

The STEREO experiment, a search for sterile neutrino at ILL

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on behalf of the STEREO collaboration



supported by



Neutrino physics

What's the status of neutrinos today ?

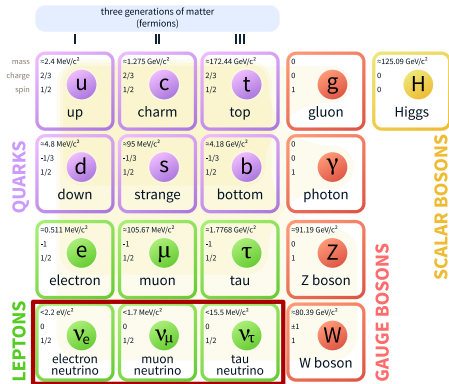
Neutrino status in the Standard Model:

- Historically introduced as **massless**
- Electrically **neutral**
- Fermion**, existing in three families (**flavors**)

Neutrino physics construction:

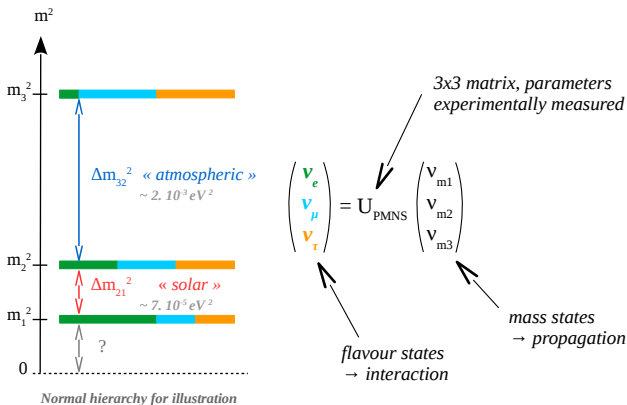
- 1930: Predicted by Pauli
but "undetectable" !
- 1934: Theory of weak interaction
- 1956: First experimental detection of neutrinos ! (Cowan and Reines)
- ... until today: development from experimental anomalies

Neutrinos have mass and oscillate !



Neutrino physics

Masses and oscillations



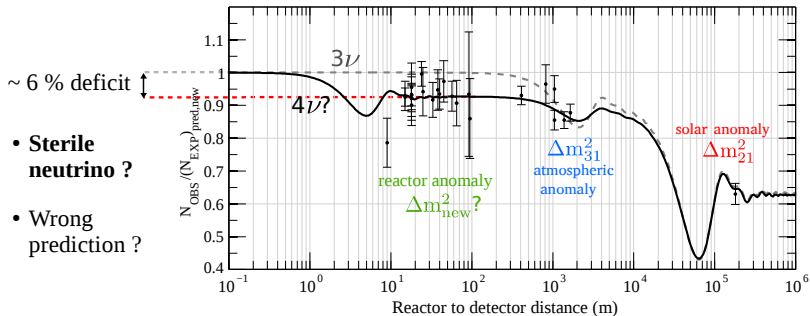
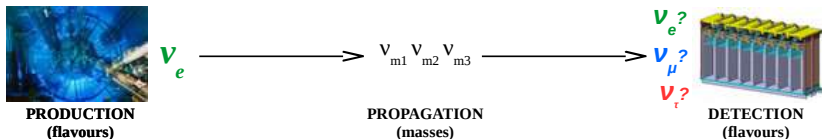
→ After propagation, neutrinos have a given **probability** to be detected in an other flavour state.

In most of the cases: $P^{\text{appearance}} = 1 - P^{\text{disappearance}} \propto \sin^2\left(a \frac{\Delta m^2 L}{E}\right)$
 \equiv Neutrino oscillations

Motivation

The Reactor Antineutrino Anomaly (RAA)

Phys.Rev.D83:073006,2011



- Sterile neutrino ?
- Wrong prediction ?

$$P_{\bar{\nu}_e \rightarrow \bar{\nu}_e}(E_{\bar{\nu}_e}, L) = 1 - \sin^2(2\theta_{\text{new}}) \sin^2\left(1.27 \frac{\Delta m_{\text{new}}^2 [\text{eV}^2] L [\text{km}]}{E_{\bar{\nu}_e} [\text{MeV}]}\right)$$

