Improvement of the tomographic reconstruction procedure at PITZ.

- Introduction: motivation & implementation
- Simulation results
- Summary and outlook

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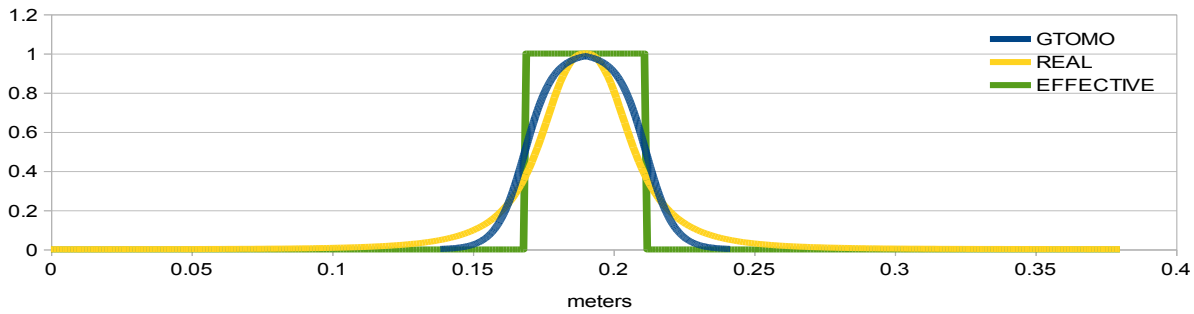
HELMHOLTZ ASSOCIATION

DESY

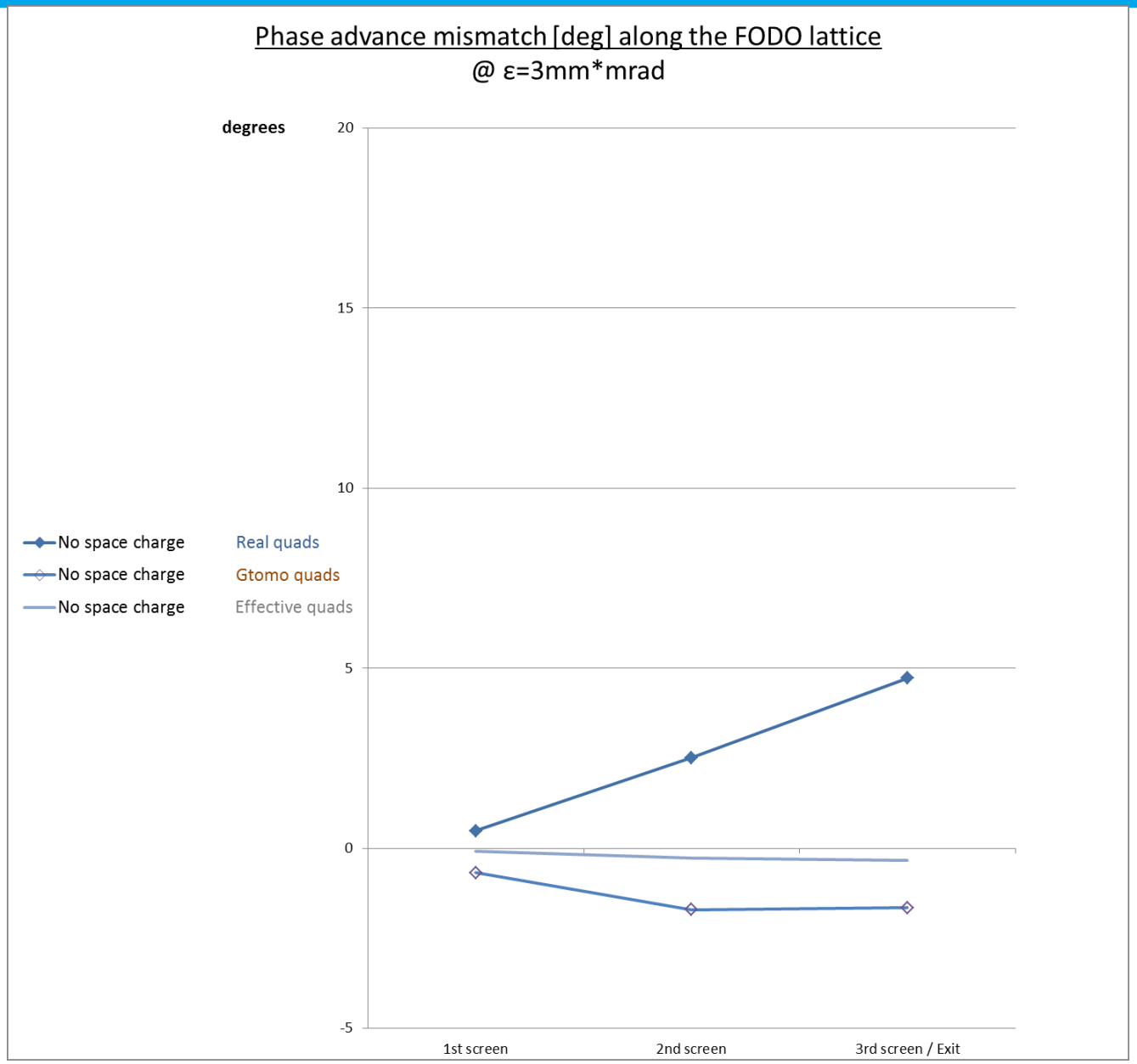
Motivation & Implementation

- Aim: Refine the calculation of the beam transport along the tomography lattice by including:
  - quadrupole fringe fields
  - linear space charge

