



MASTER IN ENGINEERING PHYSICS



Thesis Proposal

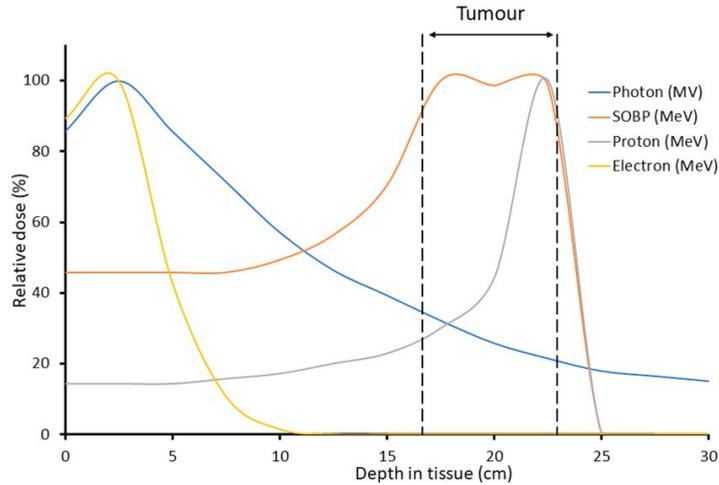
Automated positioning and calibration procedures for improved imaging performance of a novel small animal in-beam PET scanner

PIC2 Workshop Presentation | 28 January 2026

Carolina Fernandes Miranda

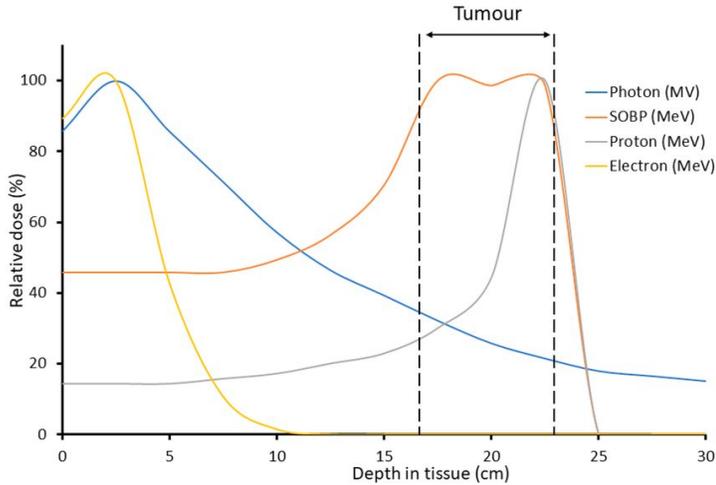
Supervisors: Prof. Katia Parodi, Prof. Pedro Assis
Ludwig-Maximilians-Universität München | IST - U.Lisboa

Charged particles offer a **superior dose profile** compared to photons, depositing a low dose up to the **Bragg peak**, and null dose beyond.



