

# Beam studies considering different positions for EMSY1

Transverse emittance optimization comparing flat-top and 3D ellipsoidal laser profiles (shifted (and fixed) booster position, different positions of EMSY1)

Martin Khojoyan

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# Flat-top, EMSY1 at 5.37m

## ASTRA simulation setup: fixed parameters

- Laser temporal profile: **flat-top** with 21.5ps FWHM length and 2ps rise and fall times
- 0.55 eV average kinetic energy of the photoelectrons
- Gun gradient: 60.58 MV/m corresponding to  $P_z \sim 6.7$  MeV/c beam momentum after the gun
- Gun ASTRA phase **fixed** to -1deg ( $\sim$  on-crest)
- Initial Z position of CDS booster: 2.7m
- Bunch charge: 1 nC
- Searching for the best transverse emittance at **EMSY1**

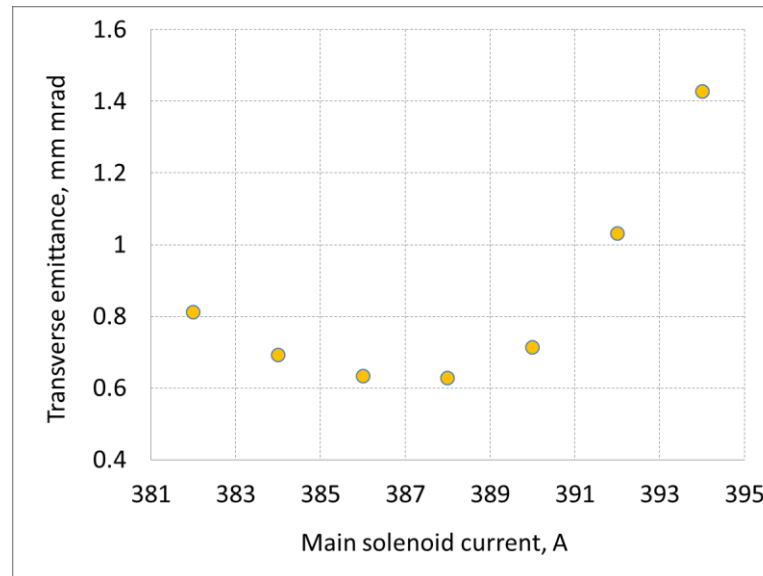
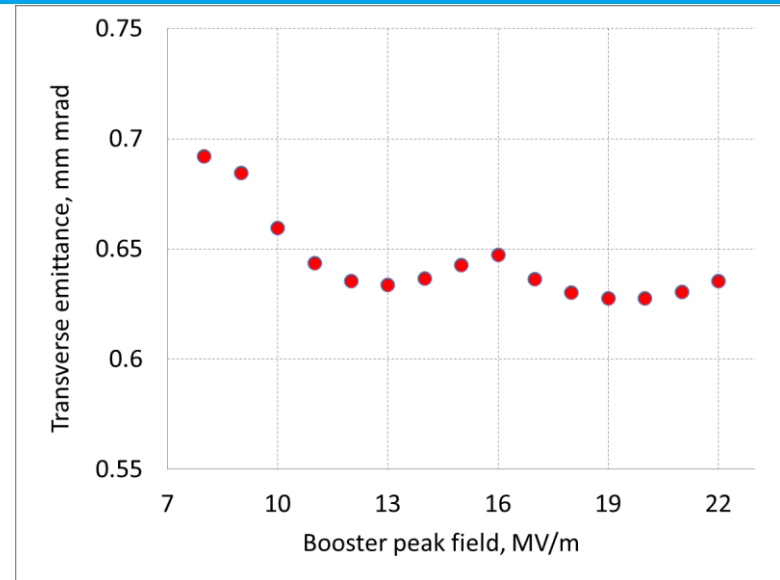
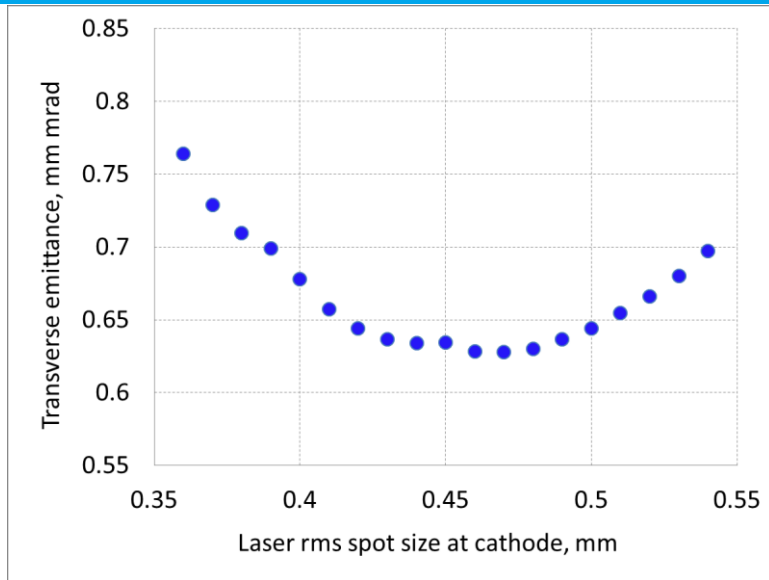
## ASTRA simulation setup: varied parameters