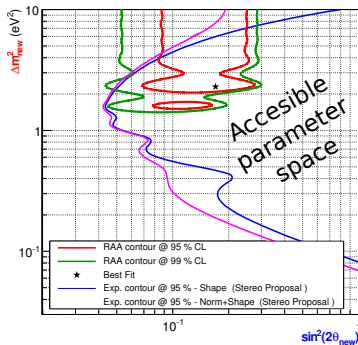
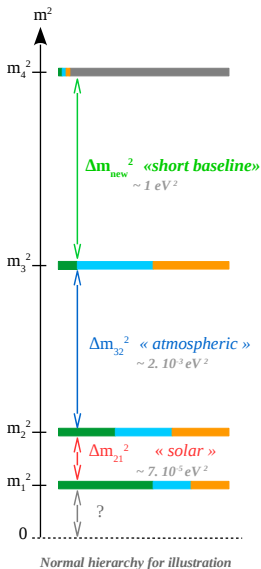
Motivation

A light sterile neutrino at the eV scale ?

Introducing sterile neutrinos at the eV^2 mass-scale

→ U_{PMNS} is now a 4x4 matrix

Mainly two new parameters of interest: $\sin^2(2\theta_{new})$ and Δm_{new}^2



→ STEREO will look for oscillations in this parameter space region

The STEREO detector

Designed to probe the Reactor Antineutrino Anomaly region

- ✓ **Segmented** detector filled with liquid scintillator
- ✓ Close to the **compact** ILL nuclear core in Grenoble: $9\text{m} < L_{\text{core}} < 11\text{m}$



In case of discovery:

- Toward a **new physics** ! Measure of **oscillation parameters**.

Otherwise:

- **Exclusion** of one region of the parameter-space

In any cases:

- First measurement of the antineutrino **spectra associated to ^{235}U**

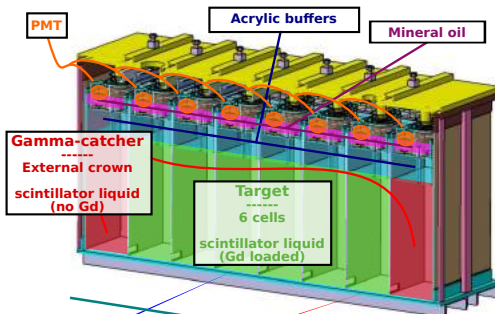
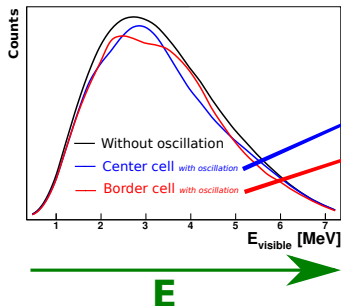
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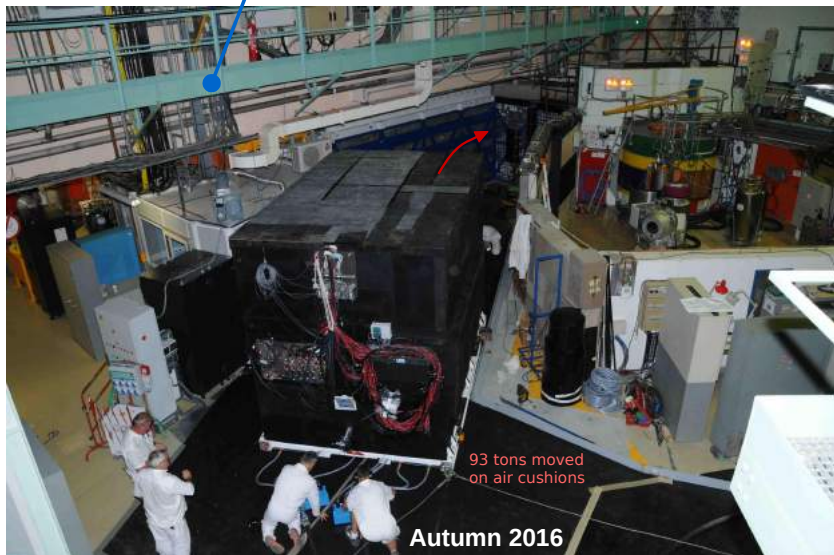
What are we looking for ?

Remember:

$$P \propto 1 - \sin^2\left(a \frac{\Delta m^2 L}{E}\right)$$



Water channel
15 mwe overburden



93 tons moved
on air cushions

Autumn 2016

Data analysis

A challenging measurement !

- 10 meters from reactor...
- Ground-level experiment...

