CESR Sextupole Calibration Correction Factors and Horizontal Offset Results from 16 January 2022

CesrV sextupole calibration output for sextupole 34W

```
------------------------------------------------------------
&Params
 Lattice = "CHESS-U_6000MEV_20181120"
  i_Sex          = 34
  i_butns1       = 51
  i_butns2       = 52
  cu_sex_set1    = -12000
  cu_sex_set2    = 12000
  grp%rec%icoef  =     55091    -57687     45252
  grp%rec%name   = "CSR HORZ CUR", "CSR HORZ CUR", "CSR HORZ CUR"
  grp%rec%l1     =      32      34      36
  grp%rec%l2     =      32      34      36
  biggrp_set     = 0
  csr_set        = 0
  Date           = "2022-01-16 19:16:23"
/end
```

	Delta		@Sex_set1		Positions at nearest Dets				
CU_bump	f_x	f_y	f_x	f_y	x1	y1	x2	y2	Butns
-80	4.062	-1.337	215.747	248.925	-1.374	-1.549	2.447	-0.059	1581972
-40	2.284	-0.839	216.911	248.565	-2.062	-1.506	2.103	-0.053	1581973
0	1.157	-0.424	217.899	248.092	-2.747	-1.473	1.759	-0.050	1581974
40	-0.255	0.080	219.188	247.680	-3.469	-1.434	1.406	-0.043	1581975
80	-1.551	0.584	220.153	247.365	-4.188	-1.389	1.049	-0.035	1581976

