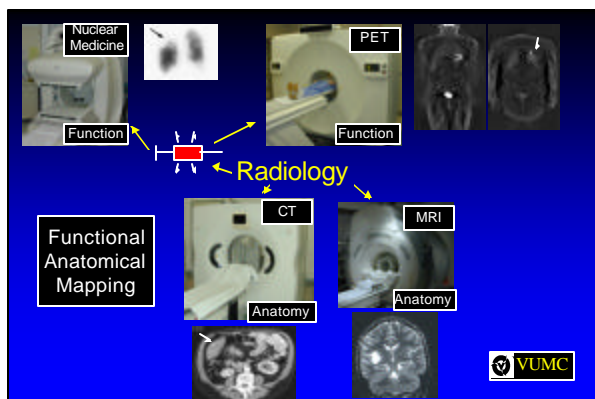
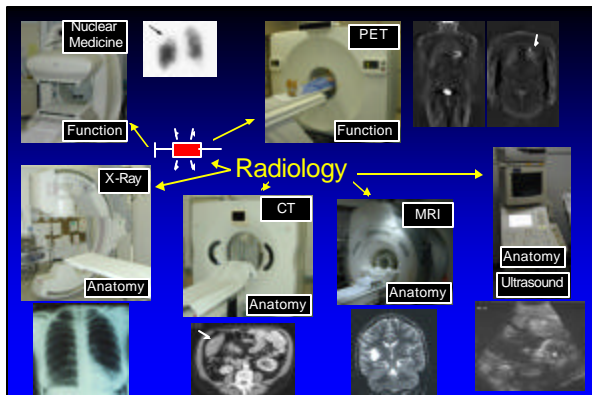


Image Fusion in Nuclear Medicine PET/CT


AAPM 2001
 Continuing Education

James A. Patton, Ph.D.
 Vanderbilt University Medical Center
 Nashville, Tennessee






Functional Imaging with Radiopharmaceuticals




- Conventional Nuclear Medicine
 - Bone Scans
 - Lung Scans
 - Cardiac Evaluations
 - Tumor and Infection Imaging
- Positron Emission Tomography (PET)
 - Brain Metabolism
 - Cardiac Metabolism and Ischemia
 - Tumor Metabolism




Fluorodeoxyglucose (FDG)

