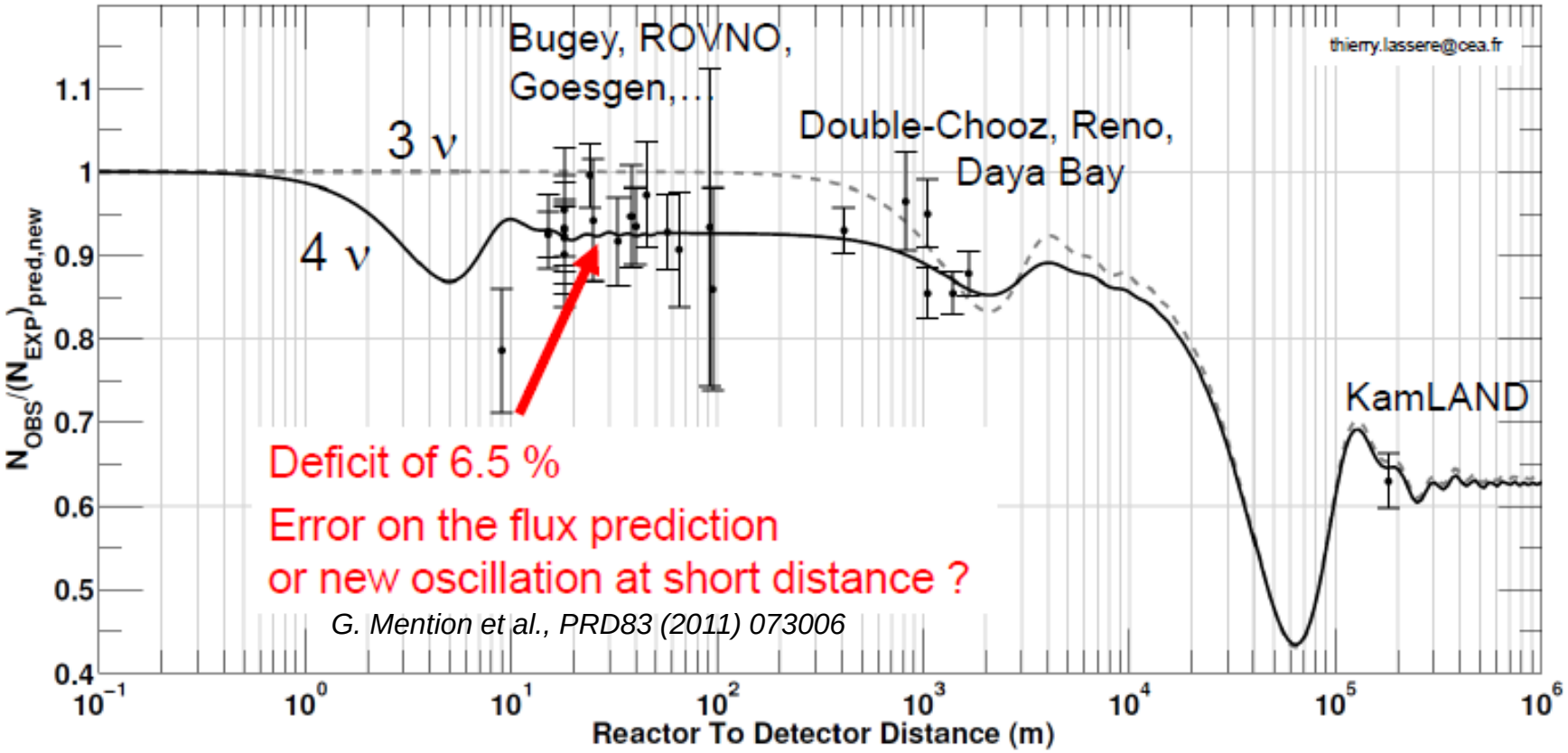
SEARCH FOR LIGHT STERILE NEUTRINO STATE IN THE SHORT BASELINE NUCIFER AND STEREO EXPERIMENTS

