

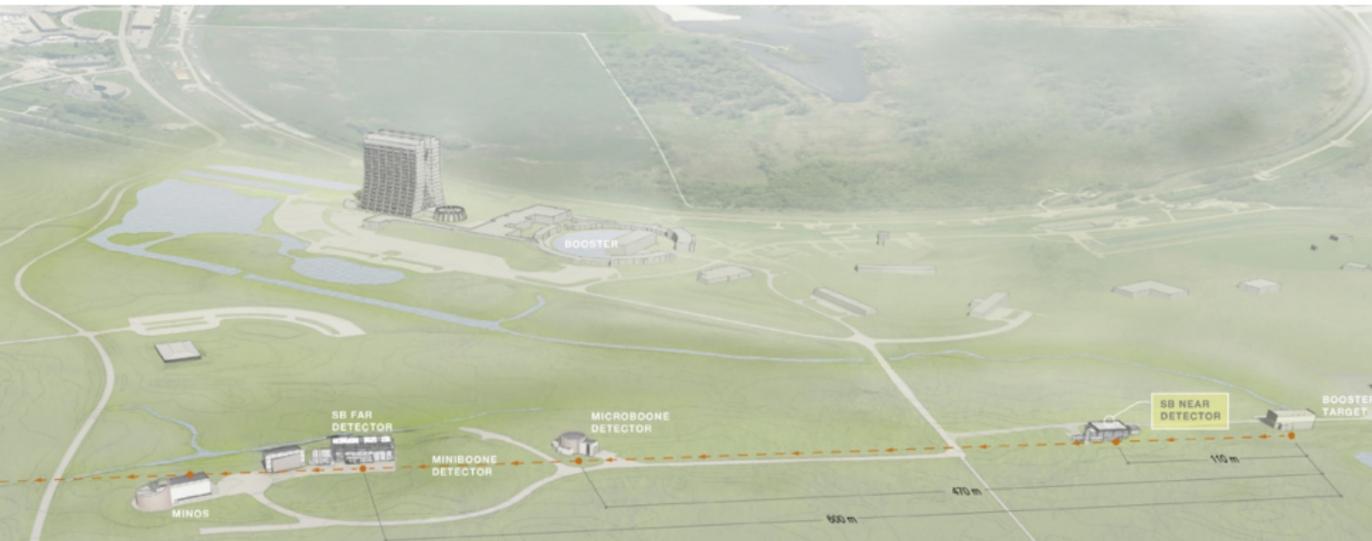


# in 10 minutes

Tom Brooks



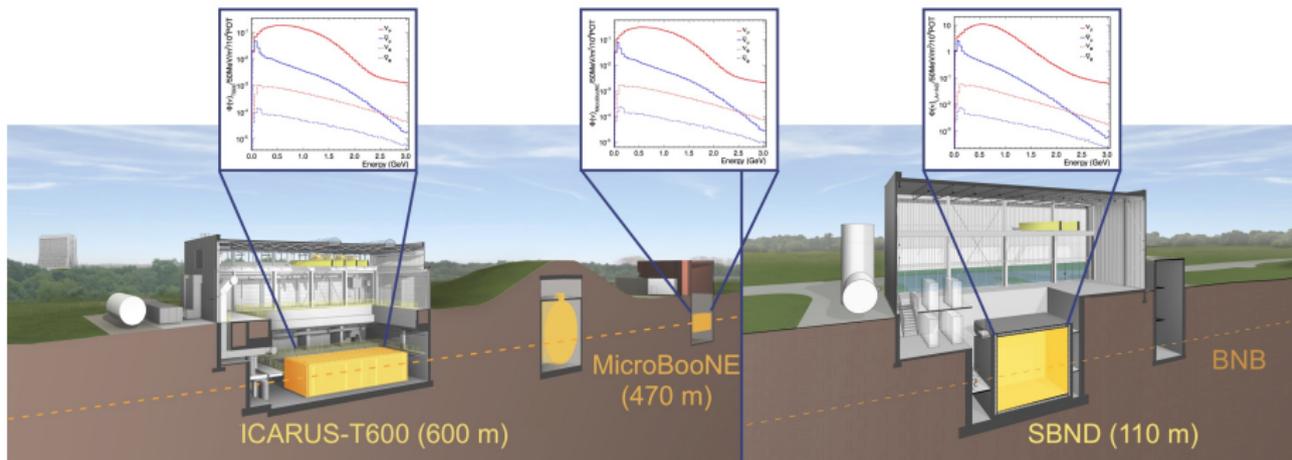
The University Of Sheffield.

