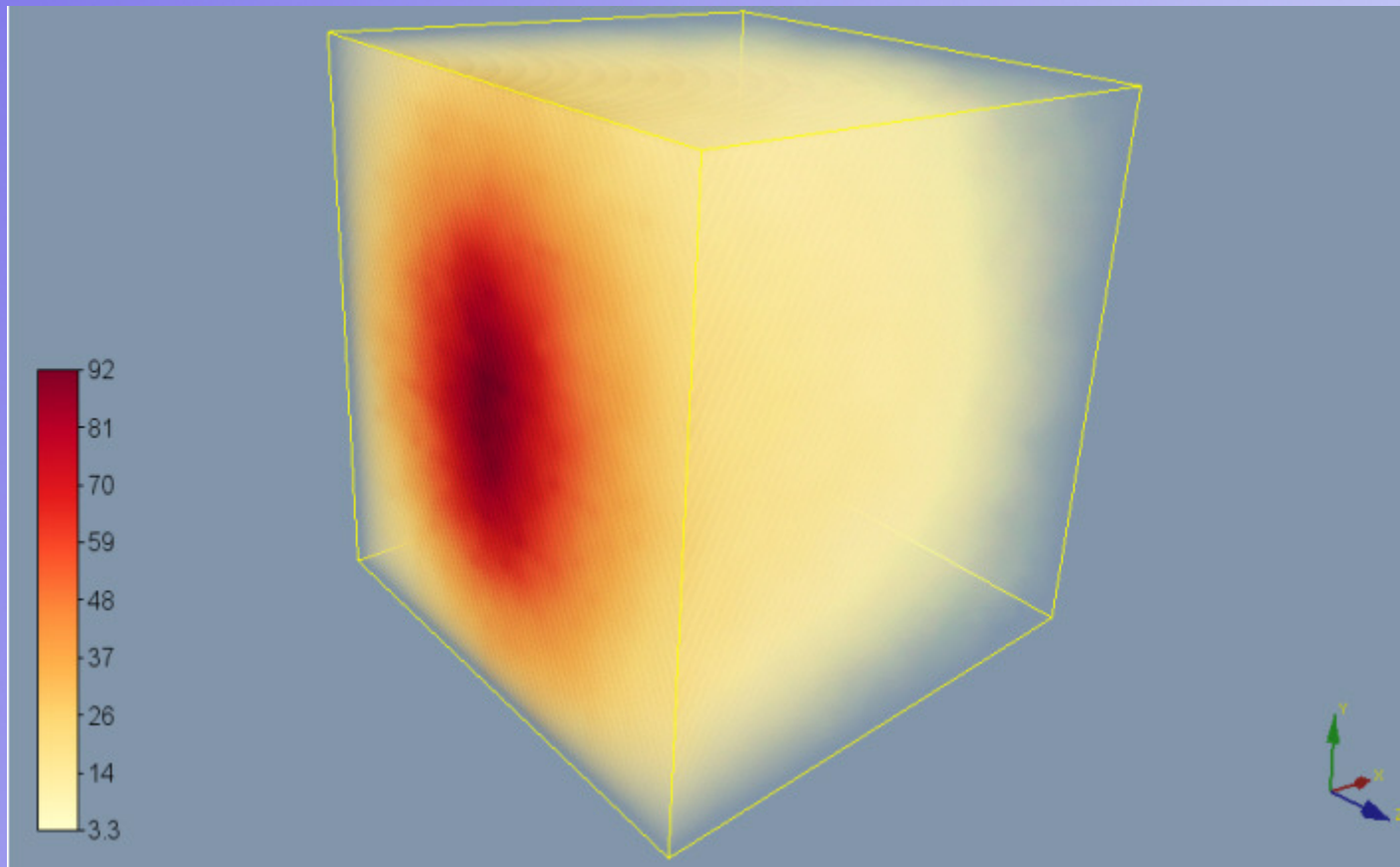
Very low yield:

- 5 MeV 8%
- 7.5 MeV 10 %

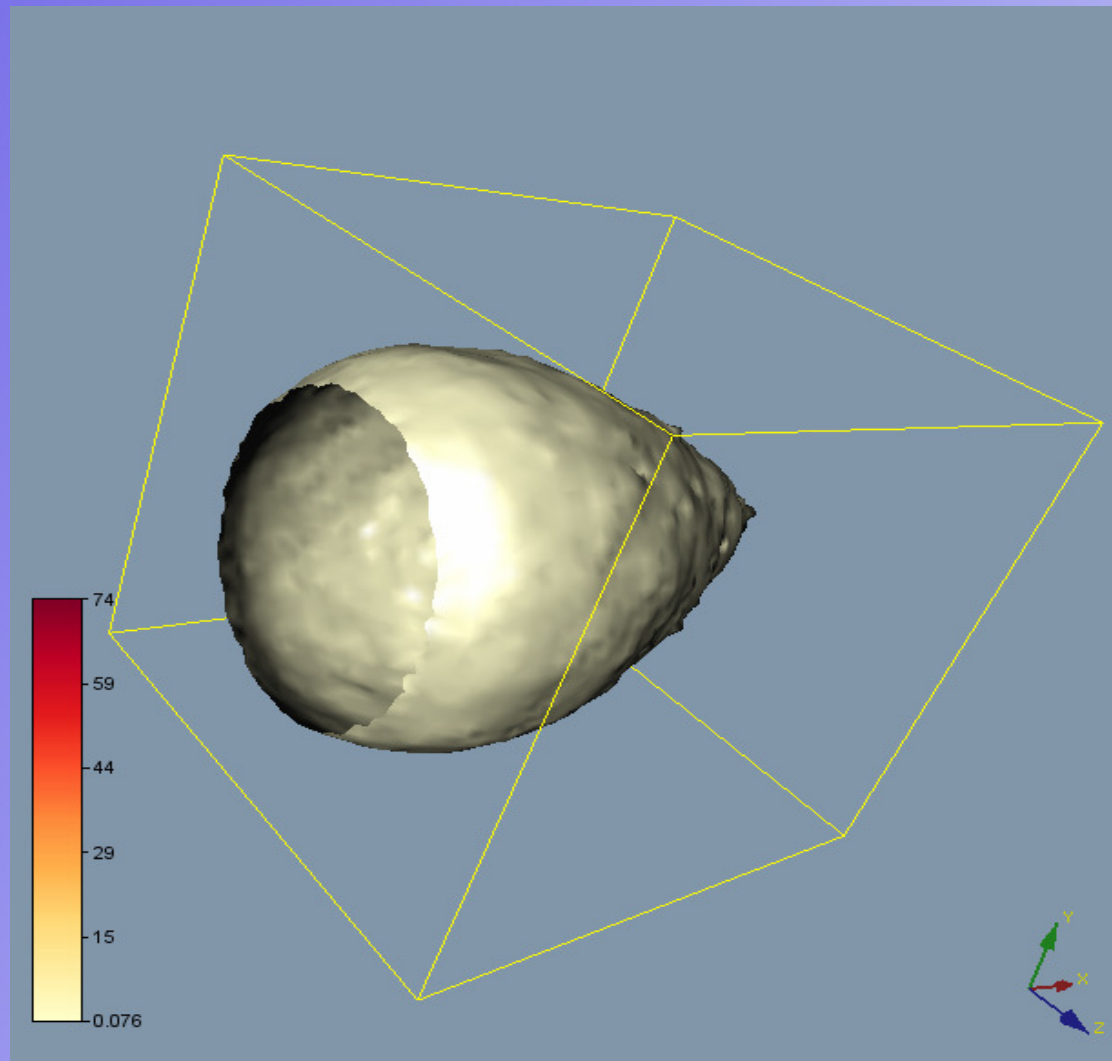
# X-Ray Spectrum:



# X-Ray Dose Modelling



# Iso-Dose Distribution



High Surface  
Dose

Maximum  
Utilisation of  
the radiation  
field



# Sterigenics X-Ray Facility



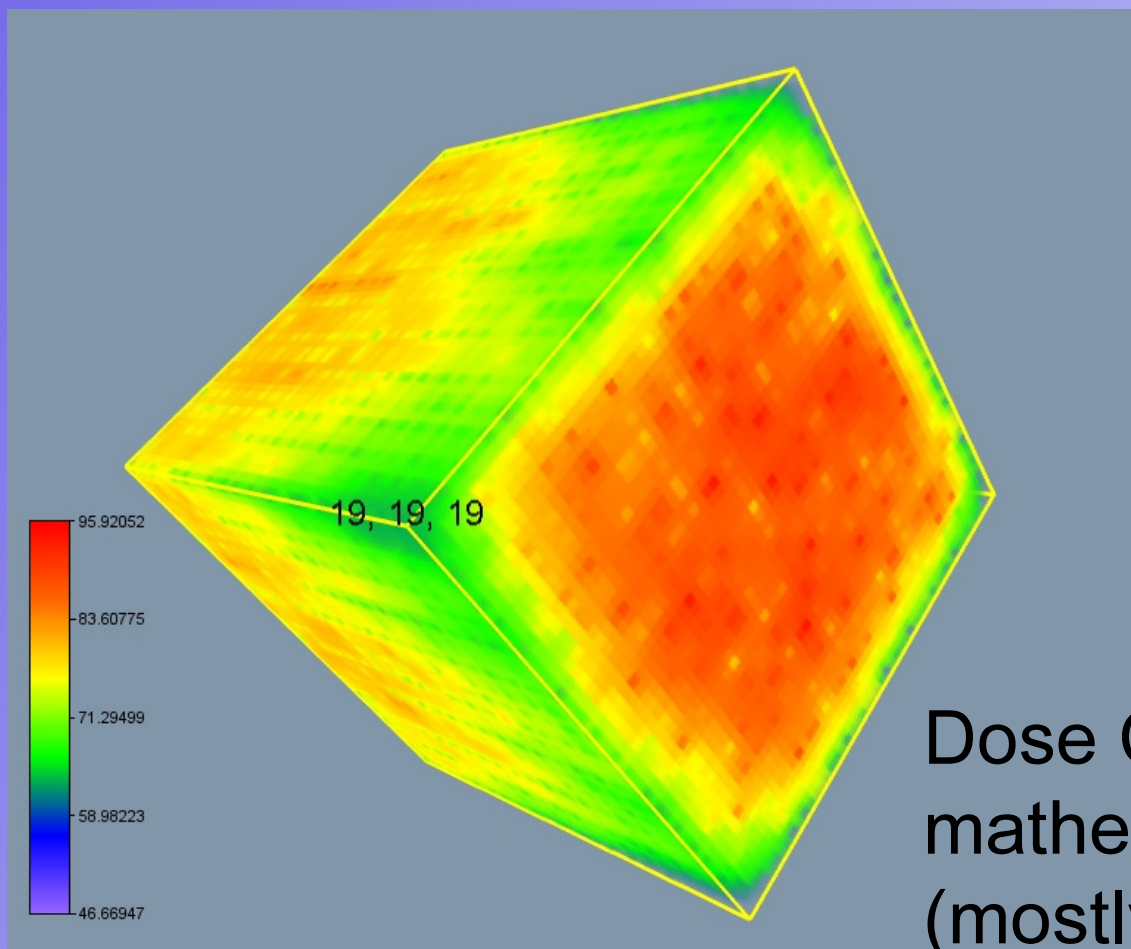
■ TT-300

10 MeV Elektrons

5 MeV X-Ray

7.5 MeV X-Ray

