The Henryk Niewodniczański Institute Of Nuclear Physics, Kraków

X-ray microprobe in Krakow – our experience with computed microtomography

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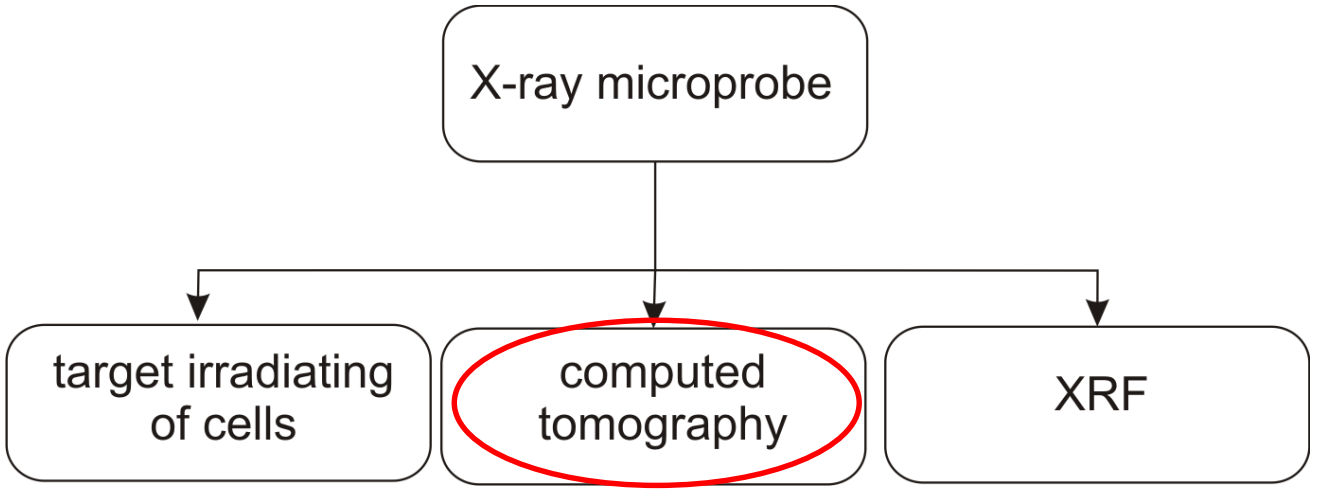
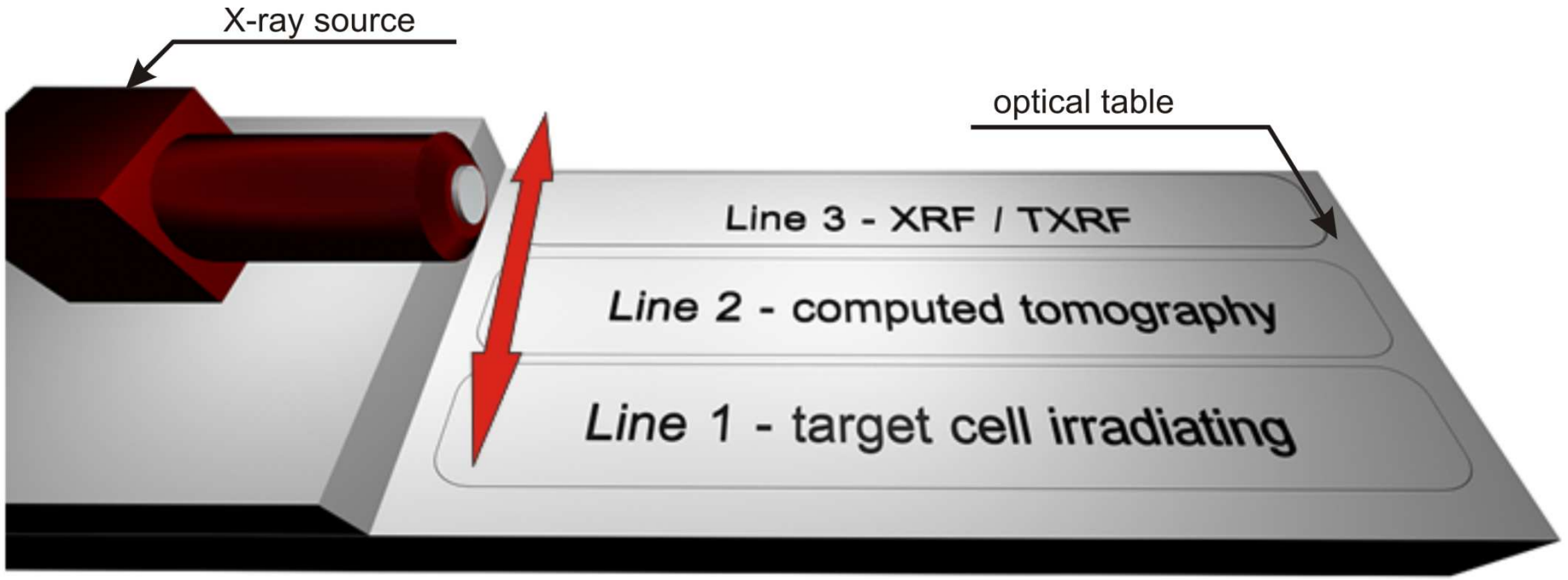
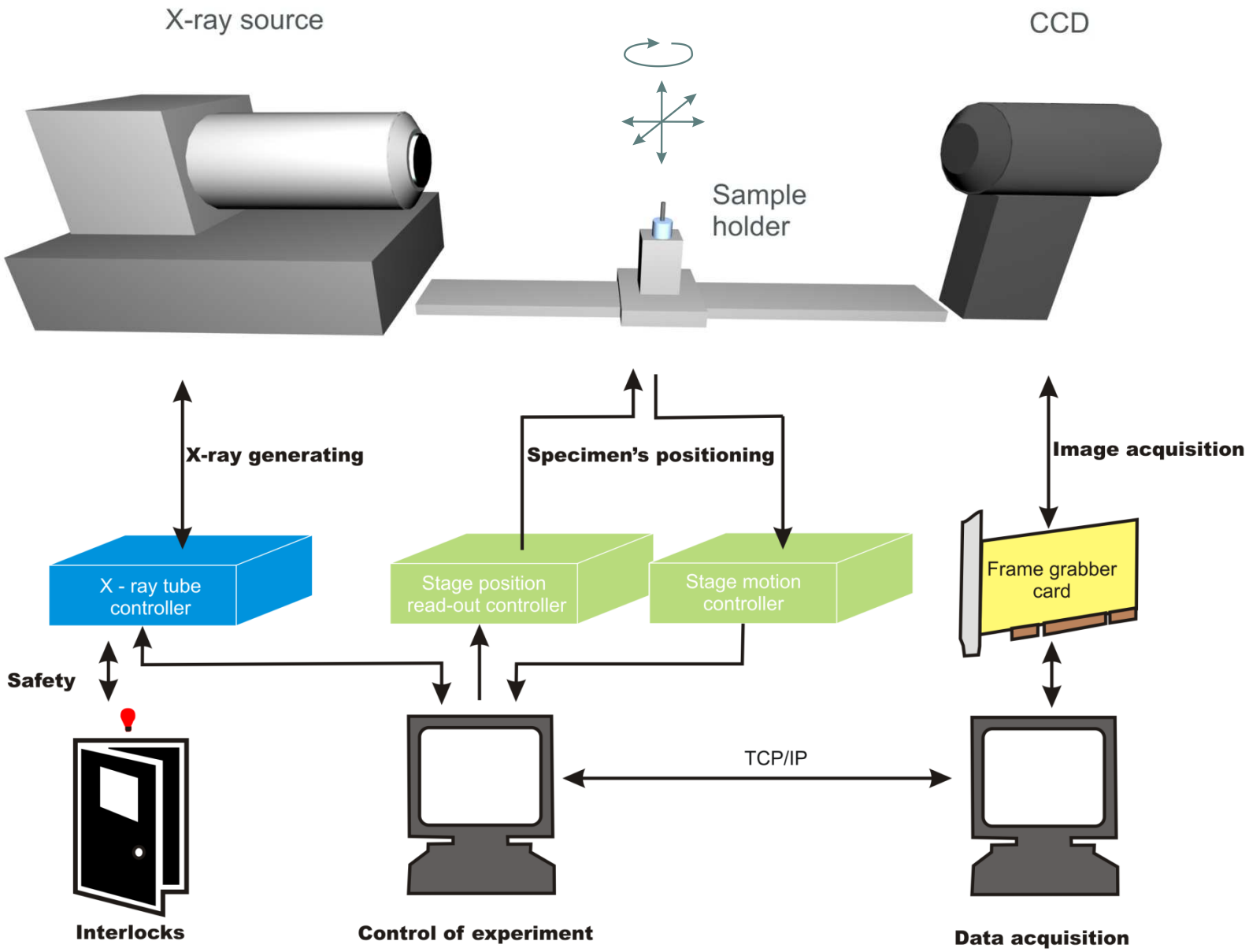
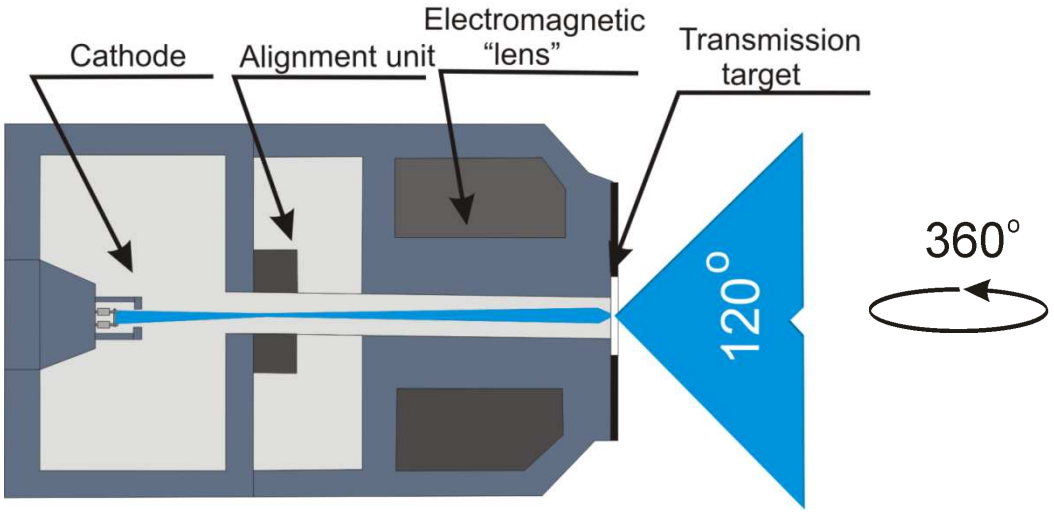
Outline

