

# DOE HEP and Quantum Sensing Research at Los Alamos National Laboratory

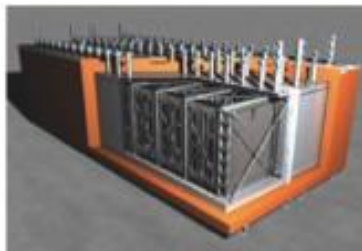
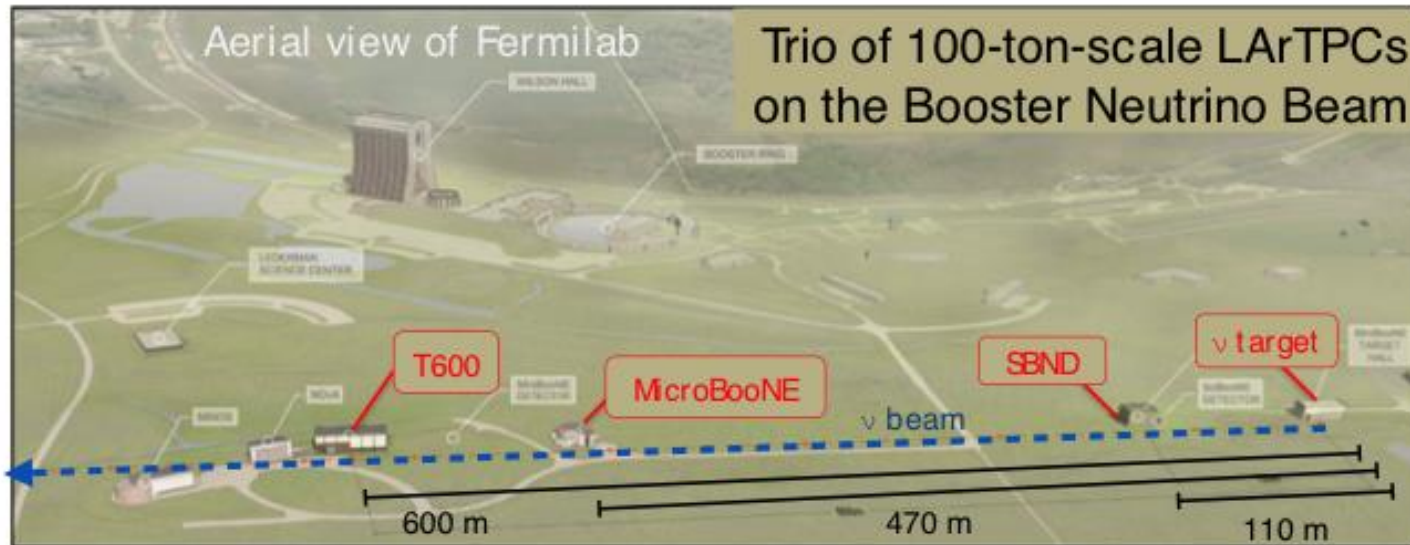
Malcolm Boshier

