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NA-22 Project Review: Above-Ground Reactor Monitoring

Project Overview

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Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000

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Lawrence Livermore National Laboratory

Sandia National Laboratories

Today's Agenda

8:30	9:00	Project Overview	D. Reyna
9:00	9:30	Aboveground Detector Deployments	L. Kogler
9:30	10:00	CANDU Deployment	T. Classen
10:00	10:20	Break	
10:20	10:50	Applications to PMDA	N. Bowden
10:50	11:10	Reactor Simulations	A. Erickson
11:10	12:00	Lab Tour	
12:00	1:30	Executive Session, Lunch	
1:30	2:30	Out-Brief	

A Novel Technology for Reactor Safeguards

- Antineutrino Monitoring of Reactors provides independent measurements of Thermal Power and Fissile Inventory
  - Non-intrusive with NO connection to plant systems
  - Continuous Remote Monitoring
  - Highly tamper resistant
- Potential Applications to Present and Future Safeguards
  - Independent Confirmation of Operator Declarations
  - Reduction in needed Inspector visits
  - Provide fissile content information for Next-Generation fuel cycles (MOX, Th, bulk process)
  - Non-intrusiveness attractive for Treaty Verification

Proof-of-Principle Demonstrations

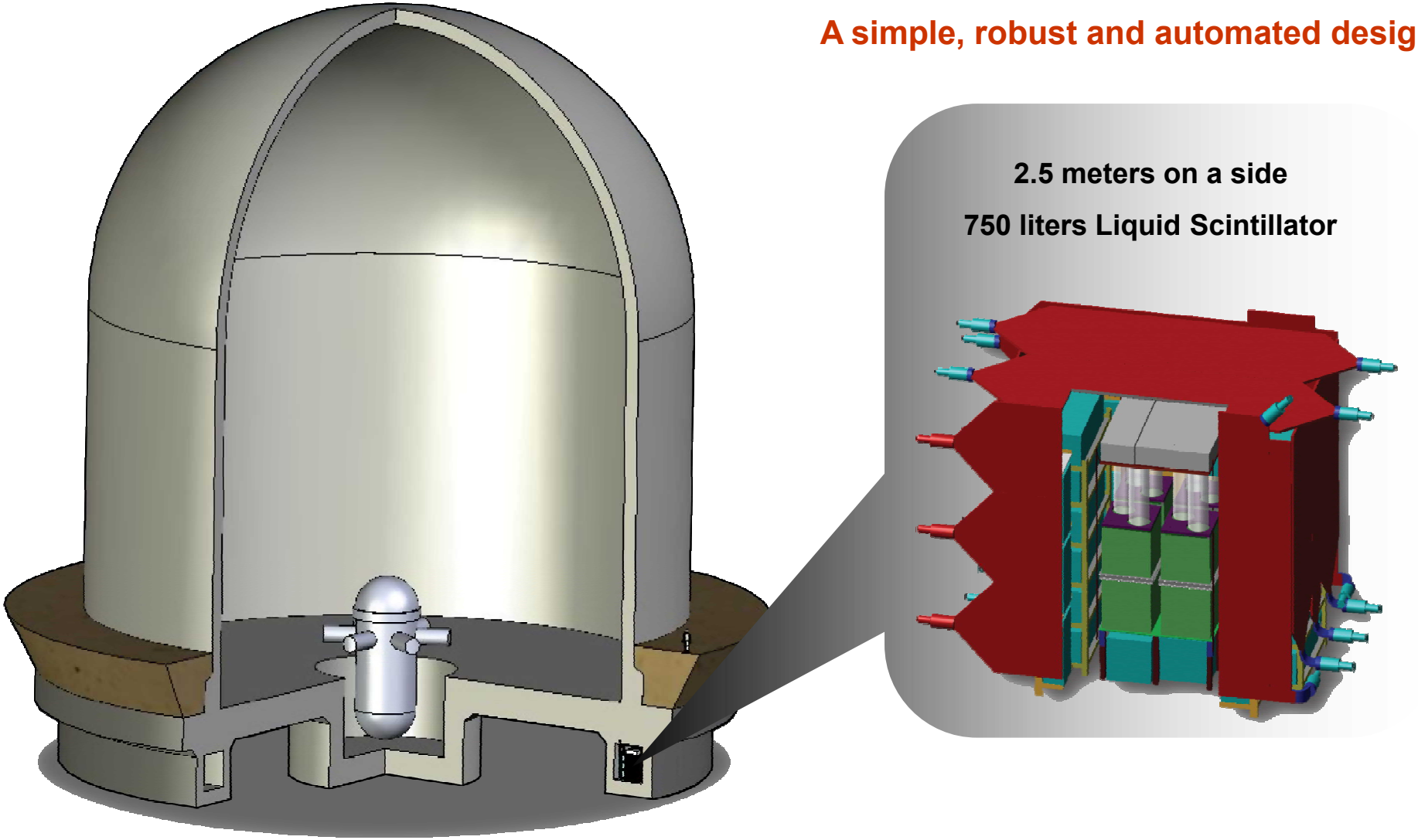
San Onofre Nuclear Generating Station (SONGS)

