Université Claude Bernard Lyon 1

iP2i LES 2 INFINIS LYON

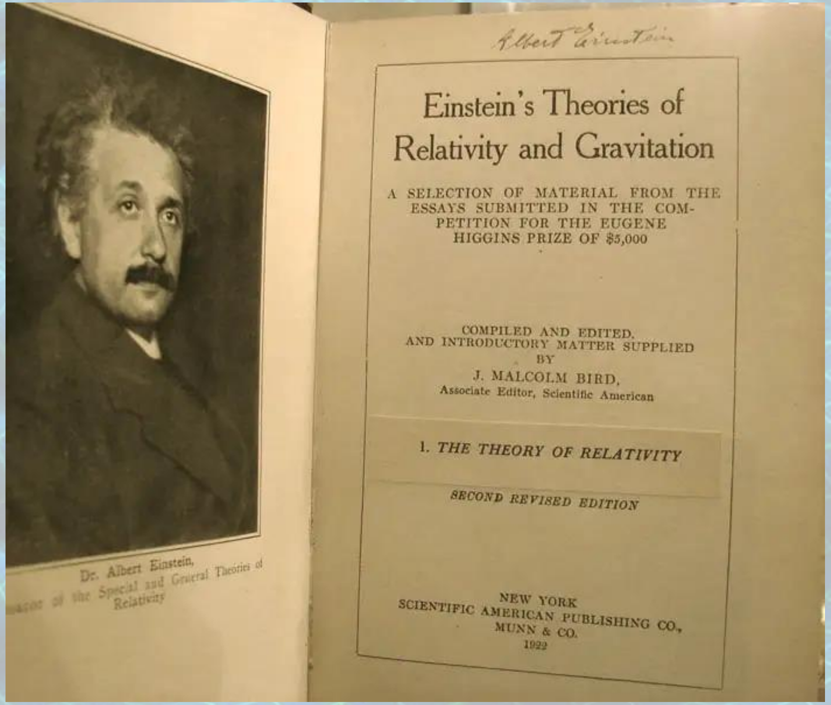
Simulations de merger de SSM et estimation des possibles détections actuelles et futures

Odin Asnar M1 COSMO

Tuteur : Alexis Boudon

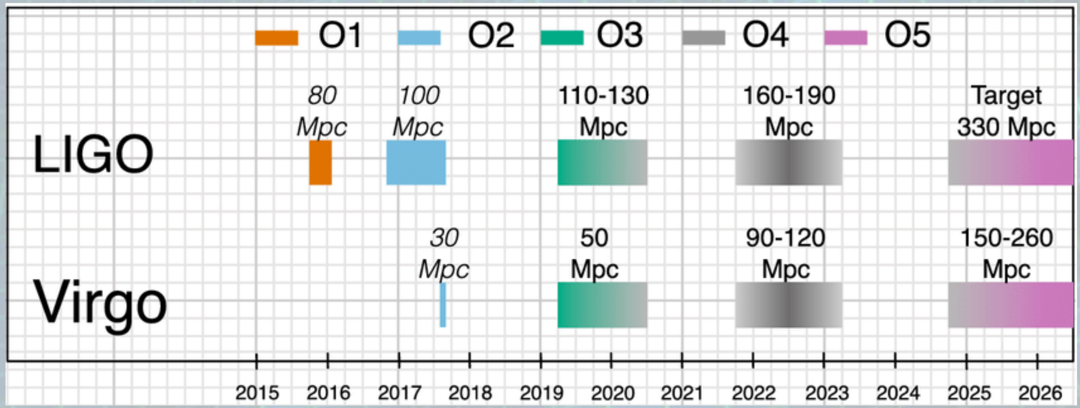
I - Contexte

Publication de la théorie de le relativité générale : 1915



Source : Einstein Archives

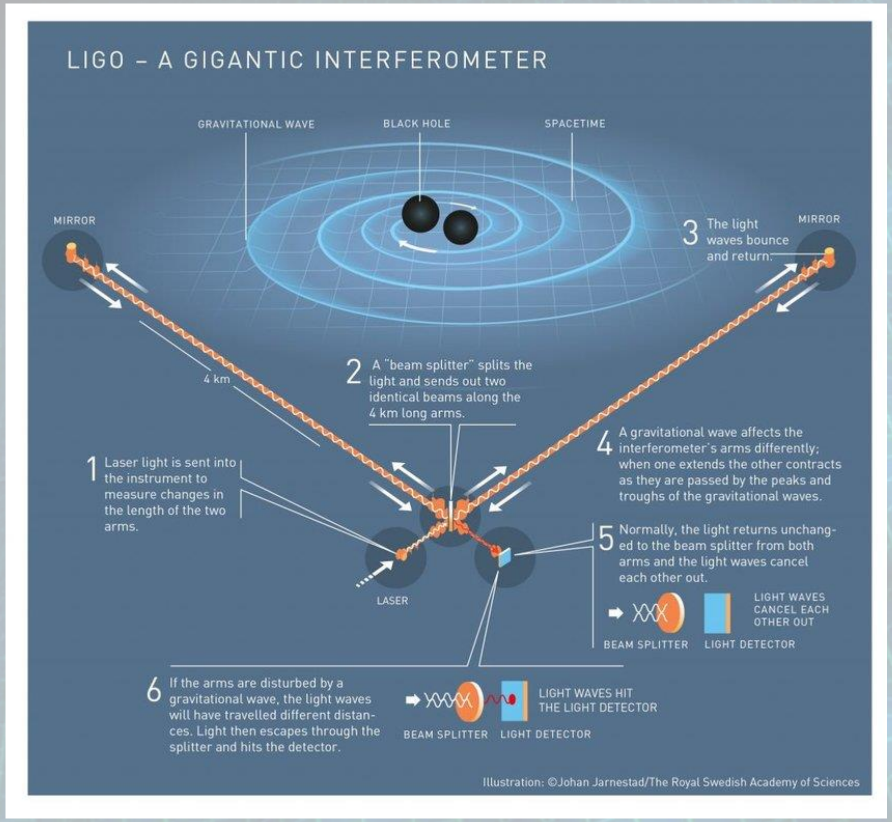
Source : indico.cern.ch



Première détection des Ondes gravitationnelles issues de merger de trous noirs : 14 septembre 2015

Première observation d'un merger de BNS : 17 août 2017

I - Contexte



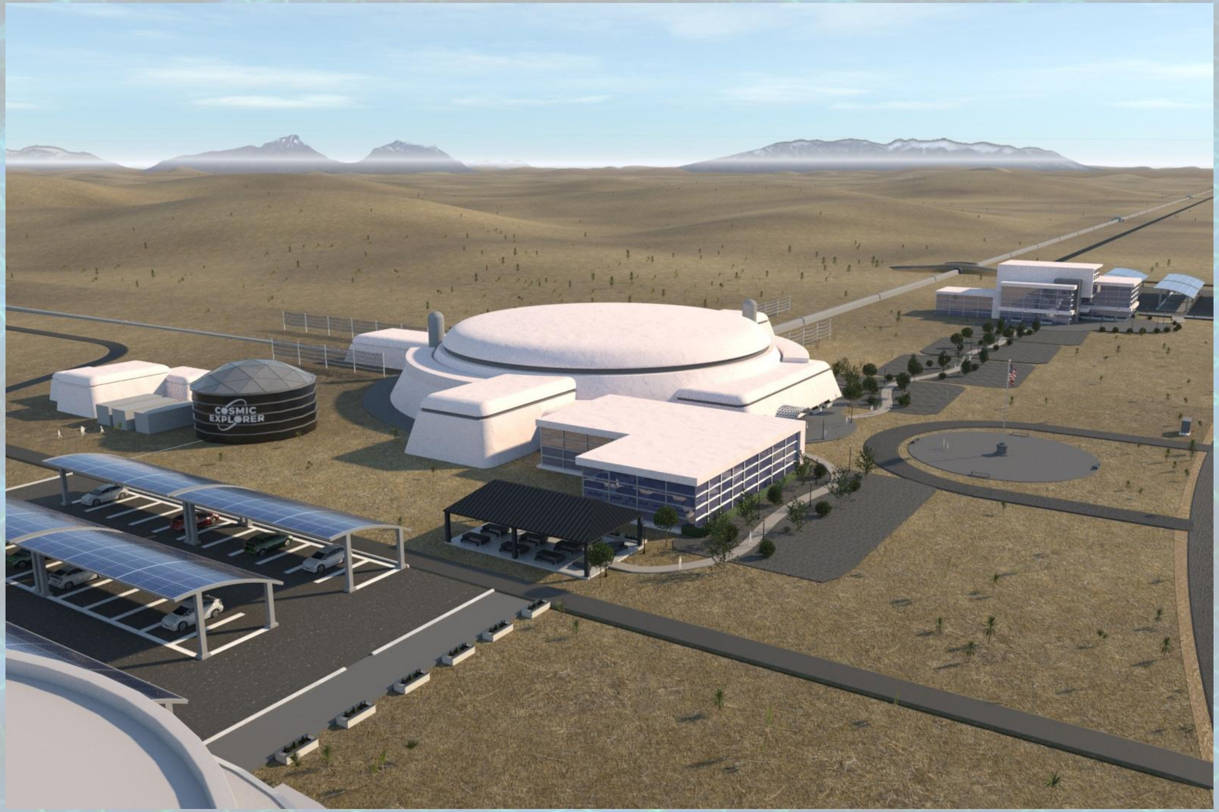
Source : the Virgo Collaboraion

Détecteur LIGO :
Bras : 4km
Mise en service : septembre 2002

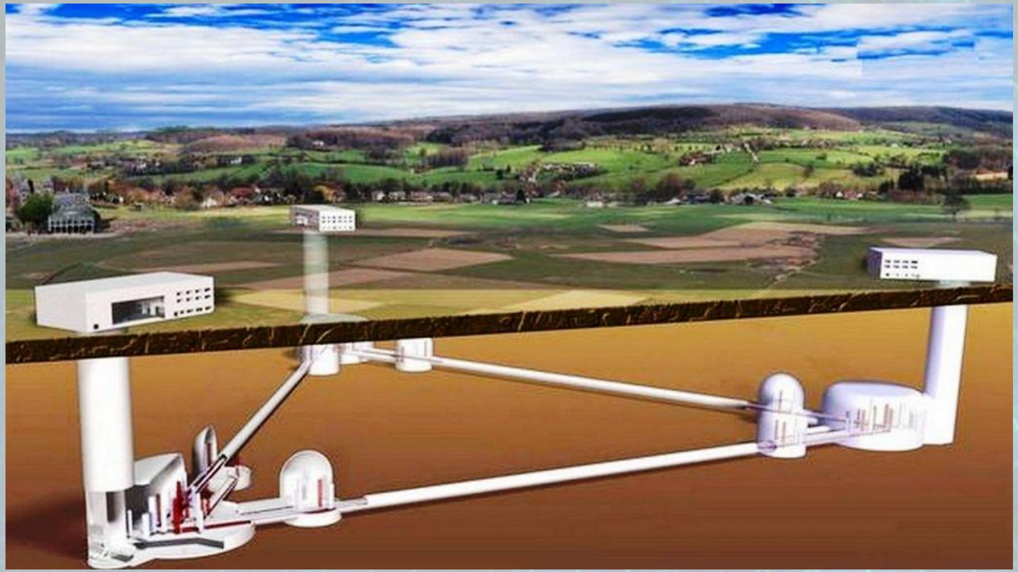
Détecteur Virgo :
Bras : 3km
Mise en service : 2007

