AEGIS spot size optimization with SIMPA

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Introduction

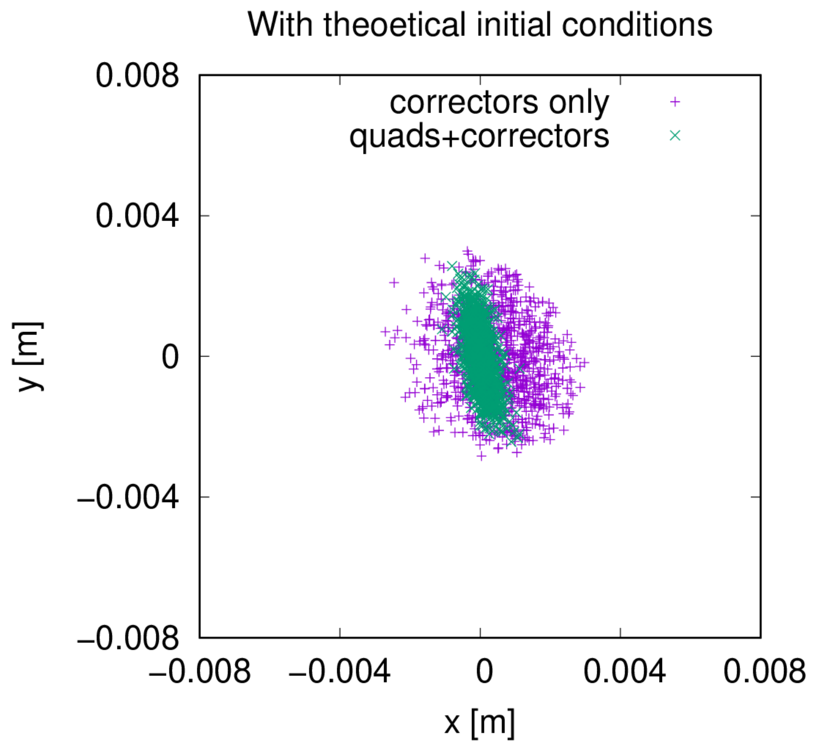
- Build up a model with the SIMPA tracking code for AEGIS.
- Previously this code was used for the H- source line and gave very nice results.
- SIMPA is a tracking code able to model accurately any element with realistic fields.
- Can include any static magnetic or electric field in the model.
- It naturally includes all fringe fields in the tracking.
- It handles the beam region as a whole and not the usual element by element method.
- Individual elements in the line can be still scaled.
- It is symplectic, meaning the tracking is physically valid even at very long tracking. This feature is important mostly for rings, less for transfer lines.

Steering and optics optimization

- Tracked 1000 particles with the operational settings for the AEGIS line elements with both solenoid ON.
- The results showed that the beam is smeared into a spiral in the solenoid, because the steering was not optimal. This is expected when the steering is not optimal.
- To obtain a more realistic value of the beam size with the actual settings in the line, optimized the spot size at s = 24.552 [m] using the last 4 steering elements.
- Made a second optimization using the last 4 steering elements + the last 4 quadrupoles.

Comparison I.

- Here is a comparison of the two results. The optimization with corrector+quads gave a much smaller beam size .

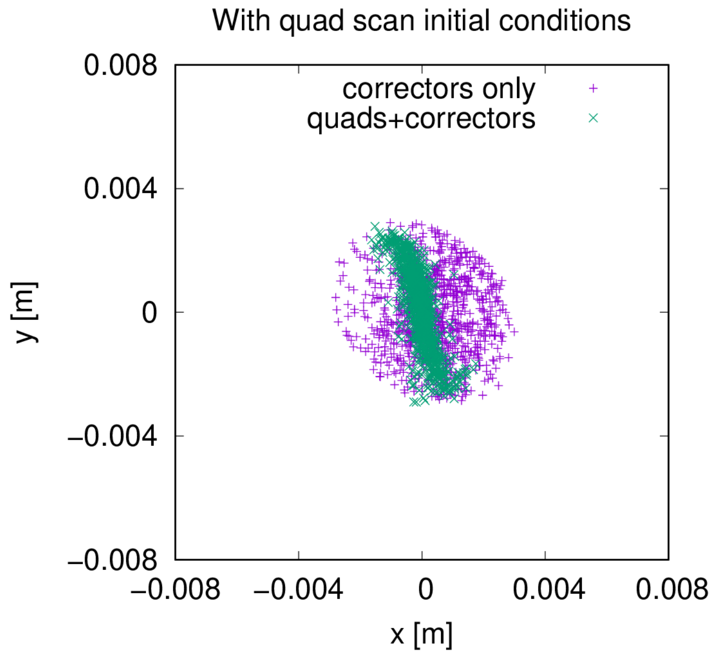


RMS area for correctors only = 1.28E-6 [m^2]

