CT line commissioning

C. Biscari

CTF3 collaboration meeting – 23-25 November 2004 - CERN

TEAM

LNF

Alesini, Benedetti, Biscari, Castellano, Drago, Filippetto, Ghigo, Marcellini, Milardi, Preger, Sgamma, Serio, Zobov

CERN

Corsini, Lefevre, Tecker, …

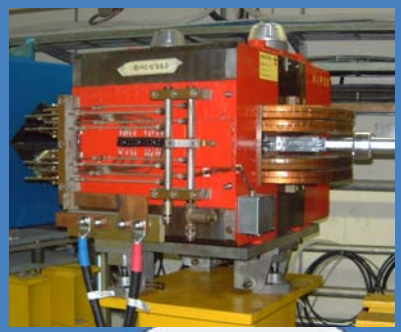
CT installation and alignmnent

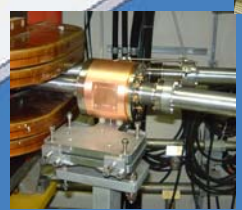
- Started at Linac completion – about 1 month
- Francesco Sgamma with three people in average

Alignment to be completed:

(mm)	$\Delta s <$	$\Delta x <$	$\Delta y <<$
Dipoles	0.3	0.2	0.1
Quads		0.2	0.1

1/3 of present LNF part



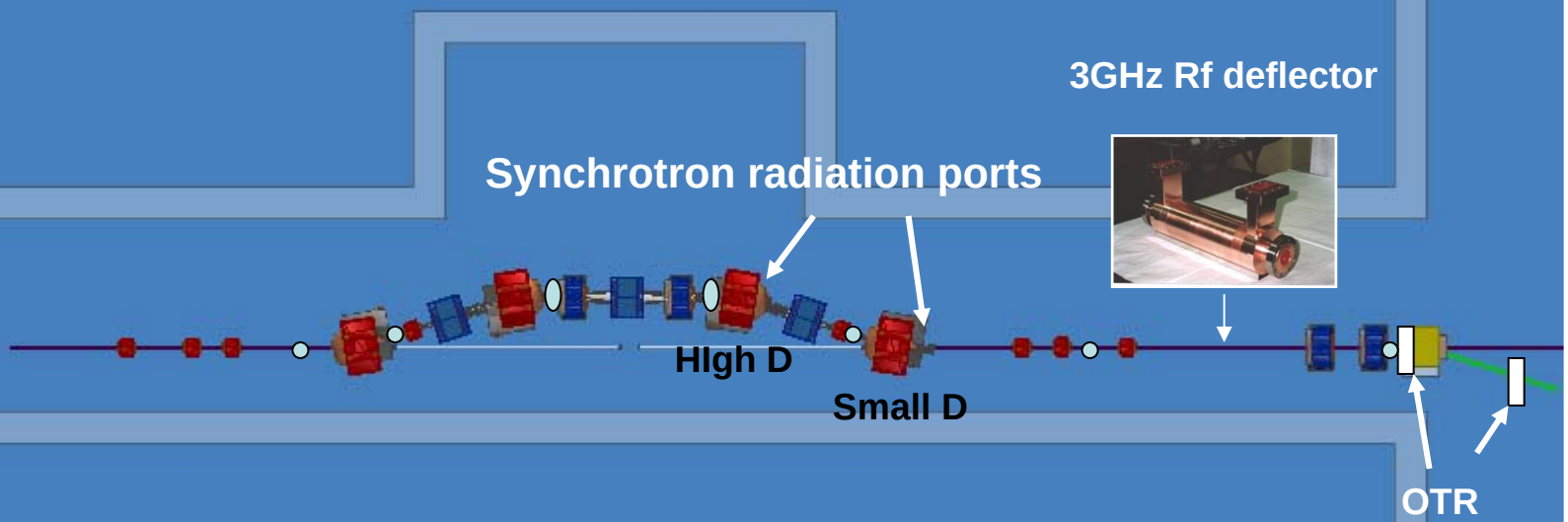


Stretcher – Compressor Chicane Layout

CT commissioning schedule

Week	Date	Dedicated time (days)	2-3 LNF people per week
40	29-30 Sept	2	First beam in the chicane
41	4-9 October	2	Beam through bypass Emittance measurements, quad scans Rf deflector on – phase scan at bpm
42	11-15 October		BPI, SLM installation Software
43	18-22 October	2	Beam through bypass Beam through chicane Check of dispersion function
44	25-29 October	1	Emittance measurements
45	1-5 November	2.5	Beam through bypass Check of BPIs Bunch length measur after bypass
46	8-12 November	2.5	Bunch length measurements with different R56 setups

CT line diagnostics



BPM

BPI

R_{56} tuning

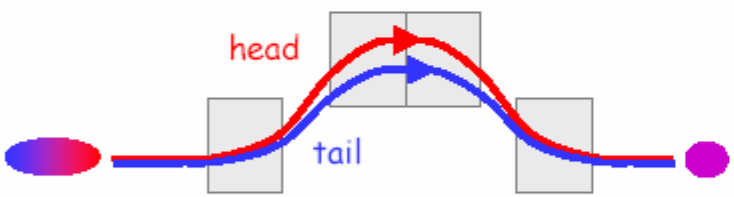
$-0.5\ m < R_{56} < 0.5\ m$

Magnetic bunch compression (stretching)

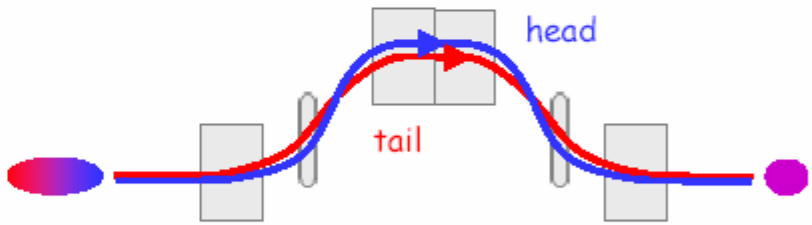
$$c\,\Delta t = R_{56}\,\Delta p/p$$

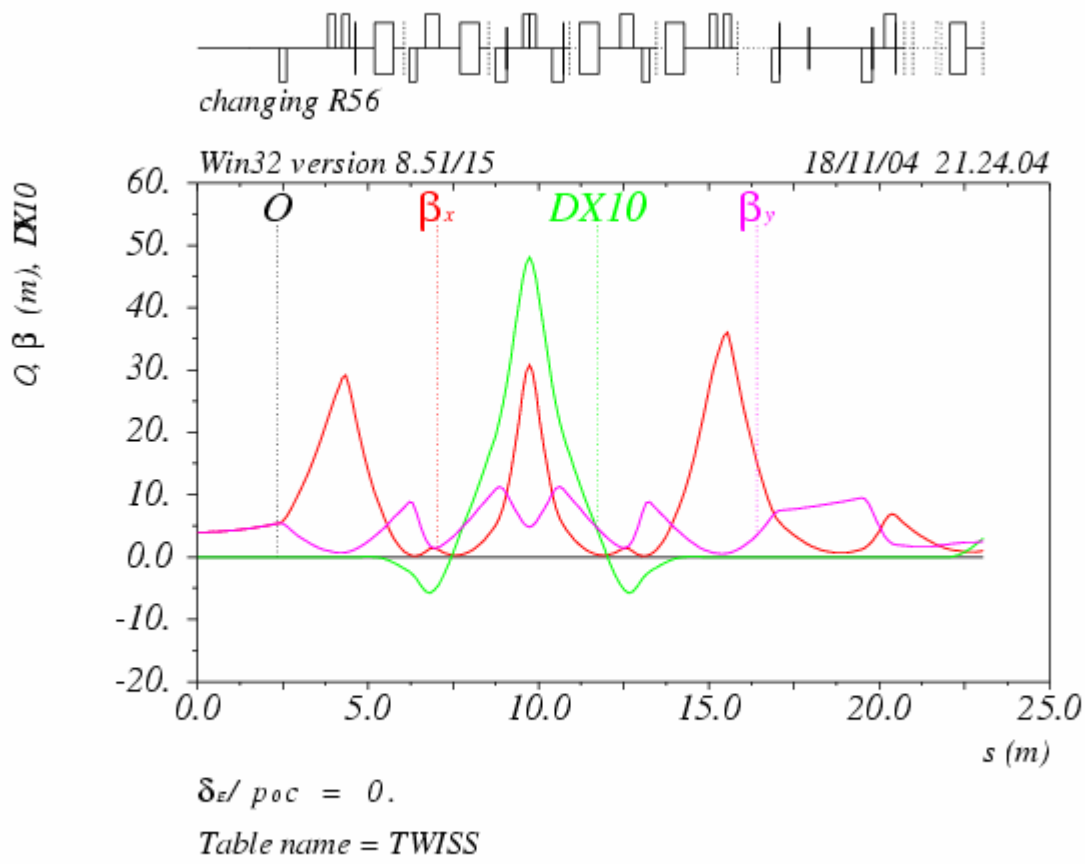
$$R_{56} = \int \frac{D}{\rho}\,\mathrm{d}s$$

$R_{56} > 0$



$R_{56} < 0$




changing R56
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18/11/04 21.24.04
O
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Q, β (m), DX10
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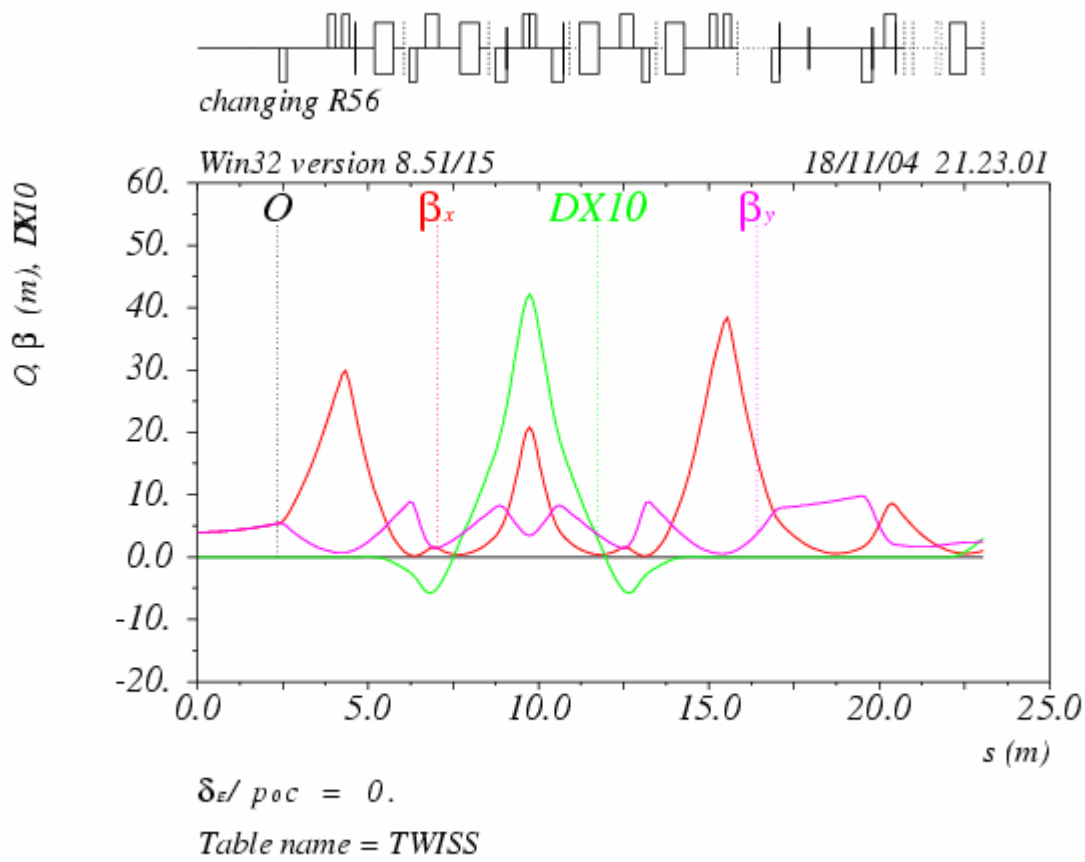
s (m)
δE/ poc = 0.
Table name = TWISS

-0.5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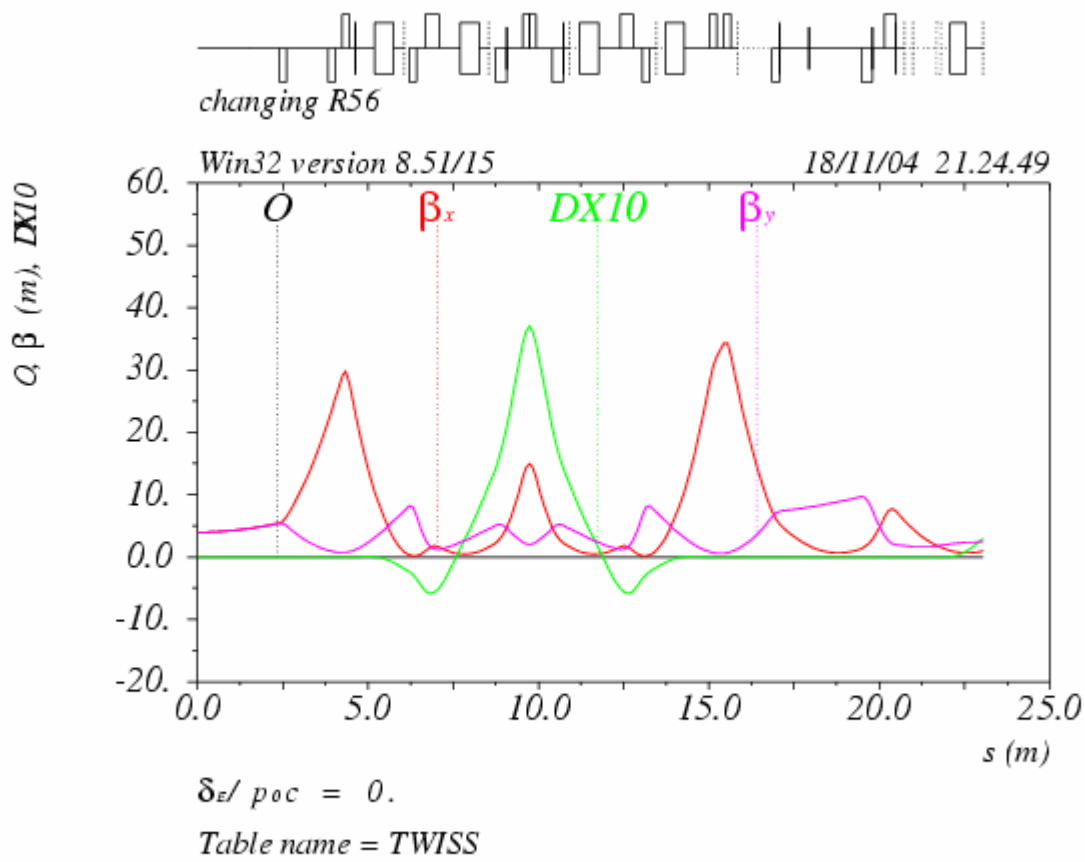
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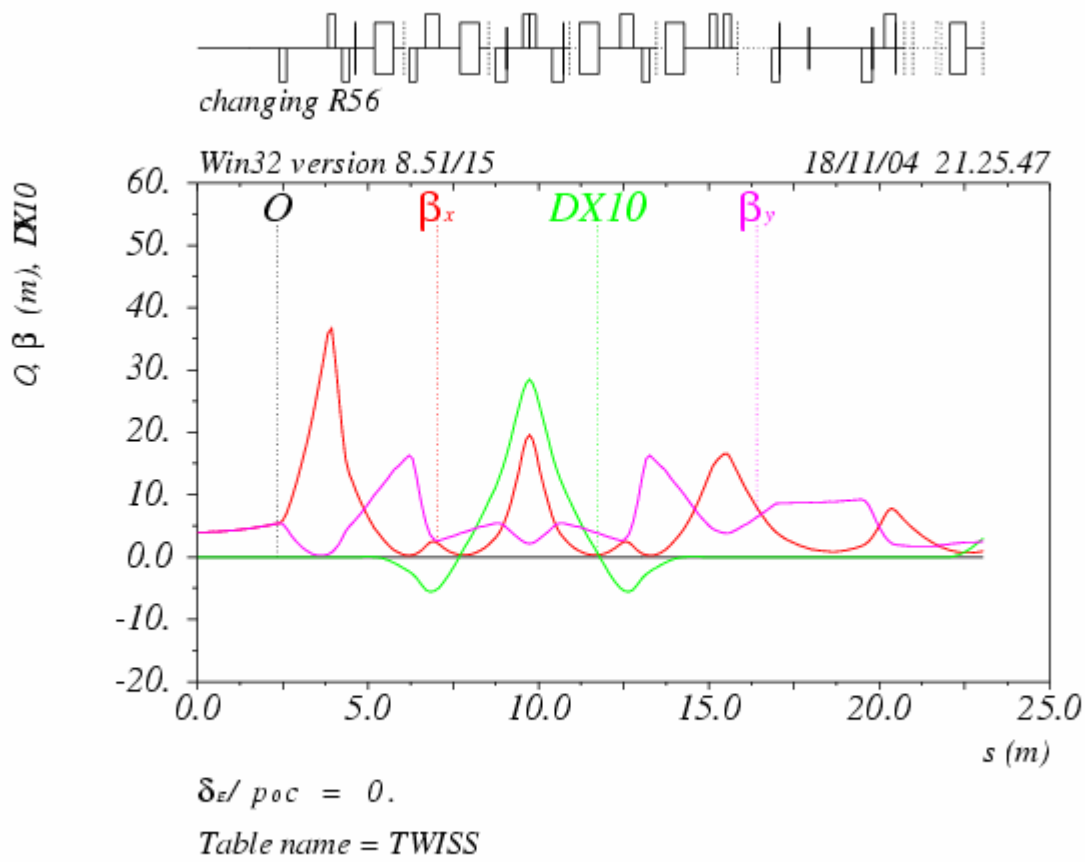
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Table name = TWISS

