Emittance optimisation and optics matching with 3 laser shapes

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Content:

- Emittance optimization
- Optics matching
- Results at nominal parameters
- Emittance optimization at low gradient (30 MV/m)
- Summary

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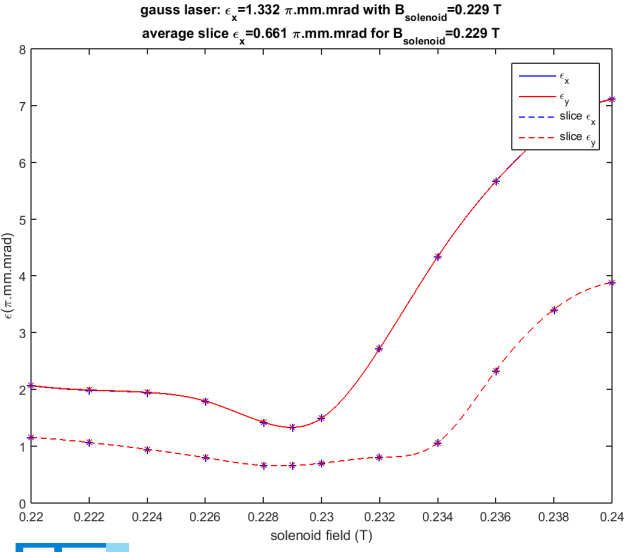
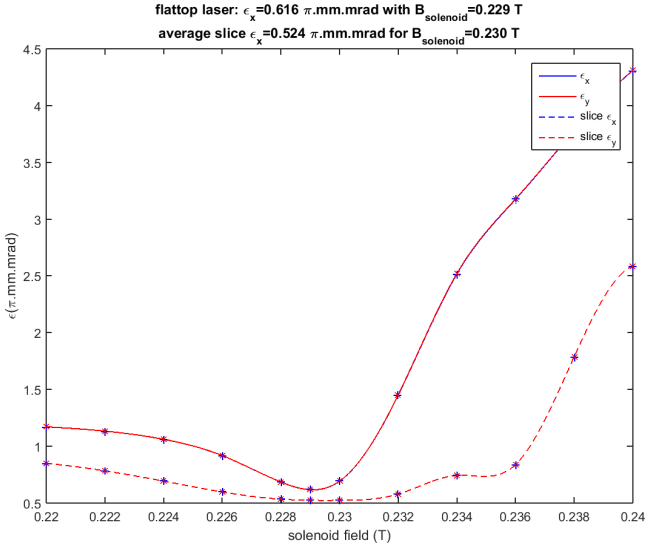
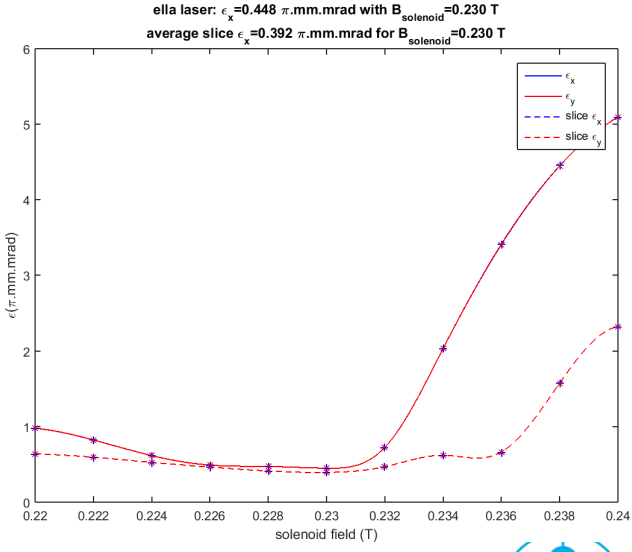
DESY

Emittance optimisation with 3 laser shapes

- Look at emittance at EMSY1 while scanning solenoid current.
- Longitudinal and transverse size taken from Martin's simulations (cf. “3D ellipsoidal beams for ultimate performance at the high brightness photo-injector PITZ”).
- Script to scan: /doocs/data/yrenier/sim1/astra/PITZ/TDS/run_solenoid_scan_qsub.sh
- 1nC beam, 7 MeV after the gun, 24 MeV after the booster.



