A Resonant-Mass Gravitational Wave Detector in the 100 kHz Range

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Sao Paulo Federal Institute

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Sao Paulo Federal University - Diadema

Reuven Opher Workshop on Challenges of New Physics in Space

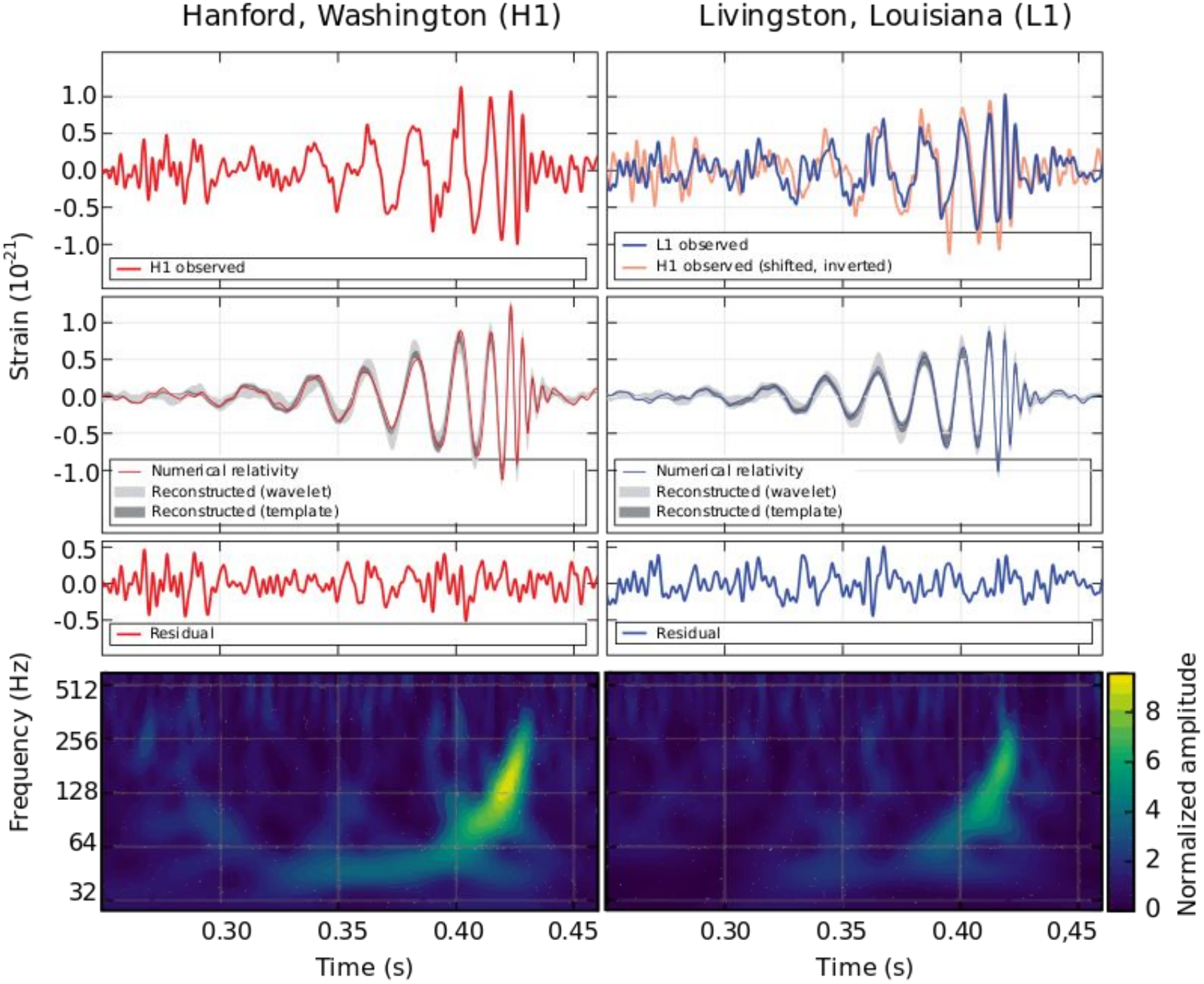
Abstract

The detection of gravitational waves came after one hundred years of waiting. In 2015 gravitational waves were observed with laser interferometric detectors, very complex machines very hard to calibrate. There is a different technology to detect gravitational waves, which is the Resonant-Mass Gravitational Wave detectors, that are easily calibrated. Before the age of the laser interferometric detectors, the resonant-mass detectors were the only detectors available, there was a global network of detectors that operated for quite some time, with no detection accounted for. This lack of detections may be due the operational frequency range, the resonant-mass detector operated around 1 kHz, and the detected Gravitational Wave signals are close to 100 Hz. This work shows the design of a 100 Hz Gravitational Wave Resonant-Mass that can be used to calibrate the laser interferometric detectors.

