Beta* and beta-waist

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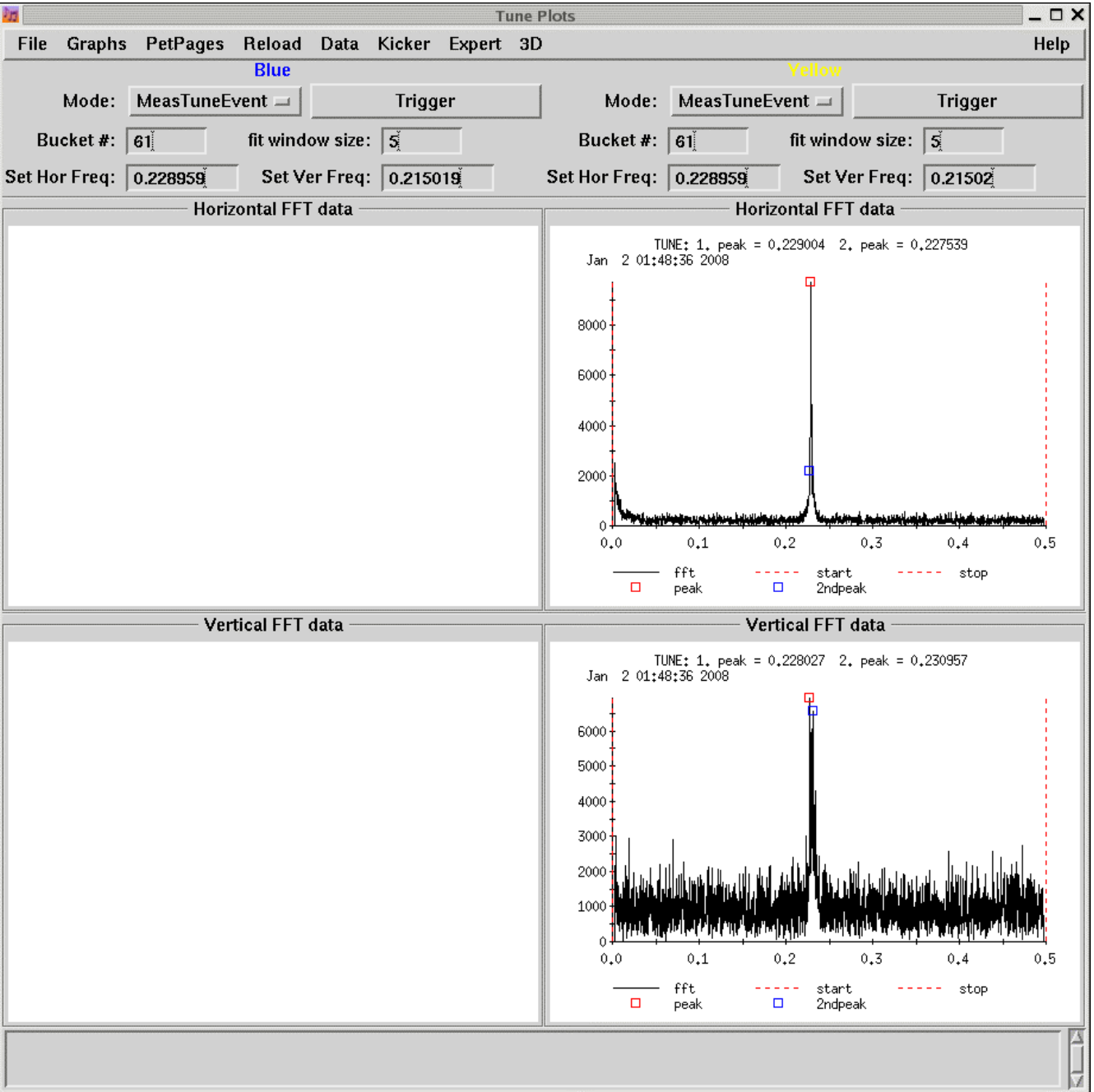
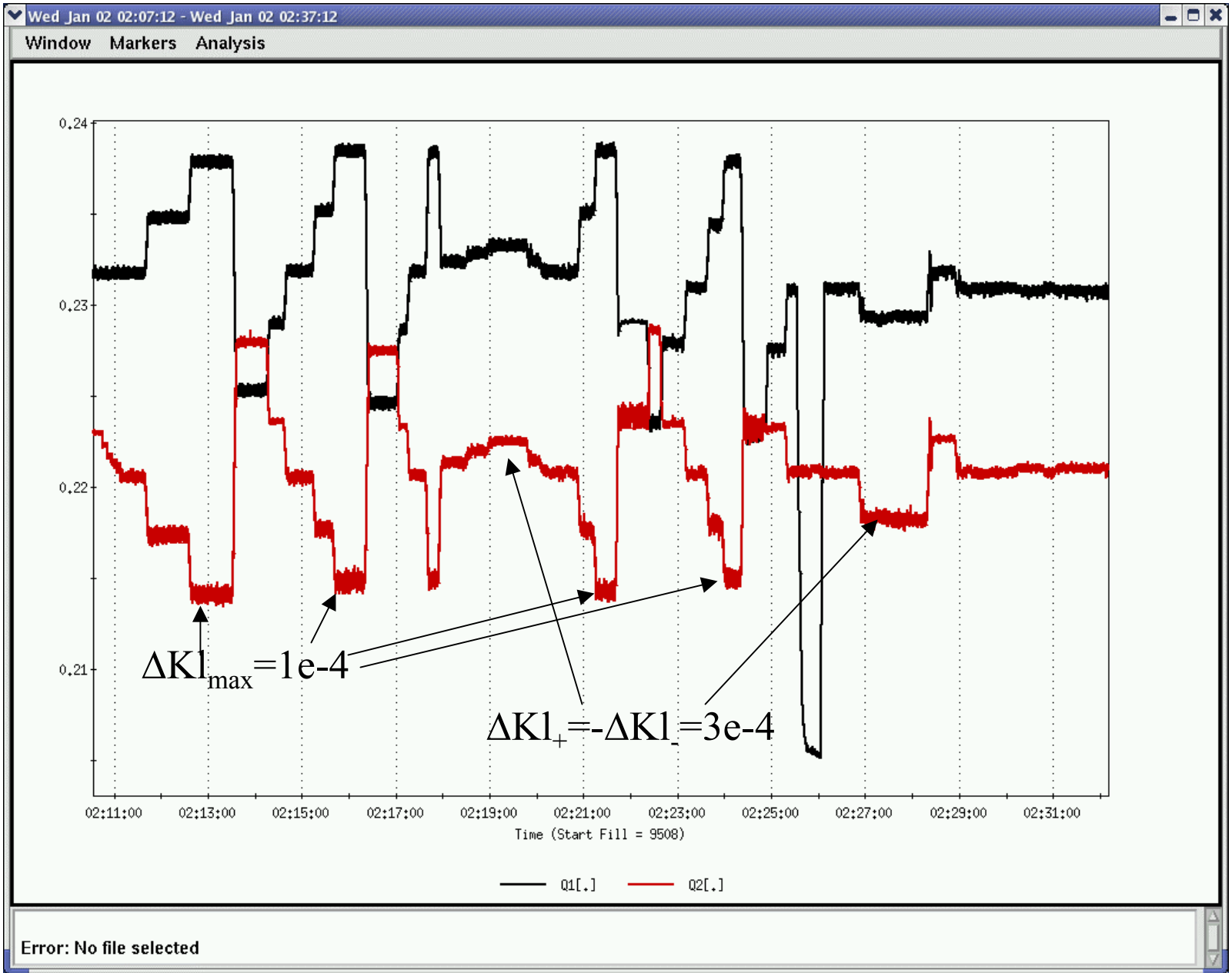