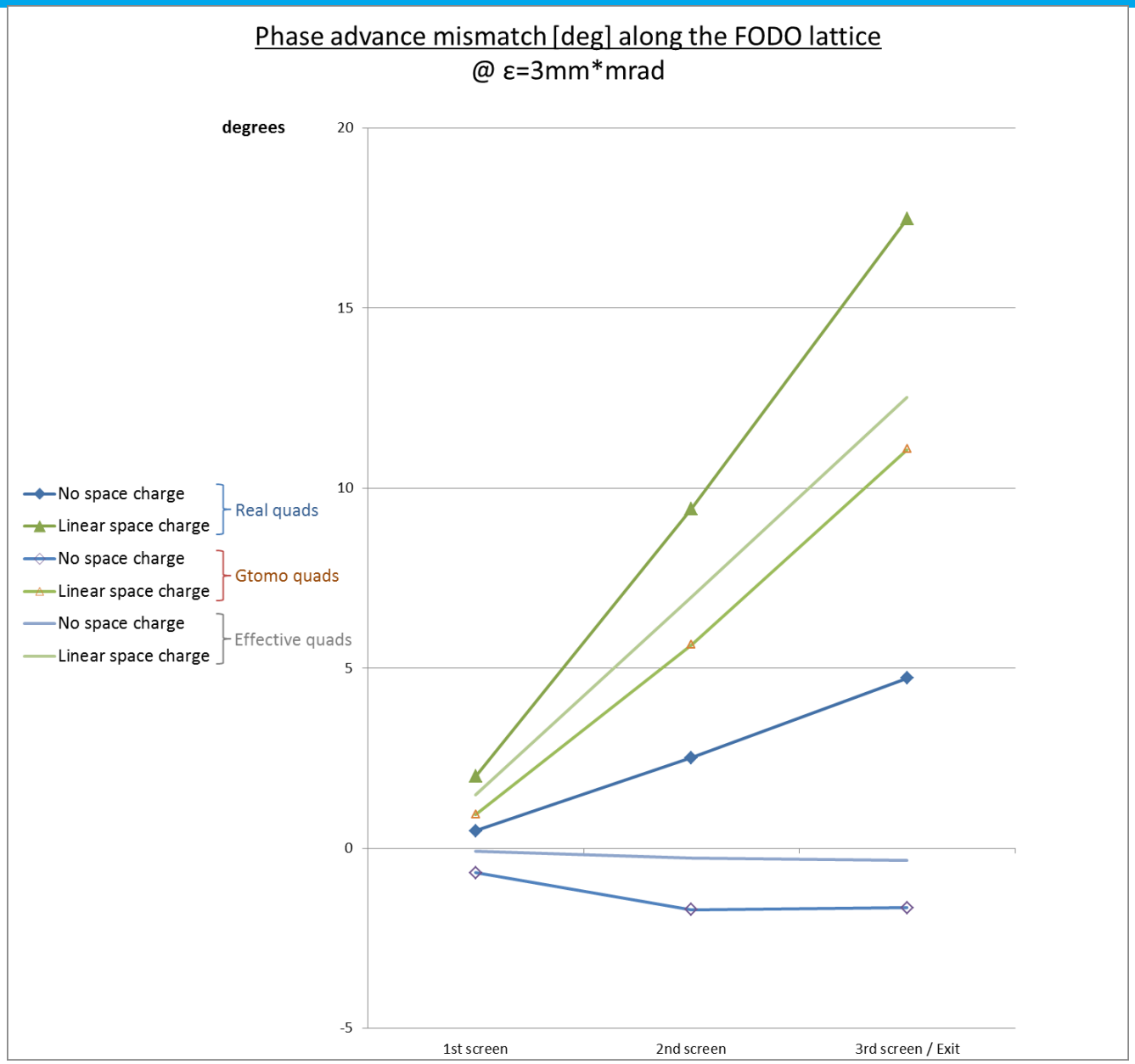


- Gain: Better estimation of the phase space rotation → more accurate reconstruction
- Use V-Code to simulate the phase advance mismatch (difference from the target value of 45º between consecutive screens) for:
  - Current approach: Approximated magnetic profile of the quadrupoles, no space charge
  - New approach: Measured magnetic profile of the quadrupoles, linear space charge
- The simulated beam enters the FODO lattice perfectly matched, with zero momentum spread. Non-linear space charge is excluded

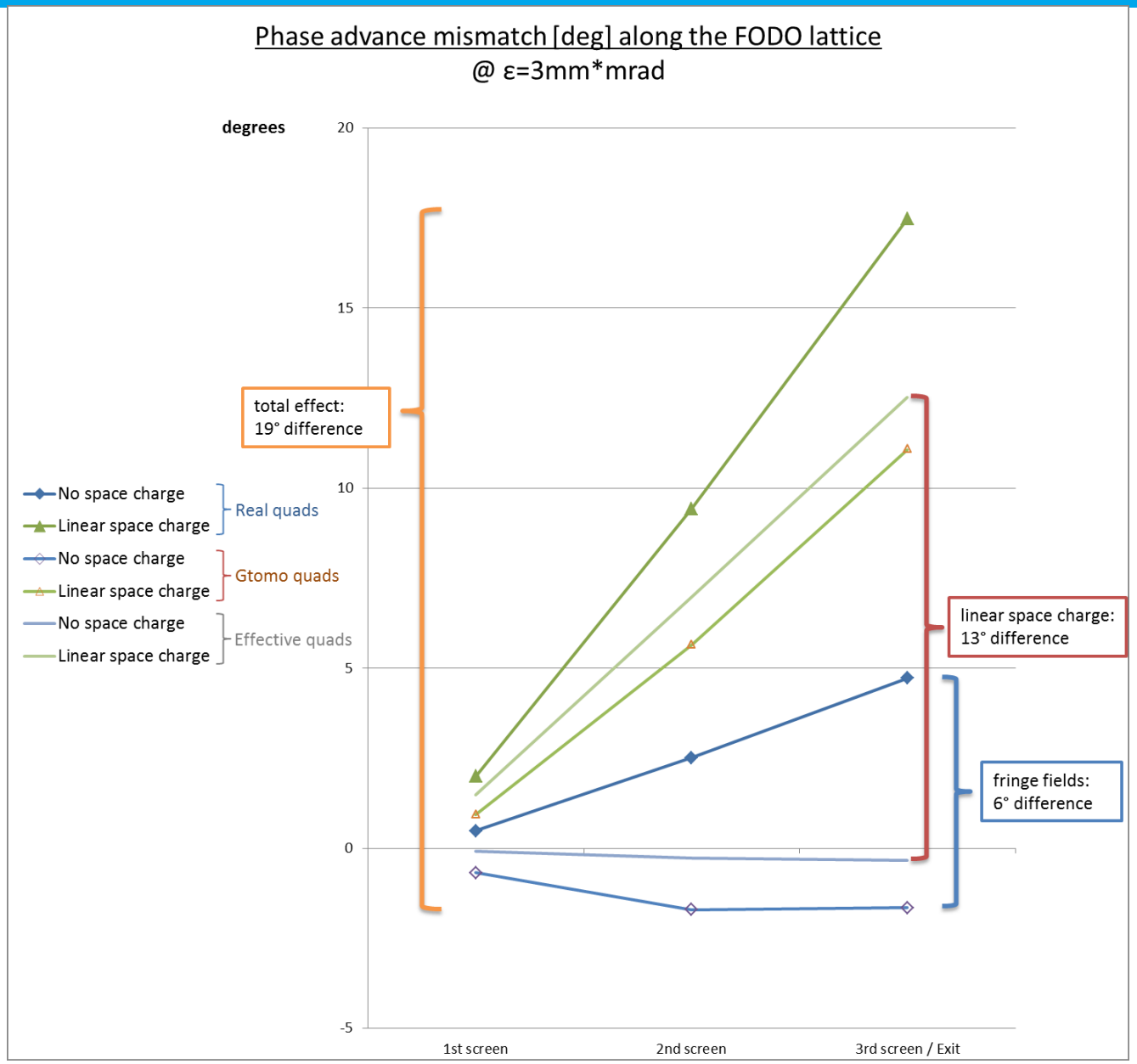
Simulation results (25MeV / 1nC / 20ps – X plane)



