# Dynamic multipoles of the Tender in-vacuum undulator

Erik Wallén
ejwallen@lbl.gov

Tue 18 Feb 2020

# Contents

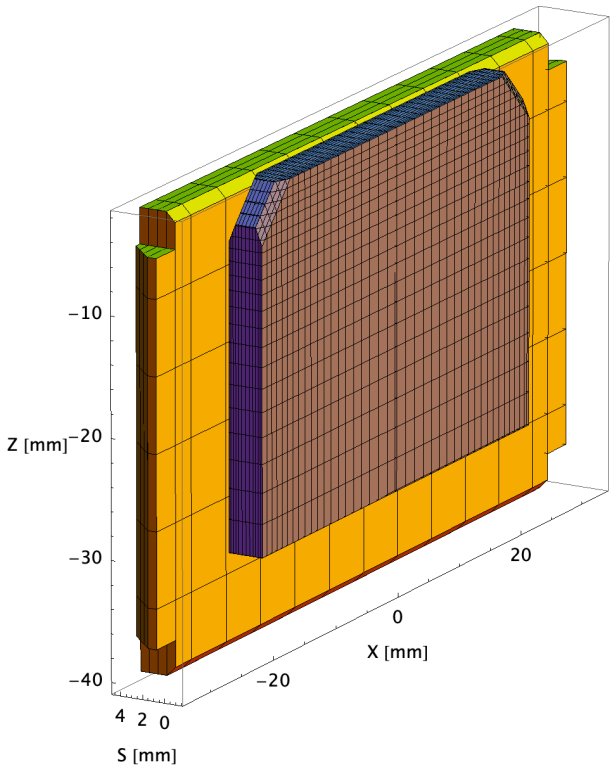
## Introduction

- The Tender beamline in straight section 8 of the ALS-U will have a full length in-vacuum undulator that is 4 m long.
- The undulator will be procured from industry.
- As a reference design for the procurement process, the in-vacuum undulator has been modeled using conservative design parameters for the magnet material and the pole and magnet dimensions.
- The final undulator design will have narrower poles and magnets then in the reference design, still keeping the low transverse field roll-off.
- Radia [1] has been used for the magnet model calculations.
- The dynamic multiples and the corresponding kick map have been calculated using the method described in [2].

1. O. Chubar, P. Elleaume and J. Chavanne, "A 3D Magnetostatics Computer Code for Insertion devices". Journal of Synchrotron Radiation, 5:481-484, 1998.
2. P. Elleaume, "A New Approach to the Electron Beam Dynamics in Undulators and Wigglers", Proc. of European Particle Accelerator Conference 1992, EPAC 1992, Berlin, Germany, pp 661-663.

# Description of the Tender in-vacuum undulator

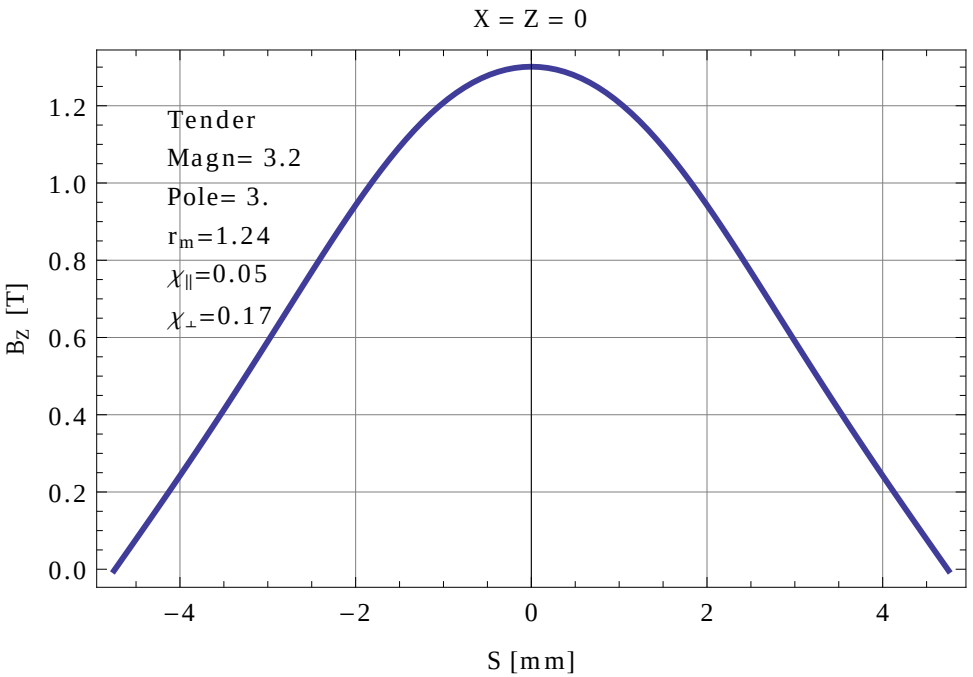
| Undulator Parameters | | |
|---|---|---|
| Period Length | 19.0 | mm |
| Magnetic Gap | 4.4 | mm |
| Physical Gap | 4.0 | mm |
| Total Length | 4.0 | m |