Physics Division

Los Alamos National Laboratory

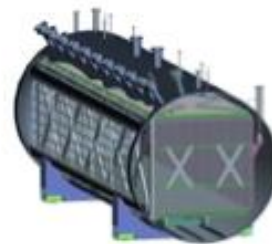
# Short Baseline Neutrino (SBN) Program

PI: Bill Louis



ICARUS-T600

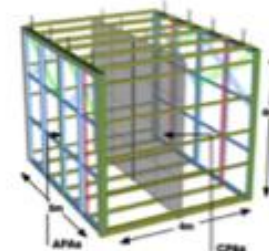
M. Toups **476 tons**



MicroBooNE

First Results From MicroBooNE

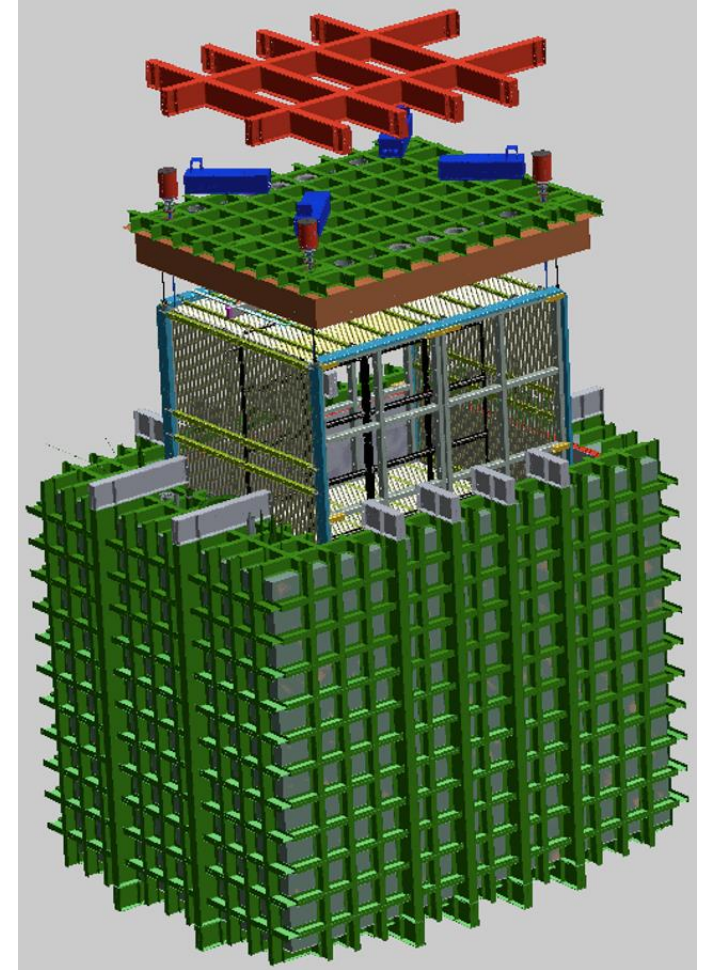
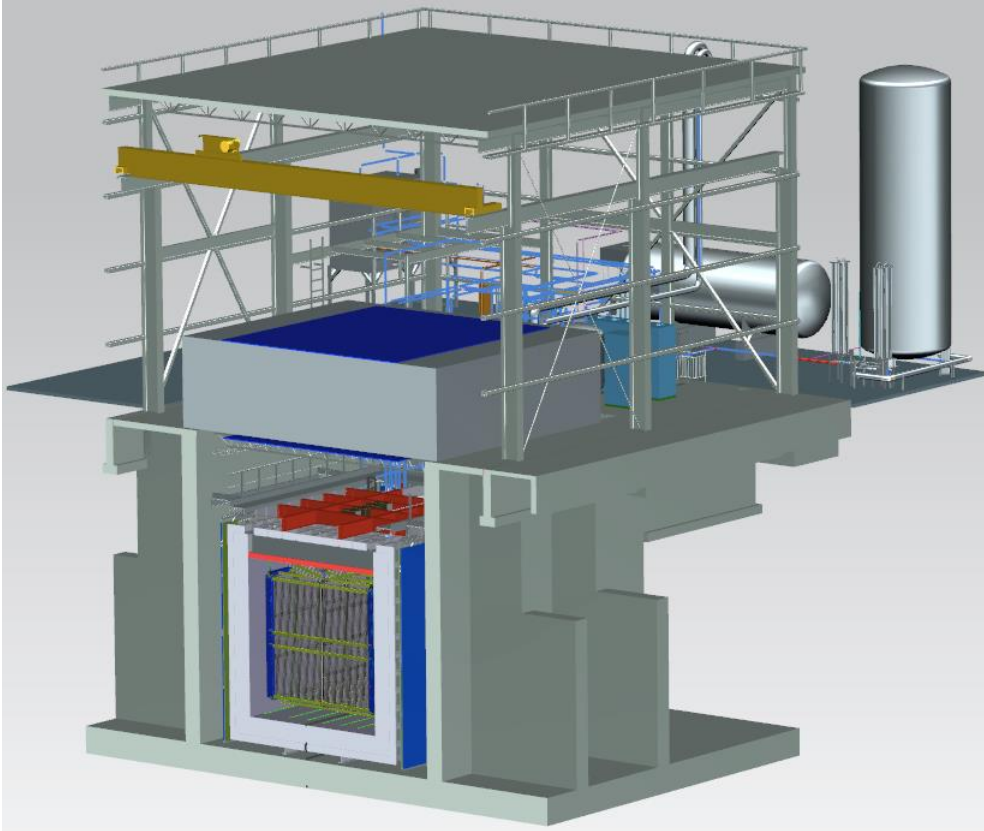
**89 tons**



