IR6 squeeze for layout HLLHCV1.2

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Acknowledgments: R. Bruce, S. Fartoukh, J. Uythoven, M. Fraser

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

Outline

1. IR6 optics – aperture optimization at injection
2. IR6 constraints from ABT and collimation
3. IR6 squeeze (round, flat, flathv)

IR6 constraints from ABT + collimation

Constraints derived from V1.0 squeeze analysis and RunII optics (M.A. Fraser, J. Uythoven, R. Bruce):

1. maximize β-functions at dump in order to ensure a sufficient distribution of the beam energy

   Beam 1: $\beta_x > 5012$ m, $\beta_y > 3955$ m

   Beam 2: $\beta_x > 5052$ m, $\beta_y > 3698$ m

   Limits taken not to decrease nominal LHC ones.

   -> Can they be relaxed to minimum over both beams ?

   -> What is the true minimum on the β in one plane, what is the minimum on sqrt(β_x*β_y) ? -> FLUKA simulations needed (Jan)

2. MQY.4L6.B1 and MQY.4R6.B2 constant in order to ensure enhancement of the MKD kick (1% gradient error acceptable)

3. dispersion smaller than 0.5 m in straight section (educated guess)

IR6 constraints from ABT + collimation

Constraints derived from V1.0 squeeze analysis and RunII optics (M.A. Fraser, J. Uythoven, R. Bruce):

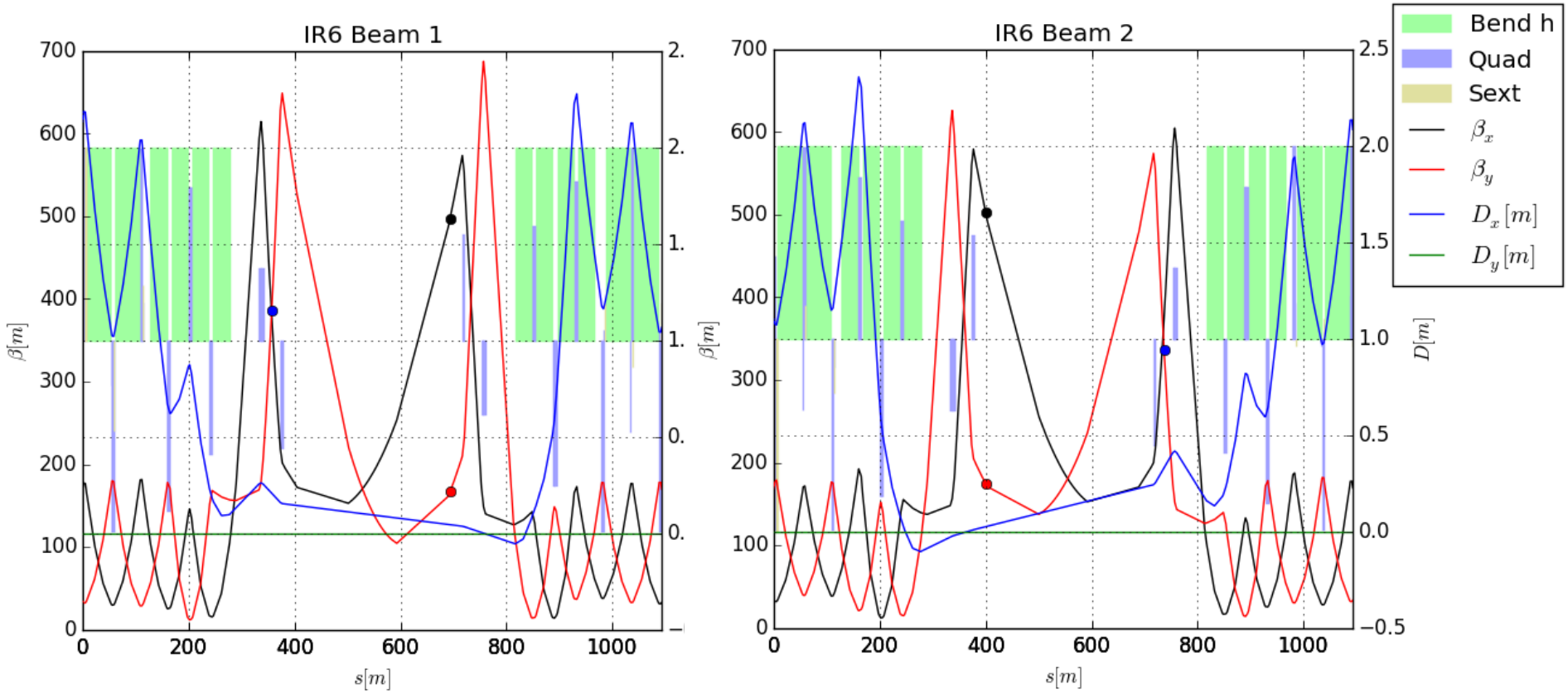
2. asynchronous dump:
   - phase advance of π/2 between MKD and TCDQ to ensure protection by TCDQ in case of asynchronous dumps -> 10% relative error tolerable

