

LSO – the crystal of choice for PET

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Important characteristics of PET Scintillators

- High detection sensitivity for 511 keV
- Fast decay of scintillation light
- High scintillation light output
- Easy manufacturing
- Limited influence of humidity, temperature, ...
 - ▶ number of “significant” counts in image!

PET Scintillators

- NaI (TI) (1940s, Hofstadter) **ECAT II, 1977**
 - ▶ *pros: high light output*
 - ▶ *cons: hygroscopic, low atomic number, low density, slow*
- BGO (1970s, Weber) **ECAT 911, 1982**
 - ▶ *pros: high density and atomic number, rugged and nonhygroscopic*
 - ▶ *cons: low light output, slow*
- GSO (1980s, Takagi) **Scanditronix PC-2048, 1983**
 - ▶ *pros: high density, fast, nonhygroscopic*
 - ▶ *cons: low atomic number, low light output, cleaving*
- LSO (1990s, Melcher) **ECAT ACCEL, 2000**
 - ▶ *pros: high light output, fast, high density, high atomic number, rugged, nonhygroscopic*
 - ▶ *cons: intrinsic radioactivity*

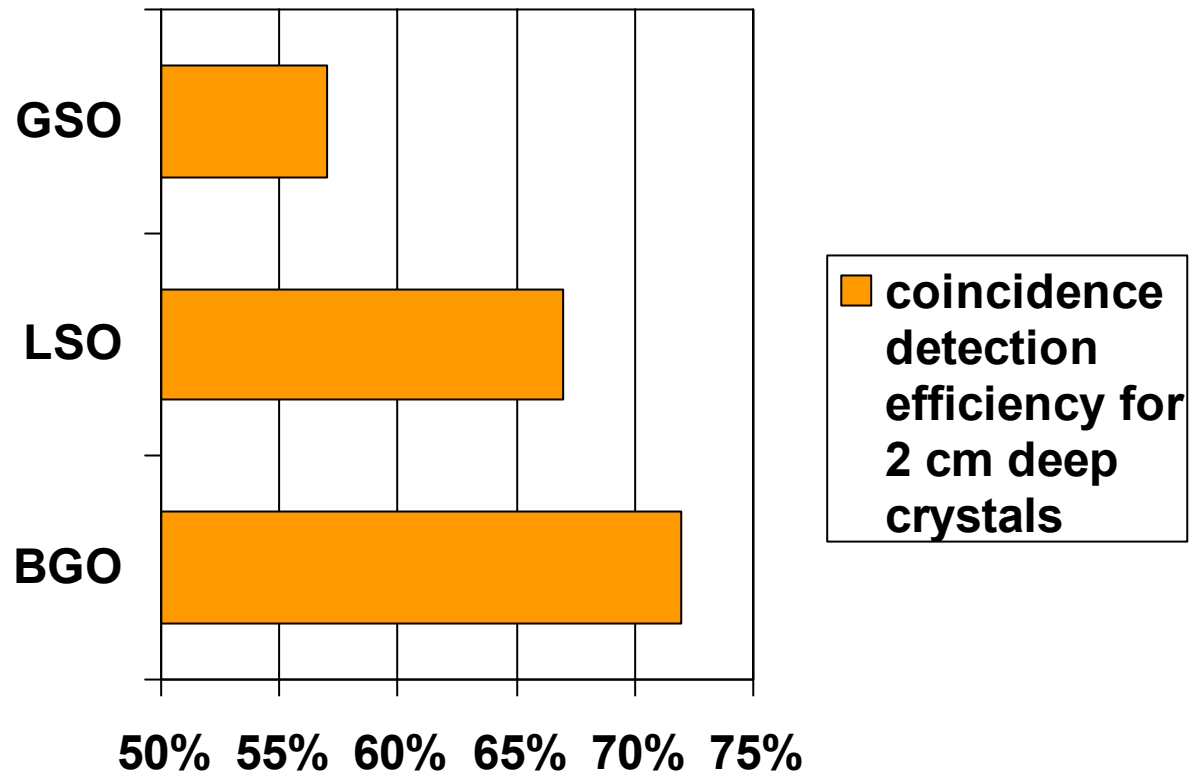
Characteristics of Selected Scintillators

