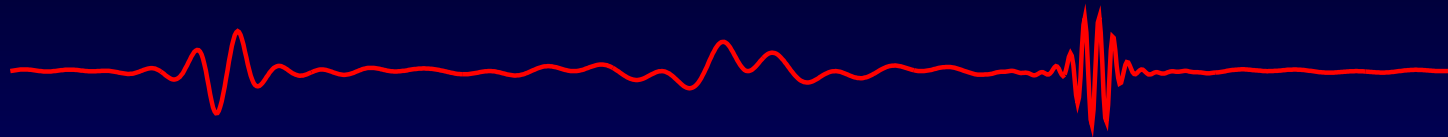


# Beam-based measurements



I. Agapov, M. Aiba, R. Calaga, B. Dehning,  
 S. Fartoukh, A. Franchi, K. Fuchsberger,  
 M. Giovannozzi, V. Kain, M. Lamont, L. Ponce,  
 S. Redaelli, F. Roncarolo, Y. Sun, R. Tomás,  
 G. Vanbavinckhove, W. Venturini-Delsolaro,  
 J. Wenninger, F. Zimmermann

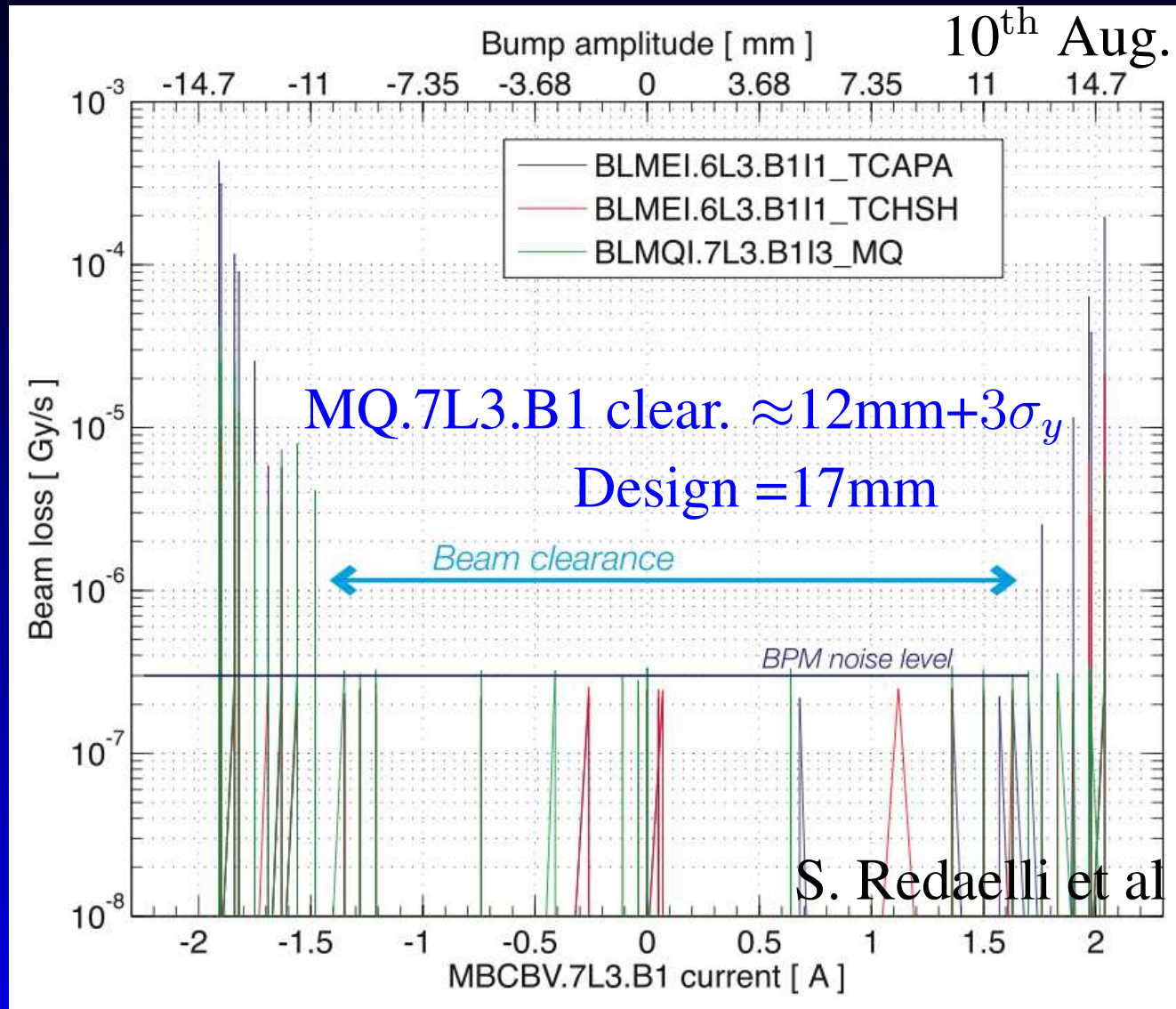
Thanks to E. Calvo Giraldo, N. Catalán Lasheras,  
 O. Brüning, R. Jones, Y. Papaphilippou, S. Peggs,  
 F. Schmidt, R. Steinhagen

Chamonix 2009

# Contents

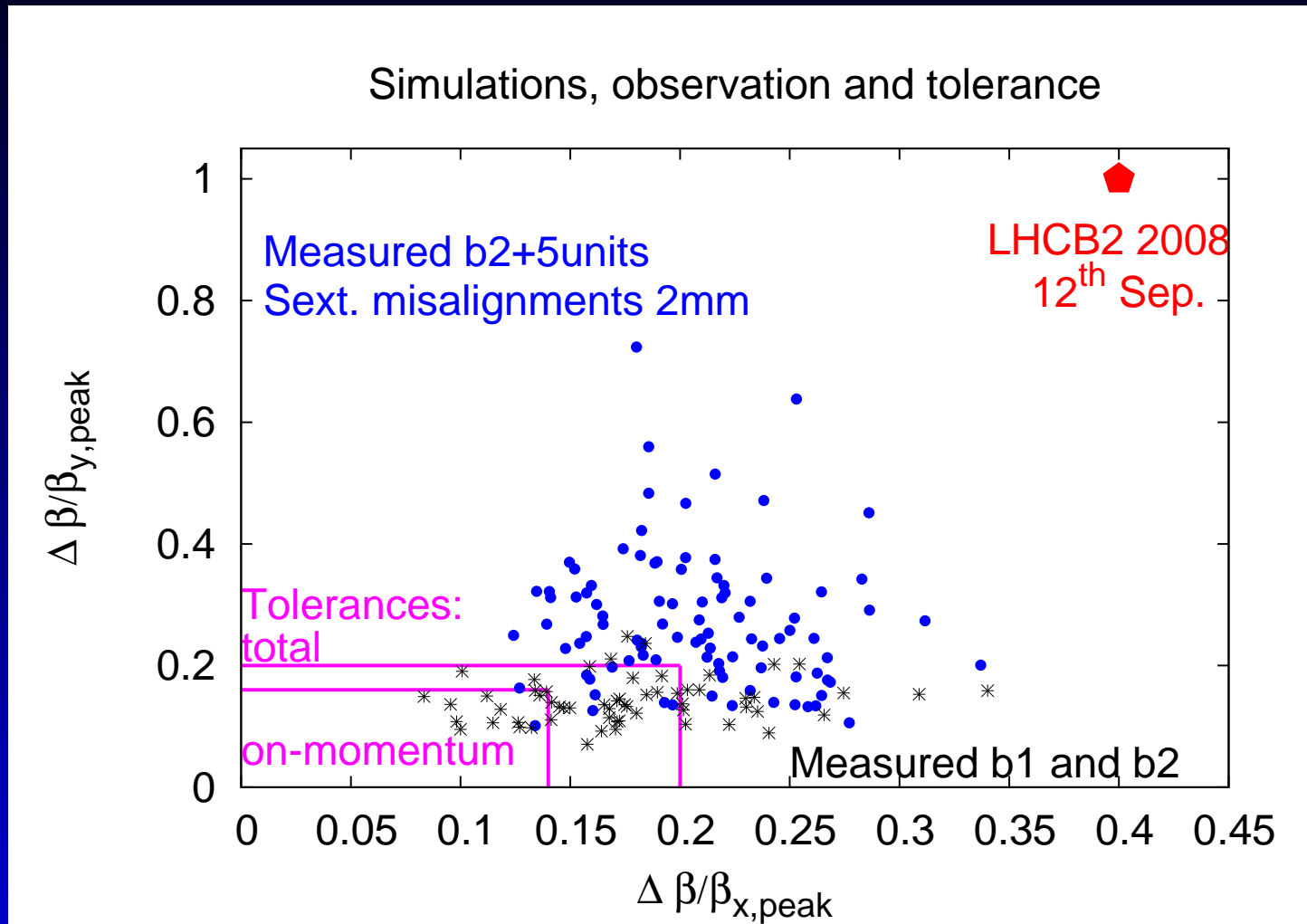
- Motivation: Aperture, simulations, observation and tolerances.
- Polarity checks in sectors 23 & 78
- Beta-beating measurement and error reconstruction
- Coupling measurement

# Motivation: Aperture (see previous talk)



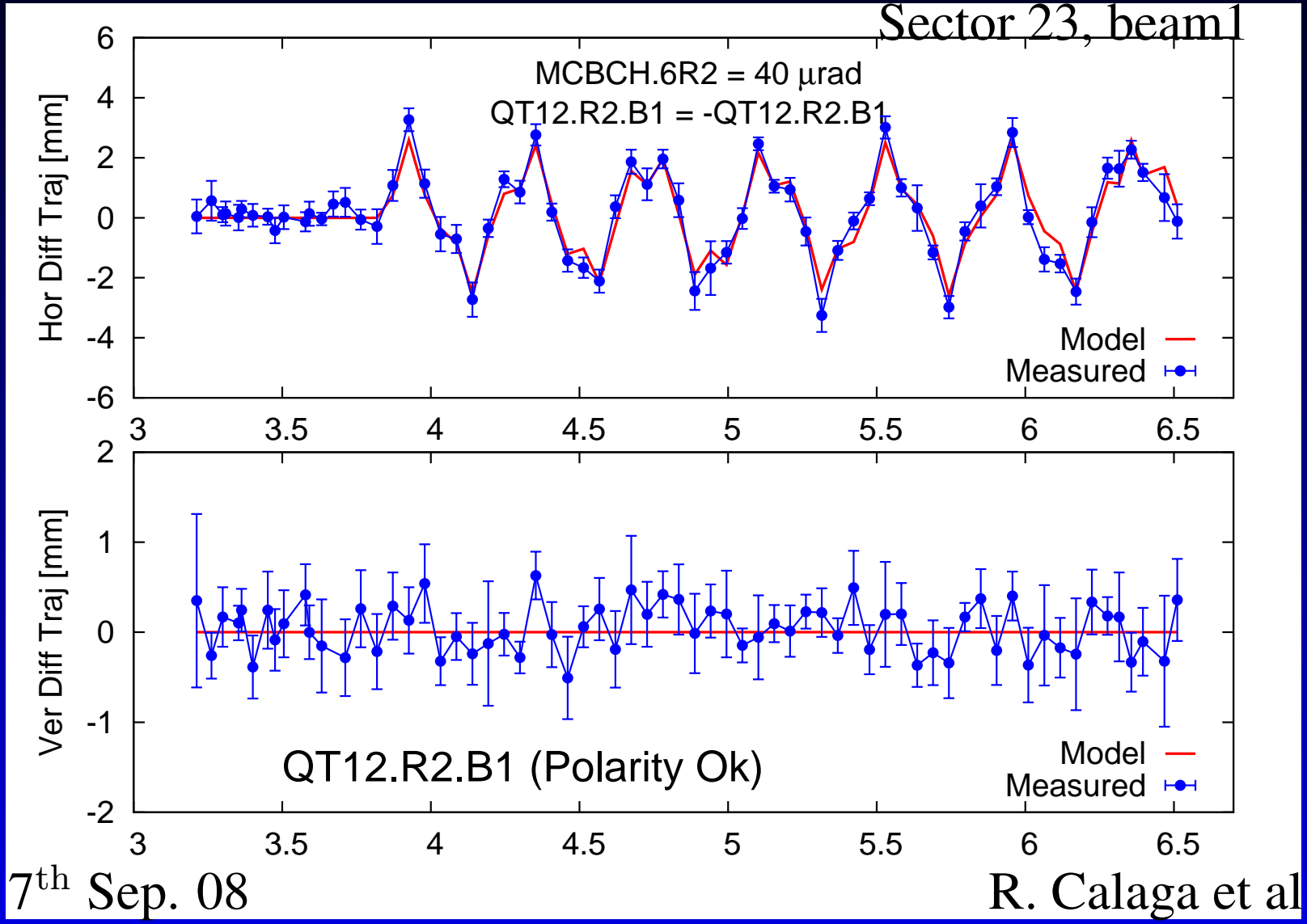
LHC has a tight aperture but so far so good!

