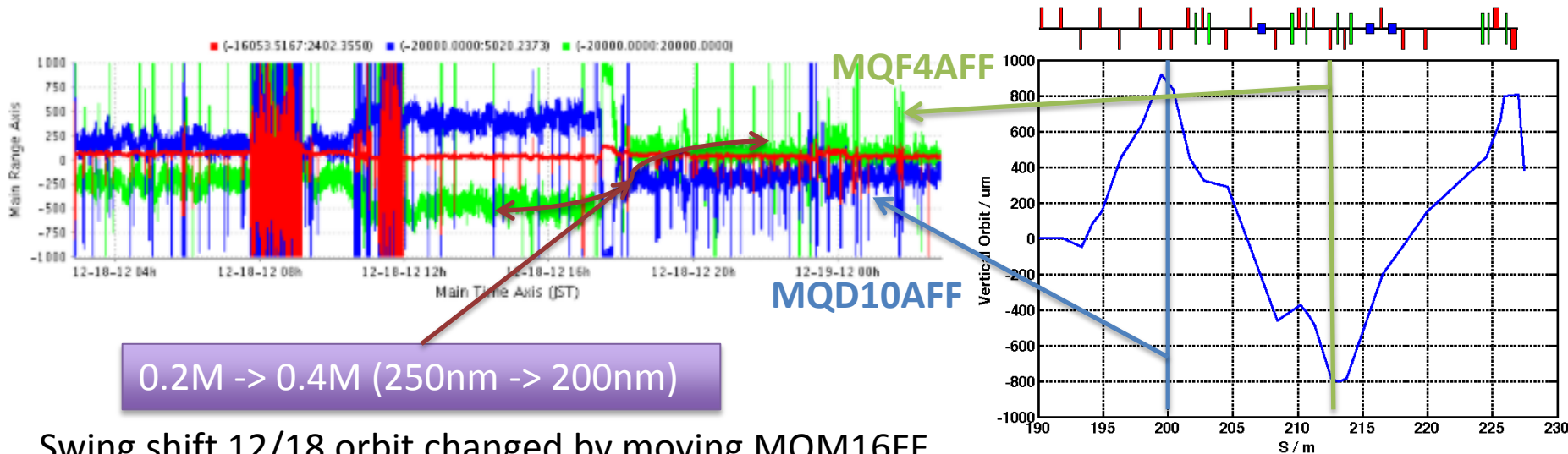


BPM Orbit Data Analysis with Wakefields

Glen White, SLAC

January 2013

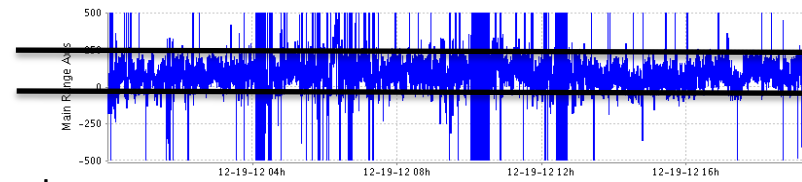
FFS Orbit Stability



0.2M -> 0.4M (250nm -> 200nm)

In model, this orbit generates 30nm beam size growth at IP due to change in vertical orbit in sextupoles