	LSO	BGO	GSO	NaI
Density (g/cc)	⇒ 7.4	7.1	6.7	3.7
μ (cm ⁻¹)	0.86	⇒ 0.95	0.70	0.35
Decay Time (nsec)	⇒ 40	300	56, 600	230
Relative Light Output	75	15	25	⇒ 100
Energy Resolution	10	10	9	⇒ 8

Detection of 511 keV photons

■ Relevant parameters:

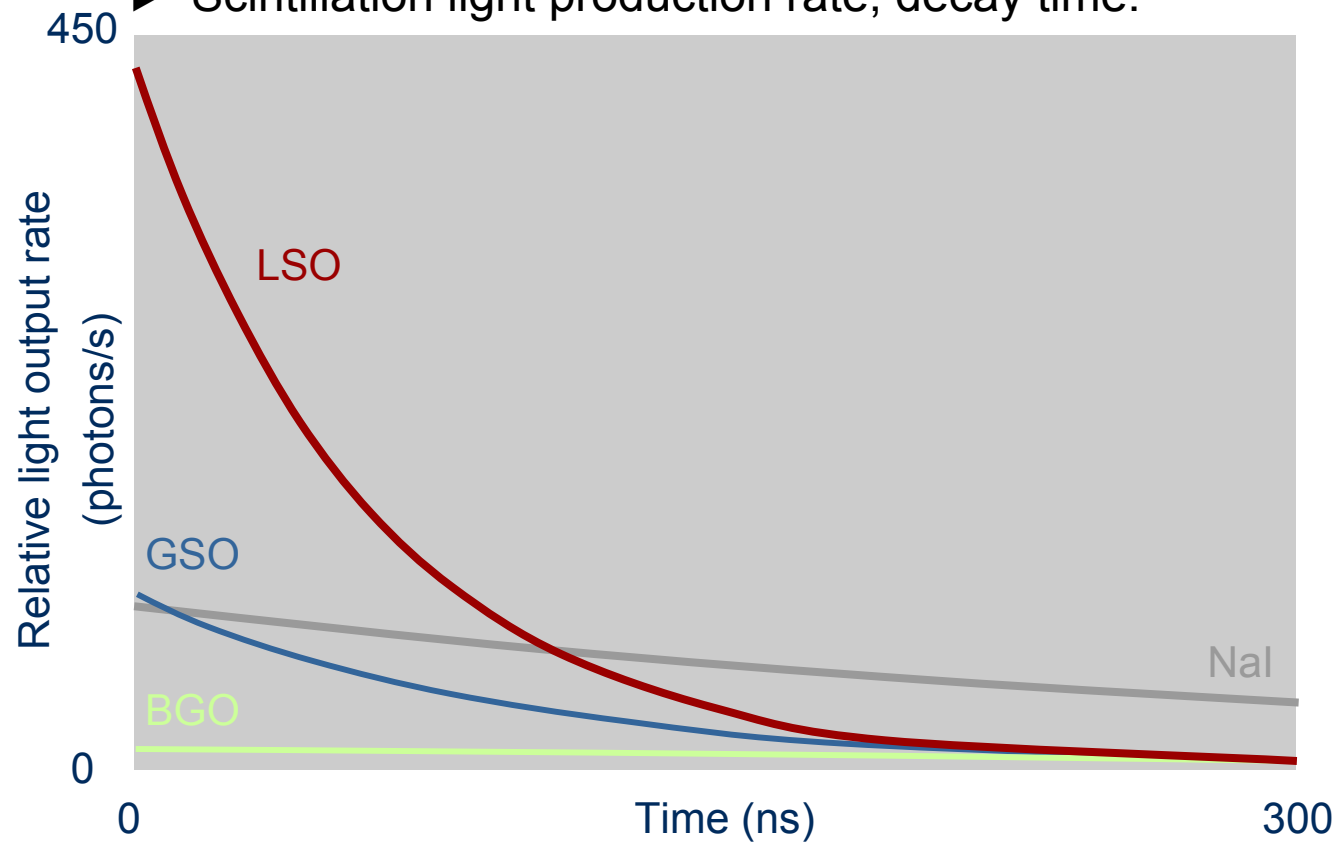
- ▶ Density, effective atomic number, absorption coefficient



