Simulations on 5 nC beam focusing around H1S2 for the exit window test

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May 25, 2022

Outline

- Background
- Focusing with solenoid only
- Focusing with quadruple doublet
- Focusing with quadruple triplet
- Discussion

Background

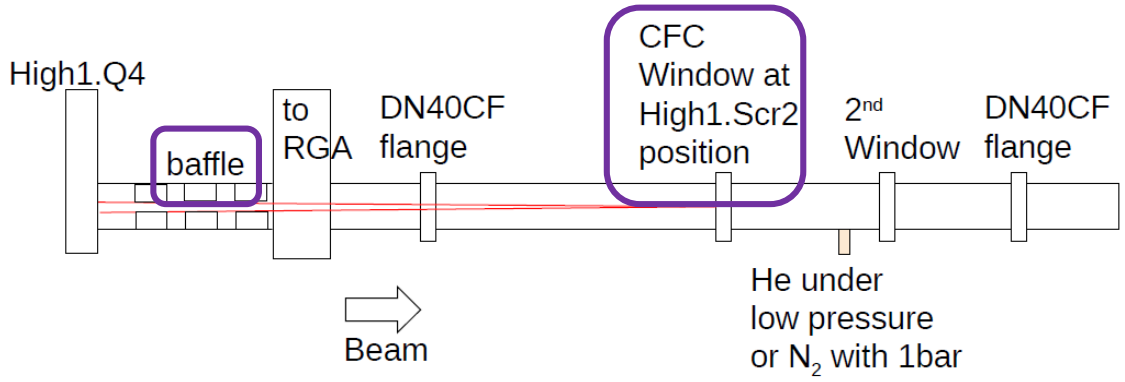
Carbon window test around High1.Scr2

Experiments

- Preparation: beam sizes with quad focussing (with High1.Scr2); 2mm downwards in 0.2mm steps
- Damage threshold
- …

Possible setup

Window in vacuum (low pressure); later maybe with 1 bar pressure difference



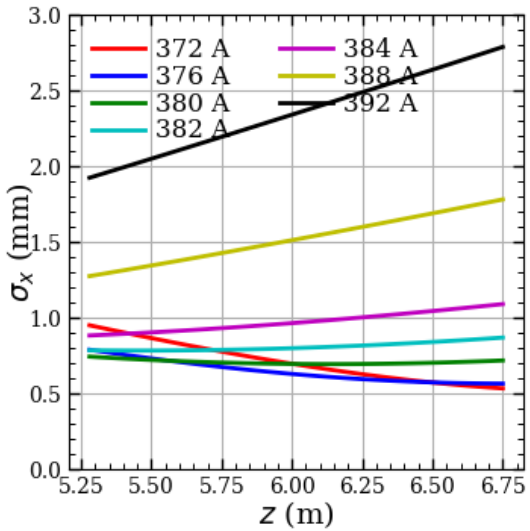
What is needed

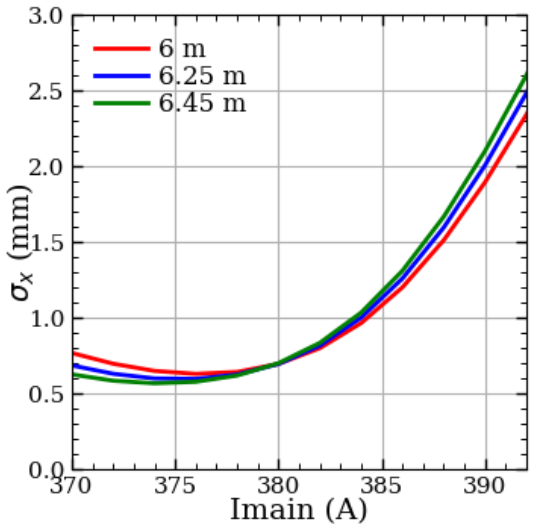
- Test gas vessel
- Static filling of gas vessel to mbar
  - Turbo pump & needle valve for He
- RGA in vacuum bypass
- Diagnostics
  - PGs
- Baffle to hinder particle flow if CFC window is destroyed
- 2nd window, e.g. copper plate (5 mm beam diameter)
- Mechanical frame (existing one ok?)

