PAUL SCHERRER INSTITUT

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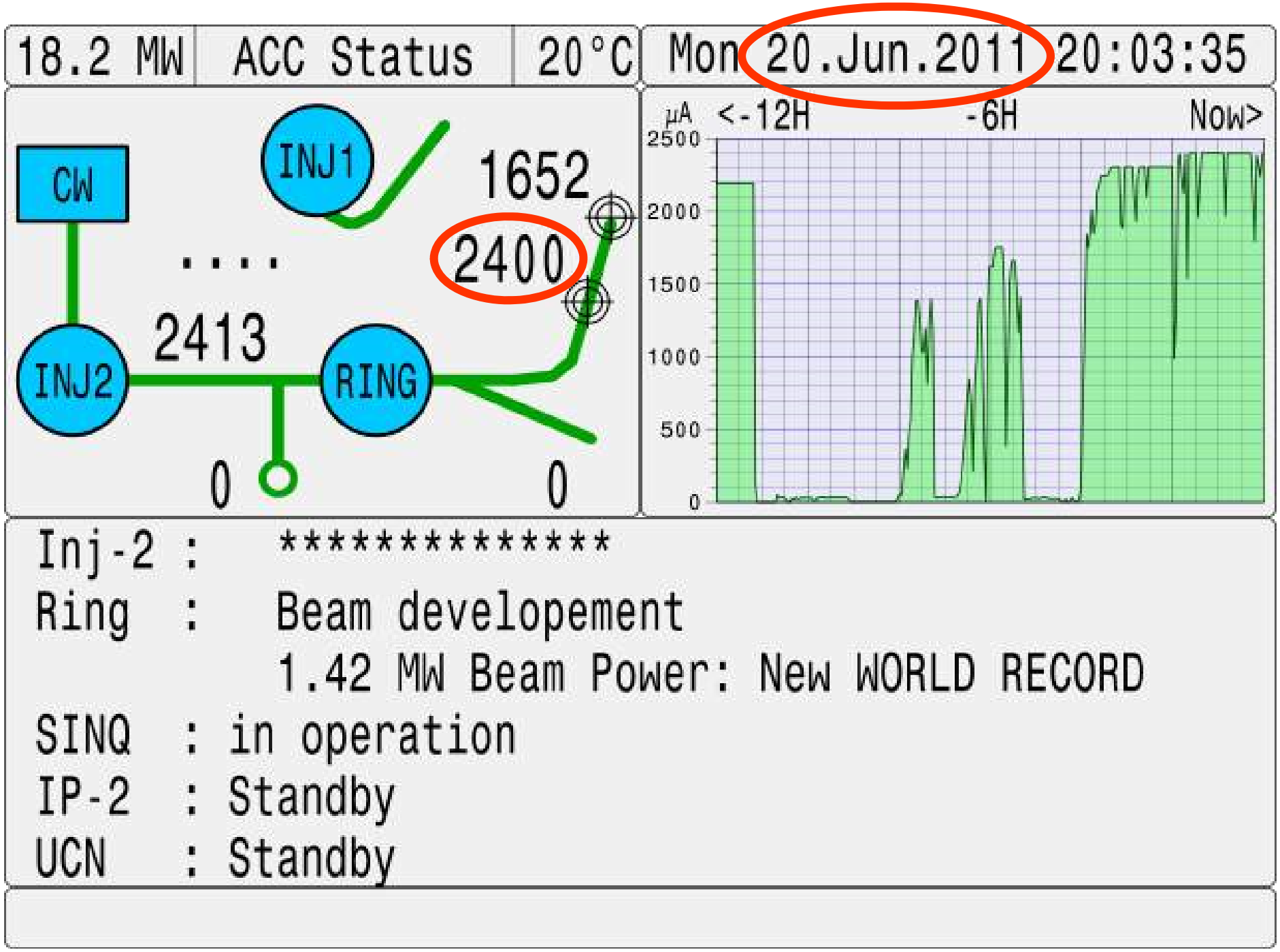
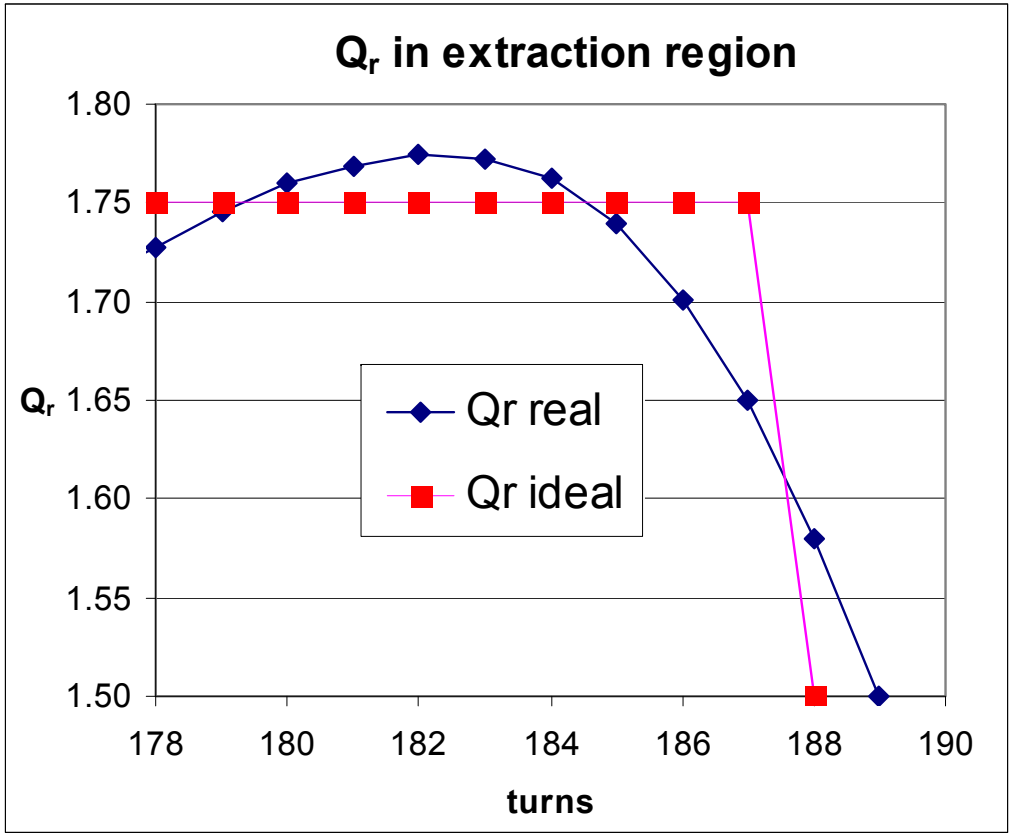
Commissioning of the 72 MeV Transfer Line for the Buncher Based Beam Injection into the Ringcyclotron

M. Humbel, Ch. Baumgarten, R. Dölling, W. Joho, H. Müller, M. Schneider, H. Zhang

PSI Villigen, Switzerland


18.2 MW
ACC Status
20°C
Mon 20.Jun.2011 20:03:35
CW
INJ1
1652
2400
....
2413
INJ2
RING
0
0
µA
<-12H
-6H
Now>
2500
2000
1500
1000
500
0
Inj-2 : **********
Ring : Beam developement
1.42 MW Beam Power: New WORLD RECORD
SINQ : in operation
IP-2 : Standby
UCN : Standby