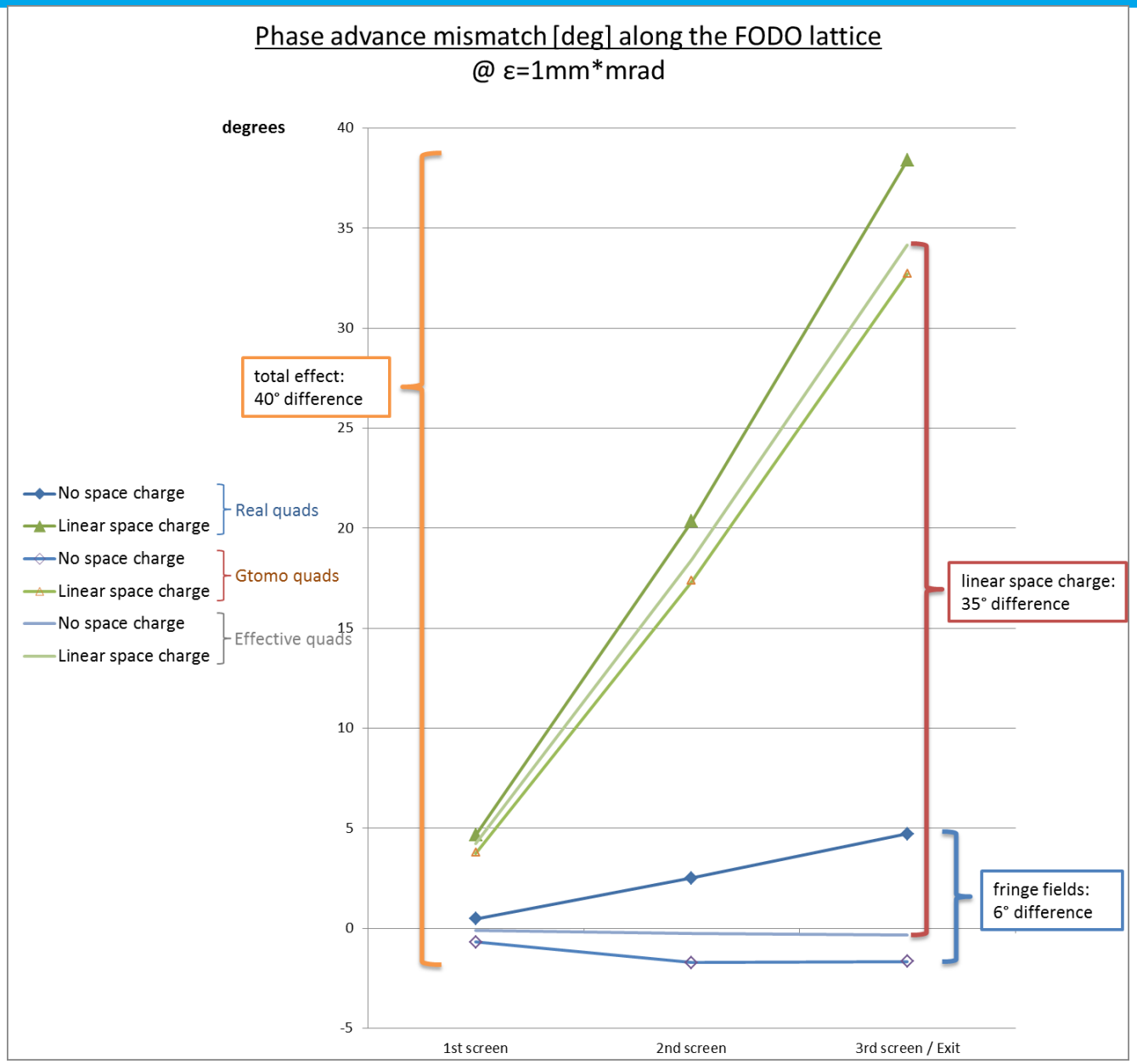
Simulation results (25MeV / 1nC / 20ps – X plane)



Simulation results (25MeV / 1nC / 20ps – X plane)



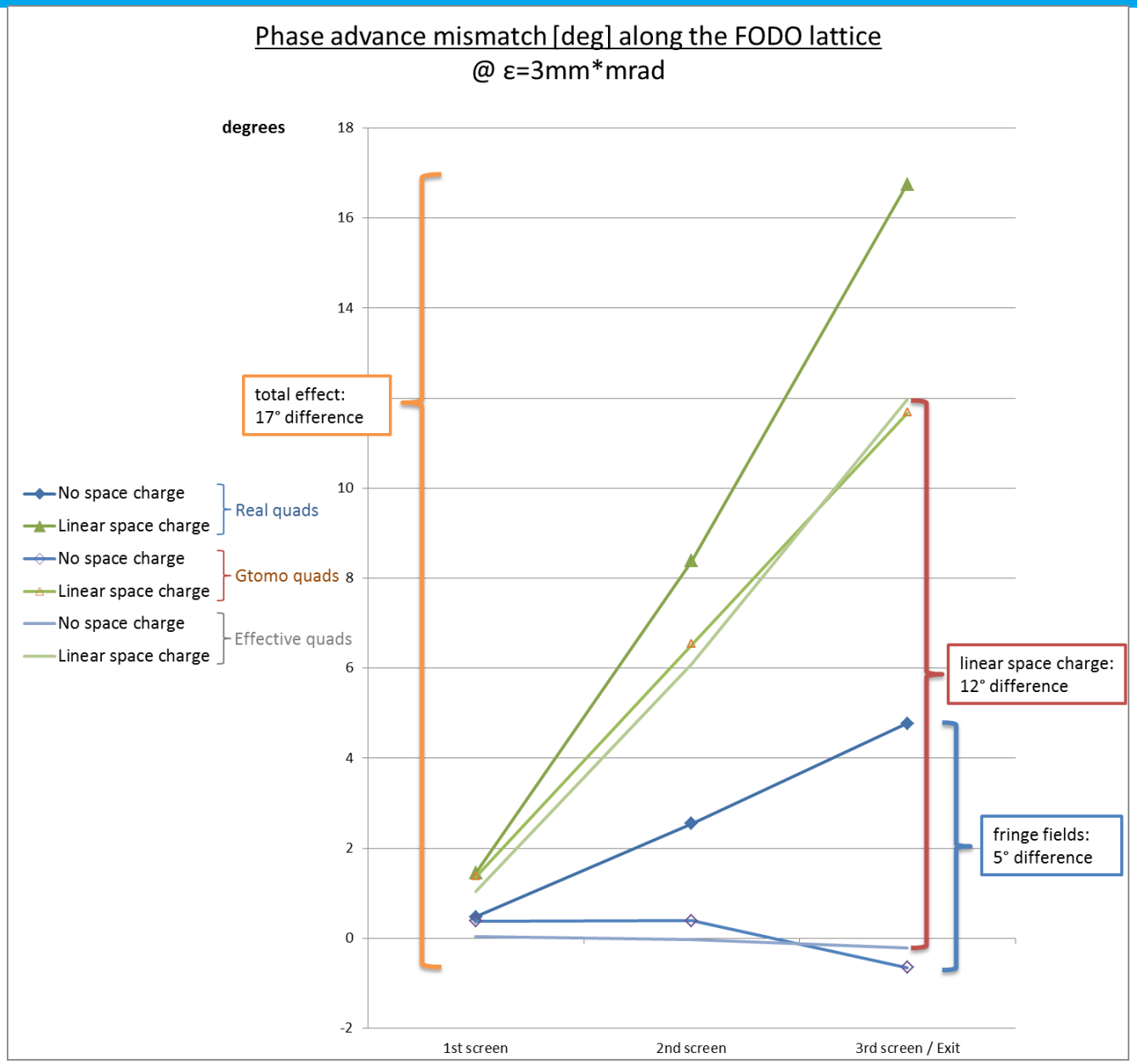
Simulation results (25MeV / 1nC / 20ps – X plane)



