

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



JORDAN HEALEA

MOREHEAD STATE UNIVERSITY

04/17/2015



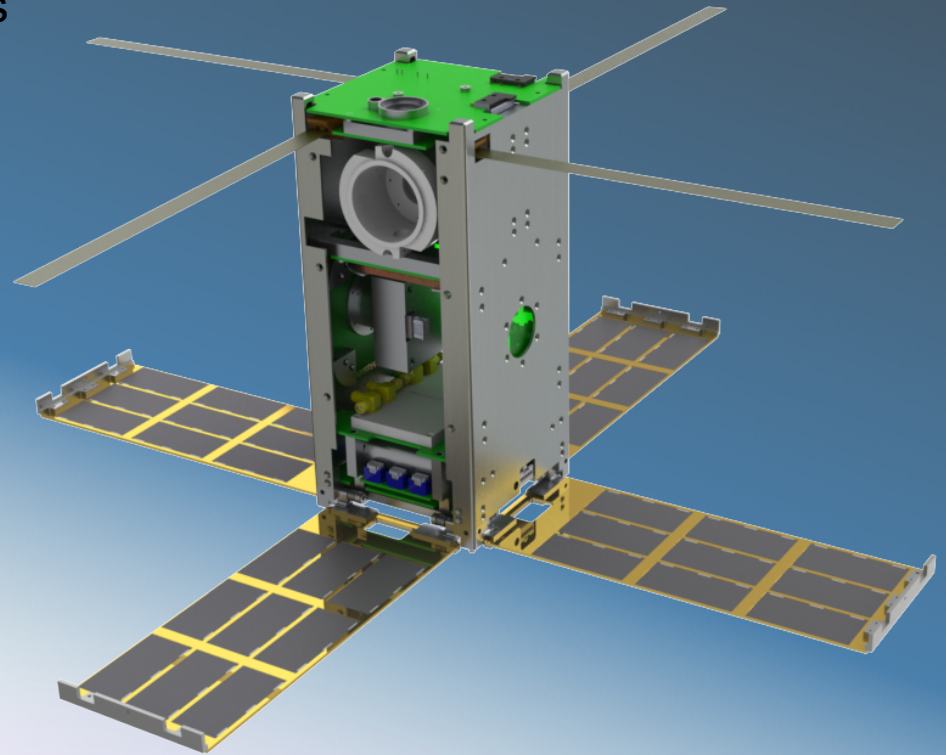
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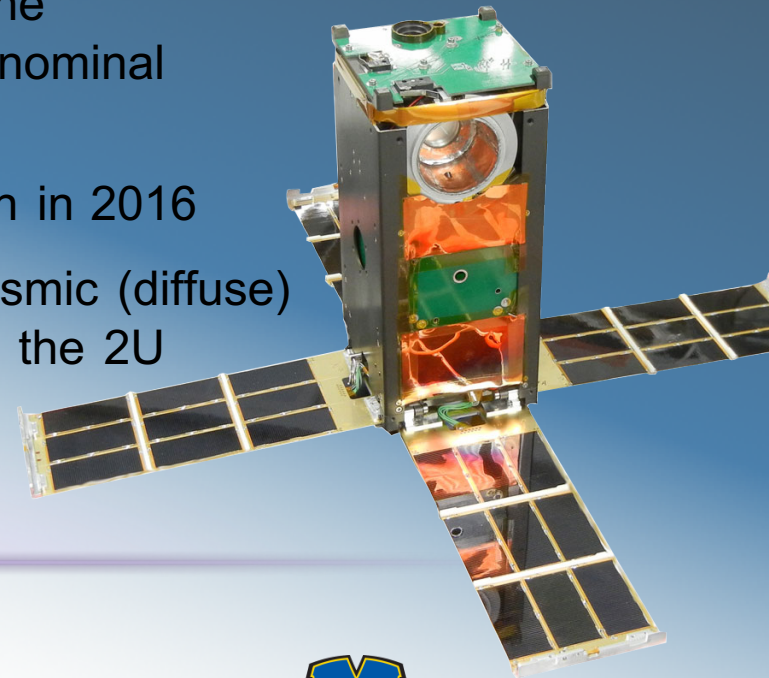
# OVERVIEW

- 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**

The image shows a field of stars against a dark background. In the center, there is a prominent, bright yellow star. Surrounding it is a diffuse, glowing region, likely a galaxy cluster or nebula. Several other bright stars are scattered throughout the field, some appearing as sharp points of light and others as slightly blurred spots. The overall scene is a typical astronomical observation of a star-forming region or a specific cluster of stars.