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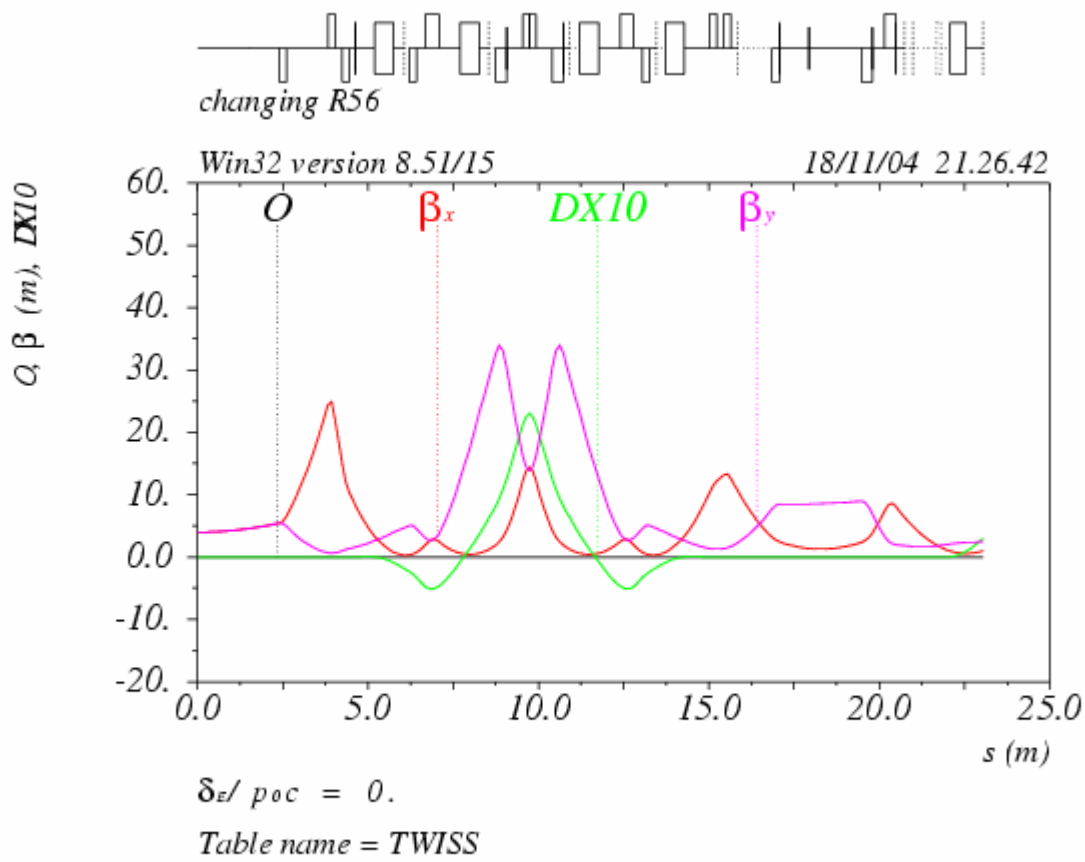
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Table name = TWISS

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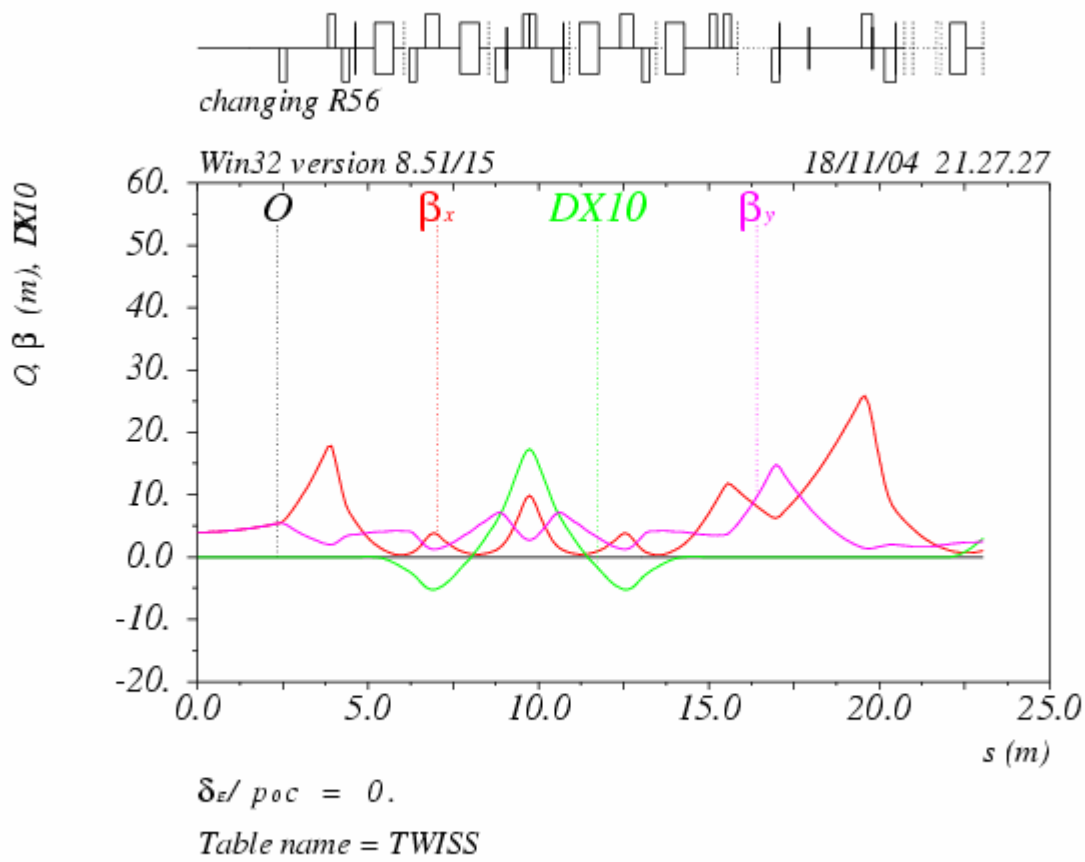
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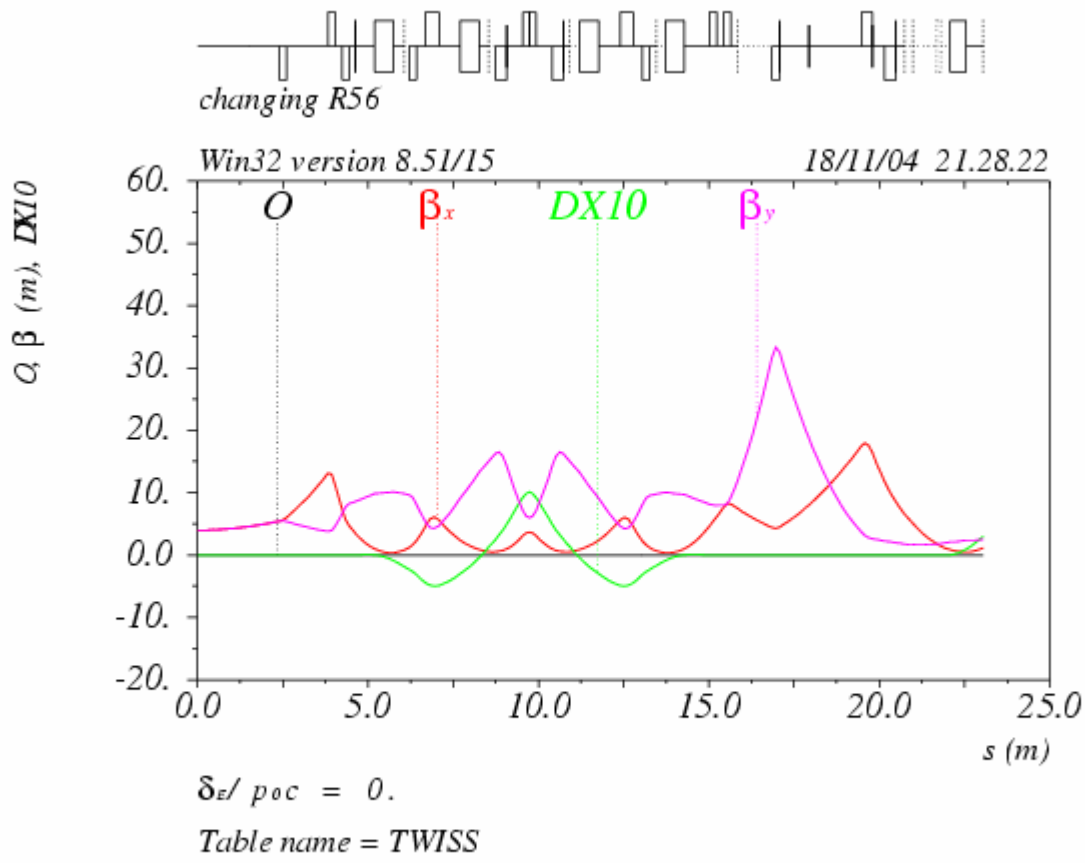
Table name = TWISS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s (m)
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Table name = TWISS

