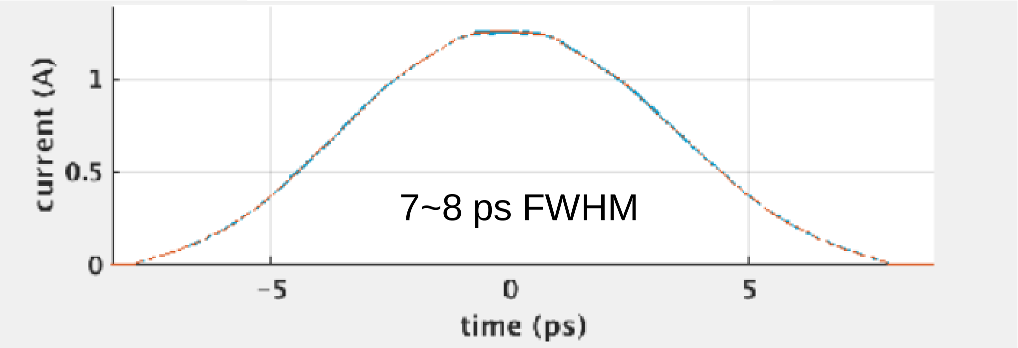
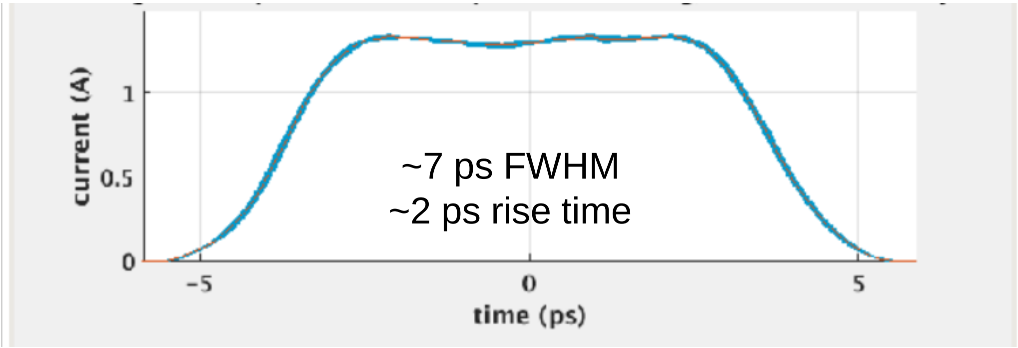
Summary of emittance measurements for PHAROS flattop shaping