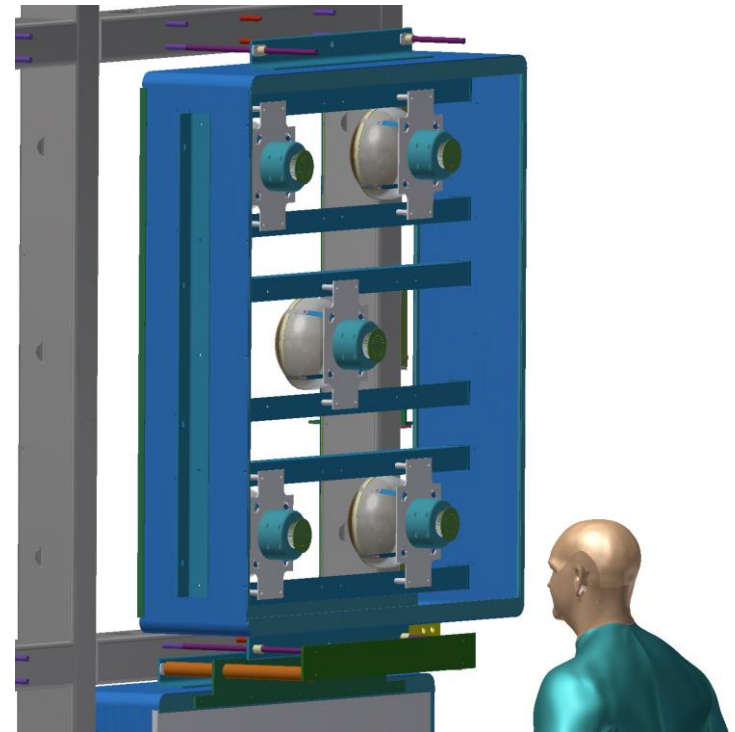
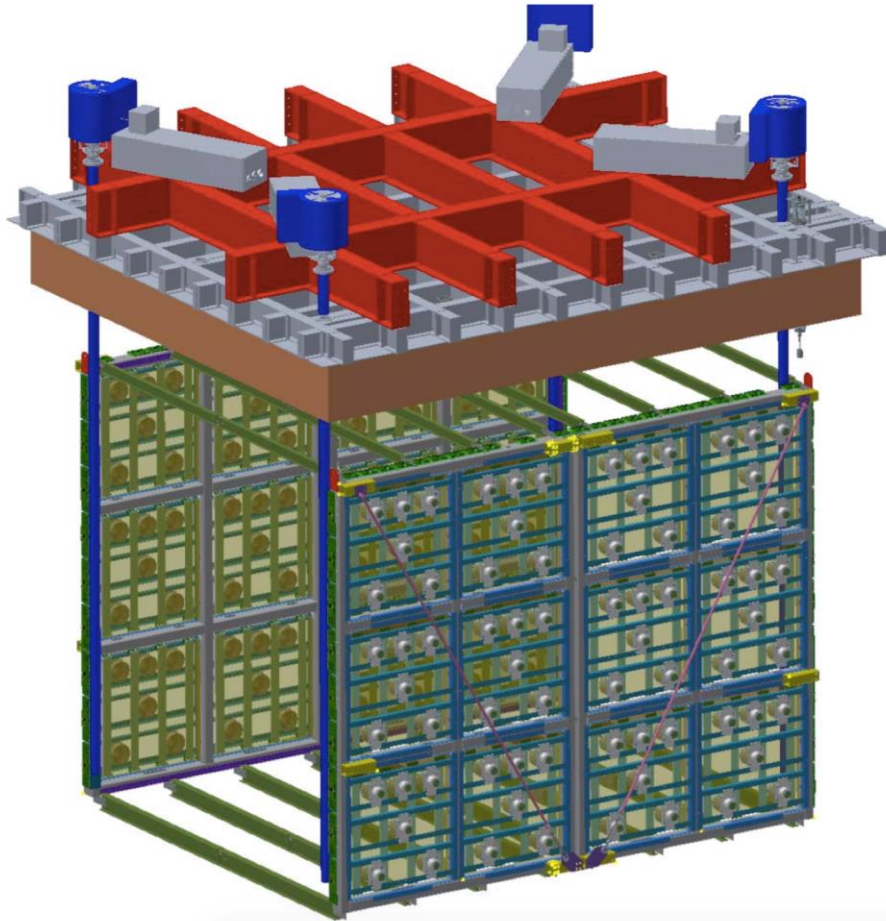
Short Baseline Near Detector (SBND)