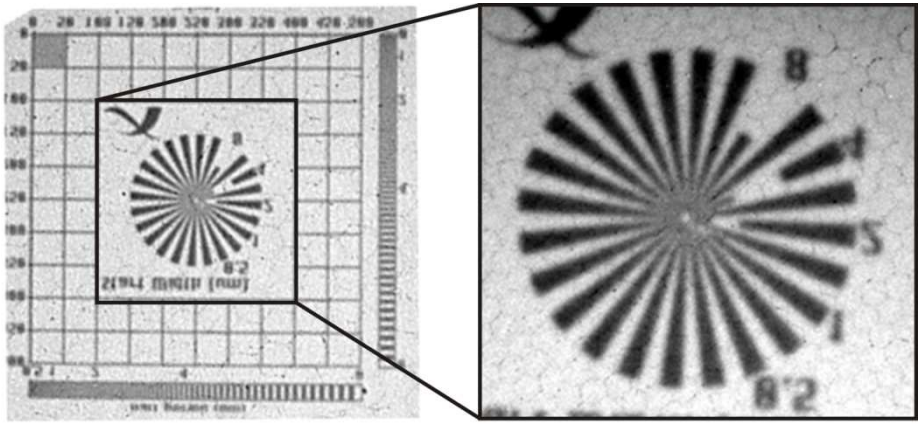
- Microbeam applications
- (micro)tomography
- Hardware
  - X-ray tube
  - Detectors
  - Sample stage
- Software
- Source intensity
- Some results
- Artefacts