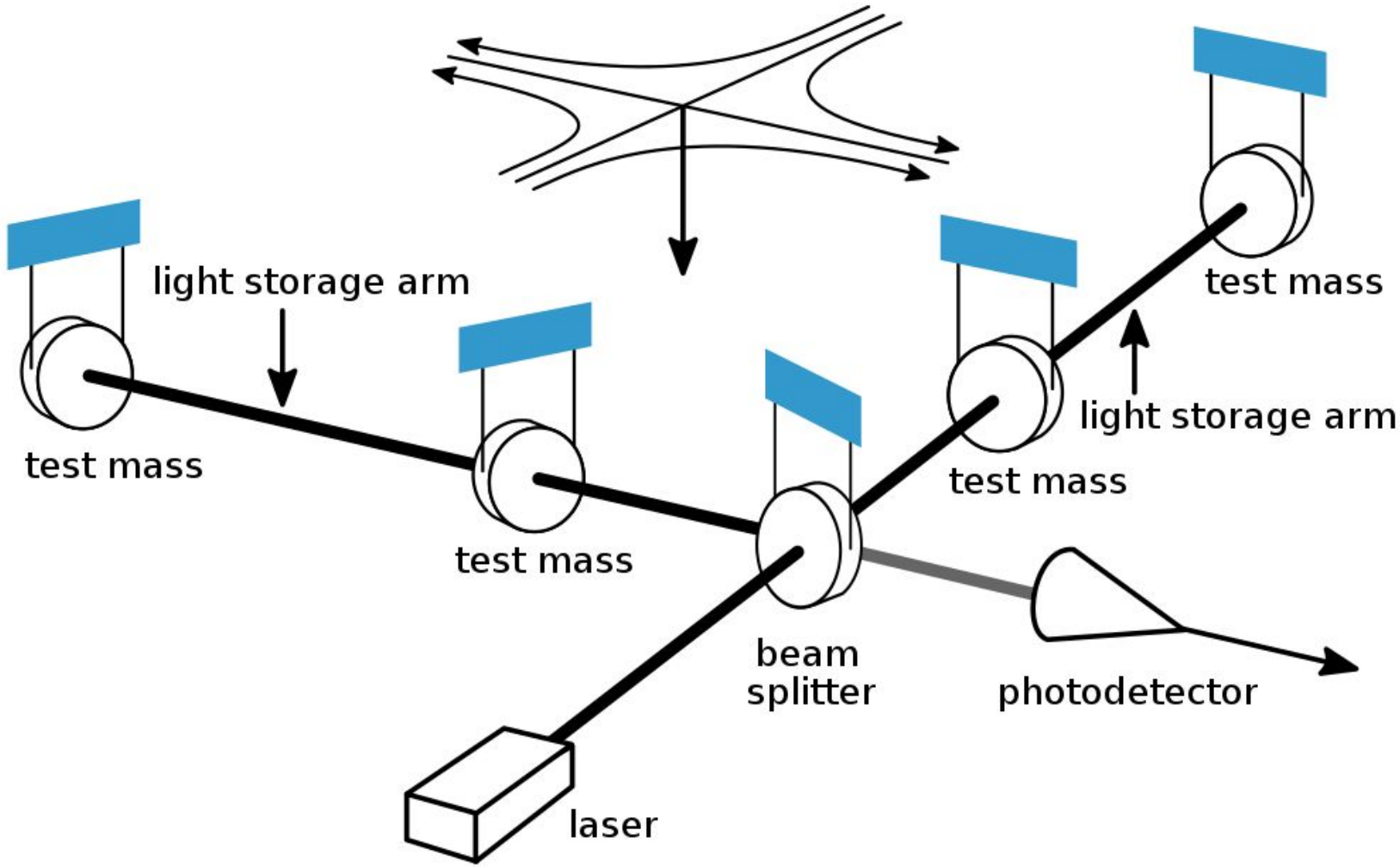
Outline

- The first detection of gravitational waves
- The GW detection frequency range
- Resonant Mass Gravitational Wave Detectors
- Detector sensitivity
- The comparison with a Laser Interferometric Gravitationas Wave Detector

First Gravitational Wave Detection

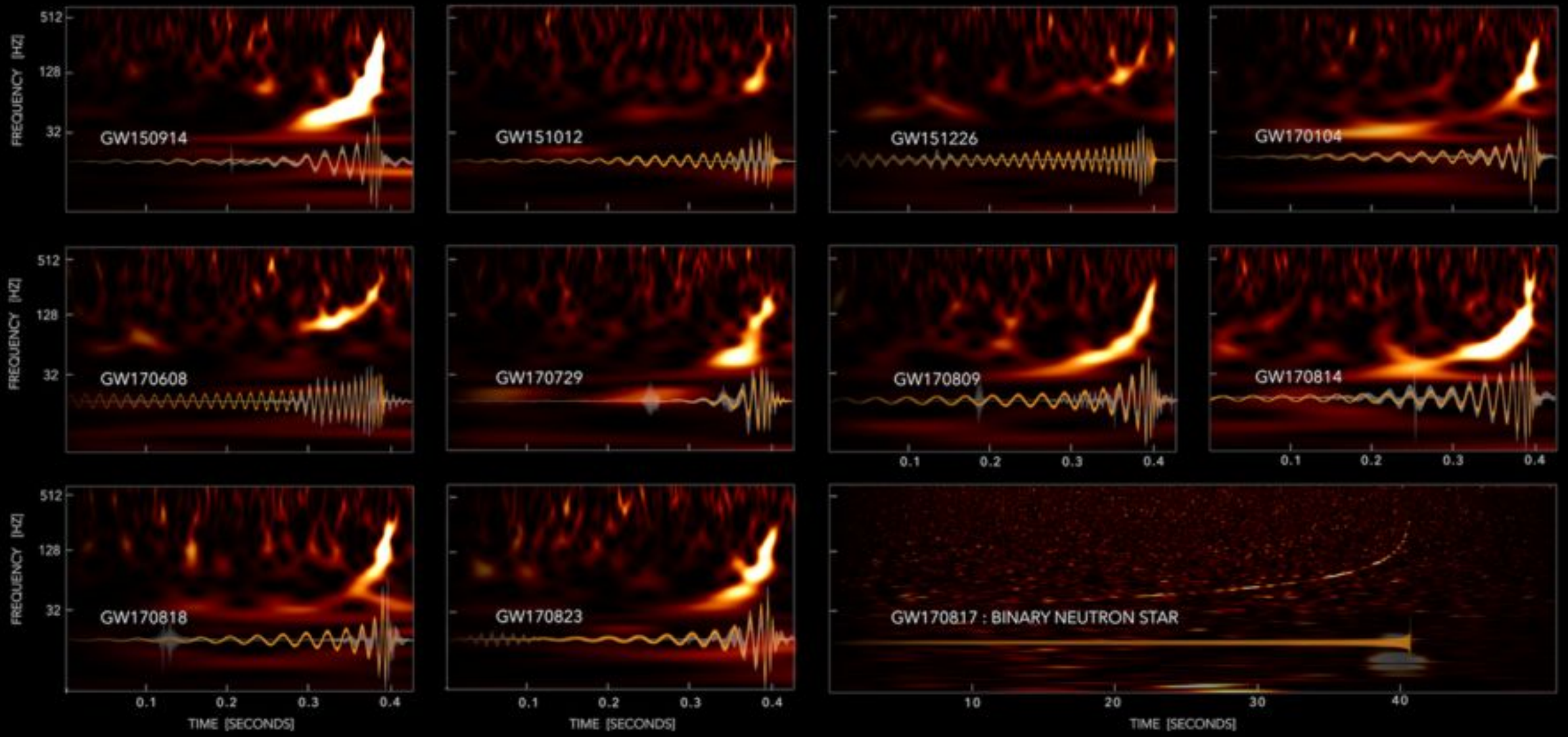


Laser Interferometric Gravitational Wave Detector



GRAVITATIONAL-WAVE TRANSIENT CATALOG-1

LIGO VIRGO Georgia Tech



LIGO-VIRGO DATA: HTTPS://DOI.ORG/10.7935/82H3-HH23

WAVELET (UNMODELED)

