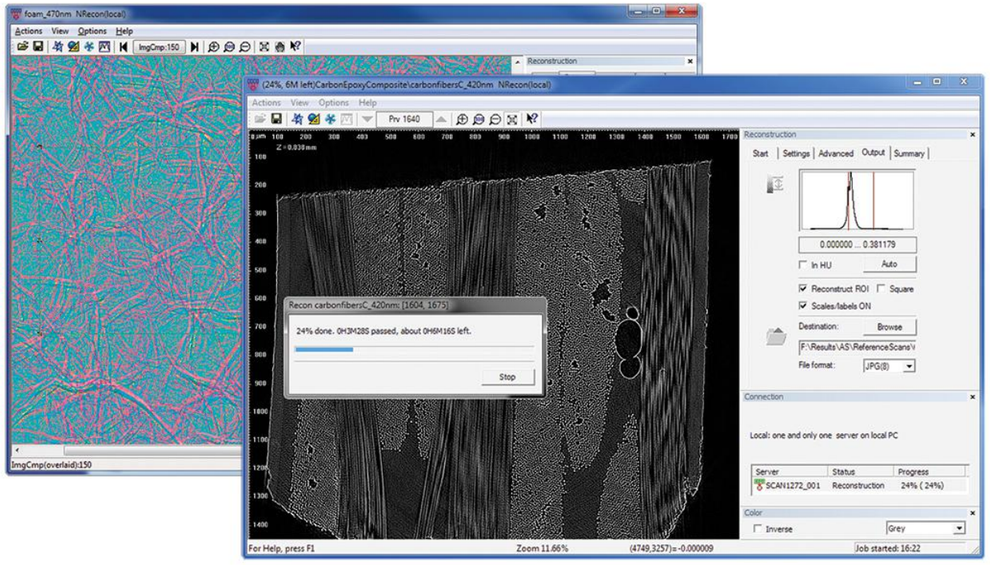
Software Suite for Reconstruction, Visualization and Analysis

NRecon: GPU-accelerated reconstruction and world's fastest hierarchical reconstruction

The supplied reconstruction program **NRecon** includes several reconstruction engines. It can run on single PC or cluster of several PCs. It supports beam-hardening correction, misalignment correction, ring artifact elimination, reconstruction of objects larger than field of view, volume of interest reconstruction, automatic merging of partial scans, drift compensation and many other options. The results can be saved in conventional formats, such as 16-bit TIFF, 8-bit BMP, 24-bit JPG, lossless compressed PNG as well as in DICOM format (compliant with the DICOM 3 convention). A special utility named **DICOM-CT** converts datasets, previously saved as JPG, BMP or TIFF files, to standard DICOM format. Additional **NRecon** features provide automated co-registration of several datasets in 2D and 3D, batch reconstruction of multiple datasets with individually adjusted settings, defect pixel masking, fifth order polynomial beam-hardening correction, fine tuning of reconstructing parameters for best possible results and many other features.

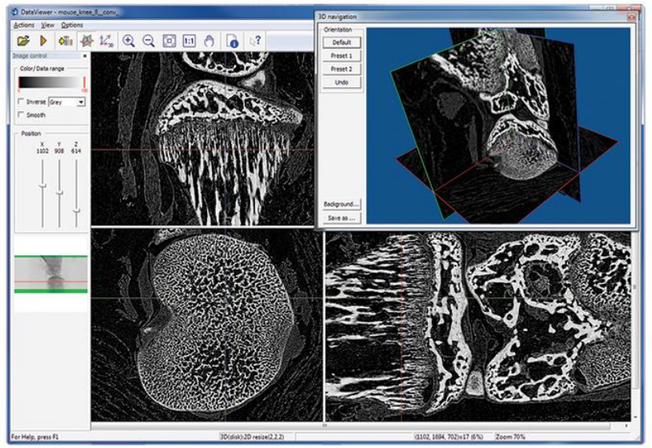


The reconstruction engines supplied with **NRecon** utilize a filtered back-projection algorithm and can use computer processors (CPU) running on all available cores or employ graphics card processors (GPU) to accelerate reconstruction. The GPU-accelerated reconstruction uses a unique parallelization algorithm to support execution on multiple GPUs or several graphics cards in parallel.

All SkyScan systems with large image formats are supplied with the world's fastest InstaRecon® reconstruction engine, which is using a unique hierarchical reconstructing algorithm. Compared to standard filtered back-projection algorithms it provides incredible speed-up of 20x ... 150x (dependent on image format) using CPU only.