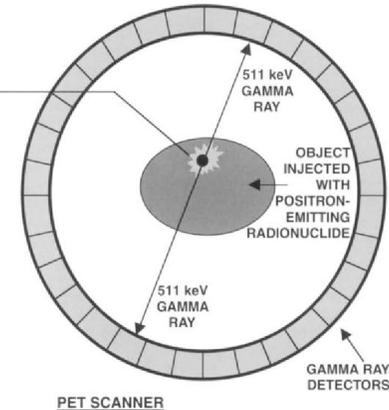
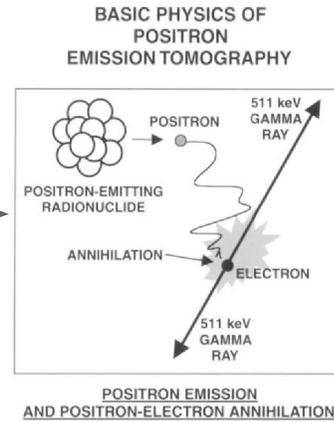
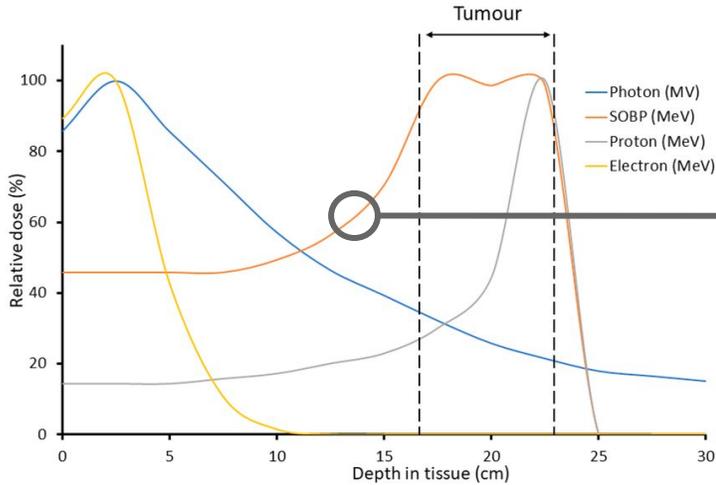
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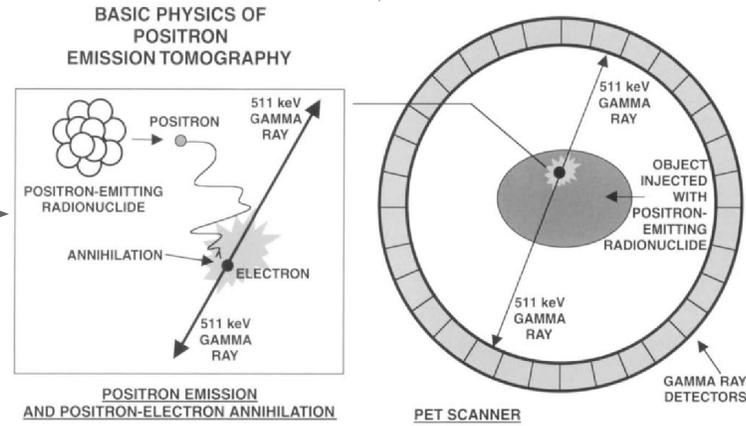
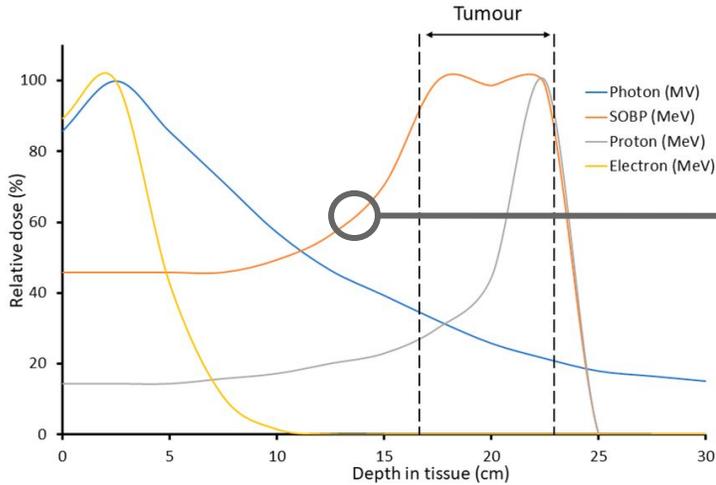


Nuclear interactions with tissue generate β^+ -emitting isotopes : ^{11}C , ^{15}O , ^{13}N .

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High sensitivity to range uncertainties from particle beam.

The reconstructed activity map is **correlated with the proton range**, enabling **non-invasive range verification**.



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Bridging the gap between *in vitro* cell studies and clinical trials using small animal models.

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Validating new delivery concepts like **FLASH therapy** (ultra-high dose rates) and **Proton Mini-Beams**.