| Magnet Parameters | | |
|---|---|---|
| Material | | NdFeB |
| $r_m$ | 1.24 T | Remanence |
| $\chi_\parallel$ | 0.05 | $\parallel$ Susceptibility |
| $\chi_\perp$ | 0.17 | $\perp$ Susceptibility |
| Width | 66 mm | $\hat{X}$ |
| Thickness | 3.2 mm | $\hat{S}$ |
| Height | 38 mm | $\hat{Z}$ |
| Chamfer | 0.8 mm | Edge 45° $\hat{X}$ |

| Pole Parameters | | |
|---|---|---|
| Material | | Vacoflux50 |
| Width | 43 mm | $\hat{X}$ |
| Thickness | 3.0 mm | $\hat{S}$ |
| Height | 30 mm | $\hat{Z}$ |
| Chamfer | 3.0 mm | Corner 45° $\hat{S}$ |
| Chamfer | 0.6 mm | Corner 30° |

# Magnetic field strength of the Tender undulator




Vertical magnetic field along the e-beam axis.

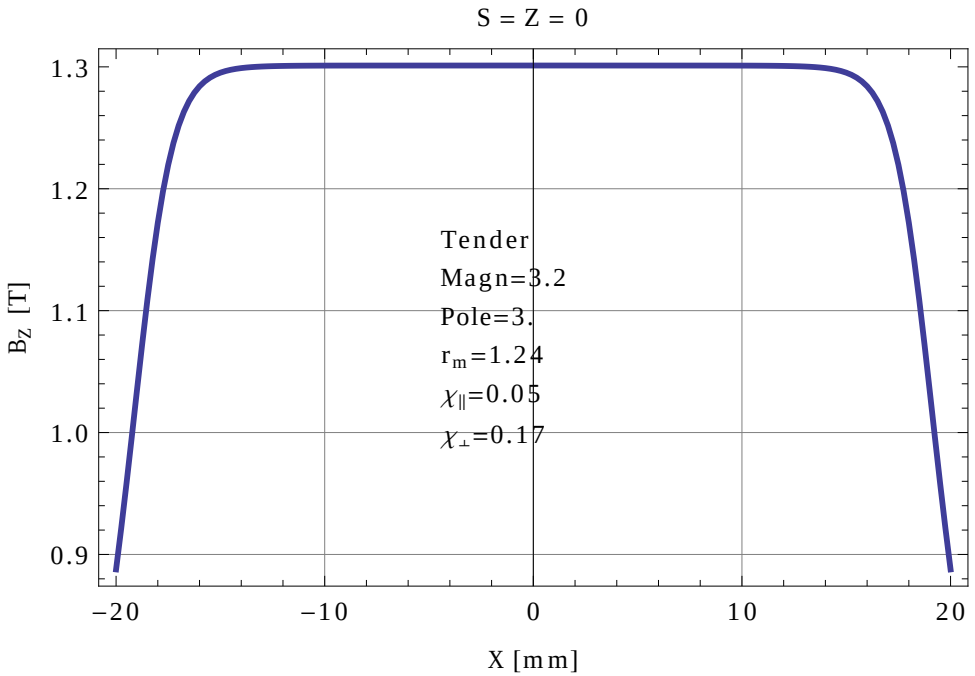
**Parameters**

| | | |
|---|---|---|
| $B_{eff}$ | 1.2333 T | Effective Field |
| $B_{peak}$ | 1.3011 T | Peak Field |
| $r_m$ | 1.2400 T | Remanace |
| $\chi_{\parallel}$ | 0.05 | $\parallel$ Susceptibility |
| $\chi_{\perp}$ | 0.17 | $\perp$ Susceptibility |

