Optics measurements
OMC team

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CERN - NIKHEF

December 1, 2011

OMC-team:

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A small introduction

Measurement technique

Correction techniques

Optics correction 90m

Measurement resolution

How well can we measure Ly?

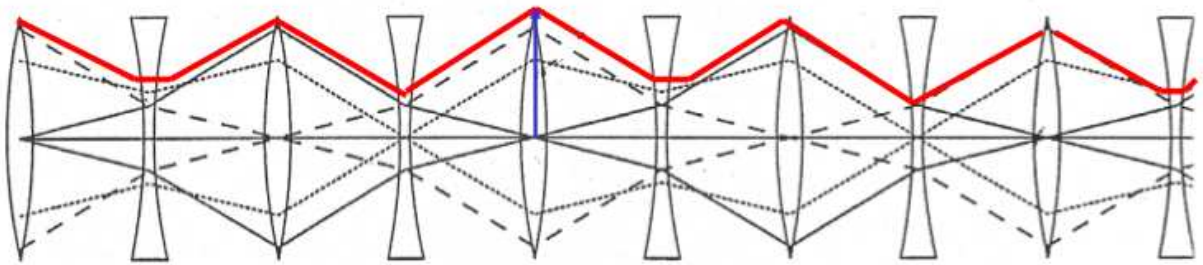
Conclusions

The E.O.M of the betatron oscillations can be written as:

$$x_\beta(s) = \sqrt{\epsilon\beta(s)}\cos[\psi(s) + \psi(0)]$$

With:

- $\beta(s)$=beta function at location s.
- $\psi(s)$=phase at location s.
- ϵ=emittance.
- $\sigma(s) = \sqrt{\epsilon\beta(s)}$= beam size at location s.



Two techniques are used to measure the β-function:

- Segment-by-segment technique using turn-by-turn data.
- K-modulation

Optics measurement using turn-by-turn data:

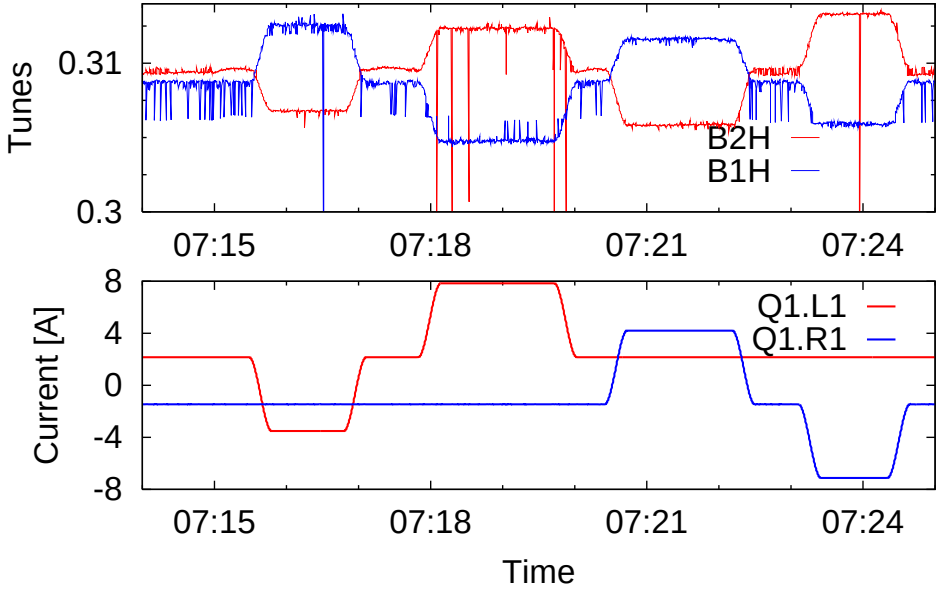
- AC-dipole is used to introduce transverse oscillations.
- Turn-by-turn data is acquired for around 2000 turns for all BPMs.
- Amplitude and phase is calculated using an interpolated FFT.
- Several algorithms are used to calculate linear and non-linear optics at the BPMs.

Set-up conditions:

- Dedicated fill.
- Intensity limited to 8×10^{10}.

