A comparison of the relative biological effectiveness of low energy brachytherapy source in breast tissue: A Monte Carlo study.

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Conflict of interest

This work was supported by Xoft®

Introduction

- Purpose
- Background
  - RBE
  - LET
  - DNA damage
- Workflow
- Electron spectrum
- RBE
- Conclusion

Purpose

Xoft Axxent

Zeiss Intrabeam

Average energy difference vary by 1.7 keV or 5.6% for 50kV operating voltage

Do subtle spectral differences influence RBE?

Relative Biological Effectiveness (RBE)

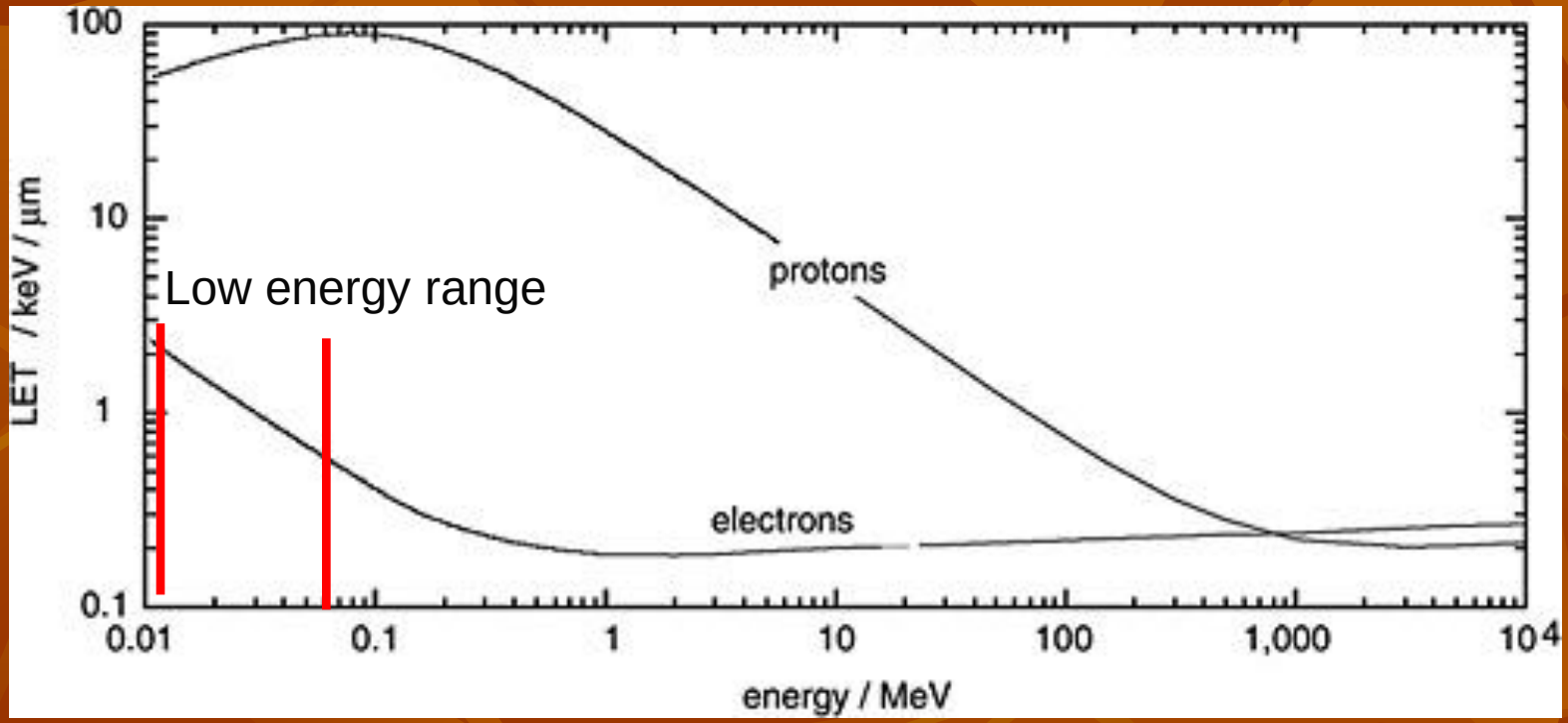
"Inverse ratio of the amount of radiation required to produce a given effect compared to a reference radiation producing the same effect"

Complex quantity determined by:

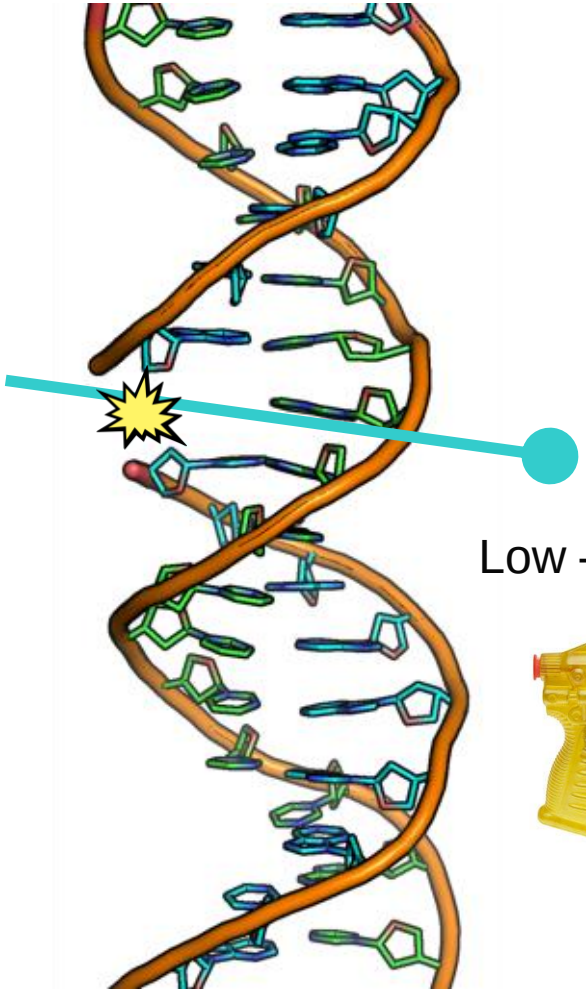
- Radiation dose
- No. of fractions
- Dose rate
- Biological system or endpoint
- **Radiation quality (Linear energy transfer)**

