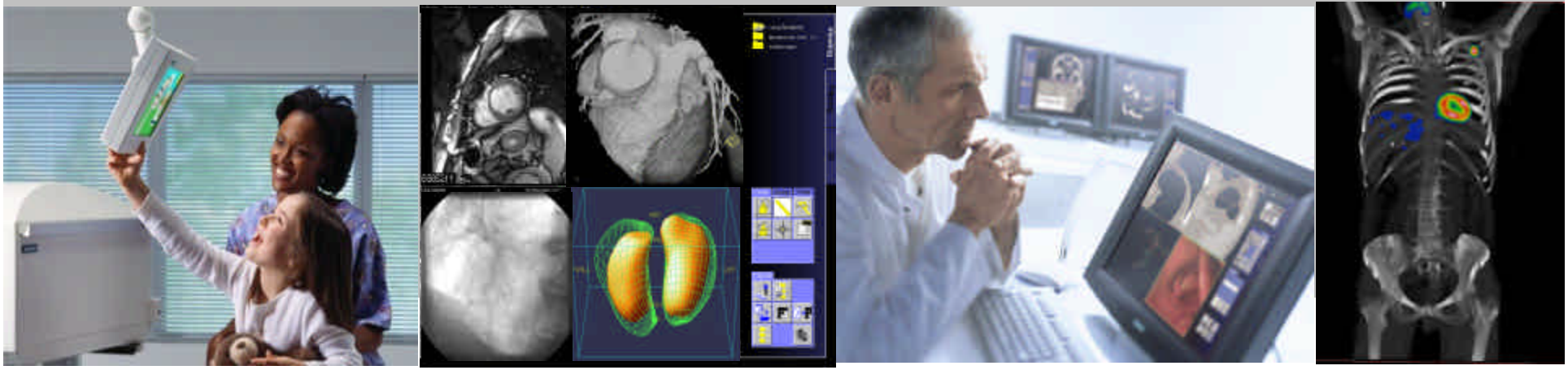


Advances in SPECT Attenuation Correction and Image Fusion

Raffi Kayayan

SIEMENS
medical

Presentation Topics

- 3D OSEM iterative SPECT reconstruction
- Cardiac and General SPECT Attenuation Correction
- Advances in Image Fusion
- New Products and Solutions
  - e.soft@LEONARDO
  - New biograph Family
  - Small Animal Imaging

SPECT Reconstruction Techniques

- **Conventional FBP**
  - **Pros**
    - Not computer intensive
    - Single-pass
    - Fast
    - Linear
  - **Cons**
    - Prone to streak artifact
    - Strongly correlated noise
    - Poorer resolution
    - Attenuation correction not built-in
    - Resolution recovery not built-in
- **Iterative - OSEM**
  - **Pros**
    - Better resolution
    - Better contrast
    - Less distortion
    - Lower noise
    - Better lesion detection
  - **Cons**
    - Longer computation time than FBP
    - Optimal utilization may require user training

Flash 3D = Fast OSEM 3D

- 3D Distance Dependent Collimator Beam Modeling
- Fast implementation
- User optimized parameters
  - Number of iterations
  - Number of subsets
  - Post reconstruction filter parameters

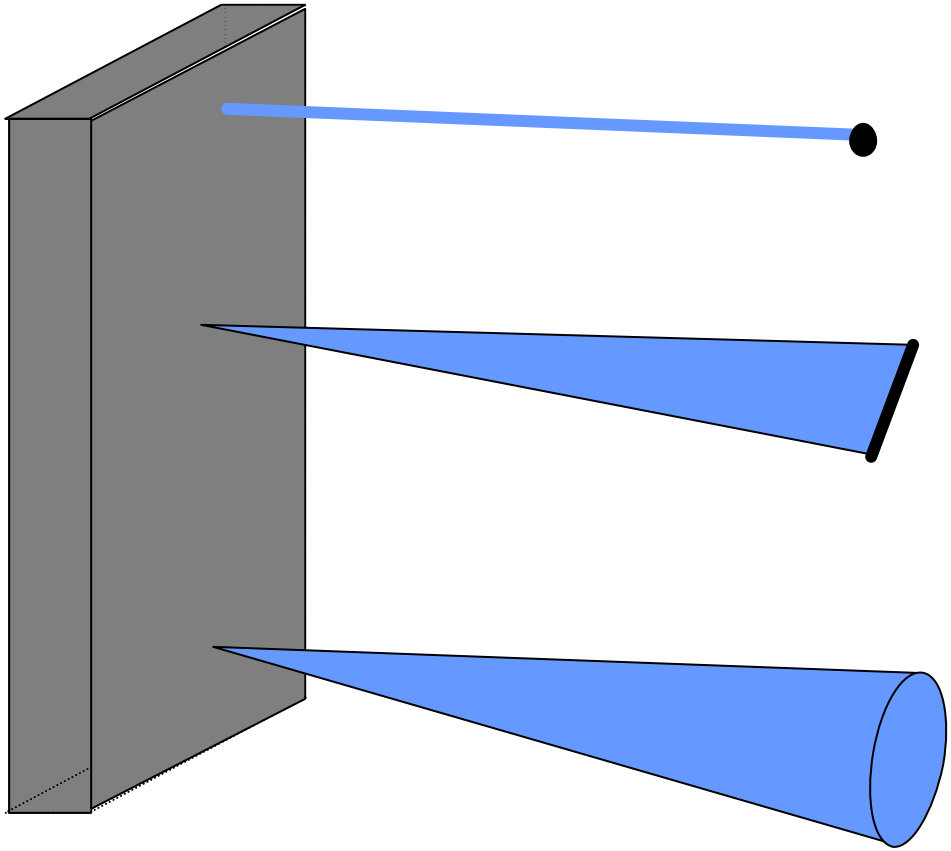
Flash 3D

Flash 3D

- State-of-the-art iterative SPECT reconstruction method
- Significantly improves image quality:
  - Higher spatial resolution
  - Reduction of distortions
  - Reduction of artifacts
- Flash 3D images are more accurate and easier to interpret.
- Very fast (Siemens proprietary development)
  - reconstruction times (128^3, 10iter, 2 CPUs, 2.2 GHz, 1 GB RAM, LEHR):
    - No AC: ≈ 100 sec or ≈ 0.08 sec/iteration/slice
    - AC: ≈ 200 sec or ≈ 0.16 sec/iteration/slice
    - 8-15 iterations is usually quite sufficient
- Flash 3D improves image quality of re-orientated Volumes-of-Interests.

- Clinical collaborations:
  - UM, UHC, Rush, AZH Hart, MDA
  - Very positive feedback
  - SNM 2003 & ICNC 2003, IEEE MIC 2003

Collimation Beam Models



1D or Pencil Beam (FBP)

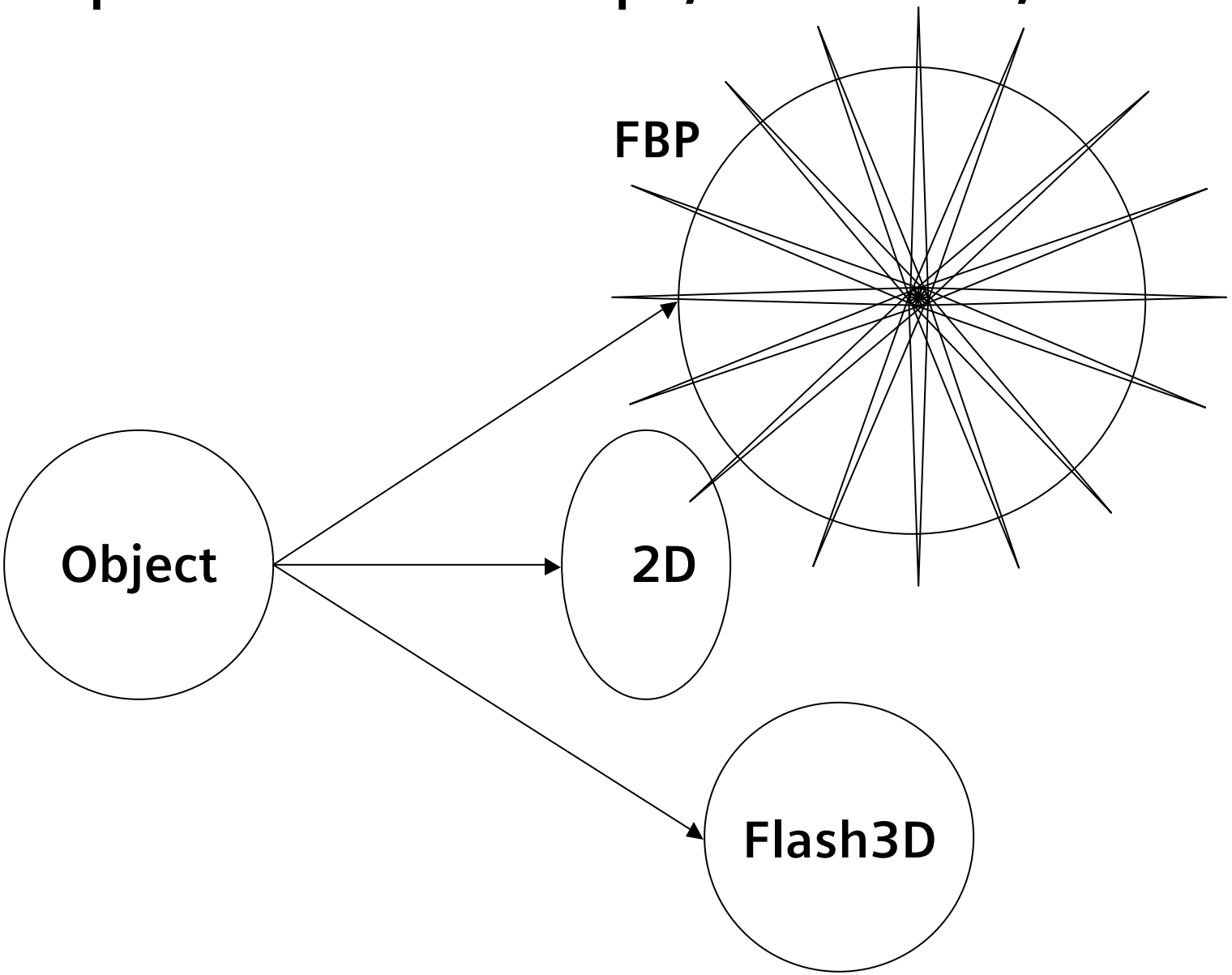
2D Fan (OSEM-2D)

Flash 3D (OSEM-3D)

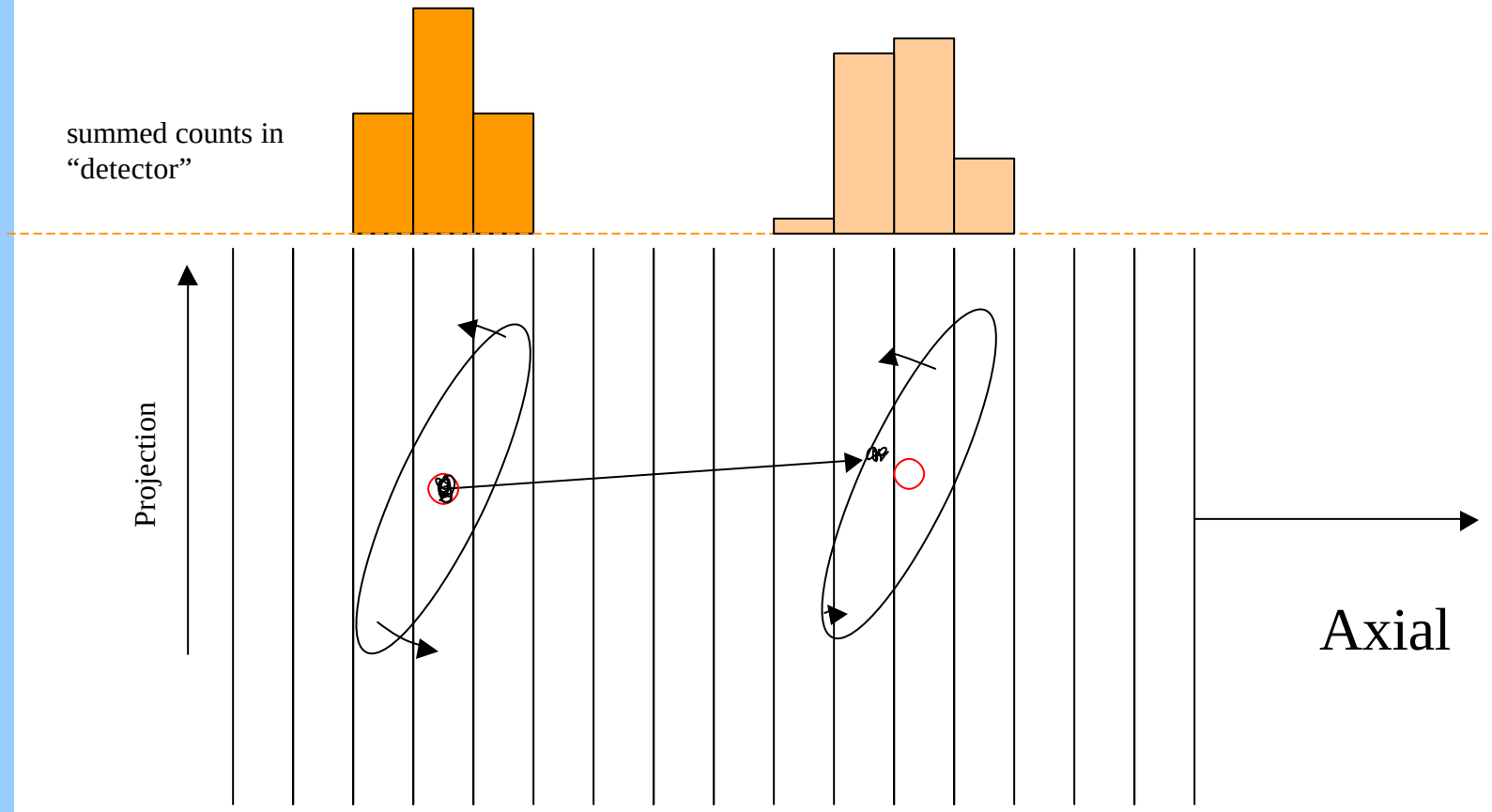
Benefits

- Better spatial resolution
- Higher image contrast
- Less noisy images
- Fewer distortions and artifacts

