PHILIPS

Allegro

Enhancing PET to a new level of performance

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Outline

- Allegro technology
  - Clinical goals of PET
  - 3D Imaging to meet clinical goals
  - GSO ideal for 3D imaging
  - Detector design to optimize performance
- Cs-137 attenuation correction benefits
- 3D RAMLA benefits

If you cannot see the lesion you cannot localize it

Clinical Goal

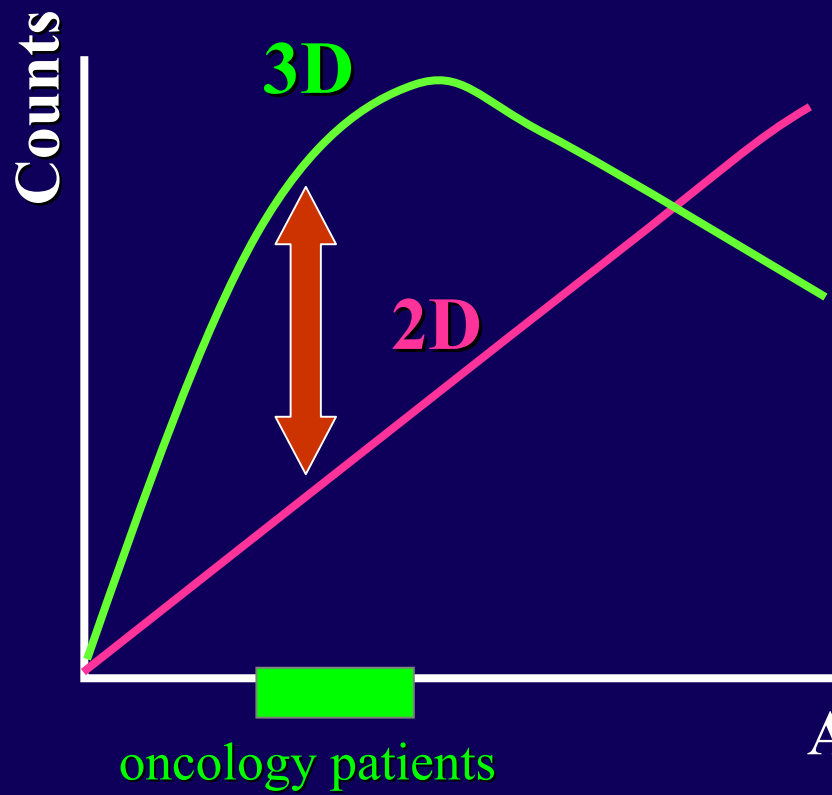
Image the smallest possible lesion with a low contrast in a background of radioactivity

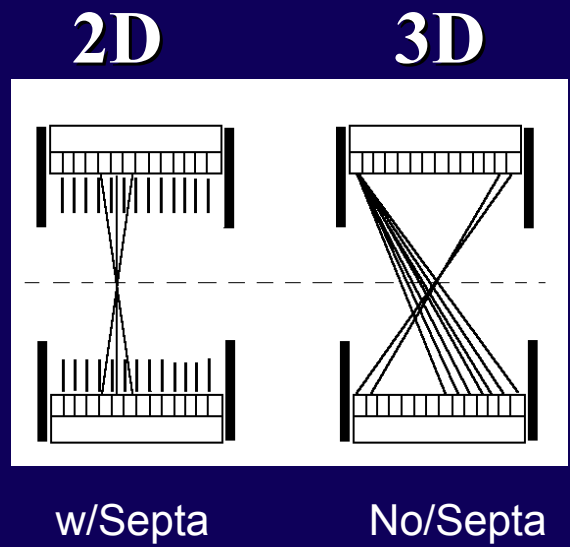
Large number of counts in the image – high sensitivity

3D imaging maximizes Sensitivity

Allegro is the only PET System designed for 3D imaging from the beginning

- 3D imaging maximizes the sensitivity





3D Imaging provides 5 times Sensitivity vs. 2D

- 2D Imaging is limited by the Septa for FDG Whole-Body scans

	2D	3D
Sensitivity	1x	5x
Count rate	1x	5x
Throughput	1 hour	~ 30 mins.
Scatter	20%	40%

Source: Moszynski et al. IEEE NS-45: 472-477, 1998

3D Imaging Requirements

Feature	Benefit
• Fast decay time	Permits high singles rate
• Good energy resolution	Limits randoms and scatter
• High stopping power	Gives high coinc. fraction
• Good timing resolution	Reduces randoms