I - Contexte

Source : Cosmic Explorer.org



Source : Ardenne web.eu

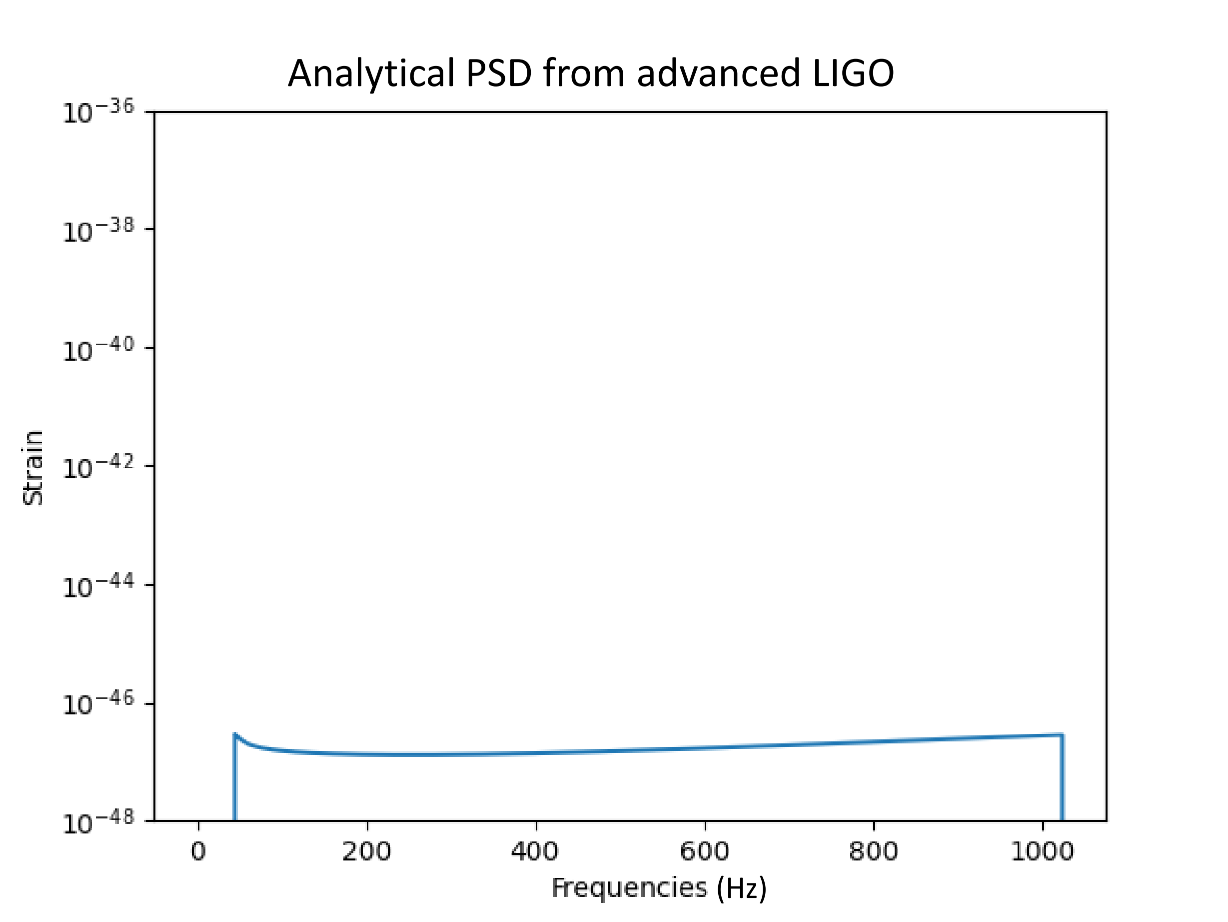


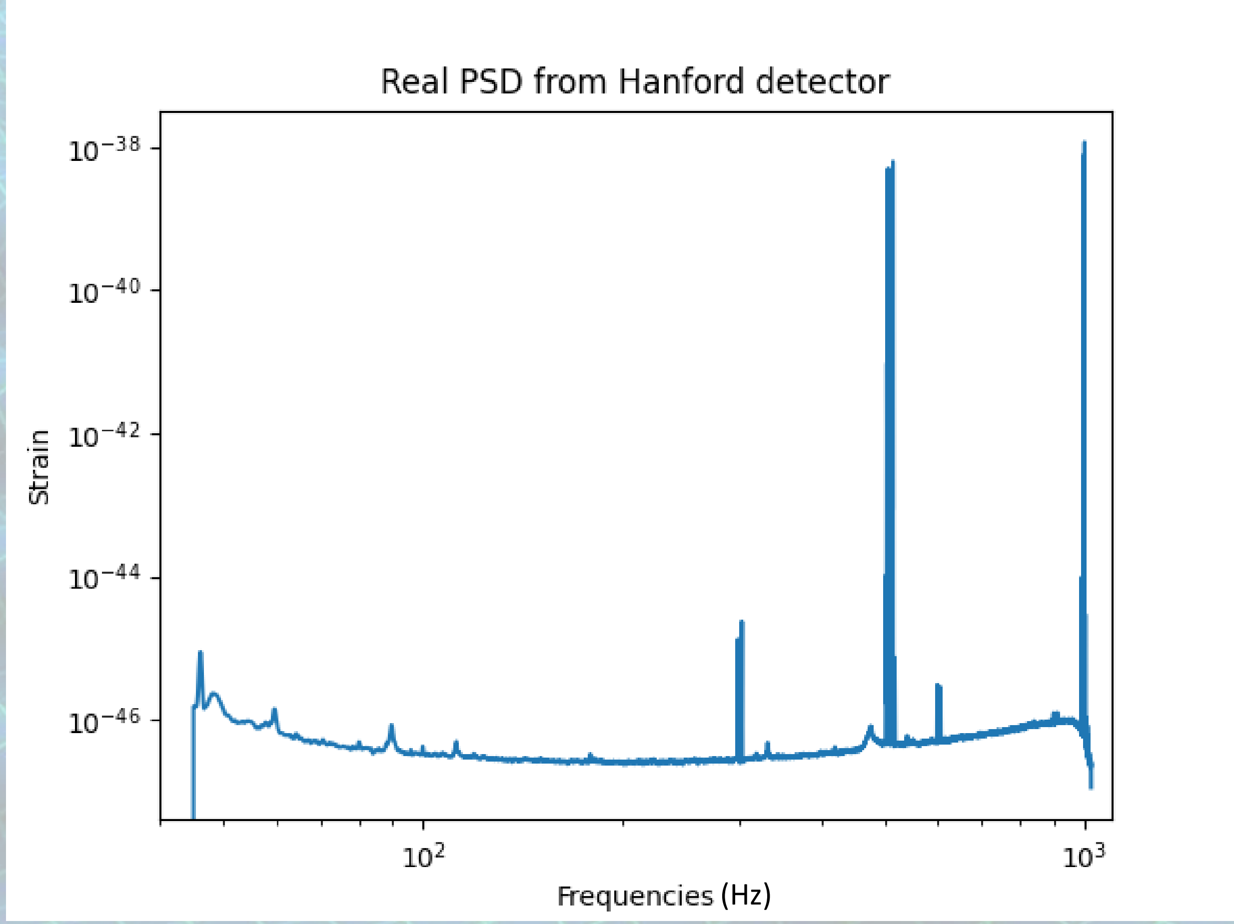
Futur détecteur Einstein Telescope :
Bras : 10km (trois bras)
Profondeur : 300m
Mise en service estimée : 2035

