LHC Phase 1 Upgrade

Optics Status

Baseline & Goal

- $\beta^* = 0.25\ m$
- operation with $\mathscr{L} = 2 \sim 3 \times 10^{34}\ cm^{-2}s^{-1}$
- wide aperture low-β quadrupoles using Nb-Ti Rutherford-type cables at 1.9 K

- Details:

  Conceptual Design of the LHC Interaction Region Upgrade : Phase-I,

  LHC PROJECT-Report-1163

Constraints

- low-β quadrupole G_{max} = *120T/m*
- Coil aperture = *120mm*
- *L* = 23m*
- Wide aperture superconducting *D1*
- Position of the matching sections and dispersion suppressors remain unchanged
- Phase shift across the IR to be compatible with injection optics
- Aperture not limited by IR elements

Detailed Studies $G_{max} \approx 126T/m$

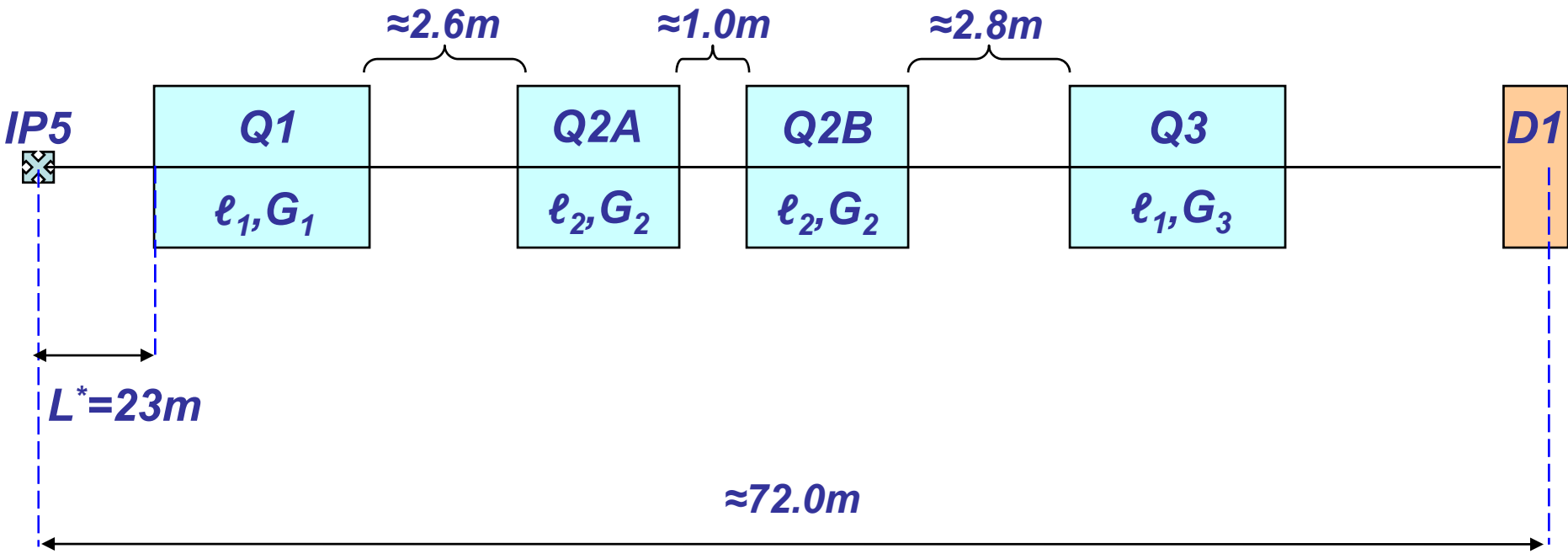
- … have shown that this is not a plug&play exercise
- $\beta^* = 0.25\ m$
- SF Case IIa (Q1/Q3 = 9.09m, Q2 = 7.75m)
  - Robust match
  - Aperture OK
  - IR phase OK (2.6/2.6)
  - Injection optics OK
  - D2/Q4 displacement ≈ *16m*
  - Q5 displacement ≈ *10.5m*

Detailed Studies $G_{max} \approx 126T/m$

- SF Case IIb (Q1/Q3 = 9.00m, Q2 = 7.70m)
  - Difficult to match – local minimum? – not robust/unstable
    - Q7 goes to $G_{max} = 200T/m$
    - Q4/Q5 approaches zero
  - Optical anomalies appear
  - Aperture probably OK
  - IR phase BAD (2.6/2.1)
  - Injection optics constrained by phase
  - Matching section/DS positions unchanged

