Beam losses in the triplet due to AC-dipole excitation

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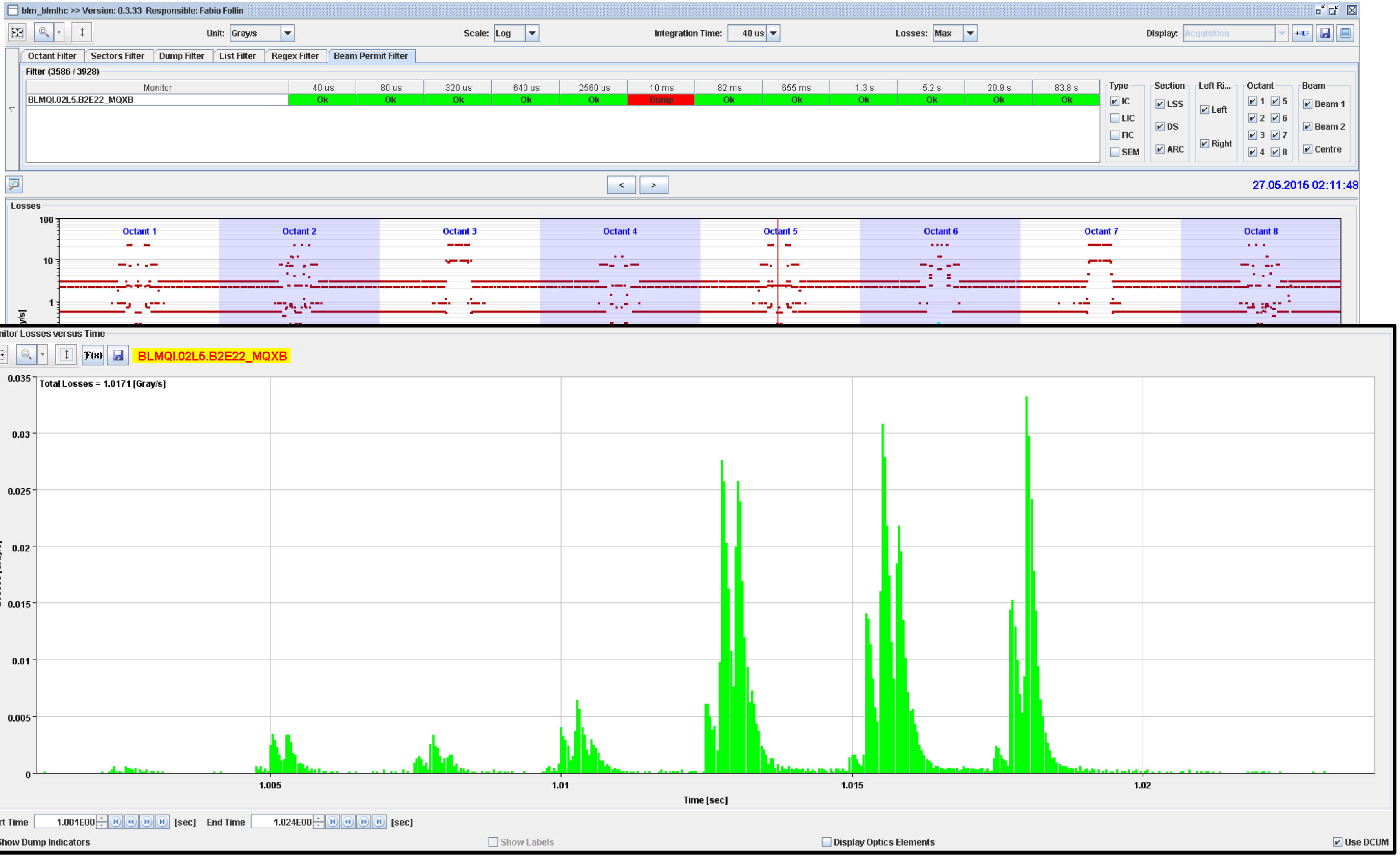
Sequence of events

<u>Optics (beta-function)_measurements</u>

- Beam:
  - 6 bunches at 6.5 TeV
  - intensity ~7e9 (SMP: present, safe)
- Beam setup/ squeeze
- BSTAR: 0.8 / 10 / 0.8 / 3 m
- Half-gap of the collimators:
  - TCP.D6R7 (vert.): 4.5 mm
  - TCP.C6R7 (hor.): 6 mm
  - TCTPV.4R5: 15 mm
  - TCTPH.4R5: 15 mm
- The beam was excited by AC dipole (MKQA.6L4)

Sequence of events

- Beams were dumped due to 10ms RS by a BLM at IP5:

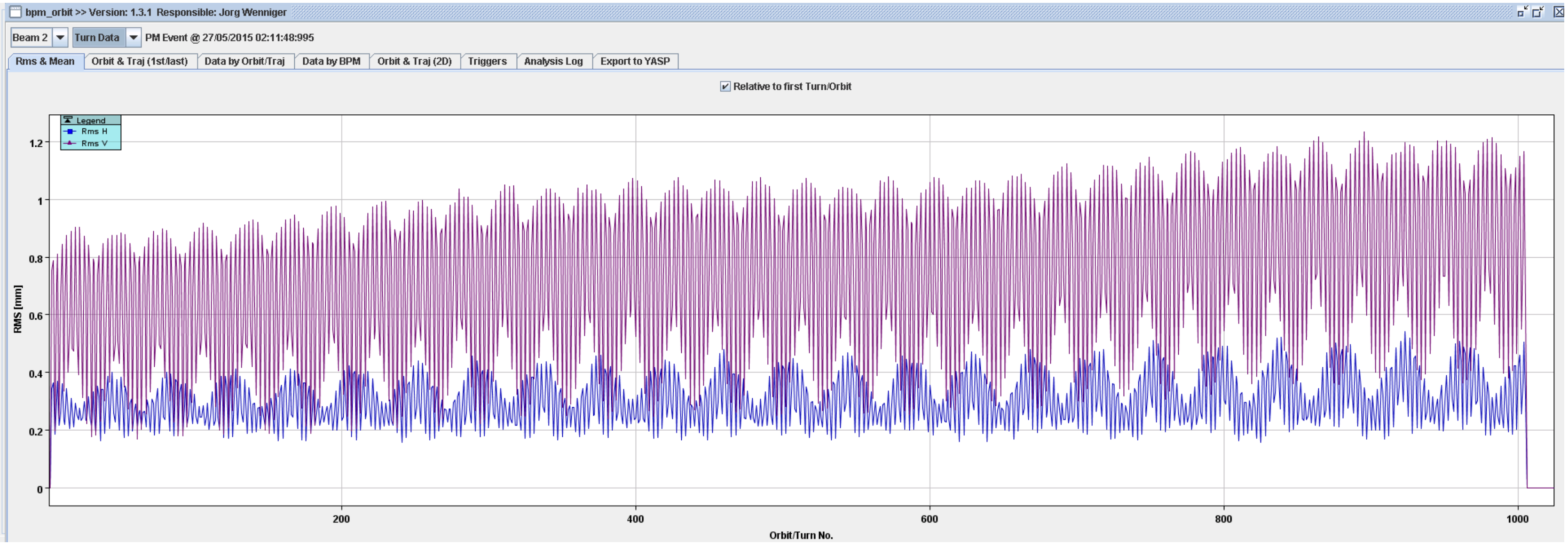


Sequence of events

- BLM signal at IP1:

Sequence of events

- Beams were dumped due to 10ms RS by a BLM at IP5: BLMQI.02L5.B2E22_MQXB
  – Beam losses were observed during ~15ms, with peaks every ~3ms
- BPM ORBIT:



- Frequency of the AC dipole trimmed too close to the tune value

Concerns

- Why was the triplet at IP5 first hit by beam losses? Is this the general aperture limitation?
- The TCT in IR5 did not protect the triplet, why?
- What should be the position of the TCT to protect the triplet?

MAD-X simulations

Task:

- Check where the losses occur when MKQ has
  - Tune frequency (Qy = 59.32)
  - Nearly tune frequency (Qy-0.001; Qy-0.01)
- Check the aperture size at the bottlenecks