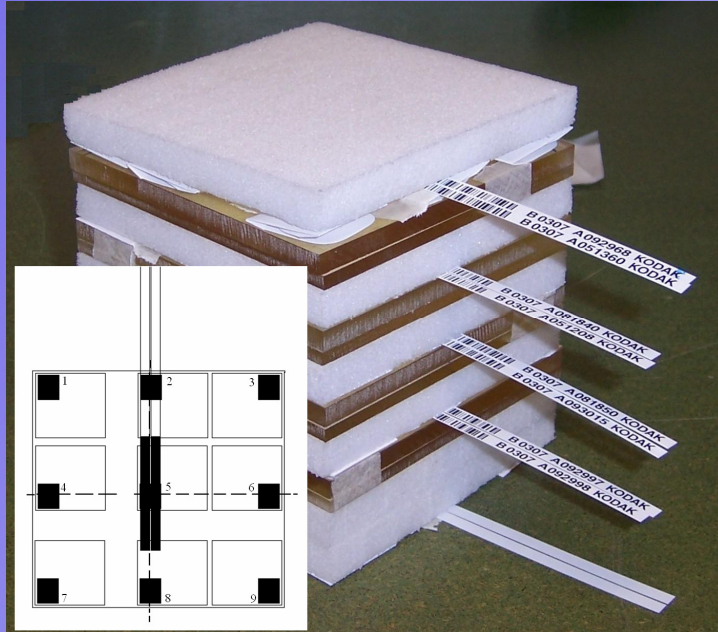
# Modelling



Dose Calculation through  
mathematical modelling  
(mostly Monte Carlo  
method)

# 9 FWT Dosimeter Stack

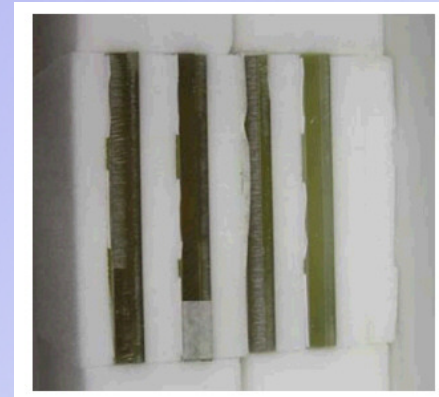
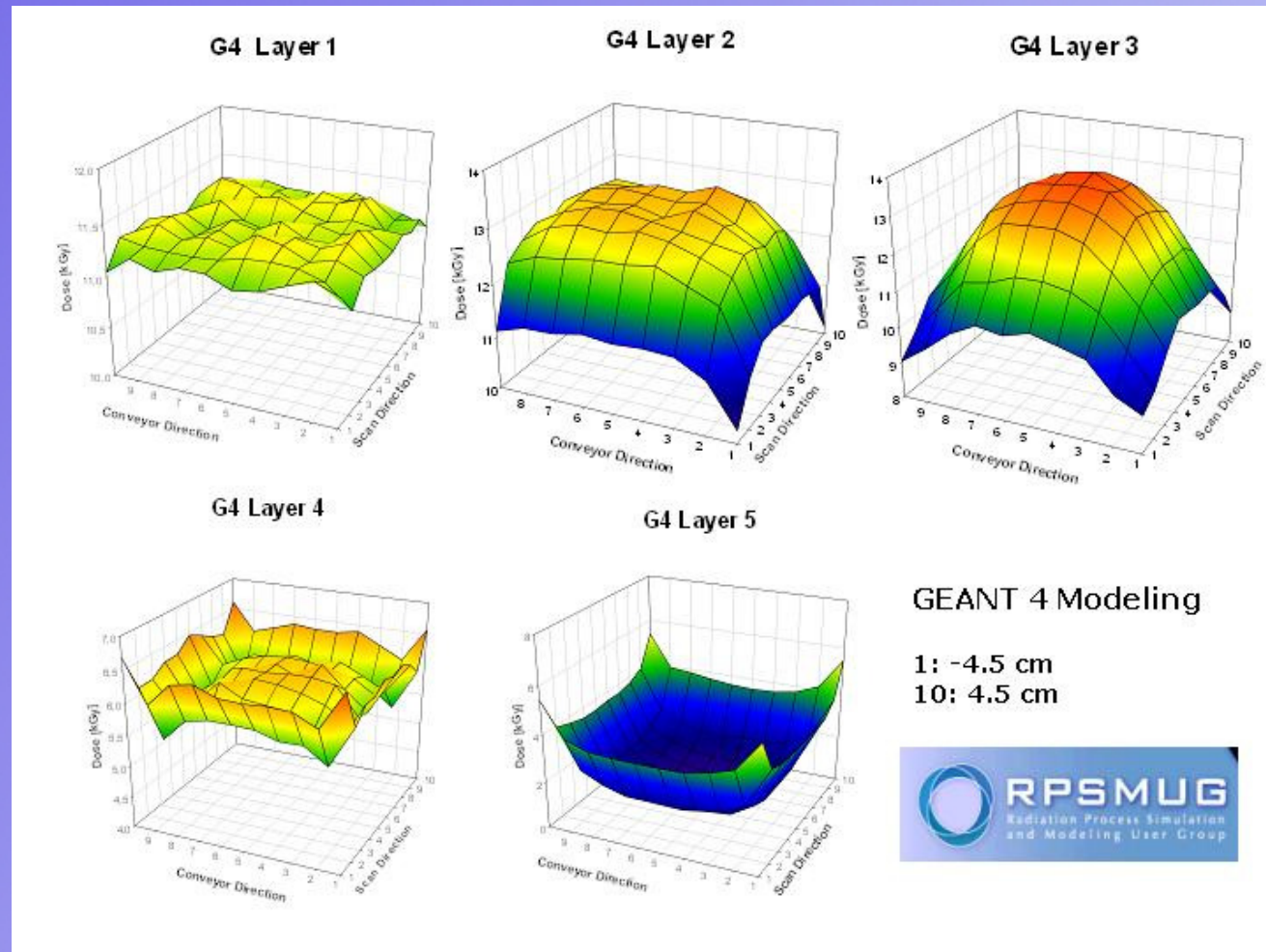
- 1 Alanine Strip



