

Longitudinal displacements of IR2 quadrupoles

- Considered fully-squeezed (ion) physics optics with $\beta^*=0.5$ m (V6.500 strengths with V6.501 sequence)
- Frank S asked for:
 - betax beating in full ring with and without rematch
 - list of quads and relative changes in their strengths
 - Plots of beta-beat,
 - beta* tables
 - tables of misalignments

Implementation of displacements

	A	B	C
1	MQXA.3L2	-0.0038	
2	MQXB.B2L2	-0.0117	
3	MQXB.A2L2	-0.0117	
4	MQXA.1L2	-0.0001	
5	MQXA.1R2	0.0016	
6	MQXB.A2R2	0.0028	
7	MQXB.B2R2	0.0028	
8	MQXA.3R2	-0.0005	
9			
10			
11			
12			

IRdisplacements[seq,ir] returns a MADinput object displacing elements in an LHC sequence according to the data in the sheet labelled ir in an Excel file (whose name is an option).

 **LHCIRdisplacements ["LHCB1", "IR2"]**

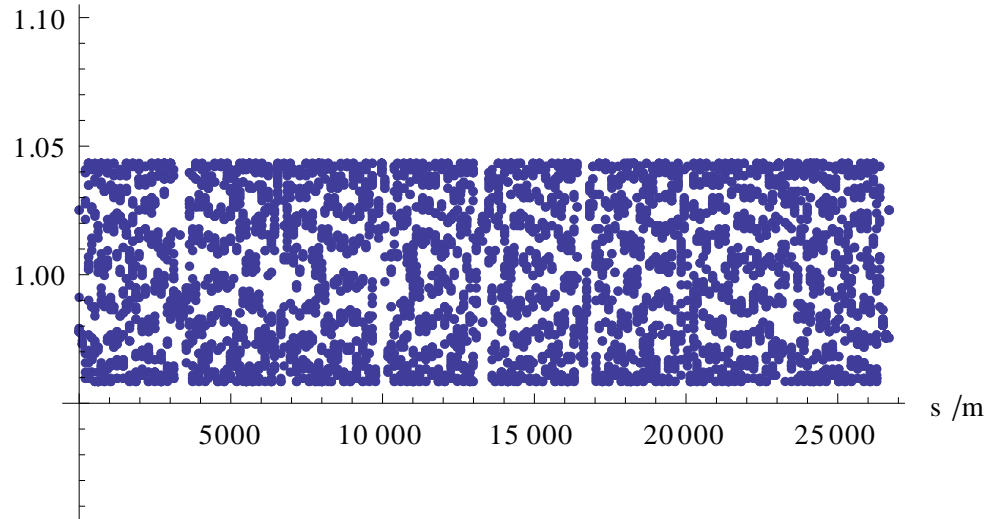
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";"
"OPTION,ECHO;"
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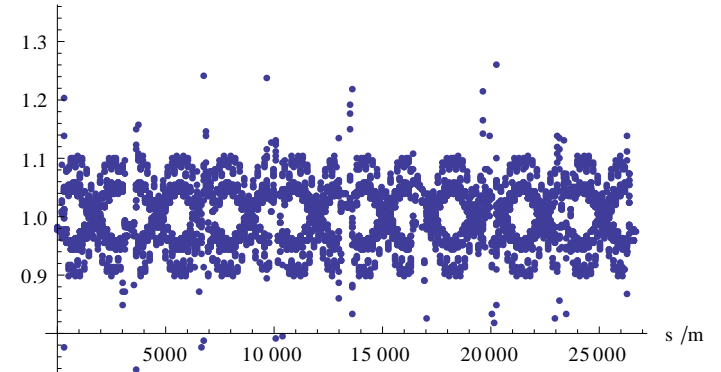
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Global beta-beating caused by displacements, **LHCB1**

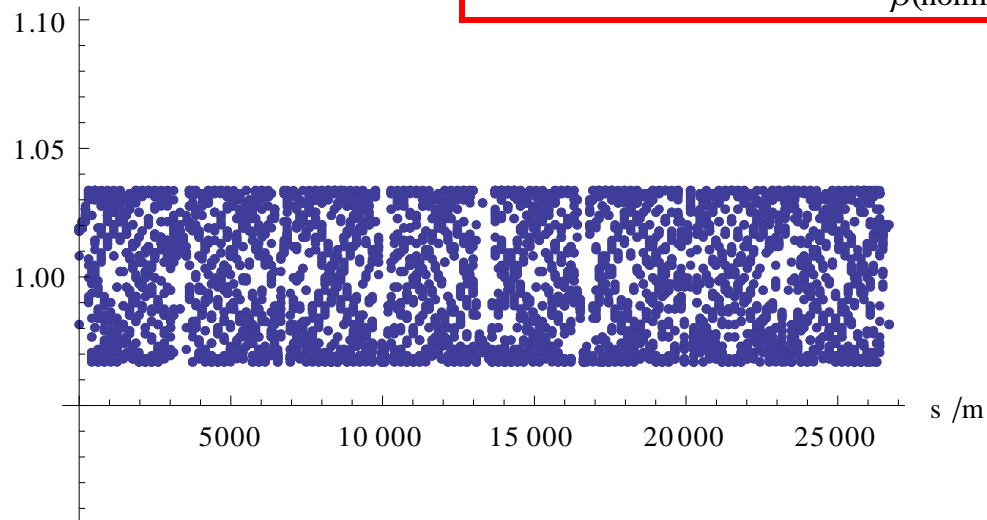
Beating of β_x



Beating of α_x

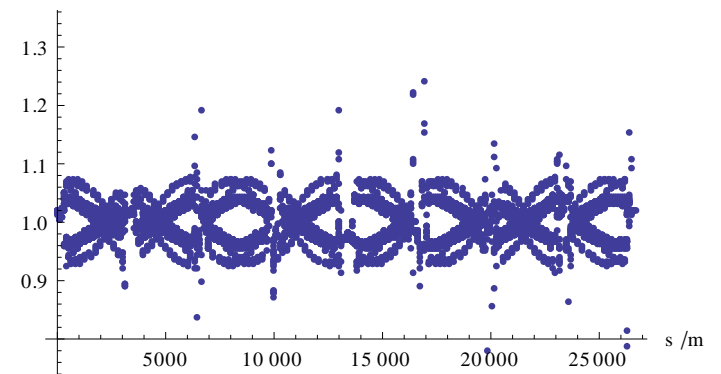


Beating of β_y



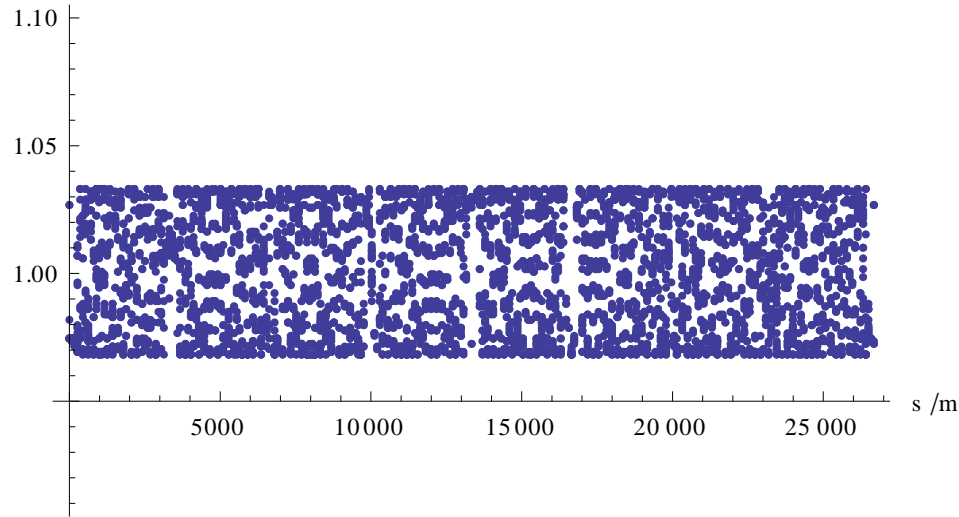
Beating defined as: $\frac{\beta(\text{displaced})}{\beta(\text{nominal})}$