These 3D imaging requirements are fulfilled by the

GSO - Fast, High Density Scintillator

GSO is the Material of Choice for 3D PET

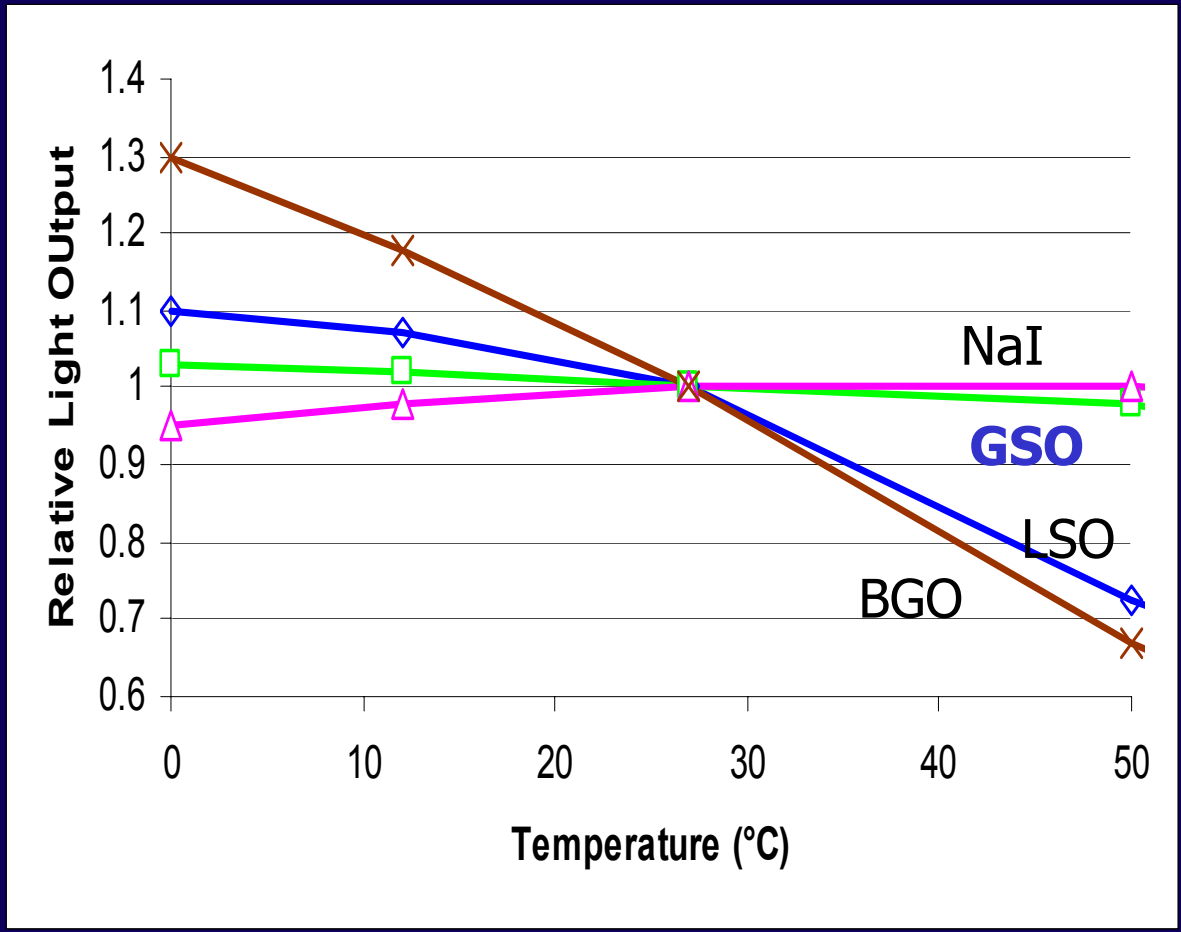
	BGO	NaI	LSO	GSO
Decay Time	300	230	40	60
Deadtime (nsec)	700	240	100	120
Energy Res. (%)	15	8	12	8
Stopping Power	11.6	30.7	12.3	16.0
Light Output	15%	100%	75%	25%

- GSO combines high stopping power of BGO with excellent energy resolution of NaI
- Fast decay time of GSO is necessary to keep up with the increased photon flux in 3D and reduce detector deadtime

Source: Moszynski et al. IEEE NS-45: 472-477, 1998

GSO Advantages

GSO Improves Systems Reliability due to High Temperature Stability



- Temperature stability of GSO is much better than LSO or BGO
- LSO and BGO based scanners require special water cooling systems
- Makes GSO the material of choice for combined PET/CT tomographs

Moszynski et al. IEEE NS-45: 472-477, 1998

System down time for detector calibrations is minimized

LSO systems have compromised Transmission capabilities

- Coincidence transmission imaging is a poor second choice – Ge-68 source
  - Source needs to be replaced about once/year
  - Maximum data rate limited to maximum true rate, i.e ~100-400 Kcps
- Long acquisition times for Transmission scans due to coincidence mode acquisitions
- Poor image quality of the transmission images due to radioactive background from LSO
  - Radioactivity increases the background counts in Transmission images
  - particularly high attenuation regions