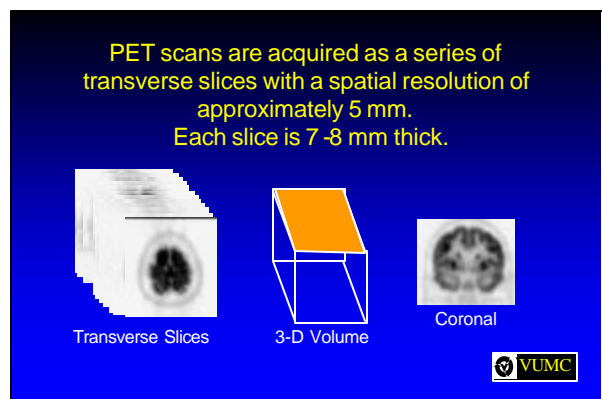
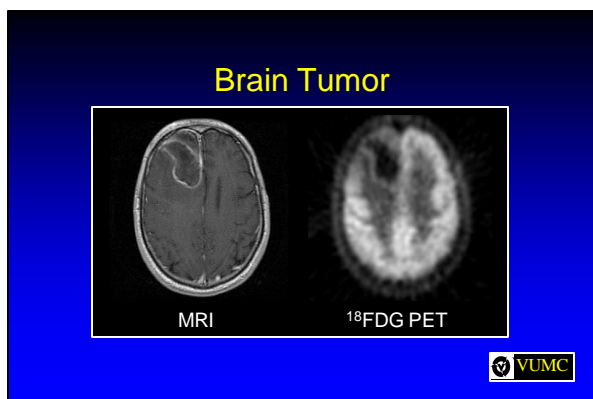
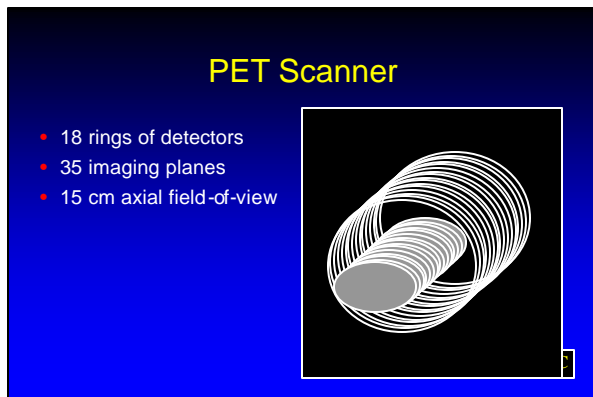
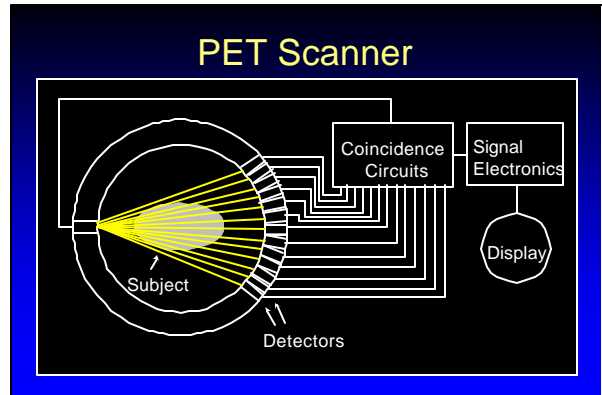
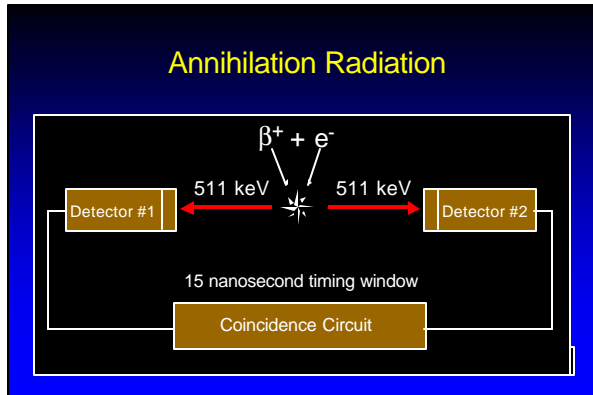
- A very special radiopharmaceutical
- Labeled with F-18
 - Positron Emitter (511 keV photons)
- Glucose analog
 - Excellent metabolic imaging agent



HCFA Approval for ¹⁸F DG

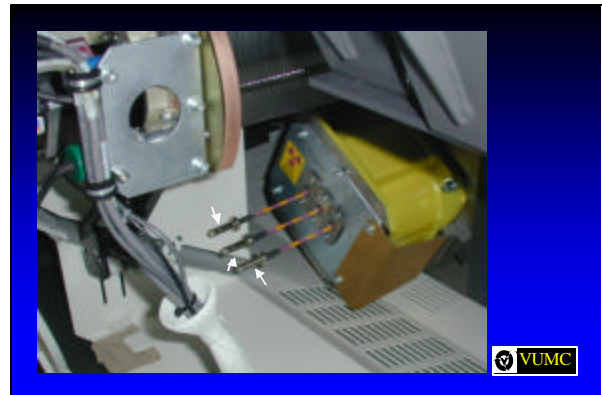

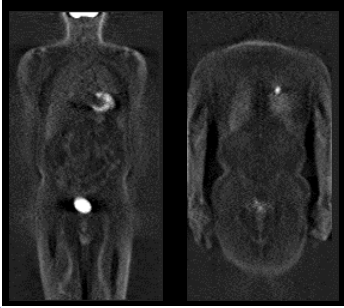
- 1998
 - Solitary pulmonary nodules
 - Staging of non-small cell lung cancer
- 1999
 - Recurrent colorectal cancer
 - Lymphoma
 - Metastatic melanoma
- 2000
 - Non-small cell lung cancer
 - Colorectal cancer
 - Lymphoma
 - Melanoma
 - Head and neck cancer
 - Esophageal cancer
 - Epilepsy
 - Myocardial viability
 - (Therapy monitoring excluded)






**Whole Body
FDG PET
No Attenuation
Correction**


Images are created by acquiring data from multiple bed positions.