MBI Gaussian laser



Flattop laser shaping

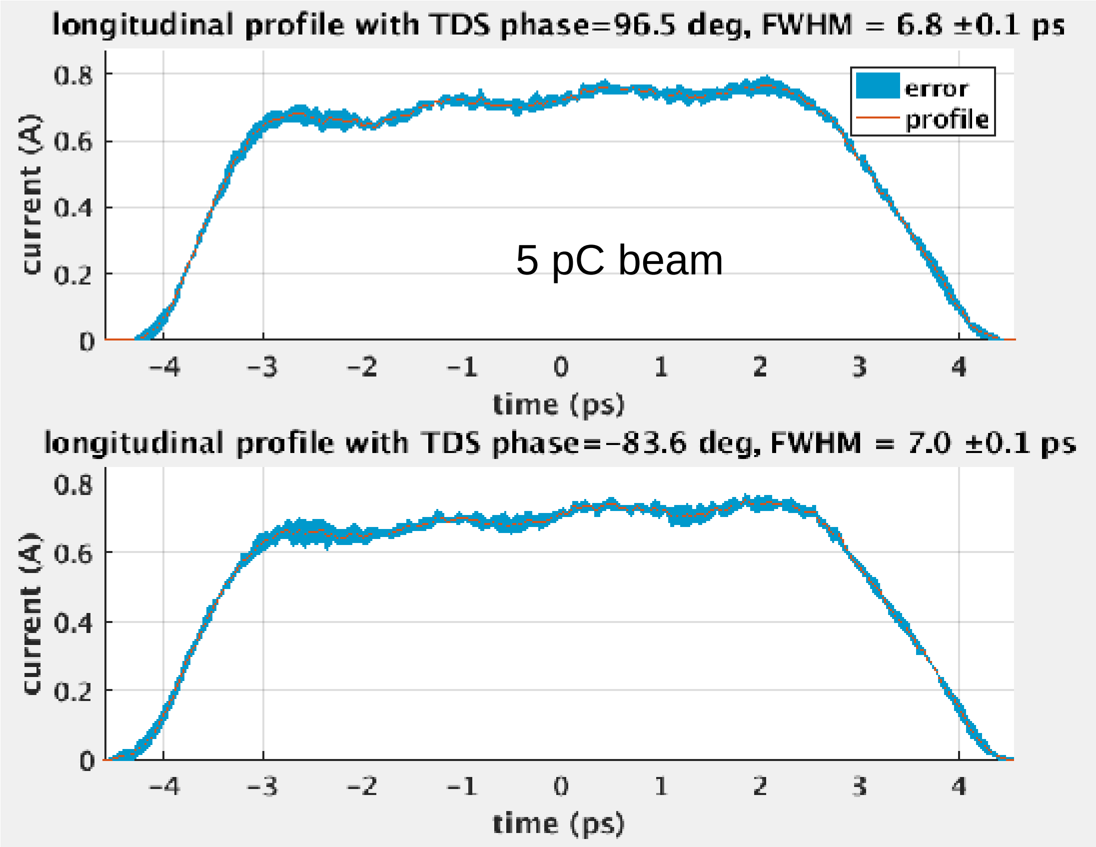


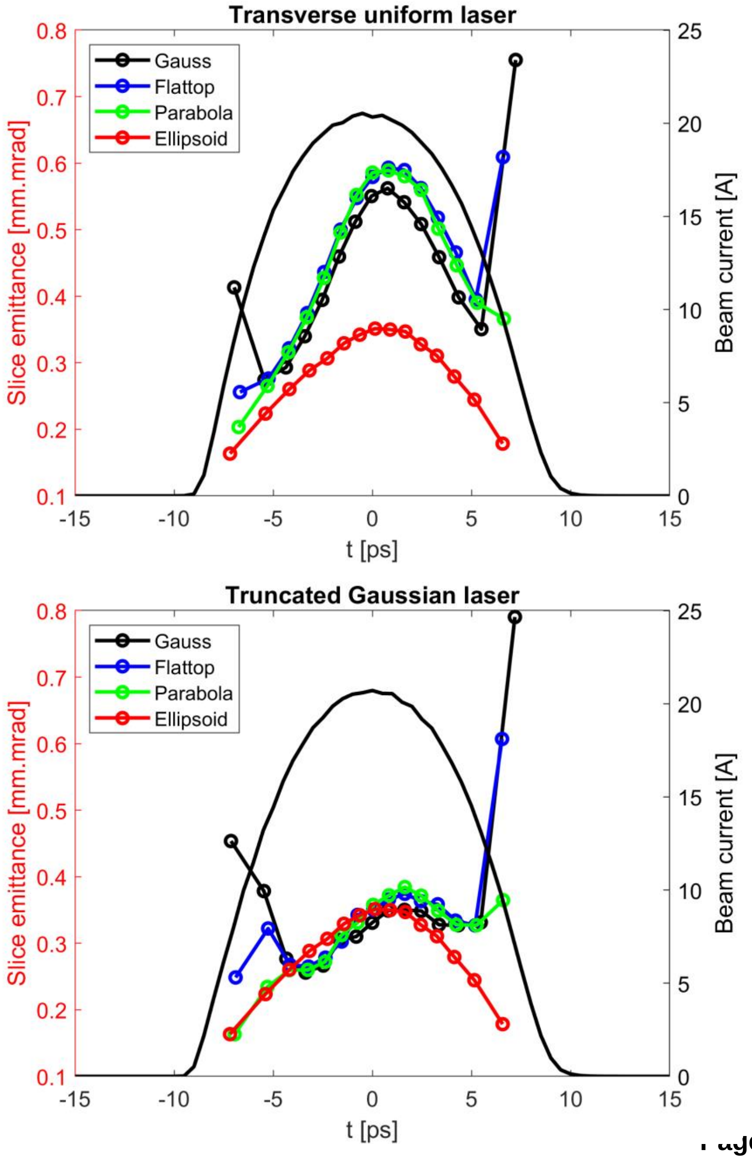
11.03.2020 @ PPS
H. Qian

Flattop laser shaping for emittance study

Based on shaping for plasma exp (2020.06)

- XFEL working point: 250 pC with 6-7 ps laser
  - Gaussian vs Flattop (vs Parabolic)
  - Current shaping leads to low UV output, new shaping needed





Gaussian vs flattop laser

Laser: BSA1mm, 250 pC

- **Beam quality within +/- σ_z**

Transverse uniform

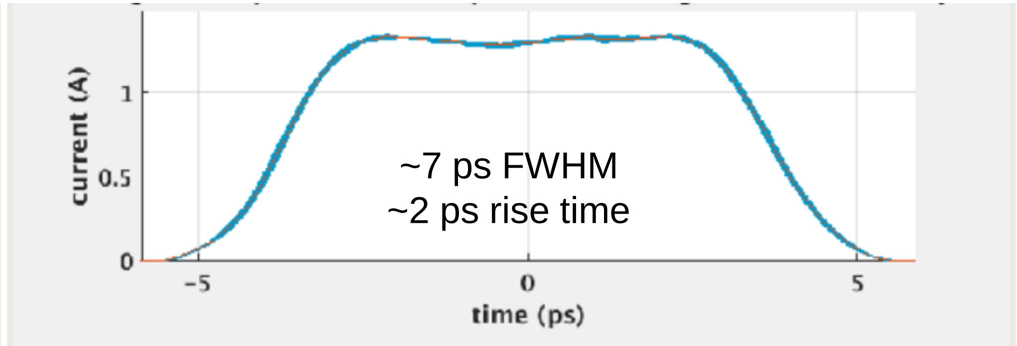
	Proj	slice	Mismatch	dE
Gaussian	0.41	0.39	0.11	3.6
Flattop7	0.50	0.45	0.18	6.3
Flattop10	0.40	0.38	0.11	7.3

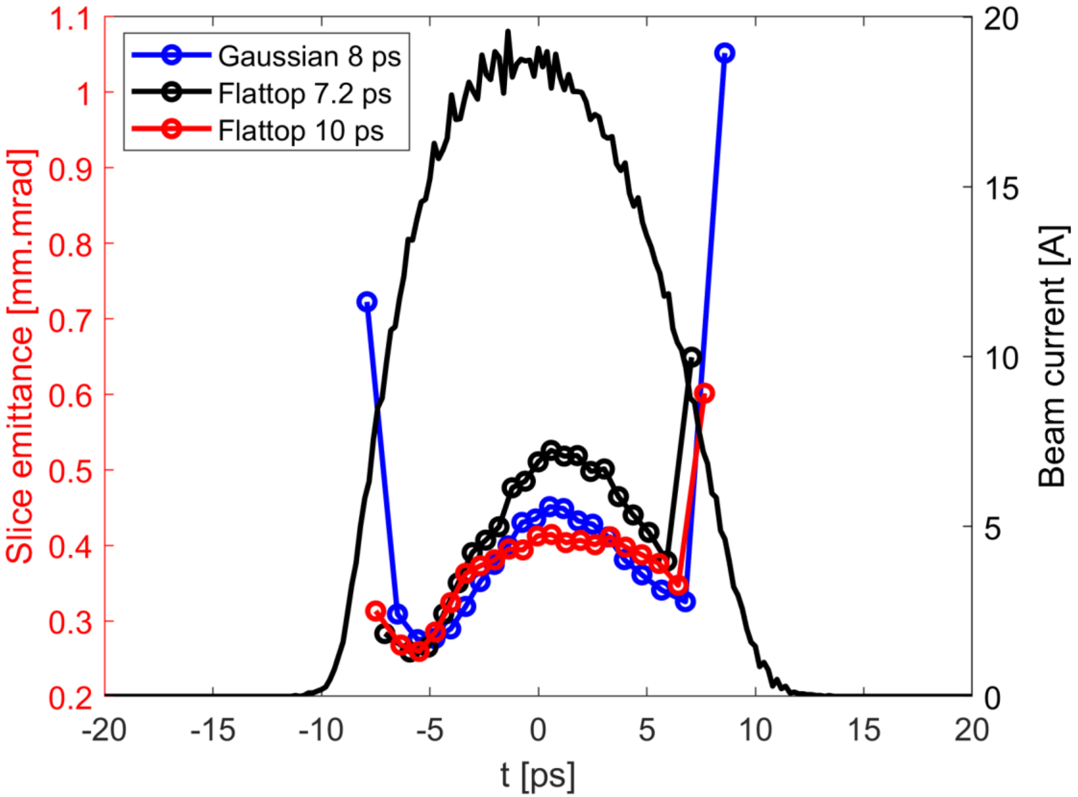
95% projected emittance FT no advantage.