Operating Demonstration Detectors since 2003

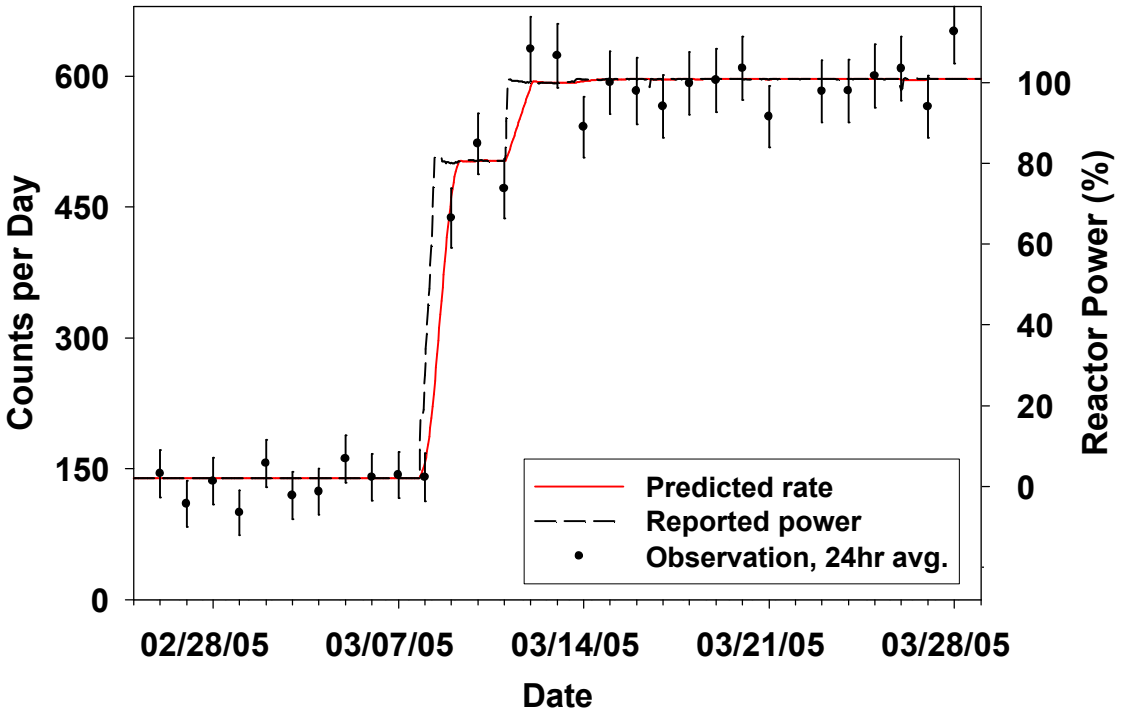
⇒ Our Longevity is a testament to our non-intrusive operation

The “SONGS1” Antineutrino Detector

A simple, robust and automated design



Reactor Power Monitoring using only $\overline{\nu}$



Timescale

1 – 3 Hours:

Sudden changes in operational status (on/off)

