The broad physics program of THEIA

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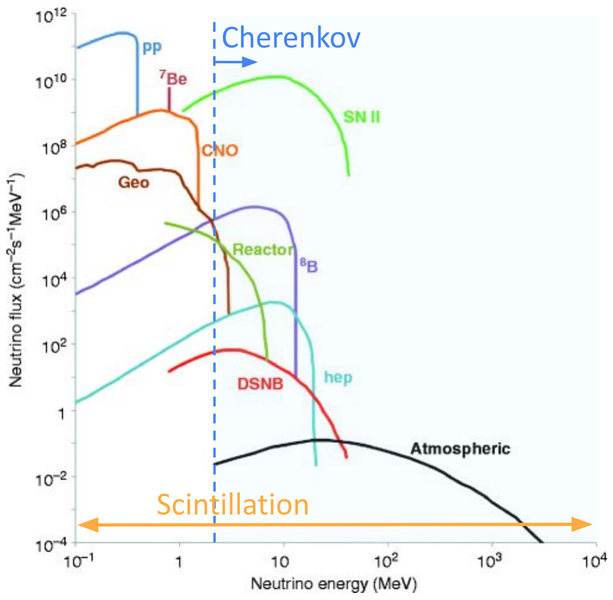
578

iNSPIRE:2039010 iNSPIRE:1764050

THEIA is a proposed large-scale neutrino detector designed to use both Cherenkov and scintillation signals to enable a rich program of fundamental physics, including both low- and high-energy neutrino physics, as well as the potential to search for neutrinoless double-beta decay with a sensitivity reaching the normal ordering regime.



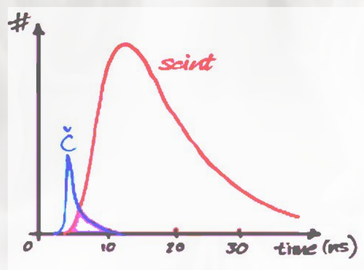
iNSPIRE:1090322

Cherenkov and scintillation

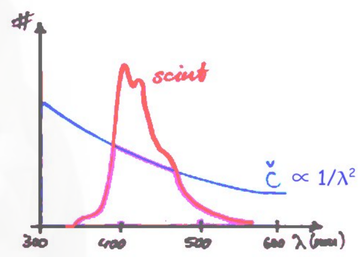
- Cherenkov photons discriminate events based on directionality/topology.
- Scintillation is abundant, providing good resolution & low *E* thresholds.

The two types of photons can be distinguished by:

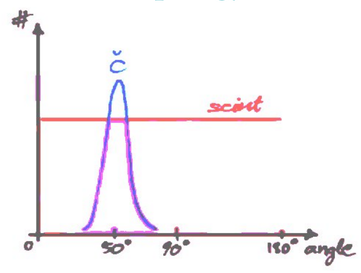
Time



Wavelength



Topology



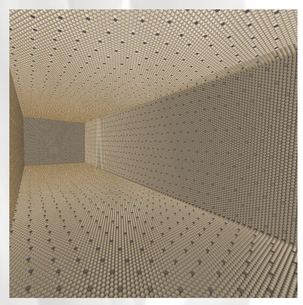
THEIA program

Primary Physics Goal	Reach	Exposure / assumptions
Long-baseline oscillations	$> 5\sigma$ for 30% of δ_{CP} values	524 kt-MW-yr
Supernova burst	$< 1(2)°$ pointing accuracy 20,000 (5,000) events	100(25)-kt detector, 10 kpc
DSNB	5σ discovery	125 kton-yr
CNO neutrino flux	< 5 (10)%	300 (62.5) kton-yr
Reactor neutrino detection	2000 events	100 kton-yr
Geo neutrino detection	2650 events	100 kton-yr
NLDBD	$T_{1/2} > 1.1 \times 10^{28}$ yr	211 ton-yr ^{130}Te
Nucleon decay $p \to \overline{\nu} K^+$	$T > 3.80 \times 10^{34}$ yr (90% CL)	800 kton-yr

