

Customer Training Guide

for μ CT and vivaCT Users

Version 1.2

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1 Initial Overview

1.1 Scanner

- Three different possibilities to turn on/off: main switch, key switch, emergency stop button →each must be on!
- If you turn on the scanner, the x-ray-tube is still off. You have to start the measurement program. **It takes 20 minutes warm up time until the tube is ready to scan!**
- Turn the scanner off if you don't use it over night (vivaCT) / for several days (microCT).
- If the scanner is not used for several weeks: turn it on and let the tube burn (i.e. open scout view) for about half a day once a month.

1.2 Sample Handling

- The scanned objects must **completely** fit inside our sample holders.
- Be careful, no fluids drop into the scanner →**no warranty!**
- If you use fluids, please seal with parafilm or covers. For vivaCT: no parafilm or covers! Please use the falcon tube holder.

1.3 Safety Information

Please read the first two chapters in our user manual carefully.

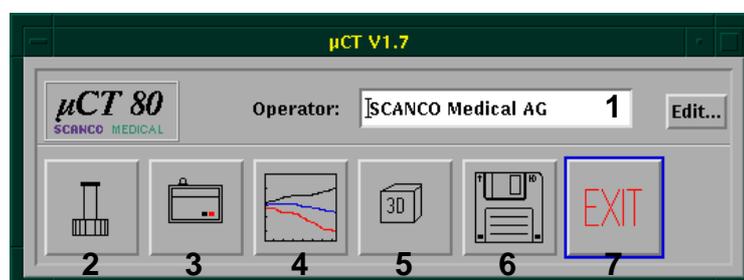
1.4 Computer (Workstation)

- The computer start up takes about 5 minutes
- Usually the workstation stays on. **Turning off:** always check for batch jobs (`$ queue`) first. Type **SHUTDOWN** as username and click OK
- You should not switch off the computer without performing a correct shutdown.
- After about one minute (grey screen) you can turn off the computer and peripherals.

1.5 Operating System VMS

- 4 windows: μ CT controlbox (application – microct), session manager, command window (terminal) and clock/calendar
- terminal commands in this document are shown with a \$ at the beginning, e.g. `$ command`

1.6 Program Overview



- 1 Define Operator
- 2 Define Samples
- 3 Measurement Program
- 4 Evaluation Program
- 5 3D Viewer
- 6 Backup/Archiving
- 7 Exit

2 The Programs

2.1 Operator Database

- Each operator has its own name and a corresponding operator number which is automatically generated by the program.
- Only the name is mandatory
- Use '**Find**' and type in the first letter or the number to search for an operator, click on 'ok'.
- If you leave search input empty and click 'ok', you see the whole list of operators.

2.2 Sample Database

- The sample number is automatically allocated by the program and cannot be changed
- The list of samples is sorted by name. Beginning with a study name recommended (for using filter)
- With '**Find**' you can type a number or the beginning of the sample name (NB: case sensitive)
- Remarks field in the sample program: for all measurements with this sample number, appearing on the evaluation sheet
- Remarks field in the measurement program: only for this measurement
- If scan was done under WRONG sample name/number: \$ import enter ISQ filename, correct sample number and delete the wrong measurement with the archive program to clean up
- correct typos with '**Update**'.
- **CAUTION!** The program is case sensitive and it does not accept numbers at the beginning of a sample name
- Exit: changes will be automatically saved
- Quit: return to the main menu without saving the edited data

2.3 Measurement Program

2.3.1 Controlfiles

Usually it is easiest to create a new controlfile by choosing an existing one. Modify it and click "save as new".

Energy/Intensity: highest Energy (70kV) and highest Intensity for most scans, only small (diameter less than about 20mm) or non-dense objects (soft tissue) with 55kV or 45kV.

Resolution: LR/MR have less noise than HR because the pixels are averaged 2x2. →Increase Integration Time to compensate the higher noise. For large objects you need more projections →use HR.

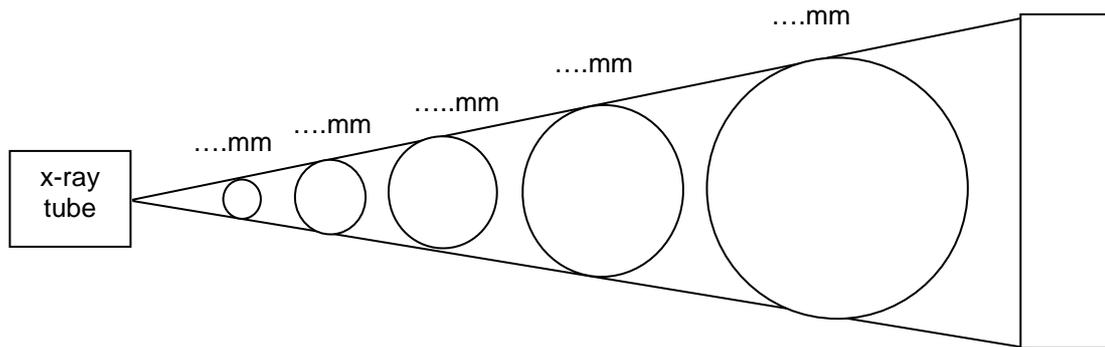
Diameter: For best resolution choose the smallest diameter possible. Before each measurement, the scanner performs a diameter test: If you chose the diameter too small in your controlfile, the measurement will be aborted.

