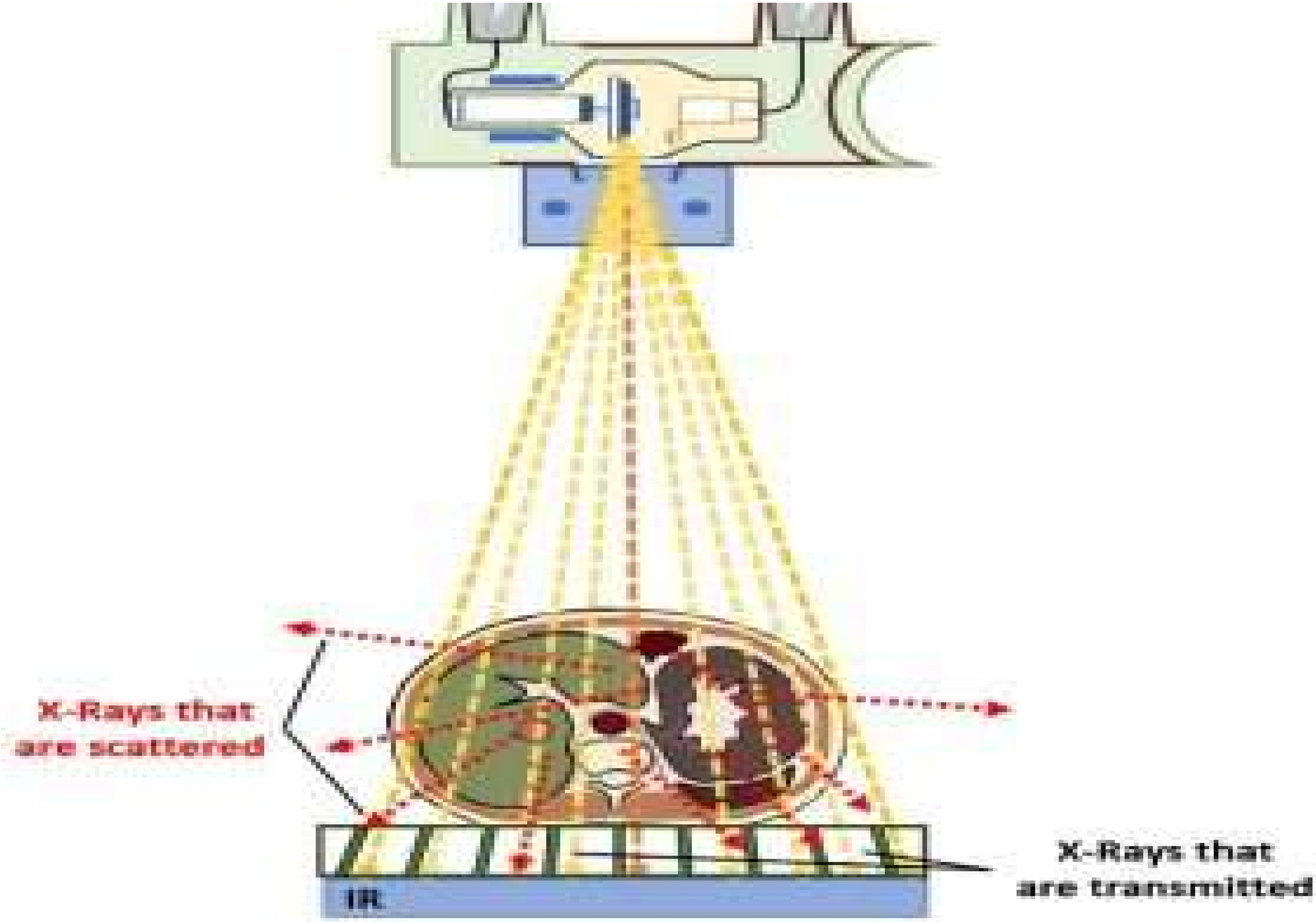
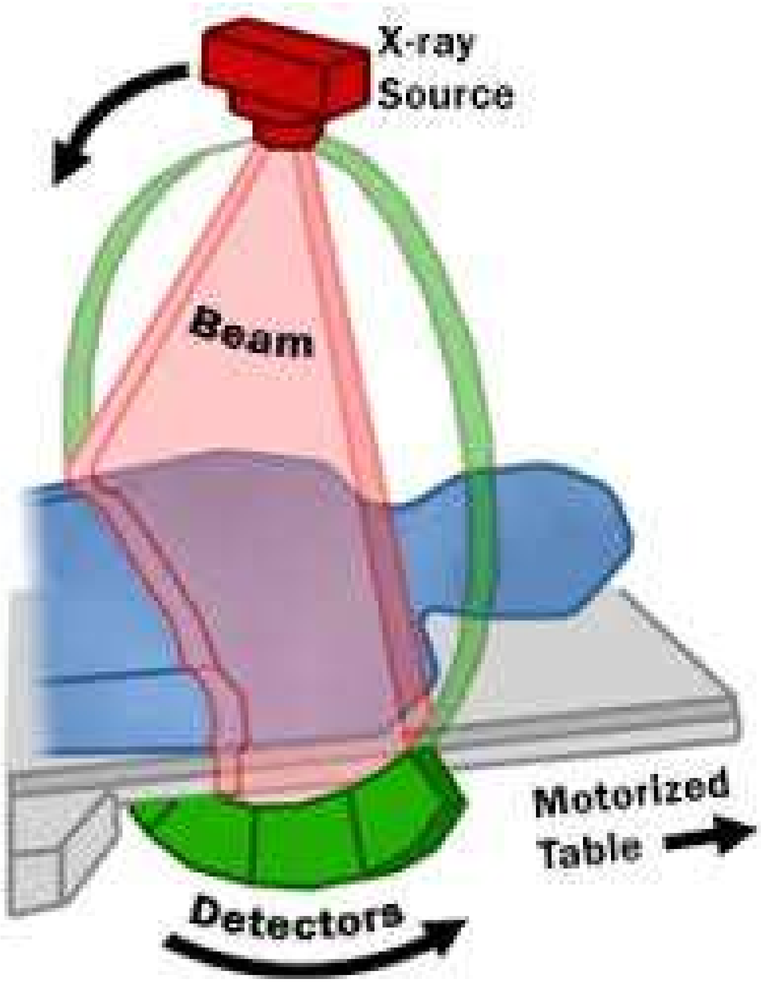
