The STEREO detector

Search for a light sterile neutrino at ILL

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STEREO Collaboration

Neutrino Oscillation

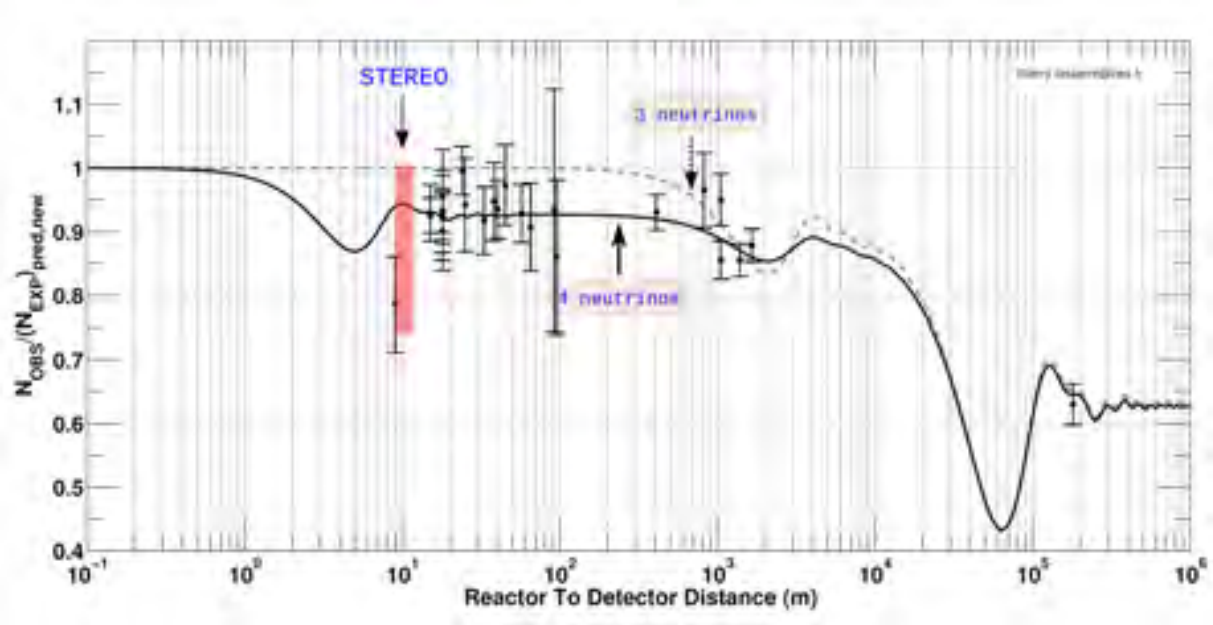
Reactor Antineutrino Anomaly

Surviving probability of a flavor state

$$P_{\alpha\to\alpha} = 1 - \sin^2(2\theta_{ij}) \sin\left(1.27 \cdot \Delta m^2_{ij} \frac{L}{E}\right)$$

- Reevaluation of reactor $\bar{\nu}_e$ spectra (Mueller *et al* **Phys Rev C83 054615**)
- Reanalysis of short baseline reactor experiments (Mention *et al* **Phys Rev D83 073006)**

$P_{\bar{\nu}_e\to\bar{\nu}_e} = 0.924 \pm 0.023$
$\Rightarrow$ **2.7**σ deviation from 1