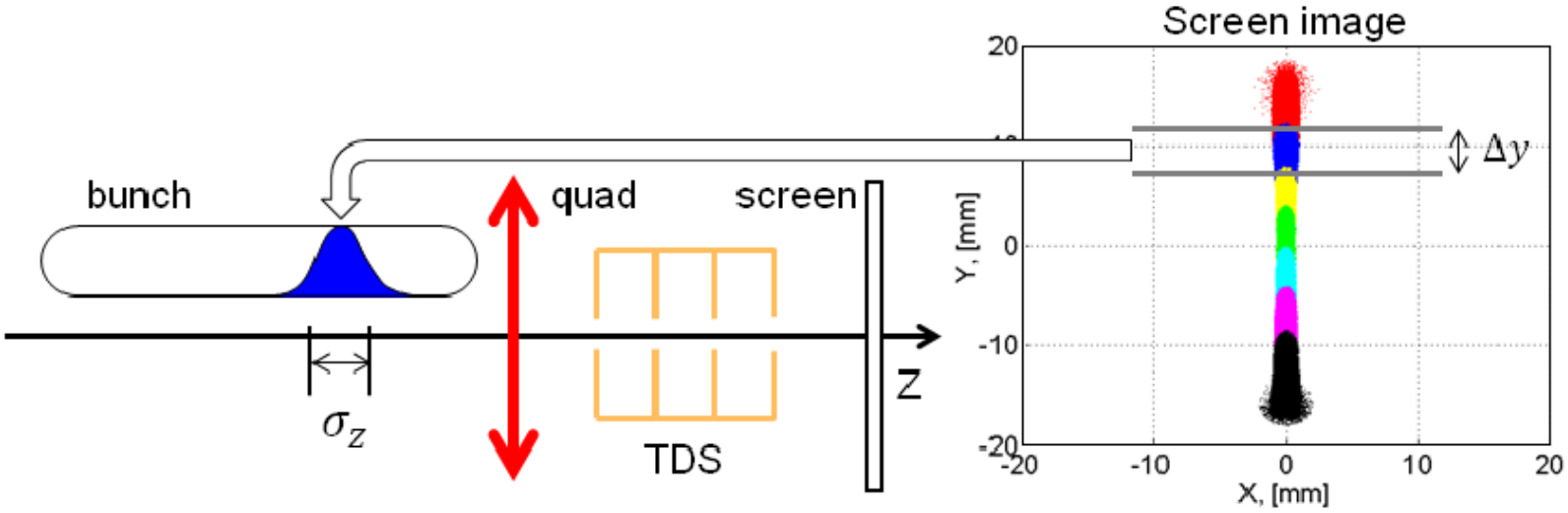




TDS measurement optimisation

To get optimum transverse measurement one need (cf. Dmitriy's PhD):

- 90 deg phase advance from TDS to screen (kick at TDS converted to position at the screen).
  - A small unstreaked beam size on the screen.
  - A small vertical beam size in the TDS to limit the amount of energy spread introduced bv the TDS



Matching strategy

- To match the quadrupoles strength in simulation in presence of space charge, there is only one option: SC code.

- SC can only match of emittance, beta and alpha functions at the end of the given lattice. Closed source, not maintained anymore, not as precise as ASTRA …

- We need to match phase advance between 2 points and constraint beam size at these two points … SC cannot do that !

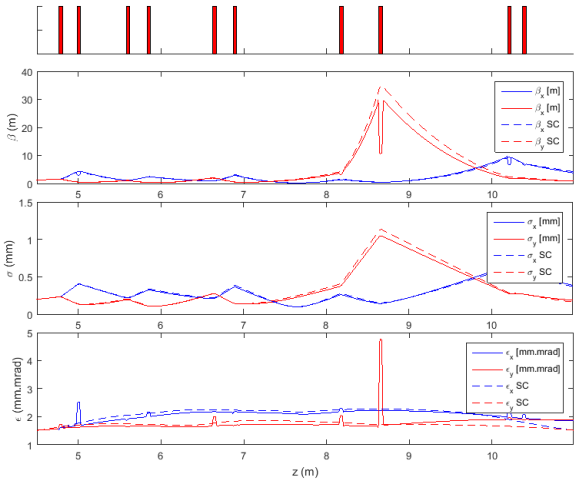
- My solution:

1) Match with MADX without space charge and all constraints to get beta and alpha functions at the TDS and the screens.
2) Use SC and the beta and alpha functions from MADX at the TDS to get the quads taking into account space charge.
3) Use ASTRA to get real distribution at the TDS
4) Use SC and the beta and alpha functions from MADX at the screen to get the quads taking into account space charge.
5) Use ASTRA to get real distribution at the screen

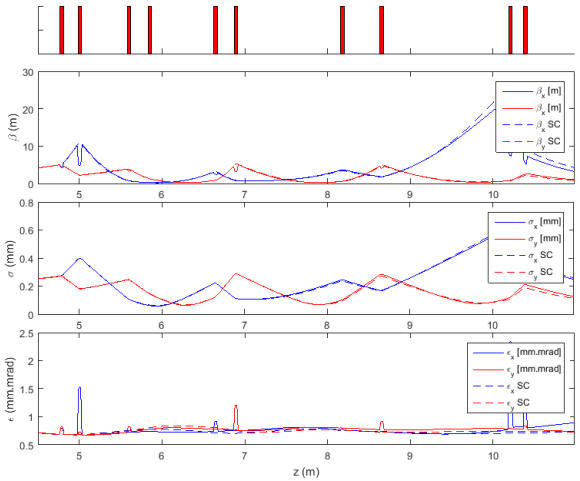
- Long procedure, but better than scanning 13 quadrupoles !!! (details in /afs/ifh.de/group/pitz/data/yrenier/sim1/astra/PITZ/TDS/README.txt)