Improvements in Shape, Resolution, Contrast

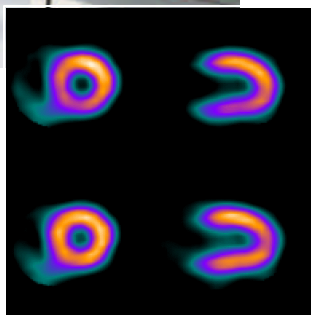


Improvements: Accuracy of Localization



Out-of-plane activity can bias in-plane estimate of activity in OSEM-2D, but not in Flash-3D

e.cam Signature Series



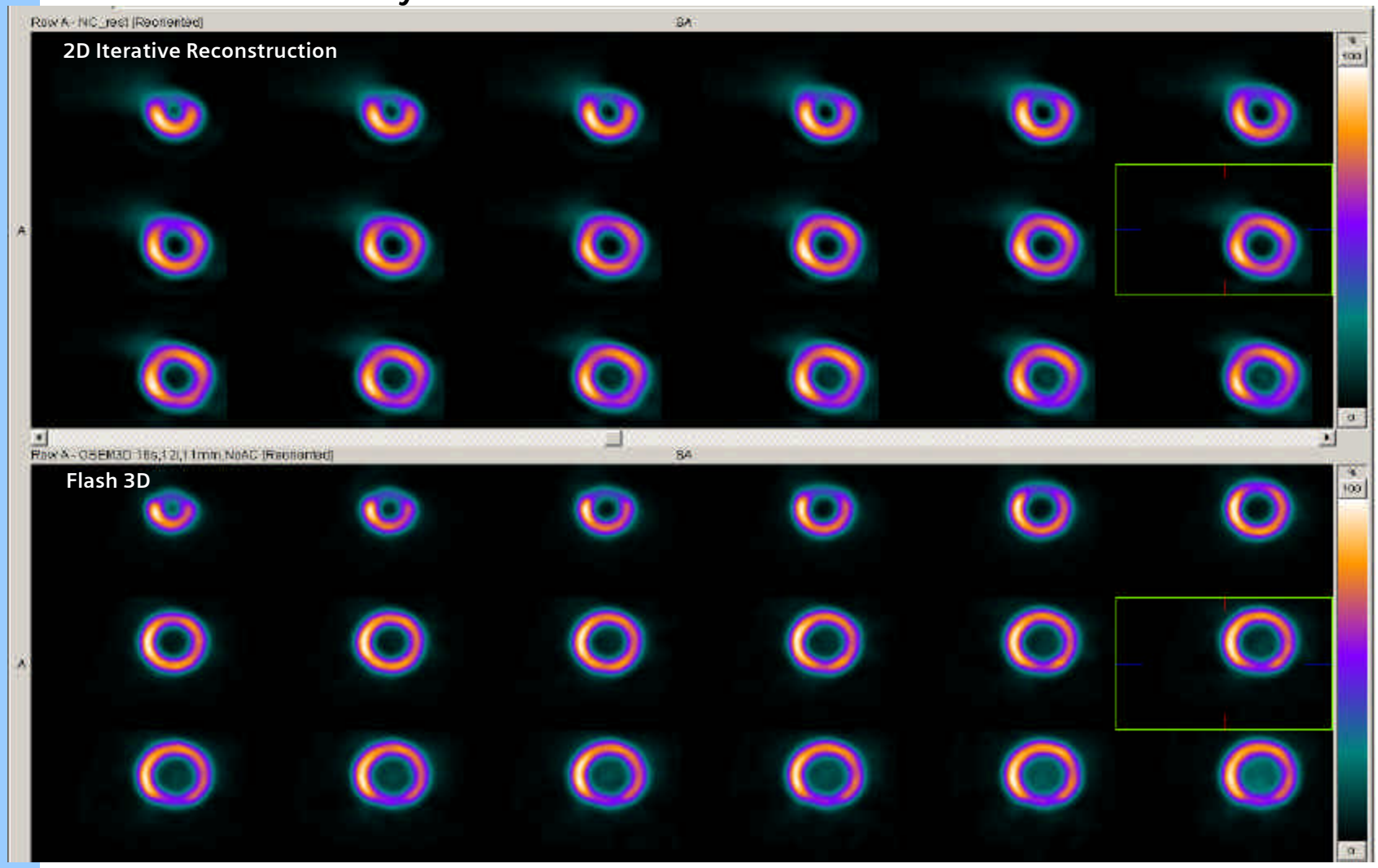
before AC

after AC

Profile Attenuation Correction

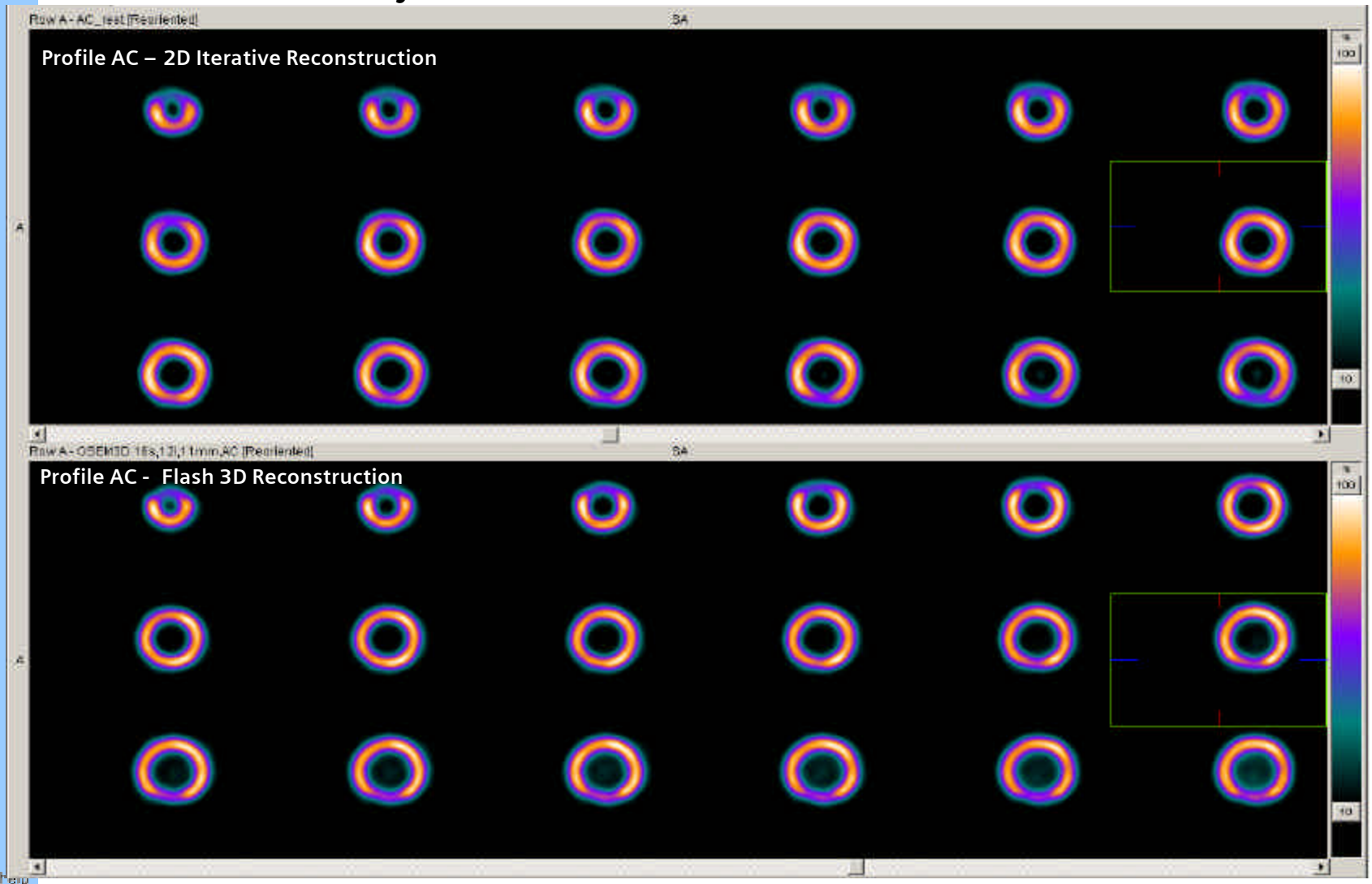
- Body-optimized source geometry provides excellent image quality with all size patients
- Simultaneous emission and transmission acquisitions preserves patient throughput with gated and non-gated SPECT
- Emission and transmission scatter correction using six energy windows
- Clinically proven to increase the diagnostic accuracy of myocardial perfusion SPECT

Cardiac Phantom Study



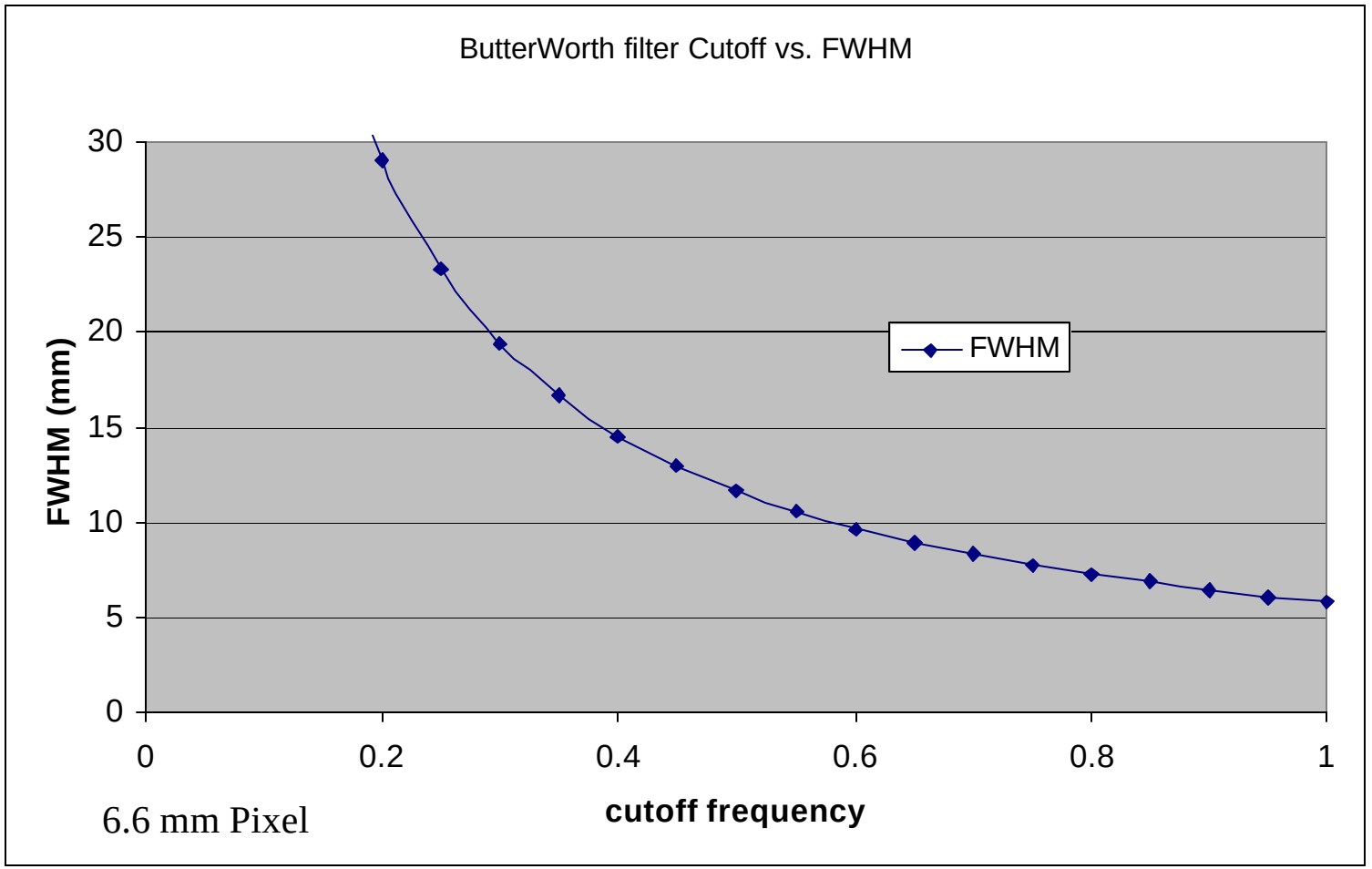
e.cam – Elliptical Heart Phantom (Capintec Inc.) Heart insert with two defects (Apex and Base)
2D Iterative reconstruction compared to Flash 3D.
Data reconstructed without attenuation correction.
Data Courtesy of Eric C. Frey, University of North Carolina, Chapel Hill, NC.