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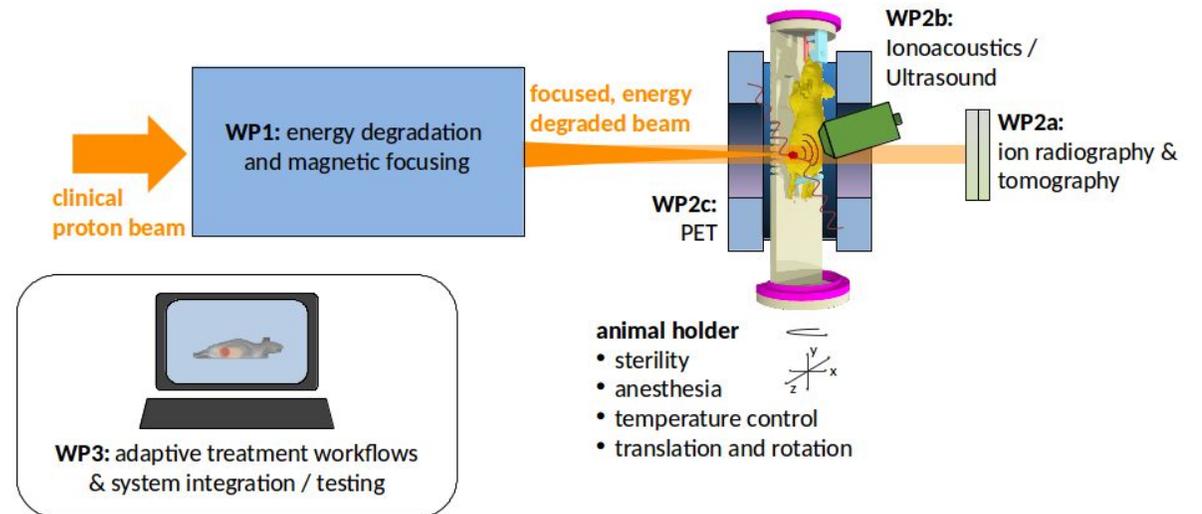
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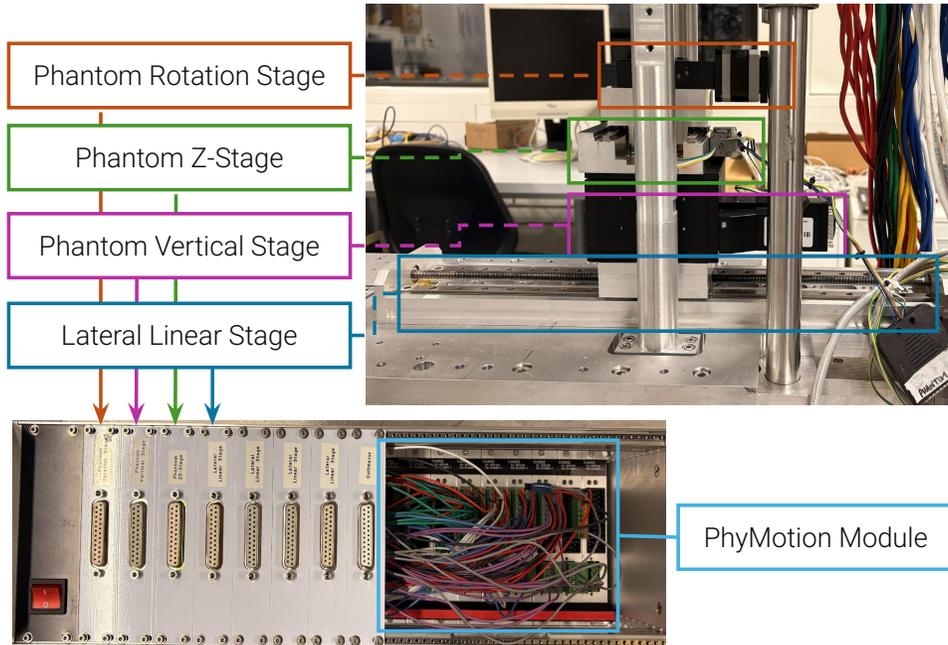
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Small Animal Proton Irradiator for Research in Molecular Image-guided Oncology