- Laser transverse rms spot size on the cathode  $\rightarrow$  [0.36:0.01:0.54] mm
- CDS booster gradient  $\rightarrow$  [8:1:22] MV/m
- Main solenoid current  $\rightarrow$  [382:2:394] A

**Emittance optimization at EMSY1 (Z=5.37m)**



# Flat-top, EMSY1 at 5.37m



# 3D ellipsoid, EMSY1 at 5.37m

## ASTRA simulation setup: fixed parameters

- Laser temporal profile: **3D ellipsoidal** with  $T_{rms}=5.5ps$  (same rms bunch length at EMSY1 as for flat-top case)
- 0.55 eV average kinetic energy of the photoelectrons
- Gun gradient: 60.58 MV/m corresponding to  $P_z \sim 6.7$  MeV/c beam momentum after the gun
- Gun ASTRA phase **fixed** to -2deg ( $\sim$  on-crest)
- Initial Z position of CDS booster: 2.7m
- Bunch charge: 1 nC
- Searching for the best transverse emittance at **EMSY1**

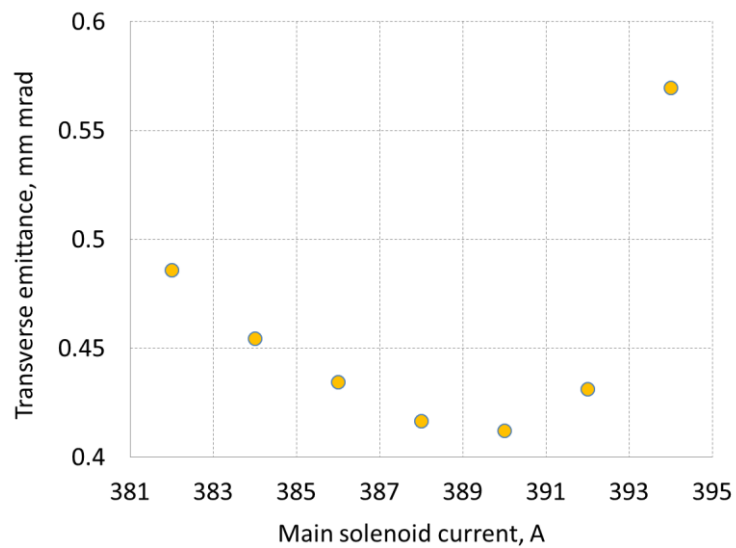
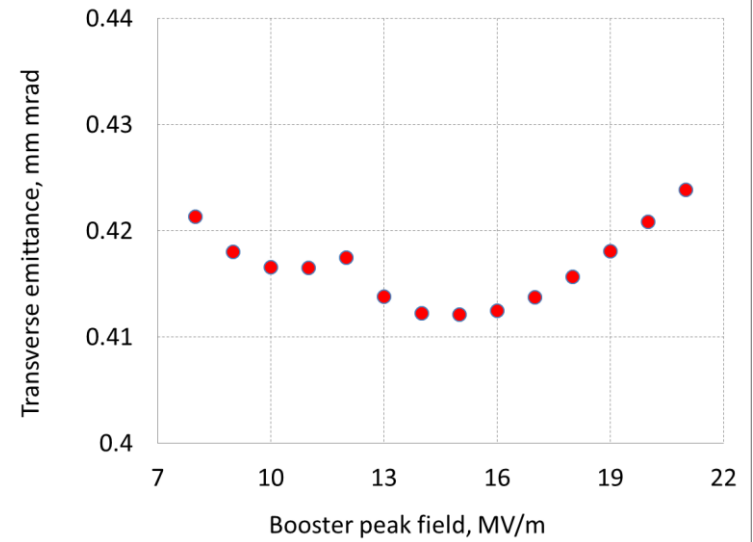
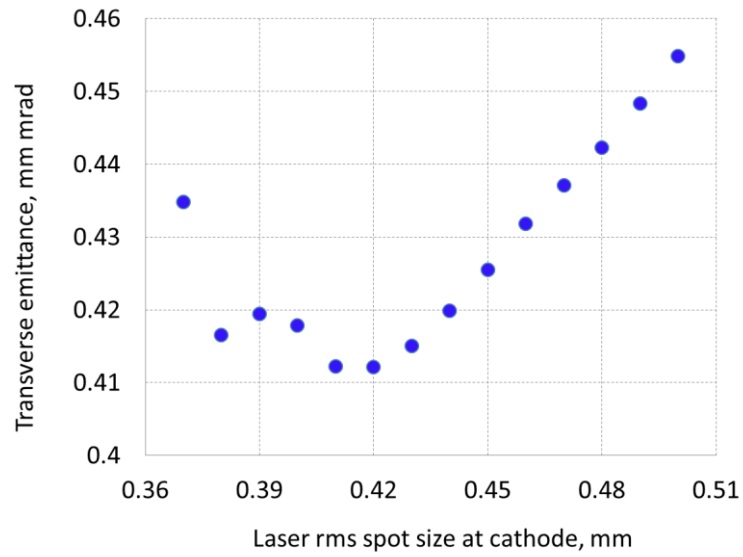
## ASTRA simulation setup: varied parameters

- Laser transverse rms spot size on the cathode  $\rightarrow [0.37:0.01:0.5]$  mm
- CDS booster gradient  $\rightarrow [8:1:21]$  MV/m
- Main solenoid current  $\rightarrow [382:2:394]$  A

