

# MD6863 - MD summary

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# MD6863 - motivation

- Aim to measure detuning vs xing measurements after all other linear/nonlinear corrections have been commissioned (initial studies during commissioning were not with final betabeat etc)
- Aim to validate and refine  $b_6$  corrections determined during commissioning period
- Aim to perform measurements of detuning vs xing with single IP and  $\pm$  crossing angles to identify sources of feed-down to  $b_4$  in LHC.

# MD6863 - some issues encountered

- 9h planned (10h requested)
  - Start time was initially moved forward, but then delayed due to previous shift (B2 injection instabilities)
    - started at 21:15 (initially scheduled at 20.00)
    - allowed to measure into the turn-around, finished 06.30
  - Injection took a while to get good emittance ( $\approx 2$ h)
  - AC-Dipole B2-H broken  $\Rightarrow$  fixed remotely (lost  $\approx 1$ h)
- $\Rightarrow$  Managed 5h.30min of detuning measurements

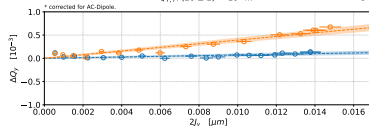
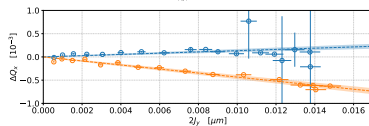
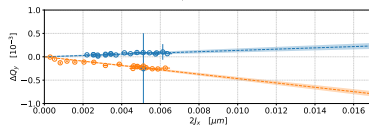
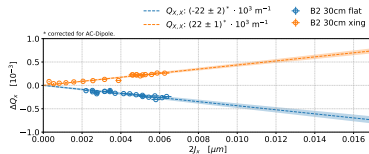
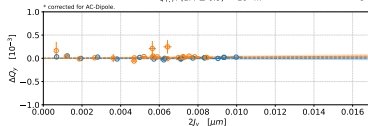
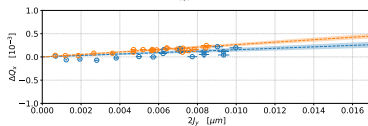
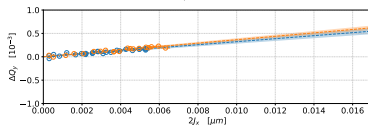
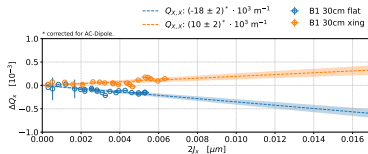
# MD6863 - Success!

In the 5h 30min we did

Beam 1: 192 kicks, Beam 2: 174 kicks:

- Amplitude Detuning measurements + online analysis:
  - Flat Orbit (H/V)
  - With crossing-scheme applied (H/V)
- ⇒ **First time doing dodecapole corrections online!**  
(LHCBEAM/ATS\_2022.06.25\_MD6863\_BX\_LOCAL\_IP15\_B6 in BETA-BEATING-MD)
- Only kicks (analysis continuing offline):
  - IP5 +160  $\mu$ rad (H/V)
  - IP5 -160  $\mu$ rad (H/V)
  - IP1 -160  $\mu$ rad, IP5 +160  $\mu$ rad (H/V) with corrections
- *Missing: Optional DA check via emittance blow-up (maybe possible to combine with future NLOptics MD).*

