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TECHNISCHE UNIVERSITÄT DARMSTADT

Current Status of Bunch Emission Simulation for the PITZ Gun

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- **Reviews:**

  motivation, simulation model and settings, technical problems & solutions, CST simulation logfiles, etc.

- **CST Simulation Results:**

  emittance studies (convergence studies for r=0.4mm, Q0=1nC, comparisons with ASTRA), charge emission study (r=0.2mm-0.4mm, Q0=1nC)

- **Summary and Outlook:**

  charge emission study (r=0.3mm, Q0=2nC), inhomogeneous case

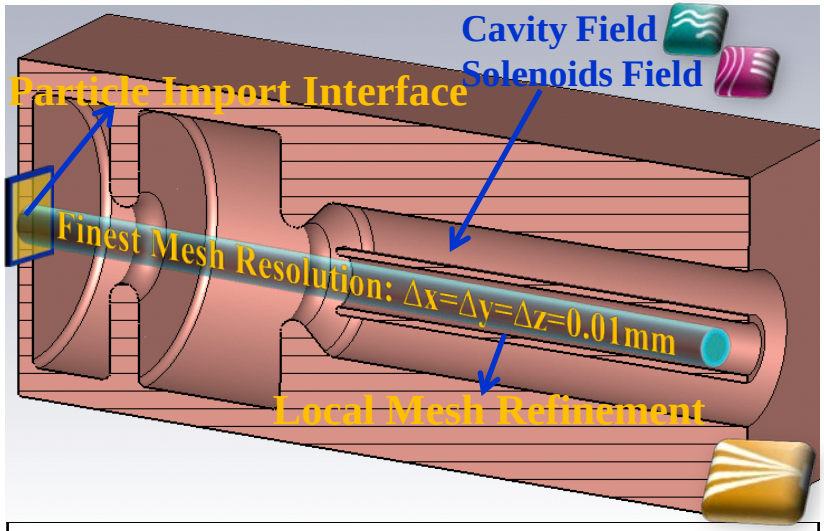
Reviews

- **Motivation of this study:** investigations on the huge discrepancies between the simulation results and experimental data which contribute to understanding on the emittance growth within the PITZ Gun.

Problem: Beam uniformity assumption violated few mm away from cathode in the boosted frame

The 3D CST PIC Approach can be performed in order to solve the problem.

see talks from Dr. Erion Gjonaj, @ Hamburg 12.2011 and Zeuthen 12.2013 for details



Simulation Parameters

Q_{tot}=1nC, XY_{rms}=0.4mm,

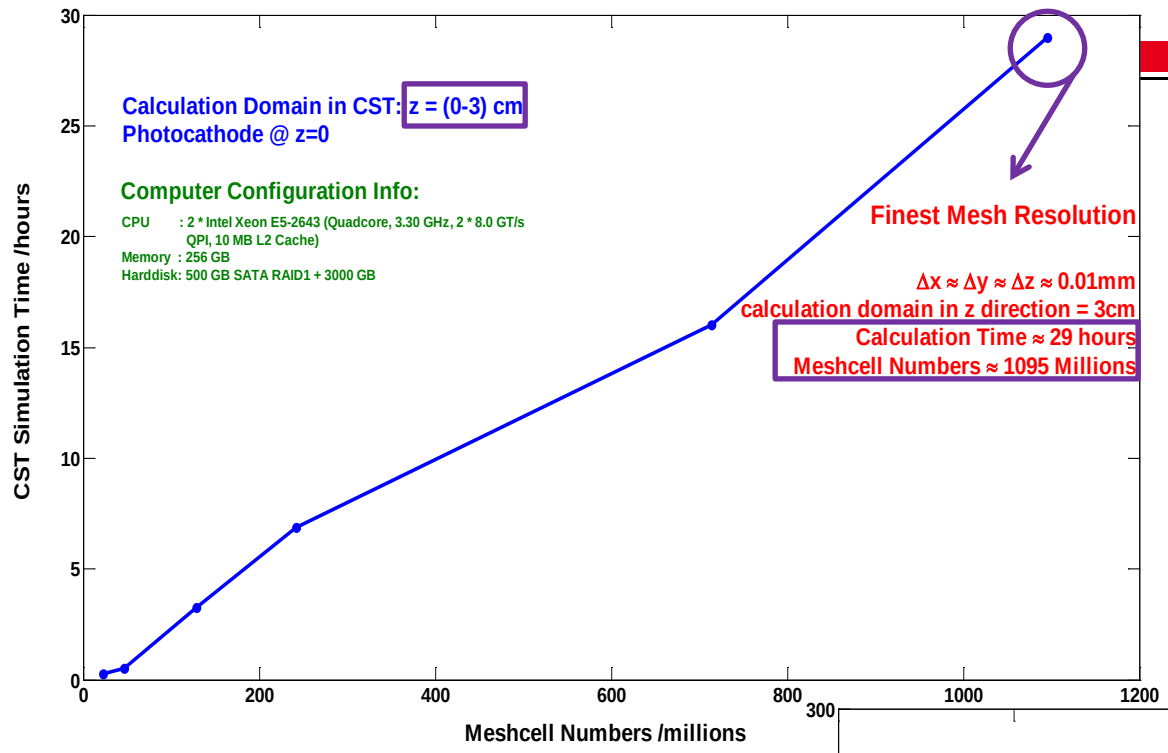
Bunch length =2ps/21.5ps\2ps, E_{kin}=0.55eV,

field gradient=60.58MV/m,

field Ratio=1.04, MaxBz=-0.2279T

Technical Problems	Applicable Solutions
Cavity field interpolation at the cathode plane	▪ Mirrored gun model ▪ Export field data in ascii and redefine mesh steps in each direction
Resolution over the initial bunch length (particle import interface)	▪ Improve the local mesh steps down to 0.005mm or so ▪ Apply an initial distribution which spreads in time instead
Cavity field accuracy	▪ Eigenmode calculations with comparable high resolution for PIC
CPU&MEMORY…	Cluster…

- Calculation domain: **3 cm**
- Meshcell numbers needed with resolution of 10μm : **1095 millions**
- Timescale: **29 hours**



