Image Reconstruction in Positron Emission Tomography

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Examples of clinical PET images

Female
82 years
1.70 m (5’7”)
101 kg
Lung carcinoma

Male
81 years
1.90 m (6’3”)
105 kg
Lymphoma +
Lung carcinoma

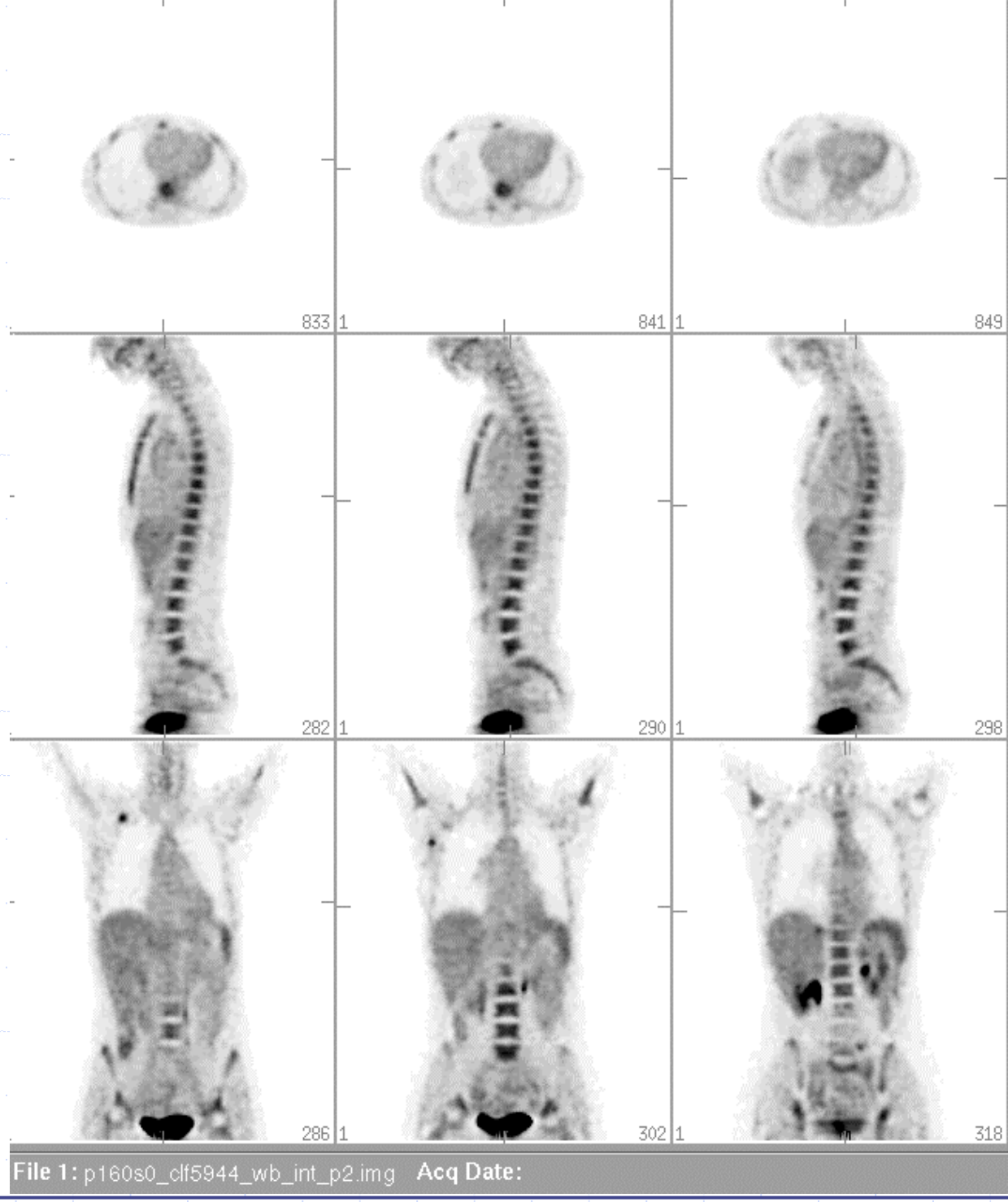
Female
24 years
1.55 m (5’1”)
45 kg
Lymphoma

