Non-magnetized beam performance of RHIC electron cooling injector

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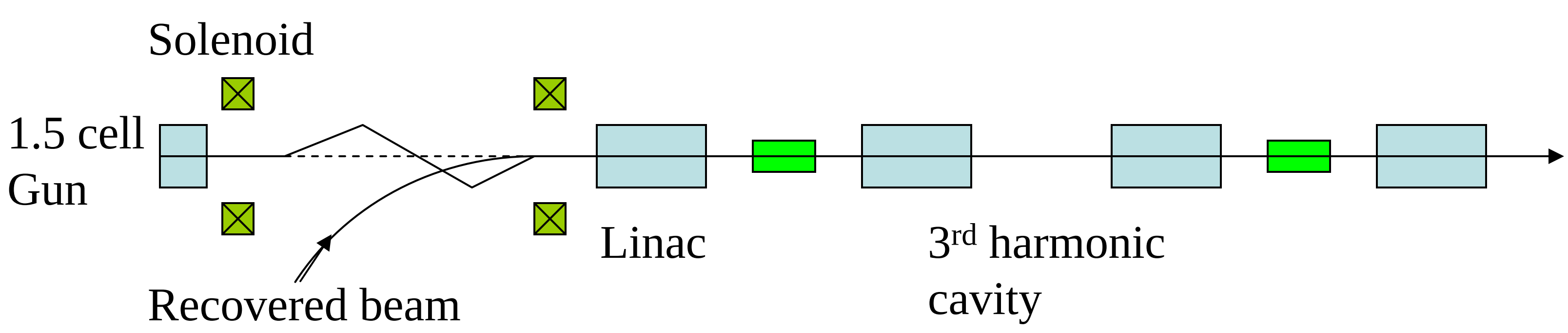
Requirements of RHIC e-cooling for a non-magnetized beam

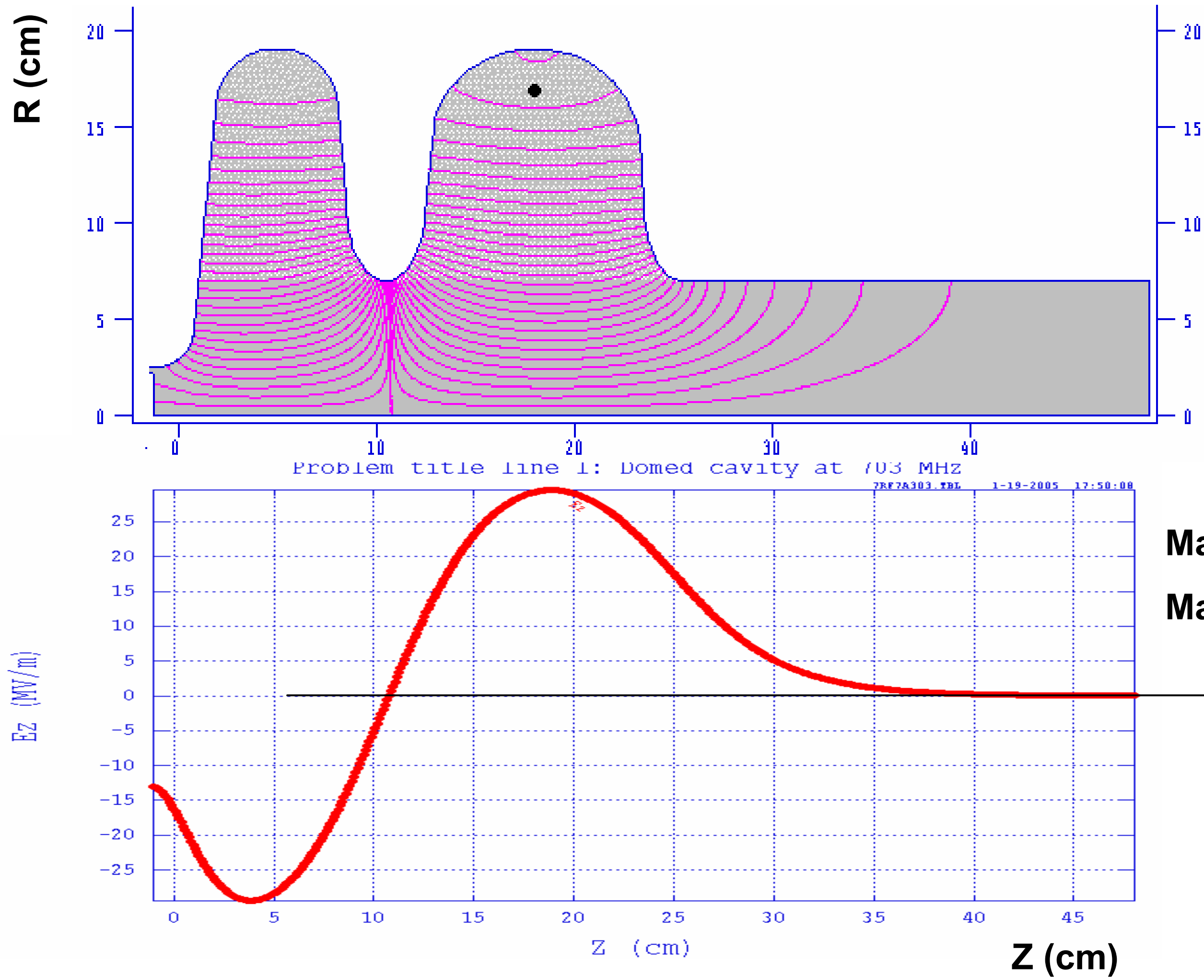
- Bunch charge 5nC.
- Emittance less than 4mm.mr (@5nC).
- The energy spread less than 0.3×10^{-3} (@54MeV).
- Needs bend system for merging of the fresh low energy beam and the high energy beam.