Cardiac Phantom Study



e.cam – Elliptical Heart Phantom (Capintec Inc.) Heart insert with two defects (Apex and Base)
2D Iterative reconstruction compared to Flash 3D.
Data reconstructed with Profile cardiac non-uniform Attenuation Correction.
Data Courtesy of Eric C. Frey, University of North Carolina, Chapel Hill, NC.

FBP Filter Cutoff vs. FWHM



FBP

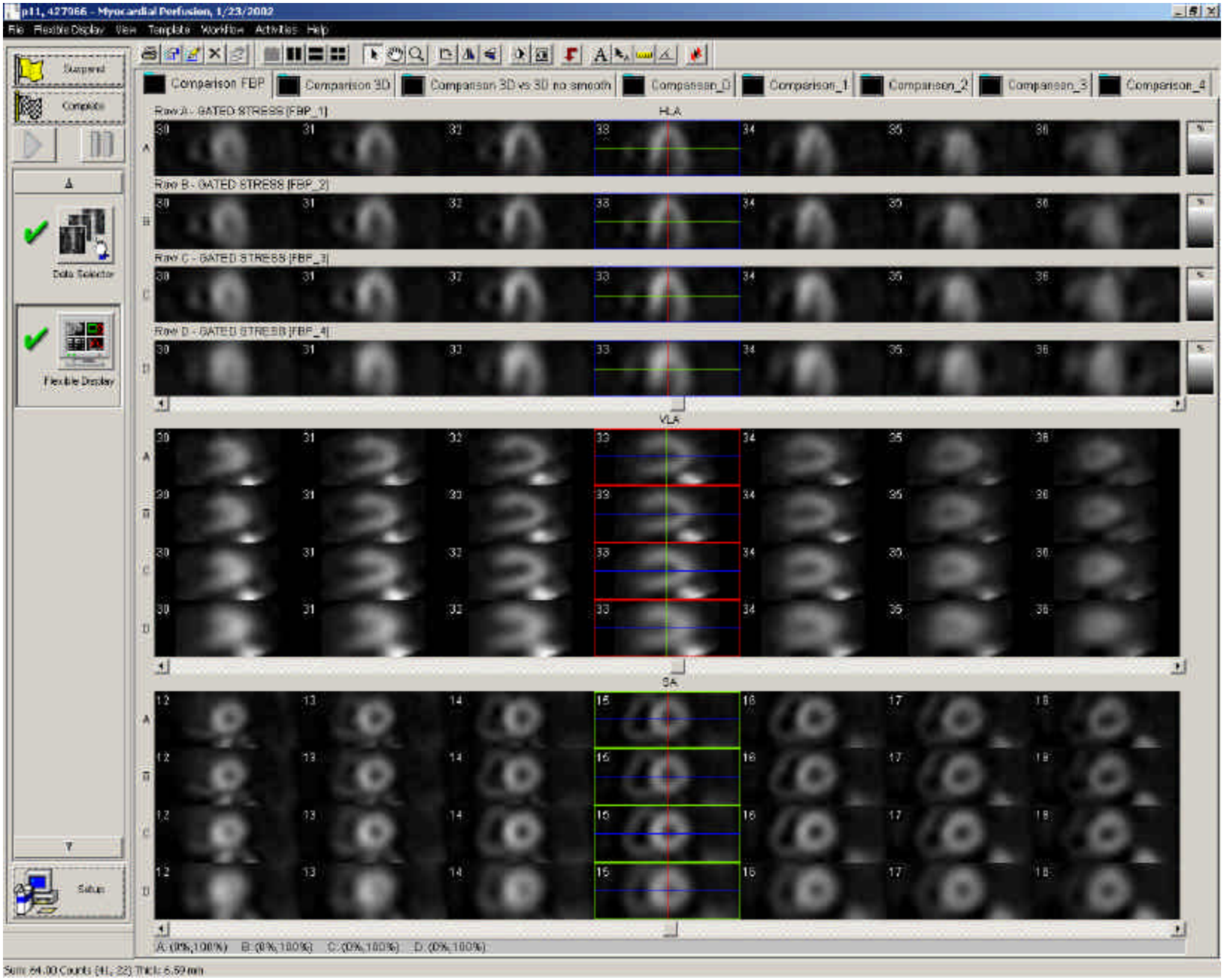
Fc (Ny)

1

0.75

0.5

0.35



3D OSEM

FWHM (mm)

5.82

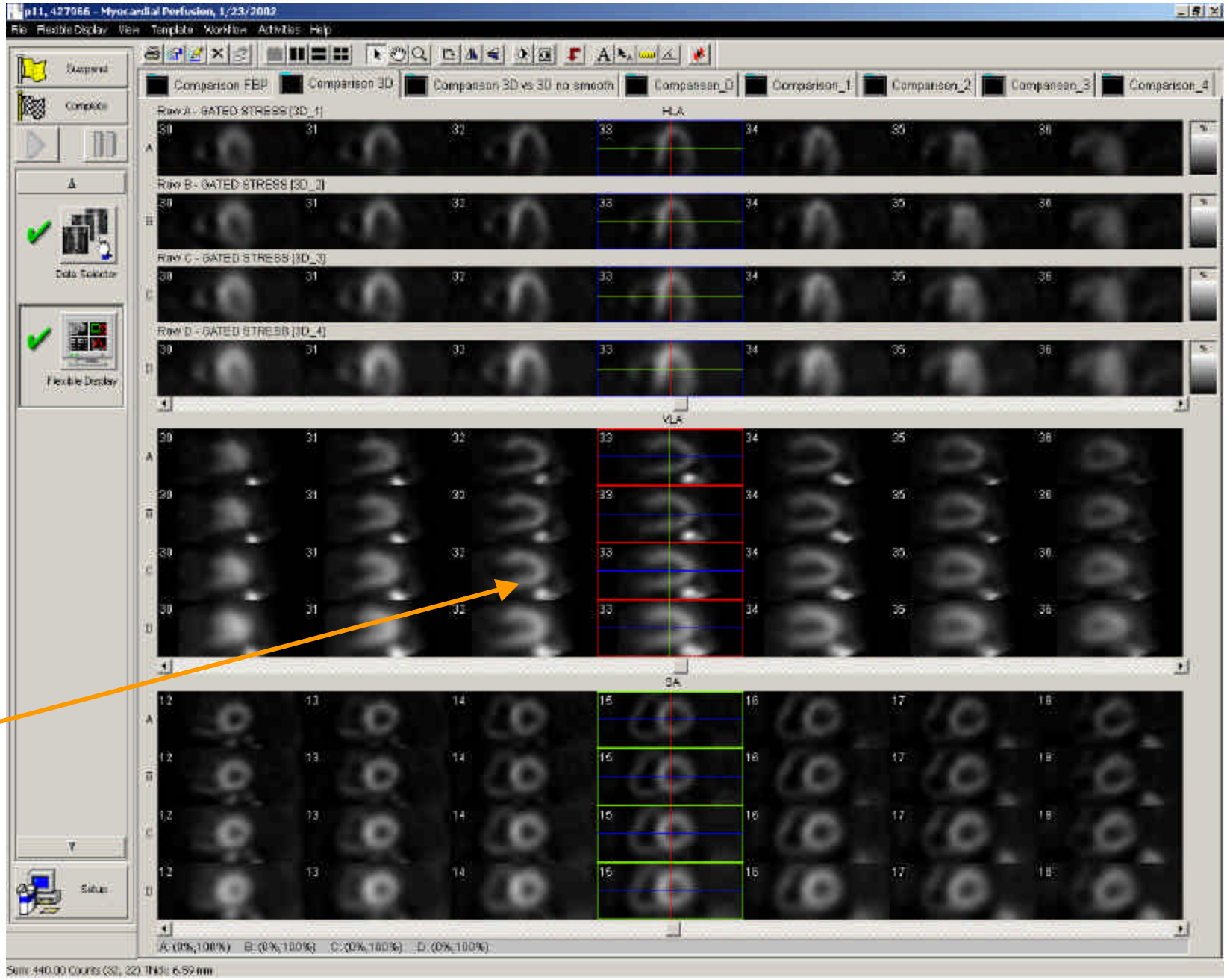
7.76

11.64

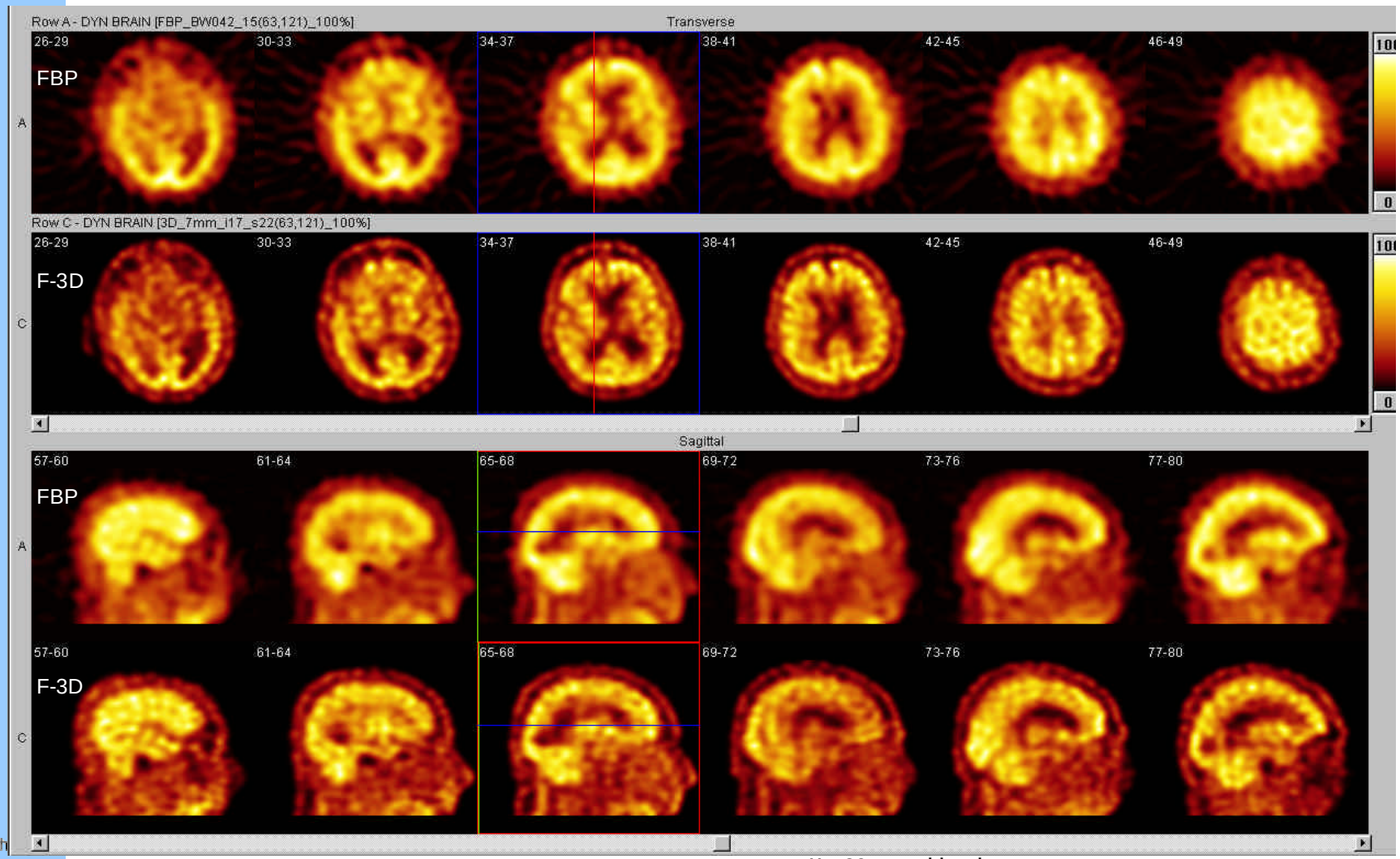
16.6

[6.6 mm Pixel]

