Data regression for H1/H2 analyses

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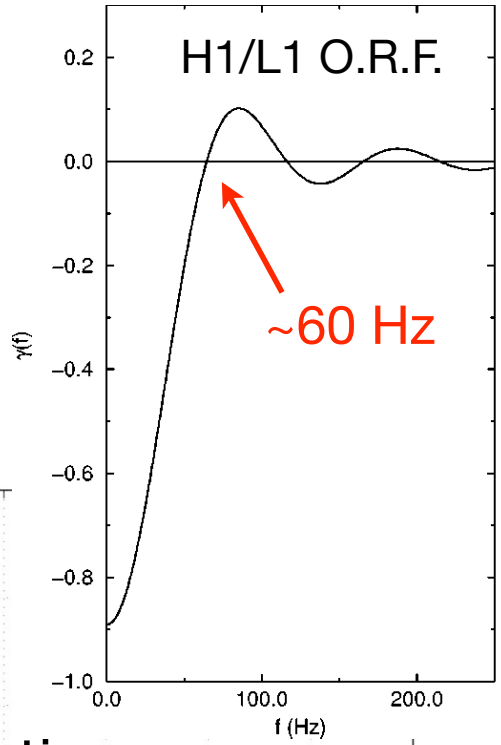
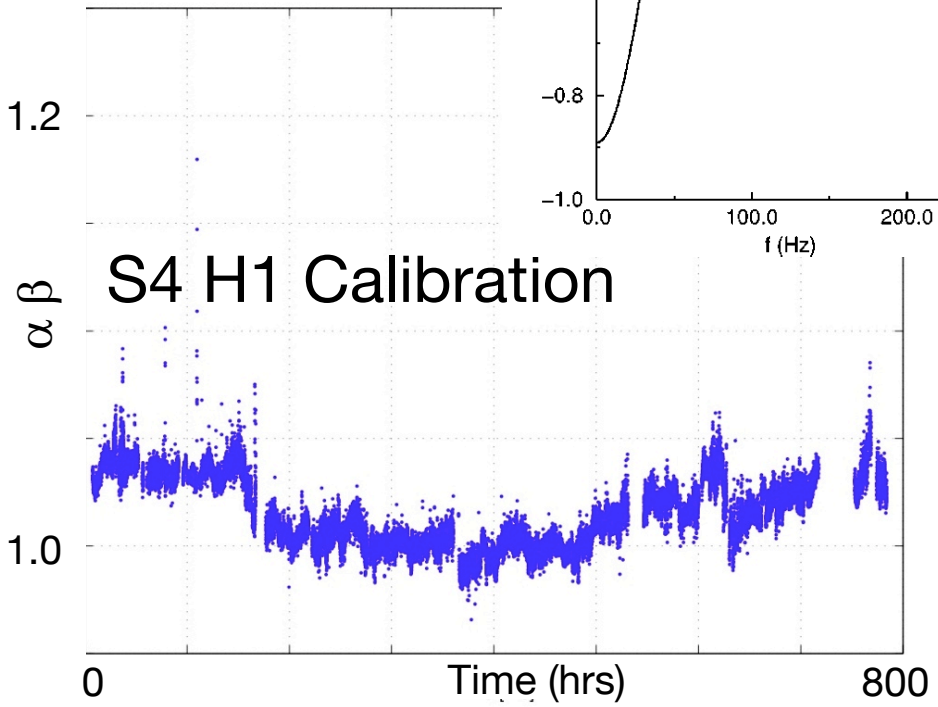
DCC: LIGO-G050660-00-Z

Stochastic search requirements

- Overlap reduction function = 1 for H1/H2
- Nonstationary noise = 60s h(f)
- Environmental correlations (cf. N Fotopoulos)

