The “Unknown” Target Type Flag Percentage As a Function of Chopping Frequency

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Abstract

The VLTI (and MIDI) FITS files use the column `TARTYPj` in the `IMAGING_DATA` table to signal whether the frame was taken while the light was coming from “sky,” “background,” “target” or “unknown” sources. We show the percentage of “unknown” frames as a function of chopping frequency and detector frame integration time.

1 VLTI FITS File Format

The VLTI (and MIDI) FITS files use the column `TARTYPj` in the `IMAGING_DATA` table to signal whether the frame was taken while the light was coming from “sky,” “background,” “target” or “unknown” sources [1]. The chopping cycle time c is given by the inverse of `ISS.CHOP.FREQ`, and may be divided into four intervals/phases (of generally non-equal length): one interval as long as the transition time U, one interval as long as the time on the sky S, another interval as long as the transition time U, and one interval as long as the time on the target T:

$$c \equiv 1/\text{ISS.CHOP.FREQ} = U + S + U + T \tag{1}$$

The Peak-to-Valley ratio defines how much of the chopping cycle time is spent on the sky or target; the exact definition depends on `TEL.CHOP.GUIDE`[2]:

$$\text{ISS.CHOP.PVRATIO} = \frac{U+S}{U+T} \quad (\text{or} \frac{U+T}{U+S}) \tag{2}$$

The MIDI LCU flags a frame as “unknown” if the frame integration time spills into (has any finite overlap with) the transition times between the “on sky” and “on target” time-intervals. As already make explicit in the formula above, the duration of the two transition times is taken to be the same, pending any further evaluation of [3] and [2].

This time U is the 4th parameter of the `CHOP` command send from the MIDI Observation Software to the LCU `lmiics1`, see the file `mioSpecific.icdt` in the `mio` module. Since its value is not specified in `mioSERVER::StartPreProcSpecialICS()`, the default of 12 ms defined in the aforementioned “incremental” Command Definition Table (CDT) is currently effective. This value is taken from the e-mail by W. Jaffe of March 6, “chopping speed on UTs.”

2 Probability Function

Since MIDI does not have methods to enforce some fixed ratio of the detector cycle time (sum of the detector integration time and any readout or ADC times) over the chopping cycle time, we may assume that the time interval `DET.DIT` is randomly aligned with the chopping cycle bars.

The probability p of a nonzero overlap of the integration time with any of the two time intervals of duration U is the sum of the probabilities of starting the integration in one of the four phases defined in (1), multiplied by the probability that this leaks with `DET.DIT` into the next phase:

$$p = \frac{U}{c} + \frac{S}{c} \cdot \max(\frac{d}{S}, 1) + \frac{U}{c} + \frac{T}{c} \cdot \max(\frac{d}{T}, 1), \tag{3}$$

$$p = 2\frac{U+d}{c} \quad (\text{if} \quad d < S, d < T) \tag{4}$$

3 Results

3.1 Monte Carlo Statistics

The Figures 1–4 show $100p$, that is how many frames (in %) as a function of the chopping frequency are flagged to be "in transition" by the LCU and therefore flagged as `U` by NRTS, if the probability p is sampled by a Monte Carlo placement of the integration time interval at 1000 equal-spacec points over the interval of length c. (This over-estimates p for small U.)

This percentage is a rising function of (i) the chopping frequency, (ii) the detector integration time becomes longer, and (ii) the transition time U.