- **Full beam quality**

	Proj	slice	Mismatch	dE
Gaussian	0.75	0.42	0.60	3.6
Flattop7	0.58	0.43	0.37	6.3
Flattop10	0.52	0.38	0.35	7.3

Flattop laser shaping





100% projected emittance FT 30% reduction, but fastscan charge cut is always high with scaling factor. Can we really measure the difference?

Gaussian vs flattop laser

Laser: BSA1.3mm, 500 pC

- **Beam quality within +/- σ_z**

Transverse uniform

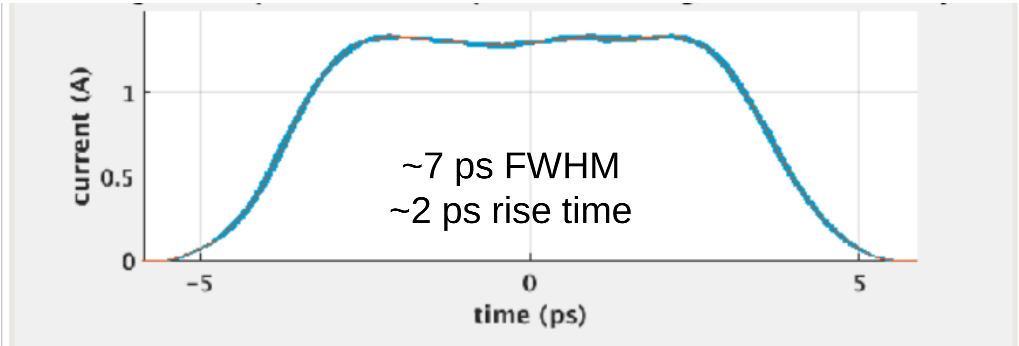
	Proj	slice	Mismatch	dE
Gaussian	0.66	0.60	0.24	4.8
Flattop7	0.80	0.70	0.39	8.5
Flattop10	0.66	0.60	0.28	9.8

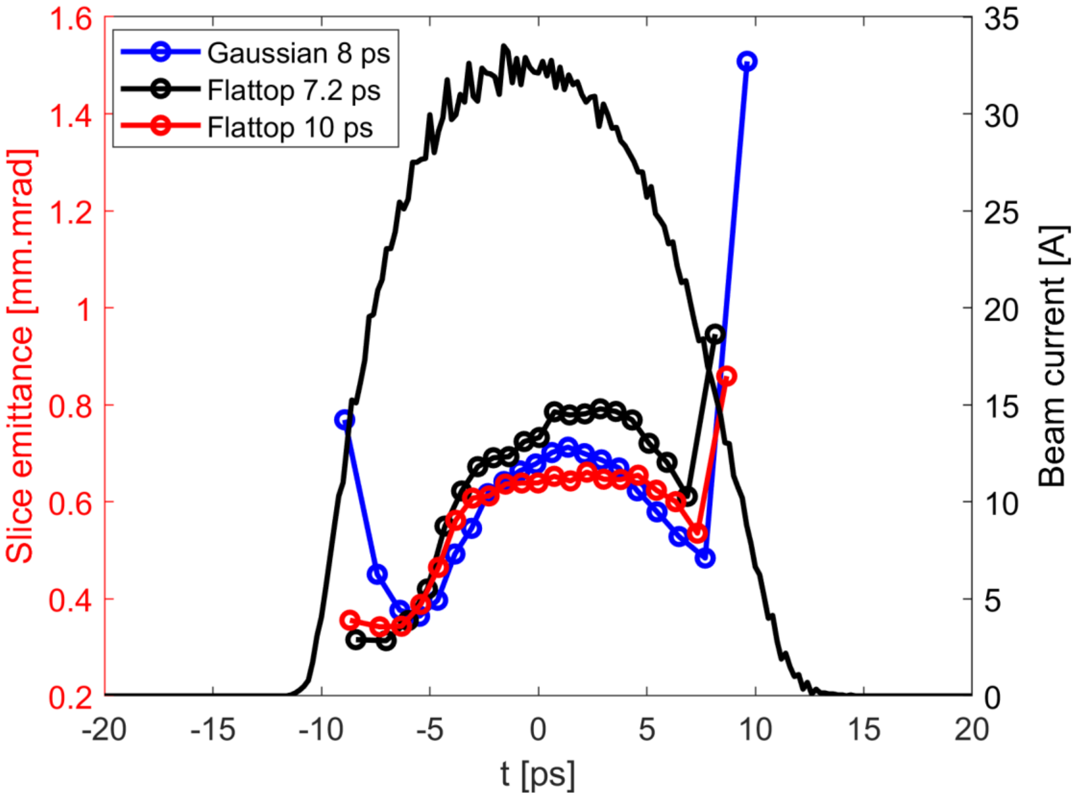
95% projected emittance FT no advantage.

