Beam-beam and emittance growth with wire compensators

Ulrich Dorda

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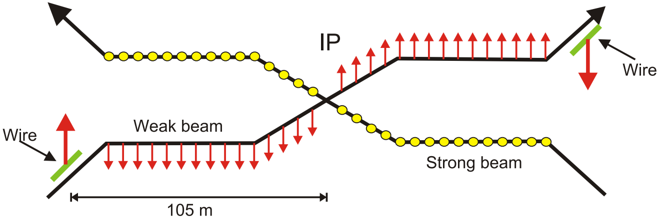
Outline

1. BBLR @ LHC upgrade
2. RF-BBLR à la F. Caspers
3. 2007 SPS BBLR MDs
4. Conclusions

BBLR @ LHC upgrade - R. de Maria, F.Zimmermann, J.P. Koutchouk



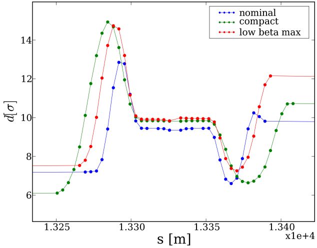
Wire compensation in LHC

- R. de Maria et al. [LHC report 1008] proposed 3 different LHC $\beta^* = 25cm$ optics.
- Average beam-beam separation equivalent to nominal LHC $d \approx 9.5\sigma$
- But they differ greatly in length $=$ # of LR encounters
- $\theta = 300\mu rad$ was chosen for nominal LHC $=$ 15 LR encounters
- For comparison: nominal LHC (IP1 & IP5): $DA = 5.4\sigma$, wire compensated: $DA = 7.2\sigma$

BBLR @ LHC upgrade

A suitable position can be found in all scenarios ($\beta \uparrow$)

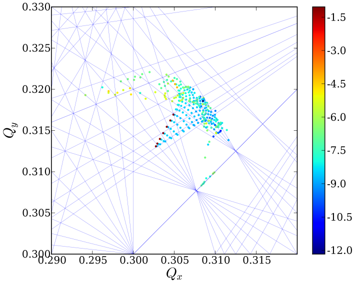
variable	nominal	low β max	"Compact"	modular
β^* [m]	0.55	0.25	0.25	0.25
#LRBBIs	15	17	21	25
wire @ [m]	104	136	170	160
β_{wire} [m]	1780	3299	2272	3000
σ_{LRBB}	1.6	3.6	2.2	X



Assuming 25ns bunch spacing and nominal intensity (1.15E11p/bunch)

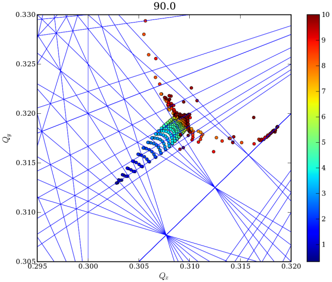
BBLR @ LHC upgrade - Low β max

Uncompensated



$DA = 5.16\sigma$

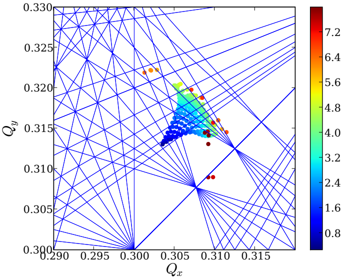
Wire compensated



$DA = 7.1\sigma$

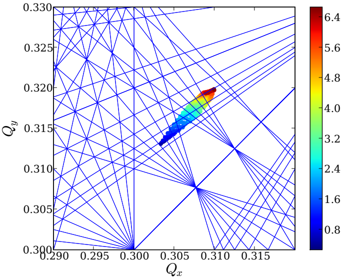
BBLR @ LHC upgrade - “compact”