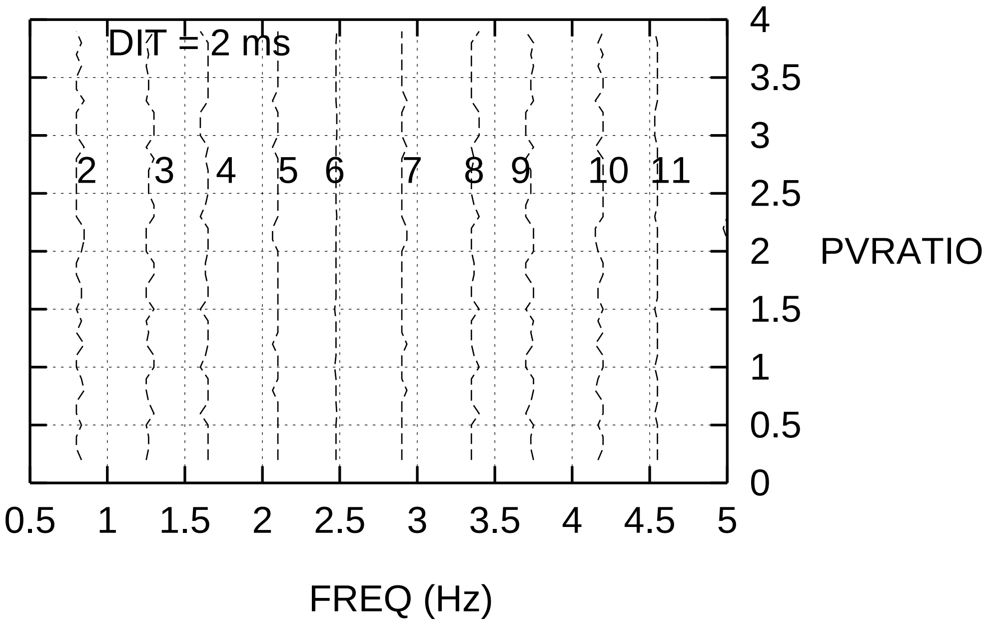

Figure 1: The percentage of `U` frames if the frame integration time `DET.DIT` is 2 ms, and the assumed mirror transition time is $U = 10$ ms.

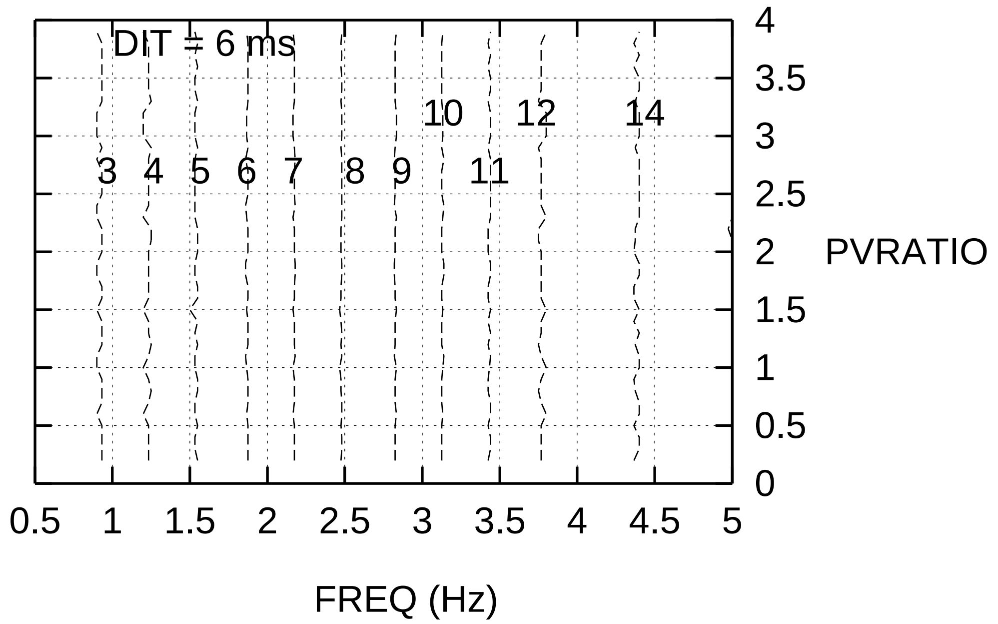

Figure 2: The percentage of `U` frames if the frame integration time `DET.DIT` is 6 ms, and the assumed mirror transition time is $U = 10$ ms.

