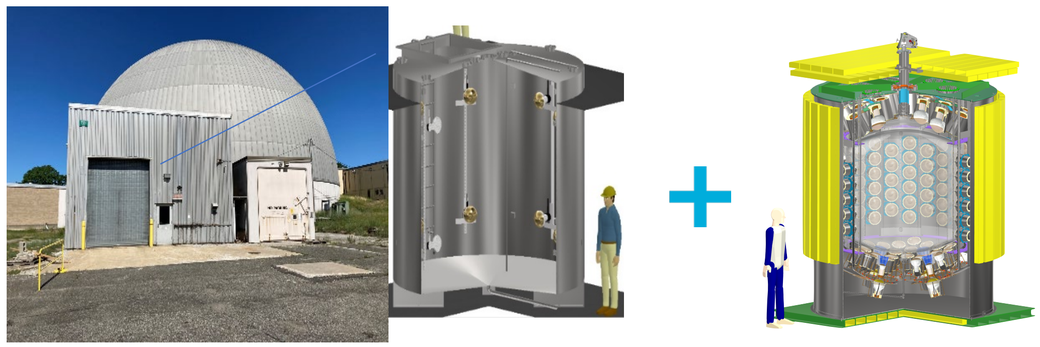
Brookhaven National Laboratory

The origin of matter: breaking ground with THEIA

Collaborative effort: UC Berkeley (& LBNL), U Minnesota

BERKELEY LAB
Bringing Science Solutions to the World

BNL LDRD FY 24-25

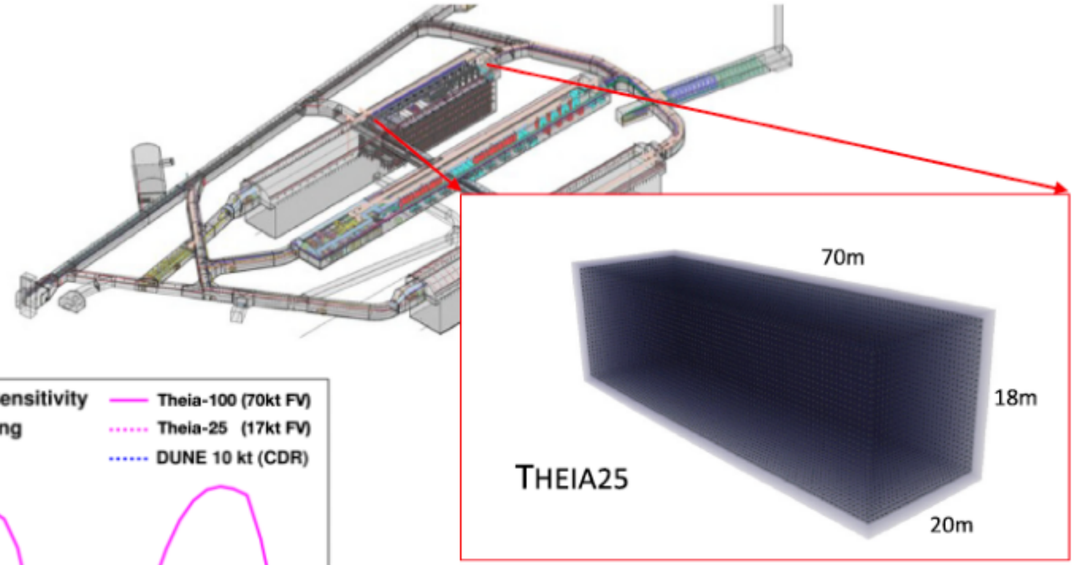


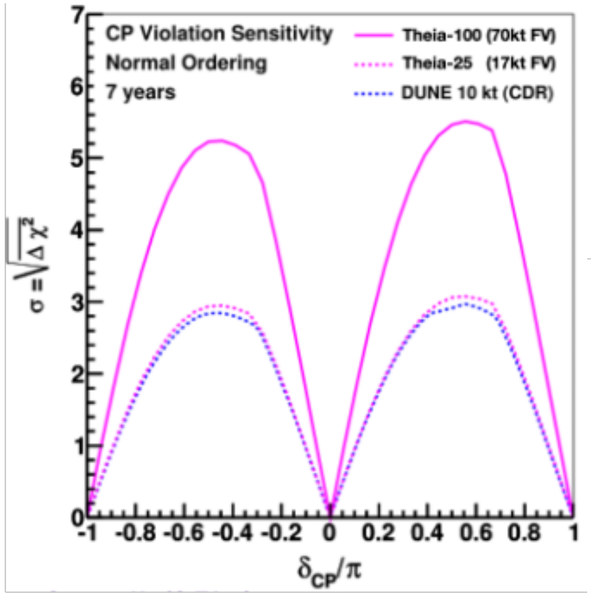
Scope

1. Critical analysis questions that affect CPV sensitivity
   a. ND requirements
   b. End-to-end oscillation analysis with parametric ND (DUNE TDR level)
2. Critical design uncertainties
   a. ND design
   b. WbLS scale up

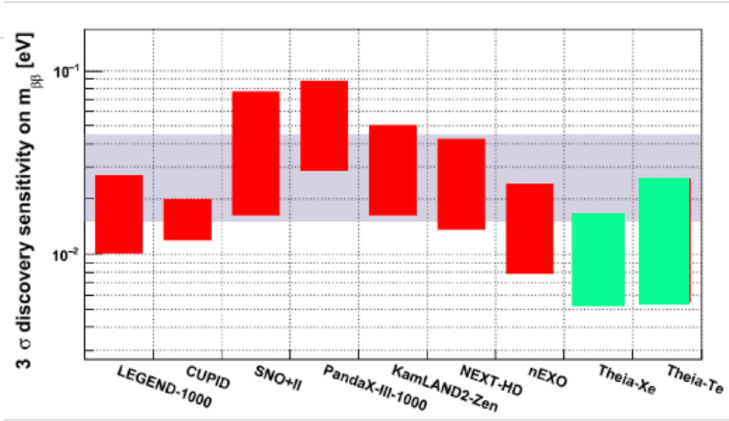
Low-energy reconstruction & sensitivity well explored in published papers

*High-energy analysis is **the** critical step to bring the broader DUNE community on board*





Expected to be a top priority in 2023 P5 report



A top science priority in 2023 NP-LRP

Tasking

1. High-energy event reconstruction
   a. Determine effort needed for full adaptation of FiTQun for Cher+scint signals
   b. Consider alternative models for detector performance
   c. Implement
   d. Evaluate impact

2. Oscillation analysis
   a. Develop end-to-end oscillation analysis leveraging existing DUNE tools
   b. Incorporate parametric FD model
   c. Incorporate parametric ND model

3. Evaluate ND requirements s.t. CPV sensitivity matches DUNE module
   a. Cross section uncertainty (interaction rates on C, H, O; detector volume)
   b. Energy resolution, target mass
   c. Hadronic energy containment

4. ND design
   a. ND design options to meet above requirements
   b. Develop conceptual design, preliminary costs

5. Develop WbLS to meet FD requirements
   a. Transparency (25-kton)
   b. Light yield, time profile
   c. In situ tuning

Deliverables / timeline

Timeline	Milestones	Deliverables
Year 1	Upgrade FitQun (Ch+S)	Report in impact of S on FD performance
	Coordinate with DUNE: shared analysis	
	End-to-end oscillation analysis	
	Evaluate ND reqs	Report on ND reqs
	Evaluate FD / WbLS reqs	
Year 2	Theia CPV sensitivity	Report on CPV sensitivity
	Down-select ND options	
	Conceptual ND design	Report on ND options
	WbLS performance assessment	

Resources

Institution	Personnel	Role
BNL	David Asner	PI, oversight
	Minfang Yeh	Task 5 lead
	Elizabeth Worcester	Interface with DUNE
	Guang Yang (25%)	LBL analysis
	Steven Linden (25%)	LBL analysis
	Postdoc-a [TBD] (50%)	Task 5
	John Tuozzolo (25%)	ND design
UMN	Mike Wilking	Theia LBL lead
	Postdoc-b [TBD] (50%)	LBL analysis
	Postdoc-c [TBD] (50%)	ND design
UCB	Gabriel Orebi Gann	Theia coordination, low-energy reqs
Other	PI	Additional LBL analysis engagement
	Postdoc-d [TBD] (50%)	LBL analysis