Questions & Answers regarding Computational Lecture #1

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PHY 542
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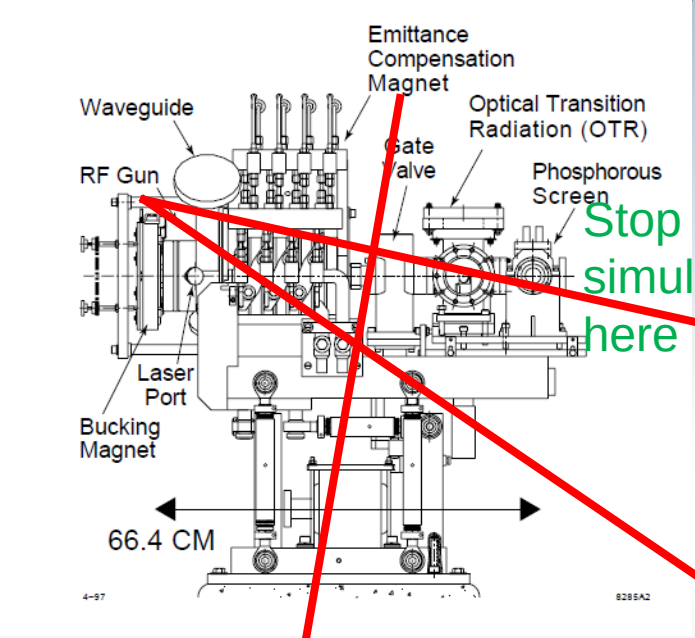
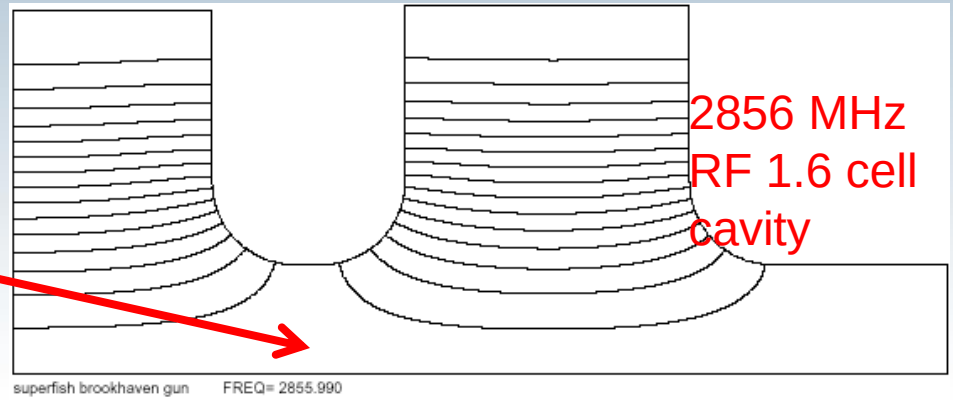
Tracking inside photocathode with ASTRA

