ENDOTOFPET-US: Project Status Update

Alessandro Silenzi

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Outline

- ENDOTOFPET US: project introduction
- Technology Challenges
- Project Design
- Outlook for collaboration
- Outlook for DESY
Project overview

ENDO TOFPET US
Endoscopic TOFPET & Ultrasound

- FP7 funded project: 2011-2014
- 13 European institutes
- 6 Work packages
  - DESY is the institute leader of the WP5 ➔ Full responsibility for integration
- Medical scope and Technologies involved are particular challenging
PET recap. and dual modalities

How does a PET work?

- Patient is injected with a $\beta^+$ radio-labeled compound ($^{18}$FDG, $^{11}$C-Choline, etc)
- Back to back 511keV $\gamma$ rays are collected by an array of detectors
- Reconstruction uses the lines of response collected to form an image

TOF PET uses the TOF information to reduce the statistical noise or ROI
Multi modality

- Standalone PET obtains metabolic images, the image needs to be overlayed with an anatomic image such as CT, MRI or ultrasound.
Ultrasound gastroscopy

➤ Medical exam of O(30 min)

- patient is sedated
- possible biopsy with an endoscopic needle or in-vivo biopsy with laser confocal microscopy
Project Overview (II)

- **Project goal**: Development of a novel multimodal tool for the test of new biomarkers for pancreatic and prostate tumors

- **Techniques**:
  - Positron Emission Tomography
  - Ultrasound Imaging
  - Endoscopic Biopsy

- **Challenging tasks**
  - Overlay multiple imaging techniques
  - 200 ps time resolution (3 cm)
  - Fully integrated detector head
  - Asymmetric design
  - 1mm spatial resolution
  - Variable geometry
Addressing Challenges

- **Overlaying Images & Variable Geometry**
  - TUM (Prof. Navab) Computer Aided Medical Procedures & Augmented Reality
    E.g.: Navigated Bronchoscopy

- **Time Resolution**
  - CERN (E. Auffray, P. Lecocq)
    E.g.: LYSO:Ca Ce -> 167ps presented at IEEE NSS-MIC Valencia

- **Digital Photodetector for PET head**
  - Delft University (E. Charbon)
    E.g.: SPAD with integrated TDCs

- **Full integration of PET and external plate**
  - DESY (E. Garutti)
    E.g.: Simulation of a SPAD array (C. Xu) and Simulation of Full detector (B. Frisch)
Full Detector simulation

The study focuses on creating a detailed simulation of the data rate on the detector head and external plate.

- NURBS model of human body
- The work was “troubled” by some GEANT4 issues (non overlapping volume)
- Results:
  - 660 KHz for the internal probe
  - 27 MHz of the external plate with actual configuration
  - .75 x .75 mm$^2$ crystals internal head
  - 3 x 3 mm$^2$ Crystals in the outer plate

Benjamin Frisch (CERN)
Detector head simulation

Chen Xu is collaborating actively with DELFT (photodetector chip designers) providing a full electronics simulation of the several geometries proposed in view of the final prototype.
Detector head simulation

- Chen Xu is collaborating actively with DELFT (photodetector chip designers) providing a full electronics simulation of the several geometries proposed in view of the final prototype. Full detection chain simulation implemented to extract figures of merit for the geometries proposed.

- Sensitivity, energy and time resolution

![Graphs showing counts, detector timeline, and CTR vs. PDE]
External plate SiPM selection

Several SiPM prototypes has been tested in close collaboration with the producers

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<th>$U_{bd}$ (V)</th>
<th>DCR (Mcps)</th>
<th>PDE</th>
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<td>MPPC (1x1)</td>
<td>75.5~78.5</td>
<td>0.1~0.4</td>
<td>~32%</td>
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<td>MPPC (3x3)</td>
<td>66.5~69.5</td>
<td>1~3</td>
<td>~32%</td>
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<td>STMicro</td>
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<td>~8.5%</td>
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<td>Excelitas</td>
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<td>6.3~7.3</td>
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<tr>
<td>MAPD</td>
<td>~90</td>
<td>0.9~9</td>
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External plate selection “winner”

- Hamamatsu MPPC 4x4 array of 3x3mm² (50μm pixel size), arranged in 8x8 arrays

- The present idea is having the SiPMs in a piggyback board
In the PET prototype, a large fluctuation on the number of pixels fired has been observed. Two scans on the surface of the crystals will be performed:
- Transmission through the crystal (red/green) will provide information on the alignment crystal/SiPM.
- Excitation of the crystal will provide measure uniformity of the response.

Both internal head and the external plate are likely to suffer from this effects.
Next months will be quite busy for:

- Uni Heidelberg will receive first batch of TOFAsic
- Delft TU will receive the first SPAD array chip
- DESY will receive the MPPC from Hamamatsu and Crystal matrix from CERN
- DESY will narrow down the external plate design possibilities

Beginning 2012 first integration of prototypes is foreseen
Outlook for DESY

➢ Diploma student has recently joined the group (Fawad Karimi):
  ▪ Alignment
  ▪ System uniformity
  ▪ Performance assessment

➢ New Laboratory space will be dedicated to this project soon
  ▪ Building 67b is being renewed

➢ Marie Curie Initial Research Training Network:
  ▪ PicoSEC:
    ▪ 2 Ph.D. “outsider” Students with 6 months work in a collaborating institute