1 Day:

Large power changes

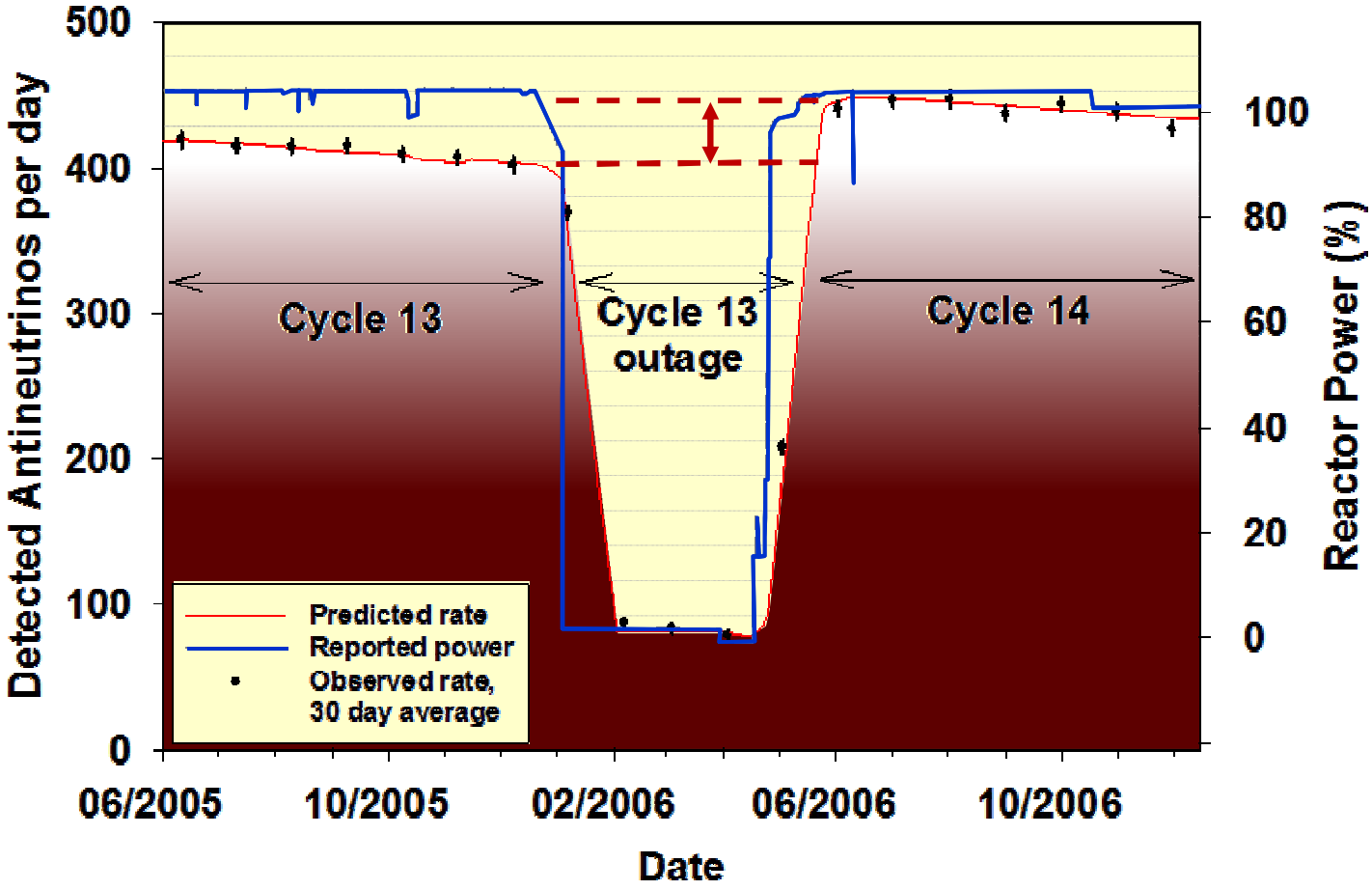
7 Days:

Relative thermal power measurement (2 – 3%)

Large power changes are readily observed with no physical connection to the plant

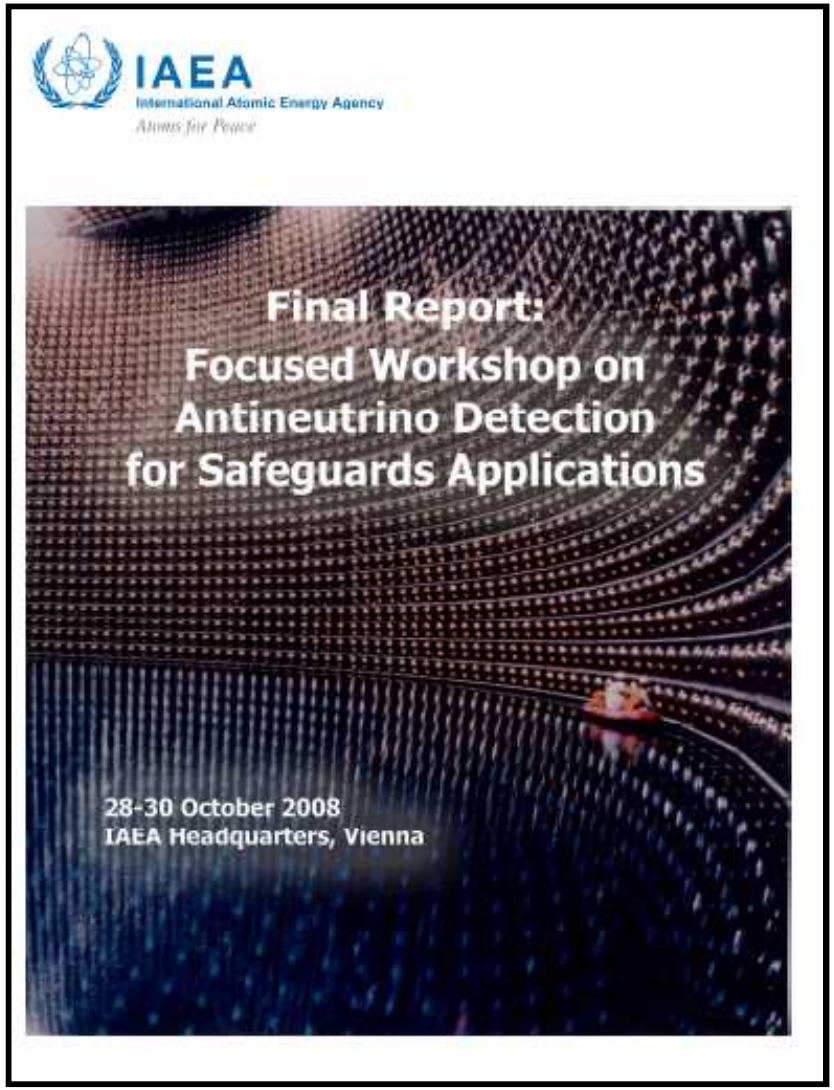
$\overline{\nu}$ Provides Information on Fuel Composition