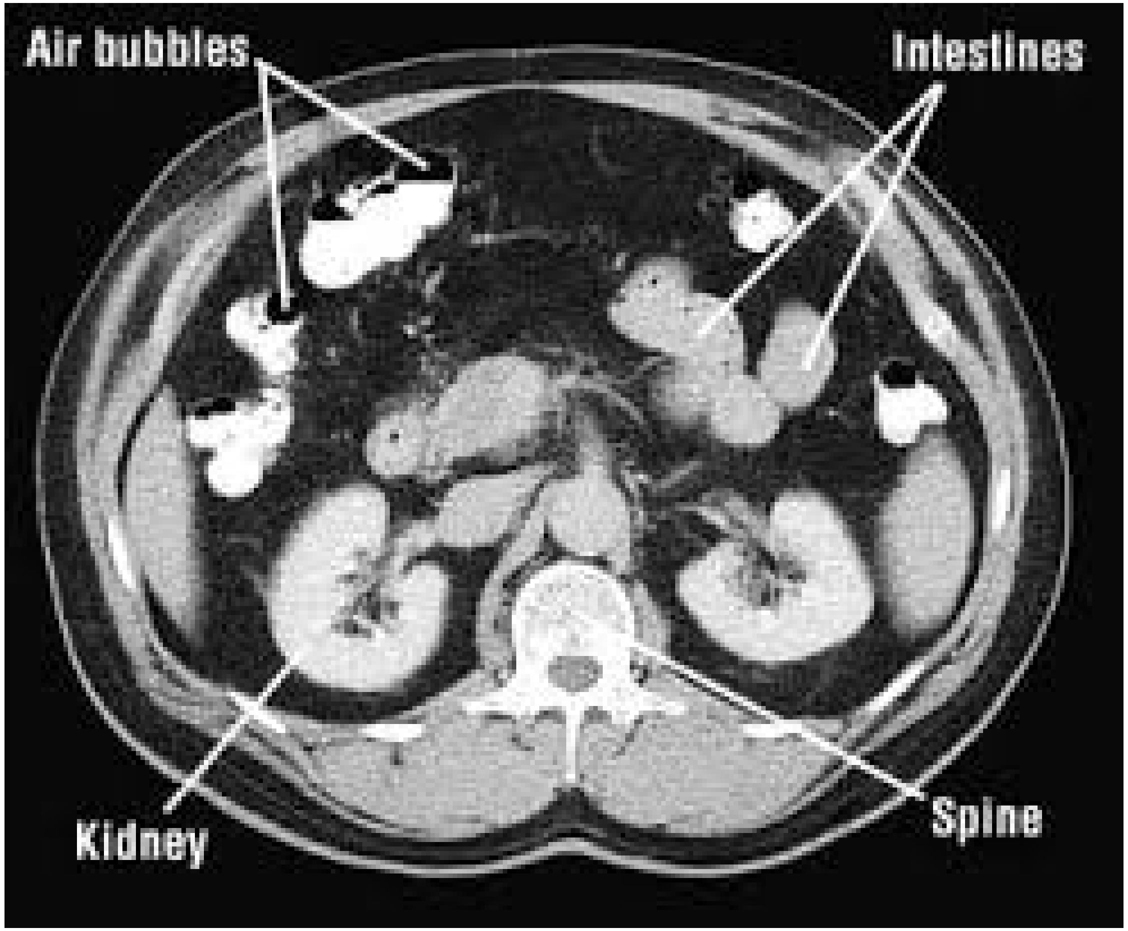
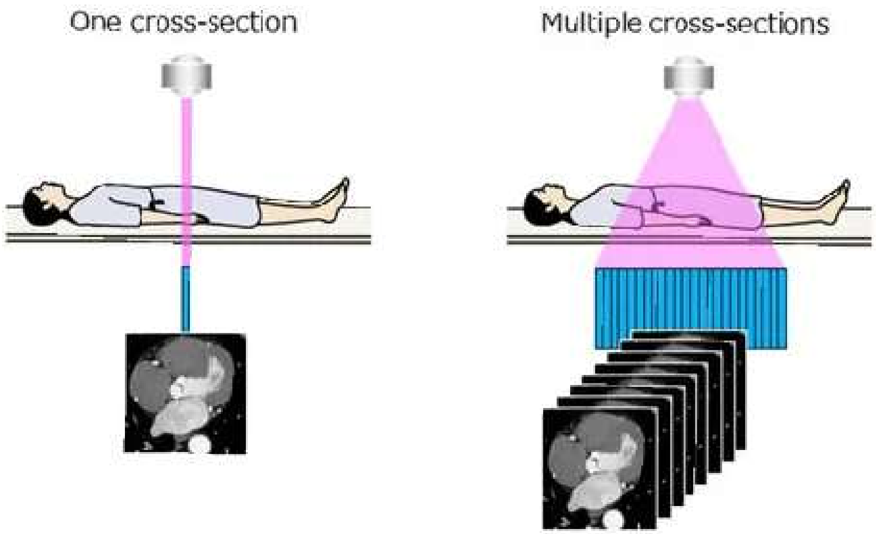