**112 tons**

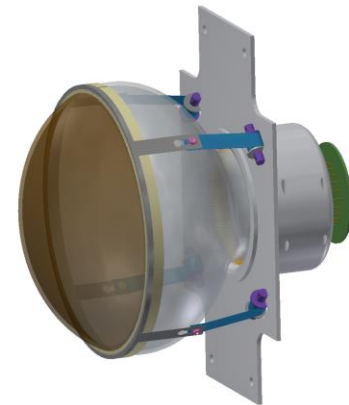
# SBND LAr TPC (4x4x5m<sup>3</sup>)



# LANL Is Building SBND Photon Detection System



*“Regarding detectors, our research would really benefit from photon detectors that are cheaper or better than the 8” phototubes that we are currently using. Our 8” phototubes have a time resolution of  $\sim 1.5$  ns, but it would be very helpful to have inexpensive photon detectors with time resolutions of  $< 1$  ns.”*



# High Altitude Water Cherenkov (HAWC) Gamma Ray Observatory

PI: Brenda Dingus

**Physics:** Sky survey 100 GeV to  $> 100$  TeV  $\gamma$ -rays

- Indirect dark matter search from  $\gamma$ -ray annihilation & decay
- Quantum gravity effects on propagation of  $\gamma$ -rays
- Particle acceleration in extreme magnetic and gravitational fields: gamma-ray bursts, supermassive black holes, neutron stars, supernova remnants

**Description:** Air Shower Detector with 300 Water Cherenkov Detector tanks covering 20,000 m<sup>2</sup> at 4100 m on Sierra Negra Volcano, Mexico. Field of view is 2 sr with exposure to 2/3 of the sky each day. Operations managed by LANL.