Source: Radioisotope decay data; SNM proceedings (2001); internal analysis

GSO Advantages versus LSO/BGO

- Excellent energy resolution
- Short decay time
- Good stopping power
- Very good temperature stability
- Not radioactive

Optimum for 3D Imaging and PET/CT

The design of the system is as important as the selection of the scintillator

Detector Designs

- Different crystal/PMT schemes are used in designing PET scanners
- Trade-off between count rate capability, system energy resolution and complexity

  - Continuous Positioning Detector Design
  - Block Design

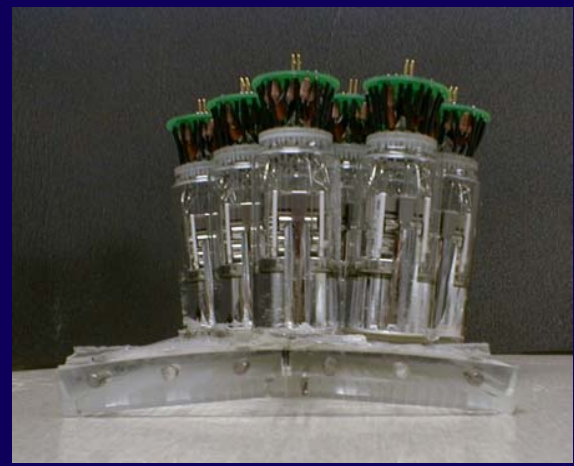
Continuous Positioning Detector Technology optimizes use of GSO for 3D imaging

Combining single crystals with continuous light guide

- Much better system energy resolution
- High count rate capability
- Small crystal size for excellent spatial resolution
- Better 3D imaging capabilities

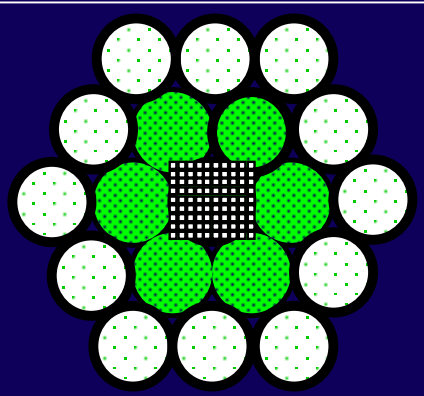
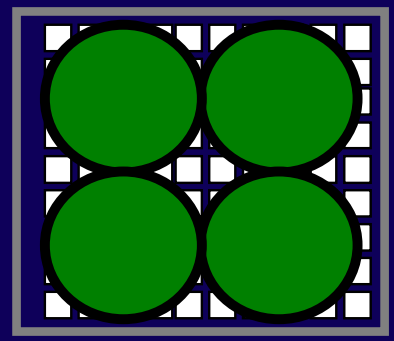
PIXELAR™

Continuous pixelated PET detectors

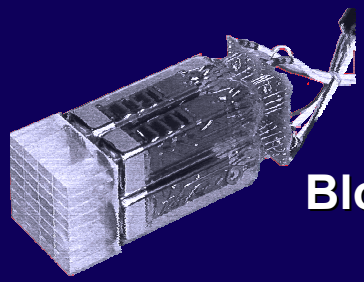
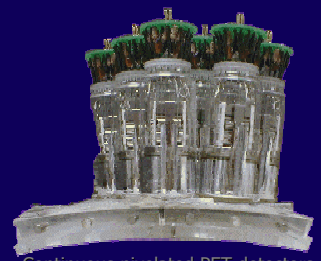


Sources: Adam, L.E., Watson, C.C., Nuklearmedizin 1999,38:61-65; Cherry S.R. et.al. IEEE NS Vol. 42 (4),1064 – 1068, 1995; Philips measurements

Allegro PIXELAR Detector *vs* Competitor Block Detectors

Continuous Positioning PIXELAR Detector - Allegro	Block Detector All competitor systems
	
• New technology	• > 20 year old technology
• Designed for 3D imaging	• Designed for 2D imaging
• Variation of light collection <20%	• Variation of light collection ~300%
• Excellent energy resolution: <18%	• Poor energy resolution: 25-35%

