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SAND2019-8056C

Mechanical Design and Fabrication of Compact, Portable Nuclear Particle Detectors

2019 INMM Conference

Andrew Druetzler

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Presentation Outline

1. Particle detection applications – Why do we care?
2. Detector experiences
   a. miniTimeCube (mTC)
   b. Neutrino Lattice (NuLat) Detector
   c. Optically Segmented Single Volume Scatter Camera (OS SVSC)
3. Lessons Learned
4. Future Plans for Improvement

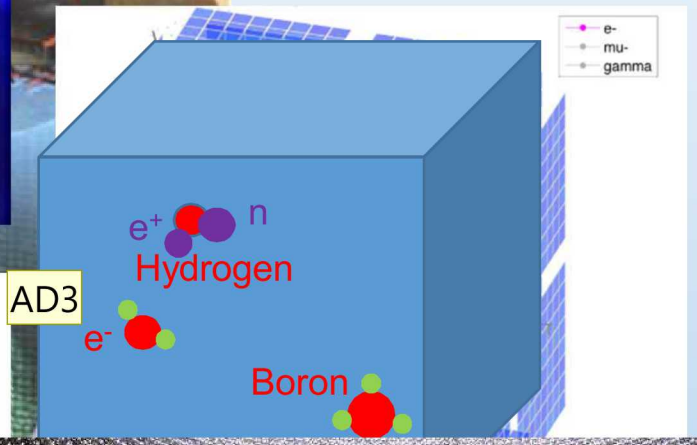
Applications – Why do we care?

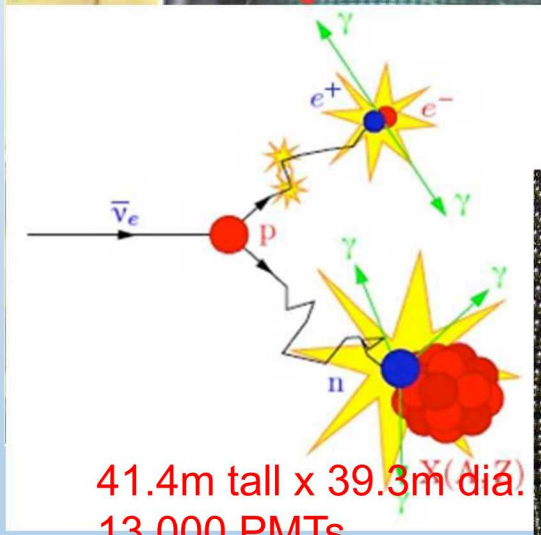
- Nuclear nonproliferation
- Treaty verification
- SNM smuggling detection/ prevention
- Nuclear waste management
- Fundamental physics

miniTimeCube (Concept)

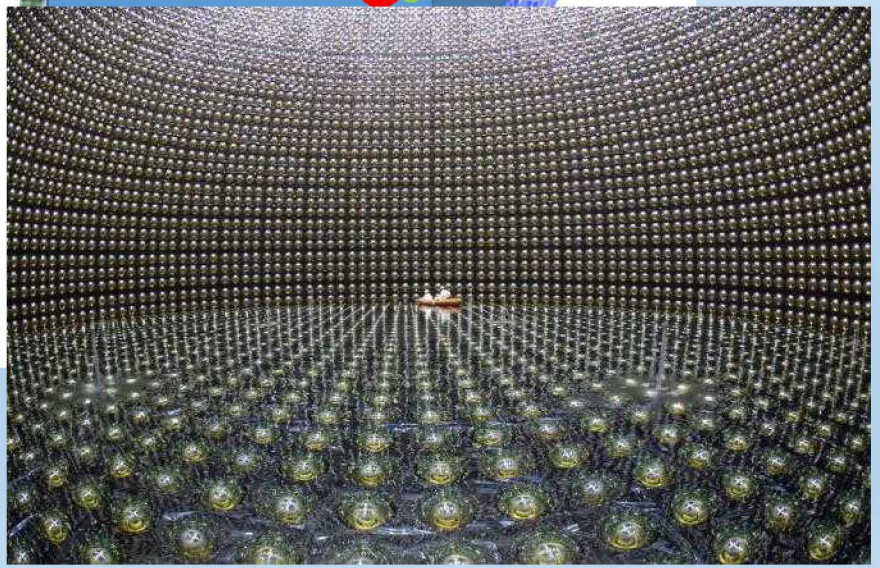
- **Compact** (~1/2mx1/2mx2m tall) neutrino detector
- Inverse beta decay
- Scintillation
- Reconstruction algorithms to localize events
- Physics statistics analysis & simulations to filter background
- Neural network programs to improve analytics

● antineutrino





41.4m tall x 39.3m dia.
13,000 PMTs



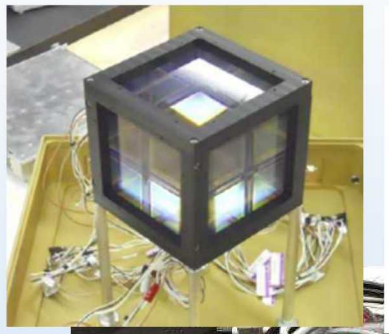
Slide 4

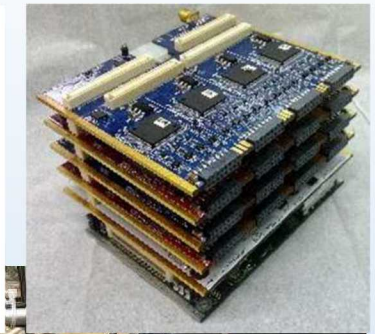
AD3 Make the balls in the annimation the same color as those in the picture.