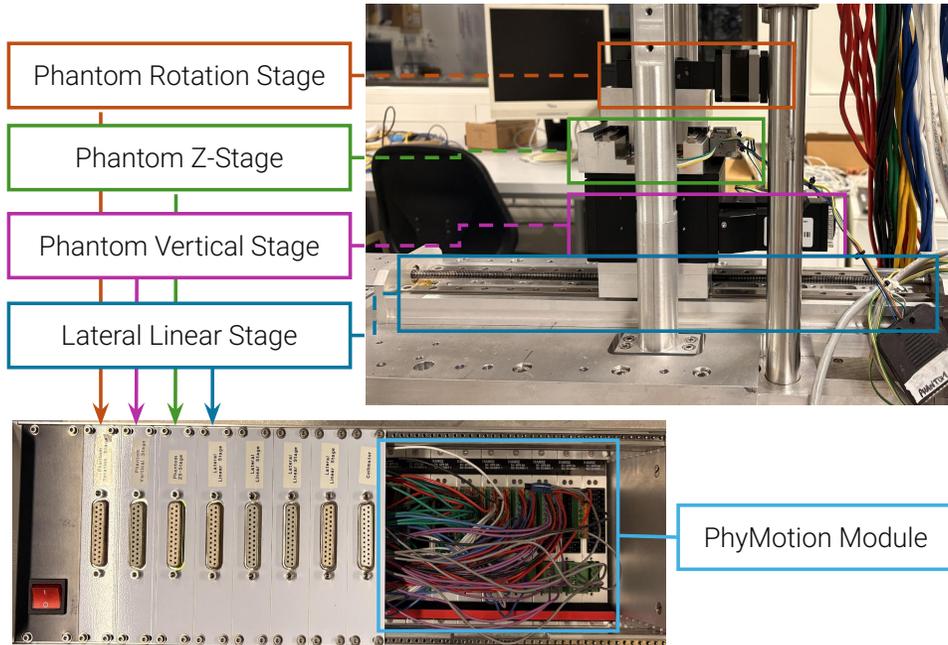




Instrumentation

4 Degrees of Freedom Motor Stages

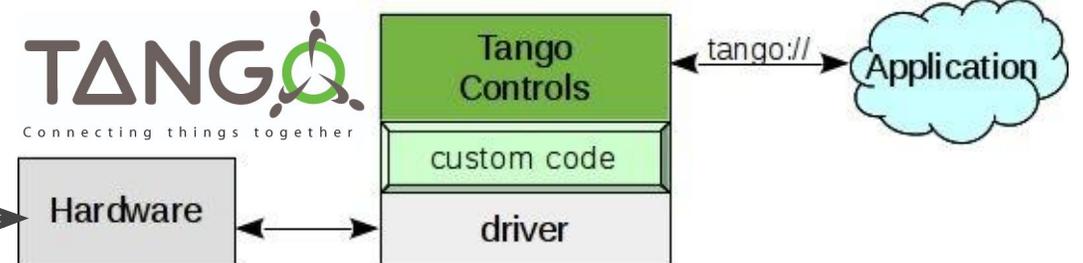
Controller: phyMOTION module for multi-axis stepper motor synchronization.