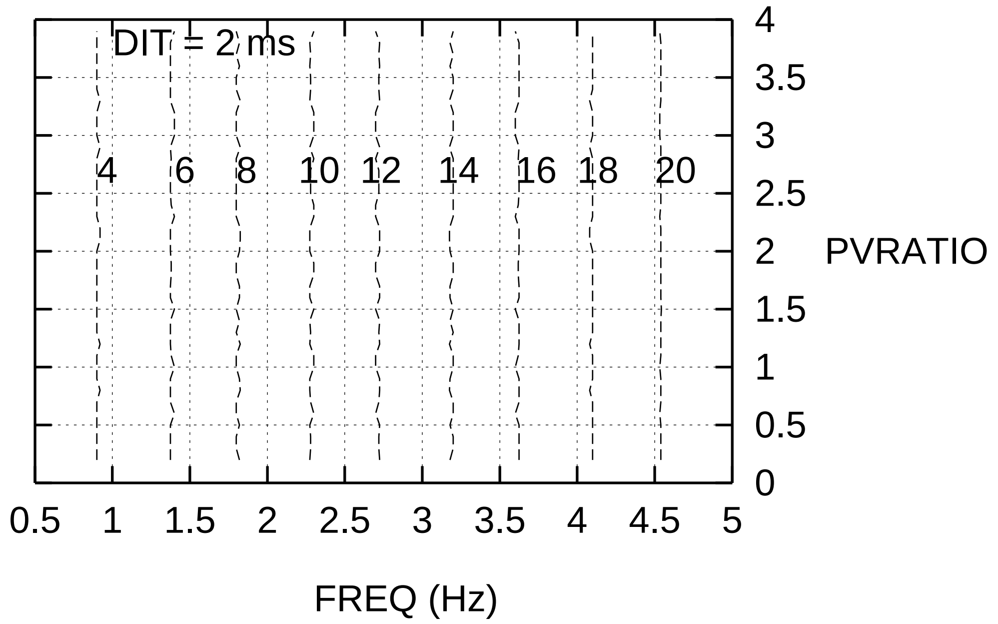

Figure 3: The percentage of `U` frames if the frame integration time `DET.DIT` is 2 ms, and the assumed mirror transition time is $U = 20$ ms.

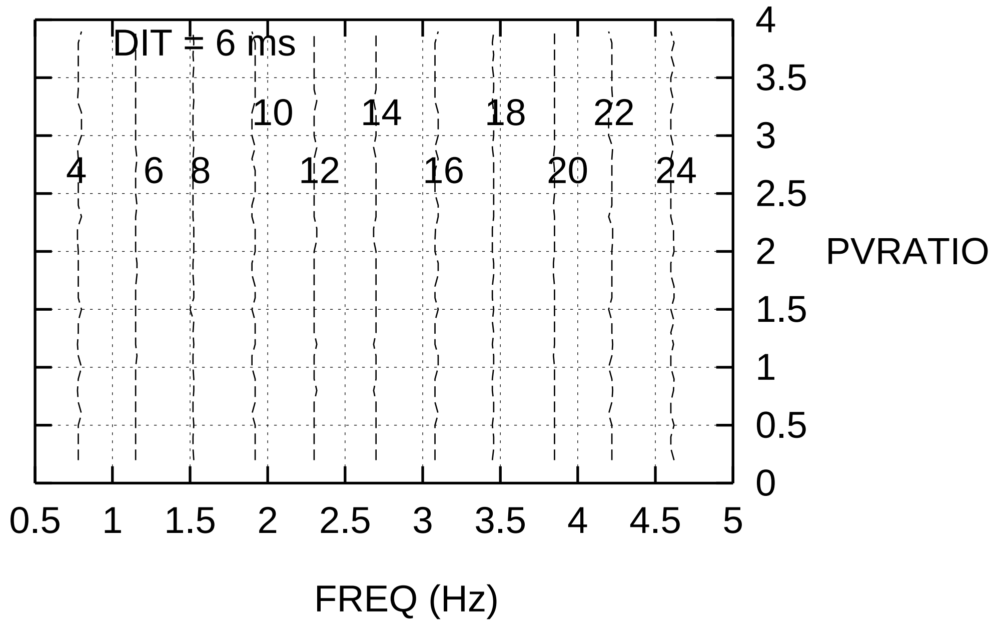

Figure 4: The percentage of `U` frames if the frame integration time `DET.DIT` is 6 ms, and the assumed mirror transition time is $U = 20$ ms.

3.2 Probability Maps

Figs. 5–6 show the percentage of `U` entries following from (4) independent of the `ISS.CHOP.PVRATIO`. [These percentages are actually upper bounds: for `ISS.CHOP.PVRATIO` deviating much from 1, the more accurate max function of (3) may reduce these values. This is not important for the realistic range of values `DET.DIT` < 35 ms.]

