Method Note

Albira SPECT Optimizations

Overview

This note is intended to provide an overview of the scan parameter (e.g. Collimator, FOV, Scan time), isotope profile variables, and post-processing relevant to achieving target resolution and contrast for a unique isotope, tracer, and model. Achieving the sufficient final total events/counts for a study is a critical variable to achieve desired results and should be considered when optimizing SPECT scan parameters.

Physical parameters (e.g. Field of View (FOV), Collimator Type, Scan Time) of a SPECT detection have a scaled impact on resolution and contrast. Further, SPECT studies may employ a range of isotopes (e.g. 99Tc, 111In, 177Lu) and tracers (ref 1-5). Each isotope/tracer presents a unique study/detection requirement. Different isotopes present variable gamma emissions and isotope profiles details, including peak emission and energy window, used in your study can provide optimized sensitivity and signal.

Physical Parameters & Acquisitions

The SPECT FOV and Collimator type have a strong influence on the achievable resolution and contrast.

Collimators

The Albira SPECT may include the collimators below. Selecting the appropriate collimator for an isotope, tracer, and model and study objective is important. Collimators offer variable sensitivity and resolution. (See Albira User Guide for instructions for exchanging collimators.) The Albira SPECT collimators are briefly described below:

Multi-pinhole (MPH)

- This is a 9-pinhole collimator intended for General Purpose use.
- This collimator provides the **highest sensitivity** and is particularly useful for achieving faster scans for applications with target object sizes >3mm (e.g. global organ or tumor uptake). In many cases, the high-count rate potential of the MPH will provide highest quality contrast and image quality.
- This is used routinely in 99Tc, 123I and 67Ga studies. The maximum recommended gamma energy is 175 keV.

Pinhole (PH)

- This is a 1-pinhole collimator.
- This collimator provides higher resolution (though only where sufficient counts are available) and is particularly useful for applications targeting objects sized <3mm (e.g. brain subregions).
- This is used routinely in 99Tc, 123I and 67Ga studies. The maximum recommended gamma energy is 175 keV.

High Resolution (HR)

- This is a 1-pinhole collimator designed for resolving small objects.
- This collimator provides higher resolution (though only where sufficient counts are available) and is particularly useful for applications targeting objects sized <1mm (e.g. brain subregions).
- This is used routinely in 99Tc, 123I and 67Ga studies. The maximum recommended gamma energy is 175 keV.

High Energy (HE)

- This is a 1-pinhole collimator designed to work with higher energy isotopes.
- This collimator provides higher blocking for higher energy isotopes and is particularly useful for applications targeting objects sized <3mm (e.g. brain subregions).
- This is used routinely in 177Lu, 131I and 111In studies. The maximum recommended gamma energy is 400 keV.

Field of View

The Albira SPECT cameras are mounted on a rotating gantry. The cameras also include independent positioning motors to control the distance of the cameras from the sample. This is controlled by the FOV parameter. The Albira SPECT provides four possible FOV settings: 25mm, 50mm, 80mm, and 120mm. The millimeter axial/transaxial image dimensions for the available settings are shown in Table 1.

	MPH	PH	HR	HE
25	25/20	25/20	25/20	25/20
50	50/40	50/40	50/40	50/35
80	80/64	80/64	80/64	80/55
120	120/96	100/80	100/80	NA

TABLE 1. Albira SPECT transaxial/axial reconstructed millimeter image dimensions (approximate) at Variable FOV (25mm, 50mm, 80mm, 120mm) and Collimator (Multi-Pinhole (MPH), Pinhole (PH), High Resolution (HR)) Combinations. Multi-position SPECT may be performed to achieve extended axial FOV (not shown).

Note that preclinical SPECT/CT is often performed using a SPECT FOV that differs from the CT FOV. Here, the SPECT FOV coverage is commonly shorter than the CT FOV coverage (e.g. Figure 1). When reviewing such SPECT/CT fusion data, it is important to consider that boundaries of the SPECT image do not match the CT image boundaries.

FIGURE 1. Albira SPECT coverage (solid circle) using a FOV50 single position SPECT scan will cover an axial range that is shorter than the CT coverage (dashed rectangle). Note that the SPECT FOV center is different than the CT FOV center, representing an H-Offset parameter that is different than the CT H-Offset parameter.

