SMEE Project Update

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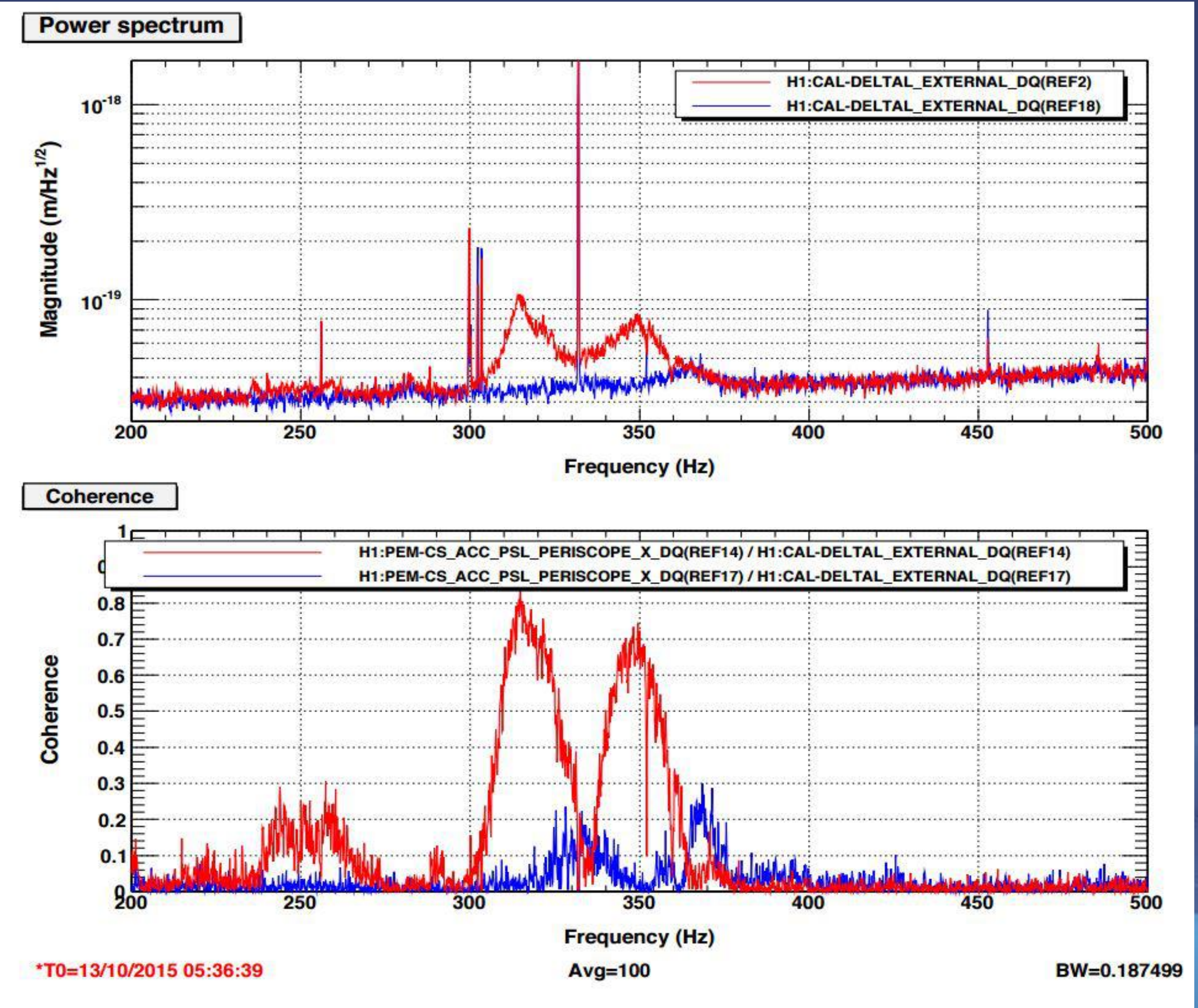
2016

PSL Periscope Noise in O1



Wiener Filter

- Filter applied through convolution in the time domain.

$$E = \sum_{k=1}^{N} \left(y(k) - \sum_{l=0}^{L} \vec{f}(l) \cdot \vec{x}(k-l) \right)^2$$

- Target data: *y*(*k*) with *N* samples
- Witness data: x(k)
- Our filter: *f*(*l*) with *L* + 1 coefficients
- *E* represents the mean square error between target data and predicted data.
- Create our filter by minimizing the mean square error. That means setting derivative with respect to each filter coefficient to zero.

$$\frac{\delta E}{\delta f_m(l)} = 0$$

- Derivative constraints lead to the Wiener-Hopf equation.

$$\sum_{l=0}^{L} R_{xx}(k-l)\cdot\vec{f}(l)=\vec{c}_{yx}(k)$$

- *Rxx* is auto-correlation matrix of witness data, *x*(*k*) where *k* = [0,..., *L*]

- c_{yx} is cross-correlation matrix between witness and target data.

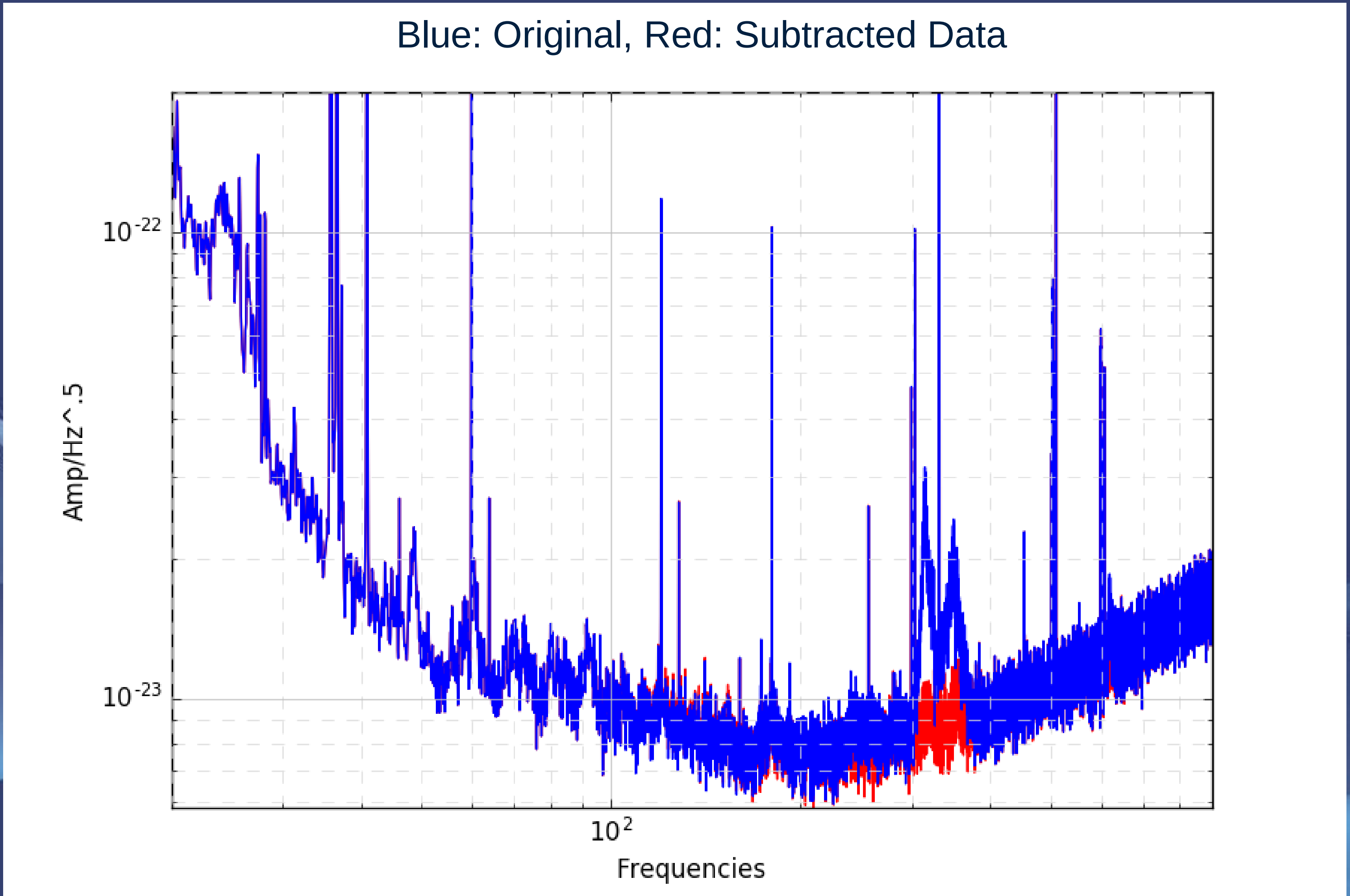
- Signals are real so the auto-correlation matrix is symmetric, resulting in a Toeplitz structured system of equations. Solution obtained with the Levinson-Durbin algorithm.