→ Radiations (neutron, gammas...)

→ Cosmic background



SHIELDING



First raw measured spectra

~ kHz of triggers

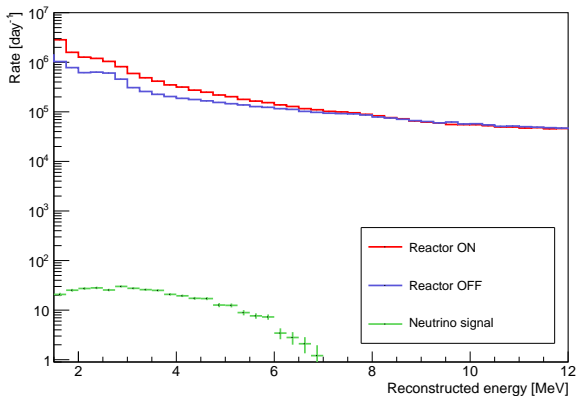


DATA ANALYSIS

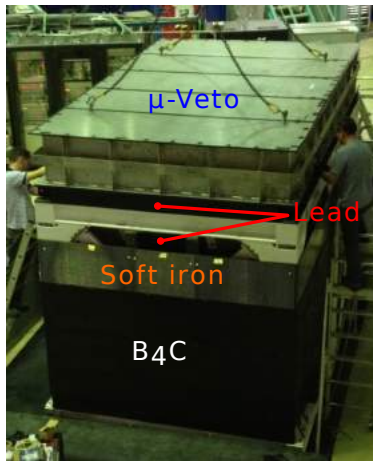
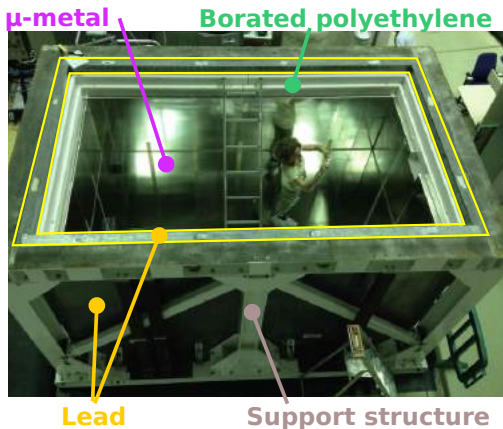


Expected neutrino signal

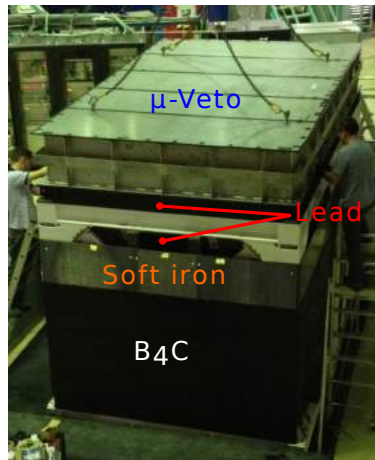
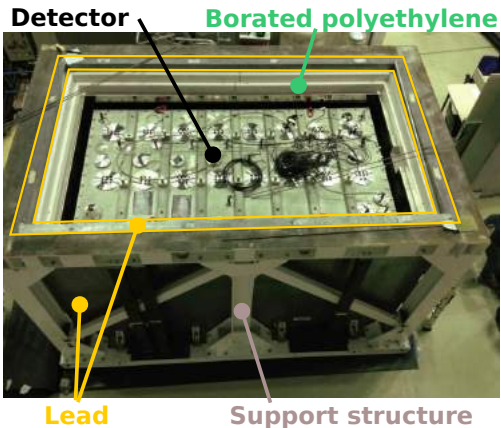
~ few hundreds per day



Shielding against background



Shielding against background



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SHIELDING



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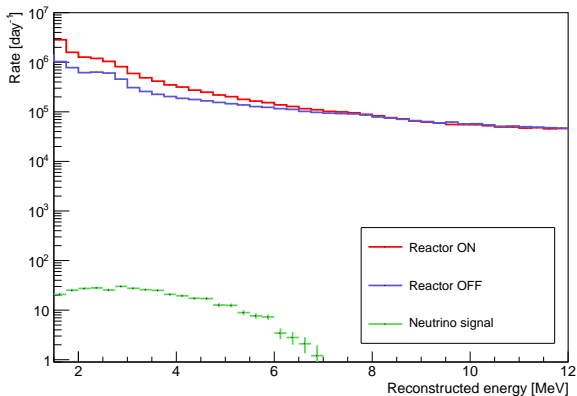


