IR2 squeeze status

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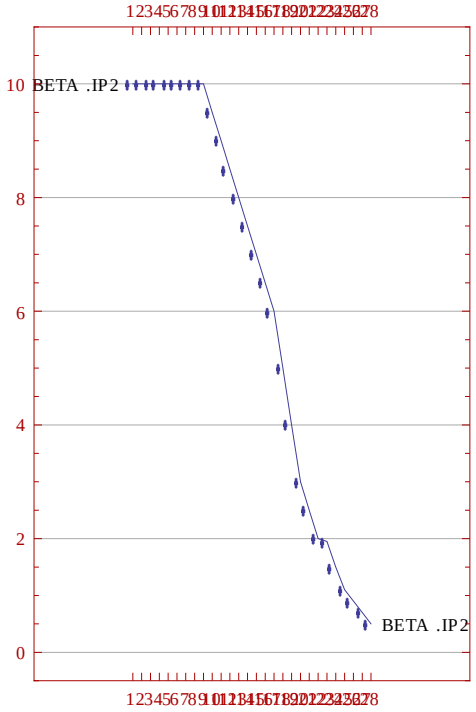
IR2 squeeze background

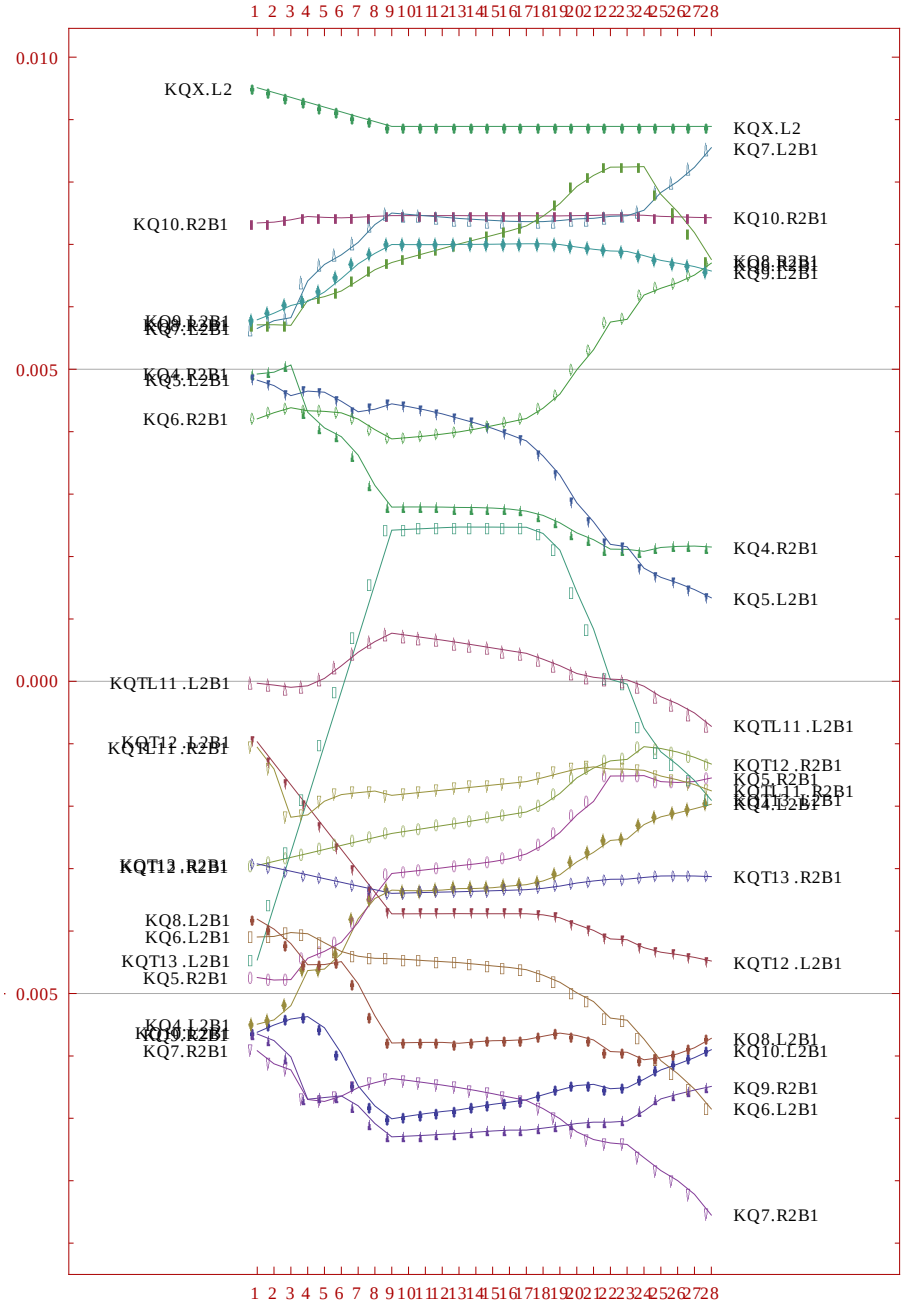
- Injection optics in IR2 is highly constrained
  - Injection phase advance constraints
  - Aperture limitations (n_1 criterion)
  - Solution found (by T. Risselada) requires high value of (normalised) gradient, in triplet quadrupoles, must be reduced for 7 TeV.
- For PB-Pb operation at 7*Z* TeV, the squeeze to β*=0.5 m requires a *pre-squeeze*, in which injection constraints are relaxed at constant β*=10 m and triplet gradient is reduced.
  - Pre-squeeze takes additional time.
- Squeeze then proceeds at constant triplet K1.
- For 3.5 Z TeV, p p operation mostly at β*=10 m but a squeeze to β*=3 m is requested.
  - Pre-squeeze is no longer necessary and could be suppressed to save time in operation.