Advantages: high sensitivity to cancer

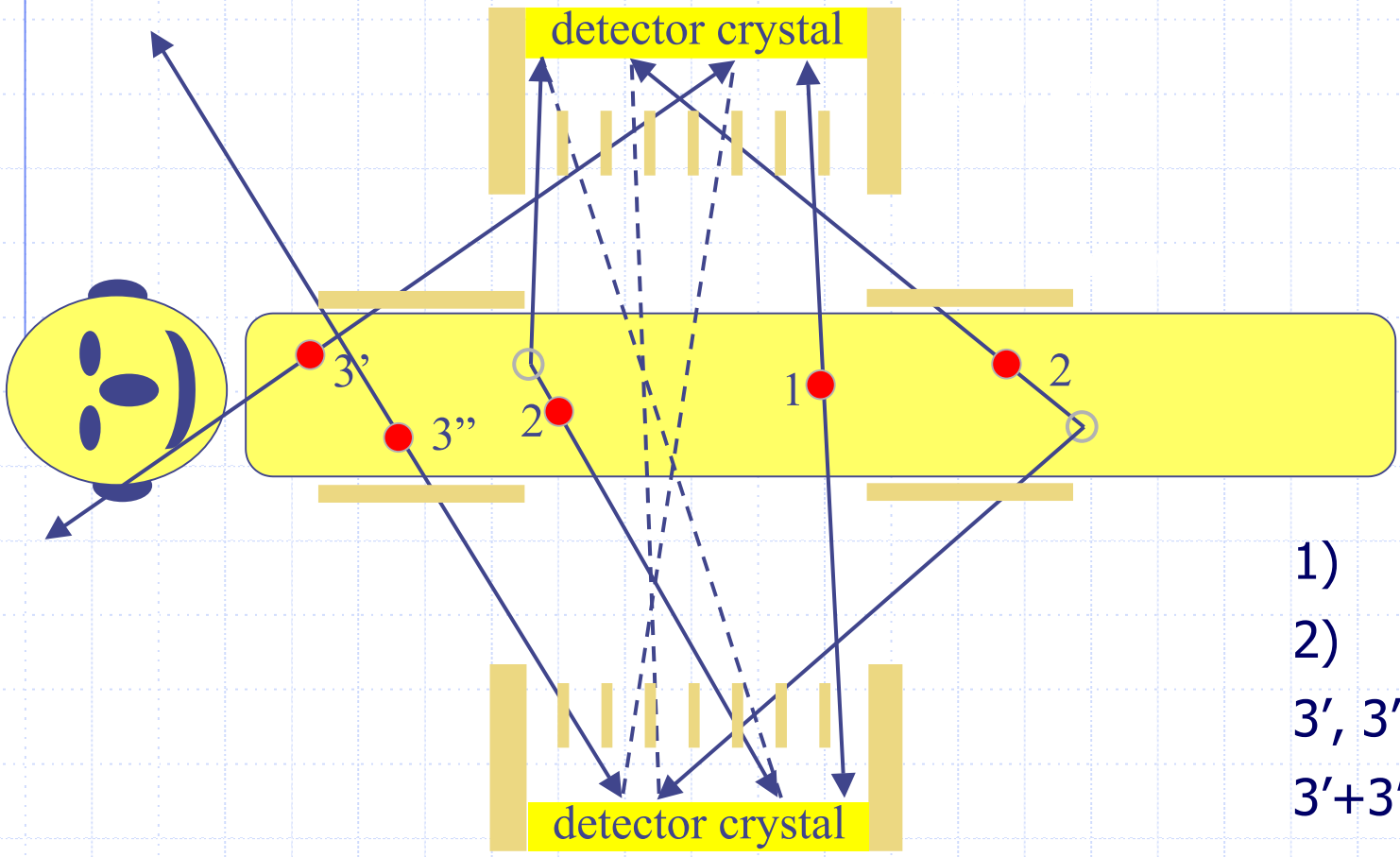
Problems: resolution, noise, attenuation, scatter, randoms

