Dose Insight

Monte Carlo Simulations as a Product Design Tool

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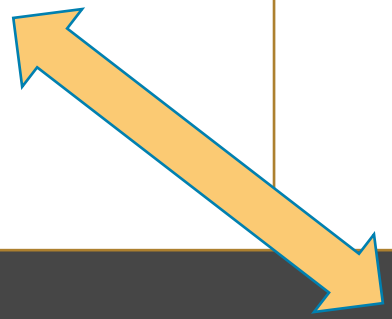
TRIPLE RING technologies

- Co-development company
- 100+ employees in Newark, CA and Boston
- Focus on life sciences and medical device development
- Internal R&D partially funded by government grants
- Spins out internal ideas as independent products



DOSE INSIGHT

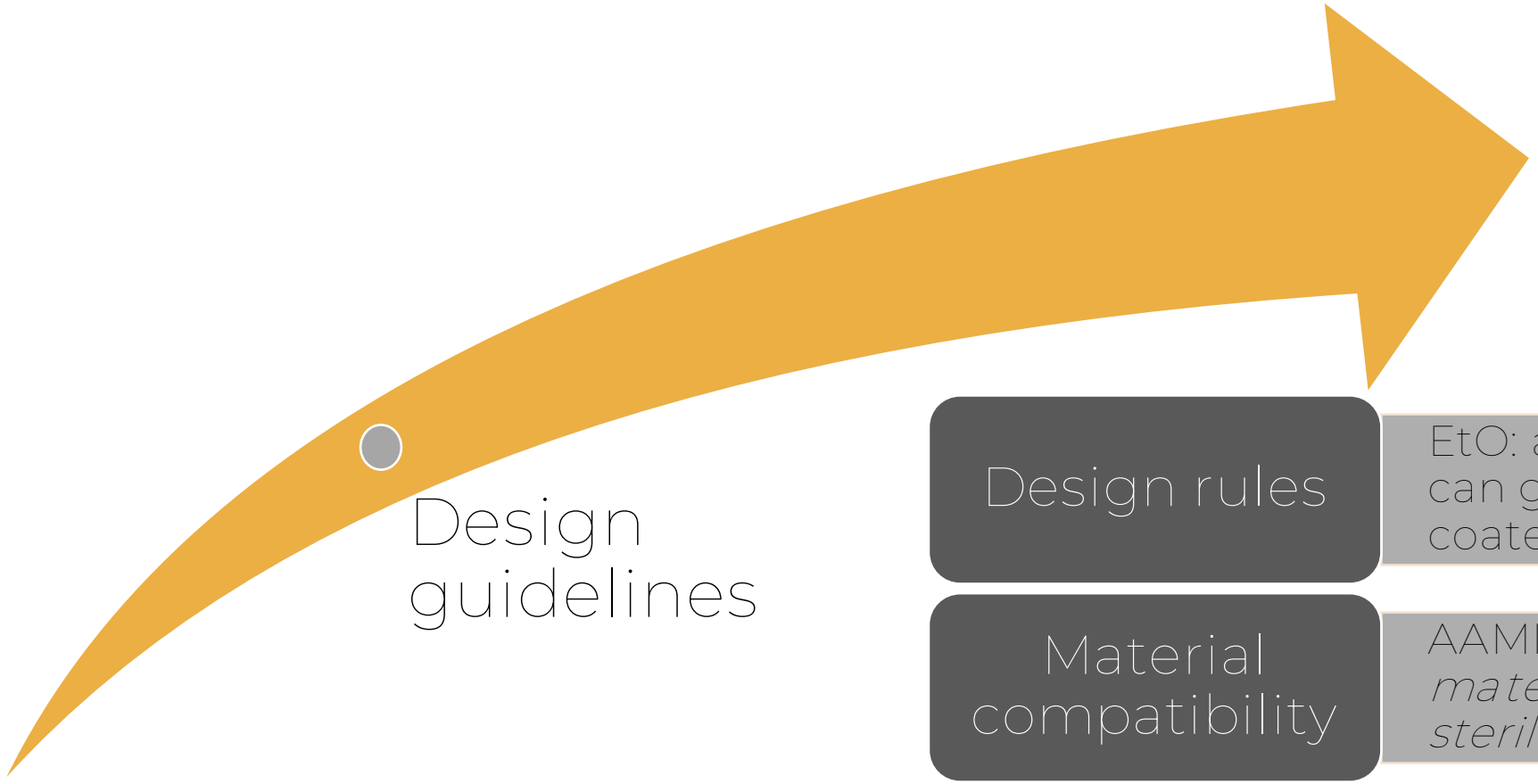
- Develops a virtual dose mapping tool
- Seeks to deploy the tool with
  - Medical device developers
  - Sterilization vendors
- Visit us at: www.doseinsight.com

Requirements that a tool can be used for Product Design

Make decisions and changes informed by the tool

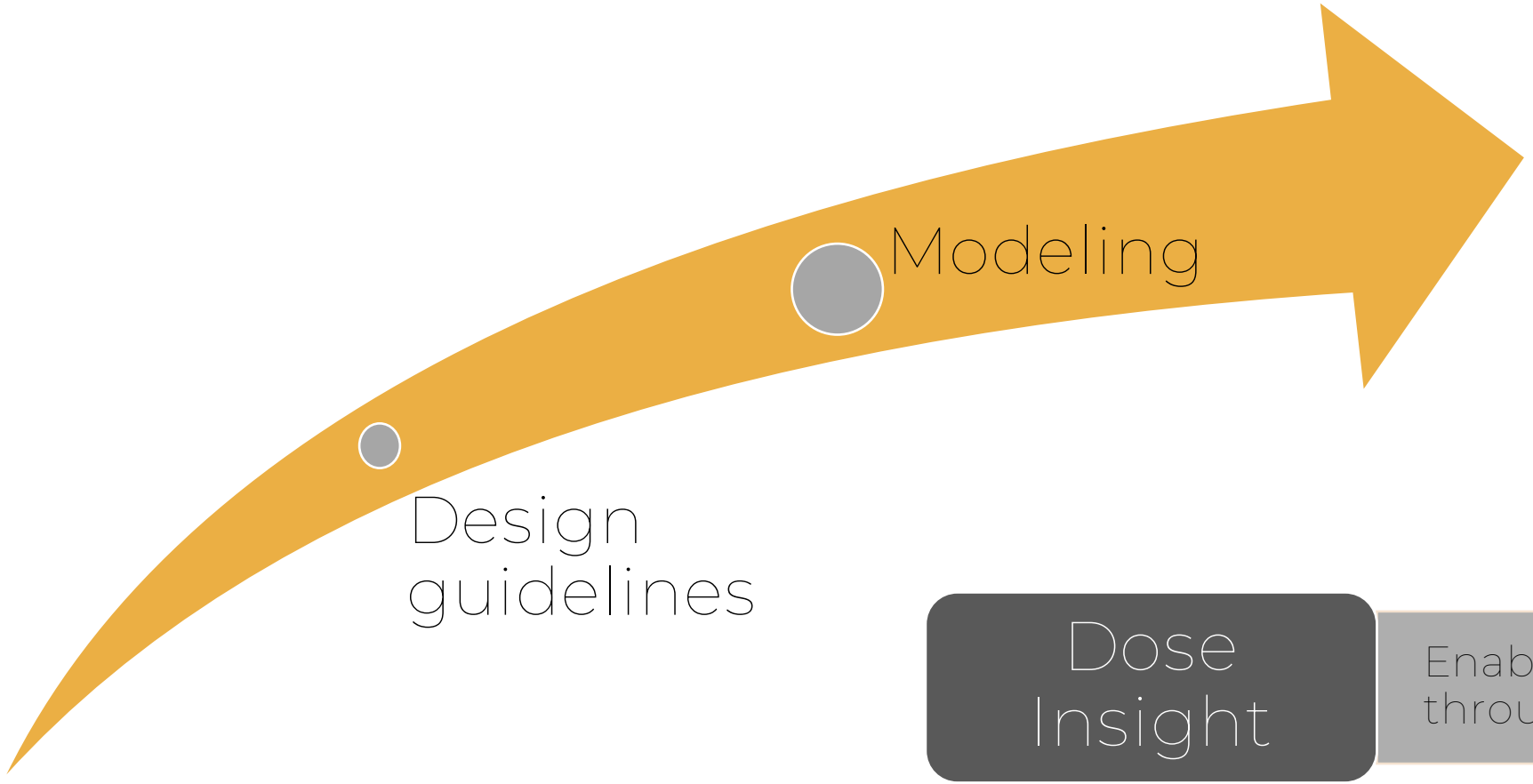
- Accuracy
- Ability to iterate on a design
  - Can be used without relying on a physical device
  - Delivers results fast (hours vs days)
- User-friendly and usable by an expert in product design
- Deliver results with small uncertainty