Present squeeze with pre-squeeze

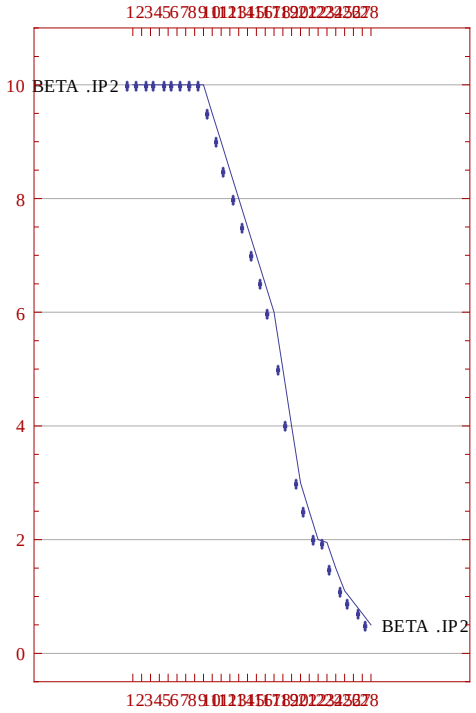


Beam 1

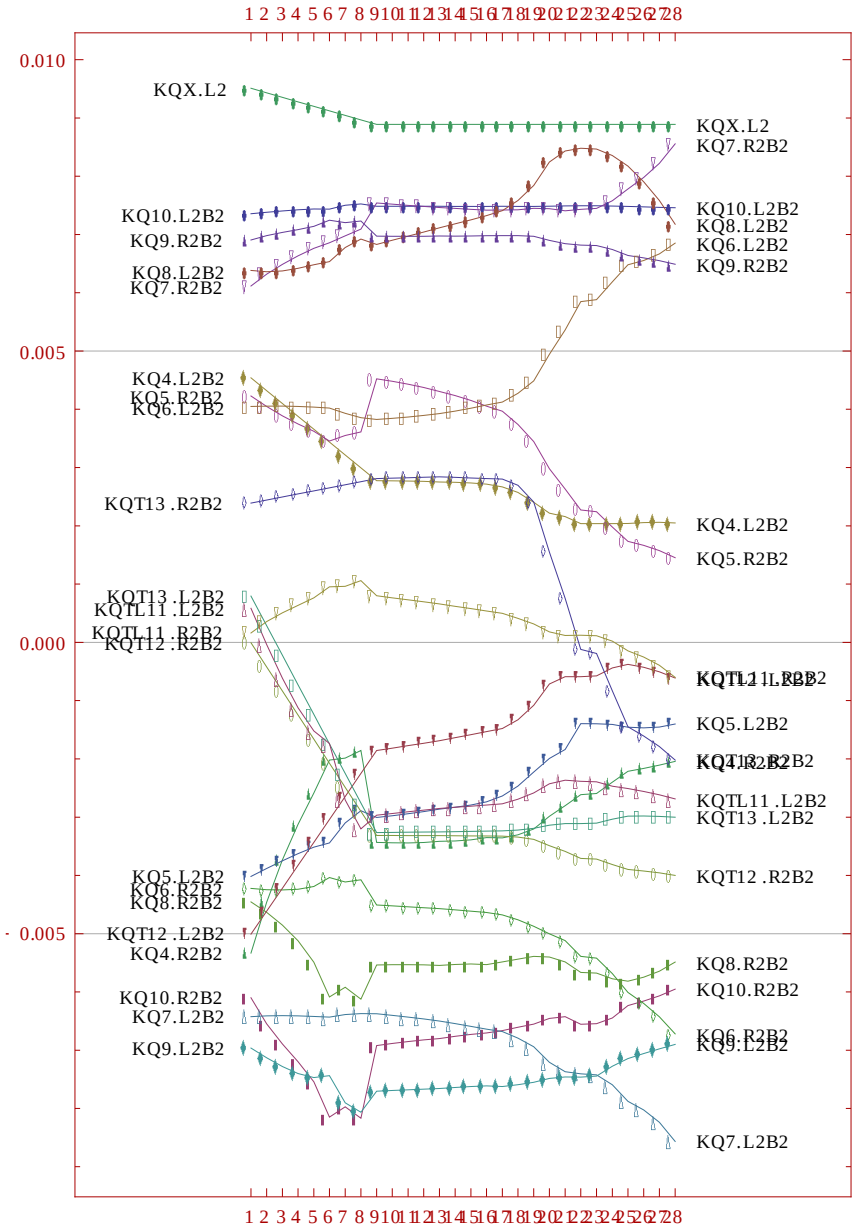
28 steps, some awkward variations of trim quads



