Laboratoire de Physique Cospusculaire de Clermont-Ferrand

SoLid Experiment: Physics Case and Detector Simulation with Geant4

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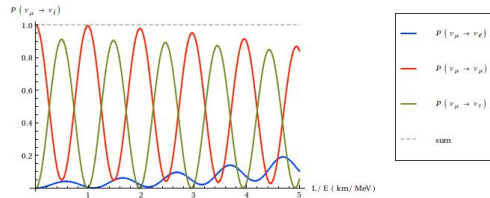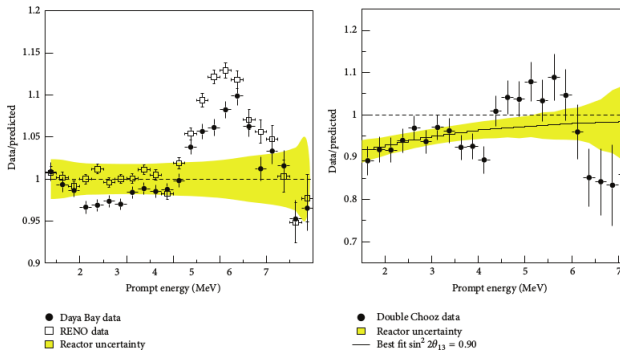bui_truongthanh@yahoo.com

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Content

- ▶ Neutrino in SM: Theorized in 1930 by Fermi and Discovered in 1956 by Reines and Cowan.
- ▶ Neutrino Oscillations : analogy with K^0 and $\bar{K^0}$ Oscillations by Pontecorvo → neutrinos have non zero vanishing masses.
- ▶ Oscillation Prove with experiments such as Super-Kamiokande, Opera, T2K ...


- ▶ Disappearance Probability:
$P_{\nu_\alpha \to \nu\alpha}(t) = 1 - sin^2(2\theta)sin^2(1.27\frac{\Delta m^2}{E_\nu}L)$

- ● Daya Bay data
- □ RENO data
- ▨ Reactor uncertainty

- ● Double Chooz data
- ▨ Reactor uncertainty
- — Best fit $\sin^2 2\theta_{13} = 0.90$

As u can see, there is a "bump" around the 5 MeV region in mid range experiments such as Reno, Daya Bay and Double Chooz.

- Reactor Neutrinos : $10^{21}\,\bar{\nu}_e/s$

- Neutrino Detection by Inverse Beta Decay : $\bar{\nu}_e + p \rightarrow n + e^+$

- IBD Cross-Section : $\sigma_{IBD} \approx 6.10^{-43}\,cm^2$

- Reactor Anomaly : discrepancy between the measured and the predicted fluxes.

- Explanations:
    1. Poor predicted neutrinos spectra due to numerous beta decay chains in the reactor core
    2. Small error on $\sigma_{IBD}(\tau_{neutron})$
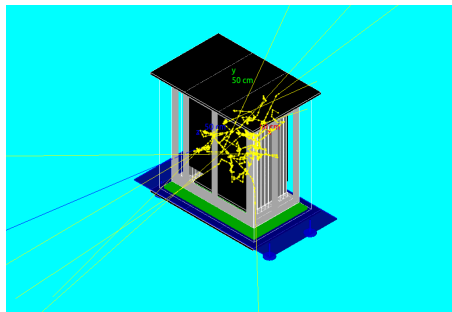   3. Oscillation to a 4th state of neutrino at short baseline (<10 m) with $\Delta m^2_{new} \approx 1\,eV^2$
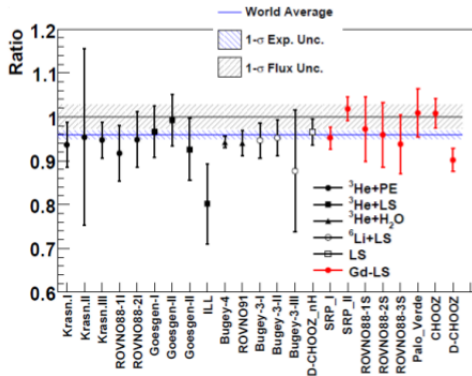
The aims of this experiments are:

► Determing the neutrinos Spectra
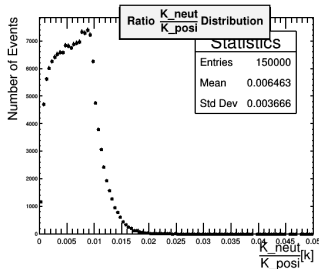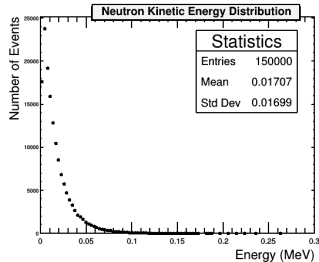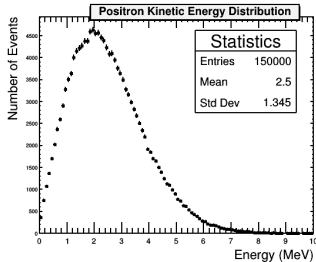
► Studying the neutrinos flux

► Solving the Reactor Anomaly
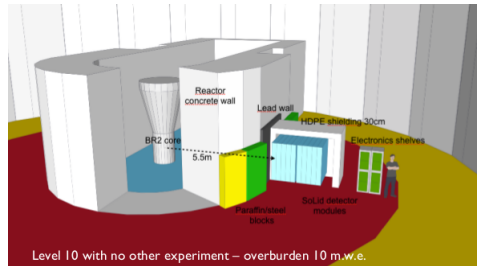
- The detector is made of 9 plans and each plan is segmented (16 times in X and Y directions)
- IBD events (paires of electron and neutron) are generated randomly inside of the detector. Kinematic formula come from Vogel Model.

Positron Kinetic Energy Distribution

Statistics	
Entries	150000
Mean	2.5
Std Dev	1.345

Neutron Kinetic Energy Distribution

Statistics	
Entries	150000
Mean	0.01707
Std Dev	0.01699

Ratio $\frac{K\_neut}{K\_posi}$ Distribution

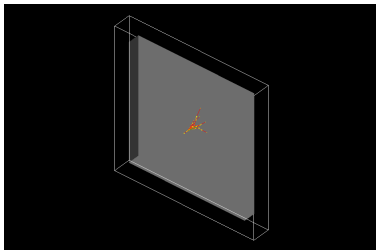| Statistics	
Entries	150000
Mean	0.006463
Std Dev	0.003666

As we can see, the positron kinetic energy is much more larger

than the neutron's one. Then, knowing the kinetic energy of the

positron is knowing the energy of the antineutrino, since

$$E_\nu + (P^2_{prot} + M^2_{prot})^{1/2} = (P^2_{posi} + M^2_{posi})^{1/2} + (P^2_{neut} + M^2_{neut})^{1/2}$$

and by assuming that the proton is at rest inside of the nucleus.

▶ The detector is a 110 μm thin scintillator (1*1 cm^2 in XY). The material used is G4_PLASTIC_SC_VINYLTOLUENE. The simulation registered 1 million electrons at 1 MeV which are fired perpendicularly to the detector.

SoLid Experiment
Electromagnetic Calibration Simulation with GEANT4