- **Full beam quality**

	Proj	slice	Mismatch	dE
Gaussian	1.01	0.63	0.77	4.8
Flattop7	0.88	0.65	0.57	8.5
Flattop10	0.78	0.58	0.50	9.8

Flattop laser shaping





100% projected emittance FT 23% reduction, but fastscan charge cut is always high with scaling factor. Can we really measure the difference?

Measurements summary

BSA1mm, 6.3 MeV/c

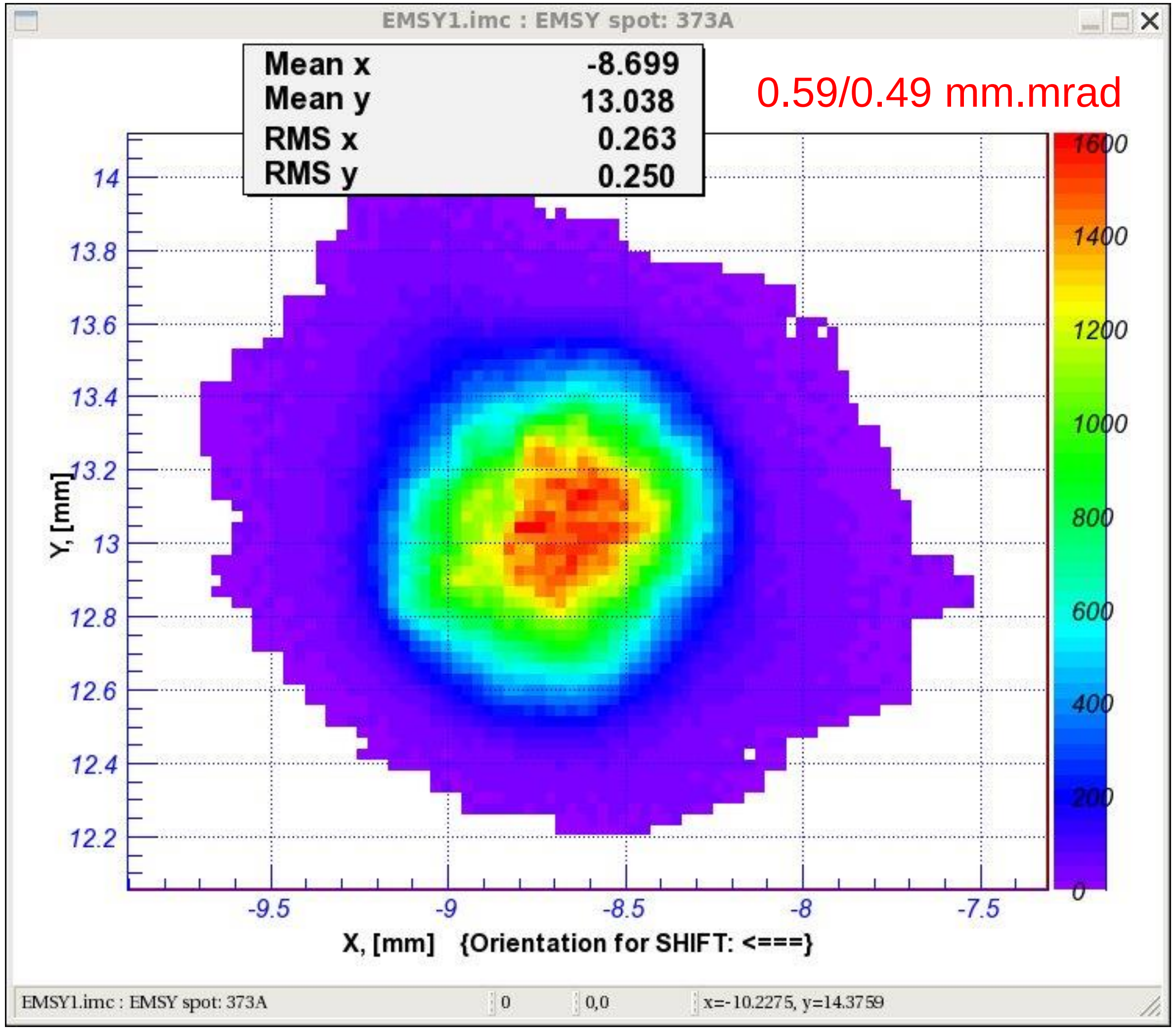
- 250 pC (MBI)
  - **2019, with high QE cathodes from INFN**
  - 0.53/0.44 um.rad, 0.21 mm, scaling 1.22 (03.07.2019A, Uniform), 2000/2000, 5 nm
  - 0.53/0.51 um.rad, 0.19 mm, scaling 1.04 (17.12.2019A, Uniform), 2000/2000, 15 nm
  - 0.45/0.39 um.rad, 0.24 mm, scaling 1.15 (18.12.2019A, 1-sig truncation)
  - **2020, High1.scr4 YAG change report on 9.3.2020, to improve uniformity**
  - 0.66/0.51 um.rad, 0.29 mm, scaling 1.3 (26.09.2020N, Uniform), 2200/2000, 5 nm

