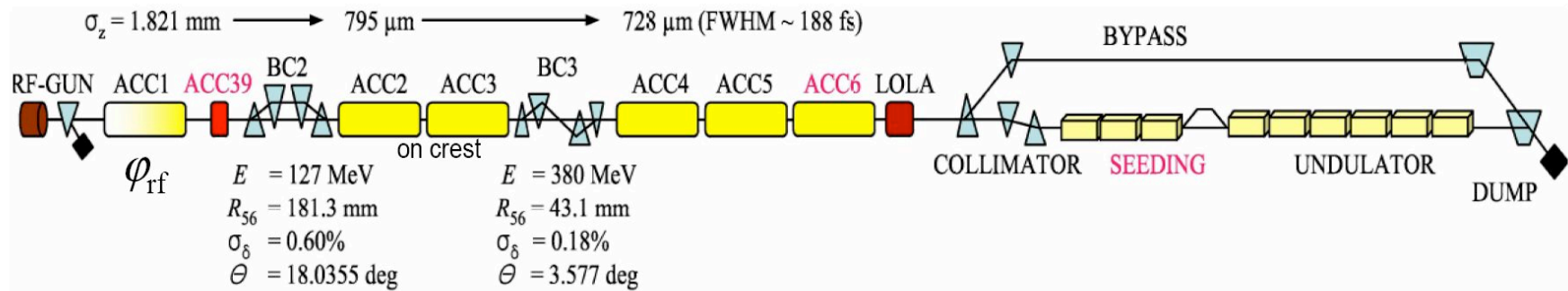


S2E Calculations for the VUV-FEL

T. Limberg

TTF-II / VUV-FEL



TTF2-S2E Method

ASTRA-Generator	→	GAUSS200000_Q1P0nCXYrms0P75mm4p4ps.ini
ASTRA	→	TTF2_09APR05_ACC1m9deg_200K.1350.001
mcad: "00_astra_to_bc1_in"	→	before_bc1_9deg.fmt1
CSRtrack	→	end_10000.fmt3
mcad: "05_fmt3_to_astra"	→	x_9deg.ini
ASTRA /linear	→	x_9deg.out
mcad: "06_astra_to_bc2_in"	→	before_bc2_9deg.fmt1
CSRtrack	→	end_10000.fmt3
mcad: "07_fmt3_to_astra"	→	y_9deg.ini
ASTRA /linear	→	y_9deg.out

mcad: add wakes
GENESIS

3 particle formats
(serial) ASTRA runs ~ 0.5 d + 0.5d +0.75d
(1d) CSRtrack ~ 1h + 2h

CSRtrack

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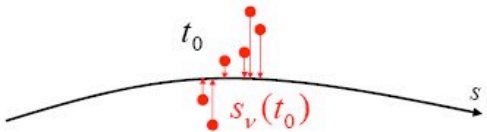
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Projected Method

(1d approach)

$$\dot{\mathbf{p}}_v = q(\mathbf{e}_{v\parallel} E^{(\lambda)}(s_v, t) + \mathbf{v}_v \times \mathbf{B}^{(\text{ext})})$$

no transverse self-forces



rigid 1d charge distribution:

$$\lambda^{(\delta)}(s - t_0 c) = \sum q_v \delta((s - t_0 c) - (s_v - s))$$
$$\lambda(s - t_0 c) = \lambda^{(\delta)}(s - t_0 c) \otimes (g(s/\sigma)/\sigma)$$

1d E-field without γ^{-2} singularity:

$$E^{(\lambda)}(s, t_0) = \int \lambda'(u + s - ct_0) K(s, u) du$$

no transverse dependency of longitudinal forces

very low numerical effort

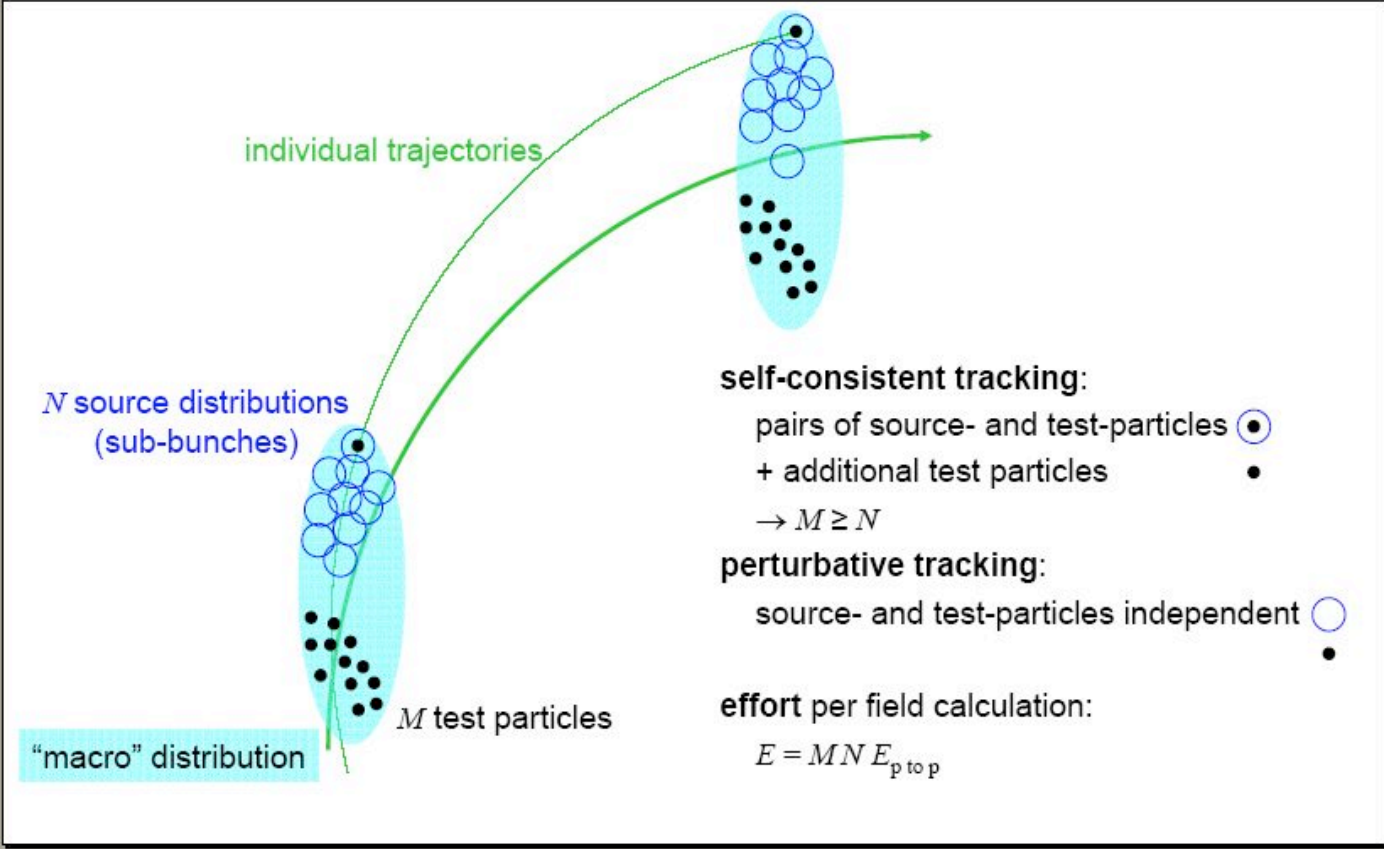
see: Saldin, Schneidmiller, Yurkov: NIM A398 (1997) 373-394
Dohlus: TESLA-FEL-2003-05

10,81 x 7,47 in

2 of 16

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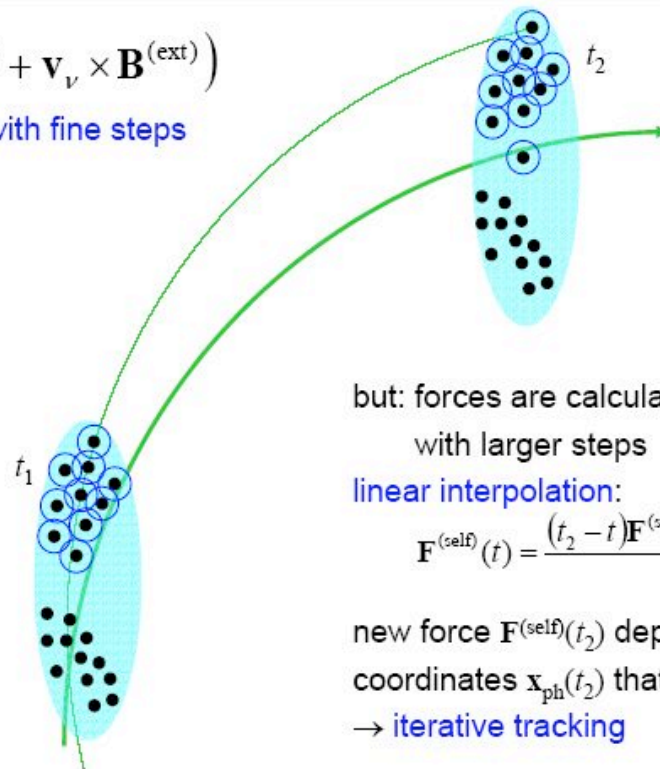
Sub-Bunch Approach



Iterative Tracking

$$\dot{\mathbf{p}}_v = q(\mathbf{F}_v^{(\text{self})} + \mathbf{v}_v \times \mathbf{B}^{(\text{ext})})$$

integration with fine steps



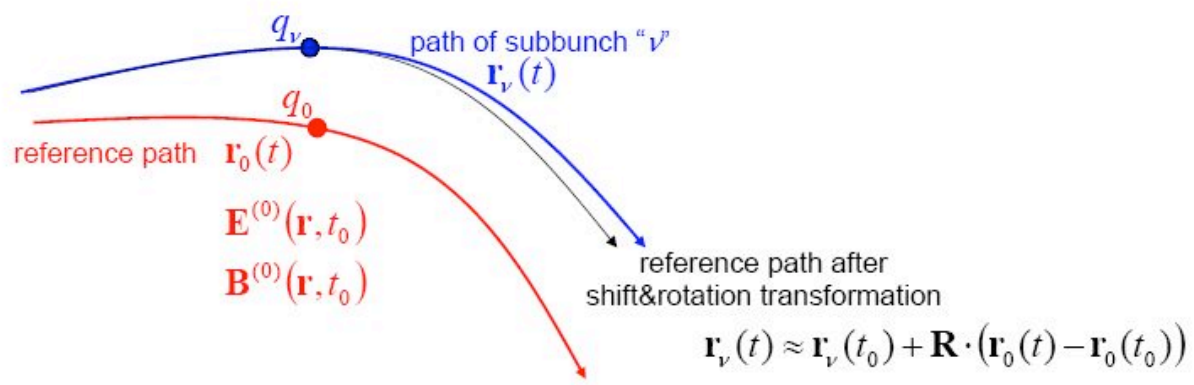
but: forces are calculated on time mesh
with larger steps $\mathbf{F}^{(\text{self})}(t_1), \mathbf{F}^{(\text{self})}(t_2), \dots$

linear interpolation:

$$\mathbf{F}^{(\text{self})}(t) = \frac{(t_2 - t)\mathbf{F}^{(\text{self})}(t_1) + (t - t_1)\mathbf{F}^{(\text{self})}(t_2)}{t_2 - t_1}$$

new force $\mathbf{F}^{(\text{self})}(t_2)$ depends on new phase space
coordinates $\mathbf{x}_{\text{ph}}(t_2)$ that depend on $\mathbf{F}^{(\text{self})}(t_2)$
→ iterative tracking

Pseudo Green's Function Approach



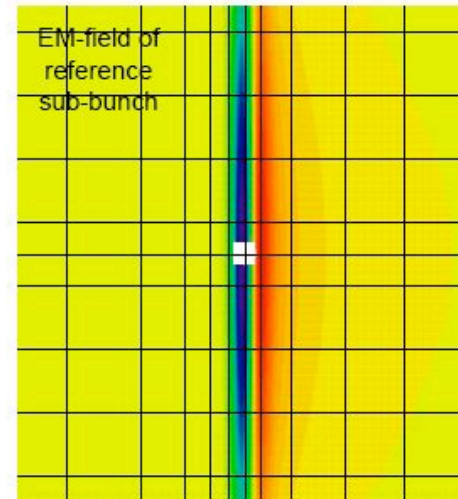
$$\mathbf{E}^{(v)}(\mathbf{r}, t_0) \approx \frac{q_v}{q_0} \mathbf{R} \cdot \mathbf{E}^{(0)}(\mathbf{r}_0(t_0) + \mathbf{R}^{-1}(\mathbf{r} - \mathbf{r}_v(t_0)), t_0)$$

$$\mathbf{B}^{(v)}(\mathbf{r}, t_0) \approx \frac{q_v}{q_0} \mathbf{R} \cdot \mathbf{B}^{(0)}(\mathbf{r}_0(t_0) + \mathbf{R}^{-1}(\mathbf{r} - \mathbf{r}_v(t_0)), t_0)$$

the "Green's functions" are calculated numerically on a 2d-mesh with M_g points

$$\mathbf{E}^{(0)} = E_x^{(0,t_0)}(x, y)\mathbf{u}_x + E_y^{(0,t_0)}(x, y)\mathbf{u}_y$$

$$\mathbf{B}^{(0)} = B_z^{(0,t_0)}(x, y)\mathbf{u}_z$$



effort per field calculation:

$$E_{f.c.} = M_g E_{p \text{ to } p} + N M E_{i,g}$$

$E_{p \text{ to } p}$ = effort per point to point interaction

$E_{i,g}$ = effort for interpolation on grid $\ll E_{p \text{ to } p}$

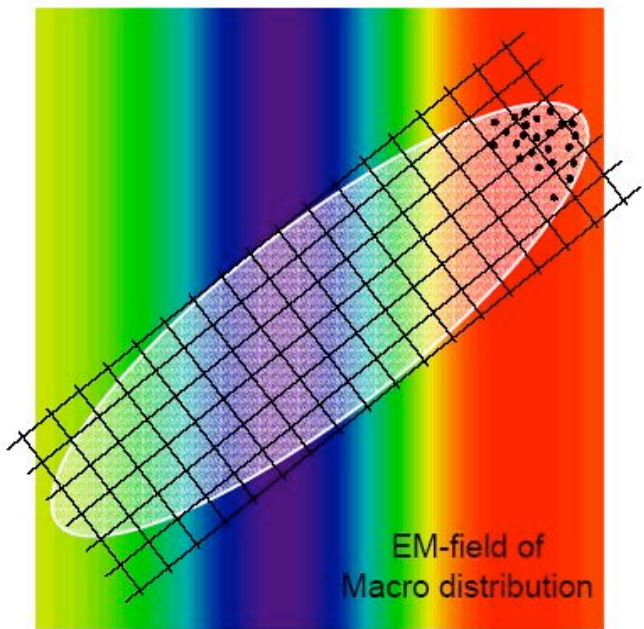
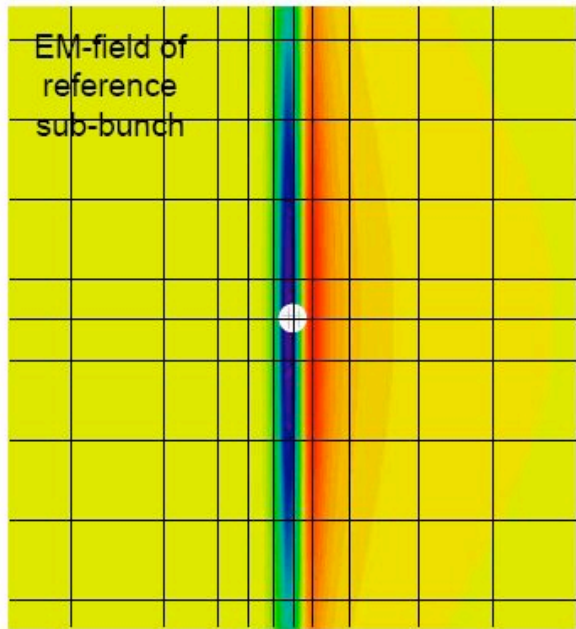
N = number of source distributions

M = number of test particles ($> N$)

Meshed EM Fields + Pseudo Green's ...

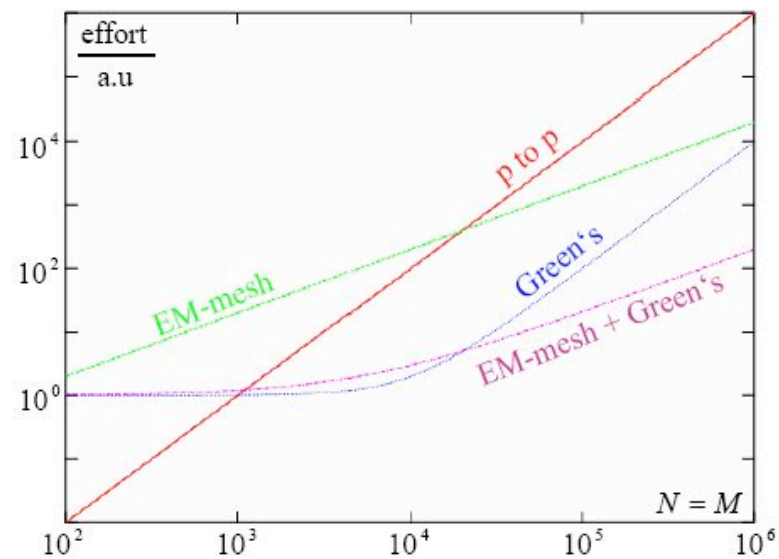
not now in CSRtrack

$$\text{effort: } E_{f.c.} = M_g E_{p \text{ to } p} + M_{em} N E_{i.g} + M E_{i.em}$$



Scaling of Effort

(simplified)



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LINUX cluster, MPI

windows XP

MATLAB pre-processor

CSRTrack

MATLAB post-processor

10,81 x 7,47 in

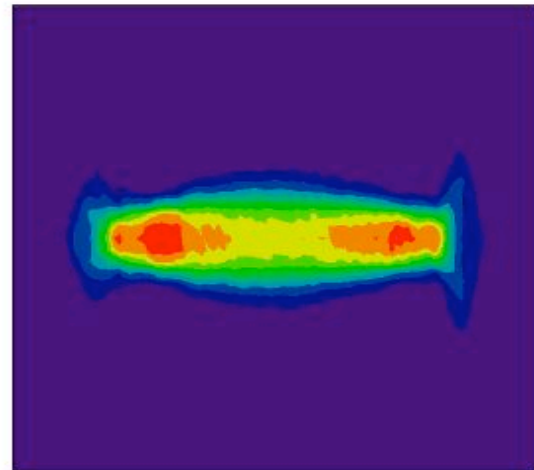
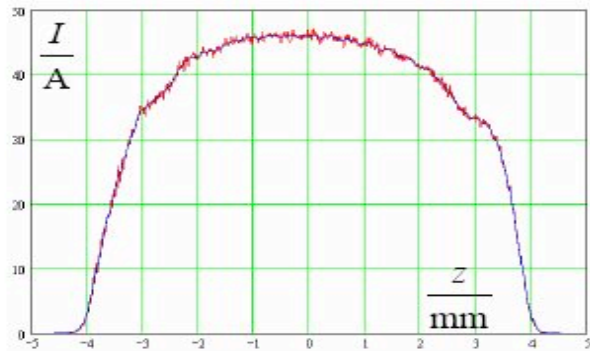
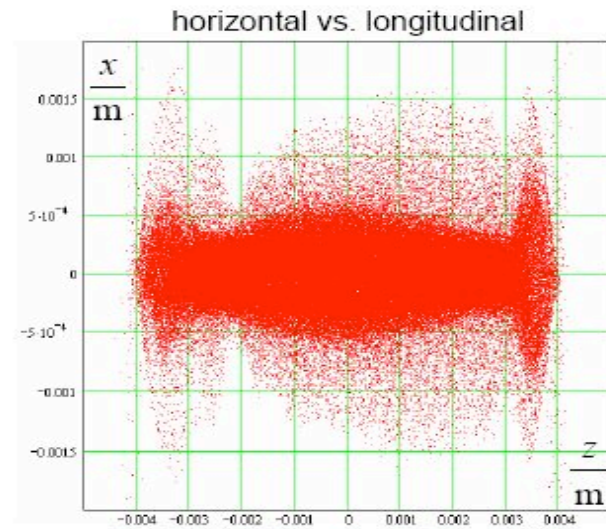
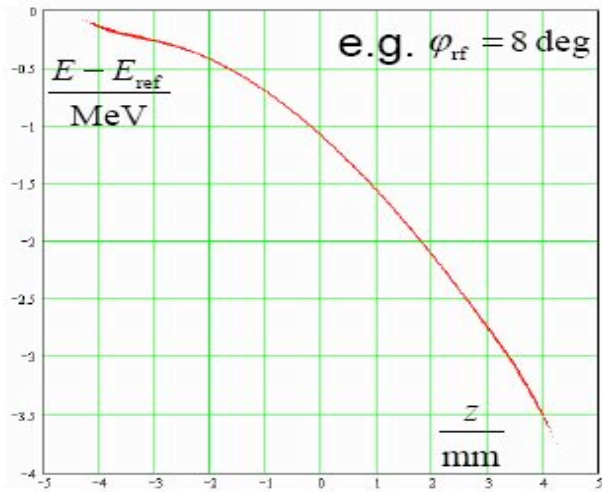
12 of 16

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# of particles	calc. steps	Method	CPU	Running time
10000	~200	Point to point	20x1GHz	~ 10 d
10000	~200	Greens funct.	1x1GHz	~0.5 d
41000	~200	Greens funct.	20x1GHz	~0.5 d

Table 1: *CPU time consumption of CSRtrack runs for TTF2 and XFEL magnet chicanes*

particles at entrance of BC1

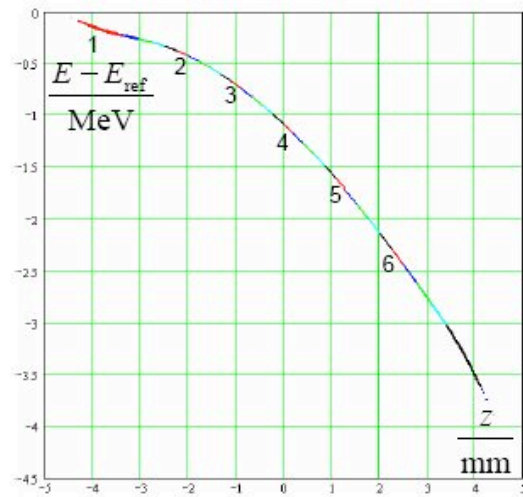


2. no CSR

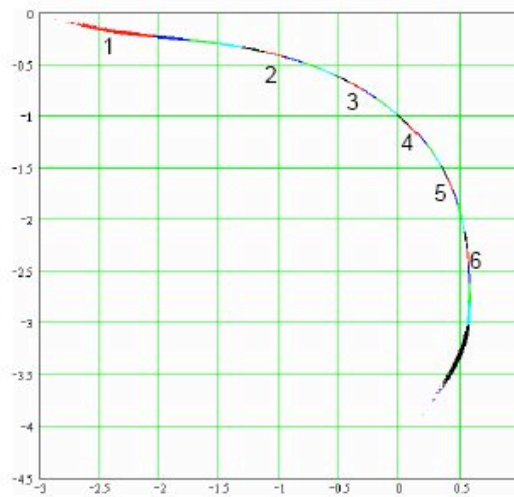
optics = option 1

$\varphi_{rf} = 8 \text{ deg}$

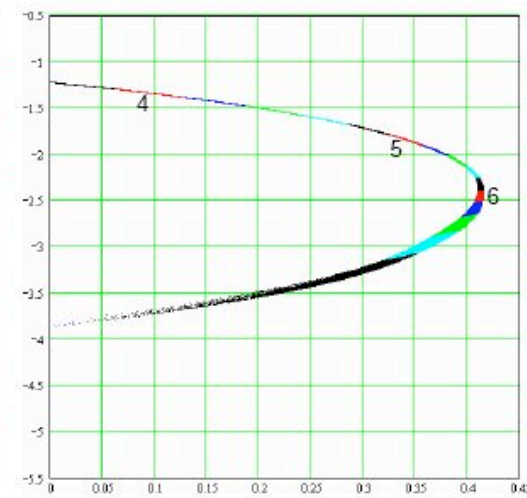
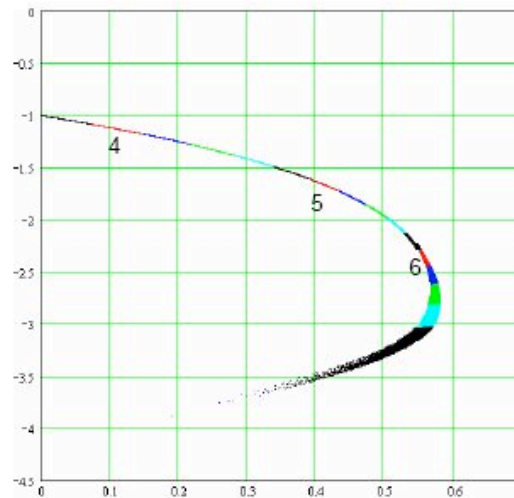
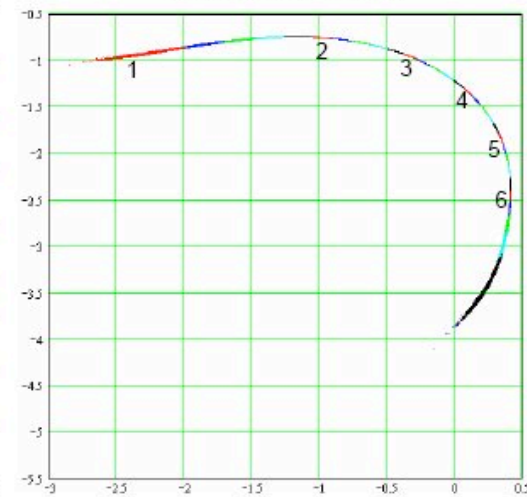
before BC2



1m after BC2



1m after BC3



no CSR

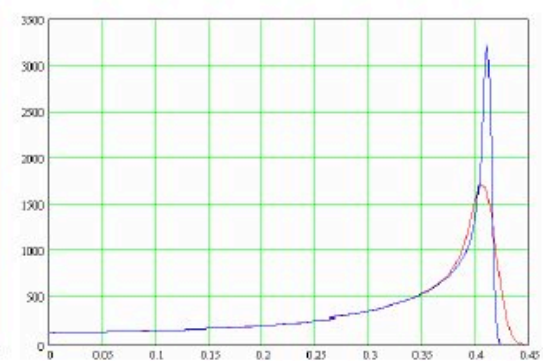
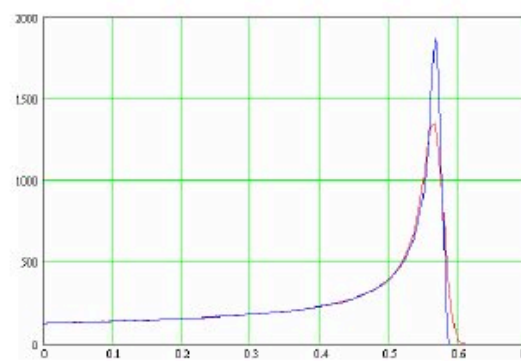
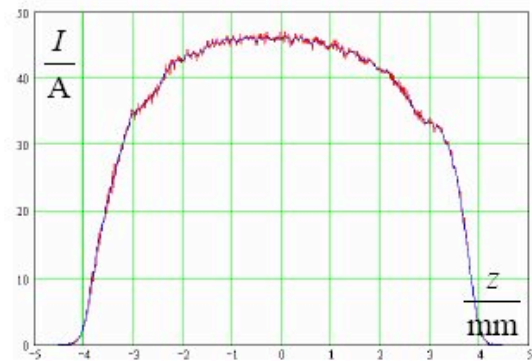
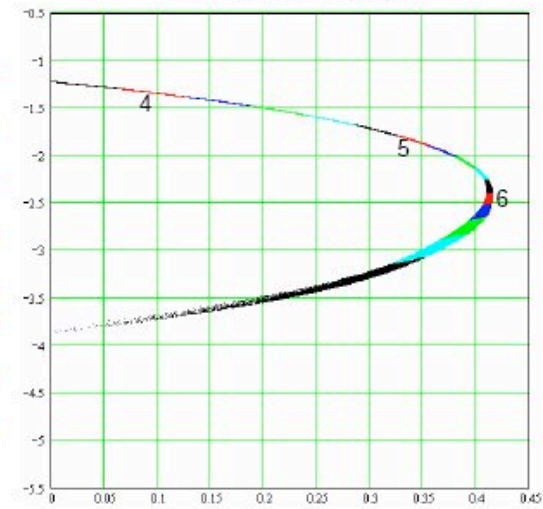
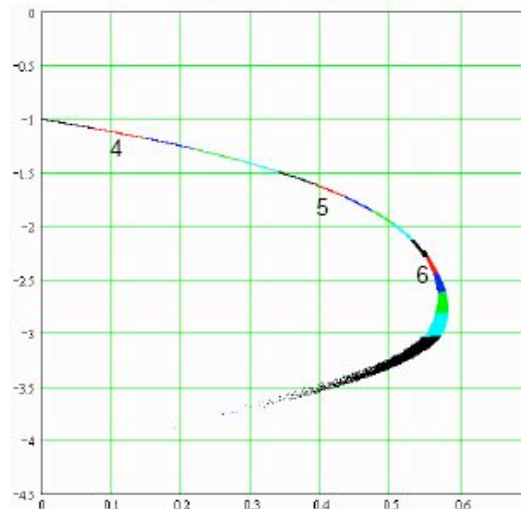
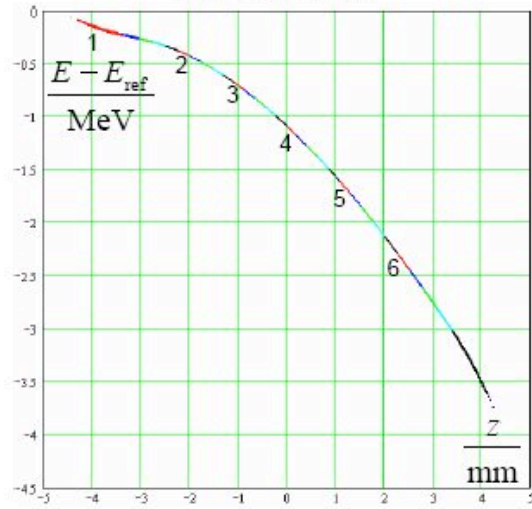
optics = option 1

$\varphi_{rf} = 8 \text{ deg}$

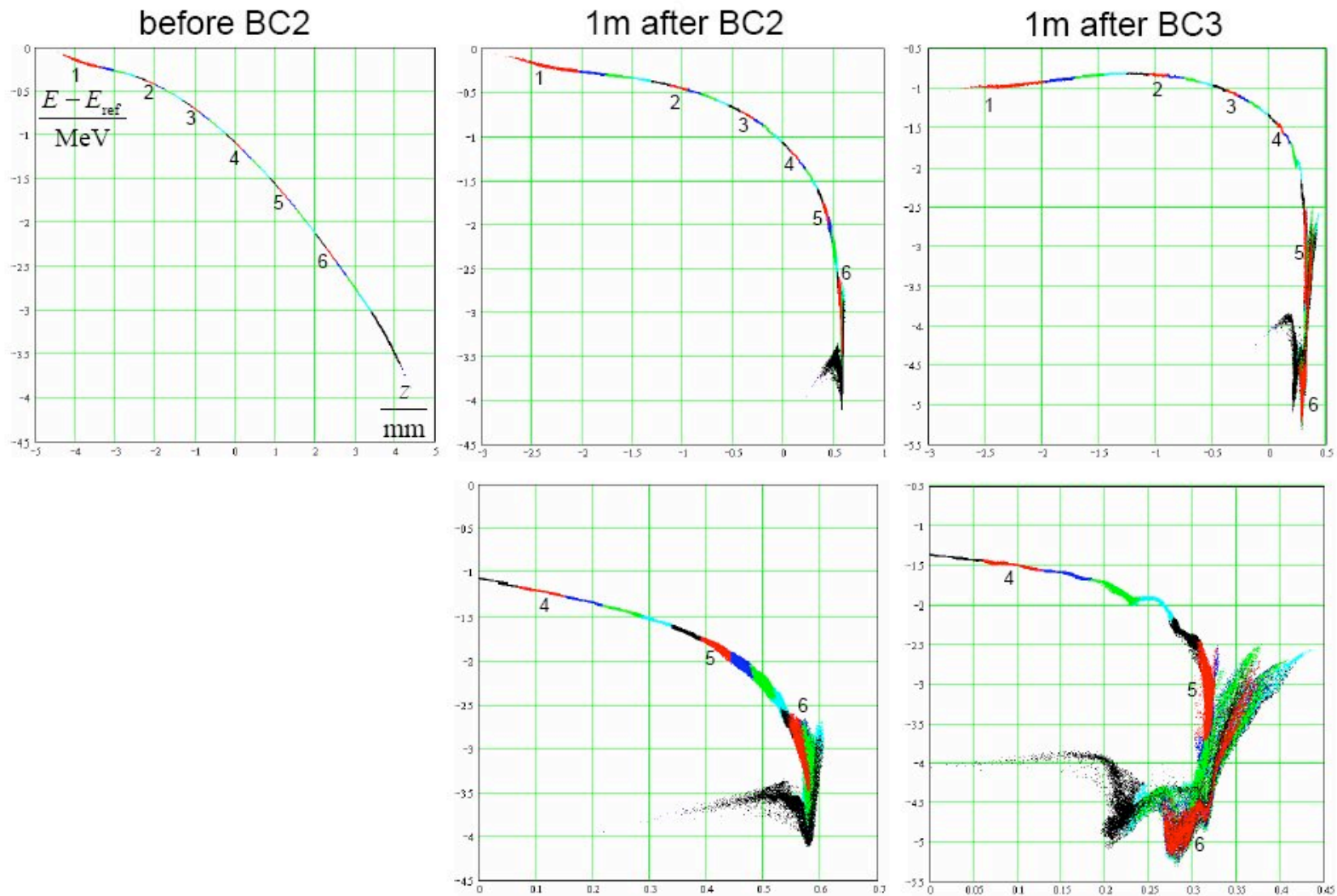
before BC2

1m after BC2

1m after BC3



3. CSR “projected” optics = option 1 $\varphi_{rf} = 8 \text{ deg}$



CSR "projected"

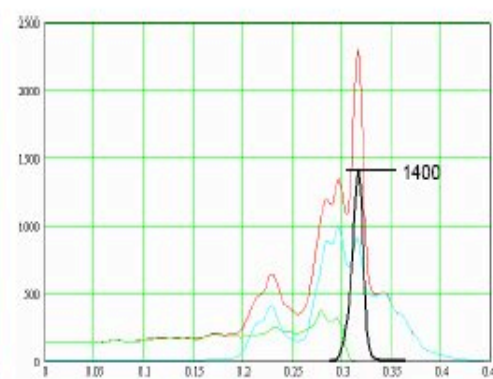
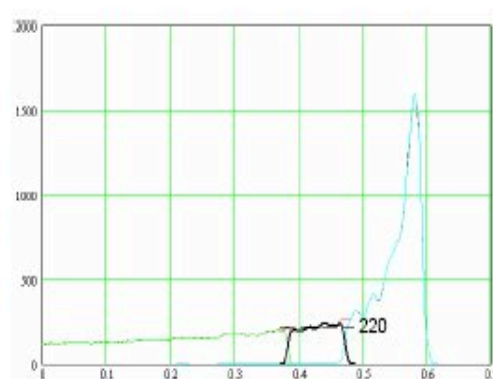
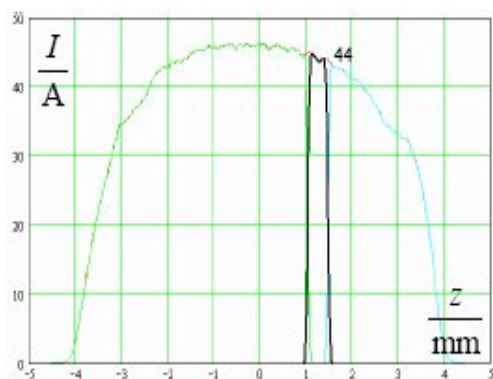
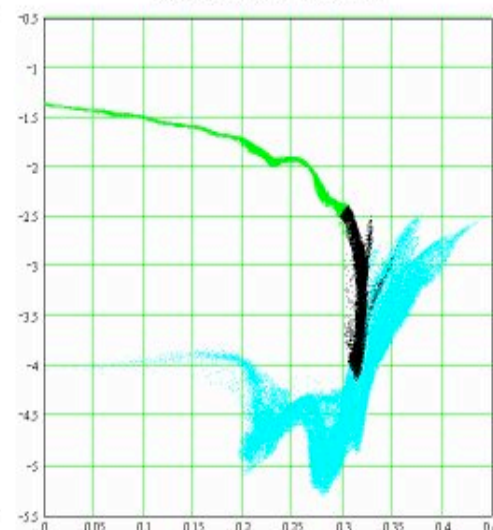
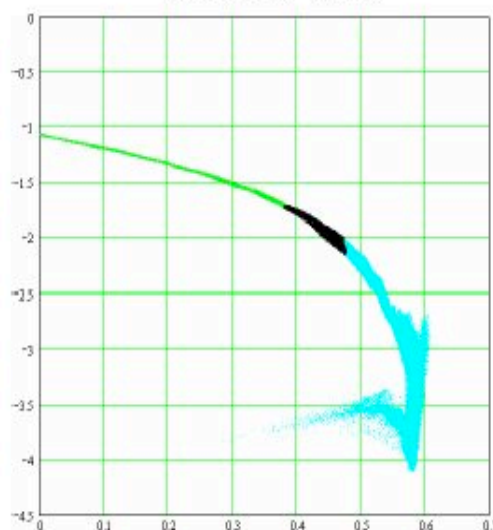
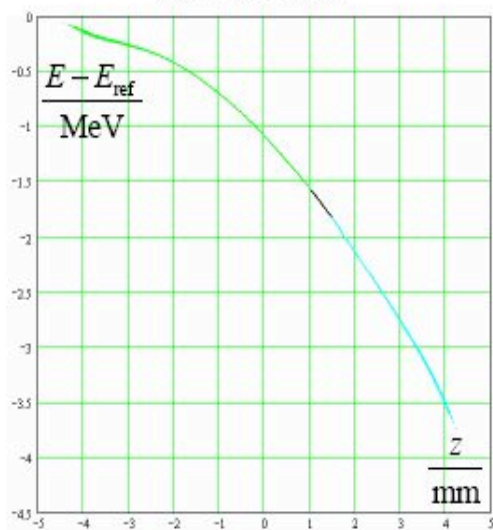
optics = option 1

$\phi_{rf} = 8 \text{ deg}$

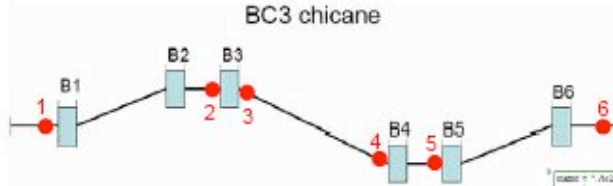
before BC2

1m after BC2

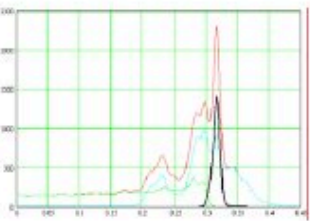
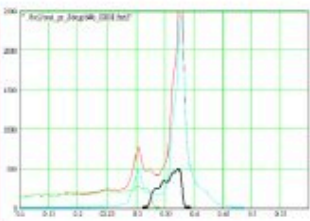
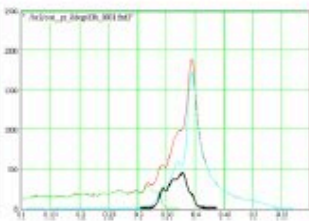
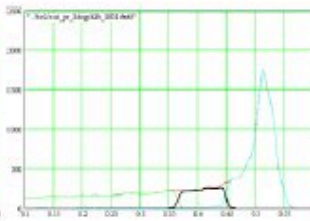
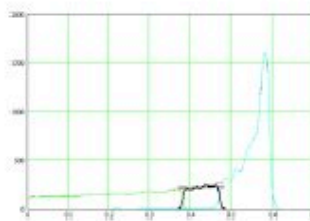
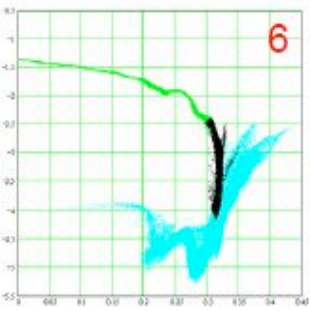
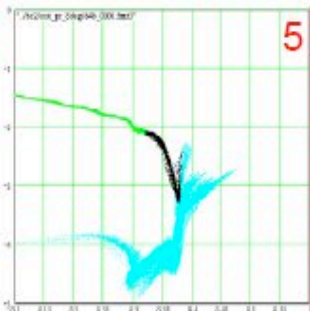
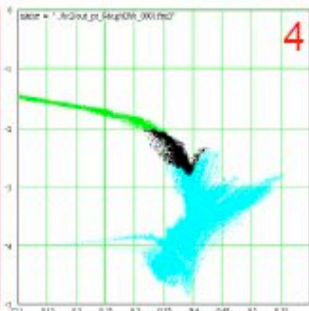
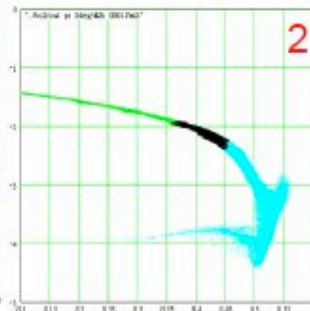
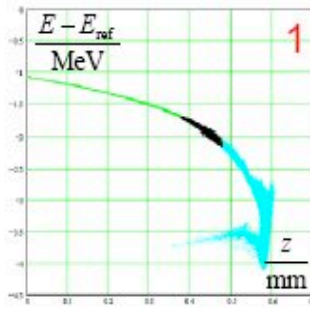
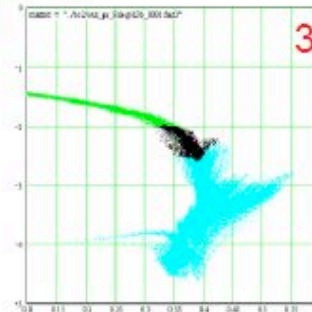
1m after BC3



long. phase space in BC3



optics = option 1
 $\varphi_{rf} = 8 \text{ deg}$

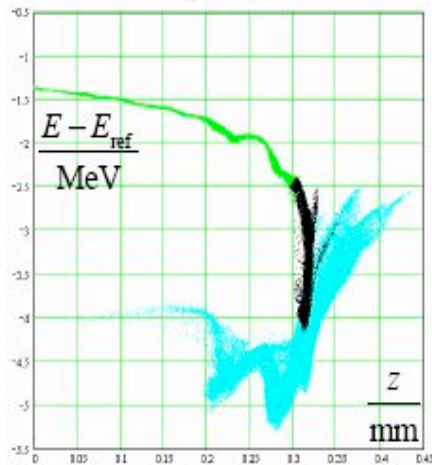


CSR "projected"

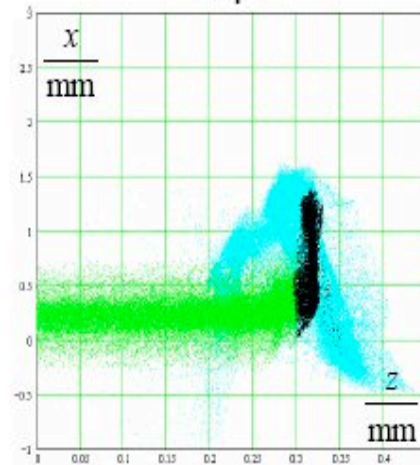
optics = option 1

$\phi_{rf} = 8 \text{ deg}$

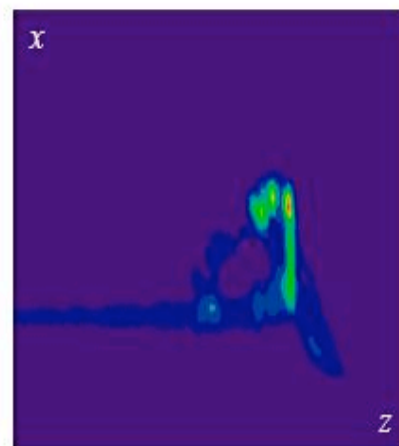
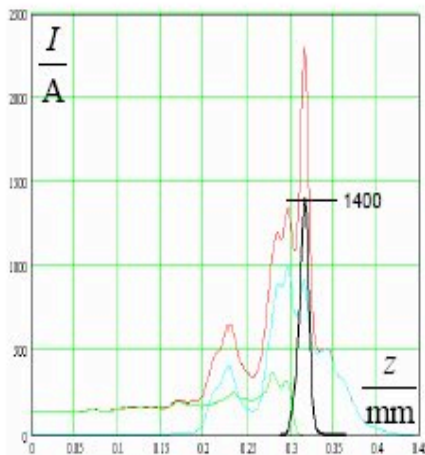
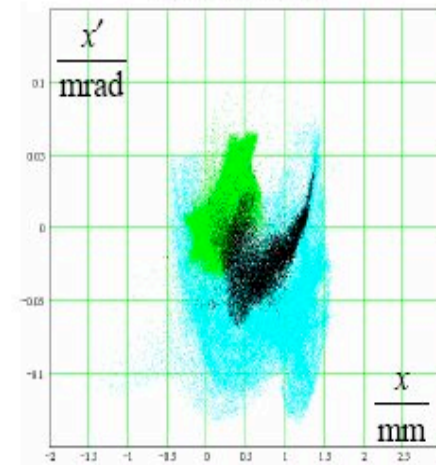
longitudinal



"top"



horizontal



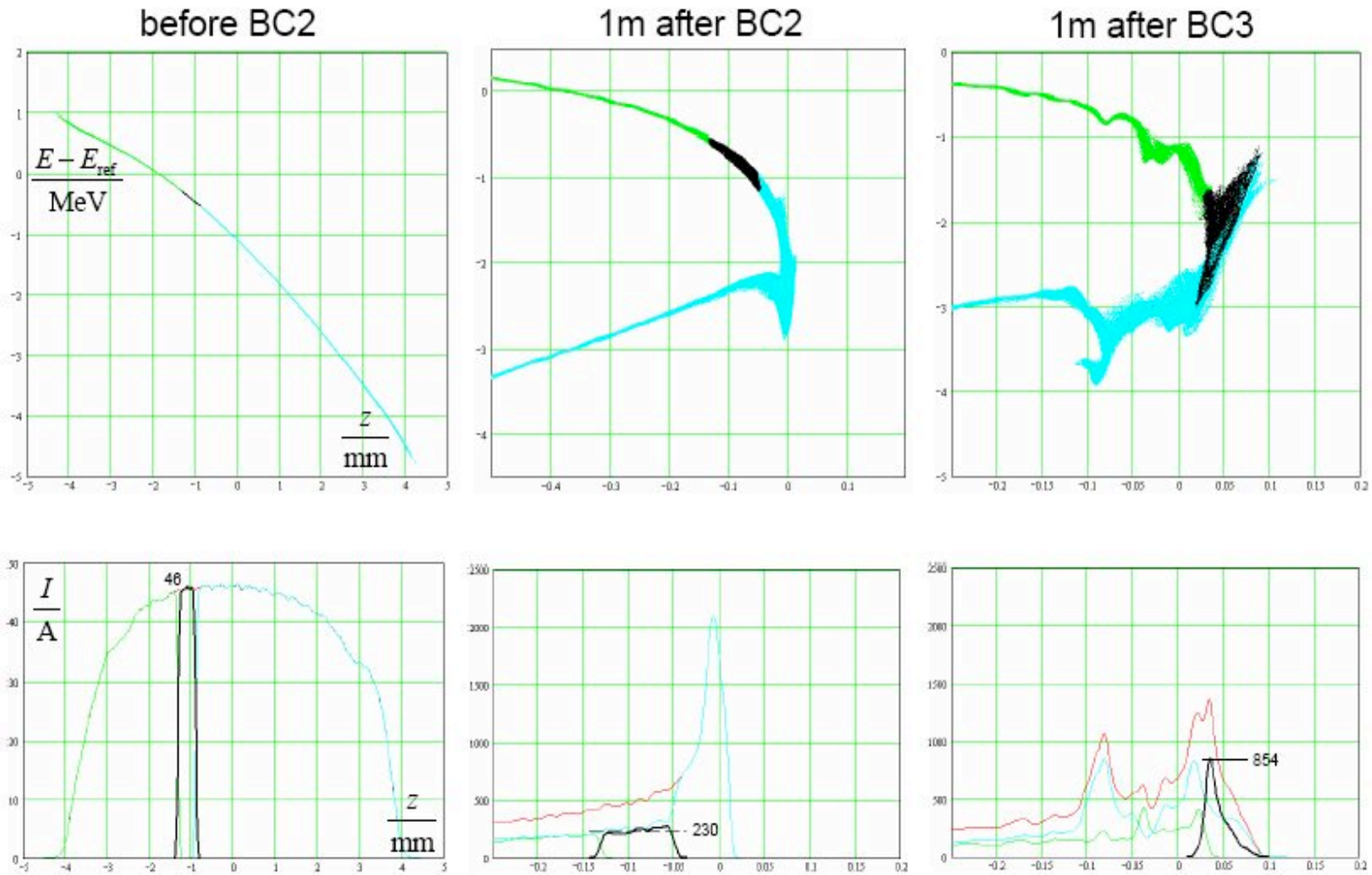
all particles:

emittance/ μm = 10.1
rms-length/ μm = 722
rms-energy spread/ keV = 1450

"black" particles:

emittance/ μm = 4.13
rms-length/ μm = 5.6
rms-energy spread/ keV = 476

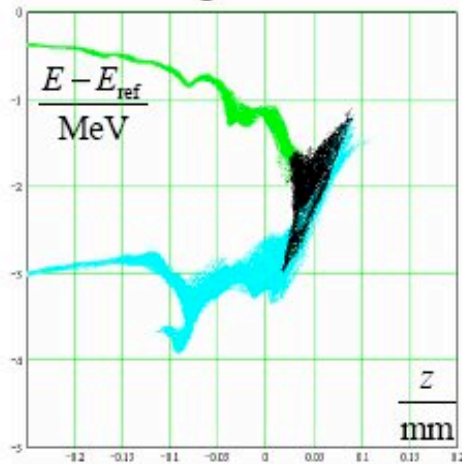
4. CSR “projected” optics = option 1 $\varphi_{rf} = 12$ deg



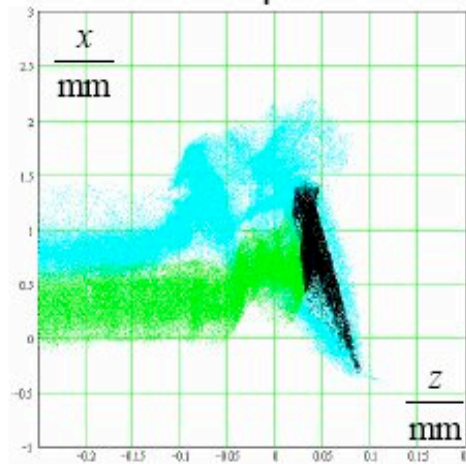
CSR "projected" optics = option 1

$\phi_{ff} = 12 \text{ deg}$

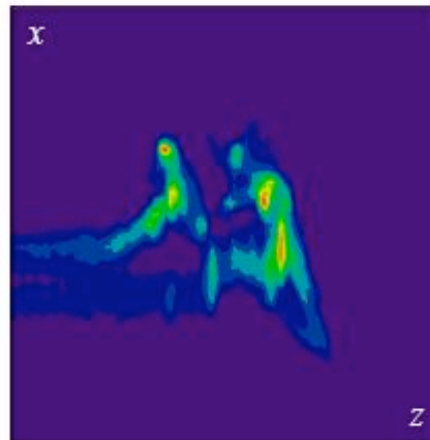
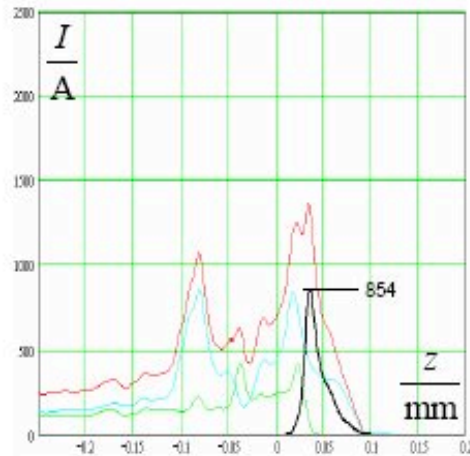
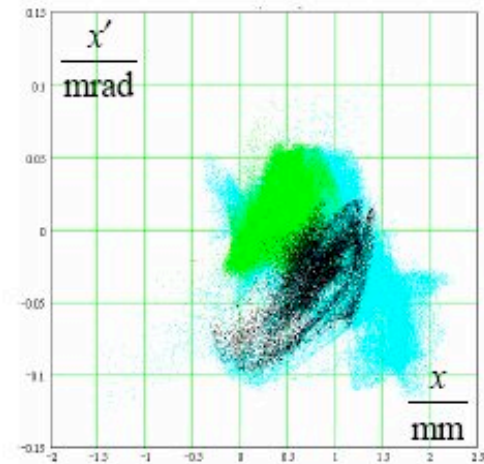
longitudinal



"top"



horizontal



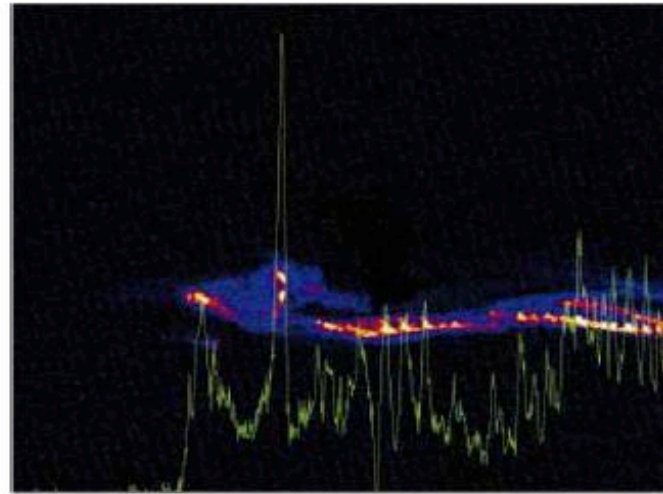
all particles:

emittance/ μm = 10.55
 rms-length/ μm = 339
 rms-energy spread/ keV = 1380

"black" particles:

emittance/ μm = 4.56
 rms-length/ μm = 13.0
 rms-energy spread/ keV = 324

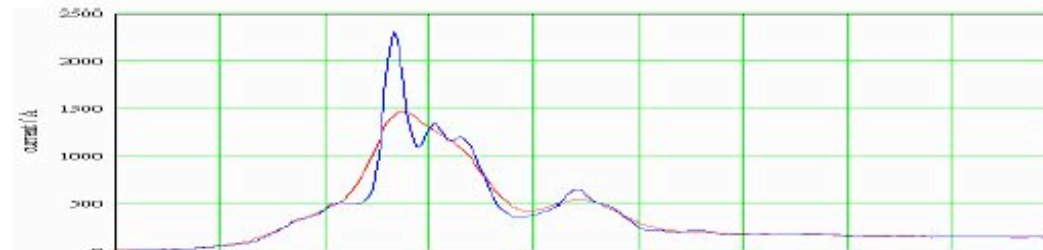
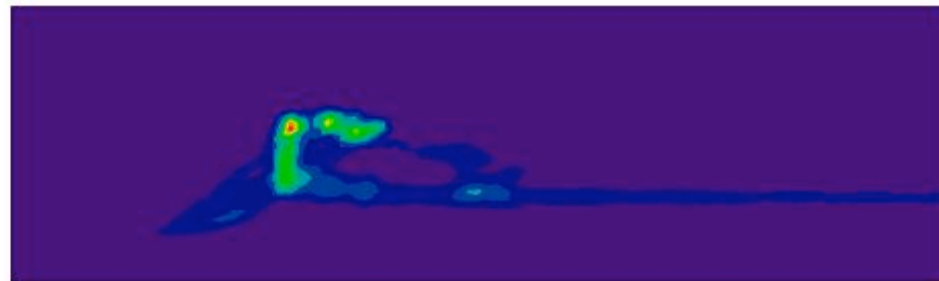
6. some LOLA pictures

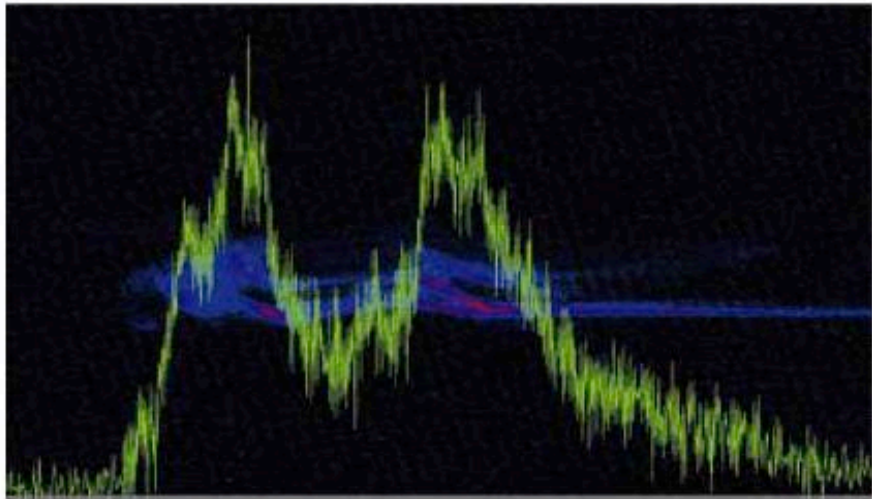


1 picosecond

optics = option 1

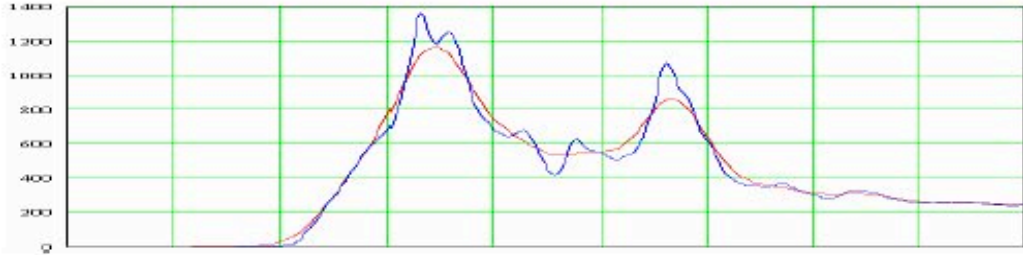
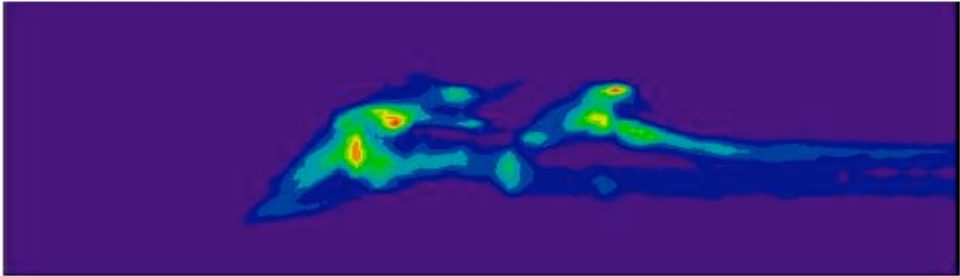
$\varphi_{if} = 8 \text{ deg}$





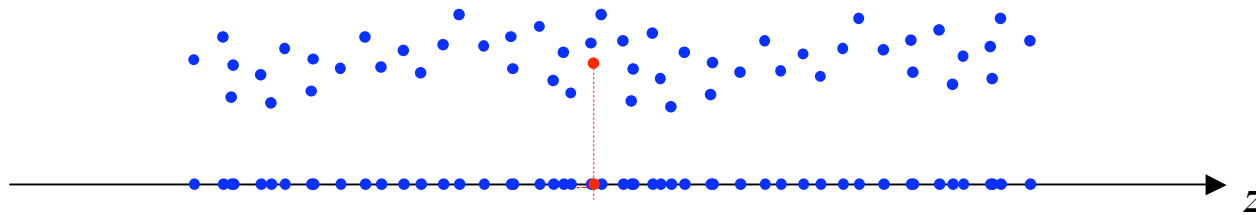
← 1 picosecond →

optics = option 1
 $\varphi_{if} = 12 \text{ deg}$

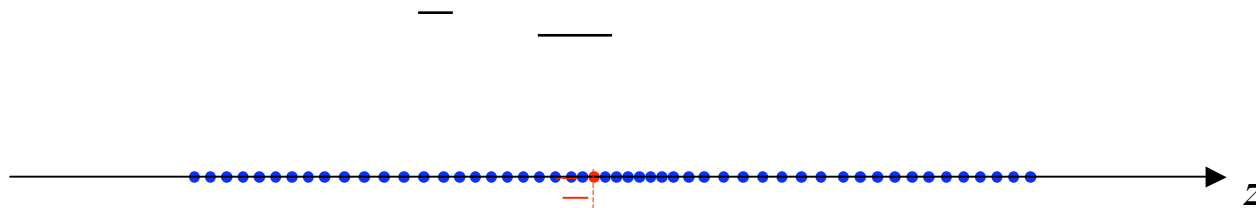


1d filtering in CSRtrack

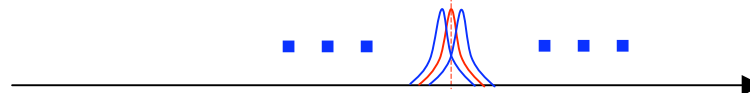
distribution of **equi-charged** particles:

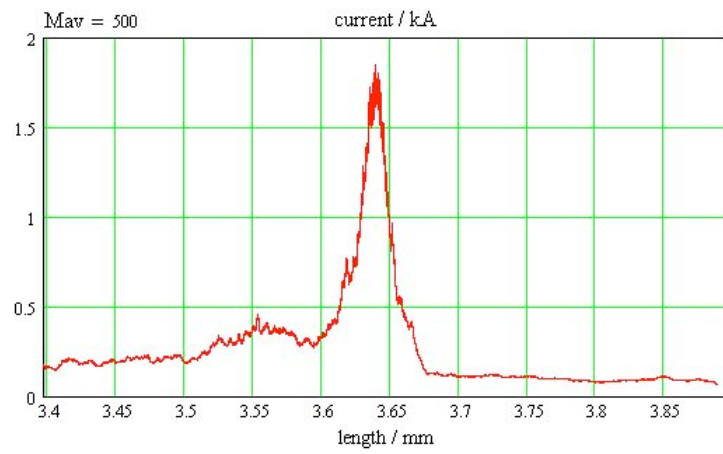
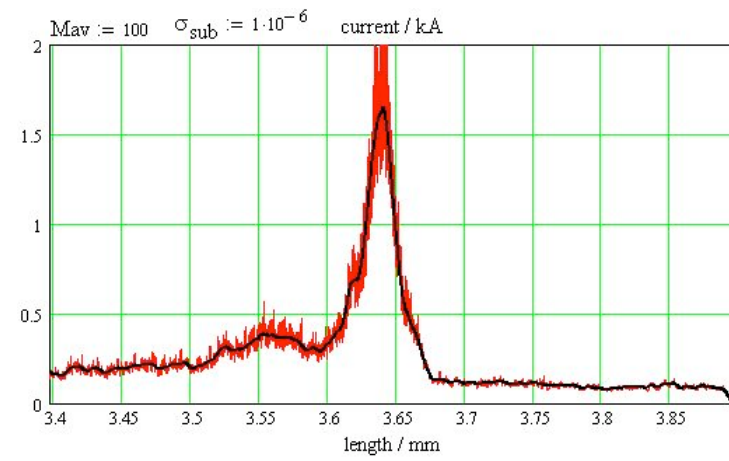
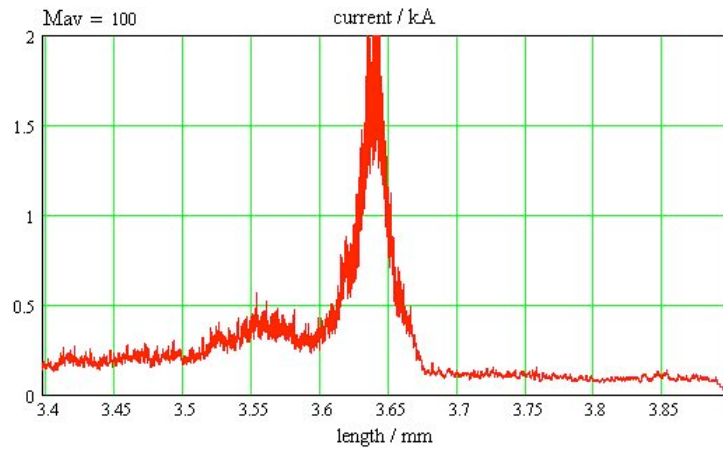


M-particle position averaging:

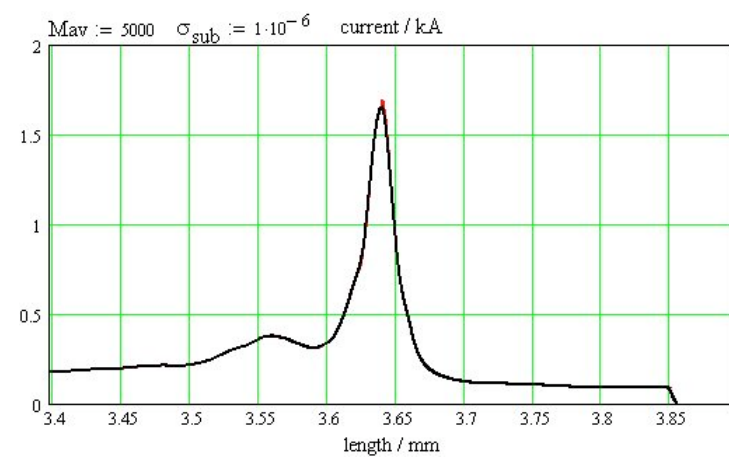
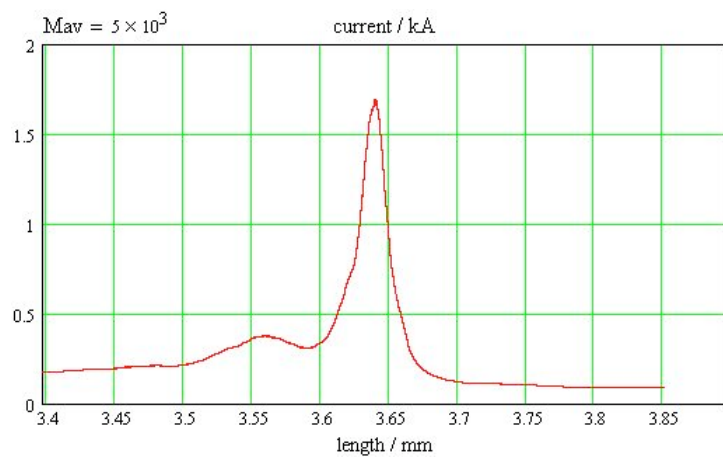


& convolution with Gaussian sub-bunch with rms-length = σ





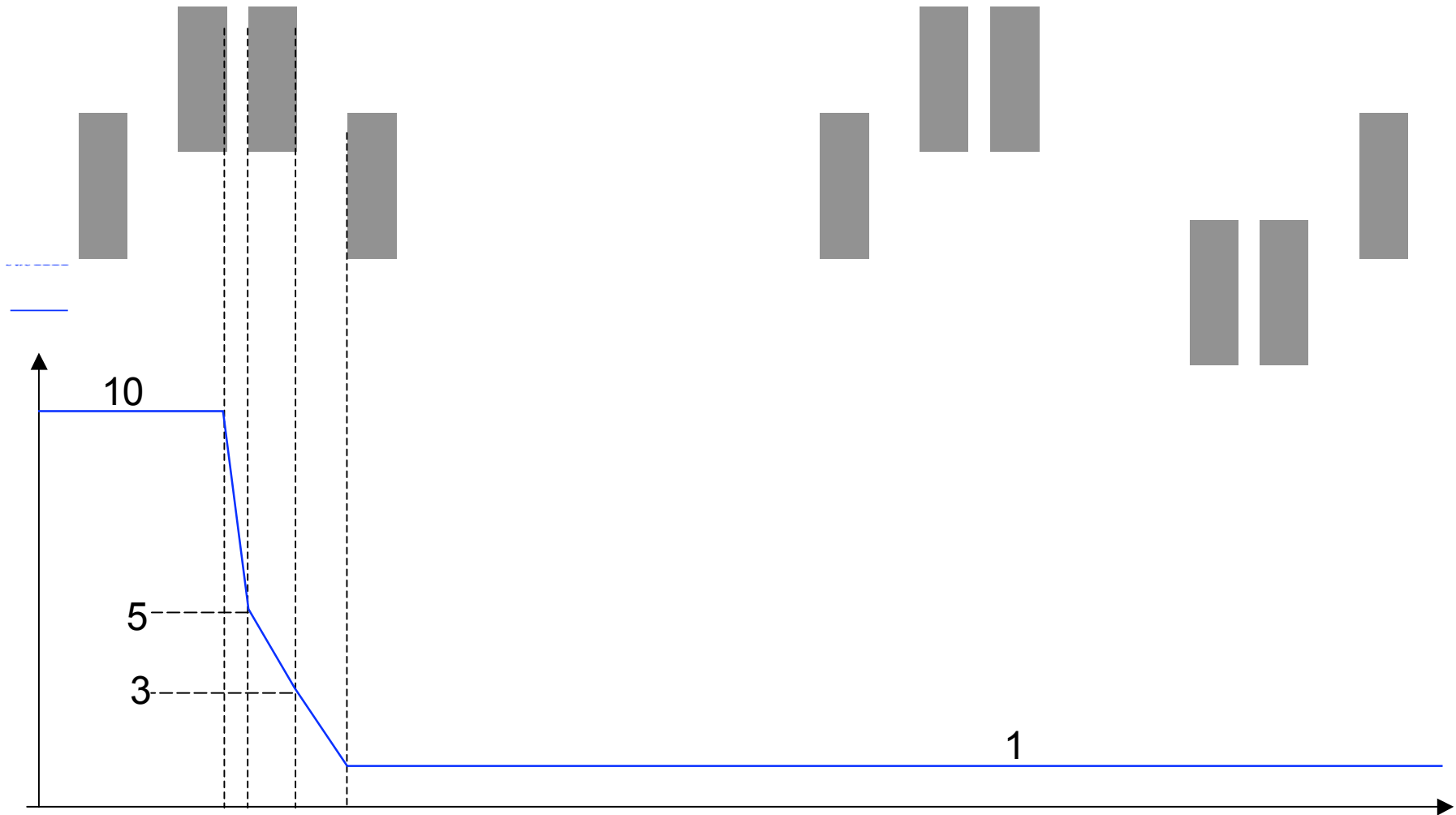
200000 particles



sub-bunch length

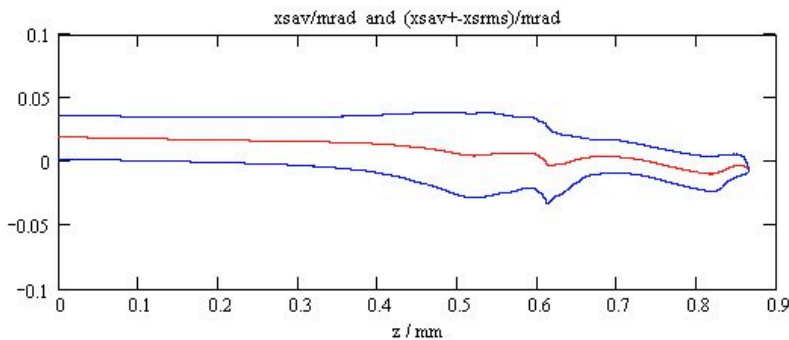
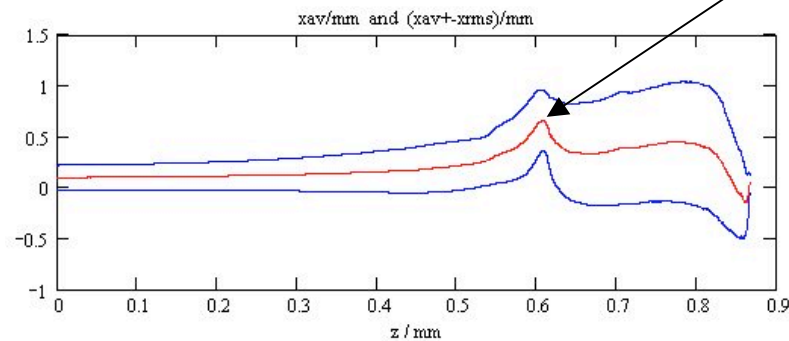
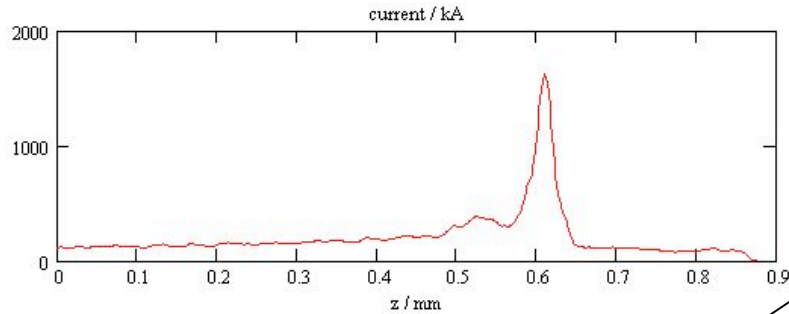
BC2

BC3



after BCs: centroid extraction

proposed by E. Schneidmiller



offset of slice with
peak current

ASTRA: monopole
charge density



SC effects underestimated

to avoid that:
shift centroids to center

more: s2e_TTF2_06oc05_B.pdf

The screenshot displays a Microsoft PowerPoint window titled "Microsoft PowerPoint - [s2e_TTF2_05oc05_B.ppt]". The interface includes a menu bar (File, Edit, View, Insert, Format, Tools, Slide Show, Window, Help, Adobe PDF), a toolbar with icons for file operations and navigation, and a search bar with the text "Type a question for help".

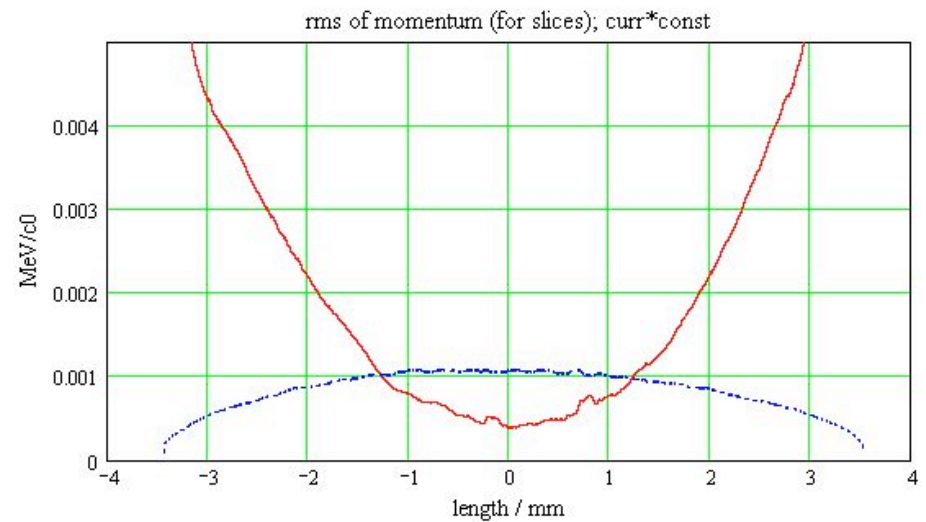
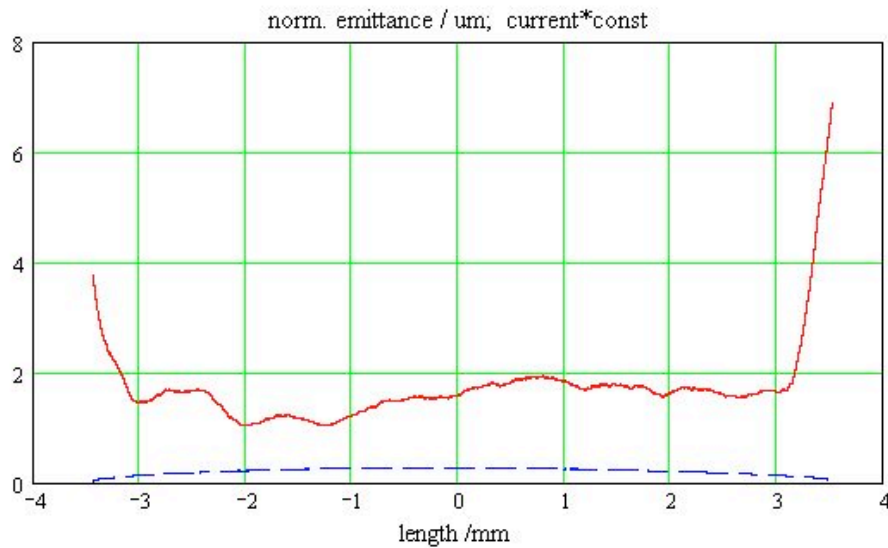
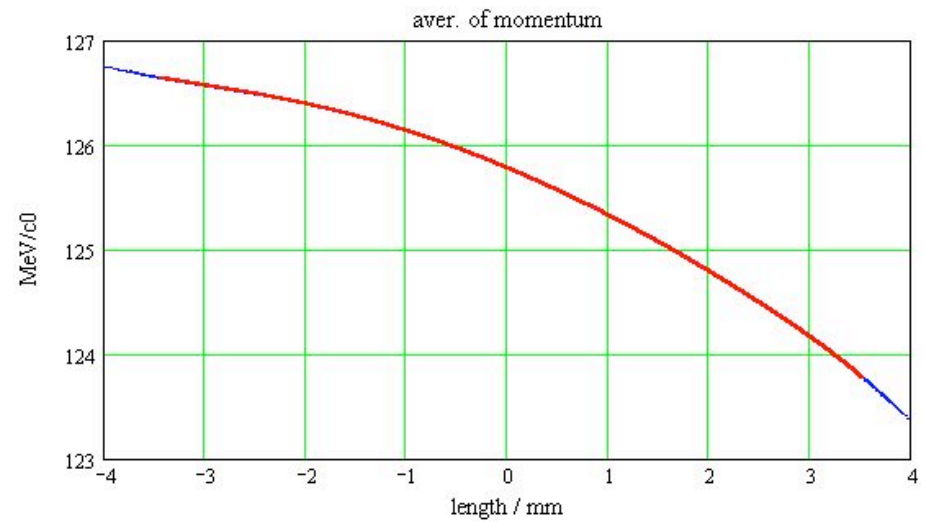
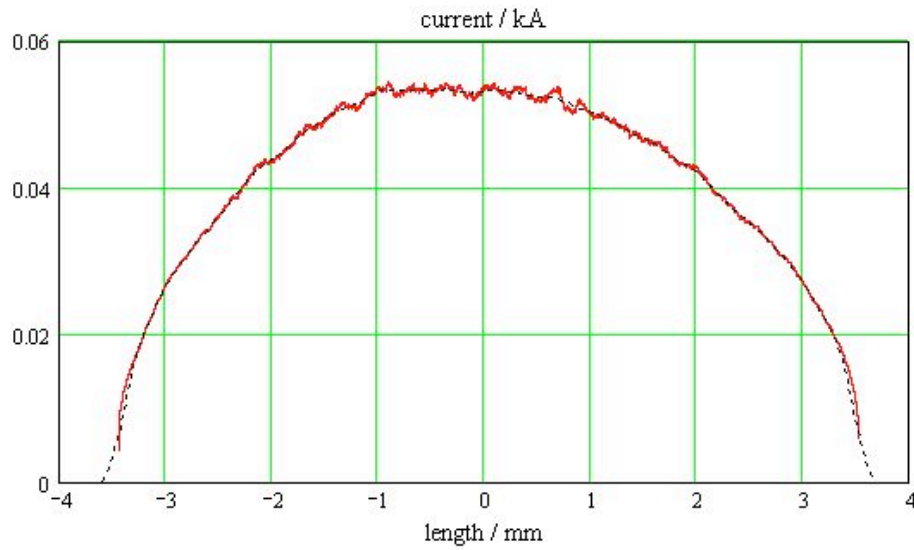
The slide sorter view shows 45 slides arranged in a grid. The slides are numbered 1 through 45. The content of the slides is as follows:

- Slide 1: "before BC2"
- Slide 2: Plot
- Slide 3: "after BC2"
- Slide 4: Plot
- Slide 5: Plot
- Slide 6: Plot
- Slide 7: Plot
- Slide 8: Plot
- Slide 9: "before BC3"
- Slide 10: Plot
- Slide 11: Plot
- Slide 12: Plot
- Slide 13: Plot
- Slide 14: Plot
- Slide 15: Plot
- Slide 16: Plot
- Slide 17: Plot
- Slide 18: Plot
- Slide 19: Plot
- Slide 20: "after BC3
without SC between BCs"
- Slide 21: Plot
- Slide 22: Plot
- Slide 23: Plot
- Slide 24: Plot
- Slide 25: Plot
- Slide 26: Plot
- Slide 27: Plot
- Slide 28: Plot
- Slide 29: "after BC3"
- Slide 30: Plot
- Slide 31: Plot
- Slide 32: "155 m"
- Slide 33: Plot
- Slide 34: Plot
- Slide 35: Plot
- Slide 36: Plot
- Slide 37: Plot
- Slide 38: Plot
- Slide 39: Plot
- Slide 40: Plot
- Slide 41: Plot
- Slide 42: Plot
- Slide 43: Plot
- Slide 44: Plot
- Slide 45: Plot

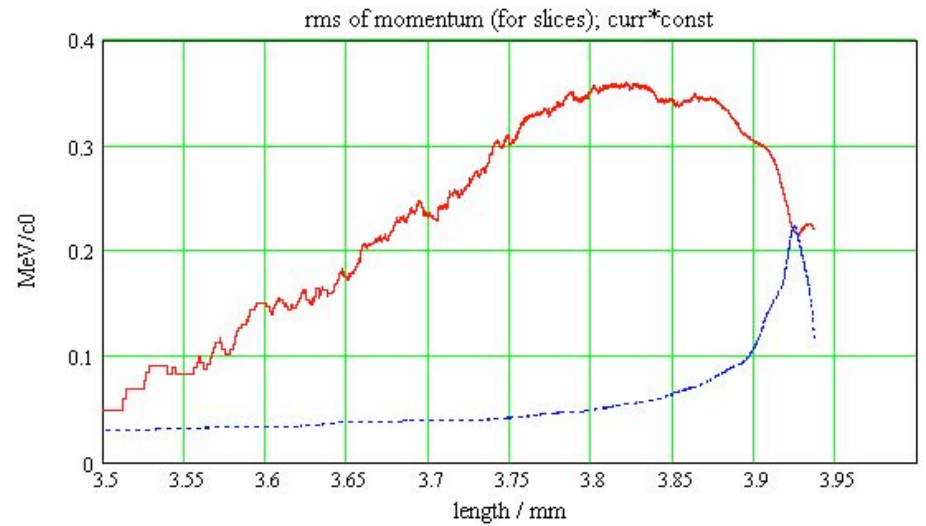
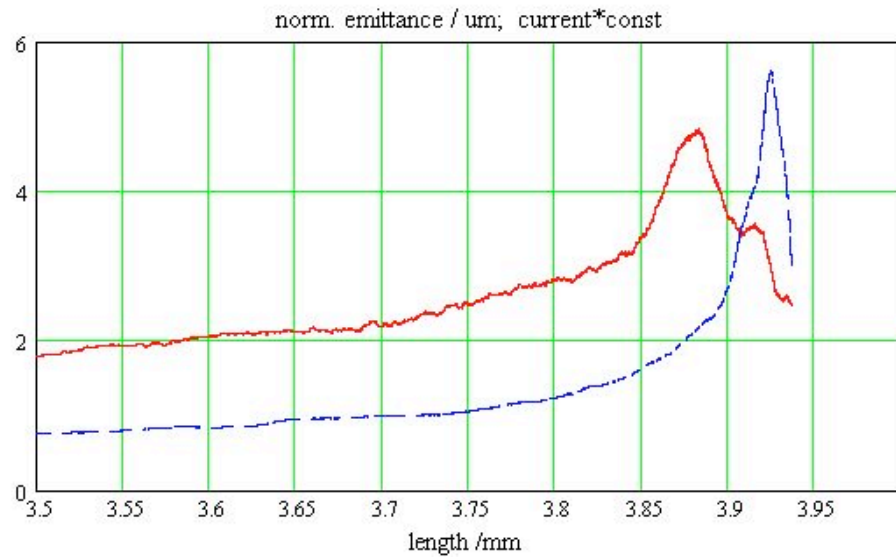
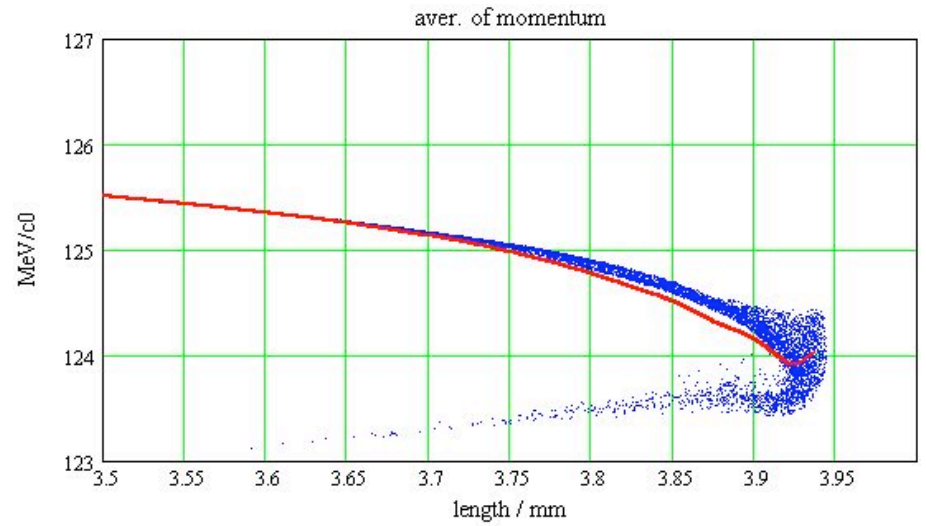
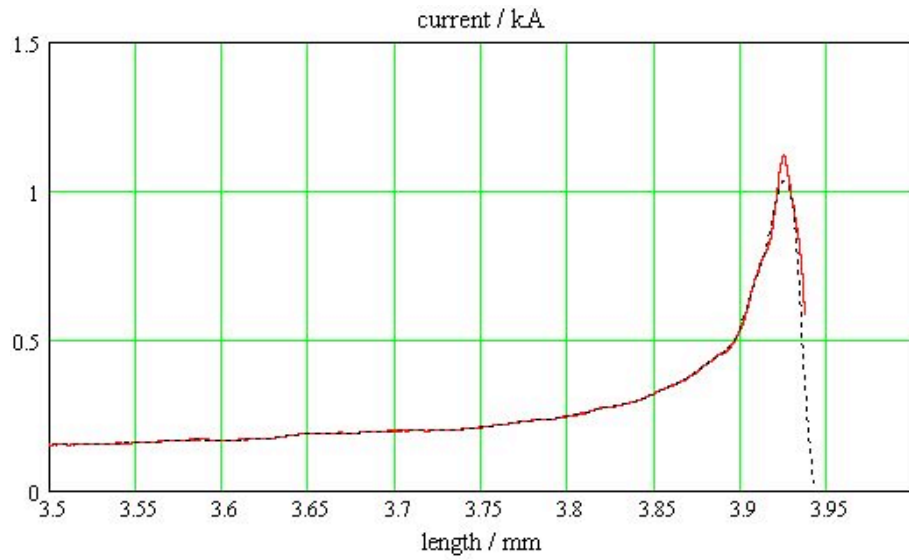
The bottom of the window shows the "Slide Sorter" and "Default Design" tabs, along with navigation icons.

9 deg case:

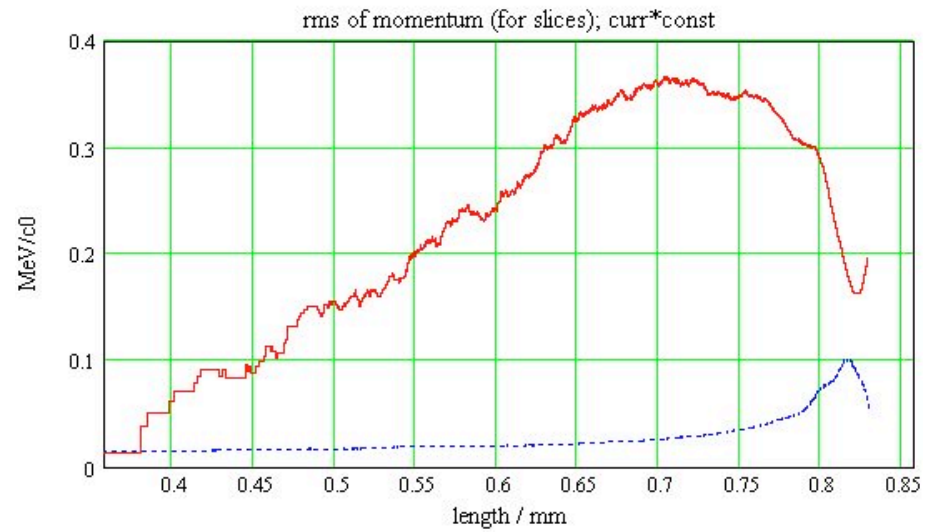
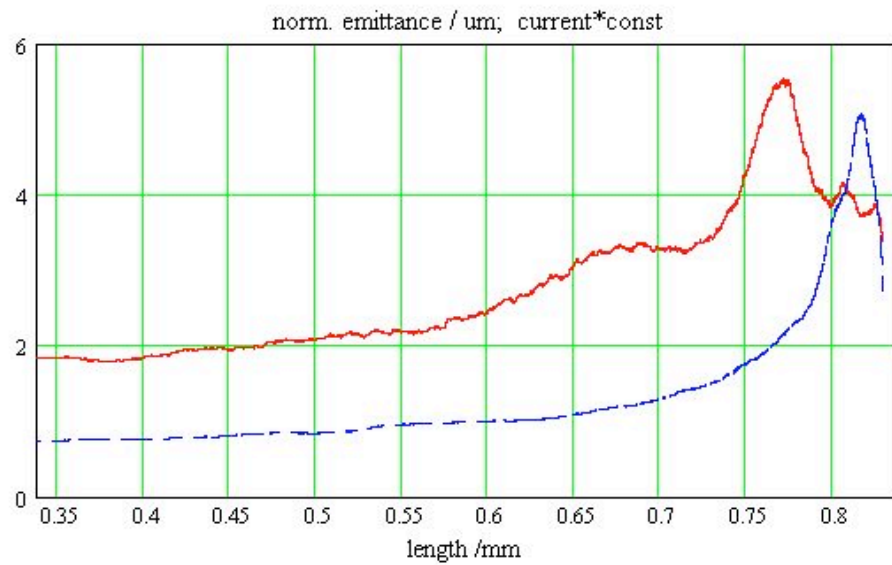
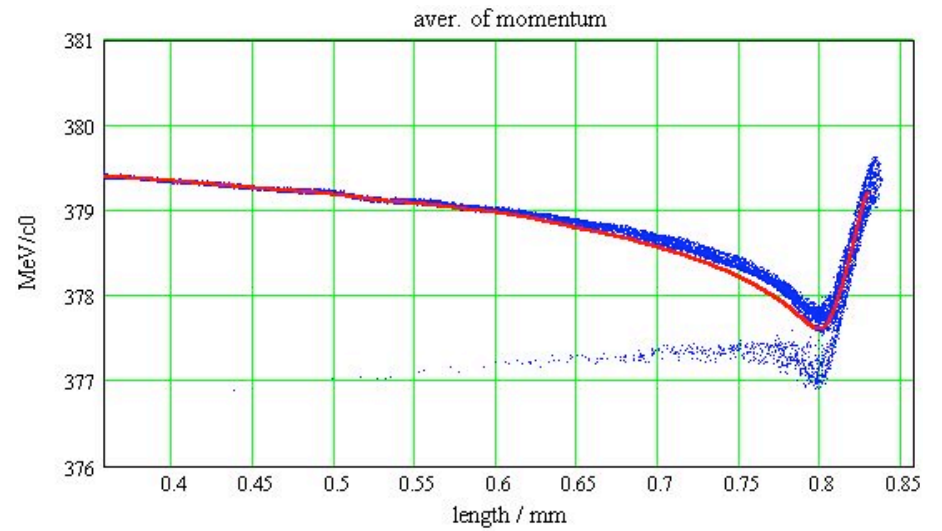
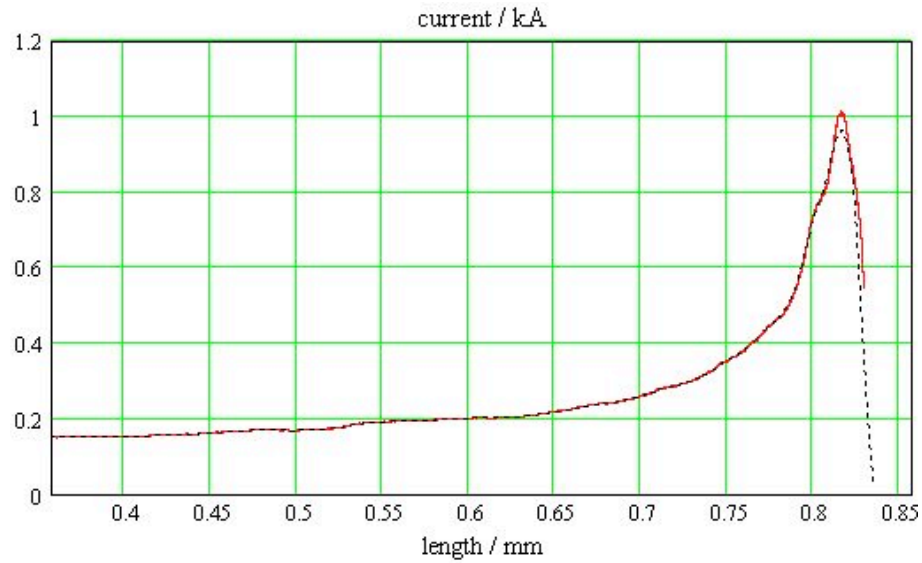
9 deg, before 1st BC



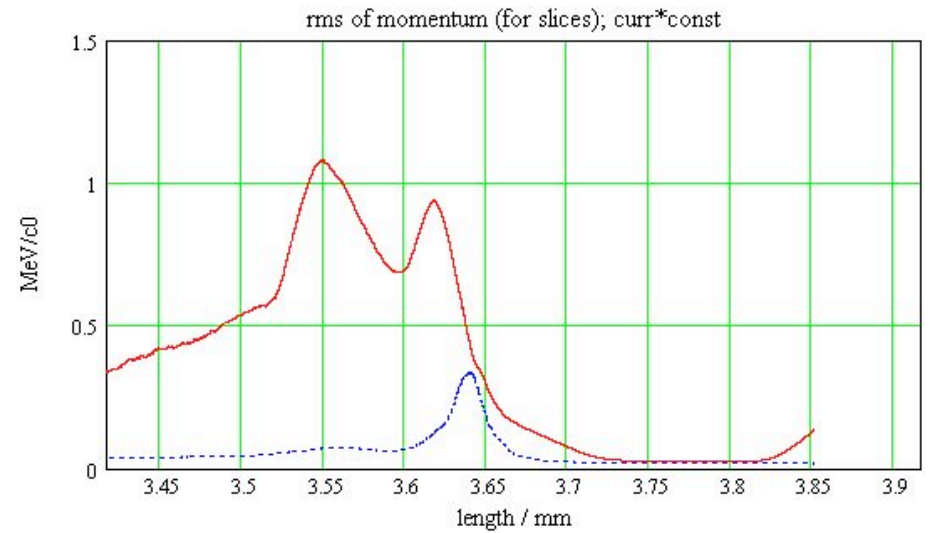
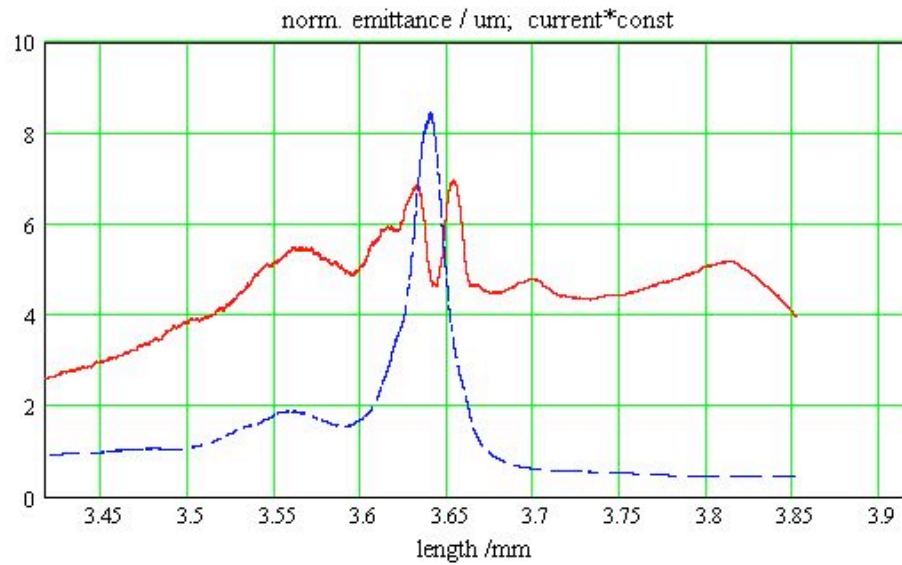
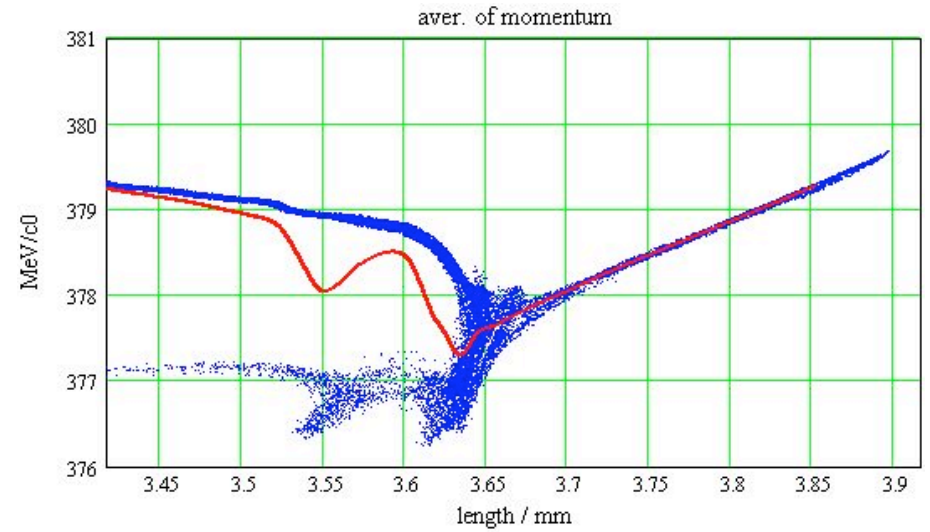
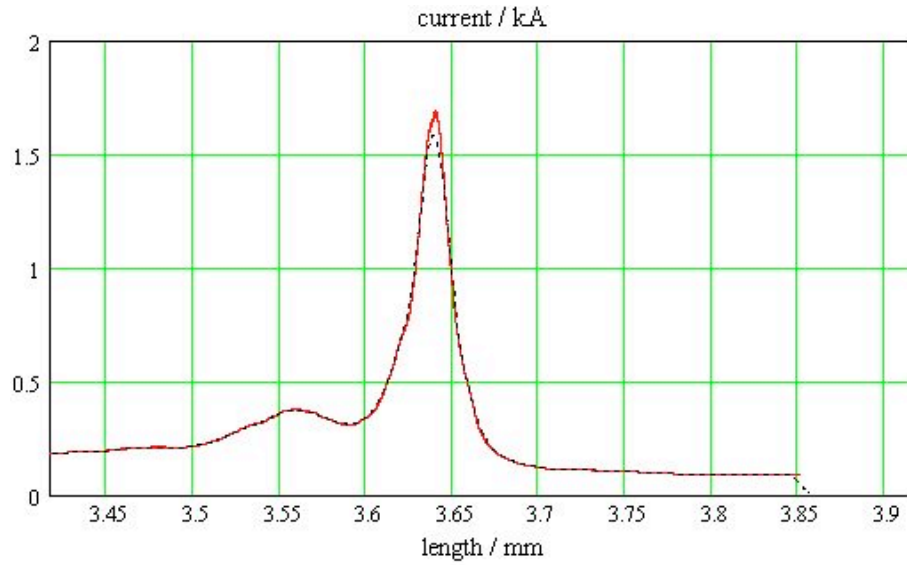
9 deg, after 1st BC



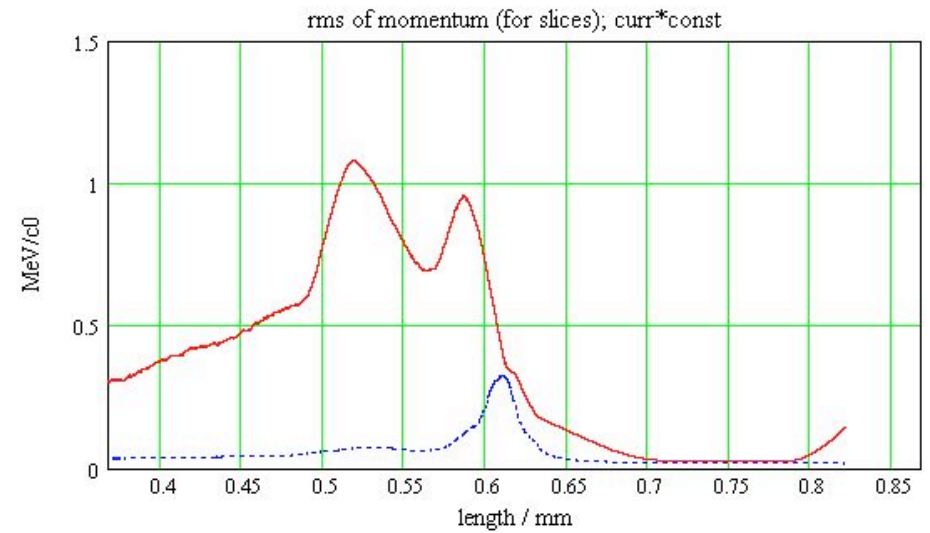
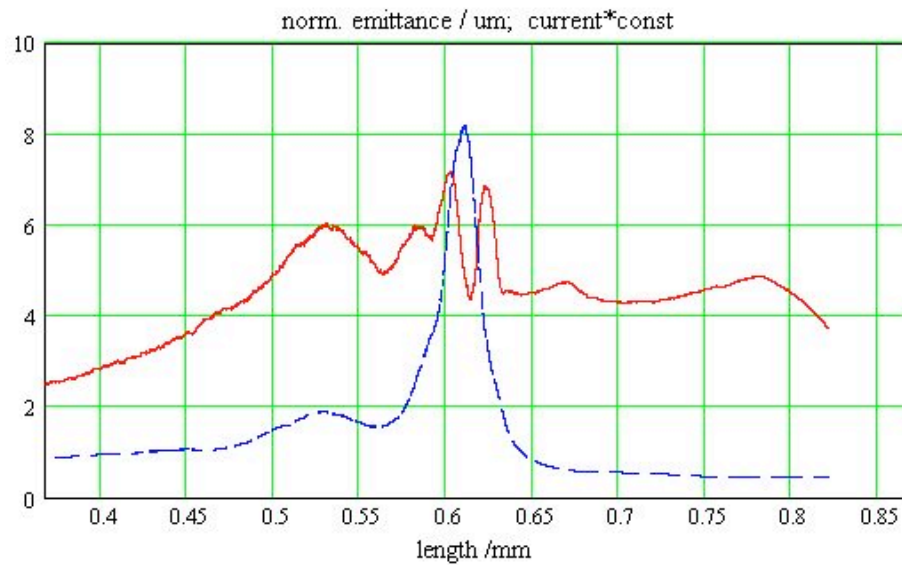
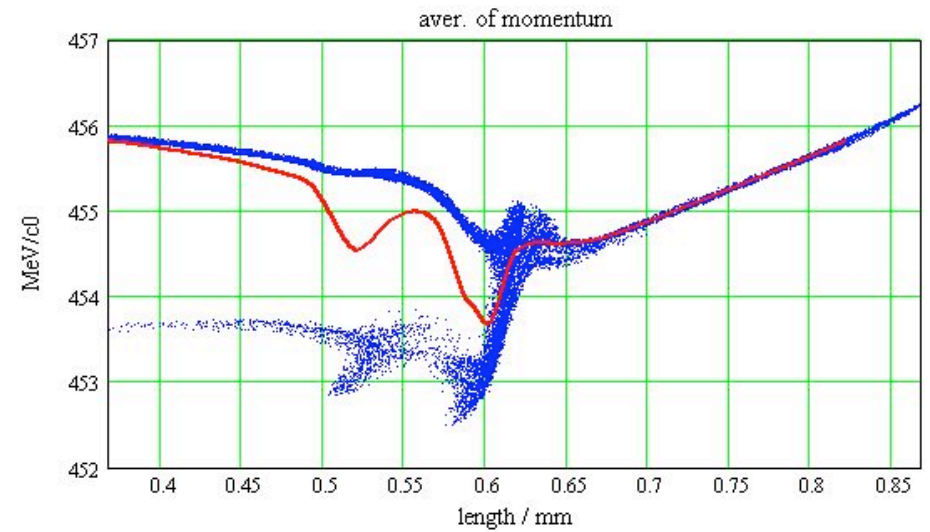
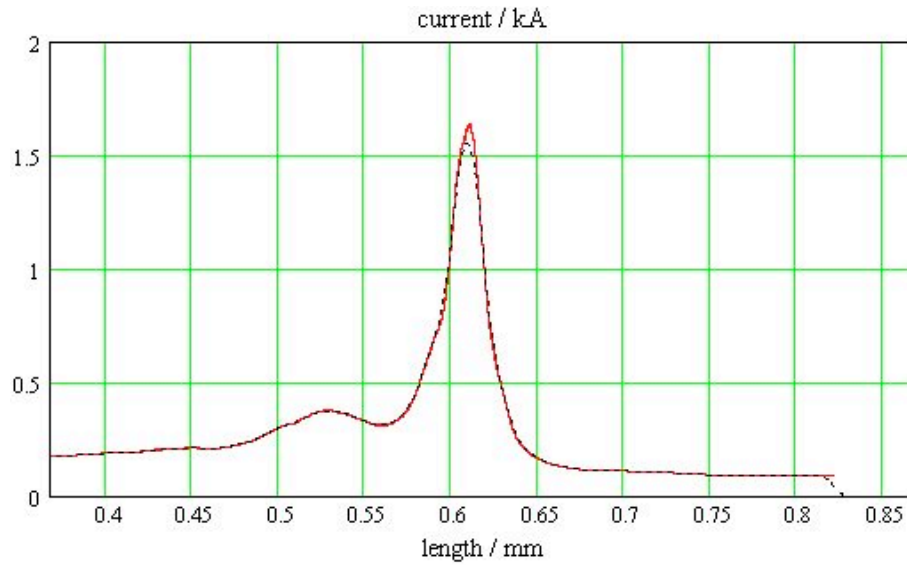
9 deg, before last BC



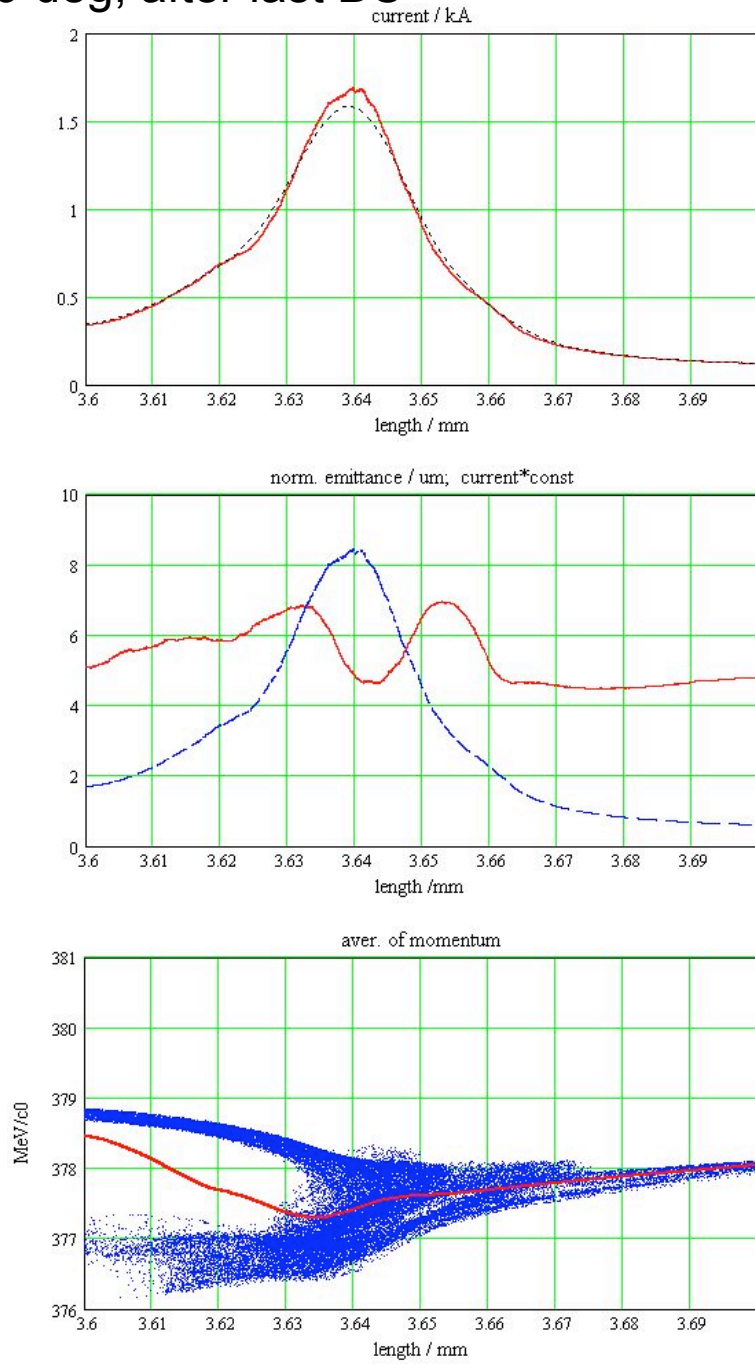
9 deg, after last BC



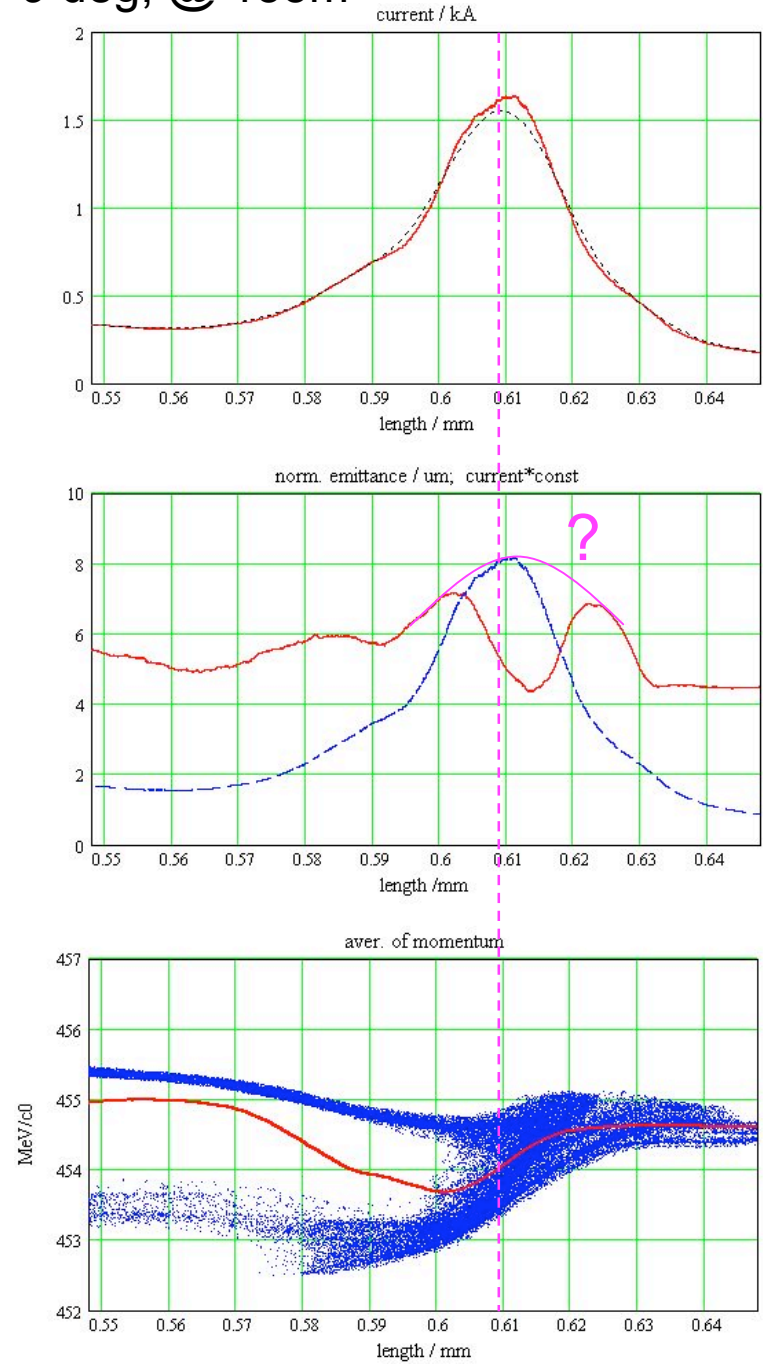
9 deg, @ 155m



9 deg, after last BC



9 deg, @ 155m

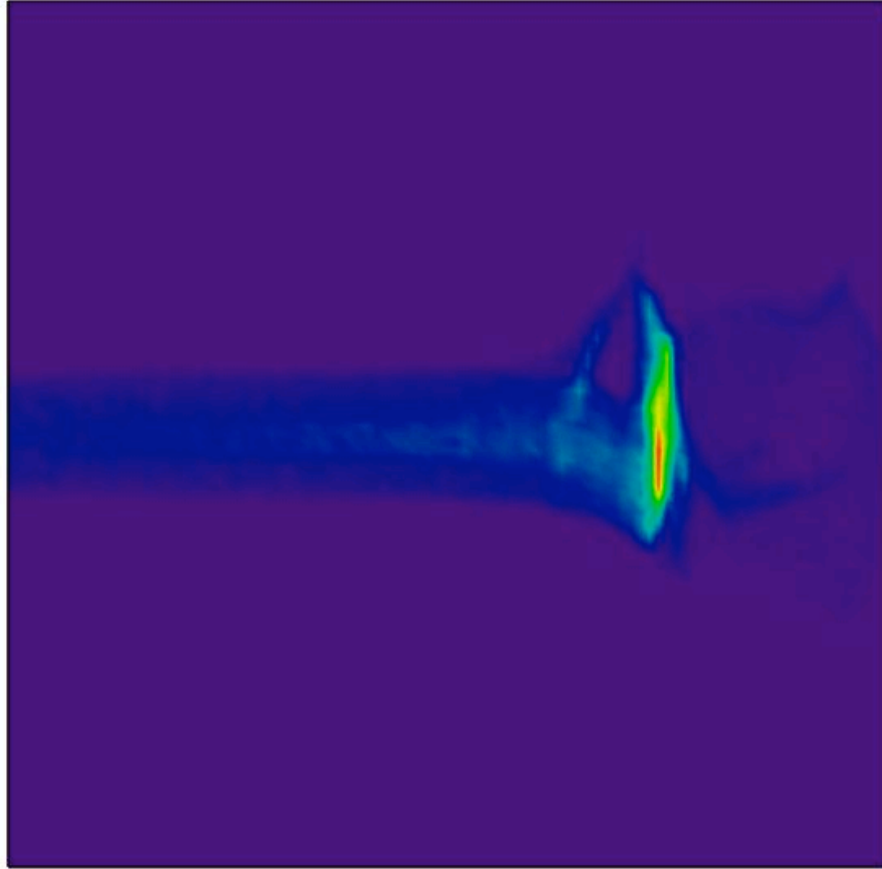


9 deg, @ 155m, x' vs. z

name = "../astra_bc_to_col/dat/y_9deg.out"

