Neutrino Interaction Capabilities of SBND

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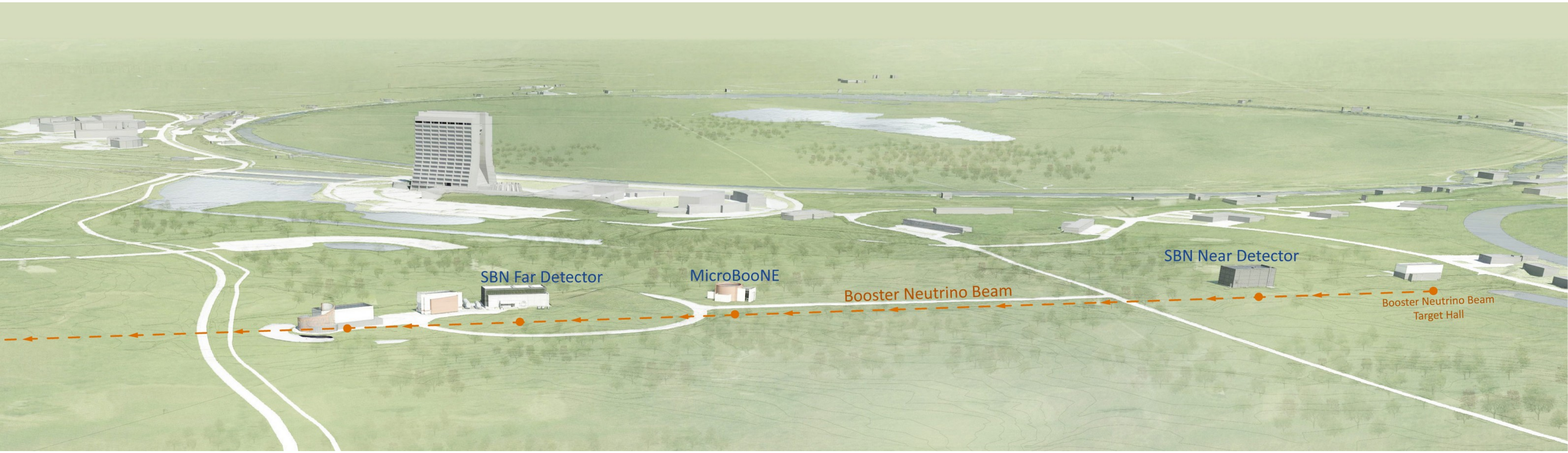
NuFact 2023, Seoul, South Korea

What is SBND?

- "Short Baseline Near Detector"
- Near Detector for SBN program
  - With world-leading eV-scale sterile neutrino sensitivity
- Single-detector physics program of its own



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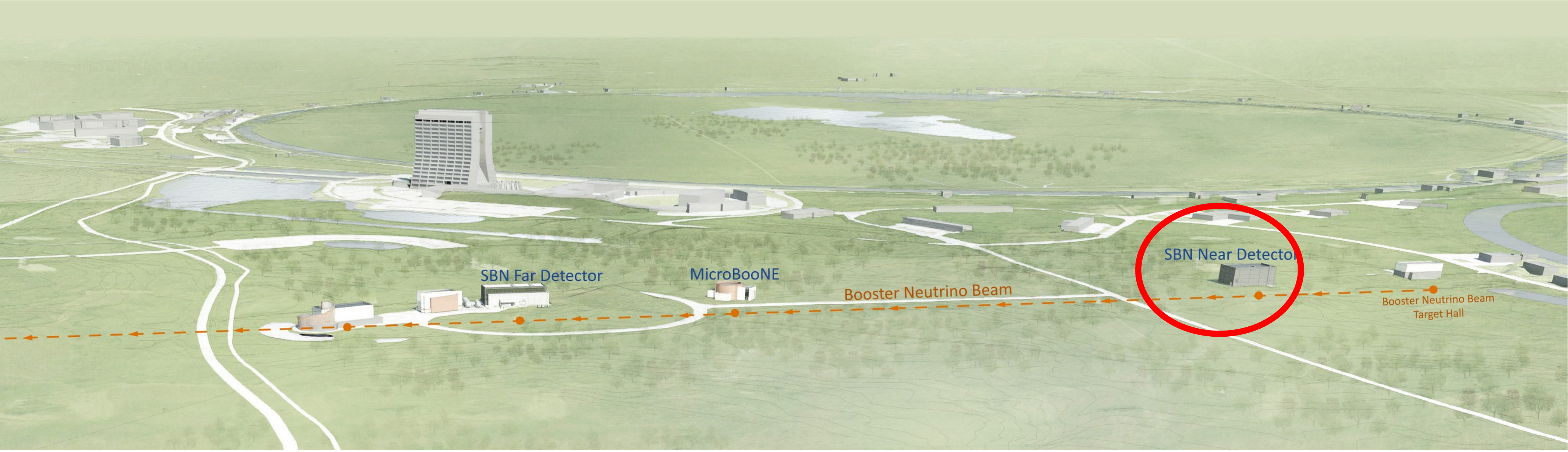

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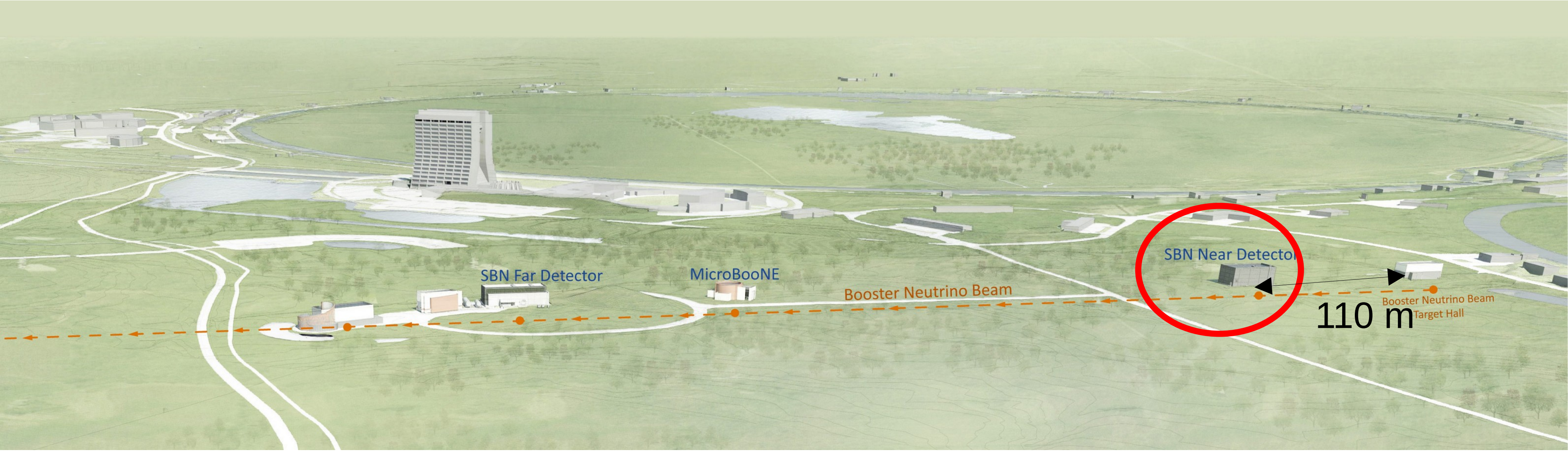