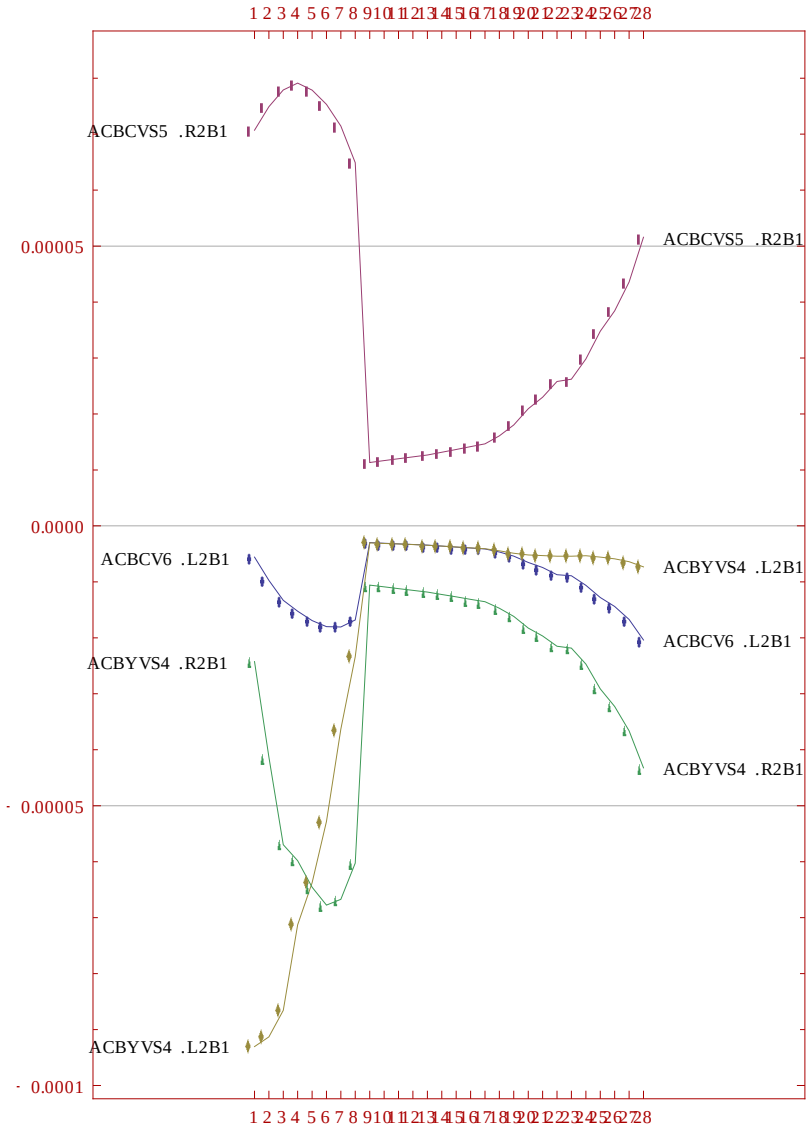
Present squeeze with pre-squeeze



Beam 2

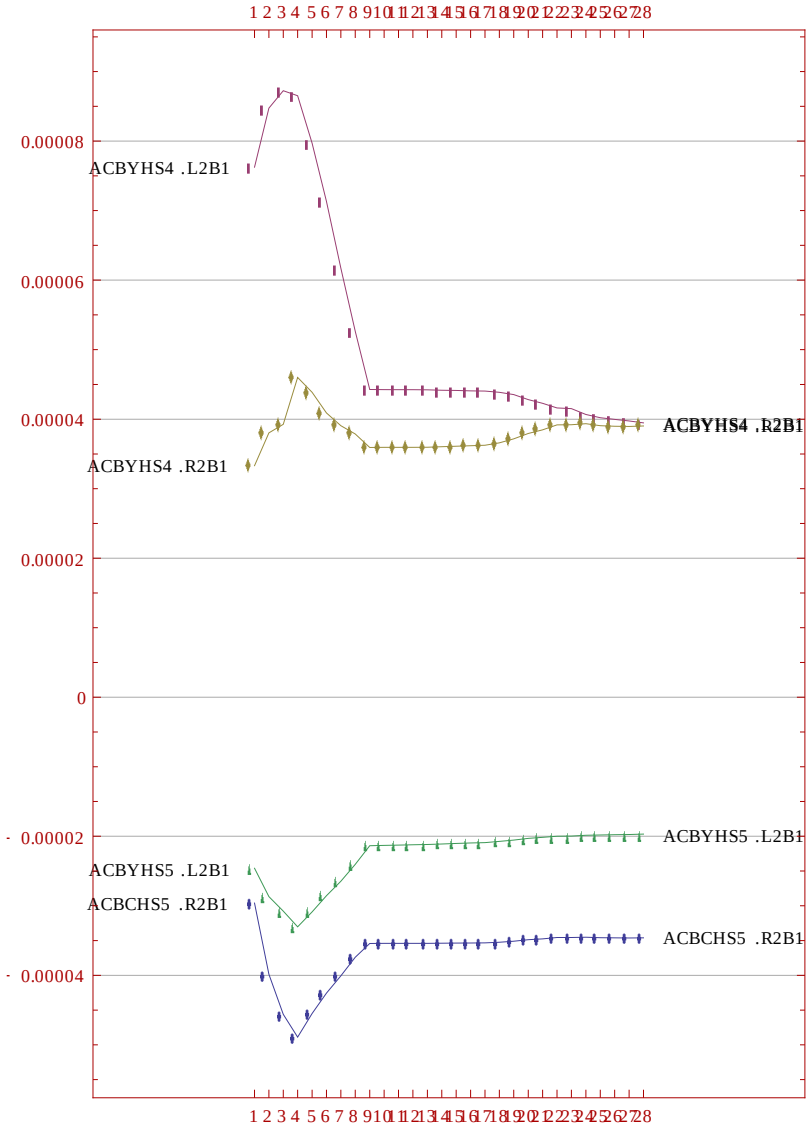


Crossing angle bumps



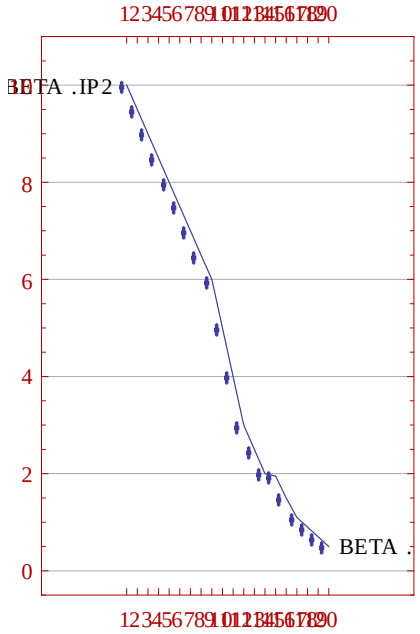
- Variation of the corrector magnets used to create the crossing angle bumps
  - Clear that the transition from the injection optics through pre-squeeze to collision squeeze sequences is not very smooth

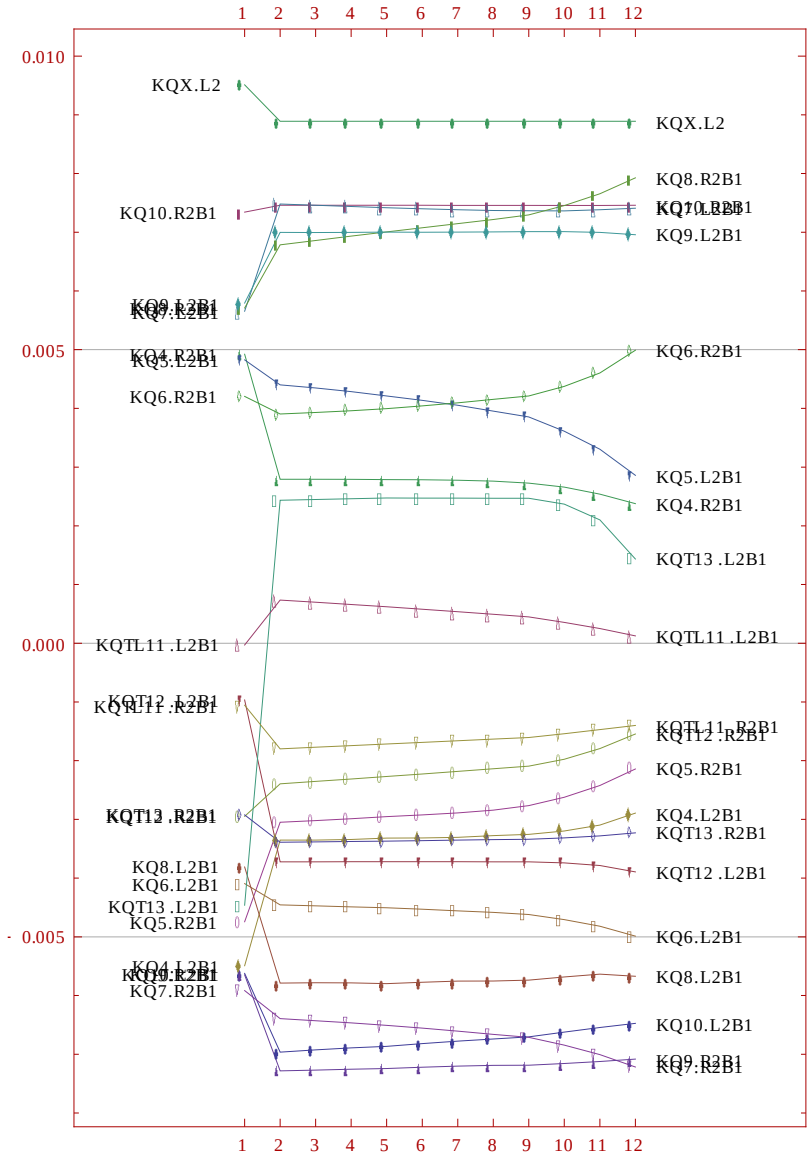
Parallel separation bumps



- Similar comments

Simple removal of pre-squeeze





Beam 1

20 steps, big jumps of quads in first step to β*=9.5 m but OK later.

