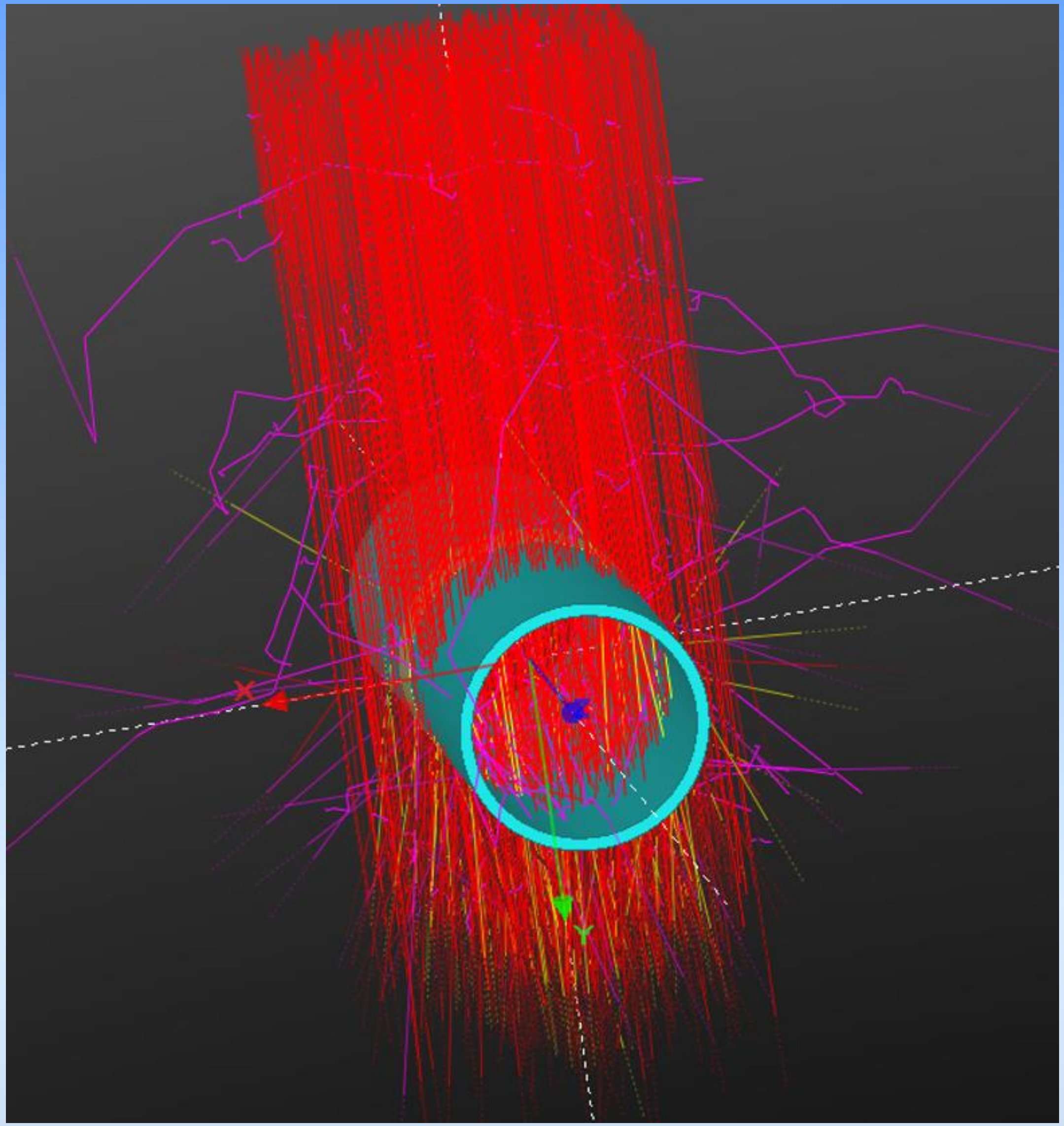


Modelling of E-Beam and X-Ray Processes

Status & Outlook

Josef Mittendorfer
High Tech Consulting

Monte Carlo Modelling

…is a virtual simulation of the subatomic and nuclear word via use of random numbers

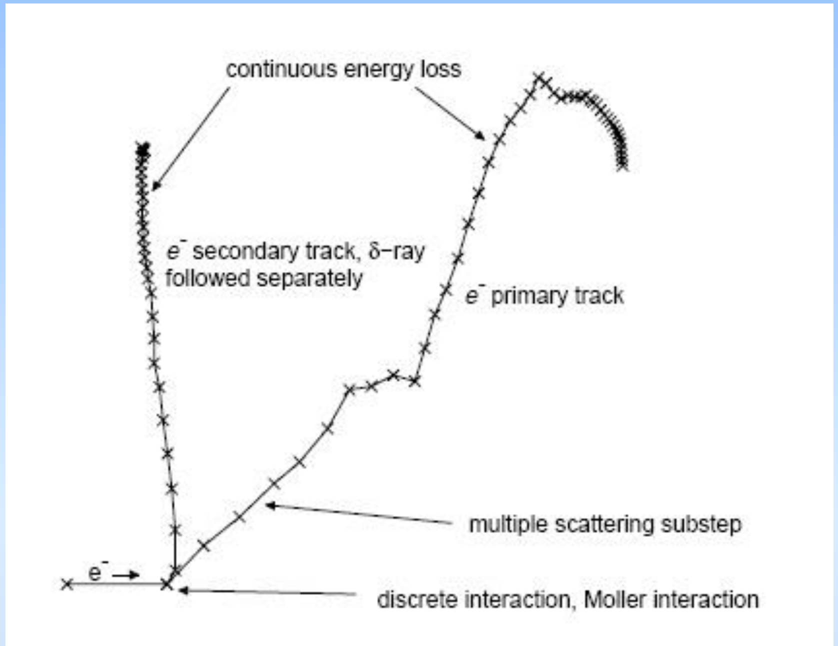
Computer needs to know:

- Details about how radiation (γ, e^-, e^+, n, p,…) propagates through and interacts with matter.
- Material and Shape of Irradiator/Packaging/Product

Method is simple (in principle…)