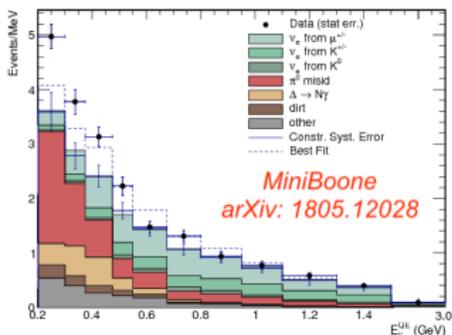


# The Short-Baseline Near Detector

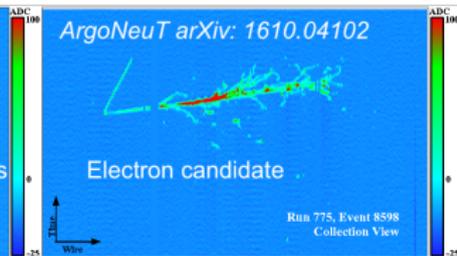
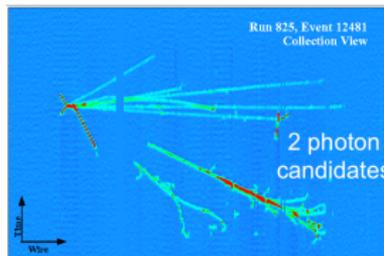
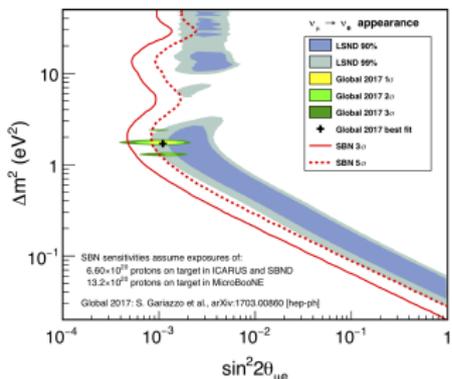


- The near detector of the Short-Baseline Neutrino (SBN) Program at Fermilab.
- A 112 ton liquid-argon time projection chamber (LArTPC).
- In the Booster Neutrino Beam.
- Designed to study short baseline oscillations and  $\nu - Ar$  cross sections.
- Research and development of hardware and software for DUNE.



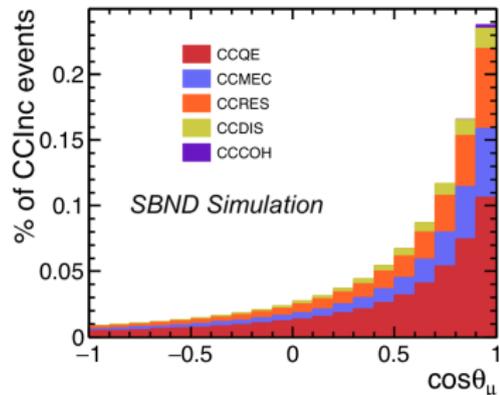
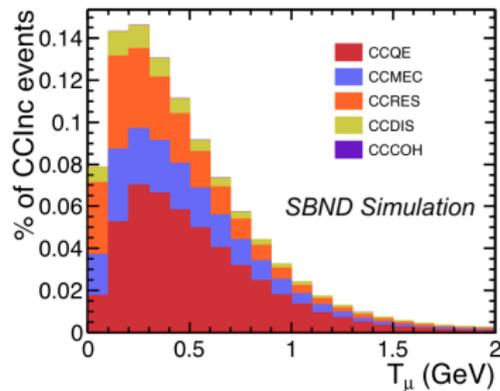
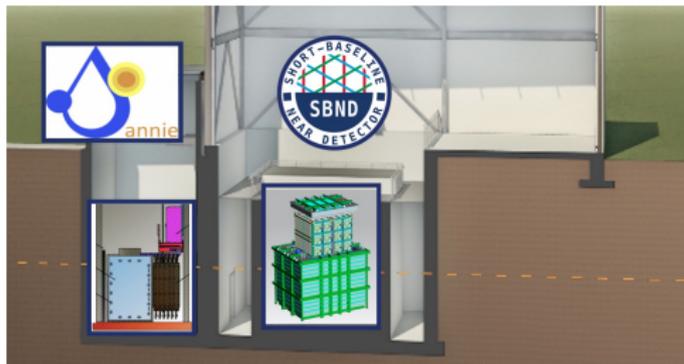


