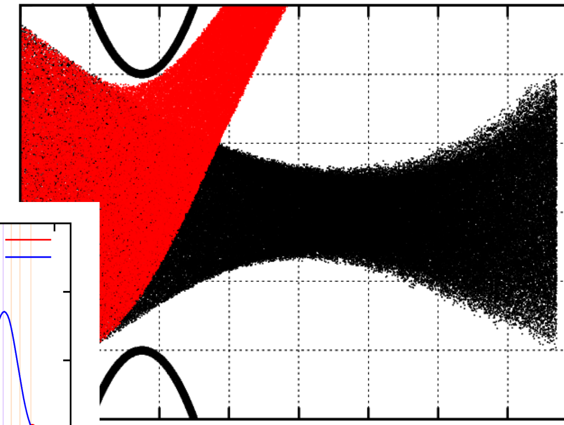
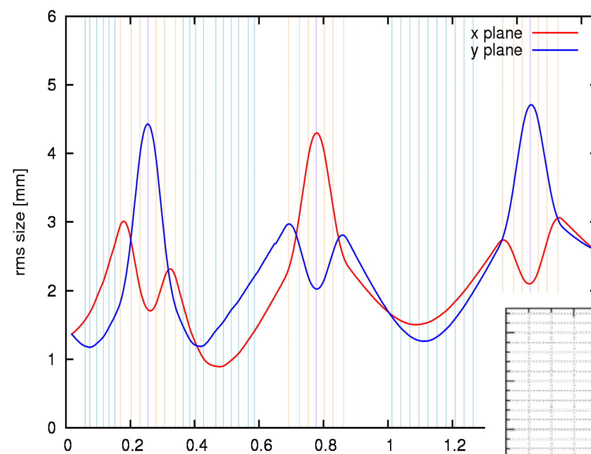
Daniel Noll
Long Phi Chau

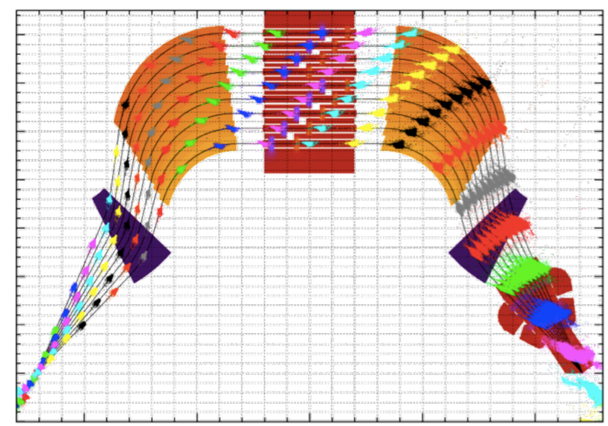
Rebuncher Cavities for a Nanosecond Bunch Compressor

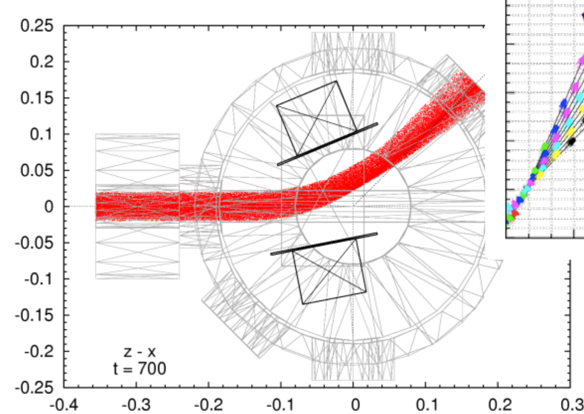
Beam dynamics code

- Transport through time-dependant electric and magnetic fields
  - Bunched and continuous beams
  - Field import from CST Studio Suite
  - Pure multipole fields
  - Flexible field transformations and time dependencies (pulses, harmonic) possible
- Space charge
  - Multiple solvers available: Multigrid, BiCGStab, PP
  - Open or closed boundaries
  - Fixed or moving lattices
- Particle loss on geometry read in from CAD export (e.g. CST MWST)
- Parallelized (for example up to 24 cpu cores on CSC ‚Fuchs')



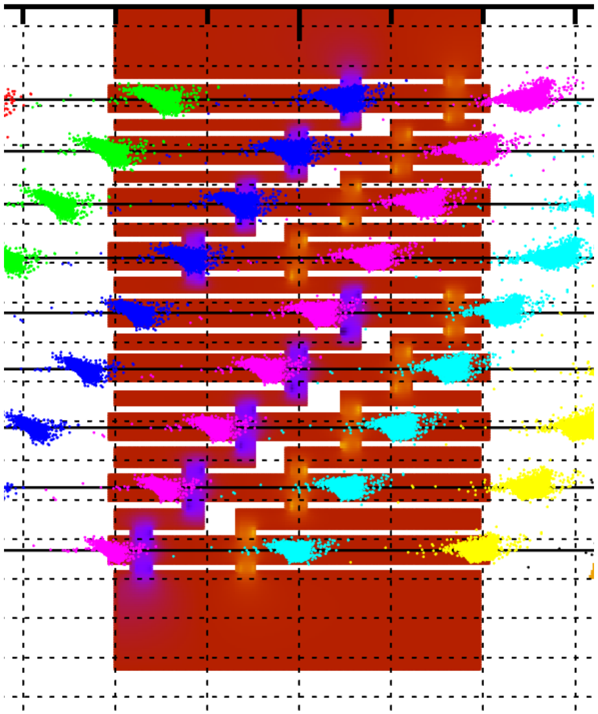


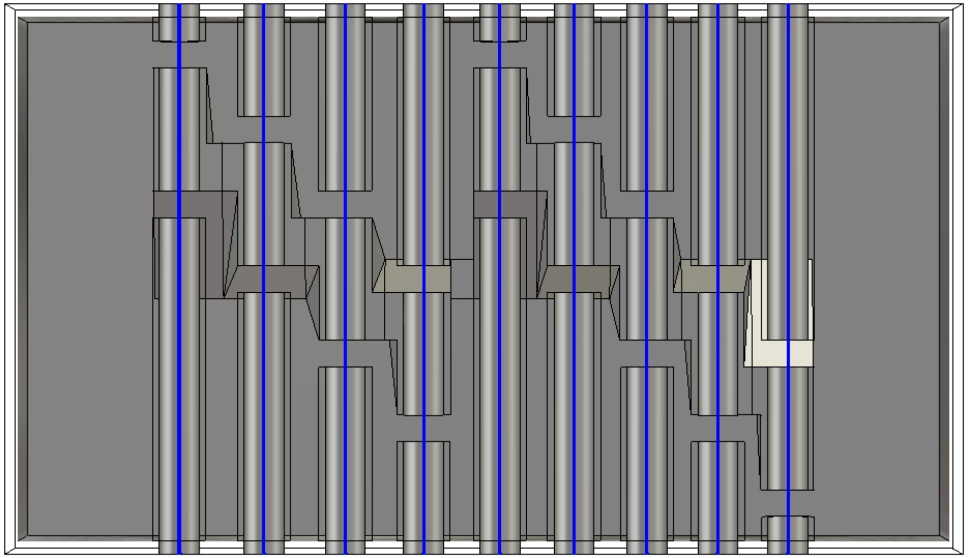




Multiaperture Rebuncher

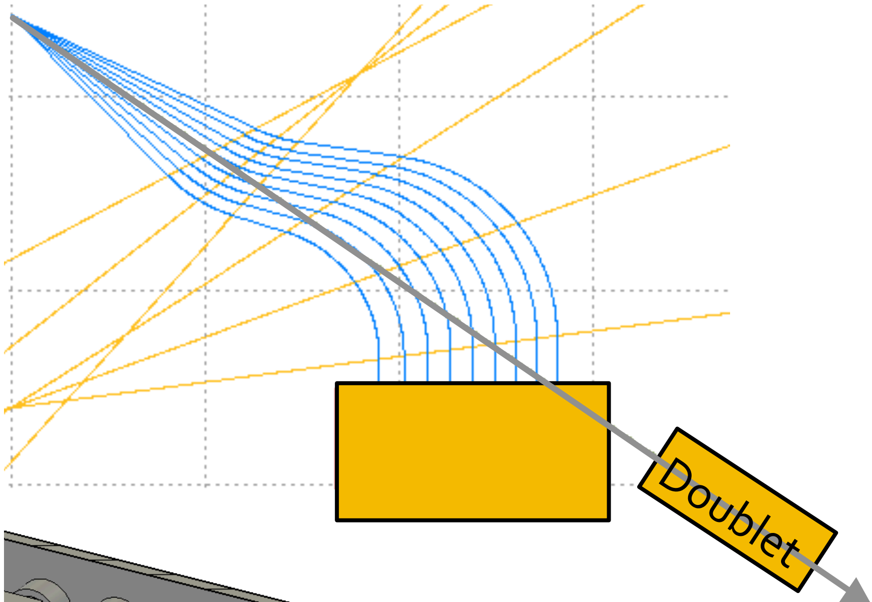
- Operation frequency: 87.5 MHz
- Gaps with relative offset due to the time structure of the beam
- Power required for voltage of 130 kV: 11 kW