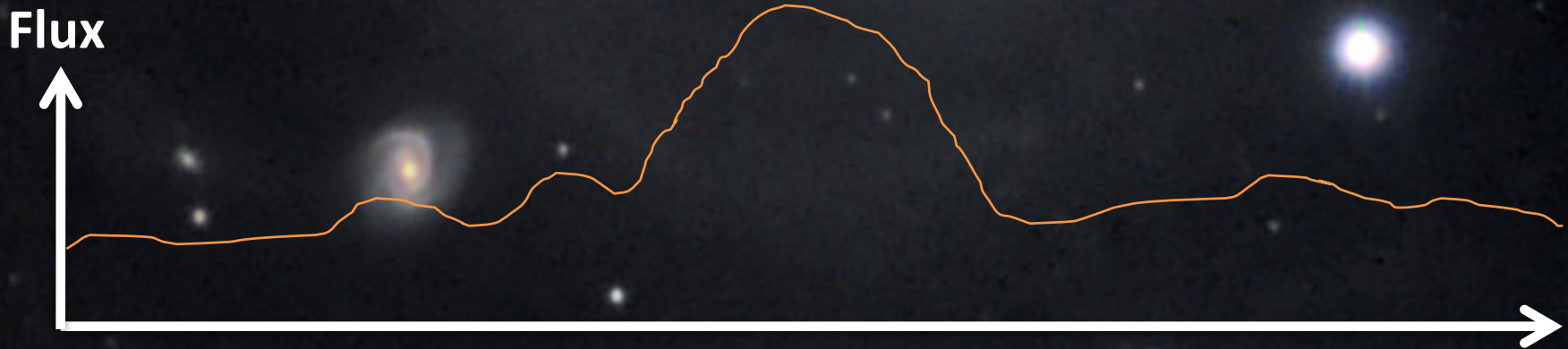


Science Mission: Mission Objectives

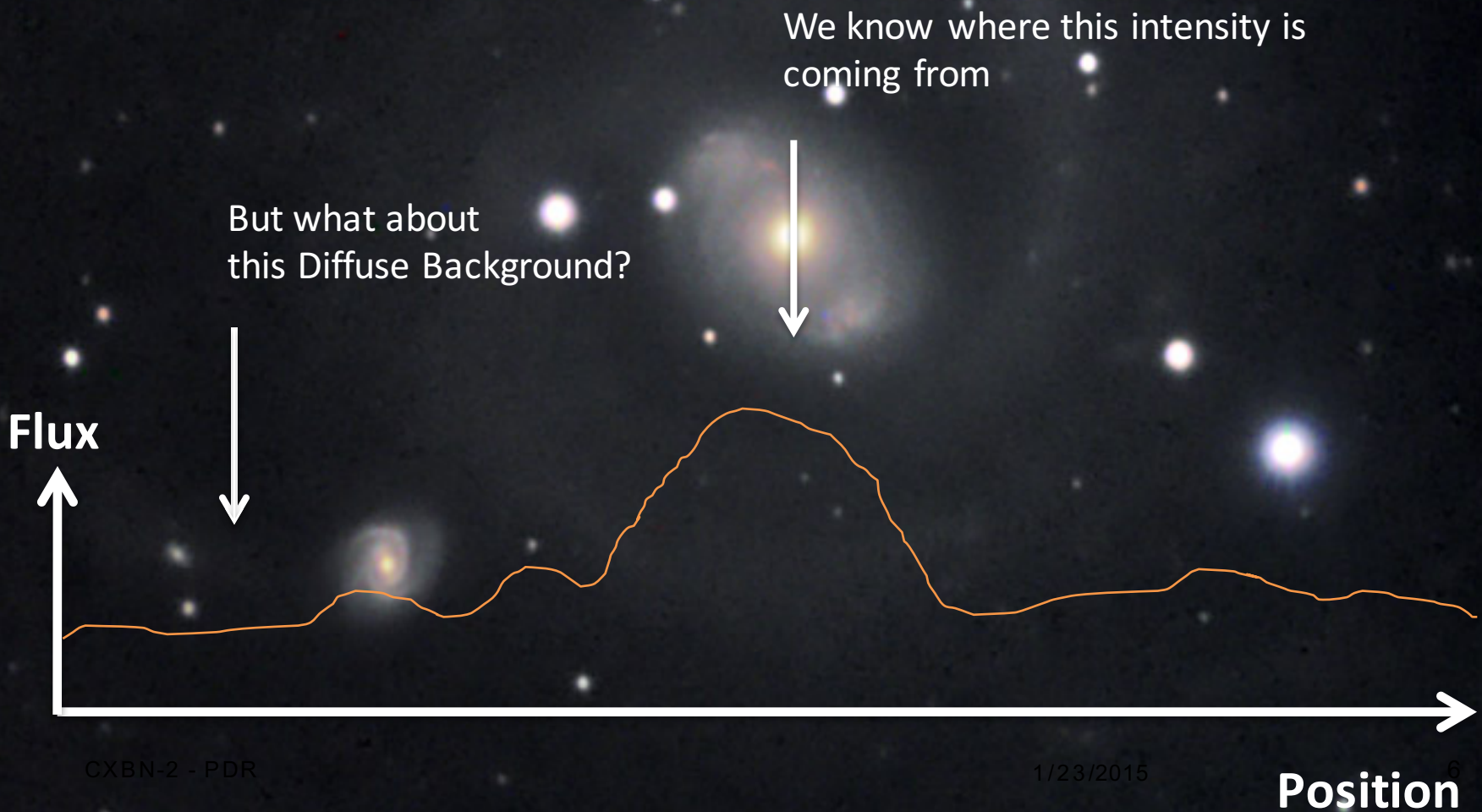
# OVERVIEW – THE X AND GAMMA RAY SKY

**NGC 4151**

**A bright Active Galactic Nucleus (AGN)  
outside our galaxy**



# OVERVIEW – THE X AND GAMMA RAY SKY

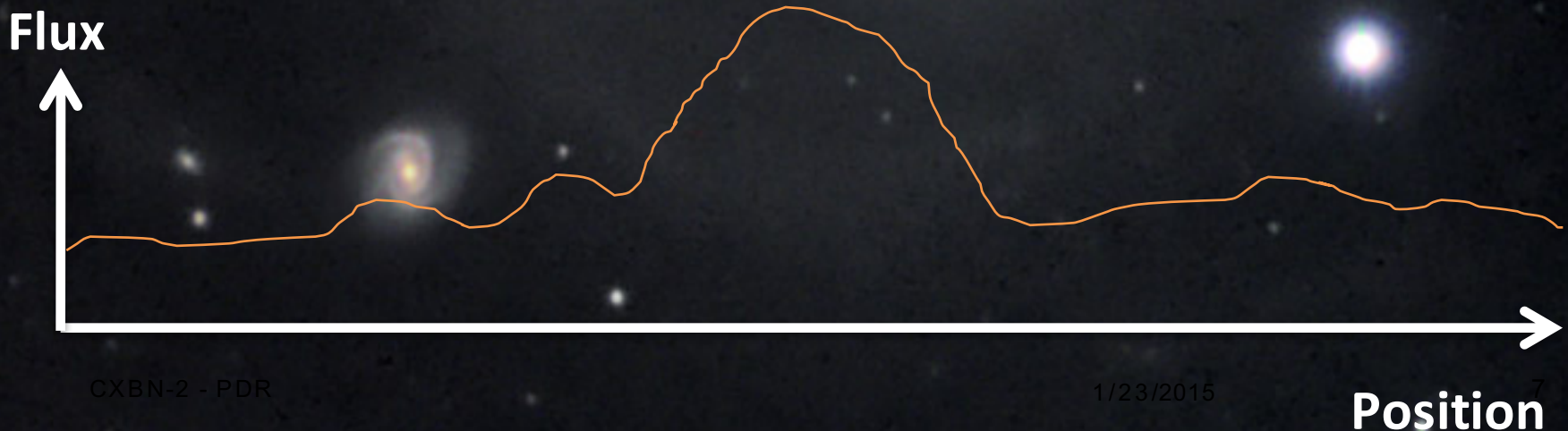


# OVERVIEW – THE X AND GAMMA RAY SKY

- 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.”*

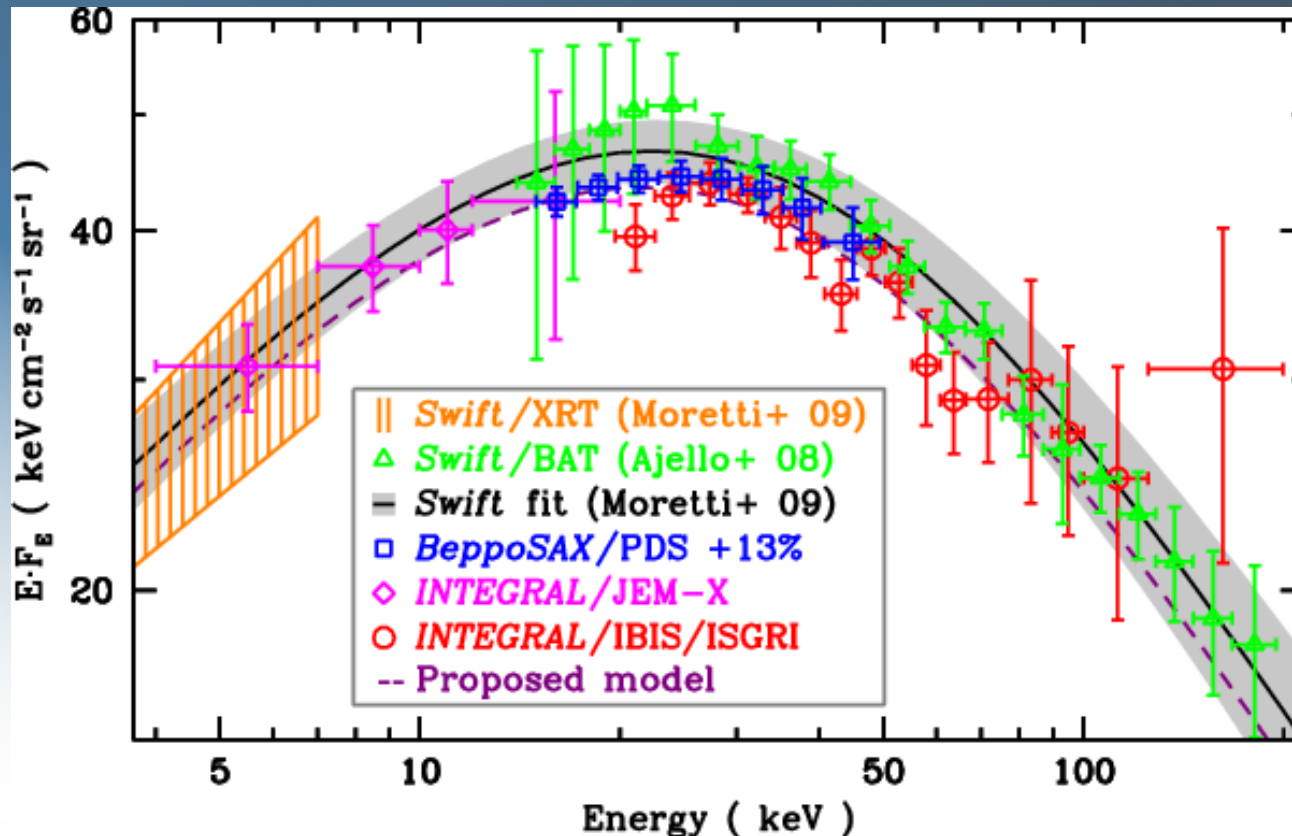