RMS area for correctors+quads = 2.95E-7 [m^2]

Comparison II.

- It is quite possible that the reality is better than the picture shows for the correctors only case, if the initial conditions are not very accurate.
- The previous picture used the theoretical values for the initial conditions.
- Repeated the procedure with the measured initial conditions. See Yann's quad scan here: https://logbook.cern.ch/elogbook-server/GET/showEventInLogbook/4049476

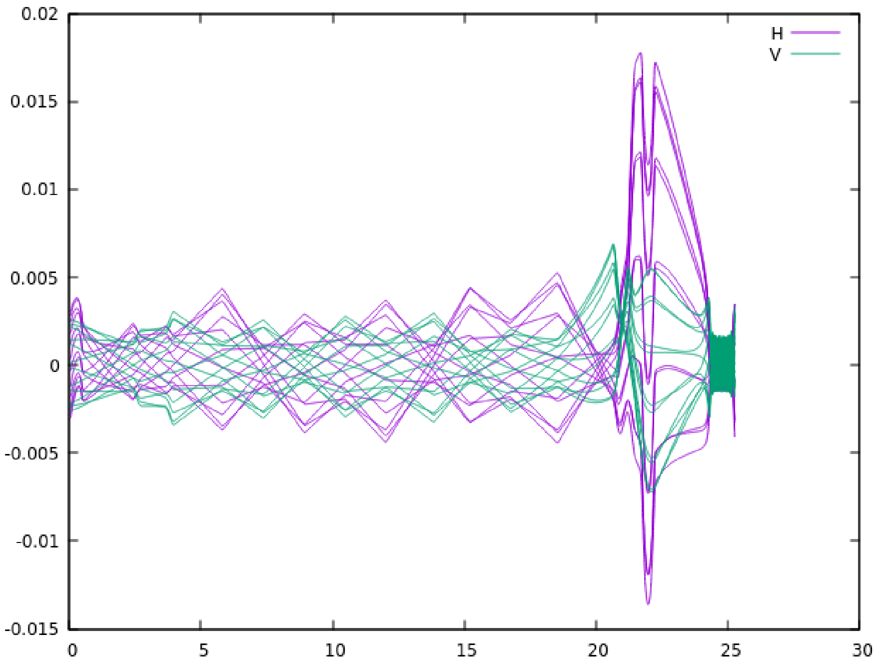


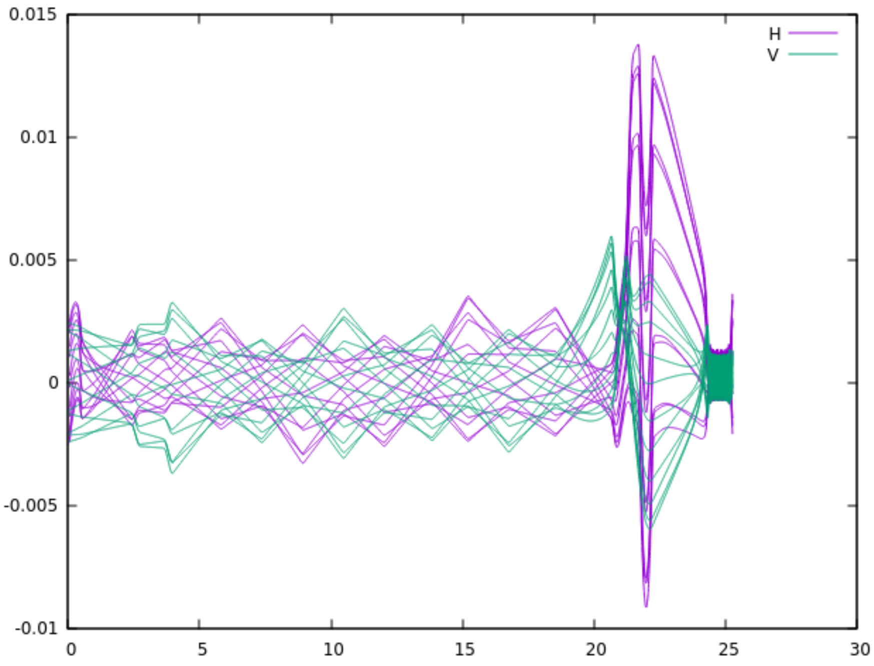
RMS area for correctors only = 1.54E-6 [m^2]