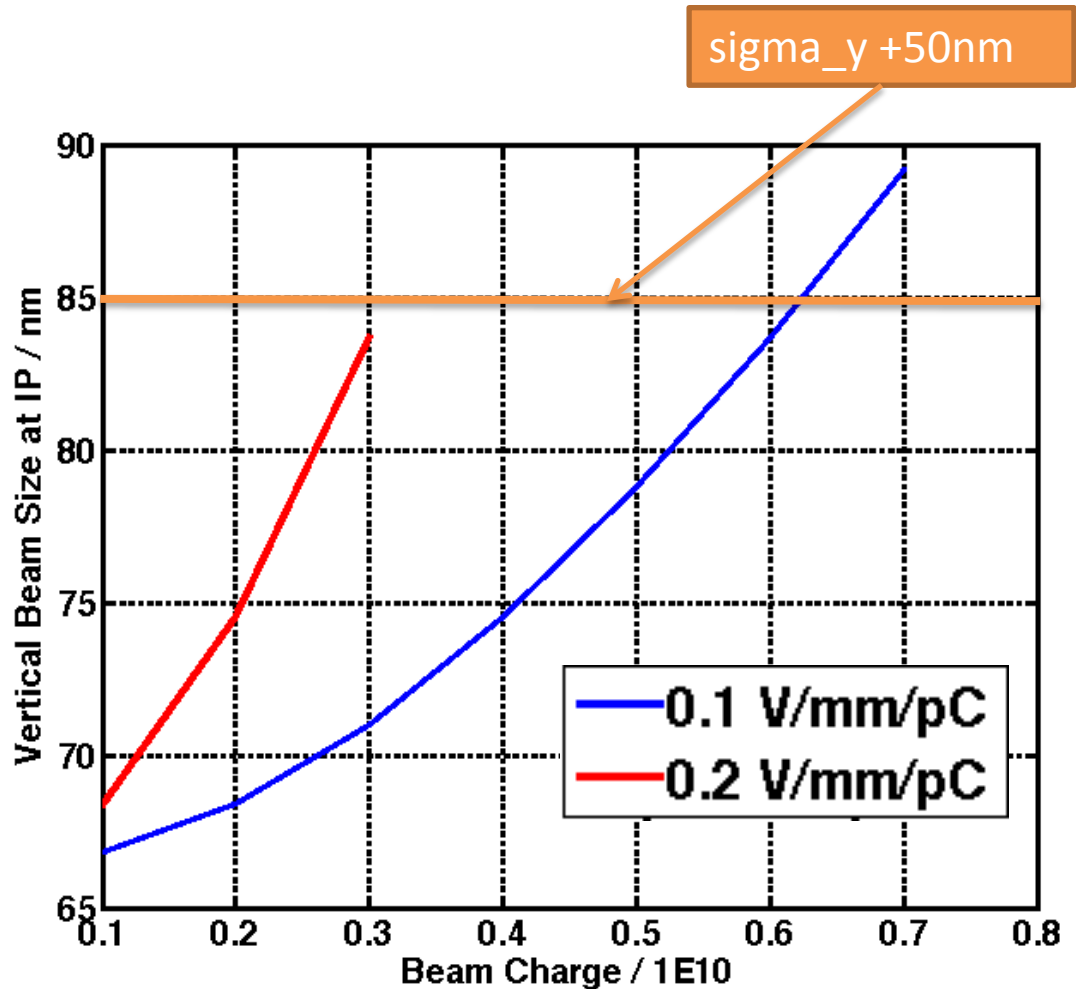
- Swing shift 12/18 orbit changed by moving MQM16FF 60um vertically.
- Beam size improved by 50nm
 - 30nm due to change in orbit in FFS sextupoles
 - Rest due to wakefields?
- Orbit seen to drift around vertically in FFS with this pattern.
 - From simulation, tolerance for this is +/- 150um at the MQF4AFF/MQD10AFF beta peaks -> ~2nm beam size growth
 - Drift with EXT/FFS feedback active is observed to be less than this so OK.
 - This tolerance drops to 70um when including cavity wakes at 1E10 charge, and 125um at 1E9 charge.