- Revnivtsev et al. 2003, A&A, Volume 411, Pages 329-334





# CXRB MEASUREMENT

Previous measurements of DXRB disagree by about 20%

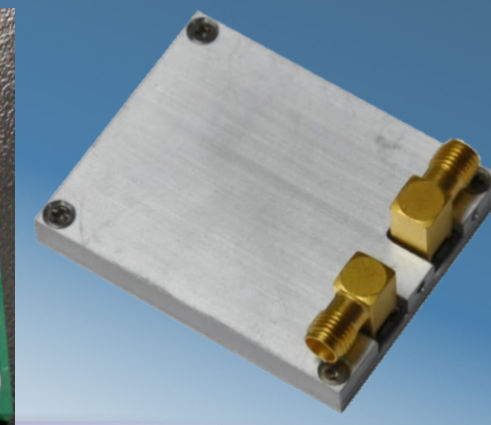
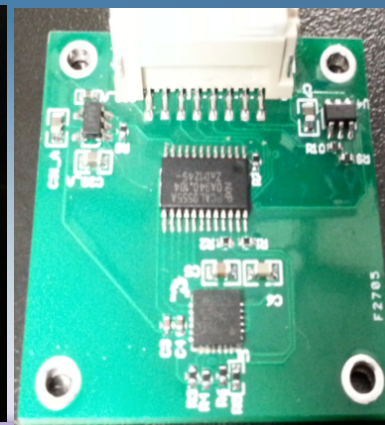
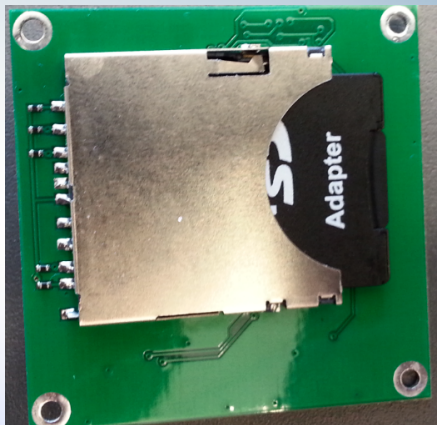
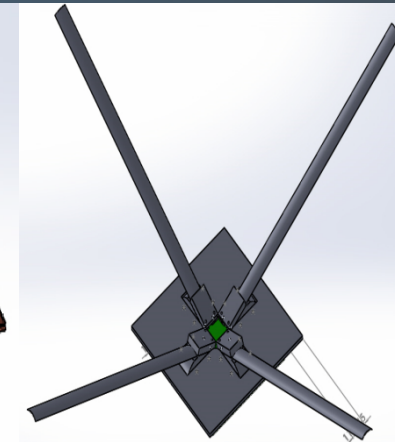
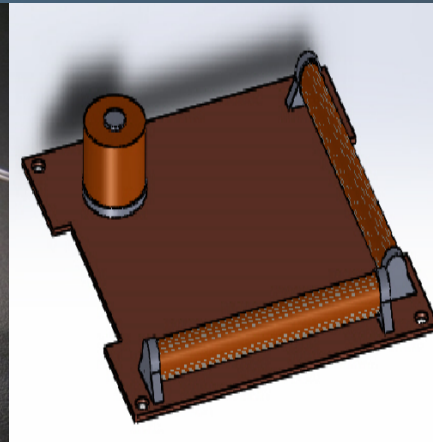
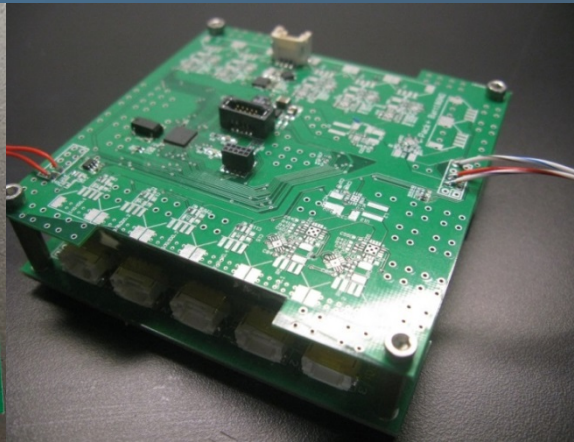
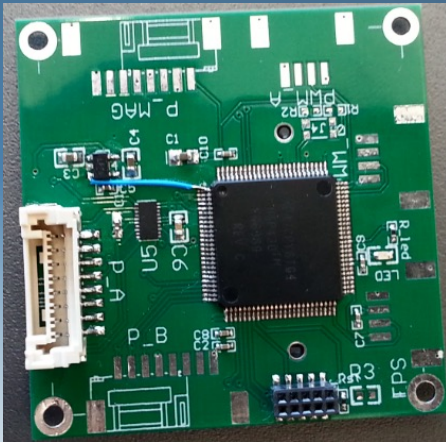
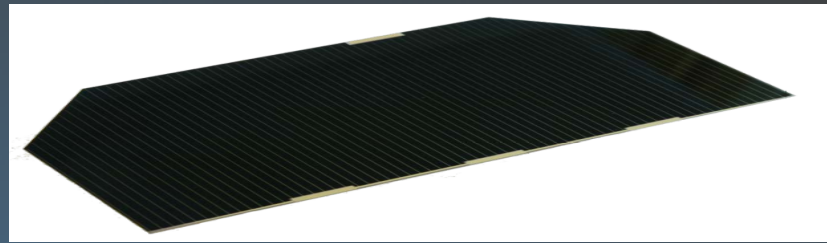


