Search for the sterile neutrino with Stereo : Energy Reconstruction

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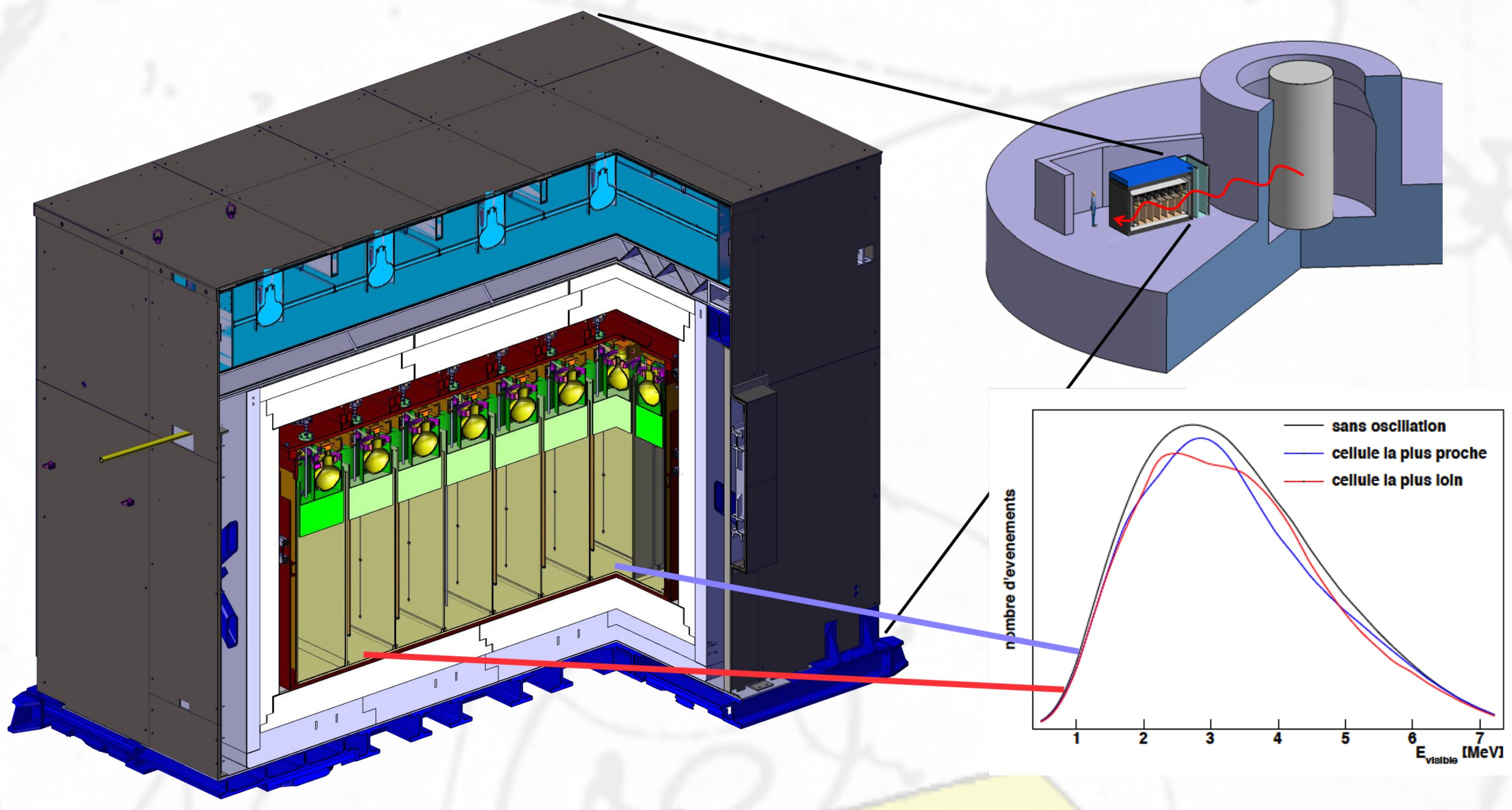
The Stereo Experiment