- Output data, *r*(*k*), is predicted data subtracted from target data.

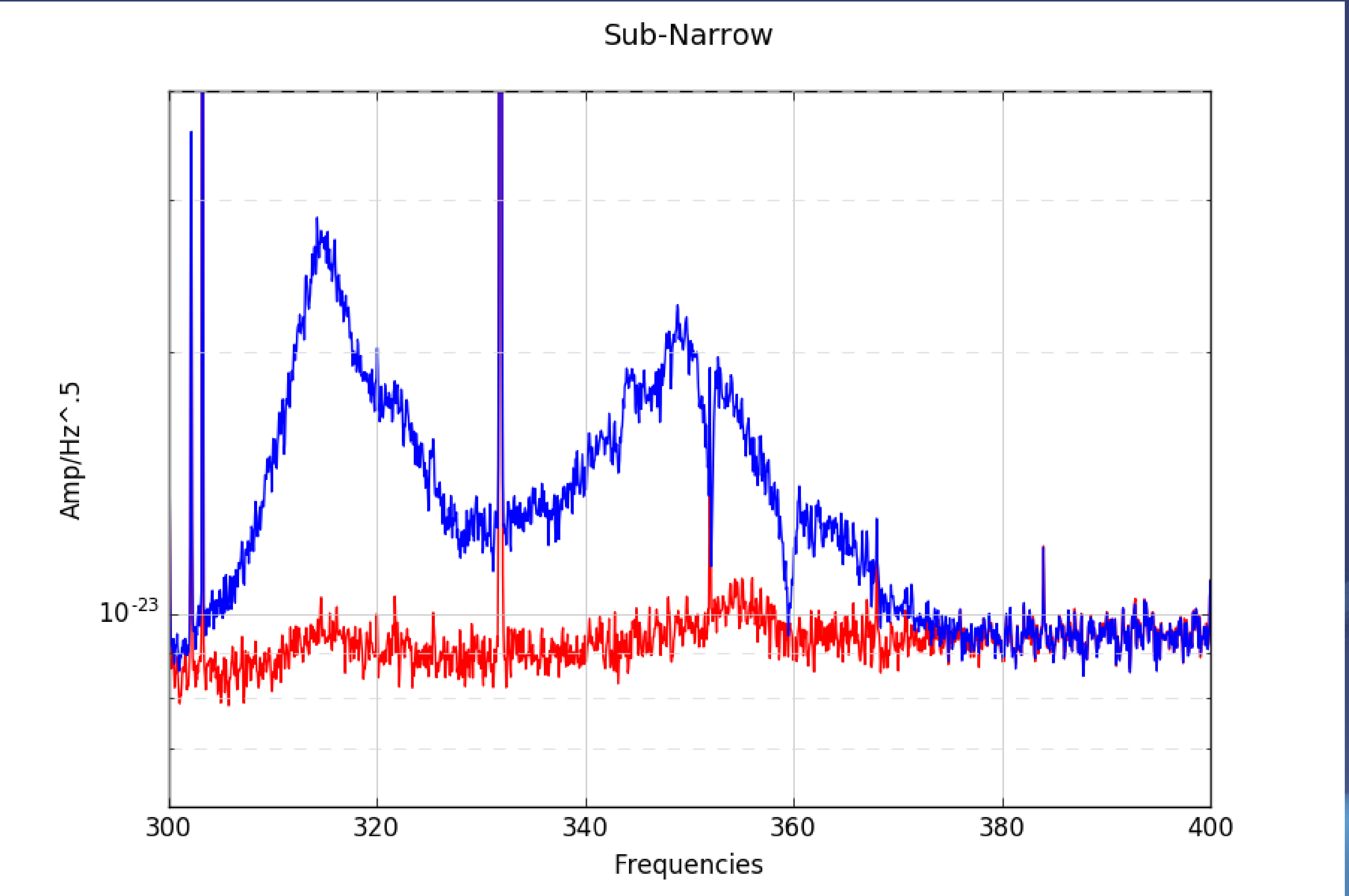
$$r(k)=y(k)-\sum_{m=1}^{M}(f_m * x_m)(k)$$