Cross section format (pixels)	1000 x 1000	2000 x 2000	4000 x 4000	8000 x 8000	14450 x 14450
Number of cross sections in reconstructed volume	615	1229	2255	2495	2610
Number of projections used for reconstruction	499	996	1990	2157	8100
NRecon configuration	**RECONSTRUCTION TIME: full volume / per slice**				
NRecon, single PC	4m / 400ms	58m / 2.8s	15h / 24s	59h / 1.5m	50 days / 28m
NRecon, GPU-accelerated (NVidia TeslaC2075)	33s / 50ms	10m / 0.48s	2h / 3s	8.5h / 12s	150h / 3.5m
NRecon, GPU-accelerated (dual GPU NVidia GTX690 card)	11s / 18ms	3m / 0.15s	44m / 1.2s	4.5h / 6.5s	140h / 3.2m
NRecon with InstaRecon, single PC	19s / 30ms	1.5m / 65ms	9m / 0.2s	43m / 1s	10h / 14s

DataViewer: slice-by-slice movie, orthogonal virtual slices crossing at any point



DataViewer shows reconstructed results as a slice-by-slice movie or as three orthogonal sections, centered at any selected point in the reconstructed space. One can rotate and resample reconstructed volume in any direction. Additional features include the 4th dimension for time-resolved tomography and compression / tension *in-situ* examination, variable smoothing options, measuring distances in 3D with saving a table of results and measuring intensity profiles. **DataViewer** includes automatic co-registration of several datasets in position and spatial orientation and outputs differential image data.

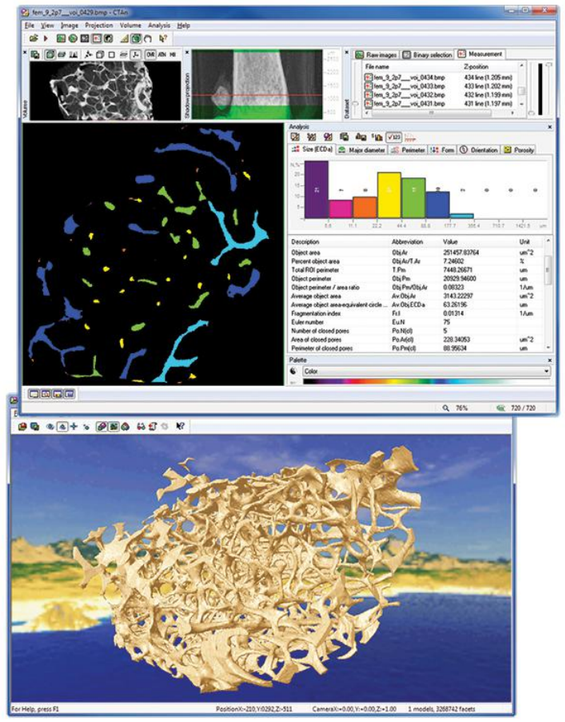
CTAn: 2D / 3D image analysis and processing; CTVol: realistic visualization by surface rendering

CT-Analyser or **CTAn** performs accurate and detailed study of micro-CT results for morphometry and densitometry. Powerful, flexible and programmable image processing tools deliver a wide range of segmentation, enhancement and measuring functions for analyses ranging from porosity to contact surface around high-density insertions to complex architectures. Versatile volume of interest selection tools are included. "CT-Volume" or **CTVol** uses surface triangulated models from **CTAn** and provides a virtual 3D viewing environment, flexible and rich in features, to give you a wide range of options for 3D presentation of micro-CT results.

Main features of **CTAn** are:

- Import of dataset in tiff, bmp, jpg, png, DICOM, etc.
- Global, Otsu, multi-level and adaptive segmentation
- Advanced region/volume of interest selection tools
- Creates max. and min. intensity projection images
- Measures 3D distances and angles
- Calibrates density as HU, BMD or attenuation
- Smooth, sharpen, despeckle, Boolean operations
- Analysis of all objects within VOI in 2D, 3D
- Analysis of individual objects within VOI in 2D, 3D
- Parameters measured (in 2D and 3D):
  - Object (pore, particle, etc.) volume
  - Object surface
  - Structure thickness
  - Structure separation
  - Structure Model Index (SMI)
  - Fragmentation index (trabecular pattern factor)
  - Euler number, eccentricity
  - Degree of anisotropy, eigenvalues, eigenvectors
  - Fractal dimension (Kolmogorov)
  - Moments of inertia (x, y, polar, product)
  - Detailed analysis of porosity
- Automated batch analysis
- Connects to user-created plug-ins
- Creates 3D models by several rendering algorithms
- Export triangulated models in STL and PLY formats

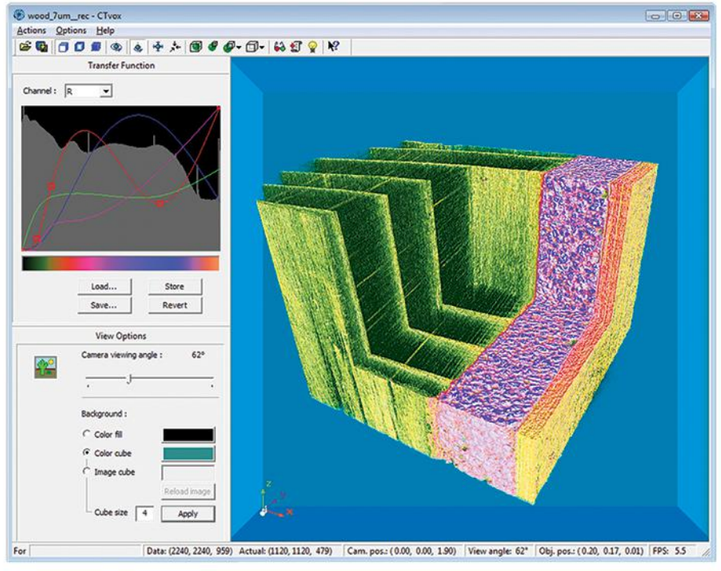
Full list of functions can be found at
bruker-microct.com/next/CTan_UserManual.pdf
bruker-microct.com/next/CTvol_UserManual.pdf



