First study of high-β^* optics for ALICE

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1. Introduction

2. 90 m Optics
   - Matching
   - Optics
   - Aperture
   - Tune compensation
   - Detection
   - Un-Squeeze

3. Conclusions

Introduction - High-β optics

Objectives

- Un-squeezed beam with small divergence at IP
- Inelastic scattering at very low angles
- Detection via roman pots left and right of IP

Challenges

- Find high-β optics
  - Uncritical aperture
  - Respect quadrupole limitations
  - Phase shift of $\frac{\pi}{2}$ between IP and RP
- Find detector positions
- Methods for tune compensation
- Un-Squeeze

Already performed at IR1 and IR5

Matching

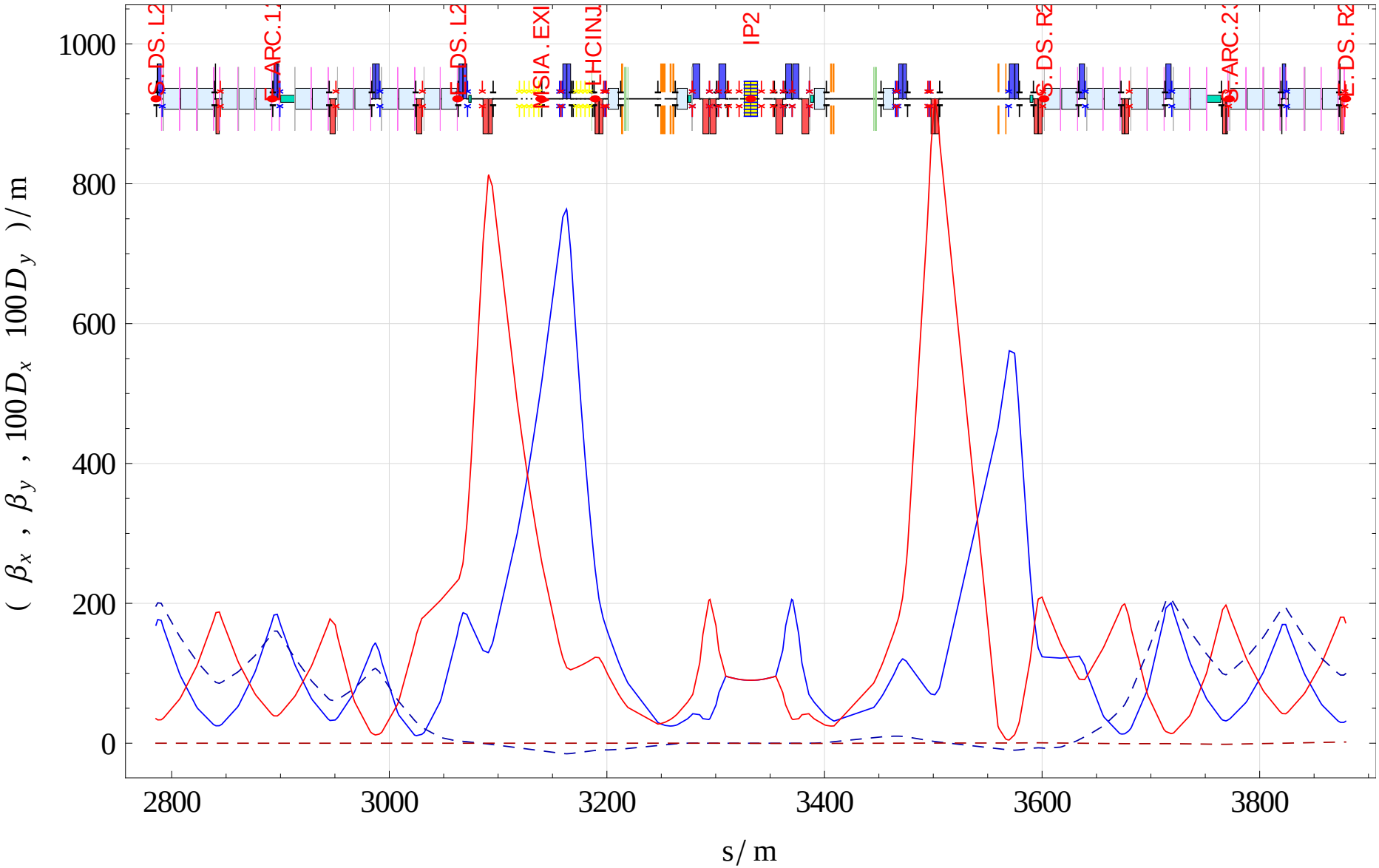
- Matching by MAD-X (Madtomma)
- Flat machine
- 7 TeV
- Also use quadrupoles of the DS
- Check several triplet quadrupole strengths

Matching

- External tune compensation required
- No constraint on $\mu \rightarrow$ No result
- Define final $\mu \rightarrow$ systematical scan
- Choose solution by β, symmetry, tune, phase shift to RP
- Best results [1] with triplet quads at 0.00754m^{-2}
- Refine by applying constraints on β

