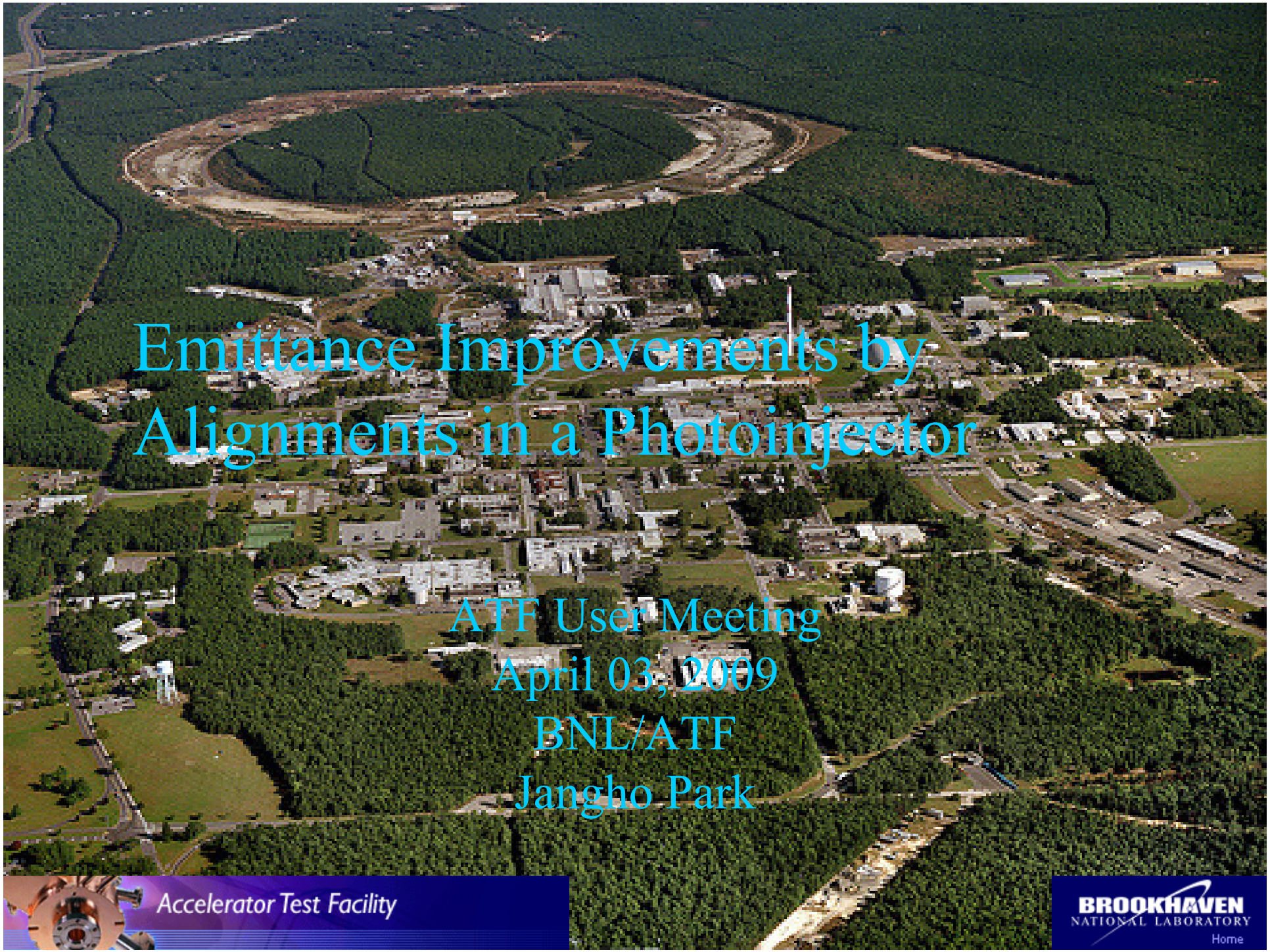
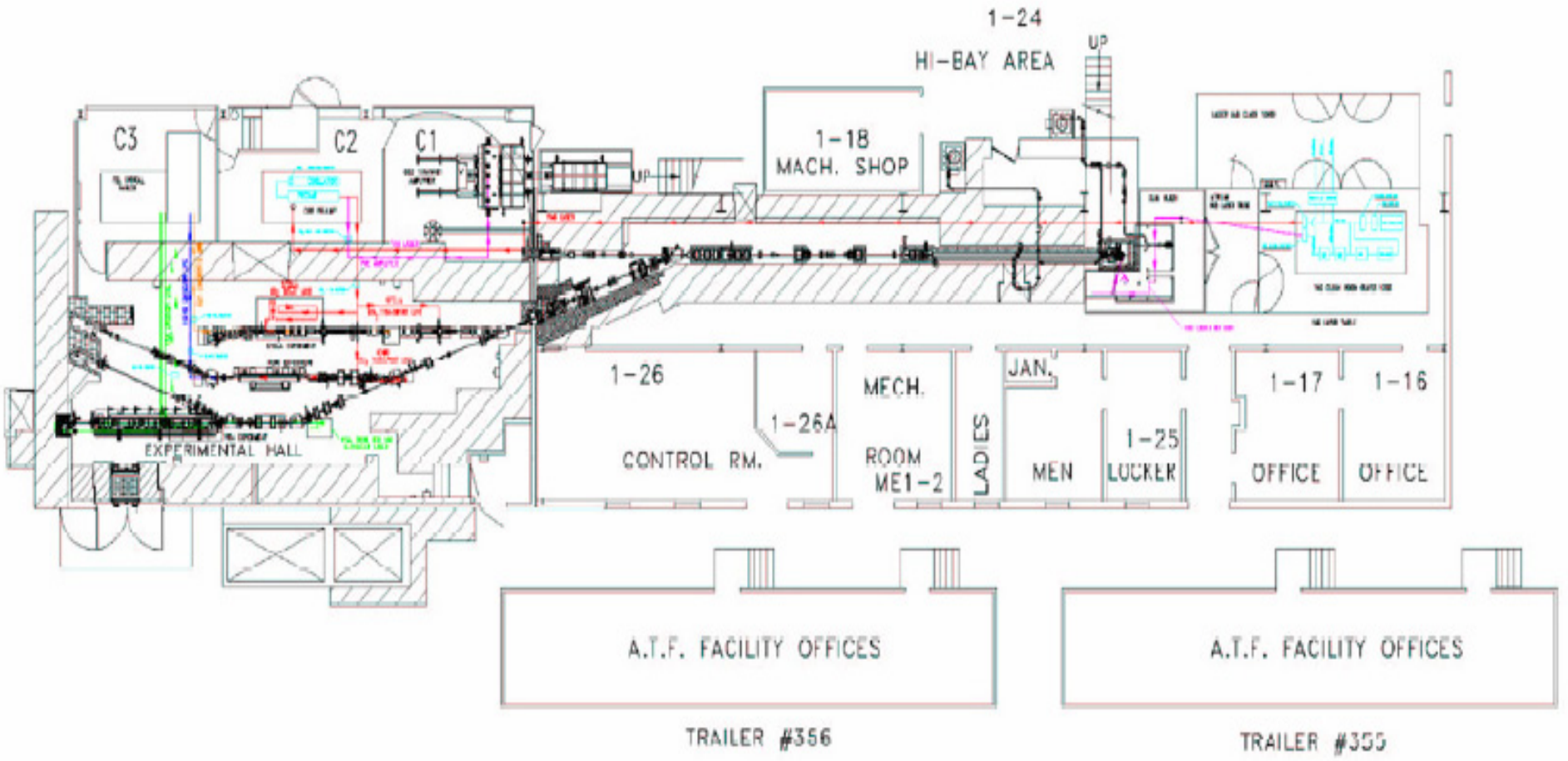
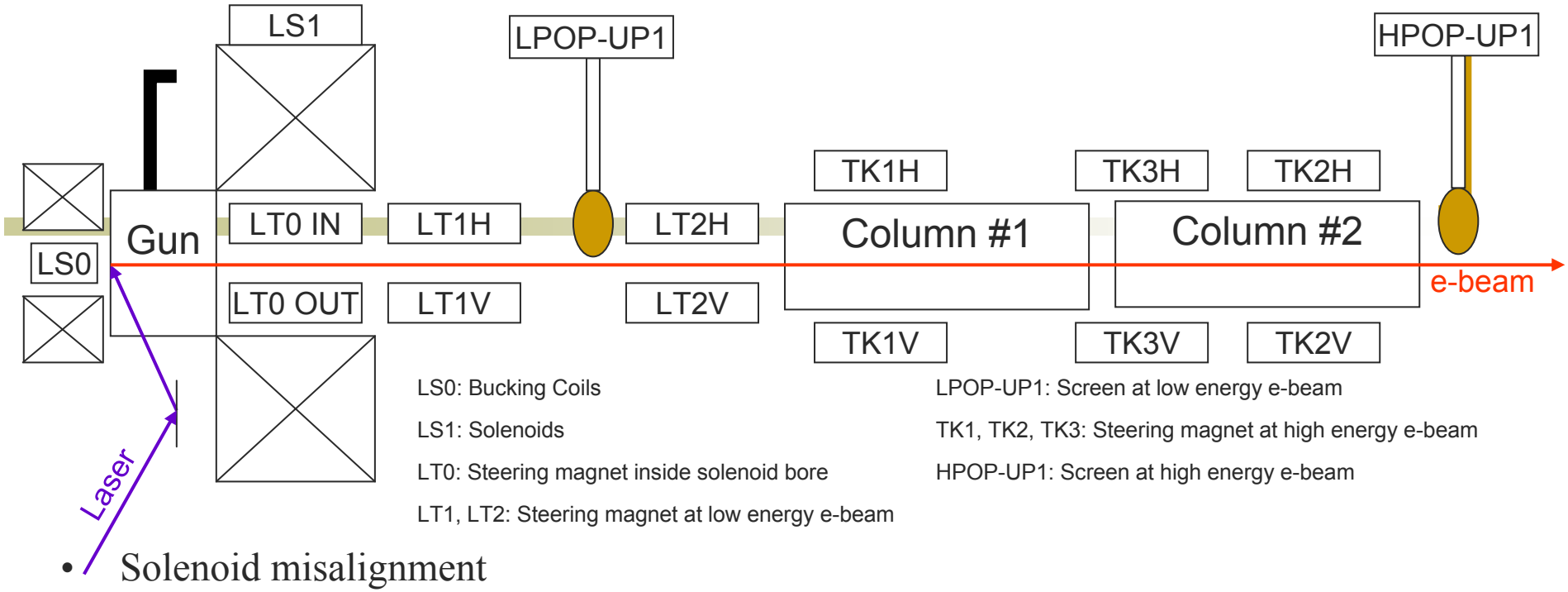