Jim Crittenden and David Sagan

Machine studies meeting

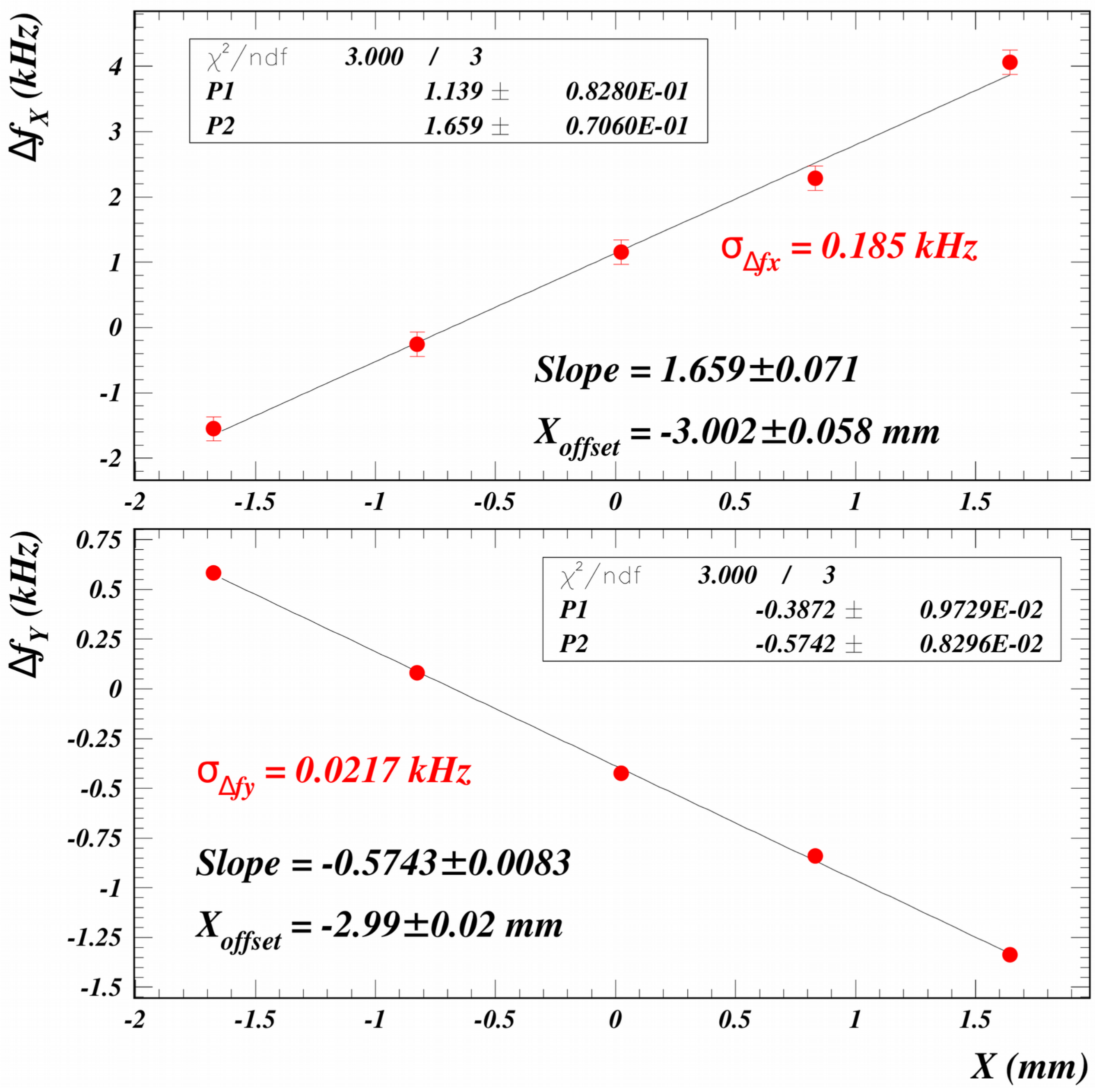
10 March 2022

Procedure

- Create a sextupole-specific bump.
- Calculate the bump settings to give the specified tune change range (± 4 kHz) using the greater of the H and V β-function values.
- Get a tune measurement.
- Loop over the specified number of tune settings (5).
    - Set the bump
    - Restore the pre-bump tunes (qtune).
    - Set the sextupole to the specified lower cu setting (-12k cu), settle.
    - Record a tune measurement.
    - Optionally record phase and turn-by-turn orbit data.
    - Record the orbit.
    - Set the sextupole to the upper cu setting (+12k cu), settle.
    - Record a tune measurement.
    - Optionally record phase and turn-by-turn orbit data.
    - Record the orbit.
    - Append results to the output file.
    - Update the bump setting.

Example: Sextupole 34W

Sextupole Calibration Data Fit for Sextupole Nr 34



The error bars $\sigma_{\Delta f}$ are adjusted to give χ^2/NDF = 1.

