WELCOME

RIGAKU WEBINAR SERIES

X-RAY COMPUTED TOMOGRAPHY FOR MATERIALS SCIENCE *FOOD AND PHARMACEUTICAL APPLICATIONS*

IS STARTING NOW.

Presenter: Aya Takase

Senior Scientist
Rigaku Americas Corporation

Host: Tom McNulty

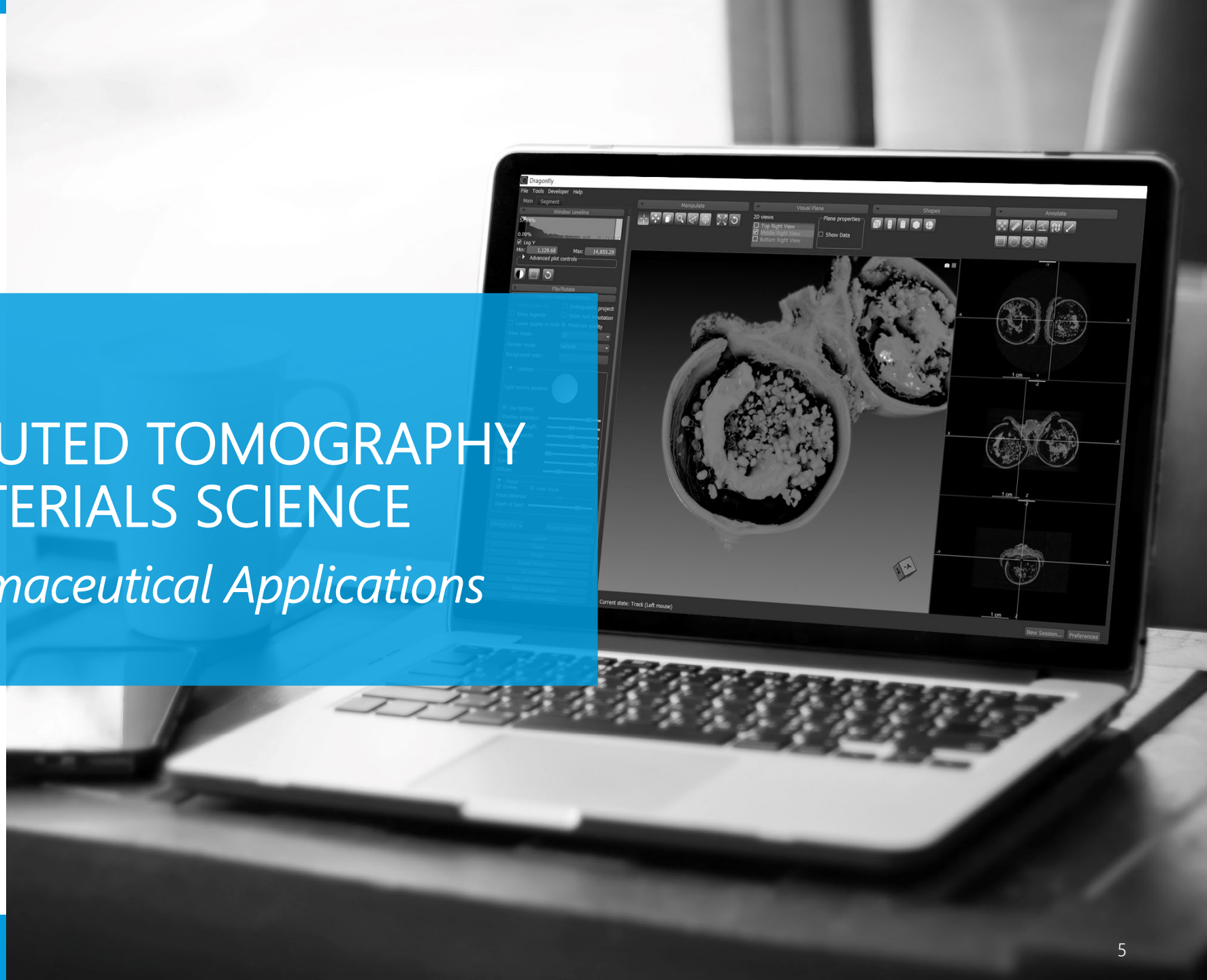
Senior Vice President
Rigaku Americas Corporation

You can send us questions during the presentation.
They will be addressed at the end of the presentation.

A recording of this webinar will be available.
You will receive an email with a link to it tomorrow.

X-RAY COMPUTED TOMOGRAPHY FOR MATERIALS SCIENCE

Food and Pharmaceutical Applications



SOMETHING ABOUT MICROSCOPY


This could be interesting to look at…


AT&T
75%
12:23
Monday, July 29
slide to unlock


SUN
MON
WED
THU
FRI

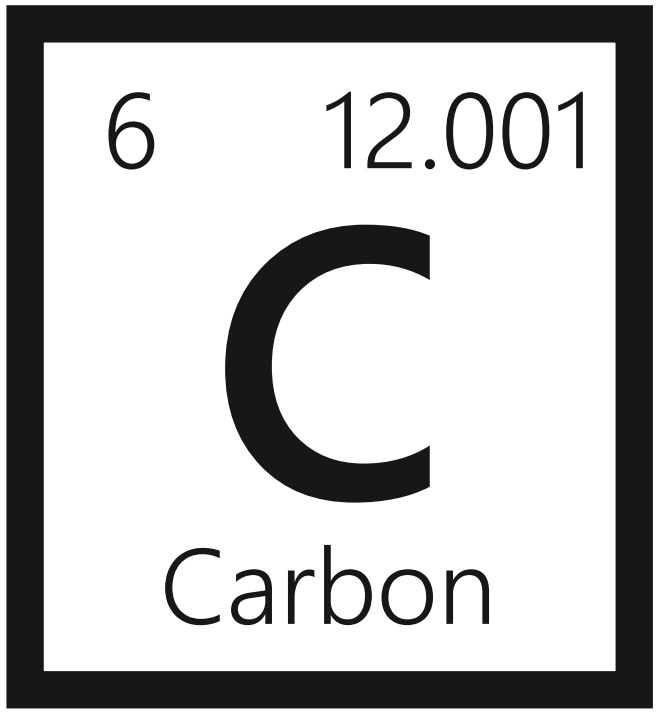

$1.69
$2.99
99¢
99¢
$1.39
$1.49
Yellow
Popcorn
Nutrition
Facts:
PLU# 70329
PLU# 70265
PLU# 70183
PLU# 71112
PLU# 70120

You will learn:

- Keys to imaging soft materials
- Food science applications
- Pharmaceutical applications

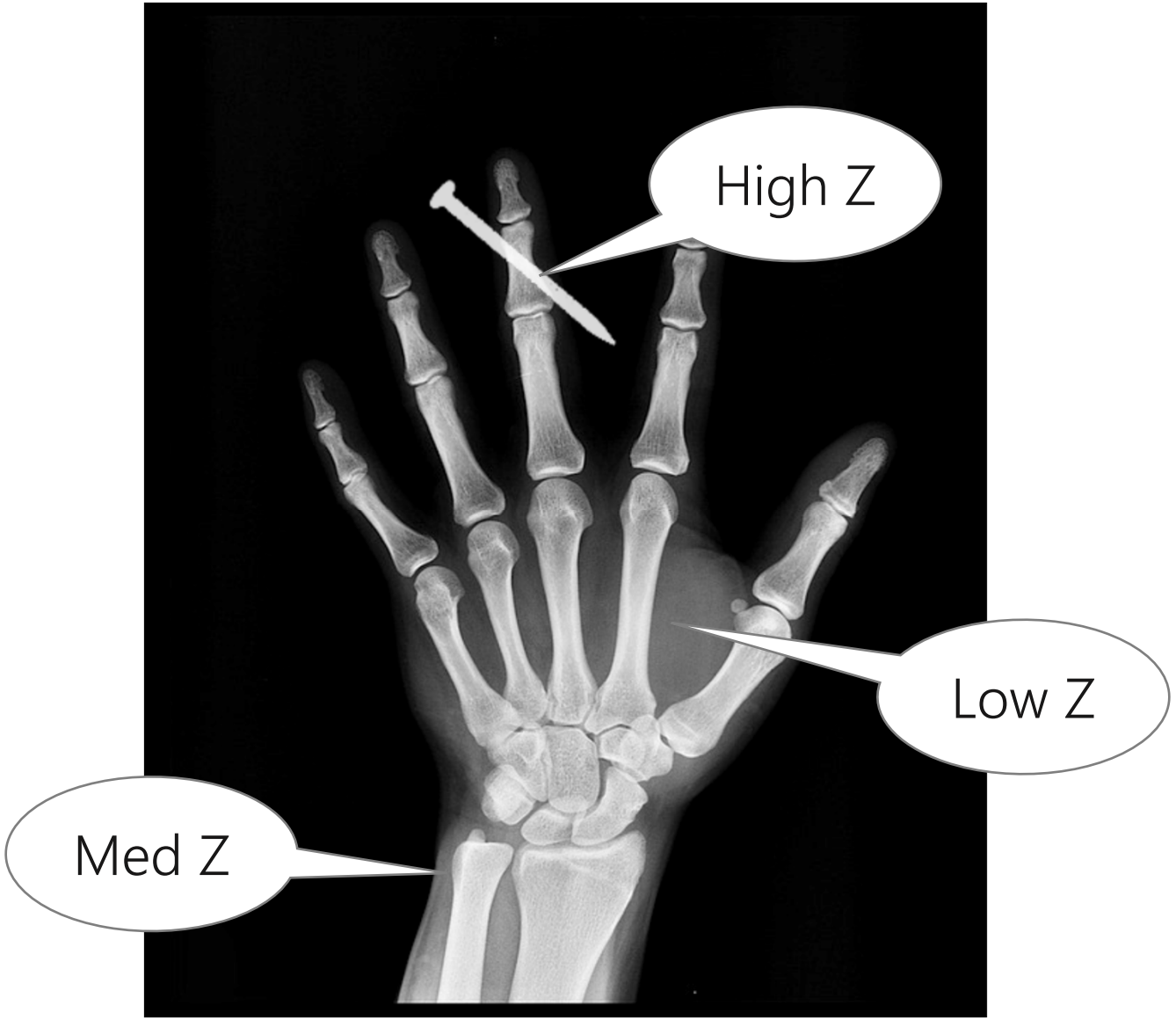
WHAT IS IN COMMON BETWEEN FOOD AND PHARMA SAMPLES?

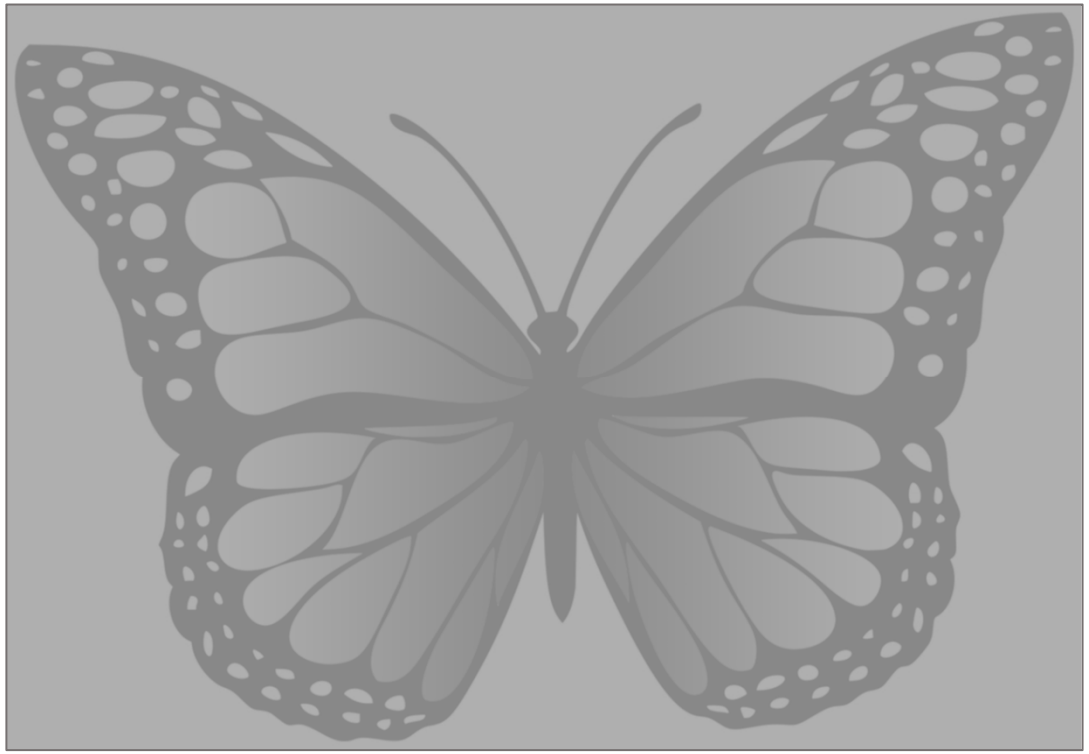
Organic compounds



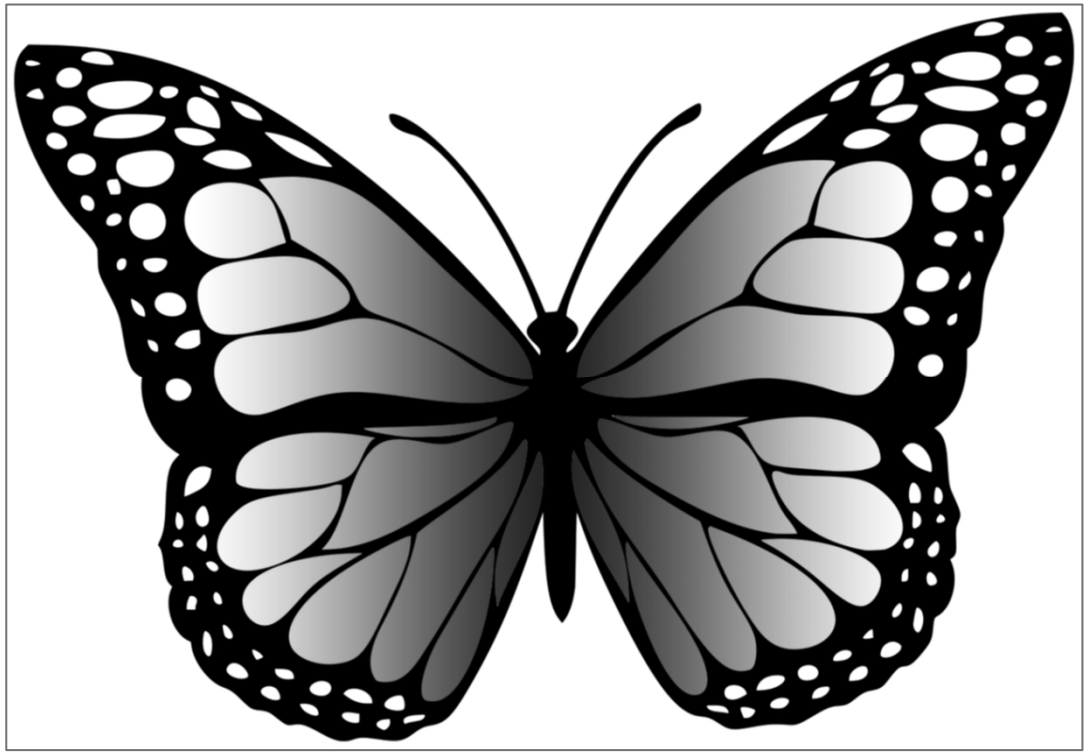
Low Z (atomic number)

WHY DOES IT MATTER?


High Z
Low Z
Med Z



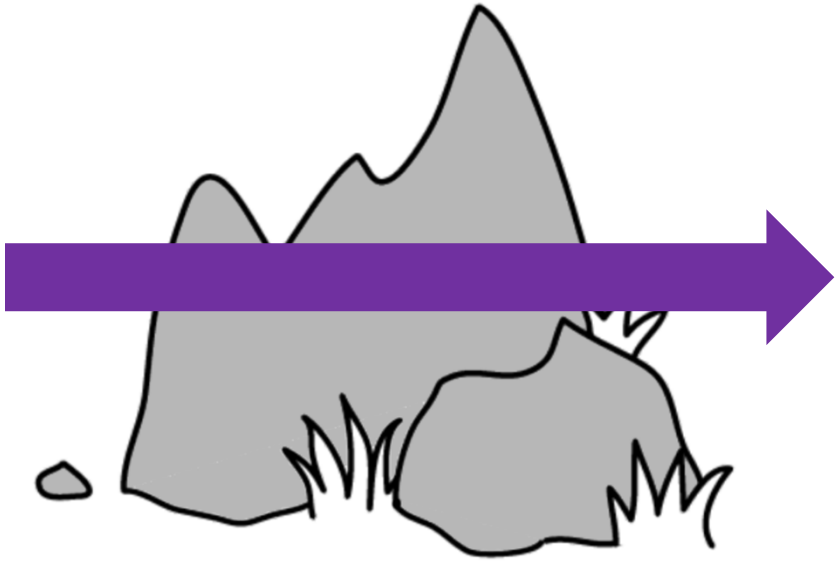
Energy: not optimal



Energy: optimal

Large, high density
High energy X-rays

Small, low density
Low energy X-rays

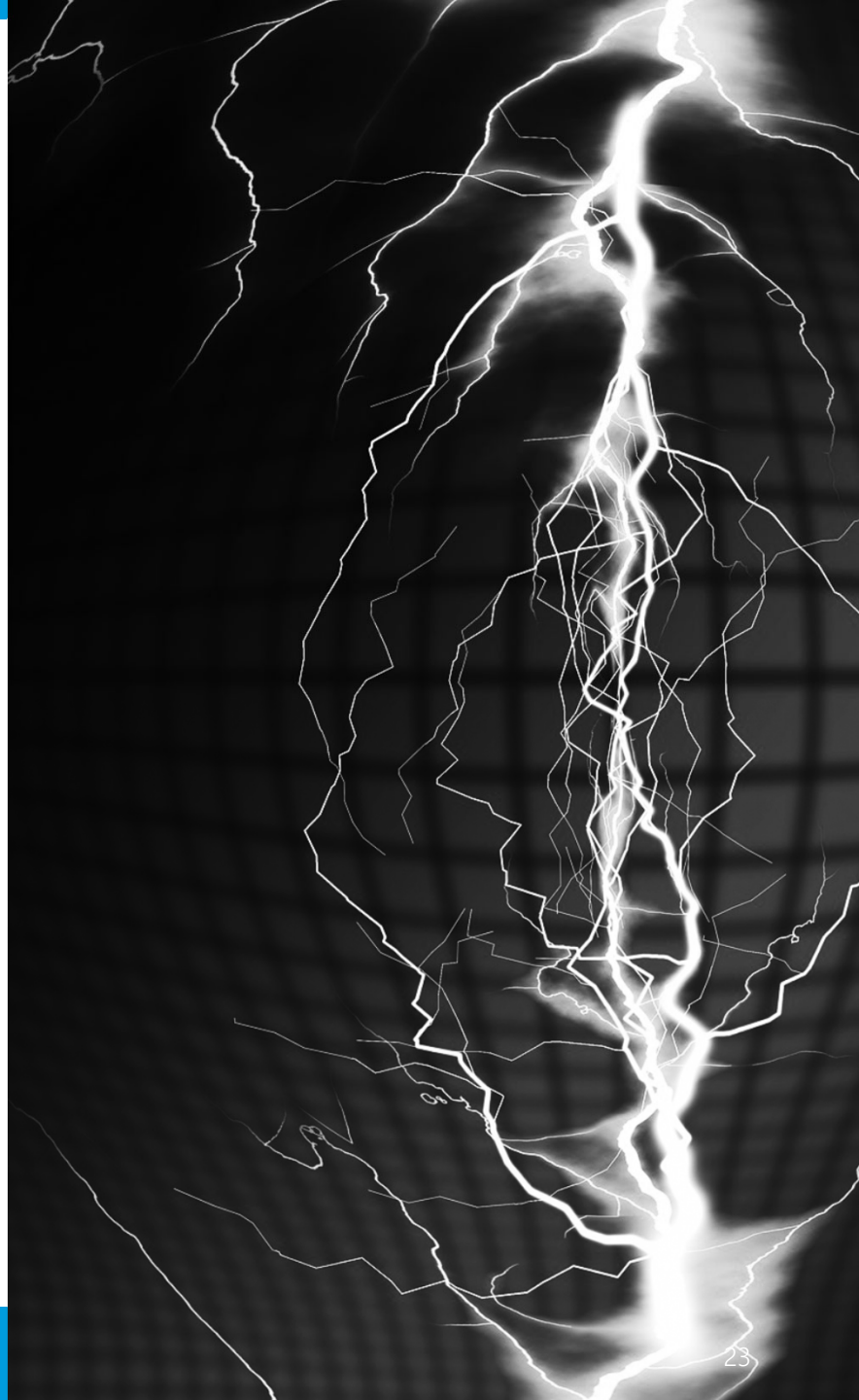


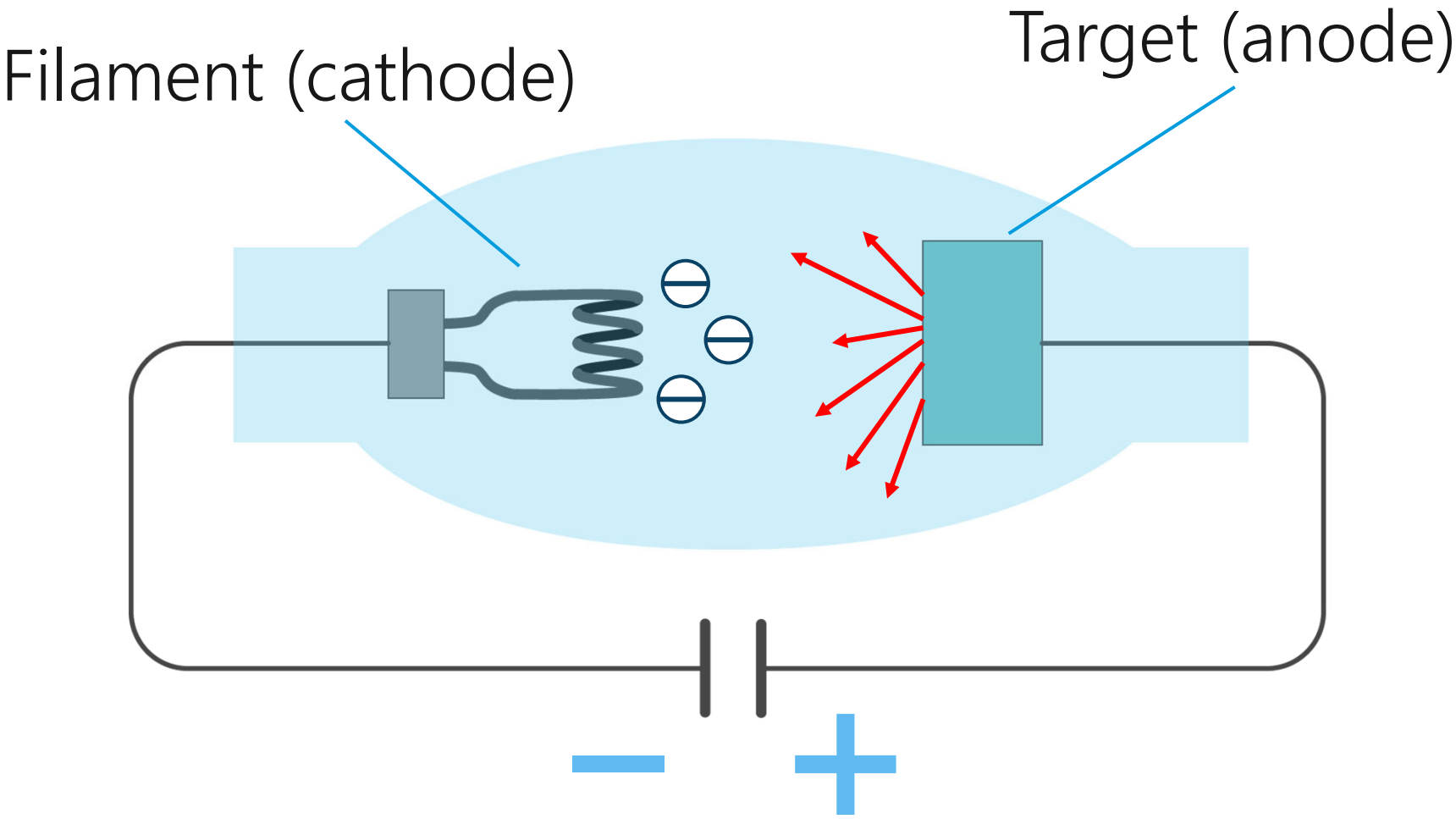
WHAT DETERMINES X-RAY ENERGY?

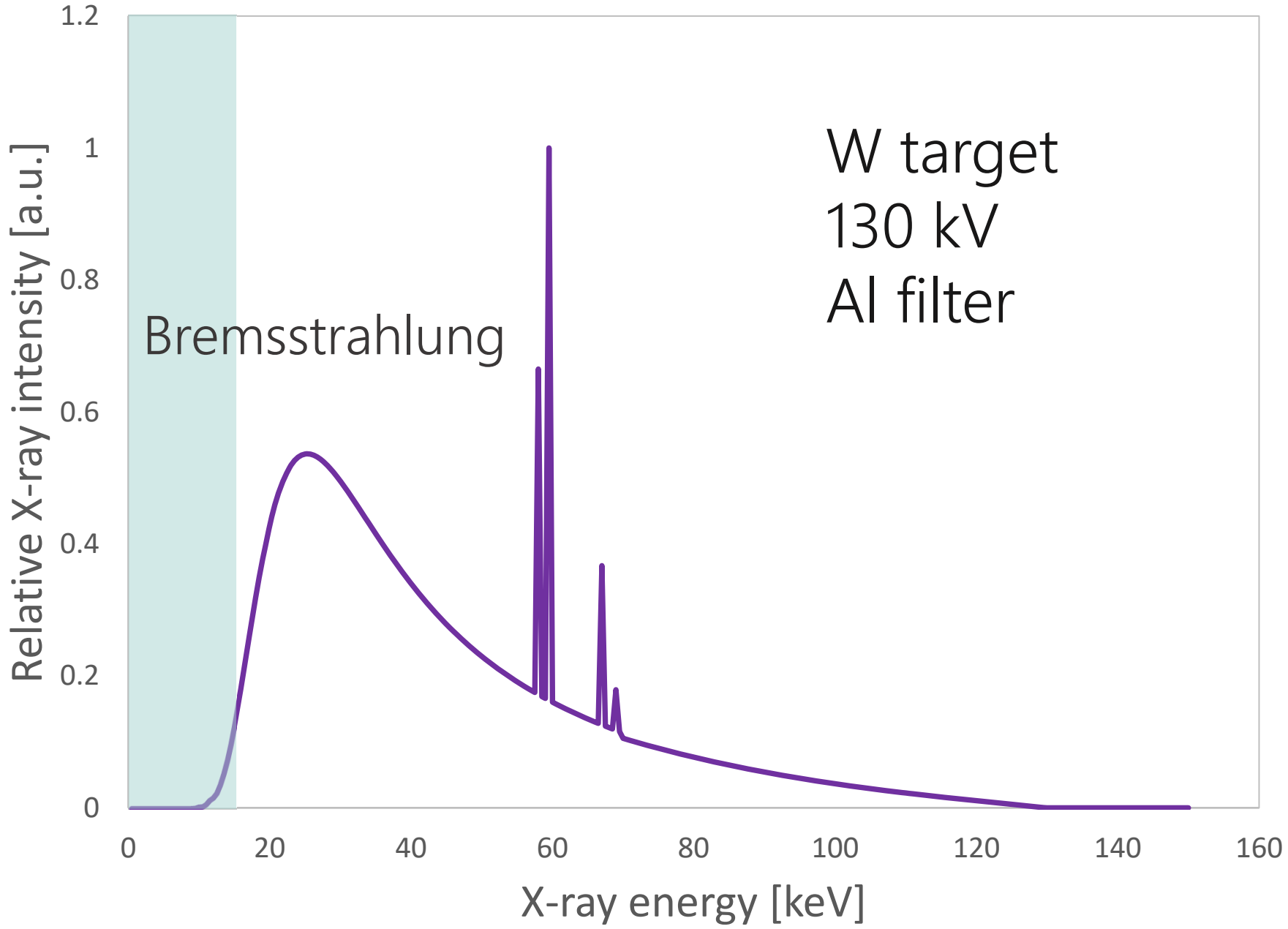
X-RAY ENERGY

- Bremsstrahlung
- Characteristic

- X-ray target material
- Applied voltage
- Filter

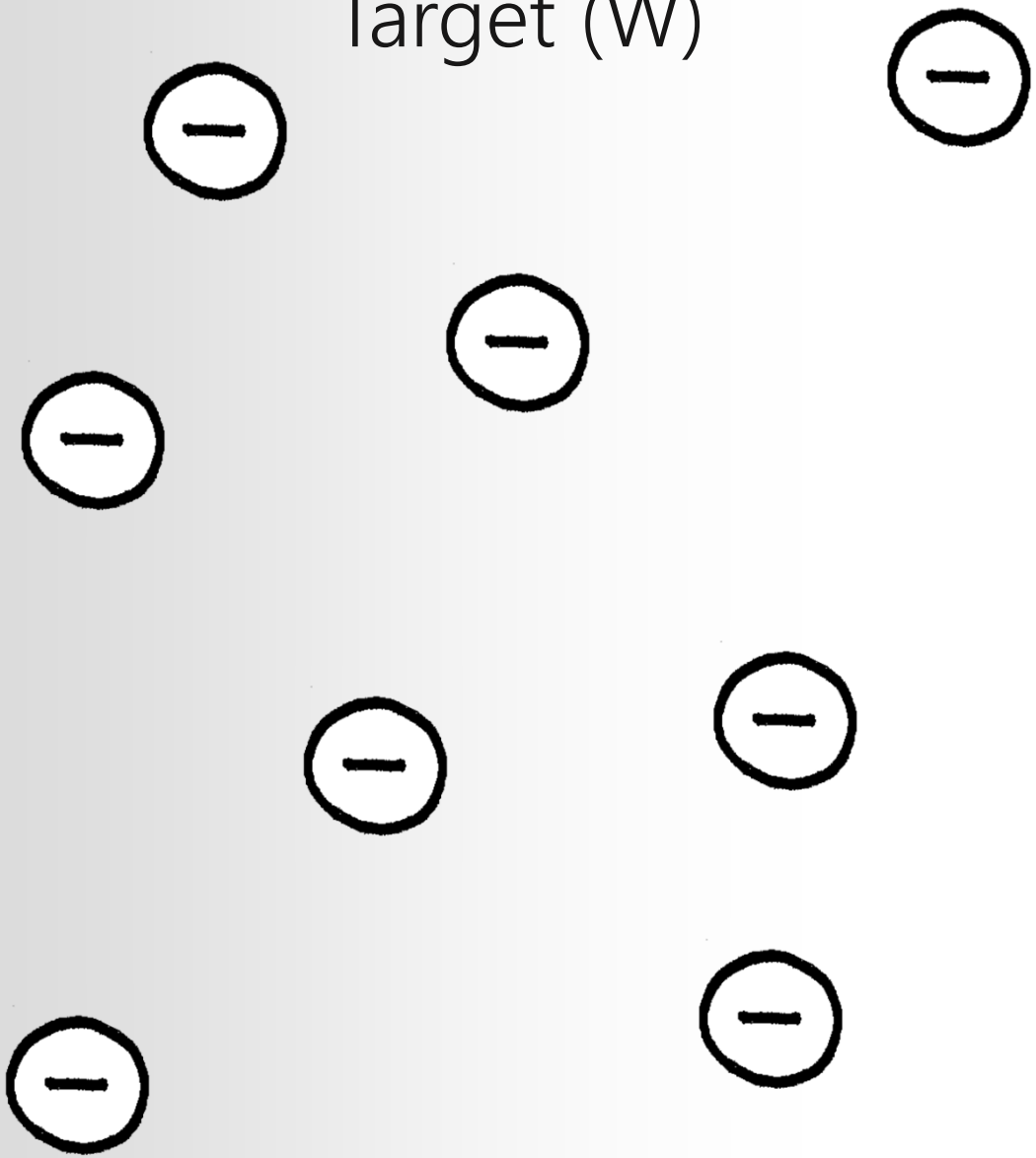



Filament (cathode)
Target (anode)
−
+

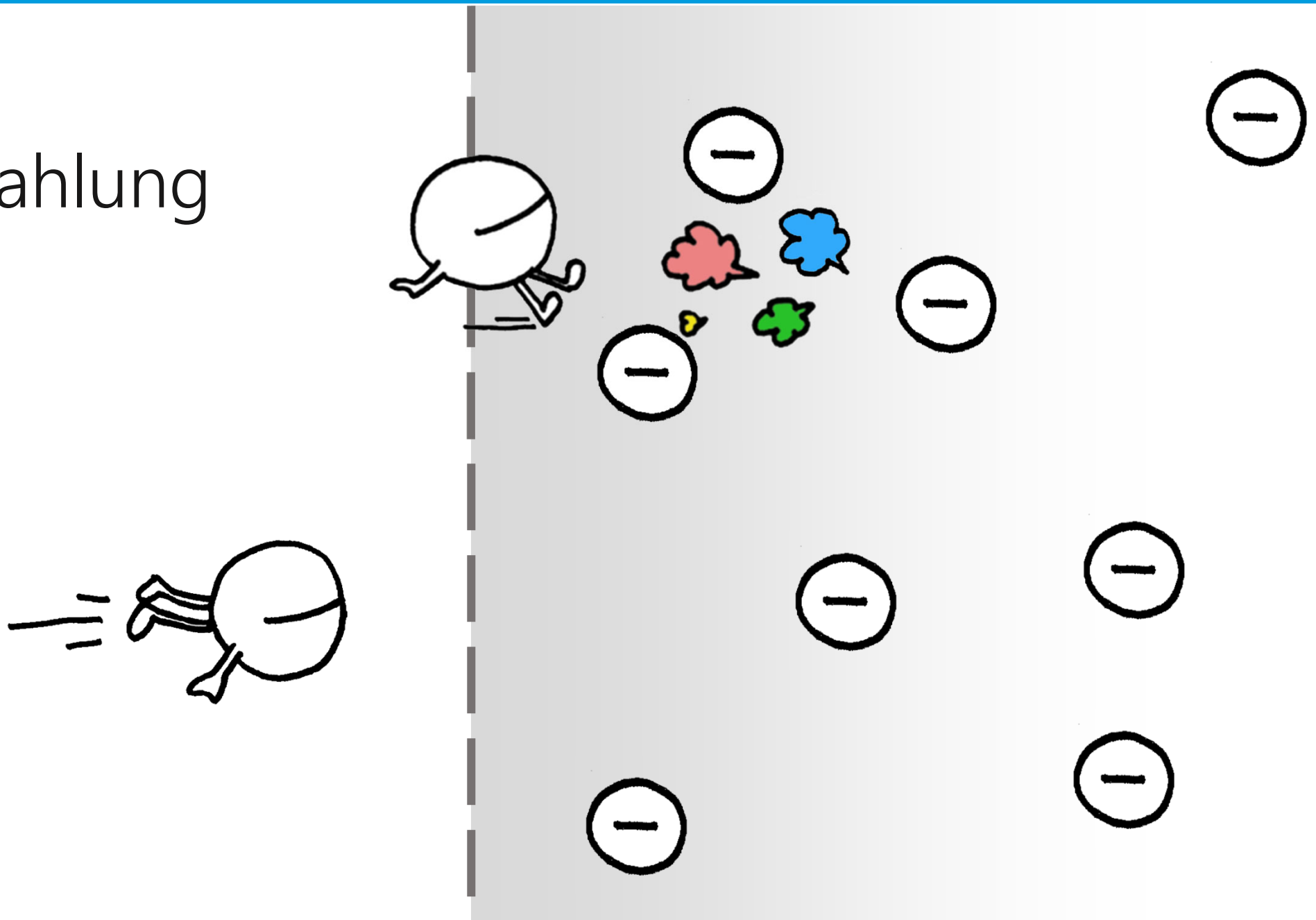

1.2
1
0.8
0.6
0.4
0.2
0
Relative X-ray intensity [a.u.]
Bremsstrahlung
W target
130 kV
Al filter
0
20
40
60
80
100
120
140
160
X-ray energy [keV]