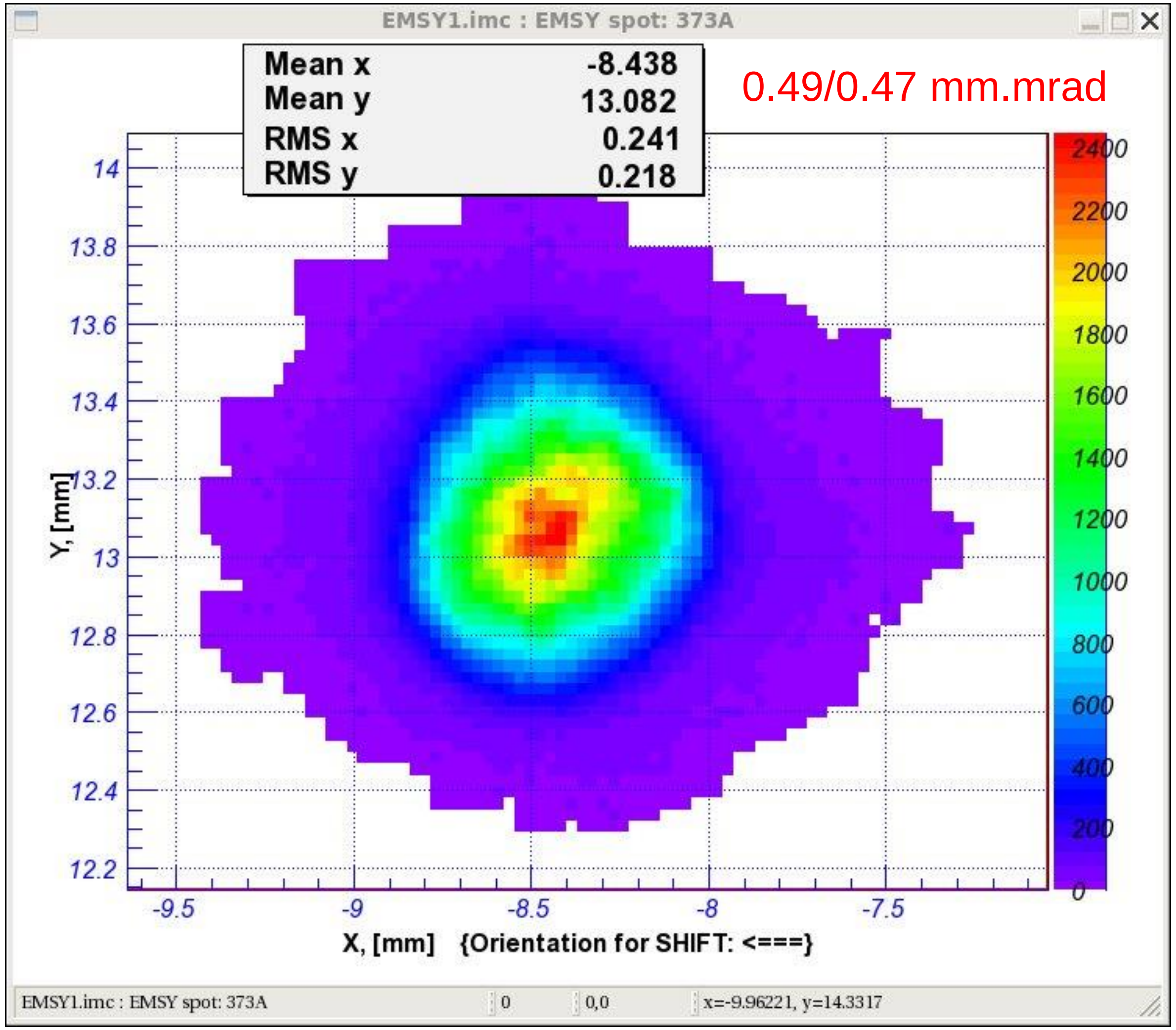
  Booster steering free

  - **2021, with 5 nm cathode from INFN, High1.scr1 YAG change before the run, to improve uniformity, much higher signal**
  - 0.87/0.51 um.rad, 0.23 mm, scaling 1.7 (24.02N, light on, Lecroy not calibrated, may overestimate Q)
  - 0.67/0.55 um.rad, 0.27 mm, scaling 1.2 (25.02A, Lecroy not calibrated, 250pC?after correction)
  - 0.78/0.57 um.rad, 0.28 mm, scaling 1.4 (25.02A, Lecroy not calibrated, 300 pC?after correction)
  - 0.81/0.57 um.rad, 0.31 mm, scaling 1.4 (25.02N, Lecroy not calibrated, 320 pC?after correction)
  - 0.74/0.58 um.rad, 0.27 mm, scaling 1.3 (27.02A, Lecroy not calibrated, 330 pC?after correction, reload low steering from 2019)
  - 0.70/0.45 um.rad, 0.25 mm, scaling 1.5 (28.02N, Lecroy not calibrated, ~270 pC?after correction, 1-sig truncation)
  - In comparison from our best values
- 250 pC (PHAROS, 7.2ps/2ps flattop), 5 nm
  - 0.81/0.68 um.rad, 0.32 mm, scaling 1.2 (26.02A, Lecroy not calibrated, 300 pC?after correction)
  - 0.87/0.70 um.rad, 0.33 mm, scaling 1.2 (26.02N, Lecroy not calibrated, 320 pC?after correction)

Same shift, different gun quads (8.7.2019A)