- Some experiments have observed an excess of low energy  $\nu_e$ -like events.
- Possible explanation: short-baseline oscillations driven by an eV scale sterile neutrino.
- Tension with exclusion limits from other experiments.
- LArTPCs are able to distinguish between electron and photon showers.



## Cross sections

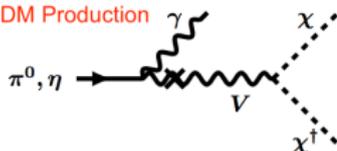
- Near detector =  $\nu - Ar$  cross section measurements with highest statistics ever.
- Vital for reducing systematic uncertainties in DUNE.
- Compare water and argon cross sections in the same beam with the annie detector.



## Cross sections and BSM physics

- A high neutrino rate means rare cross section channels can be explored.
- The proximity to the beam target, large detector mass and relative detection isotropy makes SBND well suited for beyond the standard model searches.
  - ▶ Sub-GeV dark matter (with beam dump).
  - ▶ Hidden sector particles.
  - ▶ Exotic signatures.

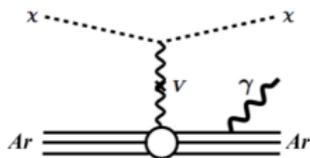
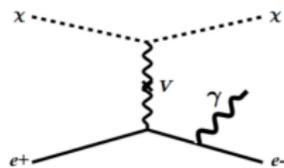
DM Production



MiniBooNE arXiv: 1702.02688



DM Interaction

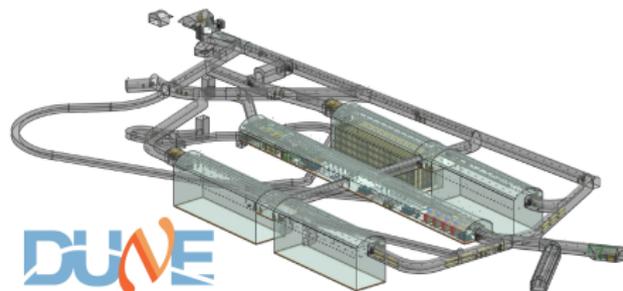


GENIE (G17.01b)  
prediction for  
 $6.6 \times 10^{20}$  POT  
( $\approx 3$  years)

Hadronic Final State	
<b>Charged Current</b>	
$\nu_\mu$ Inclusive	5,389,168
$\rightarrow 0\pi$	3,814,198
$\rightarrow 0p$	27,269
$\rightarrow 1p$	1,261,730
$\rightarrow 2p$	1,075,803
$\rightarrow \geq 3p$	1,449,394
$\rightarrow 1\pi^+ + X$	942,555
$\rightarrow 1\pi^- + X$	38,012
$\rightarrow 1\pi^0 + X$	406,555
$\rightarrow 2\pi + X$	145,336
$\rightarrow \geq 3\pi + X$	42,510
$\rightarrow K^+K^- + X$	521
$\rightarrow K^0\bar{K}^0 + X$	582
$\rightarrow \Sigma_c^{++} + X$	294
$\rightarrow \Sigma_c^+ + X$	98
$\rightarrow \Lambda_c^+ + X$	672
$\nu_e$ Inclusive	$\approx 36,000$
<b>Neutral Current</b>	
$\nu_\mu$ Inclusive	2,170,990
$\rightarrow 0\pi$	1,595,488
$\rightarrow 1\pi^\pm + X$	231,741
$\rightarrow \geq 2\pi^\pm + X$	343,760
$\rightarrow e(-)$	374

## Research & development

- DUNE far detector: kiloton-scale LArTPC.
- Will investigate leptonic  $\delta^{CP}$  and neutrino mass hierarchy.
- SBND important for testing hardware and developing software.



## Detector development

- Membrane cryostat technology.
- Front-end electronics.
- TPC construction and cathode design concepts.
- Similar anode frame and wiring concepts.