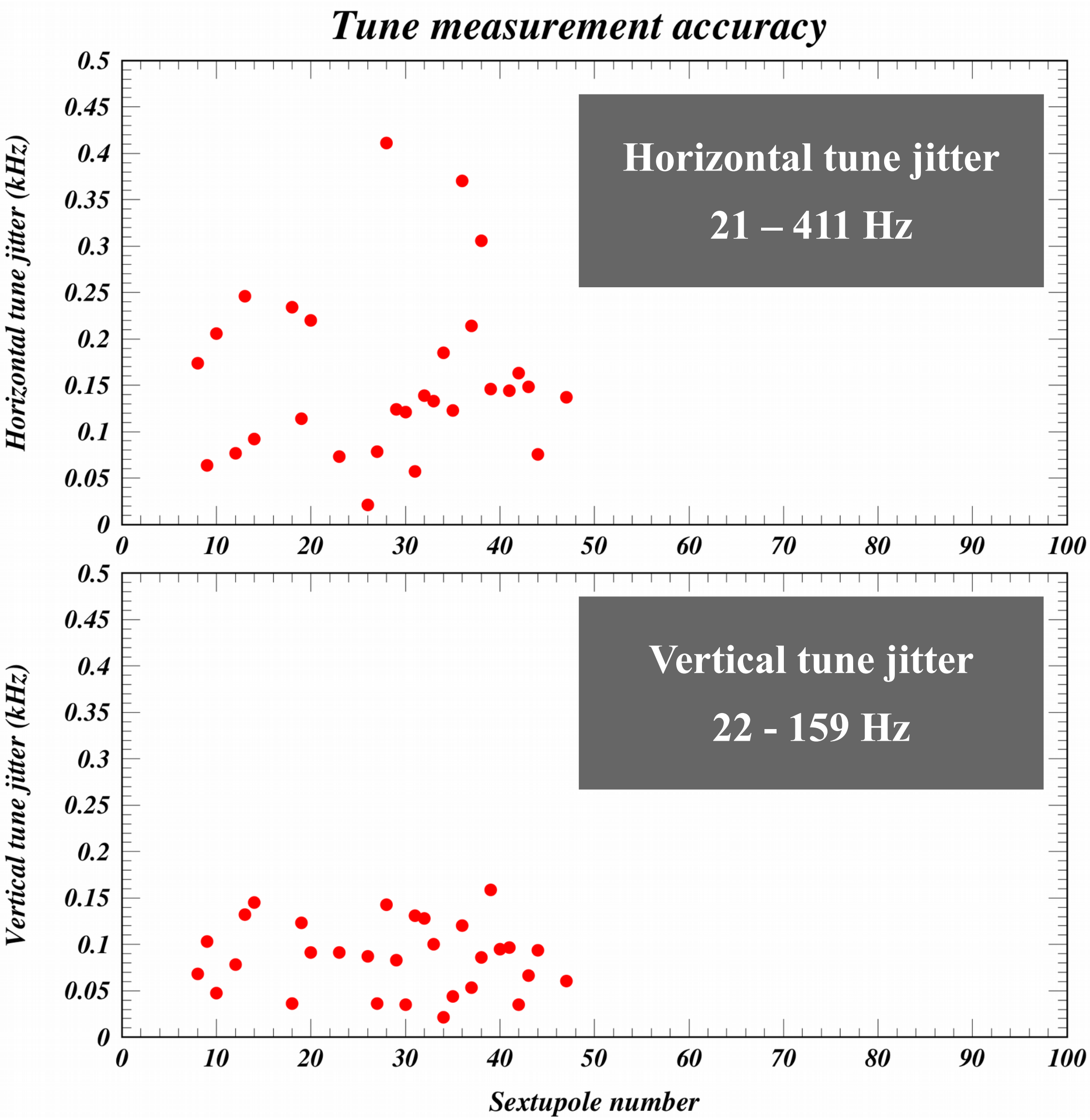
The fit is done to the X values with <X> subtracted so that the reported errors on the coefficients are uncorrelated.

The slopes, which give the calibration correction factors when divided by the CESR model slopes, are determined to 4.2% (f_X) and 1.4% (f_Y) accuracy.

The X value for which there is no tune change (X_{offset}) is determined with accuracy 58µ (f_X) and 20µ (f_Y).

The two values s agree within errors.

Tune Measurement Accuracy



The error bars $\sigma_{\Delta f}$ are adjusted to give χ^2/NDF = 1.
These values can be used as numerical estimates of the tune difference measurement accuracy.