**Emittance optimization at EMSY1 (Z=5.37m)**



# 3D ellipsoid, EMSY1 at 5.37m



# Optimization of the EMSY1 position (flat-top)

## ASTRA simulation setup: fixed parameters

- Laser temporal profile: **flat-top** with 21.5ps FWHM length and 2ps rise and fall times
- 0.55 eV average kinetic energy of the photoelectrons
- Gun gradient: 60.58 MV/m corresponding to  $P_z \sim 6.7$  MeV/c beam momentum after the gun
- Initial Z position of CDS booster: 2.7m
- Bunch charge: 1 nC
- Searching for the best transverse emittance at **EMSY1**

## ASTRA simulation setup: varied parameters

- Laser transverse rms spot size on the cathode → [0.38:0.02:0.54] mm
- Gun phase → [-2:1:1] deg
- CDS booster gradient → [8:2:22] MV/m
- Main solenoid current → [380:1:391] A

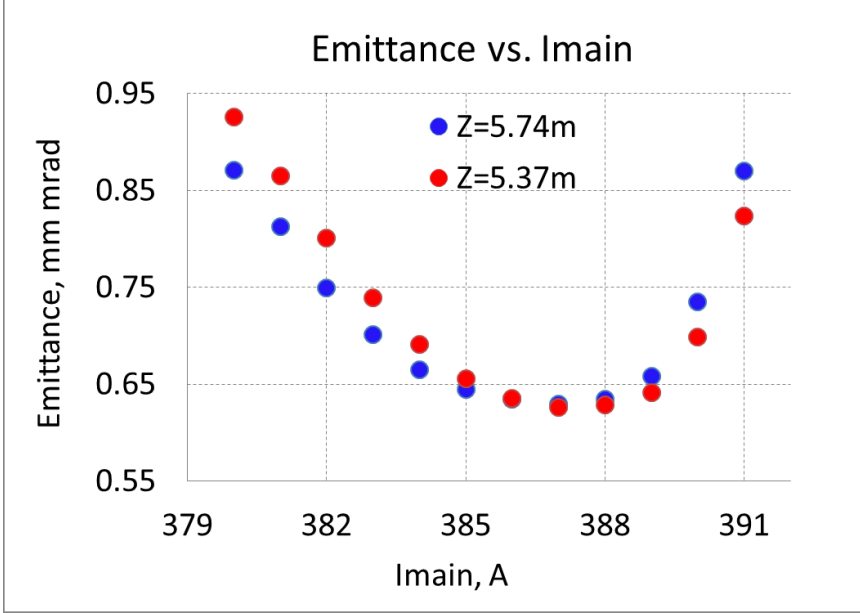
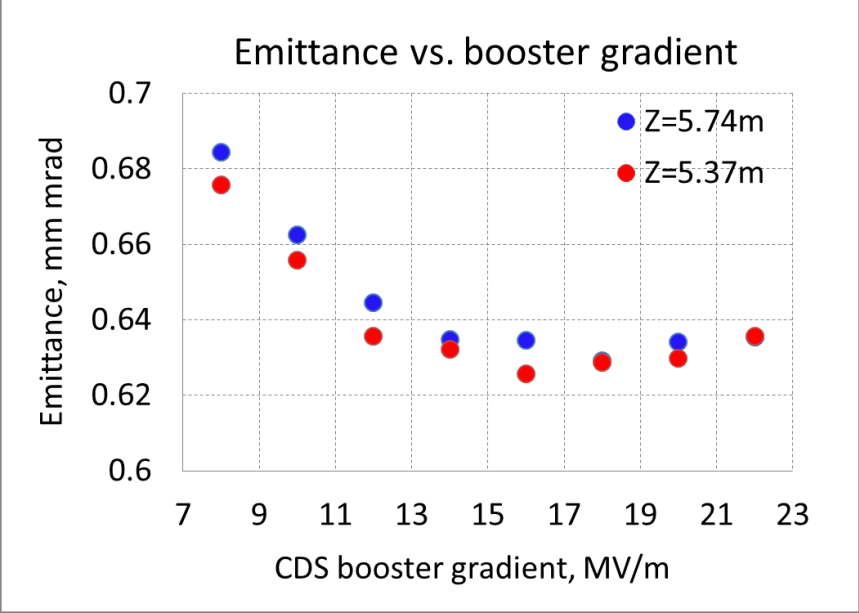
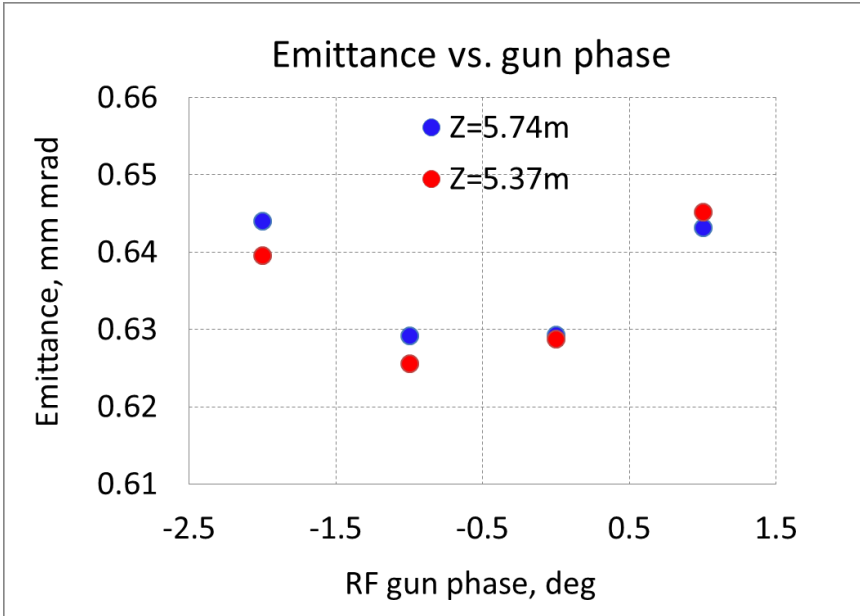
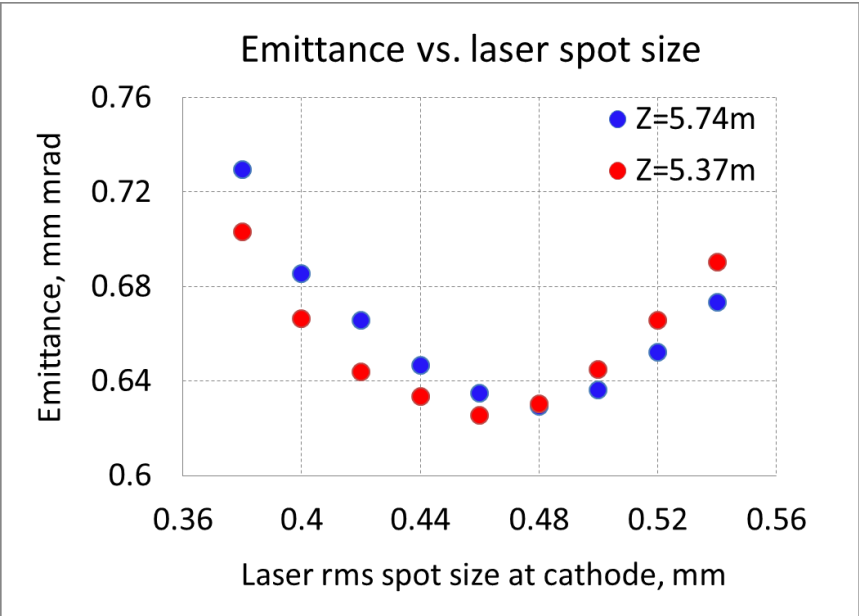
**Emittance has been optimized at EMSY1 with two different positions:**

