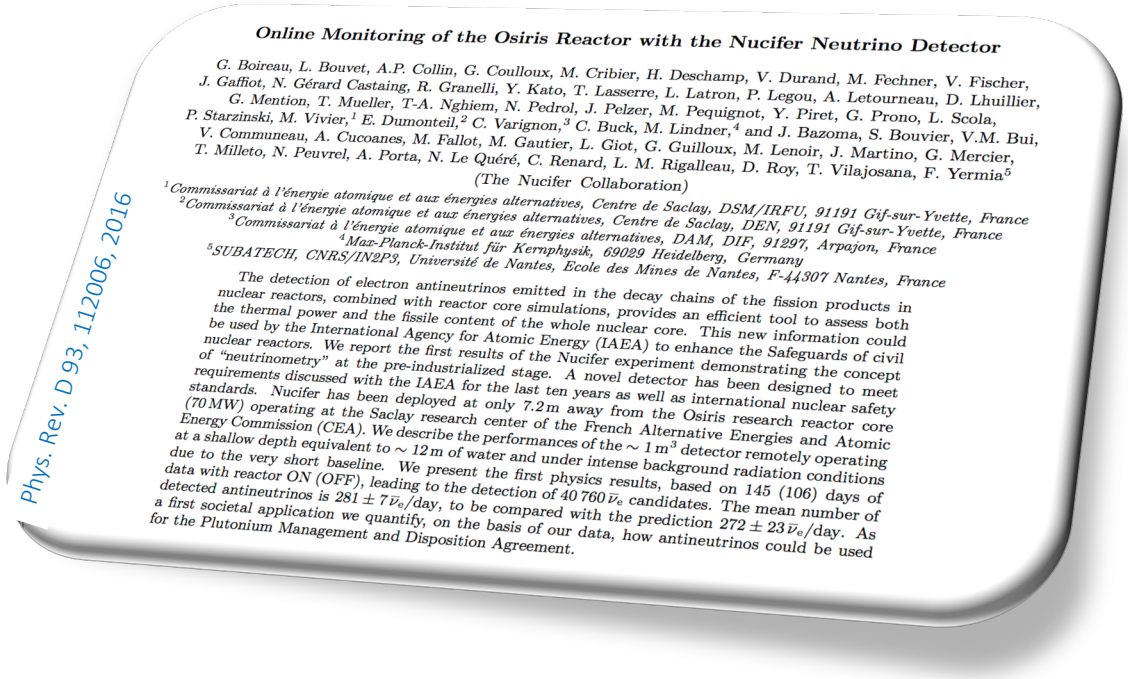
Online Monitoring of the Osiris Reactor with the Nucifer Neutrino Detector



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(The Nucifer Collaboration)

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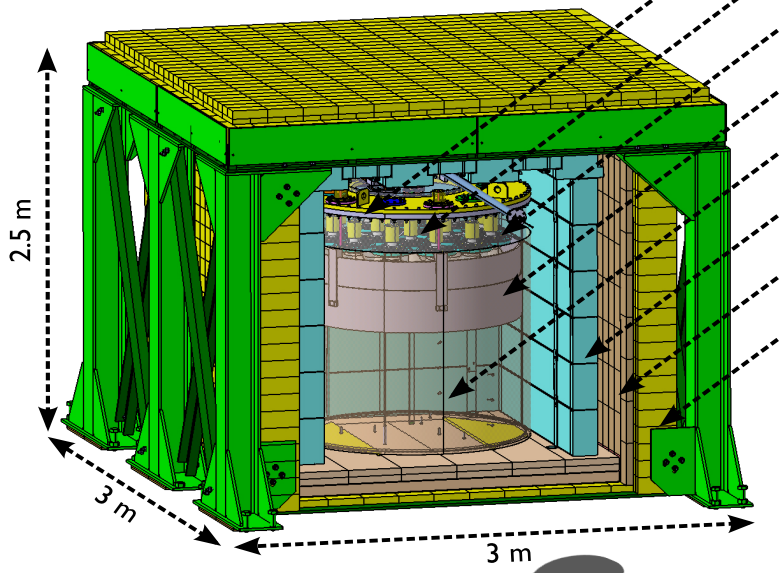
The detection of electron antineutrinos emitted in the decay chains of the fission products in nuclear reactors, combined with reactor core simulations, provides an efficient tool to assess both the thermal power and the fissile content of the whole nuclear core. This new information could be used by the International Agency for Atomic Energy (IAEA) to enhance the Safeguards of civil nuclear reactors. We report the first results of the Nucifer experiment demonstrating the concept of "neutrinometry" at the pre-industrialized stage. A novel detector has been designed to meet requirements discussed with the IAEA for the last ten years as well as international nuclear safety standards. Nucifer has been deployed at only 7.2 m away from the Osiris research reactor core (70 MW) operating at the Saclay research center of the French Alternative Energies and Atomic Energy Commission (CEA). We describe the performances of the $\sim 1\,m^3$ detector remotely operating at a shallow depth equivalent to ~ 12 m of water and under intense background radiation conditions due to the very short baseline. We present the first physics results, based on 145 (106) days of data with reactor ON (OFF), leading to the detection of 40 760 $\bar{\nu}_e$ candidates. The mean number of detected antineutrinos is $281 \pm 7\,\bar{\nu}_e$/day, to be compared with the prediction $272 \pm 23\,\bar{\nu}_e$/day. As a first societal application we quantify, on the basis of our data, how antineutrinos could be used for the Plutonium Management and Disposition Agreement.