Tune Qr in PSI Ringcyclotron Extraction Region

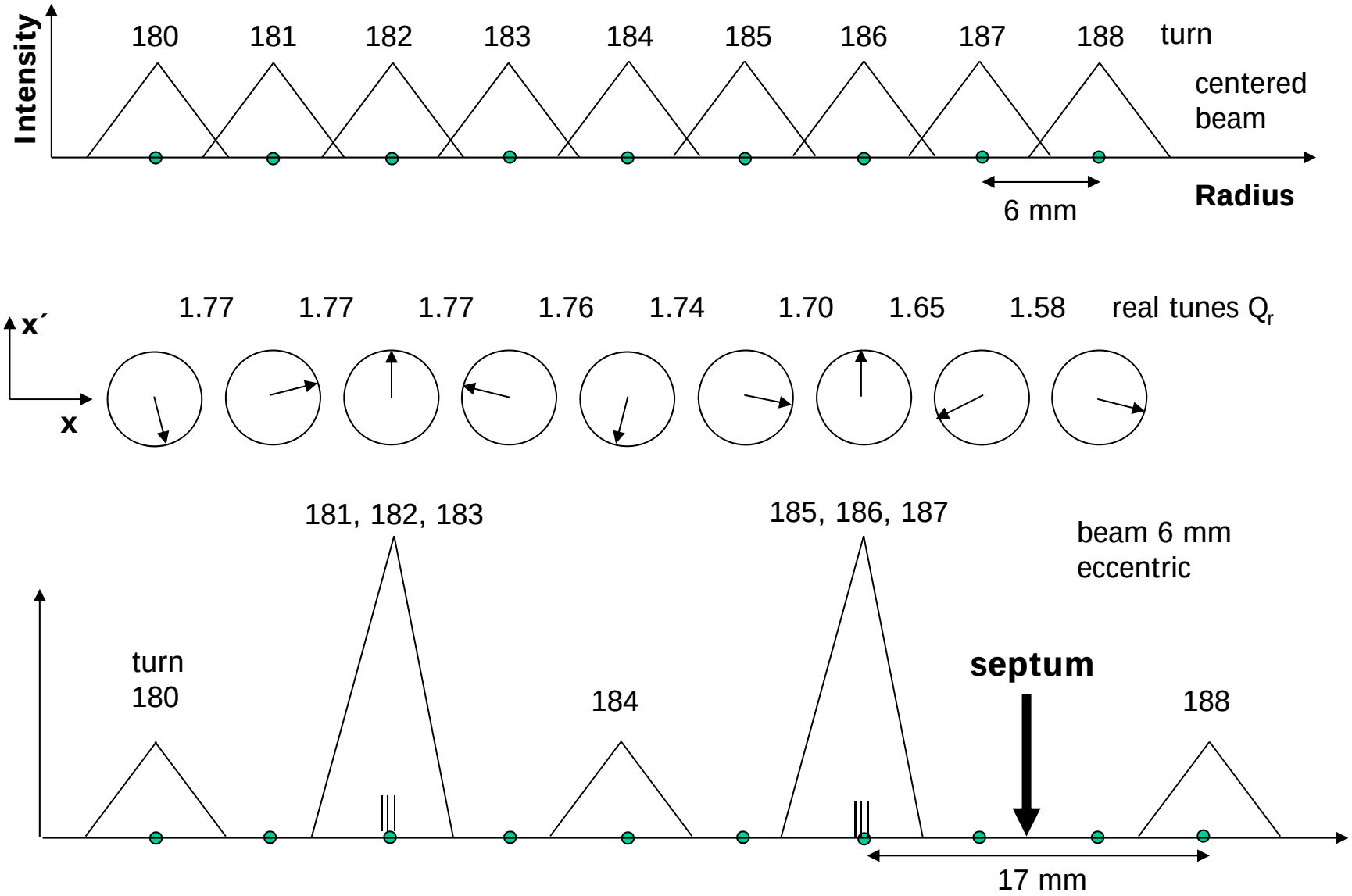


in the **ideal case** a tune of 1.75 puts 3 turns together, while with a fast drop to 1.5 the last turn is pushed away from the previous 3 turns.

In the fringe field region of the PSI ring cyclotron the **real tune** is close to the ideal one, giving an increase of the last turn separation from 6 to 17mm, using eccentric injection

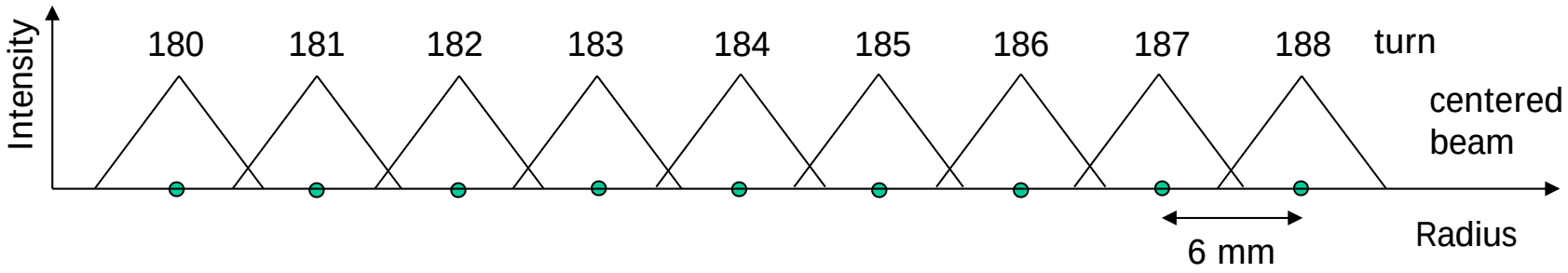
Courtesy Werner Joho

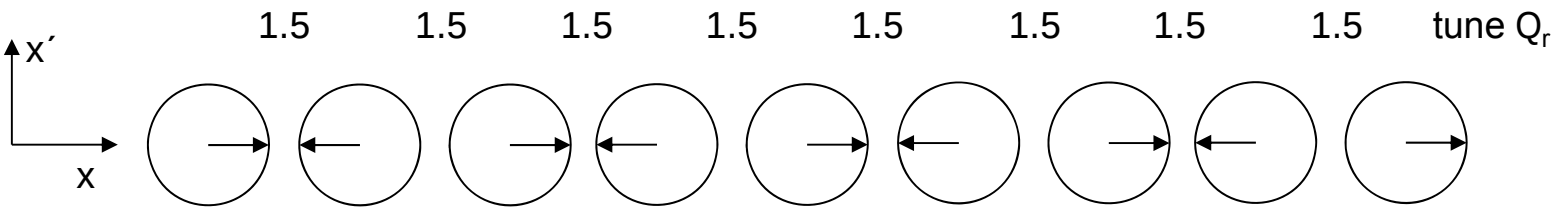
the last turns in the Ring Cyclotron, model with real tune Q_r

