To a beam scraper simulations
(radial vs. phase space cuts)

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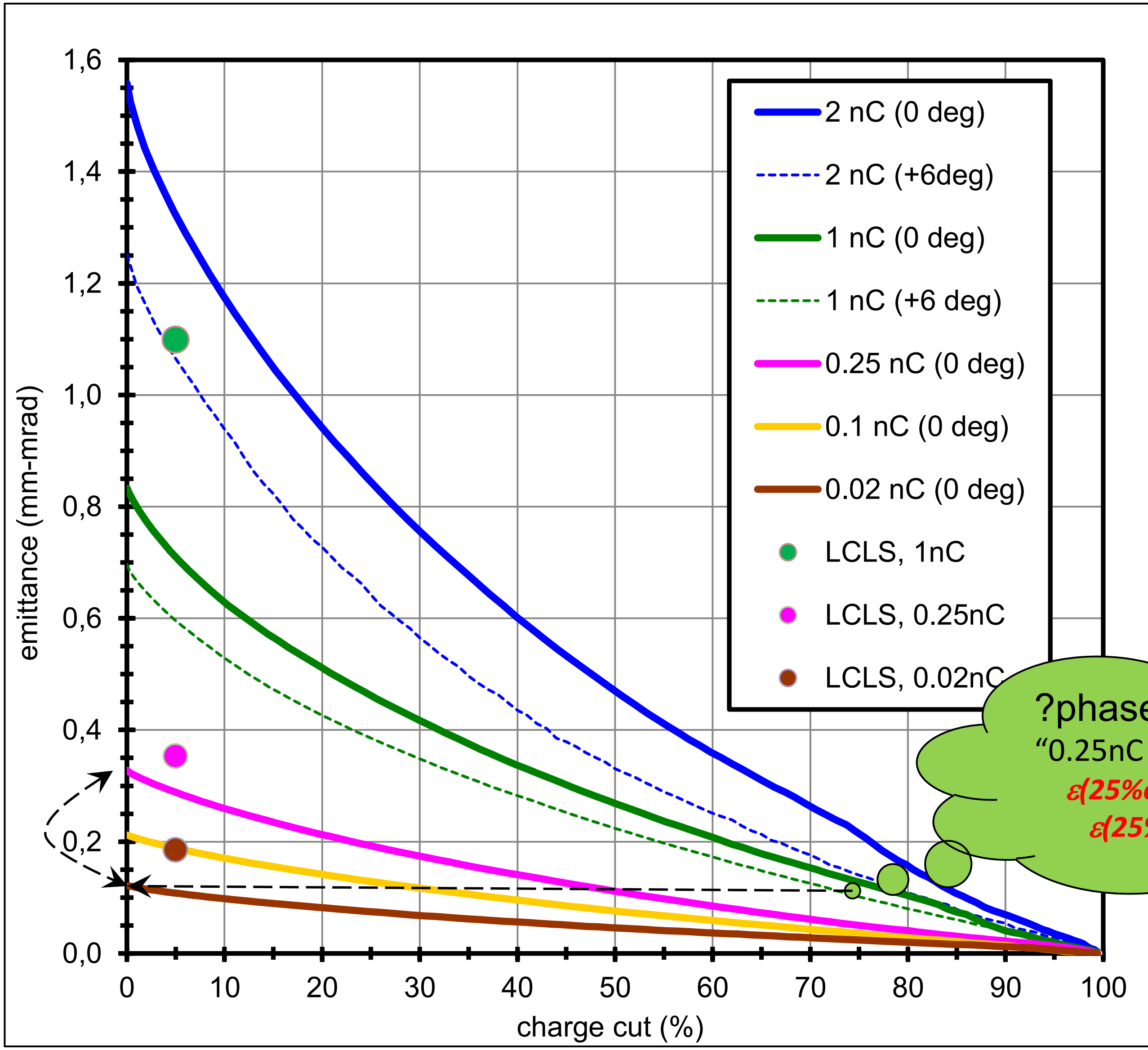
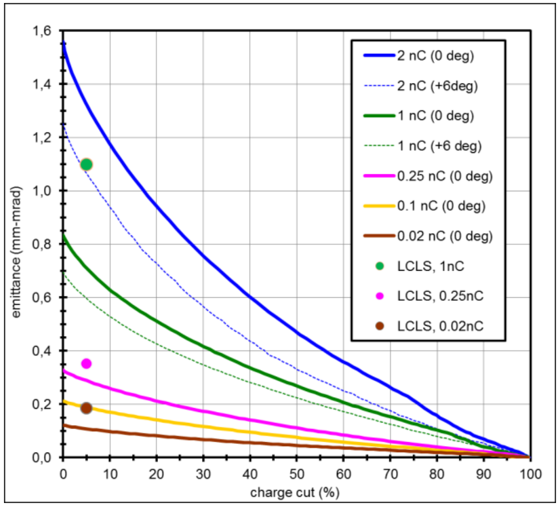
Core Emittance for various bunch charges



?phase space collimator?
“0.25nC core from 1nC beam”
ε(25%of1nC)~ε(100%of250pC)/3
ε(25%of1nC)~ε(100%of20pC)

