Walk-Through Flat Panel Total Body PET

A novel scanner design for efficient patient throughput and detector usage

Jens Maebe, Florence Muller, Nadia Withofs, Maya Abi Akl, Meysam Dadgar, Christian Vanhove, Stefaan Vandenberghe
MEDISIP, Department of Electronics and Information Systems, Ghent University, Ghent, Belgium
✉ **FlorenceMarie.Muller@UGent.be**
Jens.Maebe@UGent.be

Motivation

- **Sub-one minute PET scans** are now possible due to a combination of longer axial fields-of-view and advances in detector technology
- The current limitation for patient throughput is patient preparation and positioning on the bed, rather than scan time
- Current total-body (long axial field-of-view) PET scanners are too expensive for clinics due to high number of expensive detectors and high installation costs

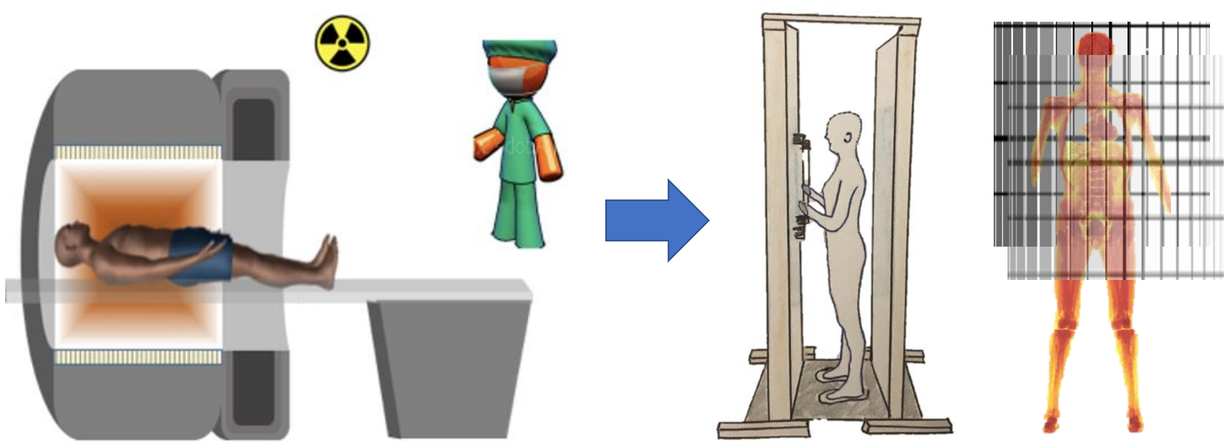
15s acquisition with Biograph Vision Quadra (106 cm field-of-view) →

Advantages of this design

- **High patient throughput** (about 3 minutes patient after patient)
- **Small footprint** (2-4m^2) compared to conventional PET/CT (30-40m^2)
- **Simultaneous head + torso imaging** due to 105 cm axial field-of-view
- **About 4x higher sensitivity than conventional PET/CT**
  → enables faster or lower dose imaging
- **Similar cost to conventional PET/CT** (only 25 cm axial field-of-view)

System design

Conventional → Walk-Through



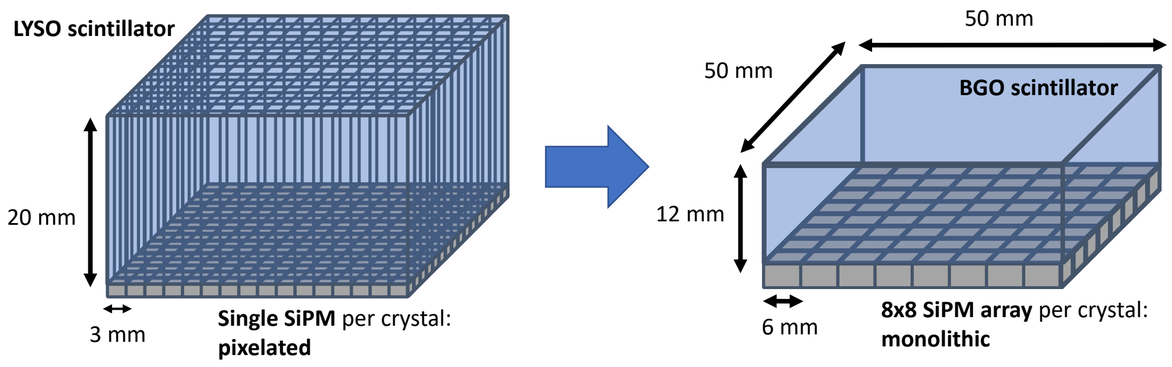
Two vertical, flat panels

- Two panels (each 70x105 cm^2) placed vertically 50 cm apart
- Dimensions chosen based on measurements of 40 PET/CT patients
- Panel position adapts to patient height
- Patient stands still for a 30 second scan
- Flat panel design reduces time for patient positioning and personnel