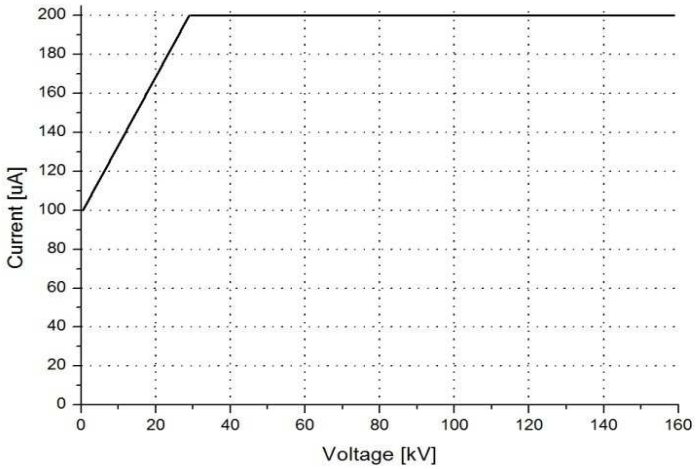

X-ray microprobe
target irradiating of cells
computed tomography
XRF


X-ray source
optical table
Line 3 - XRF / TXRF
Line 2 - computed tomography
Line 1 - target cell irradiating


X-ray source
CCD
Sample holder
X-ray generating
Specimen's positioning
Image acquisition
X - ray tube controller
Stage position read-out controller
Stage motion controller
Frame grabber card
Safety
TCP/IP
Interlocks
Control of experiment
Data acquisition

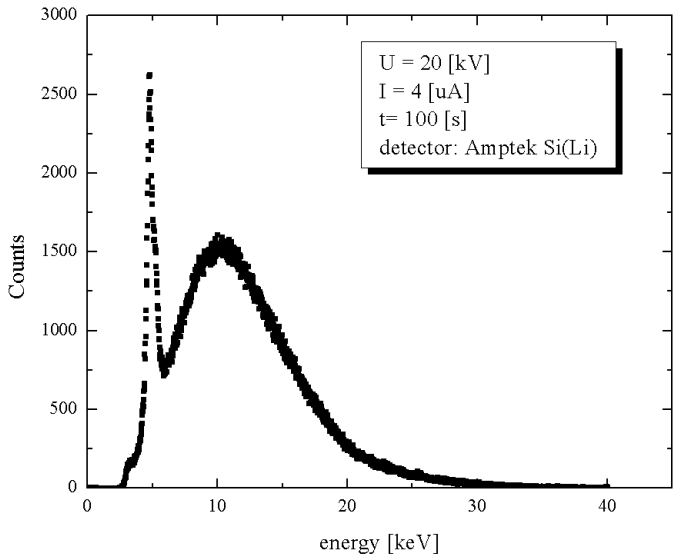


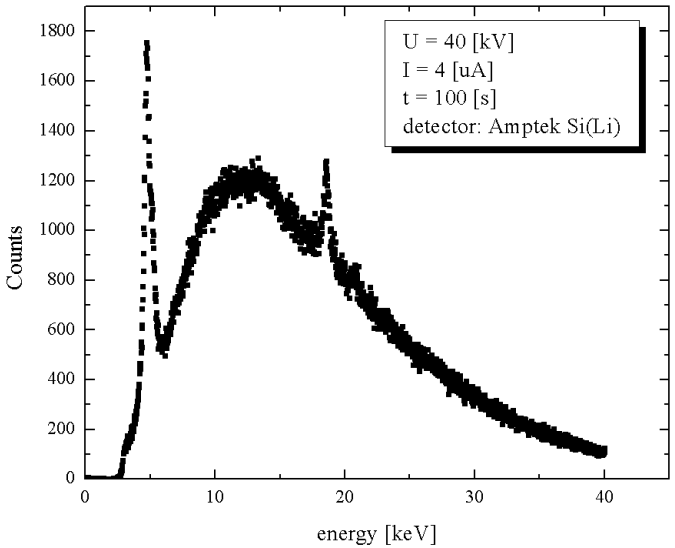


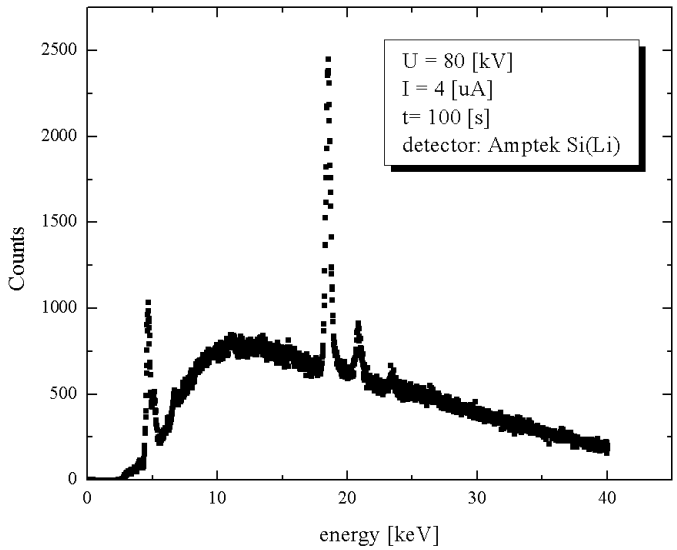


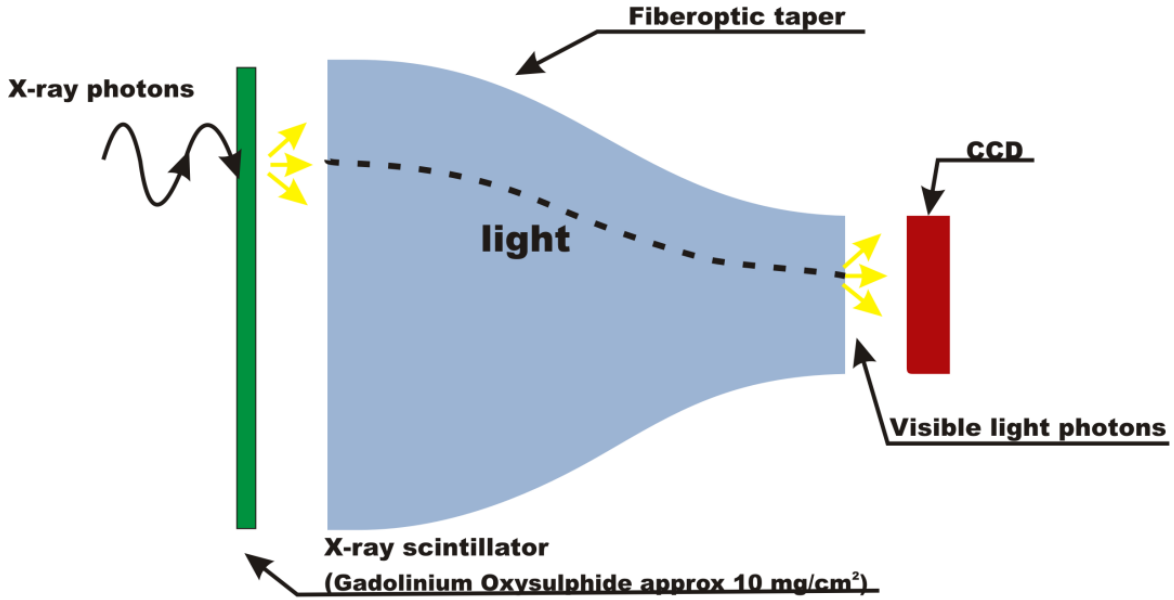
Parameter	Value
Cathode Material	Tungsten
Targets Material	Ti (Kα 4.5keV),Mo (Kα 17.4keV),W (Lα 8.4keV, Kα 59.3keV),Ag(Kα 22.2
X-Ray Output Windows Material	Beryllium / 0.5mm
X-Ray Tube Voltage Setting Range	20kV – 160kV
X-Ray Tube Current Setting Range	0 µA – 200 µA
Expected Resolution	1µm
X-ray Beam Angle	120 degrees

