How Accurate Do Frets Have To Be?

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Prerequisites

You should read my paper called "How to Intonate a Guitar" (Smith (2014b)) before reading this piece.

Notes

None.

Document History

Date	Version	Comments
25th July 2014	1.0	Initial creation of the document.

1 Introduction

Using the model described in Smith (2014b), it is possible to modify the positions of frets, once a guitar is tuned, to determined how accurately the positions of frets need to be.

The base set of data is shown in Table 1.

Table 1: Quintero String Data

	First String	Second String	Third String
Open Note	G	D	G
Open Frequency (Hz)	196.000	146.832	97.999
Core Diameter ($\times 10^{-6}$ m^2)	3500	3500	3500
Young's Modulus (GPa)	200	200	200
Density ($\times 10^{-5}$ kg m^{-1})	115	258	469
Ln (mm)	140	110	75
Lb (mm)	45	45	45
Fret Height (mm)	1.5	1.5	1.5
Nut Height (mm)	2.0	2.0	2.0
Bridge Height (mm)	4.0	4.0	4.0
f_H	0.3	0.3	0.3
f_R	0.8	0.8	0.8
Scale Length (mm)	640	640	640

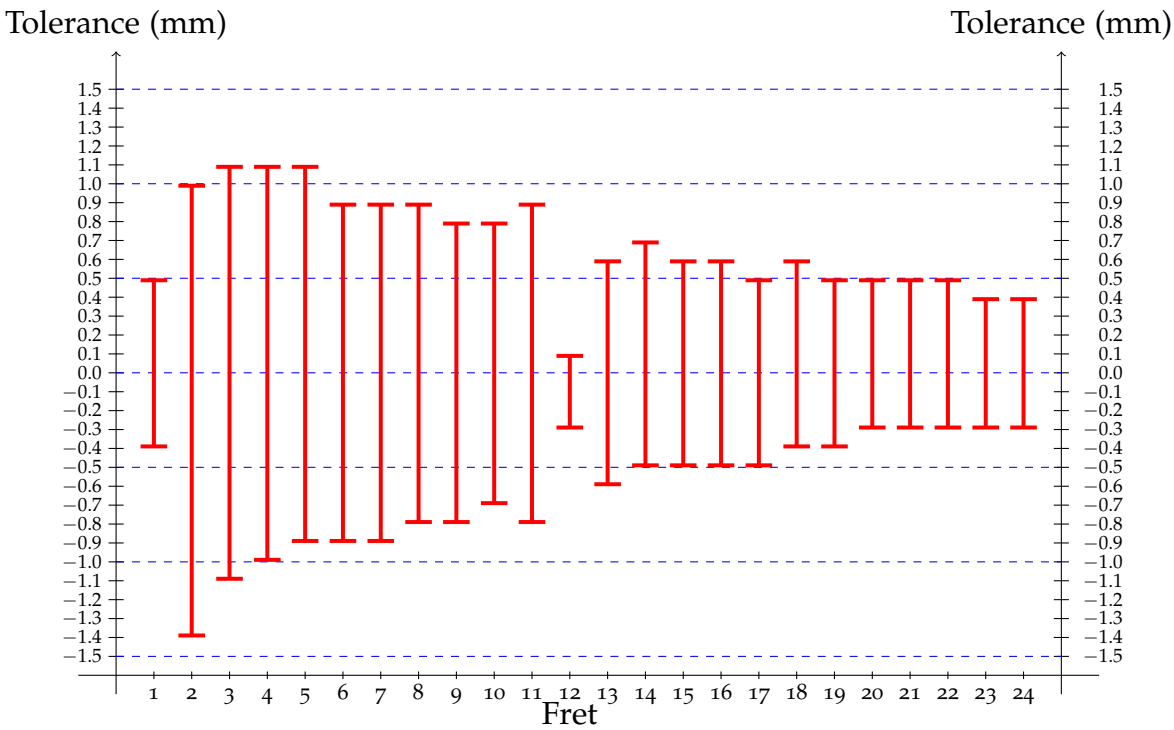
The data in table 1 was taken from a guitar that I made myself, which I call my "Quintero" guitar. Hence the unusual *Scale Length*. The guitar was tuned G-D-G using the 3rd, 4th and 5th strings from a standard packet of six electric guitar strings. The *Open Frequency*, the frequencies of the notes required at the open strings, *Ln*, *Lb*, *Fret Height*, *Nut Height*, and *Bridge Height* were measured values; *Core Diameter*, *Density*, f_H and f_R are estimated values.

2 Results

Once tuned, using the theoretically optimum fret positions (see Smith (2014a)), it is possible to manipulate the positions of frets to see how far from their theoretical position the fret can be and still produce a note to within tolerance (an arbitrary 3.5 cents).

The results are shown in Figures 1, 2 and 3.

Figure 1: Quintero Fret Tolerances: First String



Interesting features of these graphs include:

- for all strings, the first and twelveth frets need to be more accurately placed than the rest. Presumably the twelveth fret needs to be accurately placed as that fret plays a key role in the tuning of the string. The first fret is special in the way it is modelled (Smith (2014b)), so perhaps that's the reason why it needs to be accurately placed;
- all frets can be quite a bit out, as much as $\pm$ 1.1 mm(!) in some cases;
- in general, the higher the fret number (starting numbering frets at fret 0 at the nut), the more accurately it needs to be placed.

