

# Q4 conditions

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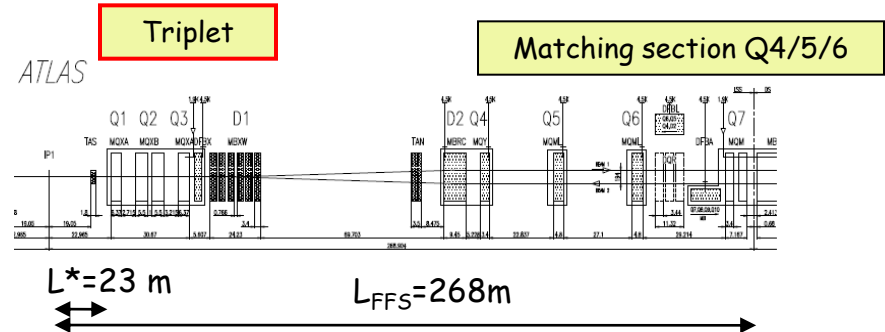
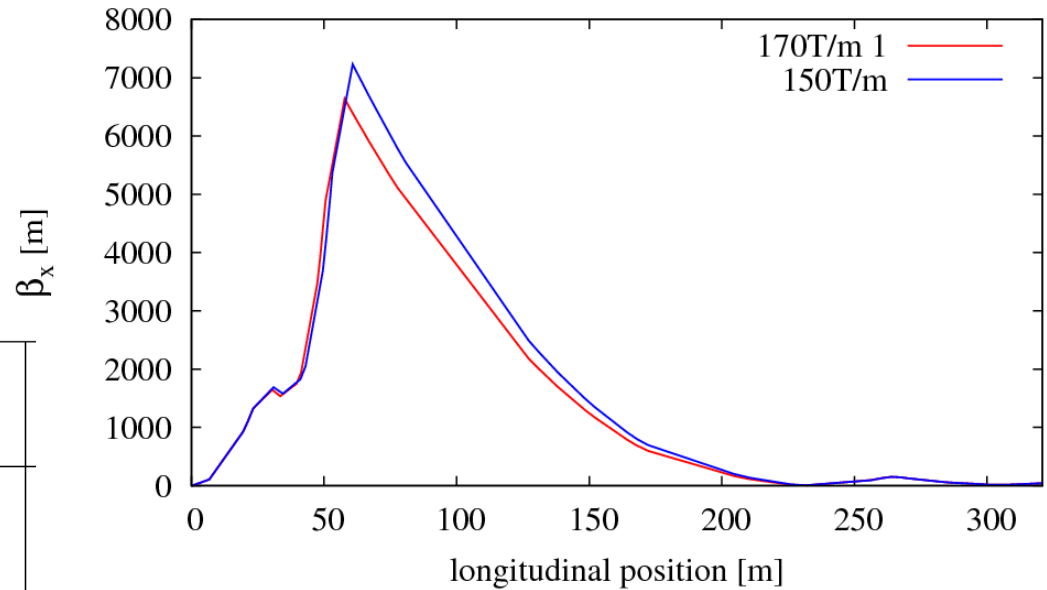
# Outline

- Motivation
- Possibility to increase  $\beta$ 's in Q4 in IR1 & IR5
  - quadrupole strength limits
  - phase advance in the IR
  - Q4-Q5-Q6 configuration, position
- Conclusion & Outlook

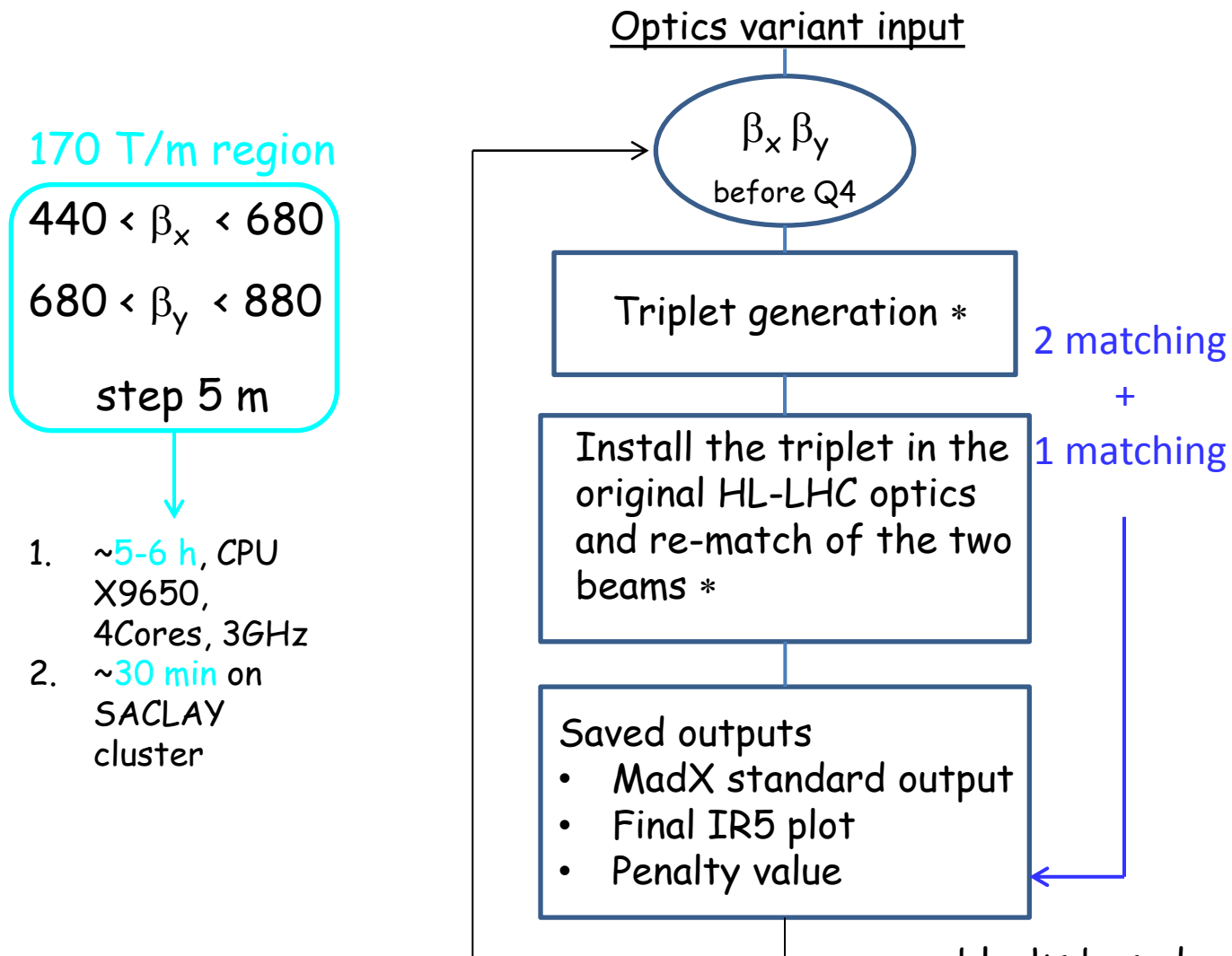


# Q4 conditions

gradient m	$\beta^{\max}$ T/m	$\beta_{\text{range}}^*$ m	$\beta_x^{Q4}$ m
100	6295	0.18 to 0.31	828
118	5447	0.24 to 0.42	652
150	4852	0.14 to 0.24	563
170	4451	0.20 to 0.34	508