Comparison of SC and ASTRA tracking

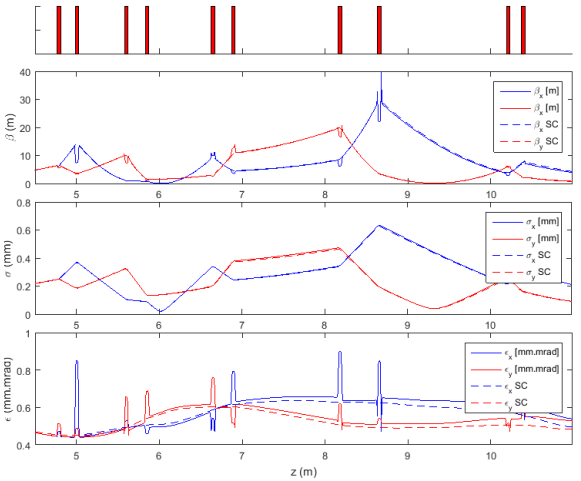
Gaussian: booster to TDS



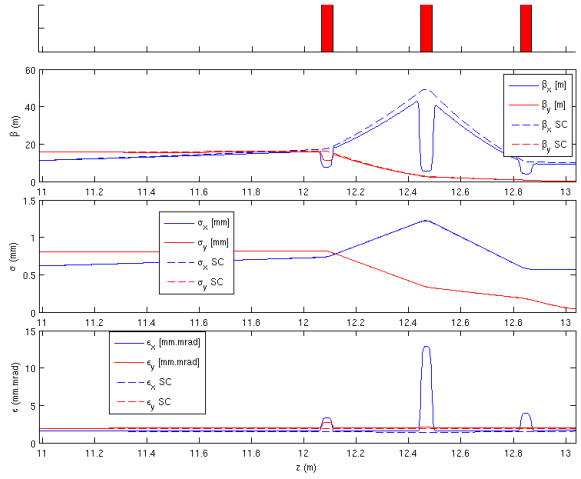
Flattop: booster to TDS



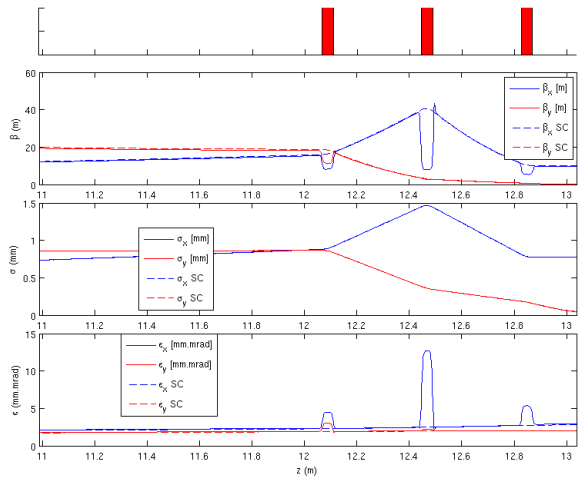
Ellipsoidal: booster to TDS



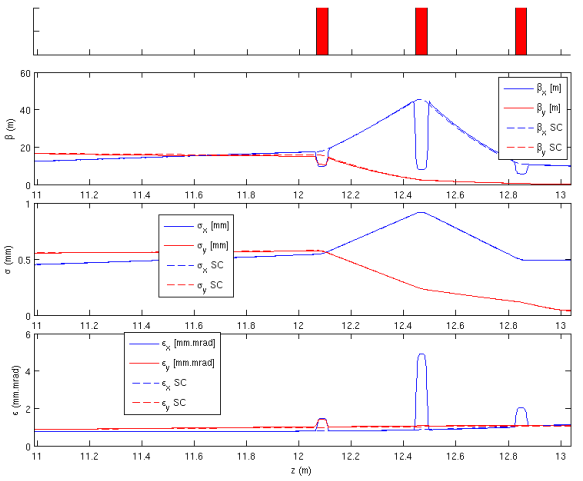
Gaussian: TDS to PST.Scr2



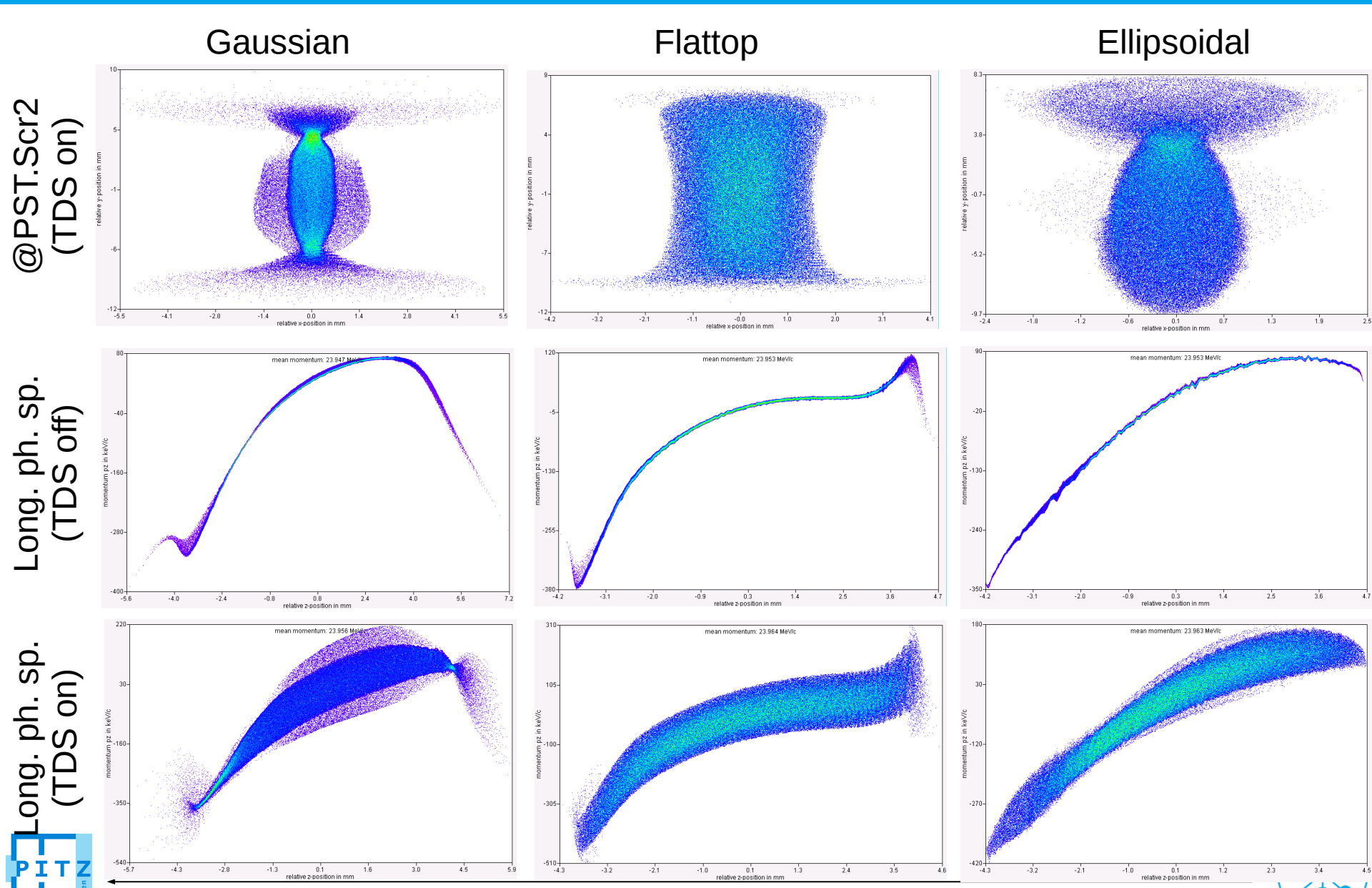