Stereo aims at measuring neutrino spectra at several distance from the reactor core. A clear pattern of oscillation would head toward the hypothesis of a new sterile neutrino flavor, solving the Reactor Antineutrino Anomaly (RAA). Two key aspects required for the experiments are :

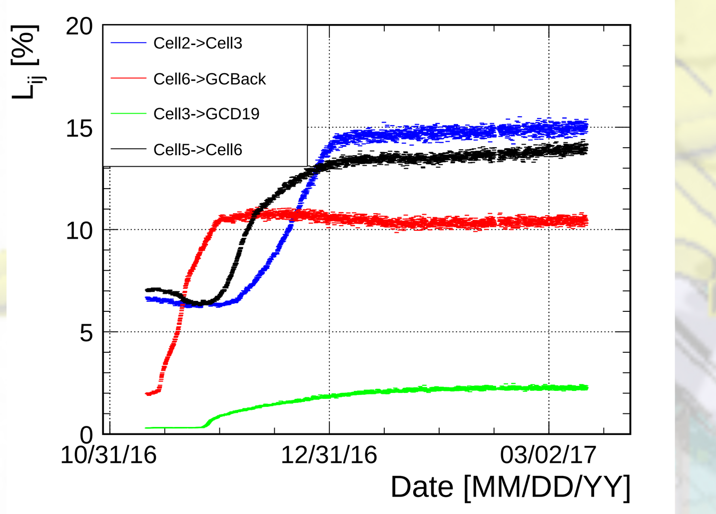
- **Accurate knowledge of detector's response**
- **Efficient topology cuts for background rejection**



Motivations

Phase-I of data taking have presented two challenges regarding energy reconstruction :

- Deals with different light collection efficiency for each cell
- Mitigate significant variations of the detector's response due light leaks evolution