Matching strategies

- Numerous approaches tried:
  - Variation of all 20 quadrupoles (per ring)
    - Many matches found but path is not smooth
  - Reduce number of variables
    - 16 (14) constraints so it may be possible to match with fewer variables by forcing some smooth variation on a few
    - Tried this with 4 power convertersthat seem to vary most wildly, not much smoother
    - Tried with only2 power supplies, various choices
  - Start matching a given squeeze step from:
    - Old squeeze settings
    - Settings found for previous step (+smoothed PC)
    - Settings found for next step (+smoothed PC)
  - Replace first part of squeeze by joining injection optics to an intermediate β* value.

Tools

- Evolving Madtomma packages
  - Automatic parsing of MAD structures to get the powering trees
  - Allows programmatic generation of correct lower and upper limits for each power converter's K_1 (relies on MAD data for KMAX, KMIN, beam energy, POLARITY)
  - Programmatic generation of proper VARY commands for any set of strengths
  - Programmatic generation of constraints
  - Much more structured matching procedures
  - Framework for interpolation, filtering sets of strengths etc.

Strength limits for the insertion

We have the problem of the polarities in building the VARY commands. We can get them from this table. The negative polarity elements are those where both K1PERCENTMAX and K1PERCENTMIN are negative. For those elements the LOWER limit for VARY is given by the KMAX and the upper by the KMIN.

10/23/09 10:43:56 In[75]:=

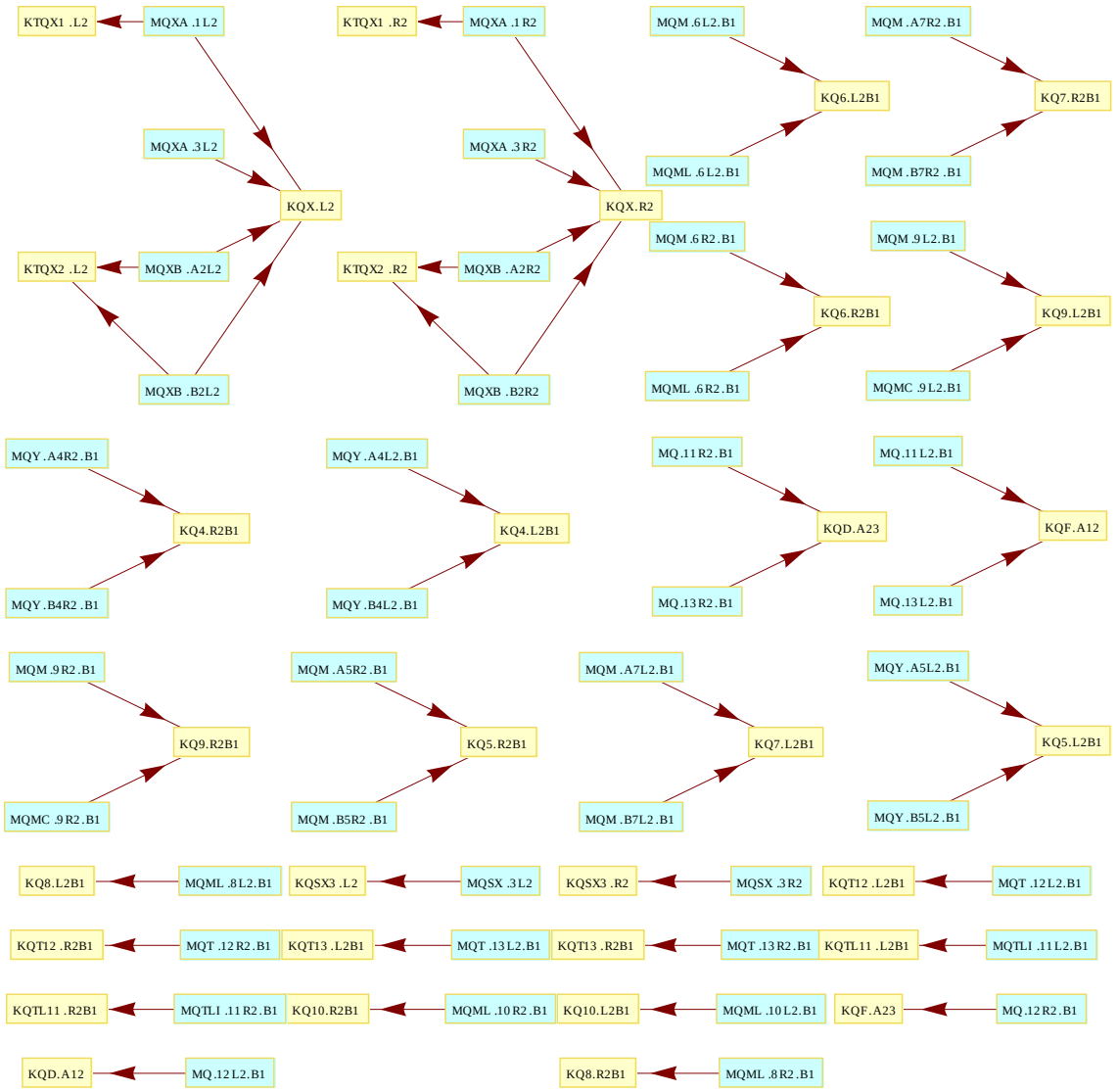
```
mfsOpticsDynamicColumnTabulate[LHCAddQuadrupoleStrengths[LHCModuleOptics["LHCB1","IR2DS.B1"]]]
```

{☐KEYWORD ☐PARENT ☐S ☐L ☐HKICK ☐VKICK ☐ANGLE ☐K0L ☐K1L ☐K2L ☐K3L ☐XC ☐YC ☐PXC ☐PYC
☐BETX ☐BETY ☐ALFX ☐ALFY ☐MUX ☐MUY ☐DX ☐DY ☐DPX ☐DPY ☐KMAX ☐KMIN ☐CALIB ☐POLARITY
☐APERTYPE ☐APER_1 ☐N1 ☑K1 ☑K1MAX ☑K1MIN ☐K1PERCENTMAX ☐K1PERCENTMIN ☑K1CHECK ☑K1NAMES}