?to be simulated?
Collimator → FODO → collimator

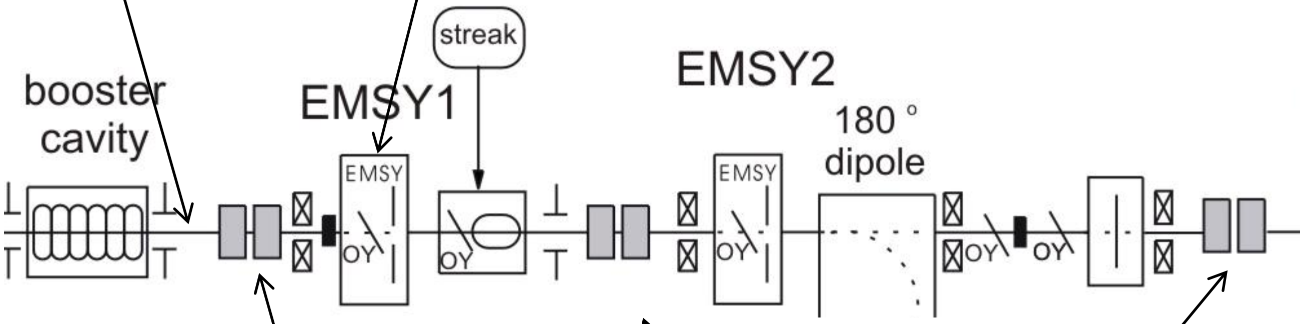
Idea: Core Emittance from beam scraper?

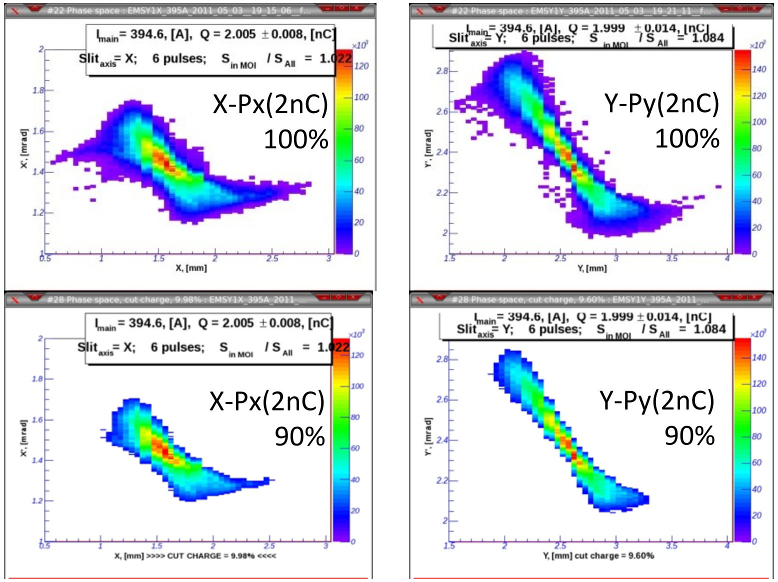


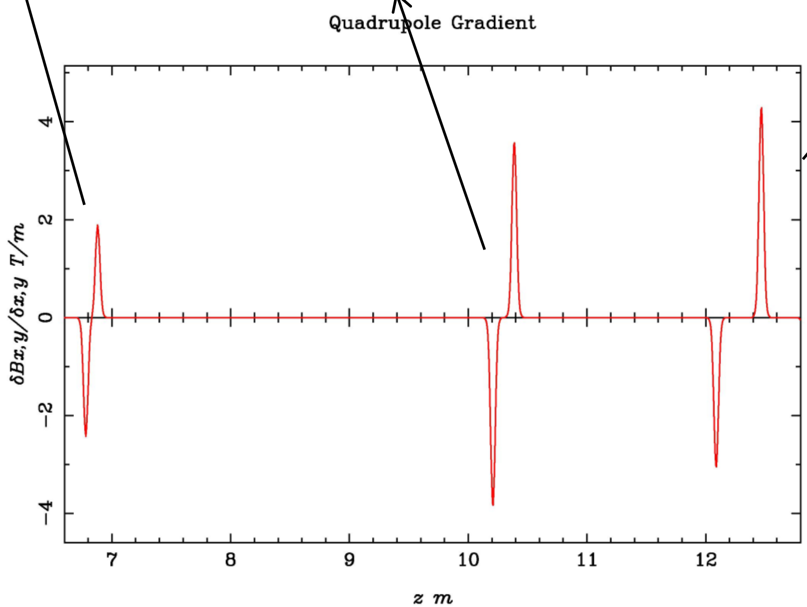
?to be simulated:

- space (image) charge
- wake field (like) effect
- …

Collimator → FODO → collimator







Very first tests: Radial collimator = R-cut for a simulated phase space

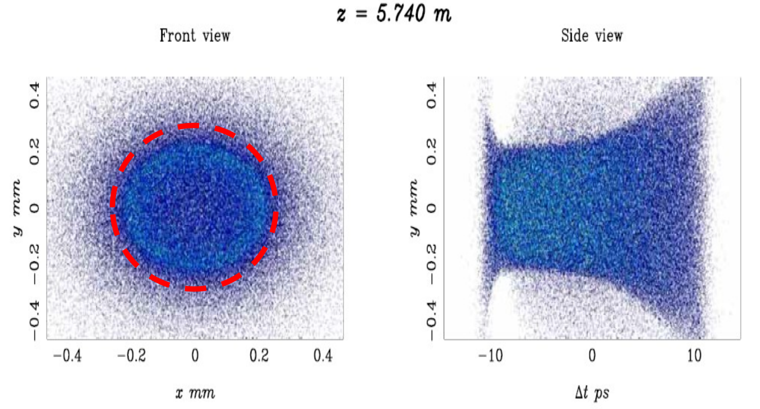
100pC case: Simulated phase space ~ measured

NB: This is not optimum setup from the beam dynamics ASTRA simulations, but simulations of the optimum experimental setup!