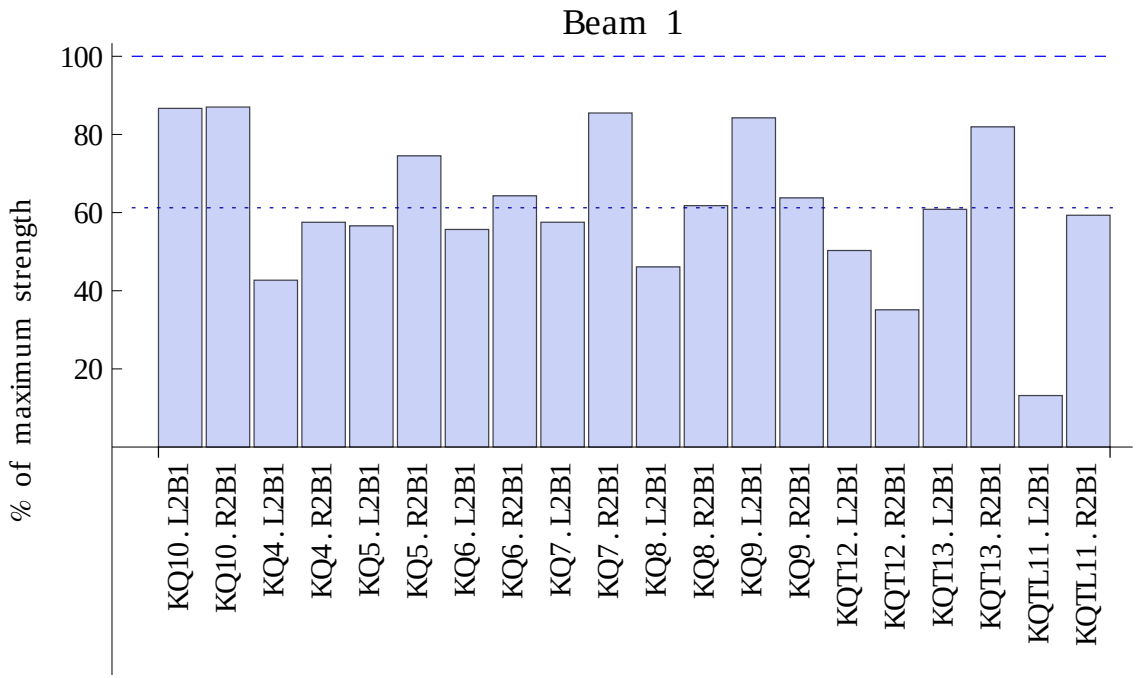
1. 10 m optics : 0.00889 TOTEM 90 m optics : 0.00764

90 m Optics - Beam 1



Beam 1 - Quadrupole strengths

- Relative quadrupole strengths
- Respect polarity
- Max. Value 87%
- Mean Value 61.2%



Beam 1 - Comparison with TOTEM

ALICE (straight)

$\beta_{\text{max}} \approx 900\,\text{m}$

$\Delta\mu_x = 0.23800$

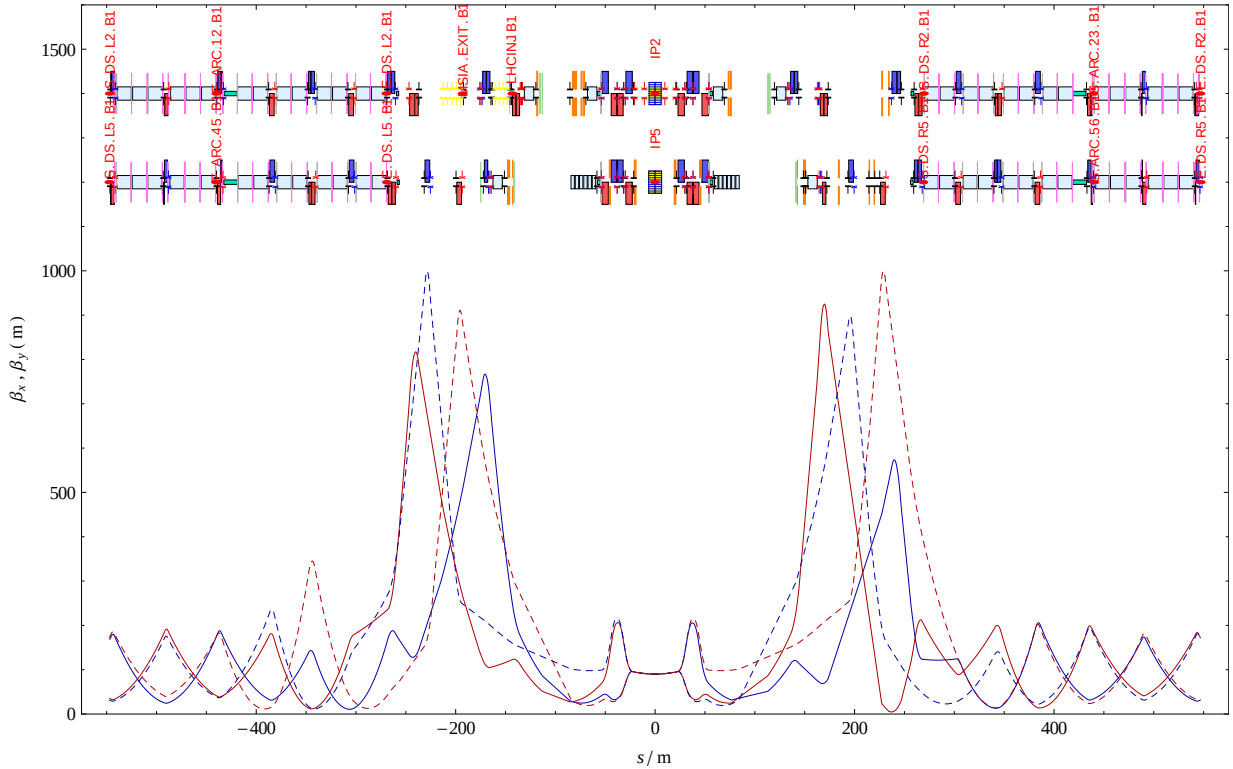
$\Delta\mu_y = 0.03468$

TOTEM (dashed)