X-Rays that
are scattered
X-Rays that
are transmitted
IR

Computed Tomography (CT Scanner)



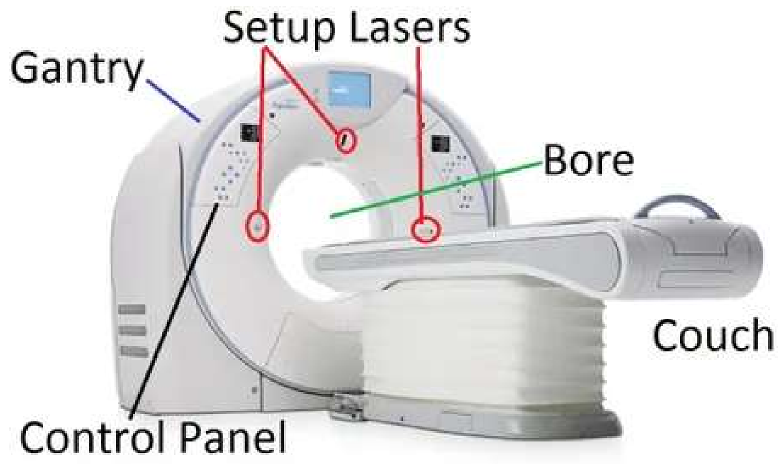


A Computed Tomography (CT) scanner is an advanced diagnostic tool that uses X-rays linked with a computer to create a series of detailed 2D images. These images, taken from many different angles around an organ or tissue, are then constructed into comprehensive 3D images. For patients, the primary benefit is clear: CT scanners provide a noninvasive, painless, and fast way to scan the body, offering a crucial window for diagnosis.