Number of Slices: on the right you see how many slices you get with one stack (=one rotation). If you change the number of slices, you should consider the stack boundaries because the measurement time (at the bottom of the window) is increasing proportionally with each additional more stack. It is therefore very inefficient if you e.g. scan 107 slices with a stack size of 106 slices.

Integration Time: Increasing integration time decreases noise! For standard measurements choose an integration time around 100 – 200ms for μ CT40/VivaCT and 400ms for μ CT35/80. The reconstruction time is not affected by this value but only the measurement time.

IMPORTANT! Try and test different controlfile settings and compare the resulting images visually before a study with many samples is started!

Calibration Record / Evaluation Script: You can apply a certain calibration record and/or evaluation script which will be applied automatically to every sample measured with this controlfile.



scan diametermmmmmmmmmm	reconstruction	proj /180°	slices /stack
	voxel size (μ m)							
HR						2048 pixels	1000	
MR						1024 pixels	500	
LR = SR						1024 pixels	250	
Custom								

2.3.2 Scout View

- determine a meaningful scout-view area (start, end) for your sample and save it in your controlfile.
- if you want to start the measurement in a certain distance from a defined reference line, you can use the parameter "rel. pos. of first slice to ref. line" in your controlfile.

Shortcuts

- changing number of slices: SHIFT-MB1
- center a predefined number of slices among two reference lines: ALT MB1

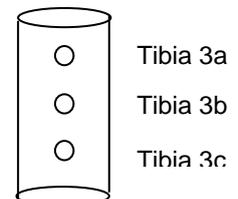
2.3.3 Batch Measurement

You can put multiple specimens in one sample holder and measure them with batch measurements. The batch measurement is working in the background. \$ `que` shows all the jobs with the belonging logfile.

IMPORTANT: Choose a separate sample name/number for each specimen within the sample tube. Select the sample number after setting the reference line in the scout-view by clicking on OTHER... or NEW...

You may even submit batch jobs with different controlfiles (without redoing the scout view)

Suggestion: use little post-it notes with the order of samples within the sample holder. Stick them next to the monitor and double-check, that the sample name and number are correct before submitting batch measurement.



2.3.4 Precalibration

For VivaCT only: Sample MUST NOT be in the x-ray beam in the initial loading position. The scanner must be able to scan pure air in the z=0 position.

Otherwise: Use 'Precalibration' (measures I0 and Dark) before you put in the sample

CAUTION: Batch scans are NOT possible then.

2.4 Evaluation Program

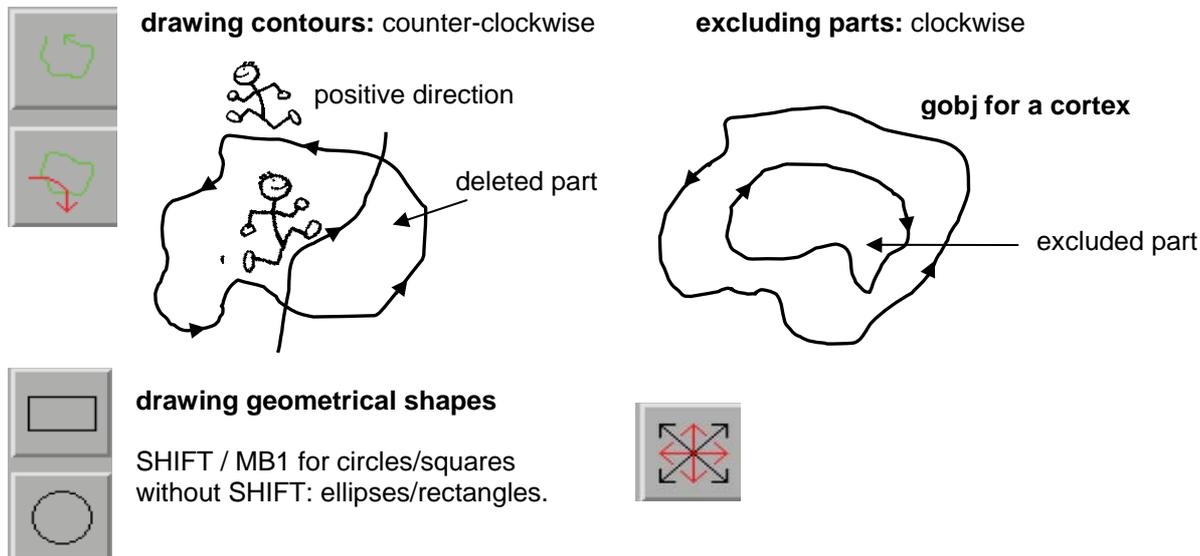
VOI = Volume of Interest

ROI = Region of Interest

MB1 = Mouse Button 1 (left)

MB2 = Mouse Button 2 (middle)

2.4.1 Contouring



move (MB1) / scale (MB2) contours

SHIFT / MB2: constraint scaling (vertical and horizontal scale factor is equal)

- **automatic contouring:** double clicking a hand-drawn object. It will automatically adapt to outer (sharp) boundaries.
- **contouring the trabecular area:** always leave a small gap to the cortex (half the cortical thickness) → less corrections after morphing. Leave about the same gap for all the samples within one study.
- **midshaft analysis:** →FAQ
- **Morph:** interpolates the missing objects between two hand-drawn breakpoints (green contours) in two reference slices. →always check the interpolated slices and maybe adjust them!