$\beta_{\text{max}} \approx 1000\,\text{m}$

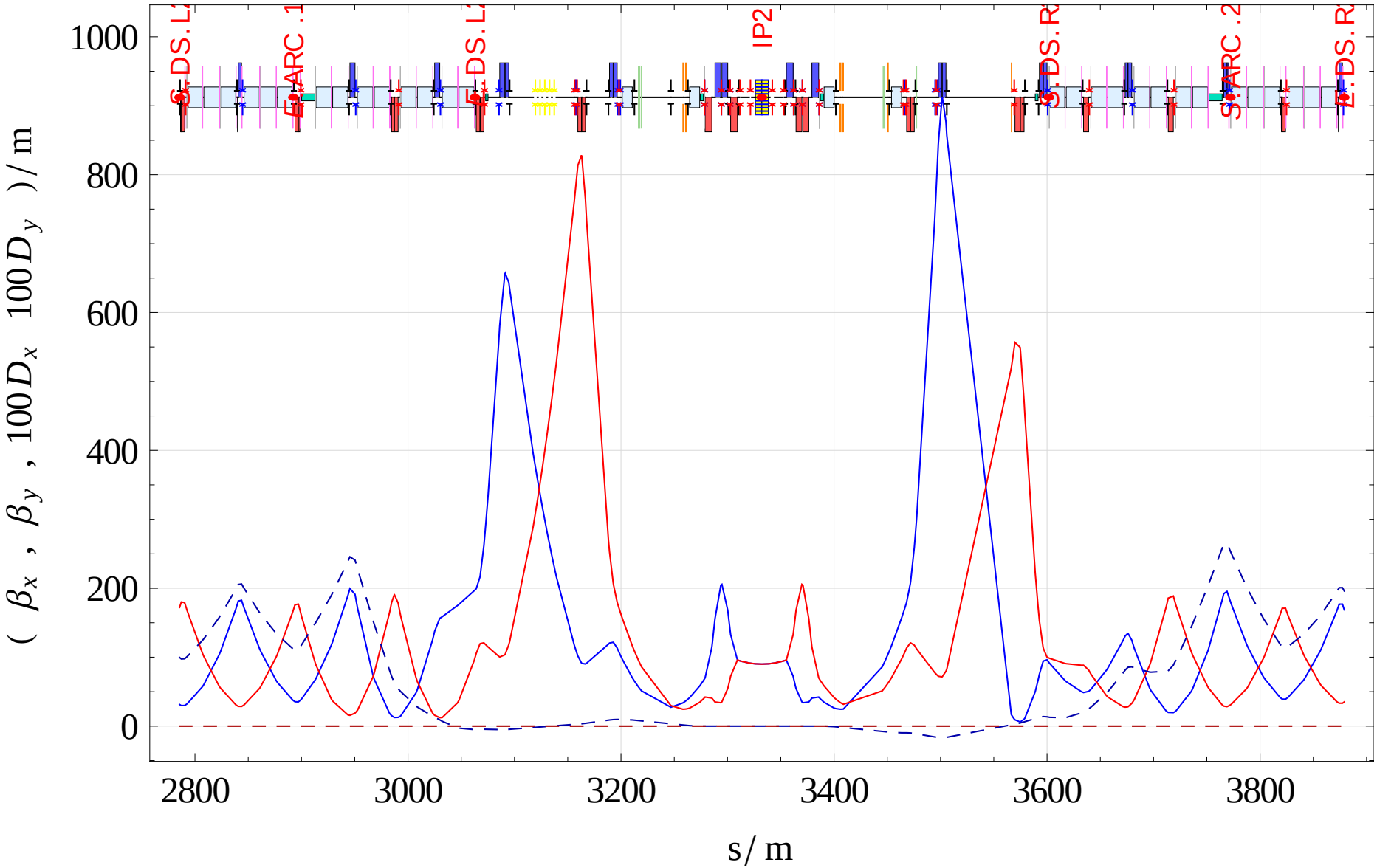
$\Delta\mu_x = 0.22033$

$\Delta\mu_y = 0.05284$



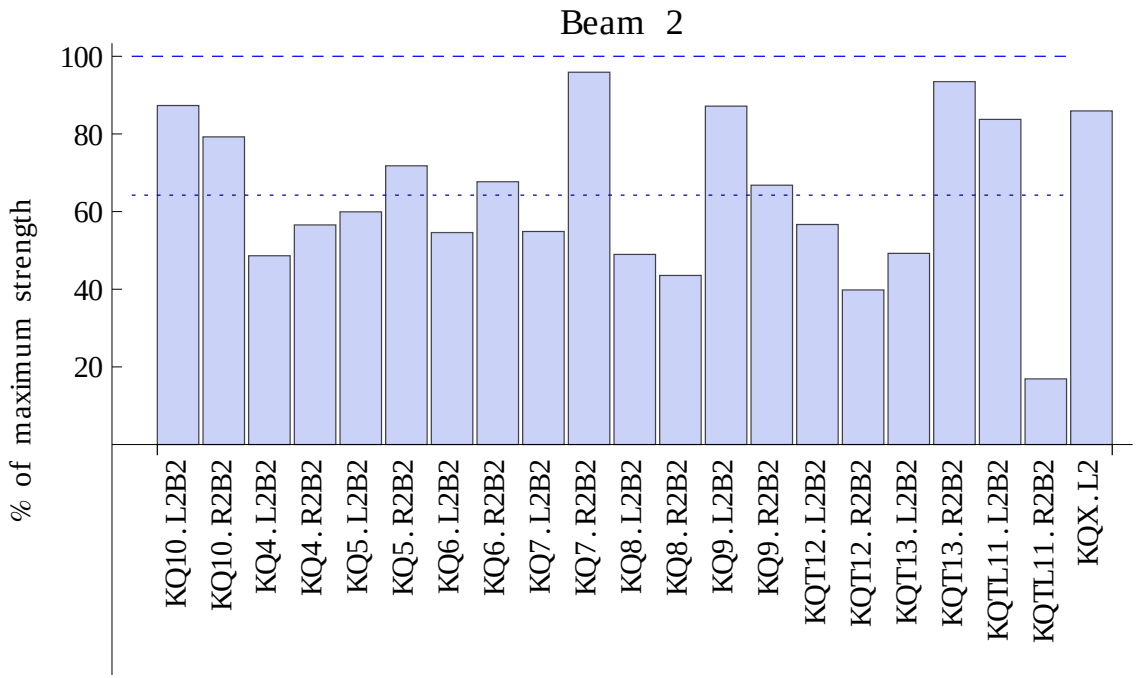
$$\text{KQX.L2} = 7.5448 \cdot 10^{-3}\text{m}^{-2} / \text{ KQX.R5} = 7.6448 \cdot 10^{-3}\text{m}^{-2}$$

90 m Optics - Beam 2



Beam 2 - Quadrupole strengths

- Relative quadrupole strengths
- Respect polarity
- Max. Value 95.9%
- Mean Value 64.2%