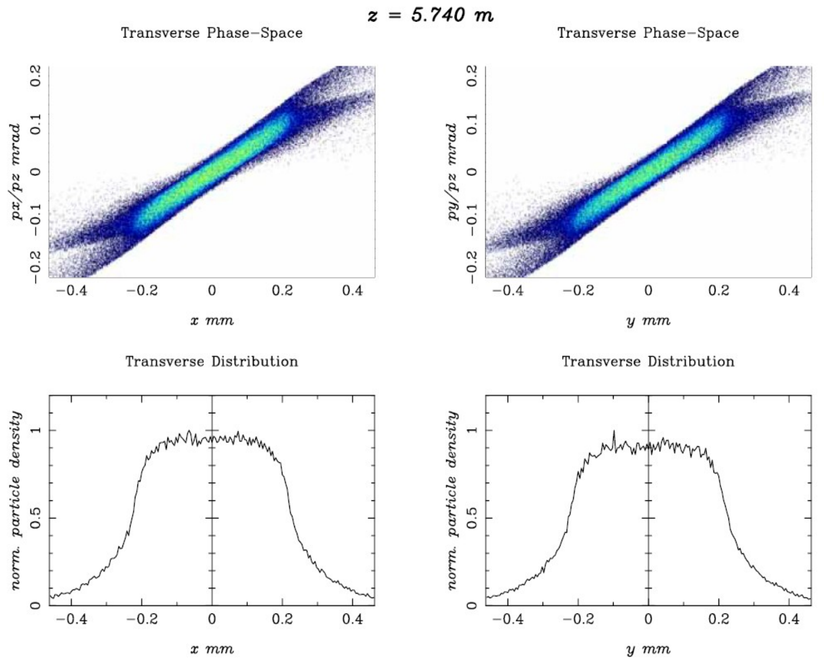
Electron beam parameters at EMSY1
(z=5.74 m from the cathode plane)

- Bunch charge 100 pC
- Beam kin.(mean) energy 23.64 MeV
- RMS bunch length = 1.74 mm
- RMS energy spread= 29 keV   [<zE'>=12.2keV]
- Transverse phase space:
- Xrms=Yrms=0.185 mm
- Xemit=Yemit=0.2075 mm mrad