Futur détecteur Cosmic Explorer :
Bras : 20 et 40km
Mise en service : 2035

II – Détections actuelles

<u>Sensibilité des détecteur la « Power Spectral Density » :</u>

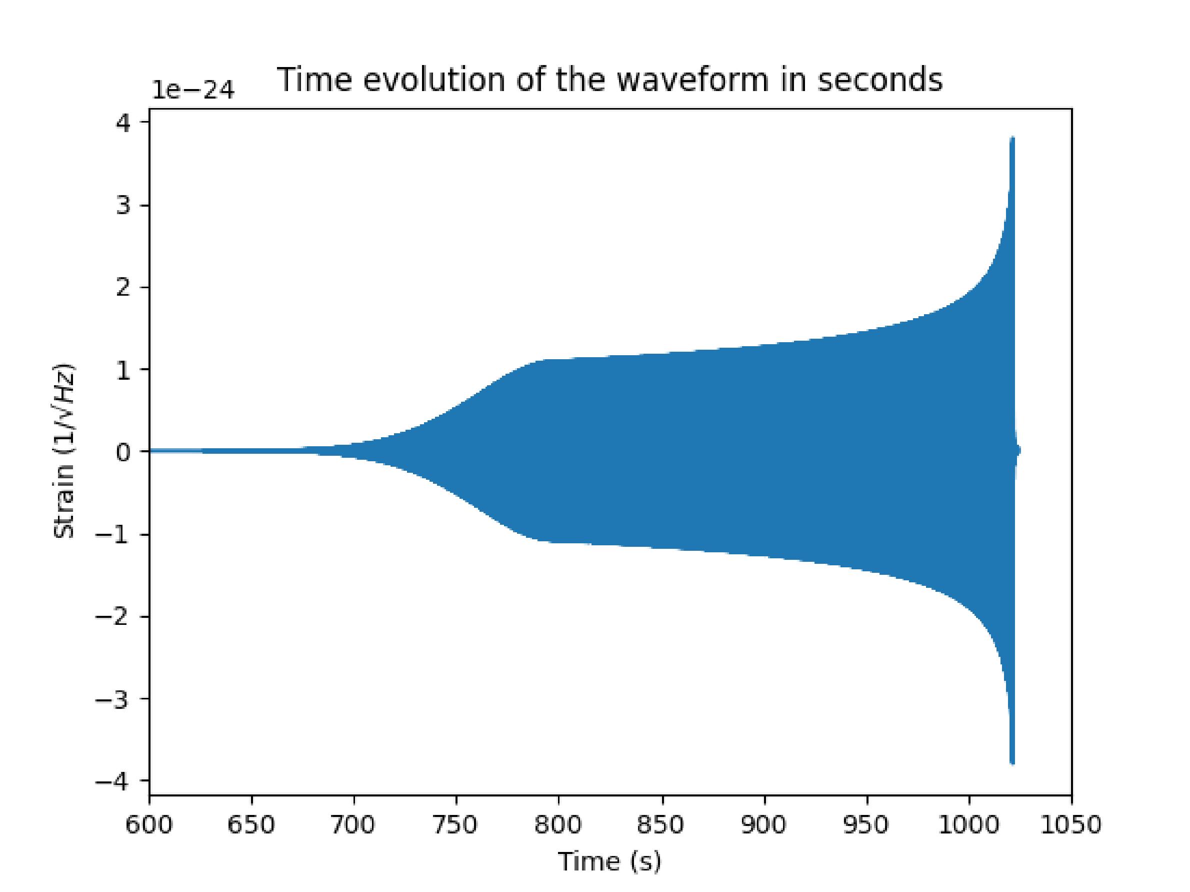


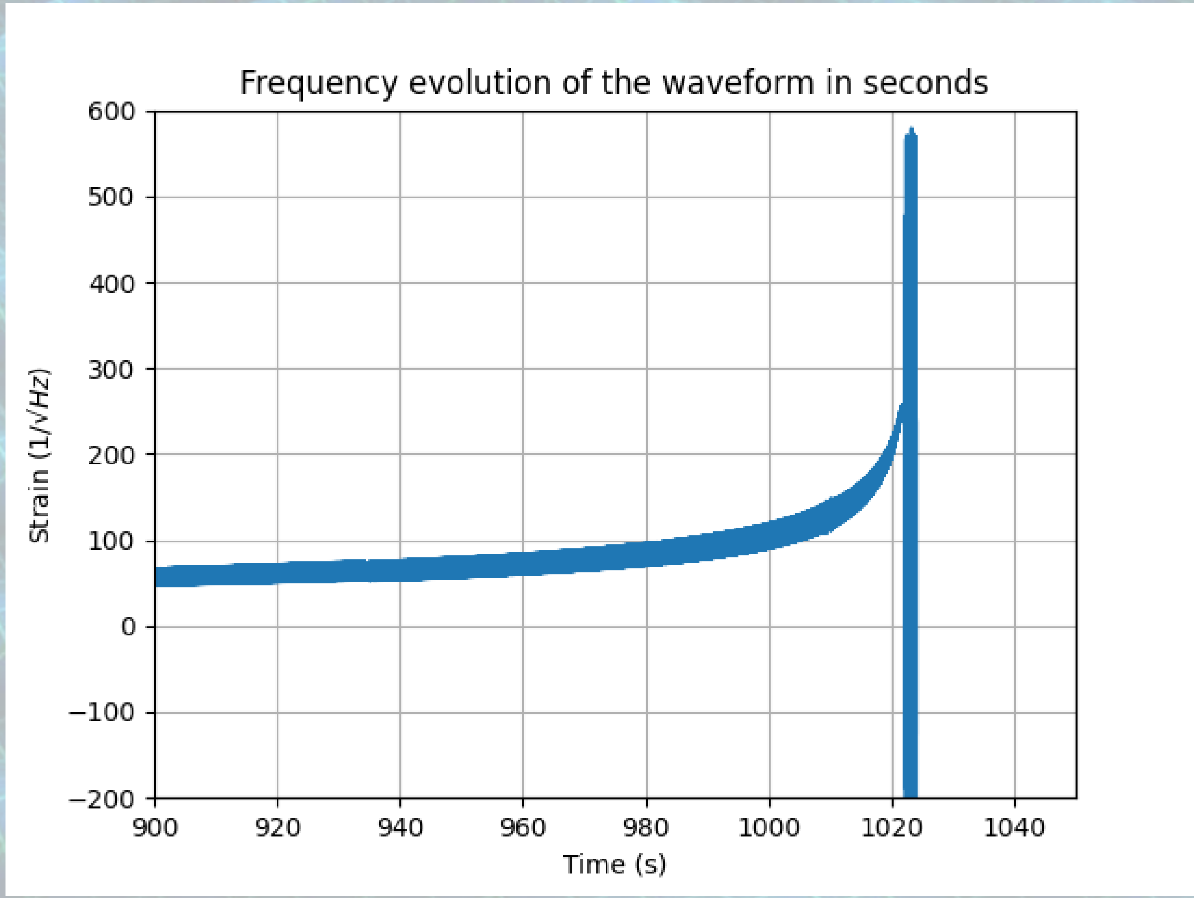


pycbc.psd.analytical.aLIGOZeroDetHighPower

II – Détections actuelles

Signal simulé, la « Waveform »:





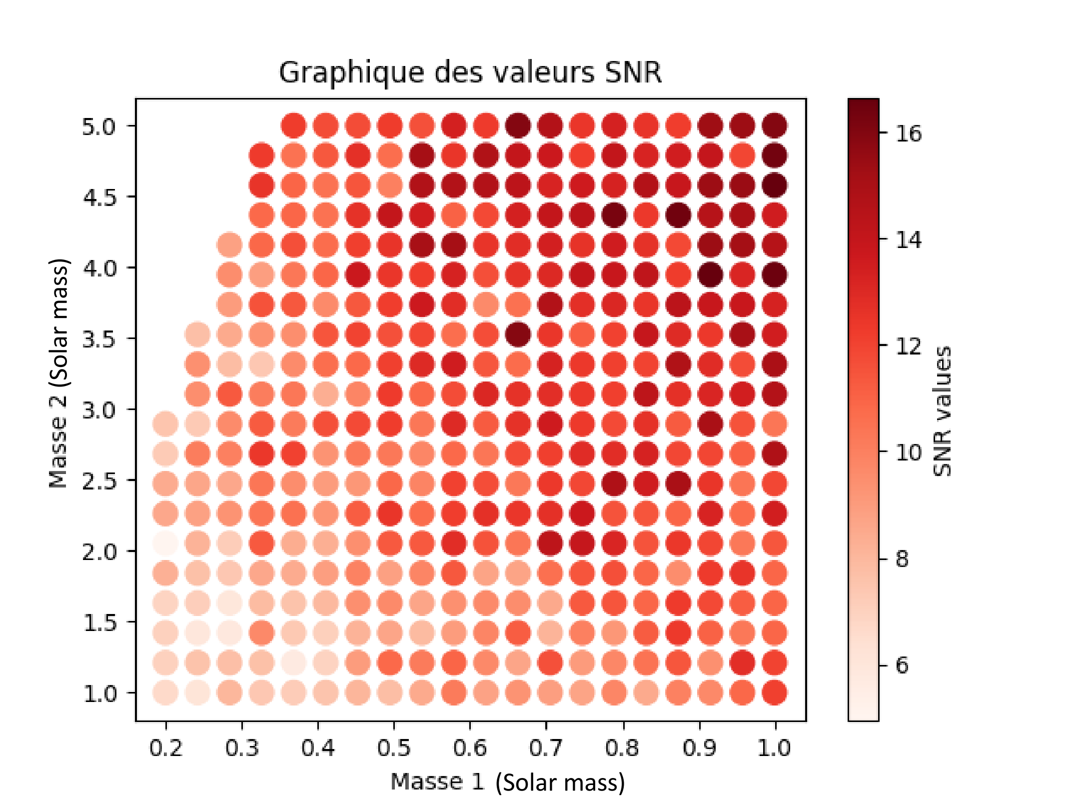
Waveform utilisée : IMRPhenomPv2

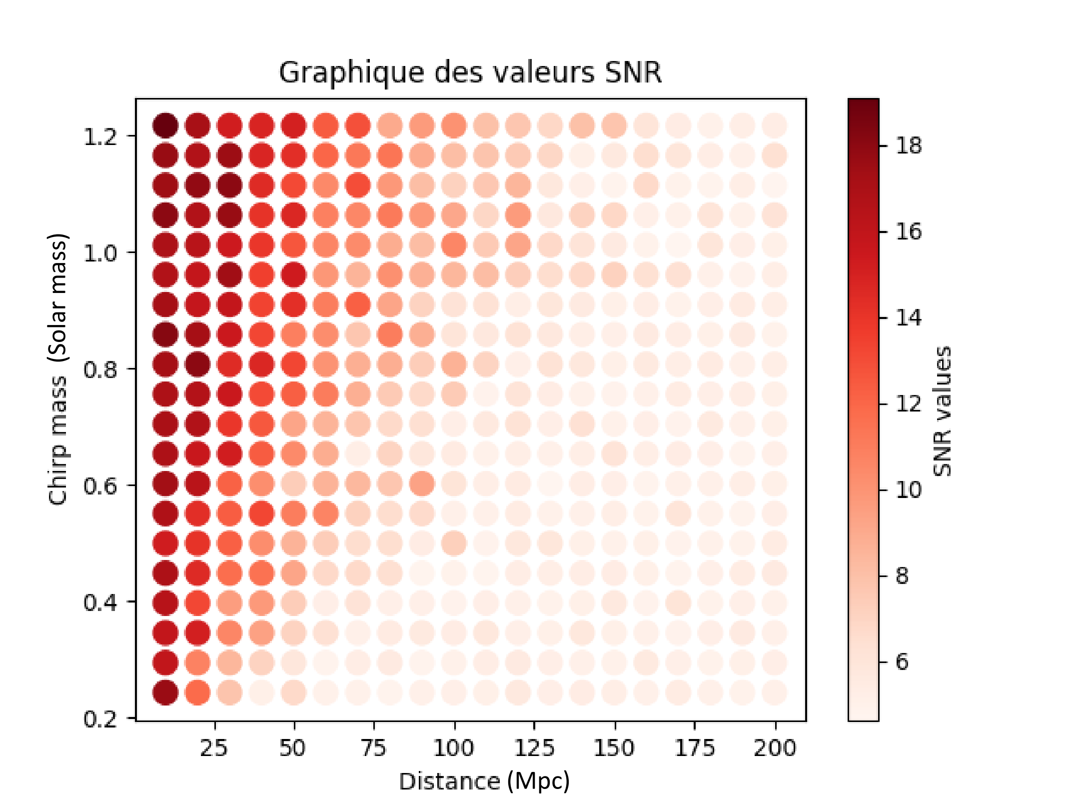
II – Détections actuelles

Distance : 100 Mpc

<u>SNR simulé pour des gammes de masses :</u>

q : 0,5





$$Chirp\ mass = \frac{(m_1.m_2)^{\frac{3}{5}}}{(m_1+m_2)^{\frac{1}{5}}}$$

$$q = \frac{m_1}{m_2}\ avec\ m_2 > m_1$$

$$SNR^2 = 4\int_0^{+\infty} \frac{|\tilde{h}(f)|^2}{S_n(f)}\,df$$

II – Détections actuelles

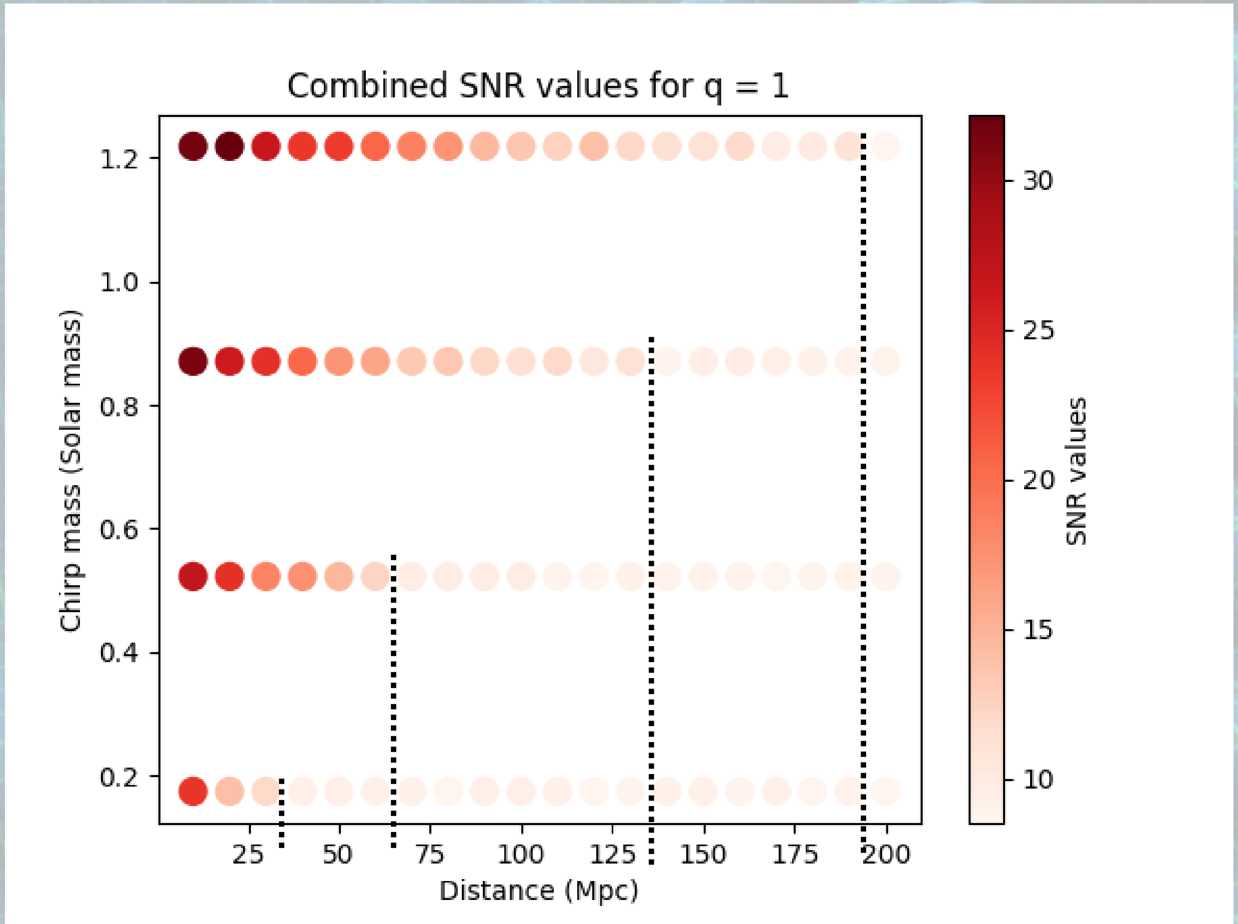
Portée de détection des détecteurs:

Masses : 1,4 (BNS)
(solar mass)

Masses : 0,8
(solar mass)

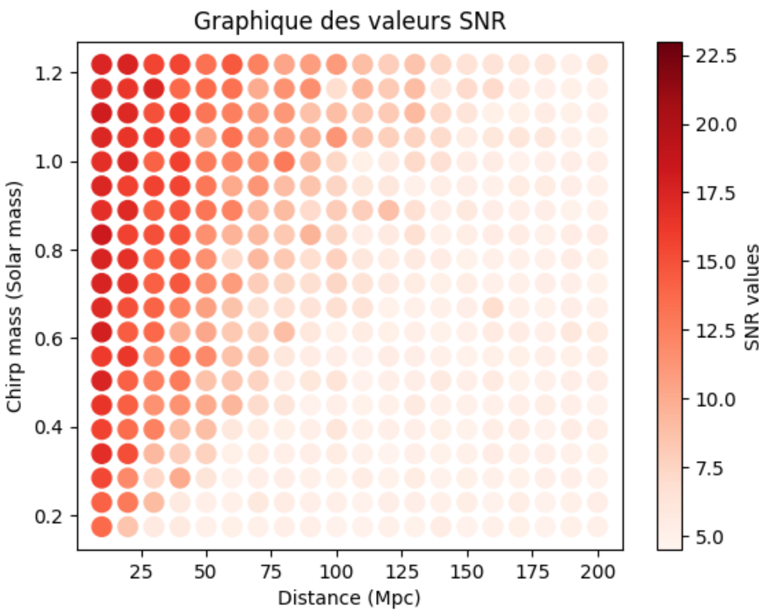
Masses : 0,5
(solar mass)

Masses : 0,2
(solar mass)

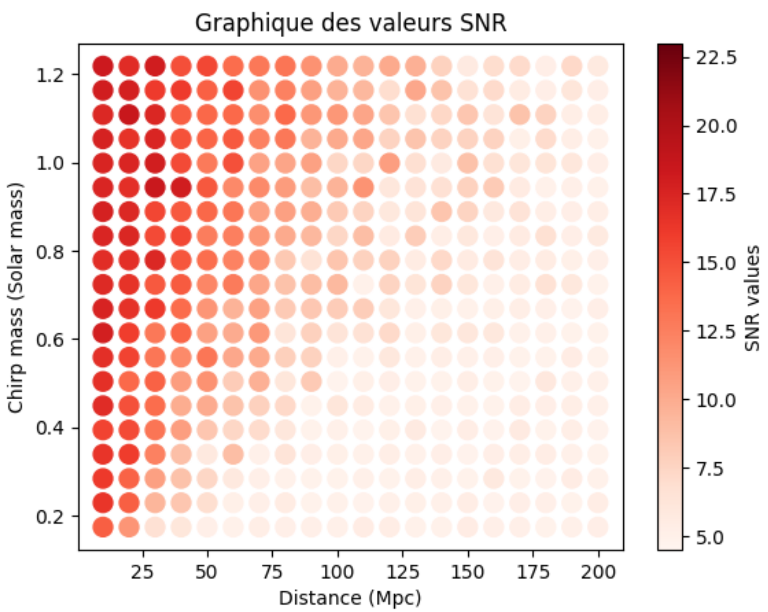


II – Détections actuelles

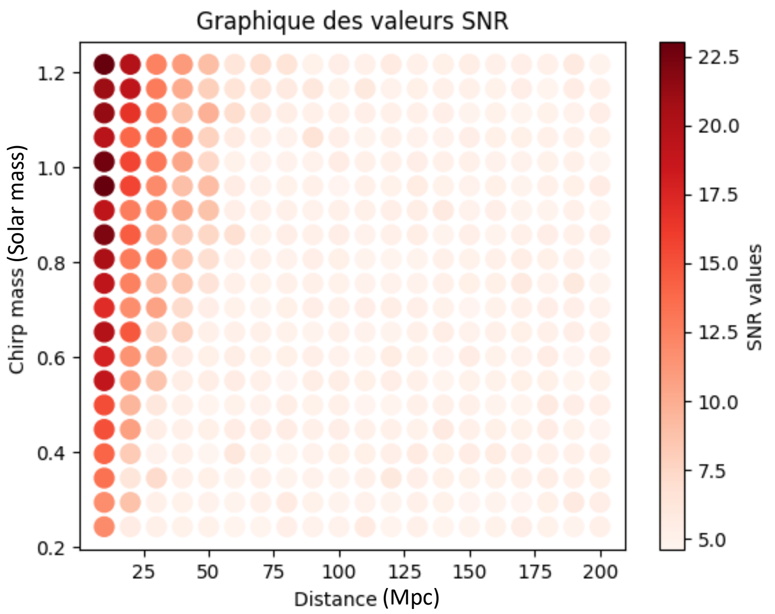
<u>Comparaison des SNR pour les détecteurs actuels:</u>