**Fourier Analysis**

| Term | Strength |
|---|---|
| Harm. Nr. 1 | 1.23300 T |
| Harm. Nr. 3 | 0.07925 T |
| Harm. Nr. 5 | -0.00526 T |
| Harm. Nr. 7 | -0.00196 T |
| Harm. Nr. 9 | -0.00036 T |
| Harm. Nr. 11 | -0.00002 T |

# Field roll-off for the Tender undulator

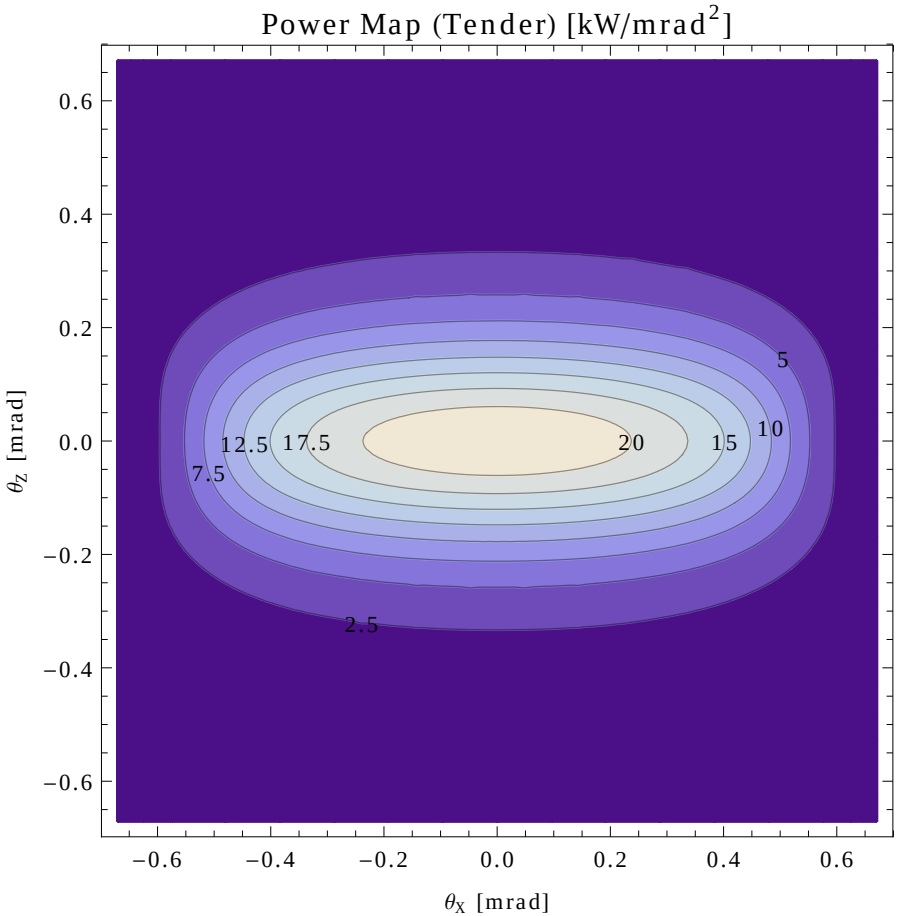



Vertical magnetic field in a central pole along the horizontally transverse direction S = Z = 0.

**Transverse field roll-off**

| X-Position | $B_Z$ Field | Roll-off |
|---|---|---|
| ± 0 mm | 1.301 T | |
| ± 5 mm | 1.301 T | 0.002 % |
| ± 10 mm | 1.301 T | 0.006 % |
| ± 15 mm | 1.295 T | 0.451 % |
| ± 20 mm | 0.888 T | 31.770 % |