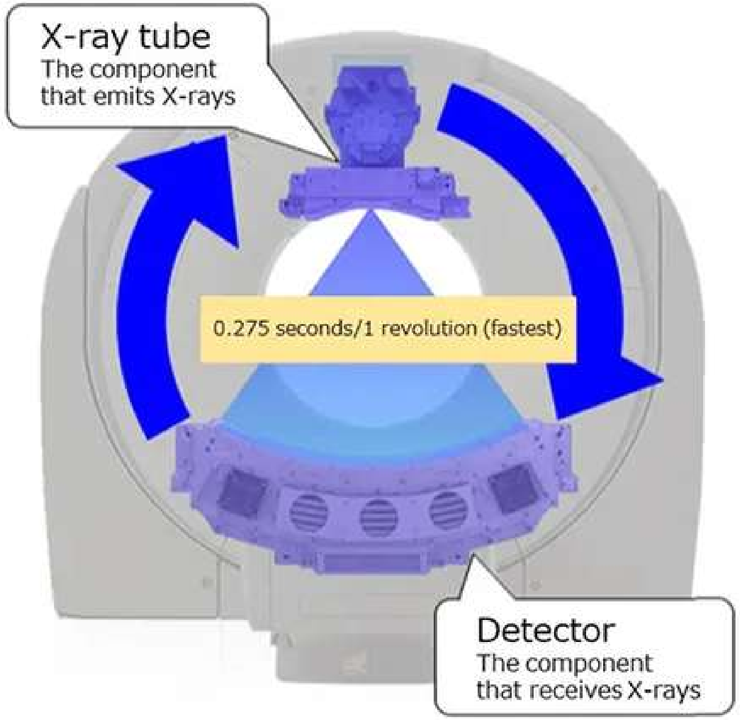
The Key Components of CT scanner

The gantry is the largest part of the CT scanner. It is a large, box-like machine with a ring-shaped housing. At its center is a short, ring-shaped tunnel called the bore, which the patient passes through during the scan. This opening typically has a diameter of up to 91 cm and a depth of about 25.4 cm. To accommodate various scanning protocols, the entire gantry can be tilted forward or backward by 20° to 30°.



The Key Components of CT scanner

Housed securely inside the gantry are the two most critical parts of the imaging process, whose perfectly synchronized rotation is the very essence of "tomography":



X-ray Tube: This is the source of the imaging process. Modern X-ray generators are compact enough to fit within the gantry and are responsible for producing the X-rays required for a scan.

Detectors: Mounted on a rotating scan frame directly opposite the X-ray tube, the detectors' function is to capture and measure the exit photons (X-rays) that have passed through the patient's body.

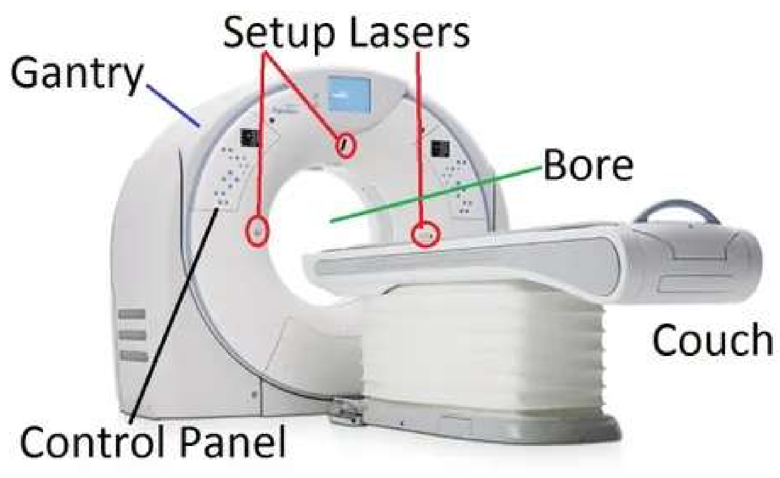
The synchronized rotation of the tube and the detector array allows for the collection of data from multiple angles

The Key Components of CT scanner

Sliding Table (Couch): This is the flat bed where the patient lies. During the scan, it slides slowly and precisely through the gantry's bore. The movement of the table is carefully controlled by the scanner's computer system.

Setup Lasers & Laser Beam: Included within the gantry, these lasers are used by the technologist to determine the exact position of the patient, ensuring that the scan targets the correct area of the body.

Microphone: A microphone is placed in the gantry, allowing the patient to communicate with the technologist, who operates the system from a control room equipped with both a speaker and a microphone.



The Key Components of CT scanner

The Brains of the Operation: The Computer System

All the hardware components are directed and managed by a sophisticated computer system.

This system has three primary functions that transform raw X-ray data into diagnostic images.

The Key Components of CT scanner

1. Data Acquisition: The first step is acquiring the raw data. The computer gathers all the information captured by the detectors as they measure the X-rays passing through the patient's body.

