DIPOLE KICK DUE TO GEOMETRY ASYMMETRIES IN HWR FOR PXIE*

MOPP049

P. Berrutti, T. N. Khabiboulline, V. Lebedev, V. P. Yakovlev
Fermilab, Batavia, IL 60510, USA

Introduction

- PXIE is a CW linac to be built at FNAL, it consists of an ion source capable of delivering 5 mA (nominal) at 30 keV followed by a LEBT section, a 5 mA RFQ, a MEBT section with integrated wideband chopper.
- After the MEBT two superconducting sections accelerate the beam from 2.1 MeV to 30 MeV: first HWRs at 162.5 MHz and beta= 0.11 then, single spoke resonators at 325 MHz and beta=0.21.
- The HWR cavities, designed and built by ANL, will bring the beam energy from 2.1 to approximately 10 MeV.
- The effect of geometry perturbation on the EM field, of the HWR cavity for PXIE, have been studied and they are presented in this paper.

EM field and ΔPc

- Any asymmetry introduced during the manufacturing process will affect the EM field.
- Simulation of field inside the cavity carrying the expected misalignments was done using Comsol.
- The momentum gain can be calculated by Lorentz's force or Panofsky-Wenzel calculation.

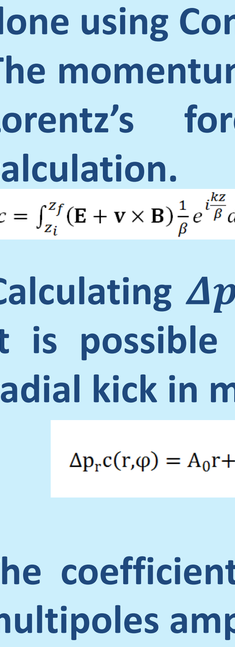
$$\Delta \boldsymbol{P}_{\perp} c = \int_{z_i}^{z_f} (\mathbf{E} + \mathbf{v} \times \mathbf{B}) \frac{1}{\beta} e^{i\frac{kz}{\beta}} dz \qquad \Delta \mathbf{P}_{\perp} c = \frac{i}{k} \int_{z_i}^{z_f} \nabla_{\perp} E_z \, e^{i\frac{kz}{\beta}} dz$$

- Calculating $\Delta p_R c$ on the whole x-y plane it is possible to expand the transverse radial kick in multipoles.

$$\Delta p_r c(r,\varphi) = A_0 r + \sum_{n=1}^{\infty} A_n r^{n-1} \cos(n\varphi) + B_n r^{n-1} \sin(n\varphi)$$

- The coefficients $A_n r^{n-1}$ and $B_n r^{n-1}$ are multipoles amplitude and n is the order.

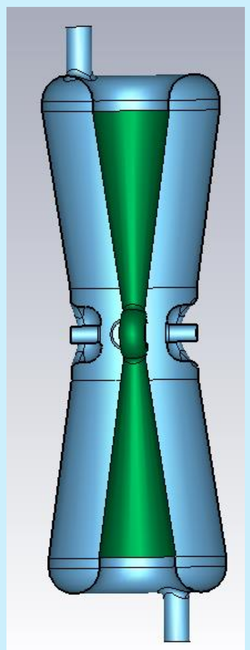
HWR geometry



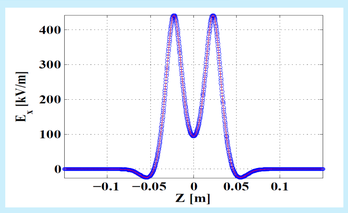
- The figure shows the YZ section of the HWR cavity.
- The multipole analysis shows a quadrupole component but zero dipole for the perfect shape of the HWR cavity.

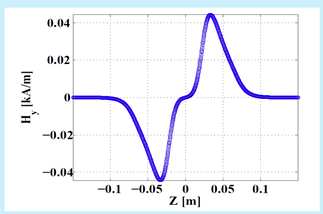
Multipoles [keV]	Designed HWR
n=1 dipole	8.22E-04
n=2 quadrupole	14.295
n=3 sextupole	8.22E-04
n=4 octupole	0.649

Spoke 1 mm X and Y

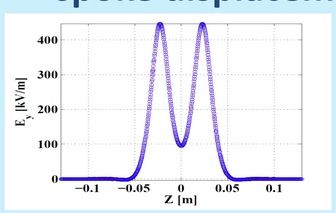


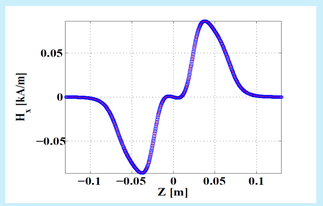
- Local mesh refinement on lines, surfaces and domains is indispensable feature is crucial in order to get precise values of the field amplitudes for geometry misalignments of the order of 1 mm.
- Spoke has been misplaced by 1 mm in X and Y directions.
- The spoke area is shown in green in the figure.



