

TOF-PET simulation

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OUTLINE

- What is PET?
- How it Works?
- The Line Of Response (LOR)
- Field Of View (FOV)
- Limitations of Current PET Scanners
- Total-body TOF-PET Scanner
- The Critical Concepts
- Simulation Package Information
- NEMA Standards Simulation

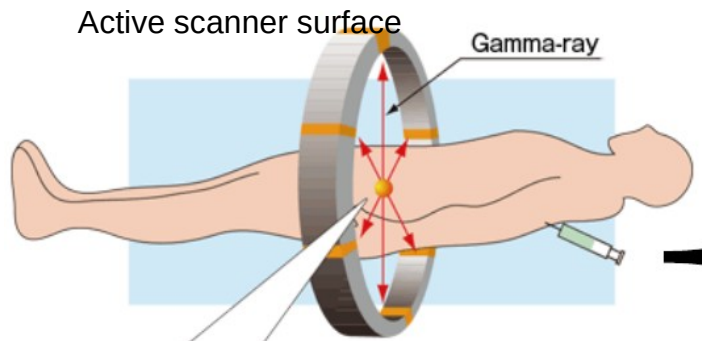
What is PET?

- Positron emission tomography (PET)
 - ⚙ A powerful medical imaging method
 - ⚙ Cancer screening
 - ⚙ Provides molecular imaging of biological function instead of anatomy

- New detectors using
 - ⚙ Time information to improve image quality
 - ⚙ Reduce the radiation dose inoculated to patients

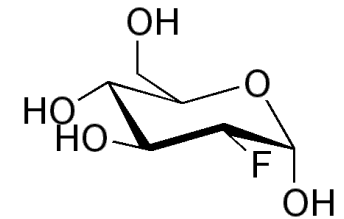
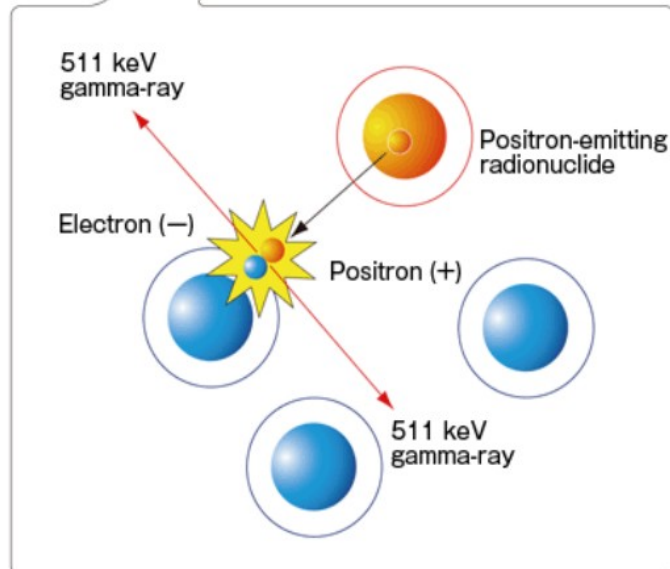
- Ultra-low dose imaging techniques suitable for
 - ⚙ Pregnant mothers
 - ⚙ Infants
 - ⚙ Children
 - ⚙ Anyone else who may be at high risk for exposure to radiation

How it Works?



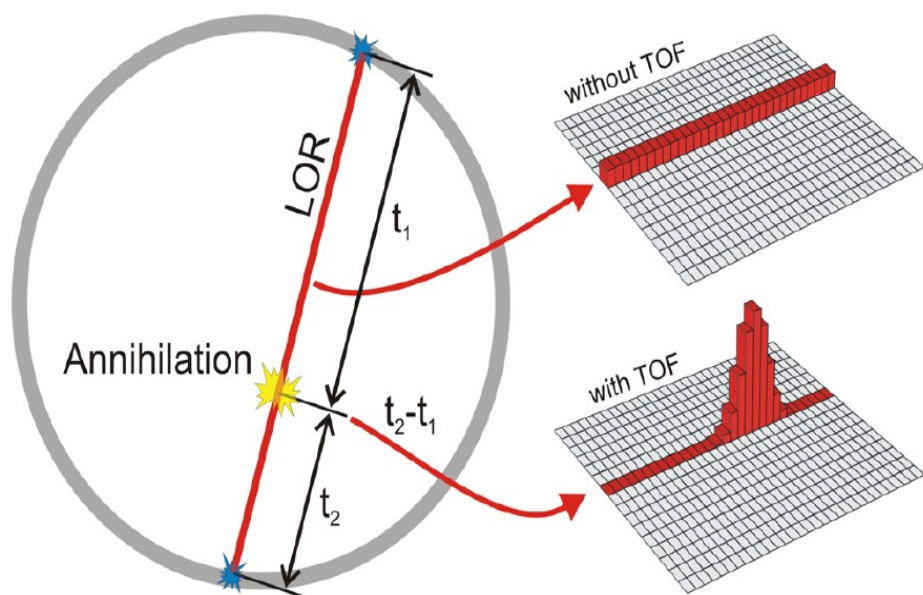
Radionuclide	Half-life
^{11}C	20 min
^{13}N	10 min
^{15}O	2 min
^{18}F	110 min

