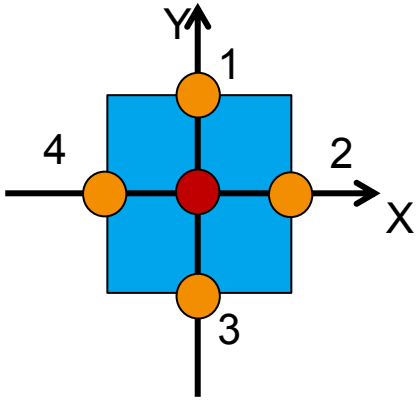
Beam based Gun RF fields asymmetry studies.

Content:

- ✓ **Motivation**
- ✓ **Method**
- ✓ **Experiment data analysis and simulation**
- ✓ **Summary and conclusions**



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PPS, Zeuthen
2016.11.10

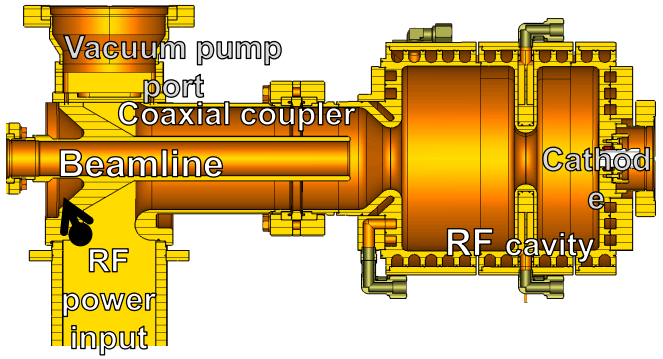
HELMHOLTZ ASSOCIATION

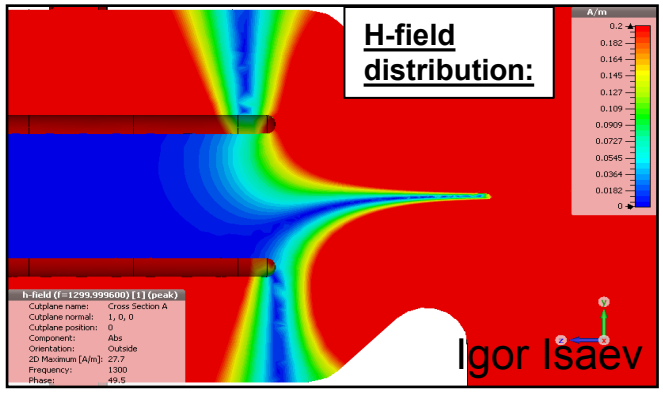
PITZ Photo Injector Test Facility Zeuthen

DESY

Motivation

RF field asymmetry observed from simulation.





#Previous studies results:

- ➢ The rotated quads position and rotation angle were estimated by ASTRA simulation:
- ✓ **Position: around z=0.18m, at the transition region of coupler to gun cavity**
- > **Rotation angle: Skew quads[45 degree (negative polarity) or ~135 degree(positive polarity)].**
- > **Polarity: same, not effected by solenoid field polarity.**
- ✓ Position: around z=0.36m, **near the exit region of the solenoid**
- > Rotation angle: normal quads.
- > Polarity: when change the solenoid polarity, the quads polarity also changed.

Questions:

- > Check the Gun RF field asymmetric or not with beam.
- > If Gun RF field is asymmetirc, what is the strength of the quadrupole component field from this asymmetric RF field?

Method: beam based laser grid experiment

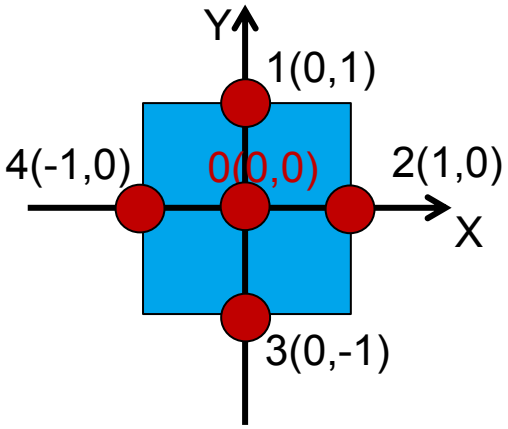
> Laser grid experiment

1 Move the laser position at the cathode at 5 positions (0,1,2,3,4);

2 With each laser position measure the beam position at low.scr1 only with gun field (main and bucking solenoid off).

3 get beam relative position, like 10=1-0, 20=2-0…

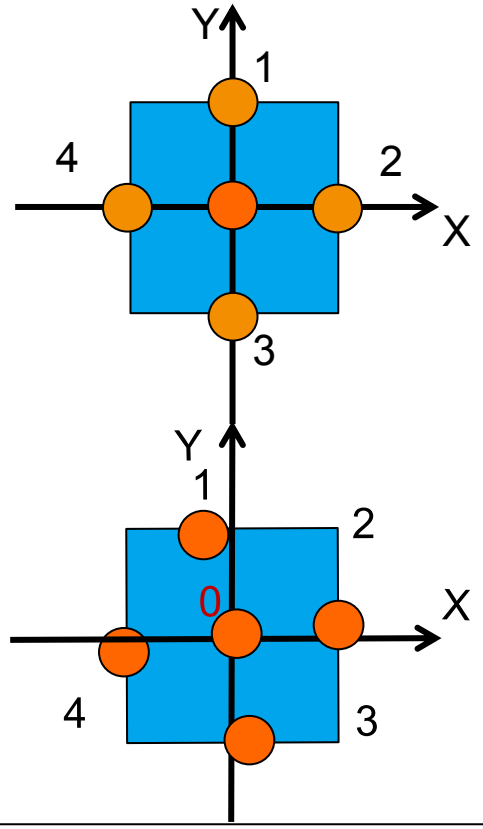
Laser relative positions on the VC2



Gun field symmetric /without X/Y coupling

Gun field asymmetric /with X/Y coupling

Beam relative positions at low. scr1.

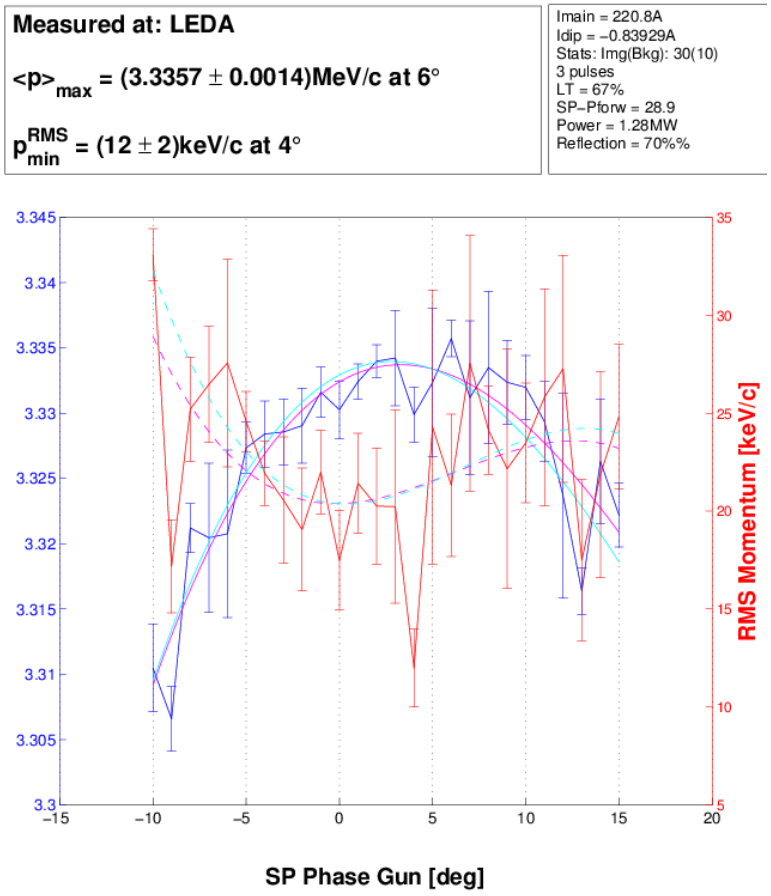


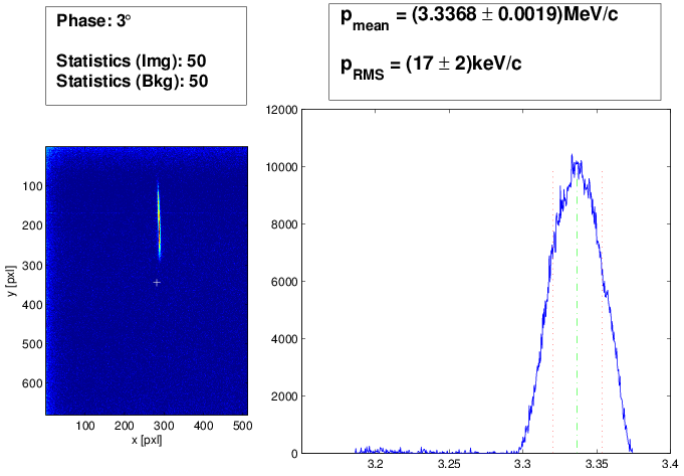
*Assuming our gun alignment is ok.