Hanford



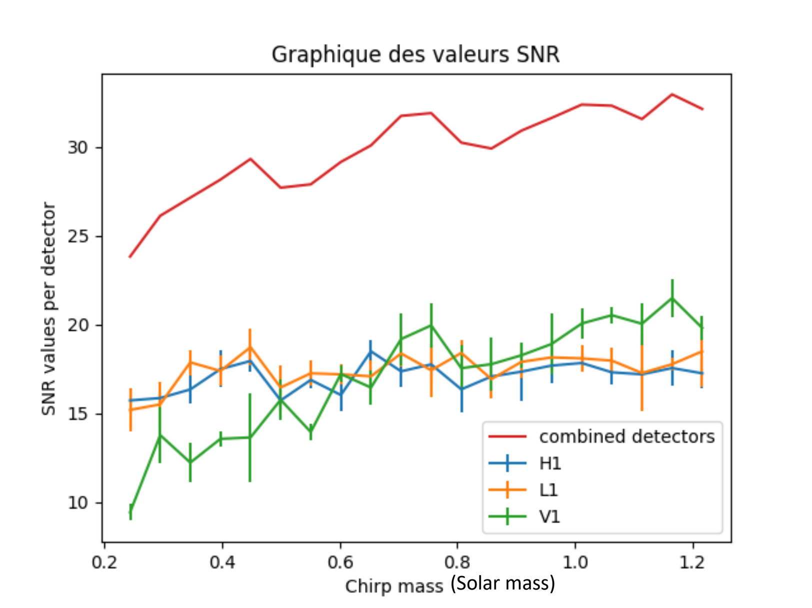
Livingston

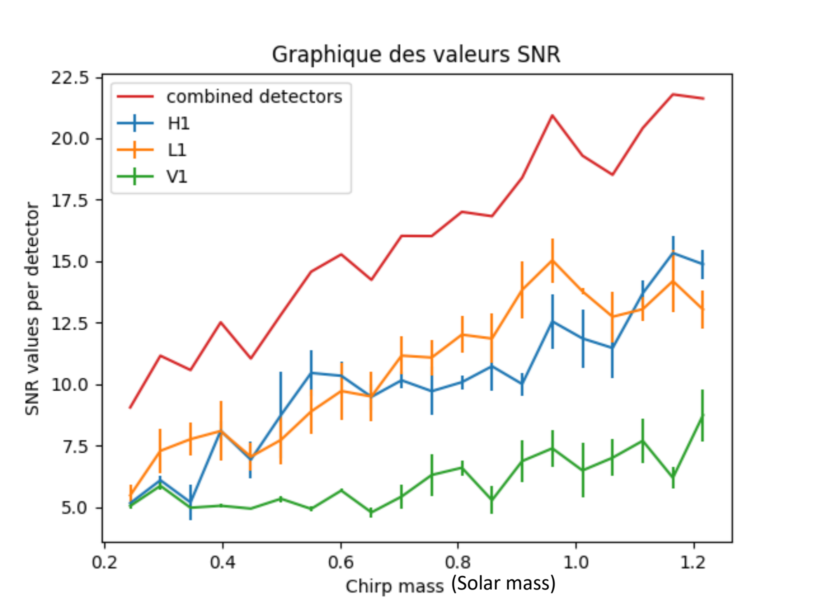


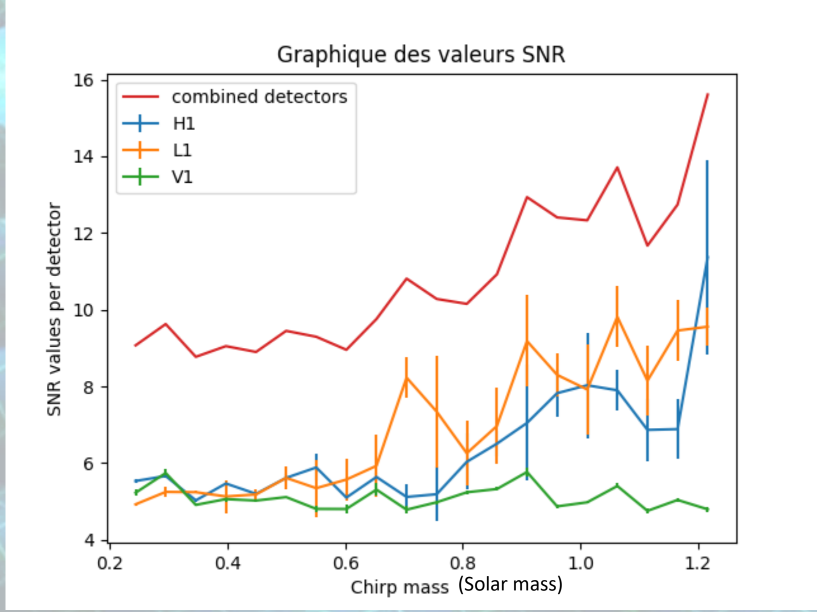
Virgo

II – Détections actuelles

Comparaison des SNR pour les détecteurs actuels:







q : 0,5

Distance : 10 Mpc

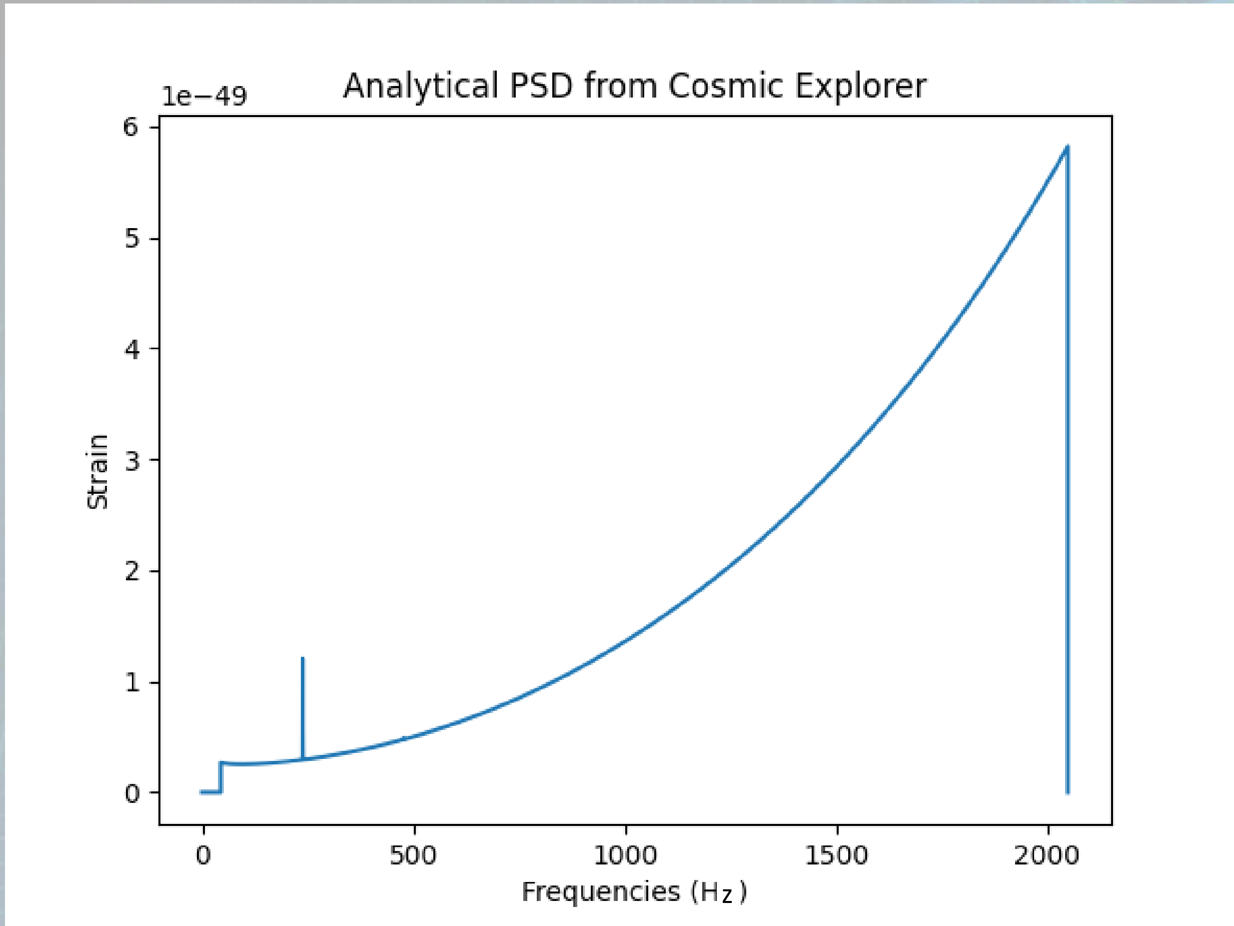
q : 0,5

Distance : 50 Mpc

q : 0,5

Distance : 100 Mpc

III – Détection futures



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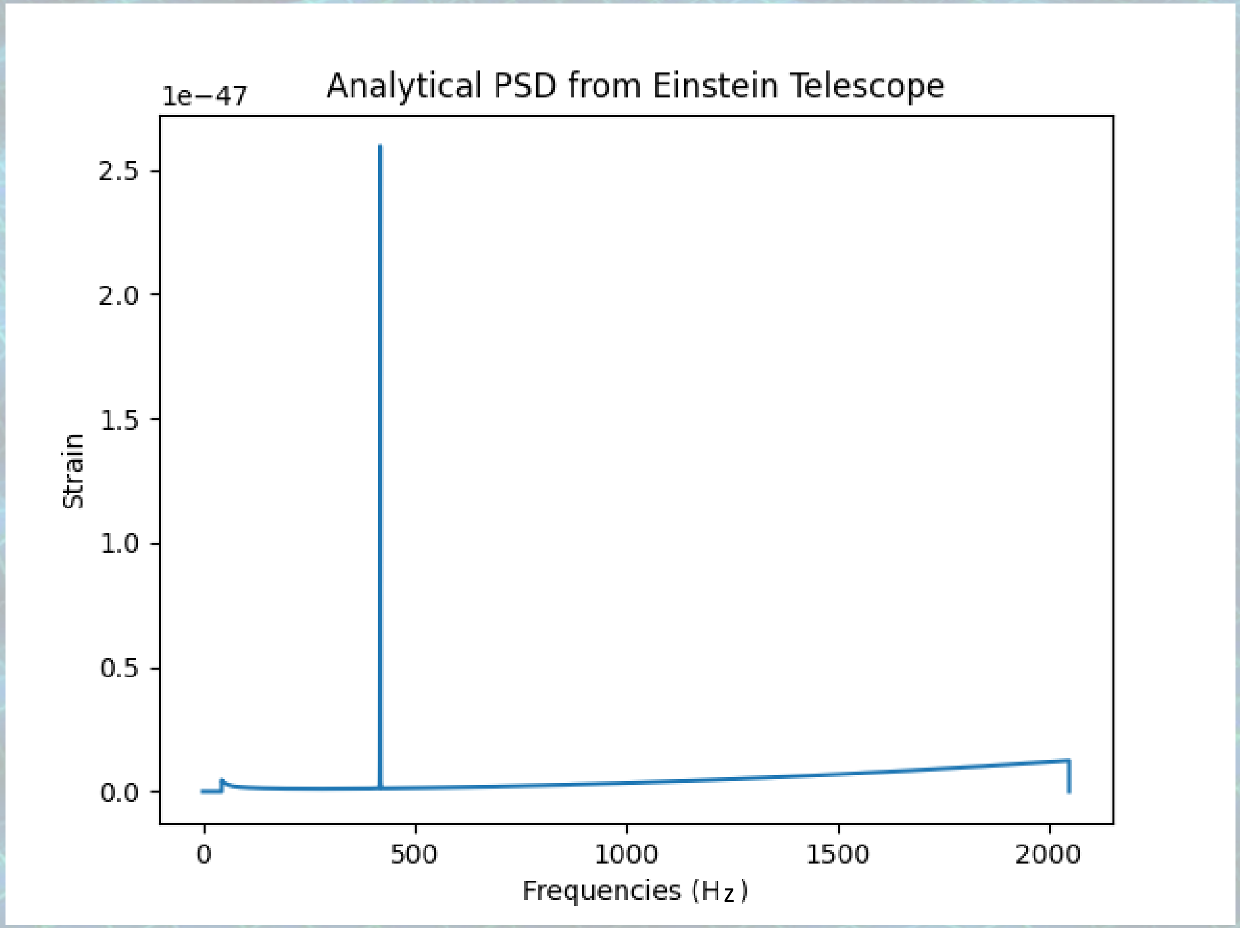
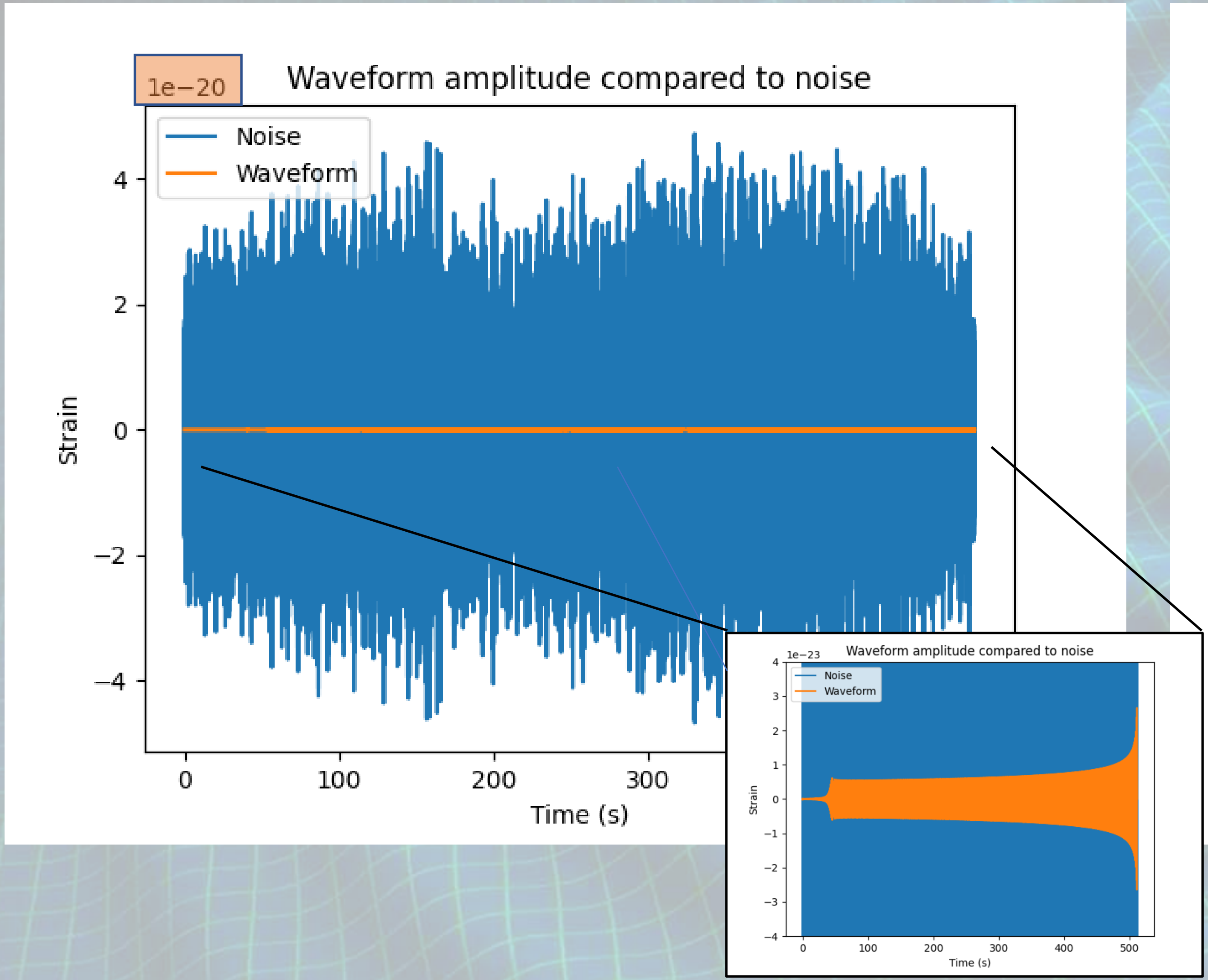


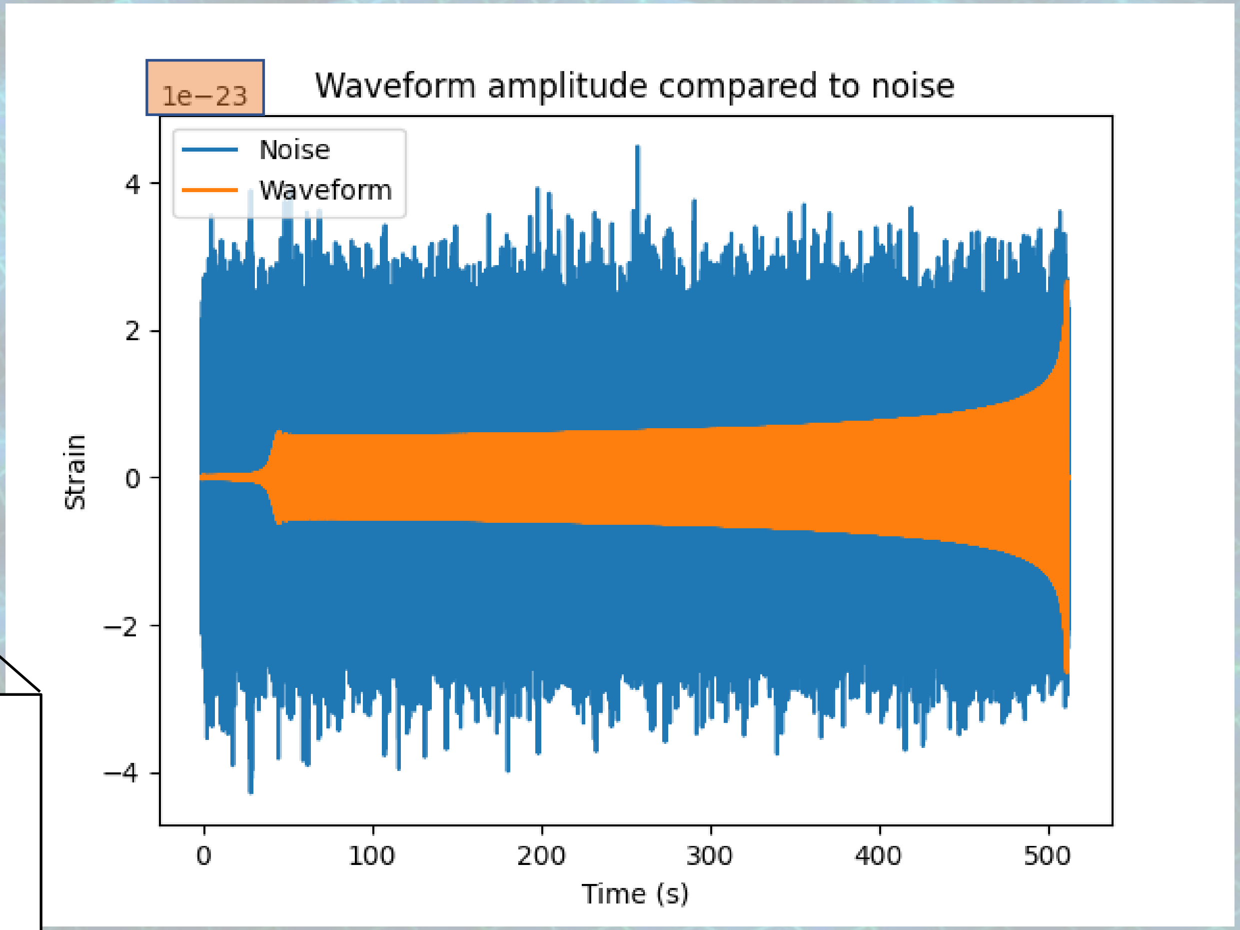
pycbc.psd.analytical.EinsteinTelescopeP1600143

