An Overview of The Double Chooz Experiment

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Introduction

- Typically, a neutrino experiment will be sensitive to one squared-mass-difference and one mixing angle
- Solar and long-baseline reactor neutrino experiments have measured mixing parameters δm^2 and θ_{12} in the $\nu_e \rightarrow \nu_e$ channel
- Atmospheric and long-baseline accelerator experiments have measured Δm^2 and θ_{23} in the $\nu_\mu \rightarrow \nu_\mu$ channel
- Short-baseline reactor experiments are primarily sensitive to Δm^2, and have placed an *upper* limit on θ_{13}

- Here, $\delta m^2 = m_2^2 - m_1^2$ and $\Delta m^2 = m_3^2 - (m_2^2 + m_1^2)/2$

Motivation

- Mixing angle θ_{13} is the last unmeasured mixing parameter and is the focus of several experiments
- The original CHOOZ experiment results provided an upper limit of $\sin^2 2\theta_{13} < 0.17$
- Recent T2K and MINOS experiment results disfavor the null hypothesis $\theta_{13} = 0$
- These results are promising, as the Double Chooz experiment was designed to provide a precise measurement of θ_{13}, provided that

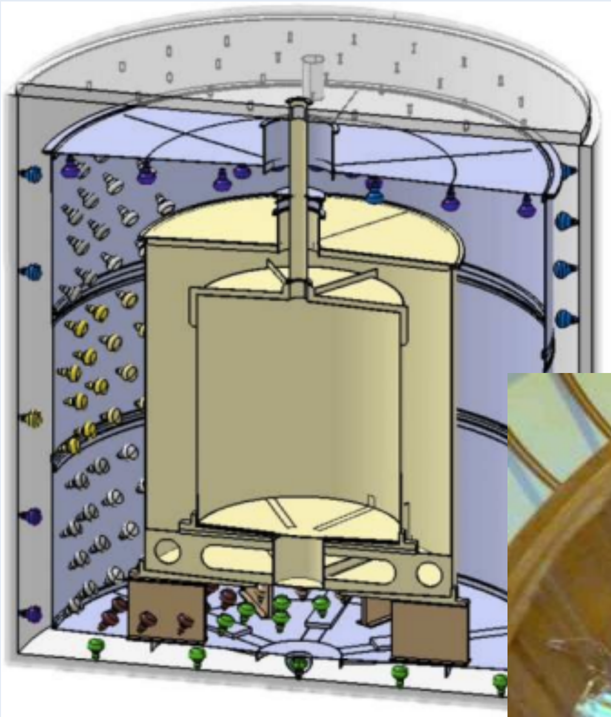
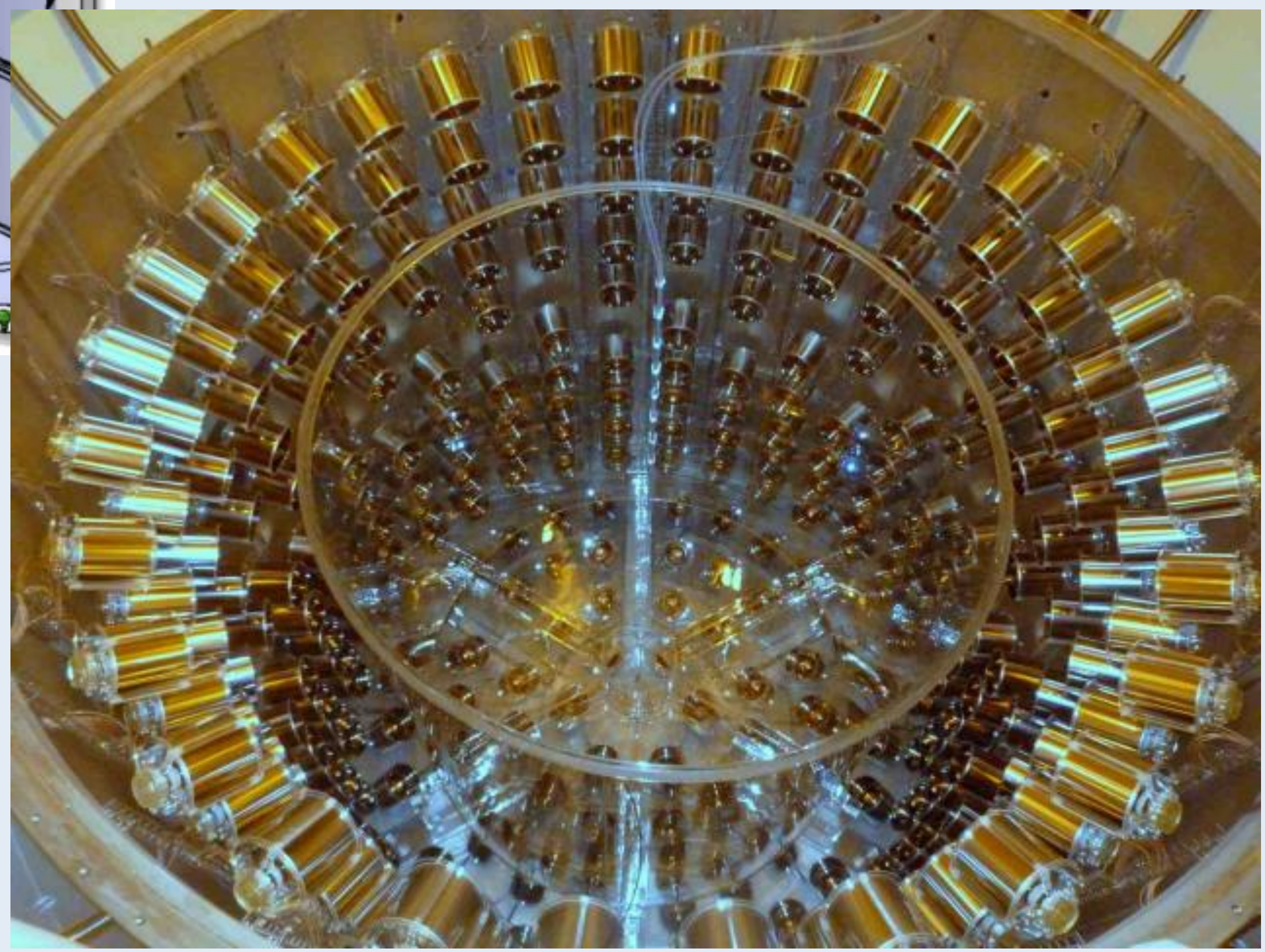
$$0.03 < \sin^2 2\theta_{13} < 0.19$$