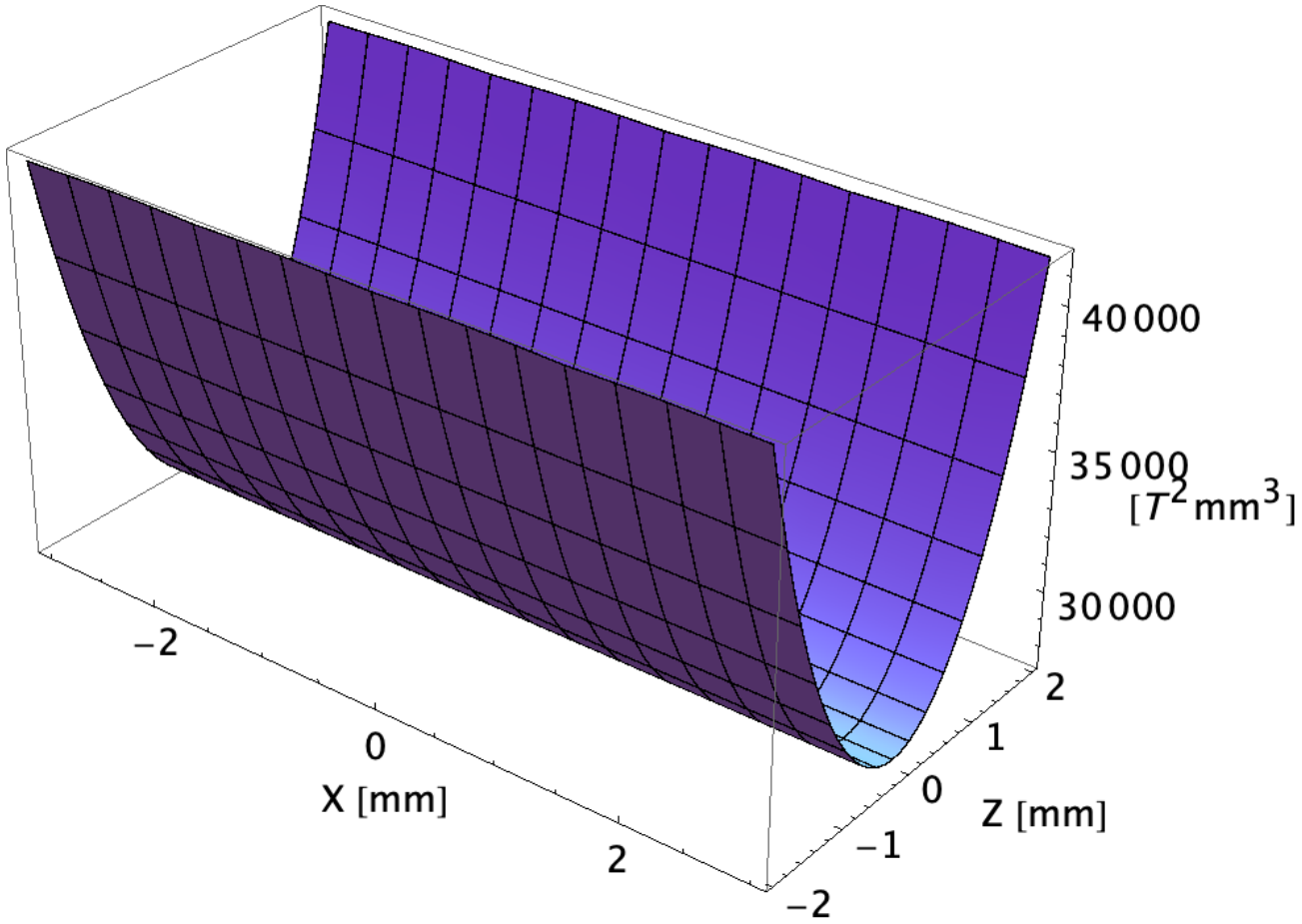
# Map of radiated power at the magnetic gap 4.4 mm