# Simulations, observation & tolerances

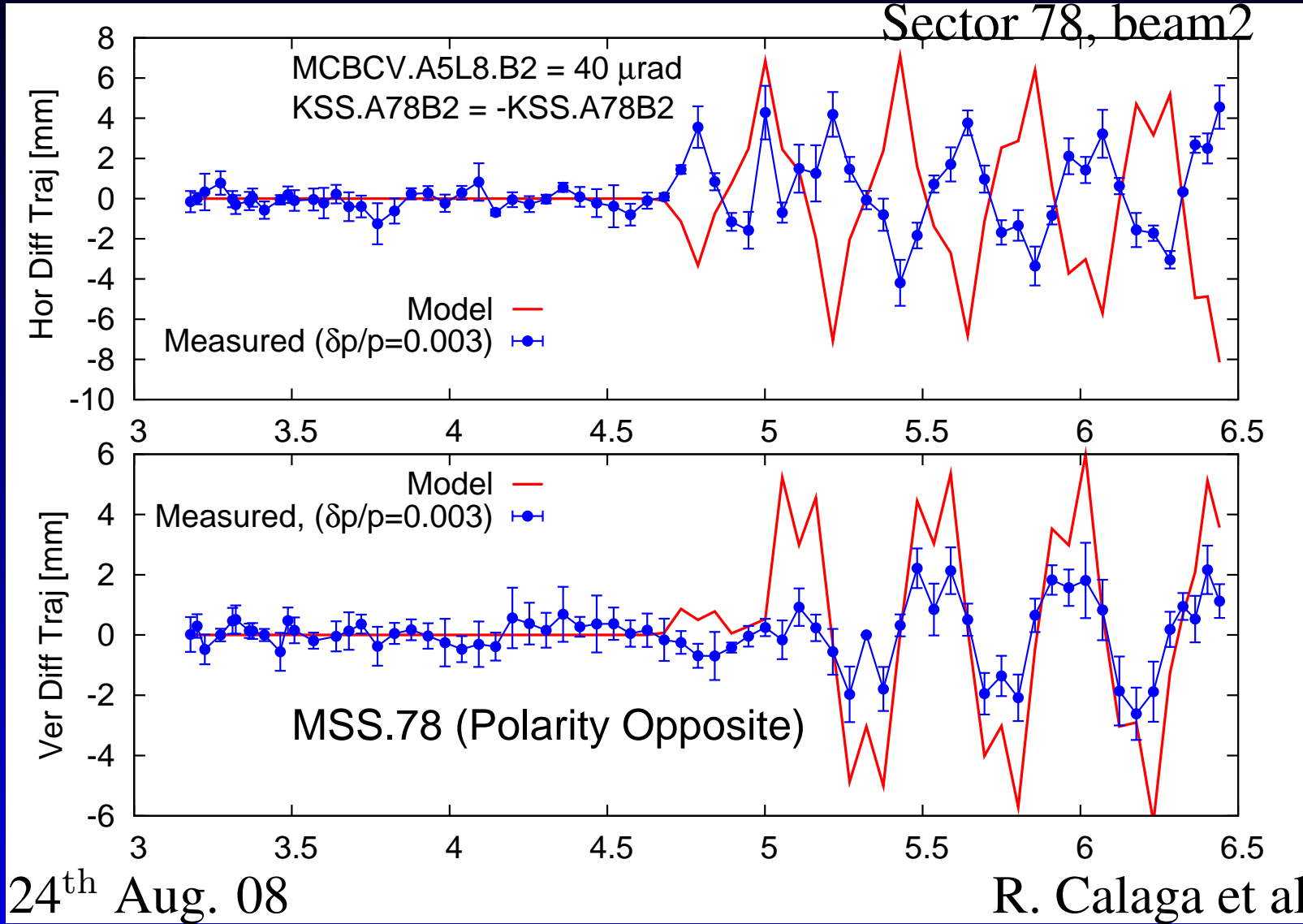


LHCB2 optics not in great shape, but let's fix it!

# Polarity tests: a good one! (QT12R2B1)



# Polarity tests: a disagreement



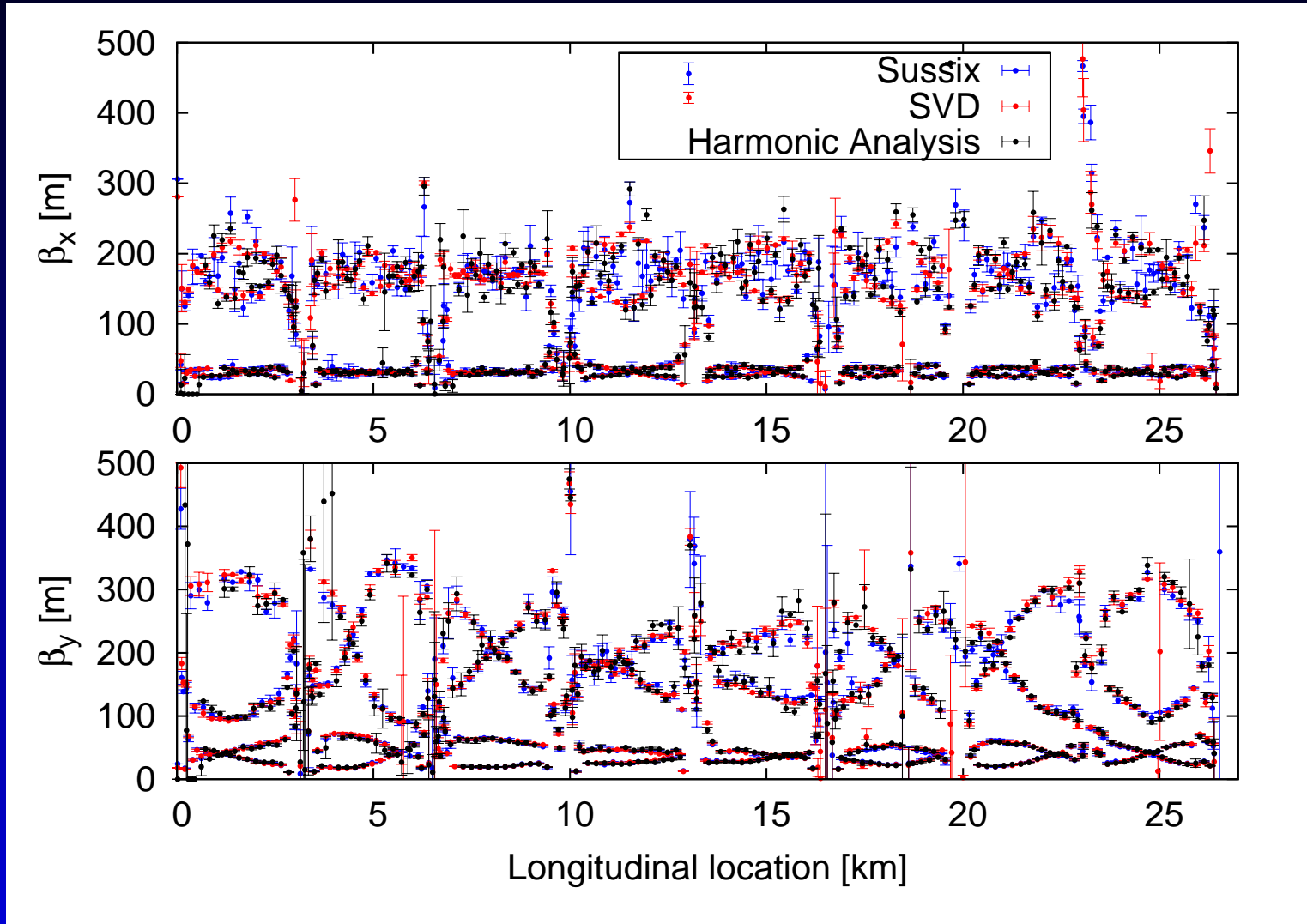
**Beam2 skew sextupoles polarity conventions?!**

# Polarity tests: summary

- **Polarity disagreement:**MQS23B1, MQS78B2 and MSS78B2
- **Already fixed:**QT11.R2B1
- **Polarity OK:**QT12R1B1, QT13.R2B1, QT12L8B2, SF[1,2].A78.B2, SF[1,2].A78.B2, SD[1,2].A78.B2, MCS.78B2, KOD.A78B2 and KOF.A78B2
- **Inconclusive:**QT13.L8B2 and KOD.A23B1

→ Only skew circuits show polarity disagreement..  
(details in a coming LHC-PerfN)