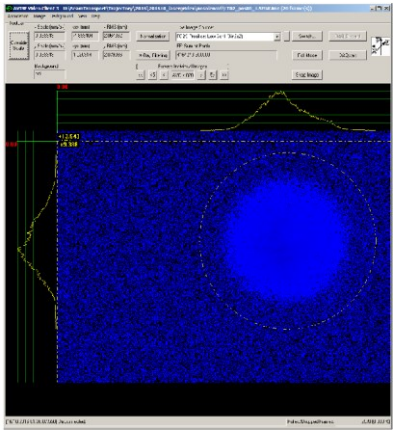
Experiment (1) for different gun power: settings for 1.5 MW

1.5 MW power in the gun(2016.15.10_n shift)
BSA0.9mm, laser spot size xrms 0.201mm, yrms 0.215mm
Laser transmission 2%, charge ~15 pC

3.3368MeV/c➔28.605MV/m





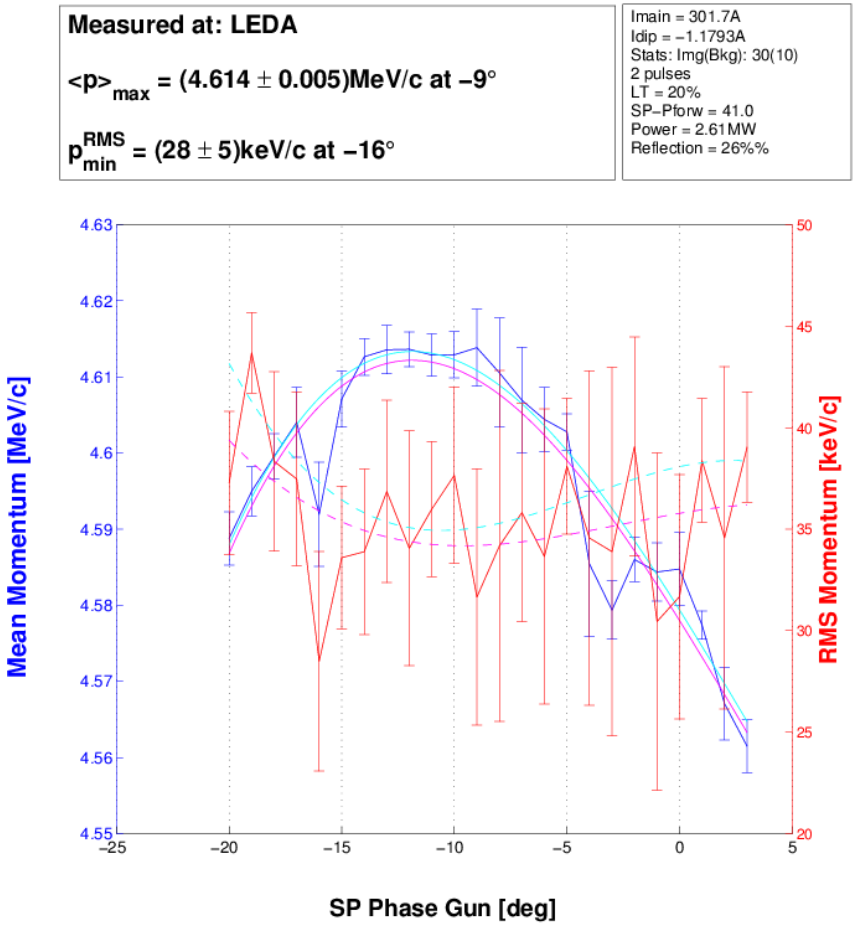


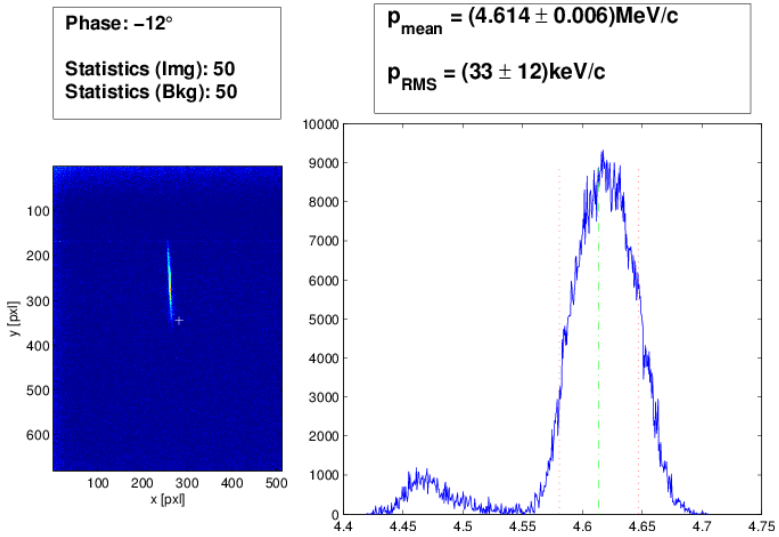
1.5 MW in the gun, Laser position(0,0), beam distribution at low scr1

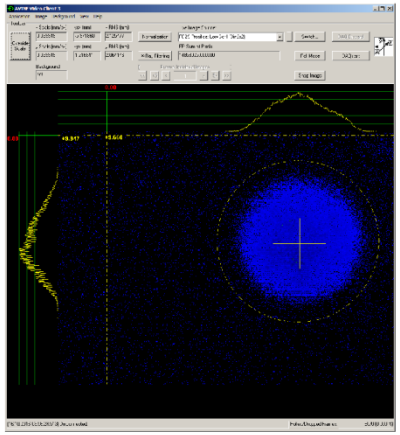
Experiment (1) for different gun power : settings for 3 MW

3 MW power in the gun(2016.15.10_n shift)
BSA0.9mm, laser spot size xrms 0.201mm, yrms 0.215mm
Laser transmission 3%, charge ~25 pC

4.614MeV/c➔40.87MV/m

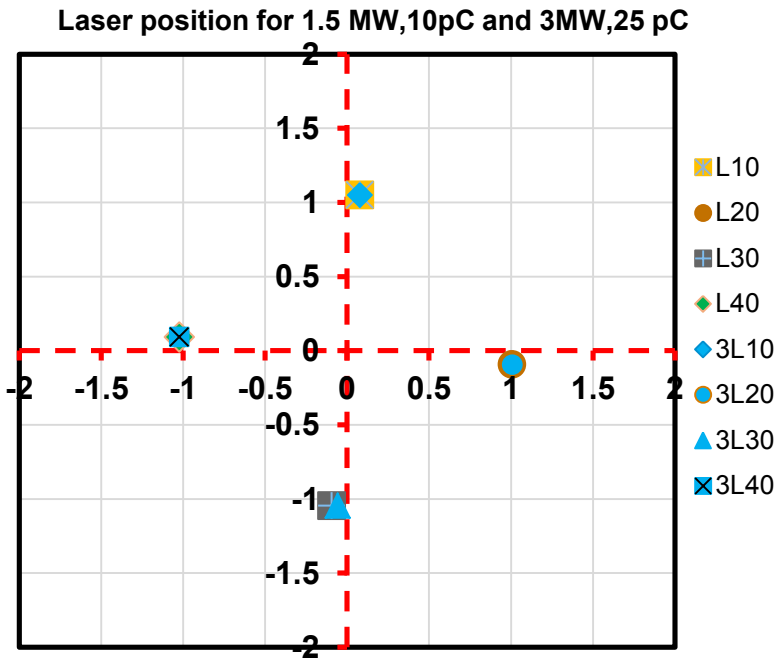


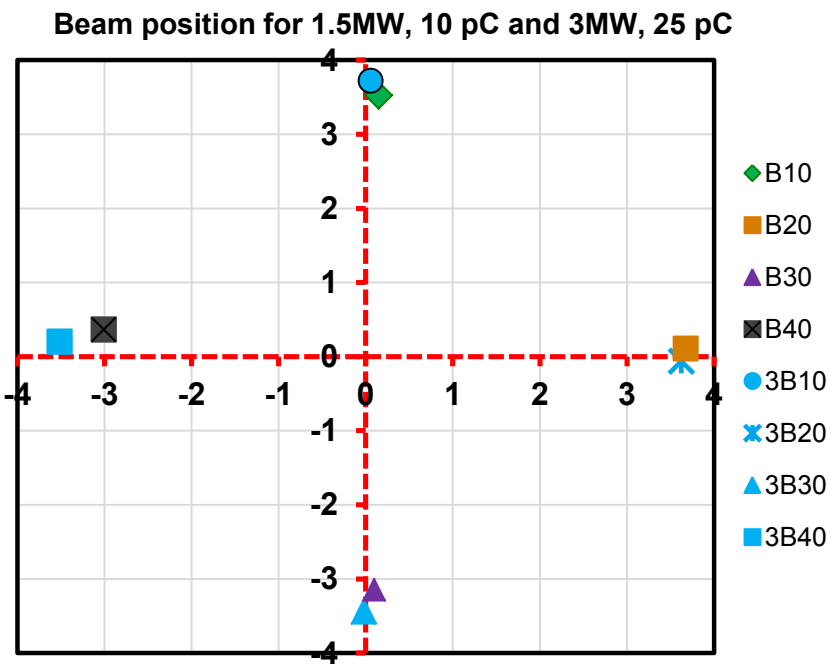




3 MW in the gun
Laser position(0,0),
beam distribution at
low scr1

Experiment(1) results: compare results for 1.5 MW and 3MW





laser relative position for 1.5 MW -3 MW

laser position difference	Deltx/mm	Delty/mm
L10-3L10	-0.012	-0.001
L20-3L20	-0.009	0.012
L30-3L30	-0.003	-0.006
L40-3L40	-0.01	0.004