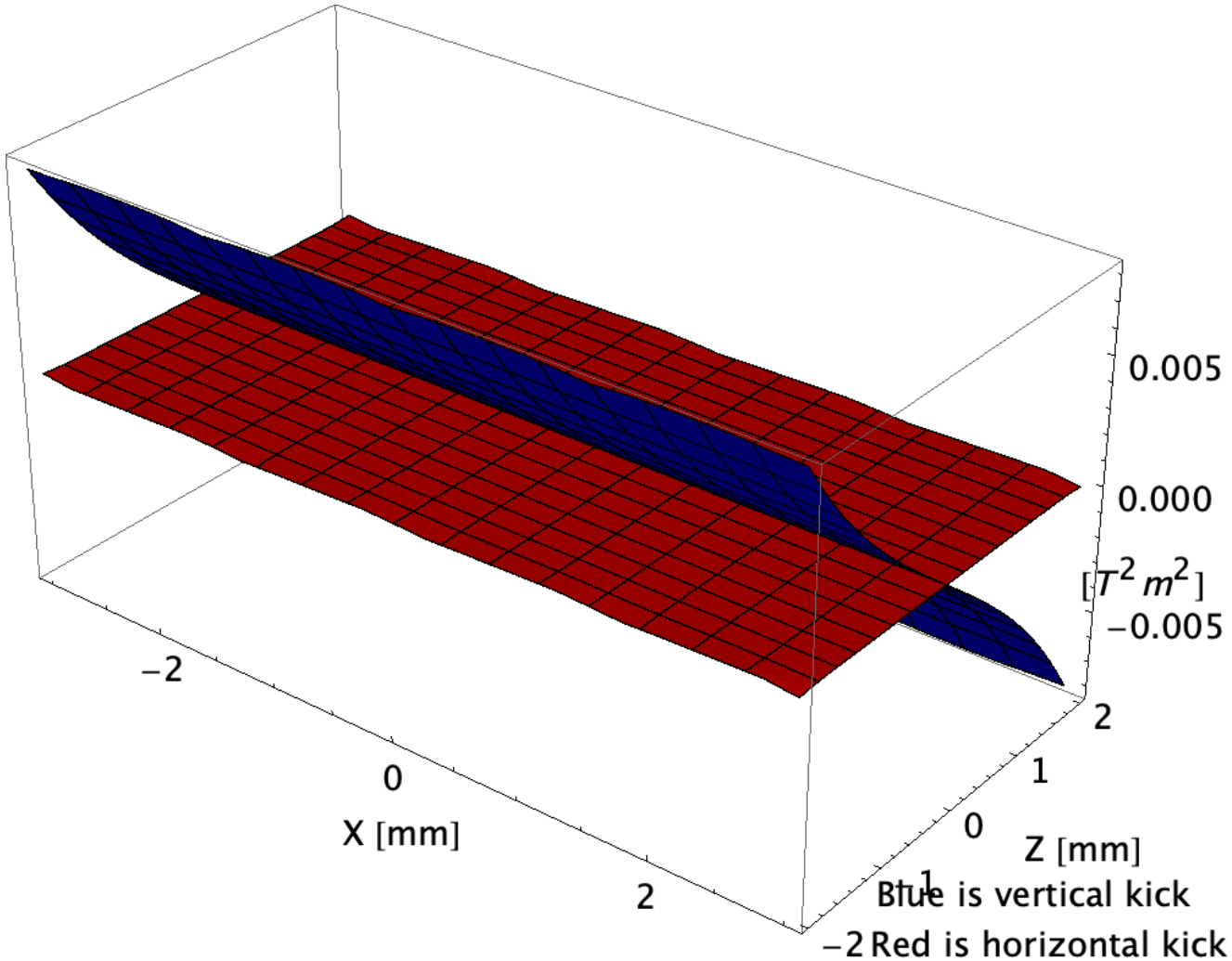

**Radiated power**

| | | |
|---|---|---|
| Magnetic gap | 4.4 | mm |
| $K_X$ from $B_Z$ | 2.189 | |
| Filament beam | | |
| Beam current | 0.5 | A |
| Beam energy | 2.0 | GeV |
| Radiated power | 7.7 | kW |
| On-axis power | 22.2 | kW/mrad$^2$ |