EINSTEIN'S THEORY

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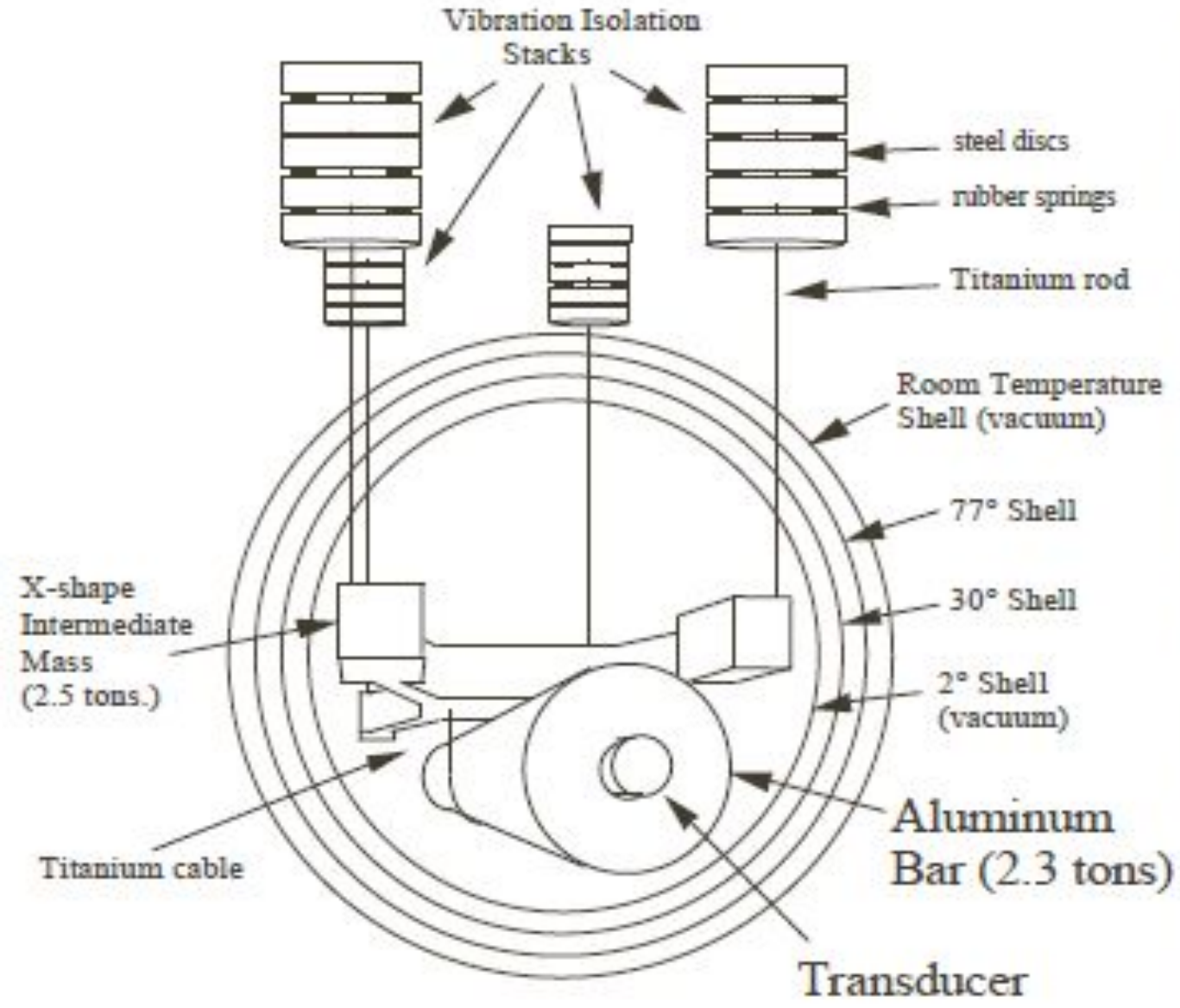
