Non-proliferation studies with Double Chooz detectors

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Abstract. The near detector of Double Chooz will provide the most accurate measurement of the spectrum and the flux of the electronic anti-neutrinos ($\bar{\nu}_e$) emitted by a nuclear power plant. This enables the collaboration to address certain safeguards issues for the International Atomic Energy Agency's(IAEA) benefit.

The flux and the energy spectrum of the $\bar{\nu}_e$ emitted by a nuclear power plant depend on the thermal power delivered by the plant and on the isotopic composition of its fuel which evolves in time. Reactor $\bar{\nu}_e$ come from the decay of the fission products (FP) produced mainly by ^{235}U, ^{239}Pu, ^{241}Pu and ^{238}U fissions. The arising FP distribution and delivered energy is an intrinsic property of the fissioning isotope : their associated $\bar{\nu}_e$ flux and energy spectra differ from each-other, especially at high $\bar{\nu}_e$ energy. The evolution over time of the $\bar{\nu}_e$ spectrum from a reactor is governed by the evolution of the FP concentrations in the core, given by the Bateman equations. We started a simulation work using the widely used particle transport code MCNPX [1] coupled with an evolution code solving the Bateman equations for the FP within a package called MURE (MCNP Utility for Reactor Evolution) [2]. As a starting point, simple Fermi decays to the ground state of daughter nuclei are implemented. To improve accuracy by taking into account decays towards excited states, as well as the type of β transition, the code will be interfaced with databases (ENDF/B-VI.8, JENDL3.3, JEFF3.1, JEF2.2). For unknown decay properties of exotic nuclei, more elaborate theoretical calculation for allowed and first forbidden transitions will be performed in collaboration with CEA/DAPNIA/SPhN, and an experimental program has started to complete databases. The extended MURE simulation will allow to perform sensitivity studies for relevant scenarios for IAEA. Preliminary results show that nuclei with half-lives lower than 1s emit about 60% (50%) of the ^{235}U (^{239}Pu) $\bar{\nu}_e$ spectrum above 6MeV. Simulations will also be performed to evaluate the possibility to use $\bar{\nu}_e$ for power monitoring. Indeed, Huber and Schwetz [3] predict that, considering our actual knowledge of the $\bar{\nu}_e$ flux, a measurement with a 3% precision of the thermal power delivered by a nuclear plant could already be performed with a detector of a few cubic meters placed at a few 10's of meters from the core.

References

[1] Monte Carlo N-Particle eXtended, *LA-UR-05-2675*, J-S. Hendricks et al.,
[2] O. Méplan et al.,*ENC.proceedings*, Versailles (2005),
[3] P. Huber and T. Schwetz, *Phys. Rev. D* **70**(2004).