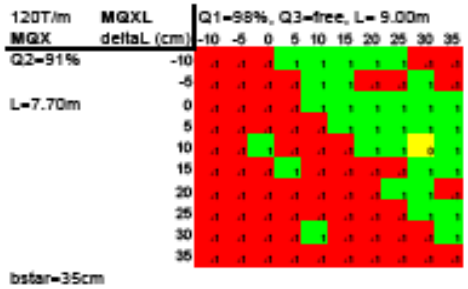
Phase 1 Layout

- IP5-Right



Parameter Scan $\beta^* = 35cm$

- $G_1 = (99\% \pm 1\%) \times G_{max}$
- $G_2 = (89\% \pm 1\%) \times G_{max}$
- $G_3 = free$
- $\ell_1 = 9.00m\ ^{+35cm}_{-10cm}$
- $\ell_2 = 7.70m\ ^{+35cm}_{-10cm}$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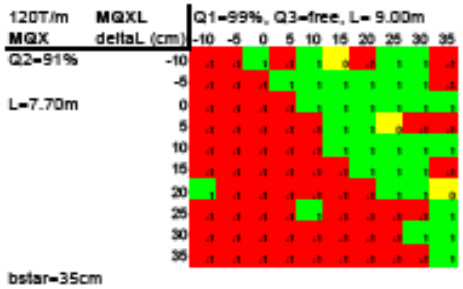
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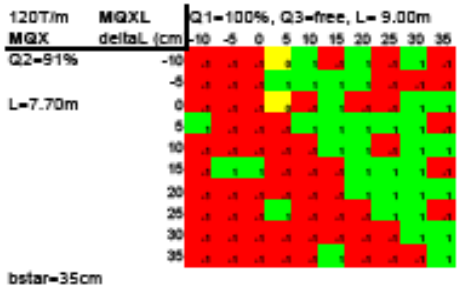
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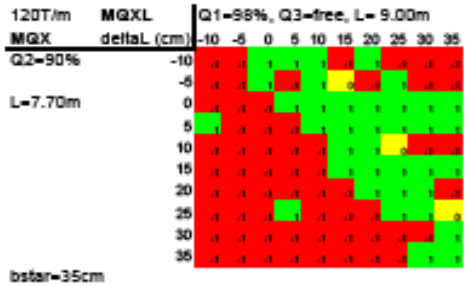
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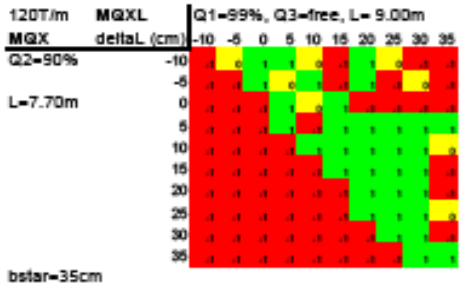
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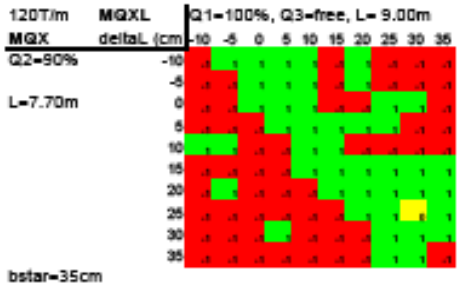
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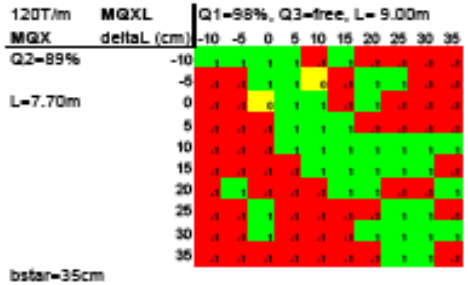