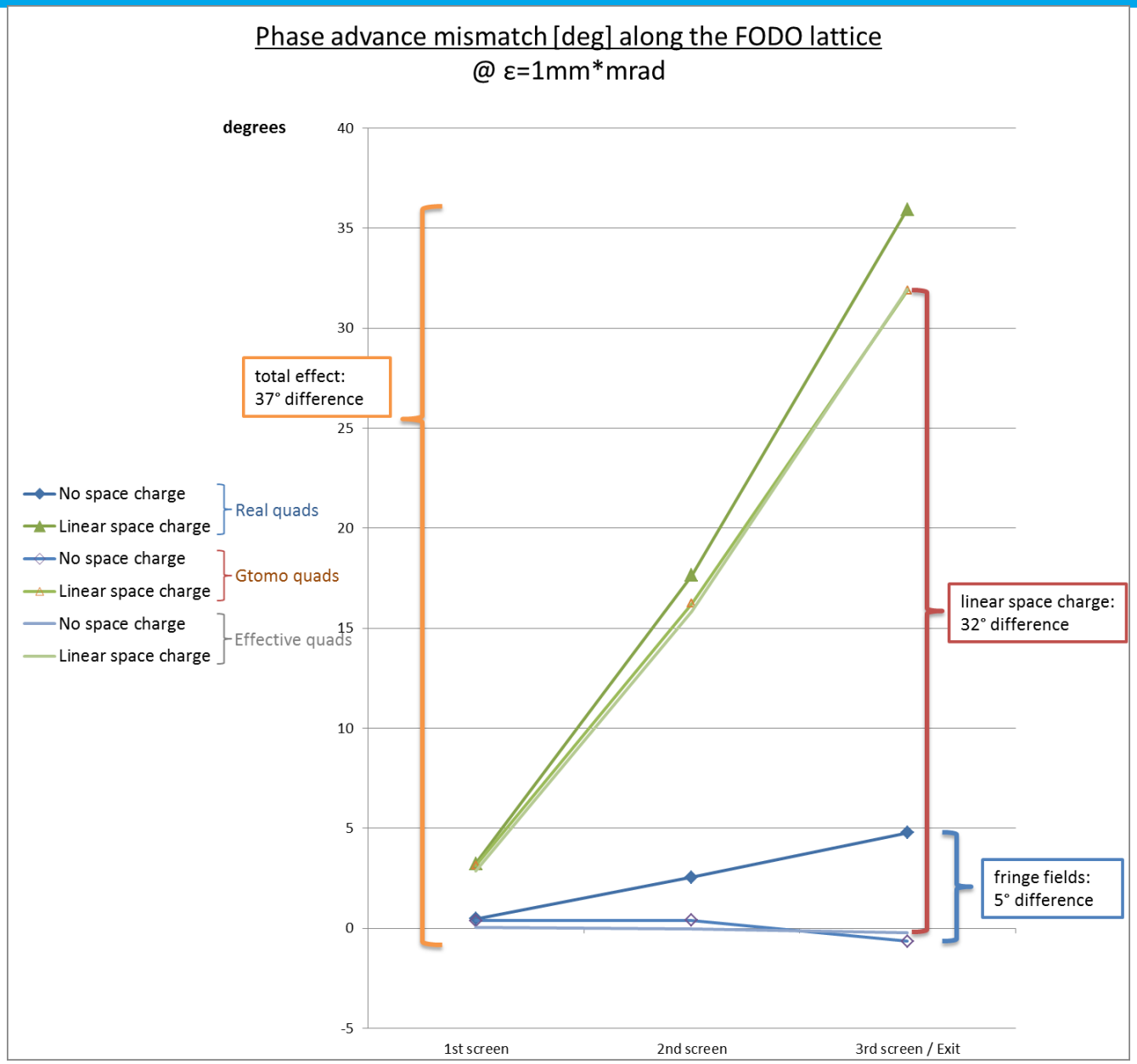
Simulation observations

- No space charge case (same for both emittance values / charge densities) :
  - Matching of the effective quadrupoles → proof of principle. Possible reason for mismatch < 0.3º : numerical artifacts (?)
  - The current quadrupole representation induces a 6.4º maximum phase advance mismatch in comparison to the measured gradient profile
- Linear space charge case:
  - The inclusion of linear space charge can shift the phase advance of the effective quadrupoles at a maximum of 12.9º for 3mm·mrad or 34.5º for 1mm·mrad
  - The defocusing effect varies slightly for the different gradient profiles
- Combined case:
  - Both features together give a maximum phase advance mismatch of 19.1º for 3mm·mrad or at 40º for 1mm·mrad
- The result will introduce a bigger effect on the reconstruction than an equivalent projection angle mismatch, due to the beam shearing

Simulation results (25MeV / 1nC / 20ps – Y plane)



Simulation results (25MeV / 1nC / 20ps – Y plane)



Thanks to Barbara Marchetti and Dmitriy Malyutin.

THE END.