**Status:** Construction completed March 2015; HEP plans 5 years of operations

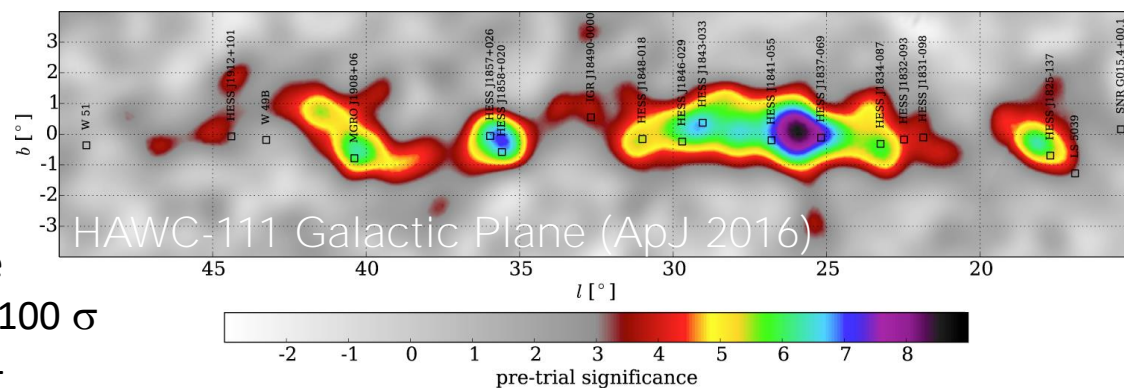
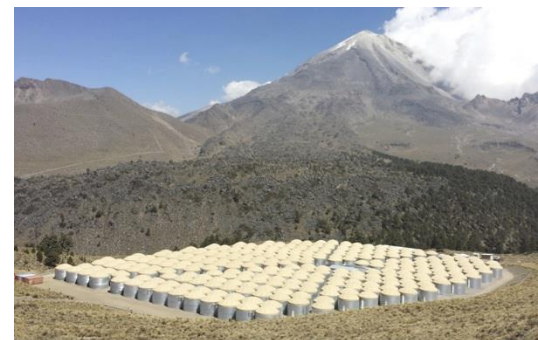
**Partnership:** DOE, NSF (lead), Mexico (CONACyT), Germany (Max Planck Inst. Heidelberg)

**Collaboration:**  $\sim 100$  scientists from US (LANL + 15 universities), Mexico, and Germany

**HEP funding:** LANL (HEP lead), Univ. New Mexico, Rochester

**Recent Highlights: (March 2016)**

- Publication of new TeV sources with data from 1/3 of HAWC for  $< 1$ yr (Astrophysical Journal, 2016)
- Current Preliminary map from the full detector is  $> 5$  times more sensitive than this publication with the Crab at  $> 100 \sigma$
- Limits on dark matter annihilation in 14 nearby dwarf spheroidals were presented at 34<sup>th</sup> International Cosmic Ray Conference



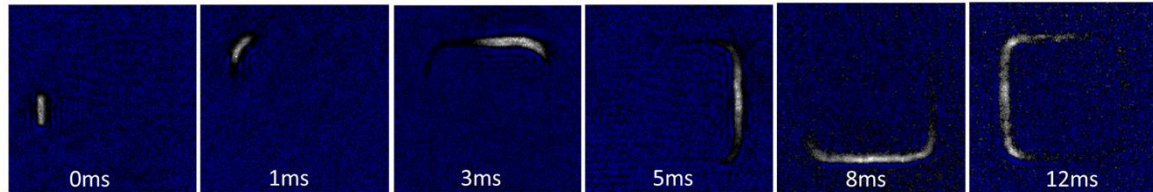
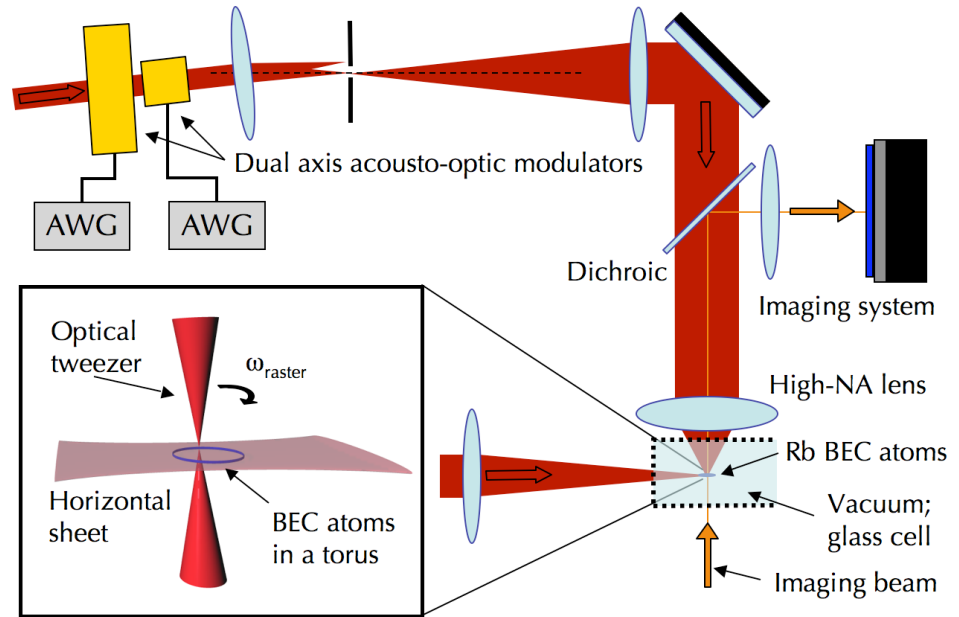
*"We too are interested in cheaper, large area photodetectors."*