# Before $b_6$ correction MD6863



# Detuning Summary

$[10^3 \text{ m}^{-1}]$	Setting	$\partial Q_x / \partial (2J_x)$	$\partial Q_y / \partial (2J_x)$	$\partial Q_x / \partial (2J_y)$	$\partial Q_y / \partial (2J_y)$
2018 flat-orbit	6.5 TeV $\beta^* = 0.3 \text{ m}$	$0.8 \pm 0.5$ $-7.5 \pm 0.5$	$10 \pm 1$ $8 \pm 2$	$8 \pm 28$ $-2 \pm 1$	$-3 \pm 1$ $6 \pm 1$
2022-05-09 flat-orbit	6.8 TeV $\beta^* = 0.3 \text{ m}$	$-15.4 \pm 0.9$ $-8.7 \pm 0.7$	$32.2 \pm 2$ $13 \pm 2$	$33.7 \pm 1.0$ $-3 \pm 2$	$-8.4 \pm 0.5$ $18 \pm 7$
<b>MD6863 (2022-06-24)</b> <b>flat-orbit</b>	6.8 TeV $\beta^* = 0.3 \text{ m}$	$-18 \pm 2$ $-22 \pm 2$	$32 \pm 3$ $14 \pm 3$	$15 \pm 3$ $13 \pm 3$	$0.2 \pm 1.0$ $3.6 \pm 0.9$
2018 full-xing @ $+160 \mu\text{rad}$	6.5 TeV $\beta^* = 0.3 \text{ m}$	$34 \pm 1$ $-3 \pm 1$	$8 \pm 2$ $-10 \pm 3$	$18 \pm 1$ $-14 \pm 2$	$-38 \pm 1$ $13 \pm 3$
2022-05-09 IP1&5 xing @ $\mp 150 \mu\text{rad}$	6.8 TeV $\beta^* = 0.3 \text{ m}$	$20 \pm 4^1$ $26 \pm 0.8$	$43 \pm 4$ $-31 \pm 3^1$	$33 \pm 10^2$ $-27 \pm 4^2$	$-10 \pm 3^2$ $18 \pm 7^2$
<b>MD6863 (2022-06-24)</b> <b>IP1&amp;5 xing @ <math>\mp 160 \mu\text{rad}</math></b>	6.8 TeV $\beta^* = 0.3 \text{ m}$	$10 \pm 2$ $22 \pm 1$	$37 \pm 2$ $-47 \pm 3$	$26 \pm 2$ $-43 \pm 3$	$1.4 \pm 0.9$ $20 \pm 2$

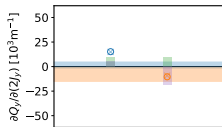
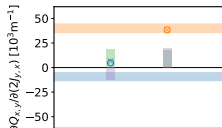
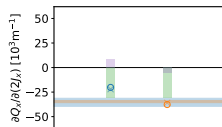
1: noisy measurement

2: very few points (beam dump)

# Calculated Corrections

**Figure:** Corrected detuning. In circles the expected detuning correction from PTC, the X marks the calculated detuning. The horizontal bars show the targets (flat - w/ xing) from the measurements.

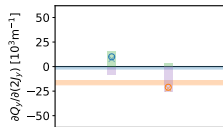
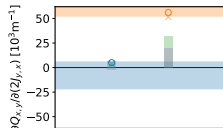
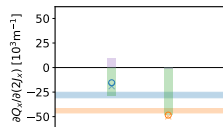
Beam 1 ○ PTC × Eq. ■ Measured ■ IP5  
Beam 2 ○ PTC × Eq. ■ Measured ■ IP1



$Q_{x,x} = -35.4 \mid -34.7$   
 $Q_{x,y} = -9.3 \mid 40.0$   
 $Q_{y,y} = 1.6 \mid -8.0$

**Corrections  
commissioning**

Beam 1 ○ PTC × Eq. ■ Measured ■ IP5  
Beam 2 ○ PTC × Eq. ■ Measured ■ IP1



$Q_{x,x} = -28.0 \mid -44.0$   
 $Q_{x,y} = -8.0 \mid 58.5$   
 $Q_{y,y} = -1.2 \mid -16.4$

**Corrections MD6863**

# Summary of analysis without $b_6$ corrections

- In general very similar tendencies to commissioning measurements.
- ⇒ Waist shift had only minor influence on this detuning.
- ⇒ New corrections are a bit different from old.



# Conclusion

- Very successful MD, despite time constraints
  - Lots of data collected
- ⇒ Preliminary analysis shows very good signal of tune in data!
- ⇒ Analysis ongoing. Will be very useful in pinpointing the source (IP? decapoles? dodecapoles?) of amplitude detuning from feed-down to  $b_4$  due to the crossing scheme and the efficiency of the proposed  $b_6$  correction.
- ⇒ Achieved all core aims (and more!). Many thanks to great OMC teamwork + new people learning procedures and software for amplitude detuning studies!
- ⇒ Many thanks to OP and EICs!