CAPP
Center for
Axion and Precision
Physics Research

Wakefields

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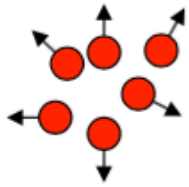
EDM Kick-off meeting at CERN
March 13 – 14, 2017

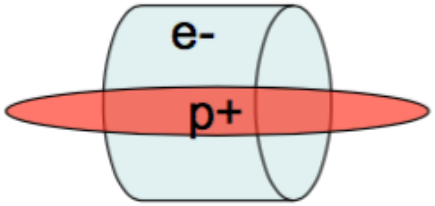
Collective effects

- In general, take into account the effects of the beam's own Coulomb force field on itself and it's environment.
- In a very general sense, we can break collective effects down into three categories: Beam-self, beam-beam, and beam-environment.

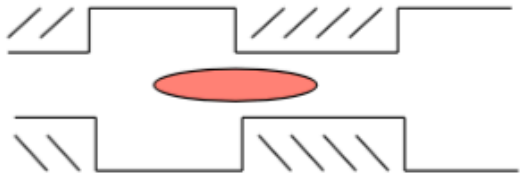
Beam interacts with itself: space charge, beam-beam effects.



Beam interacts with localized electron cloud: e-p instability.



Beam interacts with machine: impedances-related instabilities.



S. Cousineau et al., USPAS 2011

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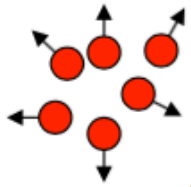

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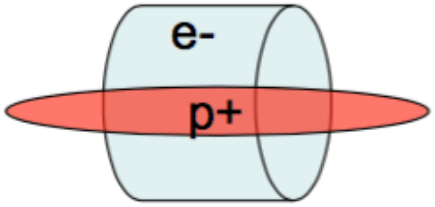

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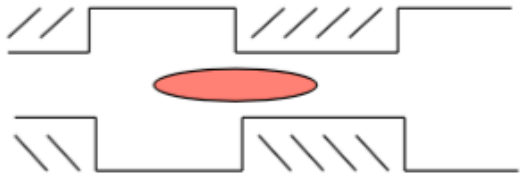
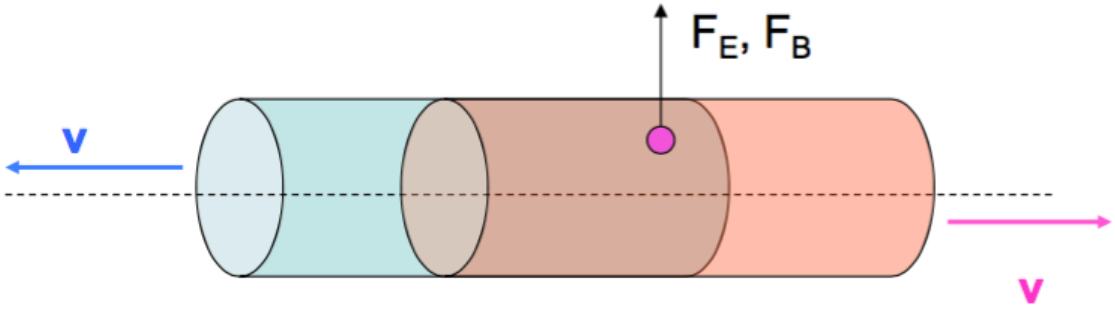


The design lattice tune can be shifted.