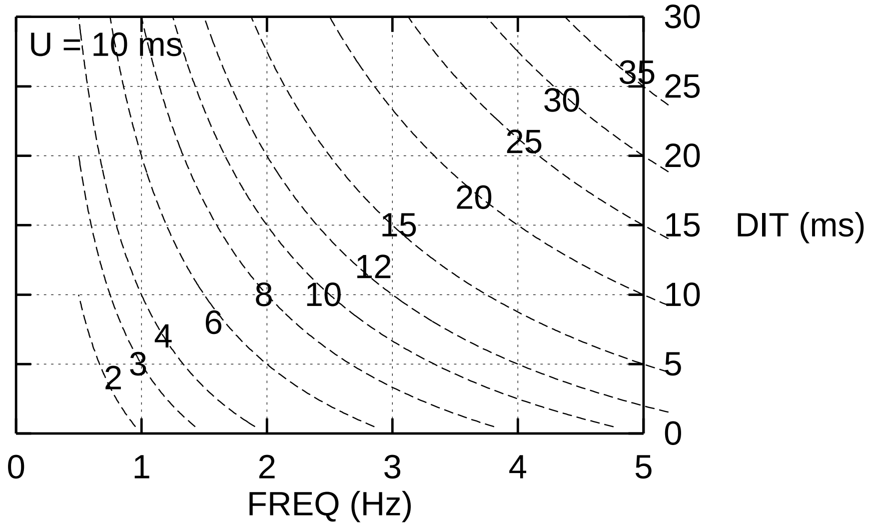

Figure 5: The percentage of `U` frames from 2 to 35, if the chop mirror transition time is $U = 10$ ms, according to (4).

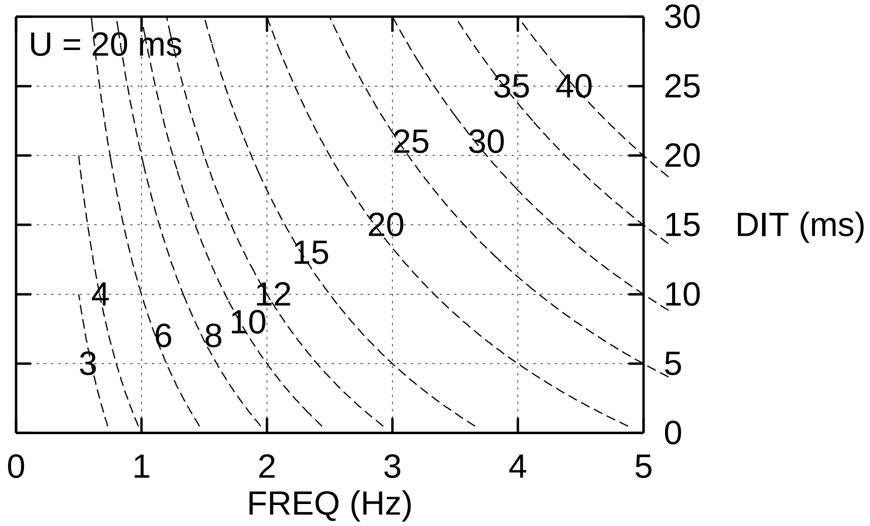

Figure 6: The percentage of `U` frames from 3 to 40, if the chop mirror transition time is $U = 20$ ms, according to (4).

4 Summary

The number of detector frames flagged as originating from an "unknown" source (and therefore "wasted" while evaluating series of detector frames while chopping) is about 2 to 15 % with the current assumption of a chop mirror transition time of 10 ms and detector integration times between 2 and 6 ms (Figs. 1 and 2).

References

[1] P. Ballester and C. Sabet. *VLT Interferometer VLTI Data Interface Control Document*, 3 June 2002. VLT-SPE-ESO-15000-2764.

[2] A. Wallander, B. Bauvier, R. Karban, and T. Phan Duc. *Technical Report on VLTI Chopping and Nodding, Results from Paranal Tests November 13 and 17, 2002*, 29 November 2002. VLT-TRE-ESO-15410-2949.

[3] A. Wallander. *Technical Report on Synchronized Chopping, Results from Paranal Tests, April 23–24, 2002*, 3 May 2002. VLT-TRE-ESO-15410-2812.