System configuration

- The gun is followed by zig-zag (Litvinenko Vladimir, Dmitry Kayran) system and linacs
  - Best choice for merging beam at low energy region where the energy variation (of head and tail) is significant.
  - The chromaticity and the energy variation effect can be well compensated.



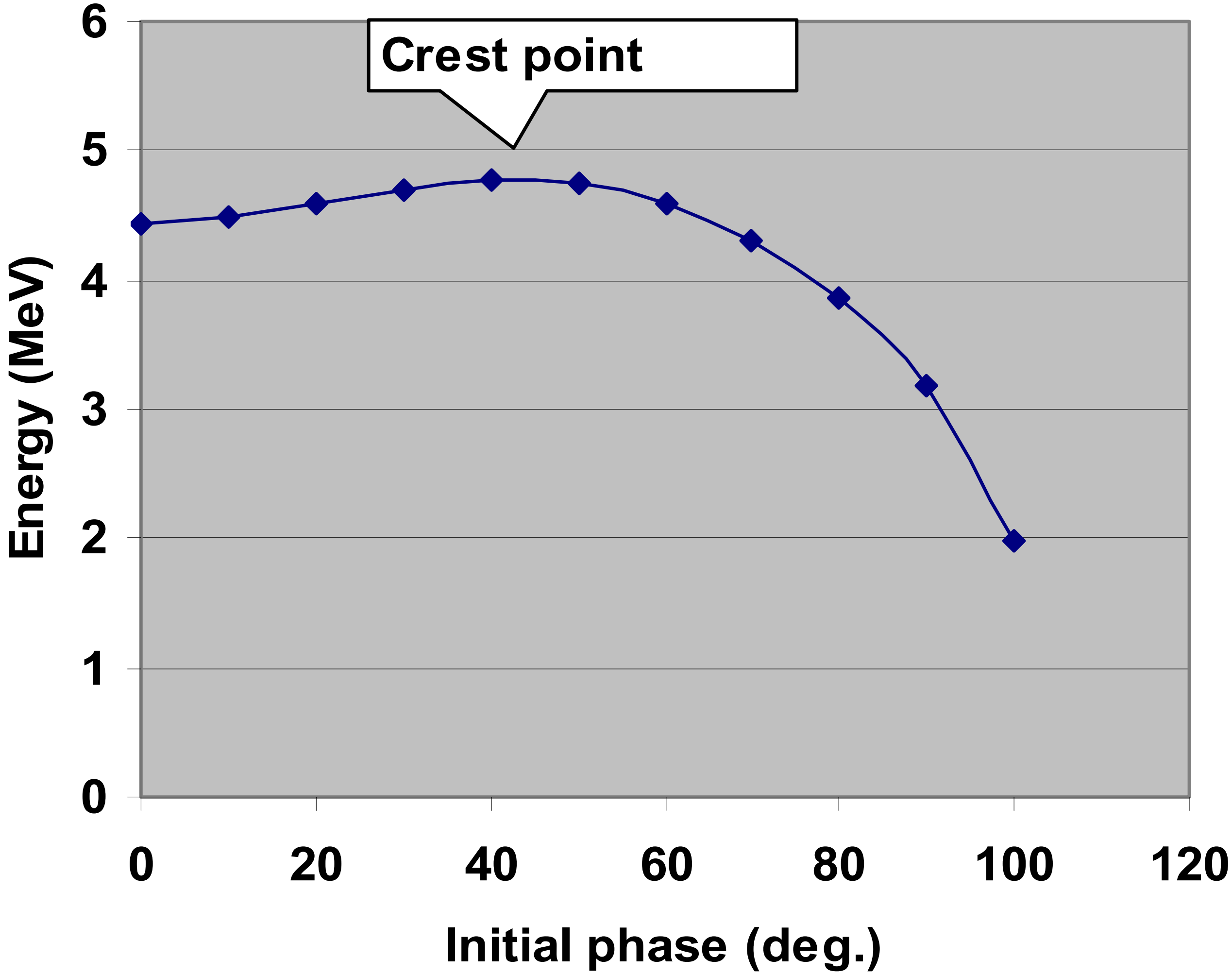
Electric field distribution of the simulated 1.5 cell gun