→ **1.9 x less detector surface for same axial field-of-view in cylindrical total-body PET**

Detector design

Conventional → Walk-Through



Monolithic BGO detectors

- **Very good detector spatial resolution** (1-1.5 mm) with deep learning for event positioning, not limited by pixel size (usually around 3mm)
- **Decent coincidence time resolution** (300 – 400 ps) due to Cerenkov light
- **Cheaper**: BGO is 3x cheaper than LYSO and fewer electronics required compared to pixelated detectors due to larger SiPMs
- BGO has roughly **20% higher sensitivity** and a **higher photofraction** (40% instead of 32% → less scattering) compared to LYSO

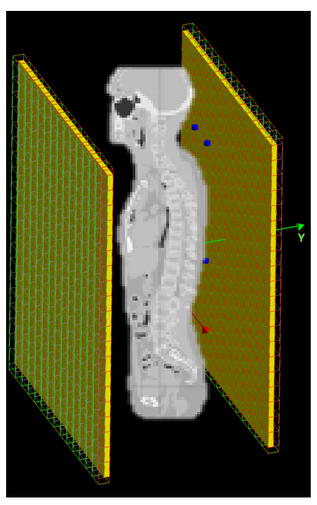
→ **Lower cost detectors (4-5 x less for a full system) with better spatial resolution but inferior timing**

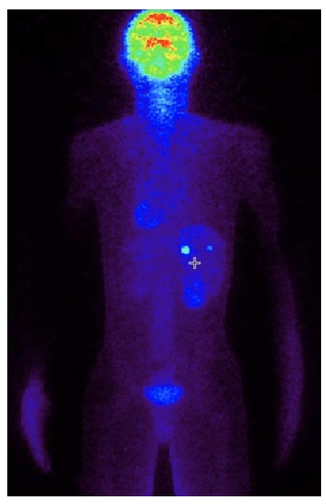
Ongoing research and results

System characterization

- Monte Carlo simulation in GATE software
- Reconstruction with QETIR software
- Comparison with Siemens Vision Quadra scanner (clinical PET scanner with same axial field-of-view)

→ **1.5 – 2 mm spatial resolution** in all directions
→ **Sensitivity only 33% lower than Siemens Quadra**





Siemens Quadra
Scatter Fraction: 31.03 %
Randoms fraction: 14 %

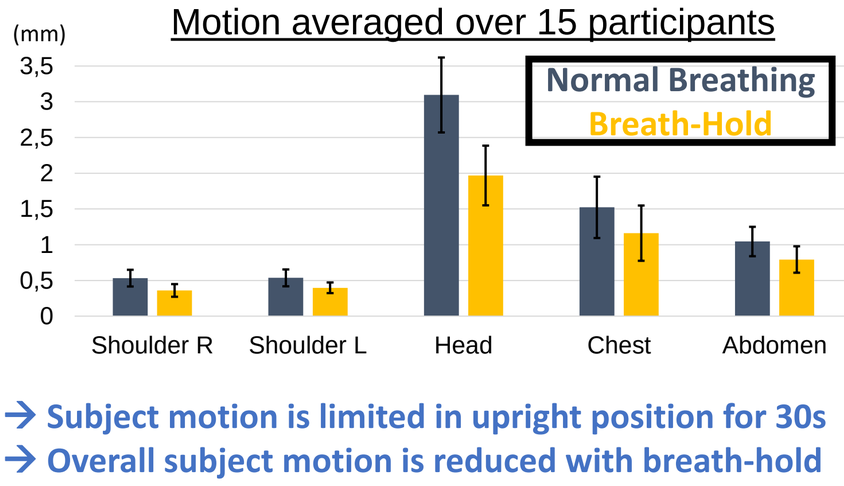
Walk-Through PET
Scatter Fraction: 29.6 %
Randoms fraction: 9%

First simulated reconstruction with XCAT phantom

Patient motion study

Patient motion while standing may be increased compared to lying down and could therefore impact scan quality → should be minimized

- Measure patient motion during 30s scan
- Motion tracked with 4 webcams and optical markers
- Compare normal breathing with breath-hold



→ **Subject motion is limited in upright position for 30s**
→ **Overall subject motion is reduced with breath-hold**

Conclusions

- Walk-Through PET allows for **high patient throughput total-body imaging** (full torso + head) at **affordable** costs for the clinic
- **Limited drawbacks** compared to more expensive cylindrical total-body PET scanners
- Increased patient throughput and lower dose imaging show **potential for screening and therapy follow-up**

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