# Measuring $\beta$ : 3 algorithms



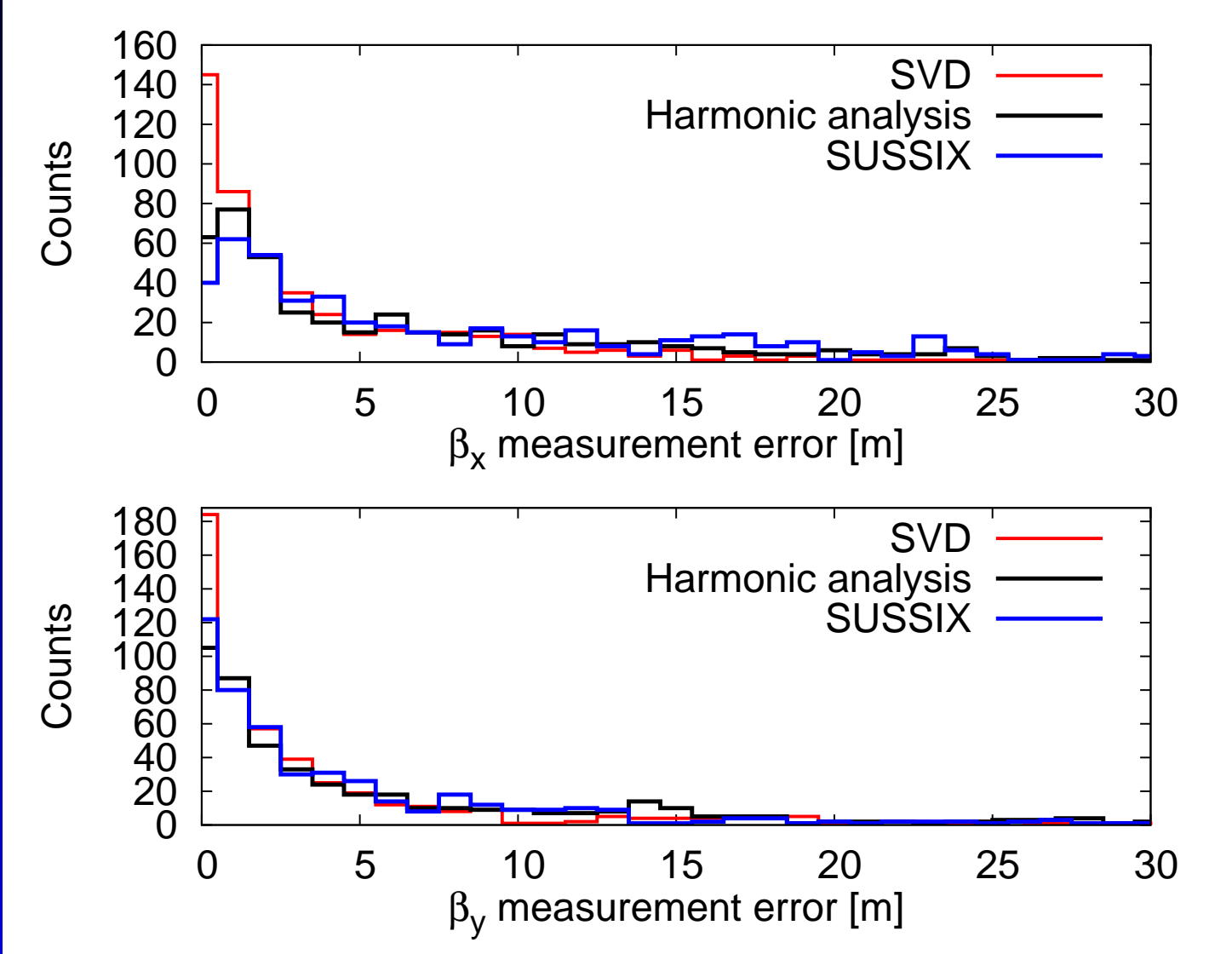
12<sup>th</sup> Sep. 08

LHCB2

LHC-PerfN-008

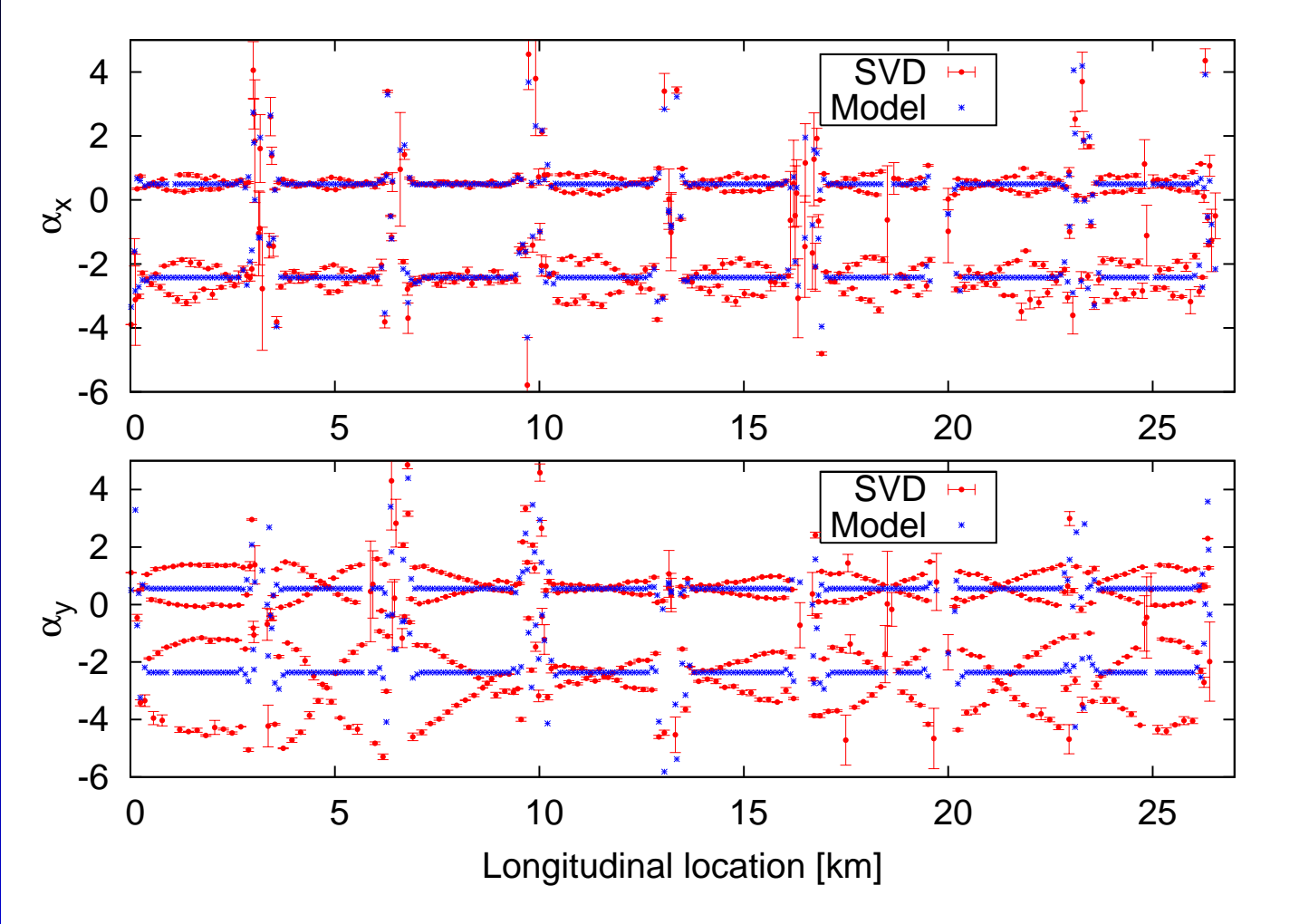


# Performance comparison



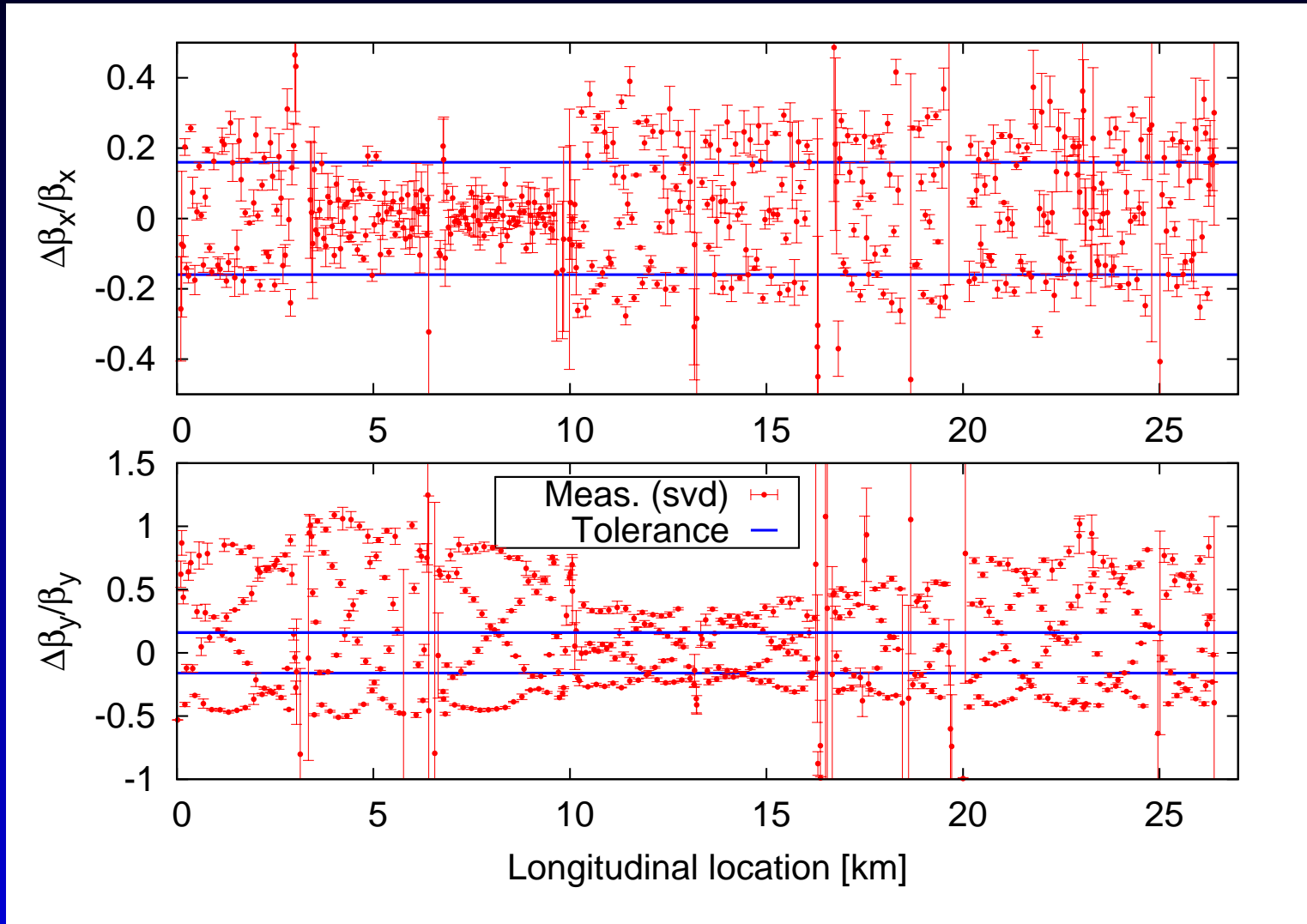
SVD wins (R. Calaga's thesis)

# The measurement of $\alpha$

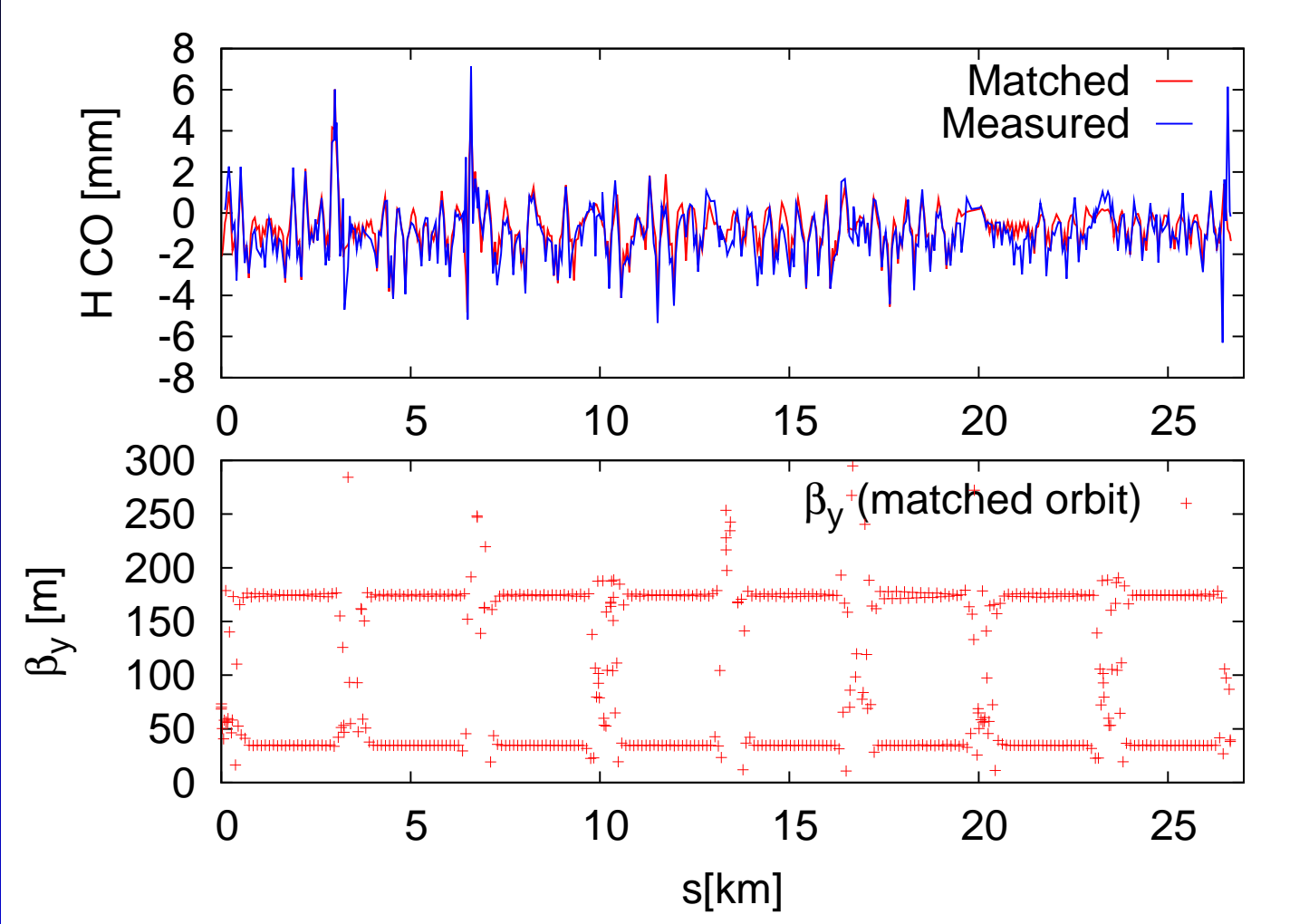


$\alpha$  is measured as  $\beta$  but typically ignored.