Uncompensated



$DA = 4\sigma$

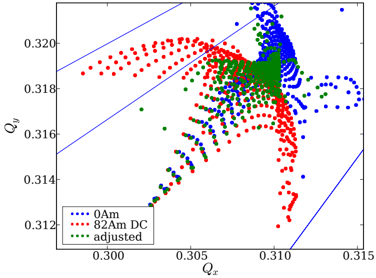
Wire compensated



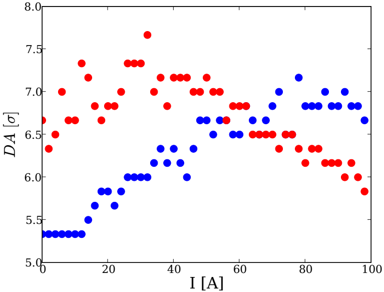
$DA = 5.2\sigma$

BBLR @ LHC upgrade - Pacman bunches

Extreme Pacmanbunch, nominal LHC

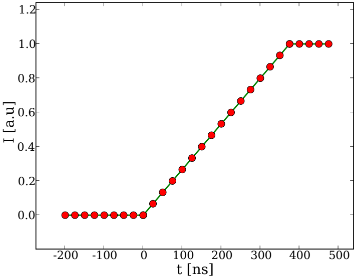


$0 - 10\sigma$,

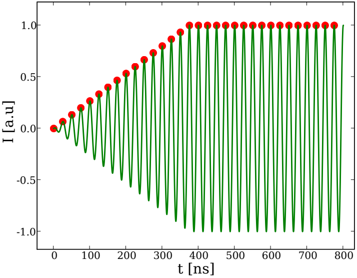


Already a DC wire improves the performance

RF-BBLR - F.Caspers, T.Kroyer



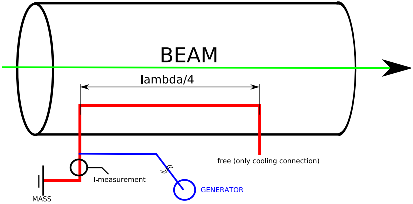
pulsed DC BBLR



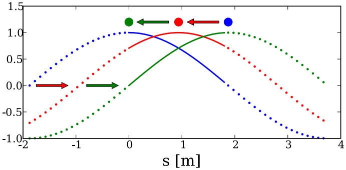
RF BBLR

A RF-version does not suffer from transmission line effects and should be as reliable as a RF-cavity

RF-BBLR



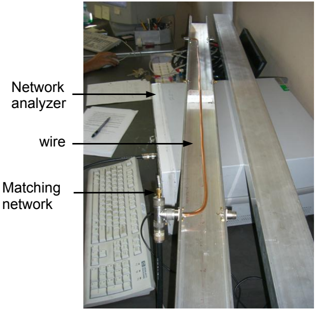
Resonant structure



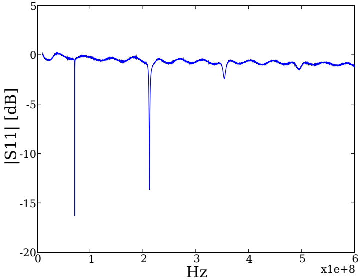
No fringe field effects

- Counterpropagating wave ⇒ Double effect
- No fringe field effects
- Resonating structure ⇒ time stable, low power
- transmission line effects manageable