Same unscaled emittance, different scaled emittance





Measurements summary

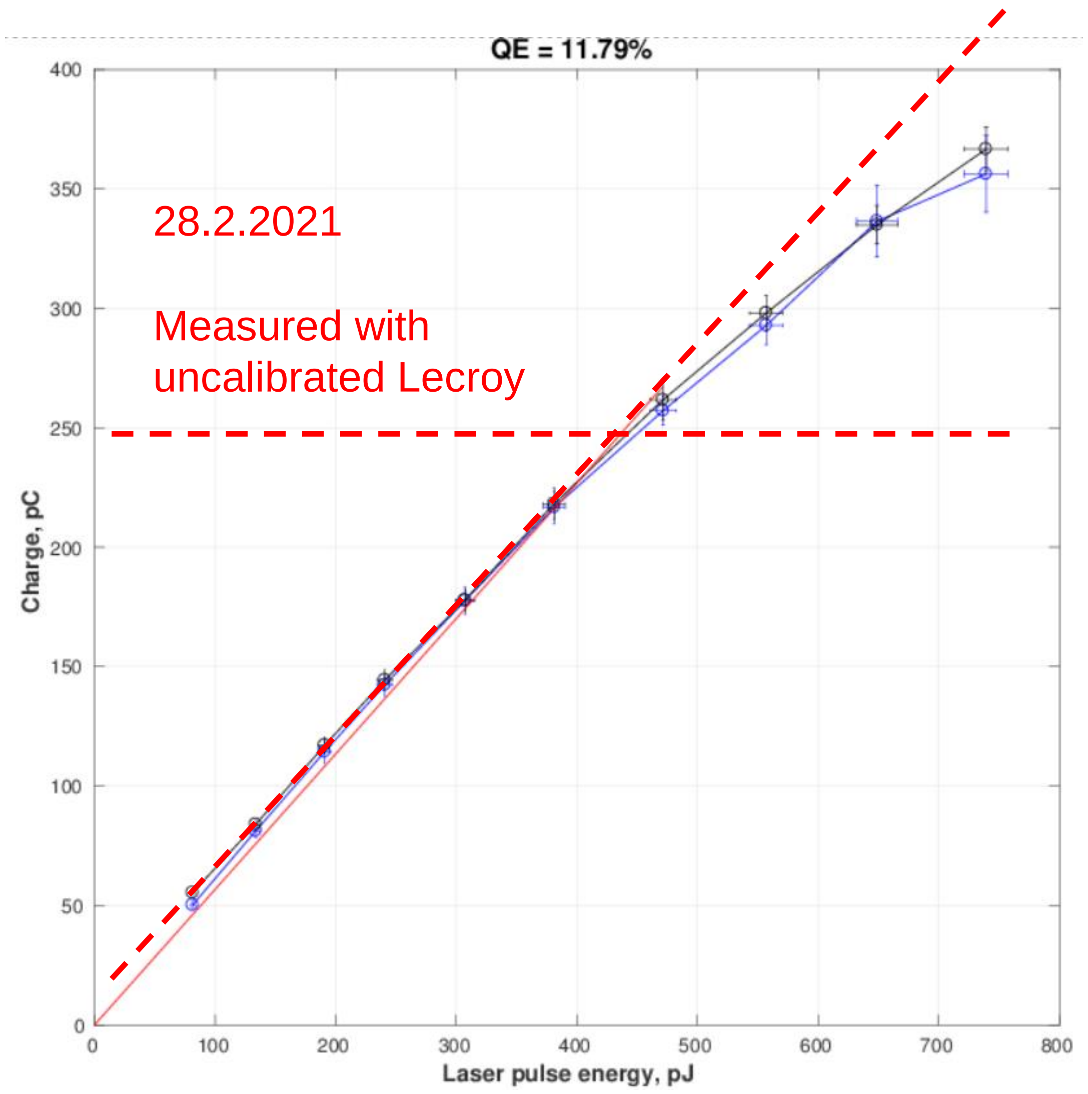
BSA1.3mm, 370A

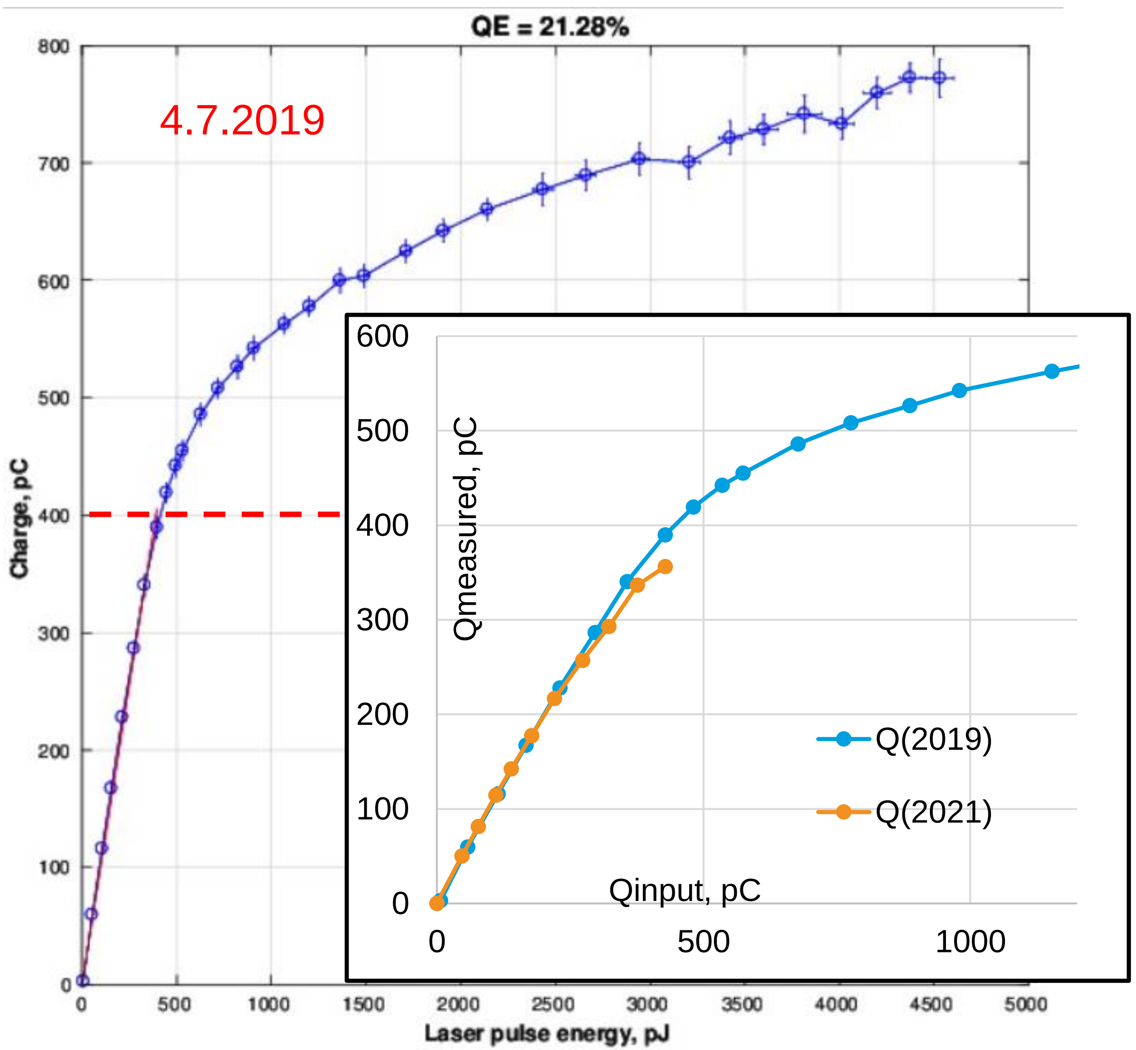
- 500 pC (MBI)
  - 2019
  - 1.0/0.84 um.rad, 0.29 mm, scaling 1.2 (21.11.2019N, 500pC)
  - 2021
  - 1.1/0.93 um.rad, 0.38 mm, scaling 1.2 (27.02A, Lecroy not calibrated, 470pC?after correction)
  - 1.4/0.85 um.rad, 0.36 mm, scaling 1.6 (27.02N, Lecroy not calibrated, 480pC?after correction)