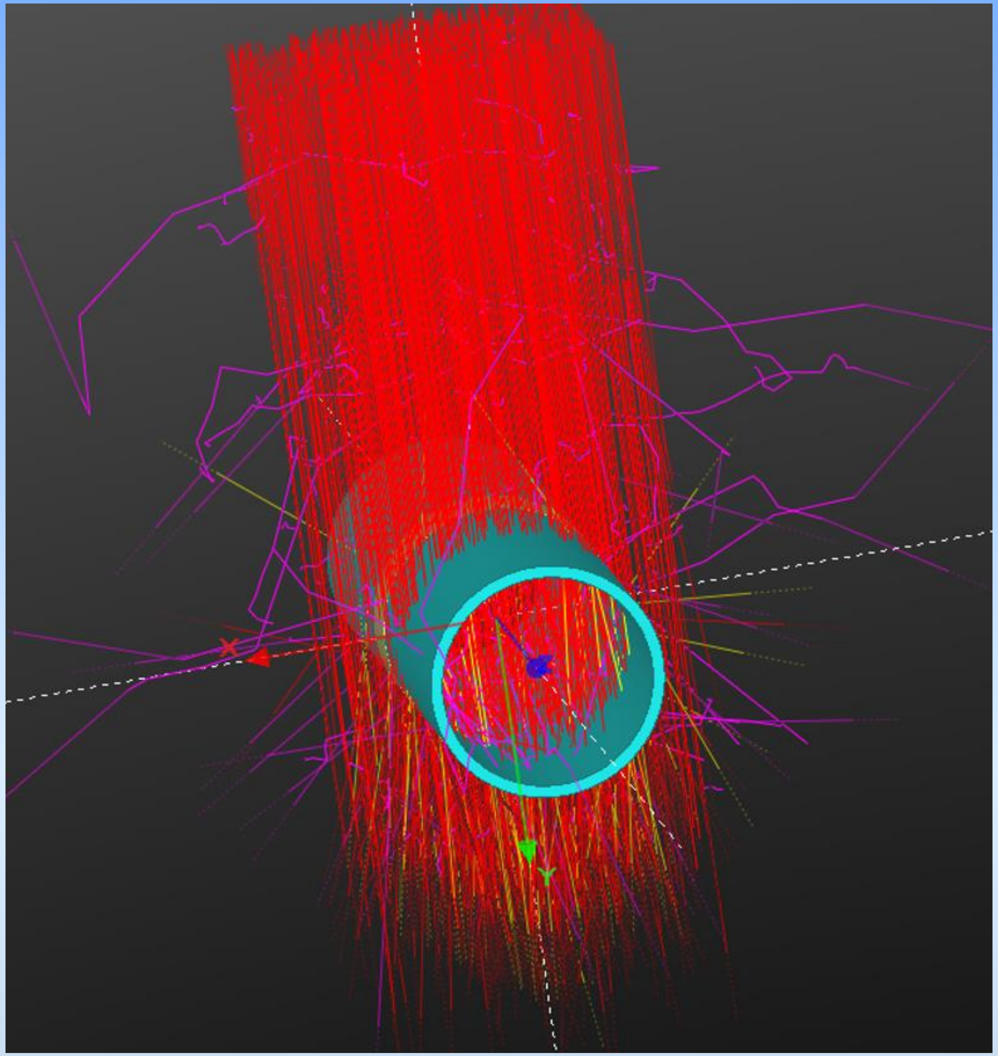
Follow many (≈10^7) particles

Interactions according to laws of physics

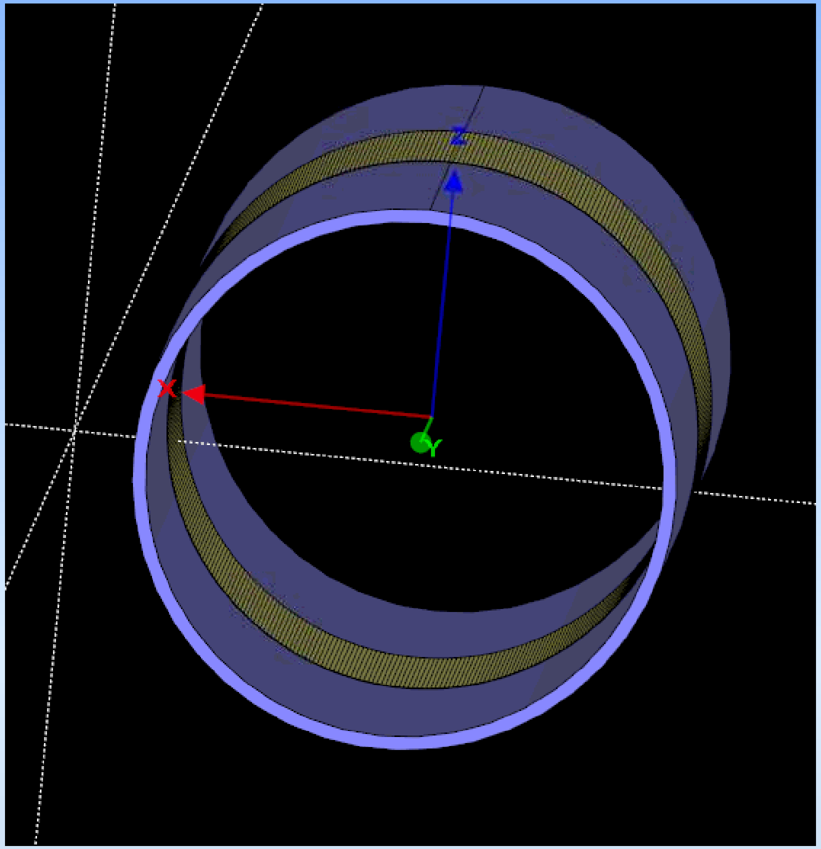


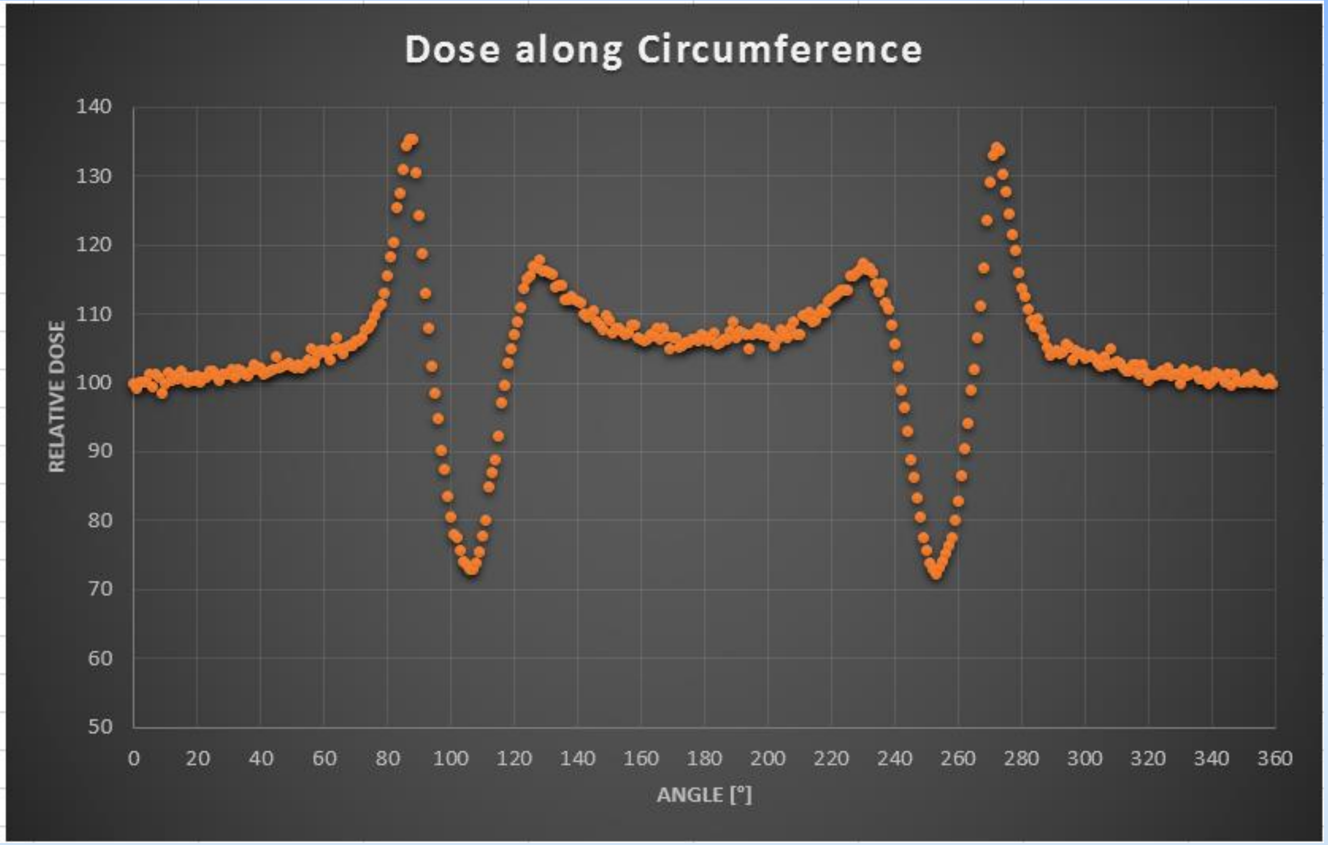
From: A.F.Bielajev, Fundamentals of the Monte Carlo Method for neutral and charged particle transport, 2001