Alain Letourneau

for the Nucifer and Stereo collaborations

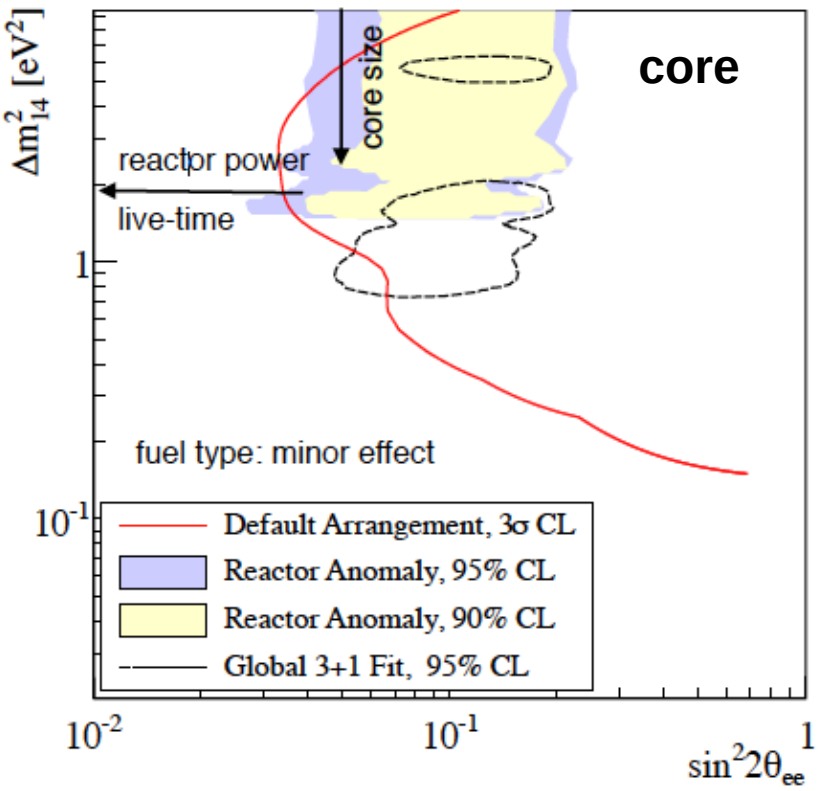
Irfu/SPhN – CEA-Saclay

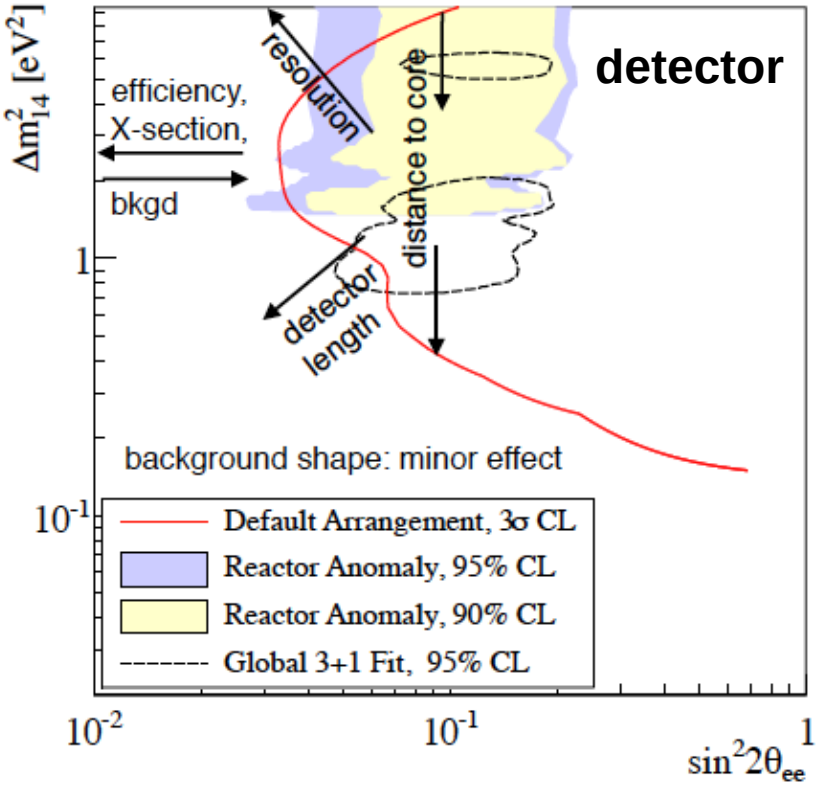
REACTOR NEUTRINO ANOMALY



- Best fit parameters consistent with L/E ~ 1 m/MeV (Δm^2 ~1 eV^2, $\sin^2 2\theta$ ~ 0.1)

SHORT BASELINE EXPERIMENTAL PARAMETERS





K.M Heeger et al., arXiv:1212.218v1

- Compact core to reduce oscillation smearing
- Short baselines (~10 m) and high power (10-3000 MW) for high statistics (few 100 events/day/t)

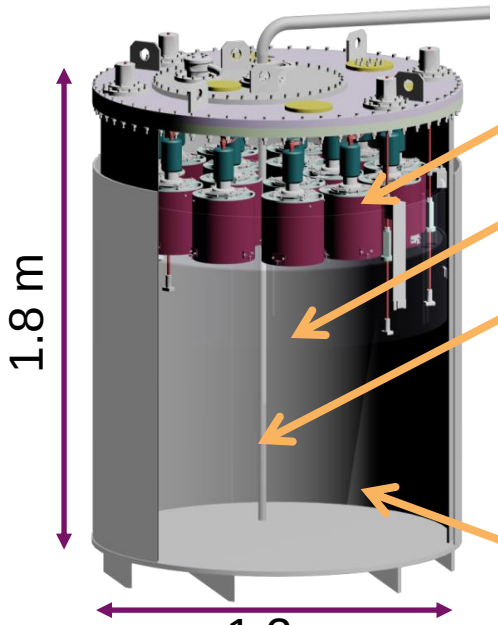
SHORT-BASELINE REACTOR PROJECTS

Experiment Type	Projects	P_{Th}	M_{det}	L	Depth
Mature Gd-doped LS detector Technology	Nucifer (FRA)	70 MW	0.7 tons	7 m	Few mwe
	Stéréo (FRA)	50 MW	2 tons	[8-11] m	10 mwe
	Neutrino 4 (RU)	100 MW	2 tons	[6-12] m	Surf.
Highly segmented detector for background reduction	DANSS (RU)	1 GW	1 ton	[10-12] m	50 mwe
	SoLid (UK)	45-80 MW	3 tons	8 m	10 m
Enhanced neutron Tagging	Hanaro (KO)	30 MW	0.5 t	6 m	Few mwe
2 detector complex or Moving detector	Prospect	85 MW	-	7m & 18m	Surf.
	China project	-			
	DANSS/Neutrino4	Movable detector			