RMS area for correctors+quads = 6.36E-07 [m^2]

Beam trajectory

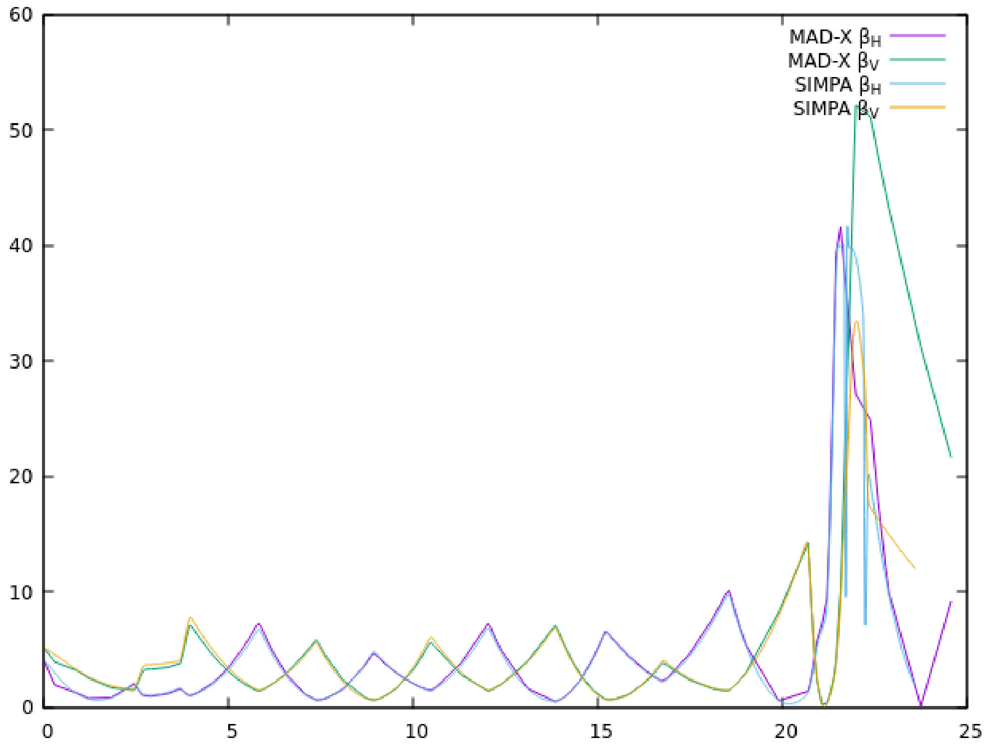
There are many optimal settings with nearly the same spot sizes.