X – ray tube spectra



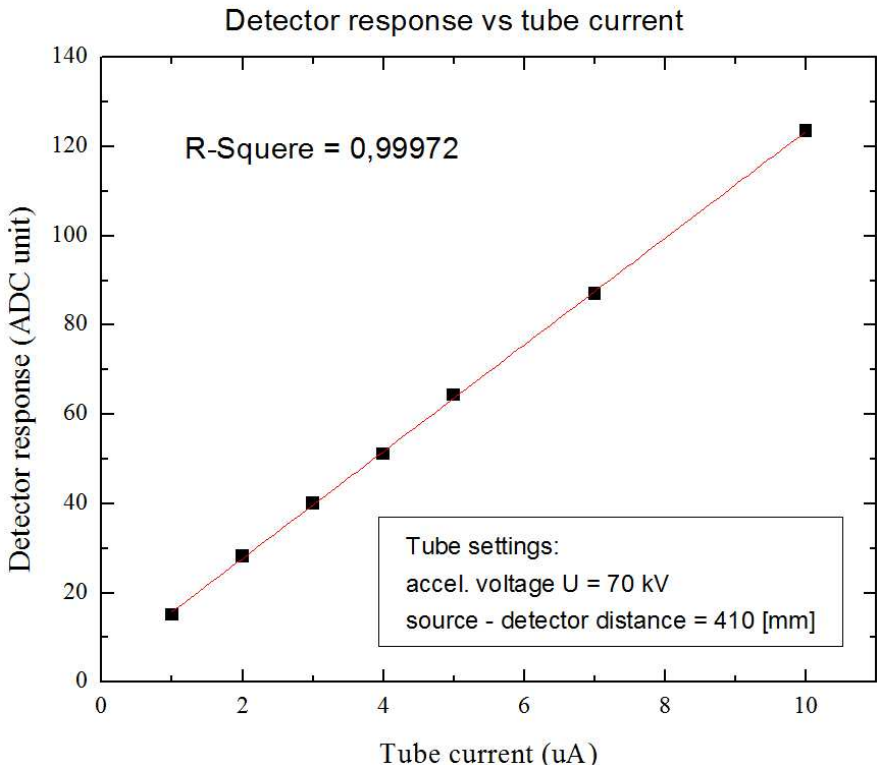


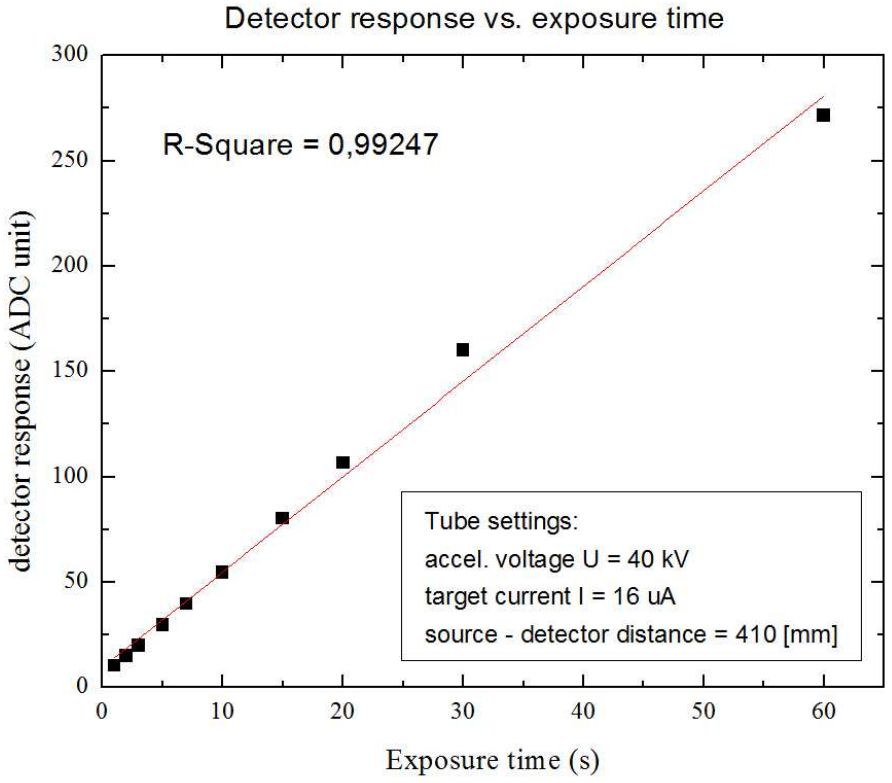




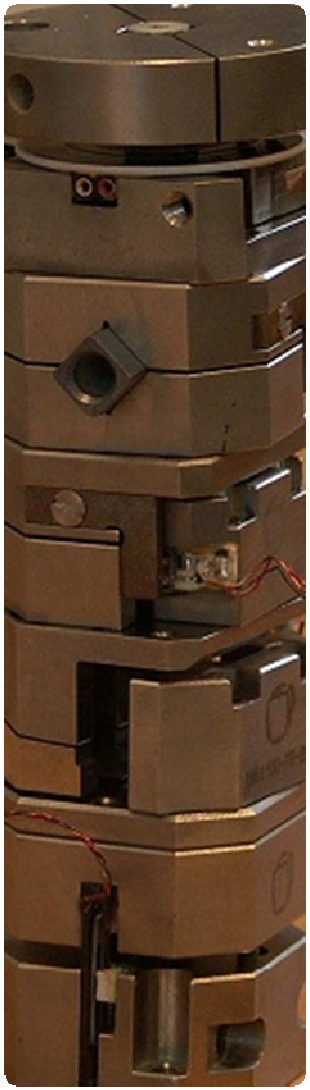
Number of projections needed =π/2 * image width (in pixels)
6000 projections * 15MB = 90 000 MB = 90 GB