Andrew Druetzler, 6/21/2019

miniTimeCube (Components)

- 13cm cube of boron doped scintillator
- 24 Multi-channel plate photomultiplier
- UH homemade electronics (1,536 channels)
- Raspberry Pi
- Active cooling system
- Robust power supply
- Clock PCI
- Etc., etc., etc.



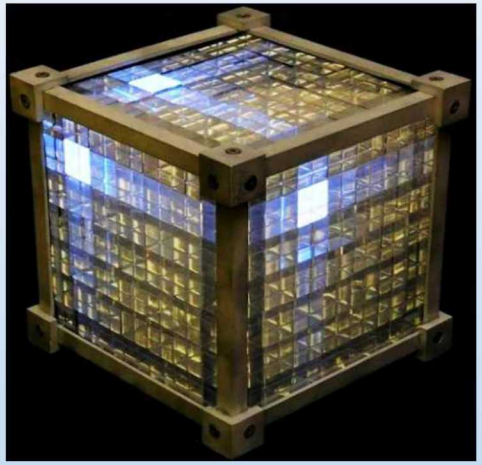


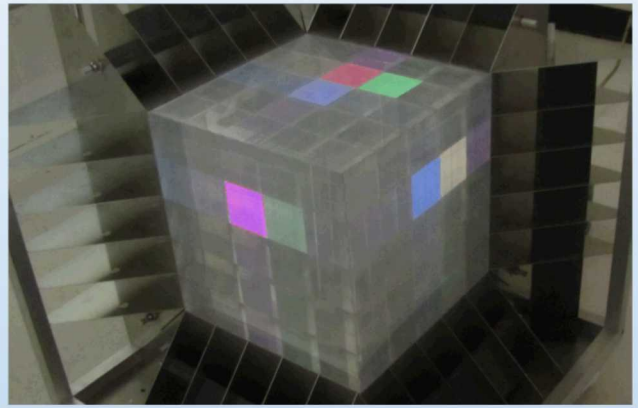
miniTimeCube (Lessons Learned)

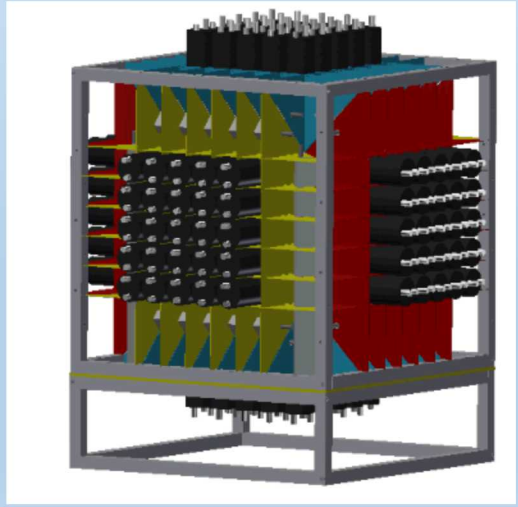
- Complete characterization of individual components
  - Crosstalk
  - Maximum efficiency
- Include cabling and auxiliary components in design documentation
- Characterize test environment backgrounds
- Segregate electronics from rest of detector to avoid heat issues
- Allow for expansion / additional components
- Prober documentation, designation and labeling
- Segmentation may simplify localization

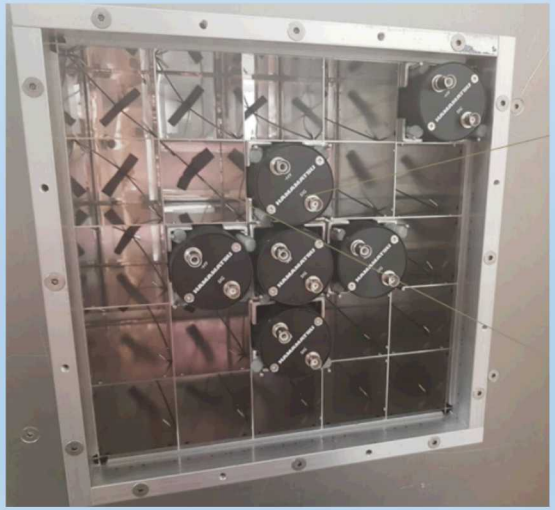
Neutrino Lattice (NuLat) Demonstrator (Concept)

- Raghavan Optical Lattice Design
  - Approx. Size: $2m^3$
- Inverse beta decay
- Total internal reflection
- Light is channeled to PMTs on rows/column where events occurred