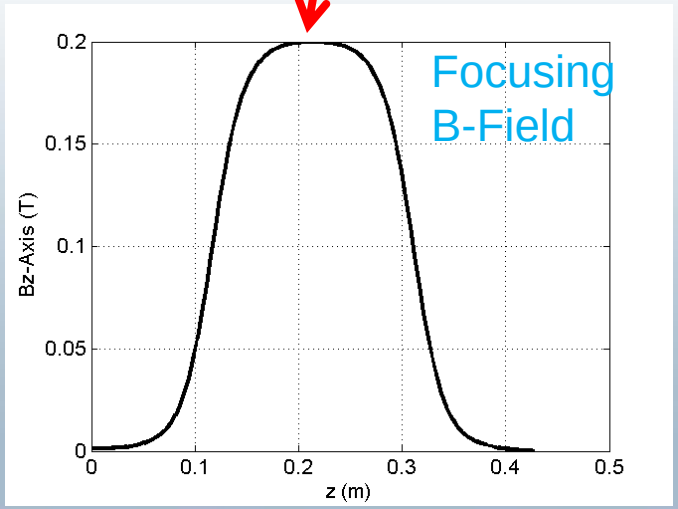


Stop simulation here

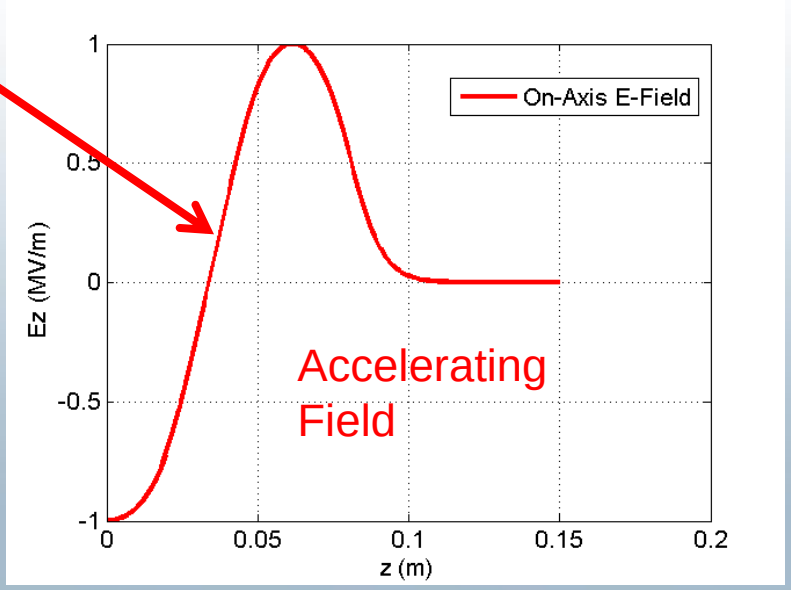


2856 MHz RF 1.6 cell cavity

Cathode



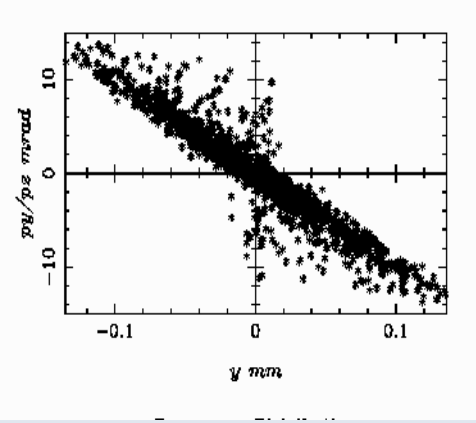
Focusing B-Field



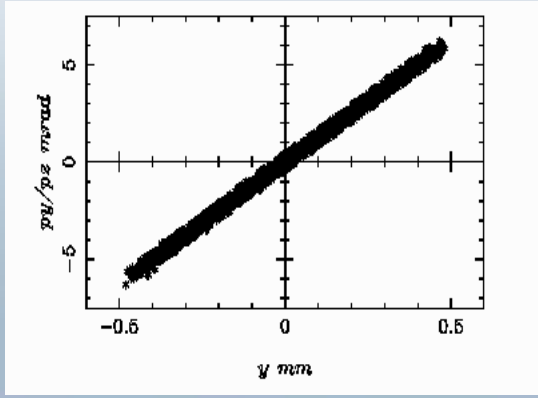
Accelerating Field

Question 1

- Why the phase-space at the exit of the injector tilts in different directions for the ‘SC’ and ‘NO SC’ cases?



