Time-Encoded Dual Particle Imager (lanTErn)

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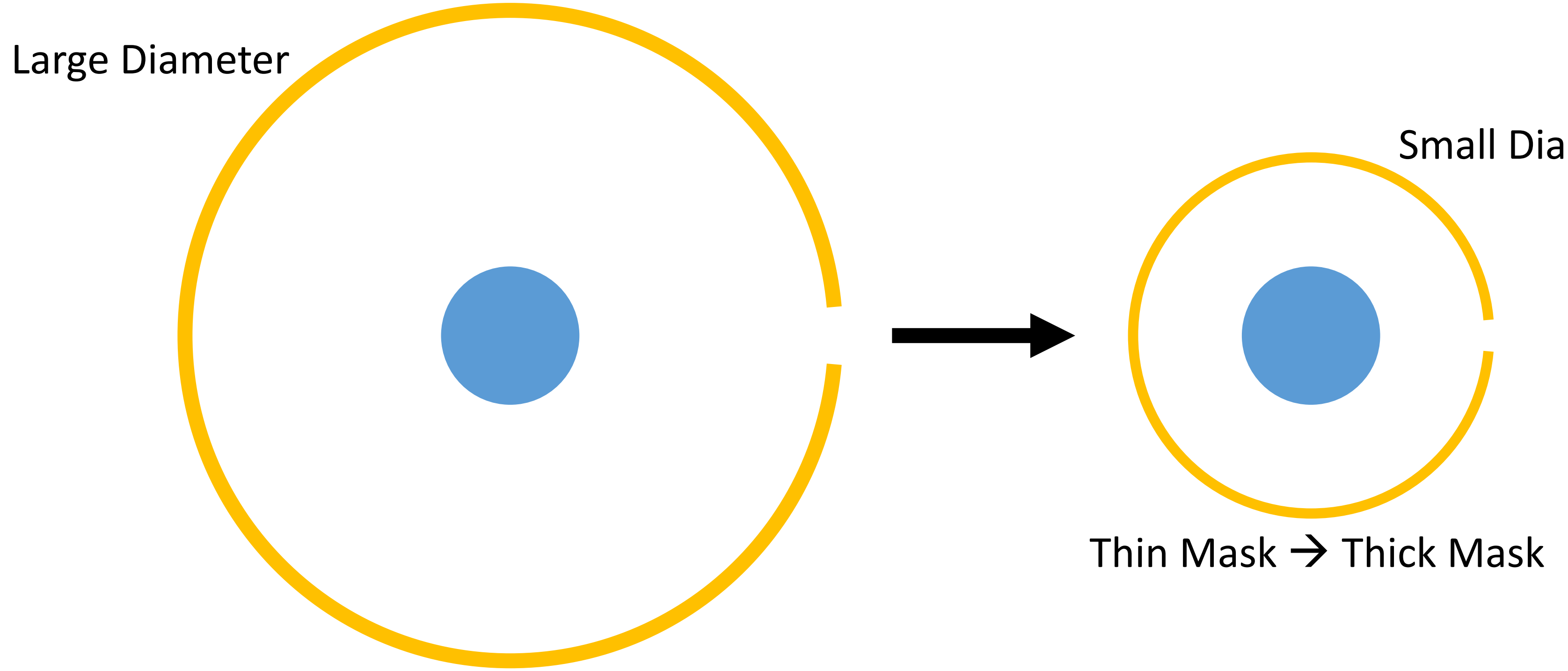
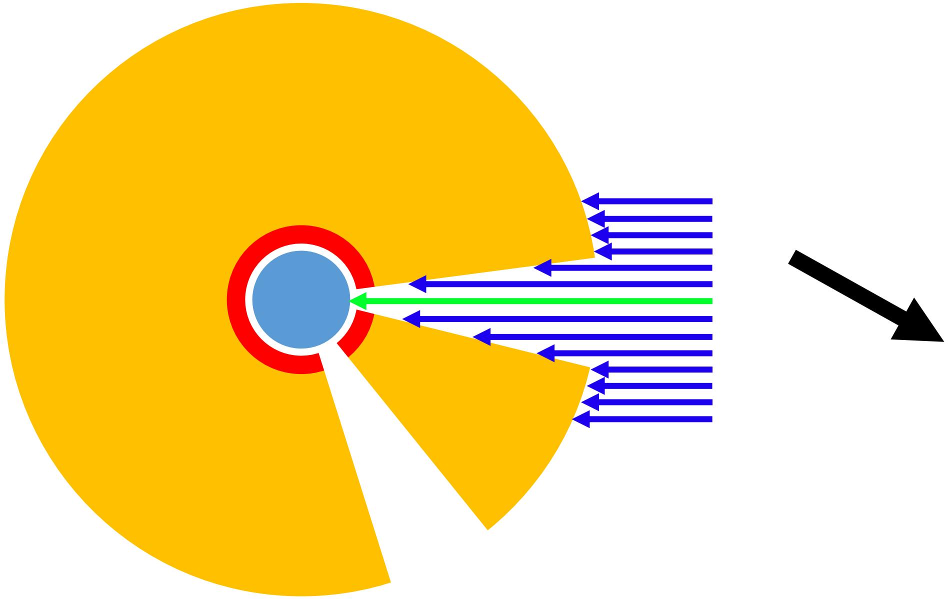
Introduction and Motivation