Note: 3D is always “sharper”, less adjacent activity



Brain SPECT

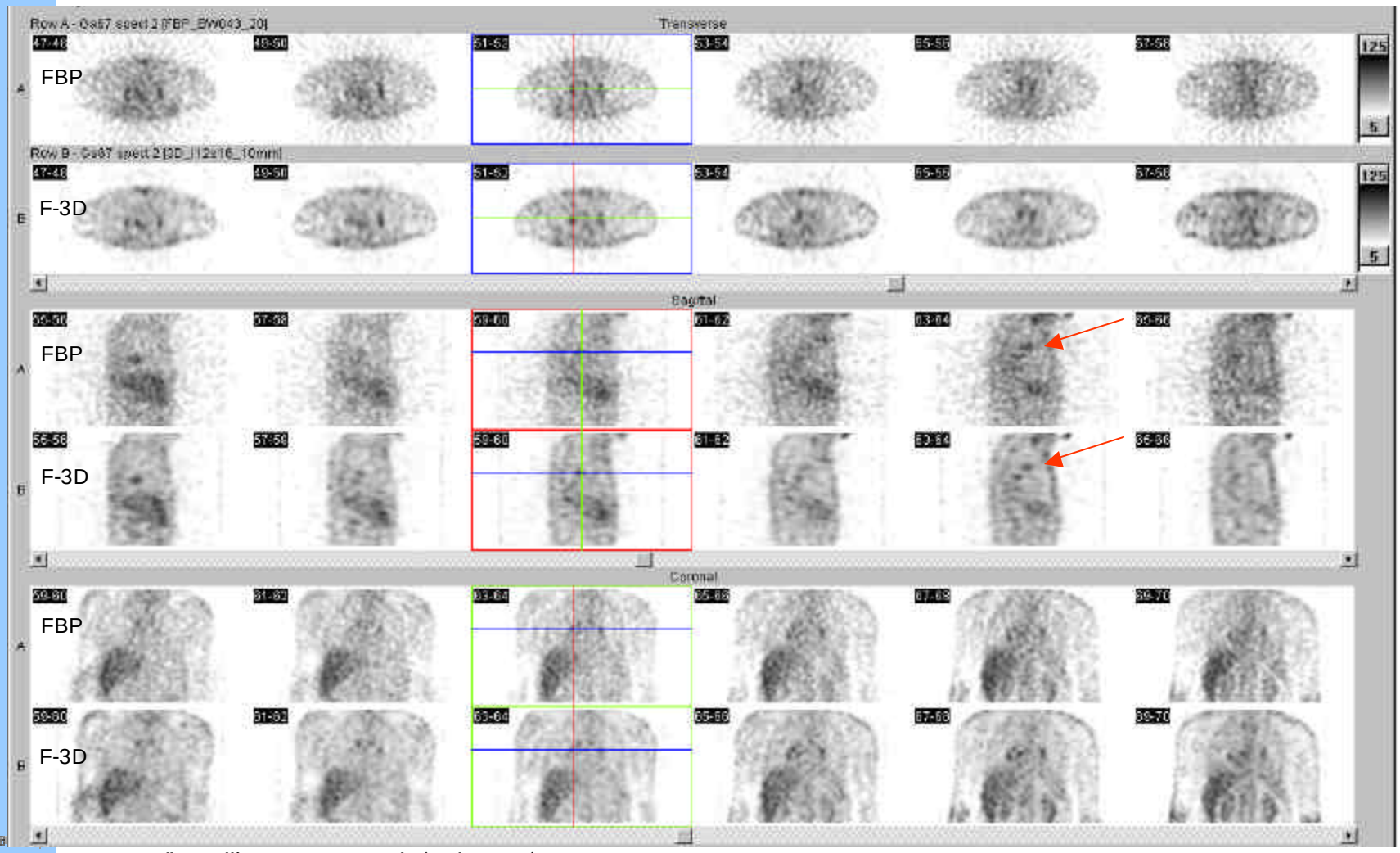


e.cam 3/8" - Brain Dynamic SPECT
Filtered Back Projection reconstruction compared to FLASH 3D
128 x 128 matrix, 66 frames/rotation, 1.8 sec/frame, LEHR
Images Courtesy of Dr. Wyndaele, Heilig Hartziekenhuis, Tienen, Belgium

Hx: 80 year old male
Dx: Dementia Alzheimer type (early phase). Perfusion deficit on left temporal cortex and on transition between the temporal cortex and occipital cortex

Flash 3D

Gallium SPECT



e.cam 3/8" – Gallium 67 SPECT Study (72 hours PI)
Filtered Back Projection reconstruction compared to FLASH 3D
128 x 128 matrix, 64 frames, 35 sec/frame, MELP collimator
Data Courtesy of Dr. Wyndaele, Heilig Hartziekenhuis, Tienen, Belgium

Hx: 69 year old Male
Injected dose: 10 mCi (370 MBq)-Ga67
Dx: Pulmonary lymph nodes in upper hilum.
Flash 3D shows better lesion to background contrast vs. FBP

CT Based Attenuation Correction

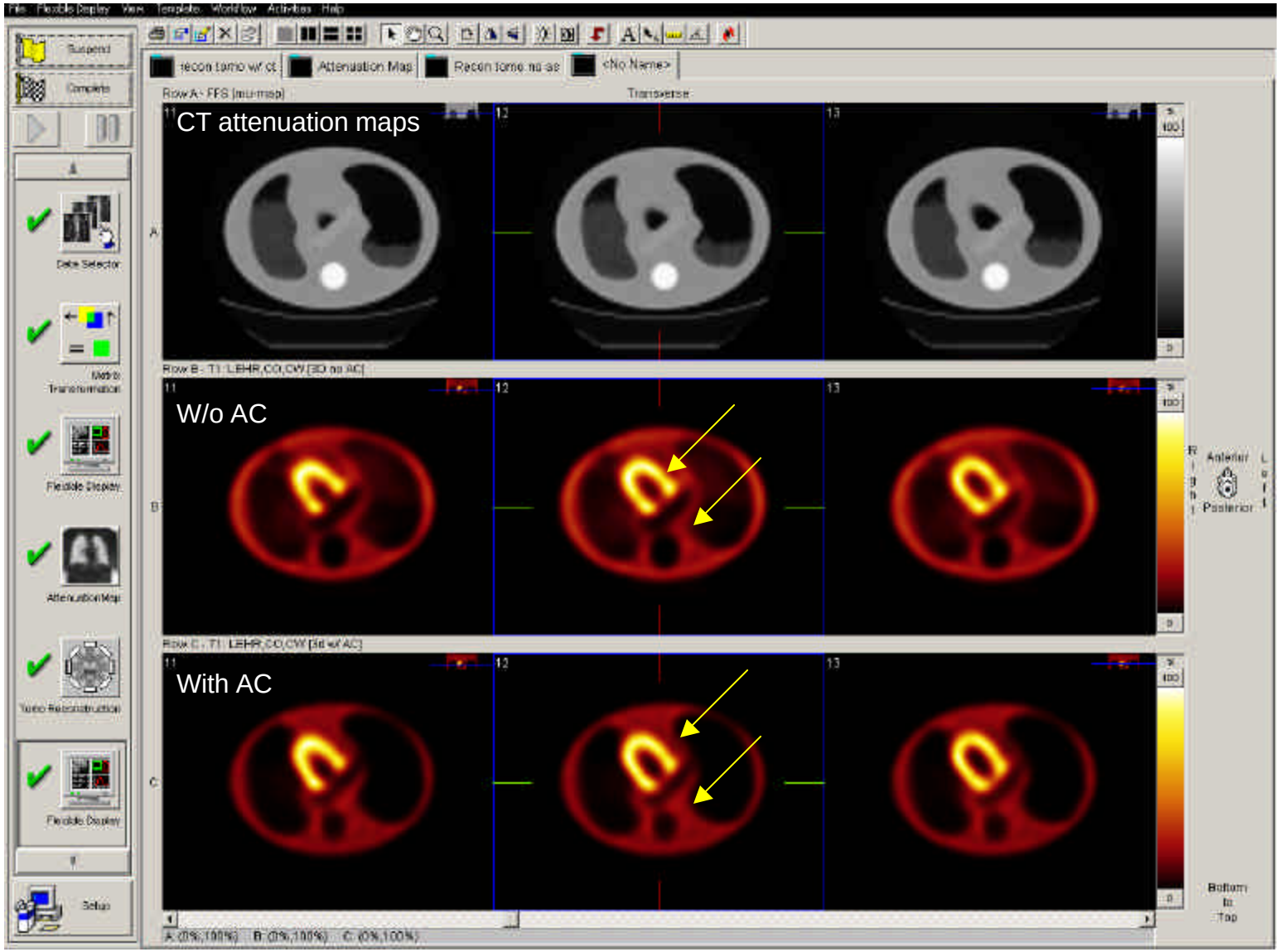
Features

- Accurate conversion of diagnostic quality CT slices to non-uniform attenuation maps
- Reconstruction with2D iterative (standard) or Flash 3-D (optional)
- e.soft image fusion (offers manual or landmark method, standard with e.soft 2.5) or *syngo* automatic image fusion software (optional)

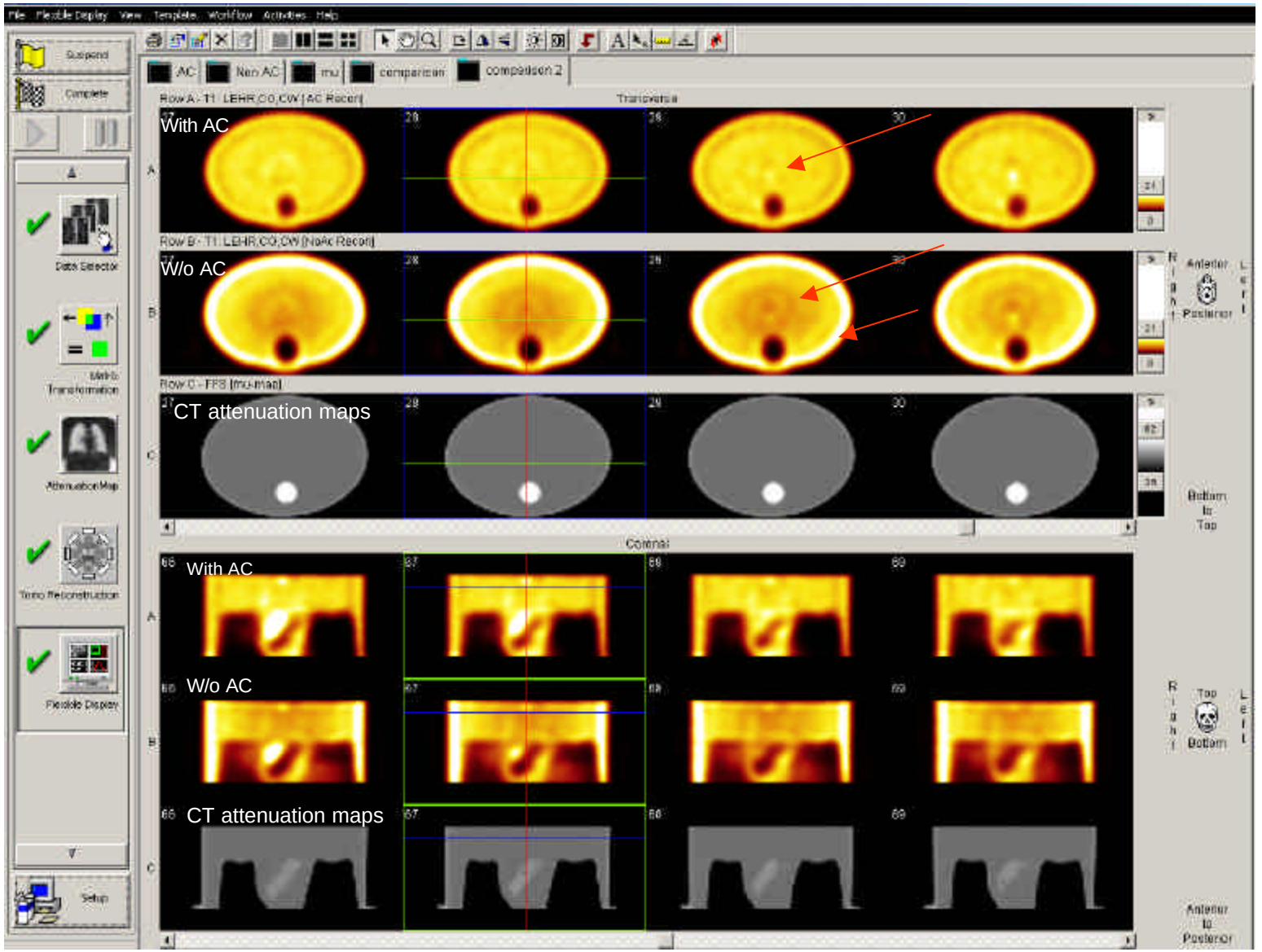
Outcomes

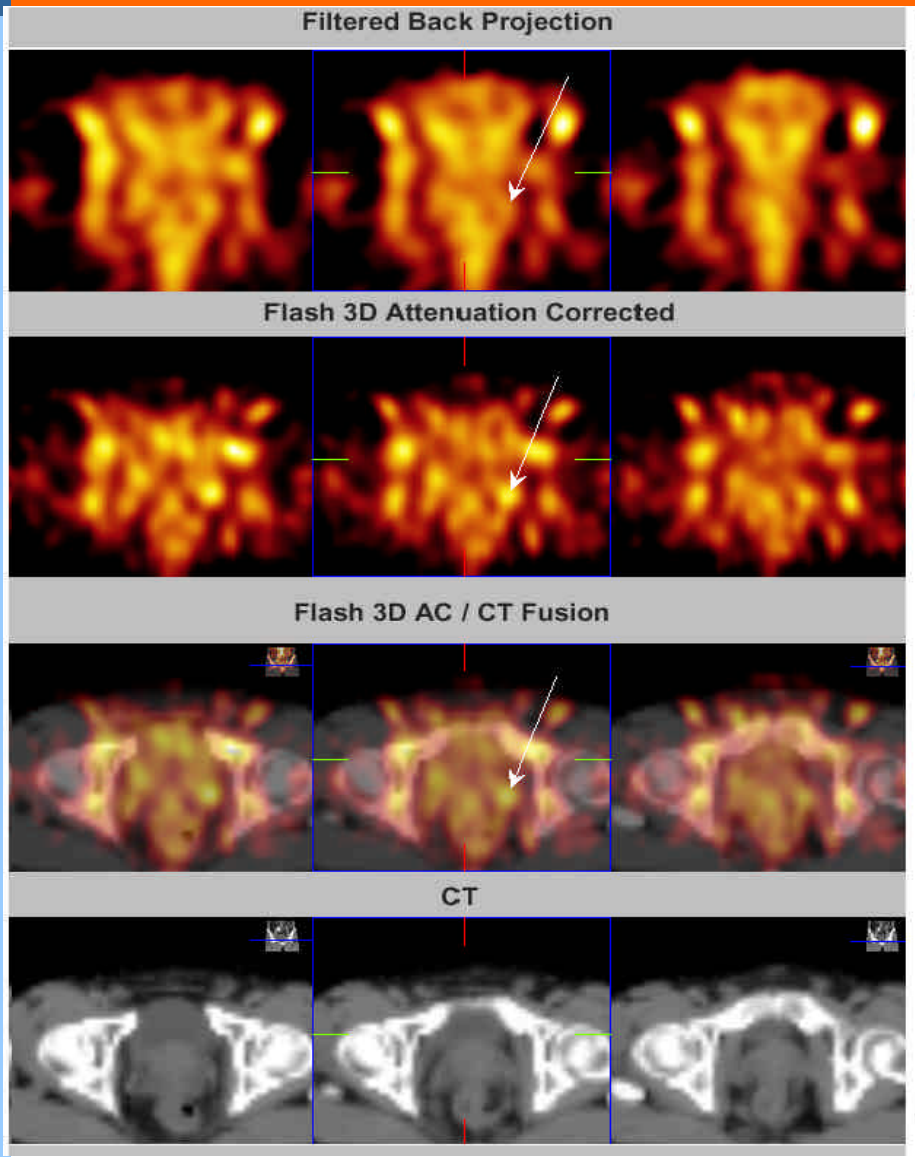
- Optimized SPECT and coincidence image quality
- Does not compromise patient throughput
- Cost effective solution