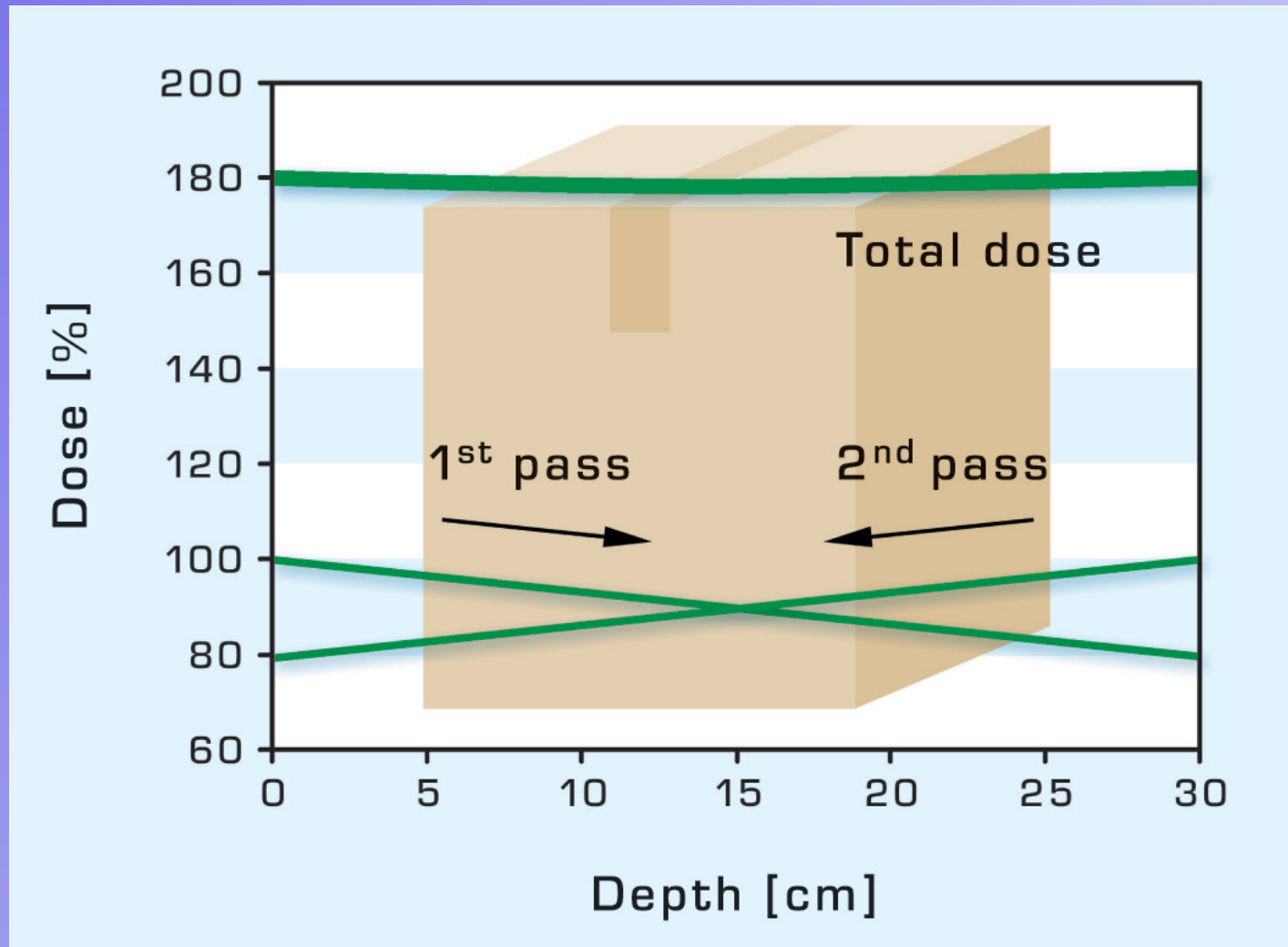
- Intercomparison of models
- Reproducibility of experiments
- Test models against experiment