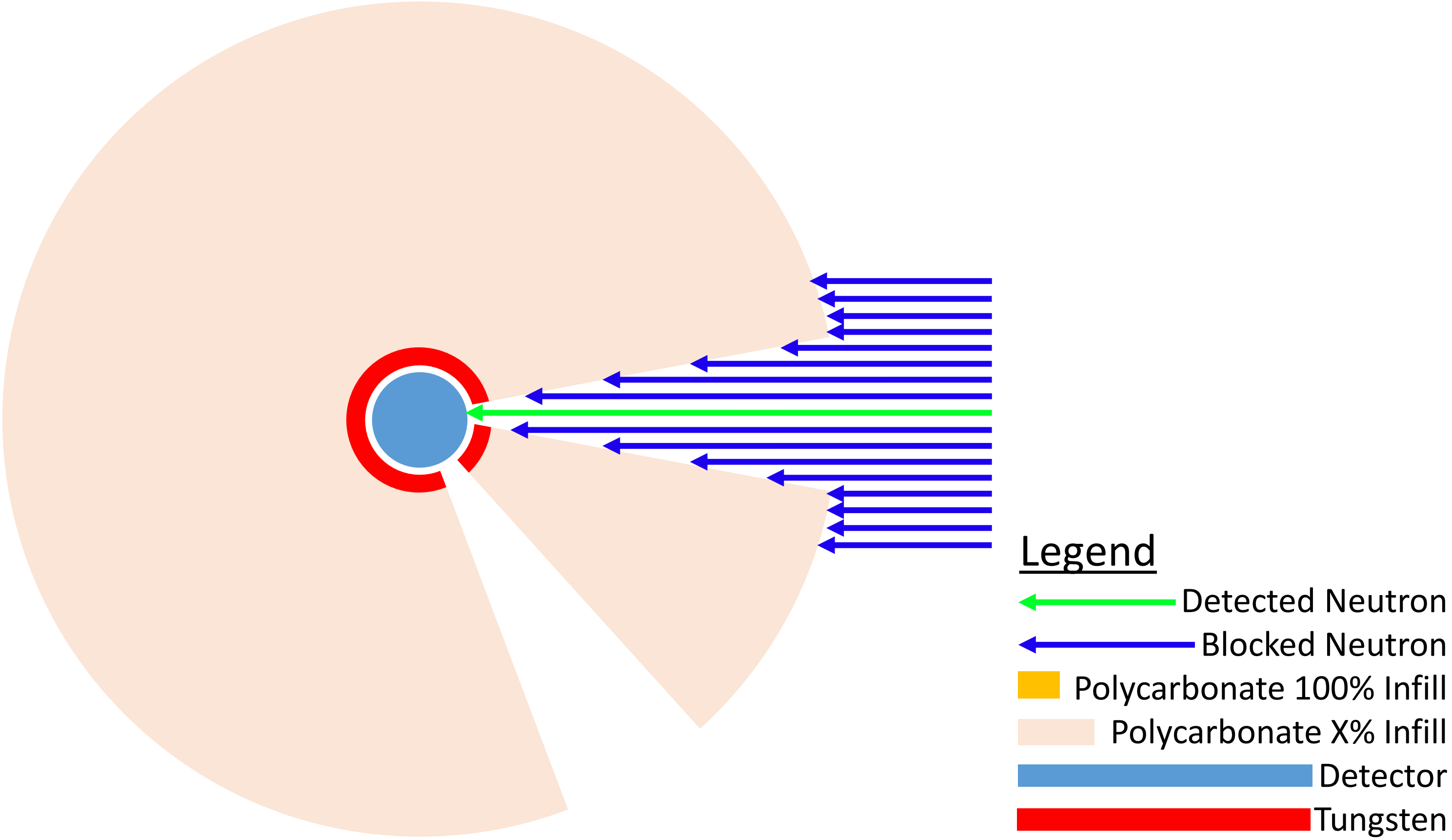
- Simple, man-portable, dual particle cTEI imaging system is desirable for nuclear nonproliferation
- Overall Goal: Improve image quality when transitioning from a large to small diameter coded mask.