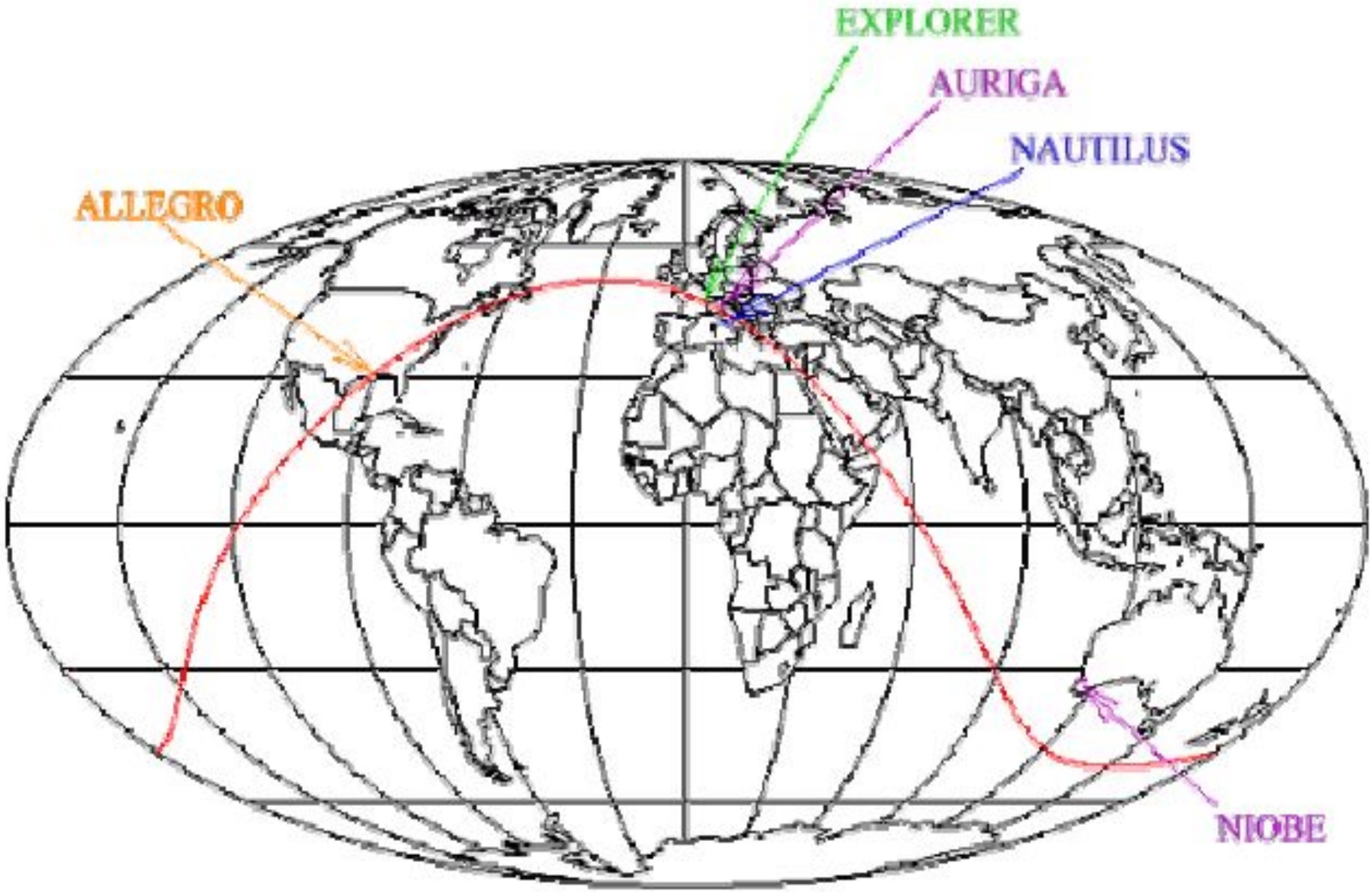
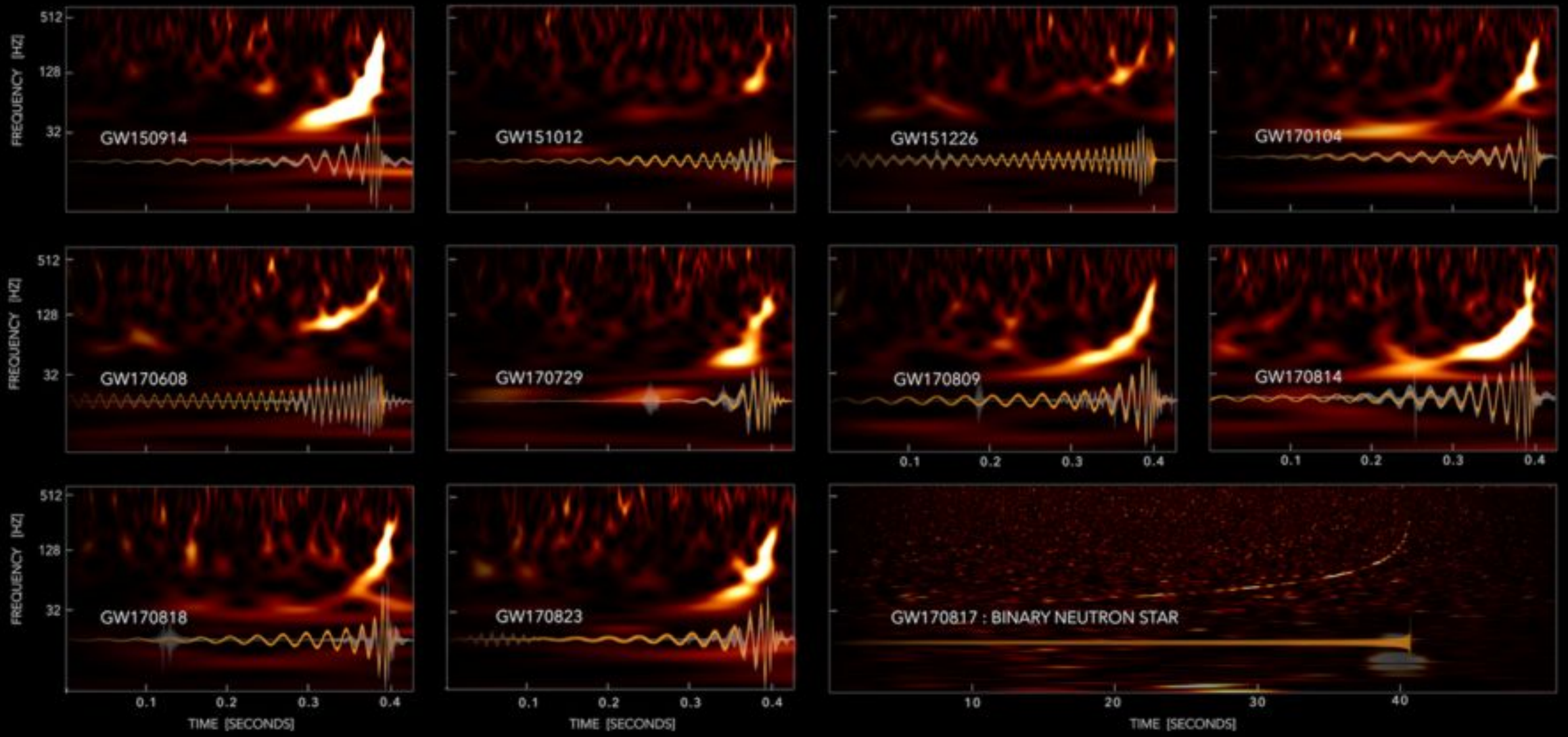
Resonant-mass GWD
Easily calibrated.