K-modulation

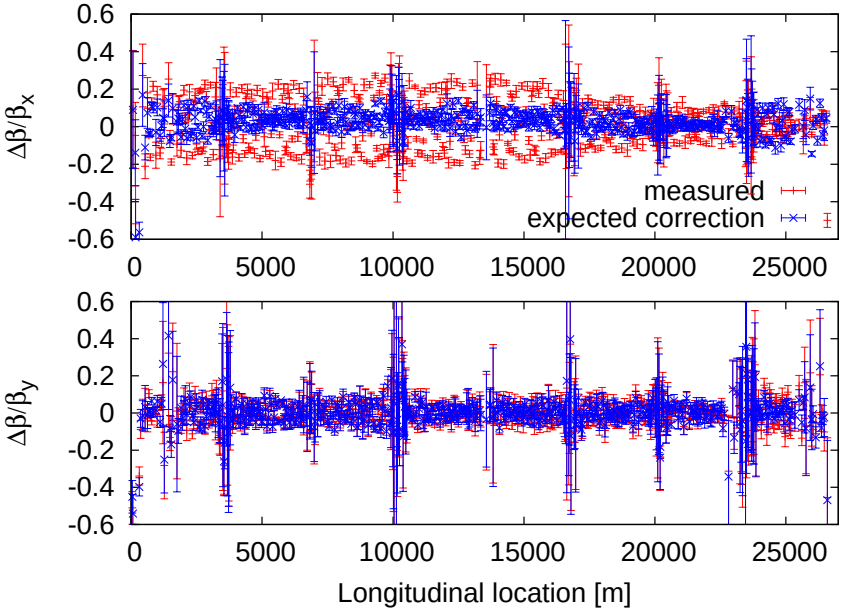
- Q_1 left and right from IP is used.
- $\beta(s)$ is calculated using $\beta(s) = 4\pi \frac{\Delta Q}{\Delta K(s) l}$

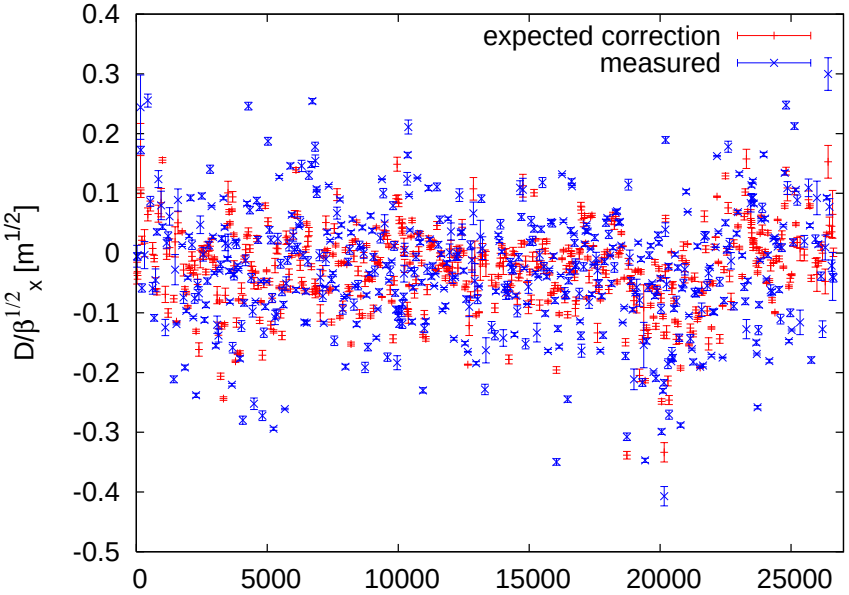


Correction technique used:

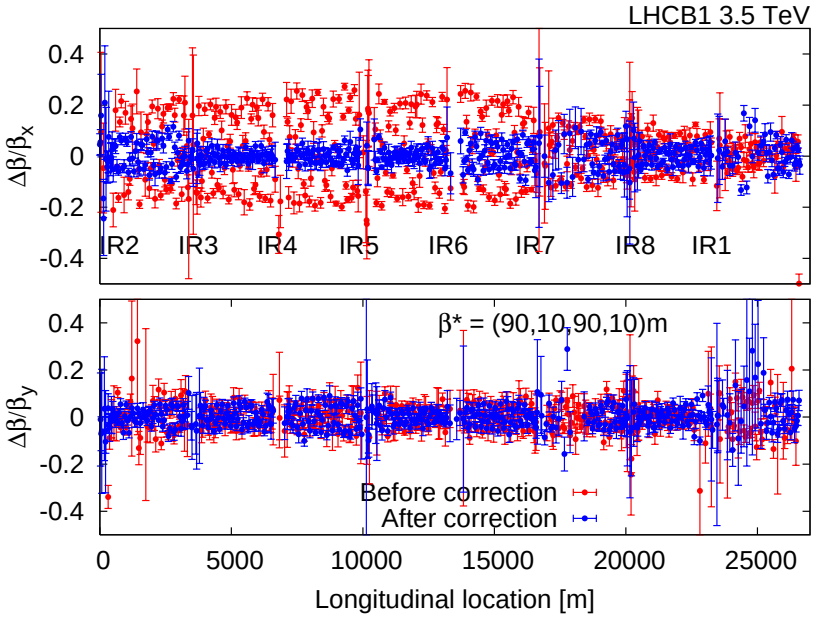
- Global correction $-> $ Used to correct distributed residual errors (after local correction).

