WELCOME

RIGAKU WEBINAR SERIES

X-RAY COMPUTED TOMOGRAPHY FOR MATERIALS & LIFE SCIENCE *METROLOGY APPLICATIONS*

IS STARTING NOW.

Presenter: Aya Takase

Director of X-ray Imaging
Rigaku Americas Corporation

Host: Tom Concolino

Southeast Regional Account Manager
Rigaku Americas Corporation

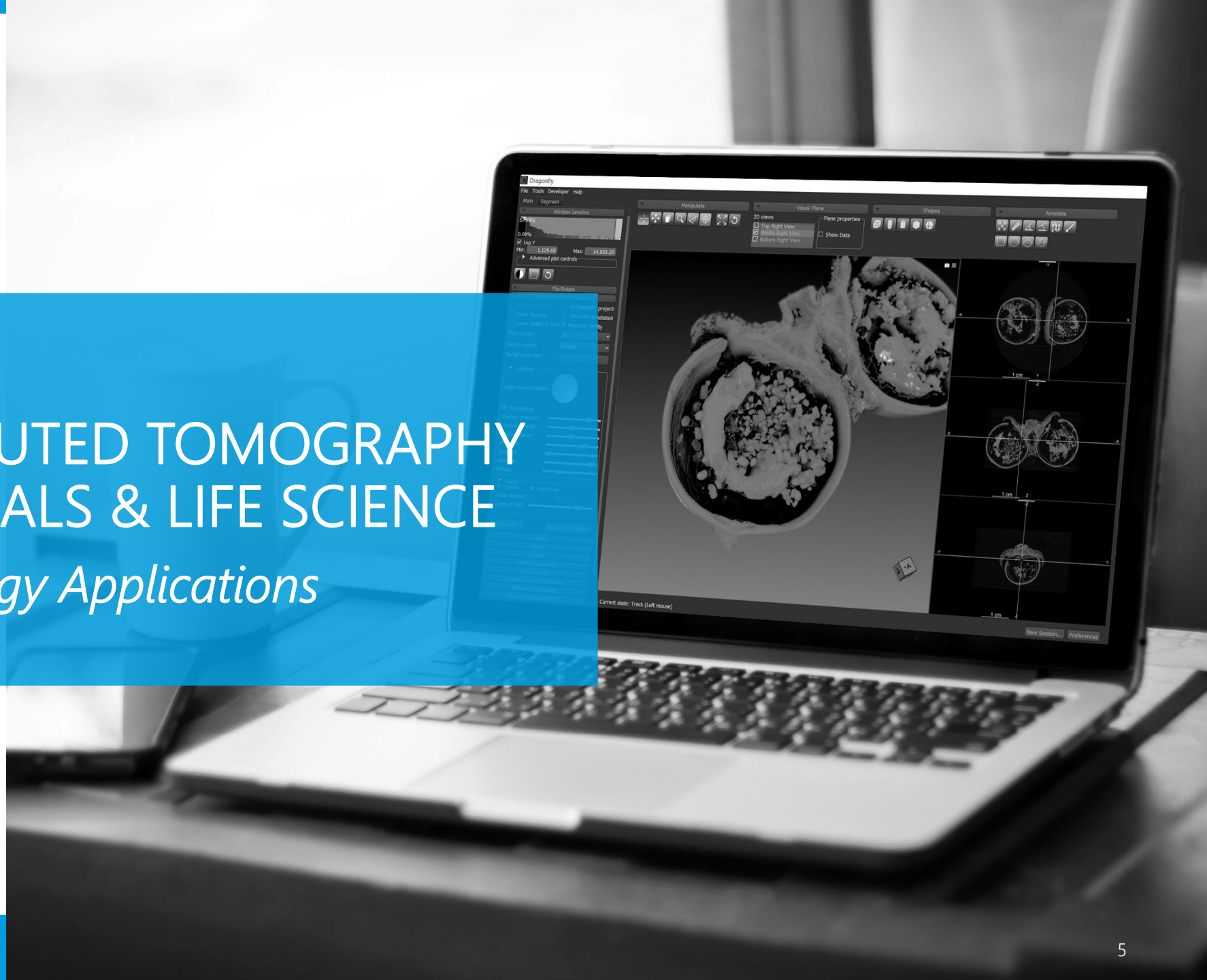
You can send us questions during the presentation.
They will be addressed at the end of the presentation.

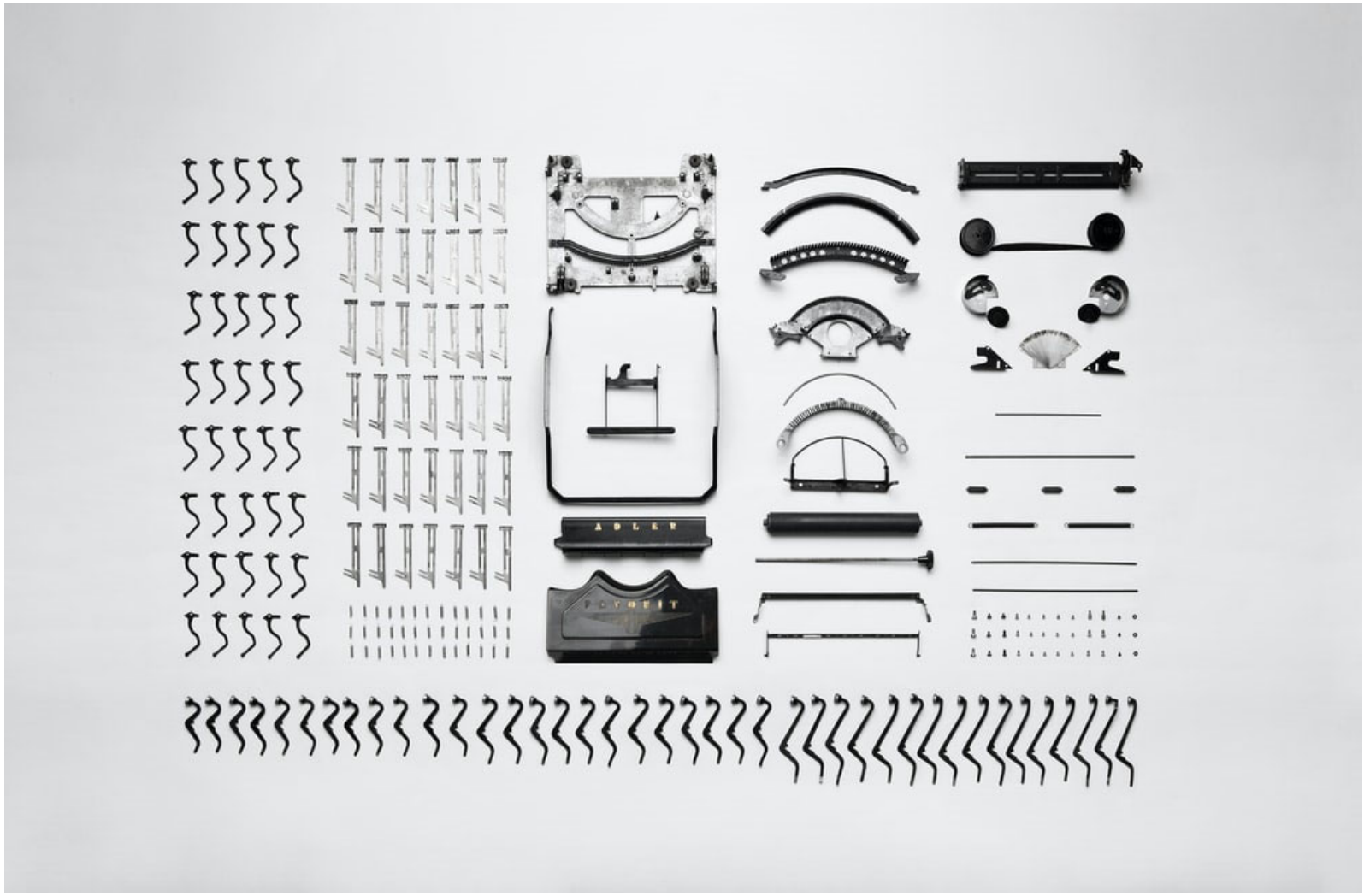
Recording will be available tomorrow.

Tell us what you want to learn next.

X-RAY COMPUTED TOMOGRAPHY FOR MATERIALS & LIFE SCIENCE

Metrology Applications




ADLER


84-342 DC
1923

You will learn:

- Keys to metrology using CT
- Analysis techniques
- Metrology applications

WHAT IS METROLOGY?

metrology

the science of measurement

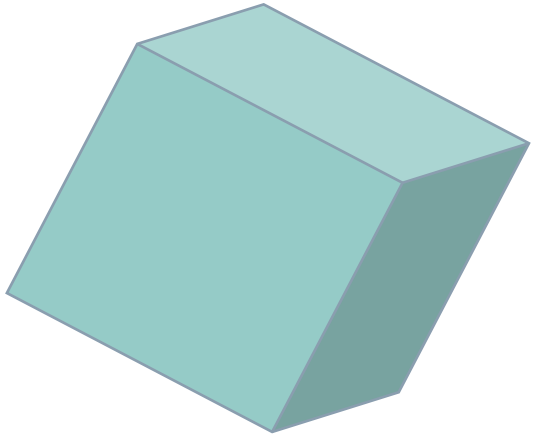
metrology

the application of measurement to manufacturing and other processes

Normal measurement

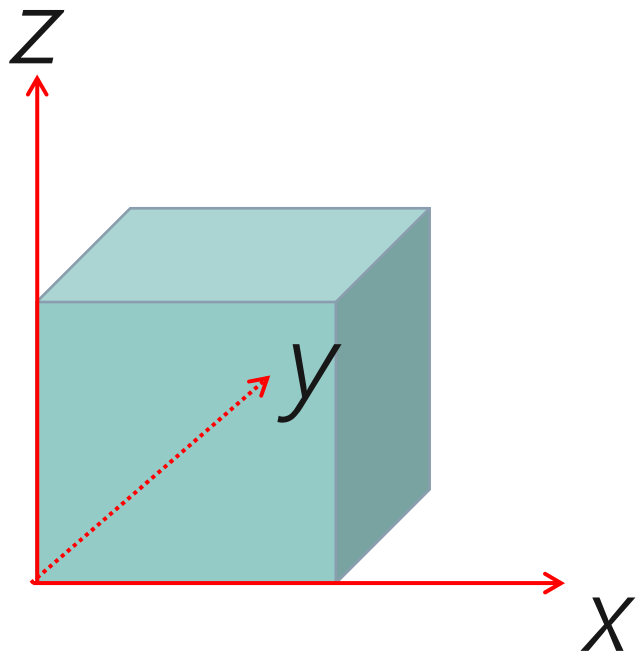
Geometrical dimensioning & tolerancing (GD&T)

Normal measurement



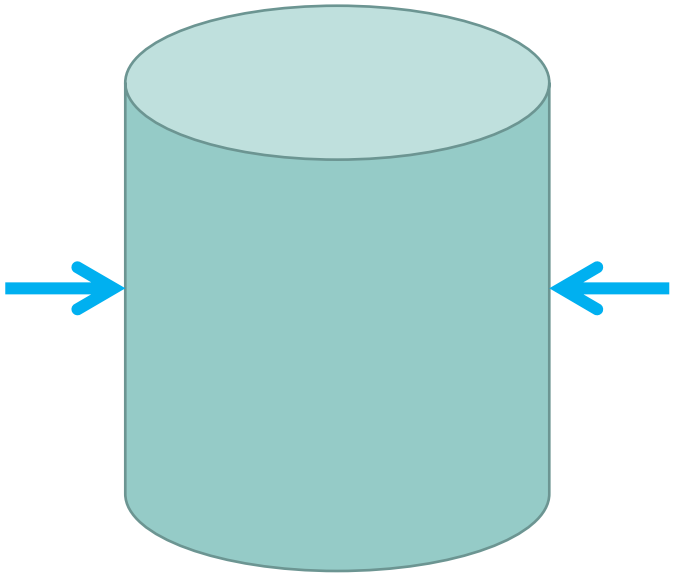
Arbitrary coordinates

GD&T



XYZ coordinates

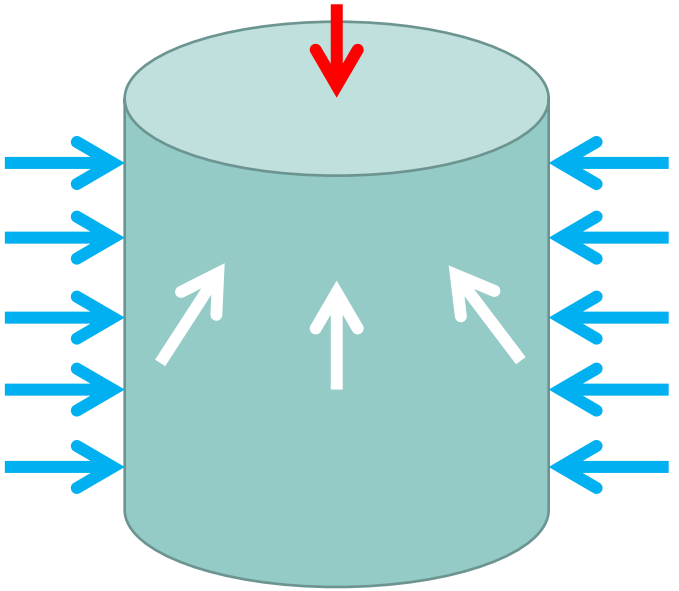
Normal measurement



D mm

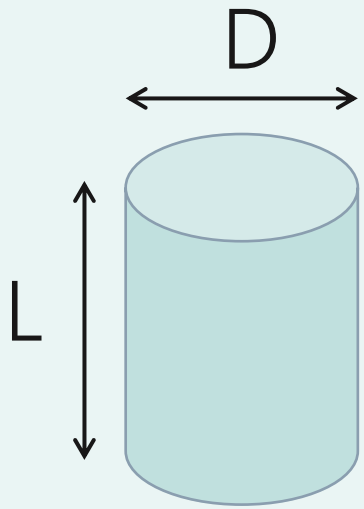
GD&T

$(x_F \pm \Delta x, y_F \pm \Delta y, z_F \pm \Delta z,)$



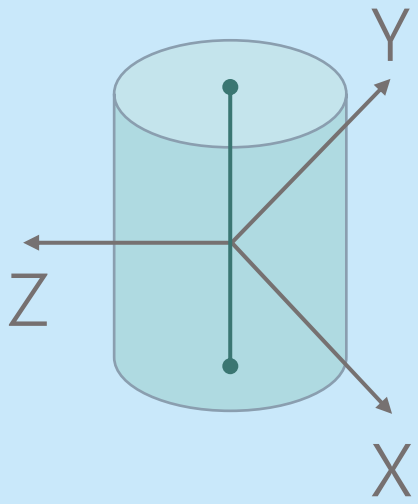
$D_F \pm \Delta D$ mm

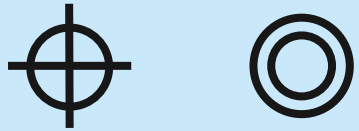
Size



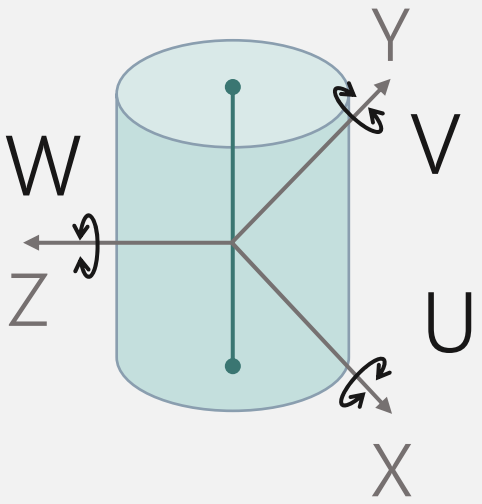
GD&T symbols

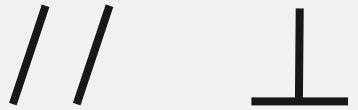
Location



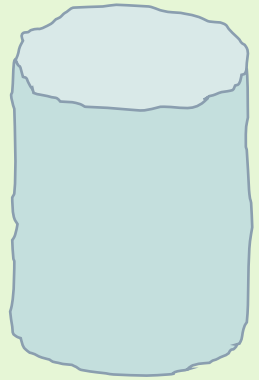


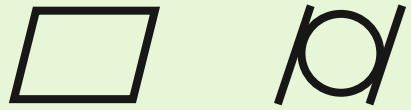
Orientation





Form





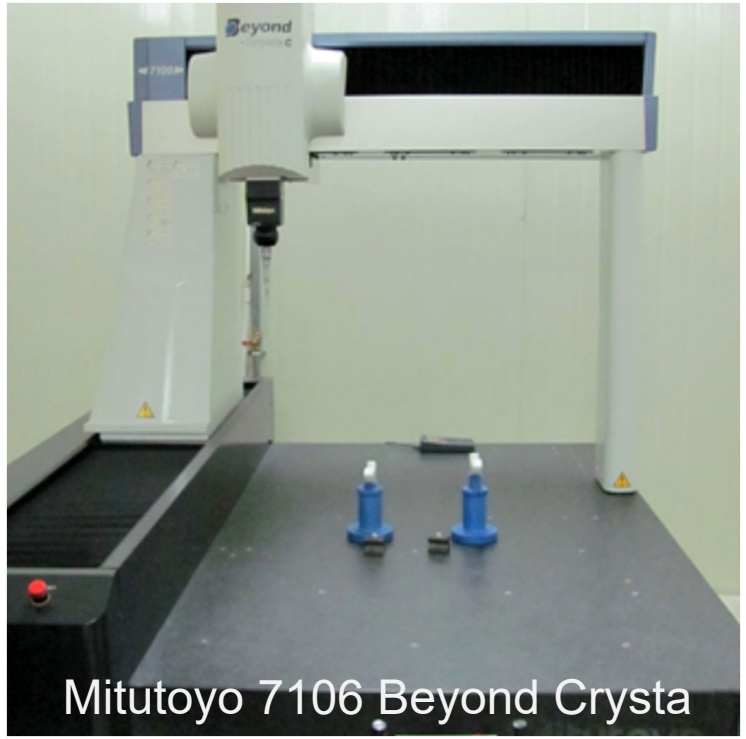
Normal measurement

Geometrical dimensioning & tolerancing (GD&T)

HOW IS CT DIFFERENT FROM CMM?

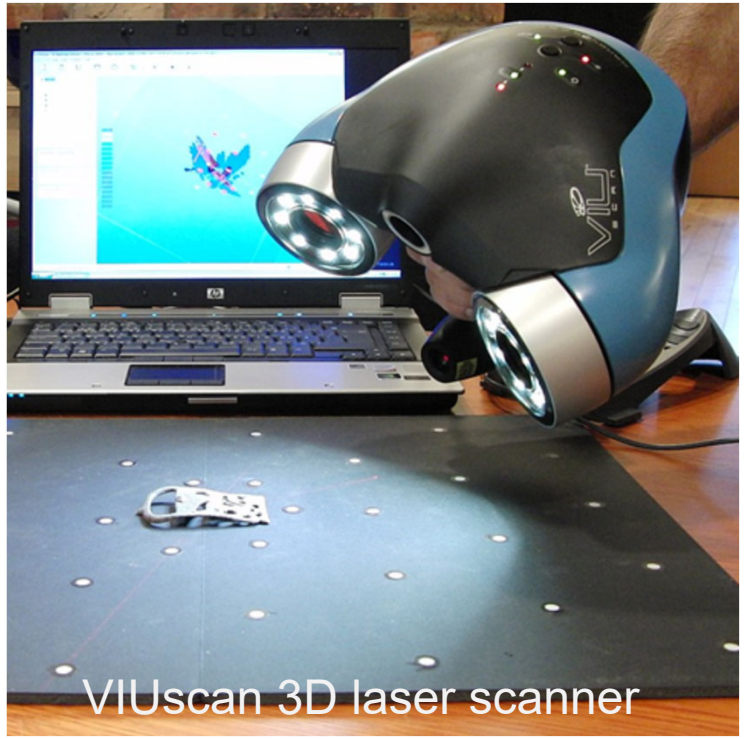
CMM

(Coordinate Measuring Machine)



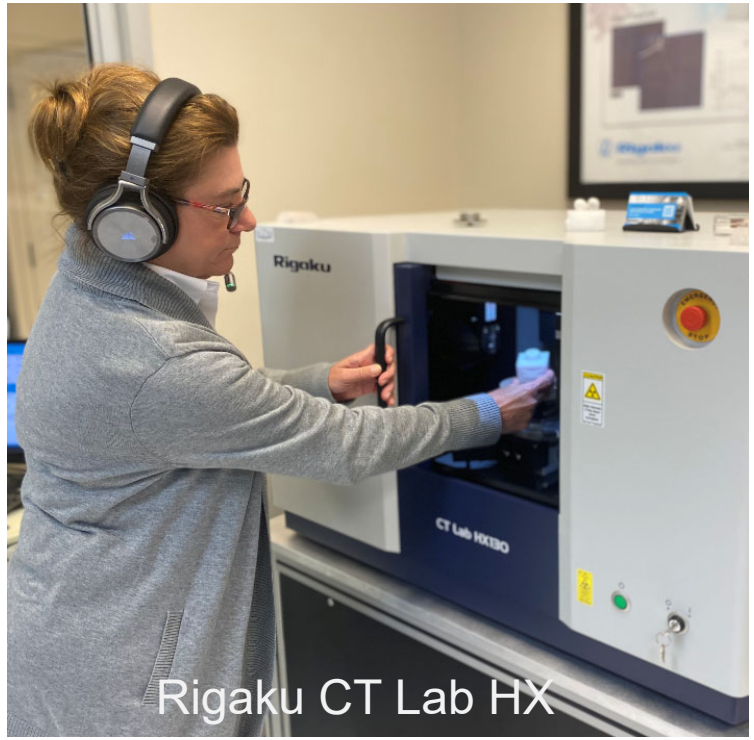
Mitutoyo 7106 Beyond Crysta

Optical scanner



VIUscan 3D laser scanner

X-ray CT

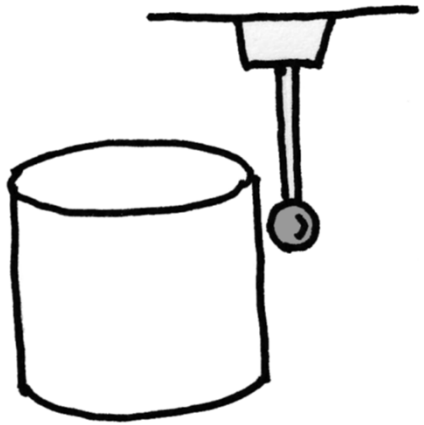


Rigaku CT Lab HX

Image source: Wikipedia Commons

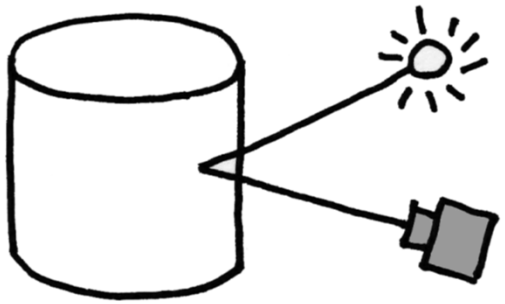
CMM

(Coordinate Measuring Machine)



