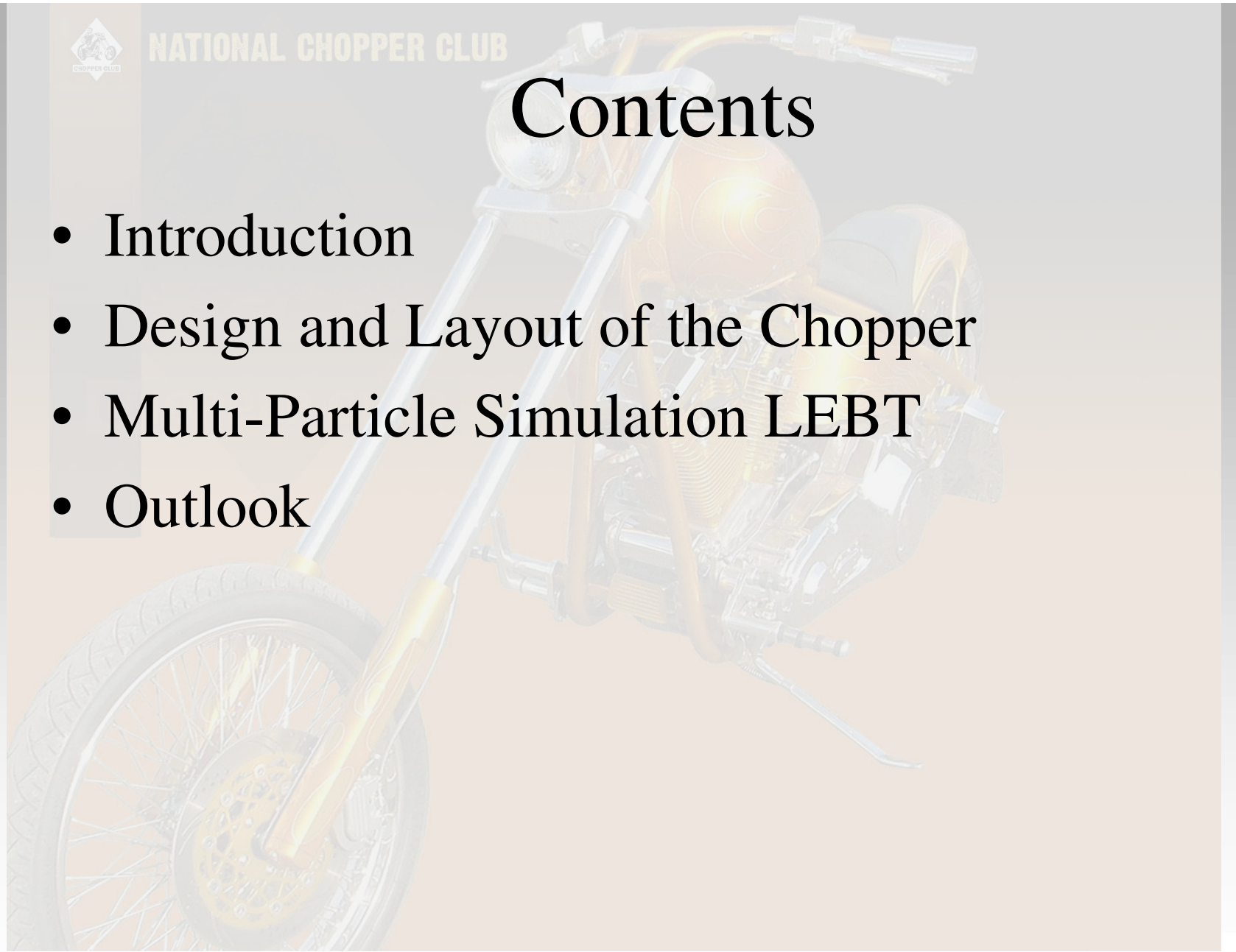
05.03.2007

# Design of a Low-Energy Chopper System for FRANZ

Christoph Wiesner



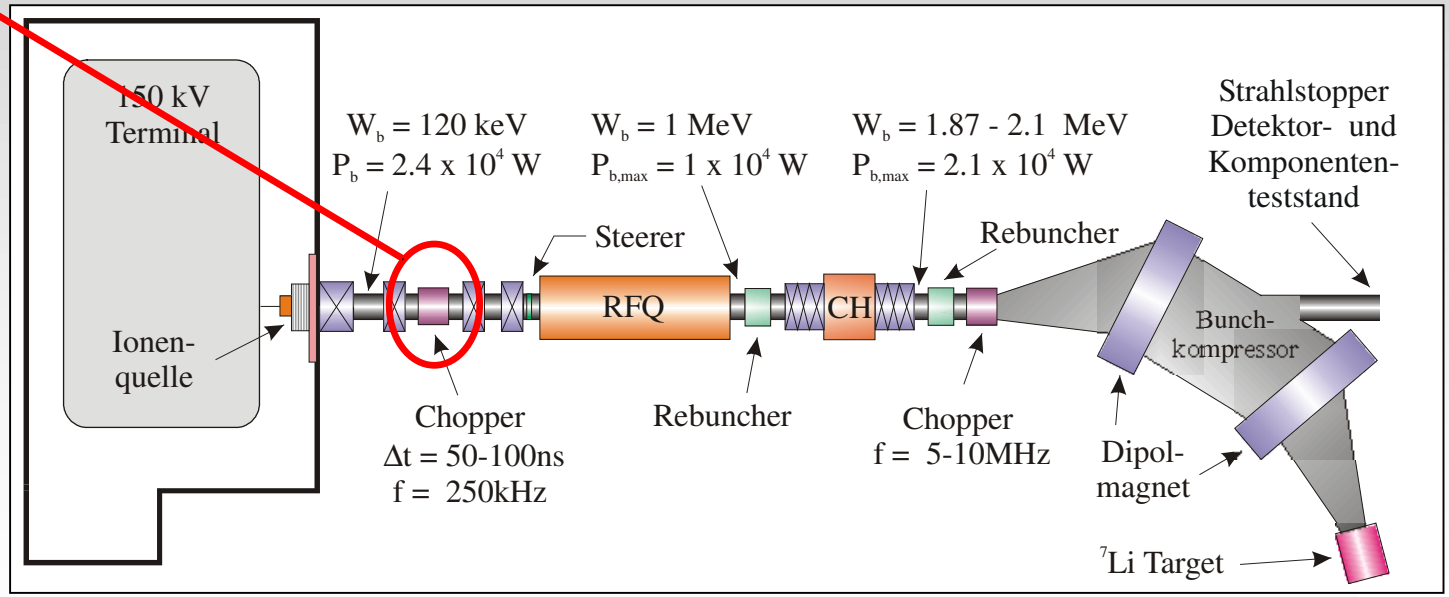

# Contents

- Introduction
- Design and Layout of the Chopper
- Multi-Particle Simulation LEBT
- Outlook

# Function of the Chopper

- Input: 150 mA cw proton beam, 120 keV
- Output: 50-100 ns bunches, repetition rate f = 250 kHz

