Purpose:
A basic tenet of 4D-CT in helical mode is that each voxel at each position must be illuminated for the entire breathing cycle. This gives rise to the oft quoted equation pitch factor (PF) < BPM/RPM (breaths per minute divided by revolutions per minute). For cine axial mode, the equivalent requirement is the cine time (TC) > breathing period. The objective of this study is to demonstrate that these formulae are incorrect for helical scans and will require overlapped scans in cine axial mode. The PF adjustment and overlap percent are dependent on scanner geometry and reconstructed field of view (FOV).

Methods: With wide detector scanners, it cannot be assumed that the x-ray beam is parallel. Therefore, in calculating the total illumination time of any voxel, beam divergence must be addressed. It can be shown analytically that the FOV and source to isocenter distance will have significant impact on the time each voxel remains in the view of the multi-detector rings.

Results: Based on these calculations, PF is inversely dependent on FOV with a larger FOV requiring a lower pitch. In cine axial mode, the overlap percent increases with FOV. This overlap percent means that each couch increment will be less than the full detector collimation.

Conclusions: The commonly used approach for estimating PF or TC based on BPM is incorrect because it ignores the effects of beam divergence. For a geometrically accurate 4D-CT scan, a new formula was developed and it is dependent on FOV and source to CT isocenter distance. A method to account for beam divergence in axial scans was also described.

Funding Support, Disclosures, and Conflict of Interest:

Authors are employees of Philips Healthcare