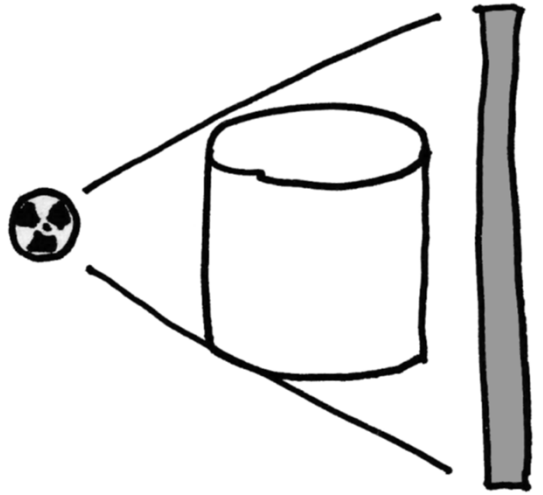
Tactile

Optical scanner



Optical

X-ray CT



X-ray absorption

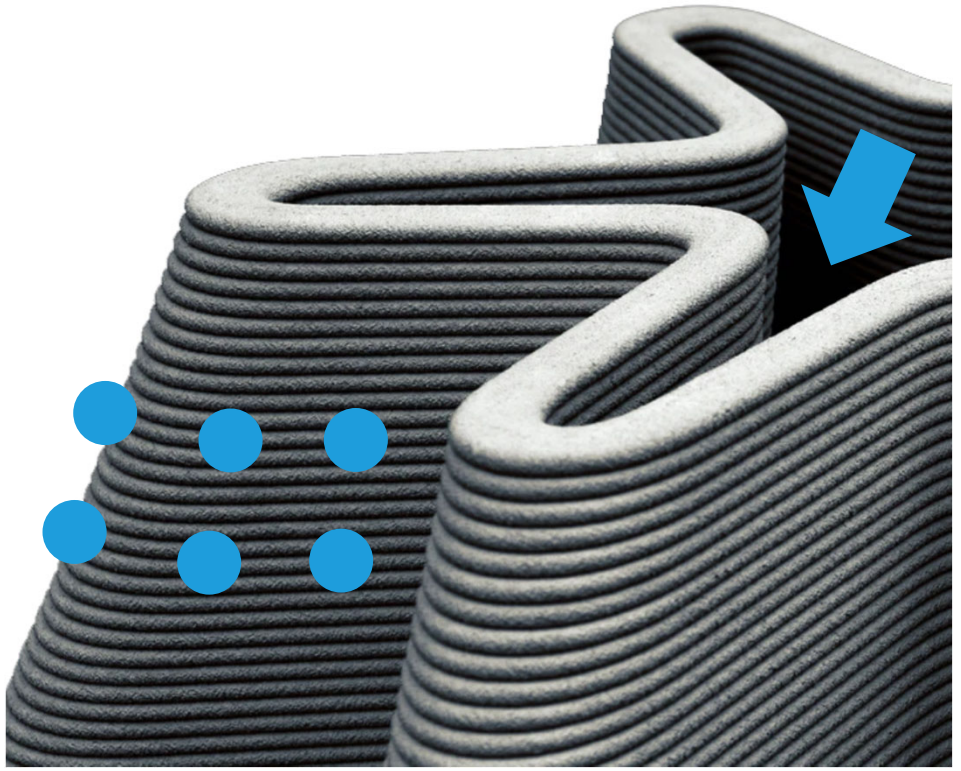
CMM

Well established

Accurate

Large objects

Pros



Cons/limitations

Optical scanner

Entire surface

Large objects

Pros

Cons/limitations

CT

Entire volume

Internal structures

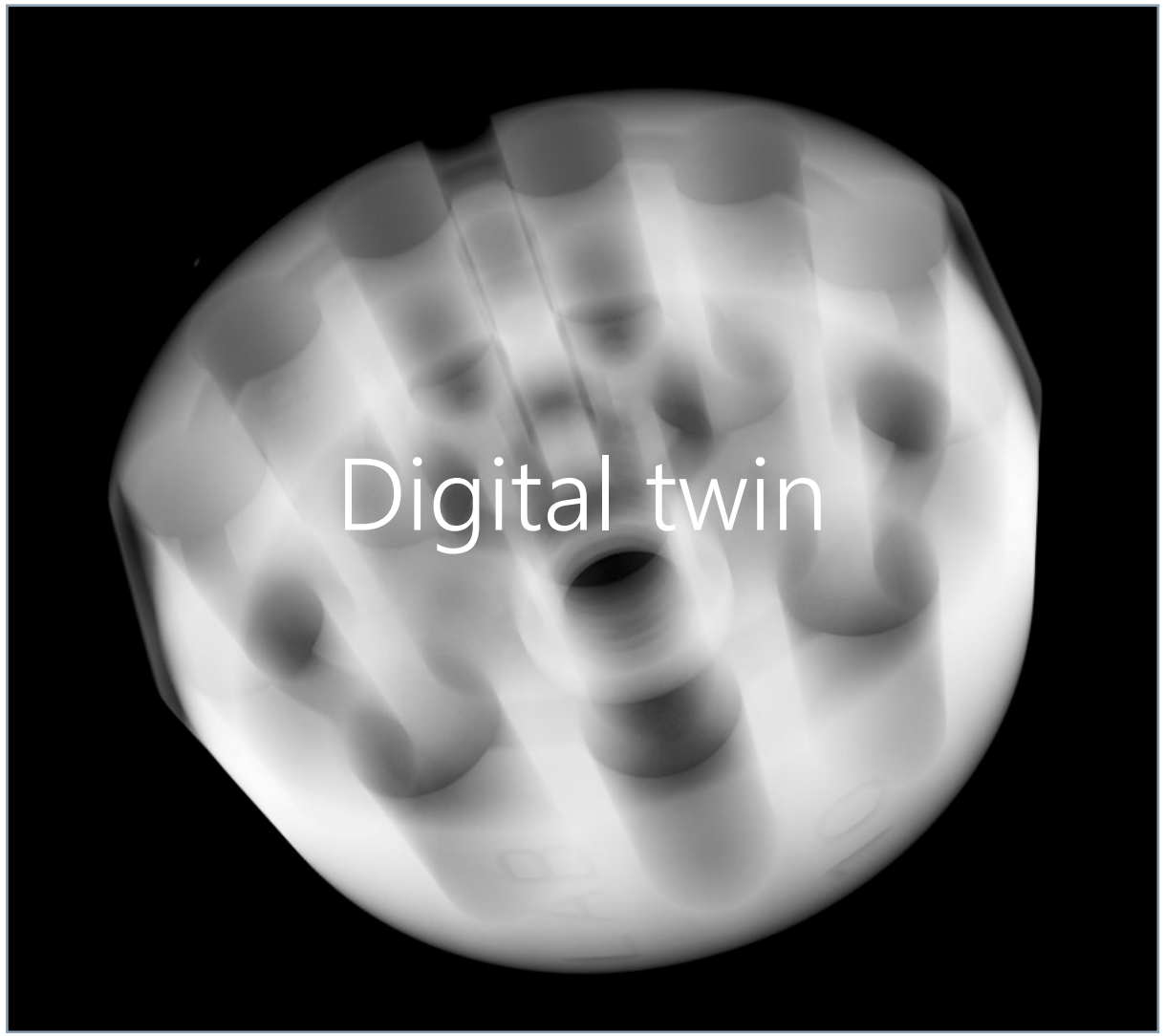
Voids & cracks

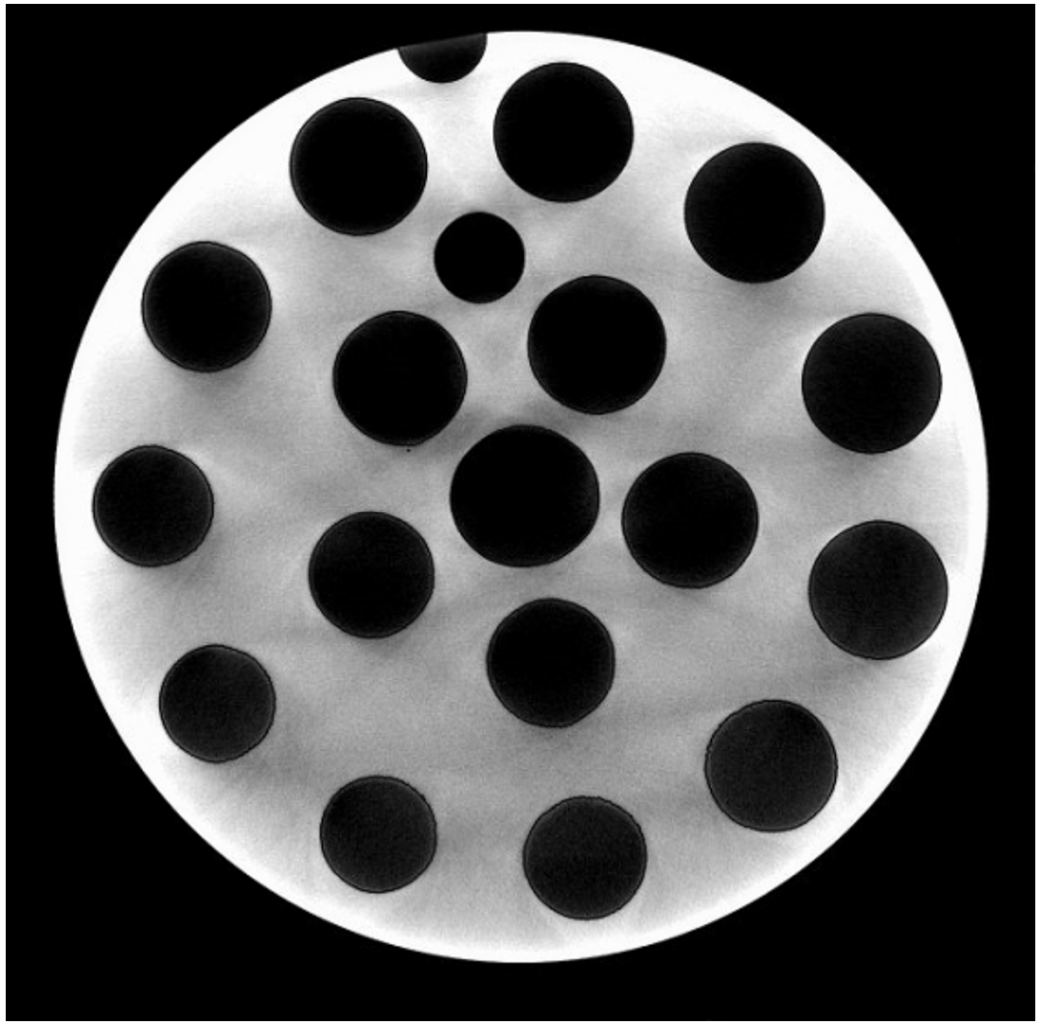
Pros

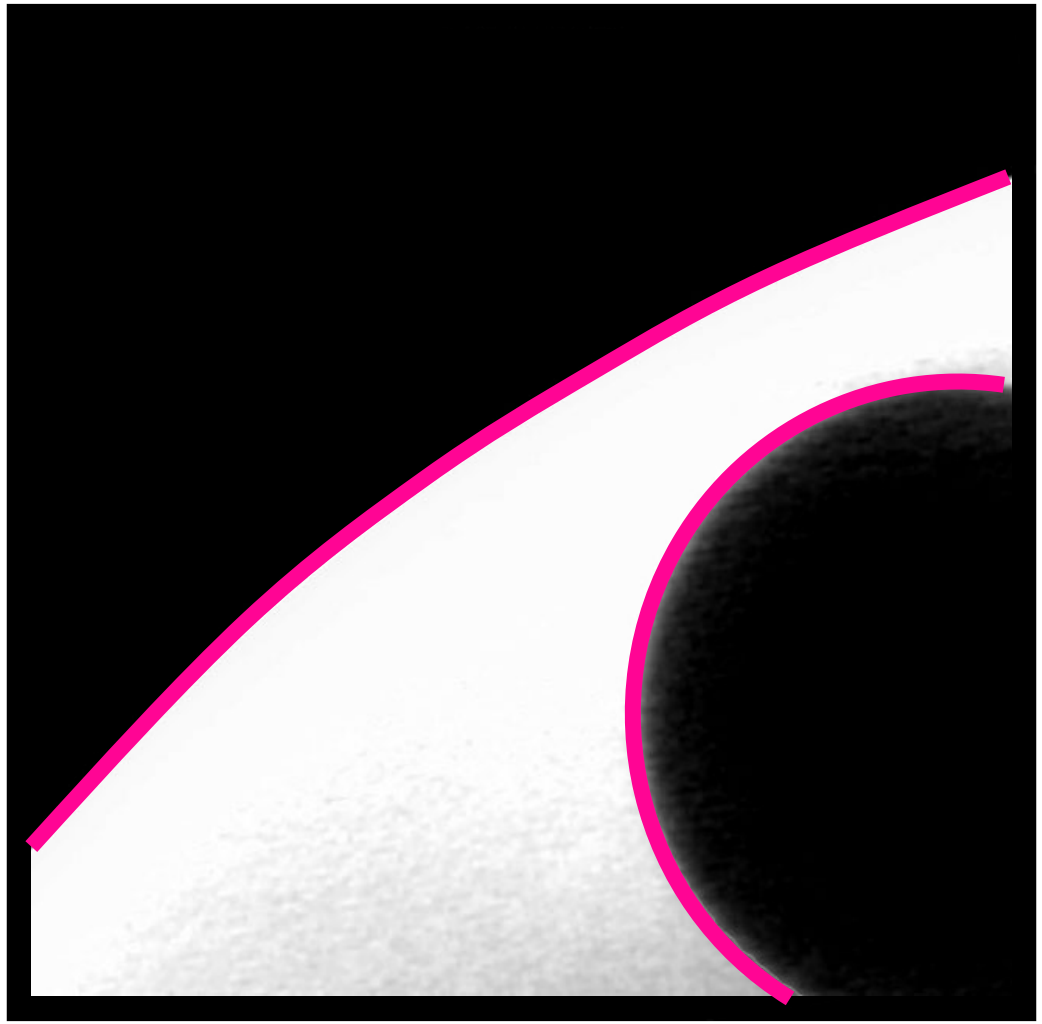
Cons/limitations

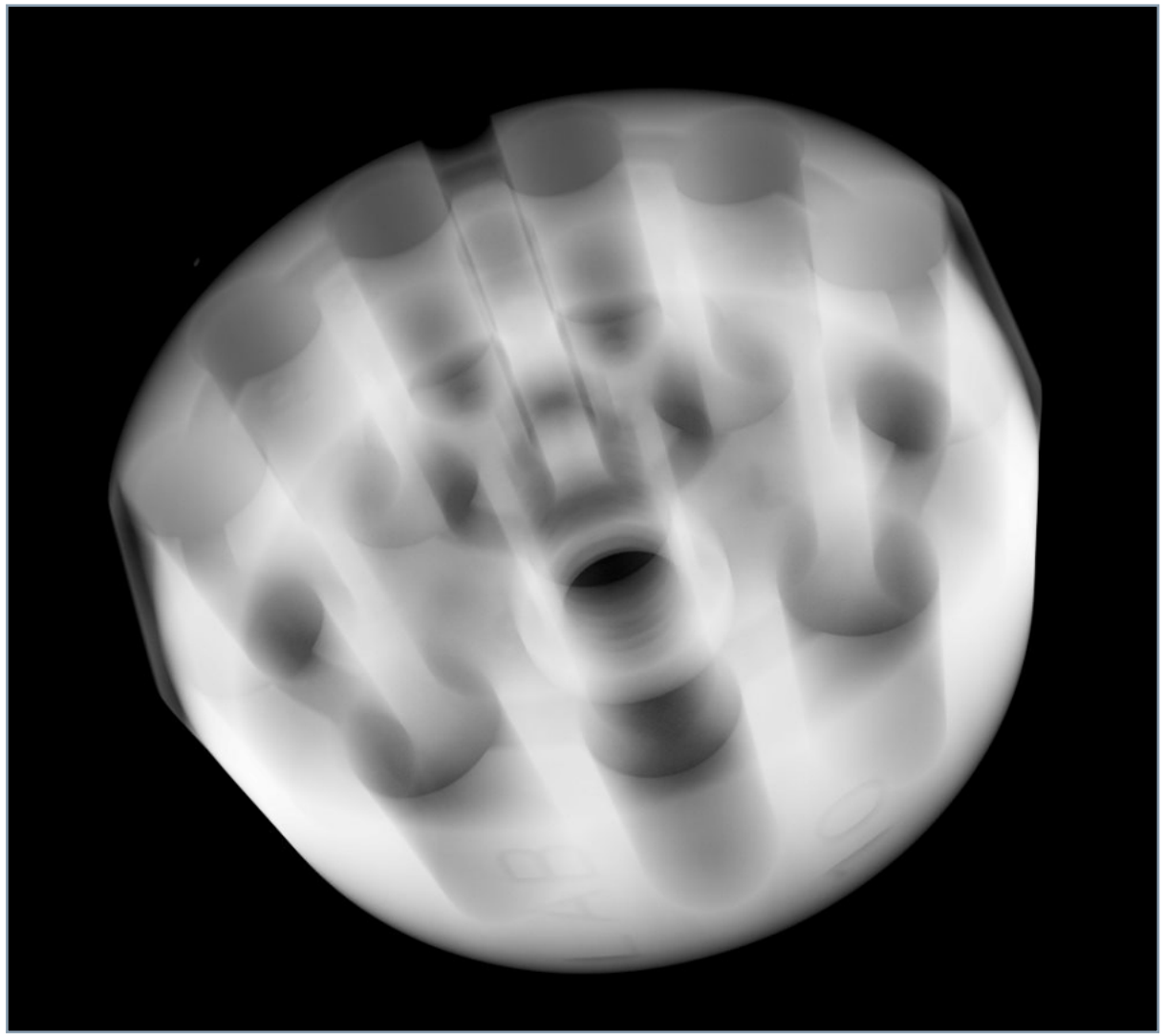
HOW DO WE DEFINE THE SURFACE?