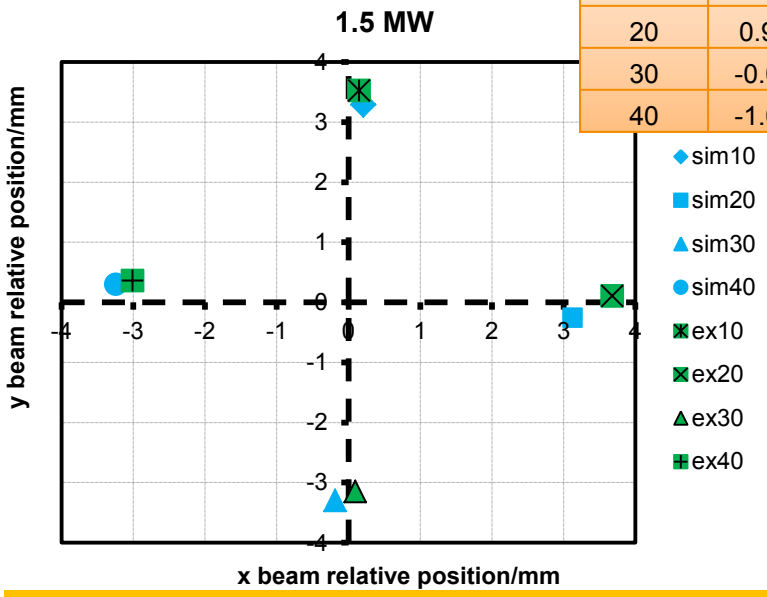
Beam relative position 1.5 MW -3 MW

beam position 1.5MW-3MW	Deltx/mm	Delty/mm
B10-3B10	0.094	-0.196
B20-3B20	0.054	0.168
B30-3B30	0.117	0.29
B40-3B40	0.505	0.163

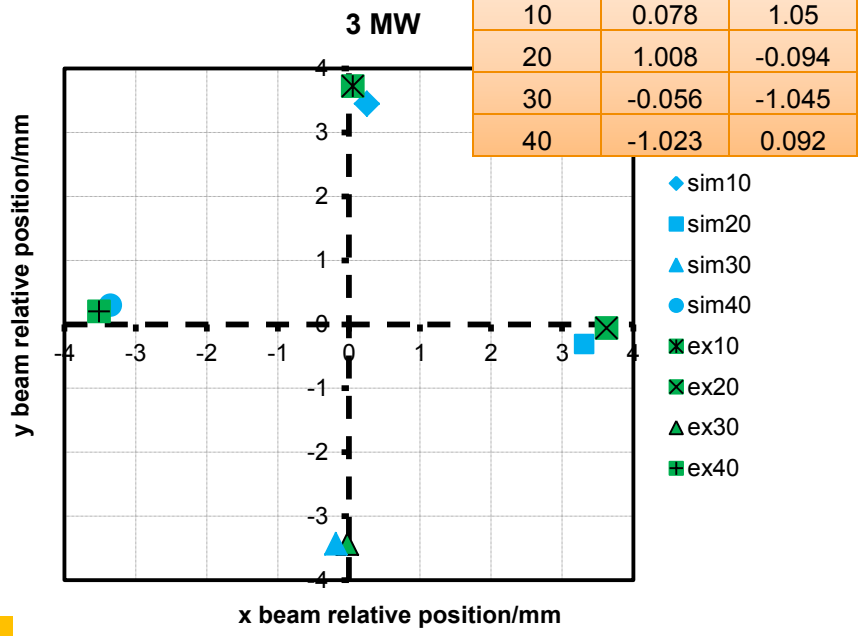
Experiment(1) results and simulation

Simulation with experimental laser position:

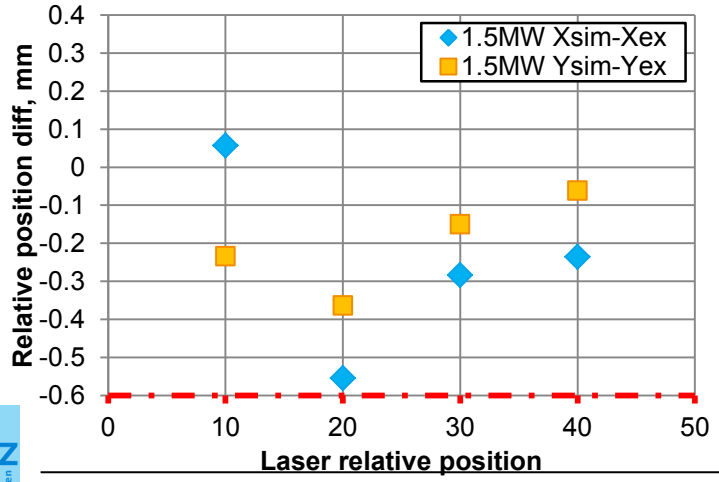
Laser 1.5	<x>	<y>
10	0.066	1.049
20	0.999	-0.082
30	-0.059	-1.051
40	-1.033	0.096