Crystal & detector design determines system energy resolution

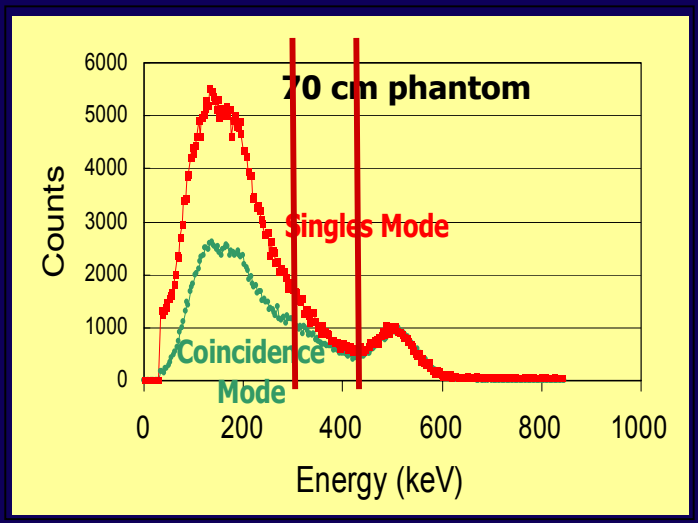
Siemens Accel		Allegro
LSO	Crystal Type	GSO
10-13 %[1,2)]	Crystal Energy Resolution	8 %[5)]
	+	
 Block	Detector Design = Light collection variation	PIXELAR  Continuous pixelated PET detectors
~300 %[4)]		< 20 %[5)]

>25 %[3)] **System Energy Resolution** **< 18 %[5)*]**

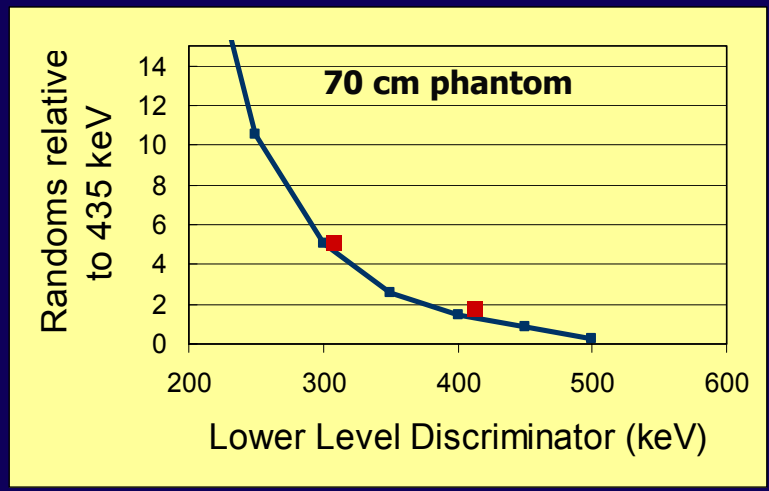
1) A. Saoudi et.al., IEEE NS 46(6), 1925-1928,1999 , 2)Moszynski et al. IEEE NS-45(3), 472-477, 1998
3) Adam, L.E., Watson, C.C., Nuklearmedizin 1999,38:61-65; 4) Cherry S.R. et.al. IEEE NS Vol. 42 (4),1064 – 1068, 1995
5) Philips measurements