2.4.2 Segmentation / Threshold

To suppress noise, we apply a gauss filter:

sigma σ : increasing the weight of neighbour pixels

support: number of used neighbour pixels

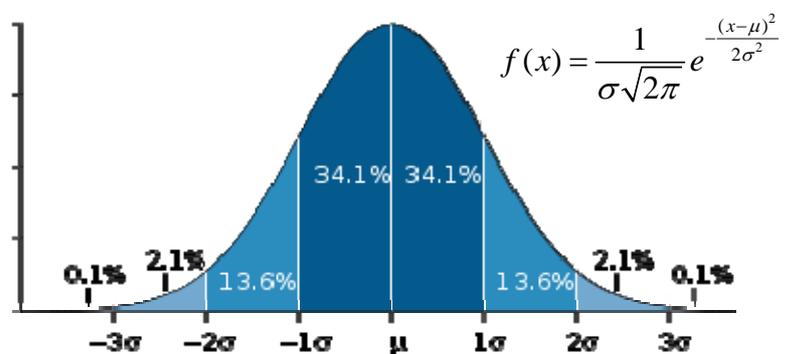
rule of thumb: support = $2 \cdot \sigma$

(round down to next integer)

standard: 0.8 / 1

very long integration time: 0.3 or lower

noisy images: sigma 1.5 or higher, support=2



Threshold Selection

Threshold is usually chosen visually, and then a fixed threshold is applied for a study with similar samples. For images with good quality, choosing a good threshold is easy, e.g. the middle between the histogram peaks can be chosen. If image quality gets worse, it gets harder to find a nice threshold.

What to look out for: Compromise between:

- A) segment structure with 'correct' thickness ('not too fat')
- B) catch also thin connections, not interrupting the structure.

Note: in 3D, even though a thin element may look disrupted in one slice, it might well be connected in previous or next slice.

Find a compromise between A and B. Do this for a few samples in your studies, each on a few slices, preferably on 'good samples' and 'bad samples' (e.g. bone with high density, and bone with low density). Then make a compromise. If you cannot find a compromise: try and rescan your samples with better scan settings, e.g. less noise (thus higher IT), and/or higher resolution.

Alternative to visual selection: run evaluation script 'AIT threshold' on a few samples, check the found thresholds, and average the found threshold for a few samples, then use the fixed threshold per group. (if necessary: To get the 'AIT threshold' script: import it into the Eval program, 'Scripts', 'Import')

IMPORTANT: Once threshold is determined for a study: create YOUR OWN evaluation script with meaningful 'project name' (maximal 15 letters!) and **preset sigma/support/gauss**

2.4.3 Evaluation Scripts

Evaluation Scripts are to the evaluation what controlfiles are to the measurement: A collection of all settings for the evaluation of a study.

By default, you have a collection of 'starter scripts' to choose from. For a specific study, copy a script and save it under a new name to be used for the evaluation of that study. Enter a meaningful 'project name' (max. 15 letters) in that evaluation script, and save the threshold settings (and sigma/support). See separate document 'Eval_V6.doc' for more info about evaluation scripts.

Collected results for one project go to tabulated text files in

Disk1:[microct.results]uct_3dlog_xxxxx.txt with xxxxx your chosen project name. (and _moi_ file for midshaft evaluations with moment of inertia calculation added)

2.4.4 Evaluation Sheet

TV:	total volume [mm ³]
BV:	bone volume [mm ³]
BV/TV:	relative bone volume [1] ("Percent")
Conn.D.:	connectivity density, normed by TV [1/mm ³]
SMI:	structure model index: 0 for parallel plates, 3 for cylindrical rods
DT-Tb.N:	trabecular number [1/mm]
DT-Tb.Th:	trabecular thickness [mm]
DT-Tb.Sp:	trabecular separation = marrow thickness [mm]
DT-Tb.1/N.SD:	standard deviation of local inverse number [mm]
DT-Tb.Th.SD:	standard deviation of local thicknesses [mm]
DT.Tb.Sp.SD:	standard deviation of local separations [mm]

2.5 3D Viewer

2.5.1 Open Images

- Default: **'segmented'** to look at 3D views of segmented objects. **'All Files'** to open any other files, e.g. gray-scale volume.

2.5.2 Colours

- **'Options', 'Display Properties'**: change colour of the objects. If a volume with multiple objects is loaded (e.g. `_transp.aim`), you can choose the individual objects with the 'From' and 'To' sliders.
- **'Faces'**: give a different color to the virtual cuts (artificial surfaces) through the object
- **Thickness colour coded images (`_TH.AIM`)**: thickness depending colours (or transparent for e.g. joins) (thickness units are limited by pixel size). Move the mouse button over the trabeculae to get the thickness.