Vacuum

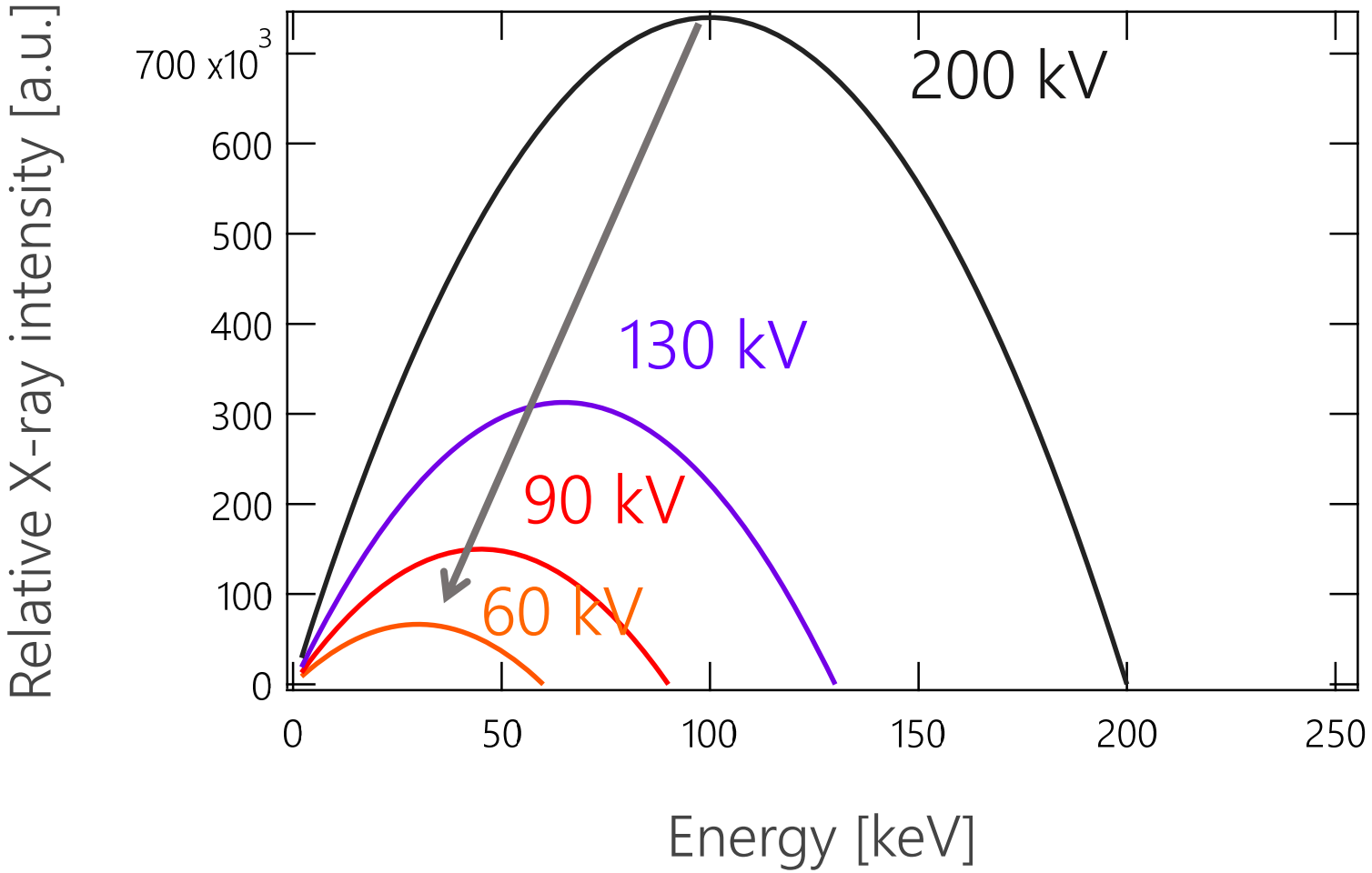
Target (W)



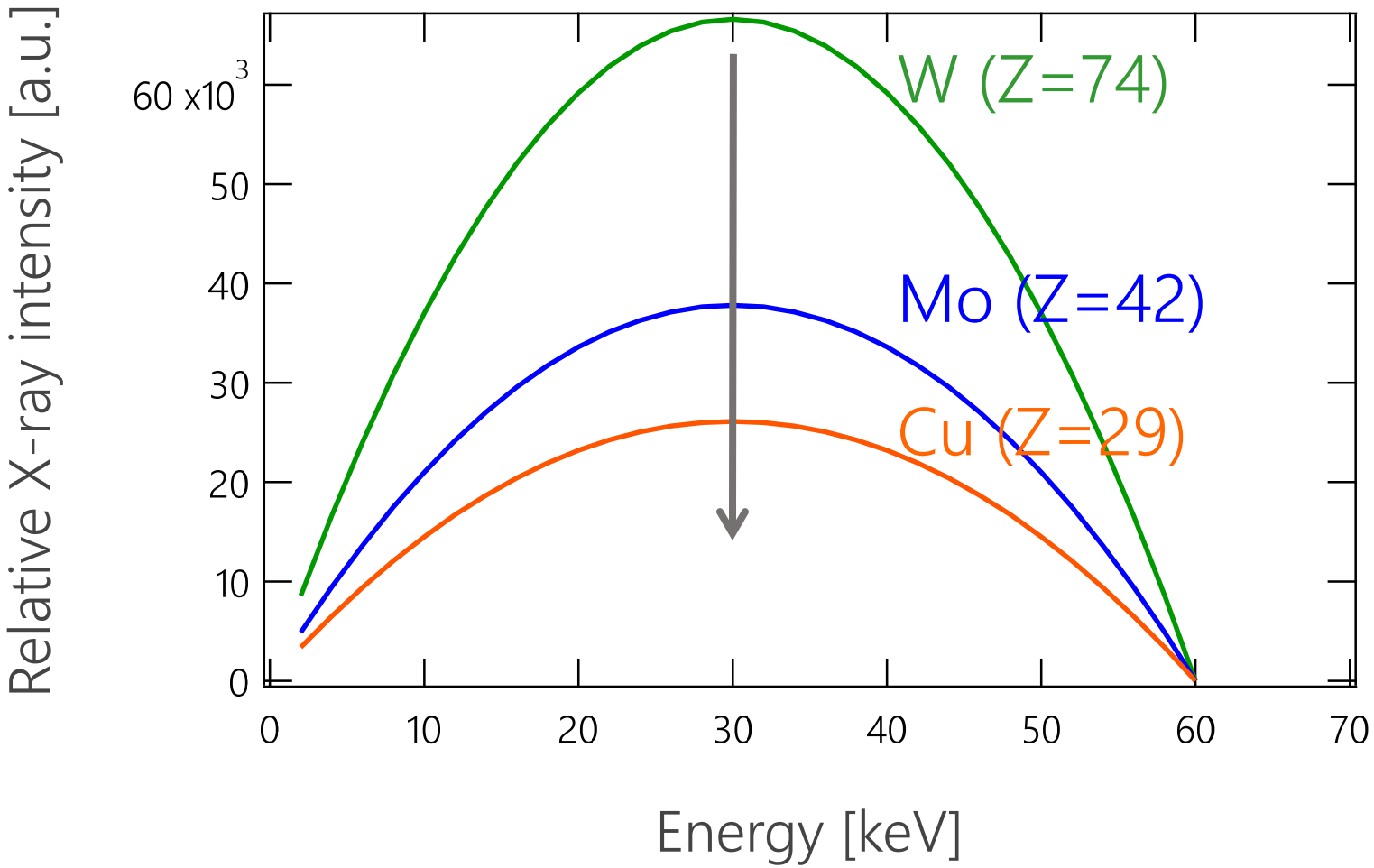
Bremsstrahlung

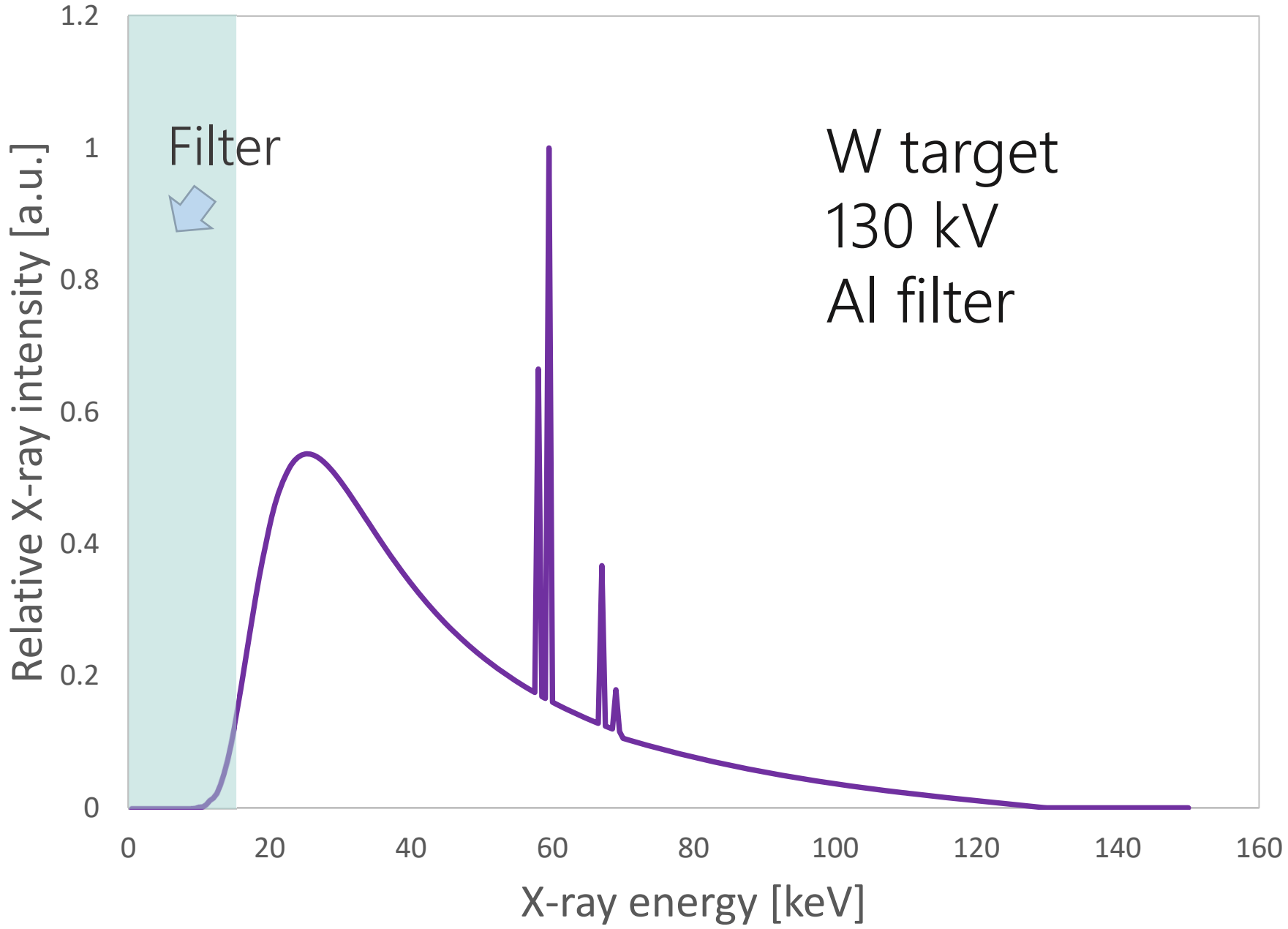


Change applied voltage (W)

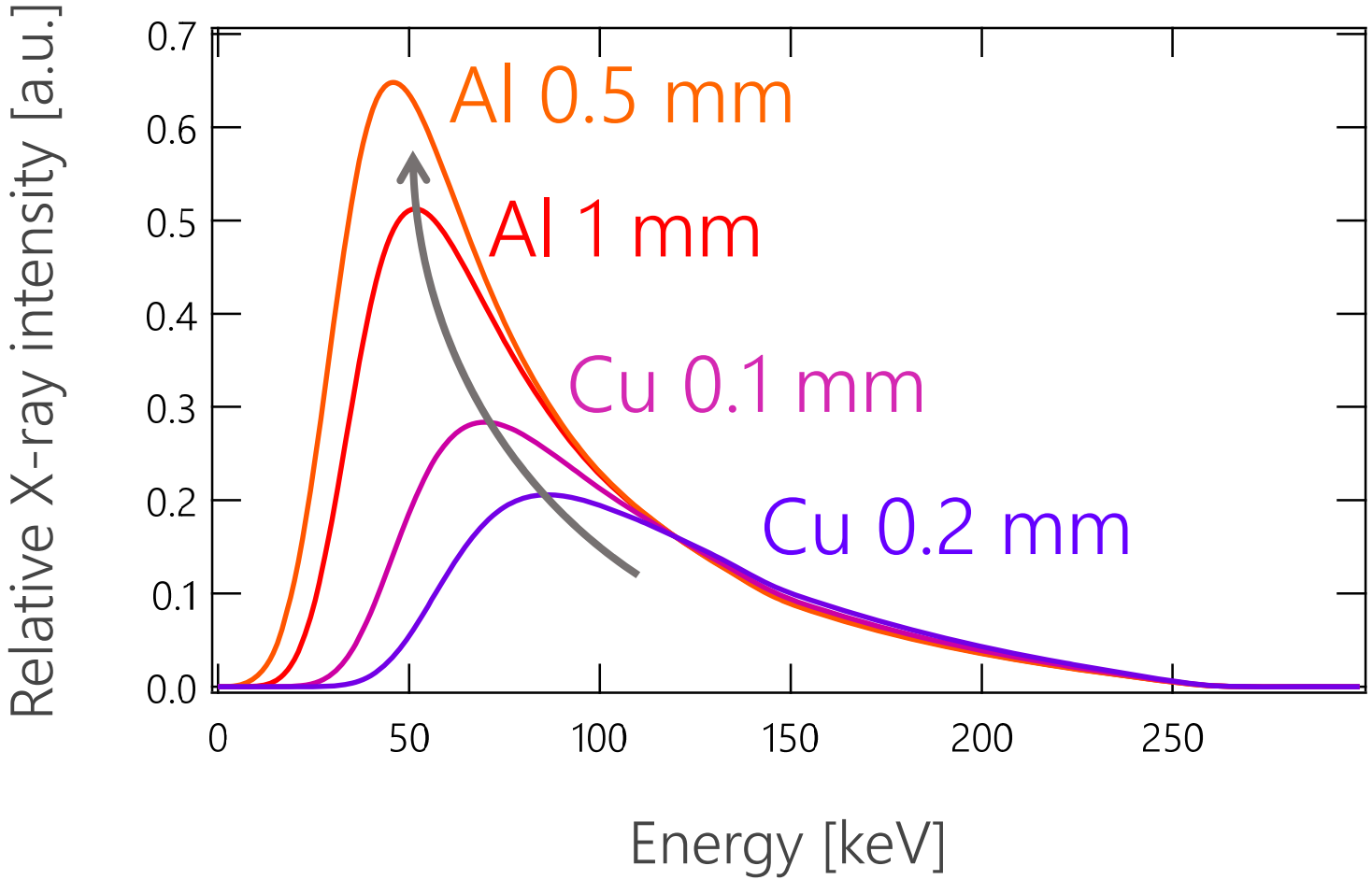


Change target (60kV)




Filter
W target
130 kV
Al filter
Relative X-ray intensity [a.u.]
X-ray energy [keV]
0
0.2
0.4
0.6
0.8
1
1.2
0
20
40
60
80
100
120
140
160

Change filter (W, 130kV)

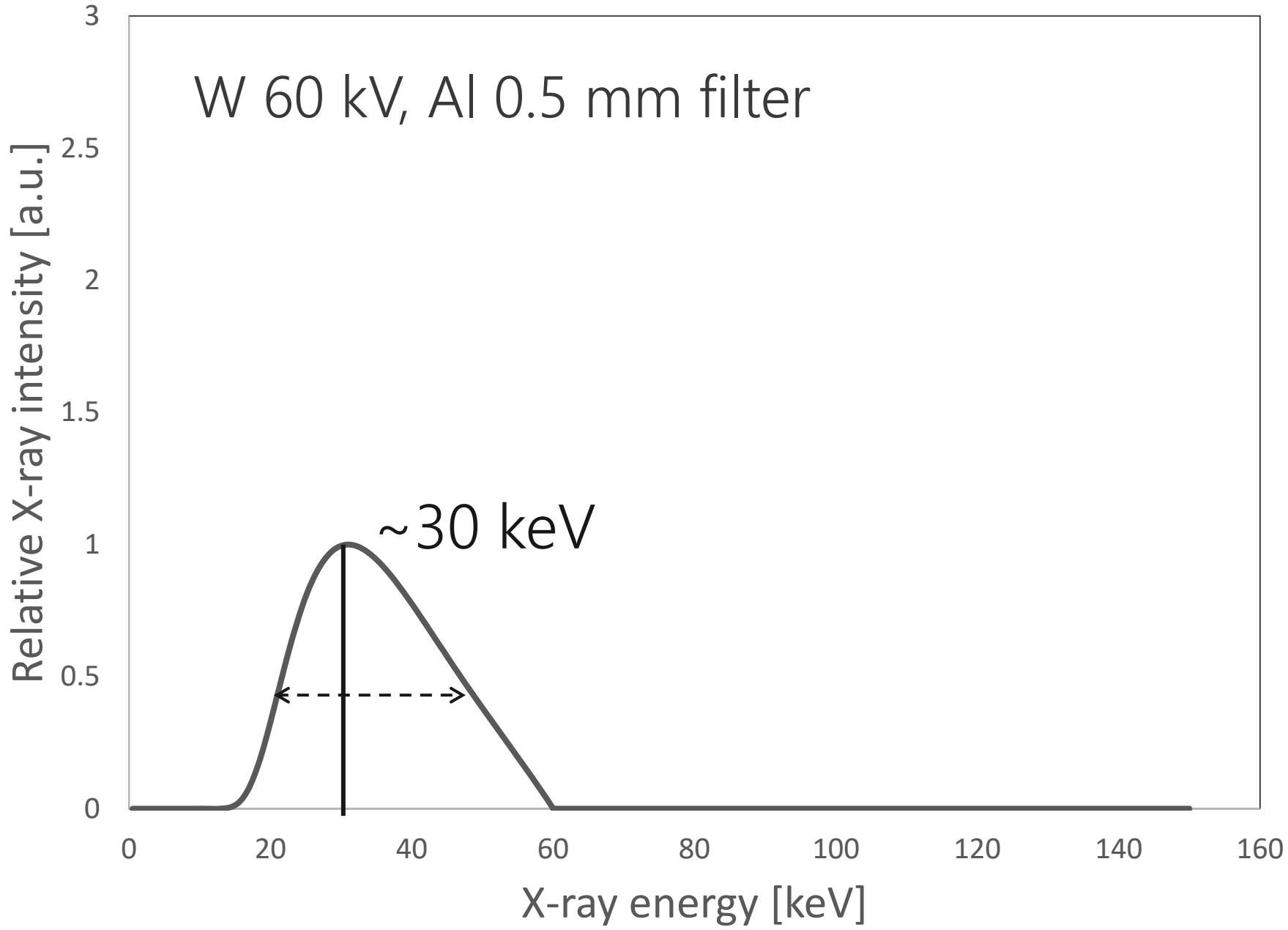


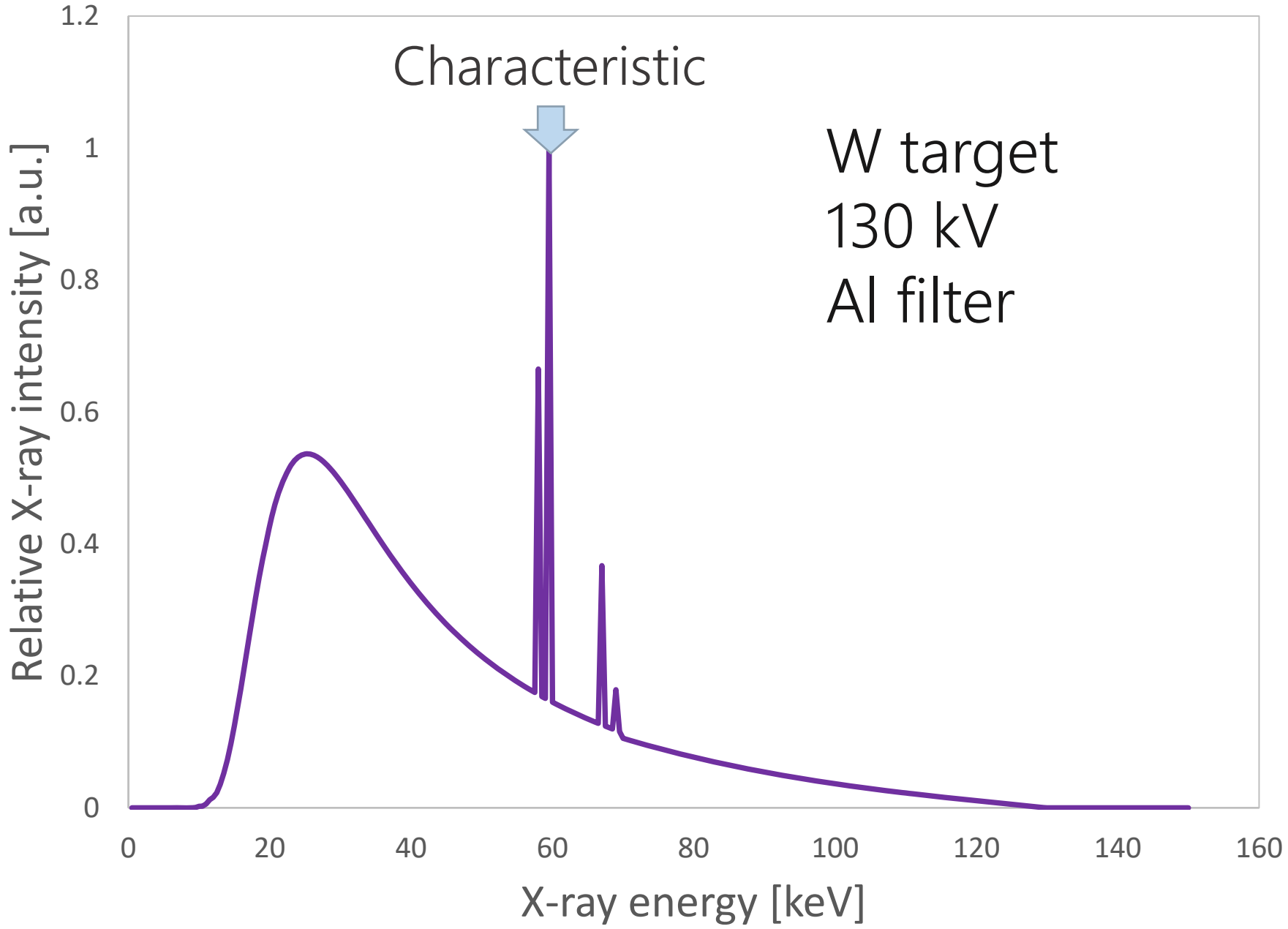
Bremsstrahlung radiation

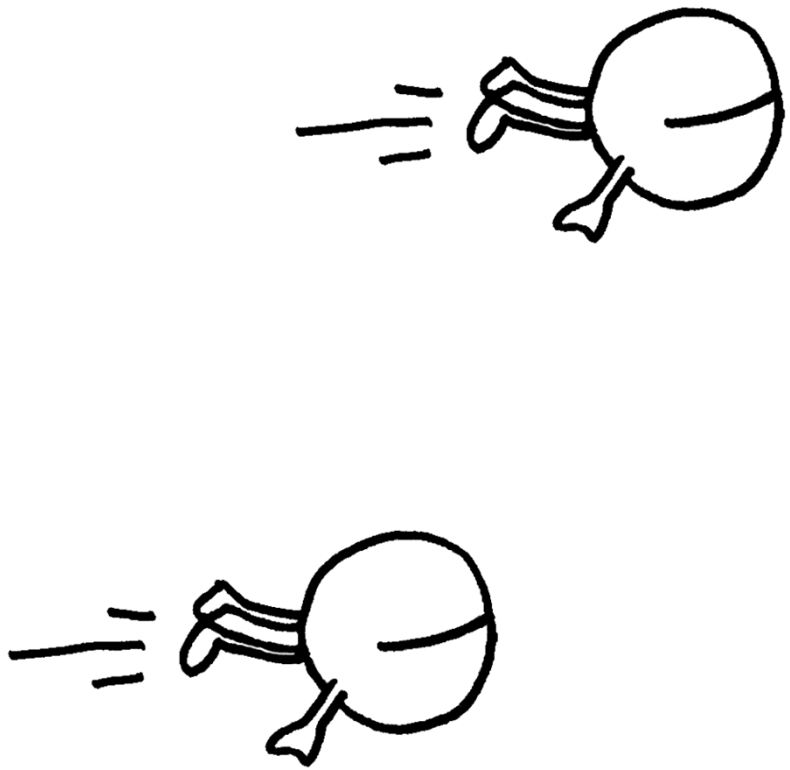
Use high atomic number target (W)

Apply low voltage

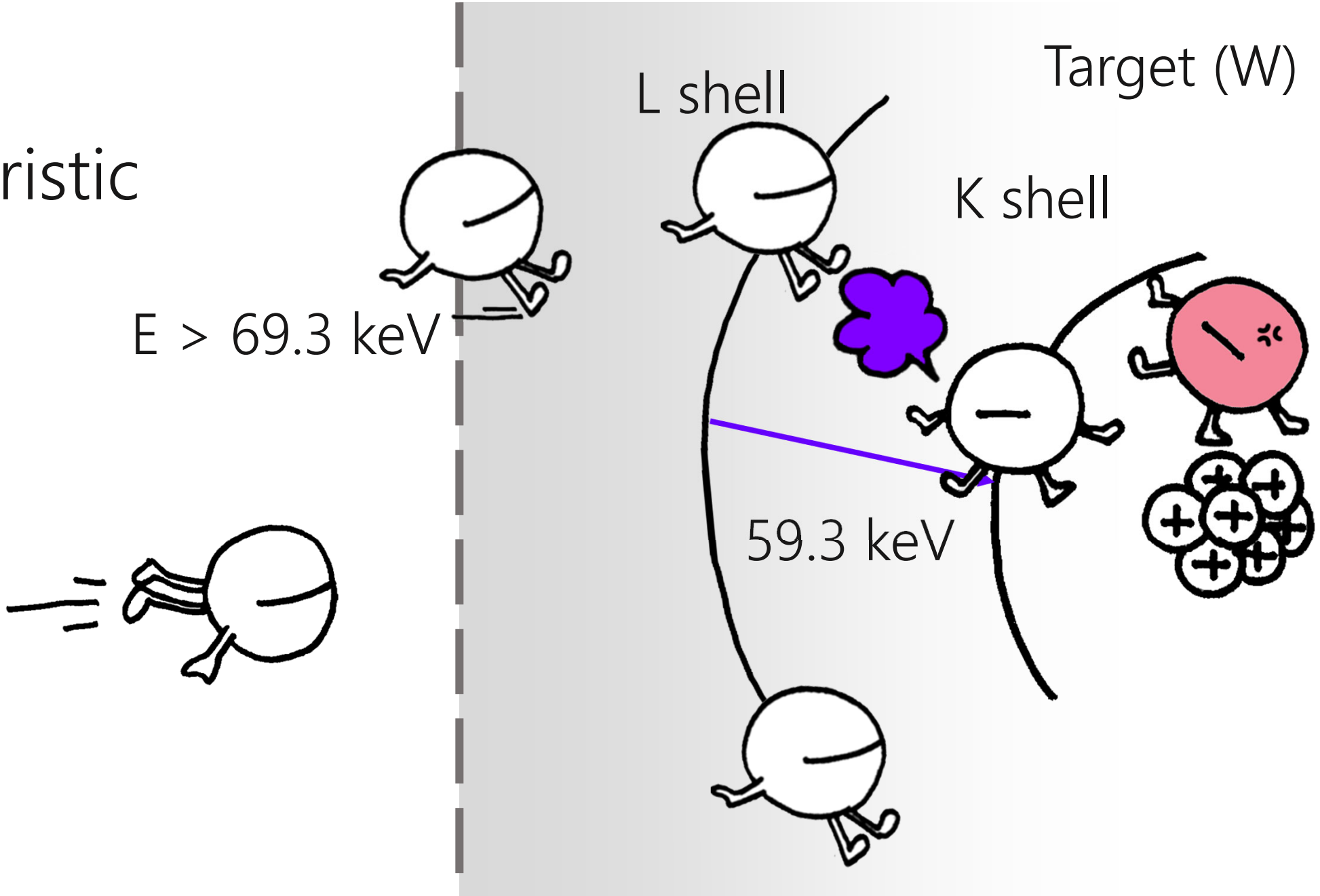
Use light & thin filter


W 60 kV, Al 0.5 mm filter
~30 keV
Relative X-ray intensity [a.u.]
X-ray energy [keV]
0
0.5
1
1.5
2
2.5
3
0
20
40
60
80
100
120
140
160


Characteristic
W target
130 kV
Al filter
Relative X-ray intensity [a.u.]
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160
X-ray energy [keV]