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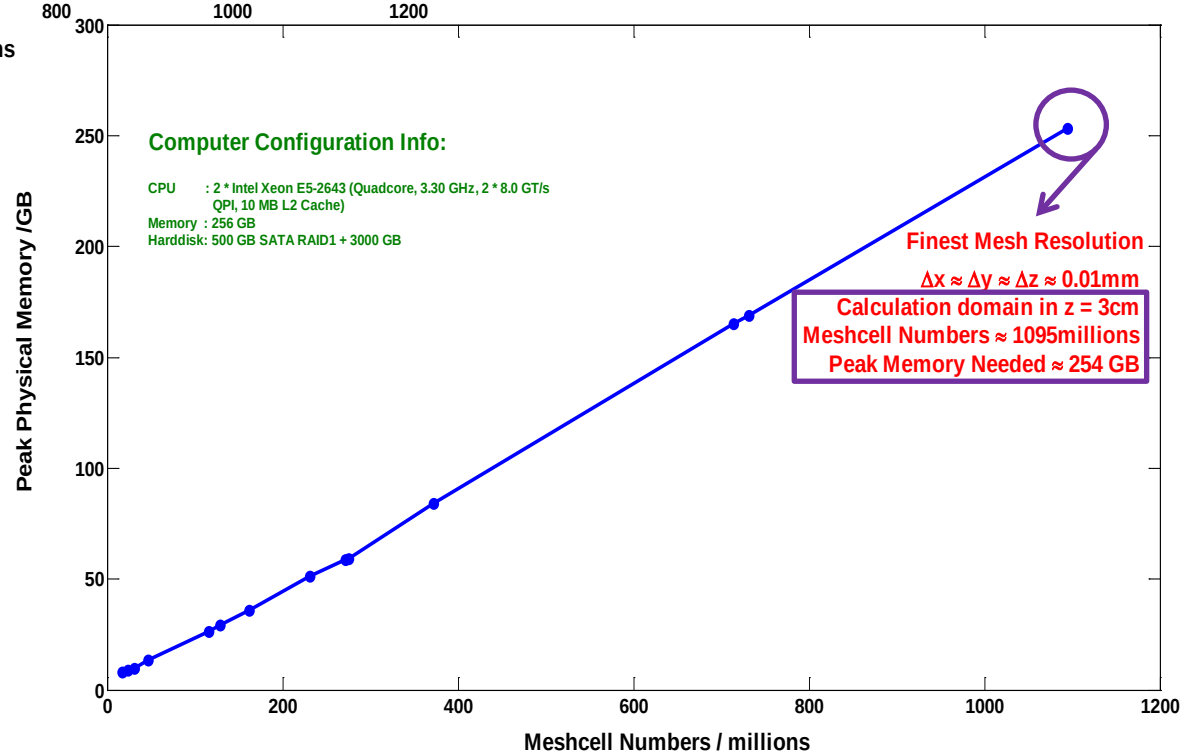
CPU

Memory



CST Simulation Results ---Emittance Studies

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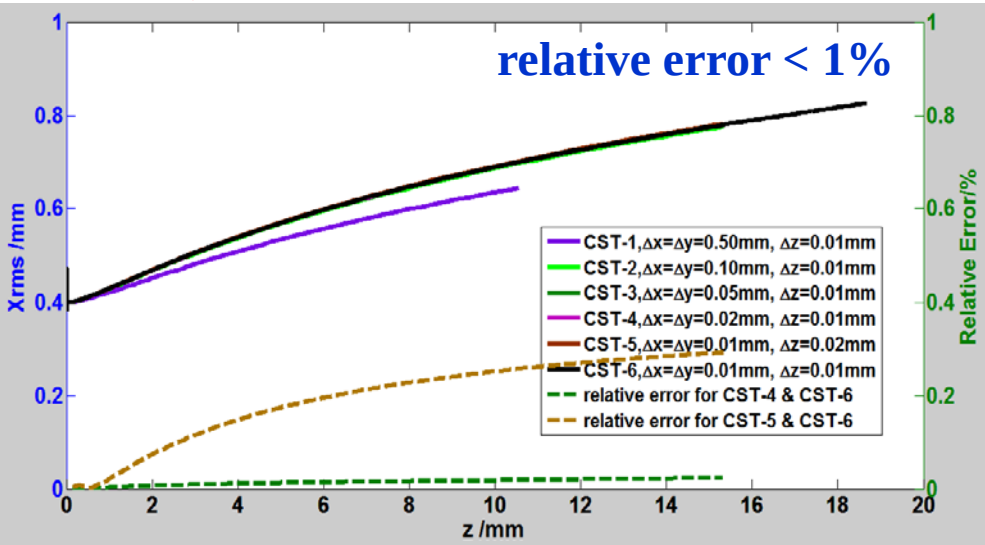
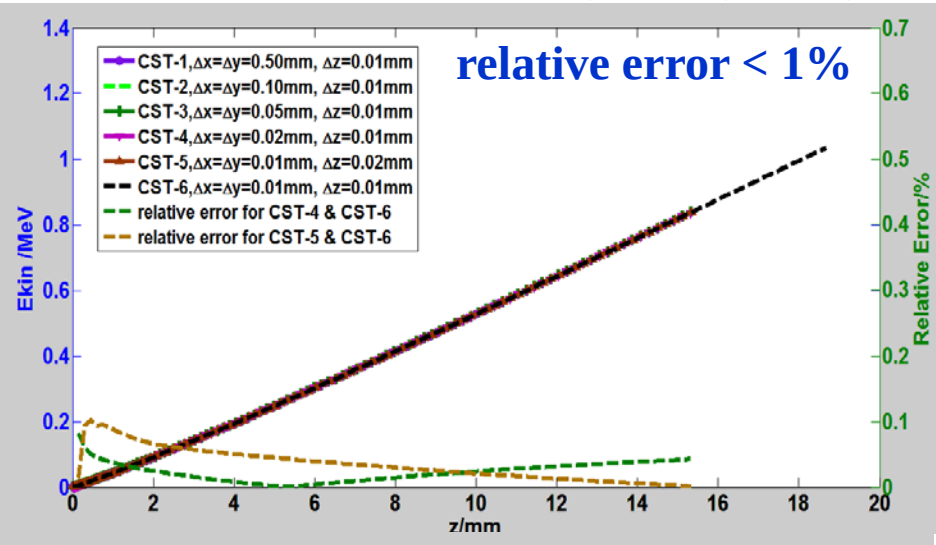
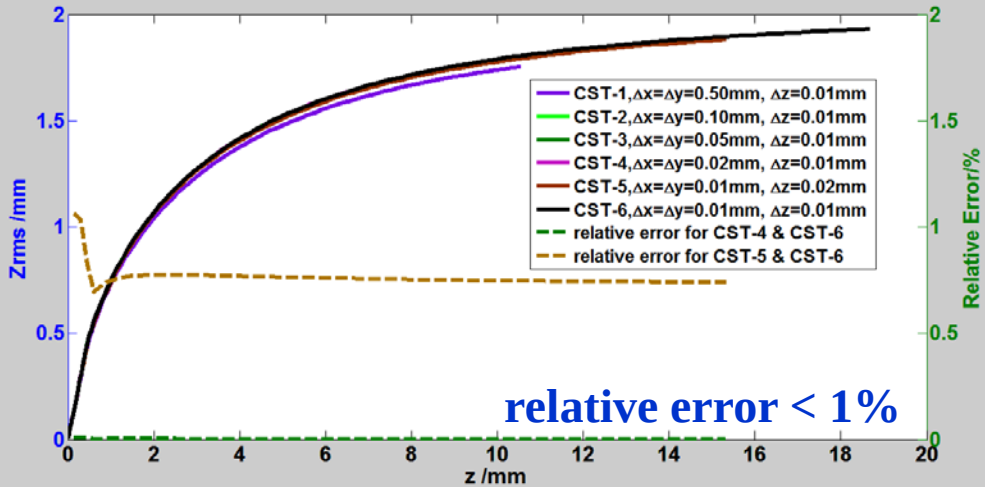
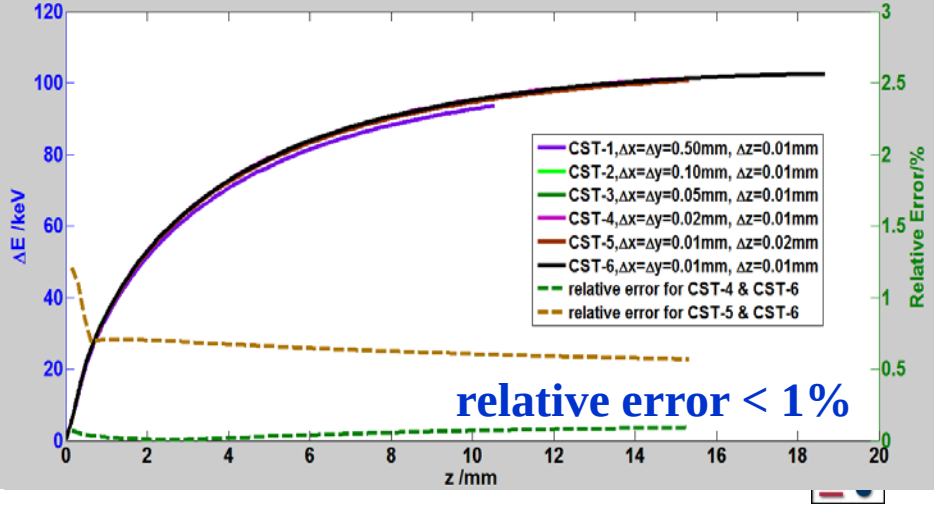
- Shorten calculation domain to 20 mm for convergence study
- Simulation results with a high resolution of 10μm for r=0.4mm, Q=1nC case

