Application Note

PET/CT Si78 Optimized MicroCT Protocols

Overview

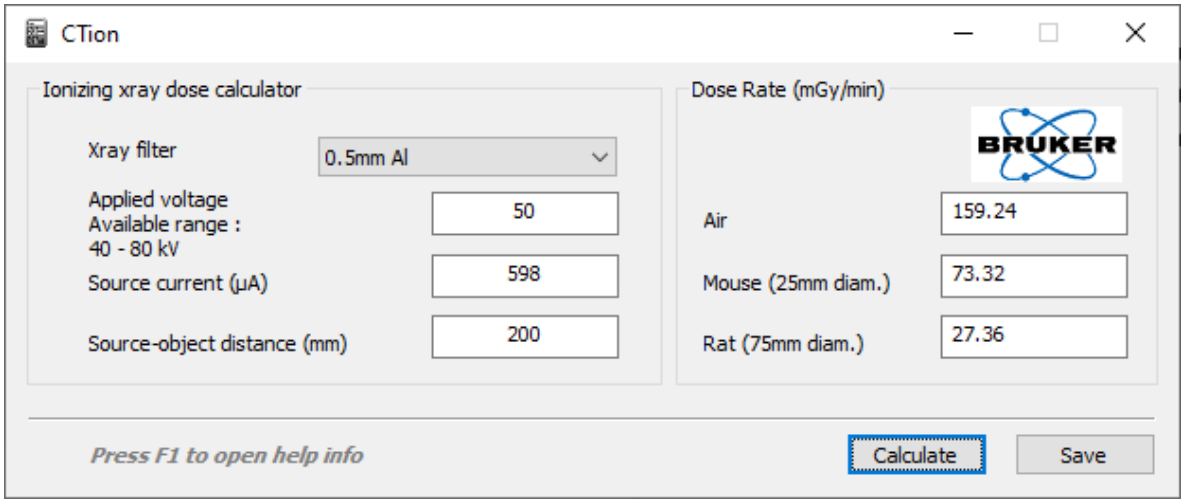
This note provides dose estimates for application optimized microCT protocols performed on the Bruker PET/CT Si78 system. Protocols provide approximate settings for specific microCT applications including anatomical reference, adipose tissue, lung, cardiac, and bone studies. Careful consideration of dose should be made for microCT protocols. Users have sole responsibility for ensuring that protocols used for studies are appropriate.

Dose from X-rays (or any other ionizing radiation) is the concentration of energy deposited in material by ionizing particle interactions. Dose is expressed in units of Grays (Gy), one Gray being one joule of energy absorbed per kg of material (j/kg). One Gy is a large preclinical dose; so for microCT it is convenient to use the smaller unit milliGray or mGy.

Strategies for estimating dose in MicroCT vary and are complex. Often, studies/reports may include both real and modeled calculation estimates. For example, dose estimates may be derived using ion chambers and equivalent tissue phantoms for mice and rats, or may be derived purely through modeled calculations. Ambient dose (or dose in air) estimates and absorbed dose estimates are possible. Absorbed dose estimates consider tissue mass, and users may consult specific literature for expected biological related effects (e.g. neurological, tumor, acute radiation toxicity) for specific associated doses. For more details on dose considerations readers are referred to Bruker Method Note MCT-143 X-ray Dosimetry for In-Vivo MicroCT and Radiation Effects.

Bruker provides two dose tools. ParaVision 360 includes an onboard ambient dose (dose in air) estimate tool (see ParaVision User Manual for details). Bruker also provides a standalone dose calculator tool, CTion, which provides an dose in air and absorbed dose (Mouse 25 mm diam. Or Rat 75 mm diam.) estimate. The calculation of X-ray dose in CTion is based on the simulations of X-ray photon energy spectra and dose by the program SpekCalc (http://spekcalc.weebly.com/) created by scientists from the McGill University in Canada. X-rays are assumed to be emitted from an X-ray source using a tungsten (W) target – the type most commonly used in laboratory X-ray sources. For more details on dose and CTion readers are again referred to Bruker Method Note MCT-143 X-ray Dosimetry for In-Vivo MicroCT and Radiation Effects.

To use CTion (interface shown below), 4 scan parameters are entered – the X-ray filter, applied voltage, current, and source-object distance. The parameter source-object distance for the PET/CT Si78 is fixed at 200 mm. CTion provides a dose rate in mGy/min. Further consideration for the total scan time should be made to determine the total scan dose (mGy). The tables below provide details of standard ParaVision PET/CT Si78 protocols (ParaVision 360 3.3) along with dose estimates derived using CTion. Users should check the dose values and estimates for their settings, cross reference literature for the species and model used, and consider the dose received in longitudinal studies. When users create custom protocols, they should recalculate the dose estimates.



