

# Warhead confirmation techniques and considerations

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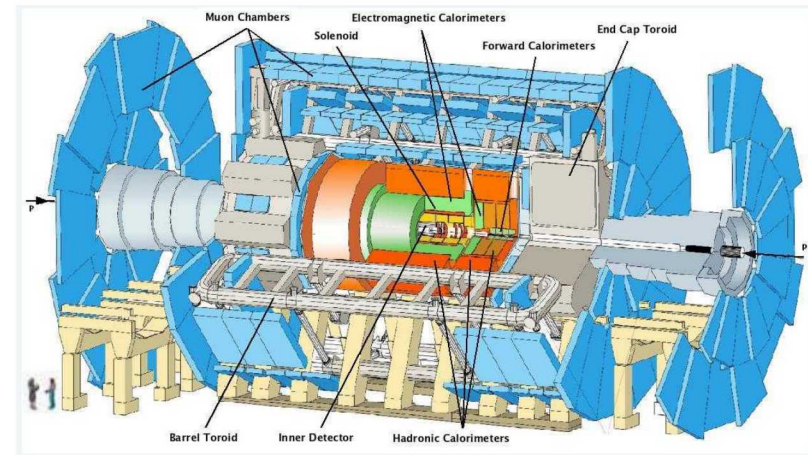
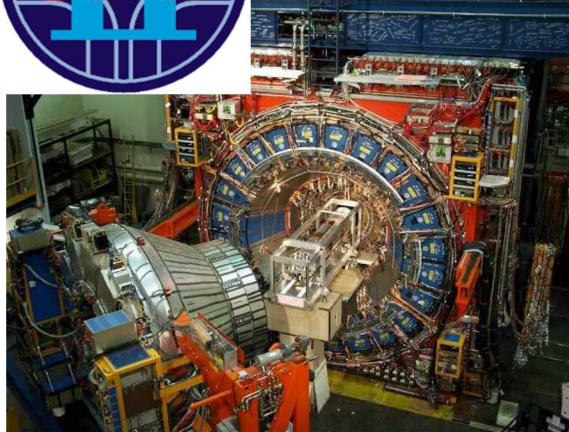
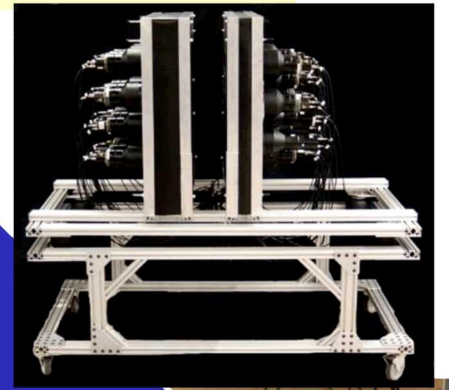
Sandia National Laboratories, Livermore, CA

October 21, 2019

# My path to neutron detection/imaging

Experimental particle physics

Applied radiation detection



- Neutron imagers for:
- Source detection
  - Localization
  - High-resolution imaging