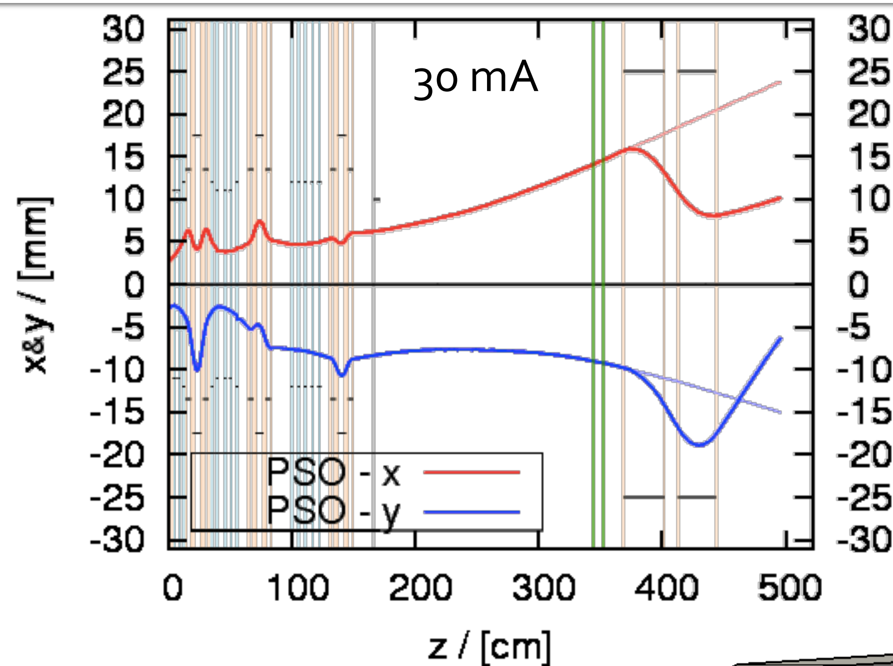


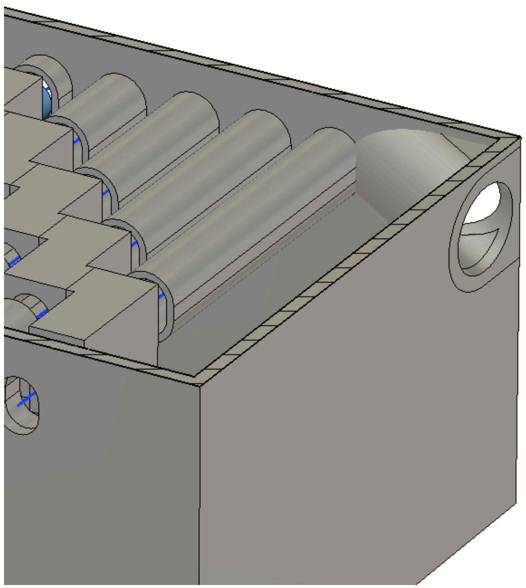


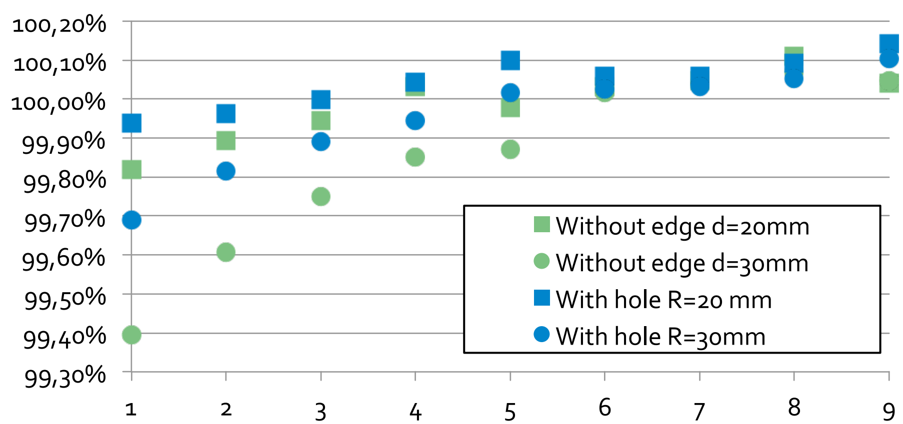
Multiaperture Rebuncher

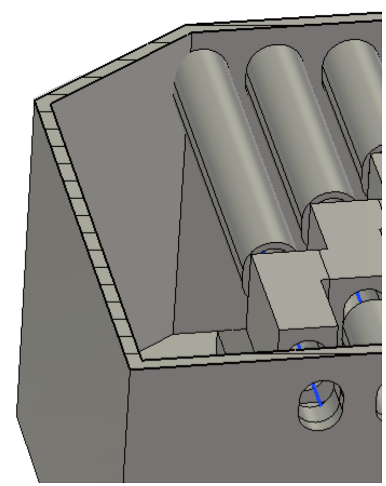
Considerations for activation mode





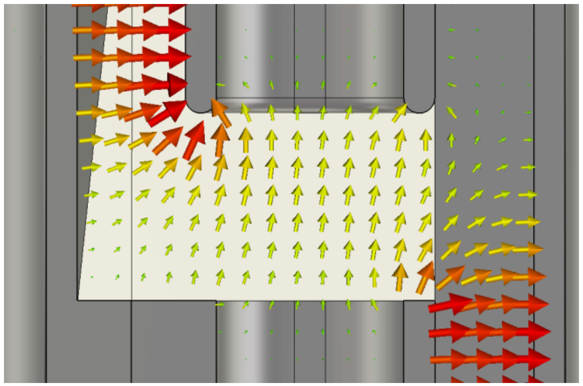




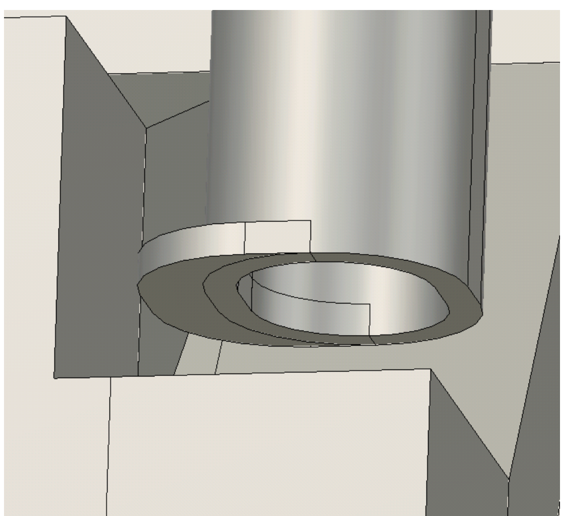


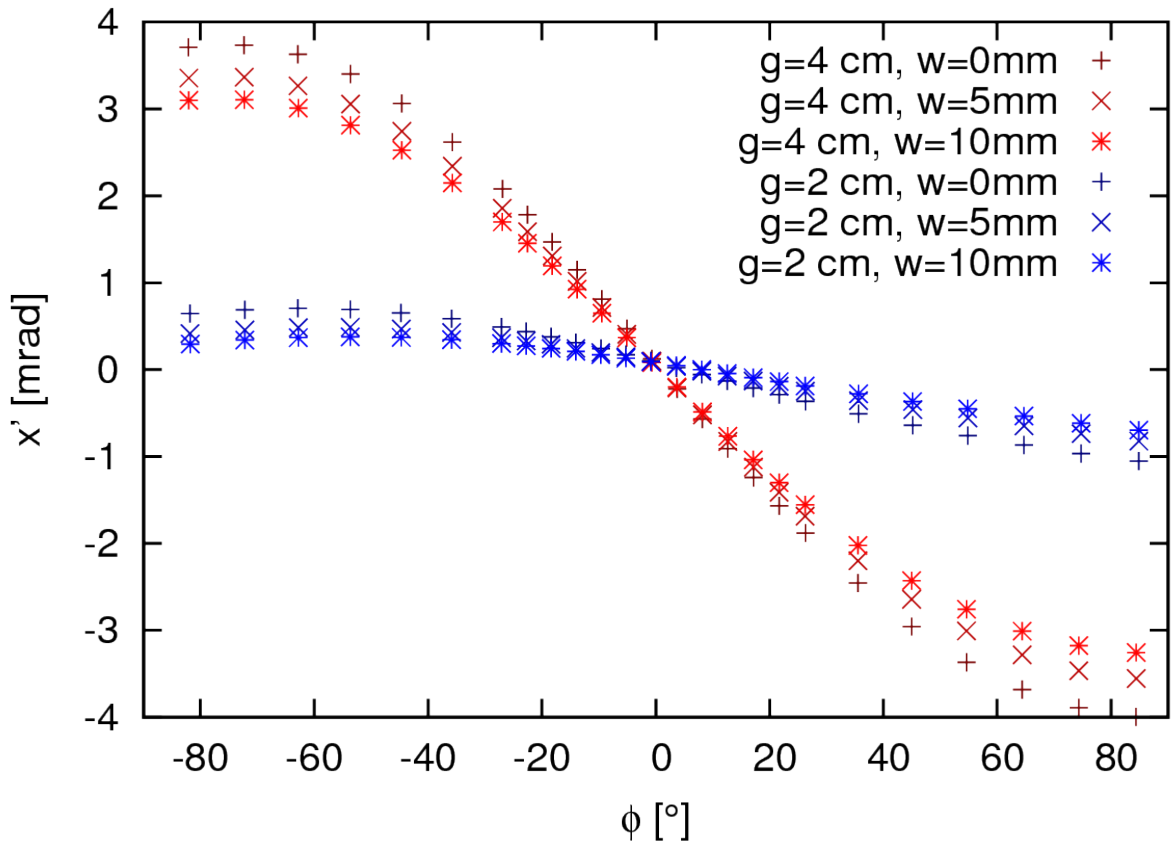
Multiaperture Rebuncher

Dipole fields within the gaps

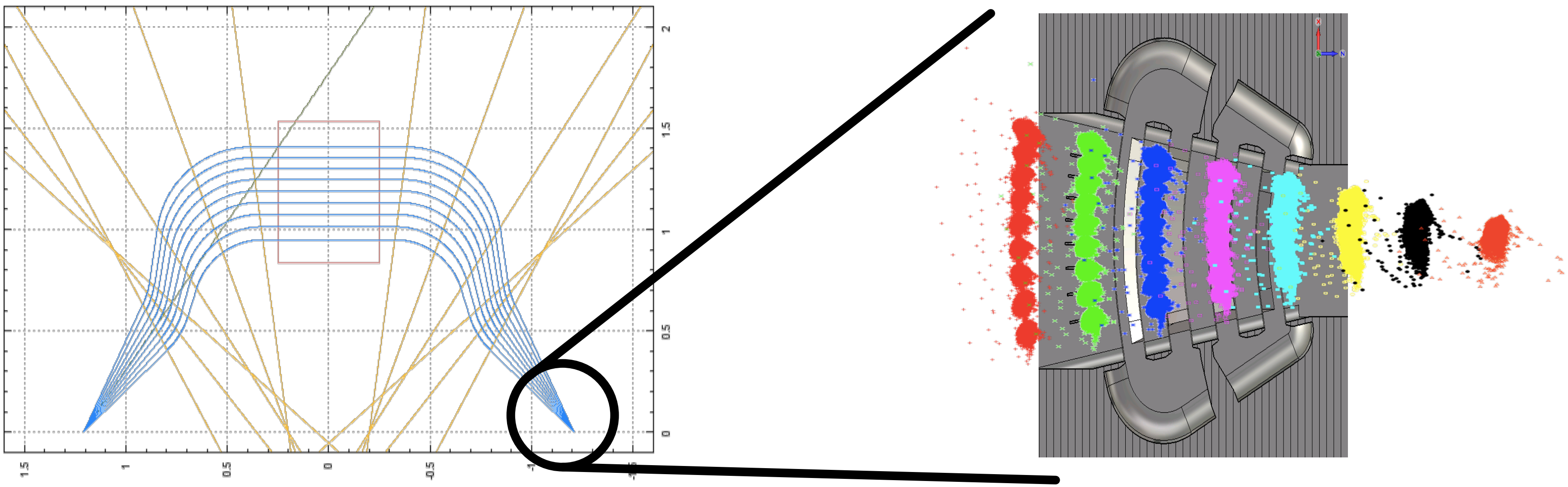


Dipole components of the electric field leads to a fanout of the beam





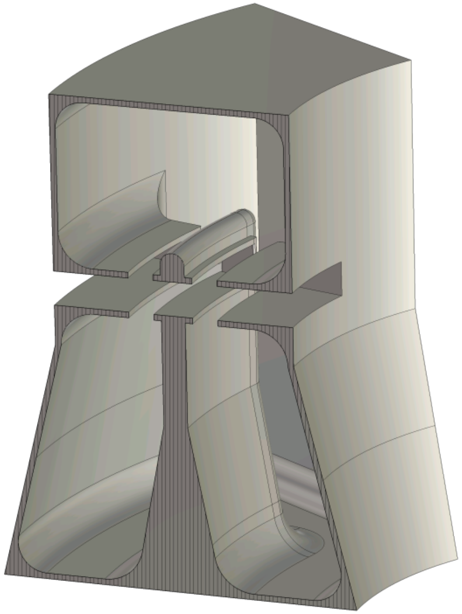
Final Focus Rebuncher

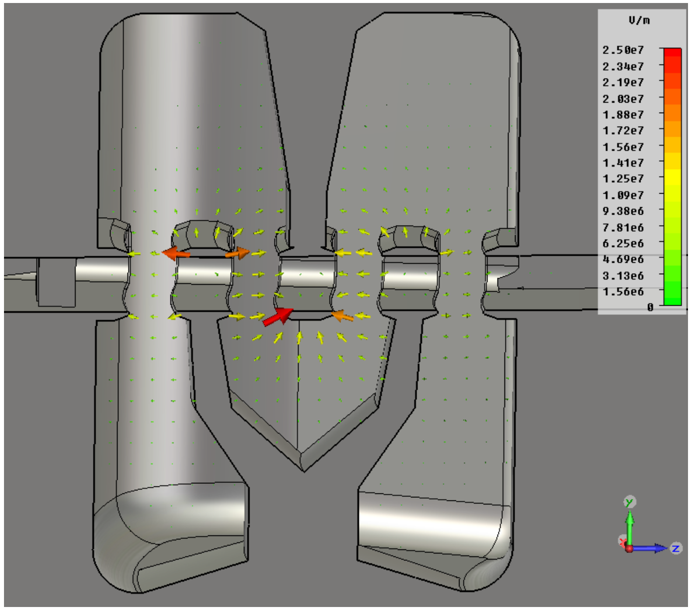


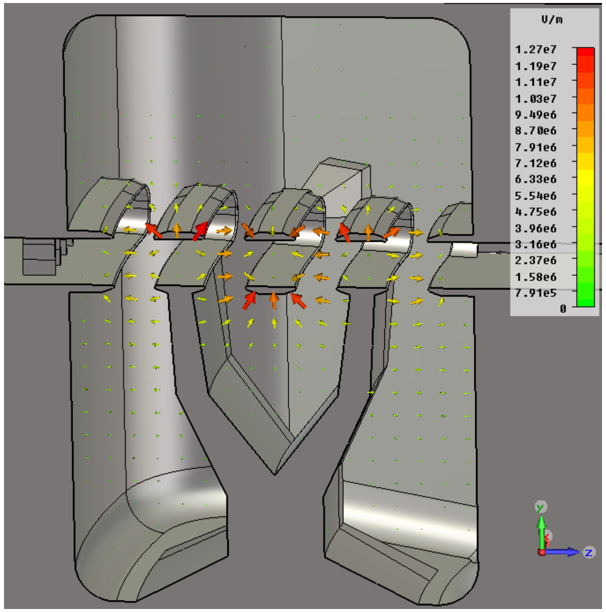
- Final longitudinal focusing (120 kV) of the beam required to achieve nanosecond pulse length
- Energy variation of ±200 keV for variation of neutron energy
  → 233 kV required

