A first study of the physics potential of a reactor neutrino experiment with Skipper-CCDs

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νIOLETA experiment

Skipper-CCDs, sensitive to **single electron excitations**, open a new window to low-energy phenomena, such as coherent neutrino-nucleus scattering (**CEνNS**). Particularly interesting is the use of **Skipper-CCDs** to study **CEνNS** from **reactor neutrinos**, with energies below **~5 MeV.** The **νIOLETA** experiment aims to measure **CEνENS** using neutrinos from the **Atucha reactor**, placing a **1 kg Si** skipper-CCD detector **12 m** (**see Poster-523** and **Poster-521** for other possibilities) away from the reactor.

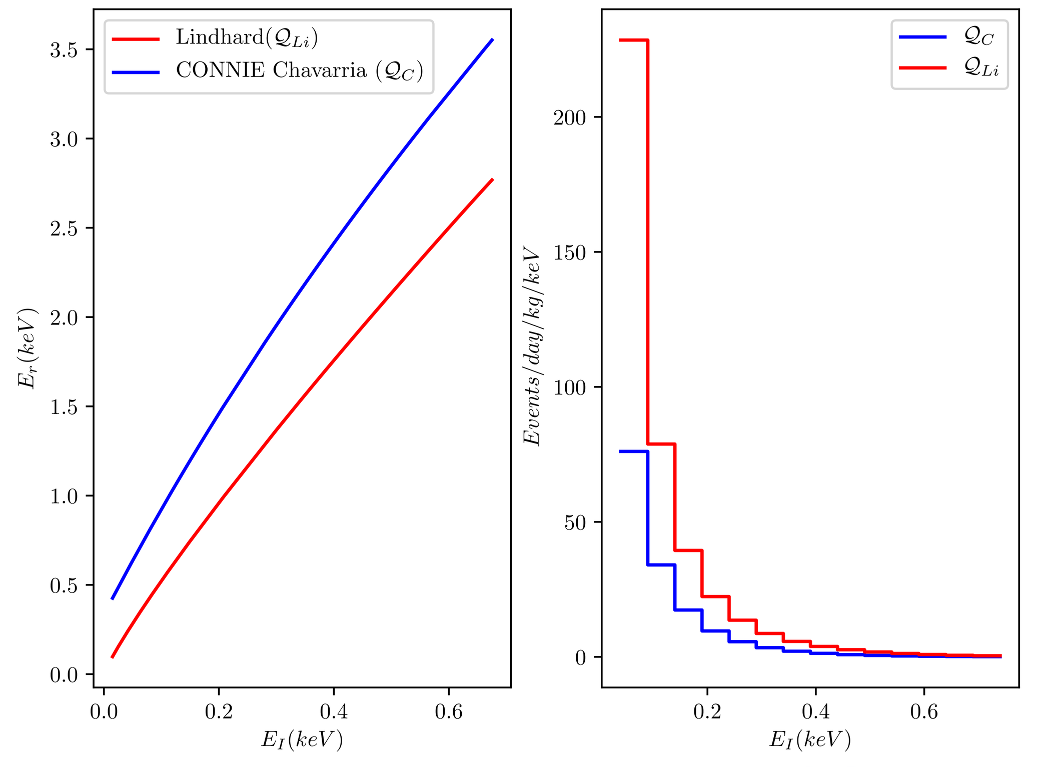
Sensitivity to the weak mixing angle

The **event rate** at the detector is given by

$$n_i = TN_T \int_{E_i}^{E_i+\Delta E} dE_r \int_{E_\nu^{min}}^{\infty} dE_\nu \frac{d\phi_\nu}{dE_\nu} \frac{d\sigma_{CE\nu NS}}{dE_r},$$

with the CEνNS cross section proportional to $(N-(1-4\sin^2\theta_W)Z)^2$, where N and Z are the mass and atomic numbers, respectively. Thus, a **precise measurement** of $\sin^2\theta_W$ at **low momentum transfer** could be possible. The measured **ionisation energy** is related to the **recoil energy** through the **quenching** factor$E_I = \mathcal{Q}E_r$.