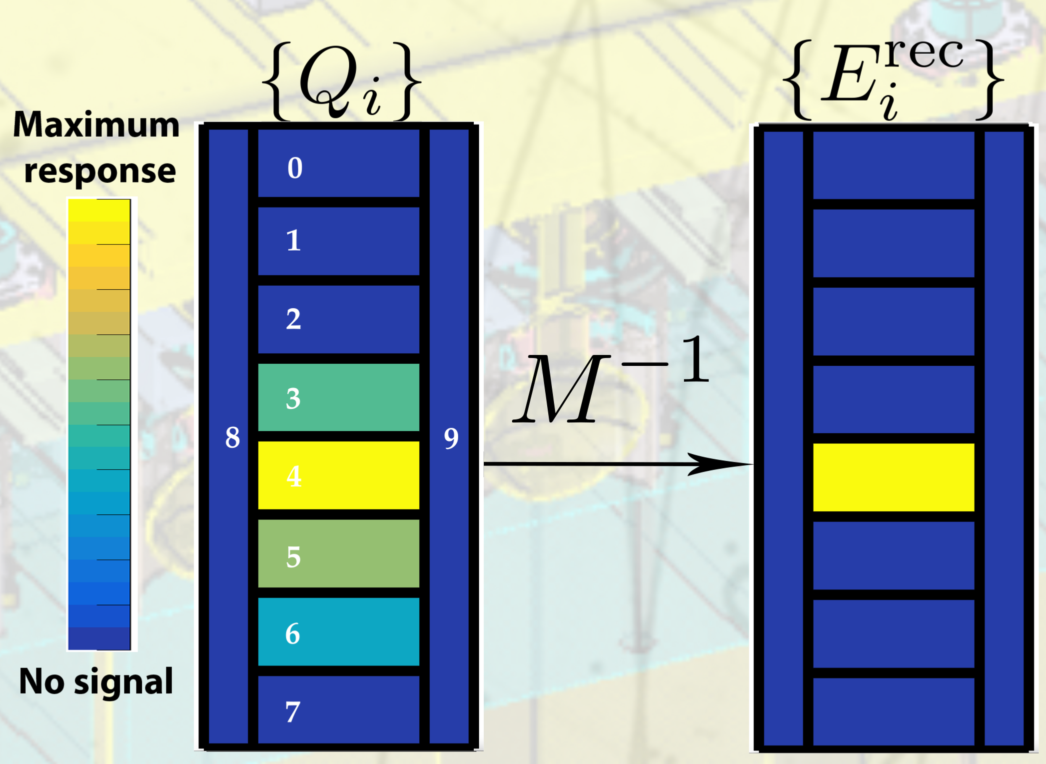


Calibration coefficients C_i and light leaks L_{ij} have been measured three times a week to keep track of the detector response.

Method

We used a matrix formalism to reconstruct events energy :

$$Q_j = \sum_{i=\text{cells}} E_i C_i L_{ij} = \sum_{i=\text{cells}} E_i M_{ij}.$$



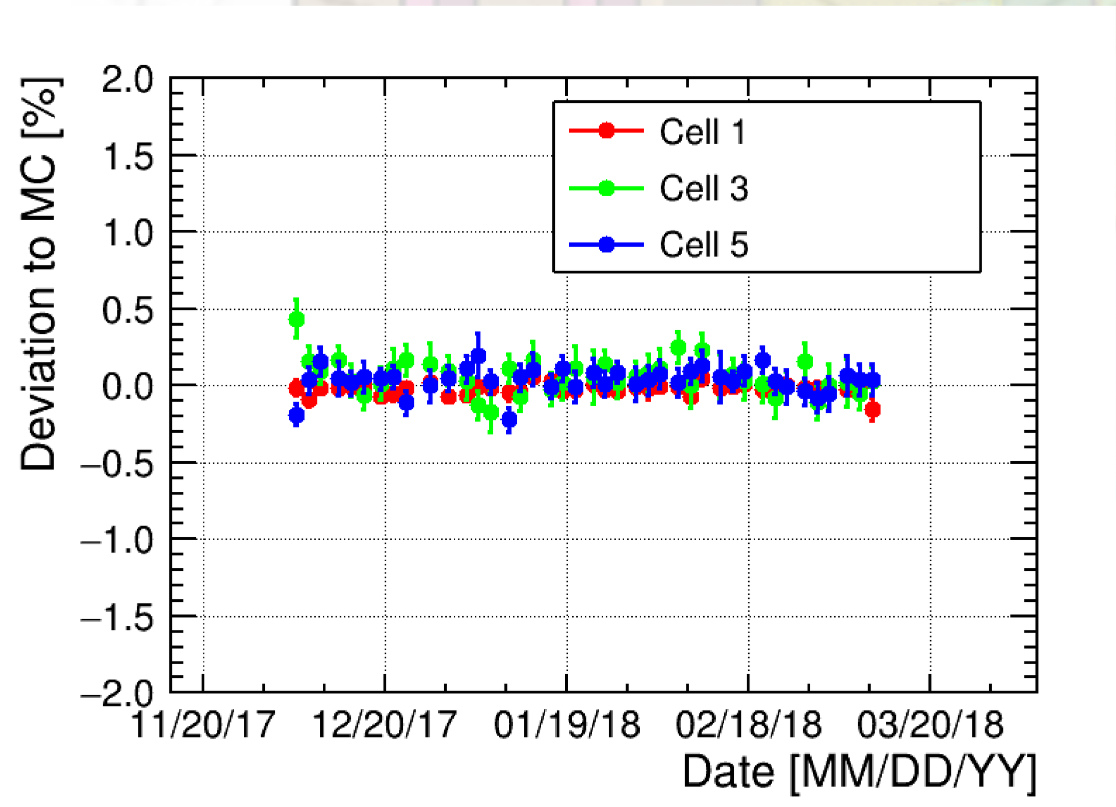
Fine Tuning

1. Using 835 keV gammas from ^{54}Mn source, deployed at 5 different heights in 3 cells for phase 1 and 5 for phase 2
2. Start from first order C_i and L_{ij}
3. Raw selection of full E deposition ($E^{\text{neighb.}} < 100$ keV)
4. Using reference E^{ref} built from the true deposited energy of the MC and convolved by the detector resolution
5. Measure reconstructed energy shifts and correct C_i and L_{ij} iteratively :