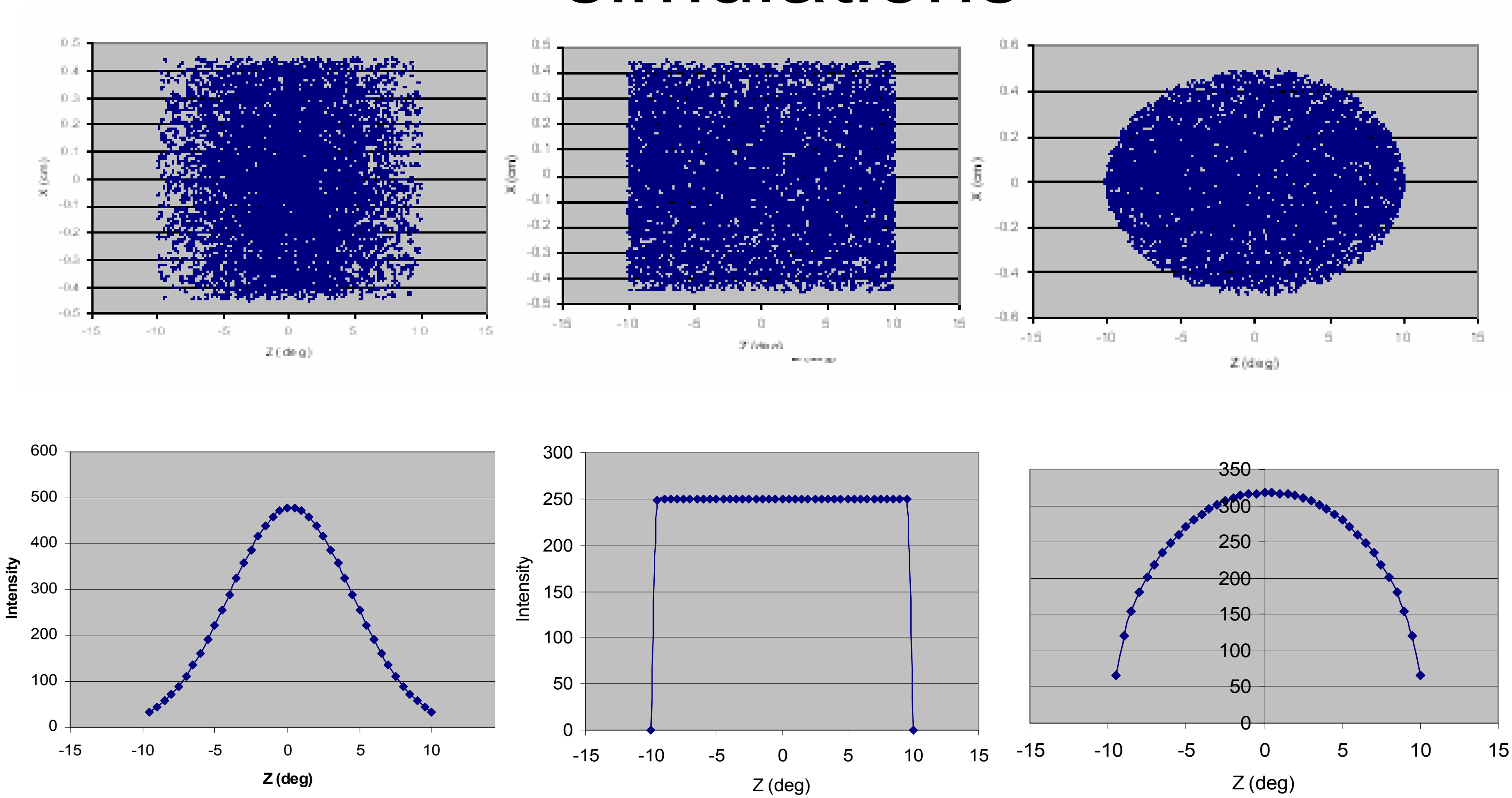
Maximum field on axis: 29.5 MV/m

Maximum field on surface: 49.3(MV/m)