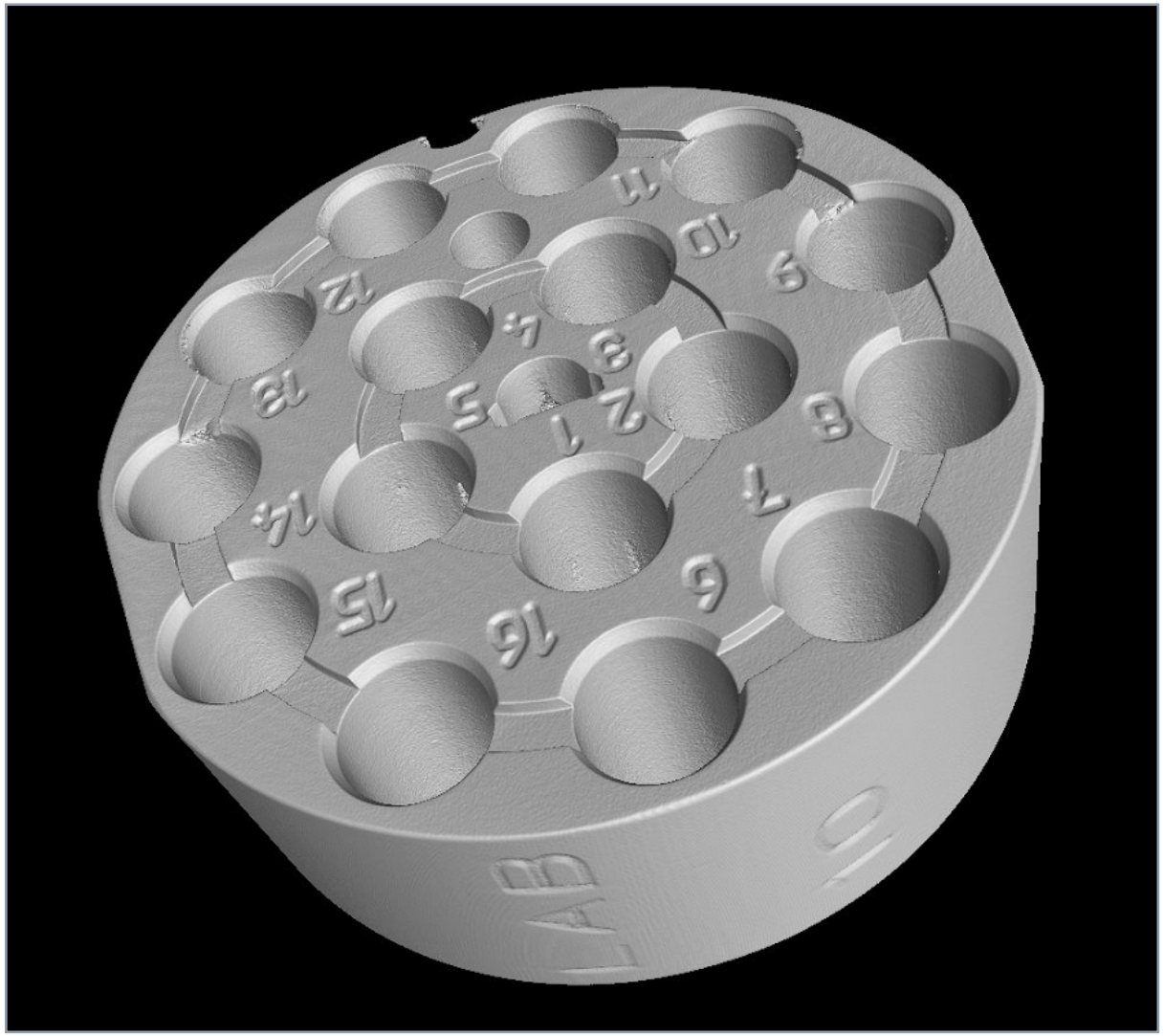

LAB
10

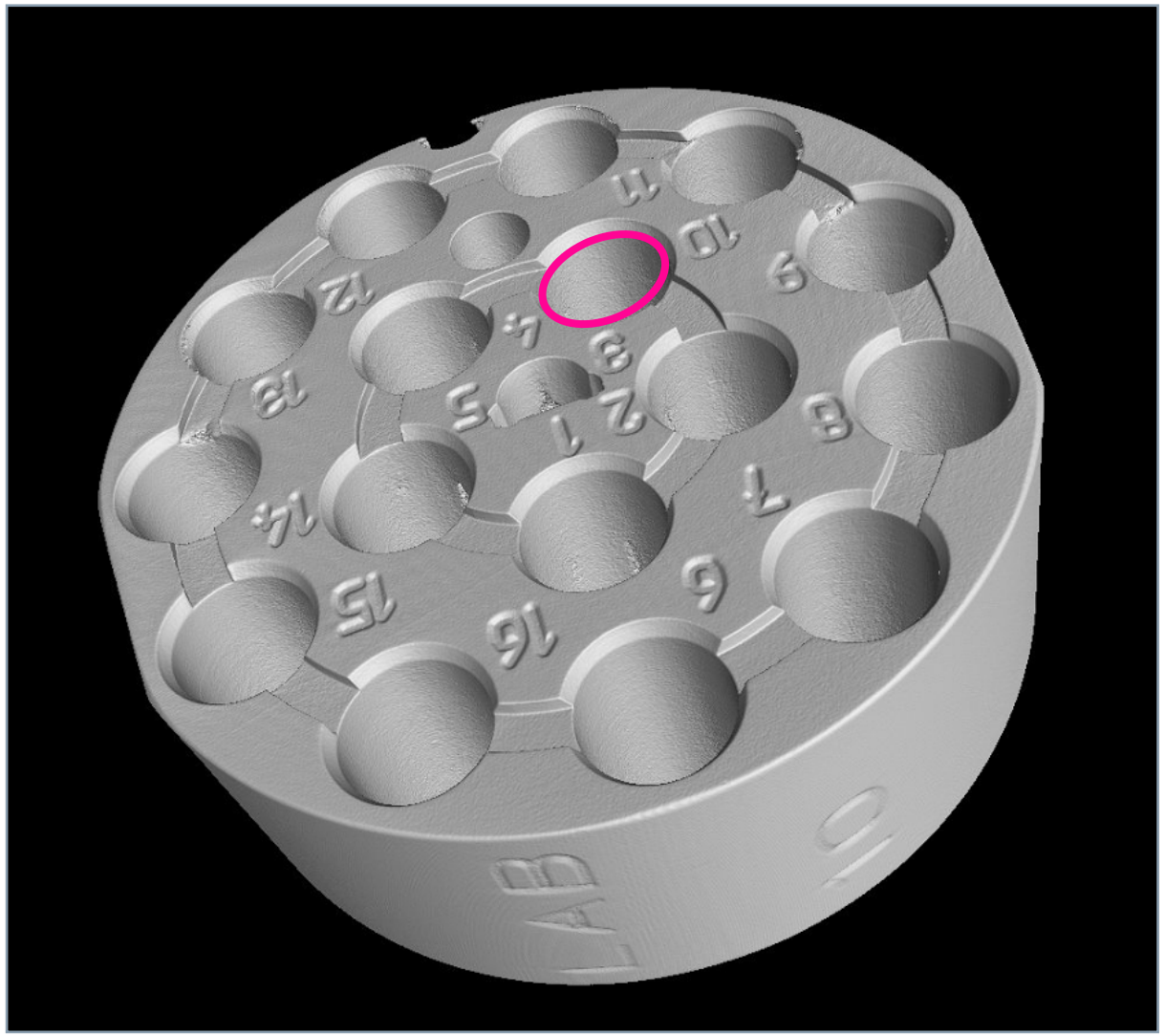

Digital twin

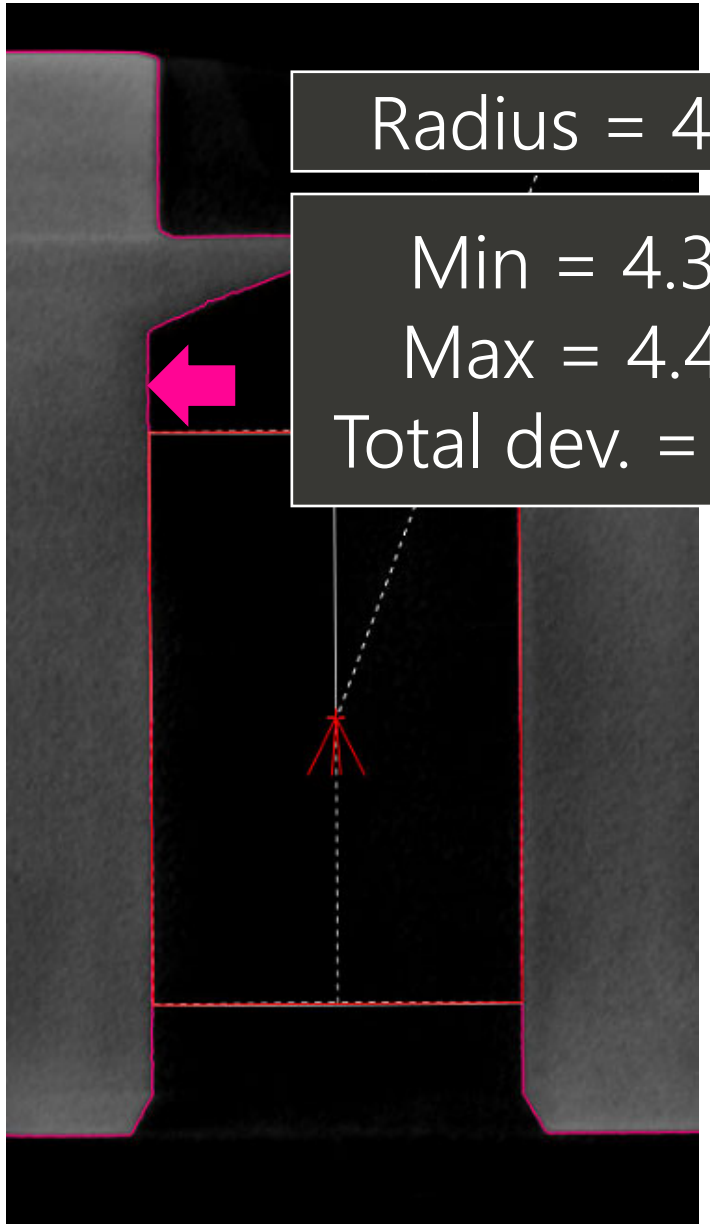


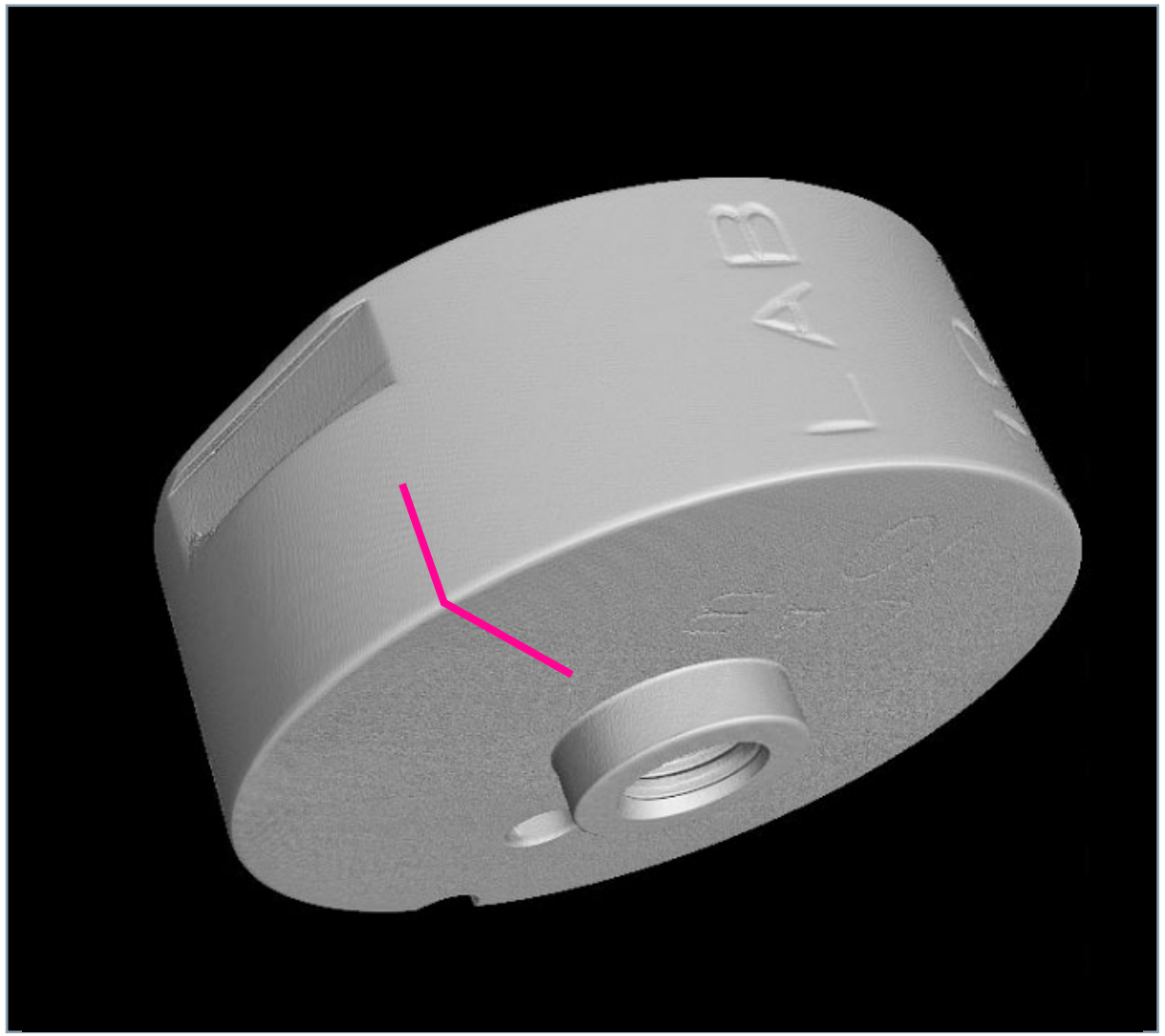


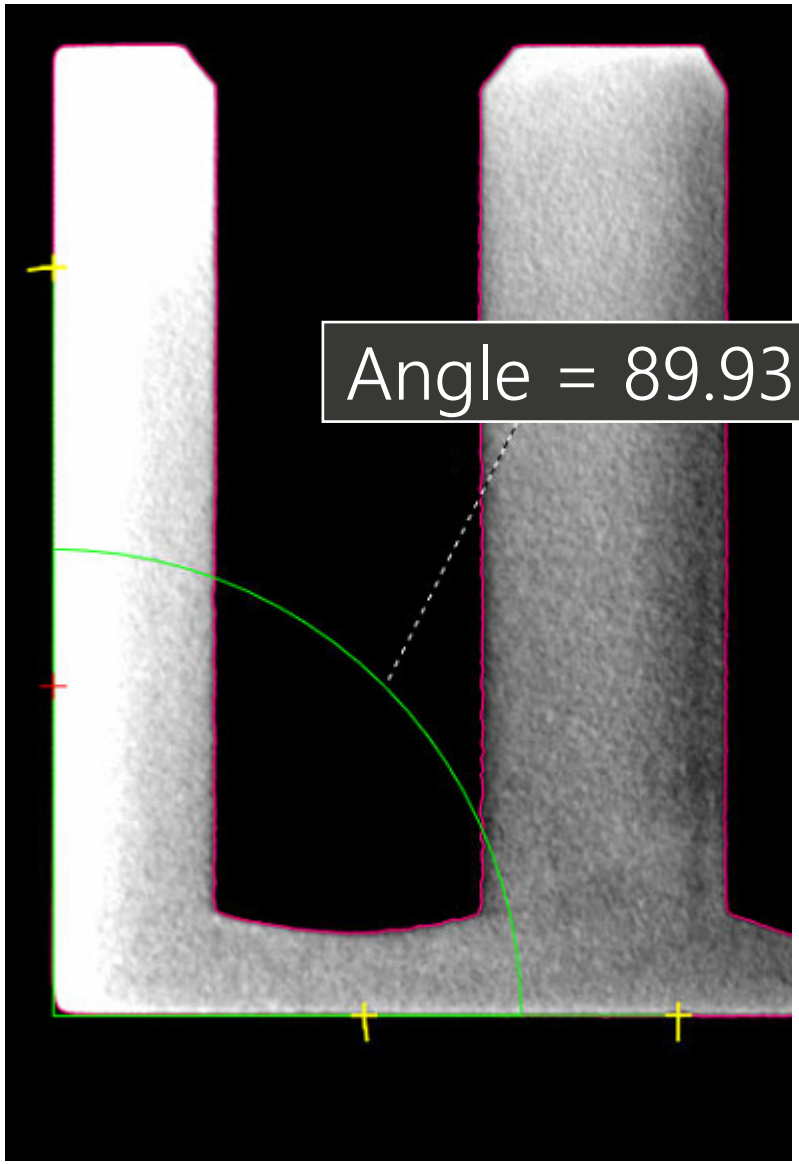



11
10
9
12
4
3
13
5
2
1
8
14
7
15
6
16
LAB 10


17
10
9
12
4
3
13
5
2
1
8
14
7
15
6
16
LAB


Radius = 4.415 mm
Min = 4.333 mm
Max = 4.454 mm
Total dev. = 0.121 mm

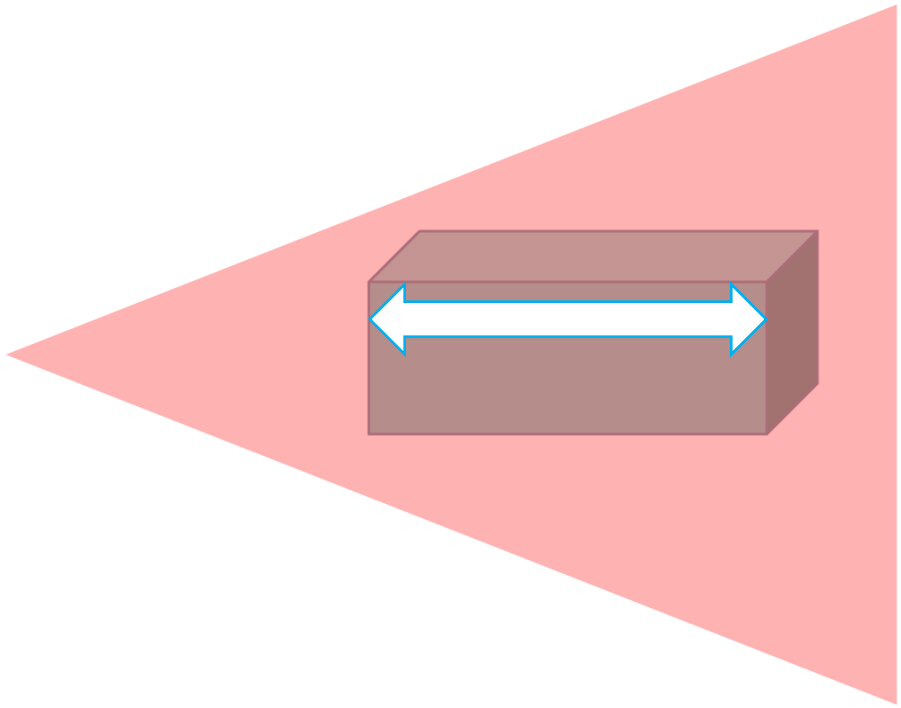


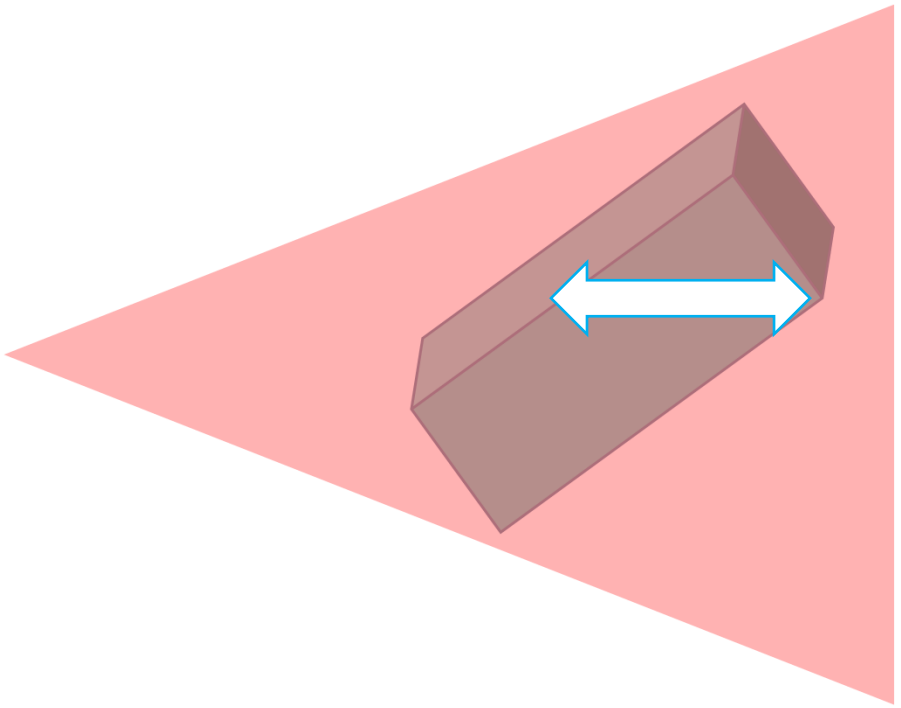

Angle = 89.93 deg

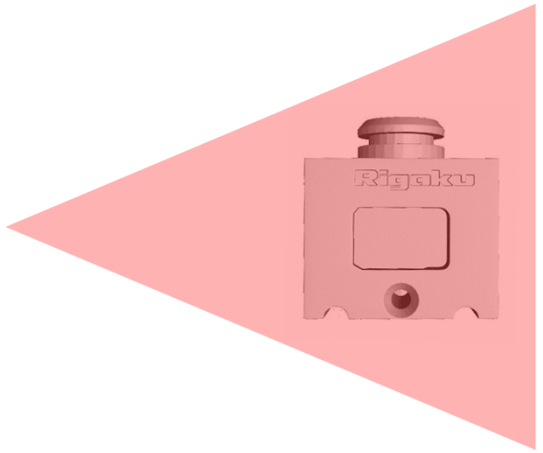
ANY SPECIAL CONSIDERATIONS FOR SCAN CONDITIONS?

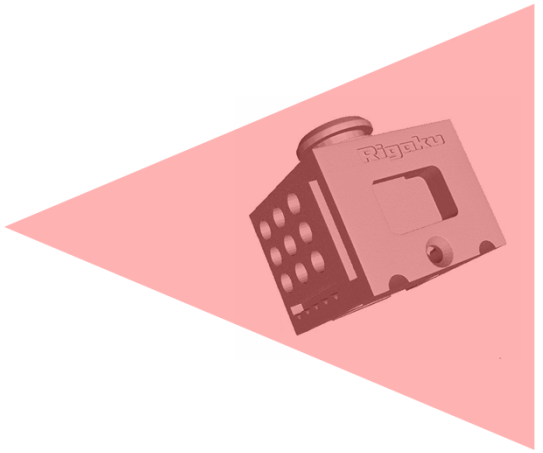
Use high energy for large & dense samples

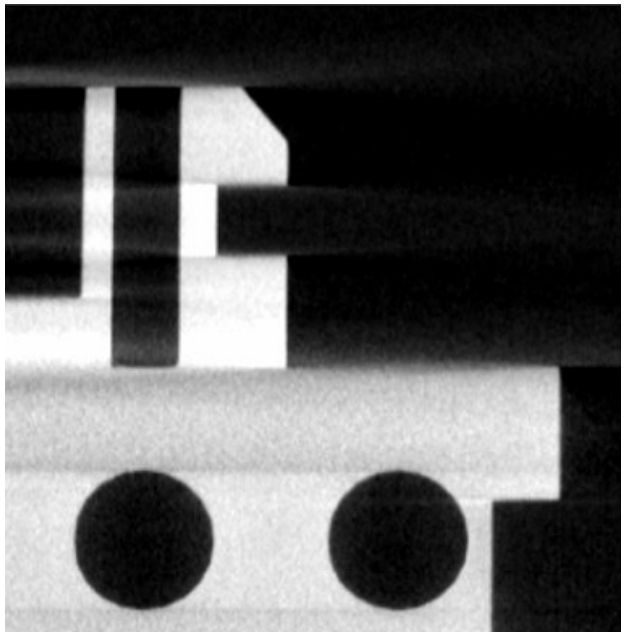
Tilt the sample






Rigaku


Rigaku



Use high energy for large & dense samples

Tilt the sample

HOW PRECISE IS IT?

Resolution

Accuracy

Resolution ~ voxel size x /10

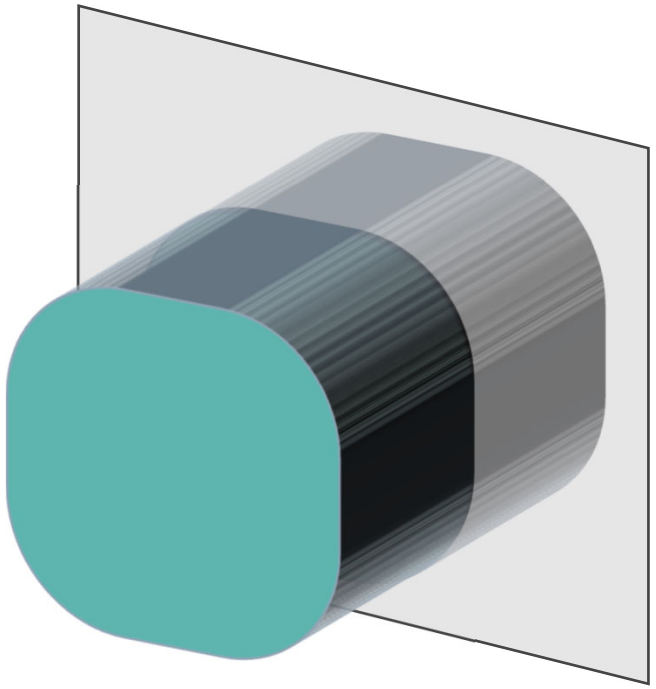
Accuracy ~ ±10 + L/100 µm

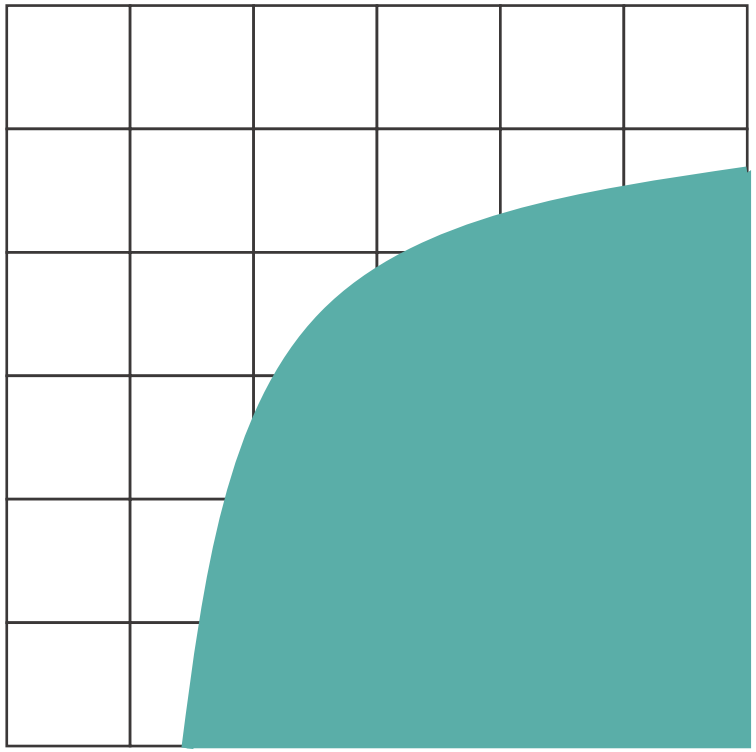
Measured length [mm]

Resolution ~ voxel size x /10

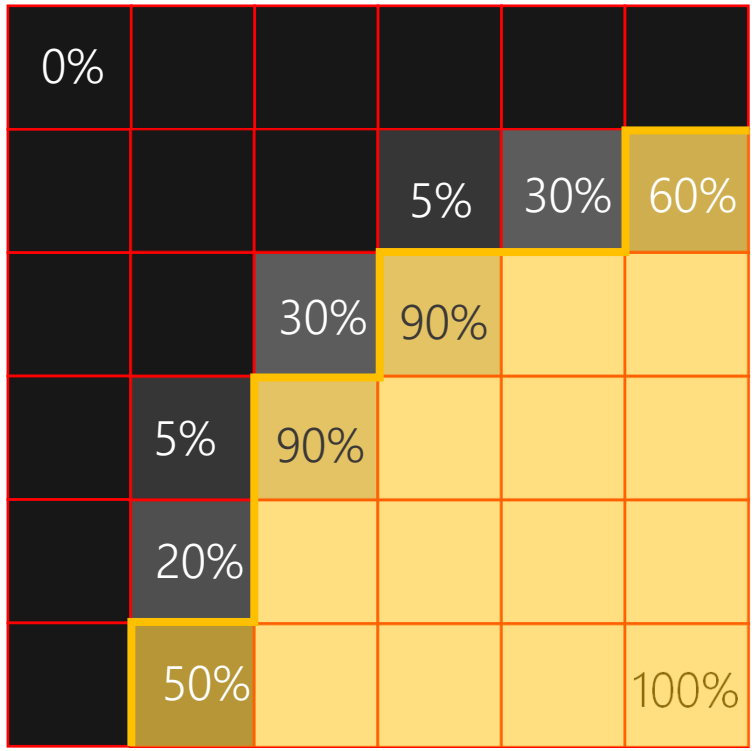
Accuracy ~ ±10 + L/100 µm

HOW CAN WE GET RESOLUTION BETTER THAN THE VOXEL SIZE?