Comparison of past CXB measurements (Türler et al. 2010)



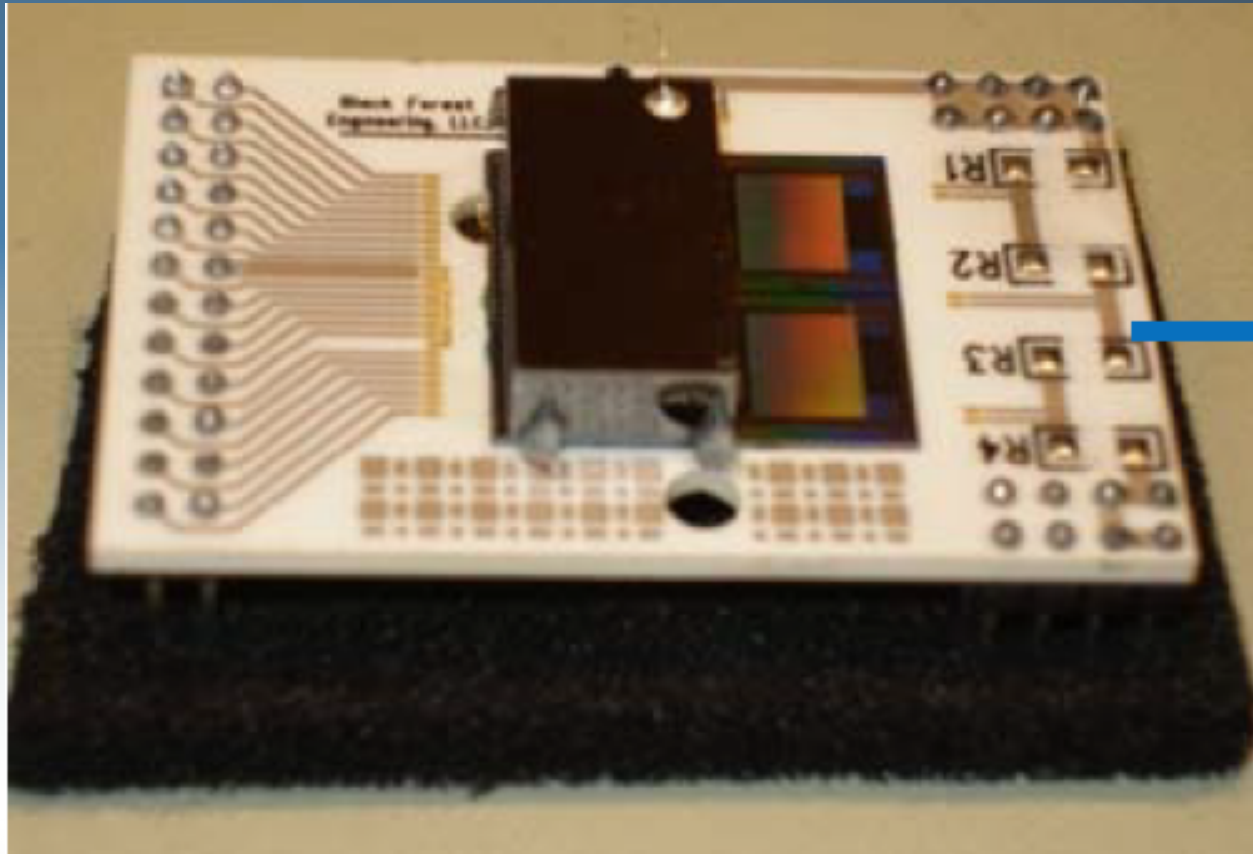
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# CXBN-2 OVERVIEW



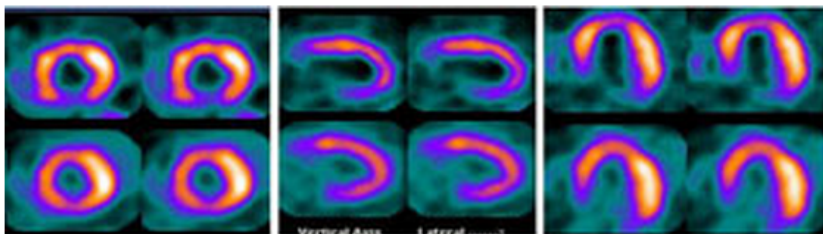
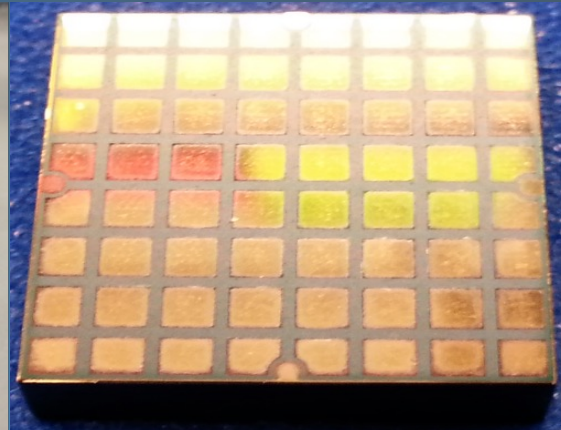
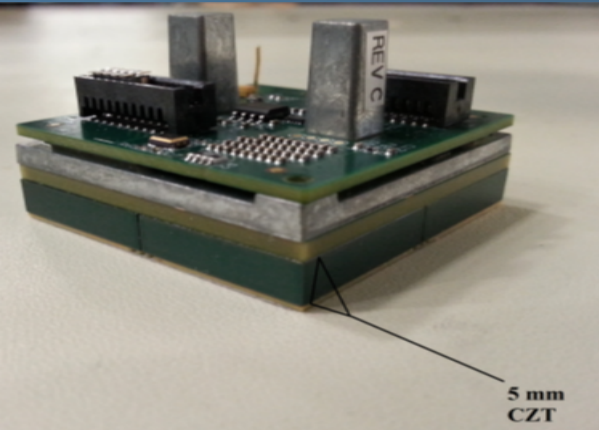
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# CXBN-1 DETECTOR – BFE CZT ARRAY