Beating of α_y

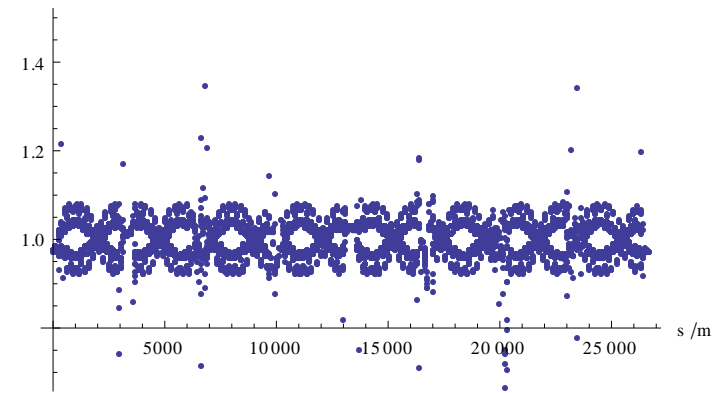


Global beta-beating caused by displacements, LHCb2

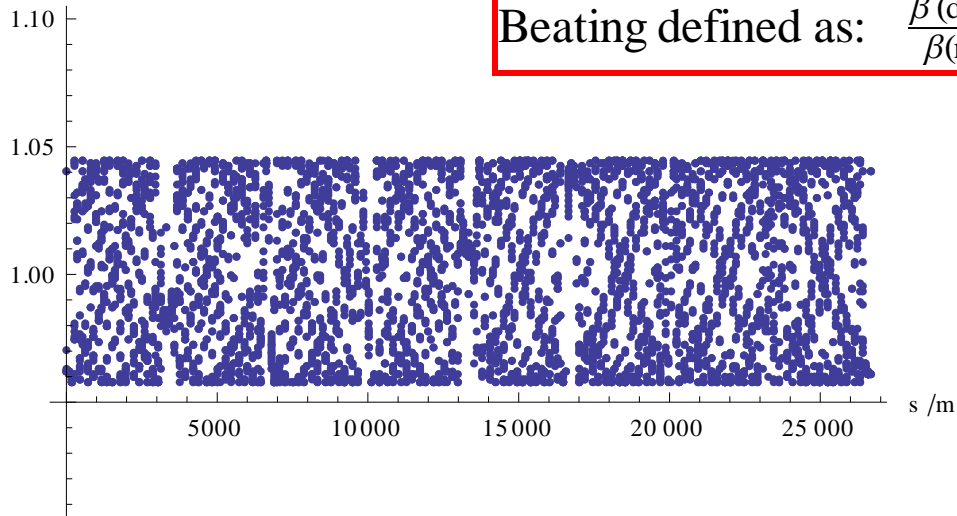
Beating of β_x



Beating of α_x

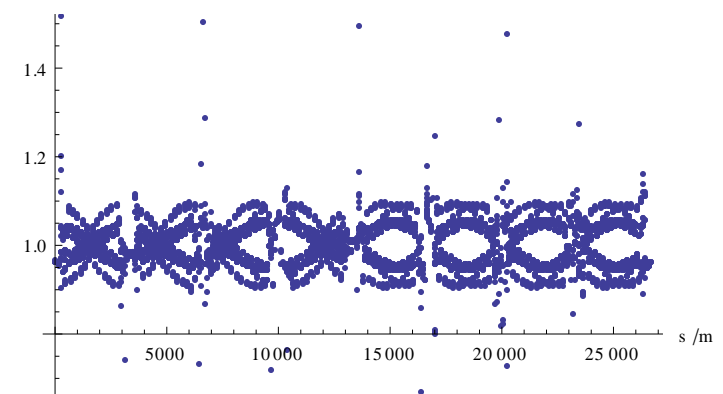


Beating of β_y



Beating defined as: $\frac{\beta(\text{displaced})}{\beta(\text{nominal})}$

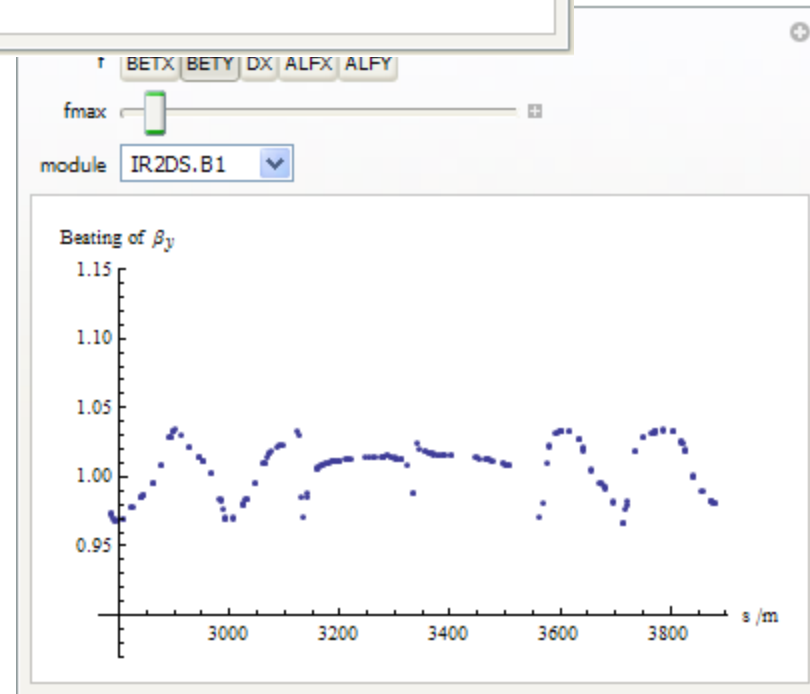
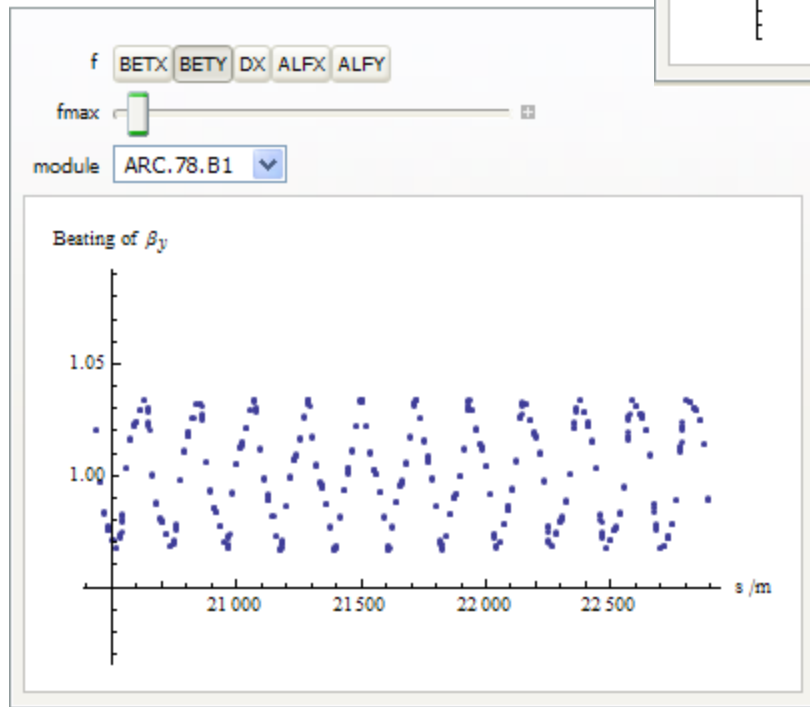
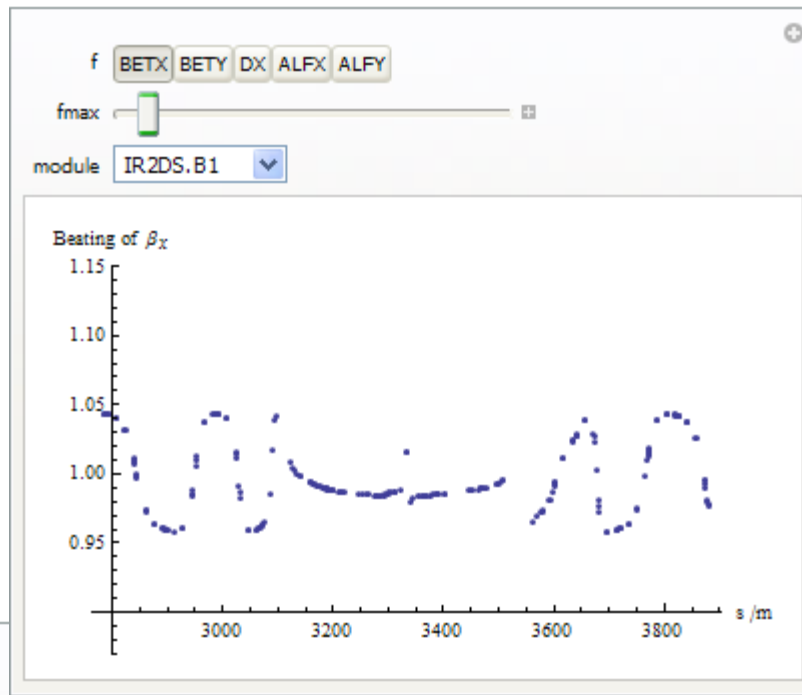
Beating of α_y