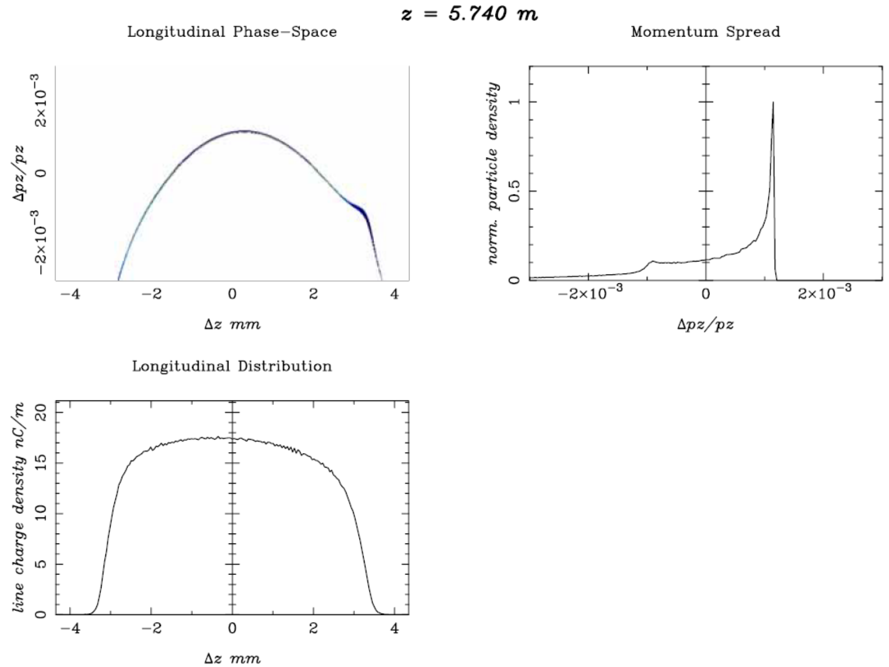
Side view



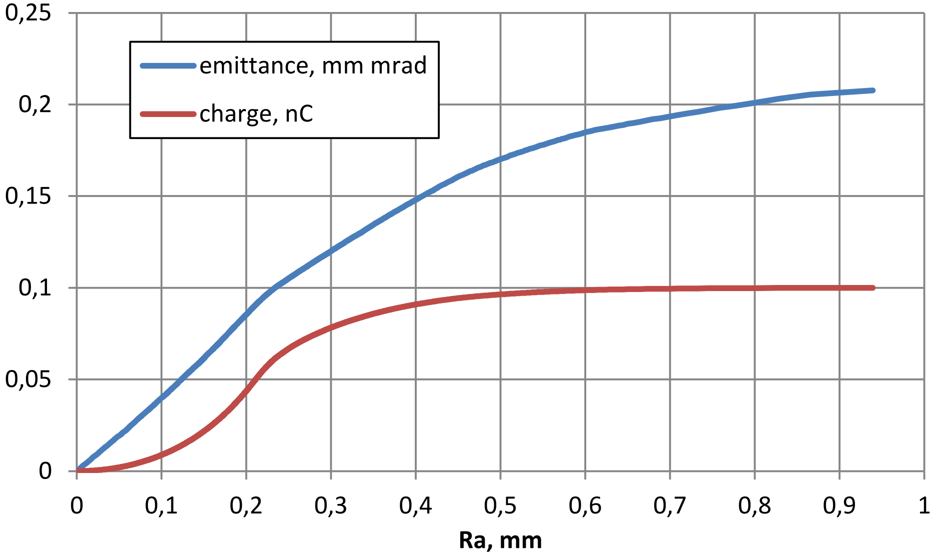
Transverse phase space



Londitudinal Phase space



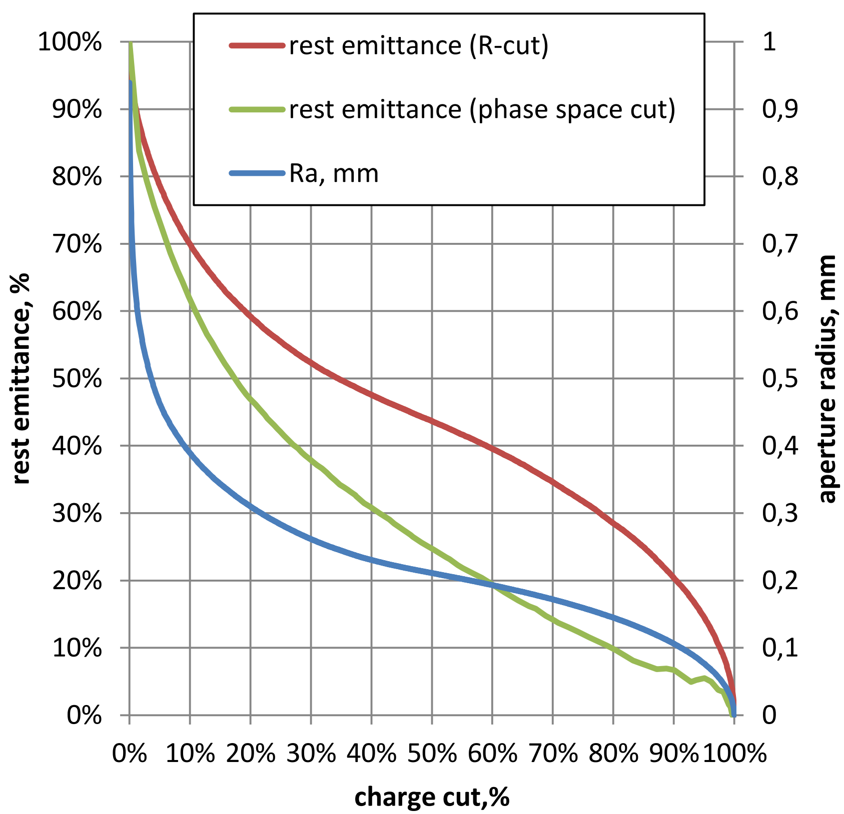
100pC case: Charge cut using a radial aperture Ra



Emittance reduction, %	Corresponding charge cut, % (rest charge, pC)	Required aperture Ra, mm
-41%	20% (80pC)	0.31 mm
-52%	40% (60pC)	0.23 mm
-72%	80% (**20pC**)	0.14 mm

very small apertures!
→ not a practical case?

Compared to a phase space cut:



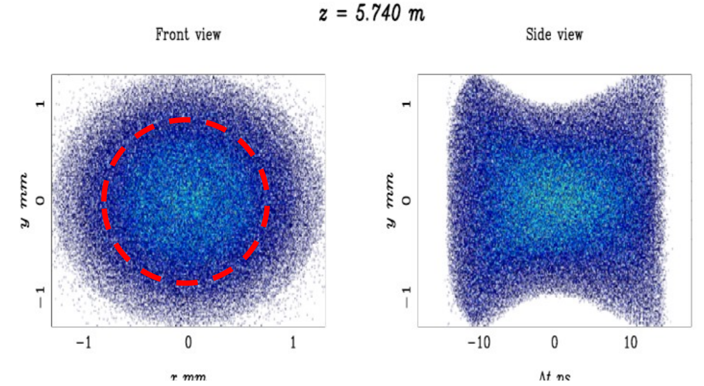
1nC case: simulated phase space ≠ measured

NB: This is optimum setup from the beam dynamics ASTRA simulations. There are some discrepancies with corresponding measured phase space.