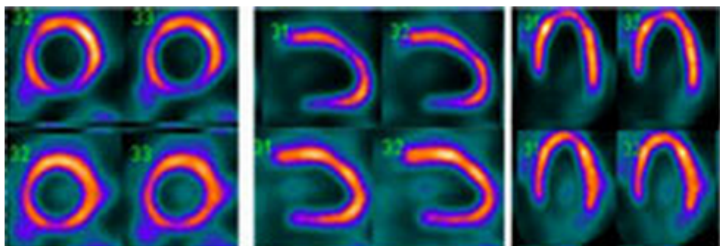




# CXBN-2 DETECTOR – REDLEN MI 770 CZT ARRAY

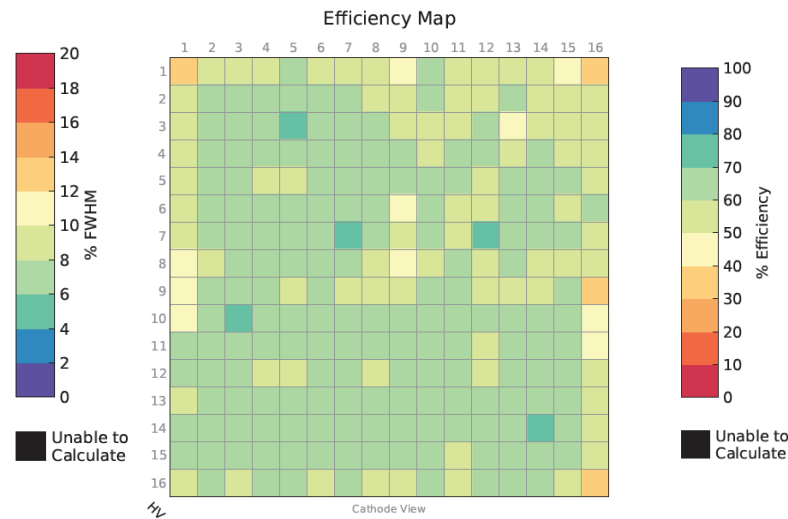
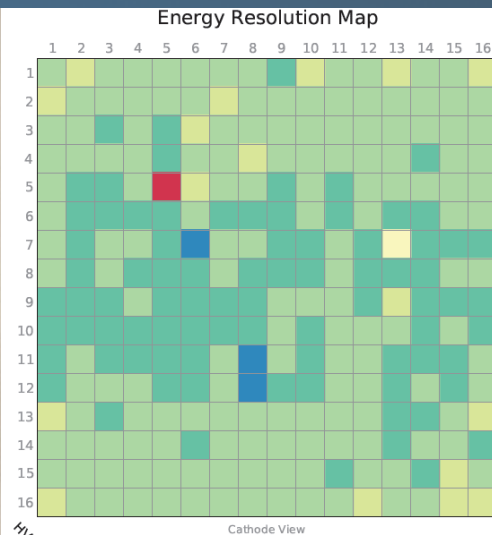
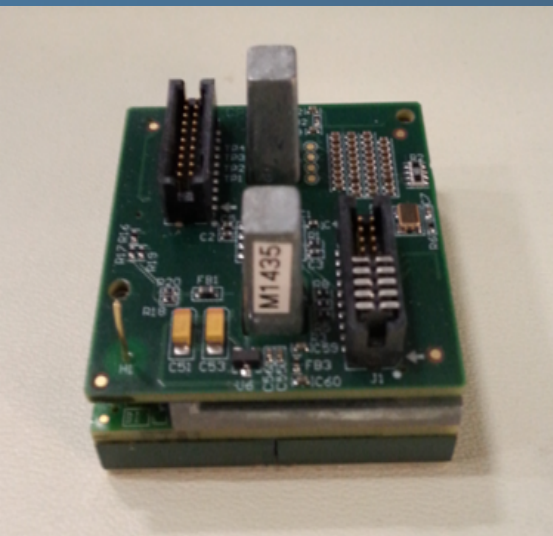


**DUAL ISOTOPE NUCLEAR  
CARDIOLOGY IMAGING**  
FIRST SCAN - 16 MINUTES.  
6 HOUR WAITING PERIOD.  
SECOND SCAN - 21  
MINUTES



**DUAL ISOTOPE  
NUCLEAR CARDIOLOGY  
IMAGING WITH CZT:**  
DUAL SCAN - 15 MINUTES  
TOTAL

# REDLEN MI770 – WILL IT WORK?



## REDLEN TEST REPORT

September 27, 2014 10:12:17

<b>Product ID:</b>	<b>M1770</b>	<b>Serial #:</b>	<b>M2133_RMA_073_retest</b>	<b>Pixels:</b>	<b>256</b>
<b>Product Description:</b>	<b>40x40x6mm Gamma Imaging Module (V7E)</b>				
<b>Test Platform:</b>	<b>System Code: 81-000-0004933, Software Version: 3.12.130903</b>				