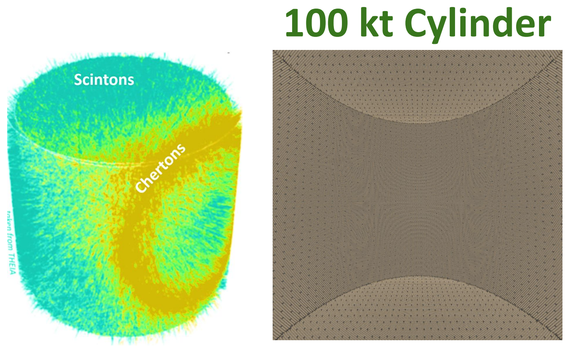
THEIA detector

THEIA's baseline design consists of 25 kt or 100 kt of a novel scintillator, such as water-based liquid scintillator (WbLS), along with fast, spectrally-sensitive photon detectors. See poster 596.

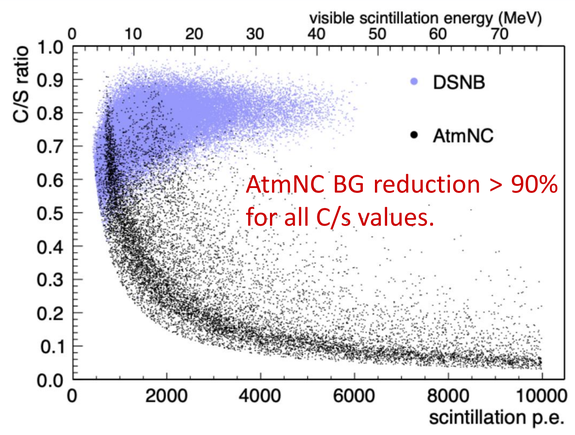
25 kt Box



100 kt Cylinder

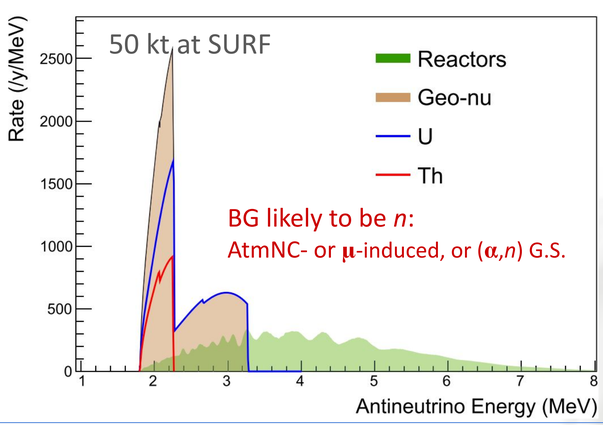


Simple **C/s** ratio offers powerful discrimination: heavy particles (α,*p*,*n*) produce no Cherenkov at low *E*.



(DSNB) Diffuse Supernova Neutrino Background

Discovery and spectroscopy to inform astrophys.



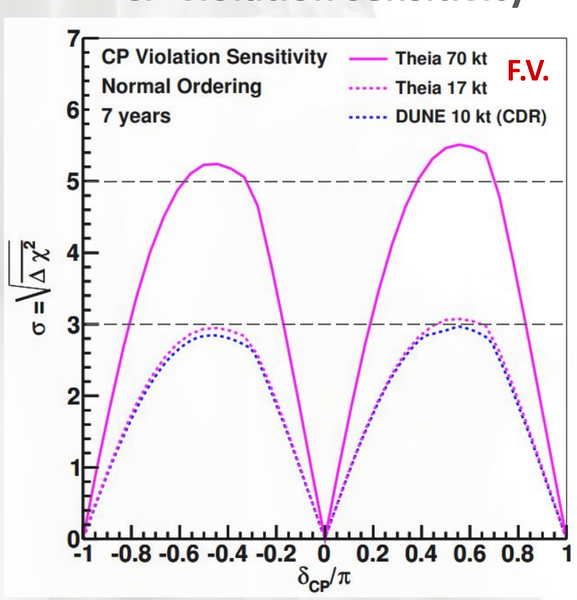
Geoneutrinos

Tests of geo models.