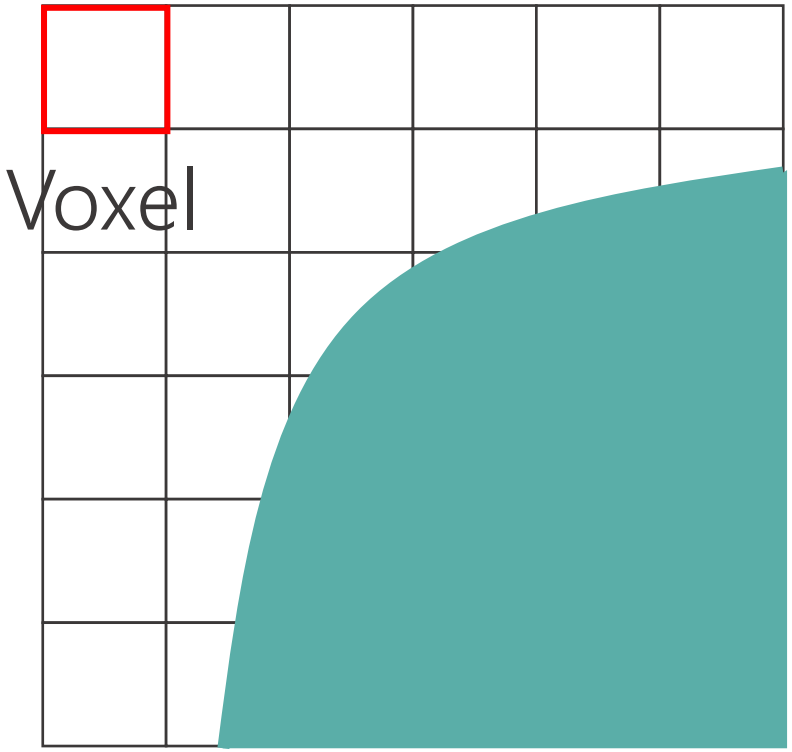




CT

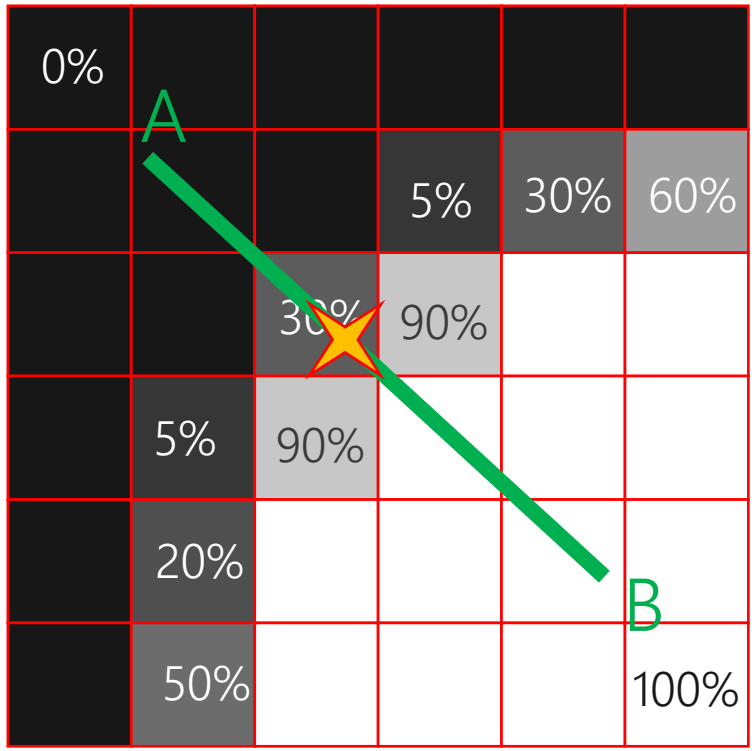


Actual

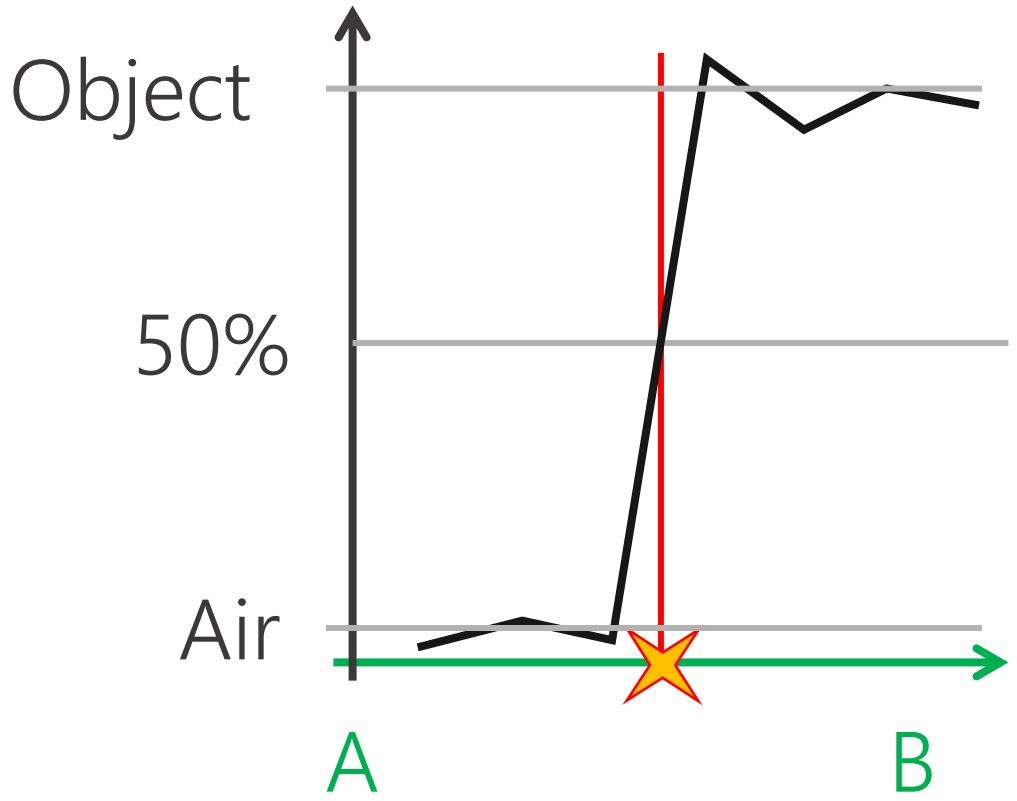


Voxel value thresholding at 50%

CT

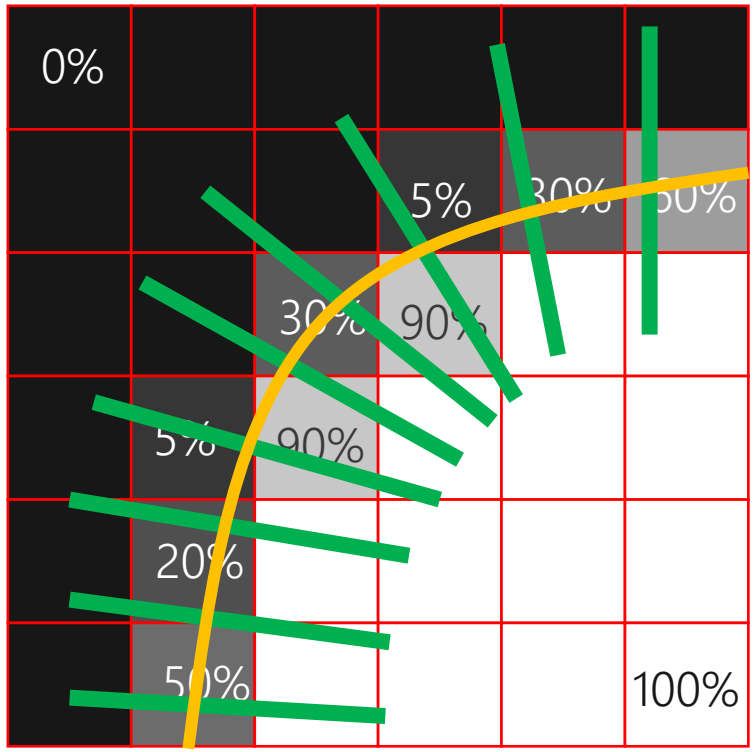


Gray value

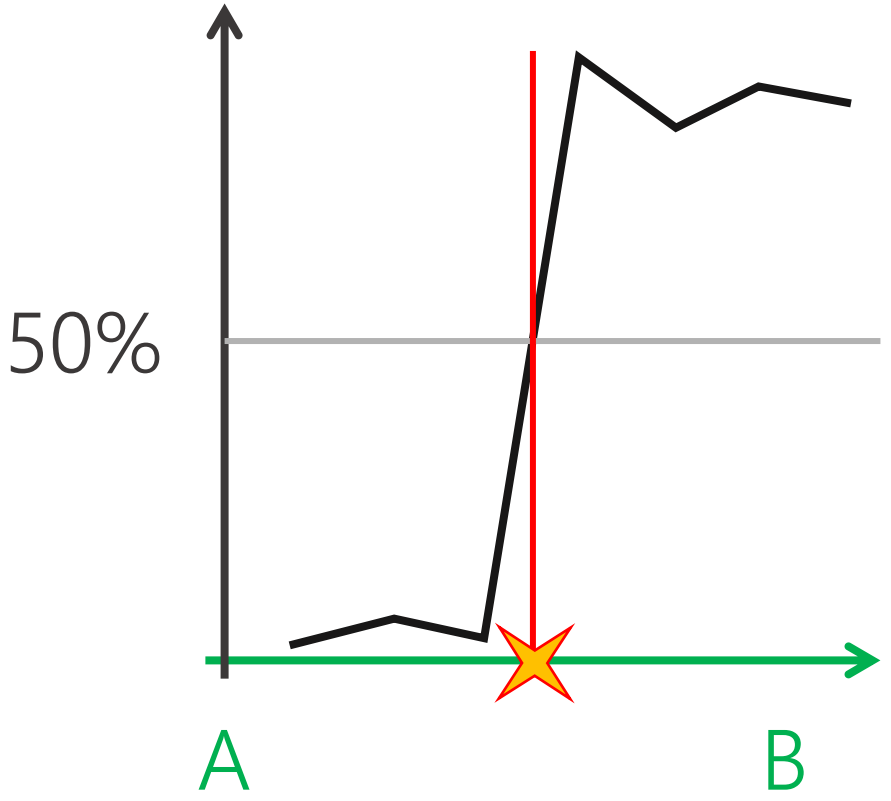


ISO50 surface determination

CT

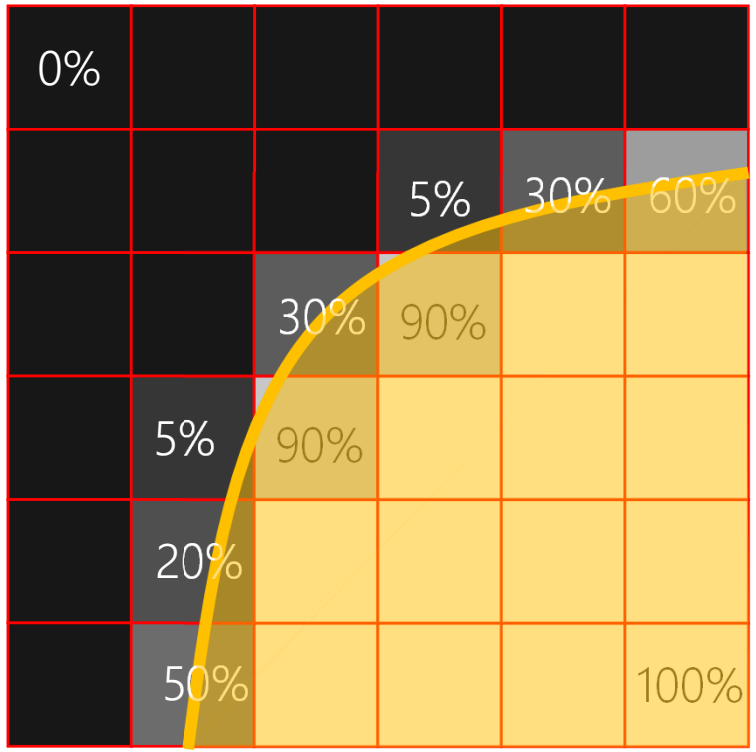


Gray value

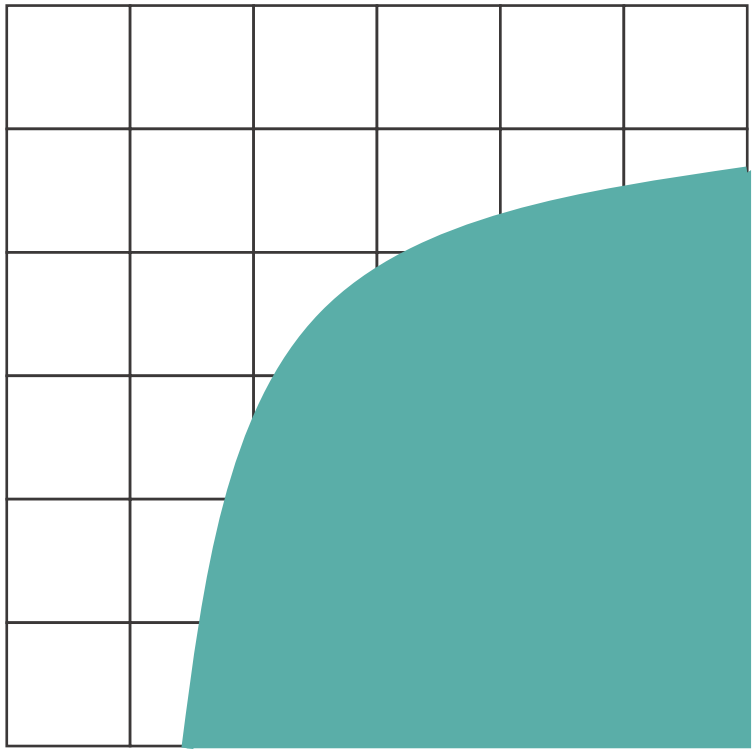


ISO50 surface determination

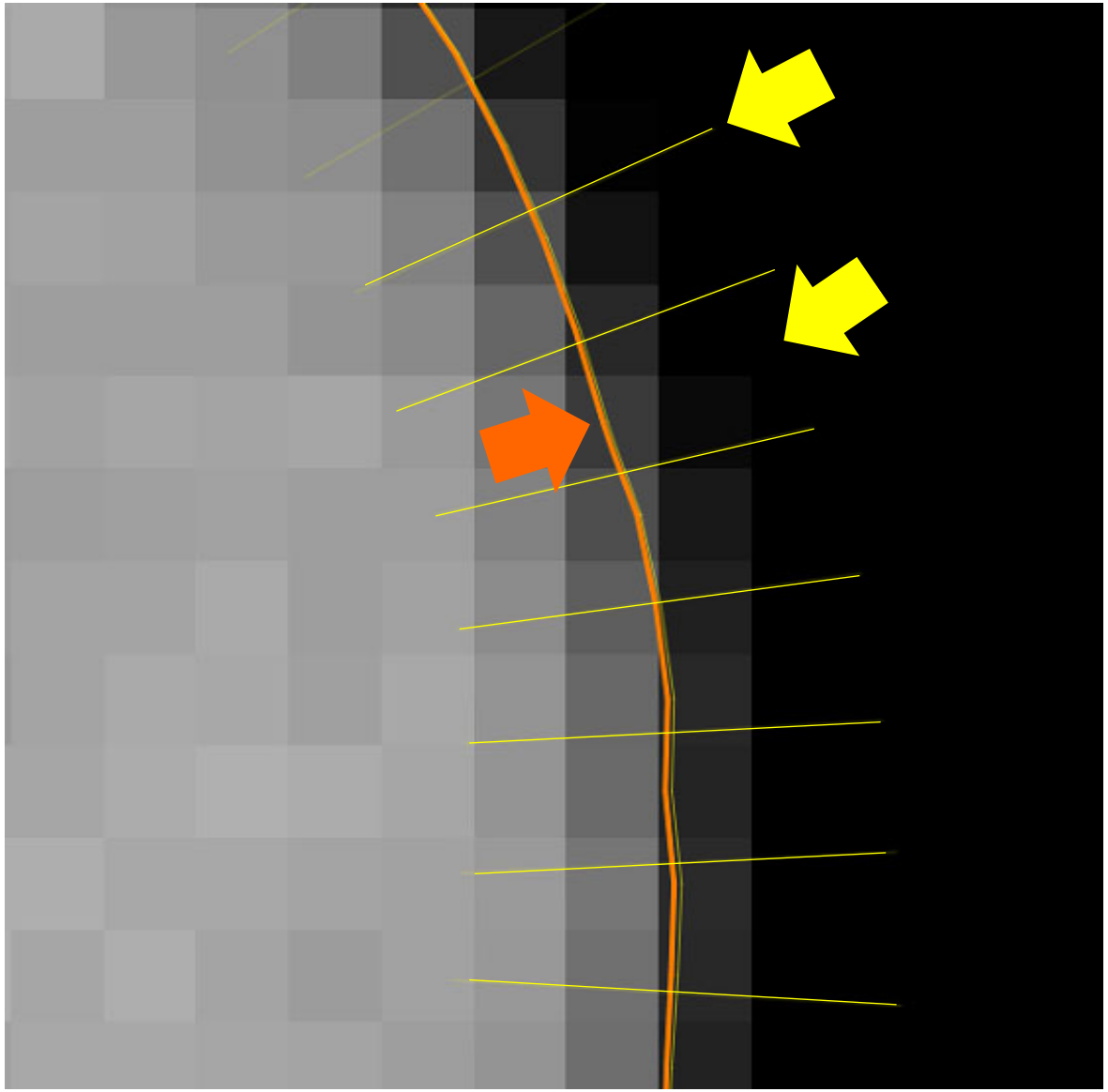
CT

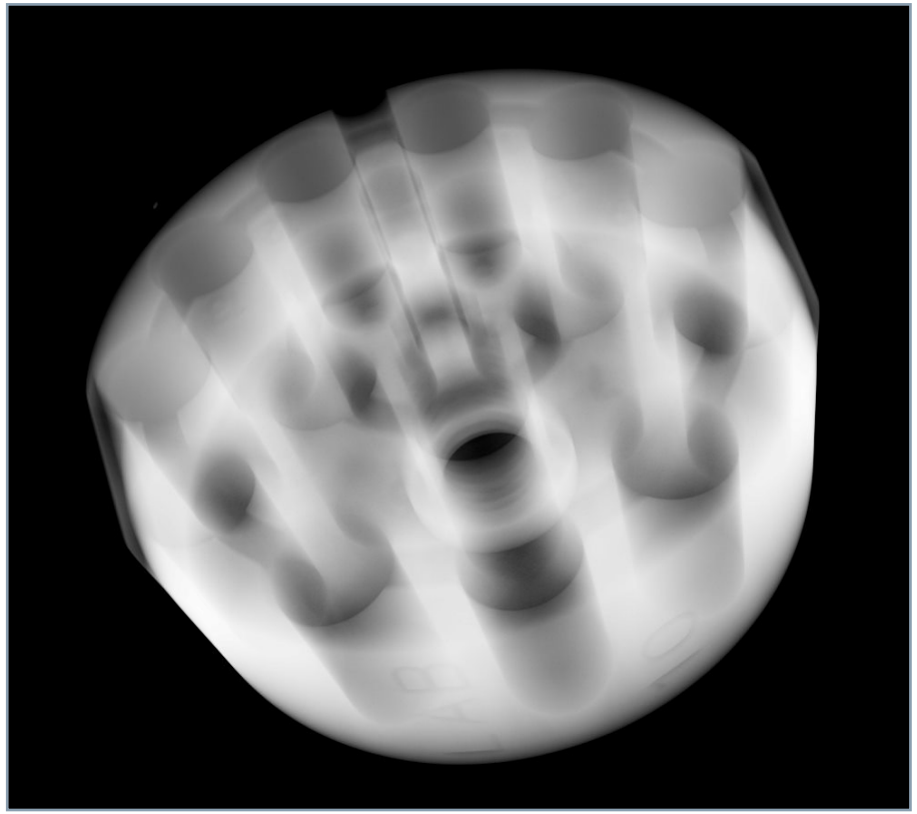


Actual



ISO50 surface determination





Voxel = 69.5 µm

Resolution ~ 7 µm

WHAT SOFTWARE CAN DO THIS?

https://www.volumegraphics.com

Resolution ~ voxel size x /10

Accuracy ~ ± 10 + L/100 µm

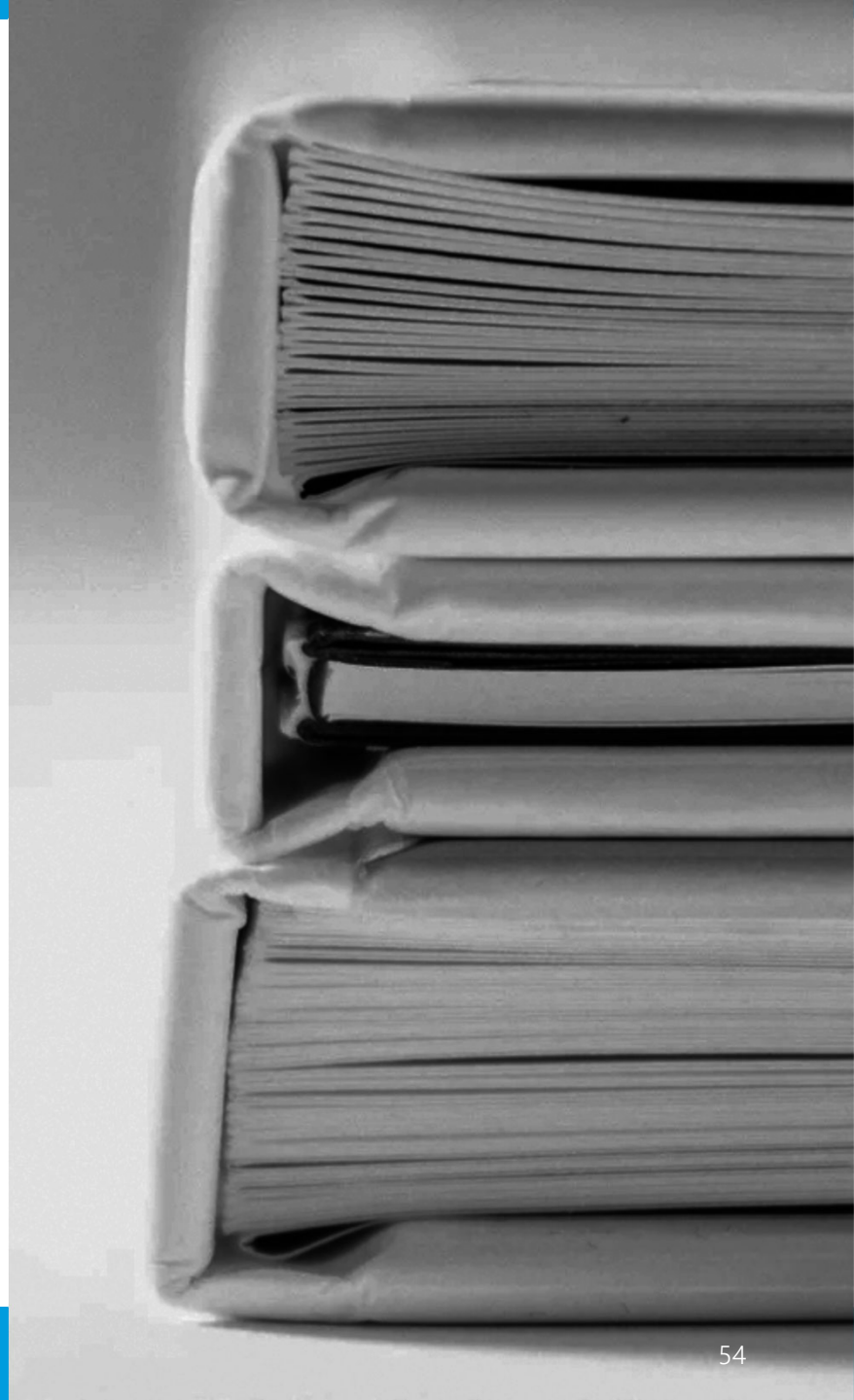
HOW DO WE DEFINE THE ACCURACY?

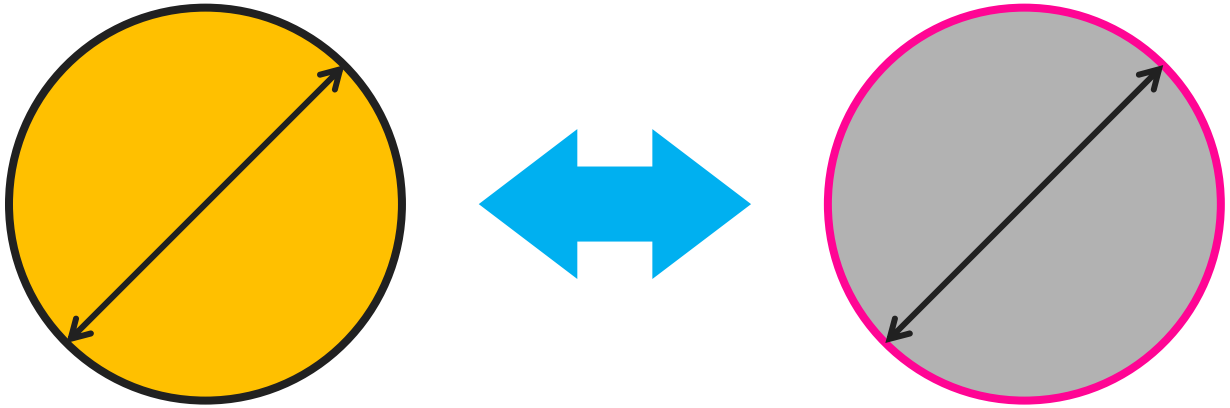
ASTM E1441-19 etc.

VDI/VDE 2630

ASME B89.4.23

ISO 10360-11

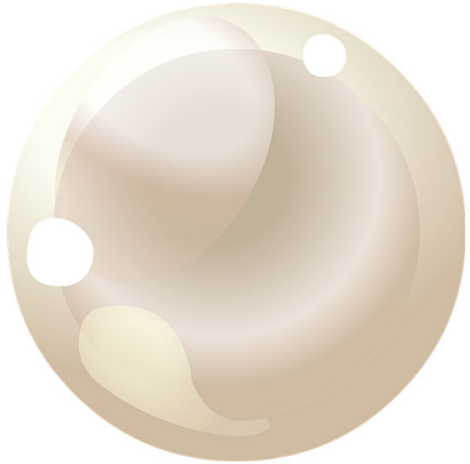




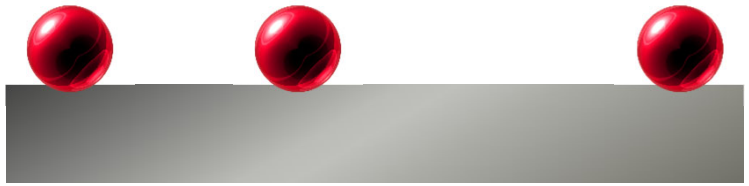
Calibrated standard

CT measurement

Correct systematic shifts



Precision ceramic sphere

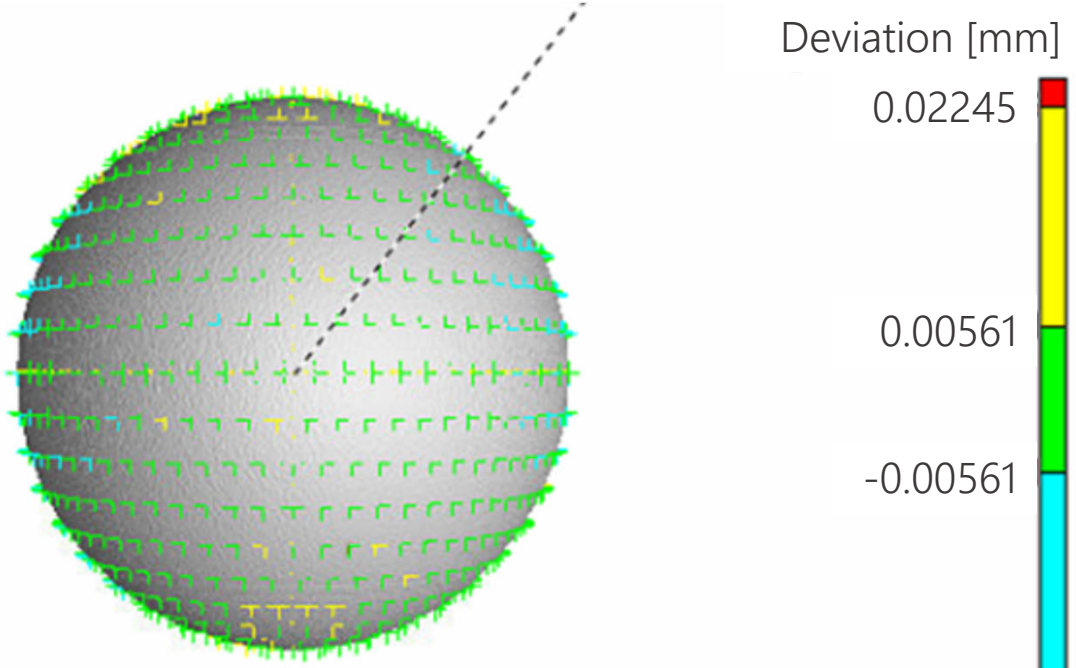


CMM calibrated fixture

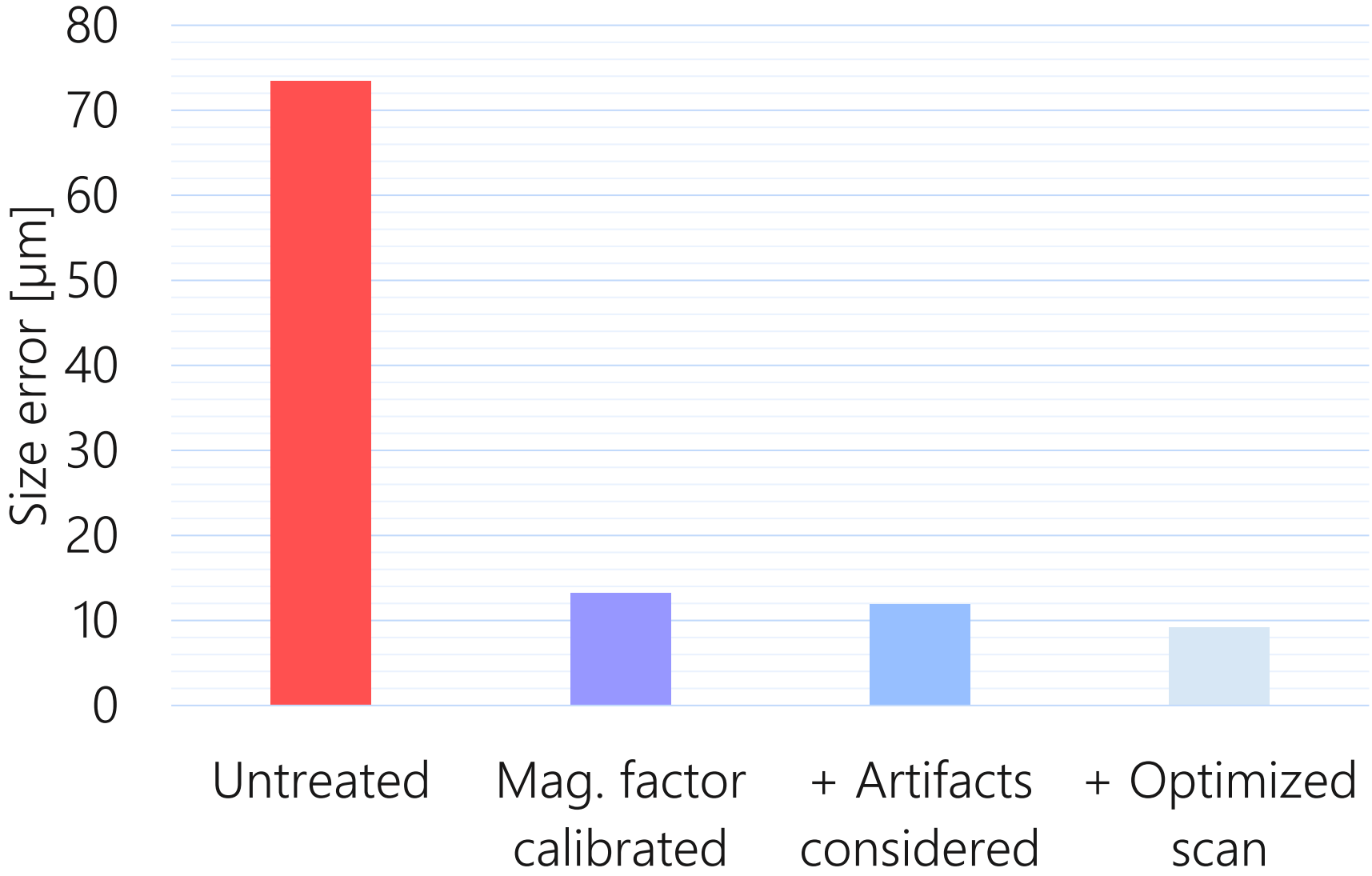
CT Lab HX

Goodfellow AL606895
Alumina sphere
Certified diameter = 20 ± 0.00125 mm

Fitted radius = 10.0027 mm
(Certified radius: 10.00 mm)