- V6.503 sequence
- 0.8 / 3 / 0.8 / 3 m optics

0.8 / 10 / 0.8 / 3 m optics was not yet available at the time of event

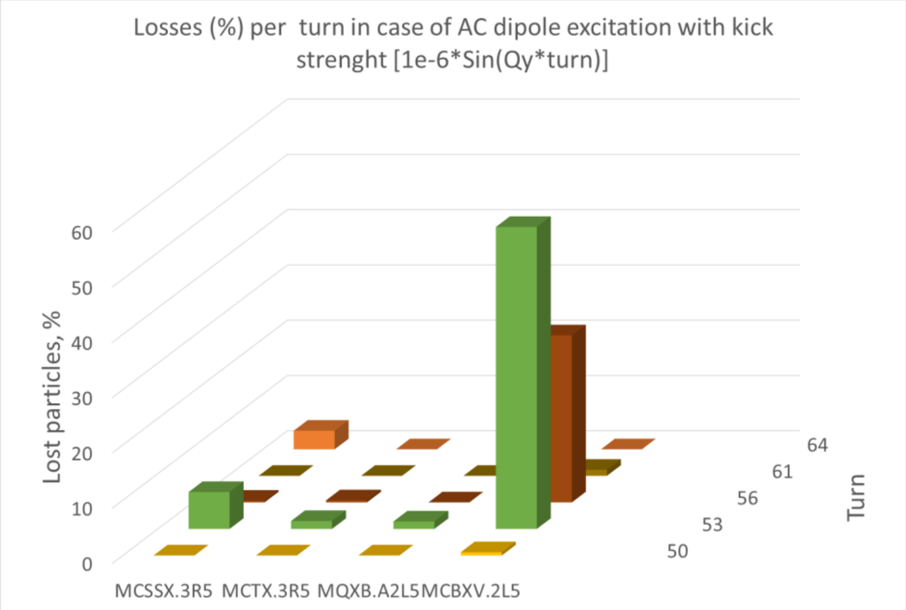
- 3.5 mm·mrad – normalized emittance

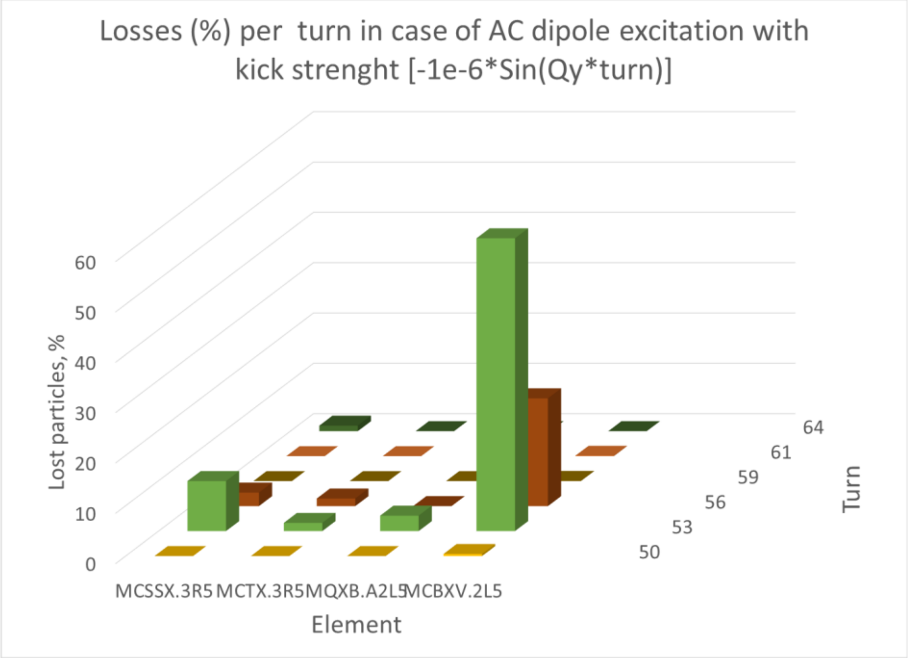
lhc_as-built sequence (run 2 version)