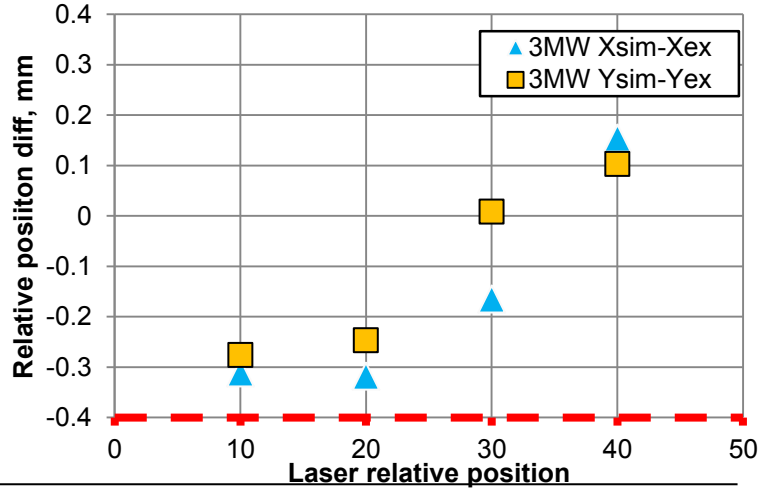


Laser 3	<x>	<y>
10	0.078	1.05
20	1.008	-0.094
30	-0.056	-1.045
40	-1.023	0.092



Beam position difference analysis from simulation and experiment





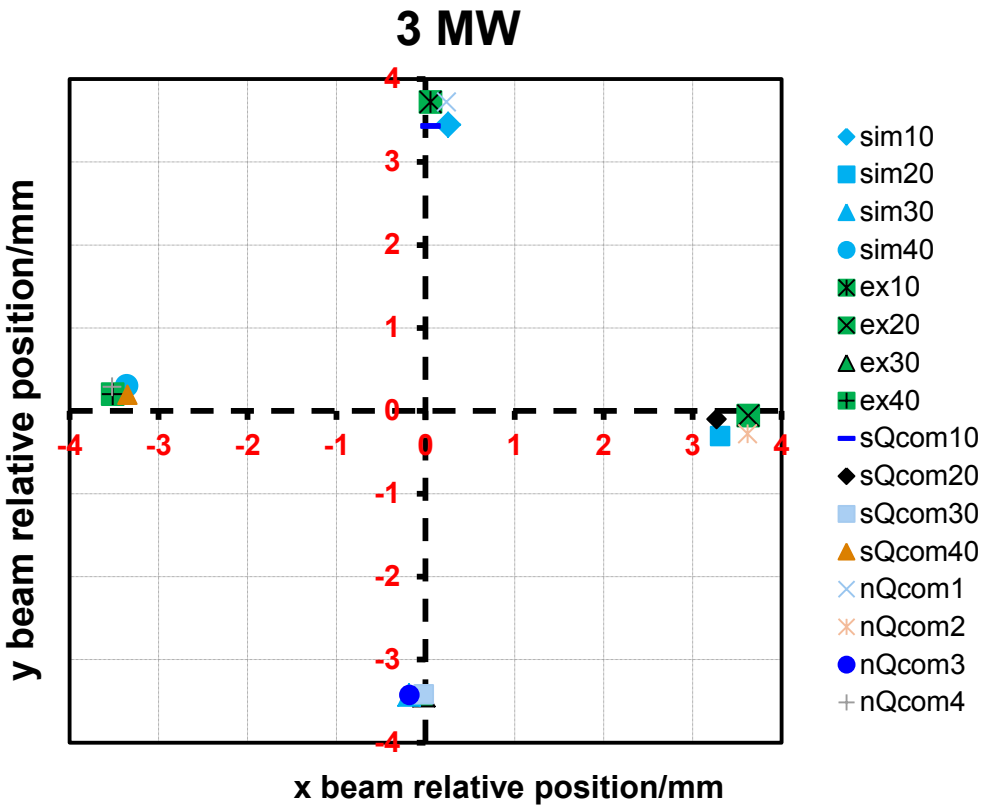
Quads like field behavior on the beam position

3.0 MW compensation with single norm quads or skew quads						
	skew field/T/m	sim_sQx	sim_sQy	normal fields/T/m	sim_nQx	sim_nQy
10	0.139	0.058	3.43	-0.19	0.236	3.72
20	0.3	3.27	-0.101	-0.226	3.62	-0.28
30	0.116	-0.019	-3.42	0.006	-0.18	-3.43
40	0.0798	-3.348	0.192	0.116	-3.519	0.287

Laser relative position:

	<x>	<y>
10	0.078	1.05
20	1.008	-0.094
30	-0.056	-1.045
40	-1.023	0.092

Quads length 0.01m

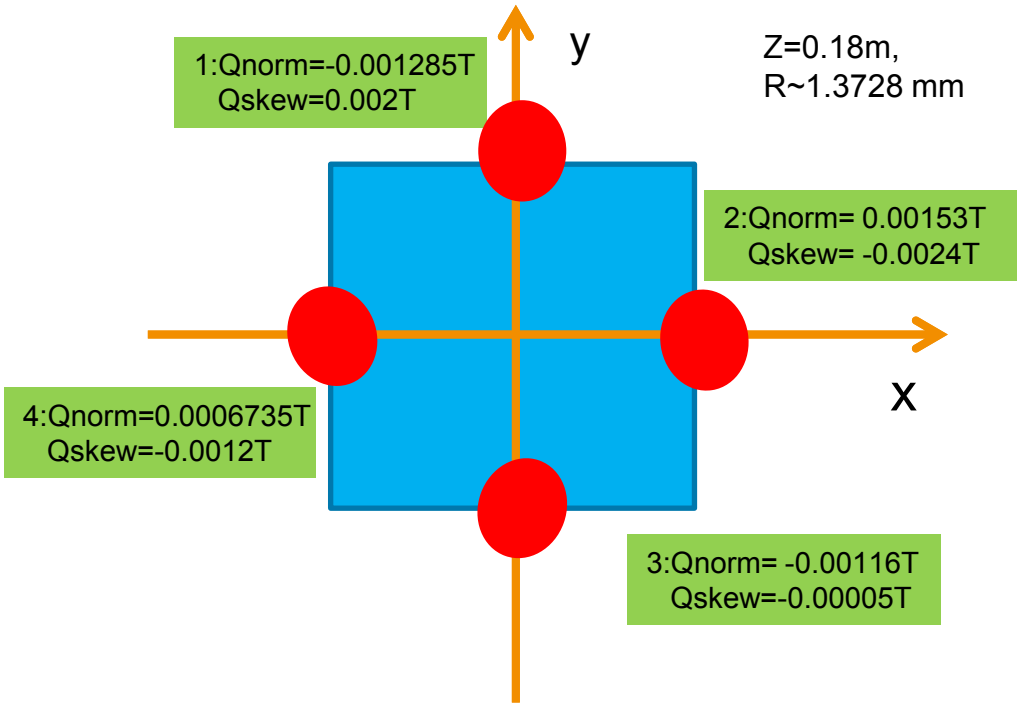


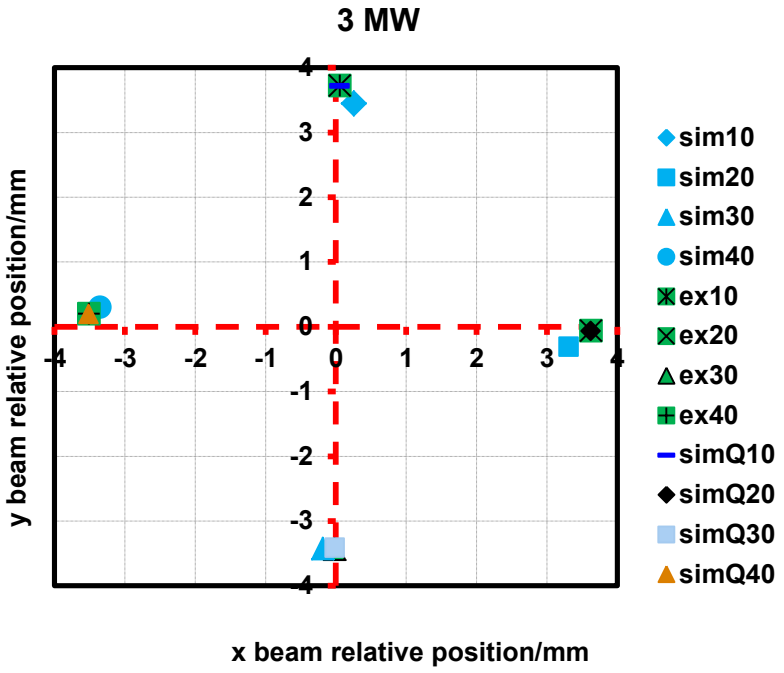
- From previous studies Assuming the asymmertic RF field are quads like field.
- Rotated quads can be decomposed into Normal quads and skew quads.

- Quads like field behavior observed by simulation:
  Skew quads: like rotating
  Norm quads: like scaling.

Quads like fields estimated for 3MW

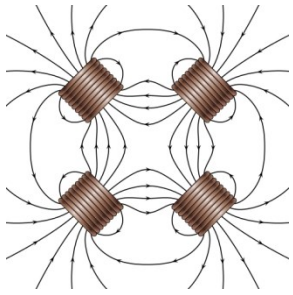
Gun field asymmetry estimated from simulation for 3 MW :



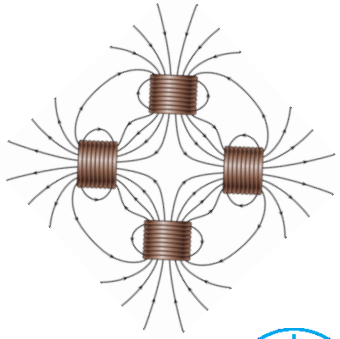


3MW quads com	Skew /[T/m]	Normal/[T/m]	simQX	simQY	exX	exY
10	-0.1285	0.2	0.052	3.72	0.056	3.722
20	0.153	-0.24	3.62	-0.068	3.627	-0.062
30	-0.116	-0.005	-0.019	-3.414	-0.019	-3.438
40	0.06735	-0.12	-3.516	0.194	-3.512	0.199