S. Cousineau et al., USPAS 2011

Beam-beam tune shift

- In a colliding beam accelerator, two beams are circulating in opposite directions and pass through each other at certain interaction points.
- During this time, the particles in one beam feel the electric and magnet forces of the particles in the other beam

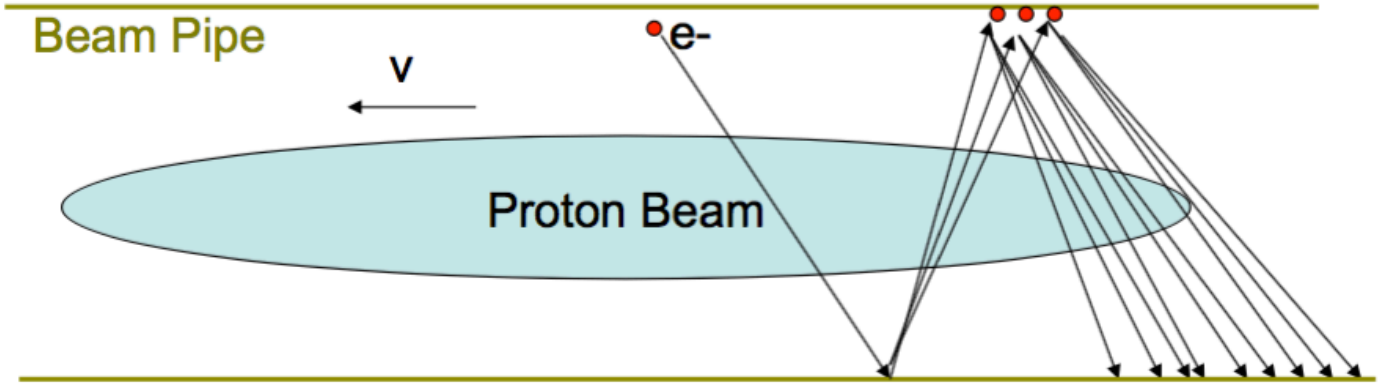


- The beams only overlap and 'feel' each other for a short time, this tune shift is much smaller than the space charge tune shift.

S. Cousineau et al., USPAS 2011

e-p instability

- Electron-proton instability can be generated when the proton beam interacts with ambient electrons in the vacuum chamber.



Simplified scenario:

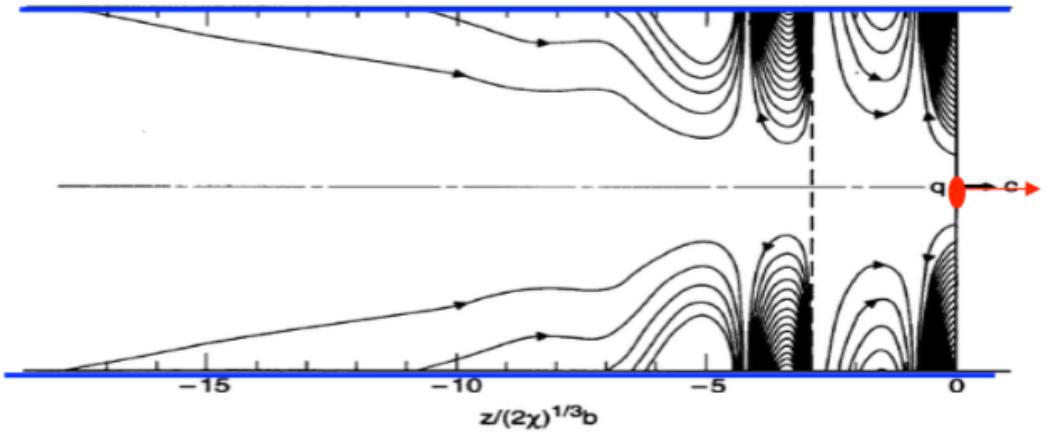
1. Ambient electron is accelerated through beam potential
2. Electron strikes the wall on the opposite side and ejects more electrons
3. These electrons are accelerated through the beam and strike the opposite side wall, ejecting more electrons
4. If electrons live until the beam returns on the next pass, the 'electron cloud' grows until it causes an instability in the proton beam