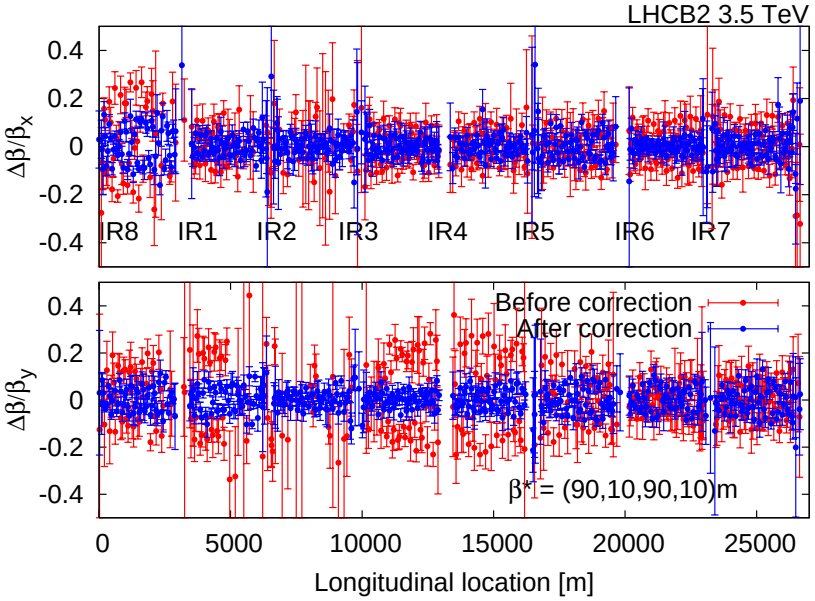
$$\frac{\Delta\beta}{\beta} = \frac{\beta_{measurement} - \beta_{model}}{\beta_{model}}$$