L shell
Target (W)
K shell

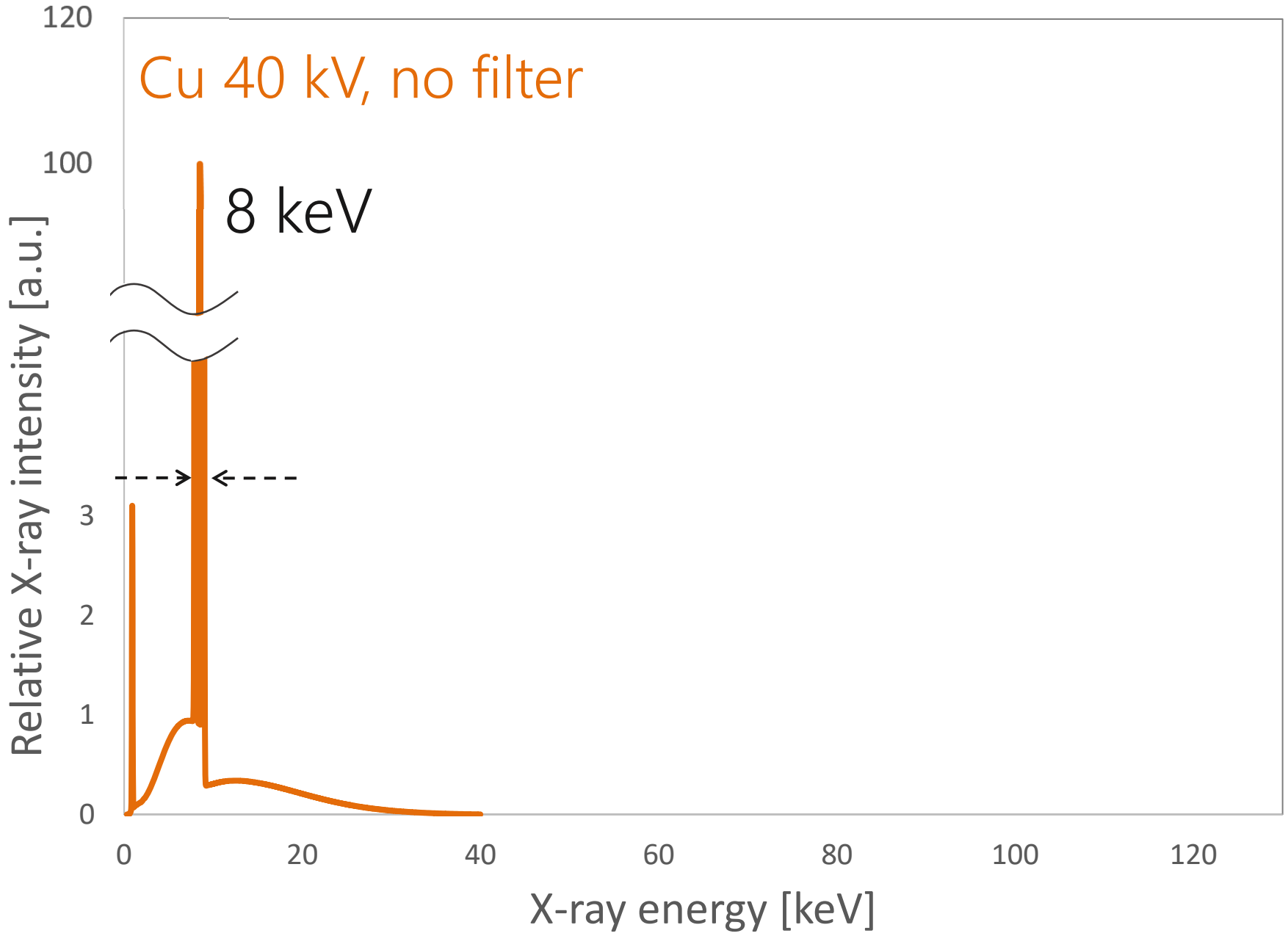
Characteristic



	Kα1 radiation
W K	59.3 keV
Mo K	17.5 keV
Cu K	8.0 keV
Cr K	5.4 keV

Characteristic radiation

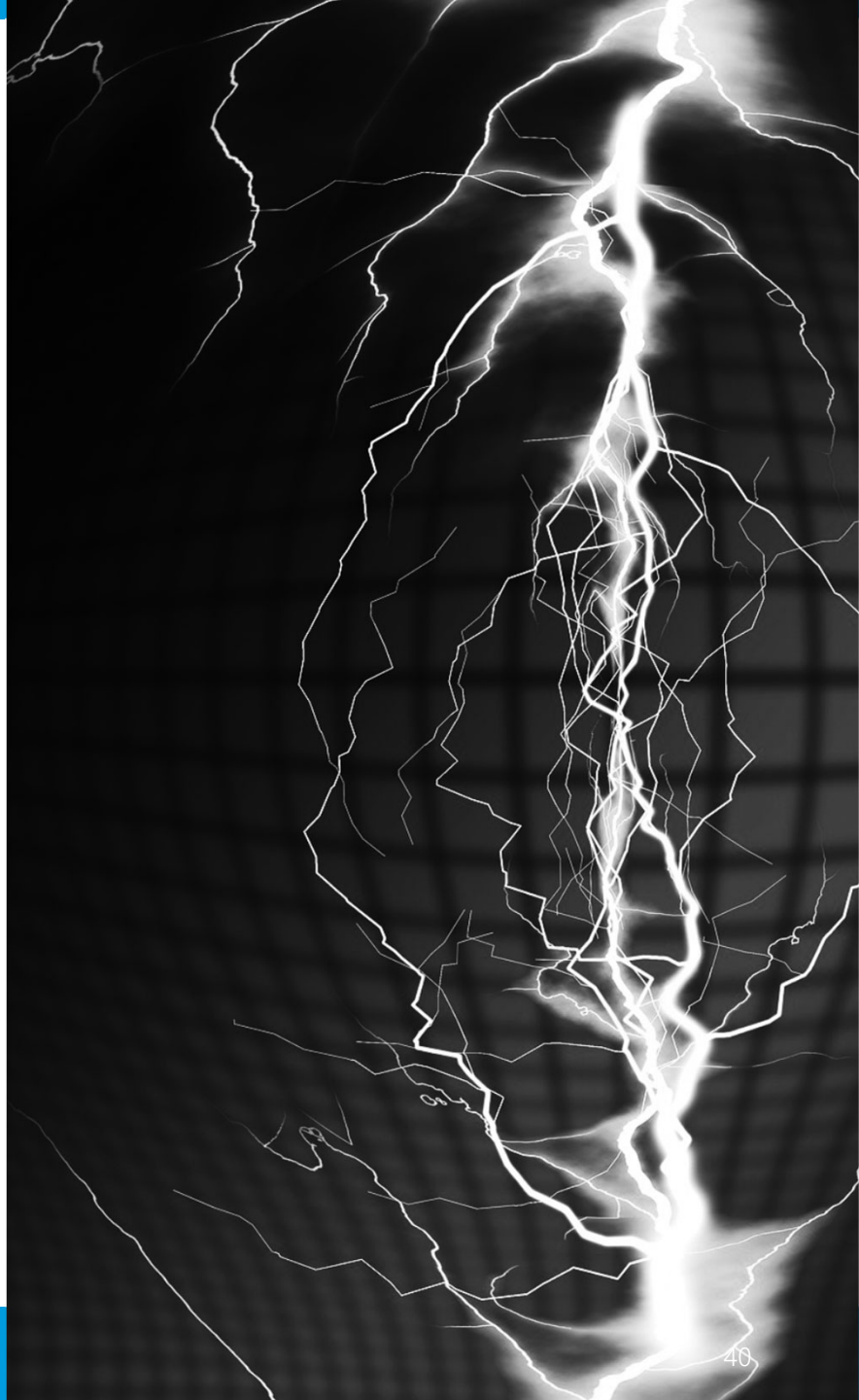
Choose target for desired energy

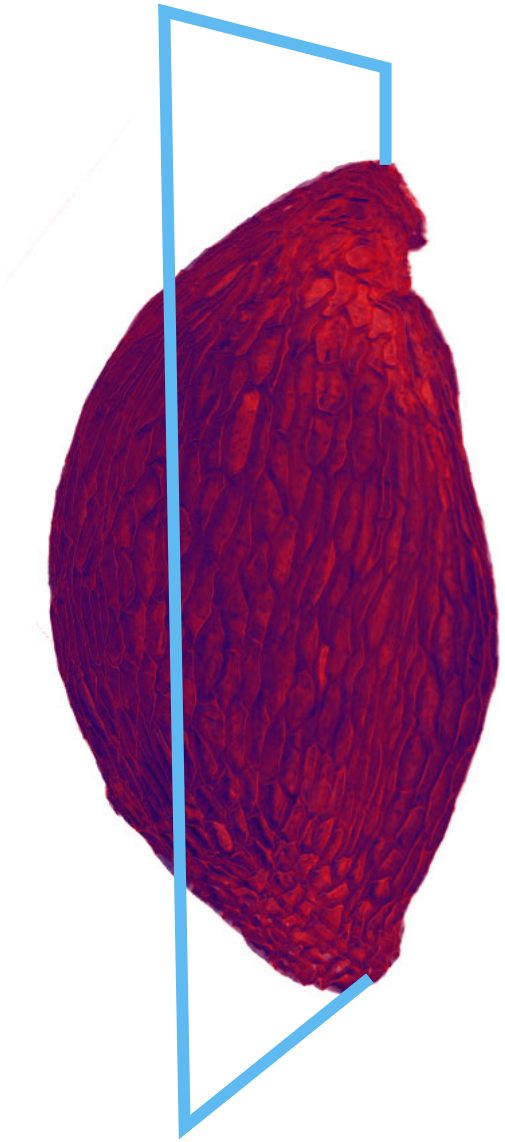

Cu 40 kV, no filter
8 keV
Relative X-ray intensity [a.u.]
120
100
3
2
1
0
0
20
40
60
80
100
120
X-ray energy [keV]

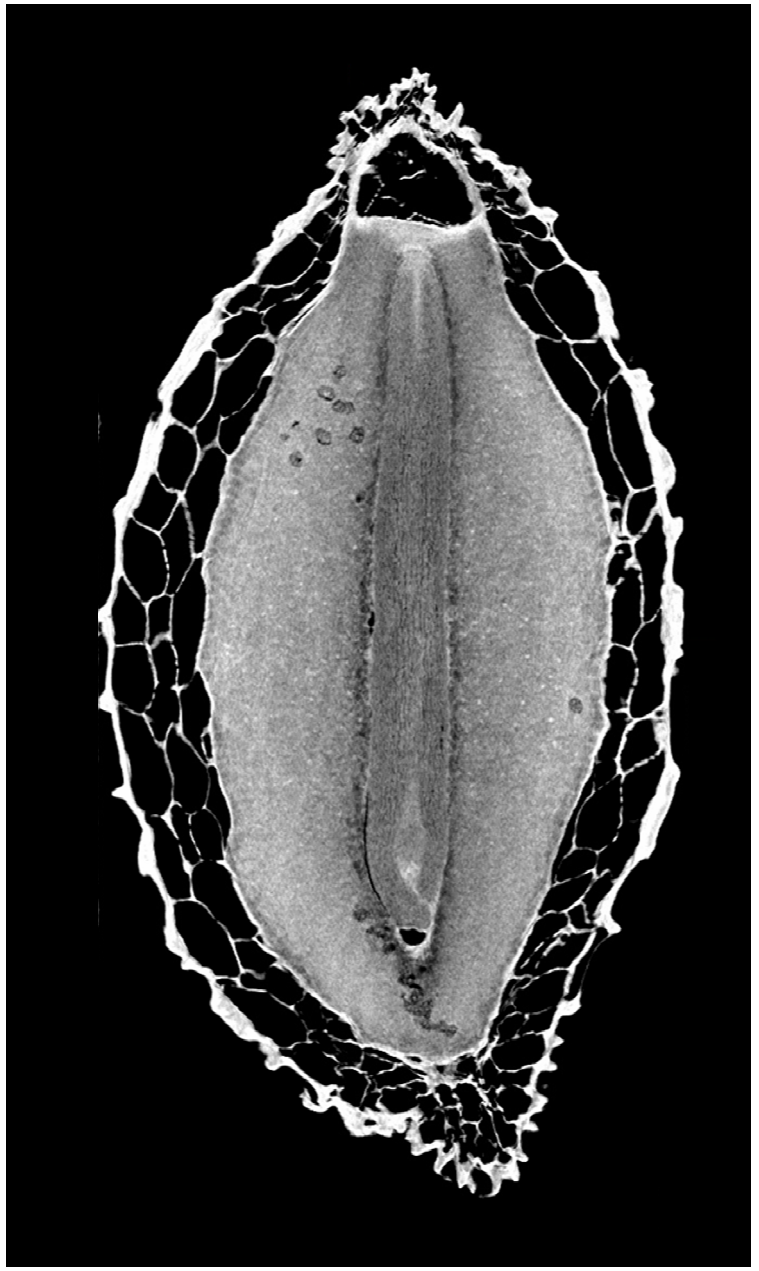
X-RAY ENERGY

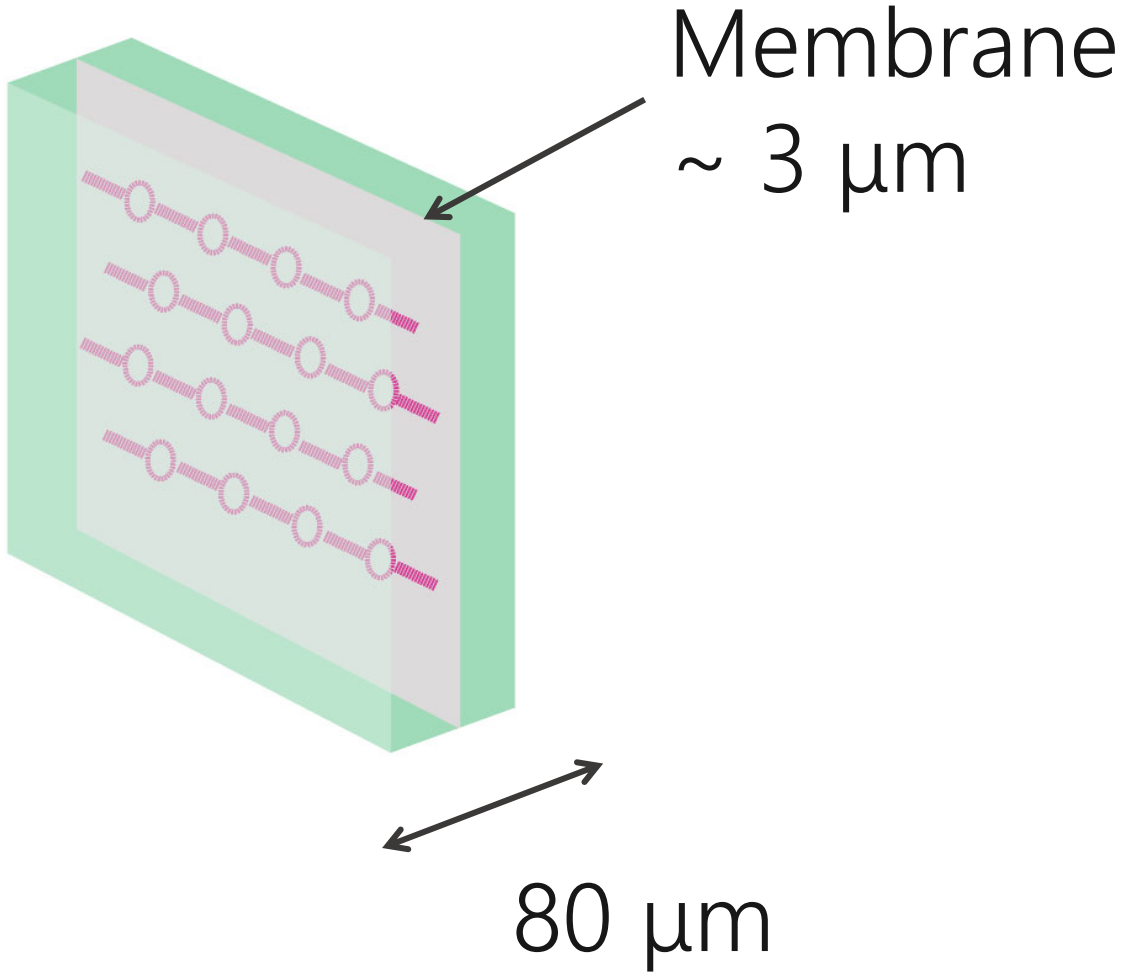
- Bremsstrahlung
- Characteristic

- X-ray target material
- Applied voltage
- Filter

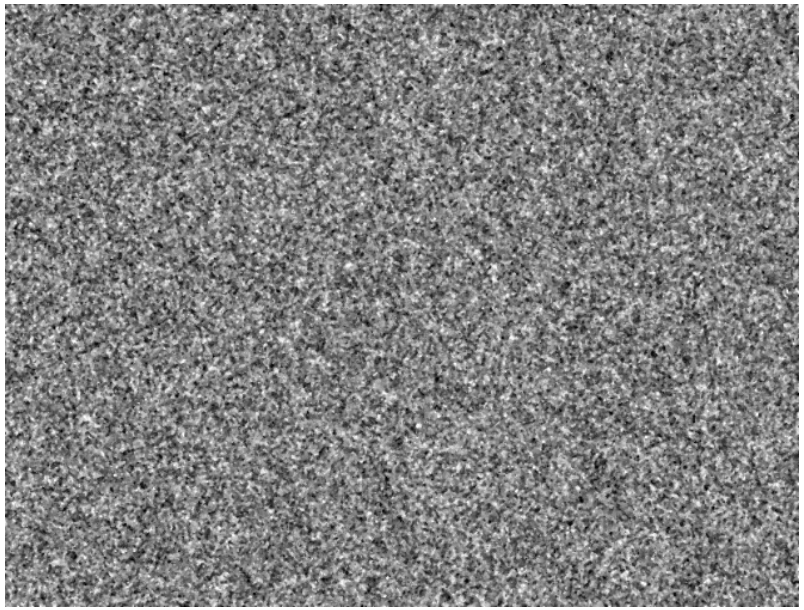




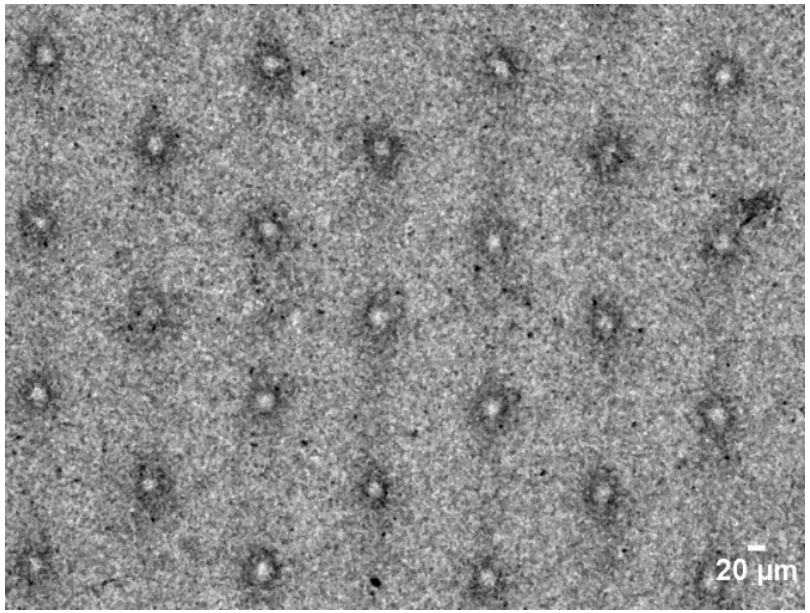


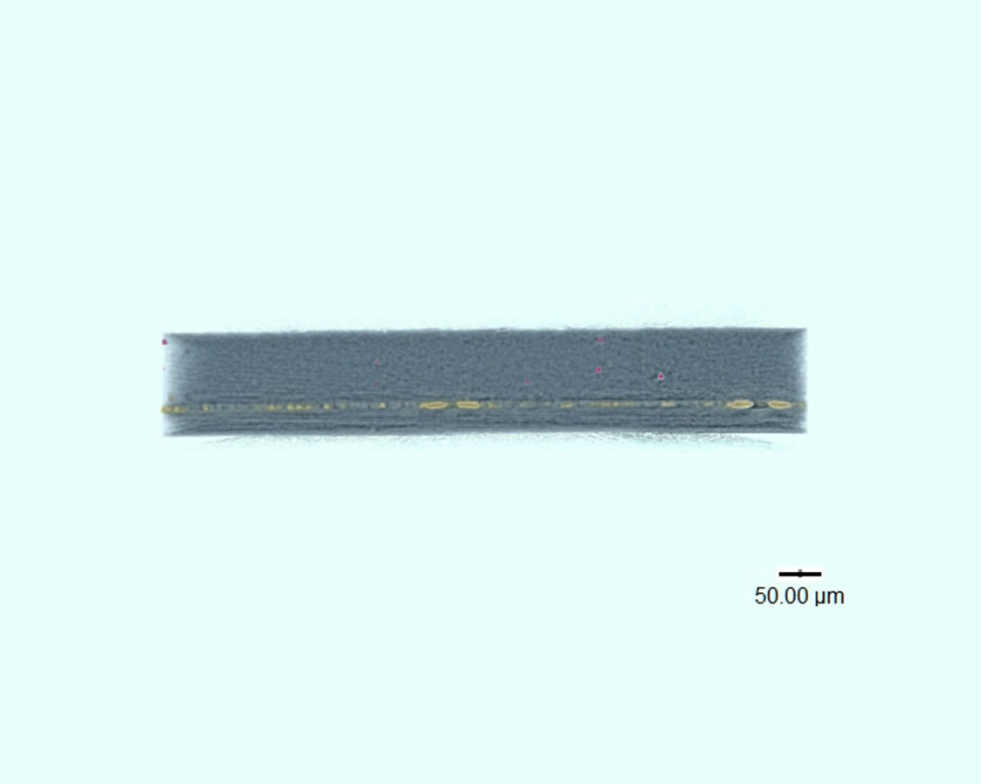

Membrane
~ 3 µm
80 µm

W bremsstrahlung
35 kV applied

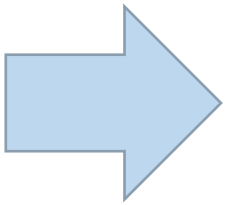


Cr characteristic
5.4 keV




50.00 µm

Low density
Small



Low energy
X-rays

W target → Lower kV
Less filter

Selectable target → Mo, Cu, Cr target

WHAT CAN WE DO WITH CT FOR FOOD APPLICATIONS?

FOOD APPLICATIONS

- Meat fat distribution
- Breading void/oil distribution
- Food coating thickness
- Freezing process
- Sprouted/infested kernels
- Phenotype classification

LET’S TAKE A LOOK AT SALAMI

THINGS TO CONSIDER

- Sample size
- Field of view (FOV)
- Resolution
- Geometry
- Sample direction
- X-ray energy

THINGS TO CONSIDER

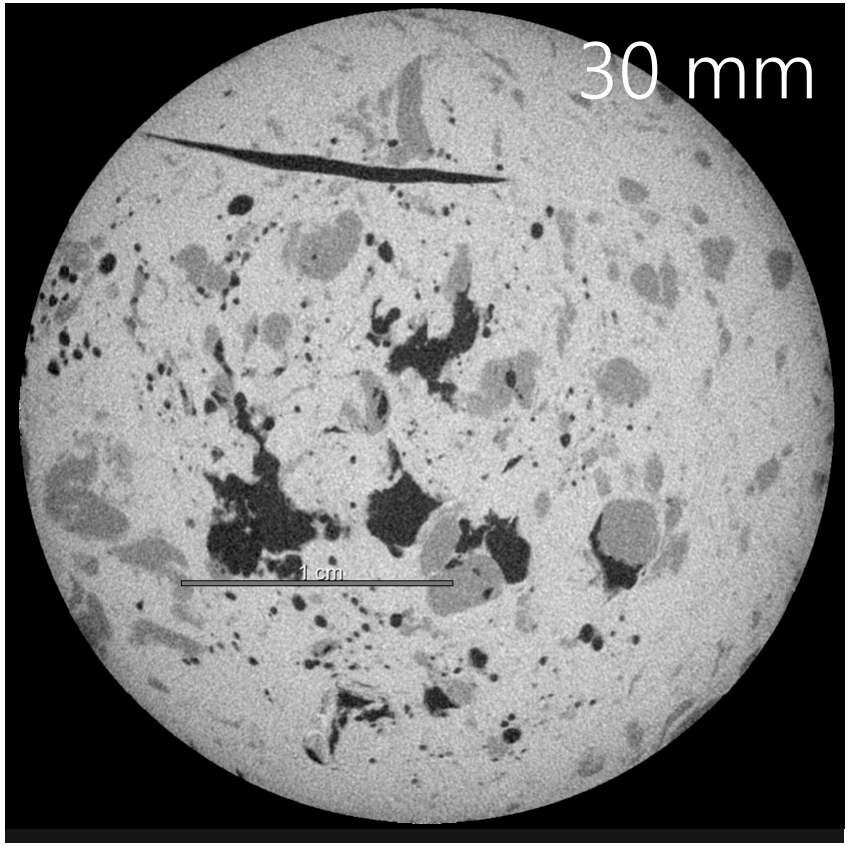
- Sample size
- Field of view (FOV)
- Resolution
- Geometry
- Sample direction
- X-ray energy

THINGS TO CONSIDER

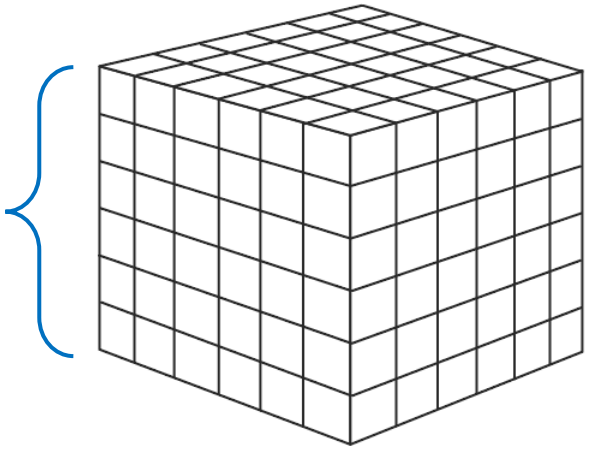
- Sample size
- Field of view (FOV)
- Resolution
- Geometry
- Sample direction
- X-ray energy ⇔ Intensity, time

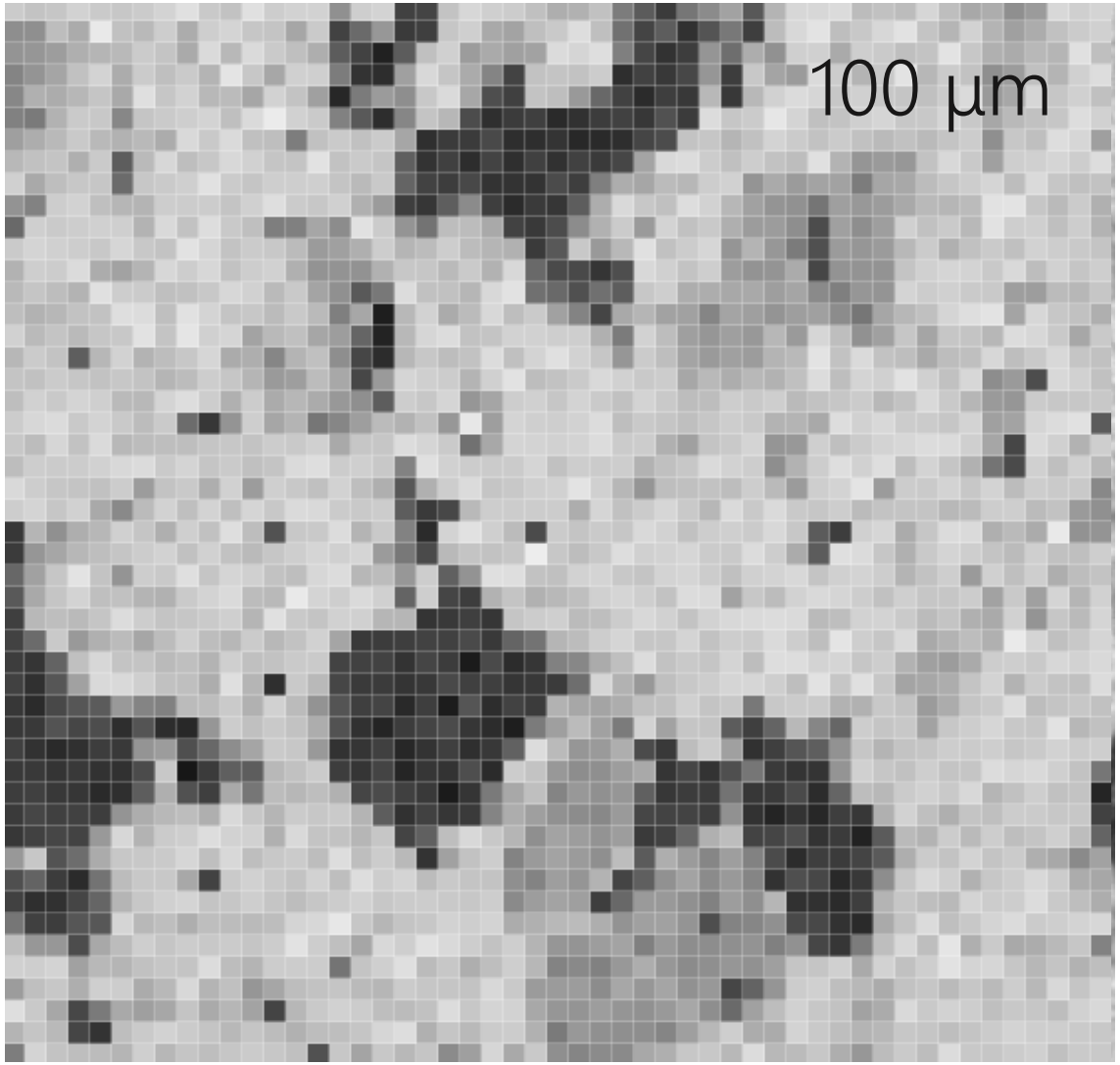
THINGS TO CONSIDER

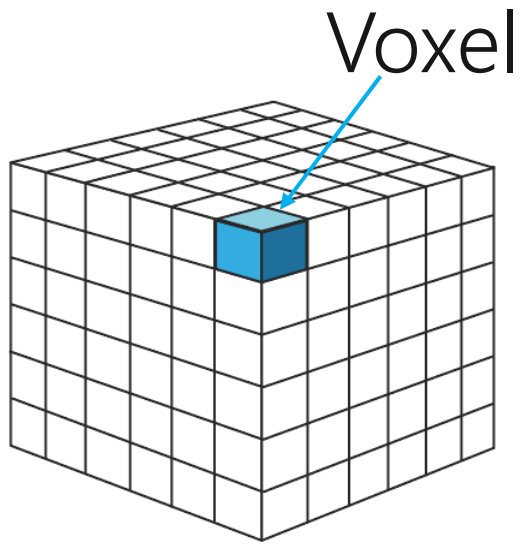
- Sample size
- Field of view (FOV)
- Resolution
- Geometry
- Sample direction
- X-ray energy



FOV



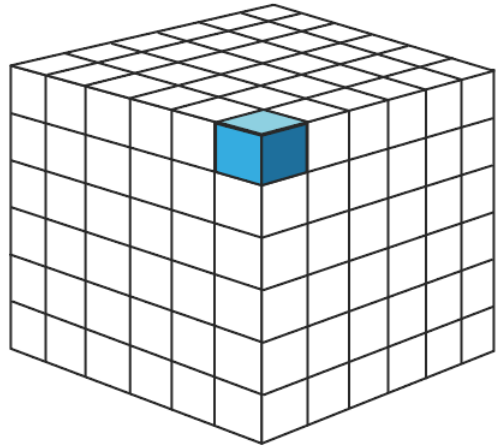

100 µm


Voxel

FOV: 30 mm

Voxel size: 30 µm

Cone beam geometry



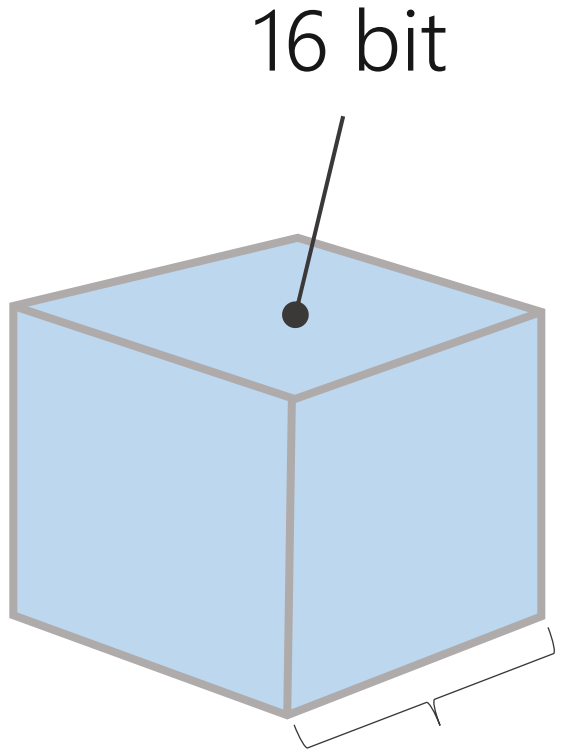
HOW BIG OF A FILE IS THIS GOING TO BE?