## Software development

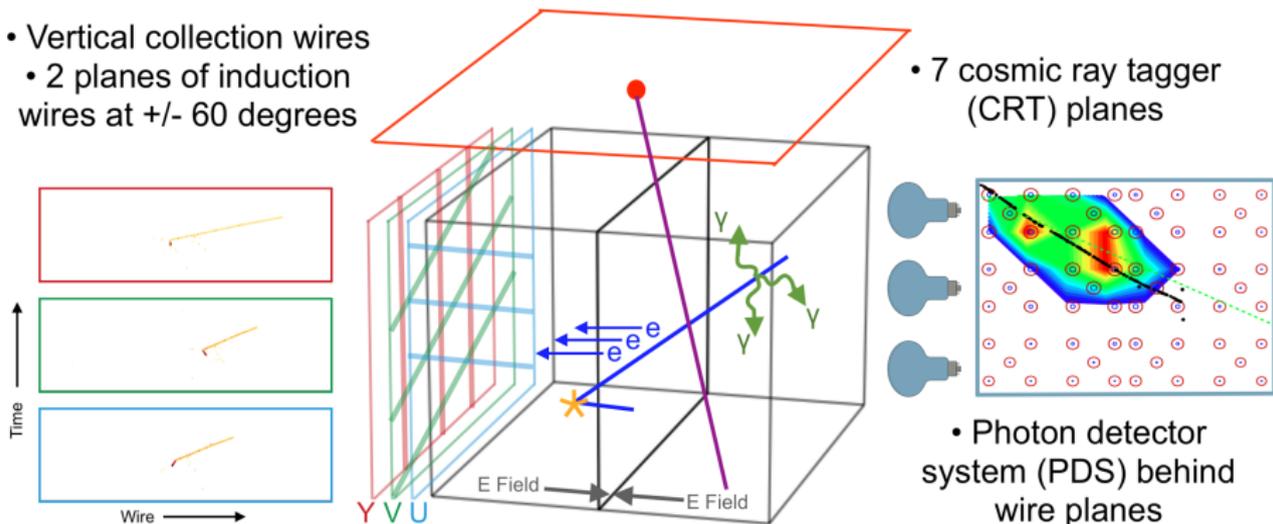
- TPC signal processing and noise filtering.
- Track, shower and kinematic variable reconstruction.
- Particle identification.
- Neutrino energy reconstruction.

# The detector



## Principle of operation

- SBND is a modular LArTPC with a central cathode plane assembly (CPA) and two drift regions.
  - Both anode plane assemblies (APAs) are instrumented with wire planes and have photon detectors behind them.
  - Good 3D position resolution and calorimetry.
- 
- Vertical collection wires
    - 2 planes of induction wires at +/- 60 degrees
  - 7 cosmic ray tagger (CRT) planes



## Time projection chamber

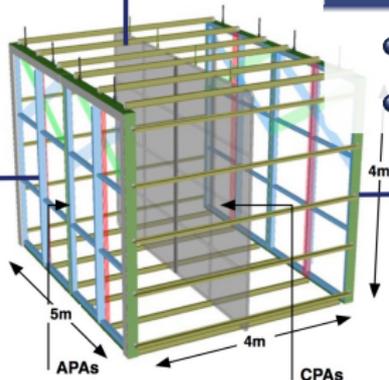


### Foils

- CPA will be fitted with TPB coated reflector foils.
- Shifts UV Ar scintillation light to visible.

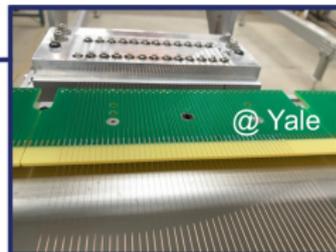
### CPA

- Frame constructed.
- Shipping to Fermilab.



### APA

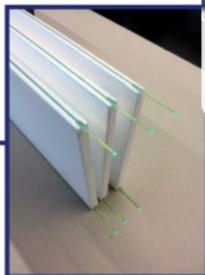
- Frames constructed.
- Wiring in progress.