### Test Conditions

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

### Quality Criteria

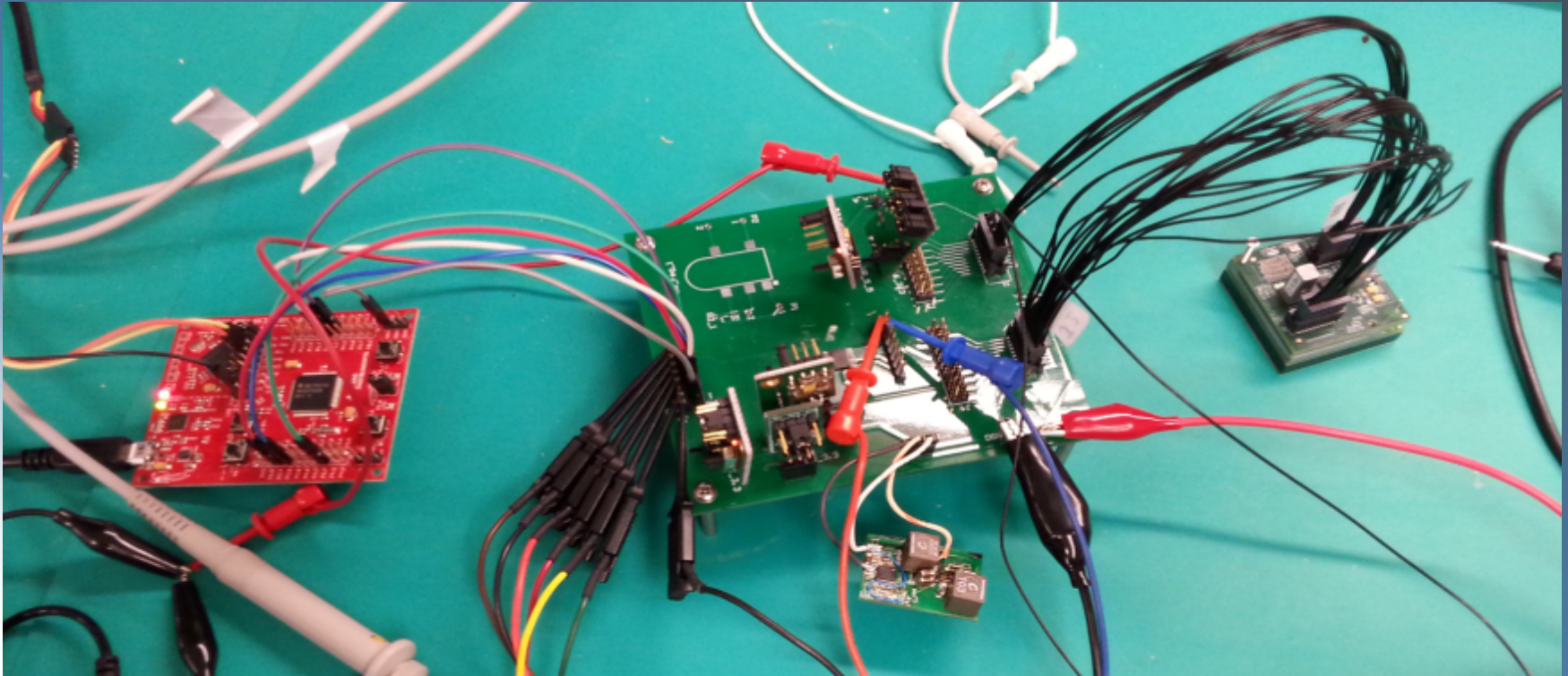
	<b>Conforming Pixels</b>	<b>Quality Factor</b>
<b>Pixels &lt;= 6.5% ER</b>	<b>140 (55%)</b>	<b>+0.09</b>
<b>Pixels &lt;= 8% ER</b>	<b>237 (93%)</b>	<b>-0.00</b>
<b>Pixels &lt;= 8% ER</b>	<b>237 (93%)</b>	<b>-0.04</b>
<b>Pixels &gt; 57% Efficiency</b>	<b>177 (69%)</b>	<b>+0.38</b>
<b>Pixels &gt; 47% Efficiency</b>	<b>251 (98%)</b>	<b>+0.05</b>
<b>Pixels &gt; 40% Efficiency</b>	<b>255 (100%)</b>	<b>+0.03</b>
<b>Peak Position Conformance</b>	<b>255 (100%)</b>	<b>+0.03</b>
<b>Pixel ER Conformance</b>	<b>255 (100%)</b>	<b>+0.88</b>
<b>Pixel Efficiency Conformance</b>	<b>256 (100%)</b>	<b>+1.00</b>

### Performance Summary

<b>Average ER:</b>	<b>6.41</b>	<b>%</b>
<b>Average Efficiency:</b>	<b>61.2</b>	<b>%</b>
<b>Non-conforming Pixels:</b>	<b>1</b>	



# REDLEN MI770 – EVALUATION

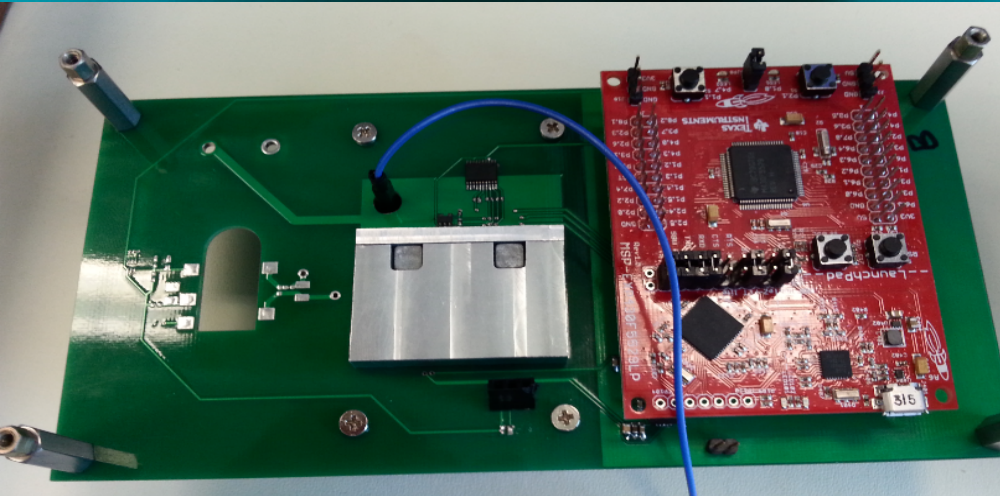
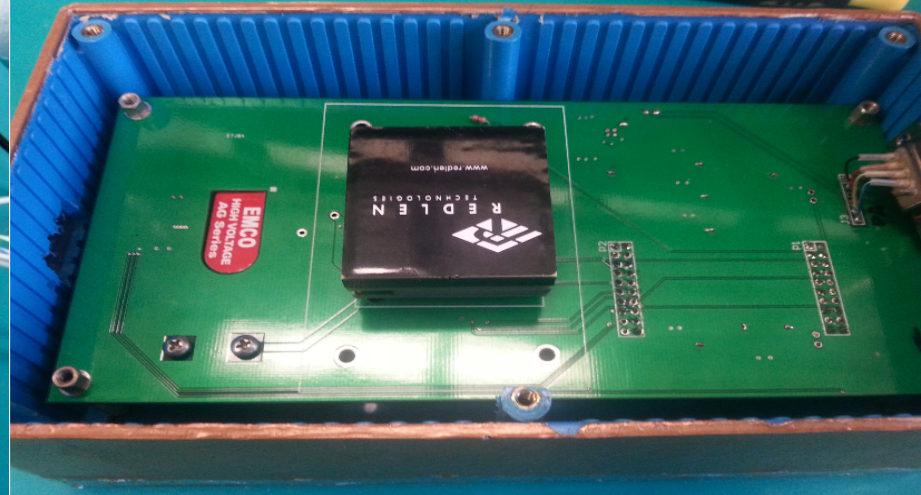
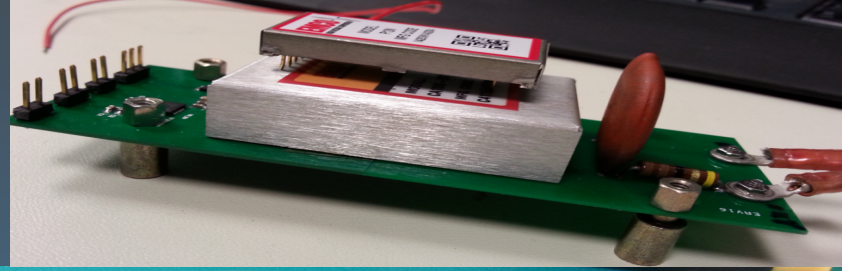