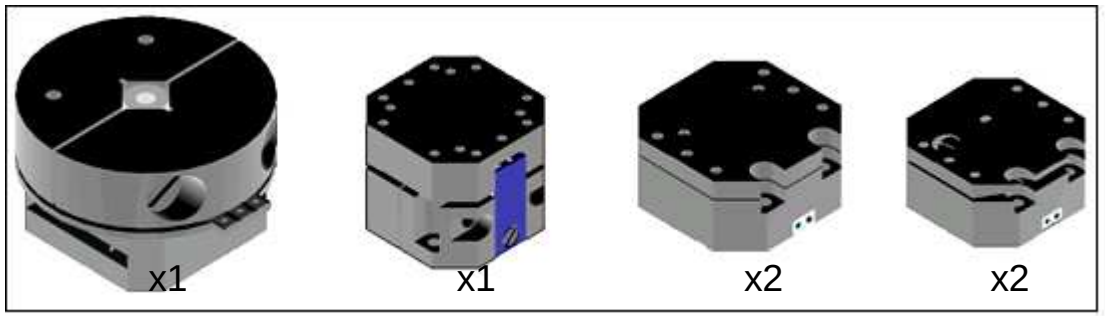
Parameter	Value
Pixels number	About 11 million (4008x2670)
Pixel's size	15µm x 15 µm
Scintilator material	Gadolinium Oxysulphide
Optimum energy	2 keV to 30 keV
Connection	Via frame grabber card


Detector response vs tube current
R-Squere = 0,99972
Tube settings:
accel. voltage U = 70 kV
source - detector distance = 410 [mm]
Detector response (ADC unit)
Tube current (uA)
0
20
40
60
80
100
120
140
0
2
4
6
8
10


Detector response vs. exposure time
R-Square = 0,99247
Tube settings:
accel. voltage U = 40 kV
target current I = 16 uA
source - detector distance = 410 [mm]
detector response (ADC unit)
Exposure time (s)
0
50
100
150
200
250
300
0
10
20
30
40
50
60

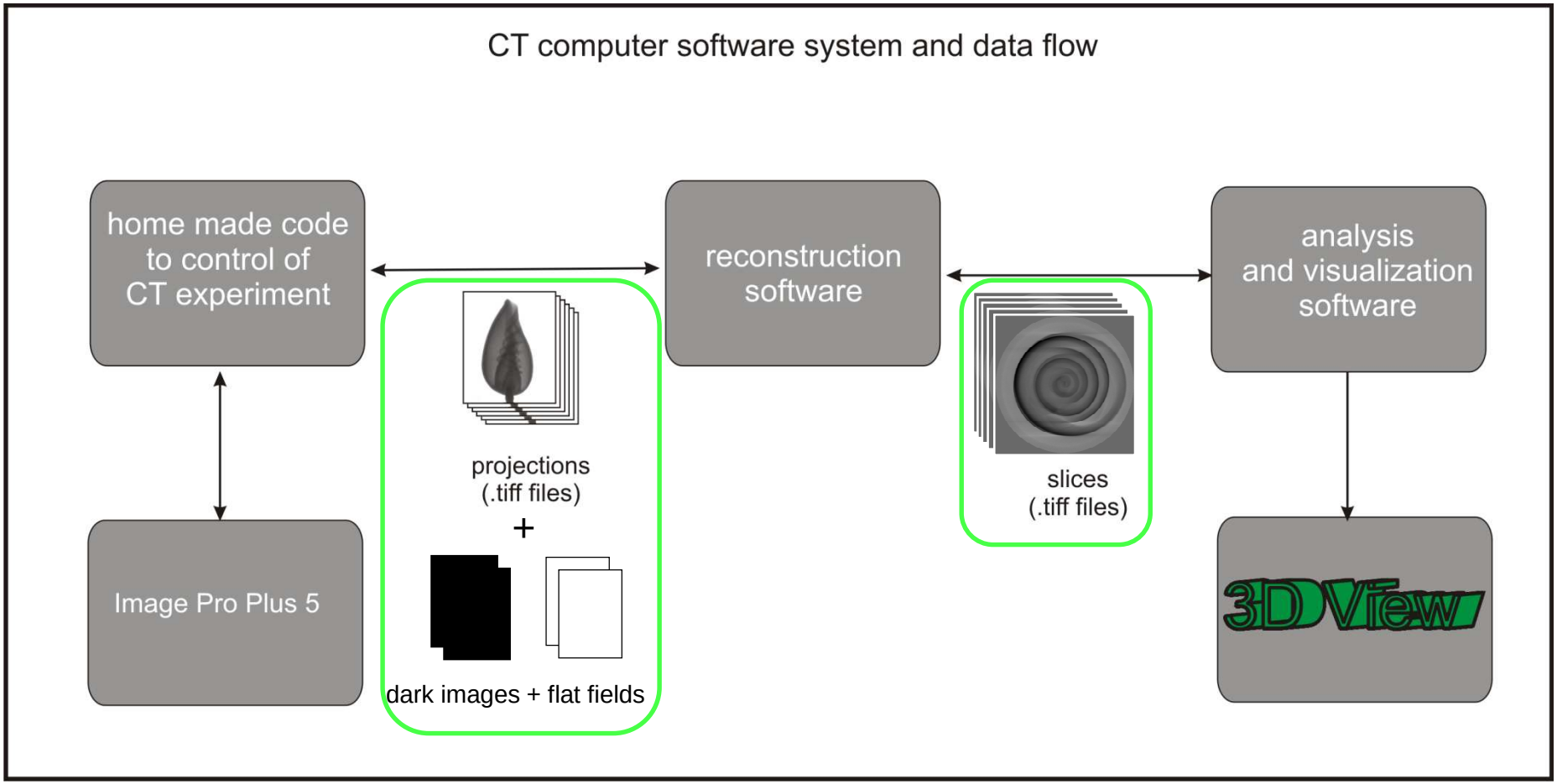
Object manipulator





Parameter	Value
Size	24 x 24 x 15 mm
Linear Travel	7 mm
Symmetry of motion	3-5 %
Maximum load	100 g
Accuracy	0.5 µm / 0.1”
Material	Ti, PZT Ceramics
Connection	RS-232, USB via ontroller

