

X-Ray Microtomography

- SkyScan Range of Instruments

• Micro-CT from Basics to Perfection

Micro-computed tomography or Micro-CT is X-ray imaging in 3D, by the same method used in hospital CT (or “CAT”) scans, but on a small scale with massively increased resolution.

It really represents true 3D microscopy, where very fine scale internal structure of objects is imaged non-destructively. No sample preparation, embedding, coating or thin slicing are required.

A single scan will image the complete internal 3D structure of your object, plus you get your sample back intact at the end!

Bruker microCT can genuinely claim to be at the forefront of the development of high performance micro-CT technology. Our research and development in 3D X-ray microscopy started in the early 1980s. This led to the first micro-CT imaging results being obtained in 1983-1987 and published in scientific journals and international conferences proceedings.

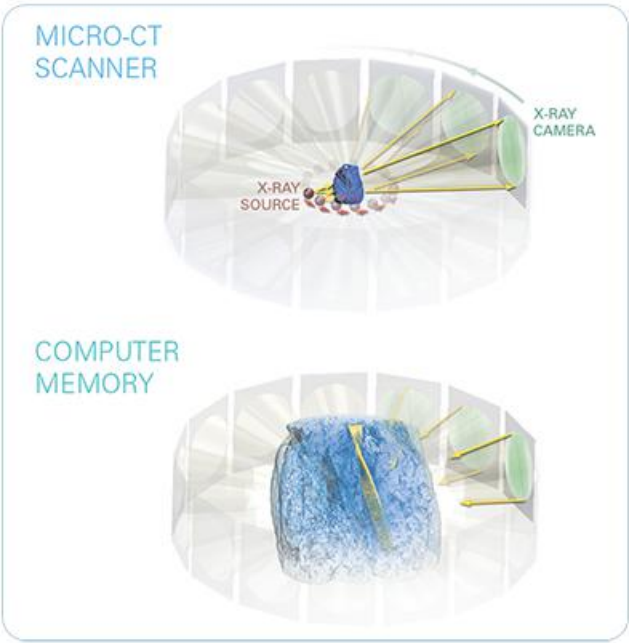
Building on this early work, SkyScan was founded in 1996, and within a year we were manufacturing a commercially available micro-CT scanner with spatial resolution in the micron range. In 2001 we designed the first high-resolution *in-vivo* micro-CT scanner for small laboratory animals. And in 2005 SkyScan became the world’s first supplier of a laboratory nano-CT scanner with submicron spatial resolution.

In 2012 SkyScan joined Bruker group, the leading producer of scientific instruments, and became Bruker microCT. We are continuing to produce our micro-CT scanners under the well-known SkyScan trademark.

How does Micro-CT work?

A micro-focus X-ray source illuminates the object and a planar X-ray detector collects magnified projection images. Based on hundreds of angular views acquired while either the source-detector pair or the object rotates, a computer “back projects” the magnified object images to memory and creates a virtual volume with all the objects’ internal details revealed.

You can then scroll through the virtual slices and visualize the object’s sections along different planes, to inspect the internal microstructure non-destructively. Selecting simple or complex volumes of interest, you can measure internal 3D morphometric parameters. You can also create realistic visual models for virtual travel within the object.



Bruker MicroCT - home of SkyScan

Bruker microCT is a fast growing company and one of the world’s leading producers of micro-CT systems with more than 1000 installations of SkyScan instruments around the globe.

Bruker microCT aims to bring to customers the newest technology, the best instrument quality and the highest level of support. Responding to demand from the growing community of micro-CT users, Bruker microCT is continually active in research and development of new methods and instruments for non-destructive 3D microscopy.

All research, development, production, service, support and application activities are located at Kontich in Belgium close to Antwerp and Brussels, in a consolidated site on more than 16 000 square meters of land with offices, production facilities and demo centers.





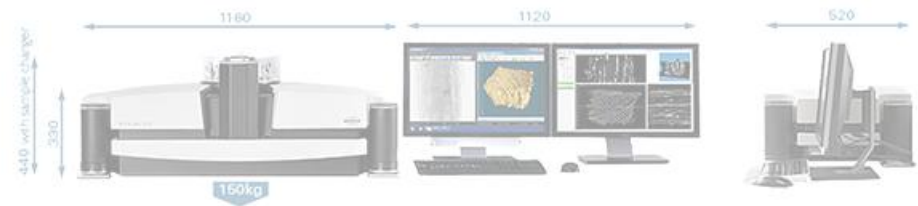
• SkyScan1272

High Resolution Desk-Top
X-Ray Microtomograph

World's first micro-CT with more than 200 megapixels in a single cross section

- A large format 16Mp or 11Mp X-ray detector in one, two or three offset positions allows scans of up to 75mm object diameter with projection image formats up to 14456 x 3240 pixels, followed by reconstruction of an astonishing 209 Mp slices, up to 2000 such slices after a single scan.
- An X-ray source with adjustable 20-100keV energy and a 6-position filter changer helps to select the optimal scanning conditions. The system can also select the optimal scanning protocol automatically.
- Isotropic detail detectability down to 0.35µm with phase contrast enhancement for submicron details make previously invisible object features well recognizable and measurable.
- Automatically variable acquisition geometry reduces scan time for most magnifications by 2-5 times compared to competitor scanners.
- GPU-accelerated and world's fastest InstaRecon® 3D reconstructions support scan formats up to 15K x 15K pixels with speed-up 20-100 times compare to commonly used reconstruction algorithms.
- Supplied software package includes programs for 2D/3D image analysis and realistic 3D visualization by surface/volume rendering of large format scanning results, data export and volume rendering on mobiles.
- An integrated micro-positioning stage allows optimizing of sample placement or selecting volume of interest for large samples. Optional stages support scanning samples under compression, tension, heating or cooling.
- Optional 16-position automatic sample changer accepts mixed samples of different materials and sizes. The scanner can automatically select magnification and acquisition parameters for each sample. Samples queued for scanning can be replaced at any time without interrupting an ongoing scanning process.
- At the end of a scan, the scanner can send you an e-mail with a direct link to scan results.

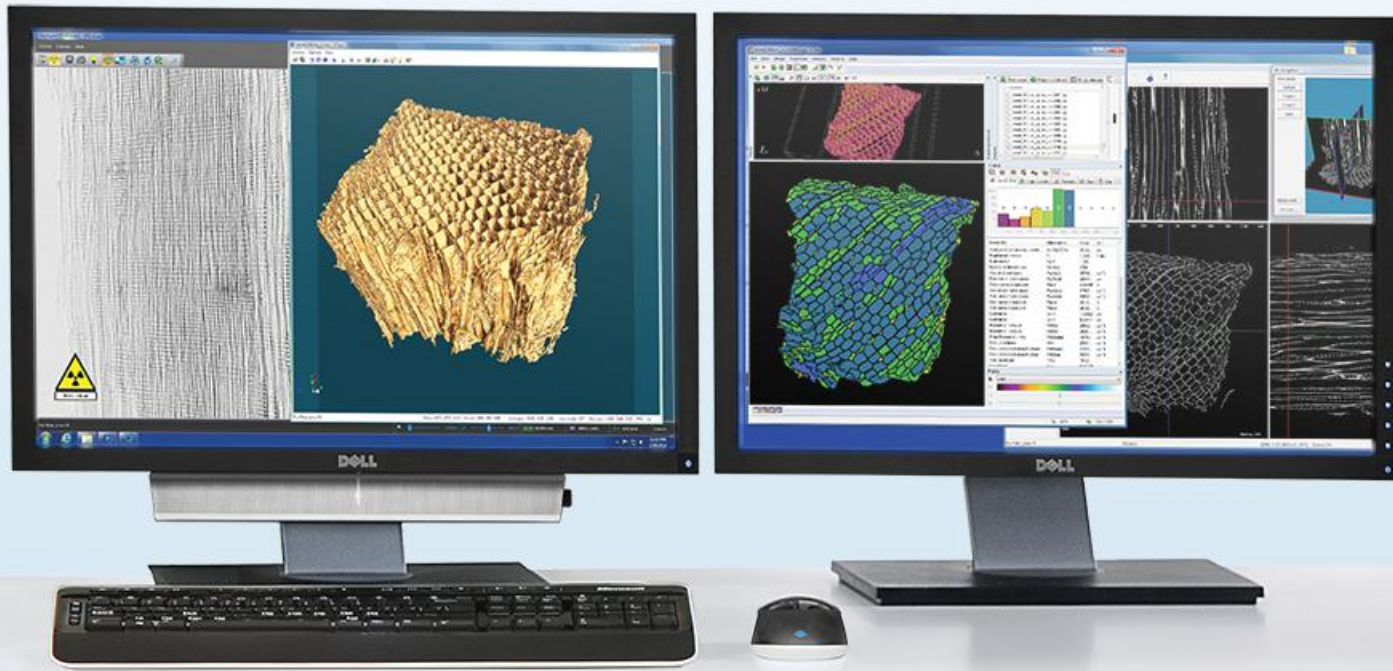
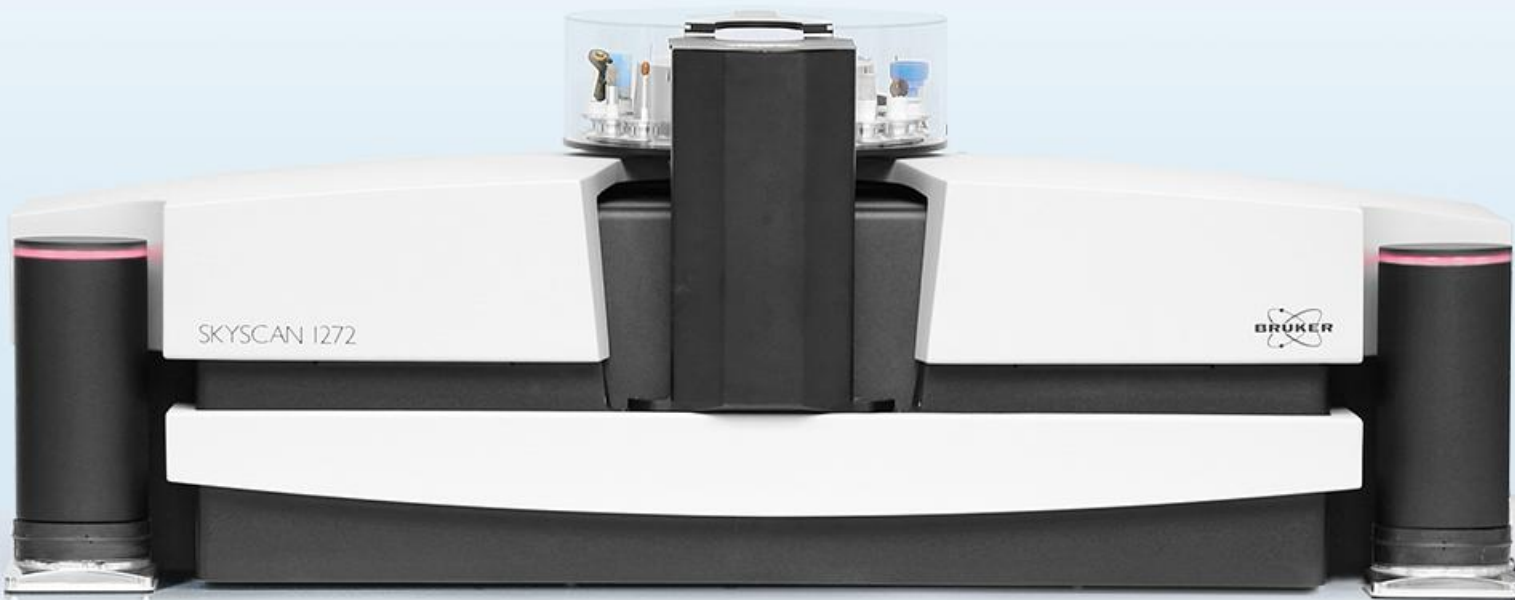
A unique combination of the world's largest imaging formats, fastest reconstruction, a wide range of X-ray energies and an automated sample changer allows efficient scanning of all types of samples.