Energy gain from gun as a function of launch phase



Laser distributions used in simulations



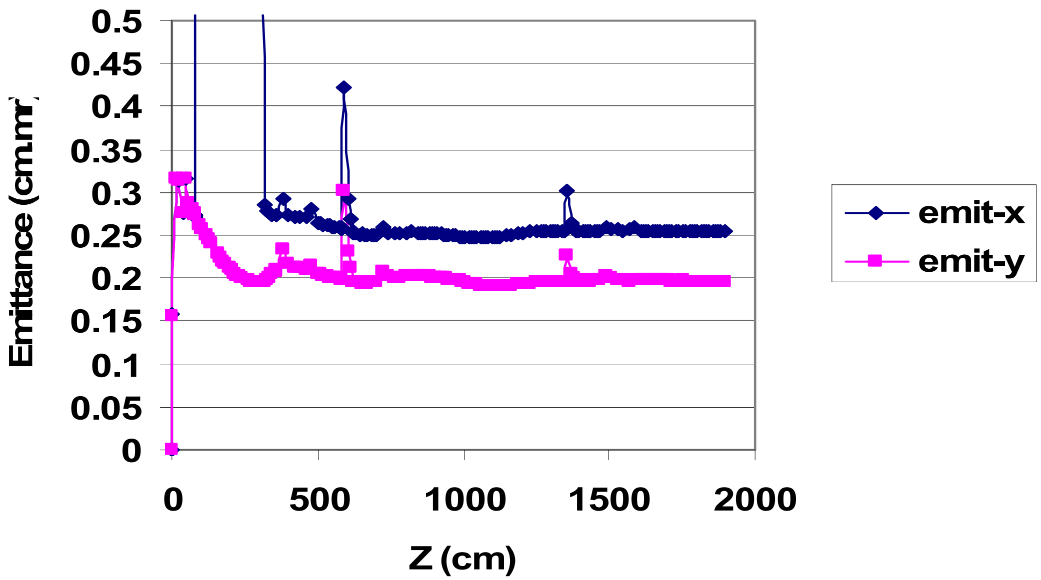
Gaussian **Beer can** **Ellipsoid**

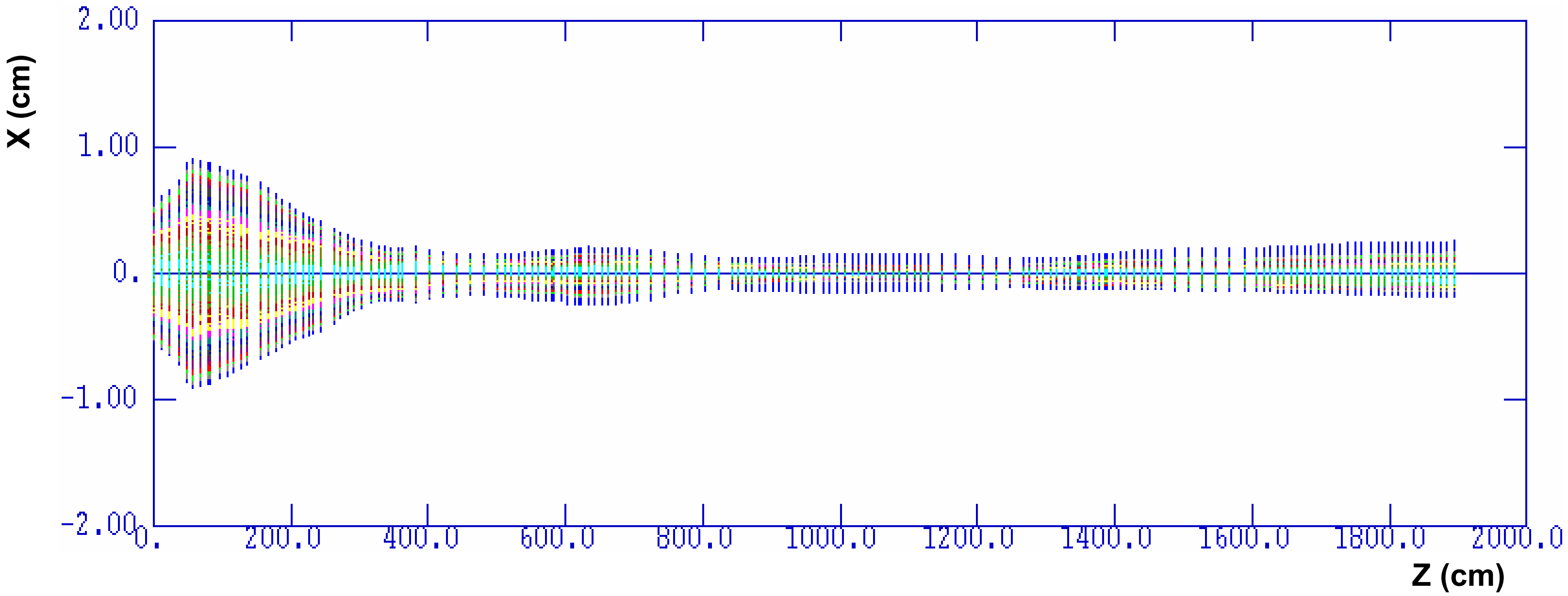
Transverse dynamics (elliptical laser)