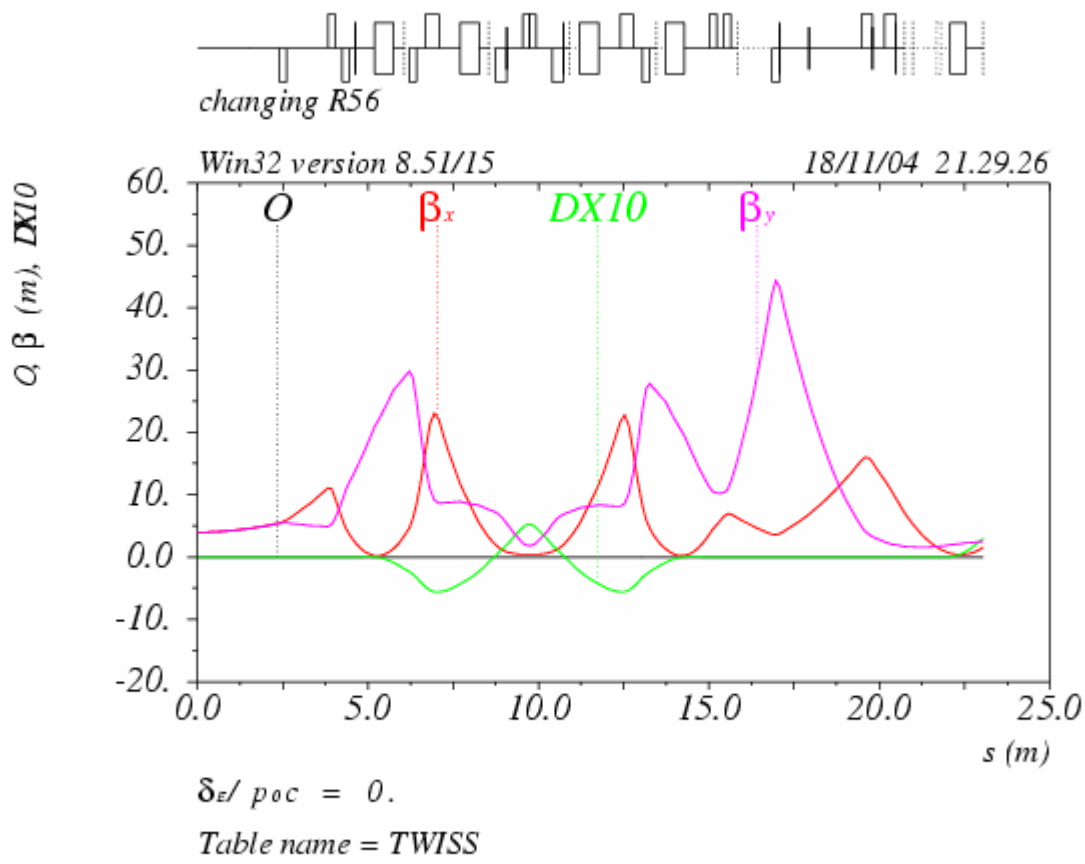
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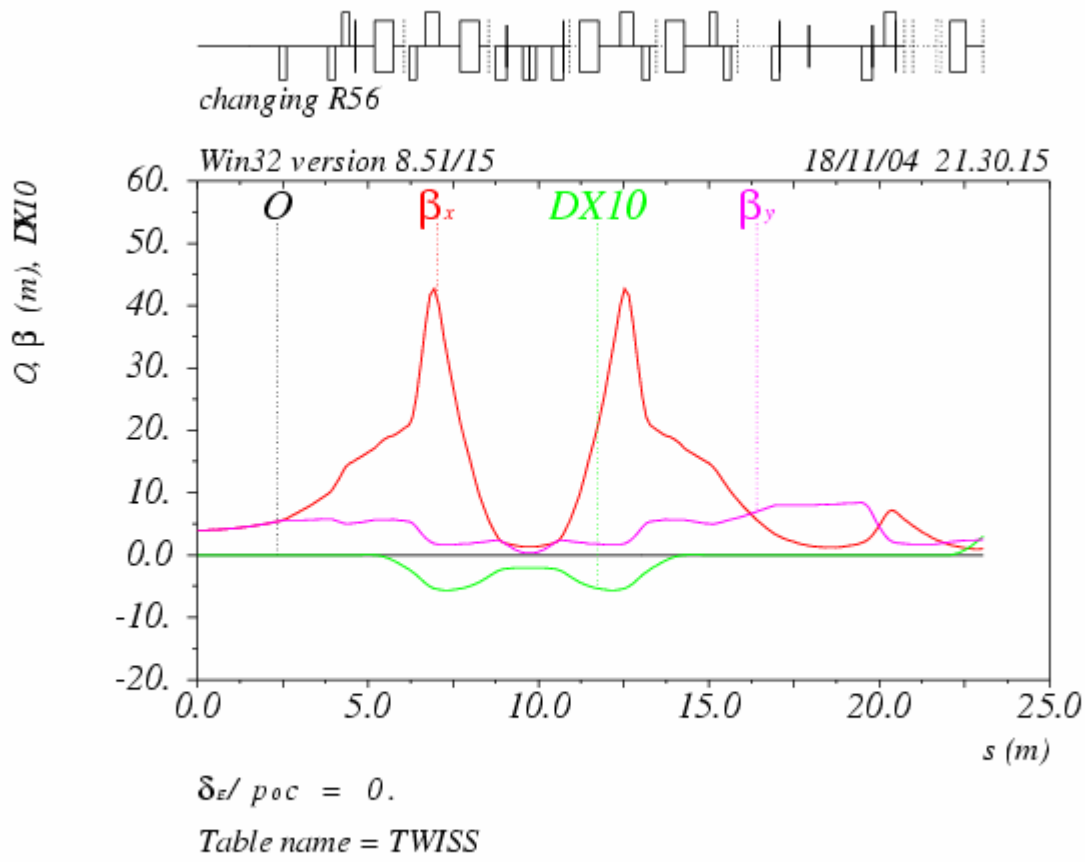
Table name = TWISS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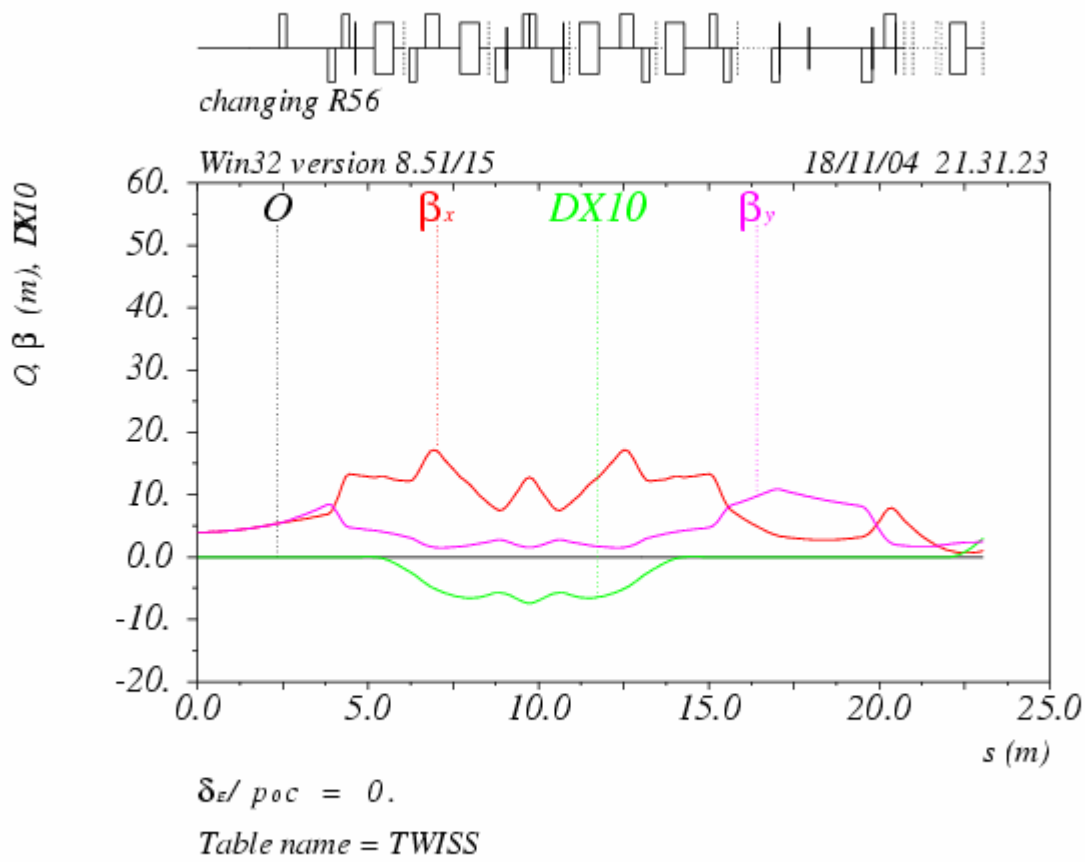
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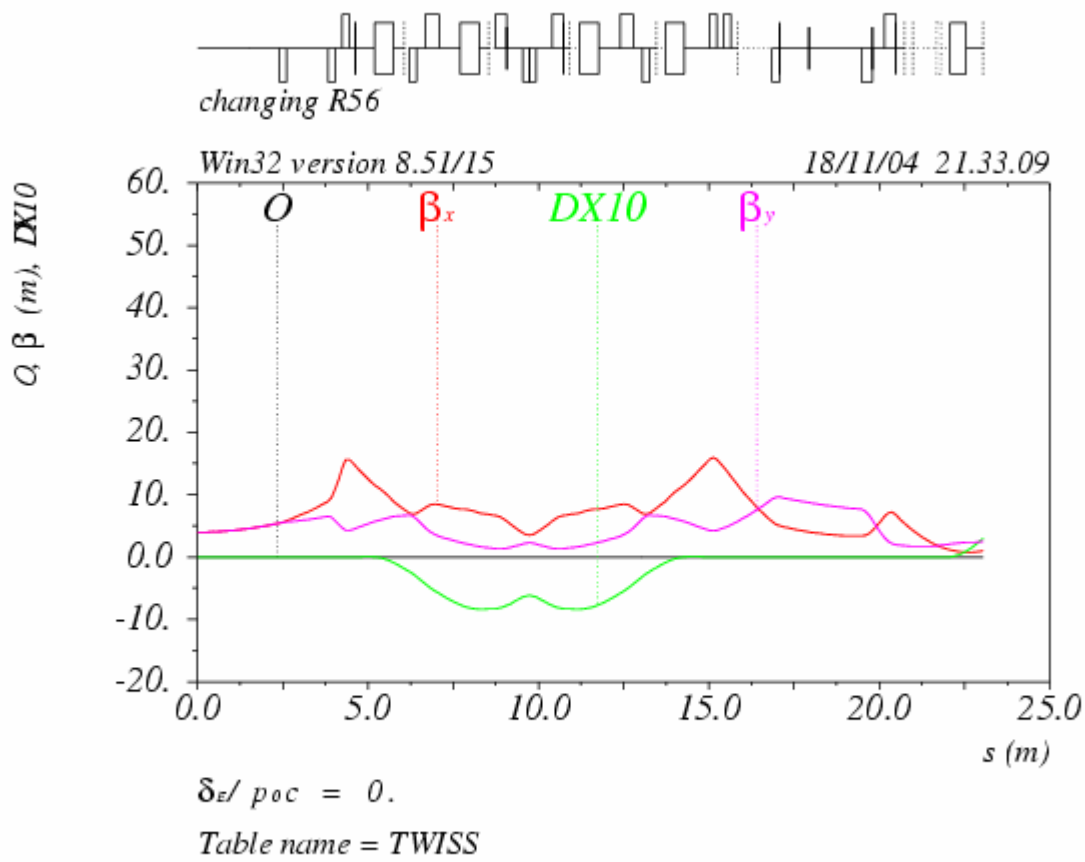
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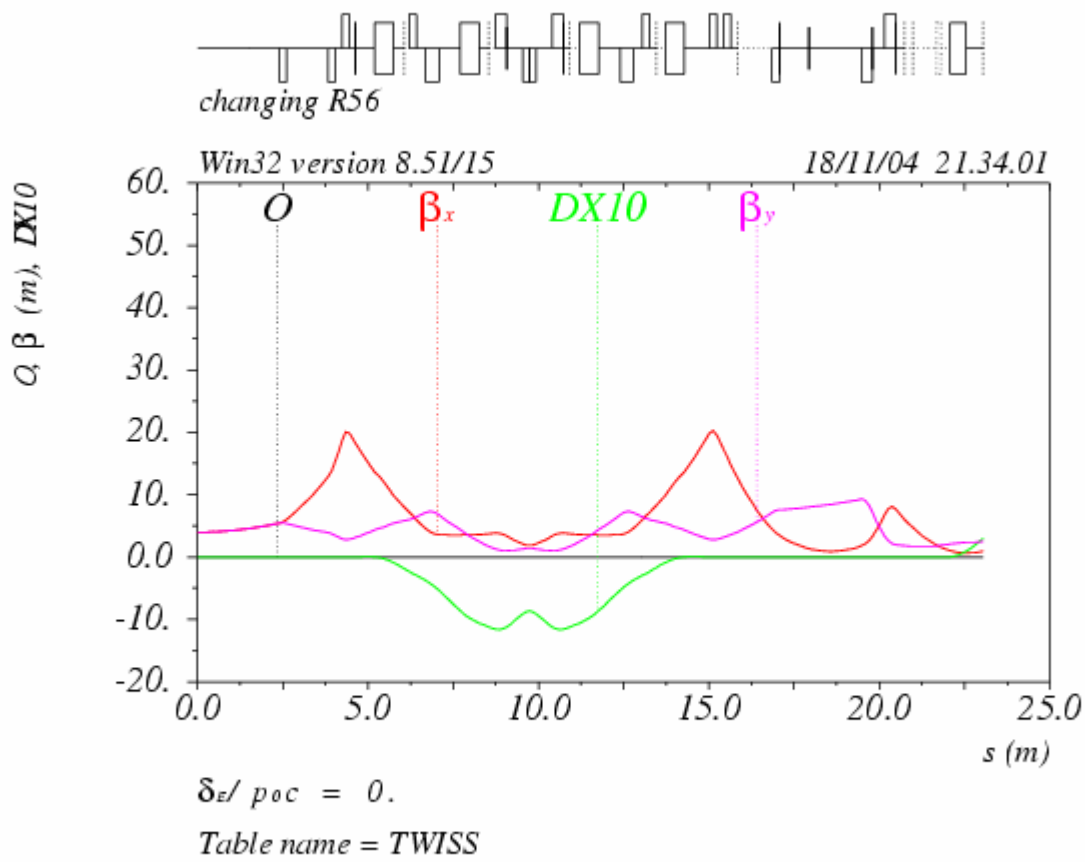
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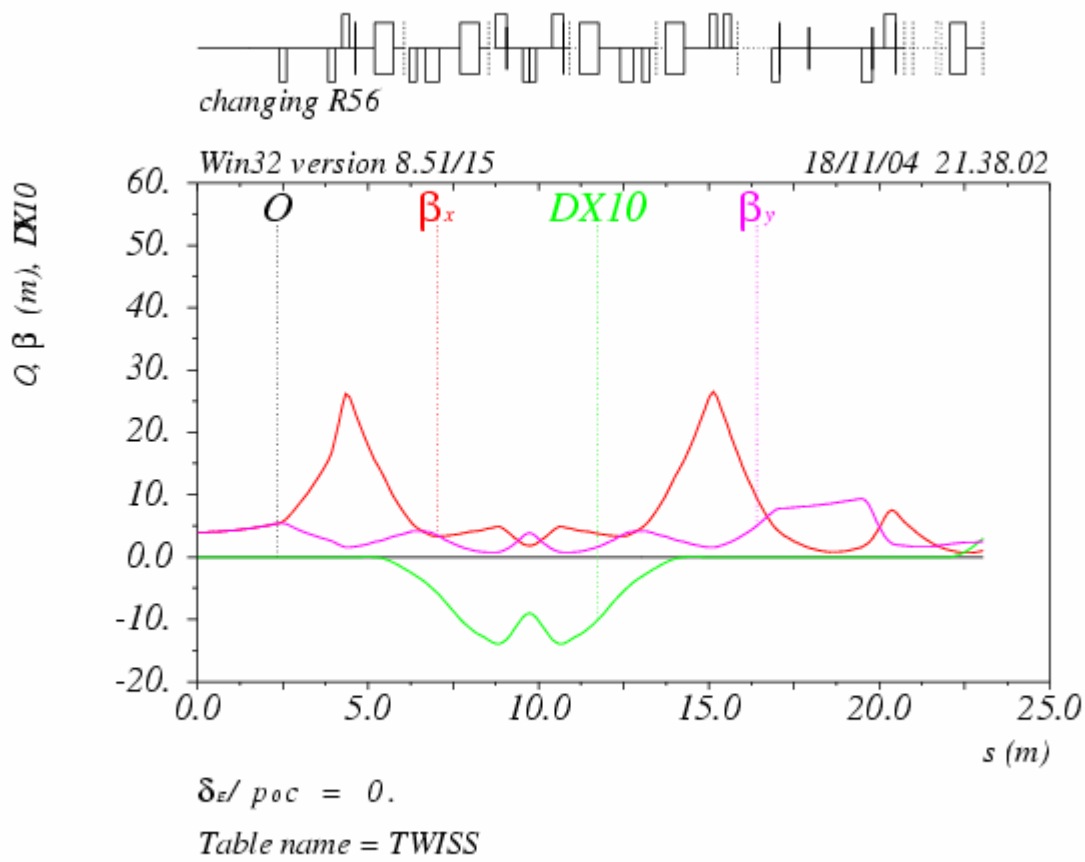
s (m)
δE/ poc = 0.
Table name = TWISS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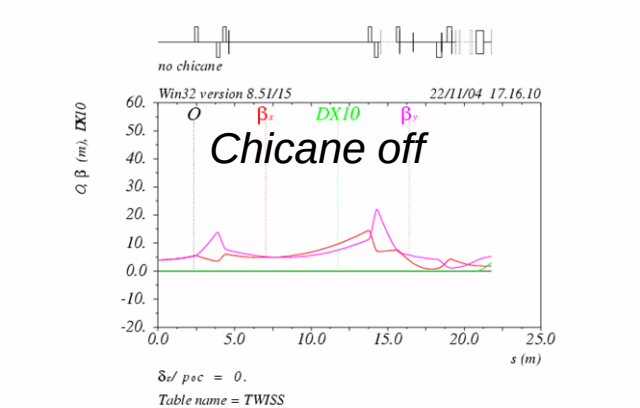
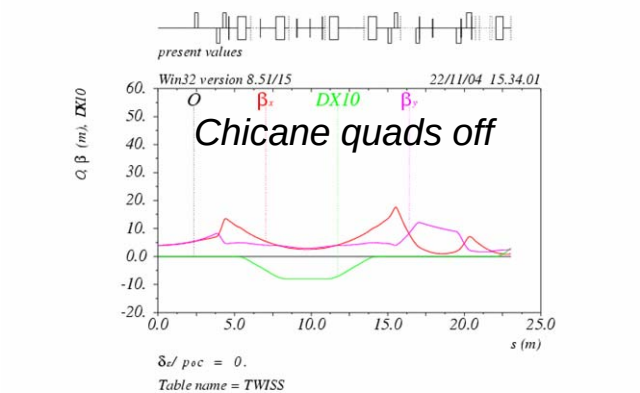
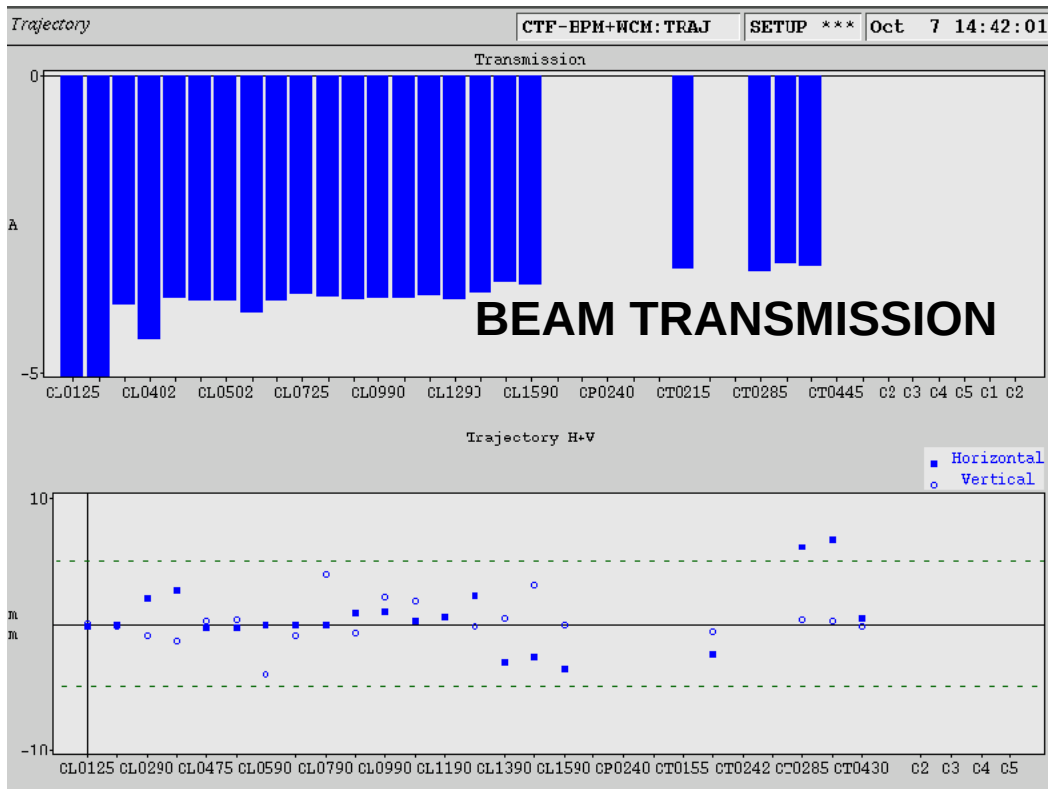
s (m)
δE/ poc = 0.
Table name = TWISS