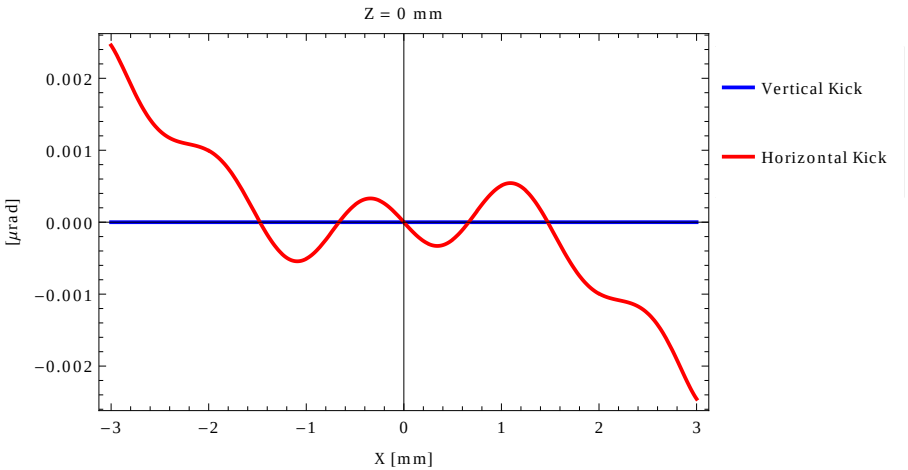
# Focusing potential

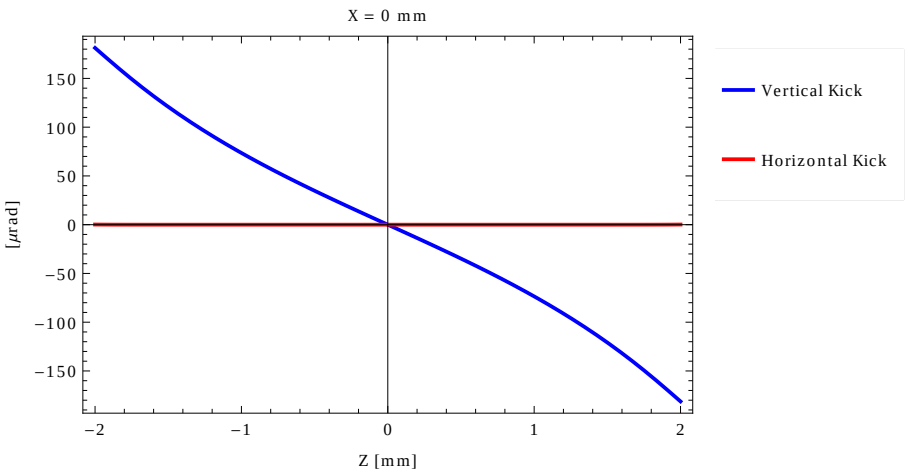


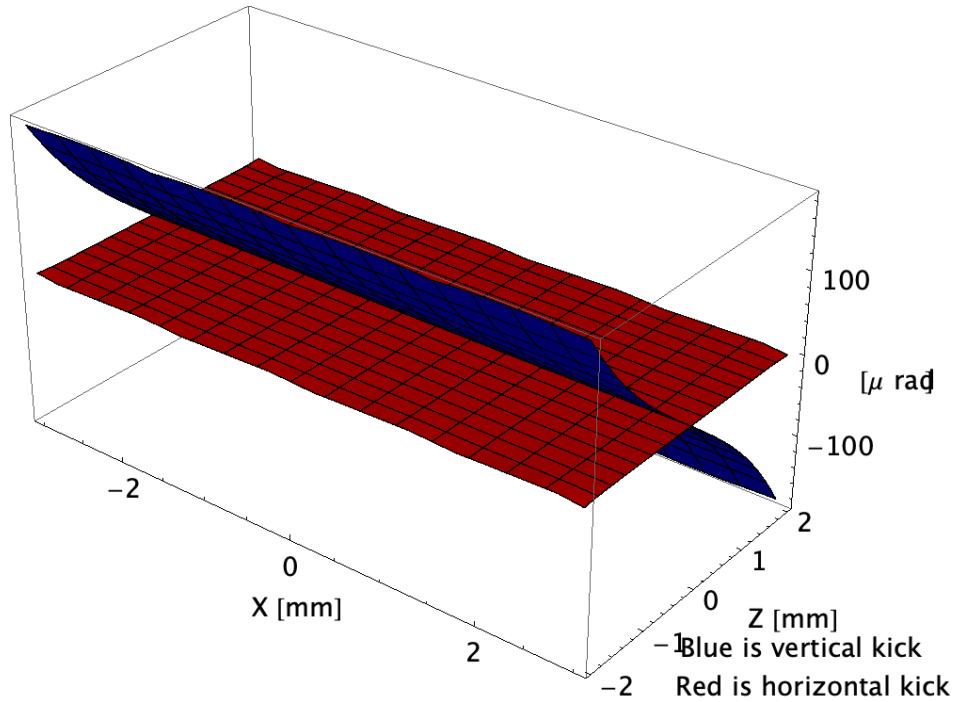
# Kick map used for tracking [$T^2m^2$]



# Kick map in the units [$\mu$rad] for a 2.0 GeV beam



# Integrated quadrupole strength map [T]