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Analytical potential model for the Radio-Frequency Quadrupole at the European Spallation Source

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The potential in the Radio Frequency Quadrupole (RFQ) can be expressed as a sum of a transverse multipolar expansion: $\sum_{m=1}^{\infty} A_{0m} \left(\frac{r}{r_0}\right)^{2m} \cos(2m\theta)$, and a longitudinal term expressed as sum of Bessel functions: $\sum_{m=0}^{\infty} \sum_{n=1}^{\infty} A_{nm} I_{2m}(nkr) \cos(2m\theta) \cos(nkz)$. Since the paper of Kapchinskii and Teplyakov \cite{osti_4032849} this potential is used considering only the first term in transversal and longitudinal components, unfortunately such approximation does not reproduce properly a realistic RFQ as the one installed at the European Spallation Source (ESS). In this paper we evaluate the potential when more terms are considered and we compare it with the field map obtained from a numerical Poisson solver used at ESS.

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