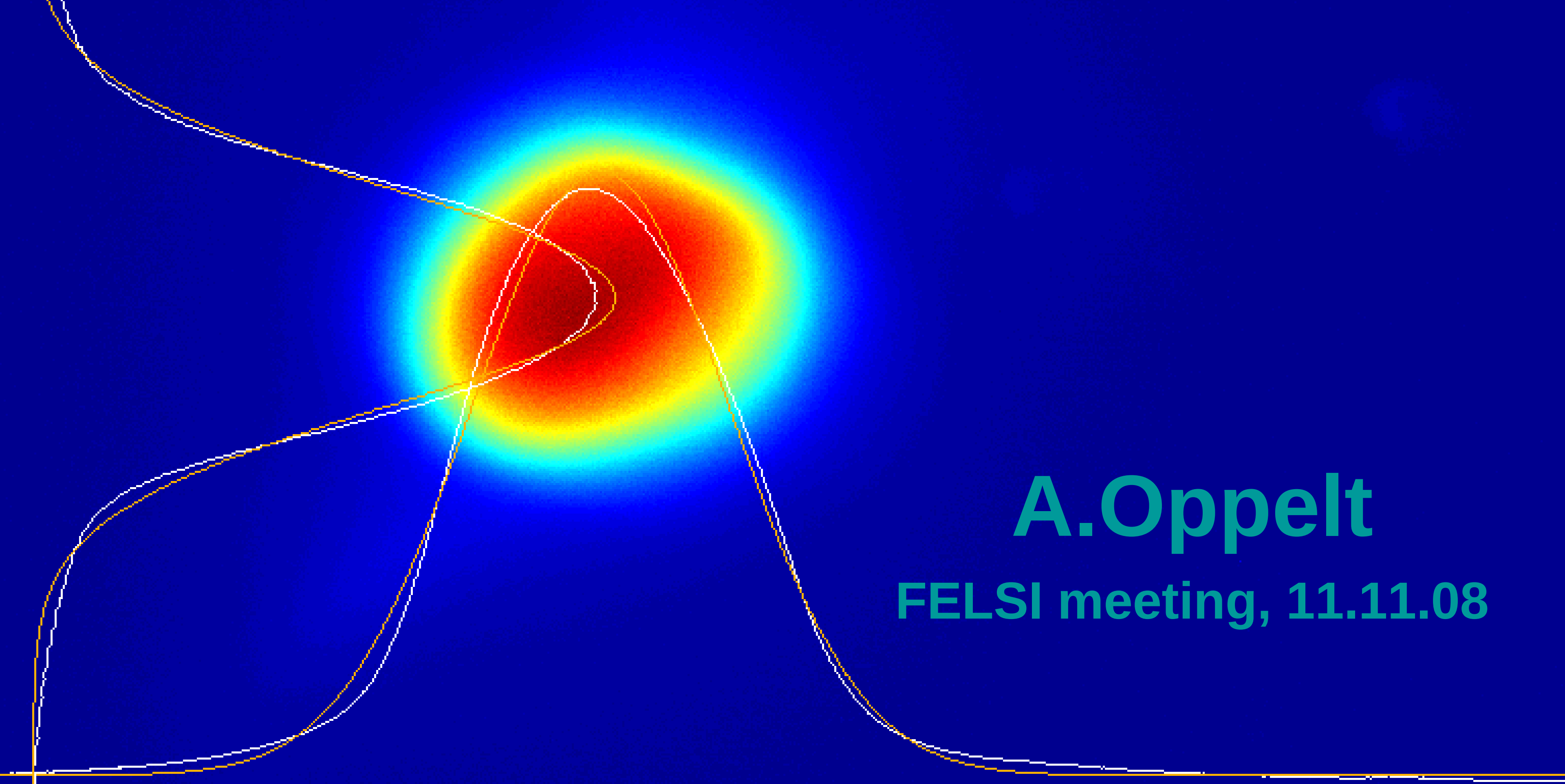
Part 2:
Comparison of measurements and simulations for OBLA-500keV



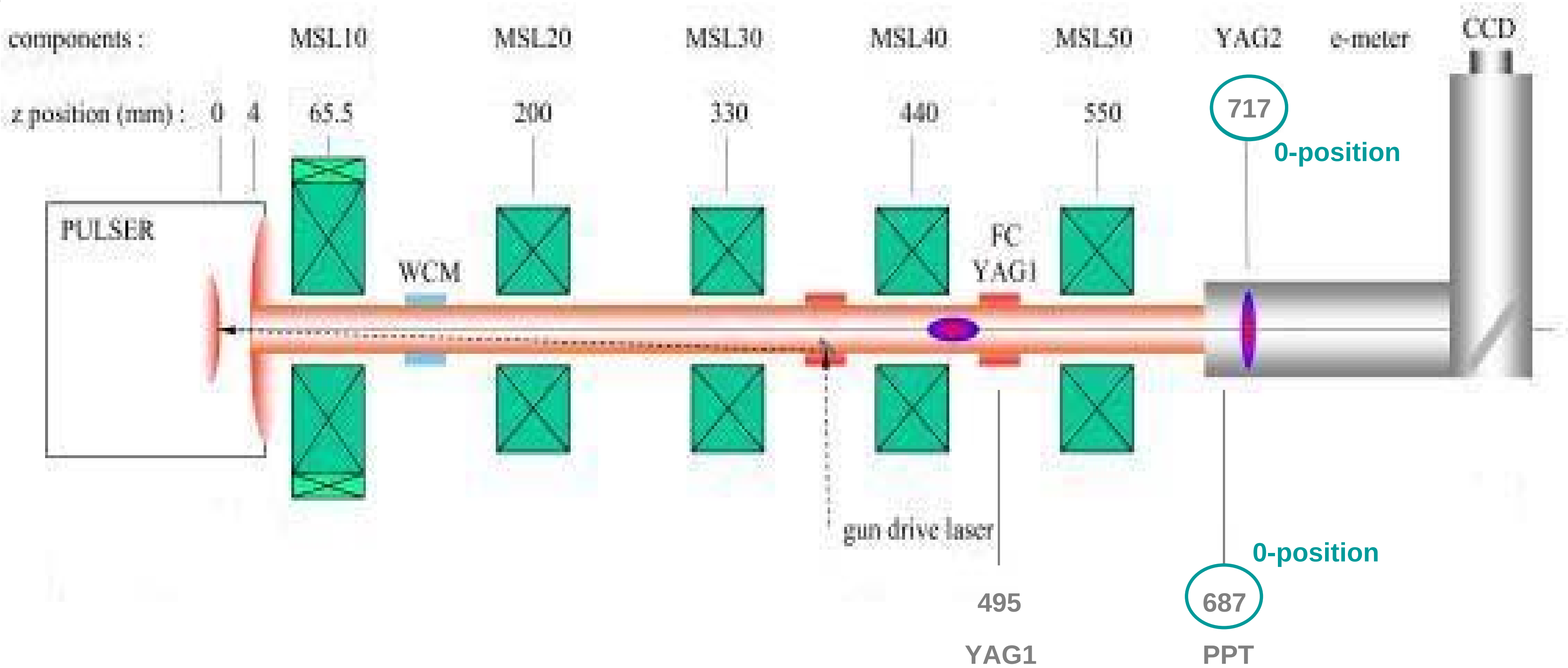
A.Oppelt

FELSI meeting, 11.11.08

General remarks

- a lot of data have been taken, but often major beam parameters are missing (e.g. laser) or the (magnet) settings have been changed within the measurement
  → we need to define precise measurement procedures
- machine stability was not great, i.e. often at least the charge changed during the measurements (this was only partly checked / recorded); parameters changed on a day-to-day basis
  → reproducibility issues forbid people to change important elements or settings without agreement; e.g. the laser beamline is a ‘holy cow’
- BBA of laser and solenoids was not done and complicates machine operation (i.e. beam steering with current change; additional steerers have to be used)
  → it is mandatory in the future !
- useful measurements (to be reproduced in simulations) of beam sizes and emittances have been done on
  22.07. / 18.+19.8. / 22.8. / 2.+3.10.

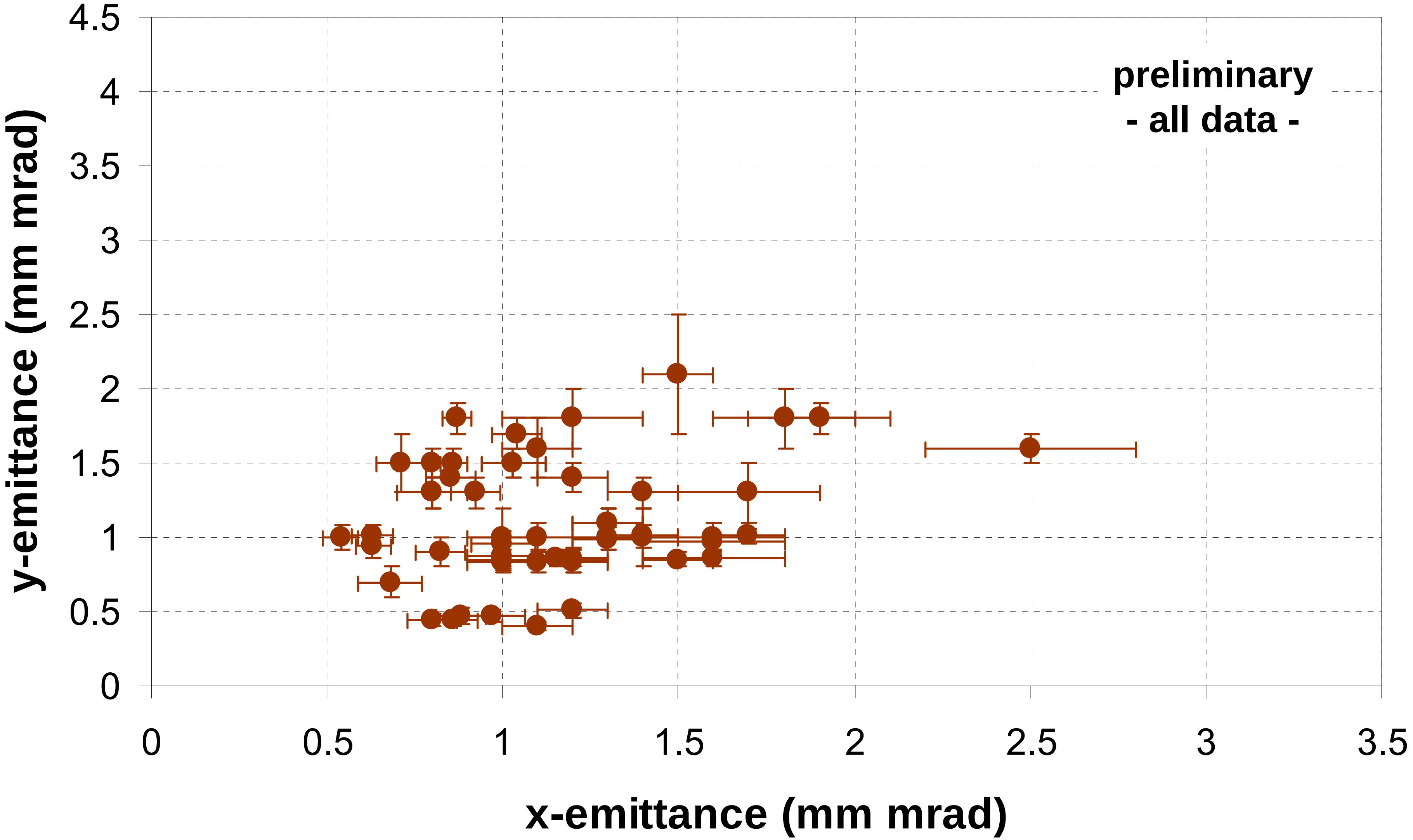
OBLA 500keV setup



Notes:

1. It's more convenient to use the anode as reference position !
2. Positions in the emittance meter are not very precisely defined. (reproducibility within a few mm)

Normalized emittance results



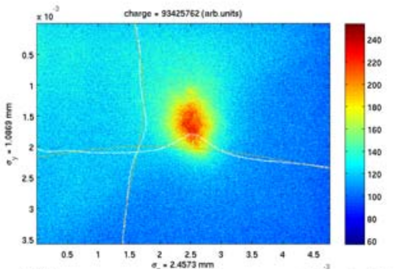
Issues: measurement vs. simulation

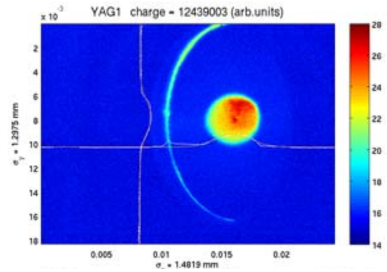
Measurement:

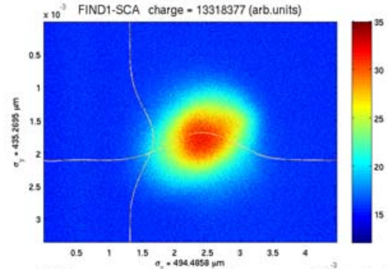
- apply different emittance calculation algorithms to the data to verify stability of XanaROOT algorithms
- need to cross-check XanaROOT results with simulations to verify emittance results (simple PPT model now implemented in OPAL)
- YAG1 resolution: 50...100 µm / YAG2 resolution: ~12 µm
- positioning reproducibility of YAG2 and PPT: few mm
- …

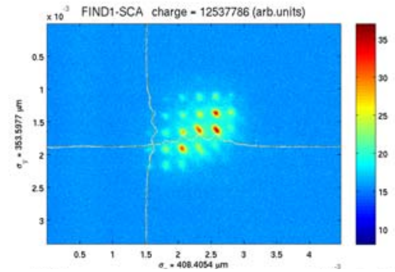
Simulation:

- anode hole (aperture) vs. laser distribution cut
- Used cathode-anode field profiles do partly not correspond to reality ('*simplified simplified*' = flat cathode vs. new design)
- halo in simulation vs. reality (i.e. depending on camera settings ?)
- …