1,100 points fitted


80
70
60
50
40
30
20
10
0
Size error [µm]
Untreated
Mag. factor calibrated
+ Artifacts considered
+ Optimized scan

Resolution ~ voxel size x /10

Accuracy ~ ± 10 + L/100 µm

CT metrology can see

Entire volume

Internal structures

Voids & cracks

with < 10 µm accuracy

Make sure to

Run calibration

Be aware of artifacts

Optimize scan conditions

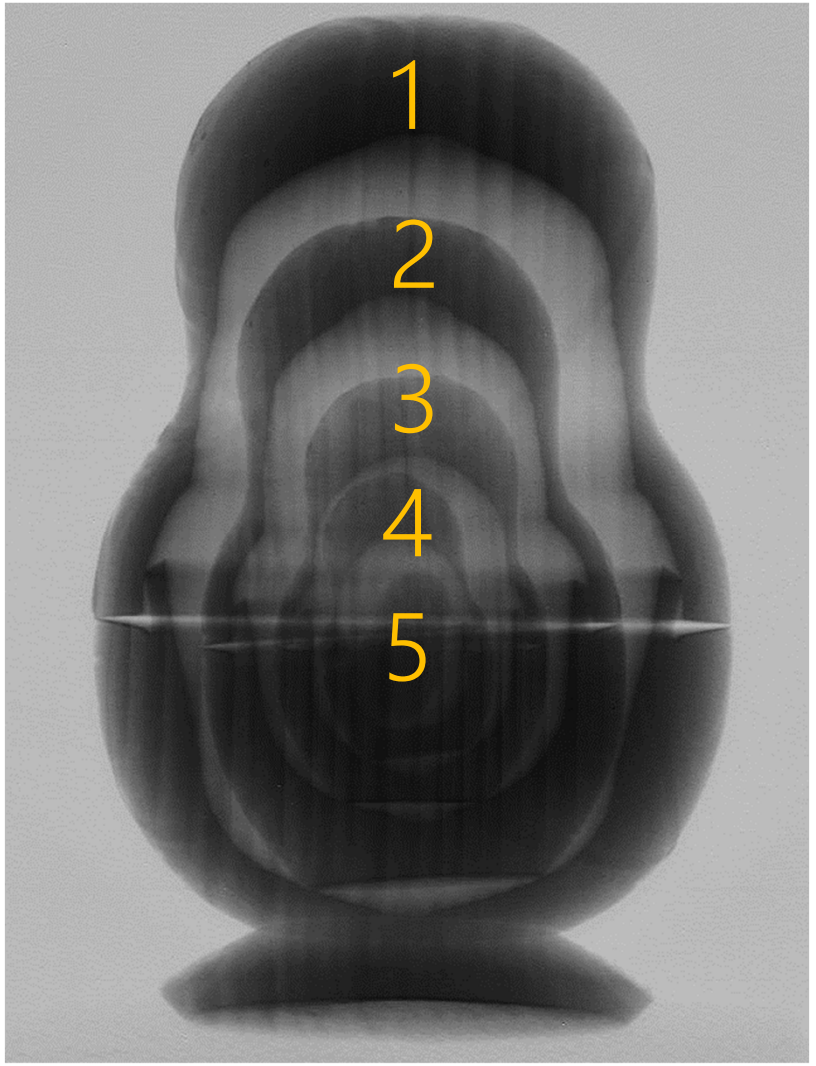
WHEN IS CT METROLOGY USEFUL?

METROLOGY APPLICATIONS

- Dimension measurements
- Internal dimensions
- Air gaps
- Voids and cracks
- GD&T analysis
- Nominal vs. actual comparison
- Reverse engineering
- Mechanical simulations

CAN WE MEASURE INTERNAL DIMENSIONS?

Matryoshka doll



Matryoshka doll

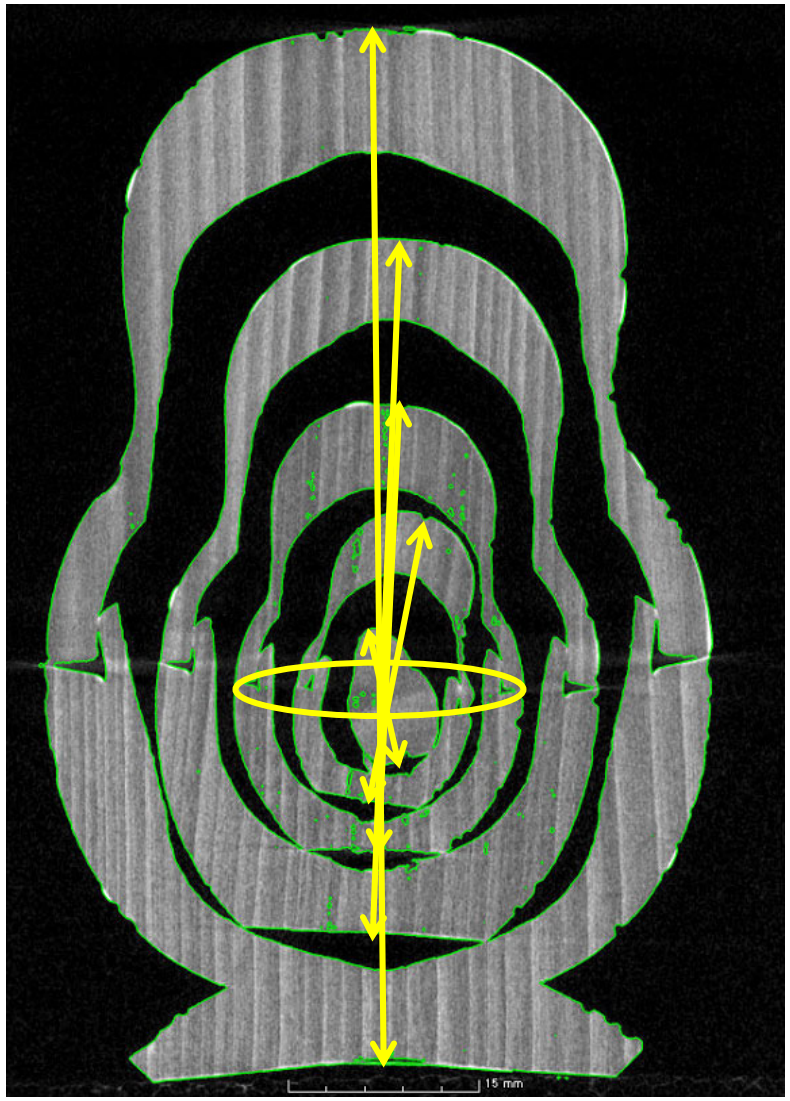
81.626 mm

54.813 mm

35.124 mm

22.976 mm

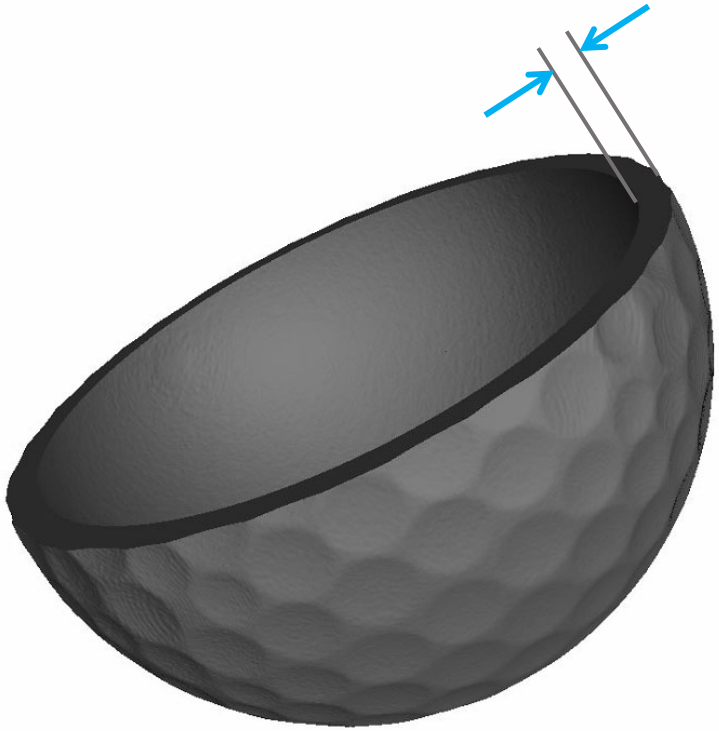
10.593 mm



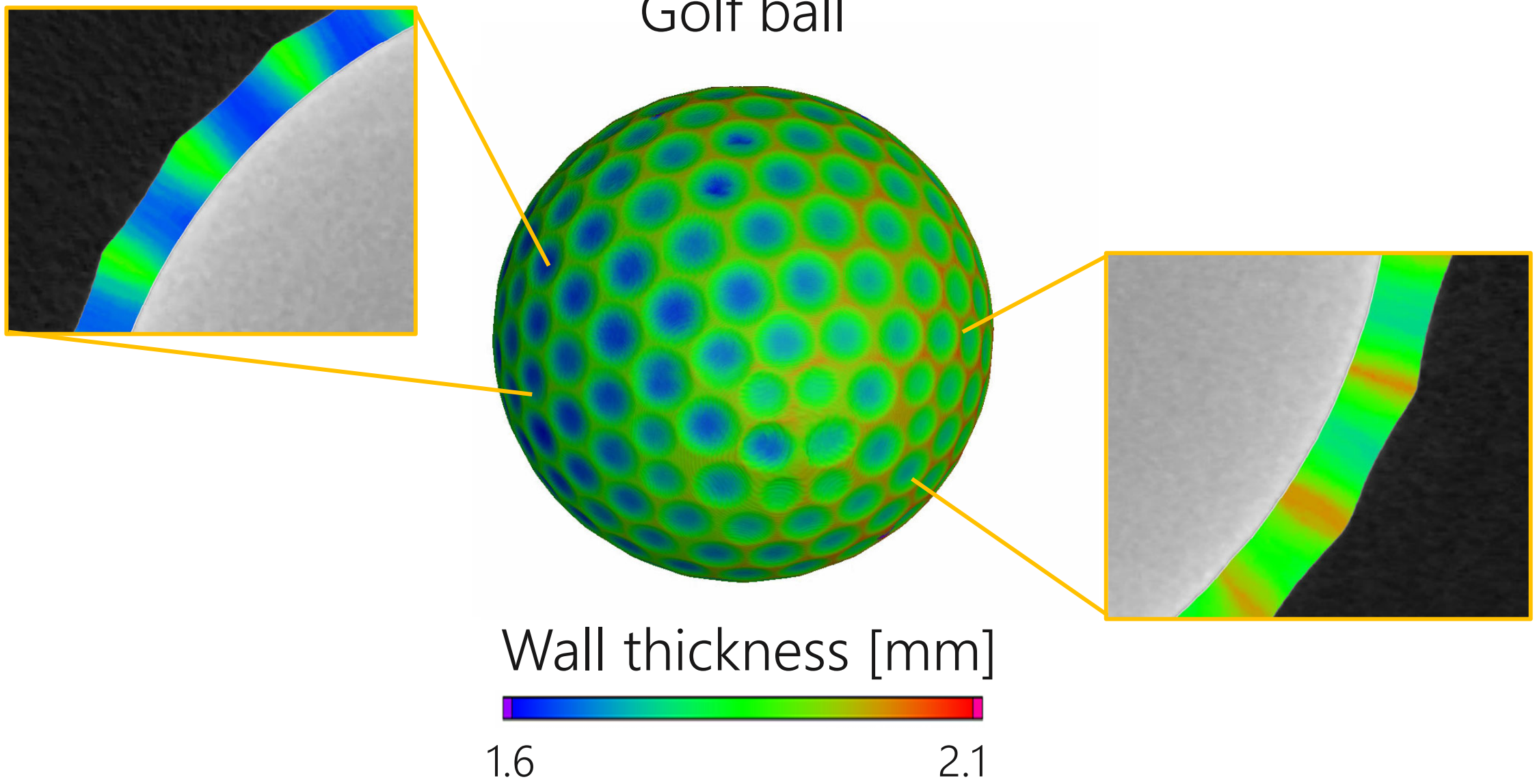
141.06 mm

Golf ball

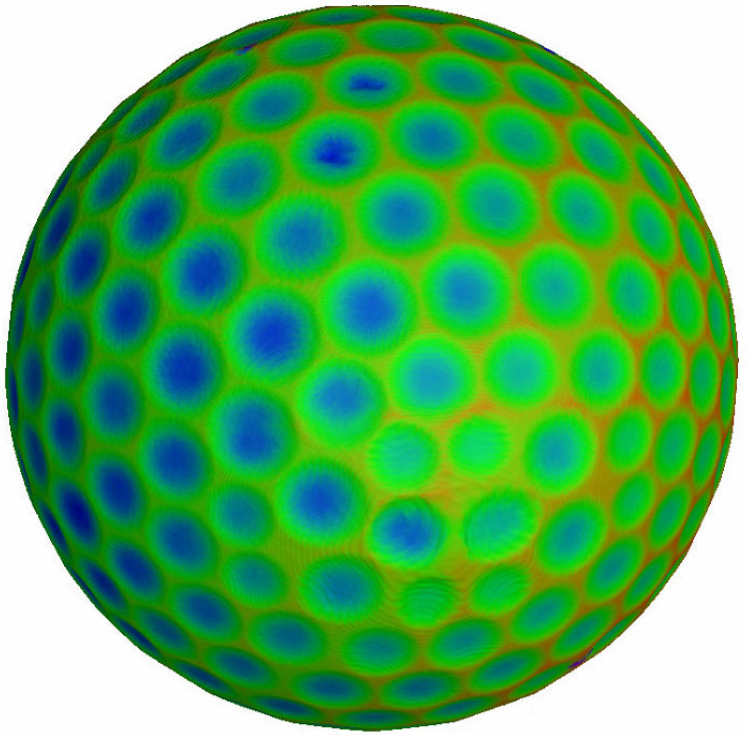
Golf ball



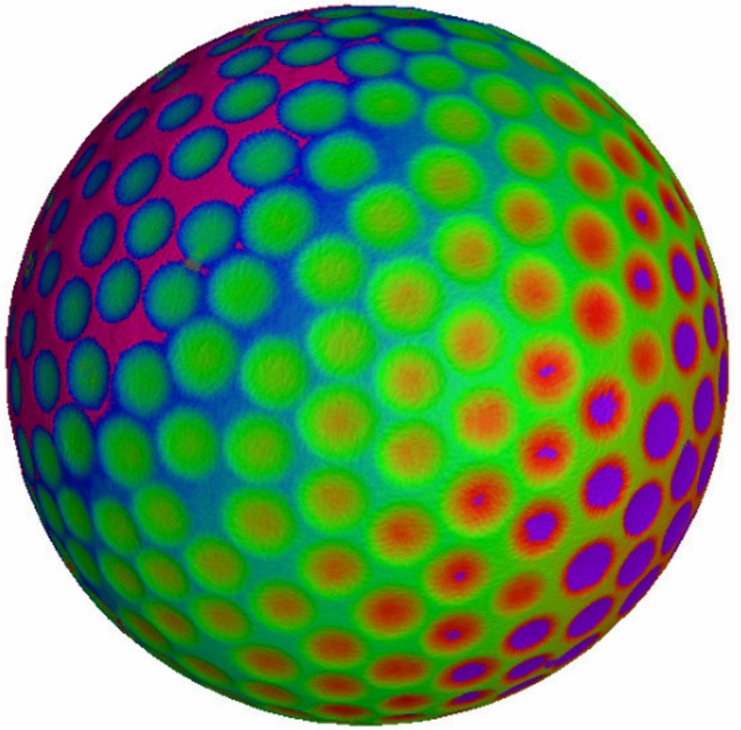
Golf ball



~ $50/dozen



~ $12/dozen



Wall thickness deviation [mm]

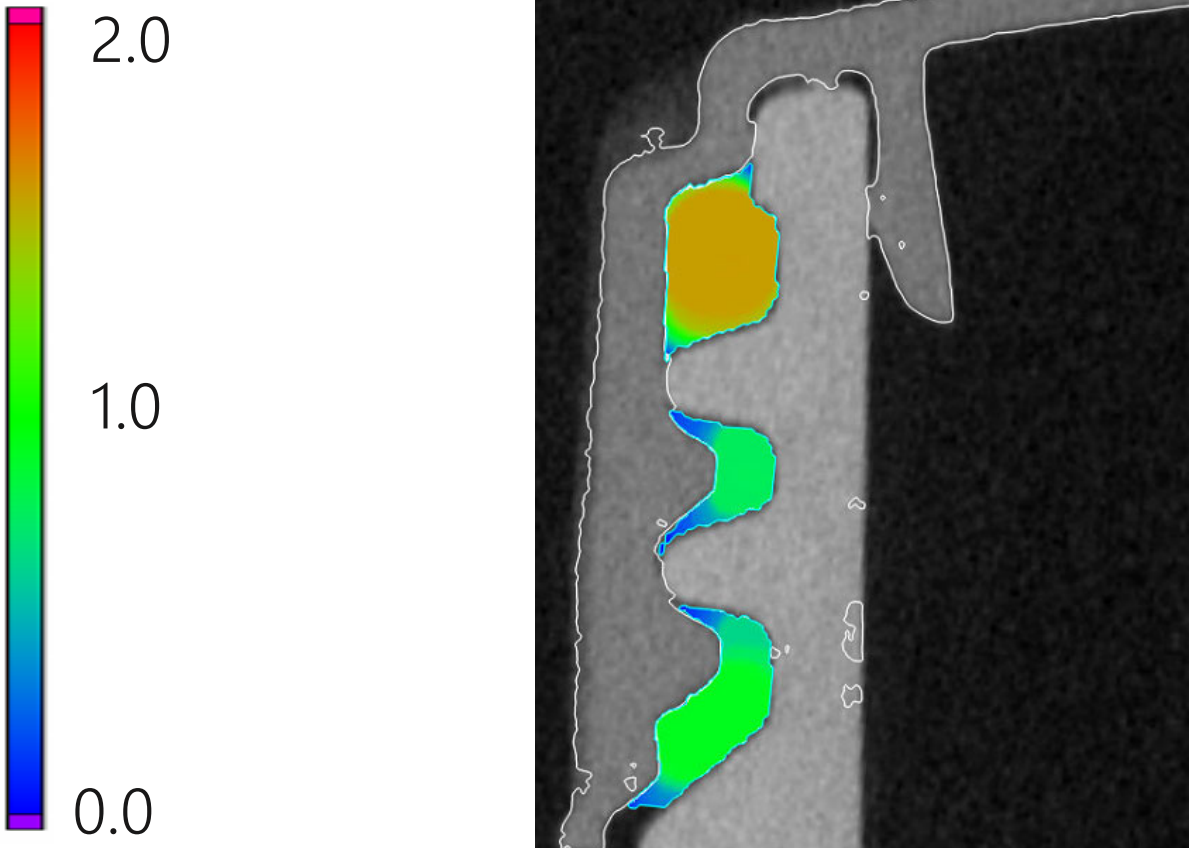
1.6 2.1

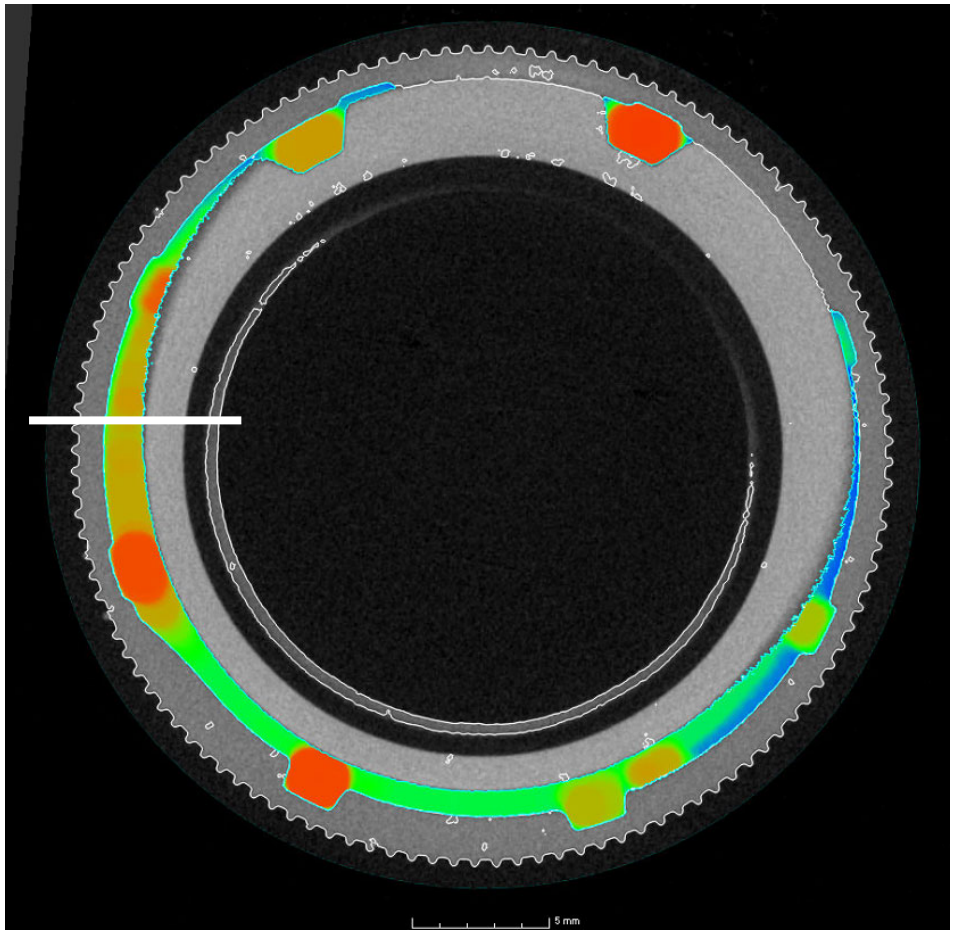
CAN WE MEASURE AIR (GAPS, VOIDS)?