Software system

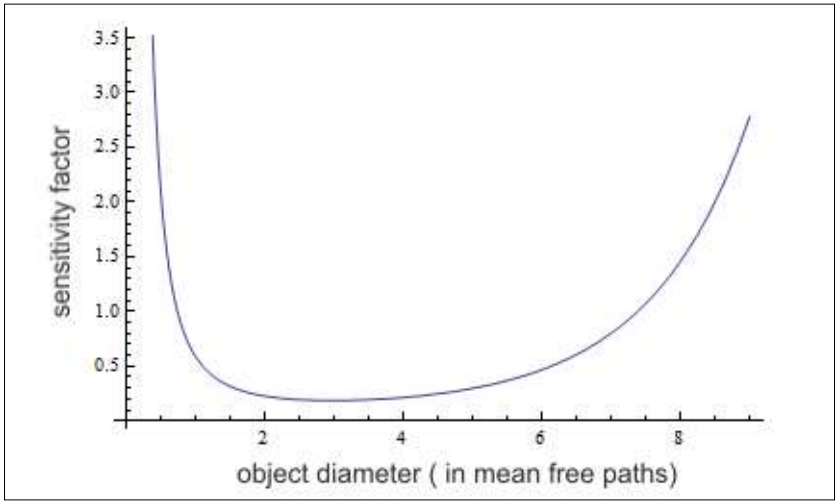


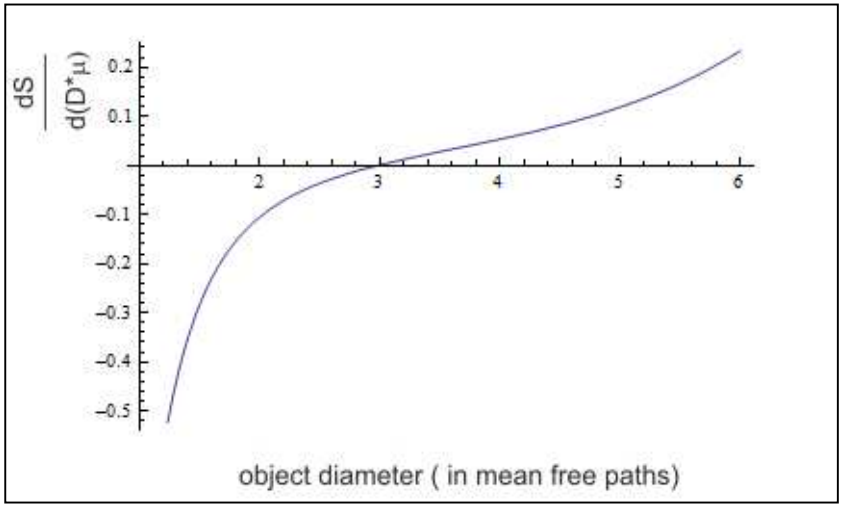
Quality of reconstructed image

Sensitivity factor: $S = \left[\frac{\sinh(\mu D)}{(\mu D)^3} \right]^{\frac{1}{2}}$

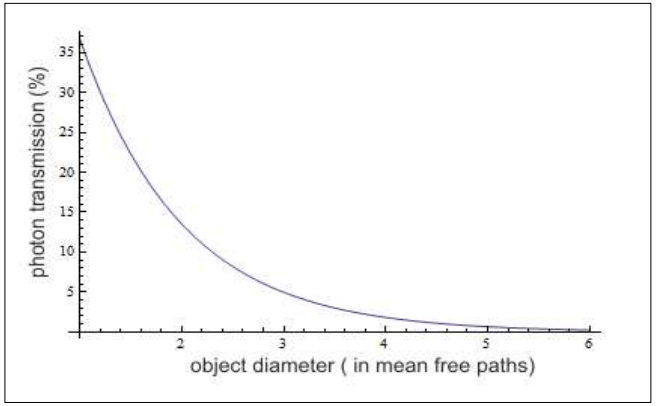
μ - linear attenuation coefficient
D – diameter of the object

Gilboy W B 1984 X-ray and gamma-ray tomography in NDE applications, Nucl. Instrum. Meth. A 221 193–200

