KREP

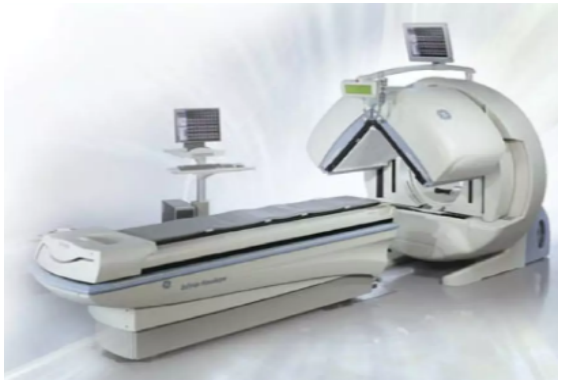
2025

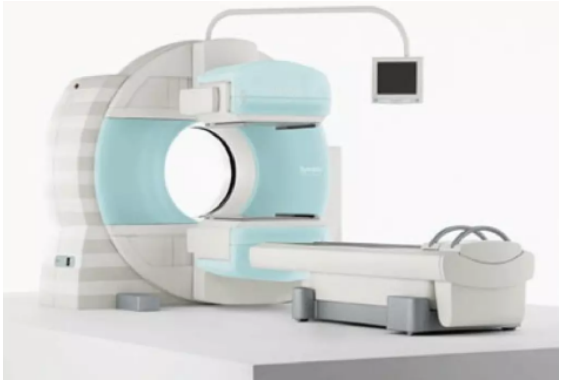
KARNATAKA RADIOLOGY EDUCATION PROGRAM

SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY

Single photon emission computed tomography (SPECT) is a three-dimensional nuclear medicine imaging technique combining the information gained from scintigraphy with that of computed tomography.

This allows the distribution of the radionuclide to be displayed in a three-dimensional manner offering better detail, contrast and spatial information than planar nuclear imaging alone.

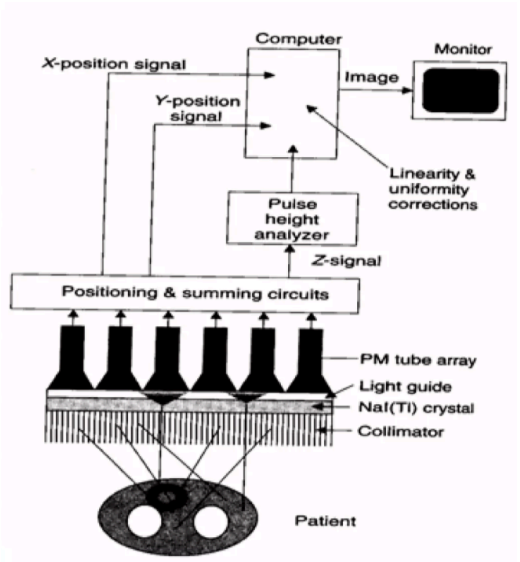




It looks like a CT or MRI system but hardware is different

Design

SPECT machines combine an array of gamma cameras (ranging from one to four cameras) which rotate around the patient on a gantry. SPECT may be also combined with a separate CT machine in a form of hybrid imaging; single photon emission computed tomography-computerized tomography (SPECT-CT) mainly for the purposes of attenuation correction and anatomical localization.



RADIONUCLIDE	HALF-LIFE	ENERGIES OF PRIMARY PHOTONS(keV)
Technetium-99m	6h	140
Thallium-201	73h	72
Gallium-67	3.3d	88,185,300
Iodine-131	8.04d	365
Iodine-123	13.2h	159
Xenon-127	36.4	172, 203, 375
Xenon-133	5.25d	81, 161

Principle

Gamma cameras rotate around the patient providing spatial information on the distribution of the radionuclide within tissues. The use of multiple gamma cameras increases detector efficiency and spatial resolution.

The projection data obtained from the cameras are then reconstructed into three-dimensional images usually in axial slices. When SPECT-CT is used, attenuation correction and higher resolution anatomical localization can be achieved.

DESIGN AND OPERATION OF SPECT

The components of the SPECT/gamma camera are:

1. **Collimators**
2. **Scintillation crystal / Detector**
3. **Photomultiplier tube (PMT)**
4. **Position Logic circuits**
5. **Pulse Height Analyzer (PHA)**
6. **Data Analysis Computer**

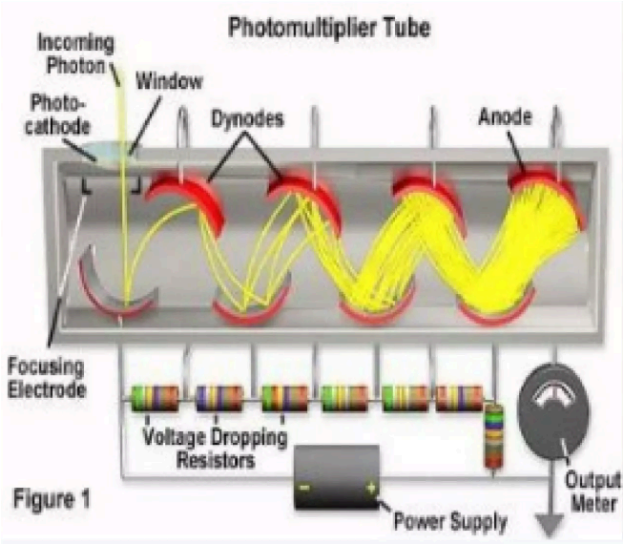
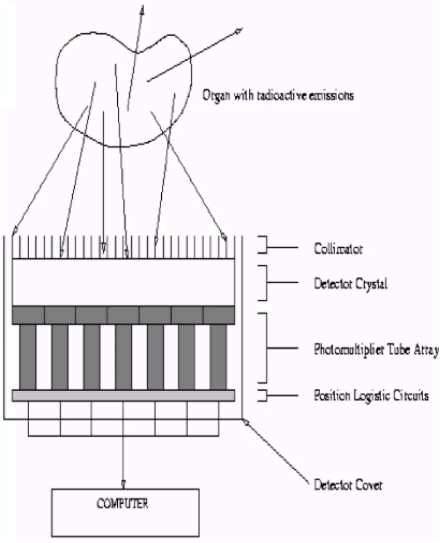