From Design Guidelines to Design for Sterilization (DFS)



Design rules	EtO: avoid cavities where gas can get trapped, conformally coated circuit boards, etc.
Material compatibility	AAMI TIR17 *Compatibility of materials subject to sterilization*, 2017
Consulting with vendors	Leverage decades of experience

From Design Guidelines to Design for Sterilization (DFS)

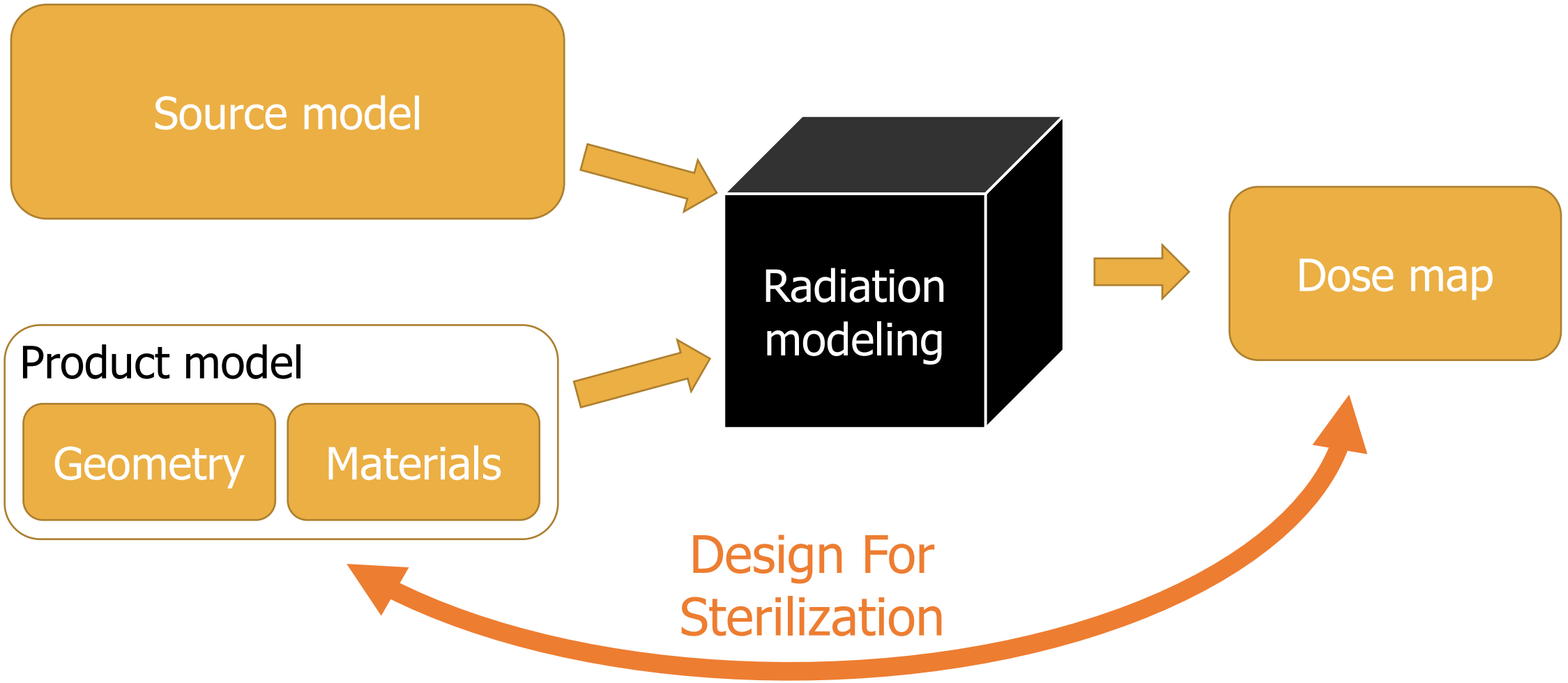


Dose Insight

Enables Design for Sterilization through modeling

Many industries went from design guidelines to modeling.
Examples: flow simulations for injection molding, data center design.

Predicting the dose map using modeling



Are Monte Carlo simulations accurate?

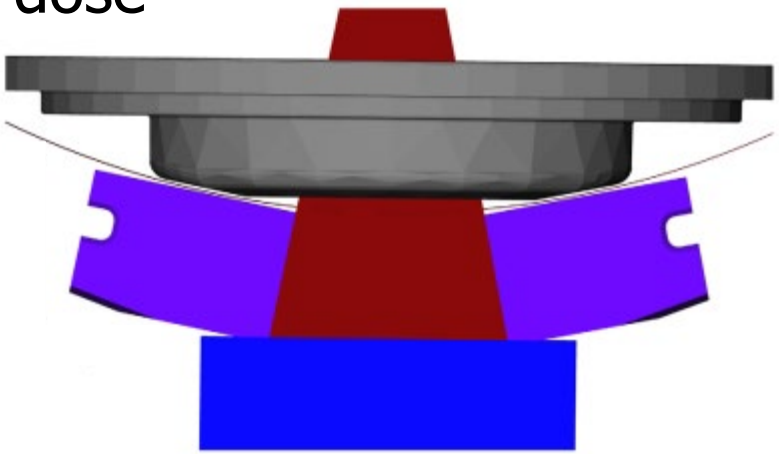
Yes!