Linear energy transfer in EBS

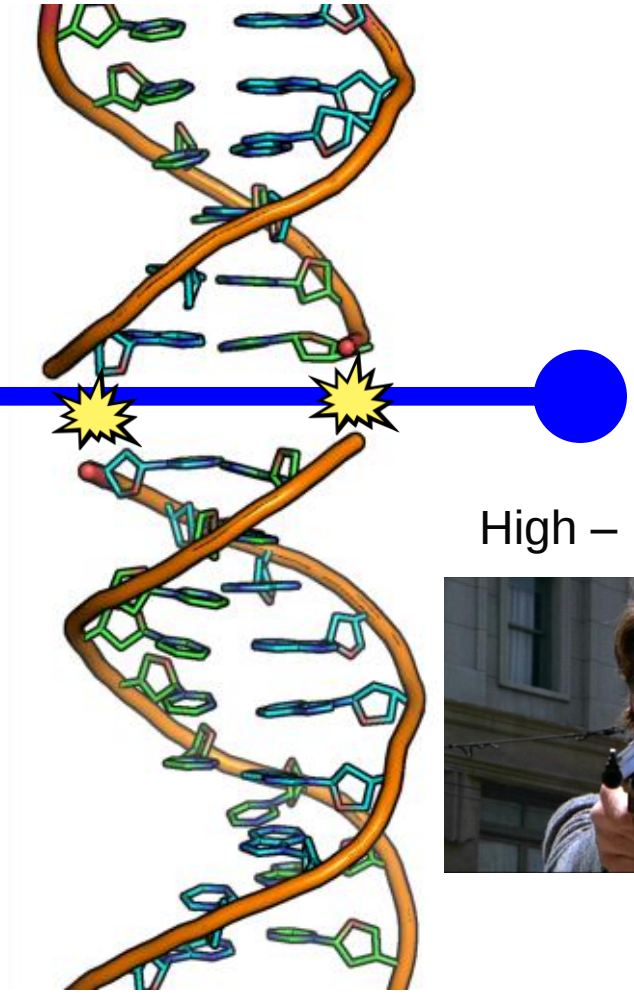
Lower electron energy >>> greater LET>>> More DNA damage