Beam 2 - Comparison with TOTEM

ALICE

$\beta_{\text{max}} \approx 900\,\text{m}$

$\Delta\mu_x = 0.16100$

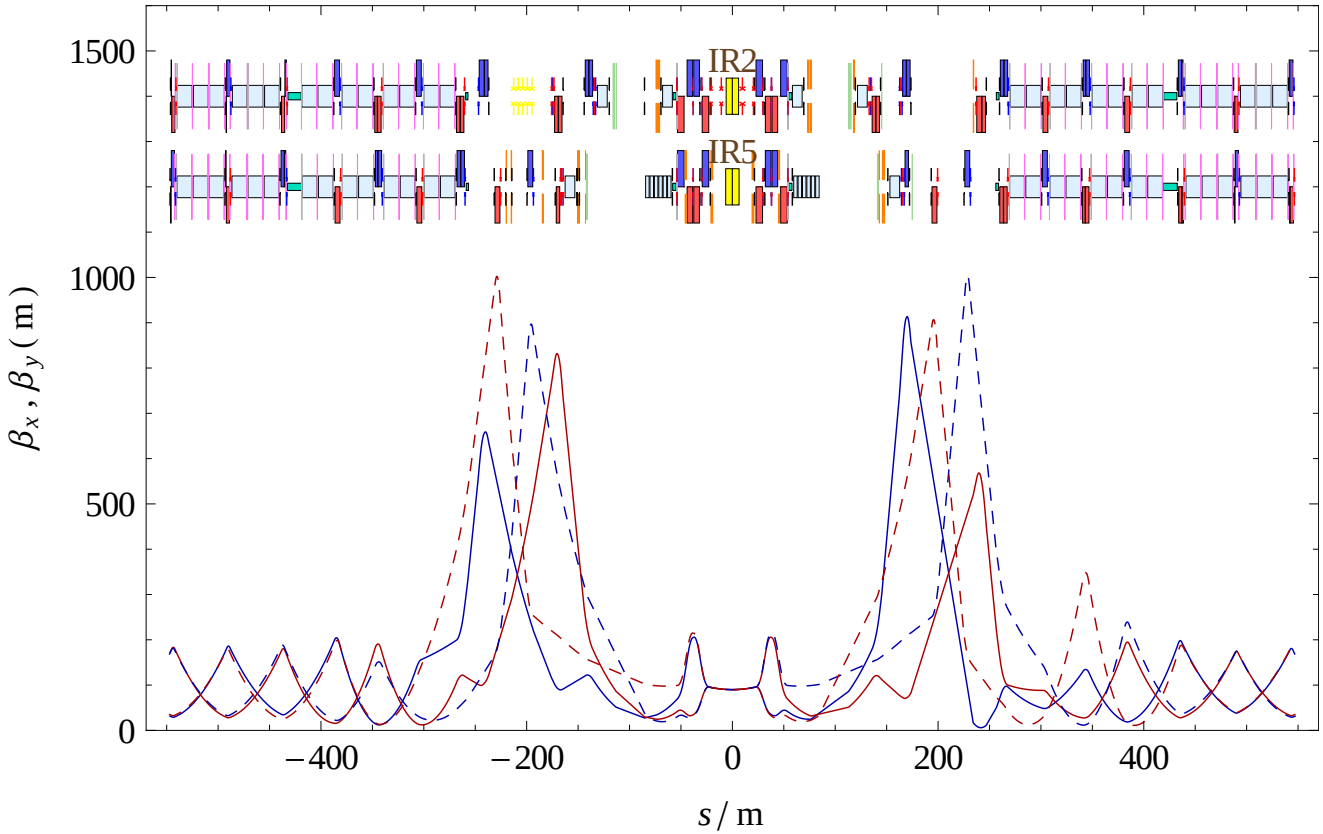
$\Delta\mu_y = 0.09068$

TOTEM

$\beta_{\text{max}} \approx 1000\,\text{m}$