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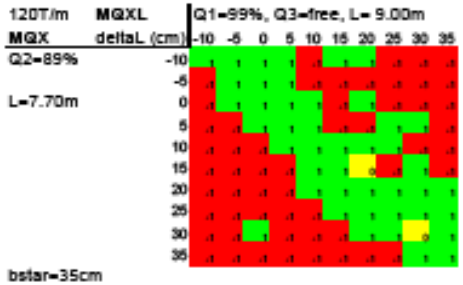
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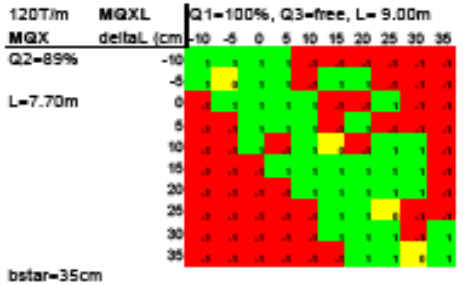
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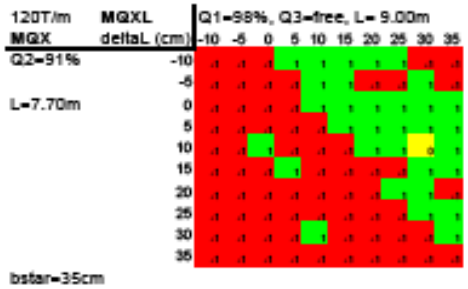
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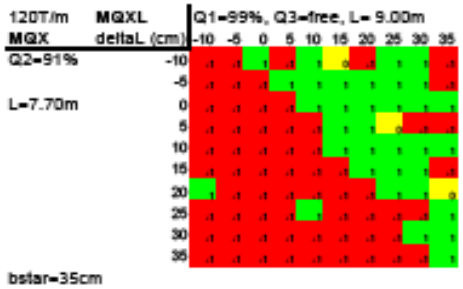
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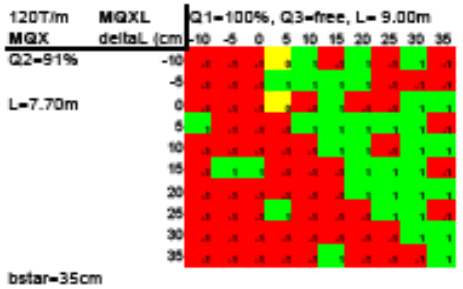
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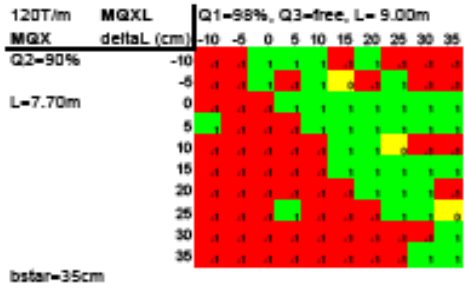
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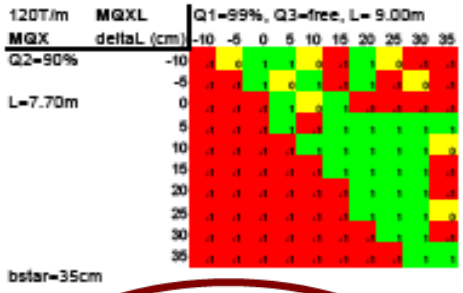
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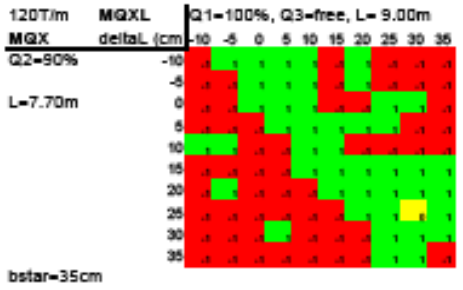
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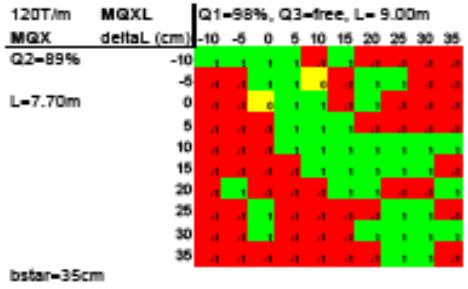