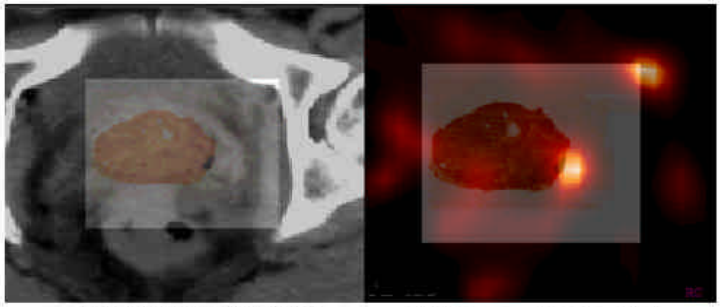
CT based Attenuation Correction - Phantom study

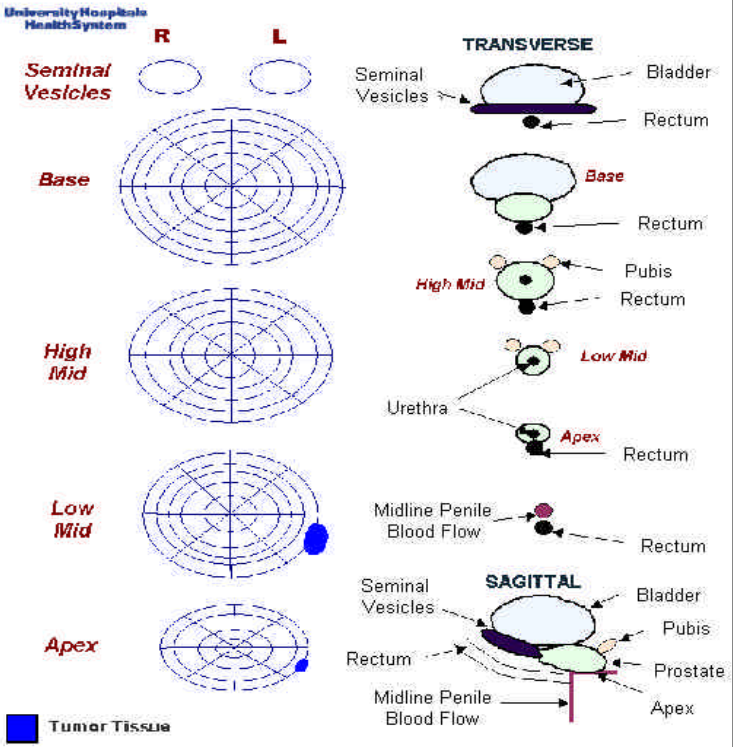


CT Attenuation Correction - Phantom study









Siemens **Medical Solutions** that help

Hx: 53 year old make with a history of prostate CA and a Gleason score of 6. Dx: Increased radiopharmaceutical activity within the apex of the prostate consistent with prostatic carcinoma. Co registration of the Prostascint scan with CT scan demonstrates a lesion to be located within the left apex and extending into the mid-prostate and base.

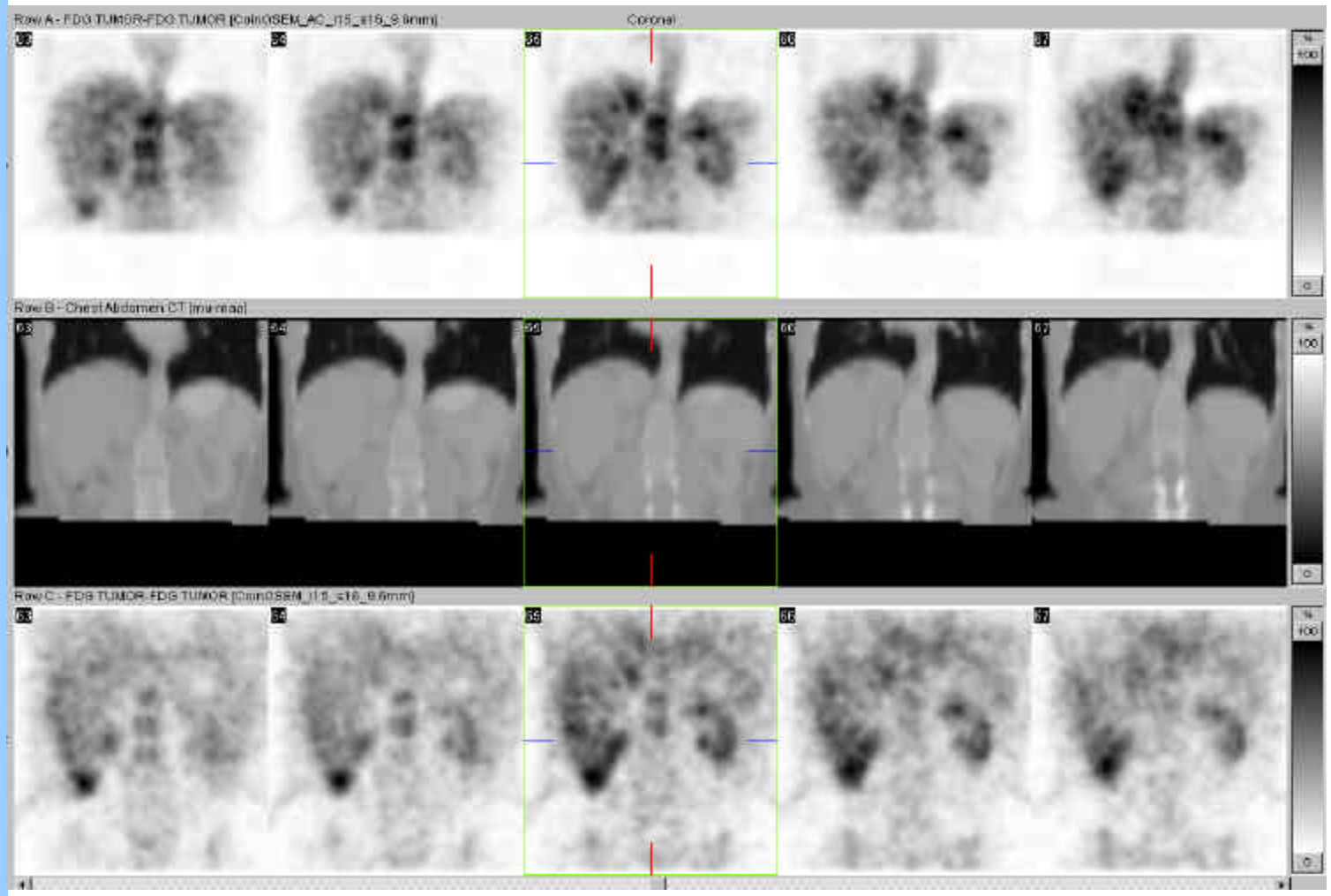
Images courtesy of University Hospitals of Cleveland.

CT Based Attenuation Correction

After AC

CT map

Before AC



e.cam duet – ^{18}F-FDG Coincidence Study
Images reconstructed using 2D OSEM iterative software with and without CT based attenuation correction. 15 iterations, 16 subsets, 9.6 mm post reconstruction filter (Gaussian)

Data Courtesy of University Hospitals of Cleveland, OH, USA.

Hx: 45 year old female with liver cancer

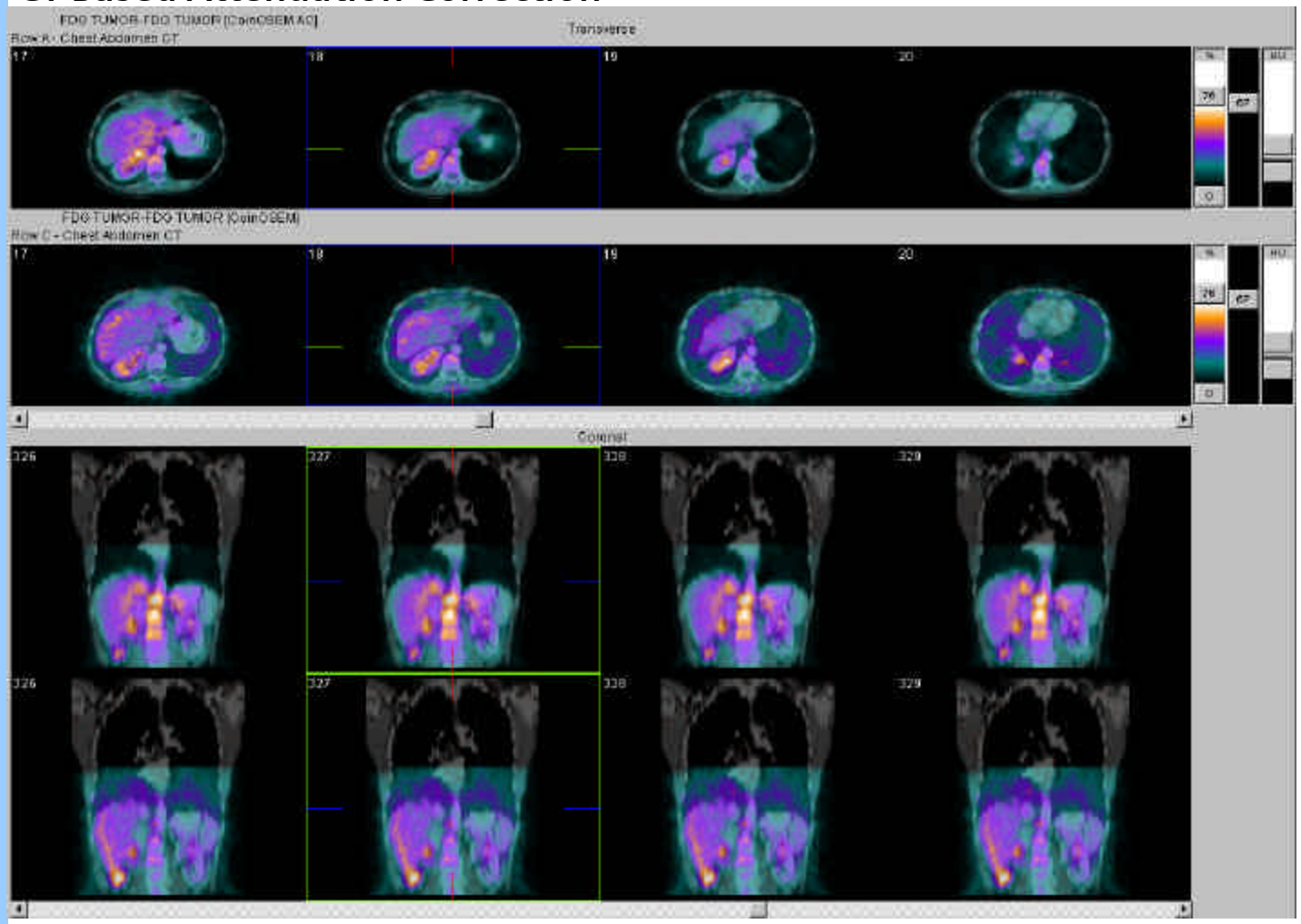
CT Based Attenuation Correction

After AC

Before AC

After AC

Before AC



e.cam duet – ^{18}F-FDG Coincidence Study – Fusion with CT
Coincidence images reconstructed using 2D OSEM iterative software with and without CT based attenuation correction. 15 iterations, 16 subsets, 9.6 mm post reconstruction filter (Gaussian).
Fusion images shown were obtained using *syngo* automatic fusion software.

Data Courtesy of University Hospitals of Cleveland, OH, USA.