Final Focus Rebuncher

Required for 233 kV (250 kV) amplitude with a 12 kW transmitter: R_p=4,5 MΩ (5,2 MΩ)







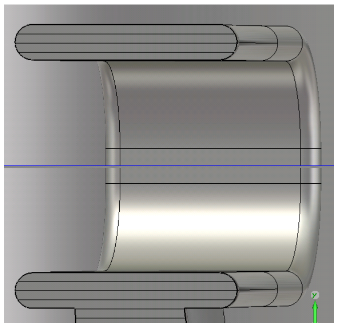
2 gap quarter wave
R_p = 2,55 MΩ
41 cm x 46 cm x 21 cm

4 gap quarter wave
R_p = 5,8 MΩ
52 cm x 29 cm x 25 cm

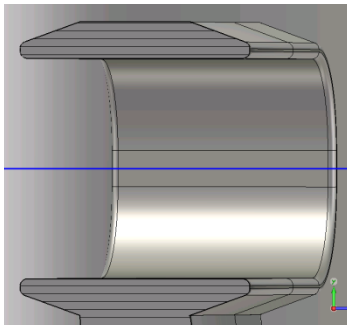
4 gap quarter wave
R_p = 5,75 MΩ
44 cm x 38 cm x 25 cm

Final Focus Rebuncher

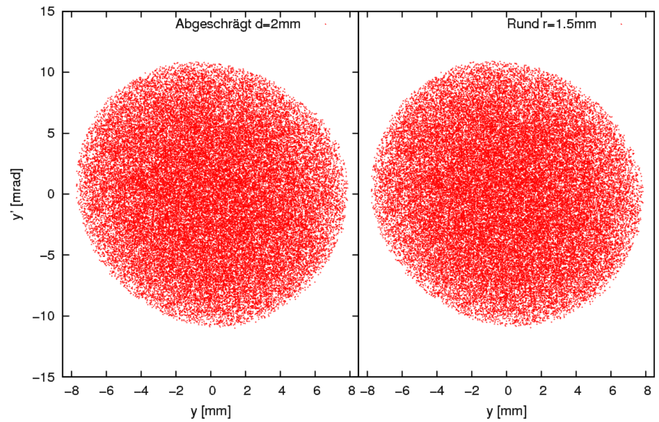
Cavity design



$\Delta R_p / R_p$ = +2 %

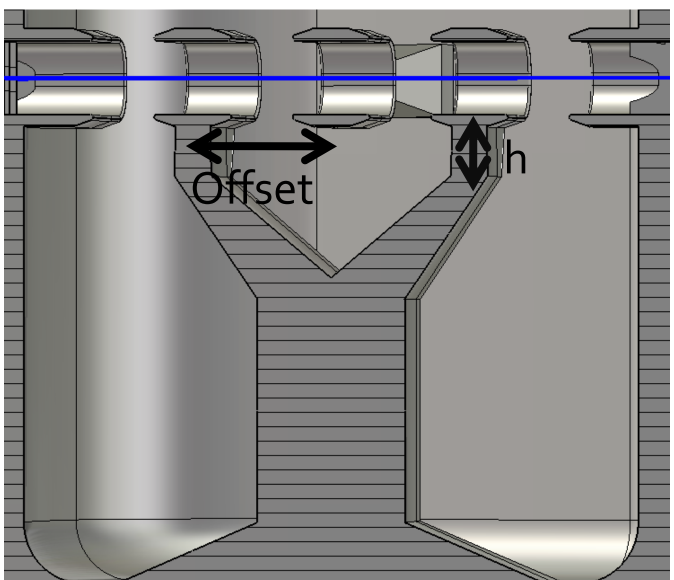


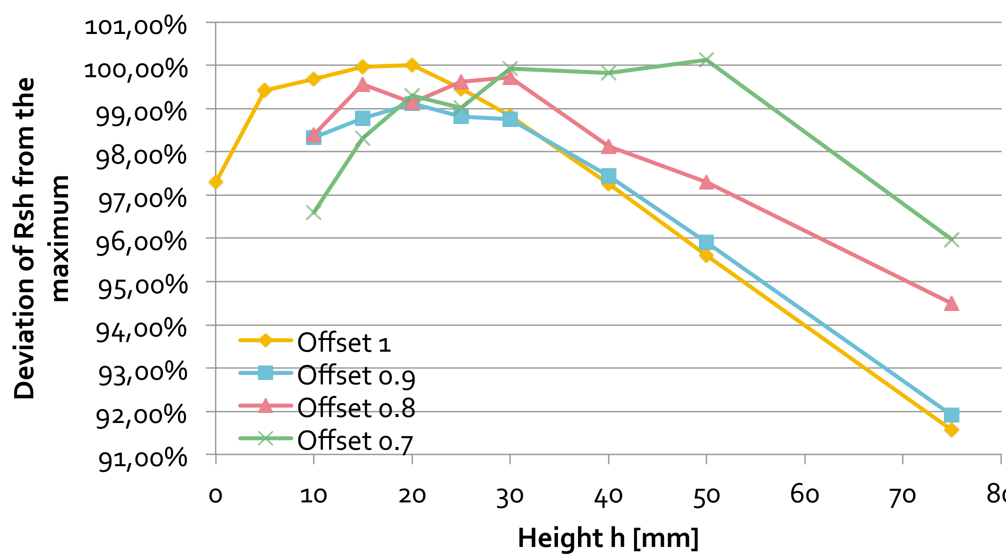
$\Delta R_p / R_p$ = +6 %



Chamfer + Rounded :
$\Delta\varepsilon_y$=0,002 mm mrad

Rounded:
$\Delta\varepsilon_y$=0,0008 mm mrad





Final Focus Rebuncher

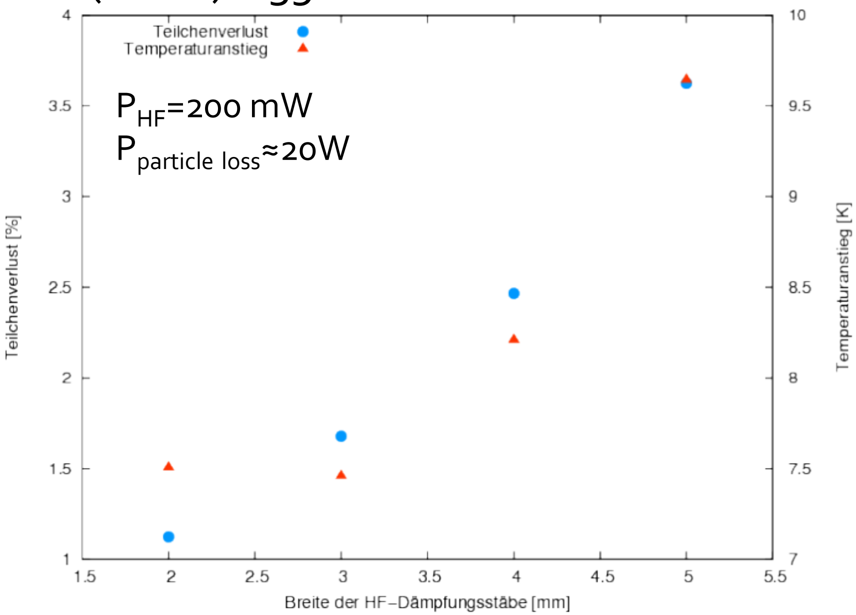
RF emission

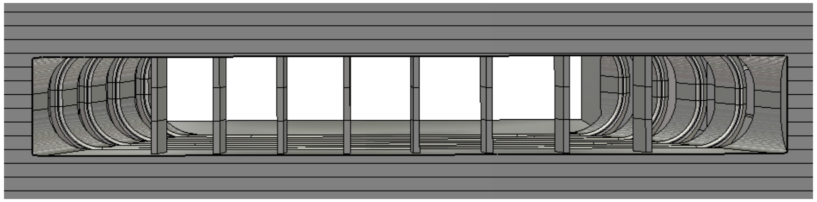
Cut off frequency:

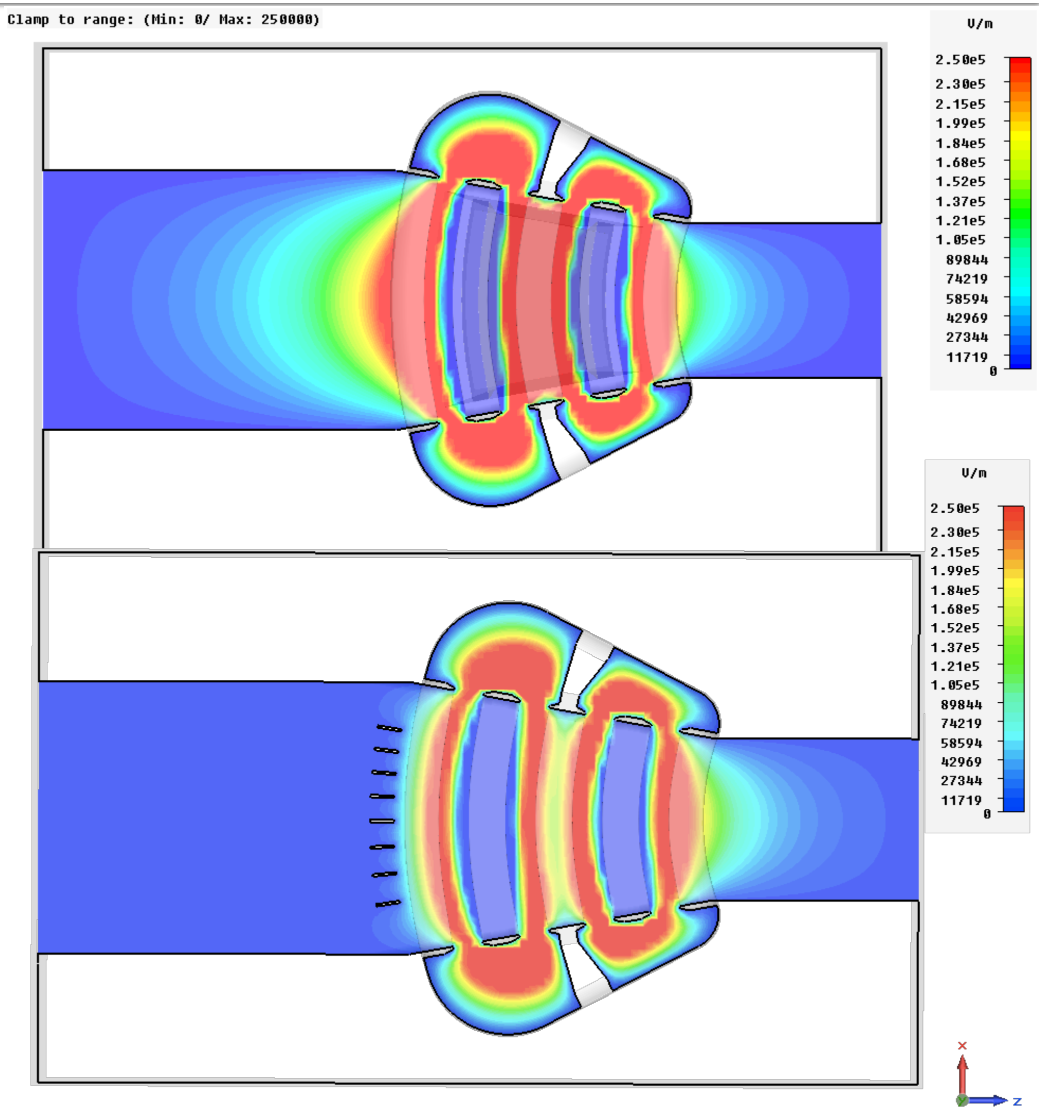
$f_{cutoff}(23\ cm) = c/(2 \cdot 23cm)$

$= 651\ MHz$

$L(20\ db) = 35\ cm$

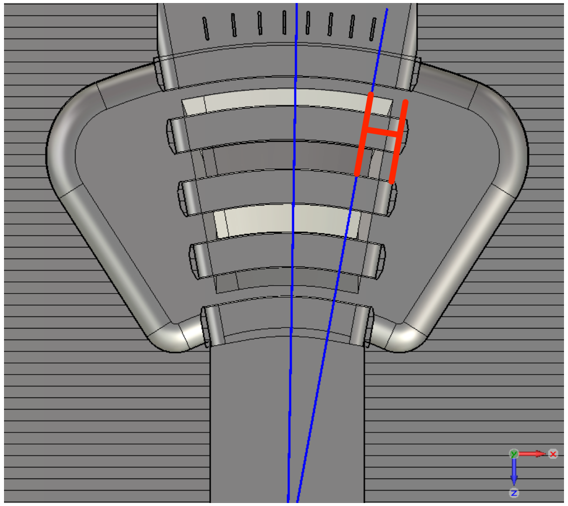




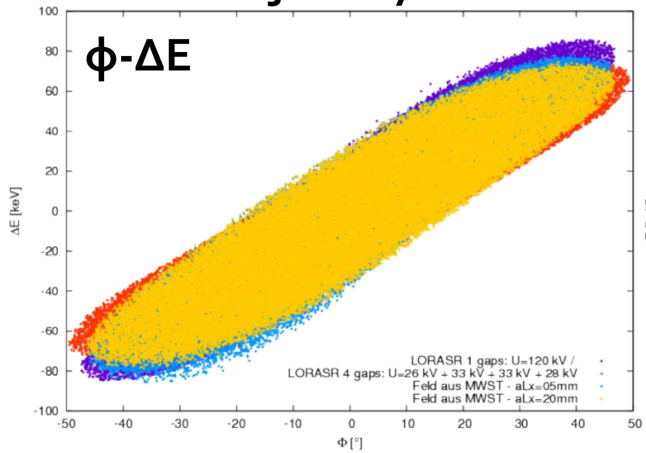


Final Focus Rebuncher

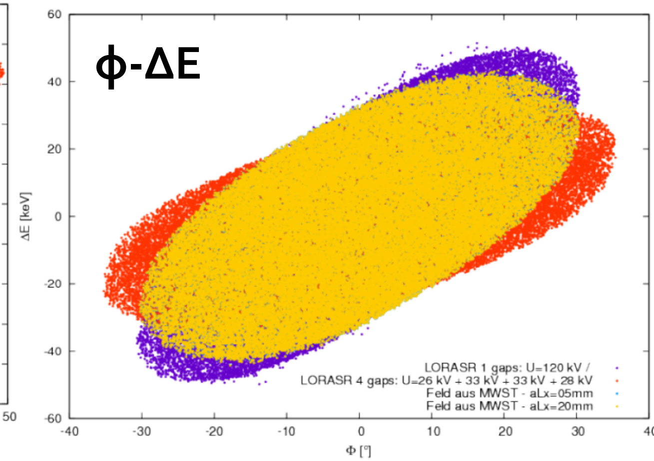
Beam dynamics

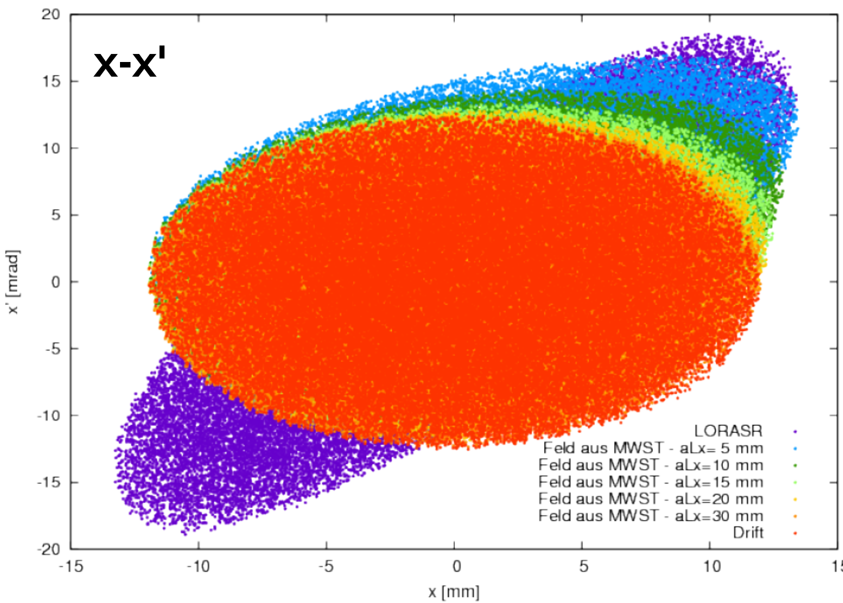


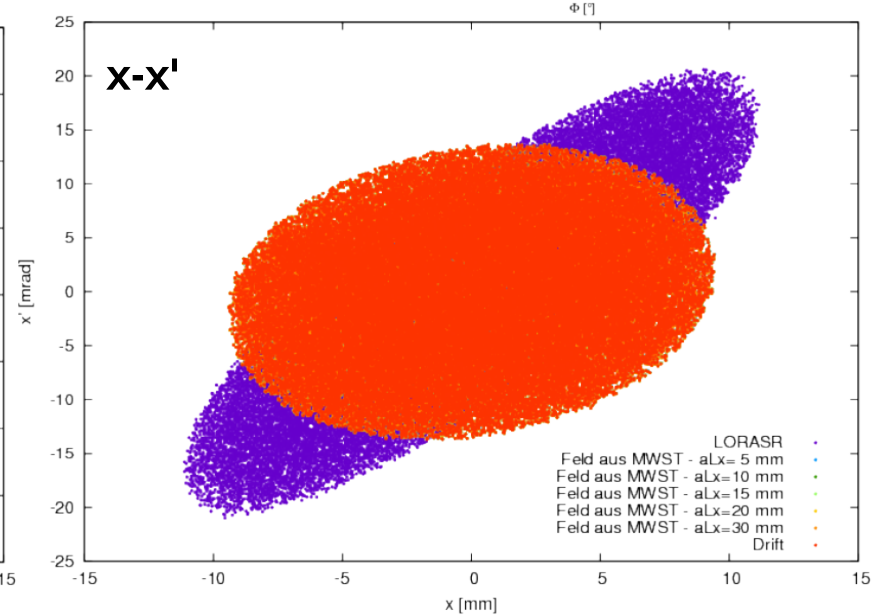
Trajectory 1



Trajectory 5



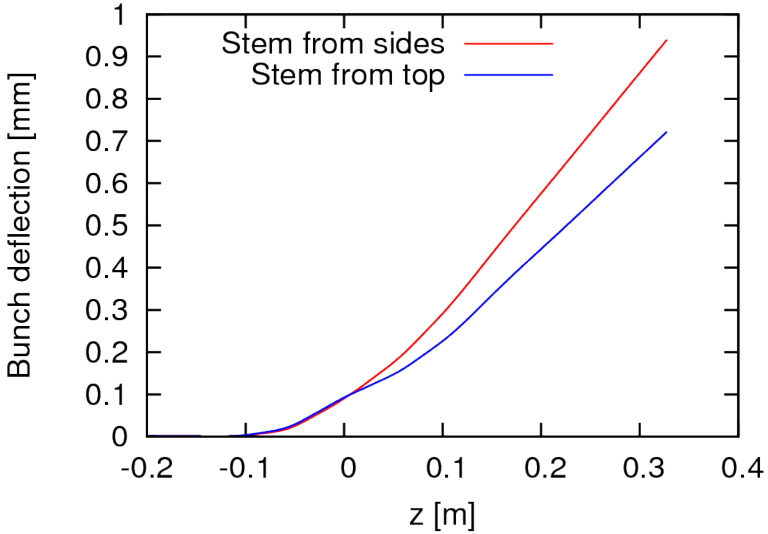


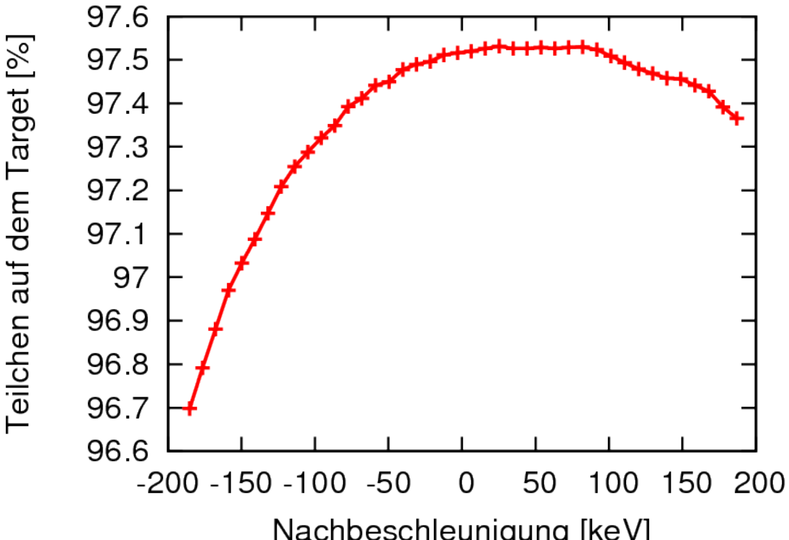


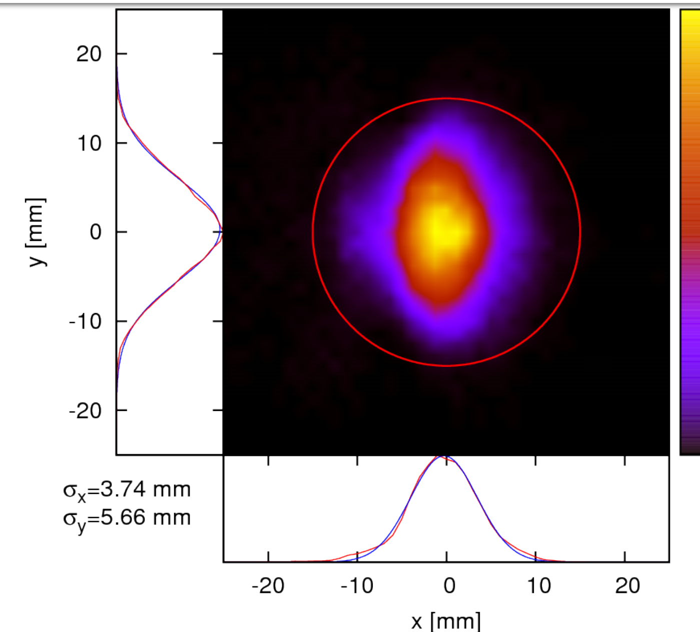
Final Focus Rebuncher

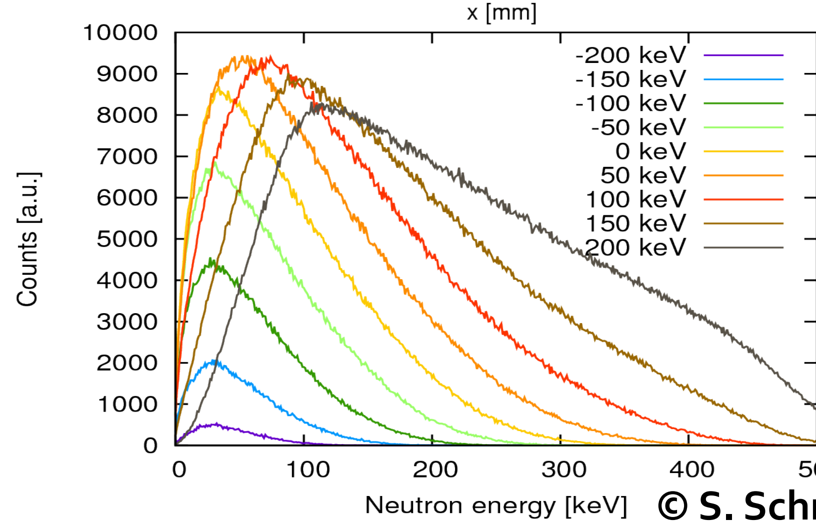
Beam dynamics / Bunch merging

Beam deflection:









Conclusion and Outlook

- Two rebunchers for the bunch compressor have been designed
  - Both cavities are feasible from an rf as well as from the beam dynamics point of view
  - Gap length for the multi aperture rebuncher yet to be decided
- Transport of 30 mA beam for activation mode possible

Conclusion and Outlook

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Thank you for your attention!