r=0.4mm, Q=1nC **for Xrms, Zrms, Ekin, ΔE**









CST Emittance Studies

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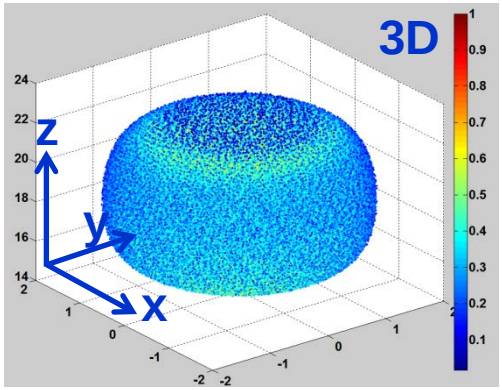
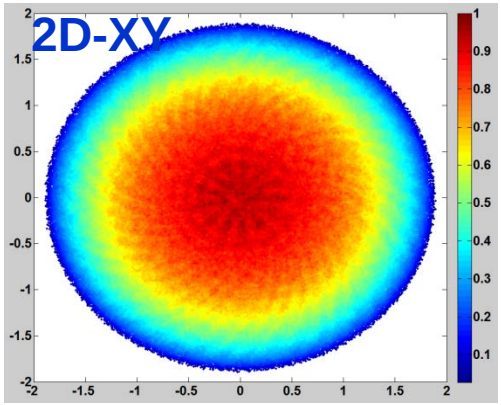
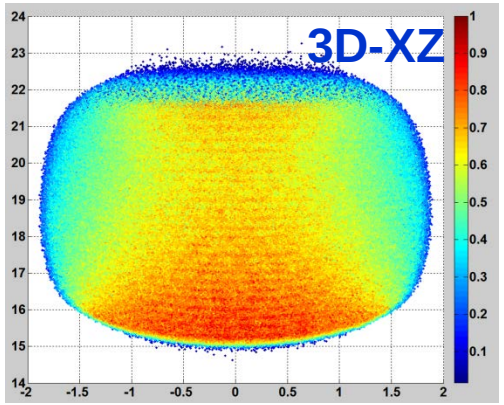
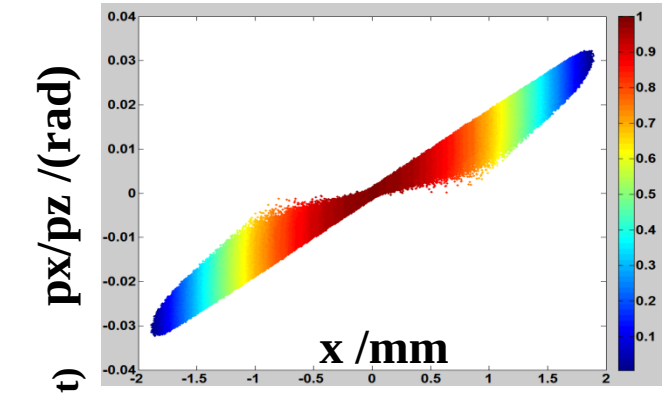
Particle Distributions @ z=18.6758 mm