DNA damage

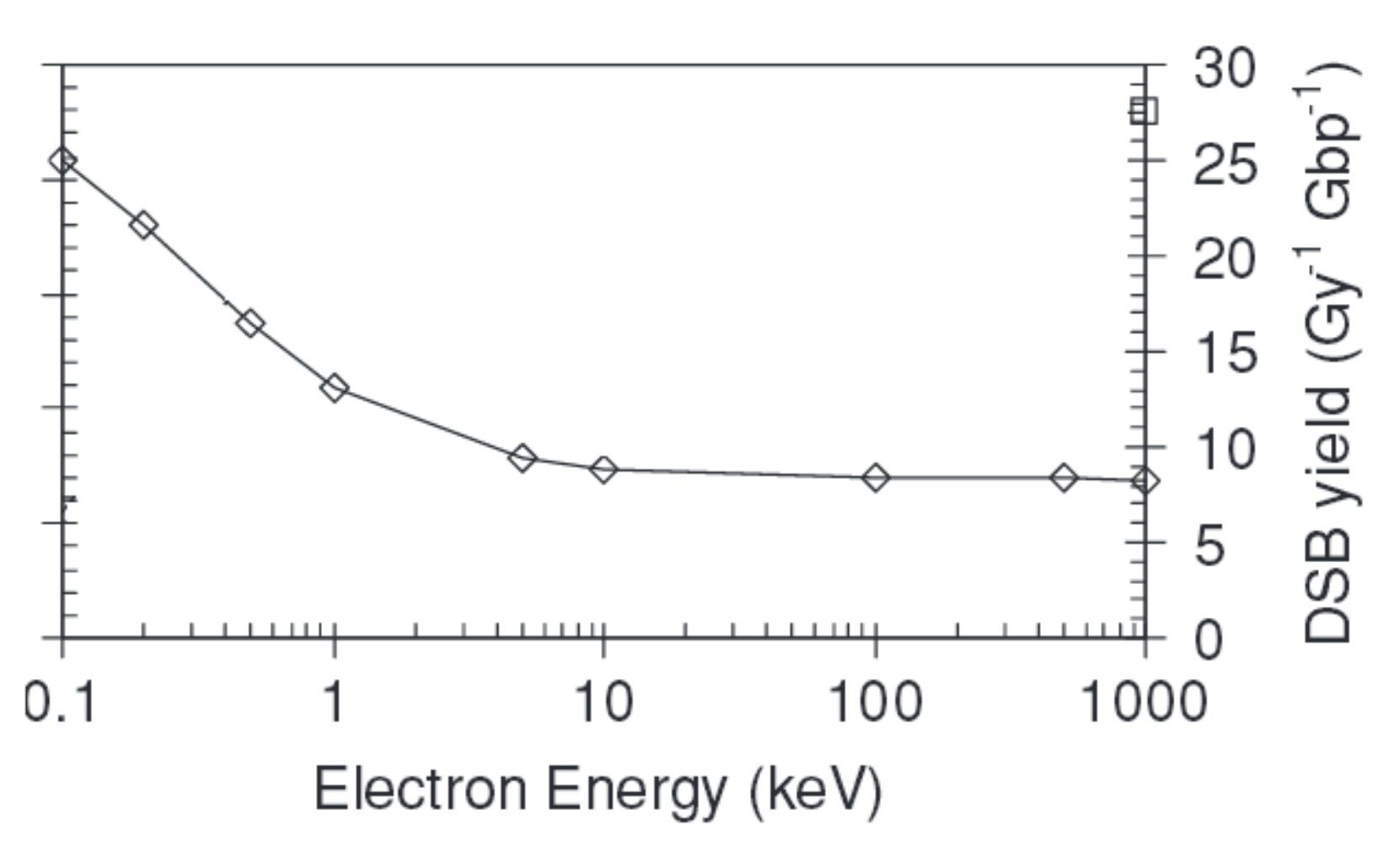


Low – LET particle



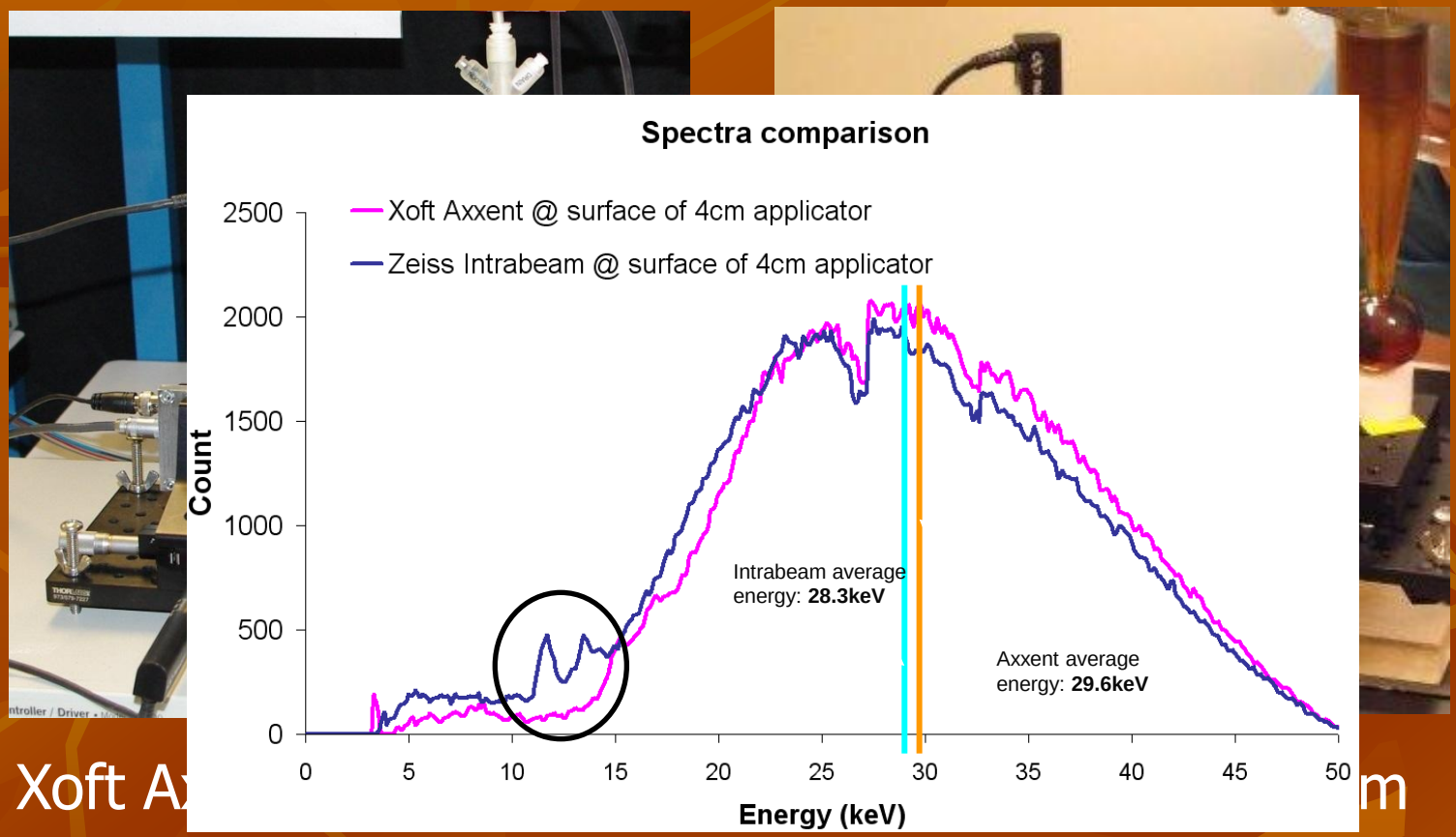
High – LET particle

DNA Damage (II)



- From Semenenko and Stewart, 2006

Purpose:



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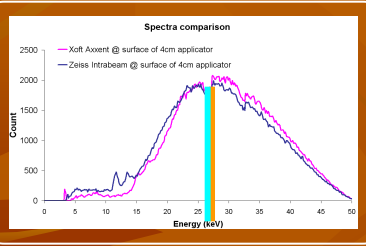
Average energy differences due to choice of material in anode,

Gold (Intrabeam) vs. Tungsten (Xoft)