EXPLORER
AURIGA
NAUTILUS
ALLEGRO
NIOBE

GRAVITATIONAL-WAVE TRANSIENT CATALOG-1

LIGO VIRGO Georgia Tech



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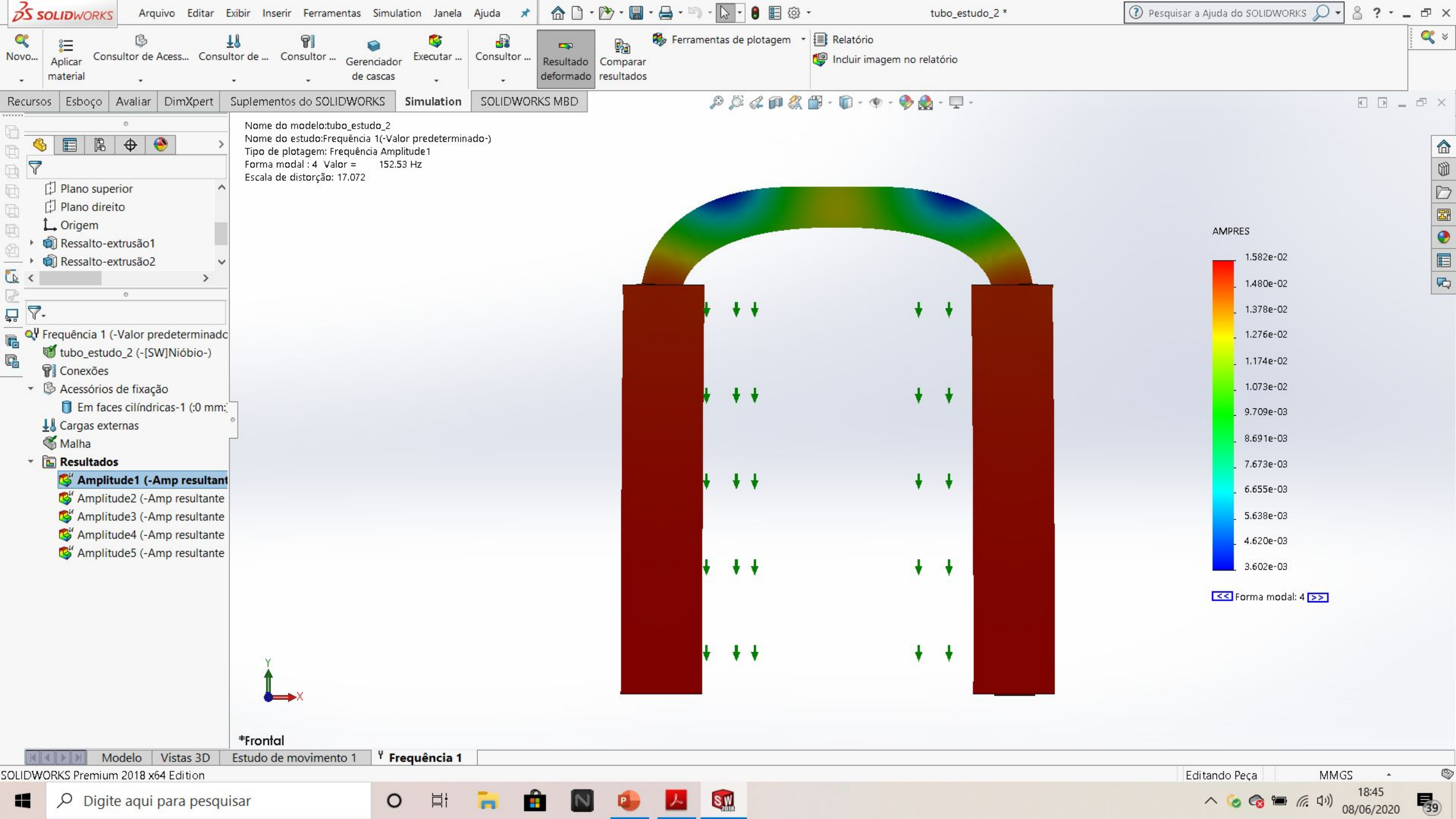
Arquivo Editar Exibir Inserir Ferramentas Simulation Janela Ajuda
tubo_estudo_2 *
Pesquisar a Ajuda do SOLIDWORKS
Novo...
Aplicar material
Consultor de Acess...
Consultor de ...
Consultor ...
Gerenciador de cascas
Executar ...
Consultor ...
Resultado deformado
Comparar resultados
Ferramentas de plotagem
Relatório
Incluir imagem no relatório
Recursos Esboço Avaliar DimXpert Suplementos do SOLIDWORKS Simulation SOLIDWORKS MBD
Nome do modelo:tubo_estudo_2
Nome do estudo:Frequência 1(-Valor predeterminado-)
Tipo de plotagem: Frequência Amplitude1
Forma modal : 4 Valor = 152.53 Hz
Escala de distorção: 17.072
Plano superior
Plano direito
Origem
Ressalto-extrusão1
Ressalto-extrusão2
Frequência 1 (-Valor predeterminadc
tubo_estudo_2 (-[SW]Nióbio-)
Conexões
Acessórios de fixação
Em faces cilíndricas-1 (:0 mm:
Cargas externas
Malha
Resultados
Amplitude1 (-Amp resultant
Amplitude2 (-Amp resultante
Amplitude3 (-Amp resultante
Amplitude4 (-Amp resultante
Amplitude5 (-Amp resultante
AMPRES
1.582e-02
1.480e-02
1.378e-02
1.276e-02
1.174e-02
1.073e-02
9.709e-03
8.691e-03
7.673e-03
6.655e-03
5.638e-03
4.620e-03
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Modelo Vistas 3D Estudo de movimento 1 Frequência 1
SOLIDWORKS Premium 2018 x64 Edition
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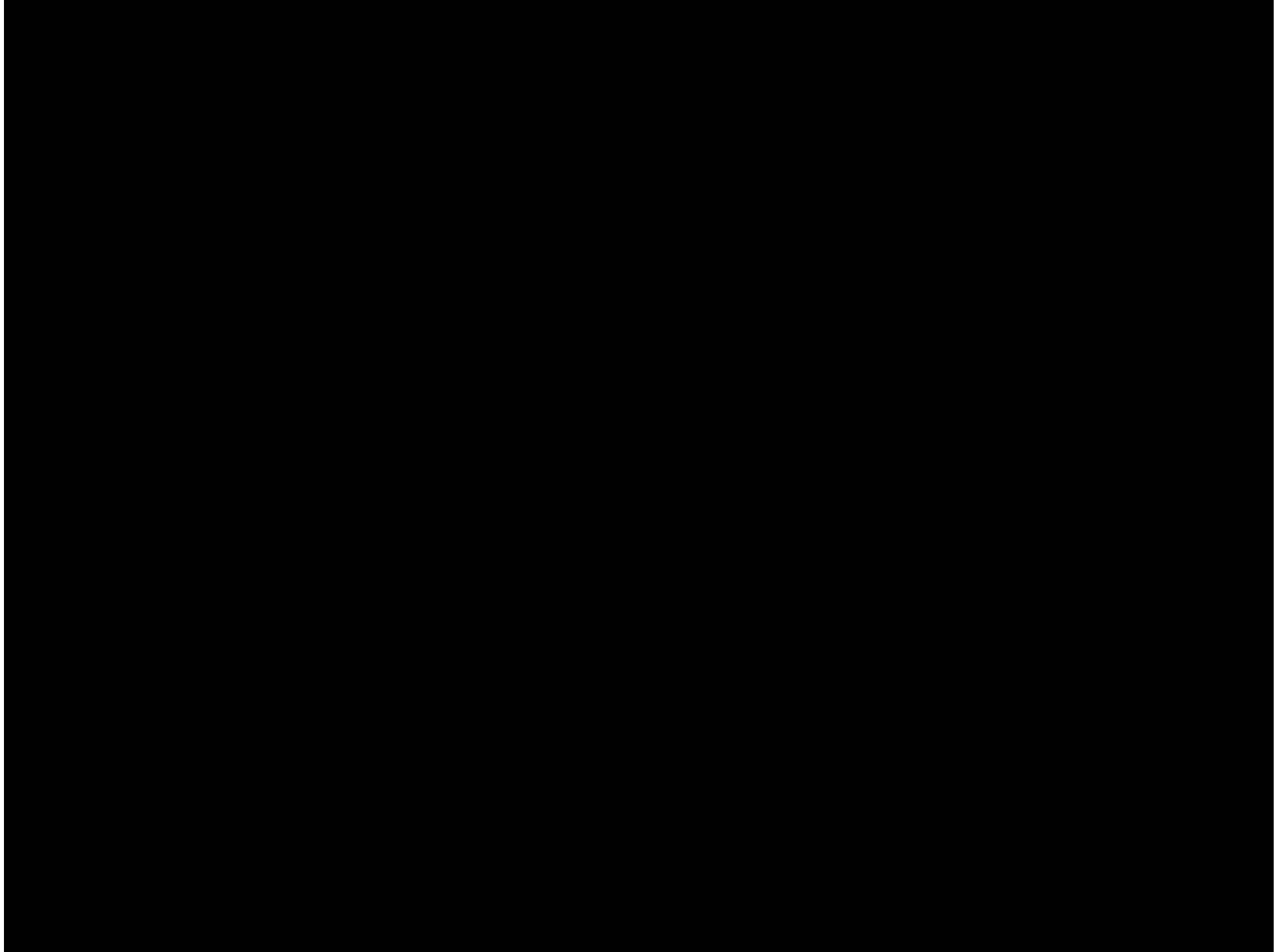