Witness Channel:
H1:IMC-WFS_B_I_YAW_OUT_DQ

1 hour of data used to train filter

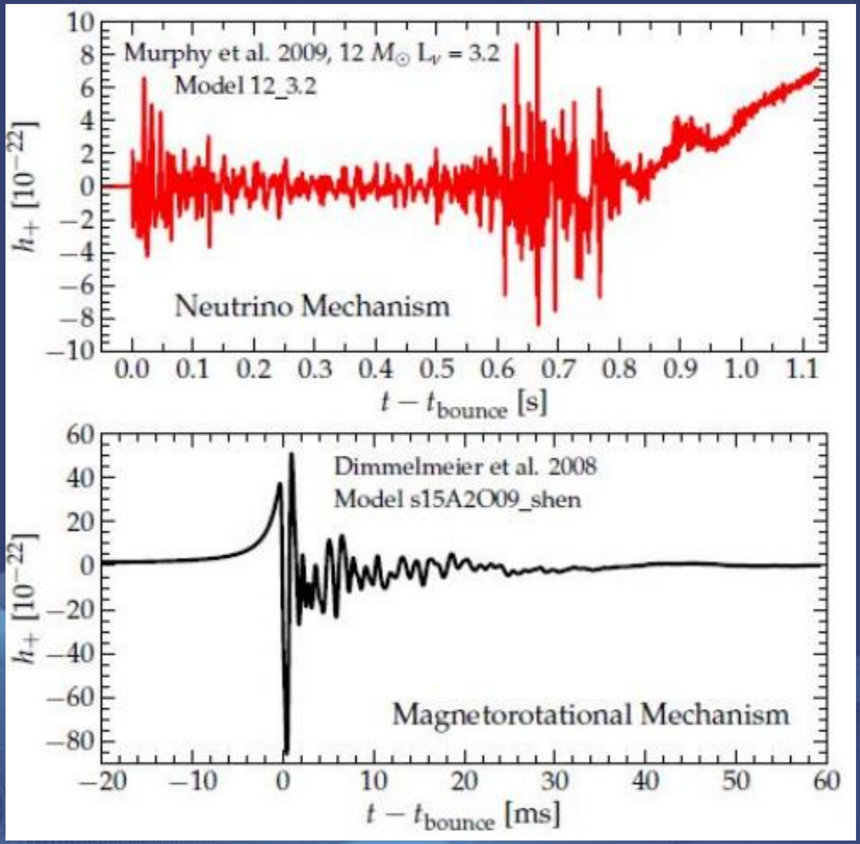


300 – 400 Hz

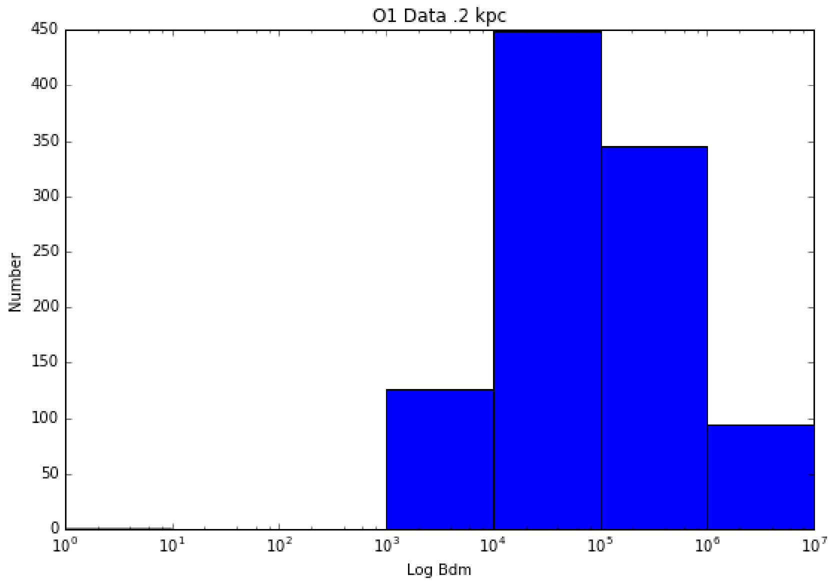


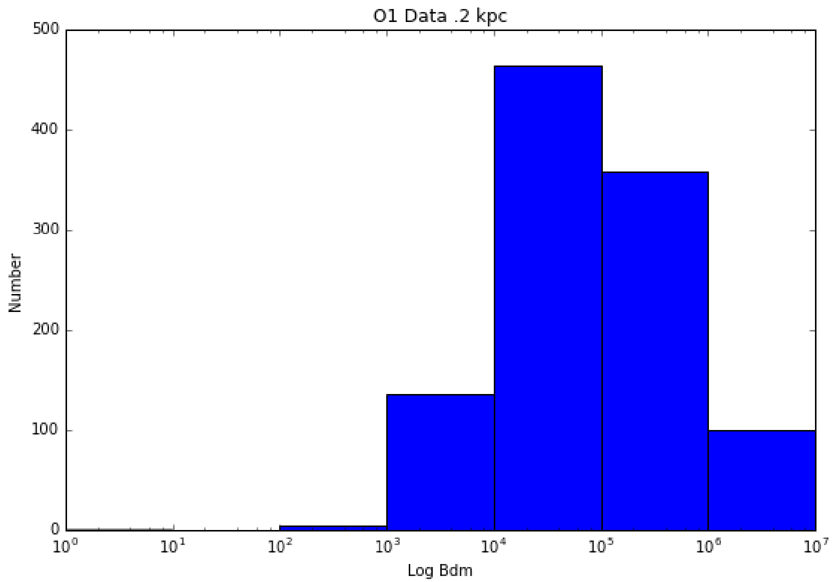
Injections

- Injected 16 waveforms from the Murphy catalog (2009) and 128 waveforms from the Dimmelmeier catalog (2008)
- Each waveform injected at 10 evenly spaced intervals over a 24 hour period to explore entire antenna pattern. 1440 total injections.
- Two sets of PCs, Dimmelmeier and Murphy.
- 6 PCs for Dimmelmeier, 9 for Murphy



Dimmelmeier .2 kpc





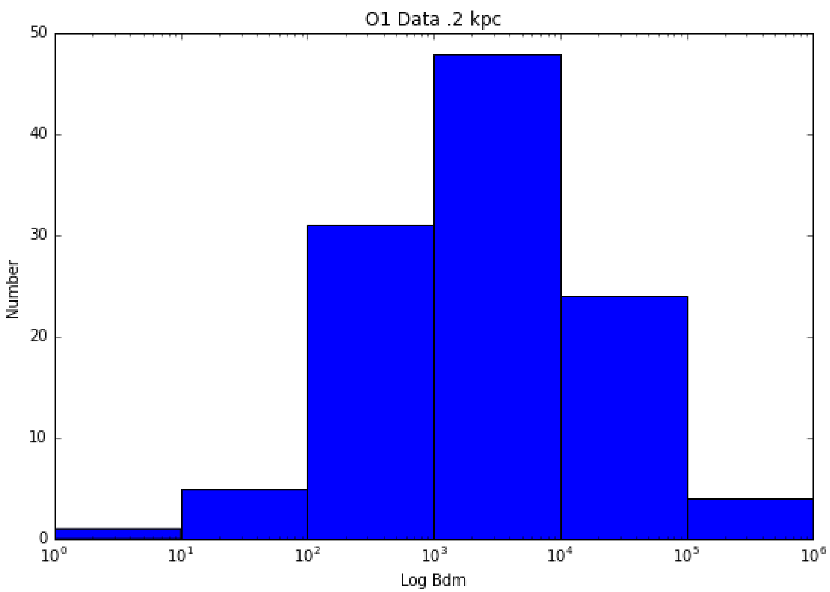
Original Data

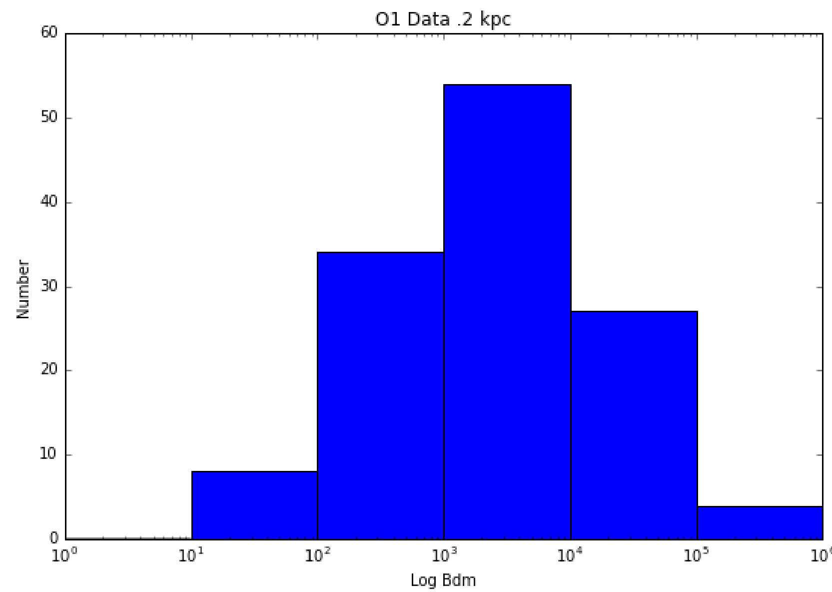
- Data points: 1016
- Avg B_{dm} = 2.7399e5
- Correctly Identified: 1016 / 1016 (100%)
- Incorrectly identified waveforms: 0 / 1016 (0%)
- Undecided: 0 / 1016 (0%)