$\Delta\mu_x = 0.22033$

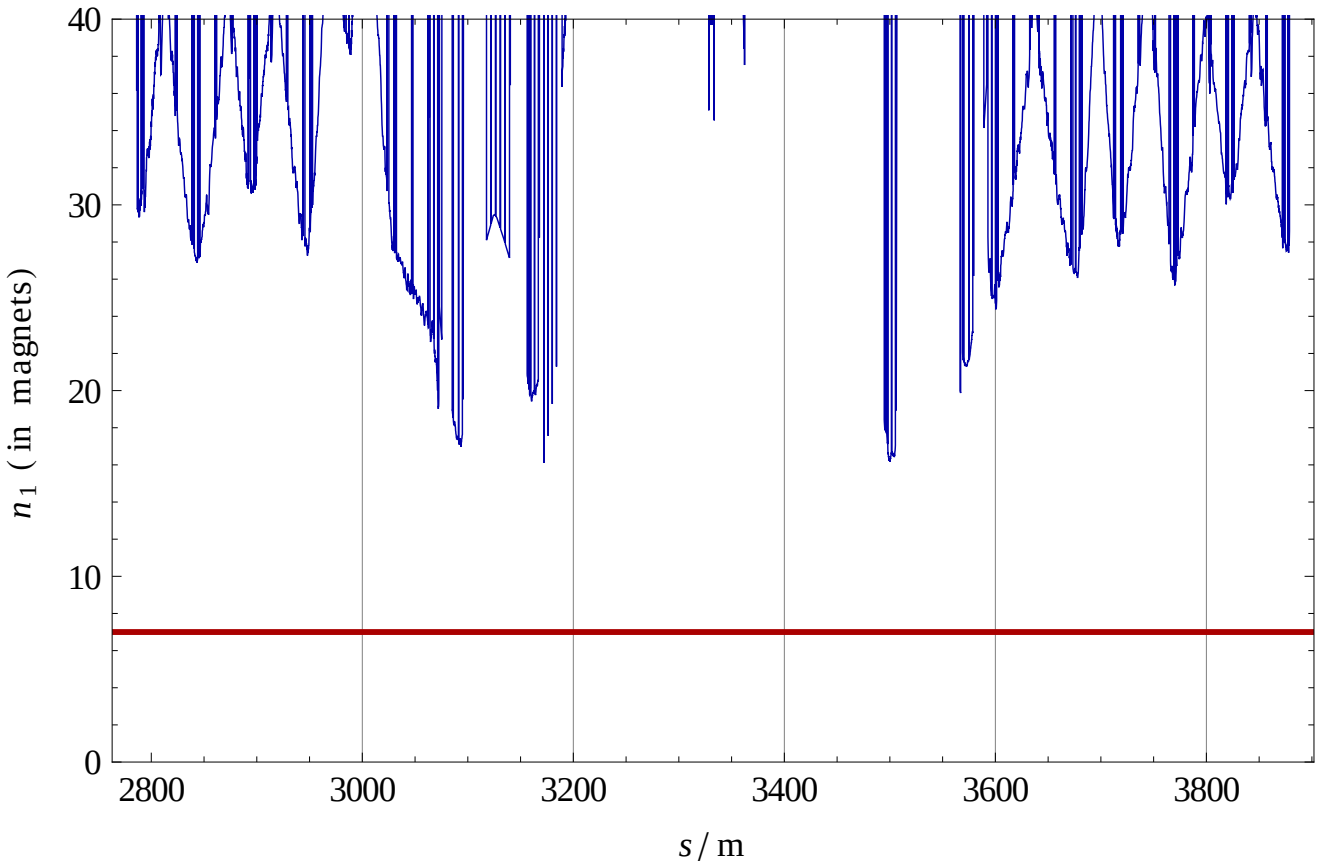
$\Delta\mu_y = 0.05284$



$$\text{KQX.L2} = 7.5448 \cdot 10^{-3}\text{m}^{-2} / \text{ KQX.R5} = 7.6448 \cdot 10^{-3}\text{m}^{-2}$$