Emittance Improvements by
Alignments in a Photoinjector
ATF User Meeting
April 03, 2009
BNL/ATF
Jangho Park
Accelerator Test Facility
BROOKHAVEN
NATIONAL LABORATORY
Home

Contents

- Introduction
- Beam based alignment
- Emittance measurement along to misalignment
- Conclusions

ATF Layout

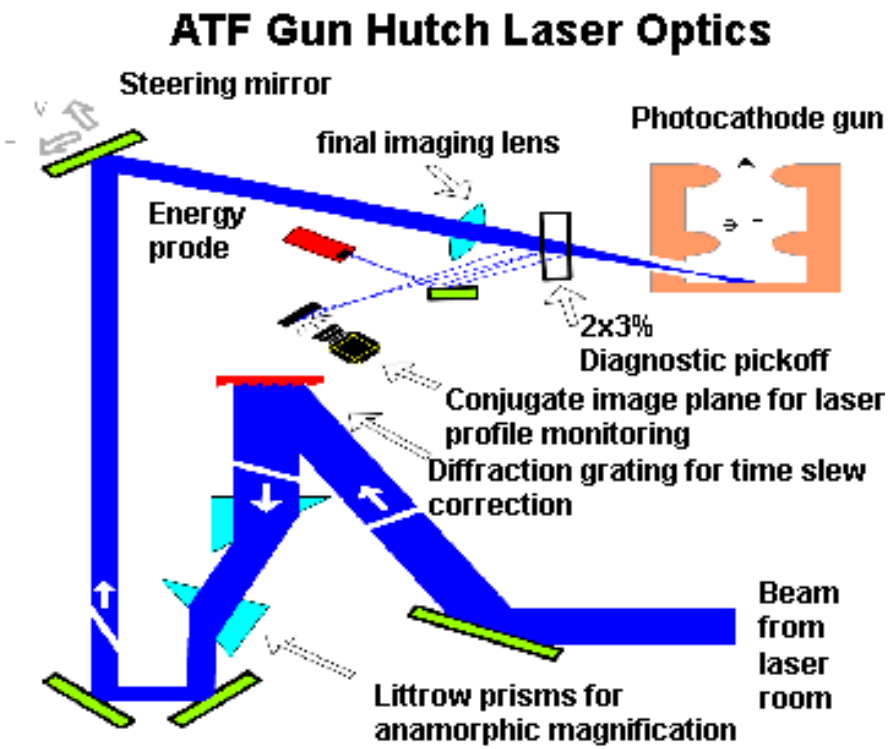

1-24
HI-BAY AREA
UP
C3
C2
C1
1-18
MACH. SHOP
UP
1-26
1-26A
CONTROL RM.
MECH.
ROOM
ME1-2
LADIES
JAN.
MEN
1-25
LOCKER
1-17
1-16
OFFICE
OFFICE
EXPERIMENTAL HALL
A.T.F. FACILITY OFFICES
A.T.F. FACILITY OFFICES
TRAILER #356
TRAILER #355