2.5.3 Cuts

- **'subdim'**: Fix cuts along x/y/z direction → cut turns synchronous with the object
- **'cutplane'**: cut in the direction of the viewing plane – always head on, irrespective of object orientation. Thus 'slanted' cuts can be produced through the object

2.5.4 Animations

- **Demos**: 'read', `uct_demo: *.msq`
- TIF-animations: → FAQ for fancy animations
- **HINT**: after calculation of animations, exit from the program and restart it, otherwise, the program may crash.

2.6 Backup/Archive Program

- **Initialize** (6 letters): One tape RAW001 for RAW (sonogram, scan data), one tape IMA001 for IMA (image data: ISQ, AIM, GOBJ...) You should keep the raw and the image data on two different places!
- **Weekly backup**: 'Week_A' and 'Week_B' tapes. ONLY Disk1 is **copied** to tape, NOT the image data on the data disk
- **Archive =move to tape → free space**: Archive RAW as soon as all the slices have been reconstructed
- **CAUTION**: When wanting to RETRIEVE from tape: look up on FAQ BEFORE one retrieves from tape to see the influence of choosing 'copy to' or 'move to'
- **Full tape**: 'Tape contains continued dataset' just means that tape is full.
- when tape is full: 'Do you want to continue?', NO' → check where it stopped and hit CTRL/C to kill the process. Move protection slider to red on full tape. Put in a new tape, initialize it and go on archiving.
- If errors appear: show the 'helper terminal' behind the archive program, if Scanco support is contacted, we HAVE to have the full screen feedback of that: see FAQ how to put this into e-mail.
- `$ write_info`: which scan is where, dk0, tp0 or deleted.

3 Additions

3.1 Filesystem

3.1.1 Disks

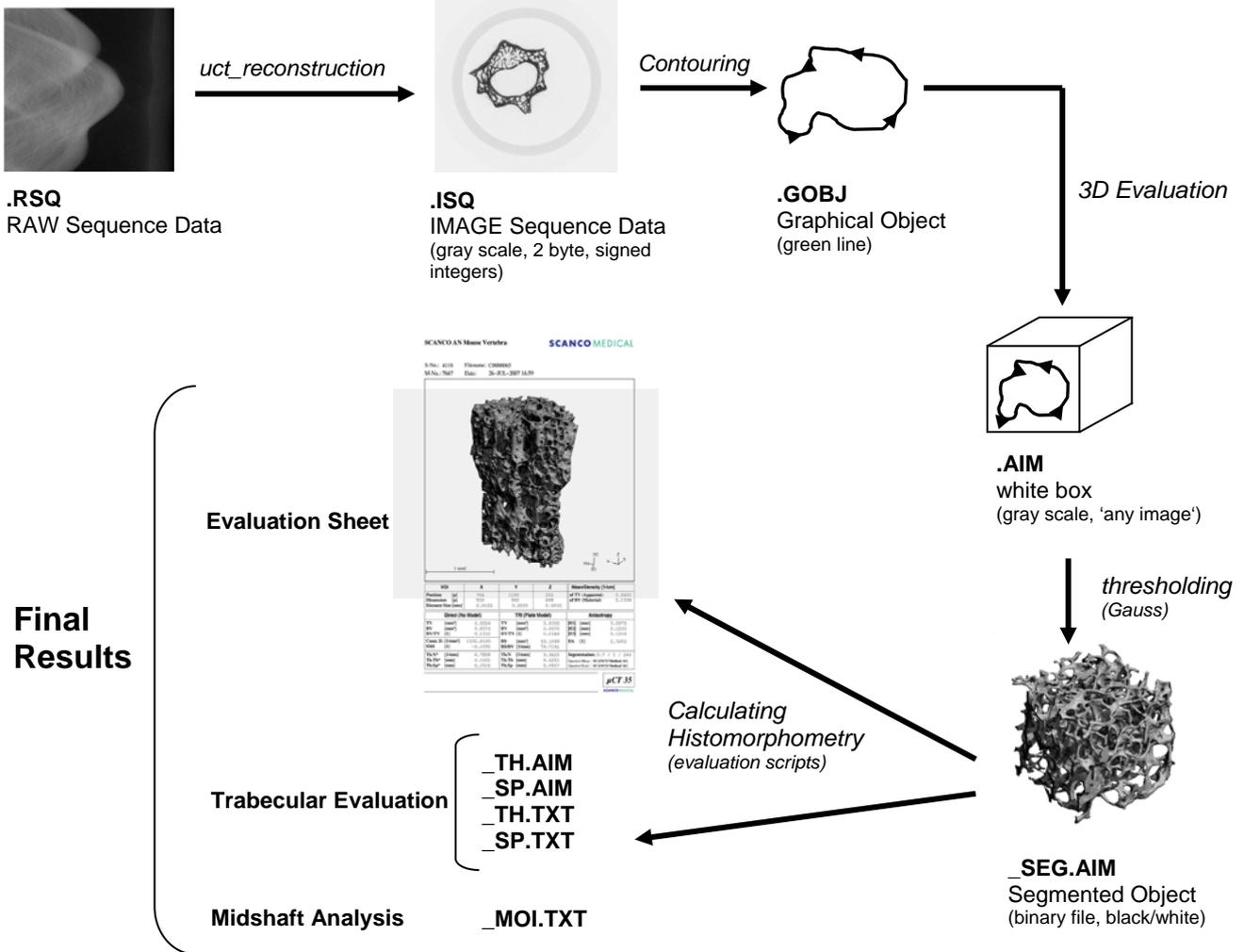
\$ disks to see all disks and the amount of data