Position of EMSY1:  $Z=5.74$  m

Position of EMSY1:  $Z=5.37$  m (shifted towards the cathode by the same distance as CDS booster position)



# Optimization of the EMSY1 position (flat-top)



# Optimization of EMSY1 position (3D ellipsoidal)

## ASTRA simulation setup: fixed parameters

- **3D ellipsoidal** cathode laser pulse with 5.5 ps rms emission time (initial bunch length)
- 0.55 eV average kinetic energy of the photoelectrons
- Gun gradient: 60.58 MV/m corresponding to  $P_z \sim 6.7$  MeV/c beam momentum after the gun
- CDS booster starting position: 2.7 m
- Bunch charge: 1 nC
- Searching for the best transverse emittance at **EMSY1**

## ASTRA simulation setup: varied parameters

- Laser transverse rms spot size on the cathode → [0.36:0.02:0.5] mm
- Gun phase → [-4:1:0] deg
- CDS booster gradient → [0:2:22] MV/m
- Main solenoid current → [381.5:1.5:390.5] A

**Emittance has been optimized at EMSY1 with two different positions:**

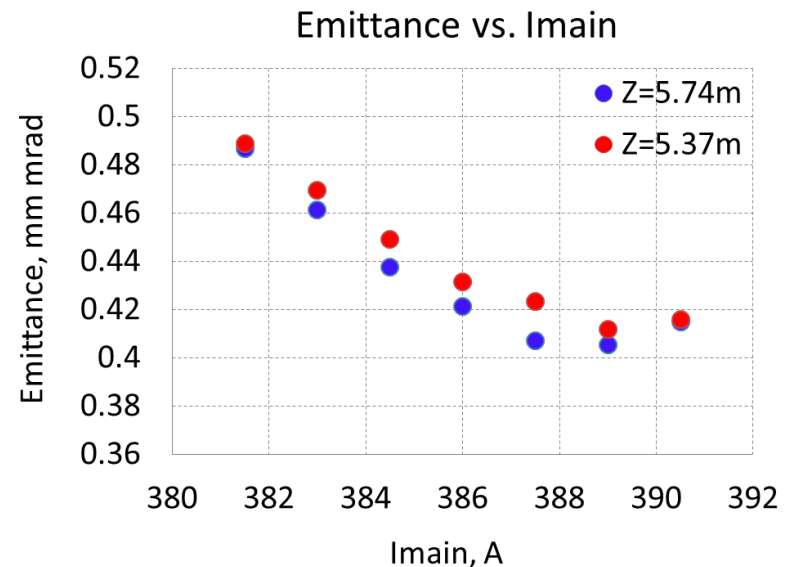
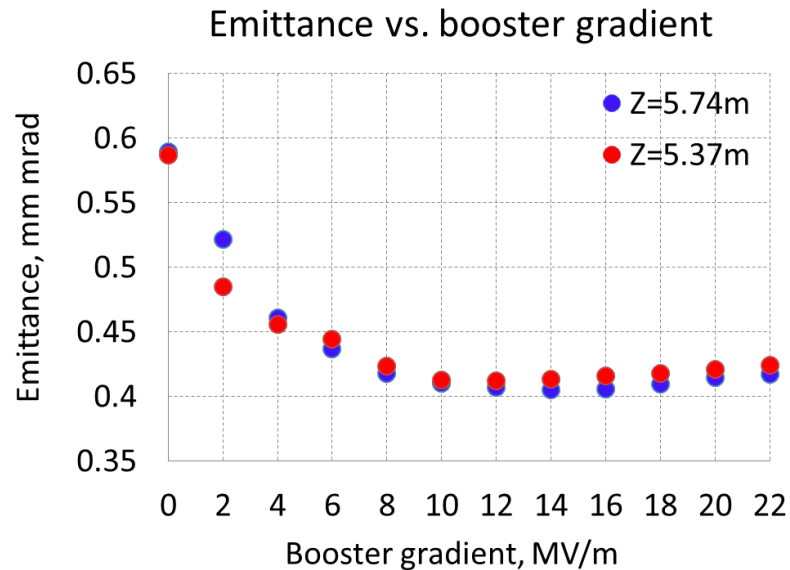
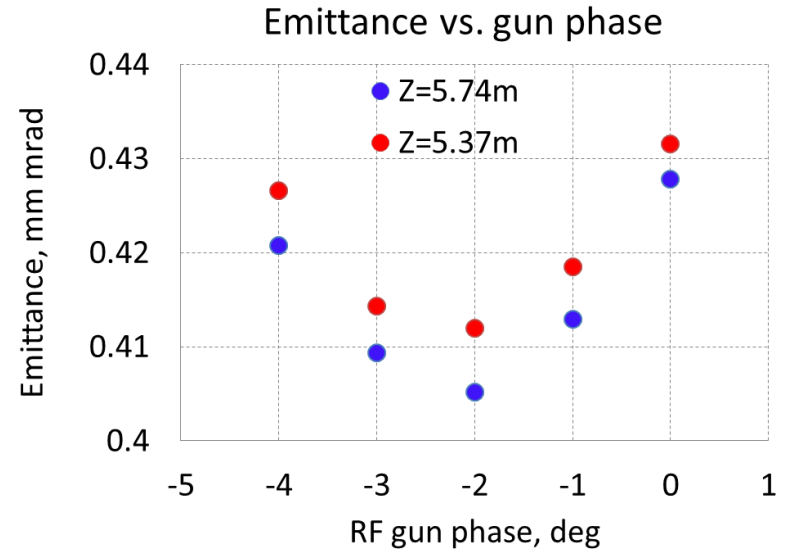
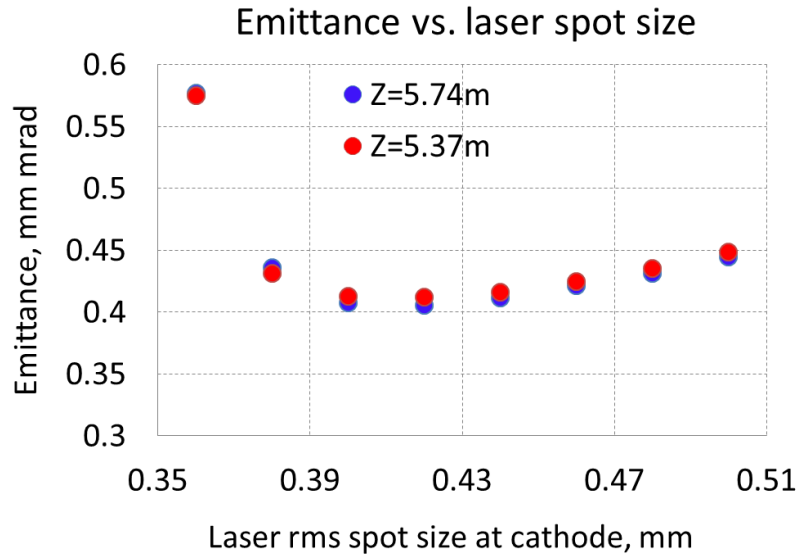
Position of EMSY1:  $Z=5.74$  m

Position of EMSY1:  $Z=5.37$  m (shifted towards the cathode by the same distance as CDS booster position)