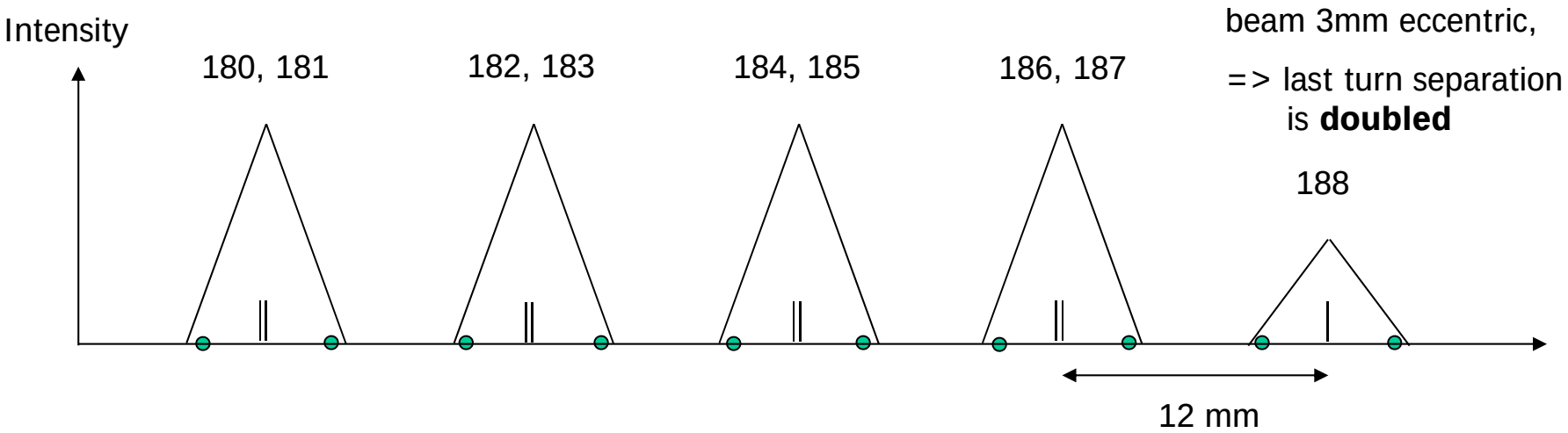


Courtesy Werner Joho

the last turns in the Ring Cyclotron, model with half integer tune



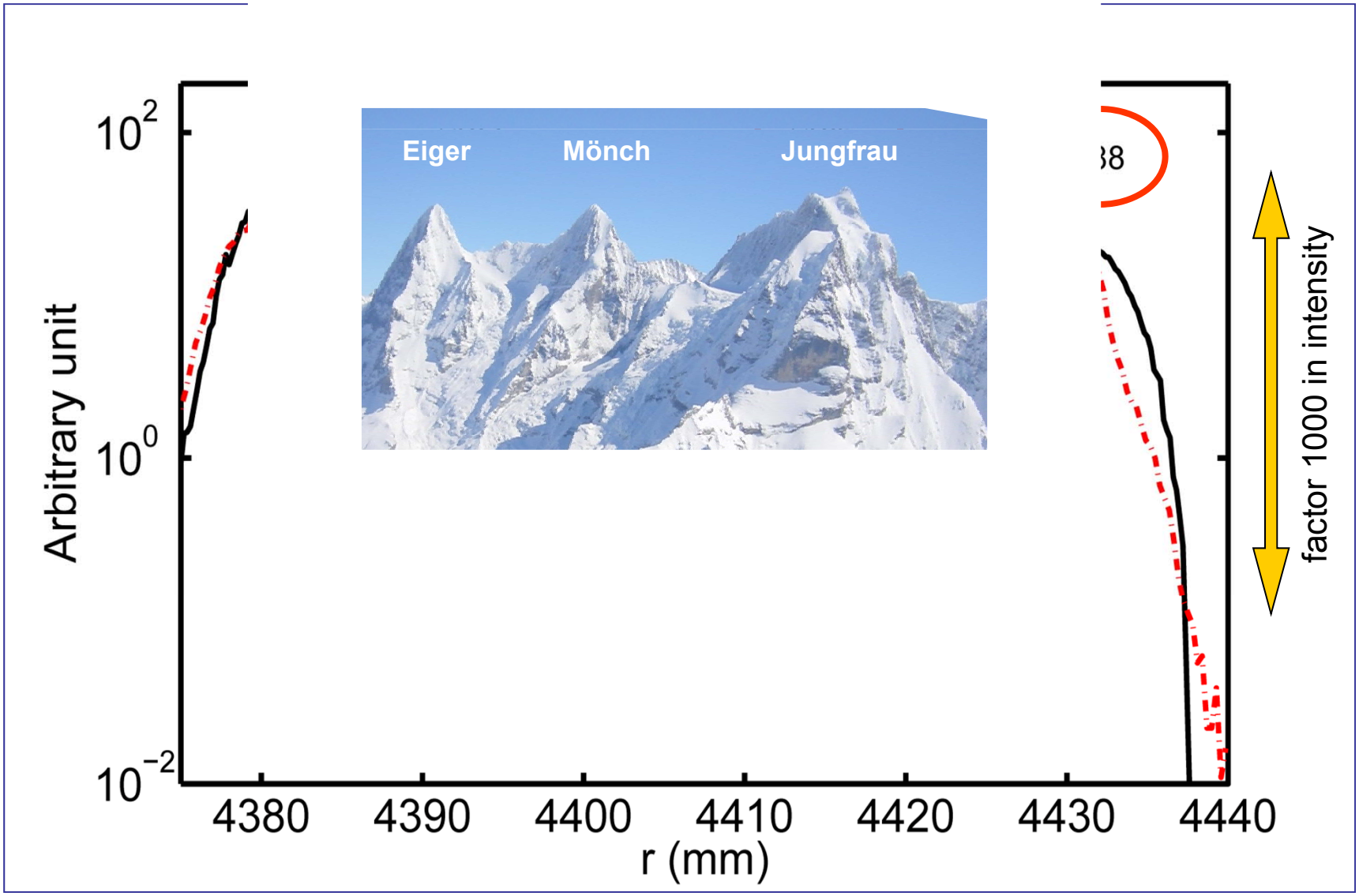




beam 3mm eccentric,

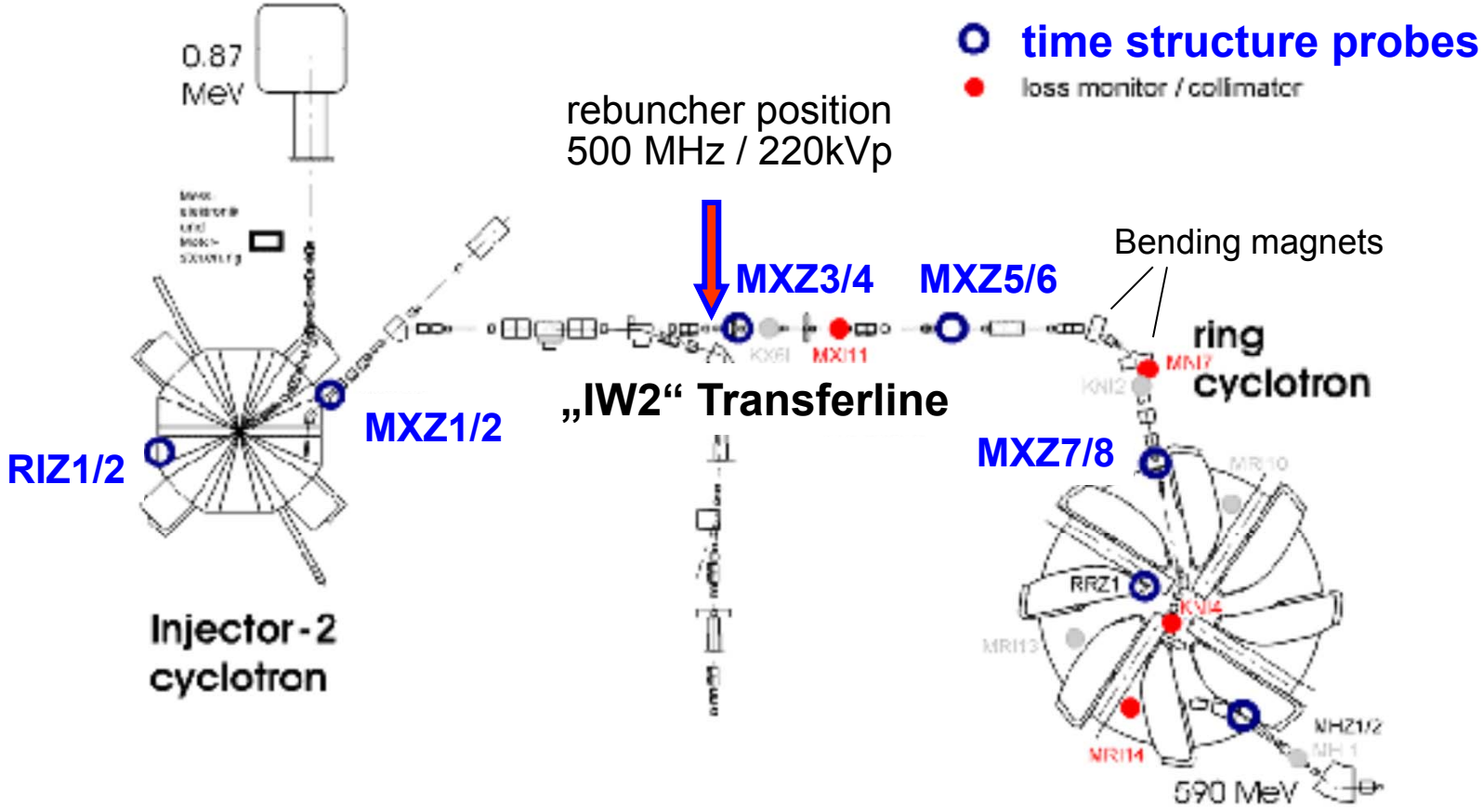
=> last turn separation is **doubled**

Turn Pattern of the Ring Extraction Region