$\varepsilon_{Thermal}$=1.6mm.mr

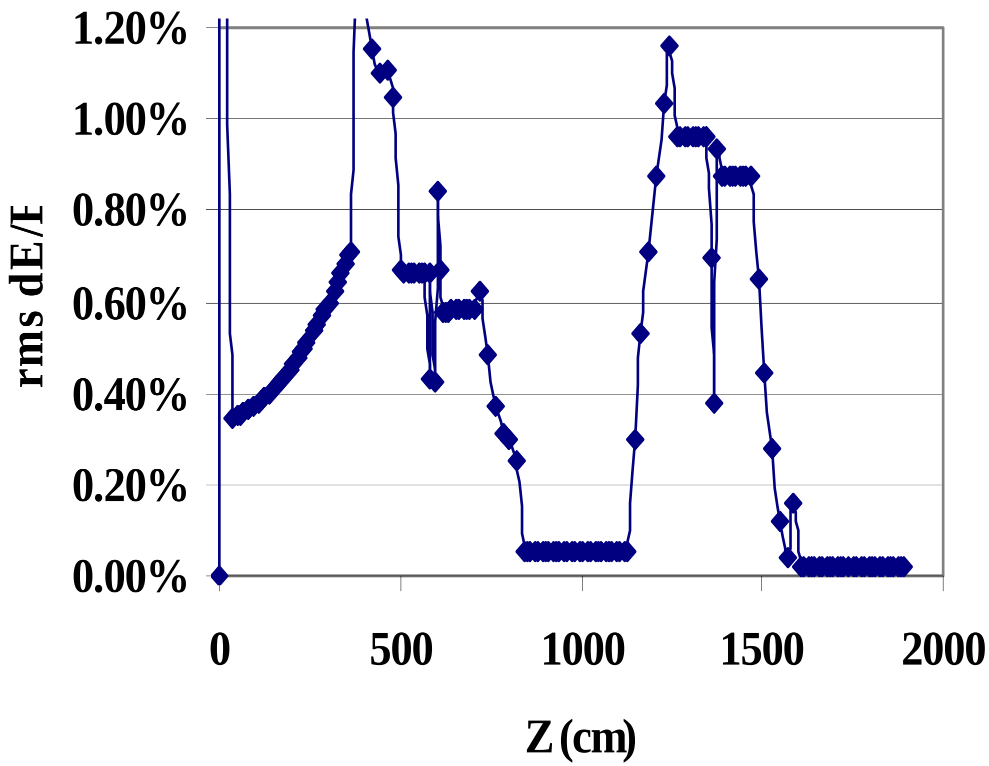
ε_x=2.5mm.mr

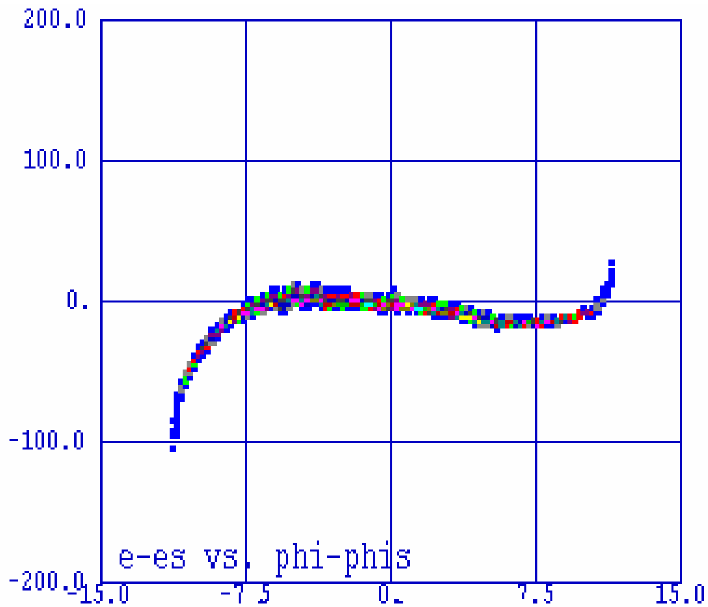
ε_y=2.0mm.mr





Longitudinal dynamics (elliptical laser)





- $dE/E=0.18\times10^{-3}$

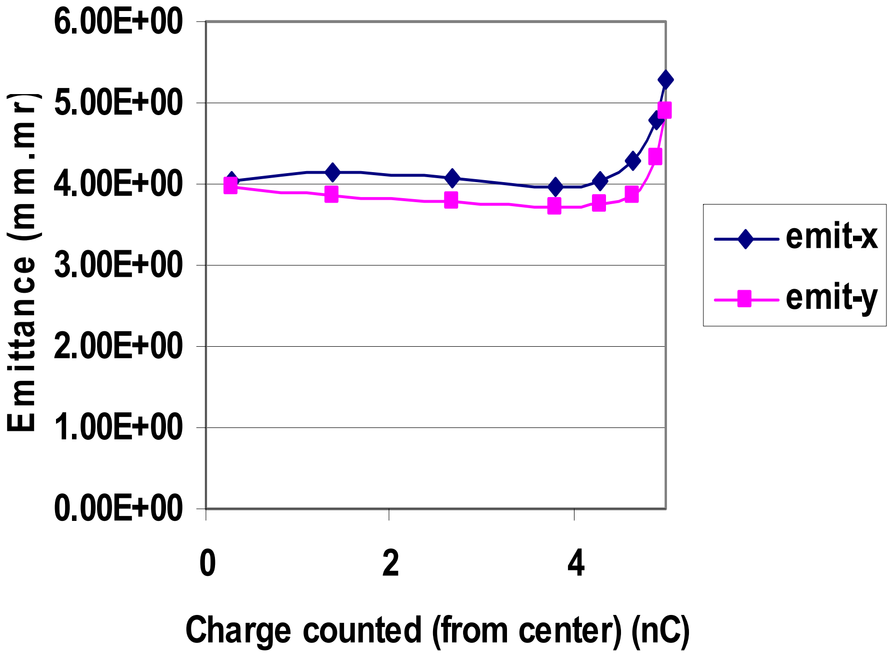
Simulations' Summary

Charge / bunch = 5nC			
Laser distribution	$\varepsilon_{x(final)}$ (mm.mr)	$\varepsilon_{y(final)}$ (mm.mr)	**Energy spread**
Elliptical	**2.5**	**2.0**	**0.18×10^{-3}**
Beer can	**3.0**	**2.5**	**0.25×10^{-3}**
Gaussian	**5.3**	**4.9**	**0.29×10^{-3}**

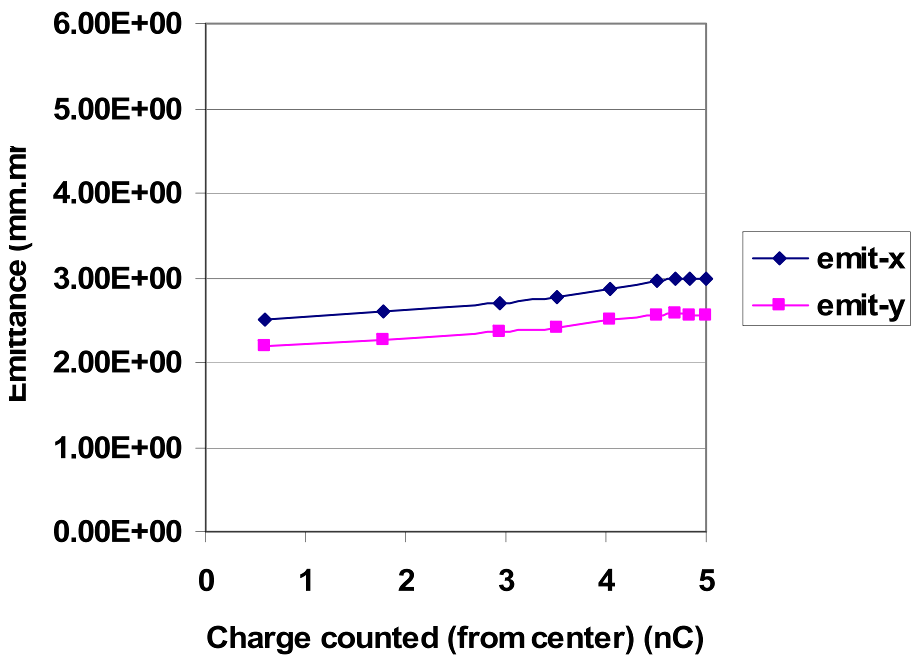
R_{max} (mm)	$\pm\phi_{max}$ (deg)	ϕ_i (deg)
5.6	**10**	**35**
5.5	**11.6**	**40**
5.0	**10**	**35**

