Creating 30-minute Calibrated SFT's in the Frequency Domain

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Goal

Want to generate 30-minute calibrated SFT's

But calibration drifts often non-negligible

Want a method to use 1-minute calibration α coefficients while introducing minimal new artifacts.

Methods Tried: "Stitched" and "0-Order"

1) Stitched: (discussed at Hannover meeting)

   Create 1-minute SFT's (high-passed & Tukey-windowed

   Apply 1-minute calibration info, window again in Fourier domain

   Compute inverse transforms, window again, and stitch to make 30-minute interval

   Compute SFT from 30-minute interval

 Machinery is in place with flexible control of parameters:

   Tukey window ramp intervals

   High-pass and low-pass filtering

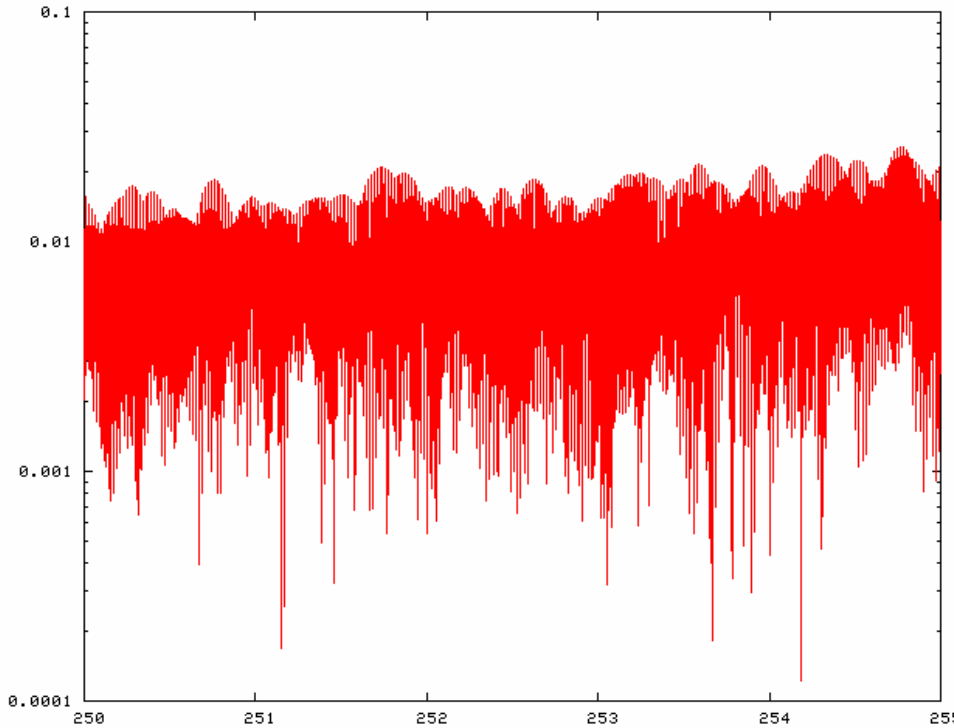   **Strong-line suppression (mean-padding in Fourier domain)**

 Troubles: Periodic windowing introduces 1/60 Hz residual "comb"

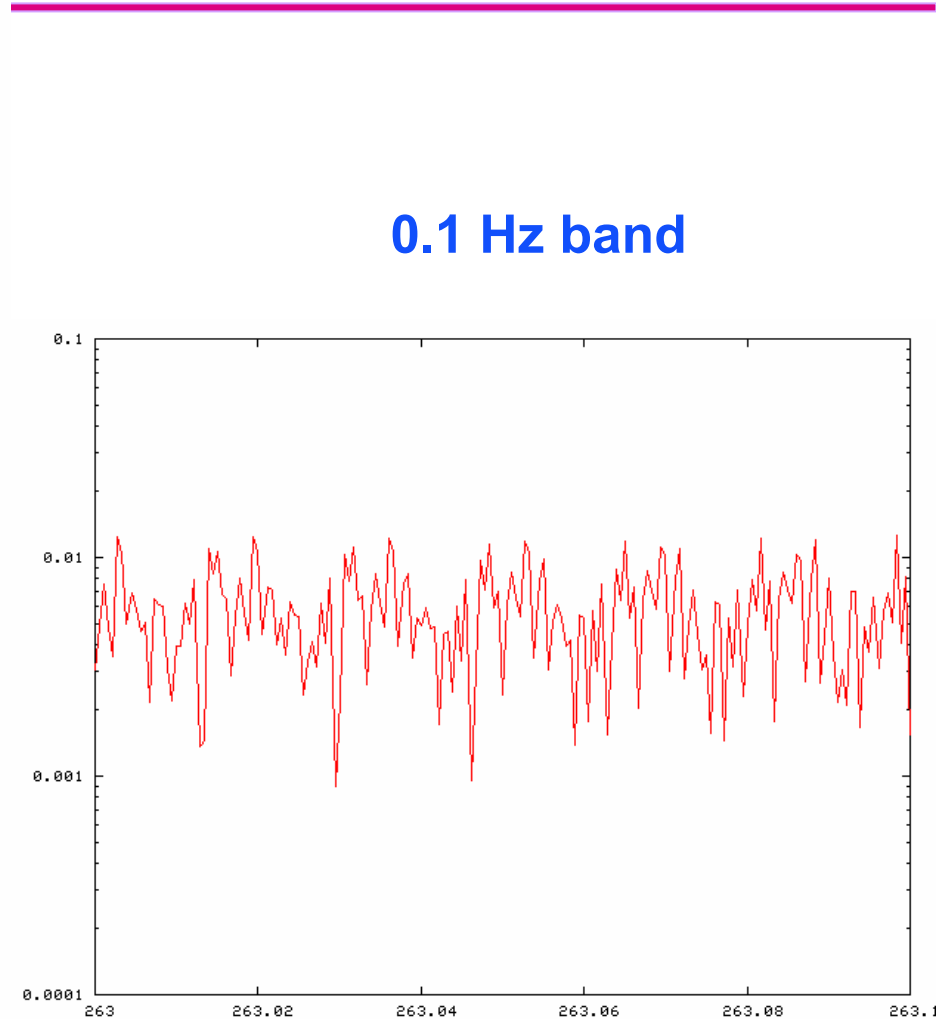   **Does not behave correctly in limit of constant calibration**