From **Matthias**

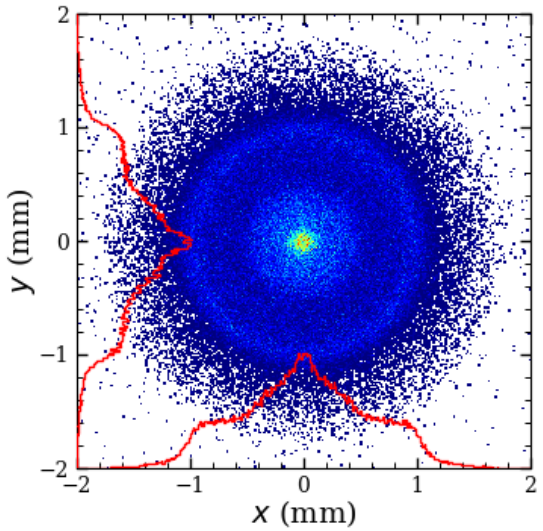
Focusing with solenoid only

- Laser BSA = 4.5 mm ($\sigma_x = \sigma_y = 1$ mm), FWHM = 8 ps
- Gun4.2, 60 MV/m, MMMG+5; Booster MMMG+16, 22 MeV
- Best emittance at EMSY1: Imain = 392 A

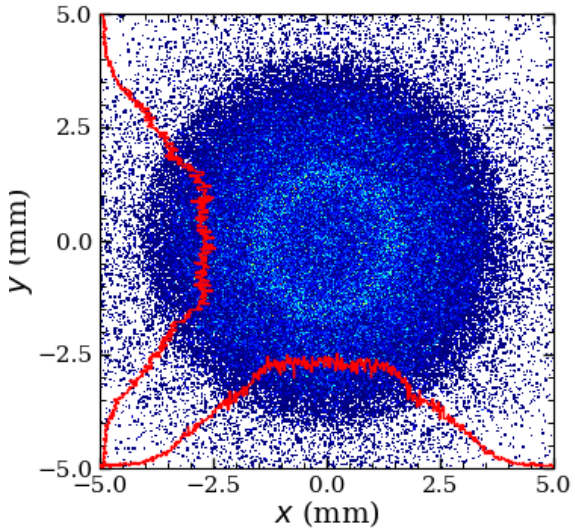




z = 6.25 m, RMS 0.6 mm, 376 A



z = 6.25 m, RMS 2.0 mm, 390 A

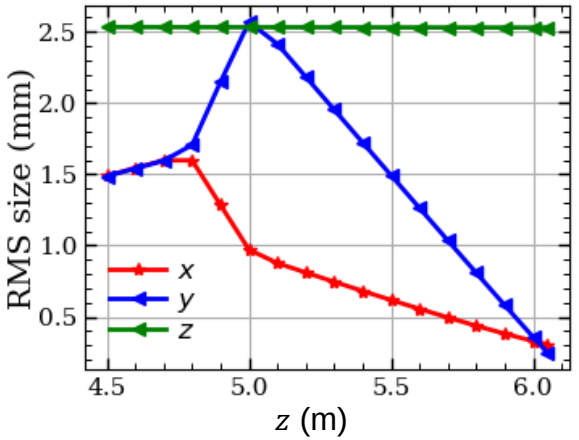


- Minimum beam size of ~0.6 mm RMS around 6.25 m (H1S2) at 376 A
- The beam has a ring structure shape (space charge effects?)
- Outer particles are <5 mm away from beam axis near 6 m