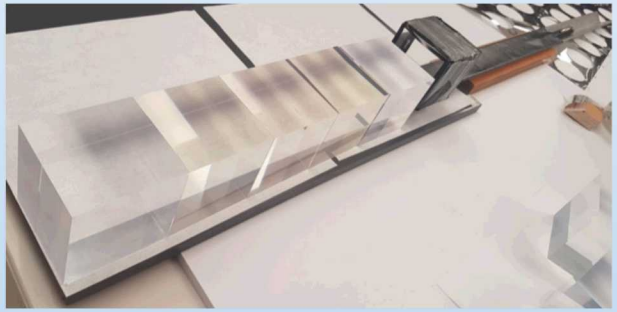


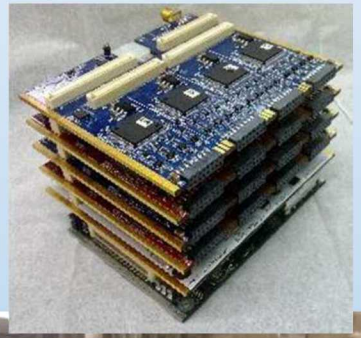


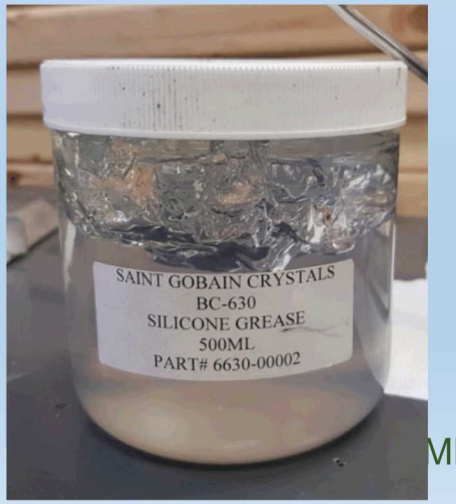


NuLat Demonstrator (Components)

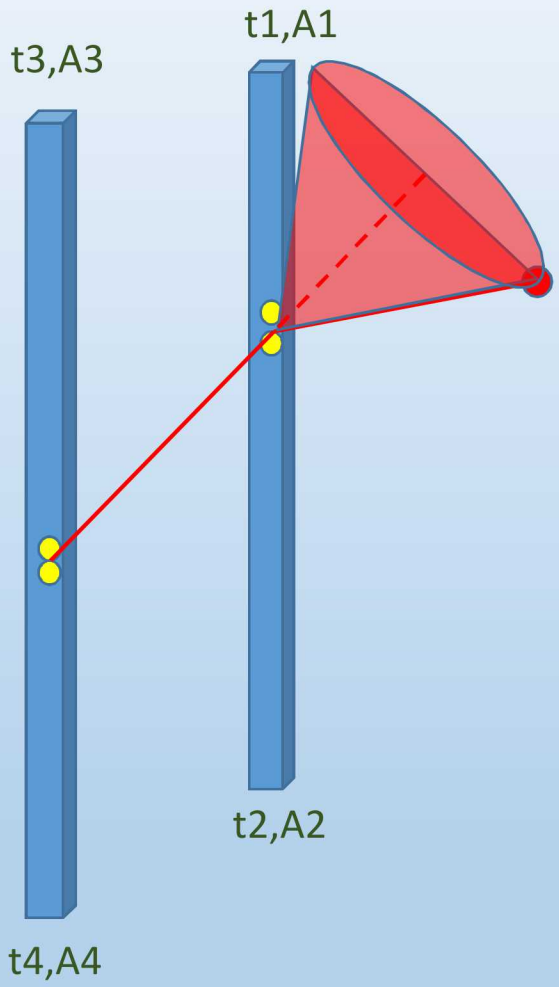
- Lithium doped scintillator cubes
- Acrylic light guides
- Photomultiplier tubes (PMTs)
- Optical grease & silicon pads
- Steel frame support & enclosure
- mTC electronics (150 channels)







Optically Segmented (OS) Single Volume Scatter Camera (SVSC) - Concept



- Neutron double scatter
- Timing & amplitude info.
- Neutron directionality
- Source localization
- Cone of probability

OS SVSC Components

- 64 plastic scintillator bars
- Optical grease
- Silicon photomultiplier (SiPM) arrays
- SiPM adapter cards
- Minimal cabling
- Electronics (digitizer)
- Reflective coating (Teflon)
- Internal supports
- Enclosure (9cmWx8.25cmTx24cmL)

OS SVSC Challenges & Future Plans

- Electrical and optical cross-talk
  - Segment SiPM pixels and redesign adapter card
- Scintillator light retension
  - New material development & reflective wrapping
- Electronics limitations
  - Exploring fast-timing electronics modules
- Scintillator-SiPM interface
  - Springs or optical cement
- Background rejection
  - Advanced algorithms & smart enclosure material

Acknowledgments & References

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  - UH OS SVSC team & other collaborators
  - UH mTC collaboration
  - NuLat collaboration

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