Details of beta-beating in LHCb1

Interactive viewer available in notebook environment:

- Choose button for optical function.
- Choose lattice module of interest from drop-down list.
- Adjust scale factor f with slider.



Rematching

- Rematch each sequence (LHCB1, LHCB2) to original ideal Twiss functions at IP2, start and end of

$$\text{IR2DS.B1} = \{\text{S.DS.L2.B1}, \text{E.DS.R2.B1}\}$$

- Do not use (triplet) quadrupoles that affect both sequences

Quadrupole strengths before and after rematch

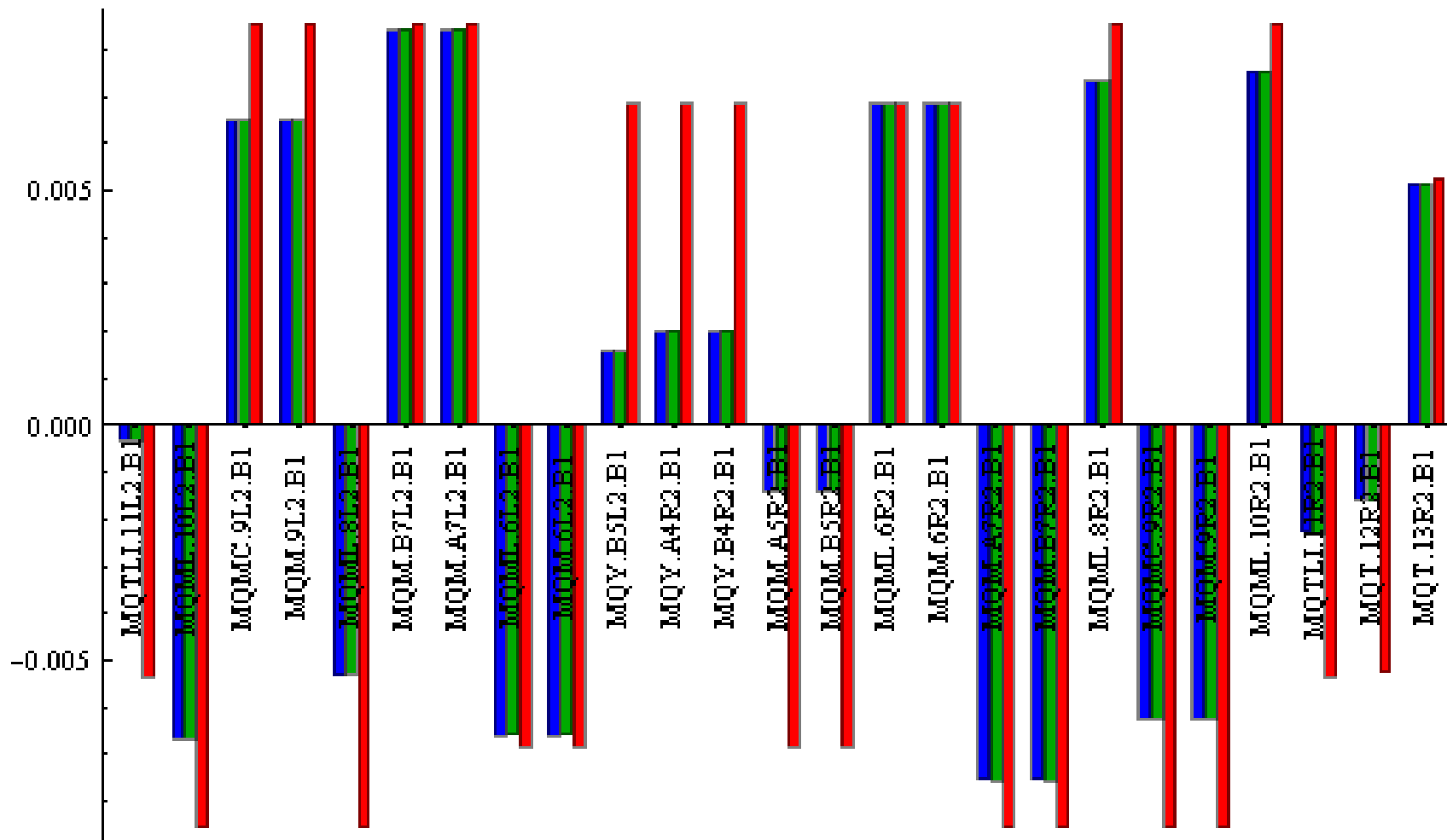
LHCB1

	K1 (ideal)	K1 (rematched)	K1MAX
MQTLI.11L2.B1	-0.000315966	-0.000315465	0.00535343
MQML.10L2.B1	-0.00667574	-0.00667043	0.00856549
MQMC.9L2.B1	0.0064849	0.00647871	0.00856549
MQM.9L2.B1	0.0064849	0.00647871	0.00856549
MQML.8L2.B1	-0.0053215	-0.00529794	0.00856549
MQM.B7L2.B1	0.00841661	0.00843105	0.00856549
MQM.A7L2.B1	0.00841661	0.00843105	0.00856549
MQML.6L2.B1	-0.00659926	-0.00658098	0.0068524
MQM.6L2.B1	-0.00659926	-0.00658098	0.0068524
MQY.B5L2.B1	0.0015699	0.00158994	0.0068524
MQY.A4R2.B1	0.00200142	0.0020117	0.0068524
MQY.B4R2.B1	0.00200142	0.0020117	0.0068524
MQM.A5R2.B1	-0.00138211	-0.0014027	0.0068524
MQM.B5R2.B1	-0.00138211	-0.0014027	0.0068524
MQML.6R2.B1	0.00685223	0.00683716	0.0068524
MQM.6R2.B1	0.00685223	0.00683716	0.0068524
MQM.A7R2.B1	-0.00754941	-0.00755916	0.00856549
MQM.B7R2.B1	-0.00754941	-0.00755916	0.00856549
MQML.8R2.B1	0.00732774	0.00731091	0.00856549
MQMC.9R2.B1	-0.00625022	-0.00625597	0.00856549
MQM.9R2.B1	-0.00625022	-0.00625597	0.00856549
MQML.10R2.B1	0.0075282	0.00752776	0.00856549
MQTLI.11R2.B1	-0.00227716	-0.00228289	0.00535343
MQT.12R2.B1	-0.00157387	-0.00158974	0.00526778
MQT.13R2.B1	0.00513572	0.00513287	0.00526778