First tests with the beam

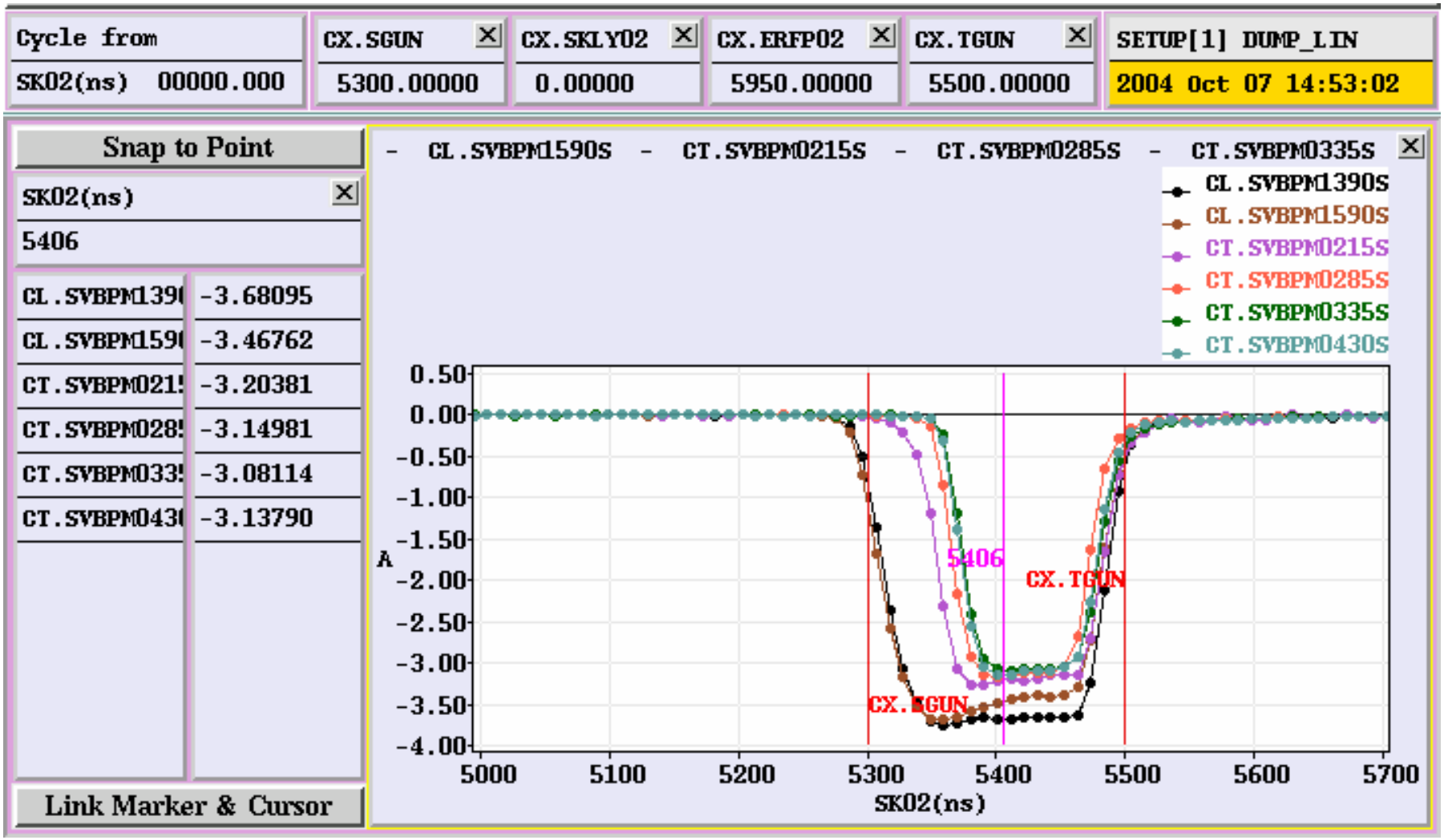
- Dipole polarities
- BPMs calibrations
- Synchrotron radiation ports and OTRs







2 – Beam transport through CT line – BPM signals vs. time



Synchrotron radiation monitors

High dispersion point -

- **1 mirror**
- **Reflections from the line behind gives background**
- **Camera spoiled by radiation**
- **Need of more mirrors and thin slits**

Low dispersion point

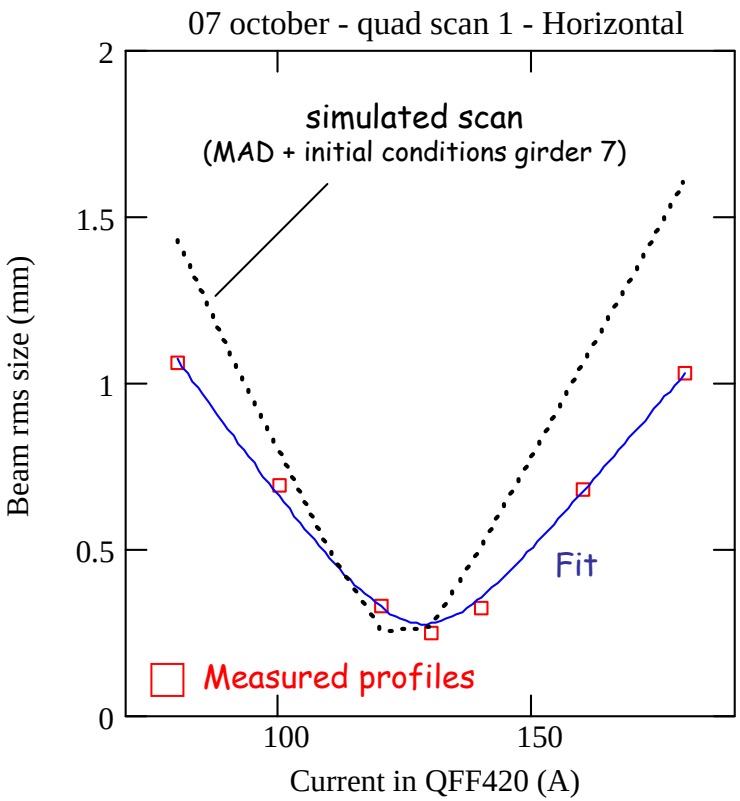
- **2 mirrors**
- **Less radiation**
- **Installed a slit but not well aligned.**
- **Need of better alignment, obscuring of the vacuum chamber, more mirrors**

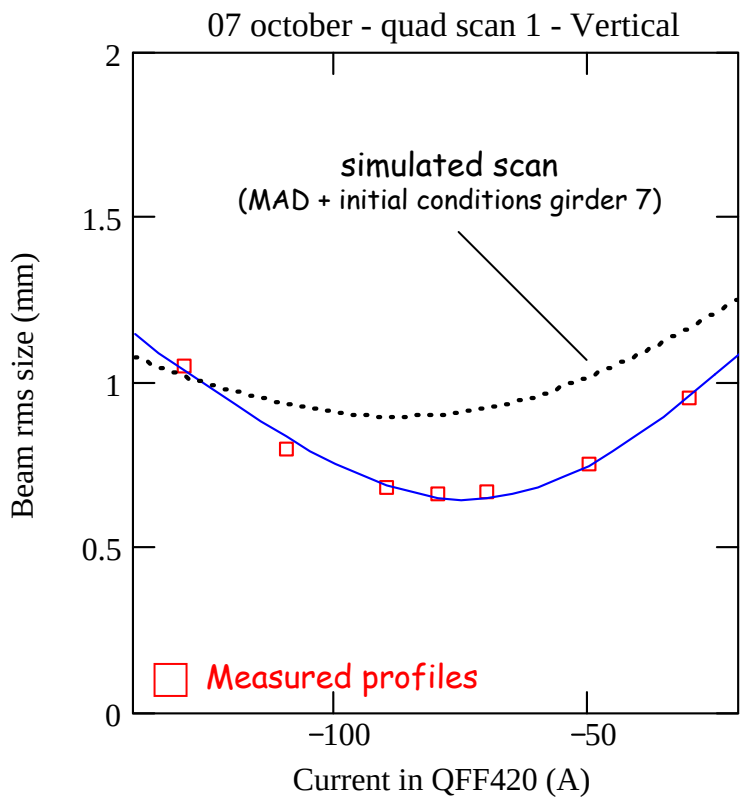
OTRs

- **On the straight line - MT0435**
- **Two screens : Al and C**
- **Al : for low intensity beam, used at the very beginning for first passage of the beam**
- **C: used for bunch length and emittance measurements**

- **After the spectrometer – MT0455**
- **Dispersion not too high (0.5 m)**
- **Need of increasing the distance between dipole and screen for higher D**
- **Problems with the flatness of the screen**

3 – Emittance and twiss function measurements on MT0435

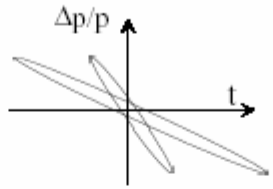




Optimizing the bunch length in CTF3

DBA

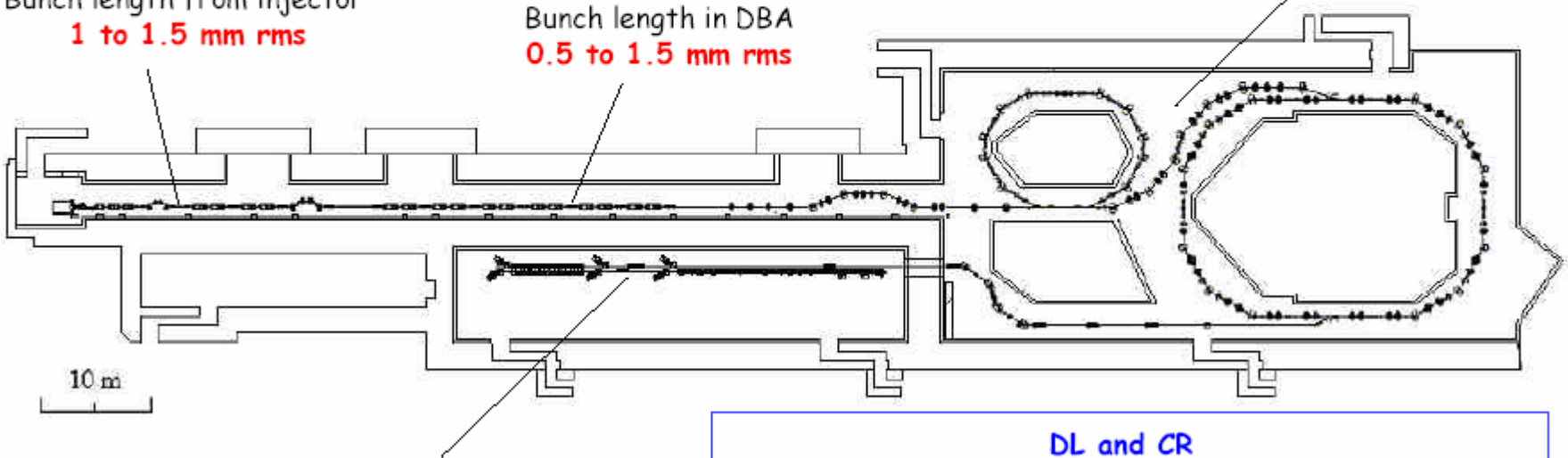
short bunches are good for transverse stability
& larger correlation for the same total energy spread



Bunch length in DL and CR
~ 2 mm rms

Bunch length from injector
1 to 1.5 mm rms

Bunch length in DBA
0.5 to 1.5 mm rms



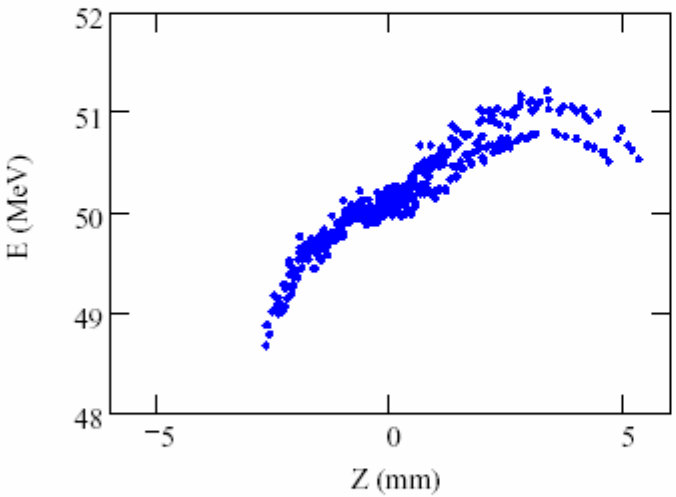
Bunch length needed for 30 GHz
power production
~ 0.5 mm rms

DL and CR

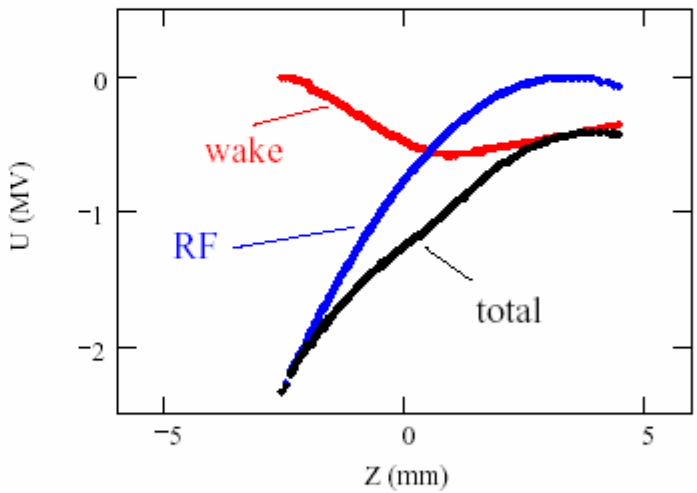
long bunches are good to avoid CSR and impedance effects
max bunch length limited by injection with RF deflectors
energy spread limited by the momentum acceptance of the
ring and the transfer lines

Phase space before the compression chicane

(2) The beam is accelerated in a first linac section. A correlated energy spread is introduced by the combination of off-crest acceleration and short-range wake-field.