Übersicht

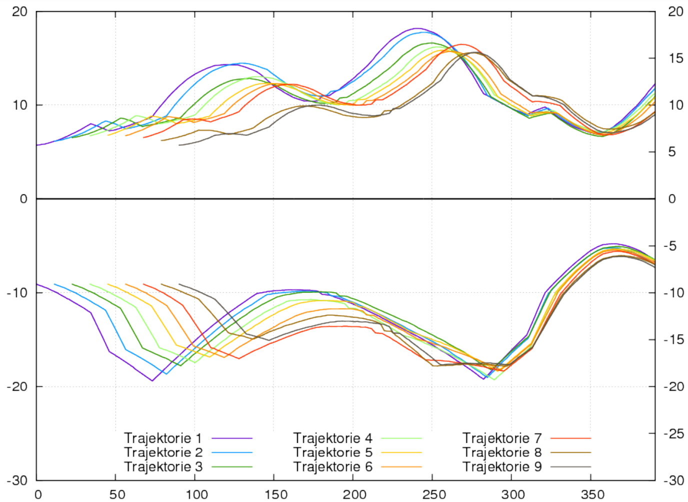
- Einzeltrajektorienstrahldynamik im Bunchkompressor
  - Fehleranalyse
- Final Focus-Rebuncher
- Strahldynamik im Multiaperturrebuncher

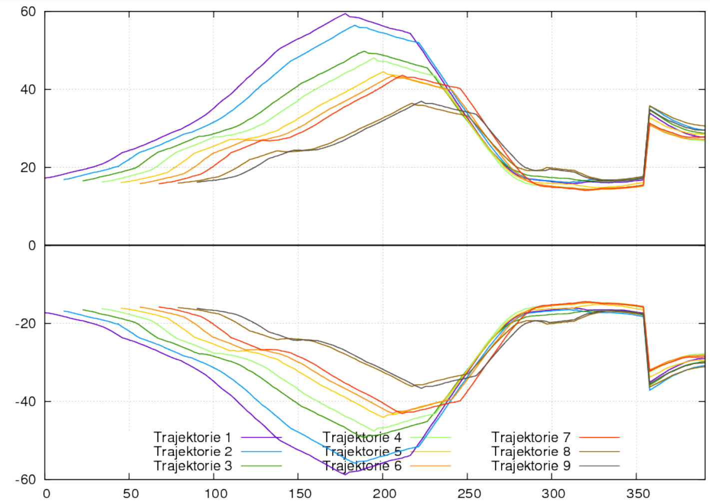
Einzeltrajektorienstrahldynamik

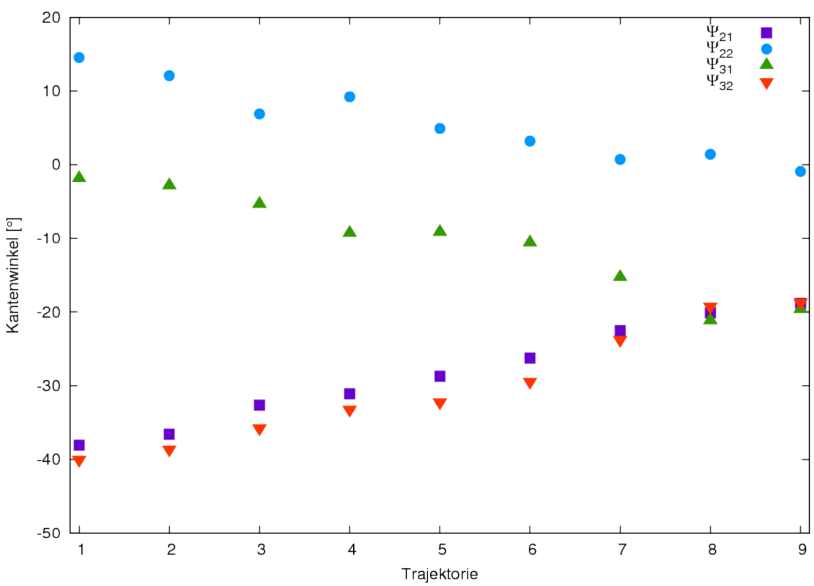
Derzeitige Parameterwahl

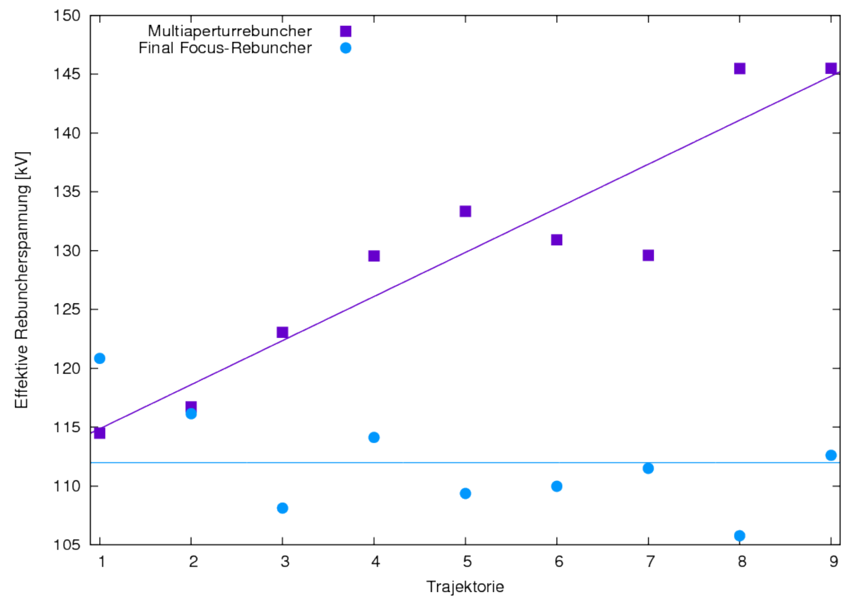
Einstellungen des Linac:

- U_{ch} = 260 kV
- k1x = 6000 G/cm
- k1y = 5400 G/cm
- k1x = 4600 G/cm
- k1y = 5600 G/cm
- k1x = 3800 G/cm
- k1y = 4200 G/cm