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DESY

Backup Slides

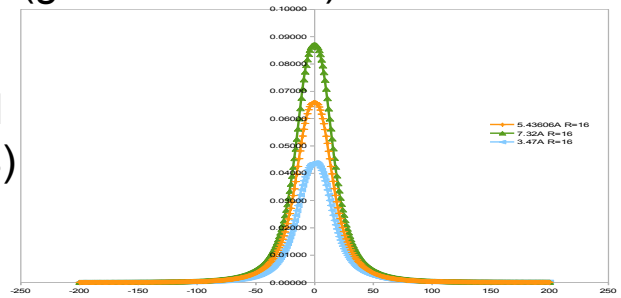
V-Code simulations (fields)

Normalized gradient profile calculation:

- Gtomo:
  - Profile directly calculated as in the code: and then divided by the strength

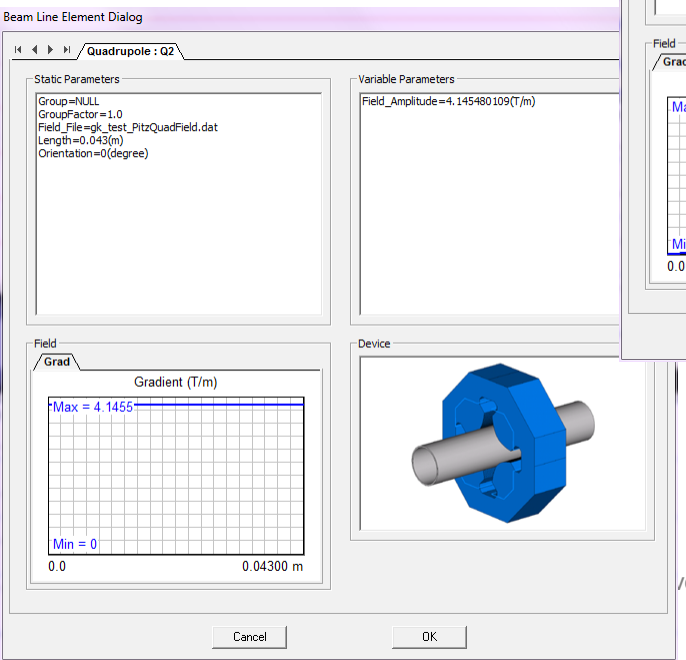
$$G(z)=\frac{k}{1+e^{\frac{2\cdot(2\cdot\|\Delta z\|-L_{eff})}{Q_{bore}}}}$$

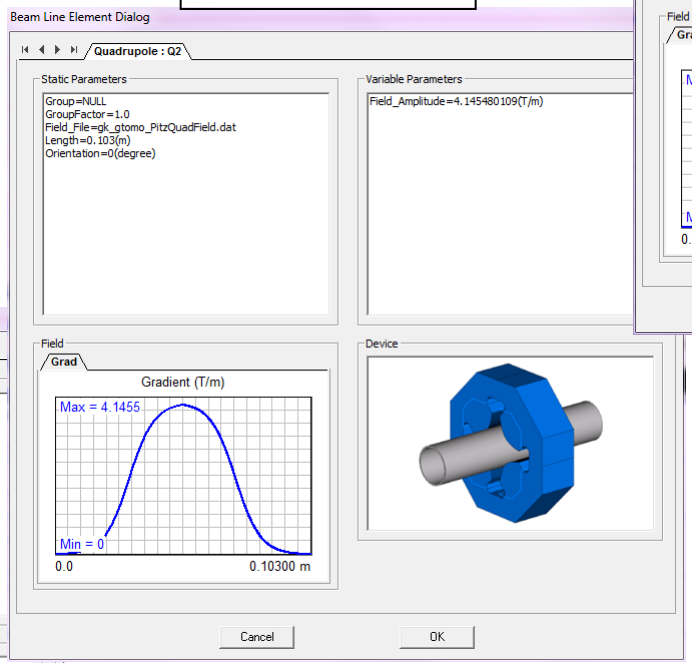
  - Effective length (integrated normalized flux) : 43.11 mm
- Real:
  - [grad->I] convert the gradient required for matched solution (g = 4.1455 T/m) to current (average of all tomography quads)
  - [I->B] for that current calculate the curve of the longitudinal magnetic profile (interpolate between the measured values)
  - [B->B/m] get the gradient by dividing with the radius
  - Normalize by dividing with the gradient for matched solution (g)
  - Exclude 10mm from the beginning and 10mm from the end, so that the length equals exactly half FODO cell (negligible)
  - Effective length (integrated normalized flux) : 43.35 mm