S. Cousineau et al., USPAS 2011

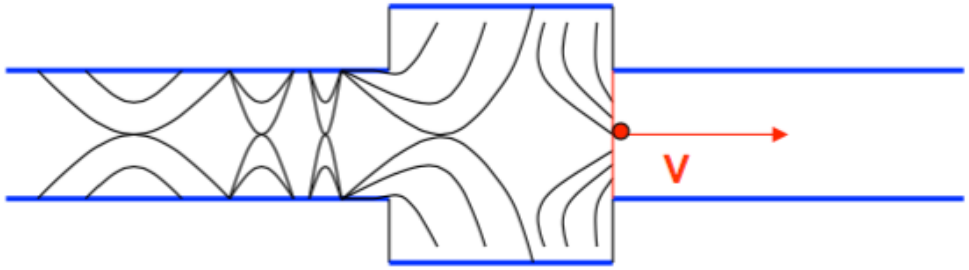
Wakefields

- Since particles travel in the accelerator environment, with beam pipes and magnets, etc, they induce fields in the accelerator structures. These fields can act back on trailing particle.

Wakefields are generated in a smooth pipe of constant radius if it has finite resistance: "Resistive wall impedance"



Wakefields are also generated in a conducting pipe near the intersection of a geometry change.



S. Cousineau et al., USPAS 2011

Wakefields and impedances

- In practice, it can be very difficult to calculate the wakefield for real accelerator beams and vacuum chamber geometries.
- It is often easier to work with the Fourier transpose of the wakefield, which is the impedance, which we can break into pieces that are transverse and parallel to beam motion.
  - Impedance is the frequency domain representation of the wakefield
- Many machines under design come up with 'impedance budgets', such that the total sum of the impedances of individual components in the machine is less than the threshold value for instability.

Simulation

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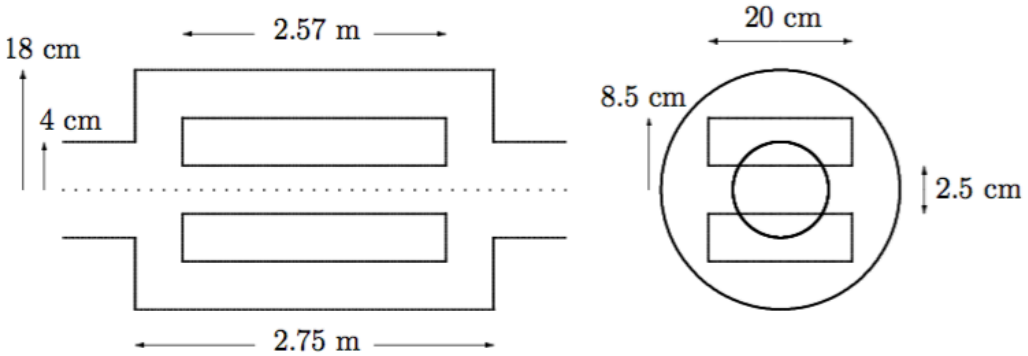
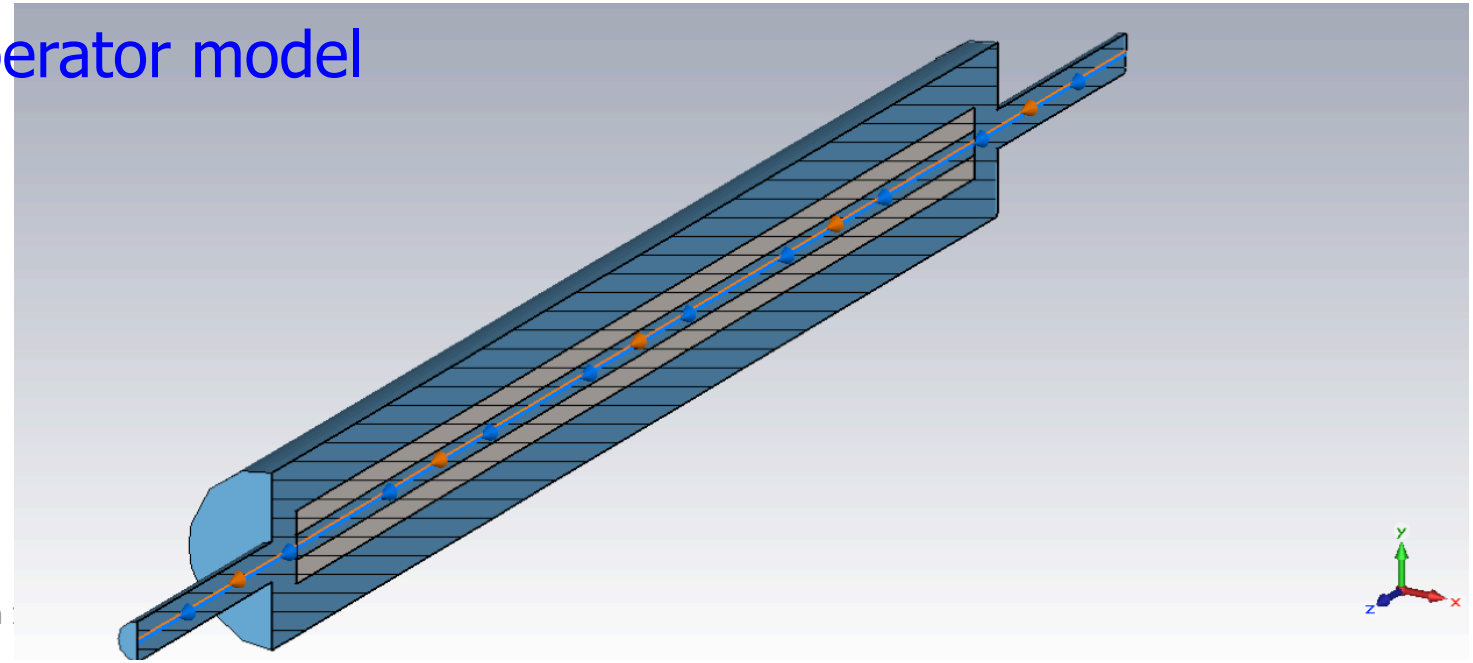
- Simplified tevatron separator:

Impedances of Tevatron separtors
K. Y. Ng, proceedings of PAC 2003



Seperator model



Simulation

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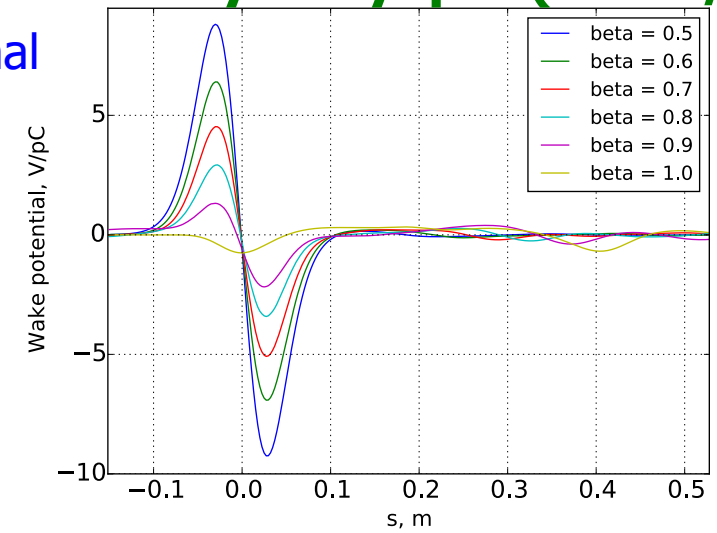
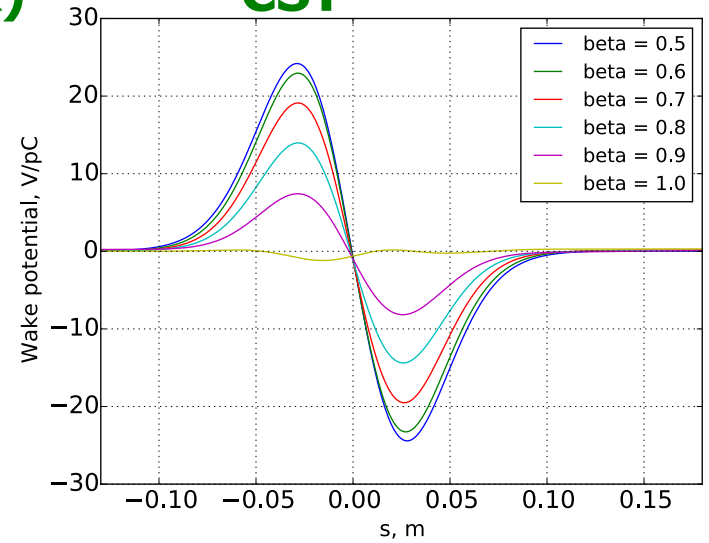
GdfidL by A. Lyapin (RHUL/UK)

