"Let's Talk X-ray Imaging" blog article

# How Much Does a Micro CT Scanner Cost?

Marco Roeder

Customers reach out to me every day asking for a quote or help with figuring out how to choose the right micro-computed tomography (CT) scanner. They may be replacing an old CT scanner, adding a new CT scanner to increase the throughput of their laboratory, or buying a CT scanner for the first time. They want to know how much a CT scanner costs and what is involved in the process of choosing and installing one.

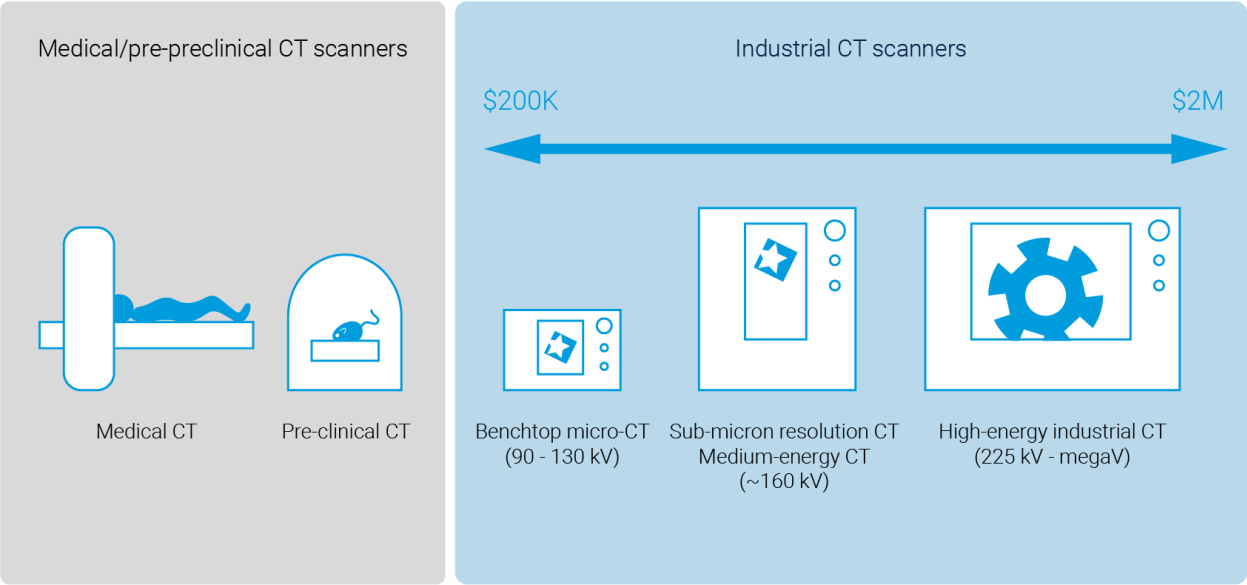
I've worked for multiple CT manufacturers as a sales engineer for more than 15 years, and I realize that this process of selecting, purchasing, and installing a CT scanner can be overwhelming. To start with, the price of a CT scanner ranges from $200K to $2M and there are so many factors going into selecting the right scanner, all affecting the overall cost. The price range is so wide because there is no one-size-fits-all solution. The CT scanner that does the best job to scan fruit flies is useless for inspection of car engines, and vice versa.

The price of a CT scanner depends on several factors. In this article, I will break down the key factors that affect the price of a CT scanner.



## 1. What type of CT scanner do you need?

There are medical/pre-clinical CT scanners and industrial CT scanners. The former is used to scan live humans and animals. The latter is used to scan anything from seeds, fruits, bones, plastics, ceramics to metals. In this article, we are going to look at industrial CT scanners. These scanners are often used for life and materials science research, product development, failure analysis, process control, or inspections. I should note that no CT manufacturer makes every kind of CT scanner, and most of them specialize in one or two categories. For example, we are specialized in CT scanners for materials and life science research.



There are a couple of ways to categorize the types of industrial CT scanners. The price increases from left to right:

- Size of the scanner: Benchtop, floor-standing, in-line automation
- Magnification mechanism: Cone beam, lenses, Fresnel zone plates

A benchtop micro-CT scanner with good resolution (< 5 microns spatial resolution) and flexible X-ray voltage range (up to 130 kV) and FOV (field of view) settings (a few to a few hundred mm) can do a lot. A benchtop scanner doesn't take a lot of space and is relatively simple and easy to use. It costs roughly $280K to $400K, depending on the configurations and options.