Courtesy Yuanjie Bi, A. Adelmann

Diagnostics in the 72 MeV Transfer Line „IW2“



Courtesy Rudolf Dölling

IW2 Time Structure Scans at 2.3mA

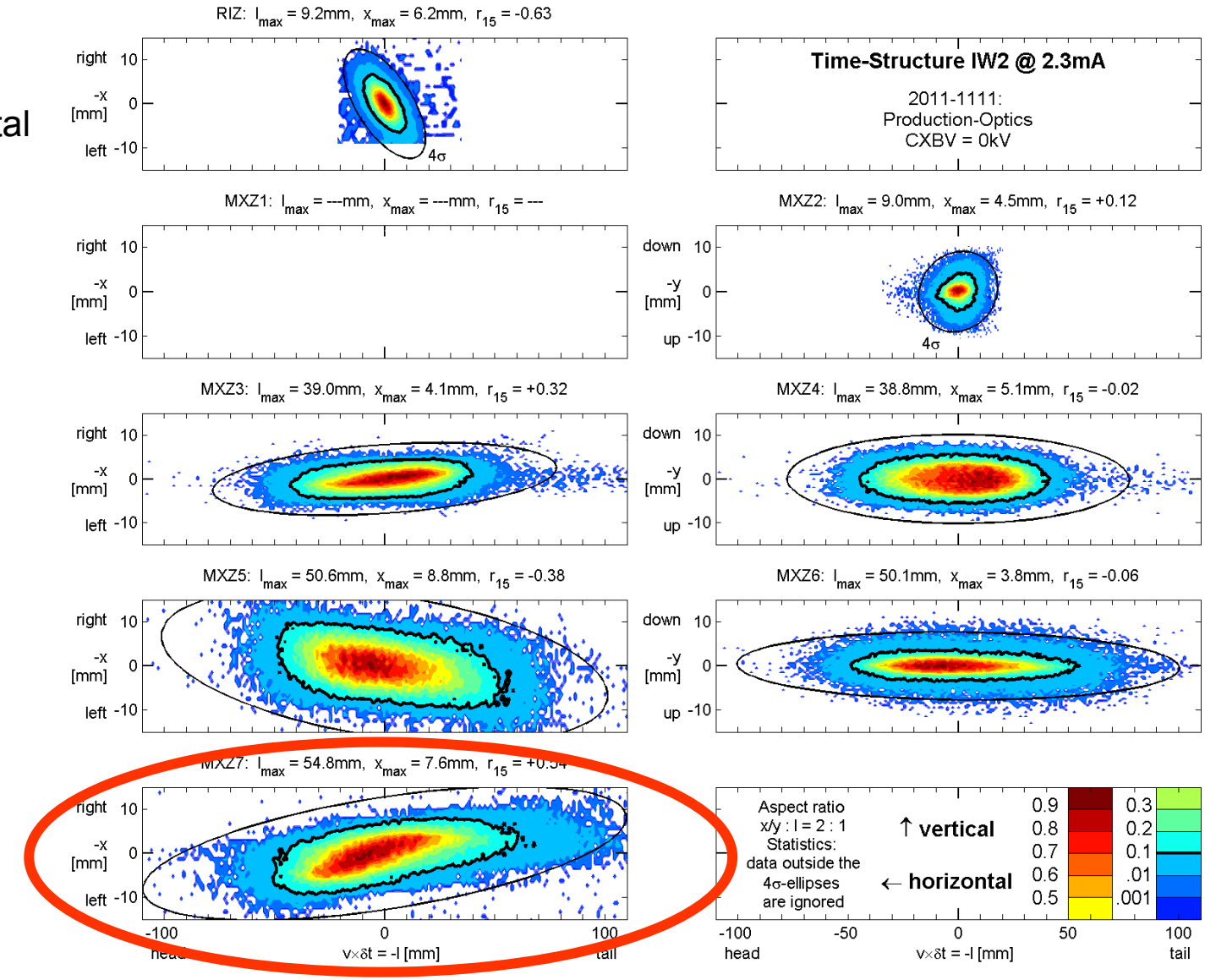
RIZ1:
Extraction
Injector2 horizontal

RIZ2: vertical

MXZ3/4:
Buncher Position

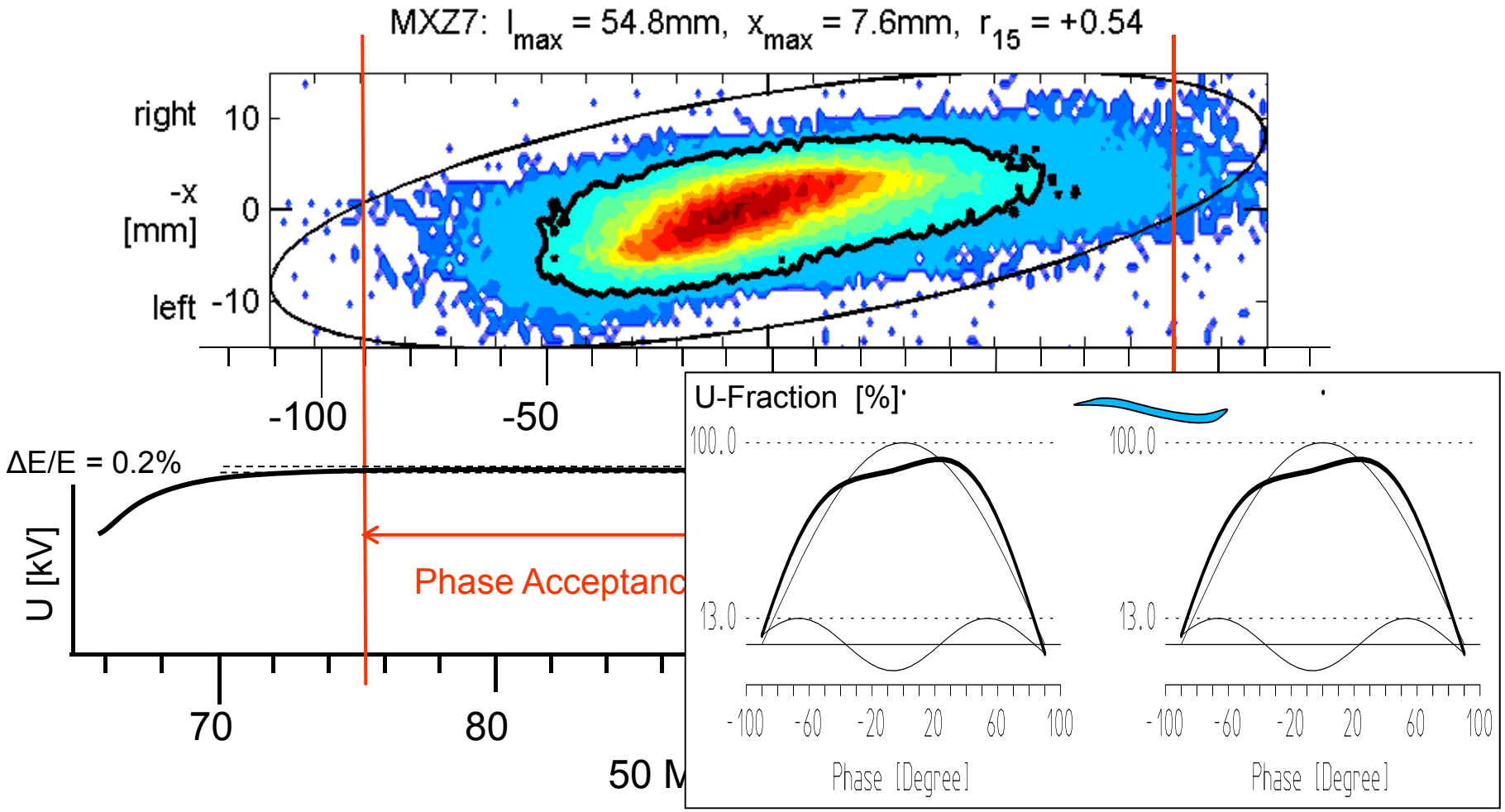
MXZ5/6:

MXZ7:
Near injection
Ringcyclotron



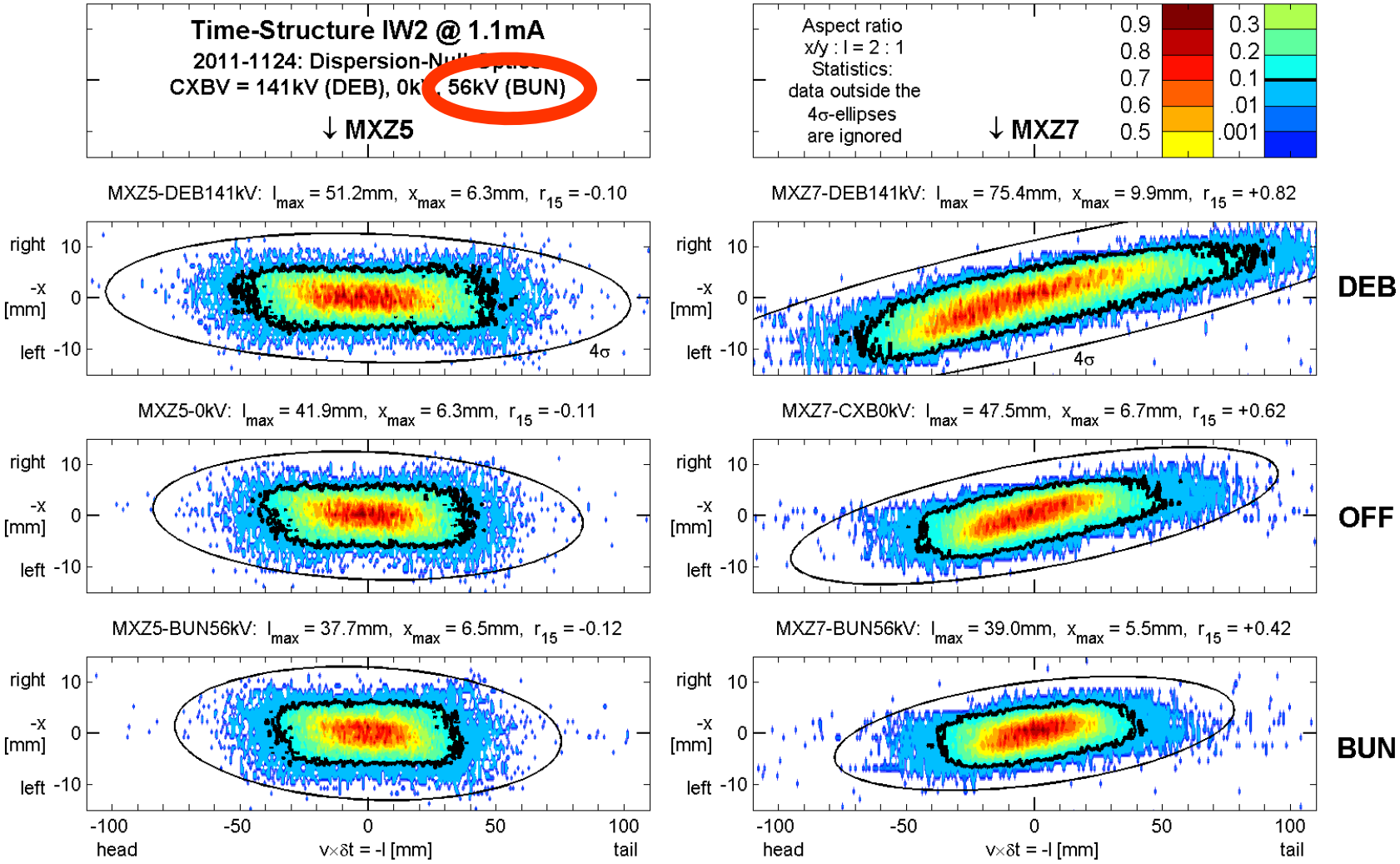
MXZ7 Time Structure at 2.3mA

Ekin = 72Mev => β = 0.371, v = 111.1mm/ns
Frq. = 50 MHz => T = 20 ns, v = 6.2mm/Deg.



500 MHz Buncher Influence

Wirkung des Superbunchers (DEB - OFF - BUN) bei MXZ5 und MXZ7



Goals for the 72 MeV Transfer Line IW2

Werner Joho, Herbert Müller
20.3.2012

1) zero dispersion at 500 MHz rebuncher

(particles are on axis for all energies)
=> after buncher no oscillations around dispersion trajectory
this can be accomplished with Quads QXA1-3 (was successful up to 2 mA)

2) matched dispersion in Ring

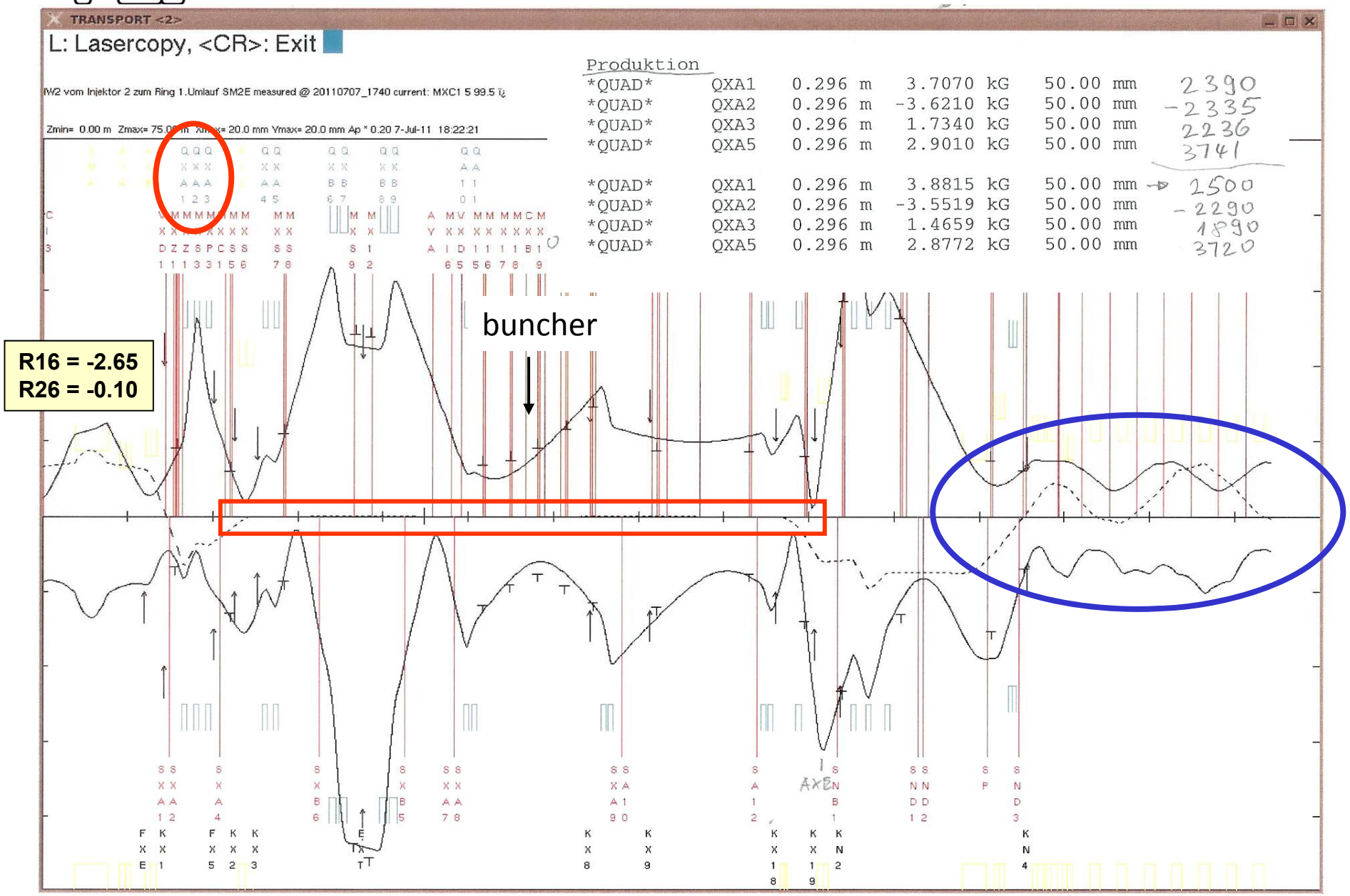
D ≈ -1.75 mm/‰dp/p
(only affected by Quads QXA16-19)

3) matched beam enveloppes in Ring in x and y

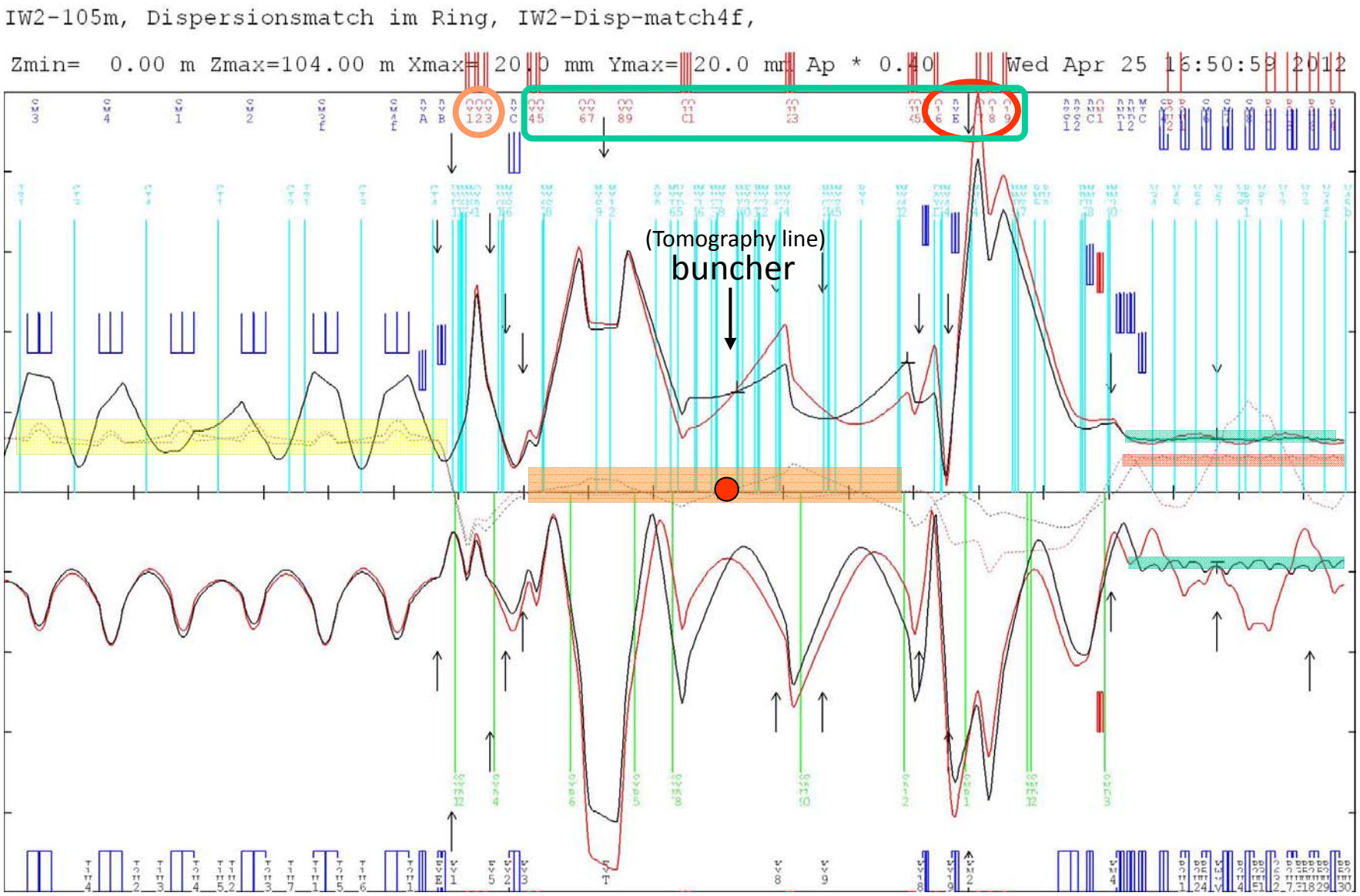
(Quads QXA4-19)