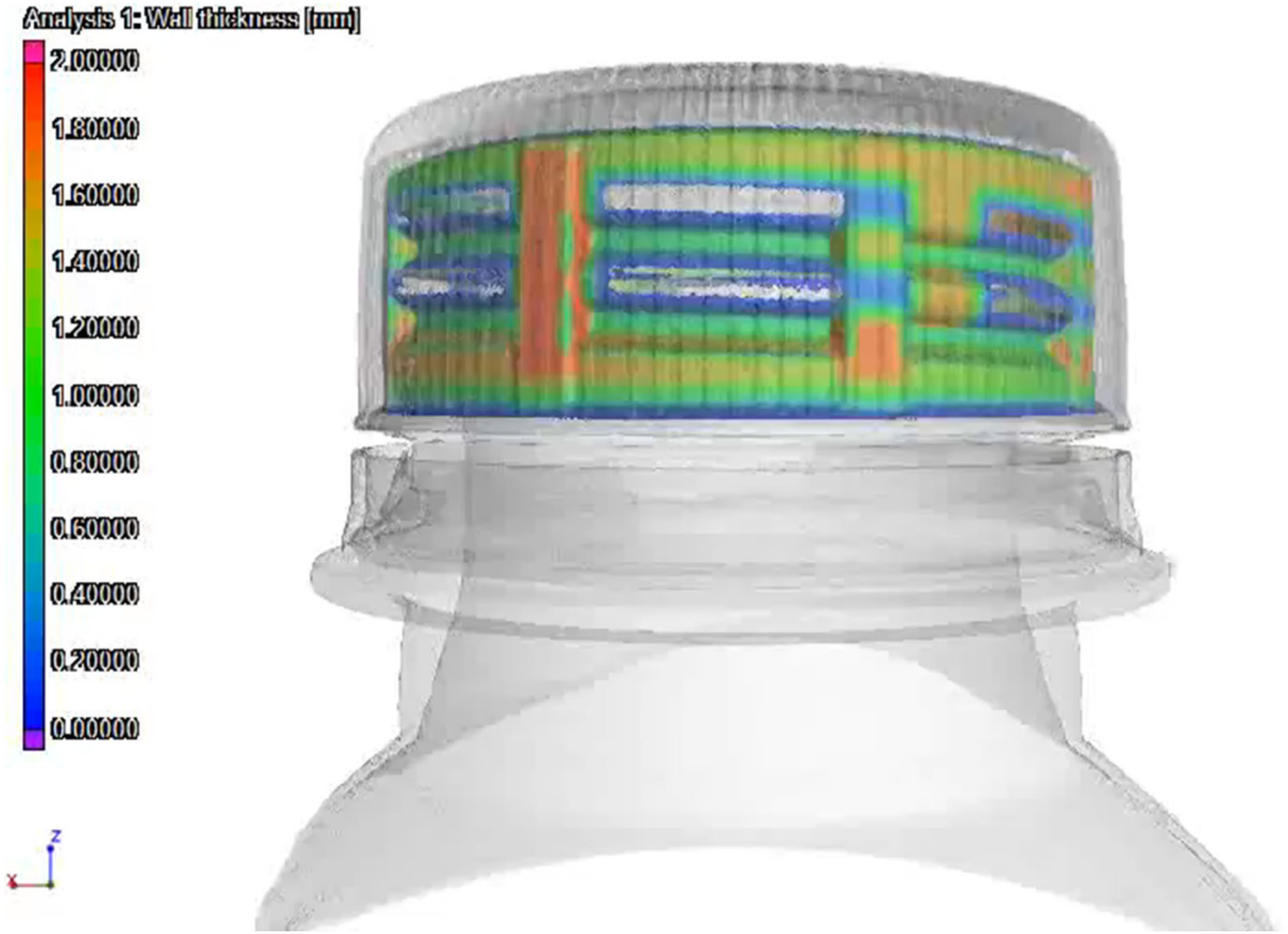
Bottle cap

Air gap thickness

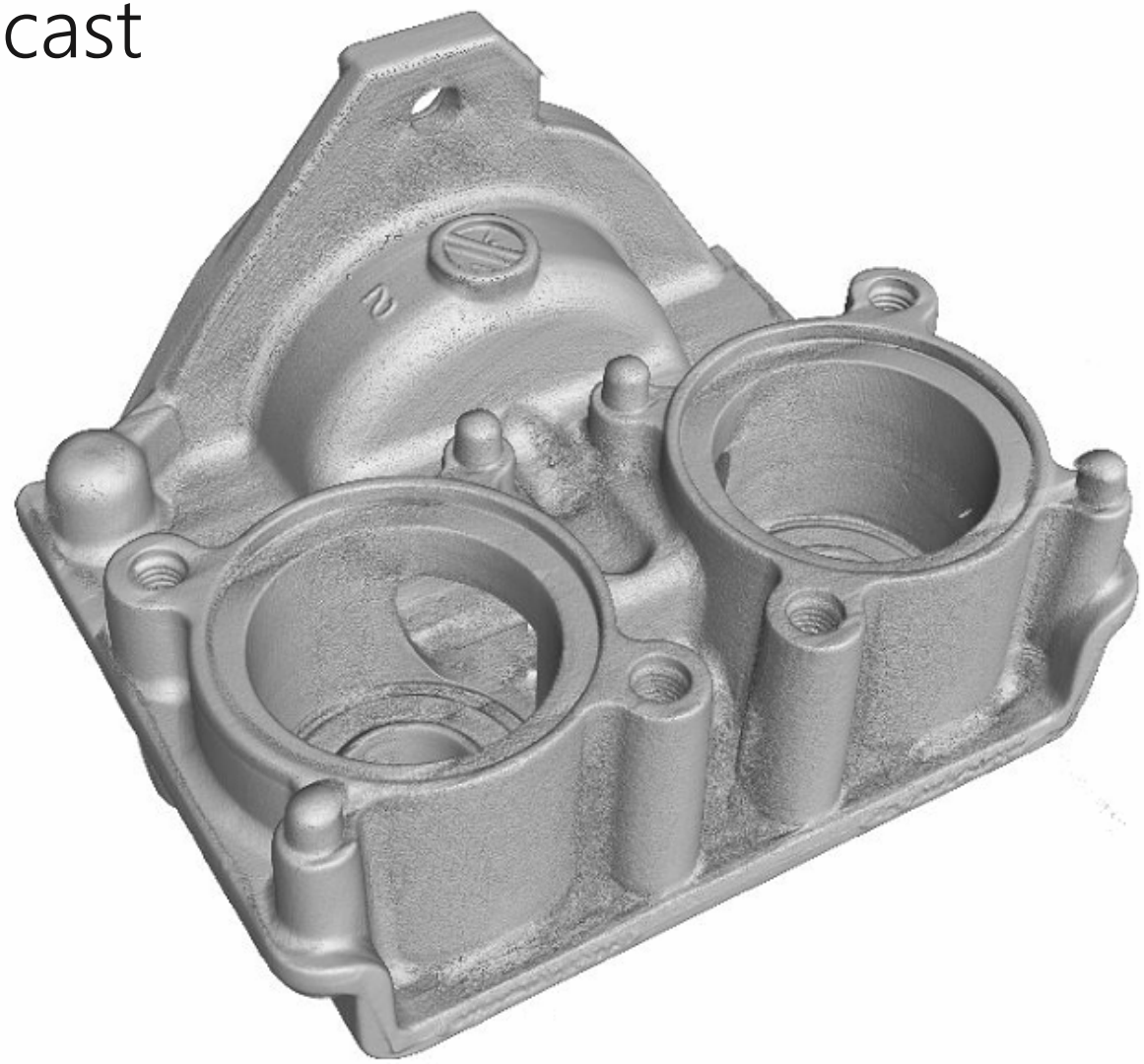
Thickness [mm]



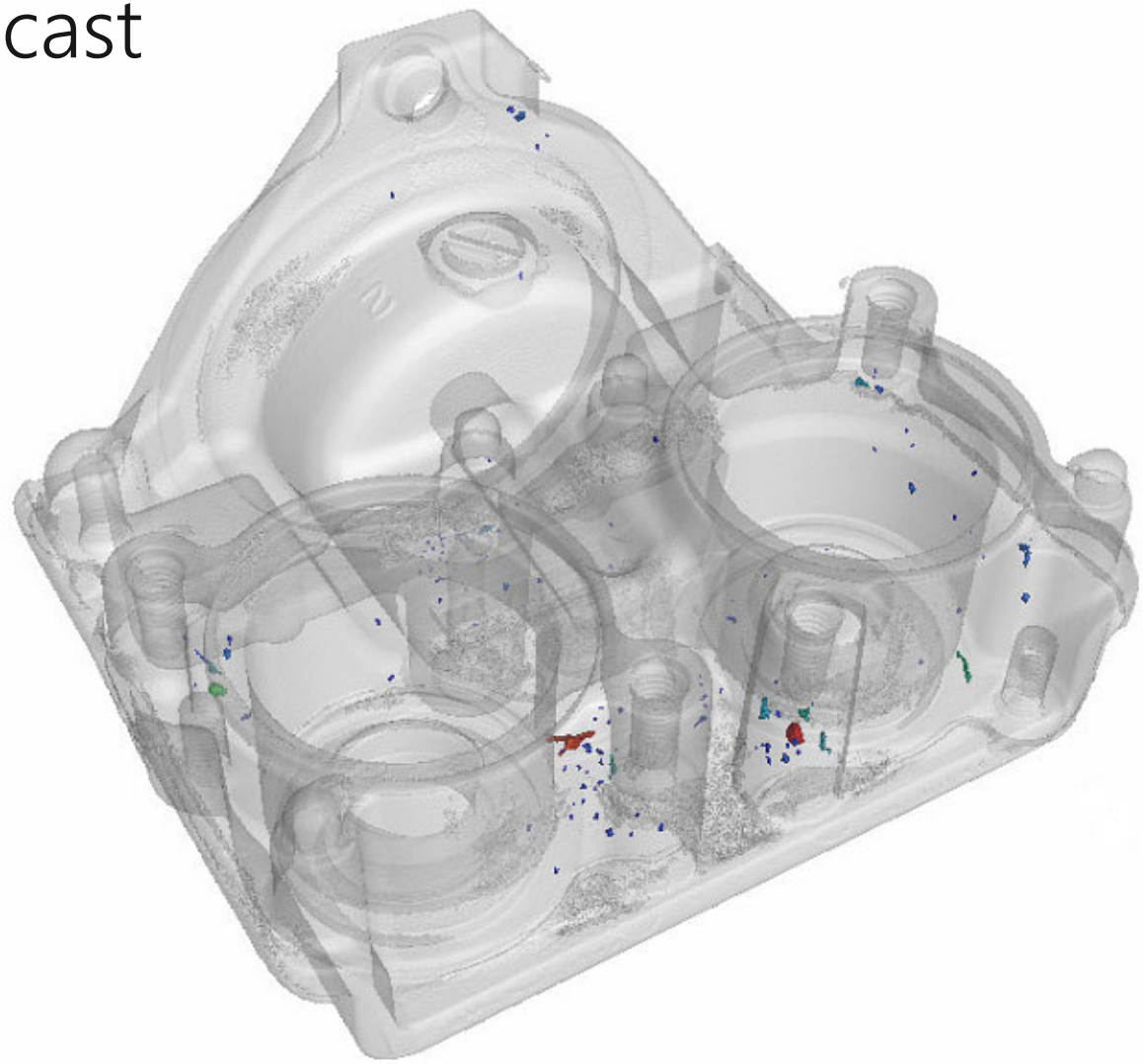


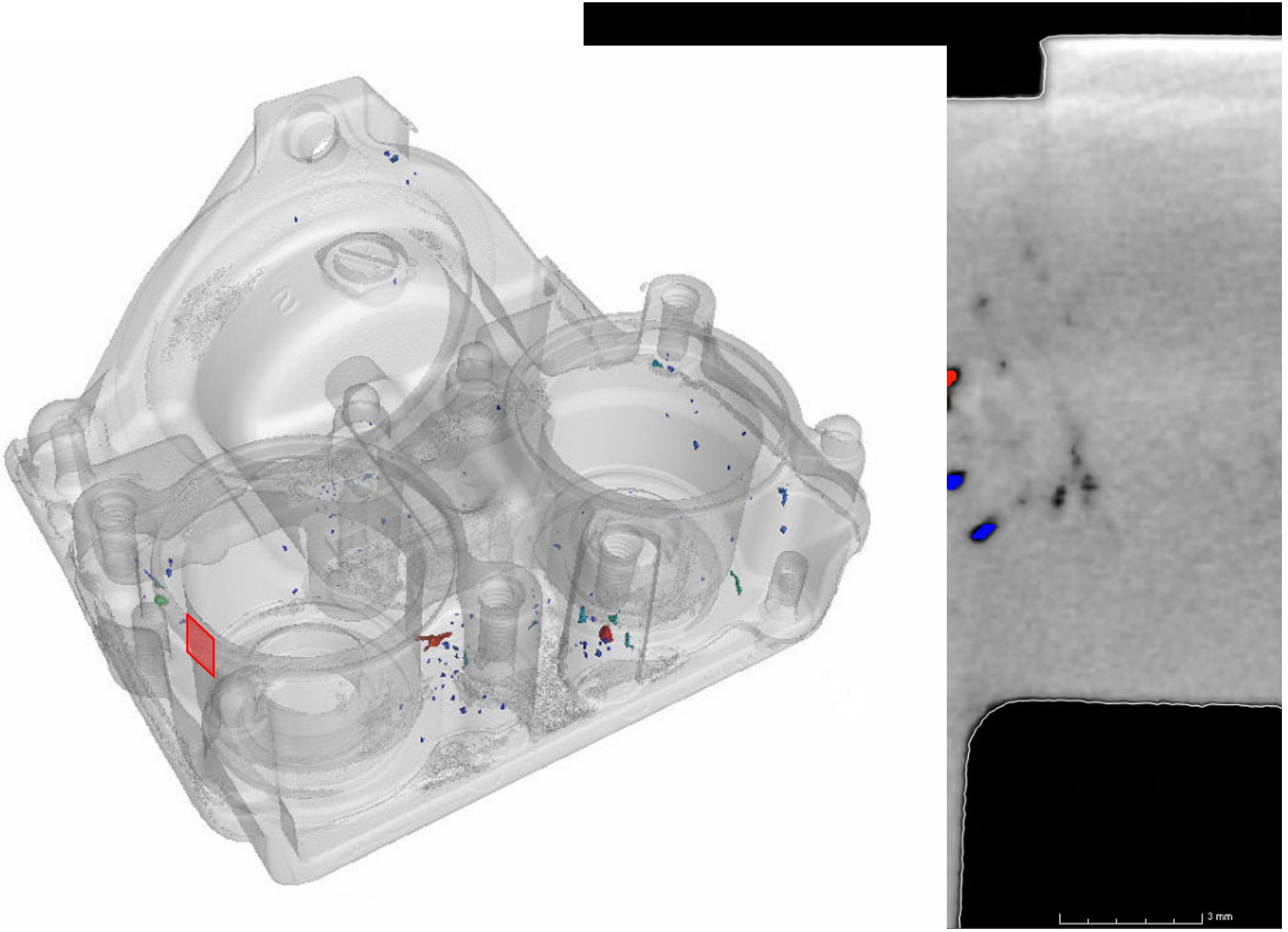

Analysis 1: Wall thickness (mm)
2.00000
1.80000
1.60000
1.40000
1.20000
1.00000
0.80000
0.60000
0.40000
0.20000
0.00000
Z
X

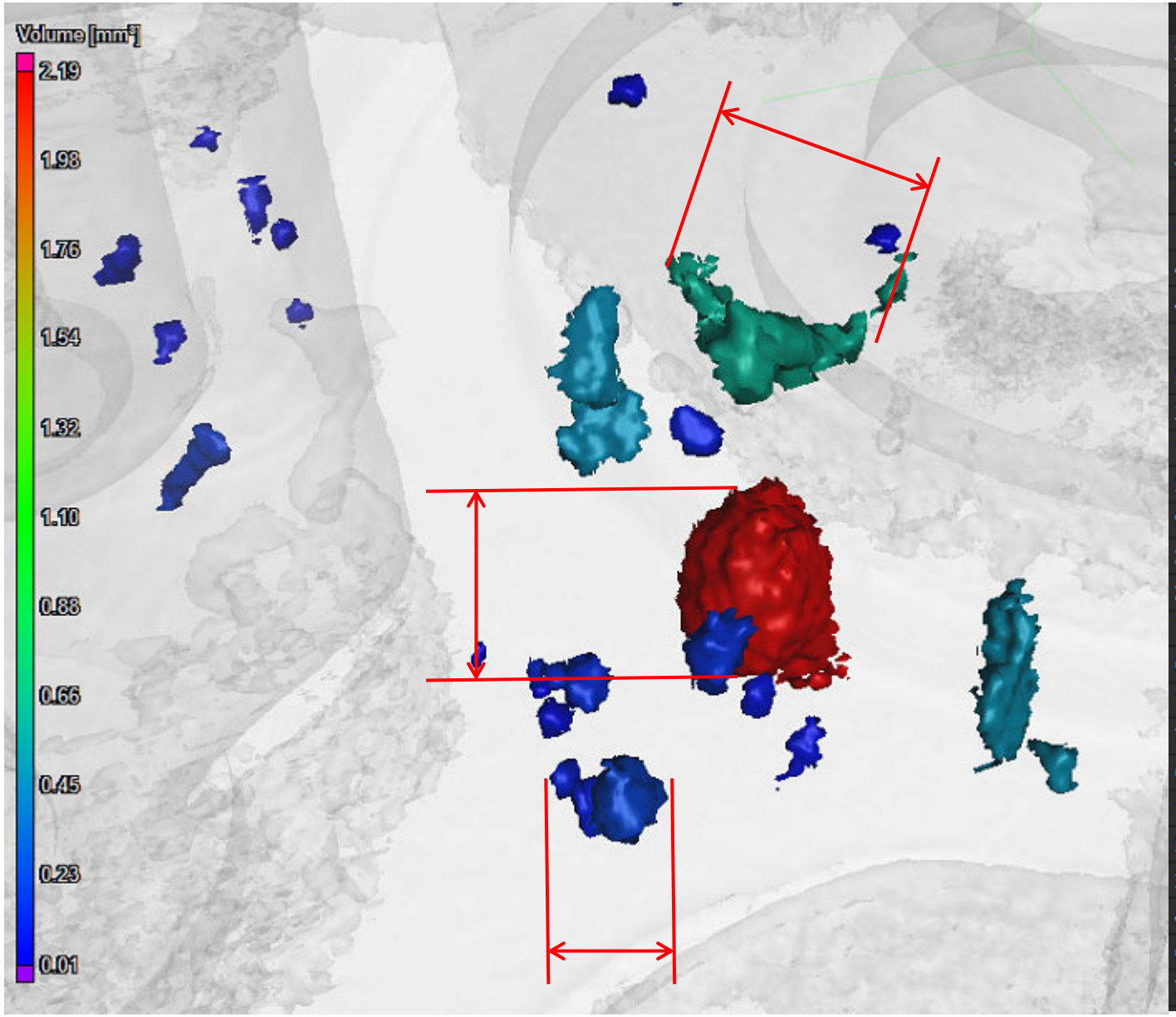
Aluminum die-cast



Aluminum die-cast




3 mm

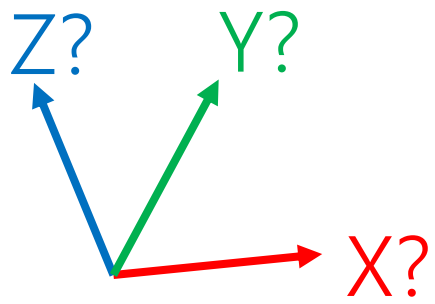


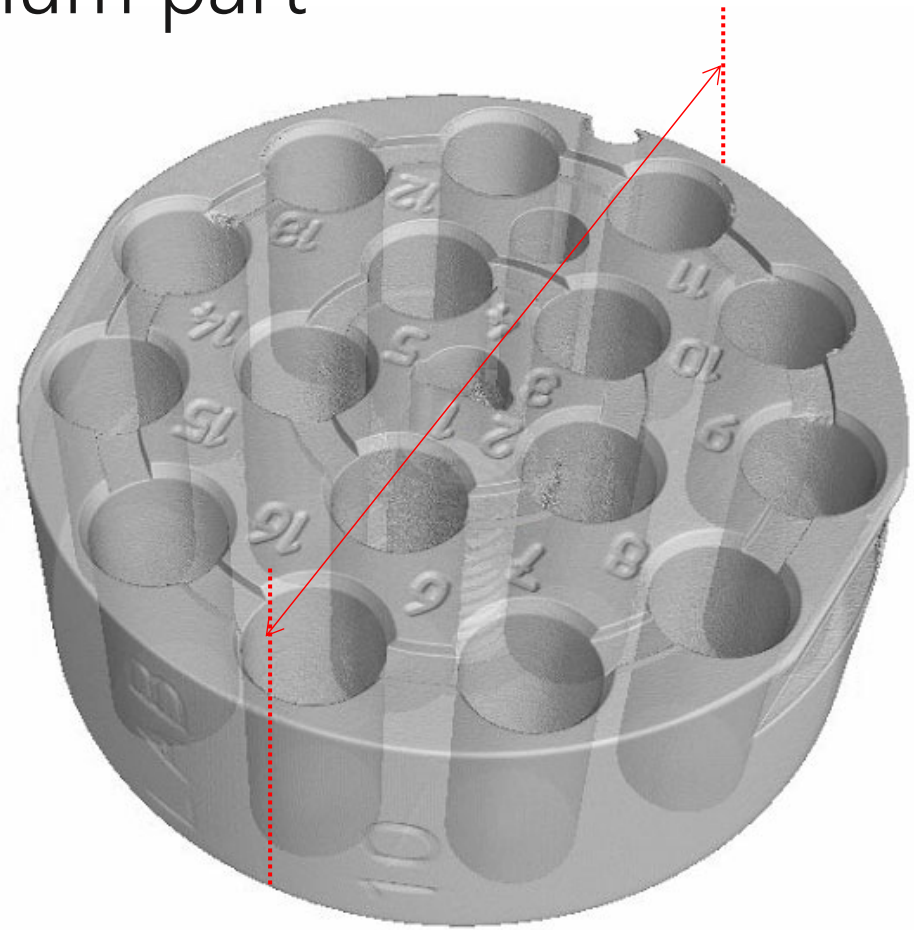
	Volume [mm³]	Center x [vox]	Center y [vox]	Center z [vox]
23	2.20	493	428	95
14	2.10	347	455	201
31	0.98	105	400	337
80	0.72	674	454	104
115	0.63	490	390	85
10	0.56	362	462	163
46	0.53	101	360	328
4	0.48	700	320	318
111	0.48	510	431	79
58	0.47	488	434	134
2	0.38	430	515	482
12	0.26	728	355	121
53	0.26	720	351	107
9	0.26	489	115	544
3	0.25	720	396	250
39	0.24	117	365	340
100	0.23	717	385	95
62	0.20	474	434	85
1	0.20	386	462	373
72	0.19	715	325	309
68	0.17	117	412	312
16	0.15	450	462	166
59	0.14	483	421	87
29	0.14	350	433	161
43	0.14	403	592	511
63	0.13	477	451	112
75	0.12	423	554	520

CAN WE DO GD&T ANALYSIS?