$X = 30\ mm / 30\ \mu m = 1 \times 10^3$

File Size $= X^3 \cdot 16$ [bits]

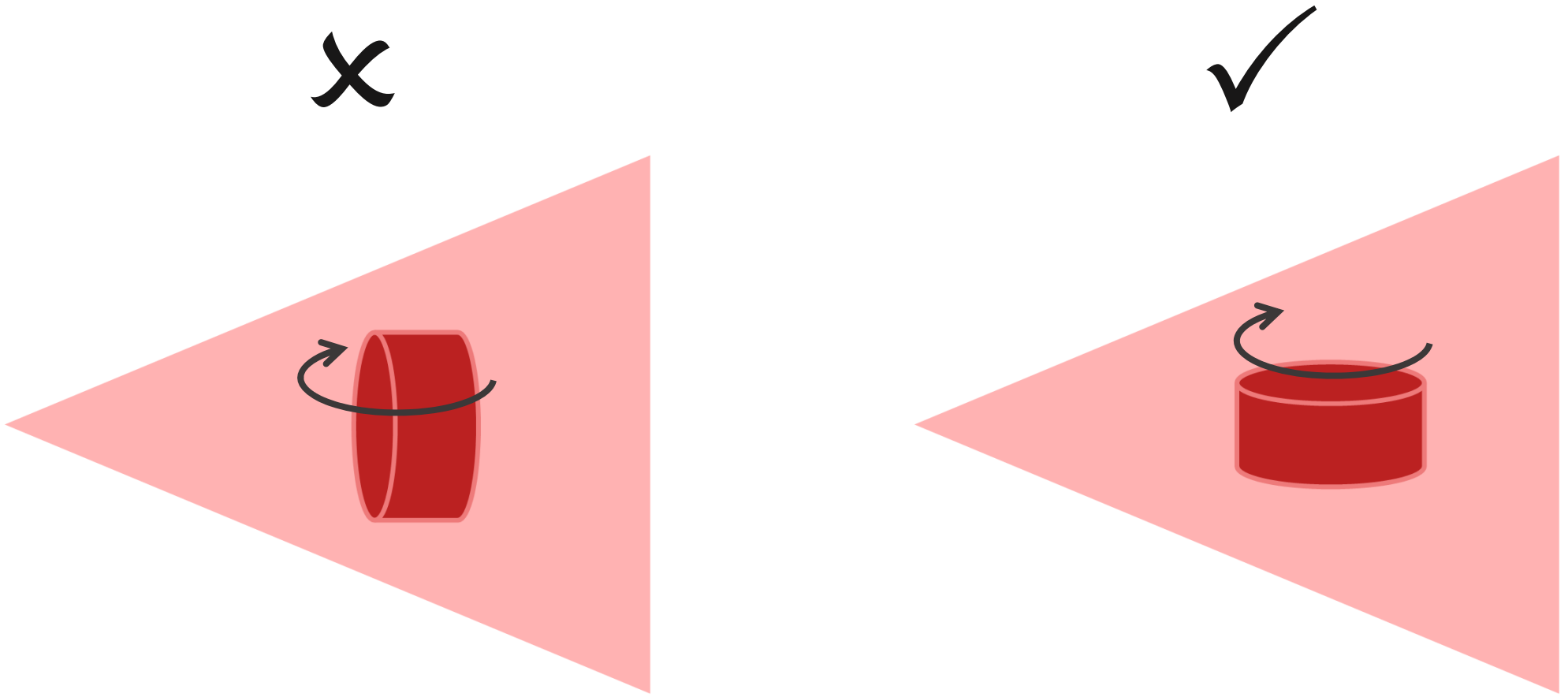
$= 16 \times 10^9 / 8$ [bytes]

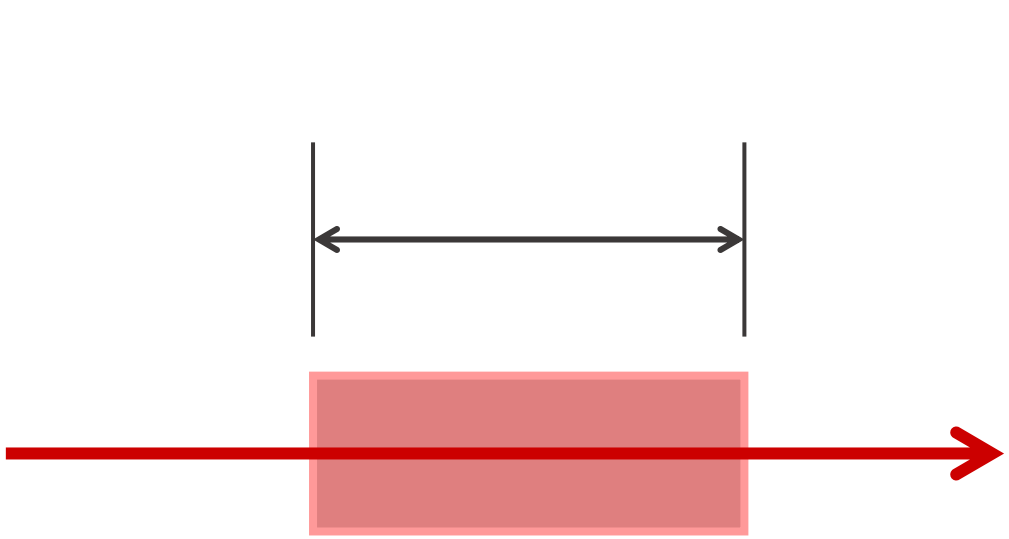
$= 2$ GB



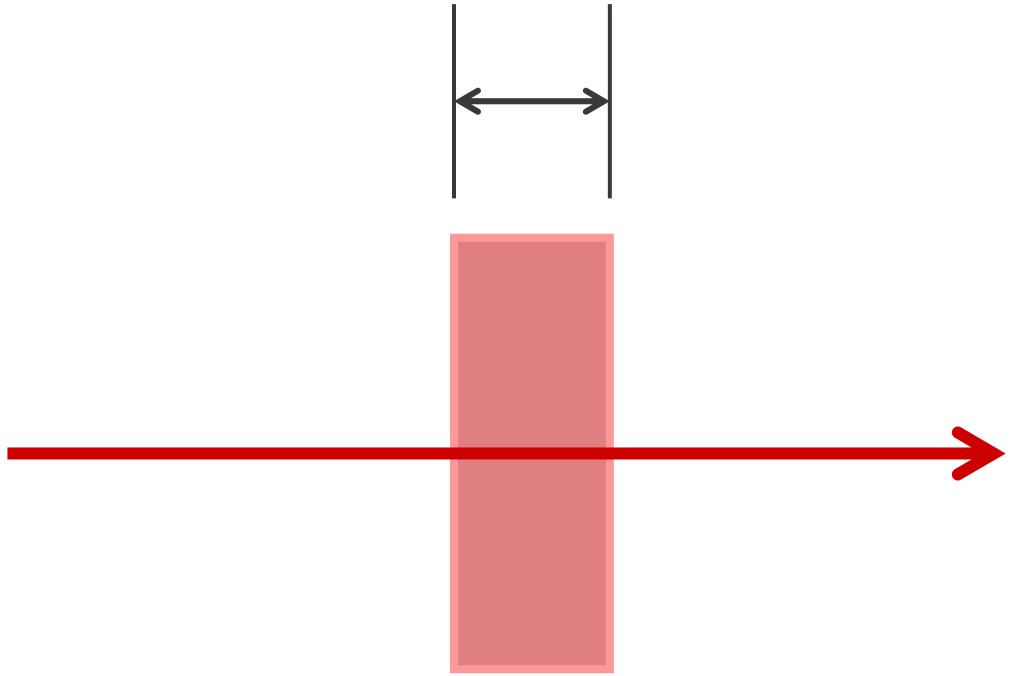
THINGS TO CONSIDER

- Sample size
- Field of view (FOV)
- Resolution
- Geometry
- Sample direction
- X-ray energy

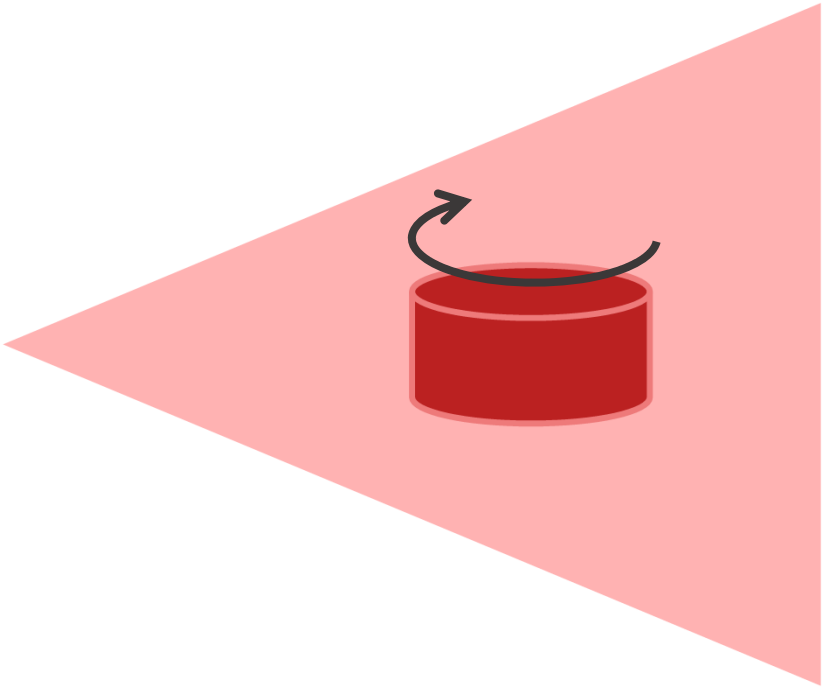


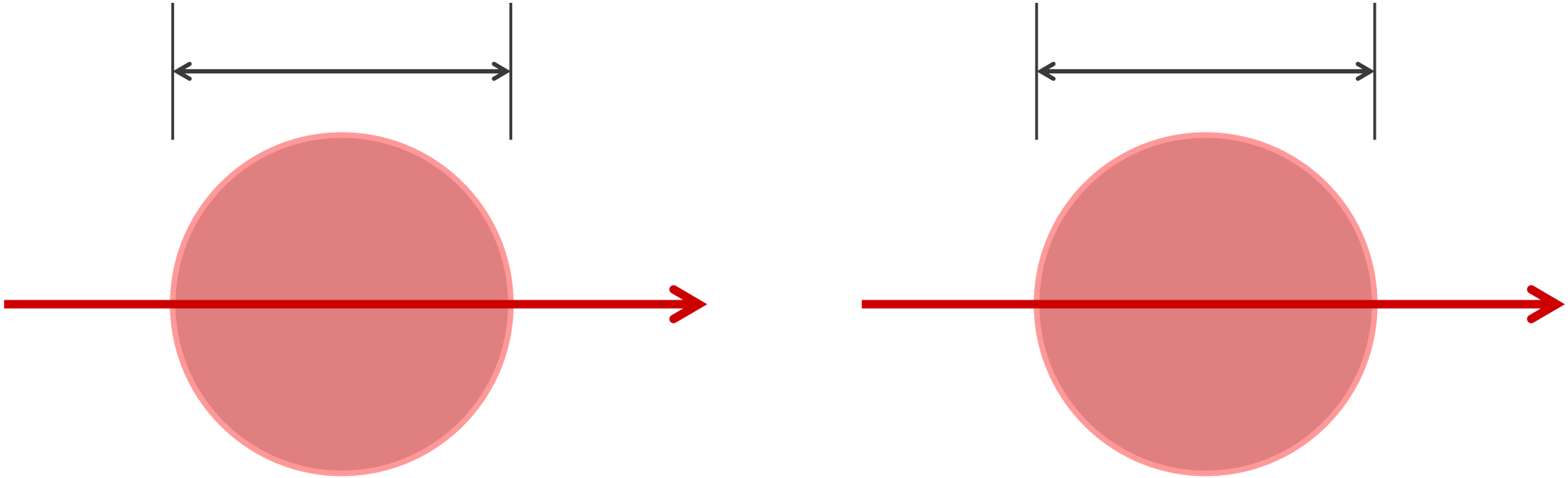


0 °



90 °





0 °

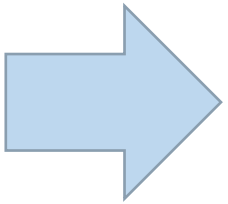
90 °

Direction with least variable thickness (LVT)

THINGS TO CONSIDER

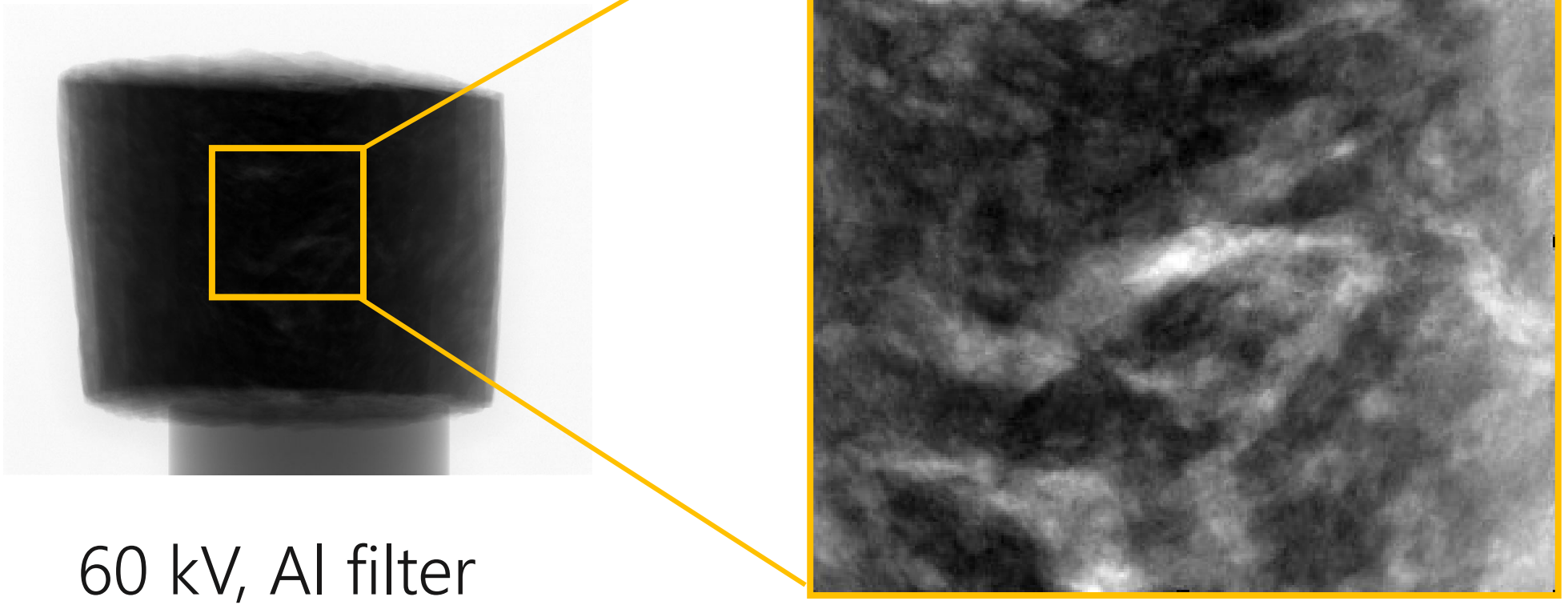
- Sample size
- Field of view (FOV)
- Resolution
- Geometry
- Sample direction
- X-ray energy

W target

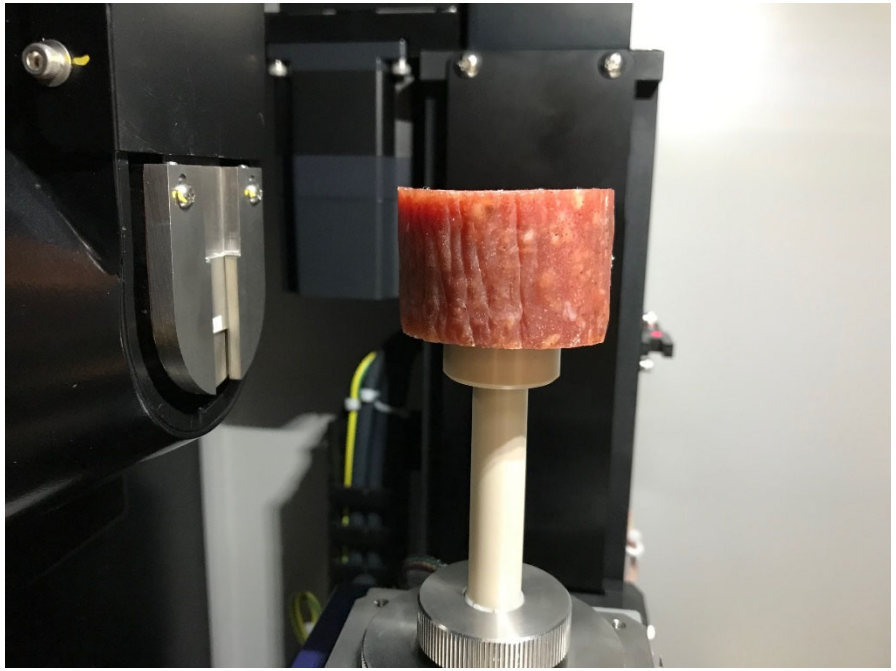


Lower kV
Less filter

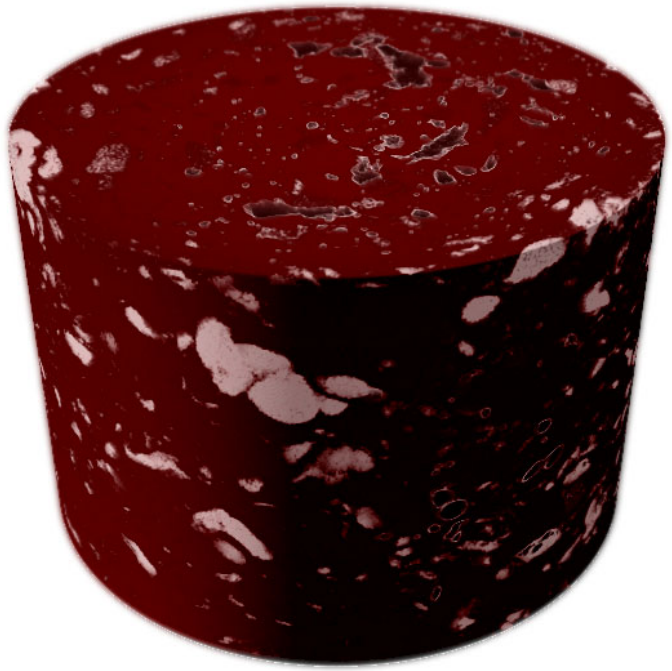
Selectable target

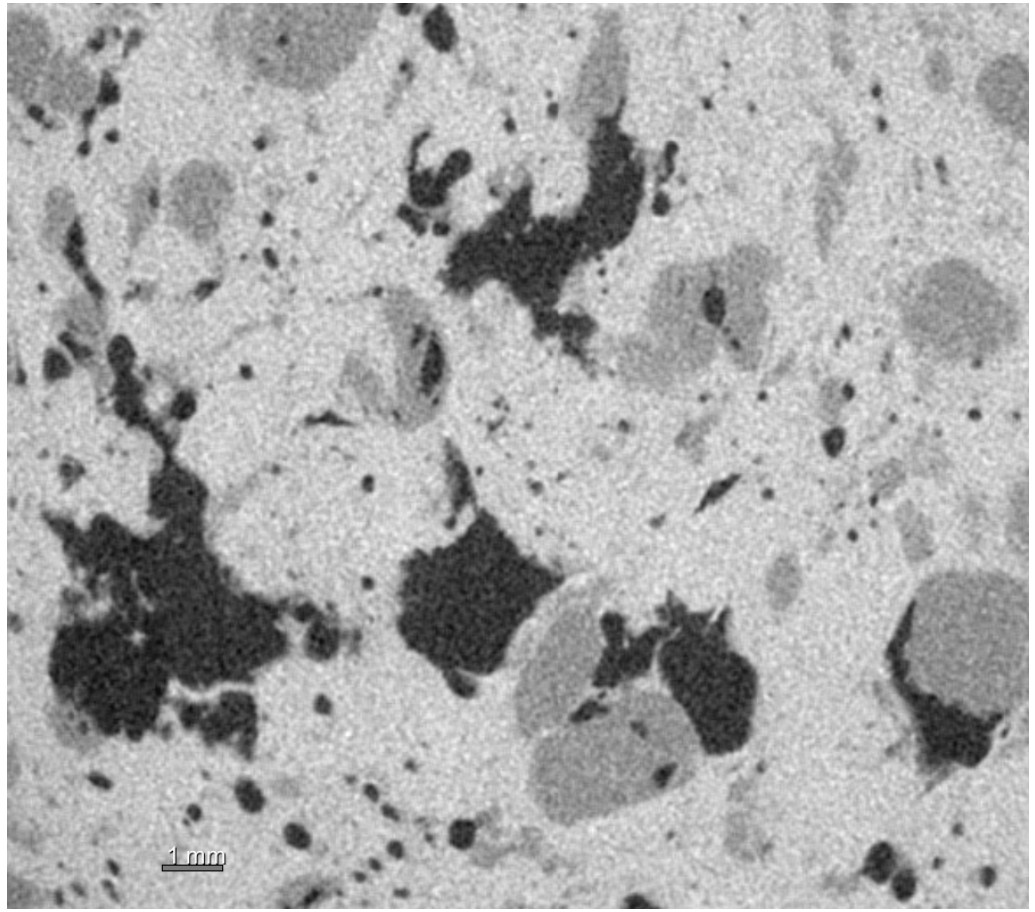


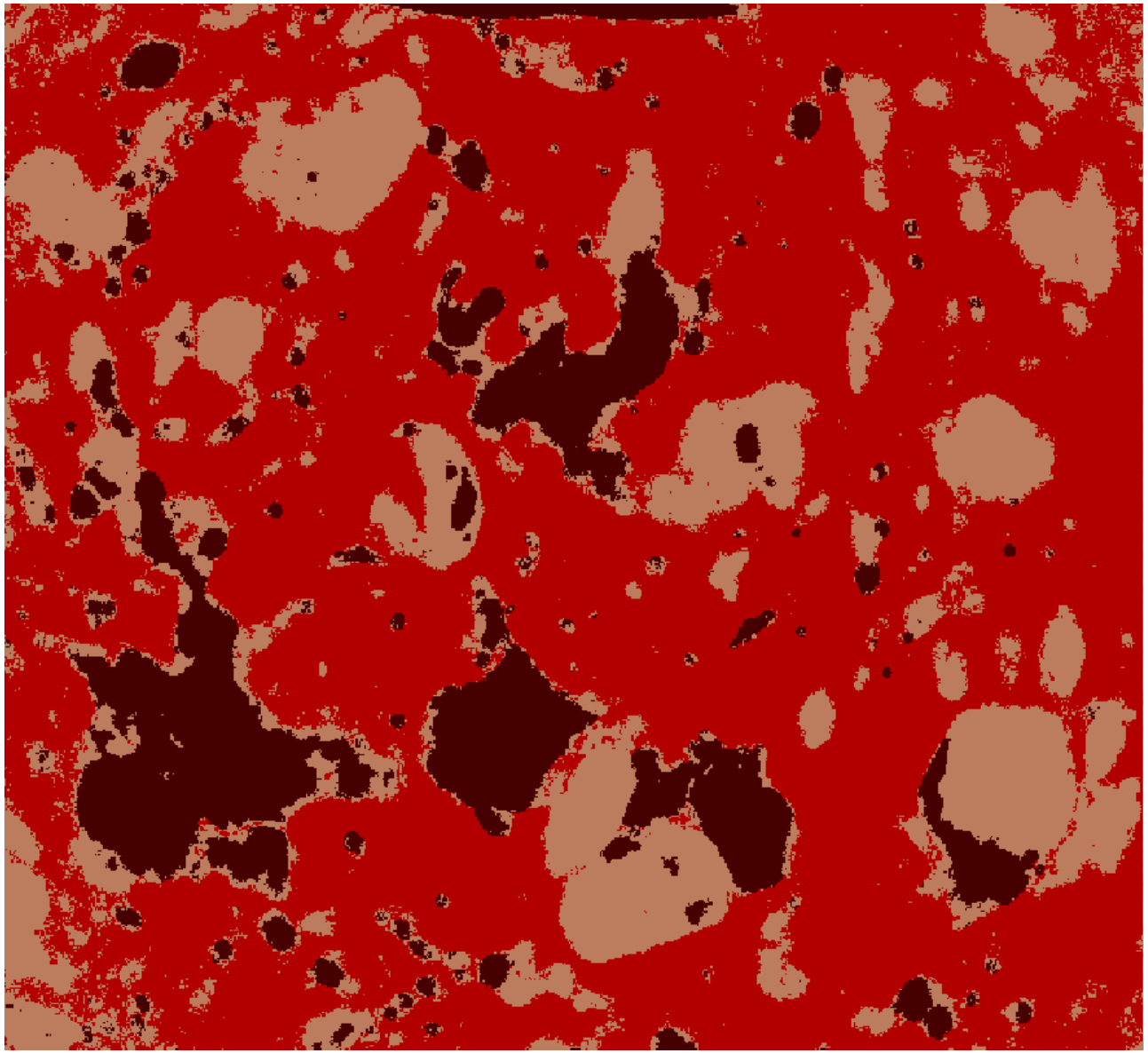
60 kV, Al filter

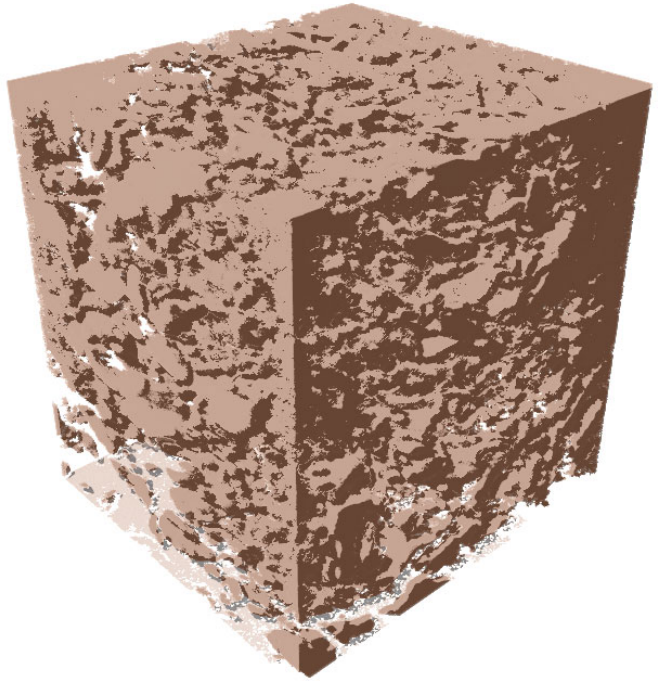


- Sample size: ~ 40 mm
- FOV: 30 mm
- Resolution: 30 µm
- Geometry: Cone
- Sample direction: LVT
- X-ray energy: 60 kV, Al filter