- 500 pC (PHAROS, 7.2ps/2ps flattop)
  - 1.31/1.00 um.rad, 0.40 mm, scaling 1.3 (27.02A, Lecroy not calibrated, 500 pC?after correction)

Emission curve during measurement

Scope calibration related issue

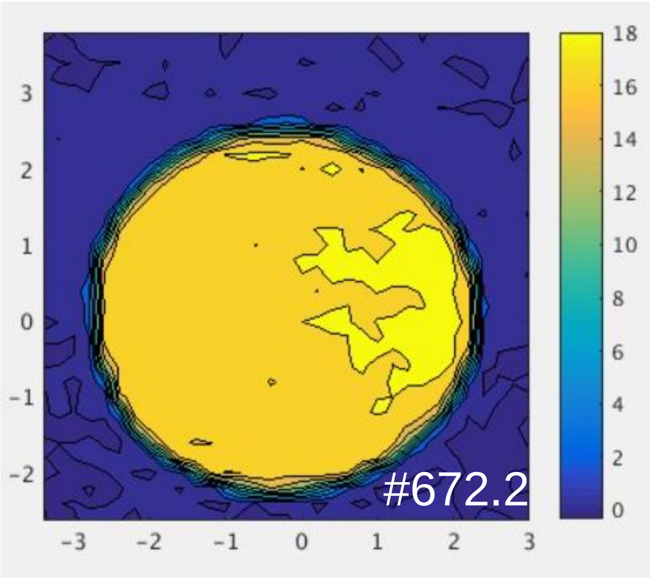




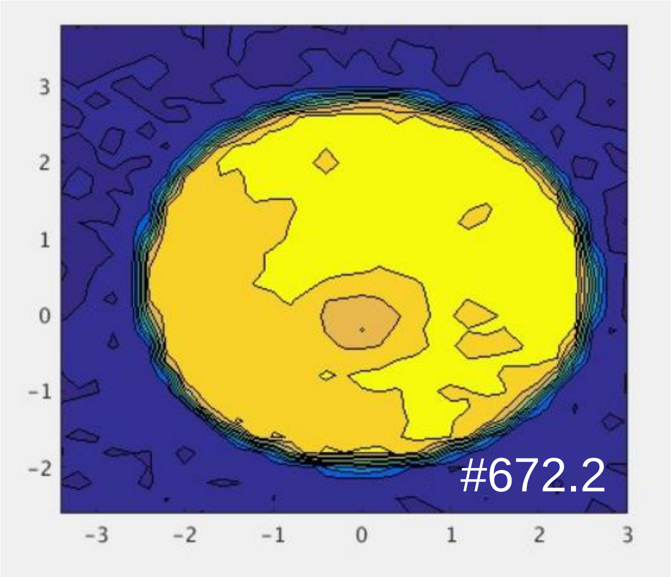
10 nm #672.2 (672.1) VS 5 nm #676.1

22%

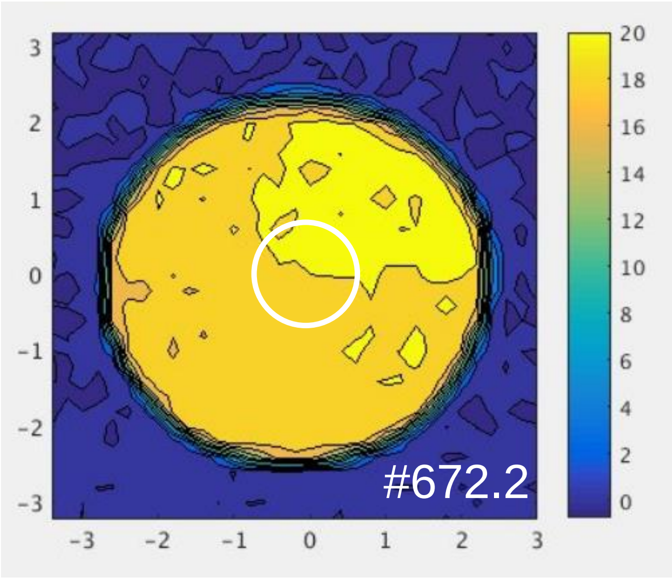
2019/07/12M



2019/07/27A

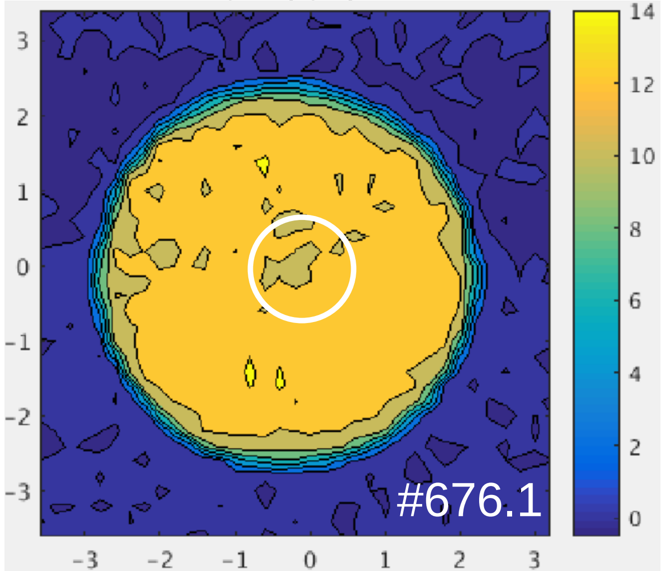


2020/03/15N



22%

2021/02/24M

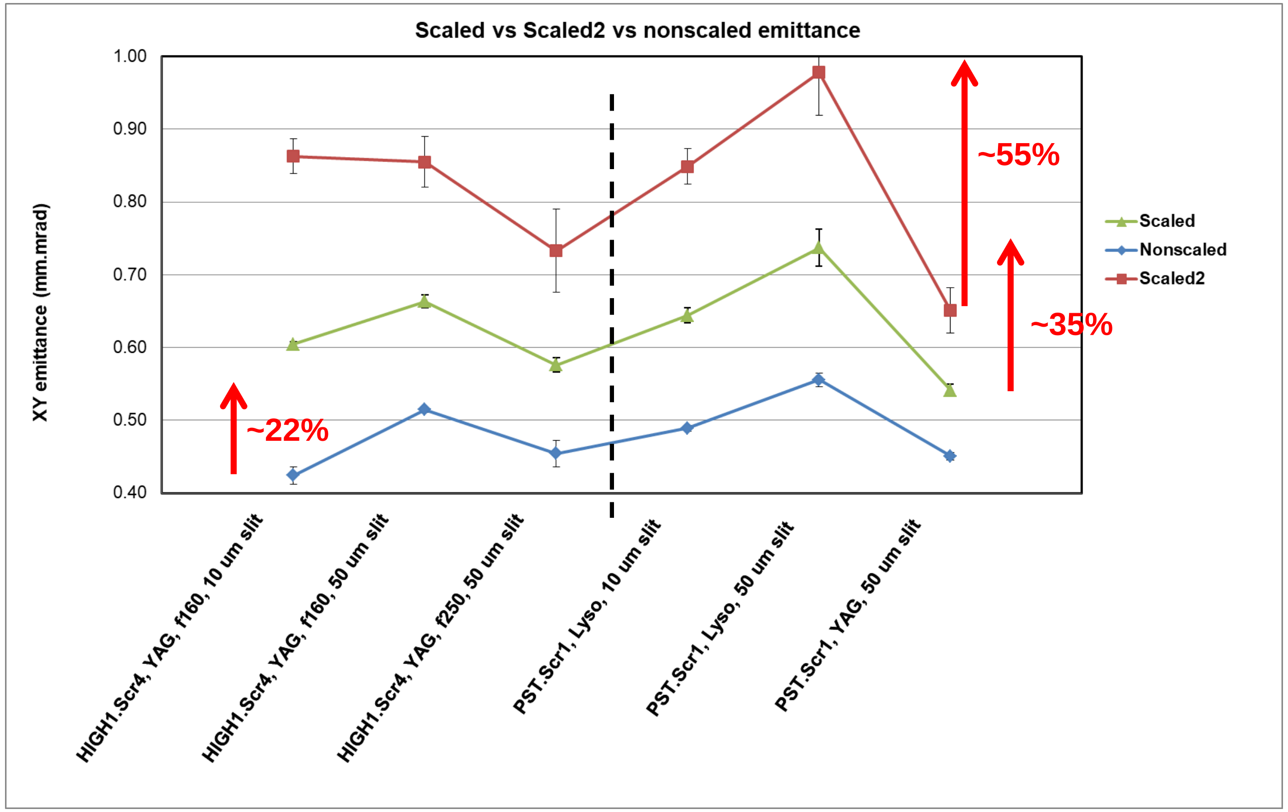


11%

Emittance systematics (scan beamlet screens vs. slits) cont.

20200926A, 20200926N, 20200927A, 20200927N

- BSA = 1 mm, 250 pC, gun ➔ 6.3 MeV/c, booster ➔ 19.5 MeV/c
- Values of I_{main} for minimum emittance are between 370A and 373A
- All results in plots are derived from 1x3 statistics
- There are results for 500 pC cases (not include in this presentation)
- Maximum discrepancies are ~55%, ~35% and 22% for the scaled2, scaled and non-scaled cases, respectively.
- Detailed results and discussions should be for a dedicated meeting



High emittance investigation in 2020

Station	H1S4	H1S4	H1S4	PSTS1	PSTS1	PSTS1
Material	YAG	YAG	YAG	LYSO	LYSO	YAG
Lens	F160	F160	F250			
Slit width	10um	50um	50um	10um	50um	50um
Solenoid	373A	373A	373A	371A	370A	371A
Statistics	**1000**	**2000**	**1500**	**2000**	**1800**	**300**

250 pC emittance

XFEL Working point, as reference for PHAROS shaping program