Design #1: Variable Density Mask

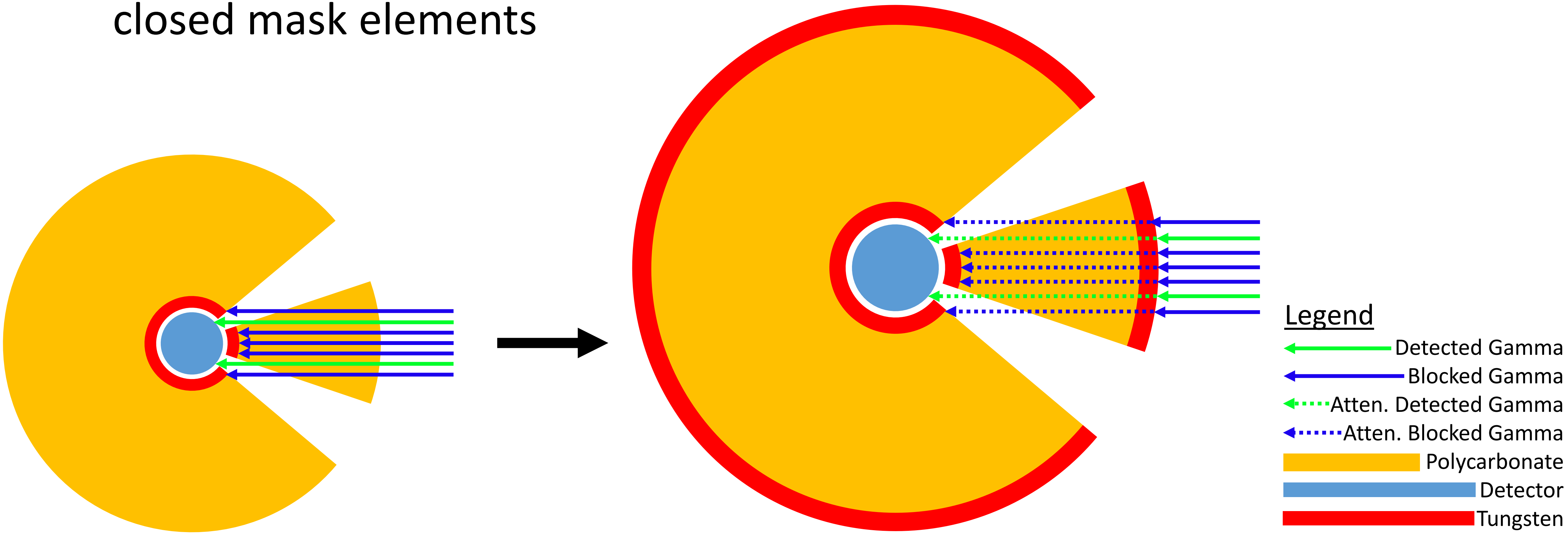
- Infill of polycarbonate is user specified with the use of 3D printing
- For fixed mass, tradeoff between attenuation and collimation
- Goal: Improve neutron image quality