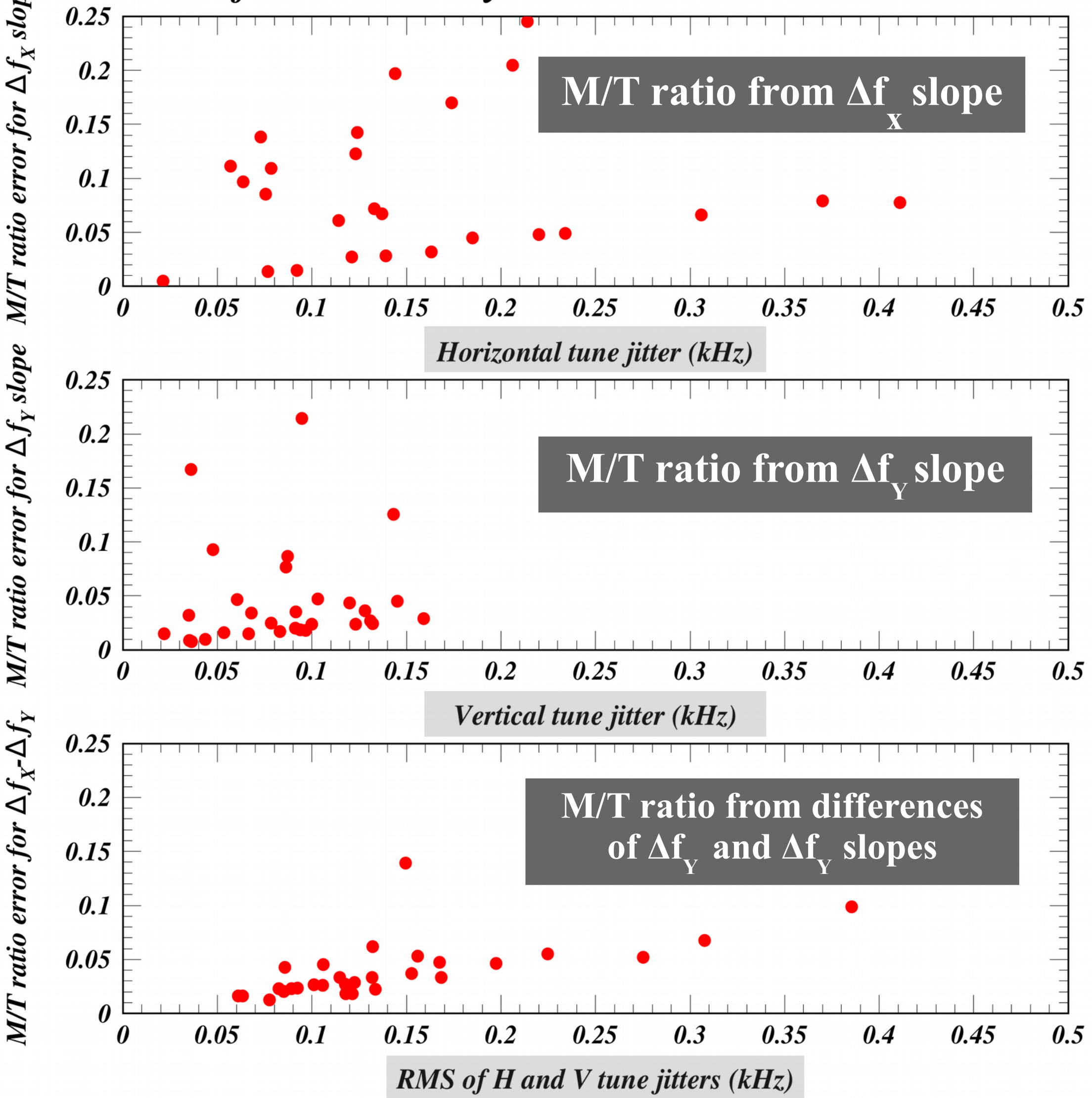
For sextupole 34W they are 185 Hz for the horizontal tune and 22 Hz for the vertical tune difference.

Horizontal tune jitter is usually, but not always, larger than the vertical tune jitter.

The tunes are given by a single read with DTT filter parameter n=5. This can be improved significantly by averaging 20 reads, for example. See talk of 9 September 2022.

