Targeted radionuclide therapy (TRT) is becoming an increasingly important tool for therapy of some cancers including non-Hodgkins lymphoma, thyroid cancer, and neuroendocrine tumors. The dose delivered to neoplasms and normal tissues, and thus the therapeutic response and incidence of toxicities, depends on the anatomy and physiology of the patient. Therefore, optimal treatment planning requires estimating the dose distribution for each patient. The dose distribution is estimated in two steps: measurement of the activity distribution of a planning dose at a series of time points using nuclear medicine imaging methods and calculating the dose to organs or voxels in the patient. State of the art dose estimation requires, as an input, estimates of the 3D activity distribution of the planning dose in the patient at each time point.

The 3D activity distribution of a radionuclide can be estimatedusing the tomographic nuclear medicine imaging modalities SPECT and PET. Since uptake times of TRT agents are typically on the order of several days, radionuclides such as In-111 or I-131 (for SPECT) or I-124 or Y-86 (for PET) having longer half-lives are used for treatment planning. The SPECT radionuclides emit medium or high-energy photons, which can make quantification of the SPECT images more difficult and requires compensating for the collimator-detector response. The PET radionuclides have prompt gamma emissions that can result in false coincidences, once again complicating quantification. For both modalitiesattenuation and scatter compensation are essential. Compensation for partial volume effects is important for dose-estimation in small objects such as tumors.

This lecture will review the challenges and recent advances in methods for quantifying 3D activity distributions from SPECT and PET imaging using radionuclides relevant for TRT. It will describe the impact of these advances in terms of metrics relevant to dose estimation and describe the levels of accuracy and precision that are obtainable with state-of-the-art methods.

Learning Objectives:
1. Understand the applications and requirements of quantitative SPECT and PET for targeted radionuclide therapy.
2. Understand the factors that limit the quantitative reliability of SPECT images and how to compensate for them.
3. Understand the factors that limit the quantitative reliability of PET.