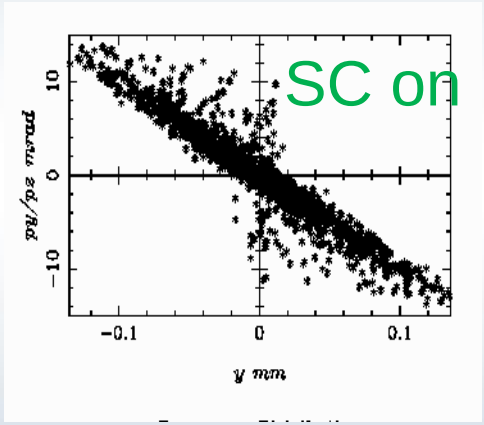
SC on

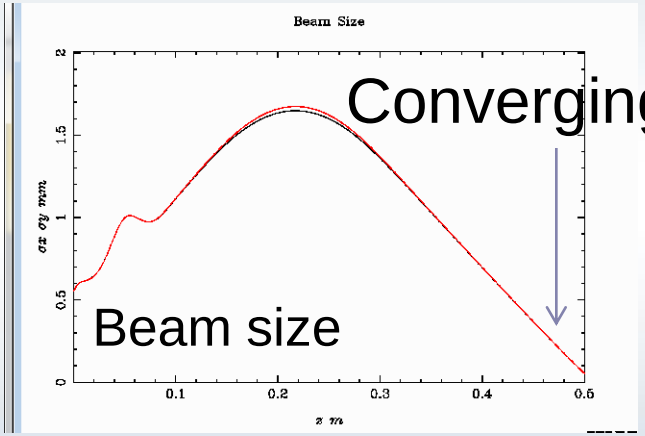


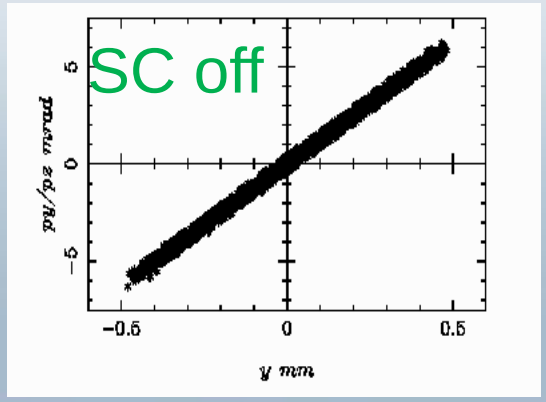
SC off

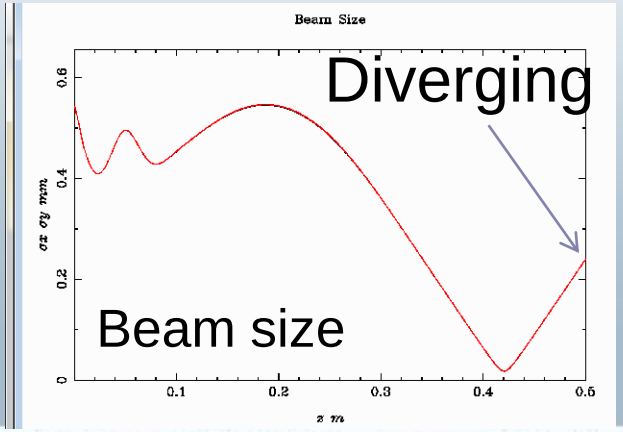
Answer 1

- Look at the beam size plot : In one case the beam is converging and in the other is diverging
- That means that the tilt of the phase-space is reversed!