UC ~ 1/√N

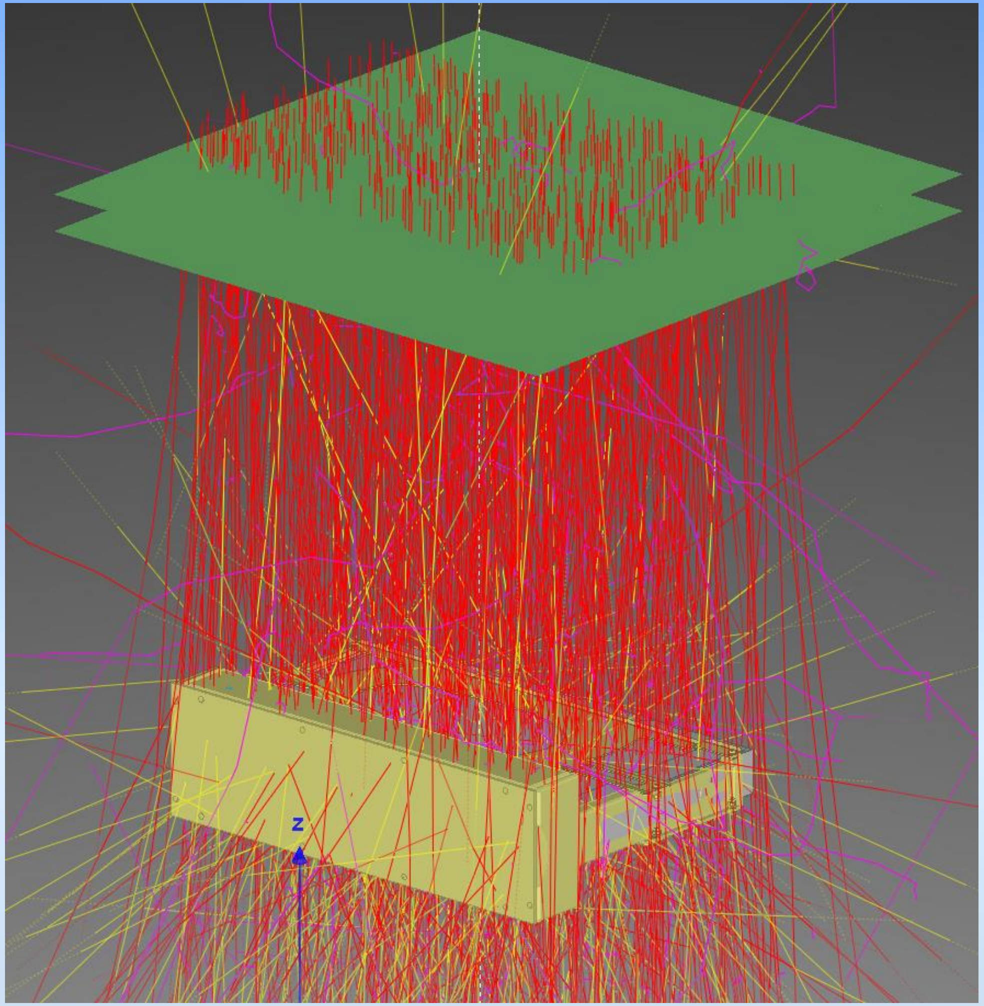


Study Electron Scattering…





Is more complex in real world…



Electron Beam:

Beam (Energy, Energy Spectrum, Geometry)

Accelerator Exit Window Structure

Air Gap

Product on Carrier

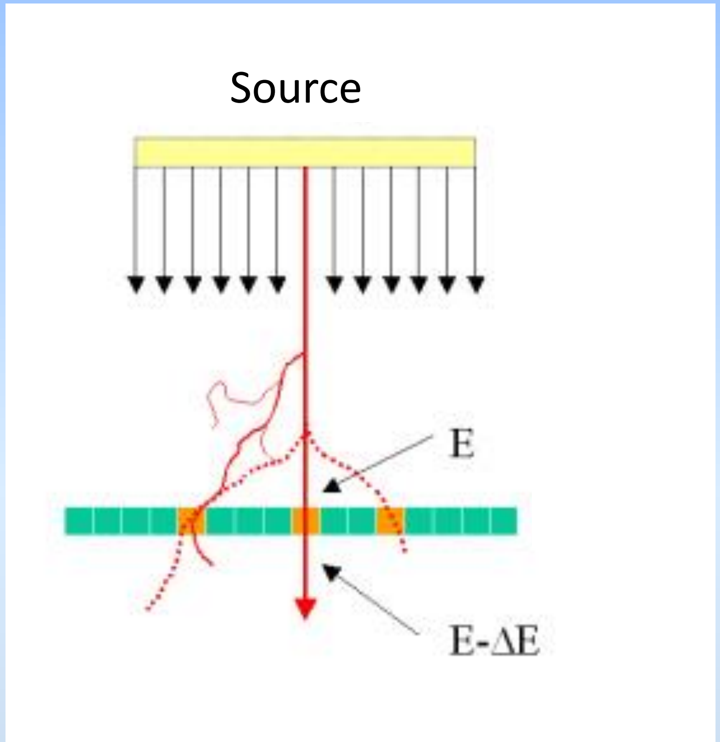
Beam Dump

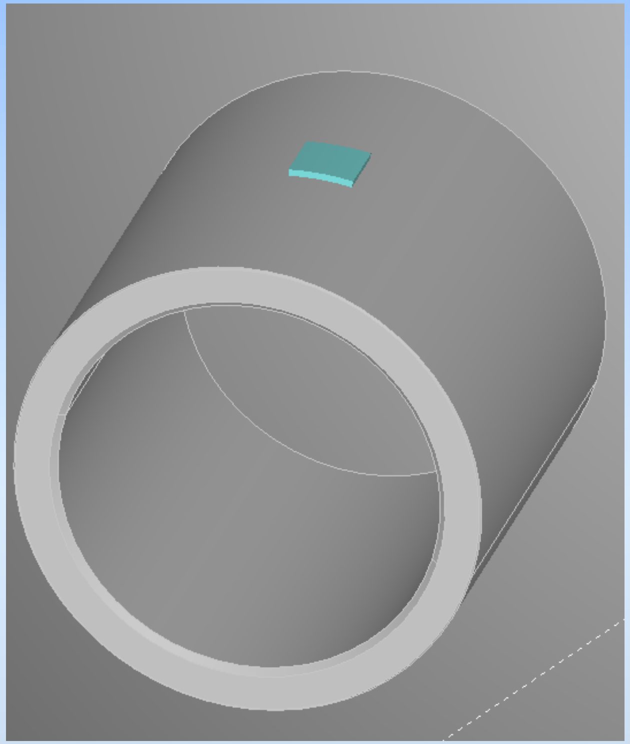
Other Structures in Beam

Virtual Dosimeters

- **Predict dose in the product at a certain location by modelling the energy deposition ΔE in a volume element with mass Δm**

