



3-D SNM Detection Using CdZnTe Detectors

May 20, 2019

Zhong He, Daniel Shy, Valerie Nwadeyi
University of Michigan



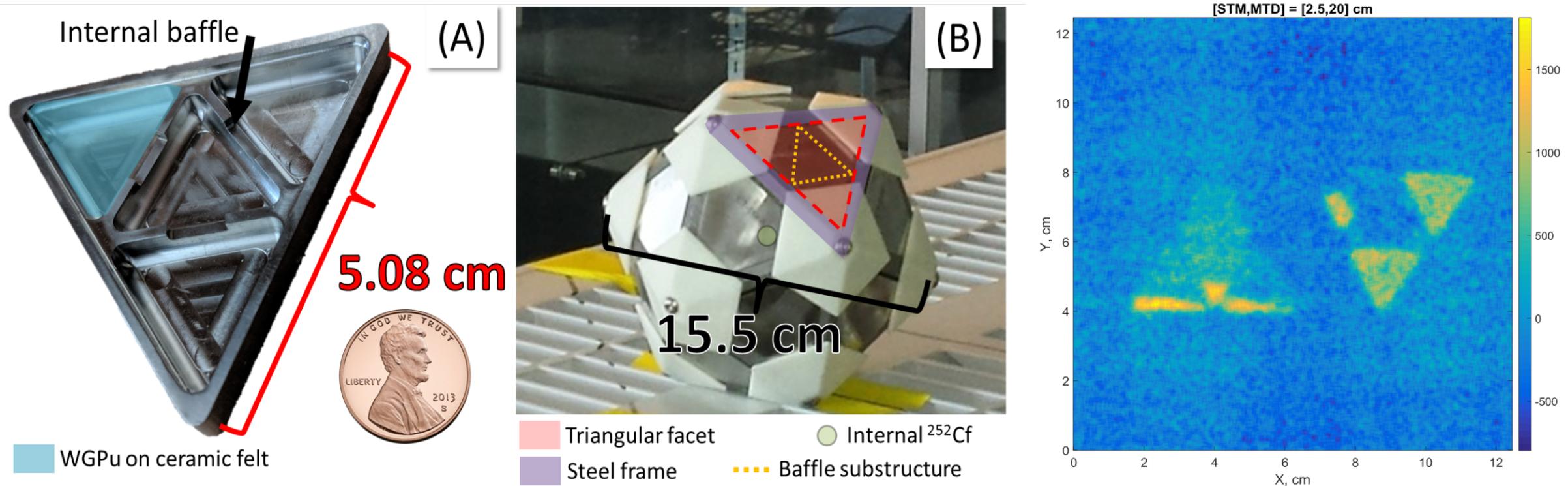
Introduction & Motivation – 3-D Gamma-Ray Imaging

- Gamma-ray imaging with high spectroscopic resolution in 3-dimensional space will be important to detect, **locate** and **characterize** special nuclear materials (SNMs) in real world applications.
- 3-D position sensitive CdZnTe detectors offer unique capabilities, including very **compact** form factor (handheld), high gamma-ray spectroscopic **resolution**, real-time gamma-ray **imaging** and **neutron detection**. Gamma-ray imaging in 3-dimensional space, especially at higher gamma-ray energies, require substantial development to be widely deployed in the field – **faster, higher signal-to-noise ratio** (less artifacts), **simpler** for handheld devices & **environmental awareness**.



High Resolution Time Encoded Imaging (TEI)

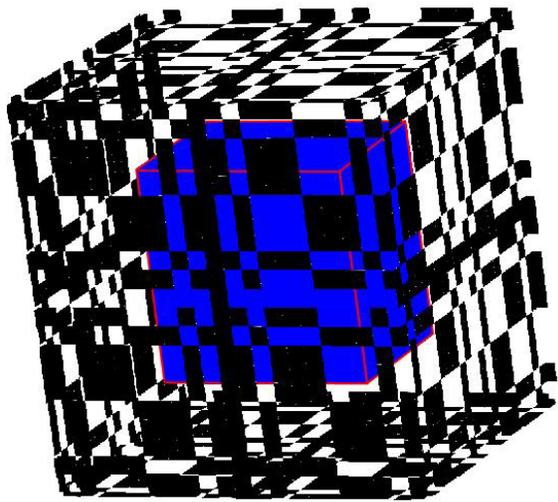
- Portable TEI for hand-held devices, make use of 3-D position sensing ($\sim 300 \mu\text{m}$) in CdZnTe, add correction on source-to-detector distance.