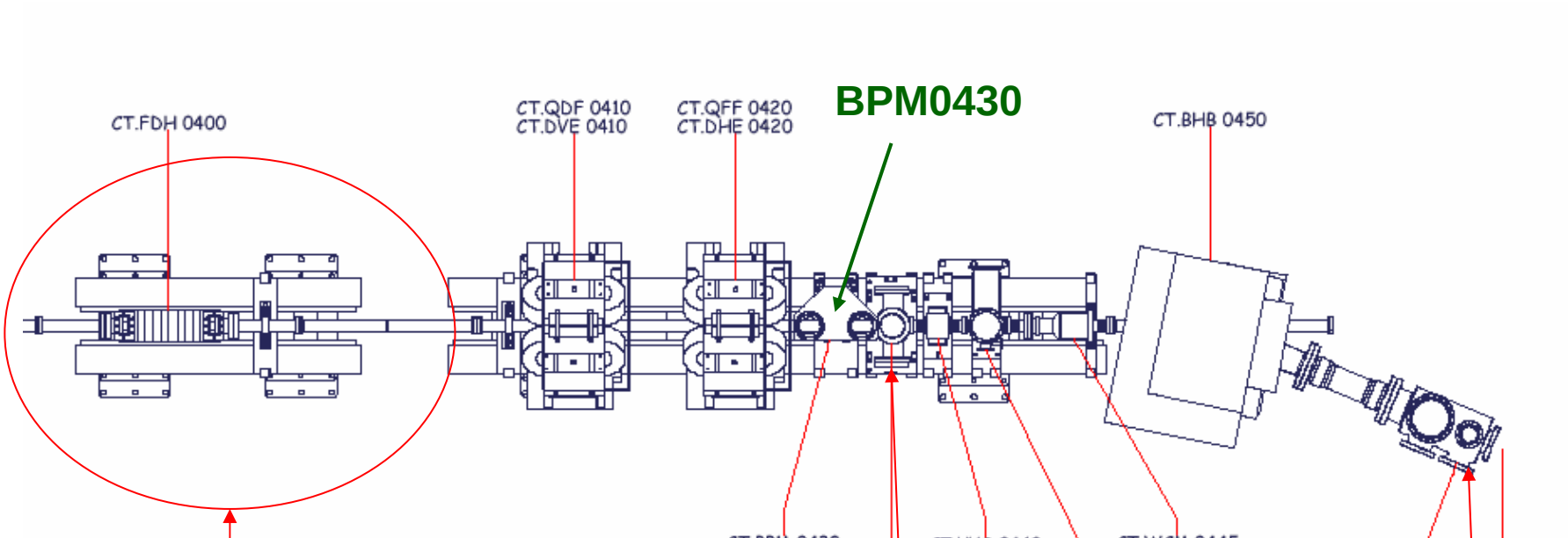
Longitudinal phase space distribution before the compression chicane



Longitudinal short-range wake-field in the linac and RF field

(-11° off-crest)

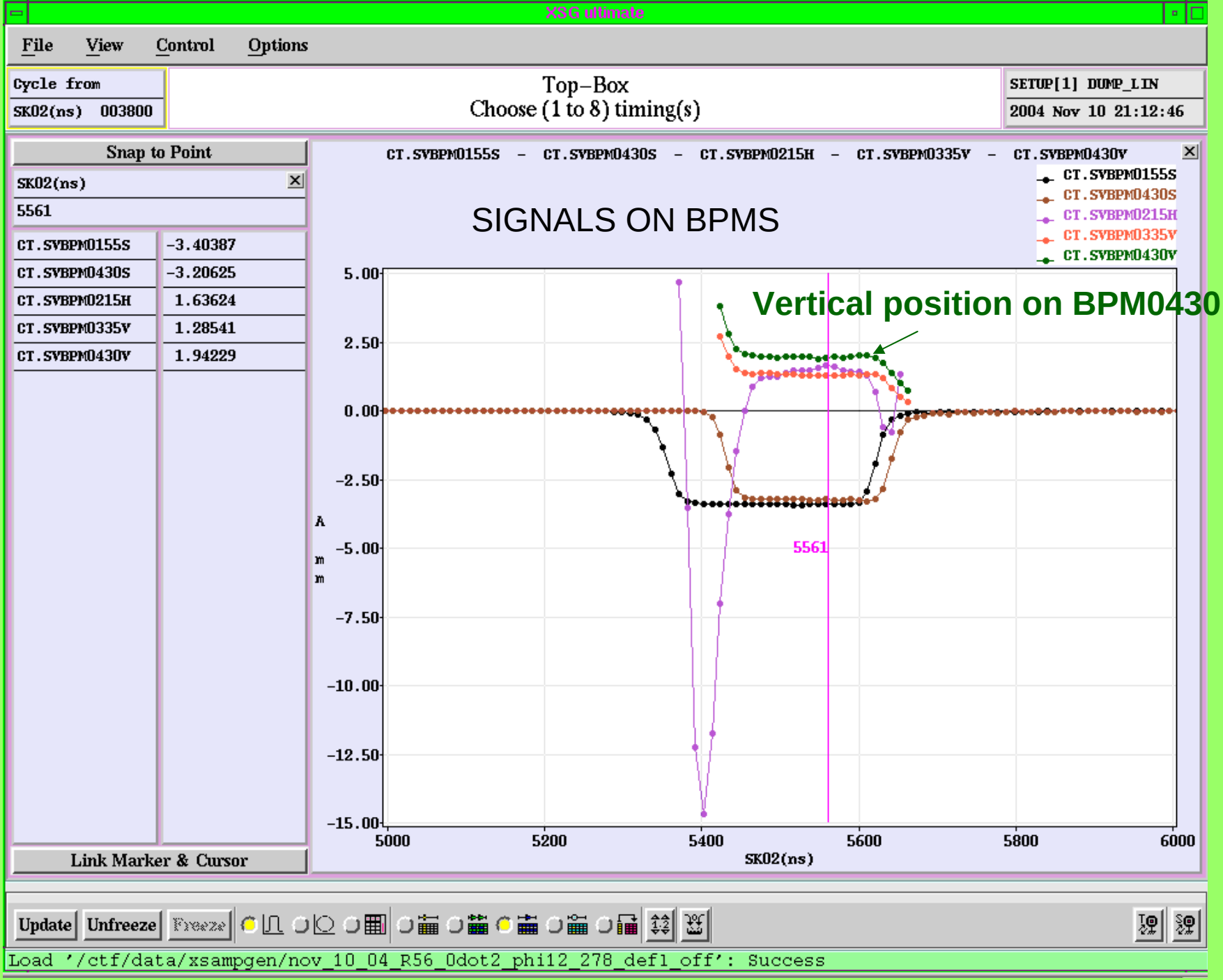
Bunch length measurement set-up



3GHz Rf deflector
Used in CTF3 preliminary phase

OTR – MTV0435

OTR – MTV0455


XSG ultimate
File
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SK02(ns) 003800
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SETUP[1] DUMP_LIN
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SK02(ns)
5561
CT.SVBPM0155S -3.40387
CT.SVBPM0430S -3.20625
CT.SVBPM0215H 1.63624
CT.SVBPM0335V 1.28541
CT.SVBPM0430V 1.94229
Link Marker & Cursor
CT.SVBPM0155S – CT.SVBPM0430S – CT.SVBPM0215H – CT.SVBPM0335V – CT.SVBPM0430V
SIGNALS ON BPMS
Vertical position on BPM0430
5.00
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0.00
-2.50
-5.00
-7.50
-10.00
-12.50
-15.00
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5200
5400
5600
5800
6000
SK02(ns)
Update
Unfreeze
Freeze
Load '/ctf/data/xsampgen/nov_10_04_R56_0dot2_phi12_278_def1_off': Success