# The $\beta$ -beating



# Impact of closed orbit

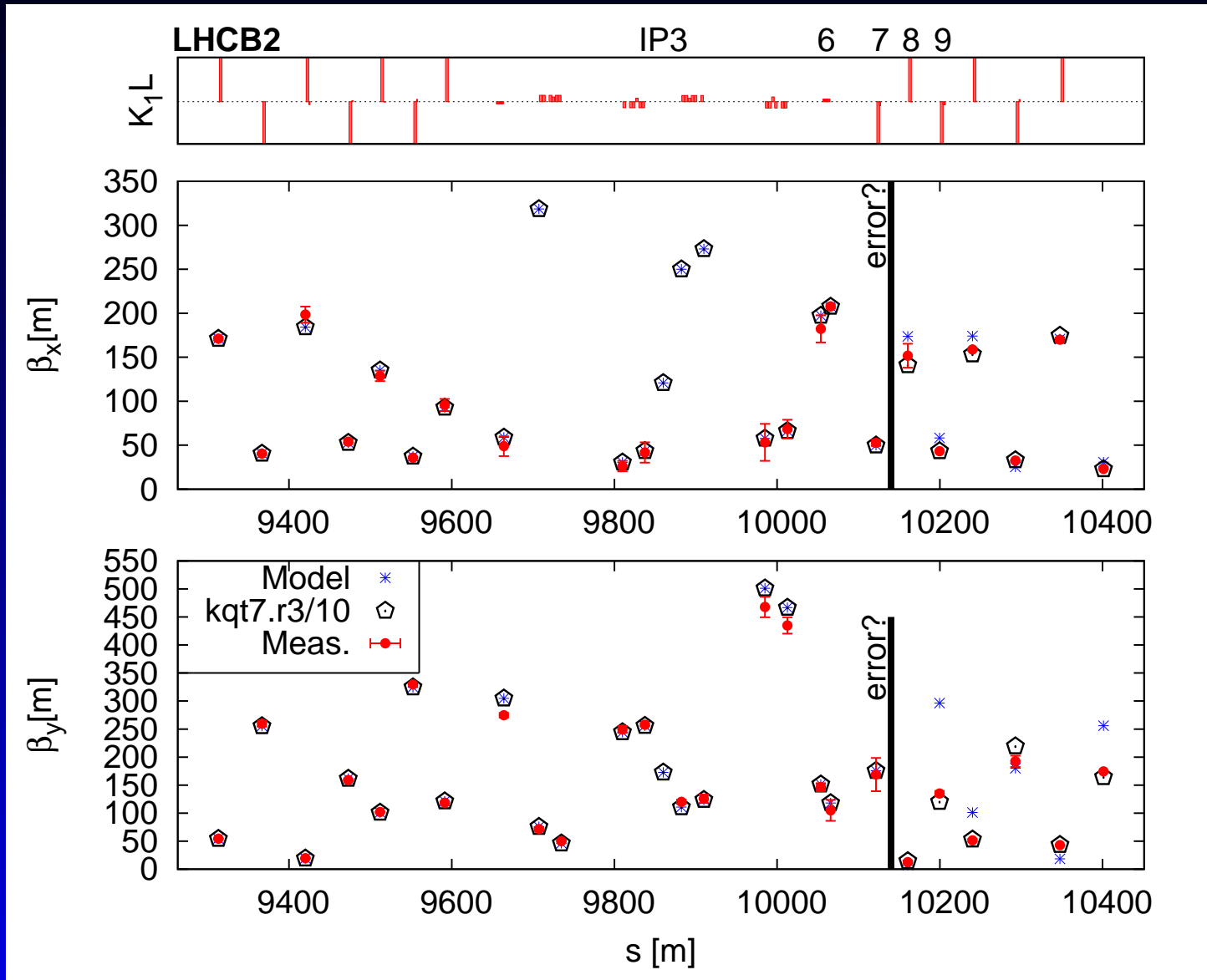


The impact of the measured closed orbit in the beta-beating is negligible.

# Error reconstruction methods

- **Standard matrix inversion correction:** Not suitable due to too large errors
- **Segment-by-segment<sup>new</sup>:** Use of measured  $(\beta, \alpha)$  as initial conditions to split the LHC into segments and reduce problem dimensions (presently under development by myself).
- **Iterative (model) correction<sup>new</sup>:** Iterate correction subtracting model betas to measured betas at every step (implemented by Masamitsu).

# Segment-by-segment in IR3



*mqtli7r3b2 off ?!*

# Segment-by-segment in IR3

**Hypothesis:** cabling swapping between apertures mqtli7r3b2 & mqtli7r3b1 since  $mqtli7r3b2 \approx 10 \times mqtli7r3b1$

At the same time elsewhere:

- M. Lamont publishes LHC-PerfN-009 concluding that mqtli7r3b2 seems to be unpowered from dispersion measurements
- N. Catalán Lasheras observed an inversion on voltage taps RQTL7.R3 and was seeking for beam-based information

→ “Non-conformity report” 985231 initiated.

# Segment by segment summary

Segment	$\frac{\Delta\beta_x}{\beta_x}$ peak [%]	$\frac{\Delta\beta_y}{\beta_y}$ peak [%]	Source
IR3	17	54	mqtli7r3b2 (/10)
IR2	9	5	mqya4l2b2 (+14%)
IR7	6	6	mqt5[r1]7 ( $\times -2,3$ )
IR6	5	4	mq4l6b2 (+1%)
ARC23	0	3	mqd23 (+0.4%)

red: confirmed source, orange: not confirmed and “effective”

mqya4l2b2 could be a cabling problem.

mqt5[r1]7 have low current, could be in *unknown* state.

→ Further verifications and studies ongoing



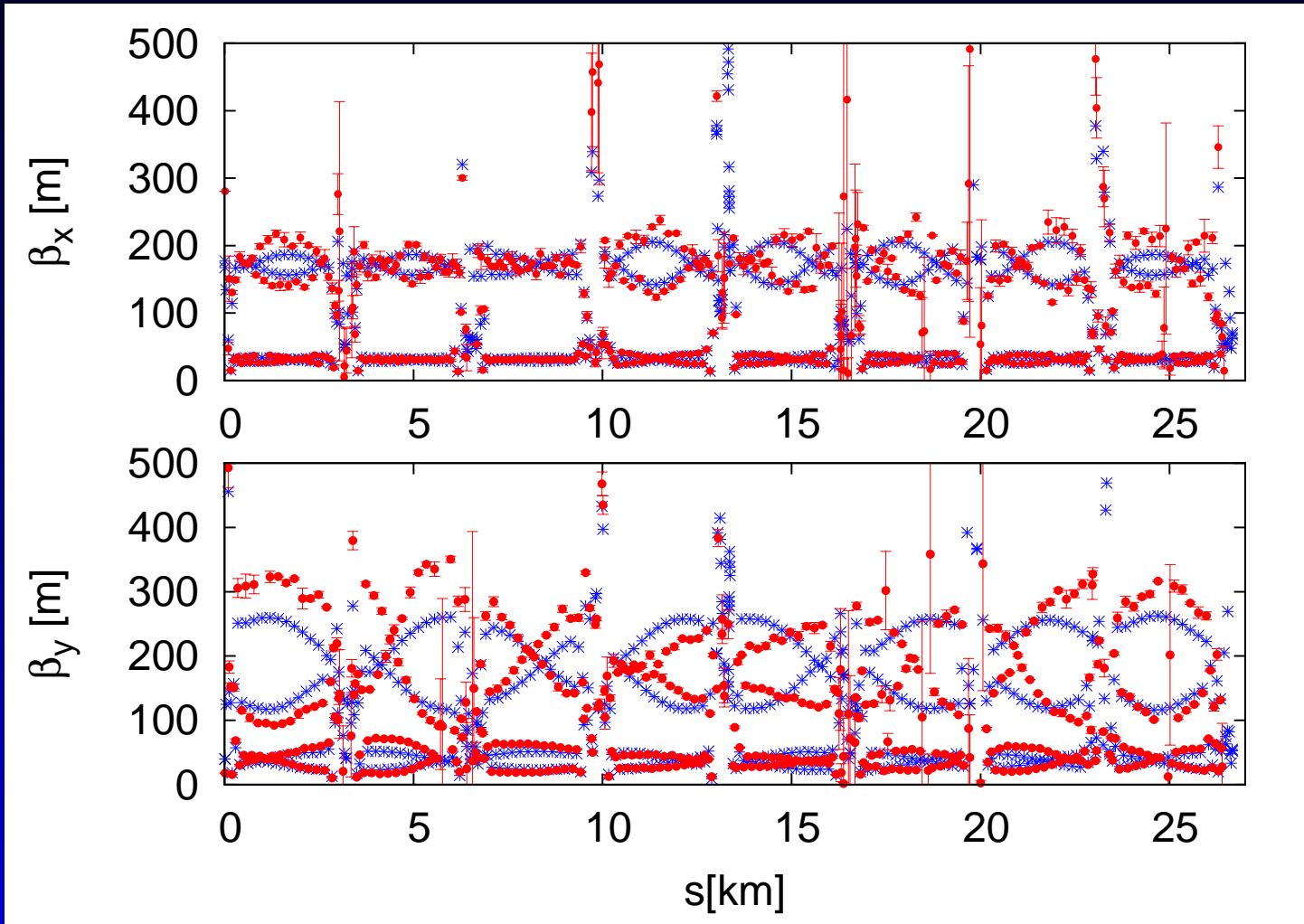
							Point							
10L1	9L1	8L1	7L1	6L1	5L1	4L1	1	4R1	5R1	6R1	7R1	8R1	9R1	10R1
10L2	9L2	8L2	7L2	6L2	5L2	4L2	2	4R2	5R2	6R2	7R2	8R2	9R2	10R2
							3							
10L4	9L4	8L4	7L4	6L4	5L4		4		5R4	6R4	7R4	8R4	9R4	10R4
10L5	9L5	8L5	7L5	6L5	5L5	4L5	5	4R5	5R5	6R5	7R5	8R5	9R5	10R5
10L6	9L6	8L6			5L6	4L6	6	4R6	5R6			8R6	9R6	10R6
							7							
10L8	9L8	8L8	7L8	6L8	5L8	4L8	8	4R8	5R8	6R8	7R8	8R8	9R8	10R8

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## S. Russenschuck, LTC-2008-07

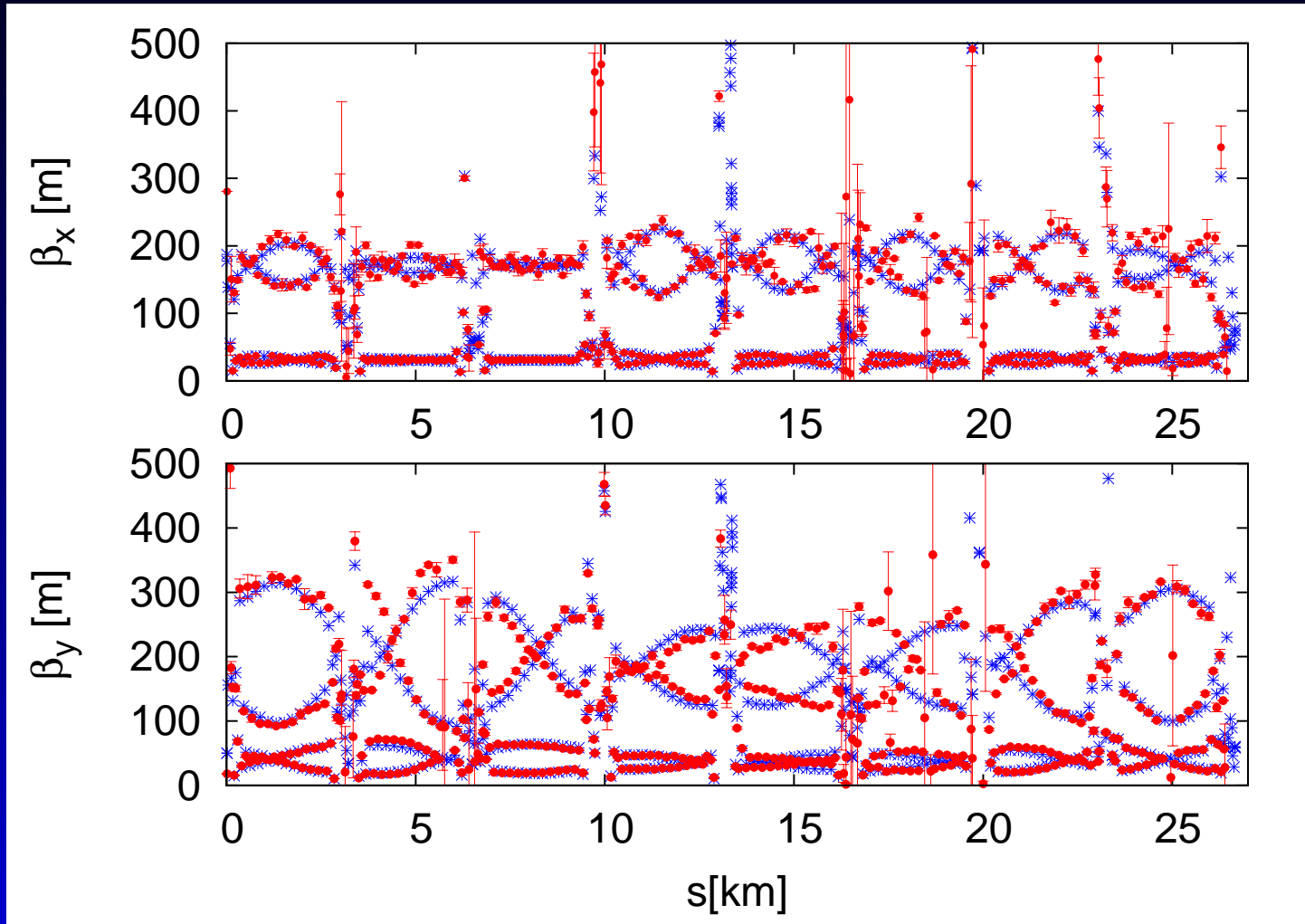
Red magnets indicate that cable swapping was found and fixed. Could IR2 still be affected?  
 IR1 and IR5 are powered with B1-B2 symmetry:  
 IR1/5 Optics are blind to cable swapping!