  Dose= **ΔE/ Δm**

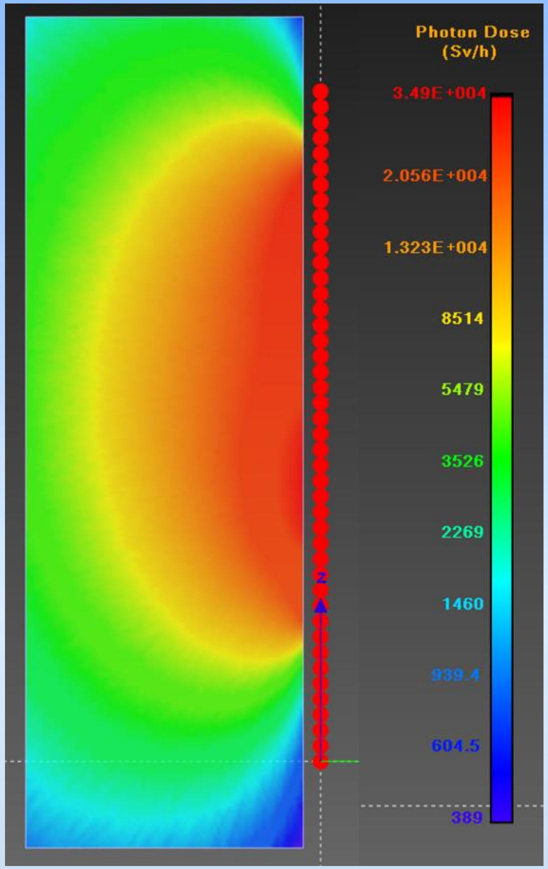




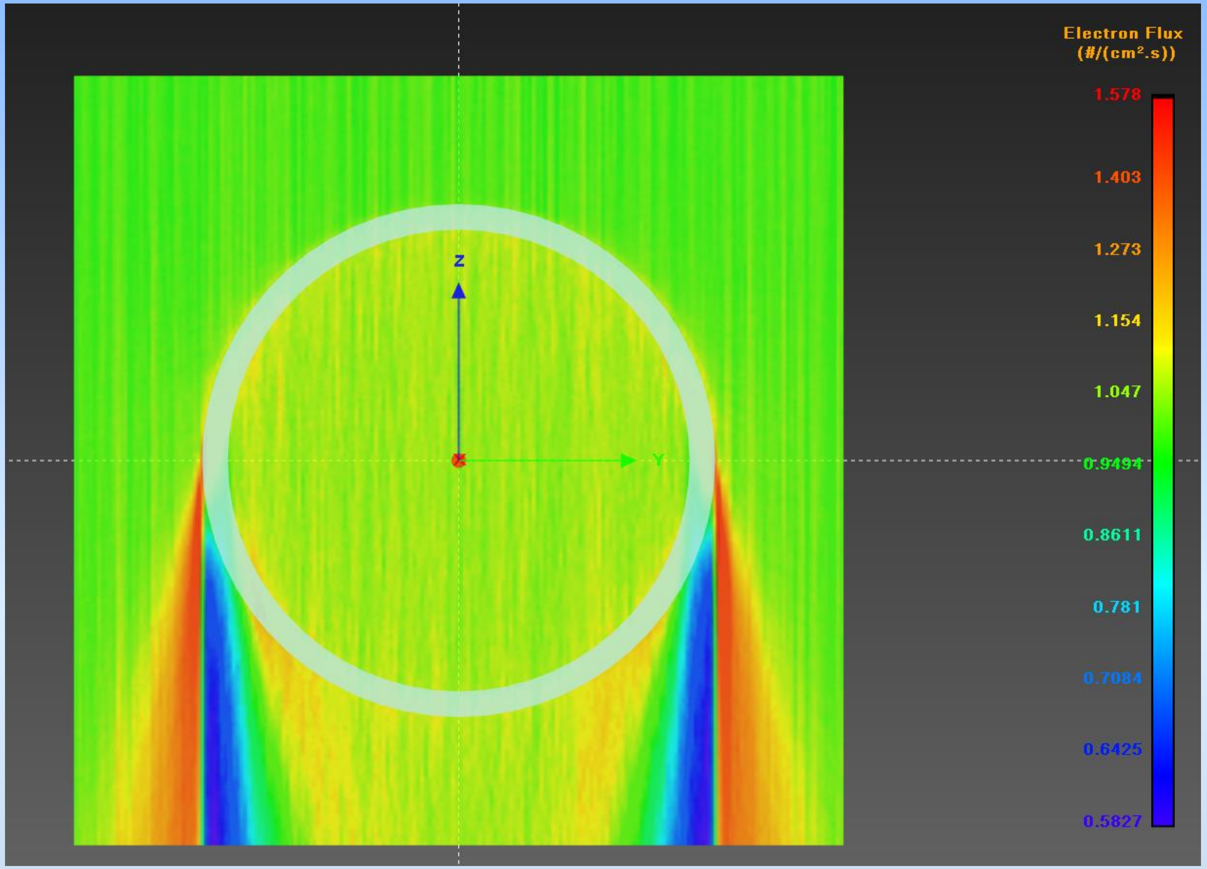
- Report Dose in a Dosimeter
- Report average Dose to Product

Physics Quantities in a Grid (Mapping)