=> 16 Quads available for 8 conditions (3 for x, 3 for y, 2 for Dispersion)

Dispersion free Fit of the Enveloppes (Setting DN01)

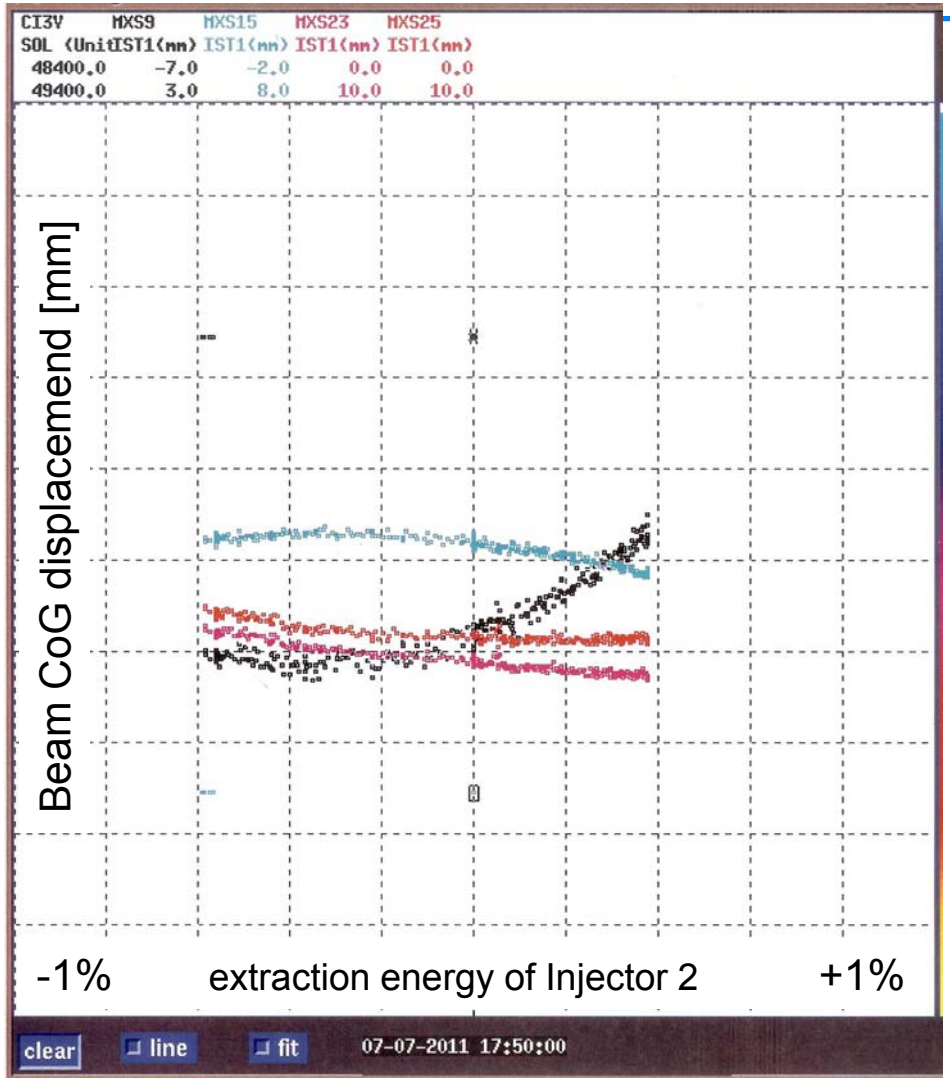


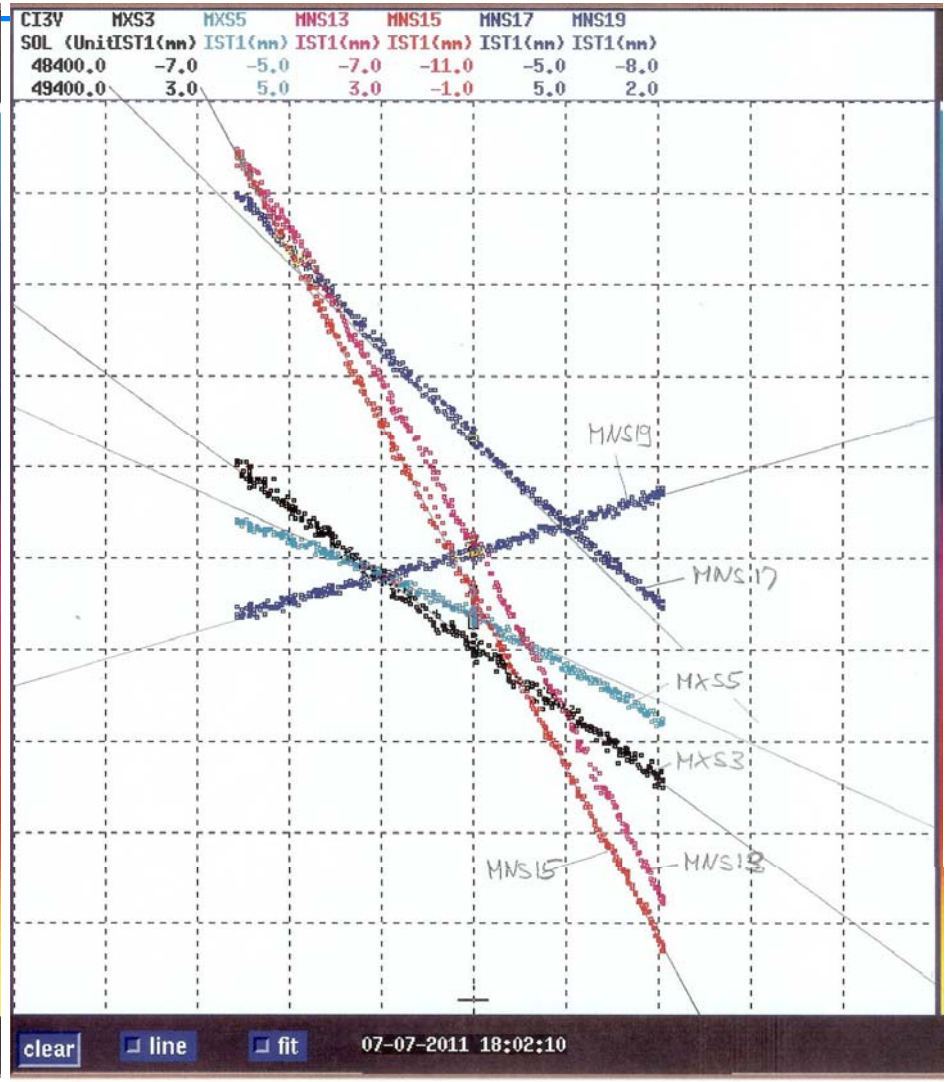
Injection Line IW2, 105m long
with 6 sectors in Injector 2, 9 sectors in Ring