Attenuation Correction




Transmission Scan Emission Scan w/o AC Emission Scan with AC




**Problems with
Dedicated PET Scanners**

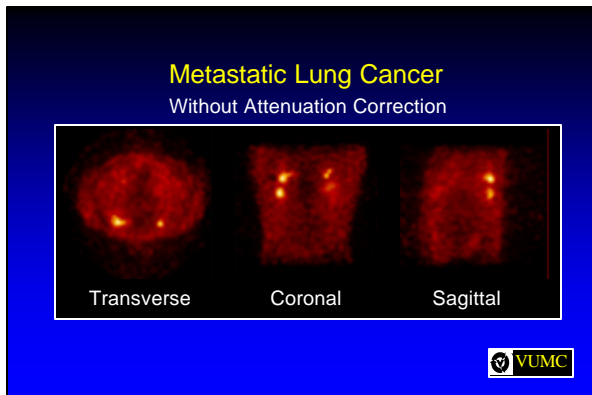
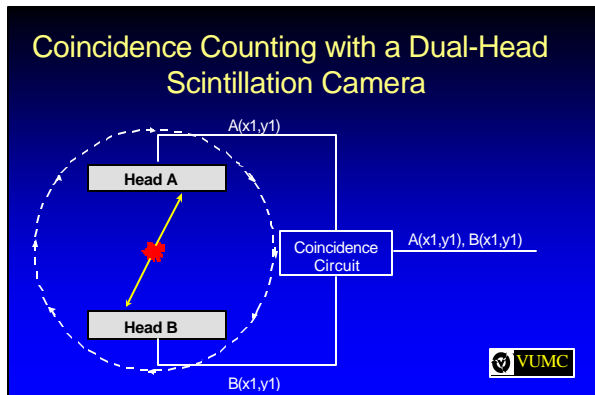
- Expensive to purchase
- Expensive to service
- Can only perform PET procedures
- Reimbursement has been a problem (but is now improving)



Hybrid Cameras

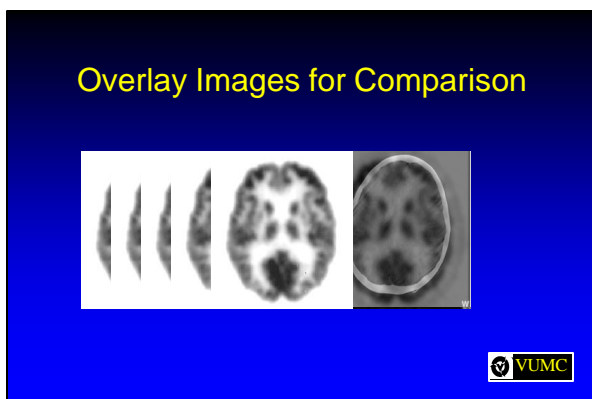
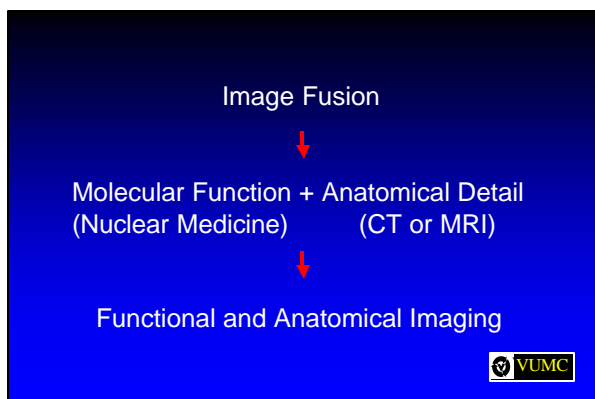
- Multi-Head Scintillation Camera
 - Routine nuclear medicine procedures
 - Collimated high energy imaging
 - Coincidence imaging (PET)






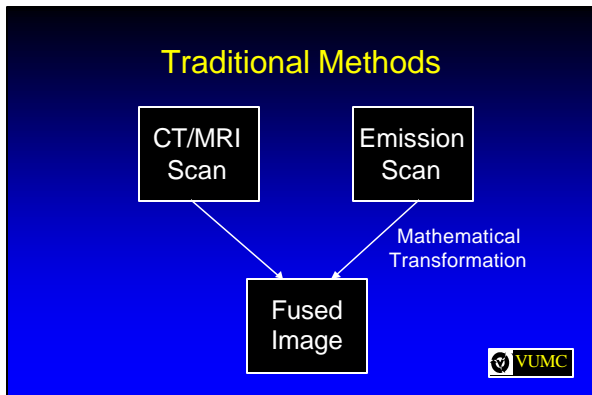
- ### Attenuation Correction
- Generally performed with a transmission scan obtained using a radioactive source as in PET scanning.
-