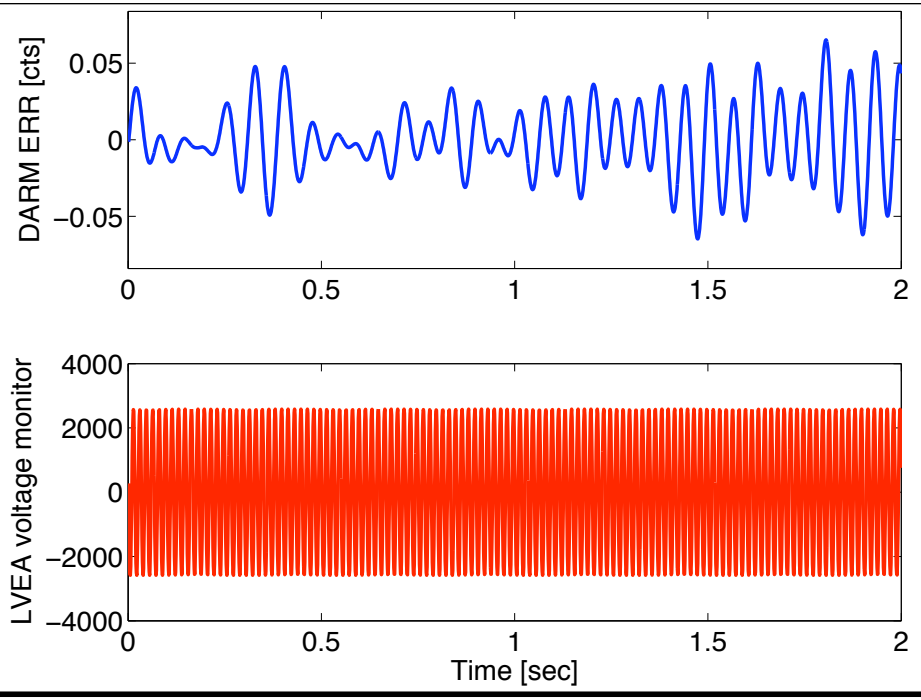


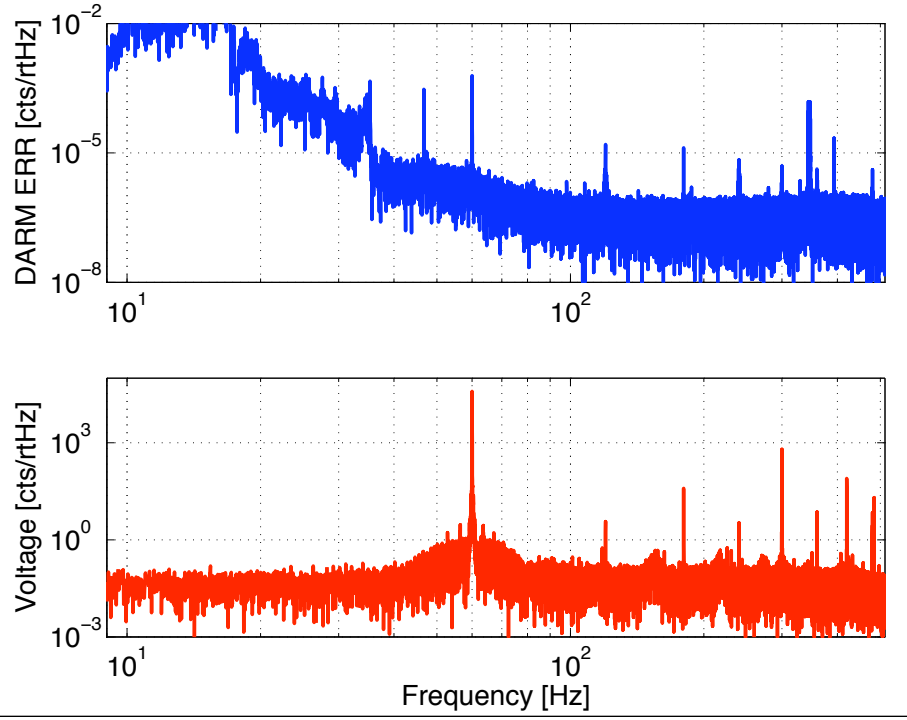


f domain regression

from Allen, Hua and Ottewill
gr-qc/9909083

- Multi-channel regression
- Unknown transfer functions
- “Inner product” of FFT intervals
- Minimize the variance of true signal