     $\Delta\mu_x$ (MKD->TCDQ) = 0.5*π ± 0.025*π
   - maximize β-functions at TCDQ in order to ensure a sufficient distribution of the beam energy (hor. less critical as already diluted by horizontal kick)

     $\beta_{x/y}$ (TCDQ) > 160 m (= nominal LHC)

<u>in addition:</u> aperture limit at 7 TeV =β_{IR6} < β_{arc} + 20 m, e.g. flat β_{arc}=1150 m

Injection β*=6m - optics



TCDQ (black/red) MKD

Injection β*=6m - aperture

layout	$\beta_{x/y}$* [m]	minimum n1, Beam 1		minimum n1, Beam 1	
		element	value	element	value
LHC, RunI	11	MQ.11R6.B1	9.54	MQML.10R6.B2	9.49
LHC, RunII*	11	MQ.11R6.B1	9.49	MQML.10R6.B2	9.47
HLLHCV1.0	6	MQ.11R6.B1	9.42	MQML.10R6.B2	9.50
HLLHCV1.1	6	MQML.10L6.B1	9.28	MCBV.12R6.B2	9.40**
HLLHCV1.2	6	MQ.11R6.B1	9.24	MQML.10R6.B2	9.25

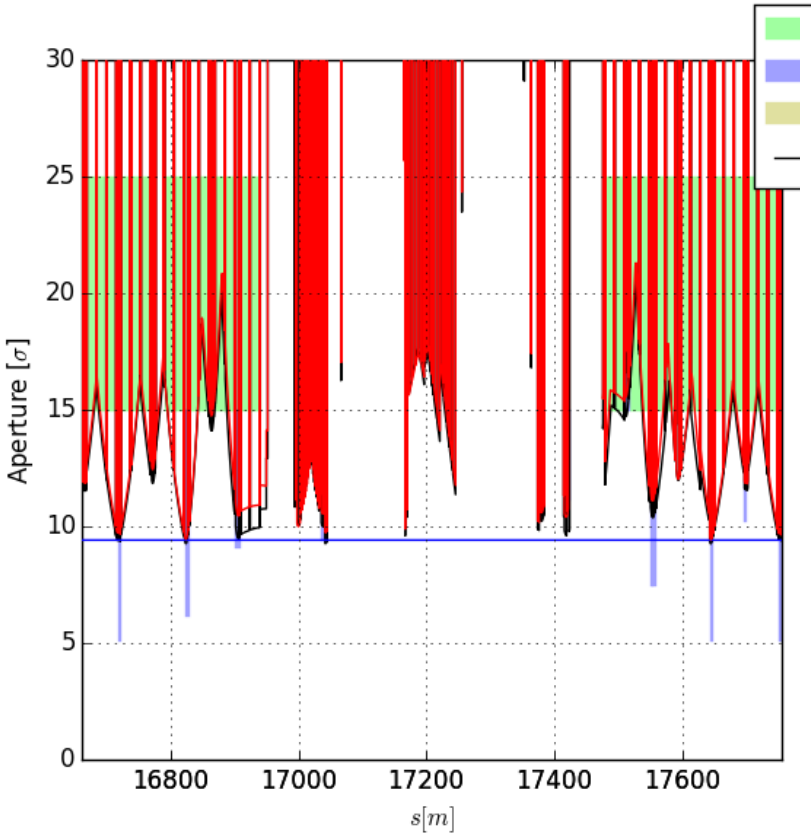
*injection with MQT for adjustment of WP (beta-betating), strength unchanged

**aperture for b1 worse in order to fulfill $\beta_{x/y}$(TCDQ)>160 m, for beam 2 dump constrained is not fulfilled $\beta_{x/y}$(dump, V1.1)=3538 m < 3955 m