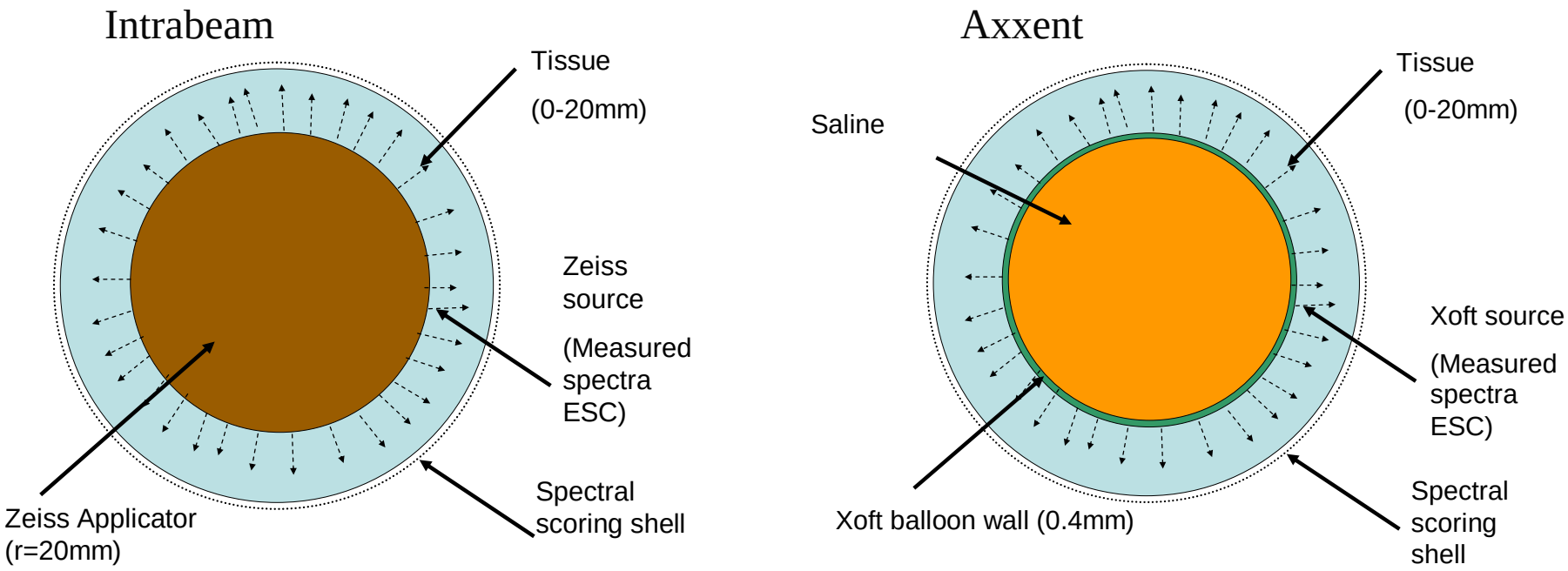
Workflow

EBS spectra



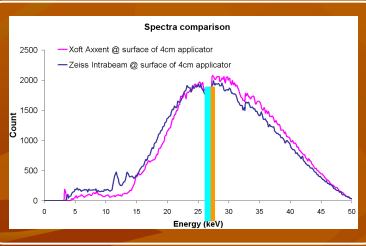
Tissue Geometry

Tissue Geometry



Electron spectra calculated at edge of sphere using EGSnrc

Workflow

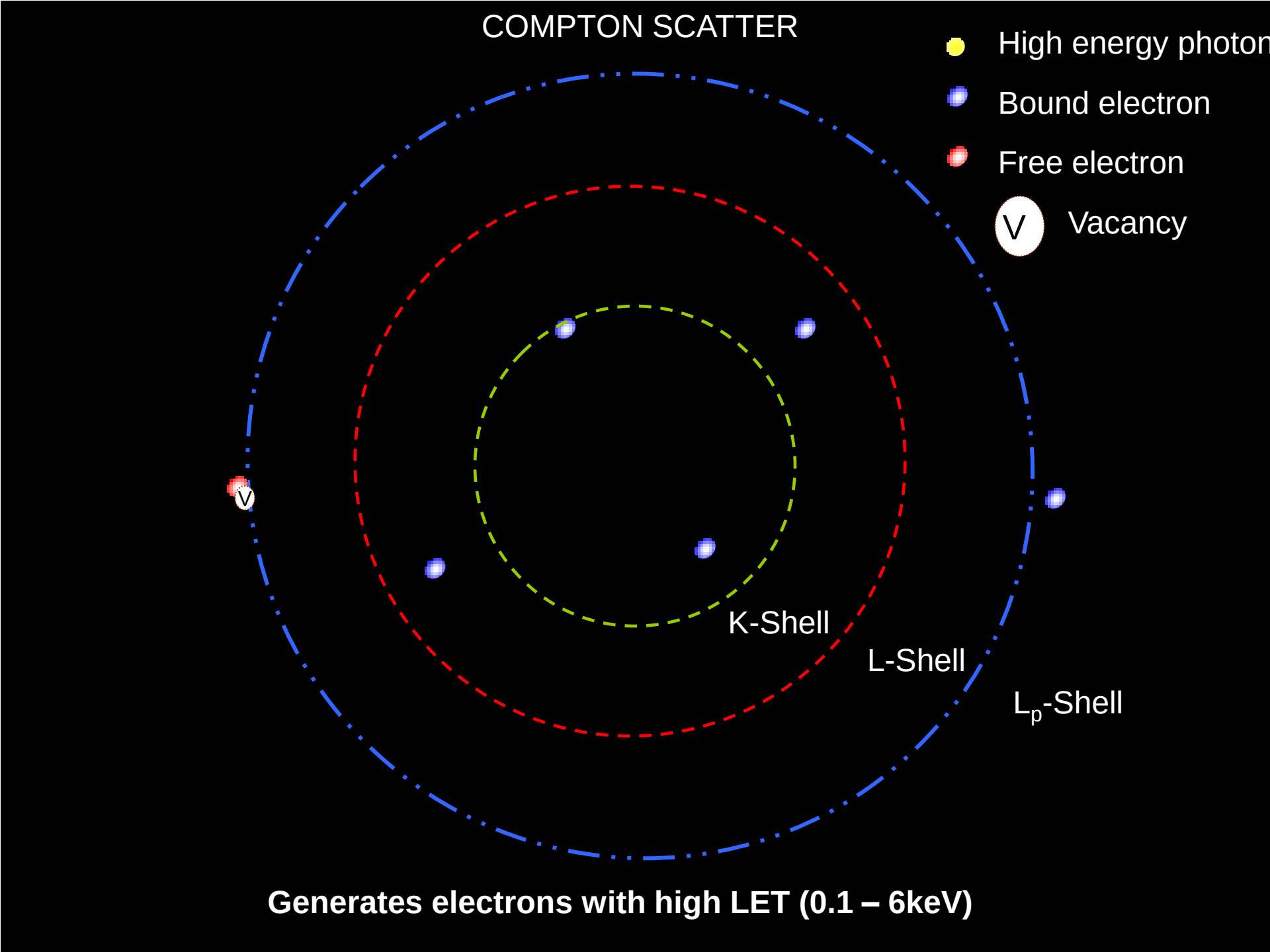


