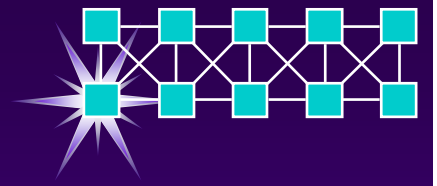
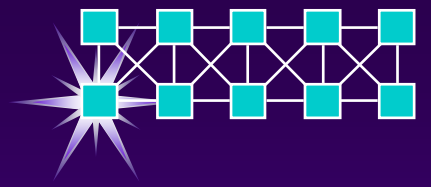
Medical Imaging Systems



- Radiography
- Tomography
- Magnetic Resonance Imaging (MRI)
- **Nuclear Imaging Systems**
- Ultrasound
- Electrical Impedance Tomography
- Breast Thermography
- Others (**Elastography, Spectroscopy, Ophthalmology**)

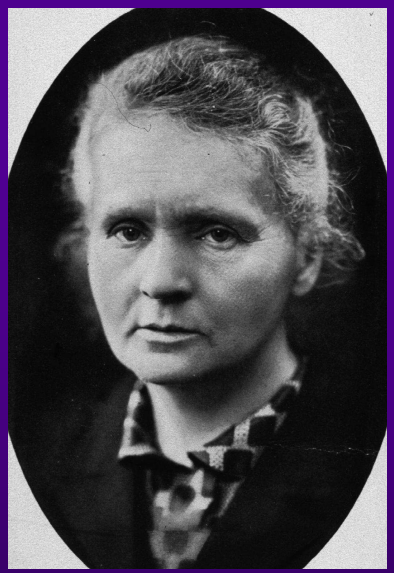


Nuclear Imaging Systems

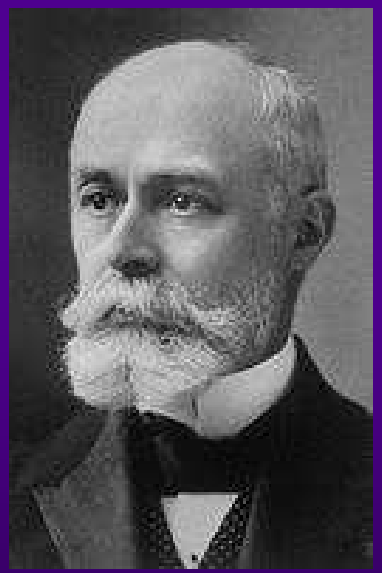
Use of Gamma rays, Radionuclides and Radiopharmaceuticals in medical imaging.

Discovery of Nuclear Medicine techniques

physics, technology, biochemistry, pharmacology and medicine



Marie Curie



Henry Becquerel

George von Hevesy

Principle of the Nuclear Medicine

- Short-lived radiopharmaceuticals are injected into a patient's bloodstream.
  - : The half life of these materials is between few minutes to weeks.

- The nuclear camera takes a time-exposure "photograph" of the pharmaceutical.

Tells physicians about the biological activity of the organ or the vascular system that nourishes it.

Used for

diagnosis of cancer

studying heart disease

circulatory problems

detecting kidney malfunction, and

other abnormalities in veins, tissues and organs.

Nuclear medicine imaging are used for generally more organ or tissue specific

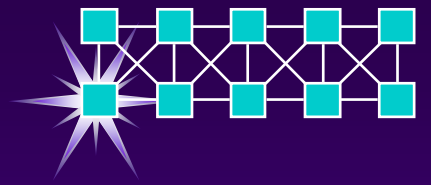
lungs scan, heart scan, bone scan, brain scan, etc

Conventional radiology imaging:

Particular section of the body chest X-ray, abdomen/pelvis CT scan, head CT scan, etc.

Nuclear camera

Whole body nuclear image

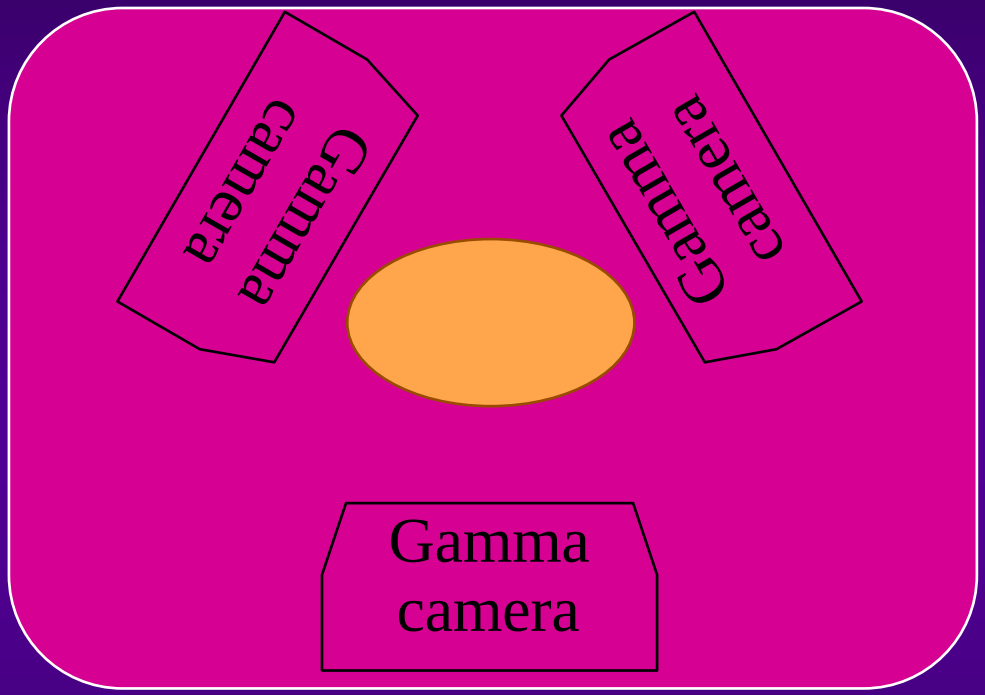


SPECT

(single photon emission computerized tomography)