X-ray source	20-100 kV, 10 W, < 5 µm spot size @ 4 W	
X-ray detector	16 Mp (4904x3280 pixels) or 11 Mp (4032x2688 pixels) 14-bit, cooled CCD fiber-optically coupled to scintillator	
Nominal resolution (pixel size at maximum magnification)	< 0.35 µm for 16Mp camera, < 0.45 µm for 11Mp camera	
Reconstructed volume (after a single scan)	up to 14456x14456x2630 pixels for 16 Mp camera up to 11840x11840x2150 pixels for 11 Mp camera	
Scanning space	maximum 75 mm diameter, 70 mm height	
Radiation safety	< 1µSv/h at any point on the instrument surface	
Power supply	100-240V AC, 50-60 Hz, typ. 90 W at maximum X-ray power	
Control workstation*	Standard	Advanced
Processors	Dual 8-core Intel XEON	Dual 10-core Intel XEON
Memory (RAM)	64 GB / 2133 MHz	128 GB / 2133 MHz
Disk space (HDD)	512 GB SSD + 8TB RAID0	512 GB SSD + 12TB RAID0
Monitors	2 x 24" wide (1920x1200)	2 x 24" wide (1920x1200)

* Computer specifications can be changed without notice.

The SkyScan 1272 microtomograph is shown with the automatic sample changer.





SkyScan1173

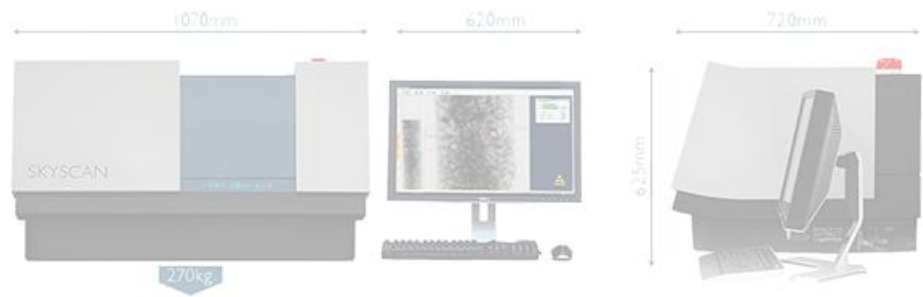
High Energy Desk-Top
X-Ray Microtomograph

Desk-top instrument for non-destructive 3D reconstruction of large and dense objects

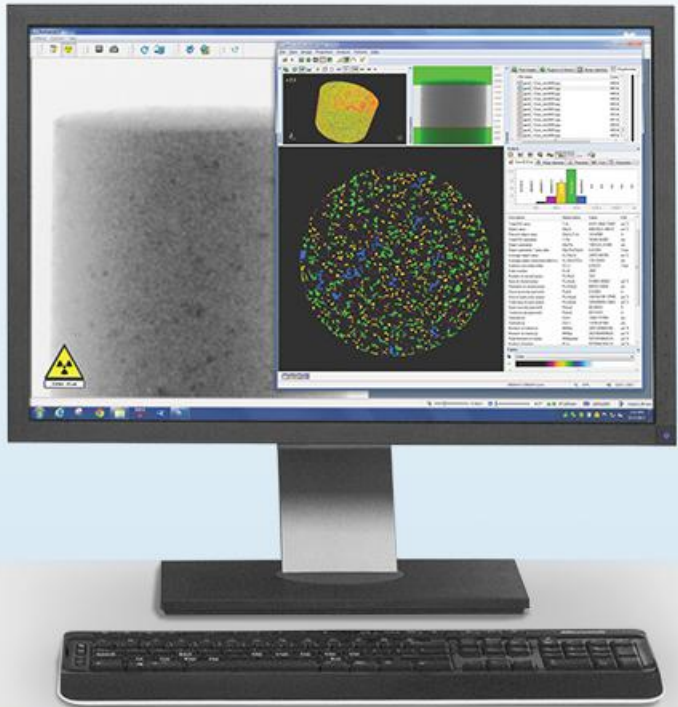
- The system is based on an X-ray source with a wide energy range of 40-130keV and a 4-position filter changer to select the ideal scanning conditions for different types of objects.
- Distortion-free flat-panel 5Mp detector includes a special lead glass fiber-optic plate to ensure long lifetime under high-energy X-rays.
- Maximum scanning size is 140mm diameter and 150mm height. An integrated micropositioning stage simplifies optimal object positioning or allows selection of a particular part of a large object for partial scanning. Optional object stages allow investigation under compression, tension, heating or cooling.
- GPU-accelerated 3D reconstruction supports all image formats with speed-up 5-10 times compared to conventional reconstruction algorithms.
- A special (optional) version of this scanner can work in ambient temperature down to -20°C.
- Supplied software package includes programs for 2D/3D image analysis and realistic 3D visualization by surface and volume rendering as well as data export and volume rendering on mobiles (iOS / Android).
- Fully shielded desk-top instrument safe to use in standard laboratory environments.



This high-energy system is specially designed to scan large and high density samples as required in many applications such as oil and gas exploration, geology, building materials, industrial metrology, electronic assemblies, medical devices, etc.



X-ray source	40-130 kV, 8 W, < 5 um spot size @ 4 W
X-ray detector	5 Mp (2240 x 2240 pixels) flat-panel sensor
Nominal resolution (pixel size at maximum magnification)	< 5 um
Reconstructed volume (after a single scan)	up to 4224 x 4224 x 1313 pixels
Scanning space	maximum 140 mm diameter, 150 mm height
Radiation safety	< 1 uSv/h at any point on the instrument surface
Power supply	100-130 V or 200-240 V AC, 50-60 Hz, typ. 150 W





• SkyScan1174

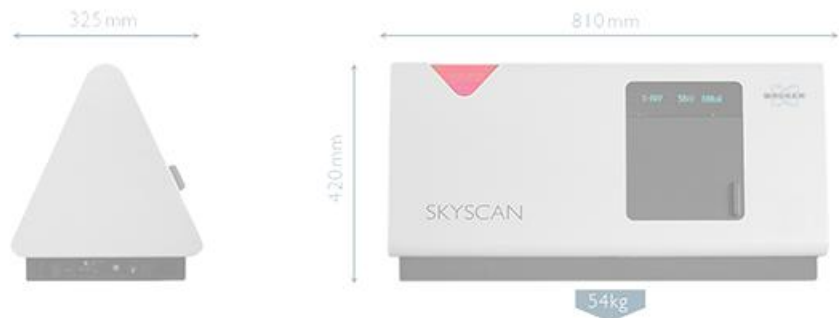
Compact Desk-Top
X-Ray Microtomograph

World's most compact micro-CT for research and industrial quality control

- A maintenance-free X-ray source with adjustable 20-50keV energy and filter holder.
- A cooled 1.3 Mp camera optically coupled to scintillator by variable zoom lens.
- Isotropic detail detectability 6 - 30µm dependent on magnification.
- The system can be controlled by desk-top or notebook computer.
- Special (optional) version of this scanner can work in ambient temperature down to -20°C.
- GPU-accelerated 3D reconstructions with speed-up 2-10 times compared to commonly used reconstruction algorithms.
- Supplied software package includes programs for 2D/3D image analysis and realistic 3D visualization by surface / volume rendering of scanning results, data export and volume rendering on mobiles.
- Optional stages support micropositioning and scanning during compression, tension, heating or cooling.

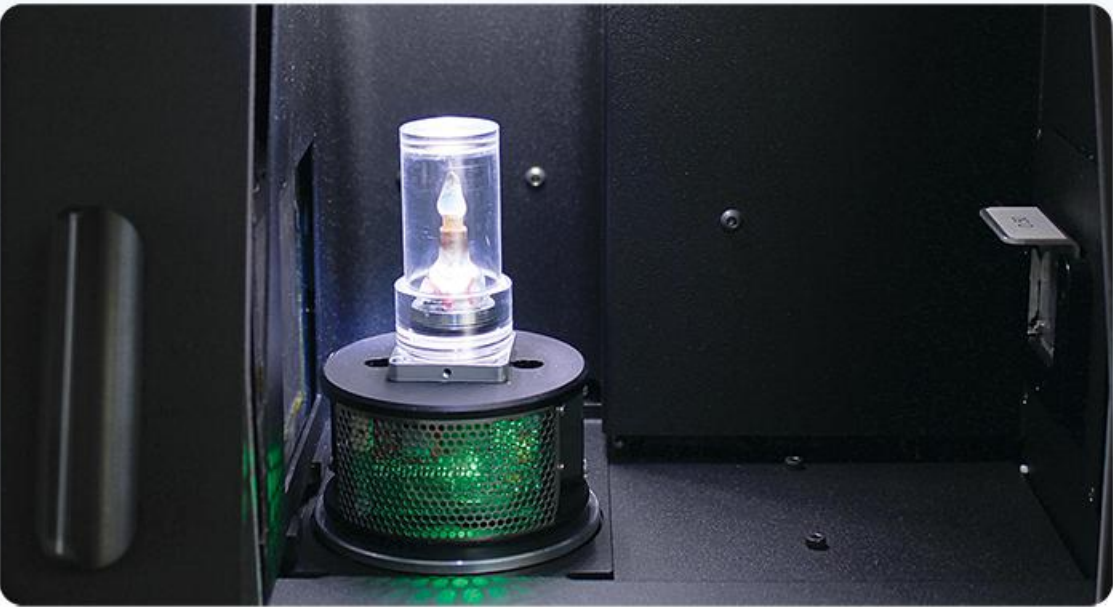


At a fraction of the price of competitor systems, with a small footprint, this scanner provides fast, high resolution 3D imaging with exceptional quality.



X-ray source	20-50 kV, 50 W, metal-ceramic X-ray tube
X-ray detector	1.3 Mp (1304x1024 pixels) 14-bit, cooled CCD camera optically coupled to scintillator by motorized zoom lens
Nominal resolution (pixel size at maximum magnification)	6 µm at maximum magnification
Reconstructed volume (after a single scan)	up to 1304 x 1304 x 930 pixels
Scanning space	maximum 30 mm diameter, 50 mm height
Radiation safety	< 1uSv/h at any point on the instrument surface
Power supply	100-240V AC, 50-60 Hz, typ. 90 W at maximum X-ray power

An ice sample kept at -20°C by the cooling stage installed in SkyScan-1174 specimen chamber. Details on optional stages for *in-situ* investigations can be found in page 18.