Aperture Beam 1

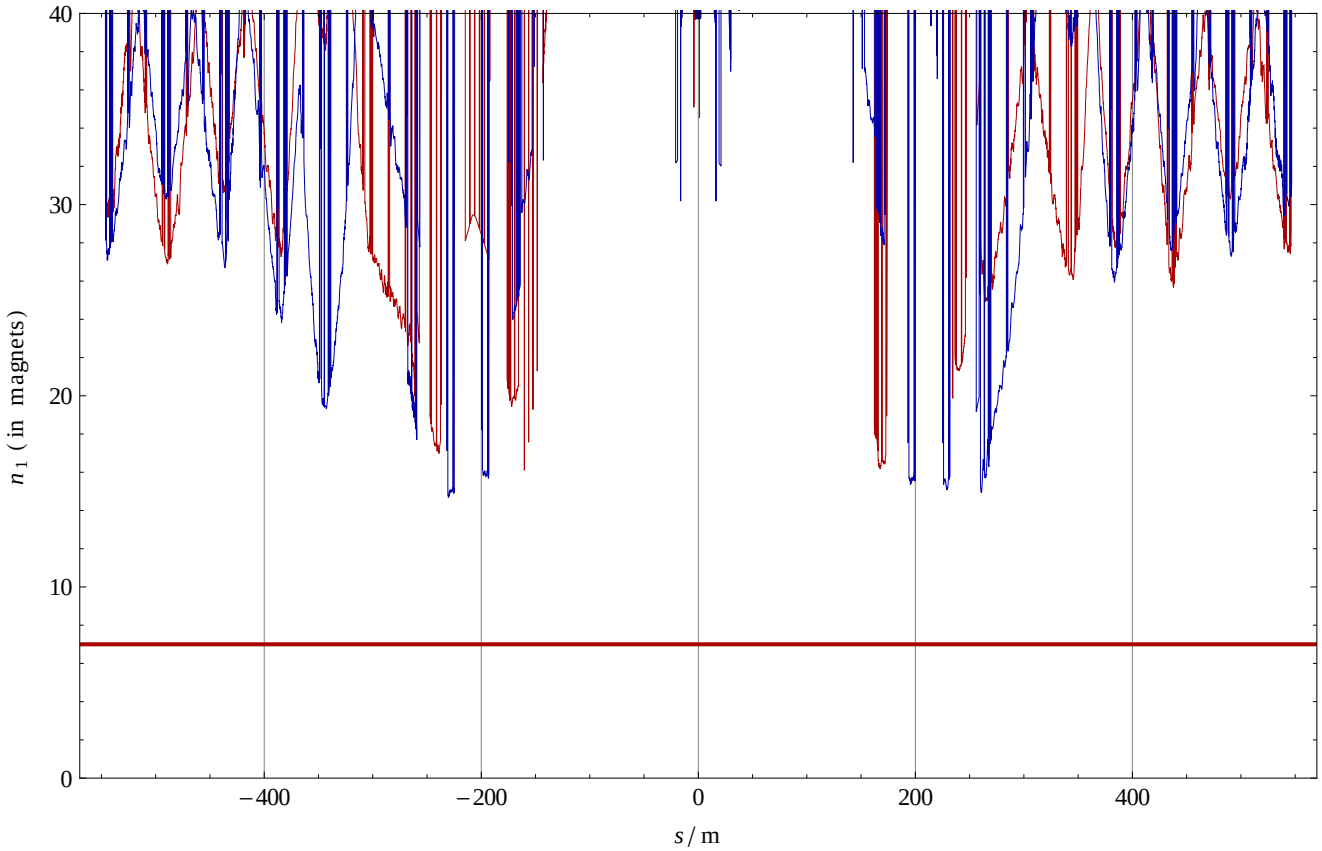
- $\epsilon_n = 3.75\,\mu\mathrm{m\,rad}$
- Not critical
- Smallest value at Q5 : $n_1 = 17.0$