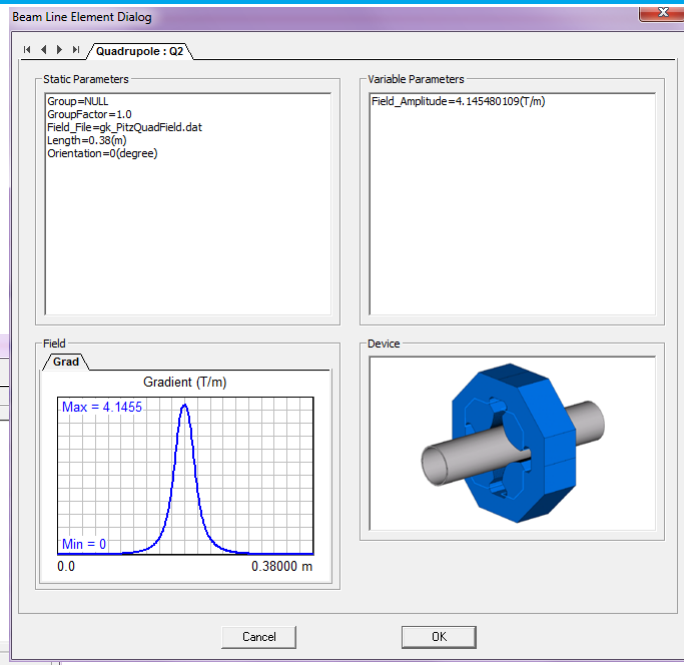


V-Code screenshot

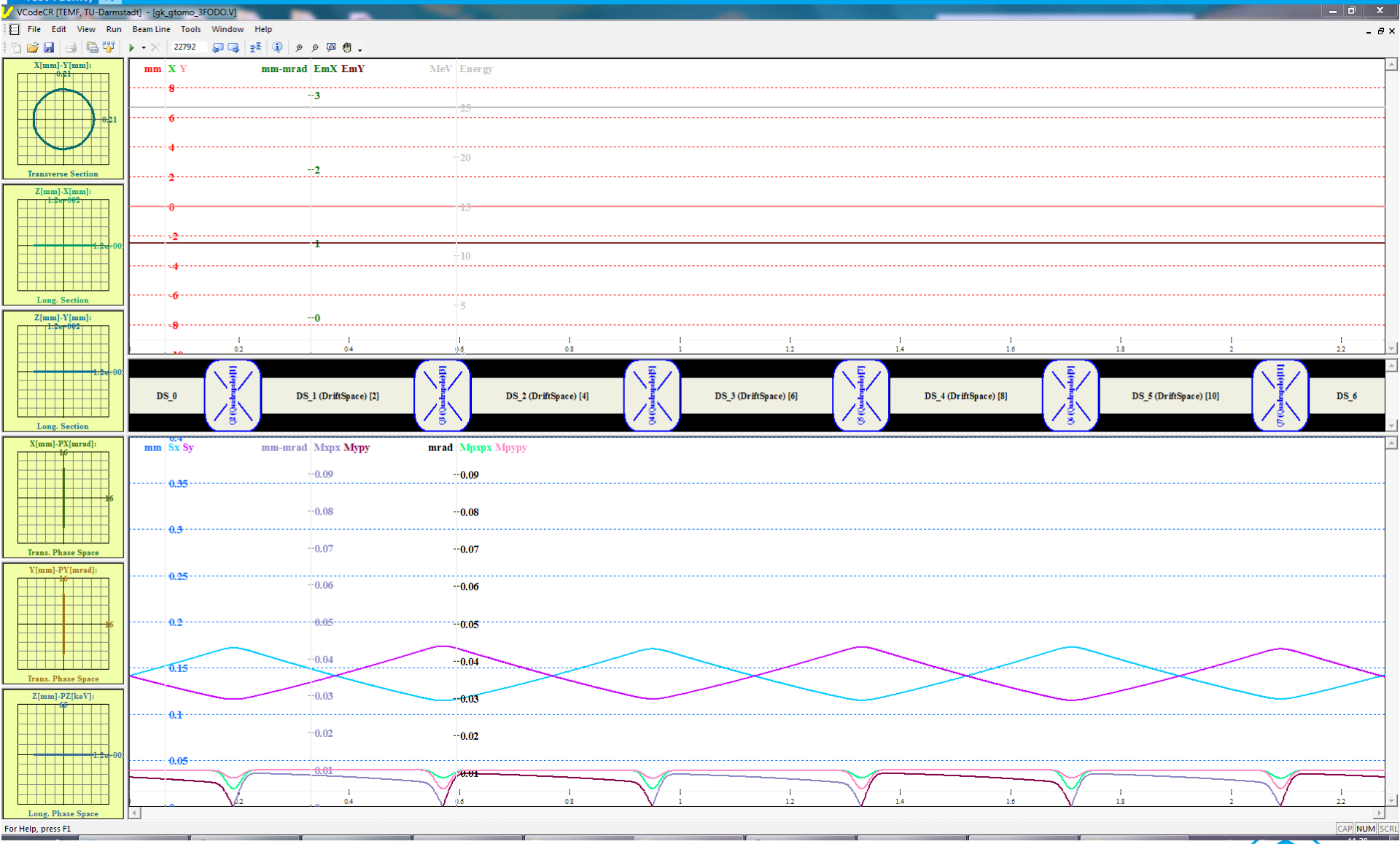
$$G(z) = \frac{k}{1 + e^{\frac{2 \cdot (2 \cdot \|\Delta z\| - L_{eff})}{Q_{bore}}}}$$