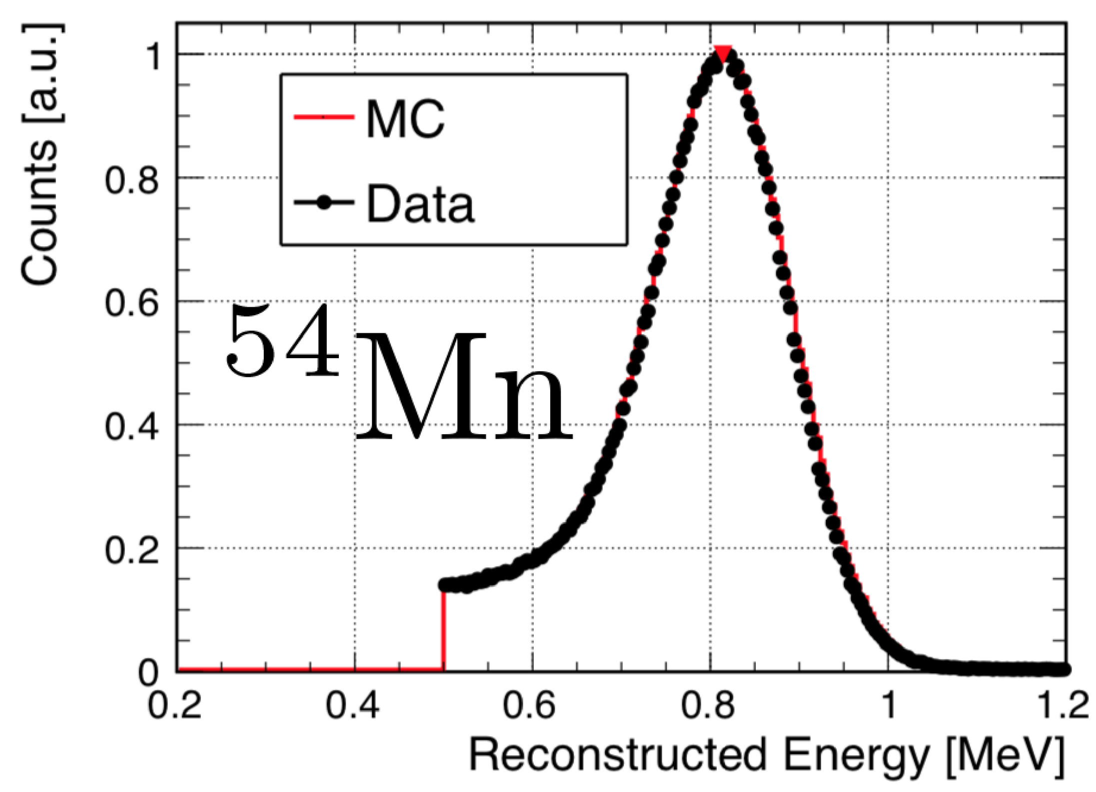
$$\delta C_i = C_i(E_i^{\text{rec}} - E^{\text{ref}})/E_i^{\text{rec}}, \text{ and}$$
$$\delta L_{ij} = -C_j(E_i^{\text{rec}} - E^{\text{ref}})/(E_i C_i(1 - L_{ij}L_{ji})).$$