Image on MTV0435 – rf deflector off

Image on MTV0435 – rf deflector off

Image on MTV0435 – rf deflector off

Image on MTV0435 – rf deflector off

Image on MTV0435 – rf deflector off

Image on MTV0435 – rf deflector on

Image on MTV0435 – rf deflector on

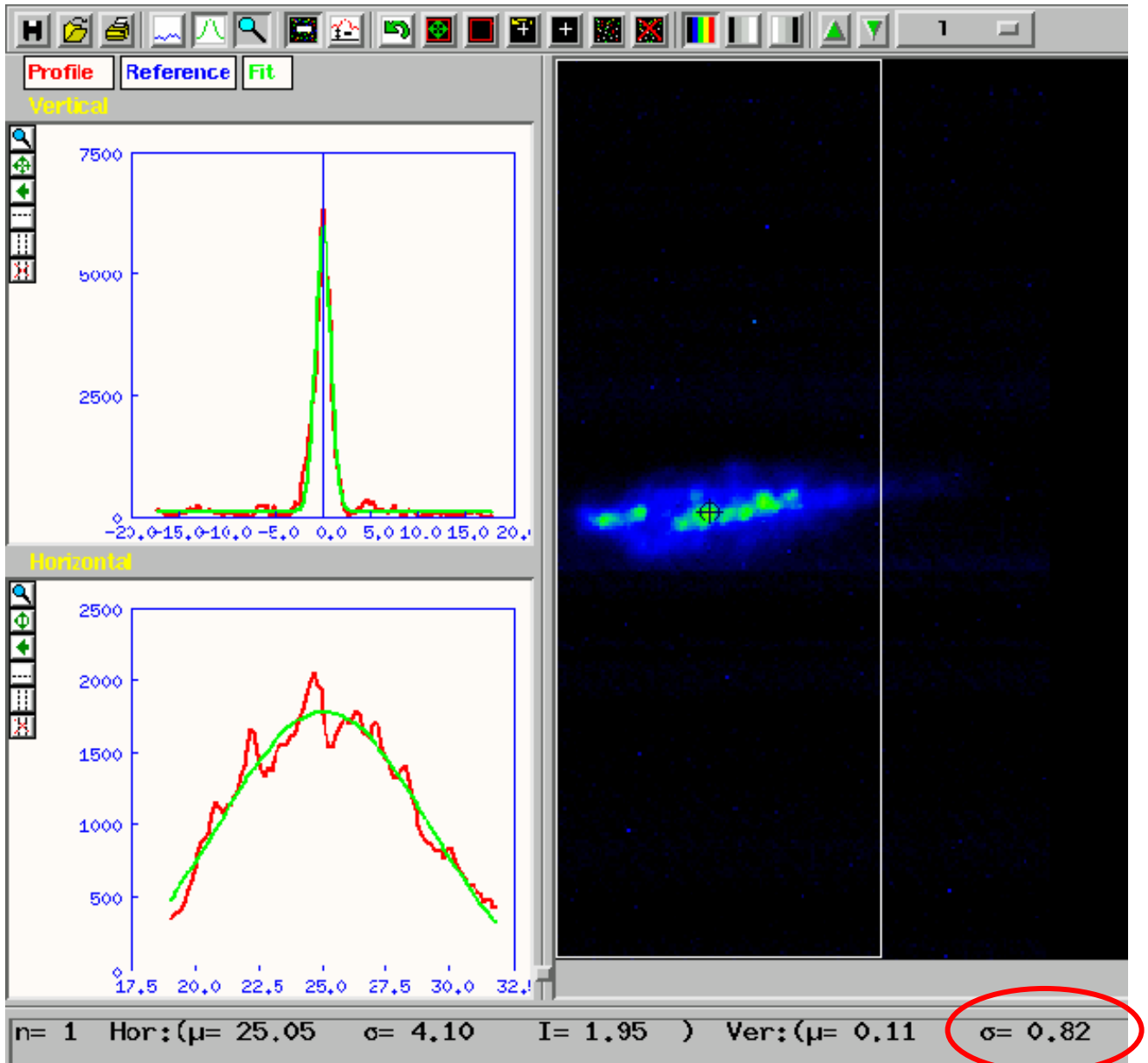
Image on MTV0435 – rf deflector on

Image on MTV0435 – rf deflector on

Image on MTV0435 – rf deflector on

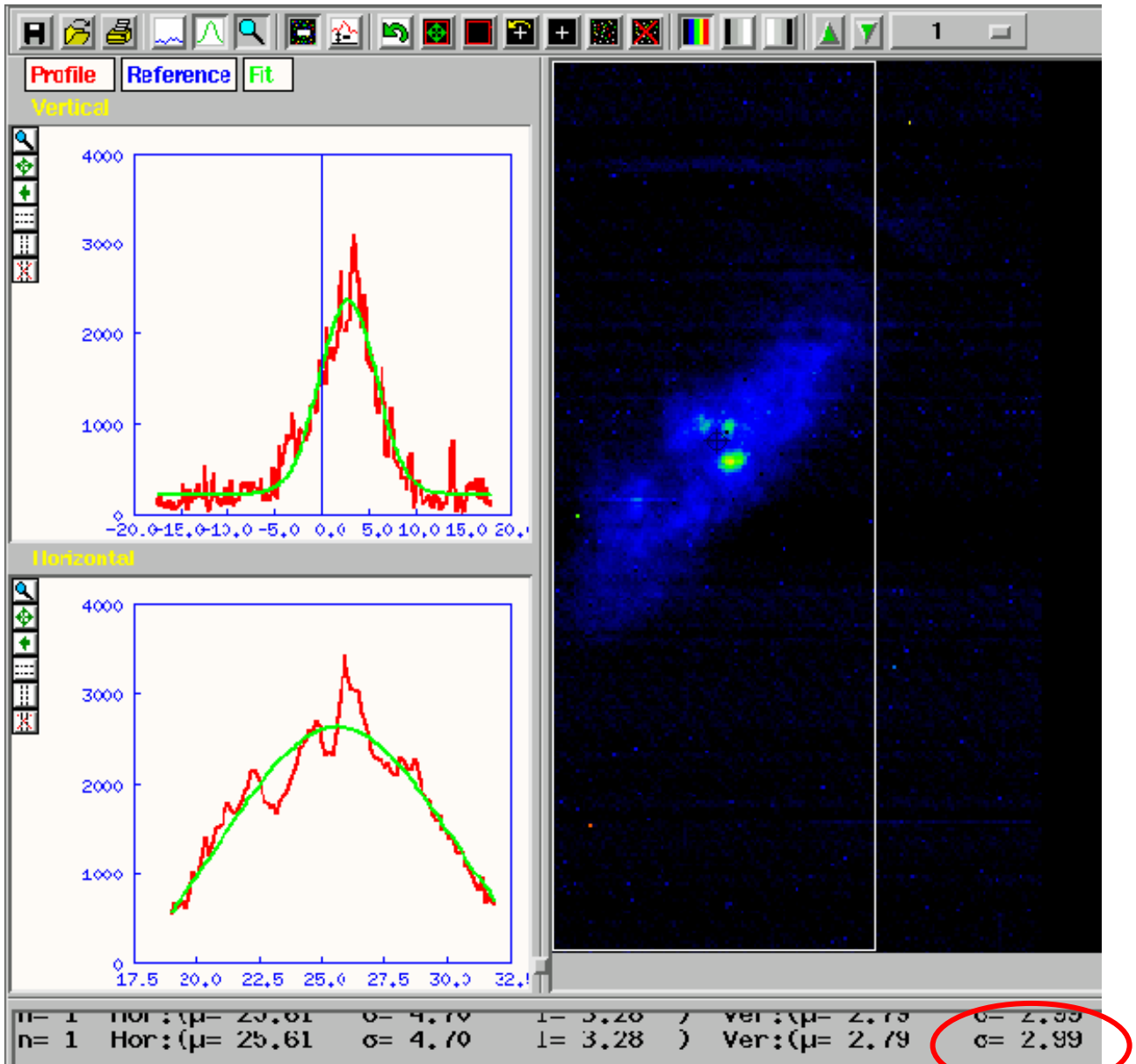
RF deflector

Beam in screen MTV 435, with RF deflector off

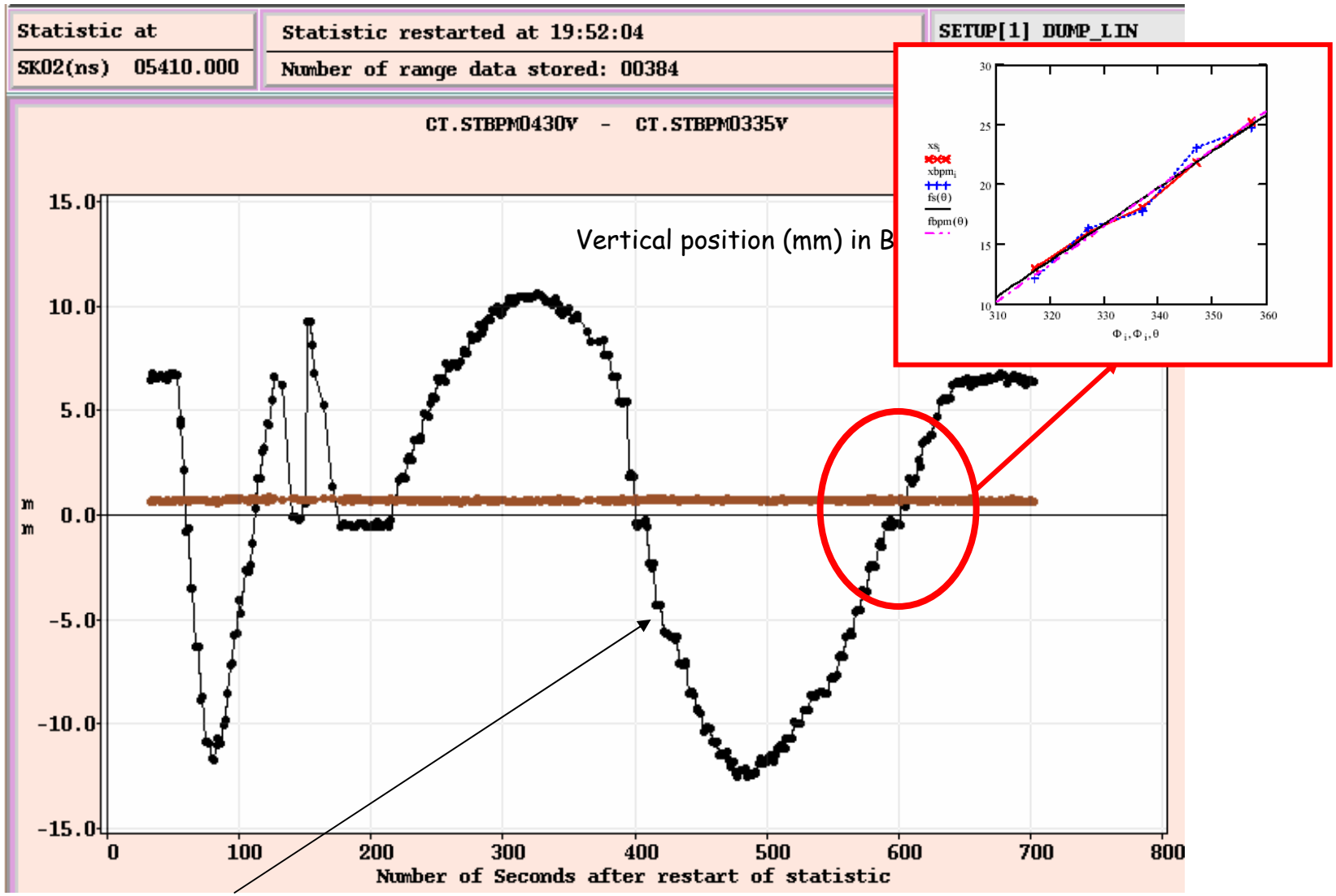


RF deflector

Beam in screen MTV 435, with RF deflector on

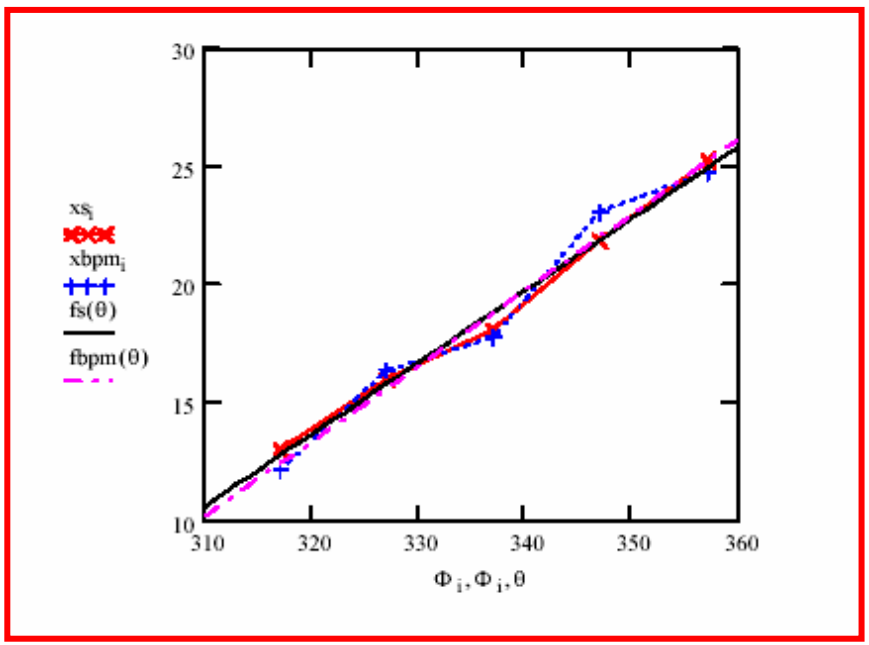


RF deflector – vert. beam position at BPM0430 vs. phase



Changing phase in RF deflector (385 degrees swing, ~ 5 degrees steps)

Calibration from position at BPM0430 and on MT0435



$$y_{OTR} = Y_{\max} \sin \frac{2\pi}{\lambda} s = Y_{\max} \sin \frac{2\pi}{360} \varphi$$

$$\frac{\partial y_{OTR}}{\partial \varphi} \approx \frac{2\pi}{360} Y_{\max}$$

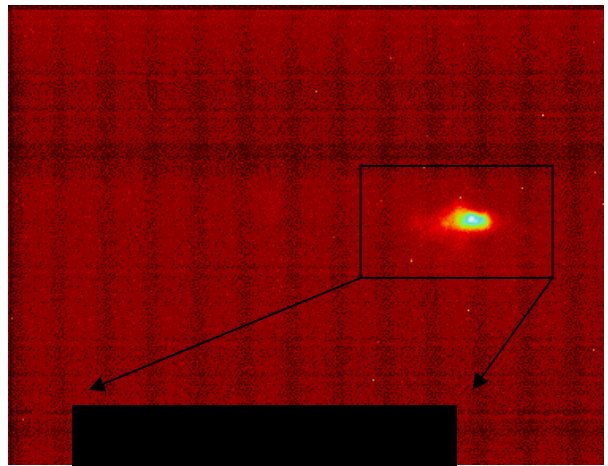
$$k = \frac{\partial y_{OTR}}{\partial l} = \frac{\partial y_{OTR}}{\partial \varphi} \frac{\partial \varphi}{\partial l} = 3.6 \frac{\partial y_{OTR}}{\partial \varphi} \left[mm / ^\circ \right]$$

$$\sigma_{y\,RFon} = \sqrt{\sigma_{y\,RFoff}^2 + k^2 \sigma_l^2}$$

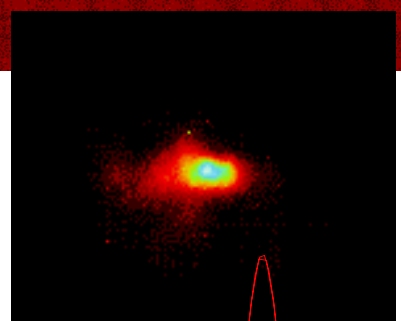
Calibrating each measurement it becomes independent of rf power and energy

Image analysis

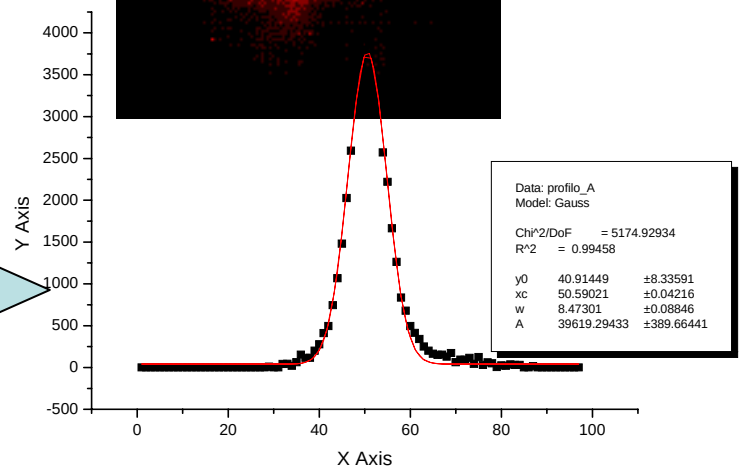
From the original image….



…we take a region of interest,
remove background and spikes…

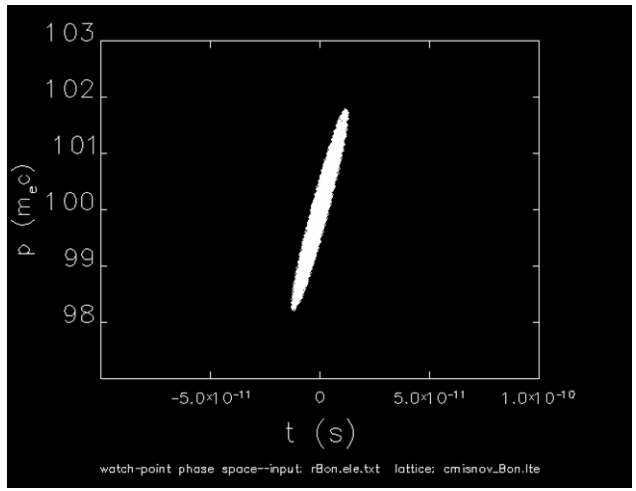


… and then we extract information about the centroid and width of the beam, averaging 16 shots for each image.



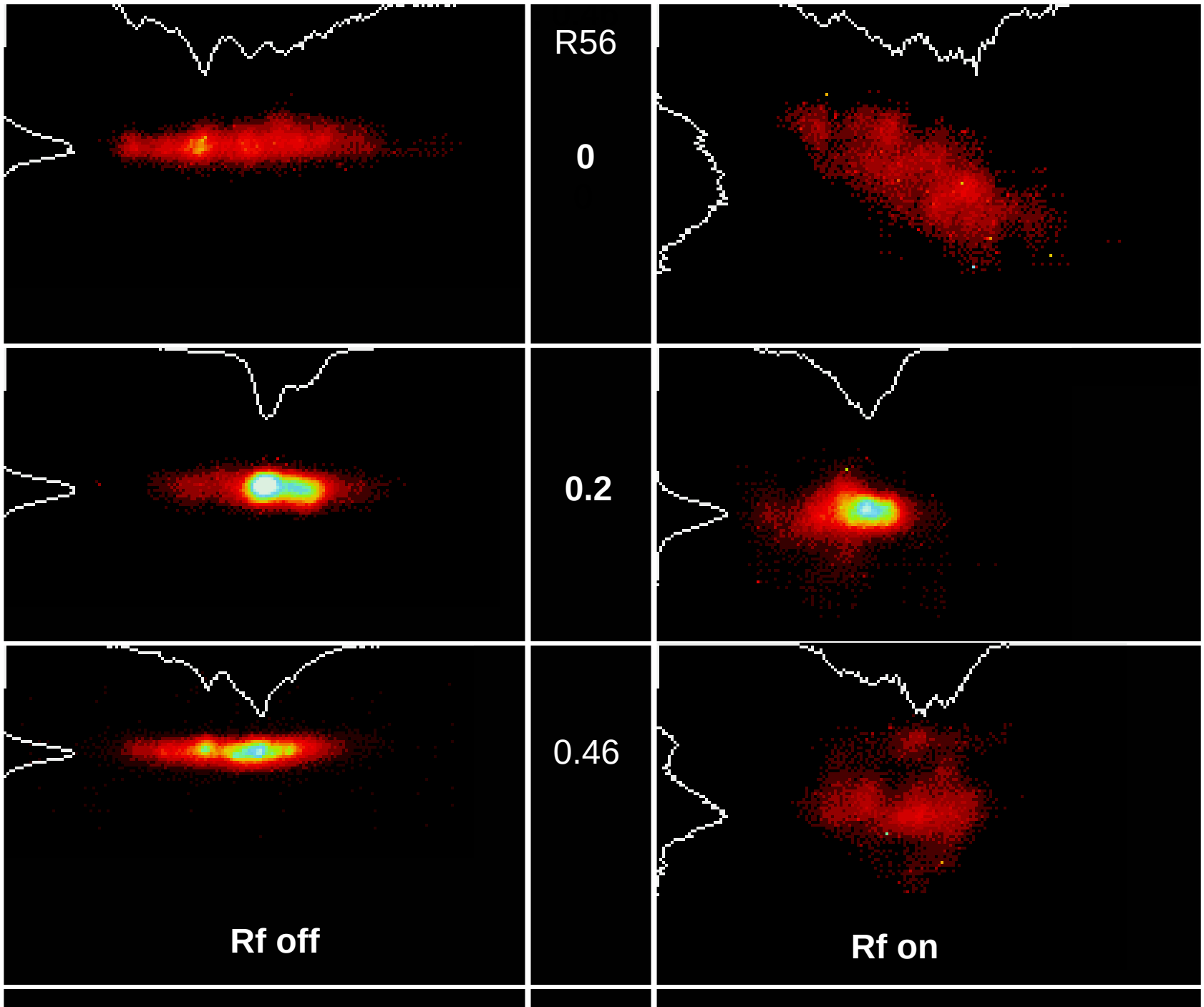
Beam parameters

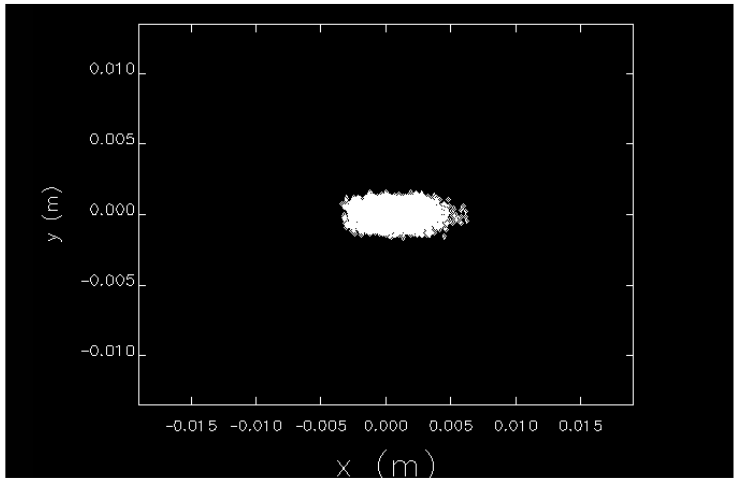
LINAC OUTPUT



- ***Q/bunch = 1.3 nC***
- ***Train length =200 nsec***
- ***N. of bunches = 600***
- ***Q tot = 900 nC***
- ***I = 3.8 A***
- ***E =100 MeV***
- ***Energy spread 1-1.2 %***
- ***Initial bunch length 5-6 psec***

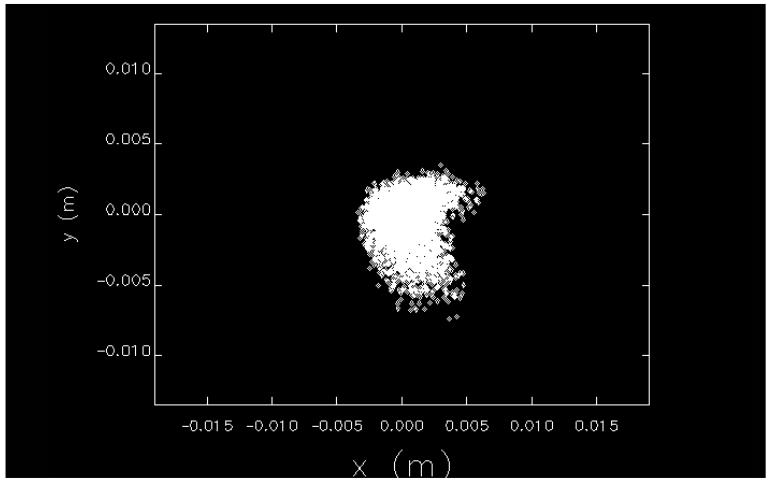
- ***Acceleration on crest all along the Linac, but on last section (30° off crest on the negative side) gives correlation in the longitudinal phase space***
- ***Maximum expected compression corresponding to R_{56} = 0.2 m***