Filtered Data

- Data points: 1063
- Avg B_{md} = 2.7481e5
- Correctly Identified: 1063 / 1063 (100%)
- Incorrectly Identified: 0 / 1063 (0%)
- Undecided: 0 / 1063 (0%)

Murphy .2 kpc





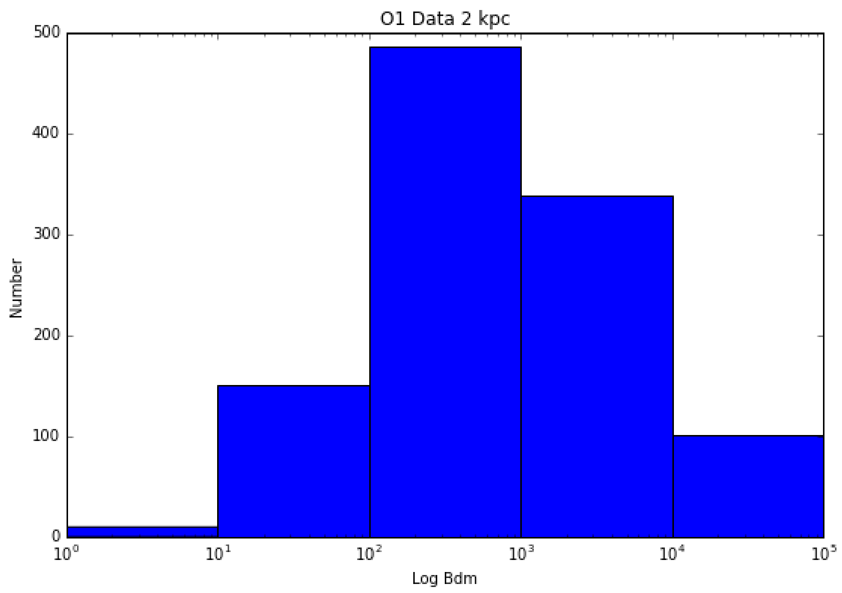
Original Data

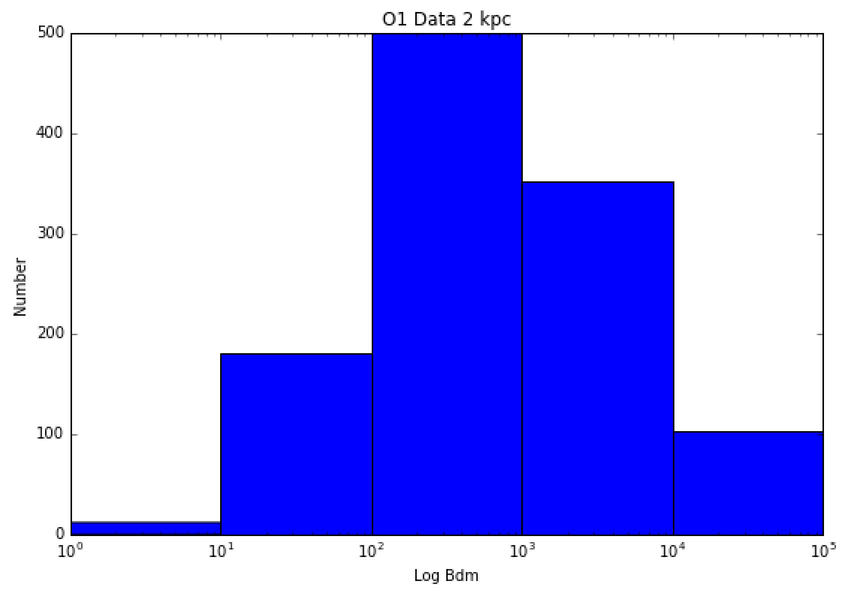
- Data points: 128
- Avg B_{dm} = 1.4e4
- Correctly Identified: 112 / 128 (88%)
- Incorrectly identified waveforms: 15 / 128 (12%)
- Undecided: 1 / 128 (<1%)

Filtered Data

- Data points: 145
- Avg B_{md} = 1.3663e4
- Correctly Idenified: 127 / 145 (88%)
- Incorrectly Identified: 16 / 145 (11%)
- Undecided: 2 / 145 (1%)

Dimmelmeier 2 kpc





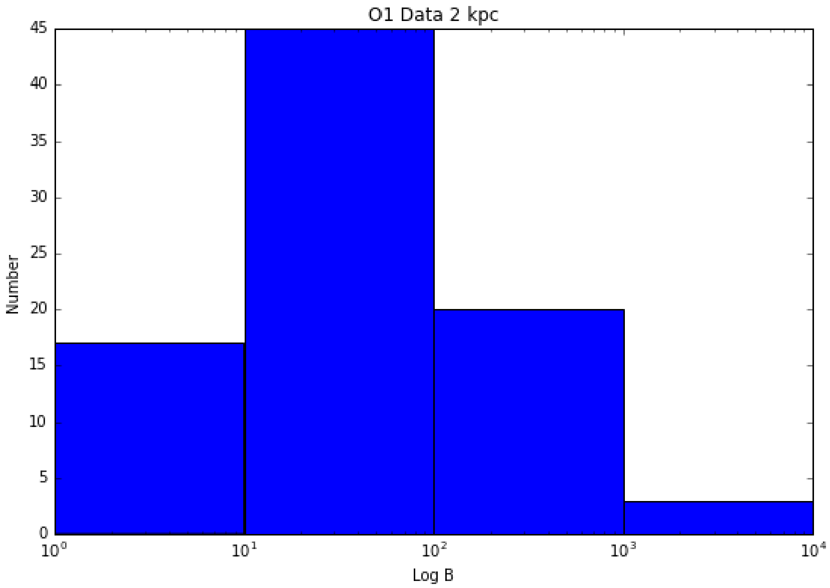
Original Data

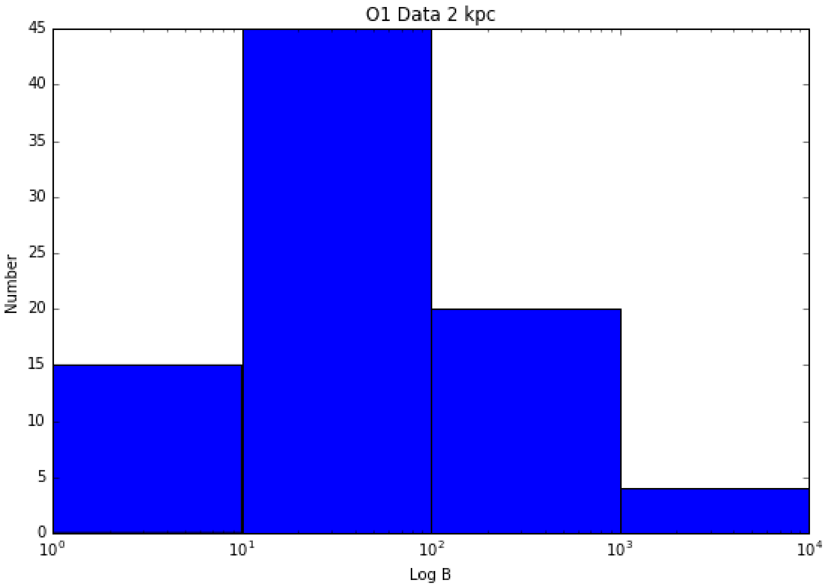
- Data points: 1090
- Avg B_{dm} = 2.657e3
- Correctly Identified: 1078 / 1090 (99%)
- Incorrectly identified waveforms: 0 / 1016 (0%)
- Undecided: 12 / 1090 (1%)