NUCIFER/STEREO DETECTORS

Nucifer (neutrino-meter)

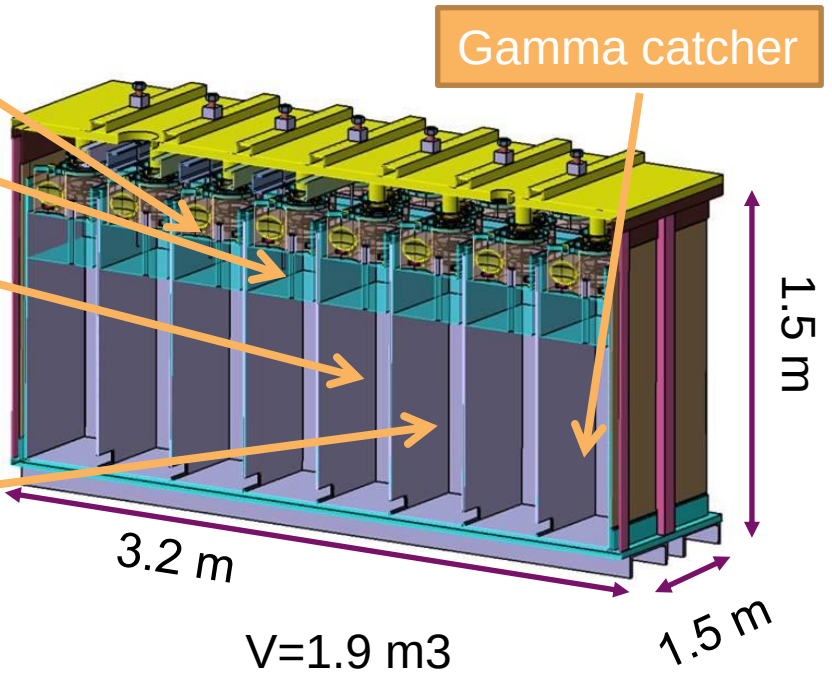
CEA – Saclay | Subatech | Max-Planck-Institut für Kernphysik Heidelberg



- Rate only analysis
- RMS/peak = 30% for 2 MeV e+

Stereo (segmented)

CEA – Saclay | LPSC Grenoble | IN2P3 LAPP Annecy | Max-Planck-Institut für Kernphysik Heidelberg | Neutrons for Science | Université Hassan II – Casablanca



- Shape and rate analysis
- RMS/peak = 11.5% for 2 MeV e+

PMT 8”