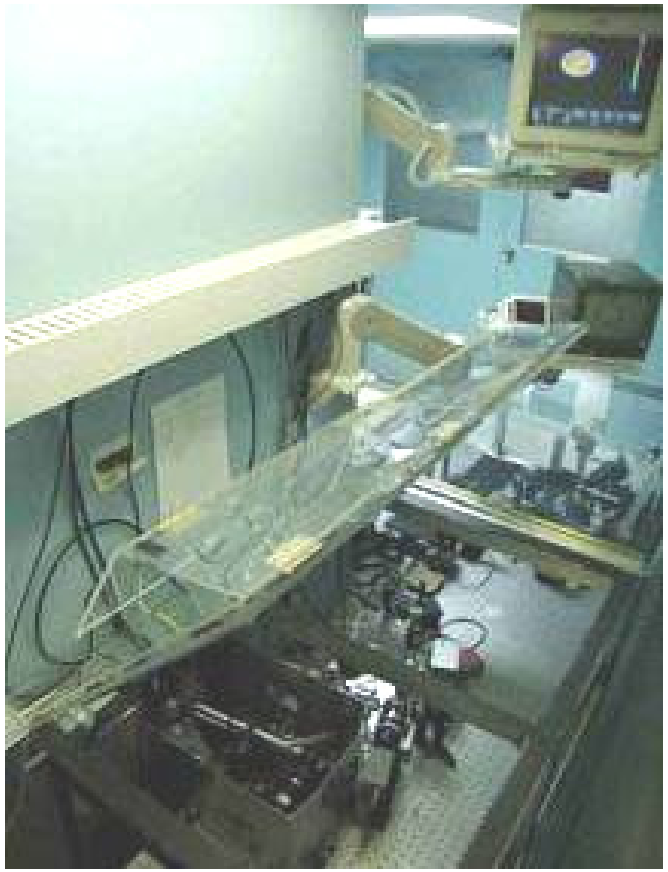


- Solenoid misalignment

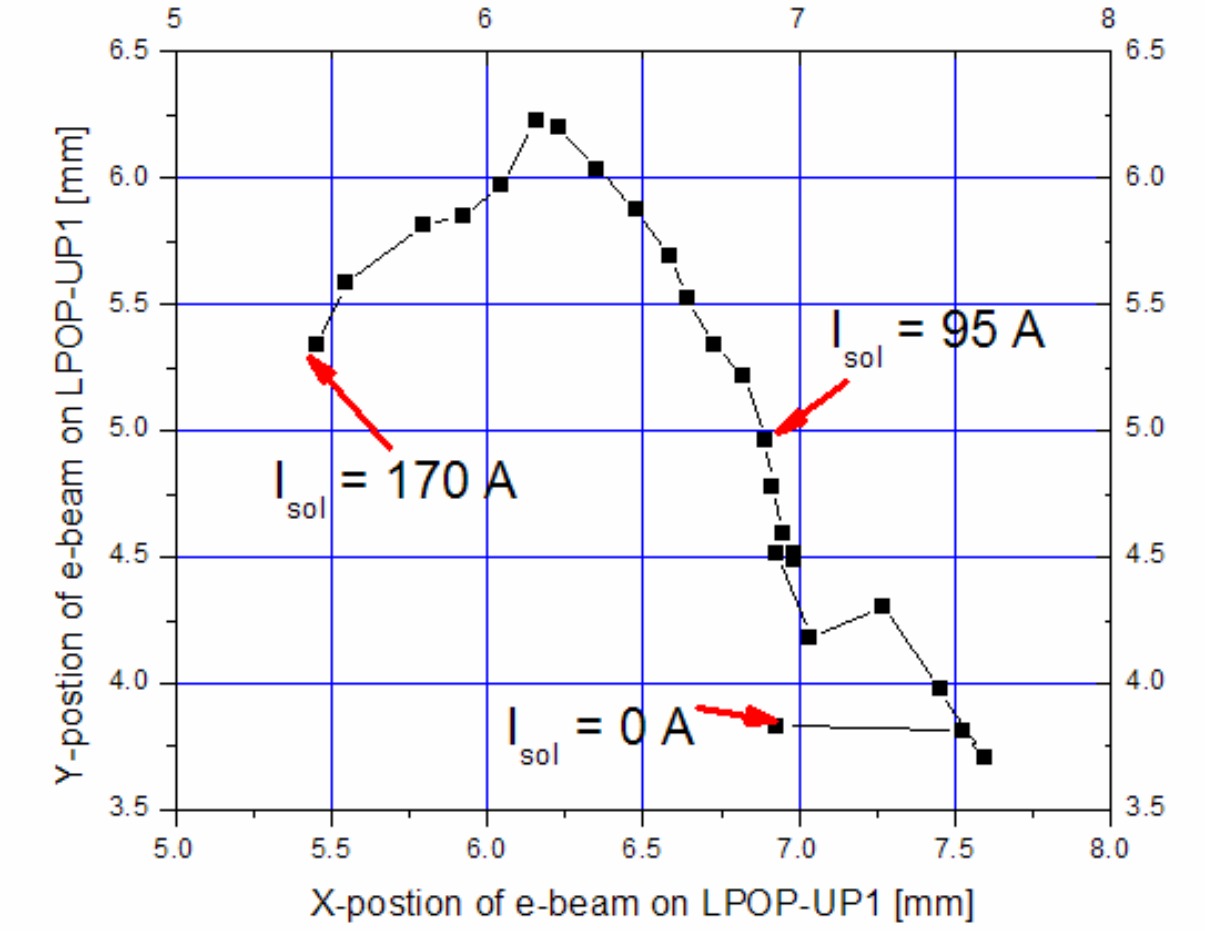
1. If laser is well aligned along to electric field in the cavity, at constant e-beam energy (phase and rf power) we will measure solenoid currents vs. e-beam position without steering coils to investigate how much misalign the solenoid against beam axis. → solenoid offset measure.
2. If we get the misalignment data from the experiment, we need simulation for knowing the status of the e-beam misalignment using such as Parmela.
3. Alignment by elimination of the largest imperfections with moving the solenoid and gun position.