Good Energy Resolution is Essential to Reduce Randoms

Singles rates are very high in 3-D mode



Singles and coincidence energy spectra for 20 cm Ø, 70 cm long phantom



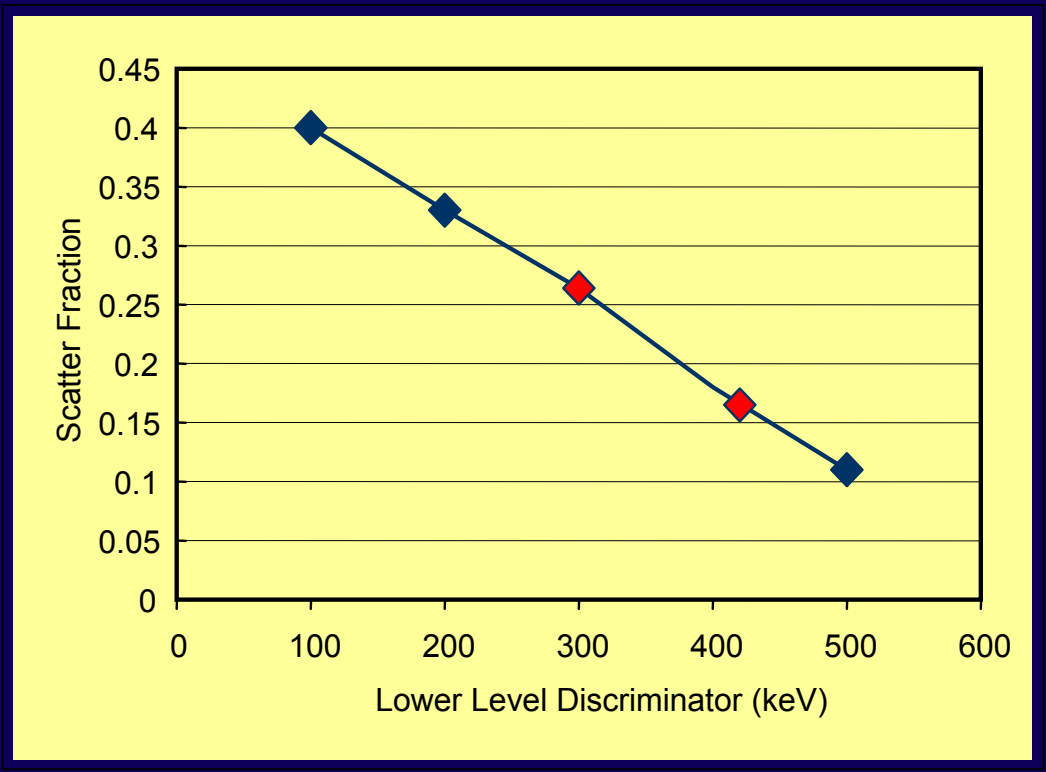
Relative Randoms Fraction

Randoms Fraction decreases exponentially with increased LLD

An LLD setting of 410 keV on the Allegro enables excellent image quality

Data courtesy of J. Karp, Ph.D. University of Pennsylvania

Good Energy Resolution is Essential to Reduce Scatter



Scatter fraction as a function of LLD for 20 cm Ø, 20 cm long phantom with line source

Scatter Fraction decreases linearly with increased LLD

An LLD setting of 410 keV on the Allegro enables excellent image quality

Data courtesy of J. Karp, Ph.D. University of Pennsylvania

Allegro is Designed for 3D Imaging to Provide High Image Quality

Allegro → GSO + Continuous Positioning Detectors → Optimum for 3D Imaging

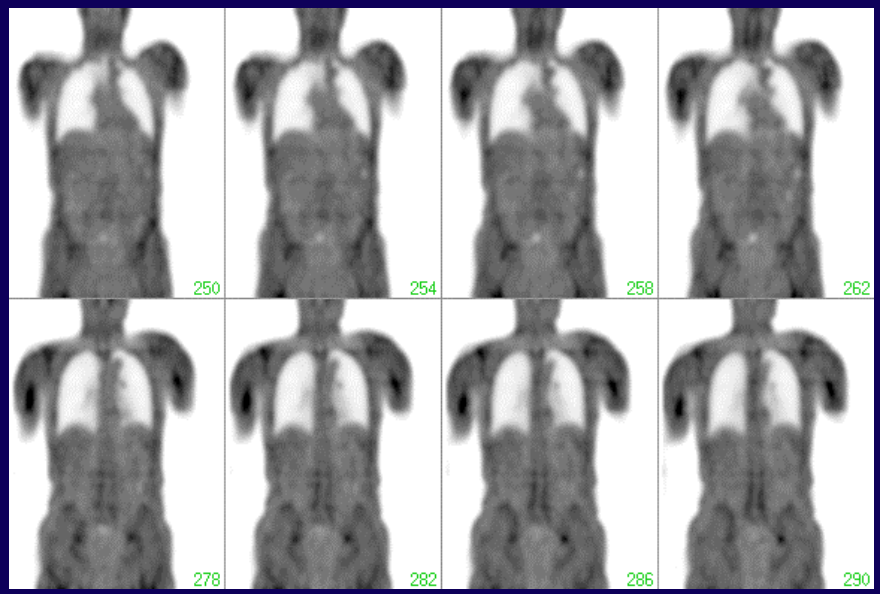
GE
Siemens
CTI
→ BGO/LSO + Block Detectors → Designed for 2D Compromised 3D

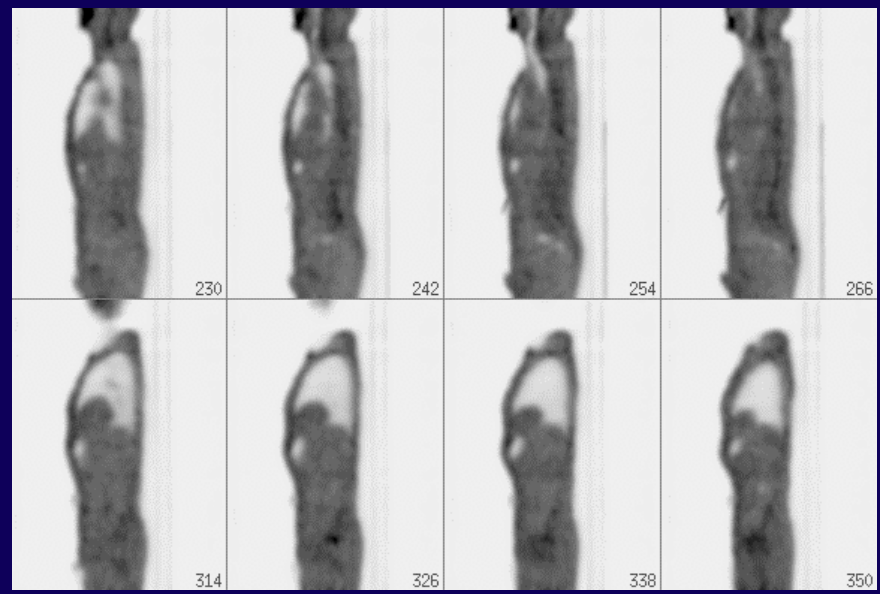
Allegro design allows use of Cs-137 for transmission for better throughput, image quality and cost