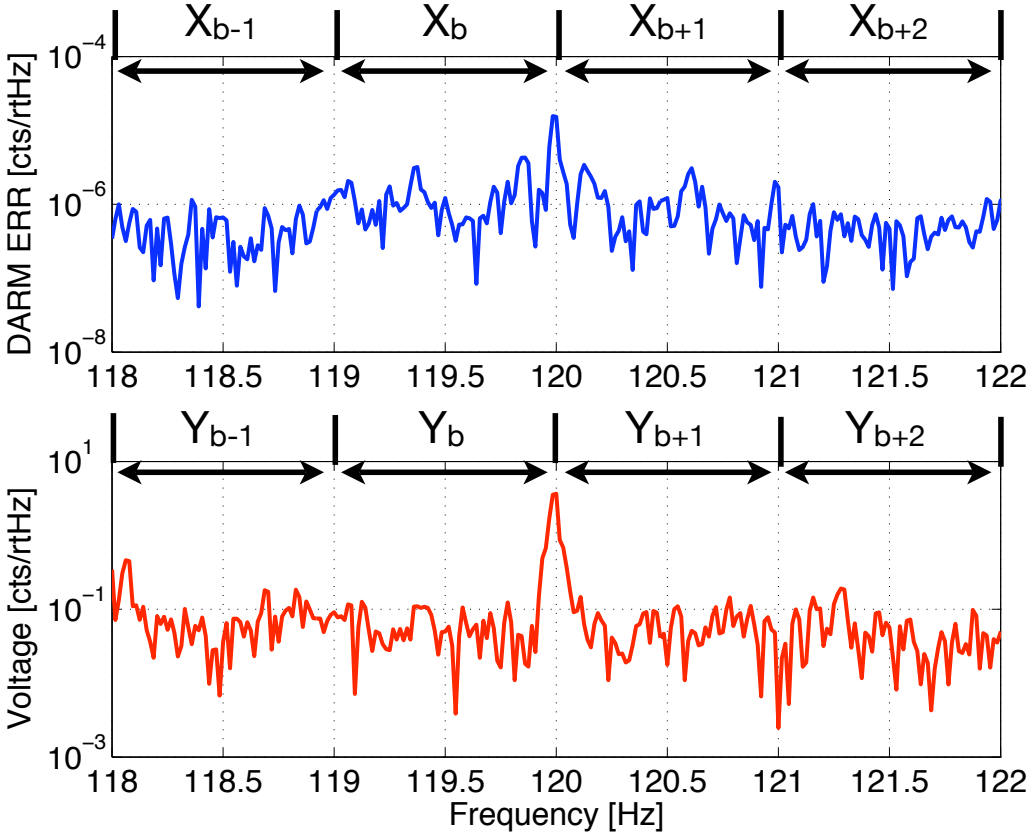




64s of H1 S4 data

Inner product

- Subdivide complex FFT into F_{bin} intervals
- Take inner product
- Derive transfer function