Primary source of error for calibration correction factor

Correction factor accuracy versus tune measurement accuracy



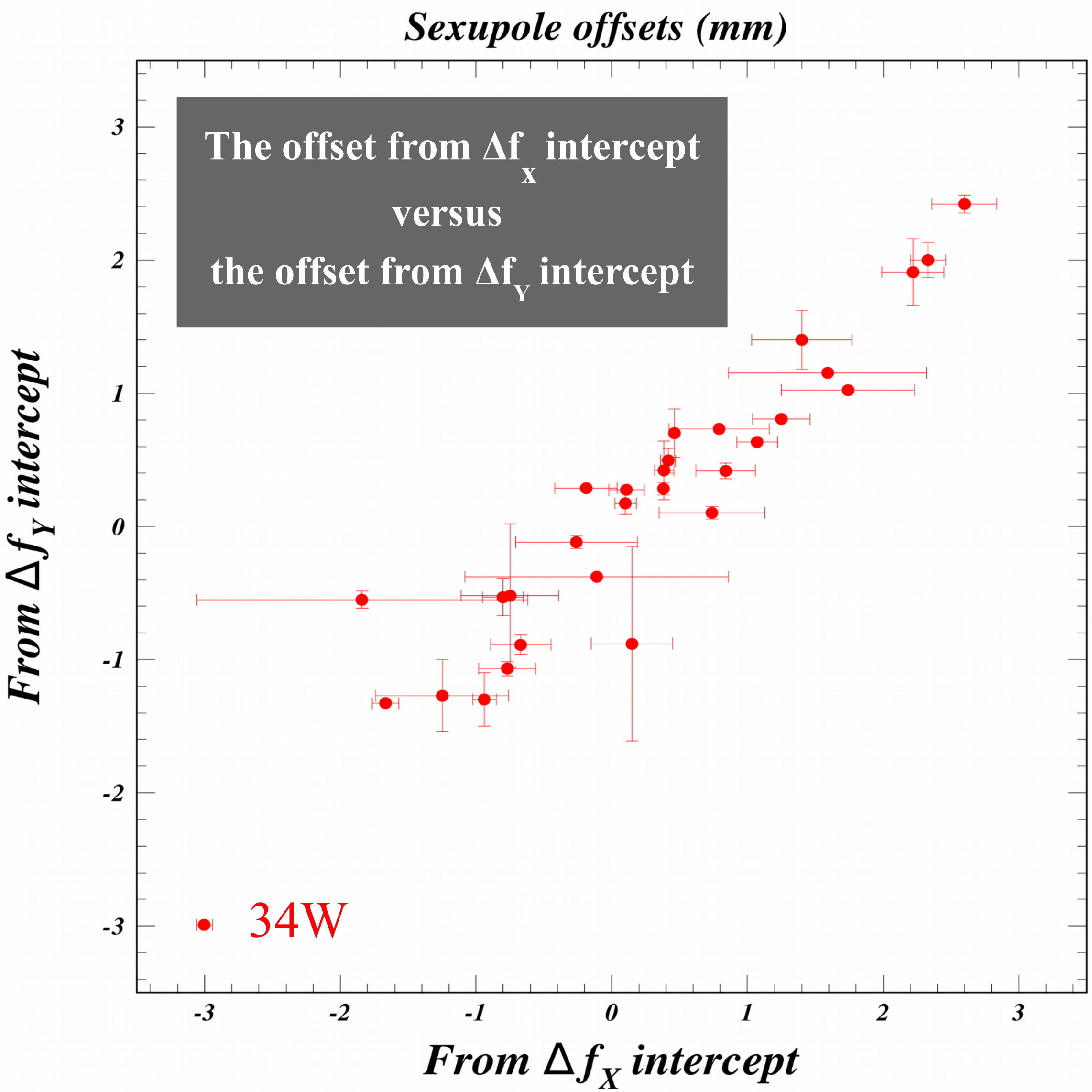
The calibration correction factor is derived from the ratio of the measured and modeled Δf(x) slopes.

The ratios for the Δf_x and Δf_Y slopes show cases of linear dependence on the tune accuracy, but also another class of error.

The measured over theory ratio (M/T) for the difference of Δf_x and Δf_Y slopes removes the β dependence in the slopes. It also largely removes the dependence on the vertical offset. These errors are much more linear with the RMS of H and V tune jitters.

The special class of nonlinear dependence for the Δf_x and Δf_Y slopes may arise from vertical offsets.