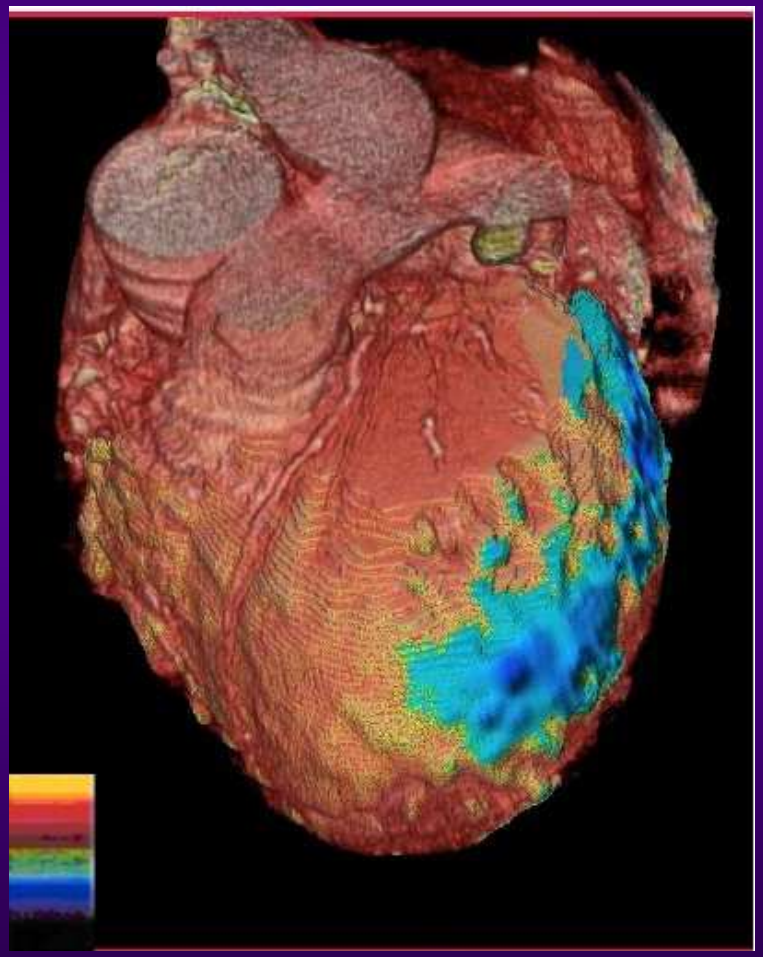
SPECT is based on the conventional nuclear imaging technique and tomographic reconstruction methods.

SPECT

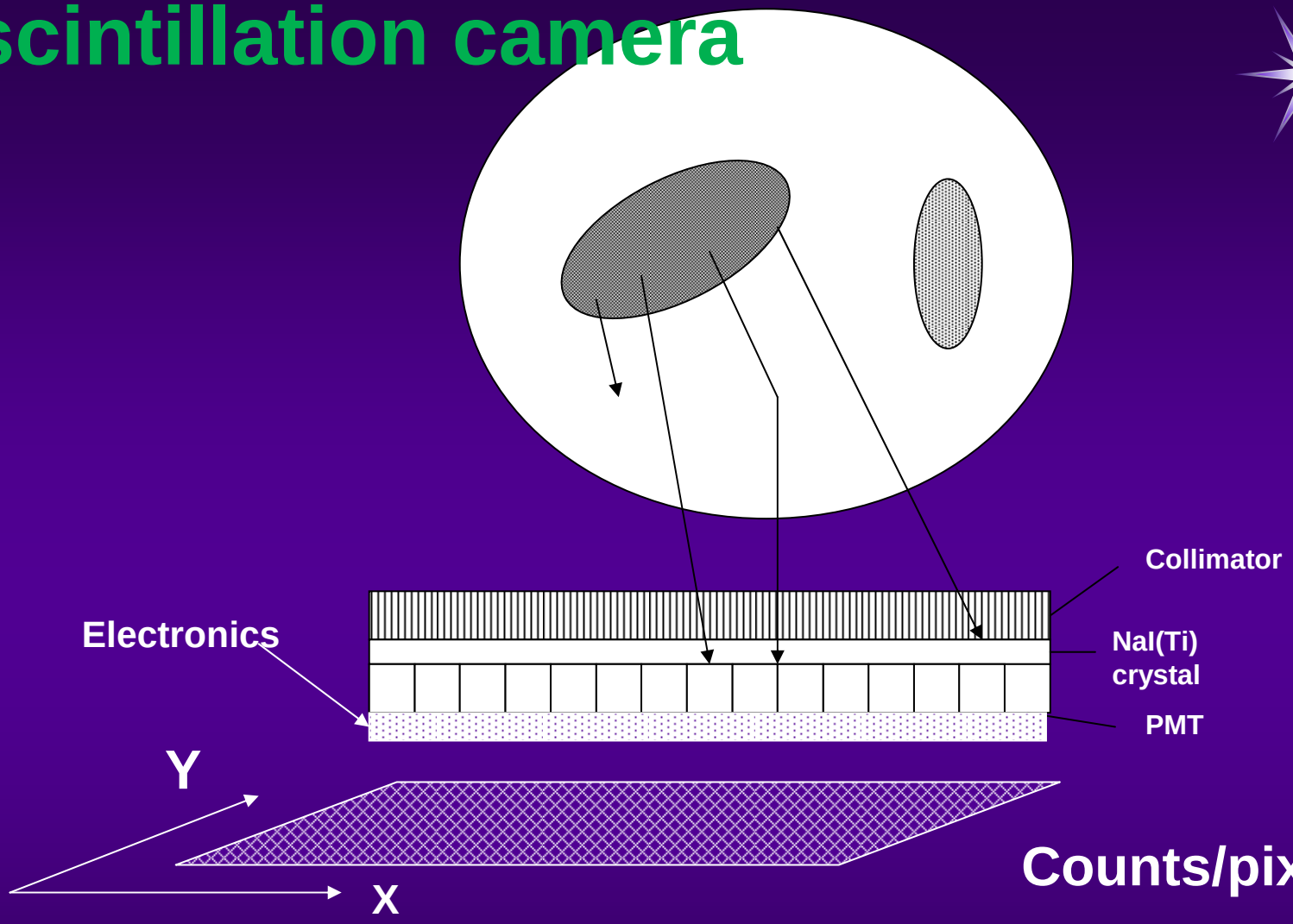


Single Photon Emission Computed Tomography. Shown here is a three-headed tomography system. The cameras rotate around the patient. A three-dimensional volume is imaged.