$$\left(\vec{X}^{(b)}, \vec{Y}^{(b)}\right) = \sum_{i=f_b}^{f_{b+1}} X_i Y_i$$

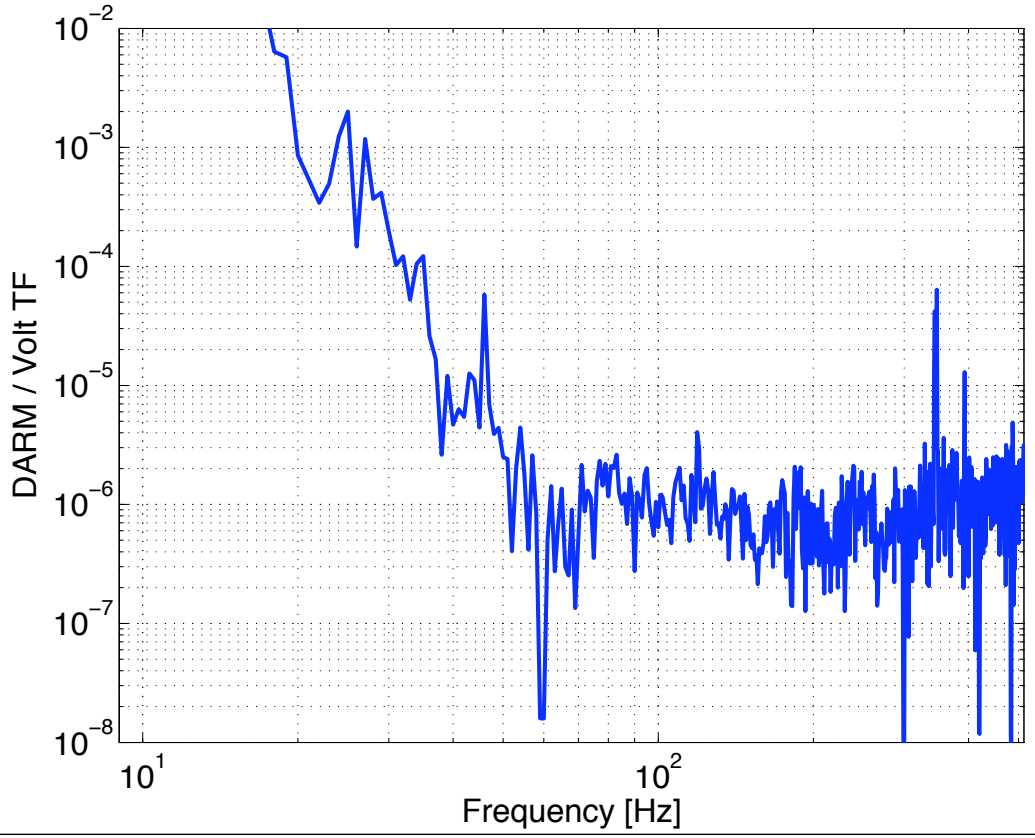
Transfer function

true signal

$$\vec{x}^{(b)} = \vec{X}^{(b)} - r^{(b)}\vec{Y}^{(b)}$$

assume: $\min\left(\vec{x}^{(b)}, \vec{x}^{(b)}\right)$

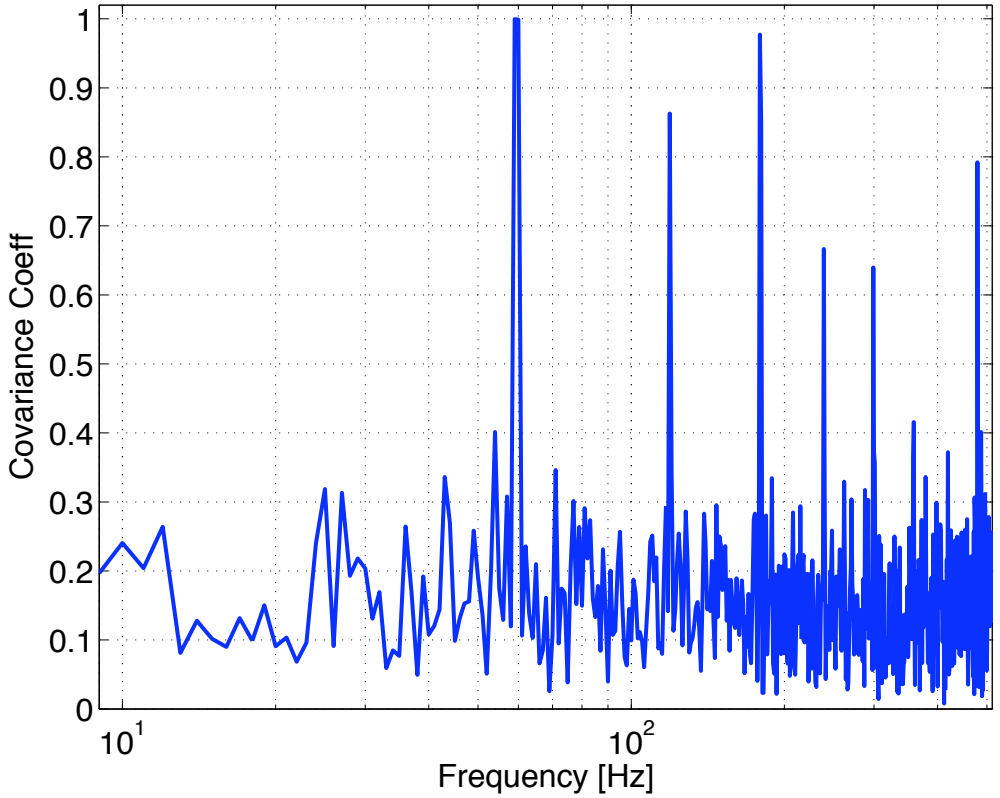
$$r^{(b)} = \frac{\left(\vec{X}^{(b)}, \vec{Y}^{(b)}\right)}{\left(\vec{Y}^{(b)}, \vec{Y}^{(b)}\right)}$$



Covariance coefficient

$$\rho_{XY}^{(b)} = \sqrt{\frac{\left|\left(X^{(b)}, Y^{(b)}\right)\right|^2}{\left(X^{(b)}, X^{(b)}\right)\left(Y^{(b)}, Y^{(b)}\right)}}$$