10/23/09 10:44:20 Out[75]=

	K1NAMES	K1MIN	K1	K1MAX	K1CHECK
MQT.13L2.B1	KQT13.L2B1	-0.0052678	-0.0044621	0.0052678	True
MQ.13L2.B1	KQF.A12	0.00028159	0.0089901	0.0095505	True
MQT.12L2.B1	KQT12.L2B1	-0.0052678	-0.00096743	0.0052678	True
MQ.12L2.B1	KQD.A12	-0.0095505	-0.008601	-0.00028159	True
MQ.11L2.B1	KQF.A12	0.00028159	0.0089901	0.0095505	True
MQTLI.11L2.B1	KQTL11.L2B1	-0.0053534	-0.000029518	0.0053534	True
MQML.10L2.B1	KQ10.L2B1	-0.0085655	-0.005622	-0.00019071	True
MQMC.9L2.B1	KQ9.L2B1	0.00019071	0.0057938	0.0085655	True
MQM.9L2.B1	KQ9.L2B1	0.00019071	0.0057938	0.0085655	True
MQML.8L2.B1	KQ8.L2B1	-0.0085655	-0.0038112	-0.00019071	True
MQM.B7L2.B1	KQ7.L2B1	0.00019071	0.0056541	0.0085655	True
MQM.A7L2.B1	KQ7.L2B1	0.00019071	0.0056541	0.0085655	True
MQML.6L2.B1	KQ6.L2B1	-0.0068524	-0.0040949	-0.0001908	True
MQM.6L2.B1	KQ6.L2B1	-0.0068524	-0.0040949	-0.0001908	True
MQY.B5L2.B1	KQ5.L2B1	0.00015187	0.0048268	0.0068524	True
MQY.A5L2.B1	KQ5.L2B1	0.00015187	0.0048268	0.0068524	True
MQY.B4L2.B1	KQ4.L2B1	-0.0068524	-0.0054927	-0.00015187	True
MQY.A4L2.B1	KQ4.L2B1	-0.0068524	-0.0054927	-0.00015187	True
MQXA.3L2	KQX.L2	0.00027225	0.0095098	0.0087796	True
MQSX.3L2	KQSX3.L2	-0.0034262	0.	0.0034262	True
MQXB.B2L2	KQX.L2 KTQX2.L2	-0.0087796	-0.0095098	-0.00031504	True
MQXB.A2L2	KQX.L2 KTQX2.L2	-0.0087796	-0.0095098	-0.00031504	True
	KQX.L2				