Most widely used radiotracer in the form of F-18 FDG

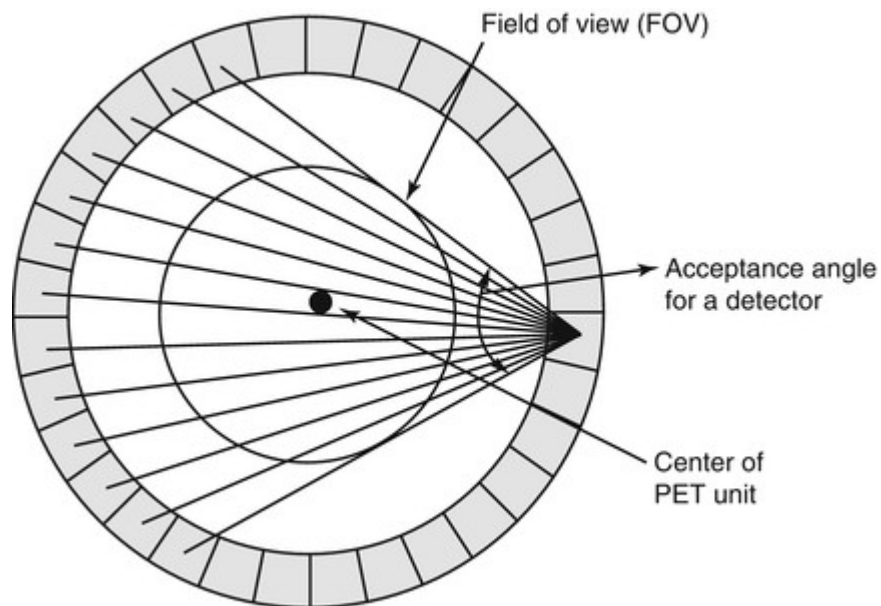


The line of response (LOR) & Field of view (FOV)

- The Photons hit detectors, construct **line of response (LOR)** for annihilation origin.
- **Field of view (FOV)** of the commercially devices is typically 20 cm to 30 cm then more than 85 % of the patient's body sit outside of the scanner.