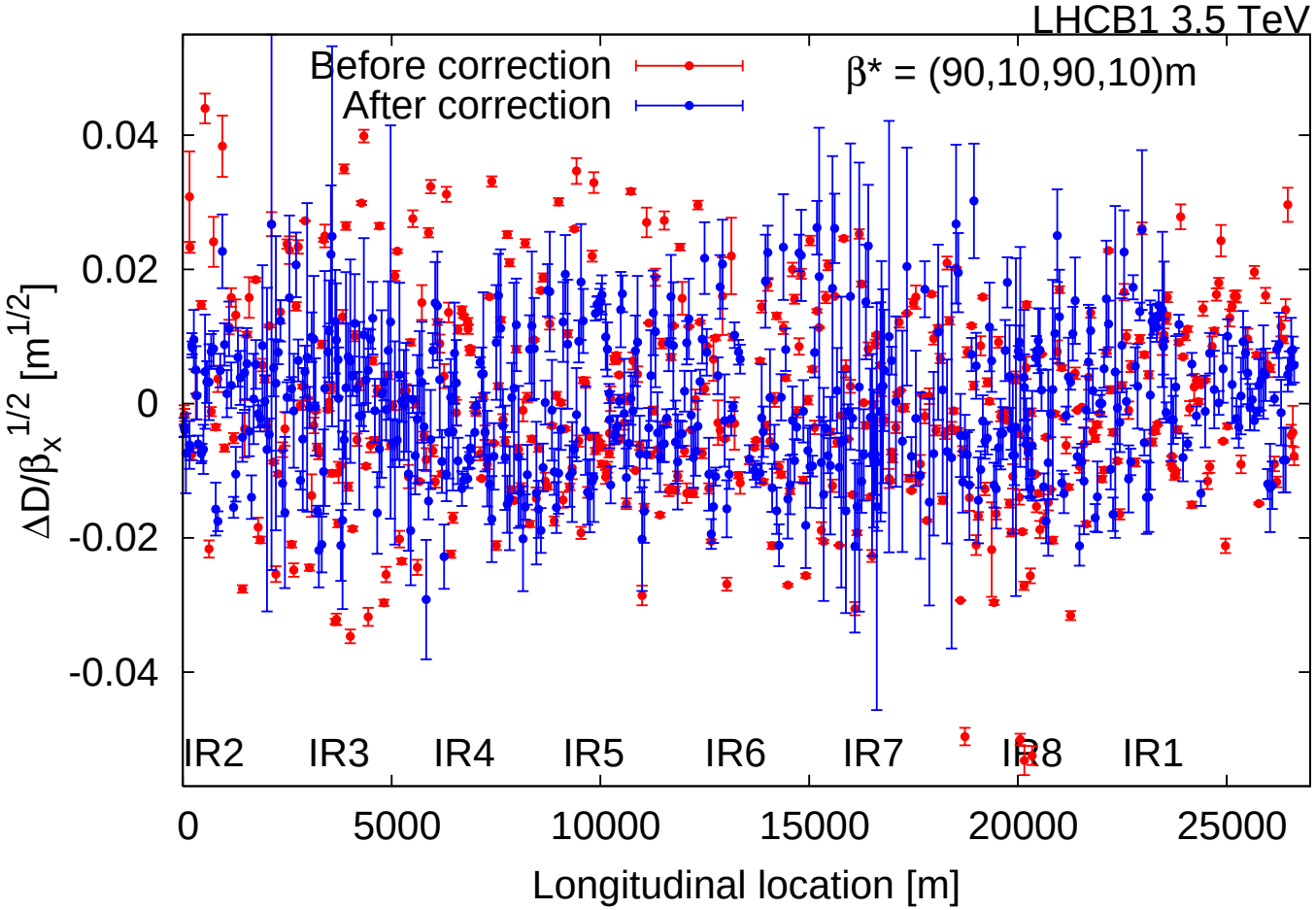


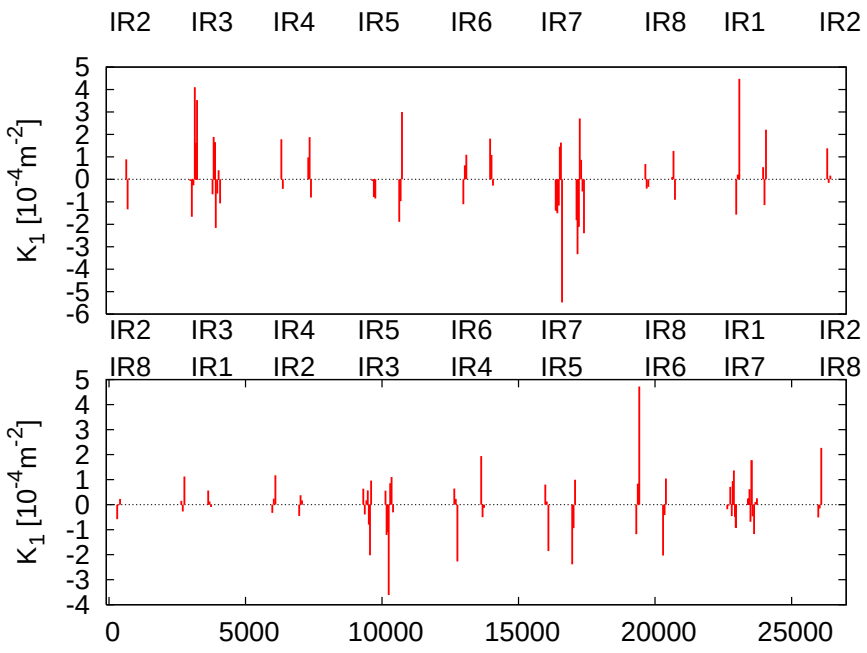
Optics correction 90m - β-beat





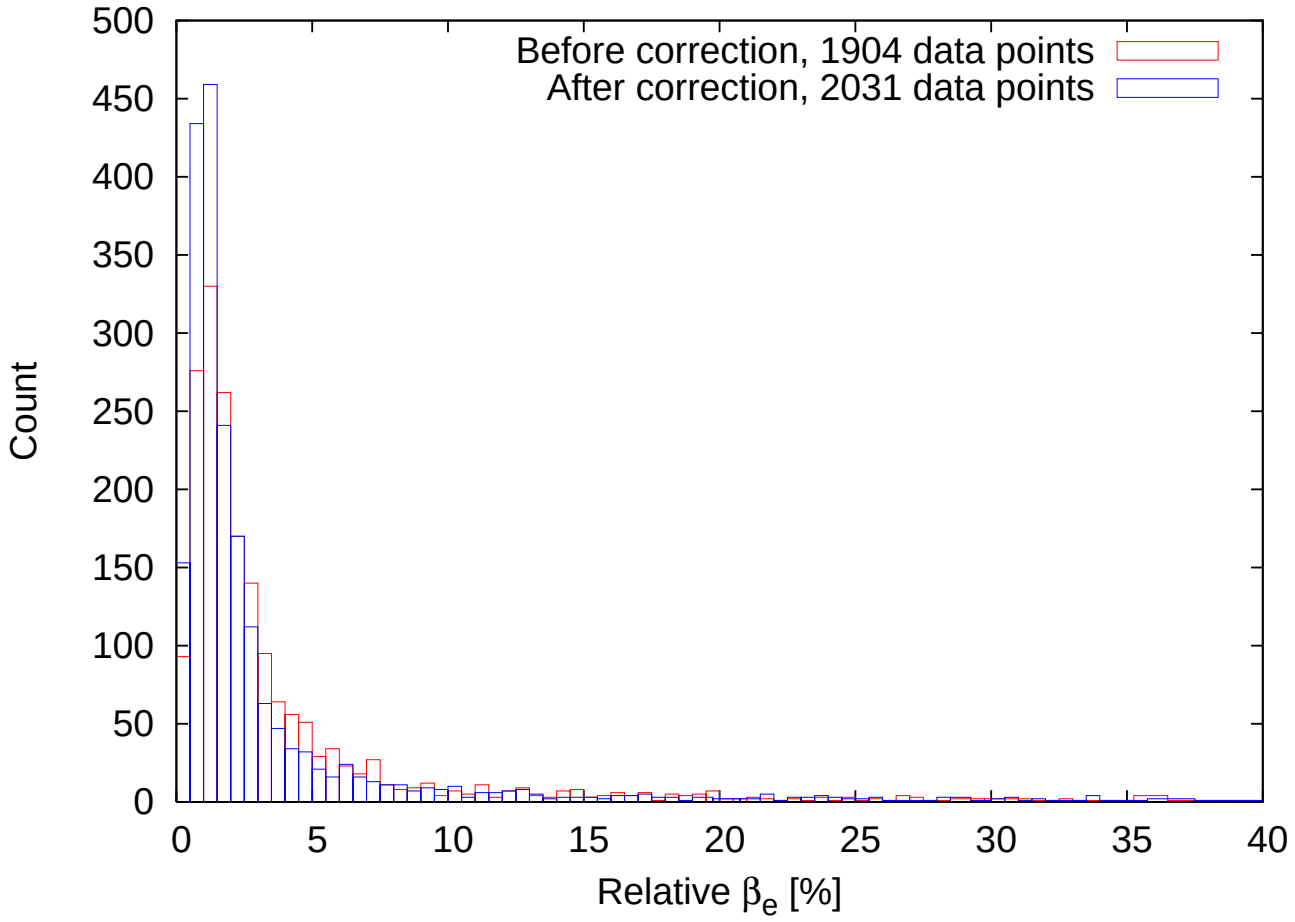
Optics correction 90m - Dispersion





- For the correction no common correctors were used (no triplets).
- Largest corrector used is about 5×10^{-4}.
- The correctors used are outside the IR-RP area (kqt.13l/r5, kqt.12l/r5, kqtli.11l/5).