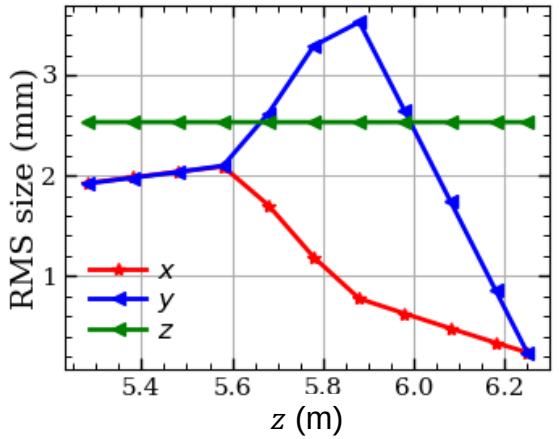
Focusing with quadrupole doublet

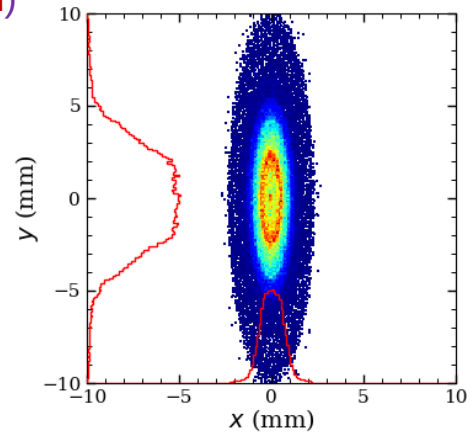
Imain = 392 A

H1.Q1 and H1.Q2 (4.25, -4.75 T/m)

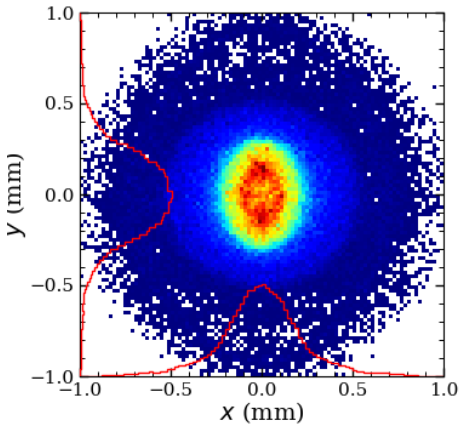


H1.Q3 and H1.Q4 (5, -7.68 T/m)

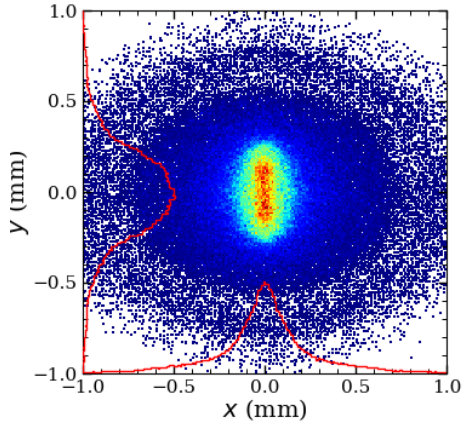




z = 6 m

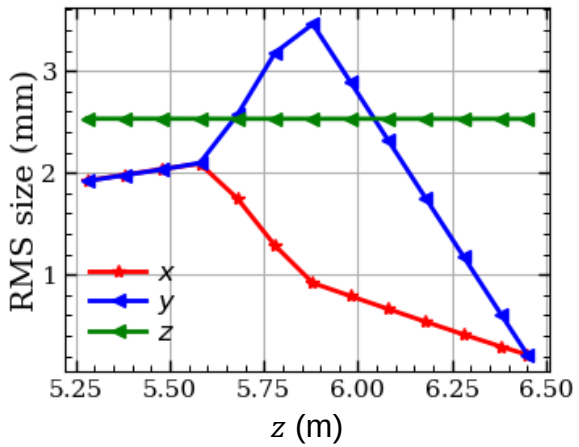


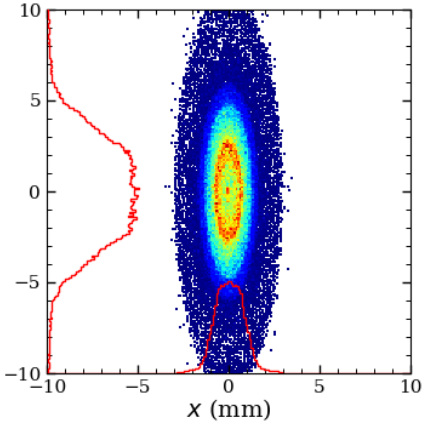
Focused at z = 6.25 m (H1S2)