MXS-Scans of Beam Setting DN01

ΔCI3V = 1000
ΔP/P = 0.23x1000/49400 = 4.6%

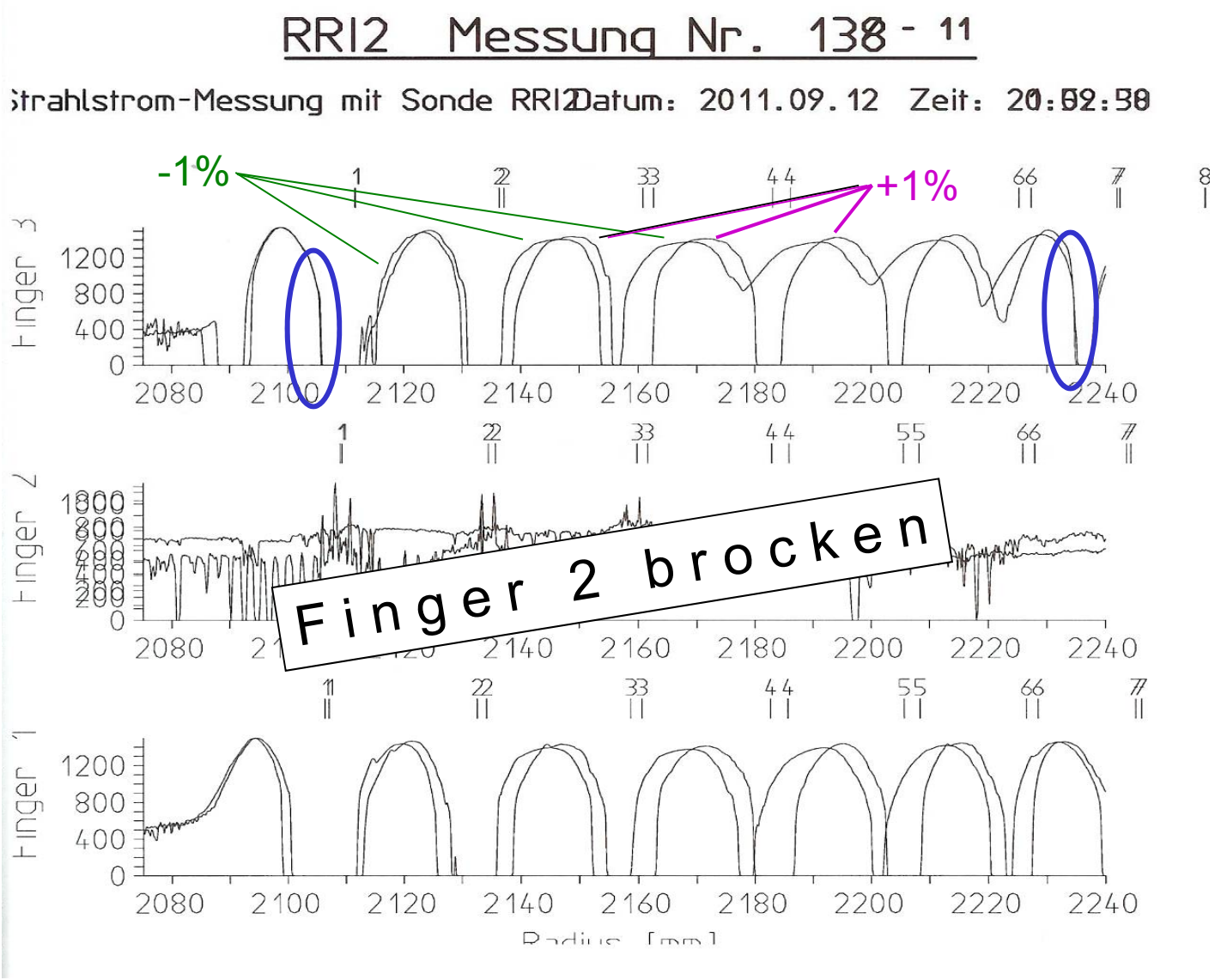




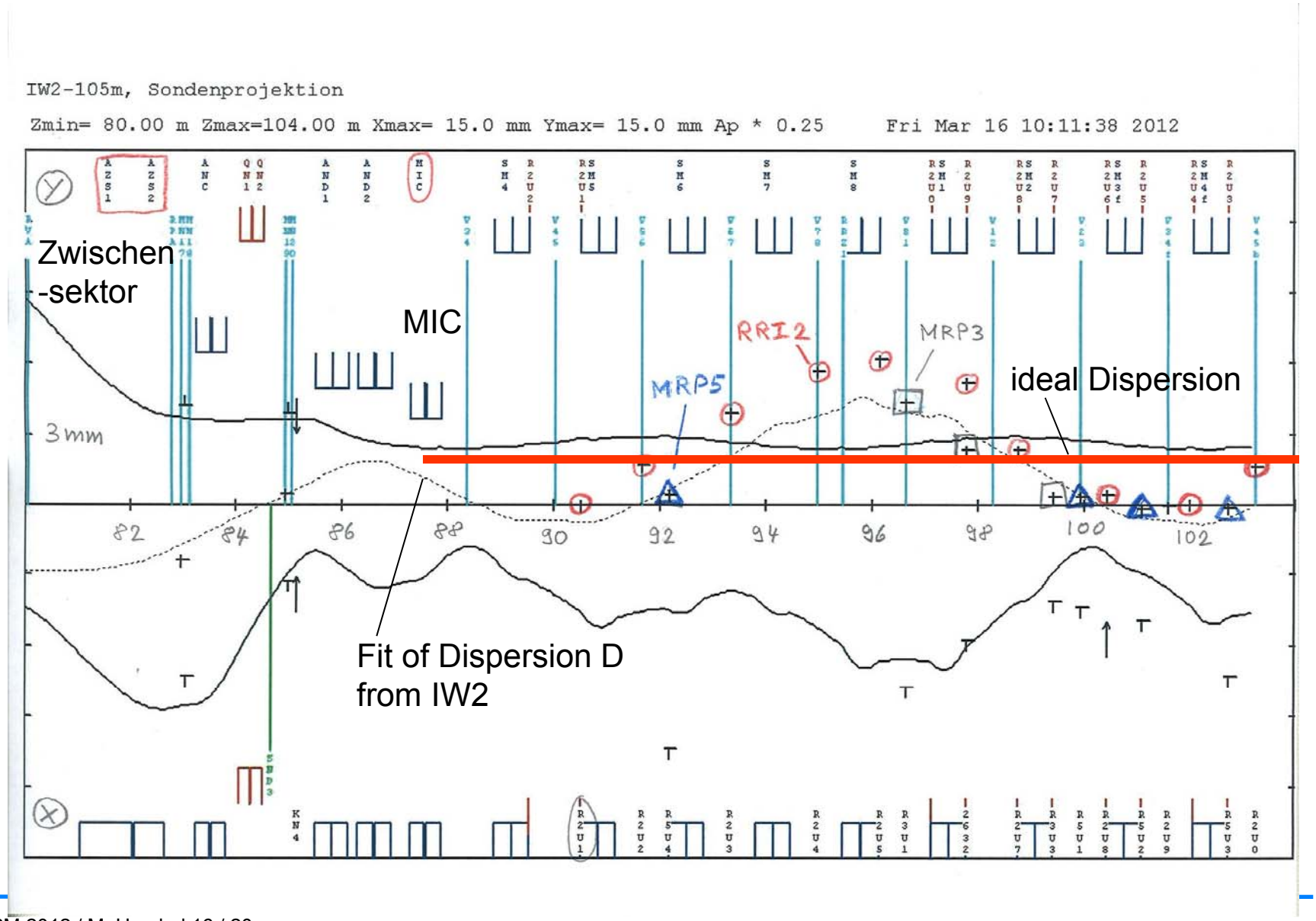
MXS3: $\Delta x_3 = -7.4$ mm / 1000 dig, $D(x_3) = +1.6$ mm
MXS5: $\Delta x_5 = -4.5$ mm / 1000 dig, $D(x_5) = +1.0$ mm
MNS15: $\Delta x_{15} = -18.5$ mm / 1000 dig, $D(MNS15) = +4.0$ mm
MNS13: $\Delta x_{13} = -18.5$ mm / 1000 dig, $D(MNS13) = +4.0$ mm
MNS17: $\Delta x_{17} = -9.8$ mm / 1000 dig, $D(MNS17) = +2.1$ mm
MNS19: $\Delta x_{19} = +2.9$ mm / 1000 dig, $D(MNS19) = -0.63$ mm