Filtered Data

- Data points: 1153
- Avg B_{md} = 2.552e3
- Correctly Identified: 1137 / 1153 (99%)
- Incorrectly Identified: 0 / 1153 (0%)
- Undecided: 16 / 1153 (1%)

Murphy 2 kpc





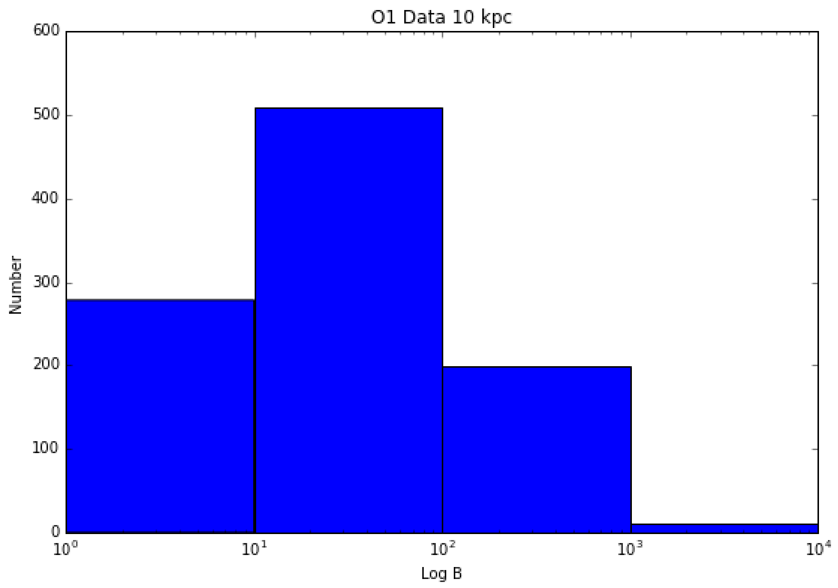
Original Data

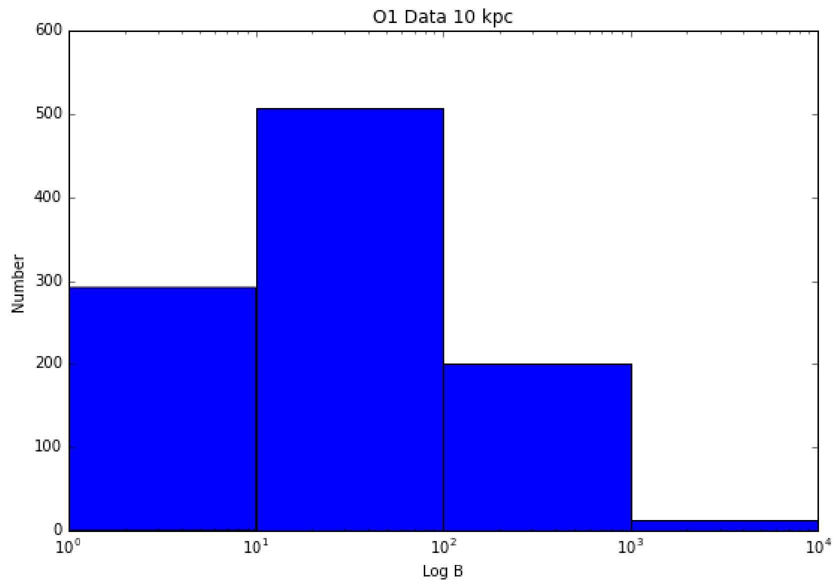
- Data points: 145
- Avg B_{dm} = 115
- Correctly Identified: 68 / 145 (47%)
- Incorrectly identified waveforms: 9 / 145 (6%)
- Undecided: 68 / 128 (47%)

Filtered Data

- Data points: 145
- Avg B_{md} = 119
- Correctly Idenified: 69 / 145 (48%)
- Incorrectly Identified: 11 / 145 (8%)
- Undecided: 65 / 145 (45%)

Dimmelmeier 10 kpc





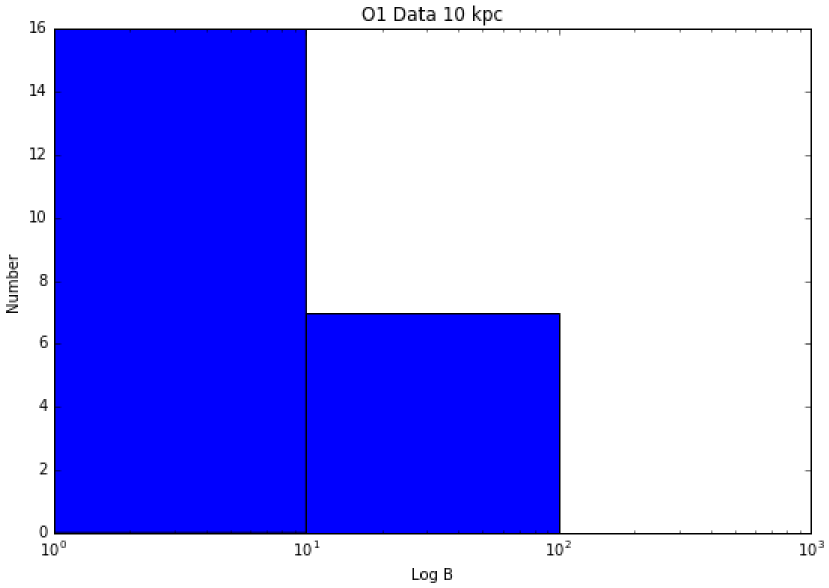
Original Data

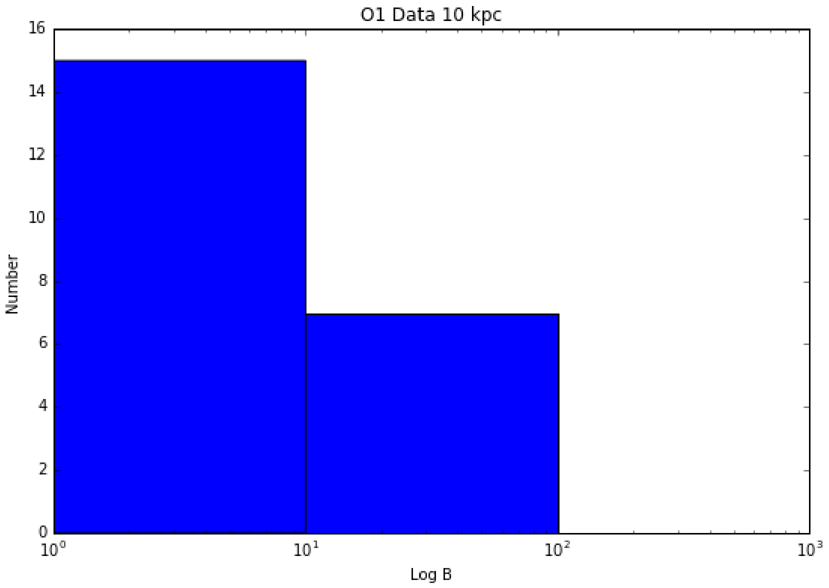
- Data points: 1152
- Avg B_{dm} = 96
- Correctly Identified: 719 / 1152 (62%)
- Incorrectly identified waveforms: 0 / 1052 (0%)
- Undecided: 433 / 1152 (38%)