Disk0 = system disk	Disk1 = user disk	Disk2 (DK0) = big CT data disk ('views', 'microct:data')
- microct_common (protected files) - program files - operating system →DO NOT DELETE ANYTHING !	- database (operator, sample, controlfiles) (Do NOT edit .dat-files) - scratch: logfiles - results (txt-files)	- raw scan data: .rsq-files - reconstructed images: .isq-files - contours, segmented images, ...

CAUTION: check disk tower for WARNING lights periodically. If there is one: don't panic! Contact SCANCO immediately and **DO NOT remove disks!**

3.1.2 From Scan to Results

Scan



3.2 Handling Data / WEB Interface

Generating Summary files

- disk1:[microct.results] contains appended uct_list_3dlog_xxxxx.txt file of the 3D results, separated after project name as given in evaluation script.
- Alternative: \$ uct_list to get results of most recent 3D evaluations, Import into EXCEL: right mouse click 'open with' Excel or similar program. Uct_eval.txt files are tab separated text files.

Scratch Directory: Logfiles

- eval_xxxx.log, measurement_xxxx.log and reco_xxxx.log files

Transfer to PC

- Samba file access if possible: [\\microct.customer.com](http://microct.customer.com) or ftp: ASCII (text) mode for .txt and .log files
- suggestion: download our "MicroCT-FTP" from <http://www.dtsoftware.ch/microct>

WEB Interface

//microct.customer.com/~microct/

- online documentation
- slice viewer, retrieving images and results

3.3 Support

- www.scanco.ch, support@scanco.ch
- **FAQ:** restart a blocked printer, re-reconstructions, import/export, general VMS commands...
- All support requests from a site have to be channelled through one single person

Sending a remote terminal to SCANCO

- please refer to our FAQ how to send the terminal and give us a call (or write an email) as soon as you have sent it

3.4 Useful VMS Commands

```
$ copy  
$ delete
```

...

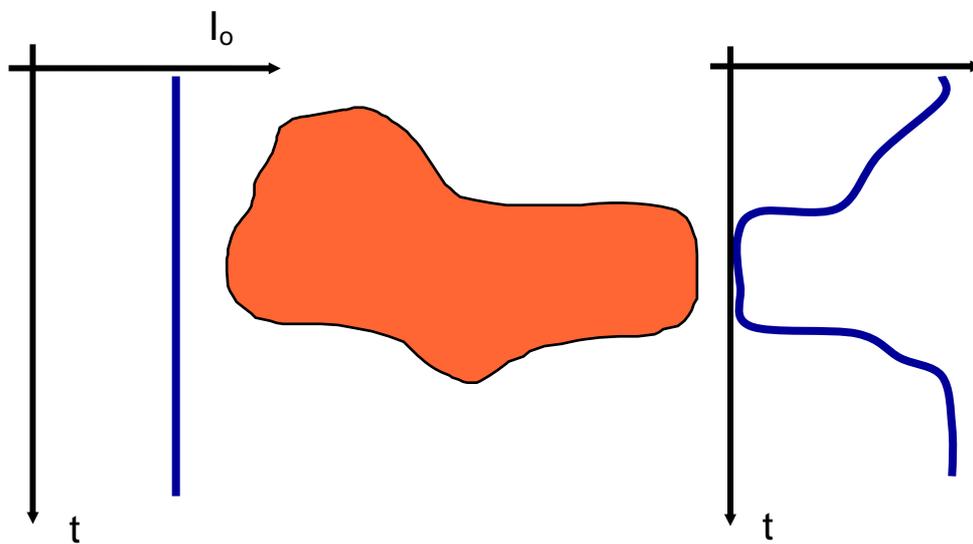
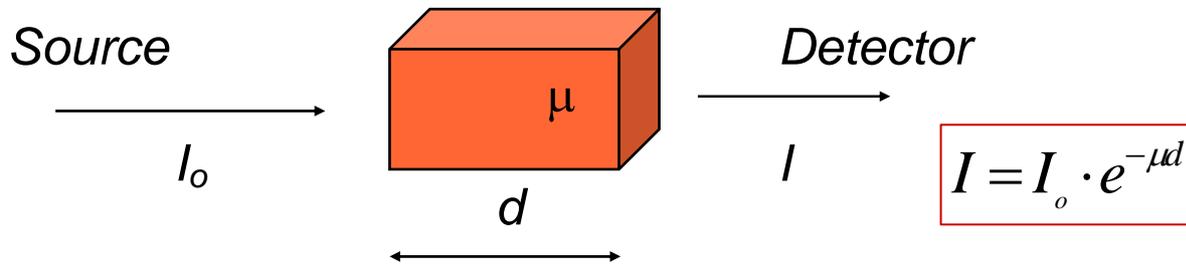
→ These commands can be executed in the session manager too. **IMPORTANT:** Click on the little dots next to the command

```
$ que  
$ show entry  
$ delete/entry=xx  
$ set entry xx/after=DD-MMM-YYYY:HH:MM:SS  
$ uct_reconstruction  
$ import  
$ disk_list to see which scan is taking how much space on the hard disk (units: MB)
```

