The ANTARES Demonstrator for APT (ADAPT) is a heliostere gamma-ray astronomy mission scheduled to fly during the 2025–26 season. To estimate ADAPT’s performance, we have developed a simulated model of the instrument that incorporates optical properties of its CsI:Na scintillators, measurements of WLS signal attenuation, characteristics of the SiPMs and preamplifiers, and the effects of signal integration and event pileup. We also update on the status of front-end data reduction. High-level synthesis (HLS) enables the logic for pedestal subtraction and signal integration across 96 ASIC channels to fit on a single Kintex-7 FPGA with sufficient throughput to handle a high sustained event rate.

**WLS Fiber Characterization**

- Lab Measurements: Single-photocathode voltage measurements normalized by reference measurements
- Exponential Fit: fit exponential function with y-shift
- CsI Adjacency Range: portion of fiber overlapping CsI (SiPM end 20 cm from crystal)
- Original model in [1] used a constant transmission efficiency determined by lab measurements of average yield
- Normalized Attenuation: normalized to middle of CsI adjacency range
- Transmission efficiency now scaled by 0.879 to 0.881
- Distance from SiPM to edge of tile
- Use [7] and datasheet to assign SiPM PDE of 50% for green WLS fiber light

**WLS Fiber Characterization**

- Normalized Attenuation: normalized to middle of CsI adjacency range
- CsI Adjacency Range: portion of fiber overlapping CsI (SiPM end 20 cm from crystal)
- Use [7] and datasheet to assign SiPM PDE of 50% for green WLS fiber light

**High-Level Synthesis of FPGA Logic**

- Parallel logic for edge detectors
- Sequential logic for pedestal subtraction
- Pipelined dataflow execution improves throughput
- Two implementations of signal integration:
  - (1) Parallel logic for edge detectors
  - (2) Sequential logic for pedestal subtraction

**Pedestal Subtraction**

- ADC count contribution from analog memory pedestal must be subtracted

**Signal Integration**

- 4 integrals over subpixels of 256 samples (32x3 mm) captured in 10 ns bins

**Event Pileup**

- SMART preamplifier noise
- CMS noise per MeV
- Scale by y2 for WLS
- Scale by y2 for edge detectors

**Noise Characterization**

- SMART preamplifier noise
- CMS noise per MeV
- Scale by y2 for WLS
- Scale by y2 for edge detectors
- Further scale by signal integration time
- SMART single-PE impulse response modeled using 10 ns binomially distributed by 27 ns exponential
- MC simulation determines mean and std for ADC count

**Results for parallel logic handling 6 ALPHA ASICs:**

<table>
<thead>
<tr>
<th>Impl.</th>
<th>FPS</th>
<th>DFF</th>
<th>LUTs</th>
<th>RAMB</th>
<th>B (Gbps)</th>
</tr>
</thead>
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<tr>
<td>2</td>
<td>27,864</td>
<td>6.8</td>
<td>60,372</td>
<td>29.6</td>
<td>540 60.7</td>
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<tr>
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<td>7.6</td>
<td>71,988</td>
<td>35.3</td>
<td>450 50.6</td>
</tr>
</tbody>
</table>

**References**


**Edge Detector Monitoring**

- Photomultiplier output signals combined into single SMART[2] shaping preamplifier channel
- SMART output from 225 WLS fibers sampled by 5x6x36 Hamamatsu APDs per ICC layer-axis

**Noise Characterization**

- SMART preamplifier noise
- Scale by y2 for WLS
- Scale by y2 for edge detectors
- Further scale by signal integration time
- SMART single-PE impulse response modeled using 10 ns binomially distributed by 27 ns exponential
- MC simulation determines mean and std for ADC count

**Event Pileup**

- GRB arrival times sampled from normal distribution
- Add earth limb background modeled in [5]
- Signals from multiple events may be captured in a single readout window

Mission Presentation

For more details, please see our presentation at parallel session GA10-05.

Friday, 28 July, 2023, 10:00 AM – 10:15 AM

“Antarctic Demonstrator for the Advanced Particle-astrophysics Telescope (ADAPT)”

James H Buckley, Washington University in St Louis

For the APT collaboration

Marion Sudvarg (msudvarg@wustl.edu) Washington University in St Louis

The Advanced Particle-astrophysics Telescope (APT) is a heliostere gamma-ray astronomy mission that will combine a pair of tracker and Compton telescope in a single monolithic design to include multiple layers of SiPMs with crossed planes of wavelength-shifting (WLS) fibers to localize energy deposition to “mm” accuracy, and SiPM-based edge-detectors to improve light collection and calorimetry. It will localize MeV to TeV transients such as gamma-ray bursts in real-time using on-board computational hardware.