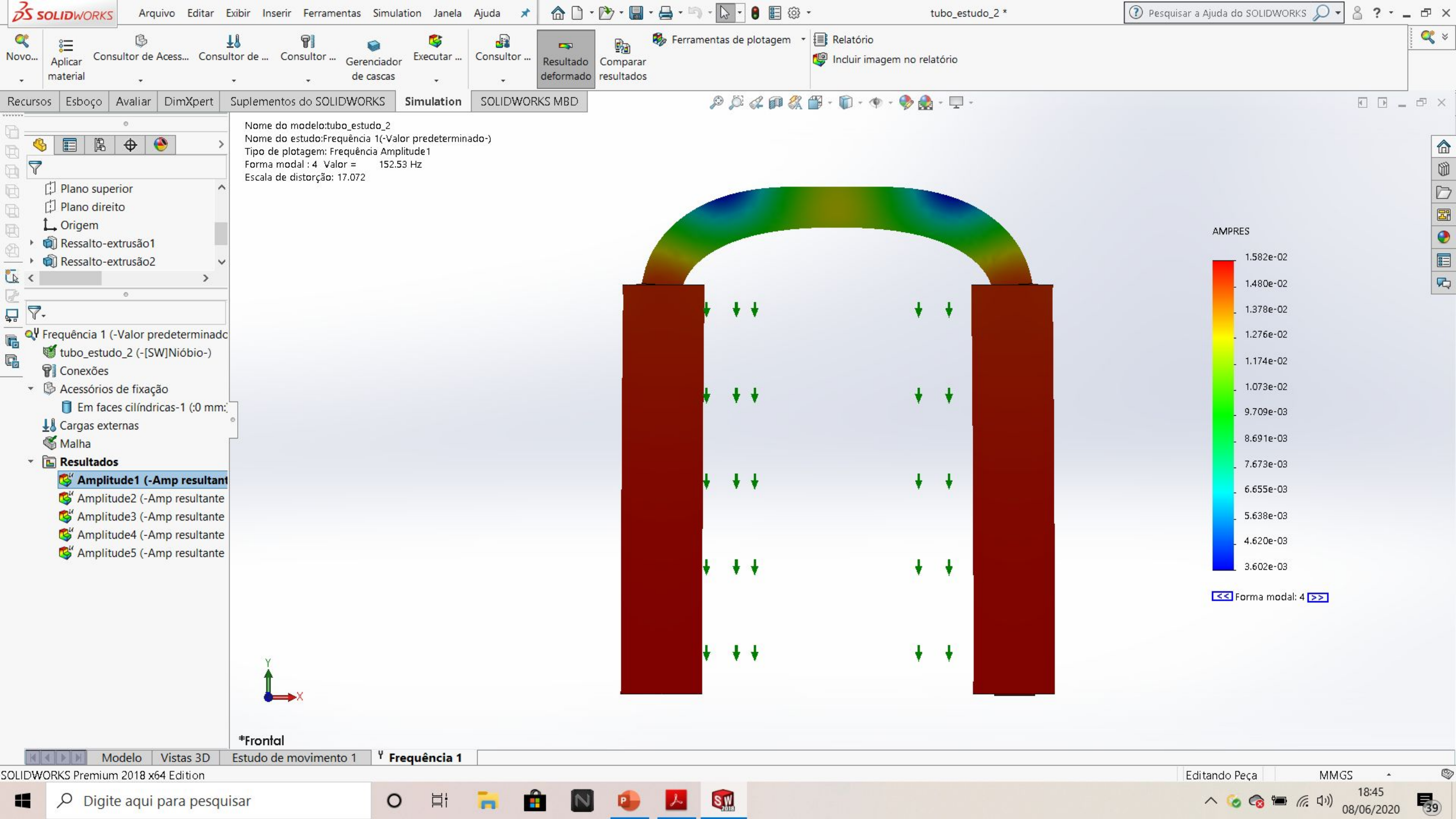
Arquivo Editar Exibir Inserir Ferramentas Simulation Janela Ajuda
tubo_estudo_2 *
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Aplicar material
Consultor de Acess...
Consultor de ...
Consultor ...
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Incluir imagem no relatório
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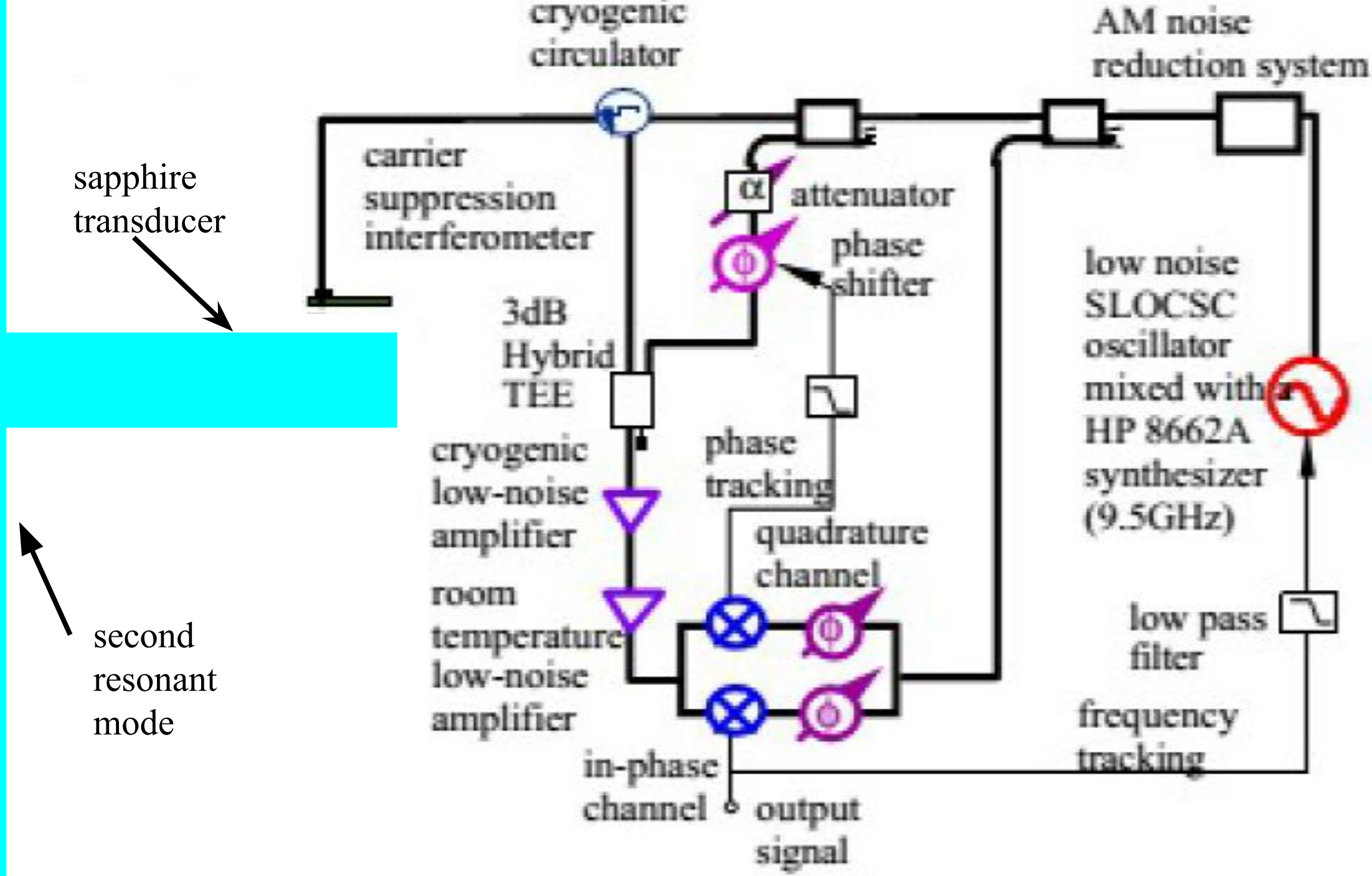