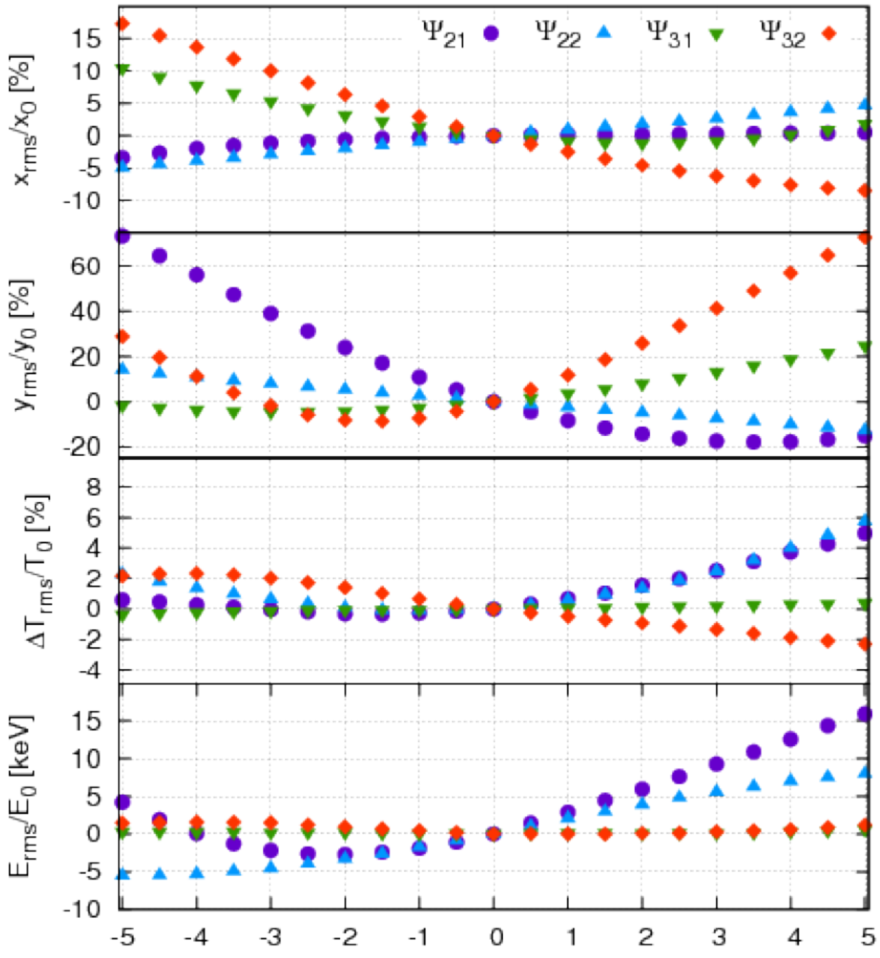


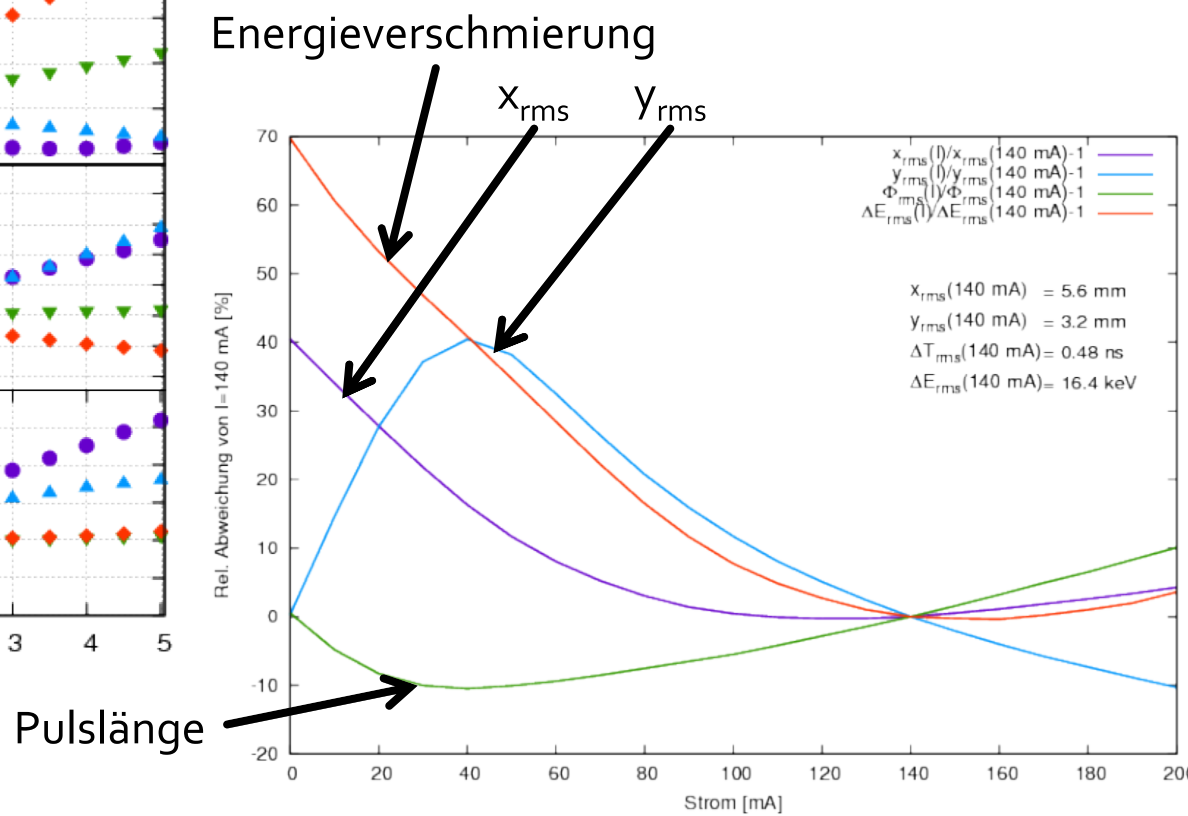




Einzeltrajektorienstrahldynamik

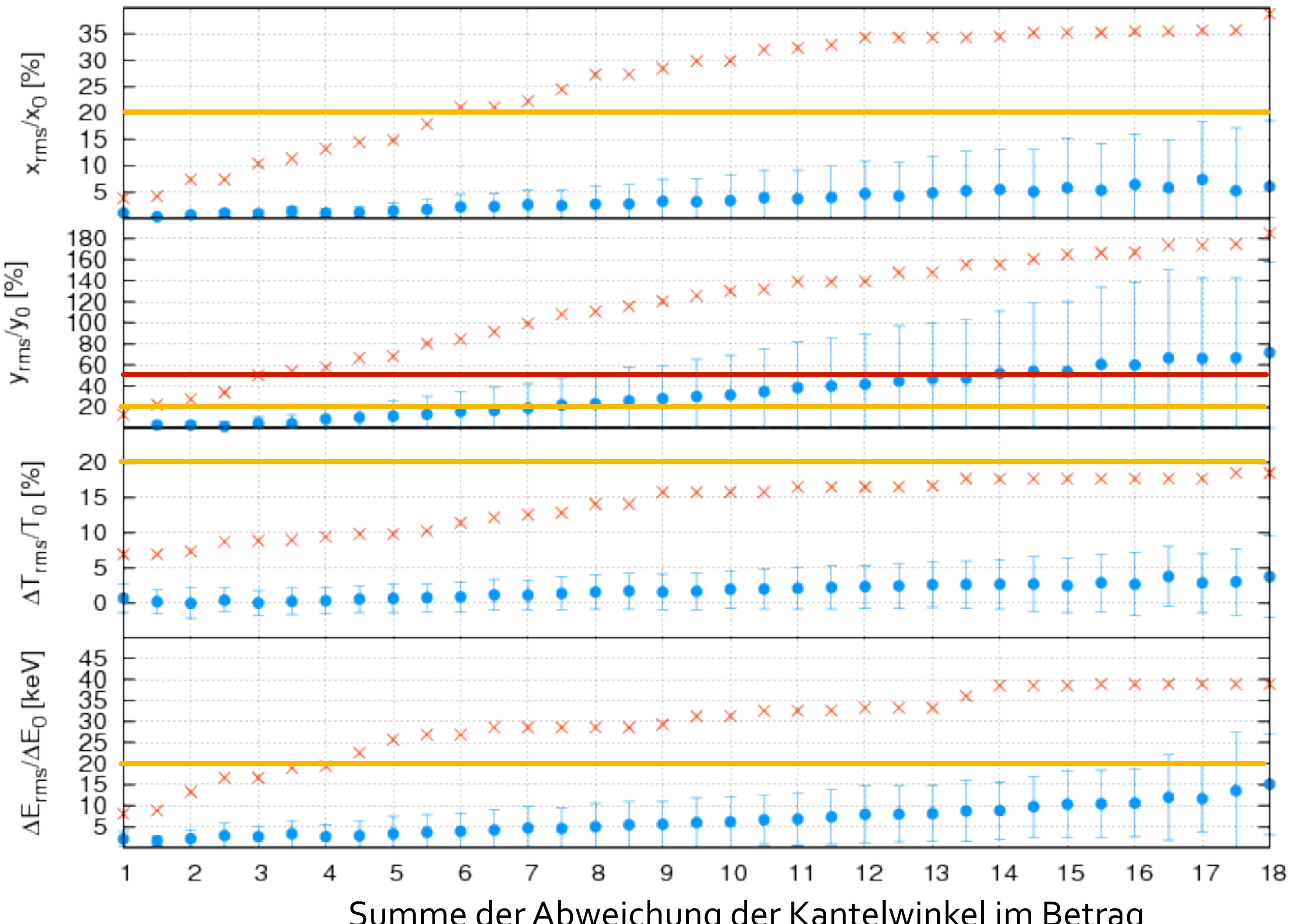
Fehleranalyse: Variation einzelner Parameter





Einzelstrahldynamik

Fehleranalyse: alle Parameter



20% Abweichung am Target (erwartet):
$|\Sigma| < 7{,}5°$

20% Abweichung am Target (worst case):
$|\Sigma| < 1.5°$

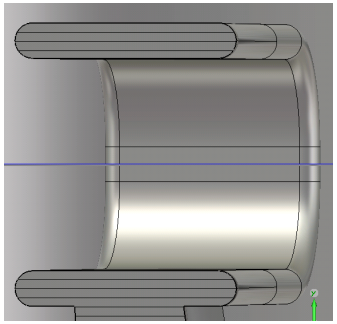
50% Abweichung am Target (erwartet):
$|\Sigma| < 13{,}5°$

50% Abweichung am Target (worst case):
$|\Sigma| < 3.5°$

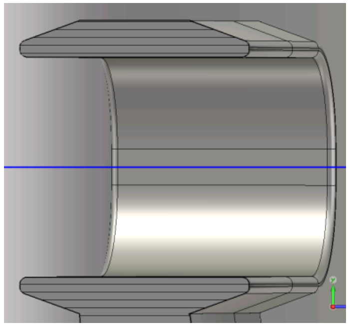
5. Trajektorie, für
$U_{multiapertur} \pm 5kV$
$U_{ff} \pm 5kV$

Final Focus Rebuncher

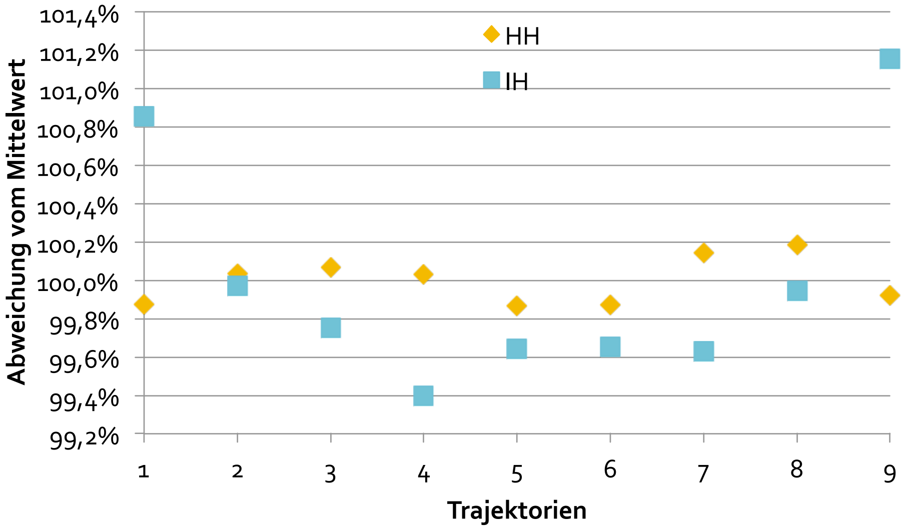
Optimierung

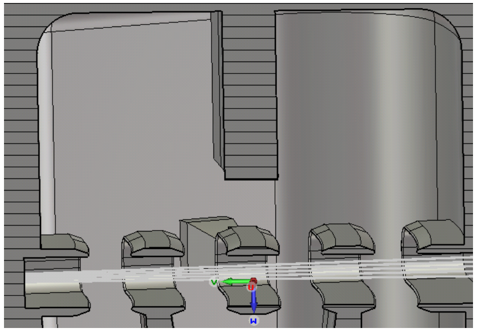


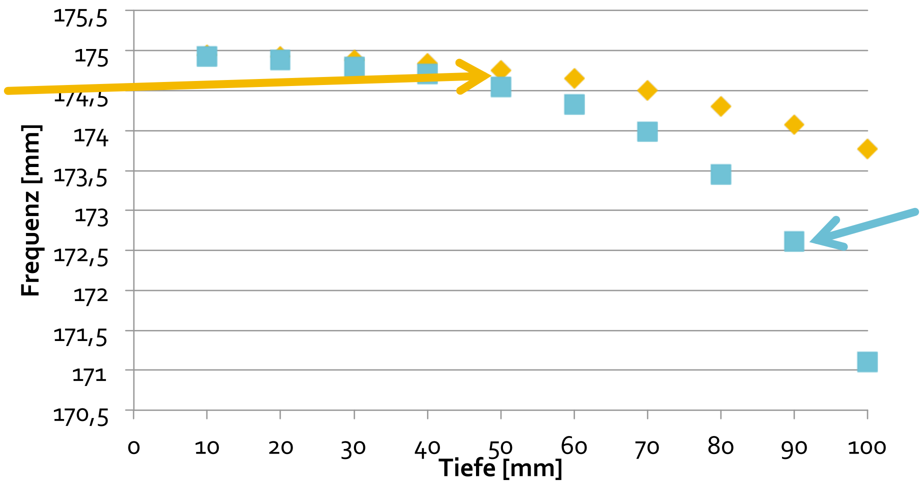
$\Delta R_p / R_p = +2\ \%$

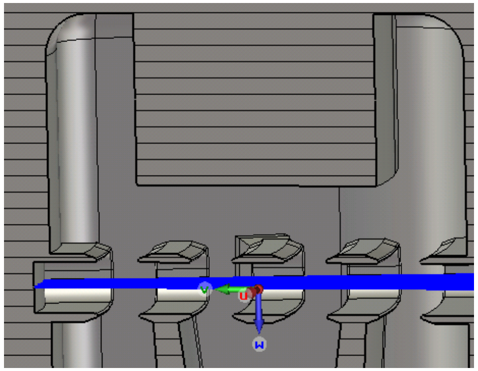


$\Delta R_p / R_p = +6\ \%$









Final Focus Rebuncher

HF-Abstrahlung

Cutoff-Frequenz:

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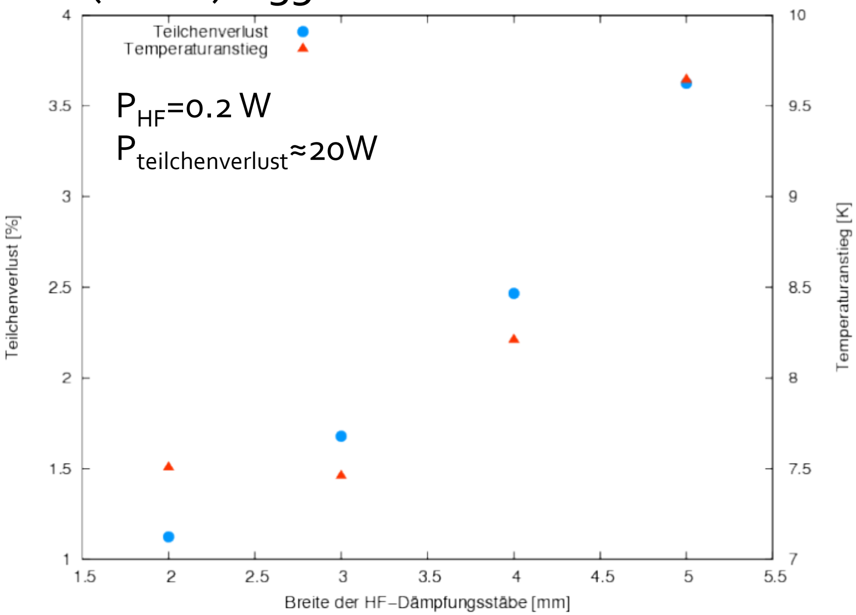
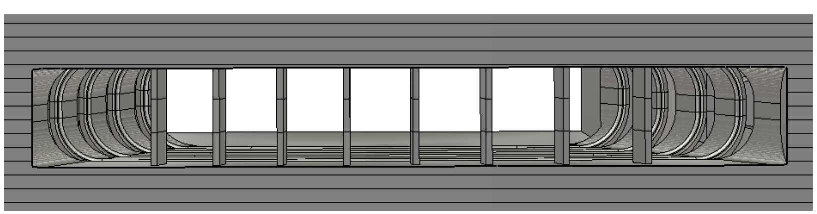
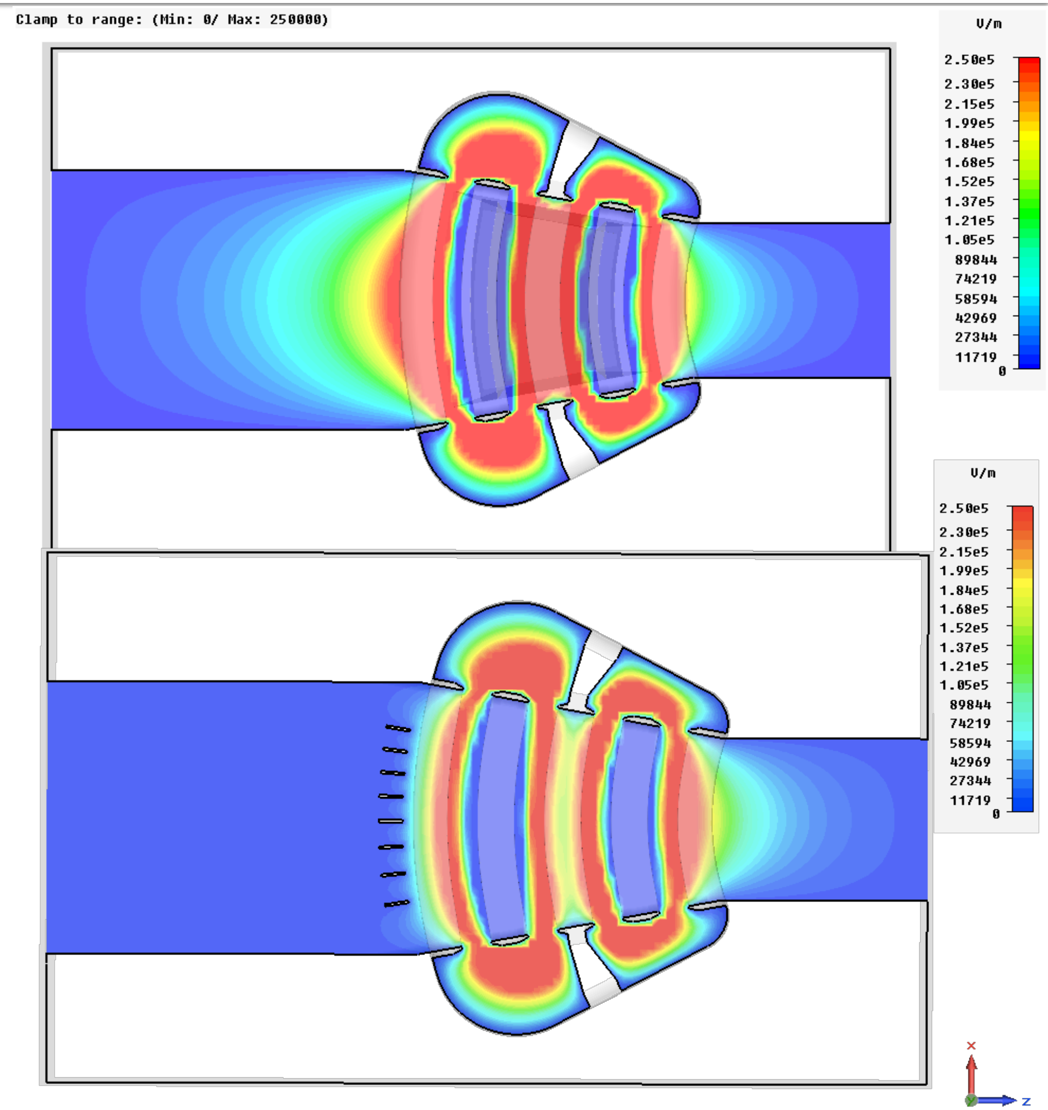
$= 651\text{ MHz}$