• SkyScan1275

Fast, Automated, Desk-Top
X-Ray Microtomograph

Micro-CT scanner for research, industrial applications and quality control

- This highly automated micro-CT system allows pushbutton operation with a preselected sequence of actions including scanning, reconstruction and volume rendering.
- A wide range of X-ray energies 20-100kV, small spot size in the X-ray source and multiple filter options provide optimal scanning conditions for any particular application.
- This scanner accommodates a generous object size range up to 96mm in diameter and 120 mm in length to scan large samples including industrial parts and assemblies.
- The distortion-free flat-panel active pixel 3Mp detector includes a fiber-optic plate to ensure long lifetime and the highest reconstruction quality and accuracy.
- Shortest scanning takes 80 seconds. The scanning can be done using circular or spiral trajectory.
- GPU-accelerated 3D reconstruction supports all image formats with speed-up 5-10 times compare to conventional CPU-based reconstruction.
- The supplied software package includes programs for 2D/3D image analysis and realistic 3D visualization by surface and volume rendering, data export and volume rendering on mobiles.
- Optional stages for micropositioning and material testing support scanning of a sample under compression, tension, heating or cooling.
- The 16-position automatic sample changer (optional) accepts a mix of the samples with different sizes. The scanner can automatically select magnification according to a sample's size and shape.

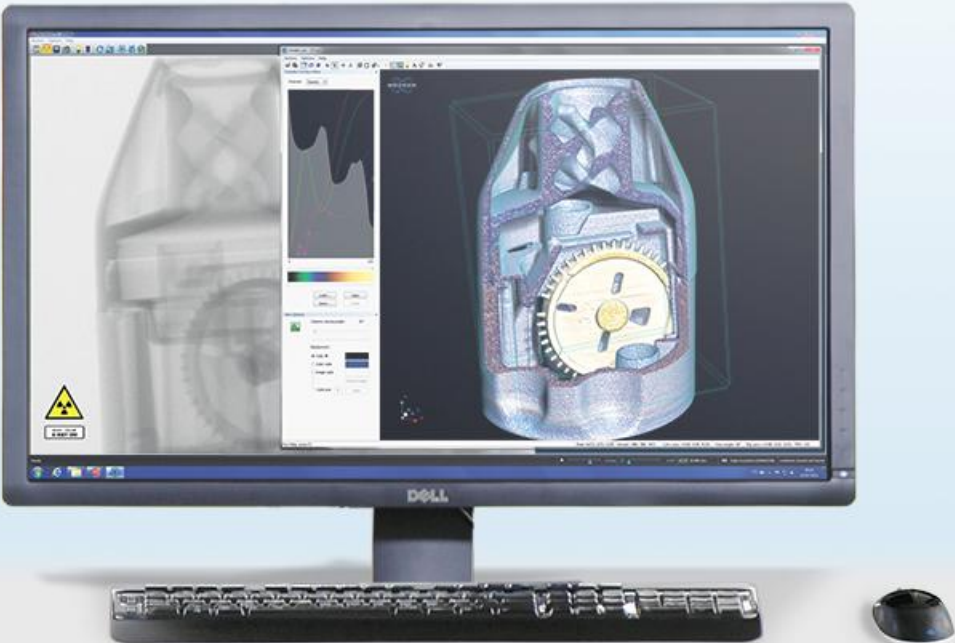
The SkyScan 1275 microtomograph is shown with the automatic sample changer.



The SkyScan1275 is specially designed for fast automated scanning in research and industrial environments and can deliver high quality results in a few minutes. Push-button activation starts a fast scan followed by reconstruction, visualization or volume rendering, executed during the scanning of the next sample.



X-ray source	20-100 kV, 10 W, < 5 µm spot size @ 4 W
X-ray detector	3Mp (1920x1536 pixels) active pixel CMOS flat panel
Nominal resolution (pixel size at maximum magnification)	< 4 µm
Reconstructed volume (after a single scan)	up to 1920 x 1920 x 1160 pixels
Scanning space	maximum 96 mm diameter, 120 mm height
Radiation safety	< 1uSv/h at any point on the instrument surface
Power supply	100-240V AC, 50-60 Hz, typ.110 W at maximum X-ray power





SkyScan1294

Phase Contrast Desk-Top X-Ray Microtomograph

World's first laboratory micro-CT system with simultaneous retrieval of phase contrast, absorption and scattering (dark-field image) in 3D

- Three-grating Talbot-Lau X-ray interferometer with 30keV design energy,
- Microfocus 100W, 20-60kV X-ray source with five position filter changer for energy window selection,
- 11 megapixel cooled CCD X-ray detector,
- Simultaneous extraction of absorption, differential phase and dark-field (scattering) images,
- World's fastest hierarchical InstaRecon® 3D reconstruction,
- Touchscreen control for main functions,
- Compact, fully shielded desk-top instrument,
- Supplied with programs for 2D/3D image analysis, realistic 3D visualization by surface / volume rendering and data export with volume rendering on mobile devices.



The SkyScan-1294 system is based on the unique technology of phase-contrast imaging with polychromatic X-rays patented by the Paul Scherrer Institut at the Swiss Light Source (Zurich, Switzerland) and licensed to Bruker microCT for commercialization.



X-ray source	20-60 kV, 100 W, metal-ceramic X-ray tube
X-ray detector	11 Mp (4000x2672 pixels) cooled CCD coupled to scintillator by fiber-optic taper
Nominal resolution (pixel size at maximum magnification)	5.5 / 11 / 22 µm
X-ray interferometer	3-grating Talbot-Lau, 5 axis motorized alignment
Phase stepping	Piezo drive 30um travel, 2nm accuracy
Scanning space	maximum 22 mm diameter, 60 mm height
Radiation safety	< 1uSv/h at any point on the instrument surface
Power supply	100-140 V or 200-240 V AC, 50-60 Hz, 2 x 6 A





SkyScan 2211

Multiscale X-Ray Nanotomograph

Widest range of object sizes and spatial resolutions

- Pixel sizes down to 100 nm, reconstructed image format up to 8000 x 8000 x 2272 pixels,
- X-ray source accelerating voltage from 20 kV to 190 kV, submicron spot size
- Unique versatility by combining two cooled X-ray detectors in one system:
 - 3 Mp flat-panel for high X-ray energy and large field of view,
 - 11 Mp CCD for optimal submicron resolution.
- World's fastest hierarchical 3D reconstruction (InstaRecon®) with x10 to x100 speed-up,
- Precision air bearing rotation stage with <50 nm accuracy, integrated micro-positioning stage,
- Maximum sample diameter is 204 mm, maximum height - 200 mm, maximum weight - 25 kg,
- Anti-vibration granite platform with pneumatic leveling.



The SkyScan2211 Multiscale X-ray nanotomograph covers the widest range of object sizes and spatial resolutions in one single instrument. It opens unique possibilities for 3D imaging and exact modelling of geological materials, composites, biomaterials, implants, etc.



X-ray source	20-190 kV, open (pumped) type, 5-position filter changer 10W (Be window) or 25W (diamond window), target material: W - standard; Cu, Mo, Ag - optional
X-ray detector	11 Mp (4032x2688 pixels), 14-bit, cooled CCD and 3Mp (1920x1536 pixels) active pixel CMOS flat panel
Nominal resolution (pixel size at maximum magnification)	100 nm (CCD) 300 nm (flat panel)
Object positioning	Direct drive air bearing stage with 50nm accuracy, integrated micropositioning stage
Reconstructed volume (after a single scan)	up to 8000 x 8000 x 2272 pixels with CCD camera up to 3776 x 3776 x 1160 pixels with flat panel
Maximum object size	204 mm diameter, 200 mm height, 25 kg weight
Radiation safety	< 1uSv/h at any point on the instrument surface
Power supply	100-130 V or 200-240V AC, 50-60 Hz, 2.5kW + 1.5kW

The X-Ray source equipped with automatic filter changer and special cooling for stability during scanning.





