β* measurement with Q1 strength modulation

Y.Luo, A. Marusic, M. Minty, C. Liu

(2011 May 25 RHIC APEX)

The Principle

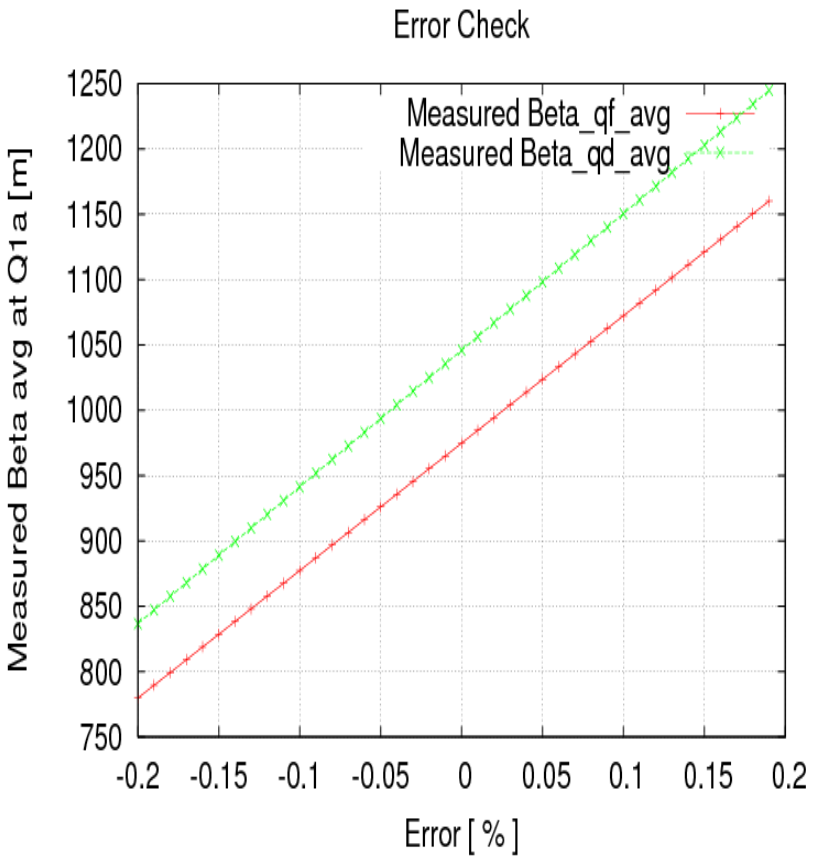
1. Measure the averaged beta function in Q1s through Q1 strength modulation.

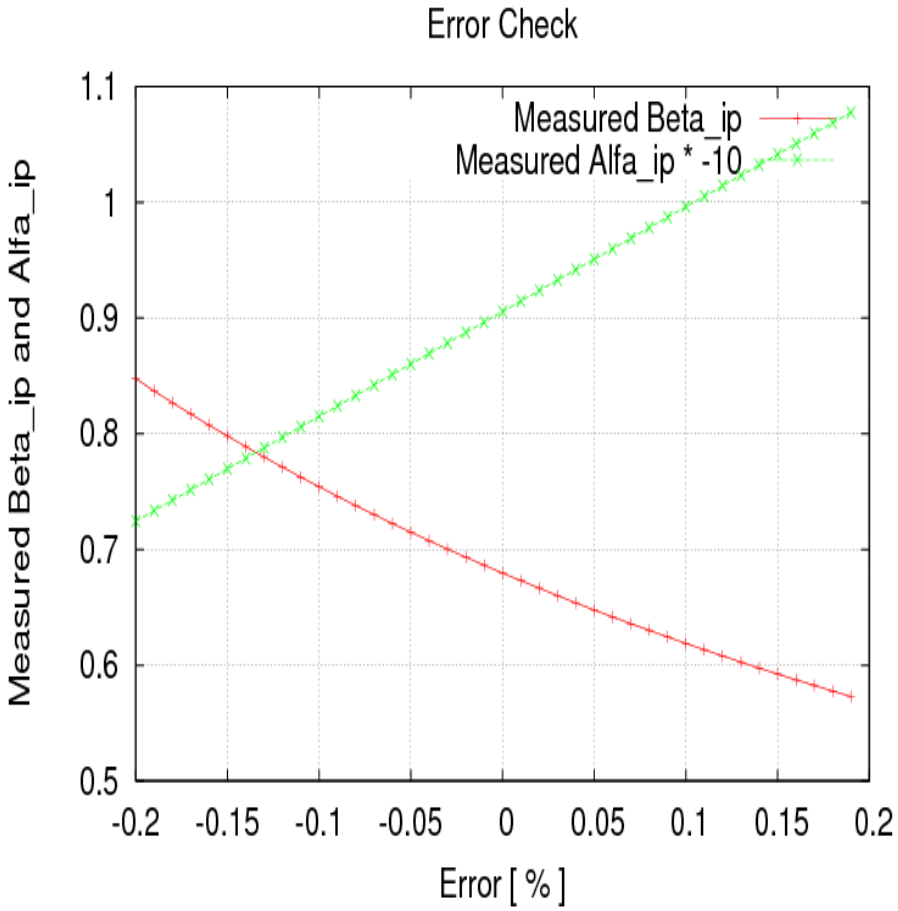
2. From averaged Beta at Q1s (one is focusing, one is defocusing), fit the beta_star and alfa_star (at center of drift between two Q1).