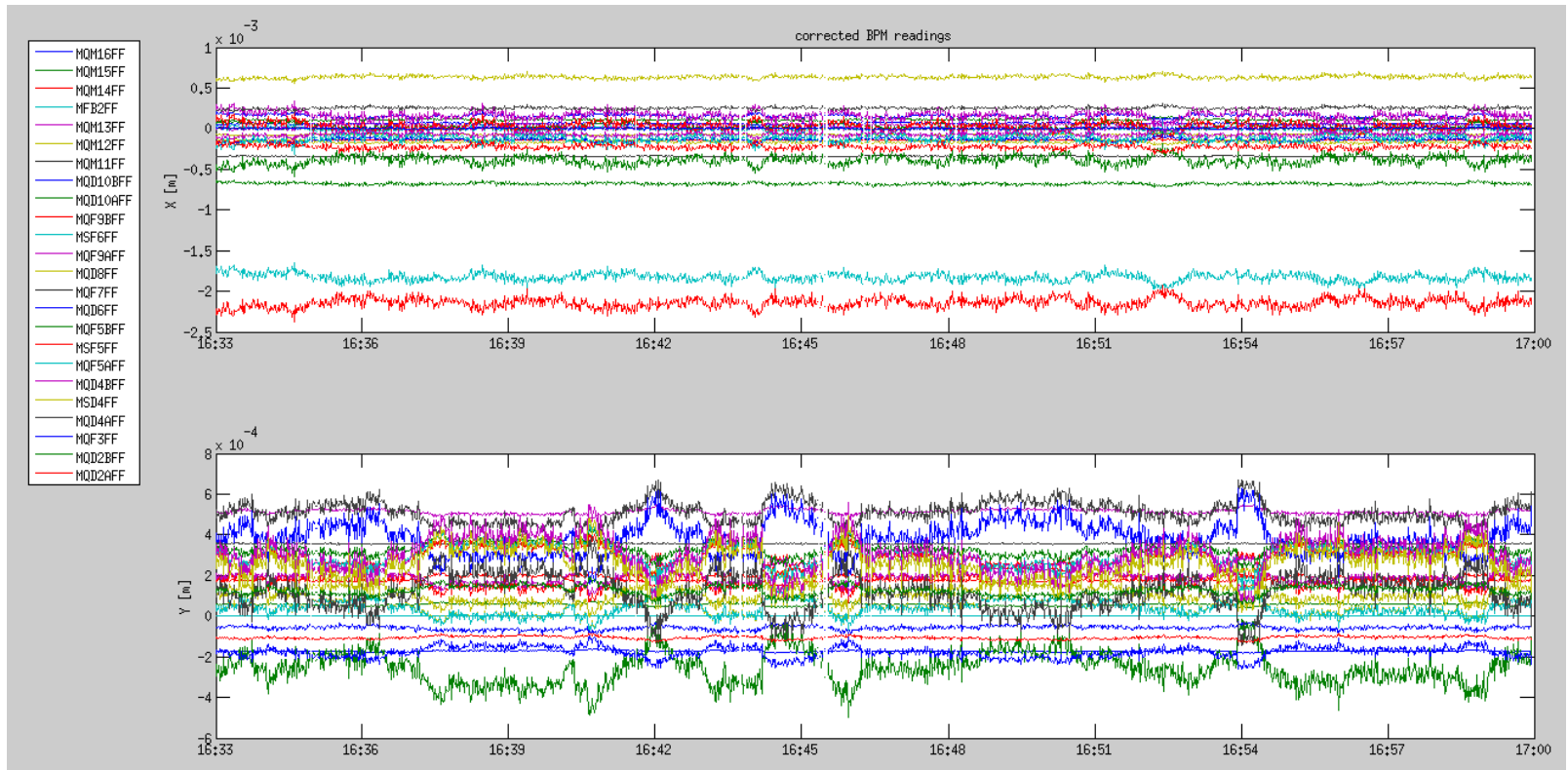
+/- 125um at MQD10AFF over 12 hours

Simulate FFS Orbit Offset

- Beam size at IP from tracking simulation.
- Start perfect lattice, offset QM16FF by 60 μ m.
- Include 0.1V/mm/pC wake in cavities.