# Segment-by-segment + Iterative



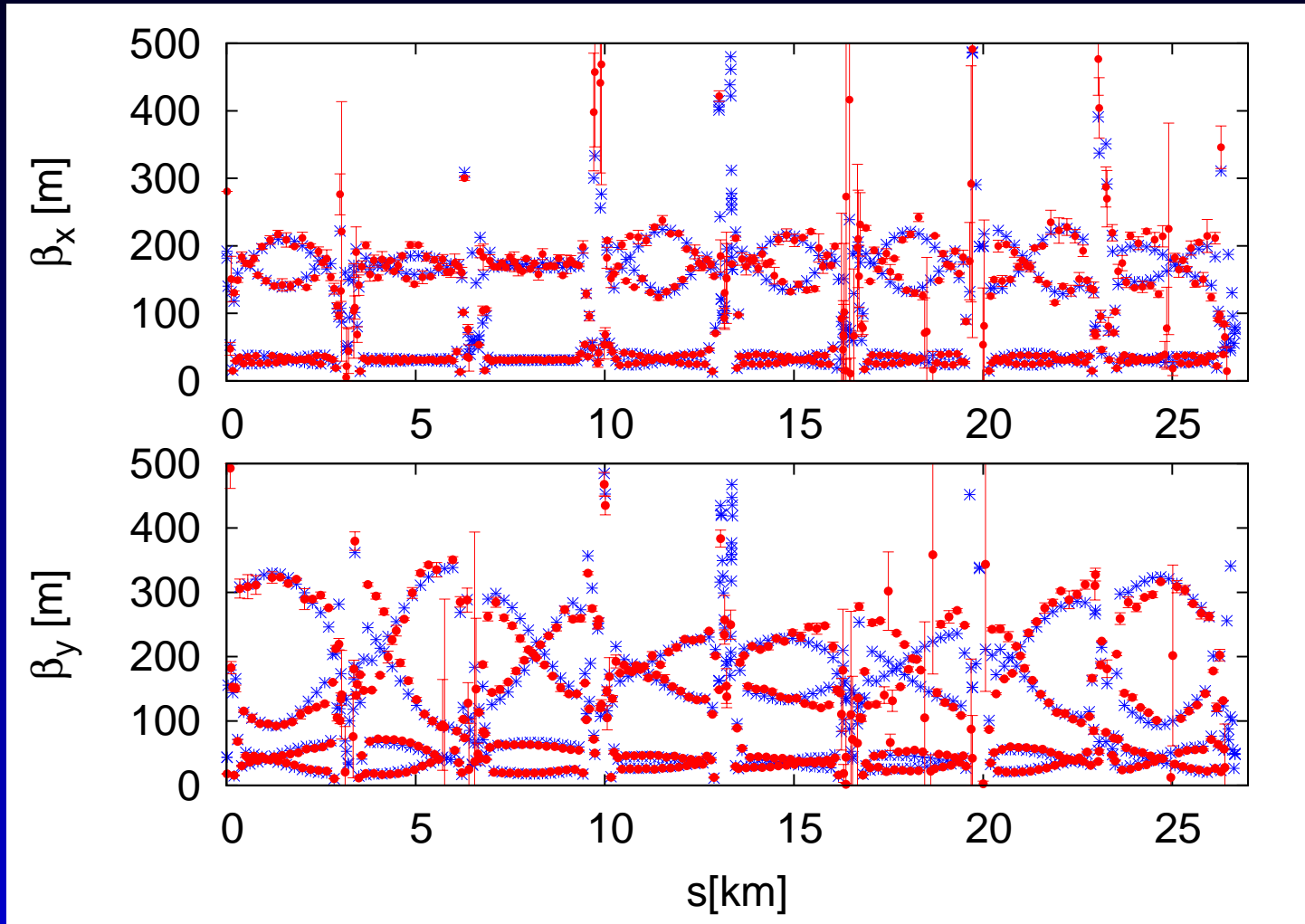
Iteration #1

# Segment-by-segment + Iterative



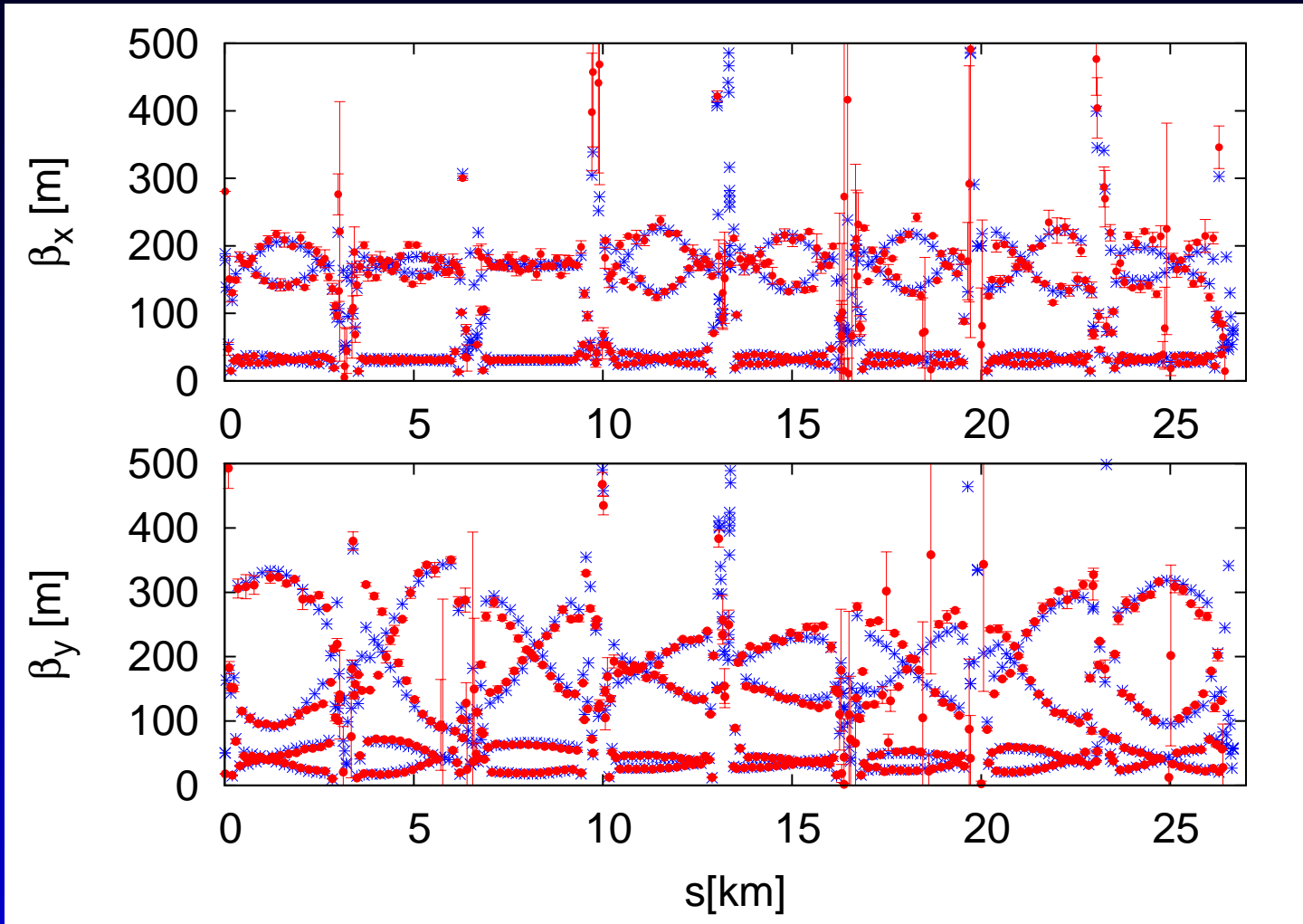
Iteration #2

# Segment-by-segment + Iterative



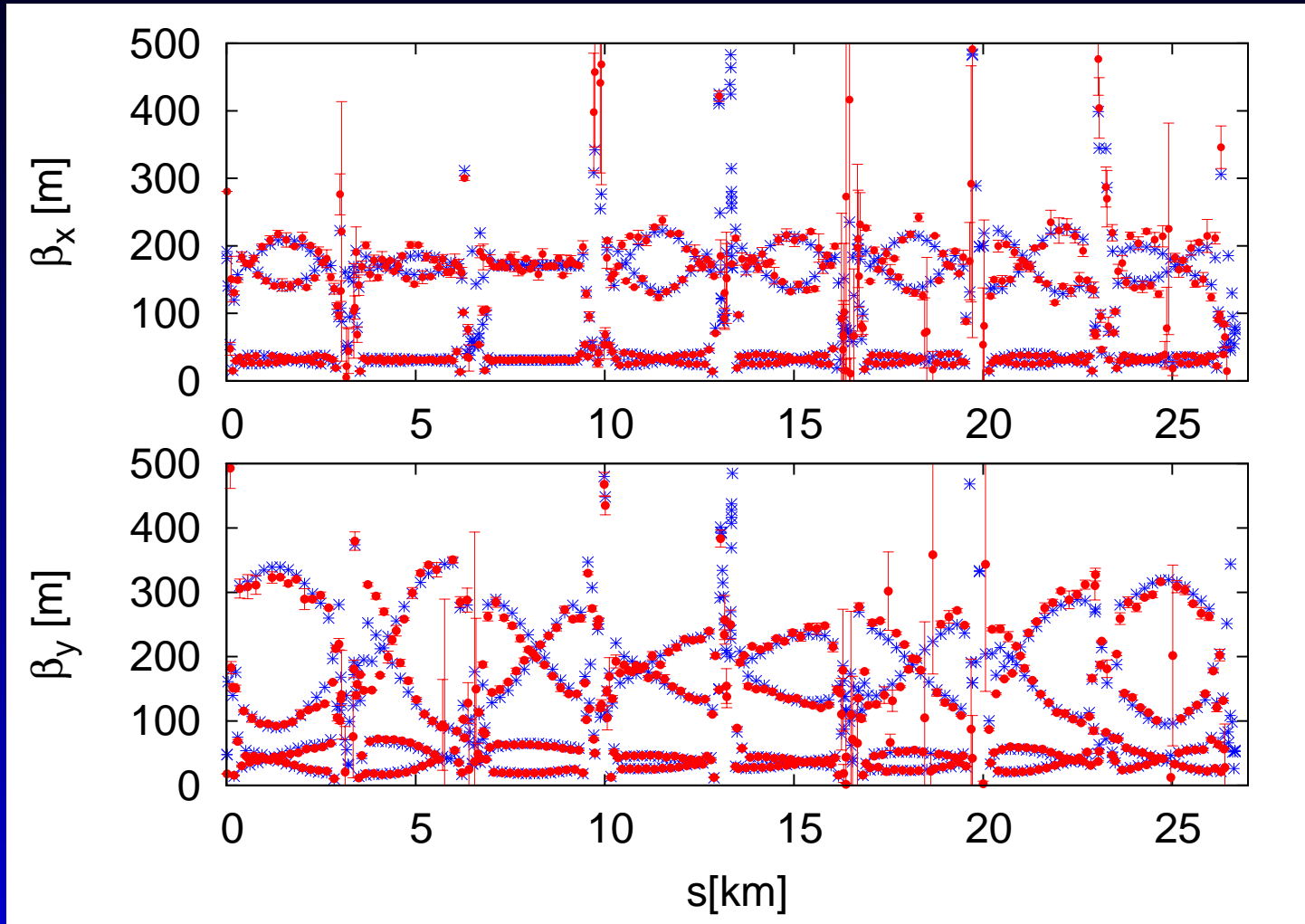
Iteration #3

# Segment-by-segment + Iterative



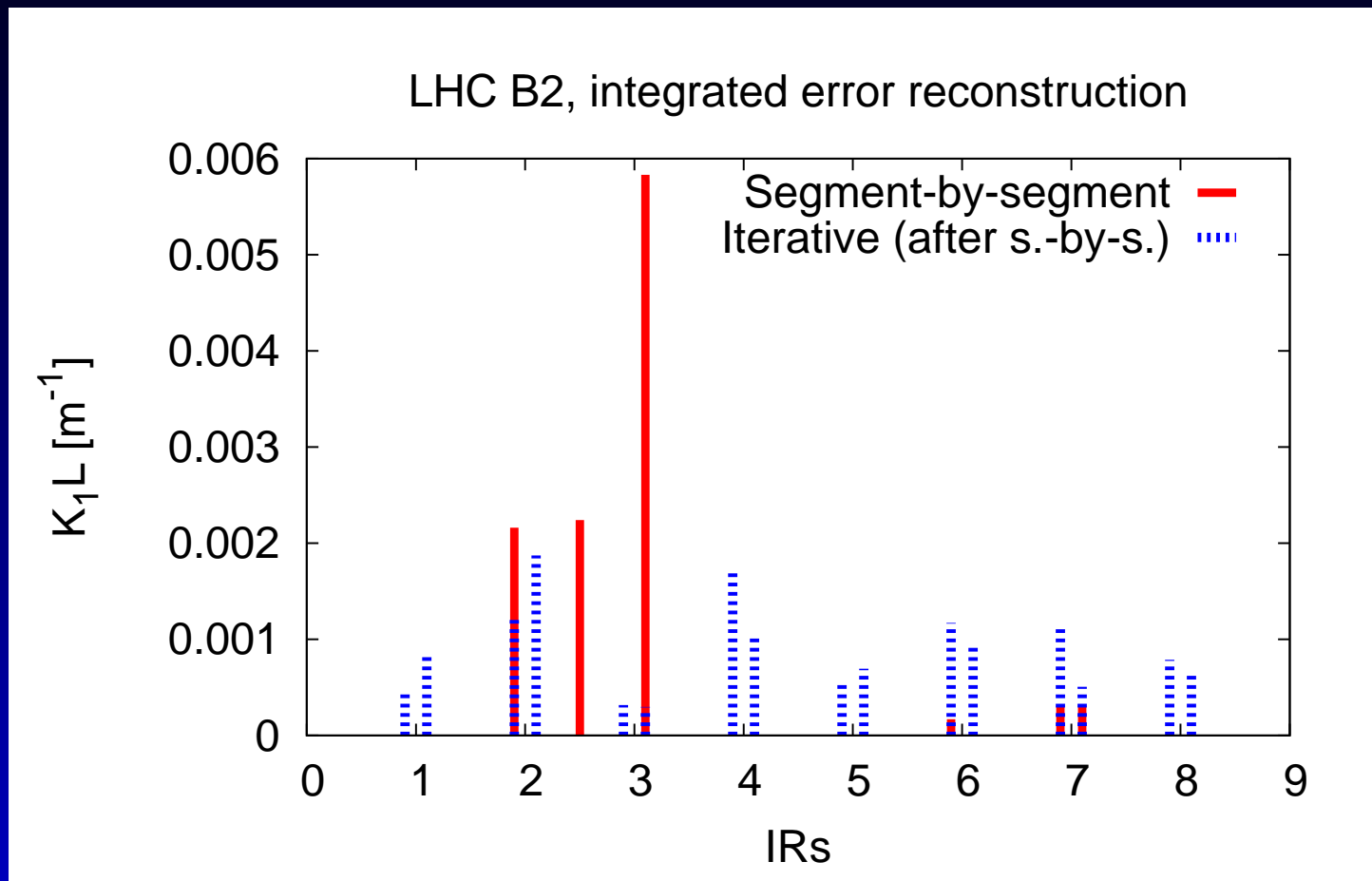
Iteration #4

# Segment-by-segment + Iterative



Iteration #5

