

# WATCHMAN: Reactor Monitoring and Neutrino Physics with a Gadolinium Doped Water Detector



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For The WATCHMAN Collaboration

- ✓ Kiloton-scale water+gadolinium antineutrino detector at old IMB location (Fairport mine, Ohio)
- ✓ Enabling Long Distance Reactor Discovery / Monitoring for non-proliferation and basic neutrino research

## Introduction

National Nuclear Security Administration

Select Initiatives

Strengthen Nuclear Safeguards:

- By 2013, deploy new non-destructive assay technologies to directly quantify plutonium in spent fuel.
- By 2016, demonstrate remote monitoring capabilities for reactor operations.

Counterterrorism and Nuclear Threat Response:

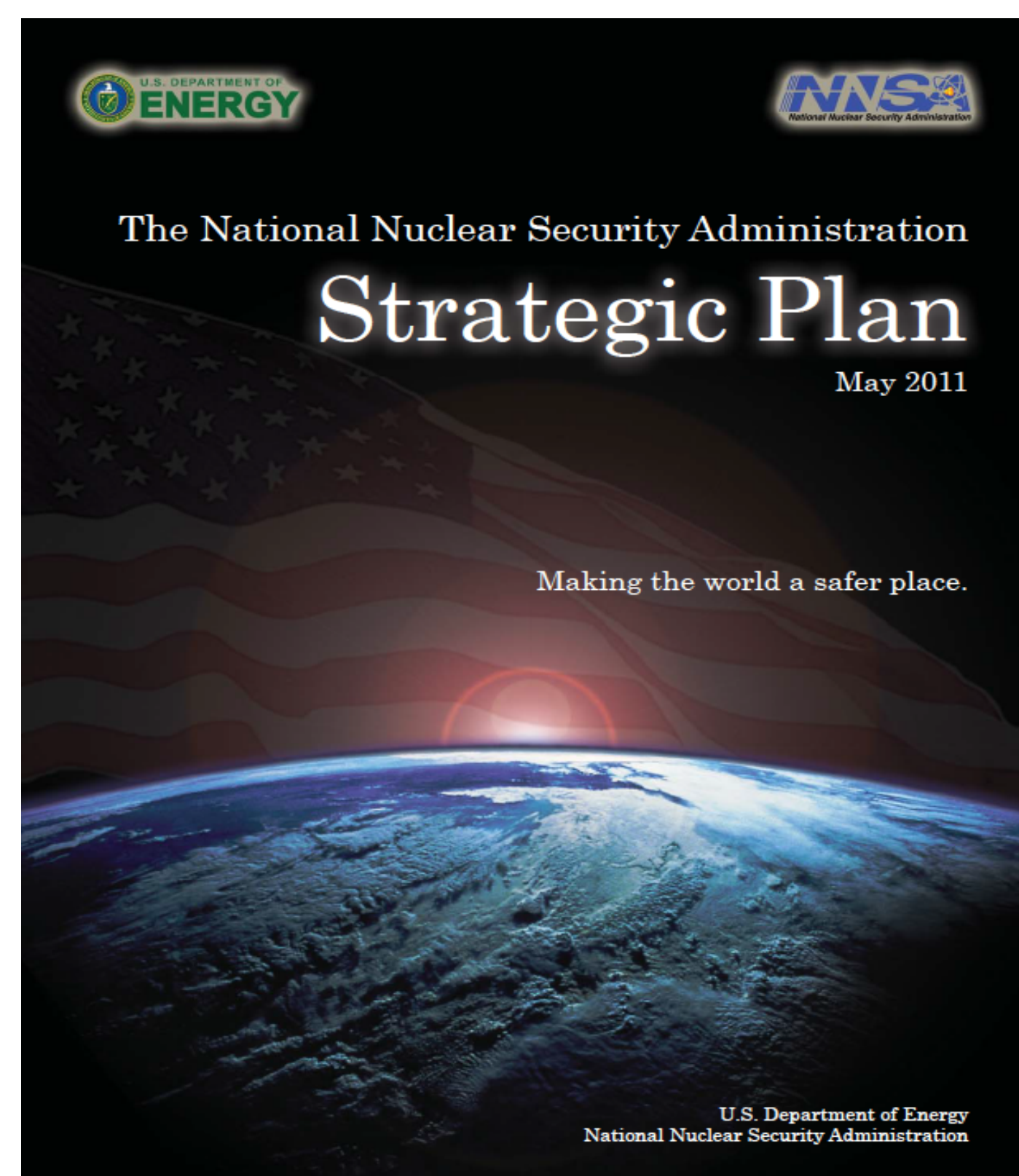
- By 2012, hold joint nuclear facility transportation security exercises with two established foreign partners.
- By 2012, establish new partnerships with two additional foreign partners.
- By 2012, complete nuclear materials and energetic materials characterization and prioritization, enhance development of new nuclear counterterrorism reactor safe tools, and conduct the 100th counterterrorism tabletop exercise.