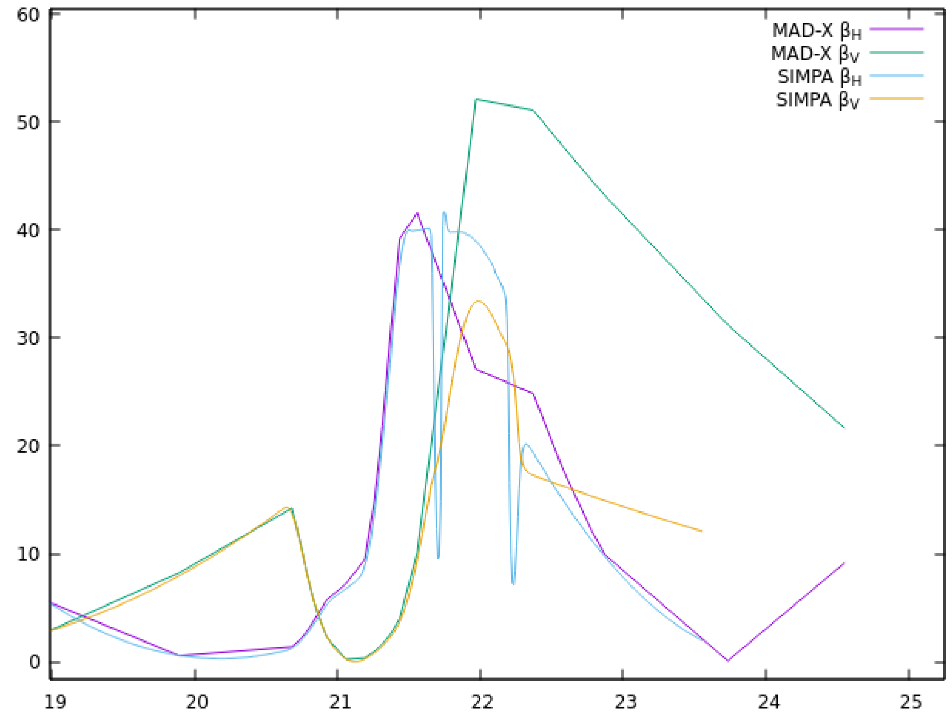




Optics comparison

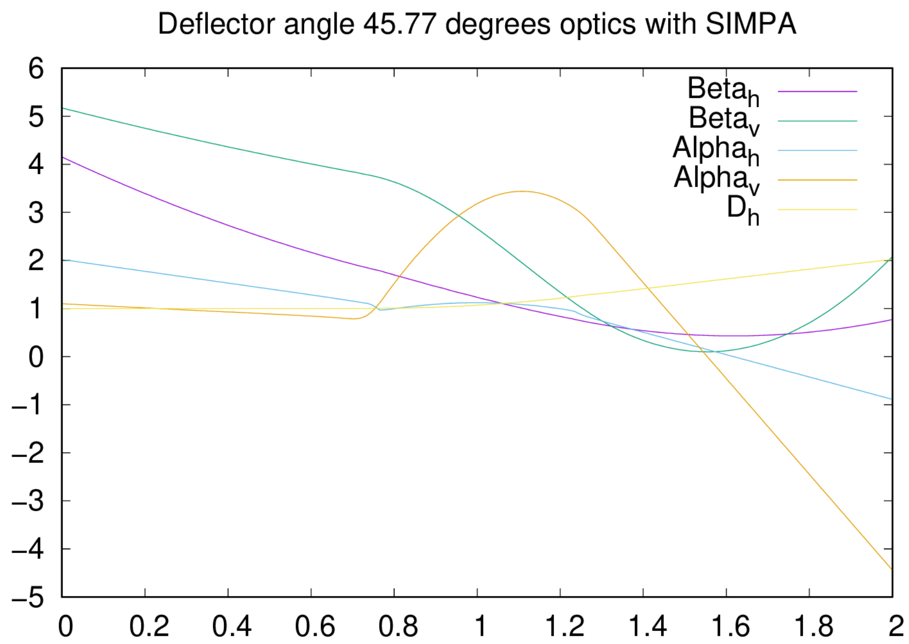
- The optics calculated by SIMPA agrees well with MAD-X before the static deflector, but deviates significantly after the deflector in the V plane.