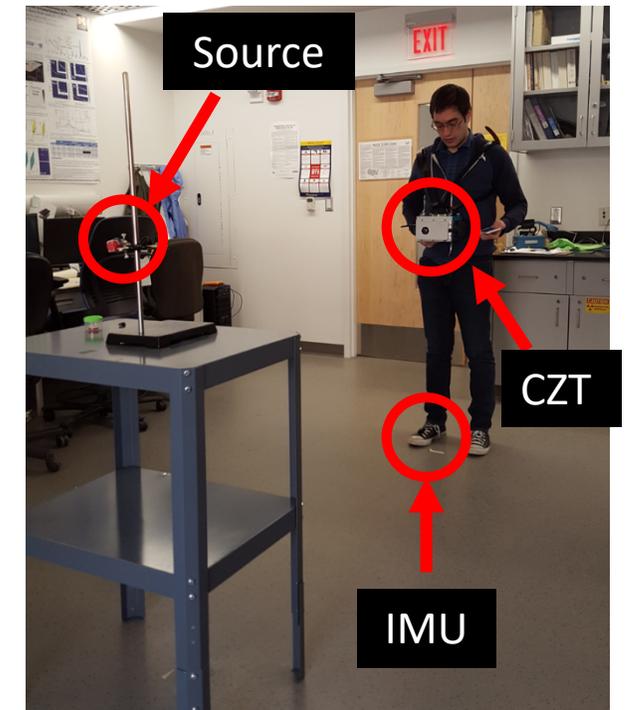
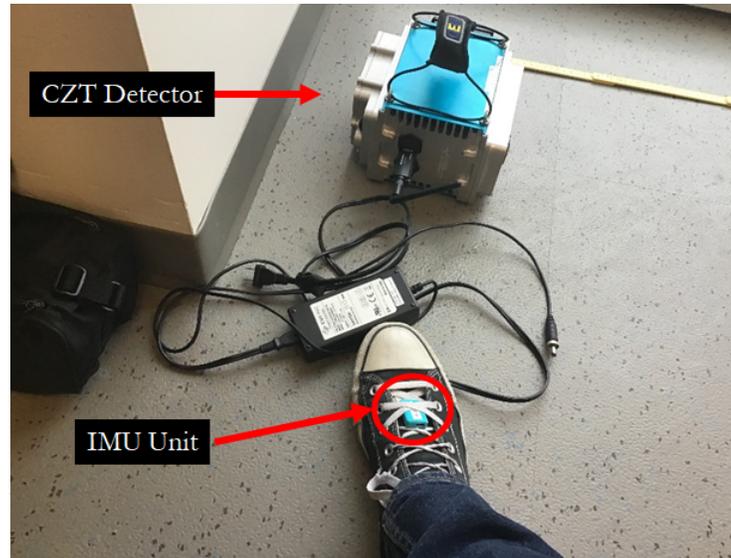
3-D Gamma-Ray Imaging

- *Motivations: GPS denied areas (**indoor** and **outdoor**), commercially availability and minimum computing for hand-held RIID's like devices.*

Sonal Joshi's cubic coded aperture



Daniel Shy's approach using Inertial Measurement Units (IMUs)