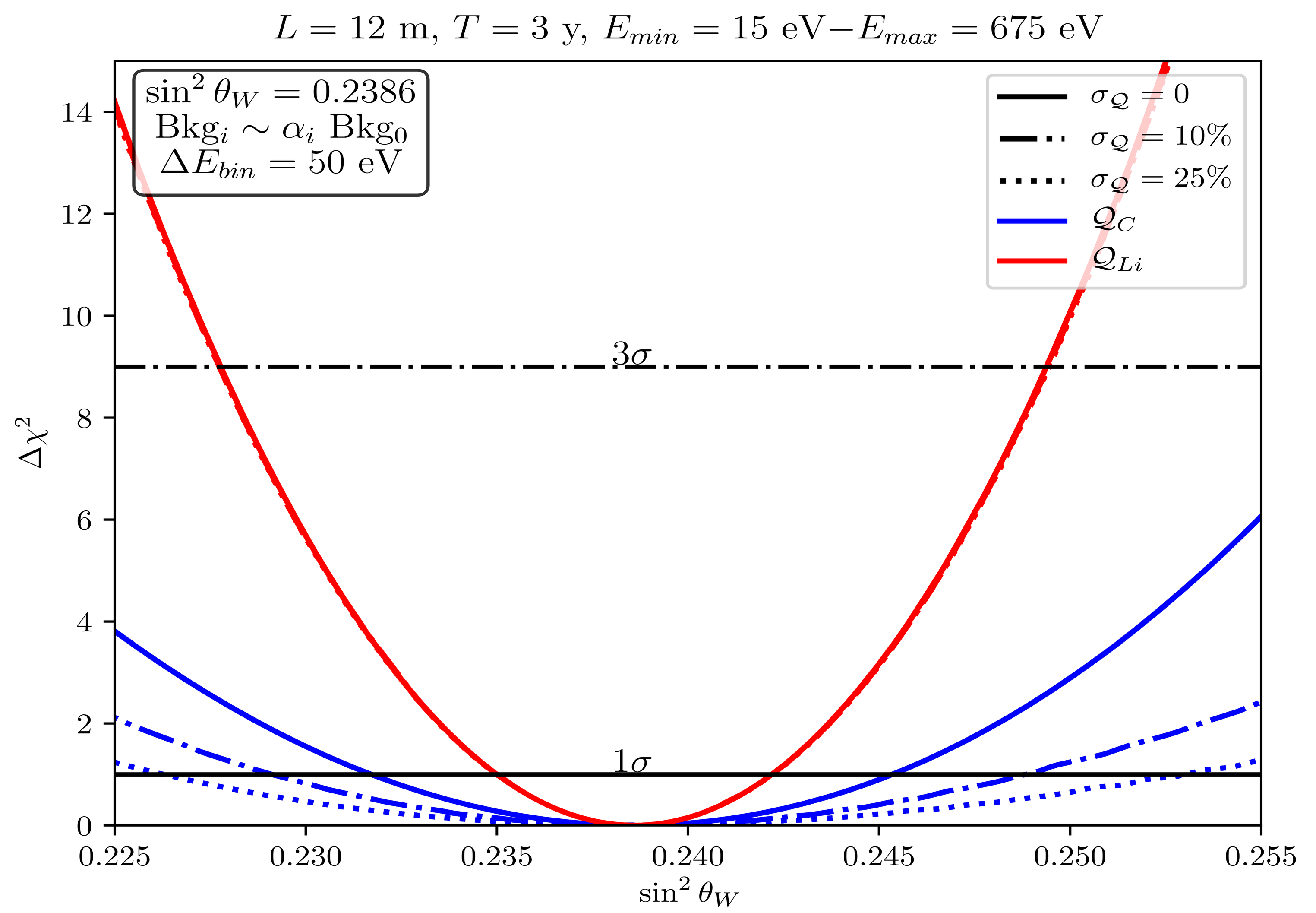
Analysis

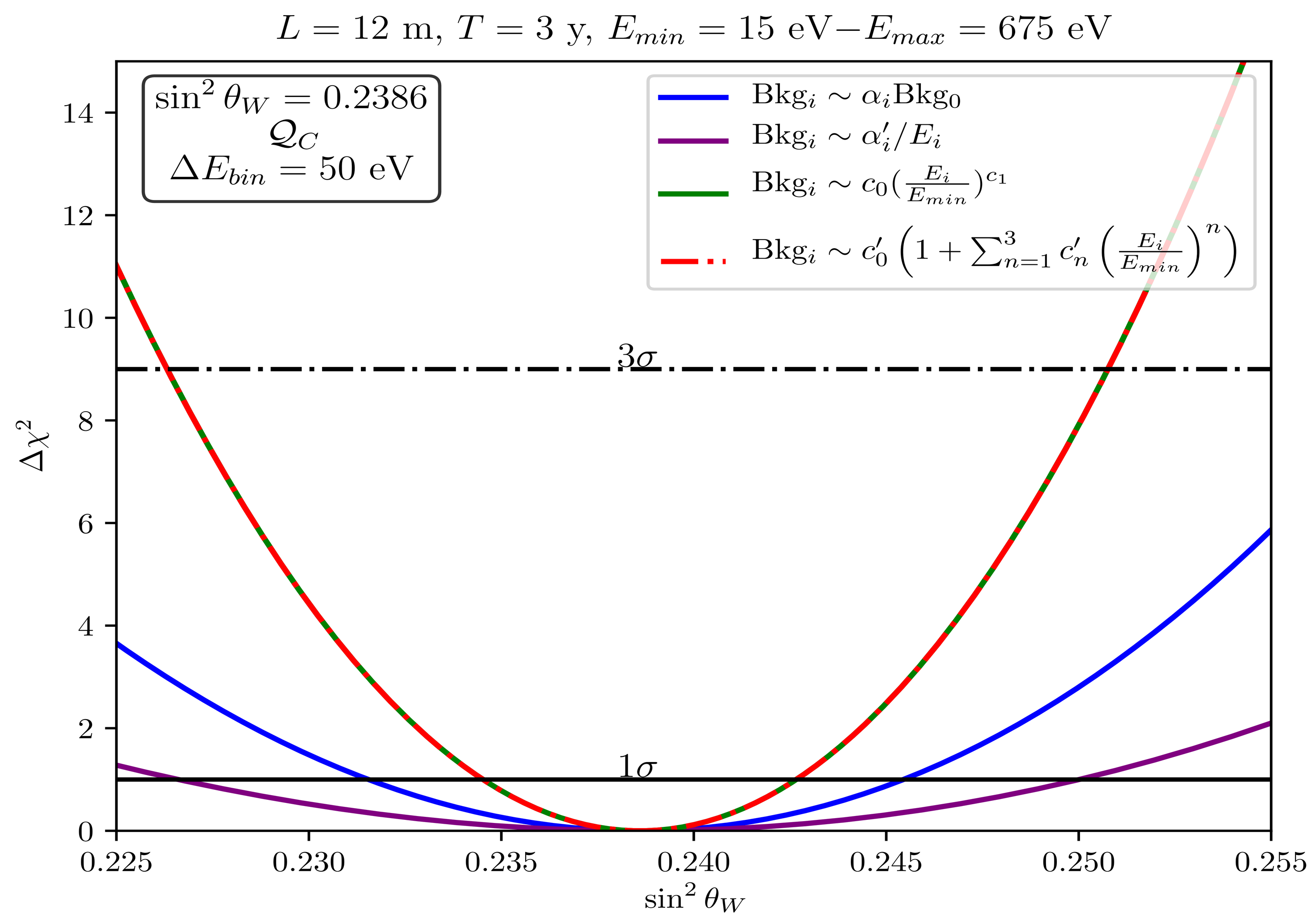


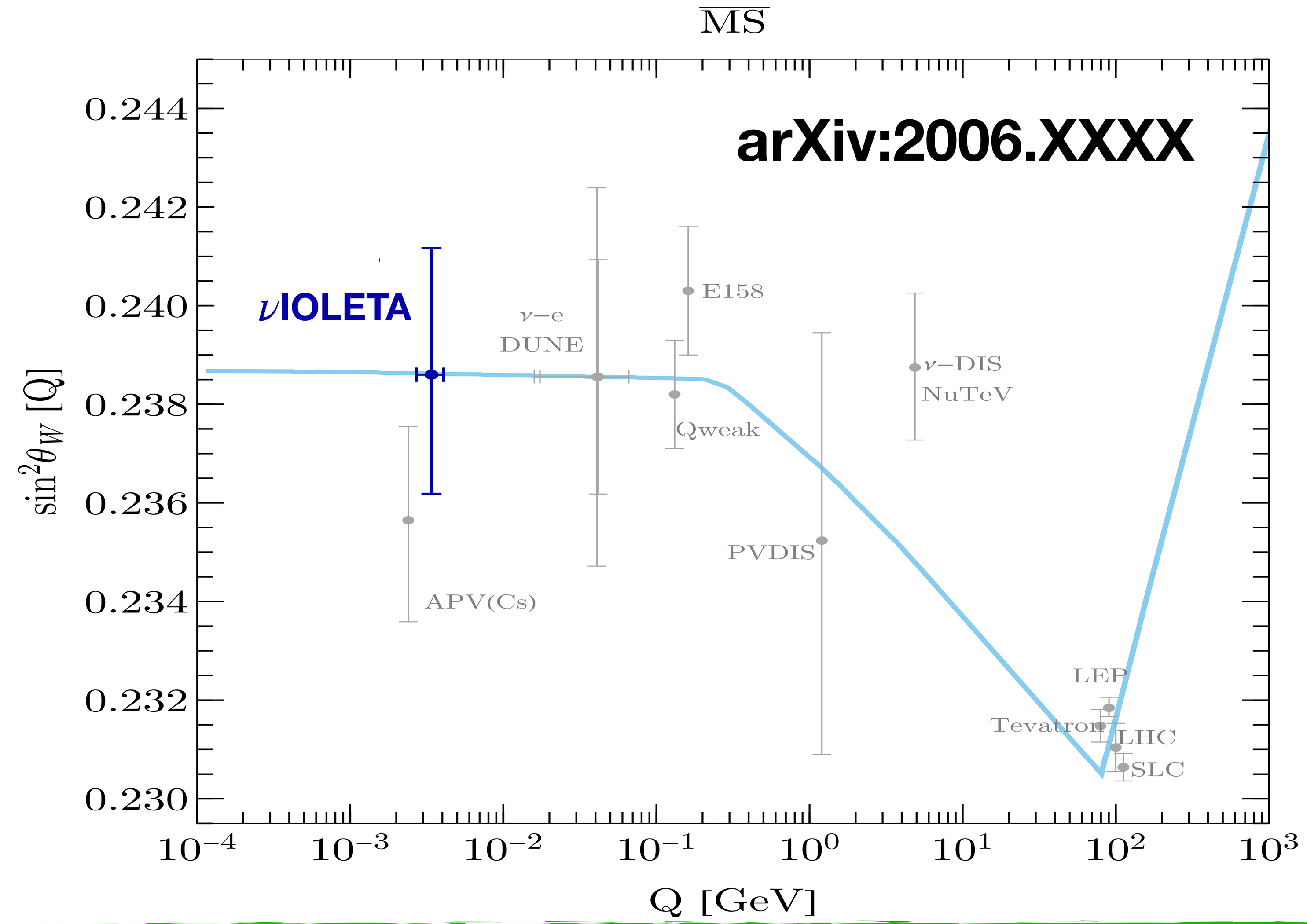
We use the **Daya Bay flux** measurements [1] and covariance matrix as input for the flux for $E_\nu \gtrsim 2$ MeV and the prediction from Vogel and Engel for energies below. The running time for the experiment is $T=3$ **years** with 135 **days of background** measurements. A total **background** of 10^3 **d.r.u** is assumed. For the quenching factor we assume two cases, the one described by Ref.[1] ($\mathcal{Q}_{Li}$) and the more conservative one dubbed as CONNIE Chavarria ($\mathcal{Q}_C$) from Ref.[2]. We perform a χ^2 **analysis** introducing **systematic uncertainties** with the **pull method** and using the **covariance matrix from Daya Bay**.