Laser for e-beam generation



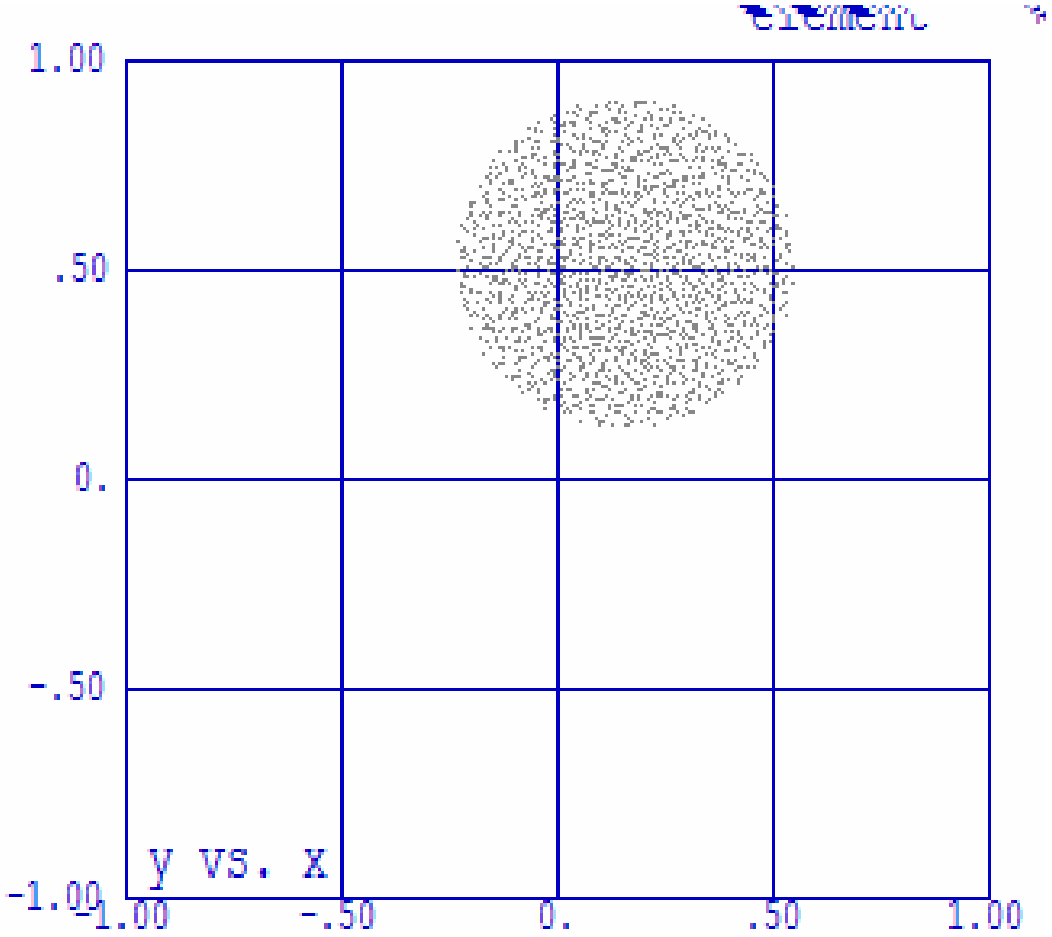


Measured beam positions along to solenoid current on LPOP-UP1



4.4 MeV beam energy

Position dependencies along to solenoid field using by PARMELA simulation



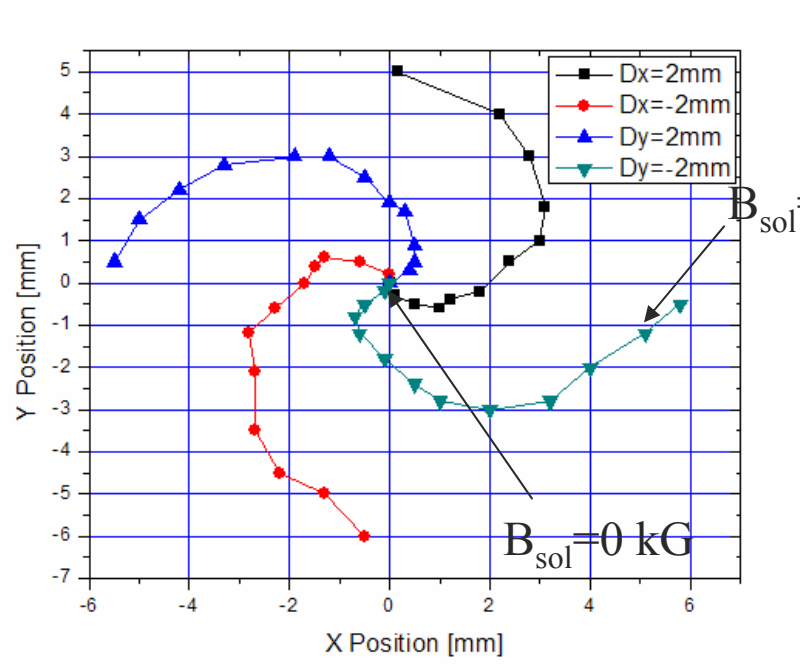
Same distance with the LPOPUP1 from the cathode

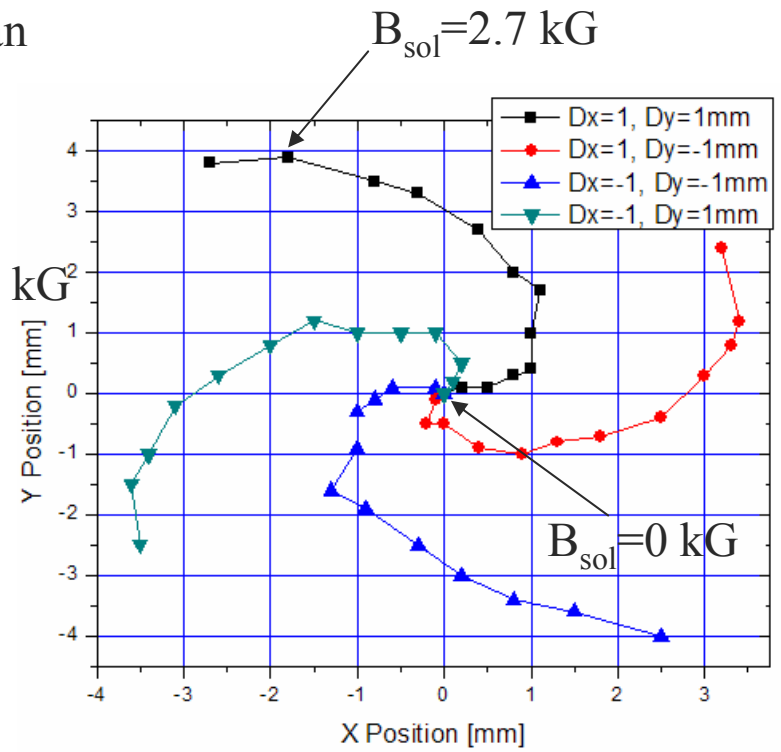
Position dependencies along to solenoid field using by PARMELA

Dx and Dy are solenoid misaligned value according to x and y direction.

@ 4.4 MeV beam energy, 200 pC charge,

Laser beam 3 mm diameter, 10 ps Gaussian



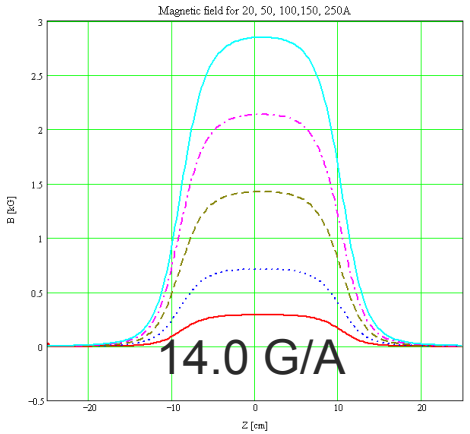


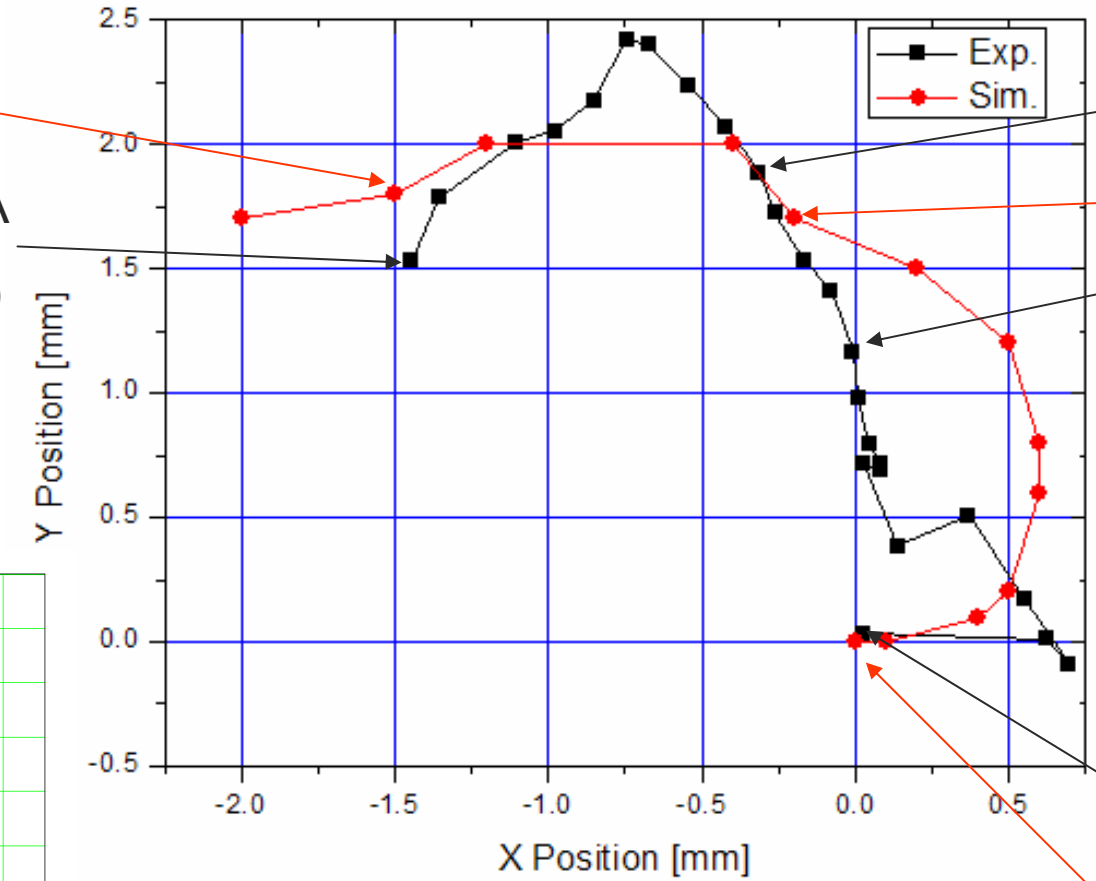
Comparison between experiment and simulation

Dx and Dy are +0.6 mm, respectively.