(Illustrated images lack proper treatment of those effects)

Whole-body PET study – Fully 3D reconstruction



PET data - classification of events

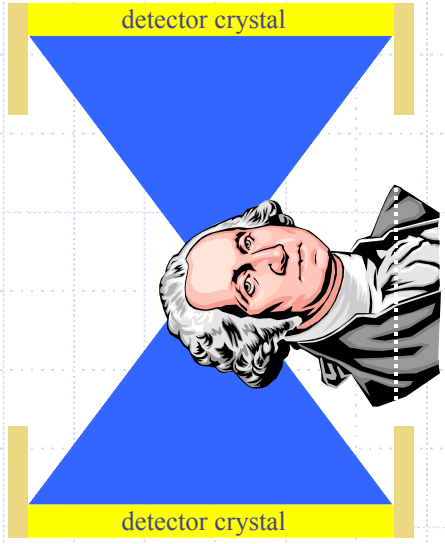


1) True event
2) Scatter event
3', 3") Single events
3'+3") Random event
- - - - - false coincidence lines

PET data - 2D vs. 3D scanner geometry

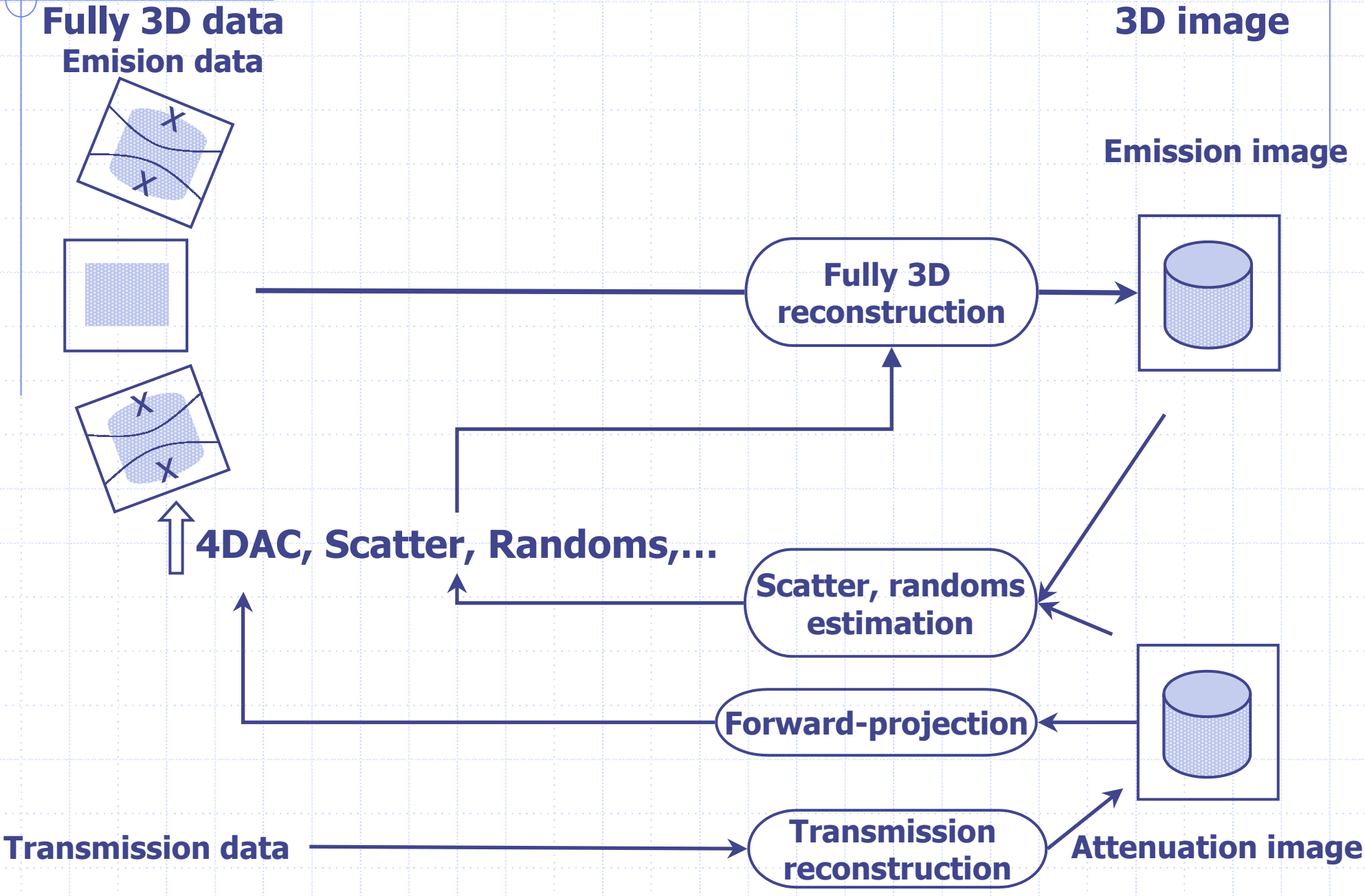
"2D"