CTion dose calculation tool interface. CTion is a standalone dose estimation tool for microCT. CTion produces a dose estimate only. This should not be considered an absolute measurement of dose. Users should consult their regional and institutional regulatory guidelines regarding imaging protocols and sample doses.

Anatomical Reference Protocols

Scan protocols below are optimized for anatomical reference with multimodal PET.

Object Protocol	Mouse AnatomicalReference Standard Contrast	Mouse AnatomicalReference Low Dose	Mouse AnatomicalReference MultiMouse	Rat AnatomicalReference Standard Contrast	Rat AnatomicalReference Low Dose
Filter	0.5 mm Al	1 mm Al	0.5 mm Al	1 mm Al	1 mm Al
Voltage	50 kV	40 kV	50 kV	60 kV	60 kV
Current	598 uA	702 uA	901 uA	590 uA	300 uA
Pixel size	200 um	200 um	200 um	200 um	200 um
Degree	180 deg	180 deg	180 deg	360 deg	360 deg
Mode	Step & Shoot	Continuous Rotation	Step & Shoot	Step & Shoot	Continuous Rotation
Rotation	0.8 deg	28 deg/sec	1 deg	0.8 deg	28 deg/sec
Frame Ave.	1	NA	1	1	NA
Scan Time (approx.)	1m	15s	1m	1m 45s	20s
CTion Absorbed Dose Rate Estimate	73.32 mGy/min	36.60 mGy/min	110.40 mGy/min	30.07 mGy/min	15.08 mGy/min

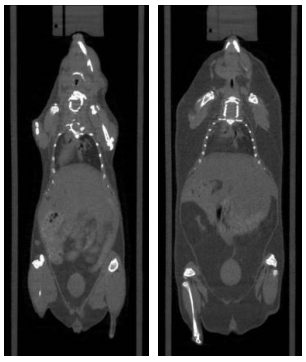
	Recon.	**Recon.**	**Recon.**	**Recon.**	**Recon.**
Smoothing	0	0	0	0	0
Ring Correction	2	2	2	2	3
Beam Hardening	25%	25%	30%	30%	30%

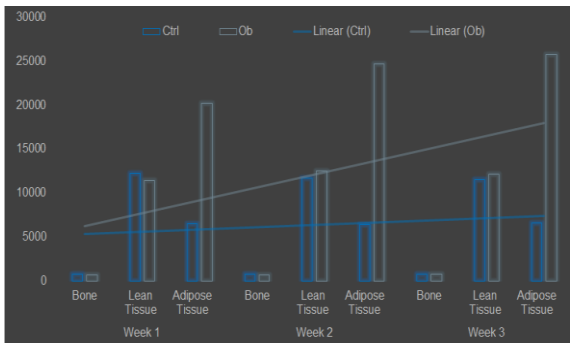
Adipose Protocols

Scan protocols below are for mice and rat in vivo adipose tissue segmentation. Typical results for in vivo tissue contrast and segmentation are shown further below.

Object **Protocol**	**Mouse** **Adipose** **High Contrast**	**Mouse** **Adipose** **Low Dose**	**Rat** **Adipose** **High Contrast**	**Rat** **Adipose** **Low Dose**
Filter	0.5 mm Al	1 mm Al	1mm Al	1 mm Al
Voltage	40 kV	40 kV	65 kV	60 kV
Current	901uA	502 uA	771 uA	502 uA
Pixel size	100 um	100 um	100 um	200 um
Degree	180 deg	180 deg	360 deg	360 deg
Mode	Step & Shoot	Step & Shoot	Step & Shoot	Step & Shoot
Rotation	0.5 deg	0.8 deg	0.5 deg	1 deg
Frame Ave.	2	2	2	2
Scan Time (approx.)	2m 15s	1m 15s	4m	1m 45s
CTion Absorbed Dose Rate Estimate	75.74 mGy/min	26.17 mGy/min	44.97 mGy/min	25.24 mGy/min

	Recon.	**Recon.**	**Recon.**	**Recon.**
Smoothing	1	1	1	0
Ring Correction	2	2	2	2
Beam Hardening	25%	25%	30%	30%