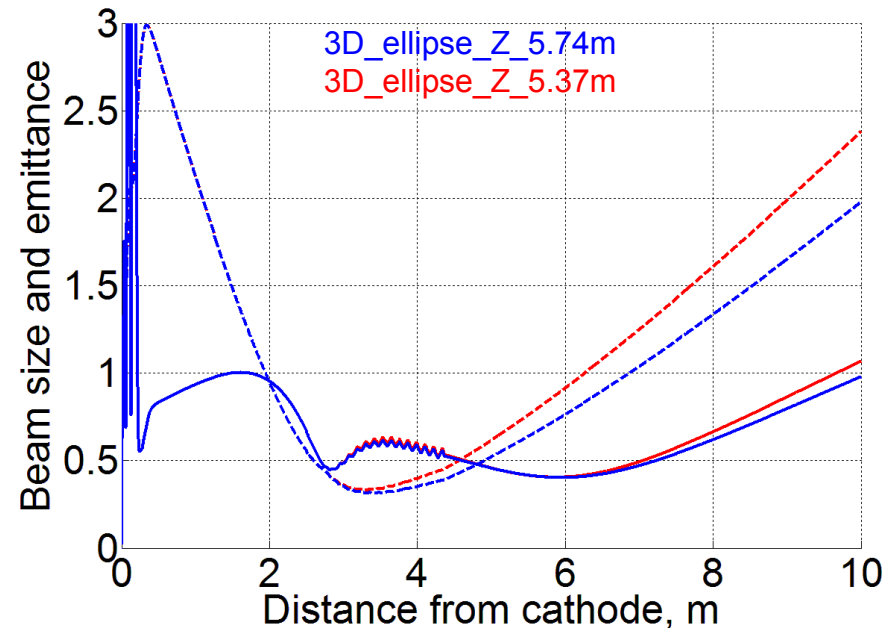
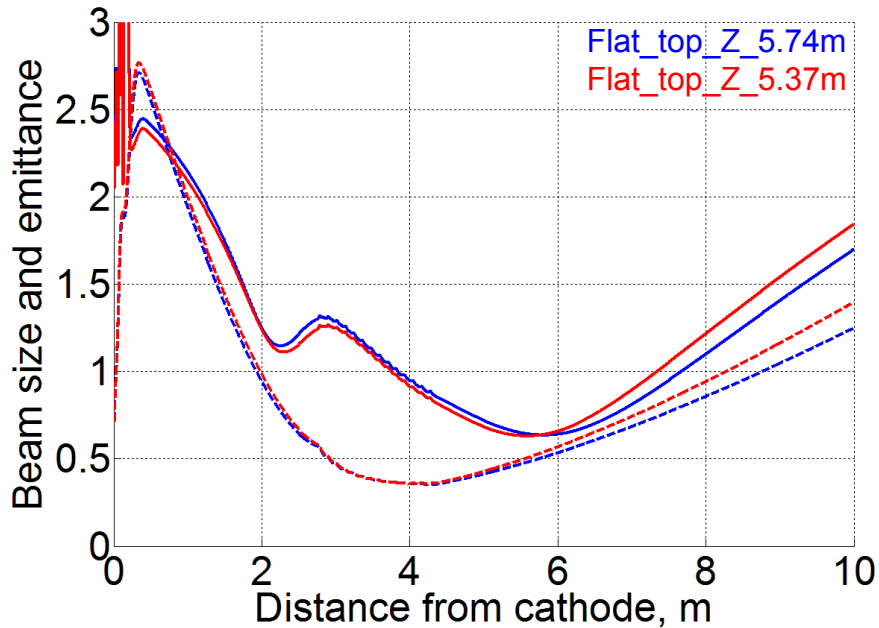


# Optimization of EMSY1 position (3D ellipsoidal)