# Effective correctors (integrated)

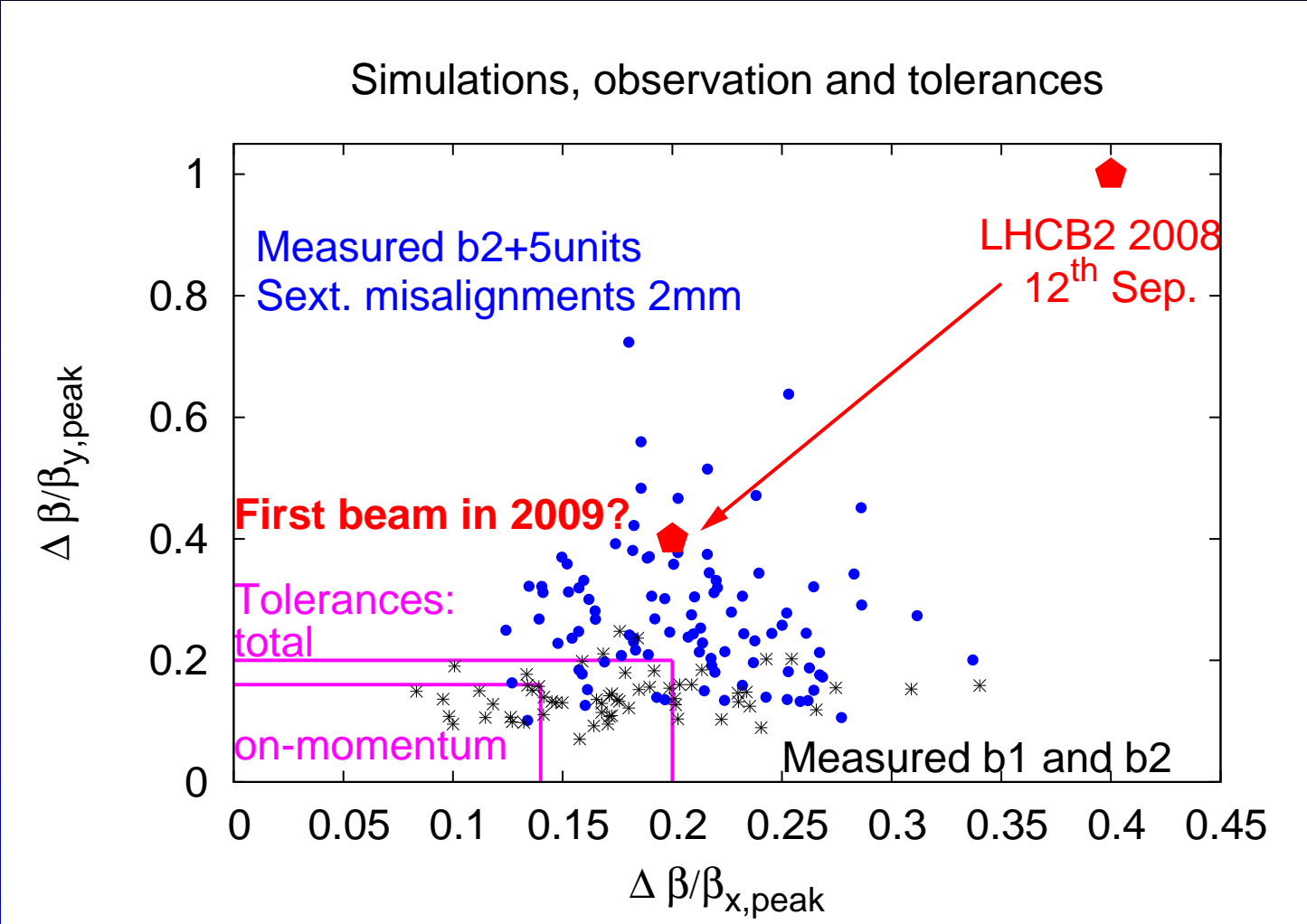


IR3, perfect after mqli7r3!

IR2, ARC23 and IR4 seem to need further studies

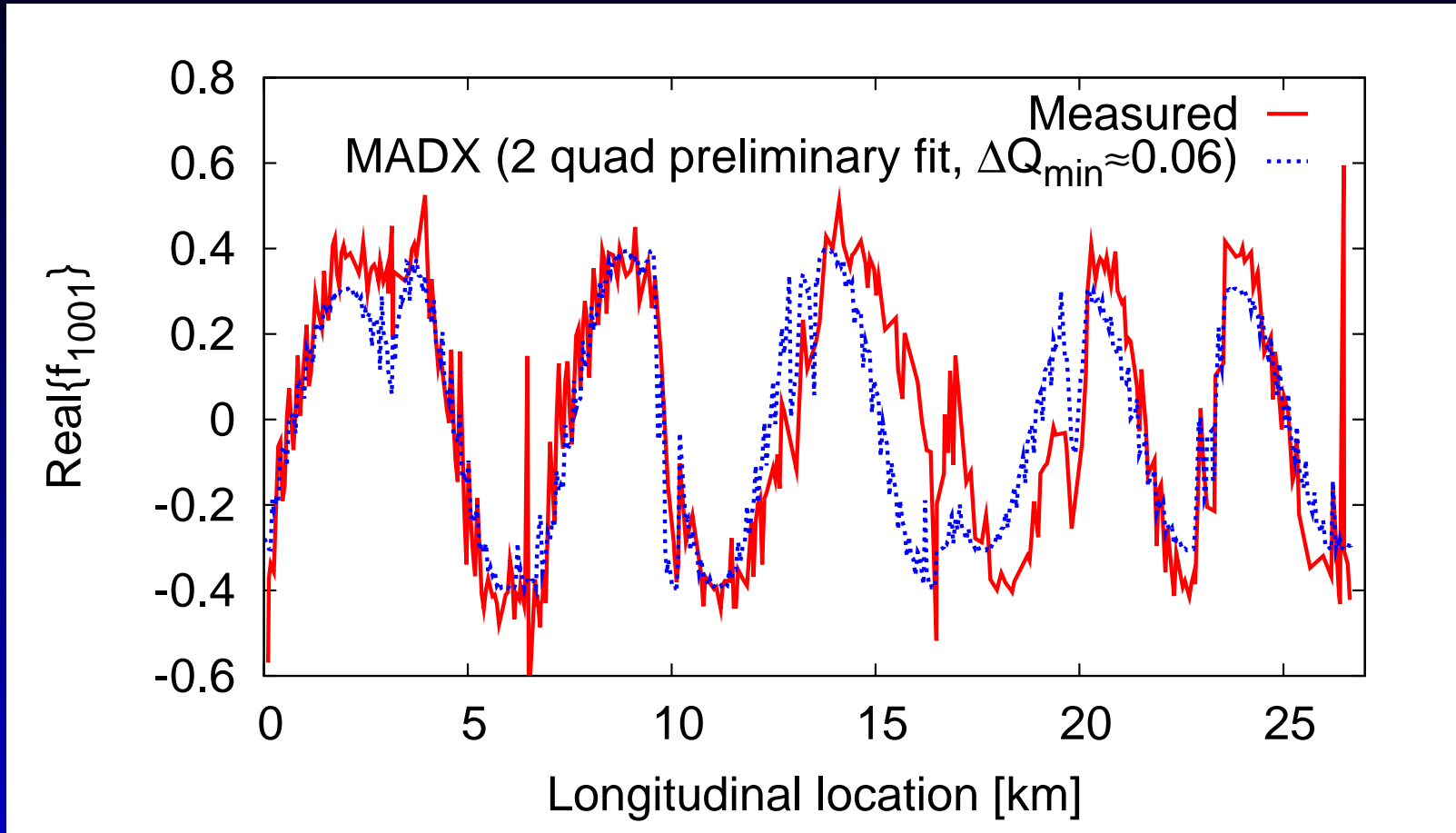
IR1, IR5 and IR8 are in great optics shape!

# Goal





# Coupling measurement



This verifies that the integer tune split is 5.  
 Sources are unclear.  
 The coupling is correctable.

