Technology and Reconstruction Development for THEIA

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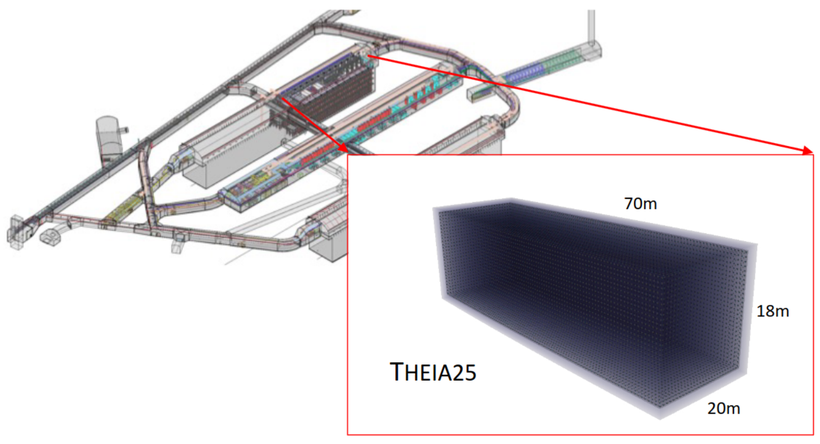
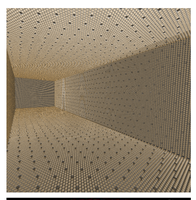
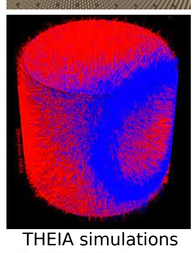
THEIA Concept







THEIA simulations
(RAT-PAC & Chroma)

THEIA [1] is a 25 - 100 ktonne scintillation-based neutrino experiment, ideally situated as the DUNE 4th far detector. THEIA will use modern technology to distinguish Cherenkov and scintillation light to unlock a broad physics program. These advances include novel scintillators, fast photodetectors, spectral sorting with dichroicons, and advanced reconstruction methods.

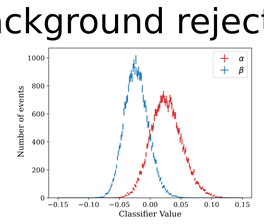
Reconstruction

THEIA will leverage advanced reconstruction methods [9] that utilize both the Cherenkov and scintillation light in order to:

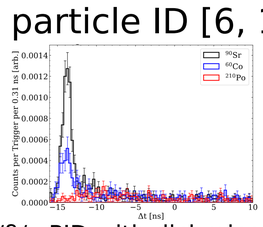
1. Reconstruct direction with resolution similar to a water Cherenkov detector

2. Maintain excellent vertex and energy resolution, and the low thresholds typical of a liquid scintillator detector

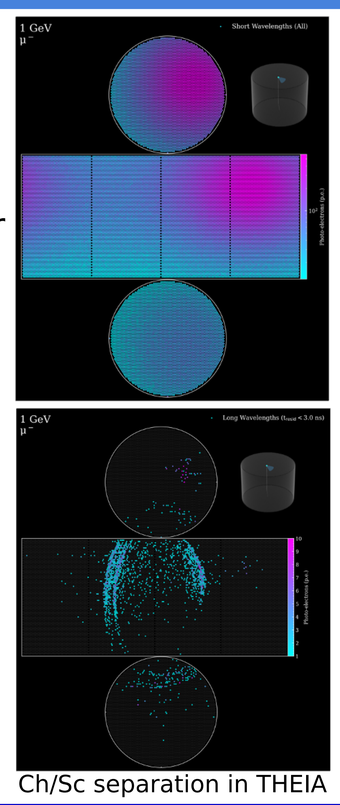
3. Combine both signals to improve background rejection with particle ID [6, 10]



α/β PID with WbLS in Eos



α/β/γ PID with dichroicons

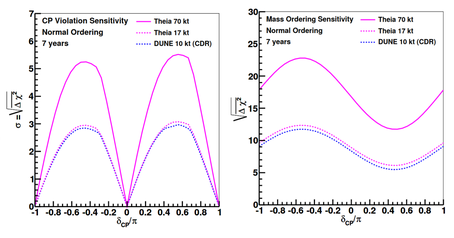


Ch/Sc separation in THEIA

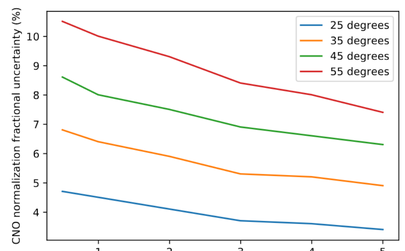
Physics

see poster #578 for details

Oscillation physics: δ_{cp} and the neutrino mass hierarchy (comparable sensitvity to DUNE LAr detector)

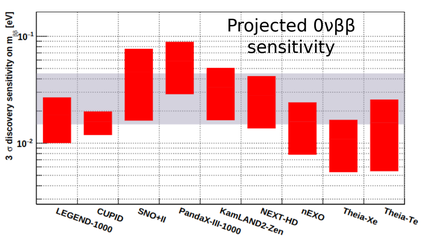


Solar neutrinos: CNO [2], ^{8}B transition region



Geoneutrinos: U/Th ratio, radiogenic heat

Supernova neutrinos: DSNB and supernova burst as a high-statistics ($\bar{\nu}_e$) counterpart to DUNE, Hyper-K, & JUNO

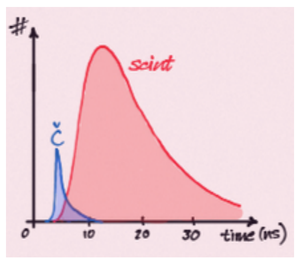


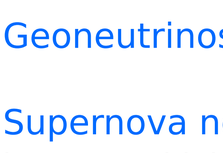
0νββ: Using Te or Xe-loaded scintillator

Other topics: nucleon decay, sterile neutrinos, exotic dark matter, etc.