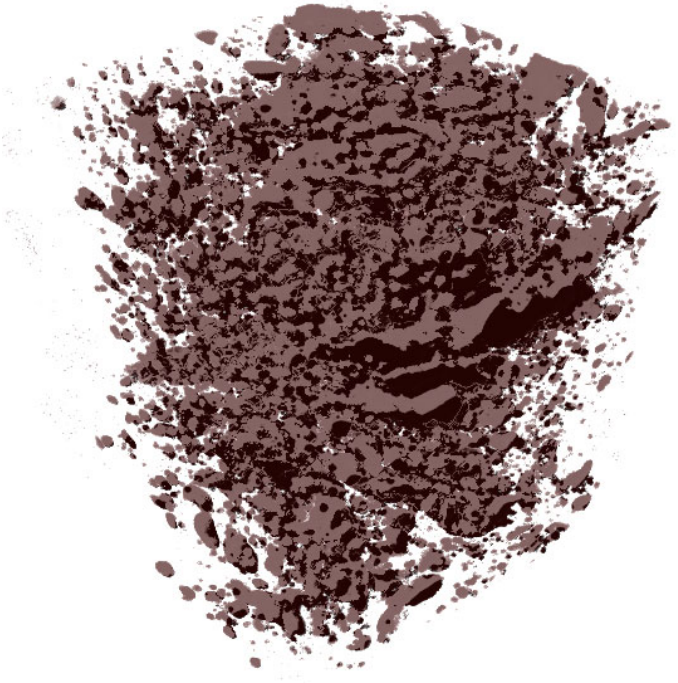



1 mm

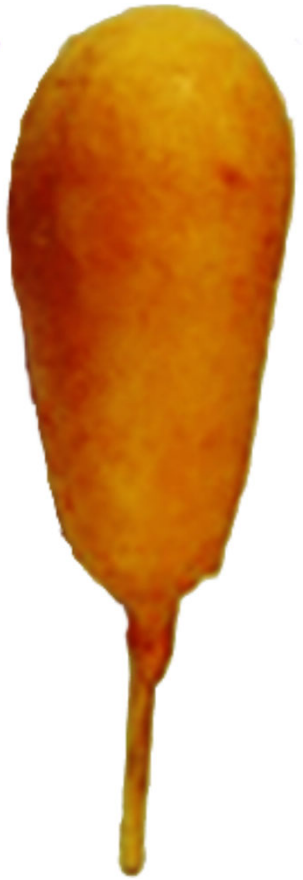




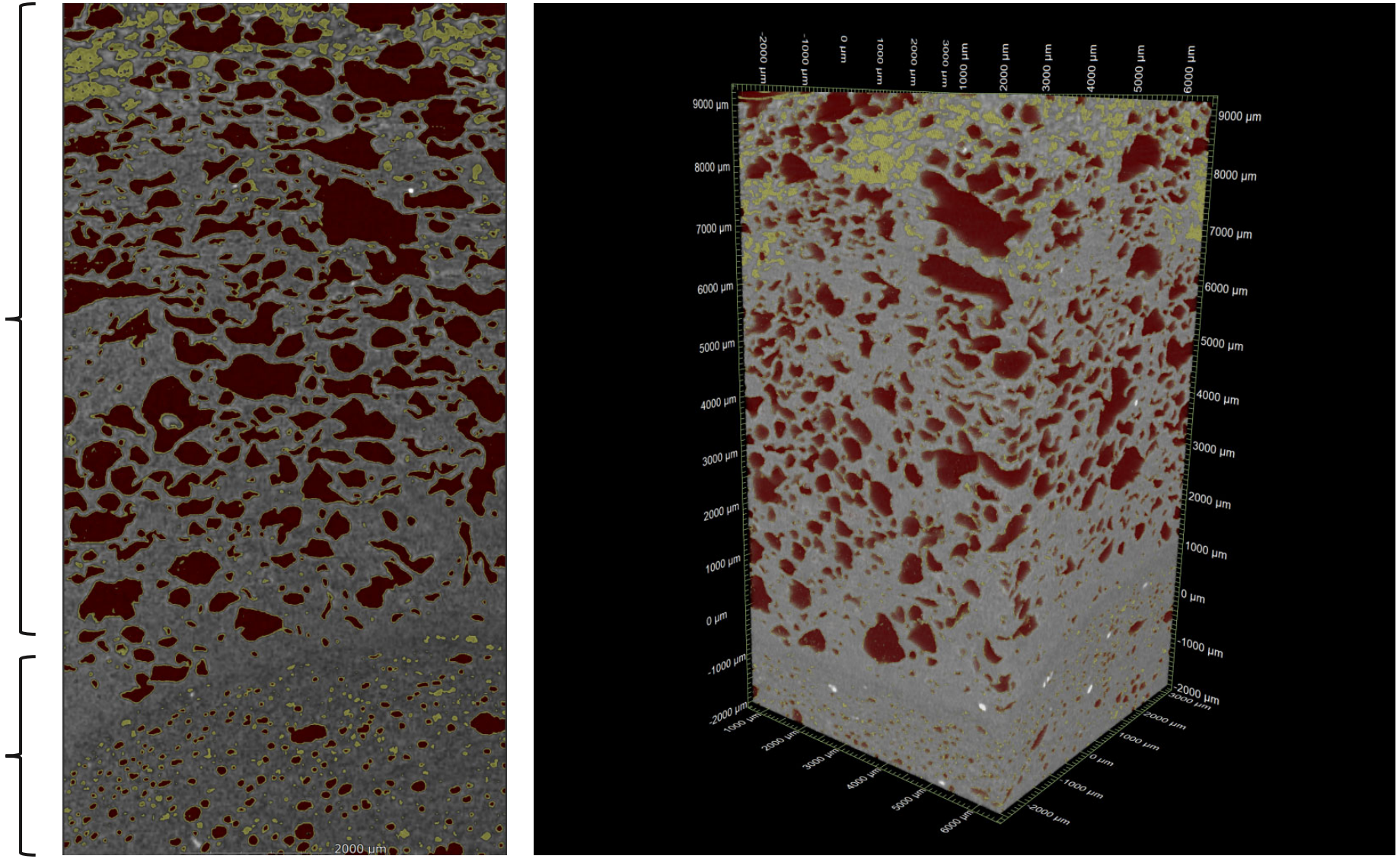
Fat 17.9 vol%

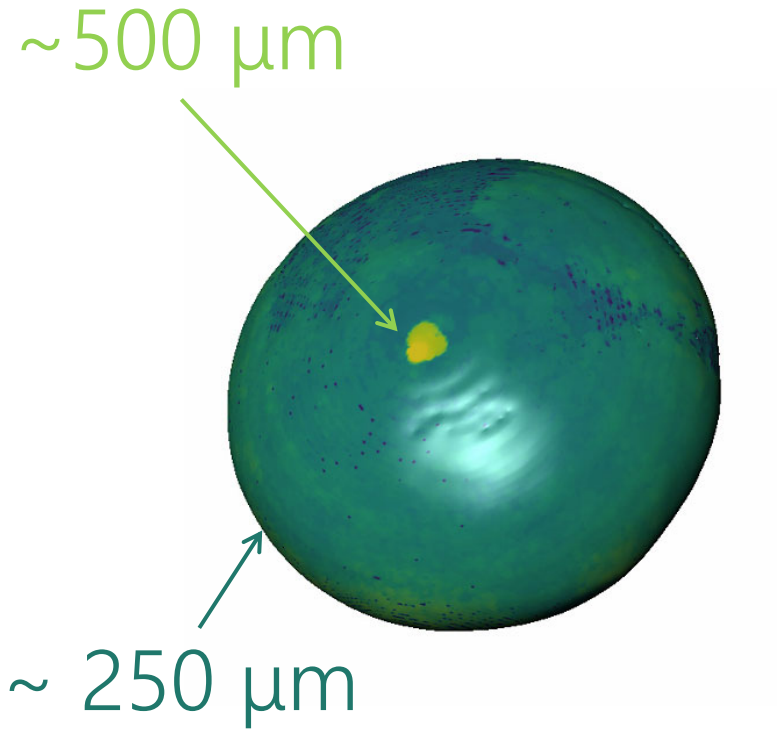


Voids 9.2 vol%

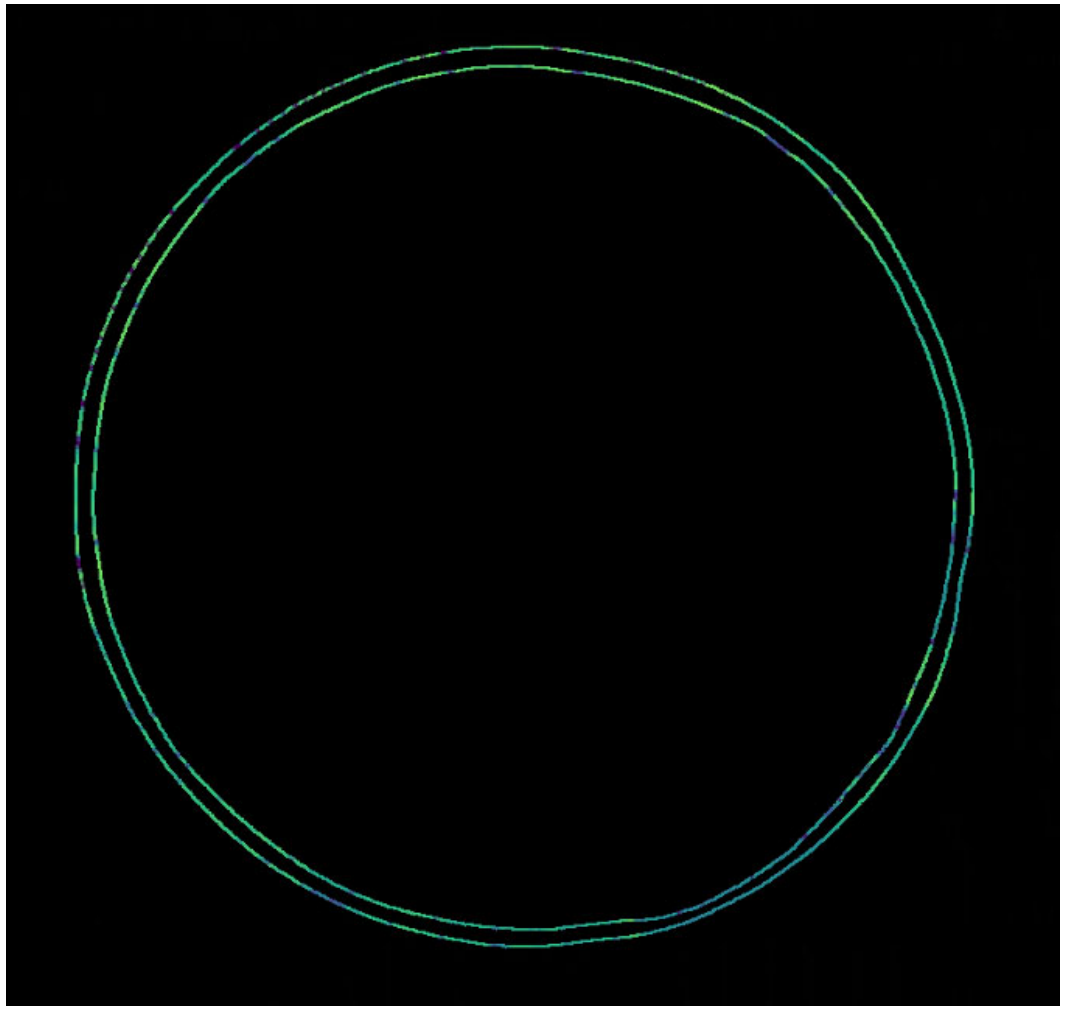


Corndog

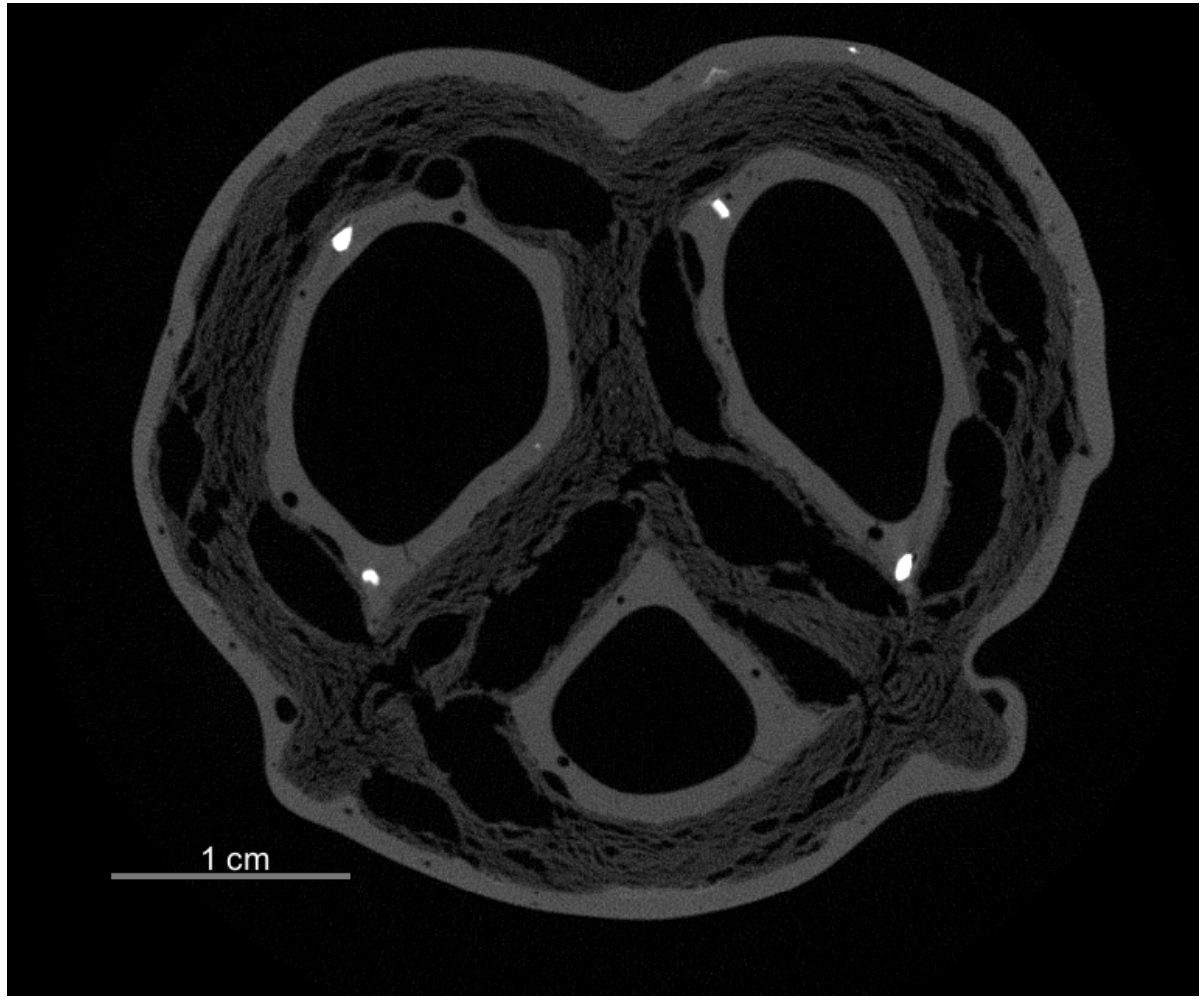

2000 µm
-2000 µm
-1000 µm
0 µm
1000 µm
2000 µm
3000 µm
4000 µm
5000 µm
6000 µm
9000 µm
8000 µm
7000 µm
6000 µm
5000 µm
4000 µm
3000 µm
2000 µm
1000 µm
0 µm
-1000 µm
-2000 µm



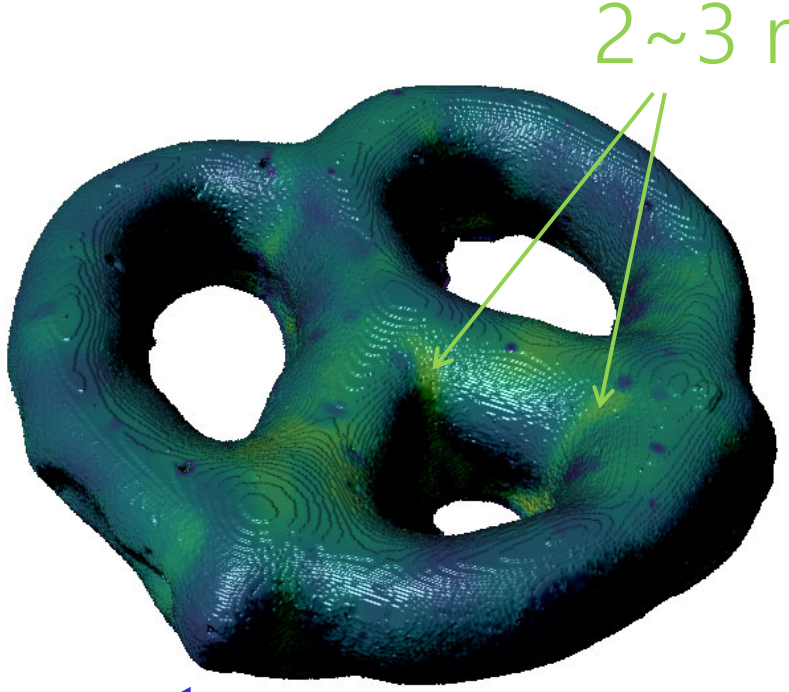
Chocolate candy

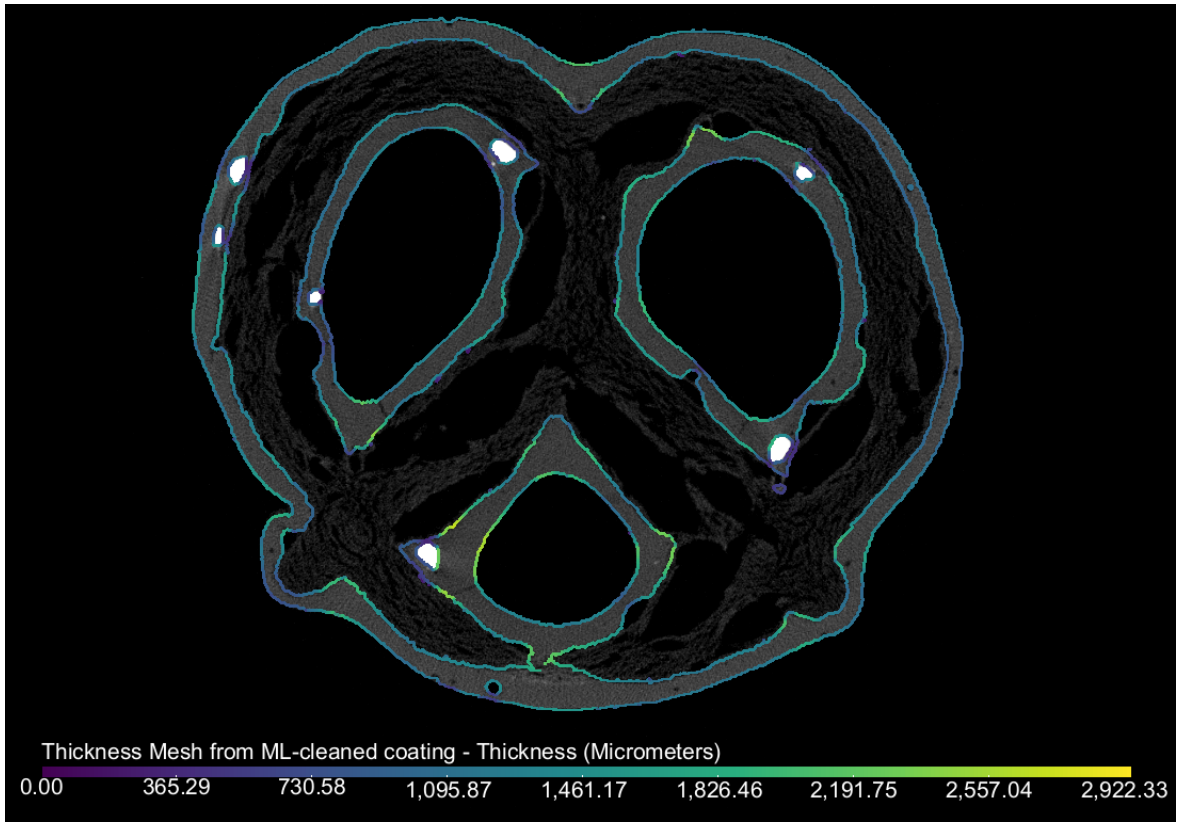


Yogurt coated pretzel



Salt grain distribution

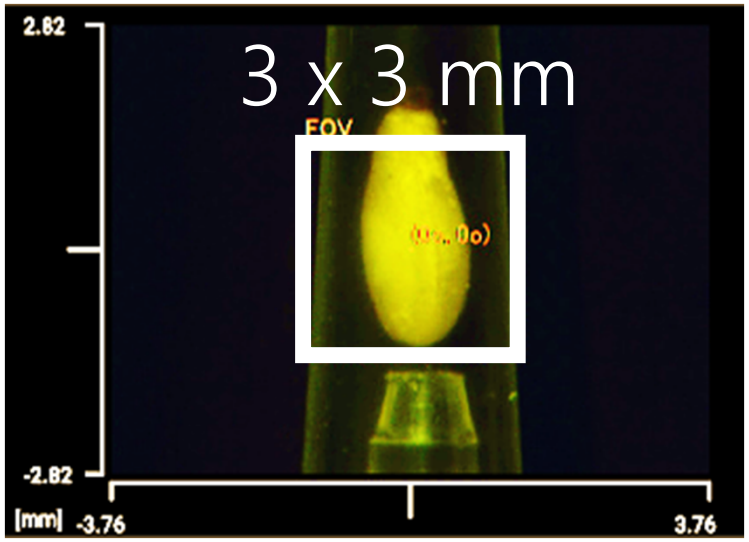




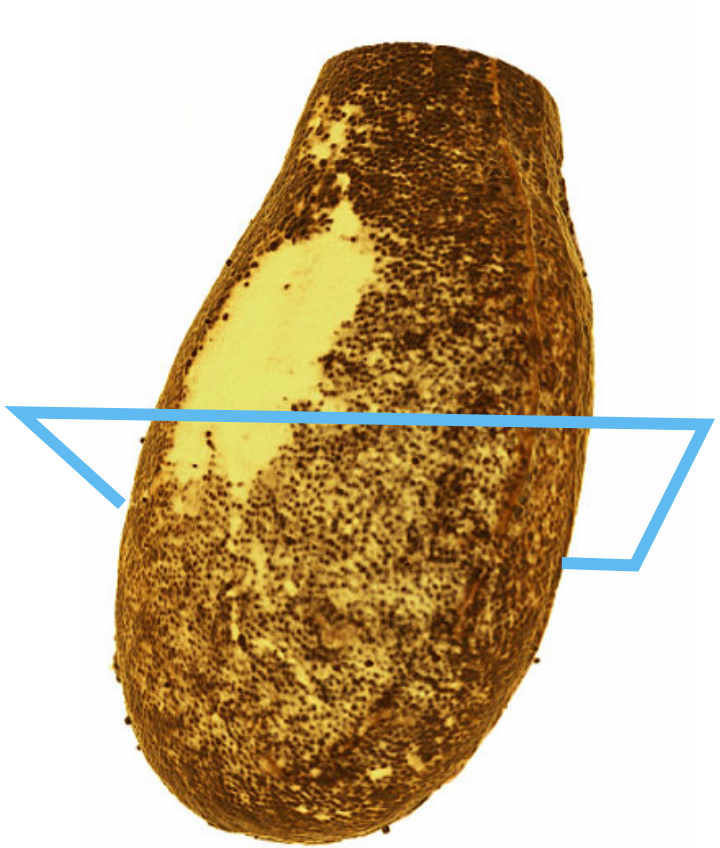
Thickness max 2.9 mm, mean 1.3 mm

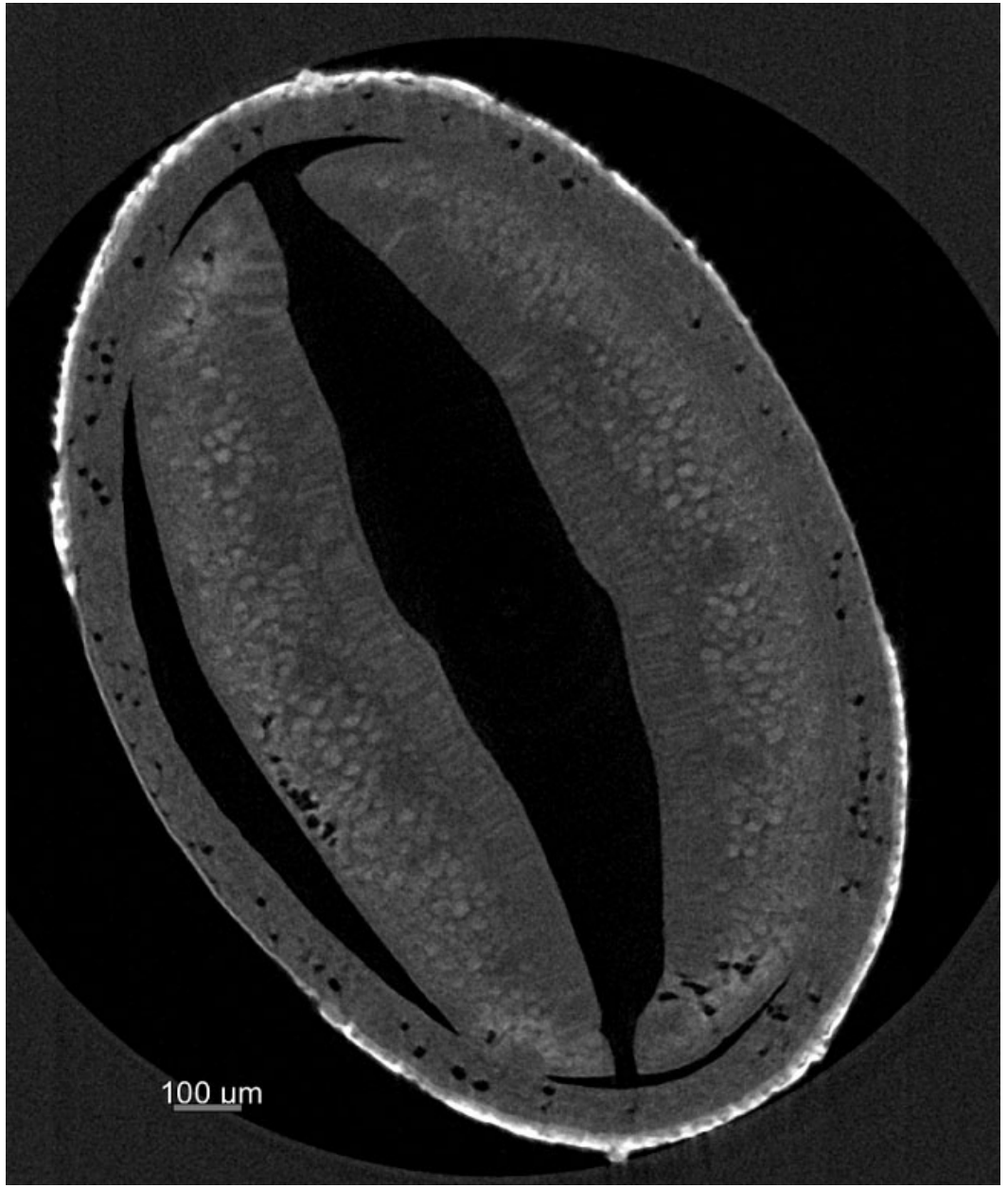
WHAT IF YOUR SAMPLE IS TINY?

- Sample size: < 5 mm
- FOV: < 5 mm
- Resolution: 0.3 ~ 2 µm
- Geometry: Parallel
- Sample direction: LVT
- X-ray energy: 5 ~ 8 keV



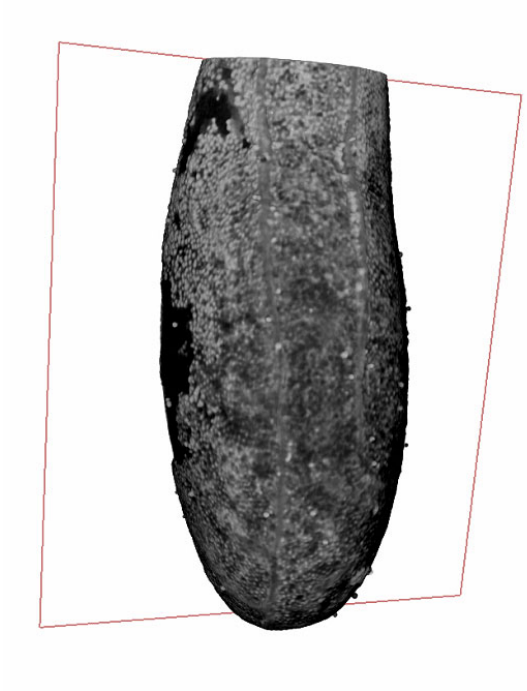
- Sample size: < 5 mm
- FOV: 3 mm
- Resolution: 1.3 µm
- Geometry: Parallel
- Sample direction: LVT
- X-ray energy: 8 keV

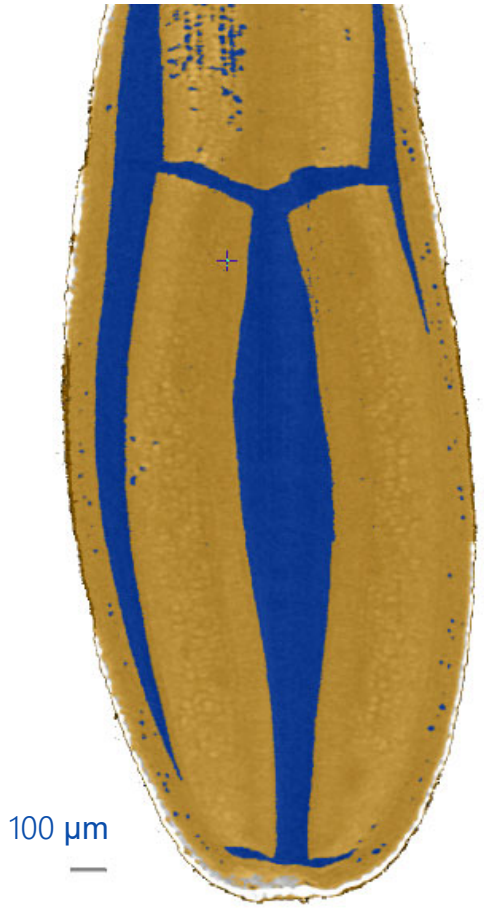


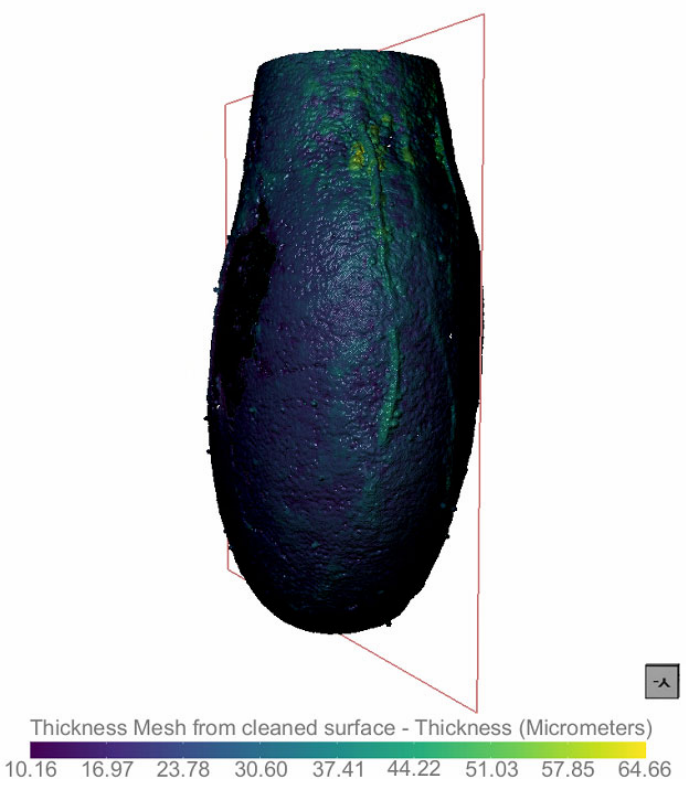

100 µm

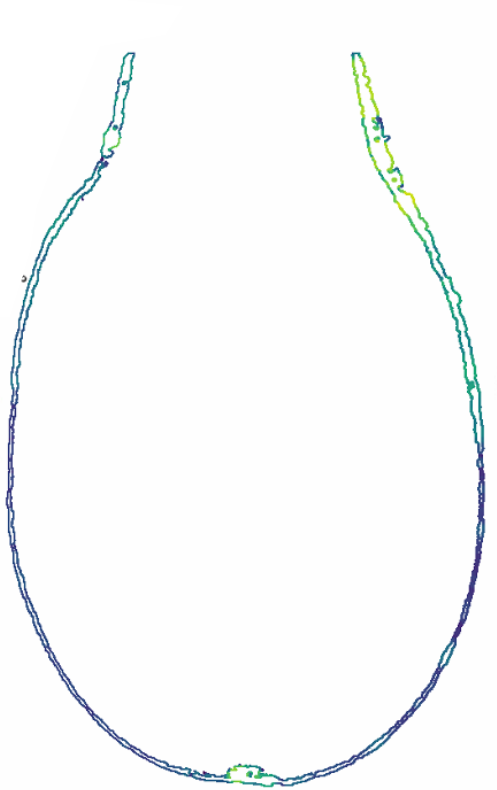
Solid part: 79.0 %

Voids: 21.0 %






Thickness Mesh from cleaned surface - Thickness (Micrometers)
10.16 16.97 23.78 30.60 37.41 44.22 51.03 57.85 64.66



Sesame A
Thin skin, large voids

Sesame B
Thick skin, small voids

FOOD APPLICATIONS

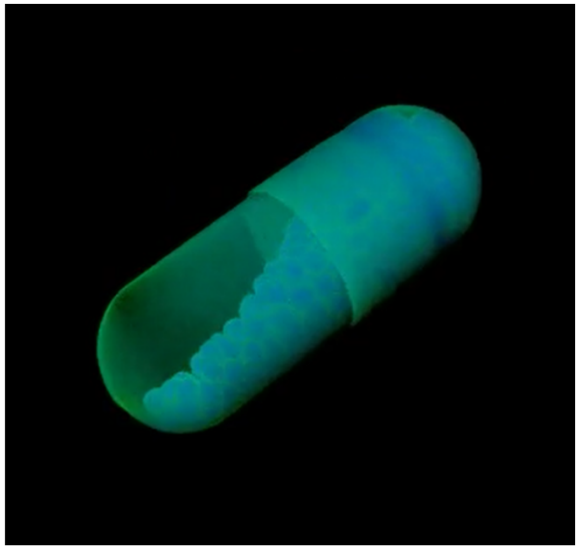
- Meat fat distribution
- Breading void/oil distribution
- Food coating thickness
- Freezing process
- Sprouted/infested kernels
- Phenotype classification

WHAT CAN WE DO WITH CT FOR PHARMACEUTICAL APPLICATIONS?

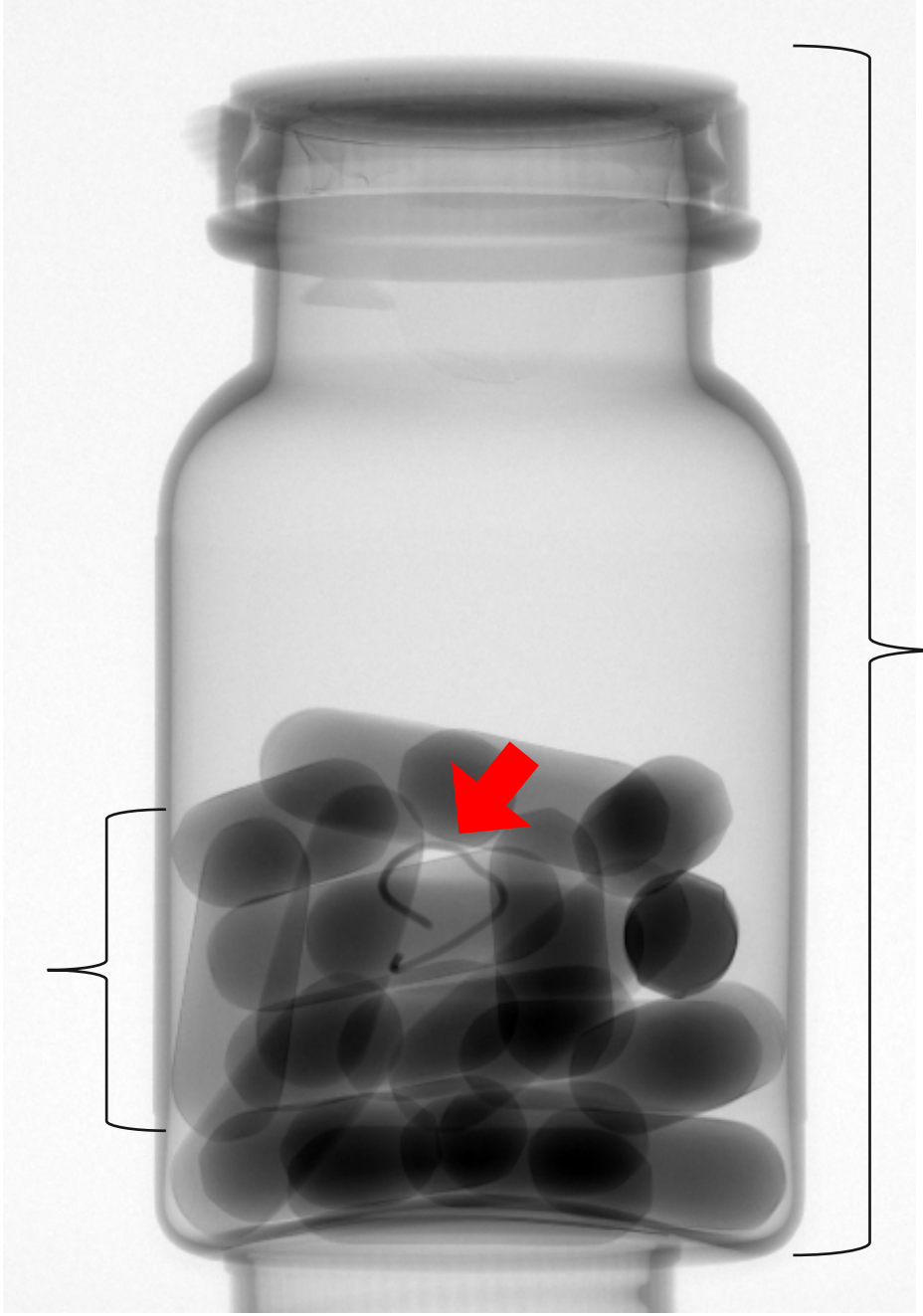
PHARMA APPLICATIONS

- Cracks
- Aggregates
- Coatings
- Crystallization process
- Dissolution process
- Contamination

CAN YOU SEE A WHOLE BOTTLE?