https://the10ps-challenge.org/assets/img/10ps_motivations_06_11_19.pdf



<https://radiologykey.com/pet-scanning-systems/>

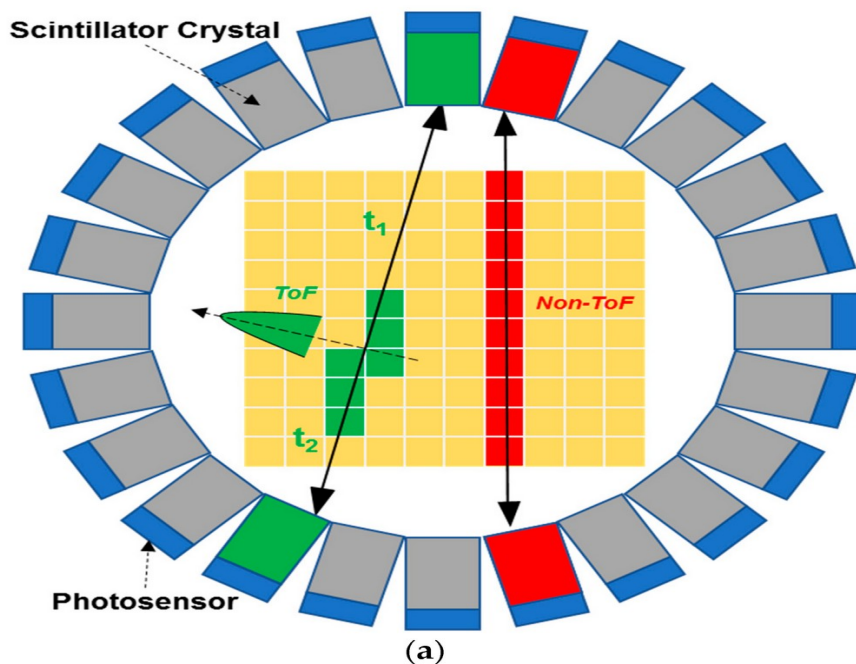
Limitations of Current PET scanners

Conventional PET scanners cover

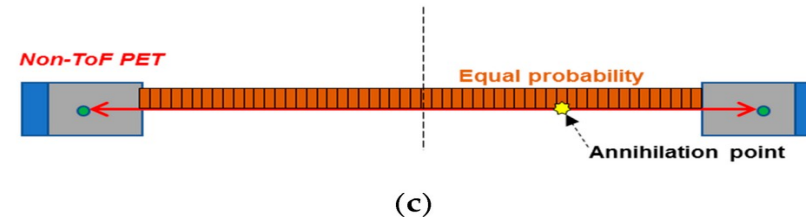
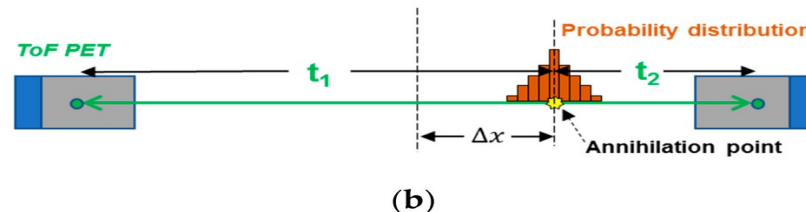
- A small field of view (FOV)
- Sensitivity limitation

The Time-Of-Flight (TOF) can increase

- The PET scanner resolution
- Reduces the number of required annihilation photons



Coincidence processing in time-of-flight (TOF) PET data acquisition



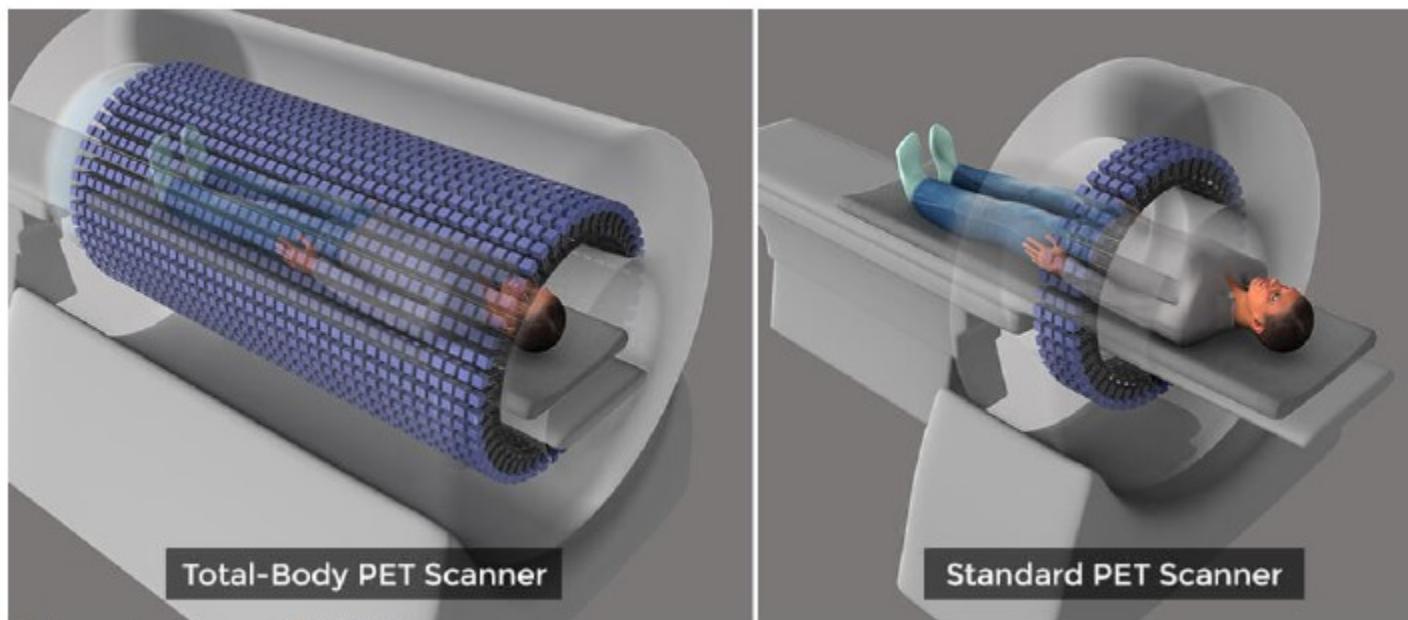
Coincidence processing in PET data acquisition