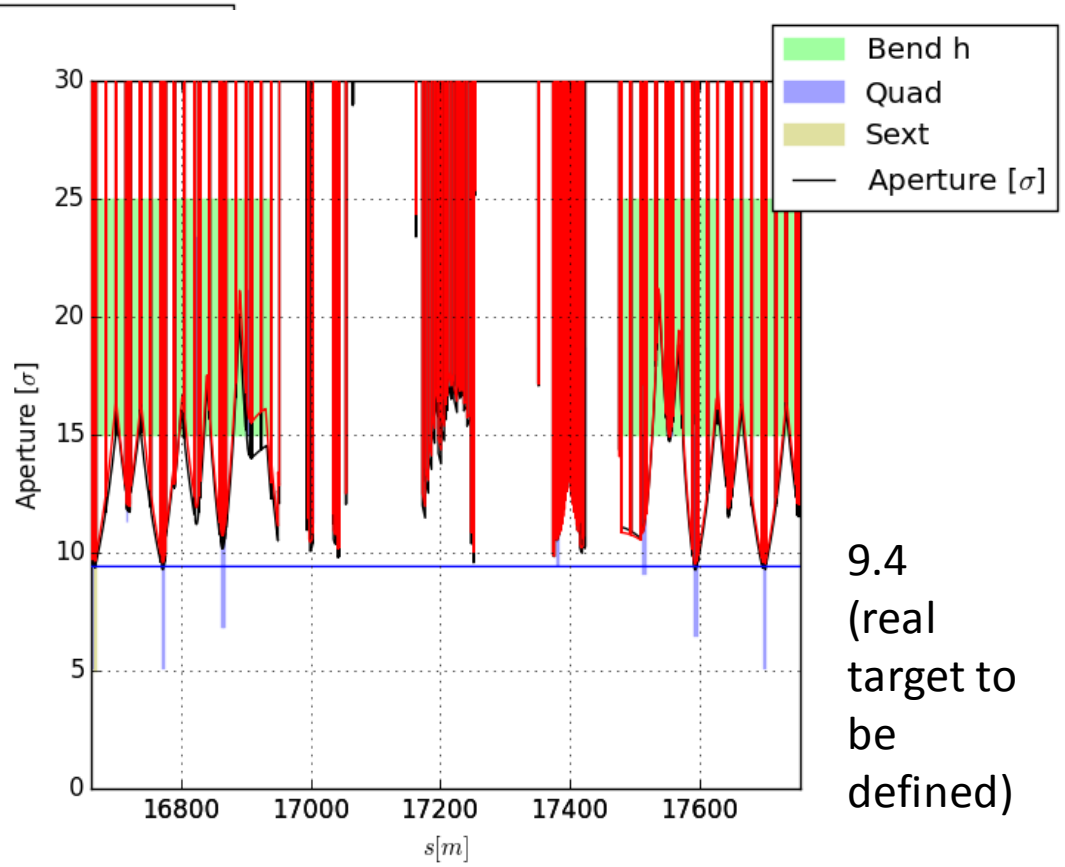
⇒ aperture degraded in order to meet ABT+collimation constraints
+ n1>9.4 in straight section

⇒ relaxation of $\beta_{x/y}$ (TCDQ) or $\beta_{x/y}$ (dump) would improve aperture at injection (see V1.1 optics)

Injection β*=6m - aperture



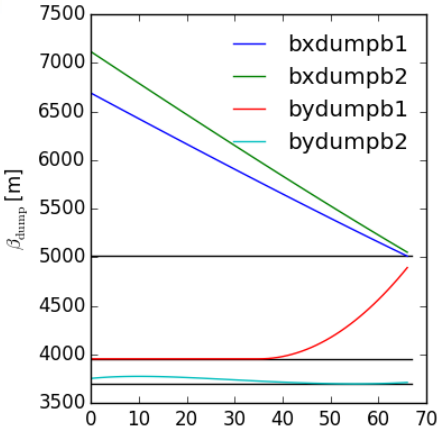
HLLHCV1.0

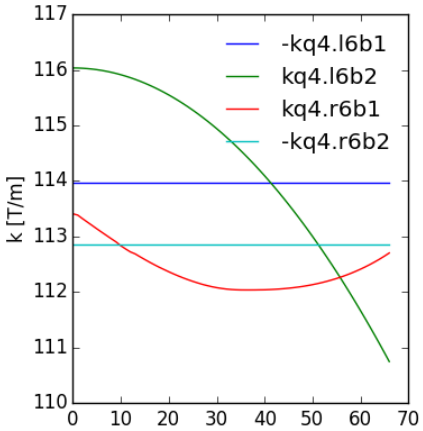


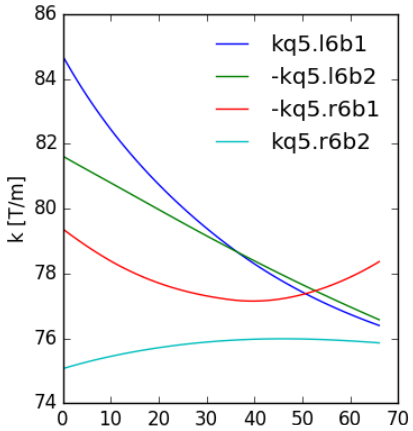
HLLHCV1.2

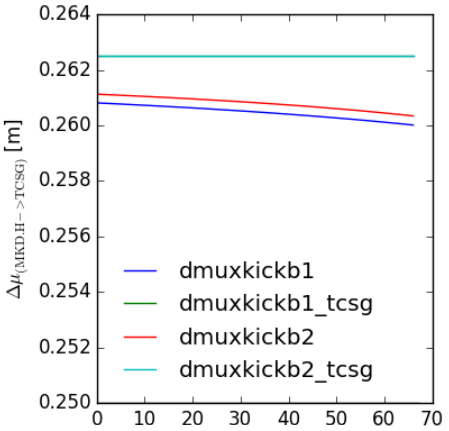
9.4 (real target to be defined)