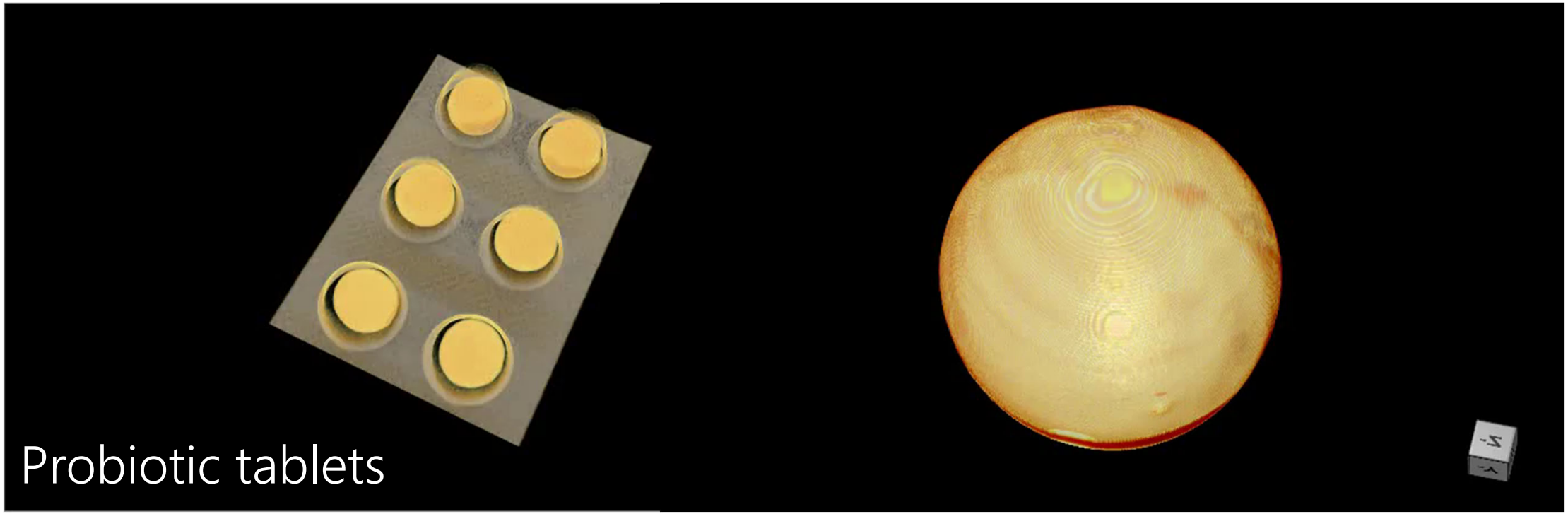
W 60 kV
FOV 25 mm
Cone beam



W 90 kV
FOV 107 mm
Cone beam

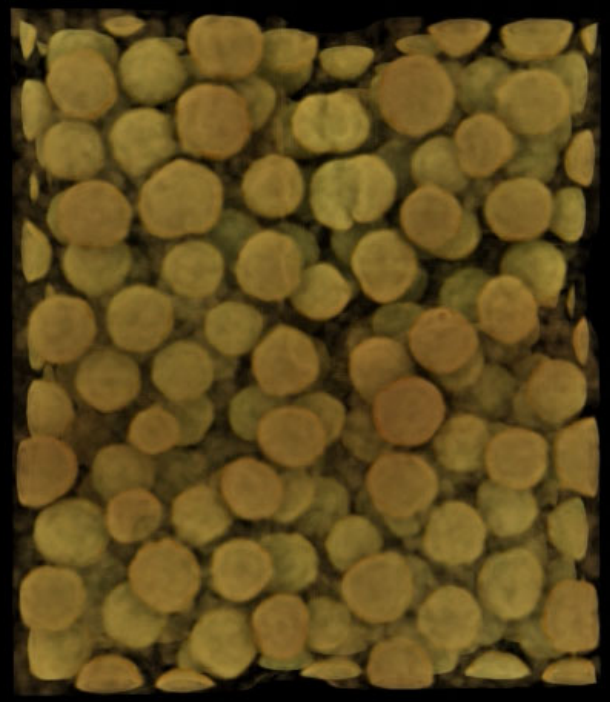
Whole package
W 60 kV, 25 mm FOV

Single capsule
Cu 8 keV, 7 mm FOV

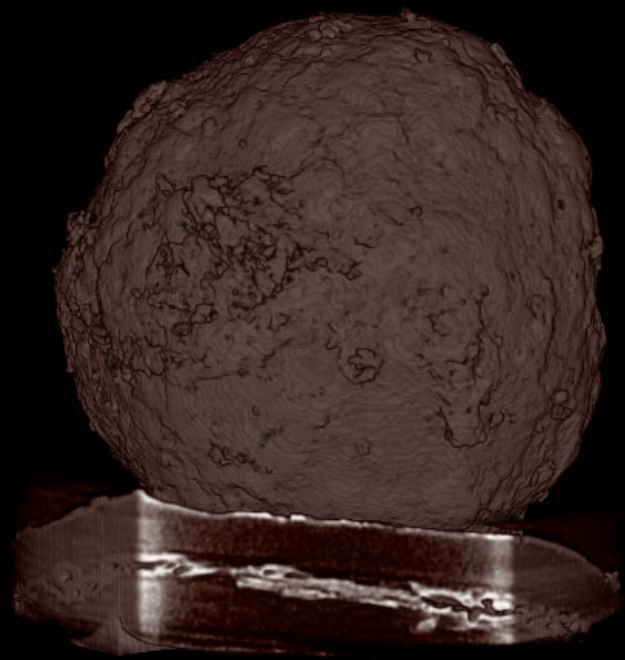


Whole tablet
Mo 17.5 keV, 10 mm FOV

Single particle
Cr 5.4 keV, 0.7 mm FOV

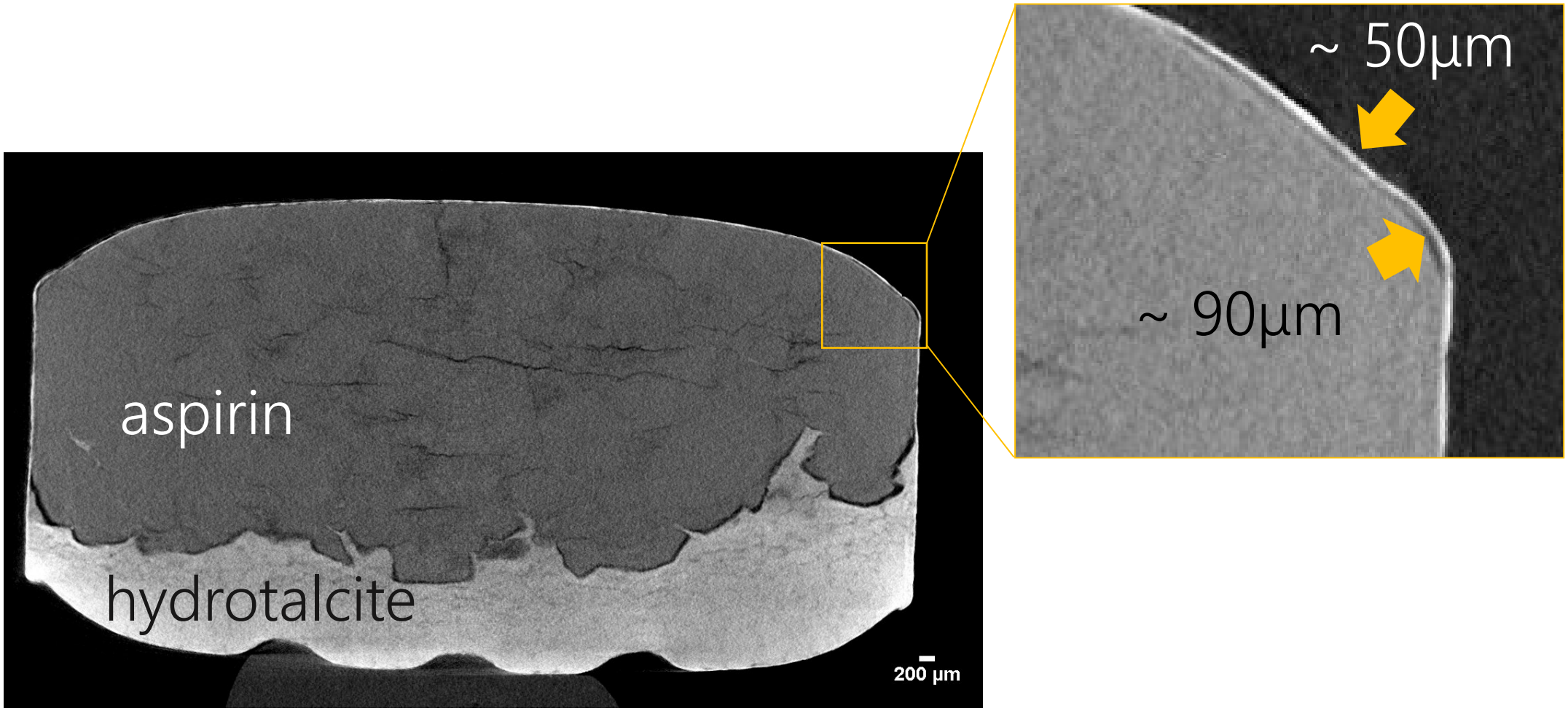


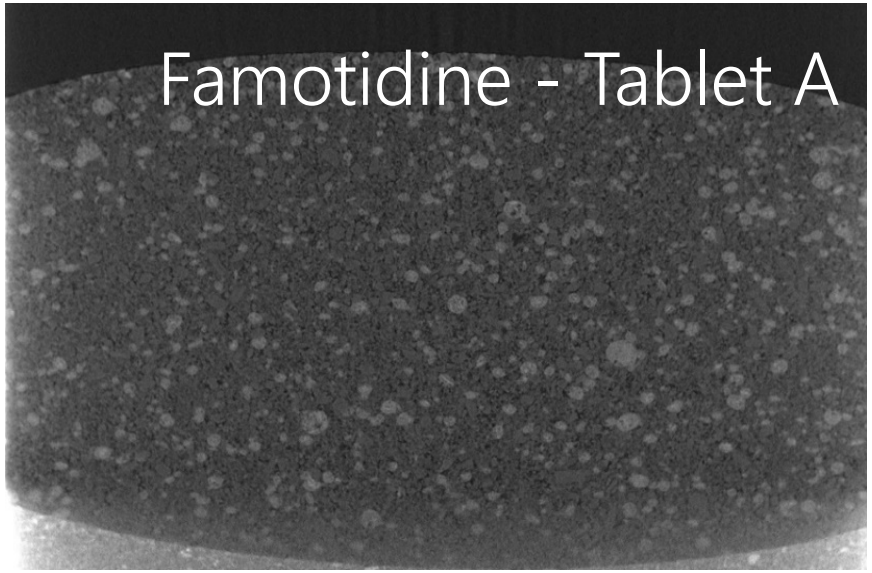
Orally disintegrating tablet

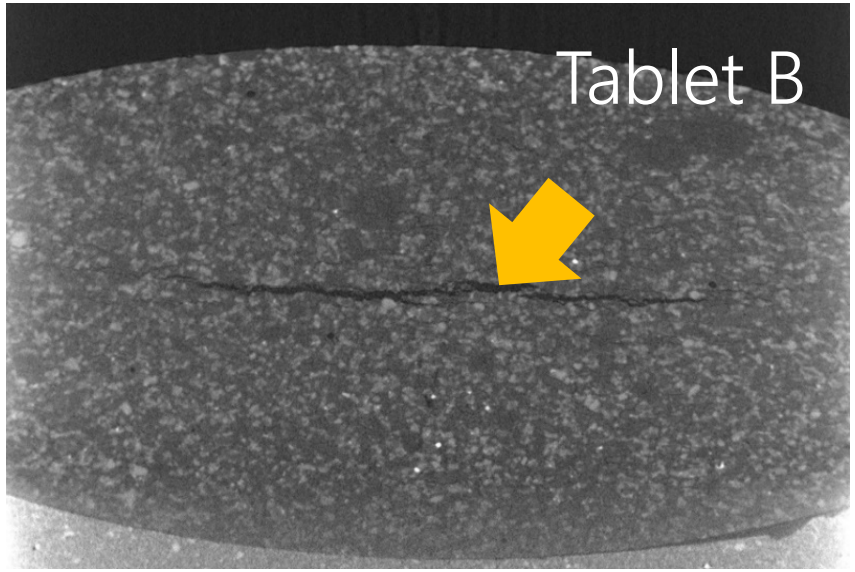


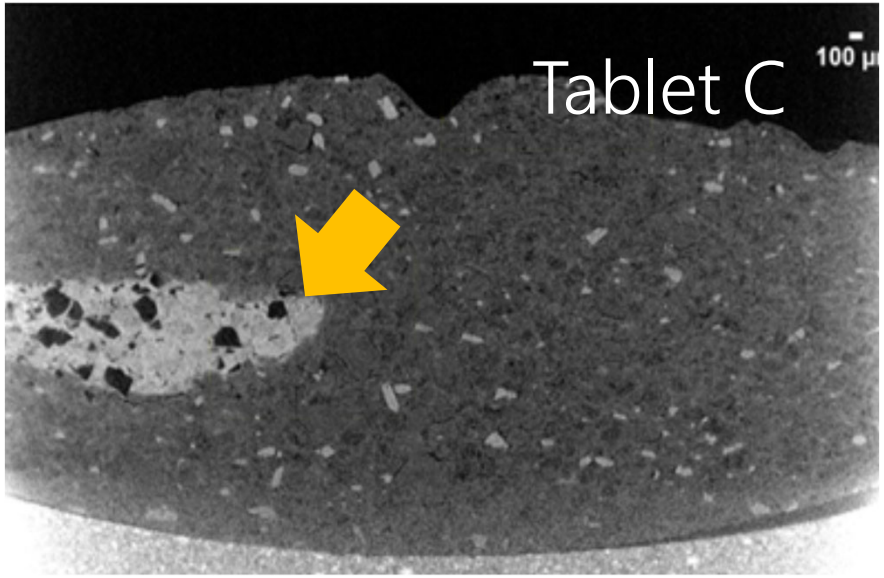
Particle with enteric coating

LET'S LOOK AT A FEW TABLETS


aspirin
hydrotalcite
200 µm
~ 50µm
~ 90µm


Famotidine - Tablet A


Tablet B

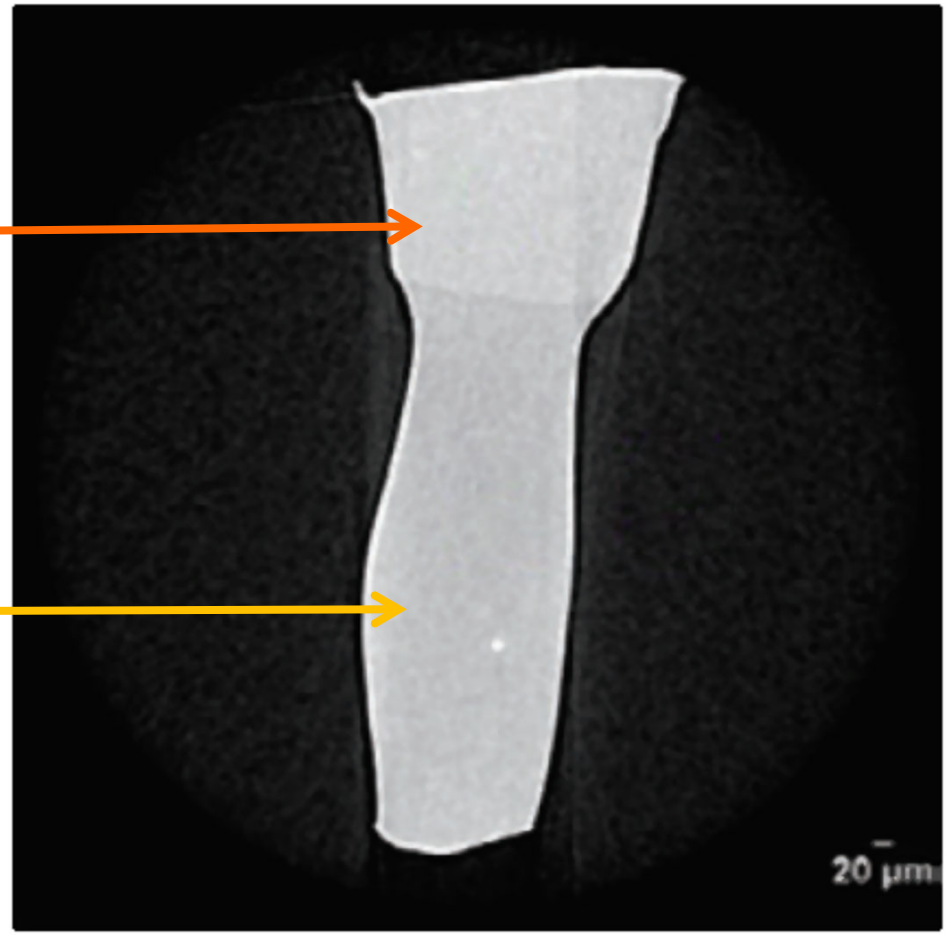

Tablet C
100 µ

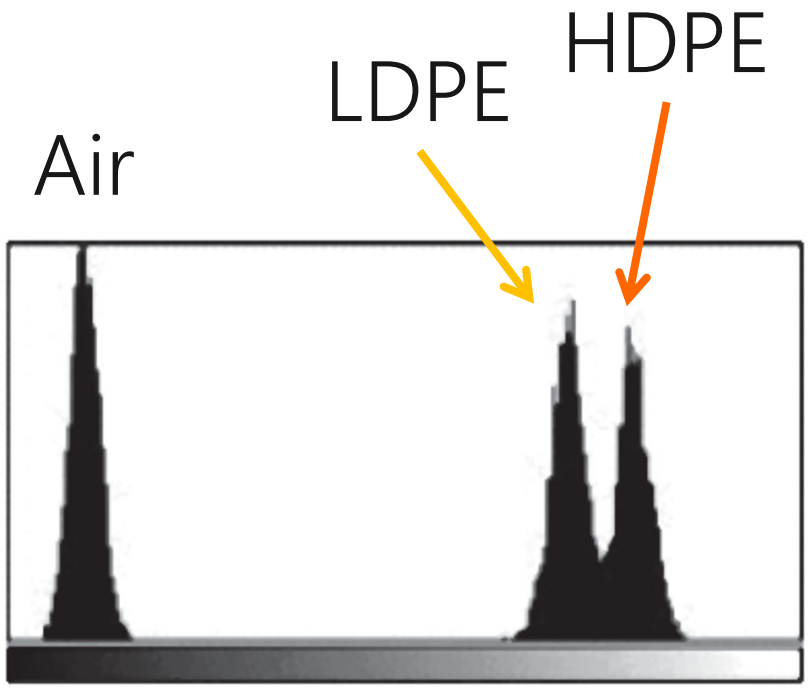
HOW BIG OF A DENSITY DIFFERENCE IS ENOUGH?

Cr 5.4 keV

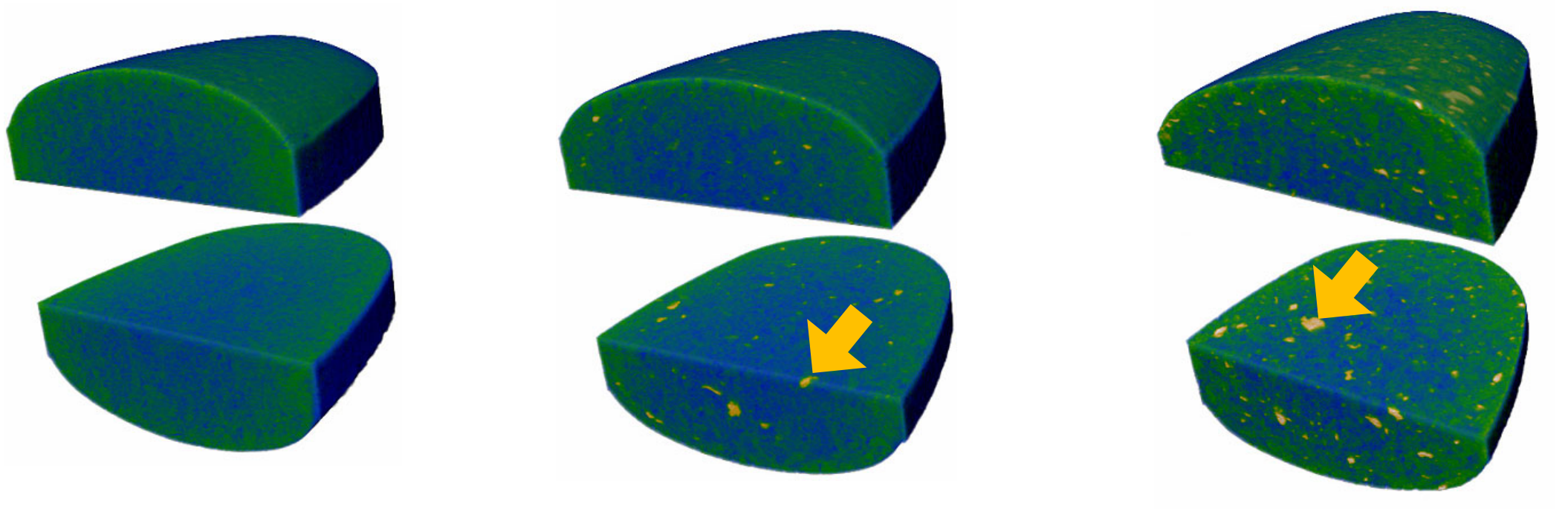
HDPE
0.93 g/cm^3

LDPE
0.88 g/cm^3

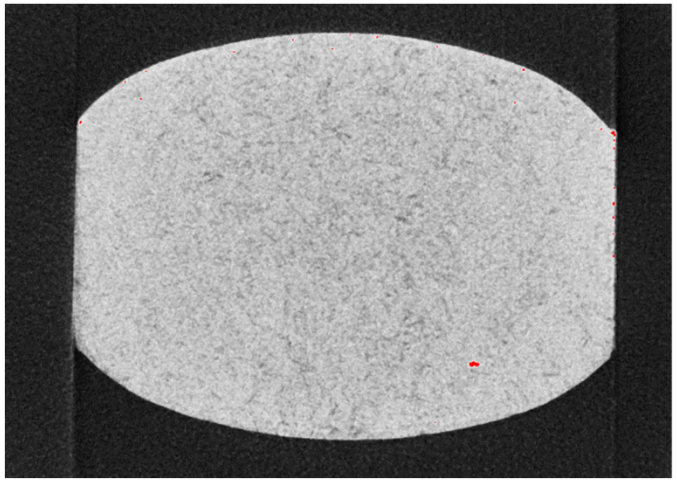


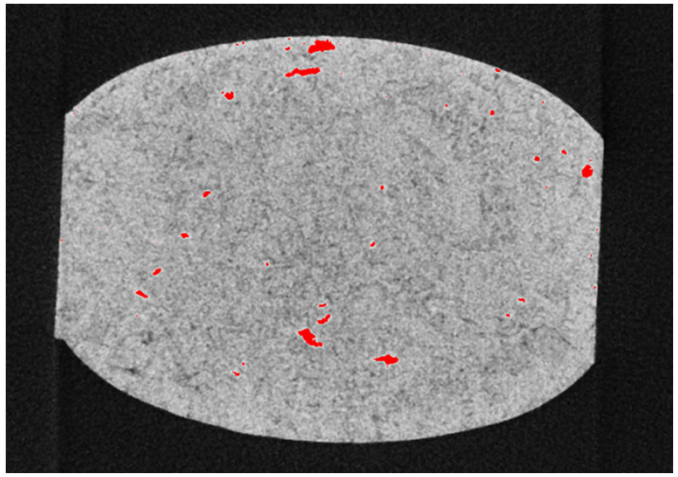


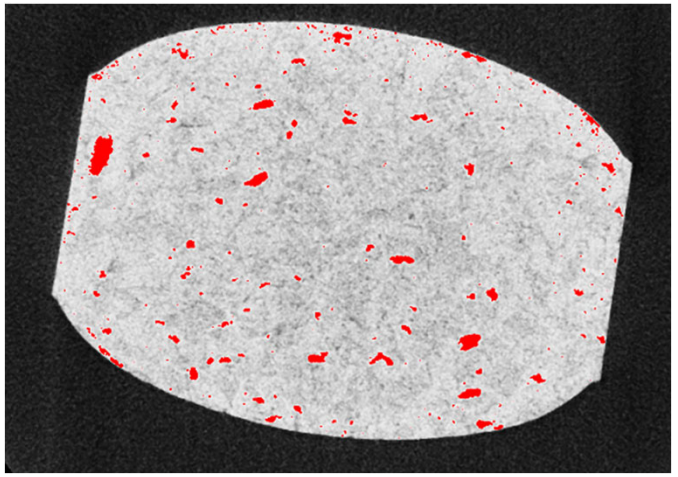
CAN YOU SEE CRYSTALLIZATION?



Density difference: 8 %

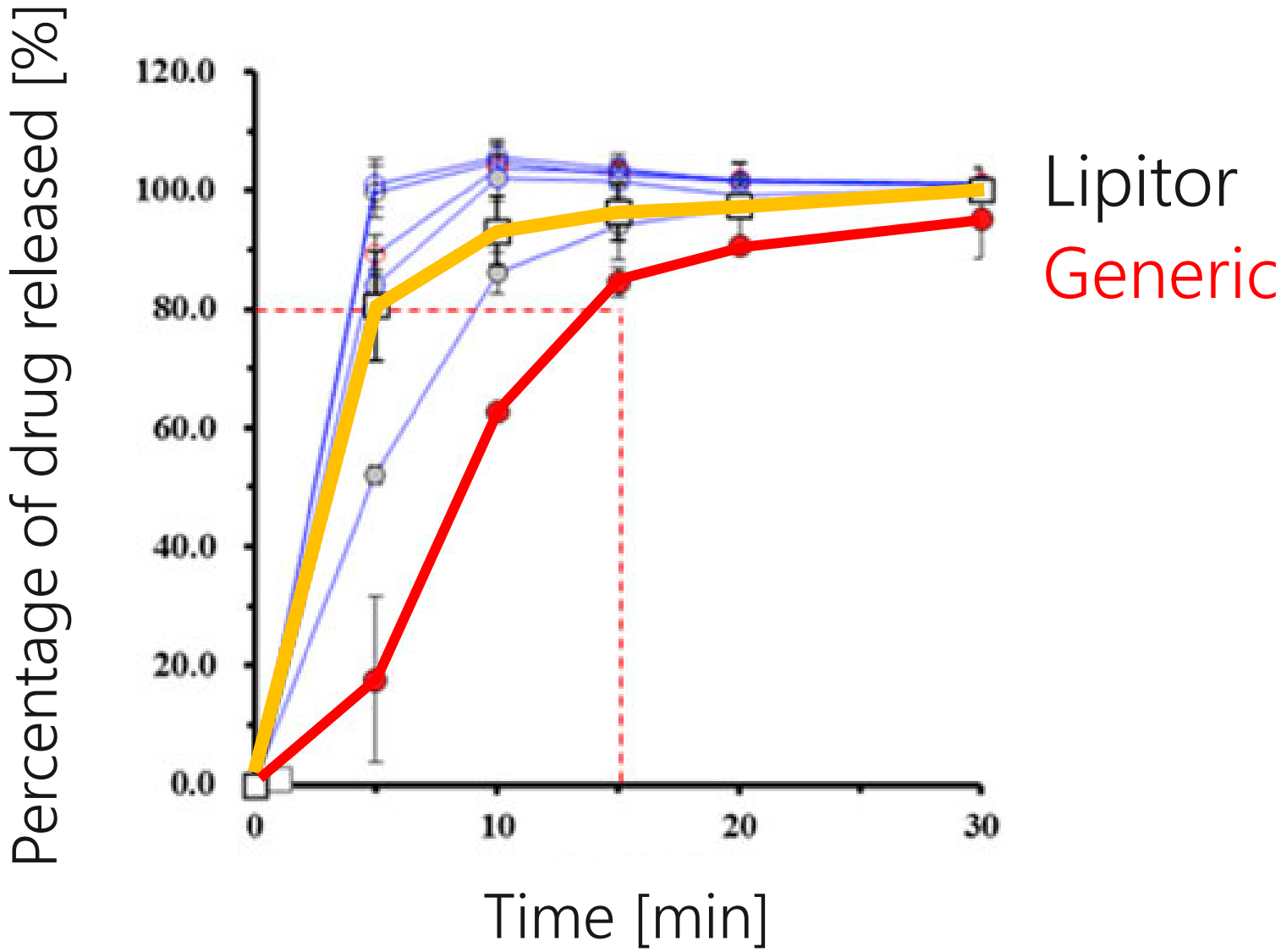






CT	0.07 vol%	0.64 vol%	2.64 vol%
CT	0.08 wt%	0.70 wt%	2.87 wt%
Spiked	0.00 wt%	1.00 wt%	3.00 wt%

ARE GENERIC BRAND DRUGS THE SAME AS BRAND NAME DRUGS?