R56
0
0.2
0.46
Rf off
Rf on
ON
MT0435

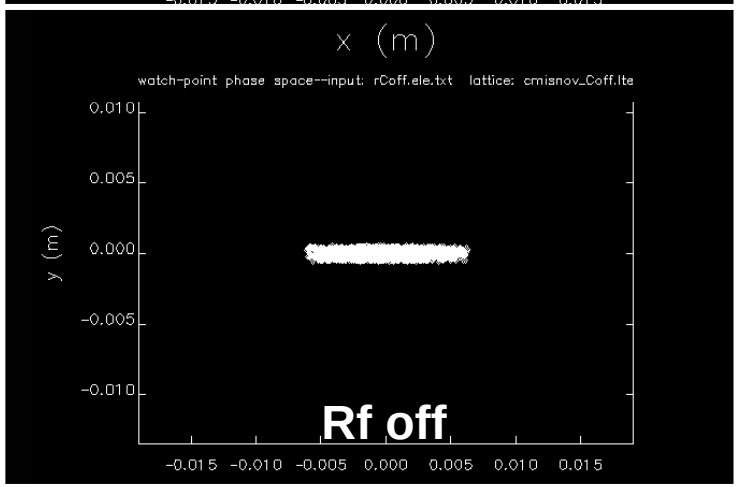


R56

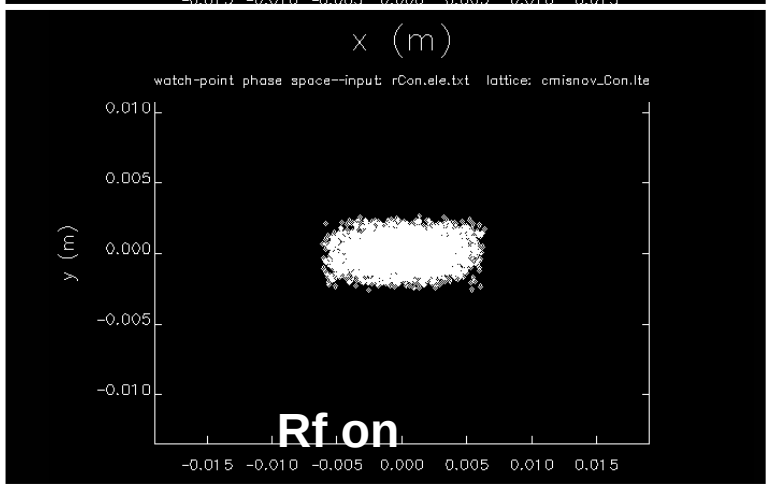
0



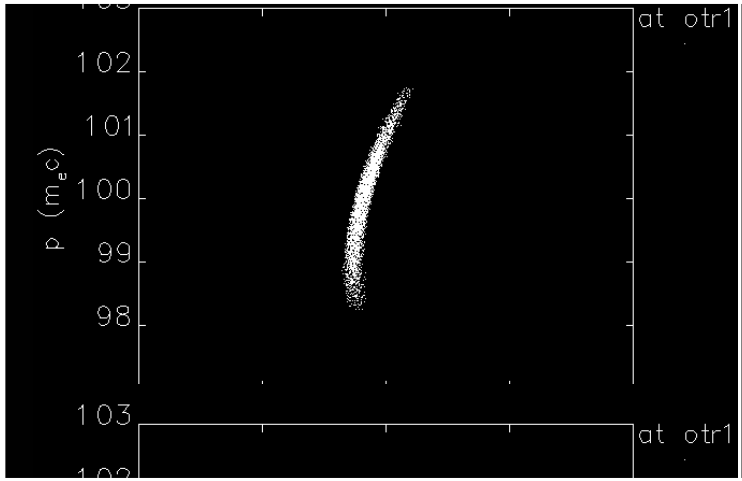
0.2



0.46



ELEGANT SIMULATIONS

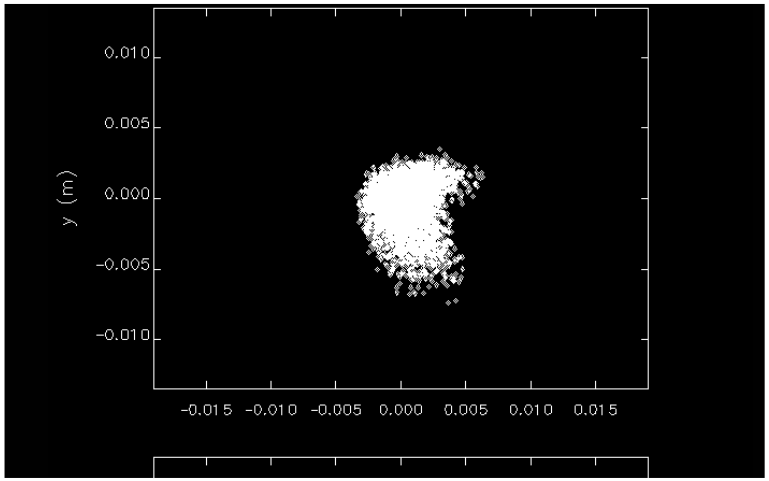


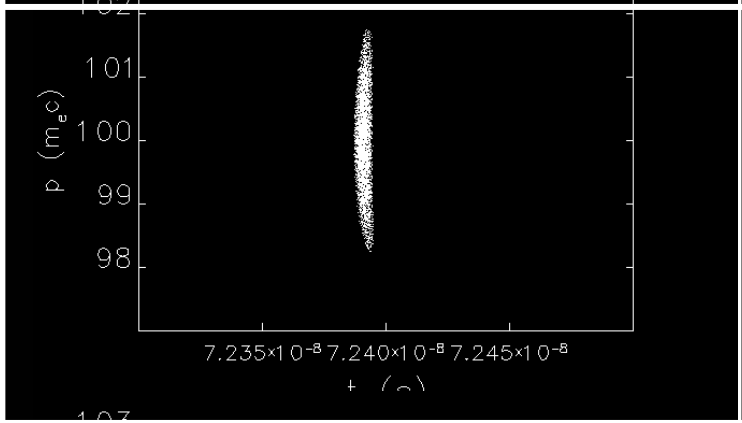
R56

T_{566}

0

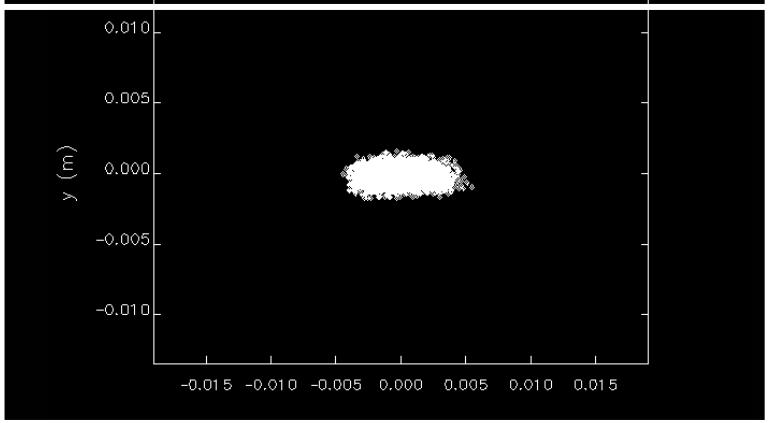
- 20

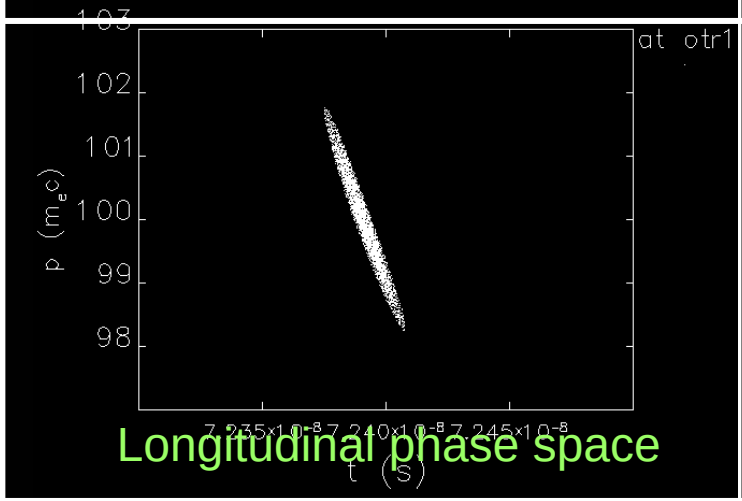




0.2

- 4

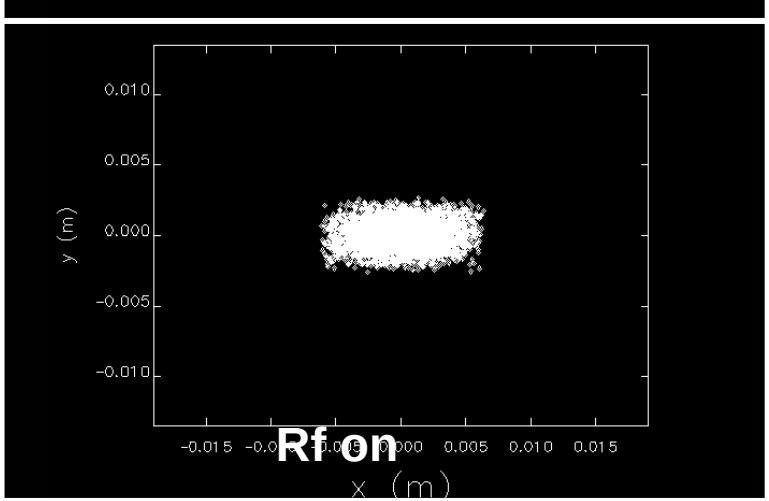




0.46

- 0.8

Longitudinal phase space

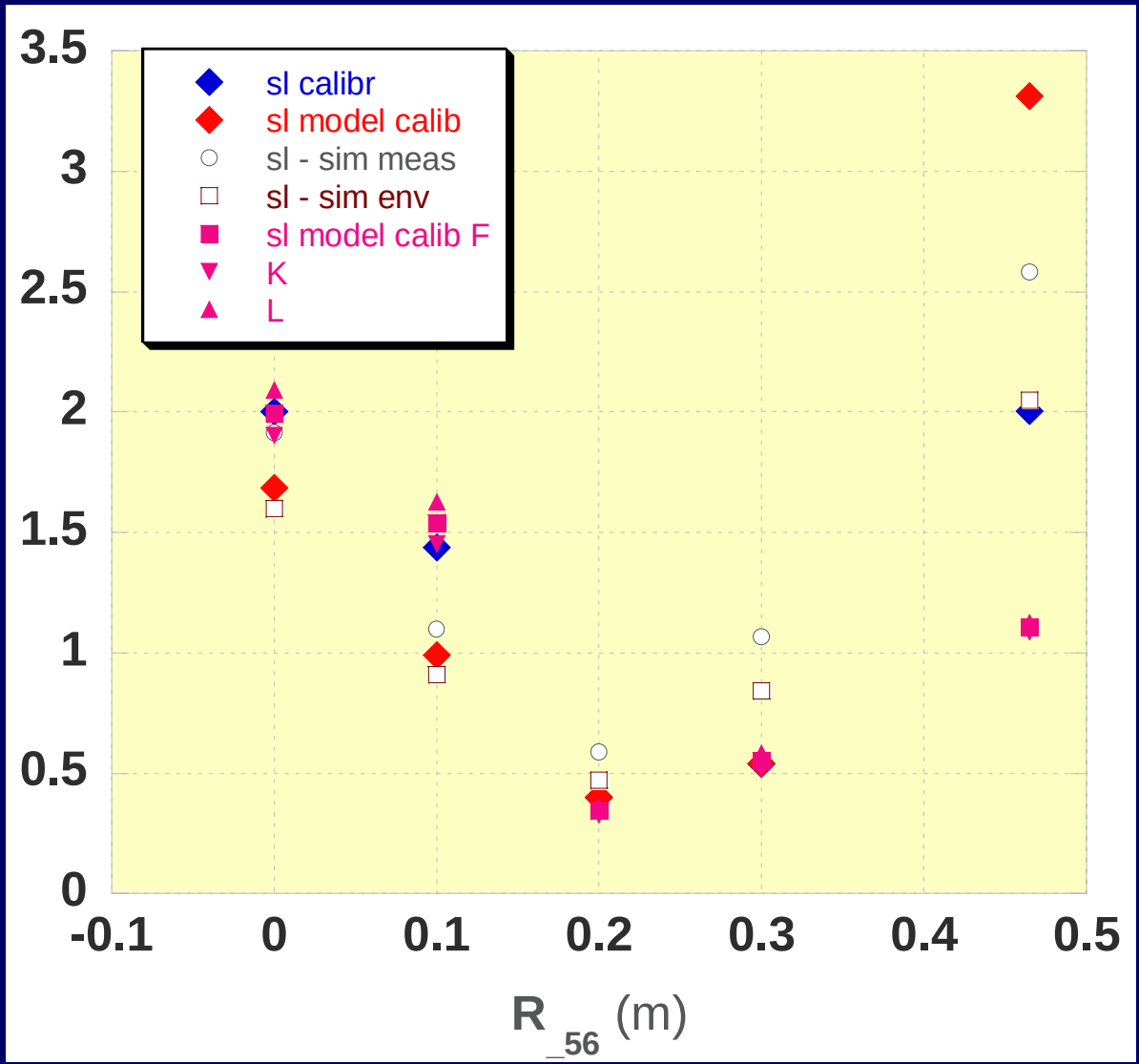


Rf on

watch-point phase space--input: r45on.ele.txt lattice: cmisnov_04.lte

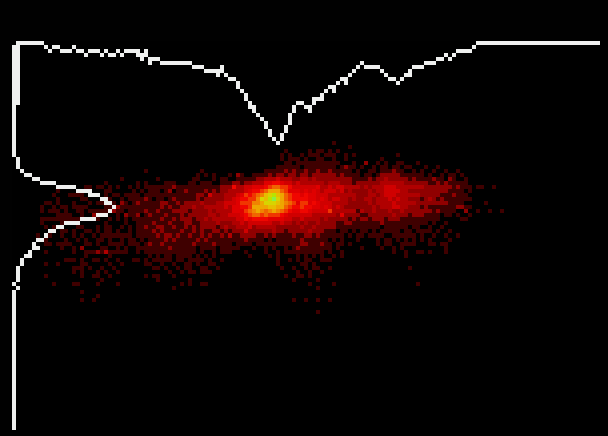
watch-point phase space--input: r4on.ele.txt lattice: cmisnov_4on.lte

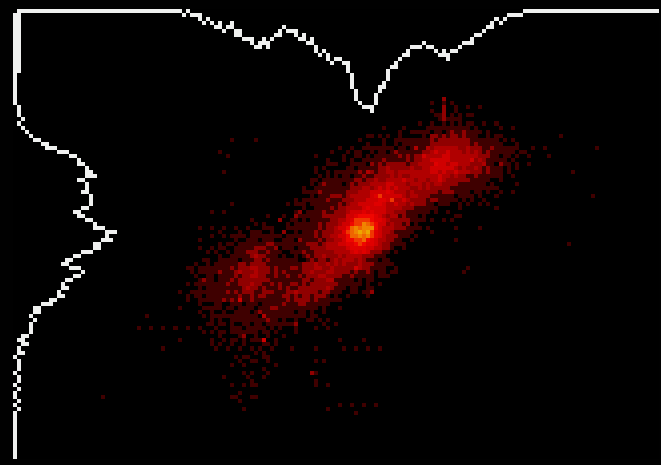
Bunch length (mm)