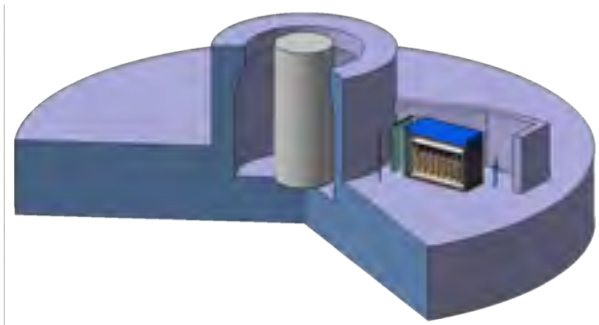


New oscillation toward a ν_s ? With $\Delta m^2_{14} = \mathcal{O}(1)$ eV^2

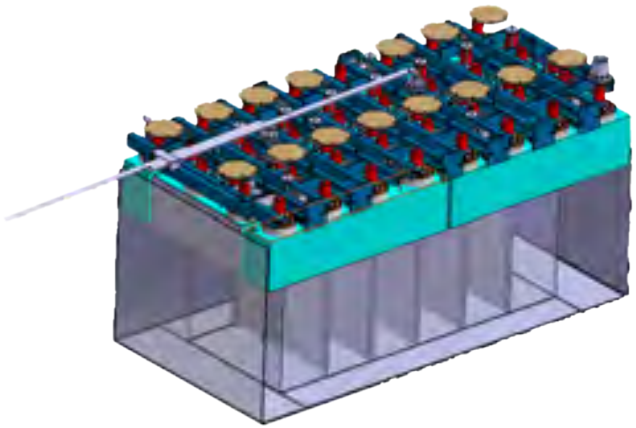
The STEREO detector

Observe an unambiguous new oscillation pattern in Energy and Distance

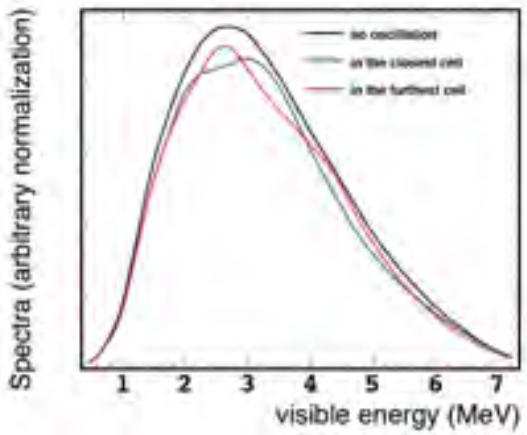
- Detection with **inverse** β**-decay** (IBD) in liquid scintillator $\bar{\nu}_e + p \rightarrow e^+ + n$
  $\Rightarrow$ Coincidence signal from the positron and delayed neutron capture
- Segmented detector of 6 identical cells
- Located between 9-11m from ILL nuclear reactor (Grenoble)



Location at ILL



STEREO detector

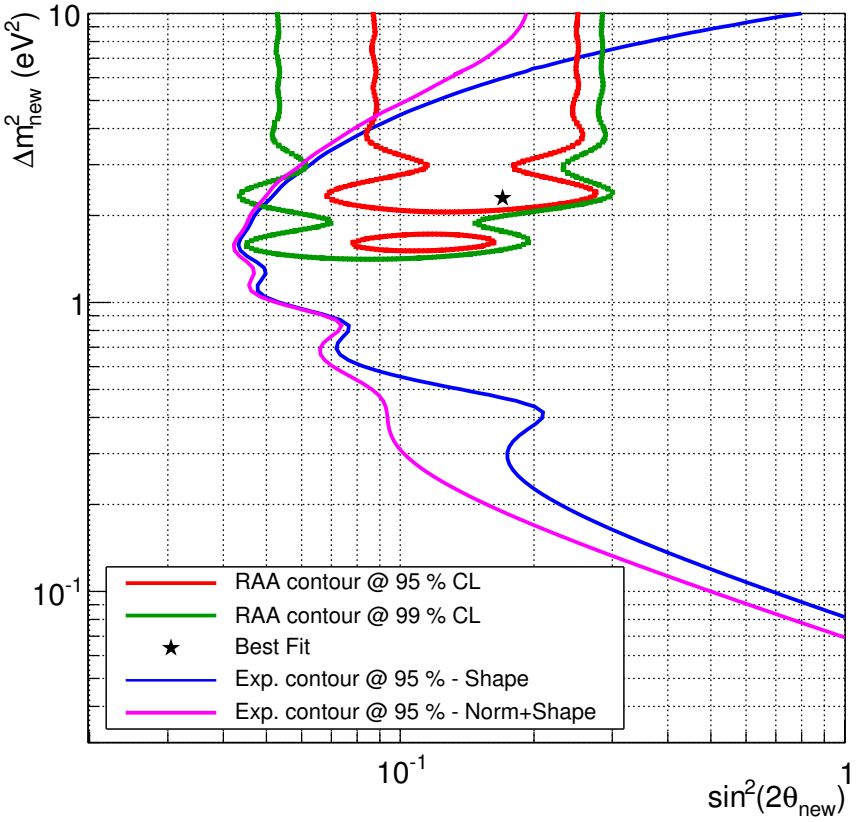


E_{e^+} spectrum between cells

High neutron and γ flux from ILL neutron beam lines and cosmic muons
$\Rightarrow$ **Heavy shieldings** and **Active shieldings**

Sensitivity

Discovery Potential



- Detection and reconstruction of systematics included
- Systematics of the $\bar{\nu}_e$ spectrum taken into account
- 410 $\bar{\nu}$ by day
  $\Rightarrow E_{e^+} > 2$ MeV
  $\Rightarrow E_{\text{neutron}} > 5$ MeV $\rightarrow$ Eff 60%
- 300 days data taking
- Normalization 4%
- $\delta E_{\text{scale}} \simeq 2\%$
- Signal/Background $\simeq 1.5$

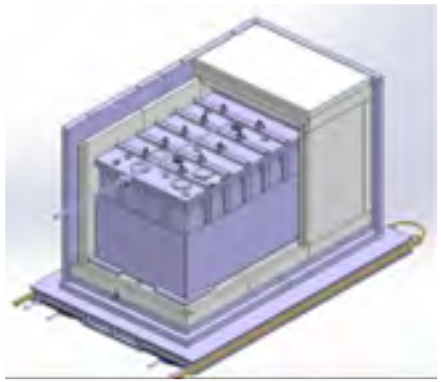
- Possibility to move the detector to study systematics and increase sensibility at low Δm^2

Status

- Validated prototypes (half detector cell, muon veto, electronics, ...)
- Background characterized onsite (measurements in 2014, 2015)
- Design completed and construction in process

Cell prototype

μ veto prototype



Detector inside shielding

- 2015-2016 : Setup and installation of STEREO detector at ILL
- April 2016 : Beginning of data taking
  $\Rightarrow$ Preliminary results expected for **end 2016** !