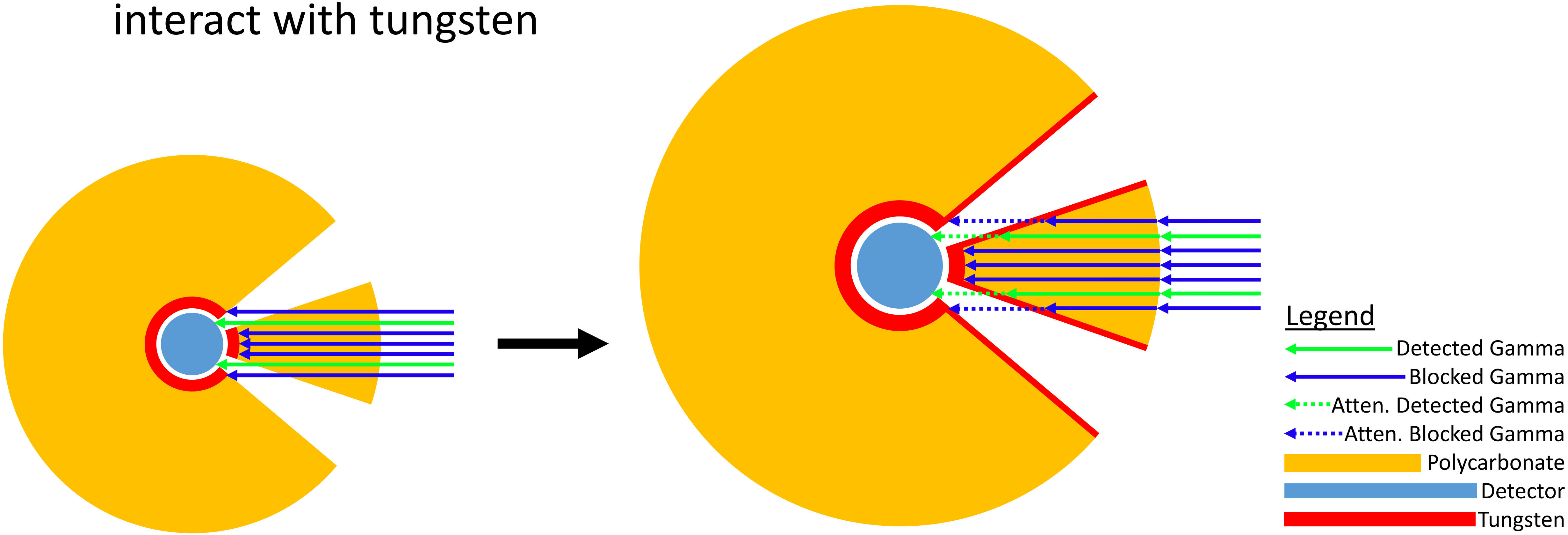
Design #2: Three Layered Mask

- Addition of an outer ring of tungsten
- Goal: Increase gamma ray collimation, decrease admittance through closed mask elements