Data/MC Comparison and Systematics Estimation

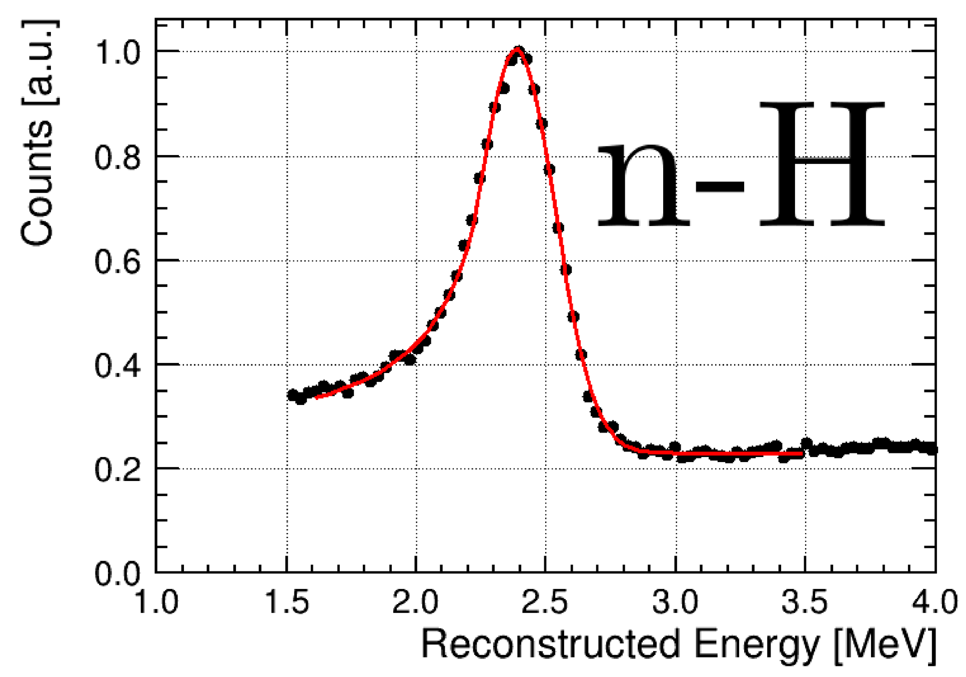
Data/MC : Sub-percent agreement for Mn peak anchoring after fine tuning



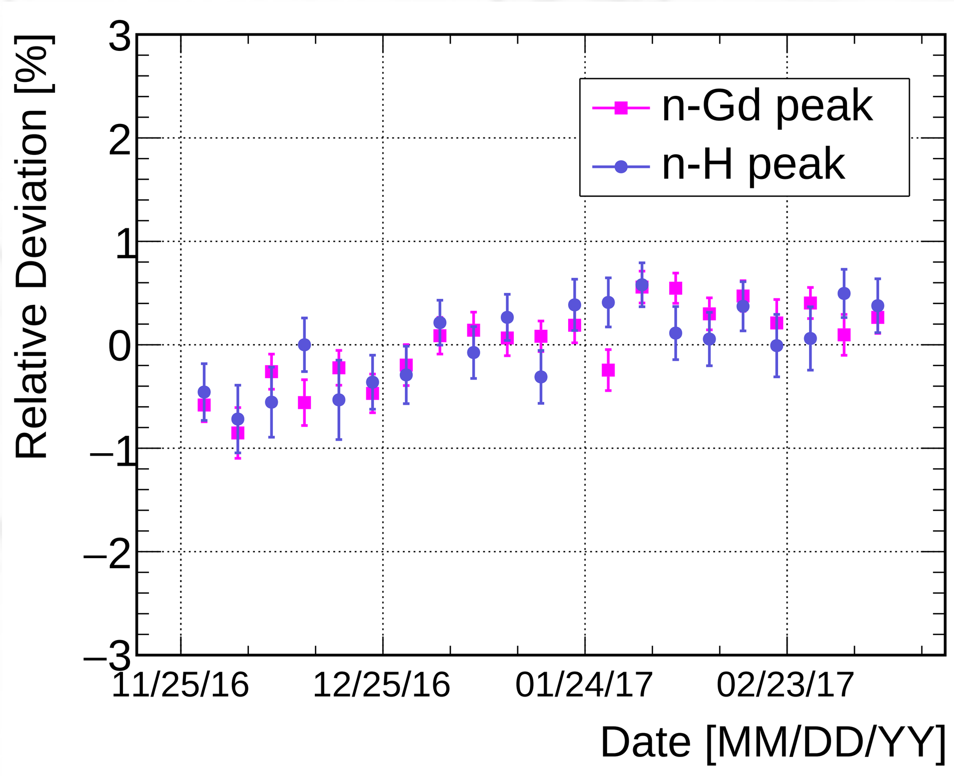
Accurate reproduction of detectors response in MC