$L(20\text{ db}) = 35\text{ cm}$

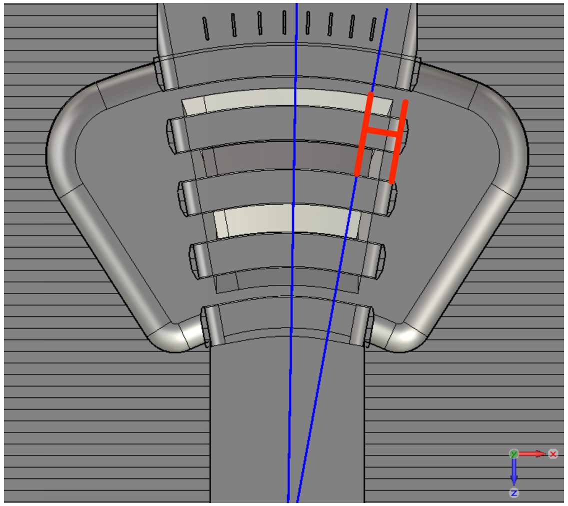


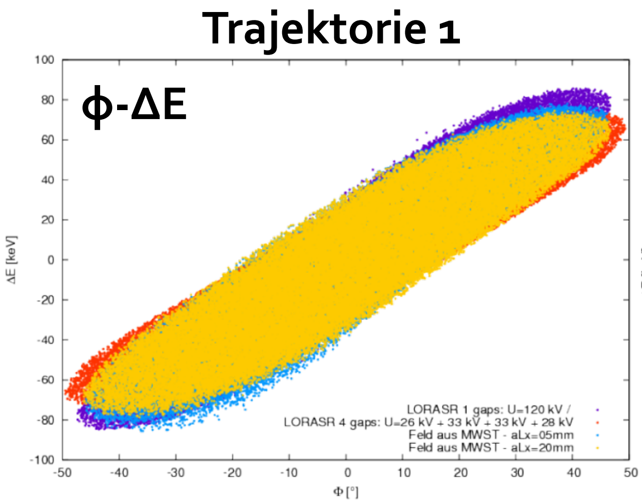


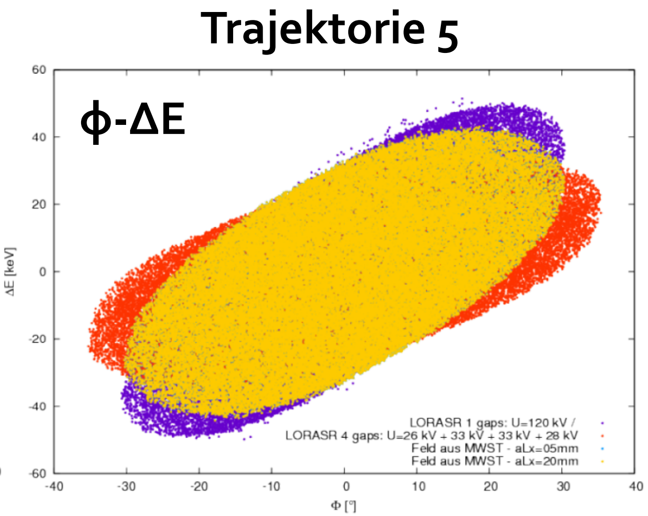


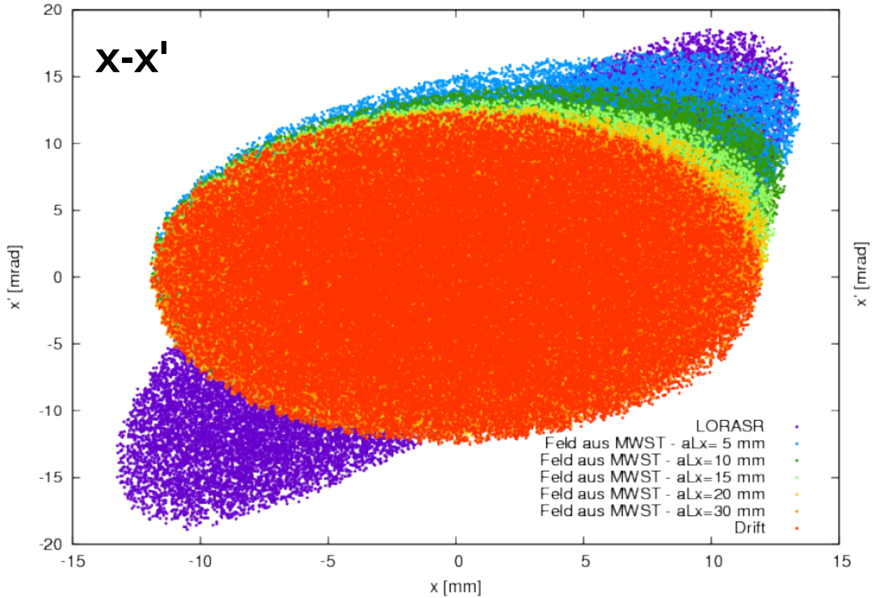
Final Focus Rebuncher

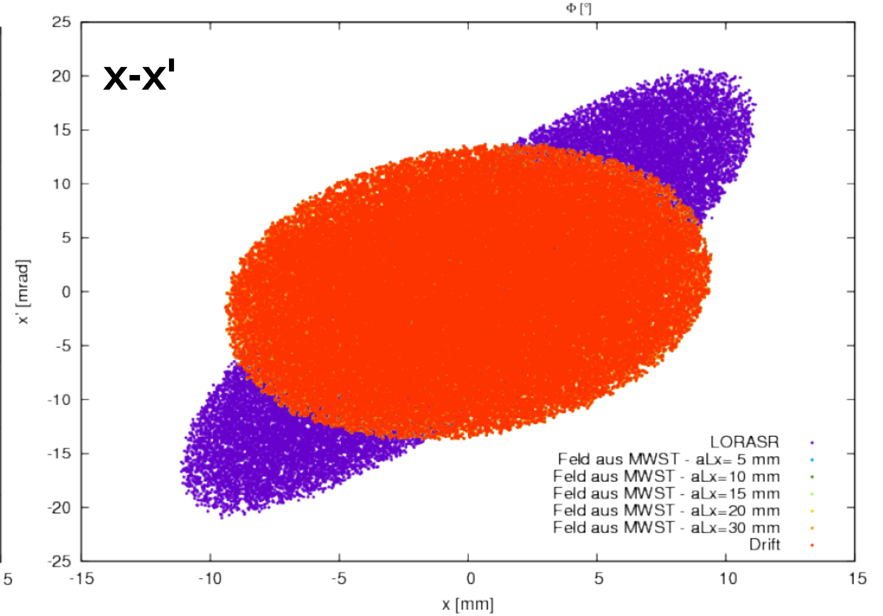
Einzelstrahldynamik





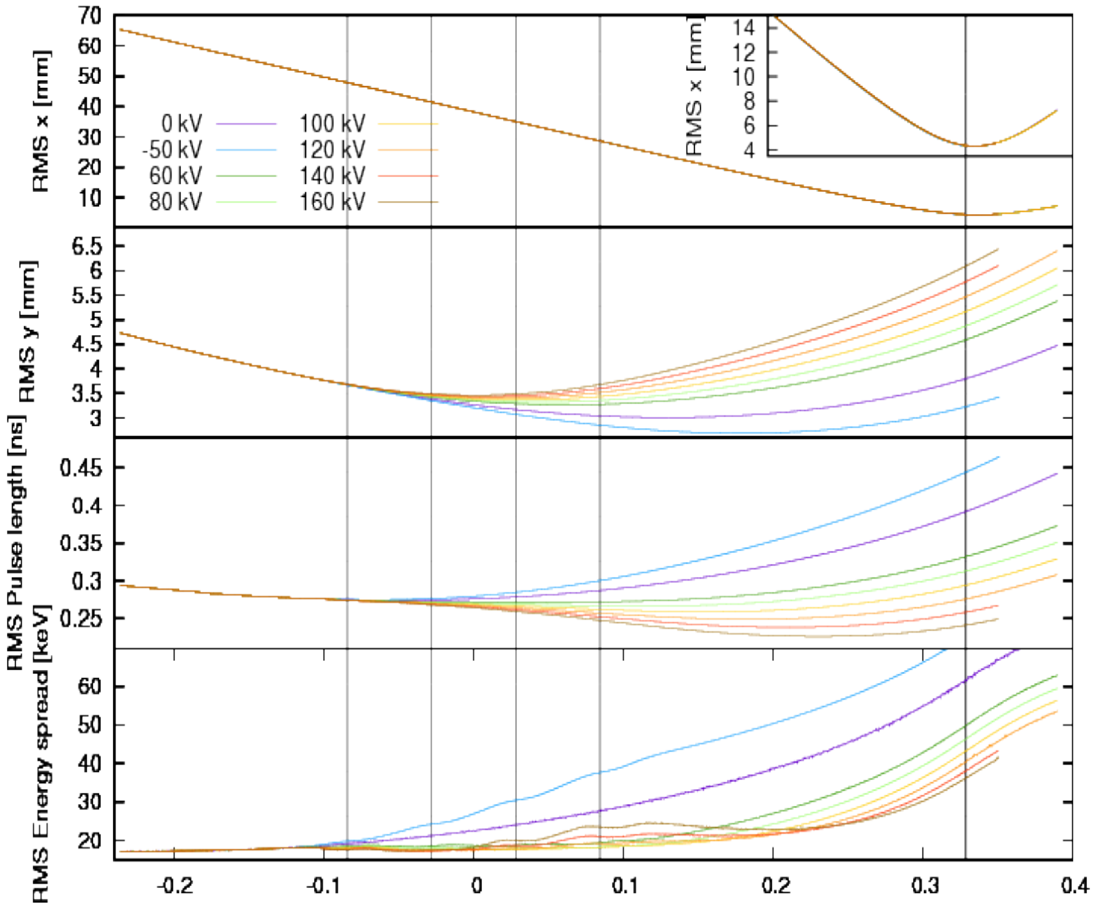


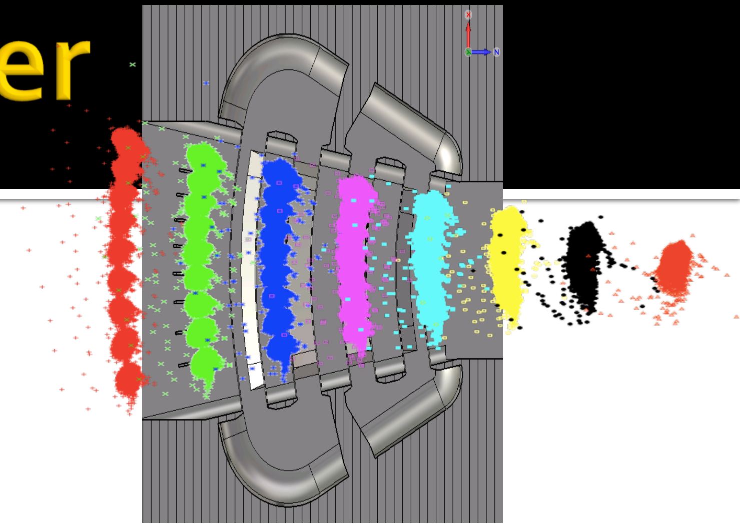


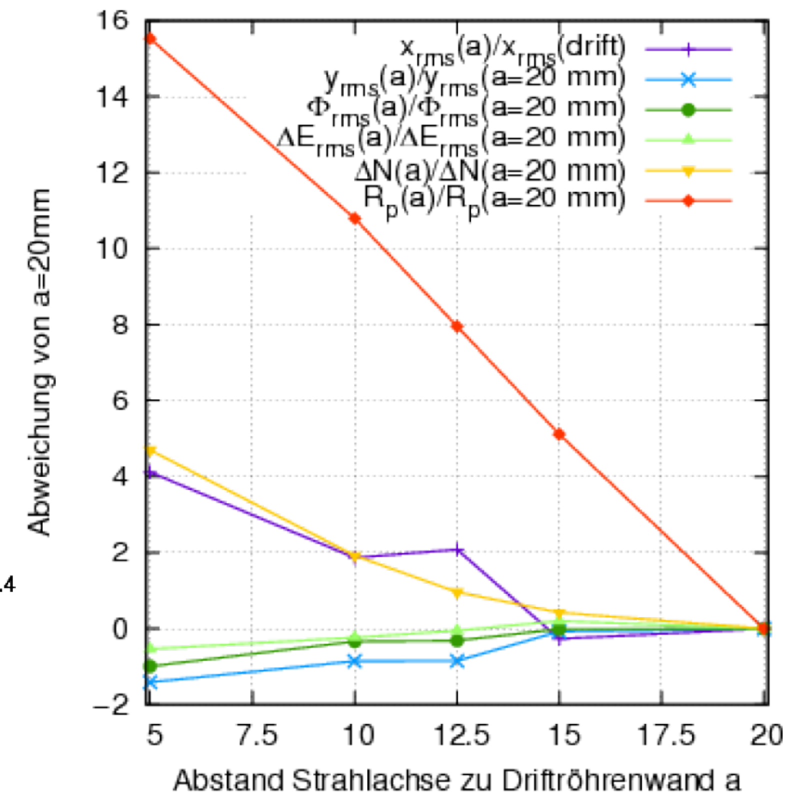


Final Focus Rebuncher

Bunchmerging und Nachbeschleunigung

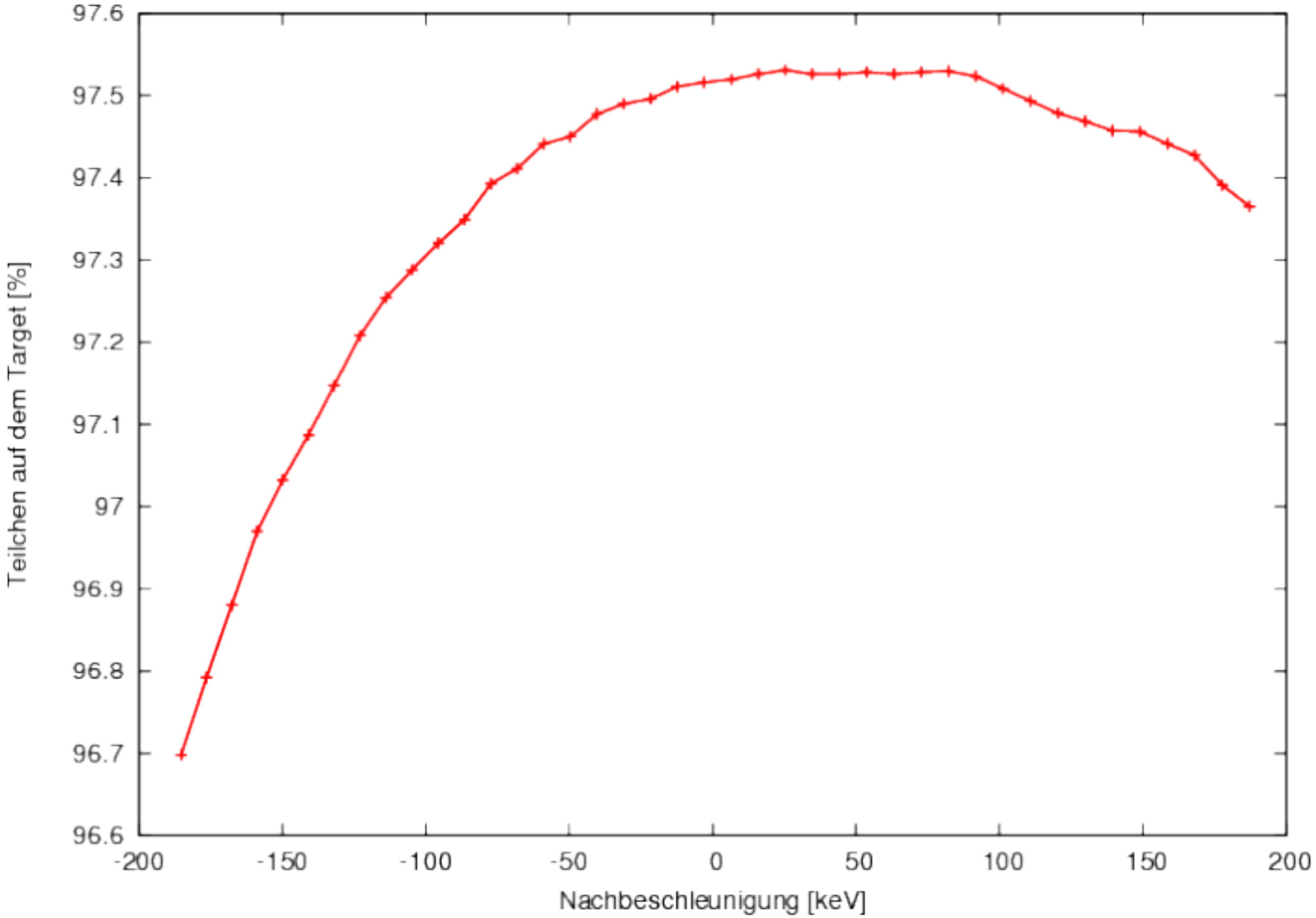






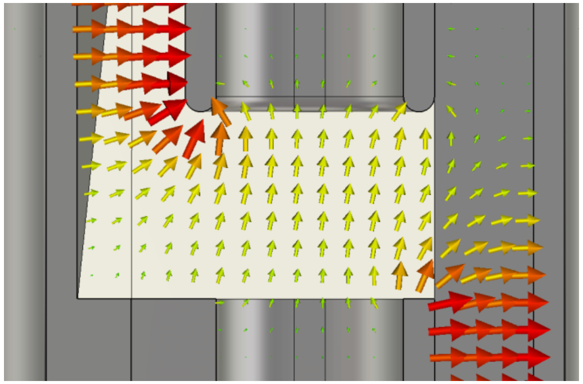
Final Focus Rebuncher