3. Error in this measurement is mainly from beta_average measurement.

4. A 200+ C++ code was developed and tested against Model to find out the beta and alfa at IPs.

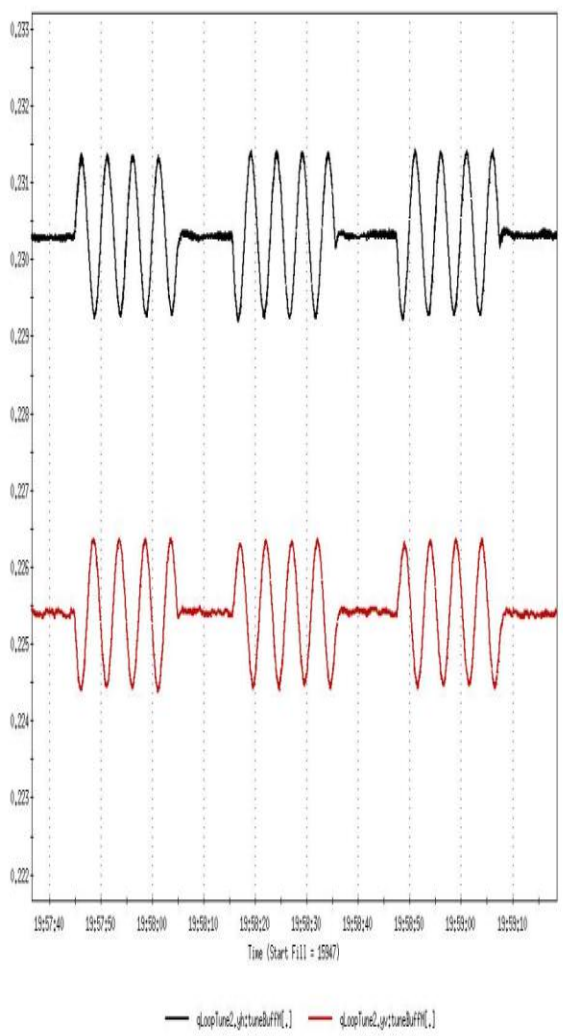
Error Budget

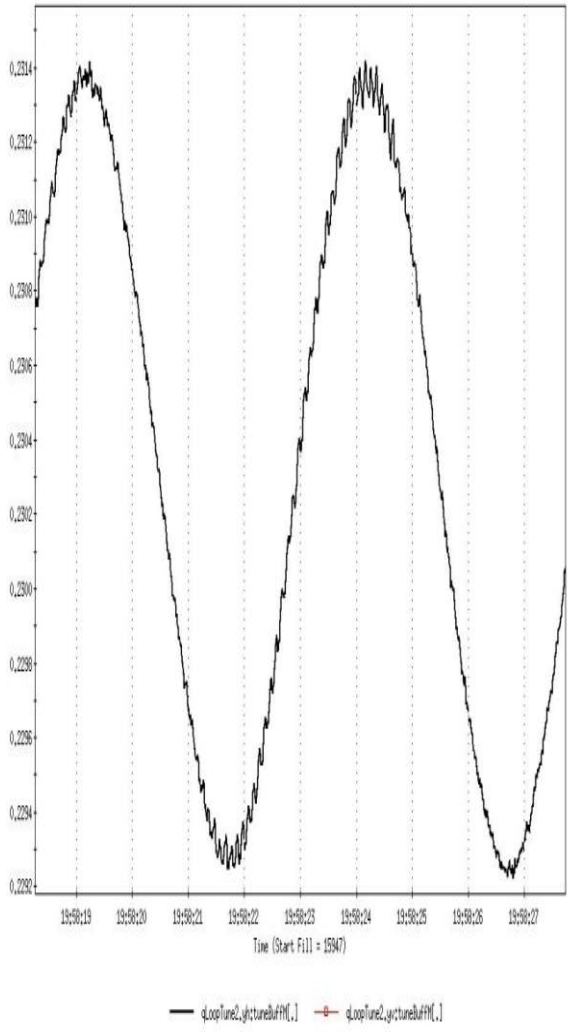


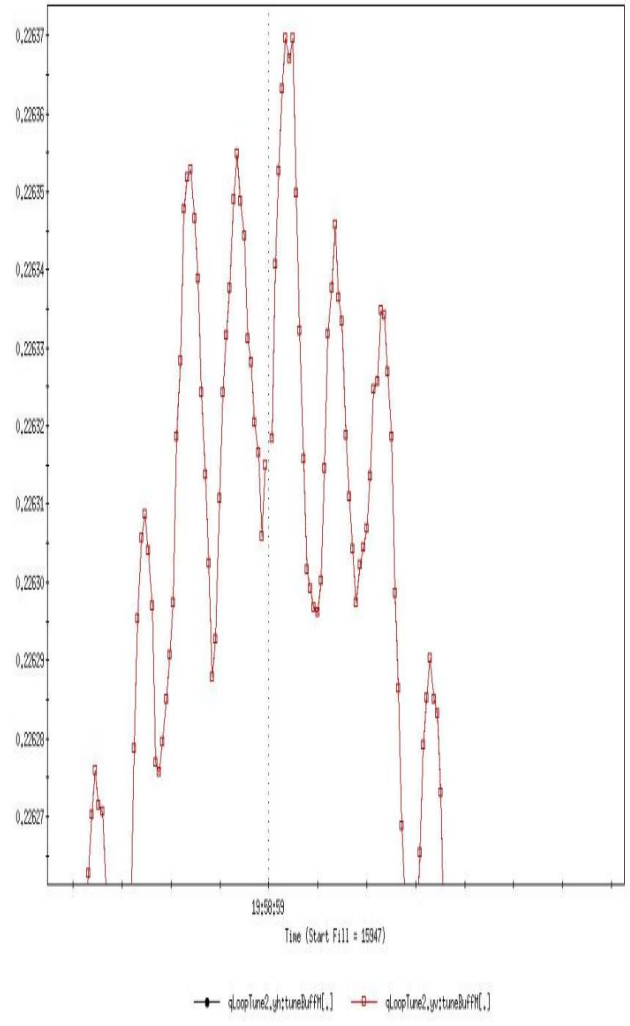


Measured Twiss parameters at IP vs. Error in Beta_avg **Error in beta_avg measurement should be less than 5% to give resolution 0.05m in beta*.**

Tune data from APEX







1A modulation of Q1 , frequency 0.2Hz, during 20 seconds

One example of measured beta*

NAME	dI	I0	K1L	dQx	dQy	betx_avg	bety_avg
yo5-qd1	1	5020.477	0.083109	0.0011055	0.000893	839.2	677.888
yo5-qd1	1	5020.477	0.083109	0.0011205	0.000883	850.587	670.297
yi6-qf1	1	5057.46	0.083131	0.001089	0.0009345	832.544	714.428
yi6-qf1	1	5057.46	0.083131	0.001105	0.0009400	844.776	718.633
yi7-qf1	1	5048.90	0.083131	0.0010115	0.0009535	771.986	727.72
yi7-qf1	1	5048.90	0.083131	0.001028	0.00096	784.579	732.681
yO8-qd1	1	5024.31	0.083109	0.0010545	0.0009535	801.096	724.367
yO8-qd1	1	5024.31	0.083109	0.001063	0.00093	807.554	706.515

```