Offset accuracy

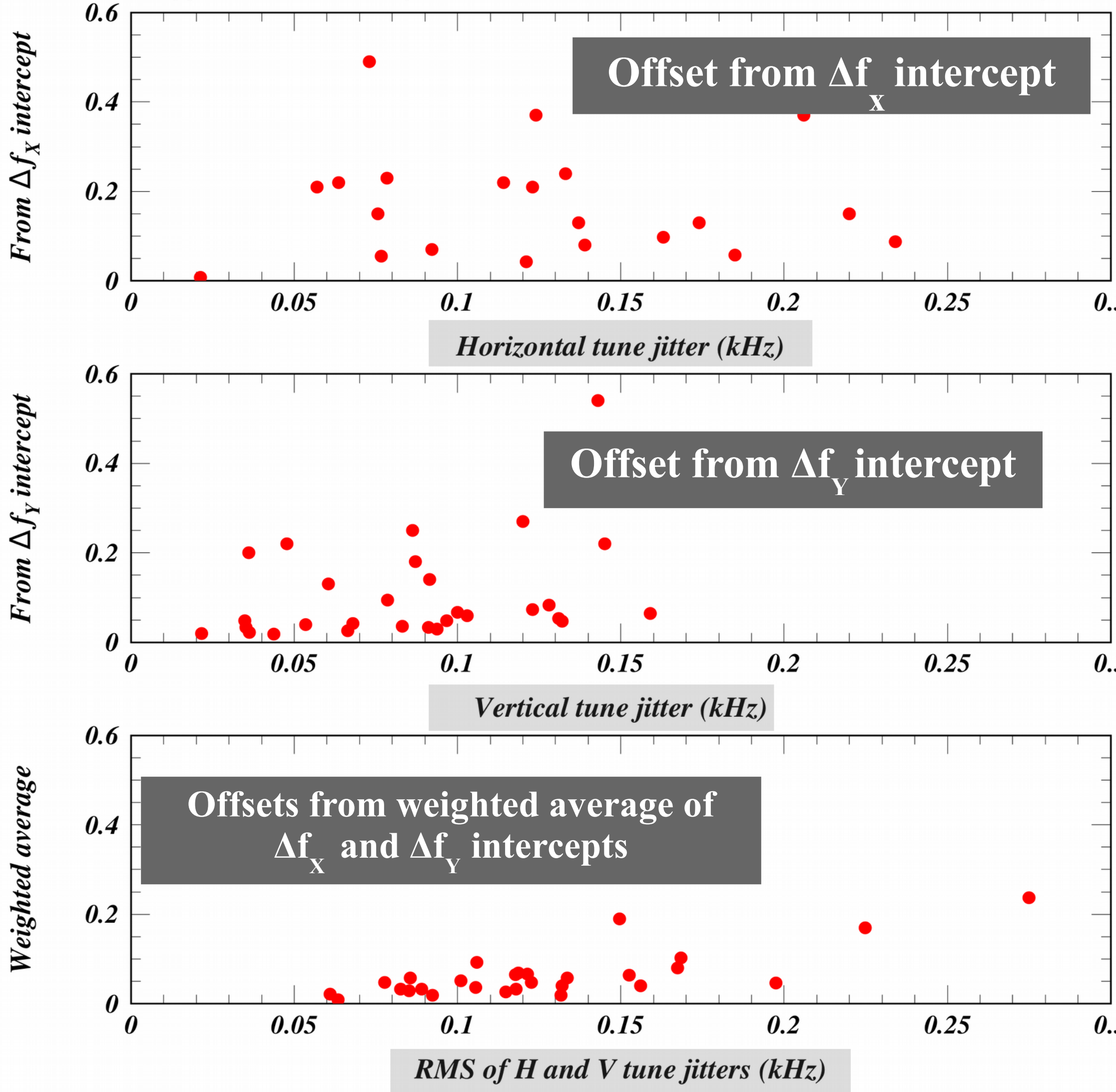


The offset determinations from the Δf_x and Δf_Y intercepts show a **high degree of correlation.**

The offsets determined with the Δf_Y intercept are generally much more accurate.