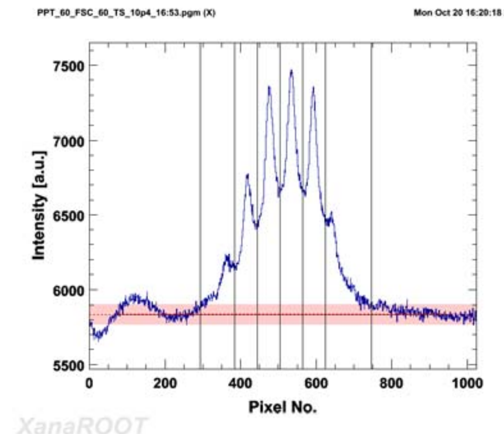






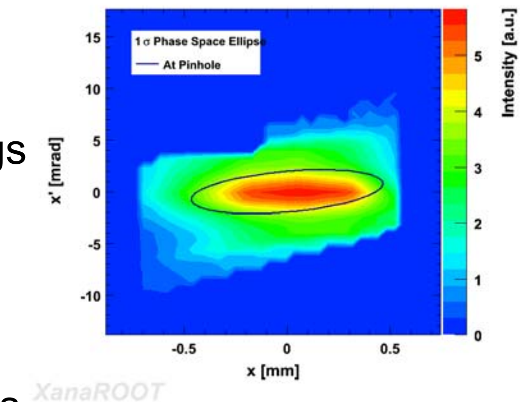


<u>22.7.2008</u> electrodes: SS hand-polished, after breakdowns
pulser: 313 kV, 7 mm → 44.7 MV/m
laser: Duettino, σ_x = 330 µm, σ_y = 370 µm
charge: 19.0...20.8 pC
solenoids (A): 28.7/15/10/38/0
YAG1: z = 491 mm, σ_x = 1.5 mm, σ_y = 1.3 mm
YAG2: z = 773 mm, σ_x = 494 µm, σ_y = 435 µm
PPT: z = 743 mm, σ_x = 0.47 mm, σ_y = 0.37 mm,
ε_x = 0.86 µm, ε_y = 0.89 µm



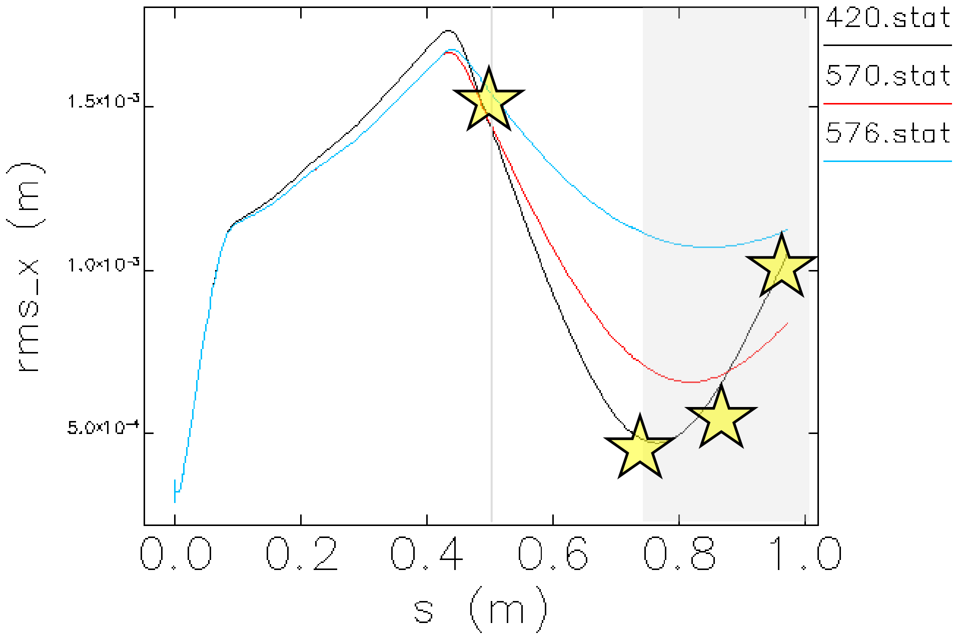
further emittance measurements with changed magnet settings

in addition to emittance measurements:
envelope scan on YAG2 between z = 773...953 mm

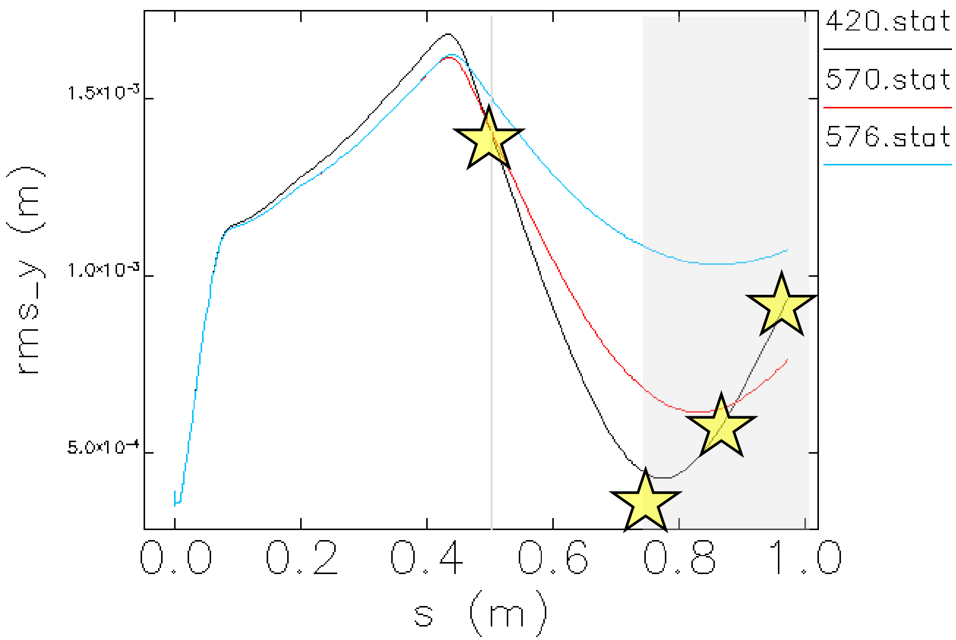


Problems: - no statistics for error estimation of beam size measurements
- beam size measurement at PPT position using PPT image may underestimate ε
- halo in simulation vs. reality (may show up, depending on camera settings)

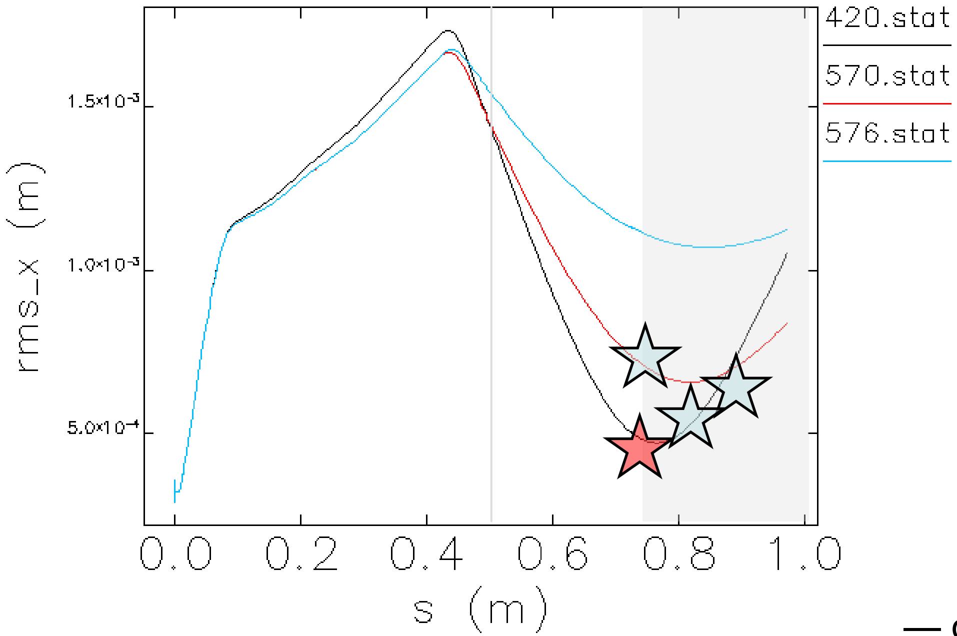
Conclusion: We need much more simulations to understand our emittance measurements !

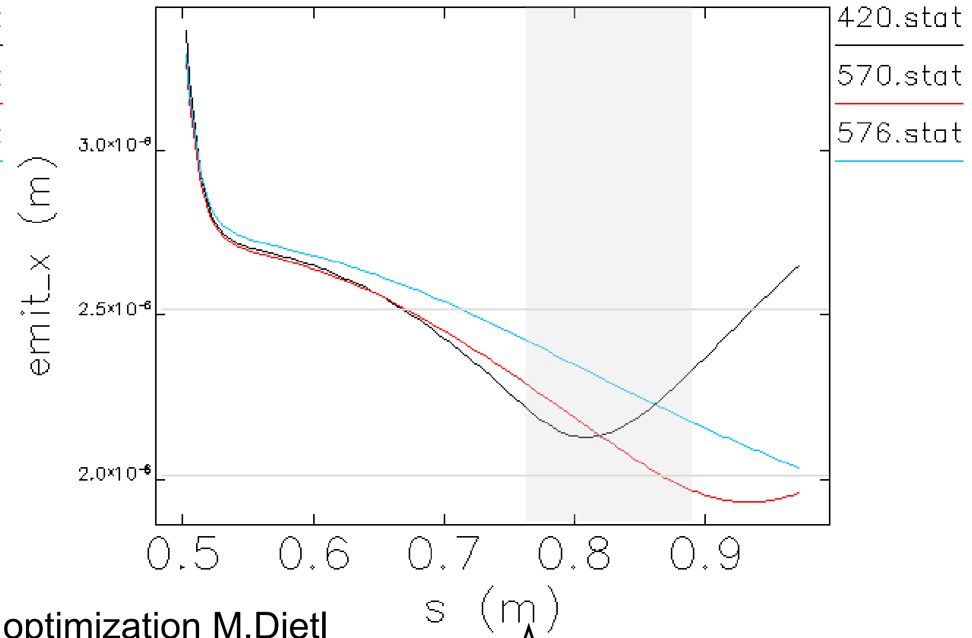


OPAL simulation vs. measurement data



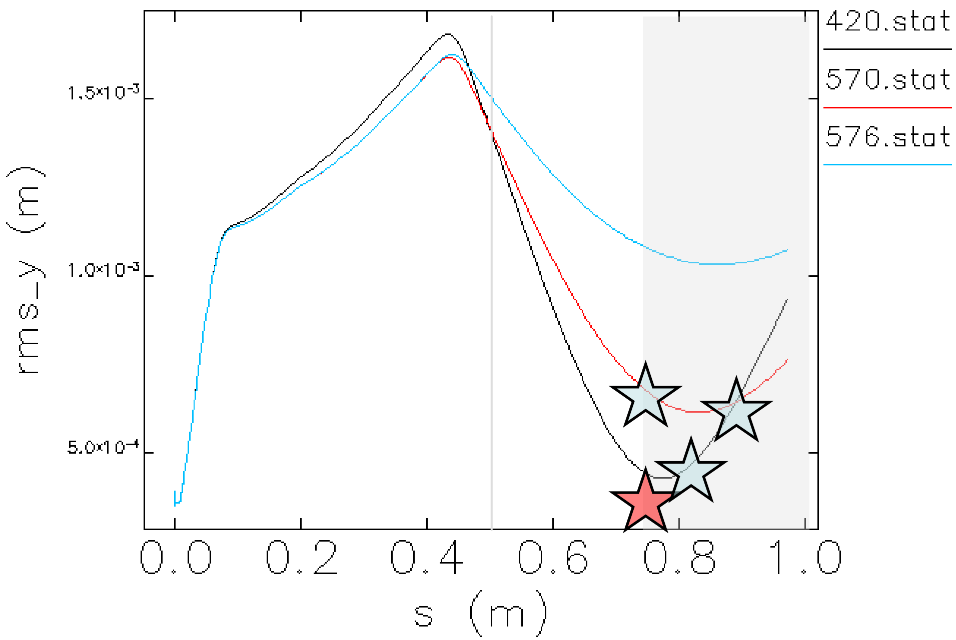
— optimization M.Dietl
— envelope scan settings
— emittance measurements

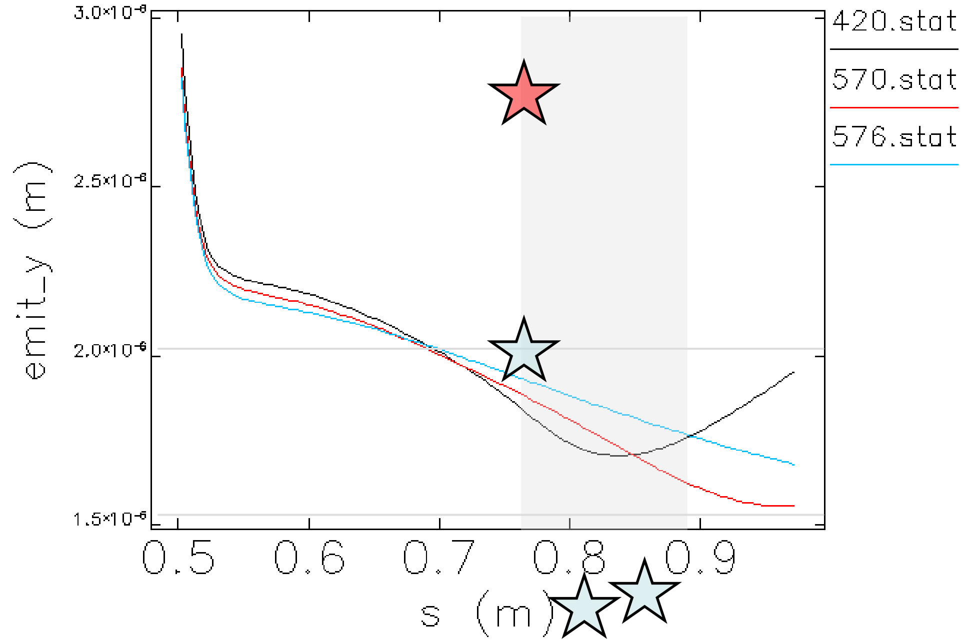


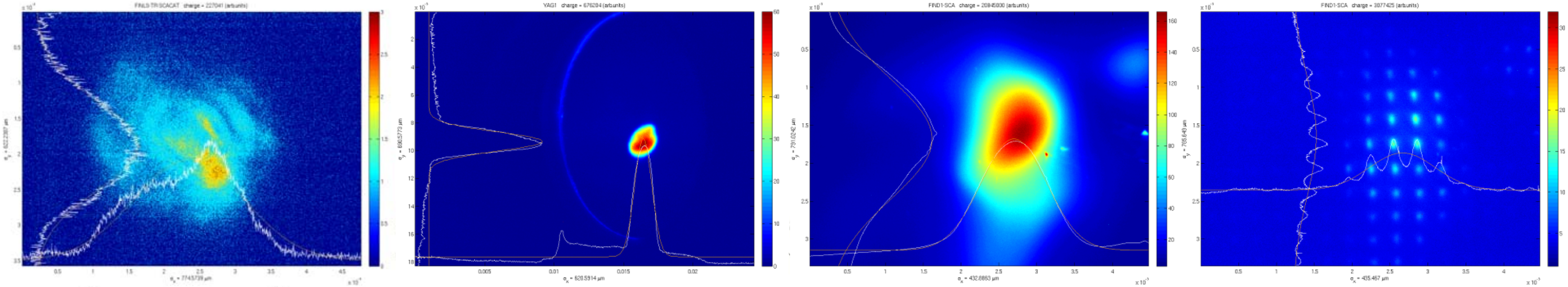


OPAL vs. XanaROOT calculation

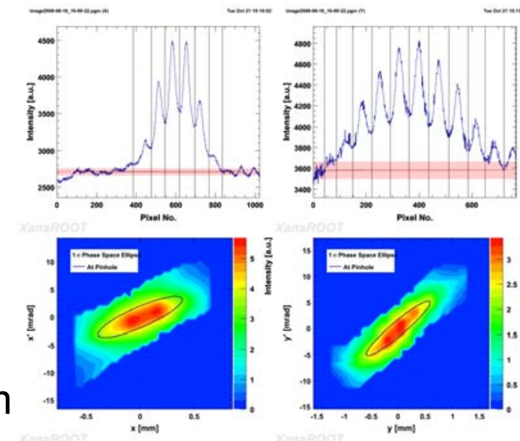
— optimization M.Dietl
— envelope scan settings
— emittance measurements