The core emittance

- The particles on bunch ends contribute more to emittance, especially for beer can and Gaussian distributions

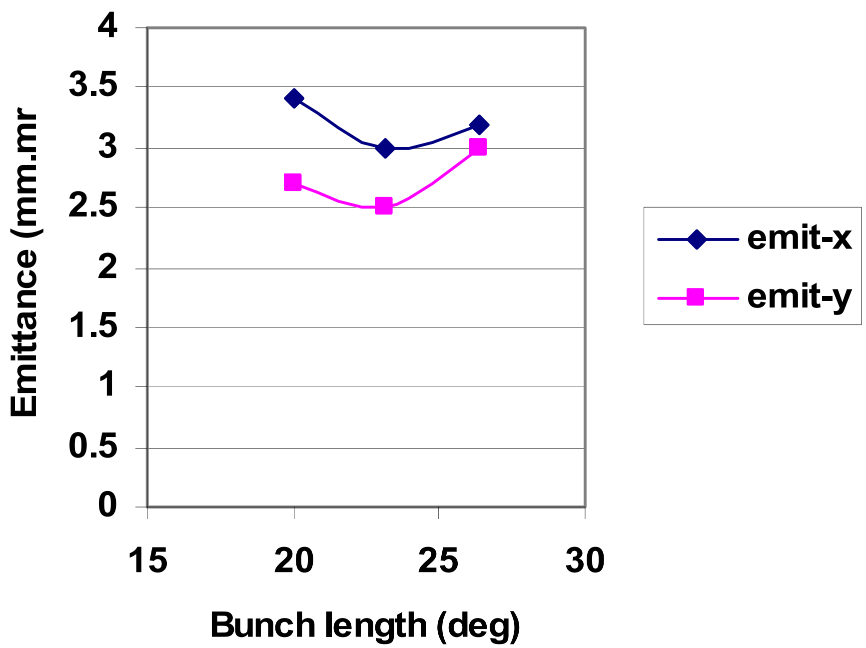


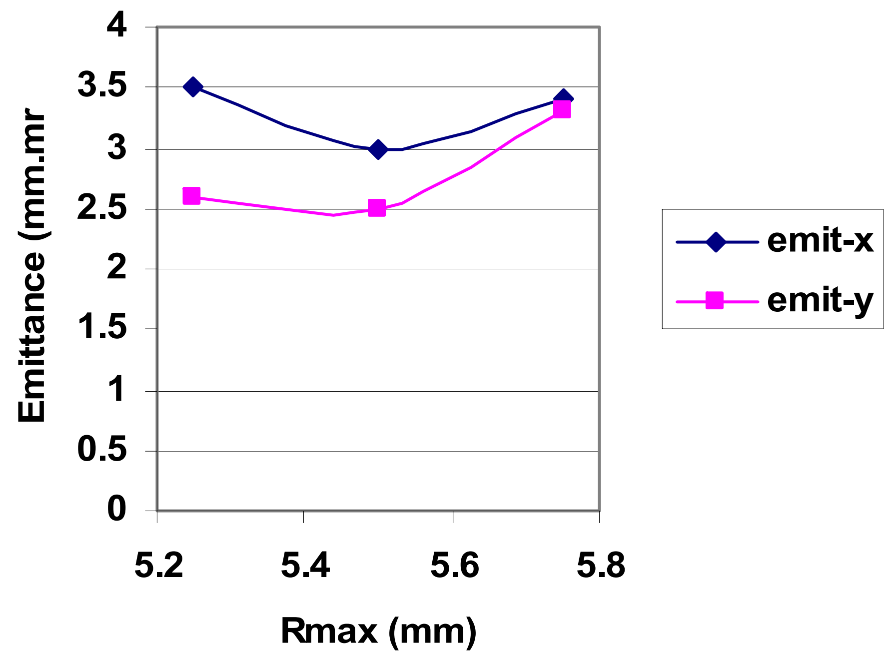
Gaussian

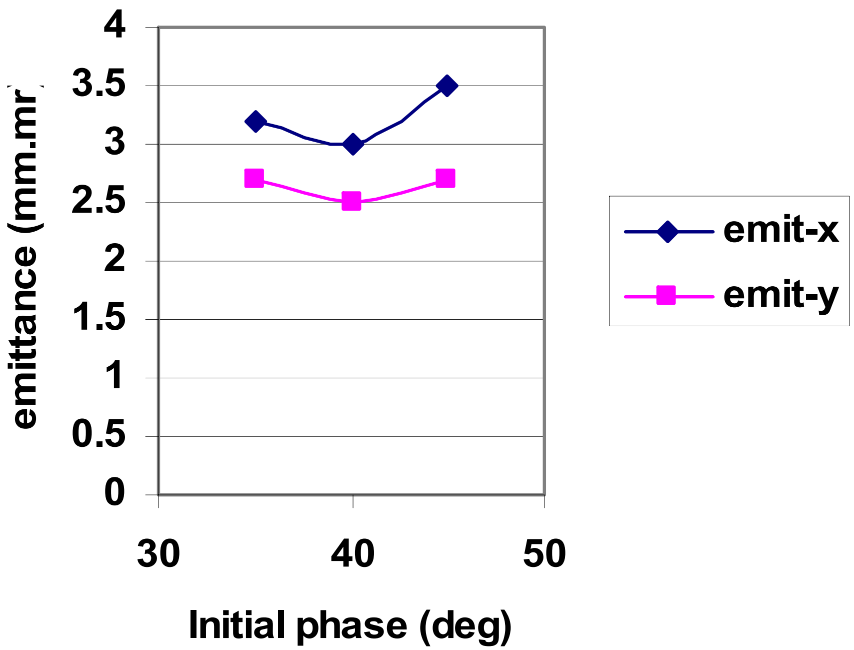


Beer can

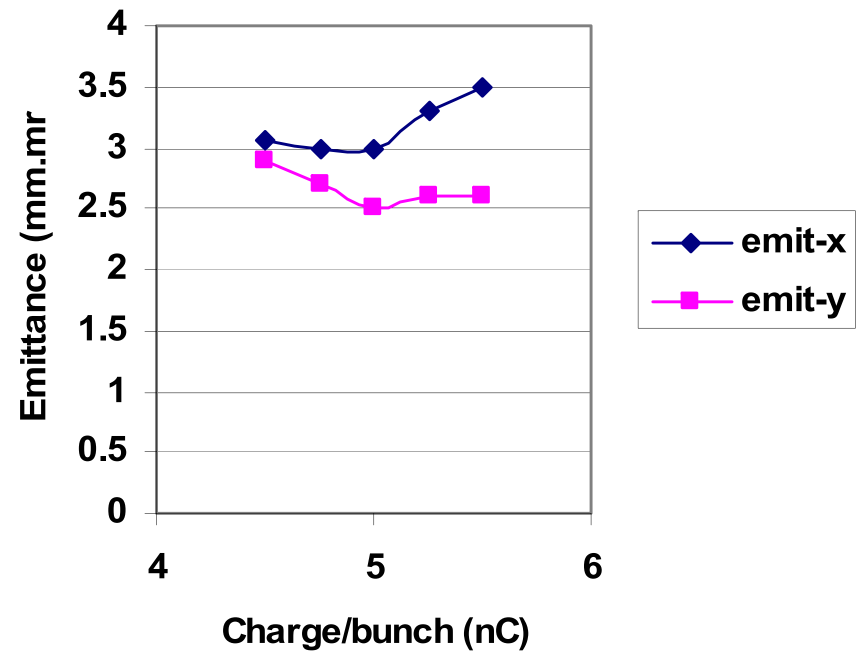
Sensitivity to laser parameters