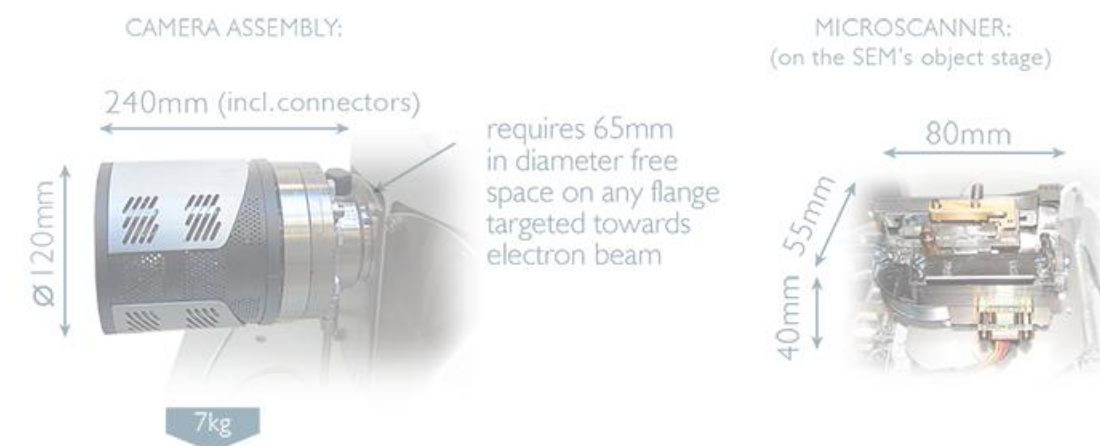
• SkyScan Micro-CT for SEM

X-Ray 2D and 3D Imaging for Any Scanning Electron Microscope

Adds transmission X-ray microscopy and microtomography modalities to any SEM

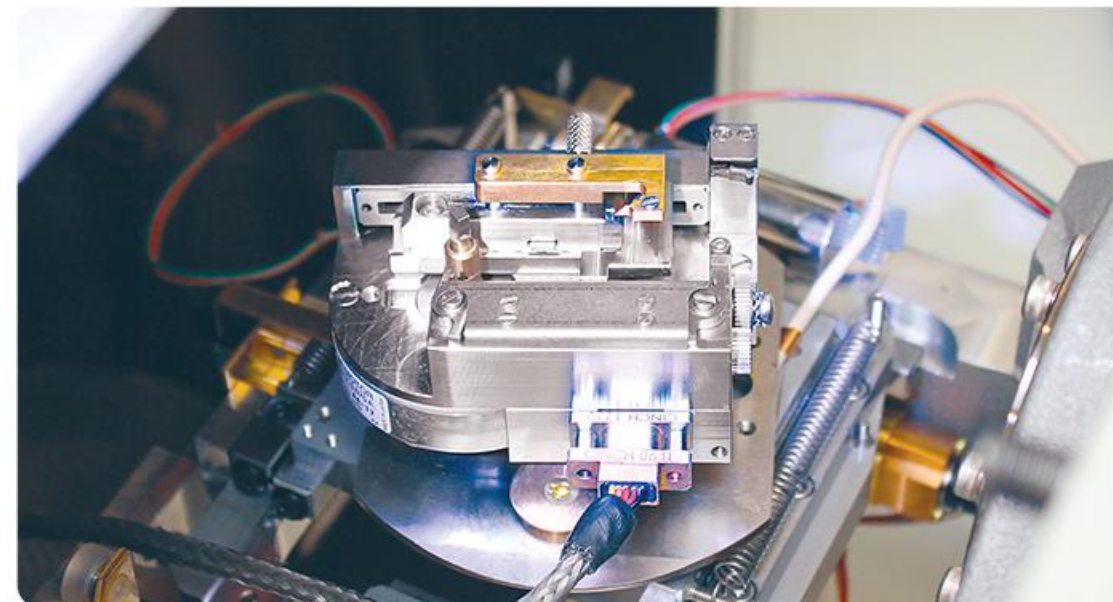
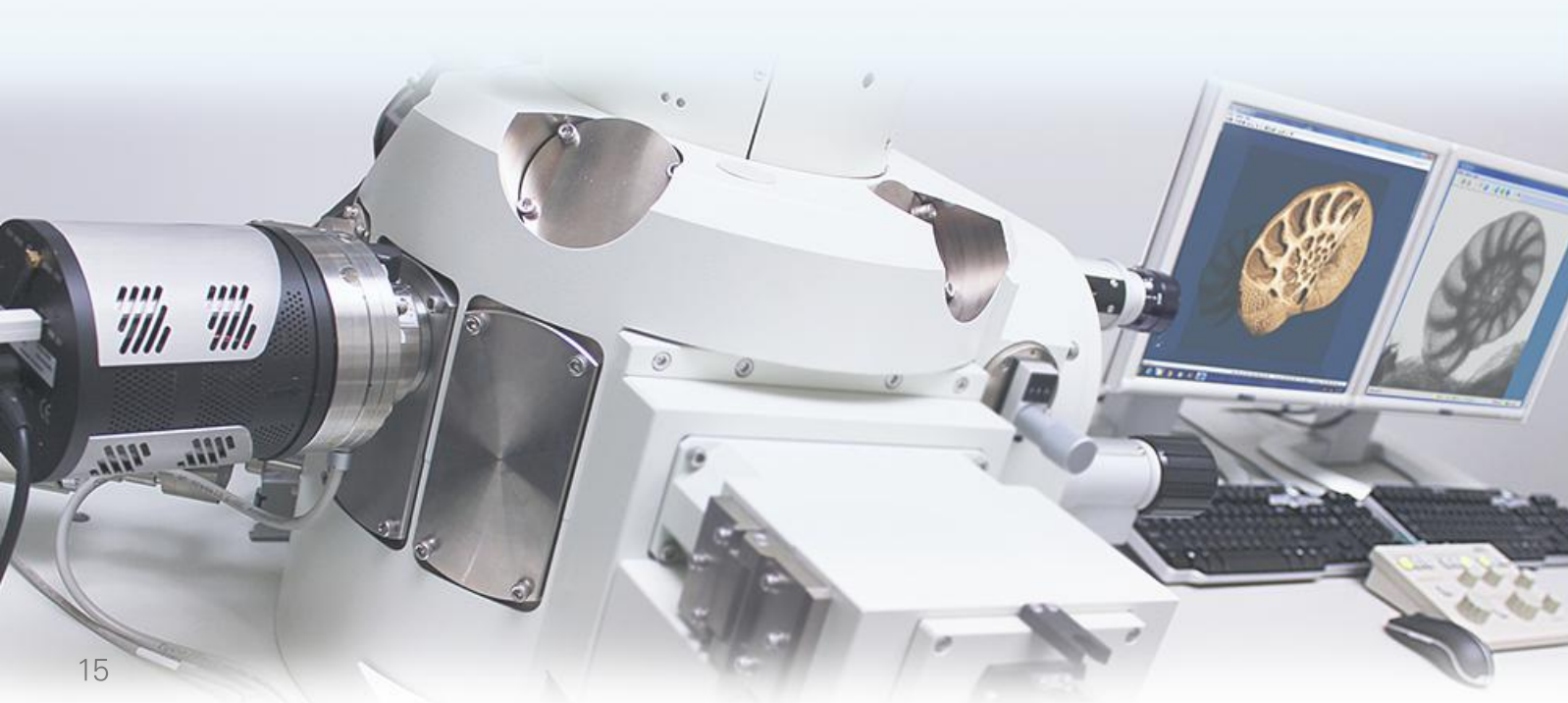
- This set-up uses the focused electron beam of a SEM to generate X-rays. Penetration power is dependent on the maximum accelerating voltage in SEM.
- Installation doesn't require any connections to SEM or modifications in standard electronics. The miniature object manipulator (microscanner) is installed in SEM and can work in low and high vacuum conditions.
- The system can reach 600 - 800 nm resolution dependent on the distance from the electron beam to the side wall of the specimen chamber used for camera installation.
- Installation requires only 65mm in diameter of available space at any flange of the specimen chamber targeted towards electron beam.
- The Micro-CT for SEM can run on the SEM host computer or using a stand-alone PC or notebook.
- Can be used for X-ray imaging of internal microstructure and for 3D reconstruction of conductive and non-conductive objects without any coating or other preparation.
- Due to use of X-ray cameras with direct photon detection, reconstructed images have no ring artifacts.
- 3D reconstruction executed directly during scanning and 3D results can be displayed immediately after the end of the scan.
- Supplied software package includes programs for 2D/3D image analysis, realistic 3D visualization by surface / volume rendering of scanning results, data export and volume rendering on mobiles.

The SkyScan SEM_Micro-CT kit can be installed in any new scanning electron microscope or retrofitted to old instruments. It adds to the SEM a unique possibility to image and measure 3D microstructure throughout the entire sample volume, and create realistic visual models for virtual travel within the object.



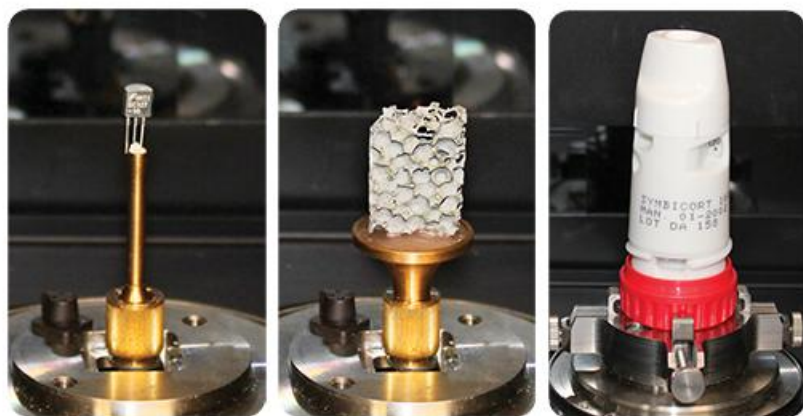
X-ray source	uses electron beam of SEM, requires >100nA beam current
X-ray detector	1024 x 1024 pixels cooled, deep depleted CCD camera
Nominal resolution (pixel size at maximum magnification)	400 - 600 nm (dependent on size of SEM specimen chamber)
Compatible SEMs	JEOL, Zeiss/LEO, FEI, Tescan, CamScan and others with W, LaB6 or Schottky field emission electron gun
Scanning space	maximum 4 mm diameter, 10 mm height
Power supply	100 - 240 V AC, 50 - 60 Hz, 1.5 A

Microscanner from the SkyScan SEM_Micro-CT kit installed to JEOL scanning electron microscope.



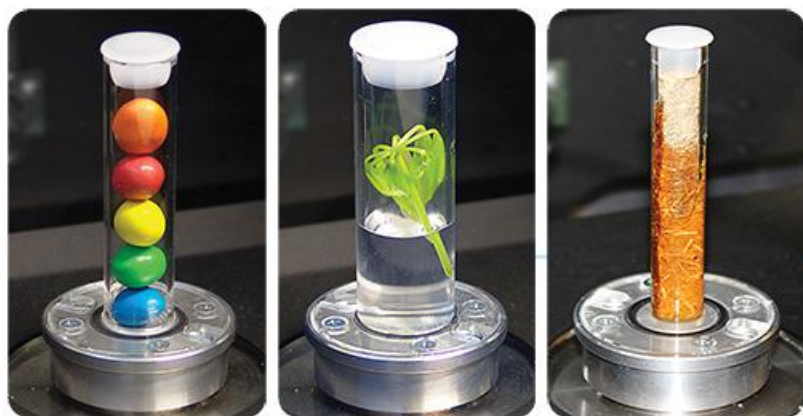
• Sample Holders for Any Size and Shape

Standard sample mounts

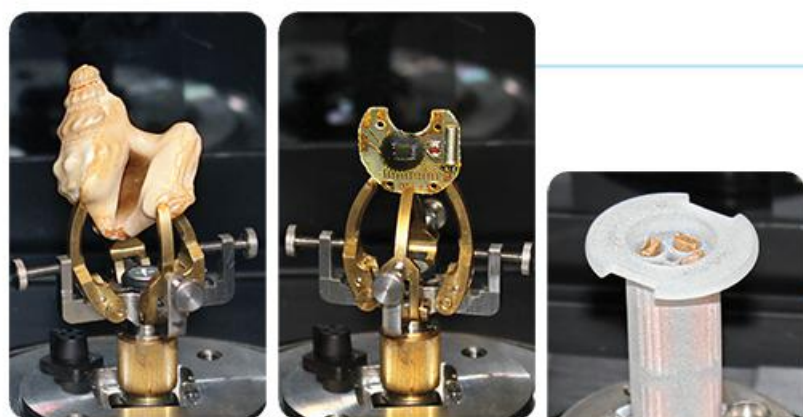


Every SkyScan system for sample scanning is supplied with several types of sample mounts. Typically there is a number of brass sample mounts for objects up to 20-60 mm in size, which can be installed into an integrated or optional micropositioning stage on top of the object rotating table. A stainless steel sample holder for large objects can be directly attached to the object rotation table. This steel mount has a chuck with four adjustable jaws to hold objects with complex shape and center them accurately.

Optional sample mounts



A large number of optional sample mounts are available. Systems can be equipped with tube sample holders for different sample sizes. These allow automated batch scanning and imaging of hydrated samples and samples in liquid. The tube set has four replaceable tube holders with internal diameters of (approx.) 6, 10, 15, and 20 mm.



Another optional "spider" sample mount has four "fingers" to hold objects with any geometry and with sizes from 0.8 to 18mm. Each "finger" is screw-adjusted to obtain a grip on any object including objects with irregular and asymmetric shape.

Another optional sample mount is dedicated to scanning several samples simultaneously for comparison. It contains two layers of parallel tube compartments for four samples up to 5mm in diameter. This allows analysis of 8 small samples in a single scan.

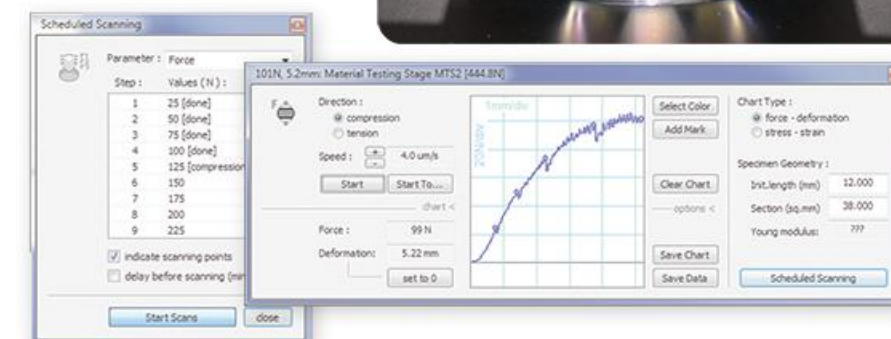


There are a number of other optional sample mounts available and their number is always growing. For example, a special mount can hold thin flat samples, such as a piece of paper or plastic; other sample mounts allow scanning of powders with different packaging geometries, etc. Your local distributor of Bruker-microCT products can help you to find best possible option for every application.