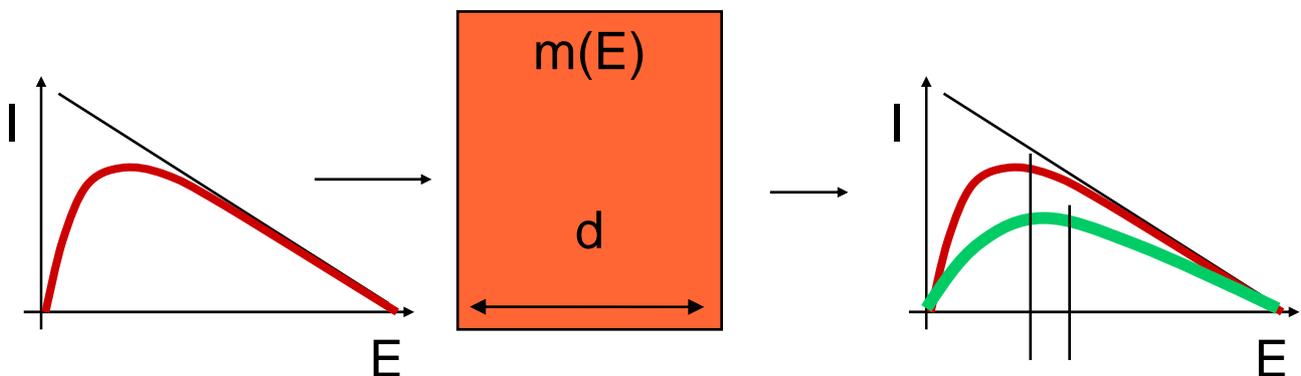
4 Appendix

4.1 Function of Computer Tomography

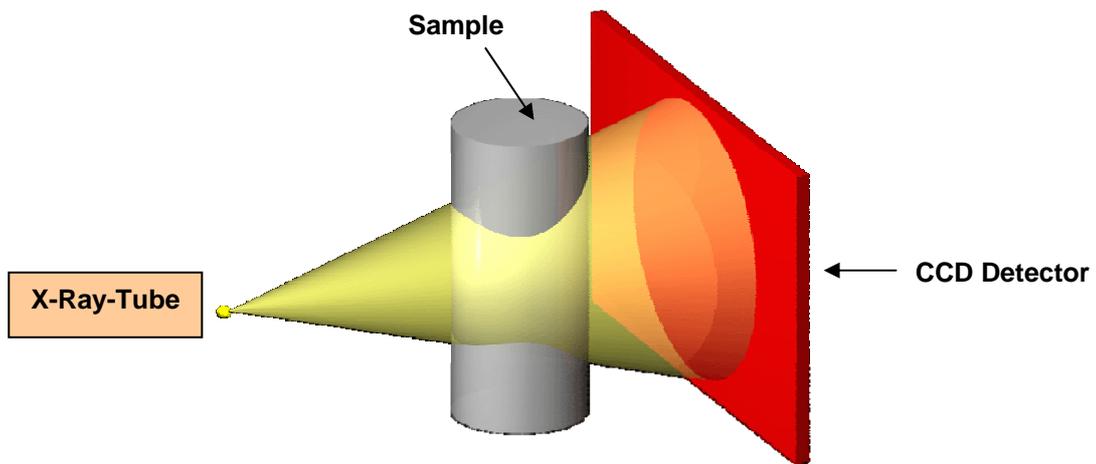
Attenuation Coefficient (Beer-Lambert law):