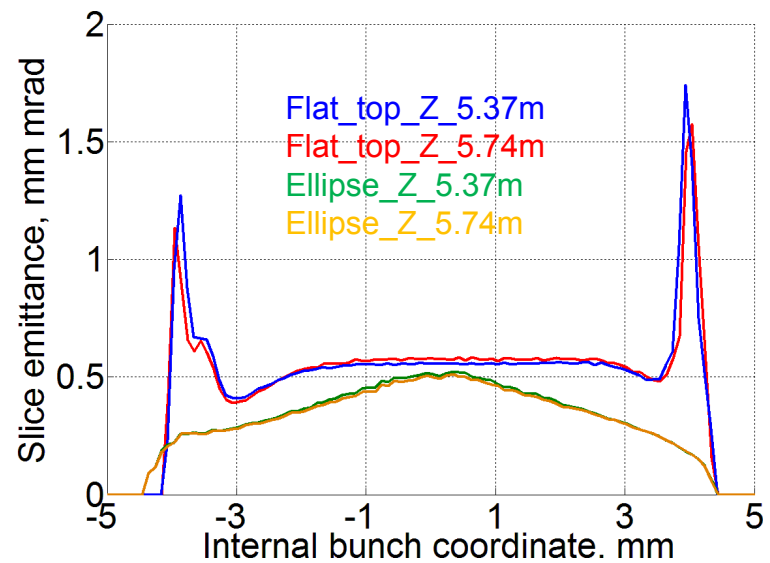
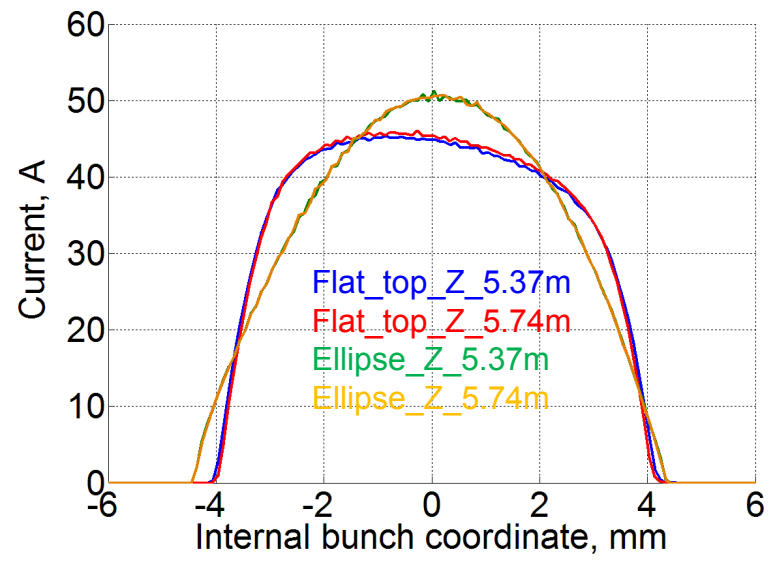
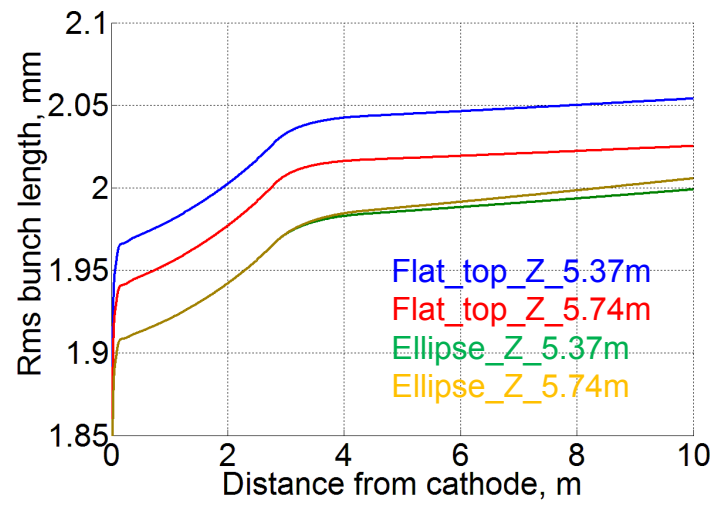