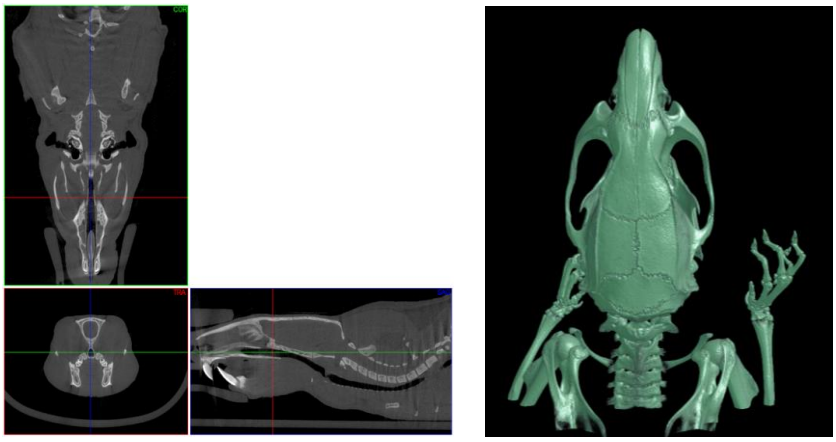
Representative Results Using Mouse Adipose Standard Contrast Protocol. A control and LepOB obese mouse imaged weekly. The adipose tissue, lean tissue and bone volume were measured and plaotted. For further details on adipose tissue analysis please refer to MN032 Adipose Tissue Measurement In-vivo.

Bone

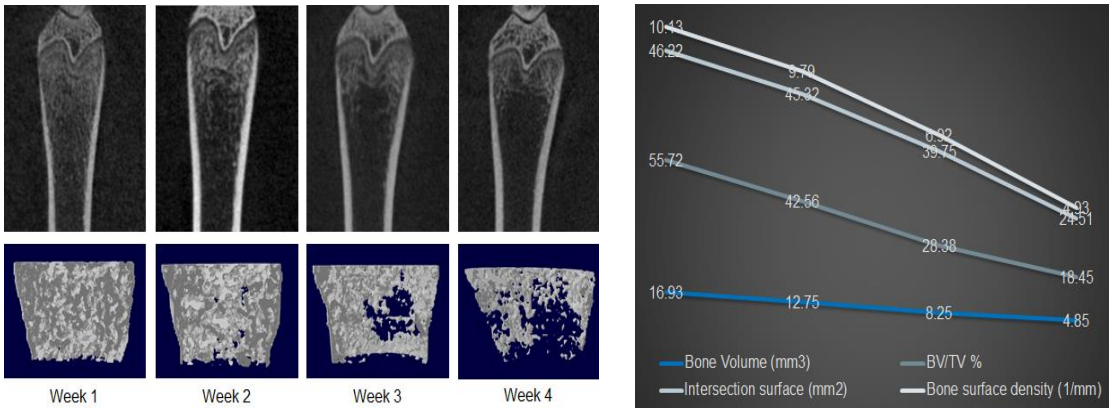
Scan protocols below are for mice and rat bone tissue. Standard Contrast and Low Dose settings will be appropriate for gross anatomy. Using the High Contrast settings, some (though limited) rat bone substructure may be visualized. Typical results are shown below.

Object **Protocol**	**Mouse** **Bone** **Standard Contrast**	**Mouse** **Bone** **Low Dose**	**Rat** **Bone** **Standard Contrast**	**Rat** **Bone** **Low Dose**	**Rat** **Bone** **High Contrast**
Filter	0.5 mm Al	1 mm Al	1 mm Al	1 mm Al	1mm Al
Voltage	40 kV	40 kV	65 kV	60 kV	65 kV
Current	901 uA	502 uA	702 uA	502 uA	702 uA
Pixel size	50 um	100 um	50 um	100 um	50 um
Degree	180 deg	180 deg	360 deg	360 deg	360 deg
Mode	Step & Shoot	Step & Shoot	Step & Shoot	Step & Shoot	Step & Shoot
Rotation	0.4 deg	0.8 deg	0.4 deg	0.8 deg	0.3 deg
Frame Ave.	4	2	3	2	2
ScanTime (approx.)	8m 30s	1m 30s	11m	2m 15s	10m
CTion Absorbed Dose Rate Estimate	**75.75 mGy/min**	**26.17 mGy/min**	**40.94 mGy/min**	**25.24 mGy/min**	**40.94 mGy/min**

	Recon.	**Recon.**	**Recon.**	**Recon.**	**Recon.**
Smoothing	2	1	2	1	3
Ring Correction	3	3	3	2	3
Beam Hardening	25%	25%	25%	30%	30%



Representative Results Using Rat Bone Standard Contrast Protocol. Details of gross bone structure can be visualized.