Windowing artifacts with stitching method (difference plot between two window choices)

5 Hz band

0.1 Hz band

0-Order

2) 0-order:

> For each 1-minute interval, treat calibration for all bins as the calibration for bin n → Apply scale factor to all data based on $R_n(t)$ variation (smoothed)

> Fourier transform of bins other than n will be incorrect, but one hopes that bin n correctly accounts for time-varying calibration

> But method produces leakage from neighboring bins. Leakage amount depends on discontinuity between start/end points of $R_n(t)$ for 30-minute interval.
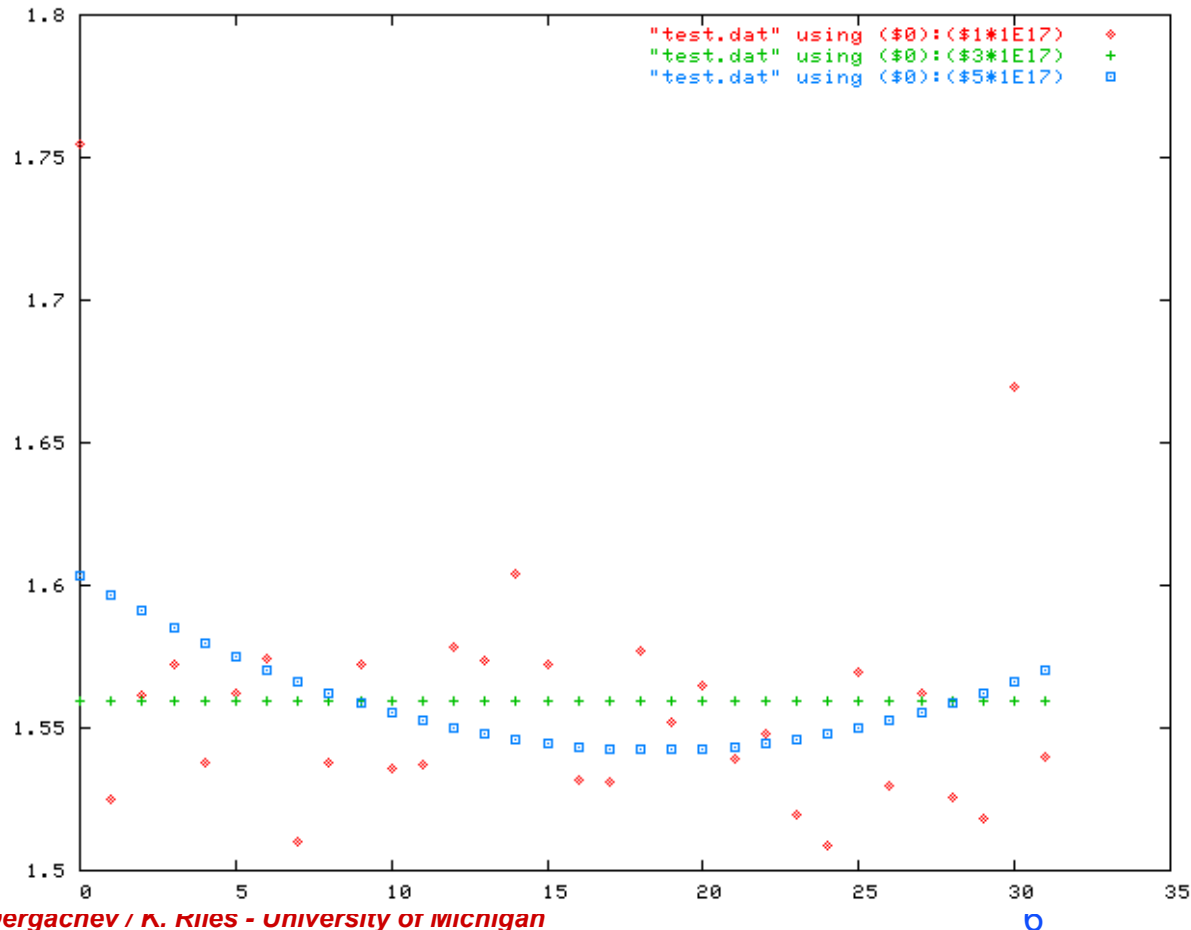
> Windowing reduces leakage. Overlapped Hann mitigates noise increase.