RF-BBLR - experimental Setup V.1



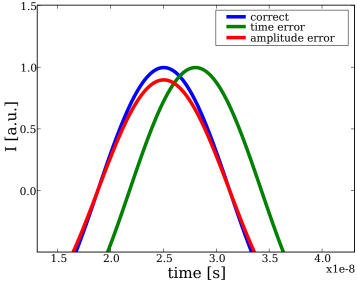
Experimental setup V1



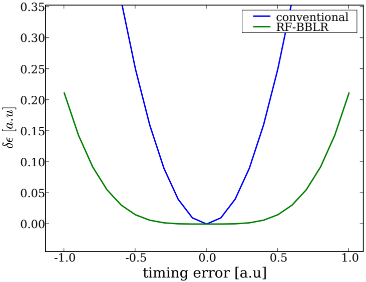
Measured S11

Construction of prototypes has started. Next step: Low power RF-BBLR

RF-BBLR - Noise I

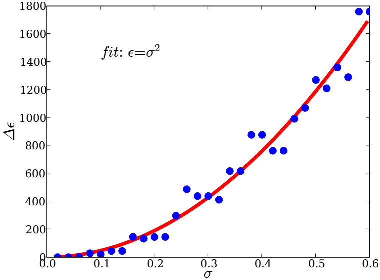


Different error scenarios

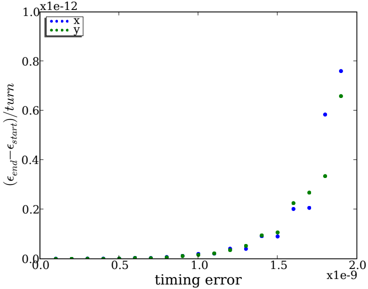


ϵ-growth due to a timing error in pulsed DC- and RF-BBLR

RF-BBLR - Noise II, Simulations

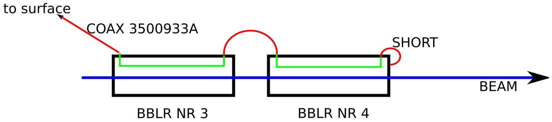


Amplitude noise: $< 3mA$ ($\Delta\epsilon <$ 10% in 20h) $= \Delta t < 0.02ns$ for a DC -BBLR

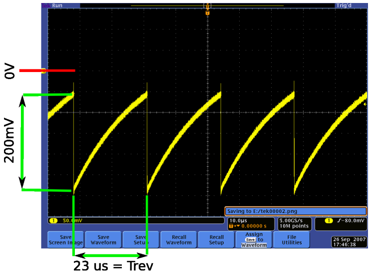


Relaxed timing precision for RF-BBLR: 10% in 20h $\Rightarrow \delta\epsilon/turn = 1.26E-10$.

RF-BBLR - beam induced signal in SPS



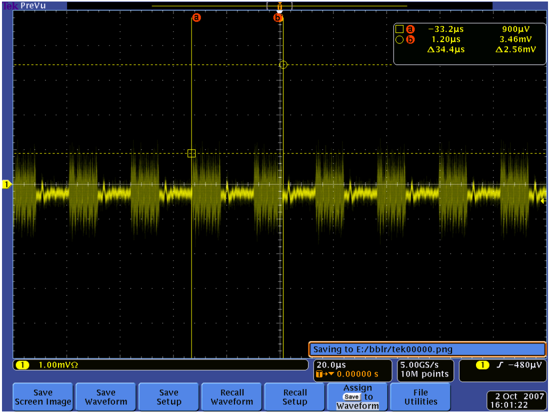
The Setup in the SPS



- effect of 1 LHC batch = 72 bunches, 5E10p/bunch
- will need to be corrected for (together with the amlitude error) by a 3-turn delay feedback
- Impedance issues checked by simulations and since installation in 2002 no adverse effects on beam stability noticed.

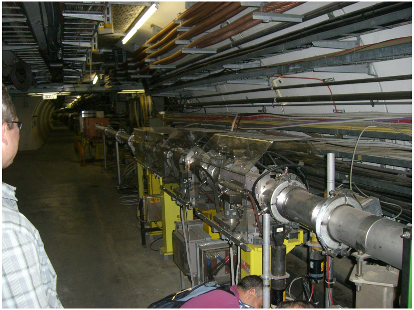
Correction

The beam induced signal shown on the previous slide was measured with $1M\Omega$ instead of 50Ω termination. Below is a corrected version. In order to protect the oscilloscope, the signal is damped by 60dB.