Hx: 45 year old female with liver cancer

Presentation Topics

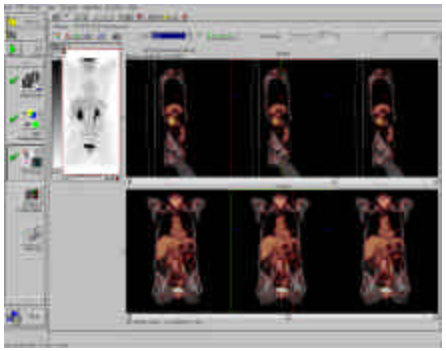
- 3D OSEM iterative SPECT reconstruction
- Cardiac and General SPECT Attenuation Correction
- Advances in Image Fusion
- **New Products and Solutions**
  - **e.soft@LEONARDO**
  - **New biograph Family**

e.soft@LEONARDO

- We see a way to integrate more multimodality applications in a single workplace

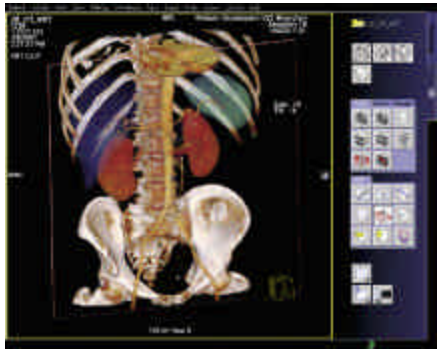
e.soft@LEONARDO – A *syngo* integration

Where function meets anatomy



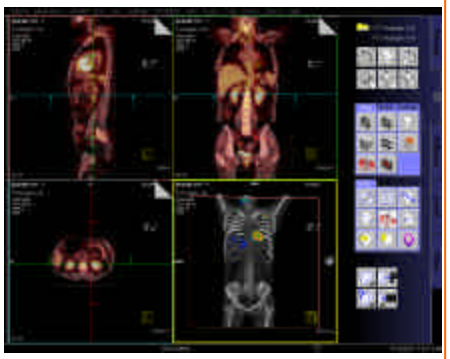
e.soft

+



LEONARDO

=



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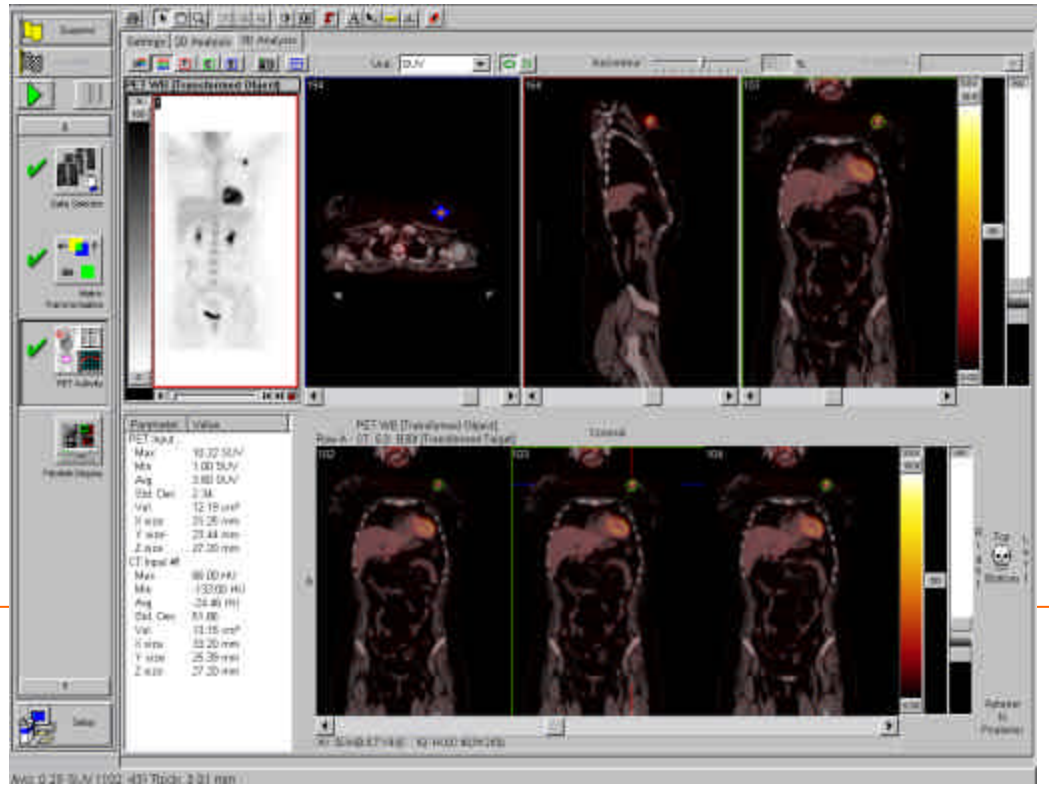
Imagine the possibilities...

e.soft@LEONARDO

✓for your oncology workflow

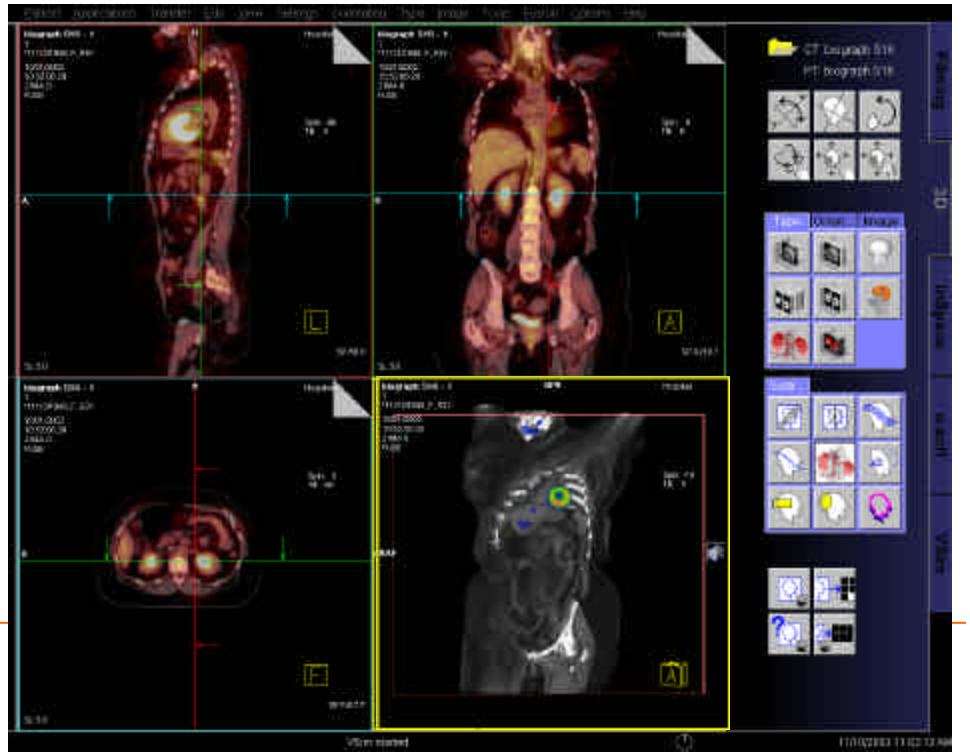
e.soft@LEONARDO – One Stop Assessment in Oncology

PET and PET/CT processing and display tools (e.g., SUV Quantification)



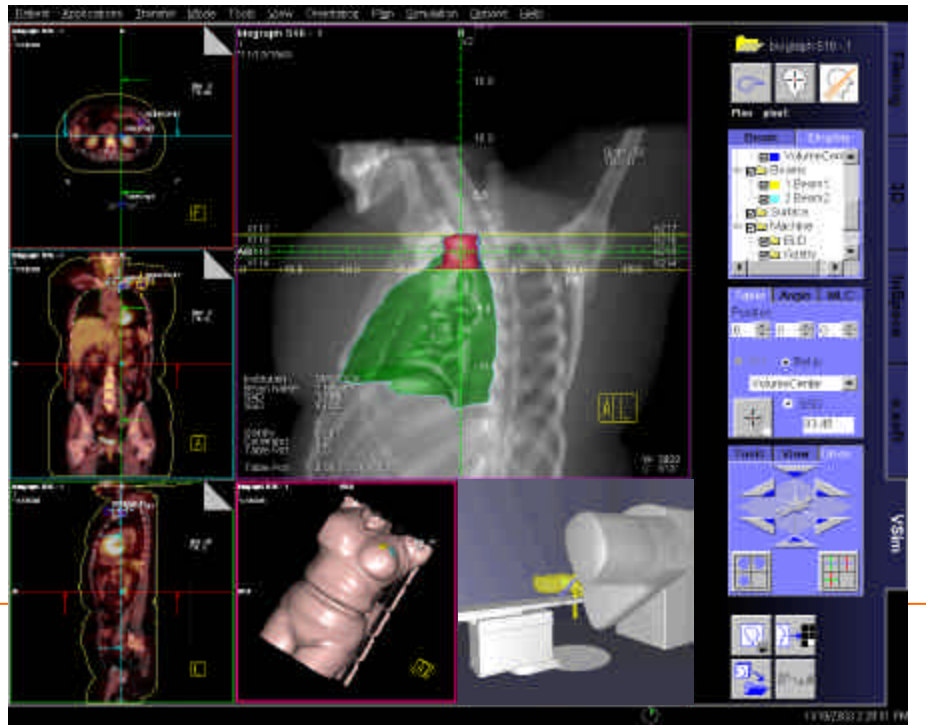
e.soft@LEONARDO – One Stop Assessment in Oncology

syngo Automatic Image Fusion and 3D Display



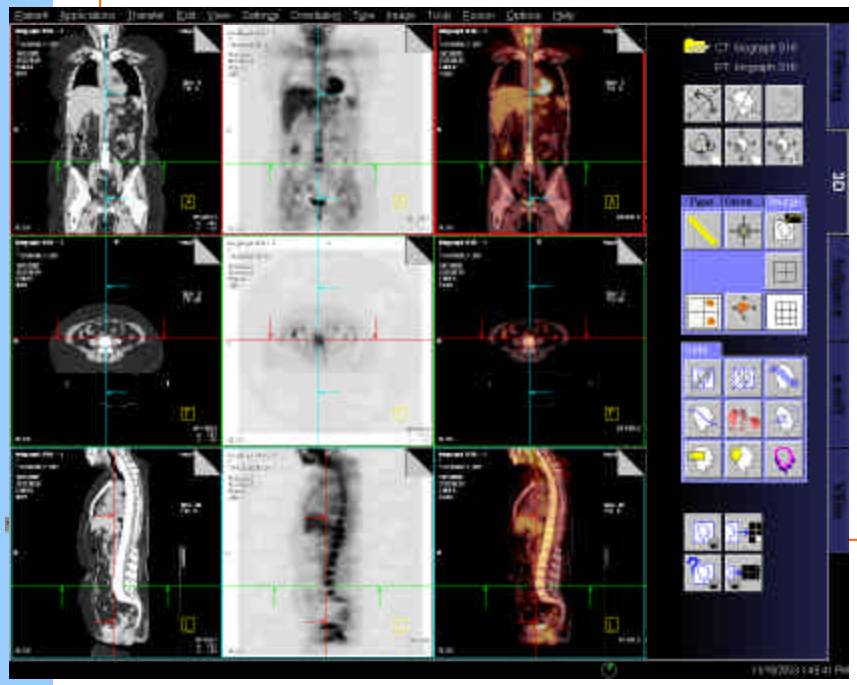
e.soft@LEONARDO –
One Stop Assessment in Oncology

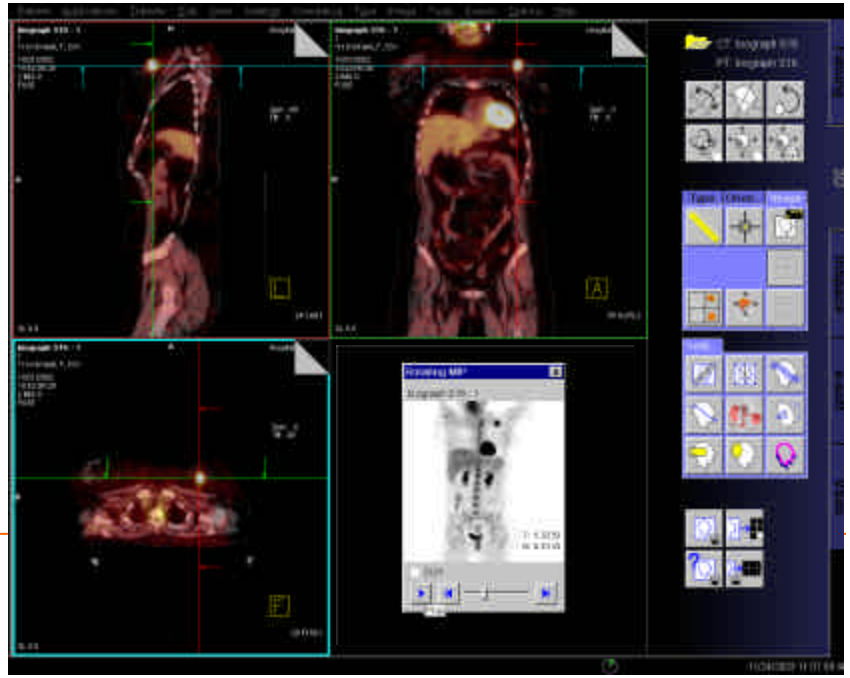
Virtual Simulation for Radiation Therapy Planning