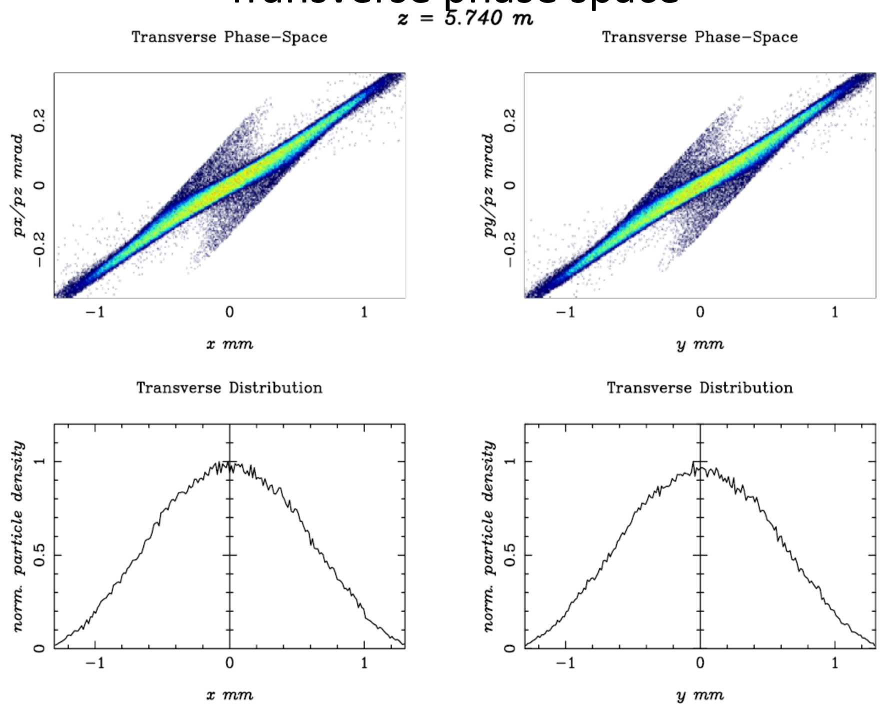
Electron beam parameters at EMSY1
(z=5.74 m from the cathode plane)

- Bunch charge 1 nC
- Beam kin.(mean) energy 23.41 MeV
- RMS bunch length = 2.16 mm
- RMS energy spread= 83.8 keV [<zE'>=70.4keV]
- Transverse phase space:
- Xrms=Yrms=0.52 mm
- Xemit=Yemit=0.607 mm mrad