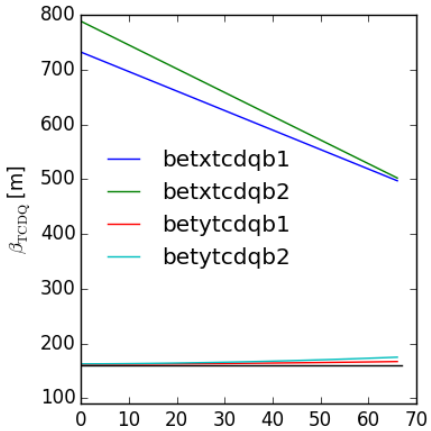
Squeeze round: 0.48 m -> 0.15 m

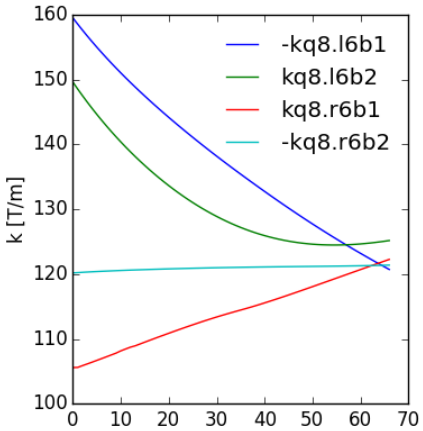




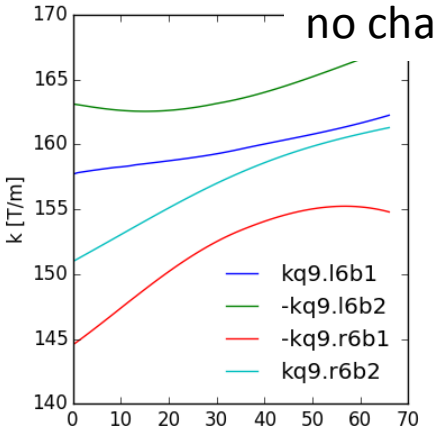


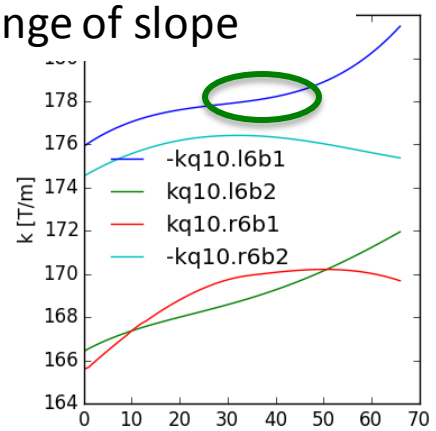




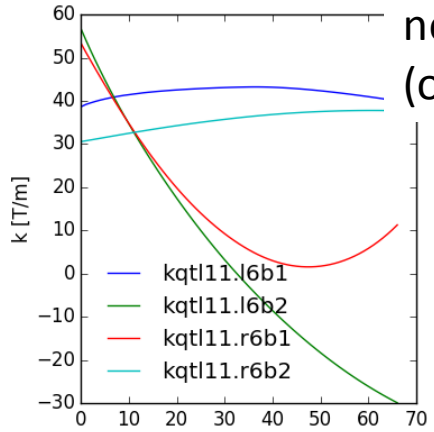


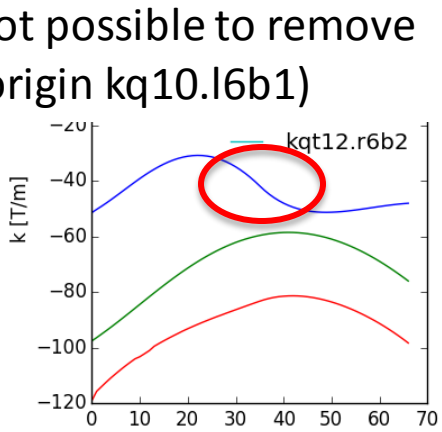
no change of slope

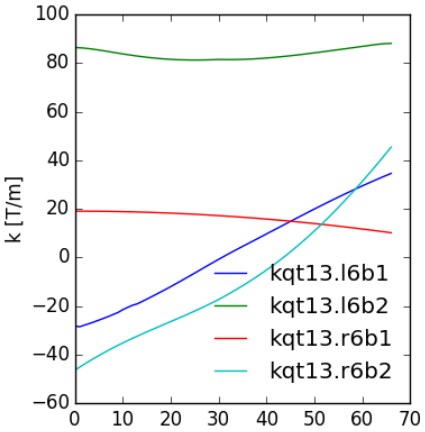


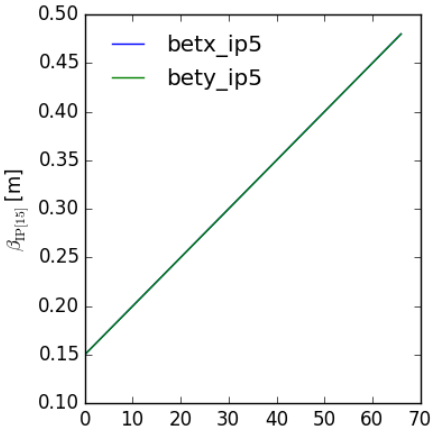


not possible to remove
(origin kq10.l6b1)