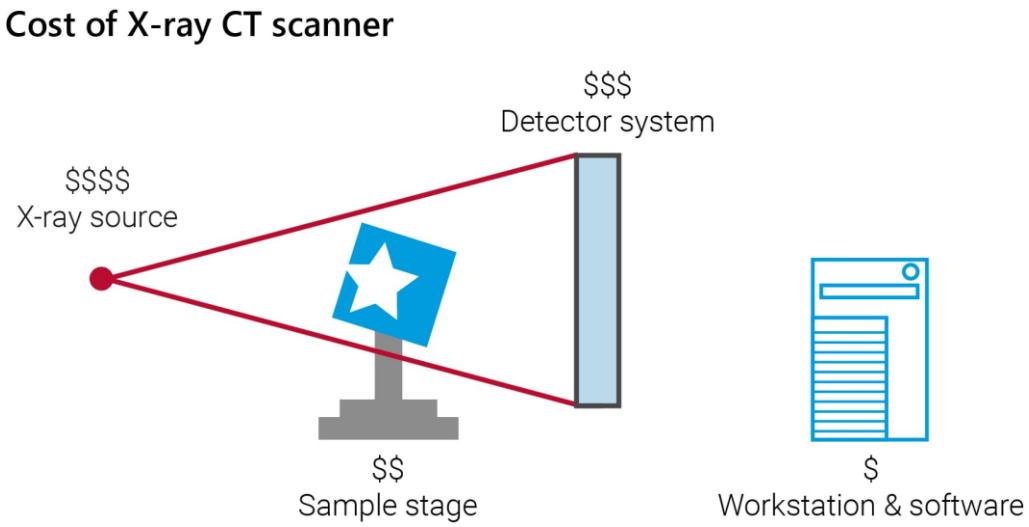
A floor-standing model with lenses or an X-ray source with higher voltage is required to achieve higher resolution or greater X-ray penetration for larger and heavier samples. It costs anywhere from $600K to over $1M. An ultrahigh-resolution scanner that can achieve 20 - 50 nm resolution costs about $2M. A scanner designed for in-line inspection with automation capabilities also can cost up to $2M, depending on the configuration and level of automation and customization. It is common for imaging and research centers and shared research facilities to own multiple CT scanners to cover a wide range of resolution, FOV, and material density while increasing the throughput.

Read: X-ray CT Scanner Buyers Guide

## 2. What makes CT scanners expensive?

**What is the cost of a CT X-ray source?**

The X-ray source, also called an X-ray generator, is often the most expensive part of a CT scanner. The higher the voltage is, the higher the cost. The price significantly increases when going higher than 160 kV, 225 kV, and so on. Other factors such as the X-ray power and focus size can also affect the price. A typical closed micro source costs anywhere from $50K to $100K, while some specialty sources, such as a high power rotating anode source and nano focus source, can cost over $100K.




**What is the cost of CT scanner optics and detectors?**

The second expensive part is the detector and associated optics. High-resolution detectors, such as CCD (charge-coupled device) and sCMOS (scientific complementary metal-oxide semiconductor), are more expensive than flat panels. In both cases, the larger the detector is, the more expensive it becomes.

**What else is included in a CT scanner?**

Although insignificant compared to the X-ray source and detector, the sample stage and X-ray source and detector axes affect the cost. A wider range of motion and higher precision drive the cost up.

If you are an SEM (scanning electron microscope) or TEM (transmission electron microscope) user, you might be wondering if there are costs associated with sample preparation. In most cases, you don't need to do anything special to prepare a sample for a CT scan. The measurement is done in the atmosphere, and imaging does not require any sectioning, coating, or staining. Life science samples such as tissues might require fixing and staining, but all you need is a few chemical products.

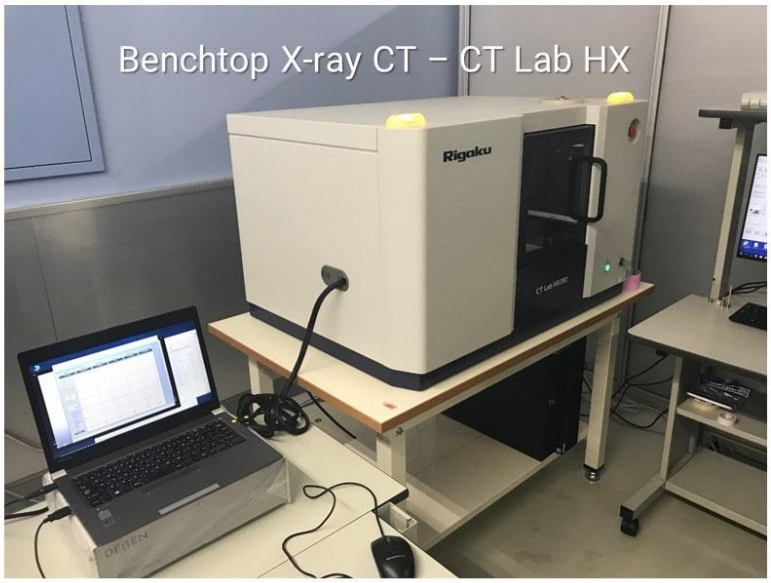
Lastly, a workstation computer and software tools for reconstruction calculation and image analysis can add a significant cost depending on the configuration. More on this in the next section.