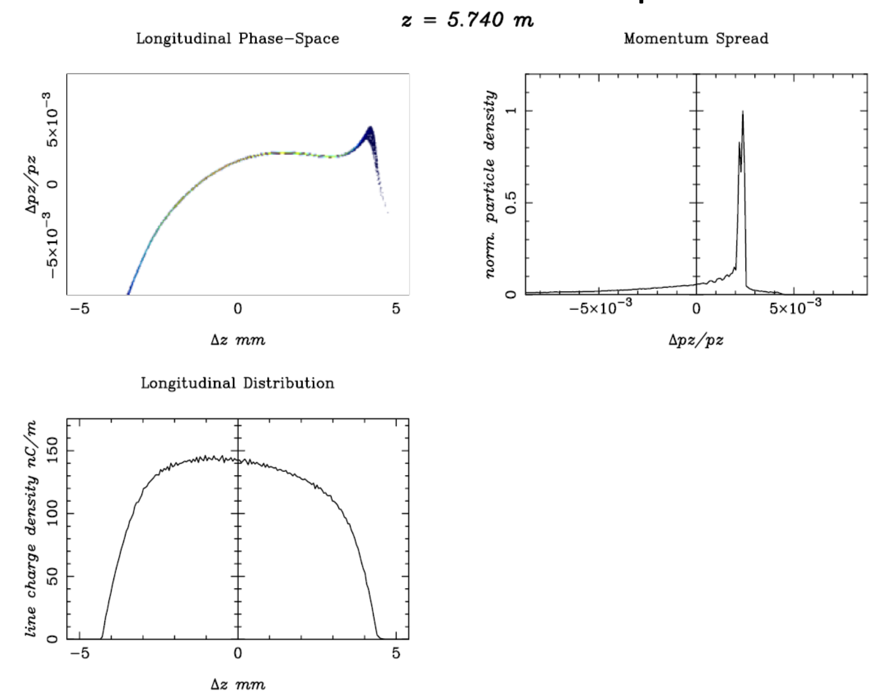
Side view



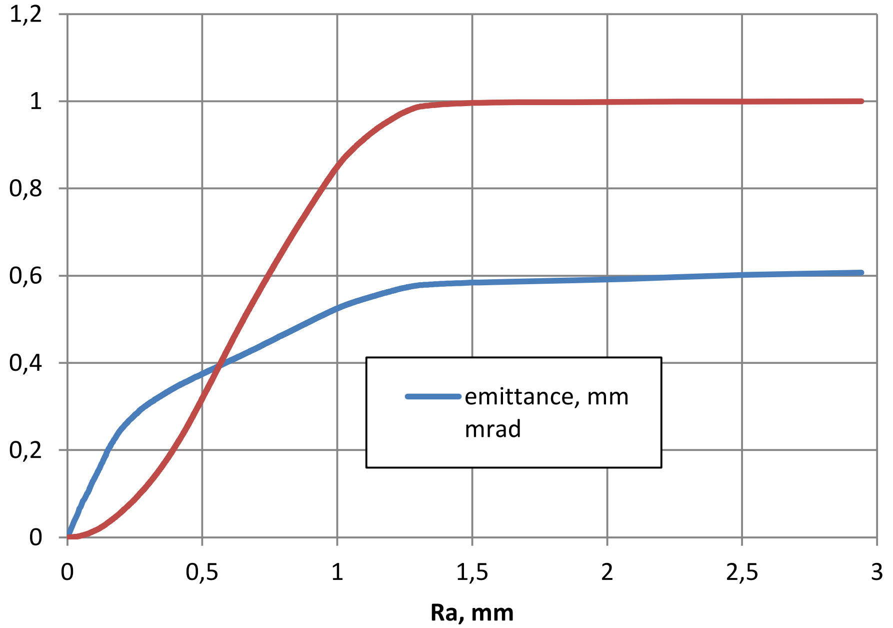
Transverse phase space



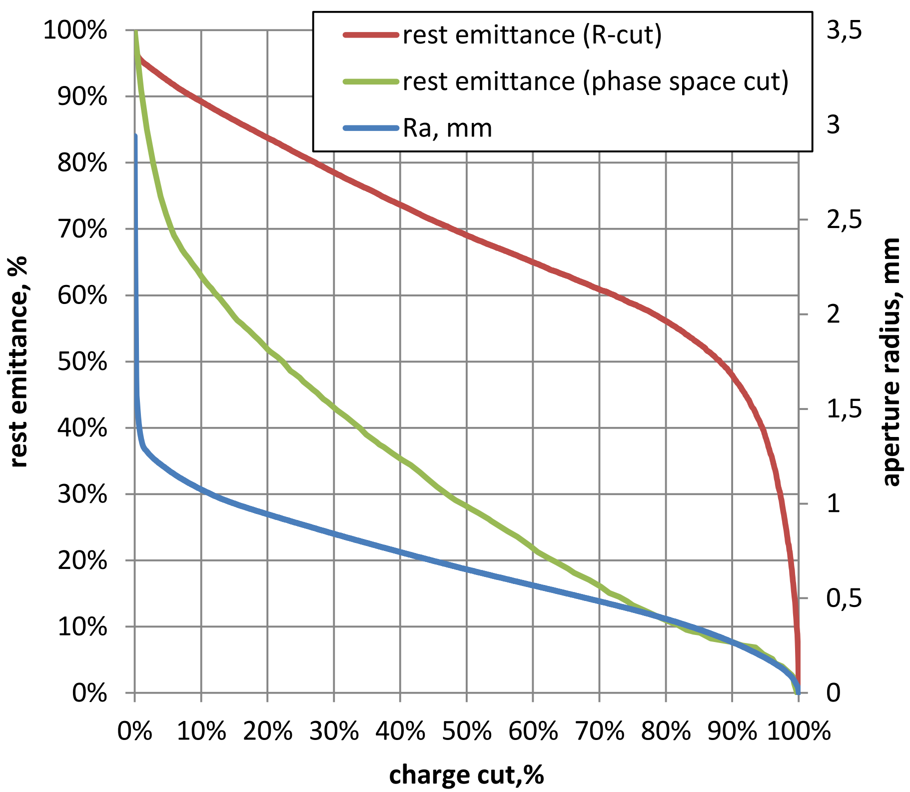