# Boundary condition search

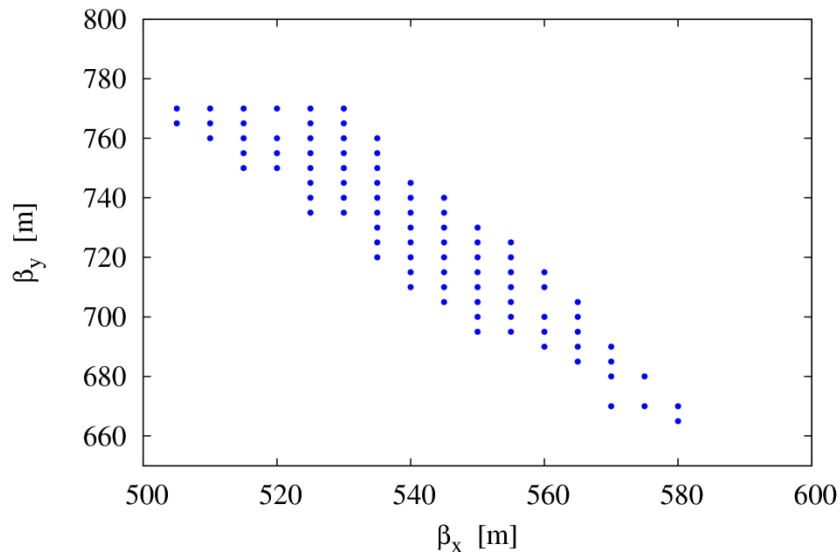


\* blocks based on Riccardo's macros

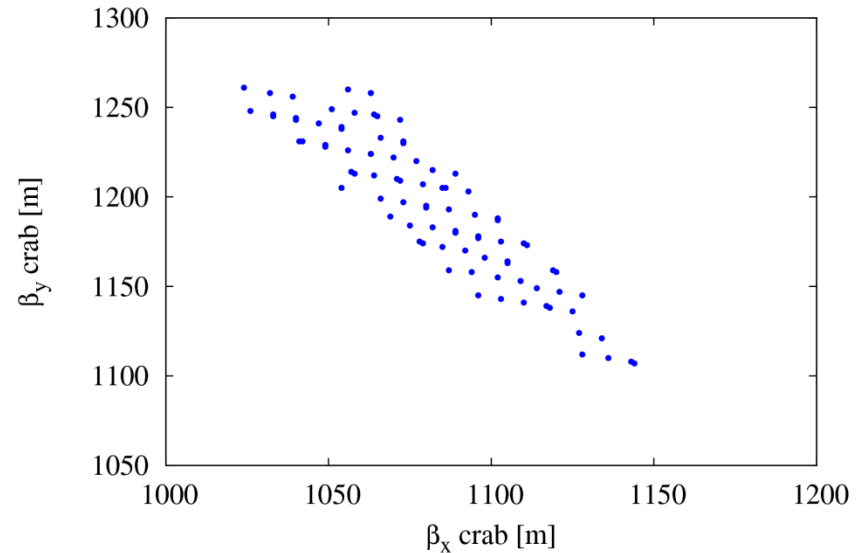
# Matched solutions

- distance between Q1 and Q2 (Q2 - Q3) = 3.05 m
- distance between Q2A and Q2B = 1.64 m
- aperture 120 mm
- maximum triplet gradient 170 T/m

@ 165 m from IP,  $\beta^* = 60$  cm



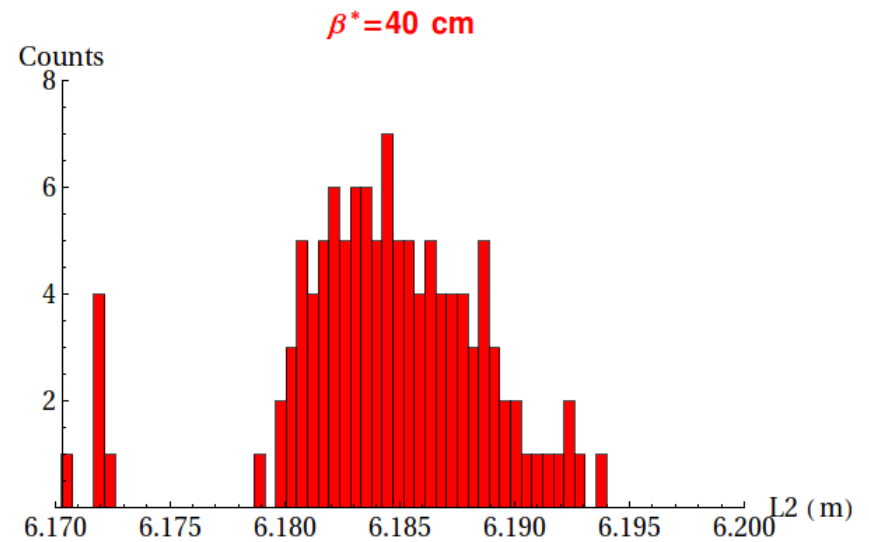
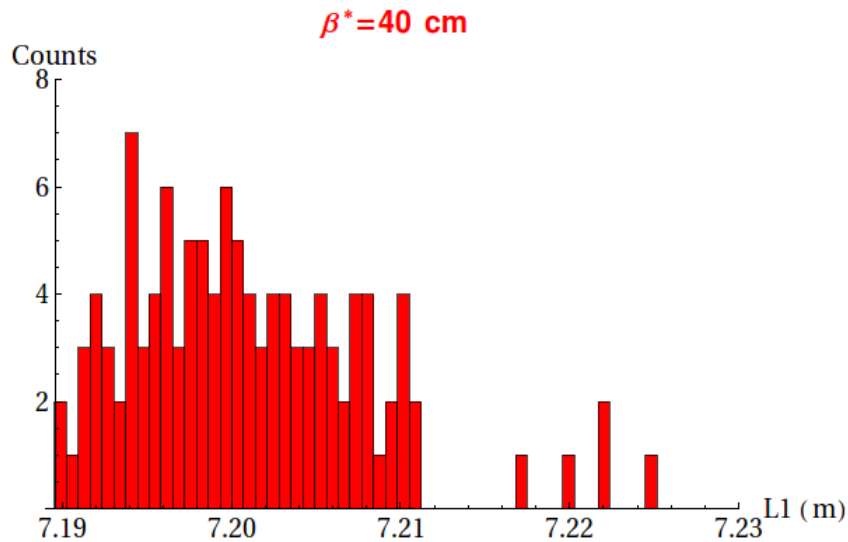
@ crab position,  $\beta^* = 40$  cm



# Triplet lengths

For all the matched solutions

	L1	L2
Mean length [m]	7.19	6.18
Rms [m]	0.007	0.008

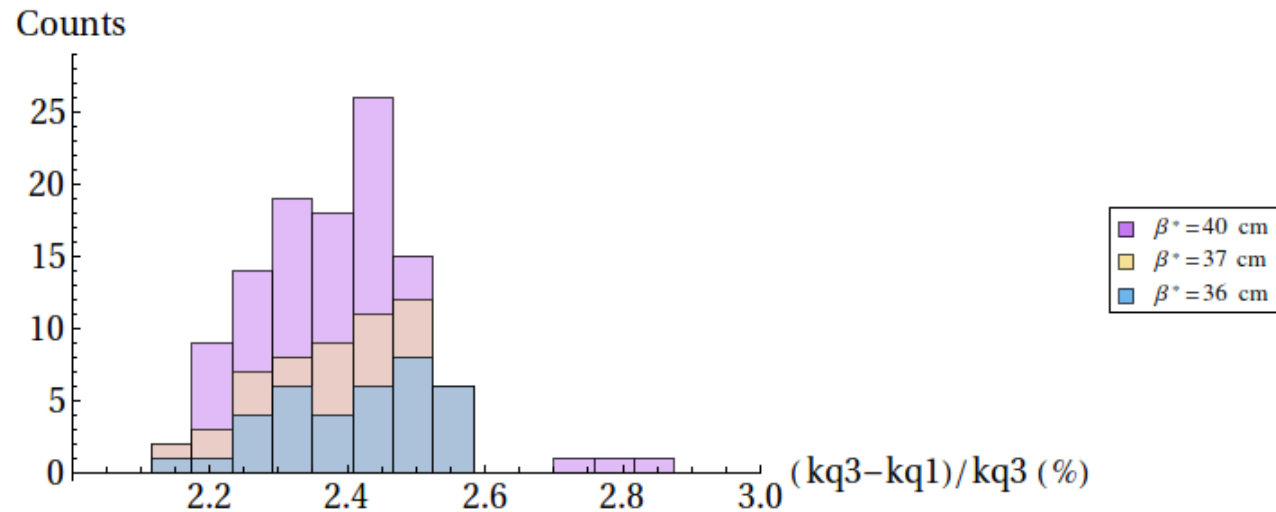


# Triplet strengths

For all the matched solutions:

average variation of Q1 strength  $\sim 2.3\%$

maximum betas variation  $\sim 1$  per mil





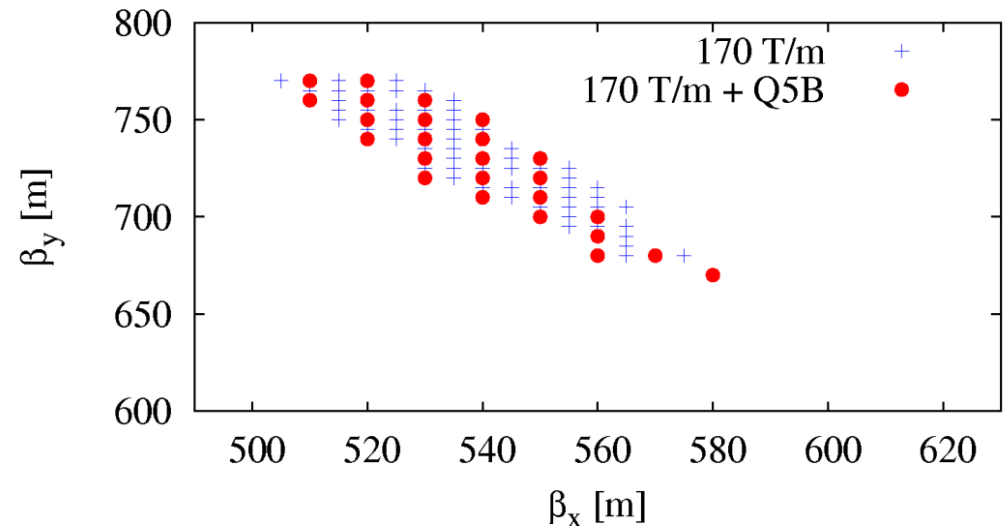
# Adding a quadrupole before Q5

- New quadrupole same type of Q5 added before Q5
- In the matching of the two beams the quadrupole strength is free to get any value

Ex.  $\beta_x$  580  $\beta_y$  670

Q5.R strength =  $1.40180e-03$

Q5A.R strength =  $-9.76032e-05$



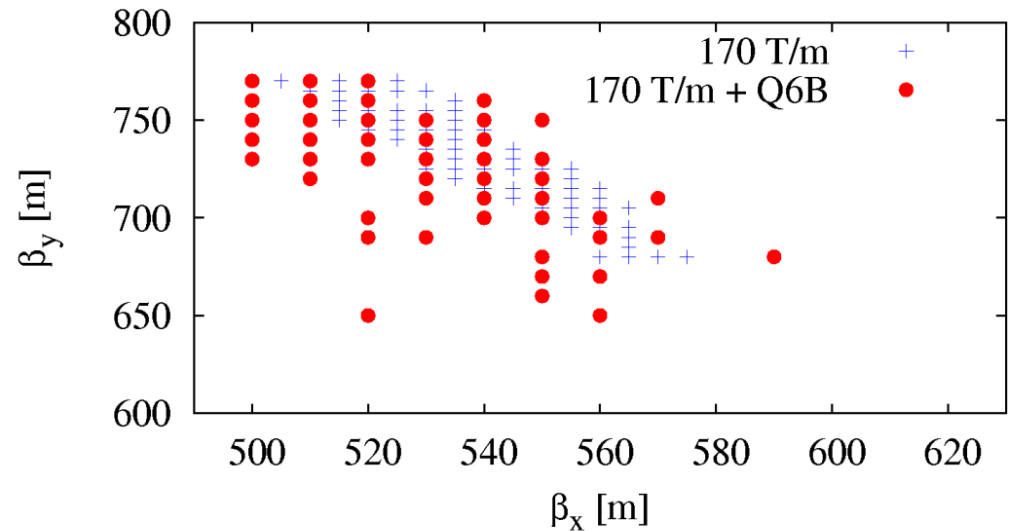
No evident increase in the space of solutions

# Adding a quadrupole before Q6

Ex.  $\beta_x$  590  $\beta_y$  680:

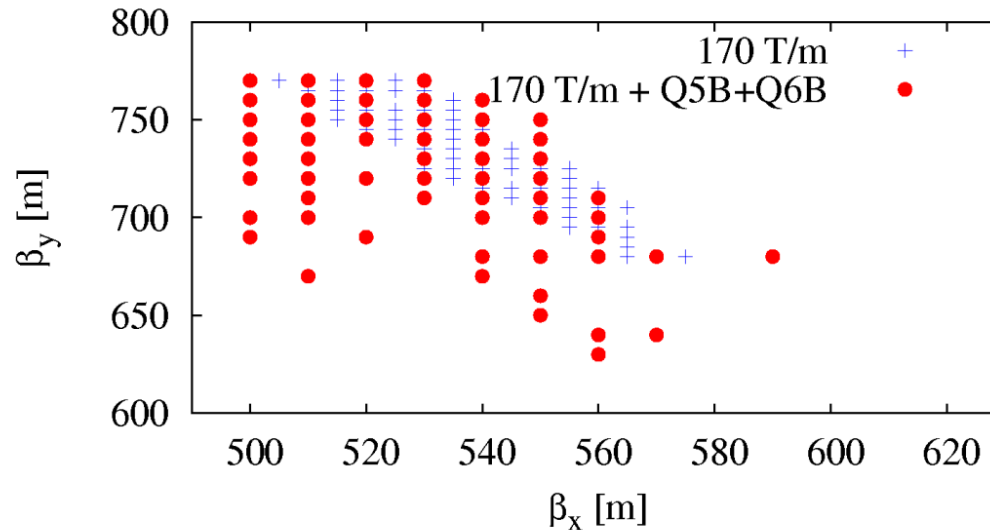
Q6 strength =  $1.02784e-03$

Q6A strength =  $-1.54075e-03$



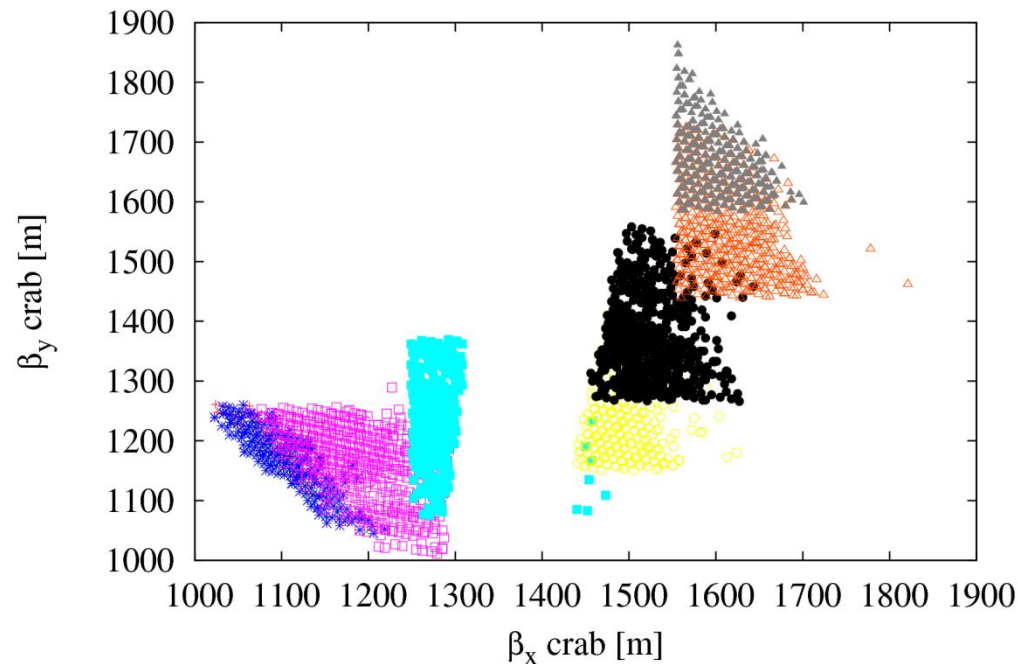
Very little increase in the minimum beta's in Q4

# Adding quadrupoles before Q5 & Q6



- Few more solutions found with respect to replace Q6 with doublets alone
- No further increase of the minimum beta in Q4
- Slight reduction of Q7/Q8 strengths