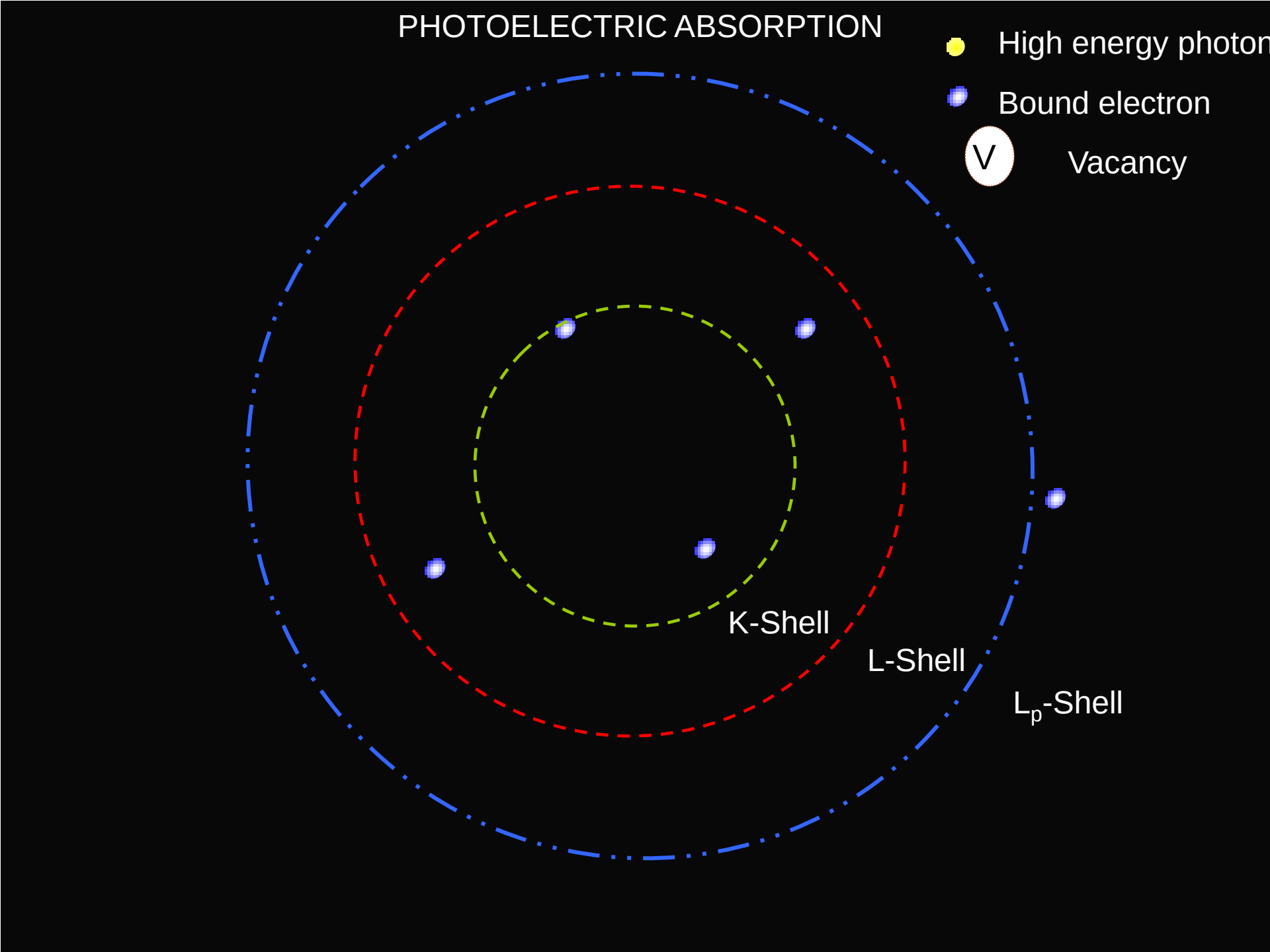
Tissue Geometry

Monte Carlo Electron spectra Calculation

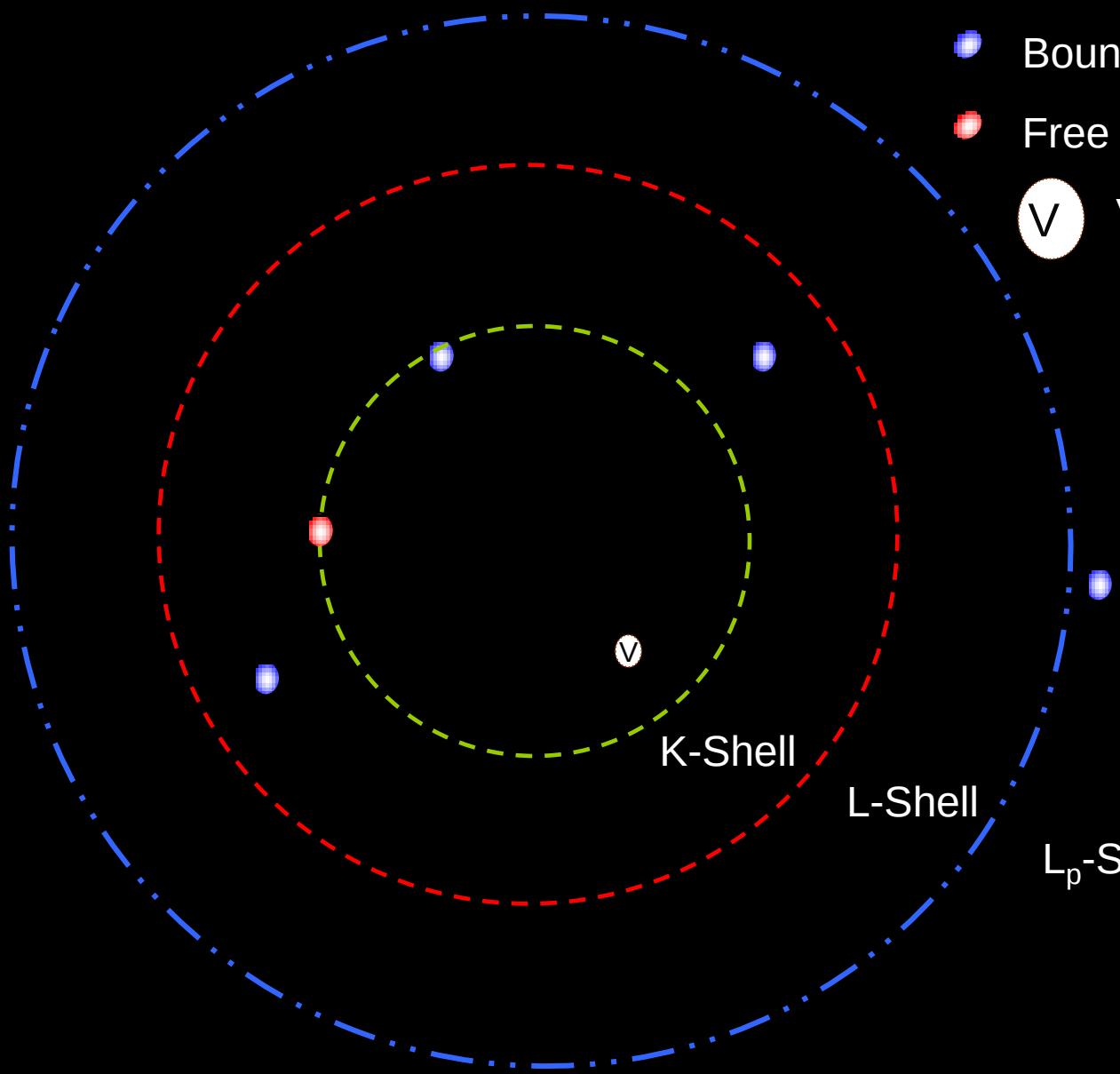
GEANT4

EGSNRC

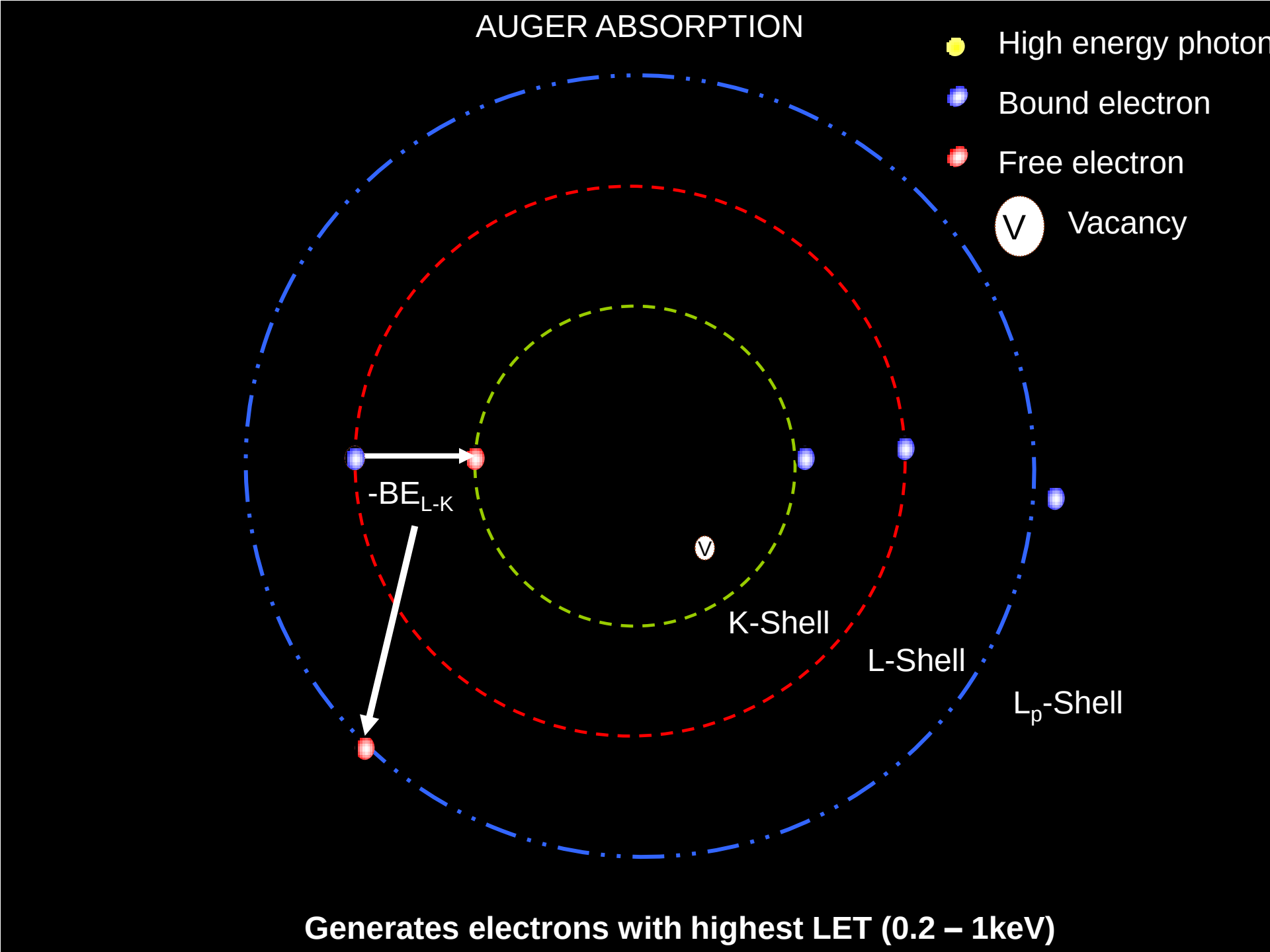

COMPTON SCATTER
High energy photon
Bound electron
Free electron
V
Vacancy
V
K-Shell
L-Shell