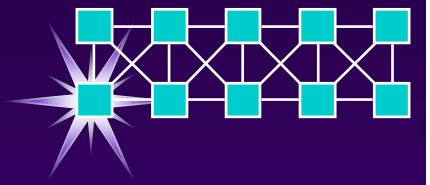
Cardiac SPECT-CT



scintillation camera



The most important tool in nuclear medicine is the scintillation camera (anger camera) based on a large area (~40 cm in diameter) NaI(Tl) **crystal.When a photon hits and interact with the crystal, the scintillation generated and detected by the area of PMTs.**

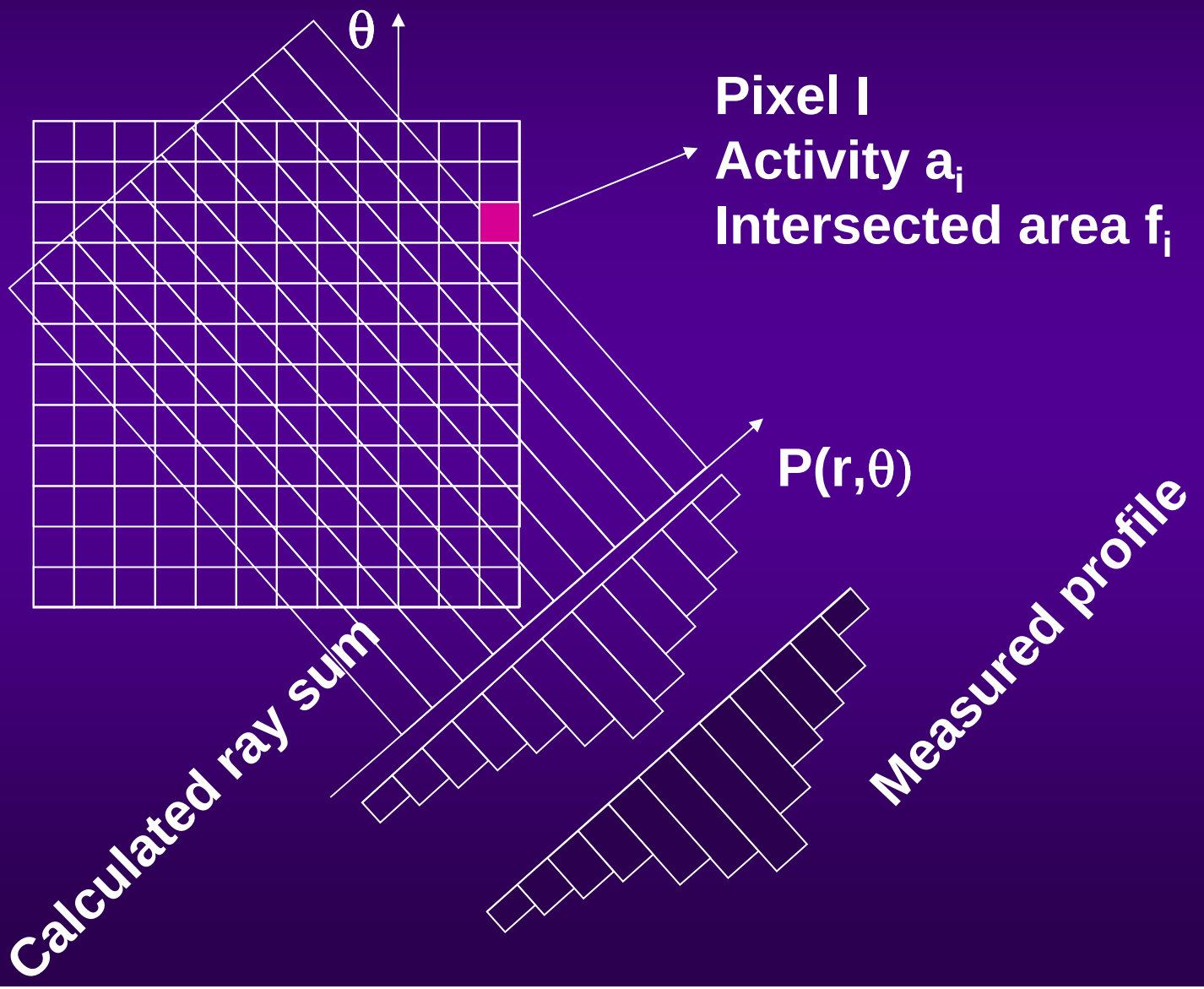


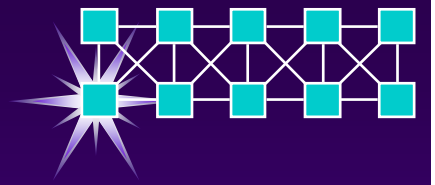
Localization

Nuclear material radiates isotropic ally into all directions.

The camera collects part that is entering into its solid angle less the photon which will impinge the collimators.