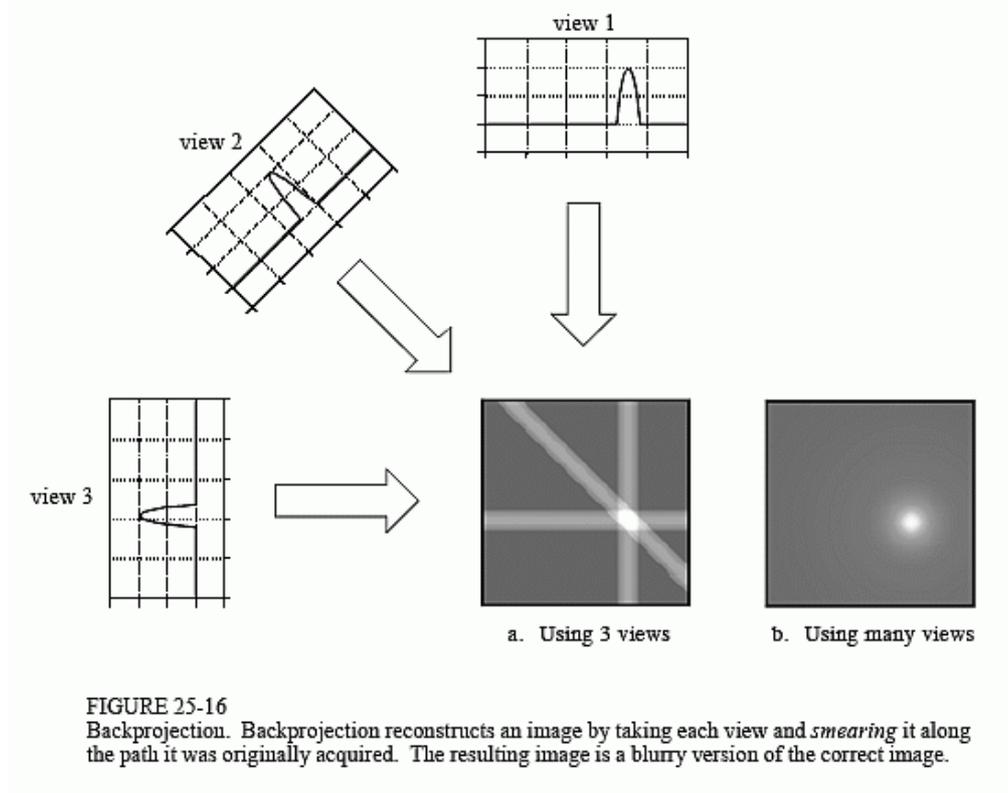
Beam Hardening



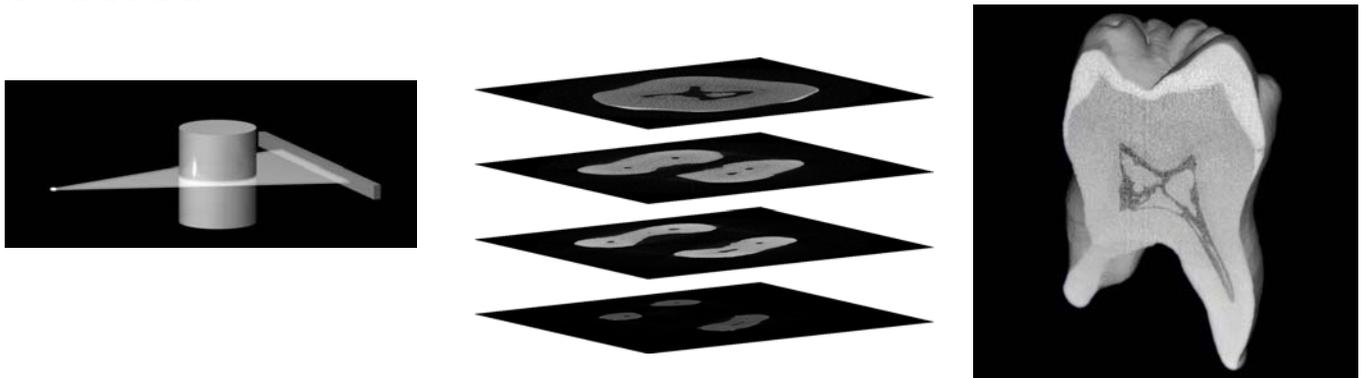
Conebeam



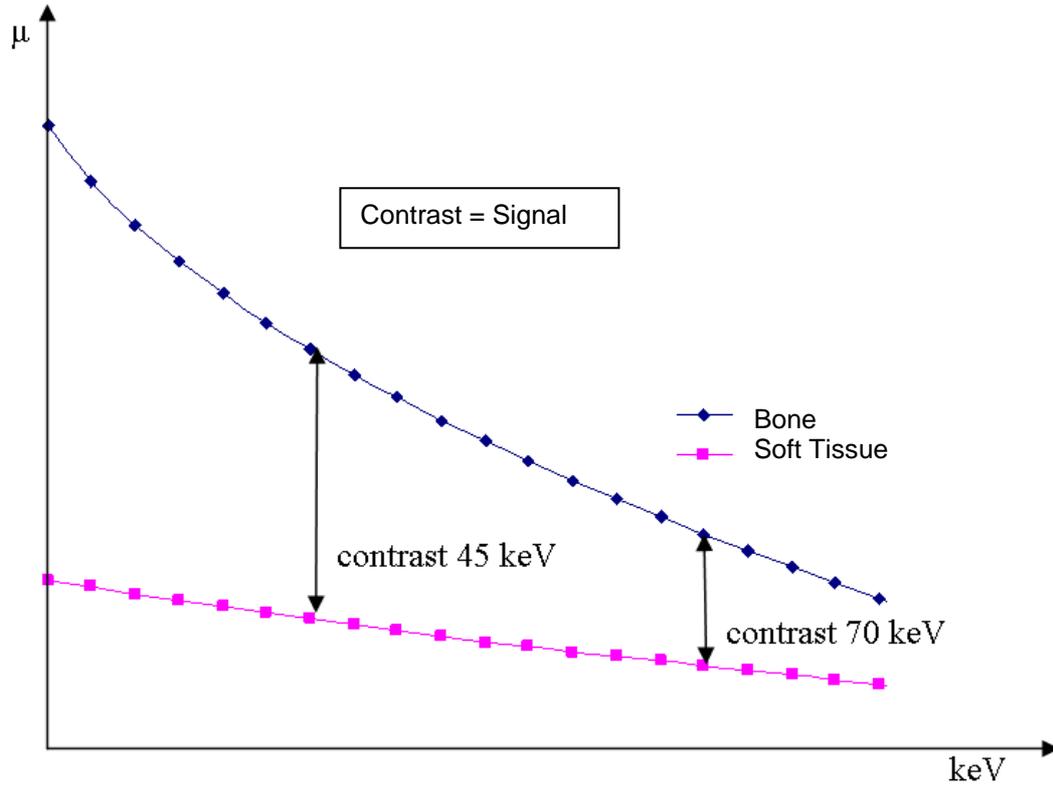
Filtered Backprojection



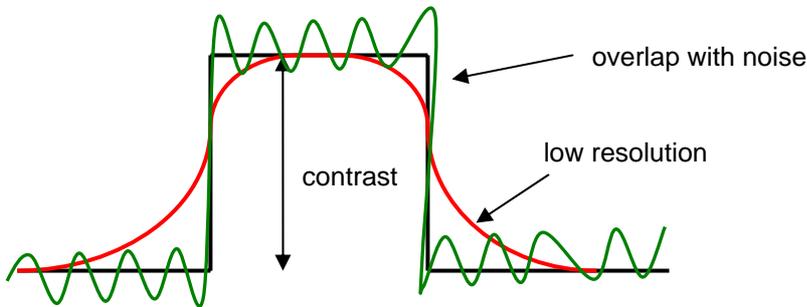
Reconstruction



Linear Attenuation Coefficient for as Function of Energy



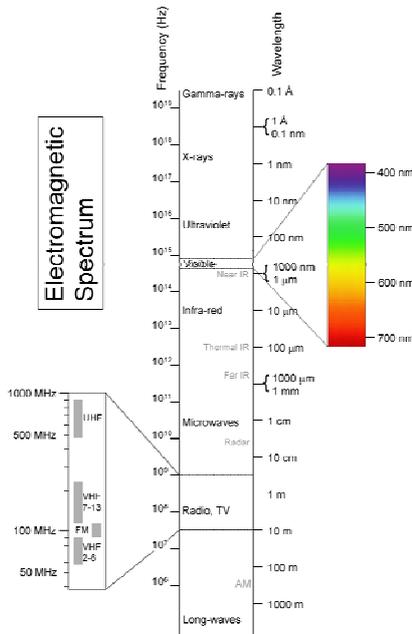
Contrast



4.2 Radiation Information and Safety

See also in the manual for explanation of the warning labels and x-ray indicators of the machine.

X-ray radiation is a type of electromagnetic radiation which is able to penetrate the human body (in contrast to visible light). In our CT scanners, the x-rays are produced by an x-ray tube by accelerating electrons and passing them through a so-called target to produce the x-rays. As soon as the electrical current is turned off, the x-ray tube does not emit any x-rays anymore. (The CT scanners do *not* use radioactive sources.)



X-ray radiation can be harmful to the human body: the unit to measure x-ray exposure is 'Gray': 1 [Gy] = 1 [J/kg]: absorbed energy per kg body weight.

1) Acute effects: for very high doses, more than about 5 Gy: skin burns, direct effects on human tissue.

2) Stochastic effects: exposure to low doses (less than 0.1 Gy) of x-rays can increase the risk of developing cancer later in life.

Exposure of the whole body is considered more harmful than exposure of a part of the body only. To compare such scenarios, the local dose to a body part can be converted into an 'effective whole body' dose in units of Sievert [Sv].

Irradiating the whole body with 1 Gray equals 1 Sievert for x-rays in the kV range.

The natural background radiation is around 2 to 4 milliSv per year.

Visit e.g. <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html> for more information about the effects of x-rays to the human body.