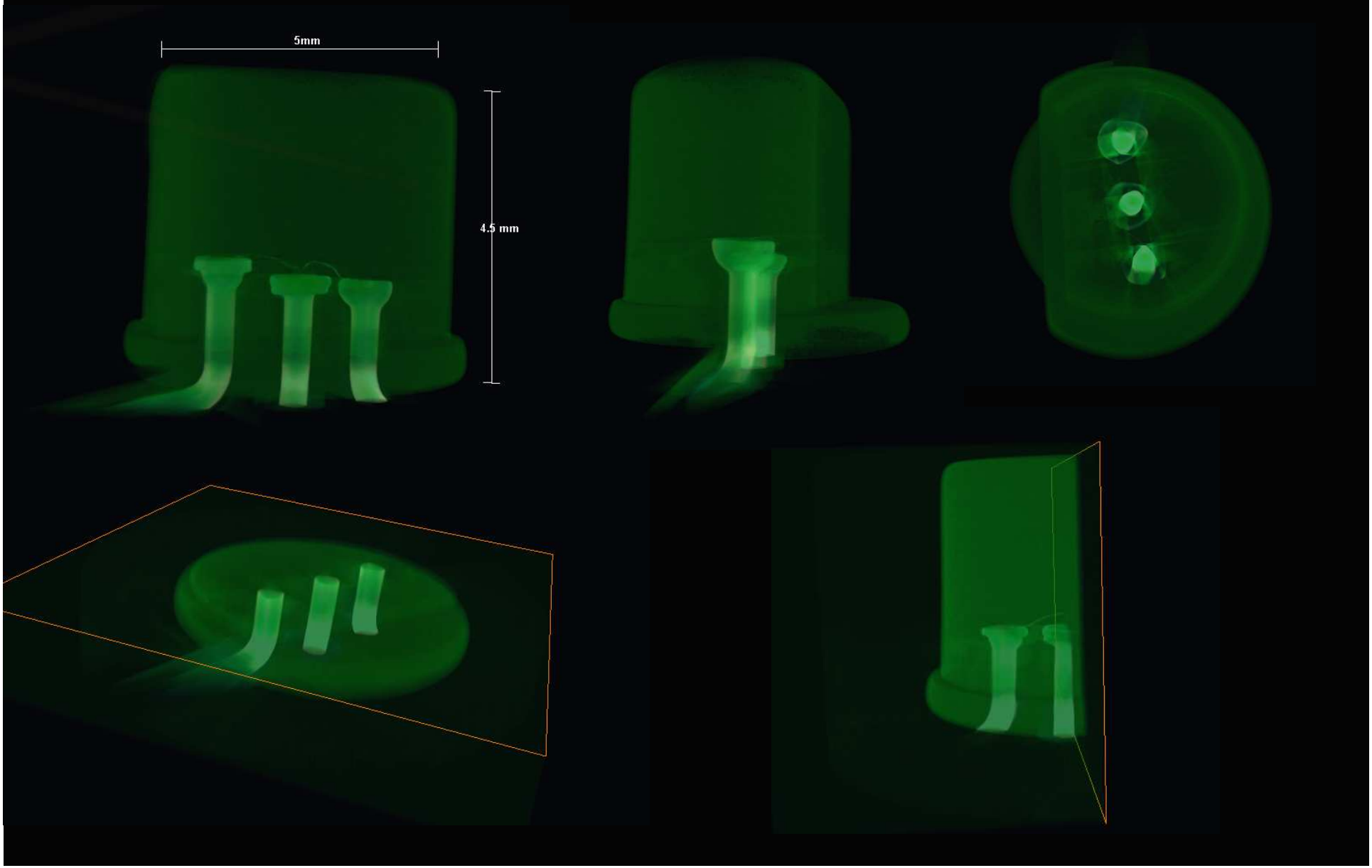




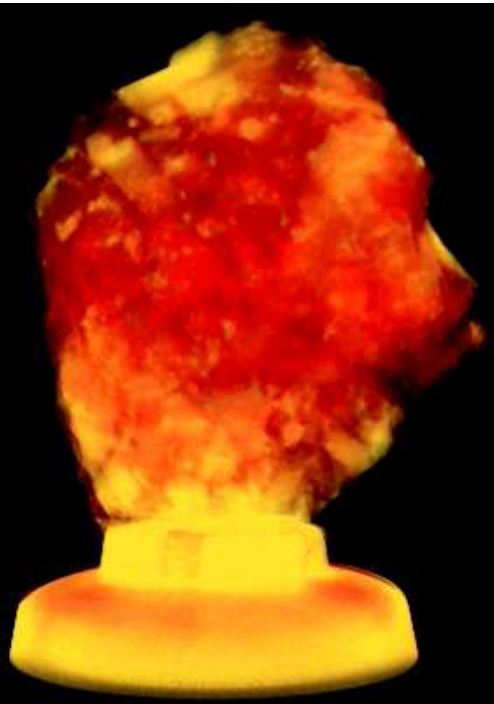
For instance: Ti tagret 4.5 keV,
Object diameter D= 0,5 [mm],
Carbon μ = 57 cm^{-1} (at 4,5 keV)
μ D = 2.8

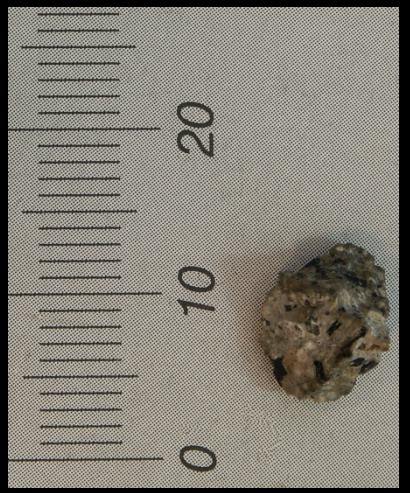


Does it work ? - Test images



beam	# of projections	Single projection acquisition	# of voxels	Voxel 's size
W target (8,4 keV)	500 (500x333)	≈20	500x500x311	10x10x15 µm