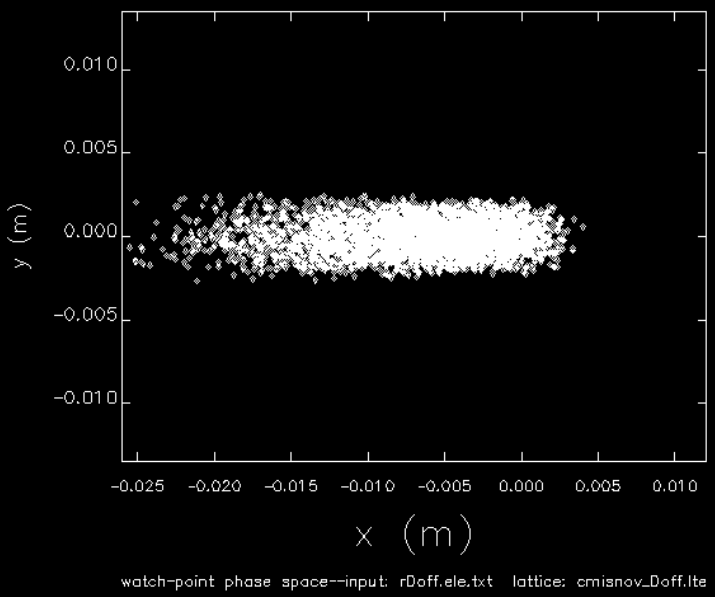


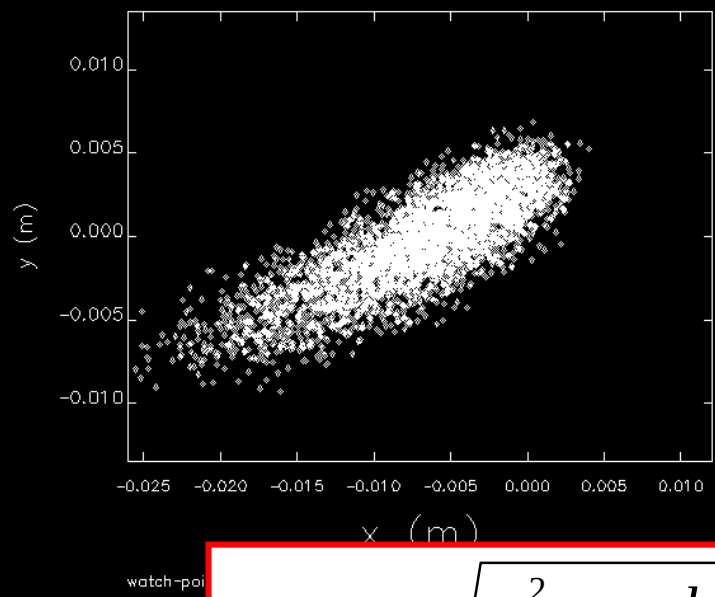
R_{56} = 0.1

H Dispersion at OTR









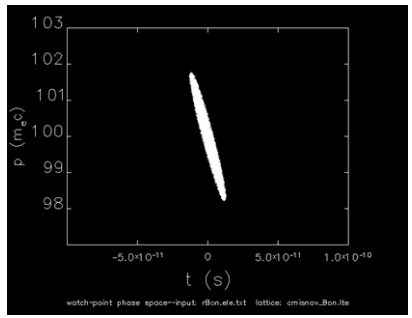
Simulation: 2% Energy mismatch with chicane setup

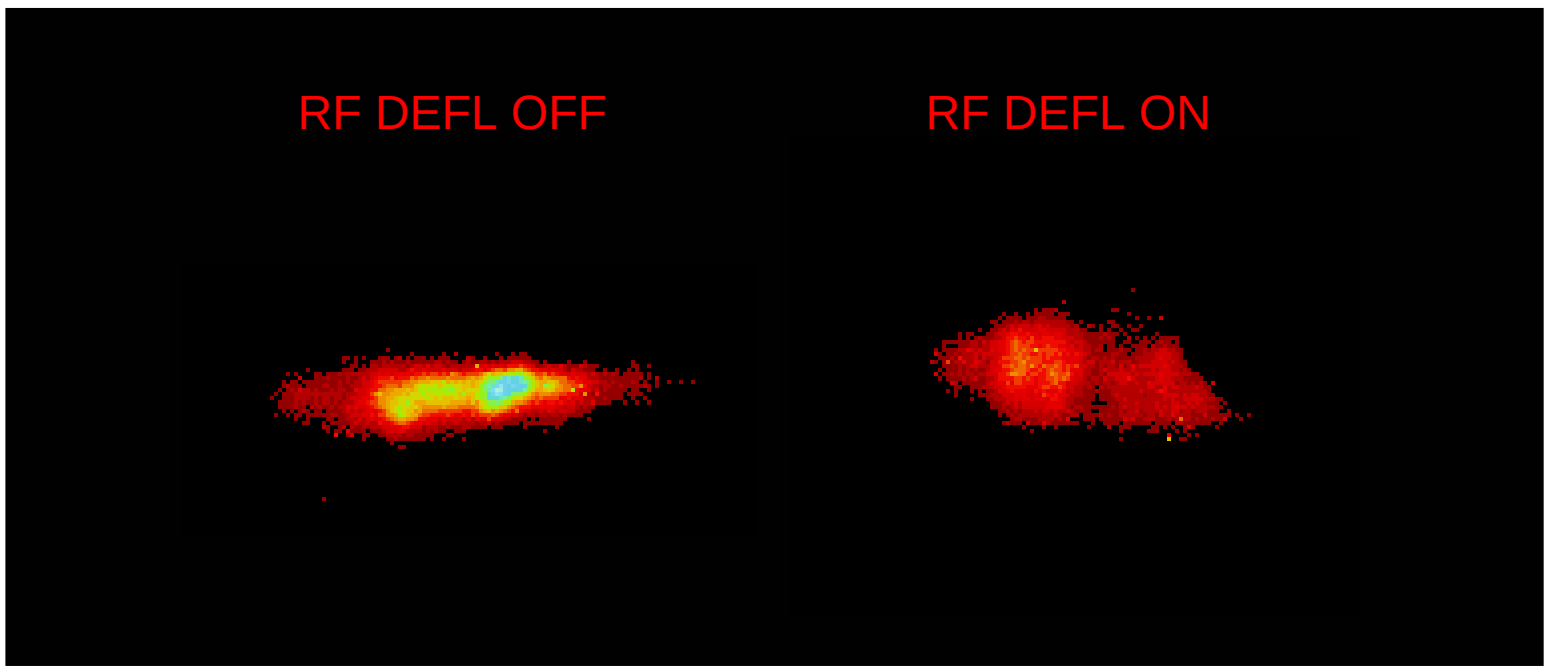
$$\sigma_{yRFon} = \sqrt{\sigma_{yRFon}^2 + k^2\sigma_l^2}$$

$$\sigma_x = \sqrt{\beta_x \varepsilon_x} + D\sigma_E$$

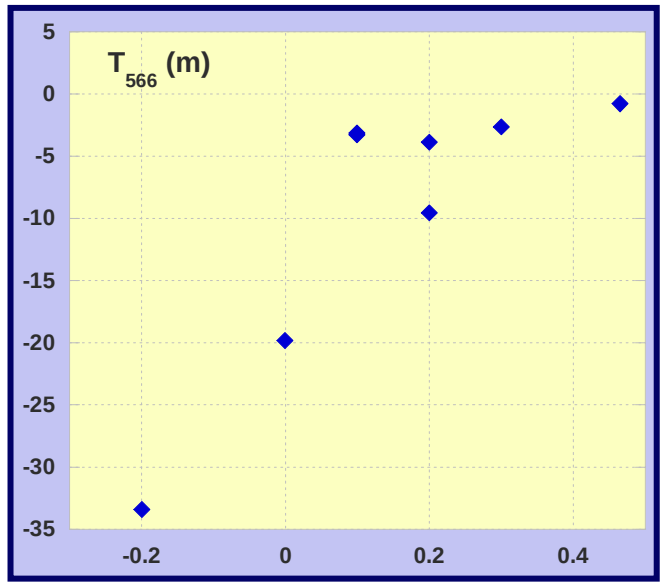
One measurement with negative $R_{56} = -0.2$

30 degrees on the positive side of last section crest
Measured 0.5 mm bunch length as expected





Non linearities in CT line

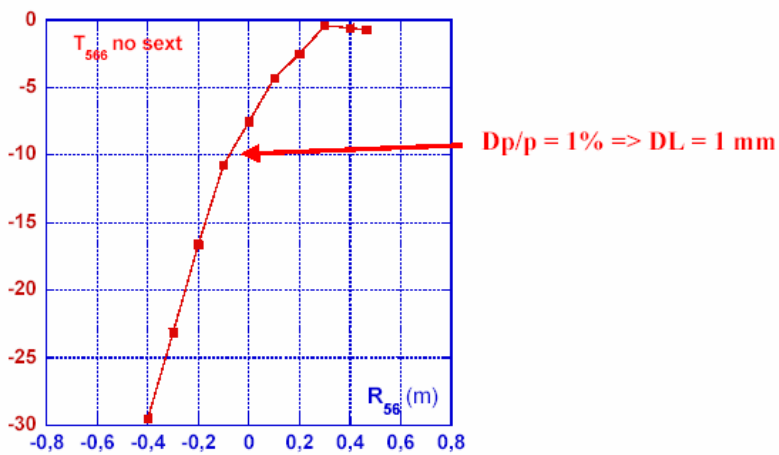


Measurement present set-ups

From last CTF3 coll. meeting

2nd order term depends on the linear optics configuration

Stretcher - compressor

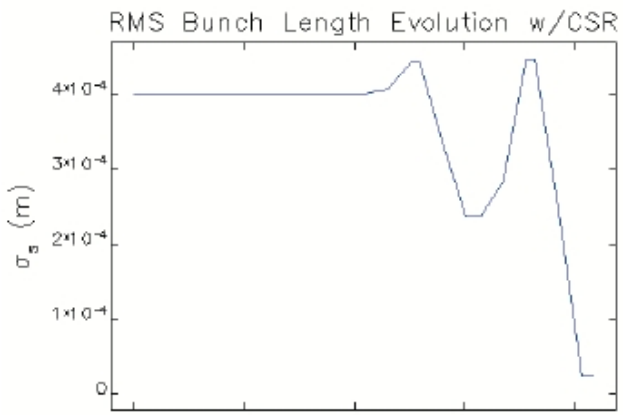


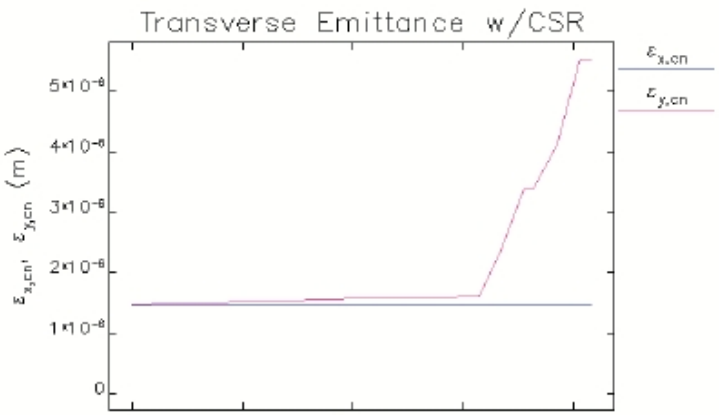
For diagnostic purpose useful
Adding one sextupole
Looking at the available ones with large aperture

Simulations for chicane compressor at ATF (BNL)

Input beam Parameters: **E ~ 72 MeV** ***Q*** **~ 200 pC**

R_{56} = 9.3 cm T_{566}= - 1.53 cm



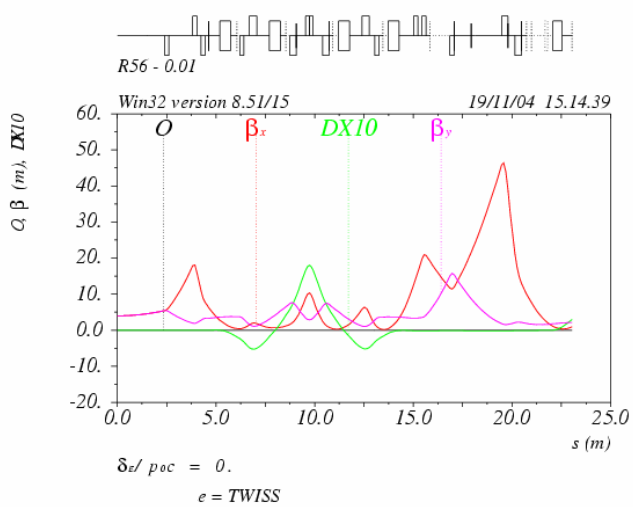


	Before Compression	Output without CSR	Output with CSR	Units
RMS bunch length	400	25	24	μm
Peak current	50	1200	1700	A
Energy spread	0.4	0.4	0.4	%
Vertical ε_n	1.5	3.1	5.8	mm-mrad
Horizontal ε_n	1.5	1.5	1.5	mm-mrad

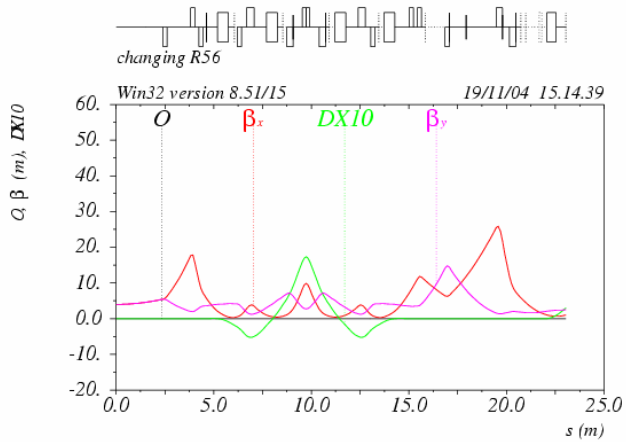
From C. Vicario, LNF

Will be added

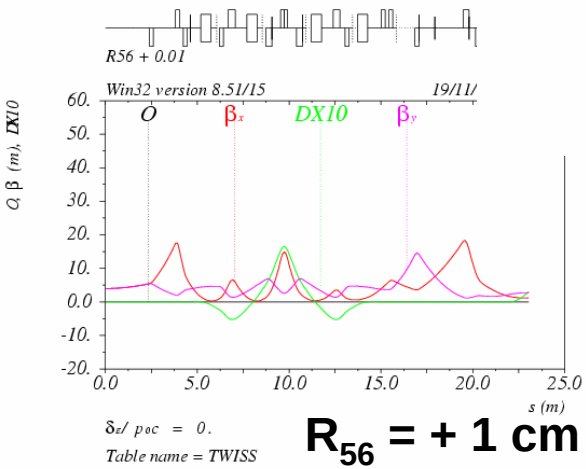
Fine tuning of R_{56} by smoothly tuning by few % quad currents



R_{56} = -1 cm



R_{56} = 0



R_{56} = + 1 cm

Next shifts on CT line

- Measurement of CSR effects on bunch length, energy spread, emittance
- Larger escursions of R56 on the negative side
- Useful to have rf deflector for diagnostics:

New 3 GHz rf deflector for CR?

Comments on the control system from outside

Appreciated

- **Naming-numbering of elements**
- **The set-undo of datasets**
- **The saving of the whole machine parameters**

To be improved

- **Electronic logbook and data accesibility**

Conclusions

Almost all systems have worked properly from the very beginning
All checks of modelling have been succesfull
Shifts very useful to point out things to be improved

All of us have enjoyed designing,
constructing,
installing,
commissioning this part

and thank all CTF3 Cern people