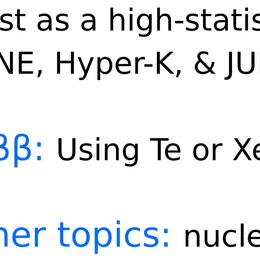
Technology

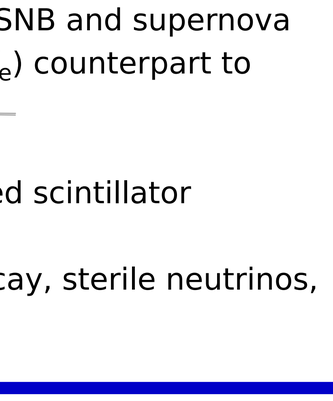
Timing
Fast photodetectors
Slow scintillators
Fast digitization / readout





LAPPD [3]



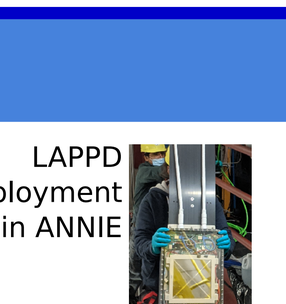


CHESS [4]

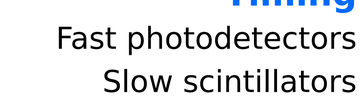
[5]
see poster #545

Wavelength
Dichroicons & filtering
Red-sensitive PMTs

[6]



Short-pass dichroicon [8]



WbLS [7]

Topology
Water-based scint. (WbLS)
Pixelization
Advanced reconstruction

LAPPD deployment in ANNIE

Demonstrators

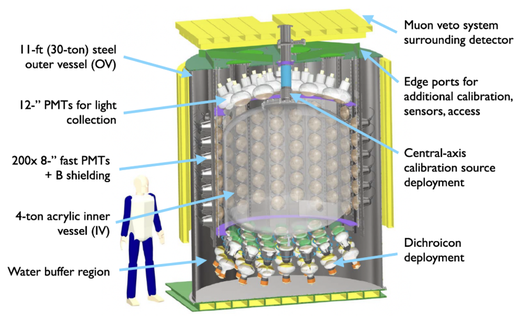
ANNIE: High-energy beam neutrino event recon. (first neutrino detection with Gd-water in 2020), fast-timing with LAPPDs (first detection in 2022), neutrino detection with WbLS (SANDI [12], 2023) (see posters 481, 518, and 553 for more details)

EOS: Advanced hybrid technology and recon. demonstration [11]
(see poster #487 for details)

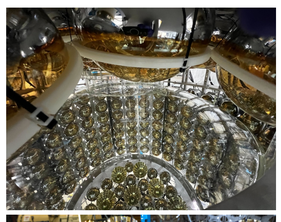
BNL 1-tonne: WbLS stability and recirculation [13]

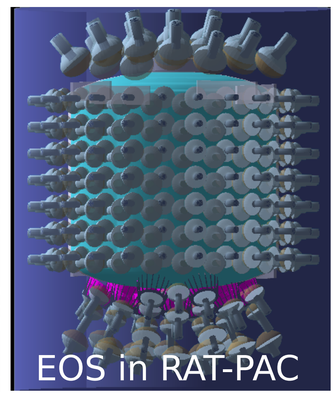
BUTTON: Underground deployment, low background testing [15]

NuDot: Liquid scintillator development, 0νββ loading [16]



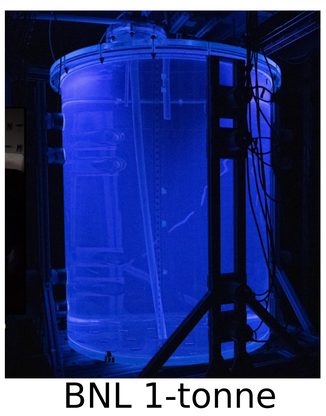
EOS



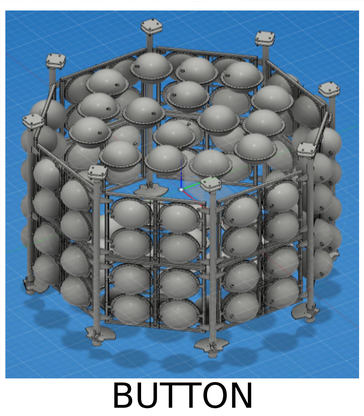


EOS in RAT-PAC

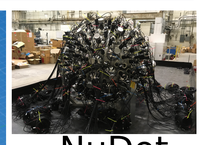
ANNIE



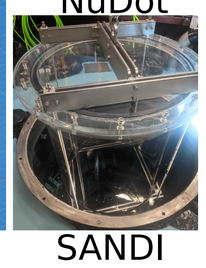
BNL 1-tonne



BUTTON



NuDot



SANDI

References

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