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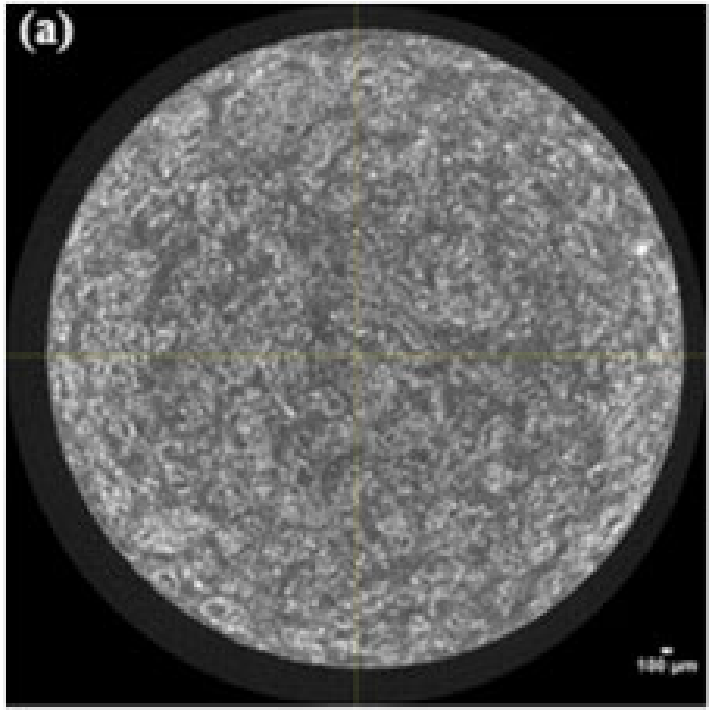
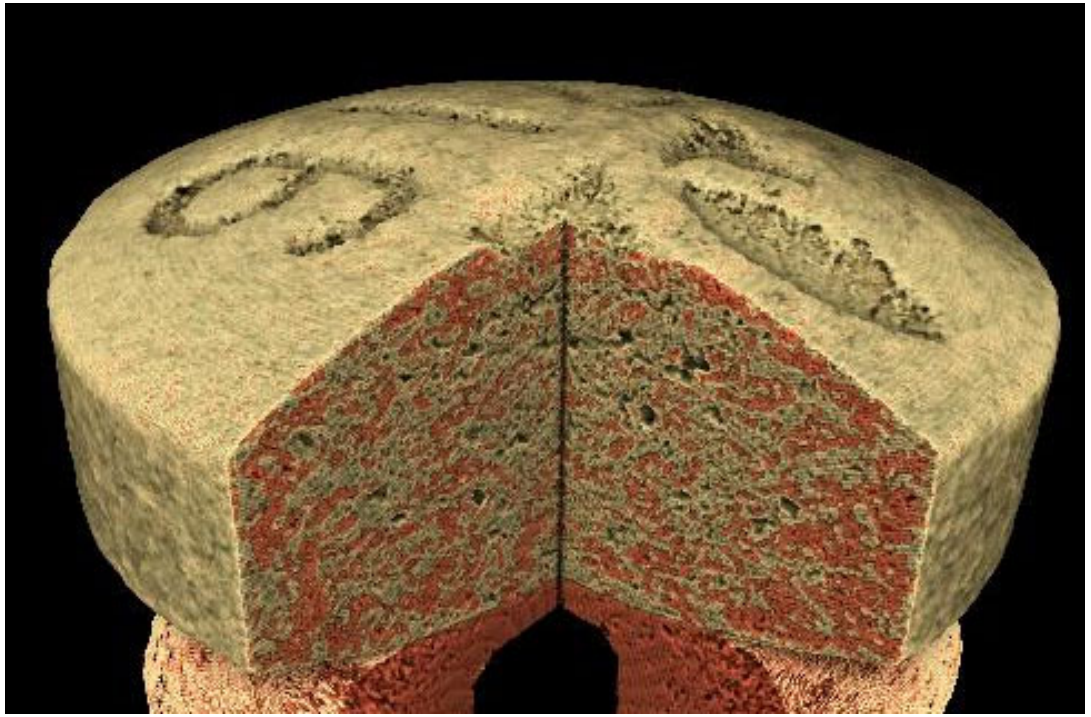
Lipitor (Astellas licensed by Pfizer)





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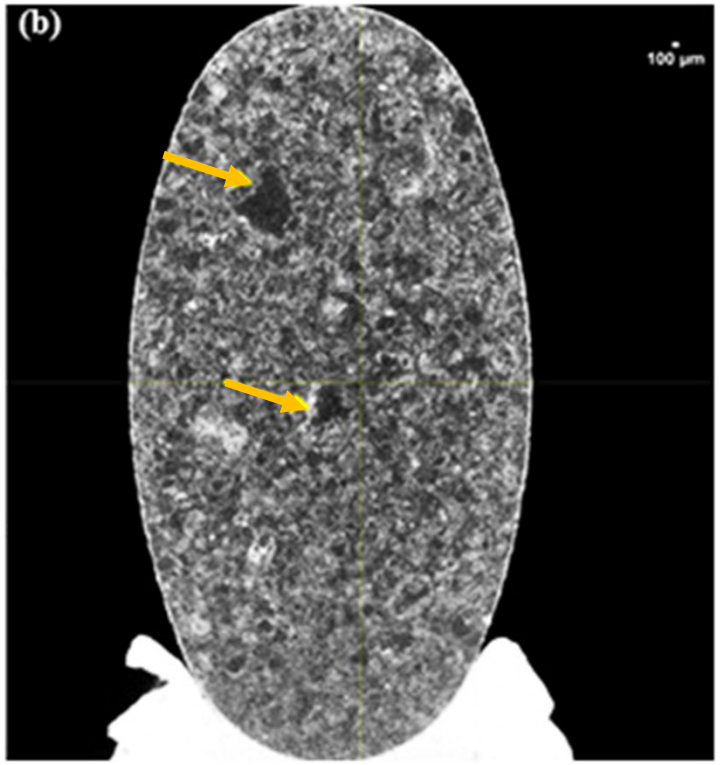
Generic brand



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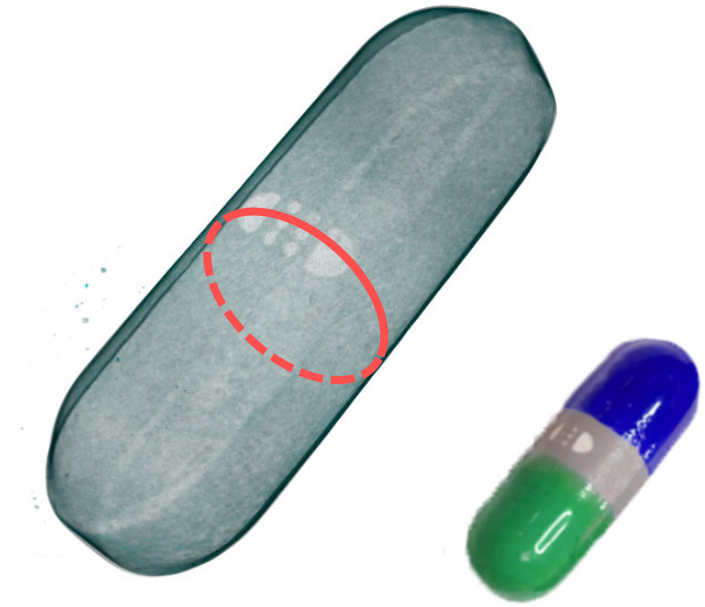
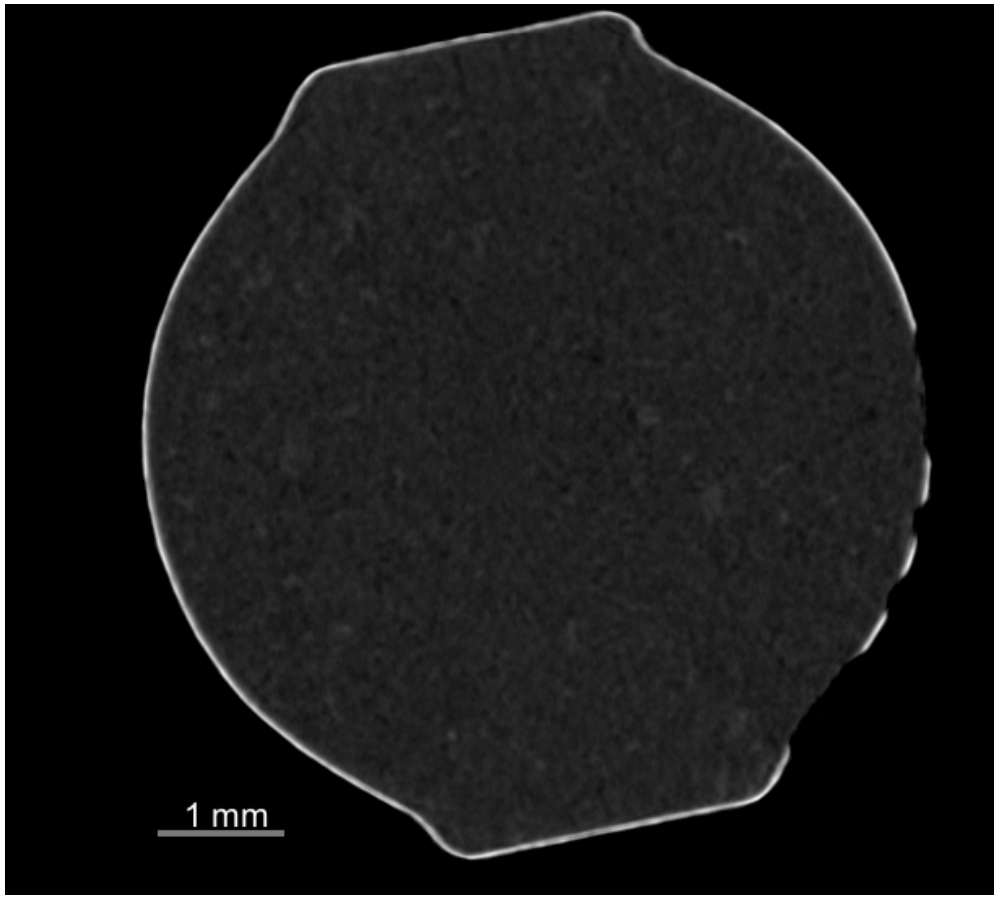
WHAT ABOUT PREMIUM AND STORE BRANDS?

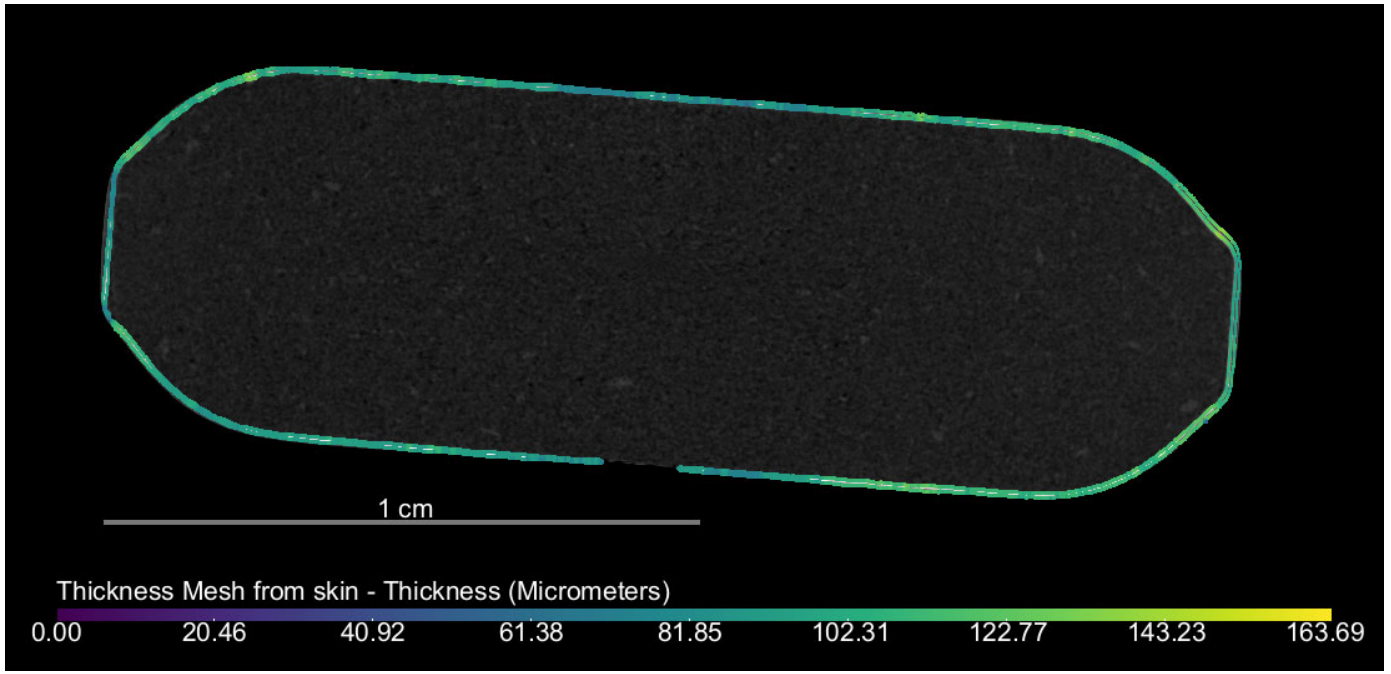
Store brand

Premium brand



Premium brand

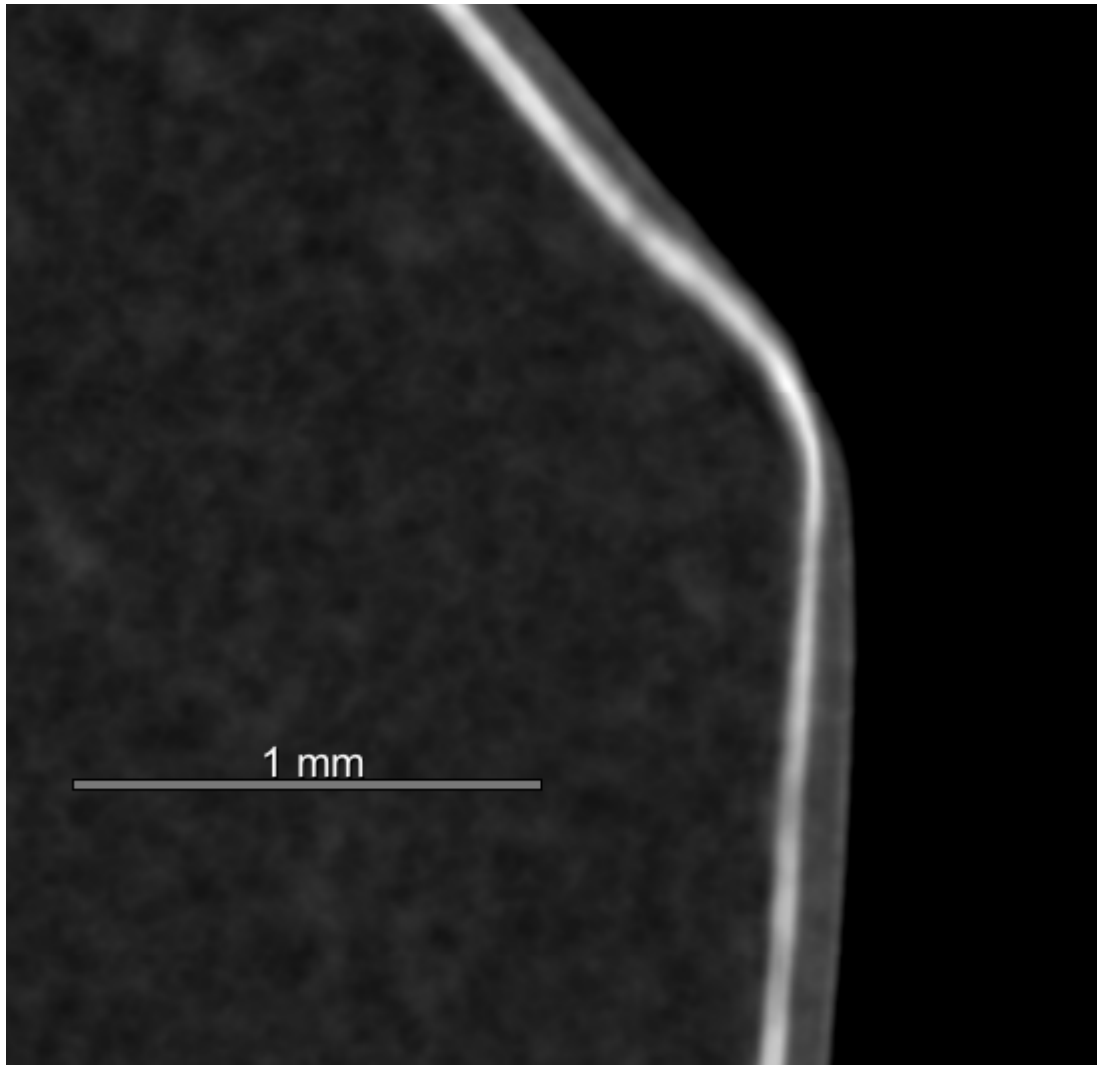




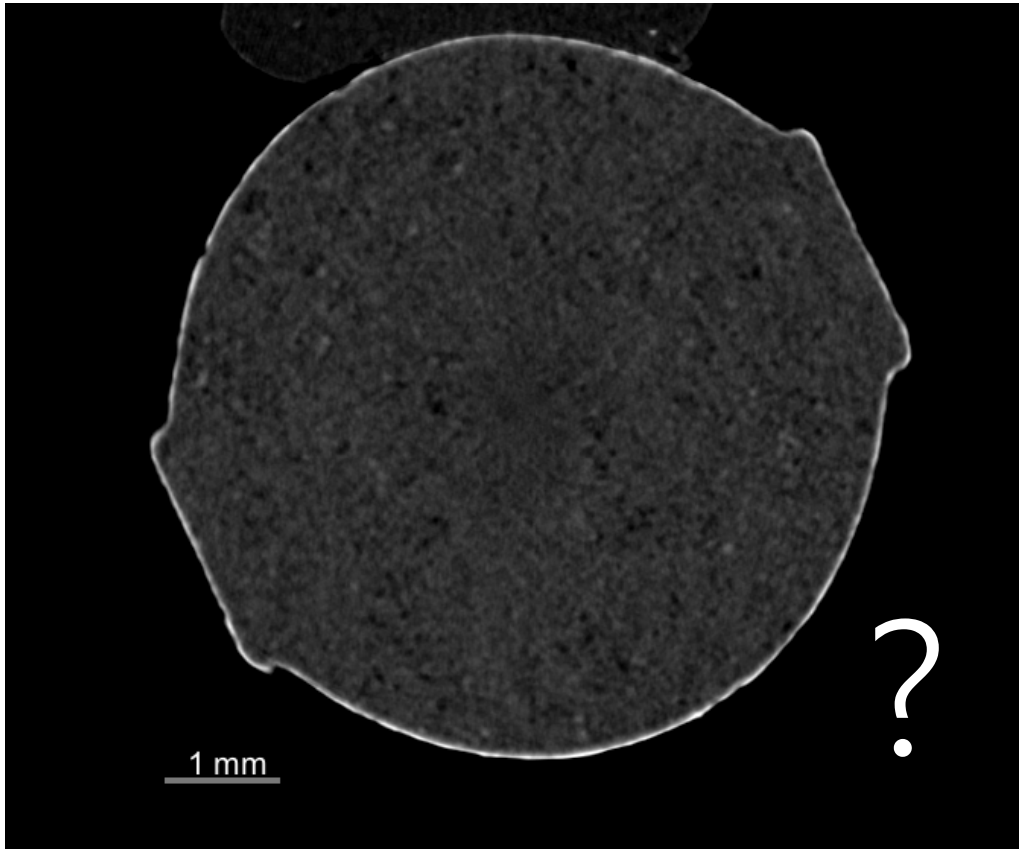
Premium brand

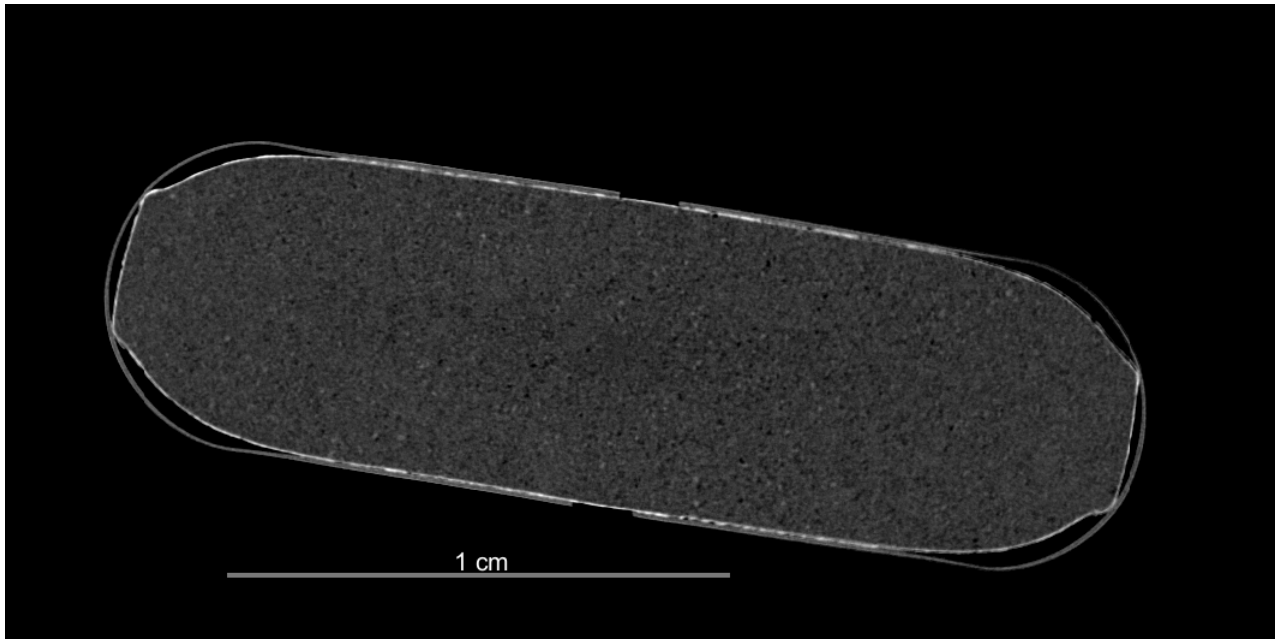
Coating thickness analysis

Premium brand

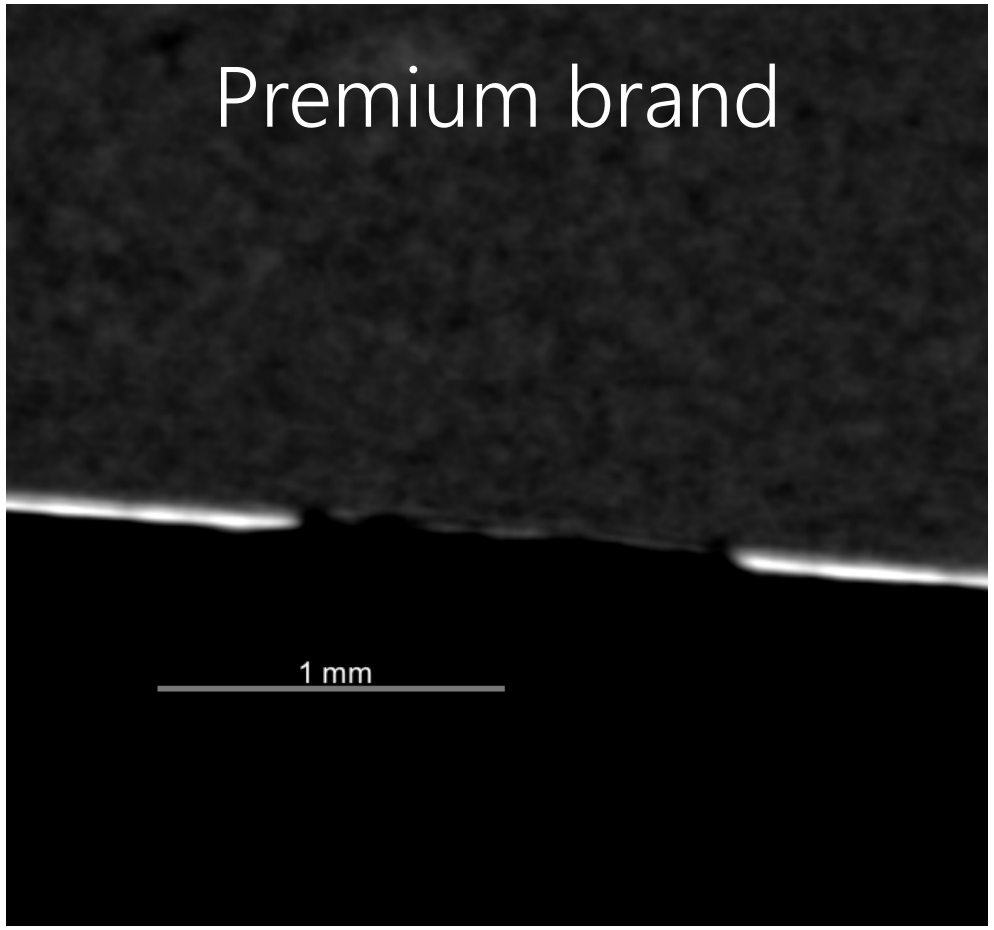


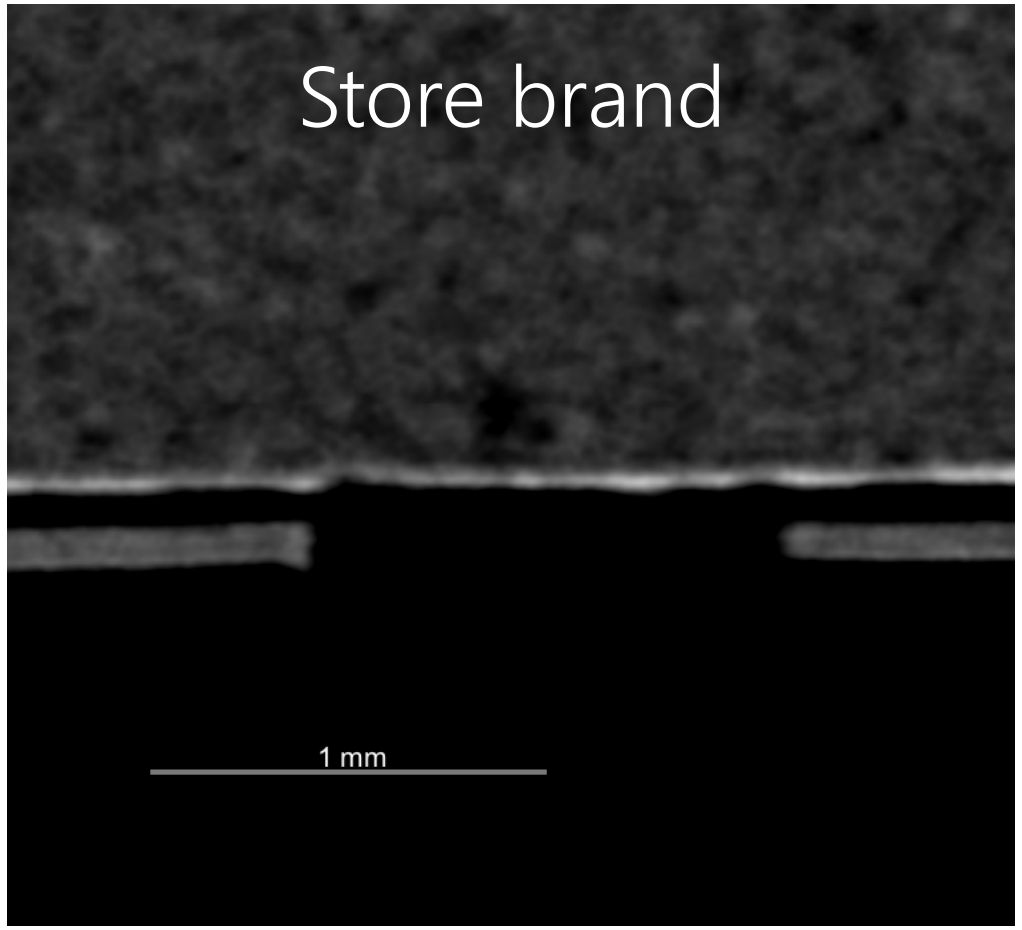
Store brand

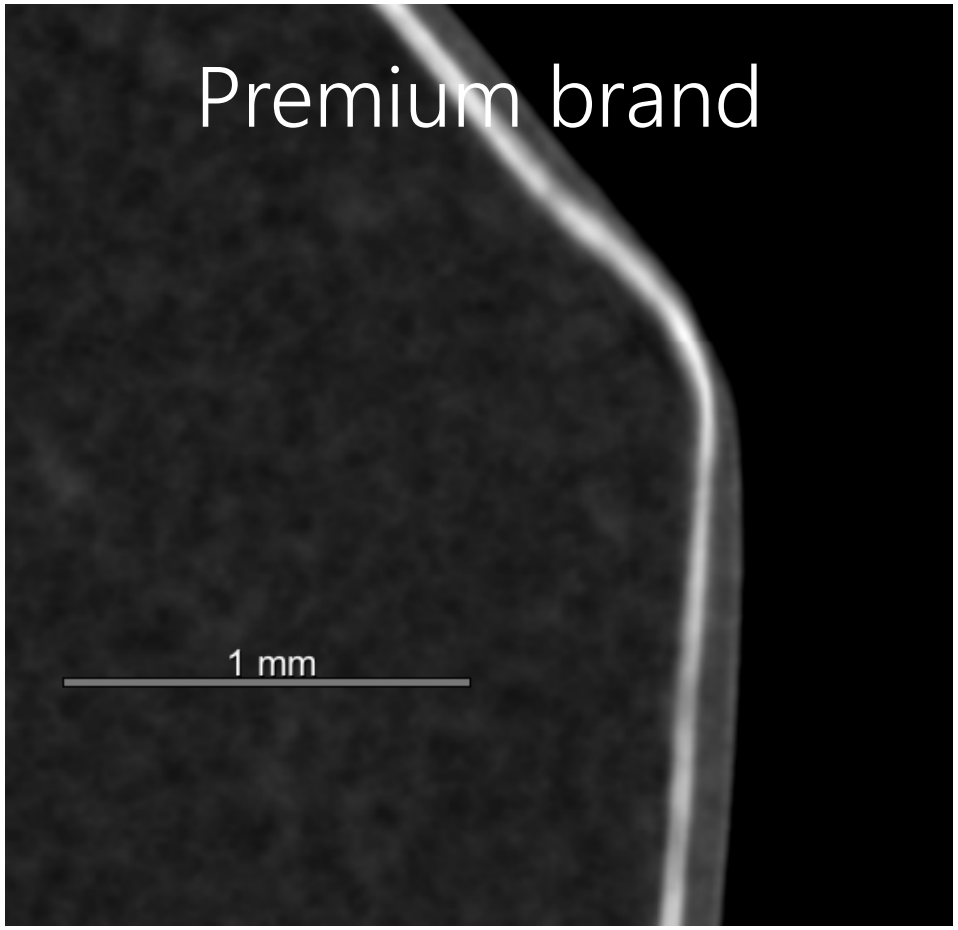




Store brand


Premium brand
1 mm

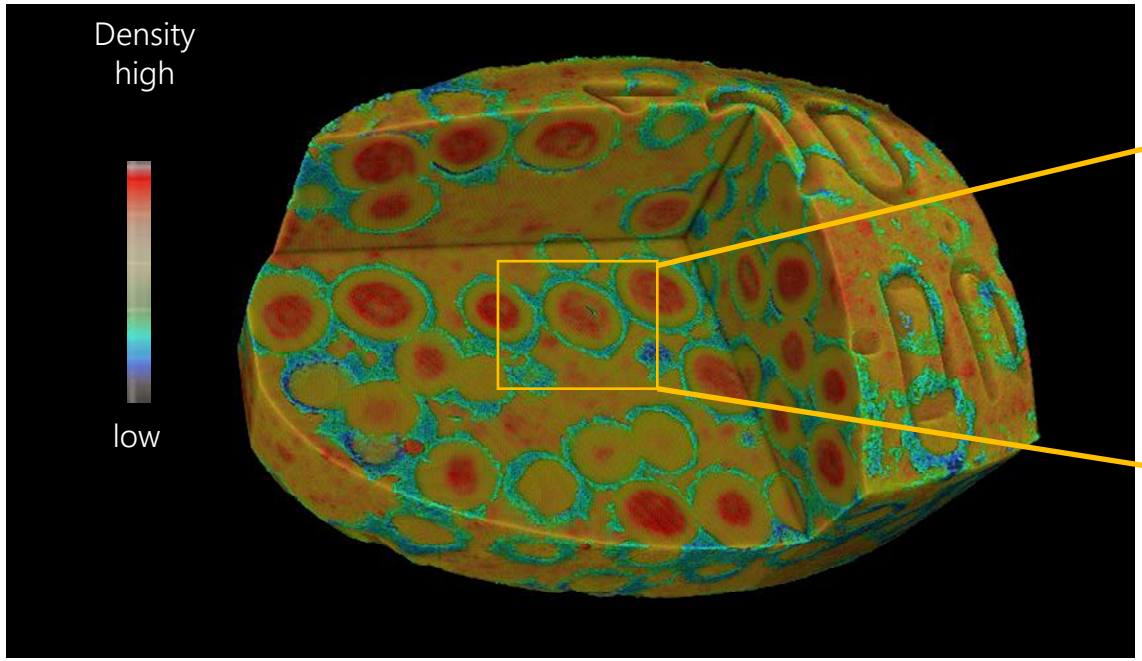

Store brand
1 mm


Premium brand
1 mm


Store brand
1 mm

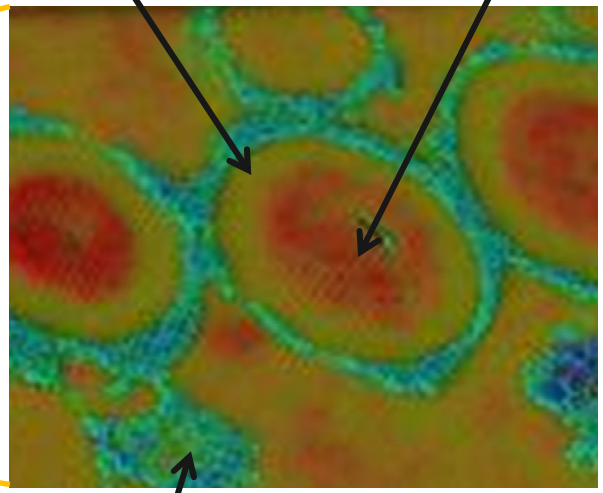
CAN YOU SEE CHANGE OVER TIME?