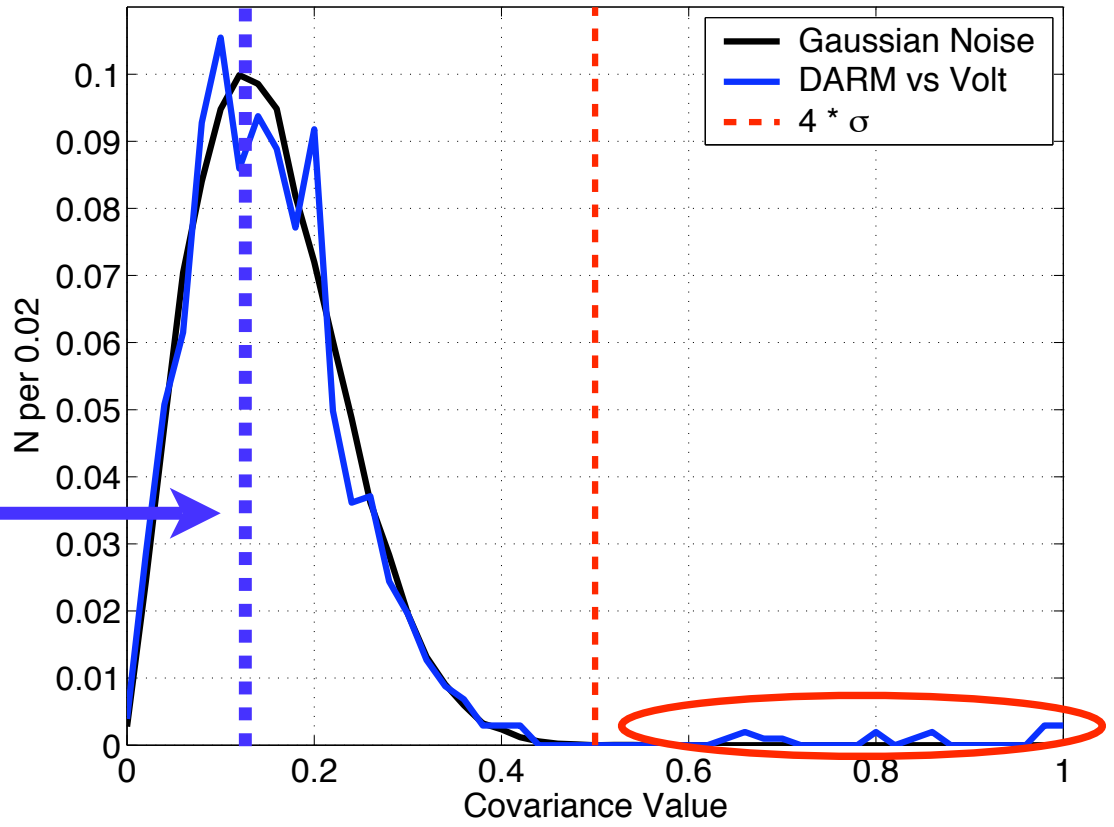
- Quantitative significance measure
- Thresholding
- a.k.a. “Coherence”