FusedVision3D –
Correlated MIP Display

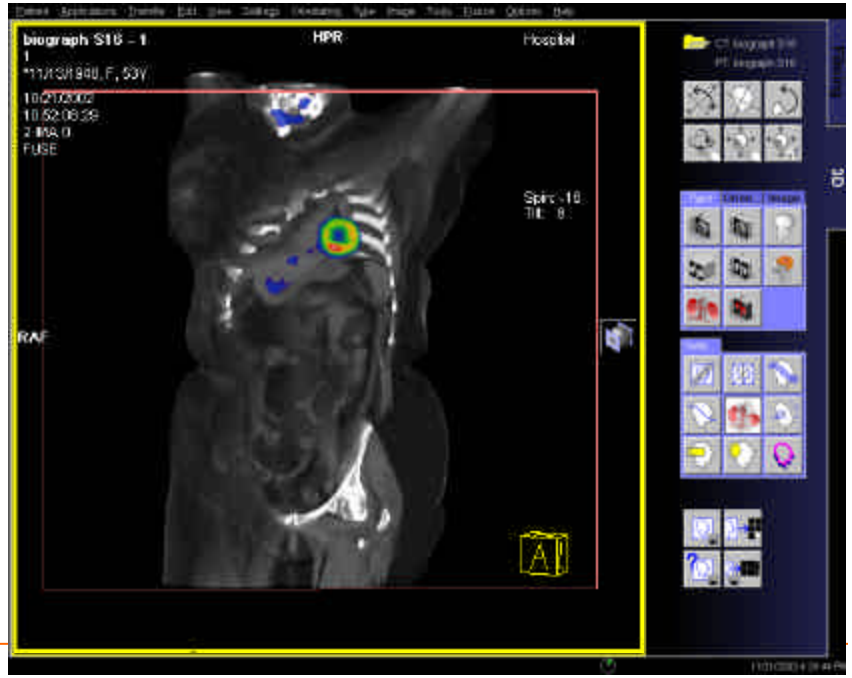
- MIP correlated with the fused images





FusedVision3D –
Fused 3D VRT

- Advanced Volume Rendering Technique (VRT)
- Provides 3D visualization of anatomical and functional volumes
- Projection of volume information onto an arbitrarily orientation plane
- Correlated Fused VRT with orthogonal planes



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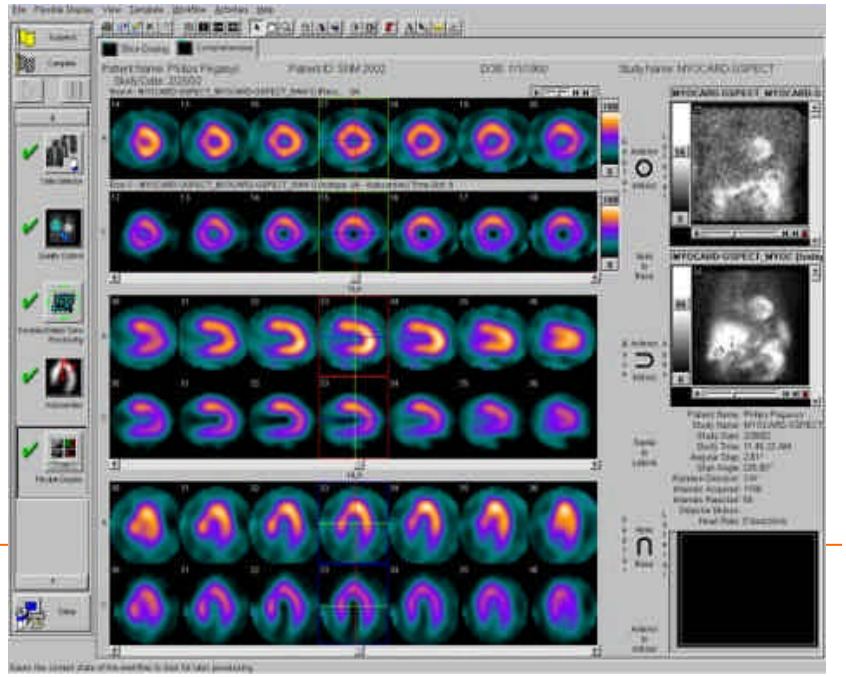
✓for your cardiology workflow

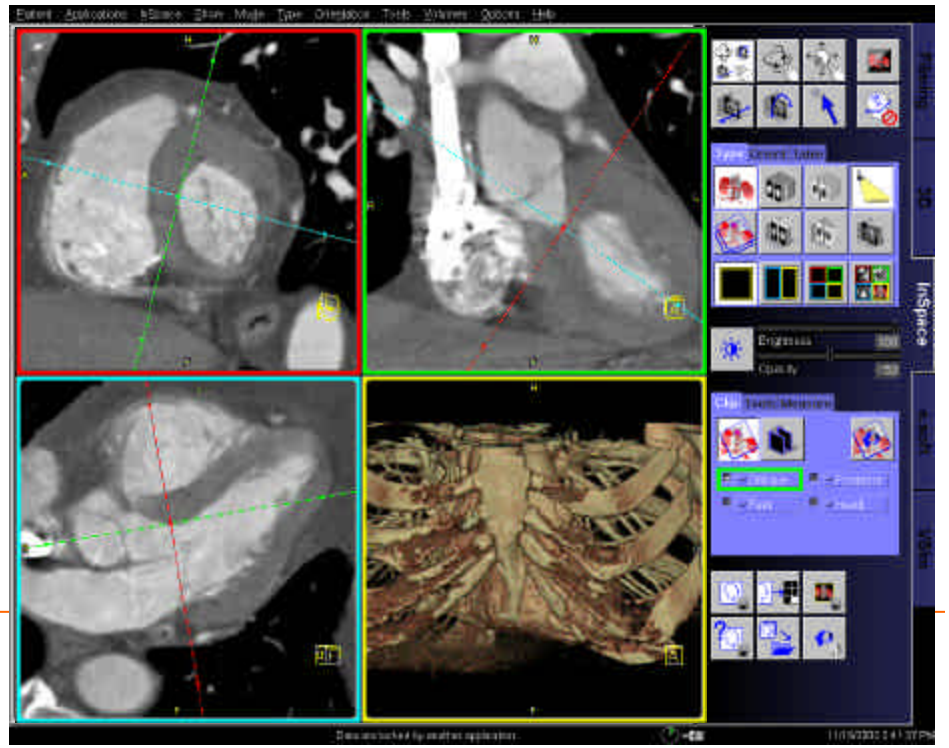
e.soft@LEONARDO – One Stop Assessment in Cardiology

Nuclear Cardiology applications: Automatic cardiac reorientation, motion correction, and quantifications (4DMSPECT, Cedars Sinai)



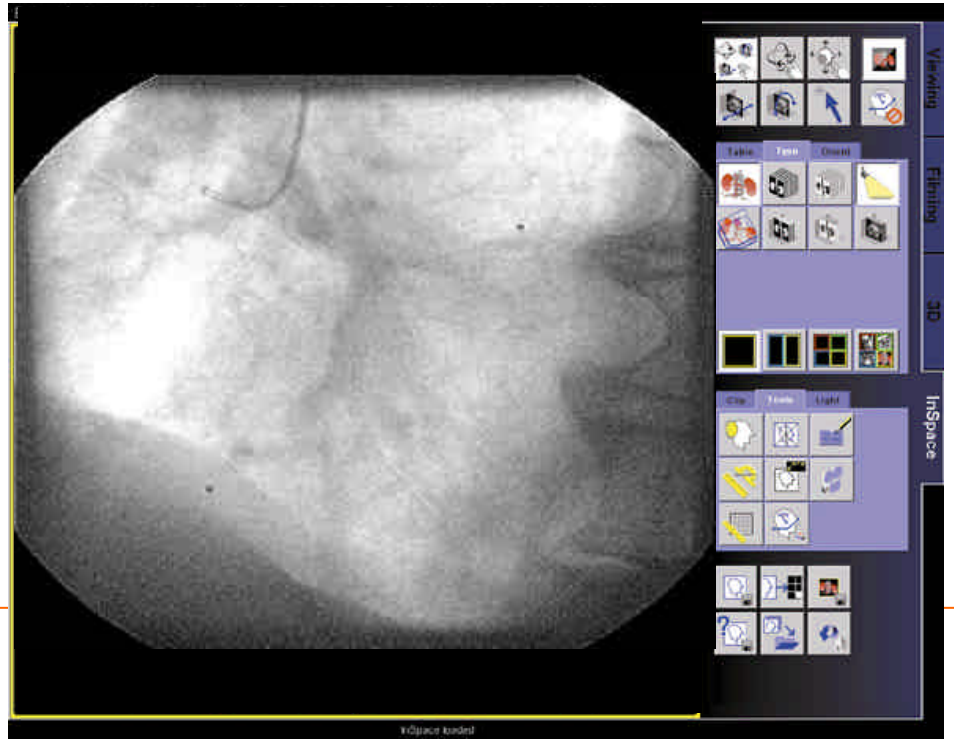
e.soft@LEONARDO –
One Stop Assessment in Cardiology

- **Cardiac CT & MR** applications (e.g. InSpace, HeartView)



e.soft@LEONARDO – One Stop Assessment in Cardiology

- **Angiography** applications (e.g. VesselView)

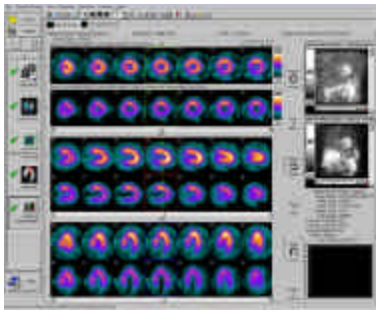


All in a Single Workplace!

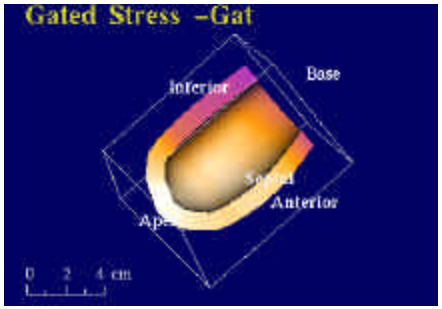
Special *syngo*® NM-applications

Do you specialize in nuclear medicine? So does LEONARDO!

e.soft Cardiac

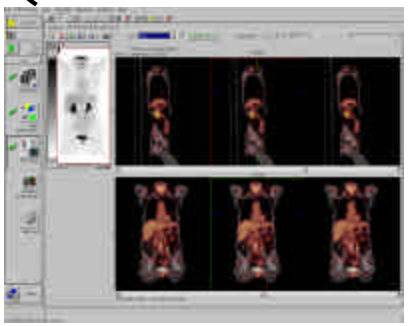


4D-MSPECT

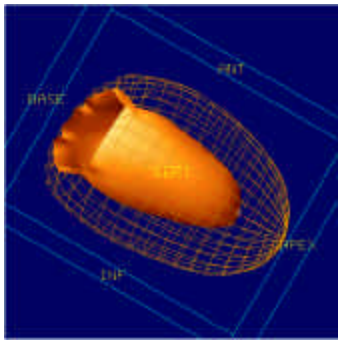


Flash 3D

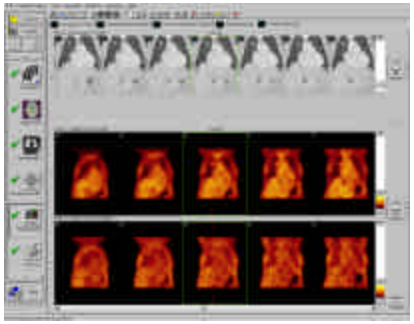
PET SUV Quantification



Cedars Cardiac



CT Attenuation Correction

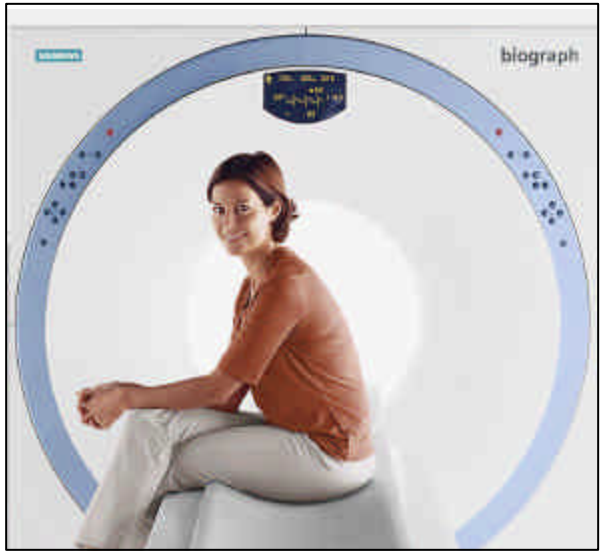


The New biograph Family

biograph 2

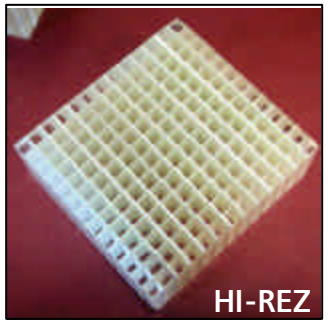
biograph 6

biograph 16



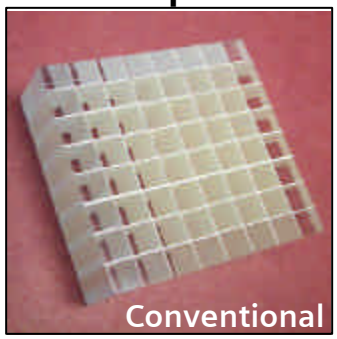
The New biograph Family
Introducing HI-REZ LSO PET