"3D"



⇒ The larger the acceptance angle, the more (good and bad) events are accepted.

Fully 3D PET reconstruction flowchart



Fast Fully 3D Reconstruction – WHY?

Modern emission tomography systems:

- Fast increase of **data sizes** (exceeding Moore's law)
  → needed – reduction of computation demands of reconstruction

- Low counts per data bin – **noisy data**
  Data attenuation, scatter and contamination
  → needed – reconstruction techniques with better modeling

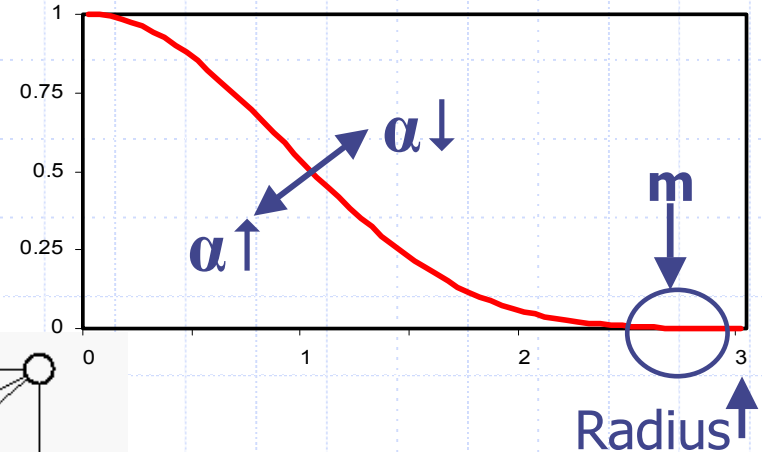
Conflicting demands
→ needed – **very fast reconstruction approaches**

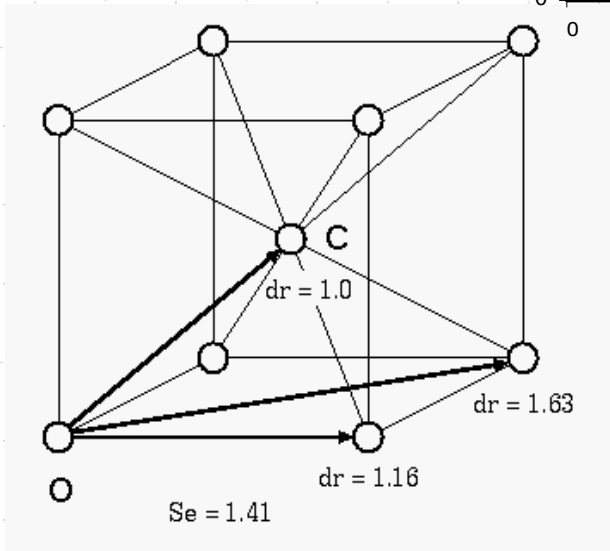
Studied 3D PET reconstruction approaches