[yunluo@jaguar beta_star_meas]$ ./beta_star_match_v1
Iteration    beta_sf fitting       beta_sd fitting     current beta_ip/beta_alfa      chi2
0   818.1-->838.66,   886.032-->844.894,  0.8  0,  2115.06
1   1120.74-->838.66,   1150.4-->844.894,  0.803907  -0.583932,  172900
2   894.486-->838.66,   905.355-->844.894,  1.01455  -0.583932,  6772.24
3   841.569-->838.66,   848.044-->844.894,  1.08081  -0.583932,  18.3901
4   838.644-->838.66,   844.876-->844.894,  1.08473  -0.583932,  0.000579893
....The beta and alfa at IP are:
  Beta_IP  = 1.08473
  Alfa_IP  = -0.583932
  Waist at       mm
```

Where measurement errors from

1. 10 Hz tune oscillation

observed: 7e-05 from peak-to-peak.
tune modulation: 2e-3 from peak-to-peak.
➔ **4% error contributing to measured beta_avg valve.**
10Hz can be filtered out . Or we don't use modulation, just knob Q1

2. Modulating current

Required 1A , output is 1A ? Precise calibration needed .
$d(K1L) = (d I / I_0) * (k1L)_0$?
I_0 ~ 5040 A, how to get 1A current change with 5% error bar
Current (strength) control gives more than 20% errors in beta_avg

The key to get beta* precisely is current modulation.