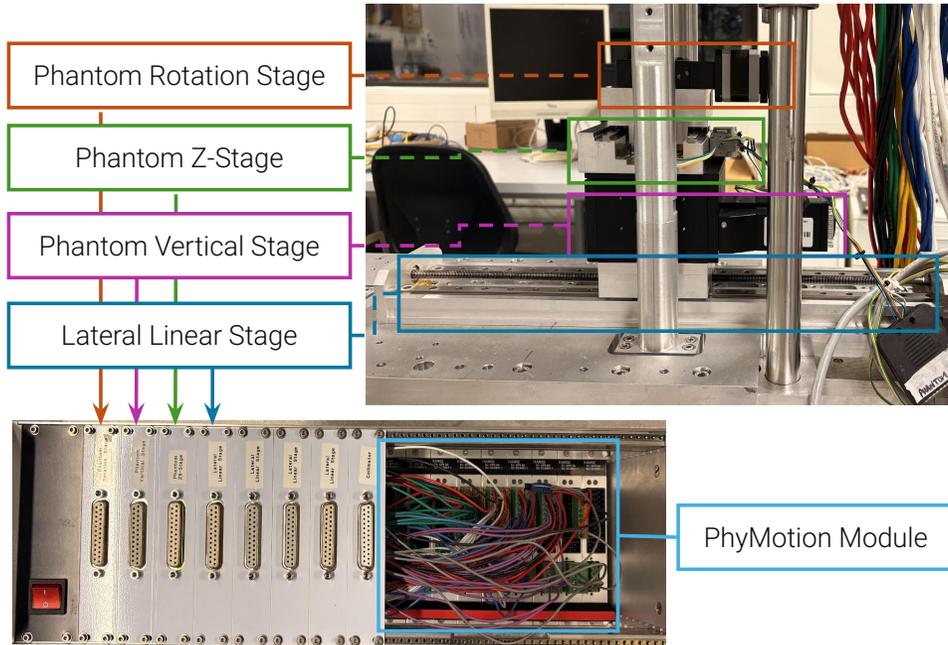


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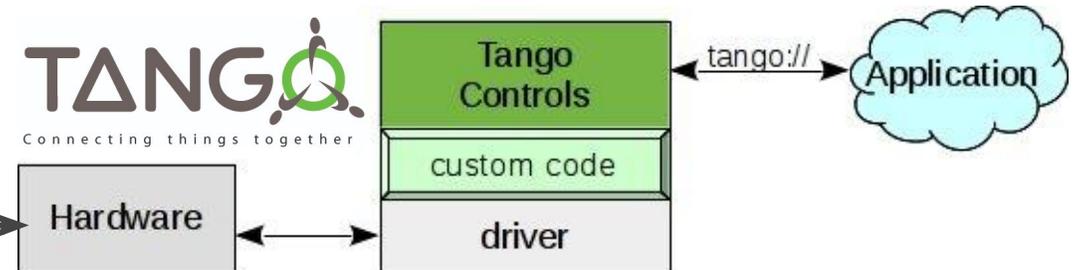
Software Implementation Steps

