U.S. Particle Accelerator School

Education in Beam Physics and Accelerator Technology

Simulations of Beam and Plasma Systems

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Example Warp Simulations – Part 2

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ECP EXASCALE COMPUTING PROJECT

NERSC

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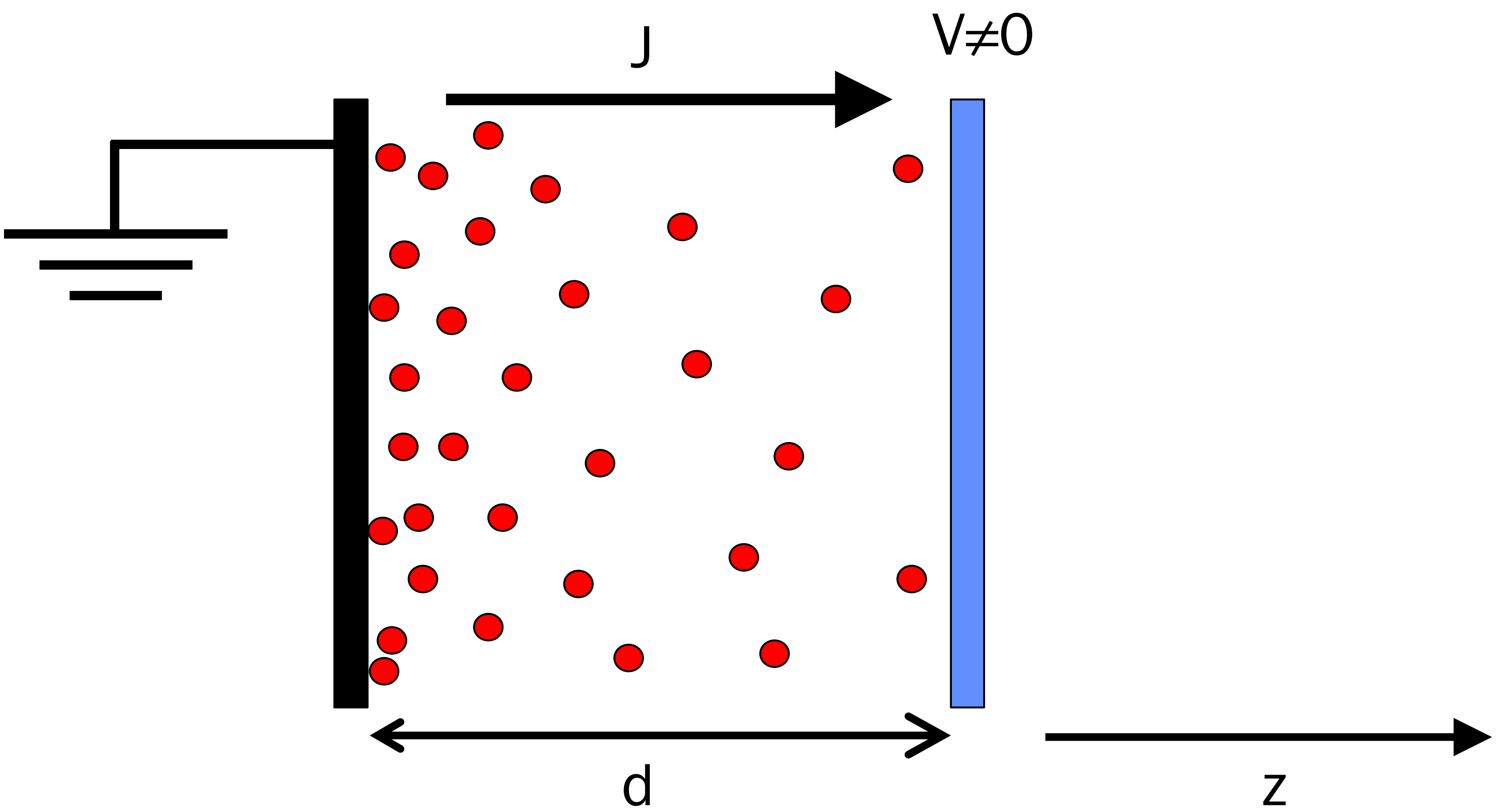
Outline