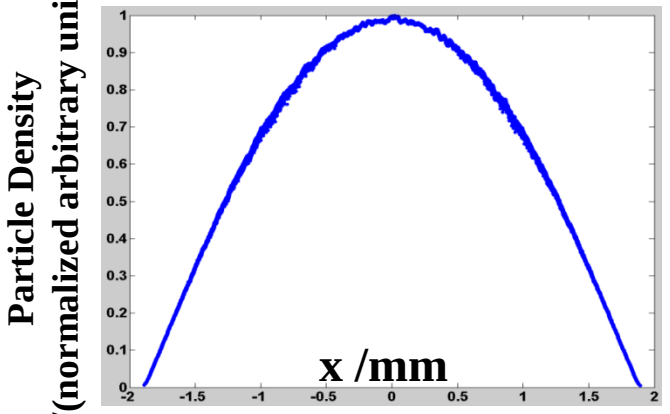






Transcerse Phase Space at z=18.6758 mm





CST Emittance Studies

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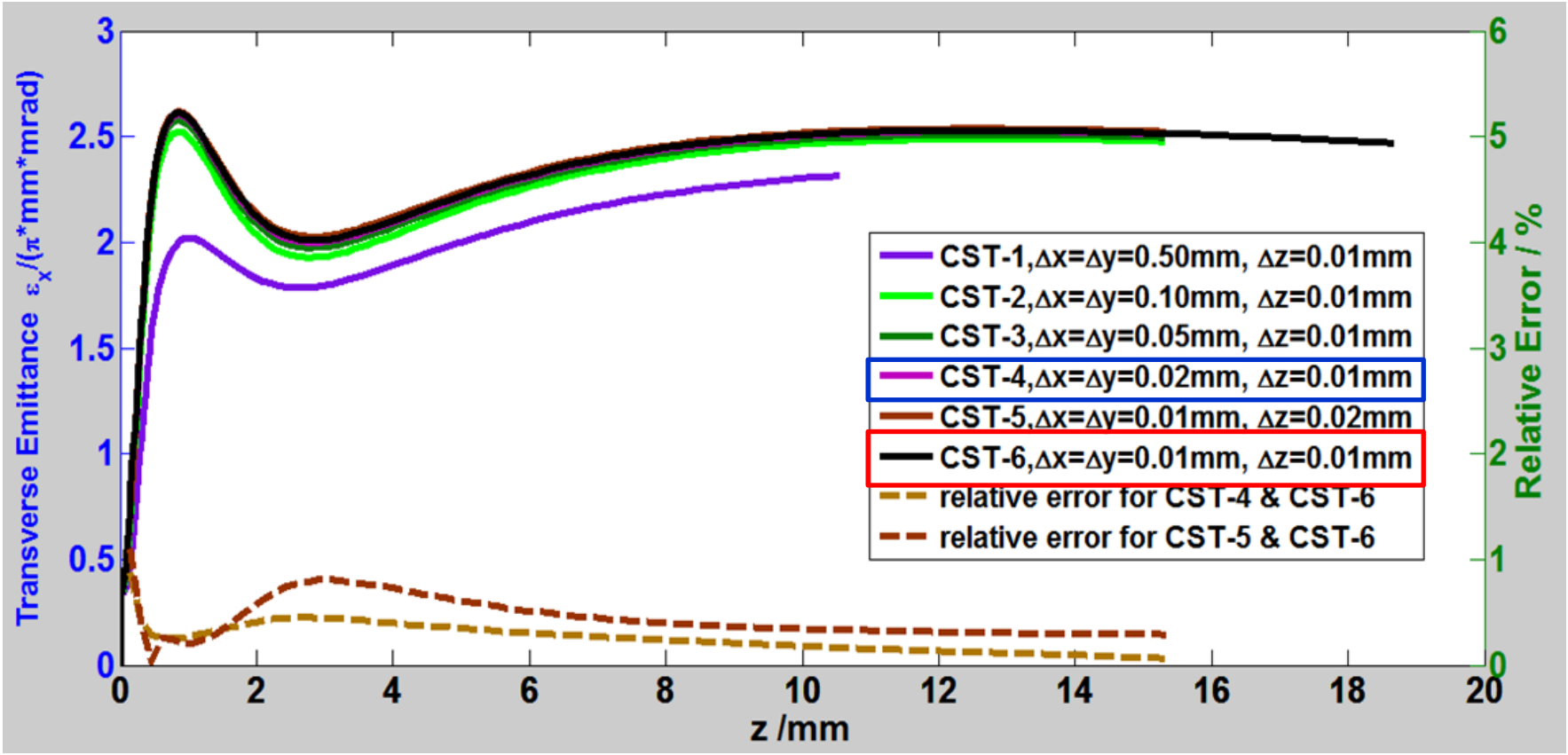
r=0.4mm, Q=1nC **for transverse emittance**



- **The relative error is below 1%.**

Comparisons with ASTRA

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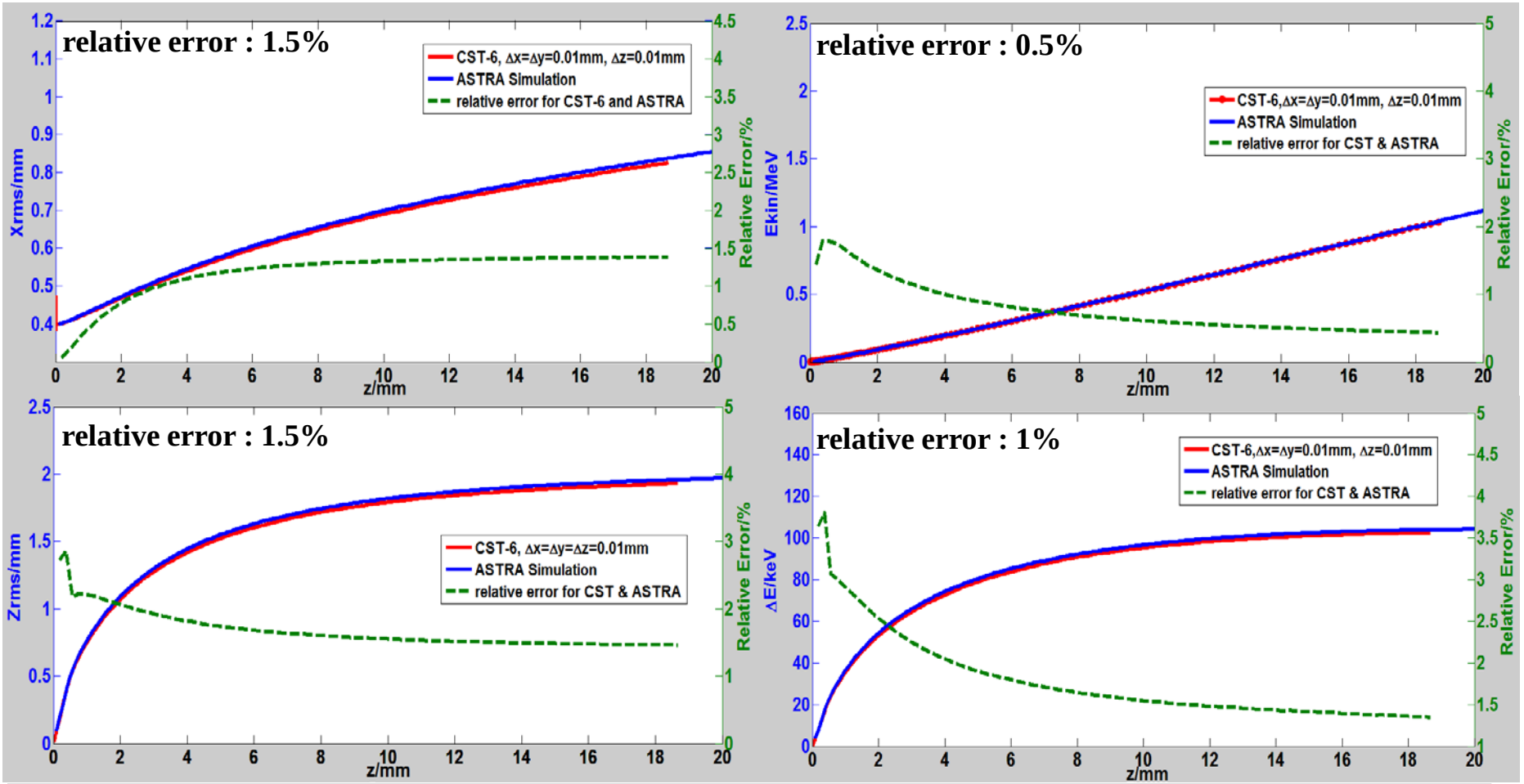
r=0.4mm, Q=1nC **for Xrms, Zrms, Ekin, ΔE**