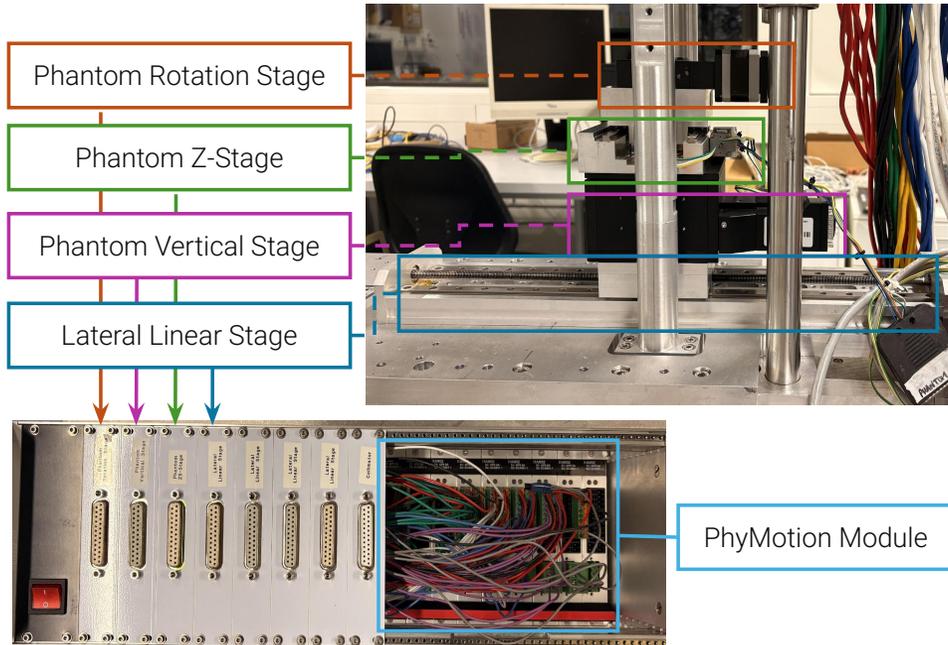
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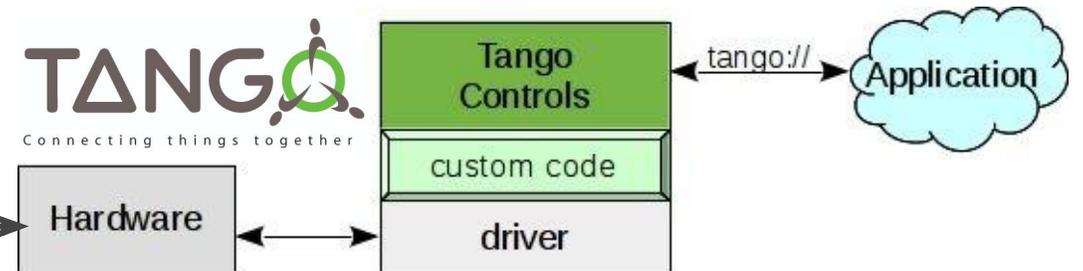
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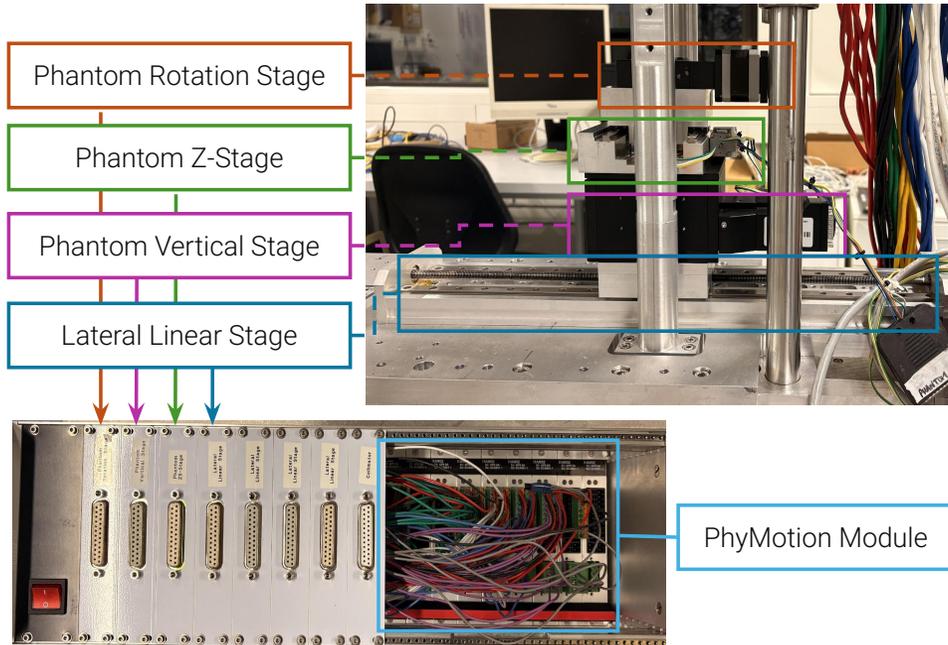
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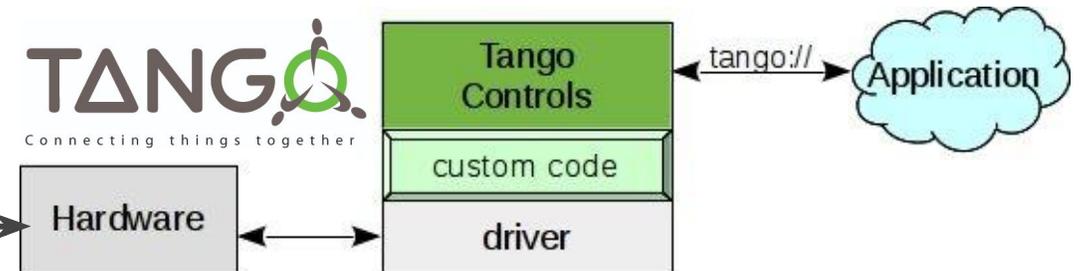
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1. **Device Classes:** Develop specific classes for each motor axis driver.
2. **Coordination:** Create a high-level "Director" class to manage complex motion sequences.
3. **Automation:** Script alignment and calibration routines to minimize manual intervention.