sapphire transducer
second resonant mode
cryogenic circulator
AM noise reduction system
carrier suppression interferometer
α
attenuator
phase shifter
3dB Hybrid TEE
low noise SLOCSC oscillator mixed with HP 8662A synthesizer (9.5GHz)
cryogenic low-noise amplifier
phase tracking
quadrature channel
room temperature low-noise amplifier
low pass filter
frequency tracking
in-phase channel
output signal

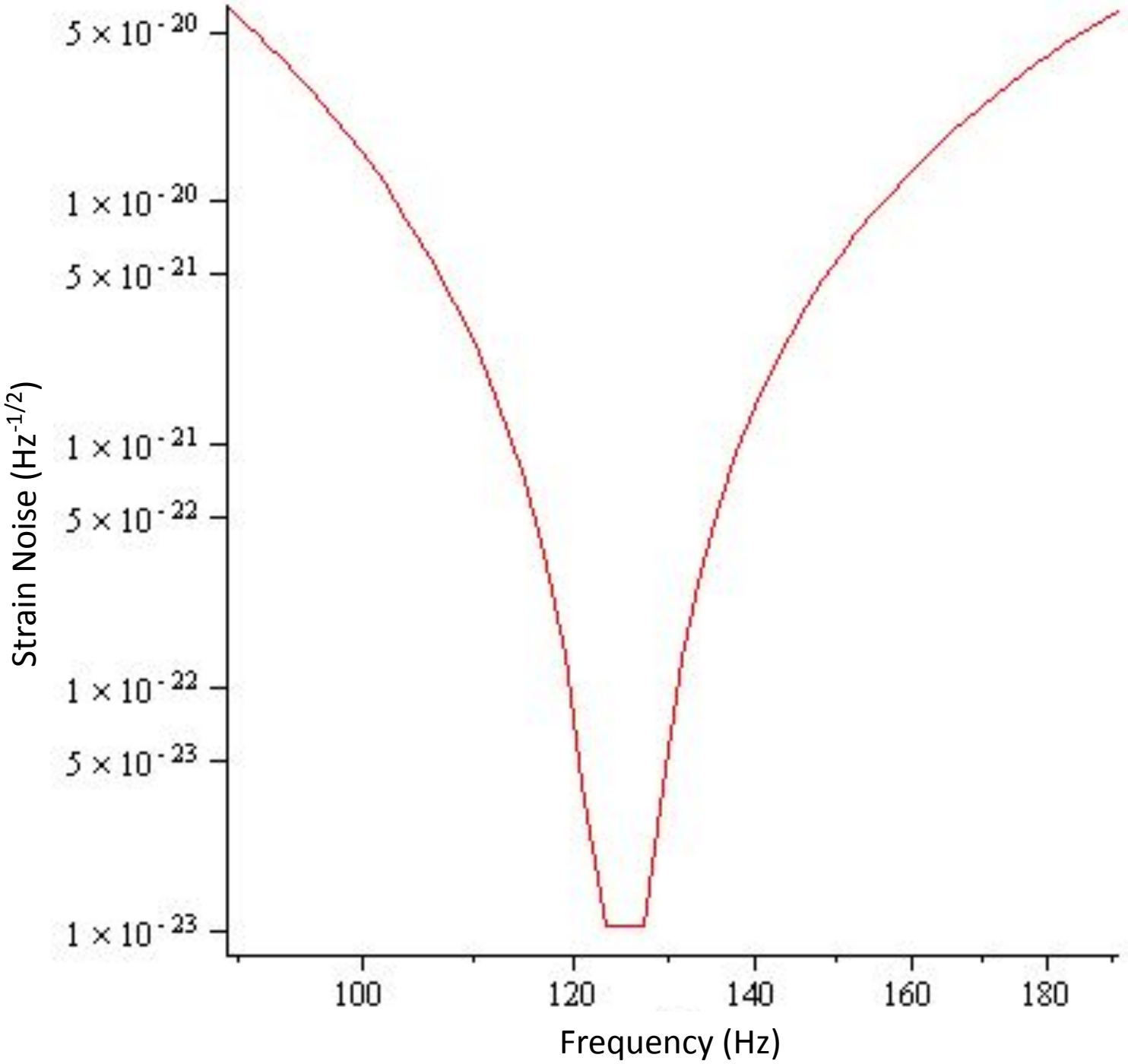
Calibrator detector characteristics

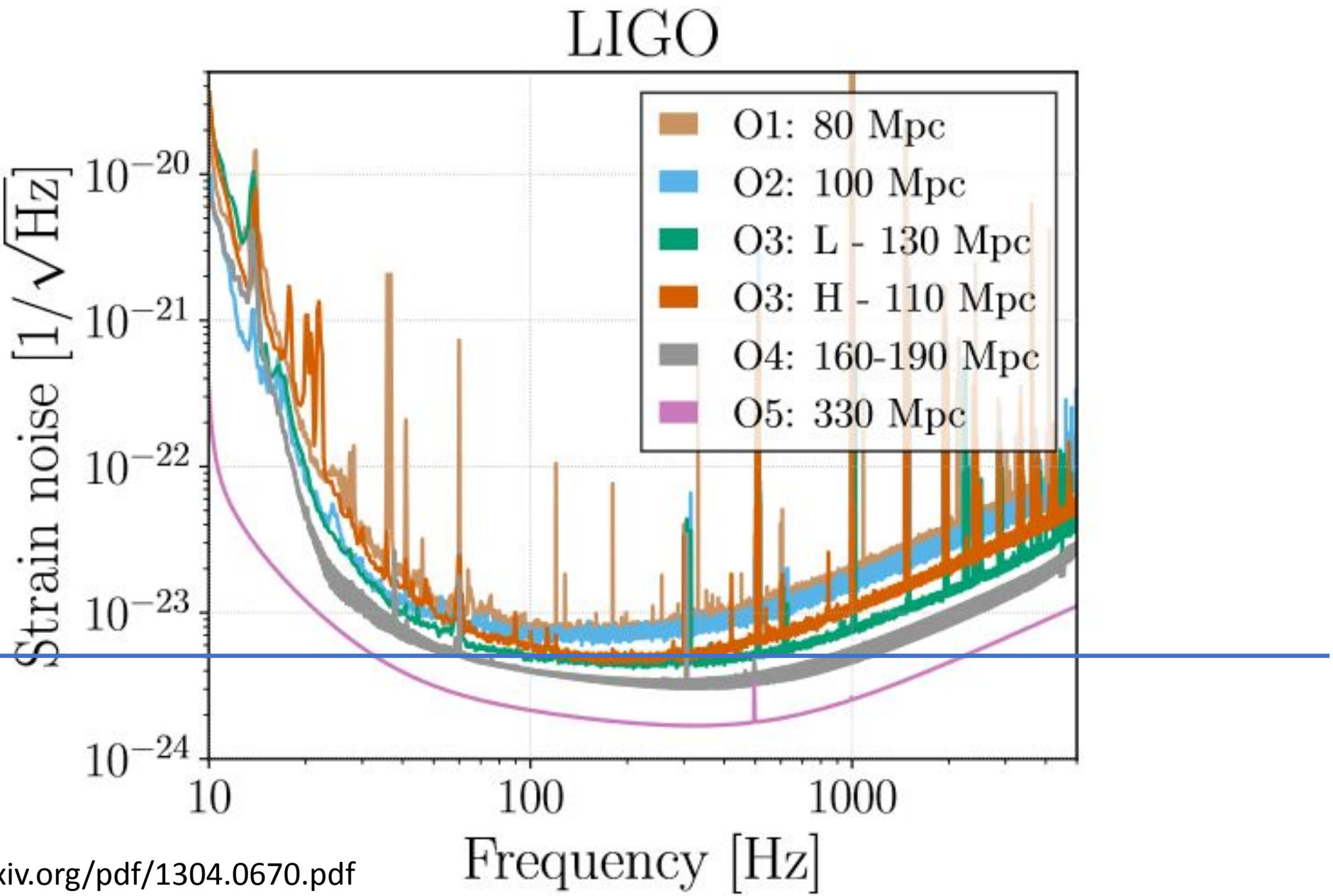