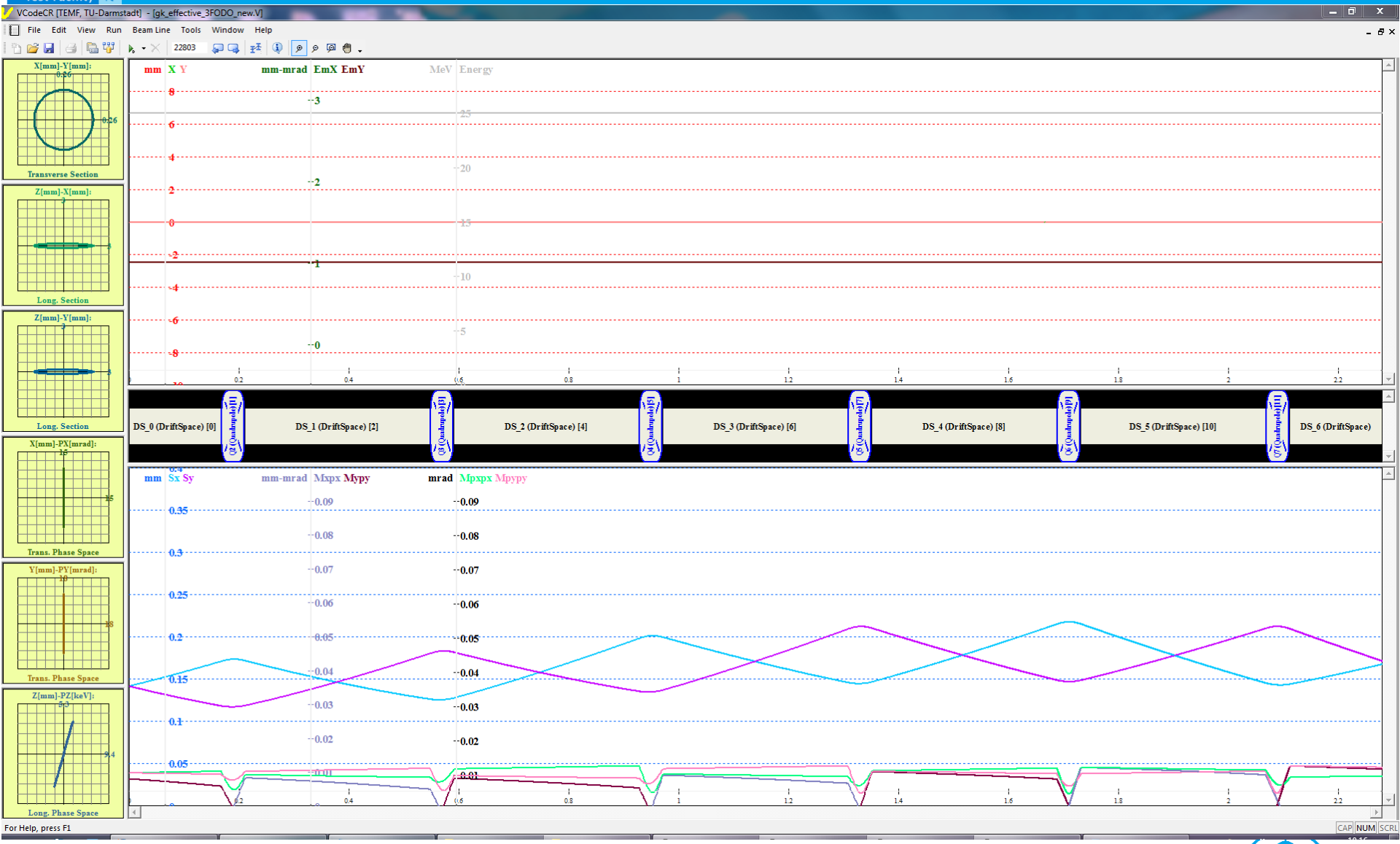




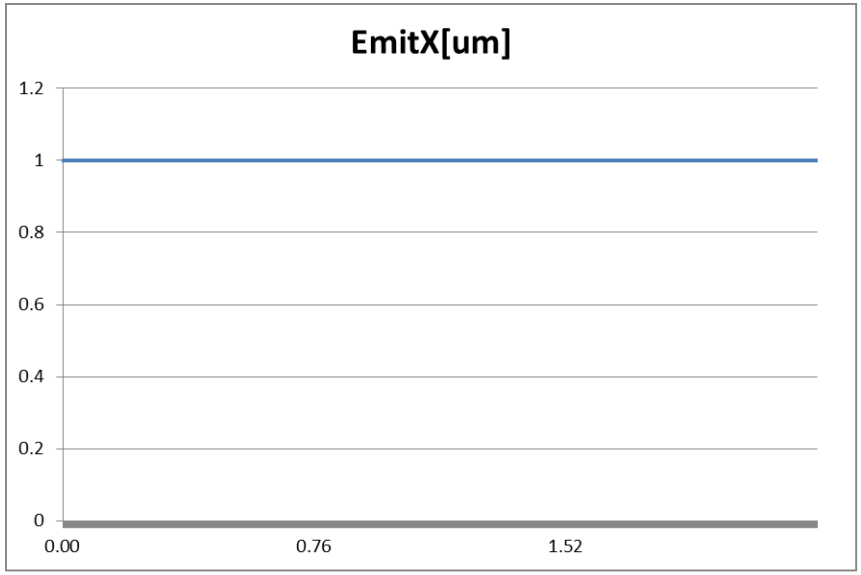
V-Code screenshot – no space charge

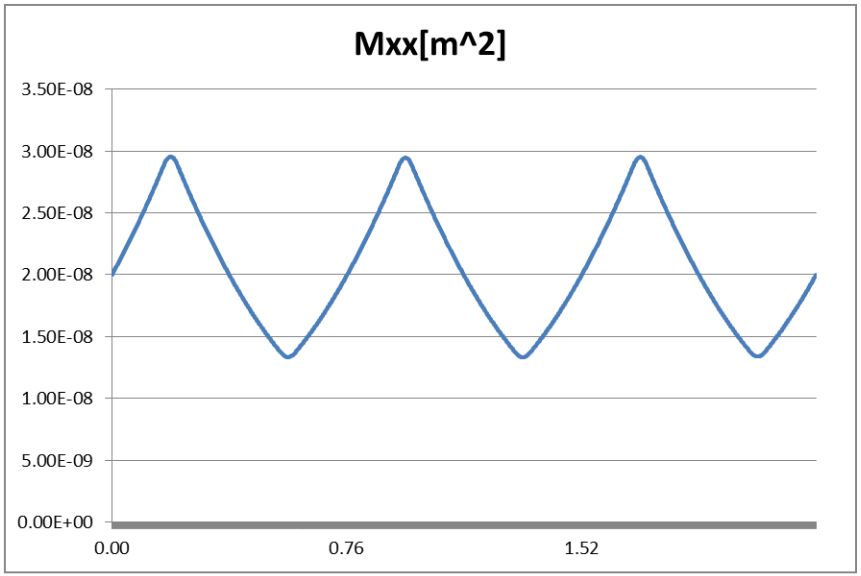


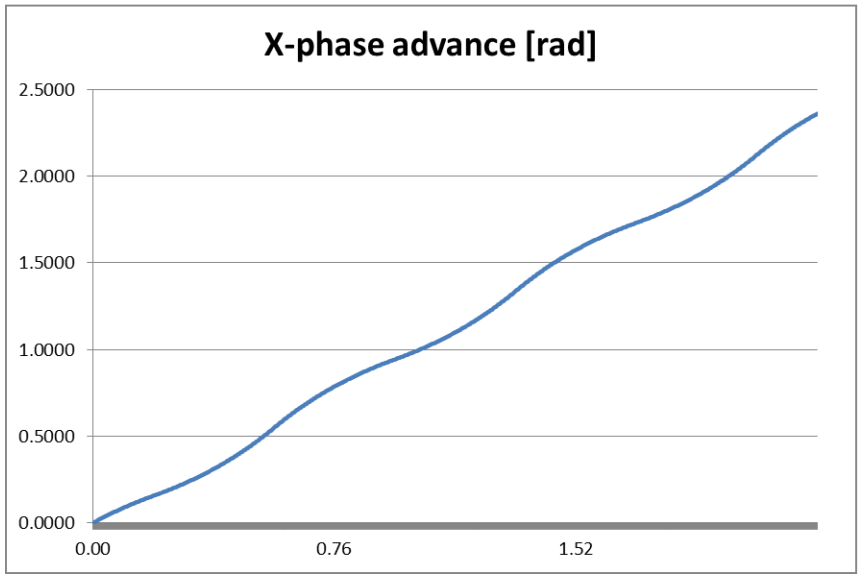
V-Code screenshot – linear space charge

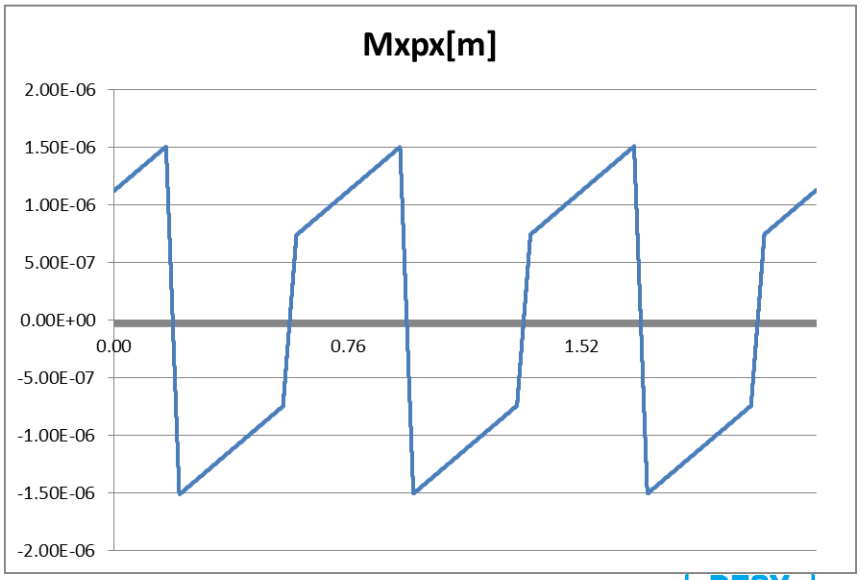


Data analysis for Effective quads with no space charge @ 1mm*mrad (same as for 3mm*mrad)