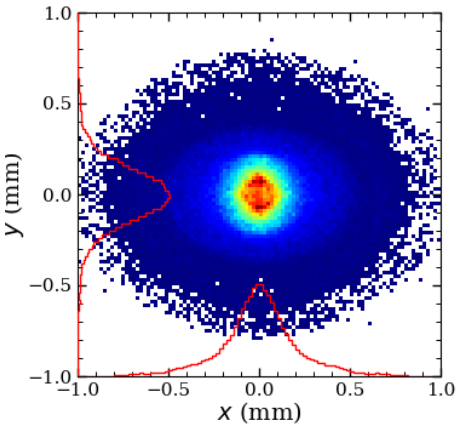
Focused at z = 6.05 m

H1.Q3 and H1.Q4 (4.5, -6.1 T/m)





z = 6 m

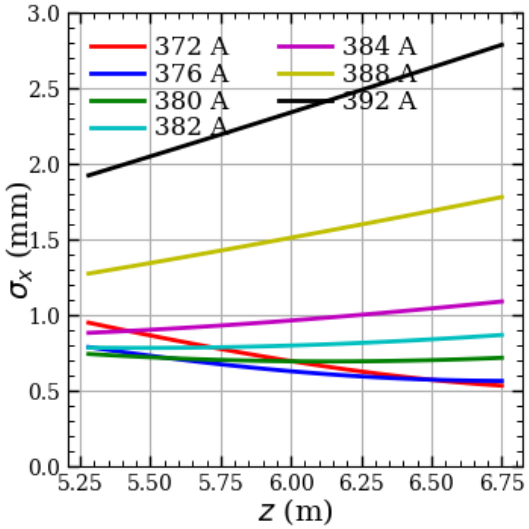


Focused at z = 6.45 m

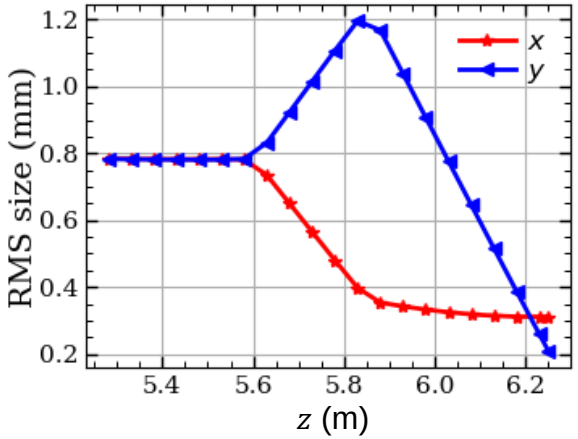
- Minimum beam size of ~0.2 mm RMS; outer particles are 10 mm away from beam axis near 6 m

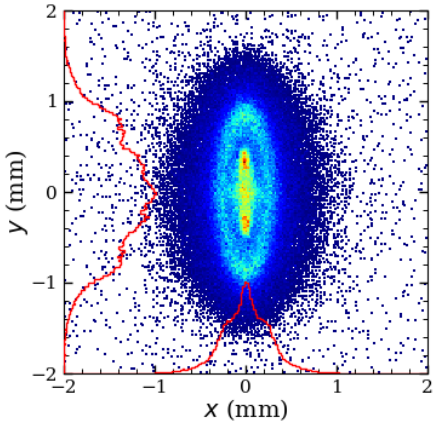
Focusing with quadrupole doublet

Imain = 382 A

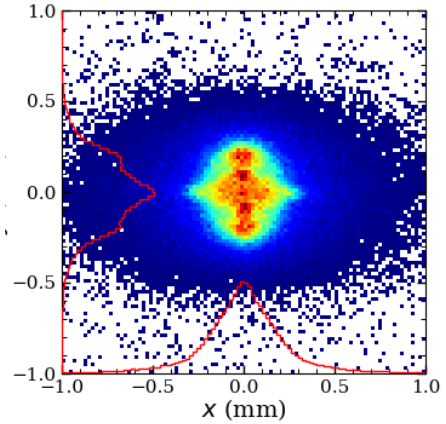


H1.Q3 and H1.Q4 (4, -6.64 T/m)