3-D Gamma-Ray Imaging

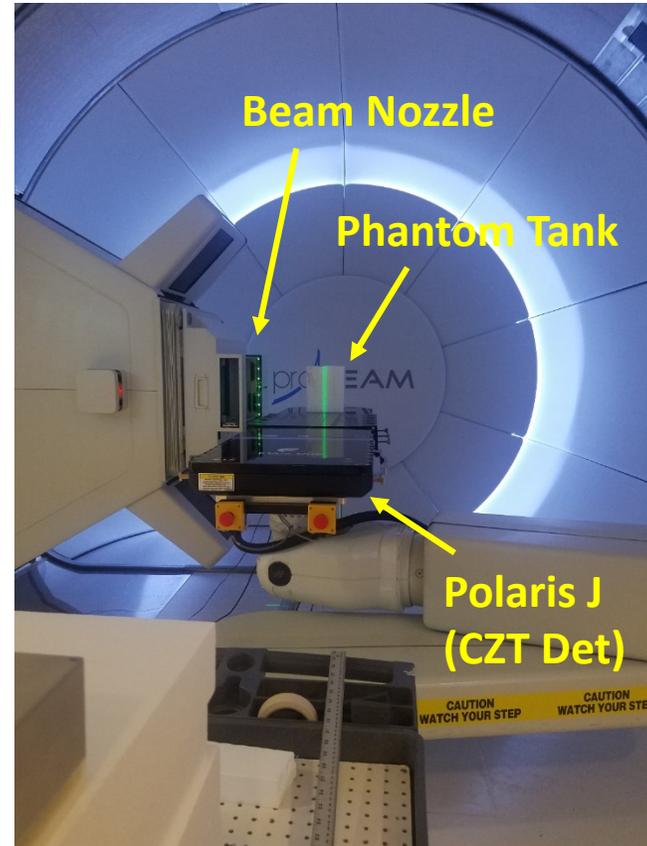
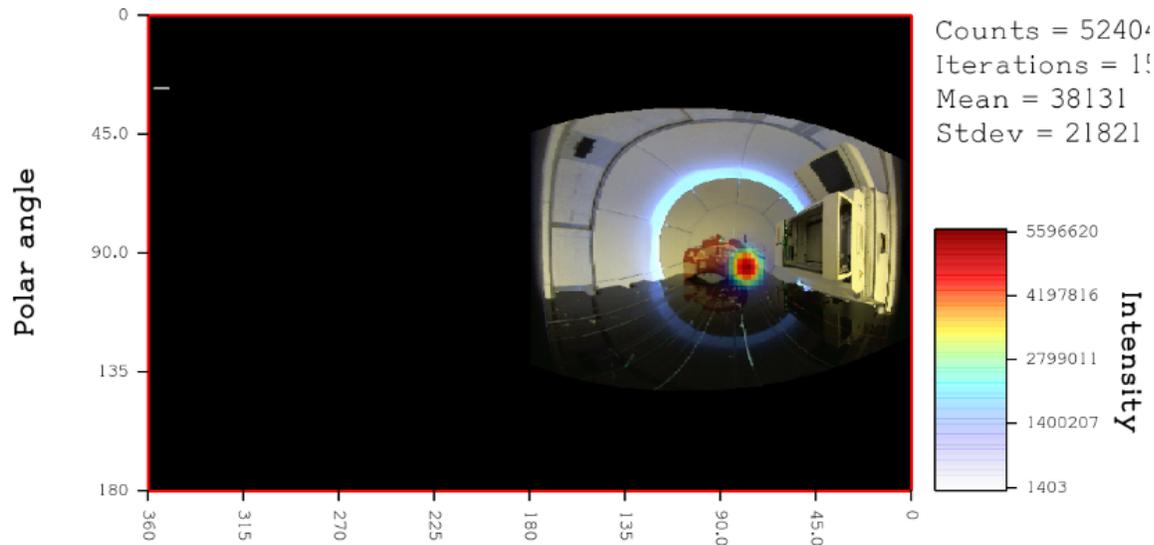


```
2: "name": "Sparse PLM in 3D",
3: "resolutionThreshold": 0.0001
4: "intervals": 5,
5: "vertices": 15,
6: "min": 0000,
7: "max": 0000,
8: "min": 00,
9: "max": 0000,
10: "min": -0000,
11: "max": 1000,
12: "min": 1000,
13: "max": 20
14: }
15: {
16: "drift_correction": false,
17: "drift_correction_path": "data/drift_correction.dat",
18: "mergeman": 2000,
19: "mergeman": 1,
20: "position": 0.00,
21: "name": "Circle Back-Projection",
22: "attach": 500,
23: "mergeman": 100,
24: "attach": 100,
25: "output": ""
26: }
27: {
28: "max_iterations": 1000,
29: "mergeman": 600,
30: "mergeman": 0.1,
31: "iterations": 10000,
32: "attach": 100,
33: "mergeman": 1,
34: "attach": 100,
35: "output": ""
36: "random_seed": 42
37: }
38: {
39: "spectrum": {
40: "mergeman": 2000,
41: "mergeman": 1,
42: "name": "Spectrum",
43: "mergeman": 2000,
44: "output": ""
45: }
46: }
47: }
48: }
49: }
50: }
51: }
52: }
53: }
54: }
55: }
56: }
57: }
58: }
59: }
60: }
61: }
62: }
63: }
64: }
65: }
66: }
67: }
68: }
69: }
70: }
71: }
72: }
73: }
74: }
75: }
76: }
77: }
78: }
79: }
80: }
81: }
82: }
83: }
84: }
85: }
86: }
87: }
88: }
89: }
90: }
91: }
92: }
93: }
94: }
95: }
96: }
97: }
98: }
99: }
100: }
```



Higher-energy & higher-flux gamma-ray imaging

- **Neutron activation** analysis with added **gamma-ray imaging** capability
- **Proton cancer therapy range verification**
- NIST: **imaging hydrogen in metal**
- NASA: **planetary science missions**



MTV Impact

- Training Ph.D students to work in radiation detection field
 - Opportunities: Internships, MTV workshops, networking, connections
- Personnel transitions: Collaborations with national labs – **INL, PNNL**
- Technology transitions
 - **Who is interested?** Radiation Detection Companies
 - **Interested Companies:** H3D Inc., RMD, PHDs



Conclusion

- MTV will support our research on **3-D gamma-ray imaging for SNM detection, location and characterization**. These are important technical development very relevant to NNSA missions



Acknowledgements



The Consortium for Monitoring, Technology, and Verification would like to thank the NNSA and DOE for the continued support of these research activities.



This work was funded by the Consortium for Monitoring, Technology, and Verification under Department of Energy National Nuclear Security Administration award number DE-FOA-0001875