# Atomtronics

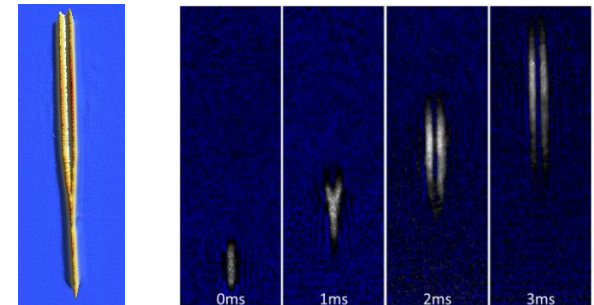
The Painted Potential technique allows us to create arbitrary and dynamic potentials for ultracold Bose-Einstein condensates (BECs).

Recently we have used it to propagate coherent matter waves from a BEC around painted waveguides that form the first atomtronic circuits.

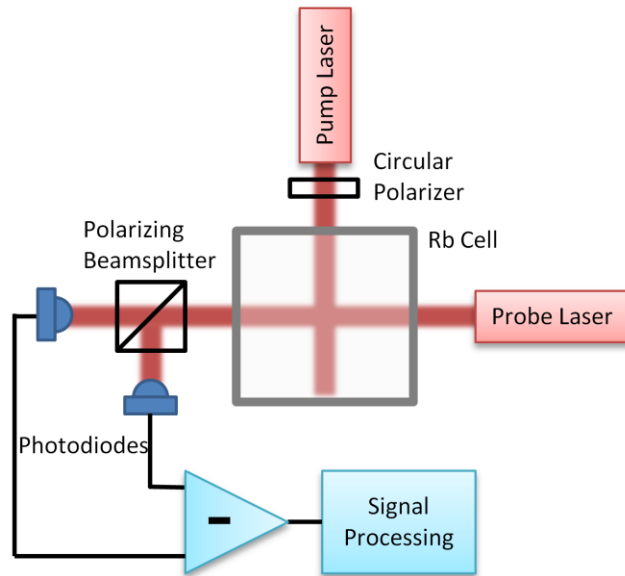
Atomtronics may enable new approaches to sensing and signal processing.



*Image sequences showing a BEC propagating around a square loop (top) and through a Y-junction (right). The leftmost panel shows the light distribution for the painted Y-junction.*



# Fieldable Atomic Magnetometer



## Performance

Shielded:  $5 \text{ fT/Hz}^{1/2}$  at 50 Hz and 22 kHz

Unshielded:  $30 \text{ fT/Hz}^{1/2}$  (so far)