HOT AND HUMID (2 WEEKS)

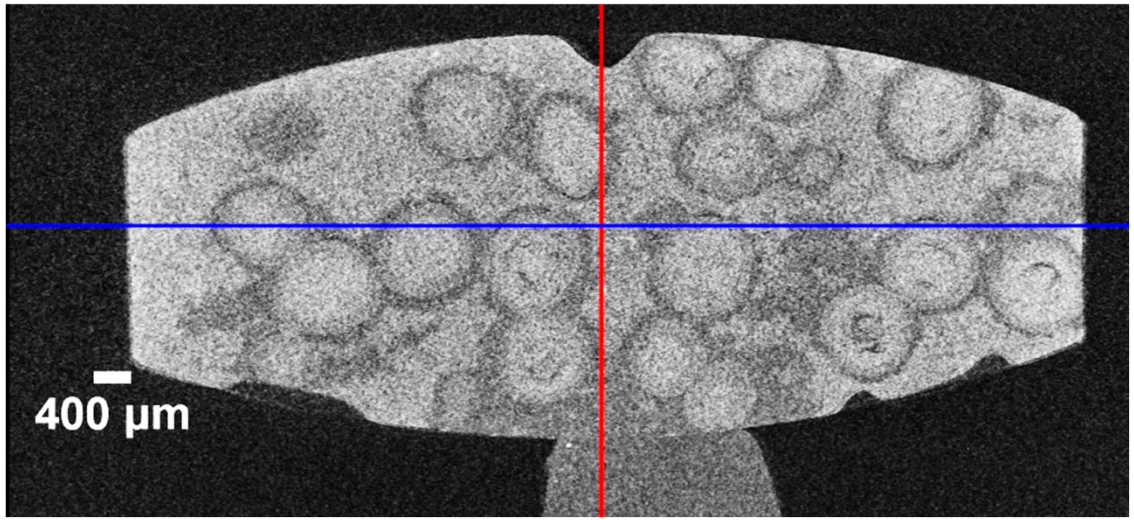


Slow dissolving shell

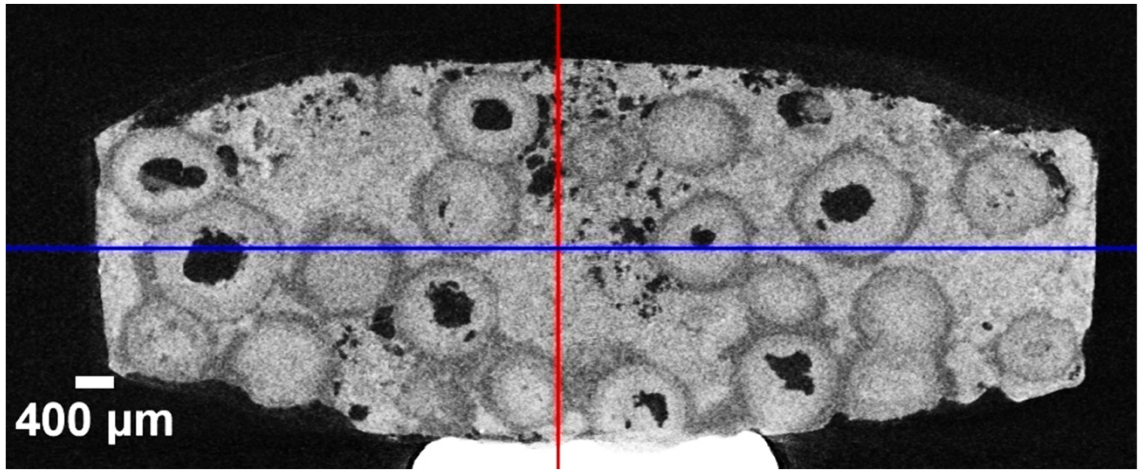
API



Rapid dissolving matrix



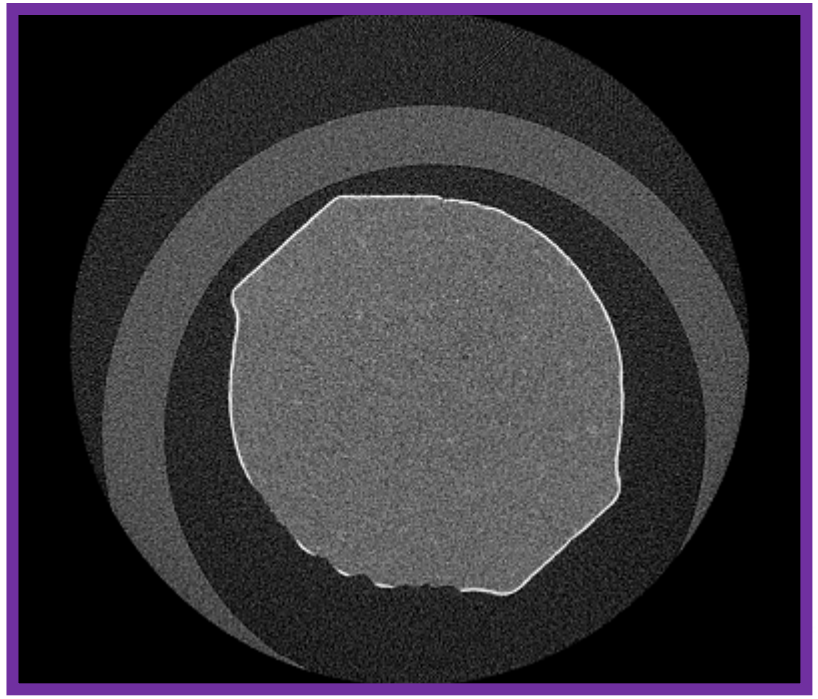
60 °C 70% RH 2 weeks later…

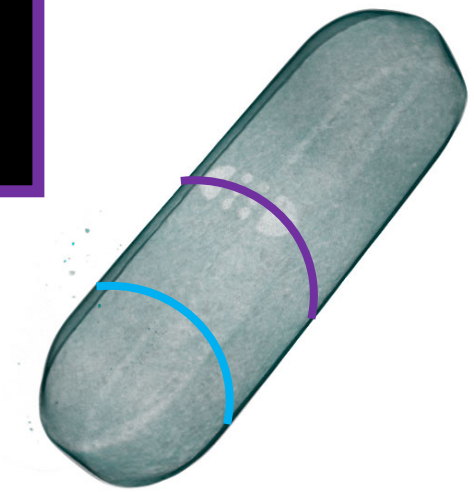


DROPPED IN WATER (44 MIN)

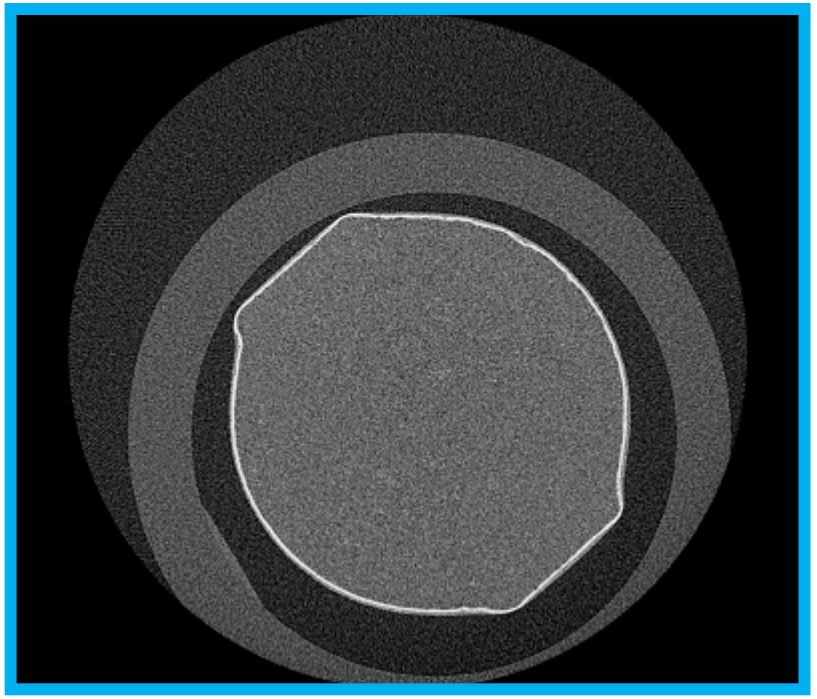
0 min (dry)

Rapid release



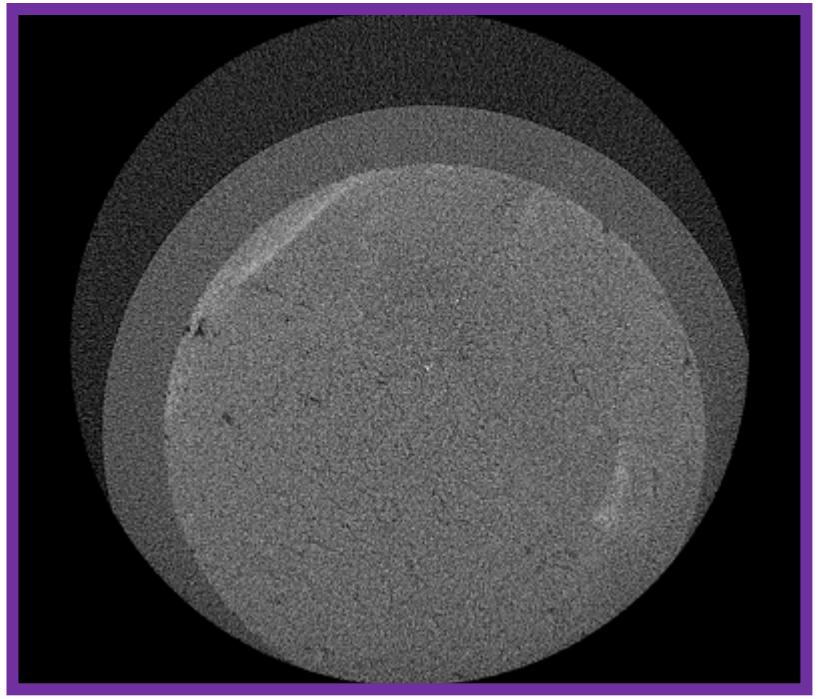


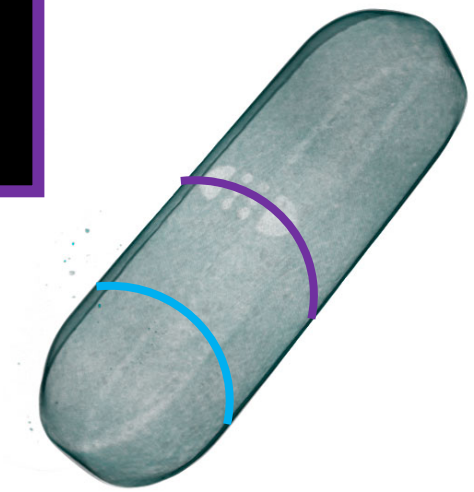
Fully coated



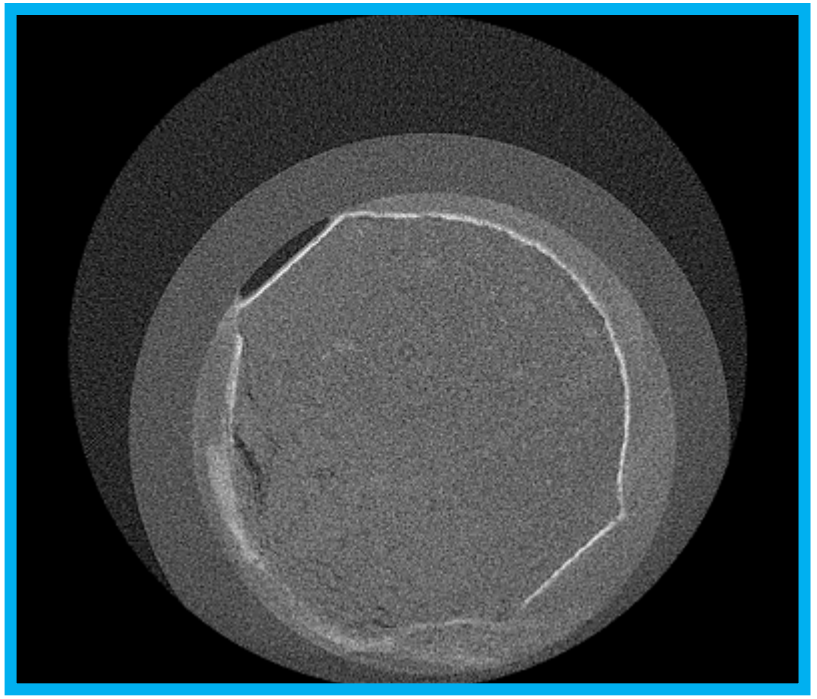
4 min (wet)

Rapid release



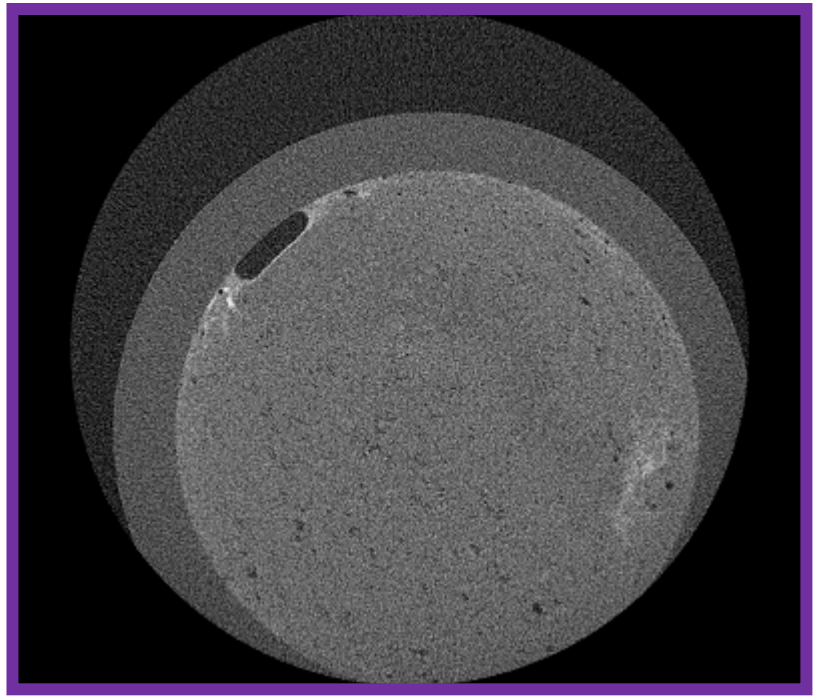


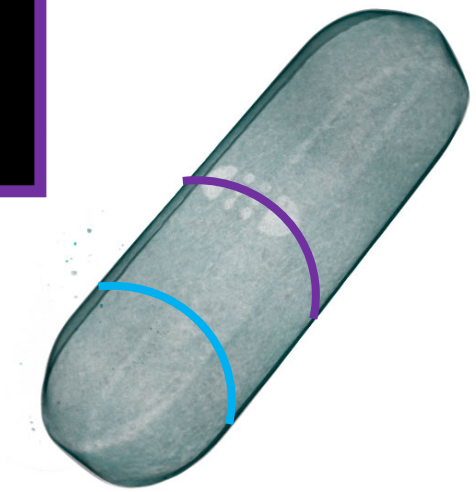
Fully coated



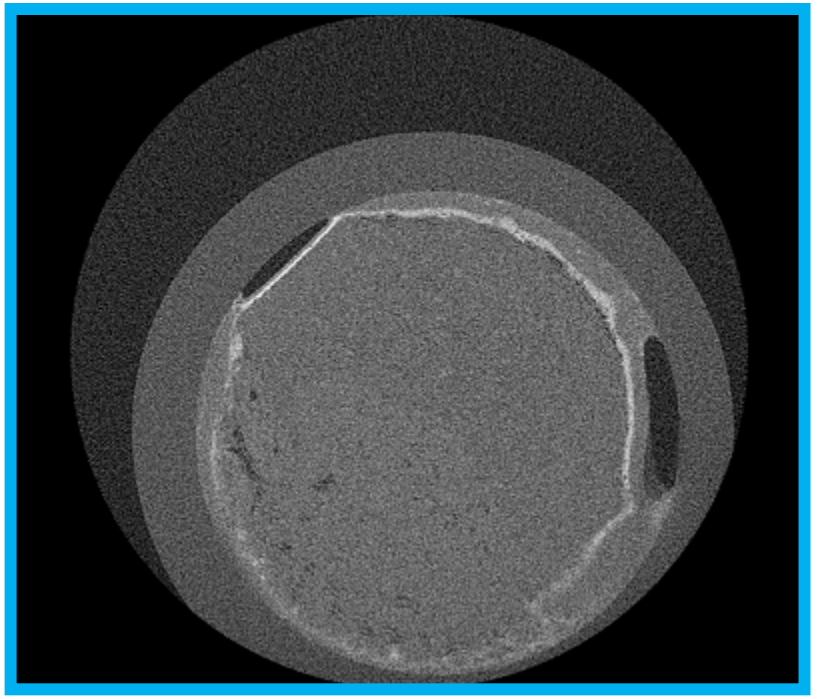
8 min (wet)

Rapid release



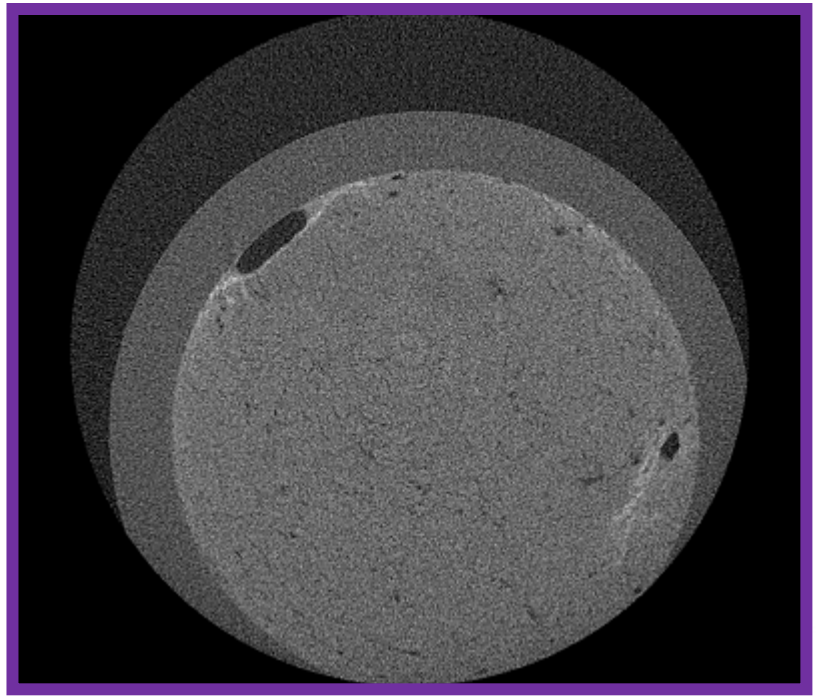


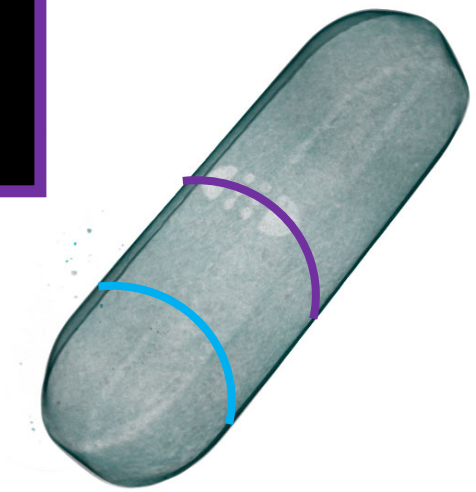
Fully coated



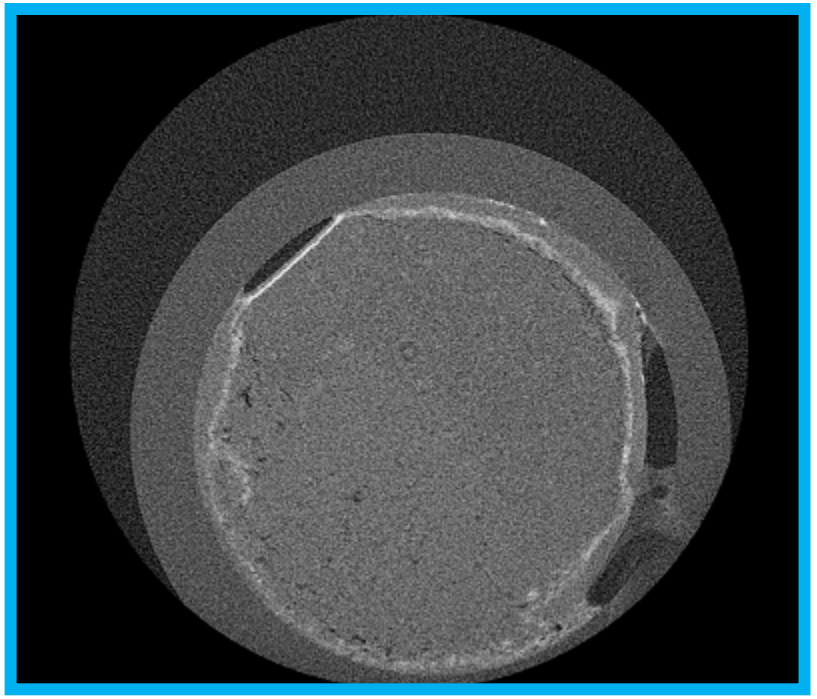
12 min (wet)

Rapid release



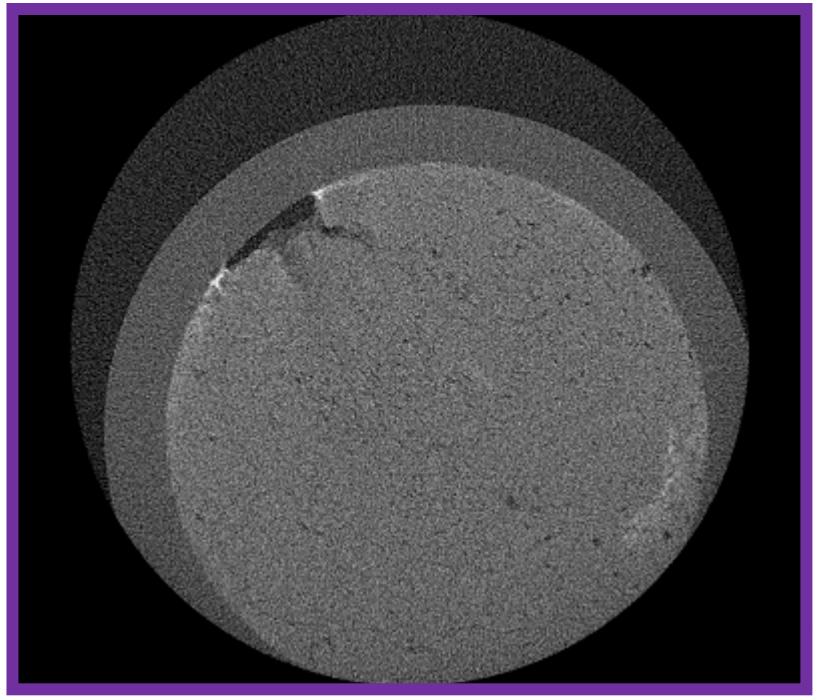


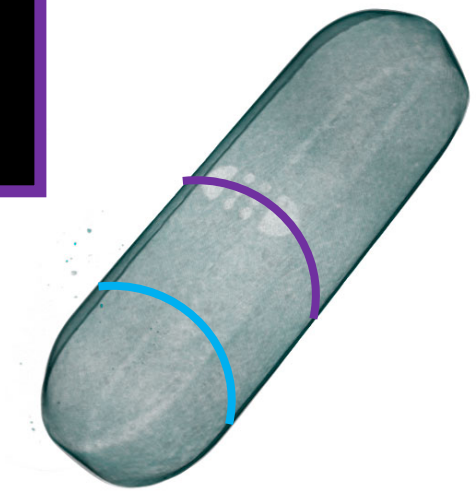
Fully coated



16 min (wet)

Rapid release





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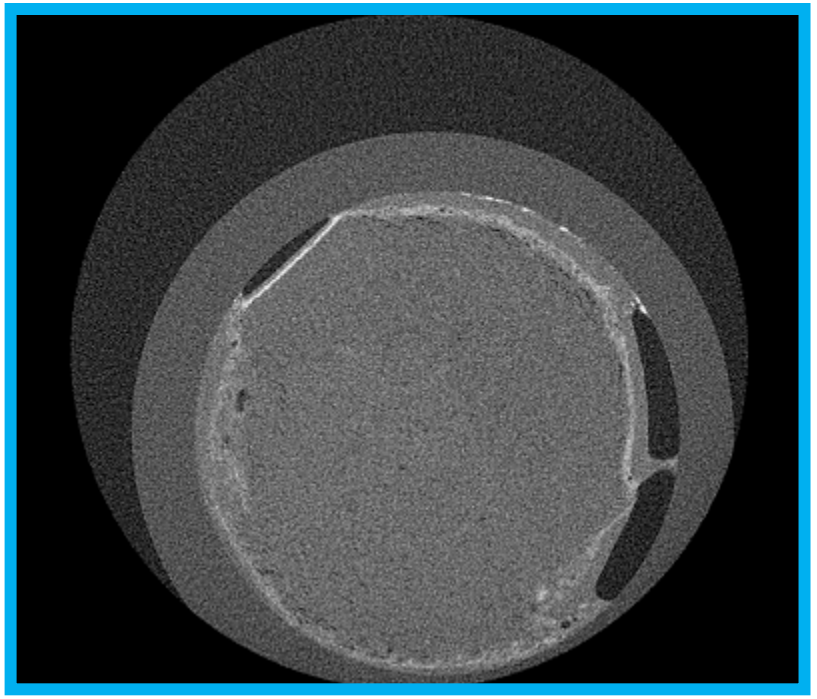
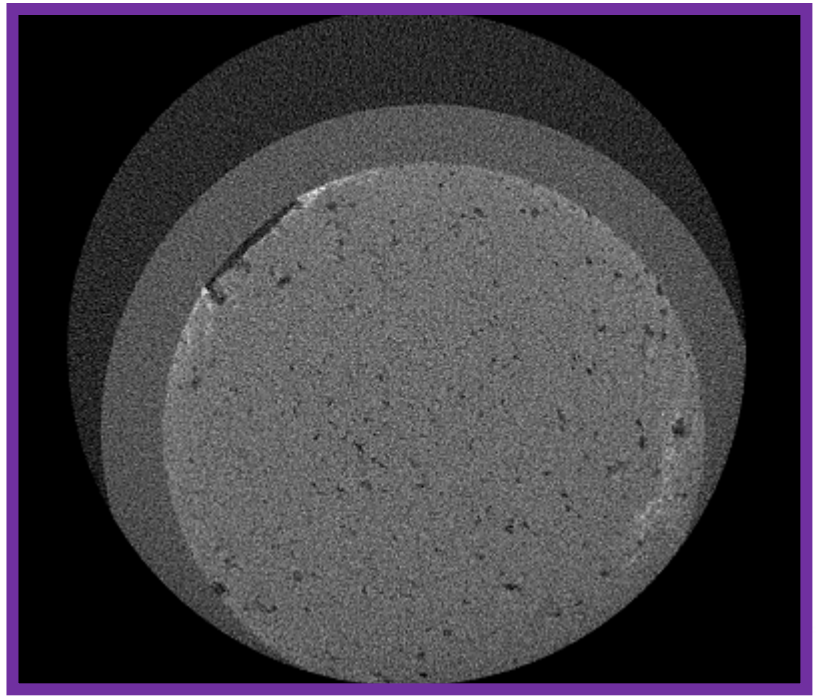
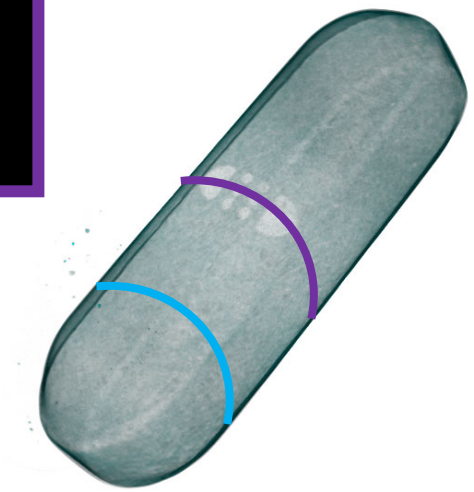


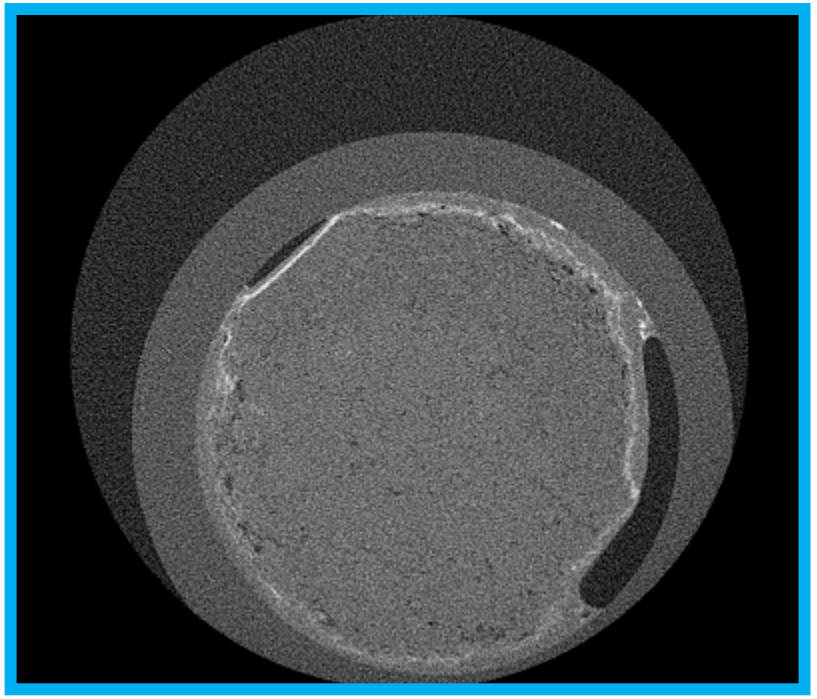
32 min (wet)

Rapid release



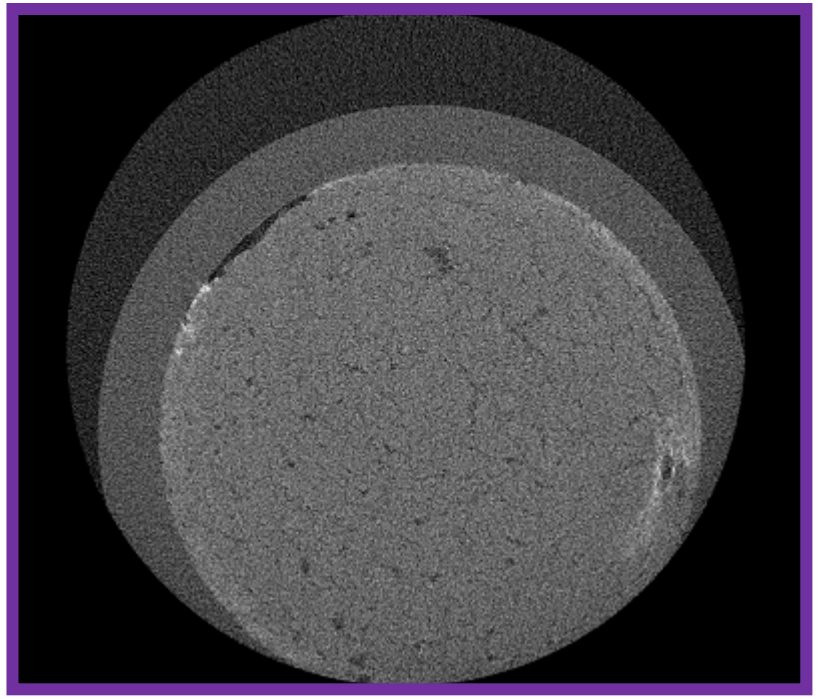


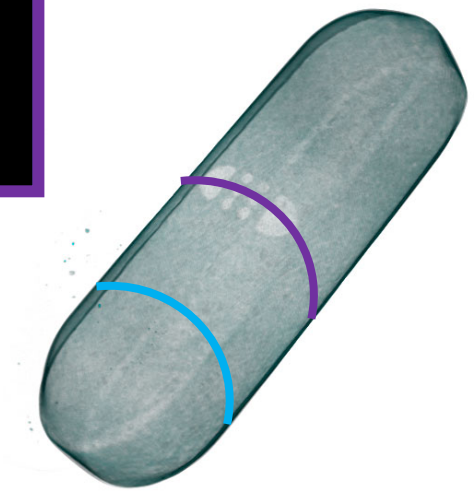
Fully coated



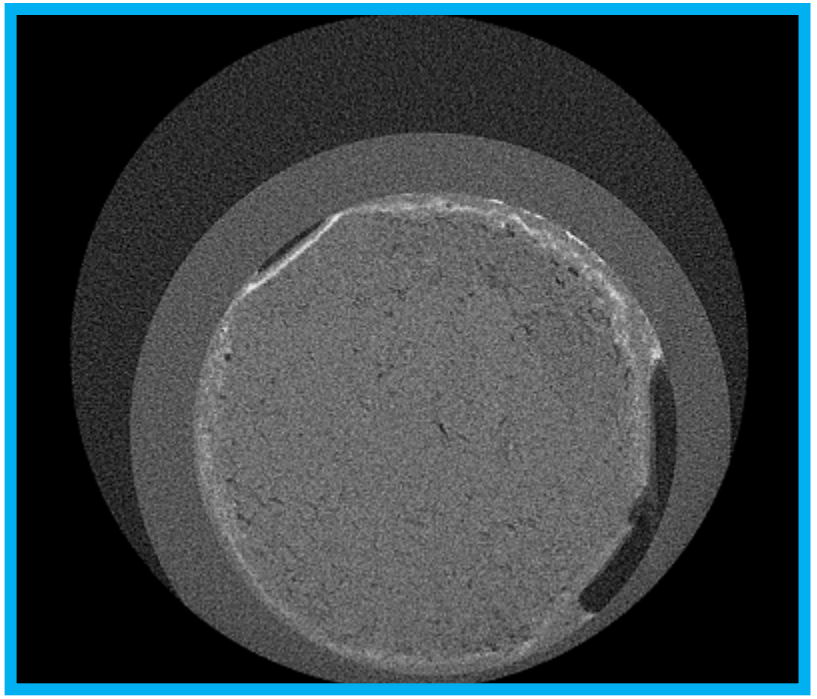
44 min (wet)

Rapid release





Fully coated



PHARMA APPLICATIONS

- Cracks
- Aggregates
- Coatings
- Crystallization
- Dissolution process
- Contamination


This could be interesting to look at…

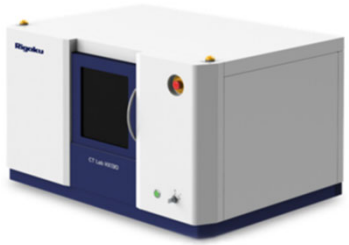
You just learned:

- Keys to imaging soft materials
- Food science applications
- Pharmaceutical applications

ALL IMAGES WERE COLLECTED ON…

nano3DX

CT Lab HX



CT Lab GX

To learn more …


Rigaku.com → Contact

Next on X-ray computed tomography
Foams and Composites Applications

December 11th Wednesday
11:00 am PST / 2:00 pm EST

X-ray Microscopy Seminar & Workshop

October 30th Wednesday

Rigaku Americas, The Woodlands, TX

Q & A SESSION

Aya Takase

Tom McNulty

We'll follow up with your questions.

Recording will be available tomorrow.

Register for the 4th webinar.


THANK YOU FOR JOINING US
SEE YOU NEXT TIME!