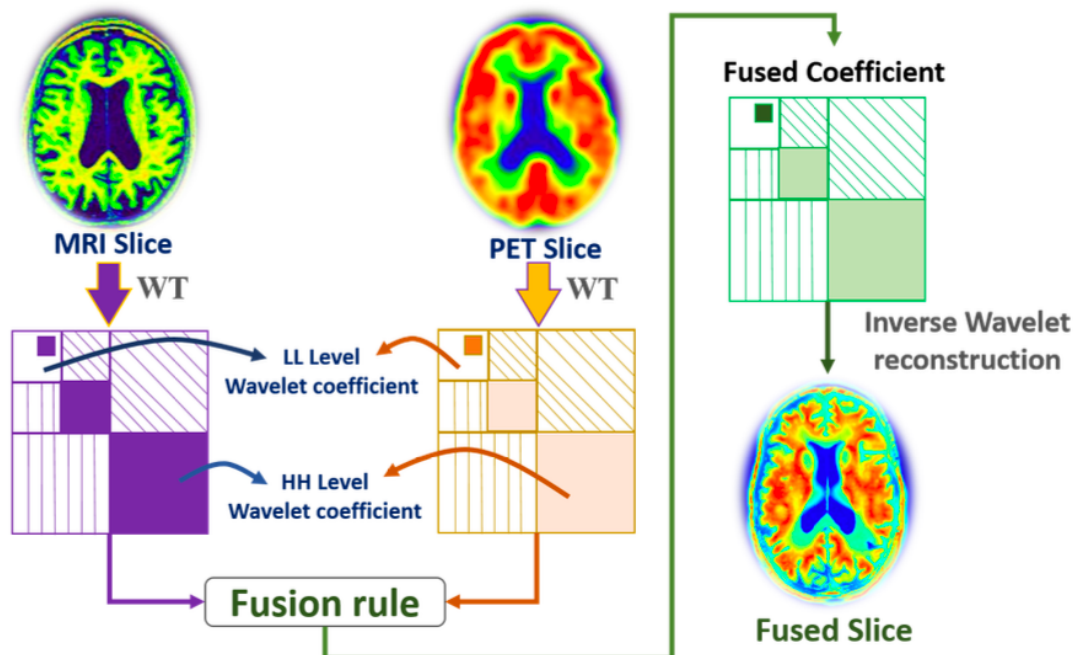


The integration of Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI) combines the strengths of both imaging modalities, offering a powerful tool for medical diagnostics. Briefly respond to the following questions:

- How does simultaneous acquisition of PET and MRI data work?
  - What are the technological advancements that have enabled the integration of these two modalities?
  - Discuss the challenges in combining the spatial resolution of MRI with the functional imaging capabilities of PET.
  - Provide examples where PET-MRI has significantly impacted patient outcomes.
- 
- How does simultaneous acquisition of PET and MRI data work?  
PET and MRI scans are conducted separately, and the images are later merged by specialized fusion software.