Aperture Beam 1 - Comparison with TOTEM

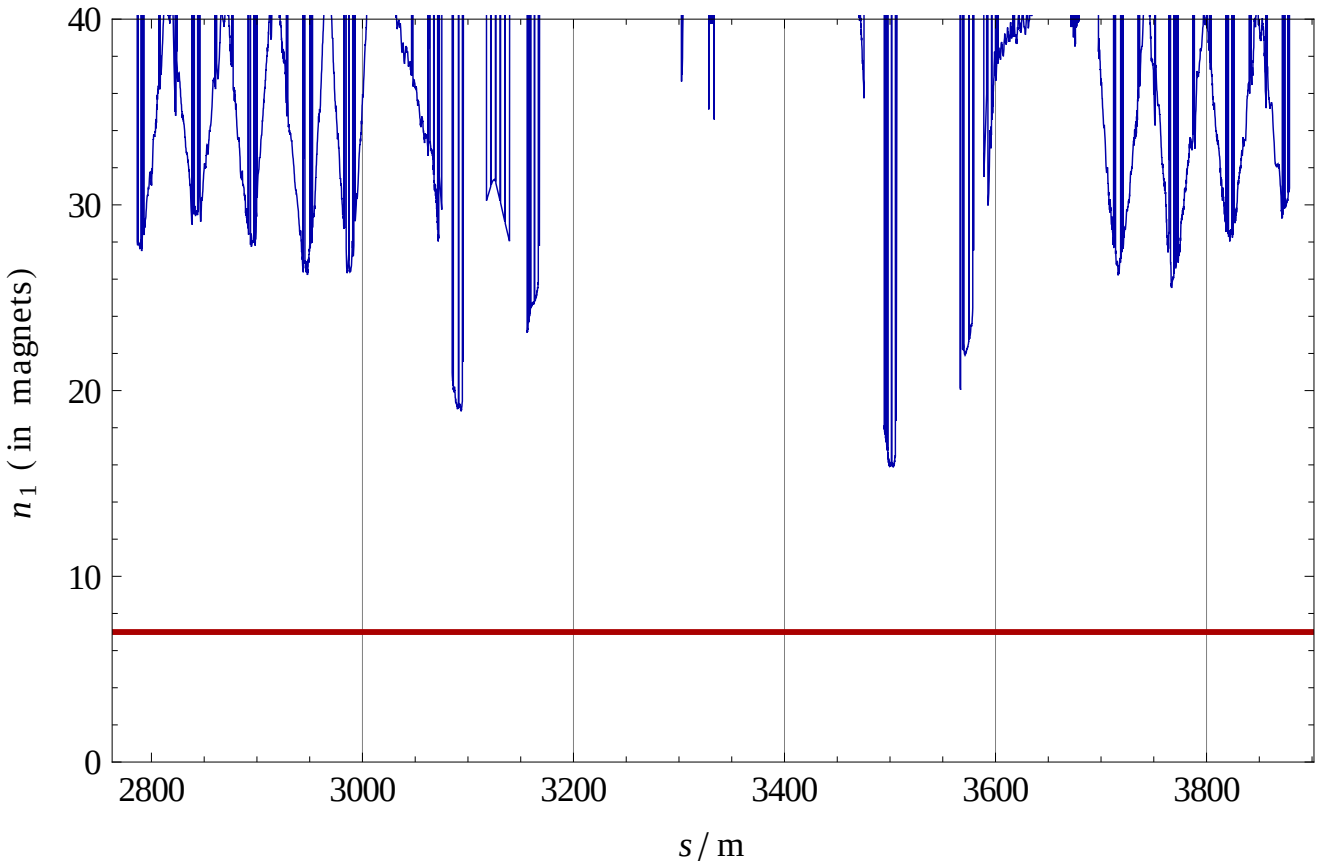
ALICE (red)
Minimal n_1 : 17.0

TOTEM (blue)
Minimal n_1 : 15.0



Aperture Beam 2

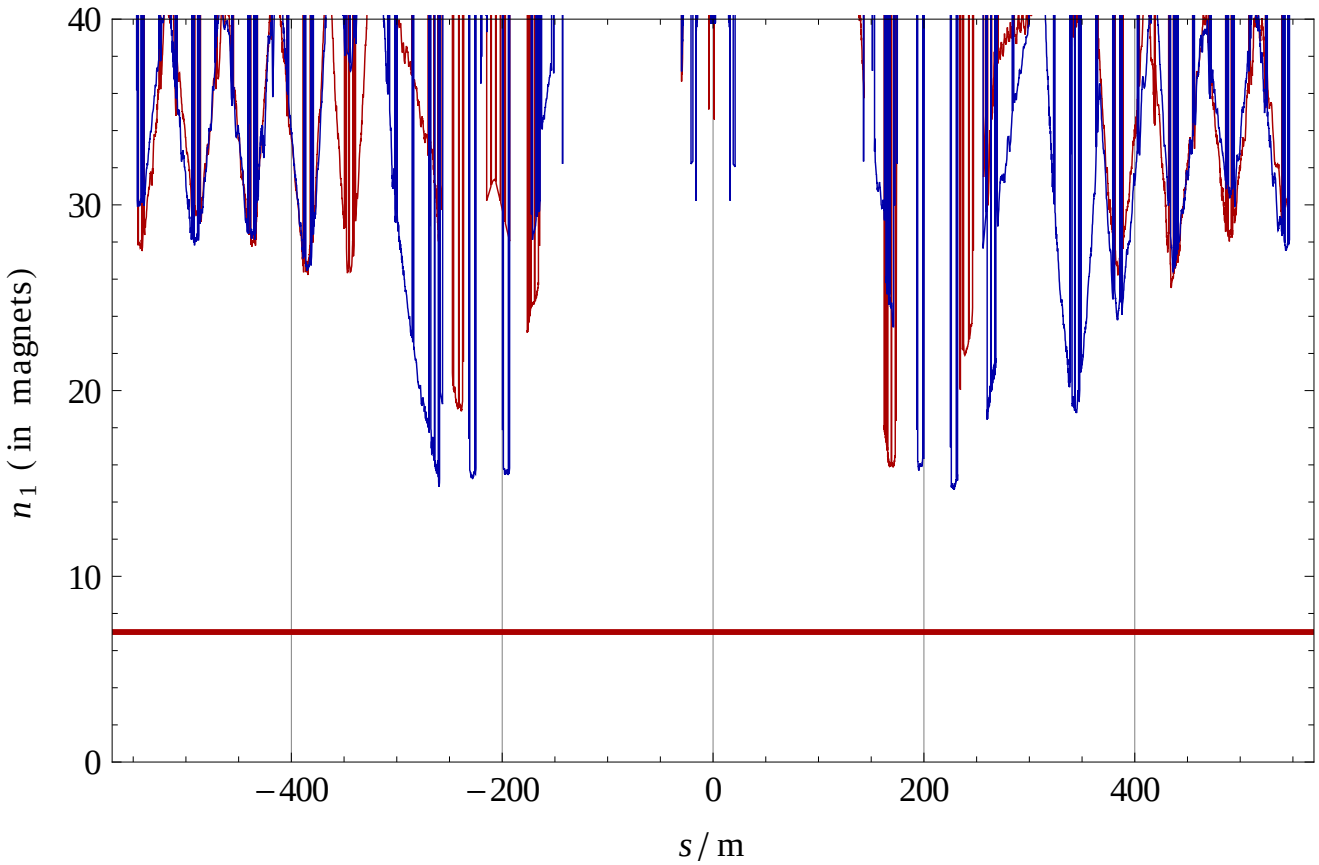
- $\epsilon_n = 3.75\,\mu\mathrm{m\,rad}$
- Not critical
- Smallest value at Q5 : $n_1 = 15.9$