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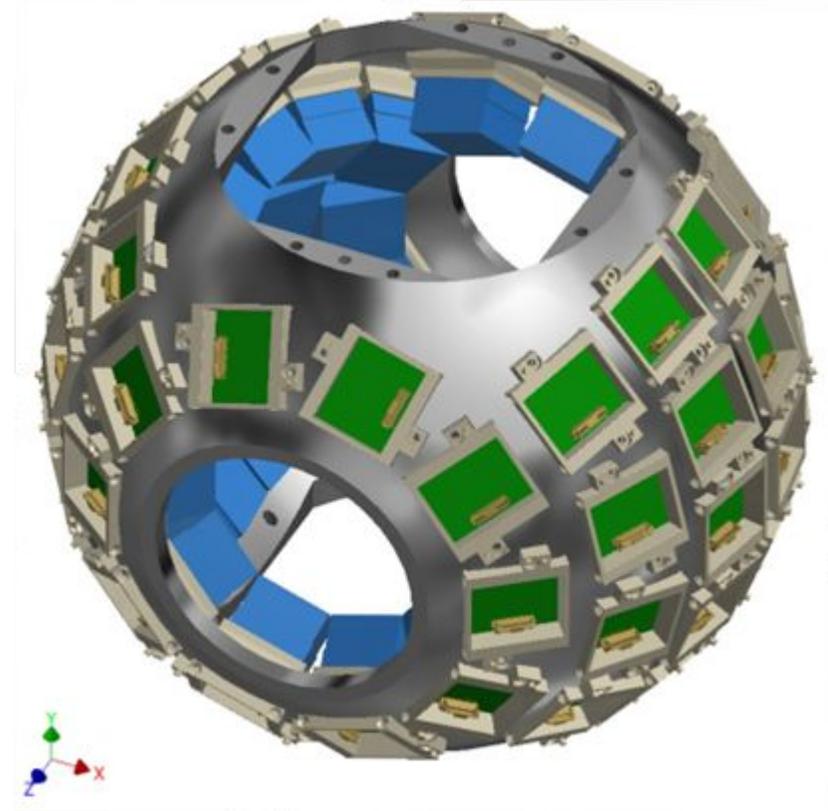




Current Limitation

Complexity: The SIRMIO PET scanner unique spherical geometry makes sensitivity characterization challenging.

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Proposed Automation

Sparse Sampling: Determine a minimal, yet sufficient, set of acquisitions for accurate sensitivity estimation.

Goal: Reduce calibration time, while maintaining reconstruction accuracy. Develop a fully automated calibration and sensitivity workflow.



The Challenge

Limitation: In-beam small-animal PET suffers from inherently low count statistics and high noise levels.

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Dual Approach Methodology

Experimental: Use the SIRMIO PET scanner to image small-scale synthetic phantoms with controlled radioactivity patterns.

Monte Carlo: Simulate arbitrary source distributions and detector responses under realistic conditions.



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