Flattop: TDS to PST.Scr2



Ellipsoidal: TDS to PST.Scr2

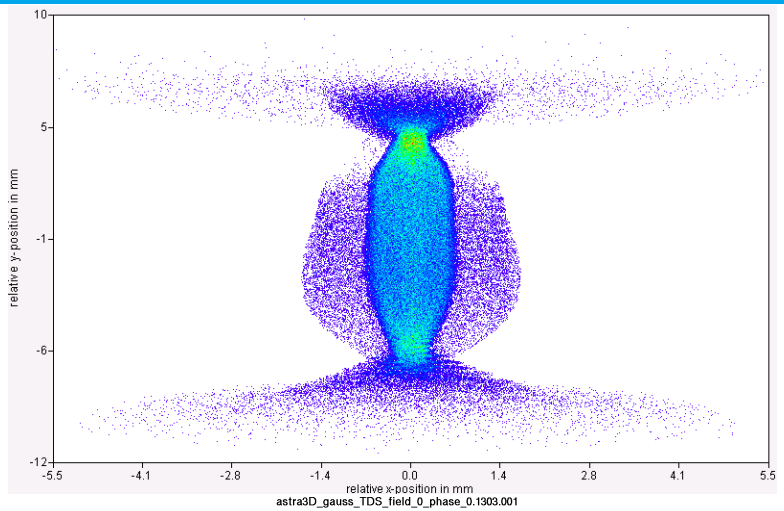


Results of simulated TDS measurement

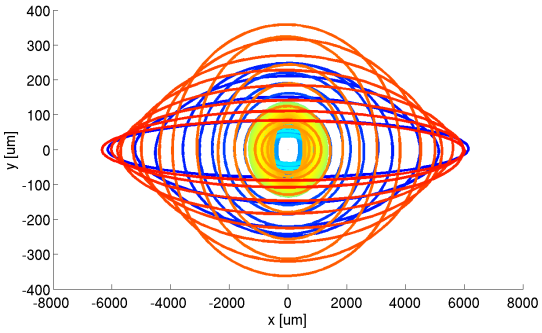


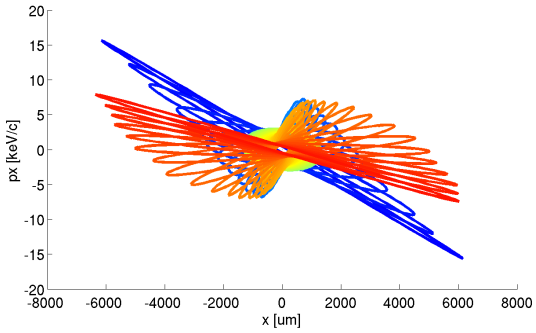
Gaussian: TDS measurements and slice parameters

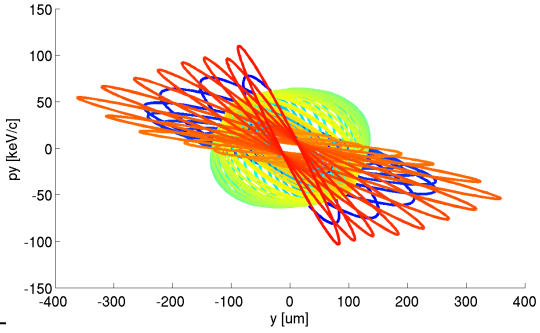
@PST.Scr2
(TDS on)