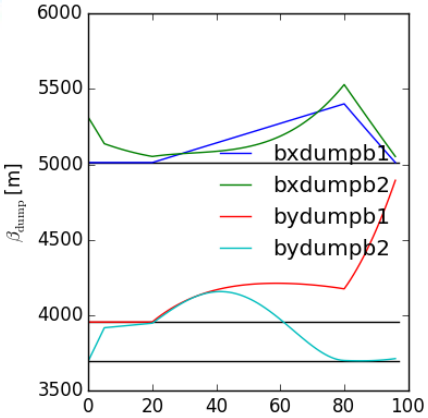


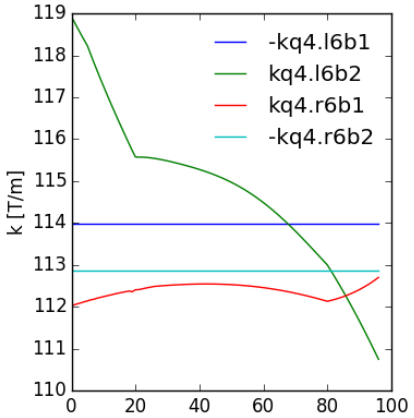


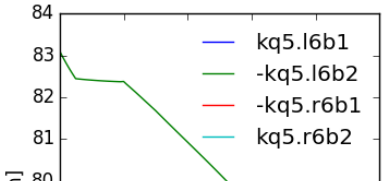


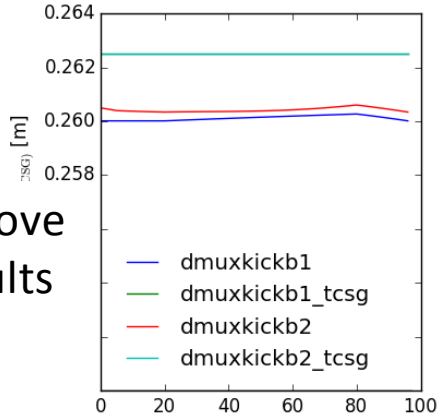


Squeeze flat: 0.48 m -> 0.075/0.30 m

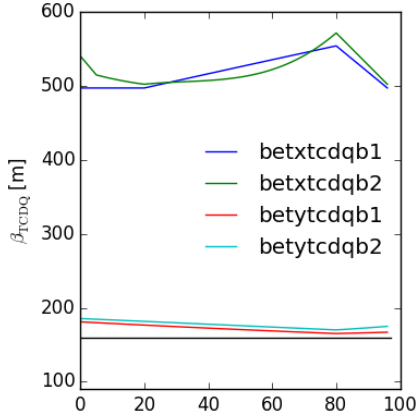


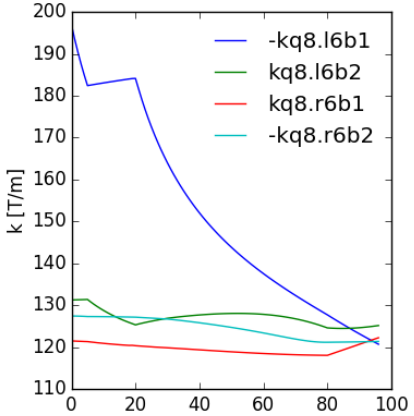


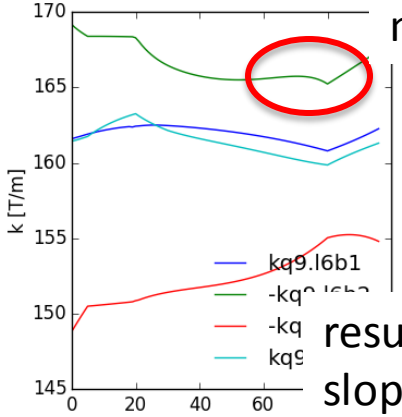




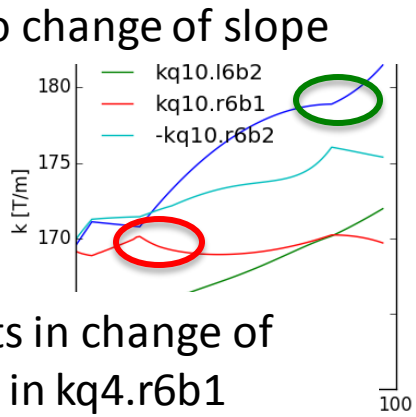
very difficult to remove
-> small change results
in large impact on
other quadrupoles