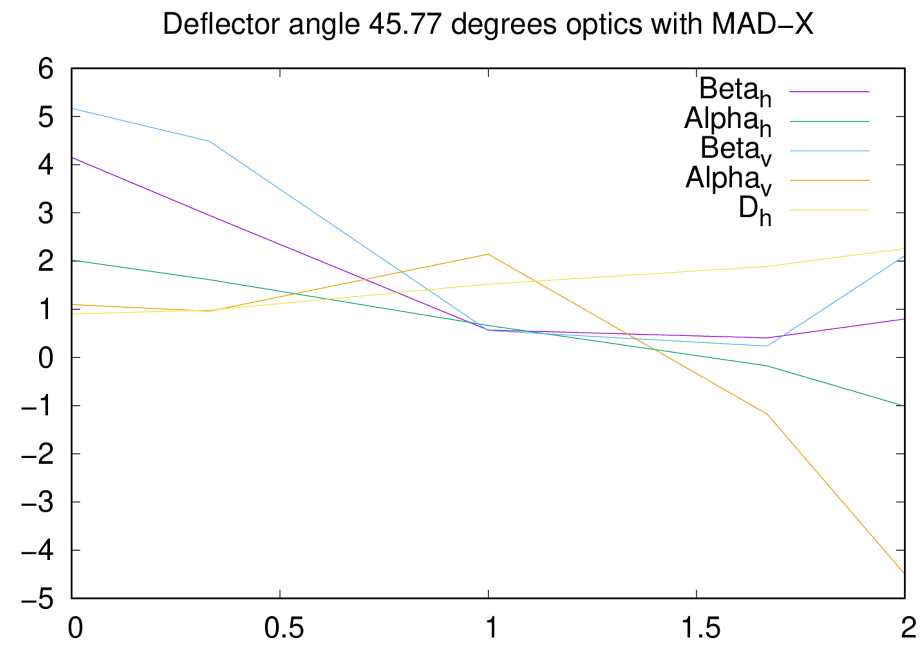




Deflector model comparison

Model of the static deflector in good agreement between MAD-X and SIMPA when the beam is on the ideal orbit. There is some deviation when it is not.





Comparison with measured beam size

- The initial condition used in the SIMPA model was based on the quad scan by Yann.
- Current vertical emittance seems to be 25 % bigger.

SEM	sigma H	sigma H simpa	sigma V	sigma V simpa	scaled simpa V
lne00.bsgw.0008	1.7	1.7	2.9	2.1	2.625
lne00.bsgw.0015	1.7	1.7	3.6	2.9	3.625
lne00.bsgw.0025	3.8	4.1	1.9	1.5	1.875
lne00.bsgw.0038	3.2	3	1.2	1	1.25
lne00.bsgw.0045	2.3	2.2	2.8	2.1	2.625
lne00.bsgw.0109	1.8	2.3	2.7	2	2.5
lne00.bsgw.0120	2.6	2.6	1.9	1.9	2.375
lne00.bsgw.0207	4	3.4	2.6	2.3	2.875
lne00.bsgw.0225	5.5 ???	5.5	10	7.6	9.5

Some optimum setting found by SIMPA

"lne.zqmd.0208_38.bin":-2835.9312265175463},
{"lne.zcv.0208_38.bin":98.15918495041664},
{"lne.zch.0208_38.bin":-410.24567844875276},
{"lne.zqmf.0209_38.bin":3628.3932971074937},
{"lne.zqmd.0214_38.bin":-2622.342776211465},
{"lne.zcv.0214_38.bin":780.105205149325},
{"lne.zch.0214_38.bin":601.0603066645382},
{"lne.zqmf.0215_38.bin":-261.11884470731593},
{"lne.zdshr.0220_38.bin":9650.0},
{"aegis-s1_38.bin":1.0},
{"aegis-s2_38.bin":1.0}]

{"lne.zqmd.0208_38.bin":-3190.2226467250625},
{"lne.zcv.0208_38.bin":-451.46290095151556},
{"lne.zch.0208_38.bin":-717.4738085235948},
{"lne.zqmf.0209_38.bin":1727.9768856371322},
{"lne.zqmd.0214_38.bin":-4157.15651030464},
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{"lne.zdshr.0220_38.bin":9650.0},
{"aegis-s1_38.bin":1.0},
{"aegis-s2_38.bin":1.0}]

Steering is not the same in SIMPA yet, it is unlikely that gives the optimum !

Suggestion

- Do the same optimization with the real machine using H-.
- The last 4 quads and the last 4 corrector were optimized.
- I used CMA-ES genetic algorithm with 300 V initial sigma for all variables.
- Initial conditions were the operational settings.
- It should converge about 2000 iterations. With H- it will take about 10 hours machine time.
- Need to monitor losses somehow during the optimization.

References

- L. Bojtár. Efficient evaluation of arbitrary static electromagnetic fields with applications for symplectic particle tracking. Nuclear Instruments and Methods A, 948:162841, 2019.
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