Initial test setup



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# REDLEN MI770 – EVALUATION



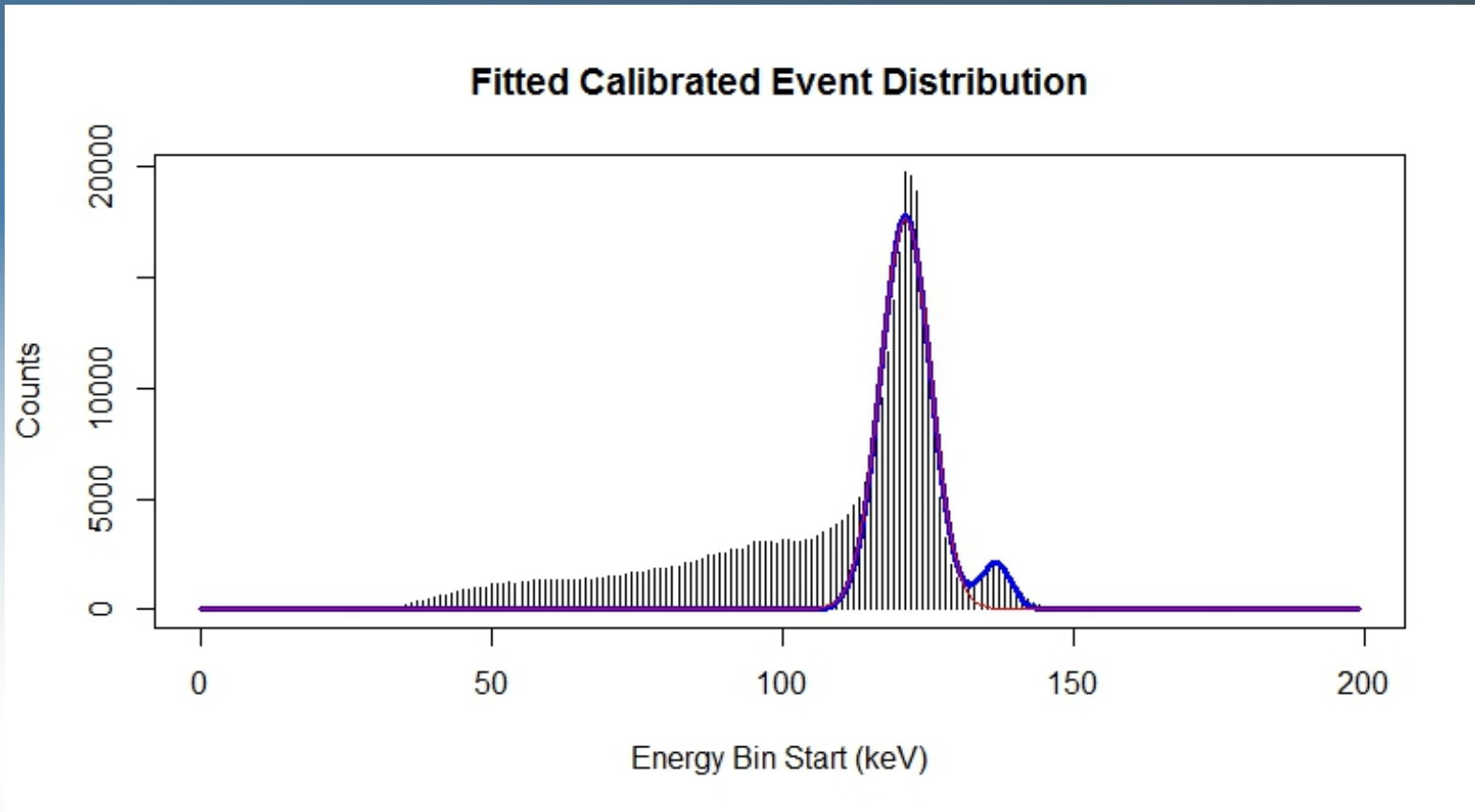
# TESTING AND CALIBRATION

- 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 measurable photon energy
- Determine Energy Resolution, Conversion Efficiency, Sensitivity