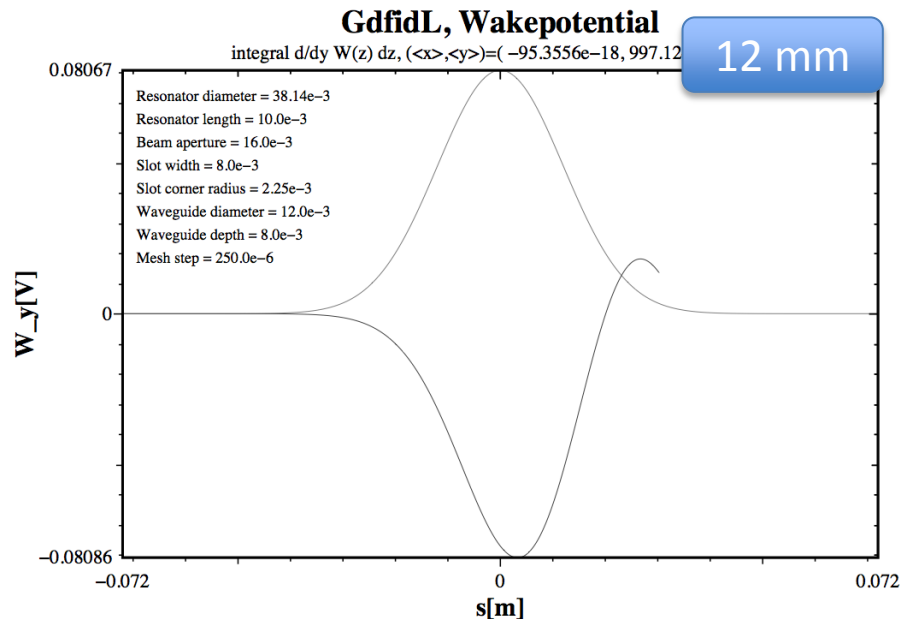
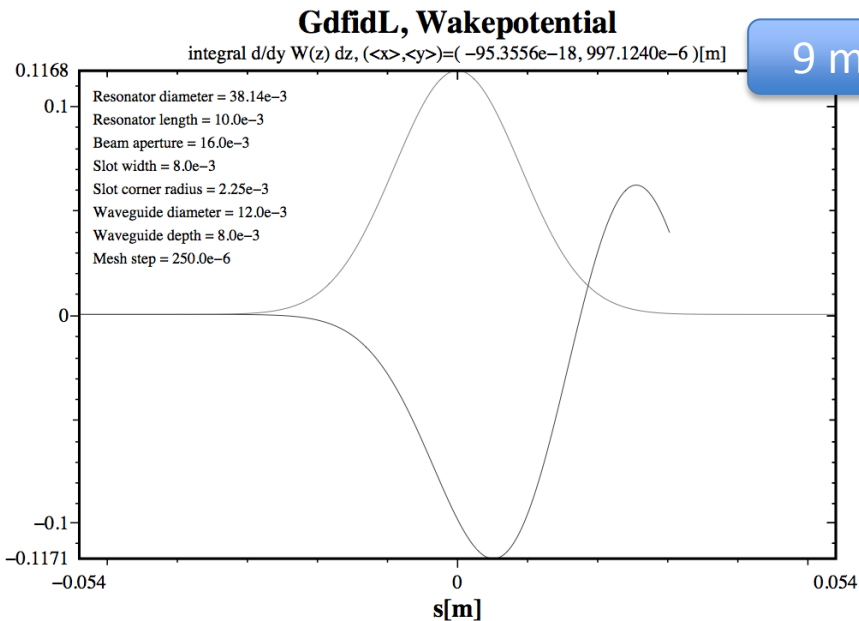


