Effect of Lattice Misalignment on Beam Dynamics in LANSCE Linear Accelerator

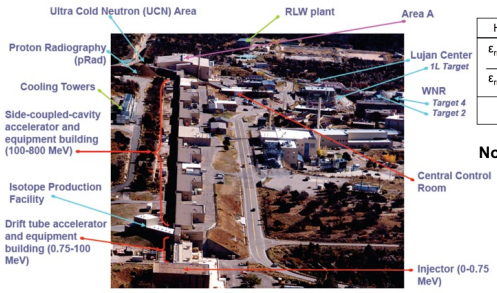
Yuri Batygin, Sergey Kurennoy

Los Alamos National Laboratory, Los Alamos, NM 87545, USA

Abstract

Accelerator channel misalignments can significantly affect beam parameters in long linear accelerators. Measurements of misalignments of the LANSCE linac lattice elements were performed by the Mechanical Design Engineering Group of the Los Alamos Accelerator Operations and Technology Division. In order to determine effect of misalignment on beam parameters in LANSCE linac, the simulations of high-energy part of LANSCE linear accelerator were performed including measured displacements of quadrupoles and accelerating tanks. Effect of misalignments was compared with those due to beam space charge and distortion of RF field along the channel. Paper presents results of simulation and comparison with experimental data of beam emittance growth along the machine.

LANSCE Accelerator Facility



Beam Emittance Growth

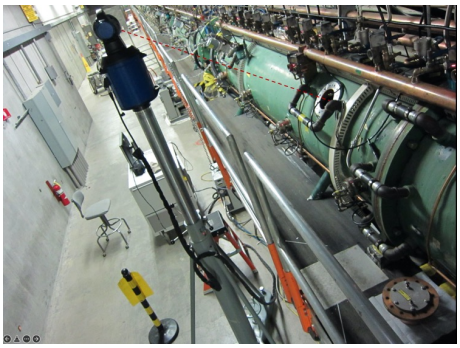
Beam emittance growth in DTL

H^- (Lujan / pRad /UCN)		H^- (WNR)		H^+ (IPF)	
$\frac{\varepsilon_{rms}(100)}{\varepsilon_{rms}(0.75)}$	$\frac{\varepsilon_{tot}(100)}{\varepsilon_{tot}(0.75)}$	$\frac{\varepsilon_{rms}(100)}{\varepsilon_{rms}(0.75)}$	$\frac{\varepsilon_{tot}(100)}{\varepsilon_{tot}(0.75)}$	$\frac{\varepsilon_{rms}(100)}{\varepsilon_{rms}(0.75)}$	$\frac{\varepsilon_{tot}(100)}{\varepsilon_{tot}(0.75)}$
1.86	2.42	1.7	1.89	5.0	6.3

Normalized rms beam emittance in CCL (π cm mrad)

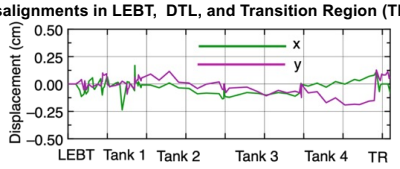
Energy	100 MeV	800 MeV
H^- (Lujan / pRad /UCN)	0.04	0.065
H^- (WNR)	0.058	0.124

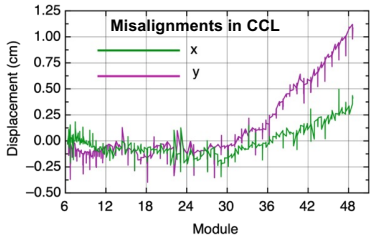
Misalignment Measurements of LANSCE Linac (C. Connor and co-workers, AOT-MDE, 2011- 2015)



Setup for misalignment measurements in Drift Tube Linac

Misalignments in LEBT, DTL, and Transition Region (TR)

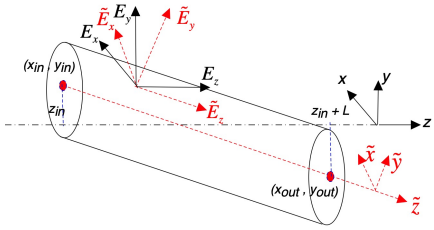




Drift Tube Linac (DTL)

Coupled Cavity Linac (CCL)

Simulation of Field Components in Misaligned Accelerating Tanks



Misaligned accelerating tank and field components in misaligned and laboratory frame.

Coordinate transformation $\tilde{x} = x - x_{axis}$ $\tilde{y} = y - y_{axis}$ $\tilde{z} \approx z$

Axes of misaligned tank in laboratory frame

$$x_{axis} = x_{in} + \alpha_x (z - z_{in}) \qquad y_{axis} = y_{in} + \alpha_y (z - z_{in})$$

Slope of the axes

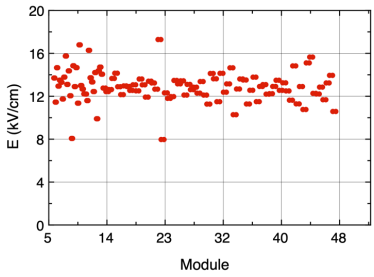
$$\alpha_x = \frac{(x_{out} - x_{in})}{L} \qquad \alpha_y = \frac{(y_{out} - y_{in})}{L}$$

Field components transformation

$$E_x \approx \tilde{E}_x + \alpha_x \tilde{E}_z \qquad E_y \approx \tilde{E}_y + \alpha_y \tilde{E}_z \qquad E_z \approx \tilde{E}_z - \alpha_x \tilde{E}_x - \alpha_y \tilde{E}_y$$

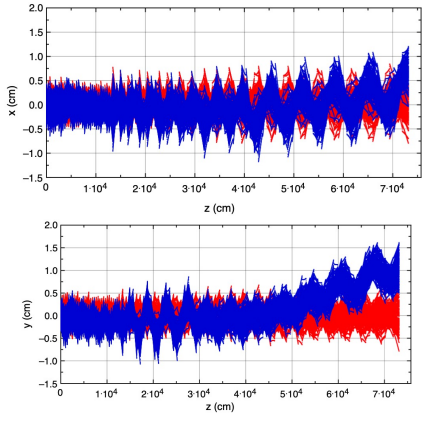
$$B_x \approx \tilde{B}_x \qquad B_y \approx \tilde{B}_y$$

RF Field Amplitudes in CCL



Measured amplitudes of RF field in CCL.

Simulation of Beam Dynamics with Lattice Misalignment



Particle trajectories in CCL linac:
(red) without misalignments, (blue) with misalignments.

Beam emittance growth along CCL linac:

(a) neglecting misalignments, beam current and RF amplitude variation

(b) Including misalignments, neglecting beam current and RF amplitude variation

(c) Including misalignments and beam current I =10 mA, neglecting RF amplitude variation

(d) Including misalignments, beam current I =10 mA, and RF amplitude variation