Thierry Lasserre - CEA
22/07/2020

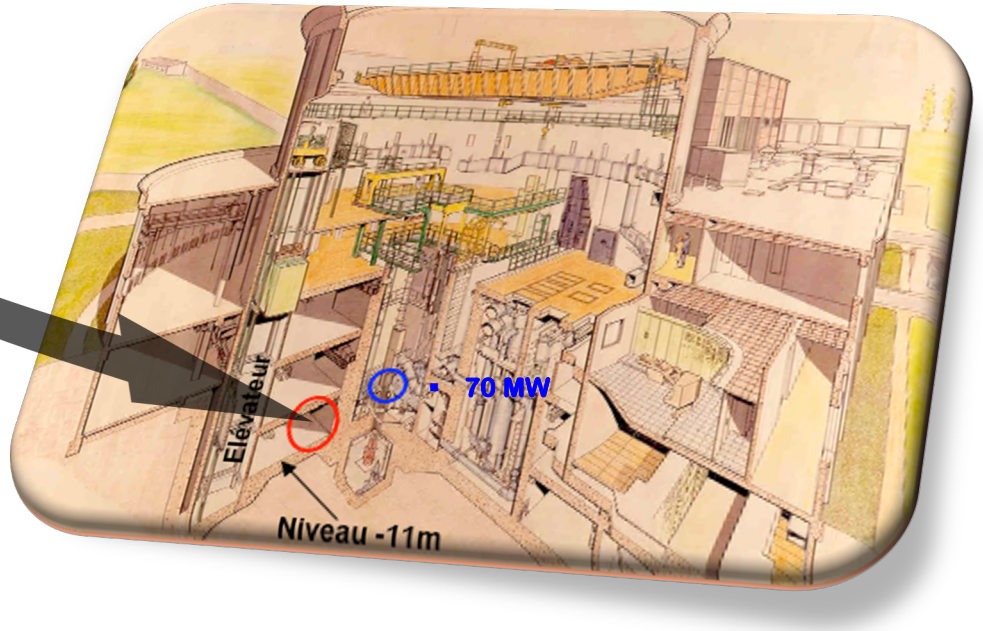
Nucifer Detector @ OSIRIS Reactor

- Detector: 850 liters



Stainless steel tank + Teflon
Nitrogen atmosphere
16 PMTs
Acrylic buffer
Target liquid (0.8 m³)
Active cosmic ray veto
(Plastic scintillator, PMTs)
15 cm of Bore doped Polyethylene
10 cm of Lead