- 3D non-iterative analytical techniques (3DRP, 3D-FRP)
- 3D iterative techniques (3D RAMLA, ...)
- Rebinning (into non-oblique data) followed by multislice 2D or 2.5D iterative reconstruction
- List mode reconstruction
- Time-of-flight reconstruction
- Dynamic list mode reconstruction

Favorite tools

- Fourier-based approaches
  - Analytical reconstruction
  - Forward and back-projectors for attenuation correction and iterative reconstruction
- Kaiser-Bessel window functions
  - Image basis function
  - Interpolators
  - Display
- Efficient grids
  - Reconstruction
  - Display



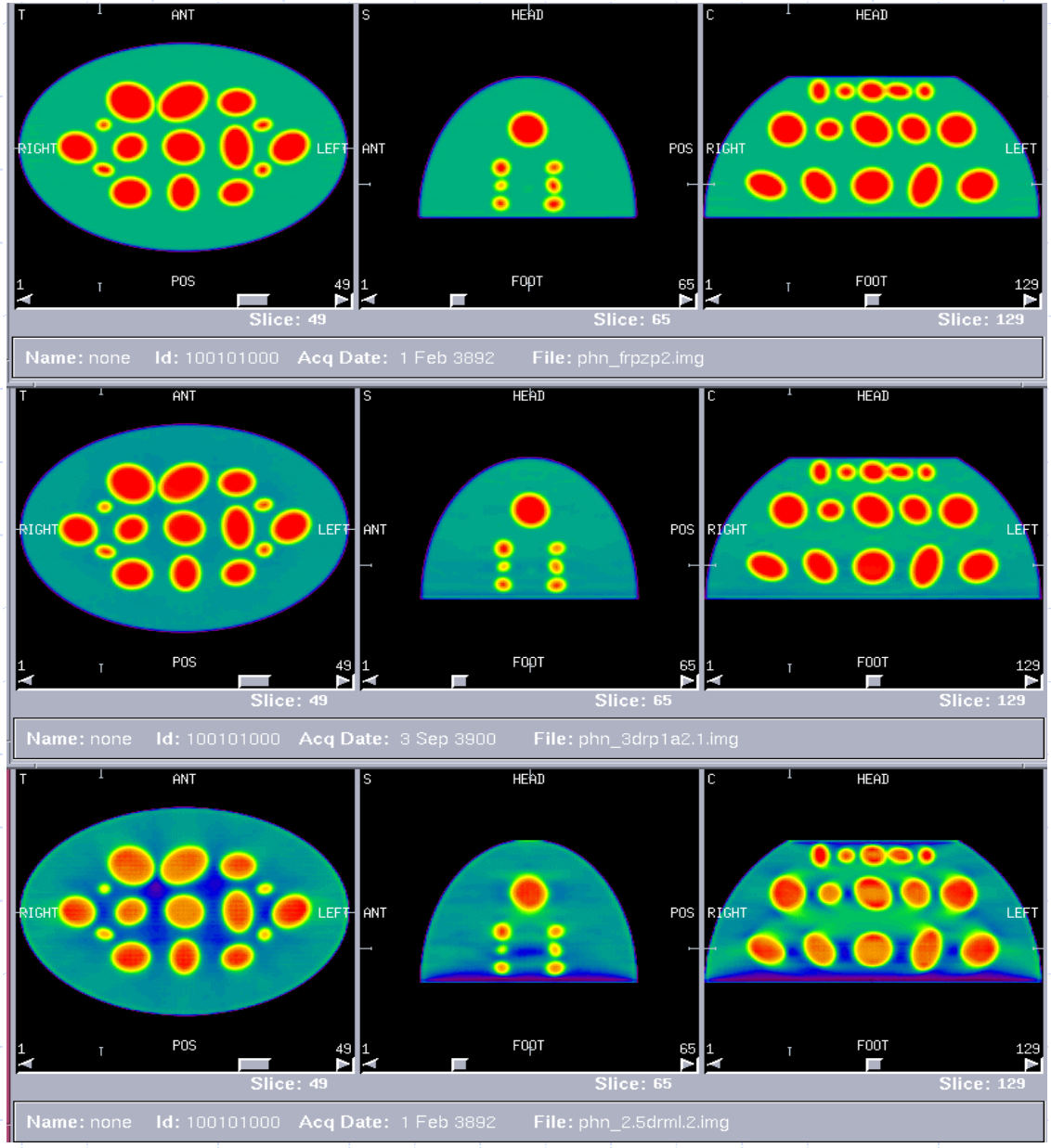


Analytical 3D/2.5D reconstructions

3D-FRP

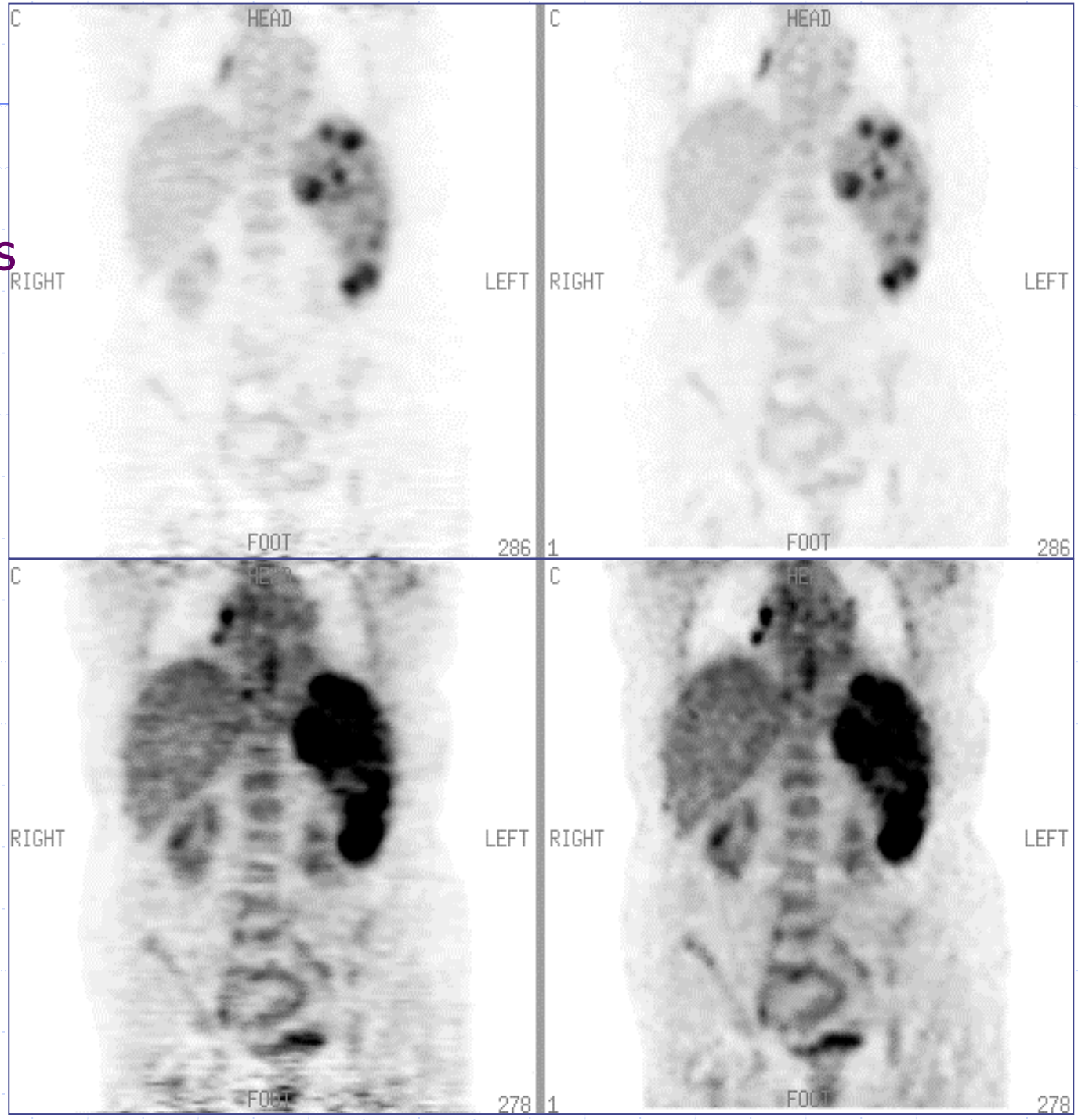
3DRP

FORE reconstruction



Allegro

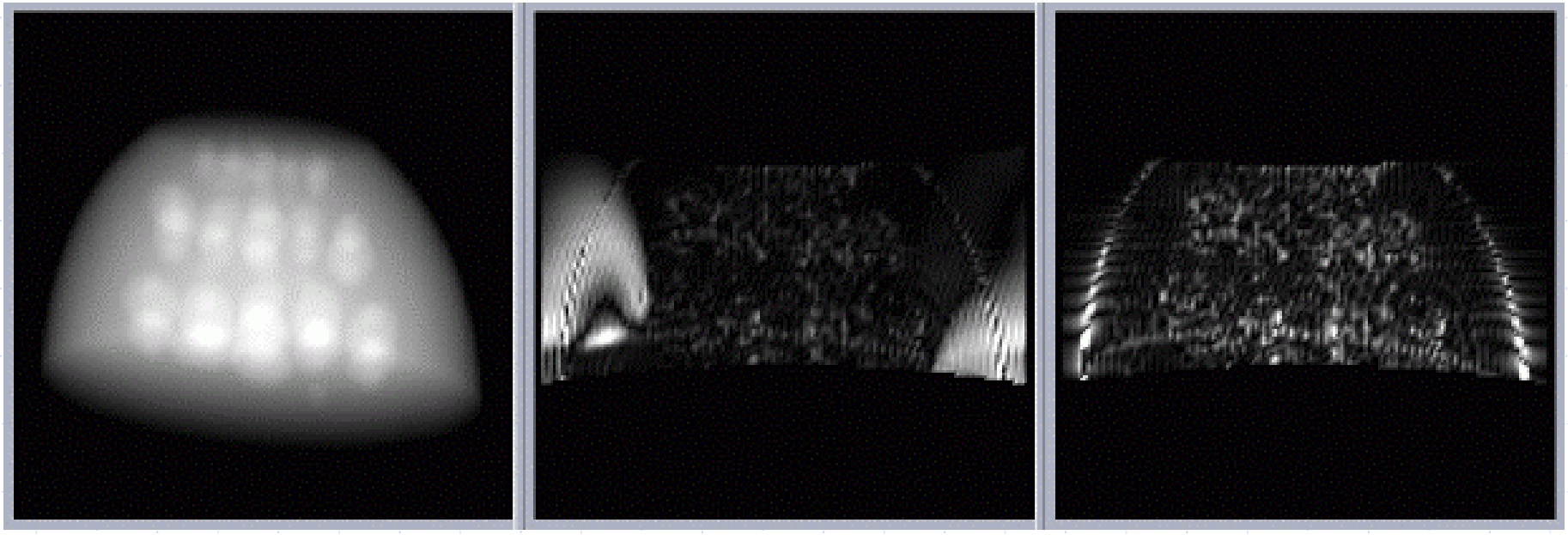
