THE COSMIC X-RAY BACKGROUND
NANOSAT-2 (CXBN-2):
AN IMPROVED MEASUREMENT OF THE DIFFUSE X-RAY
BACKGROUND

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04/23/2015
OVERVIEW

- CXBN Introduction and Heritage
- Science Mission
- CXBN-2 Spacecraft Subsystems
- Science Instrument: CZT Array
- CXBN-1 CZT Array
- CXBN-2 CZT Array
- Testing and Calibration
- Testing Results
- Payload Implementation
- Current testing
- Conclusions
- Q&A
INTRODUCTION TO THE CXBN CUBESAT SERIES

- CXBN CubeSat series is devoted to making improved measurements of the X-Ray background to provide insight into underlying physics of the early universe.
- CXBN-2 a follow-on to CXBN-1 launched by NASA ELaNa in 2012.
  - CXBN-1 S/C Bus operated successfully but the Experimental Detector Array did not achieve nominal operation.
- CXBN-2 NASA ELaNa selected mission for launch in 2016.
- Goal is to make a precise measurement of the cosmic (diffuse) X-ray background in the 20 – 50 KeV range using the 2U CubeSat platform.
Science Mission: Mission Objectives

OVERVIEW – THE X AND GAMMA RAY SKY

NGC 4151
OVERVIEW – THE X AND GAMMA RAY SKY

NGC 4151
A bright Active Galactic Nucleus (AGN) outside our galaxy
Science Mission: Mission Objectives

OVERVIEW – THE X AND GAMMA RAY SKY

But what about this Diffuse Background?

We know where this intensity is coming from

Flux

Position

1/23/2015  CXBN-2 - PDR
Science Mission: Mission Objectives

OVERVIEW – THE X AND GAMMA RAY SKY

- Is the Diffuse X-Ray Background (DXRB) due to AGN that are too distant to resolve with our telescopes or something else?

“... the cosmic X-ray background (CXB), still remains one of the most interesting topic of X-ray astronomy and observational cosmology. ”
Previous measurements of DXRB disagree by about 20%

Comparison of past CXB measurements (Türler et al. 2010)
Keldysh Institute Study shows that Free-flying is the optimal dynamical mode to meet mission objectives.

Spacecraft will free fly, allowing the detector to sweep out its Field of View (FOV) covering the regions of interest in one year of operation.

Number of scientific datasets (one second = one set) for one year of operations.
Too big: Multiple sources
Too small: Low Signal to Noise

36° Opening Angle
- Good signal to noise
- Good coverage of DXRB
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CXBN-1 DETECTOR – BFE CZT ARRAY
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CXBN-2 DETECTOR – REDLEN M1770 CZT ARRAY

DUAL ISOTOPE NUCLEAR CARDIOLOGY IMAGING
FIRST SCAN - 16 MINUTES
6 HOUR WAITING PERIOD
SECOND SCAN - 21 MINUTES

DUAL ISOTOPE NUCLEAR CARDIOLOGY IMAGING WITH CZT:
DUAL SCAN - 15 MINUTES TOTAL
# REDLEN M1770 – WILL IT WORK?

## REDLEN TEST REPORT

**September 27, 2014  10:12:17**

<table>
<thead>
<tr>
<th><strong>Product ID:</strong></th>
<th>M1770</th>
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<tbody>
<tr>
<td><strong>Serial #:</strong></td>
<td>M2133_RMA_073_retest</td>
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<tr>
<td><strong>Product Description:</strong></td>
<td>40x40x6mm Gamma Imaging Module (V7E)</td>
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<td><strong>Test Platform:</strong></td>
<td>System Code: 81-000-0004933, Software Version: 3.12.130903</td>
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<tr>
<td><strong>Pixels:</strong></td>
<td>256</td>
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### Test Conditions

- **Radiation Source:** Co-57/Am-241
- **Source Activity:** 194 uCi
- **Source Distance:** 297.2 mm
- **Source Absorption:** 0.0 %
- **HV Bias:** -600 V
- **Test Duration:** 497.20 sec
- **Temperature:** 23.4 - 30.8 C

### Quality Criteria

- Pixels <= 6.5% ER: 140 (55%)
- Pixels <= 8% ER: 237 (93%)
- Pixels <= 8% ER: 237 (93%)
- Pixels >= 57% Efficiency: 177 (69%)
- Pixels >= 47% Efficiency: 251 (98%)
- Pixels >= 40% Efficiency: 255 (100%)
- Peak Position Conformance: 255 (100%)
- Pixel ER Conformance: 255 (100%)
- Pixel Efficiency Conformance: 256 (100%)

### Performance Summary

- **Average ER:** 6.41%
- **Average Efficiency:** 61.2%
- **Non-conforming Pixels:** 1
Initial test setup
• 5 sealed radioisotopes used
  • Europium-152 - 40.1 keV, 121.78 keV, 244.7 keV, 344.3 keV
  • Barium 133 – 30.7 keV, 53.2 keV, 80.1 keV, 356 keV
  • Cadmium-109 – 22.1 keV, 88 keV
  • Cobalt-57 - 14.4 keV, 122 keV, 136.5 keV
  • Americium-241 - 59.5 keV
• Calibrate array with known radioisotopes with known spectra
• Eliminate “Hot” or “dead” pixels
• Determine noise floor of array and minimum detectable photon energy
• Determine Energy Resolution, Conversion Efficiency, Sensitivity
Histogram of the measurement of 122 keV and 136.5 keV X-Ray from Cobalt-57 beta decay
Morehead State University

REDLEN M1770 – IMPLEMENTATION
Morehead State University

REDLEN M1770 – CURRENT CHARACTERIZATION
Morehead State University

CONCLUSION

• Found better alternative Array for more precise measurement of DXRB
  • $4.5k detector vs $250k
  • More robust system
  • Provides greater flux
  • Developed detector electronics and software
• Continue characterization in the 20-50 keV energy regime
  • Individual Arrays will be properly calibrated
• Will deliver in February 2016
• Tracking will be done at Morehead State University
Questions?