https://www.mdpi.com/sensors/sensors-19-05019/article_deploy/html/images/sensors-19-05019-g003.png

Total-body TOF-PET scanner

We have proposed to use of a **total-body TOF-PET scanner** By adding more rings

- * Ultra-low dose imaging
- * Ultra-fast readout electronics
- * A tight coincidence window around gamm-ray interactions
- * Identifying individual gamma pairs
- * Reconstructed individually the true positron annihilation vertex on an event-by-event basis



<https://www.cancer.gov/news-events/cancer-currents-blog/2017/total-body-pet>

Emerging technology coming from the field of direct dark matter searches for weakly interacting massive particles (WIMPs)

The critical concepts

1. Monolithic liquid argon (LAr) scintillator
2. Fast cryogenic SiPMs
3. Xenon doping (Fast Scintillation + Wavelength Shift)

Detecting LAr Scintillation Light

- Pure LAr and all surfaces coated with (TPB), referred to as LAr+TPB
- Doping the LAr with xenon, referred to as LAr+Xe.

Simulation Package Information

- Simulation package developed for the DarkSide dark matter search experiment (modified)
- Monte Carlo simulation package, based on the Geant4 toolkit
- Tracking the charged particles, γ -rays and the scintillation photons.
- Enabling full reconstruction of all events that have been simulated.

NEMA Guide

Performance Measurements of Positron Emission Tomographs (PET) Listed in the NEMA (National Electrical Manufacturers Association (NEMA) standards and guideline publications (working from 2 versions)

- NEMA NU-2 2012 STANDARDS SIMULATIONS
- NEMA NU 2-2018 STANDARDS SIMULATIONS

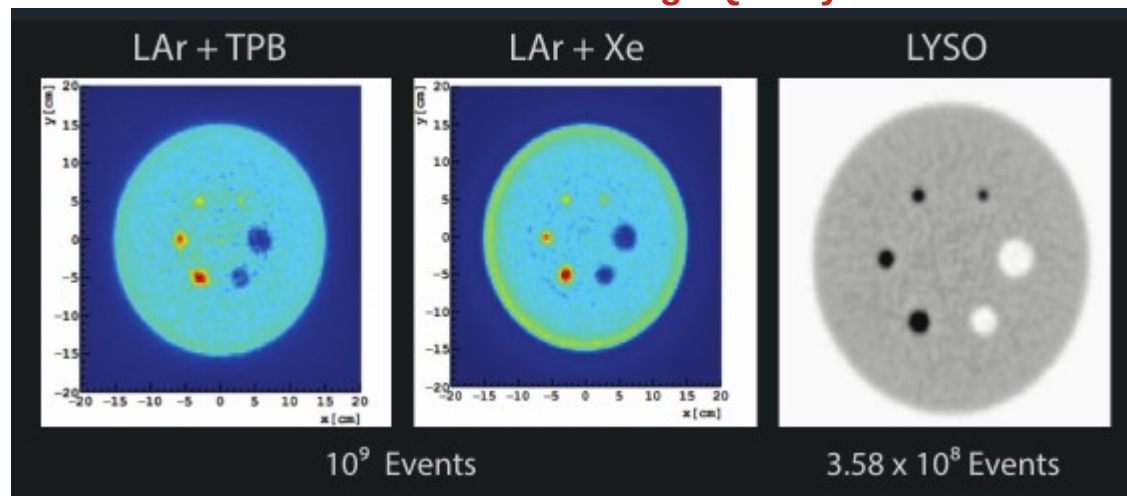
- Using three tests for each geometric configuration

- Sensitivity
- Spatial Resolution
- Scattering Fraction



- Choose the best geometric configuration and use that to run the image quality test
- Compare the image quality results with the results from the original geometry

NEMA NU 2-2012 Image Quality Test





Thank You For Your Attention

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