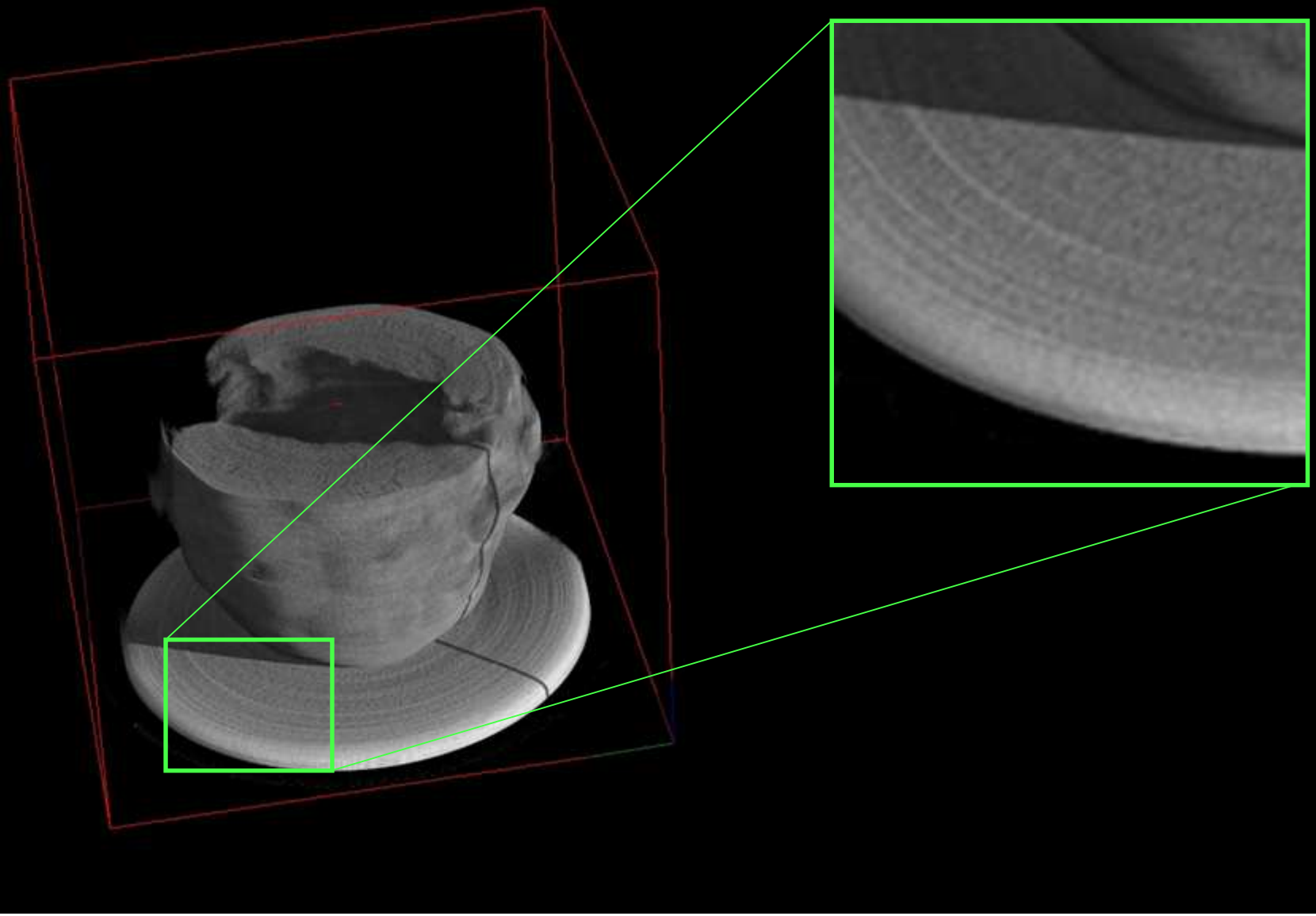


Beam	# of projections	Single projection acquisition time	# of voxels	Voxel ‘s size
W target (8,4 keV)	≈50	744x744x500	7µm	500 (744x666)

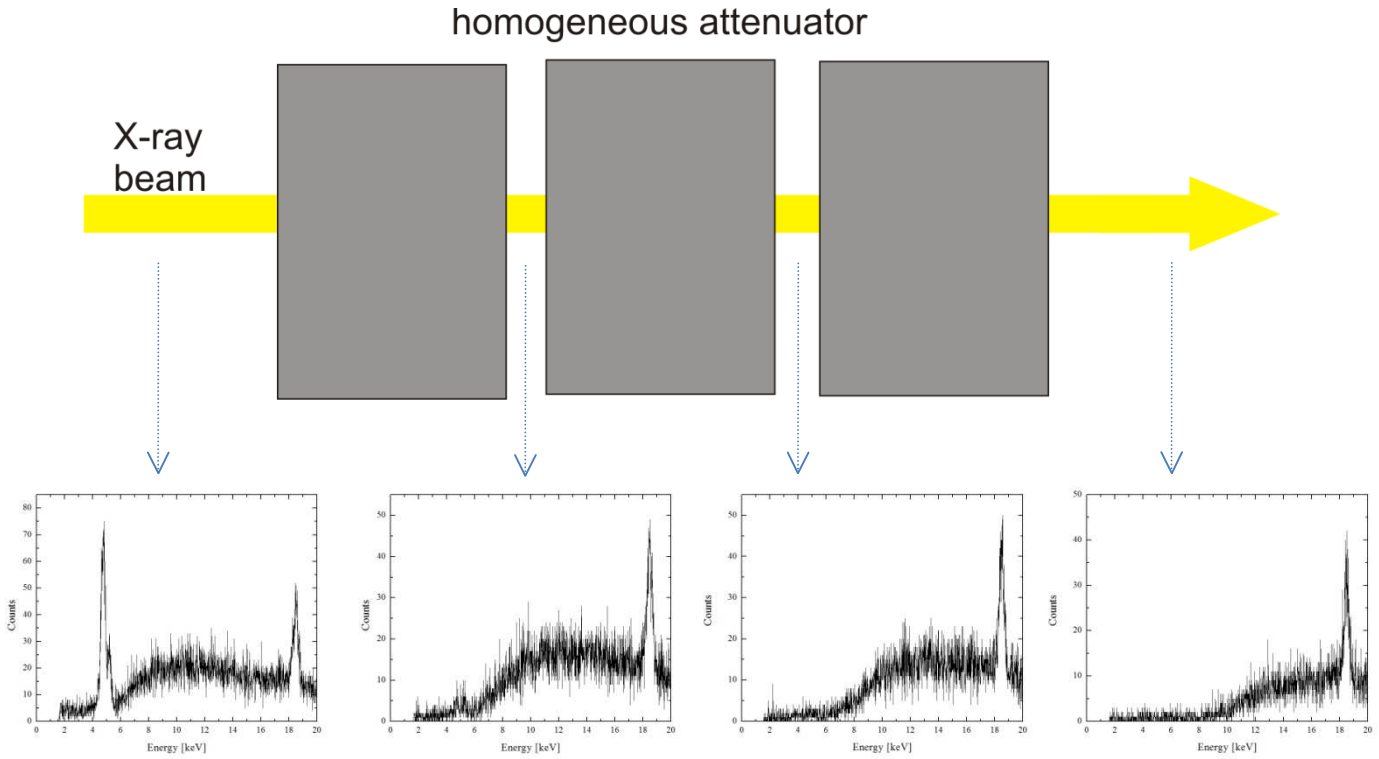
Examples ..

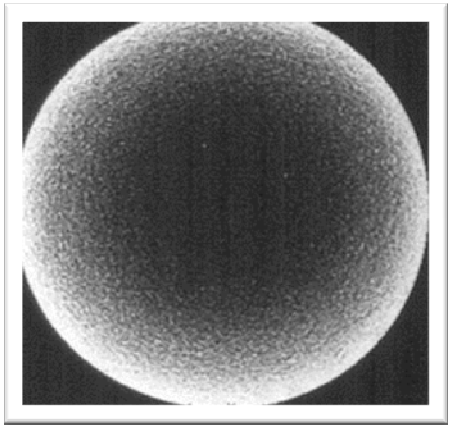
Beam	# of projections	Single projection acquisition time	# of voxels	Voxel ‘s size
W target (4,5 keV)	≈50	744x744x500	7µm	500 (744x666)

RINGS



Artefacts – Beam hardening





THANK YOU
FOR YOUR ATTENTION