Discrete geometry used for iterative reconstruction methods

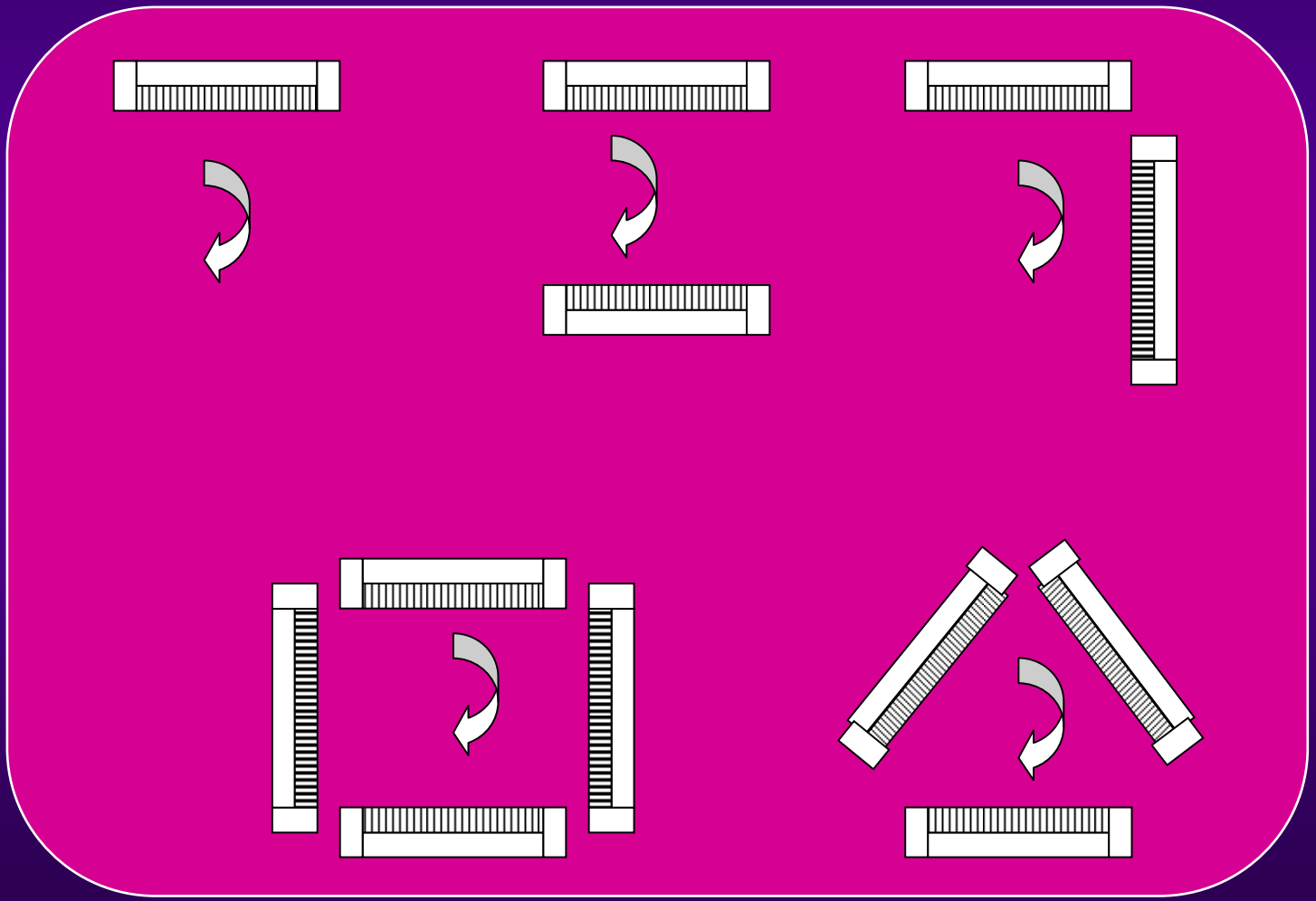




- In SPECT projection data are acquired from different views around the patient.

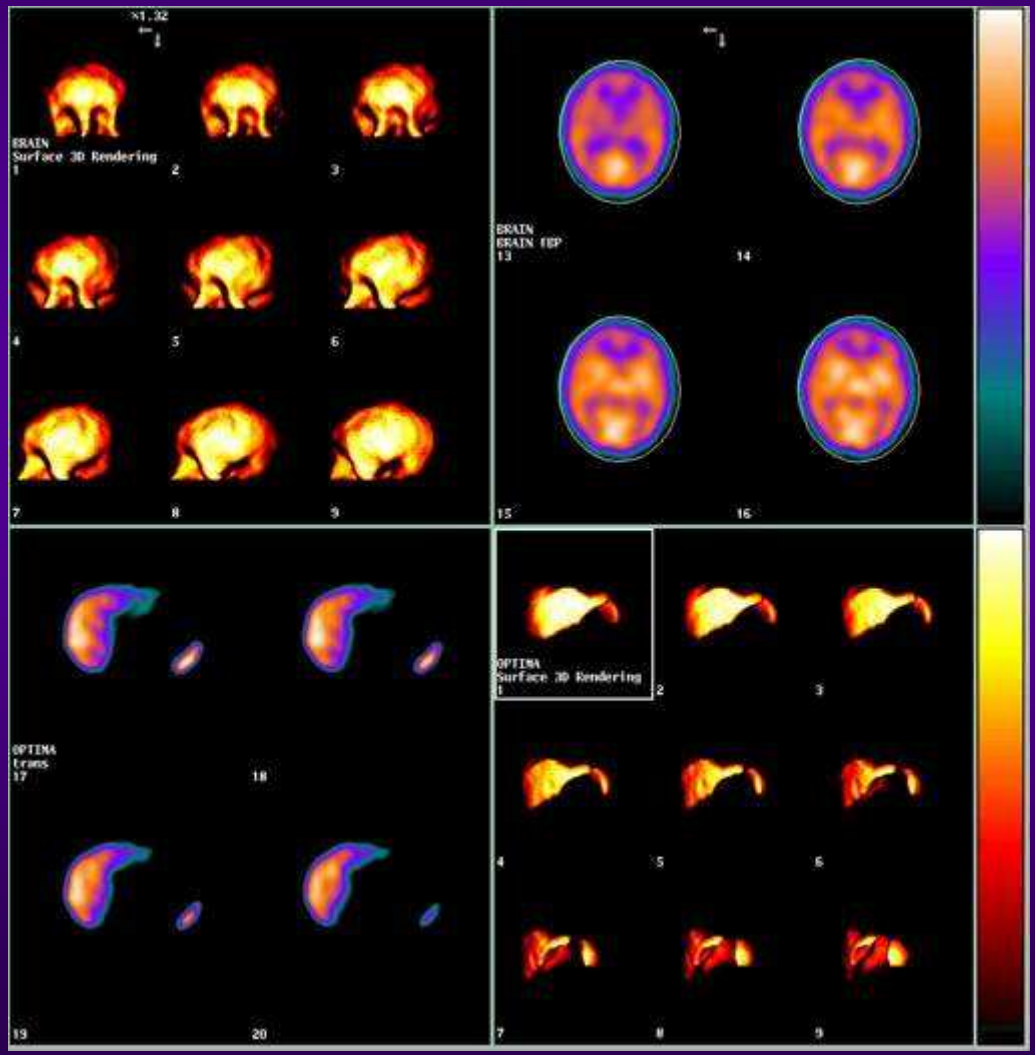
- Image processing and reconstruction methods are similar to X-ray CT