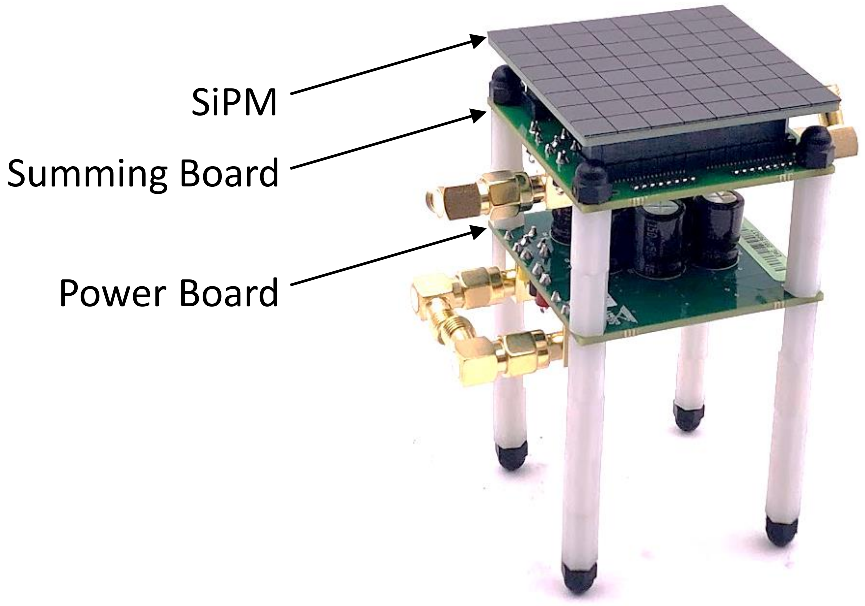
Design #3: Hollow Mask

- Addition of tungsten on side walls of each open element
- Goal: Ensure that all gamma rays in front of a closed element can interact with tungsten

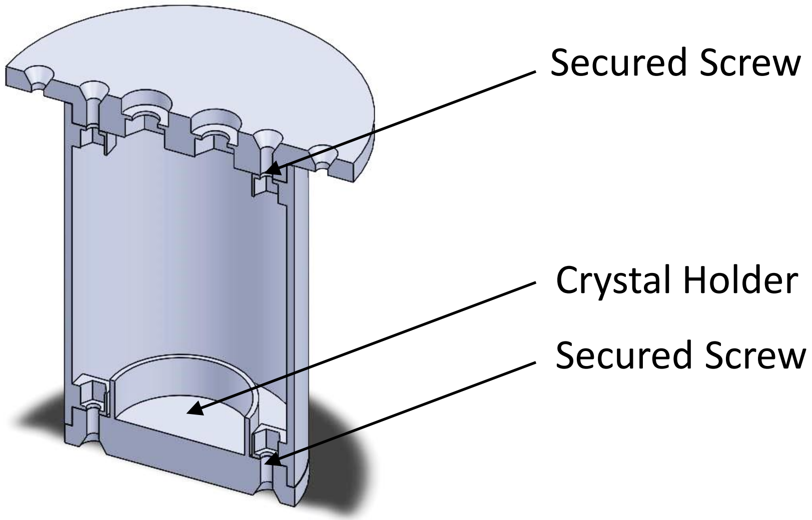


Detector Setup

- Setup includes a SensL J-series SiPM, summing board and power board from Sandia National Laboratories, and a polycarbonate light tight box
- Goal: Allow for ease of crystal swapping; maintain compact, lightweight design