LEBT-Chopper

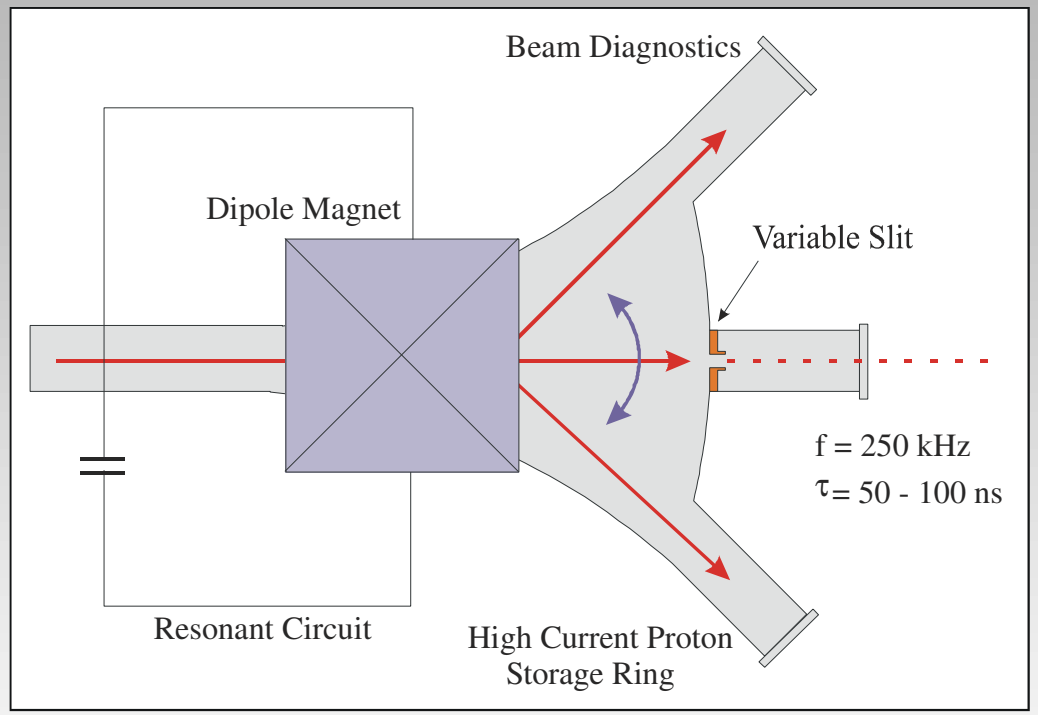


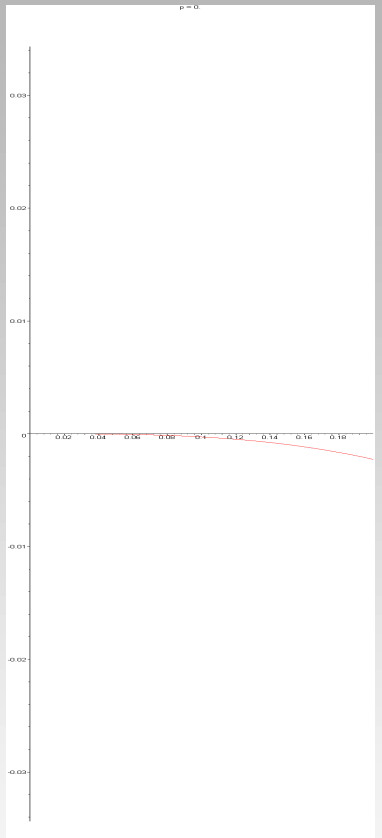
# Possible Choppers Types

- ~~Disc Chopper~~

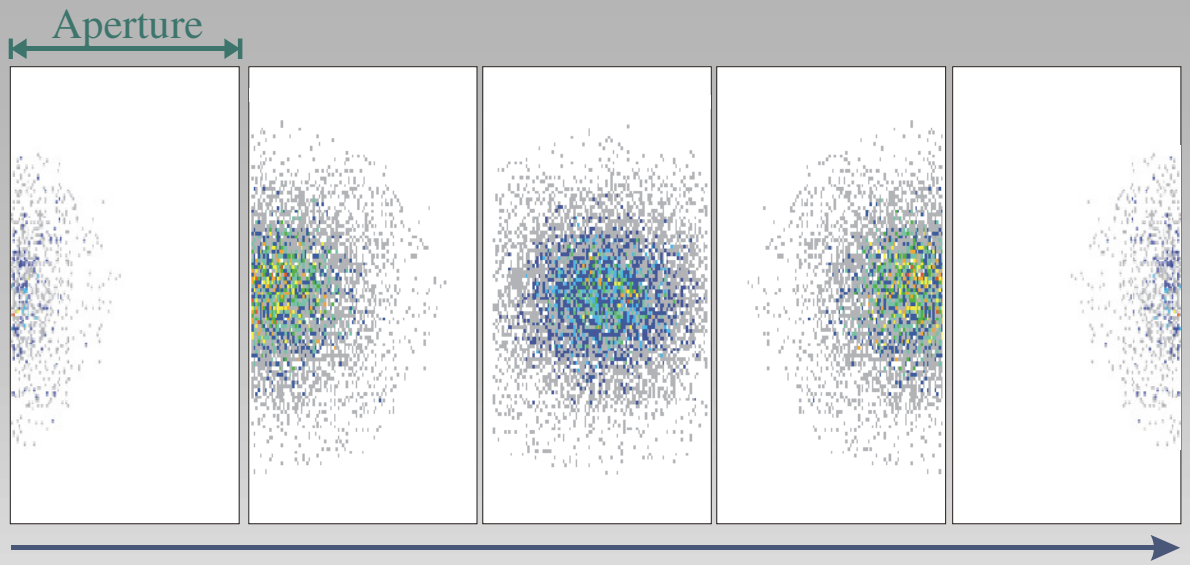
- ~~Electrical Chopper~~
- ~~Magnetic Chopper~~ with Helmholtz Coils
- Dipole System

# Functional Principle of the Dipole System

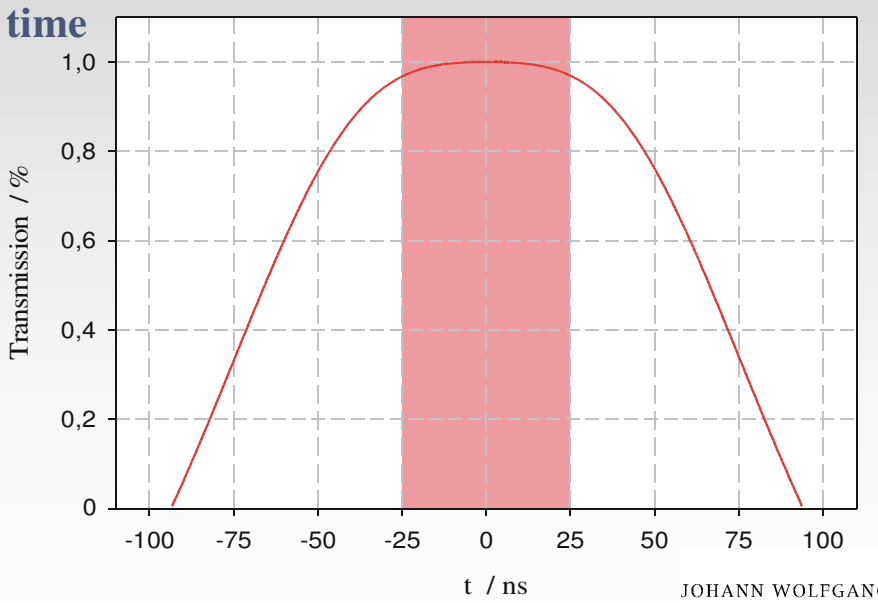


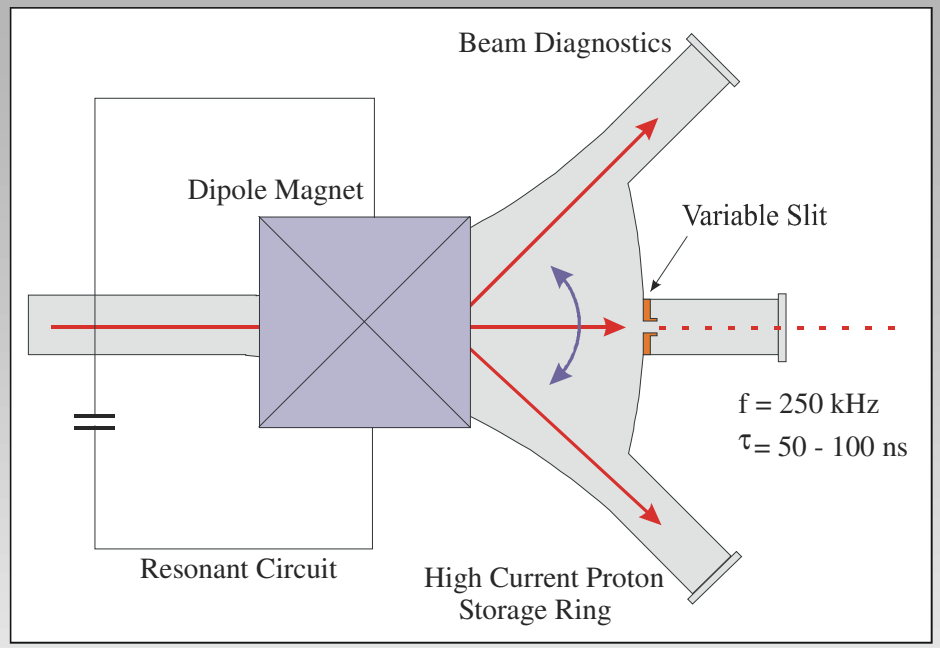
# Functional Principle of the Dipole System

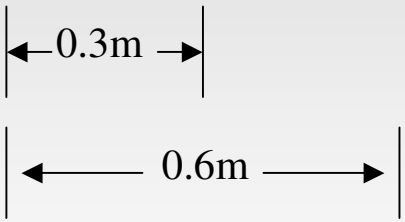



Varying the aperture leads to different bunch lengths and intensities.