Acrylic buffer

Calibration sources

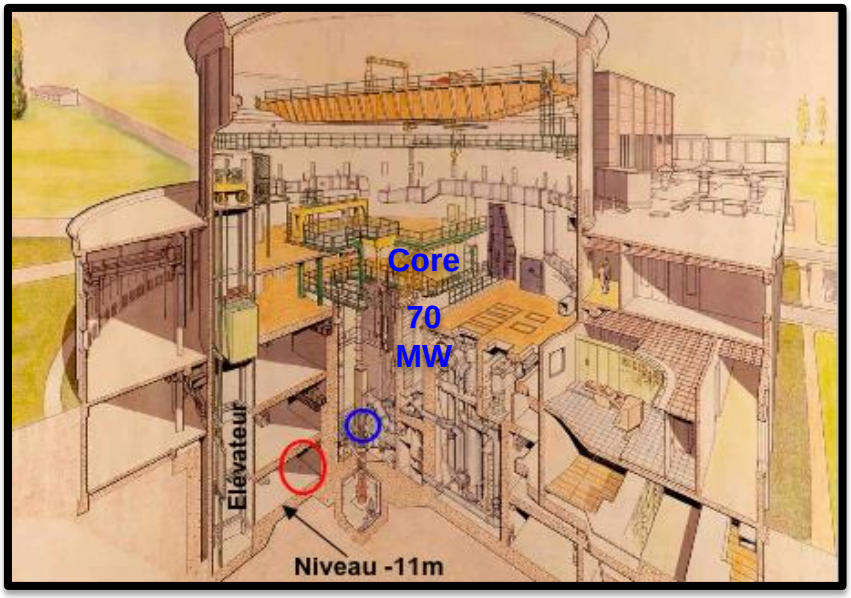
Gamma catcher

Gd loaded LS:
- e+ detection
- n detection

Design for high LY and PSD

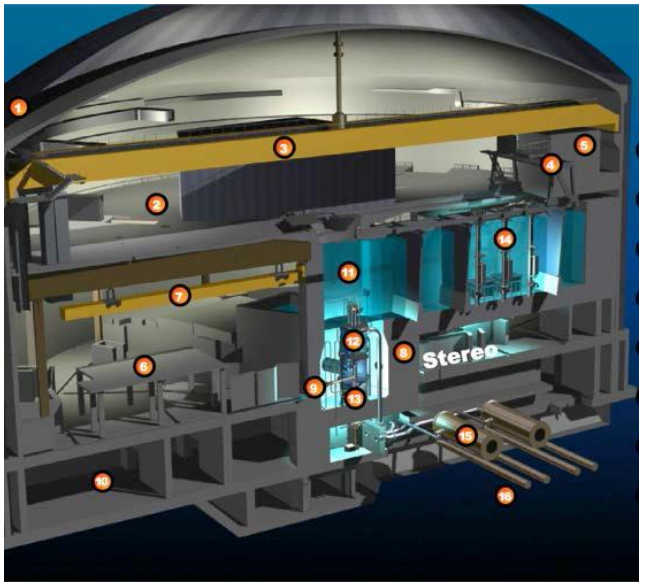
EXPERIMENTAL SITES

Osisis (70 MW) @Saclay



- Core: 80x70x70 cm
- U_3Si_2Al, 20% ^{235}U
- $1/7^{th}$ each 20 days
- Baseline: ~7.0 m
- Overburden: ~ 5 m.w.e

ILL HFR (55 MW) @ Grenoble

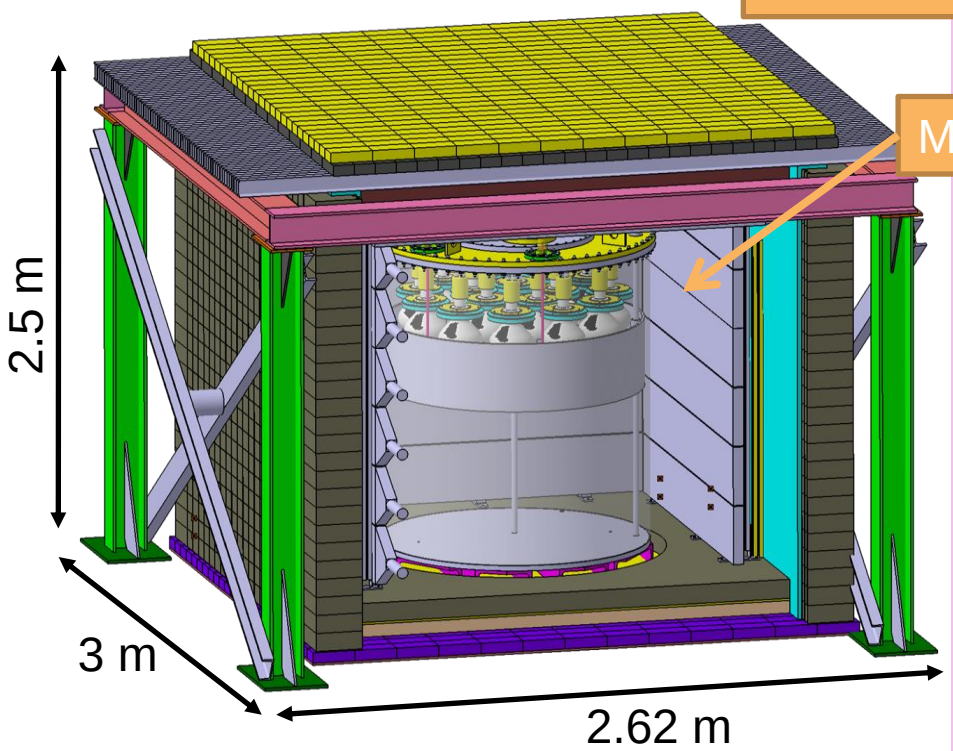


- Cylindrical core (ϕ=40cm, h=1m)
- Highly enriched ^{235}U fuel
- 4 cycles/year of 50 days
- Baseline: [8.9 – 11.1] m
- Overburden: ~ 15 m.w.e