Reducing the dead time

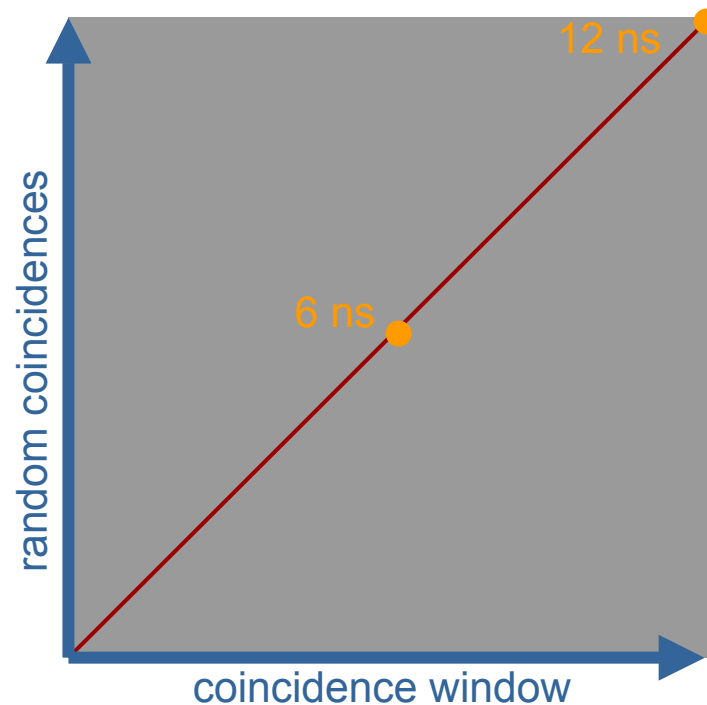
■ Relevant parameters:

▶ Scintillation light production rate, decay time:

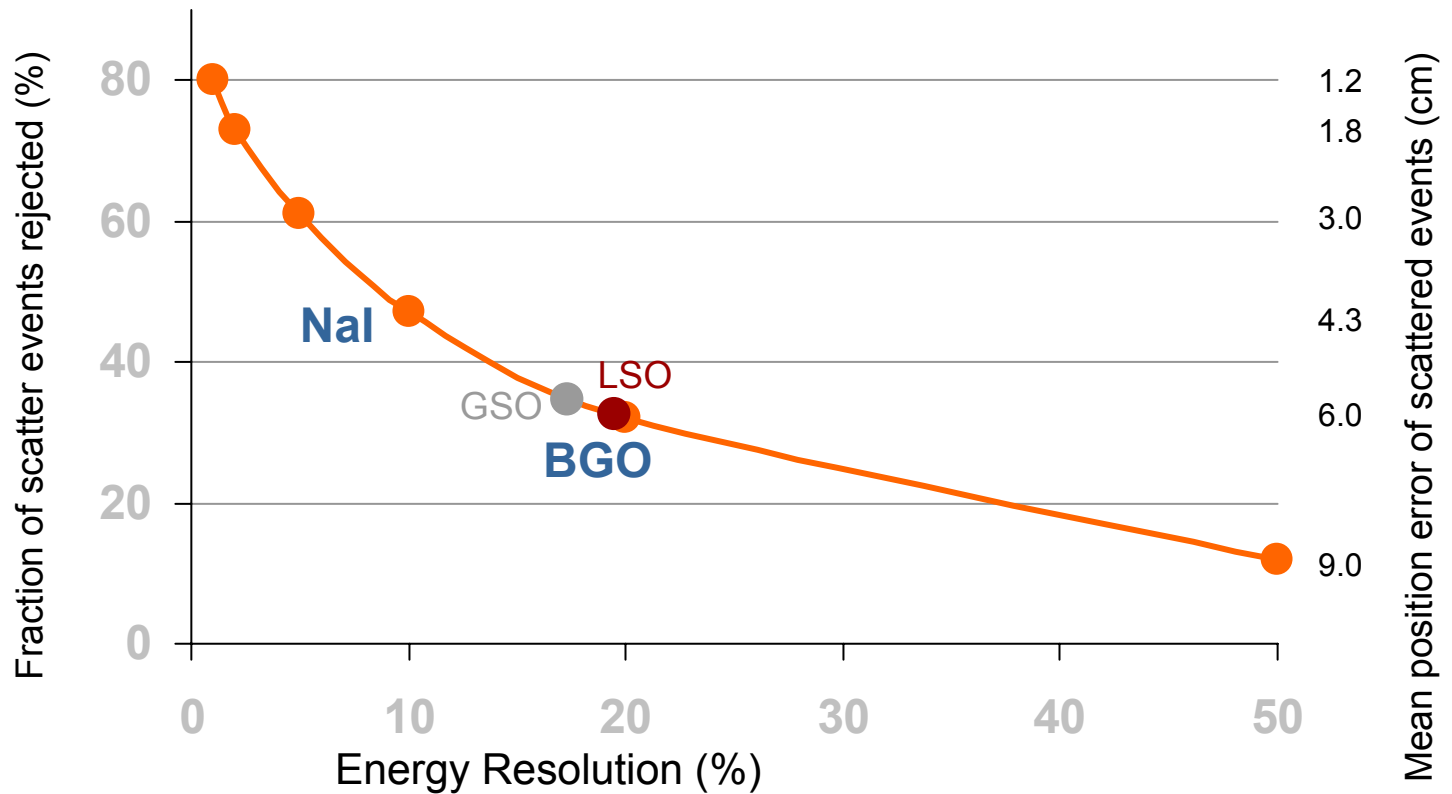


Reduction of randoms and scatter

- Relevant parameters:
 - ▶ Coincidence window
 - ▶ Energy resolution, scatter correction algorithm



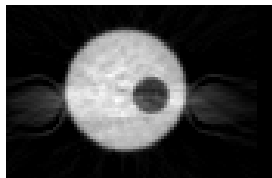
Energy Windowing Scatter Correction



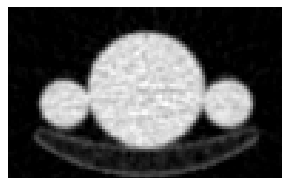
Scanner energy window = +/- energy resolution

Image-based Scatter Correction

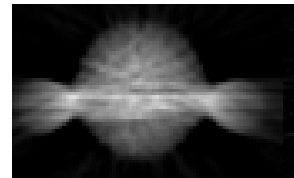
- Automatically corrects for varying patient geometry
- Corrects scatter for quantitative accuracy
- Determines scatter from both transmission and emission images:
 - ▶ Rays are traced through the attenuating medium (transmission image) starting with the isotope distribution (emission image)
 - ▶ Scatter within each voxel of the image is derived
 - ▶ The resulting scatter map can be subtracted from the emission images