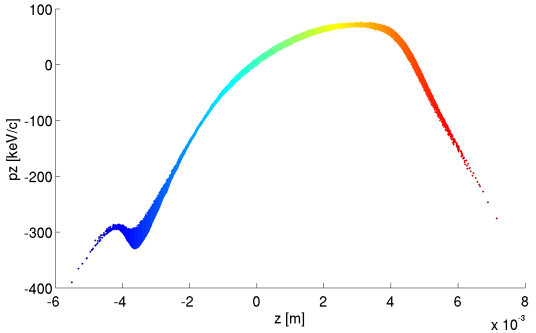


Slice parameters @PST.Scr2
(TDS off)



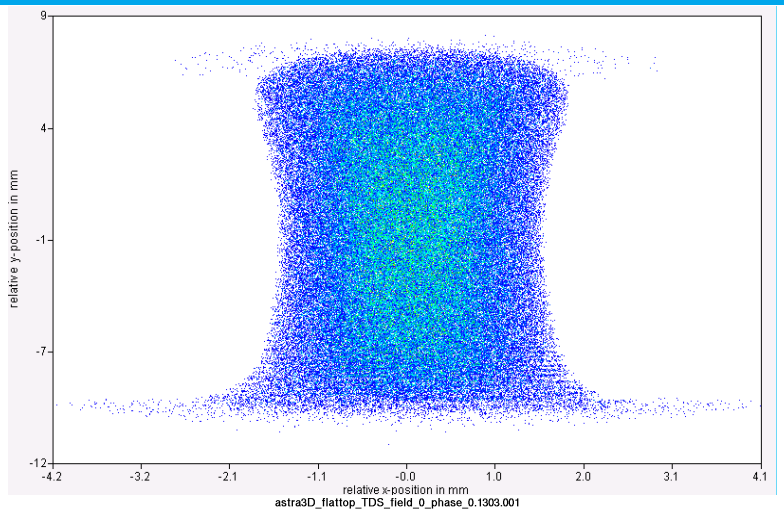




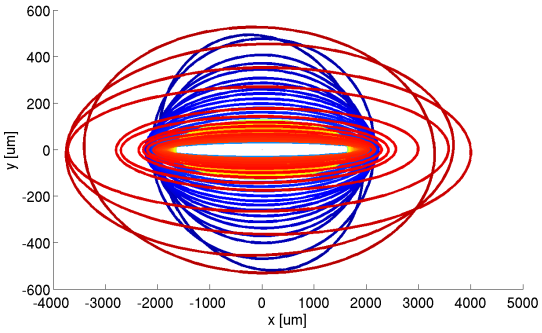


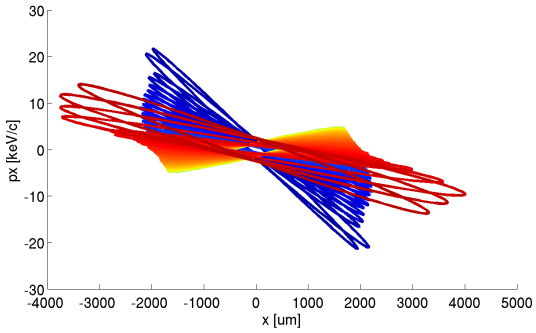
Flattop: TDS measurements and slice parameters

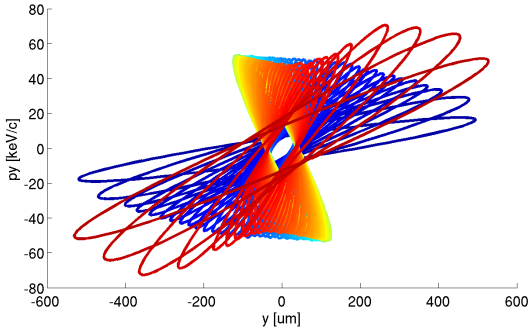
@PST.Scr2 (TDS on)

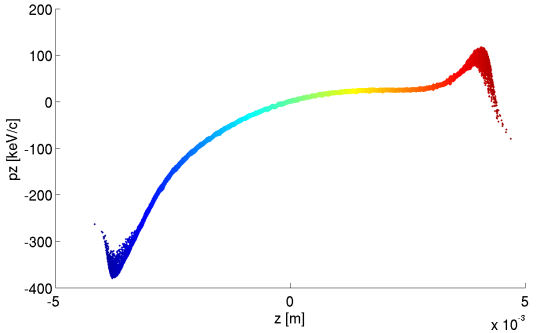


Slice parameters @PST.Scr2 (TDS off)