• Stages for *In-Situ* Investigations

Material testing stage

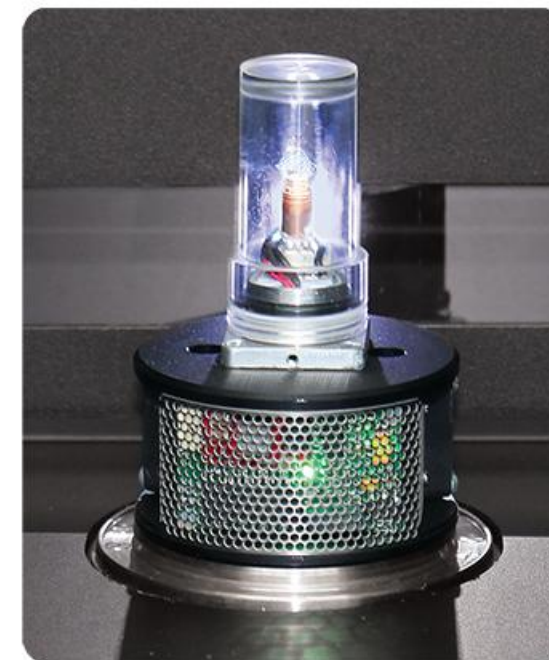
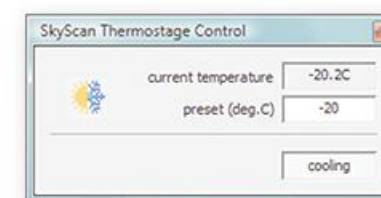
The material testing stage (MTS) applies controlled tension or compression symmetrically to both ends of an object keeping the central part in a static position, with a design which allows tomographic scanning while applying force. The loading curve is displayed on-screen in real time. An internal microprocessor controls the loading mechanics and reading out the displacement and applied force. An object can be held under specific load(s) during one or more micro-CT scans. The material testing stage supplied with several sample chambers for objects up to 24mm in diameter and 24mm in length for compression or 20mm wide and 17 mm long for tension. Travel range is 11mm. The stage can be equipped with different load cells for maximum compression or tension force of 42, 210 or 440N. A special version of MTS with force limit of 2200 and 4400N (force applied from one side, 5.5mm travel) is also available. The software for the material testing stage works in handshake with the main control software of the scanner to perform multiple scans with selected forces or deformations.



Heating and cooling stages

The heating and cooling stages allow micro-CT scanning under controlled object temperature above or below ambient. The heating stage can keep an object at a temperature up to +85°C. The cooling stage can keep an object at sub-zero temperature down to 30-40°C below ambient. An internal microprocessor controls a solid-state cooling or heating system and measures the object temperature with <1°C accuracy.

Like other stages for in-situ examination, cooling or heating stages are powered and controlled through a small connector at the top of the object stage. The power and control signals are connected to the static part of the scanner through special gold contact slip rings with low friction and high reliability in endless rotation.



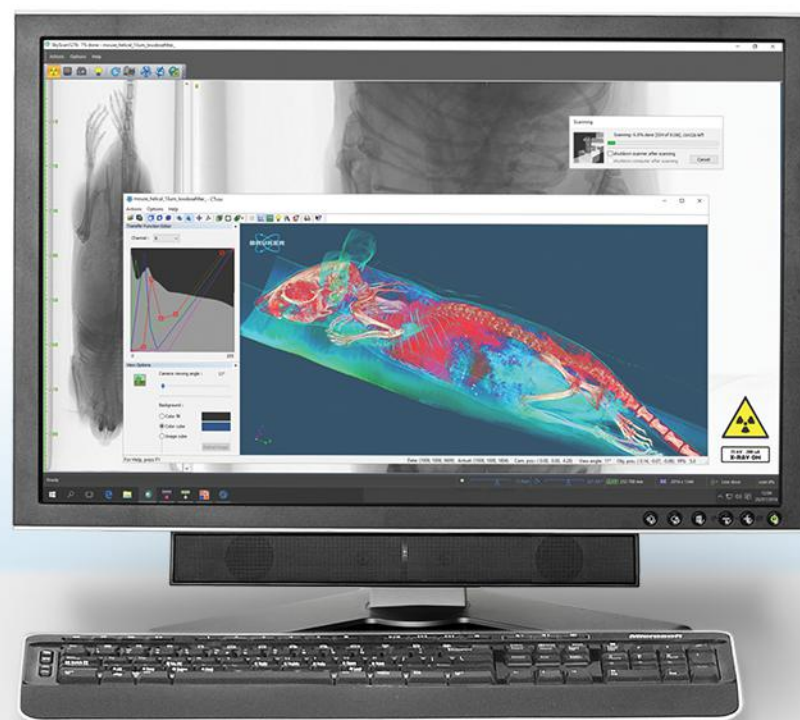


• SkyScan1276

High-Resolution *In-Vivo* Micro-CT for Small Laboratory Animals and Samples

World's highest spatial resolution in any location within the animals or samples

- Continuously variable magnification with 2.8 μm highest nominal spatial resolution
- Step-and-shoot and continuous gantry rotation with 3.9 seconds shortest scanning cycle
- Up to 8000x8000 pixels in every reconstructed slice with more than 1600 slices in a single scan
- Circular and spiral (helical) scanning, unlimited gantry rotation due to slip ring connection
- Standard, GPU-accelerated and world's fastest InstaRecon® hierarchical reconstruction with speed-up more than 10 times compared to conventional reconstruction algorithms
- Continuously adjustable 20 to 100kV peak X-ray energy, 6-position automatic filter changer
- Integrated physiological monitoring with breathing sensor, ECG, temperature stabilization and body movement detection, 4D (time-resolved) cardiac and respiratory microtomography
- Easily replaceable mouse and rat cassettes with anaesthetic gas mask and electrical connections to all physiological sensors can be inserted and removed by a single click
- On-screen dose meter indicates applied dose to the animal based on information from analysis of X-ray projection images
- Integrated touchscreen allows control of main system functions by gloved hands
- Results of reconstruction can be directly sent to mobile devices, such as iPad, iPhone or Android phones and tablets, for volume rendered 3D viewing using supplied software
- The system is supplied with a GLP (Good Laboratory Practice) software package



This system provides fast, low-dose scanning with unique spatial resolution at any location in the animal's body.



X-ray source	20-100 kV, 20W, 6-position automatic filter changer
X-ray detector	11Mp (4032 x 2688 pixels) cooled CCD camera
Spatial resolution	2.8 μm smallest pixel size, 5-6 μm resolution (>10% contrast)
Scanning space	maximum 80 mm in diameter, >300 mm in length
Physiological monitoring	motion detection, ECG, breathing, temperature stabilization
Radiation safety	< 1 $\mu\text{Sv/h}$ in 10cm from the instrument surface
Power supply	100-240V AC, 50-60 Hz, <250W at maximum X-Ray power





• SkyScan1278

Fast *In-Vivo* Micro-CT Scanner
for Small Laboratory Animals

Fast, low-dose *in-vivo* desk-top micro-CT

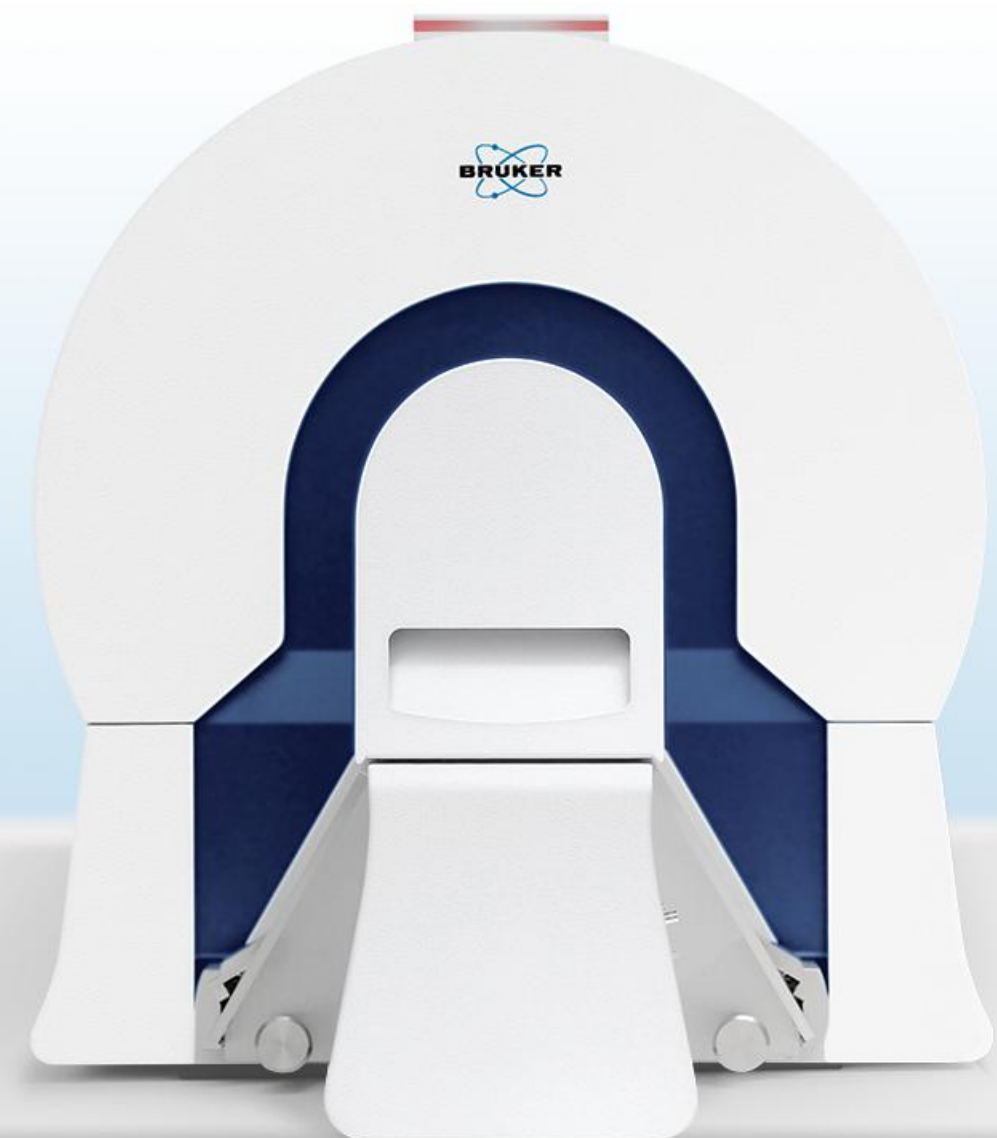
- Shortest full-body animal scan takes 7.2 seconds with typical dose less than 6 mGy.
- 50 μm nominal resolution throughout 80 mm scanning diameter and 200 mm scanning length.
- Microfocus X-ray source with adjustable energy from 20 to 65kV and automatic filter changer allows optimized scanning protocol with minimized applied dose.
- Spatial beam shaper patented by **Bruker microCT** reduces dose 2-3 times without significant impact to reconstructed image quality.
- Integrated physiological monitoring with breathing sensor, ECG, temperature stabilization and body movement detection, provides 4D (time-resolved) cardiac and respiratory microtomography.
- Physiological monitoring delivers >100 measurements per second for all parameters and images.
- Easily replaceable mouse and rat cassette with anaesthetic gas mask and electrical connections to all physiological sensors can be inserted and removed by a single click.
- On-screen dose meter indicates applied dose and dose rate to the animal based on individual analysis of X-ray images.
- Integrated touchscreen allows control of main system functions by gloved hands.
- Reconstructed image data saved in DICOM and other conventional formats such as TIFF, JPG, BMP, PNG as well as movies of 3D renderings in AVI-format.
- The system is supplied with GLP (Good Laboratory Practice) software package.



