MEASUREMENTS OF BACKGROUND SCATTER RADIATION IN CT SCAN ROOM USING ENERGY RESOLVING HYBRID PIXEL DETECTORS

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MOTIVATION

Hybrid Pixel Detectors feature
• Low energy threshold (2-4keV)
• Spectroscopic resolution
• Excellent time resolution (~ns - ms)
• High dynamic range
  – Small pixels
  – No dark current integration

• More complex calibration and data processing
• High price (depending on application)
MEASUREMENT SETUP

• Dosepix and Timepix detectors with a 300um Si sensor
• Measurements performed at CHUV in Lausanne
• Ge Medical Systems Discovery CT750 HD CT-scanner
  — at 80kVp and 120kVp
• Measured scattered radiation during scan of a abdomen phantom
DETECTORS TESTED

• Developed within the framework of the Medipix2 collaboration
• Single Photon Processing
• Hybrid Pixel Detectors
• Energy measured using Time over Threshold
## DETECTORS TESTED

<table>
<thead>
<tr>
<th></th>
<th><strong>Timepix</strong></th>
<th><strong>Dosepix</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>Hybrid Pixel Pixel</td>
<td>Hybrid Pixel Detector</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>0.25 μm CMOS</td>
<td>130 nm CMOS</td>
</tr>
<tr>
<td><strong>Pixels matrix</strong></td>
<td>256 x 256</td>
<td>16 x 16</td>
</tr>
<tr>
<td><strong>Pixel size</strong></td>
<td>55 x 55 μm</td>
<td>220 x 220 μm</td>
</tr>
<tr>
<td><strong>Sensitive area</strong></td>
<td>198 mm$^2$</td>
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</tr>
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<tr>
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<tr>
<td></td>
<td>Time of arrival</td>
<td>16 digital thresholds for event-by-event</td>
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<td></td>
<td>Photon counting</td>
<td>energy binning</td>
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<td></td>
<td></td>
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<td>Integral ToT (24 bits)</td>
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DOSEPIX ENERGY BINNING MODE

Timepix

Photon Read out

Sorted into bin

Dosepix

Photon Lost

Read out (spectrum)

Read out (frame)

Shutter signal
DOSEPIX ENERGY BINNED SPECTRA

The 16 bins per pixel can be shifted to give a maximum of 256 bins per chip.

$^{241}$Am spectrum measured with Dosepix
60 bins 5-65keV
CALIBRATION

\[ f(x) = ax + b - cx - t \]
CALIBRATION VERIFICATION

Dosepix

Before calibration

After calibration
MEASUREMENTS

1. On CT scan cradle 25cm from phantom
2. 45° 1m distance
3. 45° 2m distance
4. Next to the the cradle, 2m distance
5. On non moving part of the cradle 2m distance
TIMEPIX POS1 ON CRADLE -25CM
INTEGRATED ENERGY, TIMEPIX

- 5: 80kVp/50mA
- 4: 80kVp/50mA
- 3: 80kVp/50mA
- 2: 80kVp/50mA
- 1: 80kVp/20mA
- 1: 80kVp/10mA
- 1: 120kVp/10mA 1ms
- 1: 120kVp/10mA 5ms

Total Energy Absorbed (keV)
LOW FLUX MEASUREMENTS

Wall

1.85 photons s\(^{-1}\) cm\(^{-2}\)

Window

11.2 photons s\(^{-1}\) cm\(^{-2}\)
CONCLUSIONS

• We have tested Timepix and Dosepix for measurements of scattered radiation in a CT scan room
• First results are promising and we have proven the feasibility of using these detectors for dose, dose rate and spectroscopic measurements
• Further work including signal to dose calibration, investigation of pileup effects, testing other sensor materials is planned

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