Emission



Transmission



Scatter

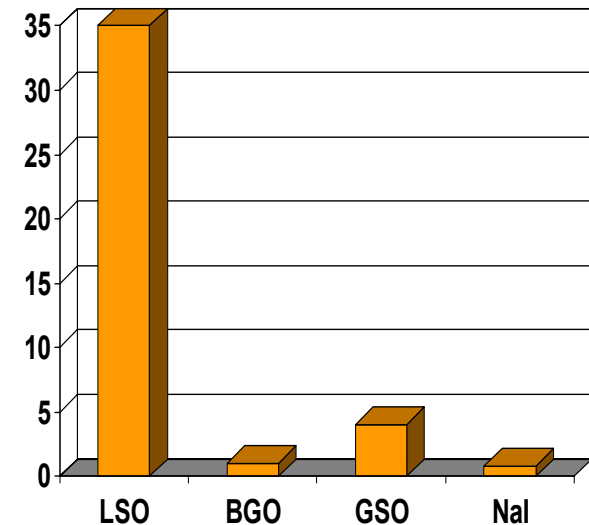


Corrected

LSO Performance (figure of merit)

$$\text{F.O.M.} = E_p \times (1/\tau) \times (\text{Light output})$$

- E_p is the PET detection efficiency
- τ is the lifetime
- *light output* is the total number of photons generated in the detector for a single gamma ray event.



LSO – the ideal PET detector

- low dead time
- high count rate performance
- low random fraction
- fully 3D compatible
- high patient throughput
- perfect image quality
- mandatory for positron emitters with short half live

- high light output for design flexibility
- time of flight ready

ECAT ACCEL

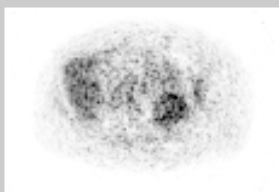
- High count LSO detectors
- Efficient 3D acquisition
- One button WB Protocol
- Automated QC and Attenuation Correction
- **e.soft PET functionality**



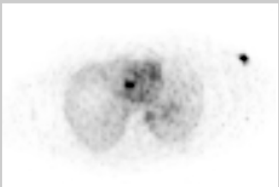
Unmatched throughput by any dedicated PET system.

Patient Throughput

August 9, 2001 on the Accel . . .



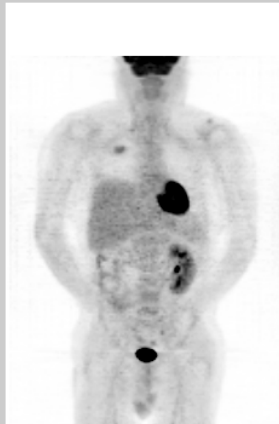
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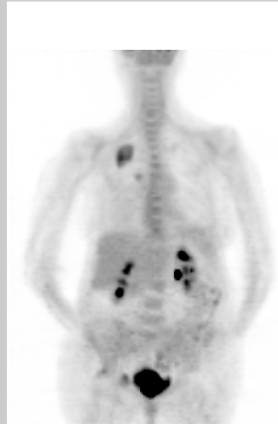
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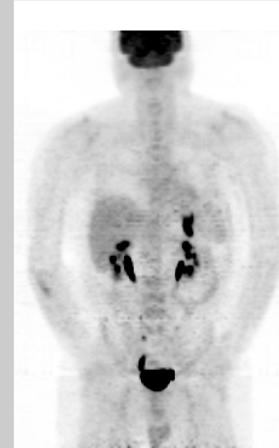
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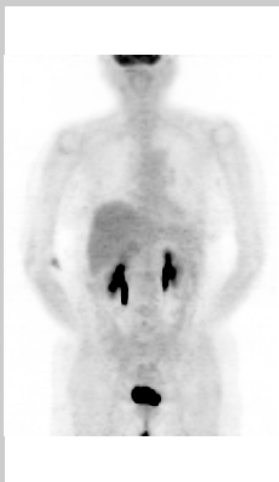
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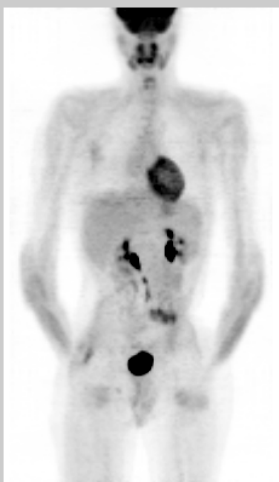
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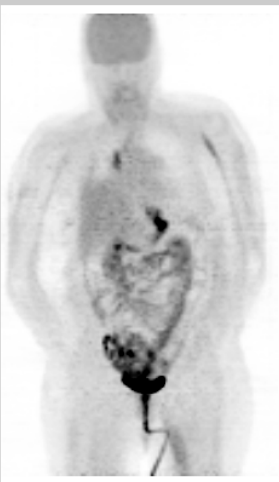
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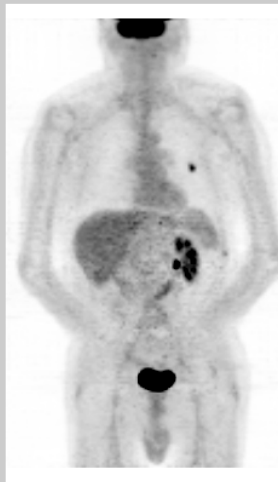
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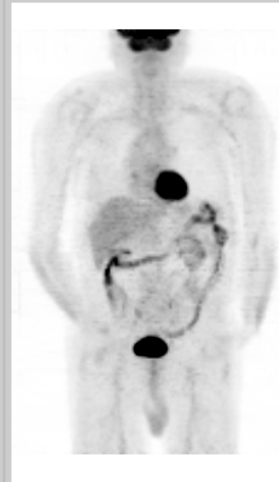
1:12 pm