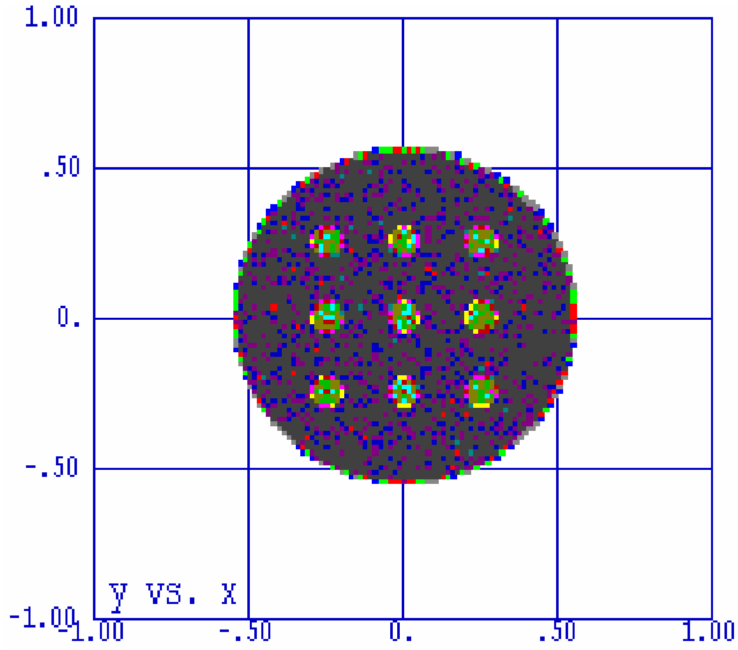


4
3.5
3
2.5
2
1.5
1
0.5
0
30
40
50
Initial phase (deg)
emit-x
emit-y



4
3.5
3
2.5
2
1.5
1
0.5
0
4
5
6
Charge/bunch (nC)
Emittance (mm.mr
emit-x
emit-y

Laser density fluctuation effect



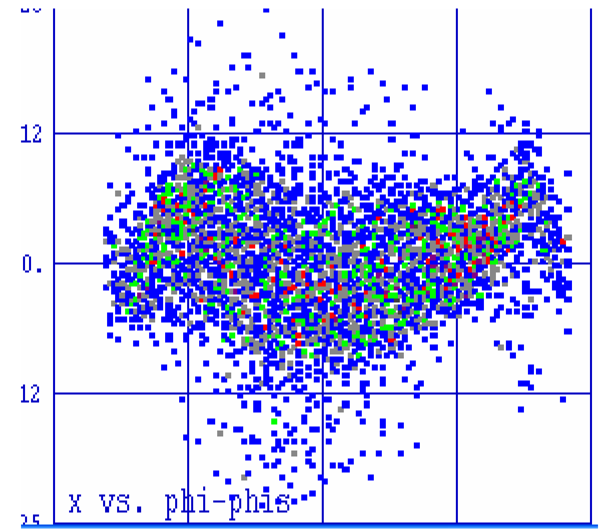
ε_X=4.3mm.mrad

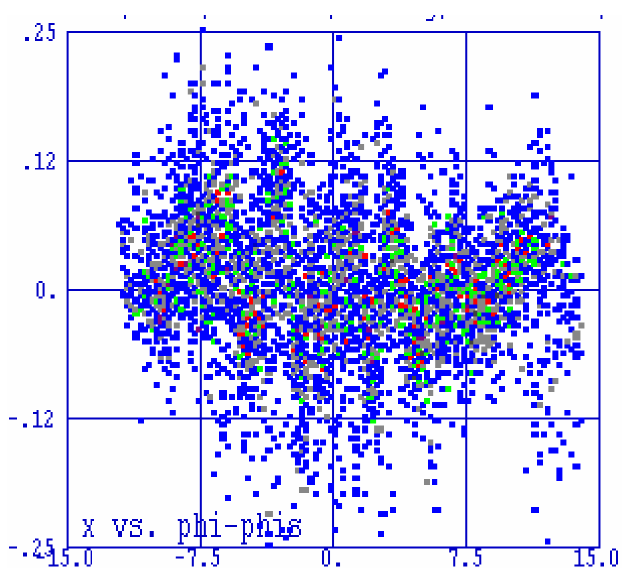
ε_Y=3.1mm.mrad