- Photon Dose Rate from a Co-60 Source



- Flux of Scattered Electrons



Modelling Tool – Basic Modules

htc
science & technology

Product Model Definition

Facility Model Definition

Modelling Run Definition

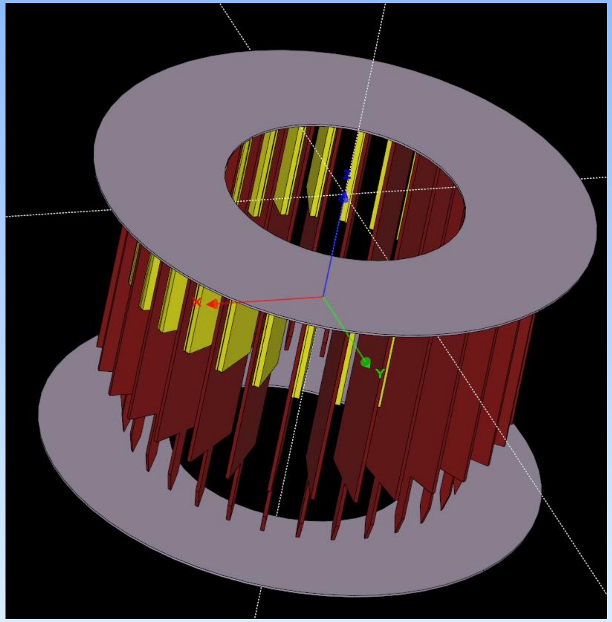
Physics Engine

Model Output

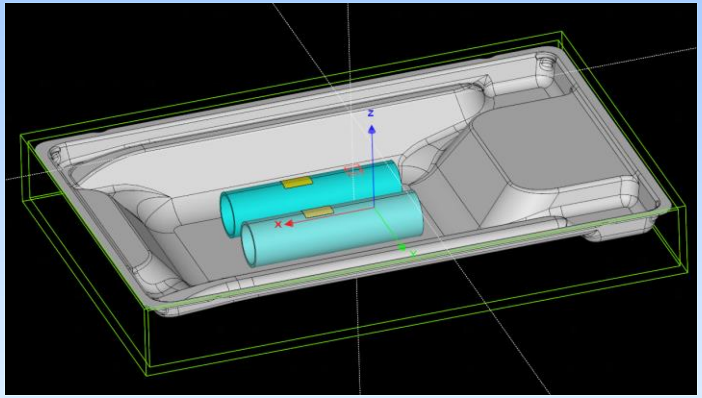
Radiation Source Definition

Penelope
EGSncr
MCNP
Geant4

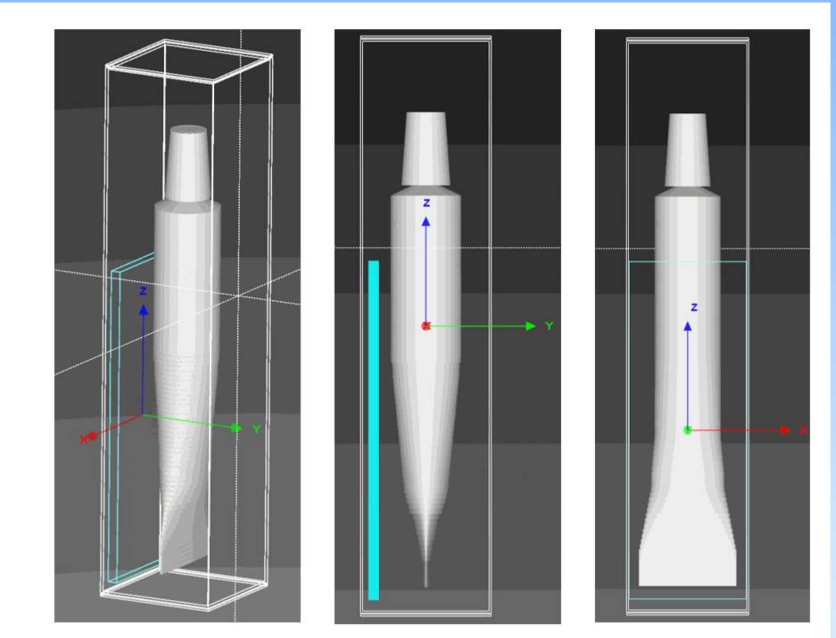
Progress in Geometry Input



CAD Input

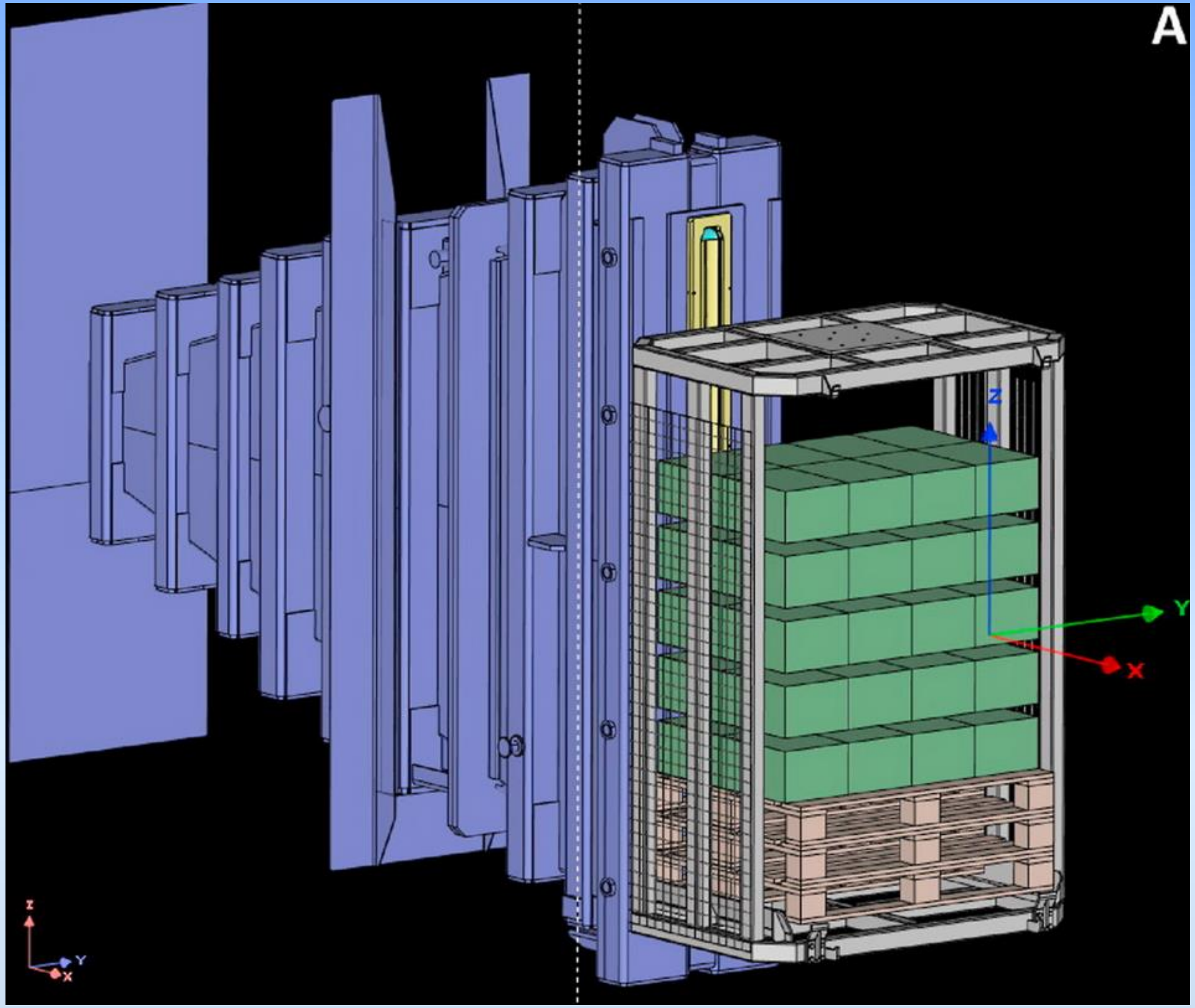


Hybrid:
CAD + Shapes



Shapes (advanced modelling)