Primary source of error for the offsets

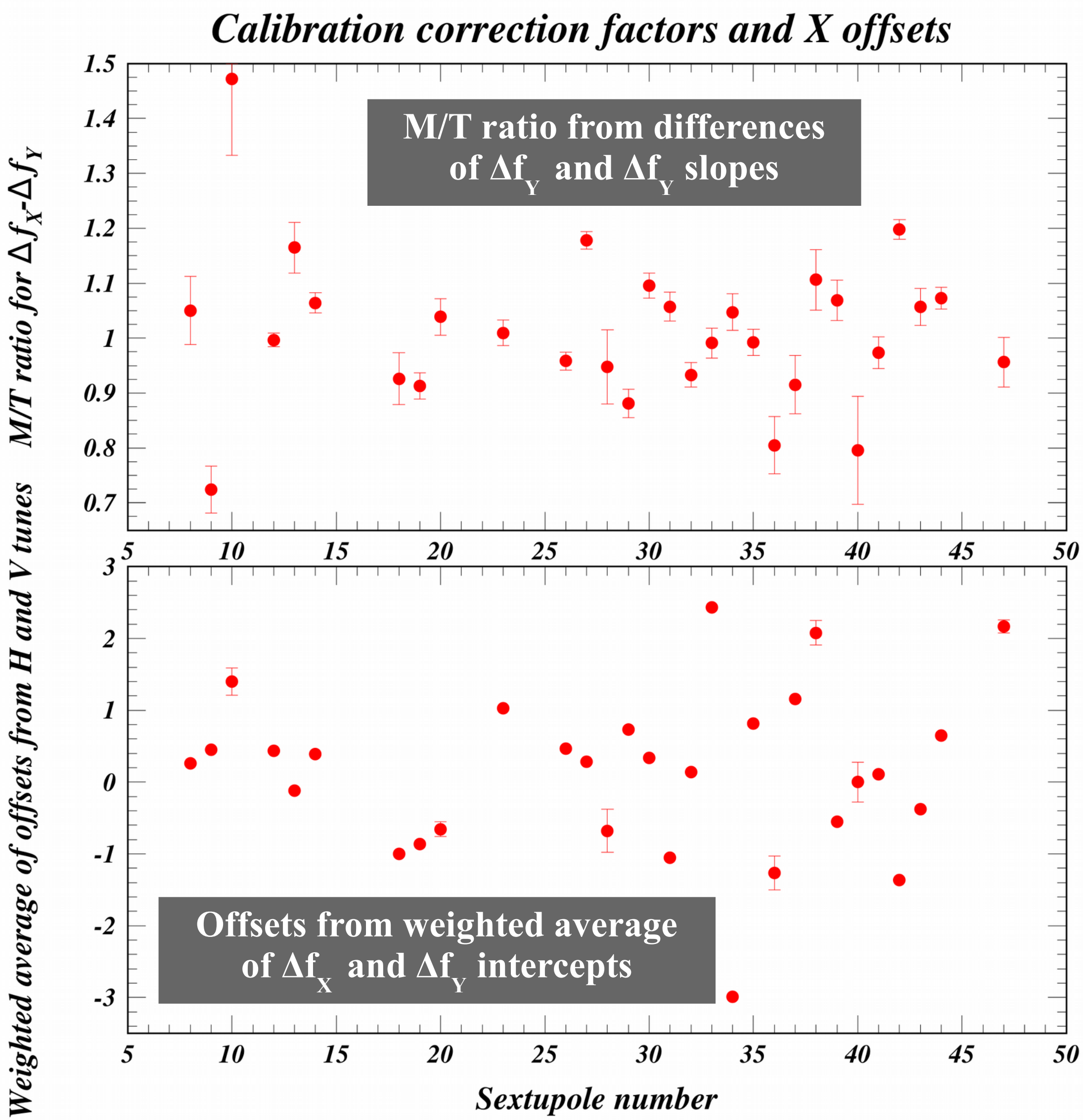
Offset accuracy versus tune measurement accuracy



The horizontal offset can be determined independently from the Δf_x and Δf_Y intercepts, so the most accurate determination is given by their weighted average.

The weighted average shows linear dependence on the RMS of H and V tune accuracies.

Results for 30 sextupoles 9AW-47W



Calibration factors

The measured over theory ratio (M/T) for the difference of Δf_x and Δf_Y slopes removes the β dependence in the slopes. It also largely removes the dependence on the vertical offset.

The average correction factor is 1.005. The RMS spread is 11.1%.

The average error in the ratio is 3.8%.

Horizontal offsets

The horizontal offsets range from -3 to 2.5 mm. The RMS offset is 1.1 mm. The average error in the offset determination is 57μ.