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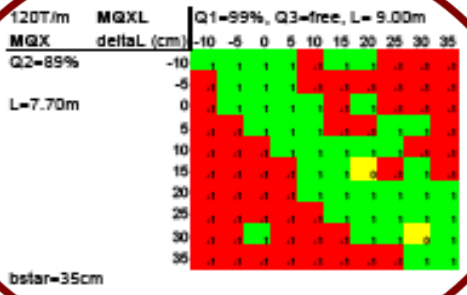
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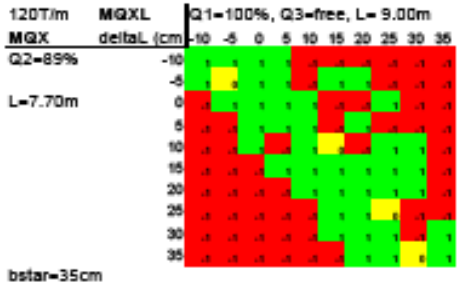
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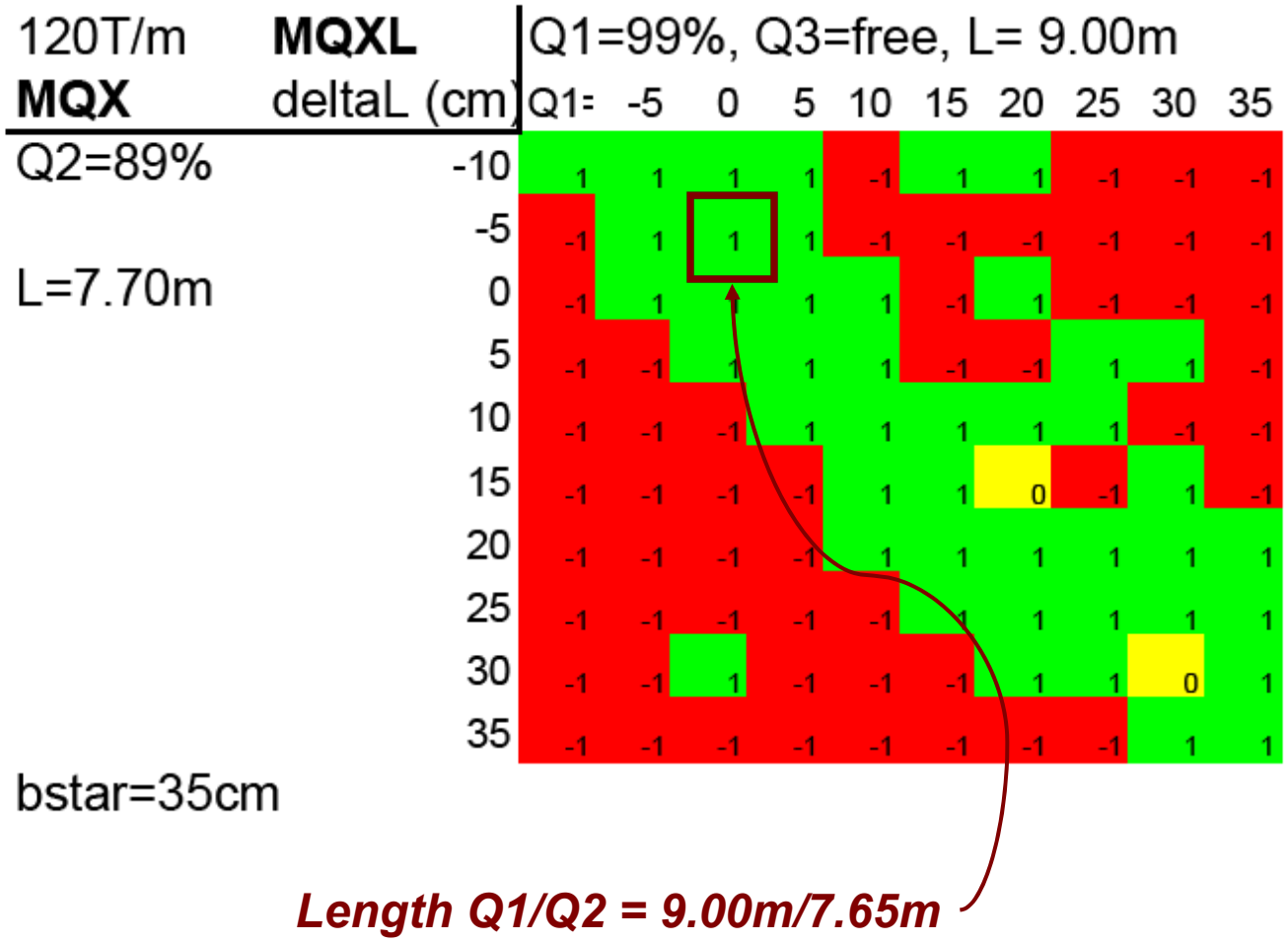
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-10
-5
0
5
10
15
20
25
30
35
Length Q1/Q2 = 9.00m/7.65m

Comments

- Individually powered quadrupoles
- Matching section/DS positions remain unchanged
- Match is apparently robust

but

- Only one-sided *(beam1 and right IP5)*
- Vertical phase advance quite low *(0.7 v.s 0.95* in current machine*)*
- Aperture not verified & other checks not performed ……..

Next steps ….

- Match IP5-left & try reducing β^*
- Phase advance?
- Aperture
- Chromatic aberrations
- Offset vertex & crossing angle
- Injection & squeeze
- Closed orbit study (WH)
- …..

Phase 1 Layout

- IP5-Right