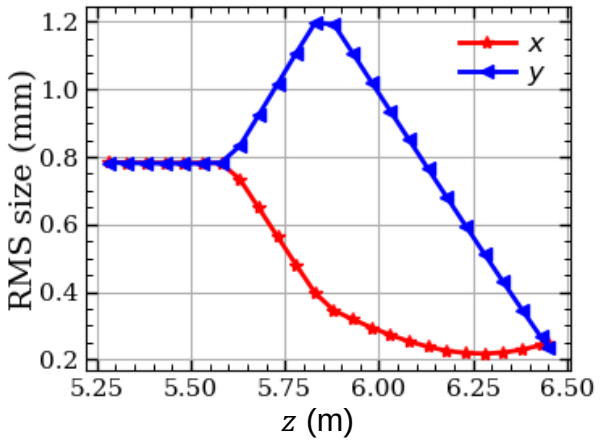


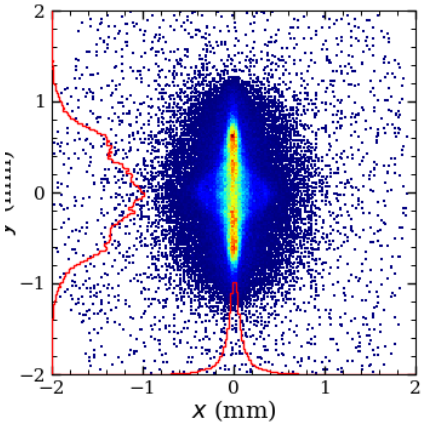
z = 6 m



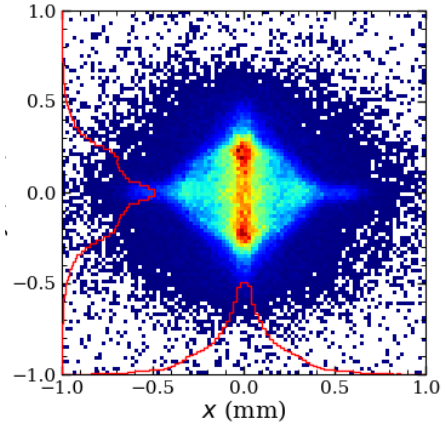
Focused at z = 6.25 m (H1S2)

H1.Q3 and H1.Q4 (4, -5.26 T/m)





z = 6 m



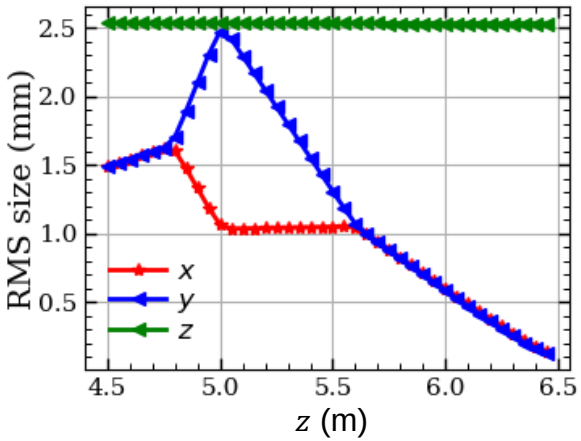
Focused at z = 6.45 m

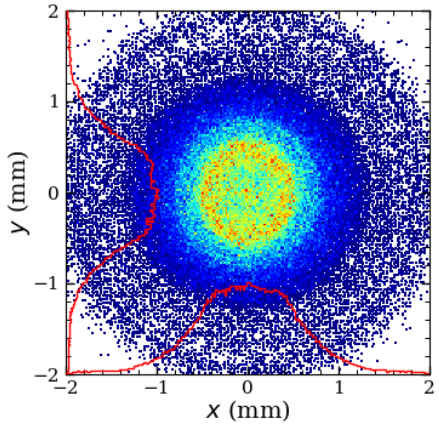
- Outer particles are <2 mm away from beam axis near 6 m