BACKUP

Sensitivity

Search for a new oscillation pattern

- Bin-to-bin comparison between measured spectrum and predicted spectrum with no oscillation

$$\chi^2 = \sum_{l}^{L_{\text{bins}}} \sum_{i=i_{\text{thres}}}^{E_{\text{bins}}} \left[\frac{O_{l,i}(\Delta m^2_{\text{new}}, \theta_{\text{new}}) - T_{l,i}\left(1 + \alpha_i^{\text{spec}} + (E_i - 1) \times \alpha^{\text{WM}} + \alpha_{\text{norm}} - d_i \times \alpha_{\text{cal}}\right)}{\sigma^{\text{stat}}_{l,i}} \right]^2 + \sum_i \left(\frac{\alpha_i^{\text{spec}}}{\sigma_i^{\text{spec}}} \right) + \left(\frac{\alpha^{\text{WM}}}{\sigma^{\text{WM}}} \right) + \left(\frac{\alpha^{\text{norm}}}{\sigma^{\text{norm}}} \right) + \sum_l \left(\frac{\alpha_l^{\text{cal}}}{\sigma_l^{\text{cal}}} \right)$$

- $O_{l,i}$: Observed number of event in the l^{th} cell of the detector and i^{th} energy bin above threshold
- $T_{l,i}$: Theoretical prediction without oscillation
- $\sigma^{\text{stat}}_{\text{l,i}}$: Background substraction
- α's : Systematical effects (β spectrum and conversion, weak magnetism, normalisation, calibration)
- d_i : Derivative of the $\bar{\nu}$ spectrum in the current energy bin i.

Sensitivity

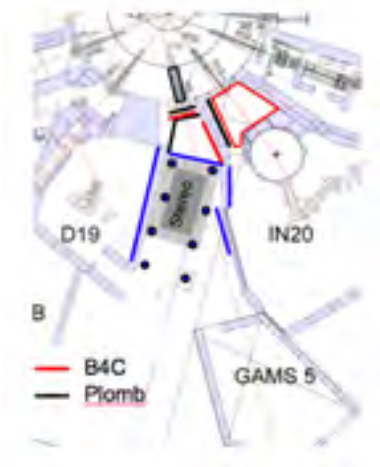
Search for a new oscillation pattern

TABLE II. Summary table of uncertainties at 1σ level.

Uncorrelated	
Fission Spectrum	$0.7 \rightarrow 4.0\%$
Correlated	
Weak Magnetism	$(E - 1.0) * 1.0\%/MeV$
Energy scale	2.0%
Normalization	
Np	0.5%
Spill in spill out	1.0%
Detection efficiency	2.0%
Thermal power	2.0%
Fission spectrum	1.8%
Total nomalization	3.5%

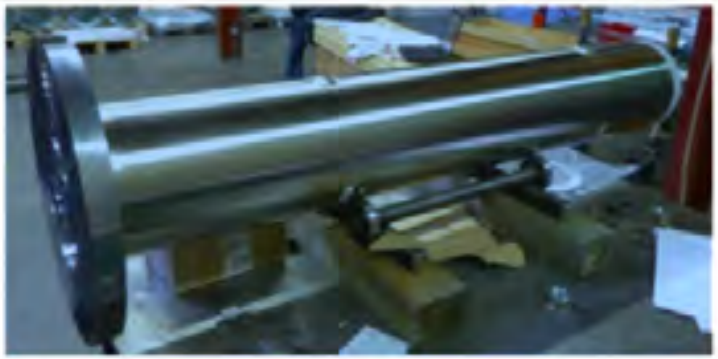
ILL site

Shieldings and installation onsite



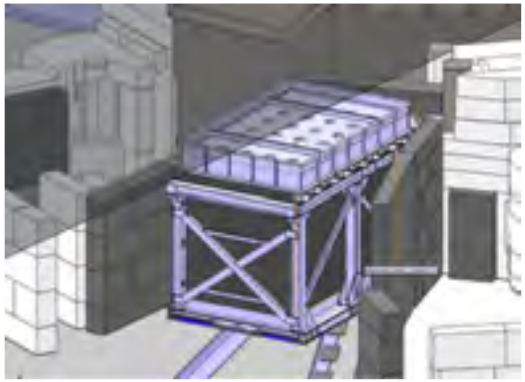
ILL site

H13 wall



H7 plug

Casemate empty



STEREO inside casemate