Camera based SPECT systems can be one of the configurations below:

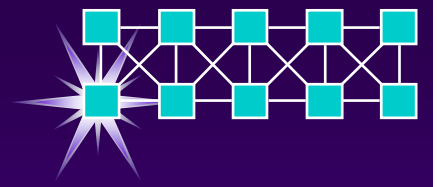


SPECT Machine

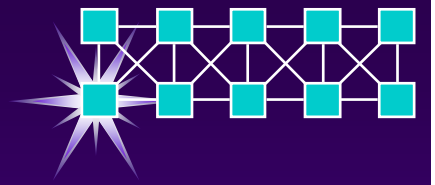
Brain and Liver Tomographic Reconstruction and 3D Rendering



Features of Radionuclide Imaging

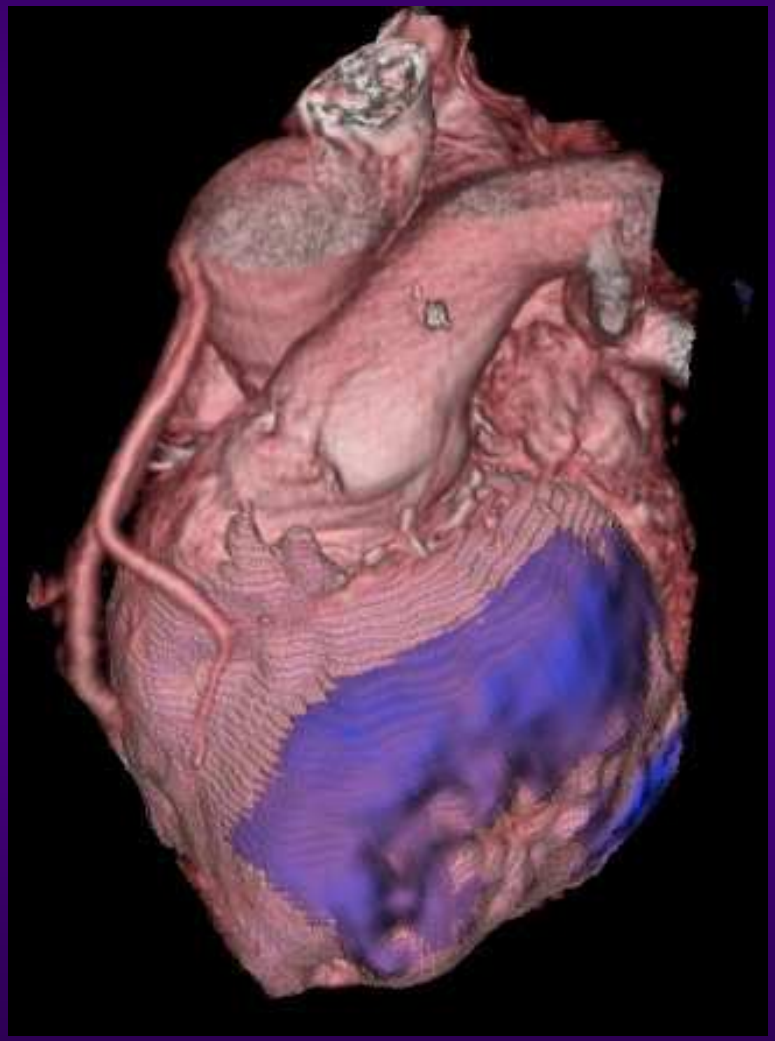


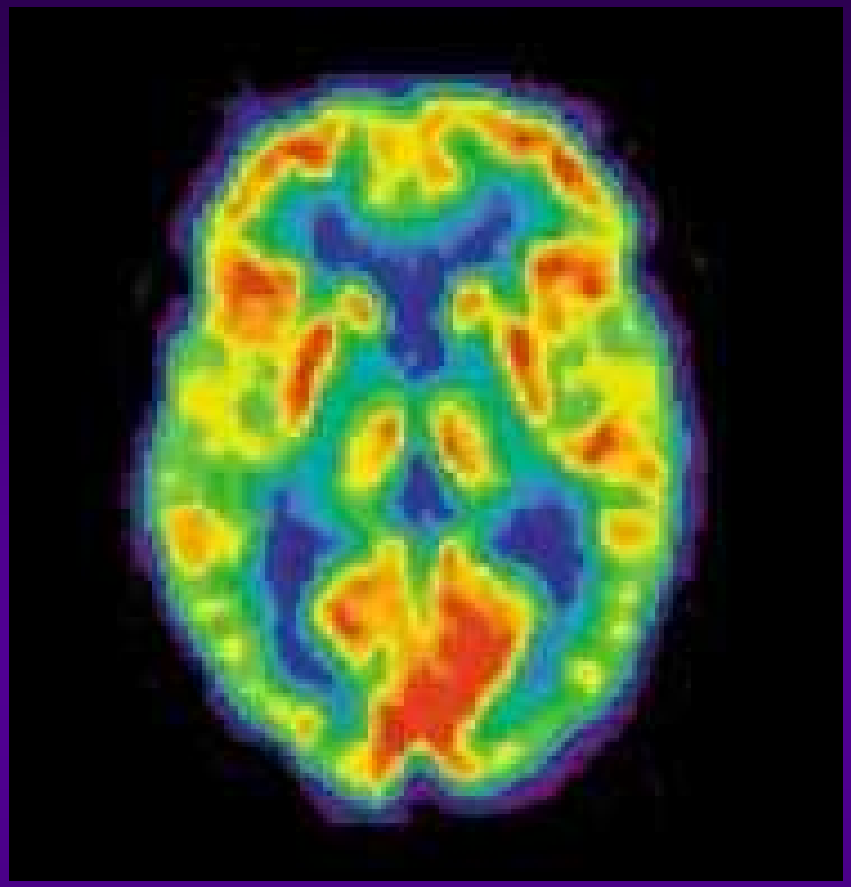
- The image is produced from an agent that is designed to monitor a physiological or pathological processes of
  - Blood flow
  - Metabolic activity
  - Tumor
  - Brain receptor concentration



Positron emission tomography (PET)

Cardiac PET-CT



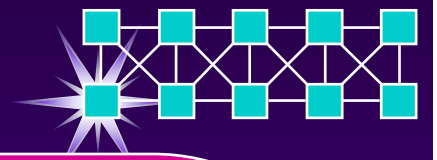


PET scan of a normal 20-year-old brain.