Relative measurement error:



Main distribution of the β error is below 8%.

Two approaches are used:

- Direct measurement using segment-by-segment technique.
- Using Monte-Carlo.

Using the segment-by-segment technique (best case):

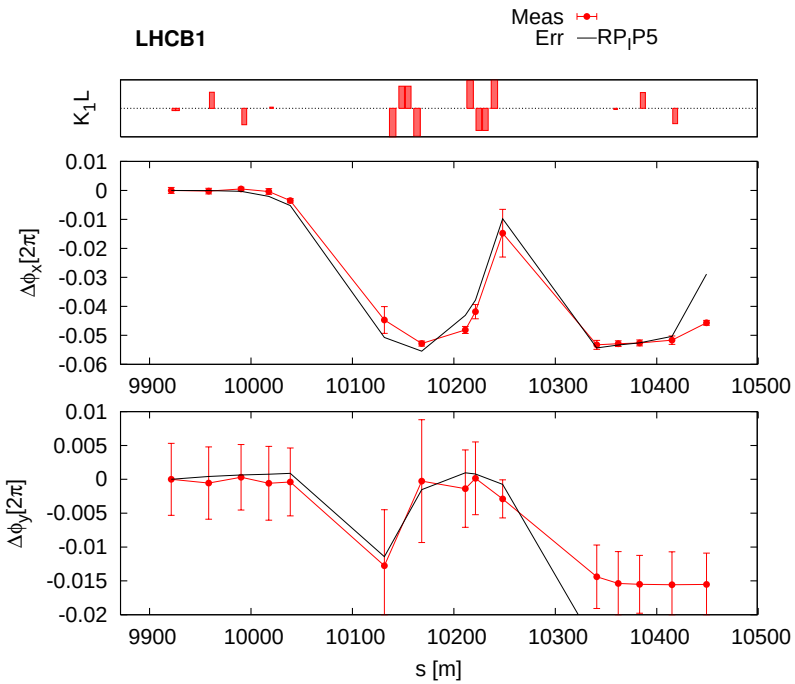
RP	β^{rp}	β_e^{rp}	β^*	β_e^*	$\Delta\phi$	$\Delta\phi_e$	L^y	L_e^y
A	871	3	89.7	5.6	0.26	0.01	277	9
B	793	7	89.7	5.6	0.27	0.01	264	8