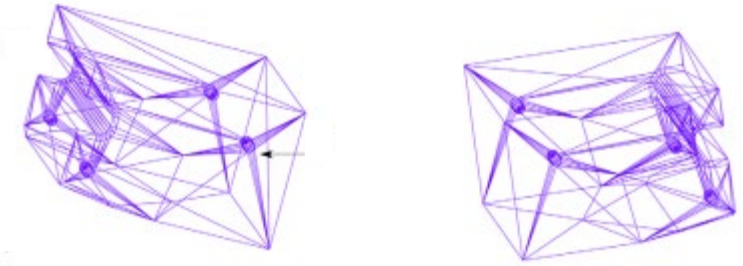
See for example:
"Monte Carlo methods for device simulations in radiation therapy,"
by Park et al.
in: Physics in Medicine and Biology, vol. 66, no. 18, pp. 1361-6560, 2021

Validation of Geant4 with a 6 MeV X-ray beam

M. Constantin et al., Medical Physics, 38 (2011). Collaboration between Stanford and Varian

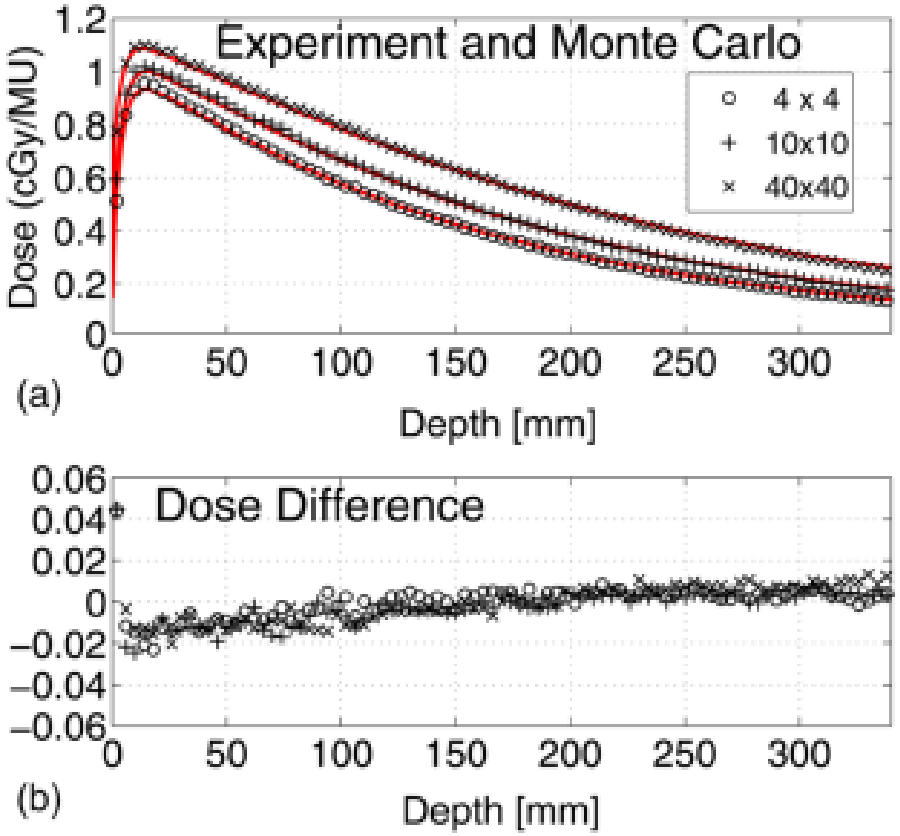
CAD model of treatment head dose





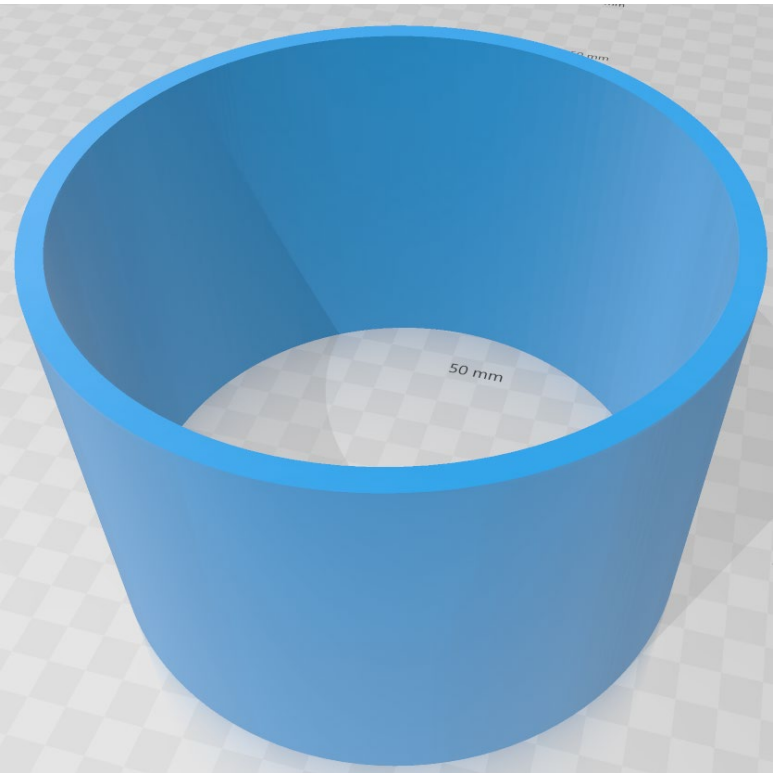
Collimator jaws

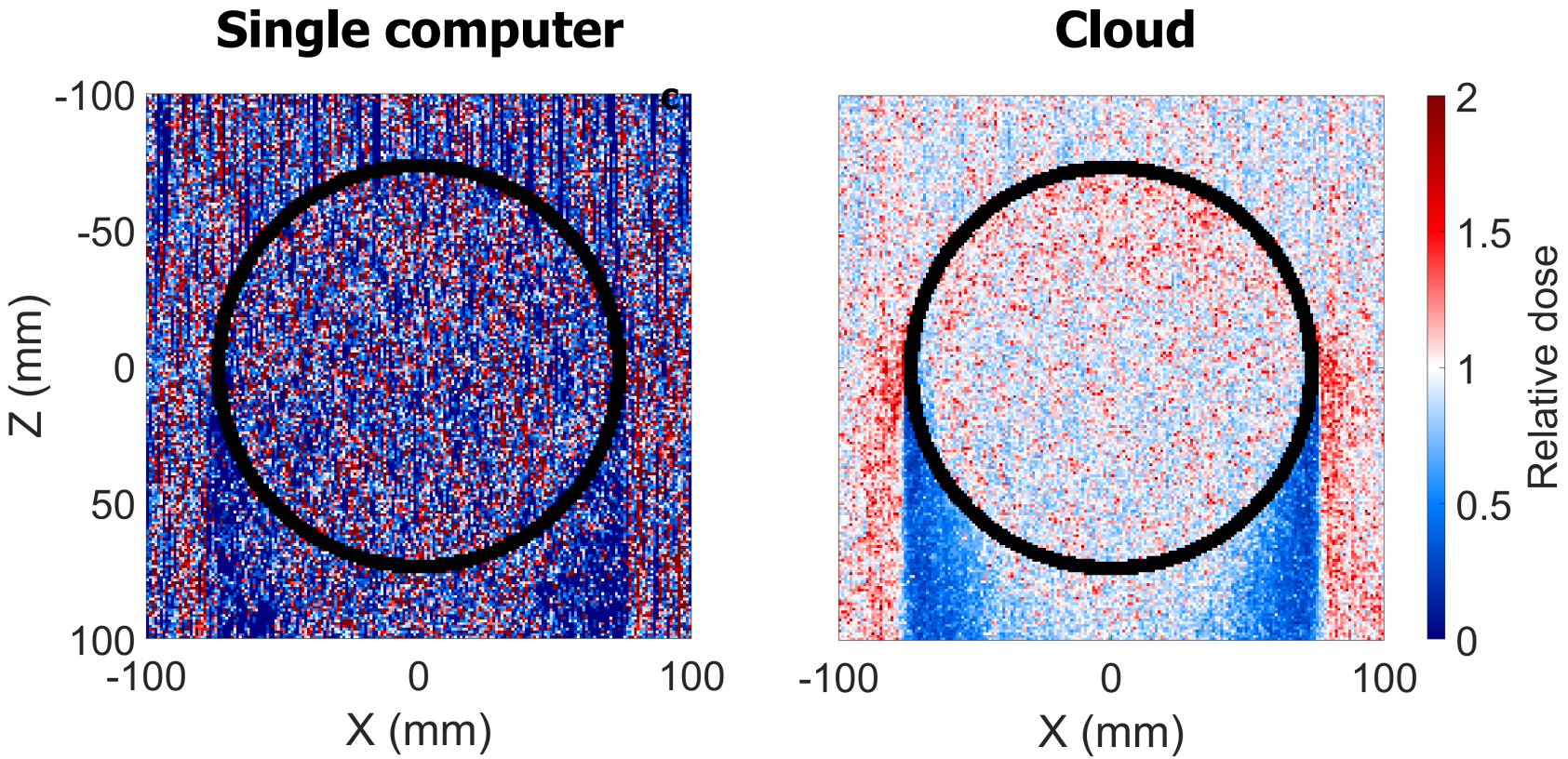
Measured (black) vs. simulated (red) dose



98% of measurement values are within 2% of simulated dose

Are Monte Carlo simulations fast?





Are Monte Carlo Simulations user friendly?