L_p-Shell
Generates electrons with high LET (0.1 – 6keV)


PHOTOELECTRIC ABSORPTION
High energy photon
Bound electron
V
Vacancy
K-Shell
L-Shell
L_p-Shell

PHOTOELECTRIC ABSORPTION

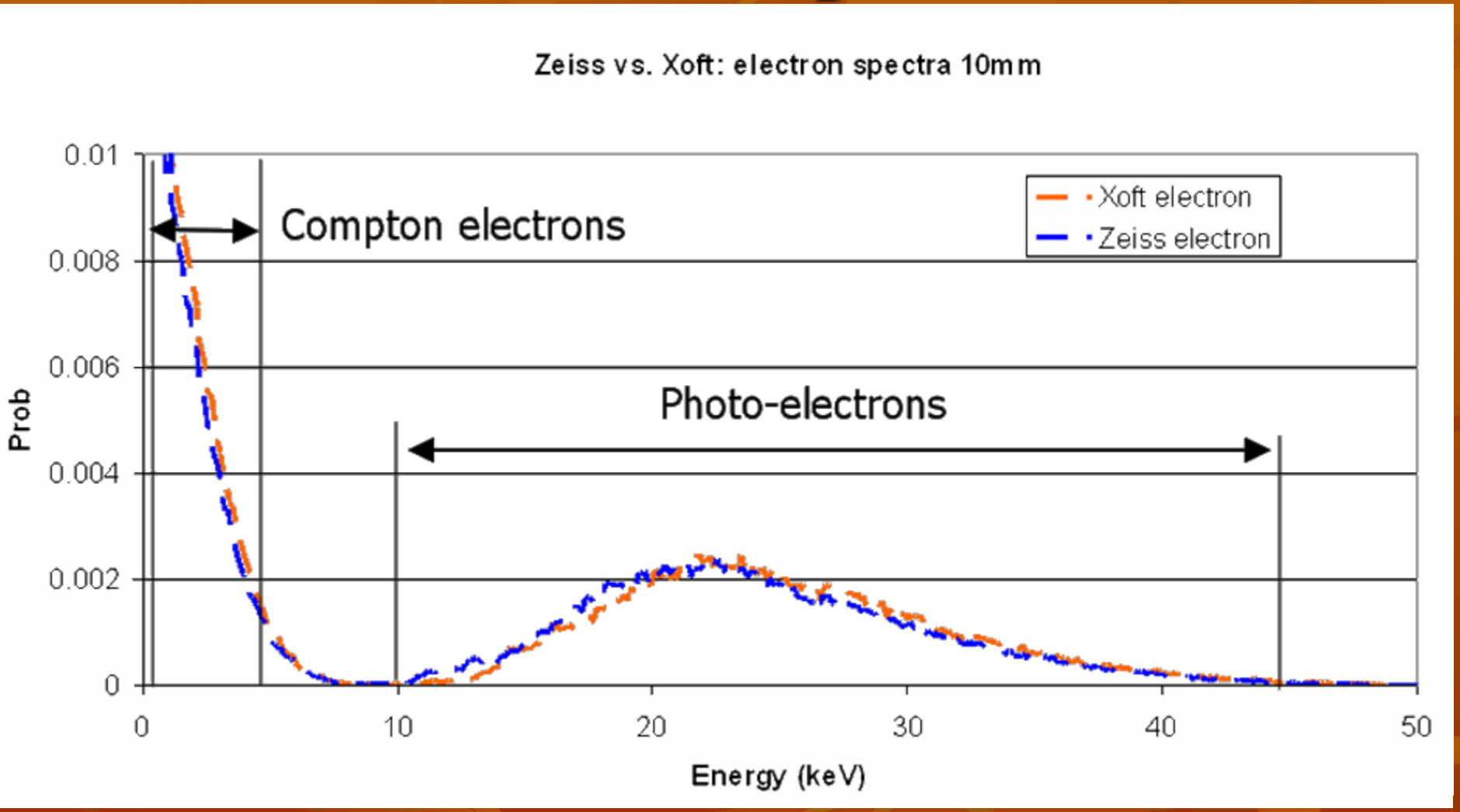


Generates electrons with lower LET (10 – 50keV)