Normal Quads



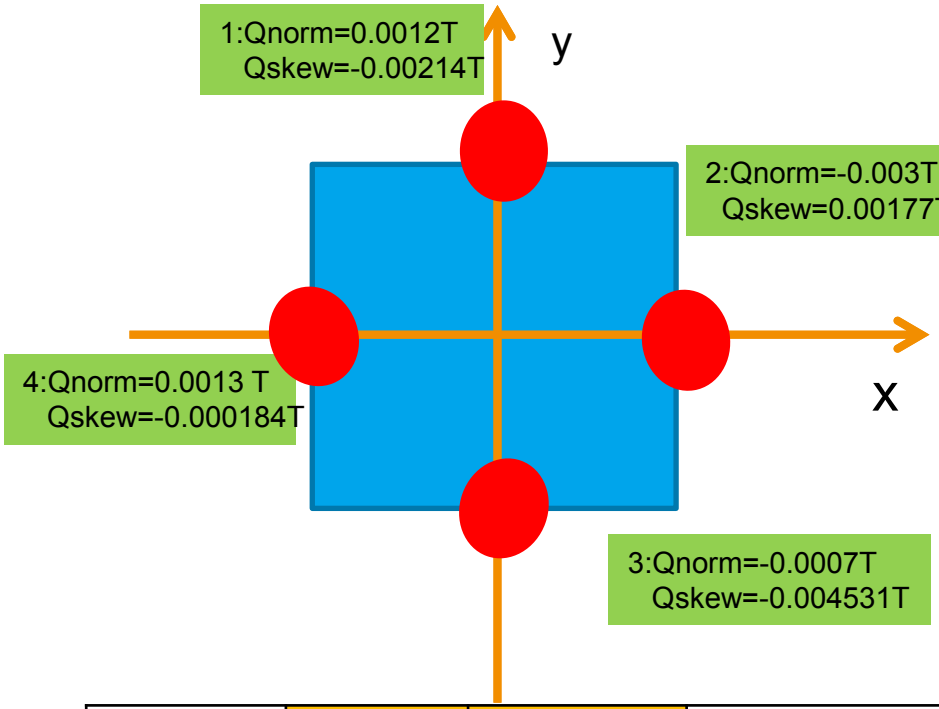
Skew Quads

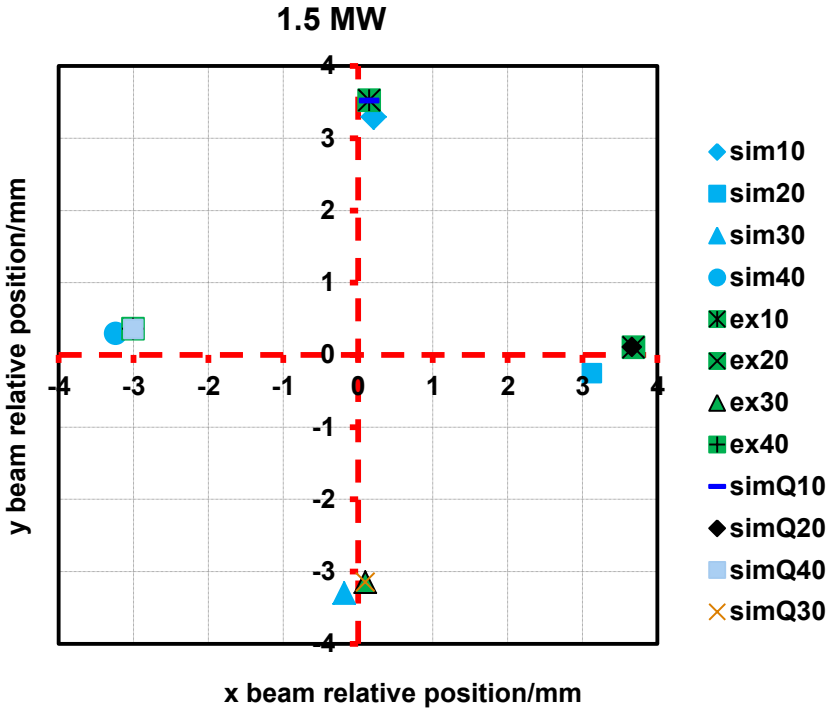


*Pic from WIKI

Quads like fields estimated for 1.5 MW

Gun field asymmetry estimated from simulation for 1.5 MW :





1.5MW quads com	Skew fields/[T/m]	normal fields/[T/m]	simQX	simQY	exX	exY
10	-0.0214	0.12	0.15	3.5189	0.15	3.526
20	0.177	-0.3	3.658	0.1096	3.681	0.106
30	-0.1531	-0.07	0.0998	-3.149	0.098	-3.148
40	-0.0184	0.13	-3.002	0.358	-3.007	0.362

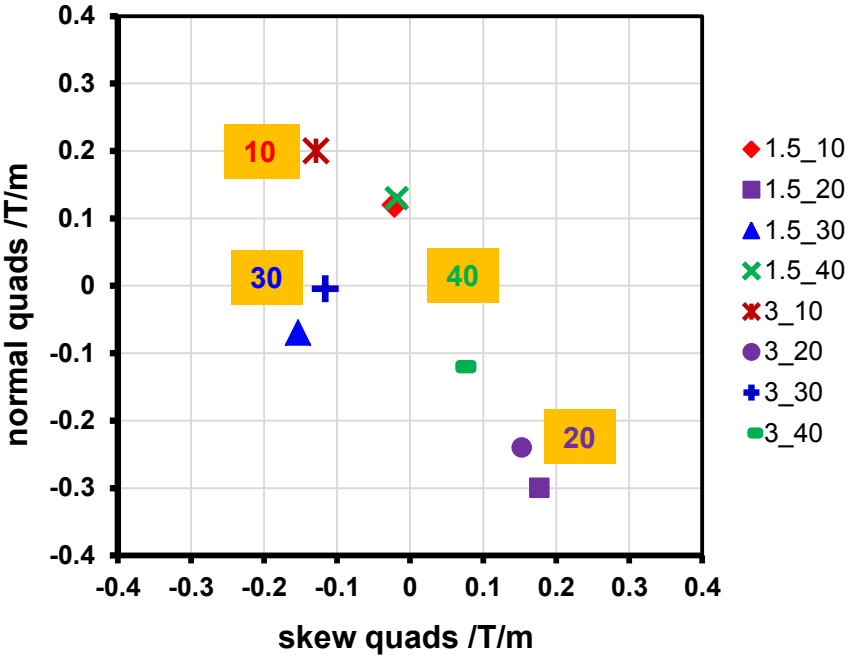
Asymmtric fields analysis for 3MW and 1.5 MW

3MW quads com	Skew /[T/m]	Normal/[T/m]	simQX	simQY	exX	exY
10	-0.1285	0.2	0.052	3.72	0.056	3.722
20	0.153	-0.24	3.62	-0.068	3.627	-0.062
30	-0.116	-0.005	-0.019	-3.414	-0.019	-3.438
40	0.06735	-0.12	-3.516	0.194	-3.512	0.199

1.5MW quads com	Skew /[T/m]	normal /[T/m]	simQX	simQY	exX	exY
10	-0.0214	0.12	0.15	3.5189	0.15	3.526
20	0.177	-0.3	3.658	0.1096	3.681	0.106
30	-0.1531	-0.07	0.0998	-3.149	0.098	-3.148
40	-0.0184	0.13	-3.002	0.358	-3.007	0.362

3MW-1.5MW		
	skew quads diff T/m	normal quads diff T/m
10	-0.1071	0.08
20	-0.024	0.06
30	0.0371	0.065
40	0.08575	-0.25

10 the quads strength for 3 MW are higher than 1.5 MW, But for other position the quads stength for 1.5 MW are close or even a bit higher.



- Asymmtric fields are not scaled with different gun power from simulation, Is it time dependent?

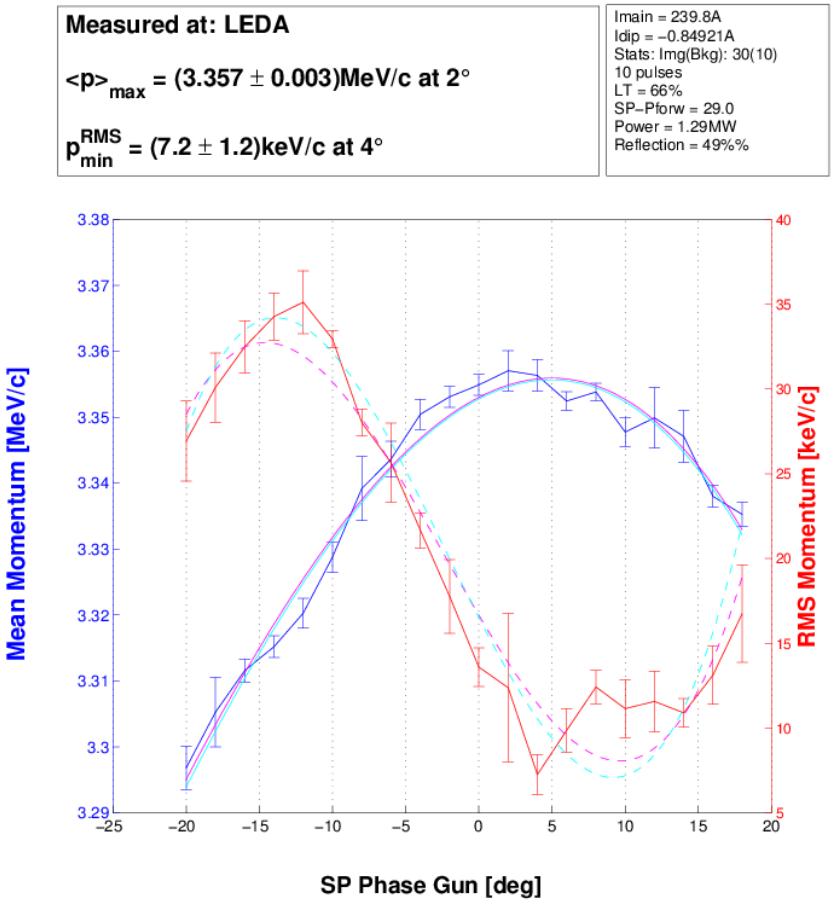
  MMMG phase different:
  1.5 MW: 3 degree
  3 MW: -12 degree