Figure 2: Quintero Fret Tolerances: Second String

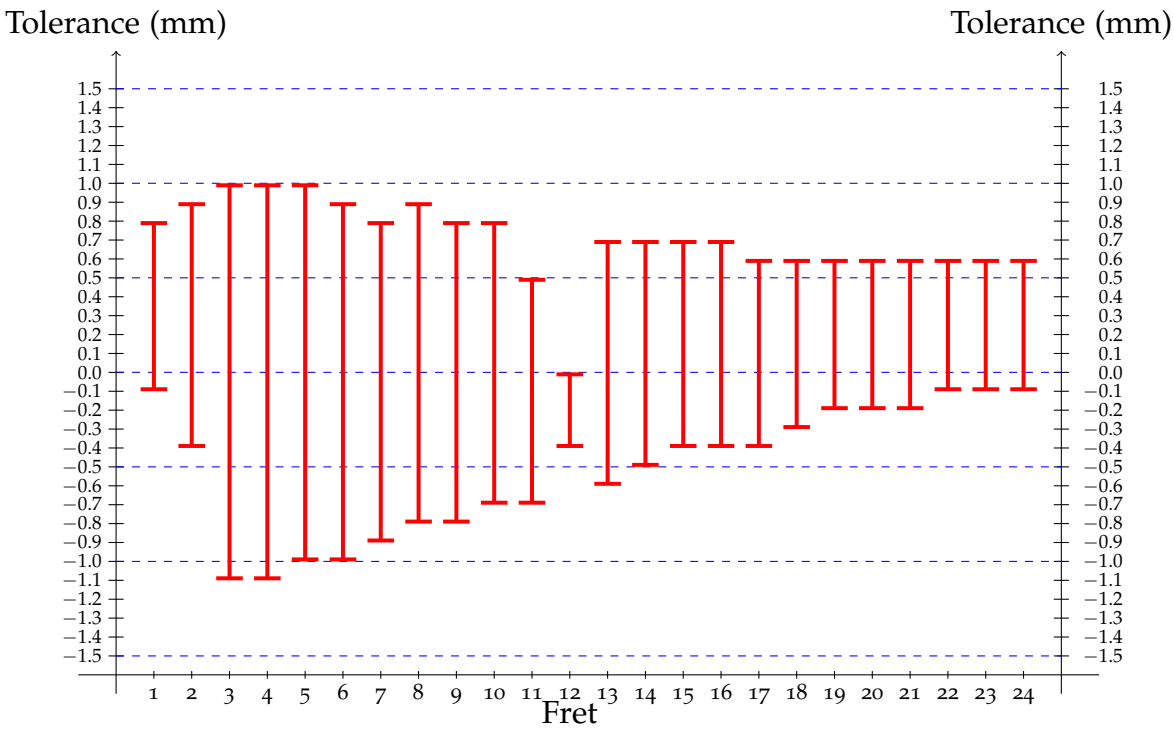
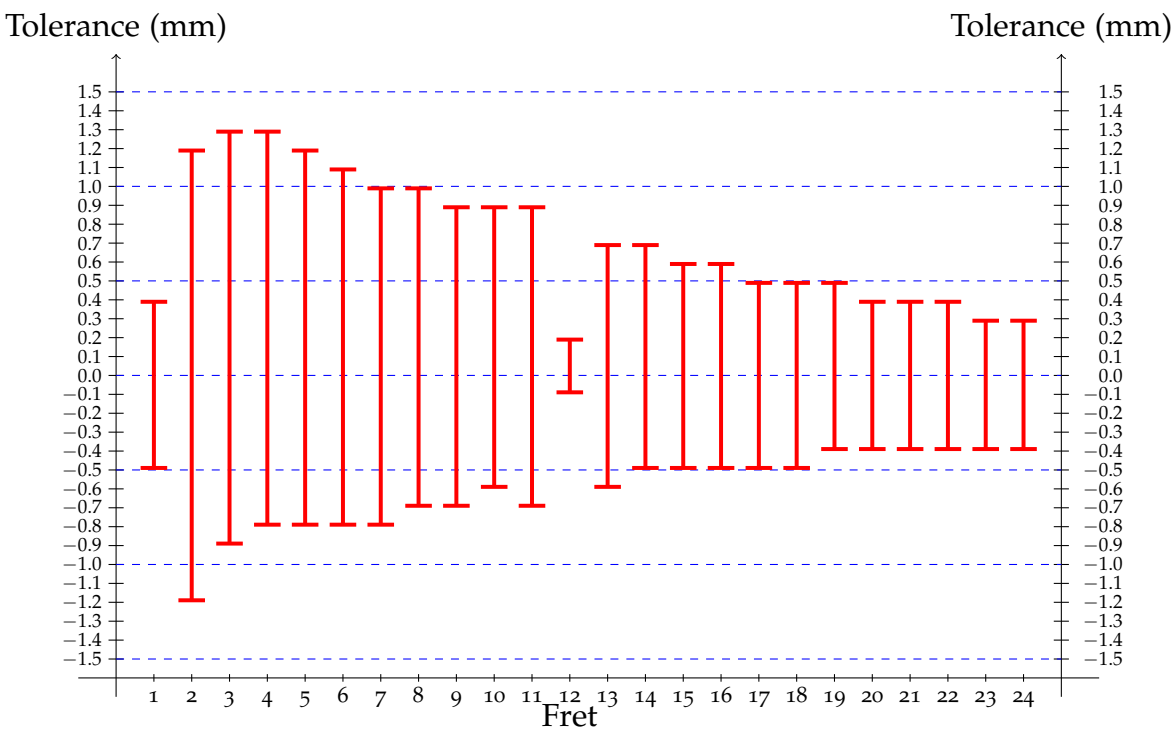


Figure 3: Quintero Fret Tolerances: Third String



References

Smith, S. (2014a). Fret positions.

Smith, S. (2014b). How to intonate a guitar.