Note that it is important to center the SPECT FOV coverage over the target object. In many cases, it will be necessary to use a SPECT acquisition H-Offset value that is different than the CT acquisition H-offset.

Field of View & Sensitivity/Resolution

With a smaller FOV parameter, SPECT cameras move closer to the sample, and provide a higher sensitivity and resolution. Since both the FOV and Collimator influence the achievable sensitivity and resolution, there is an interplay in these final achievable metrics with variable combinations of FOV parameters and Collimator Type.

Figure 2 below shows the Sensitivity (cps/MBq) and Resolution (mm) achievable at the 12 combinations of FOVs and Collimators settings. These values are for 99Tc/SPECT, but may serve as a relative benchmark for other isotopes. (Note the High Energy Collimator is excluded from Figure 2 since its use is distinctly for high energy isotope studies, still overall relative trends in sensitivity and contrast relative to FOV setting apply).

CAUTION: Check the user guide to ensure the cradle is compatible with the SPECT FOV setting.

Low Activities and Scan Time

As noted above, achieving a sufficient total study count is important for reaching desired image quality. In studies where counts are low, it can be more difficult to identify an appropriate scan study time. **A preliminary 2D-SPECT may be useful for determining the appropriate scan time for new isotopes, tracers, and models.** (Note that 2D-SPECT is only relevant to single-pinhole (PH, HE, HR) studies.) In most studies this is only required in the first study for the new isotope, tracer, and sample. In subsequent studies, the Total Acquisition Time can be used directly.

Once a user identifies a scan time that provides the desired SNR/contrast with 2D-SPECT, a factor can be applied as an estimate for the Total Acquisition Time required to achieve a comparable SNR/contrast for the final SPECT. There is no single absolute factor, but often a 6X factor can be applied from 2D-SPECT results to achieve comparable final SPECT SNR/contrast.

Example: If a 2D-SPECT Acquisition at 300 second provides a desired contrast/SNR, then a Total Acquisition Time at 1,800 seconds (60seconds/p/camera) may produce a comparable SNR/contrast for the final SPECT.