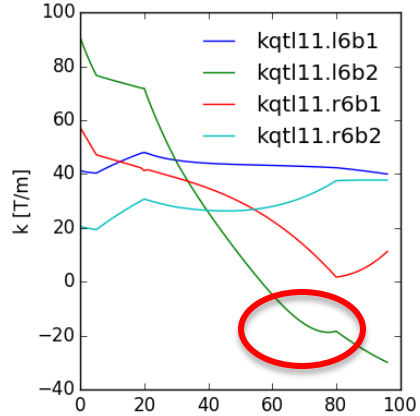


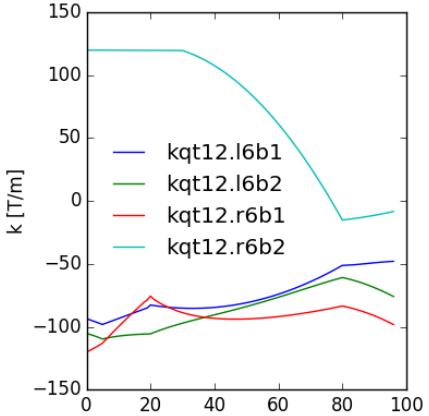


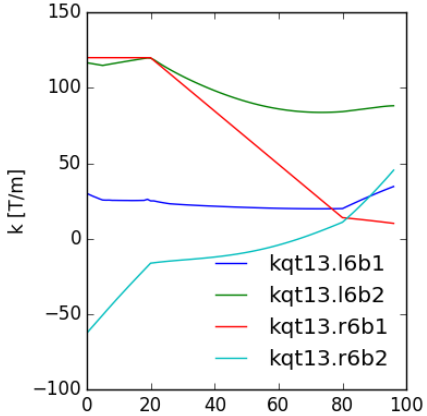
no change of slope

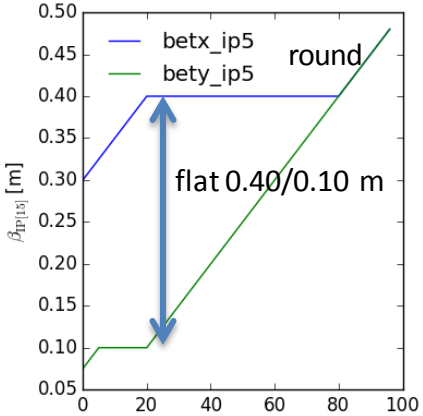


results in change of
slope in kq4.r6b1

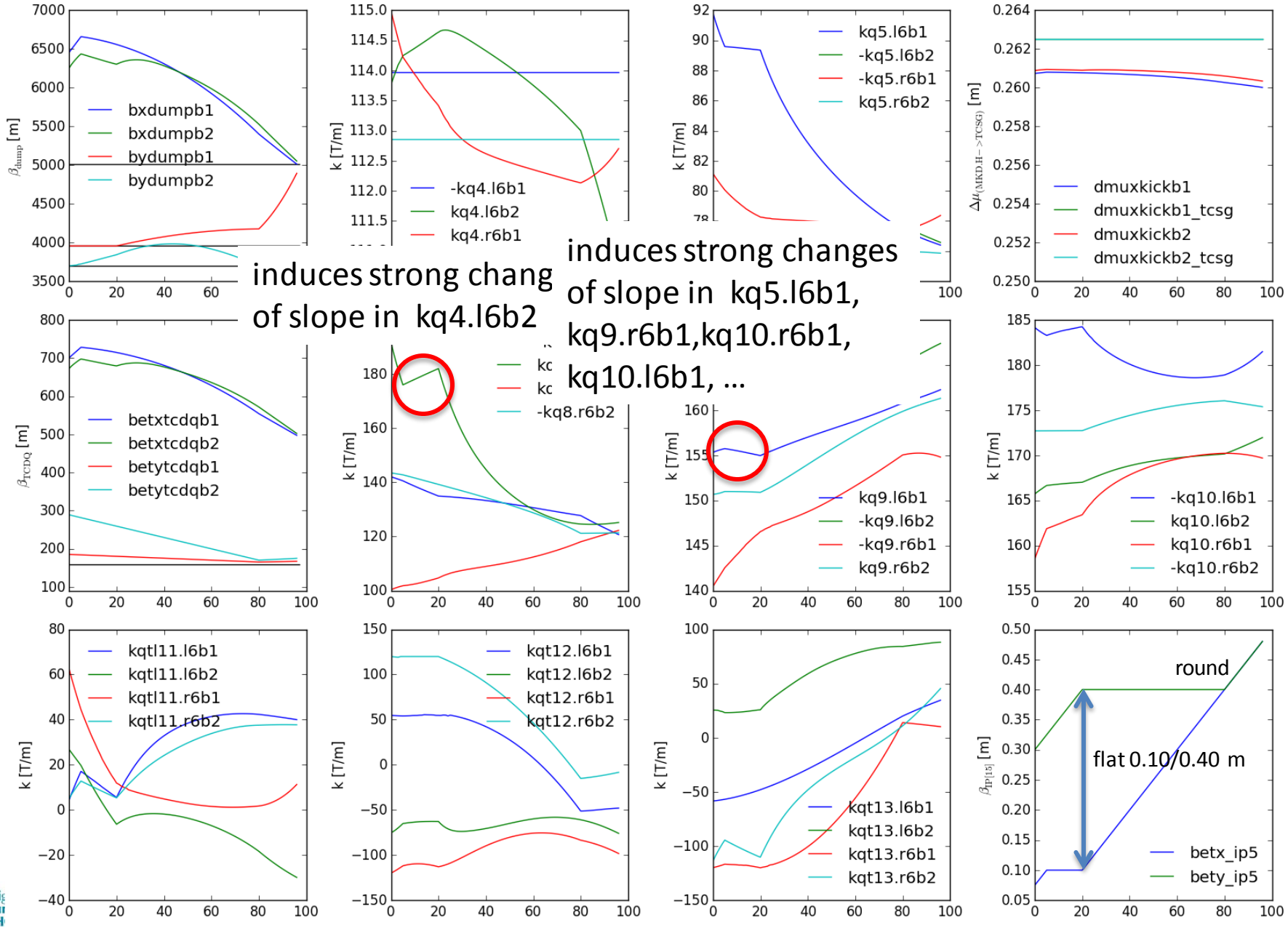








Squeeze flathv: 0.48 m -> 0.30/0.075 m



Summary

1. injection aperture could be improved if $\beta_{x/y}$ (TCDQ) or $\beta_{x/y}$ (dump) are relaxed