III – Détection futures

Hanford detector

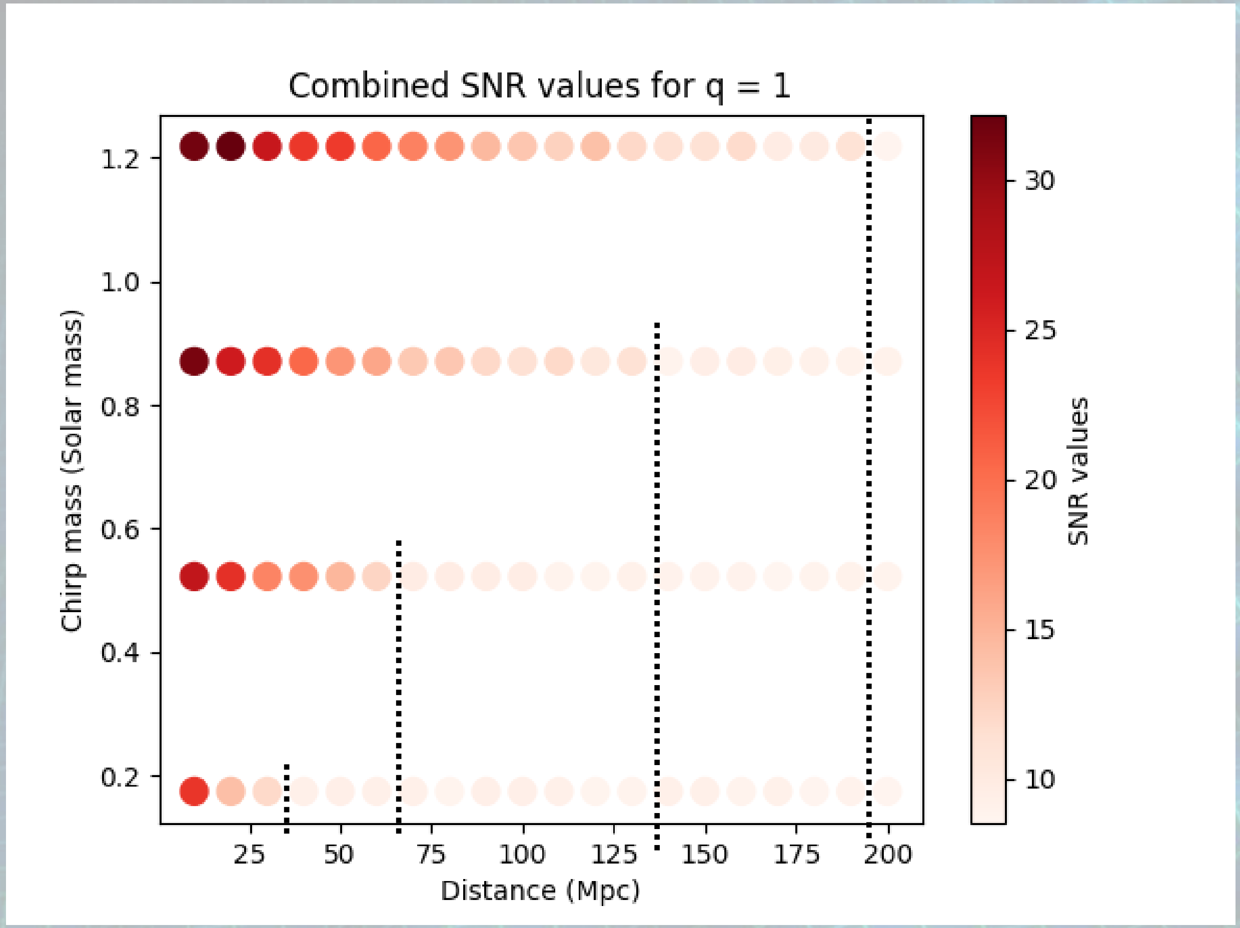


Einstein Telescope

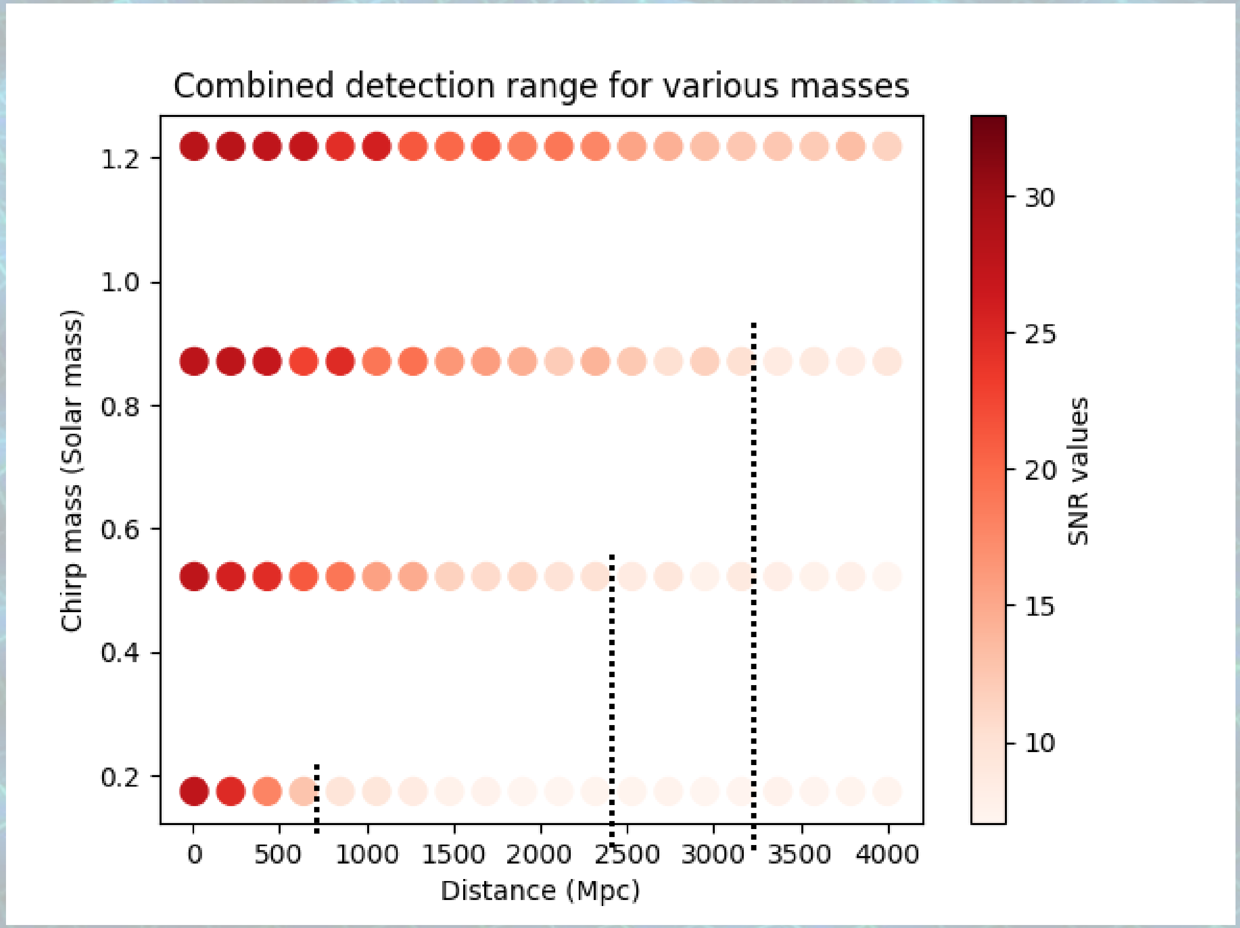


III – Détection futures

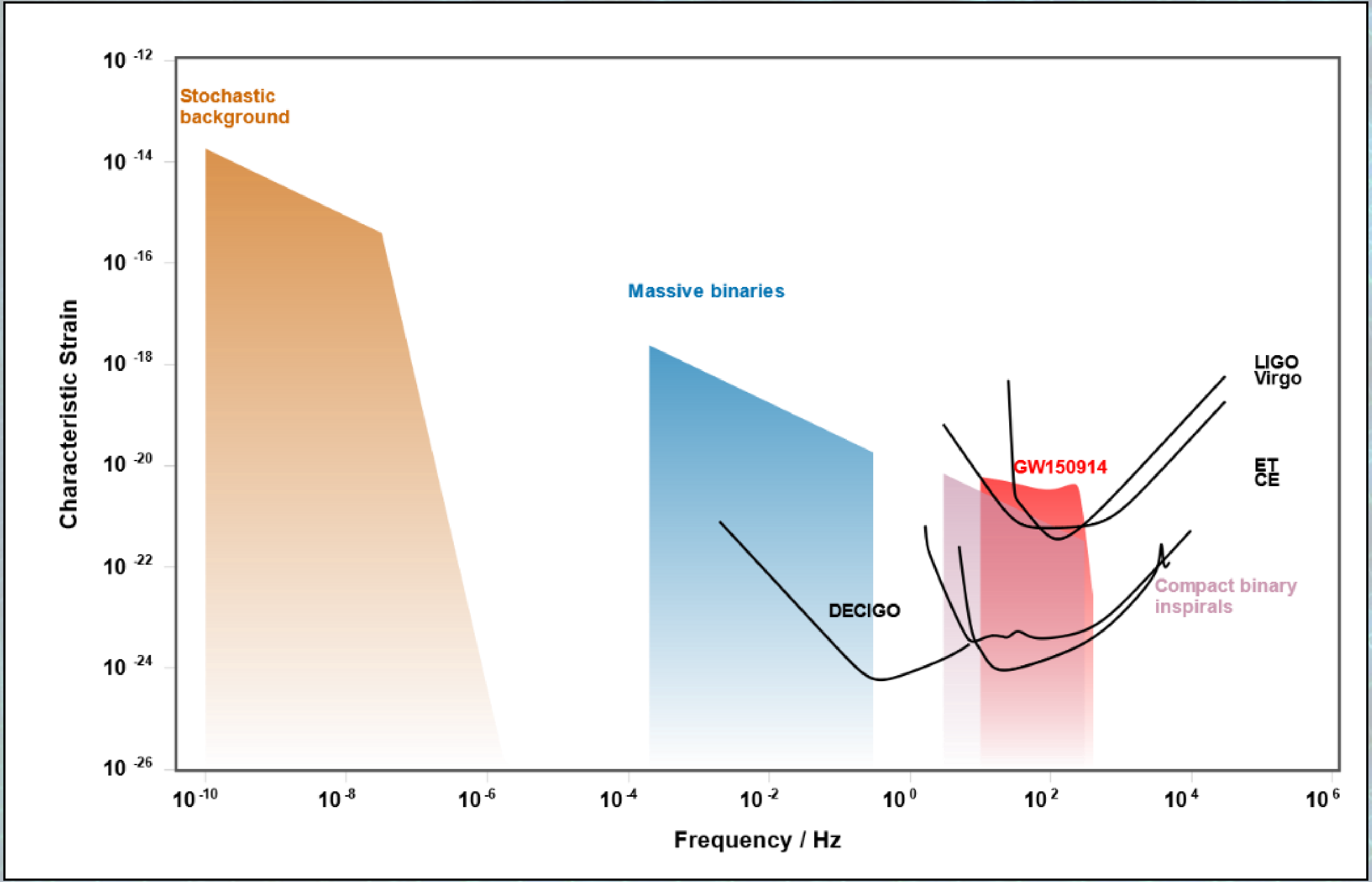
H1 + L1 + V1



ET + CE



Conclusion



Source : gwplotter.com

Références

<u>LIGO Scientific Collaboration and Virgo Collaboration (B. P. Abbot et al.) :</u>