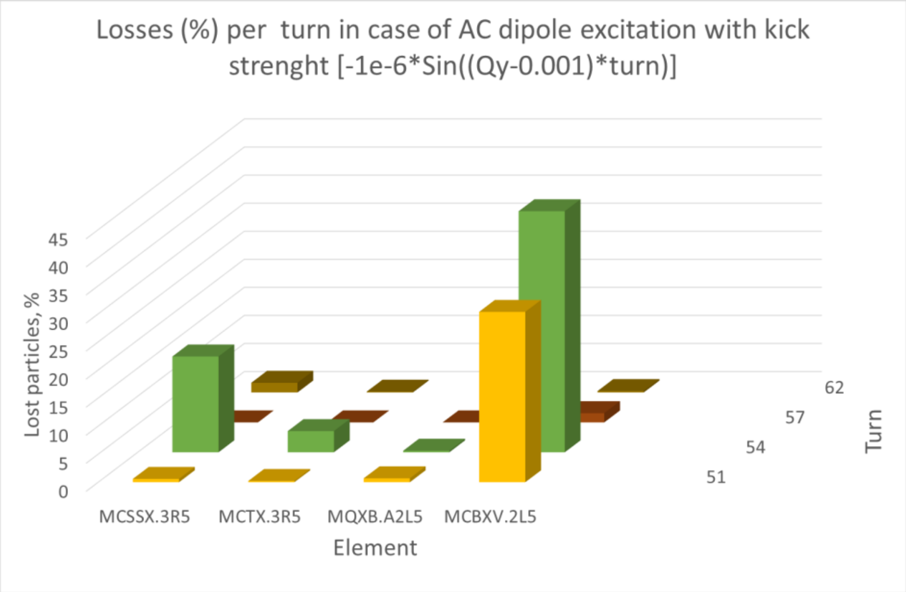
0.8 / 10 / 0.8 / 3 m optics

Preliminary

MAD-X: Comparison of the loss patterns in case of various MKQ kicks







If the MKQ frequency is equal to

- Qy
- Qy-0.001

Losses are mostly observed in MCBXV.2L5

If the difference with tune is 0.01 (Qy-0.01) – no losses are observed

MAD-X: Aperture bottlenecks

Run 1, 0.8 / 3 / 0.8 / 3 optics

vs.

Run 2, thick 0.8 / 10 / 0.8 / 3 optics

		RUN 1 : 0.8 / 3 / 0.8 / 3					
NAME	**S, m**	**Aperture-X, mm**	**Aperture-Y, mm**	**SIGMA-X, mm**	**SIGMA-Y, mm**	**Aperture-X, sigma**	**Aperture-Y, sigma**
TCTPV.4R5.B2	13183.95	40	15	0.74	0.47	53.93	31.86
TCP.D6R7.B2	6460.043	40	4.5	0.28	0.20	141.19	22.63
TCP.C6R7.B2	6462.043	6	40	0.28	0.20	21.76	195.61
MQXA.3R5	13282.32	28.9	24	0.86	1.13	33.48	21.17
MQXB.B2R5	13290.74	28.9	24	1.22	0.73	23.77	32.99
MQXB.A2R5	13297.24	28.9	24	1.16	0.60	24.87	40.11
MQXA.1R5	13306.32	28.9	24	0.69	0.63	42.12	38.15
MQXA.1L5	13358.62	28.9	24	0.63	0.69	45.94	34.98
MQXB.A2L5	13366.84	28.9	24	0.60	1.16	48.30	20.65
MCBXV.2L5	13367.31	28.9	24	0.64	1.23	45.18	19.48
MQXB.B2L5	13373.34	28.9	24	0.73	1.22	39.73	19.74
MQXA.3L5	13382.62	28.9	24	1.13	0.86	25.49	27.80
MQXB.B2R1	26617.58	28.9	24	1.22	0.73	23.77	32.99
MQXB.A2R1	26624.08	28.9	24	1.16	0.60	24.87	40.11
MQXB.A2L1	34.8	28.9	24	0.60	1.16	48.30	20.65
MQXB.B2L1	41.3	28.9	24	0.73	1.22	39.73	19.74
MQXA.3L1	50.15	28.9	24	1.13	0.86	25.49	27.80