# ORNL/SNL neutron coded aperture imager

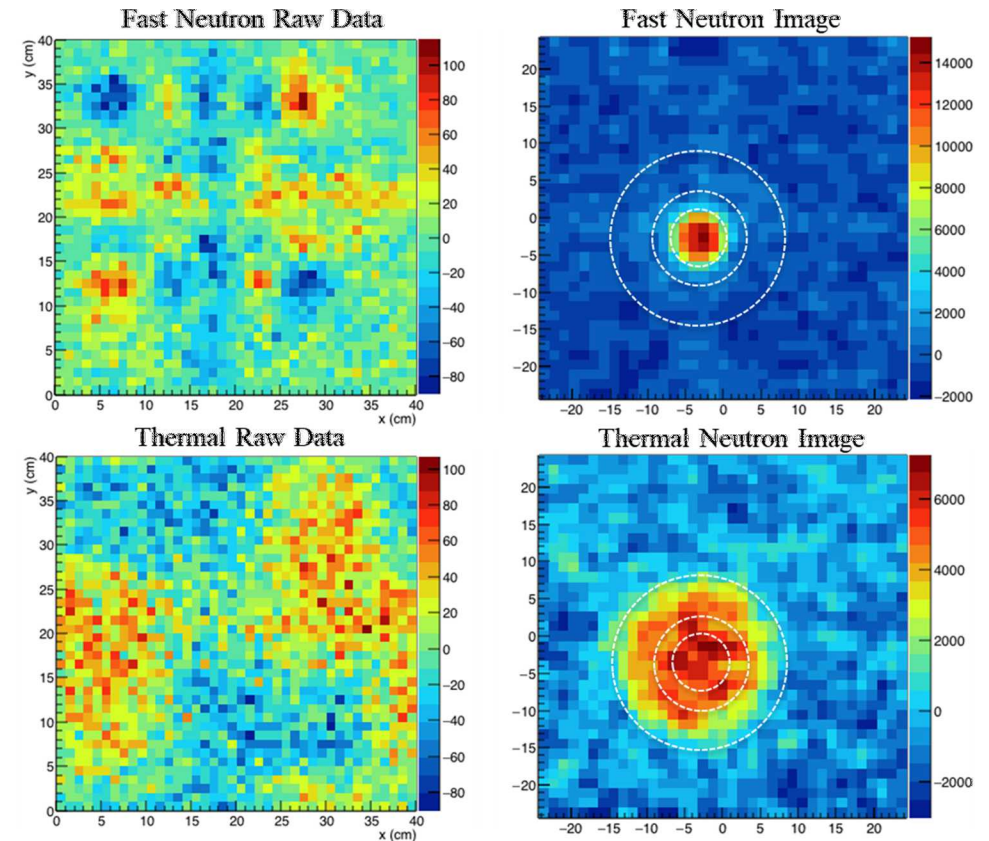
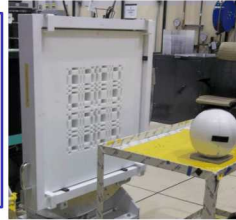
- Extension of pinhole with much higher effective area: signal modulated in unique 2-d patterns.
- ORNL/SNL fast neutron coded aperture imager was developed for arms control treaty verification.
- Image plane consists of 16 liquid organic scintillator pixelated block detectors
  - Each block consists of a 10x10 array of 1 cm. pixels.
  - PSD and pixel id accomplished by 4 photomultiplier tubes.
- Mask plane consists of 2.5 to 10 centimeters of HDPE.



21 Oct 2019

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Images of BeRP ball (4.5 kg WGPu, 3.8 cm radius) + 2.5 cm void + 5 cm polyethylene