Careful preparation:

- decoupling to ~1e-3 level
- tune separation >0.01

Example of Yellow tune changes during Q1 gradient variations



Data for both rings from individual gradient changes. Blue lattice included non-zero tq4 at IR8 region.

	Yellow				Blue			
	IR6 H	IR6 V	IR8 H	IR8 V	IR6 H	IR6 V	IR8 H	IR8 V
β*,m	0.80	0.88	0.85	0.89	0.81	0.73	0.71	0.75
s*,cm	-34	-33	2	30	-5	-3	20	5

For BBQ accuracy of the tune measurements of 1e-4:
+-6cm error for s*, ~1.5% error for beta*

$$s^* = -\frac{L^*(\beta_+ a_- - \beta_- a_+) + 2(\beta_+ b_- - \beta_- b_+)}{2(\beta_+ a_- + \beta_- a_+)}; \qquad \beta^* = \frac{1}{\beta_+}\left(a_+ L^2 + 2b_+ L - 2a_+ L s^*\right)$$

Measurement using simultaneous Q1 gradient change on both side of the IR

$$\beta_+ - \beta_- = \frac{1}{\beta^*}\left((a_+ - a_-)L^2 + 2(b_+ - b_-)L - 2(a_+ + a_-)L\,s^*\right)$$

$$\beta_+ + \beta_- = \frac{L}{\beta^*}\left((a_+ + a_-)L + 2(b_+ + b_-)\right)$$

$$\Delta Q = \left(4.32 - 8.08\,s^*\right)\frac{\Delta Kl}{\beta^*}; \qquad \Delta Kl_+ = -\Delta Kl_- = \Delta Kl$$

$$\Delta Q = \frac{108.2\,\Delta Kl}{\beta^*}; \qquad \Delta Kl_+ = \Delta Kl_- = \Delta Kl$$

Measurement with simultaneous gradient change showed the shift of the waist position. dKl = +-1e-4 shifts the waist, according to Todd's matrix, by ~8cm.