2. round, flat and flathv meet ABT/collimation constraints (MQY4 strength for kick enhancement, maximum beta at dump and TCDQ for dump and asynchronous dump protection, dispersion)
3. smoothness of flat and flathv could be improved by squeezing both planes equally fast. Each change in the squeeze causes “steps”. Ideal squeeze x/y-ratio for β*-leveling to be defined.

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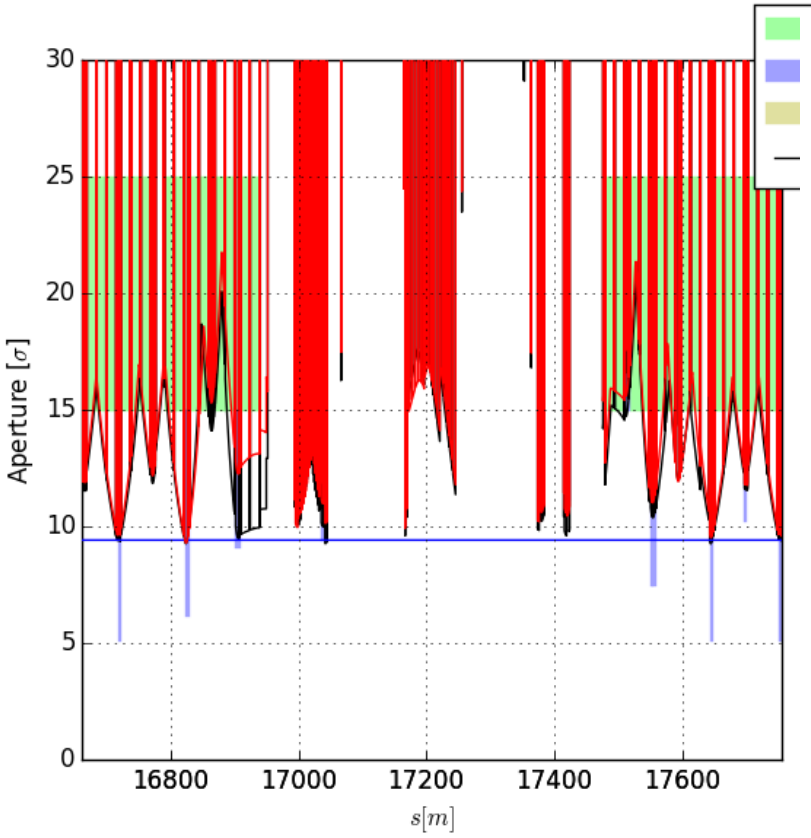
beta @ MKD and TCDQ