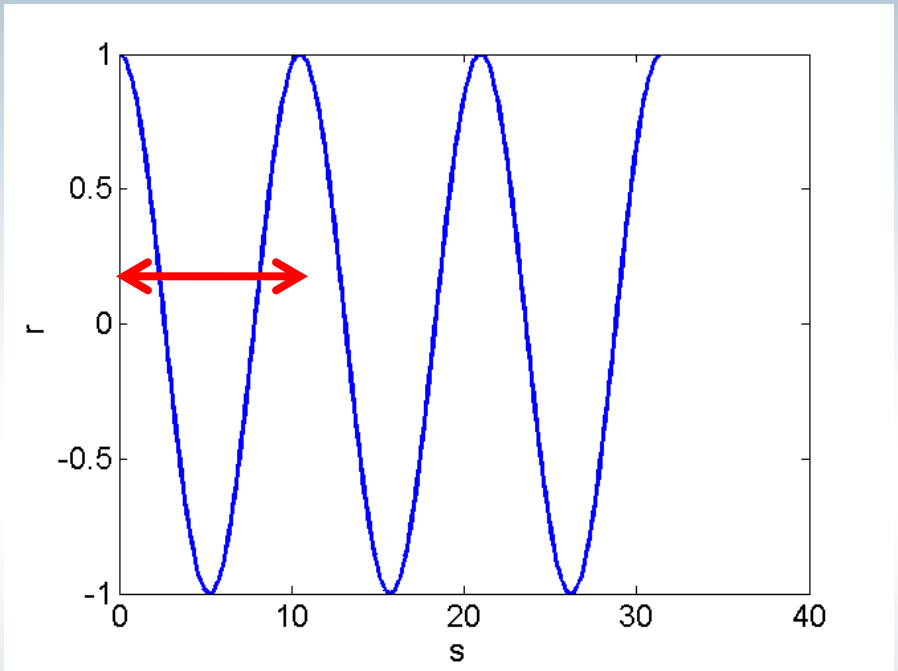


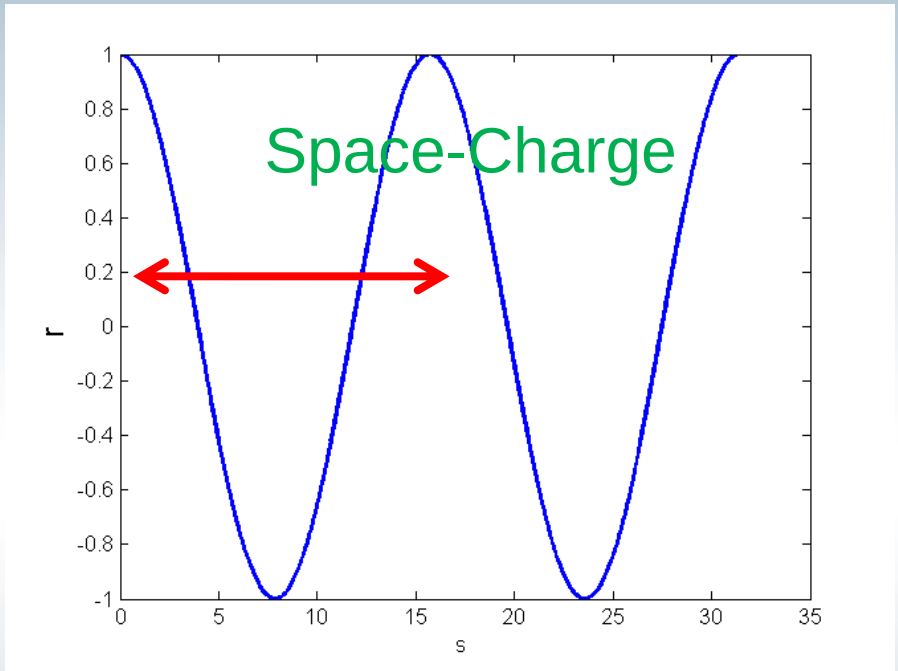


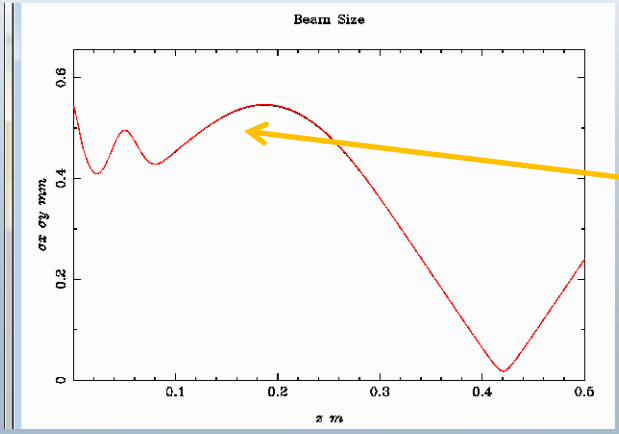
Question 2/ Answer 2

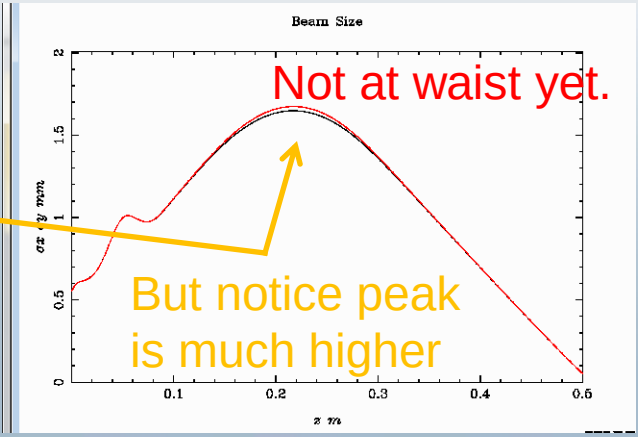
- Why the beam is diverging on one case and converging on the other?
  - In the last lecture, I showed that when the beam goes through a linear magnet (solenoid or quad), the transverse motion is described by $\frac{d^2x}{ds^2} = x'' = \kappa x$
  - So the particle oscillates with a wavelength that depends only on the focusing strength $\lambda = \frac{2\pi}{\kappa}$
  - With SC, and assuming a linear transverse SC force the above equation becomes: $x'' = (\kappa - \kappa_{sc})x$ $\lambda = \frac{2\pi}{\kappa - \kappa_{sc}}$
  - So the wavelength increases! This is called “tune depression”
  - That means that beam waist moves further away with SC!