Powering diagram for Beam1 IR2 quads



VARY commands

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MADcommand[LHCIR2Vary["LHCB1"]] // TableForm
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VARY, NAME=KQ10.L2B1, STEP=1.E-9, LOWER=-0.008565494370131453, UPPER=-0.0001907107321509768;
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VARY, NAME=KQ4.L2B1, STEP=1.E-9, LOWER=-0.006852395496105162, UPPER=-0.00015186621518243064;
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VARY, NAME=KQ6.L2B1, STEP=1.E-9, LOWER=-0.006852395496105162, UPPER=-0.0001907963870946781;
VARY, NAME=KQ6.R2B1, STEP=1.E-9, LOWER=0.0001907963870946781, UPPER=0.006852395496105162;
VARY, NAME=KQ7.L2B1, STEP=1.E-9, LOWER=0.0001907107321509768, UPPER=0.008565494370131453;
VARY, NAME=KQ7.R2B1, STEP=1.E-9, LOWER=-0.008565494370131453, UPPER=-0.0001907107321509768;
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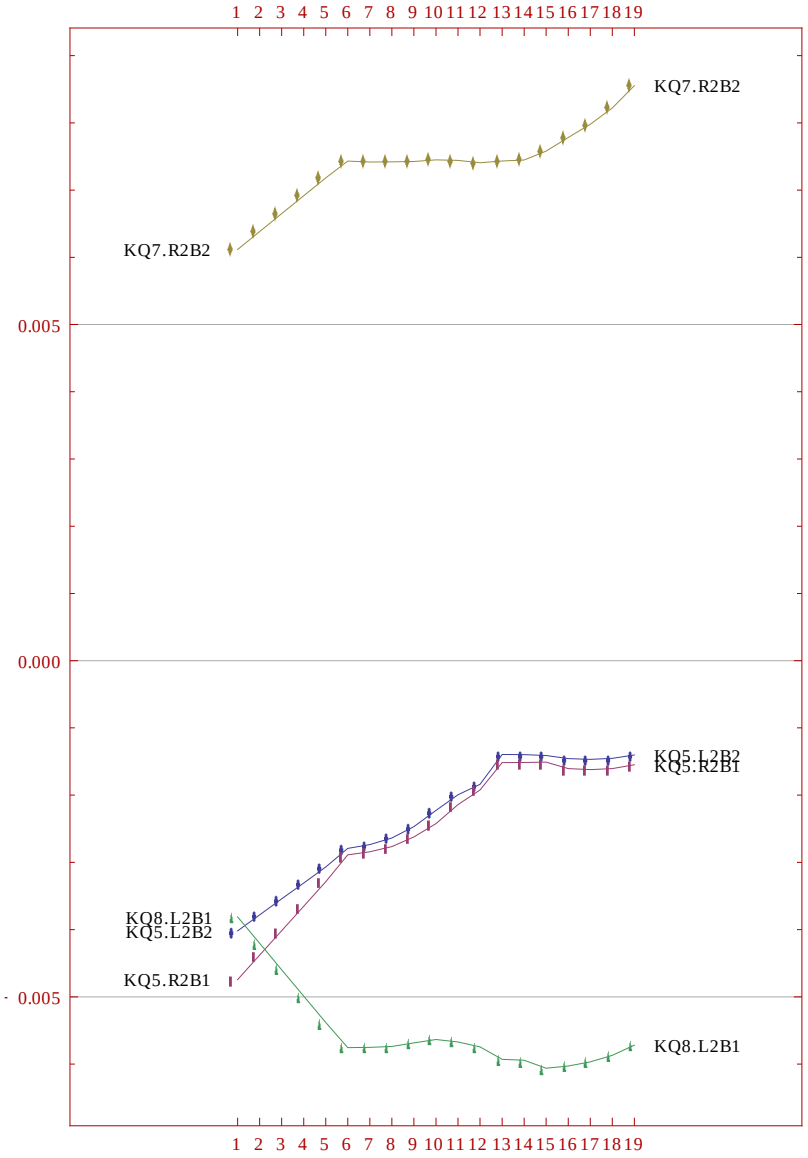