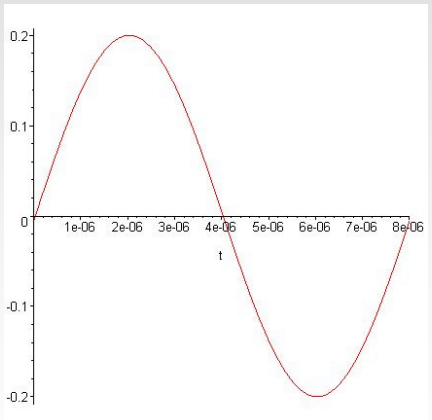
# Layout Dipole System



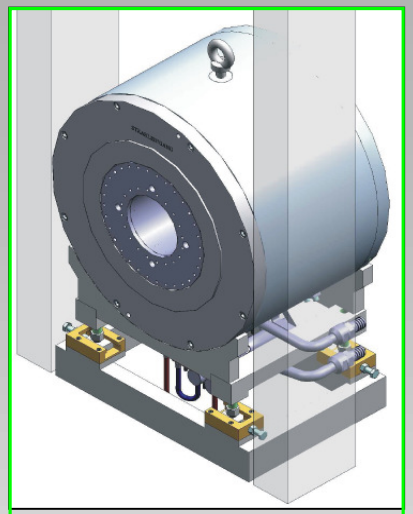

## Parameter Setting:

- $B_{max}$ = 0.3 T
- Dipole Length = 0.3 m
- Total System Length = 0.6 m
- Gap Height = 0.06 m