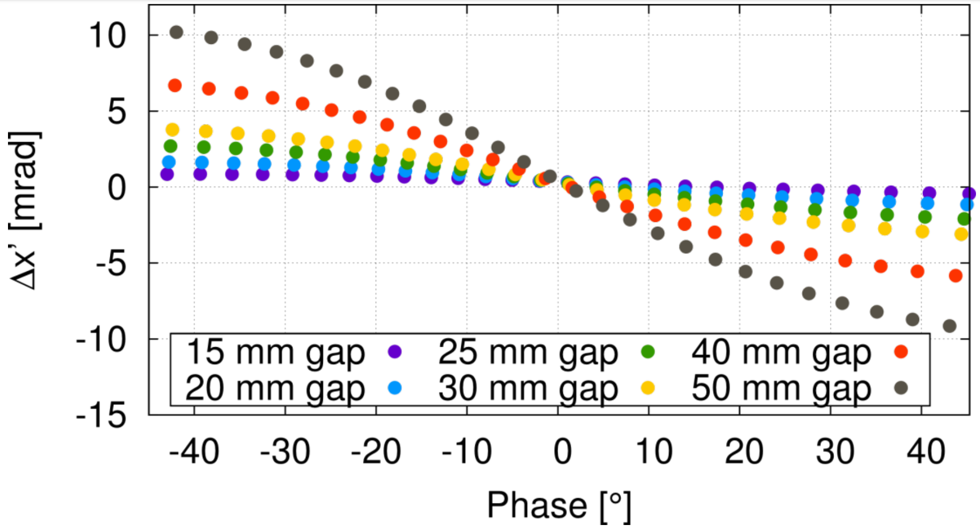
Bunchmerging und Nachbeschleunigung



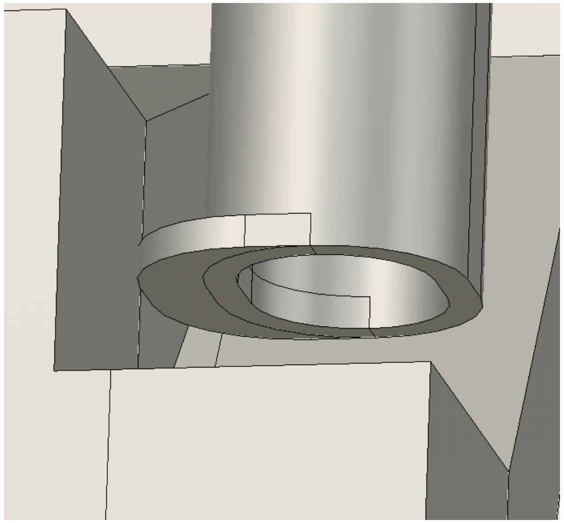
Multiaperturrebuncher

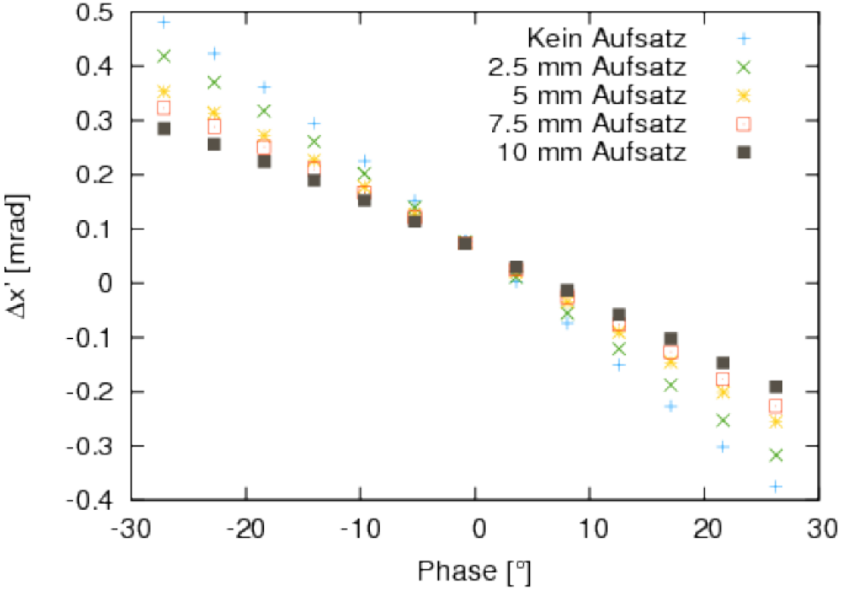
Strahldynamik





Dipolanteile in den Spalten führen zu einer Auffächerung des Strahles





Ausblick

- Multiaperturrebuncher:
  - Einfluss der Geradeausrichtung auf die HF-Eigenschaften
  - Effizienz der Driftröhrenaufsätze?
- Final Focus Rebuncher
  - Thermische Rechnungen
- Strahldynamik des Bunchkompressors
  - Optimierung der Parameter mit Bunchmerging

Vielen Dank für Ihre Aufmerksamkeit!