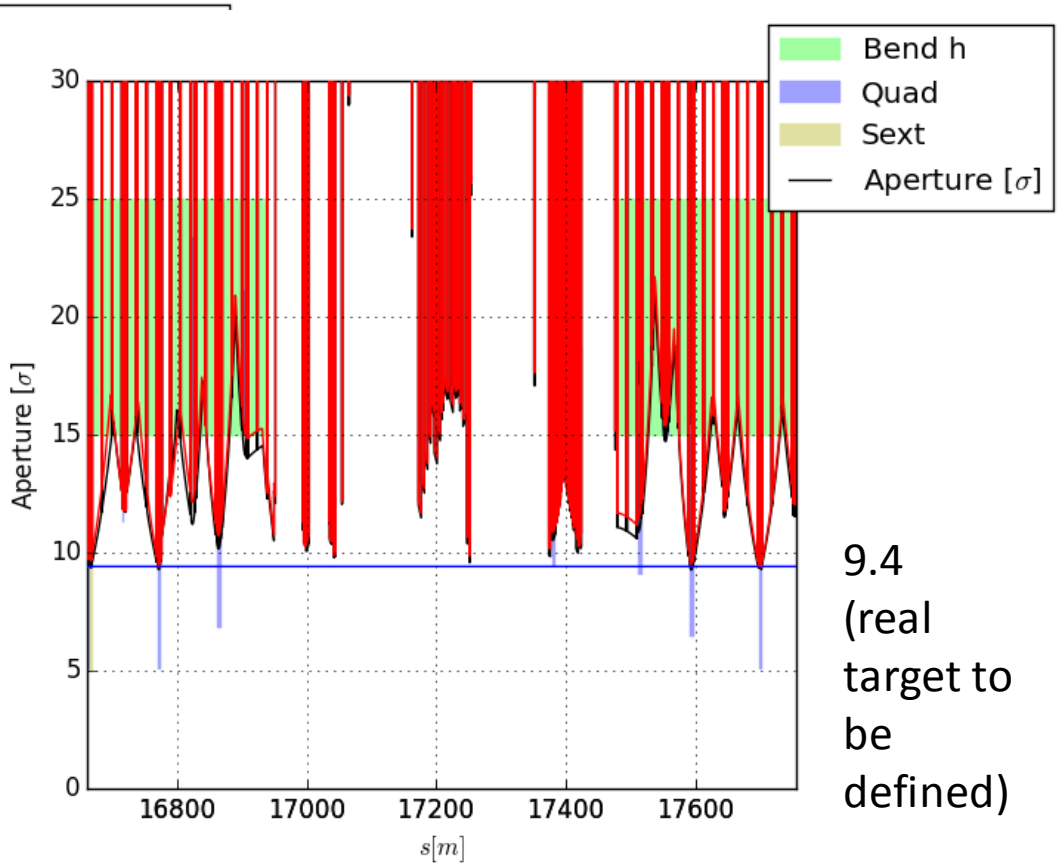
layout	$\beta_{x/y}$* [m]	MKD.H5[LR]6.B[12], β [m]				TCDQA.A4[LR]6.B[12], β [m]			
		x, b1	y, b1	x, b2	y, b2	x, b1	y, b1	x, b2	y, b2
LHC, RunI	0.6/0.6	382	356	377	355	495	165	500	165
LHC, RunII*	0.8/0.8	382	356	377	355	484	161	488	162
HLLHCV1.0	0.15/0.15	195	460	269	350	966	129	697	168
HLLHCV1.1	0.15/0.15	232	438	281	273	814	133	667	216
HLLHCV1.2	0.15/0.15	258	363	239	362	732	161	788	162
HLLHCV1.2	0.075/0.3	380	327	349	318	497	181	540	185
HLLHCV1.2	0.3/0.075	270	320	280	204	700	185	673	289

*injection with MQT for adjustment of WP (beta-betating), strength unchanged

Injection β*=6m - aperture



HLLHCV1.1



HLLHCV1.2

9.4 (real target to be defined)

Squeeze round with V1.1 injection endpoint