LHCB2

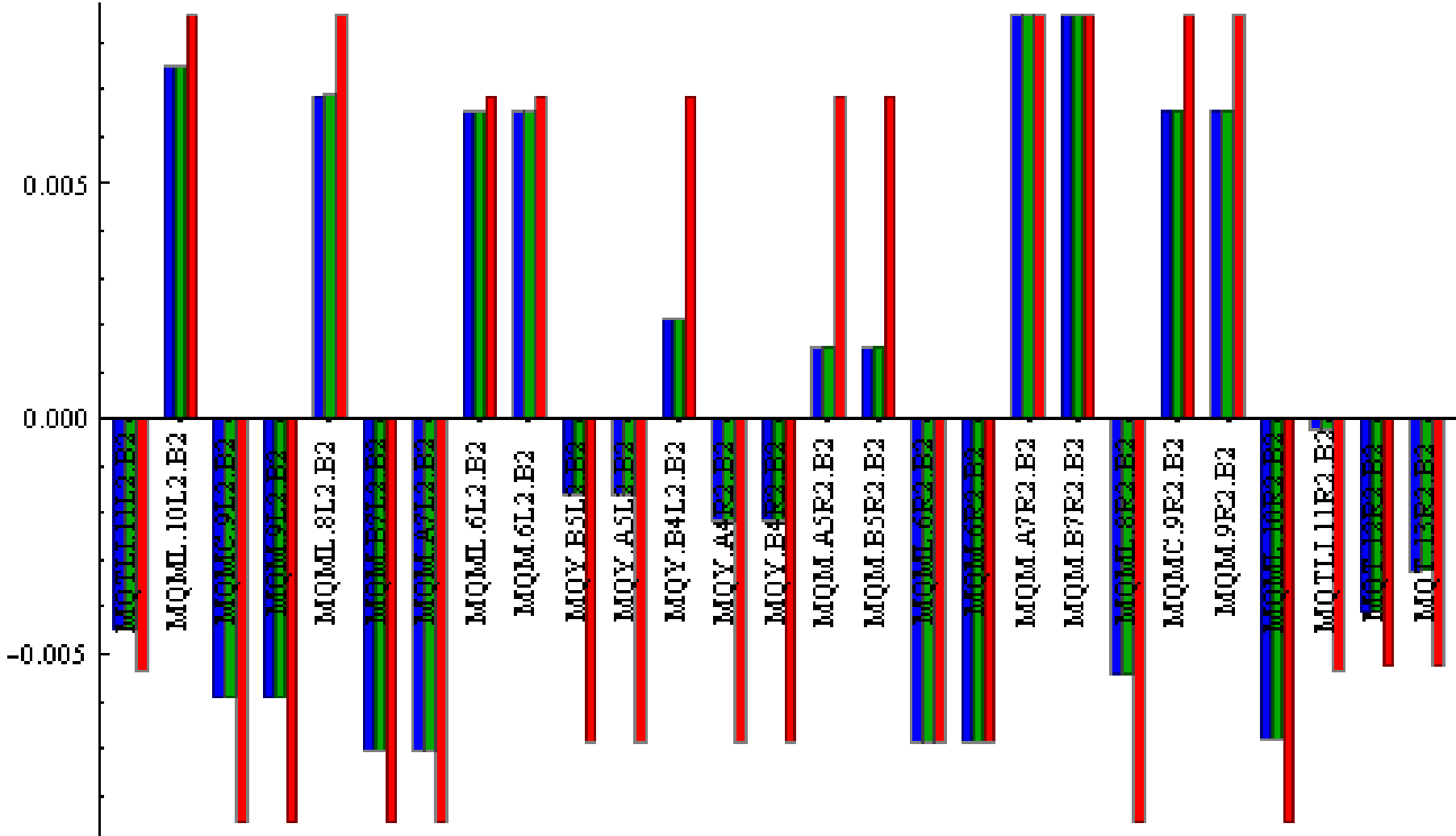
	K1 (ideal)	K1 (rematched)	K1MAX
MQTLI.11L2.B2	-0.00447345	-0.00446809	0.00535343
MQML.10L2.B2	0.00749257	0.00749452	0.00856549
MQMC.9L2.B2	-0.00591574	-0.00592947	0.00856549
MQM.9L2.B2	-0.00591574	-0.00592947	0.00856549
MQML.8L2.B2	0.00686952	0.00687661	0.00856549
MQM.B7L2.B2	-0.00704024	-0.00704956	0.00856549
MQM.A7L2.B2	-0.00704024	-0.00704956	0.00856549
MQML.6L2.B2	0.00653797	0.00652333	0.0068524
MQM.6L2.B2	0.00653797	0.00652333	0.0068524
MQY.B5L2.B2	-0.00159908	-0.00160631	0.0068524
MQY.A5L2.B2	-0.00159908	-0.00160631	0.0068524
MQY.B4L2.B2	0.00211535	0.00210885	0.0068524
MQY.A4R2.B2	-0.00213022	-0.00213332	0.0068524
MQY.B4R2.B2	-0.00213022	-0.00213332	0.0068524
MQM.A5R2.B2	0.00151939	0.00153134	0.0068524
MQM.B5R2.B2	0.00151939	0.00153134	0.0068524
MQML.6R2.B2	-0.00685257	-0.00685235	0.0068524
MQM.6R2.B2	-0.00685257	-0.00685235	0.0068524
MQM.A7R2.B2	0.0085657	0.00856553	0.00856549
MQM.B7R2.B2	0.0085657	0.00856553	0.00856549
MQML.8R2.B2	-0.00544882	-0.00544857	0.00856549
MQMC.9R2.B2	0.00655298	0.00655136	0.00856549
MQM.9R2.B2	0.00655298	0.00655136	0.00856549
MQML.10R2.B2	-0.0068068	-0.00680228	0.00856549
MQTLI.11R2.B2	-0.000200578	-0.00020062	0.00535343
MQT.12R2.B2	-0.00410469	-0.00410397	0.00526778
MQT.13R2.B2	-0.00321769	-0.00321128	0.00526778

Quadrupoles before and after matching, LHCb1



K1 values before, K1 values after matching, (signed) maximum K1 at collision energy.
Changes for rematching are very small.

Quadrupoles before and after matching, LHC B2



K1 values before, K1 values after matching, (signed) maximum K1 at collision energy.
 Changes for rematching are very small.

Comparison of optical functions at IPs for **LHCb1**

Ideal

NAME	β_x	β_y	ALFX	ALFY	μ_x	μ_y	D_x
IP1	0.55	0.55	-5.58399×10^{-10}	-7.712×10^{-10}	0.	0.	-2.93367×10^{-10}
IP2	0.5	0.5	-9.97634×10^{-10}	2.51888×10^{-9}	8.48379	7.48639	3.23339×10^{-10}
IP3	121.566842852274500	218.585056713127330	2.29573	-2.64289	16.5775	15.0257	-0.537377
IP4	142.49502342250270	190.93558151874365	0.592642	-0.513086	24.401	21.8891	8.65269×10^{-9}
IP5	0.55	0.55	-1.94971×10^{-10}	1.43463×10^{-9}	32.0496	29.6041	-2.83176×10^{-10}
IP6	187.29749859173907	168.12286692644381	-0.541994	0.605891	40.2274	36.3956	0.108039
IP7	120.81325216366454	149.43047047427436	1.27698	-1.38515	47.8658	43.5187	-0.328393
IP8	10.	10.	2.72473×10^{-10}	2.06226×10^{-9}	56.1987	50.9112	-2.08475×10^{-9}
IP1.L1	0.55	0.55	-5.58264×10^{-10}	-7.71133×10^{-10}	64.31	59.32	-2.93366×10^{-10}