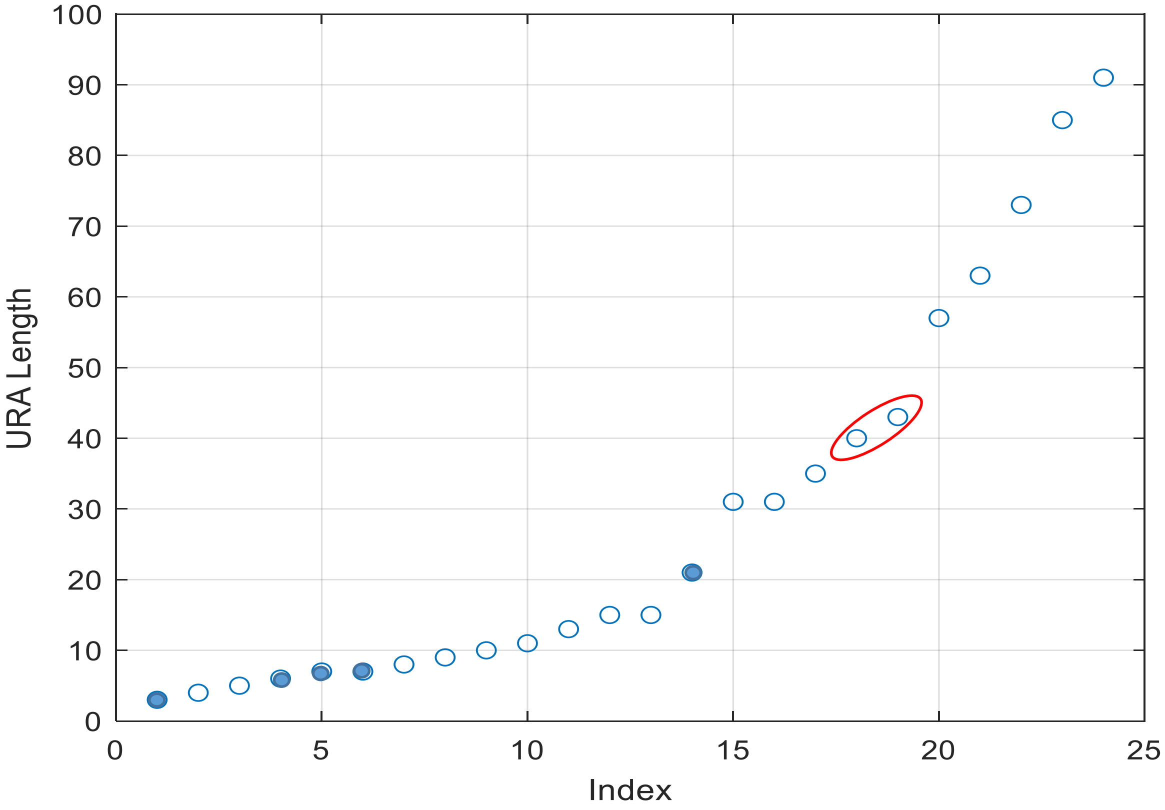
3D printed polycarbonate light tight box