Allegro (Cs-137 source)	LSO & BGO Block Detectors (Ge-68 coincidence source)
High count rates in excess of 3Mcps	10X lower count rates than Cs-137
Fast Acquisition times (45 sec)	Long acquisition times
High quality transmission images	Need for image segmentation
No need to replace source (30 yr half life)	Need to replace source annually (271 day half life -> $10K/year)

ALLEGRO™
Example of Cs-137 transmission image

- 43 sec. acquisition per step
- Transmission count rates > 3 Mcps





Ability to see bone structure and the Pelvis provide the anatomical landmarks required to perform image fusion accurately

Images courtesy of J. Karp, Ph.D.
University of Pennsylvania

Why 3D RAMLA?

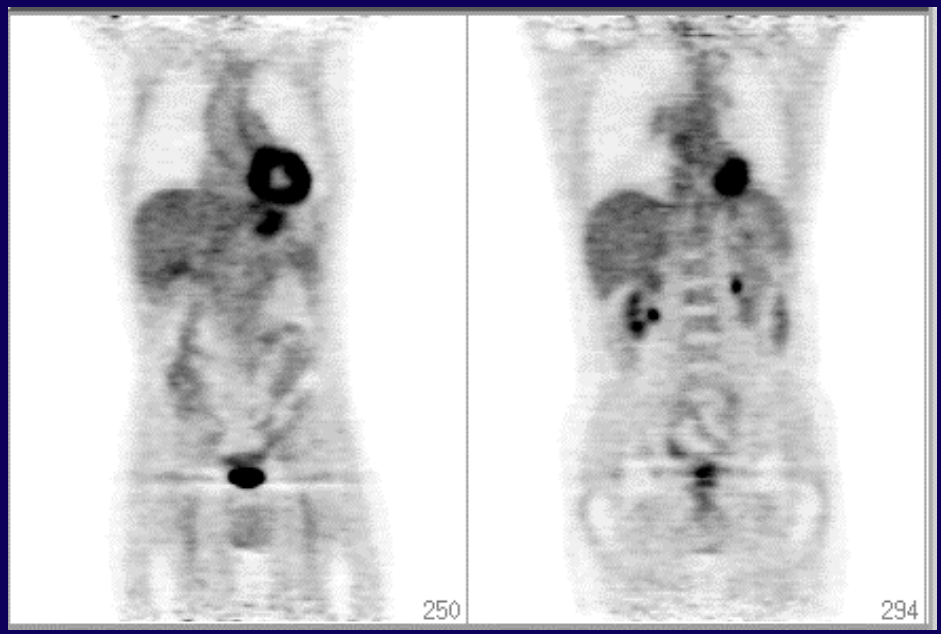
Acquire in 3D -> Reconstruct in 3D for best image quality

3D RAMLA Benefits

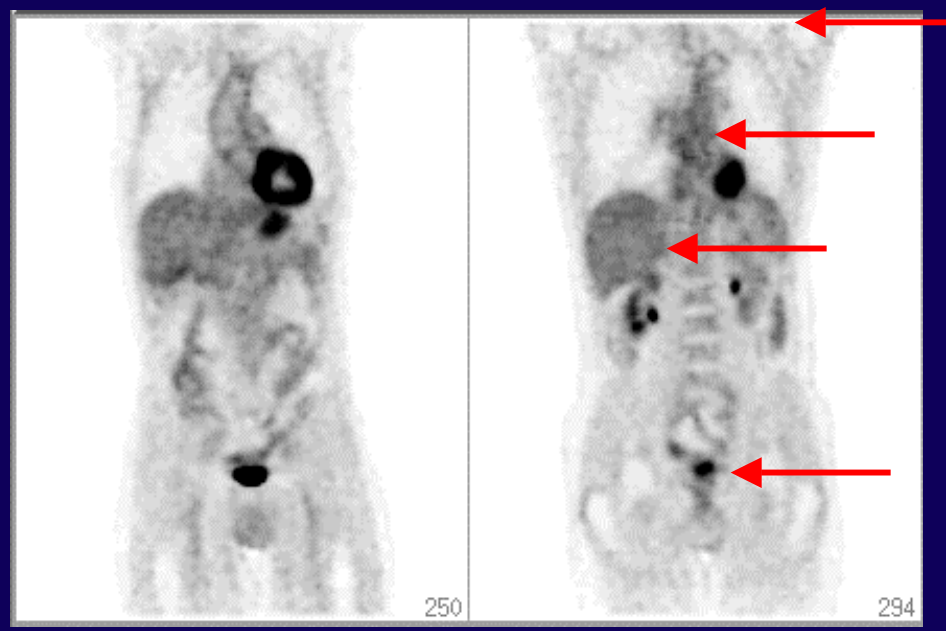
- Accurate reconstruction for 3D imaging
- Improves image quality
- Reduces artifacts
- Minimizes noise