Challenging environnements due to high neutron and γ–ray fluxes

SHIELDINGS

Nucifer

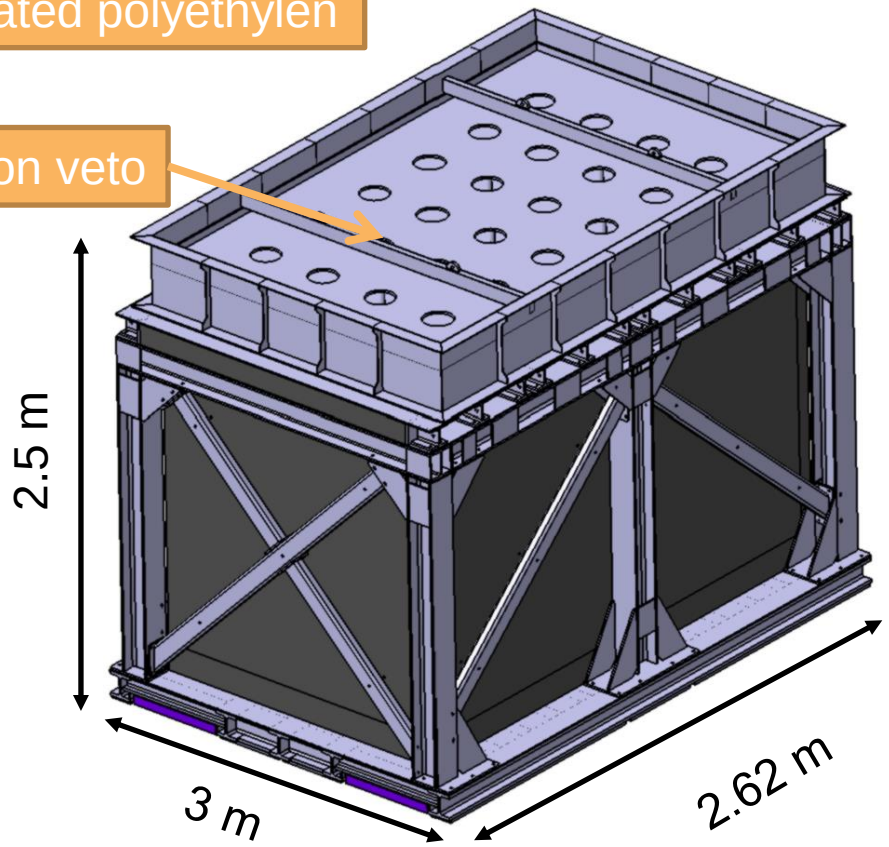


44.3 tonnes

Stereo

Lead +Borated polyethylen

Muon veto



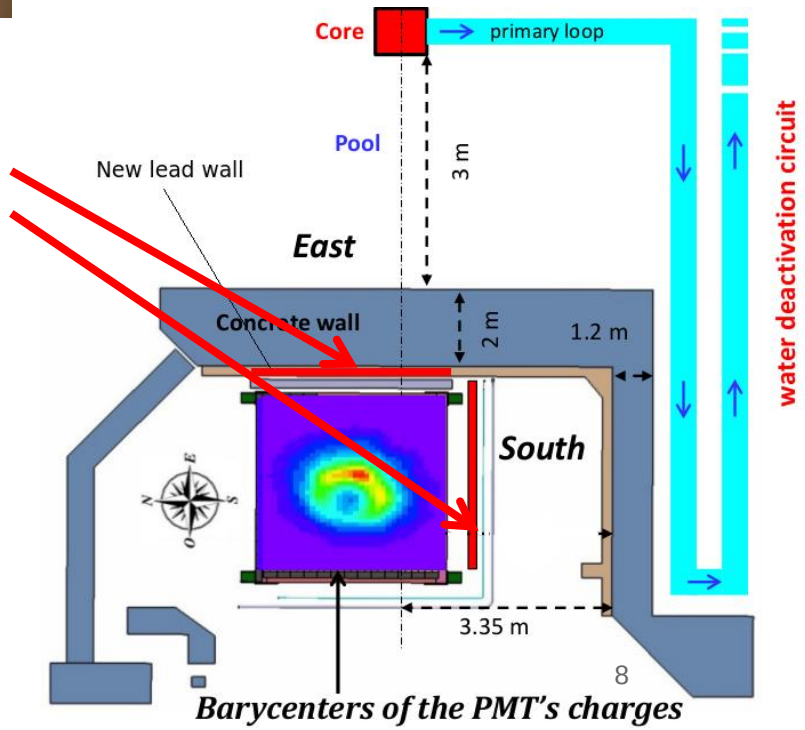
60 tonnes

Heavy structure that should respect earthquake regulation of the installation

NUCIFER STATUS

- Running since April 2012 showing very good stability (<2%)
- Full validation of the GEANT4 simulation with calibration sources

- Two upgrades of the shielding (end of 2012 for the south wall and june 2014 for the east wall) to reduce the high energetic γ-rays (accidental events)
- Four runs of ~3 weeks in 2013 (April-May) and (November-December)
- Running in its optimal configuration since July 2014 for one year of data taking