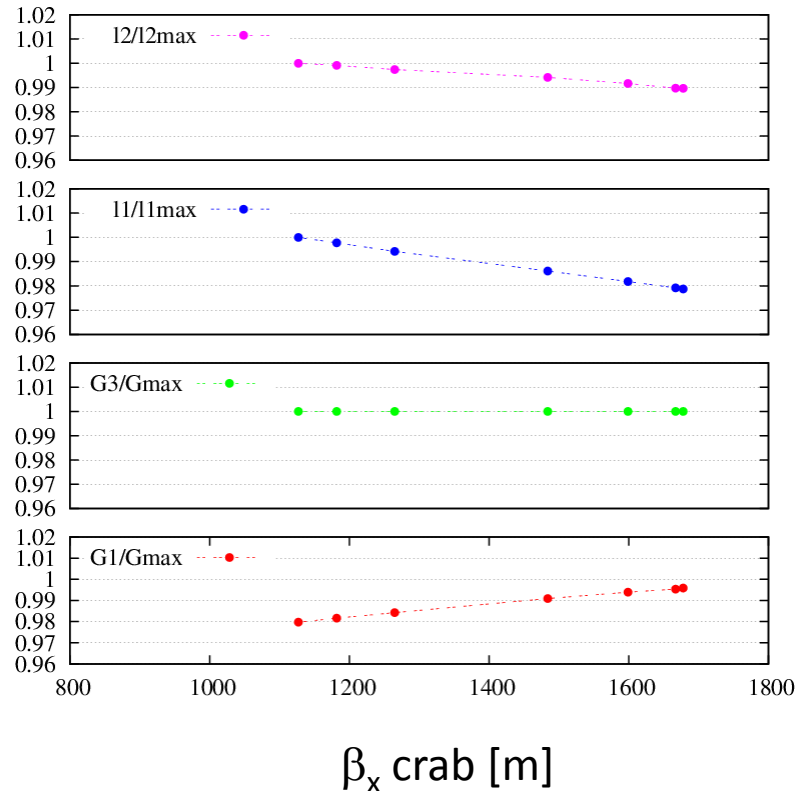
# Q7 max current & matching section initial conditions



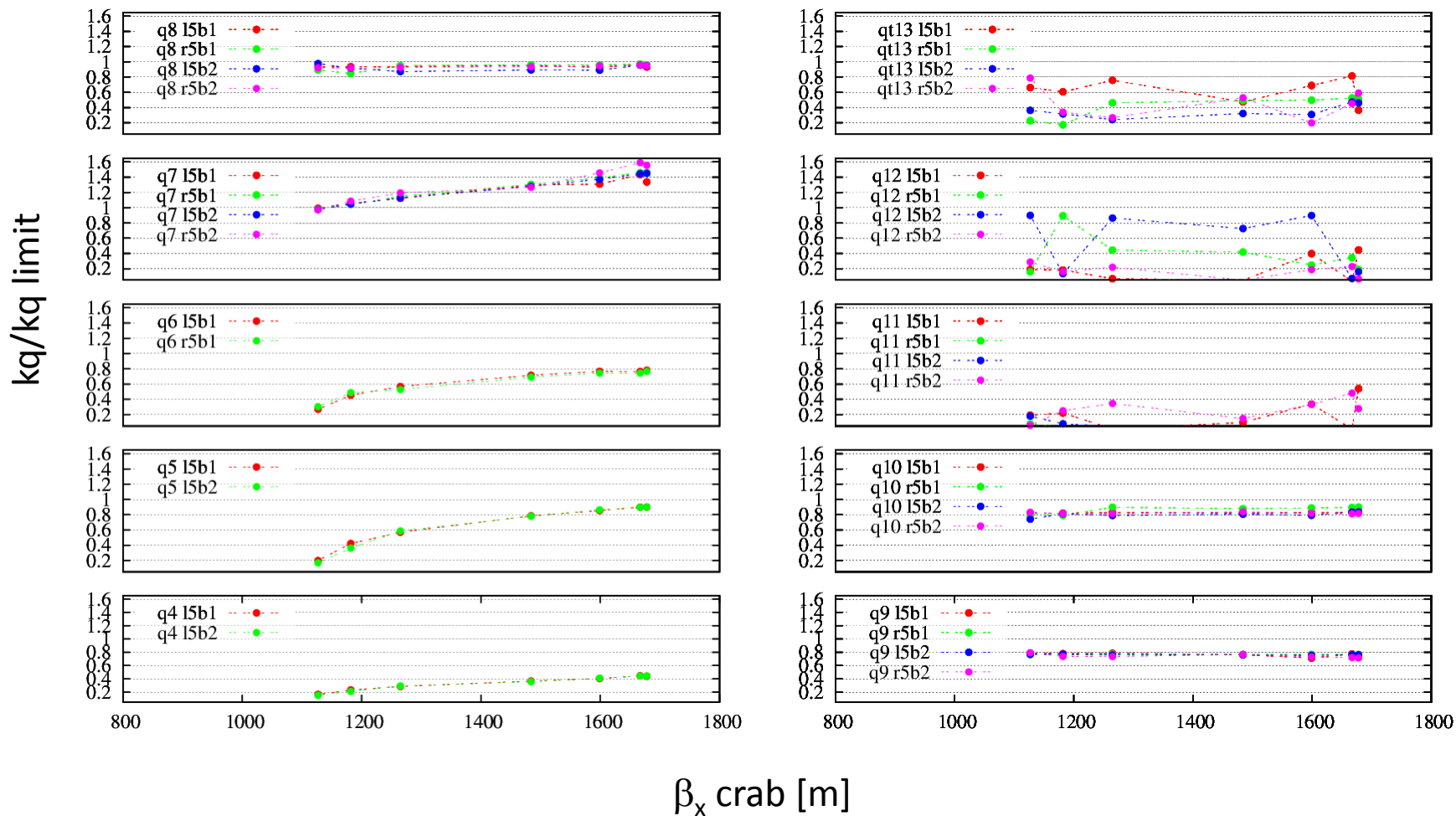
- different initial conditions in the matching section at each scan
- Q7 max current increased of 100 %

# Triplet parameters

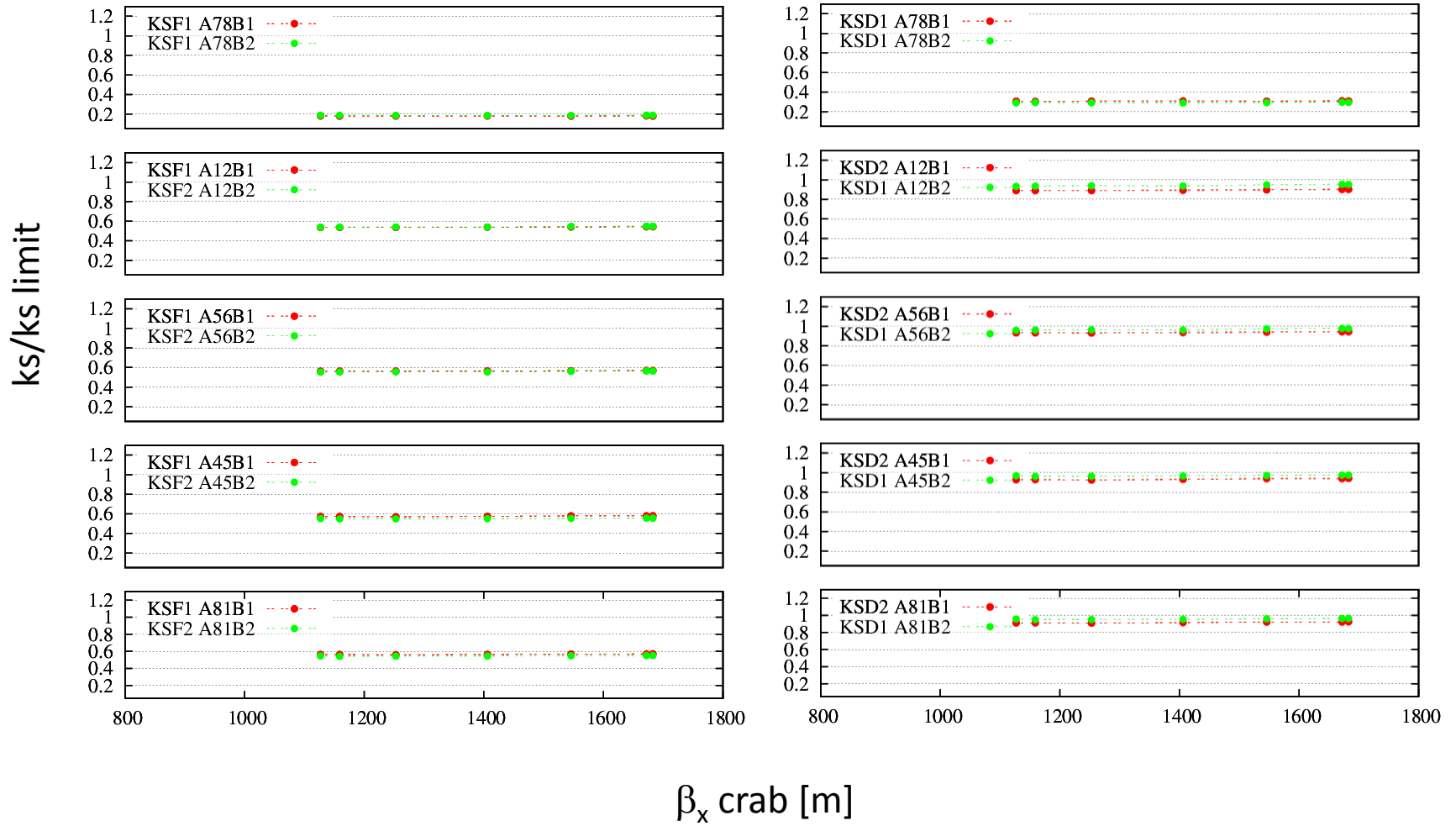
- Q2 ~6 cm shorter
- Q1 ~15 cm shorter
- Q1 strength approach the maximum (170 T/m)