- Research Reactor

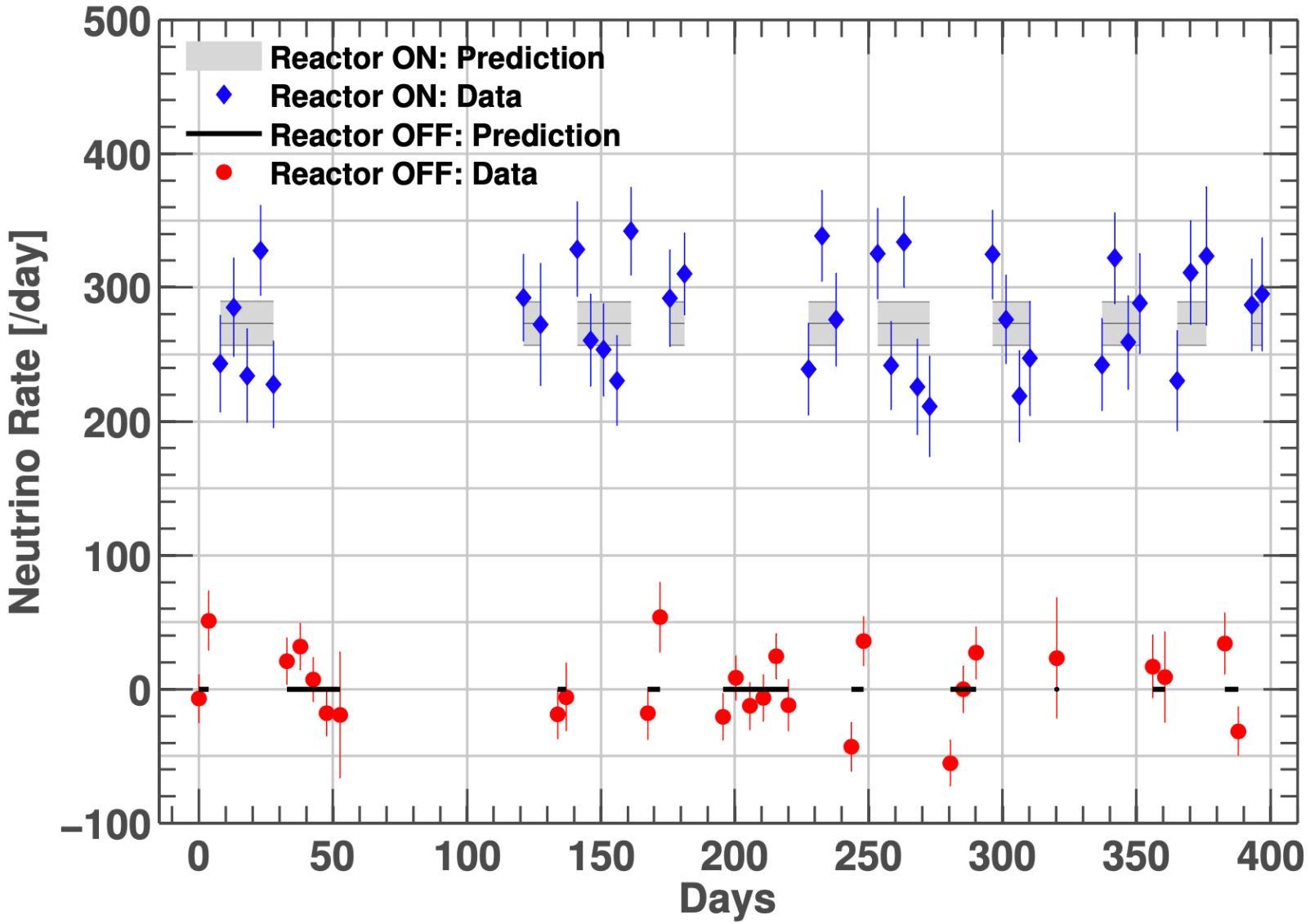


- 70 MW
- Until 2015

Distance: 7.2 m
μ Attenuation: 2.5

→ Pre-industrial design - Stable - Safe - 2 years remote operation

400 days of operation - 41 000 neutrinos



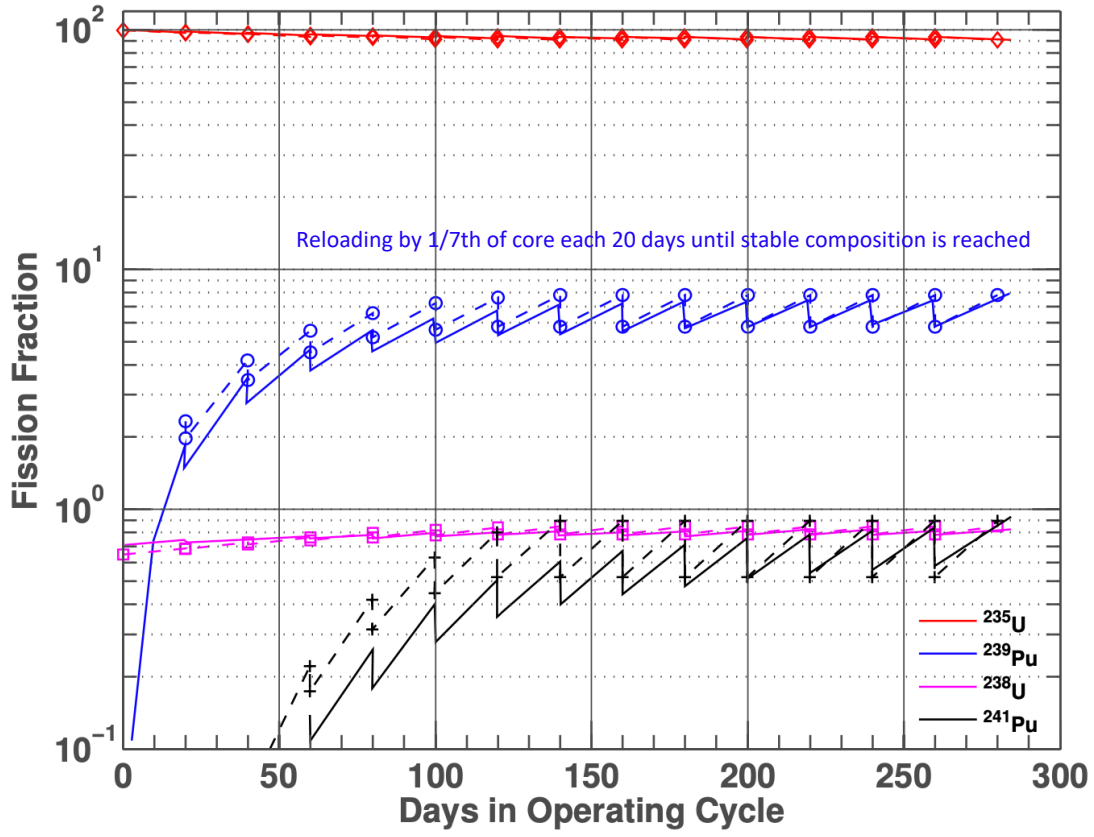
Predicted
280 ± 23 / day

Detected
281.1 ± 7.1 /day

Sensitivity to plutonium content