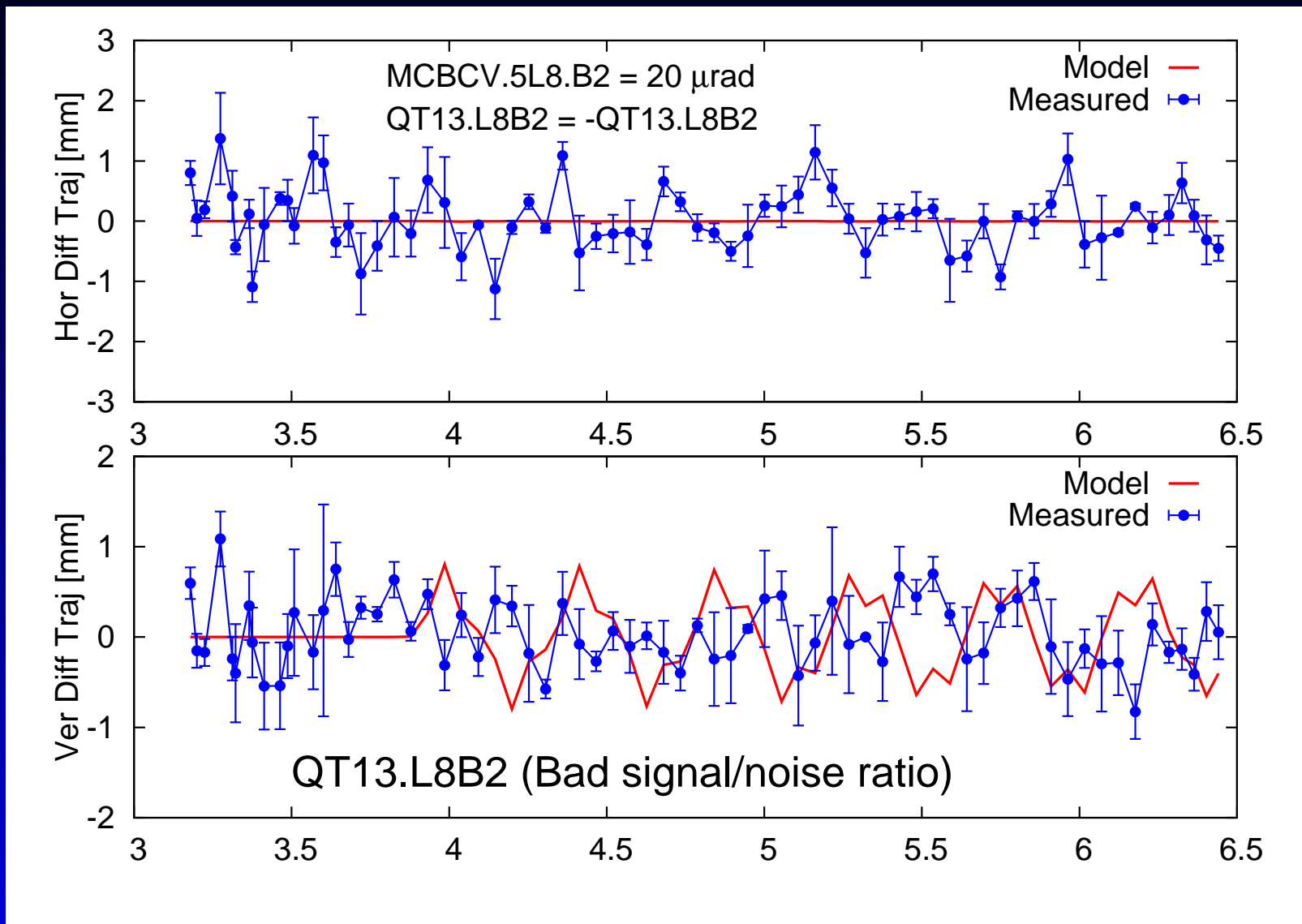
# Summary & outlook I

- The excellent instrumentation has allowed beam-based measurements from day 1
- Need more aperture and polarity checks (maybe more automatic?)
- Decent beta measurements just with a single file with 90 turns
- Off-momentum information missing
- 2 new powerful methods implemented or under development to localize and correct errors
- `mqtli.7r3.b2` cabling problem identified via the segment-by-segment approach as the leading error of the machine

# Summary & outlook II

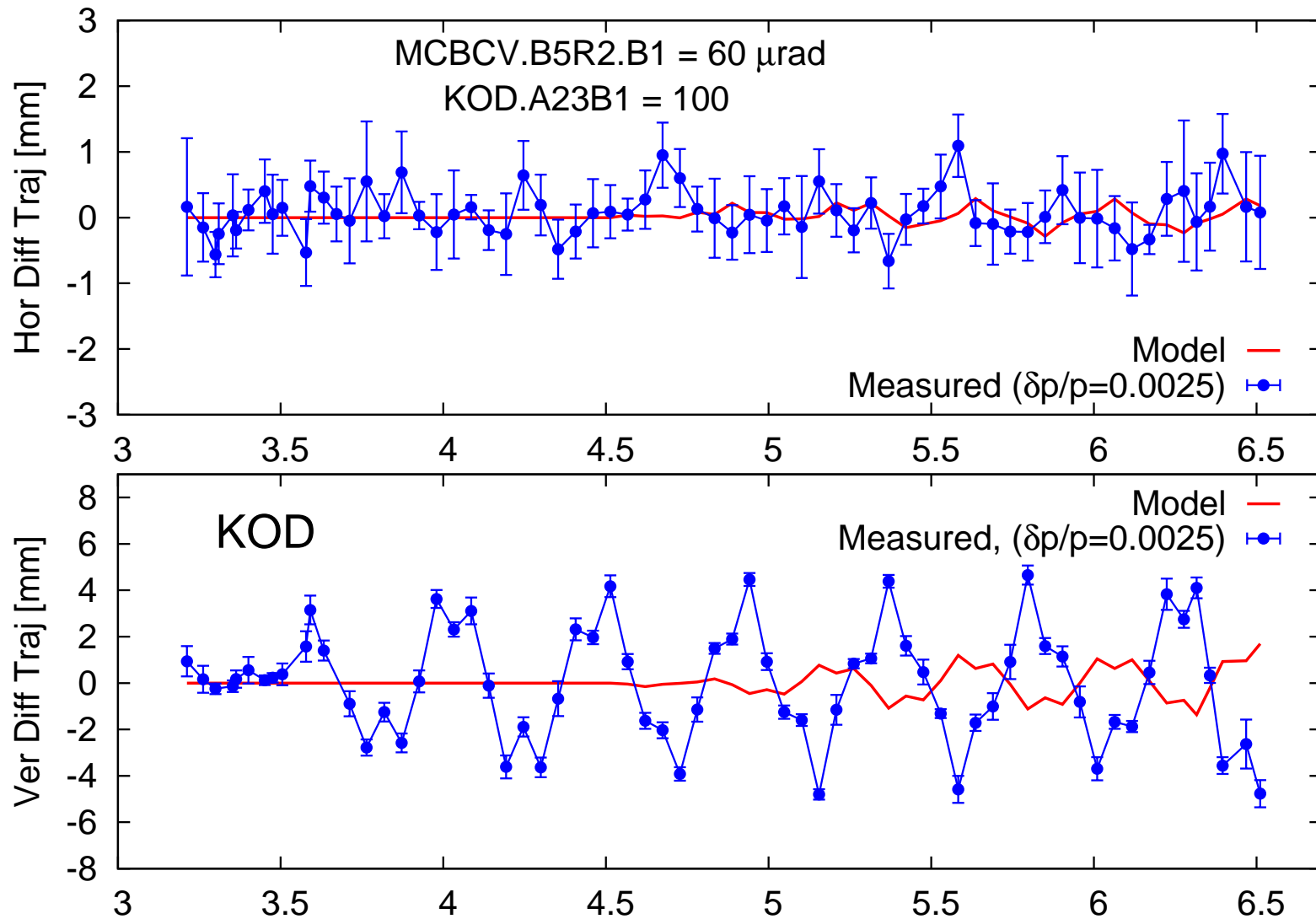
- Unclear error sources in IR2, ARC23, IR4, IR7. Maybe there is other beam data with something to say.
- IR1, IR5, and IR8 in great optics shape
- However IR1 and IR5 are transparent to B1-B2 cable swapping problems. Important check for next run:
  - Change strengths of IR1,5 B1 magnets and measure B2 optics.
- Coupling is correctable but needs understanding

# Polarity check: QT13.L8B2 Inconclusive

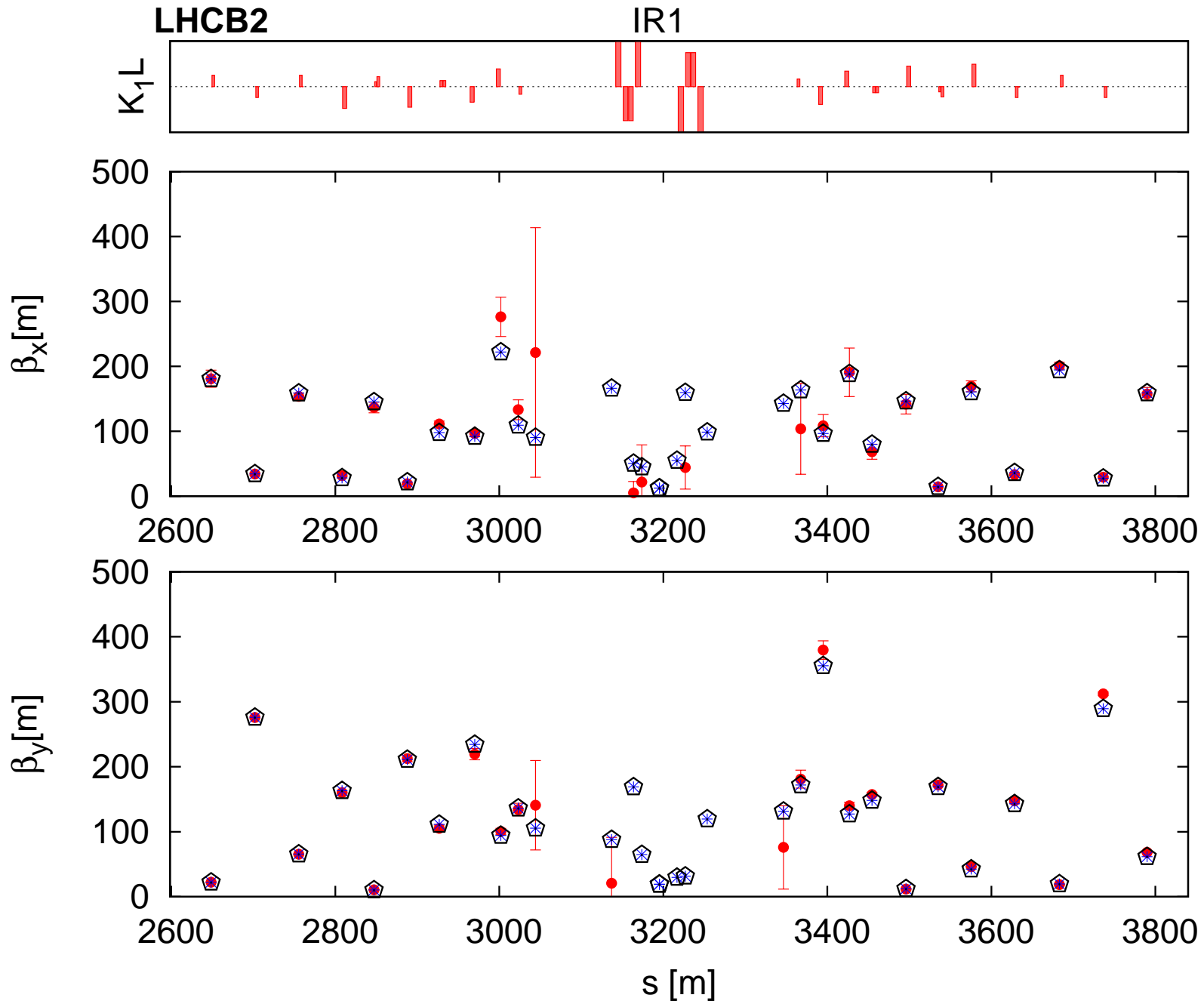


But big problem discarded from the  $\beta$  measurement.