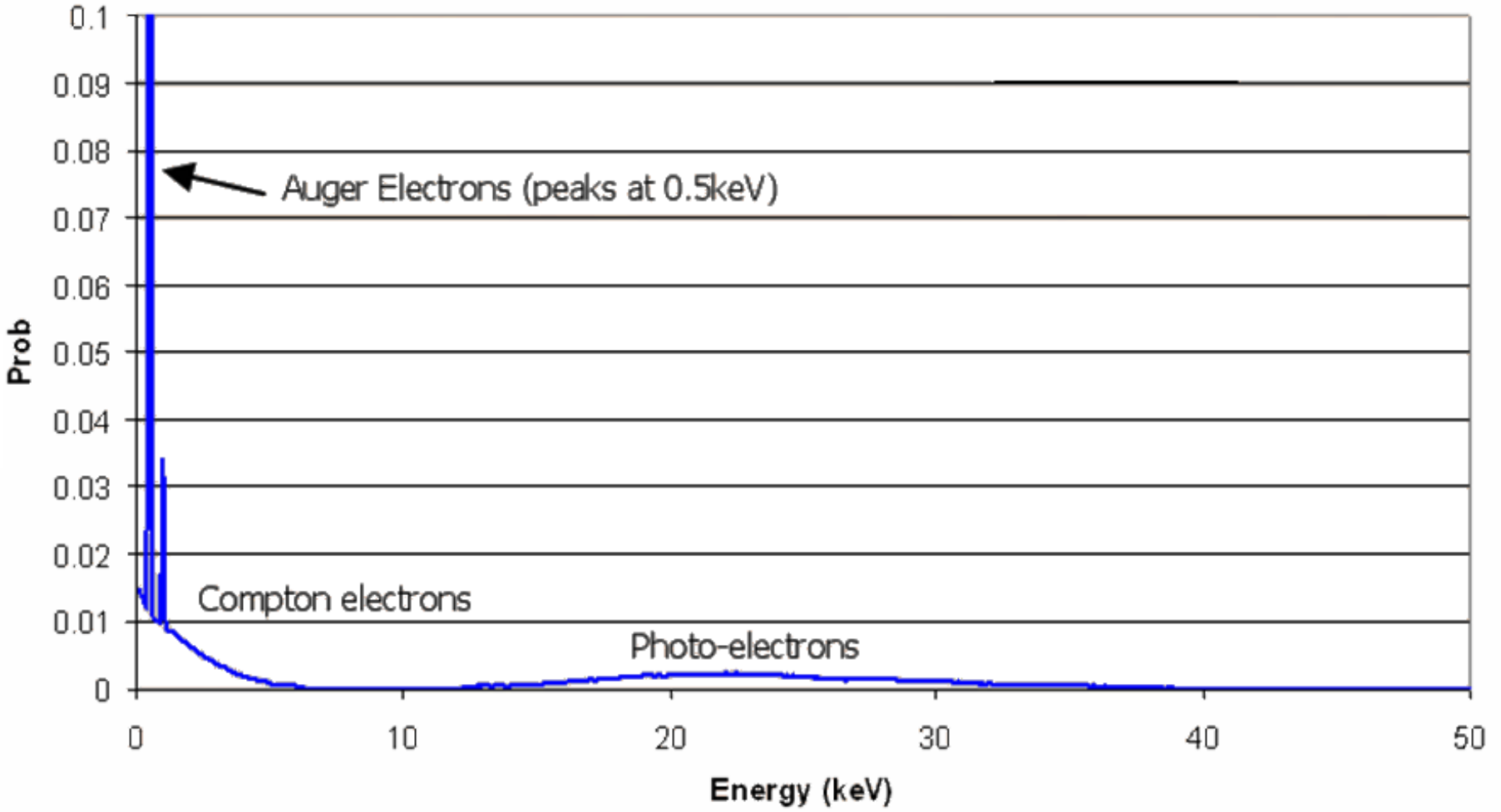


Generates electrons with highest LET (0.2 – 1keV)