Results

We assume **different background models** and the two **quenching factors** with different errors. The **most conservative background estimation** is that it is **uncorrelated bin to bin**, such that the systematic error associated to it would be $(\sigma_i^{bkg})^2 \sim 1/(10^3 d.r.u \times \Delta E_{bin} \times 135$ days). For $\Delta E_{bin} = 50$ eV, $\sigma_i^{bkg} \sim 1.2\,\%$ in each energy bin. Other **systematic uncertainties** are the **isotopic composition** of the reactor or the error in the **quenching factor.**







Conclusions

- **Skipper-CCDs** could allow us to measure for the first time **CEνNS** from **reactor neutrinos**, allowing for a measurement of $\sin^2\theta_W$ at low momentum transfer.
- The most important **systematic uncertainties** have been identified: the **reactor-off background** and the **quenching factor.** If the background is inversely proportional to the energy, the sensitivity is greatly degraded as signal and background look alike.
- If a **background model** is available the **measurement of** $\sin^2\theta_W$ is possible with an $\mathcal{O}(1\%)$ **error**, even with the **conservative quenching factor** measured by Chavarria.

References: [1] Adey, D. et al 1904.07812[hep-ex], [2] J. Lindhard, Mat. Fys. Medd. K. Dan. Vidensk. Selsk. 33, 1 (1963), [3] CONNIE Collaboration 1910.04951 [hep-ex]

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