Figure 1



OTHER COMPONENTS

1. SCINTILLATION CRYSTAL / DETECTOR

- **Usually NaI (Tl) crystal**
- **Converts gamma rays to light photons**

2. PHOTOMULTIPLIER TUBE

- **Converts energy from visible light photons to electrons**
- **Magnitude of signal proportional to photon energy**

3. COMPUTER

- **Data analysis (uniformity correction and linearity)**
- **Processes data- readable image.**

4. MONITOR

- **For display**

FACTORS THAT AFFECT SPECT IMAGING

The quality and accuracy of SPECT images are affected by two factors:

1. Physical Factors - Due to interaction of emitted photons with matter inside the patients.

a) **Attenuation**
b) **Scatter**

Attenuation (including scatter) results:

- **High image noise**
- **Poor resolution**
- **Low contrast**
- **Reconstruction artifacts and distortion**

2. Instrumental Factors - Collimation detector system

Important components that determine both:

a) **spatial resolution (Blurring) and**
b) **Sensitivity (detection efficiency)**

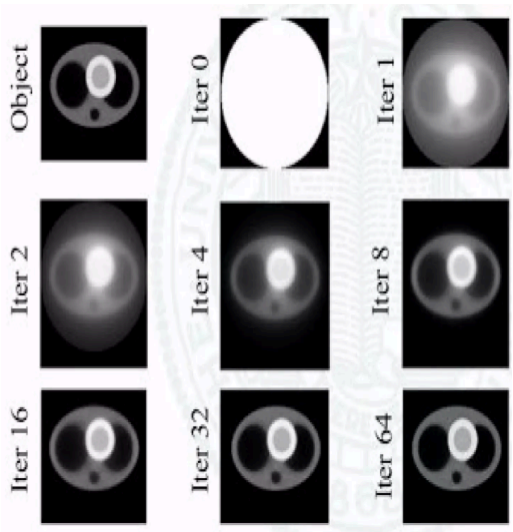
Higher resolution collimators imply lower sensitivity, and vice versa.

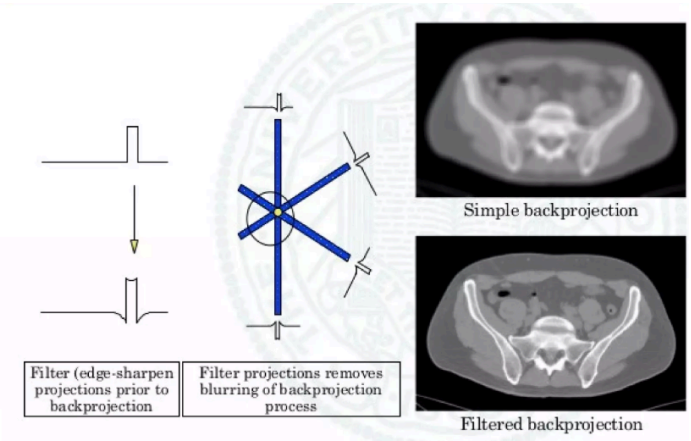
The main challenge in SPECT is finding a balance between resolution and sensitivity.

SPECT IMAGE RECONSTRUCTION

The goal of image reconstruction algorithms is to calculate accurately the 3D radioactive distribution from the acquired projections
The reconstruction of tomographic images is made by two methods:

1. **Iterative method**
2. **Filtered Back Projection**





SPECT APPLICATIONS:

- **Cardiac**
- **Whole body bone**
- **Renal**
- **Gastric**
- **Hepatobiliary**
- **Thyroid**
- **Pulmonary**
- **Brain**

ADVANTAGES OF SPECT

1. **Improved contrast and reduced structural noise, due to elimination of overlapping structures (compared to planar imaging).**
2. **Localization of defects is more precise and more clearly seen.**
3. **Extent and size of defect is better defined.**
4. **Images free of background.**
5. **SPECT (and PET) provide the only non-invasive technique for imaging brain neurochemicals.**

6. **The longer SPECT half-life affords longer synthesis times and greater flexibility in relation to administration of radiotracers.**
7. **SPECT is available in both developing and developed countries because of lower equipment cost and greater accessibility of SPECT radionuclide**

LIMITATIONS/DISADVANTAGES

1. **Radiation exposure**
2. **Limited spatial and temporal resolution.**
3. **Relatively expensive to build and maintain (compared to CT, MRI).**
4. **Not very effective for patient who just finished exercising (except in MPI SPECT).**

ARTEFACTS

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Most common artefacts are:

1. **Star Artefacts: Caused by backprojection, and solved by Filter Back Projection.**
2. **Motion Artefacts: Caused by movement of the patient. Detected on a sinogram.**
3. **Edge Packing: Increased brightness at edge of the crystal.**
4. **Artefacts may also be caused by damaged collimators, metal objects worn by patient, PMT failure, cracked crystals.**

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