- Emission between parallel plates
- Pierce diode
- Solenoid transport

Examples are in simbeamplasma18/warp_scripts from github repository :

- git clone https://github.com/uspas/simbeamplasma18.git

Emission between parallel plates

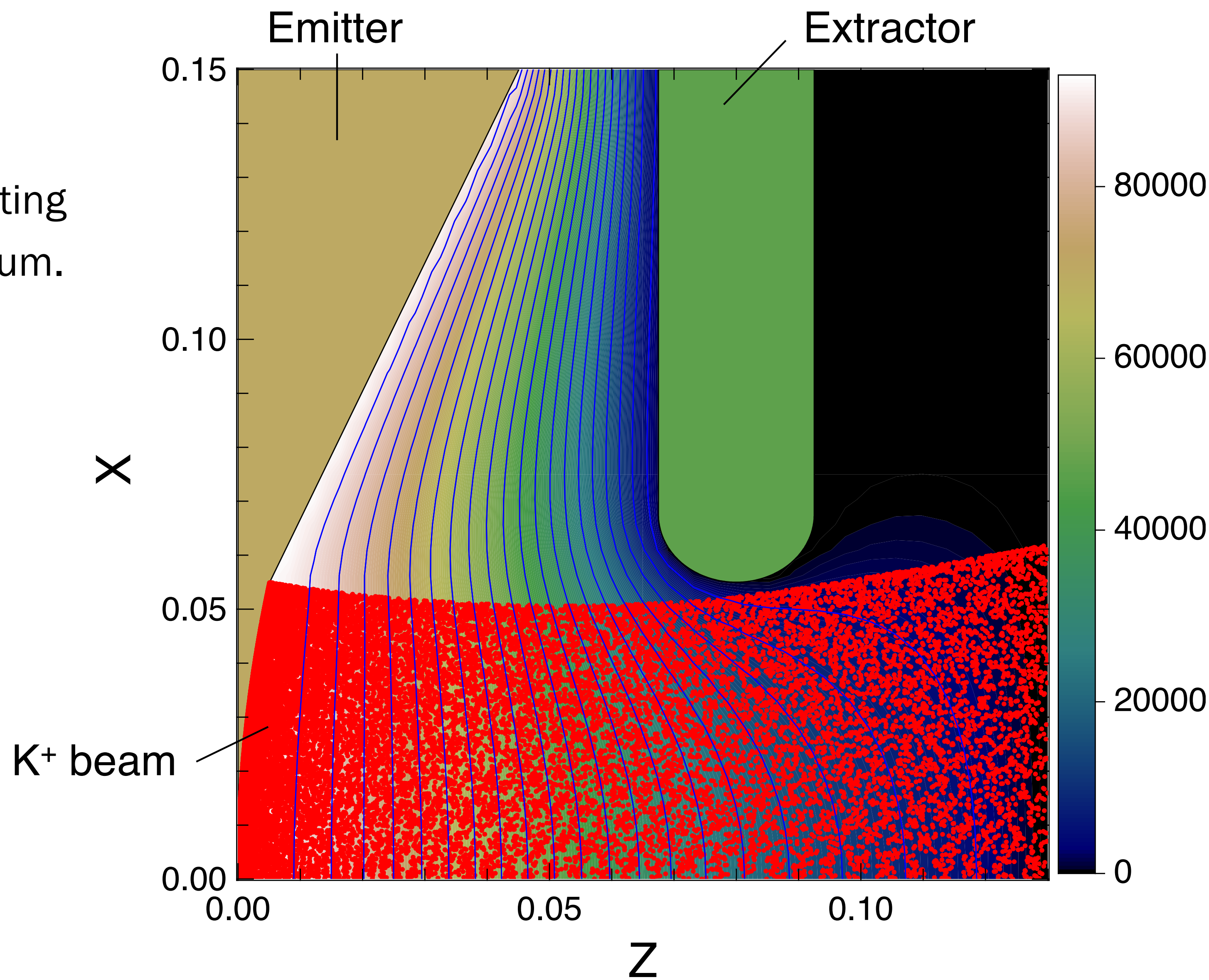


Was given as a problem yesterday. Any question?

Pierce diode: intro

File Pierce_diode.py

Hot plate source emitting singly ionized potassium.



File Pierce_diode.py

Pierce diode: tasks

① In Pierce_diode, open file Pierce_diode.py and execute: “python –i Pierce_diode.py”

② Open cgm files and explore:

   a) “gist Pierce_diode.000.cgm &”

   b) “gist current.cgm &”

③ Read input script and try to understand every command

④ Comment “w3d.solvergeom = w3d.rzgeom”, uncomment “w3d.solvergeom = w3d.xyzgeom” and rerun; observe longer runtime but similar result

⑤ Reverse to RZ geometry

⑥ Set “steady_state_gun=True” and rerun. Simulation is now generating traces, converging to steady-state solutions faster than with time-dependent mode.

⑦ Set “w3d.l_inj_regular = True”, “top.npinject = 15” and rerun with regularly spaced traces. This option can be used to enable faster simulations.

⑧ Change “diode_current = pi*source_radius**2*j” to “0.5*pi*source_radius**2*j”, then “2*pi*source_radius**2*j” and rerun each time. What do you observe?

Pierce diode: tasks

⑨ Go back to original settings

- steady_state_gun=False
- diode_current = pi*source_radius**2*j
- (optional) w3d.l_inj_regular = False and top.npinject = 150