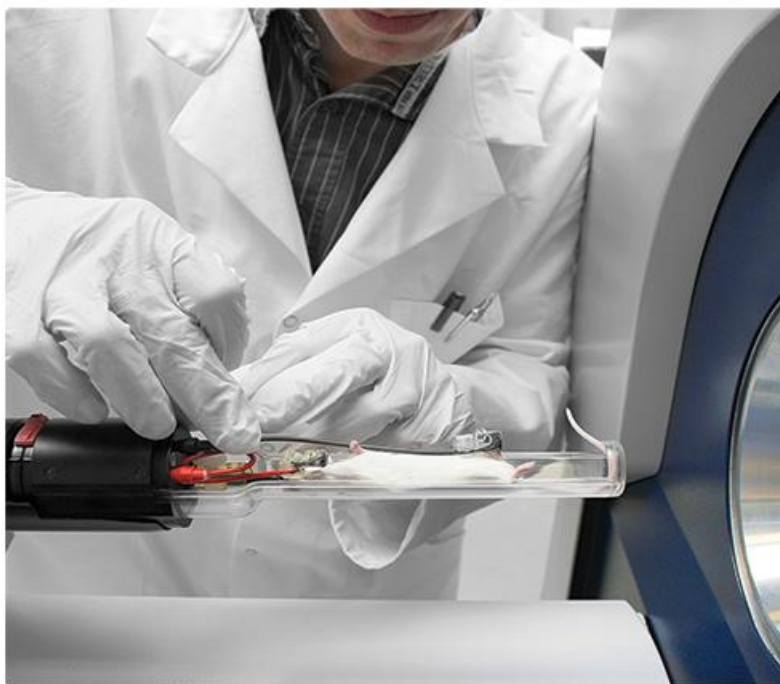
This fast *in-vivo* low-dose micro-CT performs 3D and 4D (time-resolved) animal imaging.



X-ray source	20-65 kV, 50 W, < 50 μm spot size, 4-position filter changer
X-ray detector	3Mp (1920x1536 pixels) active pixel CMOS flat panel
Nominal resolution	50 μm at any location inside scanning space
Scanning space	maximum 80 mm in diameter, 200 mm in length
Physiological monitoring	motion detection, ECG, breathing, temperature stabilization
Radiation safety	< 1uSv/h at any point on the instrument surface
Power supply	100-240V AC, 50-60 Hz, <150 W at maximum X-ray power



• Animal Handling in *In-Vivo* Scanners



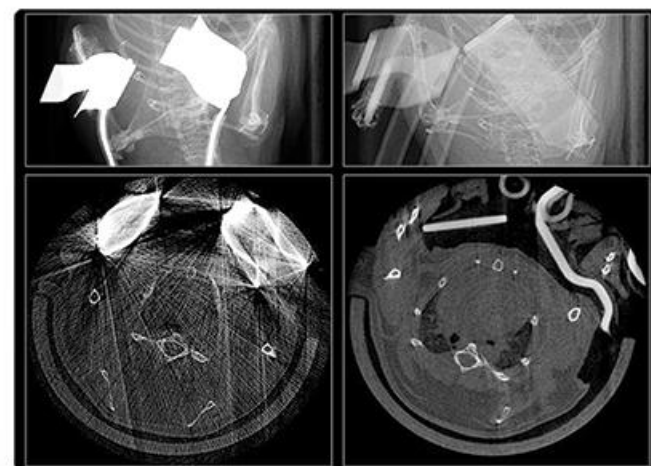
Mouse and rat cassettes

The SkyScan *in-vivo* systems are supplied with exchangeable animal cassettes that can be used in other Bruker *in-vivo* imaging instruments such as MRI, micro-PET, micro-SPECT, bio-luminescence, bio-fluorescence, etc. to collect multimodal information. It allows co-registration of functional and morphological information from the same animal.

The cassettes are equipped with face mask and tubes for anaesthetic gas as well as with connectors for ECG electrodes and a temperature sensor. All tubes and contacts are combined in a single connector, which can be attached to or detached from the animal transport system by a simple turn of a small slider. To prevent leakage of anaesthetic gas, corresponding connections have valves which stay closed if the animal cassette is disconnected from the animal transport system.

All-carbon ECG electrodes

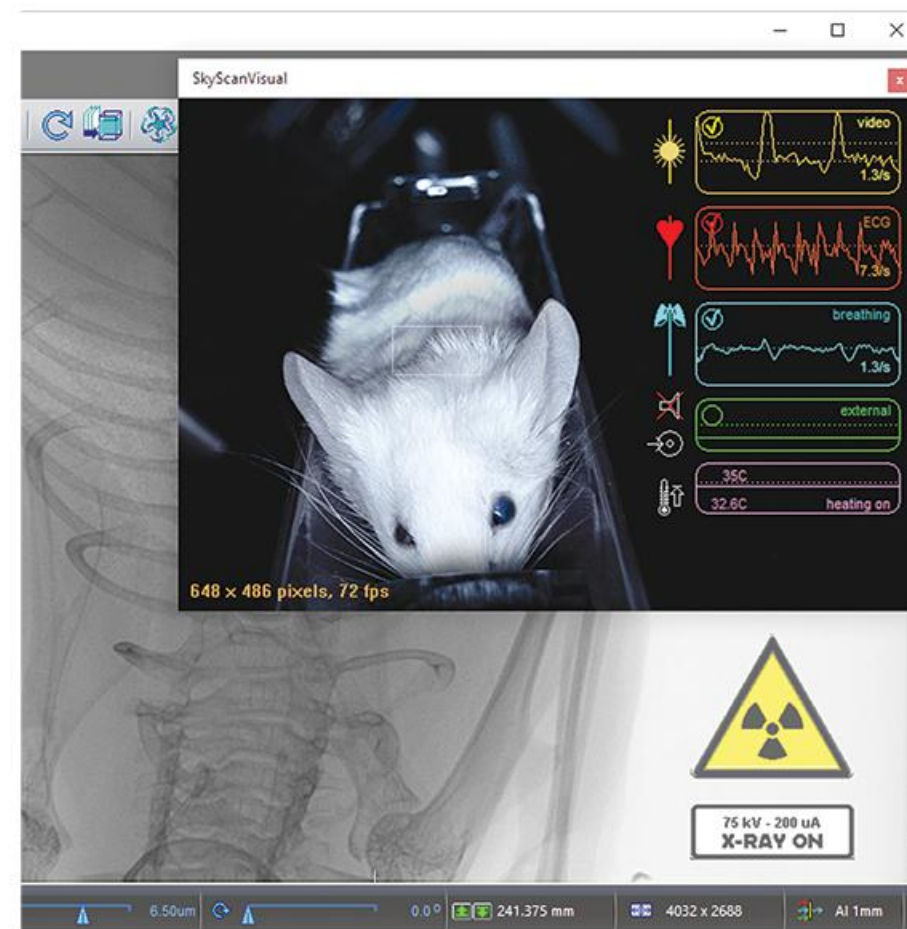
The animal cassettes include special cables and clip electrodes to detect ECG signals by a sensitive amplifier integrated in the physiological monitoring sub-system. The ECG connections use ECG wiring and electrodes specially developed by Bruker microCT which contain no metal parts. The wires and electrodes employ advanced carbon-fiber conductive parts with X-ray absorption similar to that of animal tissues for uncompromised image quality.



Shadow projections (top) and reconstructed slices (bottom) through a mouse body with attached metal electrodes (left) and carbon electrodes developed by Bruker microCT (right).



• Integrated Physiological Monitoring



Physiological monitoring

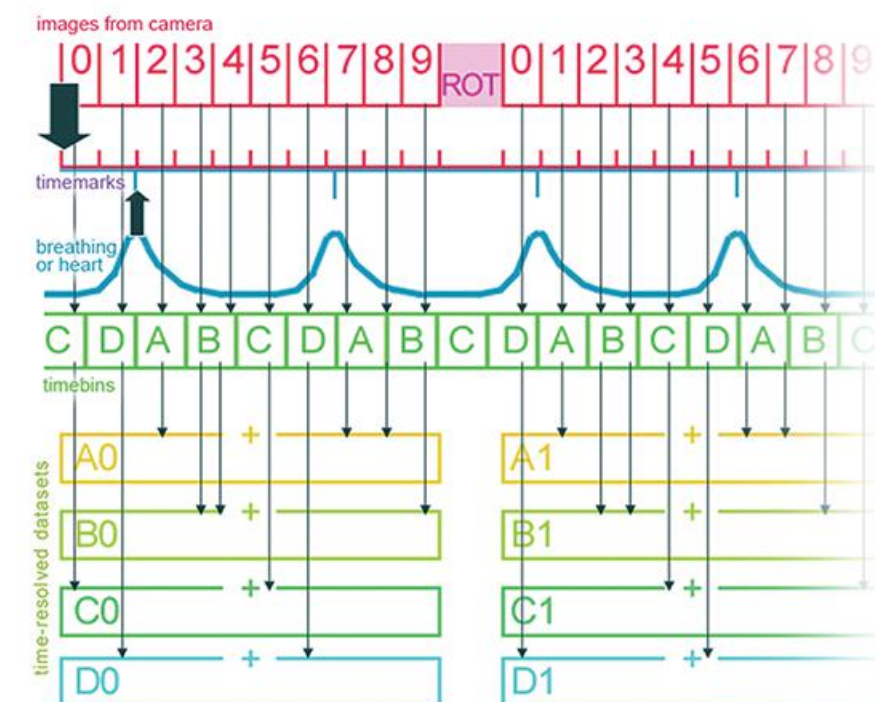
The physiological monitoring sub-system includes video monitoring of the animal with real-time movement detection, ECG and breathing detection, and temperature stabilization. A 5 megapixel color camera is mounted above the animal bed and equipped with white LED illumination to produce a real-time image of the animal during the scan. The software analyses the video stream from a user-selected area of the image, which the operator can position on a part of the animal body where breathing movement is visible. These movements are converted into a movement waveform to provide timemarks for time-resolved micro-CT reconstruction.

The face mask on the animal bed is connected to an air/gas flow sensor for direct breathing detection. The ECG electrodes in the animal cassette are connected to a sensitive ECG amplifier. Both breathing and ECG signals are digitized, sent to computer and displayed as real-time profiles on-screen. An operator can select individual gain and threshold for each signal to optimize generation of timemarks. The monitoring also includes temperature stabilization by heated airflow, which maintains the scanned animal at a selected temperature, to prevent cooling of the animal under anaesthesia.

4D time-resolved microtomography

Physiological monitoring creates reference time-marks for time-resolved reconstruction of heart and lungs dynamics. In this scanning mode, multiple projection images taken at each gantry angular position are sorted post-scan into heart or breathing time bins using recorded physiological monitoring timemarks. Such sorting creates pseudo-static sets of projections, which are reconstructed as separate datasets and produce 4D set of results corresponding to different phases of the cardiac or respiratory cycle.