# Quadrupole strengths



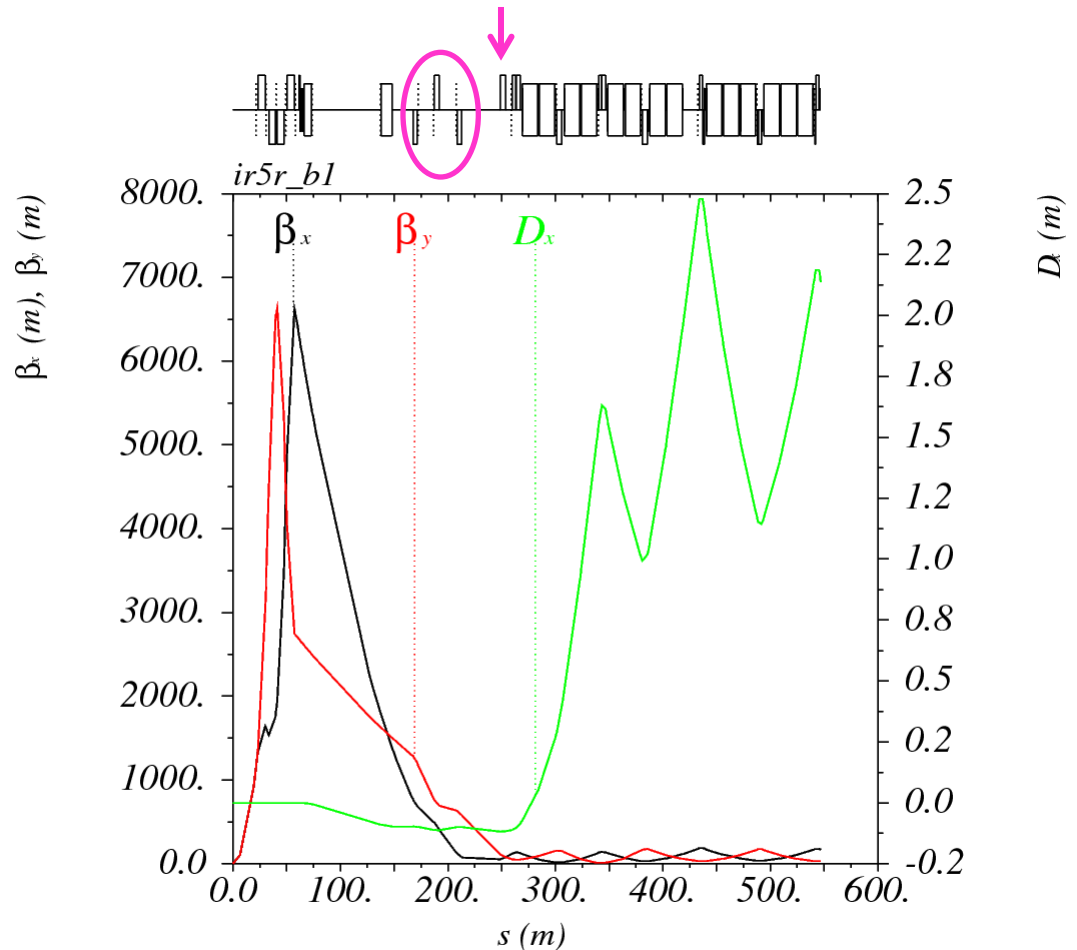
# Sextupole strengths



# New IR1/5 layout

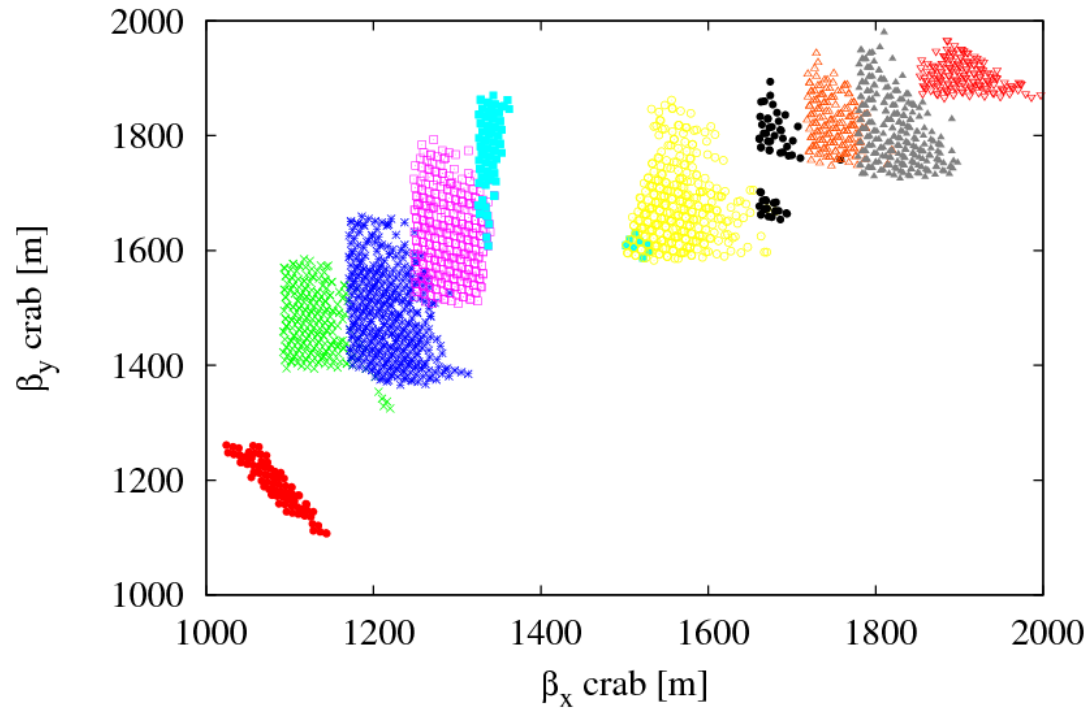
- Q4-Q5-Q6 in triplet configuration
- New quadrupole added before Q7