Comparisons with ASTRA

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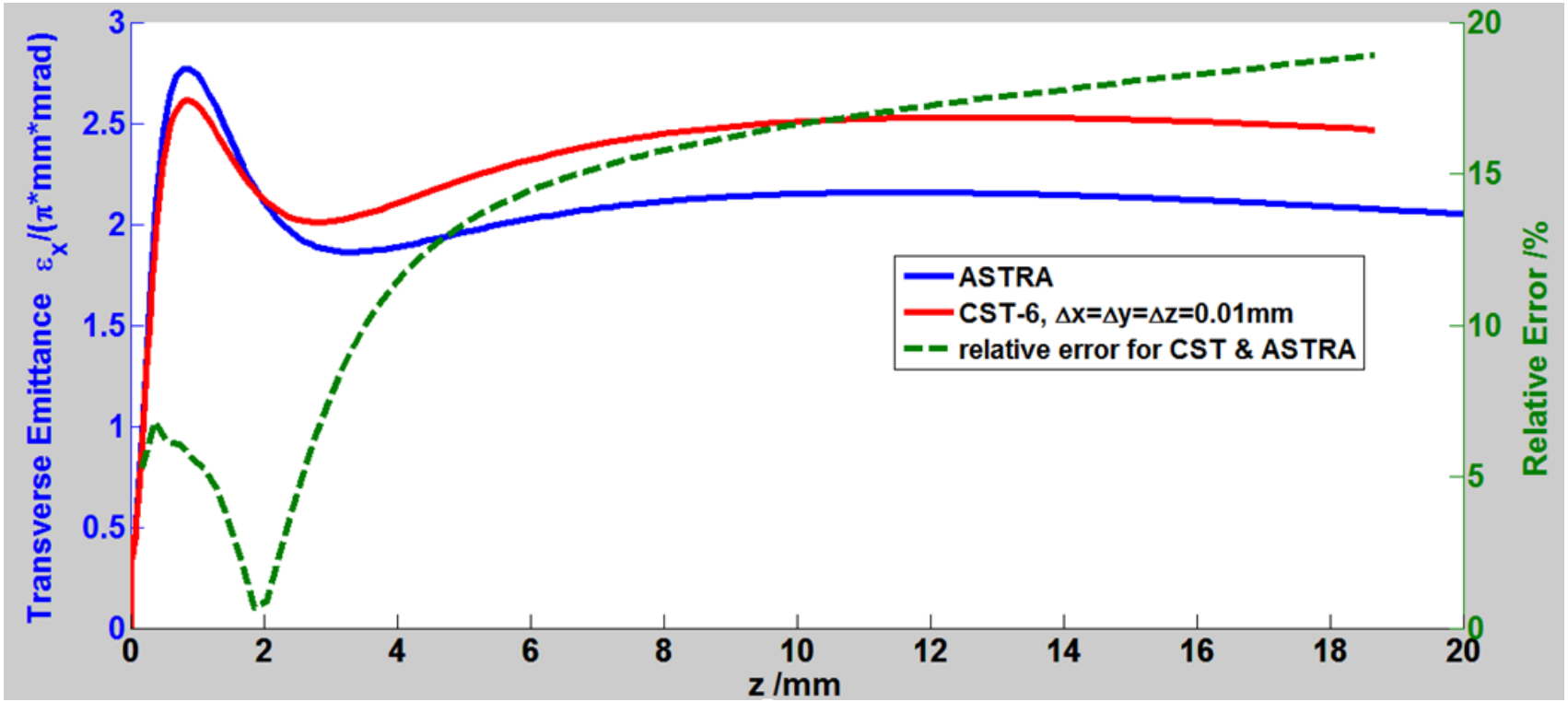
r=0.4mm, Q=1nC **for transverse emittance**



Comparisons with ASTRA

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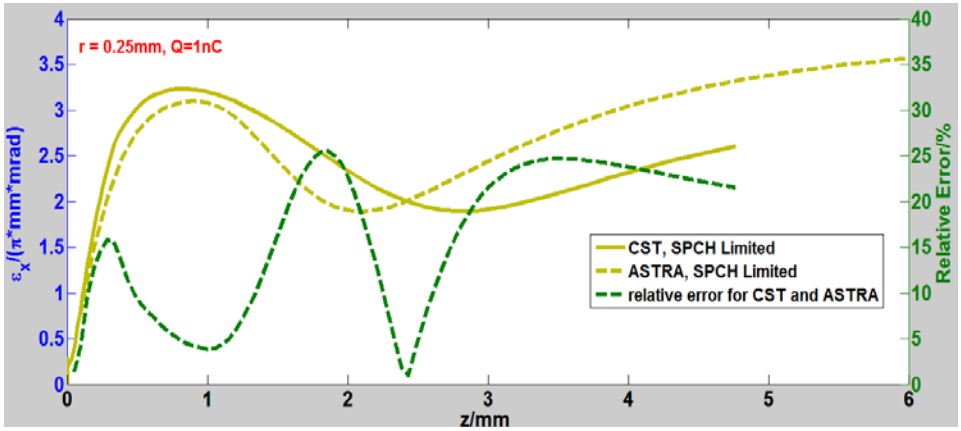
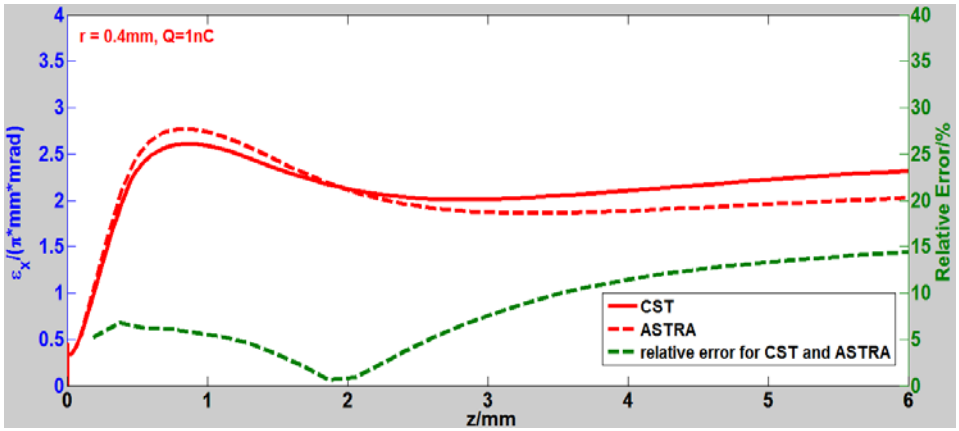
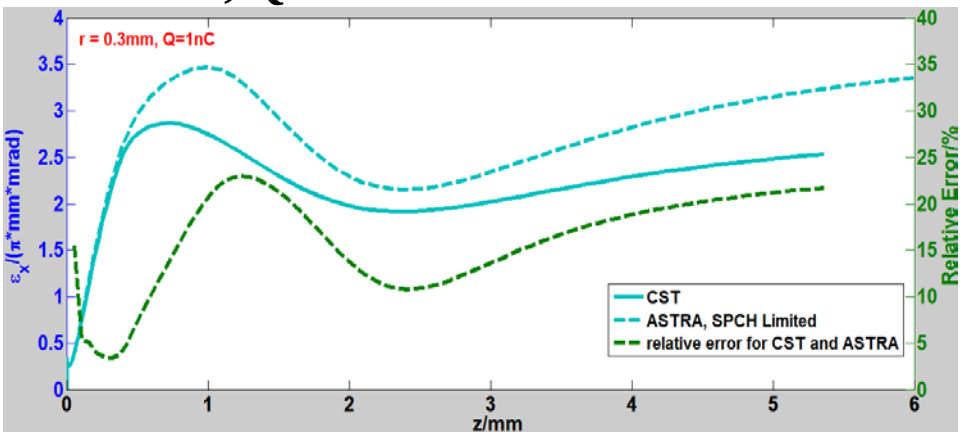
r=0.25mm, Q=1nC