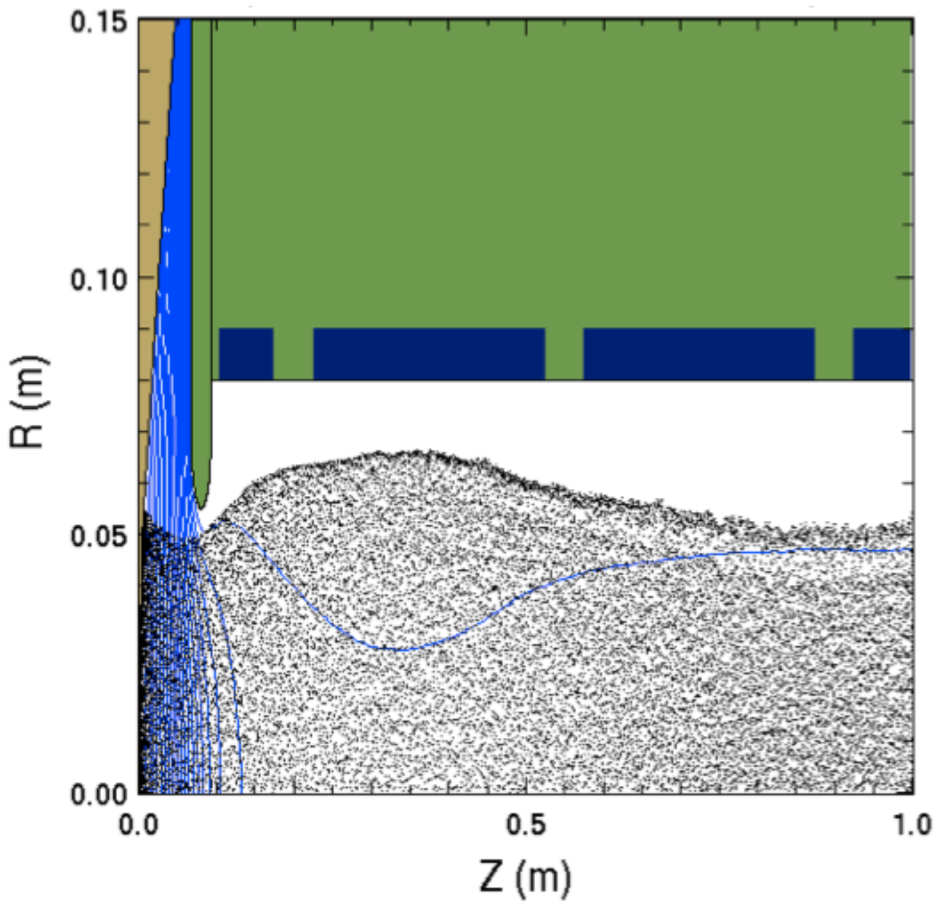
then change

- top.inject=1 ➔ top.inject=2 so that extracted current is automatically set at the Child-Langmuir limit, for a given voltage drop.

Rerun. Open the latest cgm file, page through and observe how the head of the beam has a larger current and touches the extractor. Can you explain why?

⑩ Set "l_constant_current = True" and rerun, observing how the injected current is now constant. Also observe the history of the applied voltage versus time.

Solenoid transport



File Solenoid_transport.py:

- Example Pierce diode with subsequent solenoid transport.
- Hot plate source emitting singly ionized potassium.