$\beta^* = 40 \text{ cm}$





# New layout: $\beta$ at crab cavity

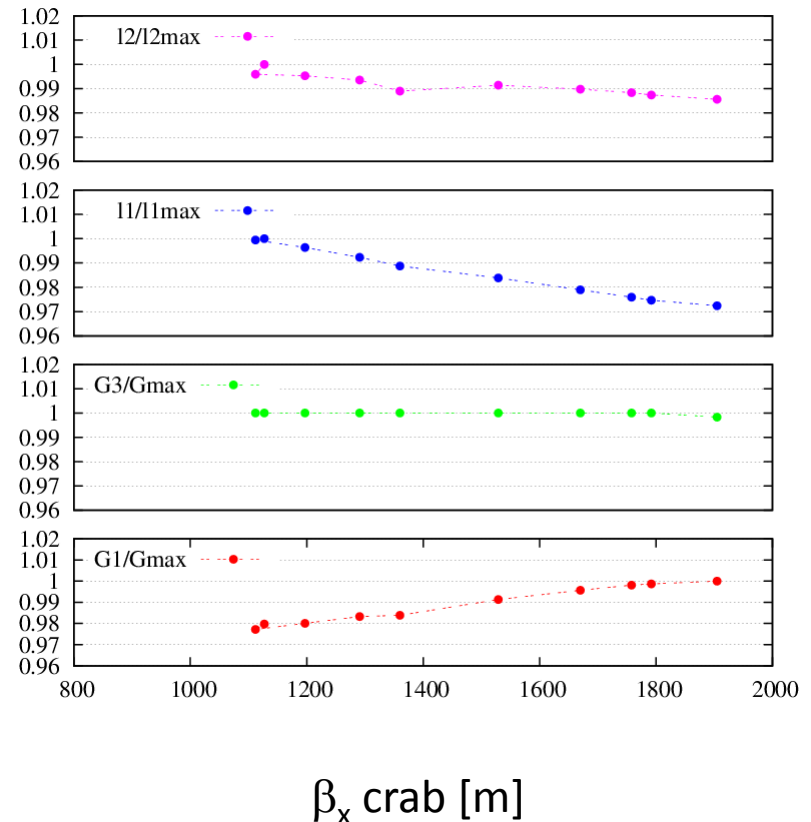


# Triplet parameters

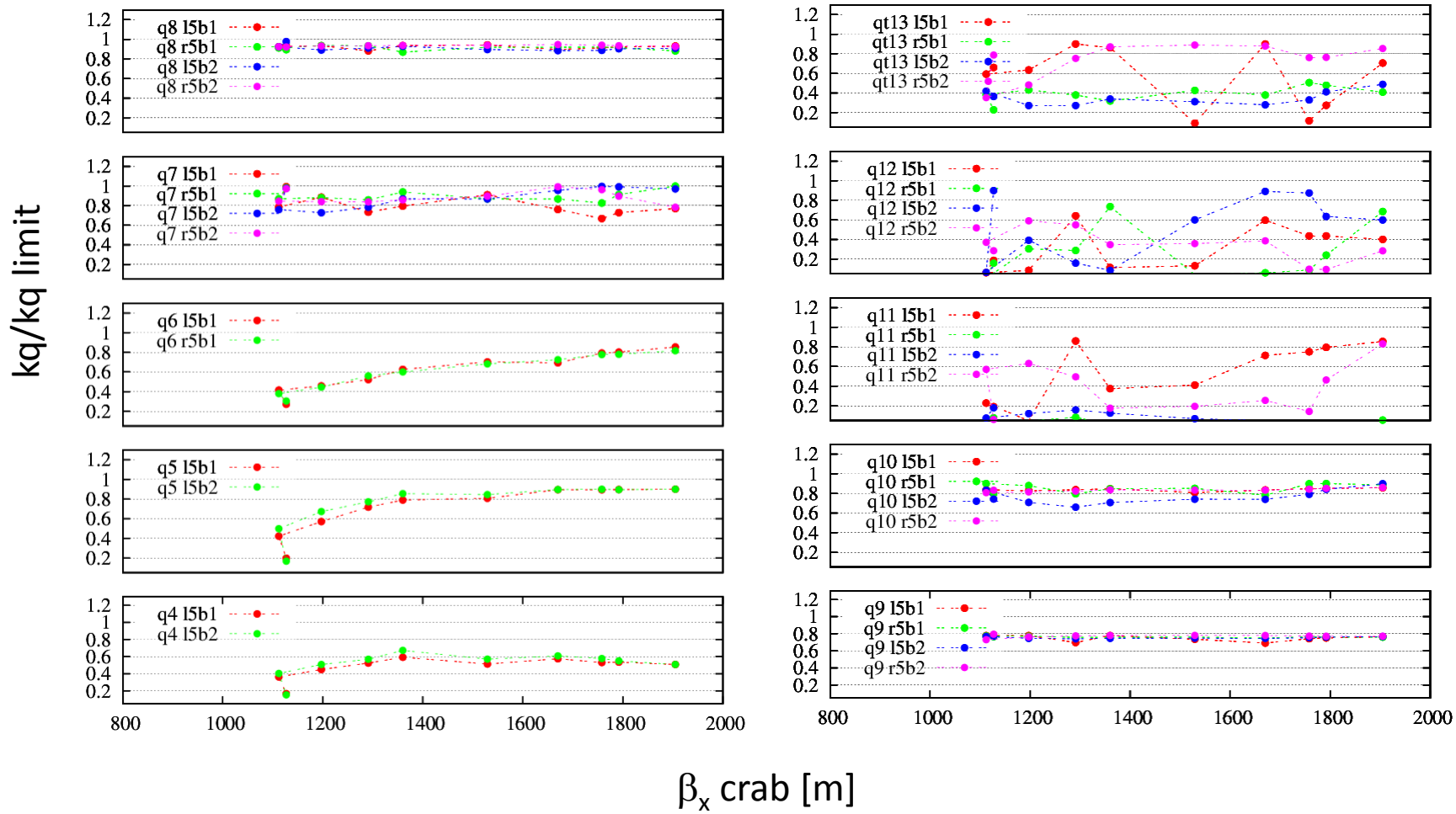
Same triplet trends as in the case of increased Q7 strength

⇒ adding a real quadrupole before Q7 equivalent to increasing Q7 strength

⇒ for  $\beta$  crab  $\sim 1900$   
Q1=Q2=maximum strength  
and Q3 strength  $\leq$  maximum strength