Principle of PET

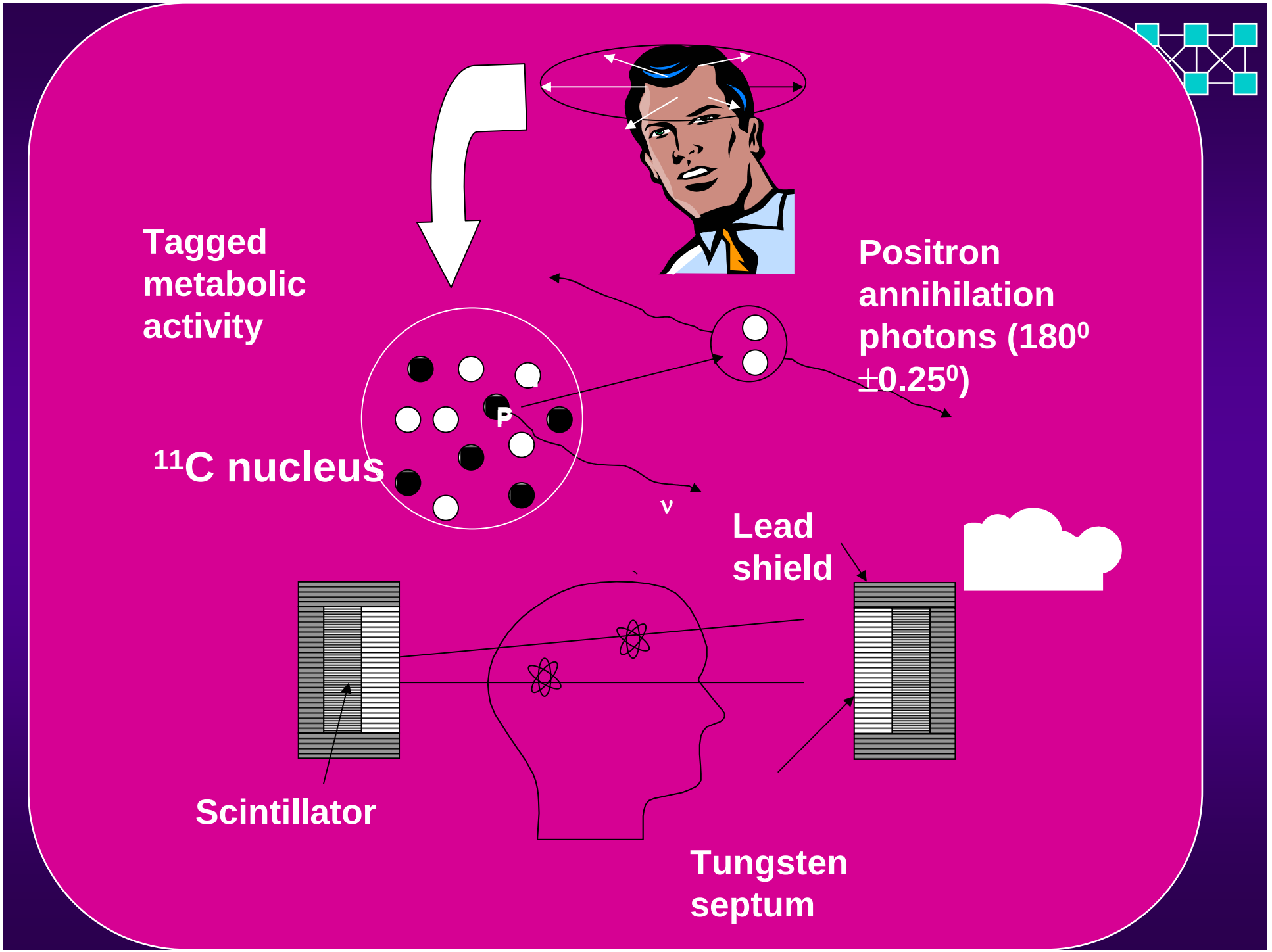
- PET enables physicians to assess chemical or physiological changes related to metabolism.

- PET imaging utilizes a variety of radiopharmaceuticals, called "tracers," to obtain images.

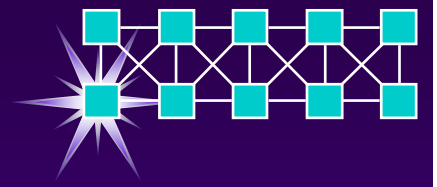


- The PET system takes a "photo" of **cellular biological activities.**

- PET images can be used to measure many processes, including
  - sugar metabolism,
  - blood flow and perfusion,
  - receptor-ligand binding rates,
  - oxygen utilization and
  - a long list of other vital physiological activities.


Tagged metabolic activity
Positron annihilation photons (180⁰ ±0.25⁰)
P
¹¹C nucleus
ν
Lead shield
Scintillator
Tungsten septum

Difference between SPECT and PET



- **PET**
  - **needs radioactive materials with positron decay which produces two gamma rays moving in opposite directions.**
  - **Localization resolution is better,**
  - **shorter life time tracer,**
    : more expensive to produce the tracer (PET has to be close to the facility that makes the tracers).

- **SPECT**
  - **only traces one single radiation or a general radiation**
  - **has a poorer image sensitivity**
  - **cheaper because radioactive materials used have longer lifetime.**

PET TRACER PRODUCTION SYSTEMS

PET scanning uses artificial radioactive tracers and radio nuclides. Their lifetime is usually rather short, thus they need to be produced on site.