Volume Rendering for Desk-Tops and Mobiles

CTVox: Realistic visualization by volume rendering

The volume rendering program **CTVox** displays reconstructed results as a realistic 3D object with intuitive navigation and manipulation of both object and camera, a flexible clipping tool to produce cut-away views and an interactive transfer function control to adjust transparency and colors. The lighting and shadowing with selection of material surfaces properties produces fully realistic visualization. A "flight recorder" function allows fast creation of "fly around" and "fly through" animations based on simple selection of several key frames with automatic interpolation in between. Imaging possibilities include displaying multiple datasets obtained from single or different modalities such as absorption + phase contrast + scattering in phase-contrast micro-CT or in multi-modal animal *in-vivo* scanning.



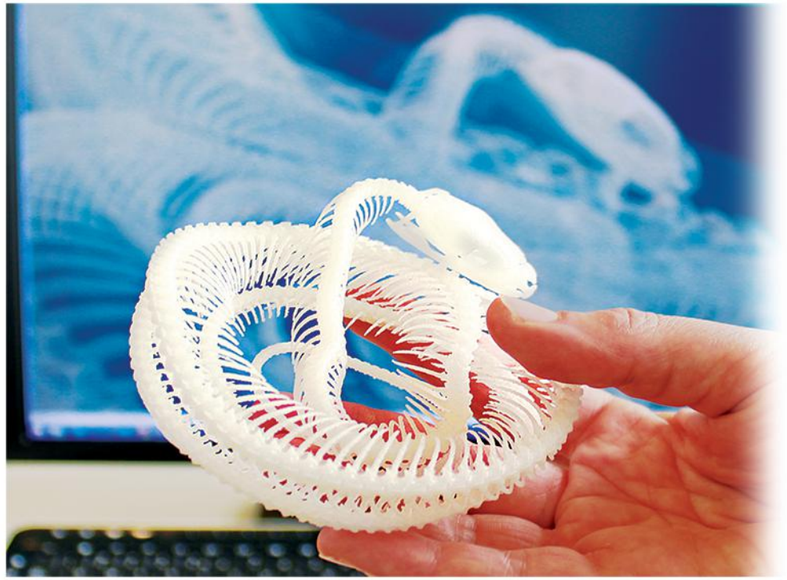
Volume rendering on mobile phones and tablets

The volume rendering program **CTVox** supplied with all systems also has its mobile versions, which can be freely downloaded from the AppStore for iPhone/iPad/iPod or from GooglePlay for Android devices. Any 3D results obtained by SkyScan systems can be sent to a mobile device for realistic visualization by real-time rendering with 3D object manipulation, virtual cut, adjustments of opacity and colors, etc.

The results can be sent to a mobile device through a cable connection or wireless network. The exported rendered data and color schemes are stored in the local memory of the mobile device and do not require any connection or downloading during manipulation. A large number of reconstructed datasets can be loaded to the memory of a mobile device, allowing you to study image results while travelling and demonstrate them at meetings or scientific conferences.

Export 3D Results, Visualizing 3D Measurements

STL file export for 3D printers, finite element analysis and 3D CAD



The **CTAn** / **CTVol** programs can create and visualize triangulated models of object surfaces. Such models can be saved in STL-file format. The STL-files can be sent to a 3D printer to build a magnified physical copy of the scanned objects using different materials.
By selecting of volume of interest in **CTAn**, the physical model may be partially opened to get access to internal object details.

The STL-file format is also used as input information for FEA (Finite Element Analysis) software packages which analyzes the impact of mechanical load on internal microstructure of objects. It is also a common file format for data import to 3D CAD software packages, such as SolidWorks. Importing STL-files from the scanned results to 3D CAD packages opens possibility for direct comparison of a scanned object with a CAD model used to create the object.

Visualization of 3D analysis results

The power of 3D numerical analysis of micromorphology in **CTAn** and imaging capability of **CTVox** can be combined for visualizing of the 3D distribution of morphological parameters across the scanned volume.

Calculation of local 3D numerical parameters, such as structural thickness or structural separation, in **CTAn** is based on the placing of a spherical probe in every point of the object's 3D space with maximum diameter which fills structural features. The obtained local information on 3D structural thicknesses and structural separations can be saved as a spatial intensity map. **CTVox** converts such maps of measured morphological parameters to color-coded 3D images, which reflect local distribution of numerical characteristics of the object. Working with multiple datasets in **CTVox** helps to display the 3D distribution of several measured parameters simultaneously. For example, local structural thickness and local structural separation (pore size distribution) can be coded in complementary color schemes and displayed simultaneously. All such 3D visualizations can be explored by virtual cut, creating movies with flying around and inside the structure and by other features of **CTVox.**