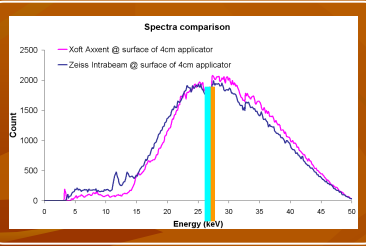
Electron spectra



Electron spectra



Workflow



Tissue Geometry

Monte Carlo Electron spectra Calculation

DNA damage Calculation DSB

Reference

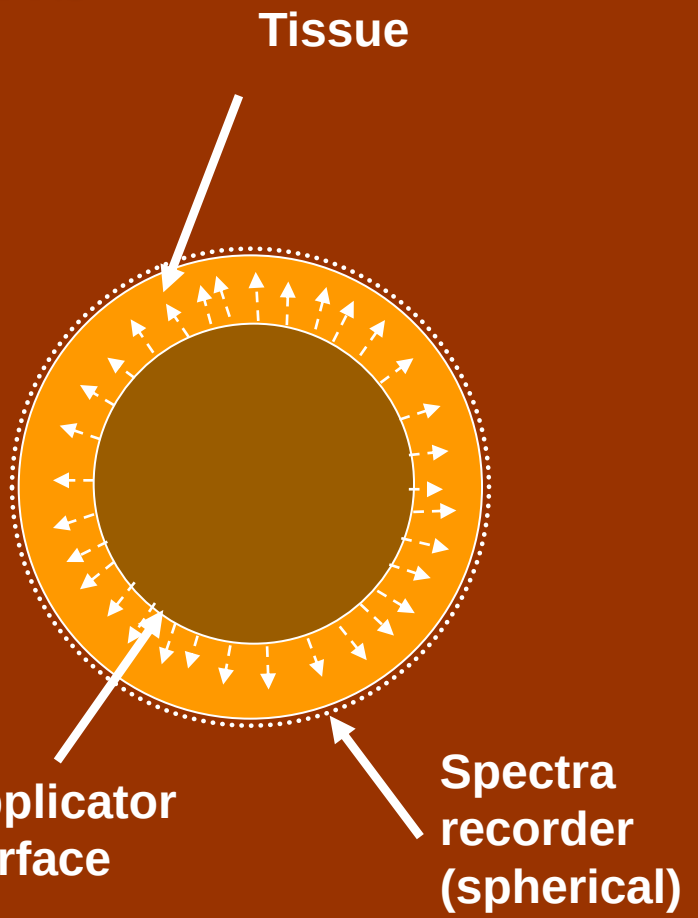
DNA damage Calculation: Cobalt-60

RBE

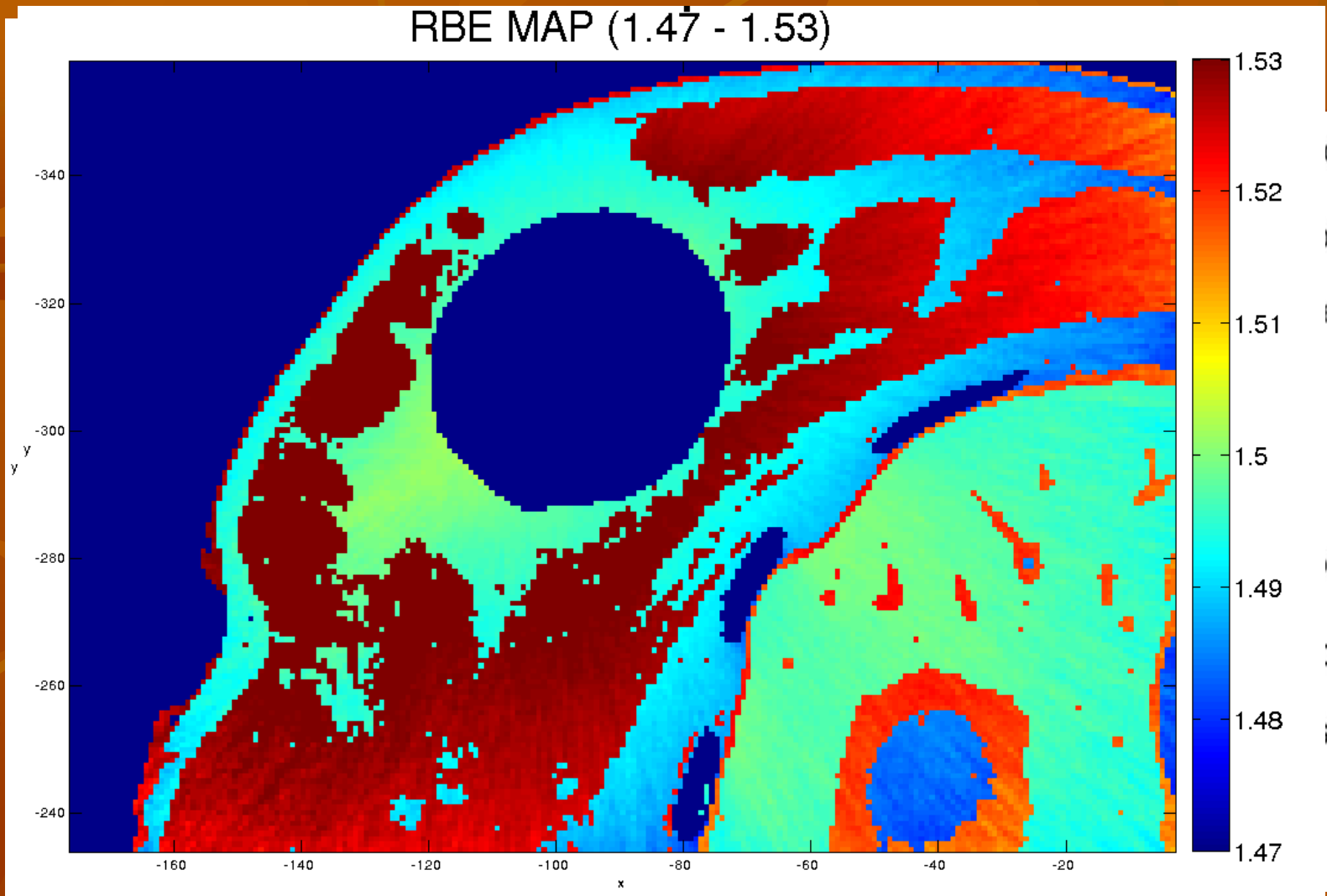
$$\mathrm{RBE} = \frac{(\text{Strand break yield})}{(\text{Strand break yield})_{\text{Reference}}}$$

RBE: Results

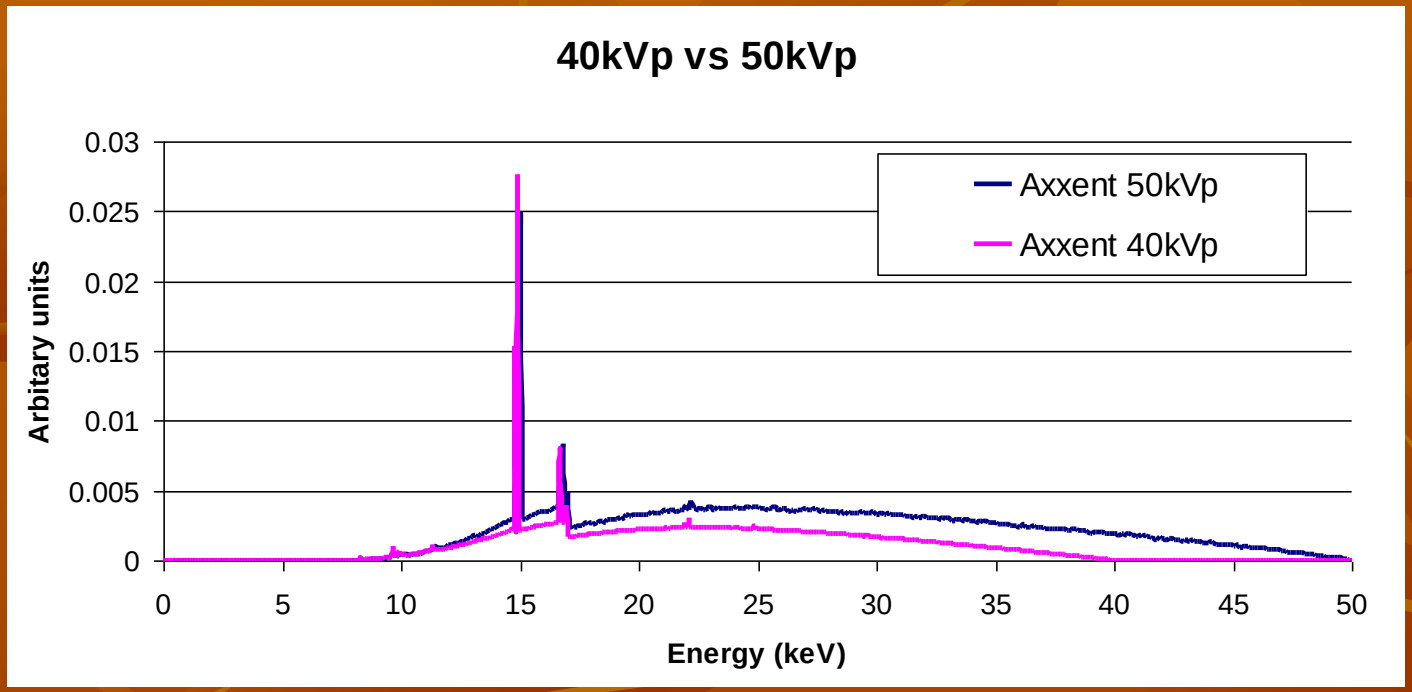
Distance from surface (mm)	Source type	Gland $RBE_{(DSB)}$	Adipose $RBE_{(DSB)}$
0	Axxent	1.50	1.54
	Intrabeam	1.50	1.55



RBE: mapping


RBE MAP (1.47 - 1.53)
-340
-320
-300
-280
-260
-240
y
-160
-140
-120
-100
-80
-60
-40
-20
x
1.53
1.52
1.51
1.5
1.49
1.48
1.47

RBE: 40kV Axxent



Material	Distance from surface (mm)	RBE_{DSB} 40keV	RBE_{DSB} 50keV
Water	0	1.520	1.506
	5	1.520	1.505
	10	1.518	1.500
	15	1.520	1.501
	20	1.518	1.495

Reduction in kVp produces no significant difference in RBE_{DSB} (RBE ≈ 1.5)

Conclusions

Zeiss Intrabeam and Xoft Axxent demonstrate similar RBE_{DSB} at all depths and tissues calculated (RBE ≈ 1.5)

Radiation Quality plateau between 30 and 50kVp.