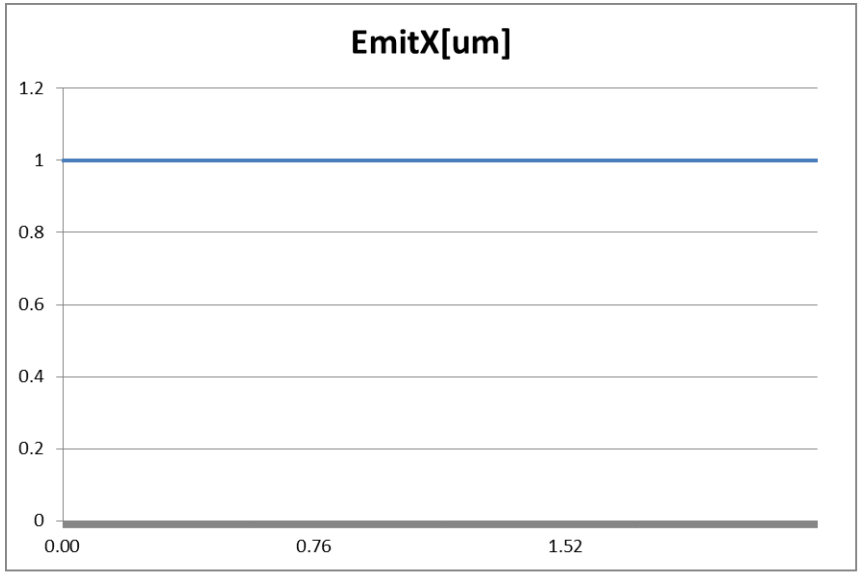


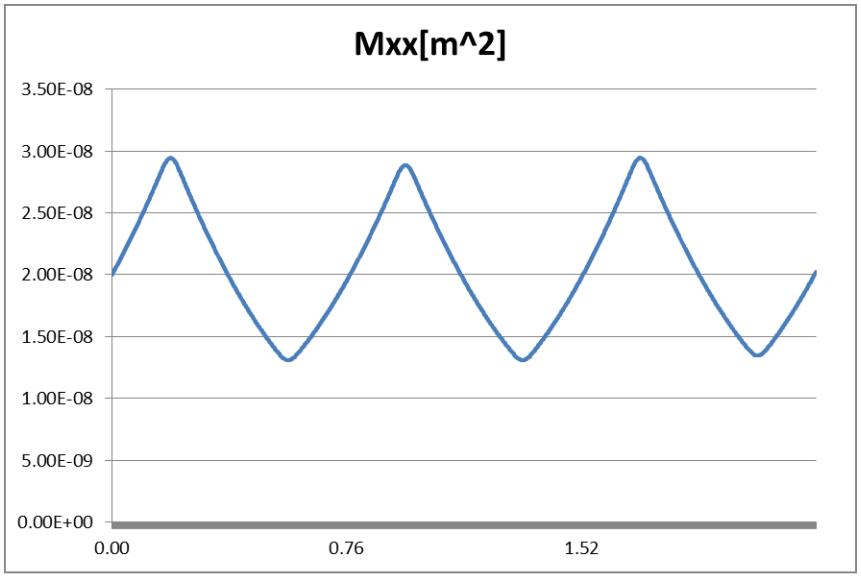


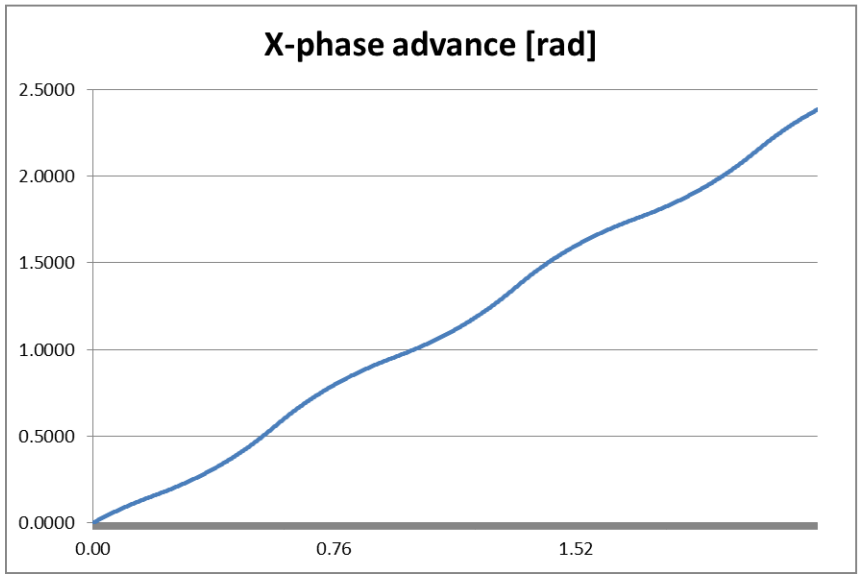


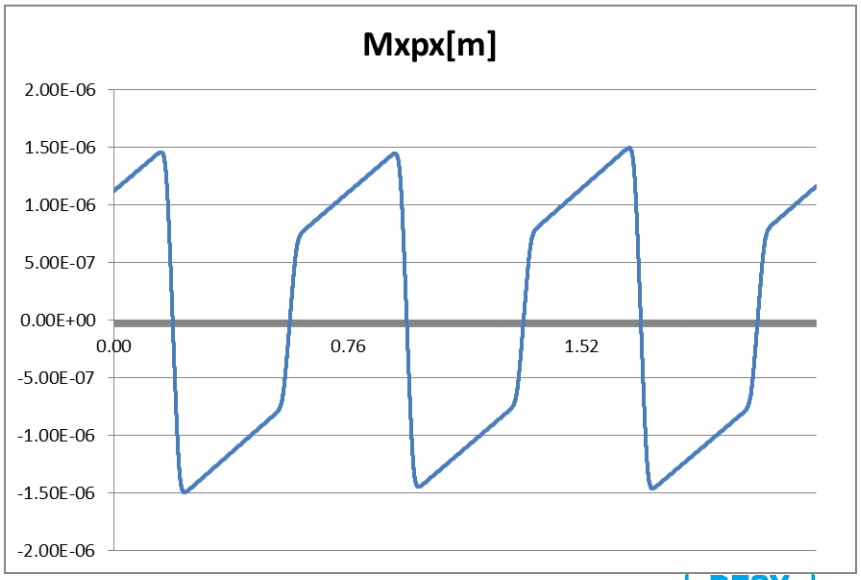


Data analysis for Gtomo quads with no space charge @ 1mm*mrad (same as for 3mm*mrad)









Data analysis for Real quads with no space charge @ 1mm*mrad (same as for 3mm*mrad)