Dose Insight

Account

Configure new simulation

Analyze simulation

Select a radiation technology and beamline

E-beam - Vancouver, BC

Select a 3MF file to upload

Choose File VIO_old_design.3mf

100%

Submit simulation job

Submit!

Instructions

- Press the **r** key to activate rotation controls of the CAD model
- Press the **t** key to activate translation controls of the CAD model
- Left-click and drag to rotate camera view
- Right-click and drag to pan camera view
- Scroll to zoom camera view

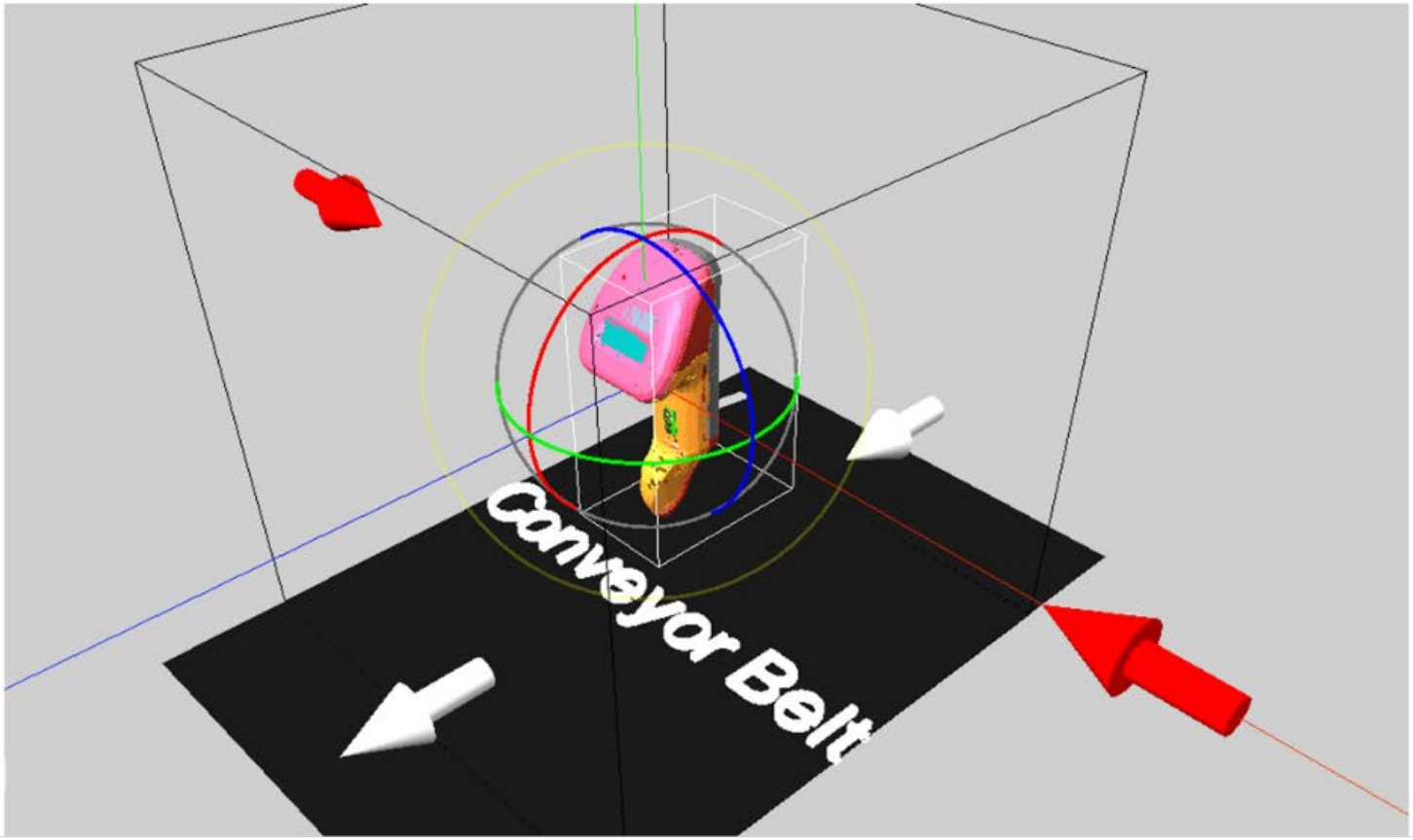
CAD transformations

Translate X [mm]		0
Translate Y [mm]		0
Translate Z [mm]		0
Rotate X [deg]		0
Rotate Y [deg]		0
Rotate Z [deg]		0