2:09 pm



2:57 pm



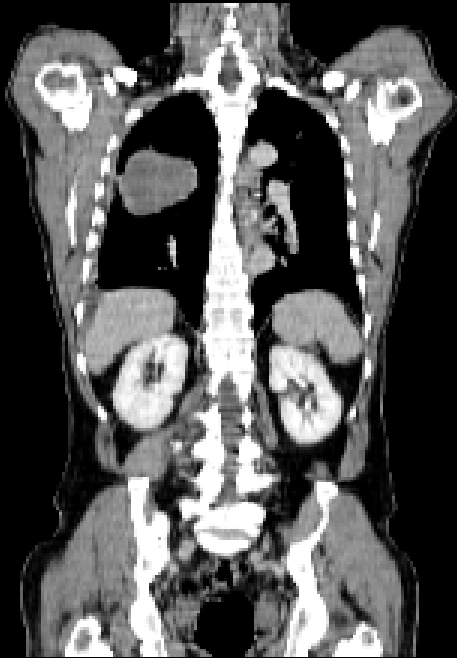
3:46 pm

NCPIC

biograph LSO

- LSO PET performance
- Somatom Emotion CT performance
- Patient handling system for perfect image matching
- syngo software integration





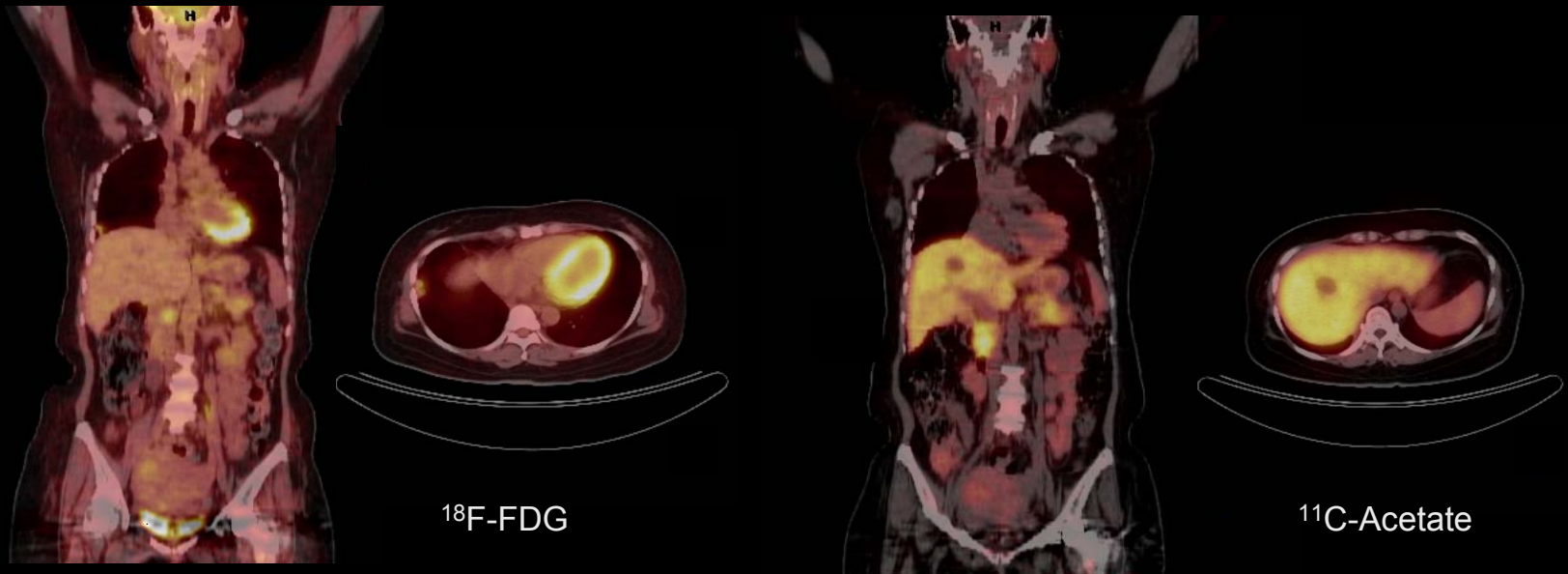
Lung Cancer

63 year old male with a mass in the right lung. biograph LSO identified peripheral lesion activity.

Scan protocol: CT i.v. and oral contrast, 100 mAs, 130 kVp, 5 mm slices

PET 500 MBq FDG, 60 min p.i, 2 min/bed, 6 beds, 12 min scan time

Data Courtesy of Hong Kong Baptist Hospital



Fluorine-18 and Carbon-11 whole body images

Carbon-11 tracers complement the use of FDG and improve the sensitivity and specificity in molecular imaging of some FDG non-avid tumors (e.g. hepatocellular CA, renal cell CA, prostate CA).

The very high count rate capability of biograph LSO enable 1- or 2-min per bed position and serial scans to be acquired in the same patient.

biograph Sensation 16

- Fastest PET, CT, & PET/CT scan times
 - ▶ PET: 3D LSO performance
 - ▶ CT: 16 slices, 0.4s rotation, 0.5 mm³ resolution
- Maximum flexibility
- Largest uniform patient port (70 cm)
- WholeView 180 cm bed travel
- ACPlus extended CT FOV attenuation correction
- Highest patient weight tolerance (204 kg)
- Integrated console design
- Automated acquisition protocols
- High precision patient handling system
- Seamless connectivity





Bladder Cancer

46 year old male (97 kg) with history of bladder cancer invading the prostate; s/p cystectomy, prostatectomy, right lower quadrant ostomies. For assessment of possible pelvic recurrence. biograph Sensation 16 demonstrates area of increased activity overlying the right anterior abdominal wall due to ostomy. No evidence of recurrent or metastatic disease.

Scan protocol: CT 140 mAs, 120 kV, 5 mm slices

PET 410 MBq FDG, 159 min p.i, 5 min/bed, 6 beds, 30 min scan time

Summary

■ LSO offers:

- ▶ high sensitivity for 511 keV
- ▶ short decay time
- ▶ high and fast scintillation light output

■ for:

- ▶ low dead time
- ▶ high image quality
- ▶ high patient throughput
- ▶ effective use of activity in the patient
- ▶ flexible scanner design

Siemens **medical** **Solutions** that help