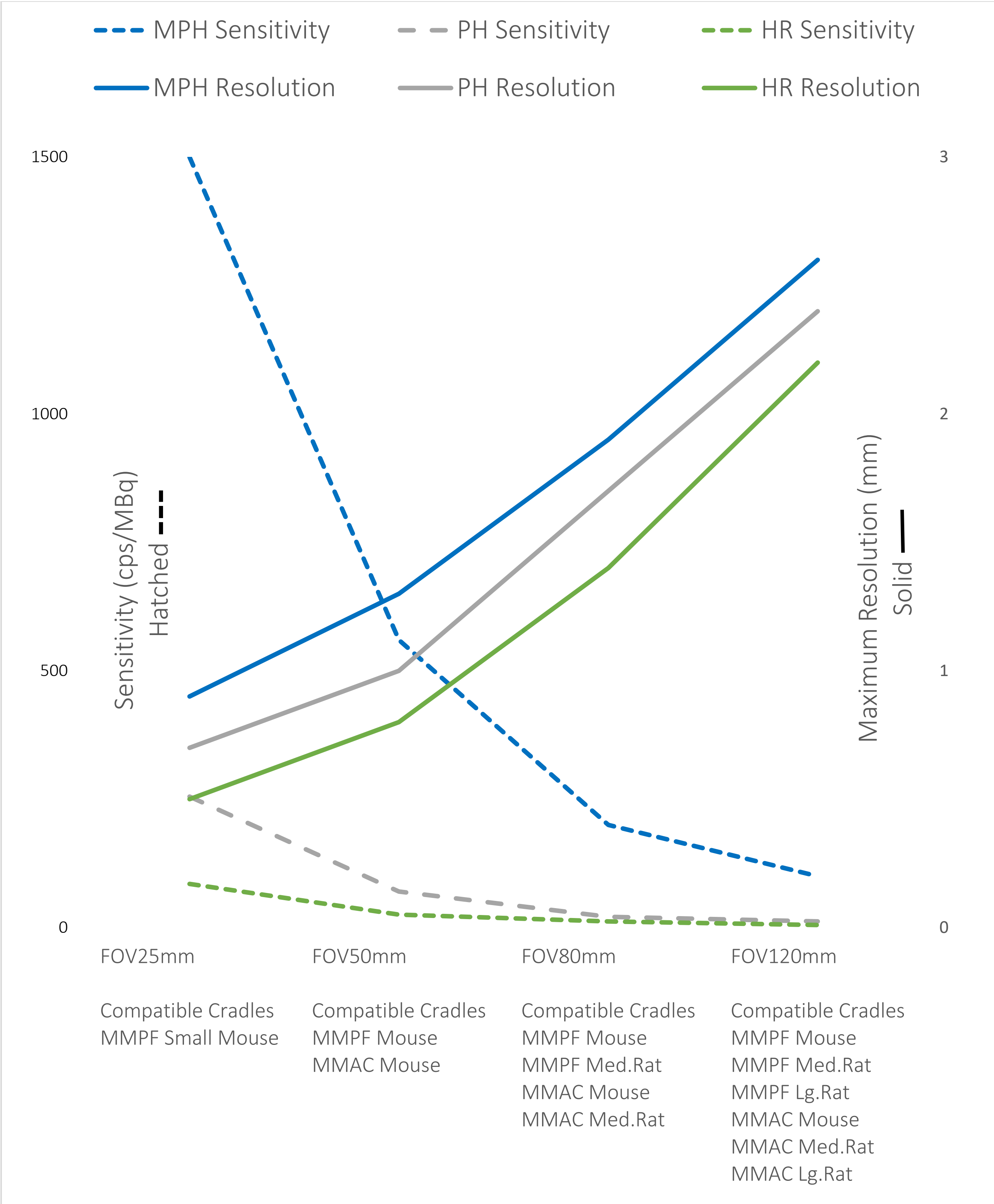

FIGURE 2. Albira SPECT Achievable Sensitivity (Primary Y-Axis, Hatched) and Resolution (Secondary Y-Axis, Solid) with Variable FOV (25mm, 50mm, 80mm, 120mm) and Collimator (Multi-Pinhole (MPH), Pinhole (PH), High Resolution (HR)) Combinations. Compatible cradles for specific FOV settings are also noted.

SPECT Isotope Parameters & Acquisitions

Your Albira SPECT scanner is provided with a default isotope profile for 99Tc. This 99Tc default profile has a 140/30 keV-Peak/%-Window, 6hr Half-Life, and 1.0 Branching factor. The system has also been calibrated for 99Tc uniformity. Users may create new isotope and compound profiles in the Manager>Isotope menu. Peak/Window, Half-Life, and Branching are required to generate the isotope profile. Certain isotopes have multiple gamma emissions. Typically, the most abundant emission spectrum is selected for peak detection. Users may reference literature and databases to determine the appropriate value. If the most abundant peak exceeds the efficient detection range of the SPECT cameras (400 kev), then a lower abundant peak may be used. For example, for 111In a peak of 173 keV rather than 247 keV is often used. For "noisy" isotopes with multiple emissions with close peaks, it may be useful to define a narrow %Window (e.g. 10-20%) to reduce noise, though this will reduce the sensitivity. To create custom uniformity profiles for isotopes other than 99Tc, scanning of the isotope in the cylinder phantom is required.

SPECT Data & Post-Processing

As mentioned above, obtaining sufficient counts is critical in nuclear imaging. Still, SPECT has a much lower sensitivity than PET. As a result, in many cases users apply smoothing or filtering techniques to improve the contrast/smoothness/shape of preclinical SPECT data. Some smoothing can be achieved by down-sampling the SPECT voxel used. Application of a 2 to 3 mm Gaussian 3D filter is used more often and can provide a better contrasted and smoothed results that accurately reflects distributions (Figure 3).