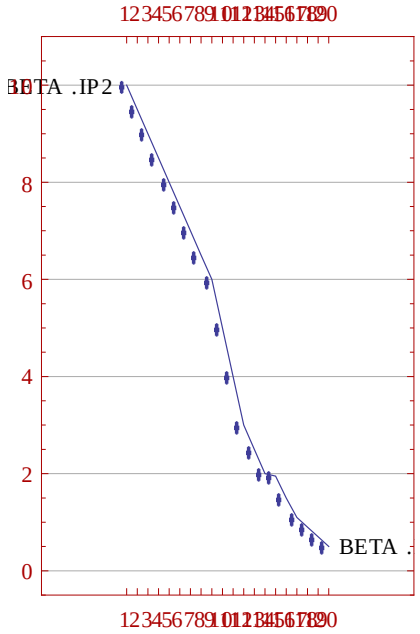
VARY, NAME=KQ9.L2B1, STEP=1.E-9, LOWER=0.0001907107321509768, UPPER=0.008565494370131453;
VARY, NAME=KQ9.R2B1, STEP=1.E-9, LOWER=-0.008565494370131453, UPPER=-0.0001907107321509768;
VARY, NAME=KQT12.L2B1, STEP=1.E-9, LOWER=-0.005267779037630843, UPPER=0.005267779037630843;
VARY, NAME=KQT12.R2B1, STEP=1.E-9, LOWER=-0.005267779037630843, UPPER=0.005267779037630843;
VARY, NAME=KQT13.L2B1, STEP=1.E-9, LOWER=-0.005267779037630843, UPPER=0.005267779037630843;
VARY, NAME=KQT13.R2B1, STEP=1.E-9, LOWER=-0.005267779037630843, UPPER=0.005267779037630843;
VARY, NAME=KQTL11.L2B1, STEP=1.E-9, LOWER=-0.005353433981332158, UPPER=0.005353433981332158;
VARY, NAME=KQTL11.R2B1, STEP=1.E-9, LOWER=-0.005353433981332158, UPPER=0.005353433981332158;
```

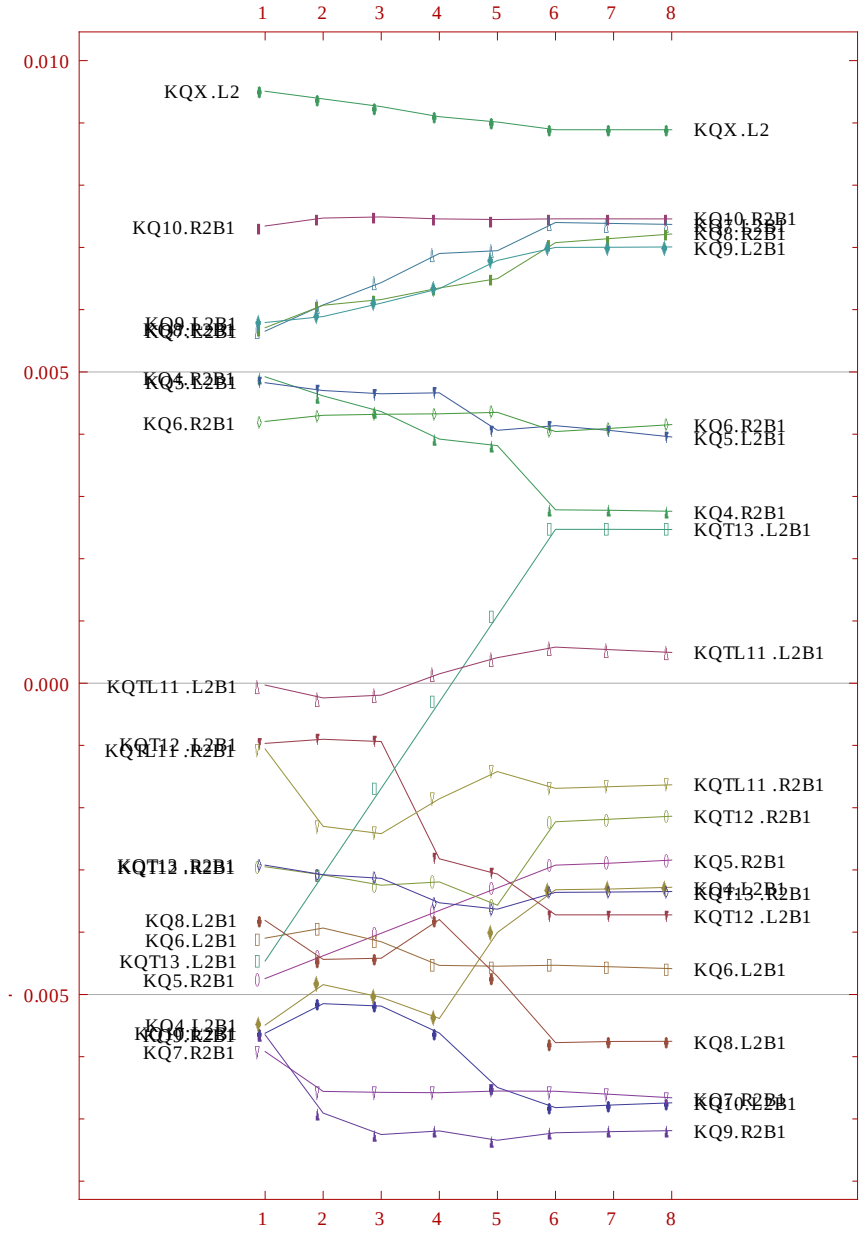
Signs are right, etc.

Latest choice for forced qaudrupoles



New squeeze for Beam1