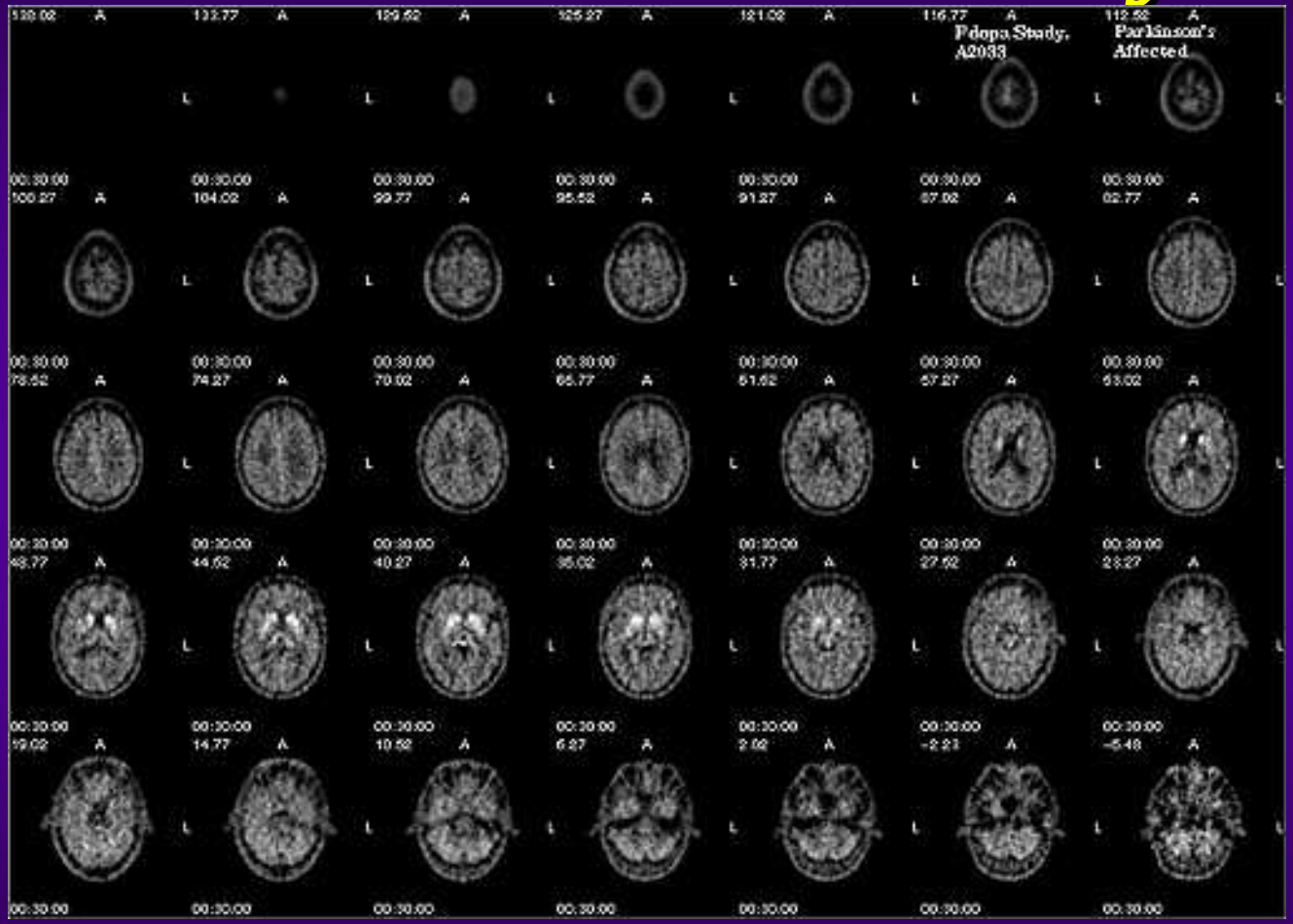
- PET has a million fold sensitivity advantage over MRI in tracer study and its chemical specificity,

- PET is used to study neuron receptors in the brain and other body tissues.

- Clinical studies: tumors of the brain, breast, lung, lower GI tract.

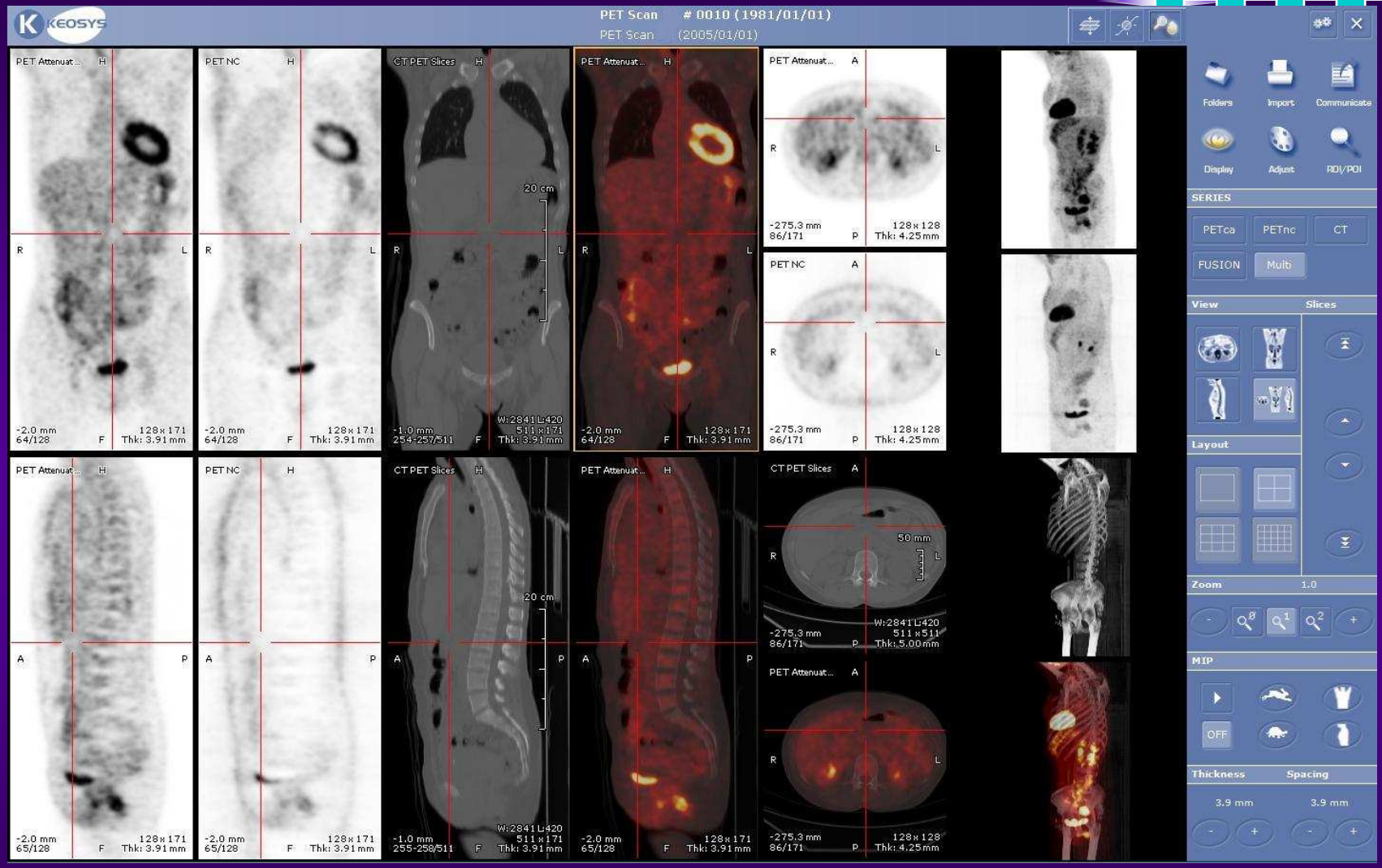
  Additionally Alzheimer's disease, Parkinson's disease, epilepsy and coronary artery disease affecting heart muscle metabolism and flow.