BPM Orbit With Respect to BPM Centres



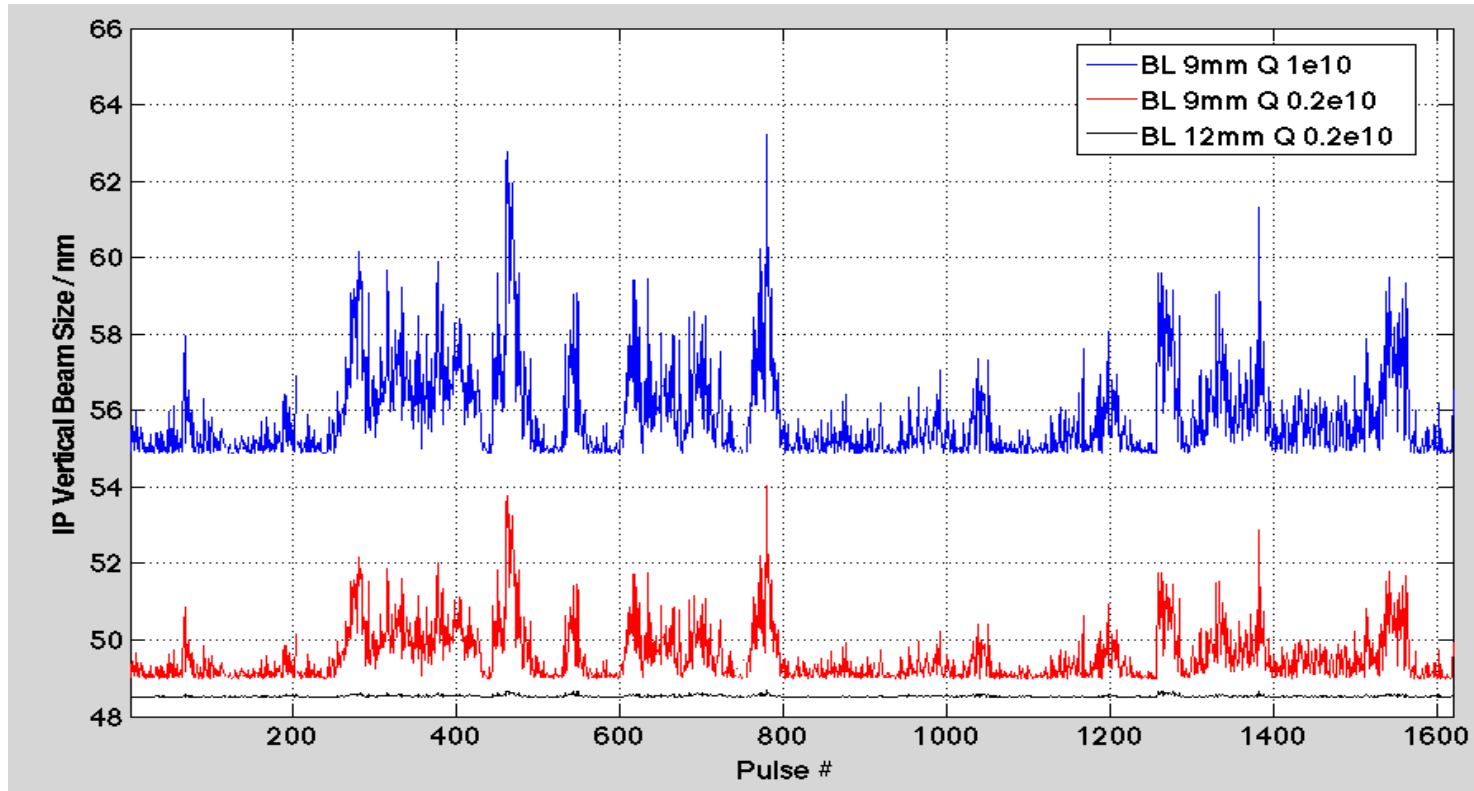
- 30 mins data taken from Friday Dec 21 archive.
 - (Data archived at 1Hz)
- Charge cuts applied based on reference cavity data.

Simulate Wakefield Effect on IP Beam Size



- Using cavity wakes calculated by A. Lyapin for 9 and 12 mm
- Track 2E4 macro-particle bunch through FFS, apply convoluted wake function at each cavity BPM location using measured BPM offset. Record IP vertical spot size for each pulse.
- Beamline is otherwise perfect, using 24pm input beam vertical emittance.

IP Beam Size from Cavity Wakes



- Used double wake potential (peak ~ 0.2 V/pC/mm)
- Design beam charge ($1E10$)
- With December conditions (Bunch length ~ 12 mm?, $1E9$ charge), effect is negligible

Emittance in EXT

- Q=3E9
 - 1.9nm x 30pm
- Q=1E9
 - 1.4nm x 20pm
- @IP
 - 44nm -> 54nm
- No EXT emittance change observed with DR RF V

Horizontal projected emittance parameters at first OTR

```

energy = 1.2690 GeV
emit = 1.3675 +- 0.0158 nm
emitn = 3395.9890 +- 38.7832 nm
emit*bmag = 1.4220 +- 0.0233 nm
bmag = 1.0389 +- 0.0058 ( 1.0000)
bmag_cos = -0.2238 +- 0.0000 ( 0.0000)
bmag_sin = 0.1584 +- 0.0000 ( 0.0000)
beta = 5.0892 +- 0.0517 m ( 6.3052)
alpha = -3.4628 +- 0.0510 ( -4.4943)
chisq/N = 0.1404
  