- ### Dilemma in Nuclear Medicine
- Referring physicians ask "You have identified an area of increased uptake. Where is the abnormality located?"
 - Nuclear medicine images must then be compared with images from CT or MRI.
 - Physiology - domain of nuclear medicine
 - Anatomy - domain of CT and MRI
-

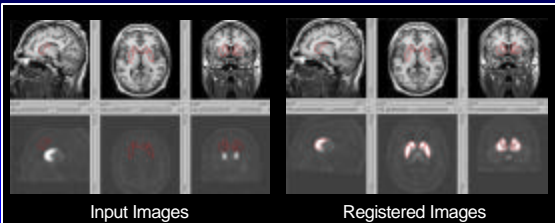


Traditional Methods

- Software Registration/Fusion
 - Rigid Body Transformations
 - Head
 - Non-rigid Body Transformations
 - Body





Rigid Body Transformations PET → MRI




Input Images Registered Images

Benoit Dawant, Ph.D., Vanderbilt University

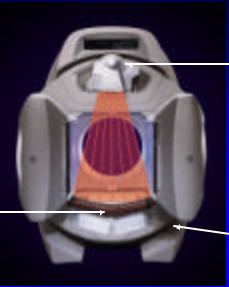



Problems

- Images are acquired:
 - With different modalities
 - With different spatial resolutions
 - At different times
 - With patient in different positions
 - With different pixel sizes
 - With different array sizes
- And organs move
 - Cardiac/Respiratory/GI



GE Millennium with “Hawkeye”




CT Acquisition
 10 mm slice
 13.6 sec/slice
 40 slices

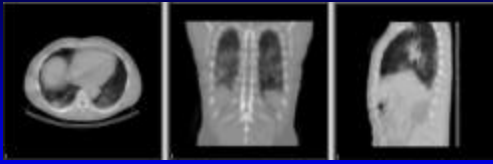
X-Ray Tube
 140 kVp max.
 2.5 mA max.

Linear Array of Detectors

Slip ring gantry




Transmission Maps for Attenuation Correction and Image Fusion

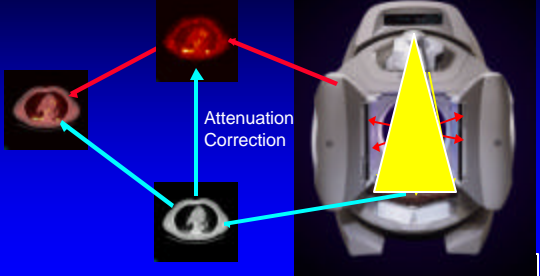


Transverse Coronal Sagittal


Attenuation maps are displayed in Hounsfield Units and measured attenuation coefficients are scaled to 511 keV for attenuation correction.



Functional Anatomical Mapping




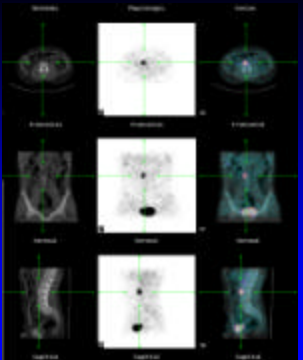
Attenuation Correction




Testicular Cancer

Elevated tumor markers


^{18}F FDG



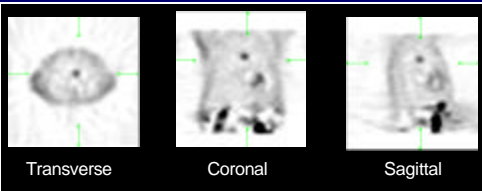
Metastatic Liver Cancer




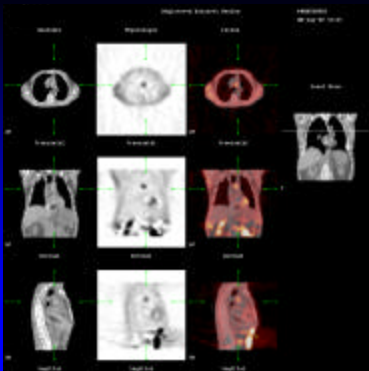

Emission Transmission Fusion



SPECT of Chest with $^{99\text{m}}\text{Tc}$ Sestamibi in Patient with Parathyroid Adenoma