@ 4.4 MeV beam energy, 200 pC charge,

Solenoid offset : x=0.6 mm, y=0.6 mm according to the simulation





B_{sol}=2.7 kG

I_{sol}=170 A
(2.38 kG)

I_{sol}=110 A
(1.54 kG)

B_{sol}=1.9 kG

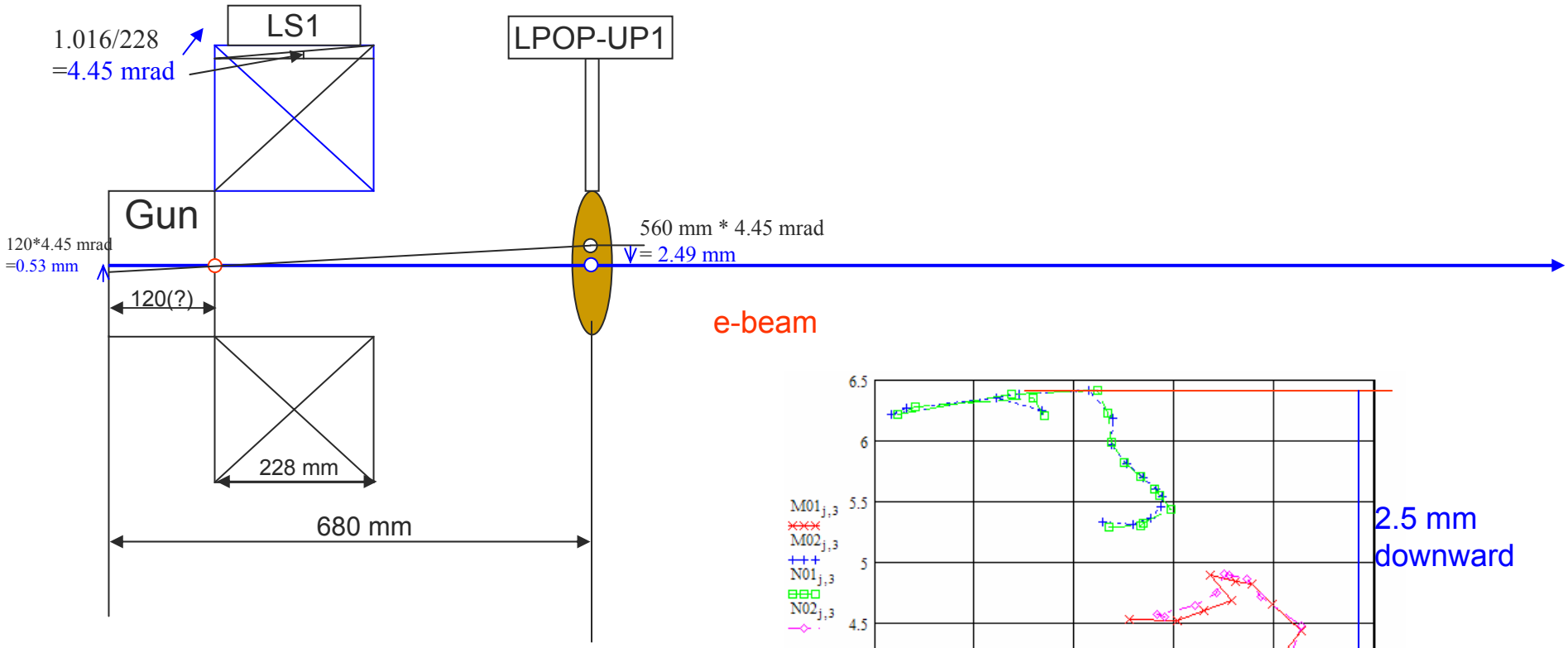
I_{sol}=95 A
(1.33 kG)

