Warm Electronics - WFEE

2nd X-IFU Integrated Progress Meeting - Toulouse - June 2017

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Warm Front End Electronics - WFEE

WFEE in the X-IFU

- 3840 TESs
- Mux factor 40
- 96 FDM channels
- 1 channel = LNA + Bias + HK + ...
- 8 channels per ASIC ⇒ 12 ASIC
- 3 WFEE boxes
- 6 independent subsystems (2 per box)
Warm Front End Electronics - WFEE

- 3840 TESs
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- 96 FDM channels
- \(1\) channel = LNA + Bias + HK + ...
  \[\rightarrow 8\] channels per ASIC \(\Rightarrow 12\) ASIC
  \[\rightarrow 3\] WFEE boxes
  \[\rightarrow 6\] independent subsystems (2 per box)
ASICv1 measured performance:

- **LNA noise**: < 1 nV/√Hz and 3 pA/√Hz
- **Bandwidth**: > 10 MHz (test bench in preparation)
- **Gain**: 3, 8, 24 ... depending on the number of stages and diodes
- **Gain drift**: < 0.02%/K (measured on 3 cascaded stages)
- **Linearity**: approx 1 Vpp at 1% (improved by new design)
- **Current sources noise**: 10 pA/√Hz in the range of 30 µA
- **Operation of the I2C serial link** (RS485 transceiver in design)
- **Cumulative total dose**: up to 100 krad (radioactive $^{60}$Co)
- **Latch-up FREE ASIC - SEL testing**
The use of high-energy ion cyclotron at the UCL for SEE testing
The use of high-energy ion cyclotron at the UCL for SEE testing
### Louvain la Neuve UCL Cyclotron Ion cocktail

<table>
<thead>
<tr>
<th>M/Q</th>
<th>Ion</th>
<th>Energy [Mev]</th>
<th>Range [µm]</th>
<th>LET [MeV/mg/cm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.25</td>
<td>13 C 4+</td>
<td>131</td>
<td>269.3</td>
<td>1.3</td>
</tr>
<tr>
<td>3.14</td>
<td>22 Ne 7+</td>
<td>238</td>
<td>202.0</td>
<td>3.3</td>
</tr>
<tr>
<td>3.37</td>
<td>27 Al 8+</td>
<td>250</td>
<td>131.2</td>
<td>5.7</td>
</tr>
<tr>
<td>3.33</td>
<td>40 Ar 12+</td>
<td>379</td>
<td>120.5</td>
<td>10.0</td>
</tr>
<tr>
<td>3.31</td>
<td>53 Cr 16+</td>
<td>513</td>
<td>107.6</td>
<td>16.0</td>
</tr>
<tr>
<td>3.218</td>
<td>58 Ni 18+</td>
<td>582</td>
<td>100.5</td>
<td>20.4</td>
</tr>
<tr>
<td>3.35</td>
<td>84 Kr 25+</td>
<td>769</td>
<td>94.2</td>
<td>32.4</td>
</tr>
<tr>
<td>3.32</td>
<td>103 Rh 31+</td>
<td>972</td>
<td>88.7</td>
<td>45.8</td>
</tr>
<tr>
<td>3.54</td>
<td>124 Xe 35+</td>
<td>995</td>
<td>73.1</td>
<td>62.5</td>
</tr>
<tr>
<td>3.54</td>
<td>124 Xe 35+</td>
<td>995</td>
<td>73.1</td>
<td>≈ 120 (60° tilt)</td>
</tr>
</tbody>
</table>

Note: The LET for 124 Xe 35+ at 995 MeV/mg/cm² is approximately 120 at a 60° tilt.
SEL cross section: Threshold LET of RHBD cells > 120 MeV
Outlook

- **Validation of the technology BiCMOS SiGe .35 AMS**
  - **Gain stability** (with diode load LNA topology)
  - Measured **noise** < 1 nV/√Hz
  - Total **dose** 100 krad and **SEE testing** (LETth > 120 MeV)
- **Mechanical** design of WFEE boxes in progress
- Currently starting design of the **ASIC v2**
  - Transition I2C / RS 485 **differential bus** for ICU/RTU com.
  - Linearity and stability with **new topology with I load comp.**
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**Analysis and Improvement of Linearity Performance of Low Noise Amplifier with Diode Loads**

*Si CHEN*, Damien PRÉLÉ*, Fabrice VOISIN*, Cyril BEILLIMAZ*, and Andrea GOLDWURM*†

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Differential voltage gain</td>
<td>&gt; 50 V/nV</td>
</tr>
<tr>
<td>Input voltage noise</td>
<td>&lt; 1 nV/√Hz</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>1 MHz</td>
</tr>
<tr>
<td>Input signal amplitude</td>
<td>&gt; 20 mV</td>
</tr>
<tr>
<td>Output signal amplitude</td>
<td>&gt; 70 mV</td>
</tr>
<tr>
<td>Gain stability</td>
<td>&gt; 30 dB</td>
</tr>
</tbody>
</table>
Outlook

- **Validation of the technology BiCMOS SiGe .35 AMS**
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- Currently starting design of the **ASIC v2**
  - Transition I2C / RS 485 **differential bus** for ICU/RTU com.
  - Linearity and stability with **new topology with I load comp.**
  - **Gain of 80**
  - 2 modes (**switch gain**) on TES bias (studied/test)
  - **push-pull adjustable current sources**
  - **Thermometer** on chip
  - **B coil** current source
  - starting discussion **FPA HK** ...