Transverse Coronal Sagittal



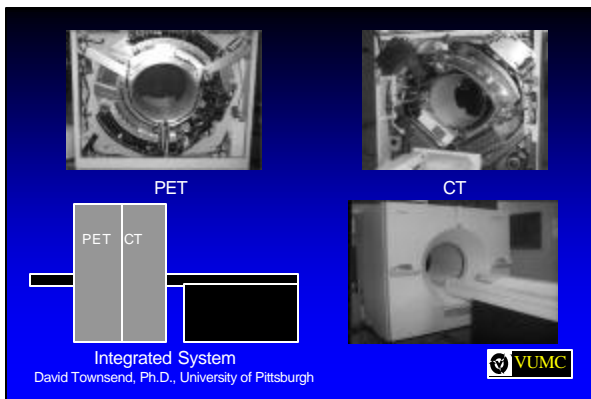
Results

- In a limited series of patients, image fusion provided added clinical value in 35% of the studies.



Hybrid Camera/CT

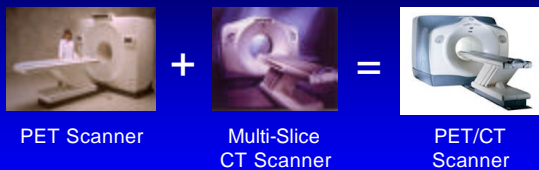
- Advantages
 - Relatively low cost
 - Multiple functions
- Disadvantages
 - Lesion detectability problems for lesions < 1.5 cm
 - CT images are not diagnostic CT quality



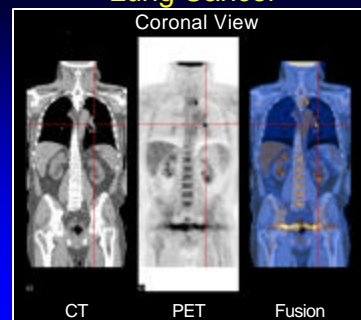
Breast Cancer



PET/CT



Lung Cancer



GE Medical Systems web site

PET/CT

- Advantages
 - Improved lesion detectability
 - High quality anatomical information
 - Increased speed → Improved throughput
 - High quality fusion images
- Disadvantage
 - Cost




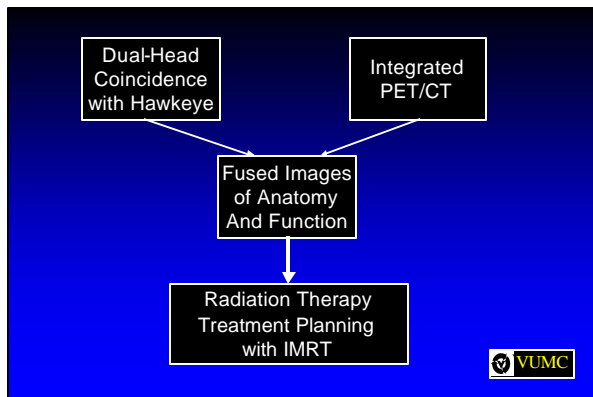



Image Fusion Applications


- Radiation therapy treatment planning
 - Conformal Therapy uses multi-leaf collimators to shape the radiation beam
 - Intensity Modulated Radiation Therapy (IMRT) permits the altering of the intensity of the radiation beam
- Use fused images as input for therapy treatment planning
 - to increase accuracy of radiation field mapping for therapy
 - Evaluate response to therapy

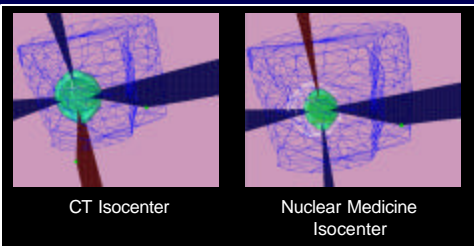
Advantage of Nuclear Medicine




Nuclear medicine provides information on regional biological activity that anatomical images alone cannot provide. This is useful for treatment planning and monitoring therapeutic response.