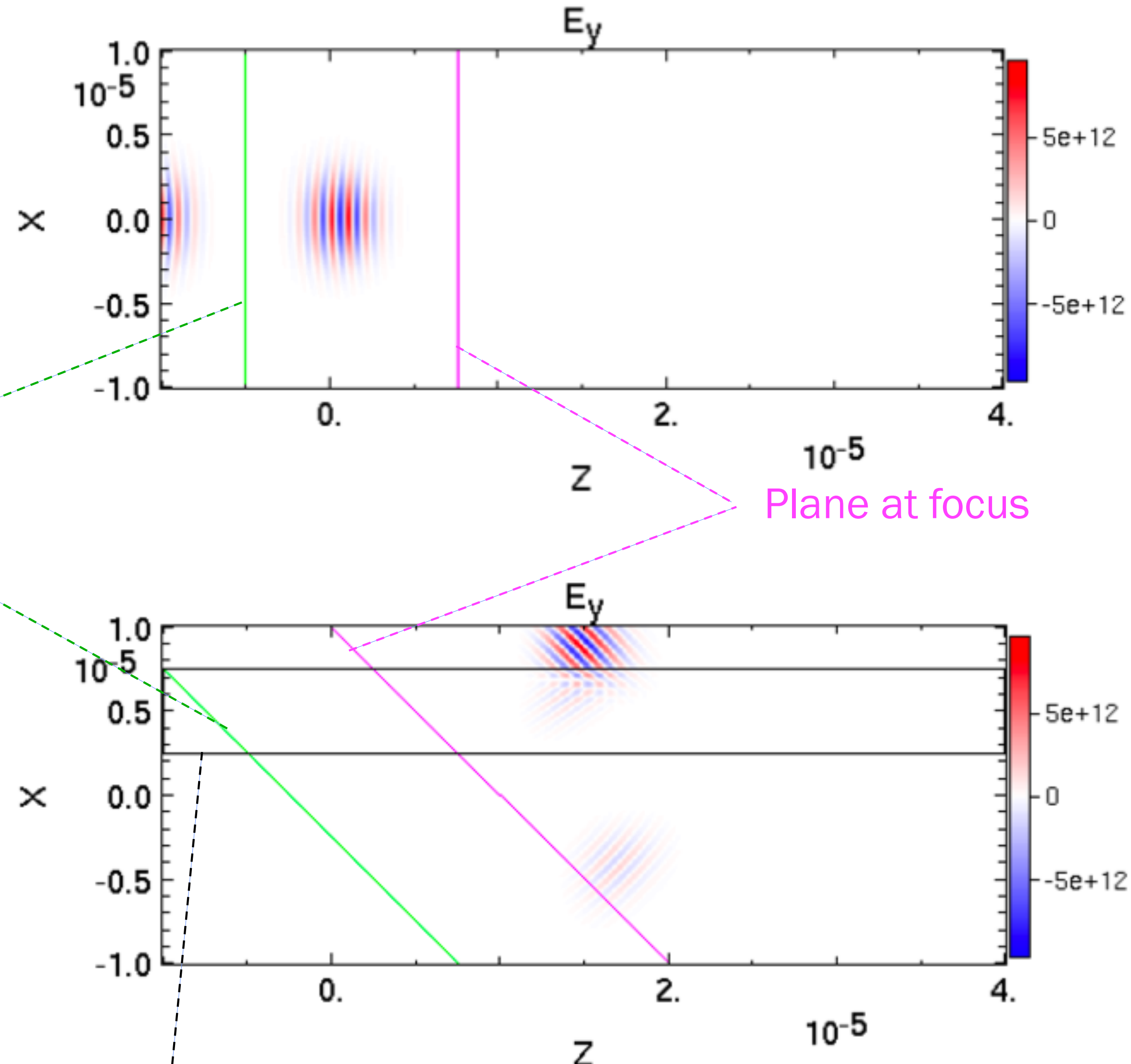
Solenoid transport: tasks

① In Solenoid_transport, open Solenoid_transport.py
② Execute file in interactive mode: “python –i Solenoid_transport.py”
③ Open cgm file and explore:
  a) “gist Solenoid_transport.000.cgm &”
④ Read input script and try to understand every command
⑤ Change “l_solenoid = False” to “l_solenoid = True”. Rerun.
⑥ Select ‘window(1)’
⑦ Type “fma()” to start next plot from empty page.
⑧ Type “rzplot(9)” to plot RZ view of beam, pipe and solenoids in upper half.
⑨ Type “ppzvtheta(view=10)” to plot particle projections of azimuthal velocity versus z.
⑩ Notice the correlations between the extremas of the azimuthal velocity and the positions of the solenoids.
⑪ Here again, faster simulations can be performed by setting “w3d.l_inj_regular = True”, “top.npinject = 15”.

Laser injection & propagation in vacuum/dielectric

File laser_injection.py:

- Laser injected with antenna
- ”backward” laser exits
- Dielectric region can be set



Antenna emission plane

Plane at focus

Contours of dielectric box

Laser injection: tasks