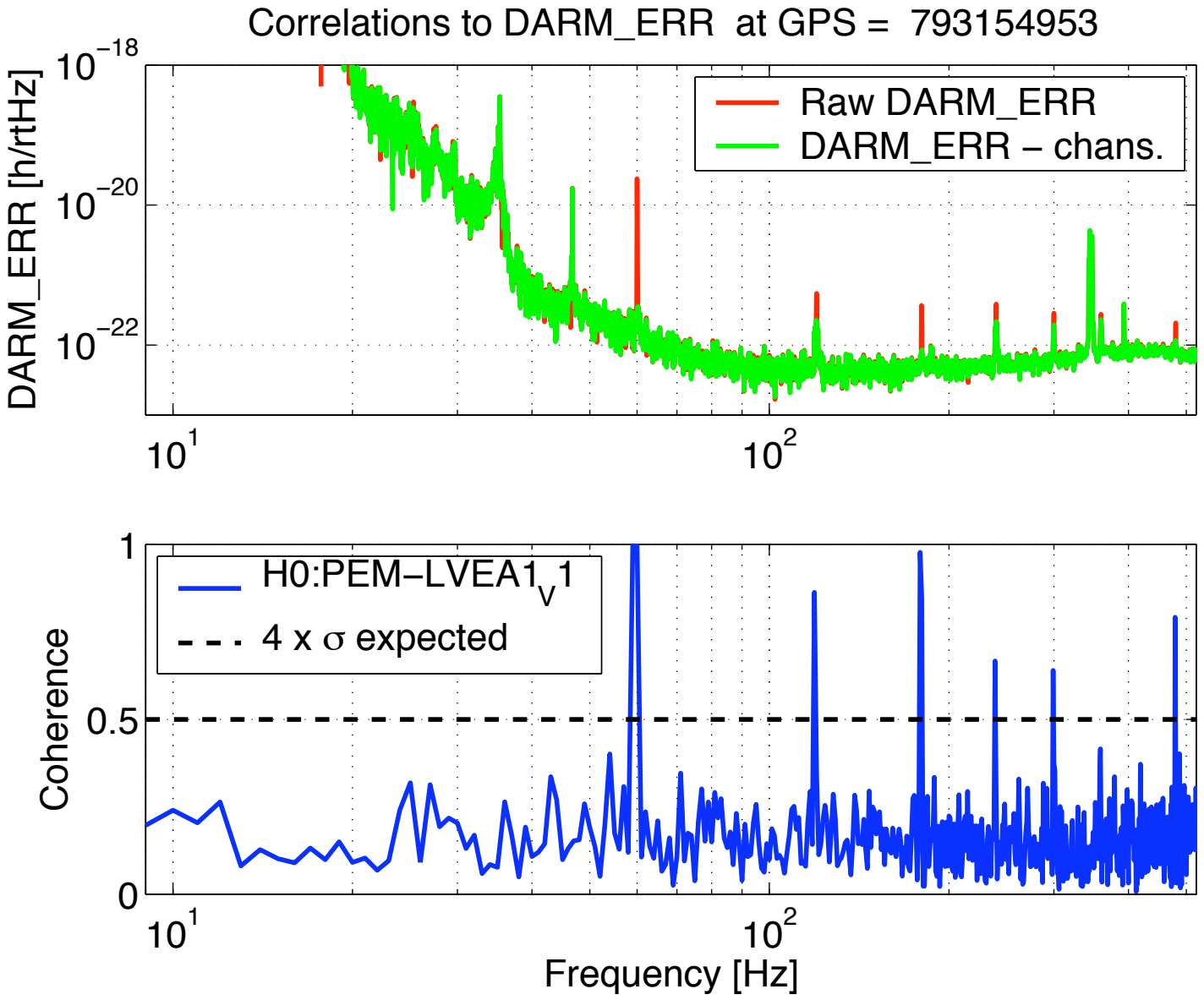
Covariance expectation

- Well defined for gaussian noise
- Threshold on ρ
- Avoid false subtraction

$$\langle \rho_{XY}^2 \rangle = \frac{1}{F_{bin}}$$



Reduced DARM

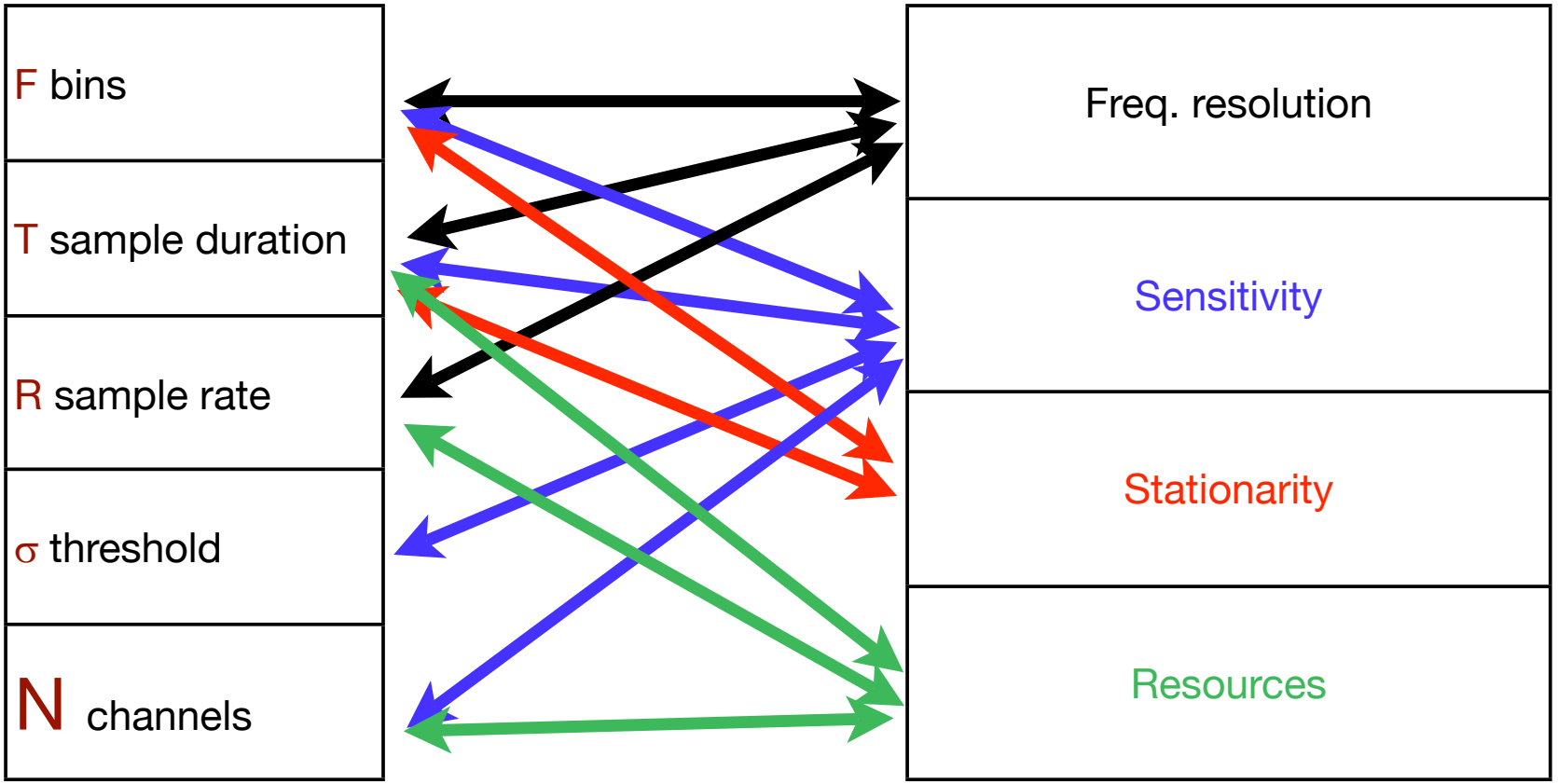


N Channels

- Extensible to N channels
- Generate N x N matrix of correlations