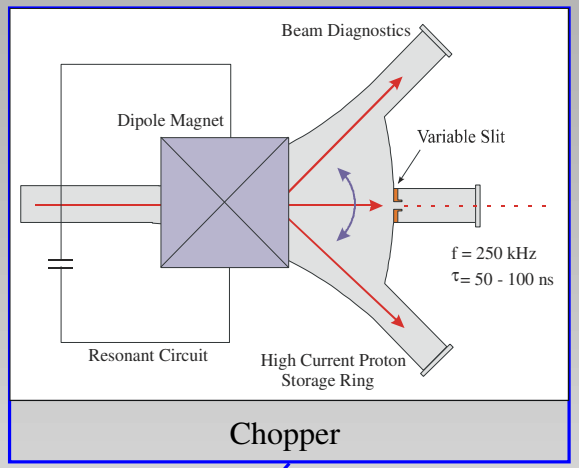



$$B(t) = B_{\max} \cdot \sin(\omega t + \Phi_n)$$

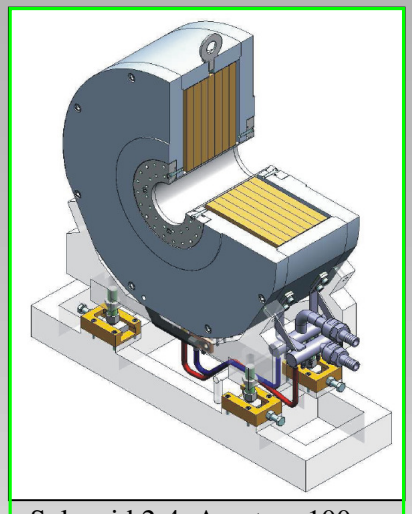
# Layout LEBT



Solenoid 1: Aperture 150mm

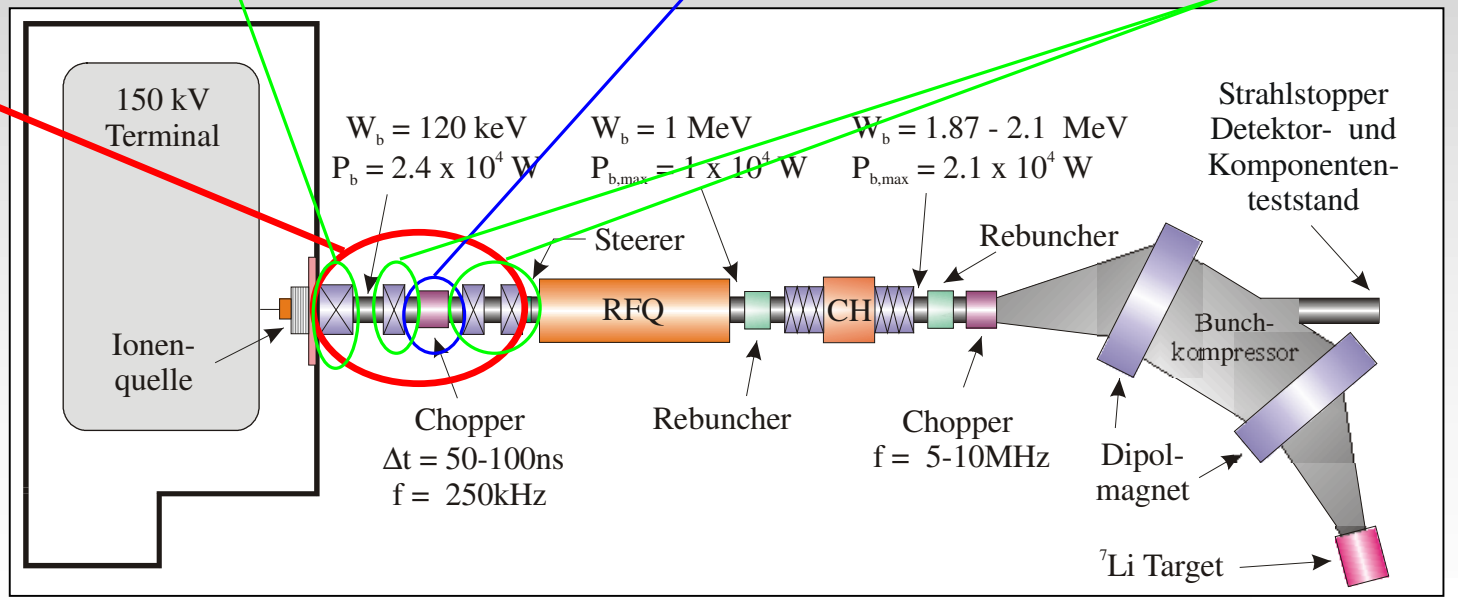



Chopper

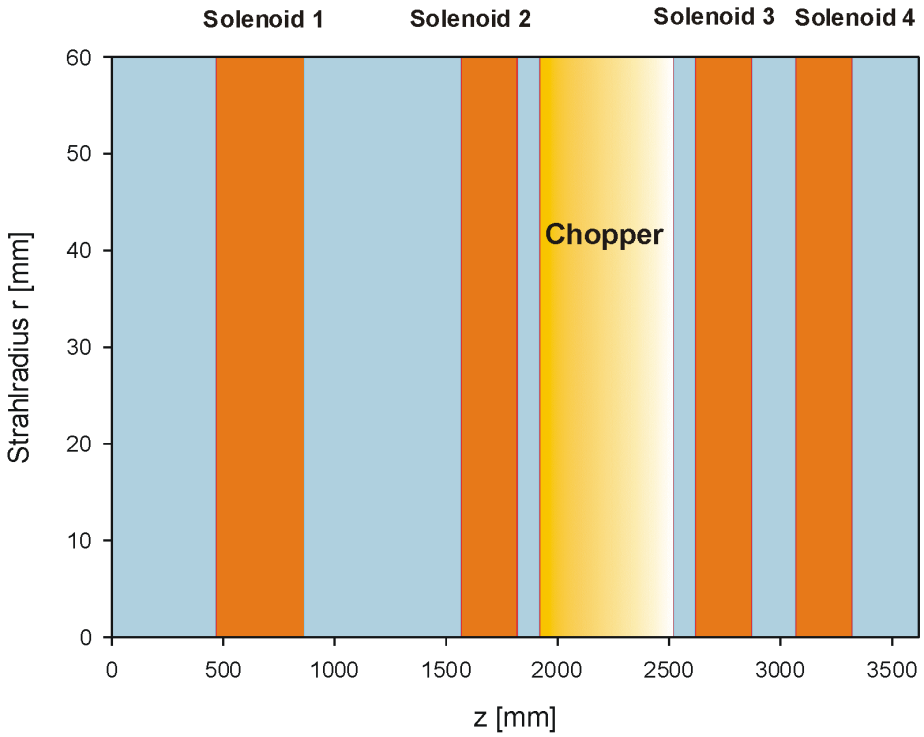


Solenoid 2-4: Aperture 100mm

LEBT

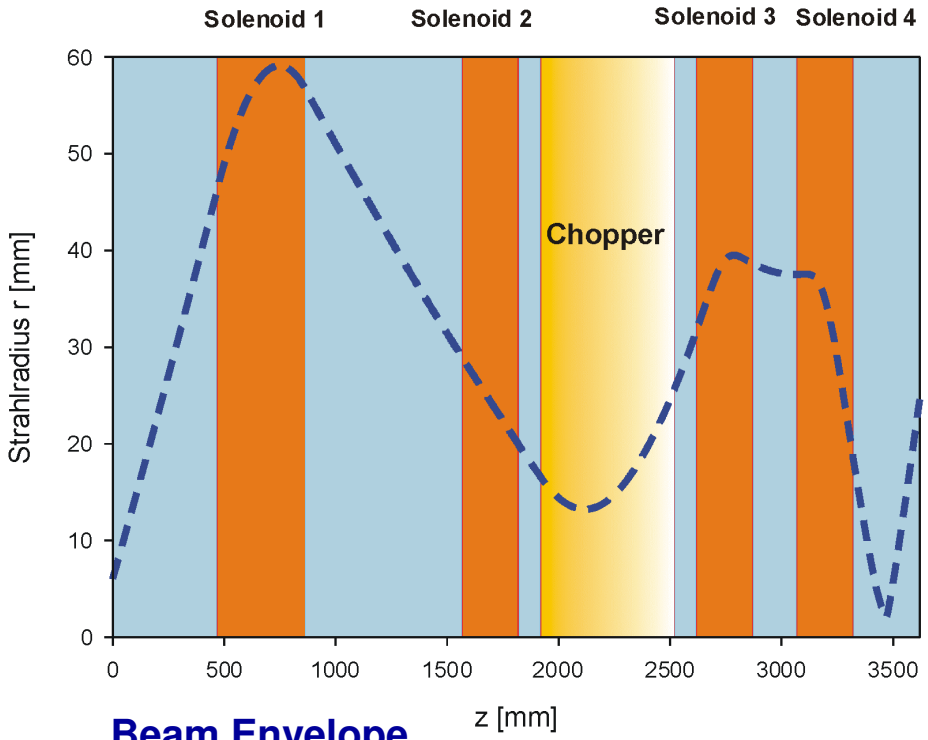


# Schematic View of LEBT




| Sektion | Funktion | von | bis | Länge | B-Feld | Max.Radius | Raumlad.komp |
|---|---|---|---|---|---|---|---|
| 1 | Drift | 0 | 470 | 470 | 0 | 75 | 0.85 |
| 2 | Solenoid 1 | 470 | 870 | 400 | | 75 | 0.85 |
| 3 | Drift (Diagnostik) | 870 | 1570 | 700 | 0 | 75 | 0.85 |
| 4 | Solenoid 2 | 1570 | 1820 | 250 | | 50 | 0.85 |
| 5 | Drift | 1820 | 1920 | 100 | 0 | 50 | 0.85 |
| 6 | Dipol (ohne Feld) | 1920 | 2220 | 300 | 0 | 25 | 0 |
| 7 | Drift bis Blende | 2220 | 2520 | 300 | 0 | 50 | 0 |
| 8 | Drift | 2520 | 2620 | 100 | 0 | 75 | 0 |
| 9 | Solenoid 3 | 2620 | 2870 | 250 | | 50 | 0 |
| 10 | Drift | 2870 | 3070 | 200 | 0 | 75 | 0 |
| 11 | Solenoid 4 | 3070 | 3320 | 250 | | 50 | 0 |
| 12 | Drift | 3320 | 3620 | 300 | 0 | 50 | 0 |

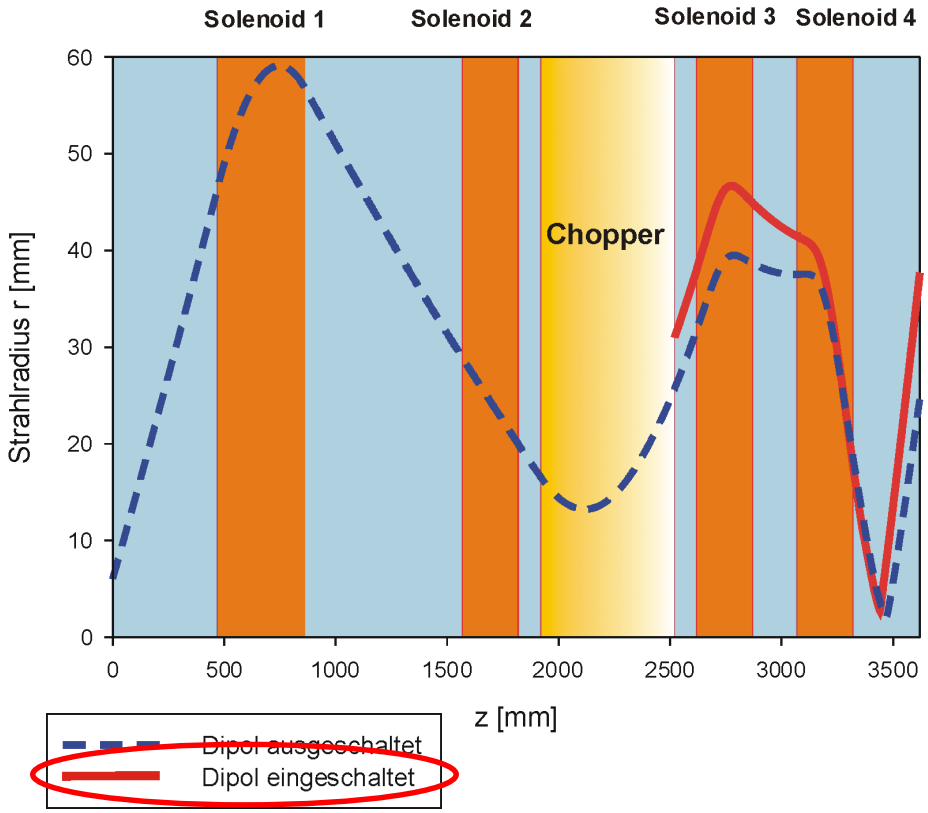
# Schematic View of LEBT




**Beam Envelope**

| Sektion | Funktion | von | bis | Länge | B-Feld | Max.Radius | Raumlad.komp |
|---|---|---|---|---|---|---|---|
| 1 | Drift | 0 | 470 | 470 | 0 | 75 | 0.85 |
| 2 | Solenoid 1 | 470 | 870 | 400 | Hom0245 | 75 | 0.85 |
| 3 | Drift (Diagnostik) | 870 | 1570 | 700 | 0 | 75 | 0.85 |
| 4 | Solenoid 2 | 1570 | 1820 | 250 | Sol0100 | 50 | 0.85 |
| 5 | Drift | 1820 | 1920 | 100 | 0 | 50 | 0.85 |
| 6 | Dipol (ohne Feld) | 1920 | 2220 | 300 | 0 | 25 | 0 |
| 7 | Drift bis Blende | 2220 | 2520 | 300 | 0 | 50 | 0 |
| 8 | Drift | 2520 | 2620 | 100 | 0 | 75 | 0 |
| 9 | Solenoid 3 | 2620 | 2870 | 250 | Sol0500 | 50 | 0 |
| 10 | Drift | 2870 | 3070 | 200 | 0 | 75 | 0 |
| 11 | Solenoid 4 | 3070 | 3320 | 250 | Sol0715 | 50 | 0 |
| 12 | Drift | 3320 | 3620 | 300 | 0 | 50 | 0 |

# Schematic View of LEBT

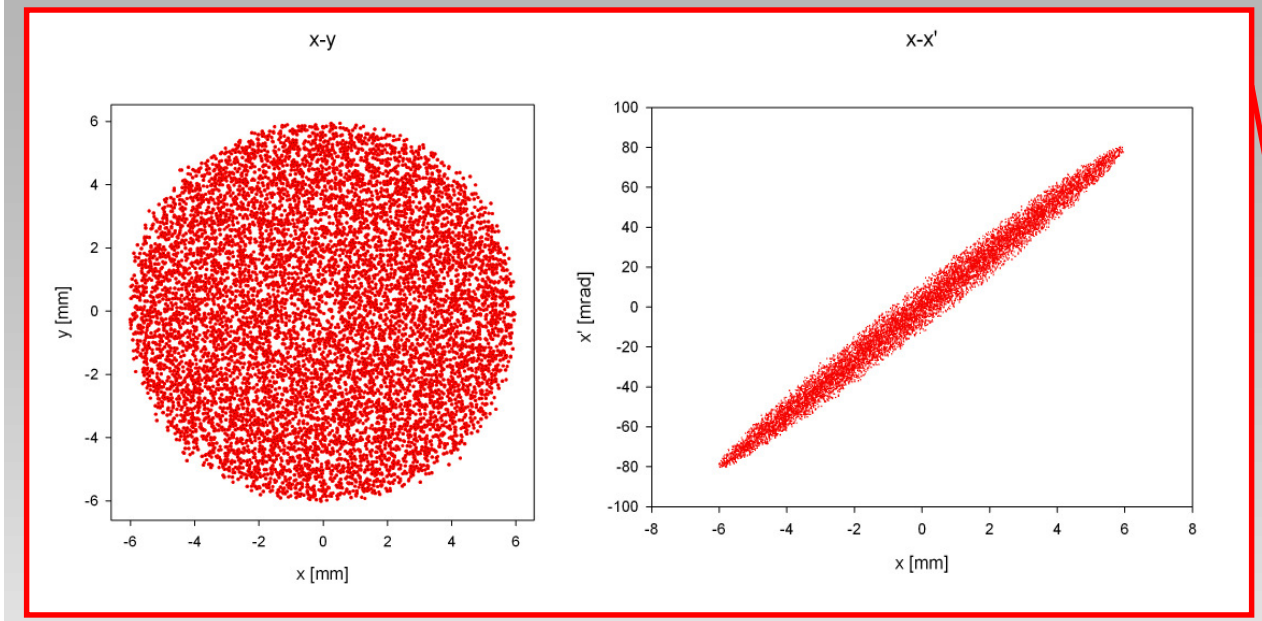


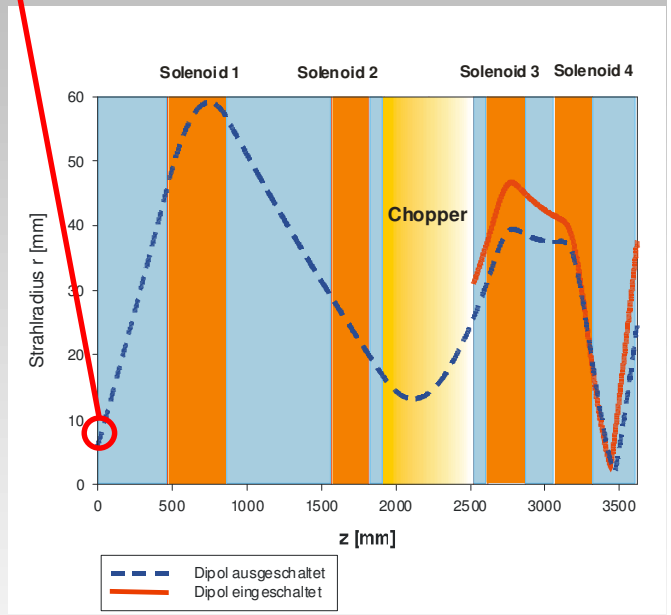

| Sektion | Funktion | von | bis | Länge | B-Feld | Max.Radius | Raumlad.komp |
|---|---|---|---|---|---|---|---|
| 1 | Drift | 0 | 470 | 470 | 0 | 75 | 0.85 |
| 2 | Solenoid 1 | 470 | 870 | 400 | Hom0245 | 75 | 0.85 |
| 3 | Drift (Diagnostik) | 870 | 1570 | 700 | 0 | 75 | 0.85 |
| 4 | Solenoid 2 | 1570 | 1820 | 250 | Sol0100 | 50 | 0.85 |
| 5 | Drift | 1820 | 1920 | 100 | 0 | 50 | 0.85 |
| 6 | Dipol (ohne Feld) | 1920 | 2220 | 300 | 0 | 25 | 0 |
| 7 | Drift bis Blende | 2220 | 2520 | 300 | 0 | 50 | 0 |
| 8 | Drift | 2520 | 2620 | 100 | 0 | 75 | 0 |
| 9 | Solenoid 3 | 2620 | 2870 | 250 | Sol0500 | 50 | 0 |
| 10 | Drift | 2870 | 3070 | 200 | 0 | 75 | 0 |
| 11 | Solenoid 4 | 3070 | 3320 | 250 | Sol0715 | 50 | 0 |
| 12 | Drift | 3320 | 3620 | 300 | 0 | 50 | 0 |

Simulation Programs used:

- „Lintrafive“ (Sek1, Sek3)
- „DipMag“ (Dipole)

# Input Distribution

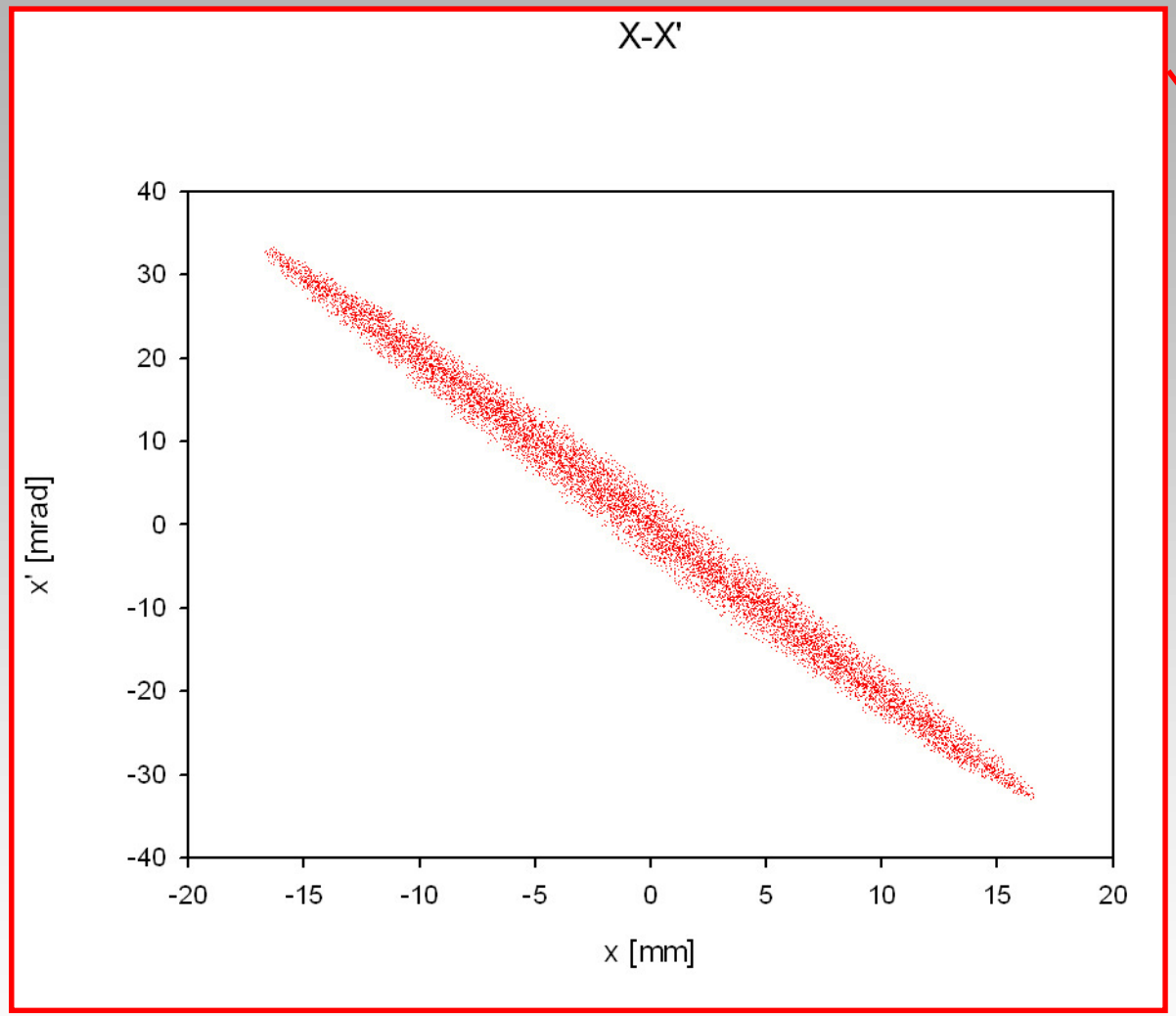


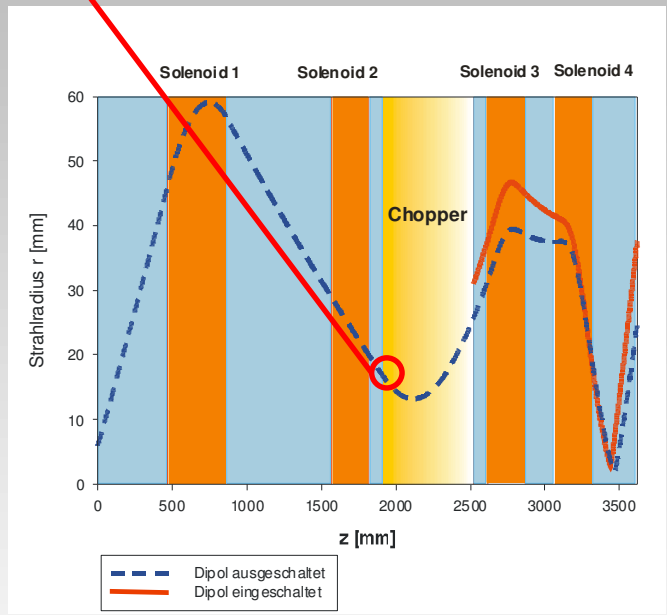




## Start Parameters Ion Source

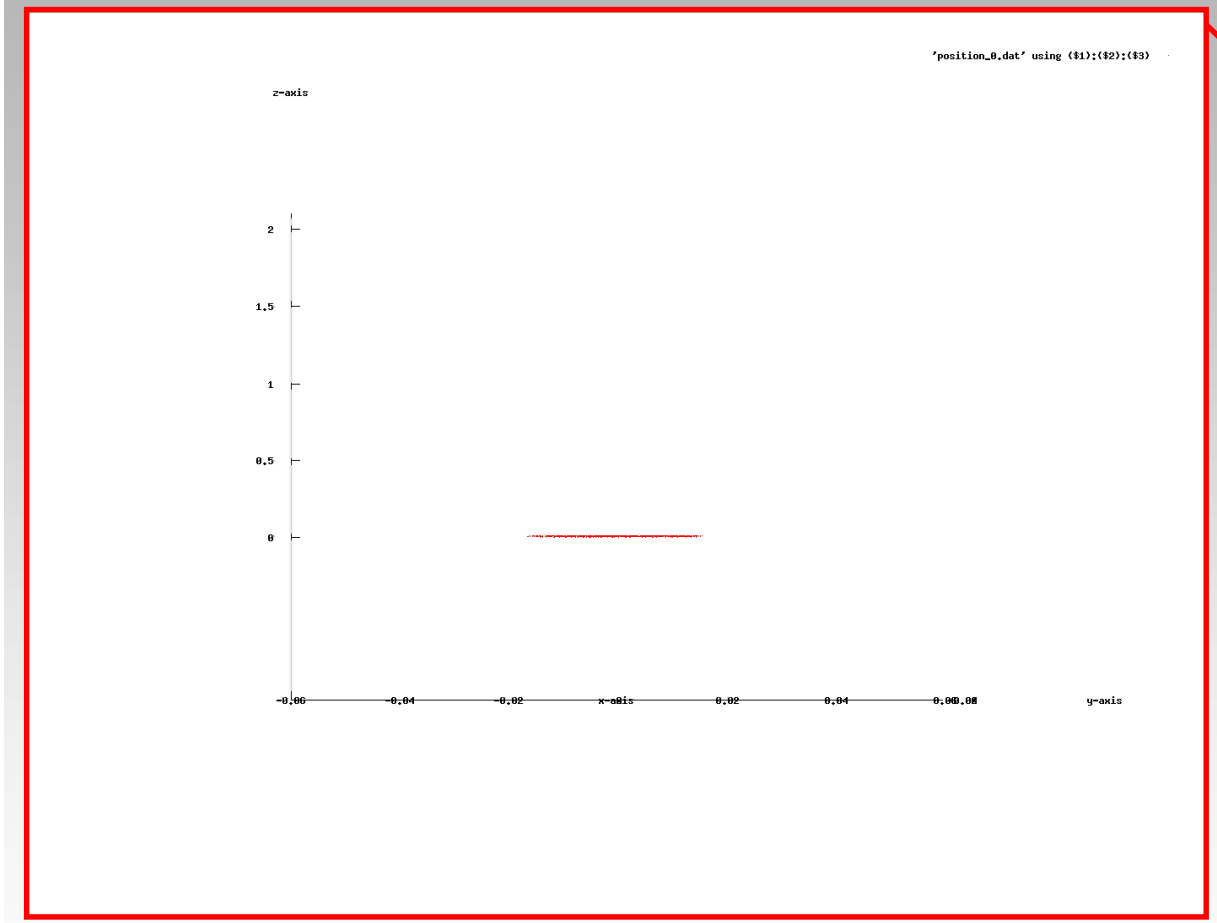
- Beam Radius: 6 mm
- Divergence Angle: 80 mrad
- Homogeneous Distribution (Assumed)

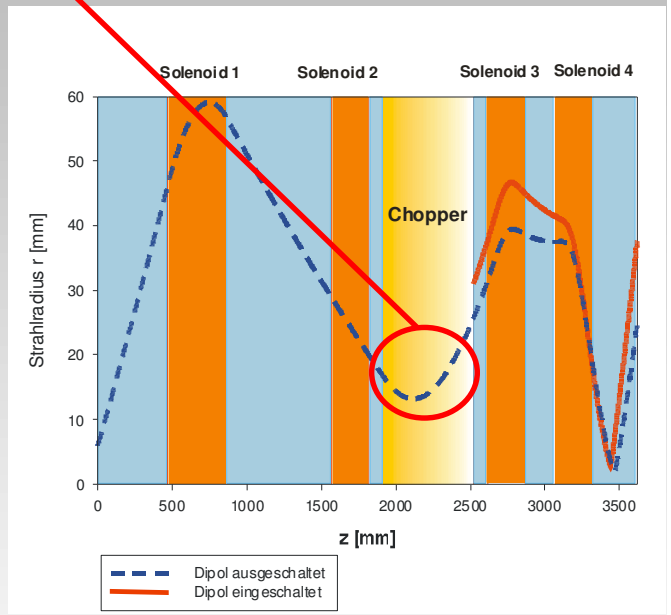
# Phase Distribution in front of Dipole



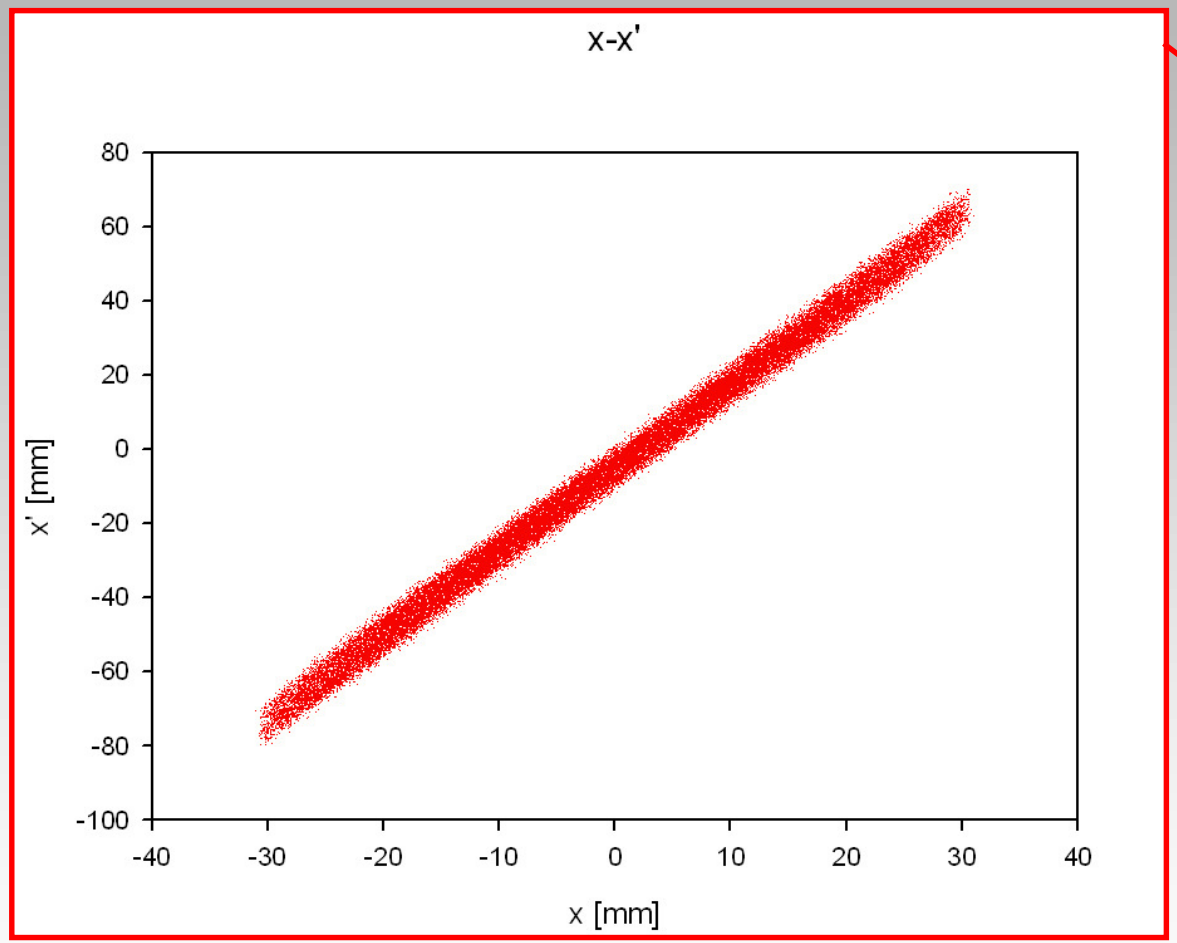



# Simulation Dipole System

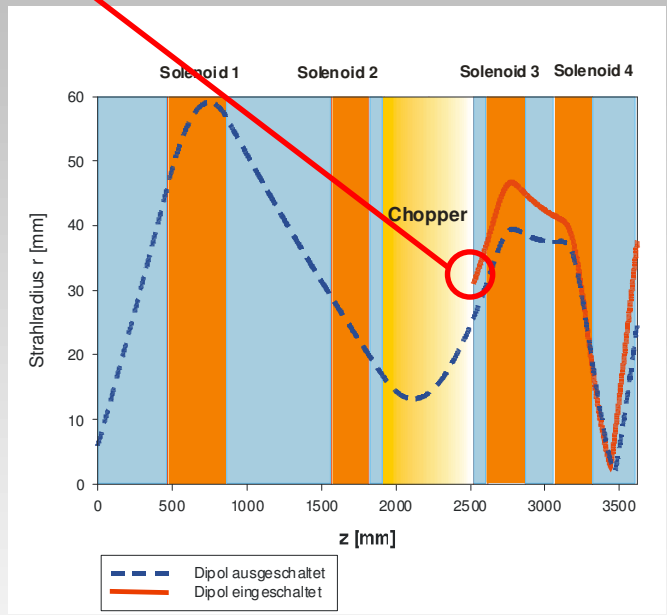


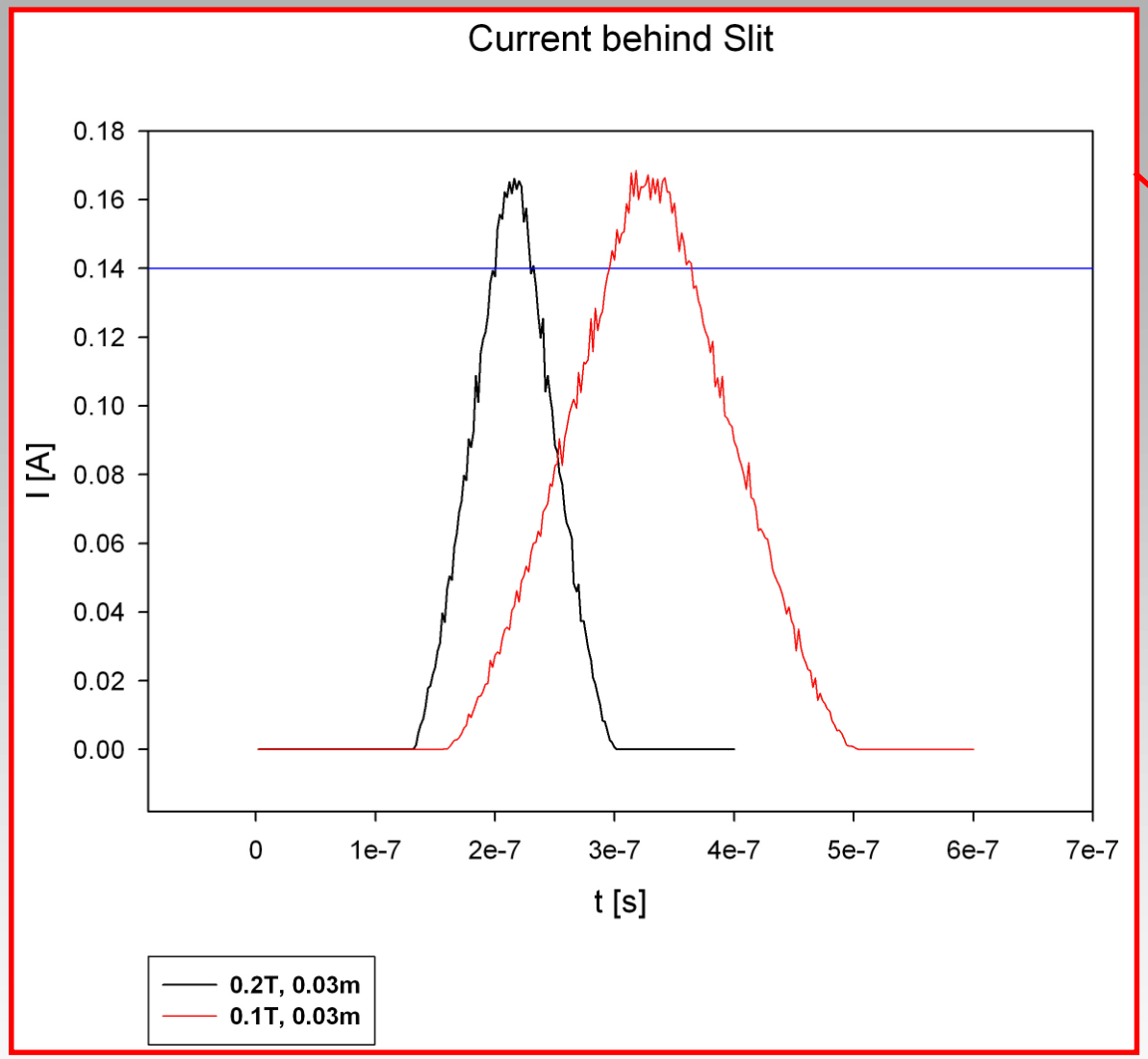



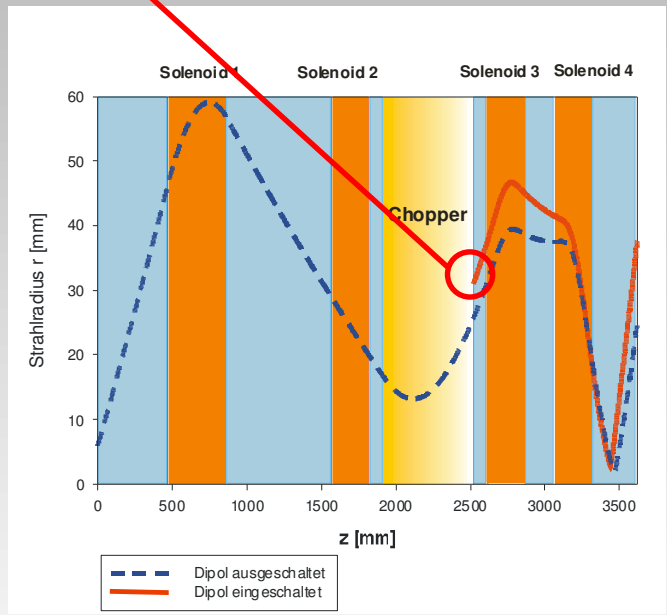
# Phase Distribution behind Slit




$B_{max}$ (Dipole)= 0.2 T

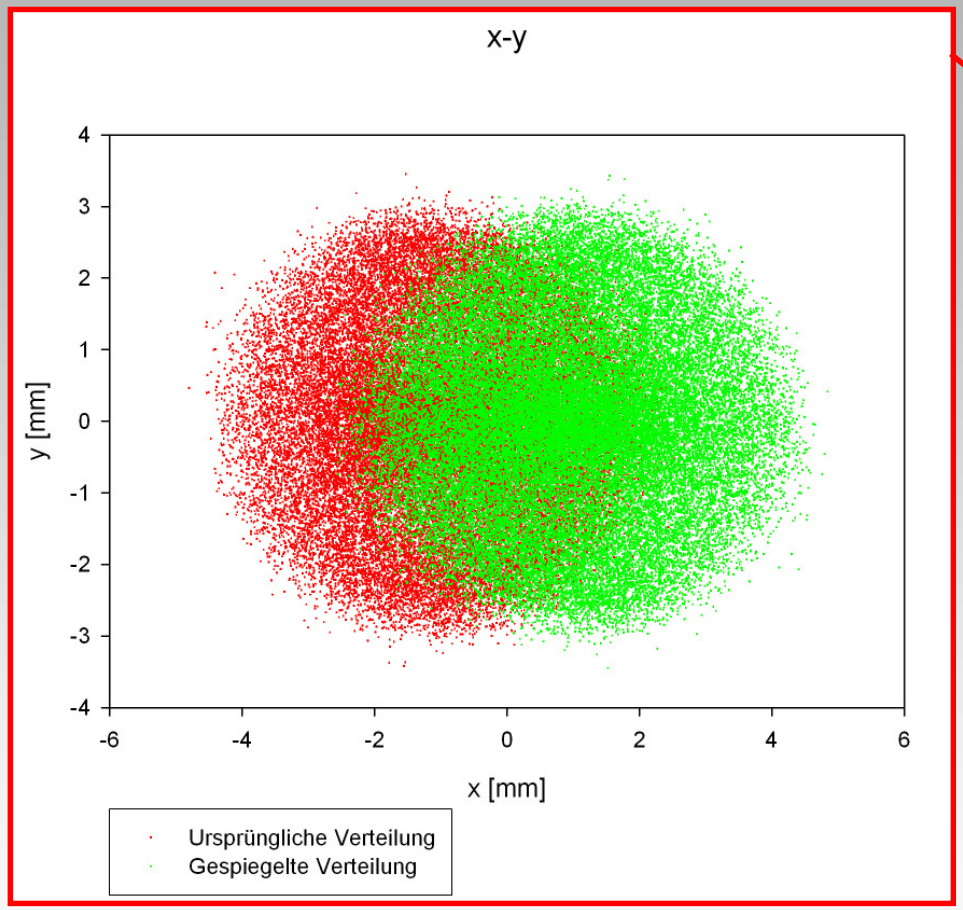


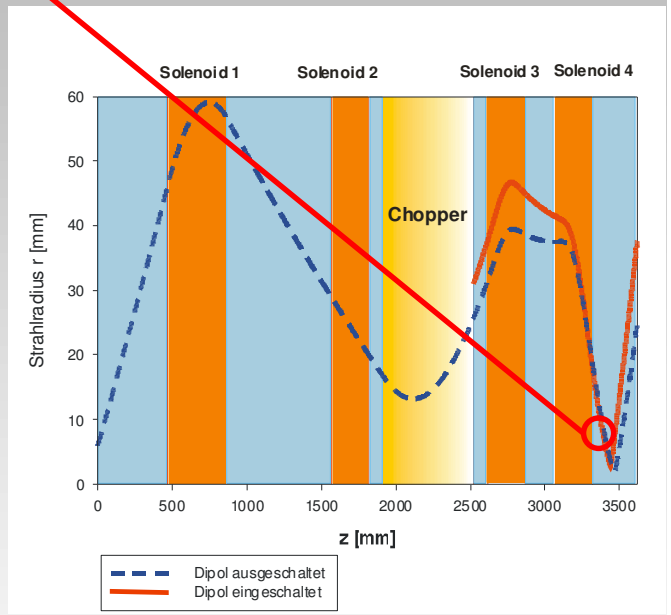

Current behind Slit
I [A]
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
1e-7
2e-7
3e-7
4e-7
5e-7
6e-7
7e-7
t [s]
0.2T, 0.03m
0.1T, 0.03m


Solenoid 1
Solenoid 2
Solenoid 3
Solenoid 4
Chopper
Strahlradius r [mm]
60
50
40
30
20
10
0
0
500
1000
1500
2000
2500
3000
3500
z [mm]
Dipol ausgeschaltet
Dipol eingeschaltet