DATA ANALYSIS



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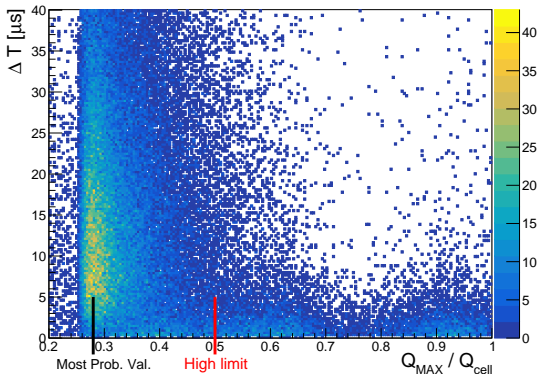
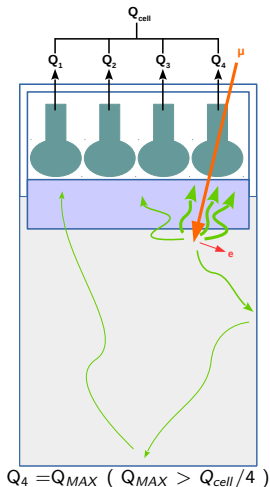


Background identification

Stopping muons

Non tagged-muons that stop and decay in top layer of the detector:

- High collected charge asymmetry between photomultipliers
- Low correlation time (μ lifetime $\sim 2.2 \mu\text{s}$)

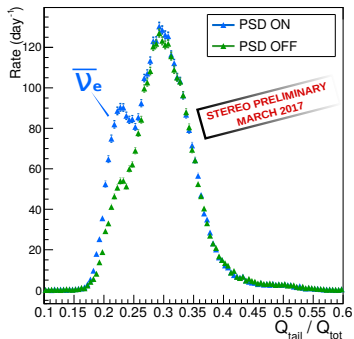
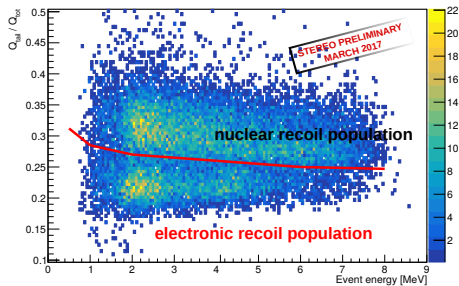
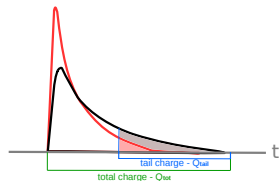


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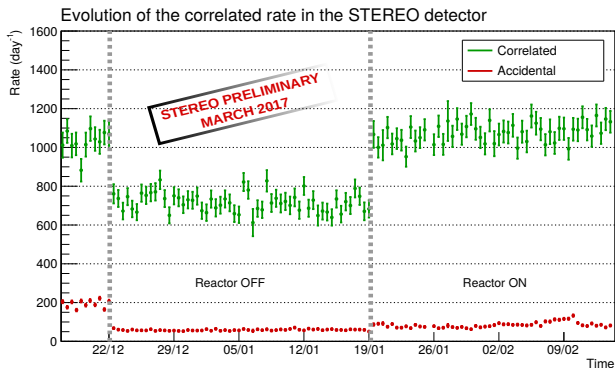
Neutrons

Fast neutrons that mimic the neutrino signal:

- Pulse Shape Discrimination (PSD)
- Correlation with atmospheric pressure



Preliminary results and next steps



Rates after preliminary IBD selection, and simple topological cut. Software dead time and pressure correction applied.

Next steps:

- Cuts optimization (deposited energy topologies)
- Full energy reconstruction \rightarrow spectra
- Data taking: 2017: + 95 days reactor ON (sept.-dec.), 2018: + \sim 150 days ON

Conclusions !

- Neutrinos have **mass** and **oscillate**
- A **three-families framework** compiles most of the experimental data...
- ... but is challenged by several anomalies.

- The **Reactor Antineutrino Anomaly** revealed a antineutrino deficit close to reactors
- It can be explained by the existence of **light sterile neutrinos**
- ... but is challenged by several anomalies.

- The STEREO detector is currently **measuring the antineutrino spectrum** at ILL (Grenoble) to answer this question !

THANK YOU !