Sense and Non-Sense About Sensitivity in PET

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Introduction

Recent advances in high-energy photon collimation have greatly improved preclinical PET performance. Over the past 20 years, new physical and hybrid collimation techniques [1–4] have addressed key limitations of electronic collimation, including image blurring due to photon non-collinearity, inter-crystal scattering, parallax effects in the detectors, and high background from random and scattered coincidences [5]. Although collimation reduces detected photon counts, efficient designs—such as super-clustered pinhole collimation in the MILabs' VECTor system with full-ring detector coverage—offer major advantages for small-animal imaging. The reduced single-photon efficiency is offset by the naturally higher abundance of single photons and the elimination of random and scatter coincidences. These improvements enhance signal-to-noise ratio and resolution by removing non-collinearity effects and reducing detector blurring, enabling more precise imaging of small regions of interest. Consequently, the VECTor achieves higher molecular sensitivity for detecting and quantifying small lesions and structures than conventional coincidence-based PET.

Sense and non-sense about sensitivity

Concerns may arise about the sensitivity of the VECTor system—the fraction of emitted photons it detects. While sensitivity affects image quality, it cannot be directly compared between coincidence-based PET and VECTor because the systems operate fundamentally differently. Coincidence PET always requires the detection of photon pairs, whereas VECTor detects individually collimated single photons.

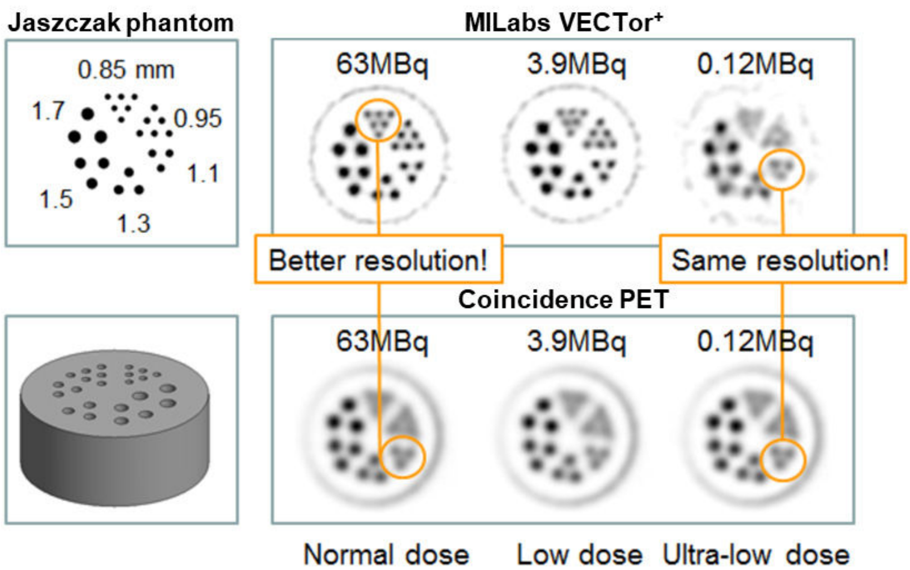

Figure 1. Comparison of coincidence imaging and VECTor at equal activity levels (equal dose and same acquisition times.

How should systems be compared?

For PET-only tasks, image quality provides a meaningful comparison. As shown by Walker et al. [6], VECTor delivers significantly better contrast and signal-to-noise ratio for small lesions. Coincidence PET typically cannot resolve structures smaller than 1.1–1.3 mm, whereas modern VECTor systems resolve features <0.75 mm (Figure 1). Thus, comparing systems by sensitivity alone is not meaningful when their imaging principles differ.

Please note that the Walker et al. comparison used an older generation of VECTor. Current VECTor systems achieve even better image quality through improved reconstruction and photon-transport models. In Figure 2, we show the best achievable resolution of 0.6 mm with the current MILabs system. Figure 3 further illustrates VECTor's superior structural detail in an *in vivo* ^{18}F-NaF mouse bone scan compared to a coincidence PET.

Conclusion: Defining "Absolute Equivalent Sensitivity"

Based on the above scans, supported by simulations, experimental results, and peer-reviewed publications, it is clear that MILabs VECTor provides substantially improved sensitivity for detecting small lesions. To achieve the same molecular sensitivity at 1.0 mm that VECTor provides at 0.75 mm, coincidence-based PET systems would require roughly a nine-fold increase in sensitivity. Although photon detection sensitivity varies slightly with the choice of collimator, the Absolute Equivalent Efficiency remains nearly constant at the high resolutions needed for rodent imaging. The table below (Table 1) summarises achievable resolutions with the VECTor system relevant to mouse studies.