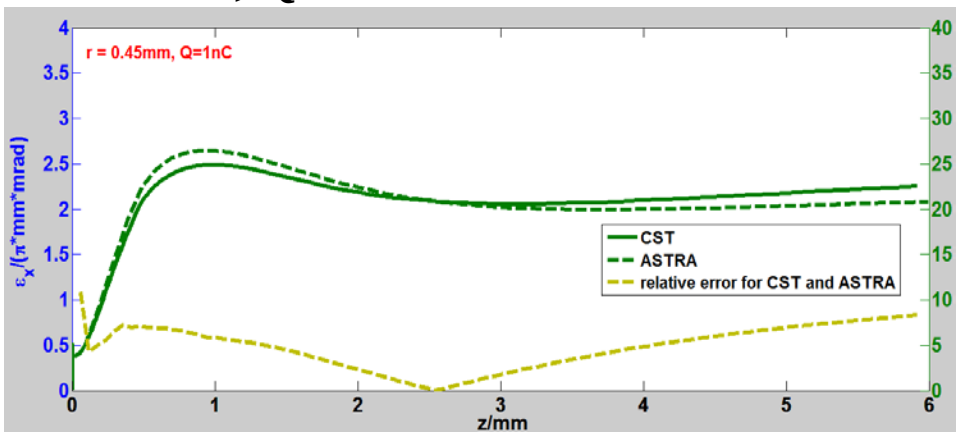
r=0.40mm, Q=1nC



r=0.30mm, Q=1nC



r=0.45mm, Q=1nC



Comparisons with ASTRA

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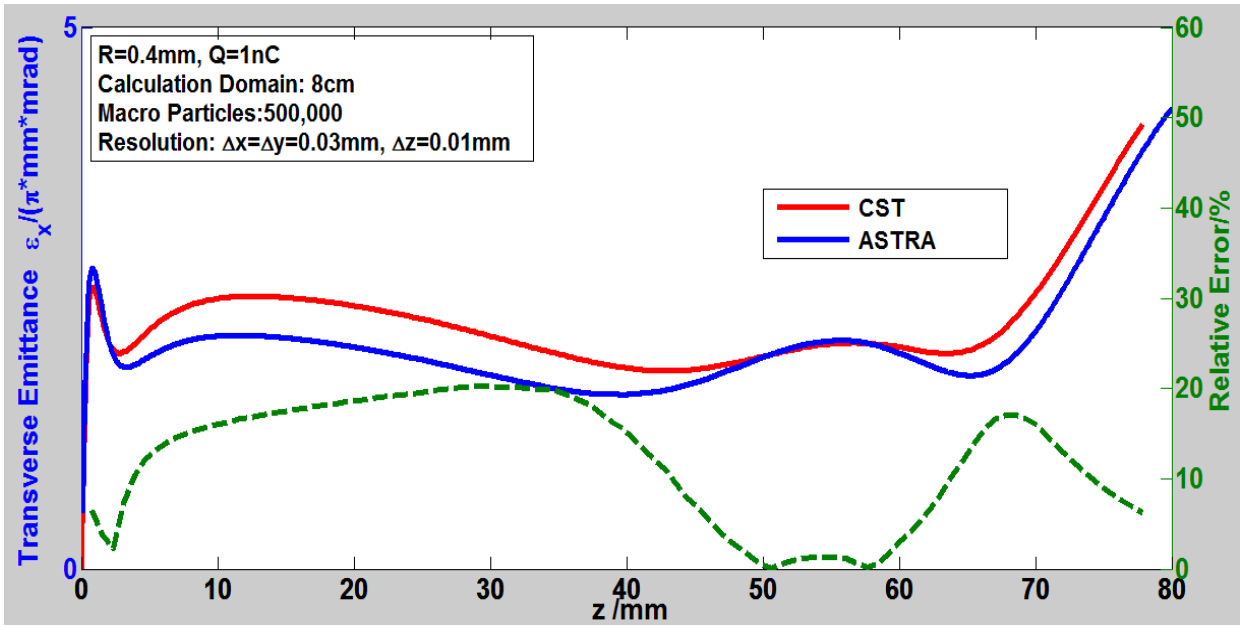
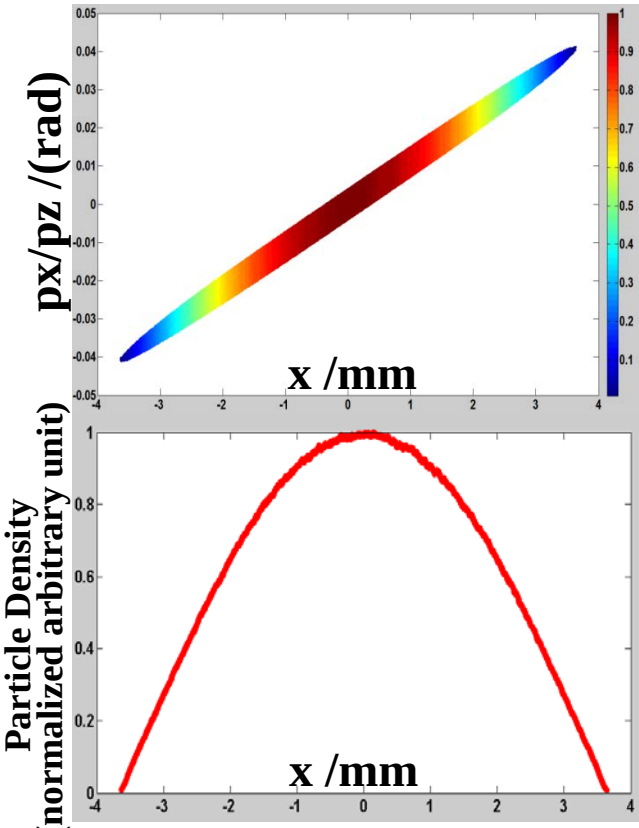
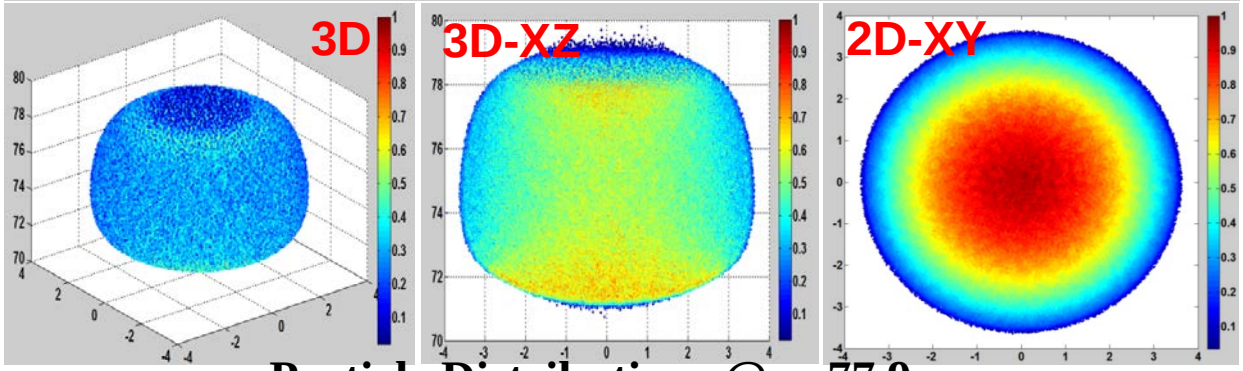
→ **Broaden the calculation domain to 8cm**
with a relatively medium resolution of 30 µm in x & y and 10 µm in z