Londitudinal Phase space



1nC case: Charge cut using a radial aperture Ra

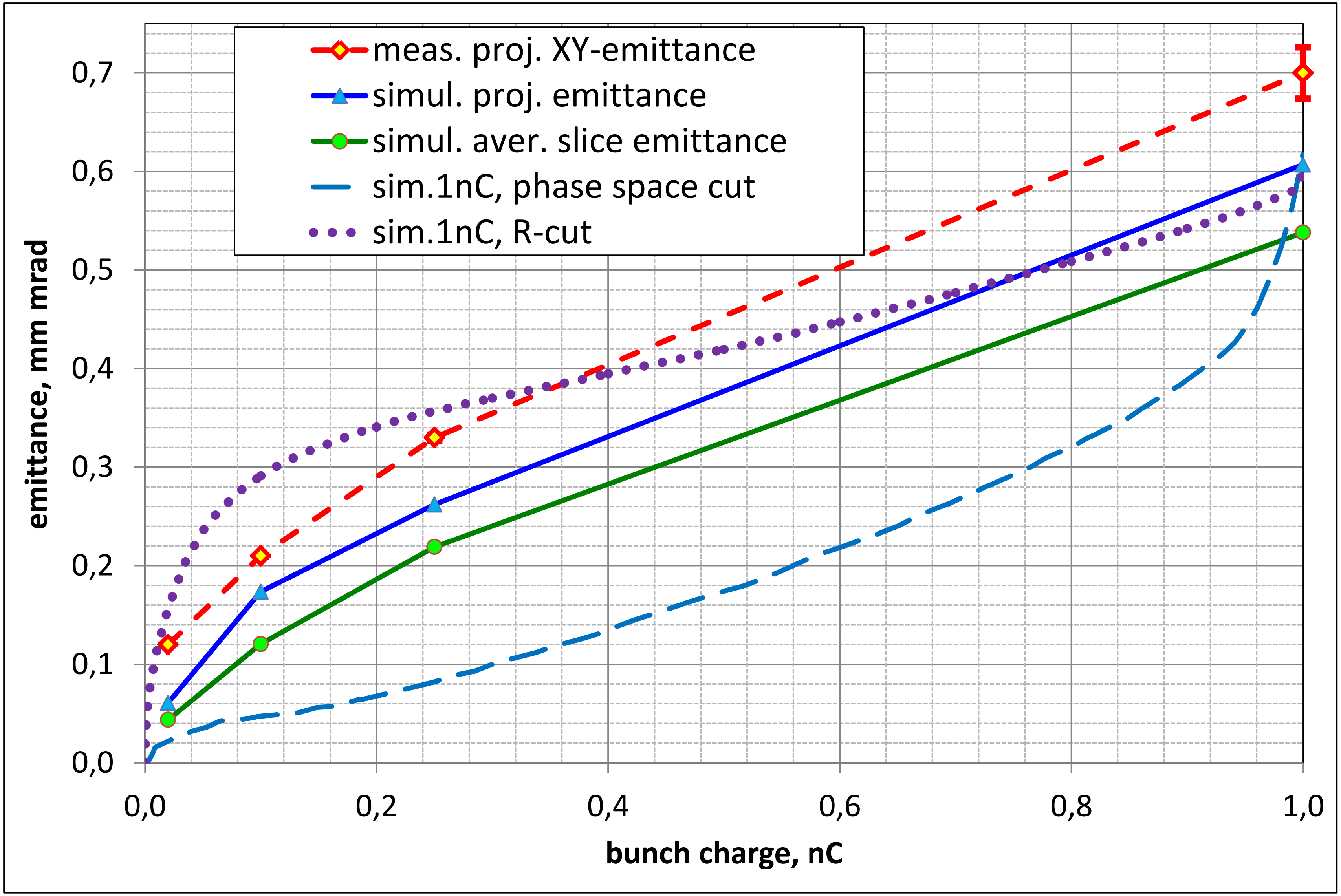


Compared to a phase space cut:

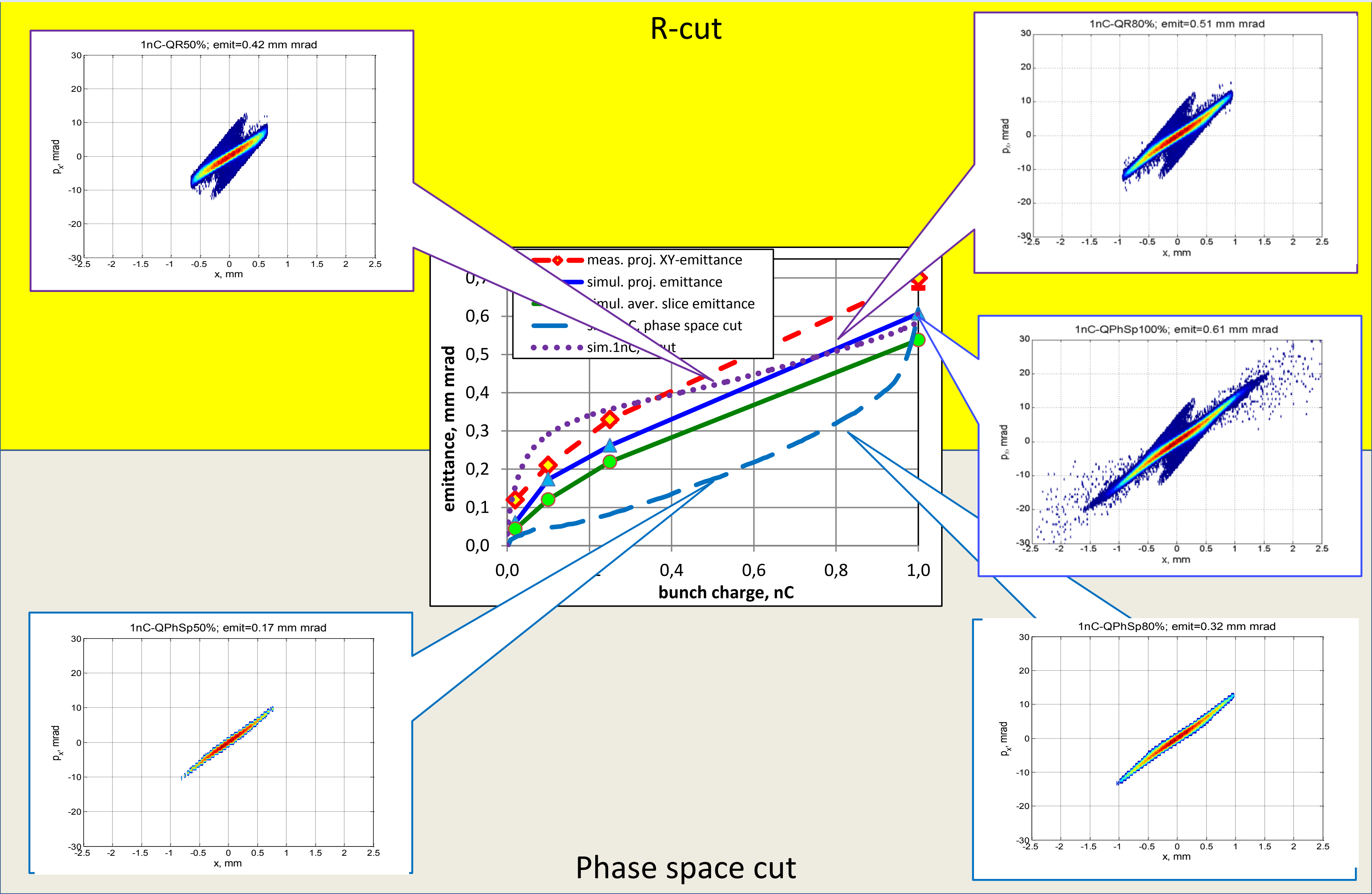


Emittance reduction, %	Corresponding charge cut, %	Required aperture Ra, mm	Remnant charge, nC
-11%	10%	1.07 mm	0.9 nC
-31%	50%	0.65 mm	0.5 nC
-41%	75%	0.44 mm	0.25 nC
-52%	90%	0.27 mm	0.1 nC
-74%	98%	0.12 mm	0.02 nC

1nC case: Charge cut vs. lower initial charges



1nC case: Charge cut vs. lower initial charges



Conclusions

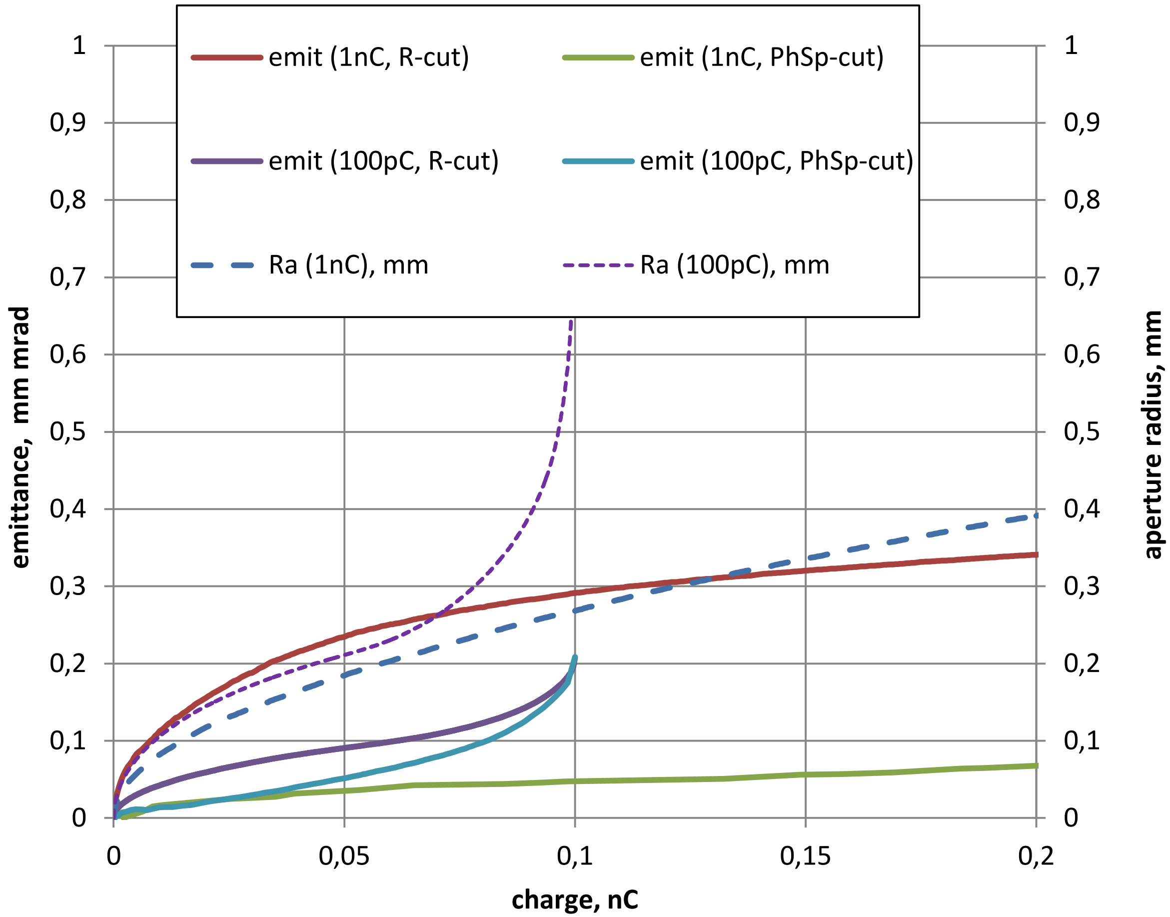
- The applied radial cut (R-cut) → "mechanical" (formal) reduction of the phase space, no electromagnetic interactions considered

- R-cut for 100pC (more realistic) case → emittance reduction requires very small apertures (~100um) – ? not a practical case:
  - challenge to produce such collimator
  - pointing jitter of the electron beam

- R-cut for 1nC requires more realistic apertures (~500um) but still a challenge

- The phase space cut differs significantly from the R-cut, it shows much stronger core emittance reduction for the same charge cut

1nC vs. 100pC


emit (1nC, R-cut)
emit (1nC, PhSp-cut)
emit (100pC, R-cut)
emit (100pC, PhSp-cut)
Ra (1nC), mm
Ra (100pC), mm
emittance, mm mrad
aperture radius, mm
charge, nC
0
0,05
0,1
0,15
0,2
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1