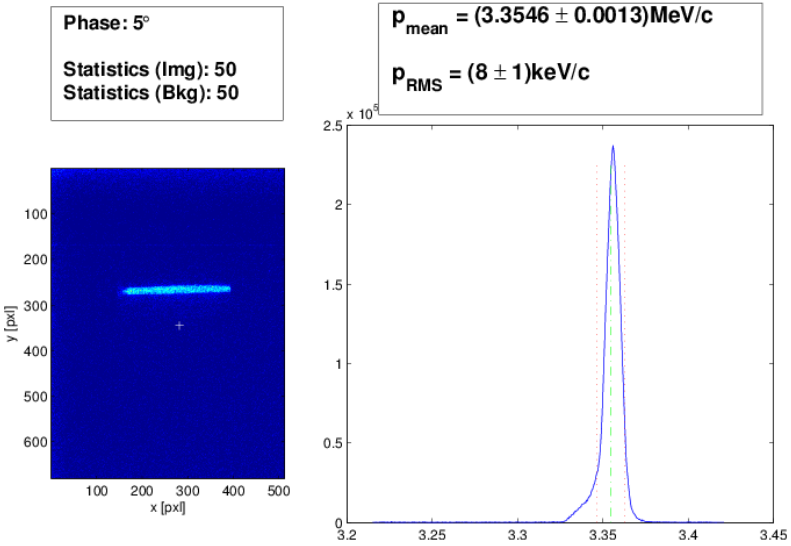
- The quads like field strength is on the order of ~10e-3T for 1.5 MW and 3 MW in the gun.

Experiment (2):different Gun phase, 1.5 MW

1.5 MW power in the gun
BSA 0.9 mm, laser spot size xrms 0.201mm, yrms 0.215mm
Laser transmission 2%, charge ~10 pC

3.3546MeV/c➔28.78MV/m





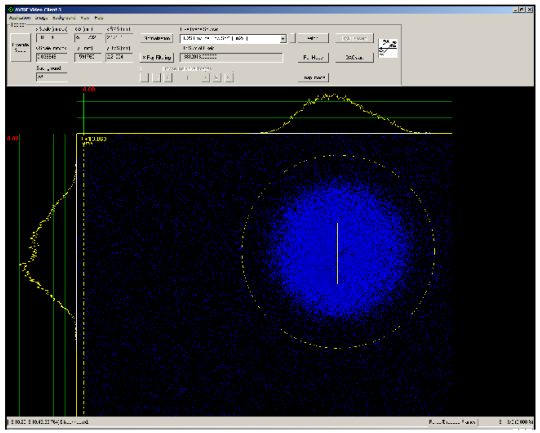
- For each laser position, scan the gun phase to get the beam position at low.scr1.

The Gun phase effect on the beam position.

From experiment.

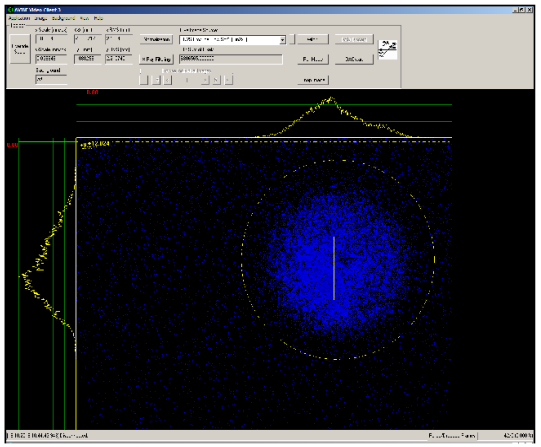
1.5MW, no solenoid, laser_pos0,GUN phase at MMMG-30 degree (-25 degree)

<x>=-5.229m
<y>=1.592mm
xrms=2.172mm
yrms=2.216mm

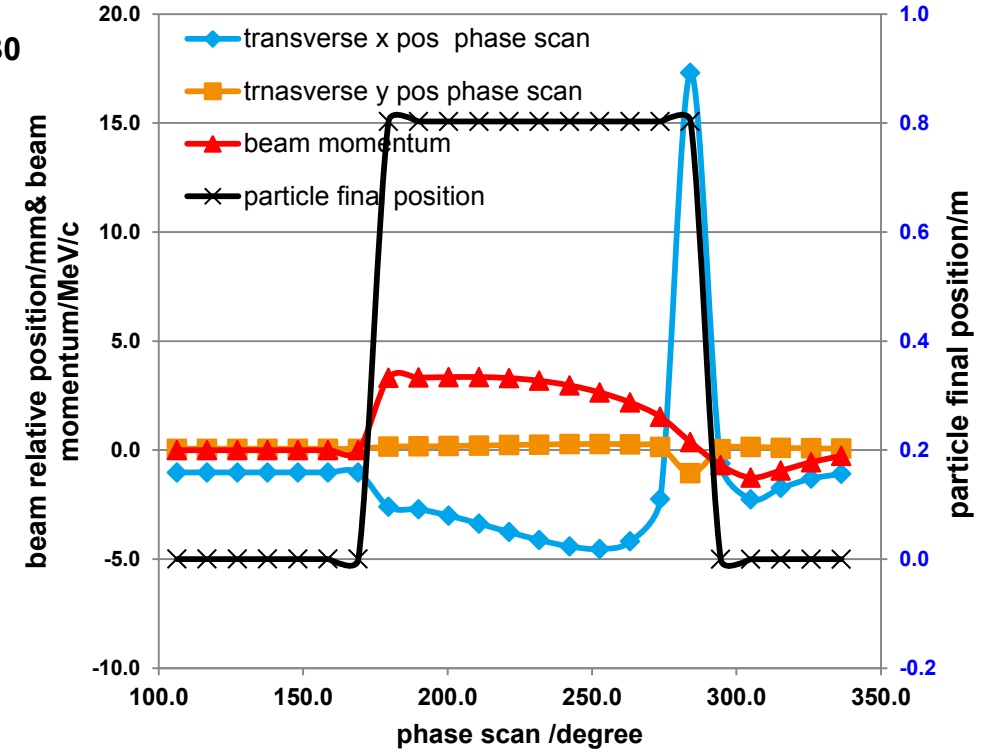


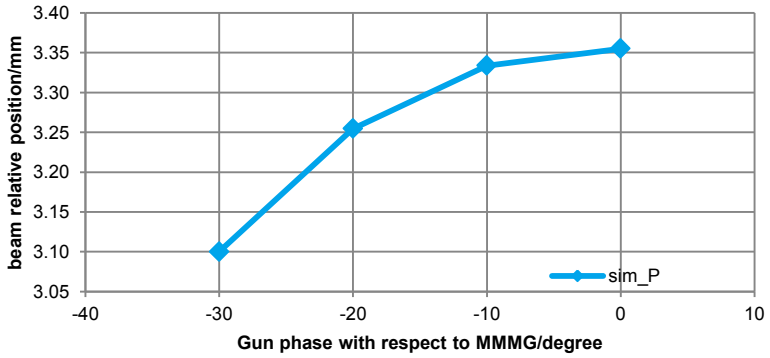
1.5MW, no solenoid, laser_pos0,GUN phase at MMMG(+5degree)