comment = "at 155m"

x2o = 2×10^{-3}

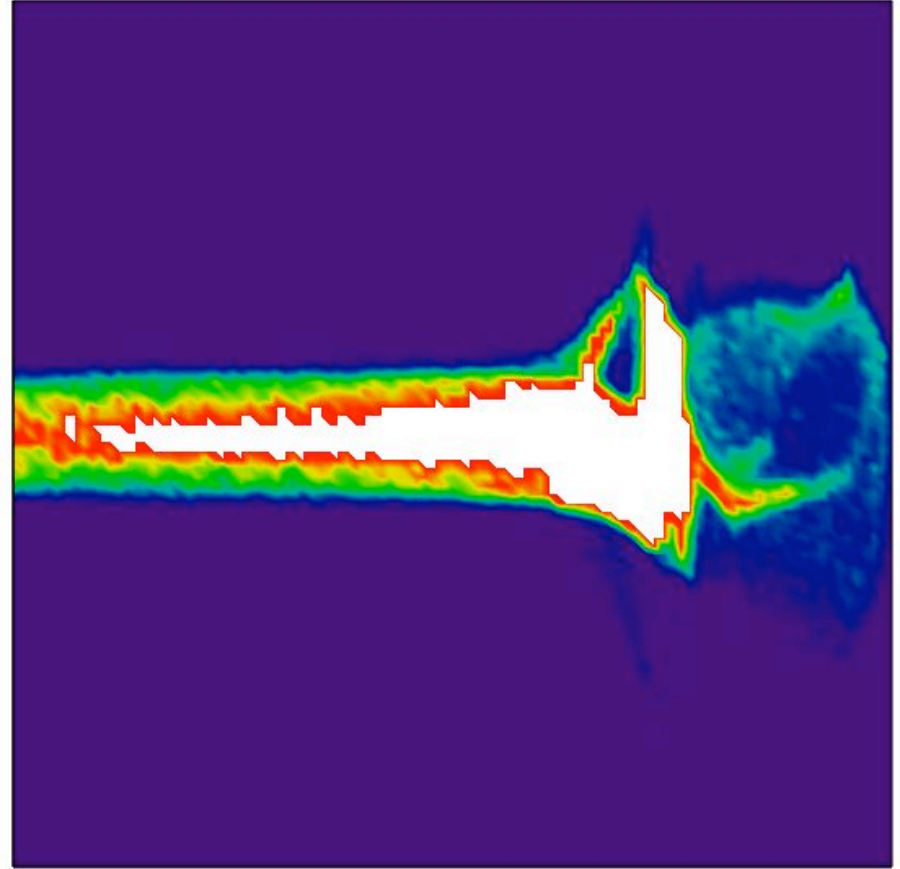


x1o = -2×10^{-3}

name = "../astra_bc_to_col/dat/y_9deg.out"

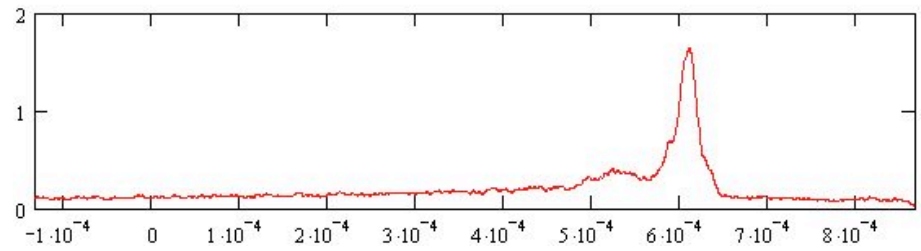
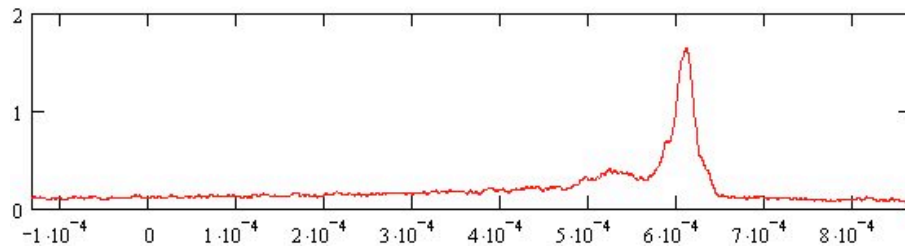
comment = "at 155m"

x2o = 2×10^{-3}

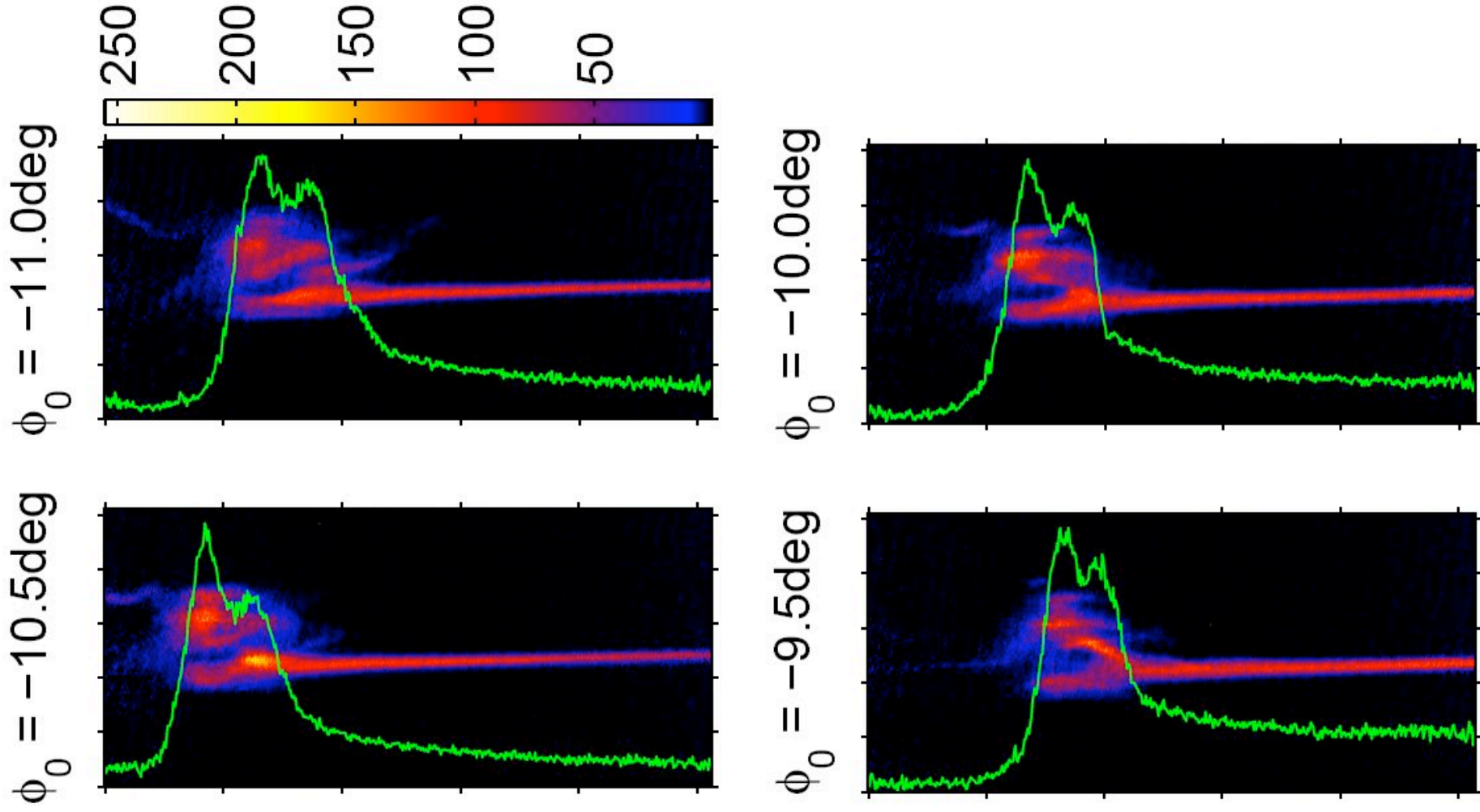


S2

x1o = -2×10^{-3}



& LOLA

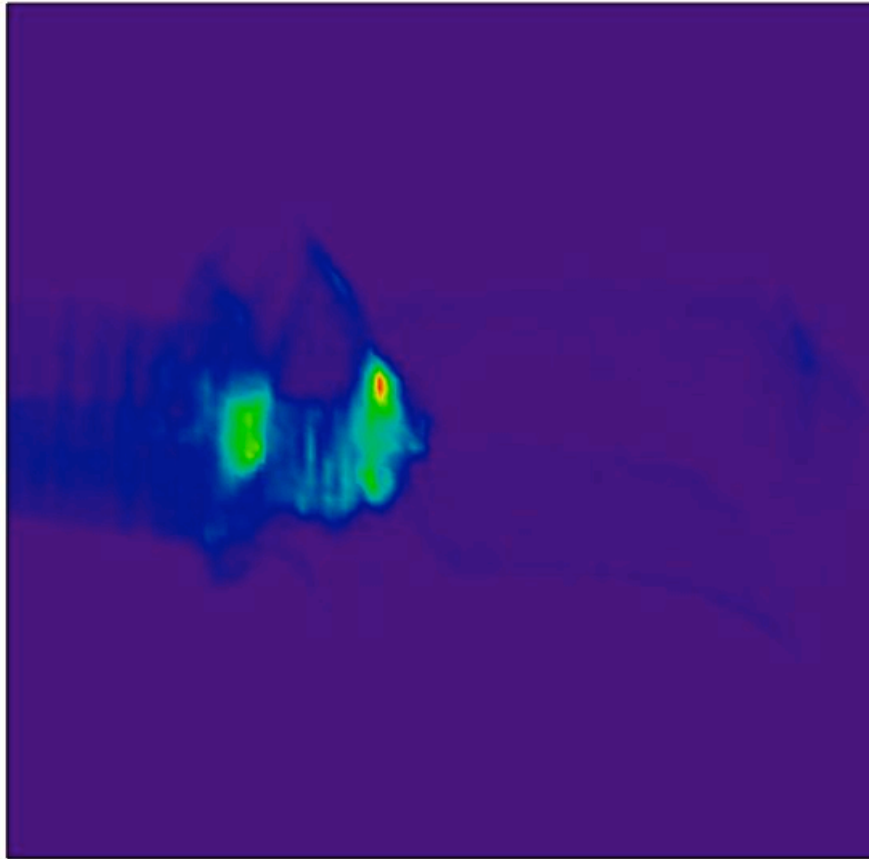


12 deg, @ 155m, x' vs. z

name = "../astra_bc_to_col/dat/y_12deg.out"

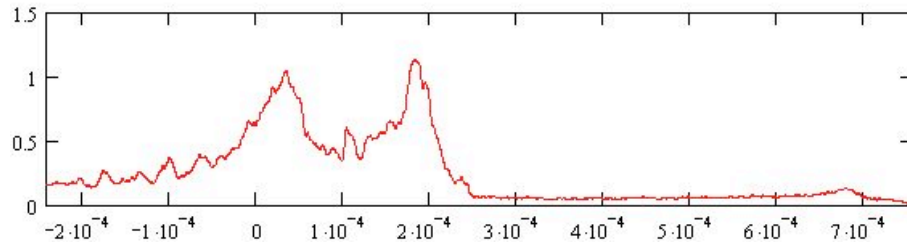
comment = "at 155m"

x2o = 2×10^{-3}



S2

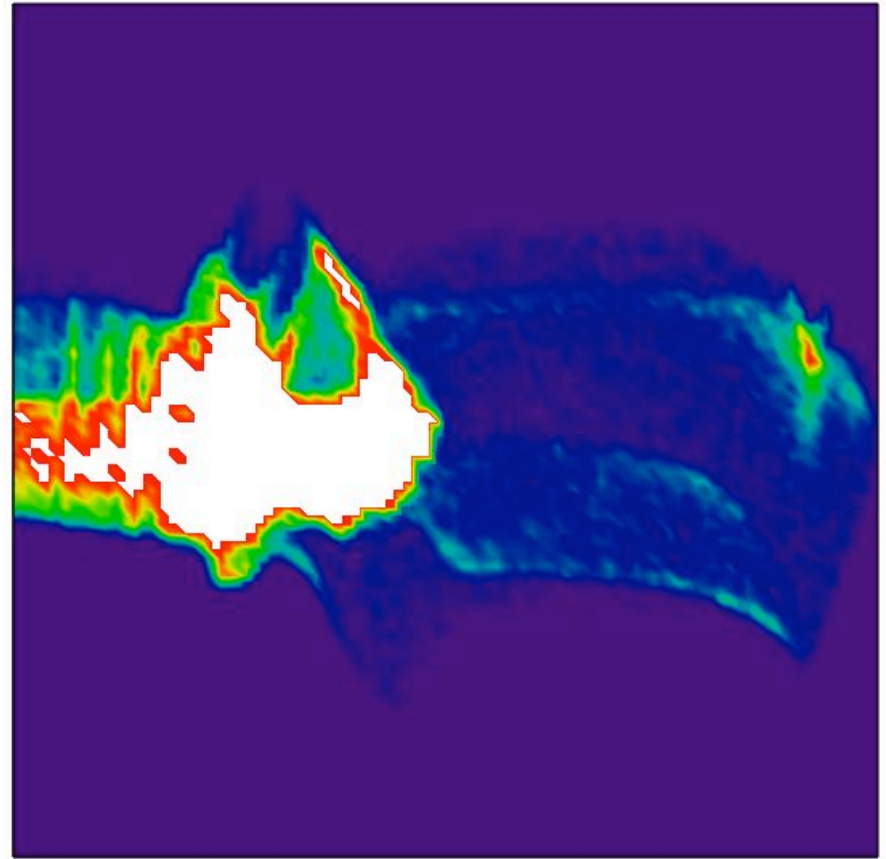
x1o = -2×10^{-3}



name = "../astra_bc_to_col/dat/y_12deg.out"

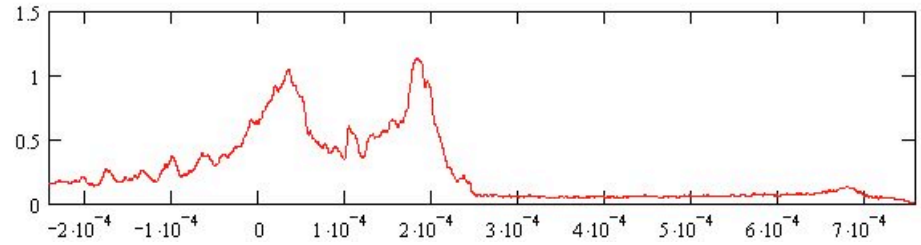
comment = "at 155m"

x2o = 2×10^{-3}



S2

x1o = -2×10^{-3}



more: s2e_TTF2_06oc05_C.pdf

Microsoft PowerPoint - [s2e_TTF2_05oc05_C.ppt]

File Edit View Insert Format Tools Slide Show Window Help Adobe PDF

Type a question for help

100%

Notes... Transition Design New Slide

after BC3
r56_BC3 = 8cm

1

2

3

4

5

6

7

8

9

Slide Sorter Default Design