Application to control of military Pu destruction by irradiation (PMDA)

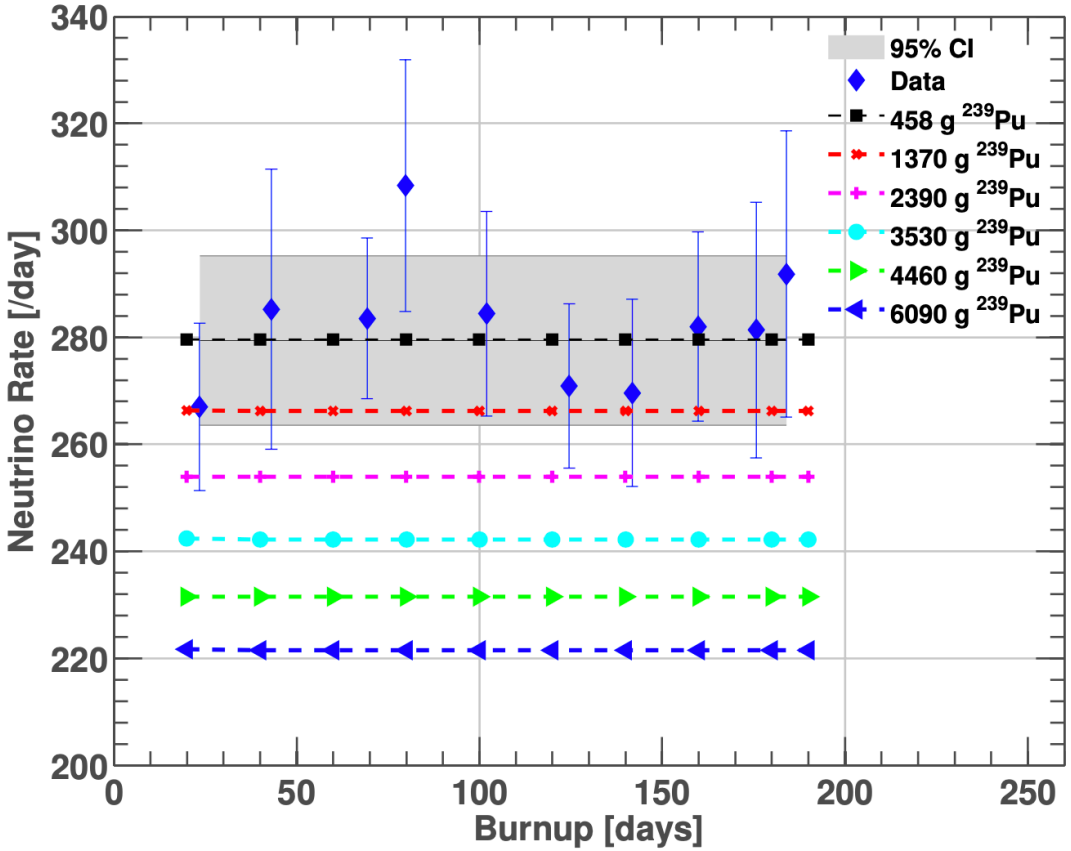
Evolution of Osiris fuel
Start with 82 kg of ^{238}U and 20 kg of ^{235}U



Restart core evolution replacing ^{235}U by ^{239}Pu

Sensitivity to presence of 1.5 kg of Pu (95 % CL)

(via daily neutrino rate evolution)



→ Application to non-proliferation: Proof-of-Concept for PMDA verification