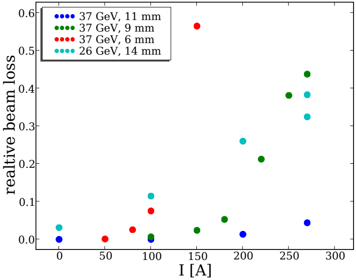
```
Ⓐ −33.2µs   900µV
Ⓑ 1.20µs    3.46mV
  Δ34.4µs   Δ2.56mV
Saving to E:/bblr/tek00000.png
1 1.00mVΩ
20.0µs
T→ 0.00000 s
5.00GS/s
10M points
1 ⨍ −480µV
2 Oct 2007
16:01:22
```

2007 SPS BBLR MDs - J. Wenninger, R. Calaga, R. Tomas, J.P Koutchouk, F. Zimmermann, U. Dorda

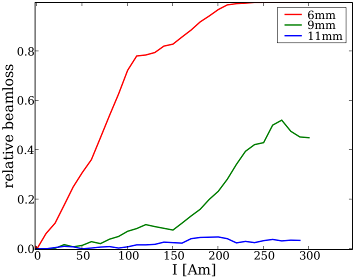


- 2 MDs
- MD1: 26 & 37 GeV
  MD2: 55 GeV
- 2 BBLRS á 2 tanks a 0.6cm
- BBLR 2 upside down
- Q_x : 0.31; Q_y : 0.30

SPS MD 2007 - Wire current scans



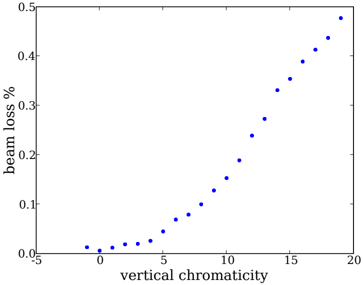
Experiment



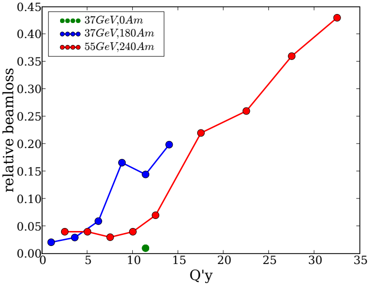
Simulation

SPS MD 2007 - Chromaticity I

RHIC observed hints for a strong chromaticity dependence. We tried to check the sensitivity to Q' at the SPS

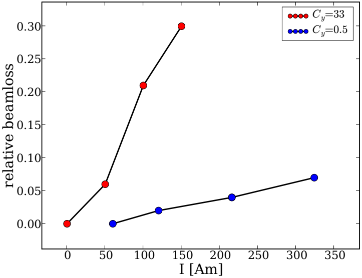


37GeV, d=6.6σ,180Am Simulations reproduce the onset of beamloss

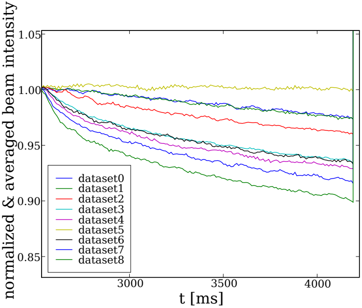


$d = 6.6\sigma$

SPS MD 2007 - Chromaticity II

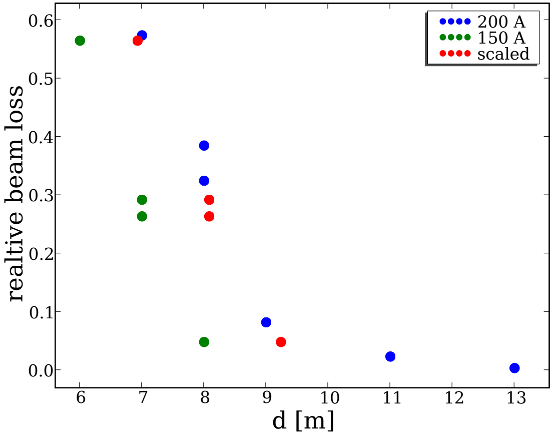


55GeV, $d = 6.6\sigma$, I=240Am



$Q'_h - scan$, BCT data

SPS MD 2007 - Current scan



In this case Frank's scaling law works well.

Conclusions & Thanks

- Low - β max optics is the best one.
- Chromaticity issue raised at RHIC confirmed
- RF-BBLR advancing

Thanks to:
R. de Maria, F.Zimmermann
F.Caspers, T.Kroyer
J. Wenninger, R. Calaga, R. Tomas, J.P Koutchouk