Displaced

NAME	β_x	β_y	α_x	α_y	μ_x	μ_y	D_x
IP1	0.563665	0.539964	-0.0351873	0.0277156	0.	0.	-2.75456×10^{-10}
IP2	0.508001	0.494074	0.0316468	-0.0582107	8.47285	7.50028	3.36008×10^{-10}
IP3	117.905475588198270	218.99250320590784	2.25572	-2.68129	16.566	15.0353	-0.537377
IP4	148.60110871624261	184.683048126859860	0.625238	-0.492748	24.3913	21.8959	8.97761×10^{-9}
IP5	0.539964	0.566055	0.0380067	-0.0173851	32.0374	29.6125	-2.93797×10^{-10}
IP6	184.06911390953215	162.58752319287746	-0.571151	0.586746	40.2214	36.4026	0.108039
IP7	125.87596843043126	149.27494359599021	1.31907	-1.41716	47.8576	43.5284	-0.328393
IP8	9.70352	9.67556	-0.0296275	-0.00570937	56.192	50.9187	-2.0523×10^{-9}
IP1.L1	0.563665	0.539964	-0.0351873	0.0277156	64.3037	59.3248	-2.75457×10^{-10}

Rematched

NAME	β_x	β_y	ALFX	ALFY	μ_x	μ_y	D_x
IP1	0.55	0.55	-4.65518×10^{-10}	-7.5506×10^{-11}	0.	0.	-3.03645×10^{-10}
IP2	0.5	0.5	-4.94425×10^{-10}	-3.48029×10^{-10}	8.48454	7.48527	3.29777×10^{-10}
IP3	121.566842875886910	218.58505682210813	2.29573	-2.64289	16.5775	15.0257	-0.537377
IP4	142.49502339993785	190.93558129145154	0.592642	-0.513086	24.401	21.8891	8.41568×10^{-9}
IP5	0.55	0.55	-3.10165×10^{-10}	1.22657×10^{-9}	32.0496	29.6041	-2.71289×10^{-10}
IP6	187.29749858973761	168.12286673150976	-0.541994	0.605891	40.2274	36.3956	0.108039
IP7	120.81325213997575	149.43047053385530	1.27698	-1.38515	47.8658	43.5187	-0.328393
IP8	10.	10.	4.6407×10^{-10}	1.4189×10^{-9}	56.1987	50.9112	-2.08745×10^{-9}
IP1.L1	0.55	0.55	-4.65479×10^{-10}	-7.56×10^{-11}	64.31	59.32	-3.03644×10^{-10}

Comparison of optical functions at IPs for **LHCB2**

Ideal

NAME	β_x	β_y	ALFX	ALFY	μ_x	μ_y	D_x
IP1	0.55	0.55	6.32813×10^{-10}	-1.0445×10^{-9}	0.	0.	9.3189×10^{-11}
IP2	0.5	0.5	1.12835×10^{-9}	-1.63089×10^{-9}	8.20265	7.94654	3.9628×10^{-11}
IP3	122.04697796980174	217.516217278087770	-2.30324	2.62867	16.3741	15.3883	-0.459487
IP4	152.61061775039212	238.91395562347086	-0.518247	0.581663	23.9647	22.5063	9.2827×10^{-11}
IP5	0.55	0.55	-6.18066×10^{-10}	5.21896×10^{-10}	32.0688	29.7145	4.6935×10^{-11}
IP6	187.74922372532114	178.368555383731320	0.551968	-0.607183	39.6197	37.3028	0.187388
IP7	120.549126135041260	149.20134079357874	-1.27249	1.37829	47.5061	44.0949	-0.379735
IP8	10.	10.	2.05862×10^{-9}	-3.64744×10^{-10}	55.7286	51.6851	-4.14464×10^{-10}
IP1.L1	0.55	0.55	6.32725×10^{-10}	-1.04447×10^{-9}	64.31	59.32	9.319×10^{-11}

Displaced

NAME	β_x	β_y	α_x	α_y	μ_x	μ_y	D_x
IP1	0.564916	0.572198	-0.0187218	-0.0186653	0.	0.	9.2371×10^{-11}
IP2	0.495201	0.509476	-0.0581105	0.0316047	8.21282	7.93691	3.5498×10^{-11}
IP3	126.00744510412876	226.399077804257620	-2.37176	2.75365	16.3769	15.3791	-0.459487
IP4	153.87296351671520	235.79051637967325	-0.490948	0.615349	23.9655	22.4952	6.4943×10^{-11}
IP5	0.534623	0.545814	0.0156877	-0.0427578	32.0708	29.7101	4.4308×10^{-11}
IP6	181.79962055377143	184.68848964247002	0.530042	-0.65539	39.6234	37.2971	0.187388
IP7	119.52898169474733	142.89090103382279	-1.23047	1.3256	47.5069	44.0867	-0.379735
IP8	9.98414	9.77553	-0.0324526	-0.0367981	55.7345	51.6803	-4.06029×10^{-10}
IP1.L1	0.564916	0.572198	-0.0187218	-0.0186653	64.3148	59.3137	9.2372×10^{-11}

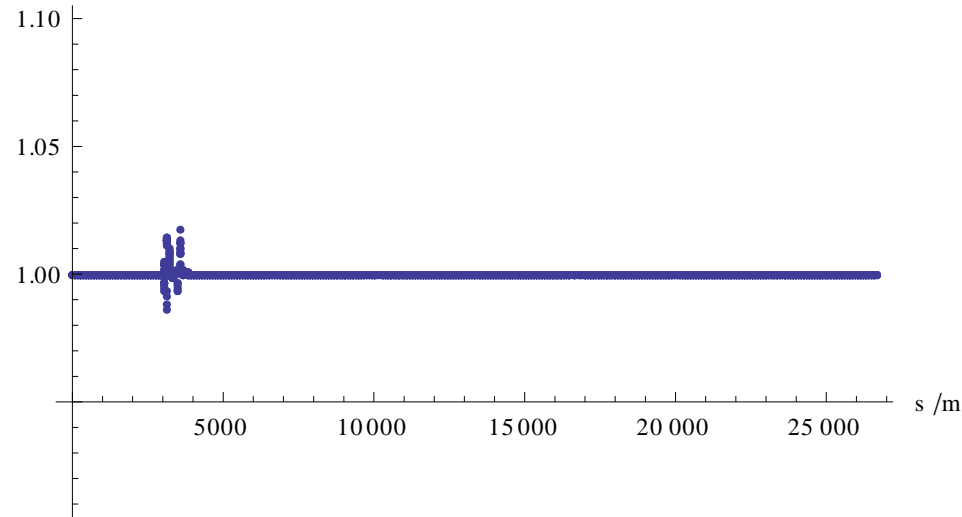
Rematched

NAME	β_x	β_y	α_x	α_y	μ_x	μ_y	D_x
IP1	0.54939	0.550528	-0.000630516	-0.00140931	0.	0.	0.000012786
IP2	0.502563	0.501291	-0.00054632	-0.00166969	8.20252	7.94721	0.000039375
IP3	122.00871033556848	217.88472227563679	-2.30376	2.63293	16.374	15.3881	-0.45908
IP4	152.762121614636020	238.99680785793001	-0.519566	0.583534	23.9645	22.5059	-0.000665676
IP5	0.55057	0.549376	0.000748698	-0.00127084	32.0684	29.7143	
IP6	187.82122005042575	178.48170697702750	0.553398	-0.60915	39.6193	37.3026	
IP7	120.70119699542718	149.000753473844180	-1.2743	1.37749	47.5059	44.0946	
IP8	9.98884	9.98484	0.000619151	-0.00077624	55.7283	51.6849	
IP1.L1	0.54939	0.550528	-0.000630516	-0.00140931	64.3098	59.3199	

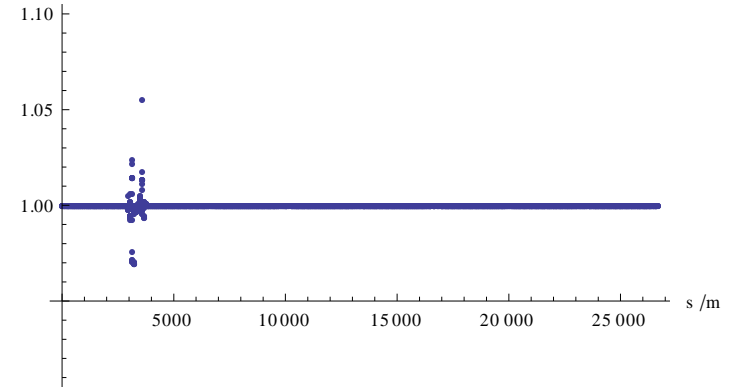
Not quite
as good as
LHCB1.