Assembly hierarchy

Model	Attach Dose Map	Material
+ Entire Model	☑	
+ vio17914	☑	ABS
+ vio09002	☑	PET
+ vio09002	☑	Not Assigned
+ vio12410	☑	PET
+ vio11986	☑	PET

CAD model



Dose Insight

Configure new simulation

Analyze simulation

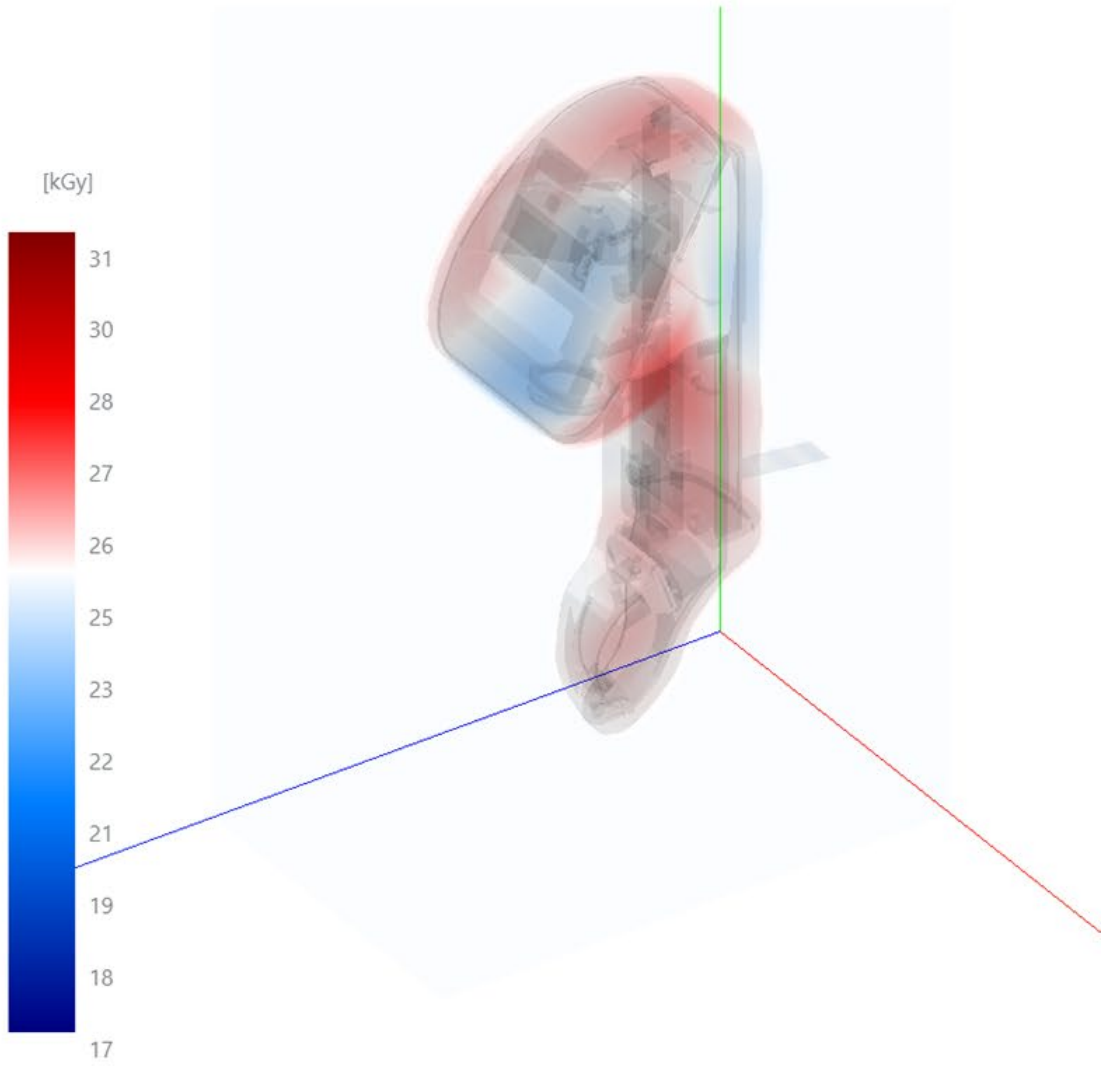
Instructions

- Change the lower/upper dose thresholds to only display low/high dose regions
- Change the colorbar's lower/upper dose to change which color is assigned to which dose
- Change the reference dose to scale the dose map
- Left-click and drag to rotate camera view
- Right-click and drag to pan camera view
- Scroll to zoom camera view

Controls

Reference dose [kGy]	25		
Colorbar lower dose [kGy]	17		32
Colorbar upper dose [kGy]	17		32
Threshold lower dose [kGy]		17	
Threshold upper dose [kGy]		31	
CAD display	Solid		

3D dose map



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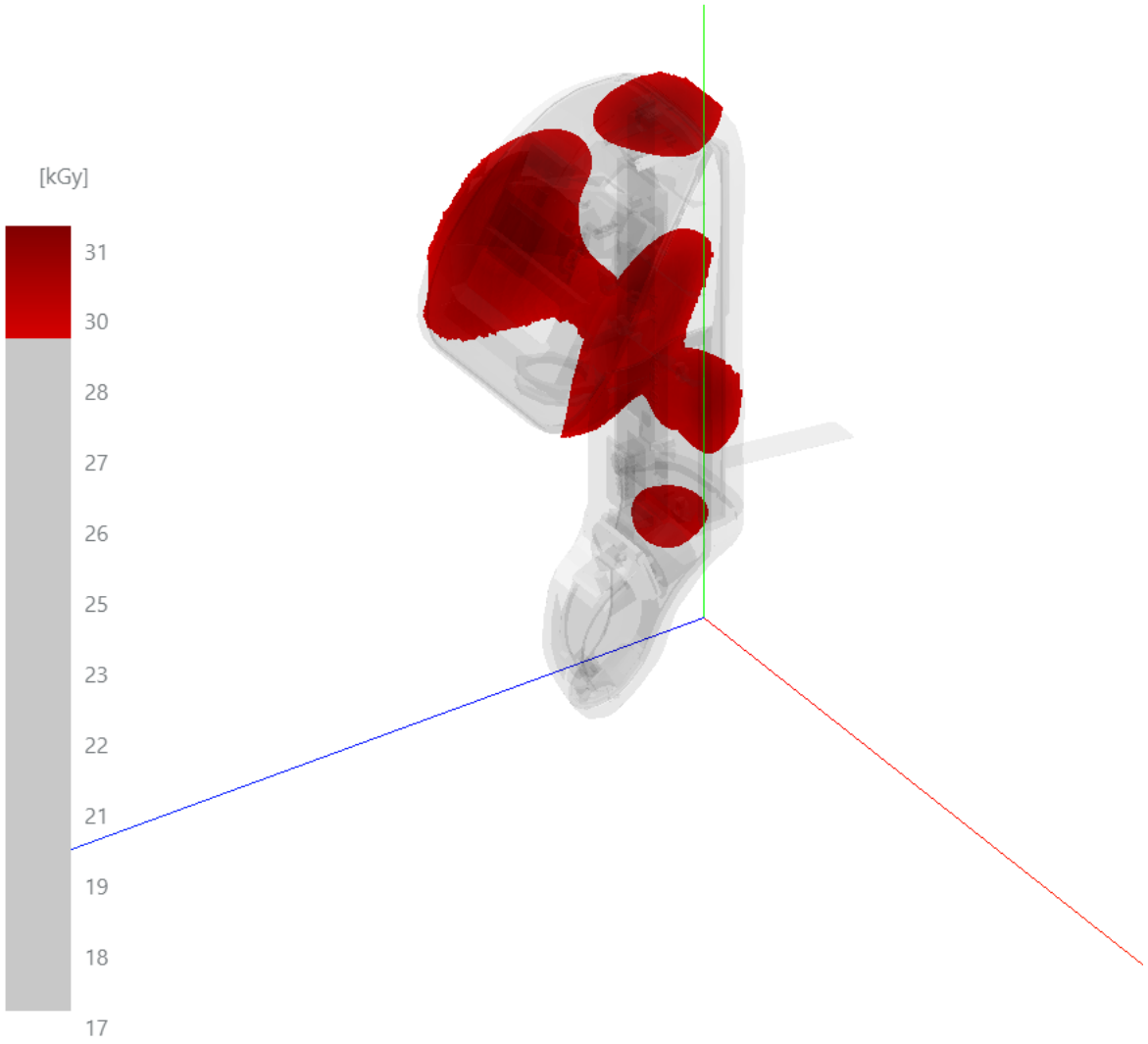
Threshold lower dose [kGy]		29	
Threshold upper dose [kGy]		31	
CAD display	Solid		