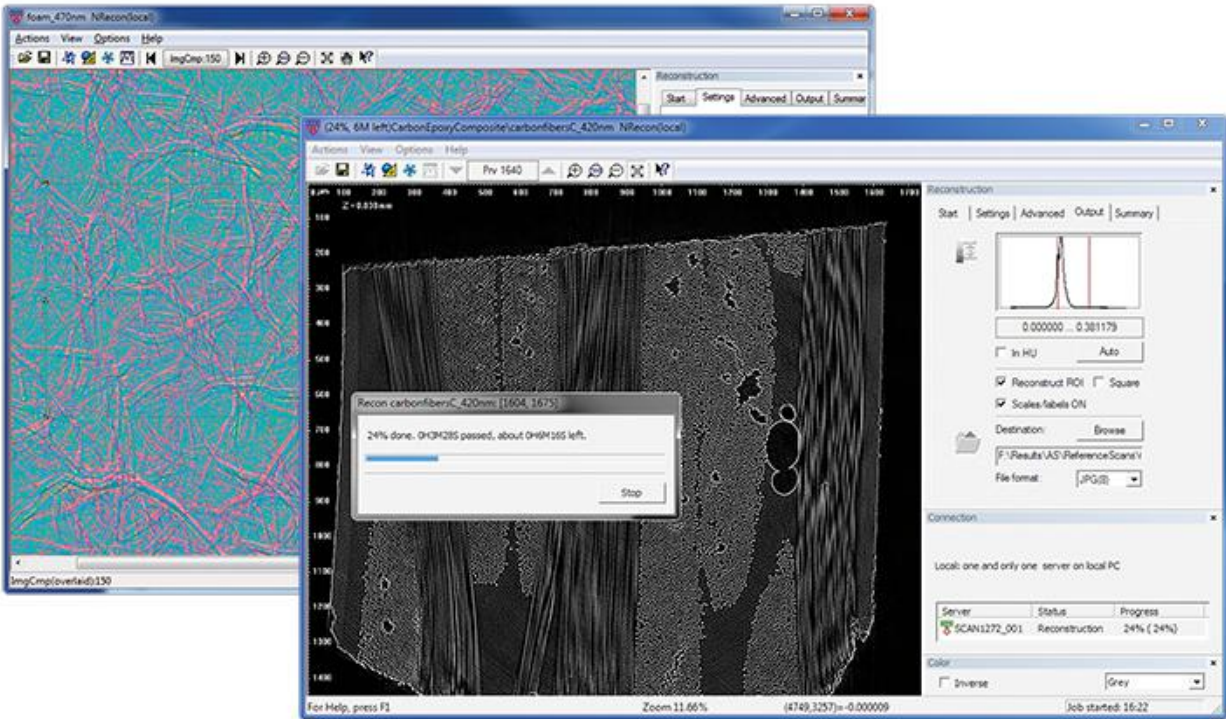
Our visualization program loads reconstructed datasets and allows scrolling in XYZ dimensions across the reconstructed volume, as well as in the time-dimension to visualize dynamics of heart or lung movements in sharp reconstructed images minimally affected by movement artifacts. Because all acquired data are sorted after the acquisition process, respiratory and cardiac cycles can be visualized by sorting according to timemarks from physiological monitoring without rescanning the animal.



- Software Suite for Reconstruction, Visualization and Analysis

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

The supplied reconstruction program **NRecon** supports several reconstruction engines. It can run on single PC or cluster of several PCs. It supports reconstruction of circular and spiral scans, beam-hardening correction, misalignment correction, ring artifact elimination, reconstruction of objects larger than field of view and 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 DICOM format. A special utility named **DICOM-CT** allows the export of datasets, previously saved as JPG, BMP or TIFF files, to DICOM format. Additional **NRecon** features allow batch reconstruction of multiple datasets with individually adjusted settings, fifth order polynomial beam-hardening correction, fine tuning of reconstructing parameters for best possible results and many other features.

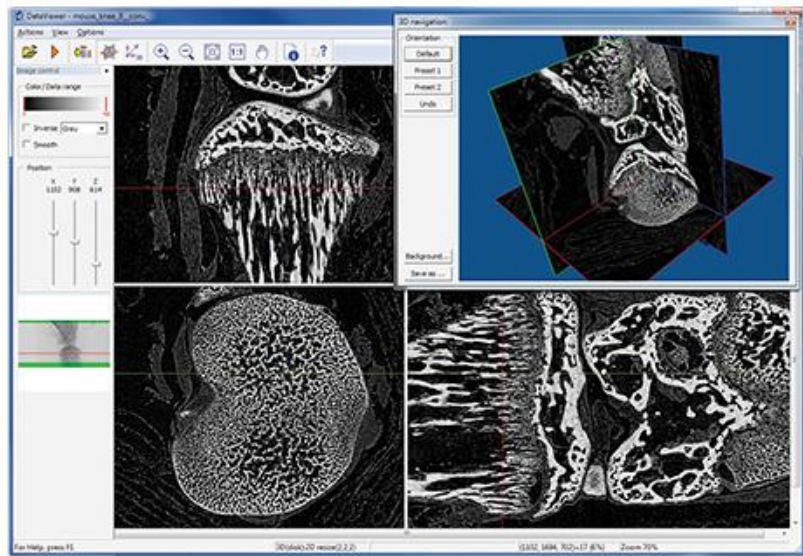


The reconstruction engines supplied with **NRecon** utilize a filtered back-projection algorithm and can use computer processors (CPU) running on all available cores or employ graphics card processors (GPU) to accelerate reconstruction. The GPU-accelerated reconstruction uses a unique parallelization 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 utilizes a unique hierarchical reconstructing algorithm. Compared to standard filtered back-projection algorithms it provides incredible speed-up of 10x ... >100x (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
<div> <div>NRecon configuration</div> <div>RECONSTRUCTION TIME: full volume / per slice</div> </div>					
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 intersecting 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** also 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

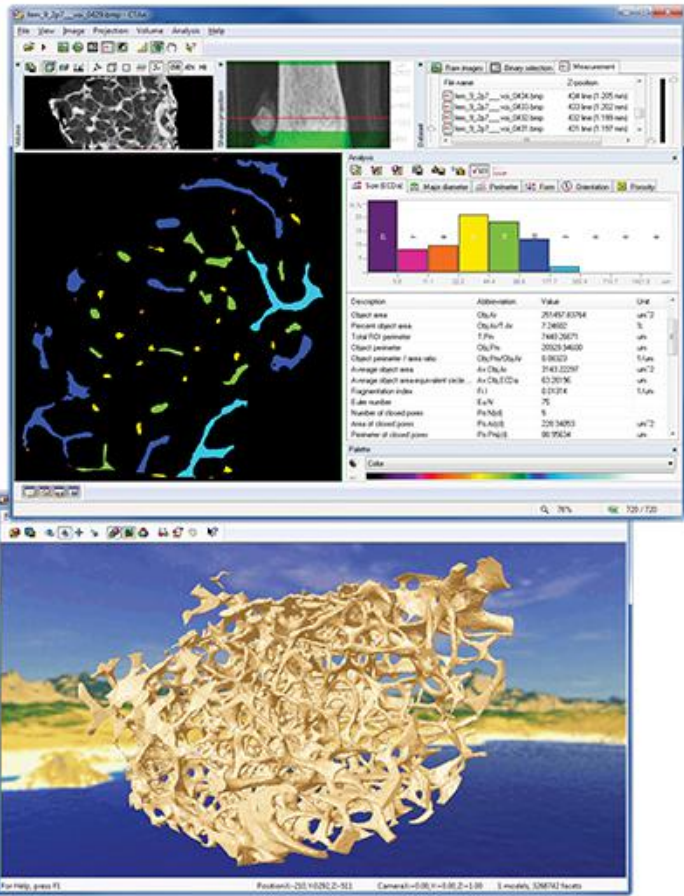
CT-Analyser or **CTAn** allows accurate and detailed study of micro-CT results for morphometry and densitometry. Powerful, flexible and programmable image processing tools allow a wide range of segmentation, enhancement and measurement functions for analyses ranging from porosity to contact surface around 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 structures within VOI in 2D, 3D
- Analysis of all objects within VOI in 2D, 3D
- Parameters measured (in 2D and 3D):
 - Object (pore, particle, etc.) volume
 - Object surface,
 - Structure thickness,
 - Structure separation, number
 - 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

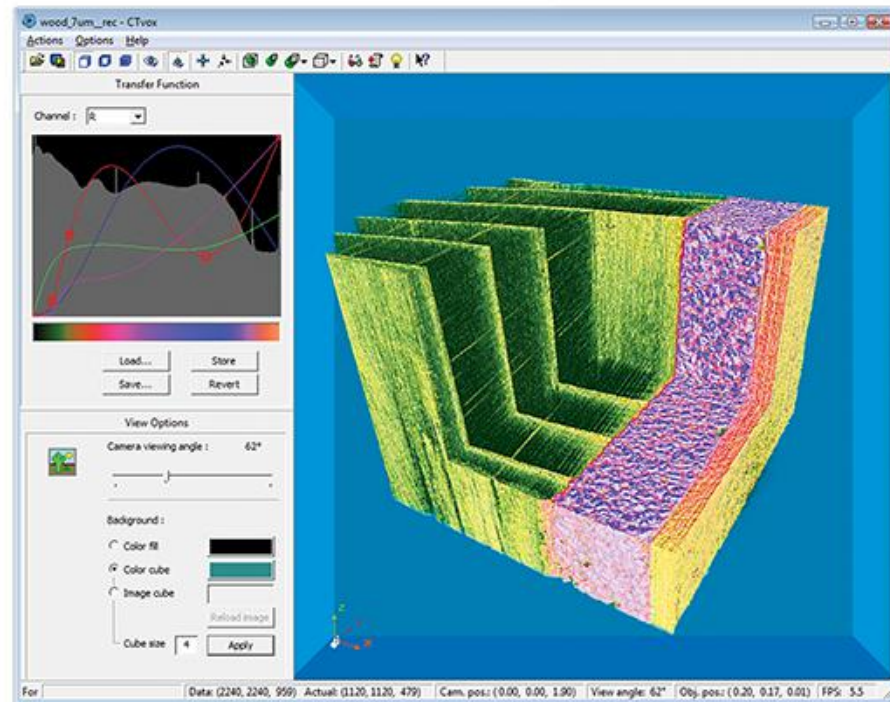
bruker-microct.com/next/CTan_UserManual.pdf
bruker-microct.com/next/CTvol_UserManual.pdf



• 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 surface 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 multi-modal animal *in-vivo* scanning.