I_{sol}=0 A

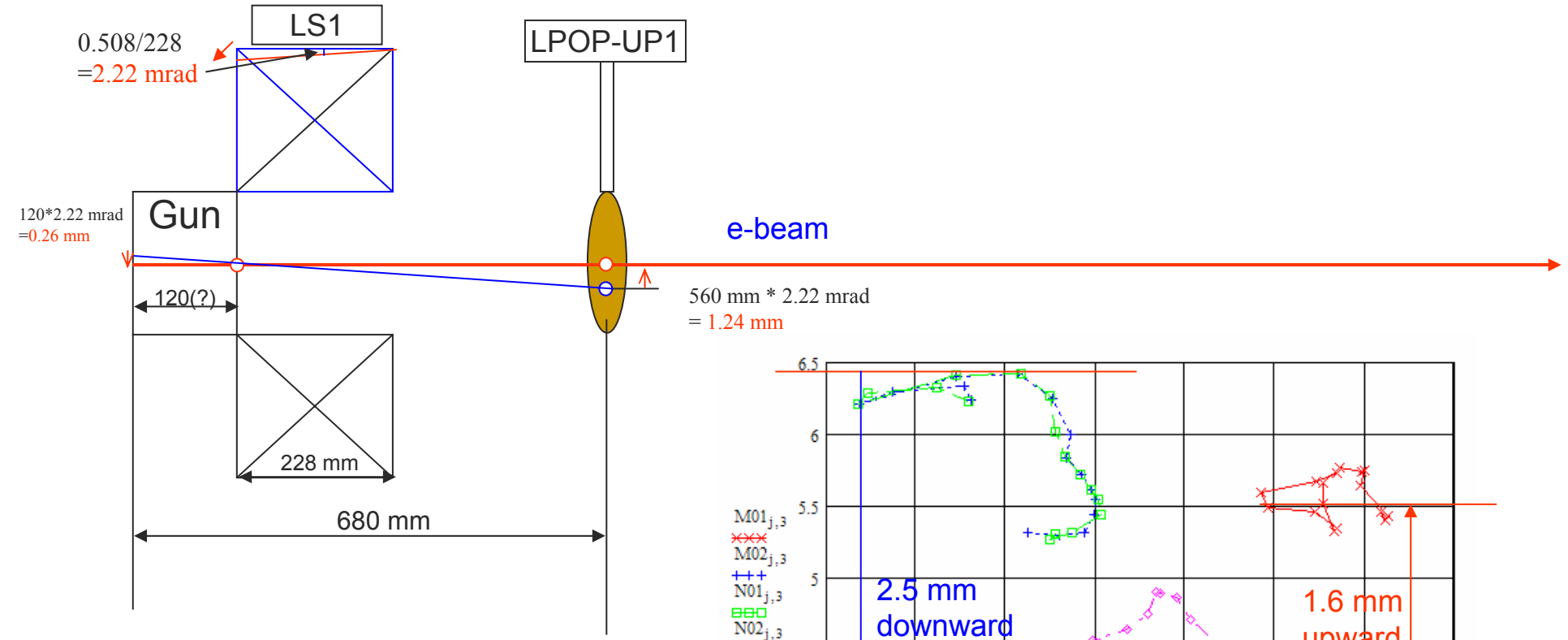
B_{sol}=0 kG

BROOKHAVEN
NATIONAL LABORATORY

First gun moving in vertical



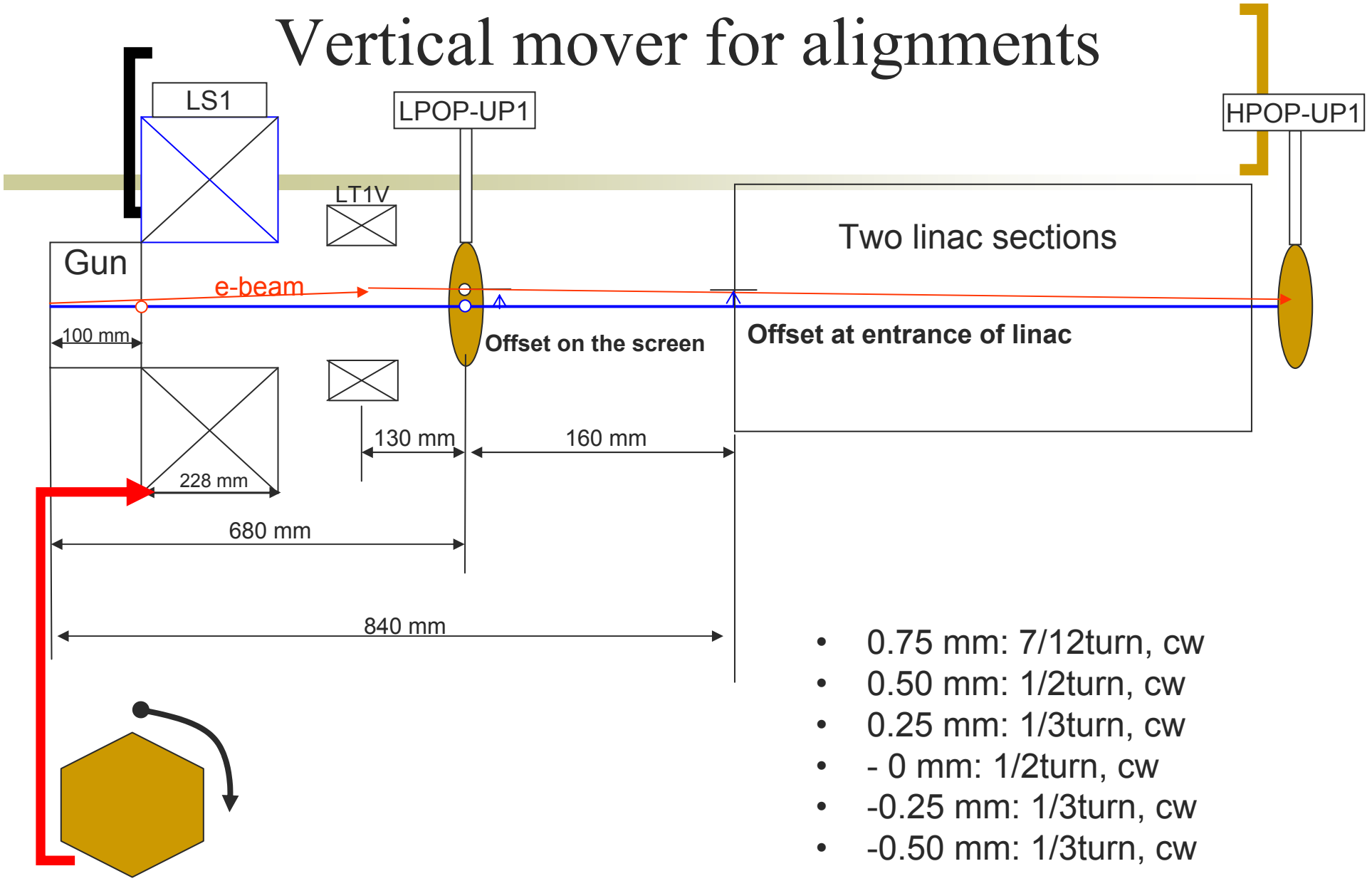
Second gun moving in vertical



Contents

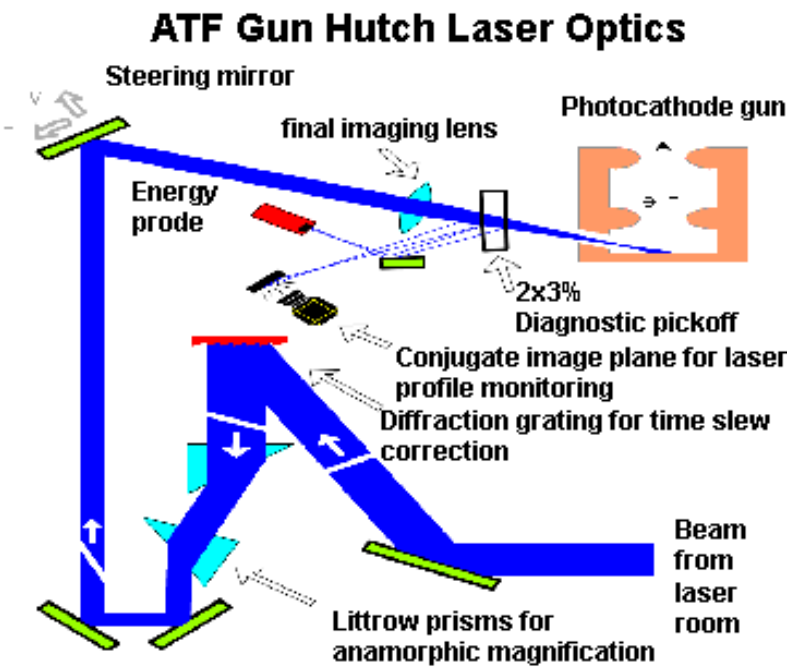
- Introduction
- Beam based alignment
- **Emittance measurement along to misalignment**
- Conclusions

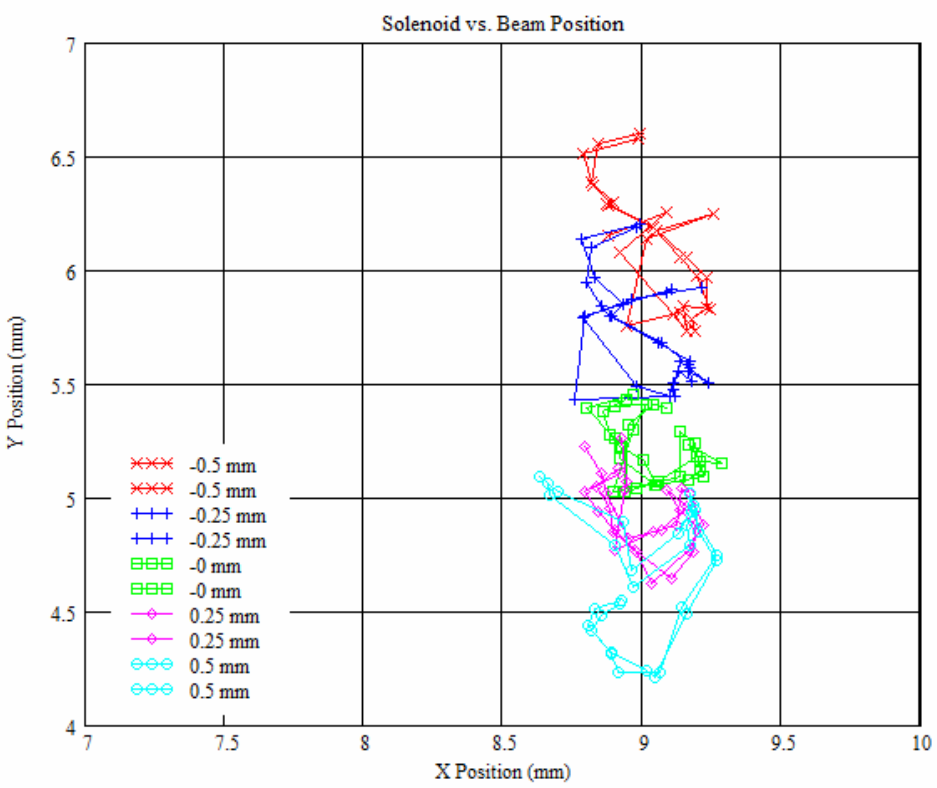
Vertical mover for alignments



- 0.75 mm: 7/12turn, cw
- 0.50 mm: 1/2turn, cw
- 0.25 mm: 1/3turn, cw
- - 0 mm: 1/2turn, cw
- -0.25 mm: 1/3turn, cw
- -0.50 mm: 1/3turn, cw