Parkinson's disease study

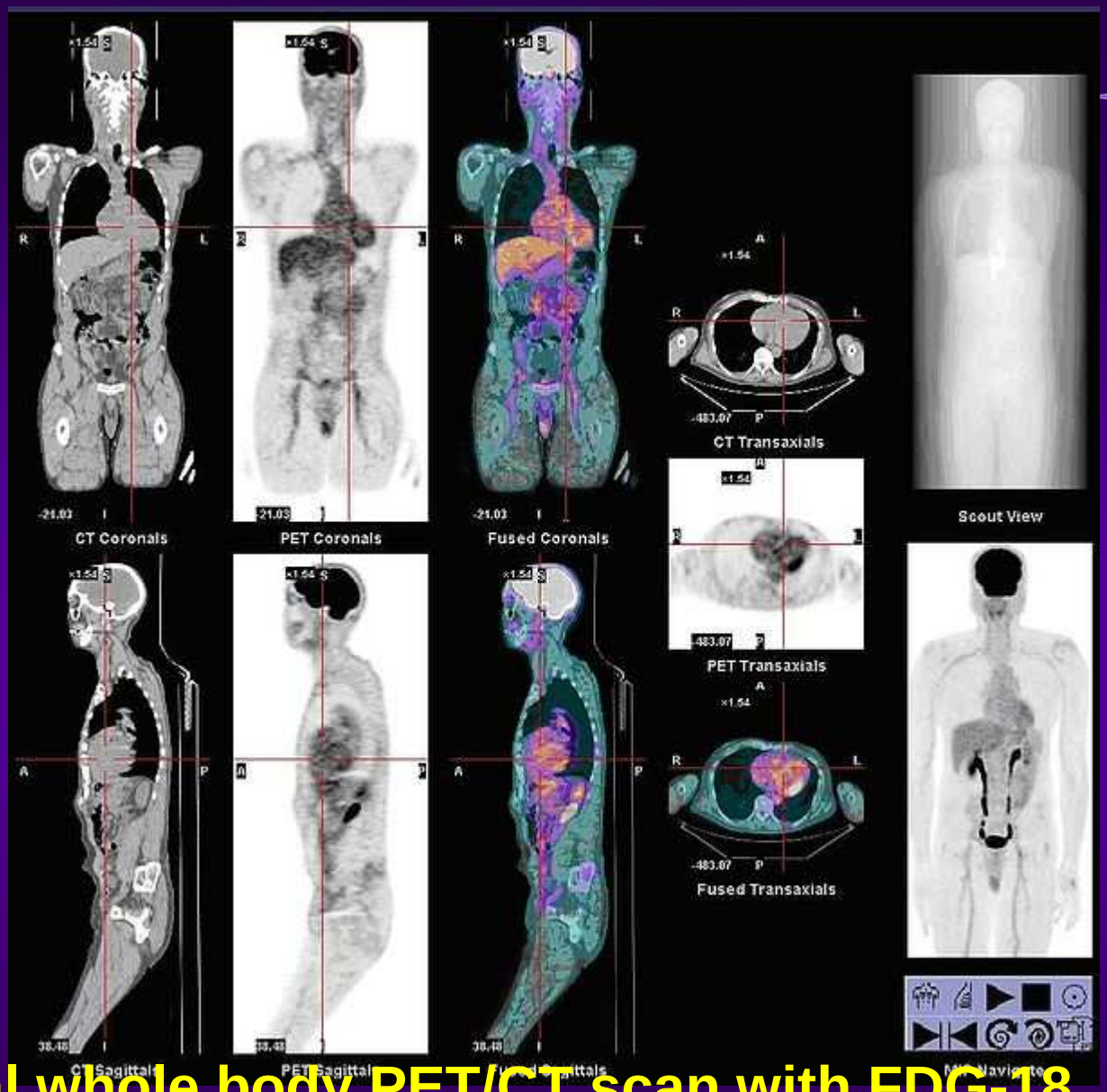


PET studies has immeasurably added to the understanding of oxygen utilization and metabolic changes that accompany disease.

Whole body PET



A whole body PET/CT Fusion image



Normal whole body PET/CT scan with FDG-18. The whole body PET/CT scan is commonly used in the detection, staging and follow-up of various cancers.