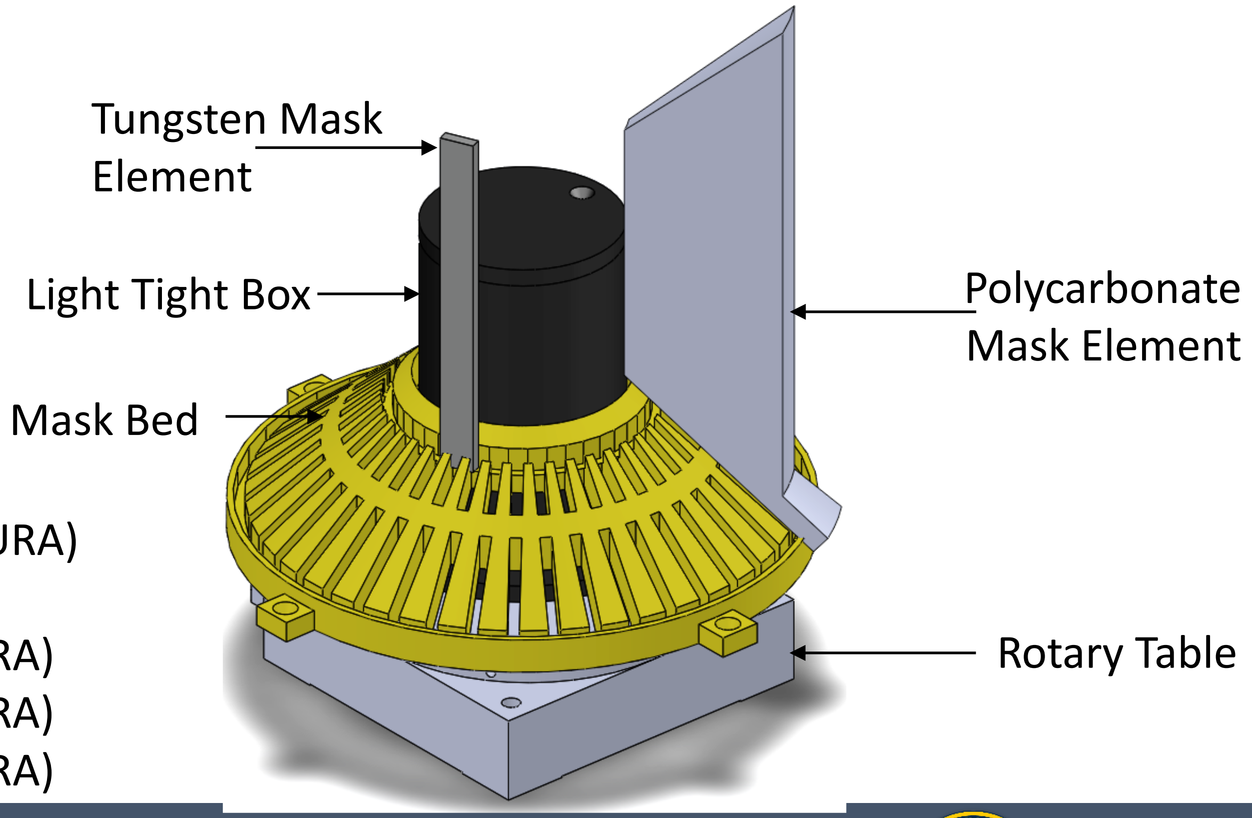
Cross section of light tight box

Mask Test Bed

- Design of a mask bed for testing of several unconventional cTEI coded masks
- Goal: Allow for even and odd numbered mask patterns



42
21 (URA)
14
7 (URA)
6 (URA)
3 (URA)



Mask Pattern Optimization

- Including the detector response instead of ideal coded aperture
- Goal: Create a pattern that produces a delta function for the point spread function

Using a URA (ideal coded aperture):
$(A \otimes A) = delta\ function$

Point Spread Function
$(A \otimes A) \otimes (D \otimes D)$

Detector Response

Mask Pattern

Point Spread Function Term Rearranging
$(A \otimes A) \otimes (D \otimes D) = (A \otimes D) \otimes (A \otimes D)$.

There is not a URA for a 42 element mask, so a mask pattern must be created

Generate mask patterns to find one where
$(A \otimes D) \approx delta\ function$
to make the PSF closer to a delta function.

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Mission Relevance

- Nonproliferation applications: source verification and search operations
- Need for a compact, cost-effective fast neutron imager

Expected Impact

- If successful, this will spark the testing of several unconventional coded mask designs
- Future improvements could include an increase in TRL for handheld use

MTV Impact

- Personnel transitions: John Kuchta will intern at Sandia National Laboratories where he will likely test unconventional masks and cTEI designs using the lanTErn system
- Technology transitions
  - This project is being conducted in collaboration with the Radiation and Nuclear Detector Systems group at Sandia National Laboratories

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Conclusion

- Unconventional Mask Designs
  - Variable Density Mask – neutron collimation and attenuation
  - Three Layered Mask – gamma ray collimation (closed element attenuation)
  - Hollow Mask – gamma ray collimation (decreased closed element escape)
- Mask Test Bed
  - Ability to test several designs, patterns and pixel pitches
- Mask Pattern Optimization
  - Creation of a coded mask pattern with respect to the detector response to improve image quality

Next Steps

- Direct steps
  - Construction of system and implementation
  - More unconventional mask designs for neutron image quality improvement
- Possible future steps
  - Multiple detection crystals
  - 2D mask design in collaboration in SNL

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