**Simple Design - yet tests “real world phenomena” which are core to any product validation in detail**

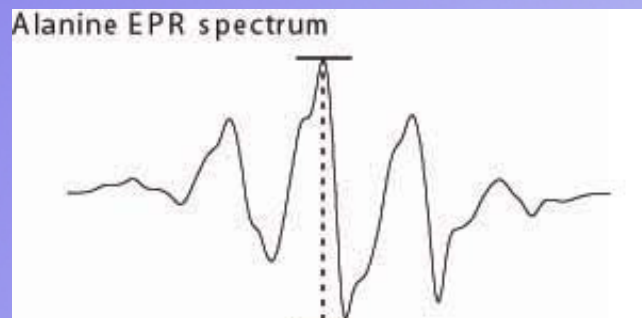
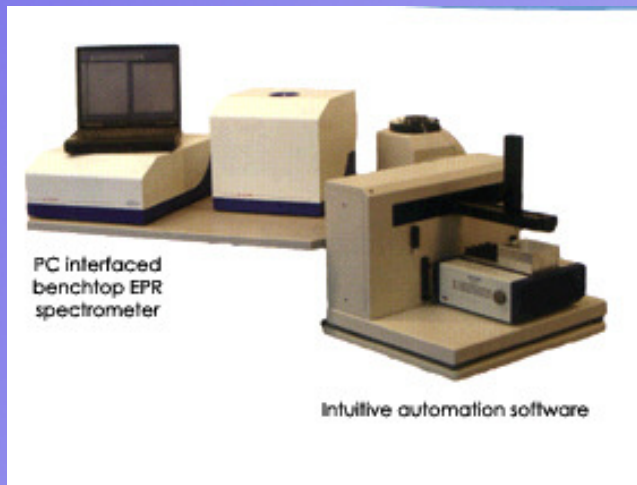
# Stack



# Very Low DUR



# Alanine Dosimetrie



- Now Referencedosimeter
- Future: Routinedosimeter ?

# Conclusions

- Precise Dose Delivery is not due to a single action
  
- It is a sum of actions to strive for quality
  - IQ of the radiation source
  - OQ to validate processes
  - PQ to validate products
  - Reliable measurement tools
  - Maintenance and training of personnel