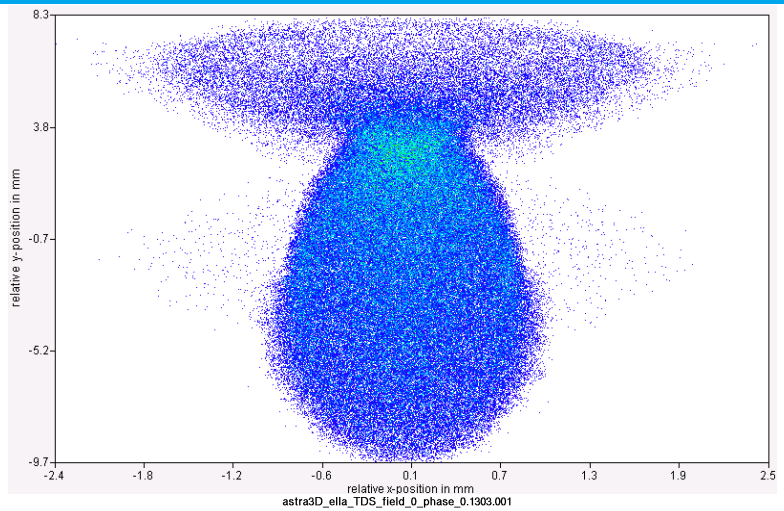




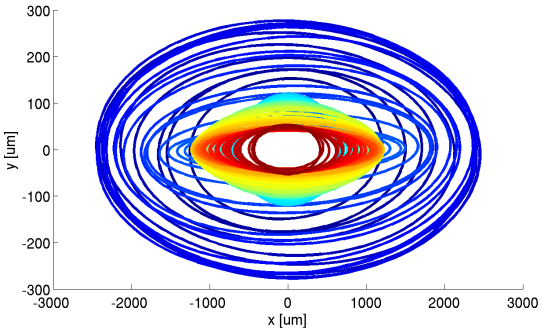


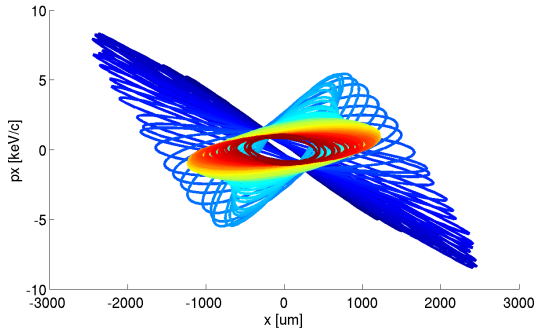
Ellipsoidal: TDS measurements and slice parameters

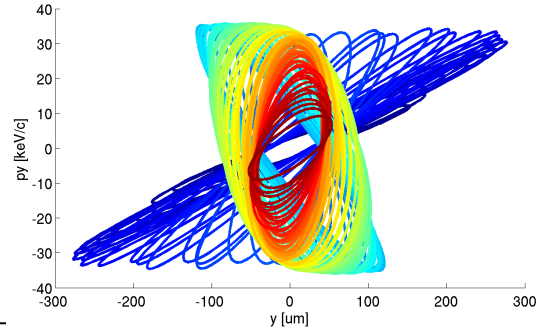
@PST.Scr2 (TDS on)

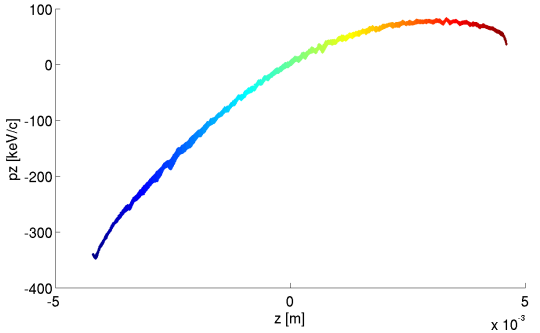


Slice parameters @PST.Scr2 (TDS off)



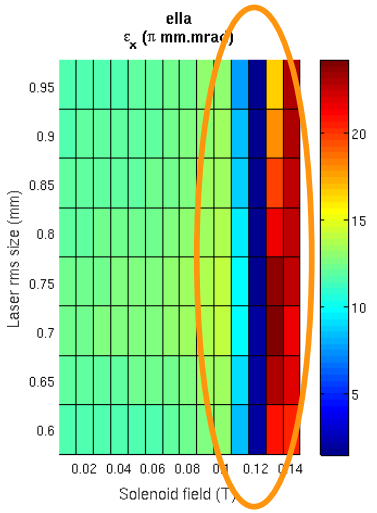


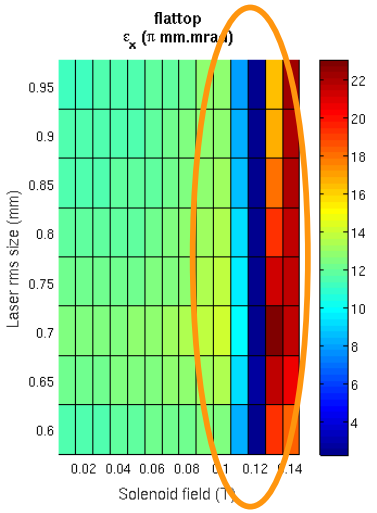


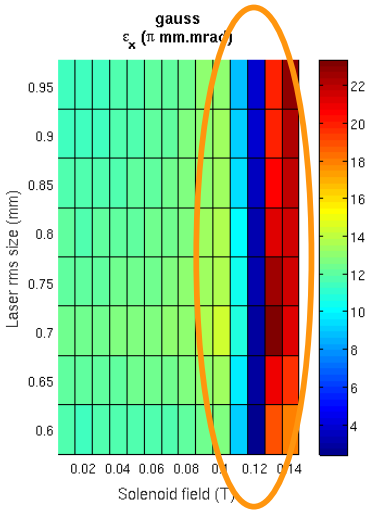


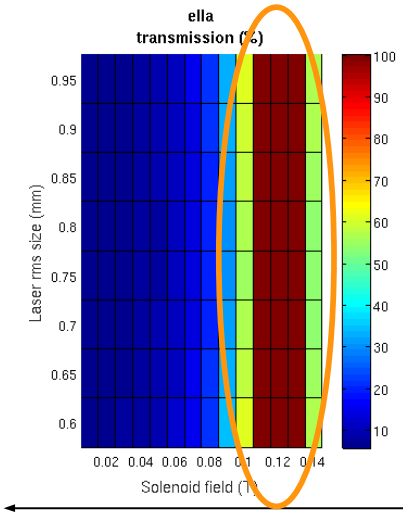
Emittance optimisation with 3 laser shapes at 30MV/m