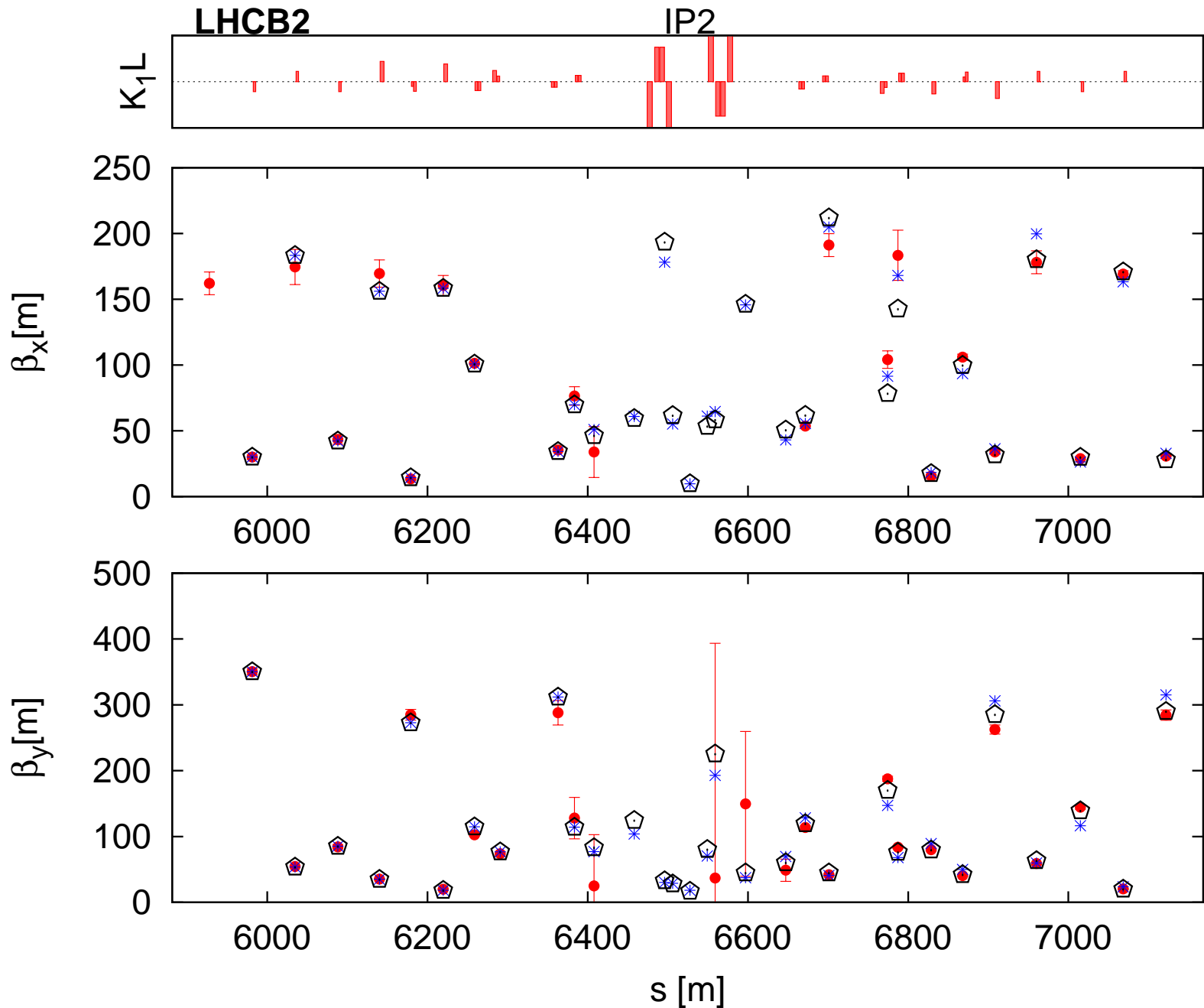
# Polarity check: KOD23B1 Inconclusive



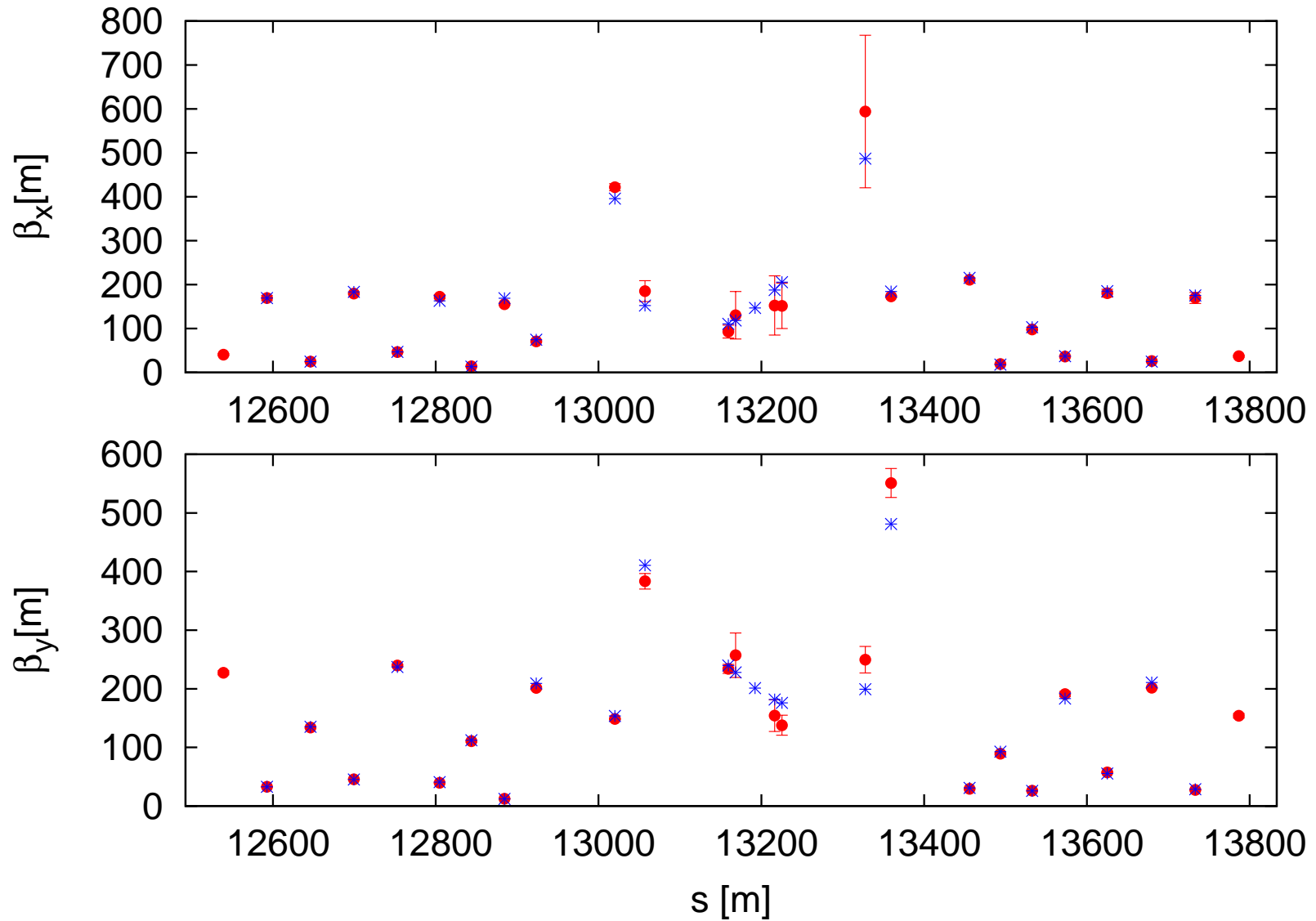
# IR1, segment-by-segment



# IR2, segment-by-segment

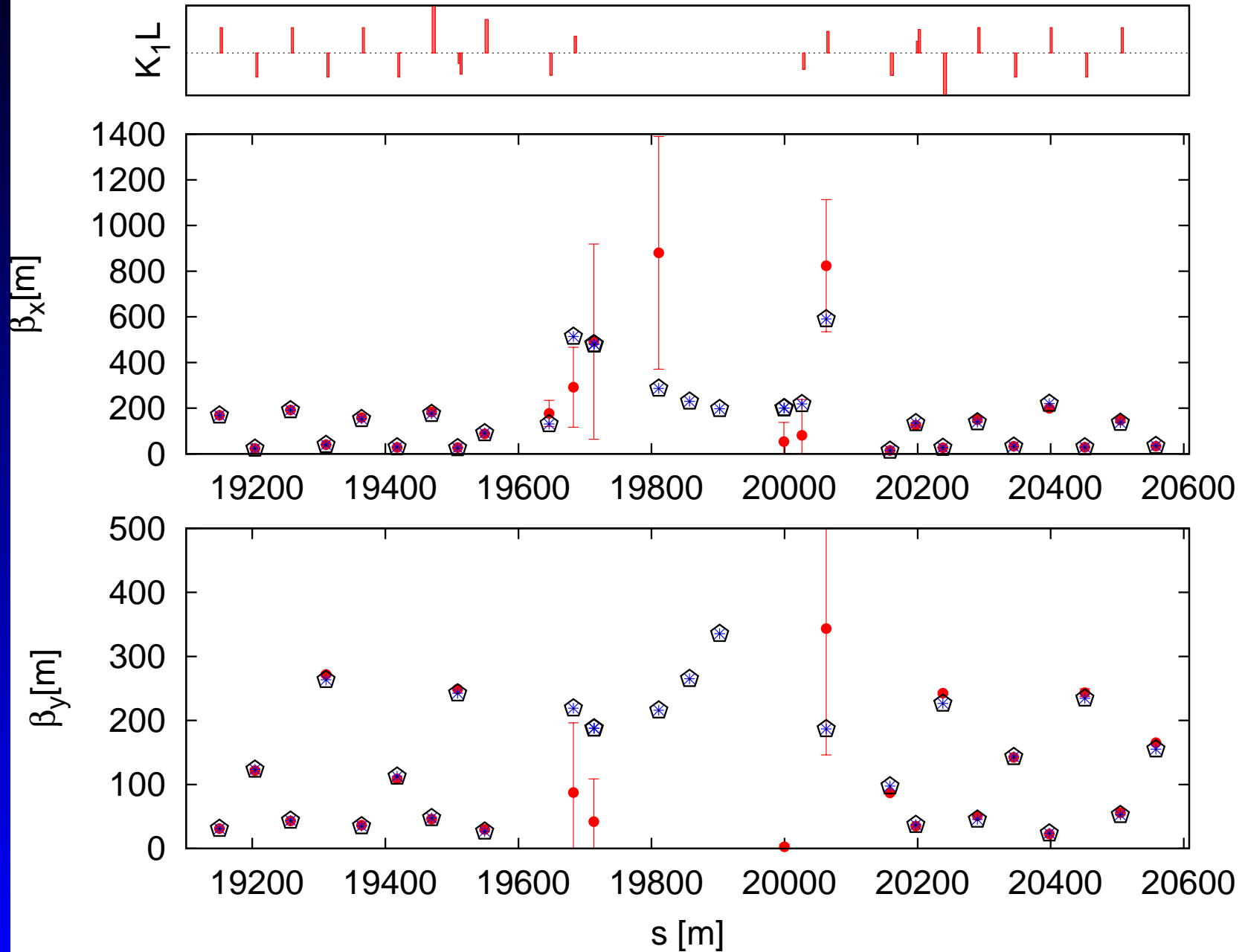


# IR4, segment-by-segment

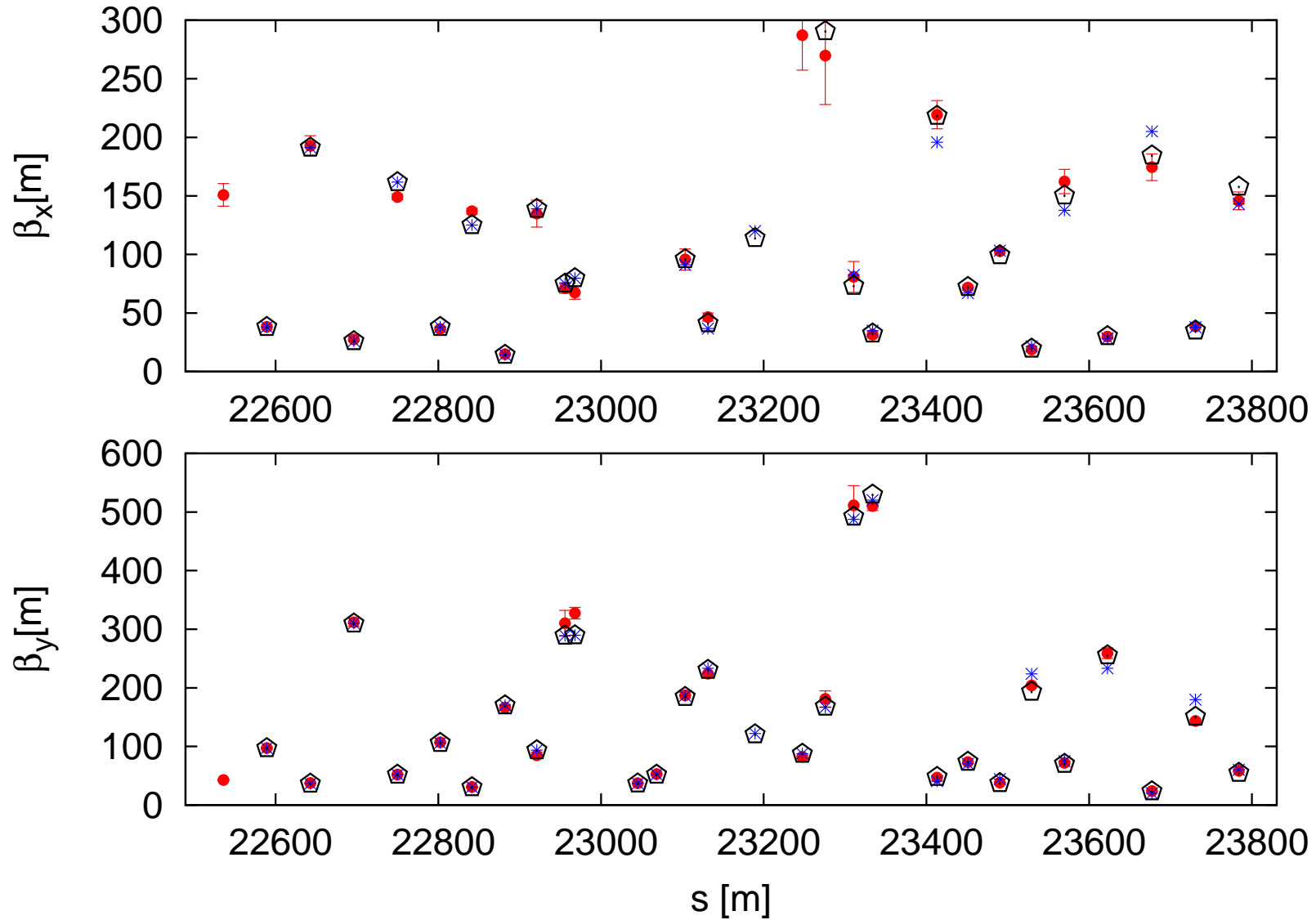




# IR6, segment-by-segment



# IR7, segment-by-segment



# Arc 23, segment-by-segment