# BD comparing different EMSY1 positions (fixed booster position)

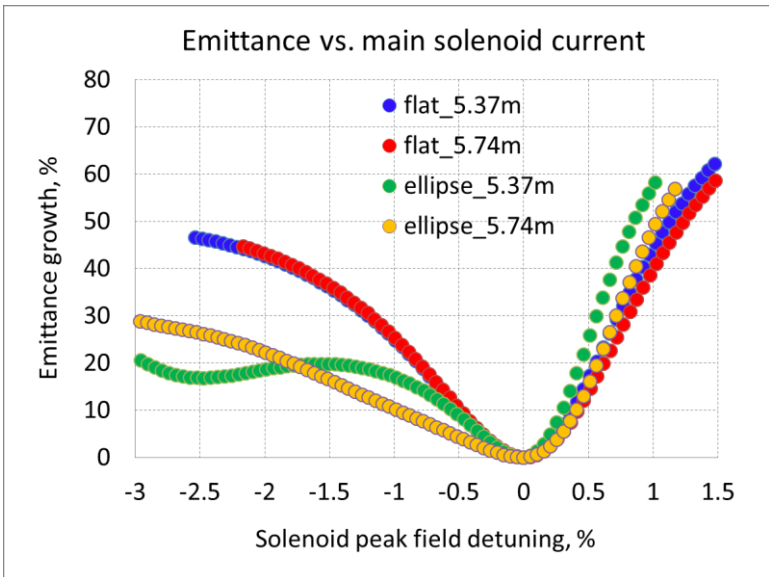
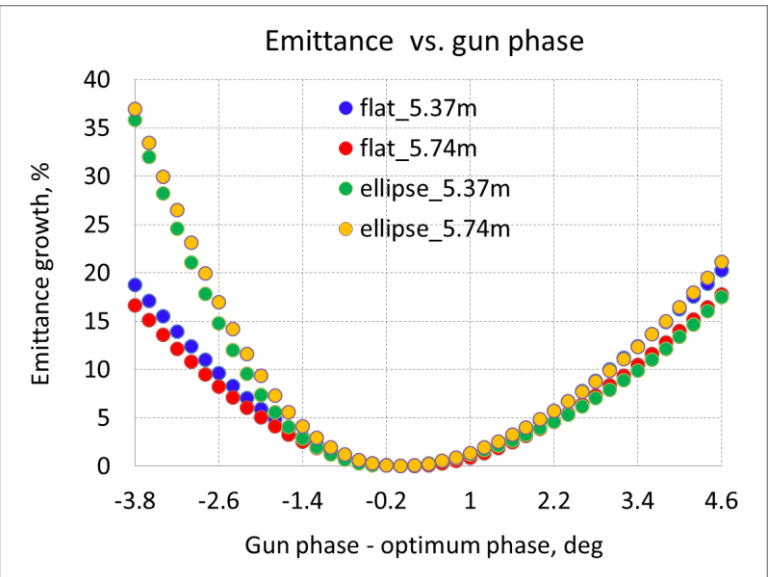
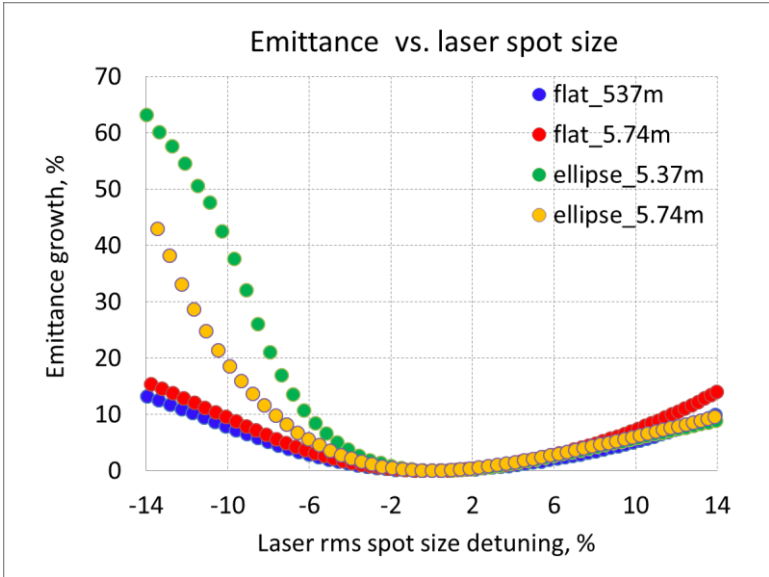
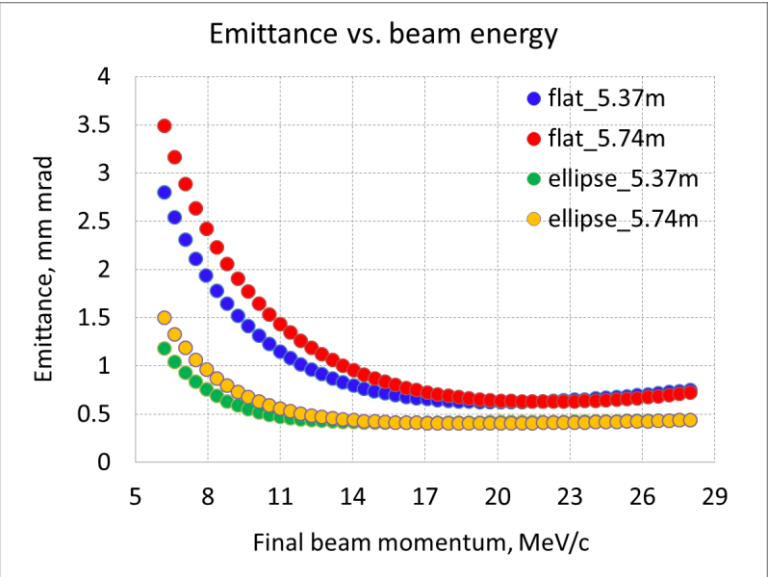
Evolution of transverse beam properties along the beamline