# Warhead confirmation

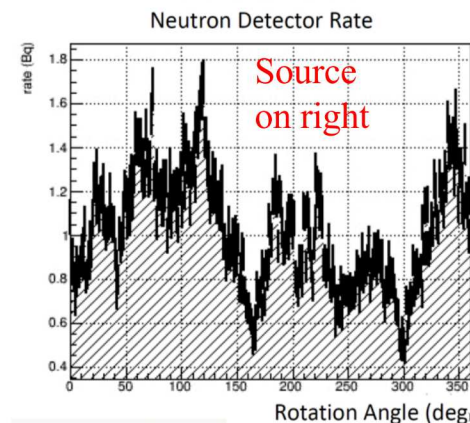
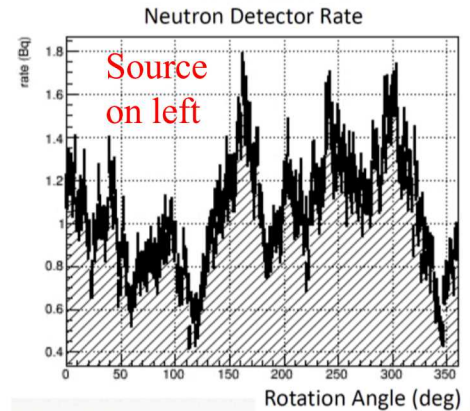
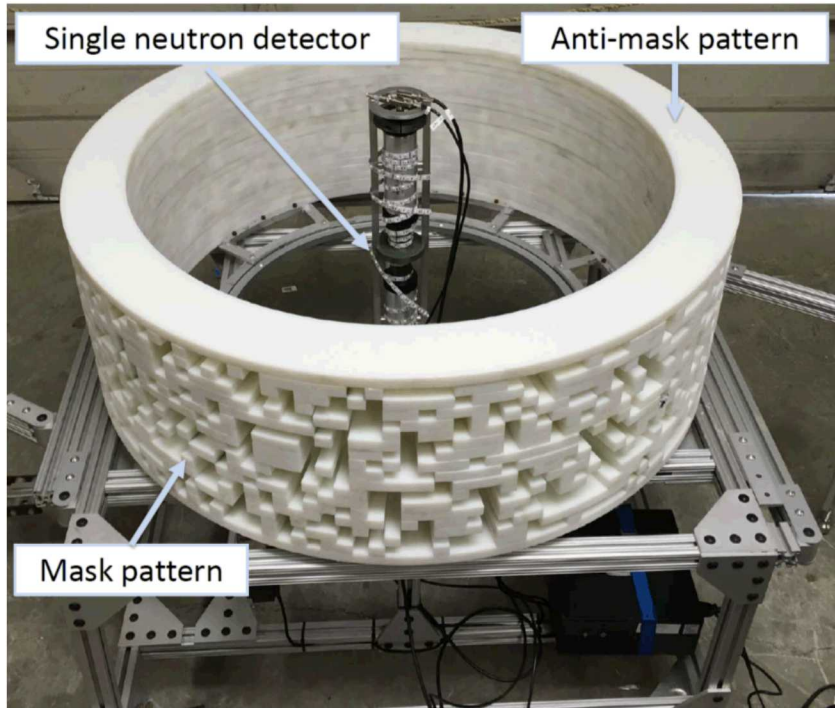
- Notional scenario:
  - In a future arms reduction treaty, nuclear warheads are dismantled to fulfill treaty obligations.
  - Verification requires positive confirmation that the item about to undergo dismantlement **is a warhead**.
- In a denuclearization context, similar scenarios may arise
- Two classes of warhead confirmation approaches:
  - Attribute measurements: if an item satisfies some previously agreed upon measurable properties, then it is a warhead.
  - Template measurements: if previous measurements on a *known warhead* match similar measurements on the current item, then it is a warhead.

# Sensitive information protection

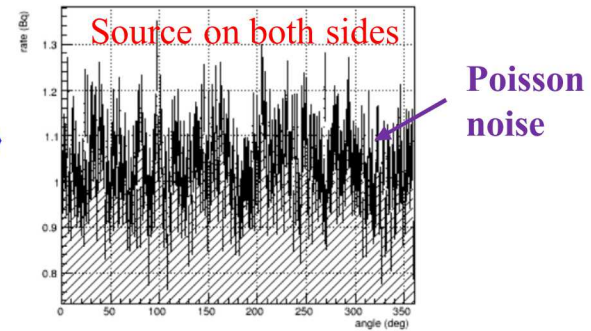
- Key challenge for warhead confirmation:
  - Collect enough information to answer **Is it a warhead?**, but
  - Avoid revealing sensitive warhead design information
- Traditional approach: Information barrier (IB)
  - Data collection, processing, analysis are inaccessible—only final confirmation result is reported
  - Requires trust/authentication of equipment and algorithm
- Recent work on alternative approaches:
  - Intrinsic IBs: Manipulate measurement or data to remove sensitive information
  - Zero knowledge protocols: Construct measurement that cannot reveal sensitive information

# Zero-knowledge techniques

- Determine whether two items are “same”, like template approach
- Example: Sandia CONFIDANTE system (Peter Marleau)



By construction, if and only if identical neutron emissions on both sides...



- Other proposed zero-knowledge methods:
- Neutron transmission with preloads (Princeton)
  - Physical cryptographic methods (MIT)
    - nuclear resonance fluorescence
    - neutron resonances

# Denuclearization verification Qs

- In the context of denuclearization:
  - Any such agreement is likely to have asymmetric obligations
    - Does this change verification requirements, including for warhead dismantlement?
  - Non-nuclear weapon states (NNWS) may have an interest in denuclearization verification
    - Can zero-knowledge approaches provide confidence to NNWS without revealing proliferation-sensitive information?
  - Warhead dismantlement is only one potential aspect of denuclearization
    - Can similar concepts apply to verification of other phases/aspects?
  - Template and zero-knowledge methods require one *known warhead*.
    - How to satisfy this initial condition?