- Before MBI laser change to modulated laser experiment (26.09.2020N)
  - Xemit= 0.614 +/- 0.007 mm mrad, Yemit= 0.717 +/- 0.018 mm mrad, XYemit= 0.663 +/- 0.009 mm mrad
- After modulated laser experiment, realignment of lyot filter (2.10.2020)
  - Xemit= 0.800 +/- 0.010 mm mrad, Yemit= 0.845 +/- 0.008 mm mrad, XYemit= 0.822 +/- 0.006 mm mrad
- After laser transport to VC2 realignment (for PHAROS program), shutdown for 2 shifts (4.10.2020)
  - Xemit= 0.675 mm mrad, Yemit= 0.696 mm mrad, XYemit= 0.685 mm mrad
- Reason for high emittance unknown

High emittance investigation in 2020

Why higher emittance?

- Compared to 2020, consistent results if same bunch charge
  - Higher charge due to scope calibration?
  - Low section steering effect, same unscaled emittance, different EMSY size, different scaled emittance
- Compared to 2019
  - Cathode thermal emittance?
  - Cathode QE uniformity?
  - Should we try the 15 nm cathode (672.2)? Less used, high QE, lower thermal emittance, maybe better QE uniformity?
- How to proceed?
  - Calibrate scope, monitor charge drift during statistics using low.ict ADC signal (IBPC)
  - Keep 2000 statistics for both EMSY and MOI measurement
  - High1.scr4 screen effect? Measure emittance with new screens in high1.scr5?
  - Measure statistics with both 10/50 um slit
  - Try different low steering? Try different gun quads?
  - …