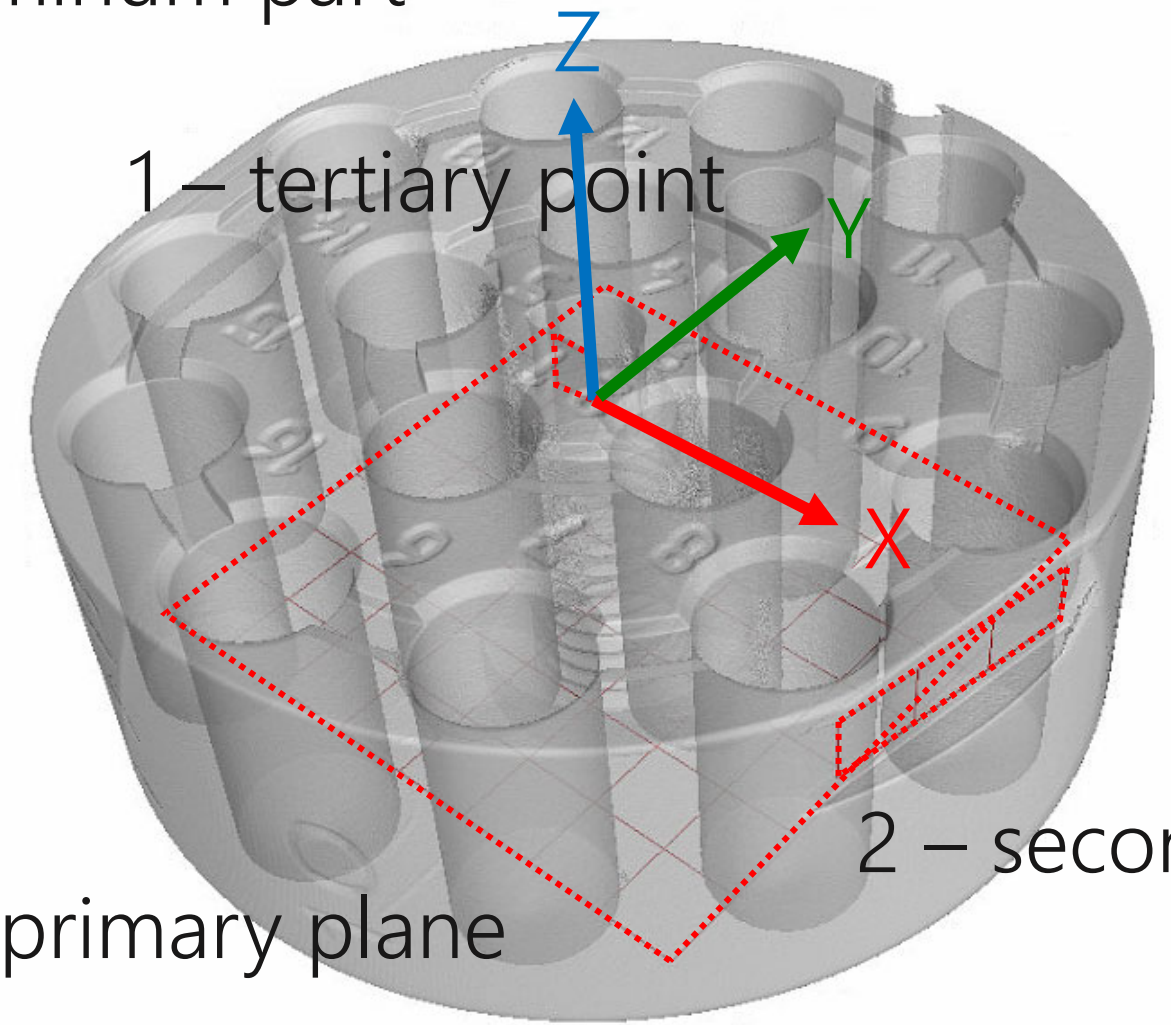
Machined aluminum part

Machined aluminum part





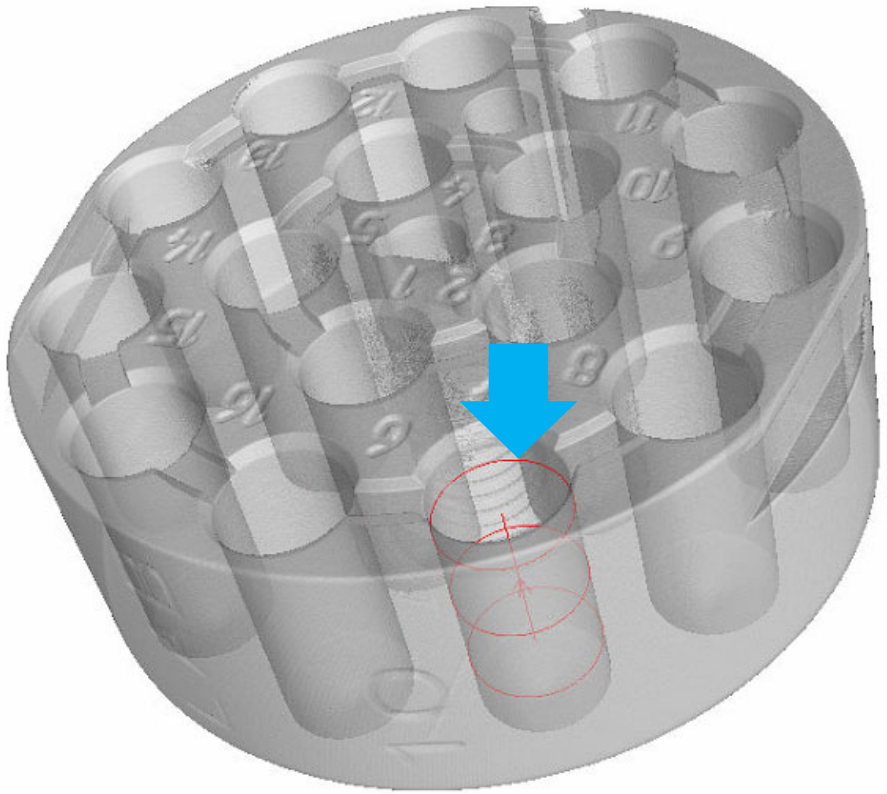
Machined aluminum part



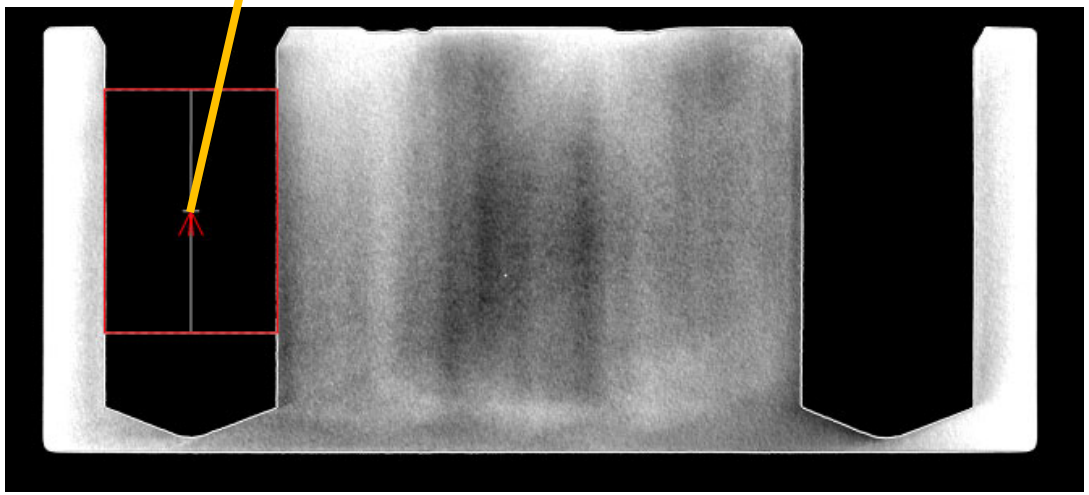
1 – tertiary point

2 – secondary line

3 – primary plane



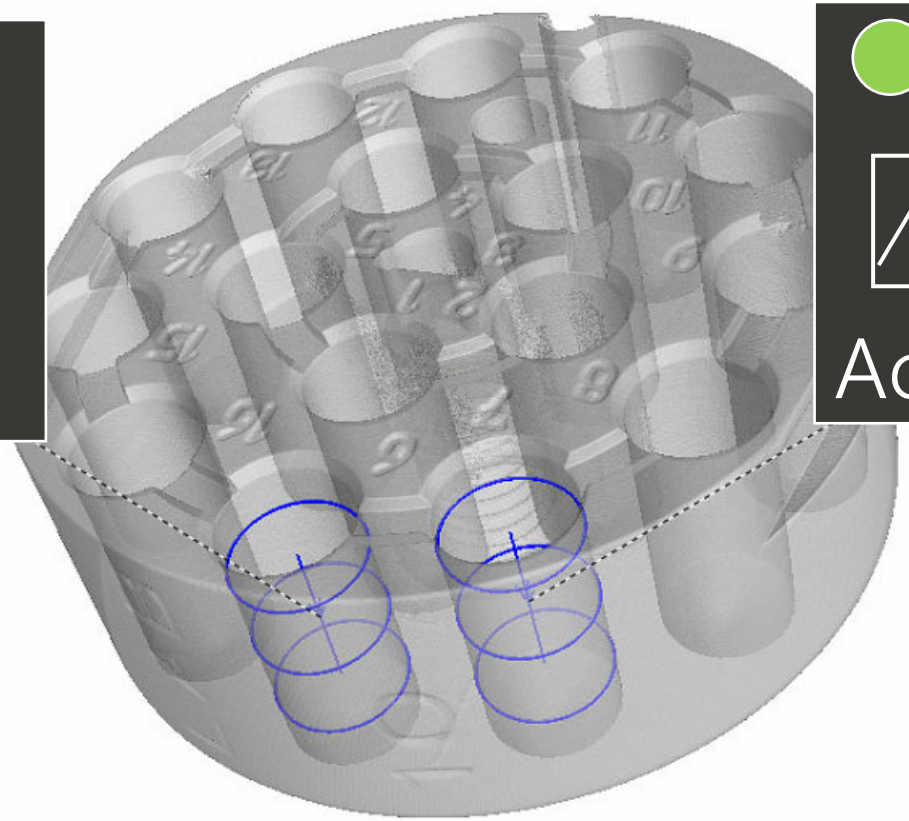
Radius = 4.414 mm
(x = 15.471, y = -17.167)



Cylindricity

⌭ 0.070

Actual 0.071 mm



Cylindricity

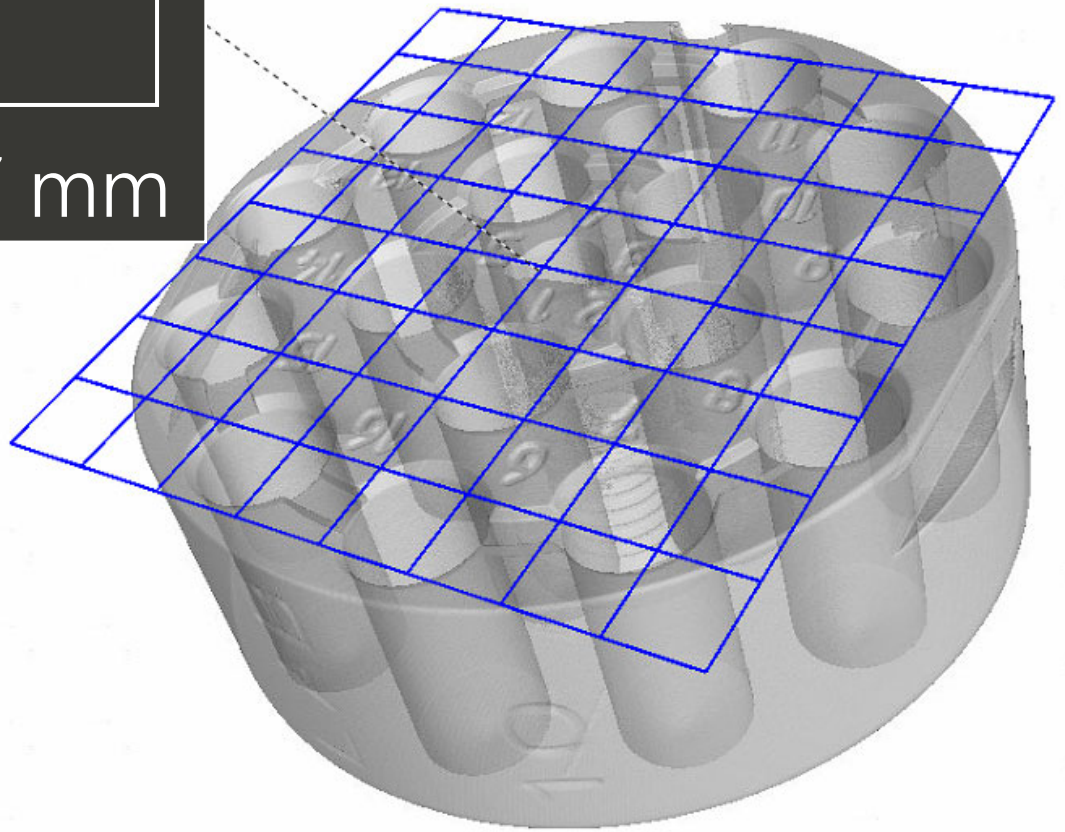
⌭ 0.070

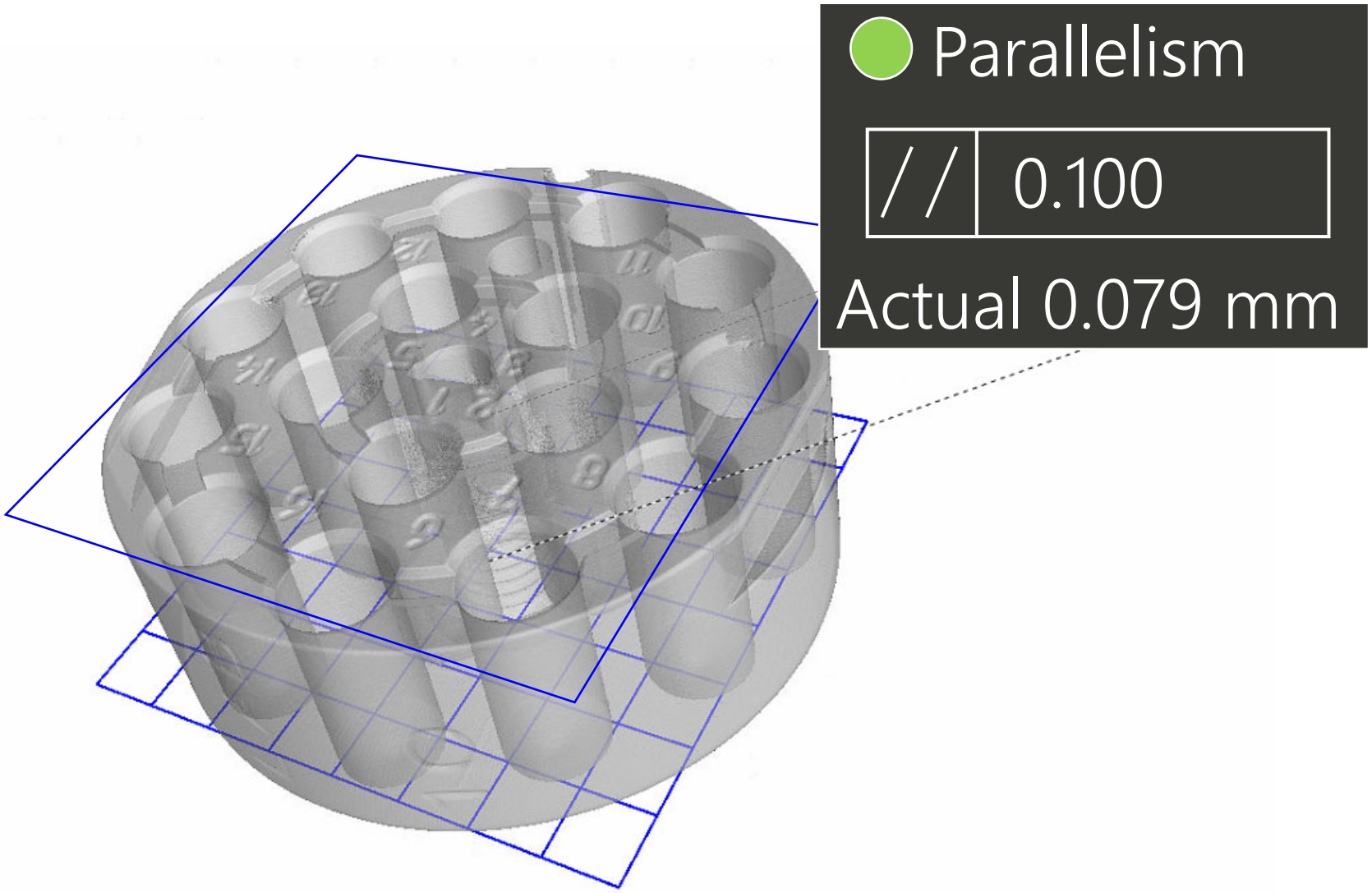
Actual 0.063 mm

Flatness

0.100

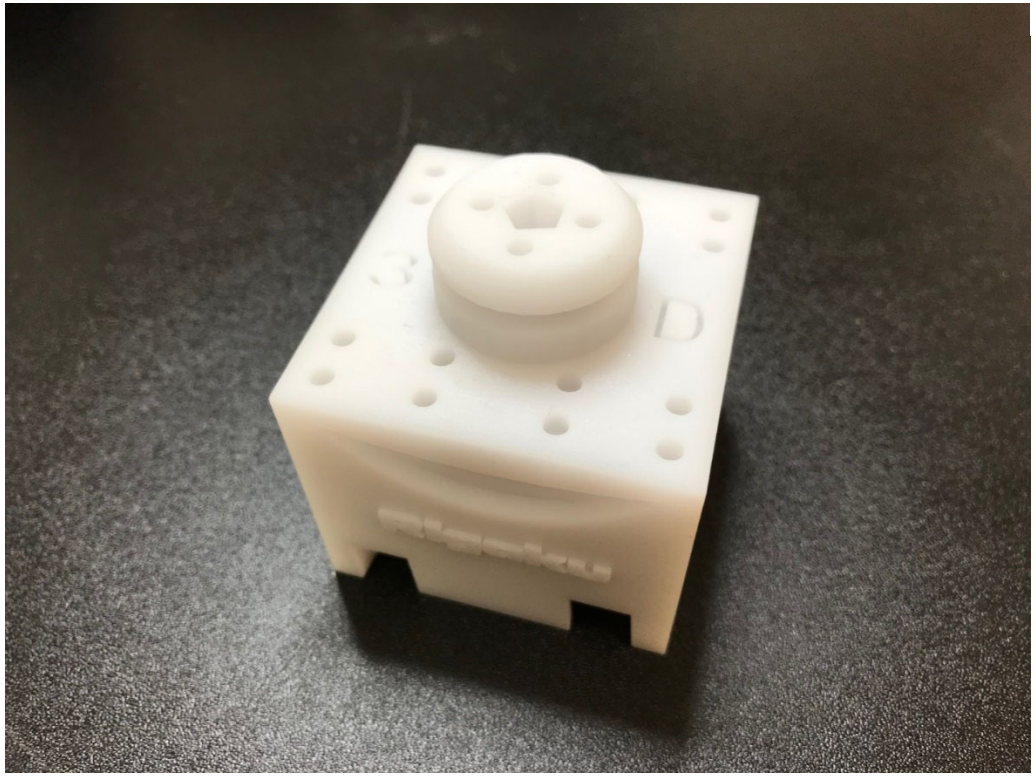
Actual 0.067 mm

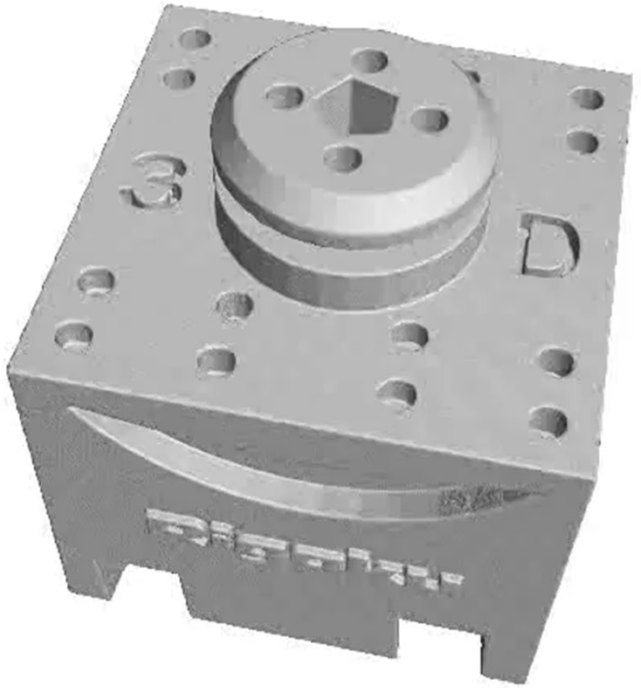



Parallelism
//
0.100
Actual 0.079 mm

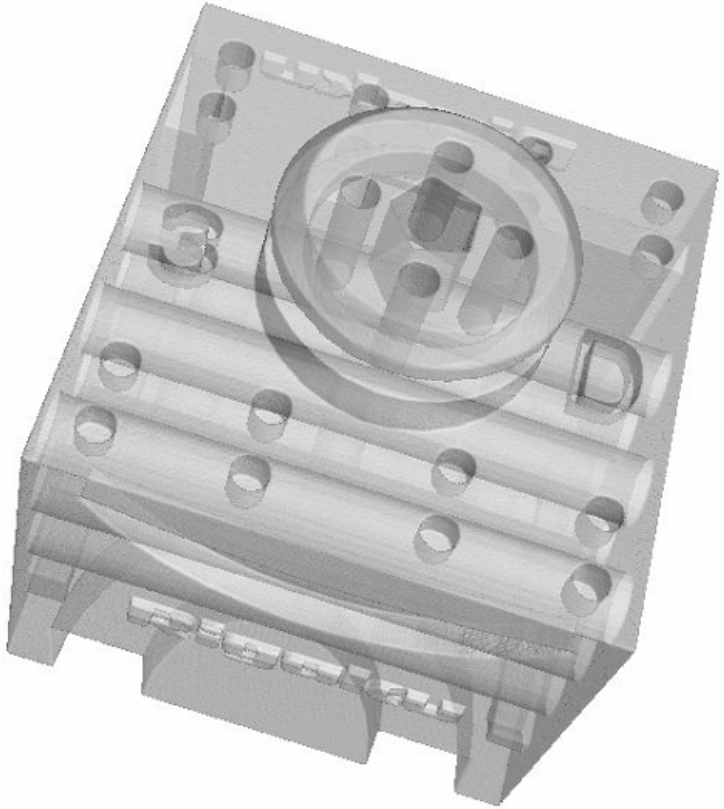
CAN WE COMPARE CAD AND CT?

3D printed part

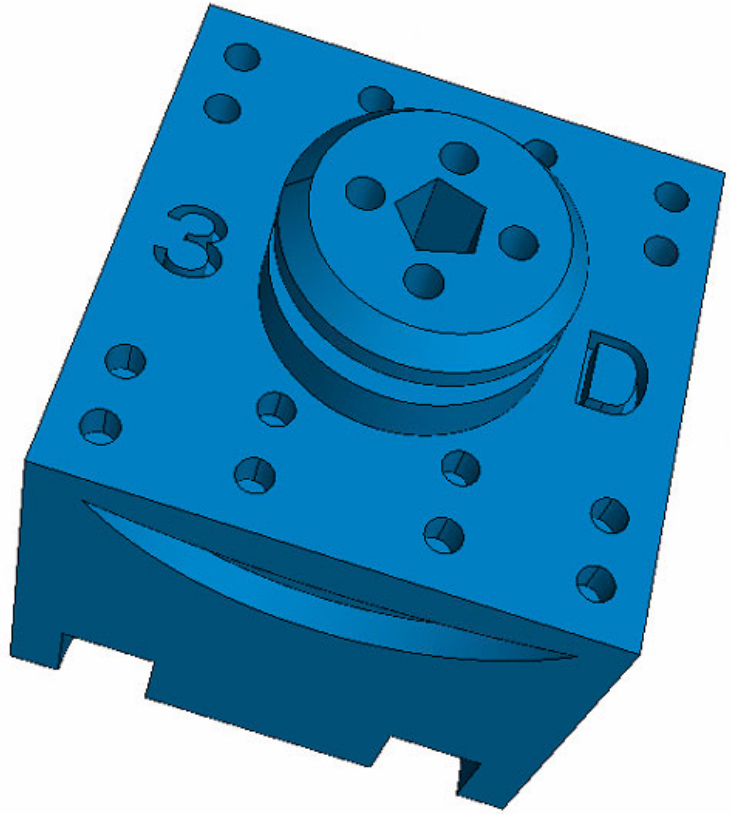




3D printed part

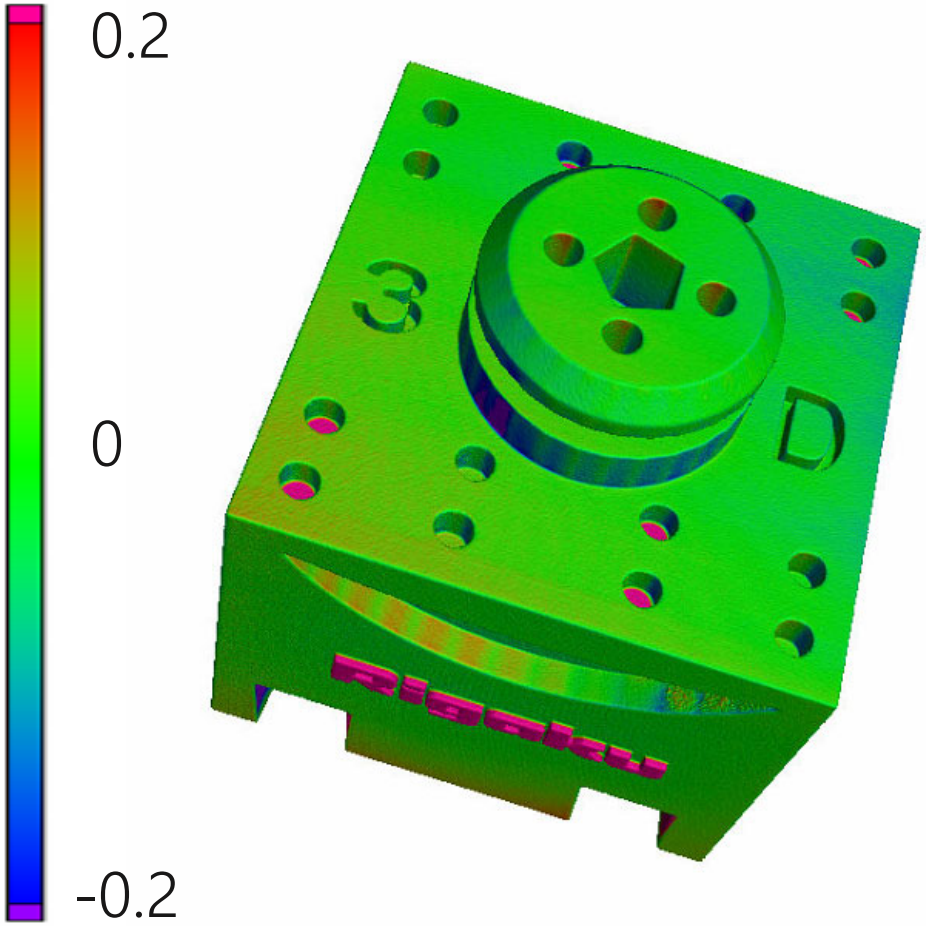


CT scan (actual)



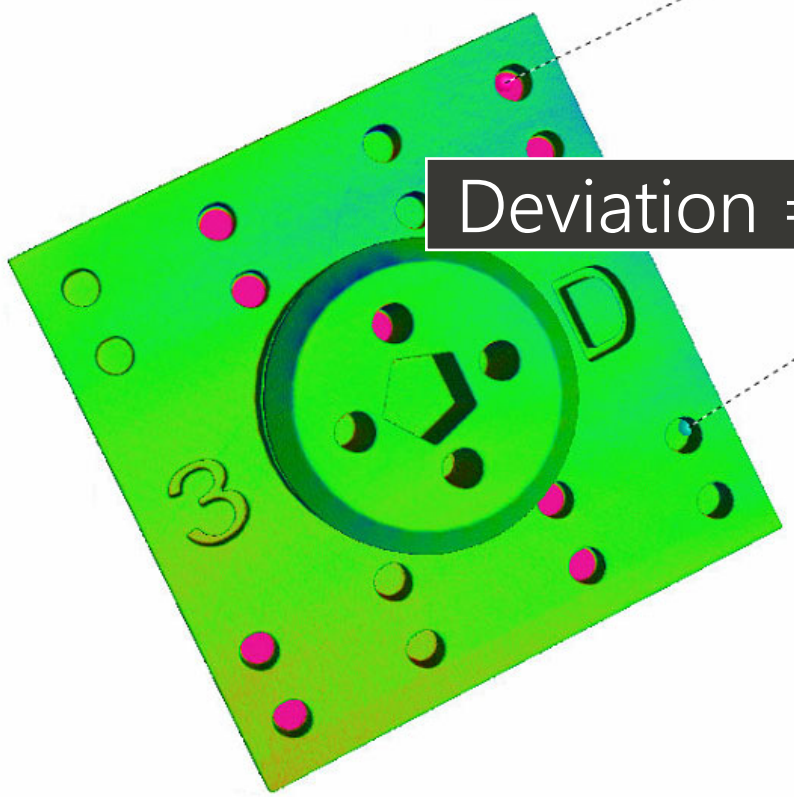
CAD

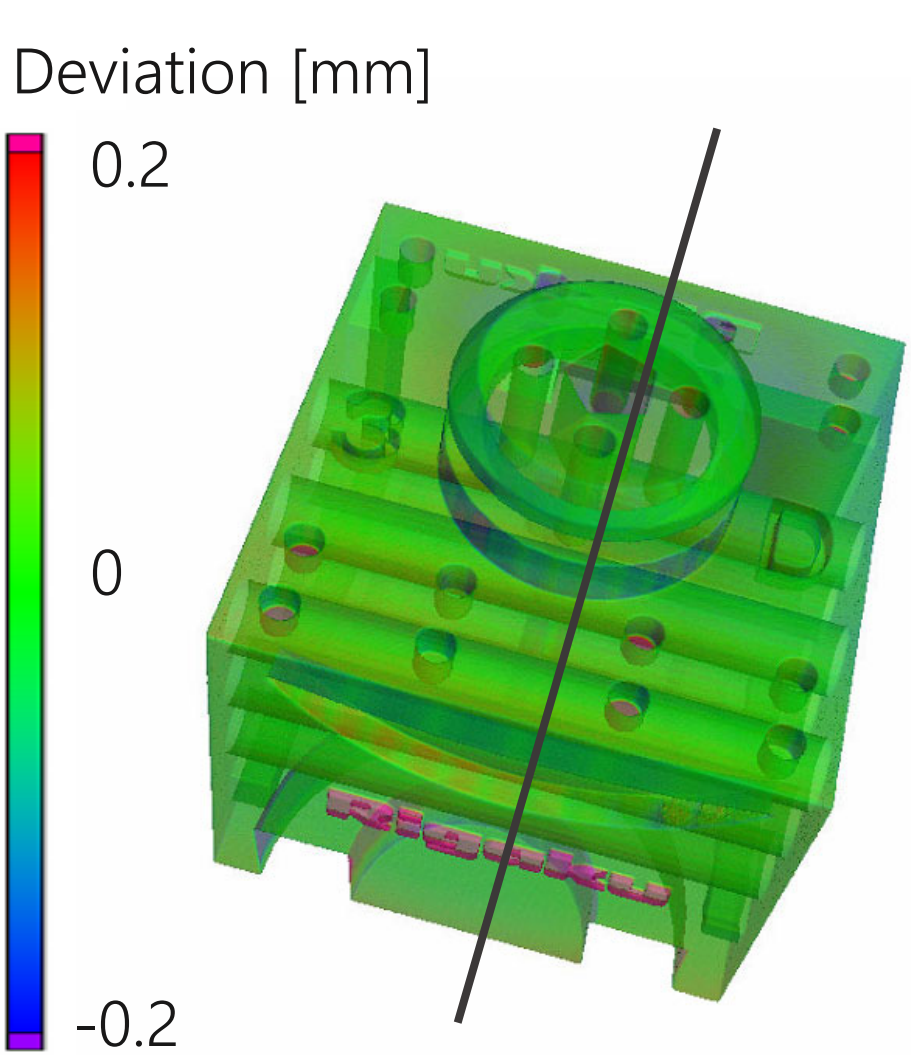
Deviation [mm]