4

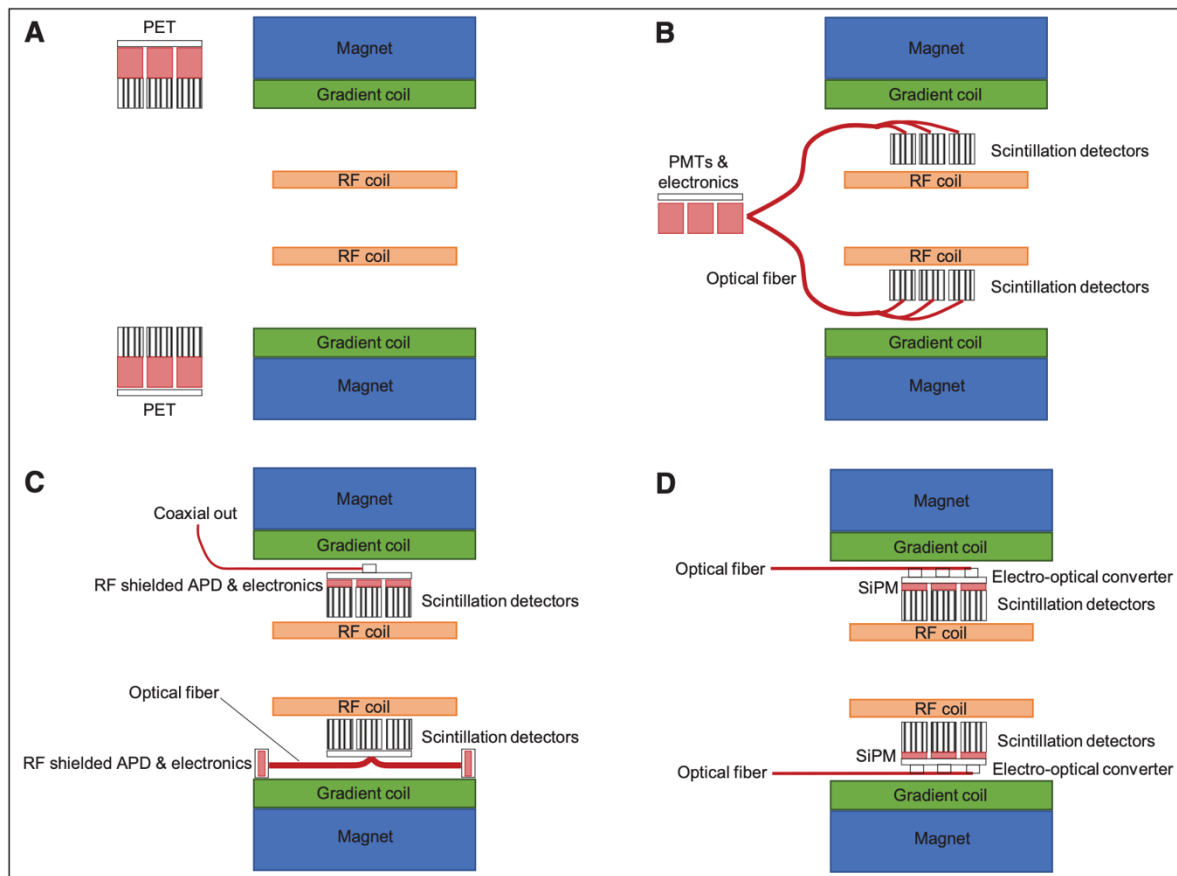


Example of Algorithm for MRI and PET slice fusion

- What are the technological advancements that have enabled the integration of these two modalities?

Photomultiplier tubes (PMTs) have been extensively employed in Positron Emission Tomography (PET) but are sensitive to small magnetic fields. In PET/MRI systems, initially long optical fibers were used to channel the light to safely located PMTs. Solid-state photon detectors like avalanche photodiode (APD)-based PET detectors can be

placed inside high-field magnets. In recent years, solid-state photomultipliers (SSPM), silicon photomultipliers (SiPMs) or multi-photon pixel counters (MPPC) have been considered to replace APDs [1].



### Different PET/MRI Integration Systems

- Discuss the challenges in combining the spatial resolution of MRI with the functional imaging capabilities of PET.

The main challenges in integrating PET and MRI [2]:

- To have a PET detector which operates in magnetic fields up to several Tesla to avoid distorting or artifacts in MR images
- Maintaining the homogeneity of the external magnetic field
- Avoiding the use of any conducting or ferromagnetic materials in the PET detectors which introduce electromagnetic interference in the radiofrequency part of the spectrum of the MR signal and create image artifacts.
- The MR radiofrequency coils must be carefully designed to minimally attenuate the 511 keV photons.
- “PET bed position” may not be enough time to complete all the required MRI sequences.
- In PET/CT systems, attenuation correction is typically performed using a low-dose CT scan, which provides a map of the body's attenuation coefficients (how much different tissues absorb or scatter the PET signal). These coefficients are directly

related to the density and composition of tissues, which the CT scan can measure. However, in PET/MRI systems, there is a challenge because MRI does not directly provide information about tissue density or the attenuation properties. Instead, PET/MRI systems use typical attenuation coefficients for tissues, Dixon-based MRI sequences or ML approaches (CNN or transformers)

- Provide examples where PET-MRI has significantly impacted patient outcomes. PET/MRI produces a reduced radiation dose which is particularly important in pediatric patients, pregnant women or cancer patients who are weakened by different regimen. PET shows the metabolic active tissue, while MR shows tissue alterations and spatial distribution of surrounding organs. PET/MR images are superior in organs that move (e.g., heart and lungs), that change (e.g. filling of urinary bladder), or in patients who move during scanning (from pain or anxiety). PET/MRI offers the chance to correct partial volume artifacts on PET images alone. PET/MRI can track stem cell migration into cancer cells or damaged brain regions.



PET/MR images with active metabolic regions within the human body

[1]: Catana C. (2017). Principles of Simultaneous PET/MR Imaging. *Magnetic resonance imaging clinics of North America*, 25(2), 231–243.

<https://doi.org/10.1016/j.mric.2017.01.002>

[2]: PET/MRI, Part 2: Technologic Principles

Geoffrey M. Currie, Peter Kamvosoulis, Stewart Bushong

Journal of Nuclear Medicine Technology Sep 2021, 49 (3) 217-225; **DOI:** 10.2967/jnmt.120.261862