Iterative approaches



2.5D recon

3D recon

Fourier-based projection

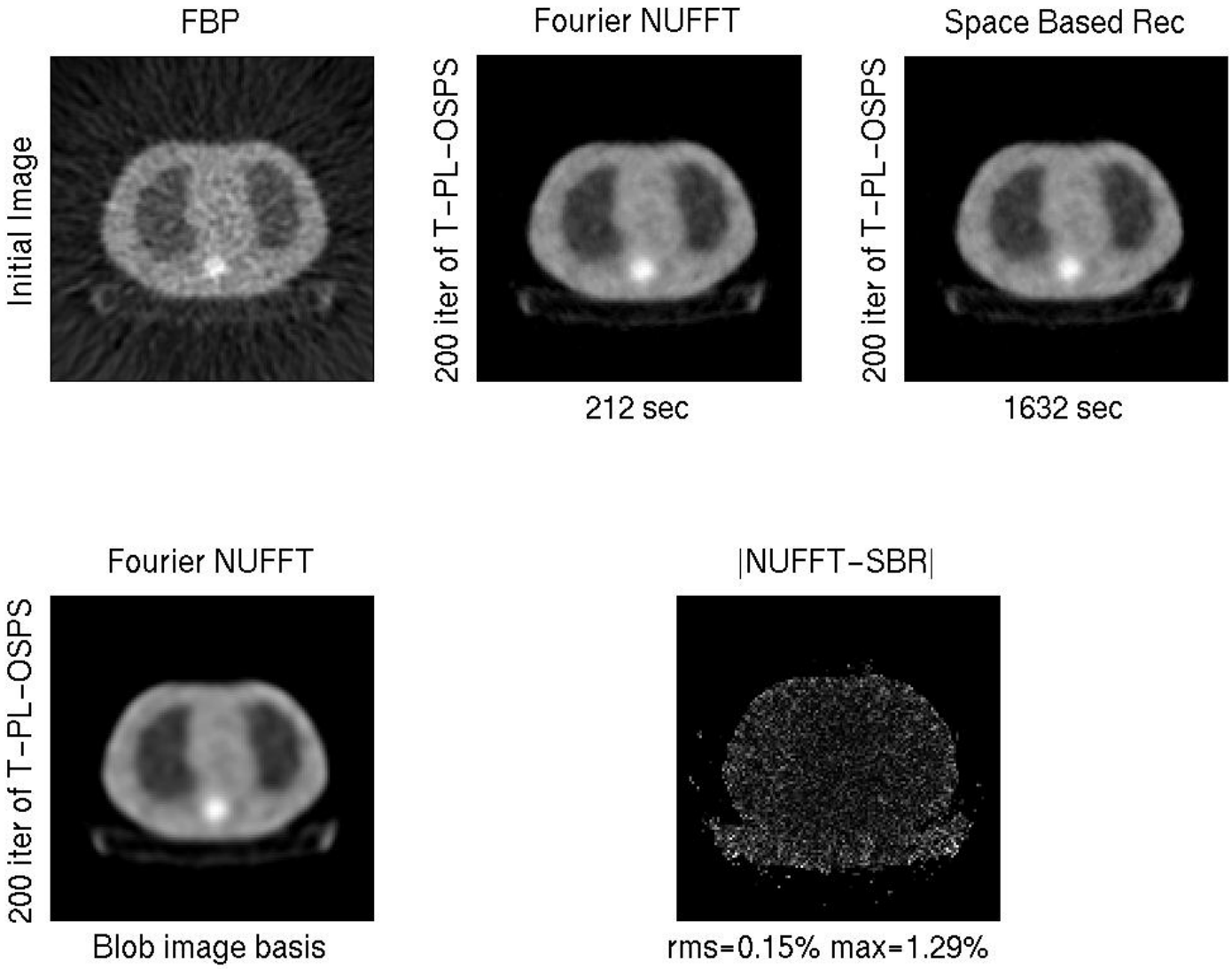


Projection

Difference

No zeropadding	100% zeropadding
1% scale	0.5% scale
58 ms/view	96 ms/view

Fourier-based iterative reconstruction



The End