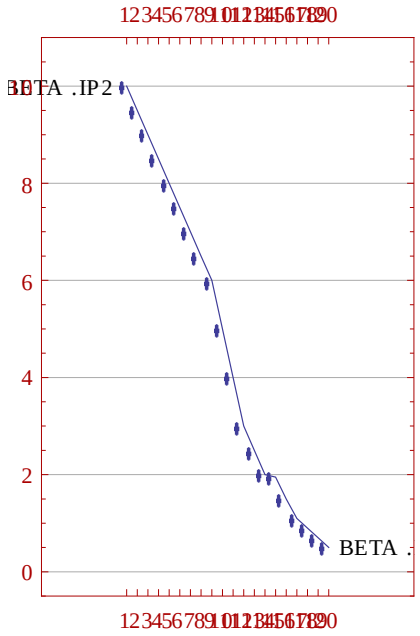


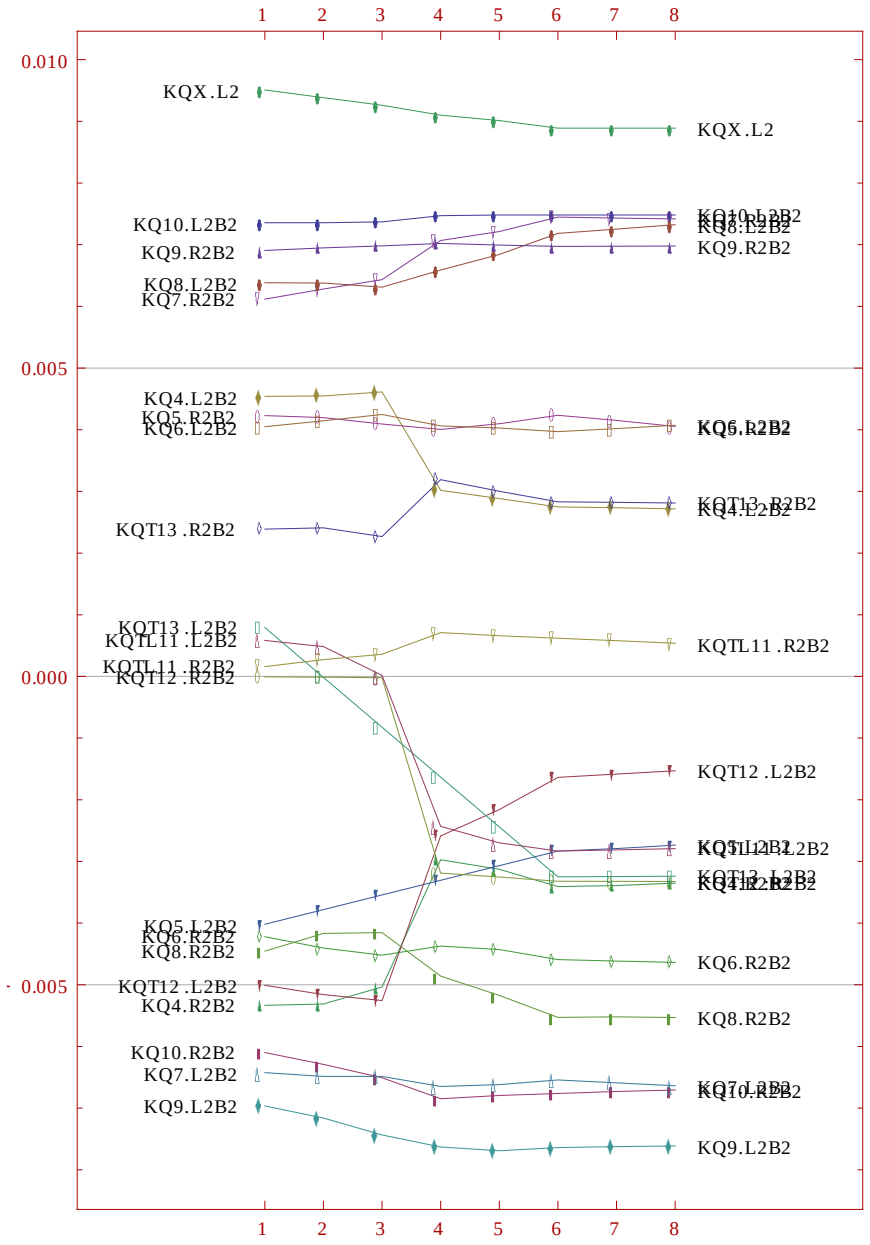
Beam 1

Only first (new) part of this squeeze shown for clarity (rest is same as before).

"Discontinuity" can be moved but always appears somewhere.

New squeeze for Beam2

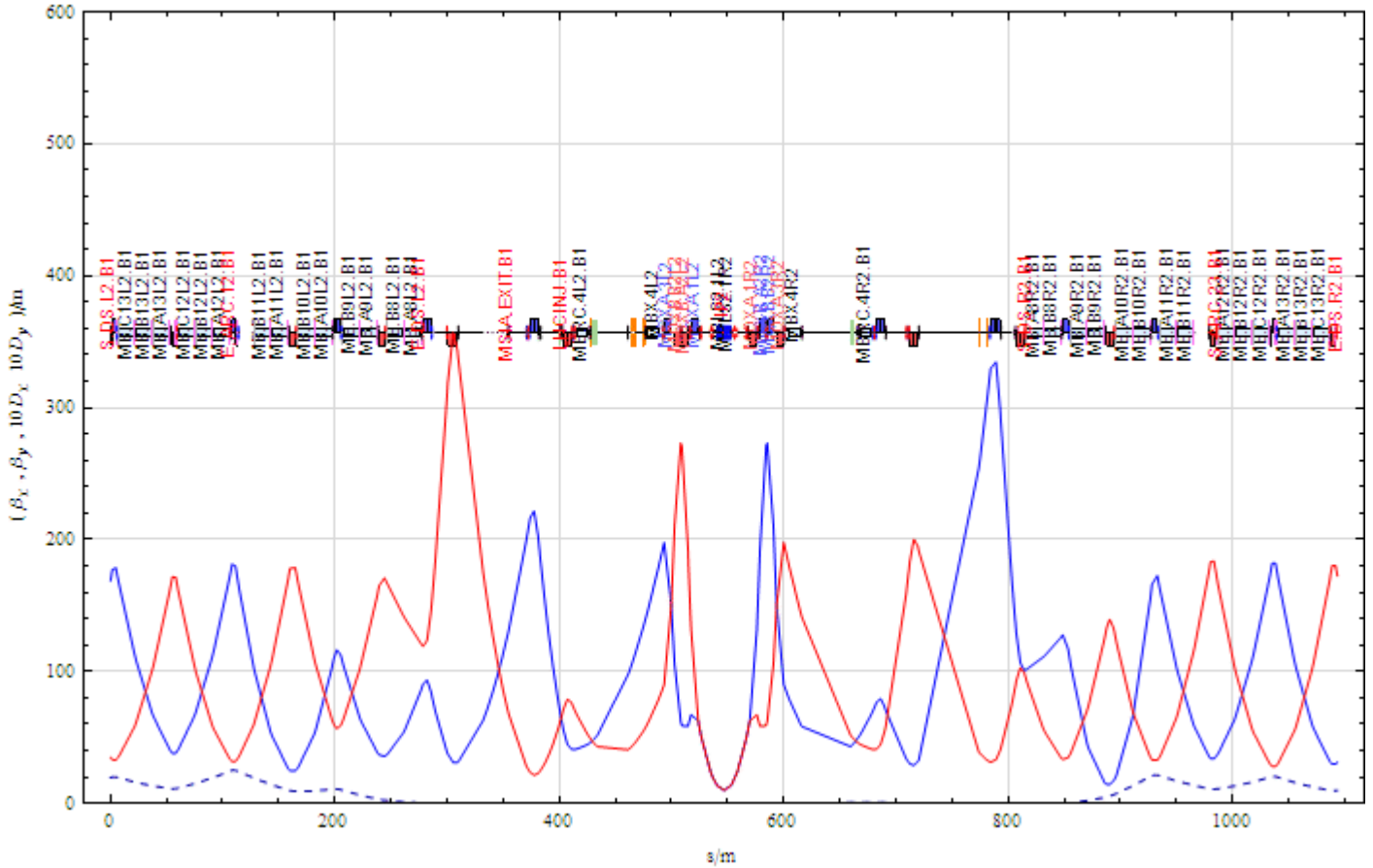




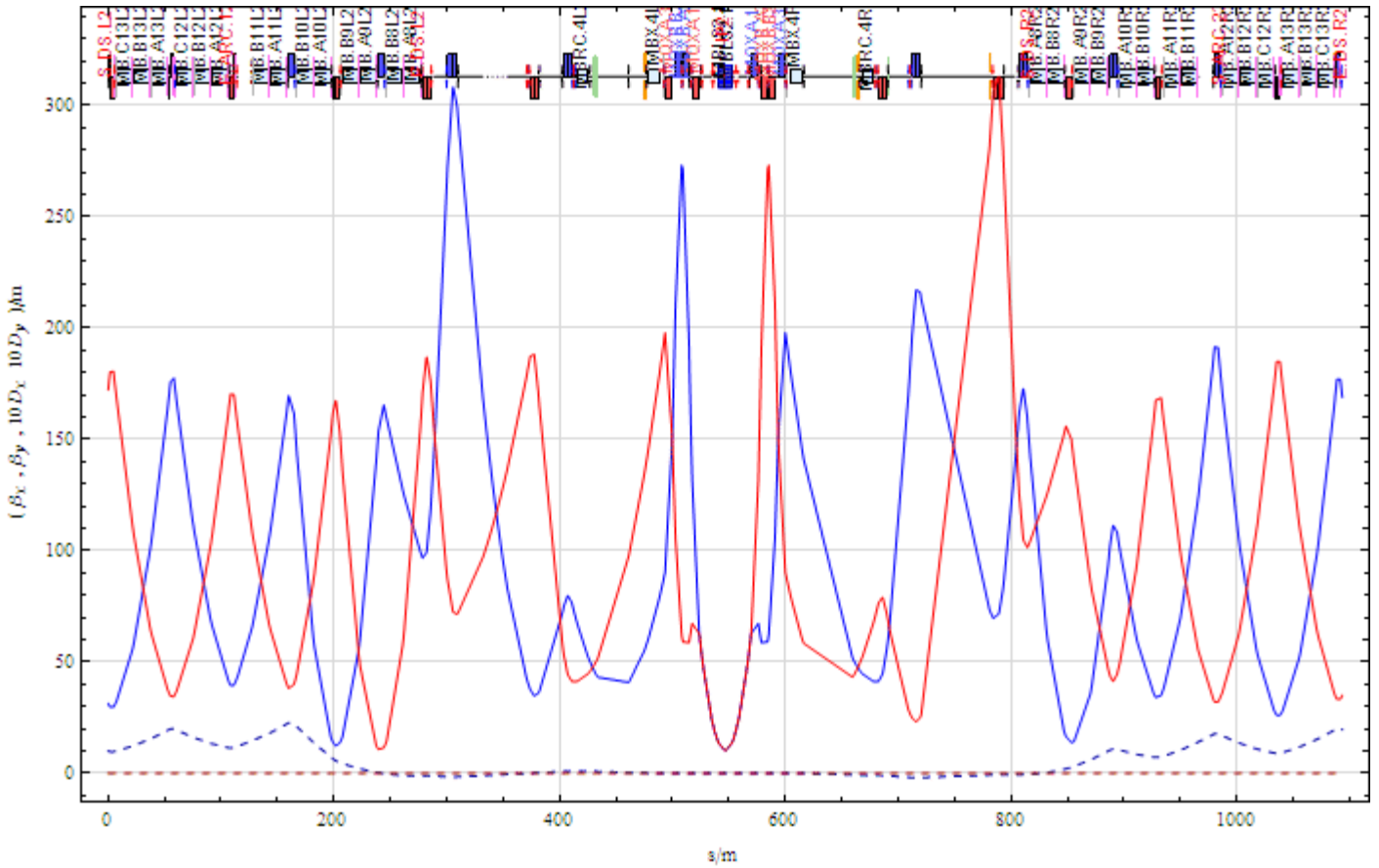
Beam 2

Only first (new) part of this squeeze shown for clarity (rest is same as before)

Animation of Optics through squeeze Beam1

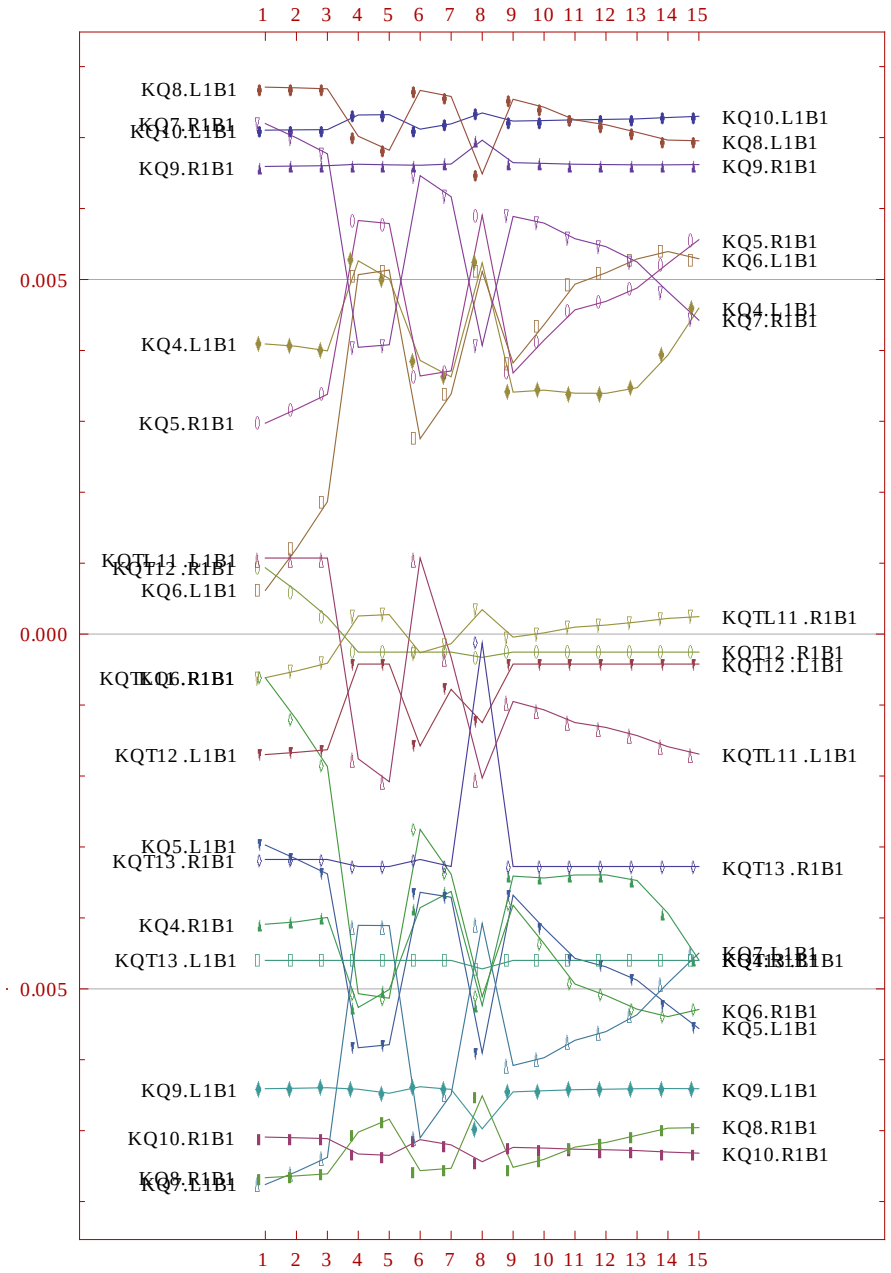


Animation of Optics through squeeze Beam2



Compare squeeze for IR1

Perhaps my squeeze for IR2 is not *so* bad ?



Conclusions

- Despite many attempts using diverse approaches, matching of the IR2 injection to collision optics in a continuous way seems to be very difficult (impossible ?)
  - Change collision optics ?
- Separation and crossing angle bumps will be generated for the new squeeze.