Fully 3D iterative recon improves image quality

FORE + OSEM



3D RAMLA

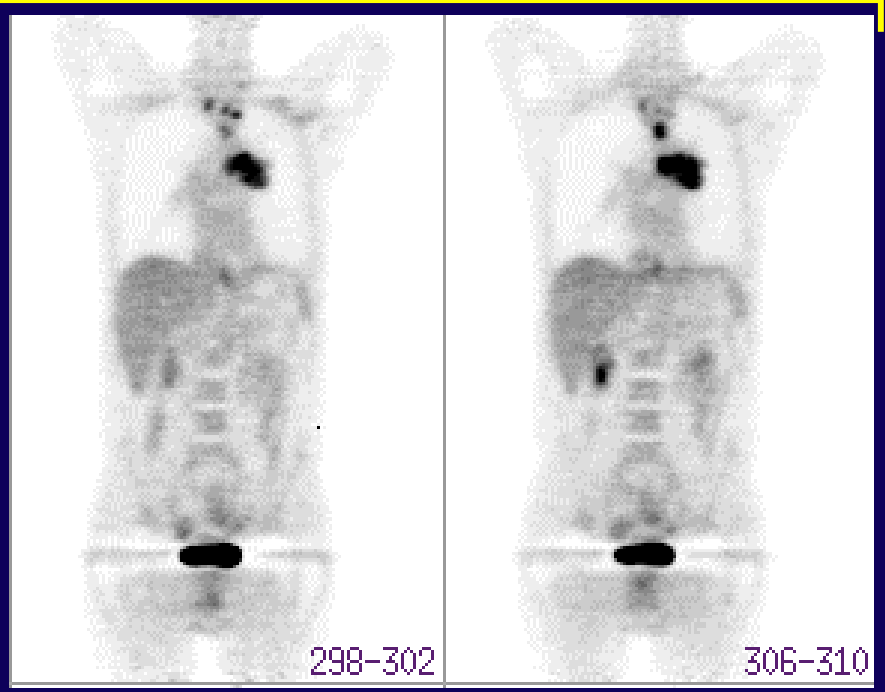


University of Pennsylvania PET Center

- No bladder artifact
- Sharper edges and definition of the Liver
- Uniform distribution
- Much better definition at the edge of the FOV