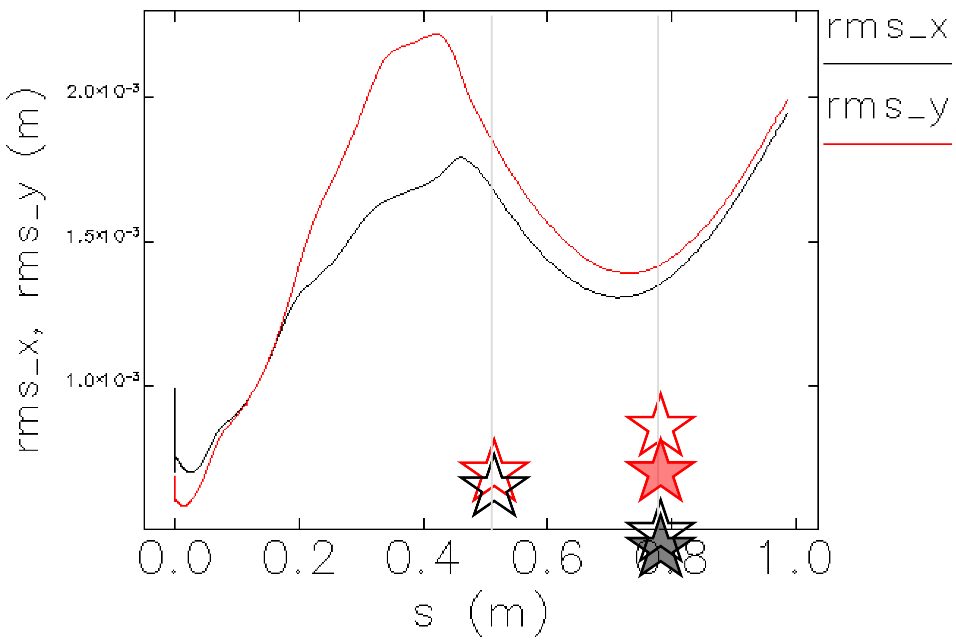


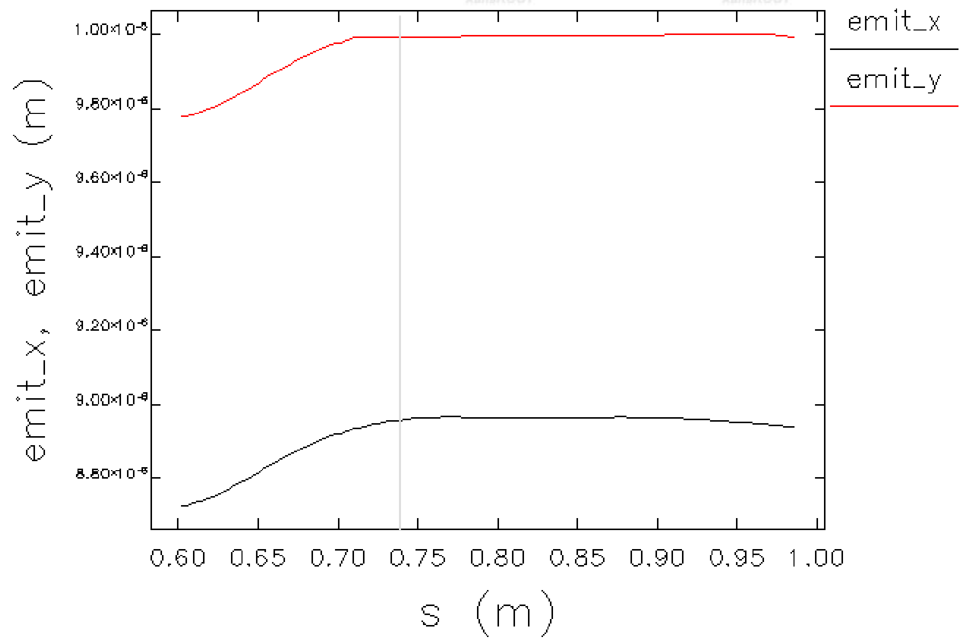


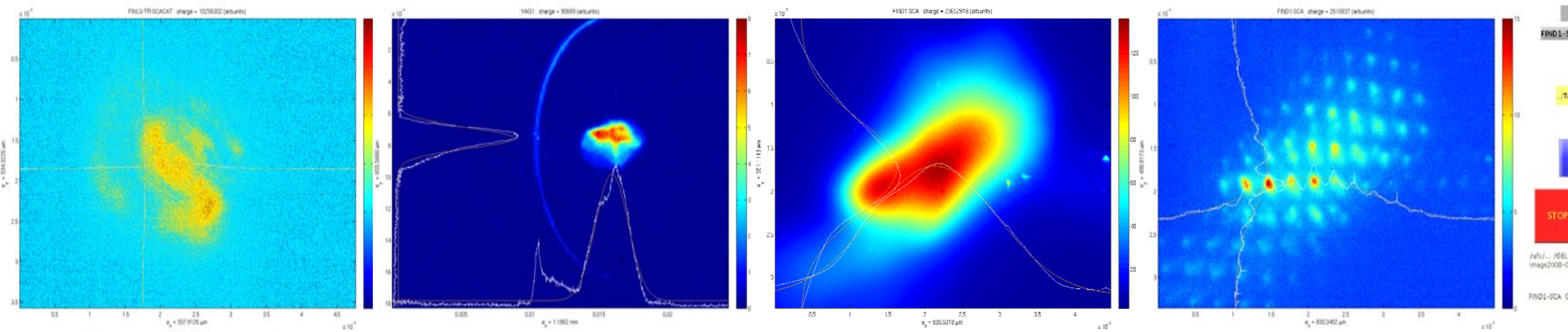
18.8.2008 electrodes: fresh SS M5-M10, hand-polished, no breakdowns
pulser: 348 kV, 8 mm → 43.5 MV/m
laser: Jaguar, 17 μJ, σ_x = 775 μm, σ_y = 622 μm (ugly spot)
charge: 10.4 pC
solenoids (A): 26.4/33/31/23/0
YAG1: z = 491 mm, σ_x = 621 μm, σ_y = 691 μm
YAG2: z = 773 mm, σ_x = 433 μm, σ_y = 791 μm

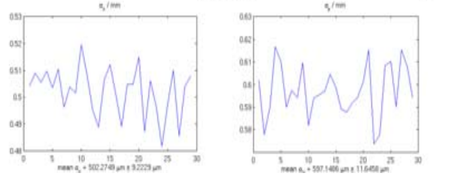


PPT: z = 743 mm, σ_x = 0.38 mm, σ_y = 0.73 mm, ε_x = 0.96 μm, ε_y = 2.0 μm



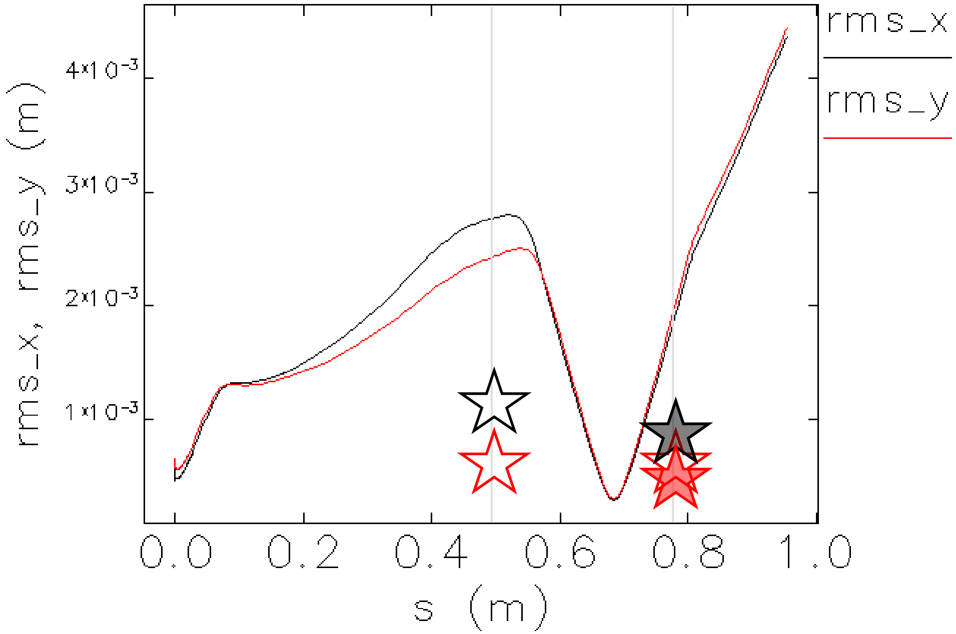


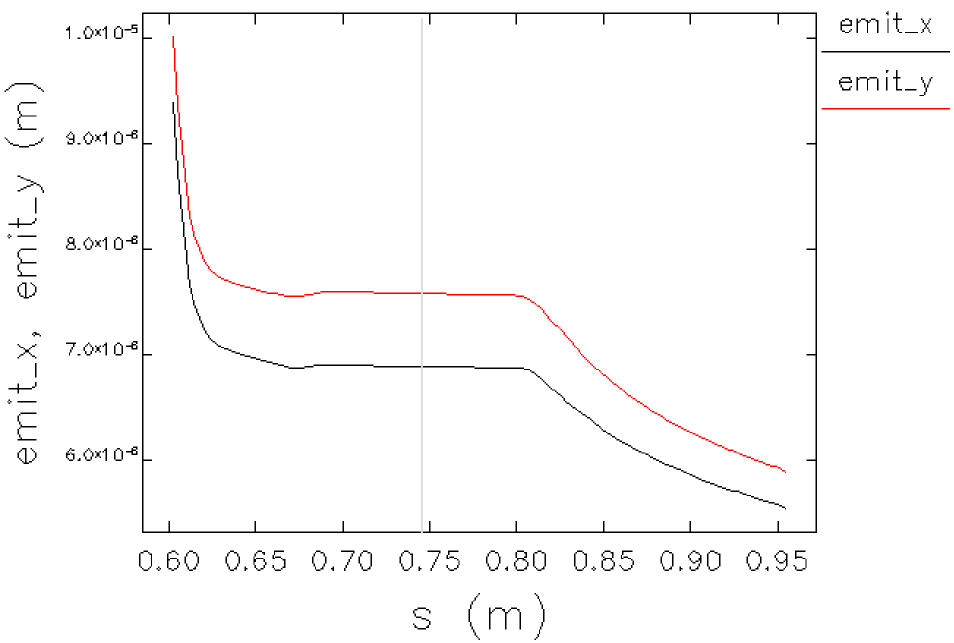


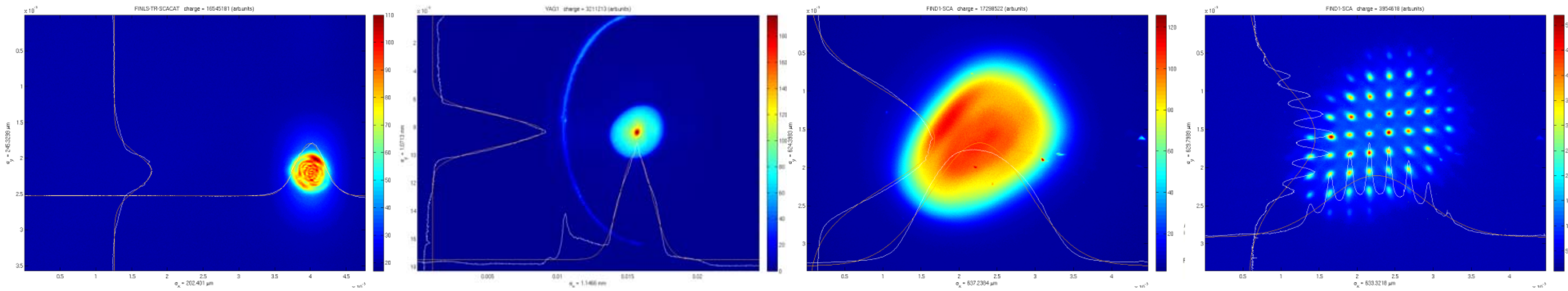


19.8.2008 electrodes: SS M5-M10, hand-polished, after breakdowns
pulser: 300 kV, 5 mm → 60 MV/m
laser: Jaguar, 18 μJ, σ_x = 508 μm, σ_y = 594 μm (ugly spot)
charge: 55.8 pC
solenoids (A): 29.8/14.8/7/18/60
YAG1: z = 491 mm, σ_x = 1186 μm, σ_y = 666 μm
YAG2: z = 773 mm, σ_x = 836 μm, σ_y = 551 μm
PPT: z = 743 mm, σ_x = 0.77 mm, σ_y = 0.37 mm, ε_x = 1.5 μm, ε_y = 1.1 μm

OPAL simulation vs. data:

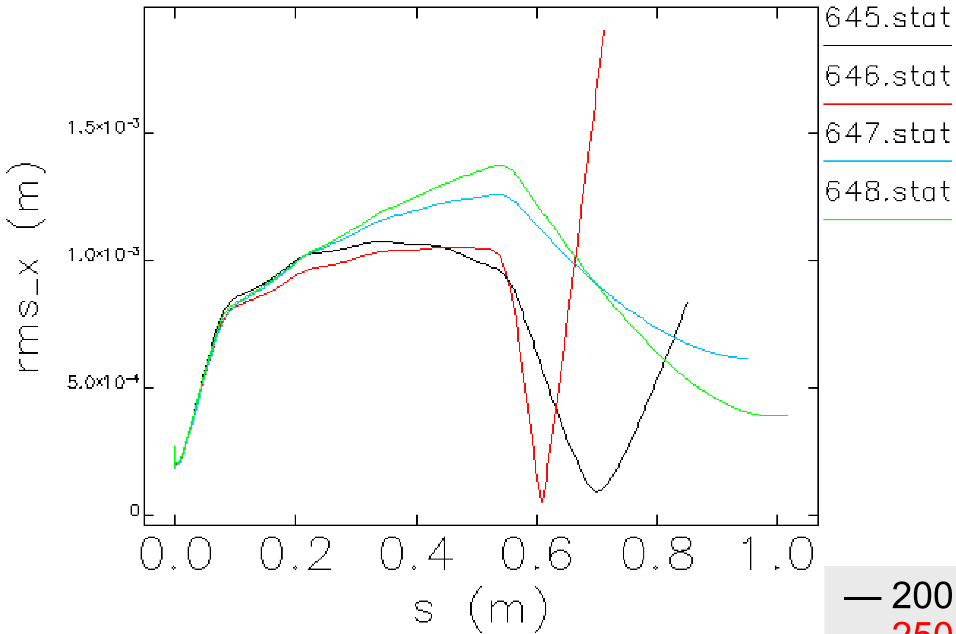


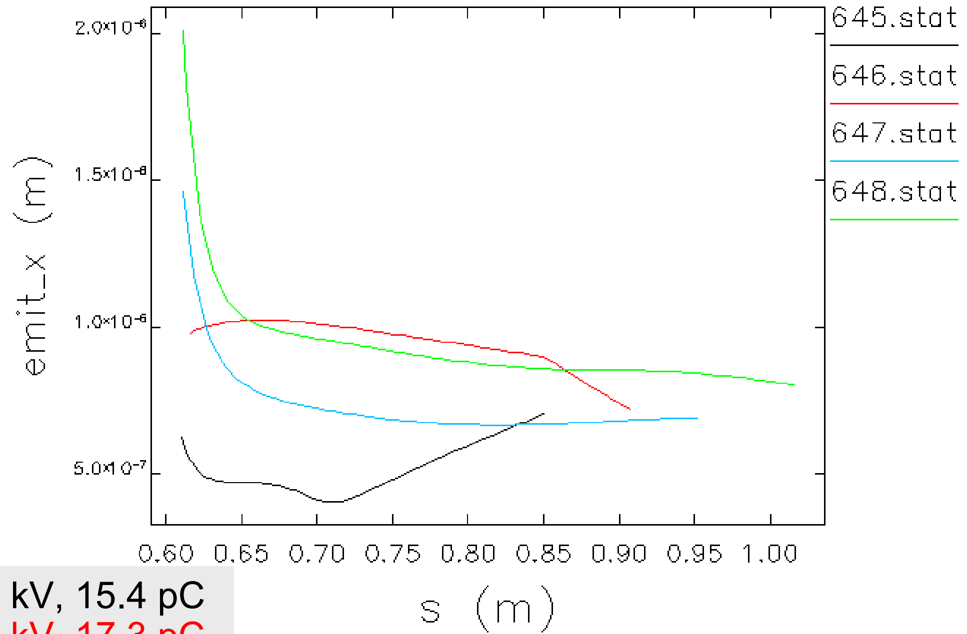




22.8.2008 electrodes: fresh OFE Cu 01/04, diamond-turned by Kugler, no breakdowns
laser: Jaguar, 2mm pinhole, 17 µJ (stable !), σ_x = 210 µm, σ_y = 240 µm
charge: 15...28 pC (QE increase with time ?!) / 54 pC
pulser: 200...400 kV, 6 (8) mm → 25...60 MV/m

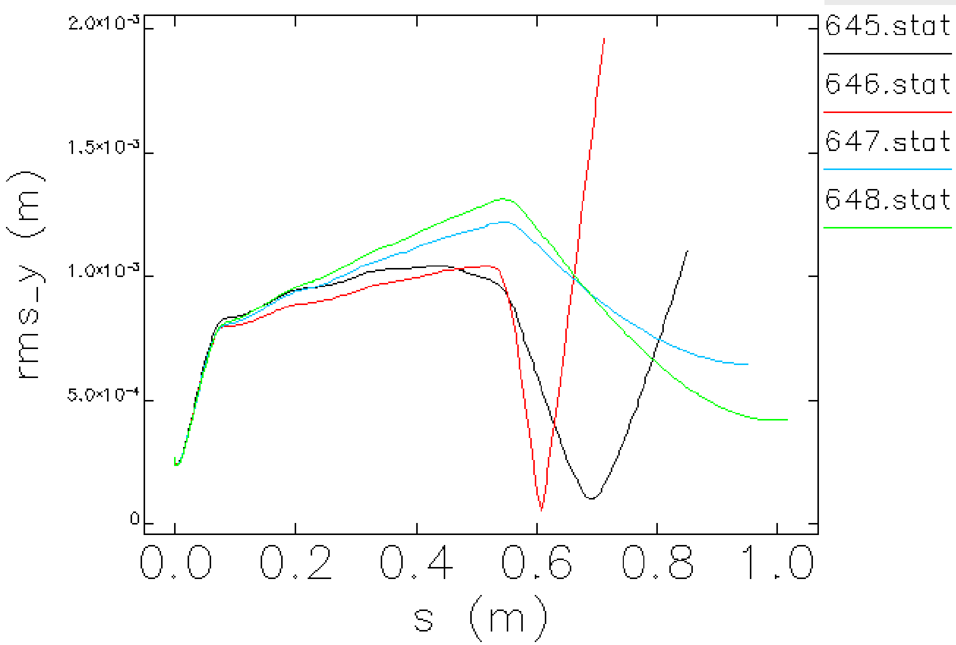
→ measured and calculated (by XanaROOT) beam sizes agree quite well
→ they are also not far from the expected values (including global behaviour)
→ but: calculated emittances are mostly far away from simulated values

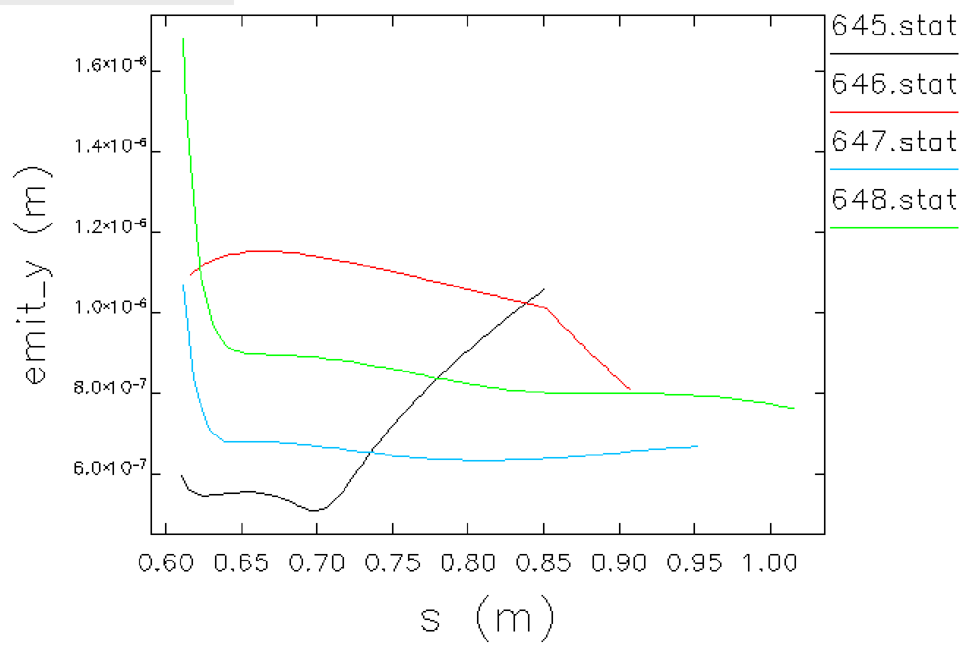


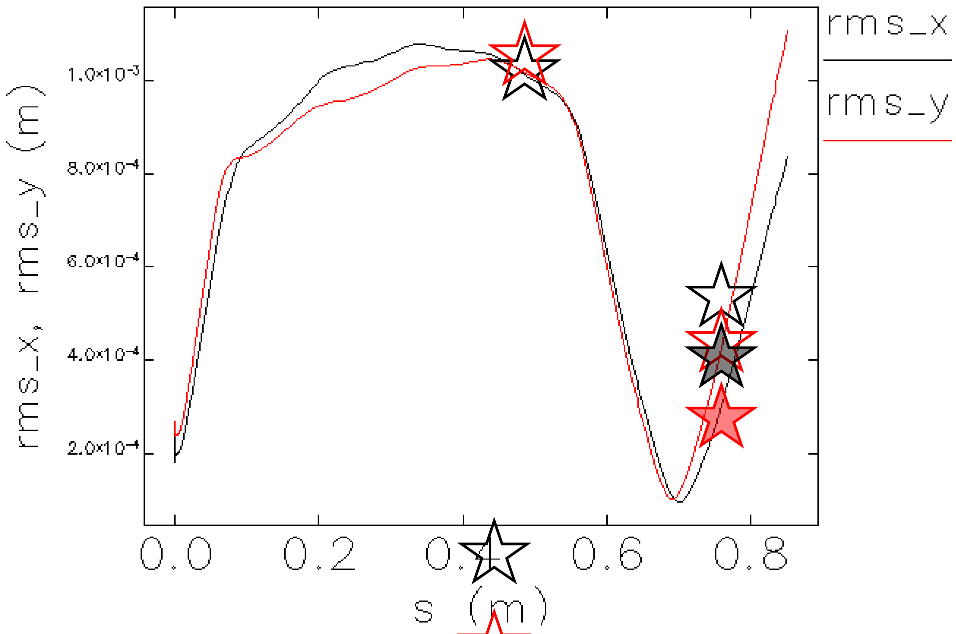


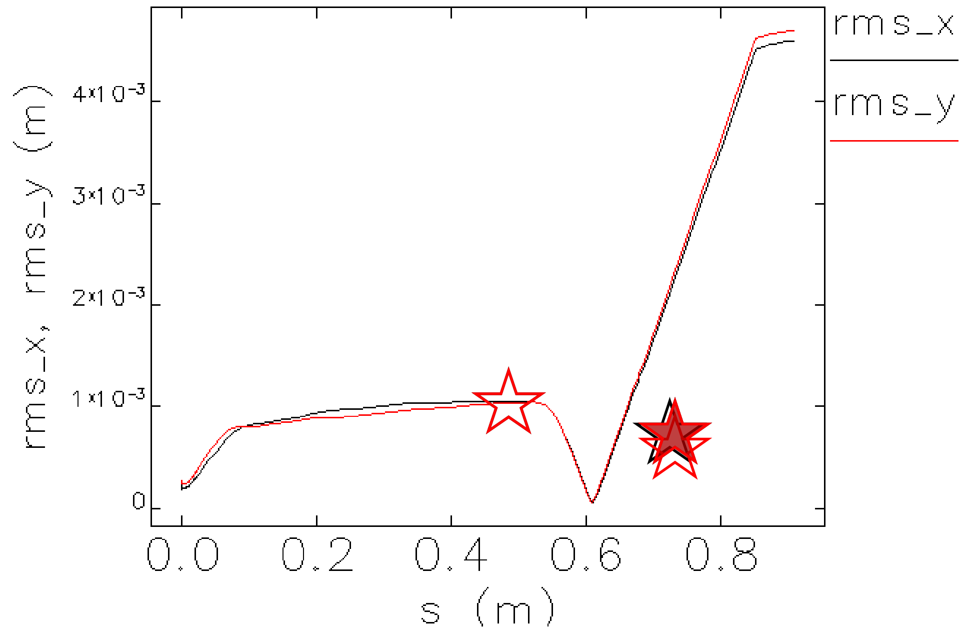
— 200 kV, 15.4 pC
— 250 kV, 17.3 pC
— 300 kV, 20.8 pC
— 400 kV, 28.4 pC

OPAL results (8 mm gap)