Our microCT machines are designed such that the operator is not subjected to any radiation (fully shielded as defined by legislators: radiation is lower than 1.0 microSv/h 5 cm away from the machine surface) when the door of the microCT machine is closed. The measurement chamber and/or side panels contain lead sheets, which blocks the x-rays of the energy used in the microCT.

The door of the vivaCT is under surveillance (interlocks), and if the door was opened during a scan, the x-ray beam is blocked (shuttered) immediately. For the ex vivo microCTs, the door is automatically locked by the machine while a scan is running; forcing the door open during a scan would turn off the x-ray tube immediately. When the machine housing is intact, it is not possible to insert any body parts into the scanner while the x-ray tube is emitting radiation.

Only trained personnel authorized by SCANCO Medical AG are allowed to open the panels of the housing. In case of damage to the outer housing of the machine, contact SCANCO Medical AG immediately.

In most countries, the legal radiation dose limit is 1 mGy per year for the general public. With the fully shielded microCT machines, operators stay far below this limit and in most countries will not be considered 'radiation workers' (who would have to wear dose monitors and who can be subjected to higher dose limits, e.g. 20 or 50 mGy per year). Please contact your local Radiation Protection Officer for more information about regulations at your institution regarding ionizing radiation. In case of an accident if you think you have been exposed to radiation; please contact your local Radiation Protection Officer and SCANCO Medical AG immediately.