## 3. What features and accessories are available to add to a CT scanner?

Additional features that can increase the cost include an automatic sample changer, in-situ stages, and analysis software. The in-situ stages can change the sample temperature, add mechanical stress, etc., during CT measurements.

**What is the cost of an in-situ attachment for CT scanners?**

An in-situ stage costs from $30K to $300K, depending on the temperature and stress range.





**How much does CT image reconstruction and analysis cost?**

The CT image reconstruction software is usually included in the system price. There are various image display and analysis software tools, and their costs vary. ImageJ is open-source and free. Commercial software costs from $10K to $50K. (See a comparison of commonly used software tools.) Some software suppliers, Object Research Systems, for example, offer a free license to non-profit organizations. Another thing to note is that most CT scanners use absorption contrast imaging. Adding special contrast enhancement techniques such as phase contrast or diffraction contrast adds a significant amount of cost.

**Preparing your lab space for a CT scanner**

Depending on the system requirements, you might need to spend some money to prepare your lab. Most X-ray CT scanners do not require anything special, but some need a particular power supply or cooling water for the X-ray generator. X-ray CT scanners can be heavier than they look because of the X-ray radiation shield that stops the high-energy X-rays. Even a benchtop scanner can weigh over

300 kg. If the scanner weight exceeds the spec of your lab floor, you might need to strengthen the floor or find a different location.

## 4. How much does user training cost for CT scanners?

You will need the initial training to start using your CT scanner and analyzing the data. So make sure that the initial training of at least a couple of days, preferably in-person, is included in the cost.

In the long run, you might also consider options for continuing skill development and dealing with staff turnover. Many hardware and analysis software manufacturers offer free webinars and educational videos to help beginners and support continuous learning for existing users. Some provide more intensive paid courses. And hardware manufacturers usually offer in-person operational training when you have a new user. In both cases, the training cost is about a few thousand dollars, depending on the length of the training and requirements for the trainer to travel.

## 5. How much does installation cost for CT scanners, and how long does it take?

The installation of a CT scanner is usually included in the system price. From purchasing a CT scanner, it typically takes four to six months for the system to be made, packed, shipped, and delivered, ready for installation. The shipping time can be shortened by selecting air flight over ocean or ground, though it would increase the cost. As you get close to the delivery and installation date, you should check the delivery route, such as the availability of a service elevator and the door and hallway clearance. You should work with the manufacturer's installation coordinator to ensure smooth delivery. Once the CT scanner is in your lab and uncrated, it takes a few days to set it up, align the optics, and test the results before you can start using it.

## 6. Is it a good idea to buy a used CT scanner?

I would not recommend it. Used CT scanner is a relatively well-established market for medical CT scanners, but that is not necessarily the case for industrial CT scanners. Part of the reason is that there are too many different kinds of scanners and configurations, and it's hard to find the right match. Also, the use of these scanners is not as regulated as that of the medical CT scanners, so used scanners might not be in very good shape. Buying a CT scanner in unknown condition without a warranty is probably not a good idea. You might save money initially, but you might end up

spending more money to repair and maintain the system. As we will see in the next section, the maintenance costs of a CT scanner are not trivial.

## 7. What are the maintenance costs of a CT scanner?

Another thing to factor in is the maintenance of the system. There are not many consumables, but the X-ray source and detector might need to be serviced, refurbished, or replaced every once in a while. The maintenance cost for the X-ray source is a notable difference between the open tubes and closed tubes.

**X-ray source lifecycles**

- *Open-tube X-ray sources*

Open tubes usually allow you to change consumables such as the filament and continue to use the same X-ray tube for the lifetime of the CT scanner. Replacement of consumables and maintenance is required once every 1-3 years and costs a few hundred to a few thousand dollars, depending on the exact type of X-ray tube.

- *Closed-tube X-ray sources*

Closed tubes usually need to be replaced when they reach their lifetime, which happens every 3-7 years or several to ten thousand hours, depending on the frequency of the use and load settings. During this lifetime, the tube might need an oil change, which costs roughly several thousand dollars. A new closed tube can cost from $50K (low voltage) to $100K (high voltage), and, usually, a service visit is required to replace the existing tube. Refurbished tubes are also available. Their costs are about half of the brand new ones, but the lead time can be significantly longer depending on the availability.