Observation of Gravitational Waves from a Binary Black Hole Merger, Feb 2016, Physical Review Letters

https://doi.org/10.1103/PhysRevLett.116.06110 / e-Print: 1602.03837

GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral, Oct 2017, Physical Review Letters

https://doi.org/10.1103/PhysRevLett.119.16110 / e-Print: 1710.05832

GWTC-1: A Gravitational-Wave Transient Catalog of Compact Binary Mergers Observed by LIGO and Virgo during the First and Second Observing Runs, Sep 2019, Physical Review X

https://doi.org/10.1103/PhysRevX.9.03104 / e-Print: 1811.12907

Search for Subsolar-Mass Binaries in the First Half of Advanced LIGO's and Advanced Virgo's Third Observing Run, Aug 2022, Physical Review Letters

https://doi.org/10.1103/PhysRevLett.129.06110 / e-Print: 2109.12197

<u>Pycbc tutorials and tools :</u>

Pycbc : Library Examples and Interactive Tutorials

https://pycbc.org/pycbc/latest/html/tutorials.html

PyCBC Tutorial : Generating Waveforms and Matched Filterig

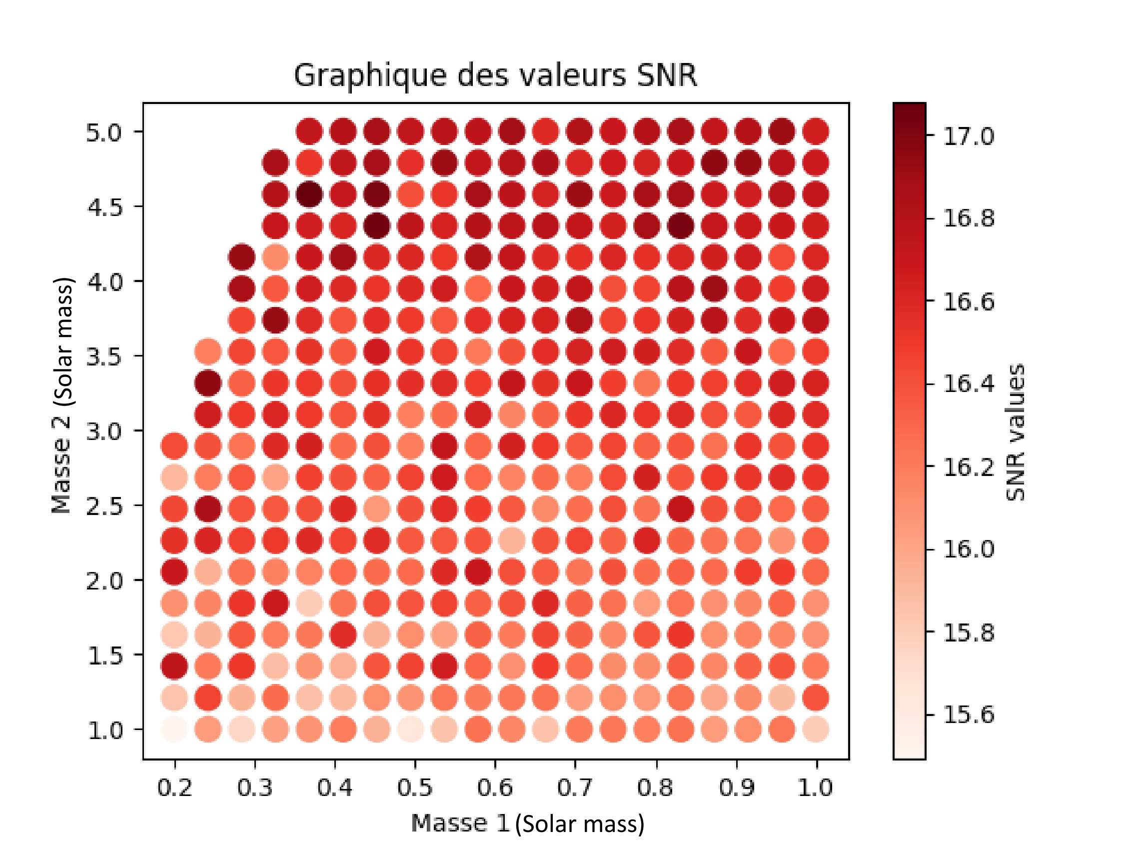
https://github.com/gwastro/PyCBC-Tutorials/blob/master/tutorial/3_WaveformMatchedFilter.i

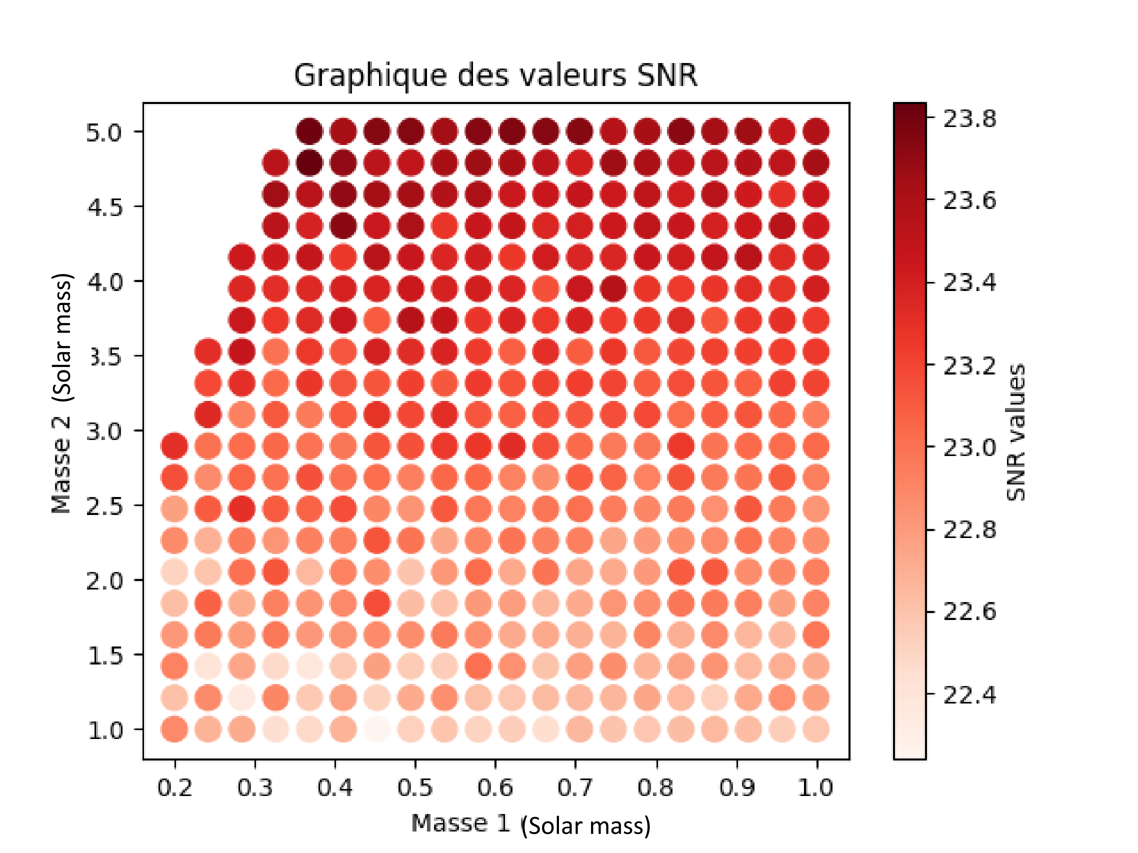
IV – Comparaisons

Einstein Telescope

Cosmic Explorer

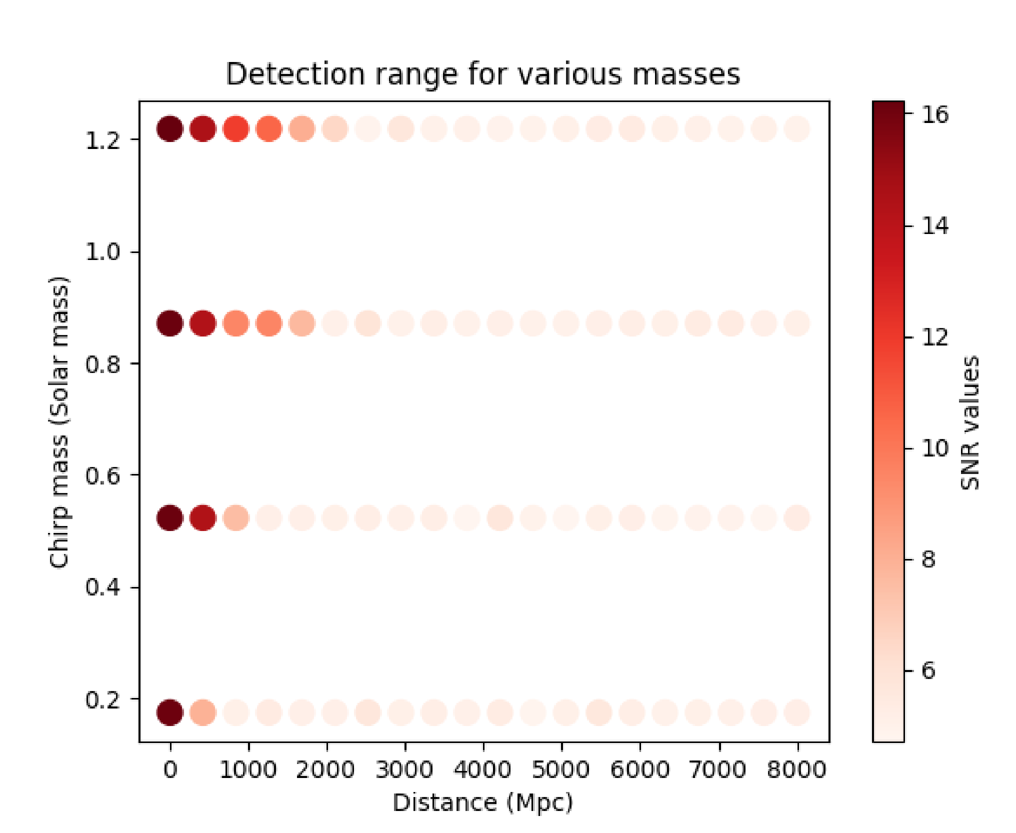
SNR simulé pour des gammes de masses :





IV – Comparaisons

Einstein Telescope



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Masses : 0,8 (solar mass)

Masses : 0,5 (solar mass)

Masses : 0,2 (solar mass)

Cosmic Explorer