> Behaves correctly in limit of constant calibration

> **Details:** http://tenaya.physics.lsa.umich.edu/~volodya/operator.pdf

0-Order

One example of response function vs 1-min SFT number @ 1400 Hz

- **Magenta = measurement**

- **Green = average**

- **Blue = quadratic fit**

Evaluation

Xavier has also looked at

- **Averaging of calibration coefficients over 30-minute interval**

- **Direct time-domain calibration via filtering** **(see next talk)**

Which method (if any!) should the pulsar group use for coherent searches?

For example, what works well for computing the F statistic?

Tried looking at S2 hardware injections (2 pulsars in three IFO's for ~9 hours)

ComputeFStatistic results, signal 1

IFO	SFT	psi	phi	cosi	$h \cdot 10^{21}$	Fstat	$A/Sh \cdot 10^{-40}$
H1	StOH	89.02	−267.7	−0.038	1.710	145.3	2.575
H1	0-HW	−1.78	−177.1	−0.042	1.809	98.3	1.553
H1	0-nw	−1.17	−177.3	−0.035	1.803	142.9	2.288
H1	AVG	−0.97	−102.5	−0.036	1.833	155.3	2.402
H1	EXP				1.560		
H2	StOH	−3.28	−175.8	0.025	1.668	54.4	1.485
H2	0-HW	−3.54	−174.8	0.013	1.556	35.8	0.945
H2	0-nw	−2.97	−176.3	0.022	1.730	65.4	1.418
H2	AVG	−3.15	−79.5	0.029	1.719	58.4	1.252
H2	EXP				1.660		
L1	StOH	−4.61	−230.4	−0.057	2.261	229.5	3.802
L1	0-HW	−3.89	−229.5	−0.041	2.336	164.9	2.452
L1	0-nw	−4.90	−230.3	−0.056	2.300	228.0	3.726
L1	AVG	−4.96	−202.9	−0.053	2.755	242.5	2.728
L1	EXP				2.000		

StOH - stitched 60-sec overlapped SFTs, Hann windowed

0-HW - 0-order method with Hann windowing

0-nw - 0-order method without windowing

AVG - averaged calibration SFTs produced by Xavier

EXP - expected (?) value

ComputeFStatistic results, signal 2

IFO	SFT	psi	phi	cosi	h · 10^{21}	Fstat	A/Sh · 10^{-40}
H1	StOH	−0.93	−53.3	0.035	1.640	558.8	10.553
H1	0-HW	89.31	−143.3	0.049	1.756	383.7	6.237
H1	0-nw	89.01	−142.8	0.035	1.741	561.0	9.417
H1	AVG	89.16	−145.0	0.034	1.753	552.7	9.116
H1	EXP				1.560		
H2	StOH	−0.56	−52.9	0.005	1.585	311.1	7.781
H2	0-HW	0.79	−143.4	0.036	1.602	197.5	4.965
H2	0-nw	−0.76	−52.8	0.007	1.623	311.2	7.420
H2	AVG	−0.89	−344.2	0.020	1.721	304.6	6.345
H2	EXP				1.660		
L1	StOH	6.15	−17.4	−0.100	1.319	143.6	4.927
L1	0-HW	−81.41	−15.5	−0.073	1.376	98.4	3.133
L1	0-nw	6.23	−17.4	−0.101	1.325	142.2	4.826
L1	AVG	7.46	−134.9	−0.157	1.475	137.0	3.360
L1	EXP				2.000		

StOH - stitched 60-sec overlapped SFTs, Hann windowed

0-HW - 0-order method with Hann windowing

0-nw - 0-order method without windowing

AVG - averaged calibration SFTs produced by Xavier

EXP - expected (?) value

Inconclusive – Need more HW injection examples

But will soon have 30 for 9 weeks to look at in S3 → Stay tuned…