Monitors's in the dispersion free section

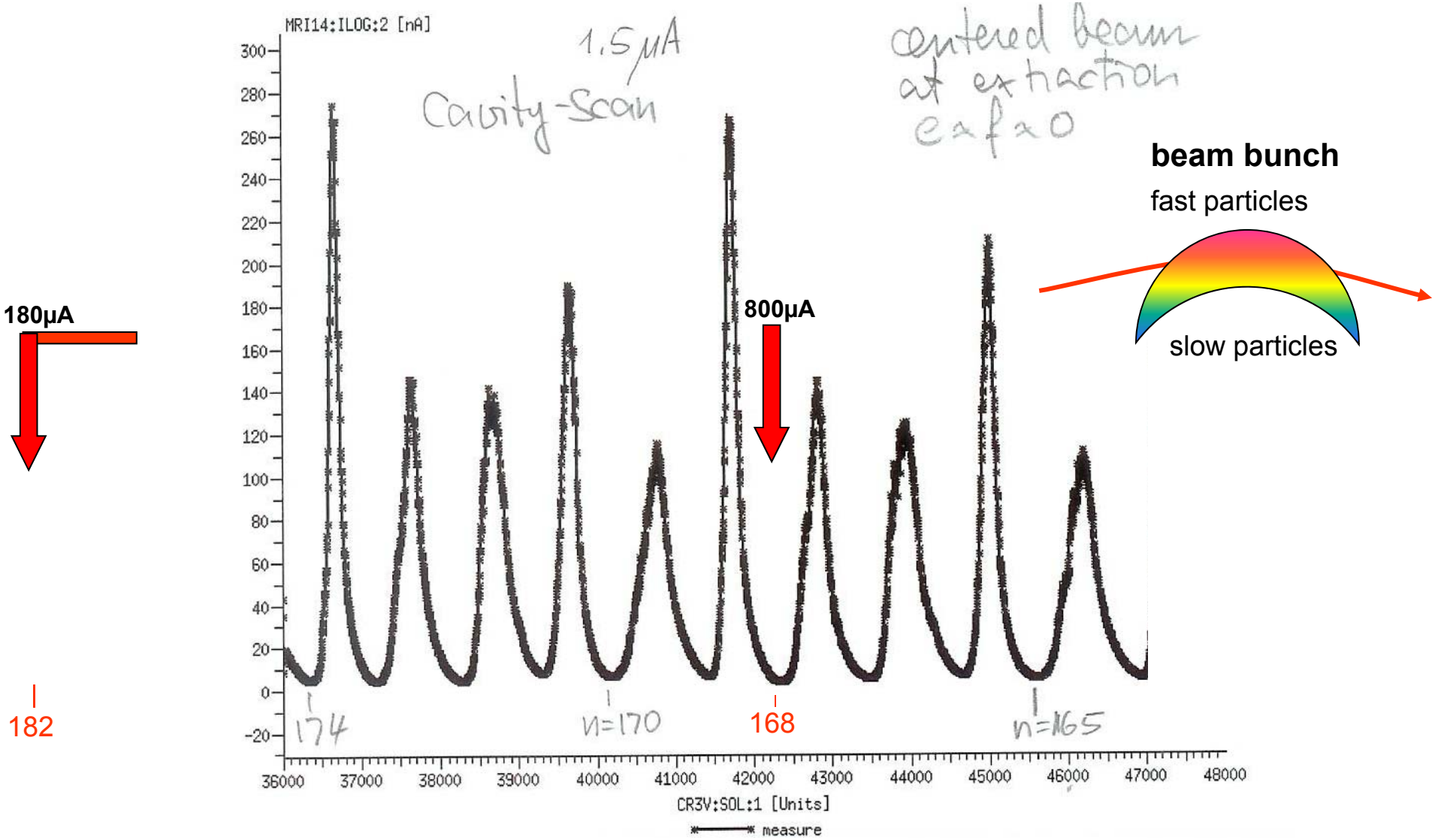
Current Probe Scans at Two Beam Energies



Backprojection of Dispersion Measurements Δx = D Δp/p at Ring Probes into first 9 sectors (Tune Qx=1.12)



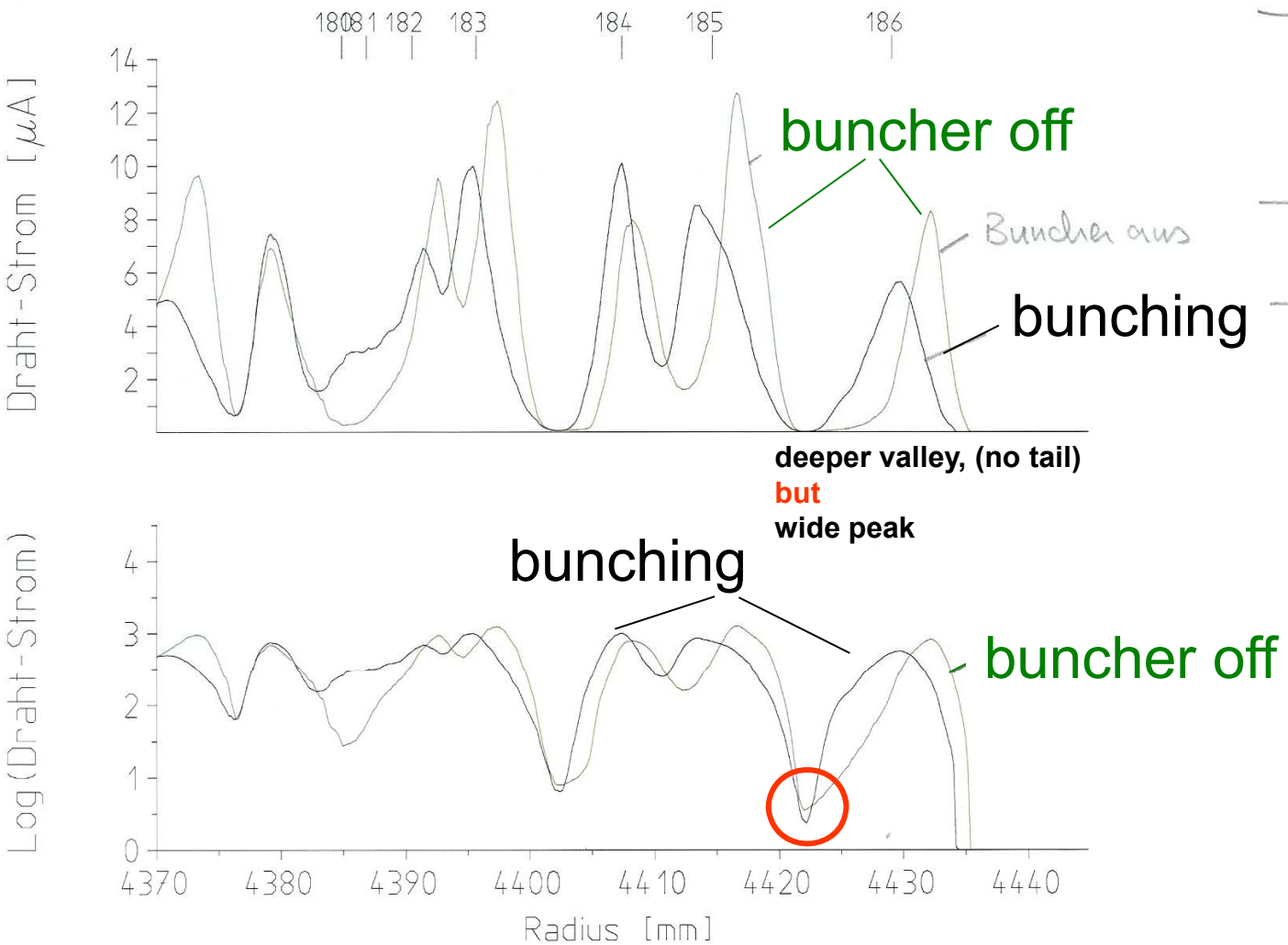
Towards a Lower Number of Turns



Setting DN06, **Bunching** and **Without Buncher**

RRE4 Messung Nr. 159 - 11 158 - 11

Bereich: 4370mm bis 4444mm Datum: 2011.09.12 Zeit: 12:13:08



Extraktion

Schwerpt	4429.06	mm
Breite	8.48	mm

Mini-Save

MNC3	513.10	μA
HS	60900	DAC
HS	2885	FEIN
CR1V	44300	DAC
CR2V	45600	DAC
CR3V	43395	DAC
CR4V	41800	DAC
CR5V	0	DAC
CIPHMO	980	DAC
CRPHFT	2813	DAC
CRREV	185.73	U FSOL
CRREV	168.62	U FIST
SND2Y	-522	DAC
SND3Y	130	DAC
TR1HA	5806	DAC
TR1HP	312.61	GRAD
TR2HA	8725	DAC
TR2HP	167.94	GRAD
TR3HA	10330	DAC
TR3HP	70.22	GRAD
AND1	53375	DAC
AND2	60641	DAC
MIC	100	DAC
EICV	2730	DAC
EICX	7.08	mm
EECX	-7.72	mm
EECW	-6.49	mrad
MRFEIN	61.64	Grad
MRFAUS	67.20	Grad

Conclusions

The eccentric injection together with the 1.75 / 1.5 Tune distribution at extraction acts as a booster of the turn reduction yields in PSI's high intensity Ringcyclotron.

The 72 MeV transfer line is equipped sufficiently for the buncher based beam injection into the Ringcyclotron, the device settings are calculated - it remains to test it out.

Thank You for Your Attention!