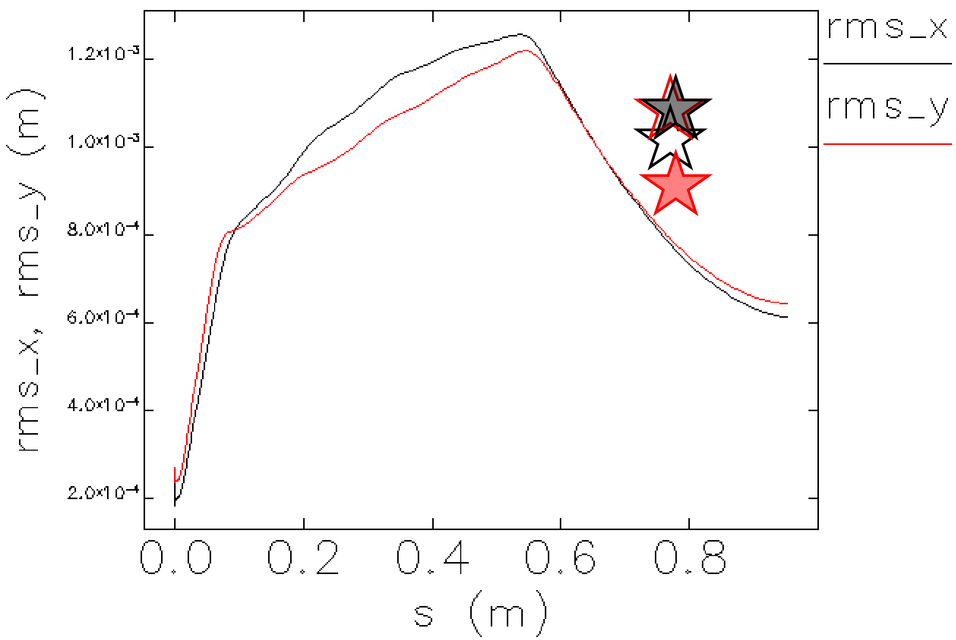


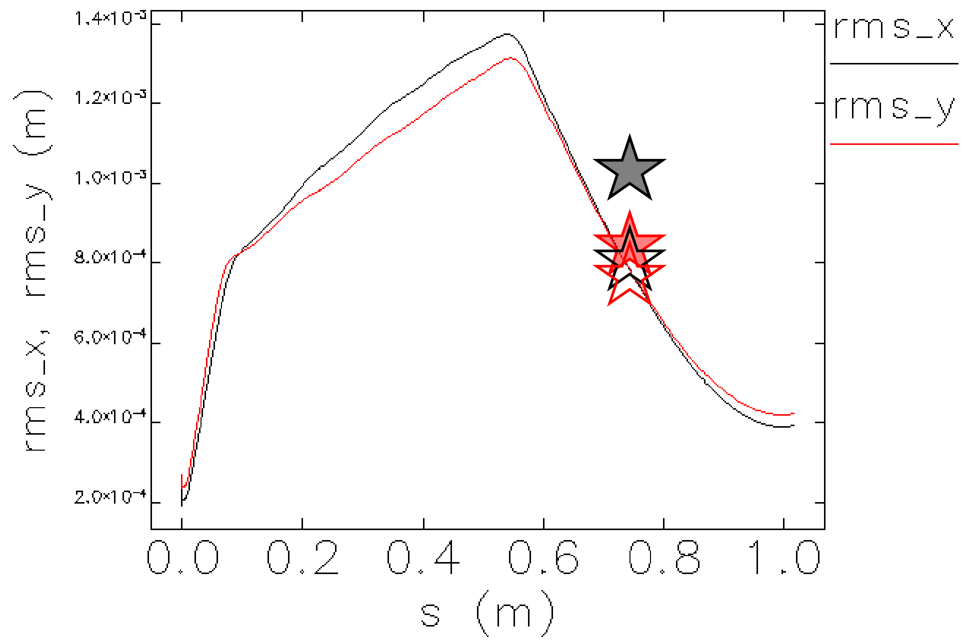


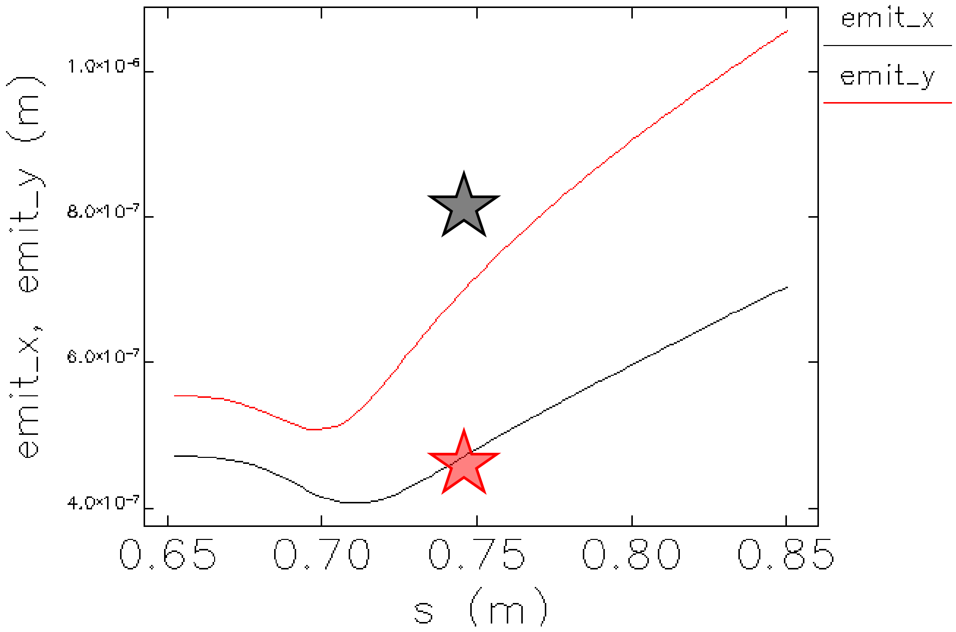


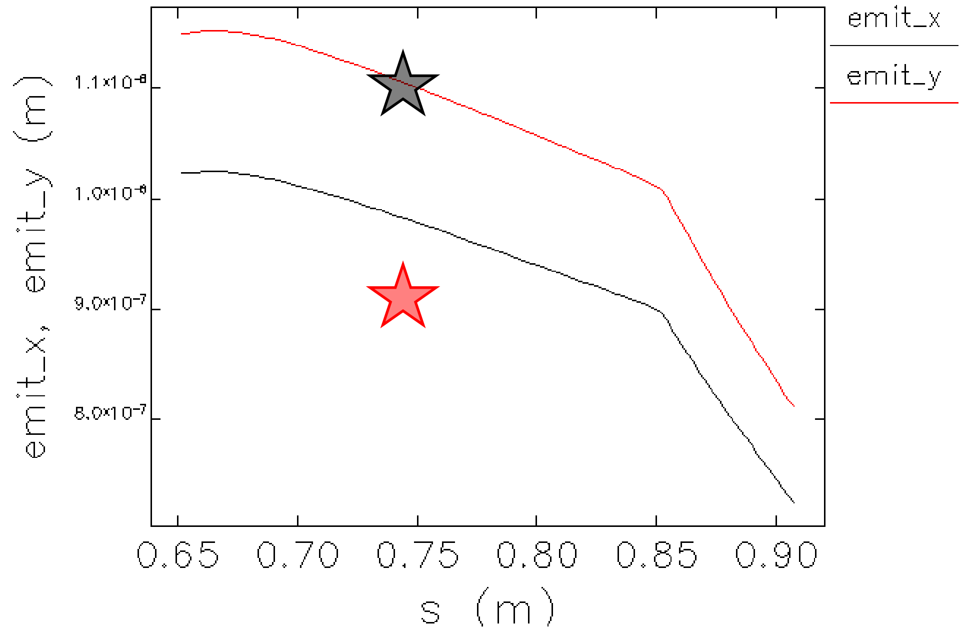
Beam size
8 mm gap

200 kV, 15.4 pC
250 kV, 17.3 pC
300 kV, 20.8 pC
400 kV, 28.4 pC



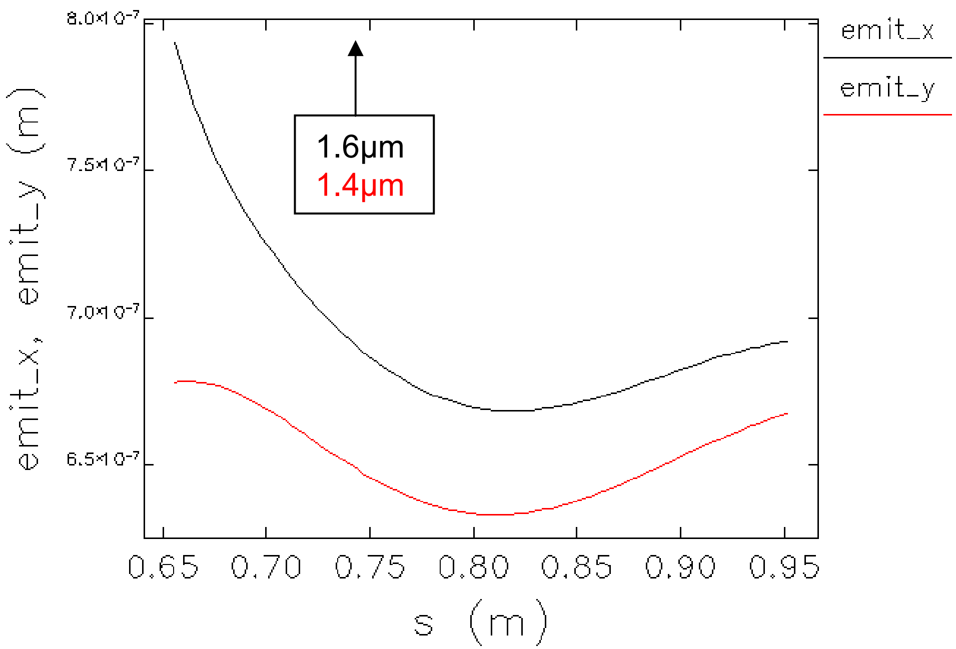


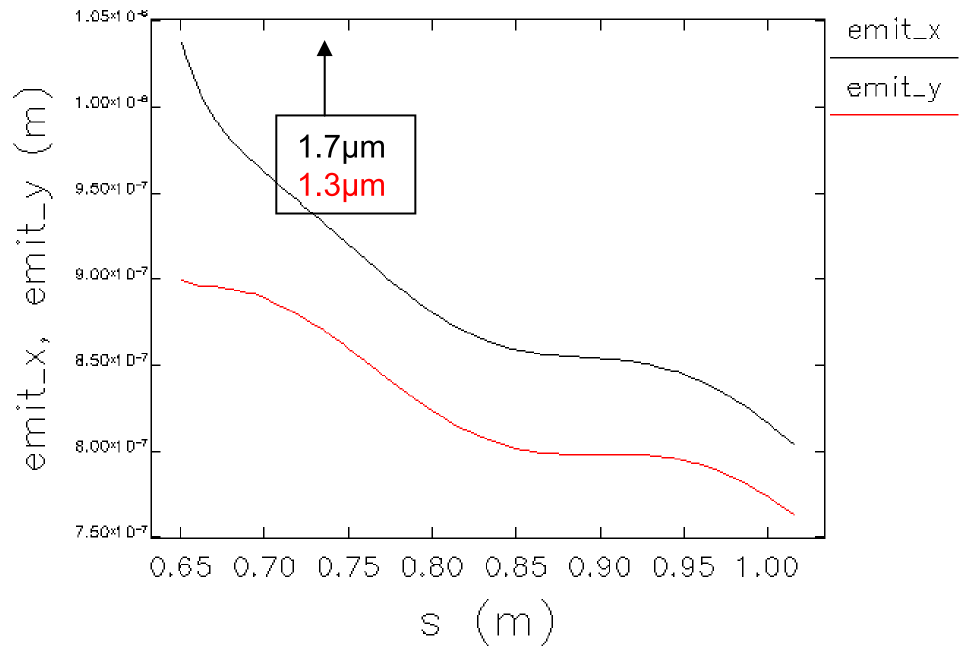


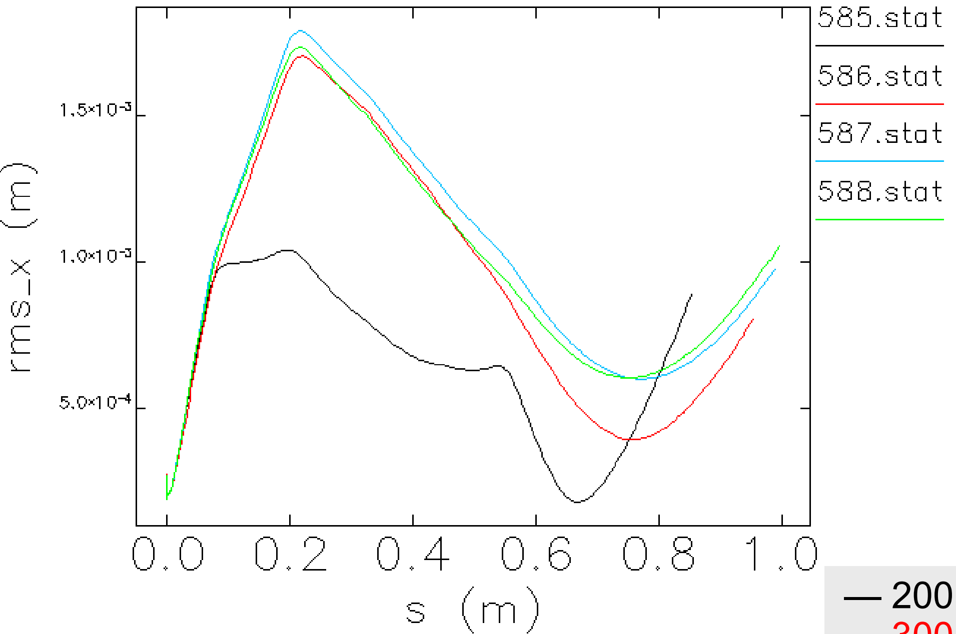