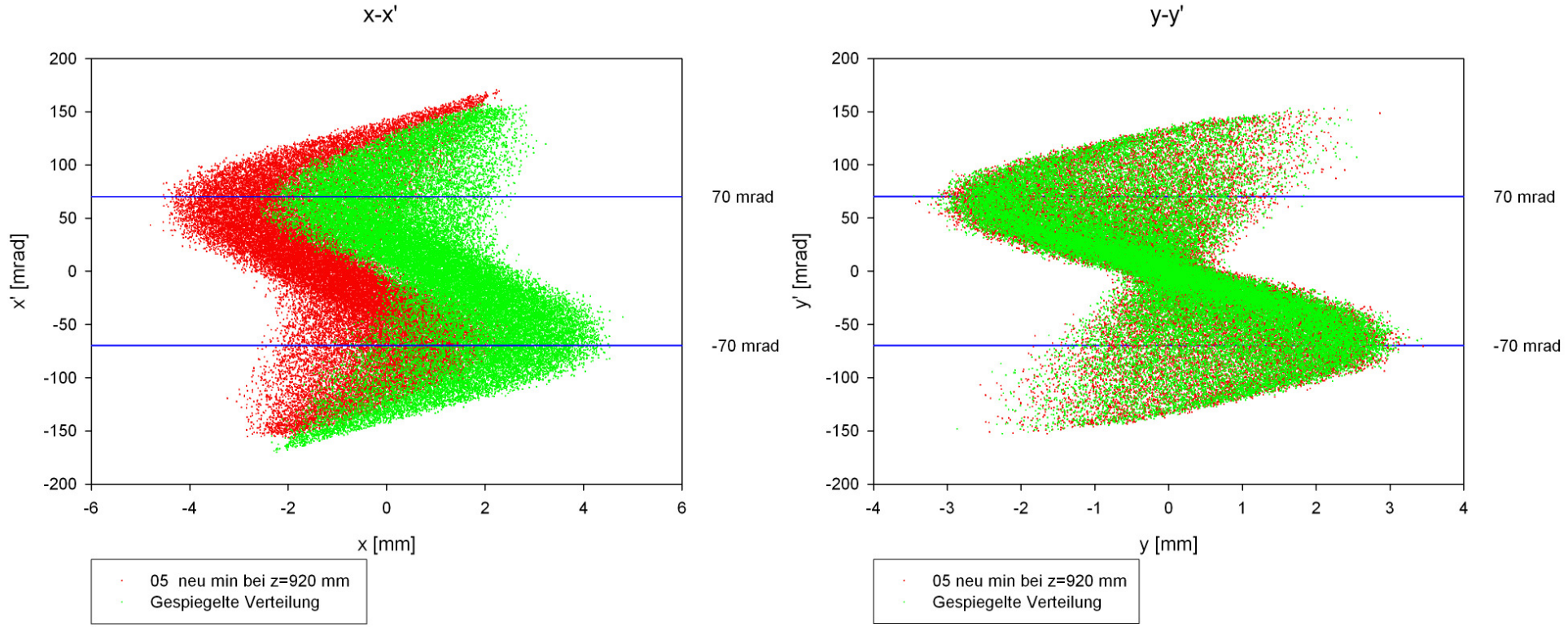
# Chopper creates different beam distribution (depending on direction of Magnetic Field).

Spatial Distribution in front of RFQ

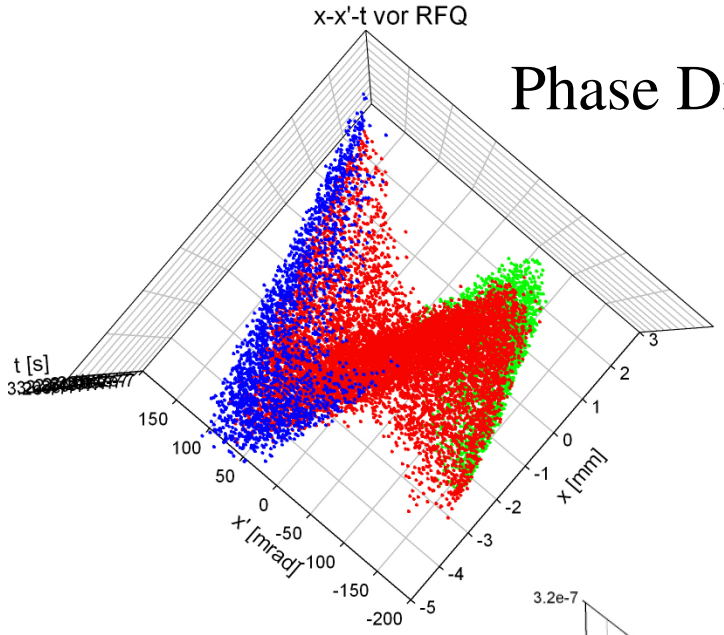


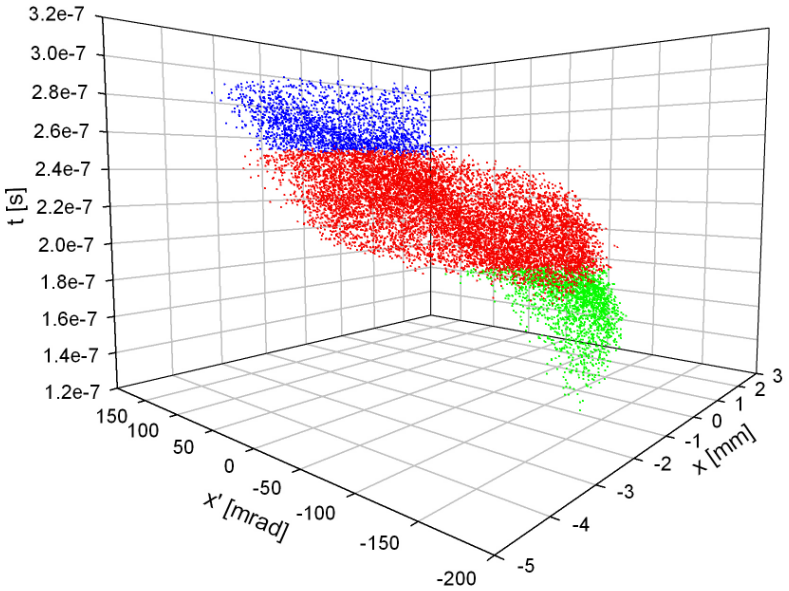



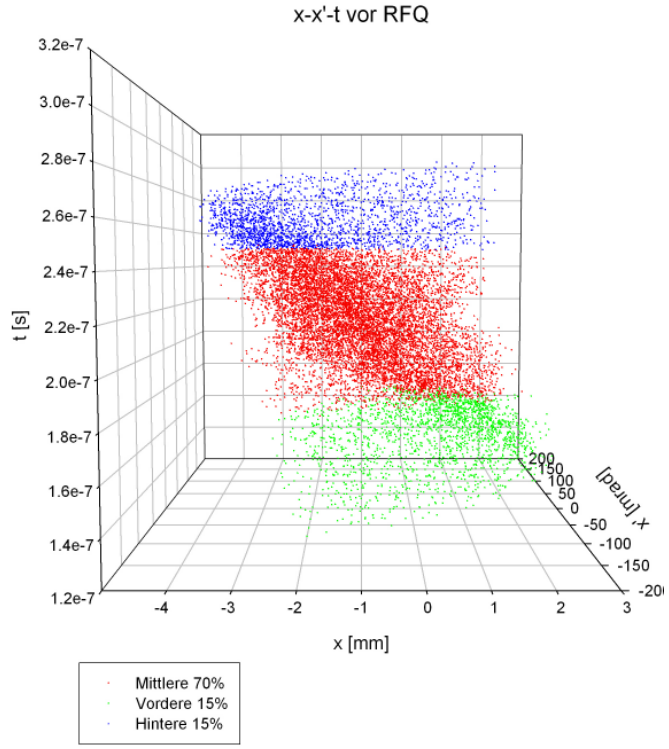
# Phase Distribution in front of RFQ

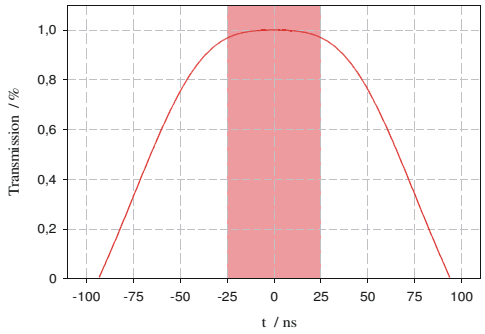


# Phase Distribution in front of RFQ - 3d



# Outlook: To Do?

## Multi-Particle Simulations

- Beam Dynamics in LEBT – Variation of Parameters
- Beam Dynamics in Chopper – Variation of Parameters
- Emittance Growth Estimations
- Simulations for $H_2^+$ and $H_3^+$

## Layout

- Fix Geometry of Chopper
- Begin Construction Vacuum Chamber

## Technical Implementation

- Choose Type of Dipole
- Choose Magnetic Material
- Design Electronic Control