**Detector lifecycles**

If you use a flat panel or CCD detector, the sensor degrades, and its sensitivity decreases over time. The warranty of the detector is often defined in terms of the accumulated X-ray dosage, so the time frame greatly depends on the usage. Generally speaking, it is every five years or so for typical usage of research and development, failure analysis, and spot-check quality control. The sensor replacement costs about $20K. Depending on the type of detector, resolution, and size, it can cost more.

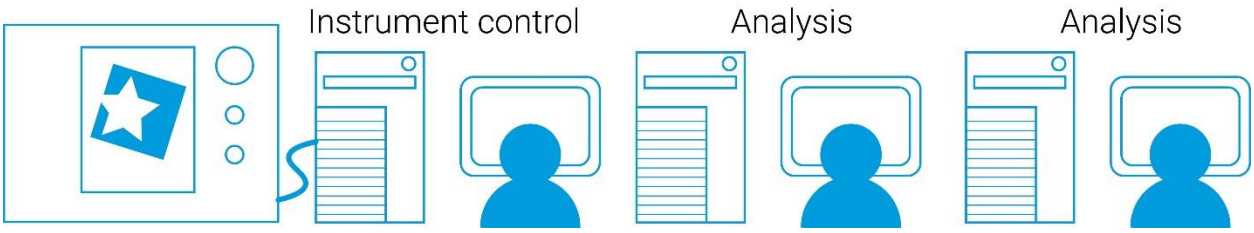
**Service contracts**

The X-ray source and detector maintenance costs might seem significant compared to other X-ray analytical instruments such as X-ray diffractometers or spectrometers. But these are necessary maintenance for X-ray CT scanners because the X-ray energy and the number of X-ray photons we need to see through solid objects are an order of magnitude higher. To enjoy the benefit of this "X-ray vision" for a long time, you should plan ahead. To spread the expense over the years, you can discuss a service contract with the supplier. A service contract is generally 8 – 12% of the cost of the system per year, depending on the coverage.

**Data management, analysis, and storage**

If you have many users sharing a CT scanner, you might need workstations separate from the one that runs the CT scanner for data collection. Data analysis can take a longer time than the measurements and require a high-spec computer. It helps to increase the throughput of the CT scanner to offload the data analysis to separate computers. You want at least 32GB (ideally 128 GB) of RAM, a dedicated GPU, and 8 – 12 TB storage. A workstation at this level costs from $3K to $15K.

Another way to offload the data analysis is to use cloud computing services. Object Research Systems and digiM, for example, offer cloud computing for CT image analysis, which you can access from your standard spec laptops. The cloud service can cost anywhere from $1K to $10K per year, depending on the number of users and data storage size. Whether you add a workstation or go for cloud computing, don't forget to budget for the software or cloud service annual license and maintenance fees.




I mentioned that you want an 8-12 TB storage drive on your workstation. This space is just for everyday operations. You will be surprised how quickly a terabyte drive fills up when you can collect a 20 GB scan in 5 minutes, and its analysis file can be 50 GB. You can easily use up more than 100 GB of space in a day. You can use external hard drives, network drives, or cloud storage services to store all that data.

You should consult with your IT department and see what options and support are available at your facility. Depending on the solution and the amount of data you need to manage, the data storage and management can cost anywhere from $500 to over $5K per year. The most important thing about data storage is, though, that you start planning early. Usually, when you realize that you got too much data to handle, it is too late.

Read: How should I manage X-ray tomography data? – The danger of relying on hard drives and how to avoid costly problems

## 8. How do you buy an X-ray CT scanner?

As you can see, many different factors can affect the cost of a CT scanner. The type of CT scanner is the most important thing to identify. It will tell you if you are looking at $200K or $2M. The first step to identifying the CT scanner type you need is to assess what specifications, such as the resolution and sample size, are important for your research.

At Rigaku, we have been designing and building X-ray instruments for over 70 years. Our team of sales and application specialists can help you find and configure the right CT scanner for your research. We have many application examples and publications that might help you get a better idea of which type of CT scanner you need. You can also try CT scans on your samples and schedule a demo.

If you are interested in scheduling a consultation or getting a quote for one of the Rigaku CT scanners, talk to one of our CT experts by clicking the "Talk to an expert" button at the right top of the page or contact us at imaging@rigaku.com. Purchasing an expensive instrument can be an overwhelming process. I hope this article will ease the stress and help you enjoy finding your perfect CT scanner.

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Marco graduated OSZ KIM with a degree in communications, radio technology, and electronic engineering. He started his career as a sales engineer and later managed sales groups and trained sales teams. As a salesperson with an engineering degree, he has been helping clients to select the right analytical tool to solve their problems for 19 years. He has worked in the X-ray computed tomography (CT) industry for most of his career and developed in-depth knowledge of the technique and its applications. He is known for always putting his customers first, so much so that he would

recommend people to talk to his competitors if he finds his business and the customer's need are not a good match.