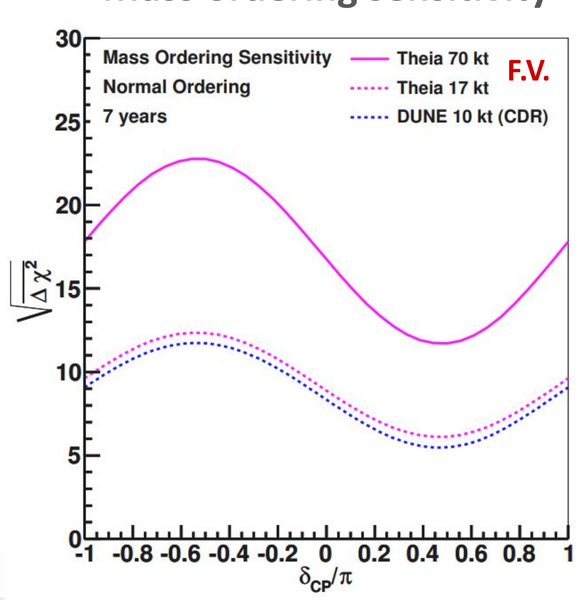
Long-baseline oscillations

At SURF, THEIA would measure GeV neutrinos and antineutrinos from the LBNF neutrino beam. Advanced Cherenkov ring imaging techniques lead to improved particle ID and ring counting, greatly improving BG rejection.

***CP* violation sensitivity**



Mass ordering sensitivity

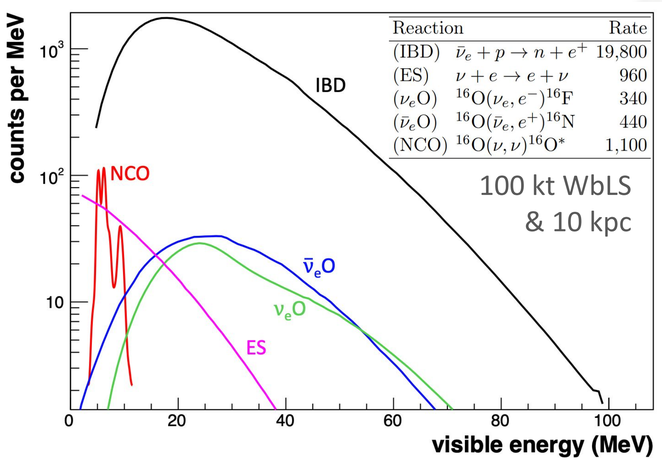


Cherenkov directionality offers powerful discrimination for directional sources or backgrounds.

Supernova burst

Flavor-resolution & spectral analyses (*E* & *t*).

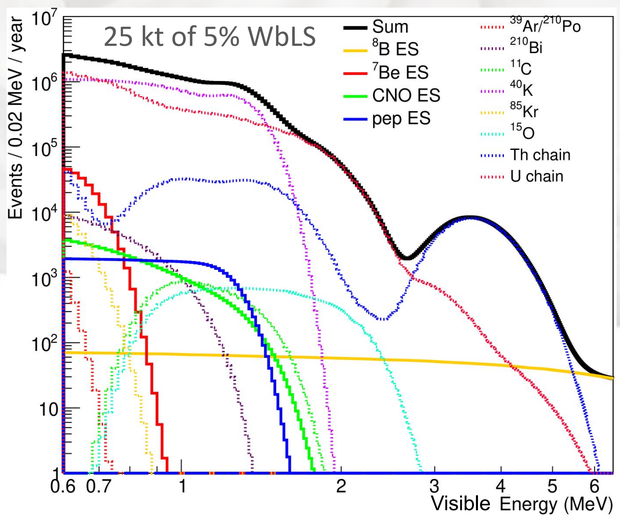
Pre-SN: 3σ detection at 3 kpc.



Reaction		Rate
(IBD)	$\bar{\nu}_e + p \to n + e^+$	19,800
(ES)	$\nu + e \to e + \nu$	960
(ν_eO)	^{16}O$(\nu_e, e^-)^{16}$F	340
($\bar{\nu}_e$O)	^{16}O$(\bar{\nu}_e, e^+)^{16}$N	440
(NCO)	^{16}O$(\nu, \nu)^{16}$O*	1,100

Solar neutrinos

Test solar models & search for new physics.



(NLDBD) Neutrinoless double-beta decay

THEIA 100 kt for 10 years