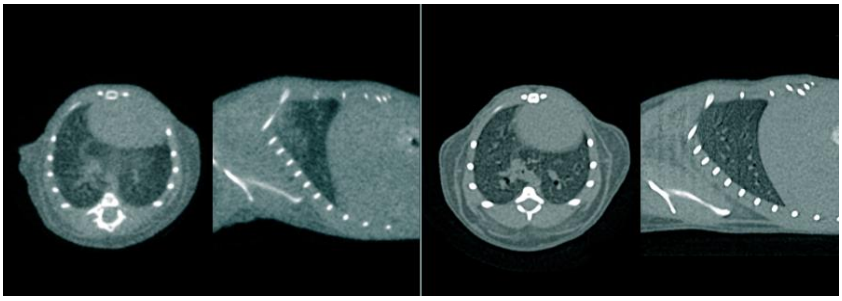
Representative Results Using Rat Bone High Contrast Protocol. A 6 month old Sprague-Dawley rat with OVX osteoporosis was scanned weekly post-surgery. Distal femur trabecular bone analysis shows severe loss in bone structures and decreasing bone volume over time.

Respiratory Gated

Scan and reconstructions settings for lung gated scans are below. Typical results are shown below.

Object **Protocol**	**Mouse** **Resp Gated** **Standard Contrast**	**Mouse** **Resp Gated** **Low Dose**	**Rat** Resp Gated Standard Contrast	**Rat** **Resp Gated** **Low Dose**
Filter	0.5 mm Al	1 mm Al	1 mm Al	1 mm Al
Voltage	40 kV	45 kV	65 kV	60 kV
Current	702 uA	702 uA	702 uA	702 uA
Pixel size	100 um	100 um	200 um	200 um
Degree	360 deg	180 deg	360 deg	360 deg
Mode	Dynamic	Dynamic	Dynamic	Dynamic
Rotation	0.7 deg	0.7 deg	0.7 deg	1 deg
Frame Ave.	10	8	12	8
ScanTime (approx.)	7m	5m 30s	8m 30s	5m
CTion Absorbed Dose Rate Estimate	46.45 mGy/min	46.45 mGy/min	40.94 mGy/min	40.94 mGy/min

	Recon.	**Recon.**	**Recon.**	**Recon.**
Smoothing	1	1	0	0
Ring Correction	2	2	2	2
Beam Hardening	25%	25%	30%	30%
Gate	Resp.	Resp.	Resp.	Resp.
Movie Frame	4	4	4	4



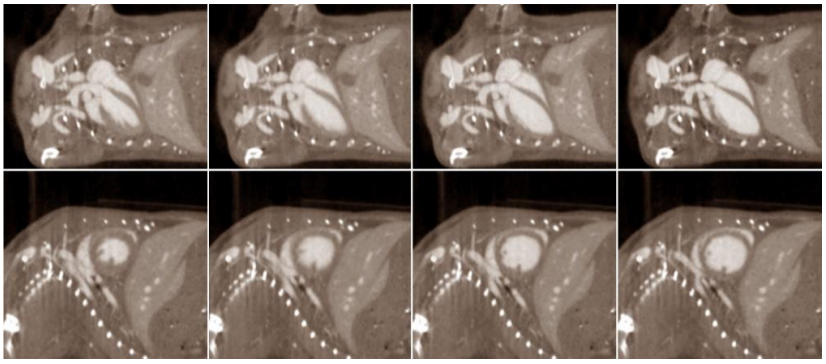
Representative Results Using Mouse Resp Gated Standard Contrast Protocol. A non-gated scan (left) showing blurring due to lung movement. The lung gated scan (right) shows clear delineation of the diaphragm, lung vasculature, and airways can be easily visualized.

CINE

Scan and reconstructions settings for cardiac gated scans are below. Typical results are shown below.

Object Protocol	Mouse CINE Standard Contrast	Mouse CINE Low Dose	Rat CINE Standard Contrast	Rat CINE Low Dose
Filter	0.5 mm Al	1 mm Al	1 mm Al	1 mm Al
Voltage	45 kV	45 kV	65 kV	45 kV
Current	901 uA	502 uA	702 uA	502 uA
Pixel size	100 um	200 um	100 um	200 um
Degree	360 deg	180 deg	360 deg	360 deg
Mode	Dynamic	Dynamic	Dynamic	Dynamic
Rotation	1 deg	1 deg	0.7 deg	1 deg
Frame Ave.	14	16	20	16
Scan Time (approx.)	10m	5m	13m 15s	8m 15s
CTion Absorbed Dose Rate Estimate	93.26 mGy/min	33.3 mGy/min	40.94 mGy/min	13.79 mGy/min

	Recon.	Recon.	Recon.	Recon.
Smoothing	1	0	1	0
Ring Correction	2	2	2	2
Beam Hardening	25%	25%	30%	30%
Gate	ECG	ECG	ECG	ECG
Movie Frame	5	6	6	6



Representative Results Using Mouse CINE Standard Contrast Protocol. A normal mouse with contrast enhanced microCT scanned with cardiac synchronization.