Focusing with quadruple triplet

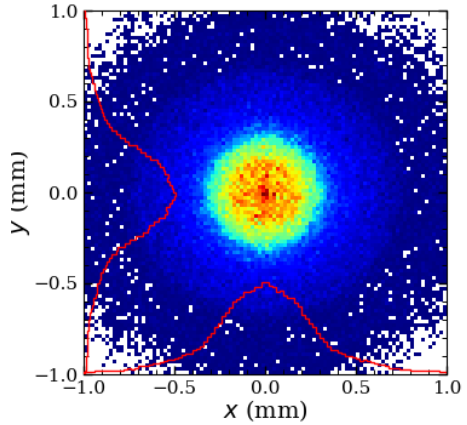
H1.Q1, H1.Q2 and H1.Q3 at Imain = 392 A

More focusing

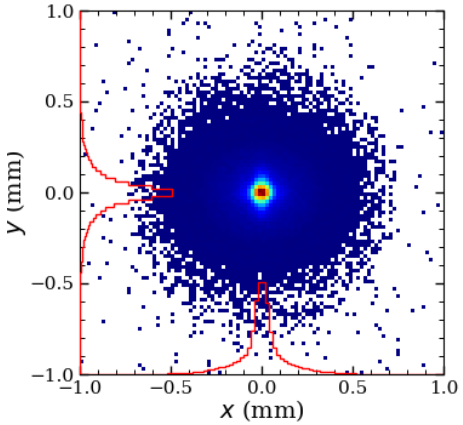




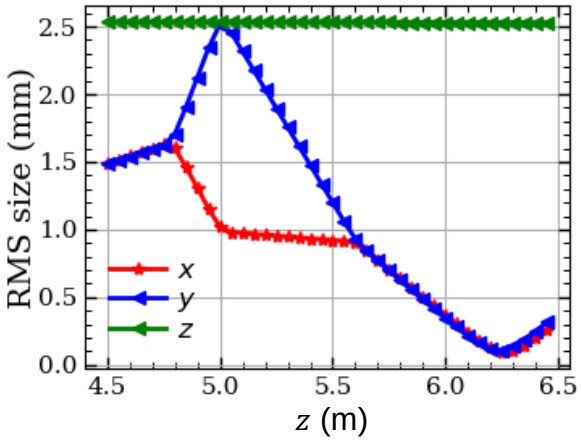
z = 6 m

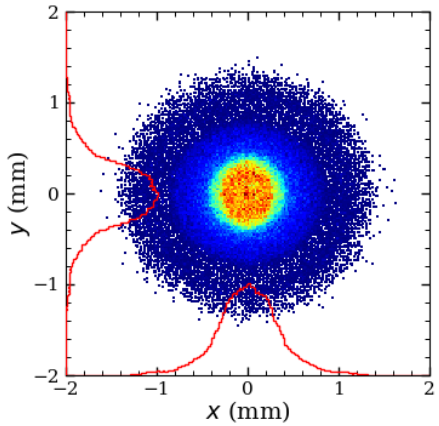


Z = 6.25 m (H1S2)