DETECTED EVENTS

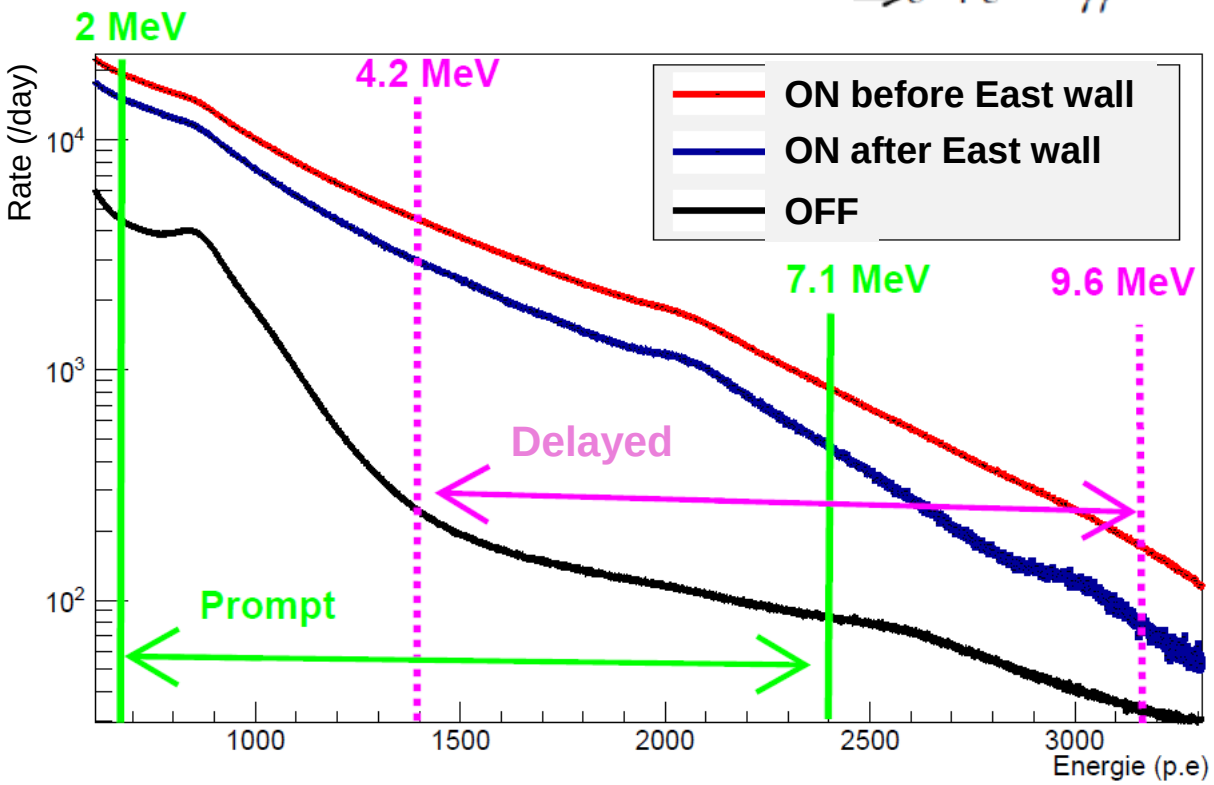
Detection reactions:

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

> 1.8 MeV

$$n + Gd \rightarrow Gd + \gamma s$$

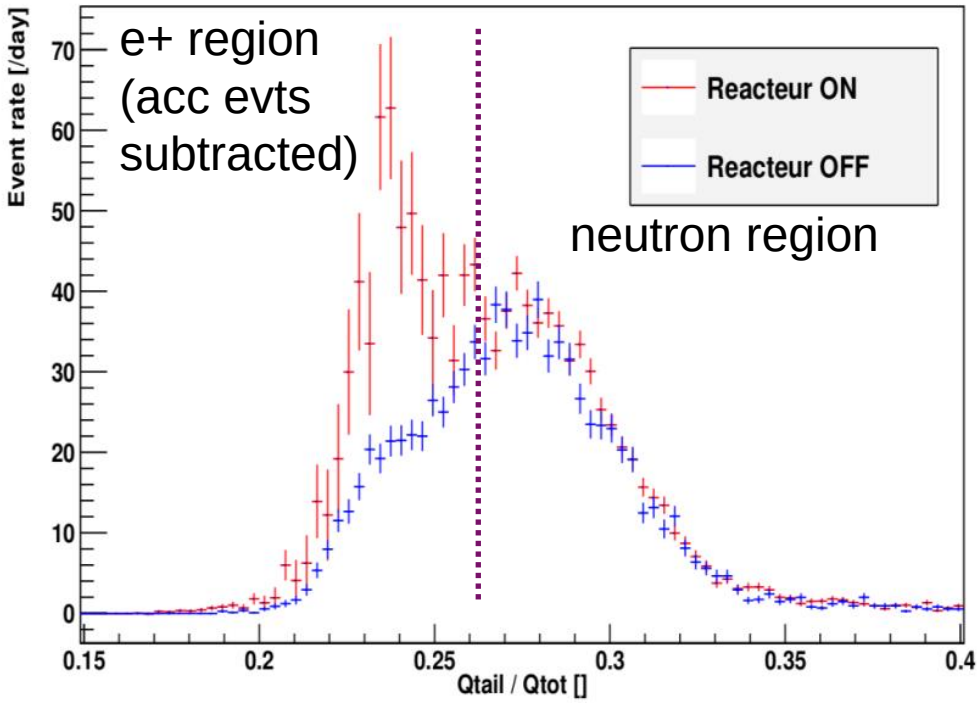
$$e^+ + e^- \rightarrow \gamma\gamma$$



- Reduction of the rate by 100/3 with the south/east wall shieldings
- Contamination of the delayed gate by high energetic γ-rays