- Independent set of events needed to test energy reconstruction
- Using neutron capture gamma peaks (n-H or n-Gd)
- Simulating neutron from realistic distribution of vertices
- Fitting capture peak with crystalball

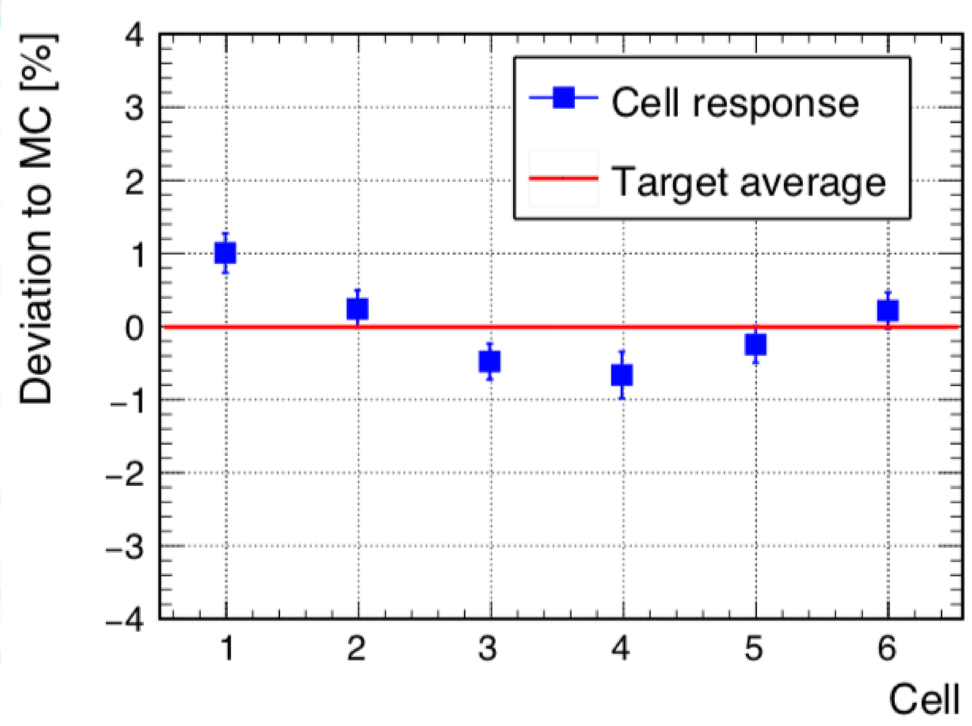


Sub-percent time stability



Results

Percent level agreement between MC and Data using calibration-independent neutron capture gamma peaks



Energy scale controlled at 1% level

Source	Cell-to-cell correlated	Cell-to-cell uncorrelated
E_{ref}	-	0.2%
^{54}Mn anchor	-	0.3%
Stability	0.4%	-
Data-MC	-	1.%
Total	**0.4%**	**1.1%**

Find more

Get more information at
`https://arxiv.org/abs/1804.09052`