```

Horizontal projected emittance parameters at IP

```

sig = 28.4870 +- 0.1898 um ( 7.3883)
sigp = 195.4085 +- 1.2122 ur ( 185.1543)
beta = 593.4239 +- 10.9225 mm ( 39.8952)
alpha = -4.0318 +- 0.0634 ( -0.0238)
  
```

Horizontal projected emittance parameters at waist

```

L = -0.1387 +- 0.0007 m
beta = 34.3808 +- 0.4042 mm
sig = 6.8578 +- 0.0678 um
  
```

Vertical projected emittance parameters at first OTR

```

energy = 1.2690 GeV
emit = 20.8767 +- 0.6618 pm
emitn = 51.3474 +- 1.8429 nm
emit*bmag = 21.0449 +- 0.5317 pm
bmag = 1.0181 +- 0.0059 ( 1.0000)
bmag_cos = 0.0187 +- 0.0000 ( 0.0000)
bmag_sin = -0.1985 +- 0.0000 ( 0.0000)
beta = 6.4197 +- 0.1529 m ( 6.1903)
alpha = 2.4819 +- 0.0860 ( 2.5763)
chisq/N = 0.8957
  
```

Vertical projected emittance parameters at IP

```

sig = 3.0635 +- 0.0822 um ( 0.0458)
sigp = 426.4898 +- 0.3422 ur ( 453.3102)
beta = 453.8997 +- 13.8134 mm ( 0.1006)
alpha = -63.1820 +- 1.9524 ( 0.0019)
  
```

Vertical projected emittance parameters at waist

```

L = -0.0072 +- 0.0000 m
beta = 0.1137 +- 0.0036 mm
sig = 0.0485 +- 0.0008 um
  
```

Horizontal projected emittance parameters at first OTR

```

energy = 1.2690 GeV
emit = 1.8721 +- 0.0145 nm
emitn = 4649.0634 +- 35.9473 nm
emit*bmag = 1.9647 +- 0.0251 nm
bmag = 1.0495 +- 0.0081 ( 1.0000)
bmag_cos = -0.2113 +- 0.0000 ( 0.0000)
bmag_sin = 0.2178 +- 0.0000 ( 0.0000)
beta = 5.2190 +- 0.0464 m ( 6.3052)
alpha = -3.4915 +- 0.0299 ( -4.4943)
chisq/N = 23.3655
  
```

Horizontal projected emittance parameters at IP

```

sig = 32.2819 +- 0.4708 um ( 8.6422)
sigp = 226.7201 +- 2.5252 ur ( 216.8846)
beta = 556.6579 +- 17.3926 mm ( 39.8952)
alpha = -3.7794 +- 0.1114 ( -0.0238)
  
```

Horizontal projected emittance parameters at waist

```

L = -0.1376 +- 0.0008 m
beta = 36.4209 +- 0.8749 mm
sig = 6.2573 +- 0.1151 um
  
```

Vertical projected emittance parameters at first OTR

```

energy = 1.2690 GeV
emit = 30.0655 +- 0.7682 pm
emitn = 74.7128 +- 1.9077 nm
emit*bmag = 30.3844 +- 0.6406 pm
bmag = 1.0099 +- 0.0071 ( 1.0000)
bmag_cos = 0.0034 +- 0.0000 ( 0.0000)
bmag_sin = -0.1399 +- 0.0000 ( 0.0000)
beta = 6.2729 +- 0.1290 m ( 6.1903)
alpha = 2.4694 +- 0.0745 ( 2.5763)
chisq/N = 7.4851
  
```

Vertical projected emittance parameters at IP

```

sig = 3.7743 +- 0.0949 um ( 0.0550)
sigp = 525.6588 +- 0.4378 ur ( 546.8062)
beta = 473.4091 +- 14.6192 mm ( 0.1006)
alpha = -65.9370 +- 2.0664 ( 0.0019)
  
```

Vertical projected emittance parameters at waist

```

L = -0.0072 +- 0.0000 m
beta = 0.1069 +- 0.0035 mm
sig = 0.0572 +- 0.0008 um
  
```