entrants into the nuclear market. The NNSA partners with the DOE Office of Nuclear Energy and others to consider, and where necessary develop, the legal, institutional, and commercial arrangements necessary to promote the expansion of peaceful nuclear energy without increasing proliferation risks. As part of this process, we will downblend surplus U.S. highly enriched uranium for an Assured Fuel Supply to be used in case of a fuel emergency domestically, and with countries that meet certain nonproliferation criteria, as determined by the U.S. Government.

We will assist in minimizing the proliferation risks associated with peaceful nuclear energy cooperation.

The NNSA is leading a cooperative, comprehensive initiative to develop the technologies, policies,

- By 2016, demonstrate remote monitoring capabilities for reactor operations.



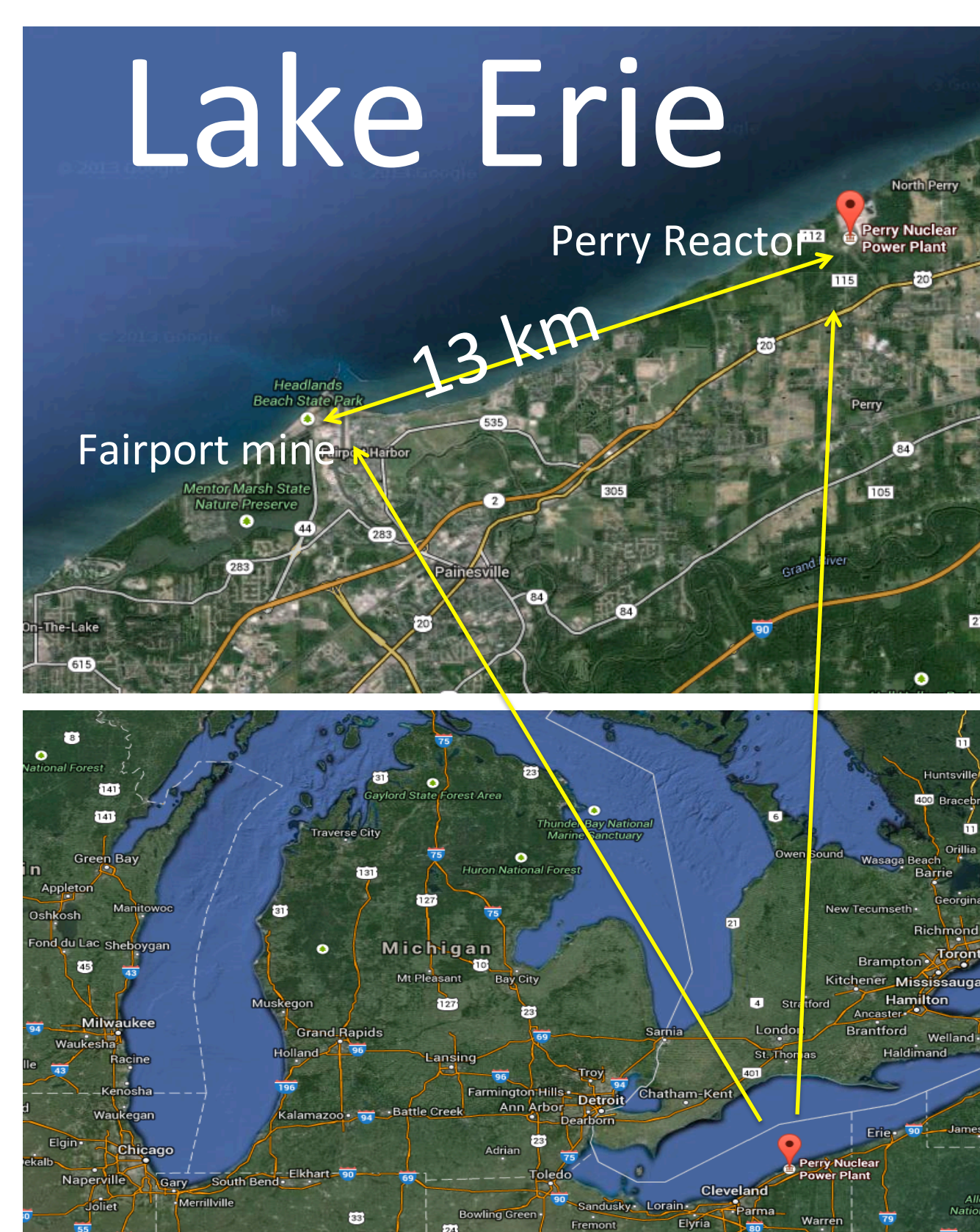
## A Remote Reactor Monitoring Demonstration is in the NNSA Strategic Plan