$$L^y = R_{34} = \sqrt{\beta^{RP}\beta^*}\sin(\Delta\mu)$$

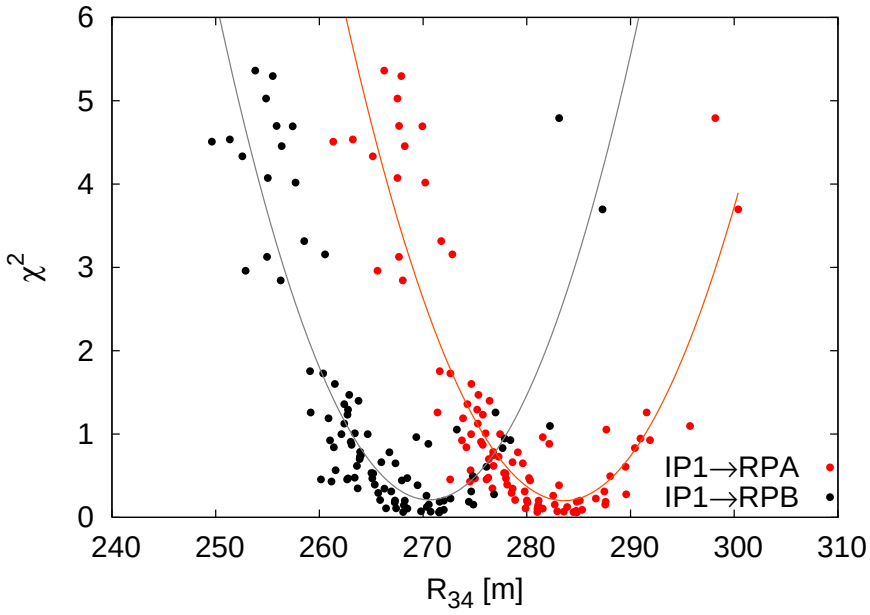
- Error of L^y is dominated by the error of the β at the IP and roman pot.
- Phase advance measurement has systematic error (using ideal model for the propagation).

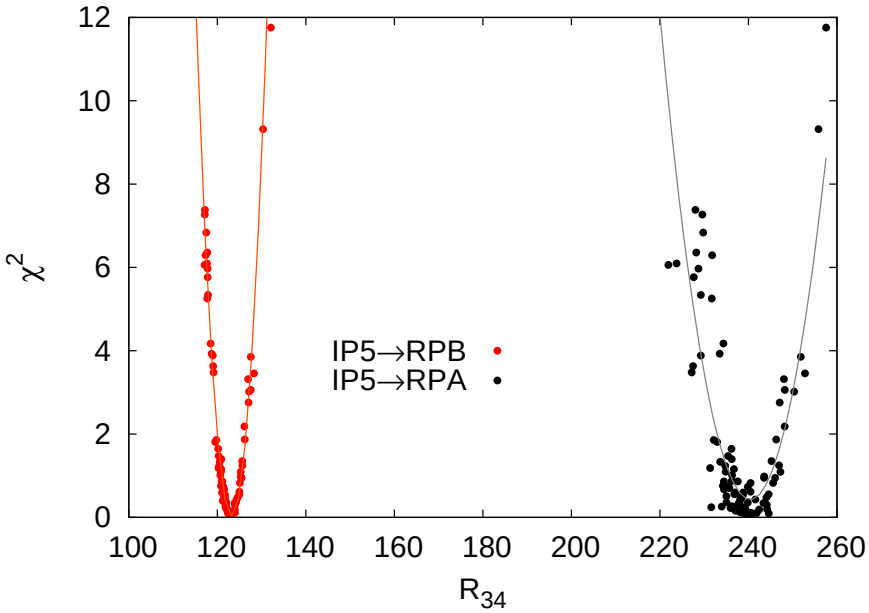
Using the Monte-Carlo approach:

Magnet IR1	Magnet IR5
ktqx2.r1	ktqx2.r5
kqx.r1	kqx.r5
ktqx.r1	ktqx.r5
kq4.r1b1	kq4.r5b1
kq5.r1b1	kq5.r5b1
kq6.r1b1	kq6.r5b1



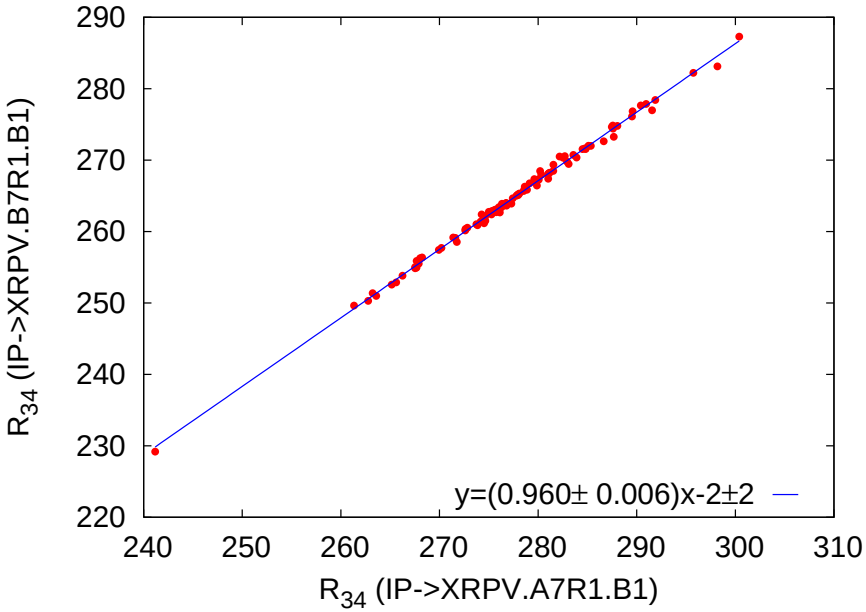
- χ^2 is constructed from $\phi_{me}, \phi_{mo}, \phi_e$.

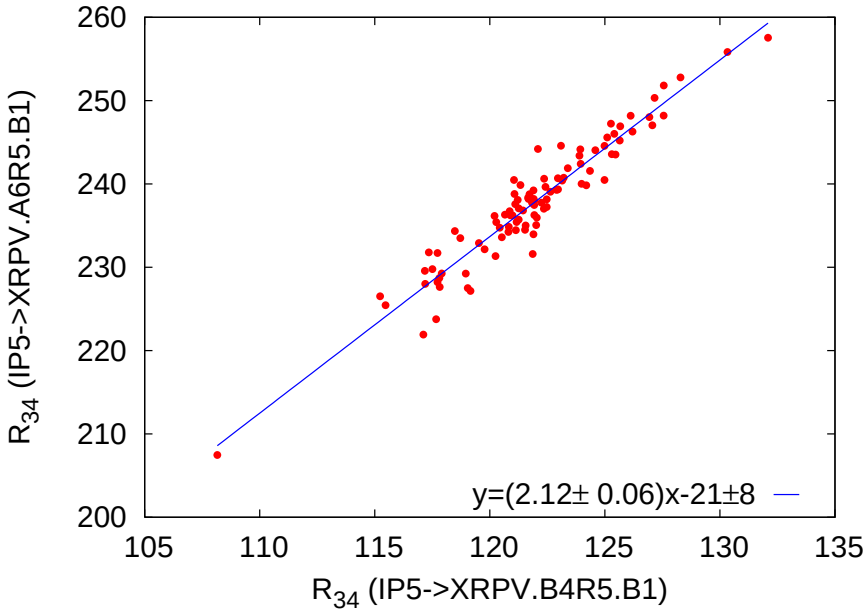




For Beam 1:

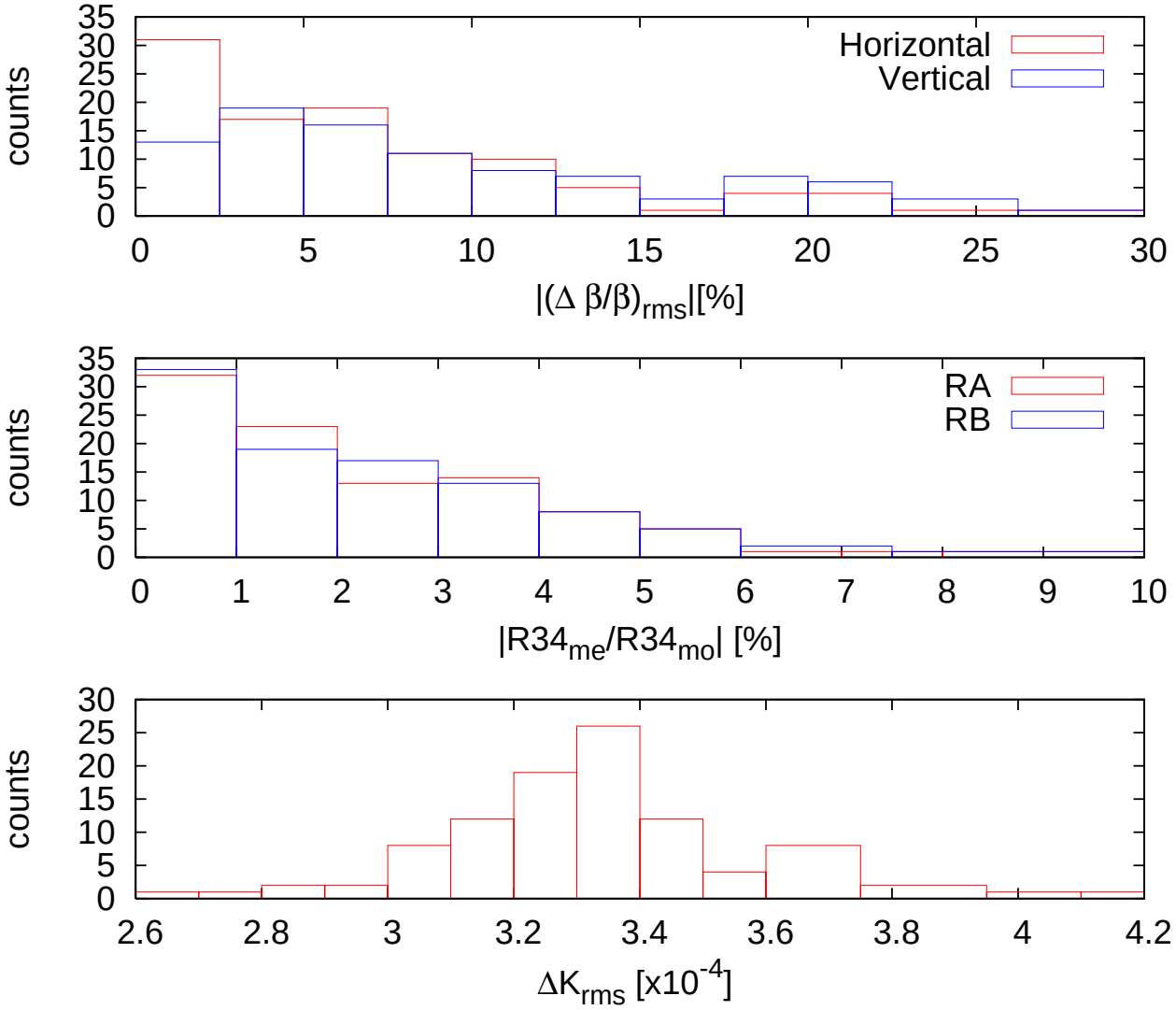
- $R34_A = 283 \pm 8$
- $R34_B = 270 \pm 8$





The correlation between the roman pots is good.

For IP1:


counts
Horizontal
Vertical
|(Δ β/β)rms|[%]
counts
RA
RB
|R34me/R34mo| [%]
counts
ΔKrms [x10-4]

- β-beat for the 90 m optics has been corrected down to 10-15%.
- Relative measurement error is below 8%.
- For both approaches the L^y could be measured with a 3% error. For segment-by-segment approach the best case was shown.
- Small disagreement between the 2 methods.

Roman pot	Approach	$L^y[m]$	$L_e^y[m]$
A	SBS	277	9
B	SBS	264	8
A	MC	283	8
B	MC	270	8

- Segment-by-Segment approach has a small systematic error.
- Errors in the quadrupole are in the order 3×10^{-4} for the Monte-Carlo.
- Monte-Carlo could be improved by adding more constraints (for instance including the K-modulation measurement at Q_1 and even Q_2, Q_3).