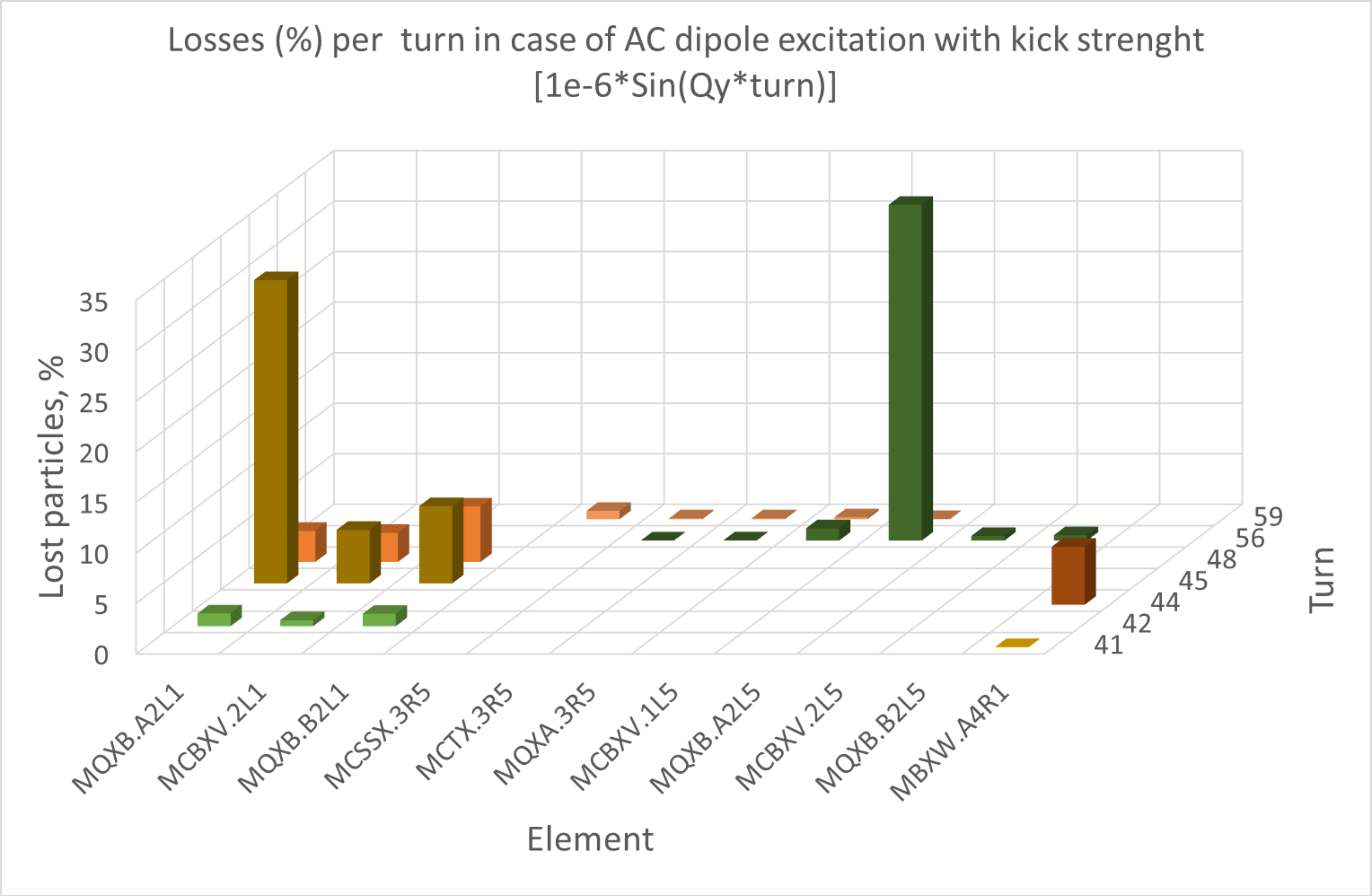
RUN 2 (thick): 0.8 / 10 / 0.8 / 3			
SIGMA-X, mm	**SIGMA-Y, mm**	**Aperture-X, sigma**	**Aperture-Y, sigma**
0.74	0.47	54.02	31.64
0.28	0.20	141.75	22.54
0.27	0.21	21.85	194.80
0.98	1.01	29.58	23.77
1.24	0.65	23.37	36.93
1.03	0.60	28.18	39.78
0.58	0.58	50.05	41.56
0.63	0.85	45.95	28.16
0.63	1.23	45.84	19.54
0.64	1.23	45.19	19.47
0.85	1.12	34.00	21.40
1.16	0.82	24.81	29.23
1.24	0.65	23.37	36.93
1.03	0.60	28.18	39.78
0.63	1.23	45.84	19.54
0.85	1.12	34.00	21.40
1.16	0.82	24.81	29.23

MAD-X: Aperture bottlenecks

Run 2, thin 0.8 / 10 / 0.8 / 3 optics is available since 2pm 18 June ☺

NAME	APER_X, m	APER_Y,m	sigma-x, mm	sigma-y, mm	Aper-X, sigma	Aper-Y, sigma
TCP.D6R7.B2	0.04	0.0044	0.28	0.20	141.75	22.03
TCP.C6R7.B2	0.006	0.04	0.28	0.20	21.67	196.43
TCTPH.4R5.B2	0.015	0.04	0.74	0.45	20.32	88.08
TCTPV.4R5.B2	0.04	0.015	0.74	0.47	54.02	31.64
MQXB.A2L5	0.0289	0.024	0.63	1.23	45.84	19.54
MCBXH.2L5	0.0289	0.024	0.64	1.23	45.19	19.47
MQXB.B2L5	0.0289	0.024	0.65	1.24	44.46	19.40
TCTPH.4R1.B2	0.04	0.04	0.74	0.46	54.12	86.66
TCTPV.4R1.B2	0.04	0.03	0.74	0.47	54.08	64.29
MQXB.B2R1	0.024	0.0289	1.24	0.65	19.40	44.46
MCBXH.2R1	0.024	0.0289	1.23	0.64	19.47	45.19
MQXB.A2R1	0.024	0.0289	1.23	0.63	19.54	45.84

MAD-X: Loss pattern vs turn



Conclusions

- In case of AC-dipole vertical excitation of Beam 2 with the frequency close to that of the tune, the aperture bottleneck is located in the triplet at IP5 (in quadrupoles and corrector).
- In order to intercept the losses in the triplet-region, the TCT should be moved to <19 sigma.