**AIM:** To demonstrate the capability to monitor the nuclear fission by remote means

### Advantages of Antineutrino-based monitoring

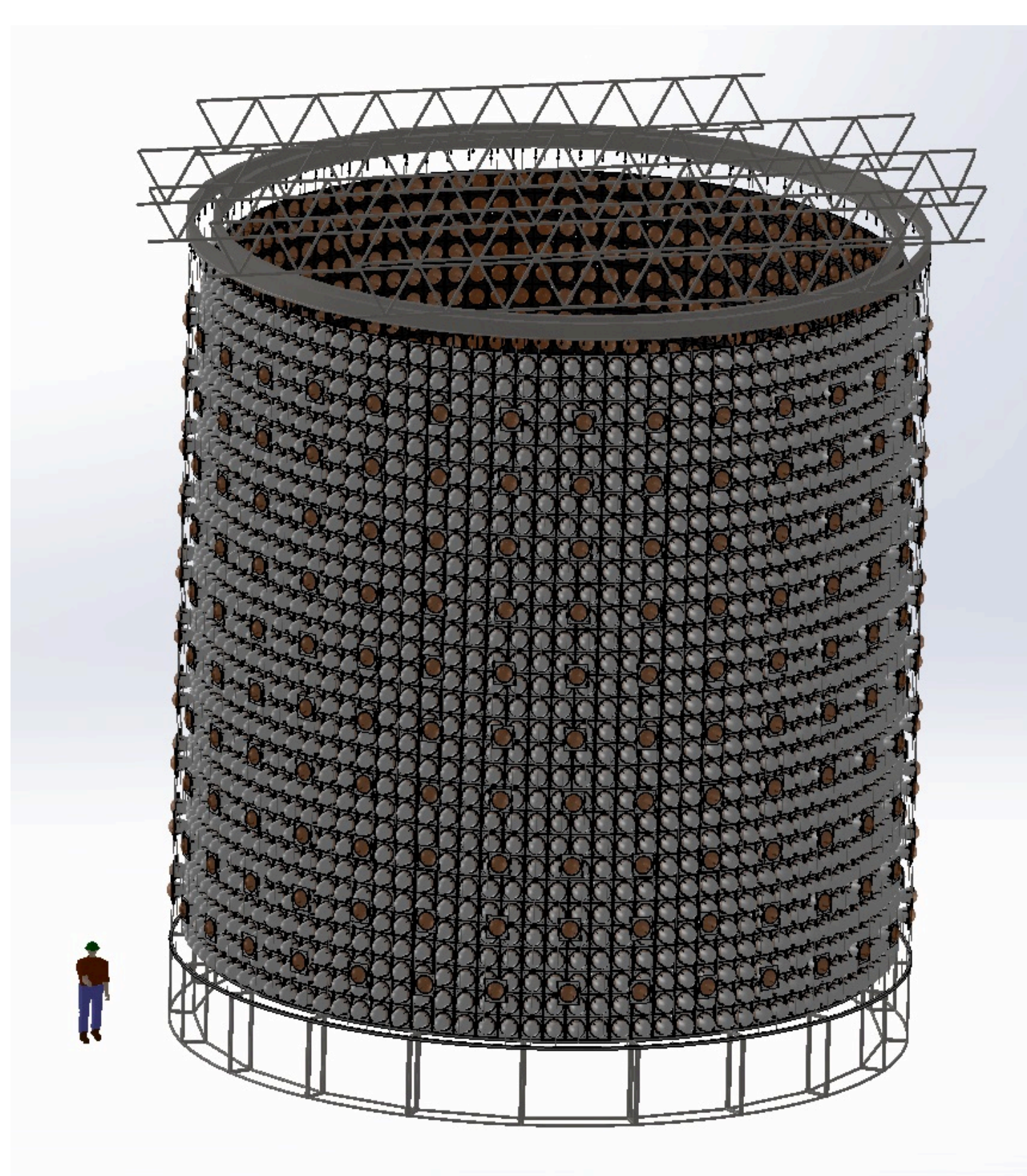
- Antineutrino emission cannot be shielded. There is no known way to hide your own reactor-based antineutrino production.
- Detection is clear indication that nuclear fission is occurring

## The WATCHMAN Detector



### Location at former IMB site

- Standoff from Perry Reactor 13km
- Reactor Power 3800 MWt
- Detector overburden 1500 mwe



### Detector Design

- 1 kiloton fiducial volume
- DI water + gadolinium
- 6000 high QE PMTs
- 40% photo coverage

## Design work

- Geant4 based simulations based on Super-K and LBNE Simulations (WCSim)
- Engineering underway now (LLNL and Sandia)

## Ultimate Aim of WATCHMAN

To prove the feasibility of long distance reactor Monitoring

## Predicted Distance scales and Detector sizes

Long Term Goals	Detector mass (Fiducial)	standoff
16 events in 1 year (power measured at $\pm 25\%$ ) from a 10 MWt reactor (3 kg of Pu)	10 kiloton	$\sim 40$ km
	1 Megaton	$\sim 400$ km