Fully 3D iterative recon improves image quality

FORE + OSEM



University of Pennsylvania PET Center

3D RAMLA

- No bladder artifact
- No artifacts
- Better definition of structure

Fully 3D iterative recon improves spatial resolution

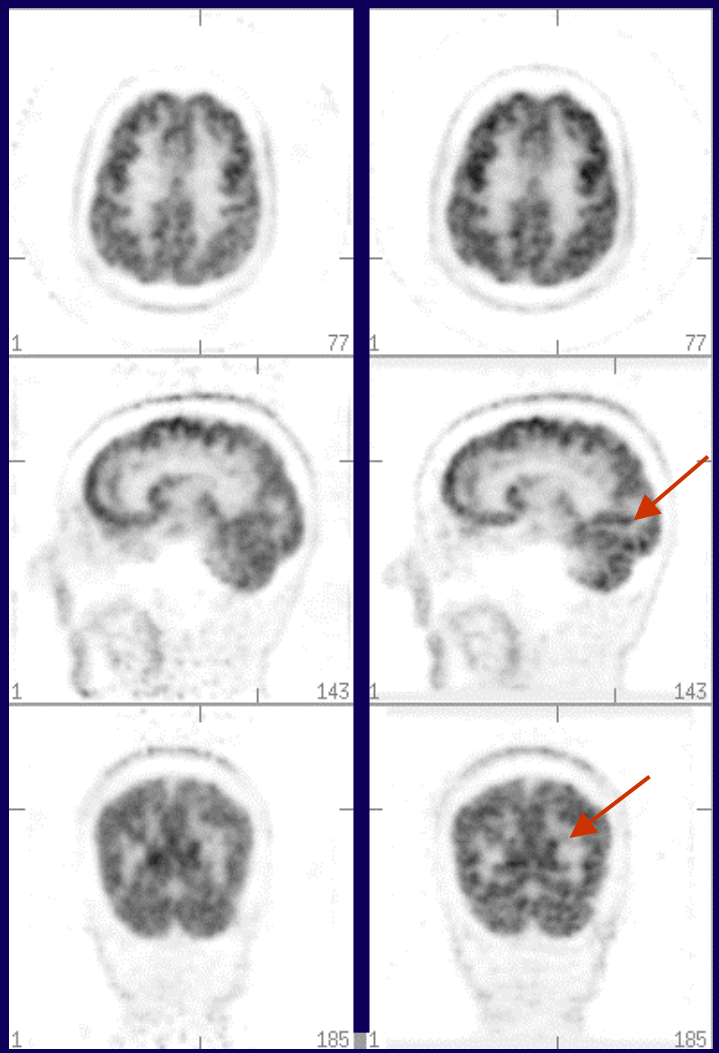
University of Pennsylvania PET Center

2D

3D

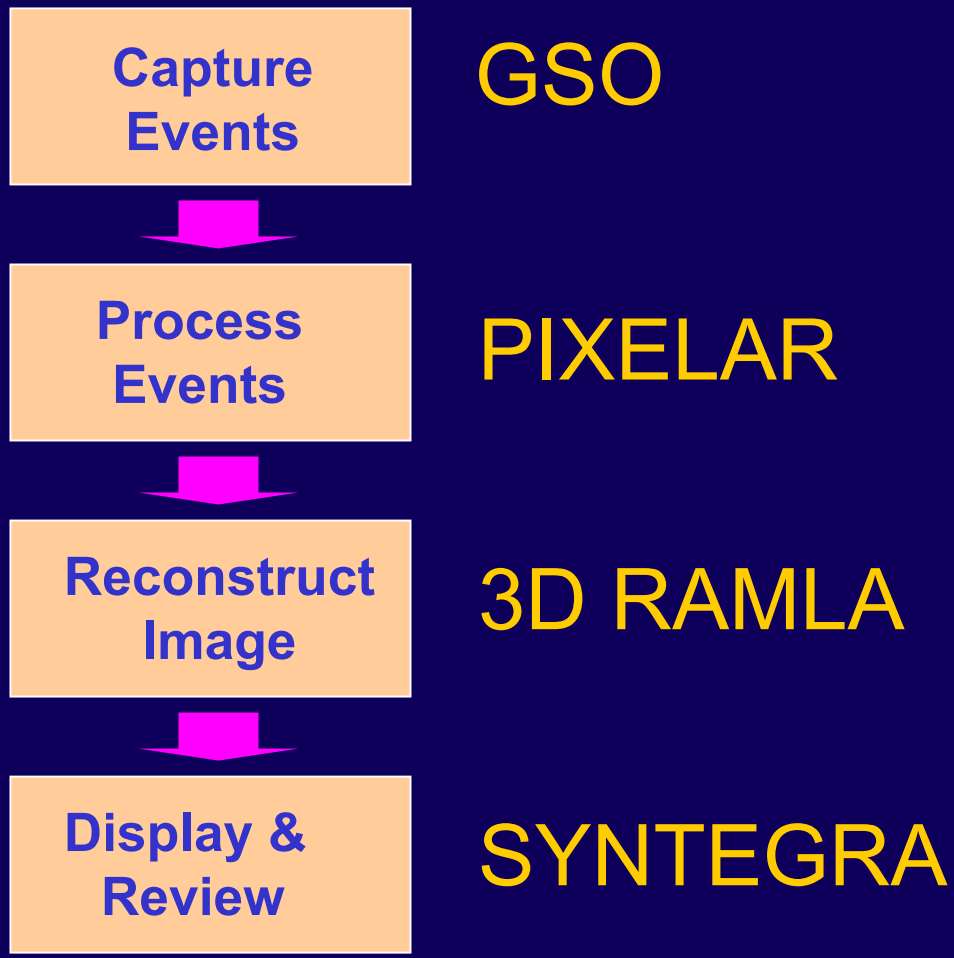
FORE + OSEM

3D RAMLA



Much better definition of structure

Allegro High Performance PET System



Allegro Key Benefits

- High quality PET images through 3D mode data acquisition that optimizes sensitivity
- Excellent energy resolution of the PIXELAR detector technology provides optimum contrast resolution to detect small low contrast lesions
- High Density, fast scintillator GSO for high patient throughput
- Accurate full 3D image reconstruction to visualize low contrast lesions provided by the unique 3D RAMLA software
- Seamless integration with Radiation Oncology through Syntegra image fusion and multi modality connectivity