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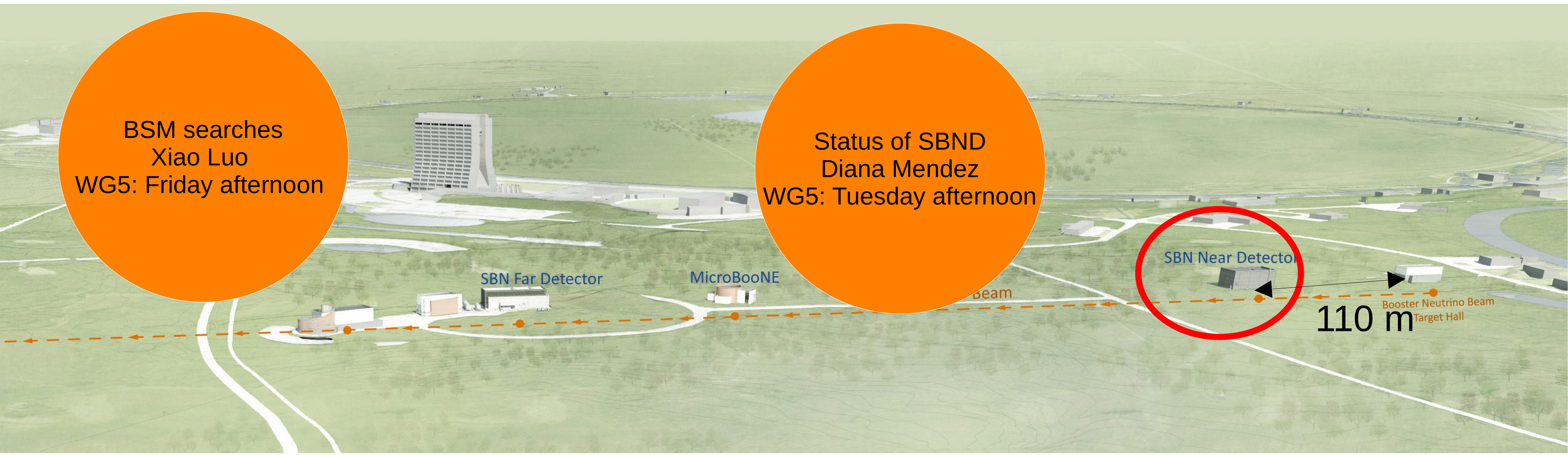
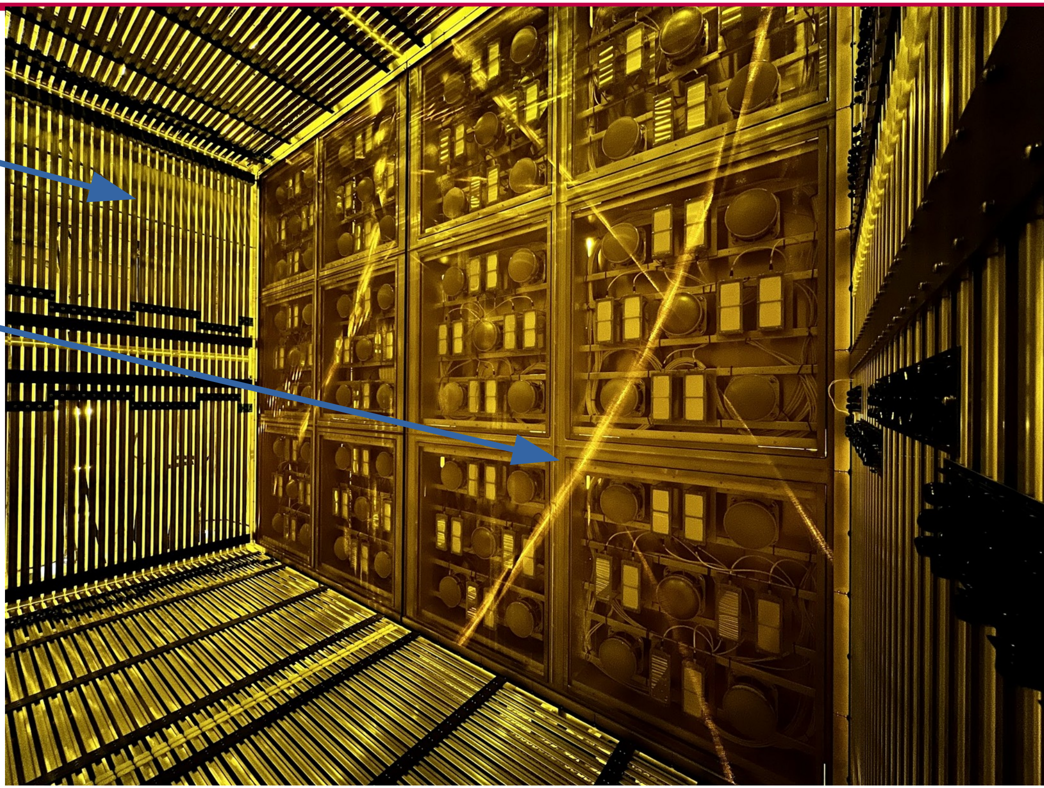


Detector Design

Two TPCs (one shown)

~10,000 readout wires (few-mm resolution)

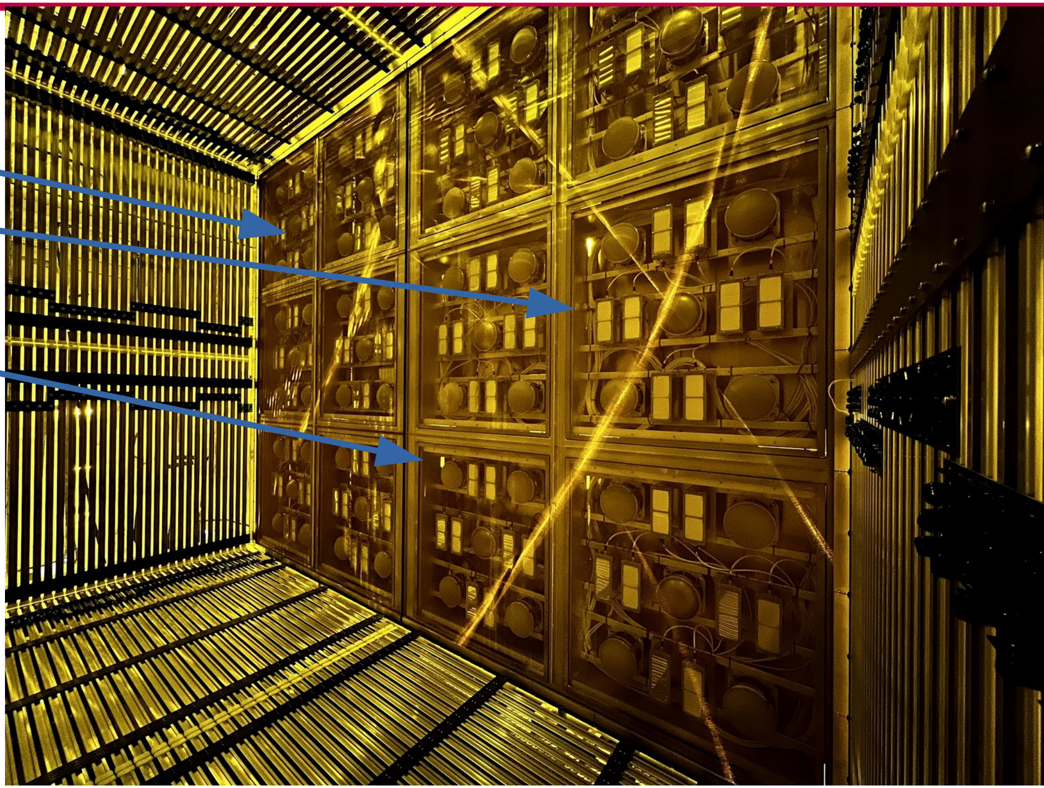


Few-mm spatial resolution leads to low particle tracking thresholds and excellent momentum/direction resolution

Detector Design

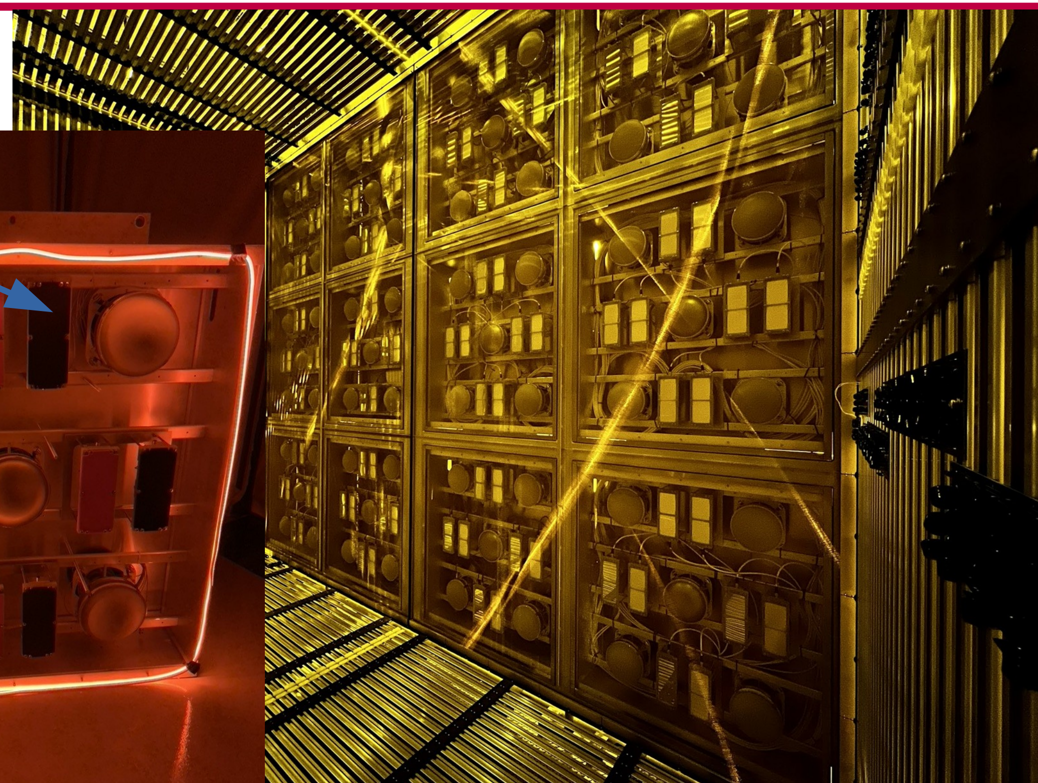
Large photocoverage

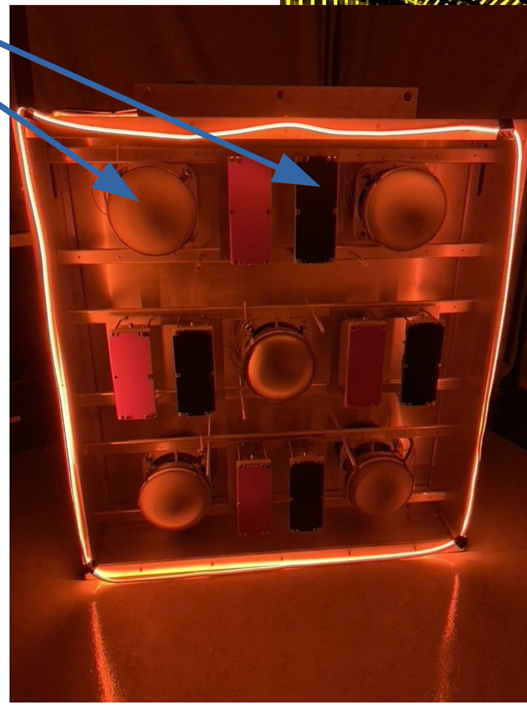
PMTs and X-ARAPUCAs



Detector Design

Some UV-sensitive

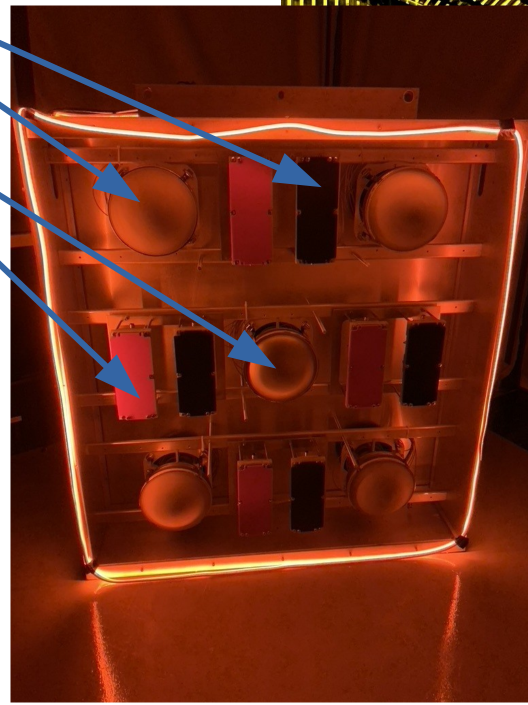




Detector Design

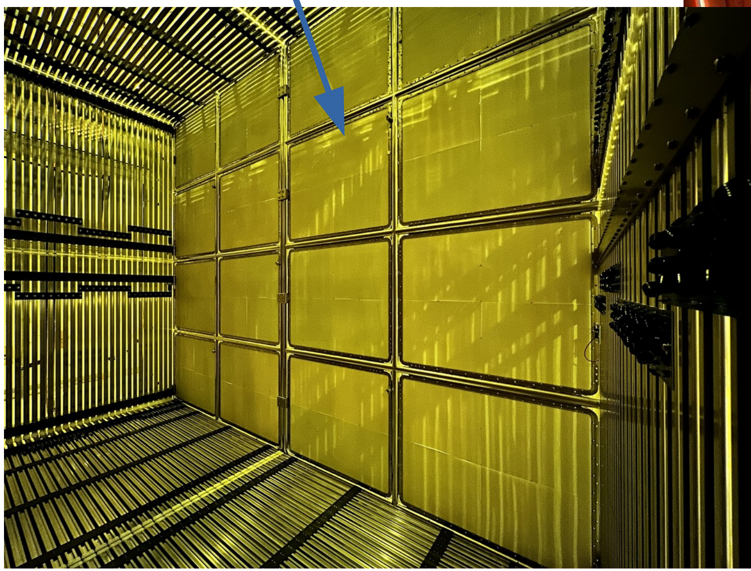
Some UV-sensitive

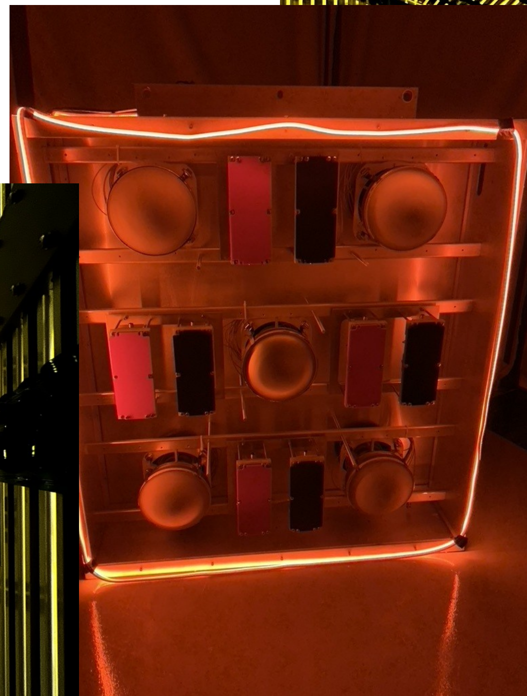
Some visible-sensitive

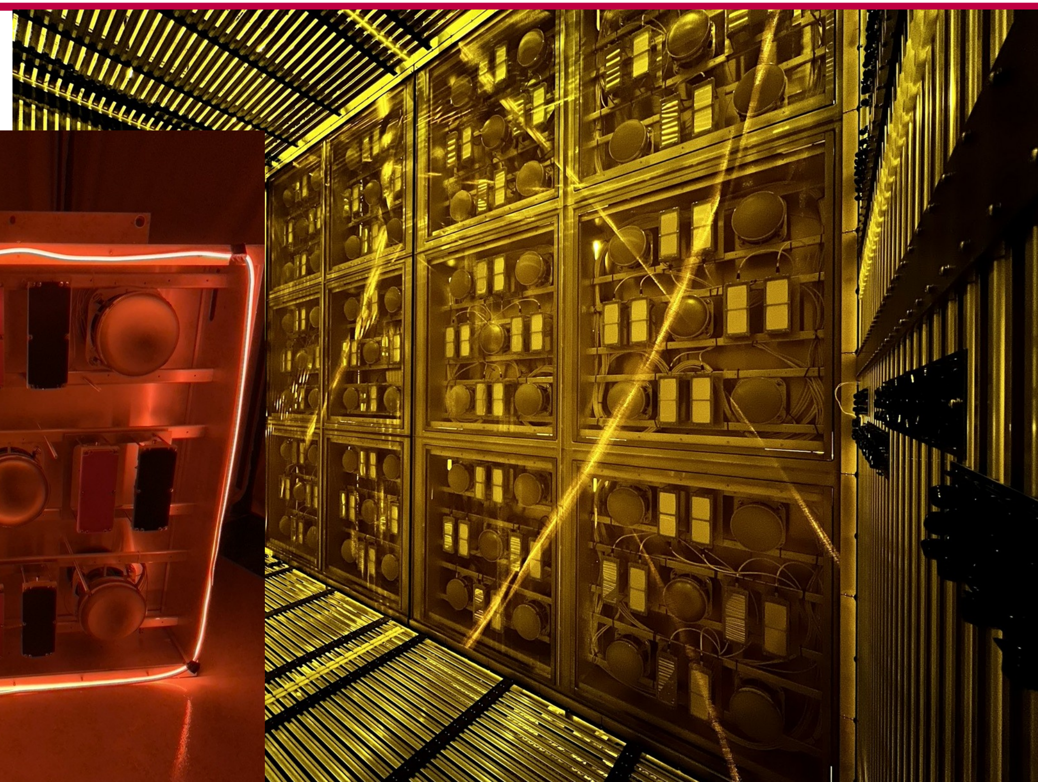


Detector Design

Wavelength-shifting reflective foils



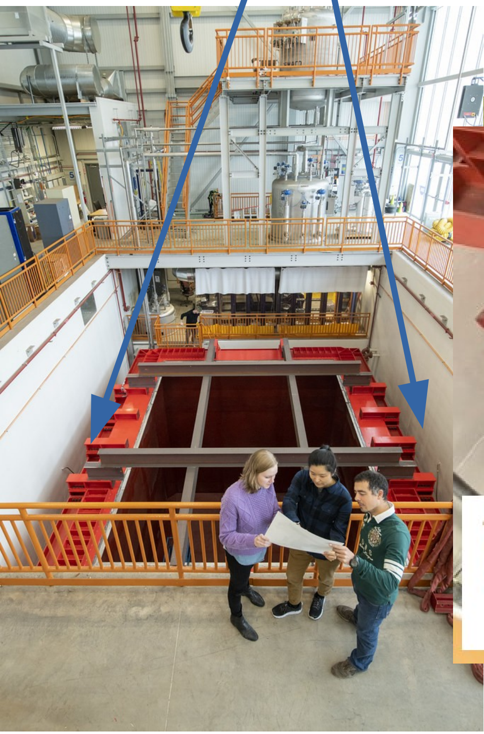


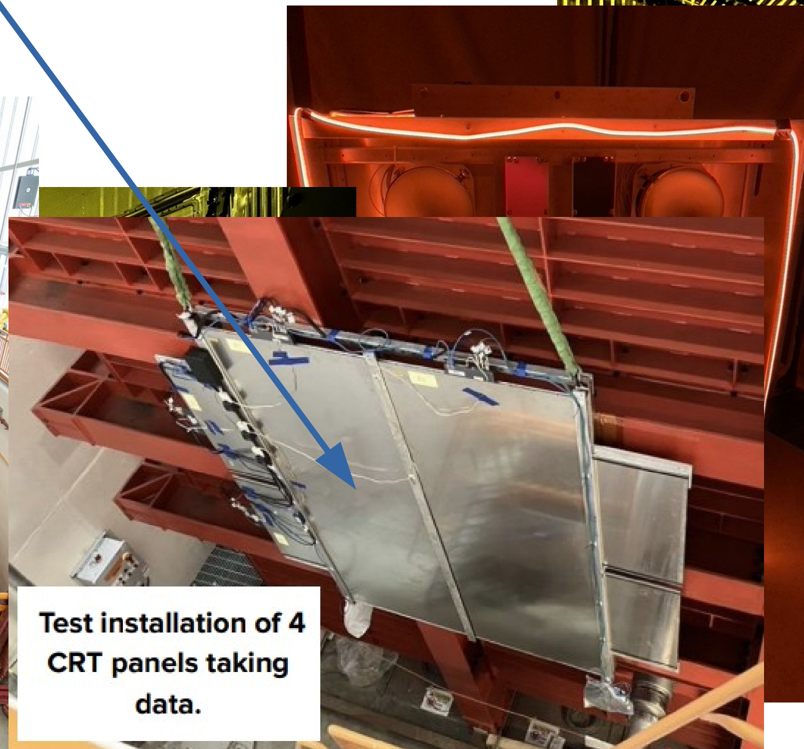


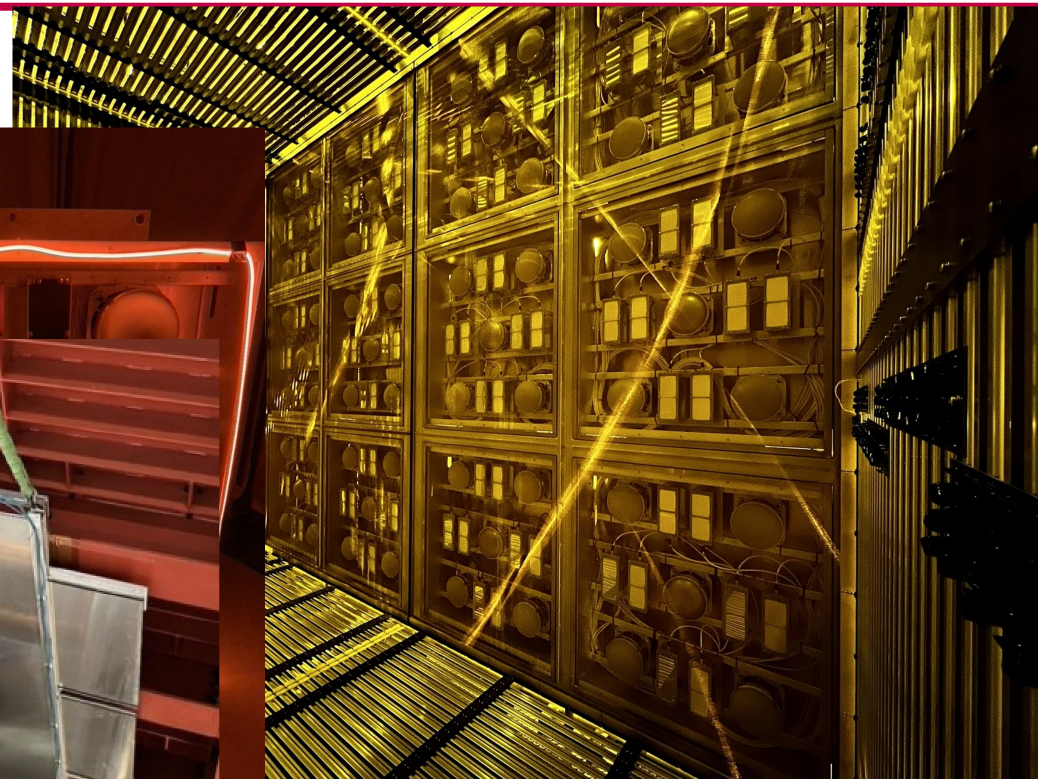
High-coverage photon detection allows for improved calorimetry, lower thresholds, and better background rejection!

Detector Design

Cosmic Ray Tagger – high coverage



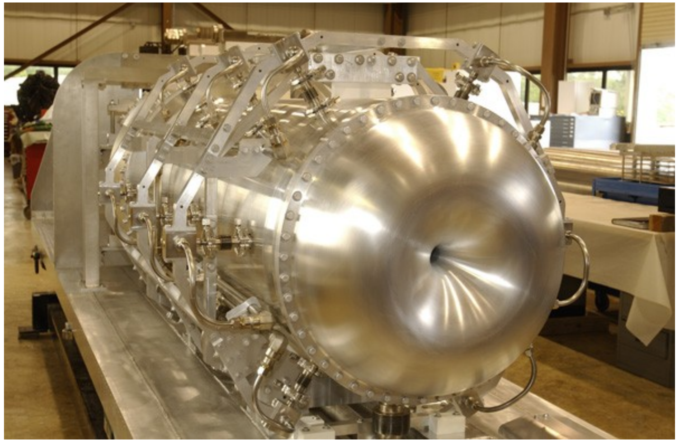


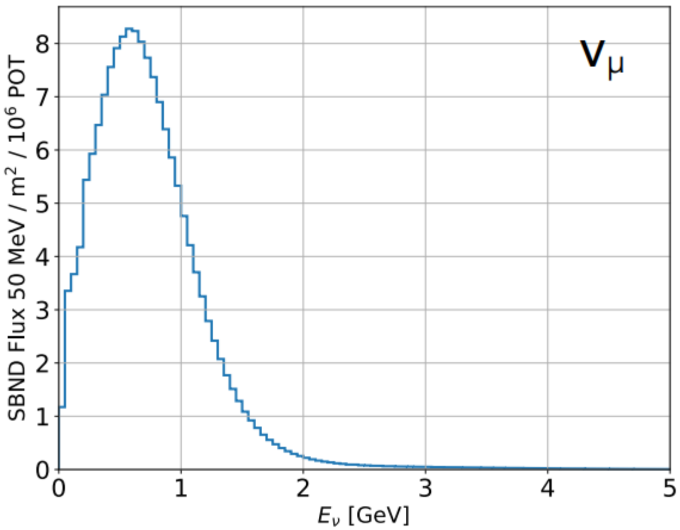


Almost 4π coverage CRT suppresses high cosmic rate at surface

Booster Neutrino Beam

- 8 GeV proton beam from Fermilab Booster
- Berylium target
- Single focusing horn
- 50m decay pipe
- 600MeV peak, 800MeV mean, tail up to ~4-5 GeV





SBND Event Rates

Process		No. Events
	ν_μ *Events (By Final State Topology)*	
CC Inclusive		5,212,690
CC 0 π	$\nu_\mu N \rightarrow \mu + Np$	3,551,830
	$\cdot\ \nu_\mu N \rightarrow \mu + 0p$	793,153
	$\cdot\ \nu_\mu N \rightarrow \mu + 1p$	2,027,830
	$\cdot\ \nu_\mu N \rightarrow \mu + 2p$	359,496
	$\cdot\ \nu_\mu N \rightarrow \mu + \geq 3p$	371,347
CC 1 $\pi^\pm$	$\nu_\mu N \rightarrow \mu + \text{nucleons} + 1\pi^\pm$	1,161,610
CC $\geq 2\pi^\pm$	$\nu_\mu N \rightarrow \mu + \text{nucleons} + \geq 2\pi^\pm$	97,929
CC $\geq 1\pi^0$	$\nu_\mu N \rightarrow \mu + \text{nucleons} + \geq 1\pi^0$	497,963
NC Inclusive		1,988,110
NC 0 π	$\nu_\mu N \rightarrow \text{nucleons}$	1,371,070
NC 1 $\pi^\pm$	$\nu_\mu N \rightarrow \text{nucleons} + 1\pi^\pm$	260,924
NC $\geq 2\pi^\pm$	$\nu_\mu N \rightarrow \text{nucleons} + \geq 2\pi^\pm$	31,940
NC $\geq 1\pi^0$	$\nu_\mu N \rightarrow \text{nucleons} + \geq 1\pi^0$	358,443

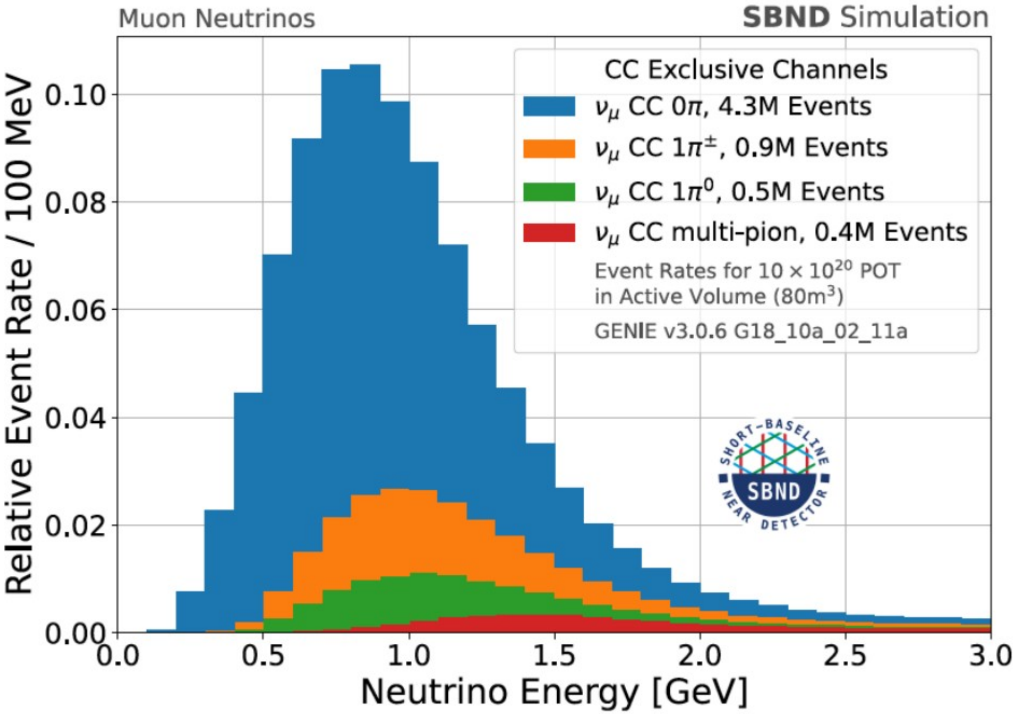
30x MicroBooNE stats

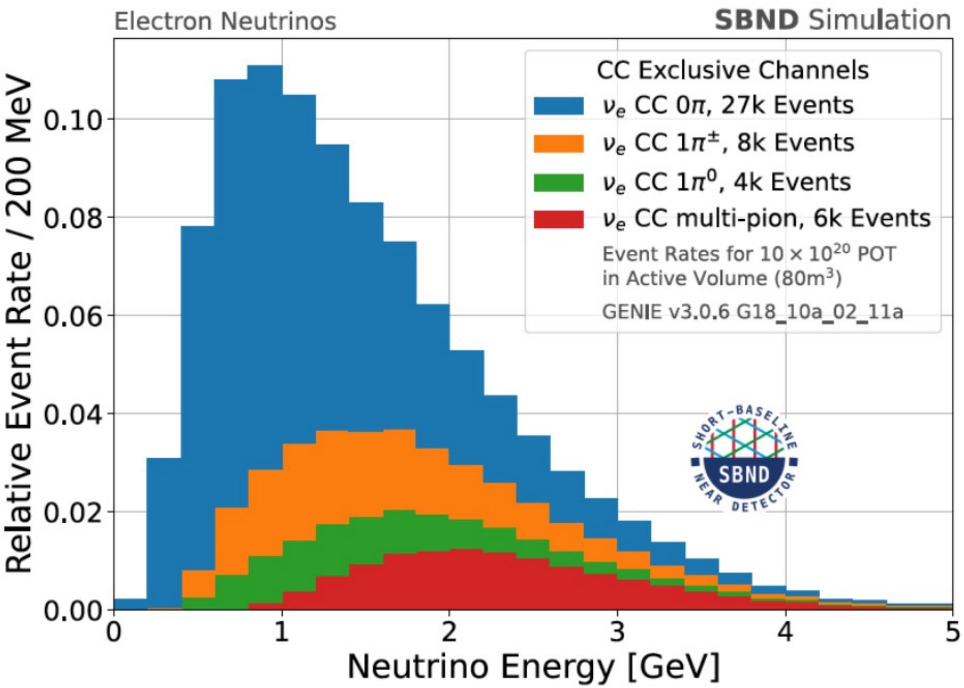
5M ν_μ CC per year
2M NC per year
12k ν_e CC per year

SBND Event Rates

Sufficient statistics for differential measurements of all topologies

Even electron neutrino multi-pion events (SIS/DIS region)





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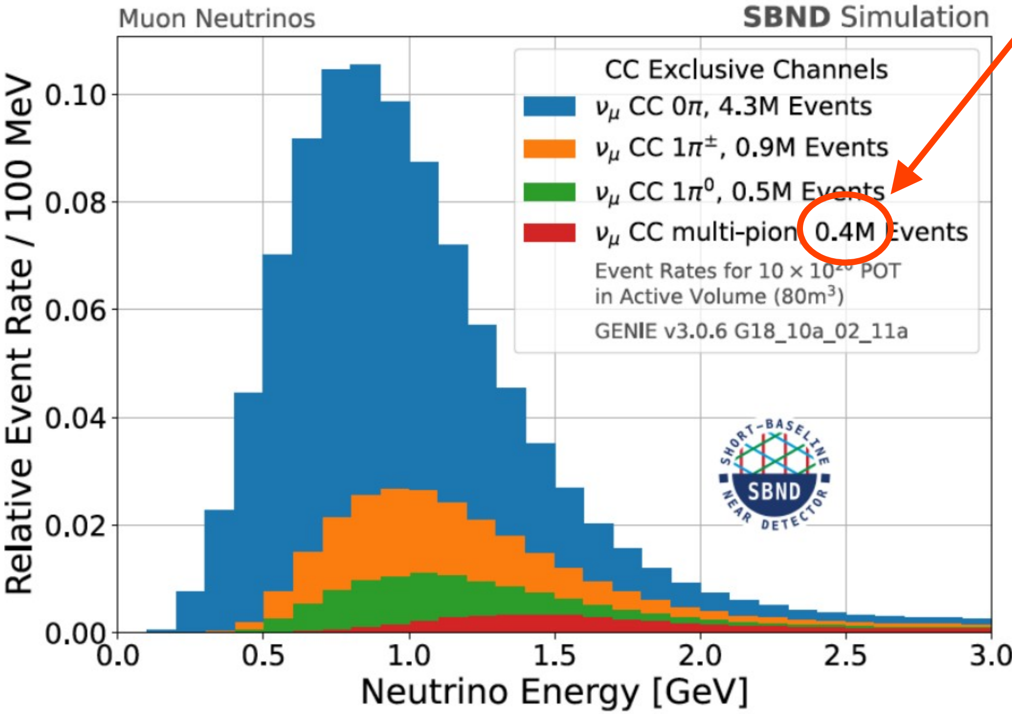
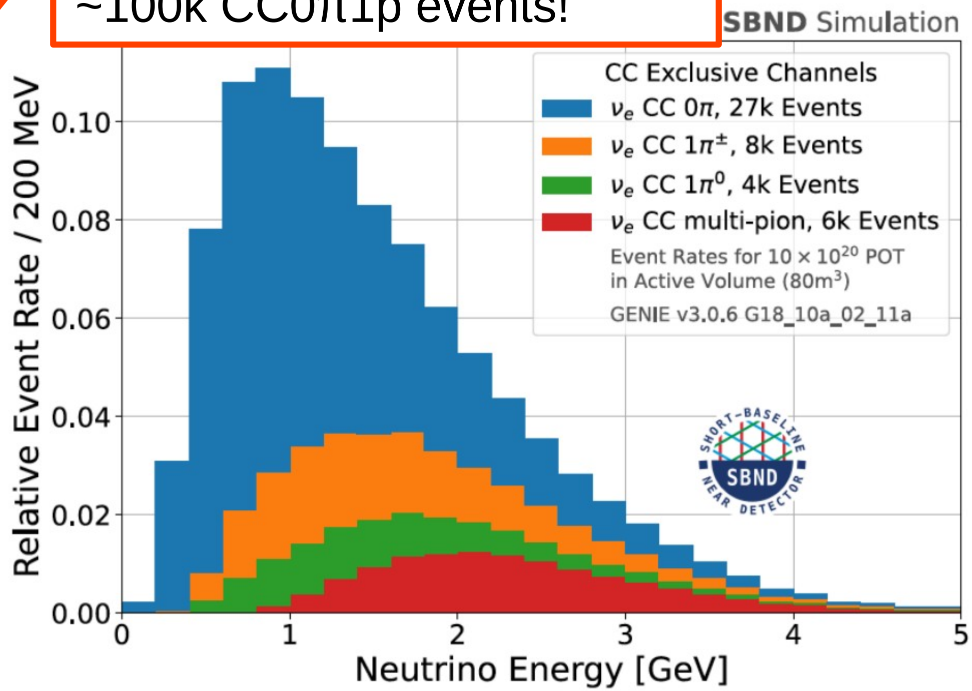
Sufficient statistics for differential measurements of all topologies

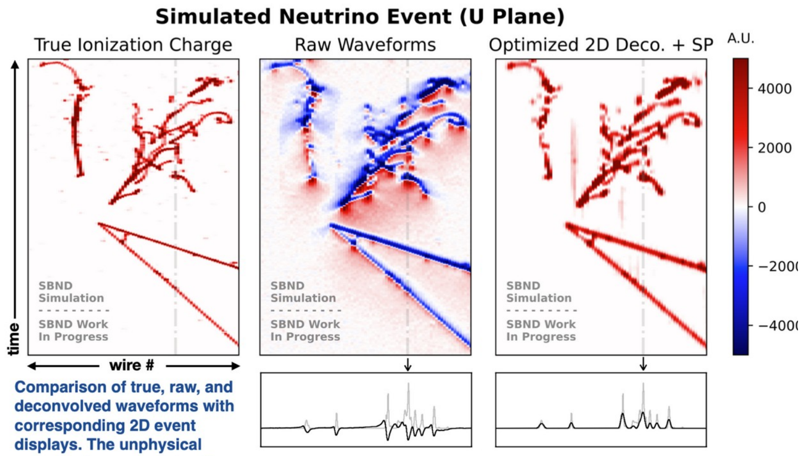
Even electron neutrino multi-pion events (SIS/DIS region)

Compare to MicroBooNE ~100k CC0π1p events!

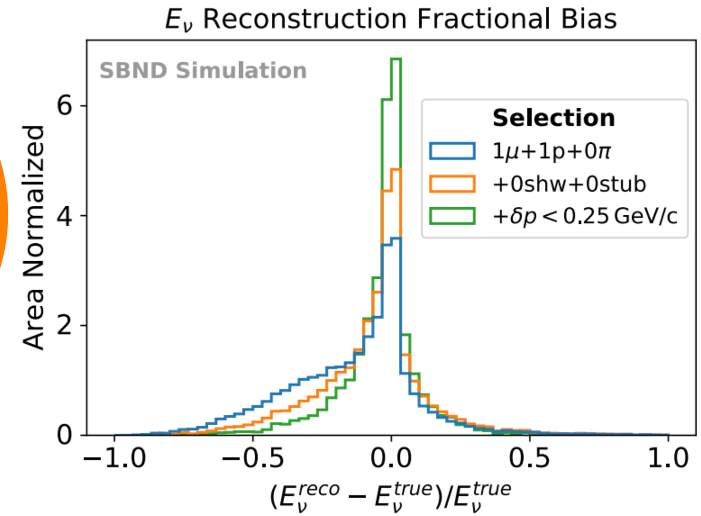


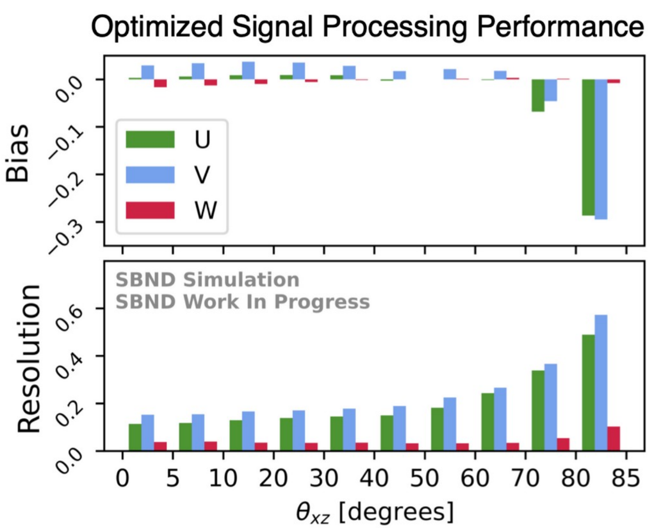


Expected Performance

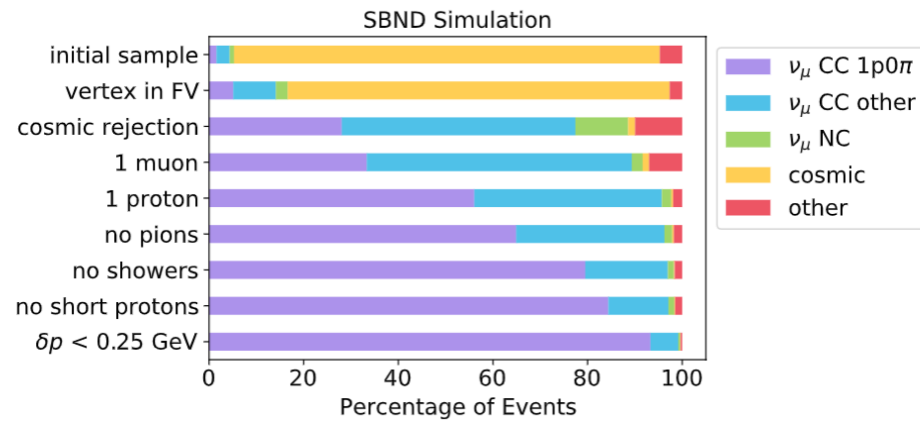


CC0π Event Selection
Mun Jung
Poster



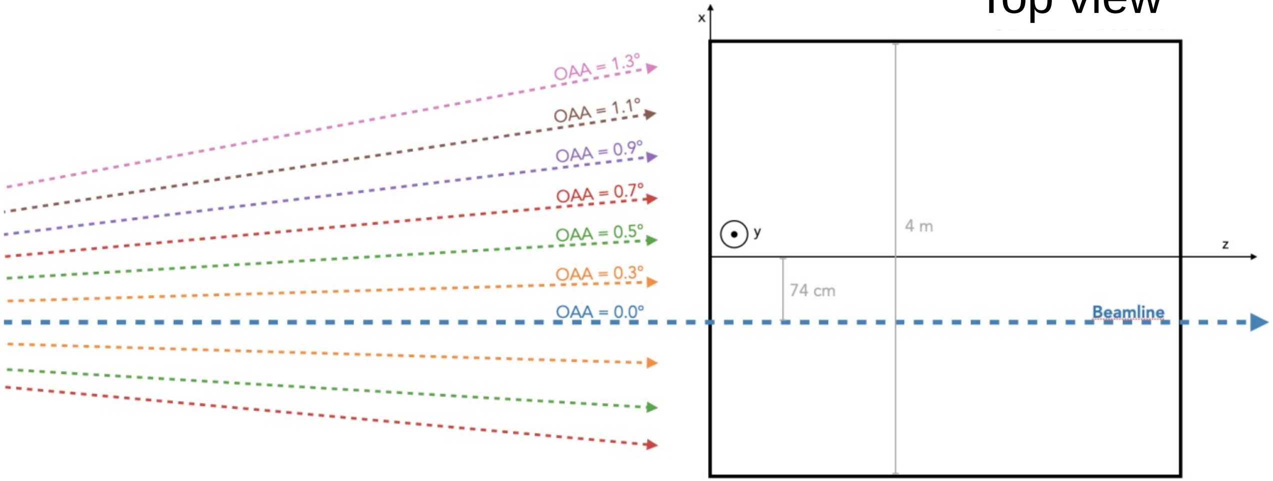


Signal Processing
Avinay Bhat
WG6: Friday Morning

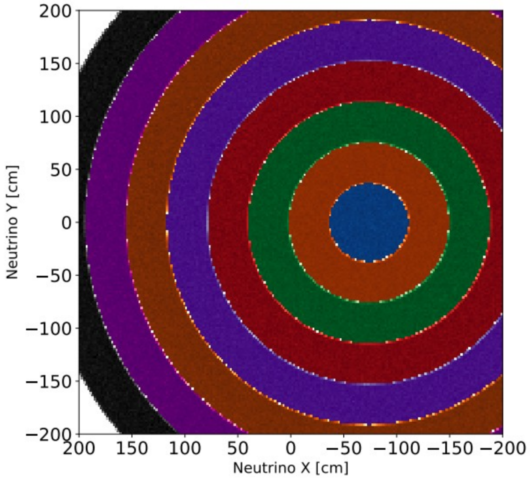


SBND-PRISM

Top view



Beam view



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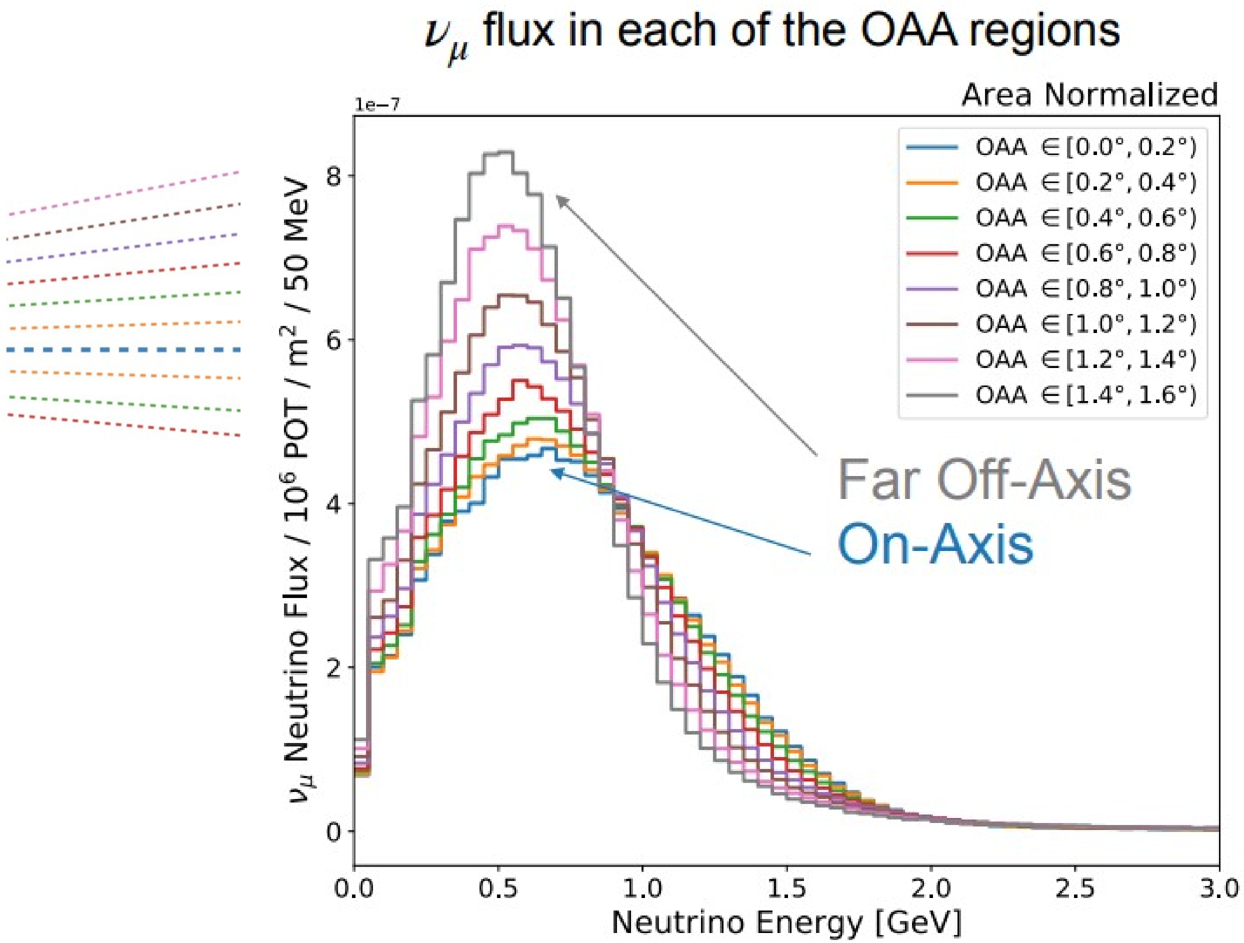

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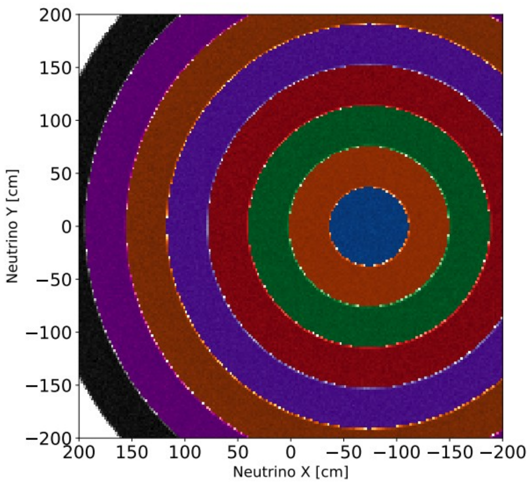
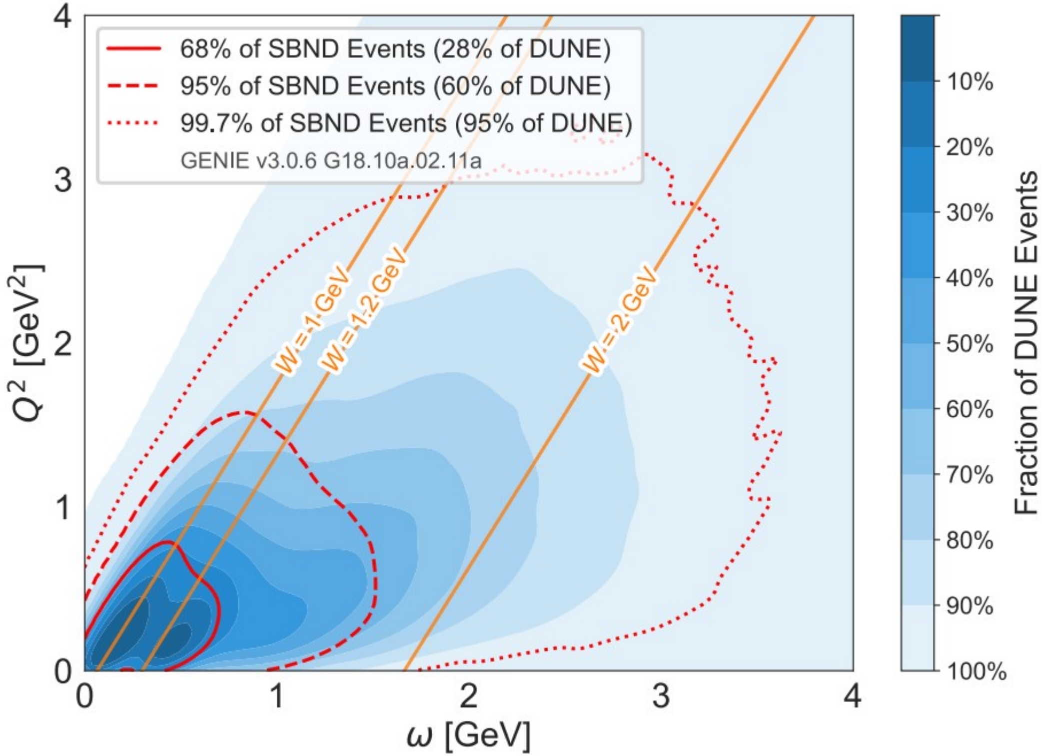


Vary energy dependence by scanning position in detector

Directly determine energy dependence of cross sections

SBND Kinematic Coverage

- 95% of DUNE phase space covered
- Extremely high statistics



SBND Status

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April 2023 – installation

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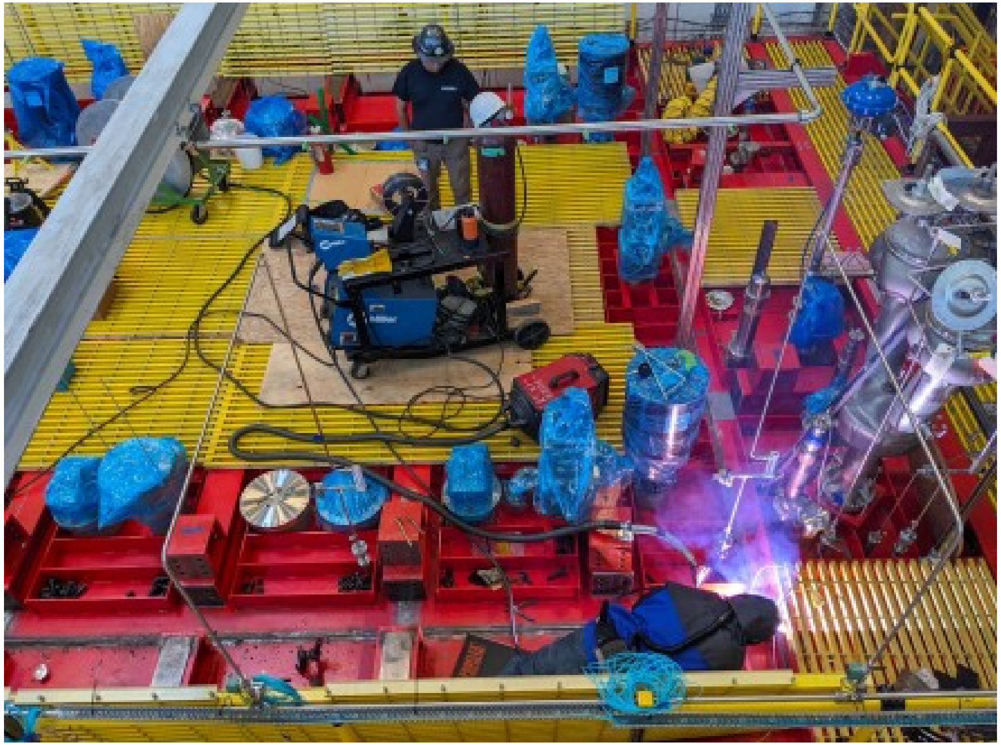
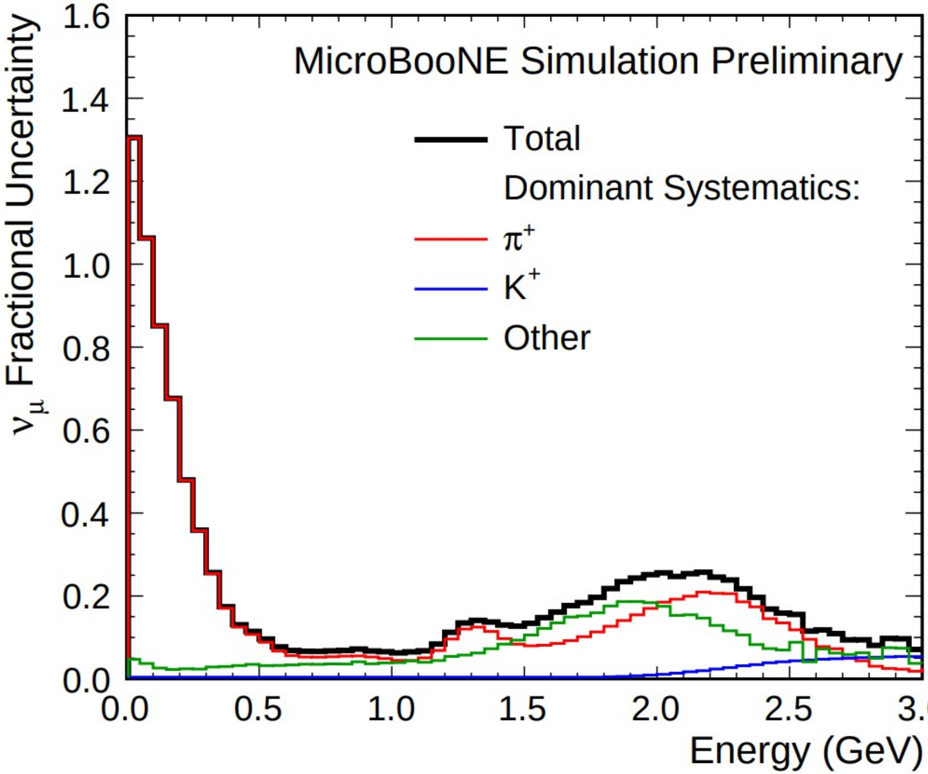
June 2023 – first CRT wall installed



July 2023 – top cap welded in place

Reducing Uncertainties

- Dominant uncertainty is expected to be the flux
- Campaign underway to reduce these uncertainties:
  - ν-e scattering (in-situ constraint)
    - O(500) events expected in 3 years: <10% stat. uncertainty
  - New hadron production measurements (ex-situ constraint)



What's Next?

- Argon fill starts soon!
- Cold commissioning, and CRT installation in late 2023 / early 2024
- Initial Physics Run planned for spring 2024
- After that, **one neutrino every six seconds!**

Conclusion

- SBND will collect the world’s largest dataset of neutrino-argon interactions
  - Within the first month of operations!
- High-granularity TPC with an advanced light collection system
  - Will produce extremely precise measurements
- PRISM effect in a single detector
  - Neutrino energy dependence
- First neutrinos expected next year!

감사합니다 ！