## Physics Research at WATCHMAN

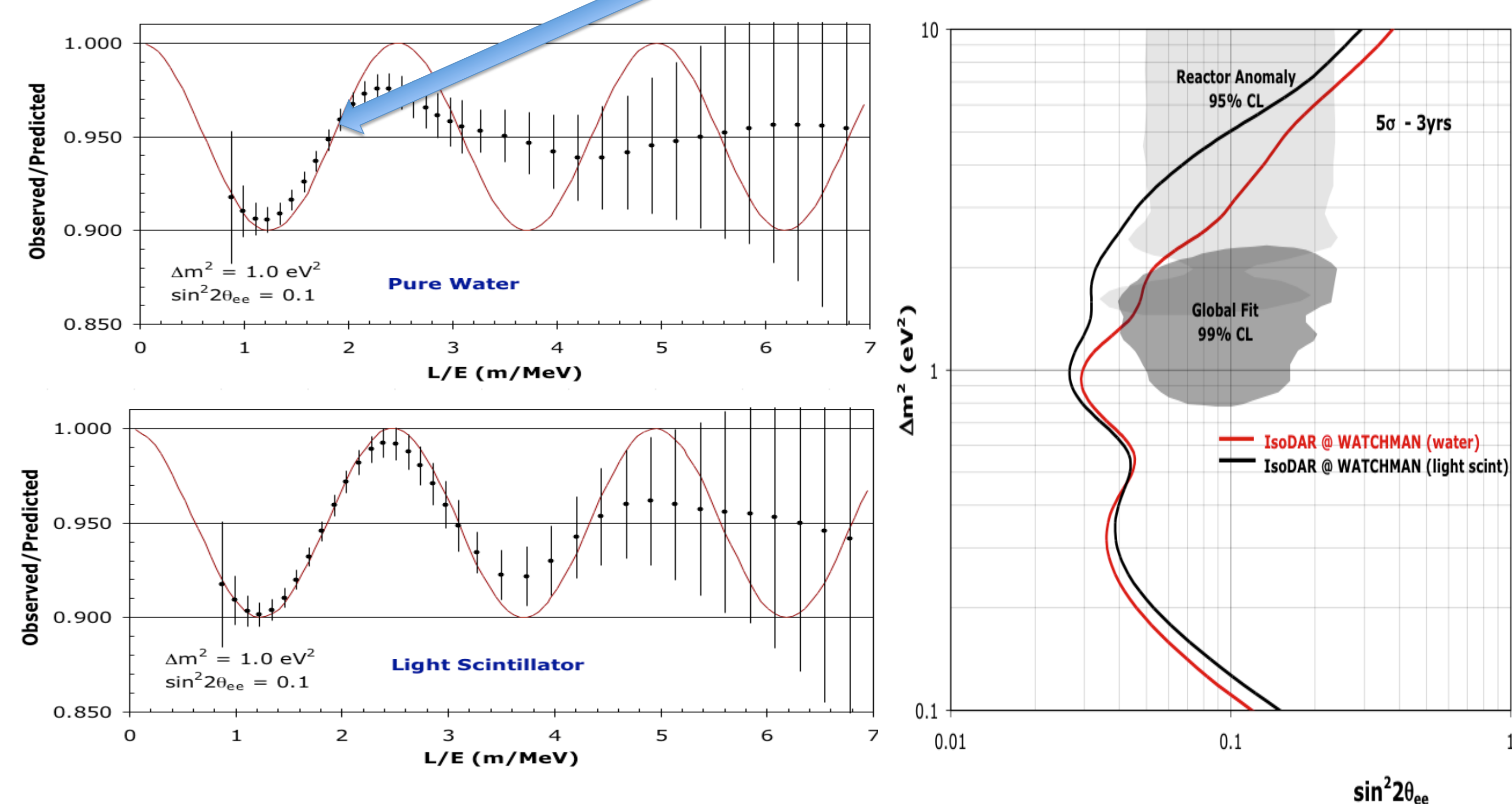
### Physics Opportunities at WATCHMAN

- **Supernova detector** – Only supernova detector capable of background free supernova antineutrino detection. Also background free electron scattering (fast pointing to galactic supernovae)
- **Sterile neutrino oscillation search** – Requires IsoDAR deployment at WATCHMAN
- **Non standard neutrino interactions** – Also Requires IsoDAR deployment at WATCHMAN

### Upgrade to liquid scintillator

- **Mass hierarchy** – using antineutrinos from the Perry reactor
- **Sterile neutrino oscillation search** – Requires IsoDAR deployment at WATCHMAN
- **Non standard neutrino interactions** – Also Requires IsoDAR deployment at WATCHMAN

## Example: Sterile neutrino oscillations can be observed with IsoDAR + water-based WATCHMAN (assuming $\Delta m^2 \sim 1 \text{ eV}^2$ )



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