Global beta-beating after rematching, LHCb1

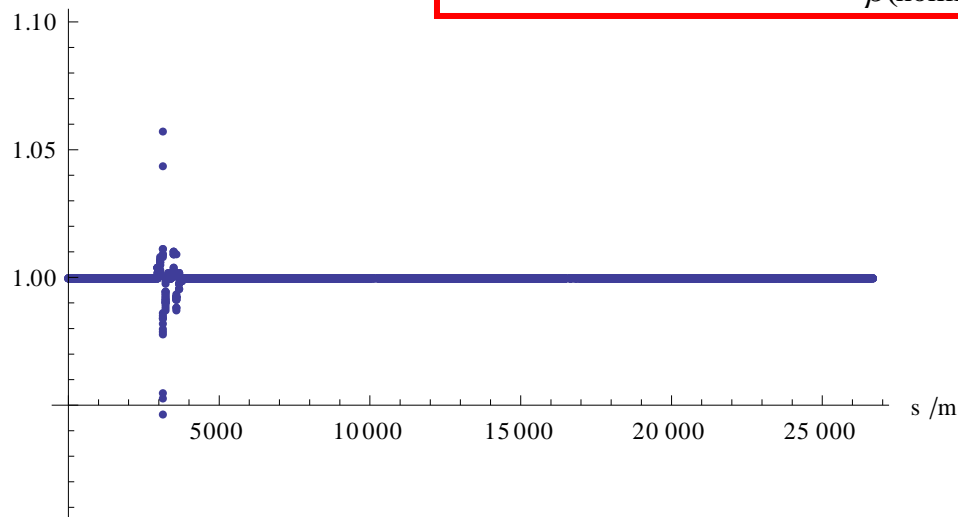
Beating of β_x



Beating of α_x

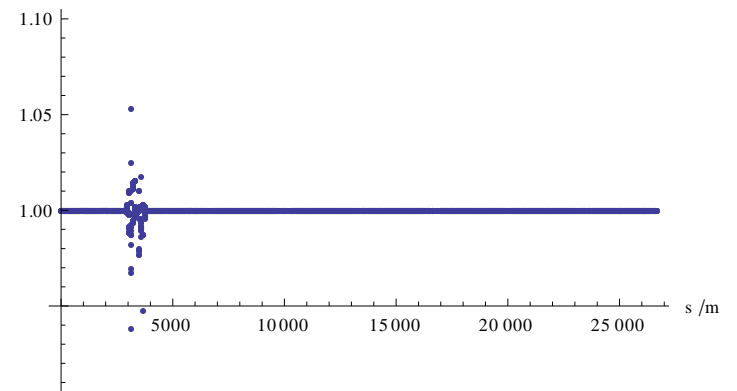


Beating of β_y



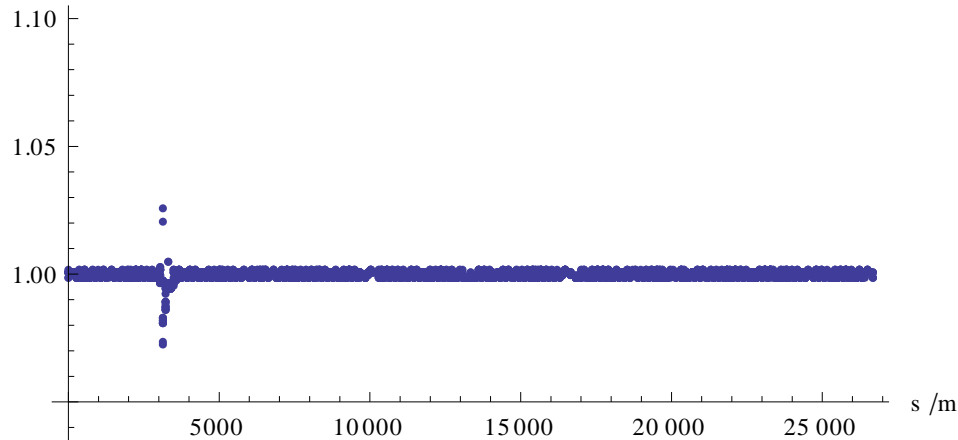
Beating defined as: $\frac{\beta(\text{displaced})}{\beta(\text{nominal})}$