Concept and Design

- Double Chooz is a two-detector short-baseline electron antineutrino disappearance experiment
- Having two detectors is an effective way to improve sensitivity while avoiding matter effect and CP violation ambiguities
- Reactor induced systematic errors from the CHOOZ experiment are reduced to negligible levels
- The location of the experiment is the Chooz nuclear power plant in northern France
- The plant has two N4-type pressurized water reactor using UOx fuel

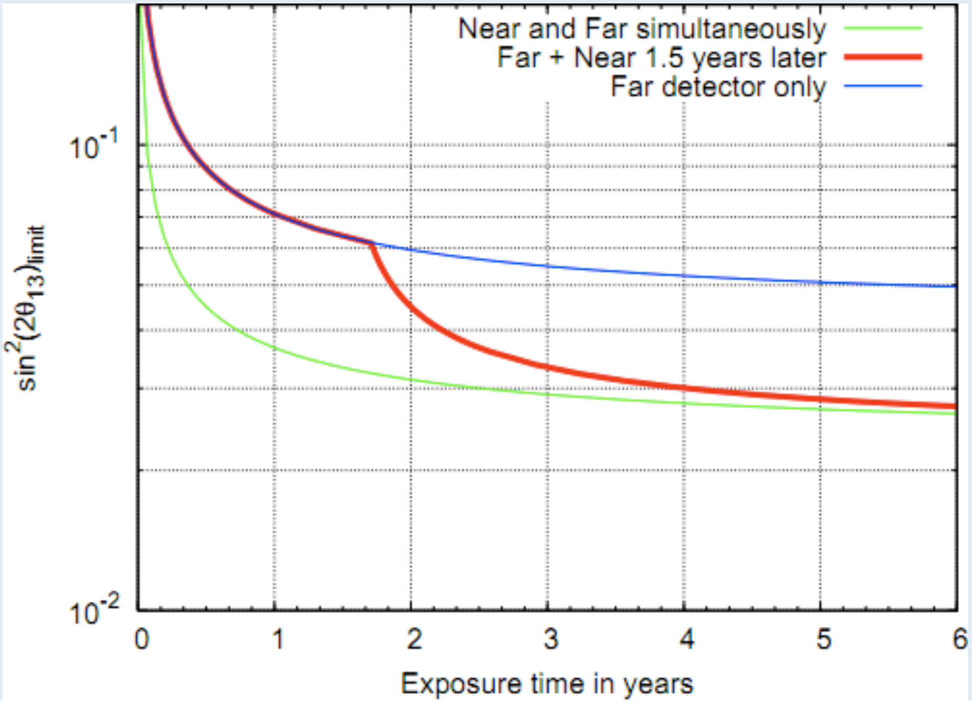
Detector Design

- Four nested volumes using acrylic vessels, surrounded by 390 photomultiplier tubes (13.5% coverage)
- Innermost volume (10.3 m^3) is the neutrino target, filled with Gd-doped liquid scintillator (PXE/dodecane)
- Next vessel is the gamma catcher, 21.5 m^3 of liquid scintillator without Gd
- These volumes are surrounded by buffer and veto volumes filled with non-scintillating mineral oil
- All volumes except the buffer contain PPO fluor and bis-MSB wavelength shifter
- Additionally, there is an outer veto to assist with background measurement

Current Progress

- Filling of the far detector was finished in January
- The far detector has been taking data since Spring
- Since the detector has been in operation, we have seen neutrino interactions
- Work toward construction of the near lab has now begun, currently working on the tunnel
- Occupation of the near lab is scheduled for next year



Thermal power	4.27 GW	each of 2 cores
Electric power	1.5 GWe	each of 2 cores
$\overline{\nu}_e$ target volume	10.3 m^3	Gd loaded LS (0.1%)
γ-catcher thickness	55 cm	Gd-free LS
Buffer thickness	105 cm	non scintillating oil
Total liquid volume	$\sim$237 m^3	
Number of phototubes per detector	534 8"	13% coverage
Far detector distance	1050 m	averaged
Near detector distance	280 m	averaged
Far detector overburden	300 m.w.e.	hill topology
Near detector overburden	70–80 m.w.e.	shaft
$\overline{\nu}_e$ far detector events (5 yr)	75,000	with a 60.5% efficiency
$\overline{\nu}_e$ near detector events (5 yr)	789,000	with a 43.7% efficiency
Relative normalization error	0.5%	
Effective bin-to-bin error	1%	background systematics
Running time with far detector only	1–1.5 year	
Running time with far+near detector	3 years	
$\sin^2(2\theta_{13})$ goal in 3 years with 2 detectors	0.02–0.03	(90% CL)