Volume rendering on mobile phones and tablets

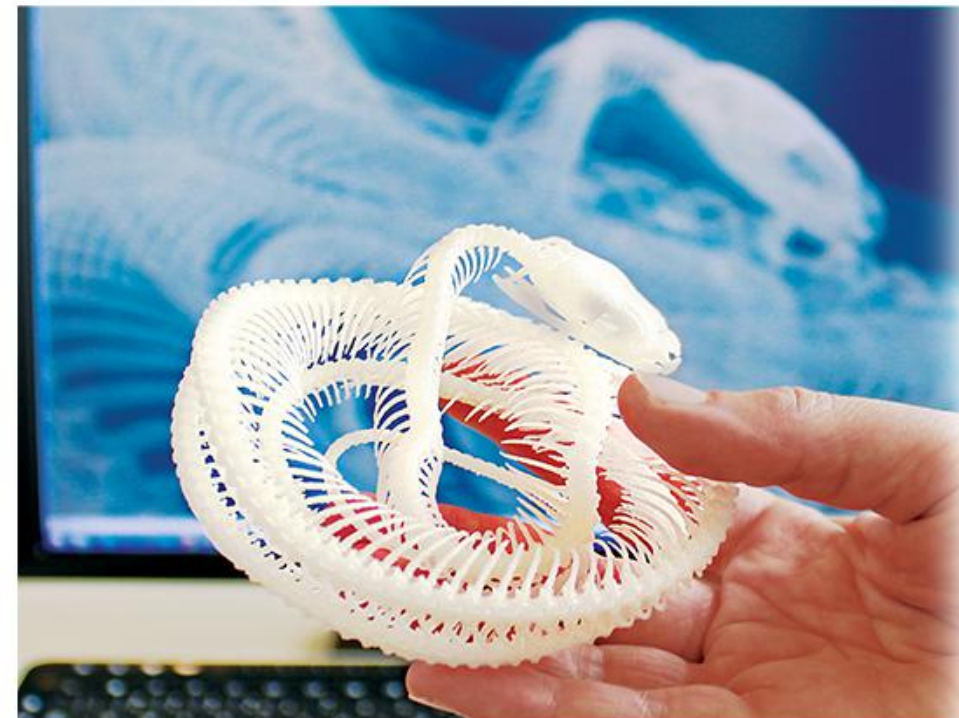


The volume rendering program **CTVox** supplied with all systems also has its mobile versions, which can be freely downloaded from the AppStore for iPhone/iPad/iPod or from Google Play for Android devices. Any 3D results obtained by SkyScan systems can be sent to a mobile device for realistic visualization 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



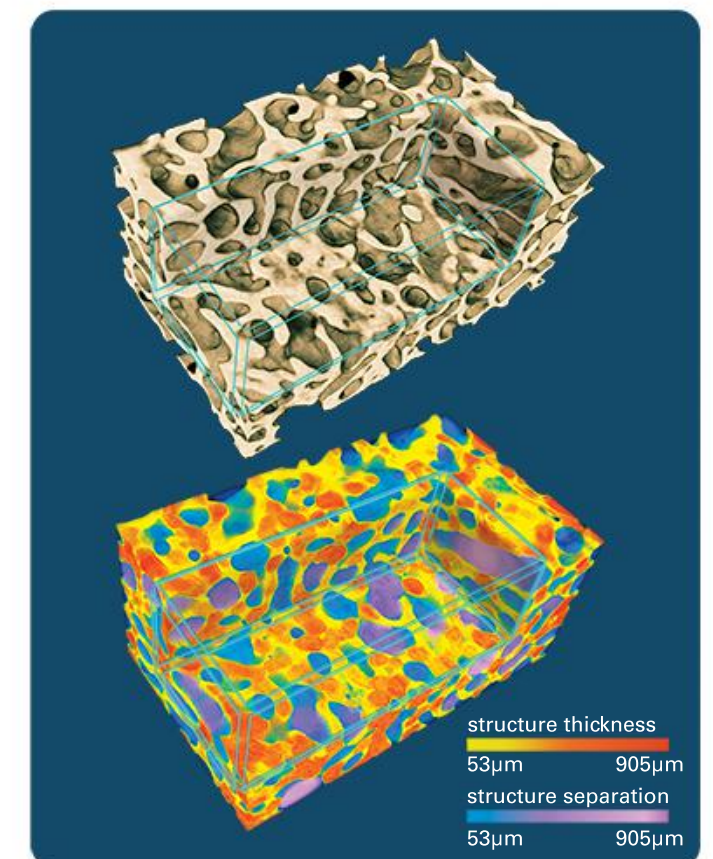
The **CTAn** / **CTVol** programs can create and visualize triangulated models of object surfaces. Such models can be saved in STL file format widely used in numerous applications. The STL files can be sent to a 3D printer to build a magnified physical copy of the scanned objects produced in different materials. Using selection 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 can analyze 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 allows direct comparison of a scanned object with a CAD model used to create the object.

Visualization of 3D analysis results

Combining the power of 3D numerical analysis of micromorphology in **CTAn** with the imaging capability of **CTVox** allows 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. The possibility to work 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**.

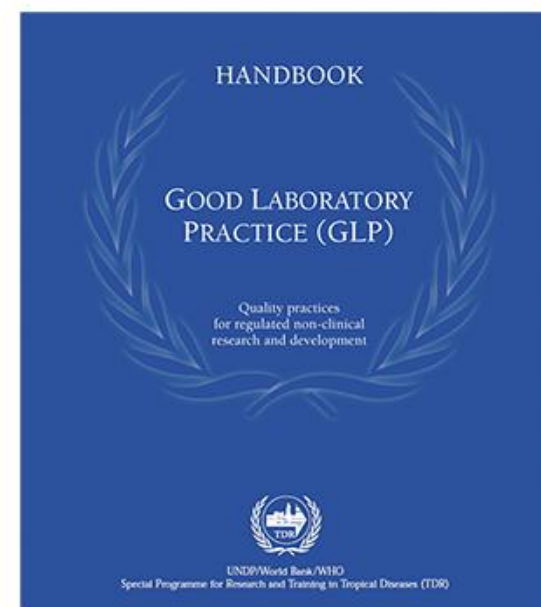
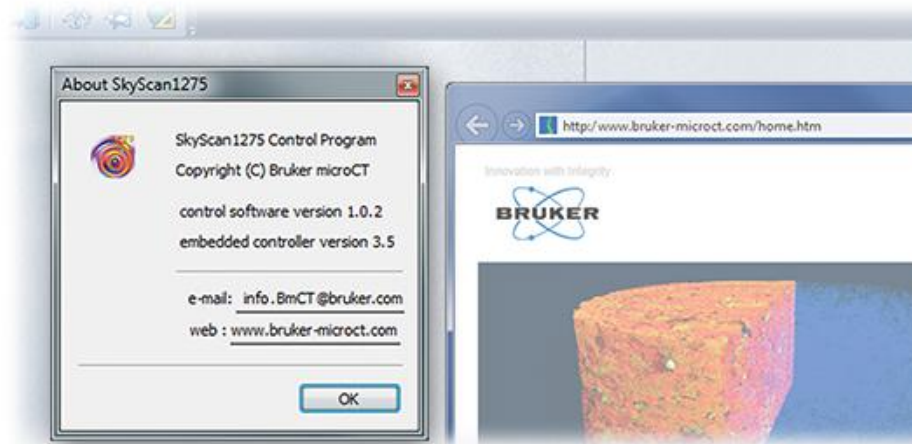


• Software Updates, GLP, Quality Management

Software updates

All users of **Bruker microCT** instruments have unlimited free access to all software updates. New versions of control and application software can be downloaded from the bruker-microct.com website.

To go to the Bruker microCT website, just click on the link in the "About" box in the control program. Using the other link at the same place, the operator can send an e-mail with requests to info.BmCT@bruker.com.



Good Laboratory Practice (GLP) software

All SkyScan *in-vivo* systems are supplied with a GLP module, which when activated allows administration of user rights and the implementing of necessary data protection according to GLP requirements. Access to control software will be protected by a user's name - password combination. Several levels of access can be granted: standard users, advanced users or supervisors. Standard user's rights allow scanning, saving and loading results and switching scanning protocols, but do not allow erasing or modifying of results or change of scanner settings. The users with advanced access rights have access to all functionality of the system.

When the GLP-module is activated, the control software duplicates every scan log-file with all scan parameters and system settings, in an encrypted copy, which cannot be directly accessed or modified. When necessary, encrypted log files can be restored to text for QA audit, to ensure the secure storing of critical scan information.

ISO 9001 quality management

Bruker microCT operates according to ISO9001 quality management rules with strict control of quality in design, production, service and customer support. This quality management system ensures high design quality, proper production processes, adequate individual testing, calibration and adjustment for all supplied instruments. It also includes fast and proper response to customer remarks and suggestions.

As an important part of ISO9001, customer satisfaction monitoring allows collecting of feedback from the user community and taking necessary steps to improve quality and reliability of the systems.



• Comprehensive Training and Support

Advanced training courses

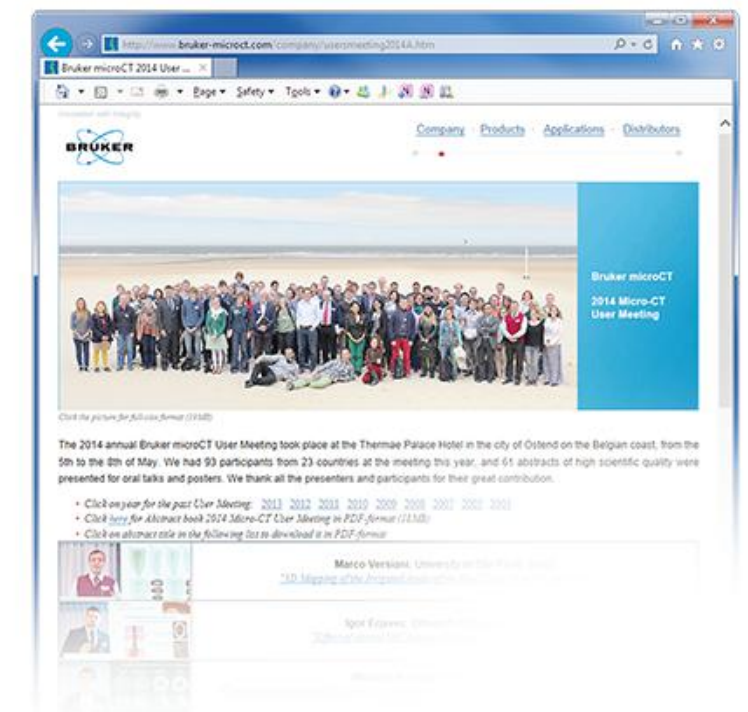
Bruker microCT offers a combination of both system and software training that covers three major topics: image acquisition, image reconstruction and data analysis/visualization. These 5-day courses are held several times a year at Bruker microCT headquarters in Belgium. The goal is to combine the basic theoretical background of microCT with as much hands-on experience as possible. After installation of every system, the new customers will receive first initial training, and later - advanced training either on-site or by course attendance, at the user's choice.



Micro-CT annual meetings

Bruker microCT also organizes the annual MicroCT Meetings in the form of a 3-day scientific conference with oral and poster presentations and best picture / best movie competition. The Meetings combined with training workshops. Intensive exchange of knowledge and experience helps new and skilled users to find the way to get the best results from their microCT imaging.

Invitation to the next MicroCT annual meeting and abstracts from presentations in the previous MicroCT meetings can be found at bruker-microct.com



'Bruker Micro-CT Academy'

The "Bruker MicroCT Academy" is an efficient educational platform for the hundreds of groups who are using SkyScan instruments. It includes a monthly newsletter with application and technical tips and keeps users updated on new methods, developments and company news.

Through participation in the Academy our users gain access to a database with detailed application and technical notes and can provide feedback with questions and suggestions for improvements of our instruments and software.



World-wide sales, distribution and support

The Bruker microCT worldwide sales and distribution network supports all SkyScan products. Local sales and service personnel provide your point of contact as well as installation, training and support. A full list of distributors and their contact details can be found at www.bruker-microct.com.



www.bruker.com ● **Bruker microCT**

Kartuizersweg 3,
2550 Kontich, Belgium
phone: +32 3 877 5705
fax: +32 3 877 5769

www.bruker-microct.com
info.BmCT@bruker.com
sales.BmCT@bruker.com

Sales representative: