3-BC Working Points for 0.5 and 1.0 nC

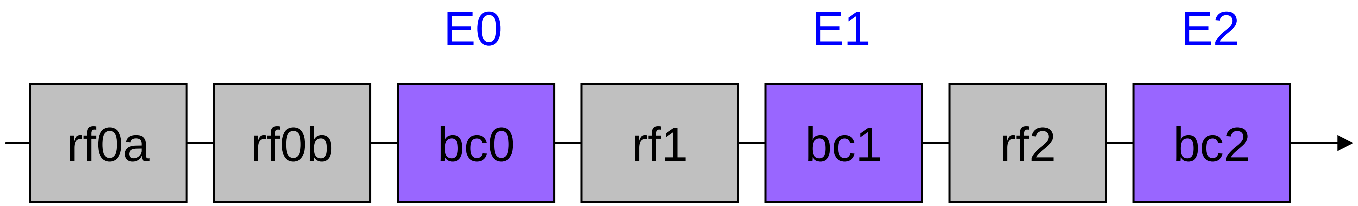
tool/method – how to find working points (1D with CSR)

example (1nC)

example (0.5nC)

some remarks

Tool / Method

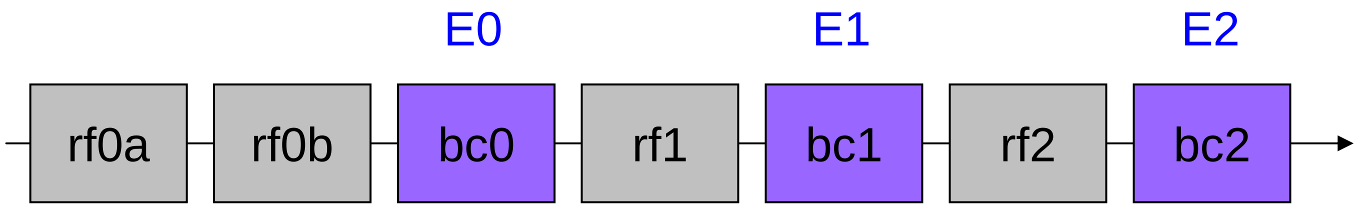


linear parameters: e0’ q56_0 e1’ q56_1 e2’ q56_2

non-linear param.: e0’’
(knobs)
e0’’’

my definition: $e0'' = \frac{E_0''}{k^2 E_0}$ $e0''' = \frac{E_0'''}{k^3 E_0}$

Tool / Method



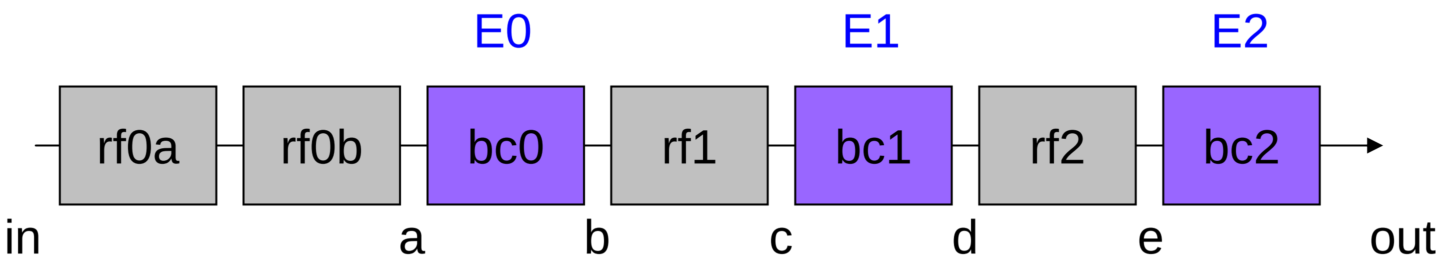
linear parameters: e0' q56_0 e1' q56_1 e2' q56_2

C0 C1 φ2 Ctot

non-linear param.: (knobs) e0''

e0'''

Tool / Method

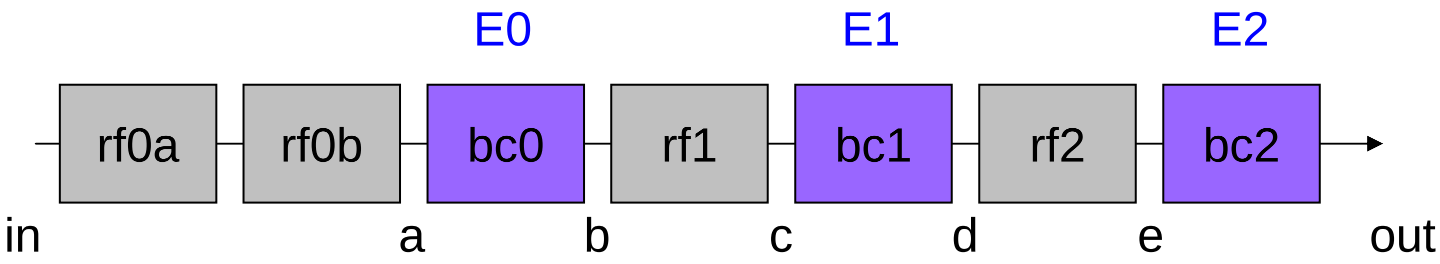


1. track without self effects: in → a,b,c,d,e,out (‘in’ with laser heater!)

2. track with SC&wakes: (Igor’s SC&wakes)
   - in → a1
   - re-adjust rf0 parameters: E0; rms{a1-a}=min
   - in → a2,b2,c1
   - re-adjust rf1 parameters: E1; rms{c1-c}=min
   - in → a2,b2,c2,d2,e1
   - re-adjust rf2 parameters: E2; rms{e1-e}=min
   - in → a2,b2,c2,d2,e2,out1

procedure takes about 1 min
total compression not quite perfect <x1-x>≠0 … in principle: modify e2’ or q45_2
few iterations to adjust e0’’ and e0’’’

Tool / Method



3. track with …&…&CSR: in $\rightarrow$ a1

re-adjust rf0 parameters: E0; rms{a1-a}=min

in $\rightarrow$ a2$\rightarrow$(1d-CSRtrack)$\rightarrow$b2,c1

re-adjust rf1 parameters: E1; rms{c1-c}=min

in $\rightarrow$ a2,b2,c2 $\rightarrow$(1d-CSRtrack)$\rightarrow$ d2,e1

re-adjust rf2 parameters: E2; rms{e1-e}=min

in $\rightarrow$ a2,b2,c2,d2,e2 $\rightarrow$(1d-CSRtrack)$\rightarrow$ out1

procedure takes about 30 min
total compression not quite perfect
few iterations to adjust e0'' and e0'''

→(1d-CSRtrack)→

(matlab-controller)

in = longitudinal phase space

create lattice with design q56 → csrtrk.in

create artificial transverse phase space
($\varepsilon_{\mathrm{n}} \approx 1\,\mu\mathrm{m}$, initial β, focus at last magnet)

run CSRtrack

{look for transverse properties}

extract longitudinal phase space → out

example (1nC)

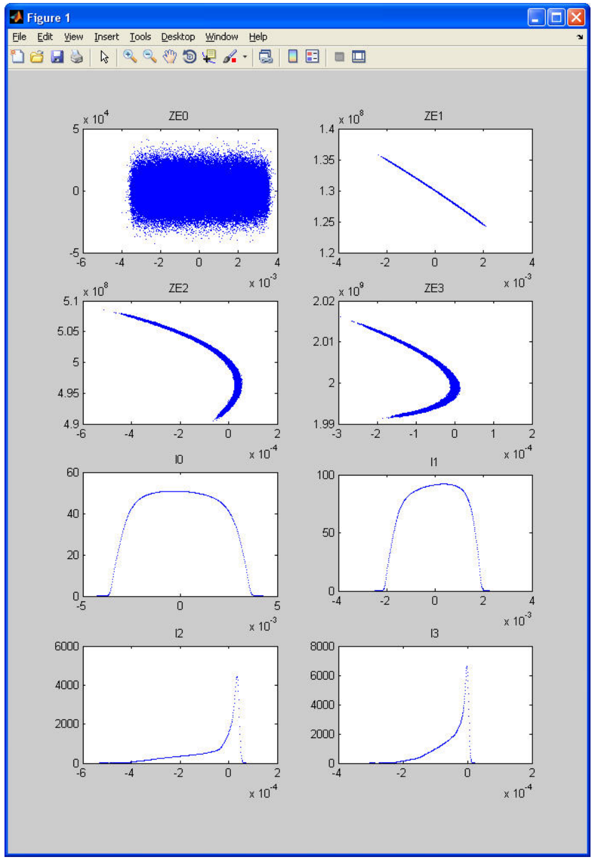
```
C0=1.80;
C1=19.0/C0;
C2=100.0/(C0*C1);
q56_0=0.040;
q56_1=0.110;
q56_2=0.027764039;
```

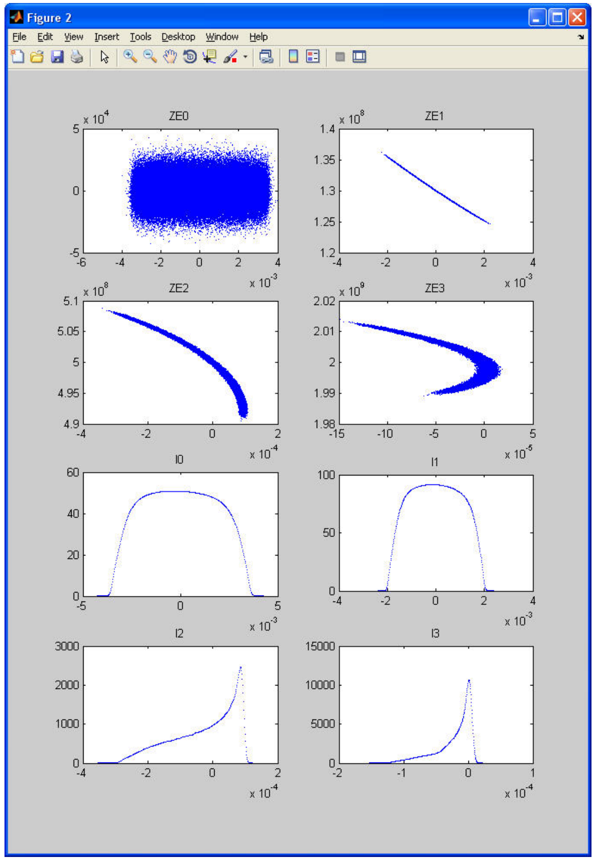
without self effects

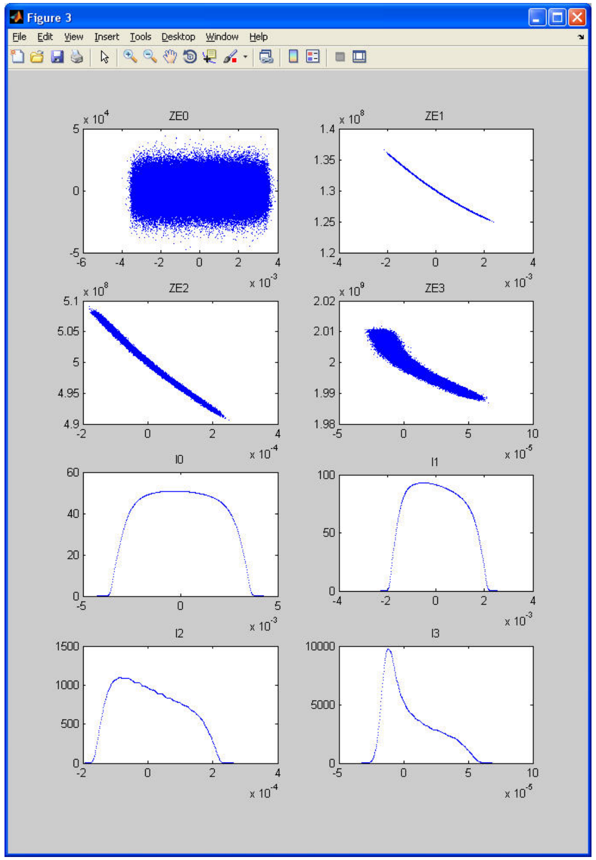
```
e0ss =0.0;
e0sss=0.0;
```

```
e0ss =0.5;
e0sss=0.0;
```

```
e0ss =1.0;
e0sss=0.0;
```







example (1nC)

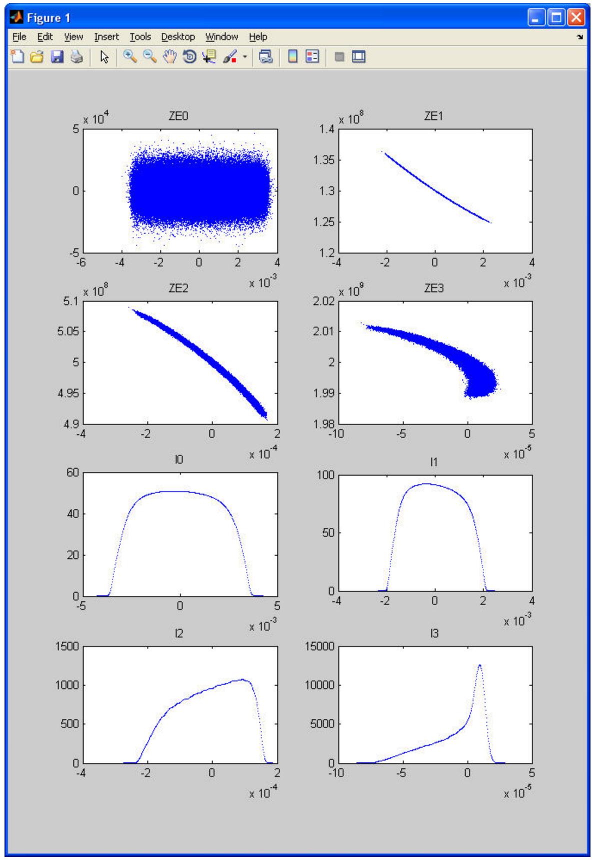
```
C0=1.80;
C1=19.0/C0;
C2=100.0/(C0*C1);
q56_0=0.040;
q56_1=0.110;
q56_2=0.027764039;
```

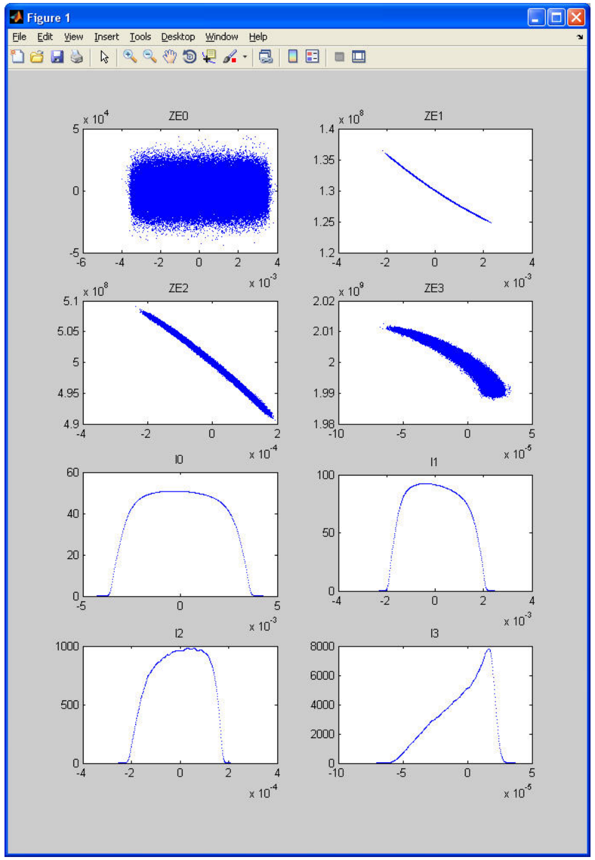
without self effects

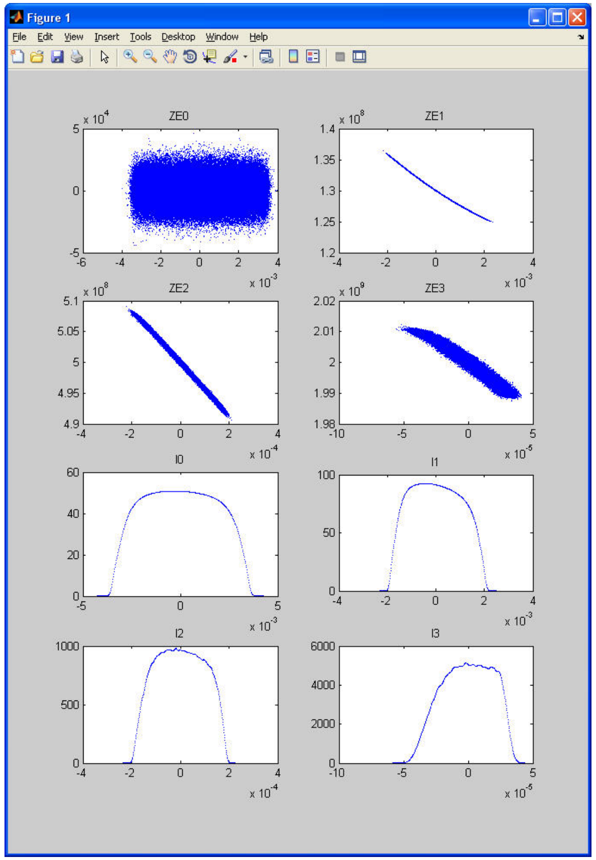
```
e0ss =0.75;
e0sss=0.0;
```

```
e0ss =0.82;
e0sss=0.0;
```

```
e0ss =0.88;
e0sss=0.0;
```





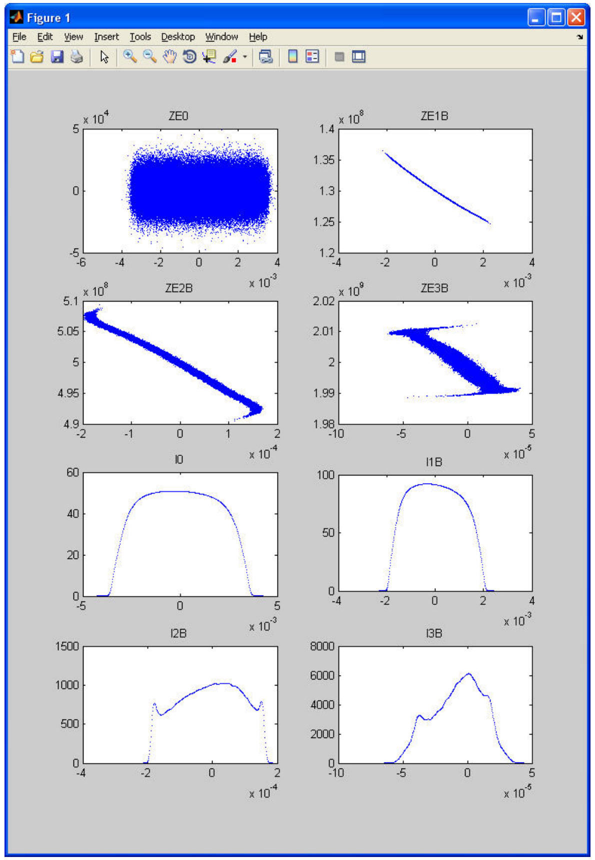


example (1nC)

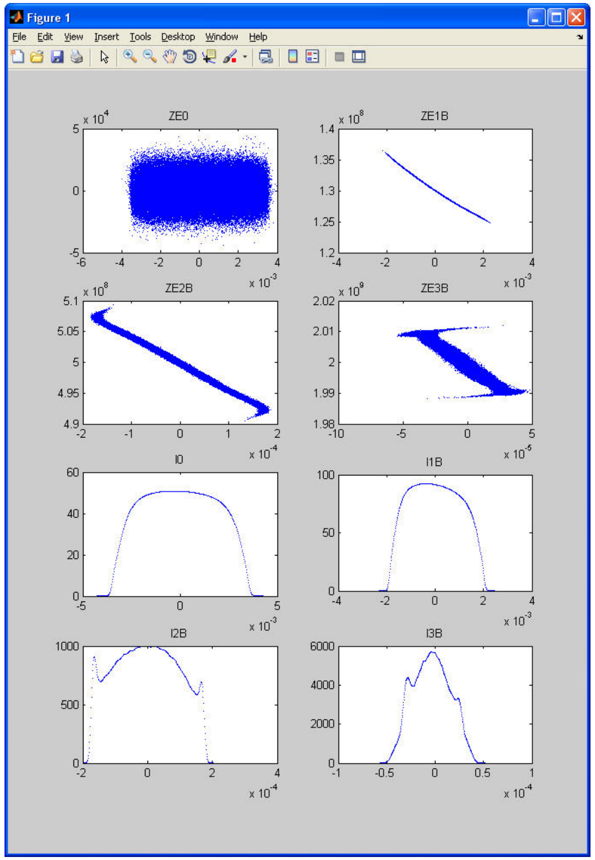
```
C0=1.80;
C1=19.0/C0;
C2=100.0/(C0*C1);
q56_0=0.040;
q56_1=0.110;
q56_2=0.027764039;
```

with wakes, without CSR

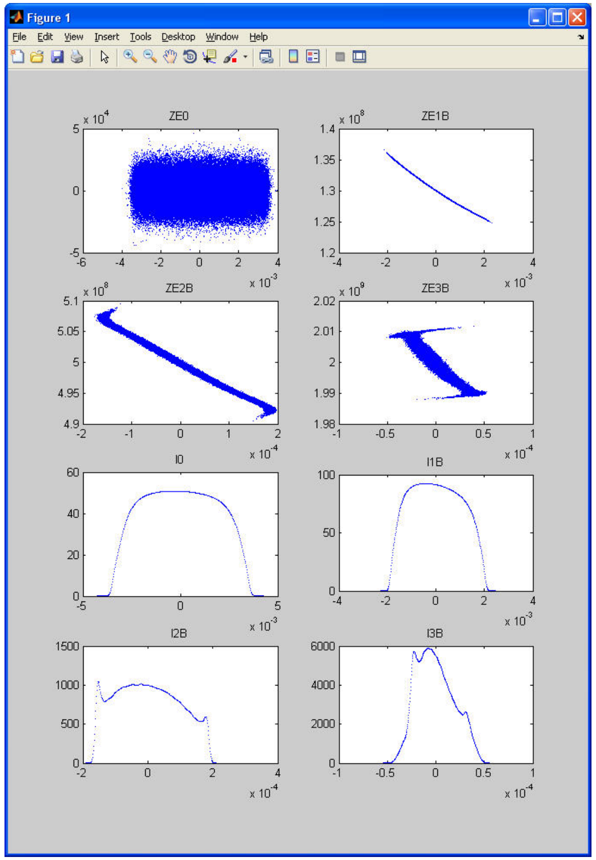
```
e0ss =0.75;
e0sss=0.0;
```




```
e0ss =0.82;
e0sss=0.0;
```




```
e0ss =0.88;
e0sss=0.0;
```

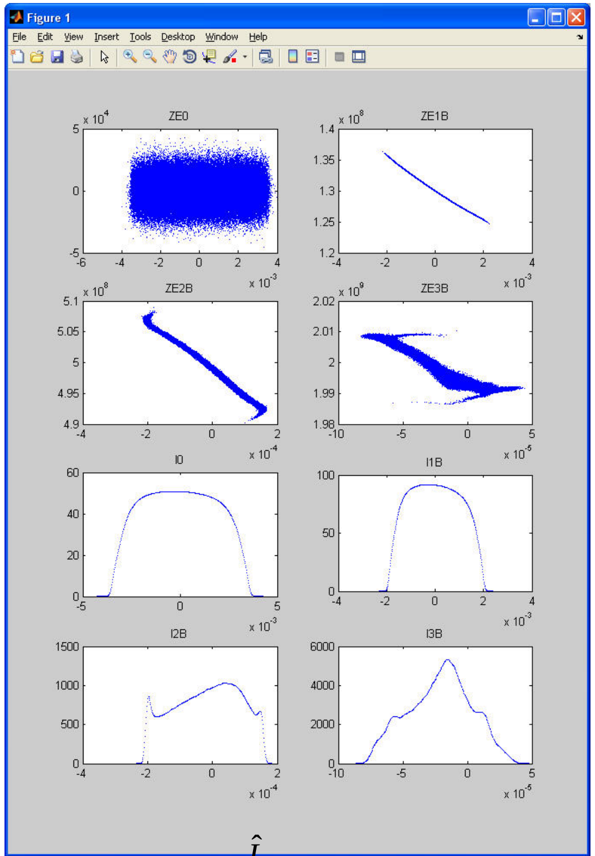


example (1nC)

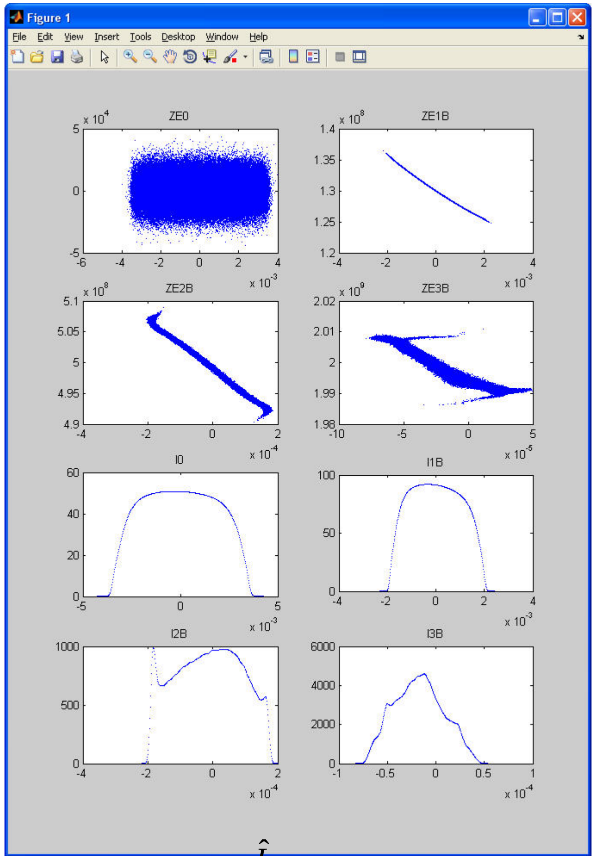
```
C0=1.80;
C1=19.0/C0;
C2=100.0/(C0*C1);
q56_0=0.040;
q56_1=0.110;
q56_2=0.027764039;
```

with wakes & CSR

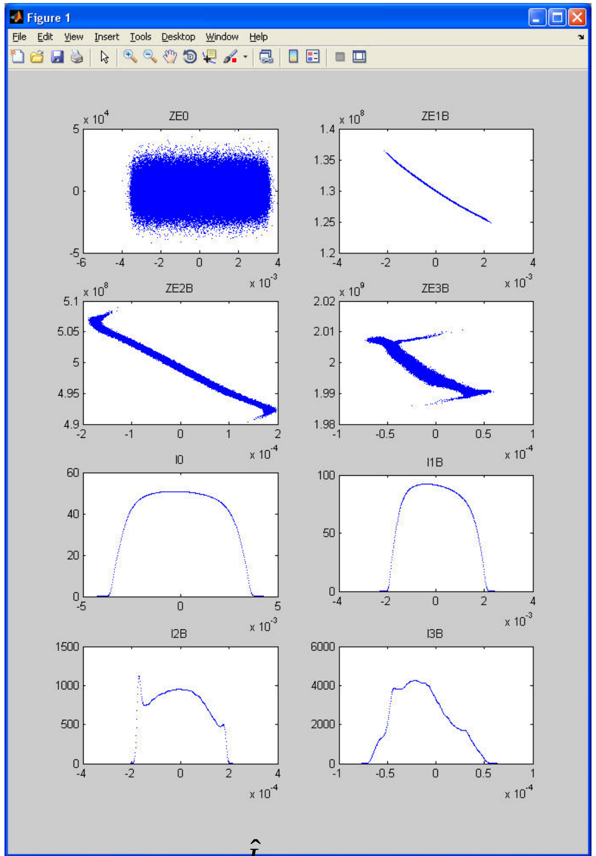
e0ss =0.68;	e0ss =0.75;	e0ss =0.82;
e0sss=0.0;	e0sss=0.0;	e0sss=0.0;



$$\frac{\hat{I}}{\mathrm{kA}} \approx 5.33$$



$$\frac{\hat{I}}{\mathrm{kA}} \approx 4.6$$



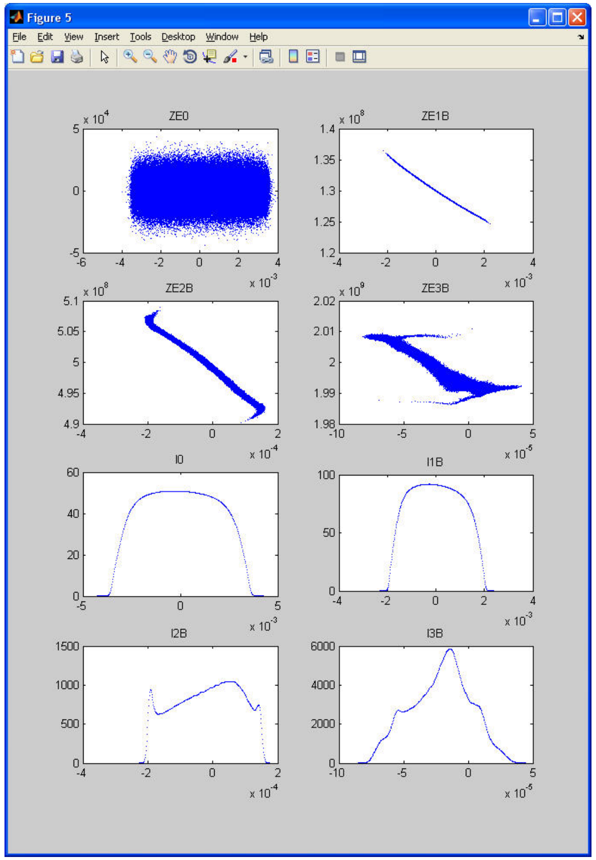
$$\frac{\hat{I}}{\mathrm{kA}} \approx 4.26$$

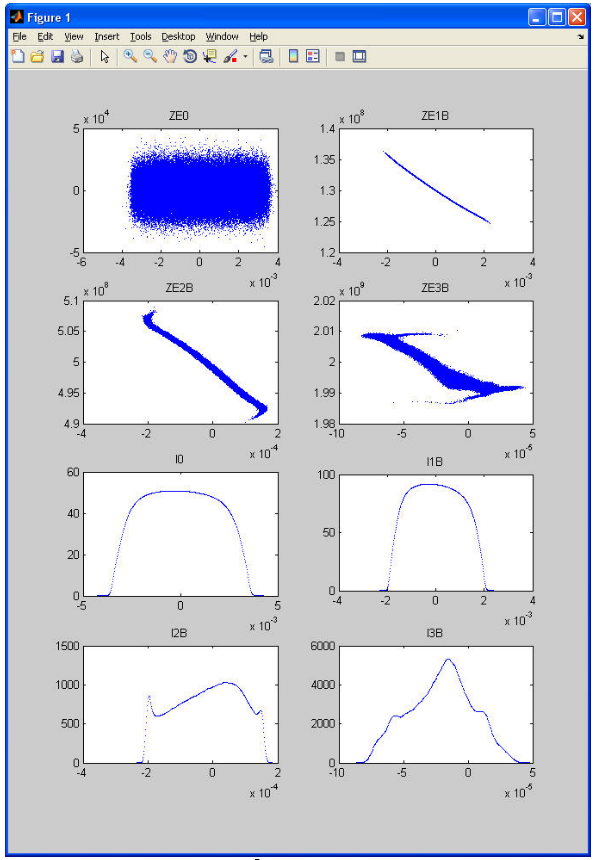
example (1nC)

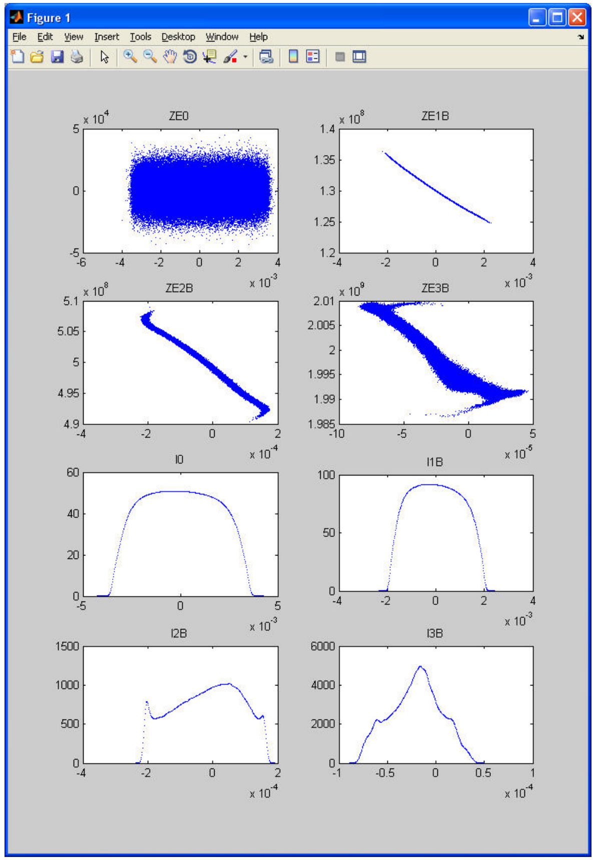
```
C0=1.80;
C1=19.0/C0;
C2=100.0/(C0*C1);
q56_0=0.040;
q56_1=0.110;
q56_2=0.027764039;
```

with wakes & CSR

e0ss =0.68;	e0ss =0.68;	e0ss =0.68;
e0sss=-1.0;	e0sss=0.0;	e0sss=1.0;







$\frac{\hat{I}}{\mathrm{kA}} \approx 5.86$

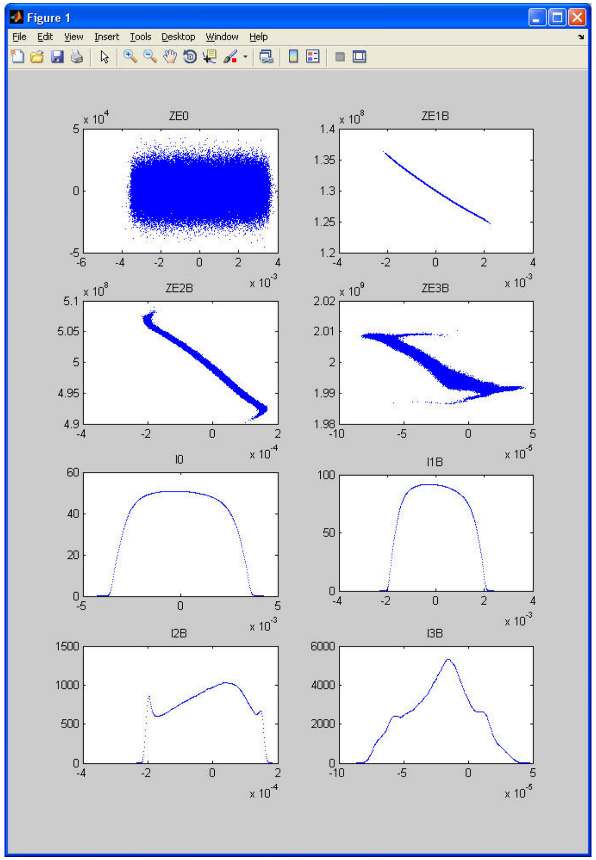
$\frac{\hat{I}}{\mathrm{kA}} \approx 5.33 \quad \frac{\varepsilon_{x,\mathrm{n}}}{\mu\mathrm{m}} = 2.07$

$\frac{\hat{I}}{\mathrm{kA}} \approx 4.96 \quad \frac{\varepsilon_{x,\mathrm{n}}}{\mu\mathrm{m}} = 1.95$

example (1nC)

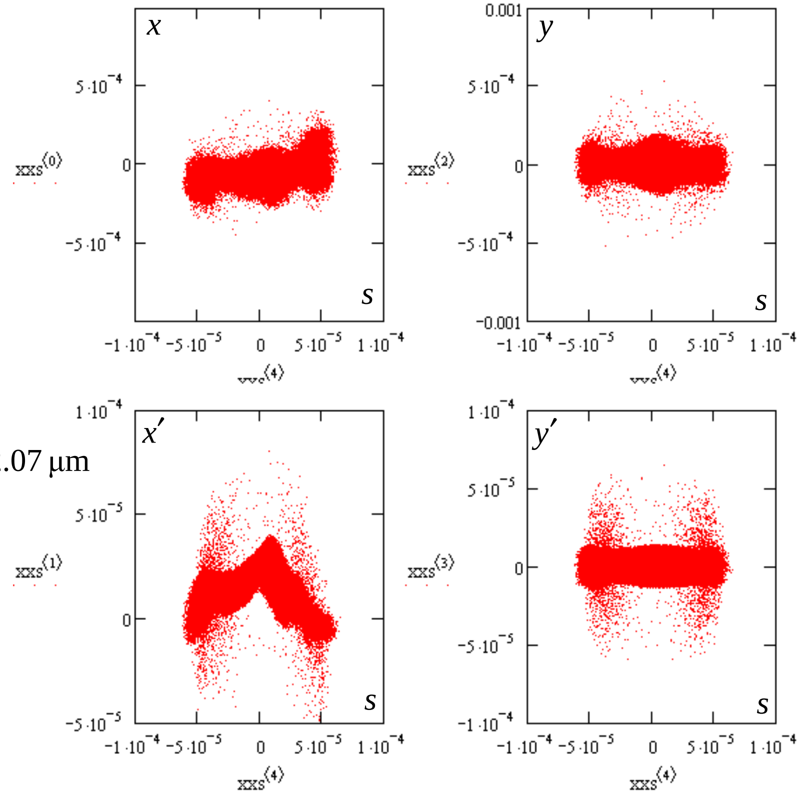
```
C0=1.80;
C1=19.0/C0;
C2=100.0/(C0*C1);
q56_0=0.040;
q56_1=0.110;
q56_2=0.027764039;

e0ss =0.68;
e0sss=0.0;
```

with wakes & CSR



$$\frac{\hat{I}}{\text{kA}} \approx 5.33$$

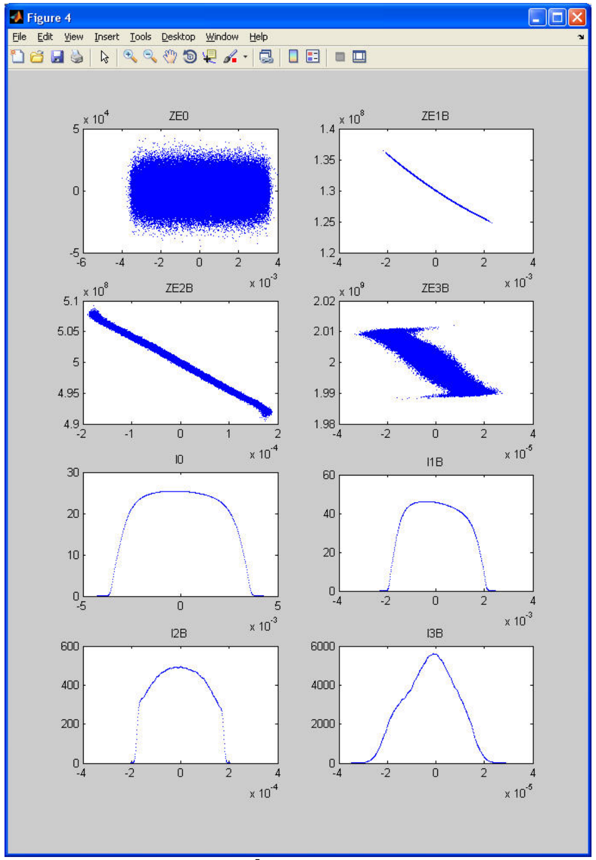
$$\varepsilon_{x,\text{n}} = 2.07\ \mu\text{m}$$



example (0.5nC)

```
C0=1.80;
C1=19.0/C0;
C2=200.0/(C0*C1);
q56_0=0.040;
q56_1=0.110;
q56_2=0.031020315;
```

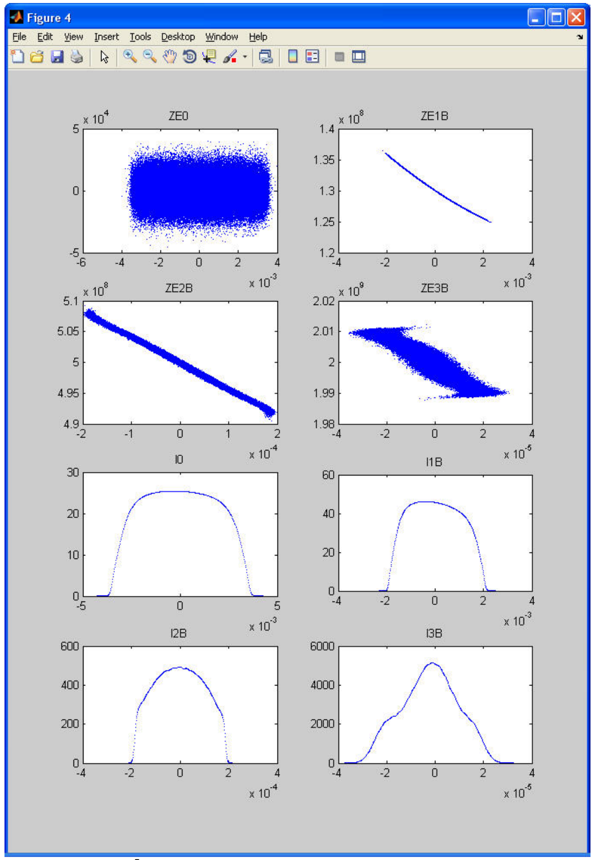
```
e0ss =0.85;
e0sss=0.0;
```



$\frac{\hat{I}}{\mathrm{kA}} \approx 5.60$

with wakes without CSR

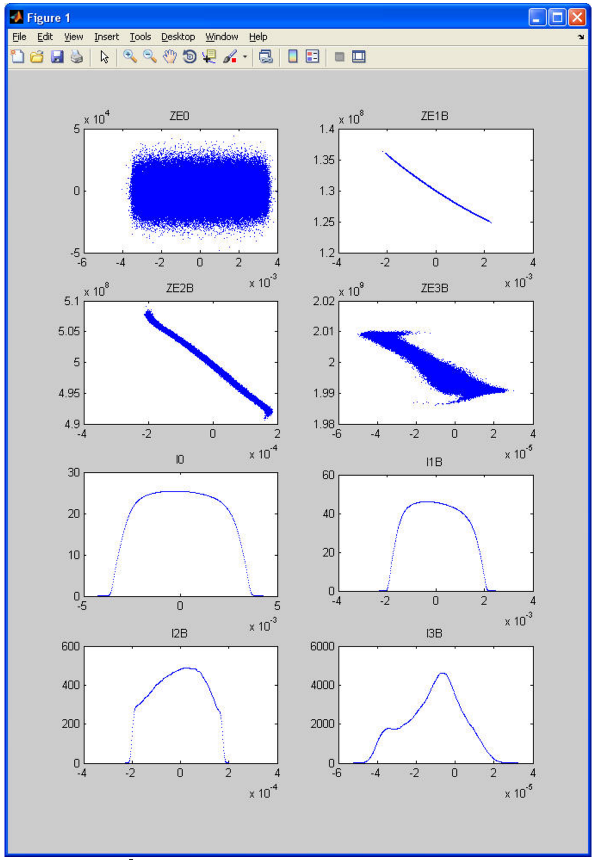
```
e0ss =0.85;
e0sss=1.0;
```



$\frac{\hat{I}}{\mathrm{kA}} \approx 5.15$

with wakes & CSR

```
e0ss =0.78;
e0sss=1.0;
```



$\frac{\hat{I}}{\mathrm{kA}} \approx 4.62 \qquad \varepsilon_{x,n} = 2.16\,\mu\mathrm{m}$

some remarks

its is easy to find working points (on the computer)

slight rollover of tails

same peak current with 0.5 nC:

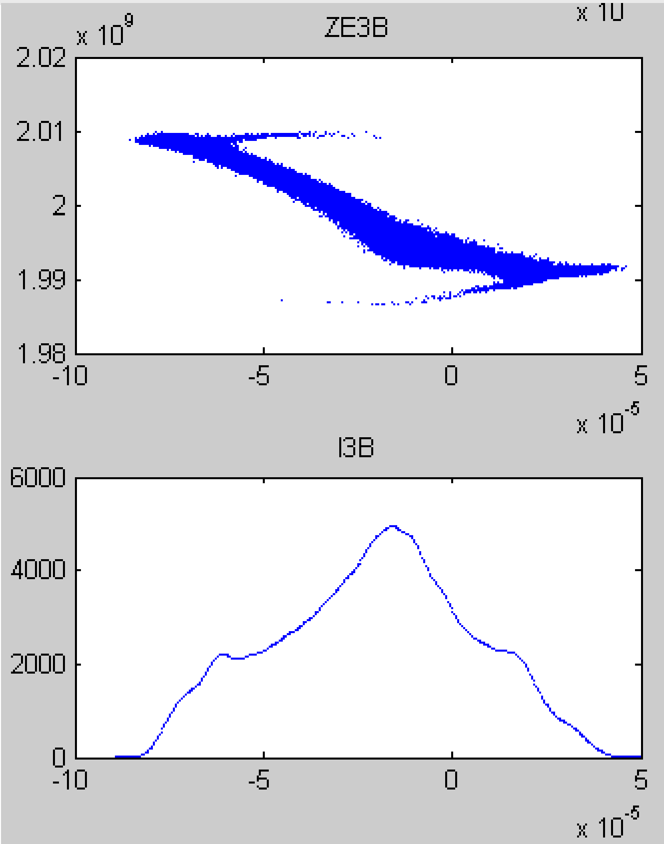
- reduce effects before BC3 $\rightarrow$ double BC3 compression
- tighter tolerances
- same LH power $\rightarrow$ twice uncorrelated energy spread
- same energy spread $\rightarrow$ $\approx$ increased µB-gain
- stronger CSR effects in BC3

$$E_{\mathrm{CSR}} \propto \frac{q}{\sigma^{4/3}} \propto \frac{I}{\sqrt[3]{\sigma}}$$