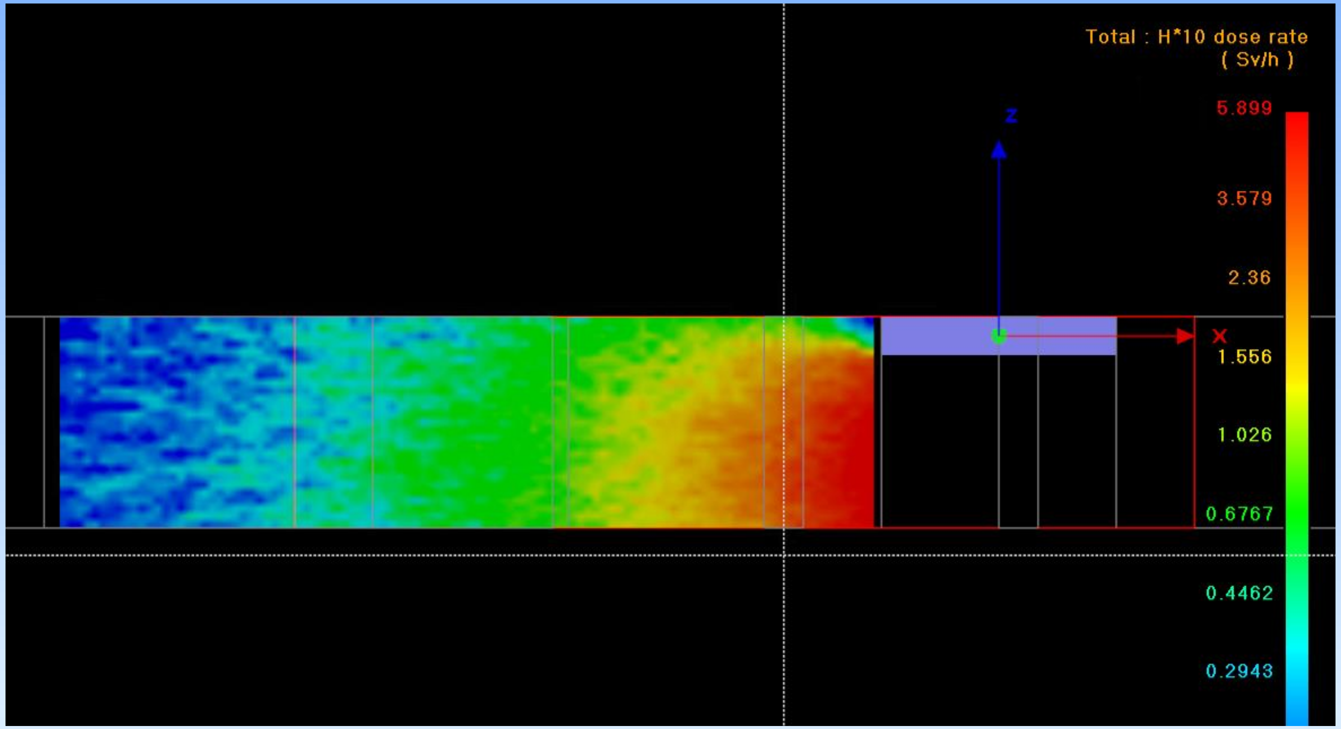
Irradiator + Irradiation Container + Product




High energy X-ray fruit irradiation qualification with Monte Carlo code

Ludovic Eychenne [a], François Vander Stappen [b], Florent Kuntz [c], Frédéric Stichelbaut [b], Cédric Dossat [a], Steven Robin-Chabanne [a], Nathalie Chatry [a]