- M_b = 10,000 kg
- M_1 = 10 kg
- M_2 = 0.01 Kg
- Q_b = 250 10^6
- Q_1 = 500 10^6
- Q_2 = 500 10^6
- Q_e = 10^6
- T = 10 mK
- T_{Amp} = 4 K
- df/dx = 3 10^{14} Hz m^{-1}
- S_P = -185 dBc @ 100Hz
- S_A = -165 dBc @ 100Hz

Strain Sensitivity = 1.31 10^{-21}

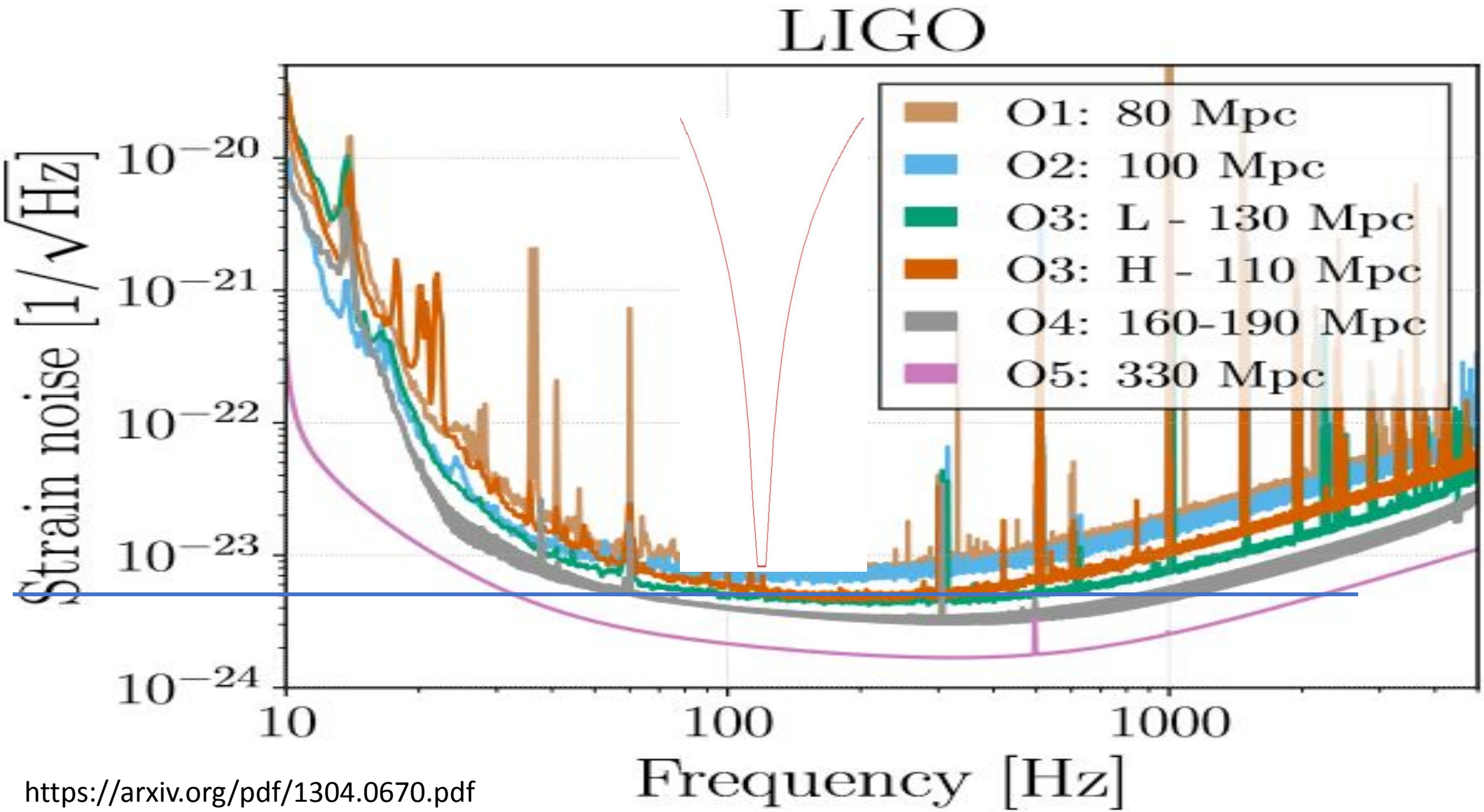
Quantum Limit = 1.29 10^{-21}

Noise temperature = 6.14 10^{-9} K





https://arxiv.org/pdf/1304.0670.pdf



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Thank you for you
kind attention!