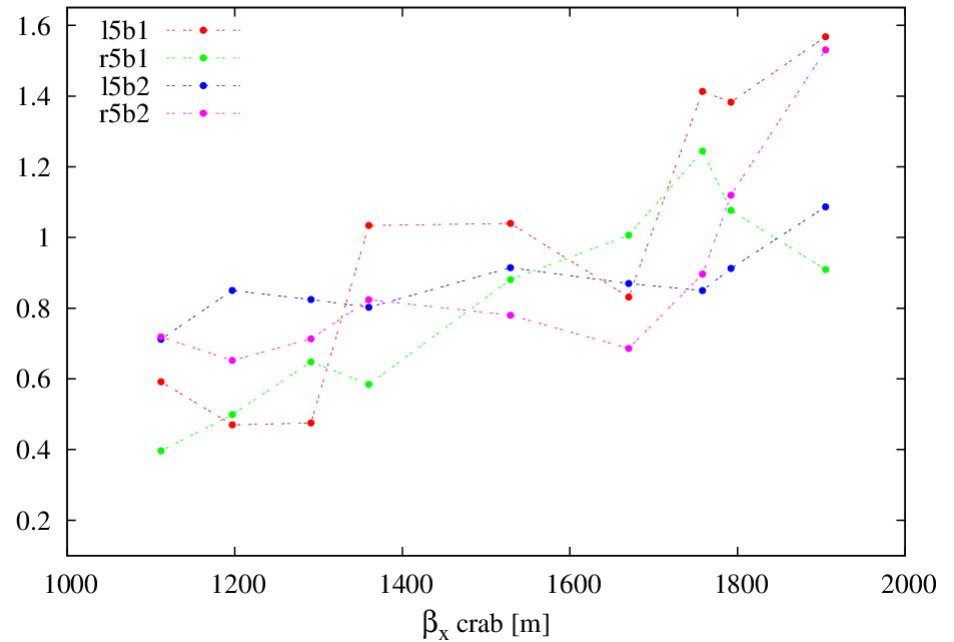


# Quadrupole strengths

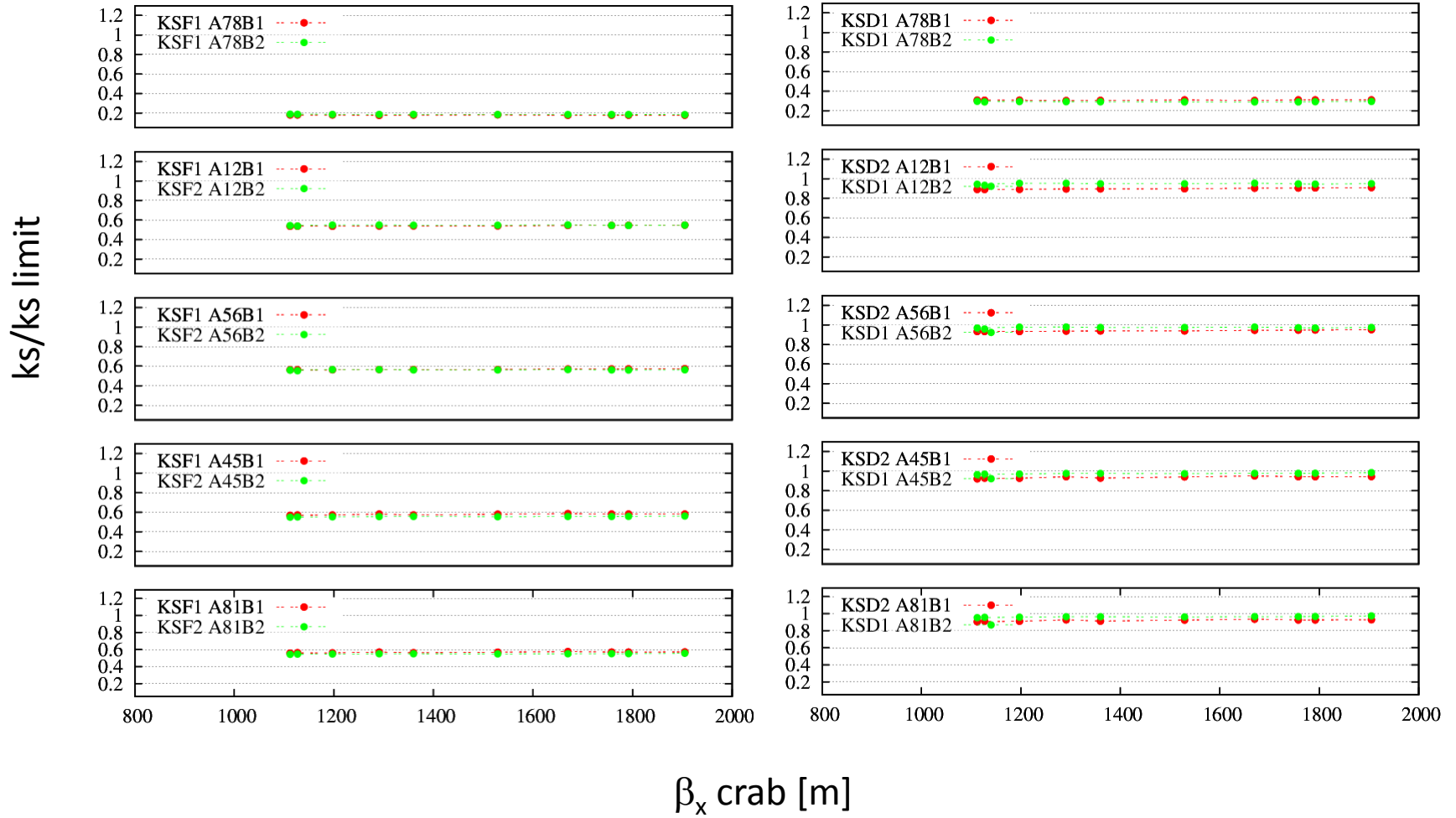


# Added strength

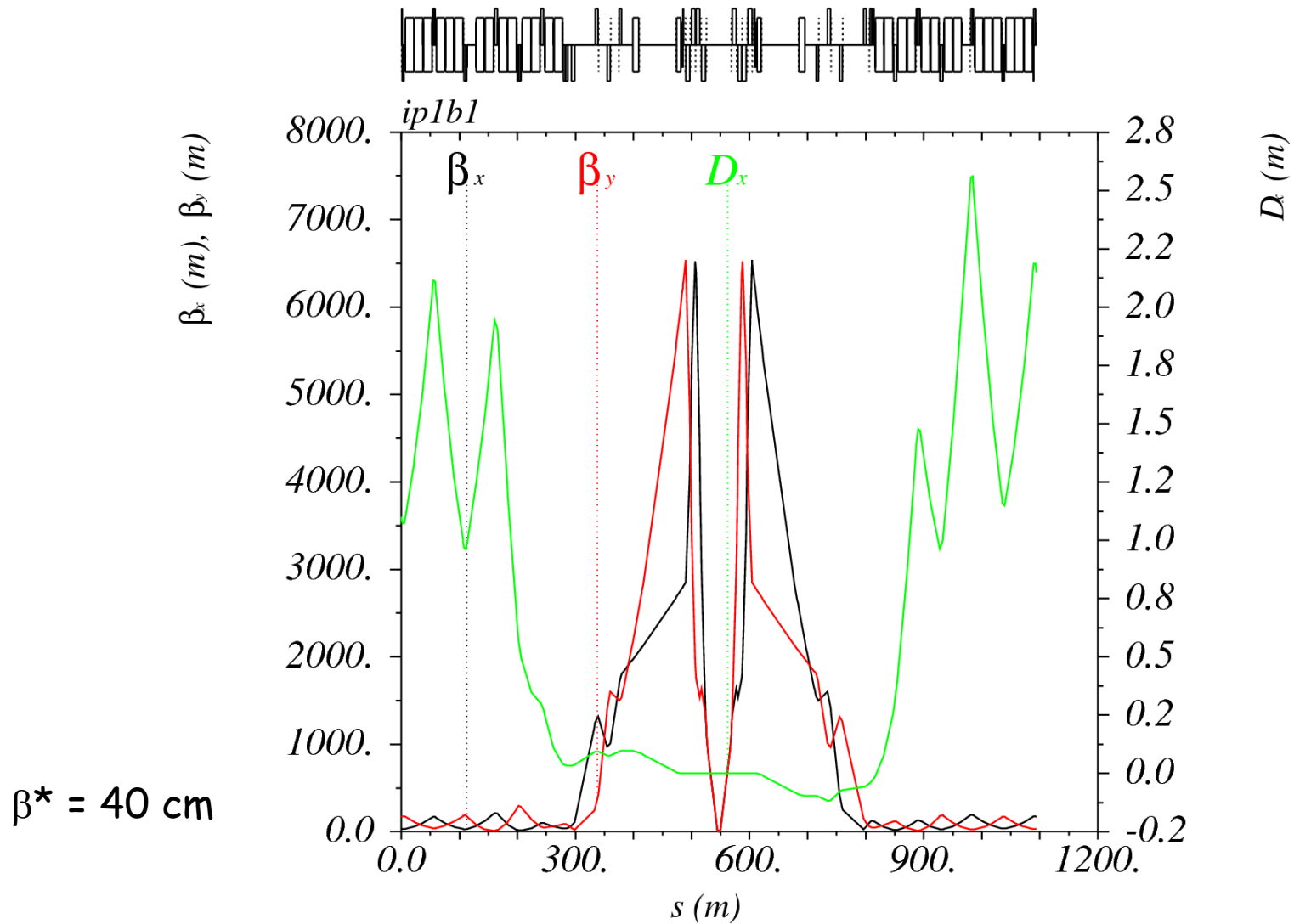
$(\text{strength}/q7\text{limit}) * (L_{\text{quad}}/L_{q7})$  →