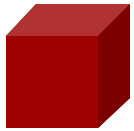
4.6 mm spatial resolution



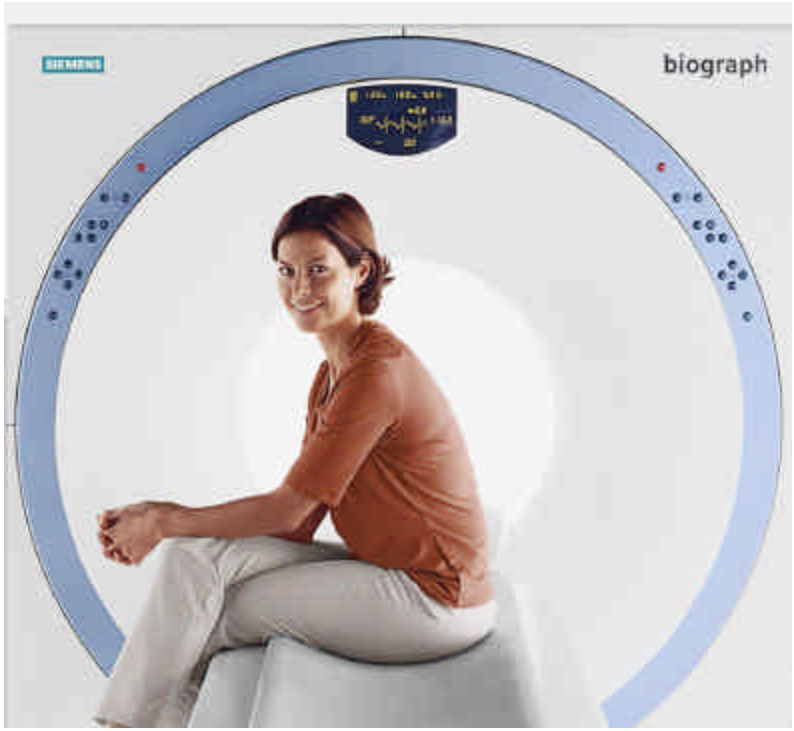
98 mm³

6.3 mm spatial resolution



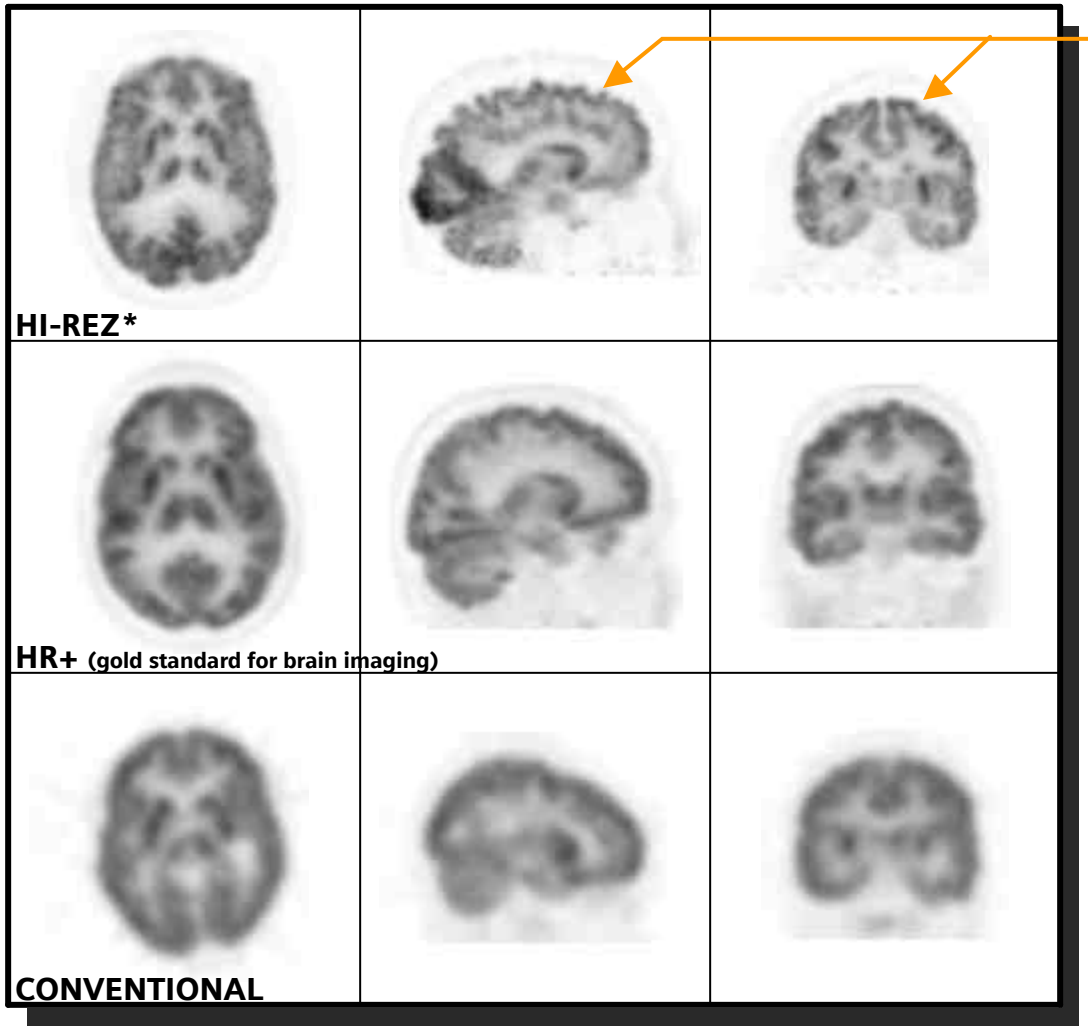


250 mm³



- We see a way to increase volumetric resolution by **more** than 250%

HI-REZ = Excellent Definition

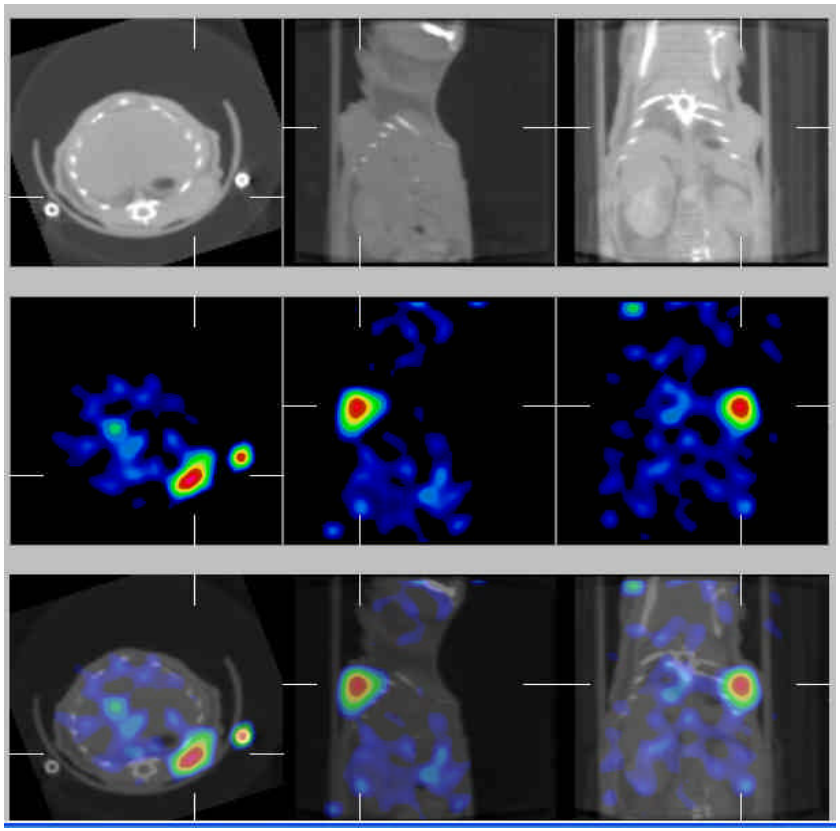


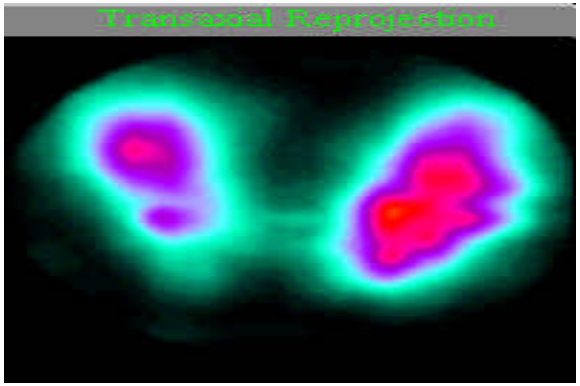
Note more definition of sulcus and gyrus!

Small Animal Imaging

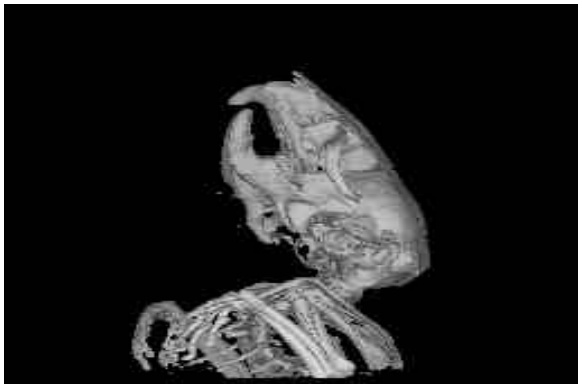
- microSPECT/CT scanner dedicated for small animal research
- X- SPECT: Introduced November, 2002 . CT option, horizontal positioning, can image up to small monkey.
- FOV 5" x 5", intrinsic resolution ~2mm. NaI crystal, 6mm thick.
- Energy range from 27 KeV to 264 KeV
- SPECT acquisition 15 min to 1 hr with SH; 90 sec SPECT reconstruction; CT 2 min reconstruction

X-SPECT





^{125}I Mouse Thyroid (microSPECT)



Spatial resolution ~ 150 µm

microSPECT/CT

- Fusion images represent I-123 antibody Xenograft tumor imaged after 23 hours post injection.

- Scan protocol: CT: Tomo acquisition, cone beam processing (Feldkamp)
  SPECT: Tomo acquisition using Pinhole (OSEM) or parallel hole collimators (FBP)

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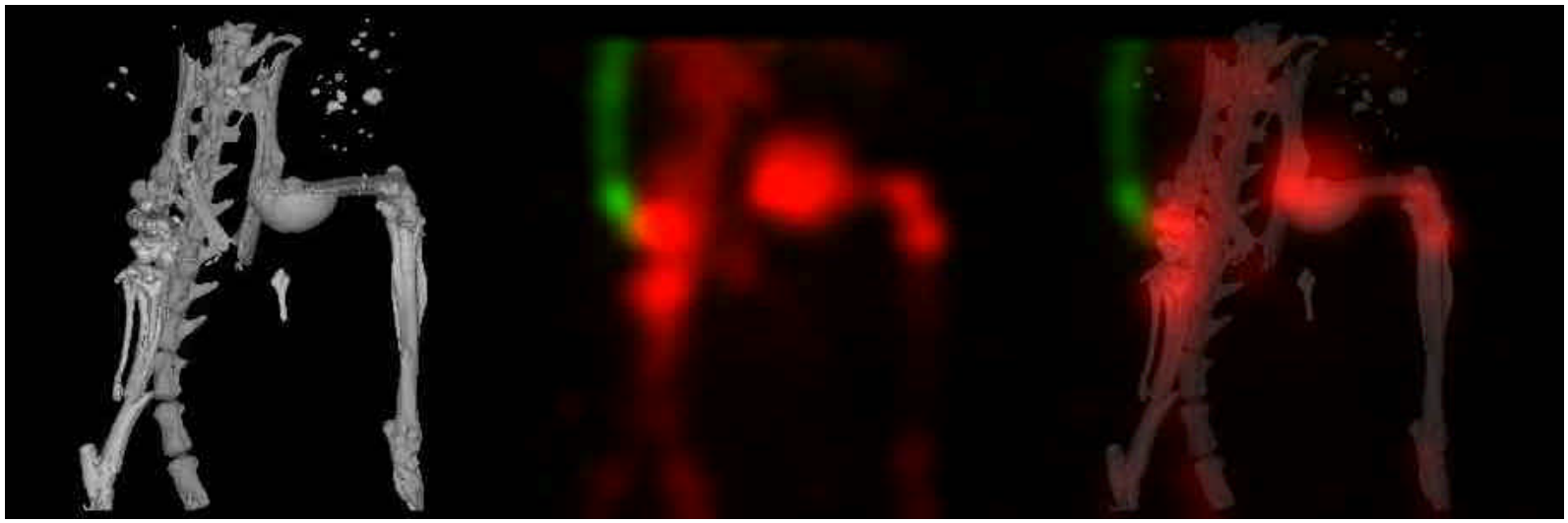
Data Courtesy of Dr. A. Wu, UCLA Crump Institute, and Gamma Medica Inc.

Unique Imaging Capabilities



Dual Isotope imaging

^{125}I and ^{99m}Tc-MDP SPECT with CT Fusion. **^{125}I-VEGF (green)** was infused through a catheter to a femur, while **^{99m}Tc-MDP (red)** was IV-injected.

"***Despite the enormous popularity of PET, SPECT will survive because of its ability to image multiple tracers simultaneously…" Dr. Henry Wagner " SNM Highlights 2002 Lecture: Reinventing Clinical Nuclear Medicine", J Nucl. Med. 2002 43(8)***

Summary

- Siemens continues its strong commitment to Nuclear Medicine
- Molecular Imaging represents an opportunity for Nuclear Medicine growth (e.g., new diagnostic and therapeutic agents and procedures)
- Siemens has currently collaboration projects with research institutions, pharmaceutical companies on Molecular Imaging and clinical protocol optimization

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