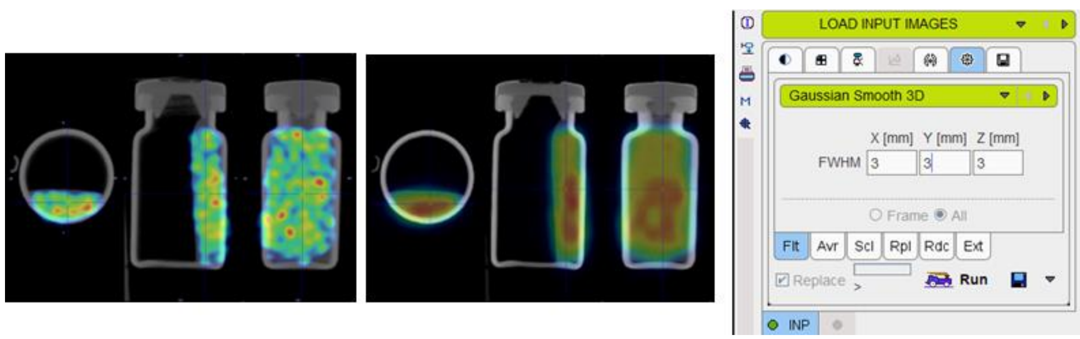

FIGURE 3. Data filtering is commonly employed in preclinical SPECT processing workflows. Example SPECT/177Lu image data, original (Left) and post processing (Right) applying a 3D Gaussian filter. Filtering selections are available in PMOD at the Image Processing Tools > Flt tab menu as shown.

Typical Results Using Parameter Concepts Above

Data below reflects typical results applying considerations above (Figure 4).

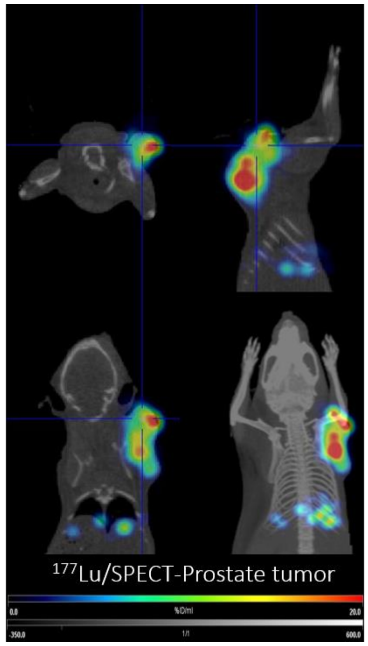

FIGURE 4. SPECT/177Lu in mouse tumor model study of candidate theranostic agent. Albira SPECT, HE Collimator, FOV50. 177Lu isotope 208keV/20%. Courtesy Nuclear Medicine Department, Imaging Facility, University Hospital of Bern (Inselspital), BERN Switzerland.

References

1. Cicone, F., Denoël, T., Gnesin, S., Riggi, N., Irving, M., Jakka, G., Schaefer, N., Viertl, D., Coukos, G., & Prior, J. O. (2020). Preclinical Evaluation and Dosimetry of [111In]CHX-DTPA-scFv78-Fc Targeting Endosialin/Tumor Endothelial Marker 1 (TEM1). *Molecular Imaging and Biology*, *22*(4), 979–991. https://doi.org/10.1007/s11307-020-01479-8

2. Lobaz, V., Konefał, R., Pánek, J., Vlk, M., Kozempel, J., Petřík, M., Novy, Z., Gurská, S., Znojek, P., Štěpánek, P., & Hrubý, M. (2019). In Situ In Vivo radiolabeling of polymer-coated hydroxyapatite nanoparticles to track their biodistribution in mice. *Colloids and Surfaces B: Biointerfaces*, *179*(March), 143–152. https://doi.org/10.1016/j.colsurfb.2019.03.057

3. Izquierdo-Sánchez, V., Muñiz-Hernández, S., Vázquez-Becerra, H., Pacheco-Yepez, J., Romero-Piña, M., Arrieta, O., & Medina, L. (2018). Biodistribution and Tumor Uptake of 67Ga-Nimotuzumab in a Malignant Pleural Mesothelioma Xenograft. *Molecules*, *23*(12), 3138. https://doi.org/10.3390/molecules23123138

4. Aranda-lara, L., Ferro-flores, G., Azorín-vega, E., Santos-cuevas, C., & Isaac-olivé, K. (2016). breast cancer. *Applied Radiation and Isotopes*, *107*, 214–219. https://doi.org/10.1016/j.apradiso.2015.10.030

5. Chapman, S. E., Diener, J. M., Sasser, T. a, Correcher, C., González, A. J., Avermaete, T. van, & Leevy, W. M. (2012). Dual tracer imaging of SPECT and PET probes in living mice using a sequential protocol. *American Journal of Nuclear Medicine and Molecular Imaging*, *2*(4), 405–414.