<x>=-4.997m
<y>=1.088mm
xrms=2.133mm
yrms=2.216mm

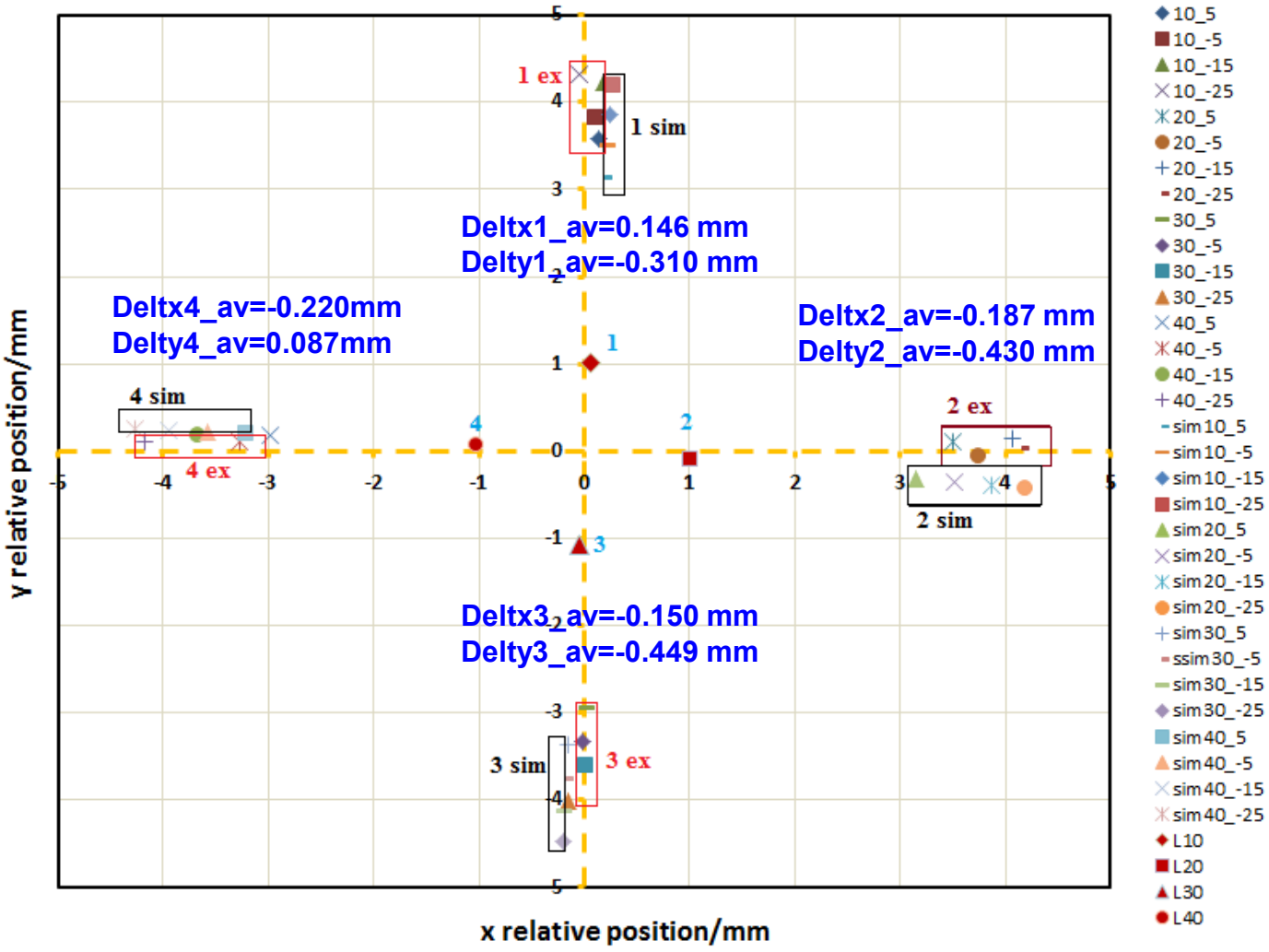


From simulation, pos40,xoff=-1.024mm, yoff=0.063mm





Experiment(2) results: comparing with simulation results



laser	<x>	<y>
10	0.065	1.004
20	1.006	-0.101
30	-0.048	-1.073
40	-1.024	0.063

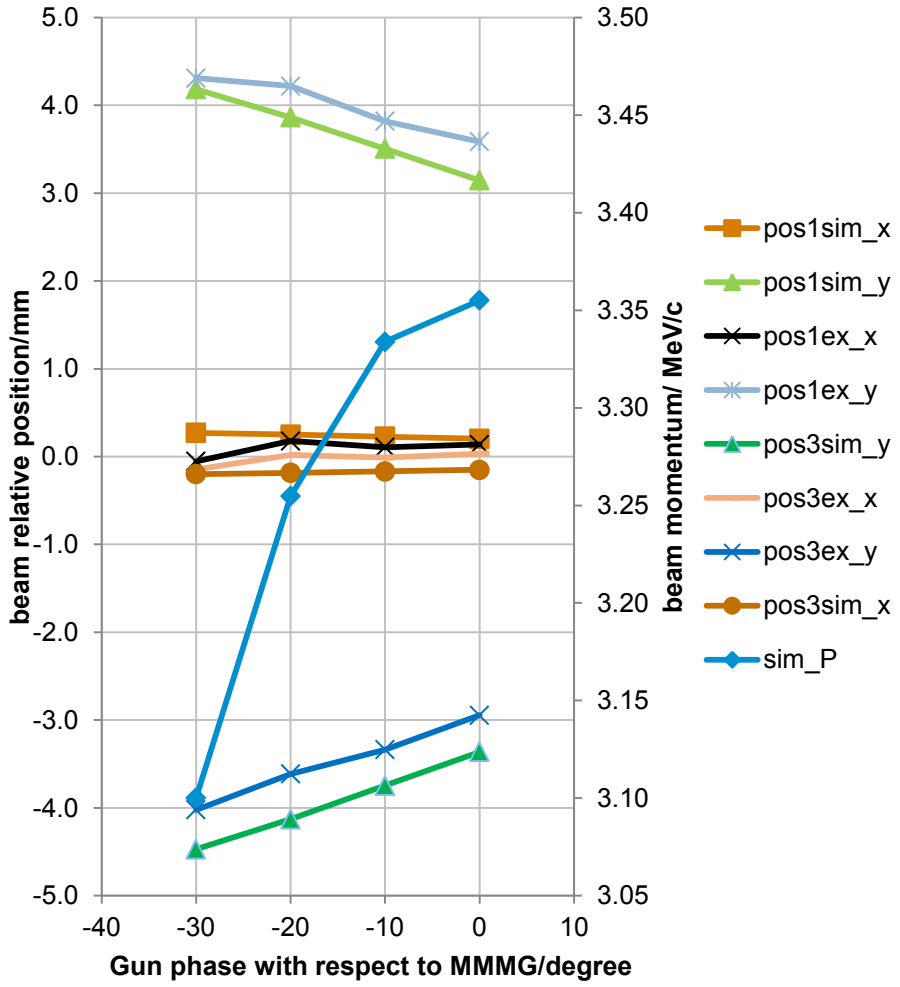
Deltx=ex_X-sim_X
Delty=ex_Y-sim_Y

➢ Confirm the Gun RF fields are asymmertic!

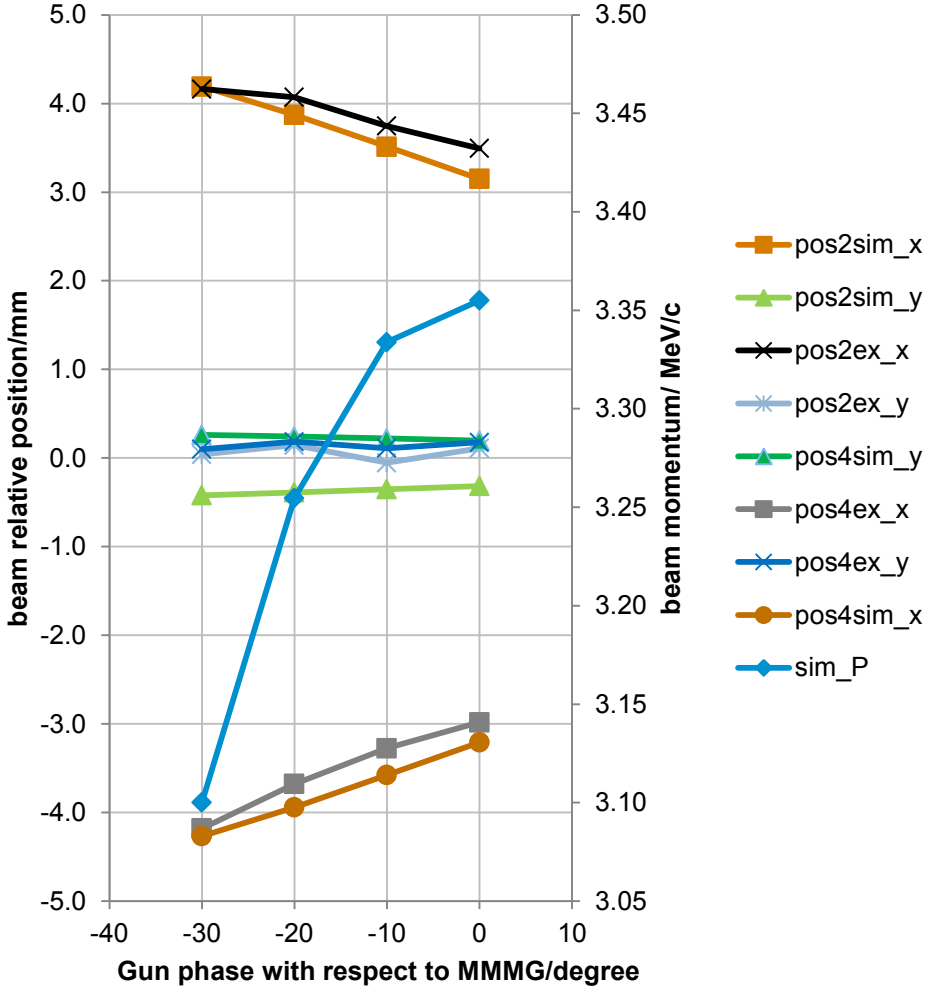
➢ The phase for position from small to big is from MMMG phase -10 degree step.