Solenoid Scan for laser alignments





Solenoid Scan for laser alignments

Emittance effect due to misalignments between Gun and Linac

$$\varepsilon_{n,rms} \cong \sqrt{\varepsilon_{sc}^2 + \varepsilon_{rf}^2 + \varepsilon_{th}^2}$$

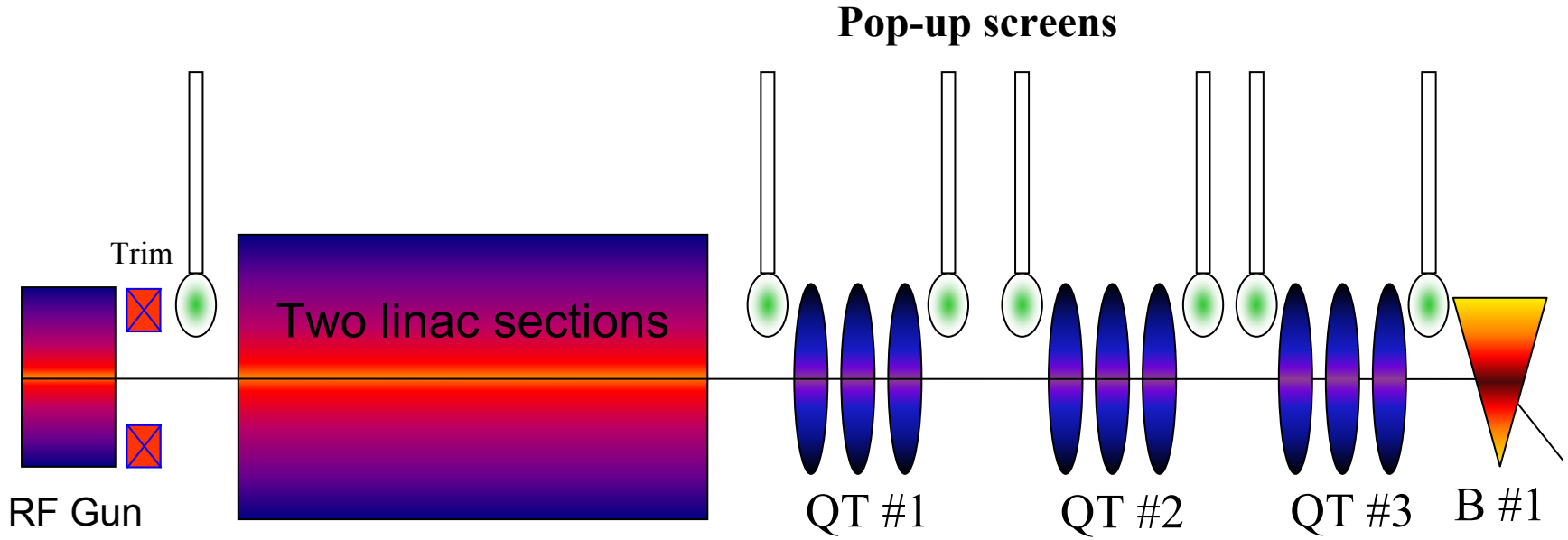
$$\varepsilon_{RF,x} = \frac{\alpha k^3 \sigma_x^2 \sigma_z^2}{\sqrt{2}}, \quad \alpha = \frac{eE_0}{2m_0 c^2 k},$$

$$\Delta\varepsilon := \left(\frac{\theta}{2}\right)^2 \cdot \left(\sigma_z \cdot k_{rf}\right)^2 \cdot \left|\beta_i\right| \cdot \frac{L_{acc} \cdot G}{\alpha} \cdot \left[\left(\frac{\gamma_f}{\gamma_i}\right)^2 - 1\right]$$

f_RF	2.856E+09
E_peak	1.000E+01
e	1.000E+00
mc^2	5.110E-01
c	3.000E+08
alpha	1.636E-01
k	5.982E+01
sigma_t	2.000E-03
sigma_z	2.000E-03
e_vertical	3.961E-07

Theta	0.0005
sigma_z	0.002
ave_beta	0.75
L_acc	6
G	1.957E+01
alpha	0.5
E_ini	5
E_final	60
delta_emitt	3.88199E-07

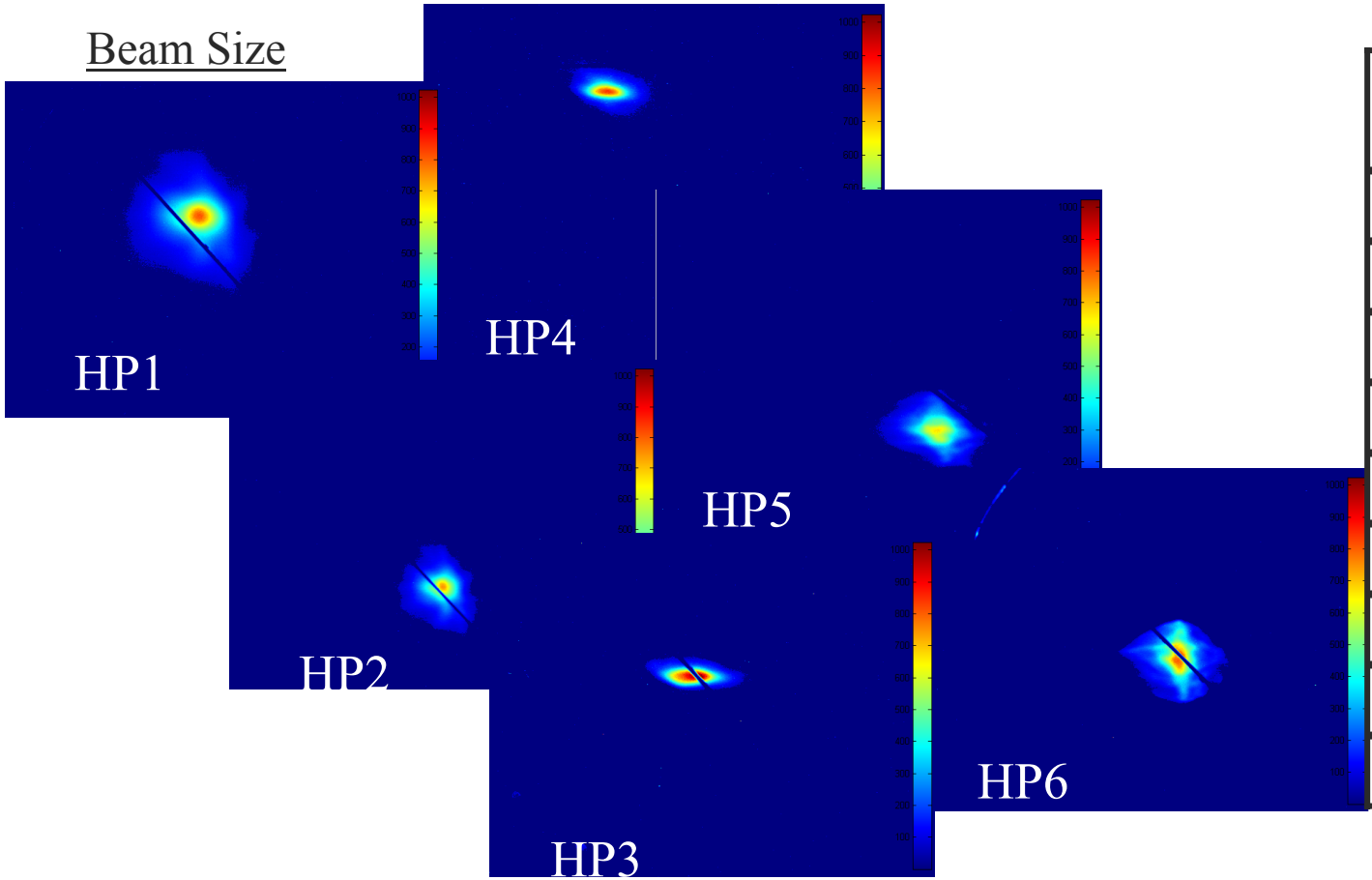
H-Line of the ATF



Schematic layout of the ATF for the experiments (not to scale).