Answer 2


1
0.5
0
-0.5
-1
r
0
10
20
30
40
s

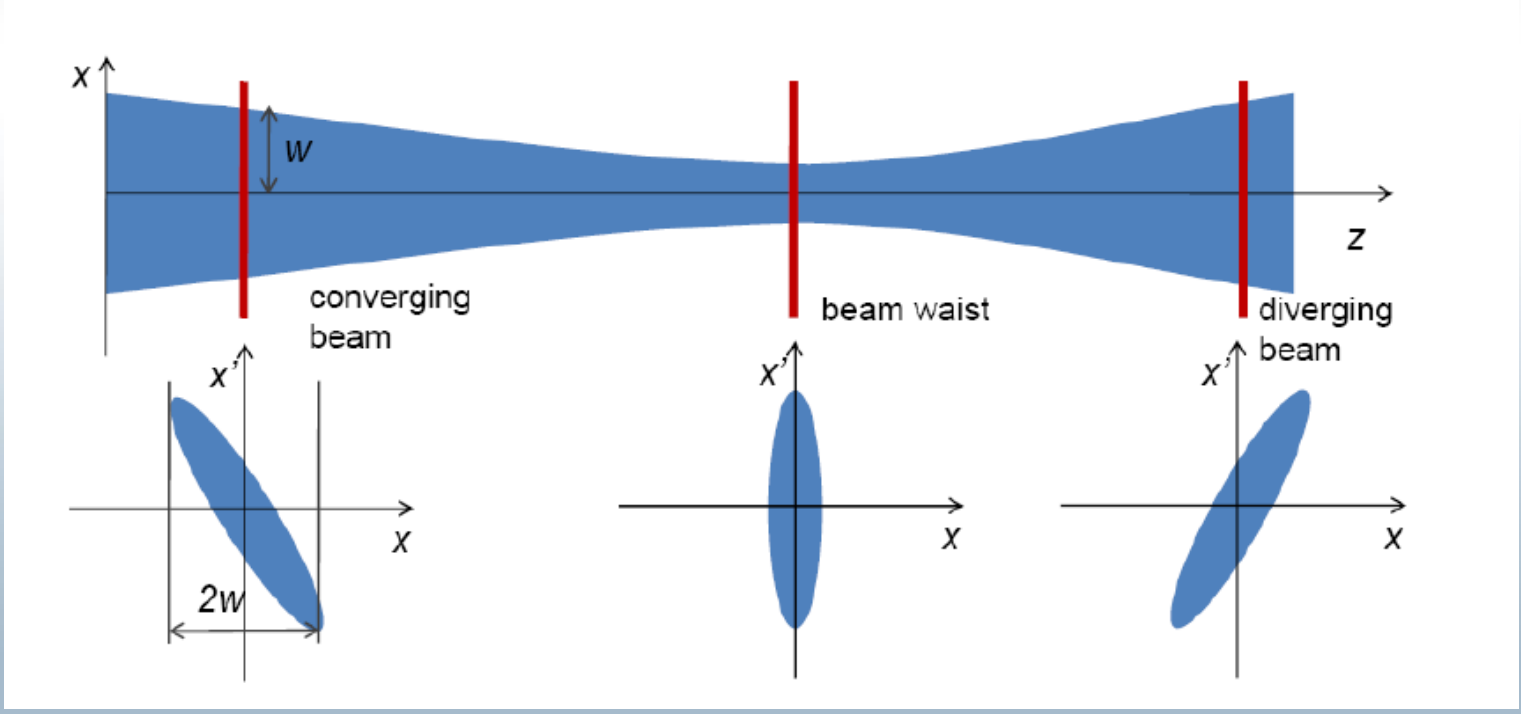

Space-Charge
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
r
0
5
10
15
20
25
30
35
s