## Cosmic ray taggers and neutron measurements

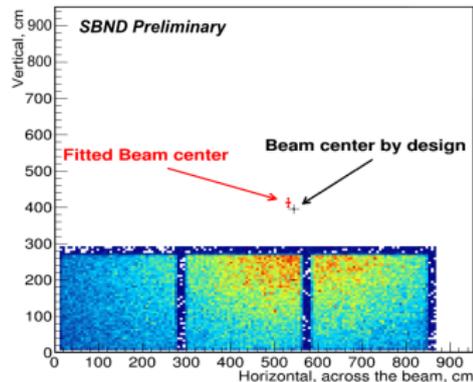
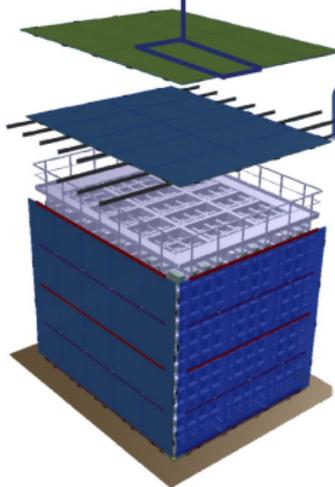
### Neutron background

- Taking measurements with portable liquid scintillator neutron detector.



### CRT

- Production in full swing.
- Several modules delivered to Fermilab.
- Beam measurements underway in SBND pit.

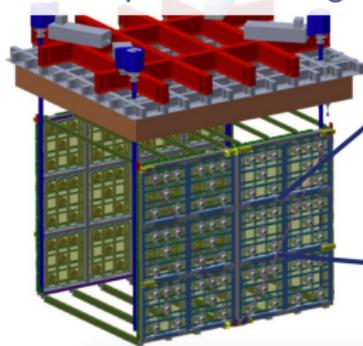


## Photon detector system



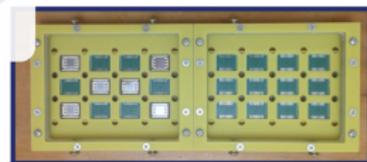
### Light bars

- Acrylic bars dip-coated with TPB coupled to SiPMS.
- Only sensitive to UV.
- Improves tracking.



### PMTs

- 120 8" Hamamatsu PMTs (96 TPB coated).
- Mounts being fabricated.
- Preparing for full system test.



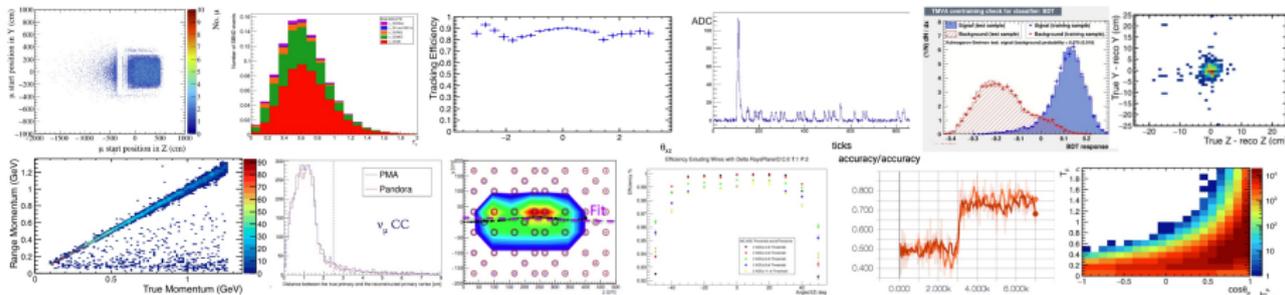
### ARAPUCAs

- Trap photons with highly reflective internal surface.
- Detect with SiPMS.
- Prototypes under construction.



- Full neutrino event reconstruction chain is operational.
- Developing algorithms for calibration and background removal.
- Work is progressing on high level cross section measurement tools.
- Have had two SBN analysis workshops.

## SBND posters at NE $\nu$ TRINO!





- SBND is the near detector of SBN, designed to investigate short-baseline oscillations.
- Will produce the highest statistic  $\nu - Ar$  cross section measurements to date.
- Many components have been constructed, installation due to start soon.
- Due to start commissioning and running in 2019/20.
- Many reconstruction tools under development to start producing results as quickly as possible after taking data.



## SBND collaboration:

- 201 total collaborators.
- 172 scientific collaborators.
- 36 institutions.
- 4 countries.