Aperture Beam 2 - Comparison with TOTEM

ALICE (red)
Minimal n_1 : 15.9

TOTEM (blue)
Minimal n_1 : 15.0



Tune compensation

- Methods for tune compensation proposed by H. Burkhardt
- Compensation in main arc quadrupoles (small beta beating)
- Rematching of IR4 (some beta beating, maximum compensation of 0.2)
- Studies on the feasibility of simultaneous high-β performance in IR1, IR2, IR5

Detection

- Detection via roman pots or Hamburg pipes
- Parallel to point focusing

  $\rightarrow$ Betatron phase shift of $\frac{\pi}{2}$ between IP and RPs
- Small momentum transfers

  $\rightarrow$ Possibly large distance between IP and RPs
- Detector positions not yet clear

Detectors

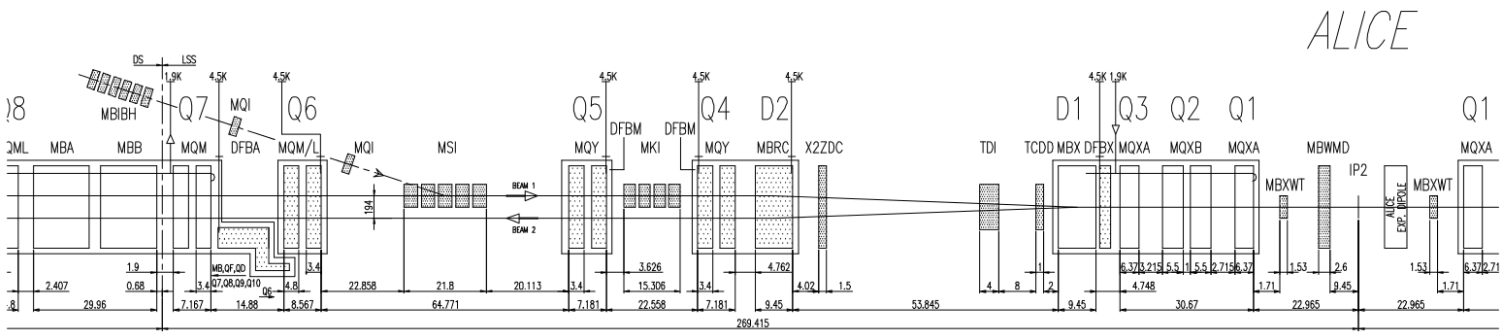
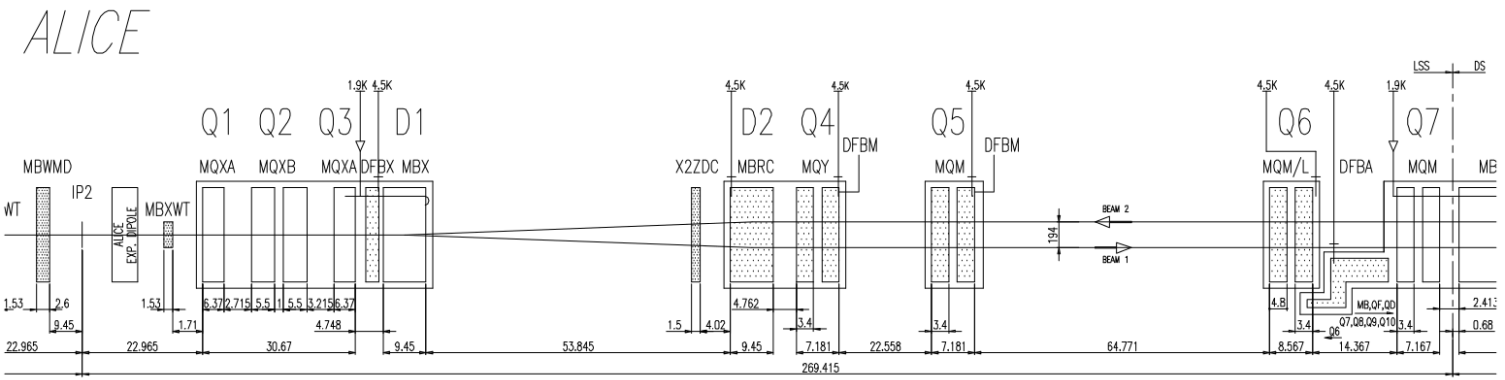


Figure 3.8: The left side of the matching section in IR2.



Detection between Q5 and Q6 left and right of IP

Detectors

	Beam 1	Beam 2
Element	TCLIB.6R2.B1	BPM.6L2.B2
Distance	227.6	236.8
$\Delta\mu_x$	0.50172	0.485825
$\Delta\mu_y$	0.52873	0.494827

- Exact positions need to be found (respect existing hardware : vacuum, electrics,...)
- Optics must be rematched to satisfy constraint

Un-Squeeze

- Smooth un-squeeze
- Intermediate steps needed
- Check the same steps as for TOTEM
- Linear approximation between steps
- Check apertures

Conclusions

Results

- First high-β optics found
- Quadrupoles ok
- Phase advance in the correct order of magnitude
- Aperture ok

Remaining tasks

- Refine the existing optics
- Match betatron phase constraint
- Find detector posistions
- Find un-squeeze

Acknowledgements

- John M. Jowett
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