3D dose map



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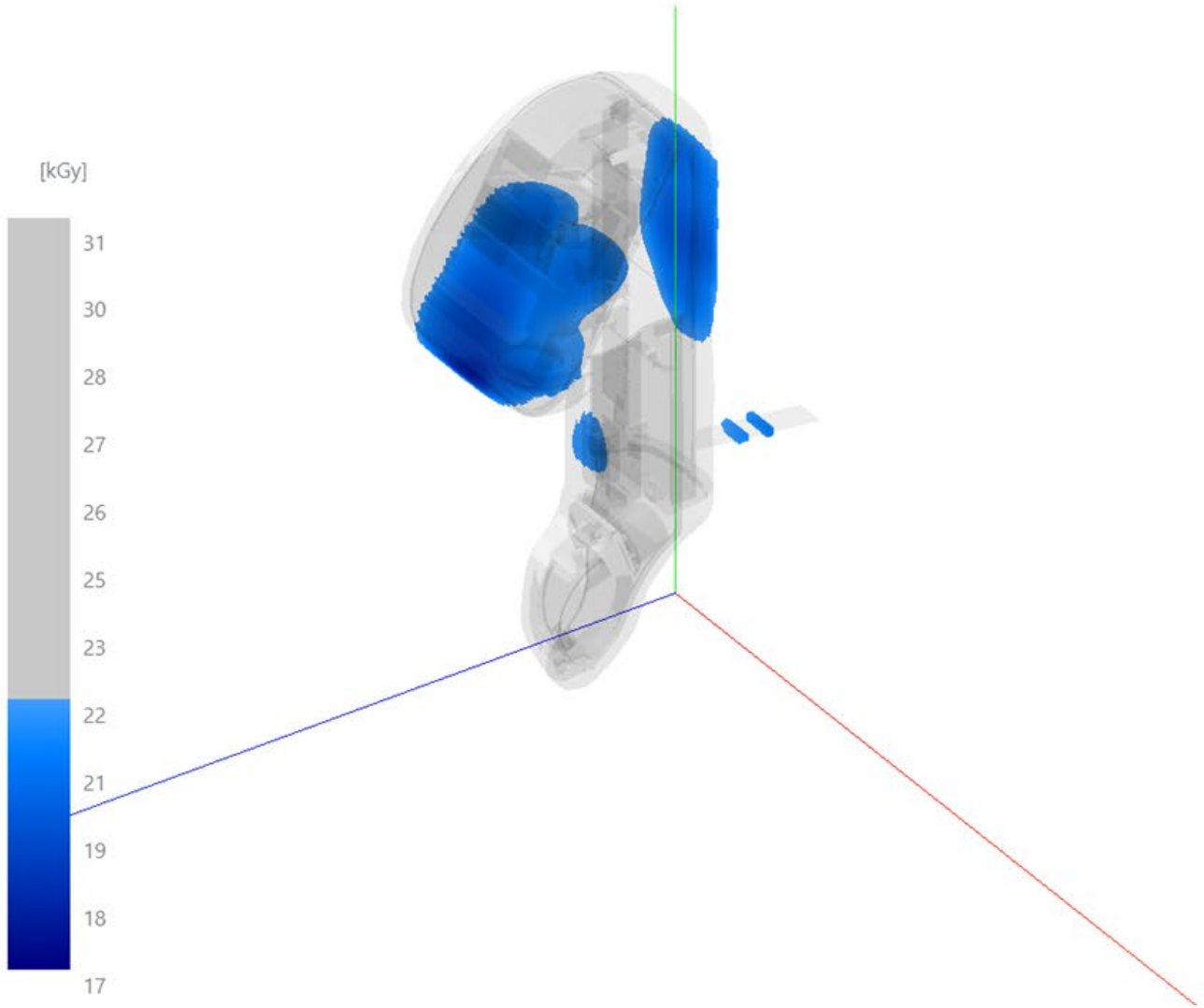
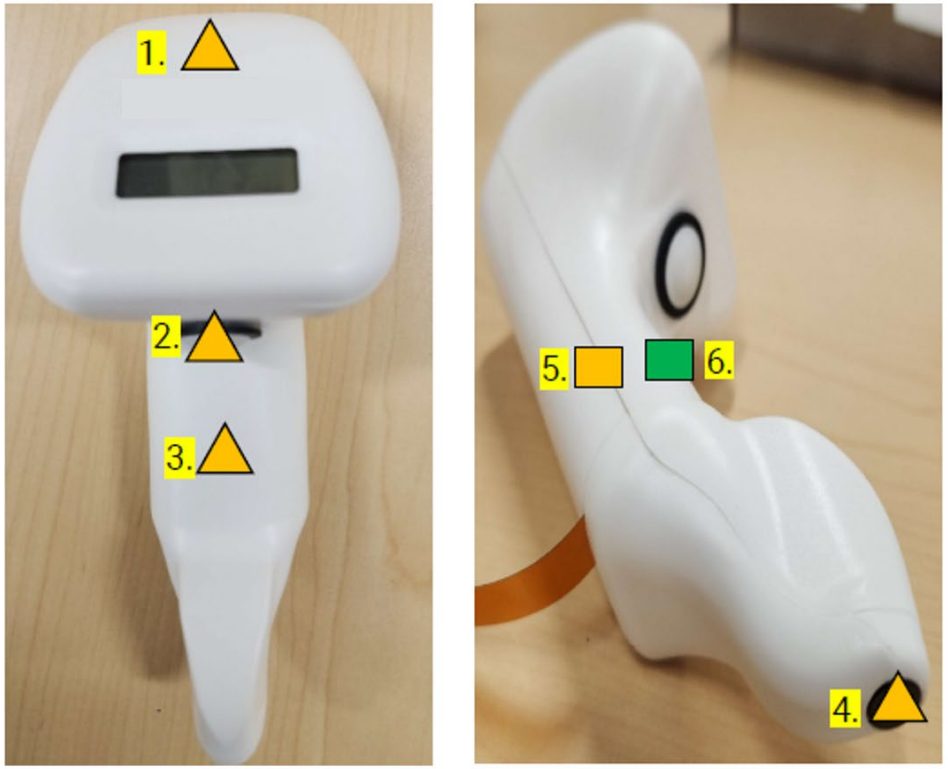
3D dose map