- Invert matrix to remove crossterms
- Apply pairwise transfer functions to regress data

Rate	# Channels IFO / PEM
16384	37 / 4
2048	219 / 151
256	20 / 33
16	4198 / 166

Algorithm Optimization

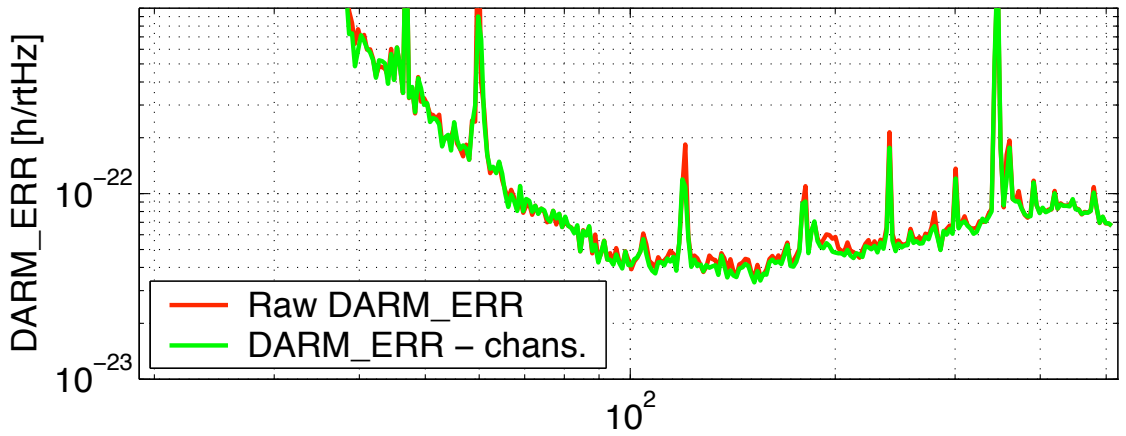


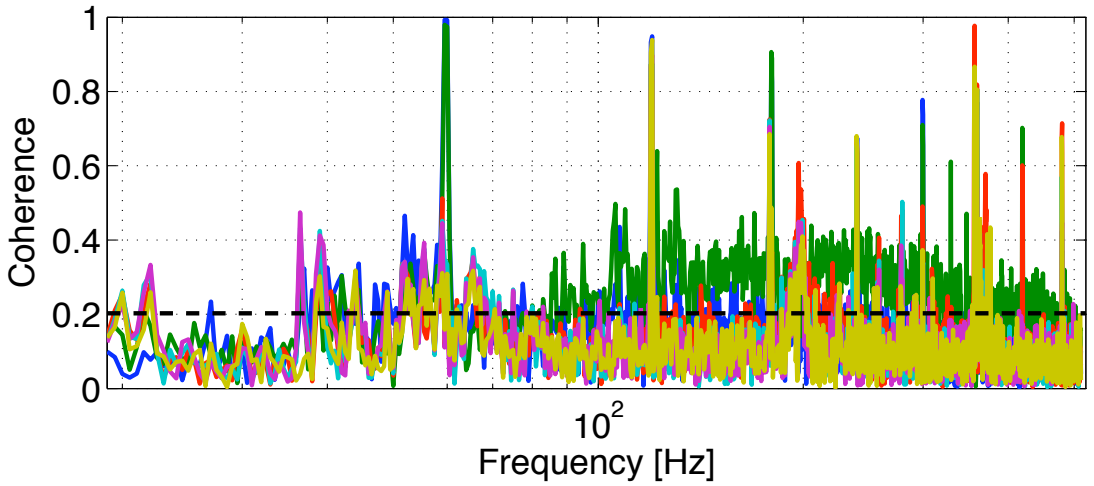
Channel “strength”