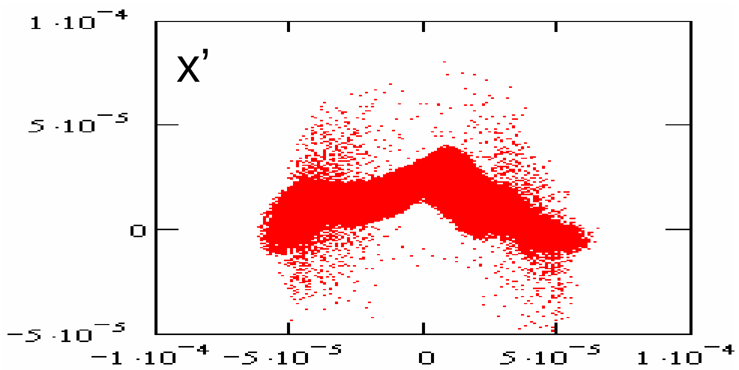
(steady state, R ~ const, same peak current)

- effects after BC3 are not decreased / might be increased

1.0nC

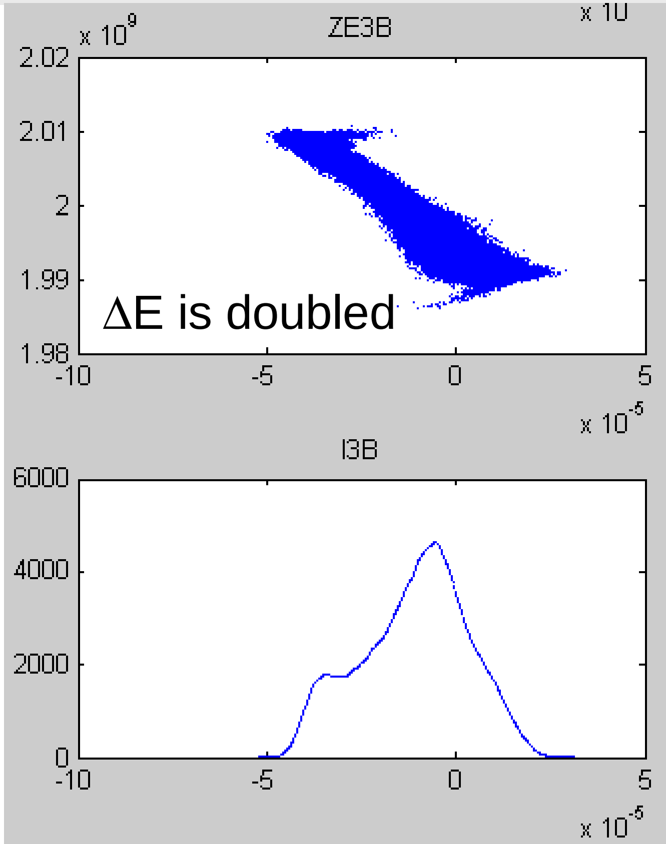


ZE3B
x 10^9
2.02
2.01
2
1.99
1.98
-10
-5
0
5
x 10^-5
I3B
6000
4000
2000
0
-10
-5
0
5
x 10^-5

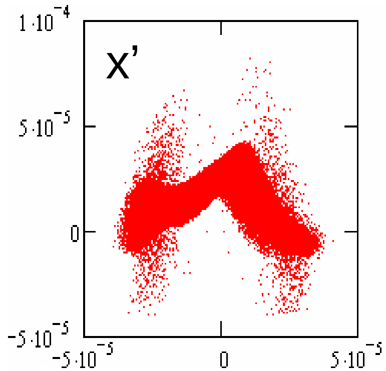


x'
1·10^-4
5·10^-5
0
-5·10^-5
-1·10^-4
-5·10^-5
0
5·10^-5
1·10^-4

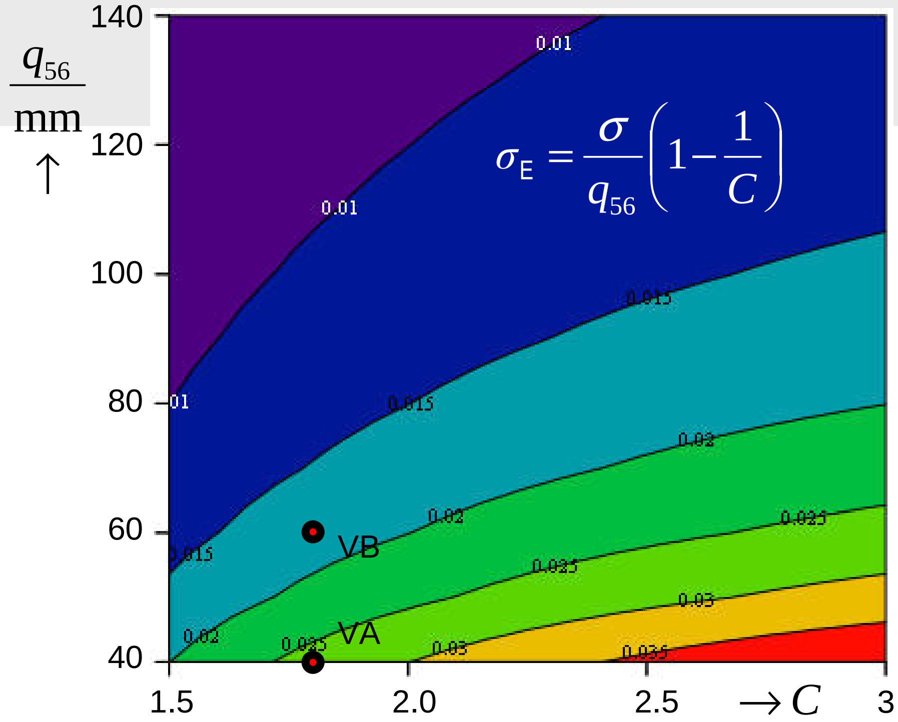
0.5nC



ZE3B
x 10^9
2.02
2.01
2
1.99
1.98
ΔE is doubled
-10
-5
0
5
x 10^-5
I3B
6000
4000
2000
0
-10
-5
0
5
x 10^-5



x'
1·10^-4
5·10^-5
0
-5·10^-5
-5·10^-5
0
5·10^-5



	q56 /mm	C	σE *100	tol. *1000	V3.9 MV	end-chirp MV@1σ	noise A
VA	40	1.8	2.7	0.758	30.2	7.4	73
VB	60	1.8	1.8	0.57	30.9	7.4	125

0.5 nC working point

VA-h	40	1.8	2.7	0.39	31	7.4	130
CB-h	60	1.8	1.8	0.313	32	7.5	190

same energy spread
C_tot*ΔE_LH