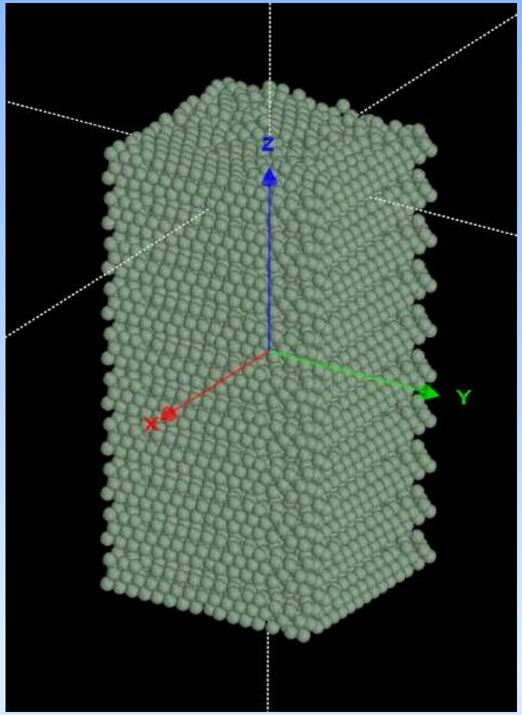
Particle Storage File

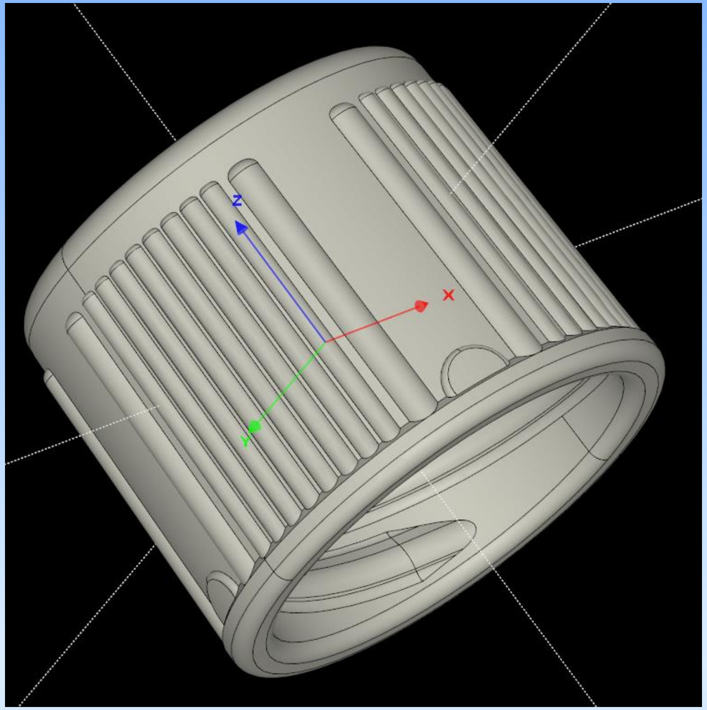


Declare detector as
Particle Storage
and generate/store events in a File

X-Ray Processing
Shielding Design & Verification

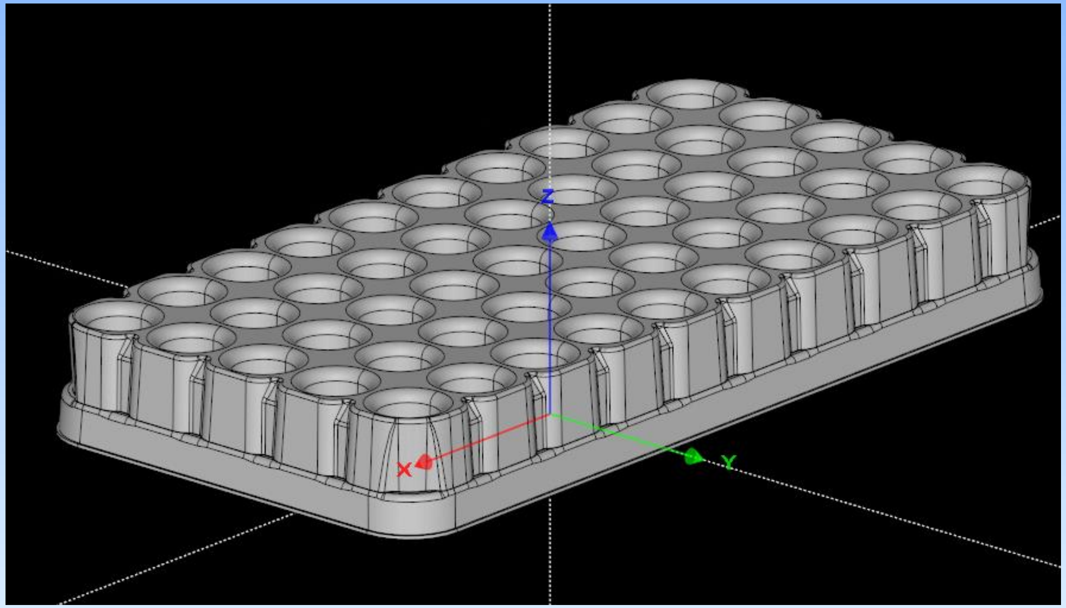
Model = Abstraction of Reality

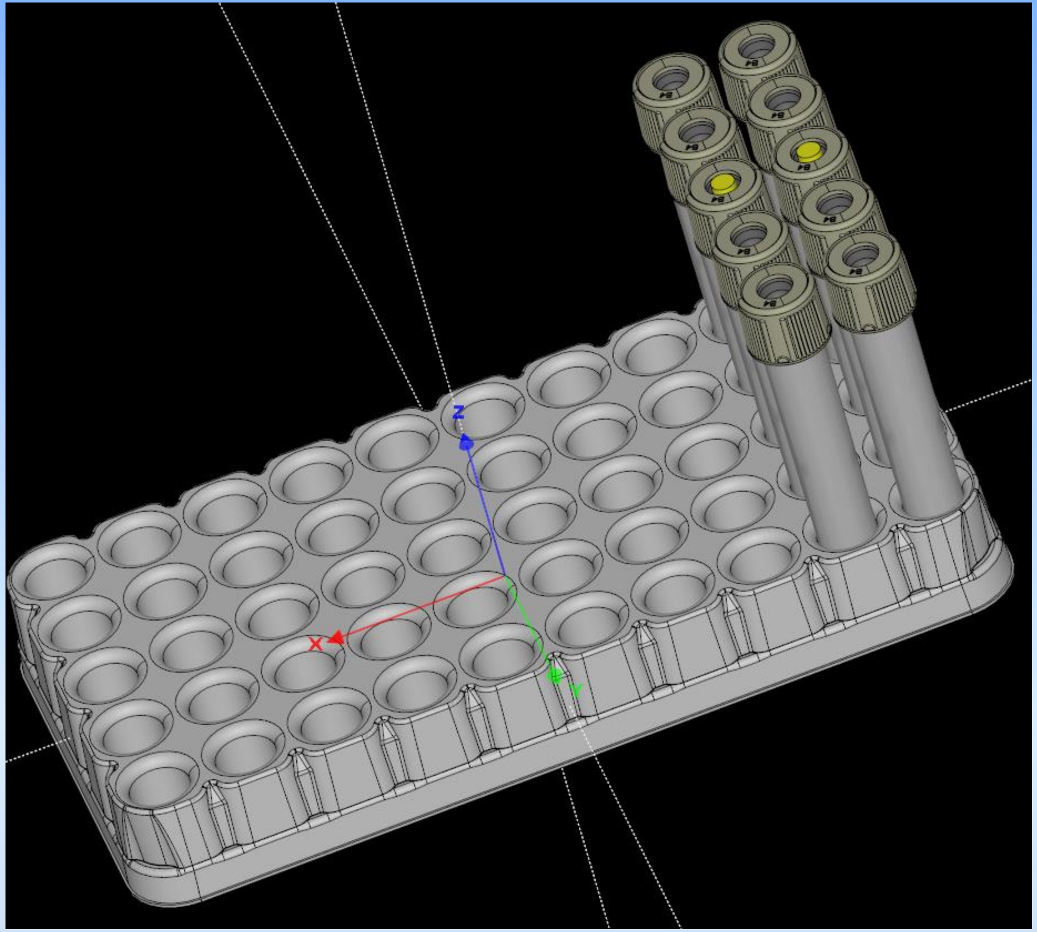




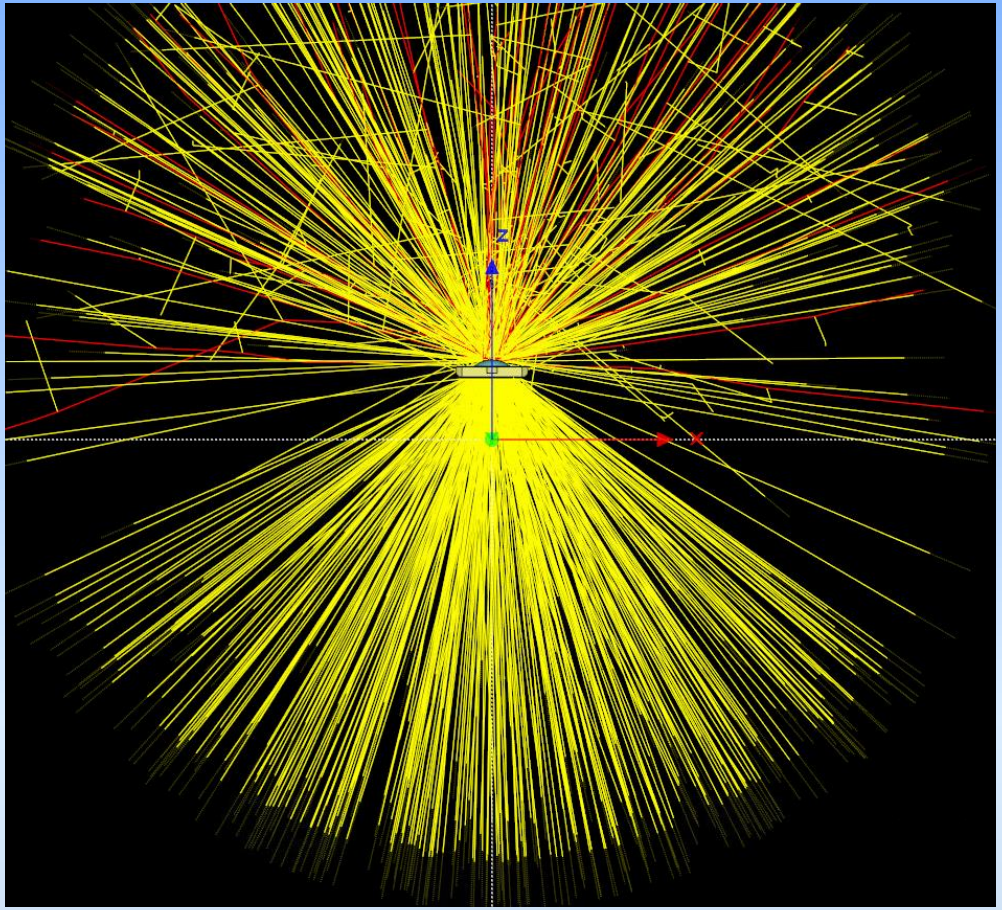
How much detail is necessary, what can be skipped?