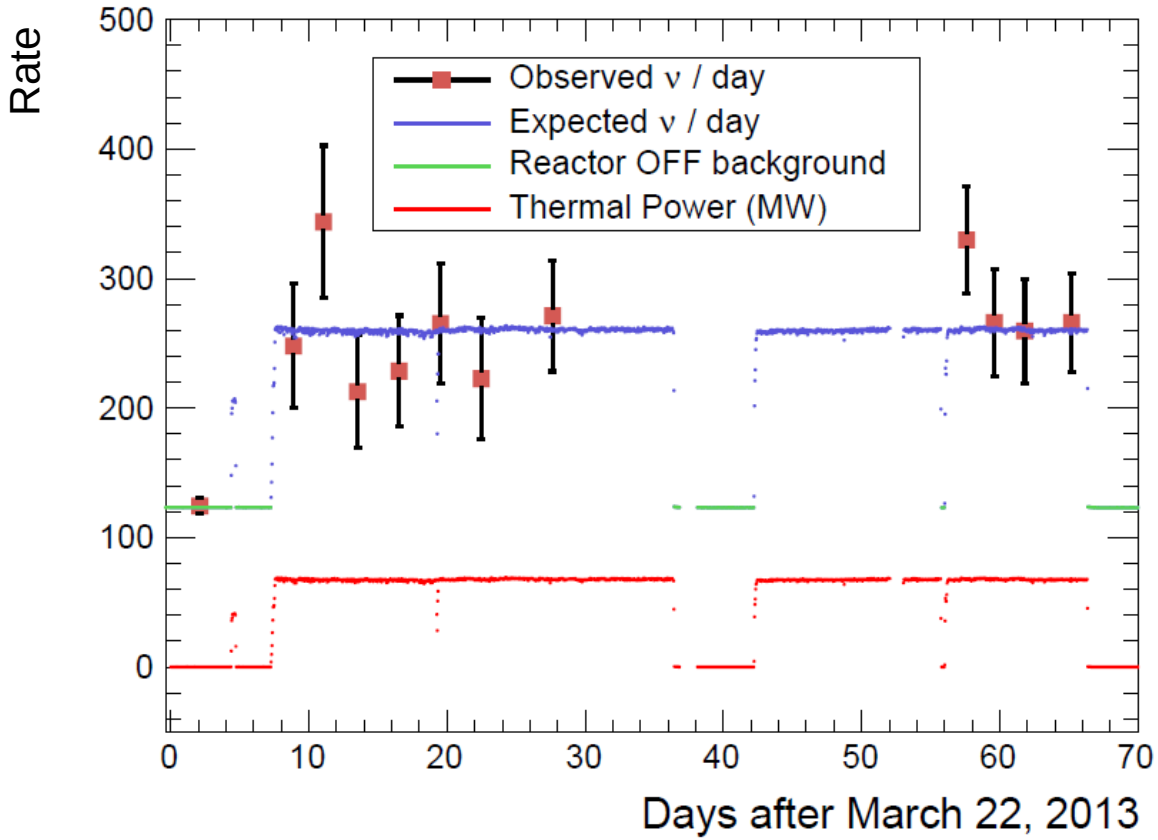
CORRELATED EVENTS

$$\overline{\nu}_e + p \rightarrow e^+ + n$$



- Very good rejection of the neutron background (muon veto + PSD)
- No reactor induced fast neutrons was observed
- $S/B_{correlated}$ ~1 but accidental events limit the accuracy

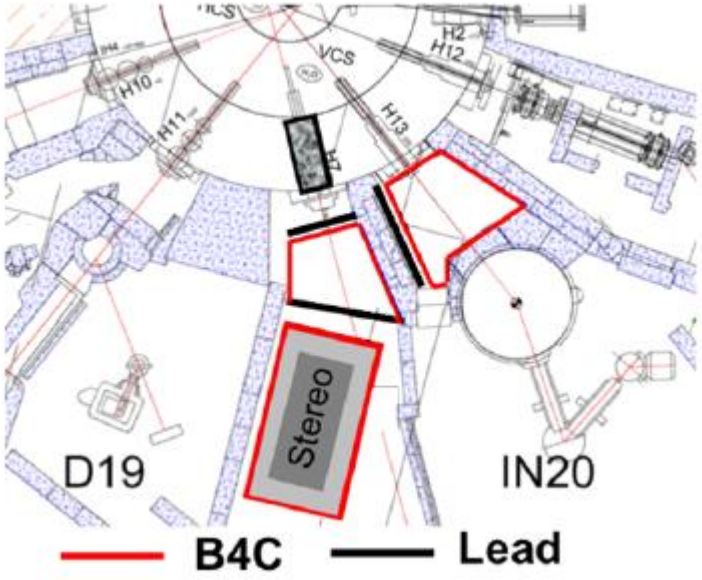
FIRST NEUTRINO RATE (PRELIMINARY)

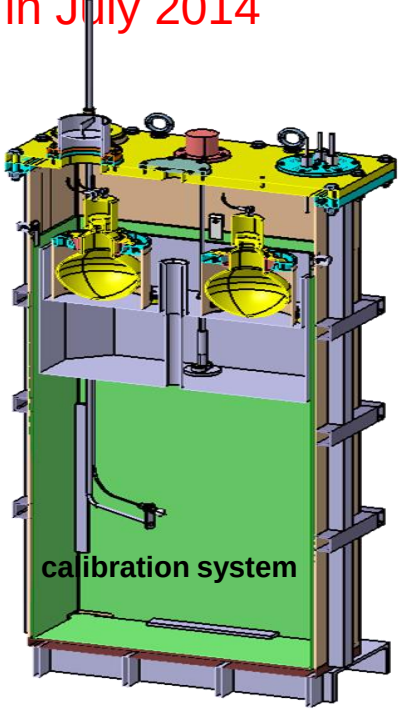


- Detection efficiency : 31±2 % due to selection cuts (without East wall)
- Need a good precision measurement for the distance from the core