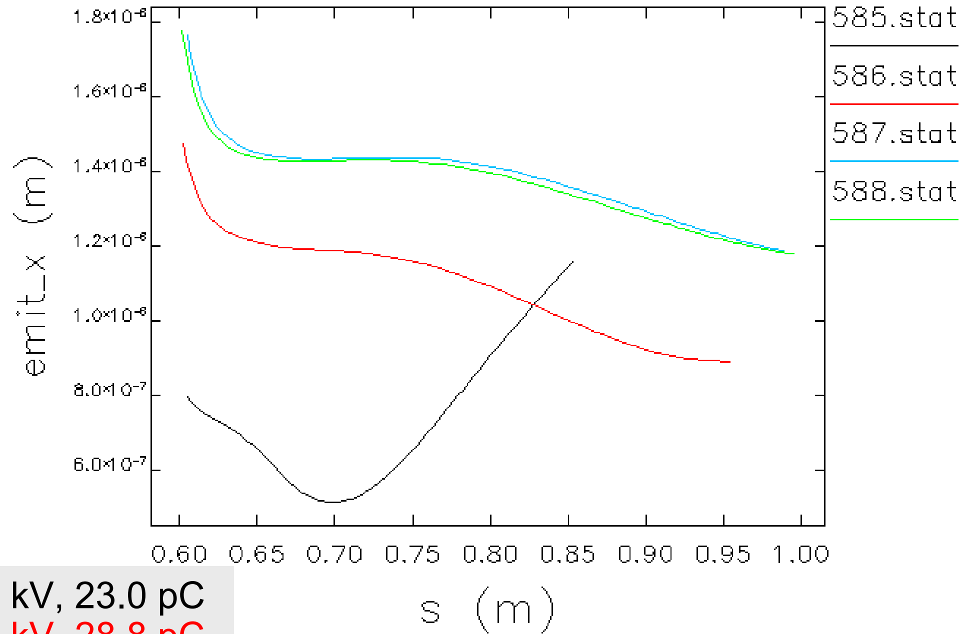
Emittance
8 mm gap

200 kV, 15.4 pC
250 kV, 17.3 pC
300 kV, 20.8 pC
400 kV, 28.4 pC



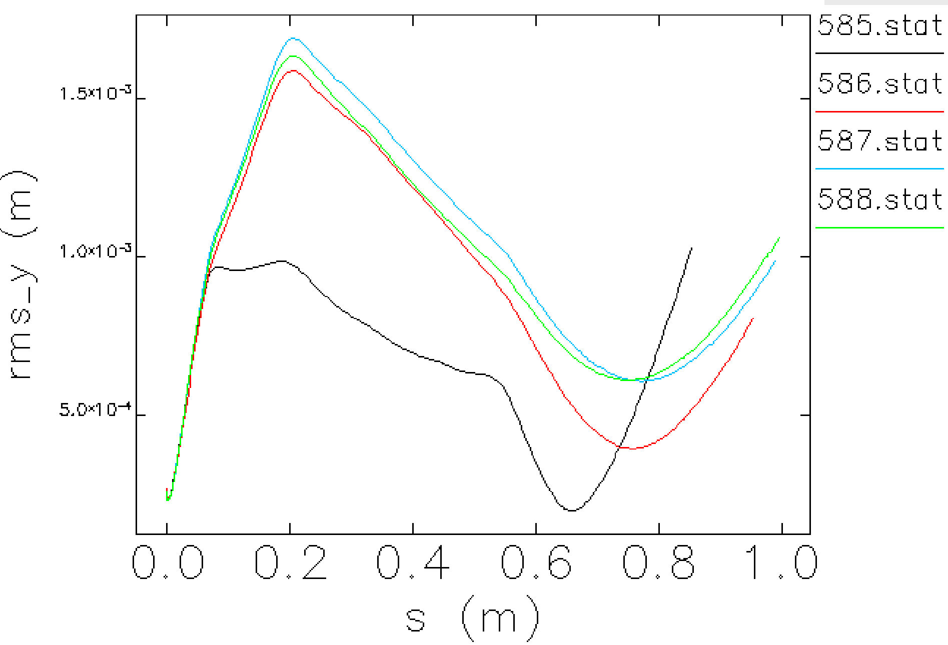


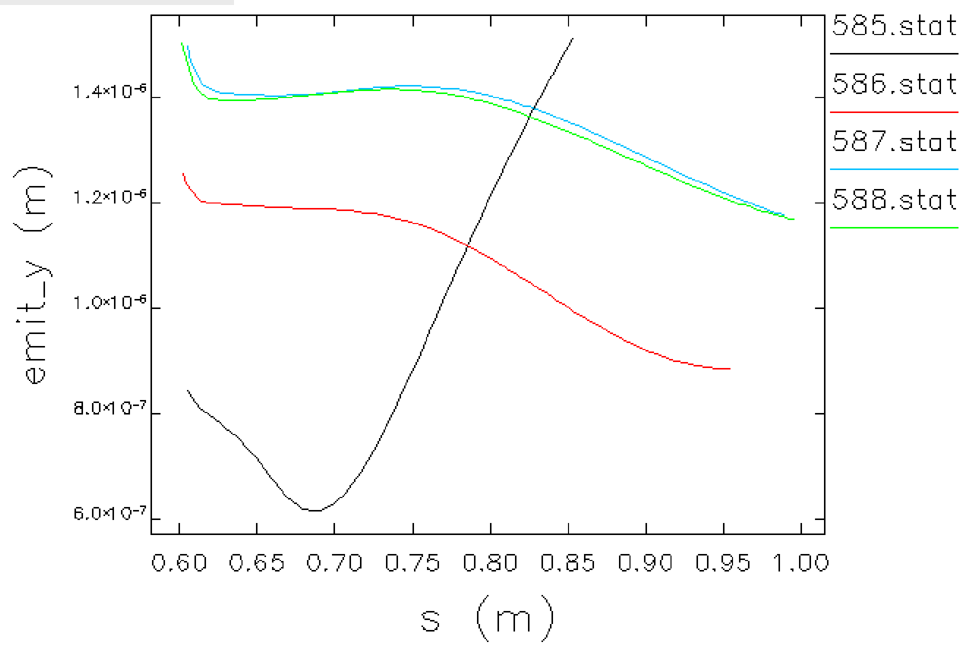


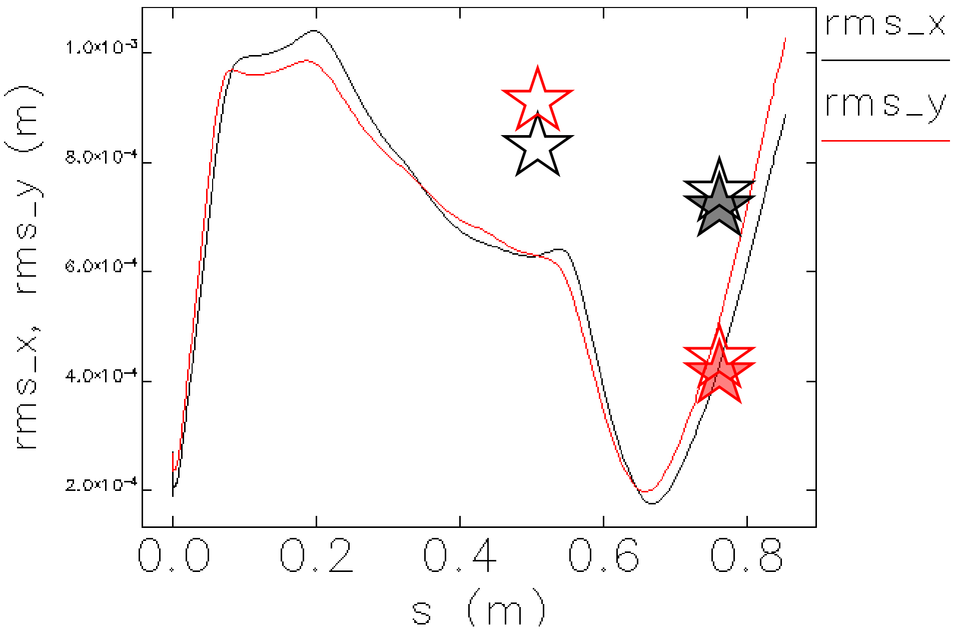


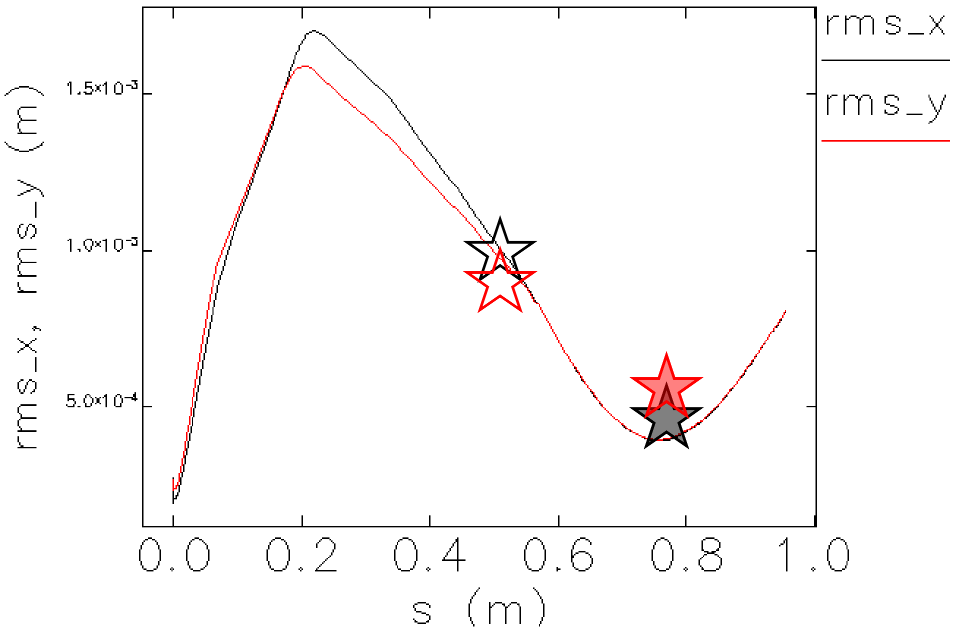
— 200 kV, 23.0 pC
— 300 kV, 28.8 pC
— 350 kV, 53.6 pC
— 360 kV, 54.6 pC

OPAL results (6 mm gap)