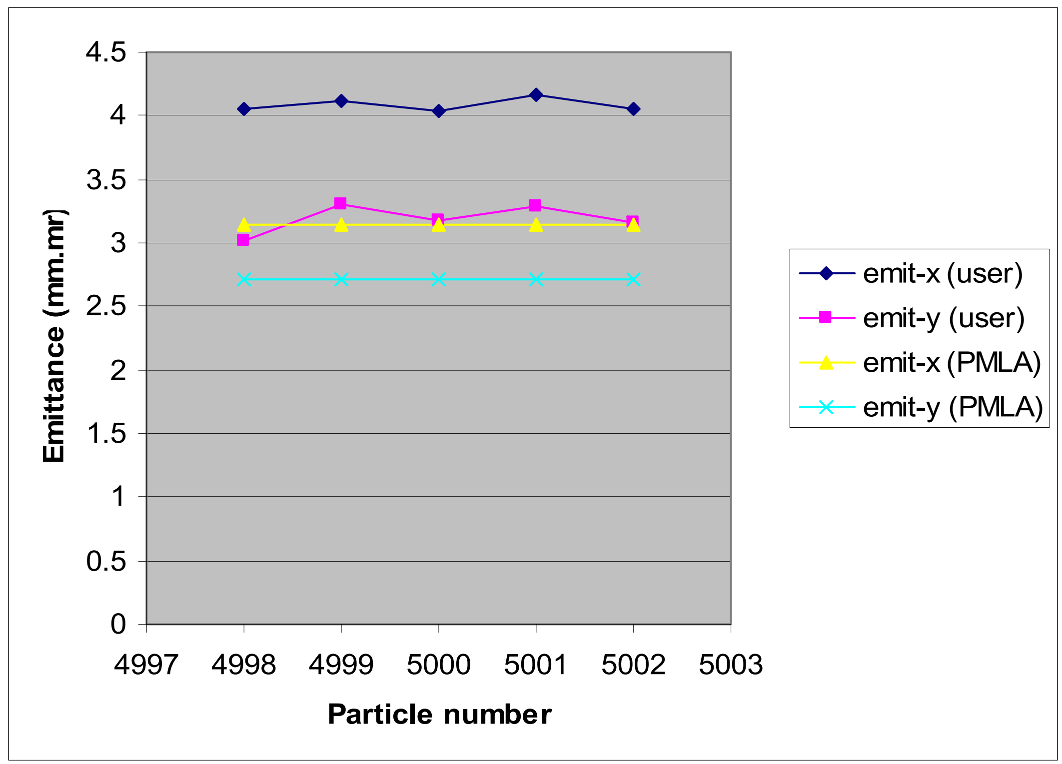
ε_{X0}=3.0mm.mrad

ε_{Y0}=2.5mm.mrad

Appendix


12
0.
12
x vs. phi-phis


.25
.12
0.
-.12
-.25
-15.0
-7.5
0.
7.5
15.0
x vs. phi-phis


Emittance (mm.mr)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4997
4998
4999
5000
5001
5002
5003
Particle number
emit-x (user)
emit-y (user)
emit-x (PMLA)
emit-y (PMLA)