① In Laser_injection, open Laser_injection.py
② Execute file in interactive mode: "python –i Laser_injection.py"
③ Read input script and try to understand every command
④ Check at beginning of scripts how to add optional arguments and their definitions
⑤ Rerun with a longer wavelength:
  - python -i laser_injection.py –ll 2.e-6

⑥ Rerun with the laser impinging a dielectric at an angle of 45 degree:
  - python -i laser_injection.py -lv '[1.,0.,1.]' -lp '[-5.e-6,0.,2.5e-6]' -er 1.5

⑦ Rerun with the laser born inside the dielectric:
  - python -i laser_injection.py -lv '[1.,0.,1.]' -bp '[-5.e-6,5.e-6]' -er 1.5

⑧ Reducing the angle of incidence:
  - python -i laser_injection.py -lv '[1.,0.,2.]' -bp '[-5.e-6,5.e-6]' -er 1.5
  - python -i laser_injection.py -lv '[1.,0.,3.]' -bp '[-5.e-6,5.e-6]' -er 1.5
  - Note: you may propagate the laser further with 'step(200)'
  - Observe the total reflection with the latest run. What happens with -ll 2.e-6?

⑨ In the script, change laser_source_v from 0. to 0.5*clight and run
  - python -i laser_injection.py (observe the Doppler effect)