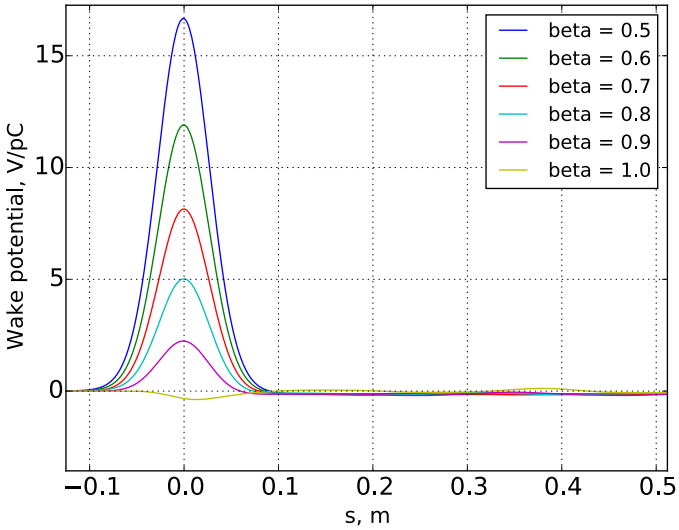
CST

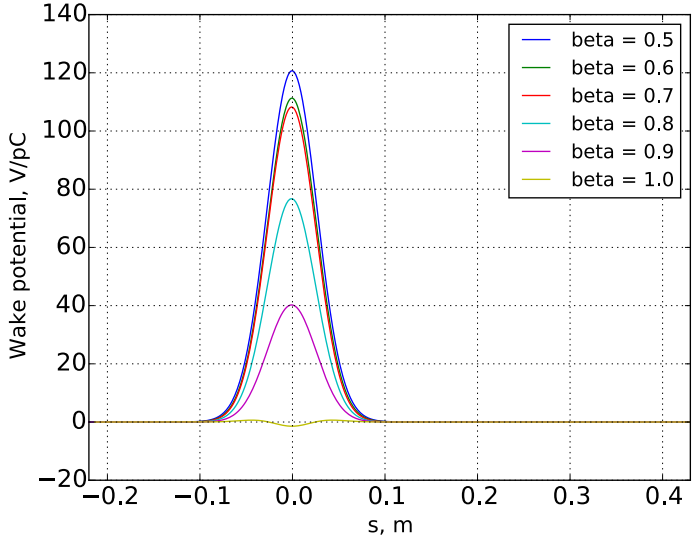
Longitudinal





Transverse





Summary and plan

- The effects of wakefield need to be studied.
- Wakefield simulations using both CST and GdfidL
  - Start with Tevatron separator structure
  - With different beta
- To do
  - With different geometries
  - Different beam parameters
  - Two beams
- Implement wakefield effects to tracking simulation and check the effect of wakefield to the EDM measurement

IBS Conference on Electric and Magnetic Dipole Moments

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- The physics potential of a precision measurement of the EDM and MDM is well motivated.
- Gather experts in the theoretical, experimental and accelerator physics that touch upon this subject and provide a platform for sharing current insights and results.
- KAIST Munji campus, Deajeon, South Korea
- Sep. 11 (Mon.) – 15 (Fri.), 2017
- No registration fee

IBS Conference on Electric and Magnetic Dipole Moments

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More information will follow soon!