Manual Placement & Overlapping Test





X-Ray



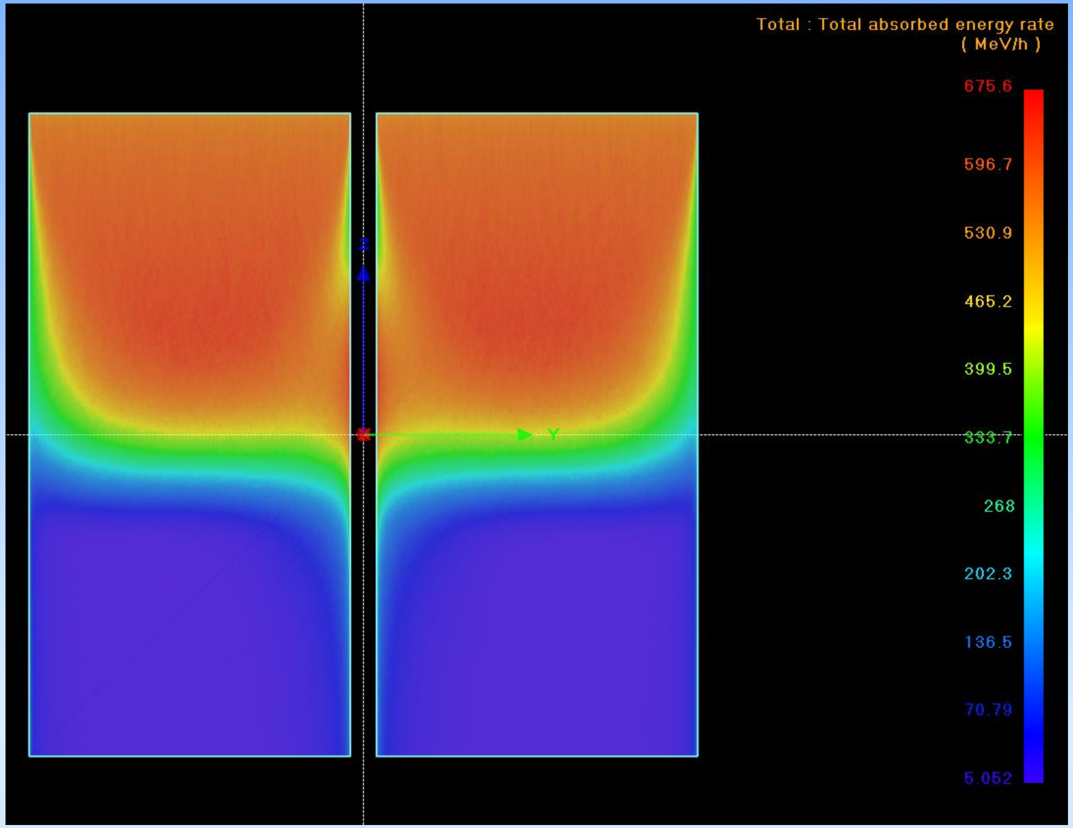
Target Model: as realistic as necessary

Dynamic Irradiation Model:
Stepping product through beam zone

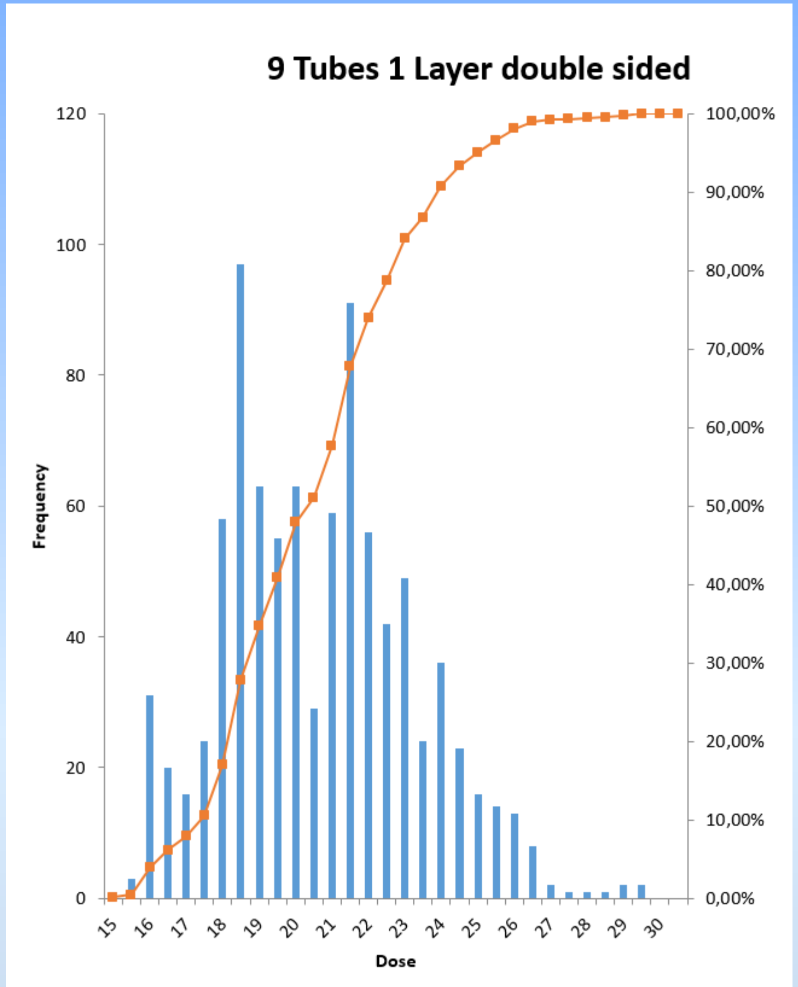
Static Irradiation Model:
Wide Target Area

Model the e-photon conversion only once:
Particle Storage File

Model Output



2D/3D Mapping: Visualization of Dose Distribution



High number of dosimeters allows a statistical interpretation of Min/Max Dose Zones

Model Verification & Validaton

Intrinsic Modelling Tool V&V

Validate Physics Engine, Modelling Tool Features
Benchmark with other Tools and Experiments (Supplier/Community)

Modelling Project V&V

Validate Geometry/Materials/Overlap/Data Manipulation (User)

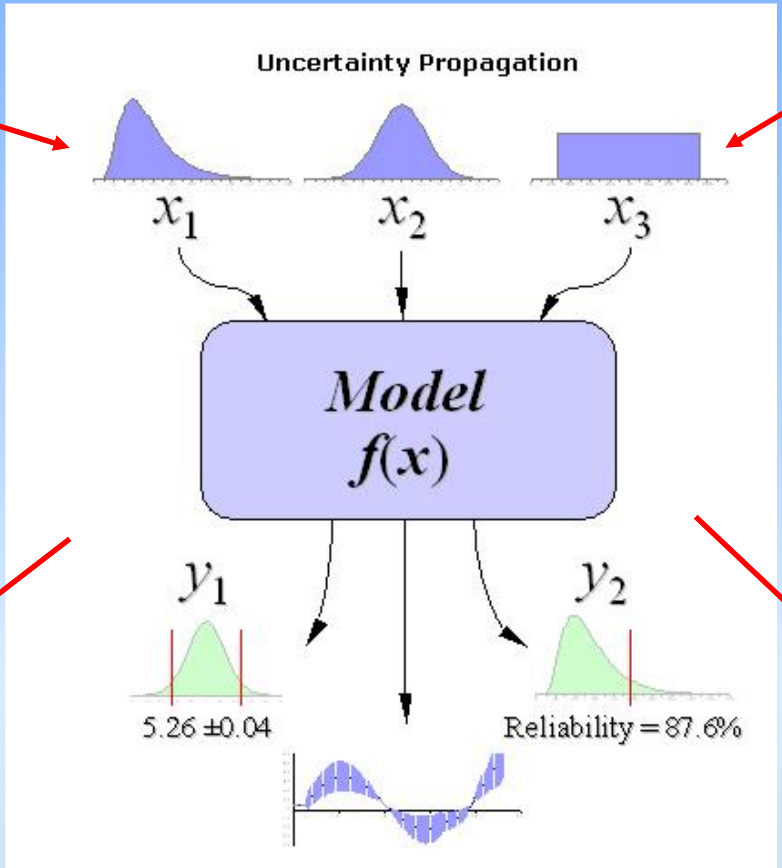
ASTM 2232

Standard Guide for
Selection and Use of Mathematical Methods for Calculating Absorbed Dose in Radiation Processing Applications[1]

Ideal For Assessment of Changes…

Beam-Energy
Spectrum
Faciliy

Product Dimensions/Changes
Carrier/Shield



Variations in
Maximum Dose

Variations in
Minimum Dose

Summary and Outlook…

CPU Time is an issue for demanding applications and complex studies

→ Workstations (64 thread limit)
→ Optimized Algorithms – GPU based physics engines
→ **Cluster–based Business Model**

Careful Balance: Model “as realistic as necessary“ Benchmarking – Competence

Object/Shape based vs. Voxel based (e.g. Input from CT Scans)

In any case: Modelling already is there and will grow as an inevitable tool for industry

Modelling for everyone ? Yes, BUT COMPETENCE IS REQUIRED!