Comparison: Measurement vs. Modeling

Product Name:	Handheld Medical Device	Configuration:	All
		Edited Date:	N/A

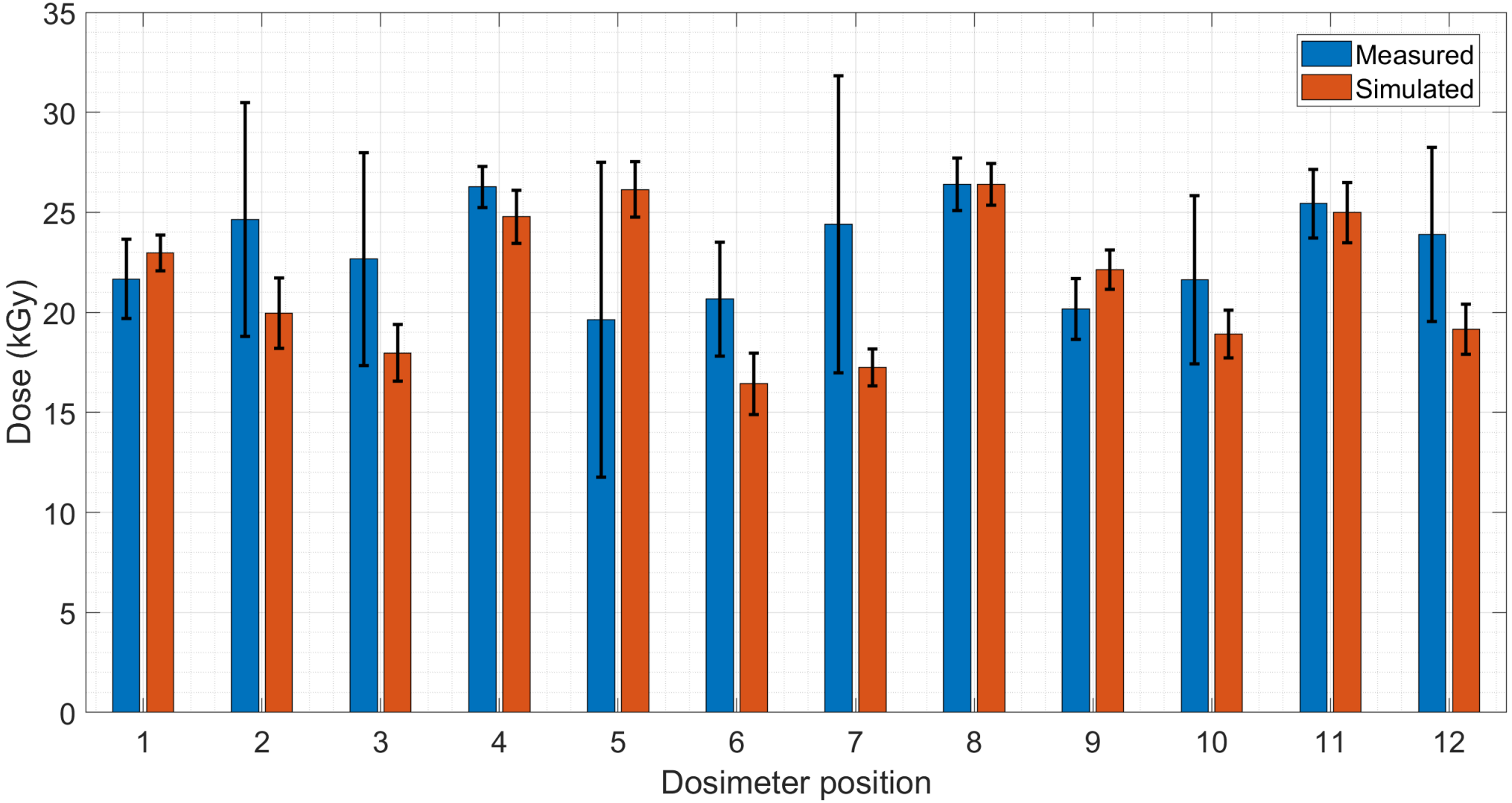
Open Device View



1. On top of device parallel to the beam.
2. On the button of device parallel to the beam.
3. On device handle parallel to the beam.
4. On the bottom of sensor parallel to the beam.
5. On the right side of device handle.
6. On left side of device handle.