2. Image Reconstruction: This is the most complex task. Using specialized programs and complex mathematical algorithms, the computer performs calculations to convert the vast amount of acquired data into high-quality, cross-sectional images.

3. Image Display: Once reconstructed, the computer stores the images and displays them for the technologist and radiologist. It also allows these images to be sent anywhere in the world via the internet for consultation or storage.

How a Scan is Created

The CT scanning process is a highly coordinated sequence of events involving the patient, the hardware, and the computer system.

1. The technologist operates the scanner from a separate control room, monitoring the patient through a window and communicating with them via a speaker and microphone system.

2. The patient lies on the sliding table, which then electronically moves into the gantry's bore to the correct starting position.

3. The X-ray source, mounted inside the gantry, begins to rotate around the patient, producing X-ray beams from many different angles. Modern scanners can collect data from hundreds or even thousands of projections in a single 360° rotation.

How a Scan is Created

4. The detectors, mounted opposite the X-ray source, rotate in perfect sync, detecting the X-rays that pass through the patient's body.

5. The computer system acquires all the data from the detectors. It processes the many 2D "slices," which have a defined thickness. Each 2D image pixel actually represents a 3D rectangular box of tissue data called a voxel. The computer then stacks these slices to create a final, detailed 3D image of the scanned area. Think of it like putting together a loaf of bread from its individual slices to see the whole loaf.

CT scanners across seven generations

- The first generation used a "rotate/translate" motion with a single pencil beam, requiring five minutes to scan one slice.
- The second generation introduced a narrow fan beam and more detectors (up to 53), reducing time to 10–90 seconds.
- By the third generation, translation was eliminated entirely; the X-ray tube and detectors rotated together, dropping scan time to approximately one second per slice.

CT scanners across seven generations

- The fourth generation utilized a stationary ring of up to 4,800 detectors, allowing the X-ray tube to rotate within the ring for faster data acquisition.
- The fifth generation (electron beam CT) removed mechanical rotation altogether by using an electron gun to sweep an electron beam along a stationary tungsten target, achieving "ultra-fast" scan times of 50–100 ms.

CT scanners across seven generations

- In earlier models, rotation was limited by cables that had to be unwound, a process taking 8–10 seconds. The sixth generation introduced slip rings (brush-like rings), which provided continuous power and allowed the gantry to rotate indefinitely without stopping. This enabled helical/spiral scanning, where the patient moves through the gantry at a uniform rate during continuous rotation.

CT scanners across seven generations

- 7th Generation: This generation introduced multi-detector arrays (rows), allowing the scanner to acquire multiple slices (up to 1,152) in a single rotation. Modern models can scan the entire brain in seconds or perform a full-body scan in a single breath-hold.

General Diagnostic and Therapeutic Uses

- Screening and Diagnosis: It is used for the screening and diagnosis of various conditions, including breast cancer (offering images comparable to mammograms without compression) and lung cancer.
- Therapeutic Planning: Physicians use CT slices to plan surgeries, radiation treatments (radiotherapy), and other medical interventions.
- Monitoring Treatment: It is employed to monitor tumor growth and see how a patient’s cancer is responding to chemotherapy or radiation doses.

General Diagnostic and Therapeutic Uses

- Modern CT scanners are used to visualize and diagnose abnormalities throughout the entire body:
- Brain: Detecting masses, strokes, areas of bleeding, and blood vessel abnormalities.
- Chest and Respiratory: Identifying enlarged lymph nodes, acute or chronic changes like emphysema and fibrosis, and bronchial wall thickening.
- Abdominal and Pelvis: Scanning the liver, spleen, kidneys, pancreas, and gastrointestinal tract.
- Skeletal and Trauma: Diagnosing bone fractures, tumors, spinal stenosis, herniated discs, and internal injuries or bleeding caused by accidents.
- Cardiac: Specialized scanners (5th Generation/EBCT) are used for "moving picture" (cine) CT to detect calcium in coronary arteries and capture the unique contraction and relaxation of the heart.

Specialized Uses by Scanner Generation

Advancements in CT design have led to specialized uses for different generations:

- Cone-Beam CT (CBCT): Used extensively in interventional radiology, ENT scanning, and visualizing soft tissues for procedures.
- Dental CBCT: Specifically designed for complex dental cases, such as planning for dental implants, treating jaw tumors, and diagnosing joint disorders.
- Spectral (Multi-Energy) CT: Utilizes different X-ray spectra to provide superior material differentiation and more accurate diagnosis.
- Nano CT: A high-resolution technique used in pathology and biology to make structures visible at a cellular level (submicrometric resolution).