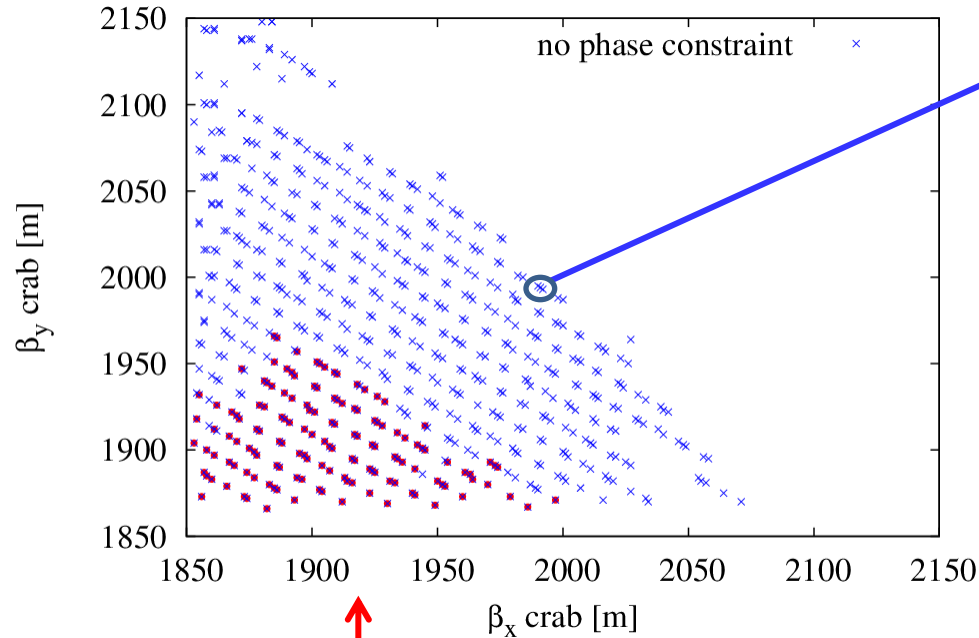
# Sextupole strengths



# Optics high $\beta$ 's



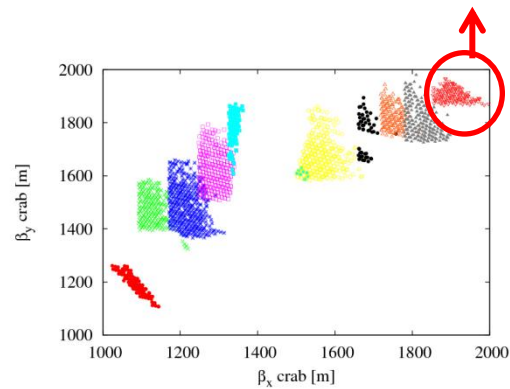
# Phase constraint



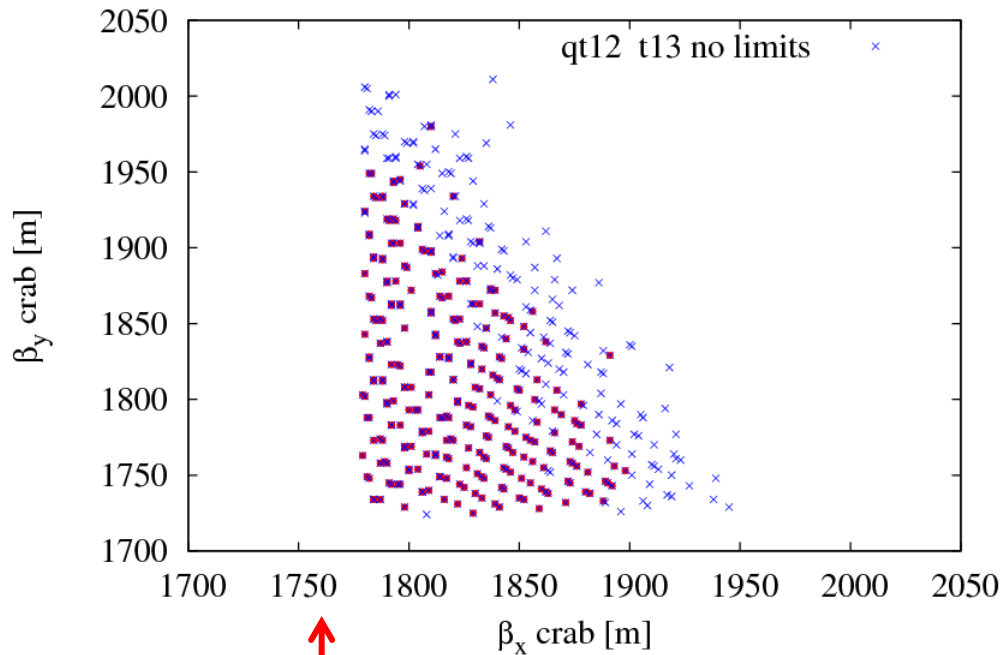
IR5	$\beta_x \beta_y \sim 2000$	Nominal ATS
$\mu_x$ Total	2.5374	2.6427
$\mu_x$ Right	1.3654	1.4858
$\mu_x$ Left	1.1719	1.1569
$\mu_y$ Total	2.4717	2.642
$\mu_y$ Right	1.3654	1.1553
$\mu_y$ Left	1.3476	1.4867

$$\Delta\mu_x - 0.1053$$

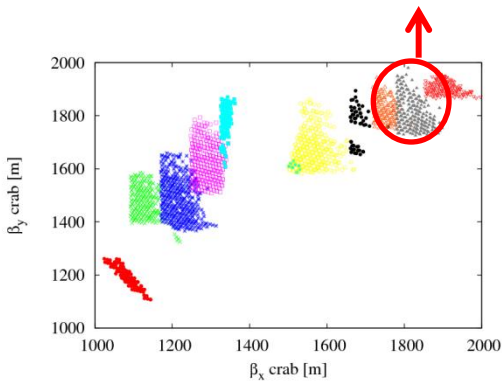
$$\Delta\mu_y - 0.1703$$



# QT12 & QT13



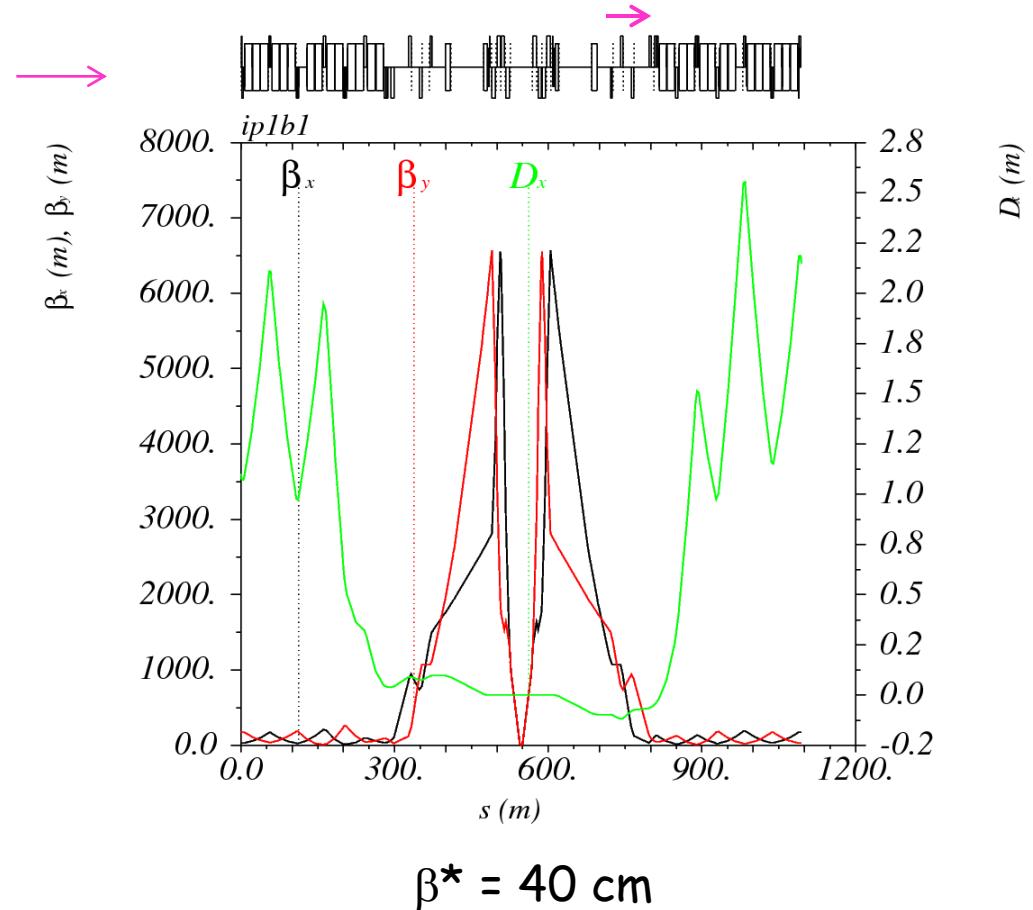
Even without limits for QT12 and QT13 there is no big gain in the number of matched solutions





# Position of Q4-Q5-Q6

- moving the triplet Q4-Q5-Q6 towards the arc
  - maximum betas found  $\sim 1680$
- triplet by moving Q4 towards Q5 and Q6
  - ...
- reducing Q4-Q5 and Q5-Q6 distance
  - ...



# Conclusions

- The most important limit in the optics layout design of IR1 and IR5 is Q7/Q8 maximum current
- Adding a new quadrupole and arranging Q4-Q5-Q6 the beta's at the crab location can be increased > 50%

# Outlook

- More "realistic" matching section layout (positions, strengths and apertures of magnets)
- Corresponding injection optics