# REDLEN MI770 – RESULTS

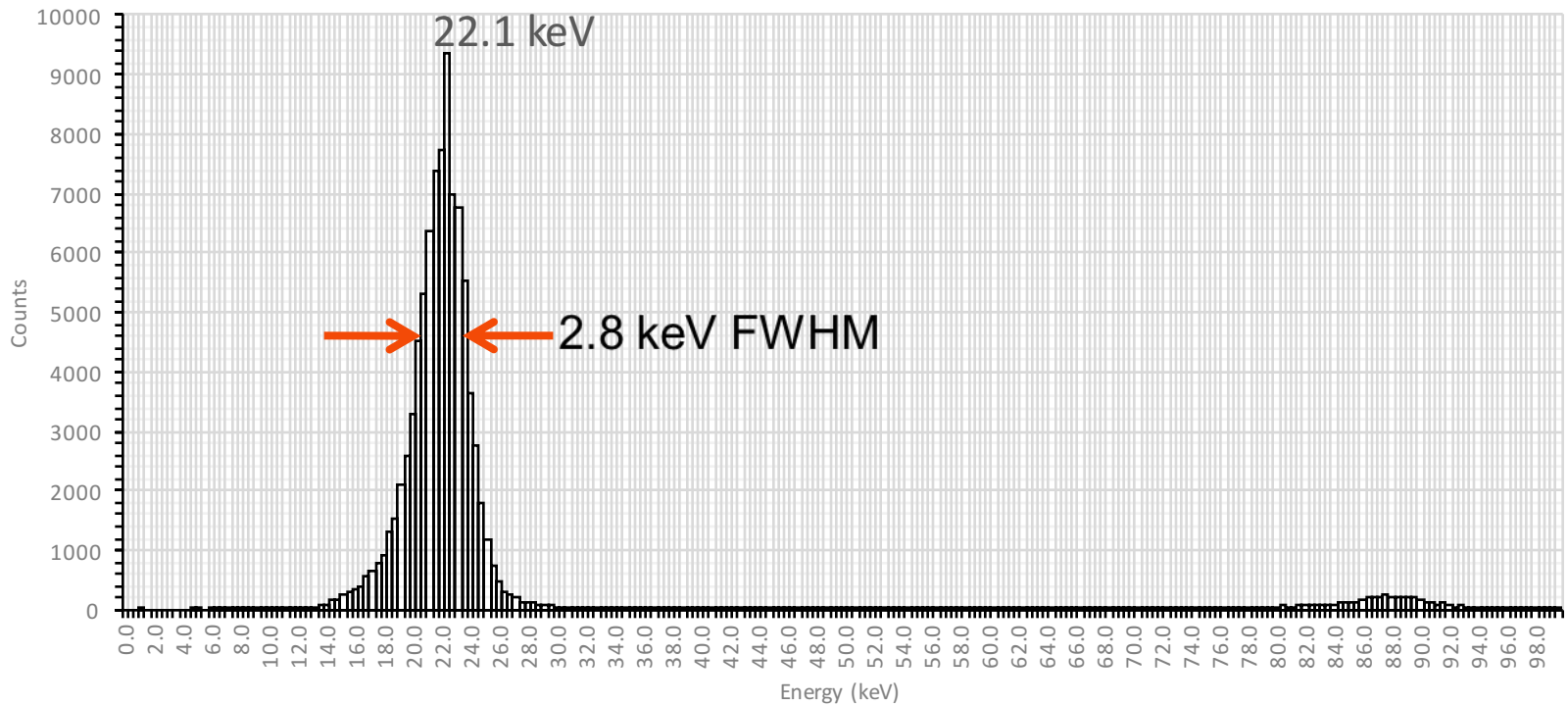


Histogram of the measurement of 122 keV X-Ray from Cobalt-57 beta decay



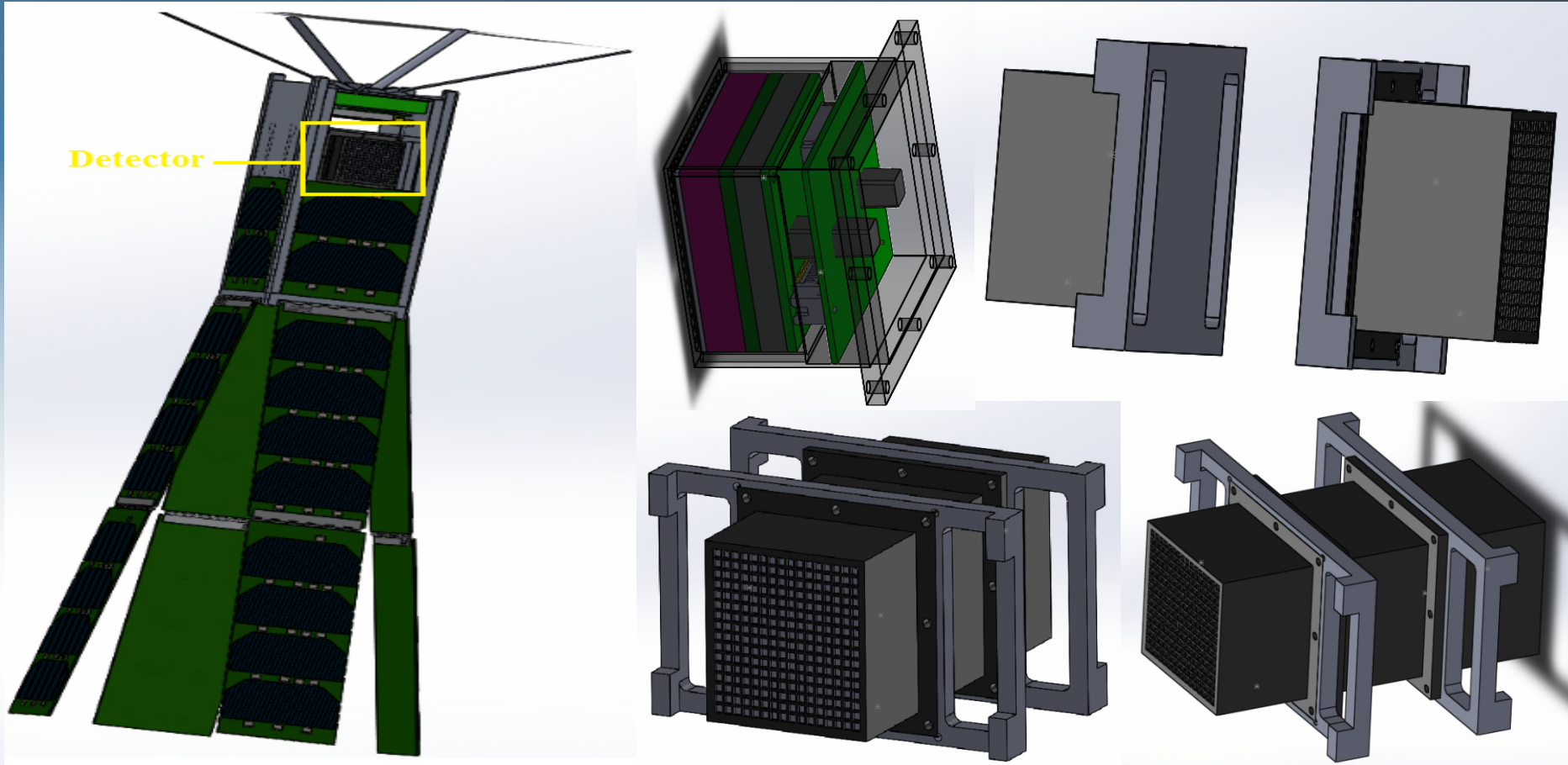
# REDLEN MI770 – RESULTS

Cd109 Spectrum (-750V Bias)



Histogram of the measurement of 22.1 keV X-Ray from Cadmium-109 beta decay

# REDLEN MI770 – IMPLEMENTATION



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# REDLEN MI 770 – CURRENT CHARACTERIZATION





# 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?