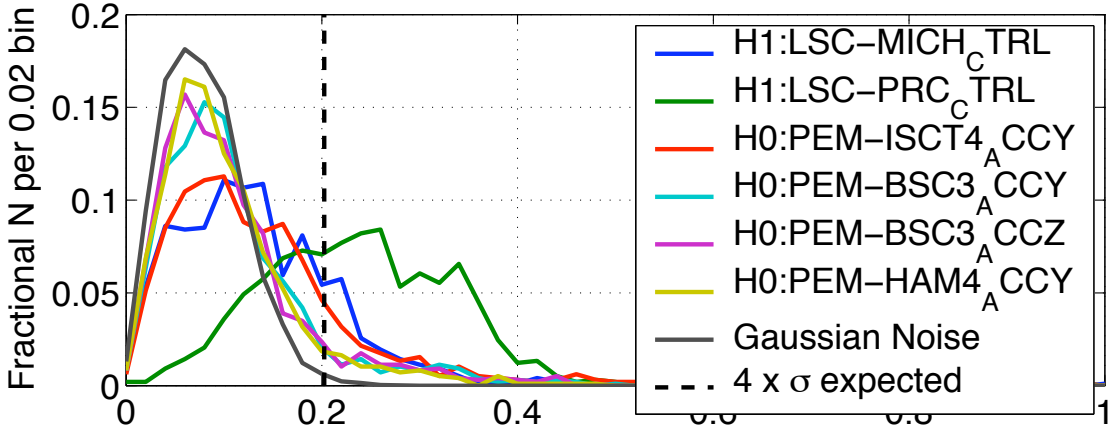
H1 Channel	S4 + 3 hrs	S4 + 398 hrs	S4 + 676 hrs
LSC-MC_AO	49 +/- 5	64 +/- 5	49 +/- 5
LSC-REFL_Q	56 +/- 11	38 +/- 6	44 +/- 4
LSC-MICH_CTRL	153 +/- 71	160 +/- 8	157 +/- 6
LSC-PRC_CTRL	408 +/- 103	613 +/- 9	450 +/- 24
PEM-ISCT4_ACCY	46 +/- 8	171 +/- 6	197 +/- 5
PEM-BSC2_ACCX	35 +/- 8	72 +/- 4	80 +/- 9
PEM-BSC2_ACCY	35 +/- 8	83 +/- 4	83 +/- 6
PEM-BSC3_ACCX	32 +/- 5	82 +/- 6	85 +/- 7
PEM-BSC3_ACCY	34 +/- 7	94 +/- 7	85 +/- 7
PEM-BSC3_ACCZ	35 +/- 9	95 +/- 6	91 +/- 3
PEM-HAM4_ACCY	34 +/- 7	80 +/- 3	93 +/- 6
PEM-PSL1_ACCX	38 +/- 5	44 +/- 3	44 +/- 4
PEM-PSL1_ACCY	50 +/- 3	53 +/- 4	57 +/- 6
PEM-PSL1_ACCZ	45 +/- 2	58 +/- 3	55 +/- 3
PEM-IOT1_ACCY	31 +/- 5	36 +/- 2	37 +/- 3
ASC-QPDX_Y	31 +/- 2	18 +/- 2	13 +/- 1

Multi-channel results

- Broadband PRC coupling
- seismic@200Hz
- Broadband DARM







Conclusions

- Insensitive to H1/H2 common noise
- Possible introduction of coherent noise

- Much algorithm optimization needed
- Hierarchic scheme may be required

- Remove PRC, improve DARM $\leq$ 10% from 100 to 300 Hz
- Useful commissioning tool