# BD comparing different EMSY1 positions (fixed booster position)



# Beam tolerances comparing two different EMSY1 positions



# Summary of beam studies: different positions of EMSY1

Beam studies comparing different positions of EMSY1 (booster position fixed !)

| Temporal                   | profile        | Flat-top                           | 3D homogeneous                       | Flat-top                            | 3D homogeneous                       |
|----------------------------|----------------|------------------------------------|--------------------------------------|-------------------------------------|--------------------------------------|
| Transverse                 | distribution   | radial homogeneous                 | 3D homogeneous                       | radial homogeneous                  | 3D homogeneous                       |
| Trms                       | ps             | 6.272                              | 5.5                                  | 6.272                               | 5.5                                  |
| XYrms                      | mm             | 0.46                               | 0.42                                 | 0.48                                | 0.42                                 |
| Th. emit.                  | mm mrad        | 0.39                               | 0.356                                | 0.407                               | 0.356                                |
| Ecath.                     | MV/m           | 60.58                              |                                      |                                     |                                      |
| RF gun phase               | deg            | -1.0                               | -2.0                                 | -1.0                                | -2.0                                 |
| MaxBz                      | T              | 0.2277                             | 0.22888                              | 0.2277                              | 0.22888                              |
| <b>EMSY1 position</b>      | <b>m</b>       | <b>5.37</b>                        | <b>5.37</b>                          | <b>5.74</b>                         | <b>5.74</b>                          |
| MaxE                       | MV/m           | 16                                 | 12                                   | 18                                  | 14                                   |
| Charge                     | nC             | 1                                  |                                      |                                     |                                      |
| Momentum                   | MeV/c          | 20.6                               | 17.2                                 | 22.4                                | 18.9                                 |
| <b>Projected emittance</b> | <b>mm mrad</b> | <b>0.638</b><br><b>0.63 (5.6m)</b> | <b>0.425</b><br><b>0.405 (5.88m)</b> | <b>0.636</b><br><b>0.635 (5.8m)</b> | <b>0.405</b><br><b>0.402 (5.95m)</b> |
| Th. / proj.                | %              | <b>61</b>                          | <b>84</b>                            | <b>64</b>                           | <b>88</b>                            |
| <Sl. emit.>                | mm mrad        | 0.555                              | 0.403                                | 0.546                               | 0.394                                |
| Rms bunch length           | <b>mm</b>      | <b>2.05</b>                        | <b>1.99</b>                          | <b>2.02</b>                         | <b>1.99</b>                          |
| <b>Peak current</b>        | <b>A</b>       | <b>45.5</b>                        | <b>50.9</b>                          | <b>45.9</b>                         | <b>50.9</b>                          |
| Longitudinal emittance     | pi keV mm      | 76.9                               | 46.2                                 | 79.2                                | 51.5                                 |