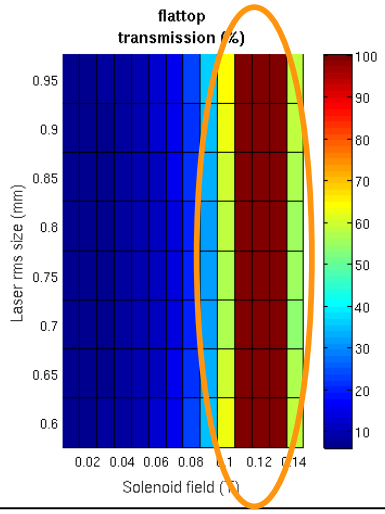
- Look at emittance at EMSY1 while scanning solenoid current and laser size on the cathode. Rough scan first.

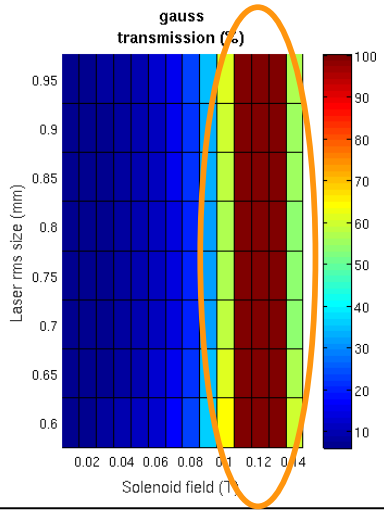






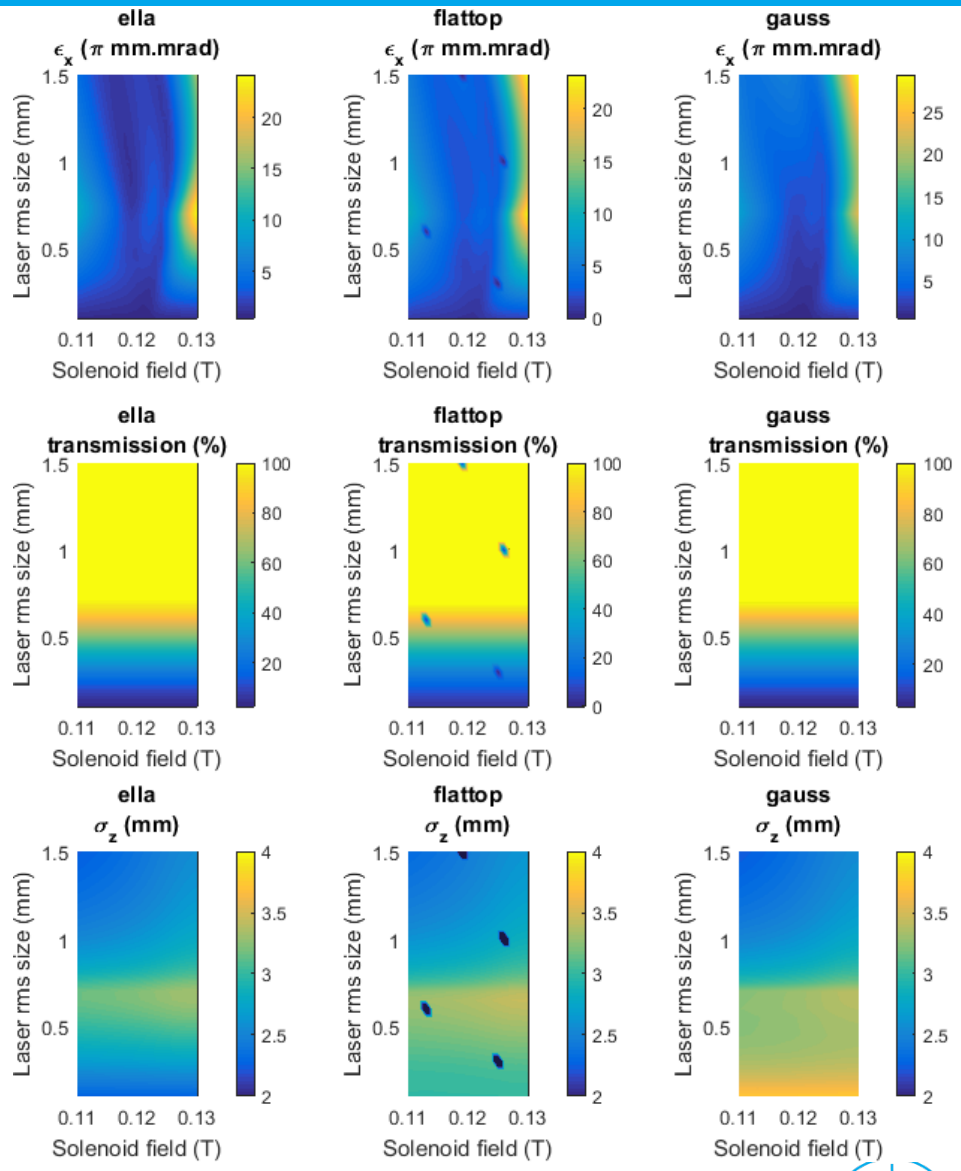






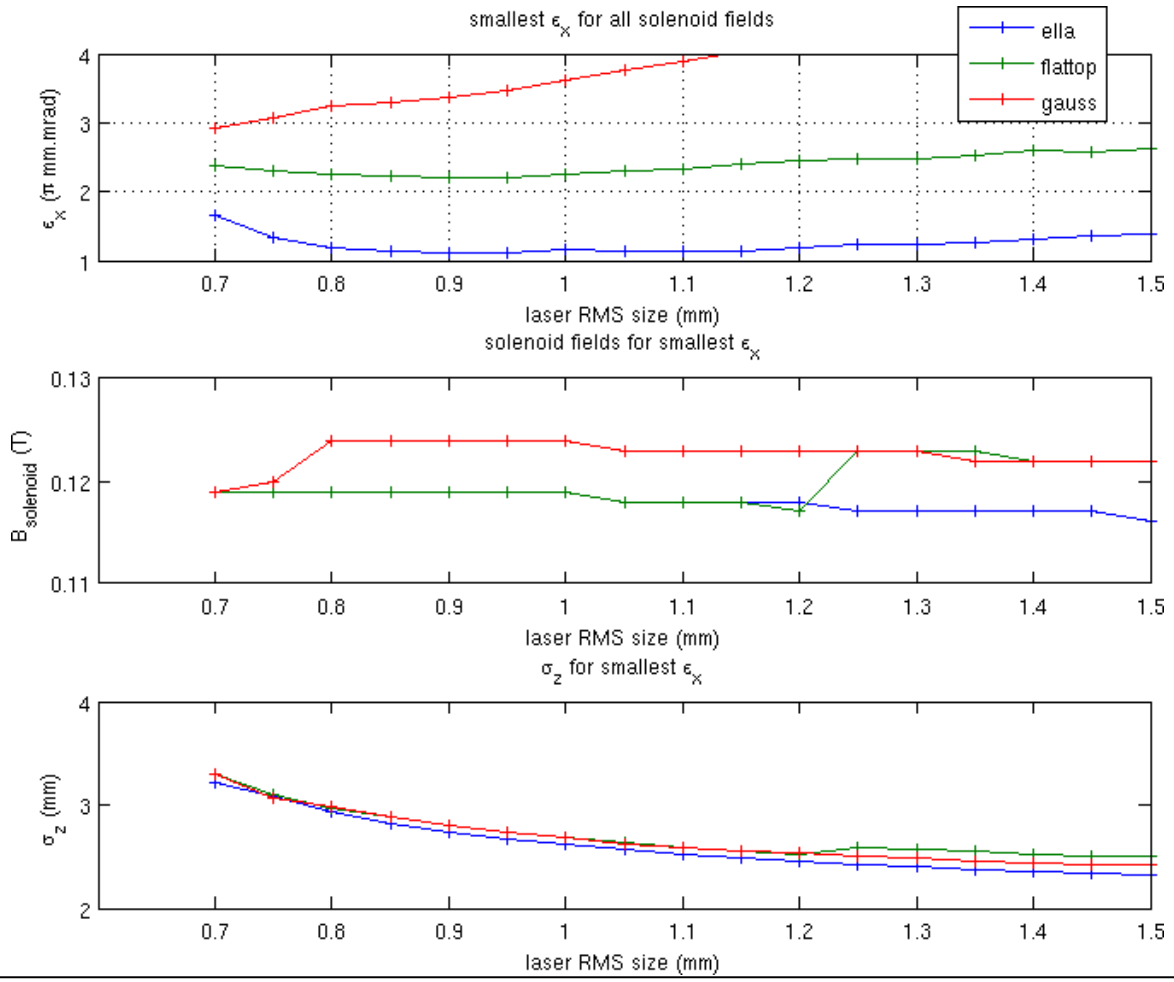
Emittance optimisation with 3 laser shapes at 30MV/m

- Look at emittance at EMSY1 while scanning solenoid current and laser size on the cathode.
- Blue dots are failed simulations
- Small laser size on the cathode => big loss during emission in ASTRA
- Scripts (to start jobs and analyze results) available in:
  /doocs/data/yrenier/sim1/astra/PITZ/scan_solenoid/30MV



Emittance optimisation with 3 laser shapes at 30MV/m

- Plot only if transmission > 95%
- For each laser size on the cathode, looks for the solenoid current giving the smallest emittance
- **Ellipsoidal laser has still a reasonable emittance despite the low gradient !**



Conclusions

- Optics matching using SC and ASTRA is possible, but long, difficult and not perfect.
- Reasonable emittance compensation using 13 quads achieved down to PST.Scr2.
- Shape of the streaked beam on PST.Scr2 is still dominated by beam slices parameters.

- Emittance optimization done for low gradient (30 MV/m).
- Ellipsoidal shows very promising results with emittance close to 1mm.mrad at that low gradient