Beam Size
σx σy mm
0.6
0.4
0.2
0
0.1
0.2
0.3
0.4
0.5
z m


Beam Size
Not at waist yet.
But notice peak
is much higher
σx σy mm
2
1.5
1
0.5
0
0.1
0.2
0.3
0.4
0.5
z m

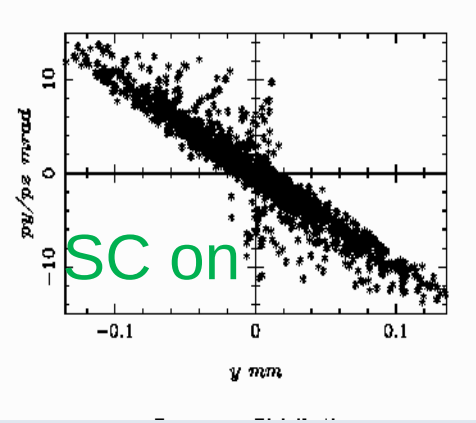
Answer 2

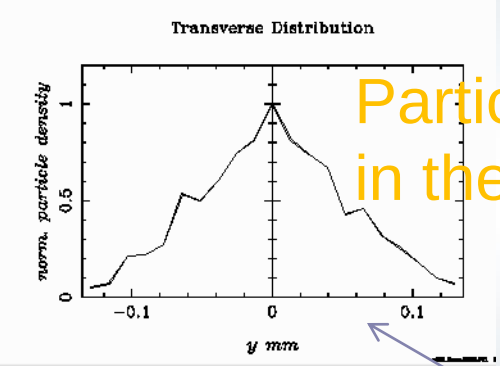
- Typical movement of phase-space in a perfectly matched system
- Ideally emittance is conserved: Area of phase-space remains the same. Forces need to be linear!



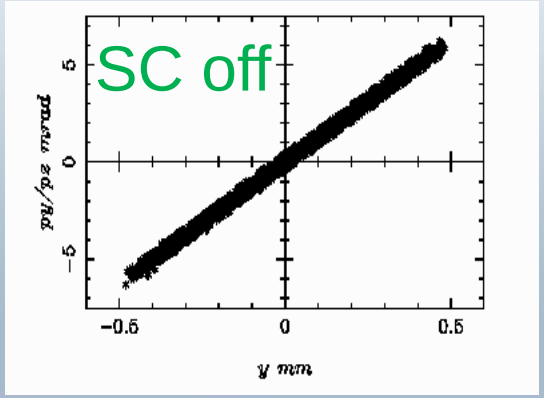
Question 3

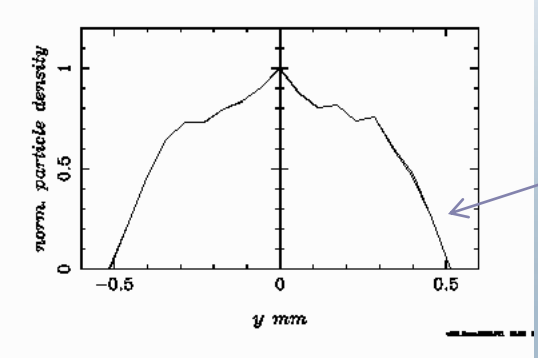
- Why the beam profile is different? Good question!
  - SC is destroying the order of the beam!
  - But eventually particles are localized in the center





Particles localized in the core





Profile at the injector exit

Answer 3

- I showed that the transverse SC scales as: $F_{r,sc} \sim \frac{1}{\gamma^2}$
- So when electrons are coming out from the cathode, they experience a strong SC force that pushes them away from the core (gamma is tinny)
- But the magnet force becomes stronger for “off axis” particles (F ~ r) . Thus, those particles experience a very strong B-force that pushes them back to the core!
- Eventually SC force becomes weaker and the particles remain localized in the core!
- If no SC, particles never move far off-axis. Thus never experience strong focusing forces. Thus, distribution is more smooth.