Visible – ■
Hidden – ■
Perpendicular – ■
Other – ▲
Wrapped – ●

Comparison: Measurement vs. Modeling

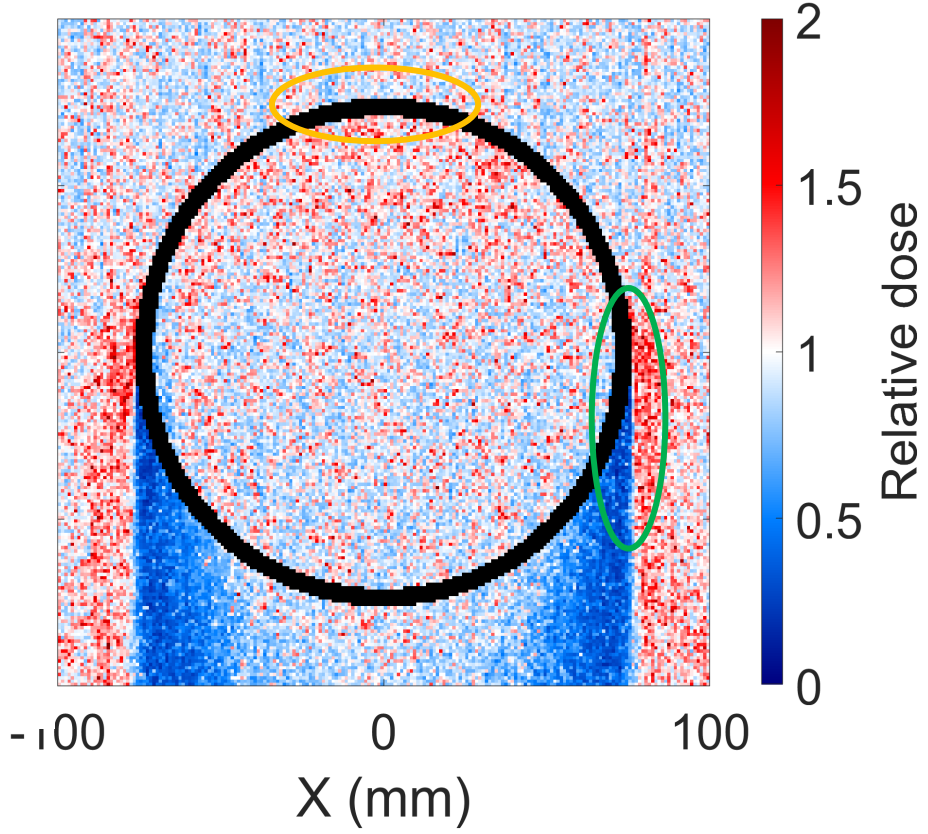


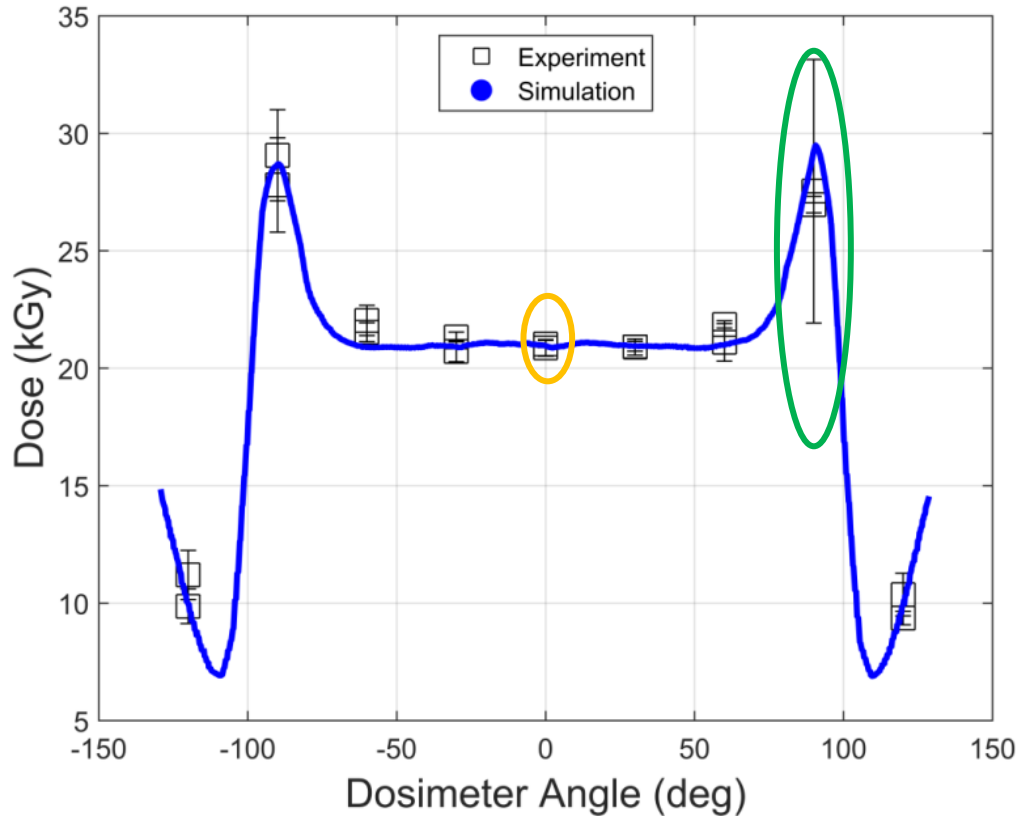
Good agreement withing error bars, but measured data has large uncertainties

Comparison: Modeling vs. Measurements at a 10MeV e-beam sterilization facility

We explore measurement uncertainties on a much simpler system.
Dosimeters were placed at the circumference of the cylinder

Comparison: Modeling vs. Measurements at a 10MeV e-beam sterilization facility





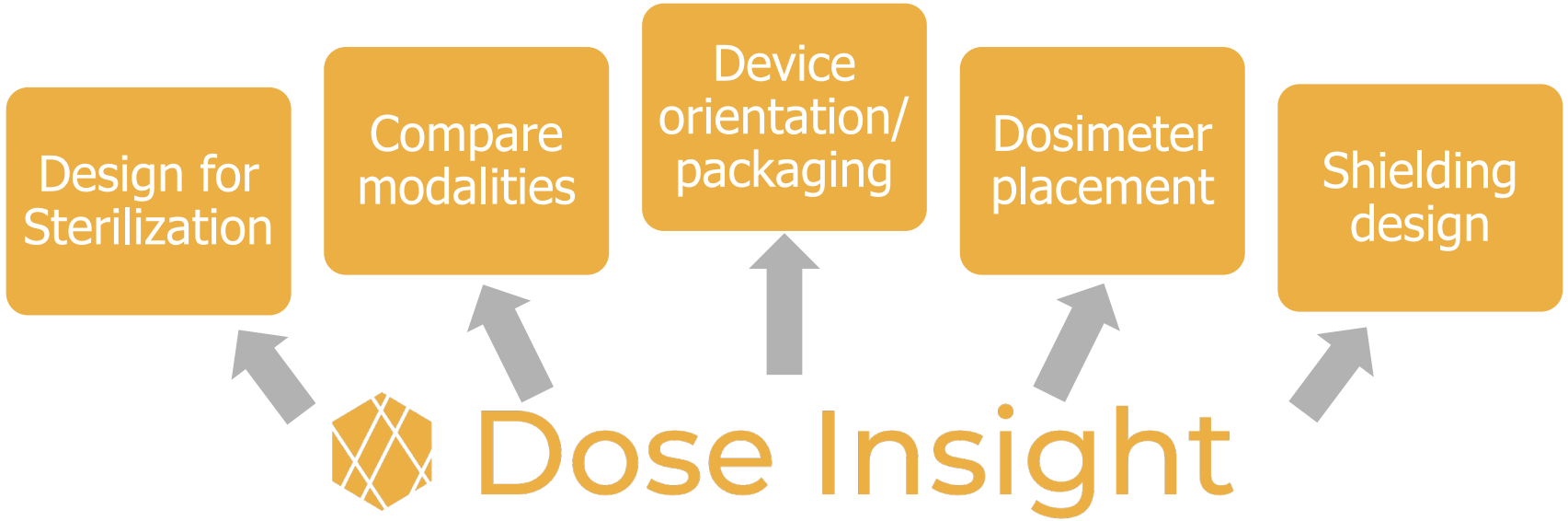
Areas with small gradients have small uncertainty, areas with large gradients have large uncertainties

Requirements that a tool can be used for Product Design

Do Monte Carlo simulations meet these requirements?

- Accuracy ✓
- Ability to iterate on a design ✓
  - Can be used without relying on a physical device ✓
  - Delivers results fast (hours vs days) ✓
- User-friendly and usable by an expert in product design ✓
- Deliver results with small uncertainty ✓

Dose Insight's approach



- Dose Insight enables any engineer to produce virtual dose maps
- Collaborate with us to use modeling in your development process
- Get in touch today! https://doseinsight.com or info@doseinsight.com