Standard Refueling is Clearly Visible



Sensitive to undeclared replacement of 70 kg ^{239}Pu

Expert's Meetings at IAEA – NTU



- Introduction of technology – 2003
  - Called for further development
- Focused Workshop – 2008
  - Suggested Application against
    - Research Reactors
    - Bulk Process Reactors
      - Motivated CANDU Deployment
  - Requested Improvements in
    - Robust Deployability
      - Support for Aboveground Program
    - Fully Independent measurement of fissile content
- Ad-Hoc Working group – 2011
  - Reiterated interest in application to future reactors/cycles
  - Requested application to PMDA
    - Initiated our latest work
  - Requested capabilities for Long Range Detection of clandestine reactors

Project Goals

Simulation/Analysis:

Study the sensitivity of antineutrino monitoring techniques and help generate future detector requirements

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Experiment:

"… demonstrate the practical utility of above-ground antineutrino detectors as a new tool for reactor safeguards and cooperative monitoring."

Our demonstration standard: Deploy a detector that can observe a reactor ON/OFF transition with:

3σ statistical uncertainty within 7 days
5σ statistical uncertainty within 30 days

Relevant Requirement for Pu Production Detection:

..“Quantify how much weapon-useable plutonium can be, is being, or has been produced in a reactor of interest over a given period of time..”

Since Previous Review

- **Previous Review – June 2009**
  - Recommendations to improve water detector
  - Recommendation to advance the segmented scintillator

- **Since the Review**
  - Deployments of both water and segmented scintillator technologies
  - Application to CANDU reactor
    - Negotiated schedule and deployment at PLGS
    - Improved design and constructed LS detector
  - Project extended by 1 year
    - Increased focus on “use case” simulations
      - Gained contributions from university collaborators (MIT, U. Michigan)
    - Initiated PMDA/MOX focus
    - Initiated bi-lateral Action Sheet with Brazil to study applicability of antineutrino detection within Brazilian SG.

Contributions to the Community

- **Academic**
  - **Graduate involvement**
    - **2 Ph.D. Student/Theses (MIT, OSU)**
    - **Masters Theses, Fellowships and other projects**
      - **U. Michigan Nuclear Engineering**
      - **MIT Nuclear Engineering**
      - **Naval Post-graduate school**
  - **Undergraduate Involvement**
    - **Harvey Mudd**
    - **Drexel Co-op**
    - **MIT Nuclear Engineering**
- **Basic Research**
  - **Collaboration members of Double Chooz and LBNE**
  - **Significant overlap with technology and simulation**
- **Applied Antineutrino Physics Workshops**
  - **Members of steering committee since 2006**
- **Safeguards**
  - **Members of the IAEA *Ad-Hoc Working Group on Safeguards Applications of Antineutrino Detectors***

Where We Stand Now

- **Aboveground Deployments**
  - **Water did not achieve desired goal of 3σ in 1 week, but…**
    - **pushed this technology to its limit.**
    - **Potential for belowground operation**
  - **Segmented successfully demonstrated background rejection**
    - **Not funded sufficiently for full sensitivity test**
- **CANDU**
  - **Significant design improvements are operating well and we have successfully navigated international partnership**
- **PMDA**
  - **Rapid response to sponsor request with demonstration of functional utility and non-intrusive capabilities**
  - **More opportunities exist to be explored**