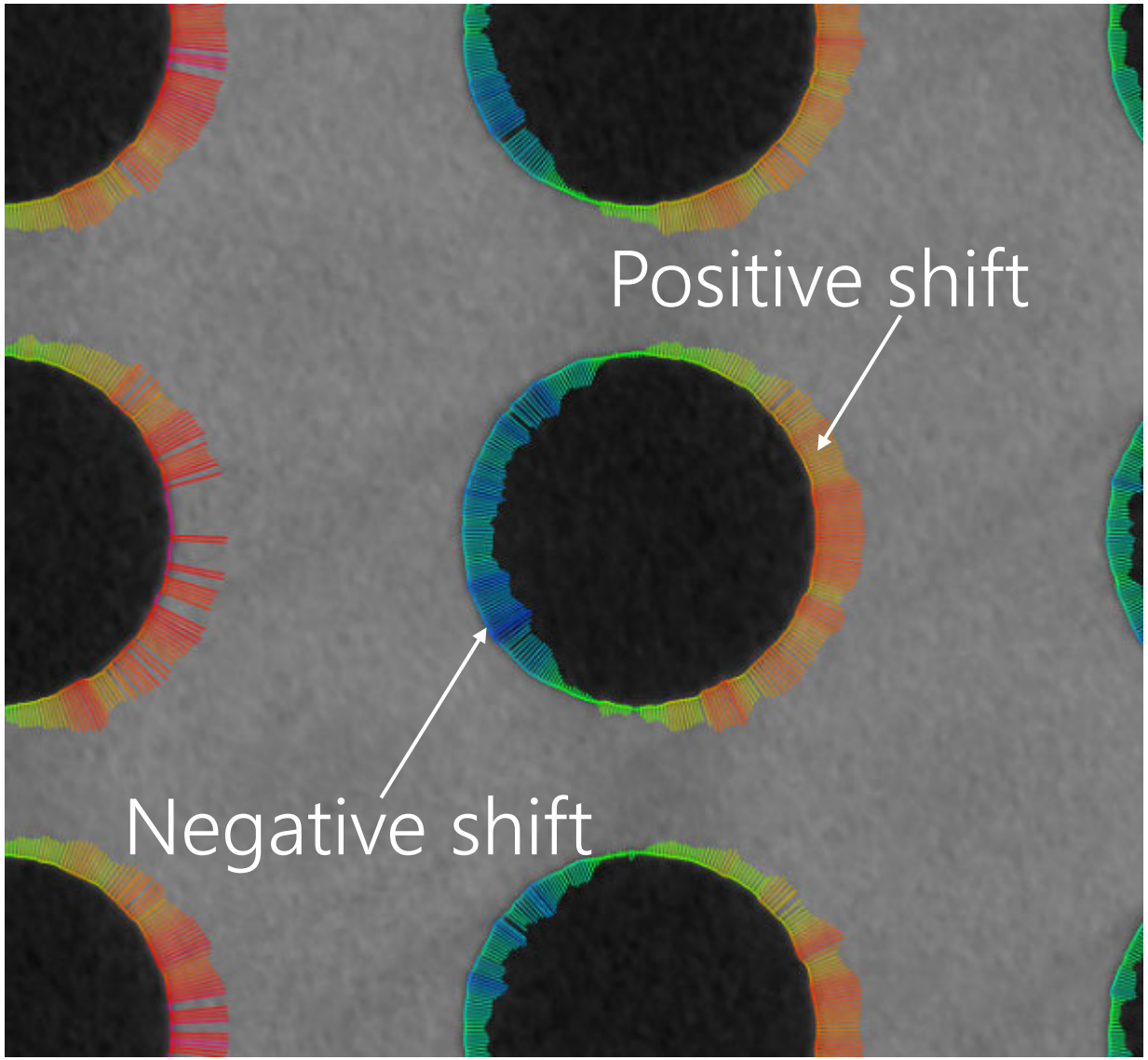


Deviation > 0.2 mm

Deviation = -0.091 mm




Deviation [mm]
0.2
0
-0.2


Positive shift
Negative shift

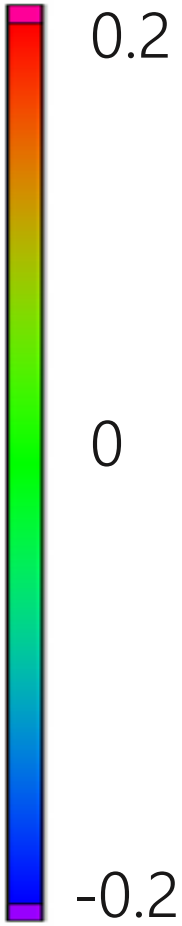
CAN WE COMPARE TWO OBJECTS?

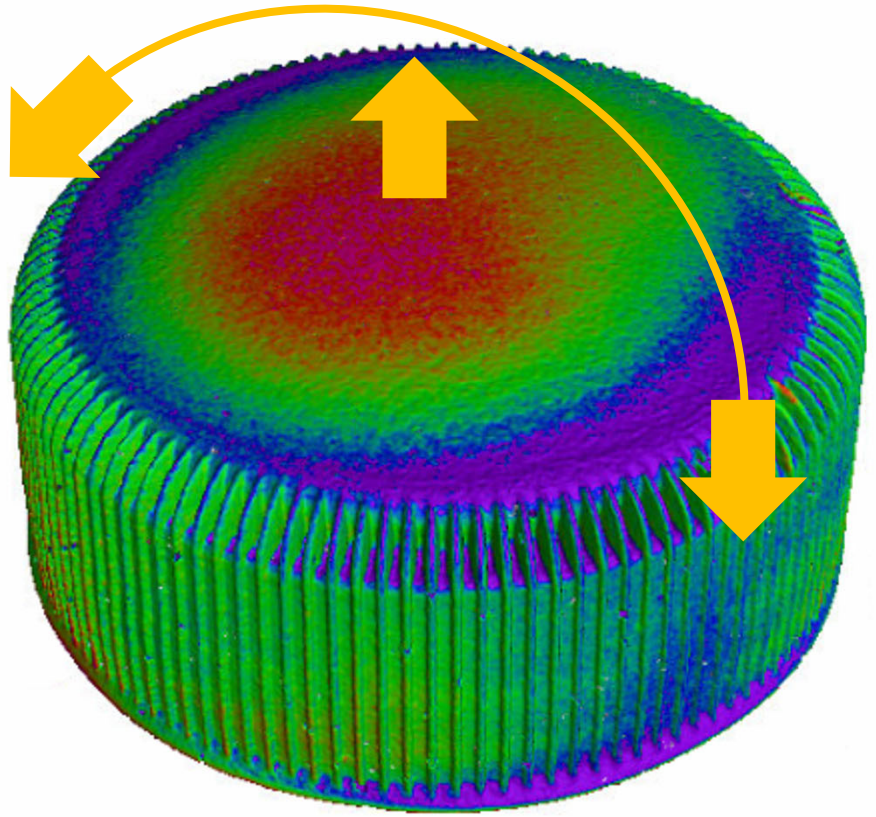
Bottle cap

Open

Closed

Deviation [mm]

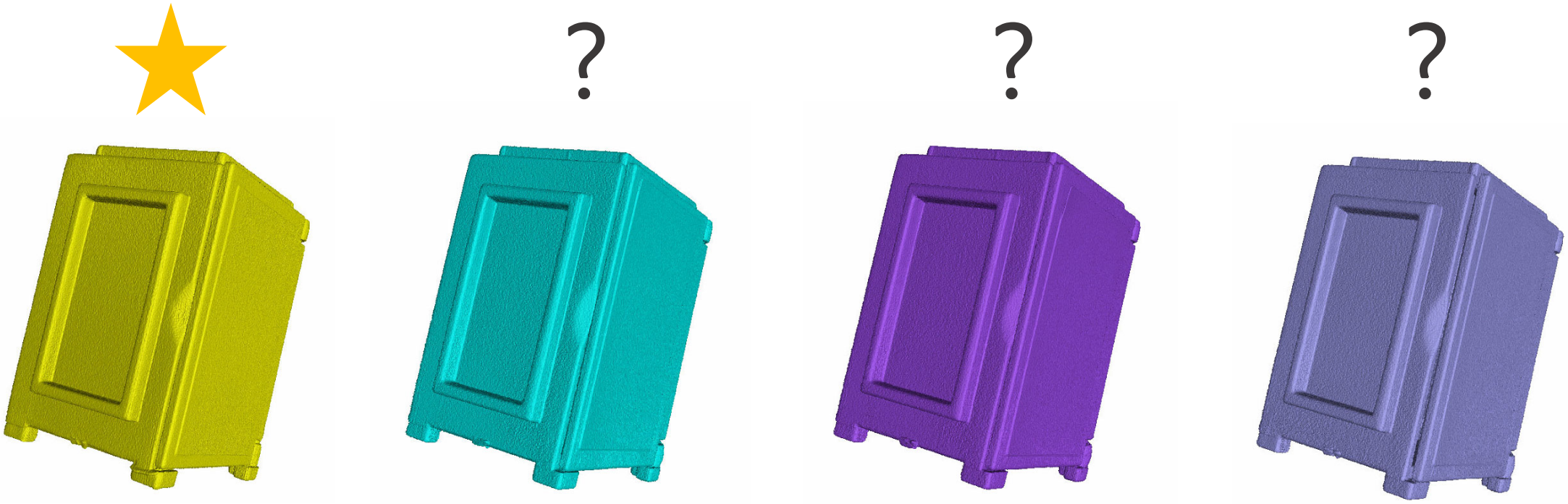




"Closed" – "Open"

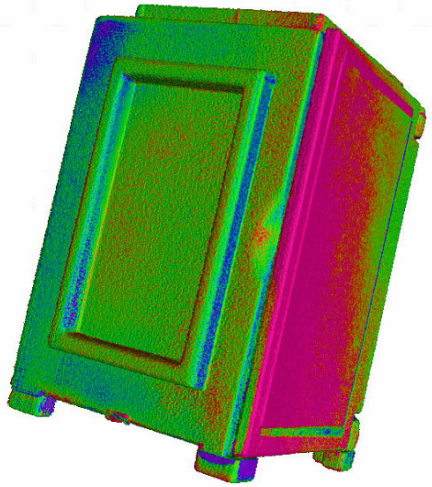
CAN WE USE THIS FOR QC?

Plastic box

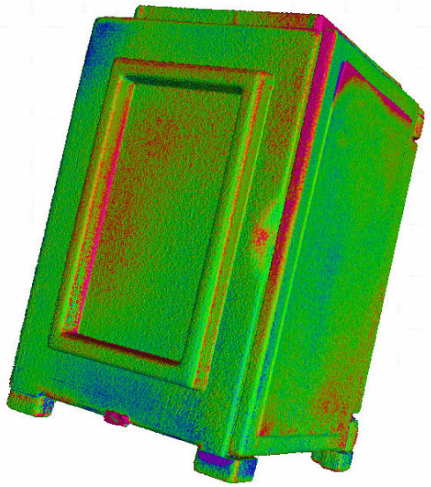


Plastic box

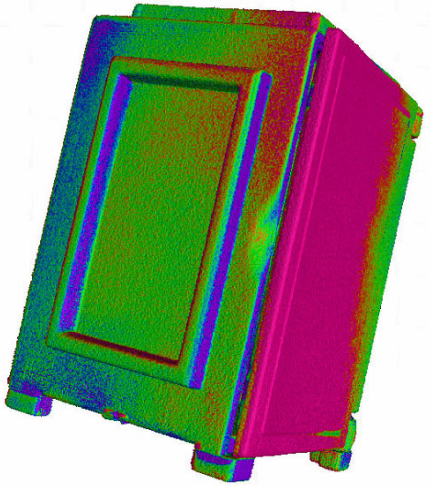
Fail



Pass



Fail

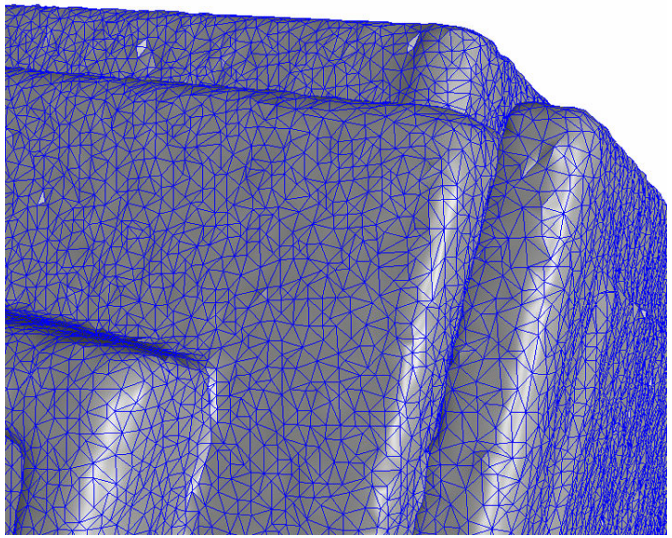


Maximum deviation for 90% surface ≤ 0.1

CAN WE DO REVERSE ENGINEERING?

Reproduction

CT scan

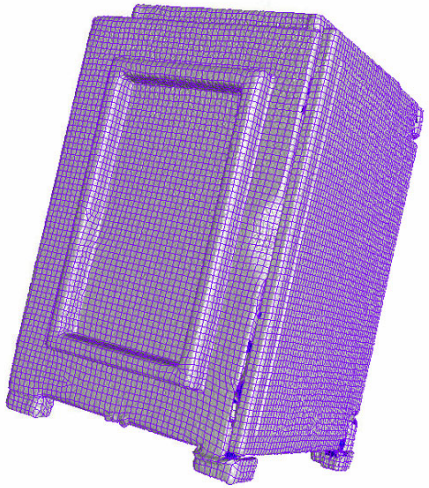


Polygon mesh

3D print

Modification

CT scan

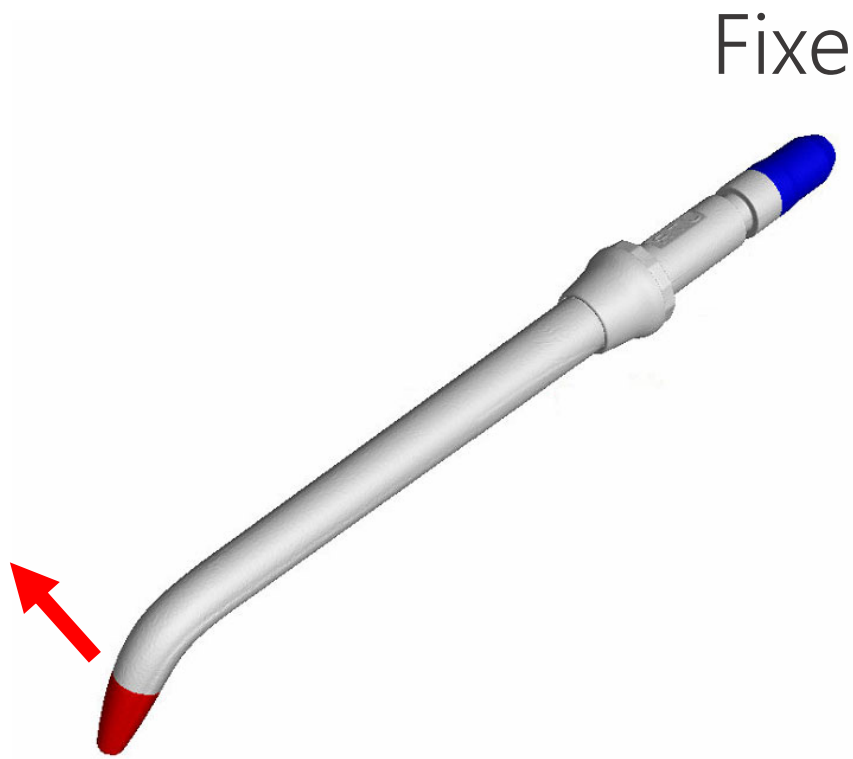


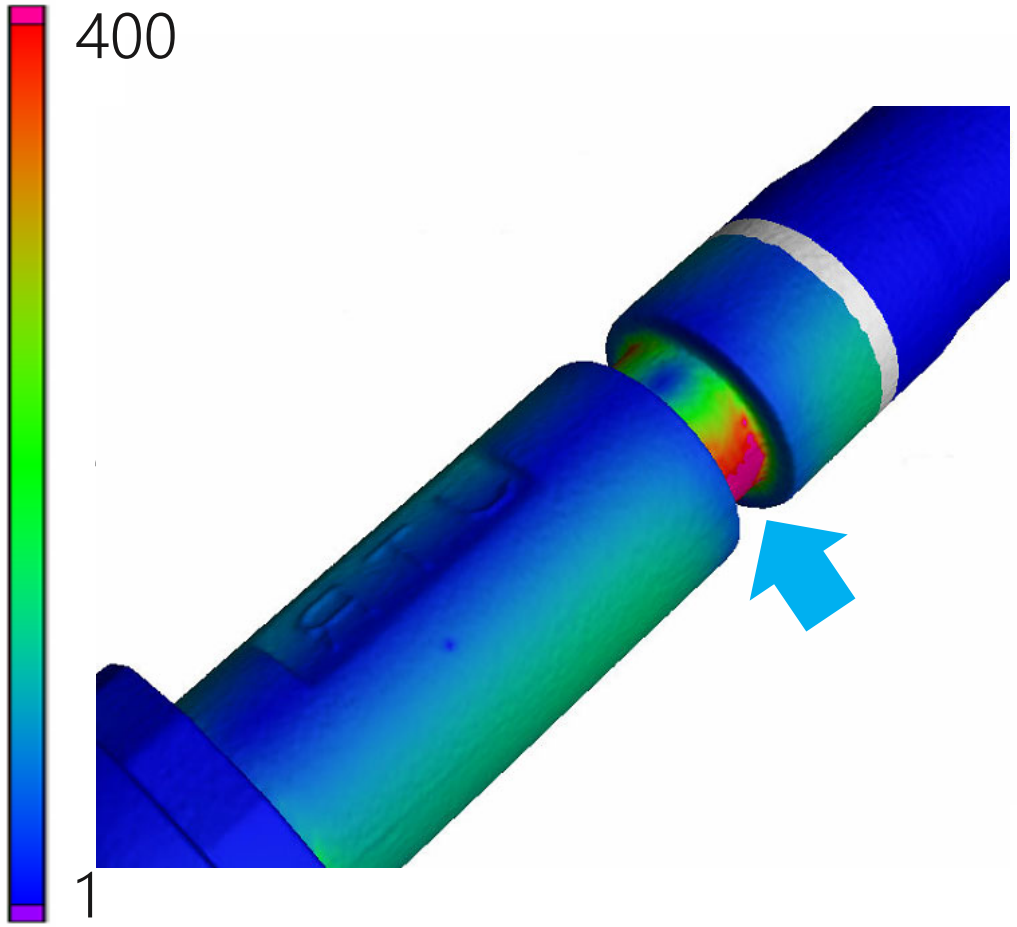
CAD conversion

CAD software

CAN WE DO A MECHANICAL SIMULATION?

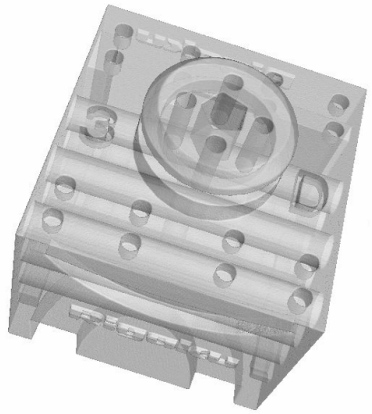
Water flosser tip





METROLOGY APPLICATIONS

- Dimension measurements
- Internal dimensions
- Air gaps
- Voids and cracks
- GD&T analysis
- Nominal vs. actual comparison
- Reverse engineering
- Mechanical simulation



CT data

Finite element analysis

ex. Abaqus, ANSYS

Material modeling

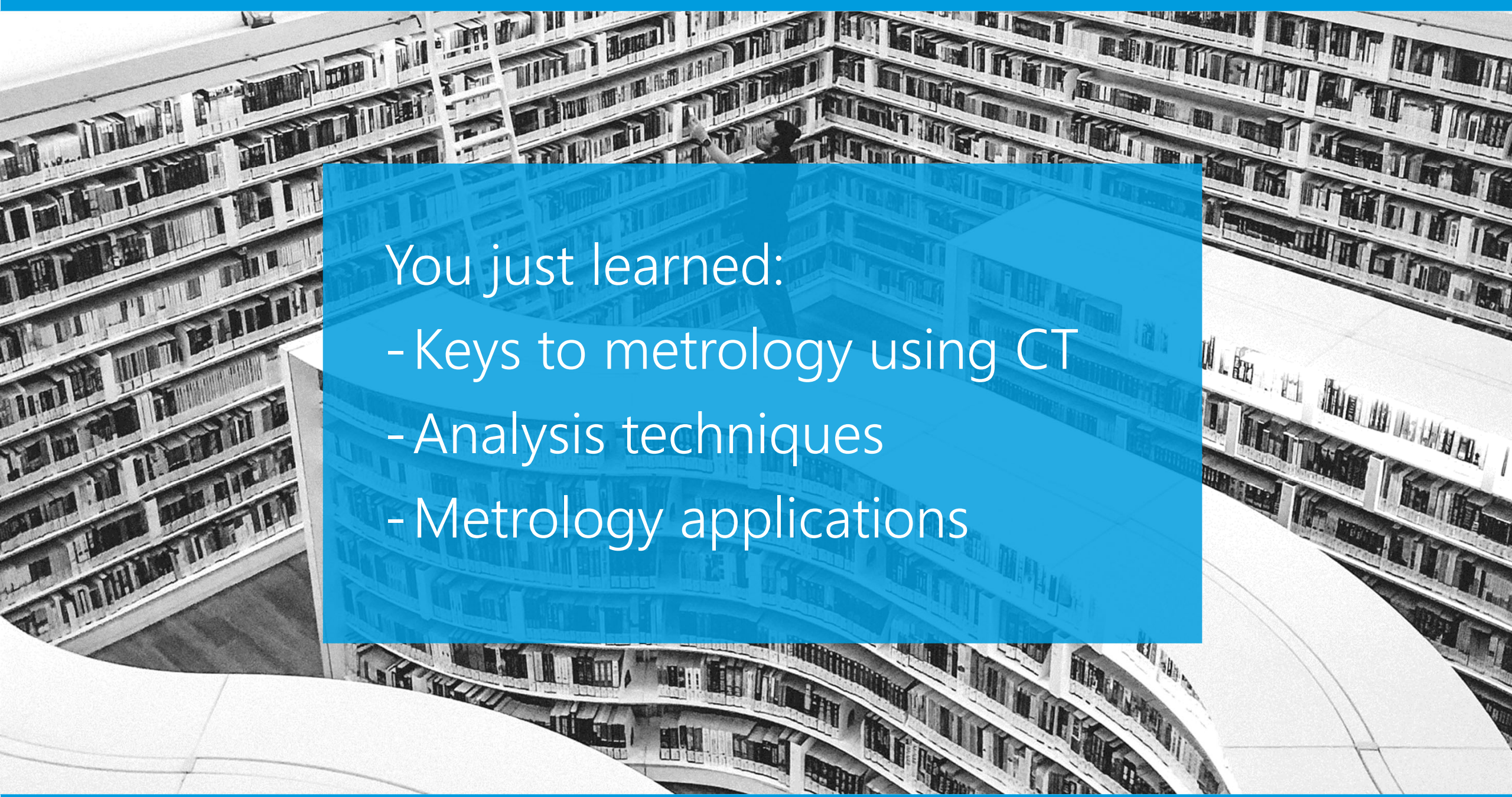
ex. Digimat

QC Statistics

ex. Q-DAS

USEFUL RESOURCES

- Volume Graphics webinars
  https://www.volumegraphics.com/en/service/webinars.html
- GD&T
  https://www.youtube.com/
  Infinity MFG: GD&T Part 1 & 2



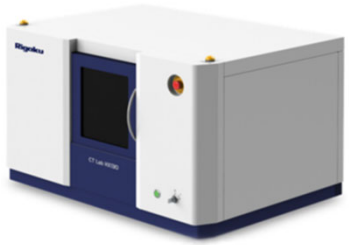
You just learned:

- Keys to metrology using CT
- Analysis techniques
- Metrology applications

ALL IMAGES WERE COLLECTED ON…

nano3DX

CT Lab HX



CT Lab GX

To learn more …


Rigaku.com → Contact

PREVIOUS WEBINARS

www.rigaku.com/en/webinars/x-ray_ct_introduction

Rigaku CT webinar

Q & A SESSION

Aya Takase

Tom Concolino

We'll follow up with your questions.

Recording will be available tomorrow.

Tell us what you want to learn next.


THANK YOU FOR JOINING US
SEE YOU IN 2021!