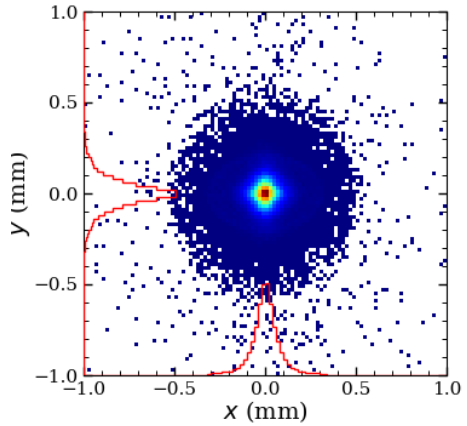


z = 6.45 m

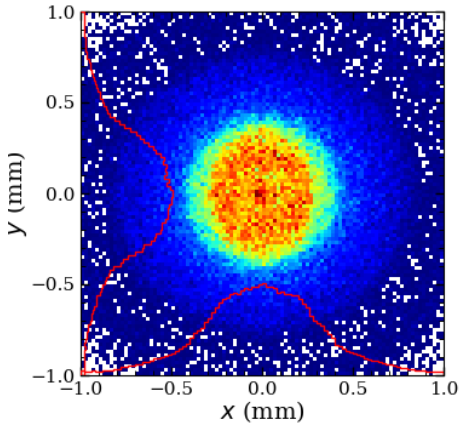




z = 6 m



Z = 6.25 m (H1S2)



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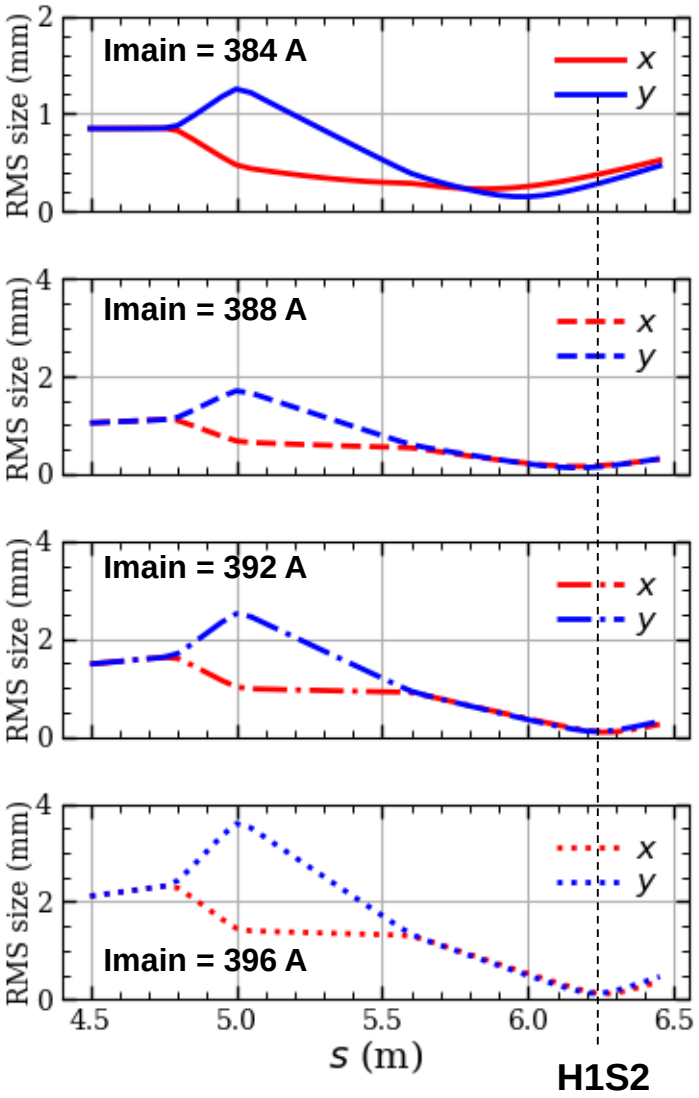
- Outer particles are <2 mm away from beam axis near 6 m

Discussion

- How to measure/know the beam profile at the window?