Filtered Data

- Data points: 1153
- Avg B_{md} = 98
- Correctly Identified: 719 / 1153 (62%)
- Incorrectly Identified: 0 / 1153 (0%)
- Undecided: 434 / 1153 (38%)

Murphy 10 kpc



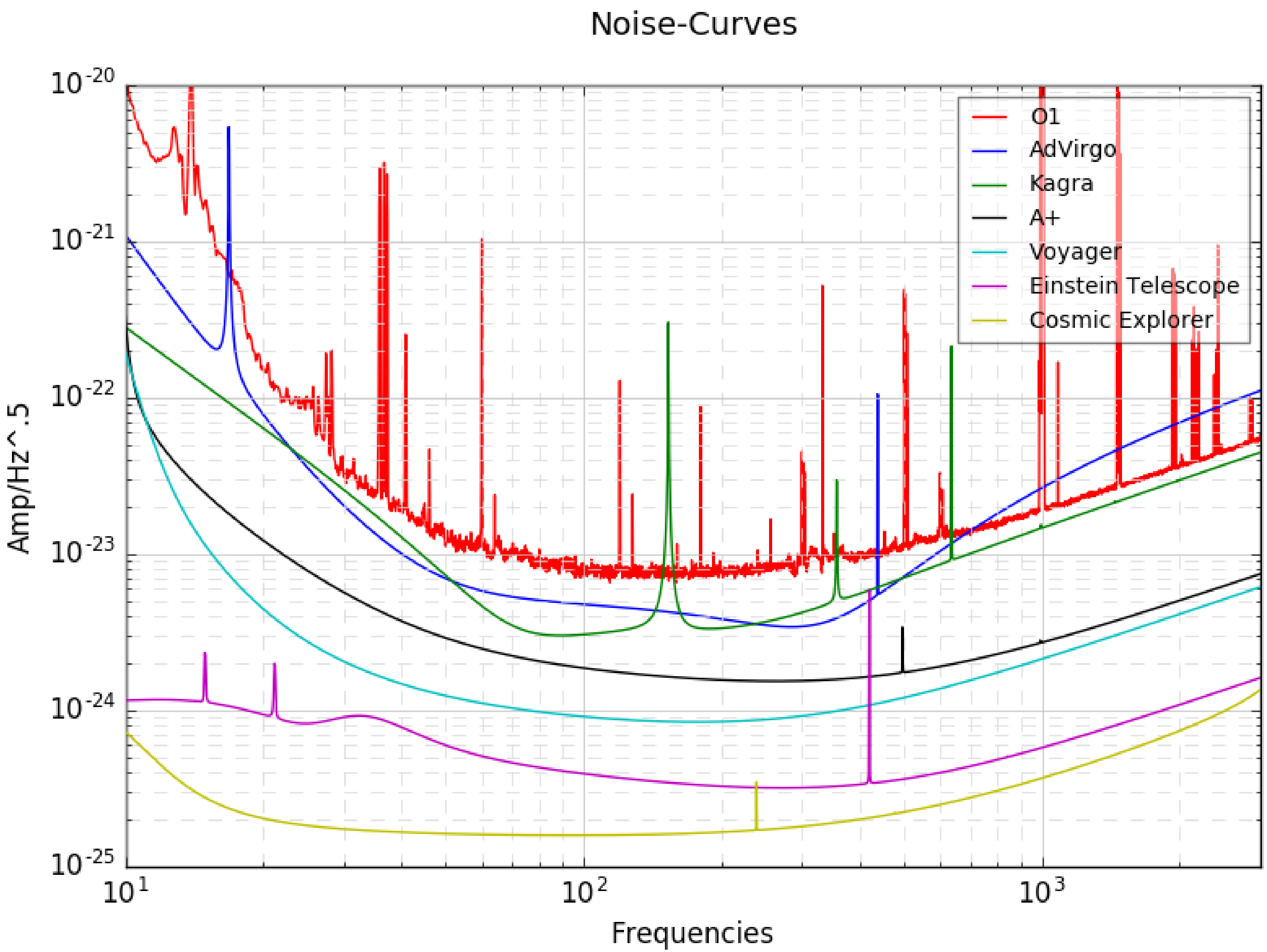