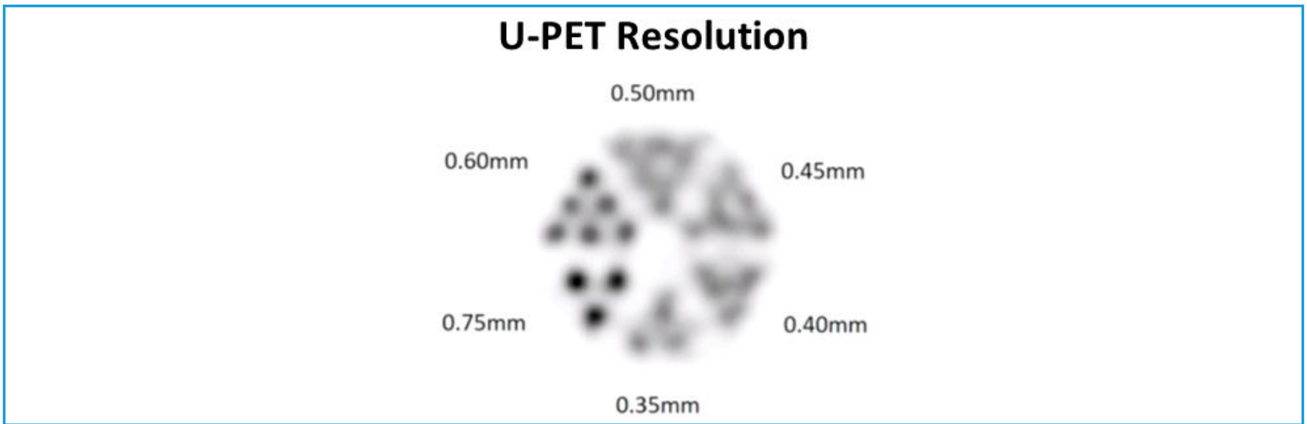

Figure 2. U-PET or VECTor resolution of 0.60mm with ^{18}F.

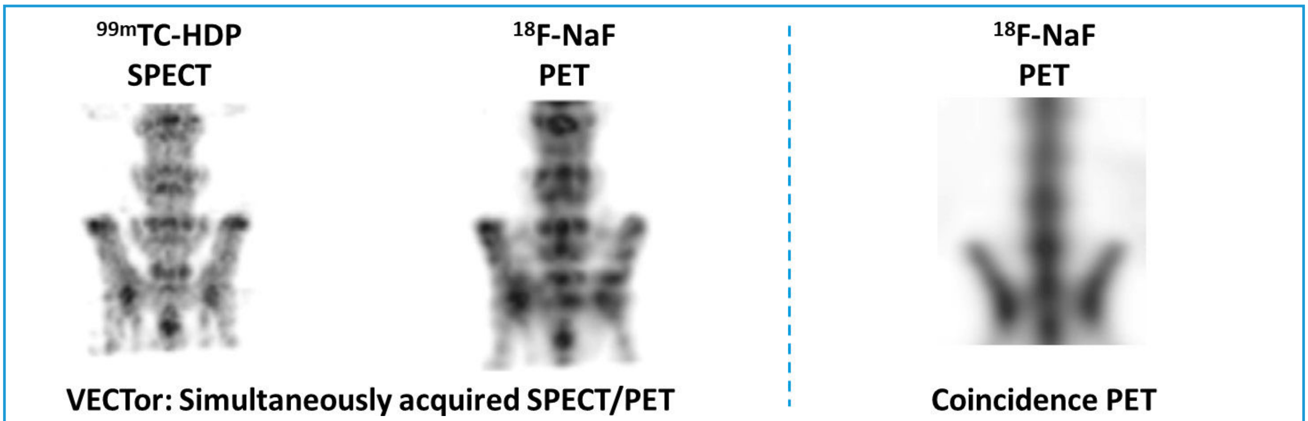

Figure 3. Comparison of VECTor (left) and Coincidence PET (right) imaging at equal activity, with double scan time for the Coincidence PET.

Clustered Pinhole Collimator	Resolution mm	Photon Sensitivity cps/MBq (%)	Absolute Equivalent Sensitivity (%)
HE-UHR	0.75 mm	9,000 (0.9%)	8.1%
HE-GP	1.25 mm	25,000 (2.5%)	7.1%

Table 1. Resolution and Sensitivity metrics for high energy collimators on VECTor systems.

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