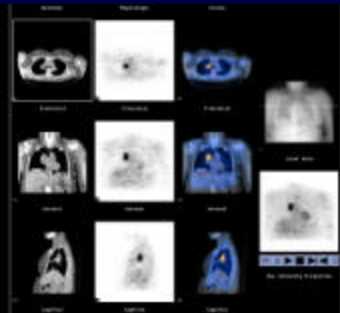

Plan Variation

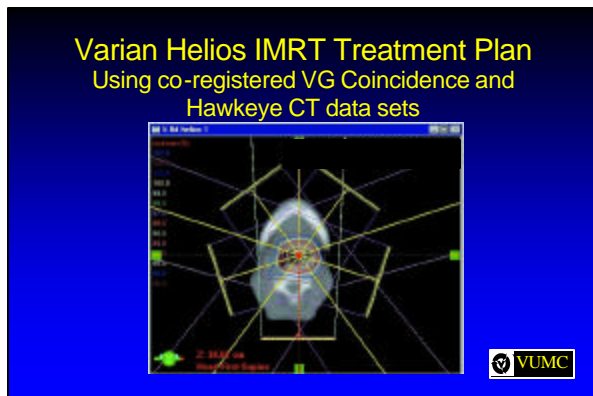
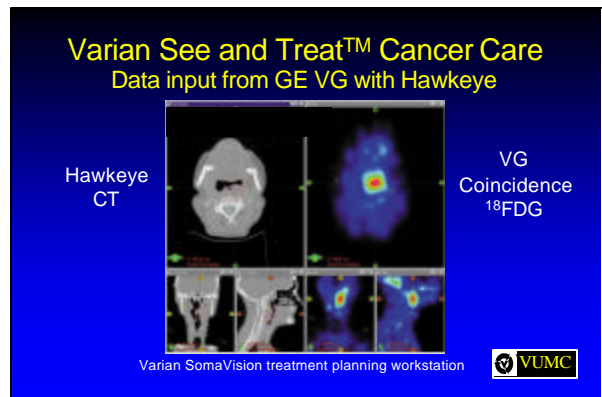
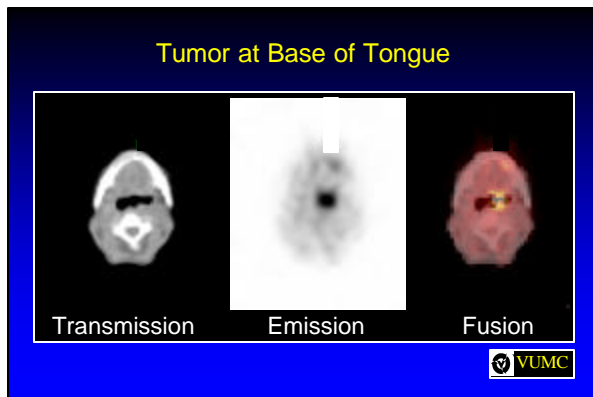
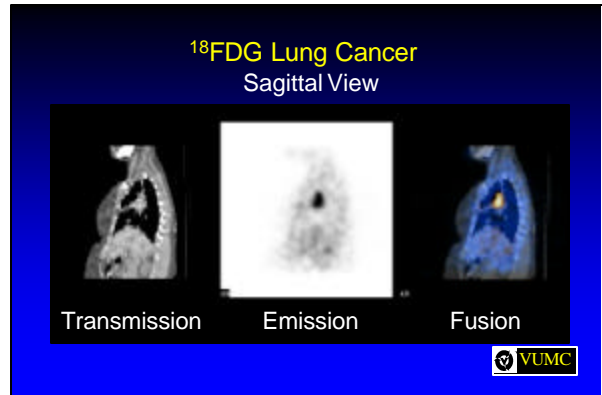
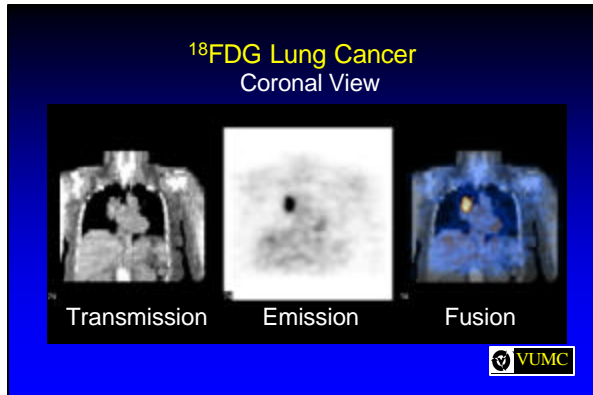


CT Isocenter Nuclear Medicine Isocenter



¹⁸FDG Lung Cancer



- Acceptance Testing and Q.A.**
- Perform routine CT procedures
 - Perform routine PET/Camera procedures
 - Verify accuracy of registration
 - Phantom measurements
 - Remember data are three dimensional
 - Watch for flexing of imaging table
- VUMC

Conclusions

- Image fusion appears to be a valuable tool to:
- Precisely locate and identify lesions
- Refine radiation therapy treatment plans
- Follow course/effects of therapy