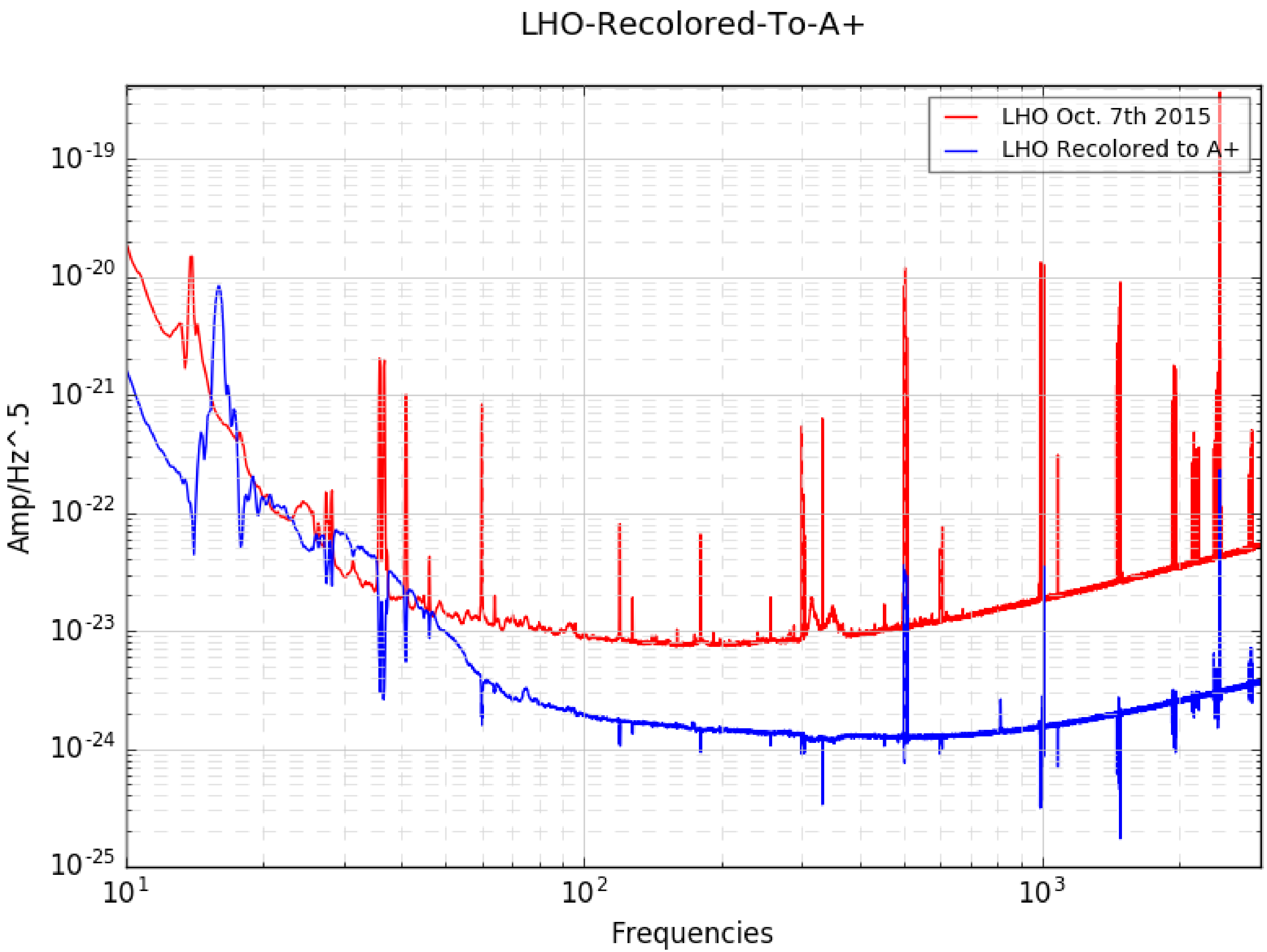
Original Data

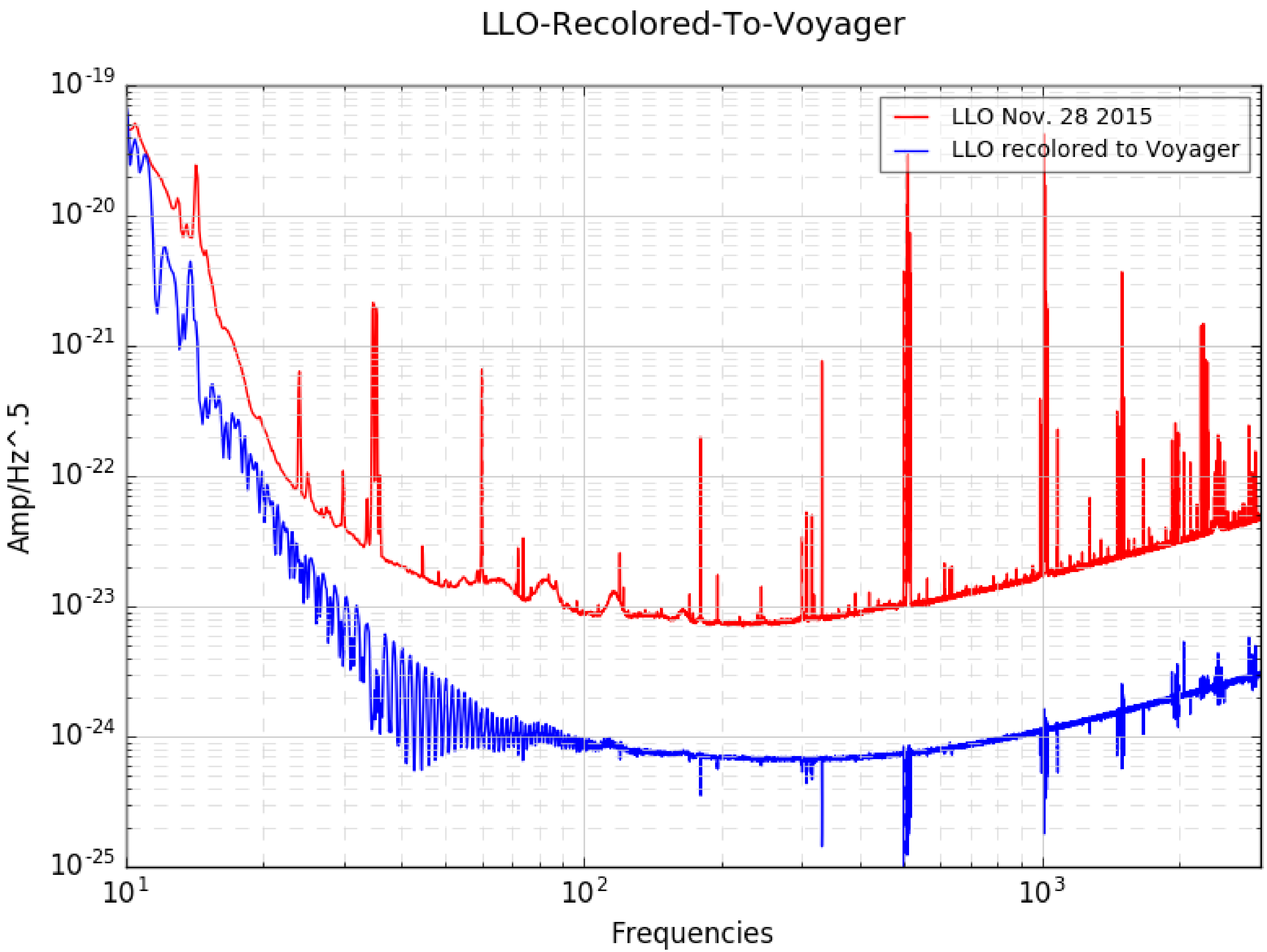
- Data points: 145
- Avg B_{dm} = -1.5
- Correctly Identified: 7 / 145 (5%)
- Incorrectly identified waveforms: 16 / 145 (11%)
- Undecided: 122 / 145 (84%)