- Beam experiment at High1.Scr2 before the window installation
  - Laser BSA, Gun&Booster gradients/phases, Imain
  - Steerers, gun quads, high1 quadrupoles

- Quadrupole calibration before the installation
  - On the right, the same quad strengths applied for 4 cases of Imain
  - Quad strengths found for 392 A, but also work for 388-396 A



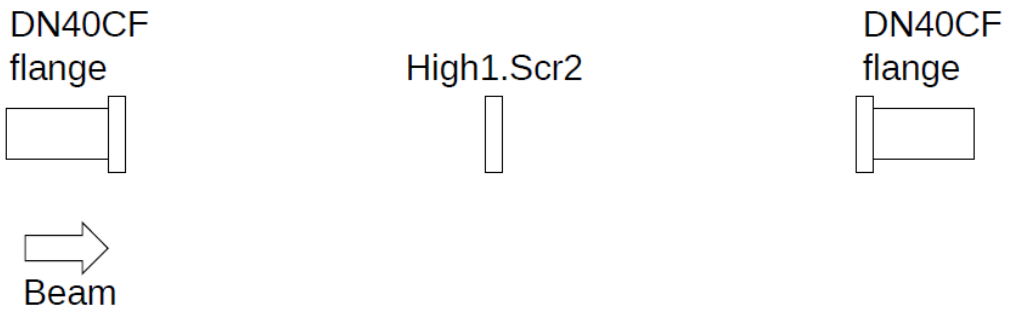
Proposed Test Area

Slot for plasma experiments etc. Currently: High1.Scr2

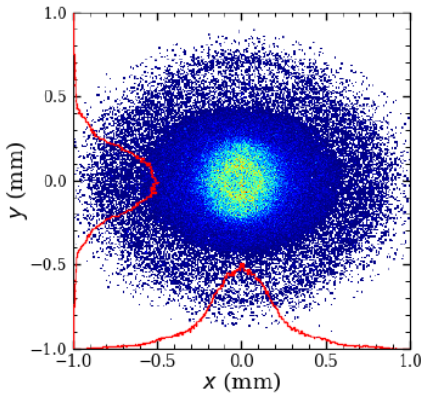
Preliminaries

Simulation and experimental plan

Upstream: Main solenoid + 4 quads for focusing



Example for focusing of e-beam with 5nC bunch charge (simulated for High1.Scr2 position, but similar results for whole range of experimental slot)



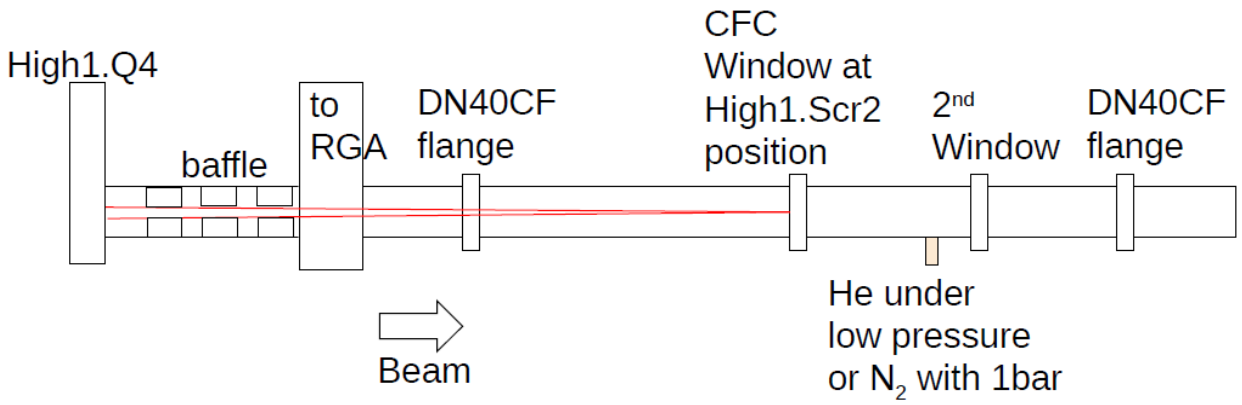
Gaussian fit: $\sigma_x=\sigma_y=200\mu m$

Experiments

- Preparation: beam sizes with quad focussing (with High1.Scr2); 2mm downwards in 0.2mm steps
- Damage threshold
- …

Possible setup

Window in vacuum (low pressure); later maybe with 1 bar pressure difference



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