Measured Data

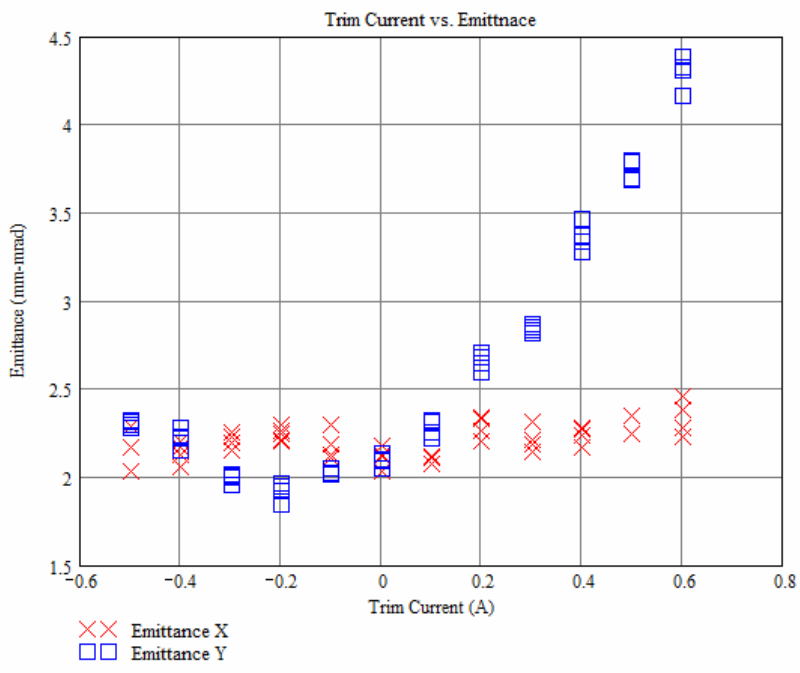
Beam Size



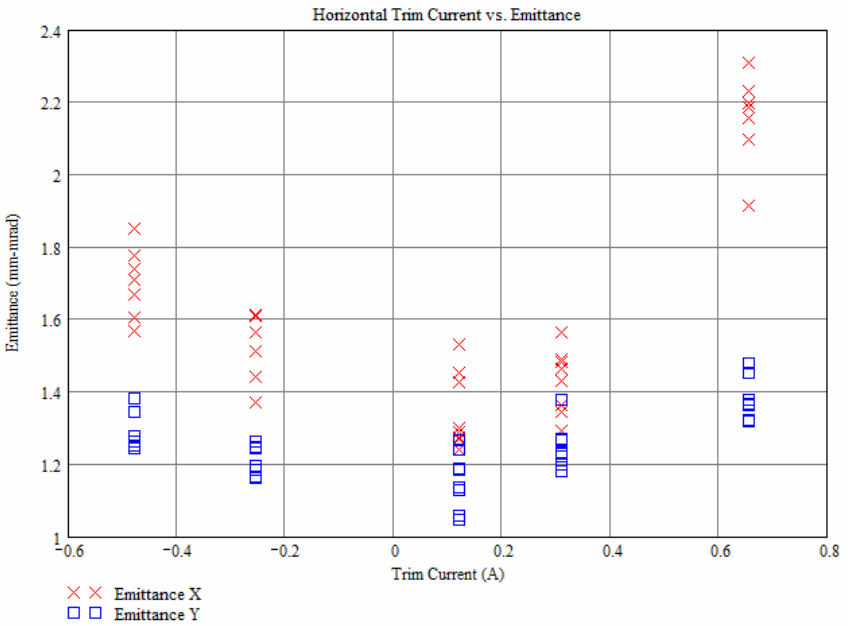
Quad. Current

Quad Name	Current (A)
HQ1	-8
HQ2	-7.3
HQ3	-5.6
HQ4	-10.4
HQ5	11.6
HQ6	-17.6
HQ7	-13.5
HQ8	-8.42
HQ9	16.5

Measured Emittance after the trim current changing

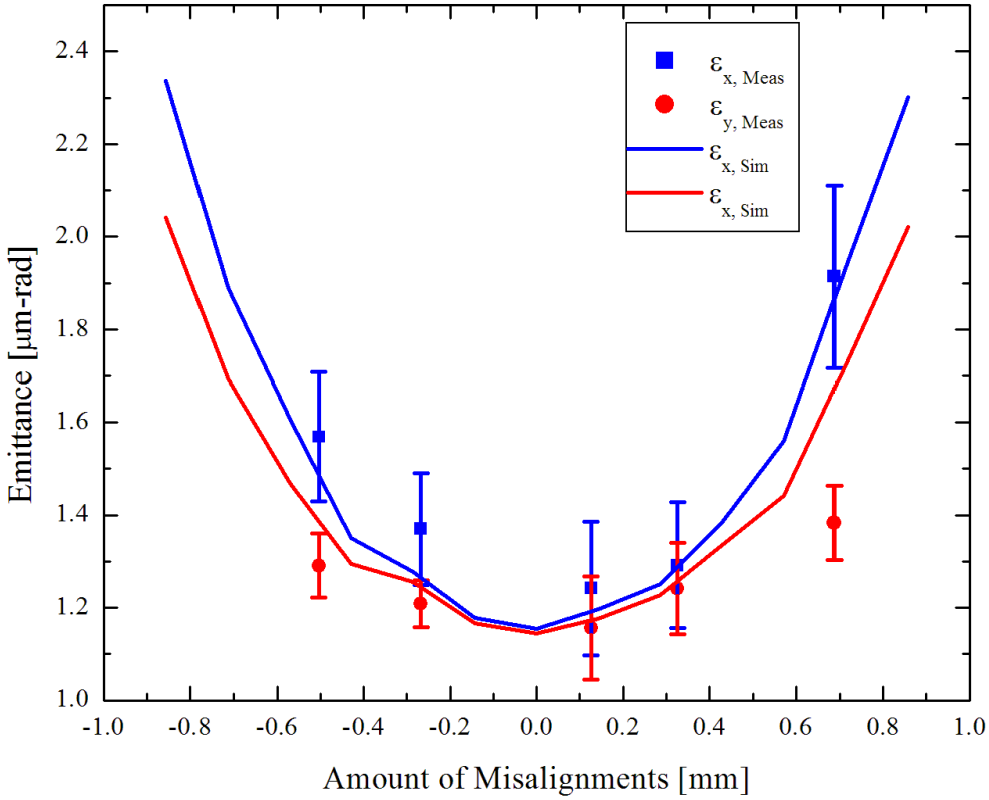


Vertical Trim vs. Emittance



Horizontal Trim vs. Emittance

Measured Emittance



1.6 um rad → 1.2 um rad
30% improvement

Summary

- Beam-based alignment of rf gun could find an misalignment of the laser and the solenoid in the photo-injector.
- Misalignments could dilute the beam emittance
- The beam emittance is improved by the alignments by installation of the gun mover for vertical.
- Horizontal alignment will be consider and install.