Beating of α_y

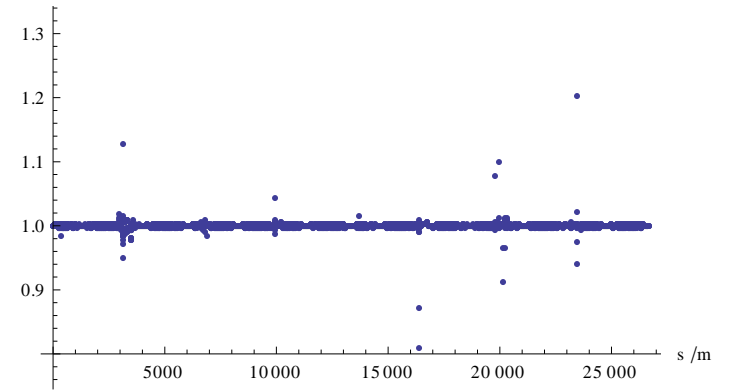


Global beta-beating after rematching, LHCb2

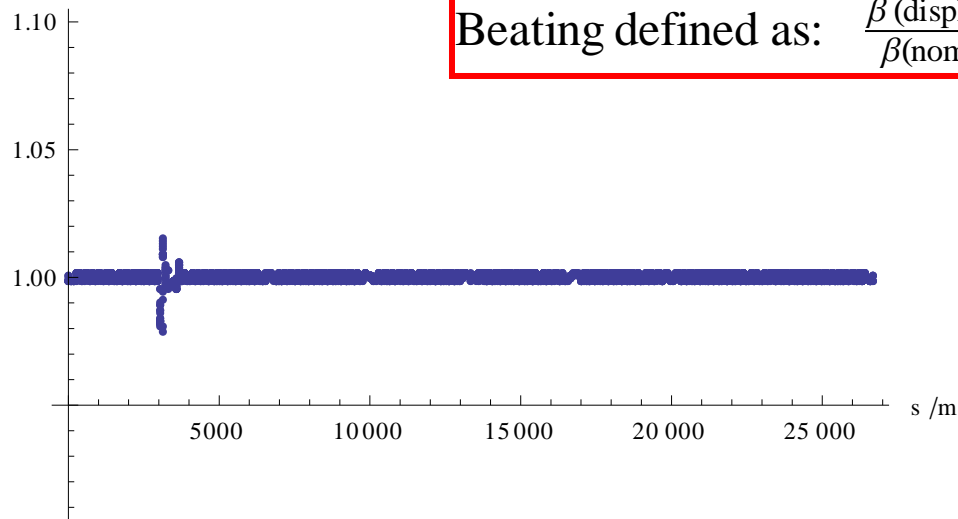
Beating of β_x



Beating of α_x

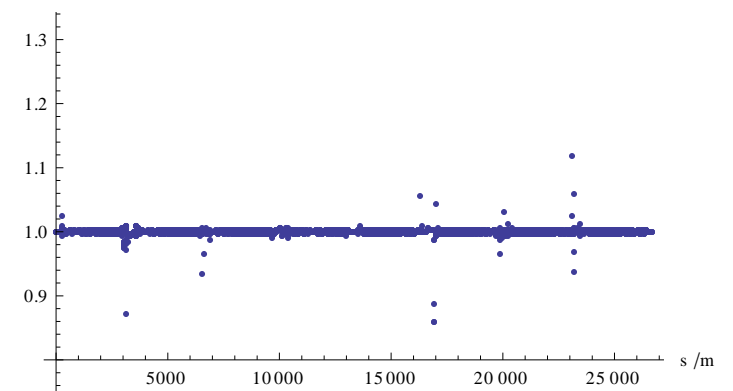


Beating of β_y



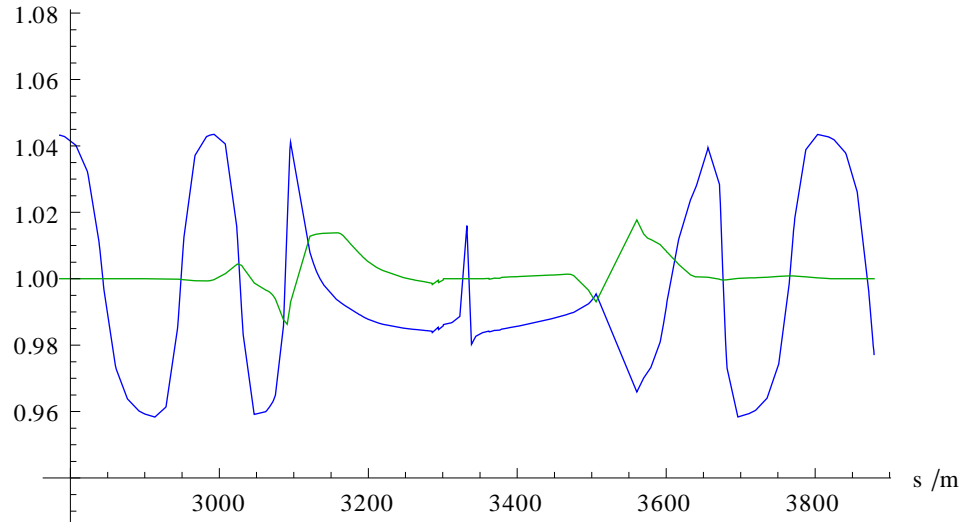
Beating defined as: $\frac{\beta(\text{displaced})}{\beta(\text{nominal})}$