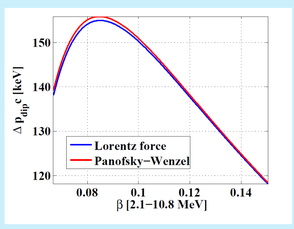


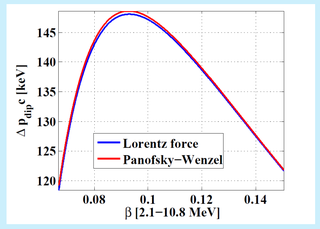
- Transverse fields on axis for 1mm X spoke displacement.





- Transverse fields on axis for 1 mm Y spoke displacement.



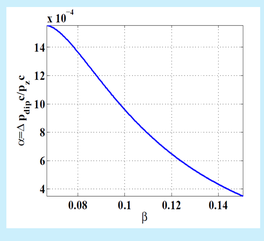


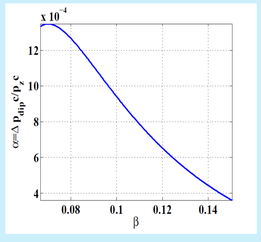
- Transverse momentum gain for 1 mm X and Y spoke displacements, for the full beta range of HWR in PXIE .

Multipoles [keV]	1 mm X Spoke	1 mm Y Spoke
n=1	149.46	148.786
n=2	12.935	12.448
n=3	0.192	0.228
n=4	0.056	0.152

- Dipole component arises in the multipole table, calculated for beta= 0.11 r= 10 mm.
- It is possible to introduce another parameter to assess the intensity of the dipole perturbation:

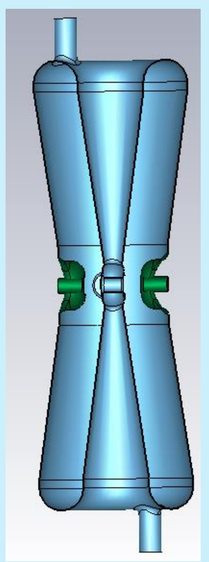
$$\alpha = \Delta p_{\perp} c / p_z c$$

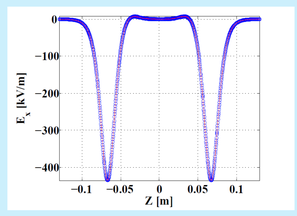




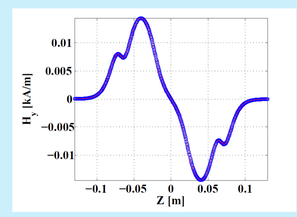
- α vs particle beta for 1 mm X and Y spoke displacements.

Beam pipe 1 mm X and Y

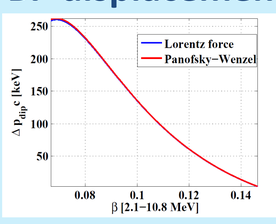


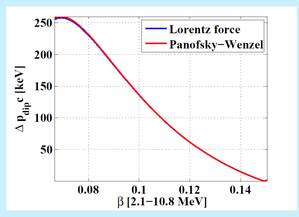


- Transverse electric field on axis 1 mm X displacement.



- Transverse magnetic field on axis 1 mm X BP displacement.



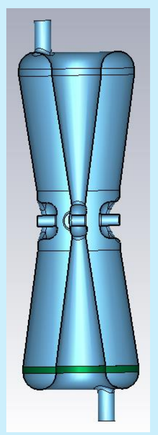


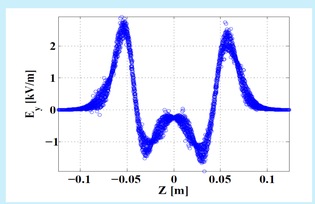
- $\Delta p_{\perp} c$ on axis for 1 mm X and Y BP displacements vs particle beta.

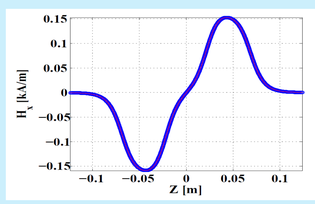
Multipoles [keV]	1 mm X BP	1 mm Y BP
n=1	97.562	98.304
n=2	12.803	12.437
n=3	0.301	0.125
n=4	0.087	0.126

- Multipole table, calculated for beta= 0.11 r= 10 mm.

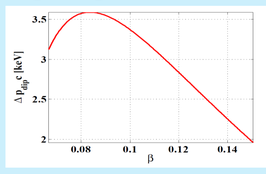
Asymmetric trimming 3 mm

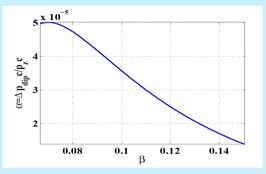






- The area affected by 3 mm trimming is highlighted in the figure.





- $\Delta p_{\perp} c$ and α vs particle beta for 3 mm asymmetry on Y axis.
- $\Delta p_{\perp} c$ is two orders of magnitude lower than for spoke and BP misalignments.

Conclusions

- The dipole field perturbation has been studied for the HWR of PXIE, different scenarios have been considered and none of them seems to be source of concern for the beam dynamic.
- Even the asymmetric trim of the cavity does not affect significantly the fields on axis. The correctors inside the solenoids will have separate leads for quadrupole and dipole corrections.

*under Contract No. DE-AC02-07CH11359