

Breathing anthropomorphic thorax phantom for experimental studies on moving tumors

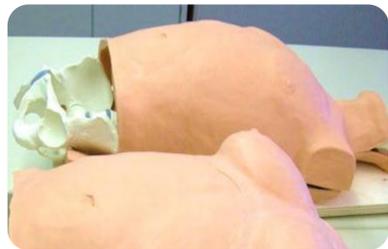
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CSEM is a private Swiss research and technology organization which delivers advanced technologies and unique R&D services to industry. Targeting emerging, strategic, high-impact technologies, CSEM brings new products to market and creates new ventures.

CSEM has developed a breathing, anthropomorphic phantom for PSI (Paul Scherrer Institute) in Switzerland for the following applications:

- Studies on motion mitigation techniques such as rescanning, gating, breath-hold, tracking
- Validation of 4D imaging techniques such as 4DCT and 4DMRI



Phantom skin options: female / male



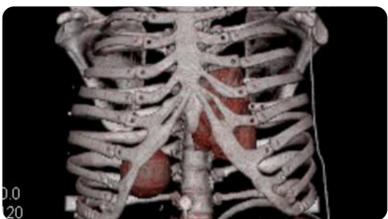
Realistic thorax motion with intercostal muscles



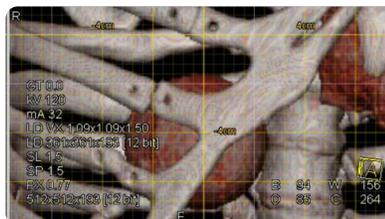
Set respiration pattern and motion range



4D CT scanning for data acquisition



4D CT sequence showing the motion patterns of the rib cage and tumor



Phantom

Thorax

- Anatomically correct phantom
- Realistic rib cage with intercostal muscle layers
- Generic lung with accessible compartment to place tumor inserts
- Realistic female and male skin
- Fully CT & MRI compatible
- Modular organ setup

Lung

- Reproducible tumor motion up to 20mm
- Freely placeable tumor location
- Optional lungs with vessels

Remote-controlled ventilation system

Ventilation system

- Fully reproducible test setups
- Multi-parameter pressure controlled ventilator
- Up to 6 meter air connection to phantom
- Optical sensor system for tumor motion tracking

User interphase

- Freely programmable respiration curves & patterns
- Import of recorded patient respiration data sequences
- Remote control

This Phantom allows for experimental studies in 4D imaging and radiotherapy delivery in a realistic human phantom.

Phantom for Proton therapy at PSI (Paul Scherrer Institute)

At the PSI proton therapy center, a spot-scanning proton beam is used for the treatment of deep seated tumors. Protons are known to have an advantage over conventional radiation therapy because of the substantially smaller dose delivered to the healthy tissue proximal to the target and no dose delivery to the tissue behind the target. Additionally, with the scanning technique as compared to proton scattering, target conformity is considerably enhanced.

However, for spot-scanning, problems can arise with the treatment of moving targets. For example, due to interferences between the dynamics of the scanning and organ motion (the interplay effect) significant dose in-homogeneities can arise. Consequently, at PSI currently, only static targets in the head, neck and spinal axis region are treated.

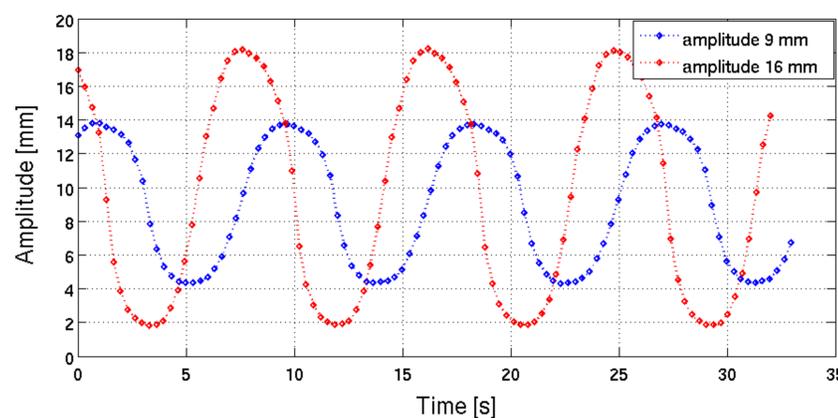
Organ motion with proton spot scanning

To tackle the problem of organ motion, PSI is in the final stages of the clinical commissioning of a new treatment facility (Gantry2) which is capable of both fast scanning and fast energy changes which in turn will allow for the implementation of various motion mitigation techniques such as rescanning, gating, breath hold and tracking.

Corresponding electron densities were determined from a CT scan. The obtained values as well as proton stopping powers are close to real tissue.

	Human tissue (HU)	Phantom tissue (HU)
Soft tissue / Tumor	40 - 80	~ 200
Bone	400 - 1000	~ 800
Lung / Foam	-700	~ -950
Intervertebral disk	50 - 100	~ 350

Motion simulates realistically complex patient internal (tumor) and external (rib cage) behavior. Main tumor motion is up to 2 cm in superior-inferior (SI) direction depending on the pressure settings. In anterior-posterior (AP) and lateral directions, the artificial tumor moves couple of mms.



Example 'Sine curve' respirations of the Phantom with 9mm and 16mm tumor motions in SI direction.

All information and test charts have been generated and provided from the PSI Proton Therapy Team of Prof. Dr. Toni Lomax.