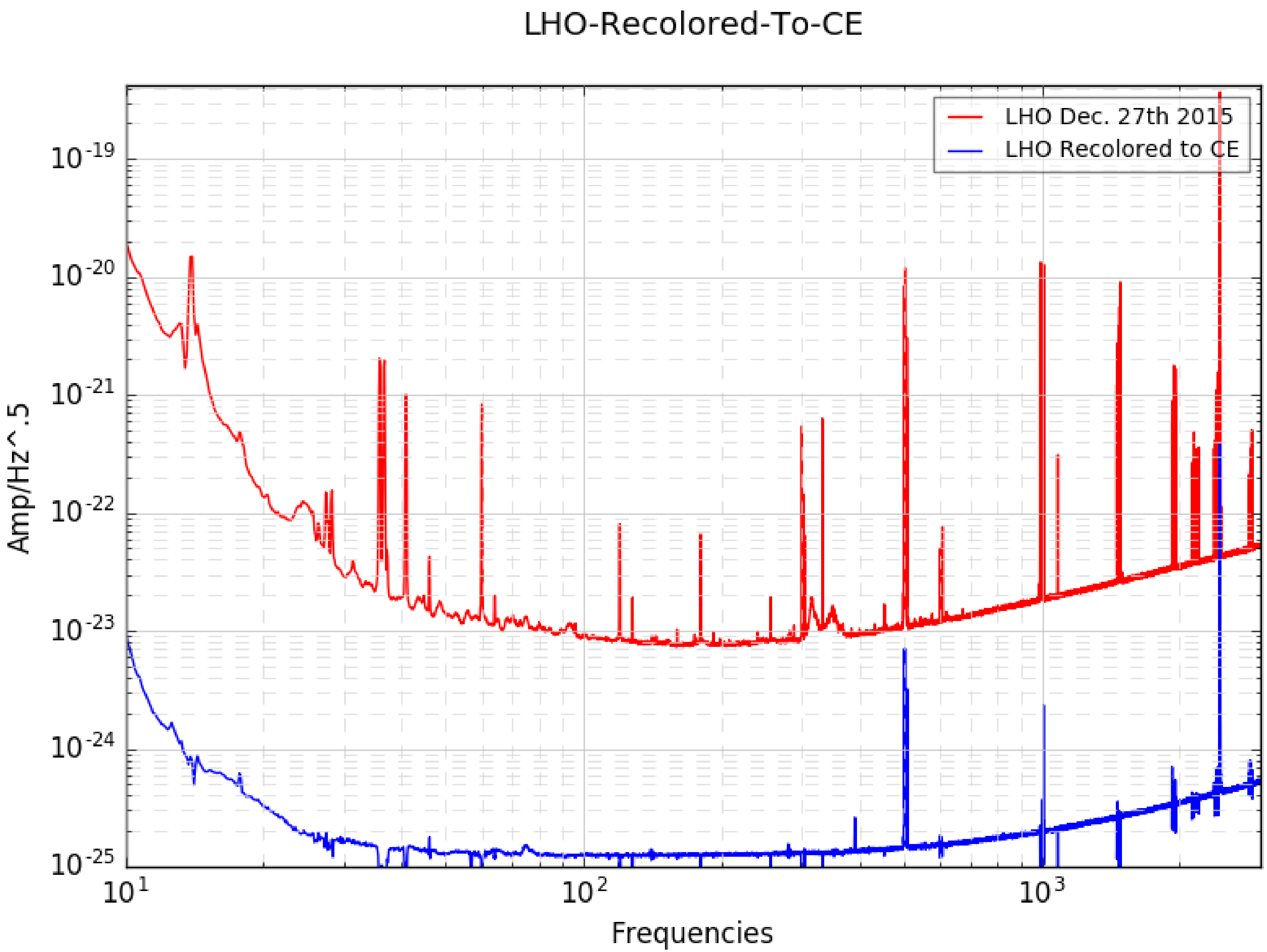
Filtered Data

- Data points: 145
- Avg B_{md} = -1.32
- Correctly Idenified: 7 / 145 (5%)
- Incorrectly Identified: 16 / 145 (11%)
- Undecided: 122 / 145 (84%)

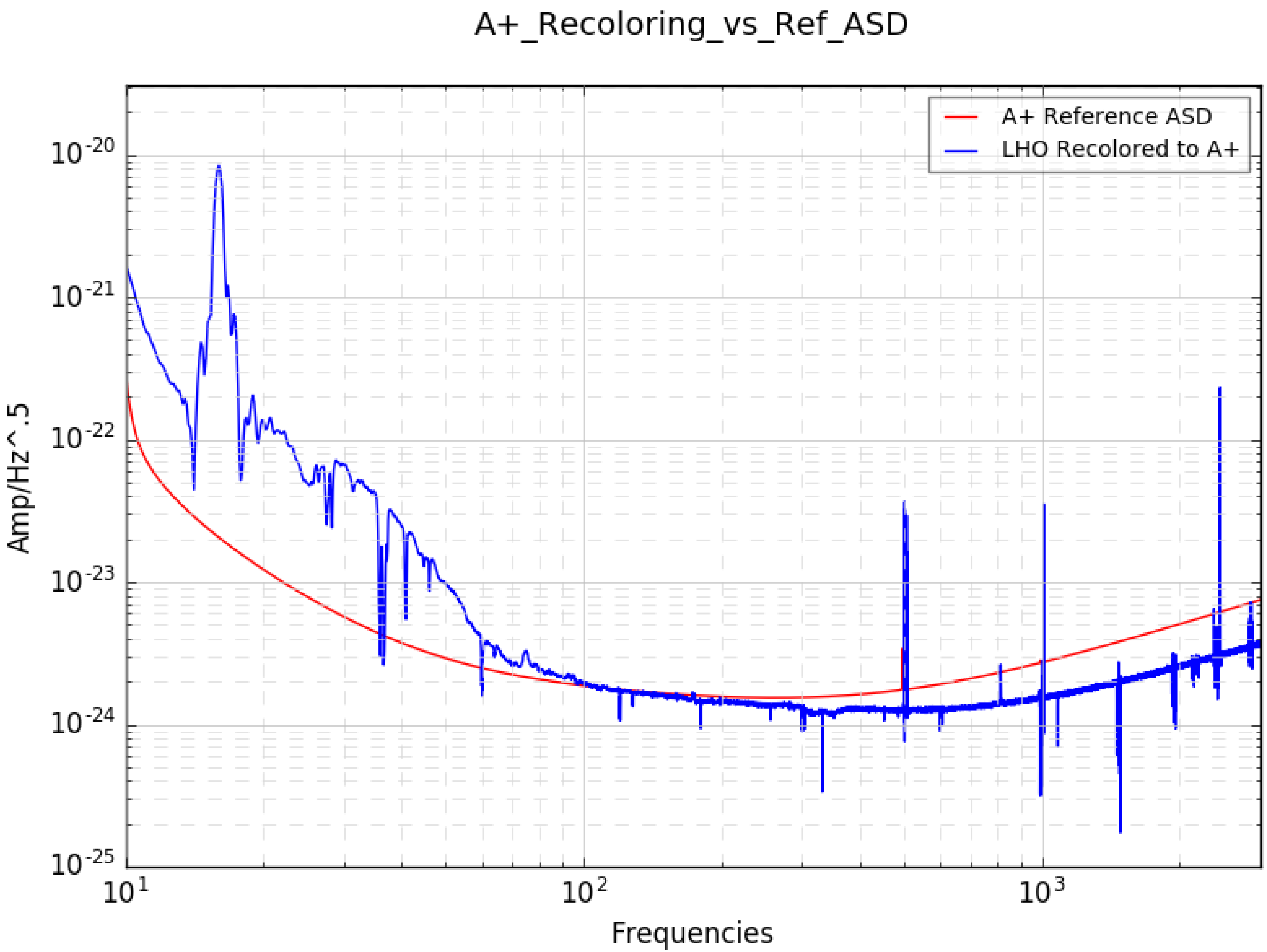

Noise-Curves
Amp/Hz^.5
Frequencies
10^-20
10^-21
10^-22
10^-23
10^-24
10^-25
10^1
10^2
10^3
O1
AdVirgo
Kagra
A+
Voyager
Einstein Telescope
Cosmic Explorer


LHO-Recolored-To-A+
LHO Oct. 7th 2015
LHO Recolored to A+
Amp/Hz^.5
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10^{-24}
10^{-25}
10^{1}
10^{2}
10^{3}
Frequencies


LLO-Recolored-To-Voyager
LLO Nov. 28 2015
LLO recolored to Voyager
Amp/Hz^.5
Frequencies
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10^{-24}
10^{-25}
10^{1}
10^{2}
10^{3}



LHO-Recolored-To-CE
LHO Dec. 27th 2015
LHO Recolored to CE
Amp/Hz^.5
Frequencies
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10^{-24}
10^{-25}
10^{1}
10^{2}
10^{3}


A+_Recoloring_vs_Ref_ASD
A+ Reference ASD
LHO Recolored to A+
Amp/Hz^.5
Frequencies
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10^{-24}
10^{-25}
10^{1}
10^{2}
10^{3}

Current/Next Steps

- Fix recoloring issues
- Study future detectors in depth
- Try Multi-Coherence method
- Examine other noise sources (LLO noise breathing, current LHO jitter, etc)
- Add new non-catalog waveforms