STEREO STATUS

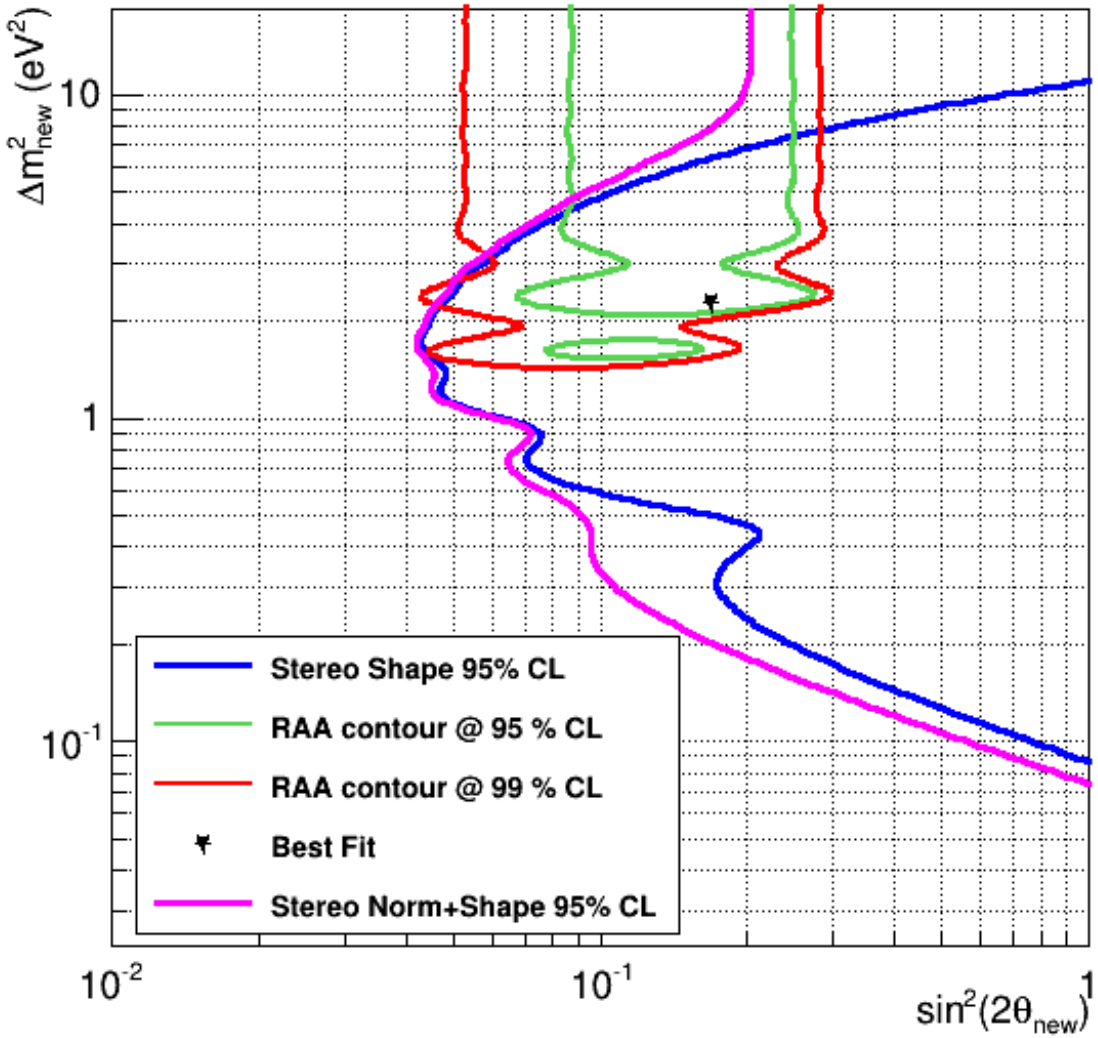
- Site preparation:
  - Measurements and characterisations of the neutron and γ-rays backgrounds in 2013
  - MCNPX and GEANT4 simulations to optimize the shieldings
  - New shieldings in the proximity of the detector were installed and their efficiency measured in July 2014





- Cell prototype to test and validate:
  - The mounting procedure
  - The light propagation and light collection
  - The data acquisition system
  - The GEANT4 simulation
  - Will be assembled and tested this month

STEREO EXPECTED SENSITIVITY



- 300 days, ~480 ν_e/day
- L_0 = 9.85 m
- E_{prompt} > 2 MeV
  $E_{delayed}$ > 5 MeV
- δE_{scale} = 2%
- All syst. of predicted spectra
- S/B = 1.5, 1/E+flat
- Norm:
  - 3.7% absolute norm.
  - 1.7% relative norm. between cells

CONCLUSIONS

- NUCIFER
  - Is now in its optimal configuration after two major shielding upgrades and should run for 1.5 year
  - About 300 nu/day are detected (~30 % of efficiency)
  - But limited sensitivity for sterile neutrinos as only a rate analysis could be performed and the statistical accuracy limited by the accidental rate of high energetic γ-rays
- STEREO
  - A cell prototype will be assembled and tested this month
  - The final detector should be assembled by the end of the year for a data taking in 2015 and first results in 2016
  - Main issues are the background and systematics on detector response

SHAPE ANALYSIS