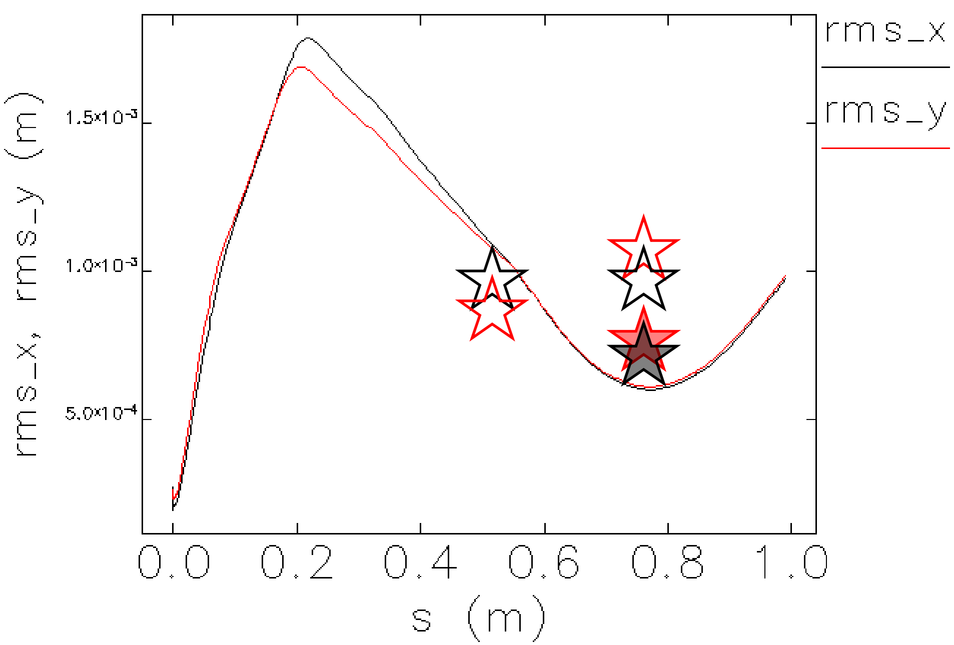


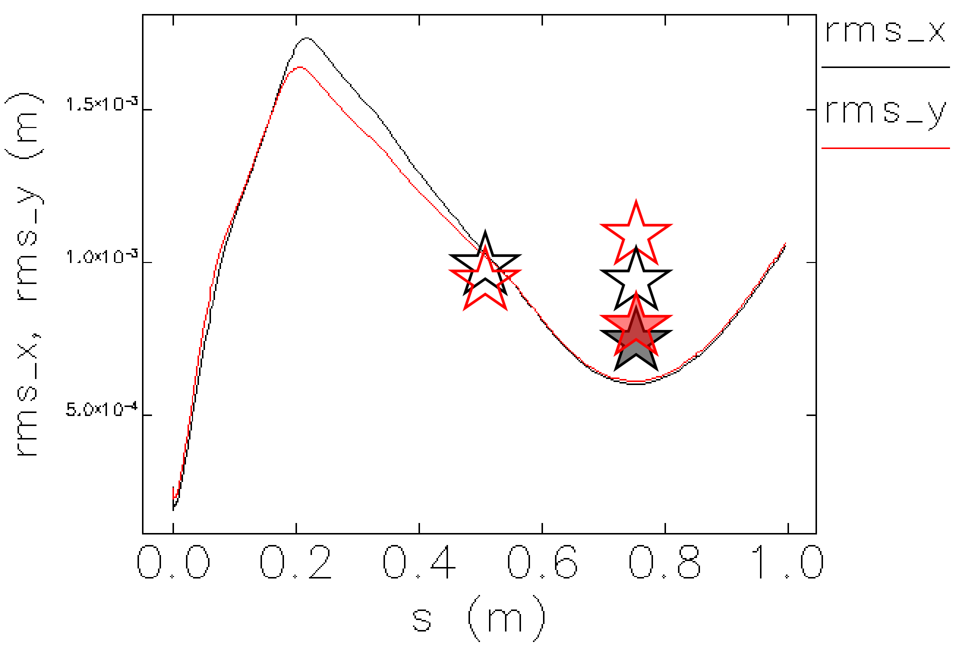


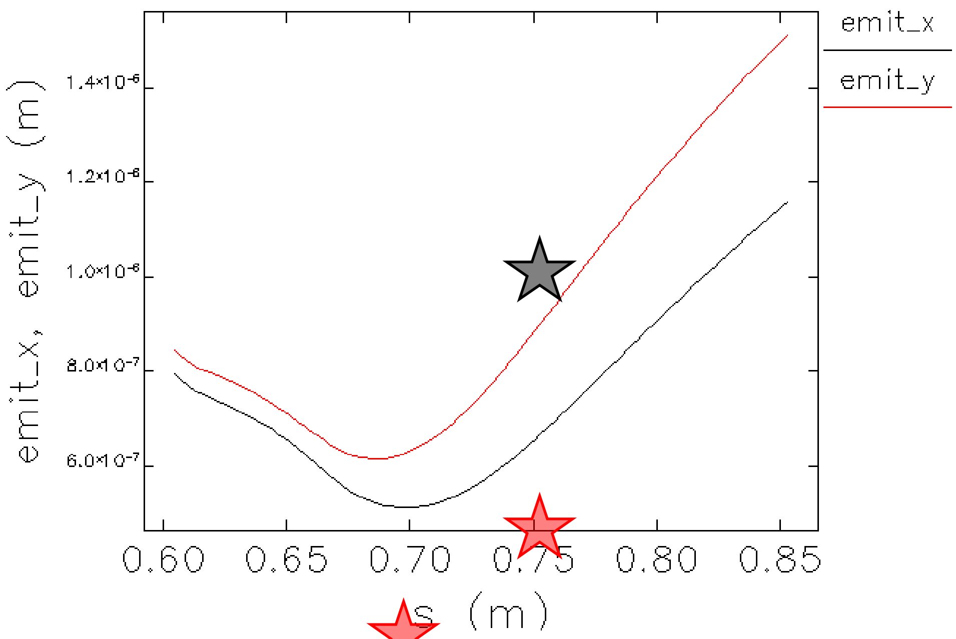


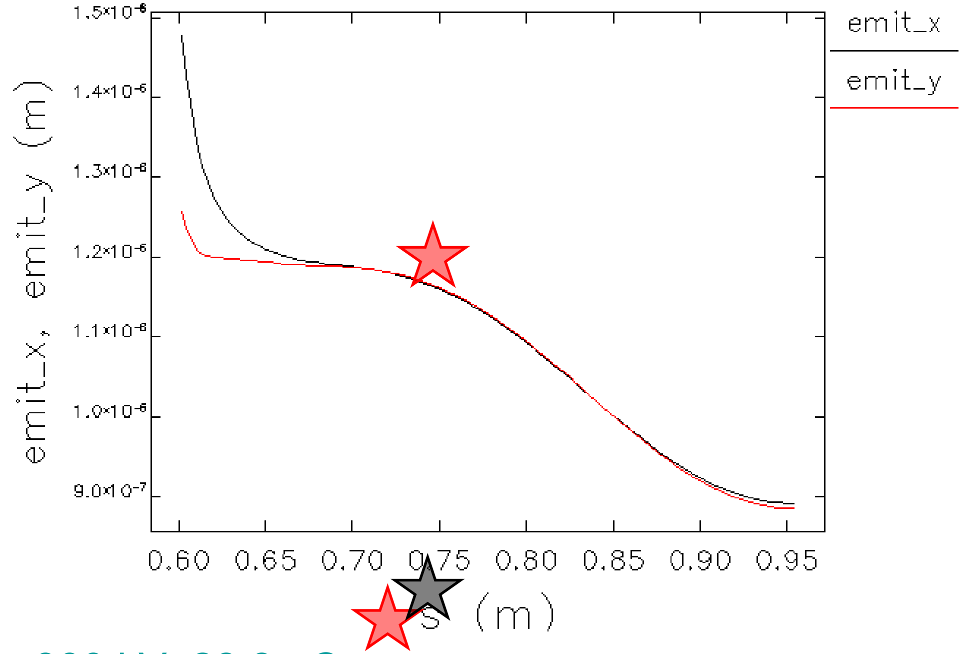
Beam size
6 mm gap

200 kV, 23.0 pC
300 kV, 28.8 pC
350 kV, 53.6 pC
360 kV, 54.6 pC









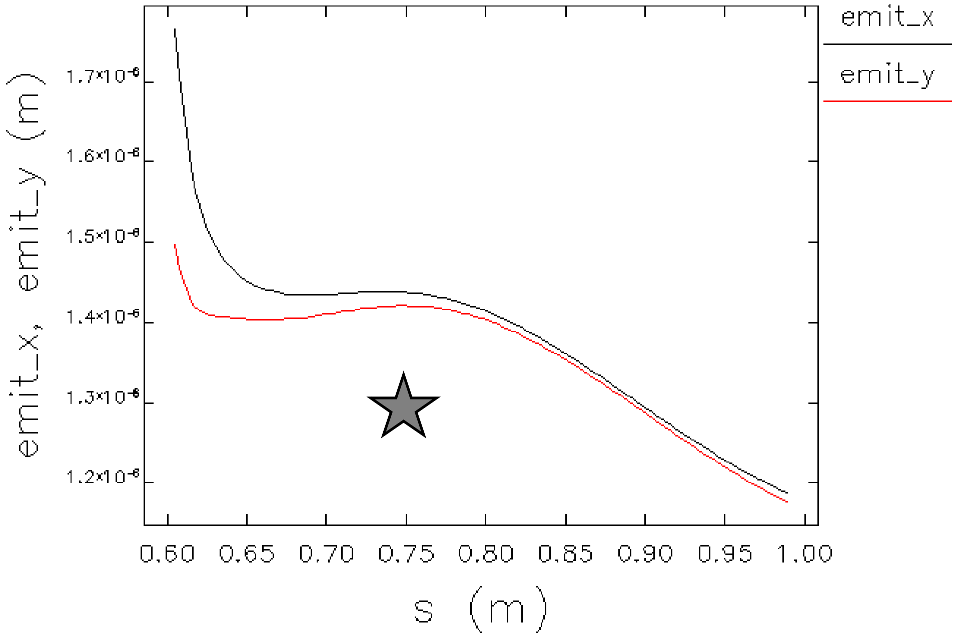
Emittance
6 mm gap

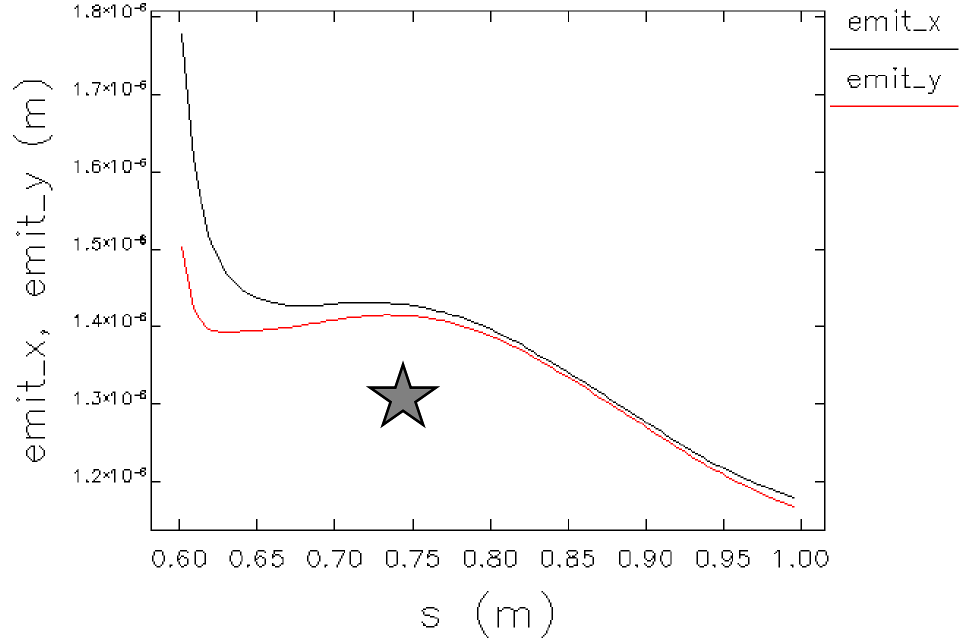
200 kV, 23.0 pC

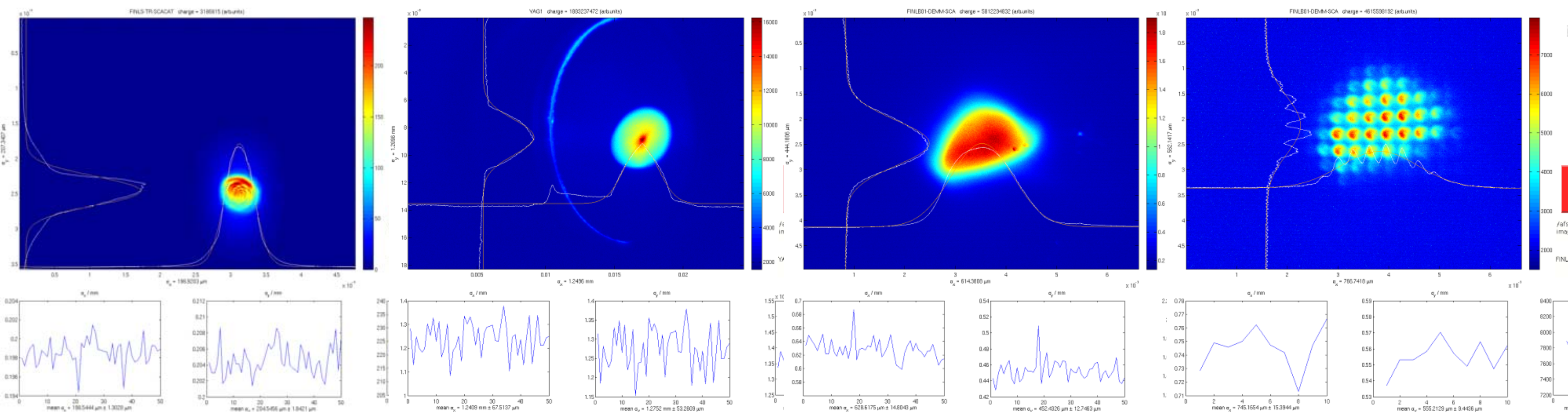
300 kV, 28.8 pC

350 kV, 53.6 pC

360 kV, 54.6 pC







2.10.2008 electrodes: fresh SS A12-A25, mirror polished, no breakdown
pulser: 300 kV, 6 mm → 50 MV/m
laser: Jaguar, 2 mm pinhole, 35 μJ, σ_x = 199 μm, σ_y = 205 μm
charge: (40 ± 7) pC

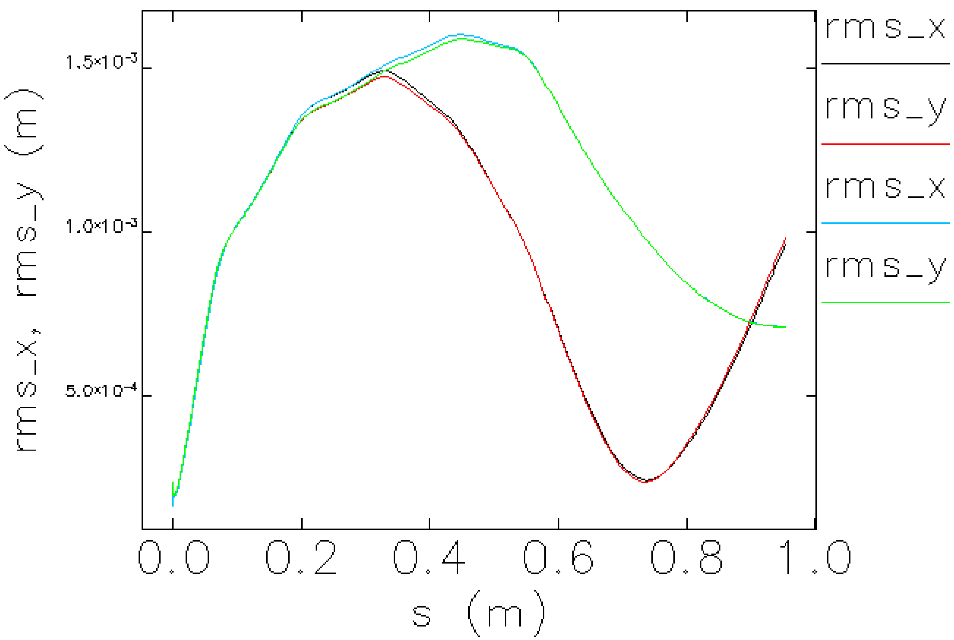
emittance data cannot be analyzed, data is lost !

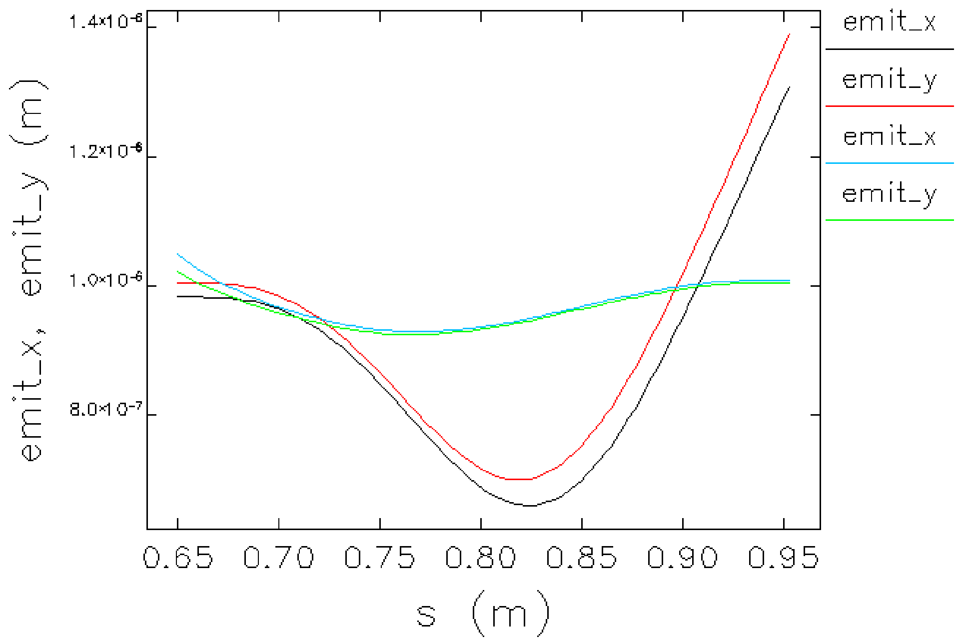
envelope scan (no focus):
solenoids (A): 26.5/29/29/25/35
YAG1: z = 491 mm, σ_x = (1241±68) μm, σ_y = (1275±53) μm
YAG2: z = (783+3) mm, σ_x = (629±15) μm, σ_y = (452±13) μm

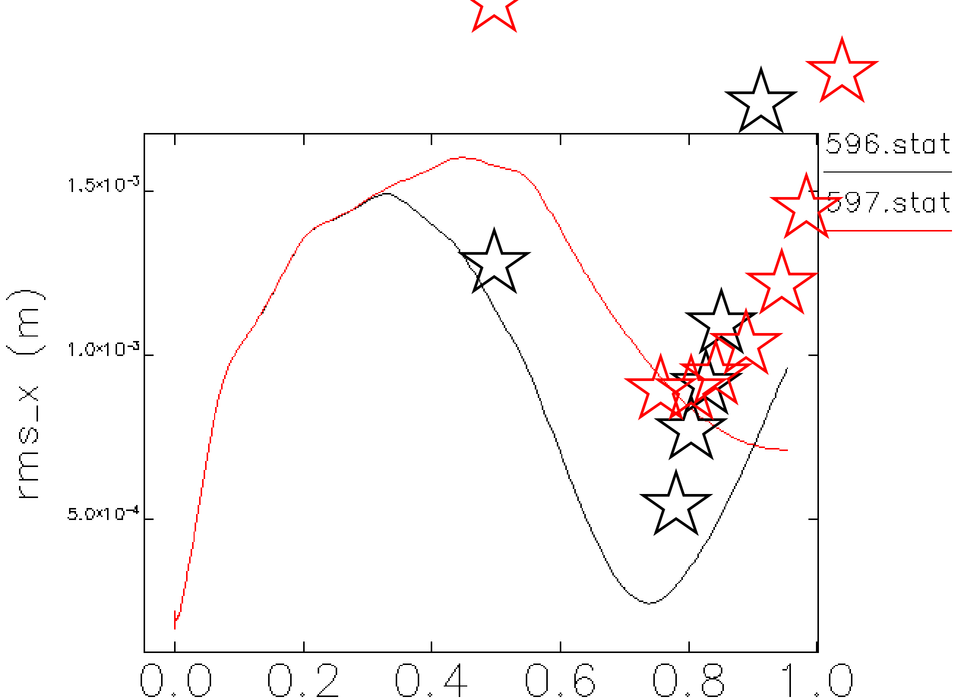
envelope scan (focus in emittance meter):
solenoids (A): 26.5/29/15/20/30
YAG1: z = 491 mm, σ_x = (2274±112) μm, σ_y = (1795±72) μm
YAG2: z=763...1113 mm (+4mm position error)