Beating of α_y



Beta-beating in IR2DS.B1, LHC B1

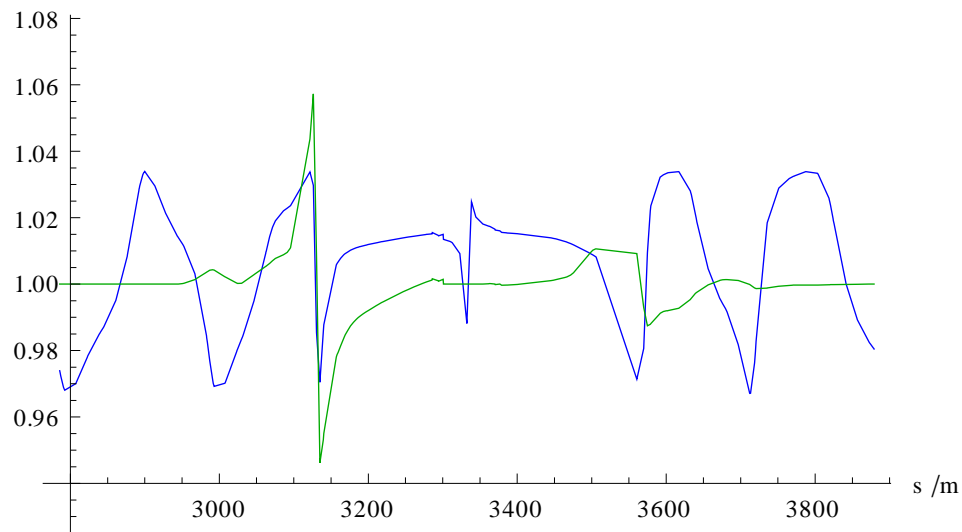
Beating of β_x



Before rematch

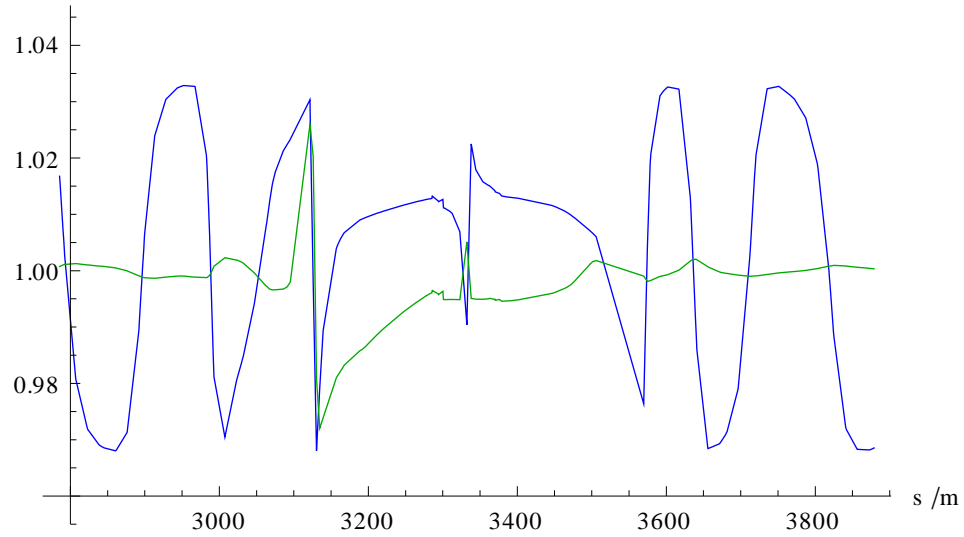
After rematch

Beating of β_y



Beta-beating in IR2DS.B2, LHCB2

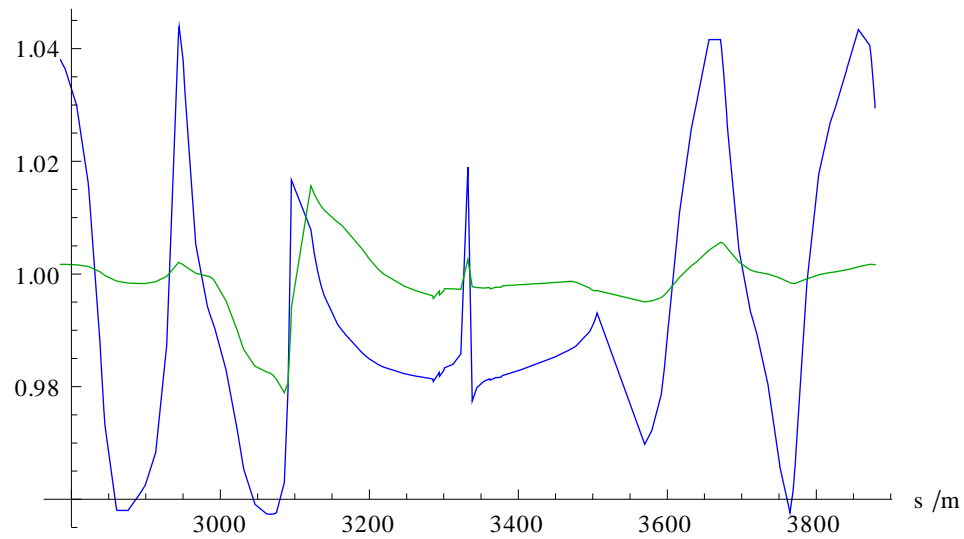
Beating of β_x



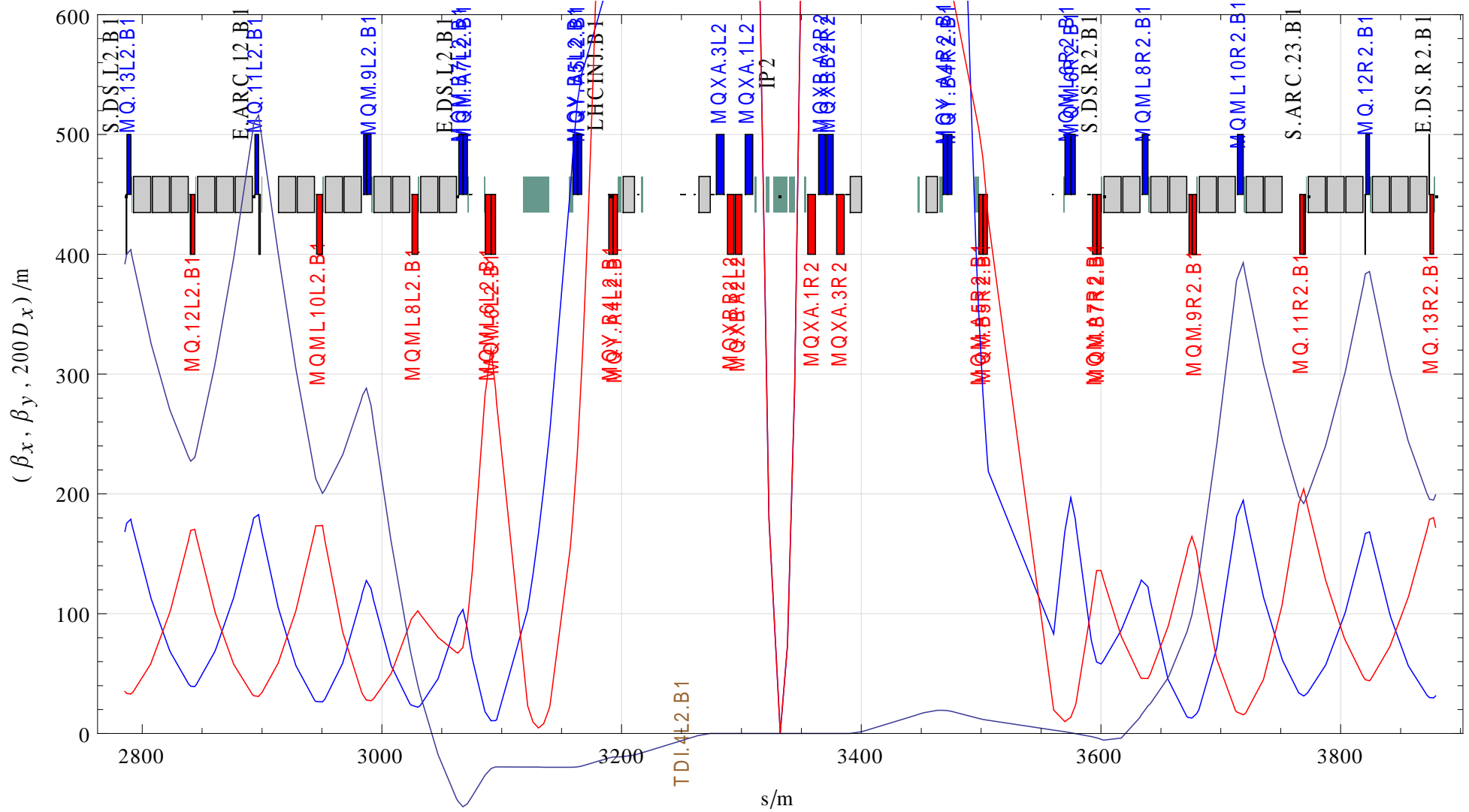
Before rematch

After rematch

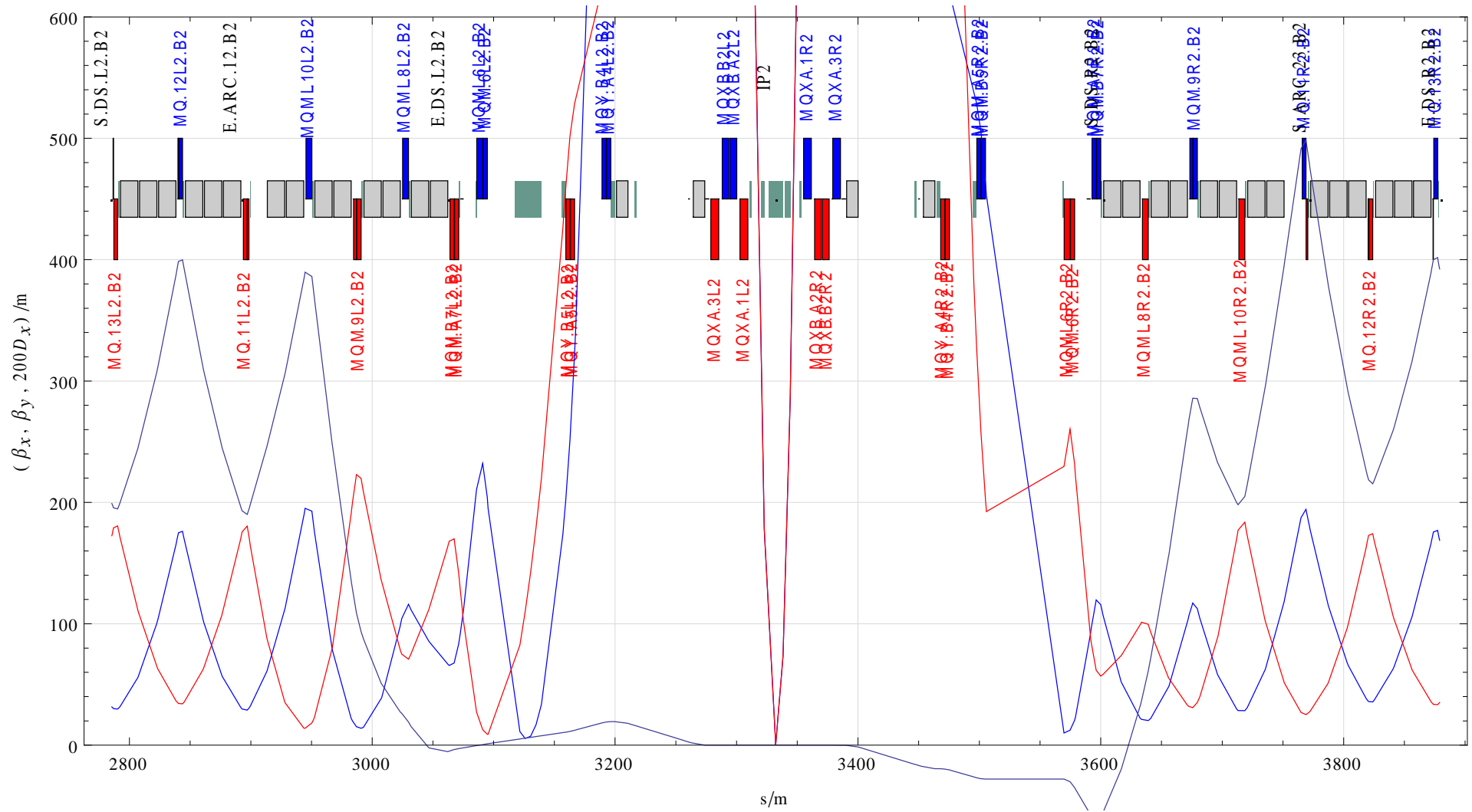
Beating of β_y



Rematched optics in IR2DS.B1, LHC B1



Rematched optics in IR2DS.B2, LHCB2



Conclusions

- Longitudinal displacements of MQX in IR2
 - Cause beat-beating of about 5% around ring.
 - Effect can be compensated for both beams with small adjustments of insertion quadrupoles (not including triplets).
 - Strength files, etc. available