AS THEMATIC MEETING

Updates and proposal discussion

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Outline

• Updates from the project

• Goals for the new project
  • Sub project 1
  • Sub project 2
  • Sub project 3

• Manpower requirements table
  • Job, Task, Sub project

• Current timeline
Updates

- Mechanics for the module and the small-animal frame are completed

- FEB1 and FEB2 - new version of the readout after incorporating the changes from debugging.
  - To be soldered

- DAQ
  - Common reset implemented, two boards synchronized

- Simulation
  - First results from the AI implementation for activity->dose mapping
Updates

ASPET modular approach

- 2mm spatial resolution
- 200-300 ps timing resolution
- 10% energy resolution
- 512 channels per module
- Scaleable in many topologies

CAD drawings by Coco
GOAL
AS Thematic program - II
Goal:
To put these systems in the hospital

TOF PET detector

PG imaging detector

Range verification, PG imaging, diagnostic PET for labs and full body, hypoxia
Goal:
TOF-PET detector and comparable mechanics
Goal:
TOF-PET detector and comparable mechanics
Goal:
TOF-PET detector and comparable mechanics
Goal:
PG detector for imaging

Elemental image maps
Goal:
DELIVERABLES

TOF PET detector

PG imaging detector

First version getting ready

Designs and initial simulations ready
AS Thematic program - II

- **Dates**
  - Mar-15 : present potential ideas.
  - Apr-1 letter of intent (250 words)
  - Apr-15 : first draft
  - May-3 deadline for submission

- **Goal:** Developing detectors for proton therapy and beyond

- **Sub-project 1:** Detector development and clinical testing
  - AS, CGMH, NCU

- **Sub-project 2:** Software integration, image reconstruction using neural networks
  - NTU and AS

- **Sub-project 3:** Clinical simulations, tests and integration
  - CGMH, NCU and AS
Subproject 1: Detector development and clinical testing

- **TOF-PET detector**
  - Readout based on new ASIC for better performance
  - Different geometries for PET and PG applications

- **PG position sensitive detector**
  - Development of a high resolution and high efficiency system
  - R&D on crystal sizes, length, collimation
  - Mechanics for linear positioning of the sectors.
  - **Implant module**
    - Direct detection of protons and PG from passive marker

- **Beam testing and compatible mechanics of a clinical setup**
  - Respiratory gated testing of the TOF-PET detector
  - Animal testing of the TOF-PET detector
  - Schematic testing of different mechanics for mounting TOFPET on the treatment couch
  - Schematic testing of different mechanics for mounting PG detector on the treatment couch
  - Schematic testing of the implant module with an anthropomorphic phantom

- Cross sections measurements in low and high energy
Subproject 2: PET and PG image reconstruction using neural networks

- TOF-PET image reconstruction
  - Deep learning techniques for reconstruction
  - Low count image reconstruction
  - Faster ray-tracing for instantaneous system response matrix
  - Realtime reconstruction with arbitrary geometry

- PG imaging with neural networks
  - Mapping PG images -> Dose distributions / material composition
    - Stage1: Training on complete 2D maps
    - Stage2: Training on collimator affected 2D maps
    - Stage3: Training on the final detector combination

- Software integration for TOFPET and PG detectors
Subproject 3: Clinical simulations and tests

- TOF-PET
  - Defining clinical scenarios for PAG testing
  - Clinical simulations: Beam->DICOM phantom->Detector
  - Image data provided to the Sub2 for AI training

- PG imaging
  - Defining clinical scenarios for PG testing - via simulation
    - Mapping PG images -> Dose distributions / material composition
    - 3 stage training on PG
    - Cases: Phantom and DICOM
    - Case: Anatomies relevant for tissue separation - lung/nasopharyngial/prostrate

- Beam test planning
  - Clinical cases of interest - prostrate equivalent
  - Head and neck cases

- GPU fast simulations and updating the treatment plans

- Physics verification and updating the cross sections

- Mechanics and integration - defining the constraints based on our designs
Deliverables

- 2 module flat panel PET
  - Mounting mechanics on a patient couch or on a gantry
  - Multi module animal PET

- PG imaging detector
  - Mounting mechanics on a patient couch or on a gantry

- Software system for realtime visualization
  - GPU parallelization for faster simulations
  - AI for activity to dose mapping
  - Merging with CT images
## Manpower

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<tr>
<th>SNo</th>
<th>Job</th>
<th>Tasks</th>
<th>Sub project</th>
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<tr>
<td>1</td>
<td>RA</td>
<td>CAD/Mechanics/PCB</td>
<td>1 DETECTOR</td>
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<td>2</td>
<td>RA</td>
<td>DAQ development</td>
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<td>Readout development</td>
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<td>Researcher/project manager</td>
<td>Coordination of the technical teams, integration, planning tests</td>
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<td>15</td>
<td>PhD</td>
<td>PG images and molecular information</td>
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Current timeline

- Apr-1 letter of intent (250 words)
  - List of reviewers suggestions from NTU and CGMH/CGU
- Apr-15 : first draft
- May-3 deadline for submission
- Next thematic meeting - 210528
BACKUP
TOF-PET - Positron emitters

Depth distribution and Ratios - 32 channel setup

Counts normalized to peak (%)

511 keV coincidences

- Coincidences - experimental
- Positron emitters simulated
- Dose CGMH
- Coincidences - simulated

Depth (mm)

Counts normalized to peak (%)

511 keV coincidences

- Coincidences - experimental
- Positron emitters simulated
- Dose CGMH
- Coincidences - simulated

Entries 91
Mean 341.3
Std Dev 257.6

hExp

Depth distribution and Ratios - 32 channel setup

Counts normalized to peak (%)

511 keV coincidences

- Coincidences - experimental
- Positron emitters simulated
- Dose CGMH
- Coincidences - simulated

Entries 91
Mean 341.3
Std Dev 257.6
TOF-PET - Range shifts

512 vs 512 channels

Geant4 simulations

\[ \rho = 1.19 \text{ g cm}^{-3} \]

\[ \rho = 1.70 \text{ g cm}^{-3} \]

\[ \rho = 0.70 \text{ g cm}^{-3} \]
PG detector for marker in-vivo

Experimental result from CGMH proton center

3mm Ti placed in the water phantom between 42mm and 45mm from beam entrance

Measured counts vs R80

![Graph showing measured counts vs R80 with 3mm Ti in the water phantom]
Prompt Gamma: Novel 3D Position sensitive detector

3D positional information of the gamma from each element

Information on material composition

Oxygen distributions very insightful

![Graphs showing energy distributions of 12C and 16O](image)