Simulation results for the two different magnet settings

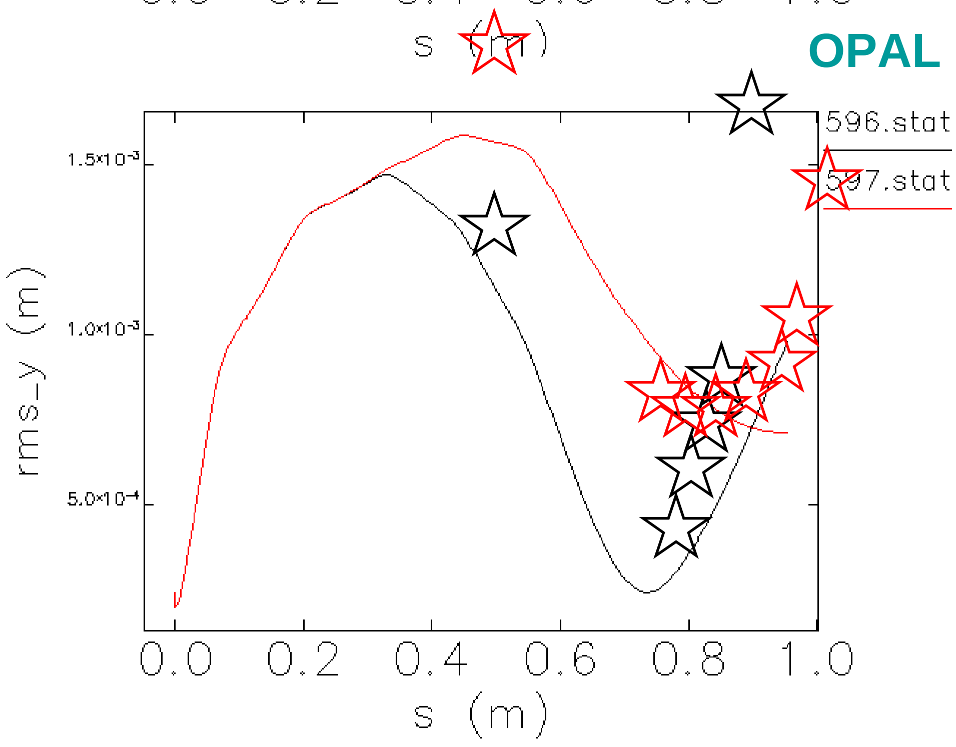
no focus
focus in emittance meter

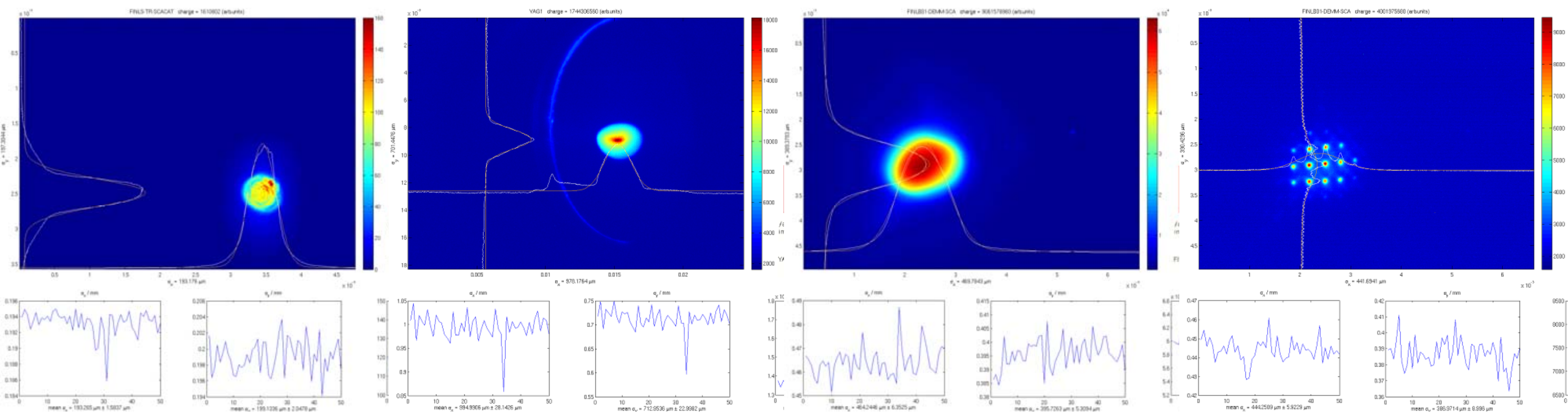






OPAL simulation results vs. envelope scan data





<u>3.10.2008</u> electrodes: fresh SS A12-A25, mirror polished, no breakdowns
pulser: 300 kV, 6 mm → 50 MV/m
laser: Jaguar, 2 mm pinhole, 17 μJ, σ_x = 193 μm, σ_y = 199 μm
charge: 20 pC
YAG1: z = 491 mm, σ_x = (995±28) μm, σ_y = (713±23) μm

solenoids (A) for **large beam on YAG2**: 21/45/0/0/0
YAG2: z = (773+4) mm, σ_x = (857±13) μm, σ_y = (502±5) μm
PPT: z = (773-1) mm, ε_x = ??? μm, ε_y = ??? μm

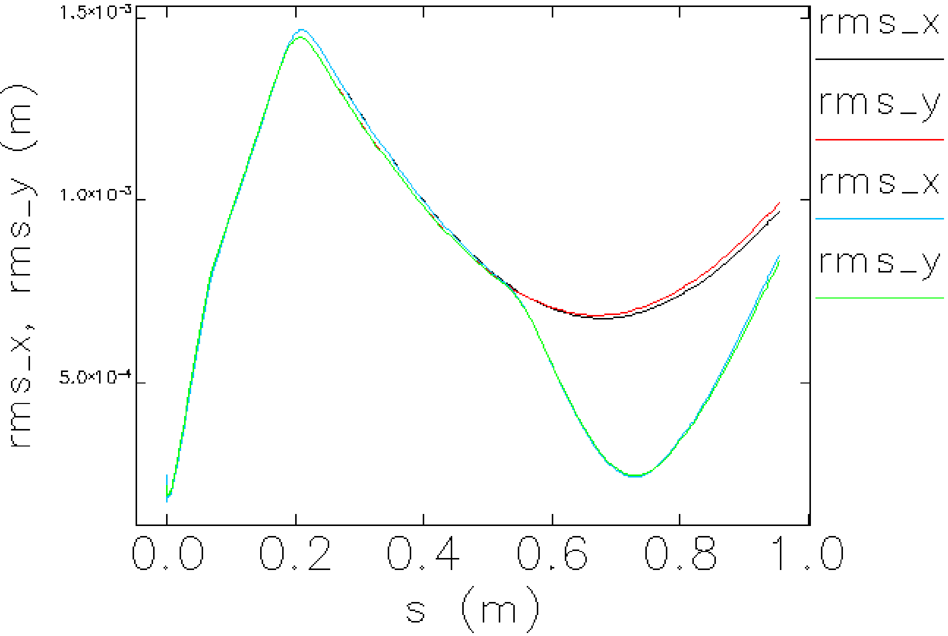
very nice data for systematic studies, but PPT images lost

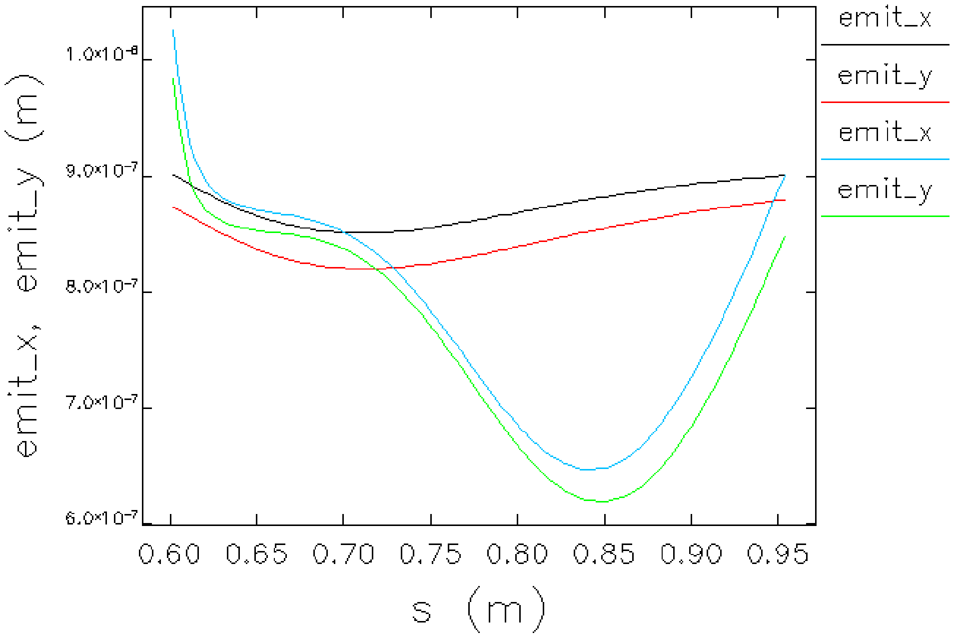
solenoids (A) for **focus on YAG2**: 21/45/0/0/42
YAG2: z = (773+3) mm, σ_x = (464±6) μm, σ_y = (396±5) μm
PPT: z = (773-0) mm, ε_x = ??? μm, ε_y = ??? μm

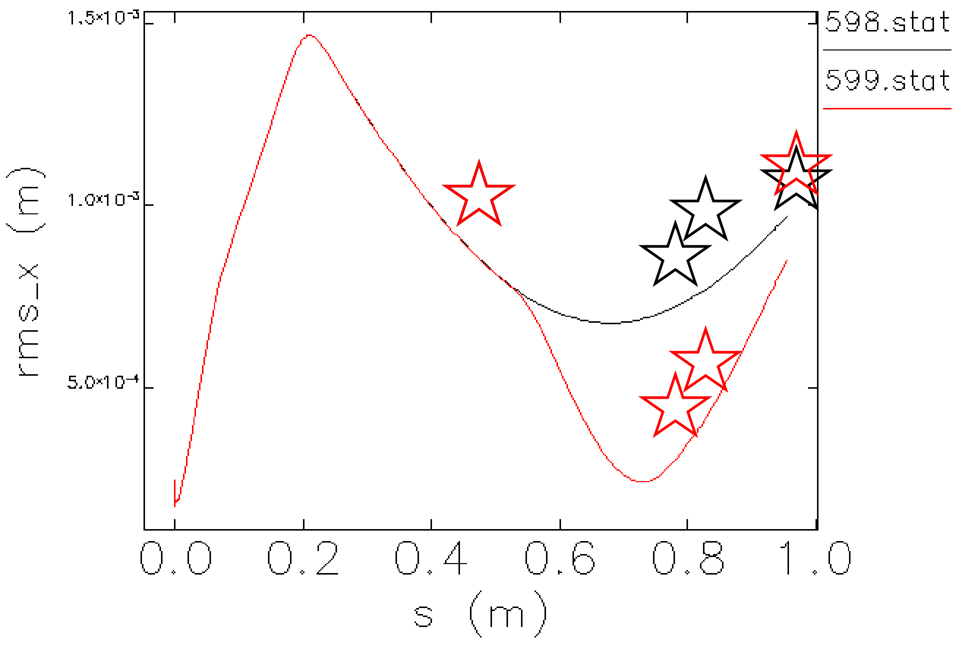
after moving laser mirror by 5.9 mm into the beam:
YAG2: z = (773+2) mm, σ_x = (449±5) μm, σ_y = (397±5) μm
PPT: z = (773-2) mm, ε_x = ??? μm, ε_y = ??? μm

Simulation results: MSL50 off vs. MSL50 on

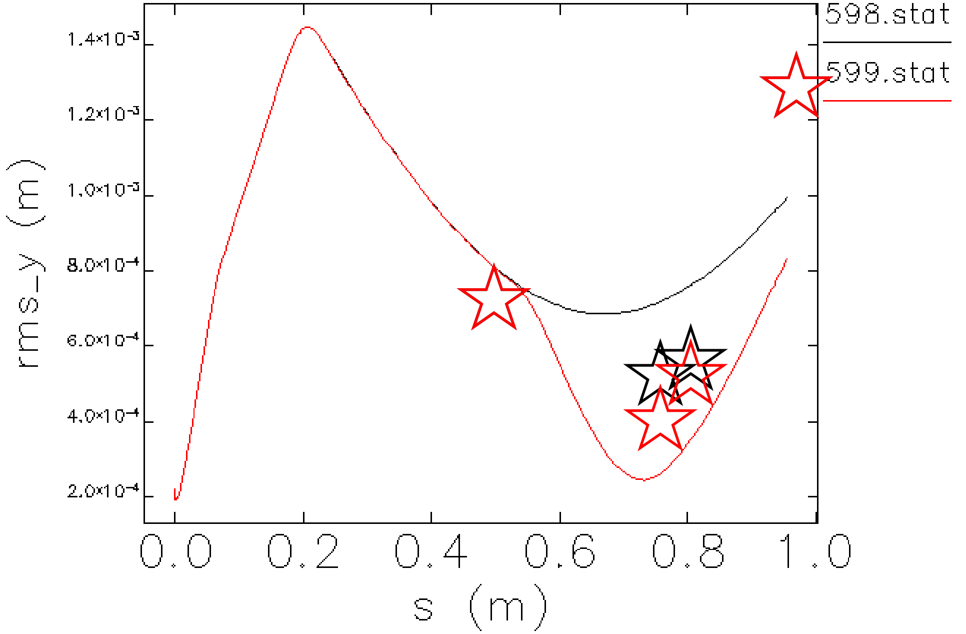
MSL50 off
MSL50 on







OPAL simulation results vs. envelope data



Conclusions

- first quick OPAL simulation without parameter tuning was compared to measurement data
- beam size development fits reasonably well
- emittance data and simulations show no relation; simulation as well as data analysis have to be improved

OPAL:
laser, diode, PPT

XanaROOT:
algorithm, stability

There is still a long way to go to understand our machine !!!