Transverse Phase Space @ z=77.9 mm

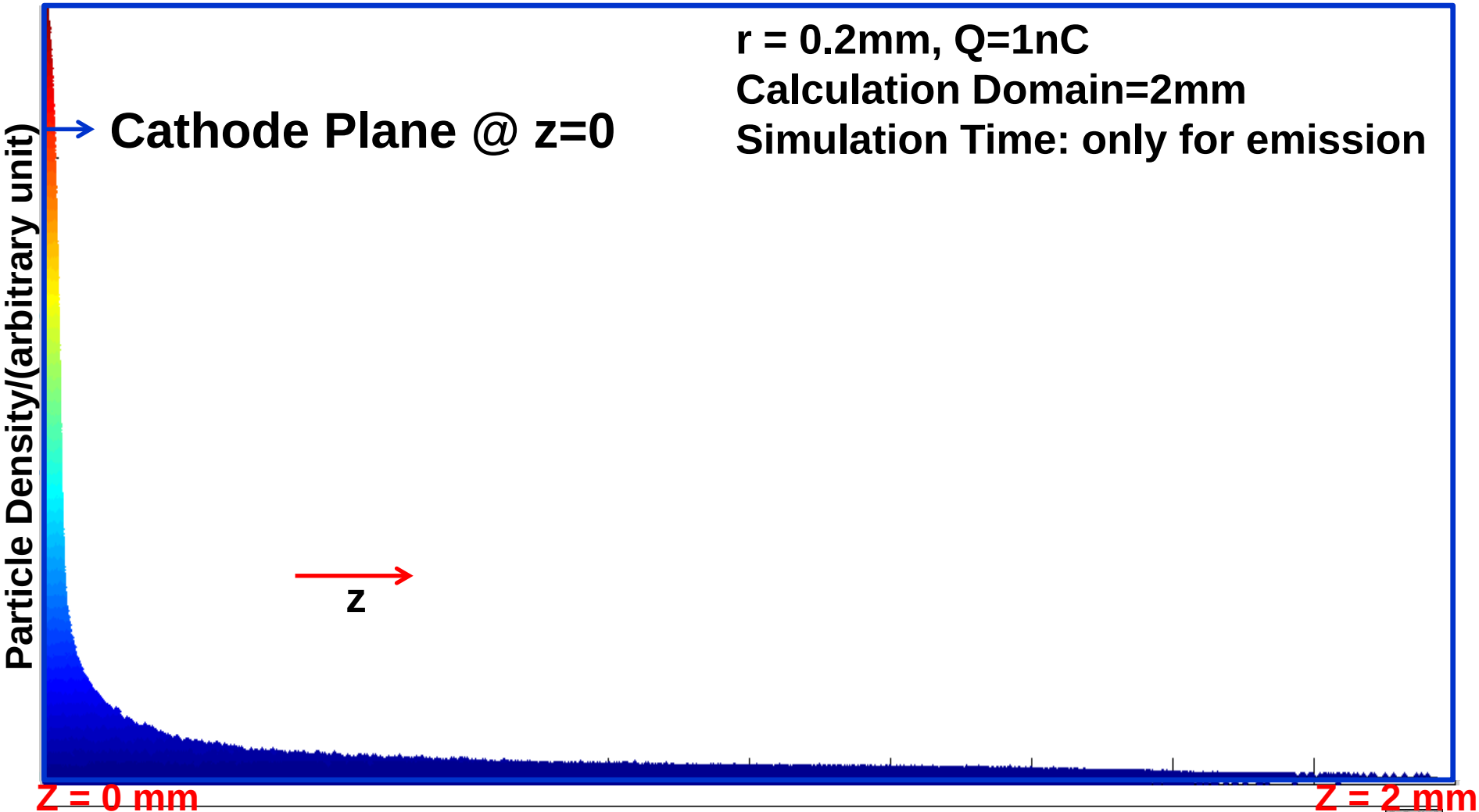




Particle Distributions @ z=77.9 mm

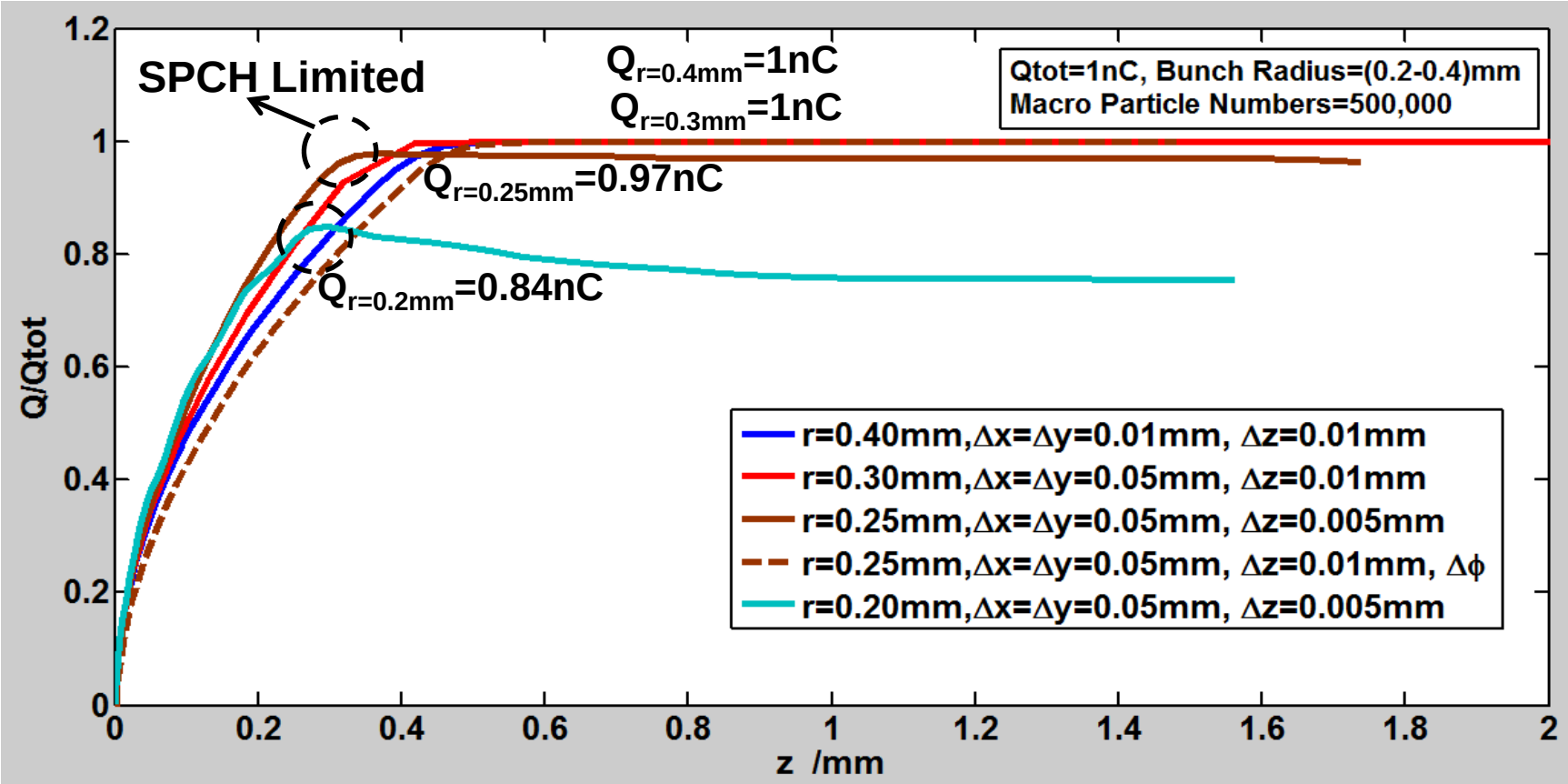
Charge Emission Studies

--- Space Charge Limit



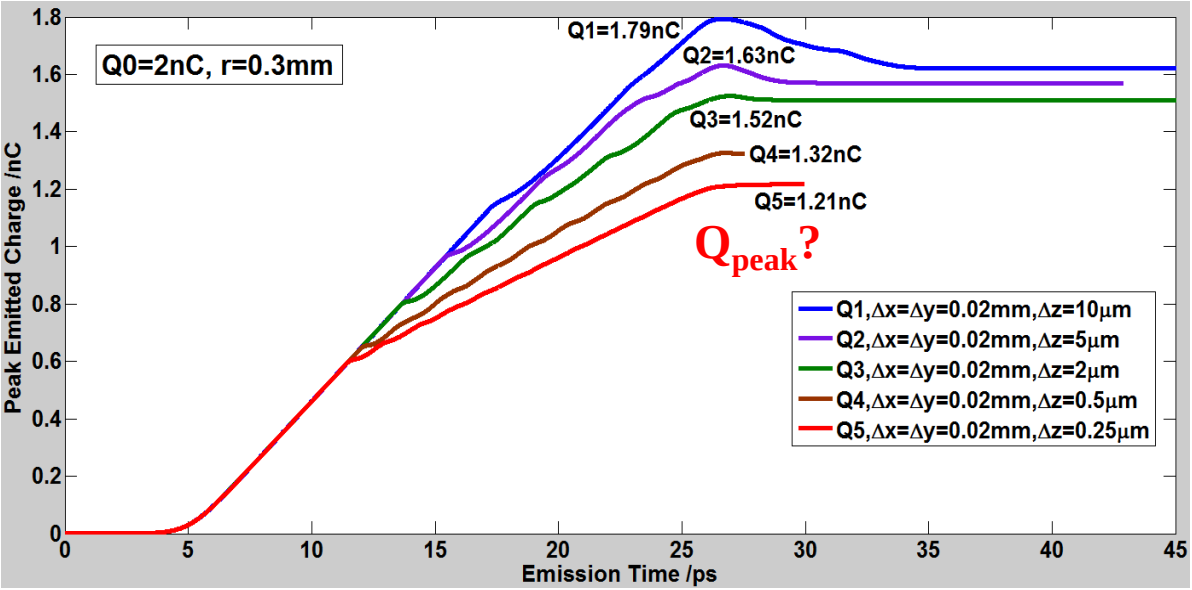
Charge Emission Studies

--- Space Charge Limit



Summary and Discussions

- Convergent simulation results obtained for Q=1nC,XY_{rms}=0.4mm case
- Good agreements on low-order beam quality parameters with ASTRA
- Discrepancies on the transverse emittance are found compared to ASTRA
- CST SPCH limit observed for XY_{rms} =0.2mm & 0.25mm case. Exact peak emitted charge need to be calculated by use of much finer resolution.



- Charge emission study, r=0.3mm, Q0=2nC, Q_{peak}??
- Emittance @ z≈8cm for different laser spot size
- Further emittance study with inhomogeneous distributions