Gun Phase effect on the beam relative position compared with simulation

Pos1&3: Move laser vertically



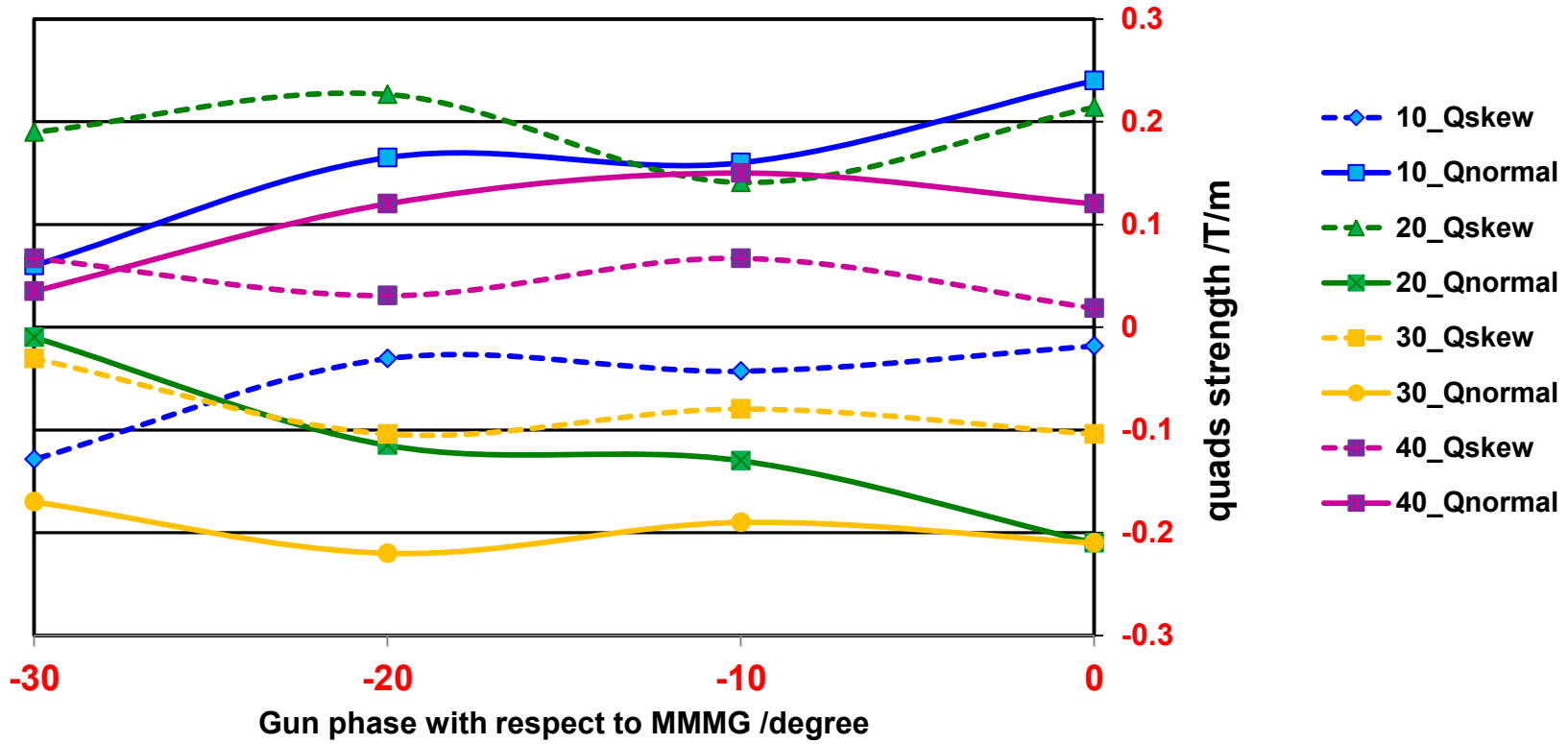
Pos2&4: Move laser horizontally



- Different beam relative positions are observed for phase scan compared with simulation.

Quads like fields estimated for the experiment(2)

Quads like fields strength from simulation for fitting to the experiment results, quads length 1cm.



For same phase, the skew quads and normal quads are different for different laser position,

➔The quads like field are irregular, transversely distribution is not asymmetric.

For different phase at same laser position, the quads like field is also different, specially for pos20 and pos40.

➔It seems the quads like fields are time dependent.

Summary and conclusions

- Gun RF field asymmetry was observed by laser grid experiment compared with simulations.

➔From two experiments, the RF field asymmetry can be confirmed.

- From data analysis, the rotated-quads like field from RF fields is also asymmetric. At each laser position, use a pair of skew and normal quads (rotated quads) can fit the beam position to experiment. It also seems these quads like fields are time dependent.
- The quads like field strength for gun 1.5 MW and 3 MW is on the orders of ~10e-3 T, assuming at position z=0.18 m.

Next step:

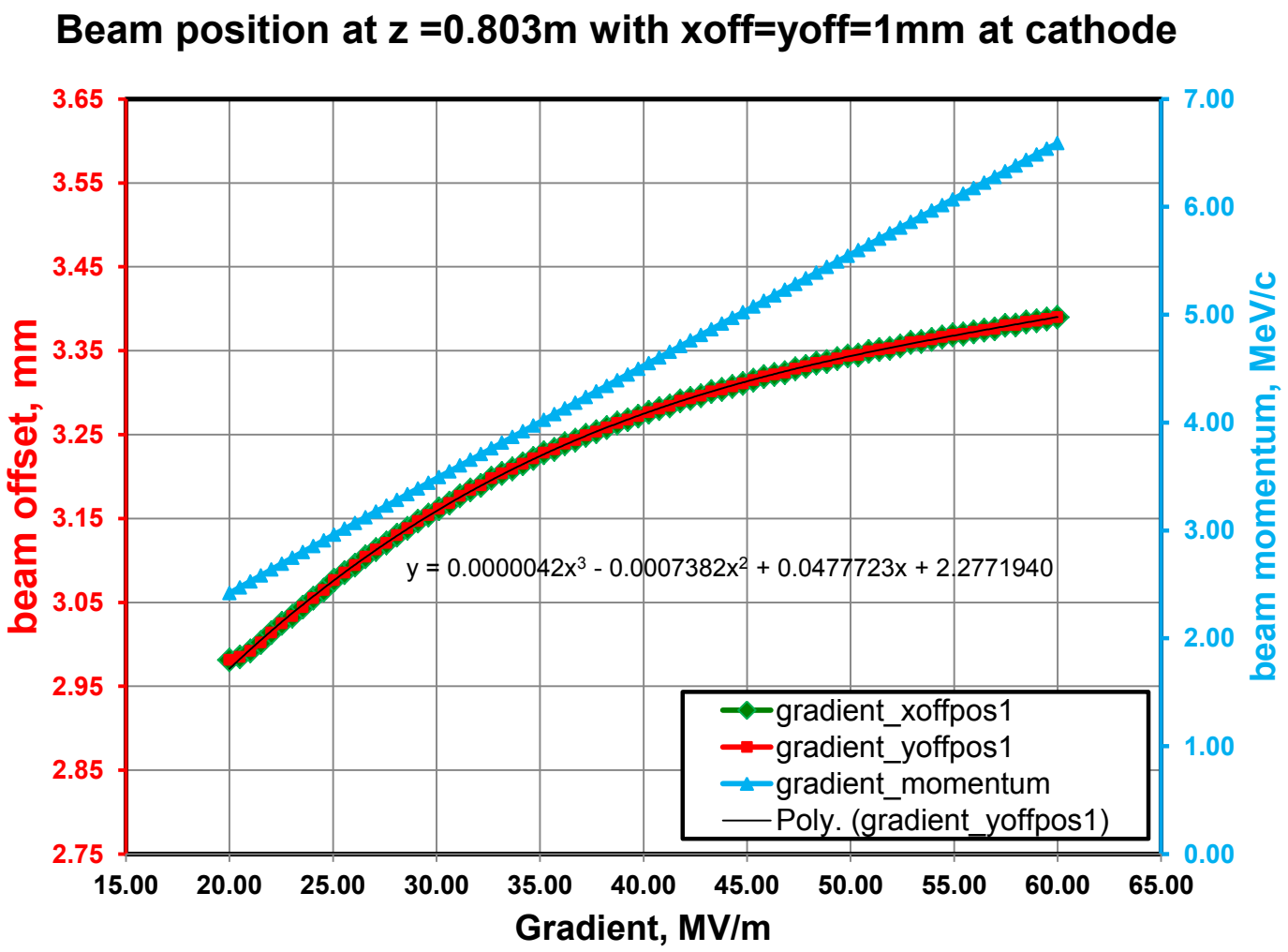
Finish the laser grid experiment data analysis for 3MW and 5MW with solenoid.

➔ongoing

?More:

Lase grid experiment with designed compensation quads…

Beam offset position as function of the gun gradient



Beam offset as a function of the gun gradient (momentum) looks like sine function.