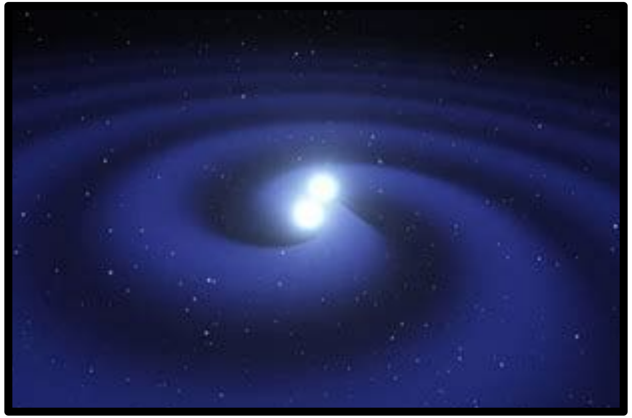
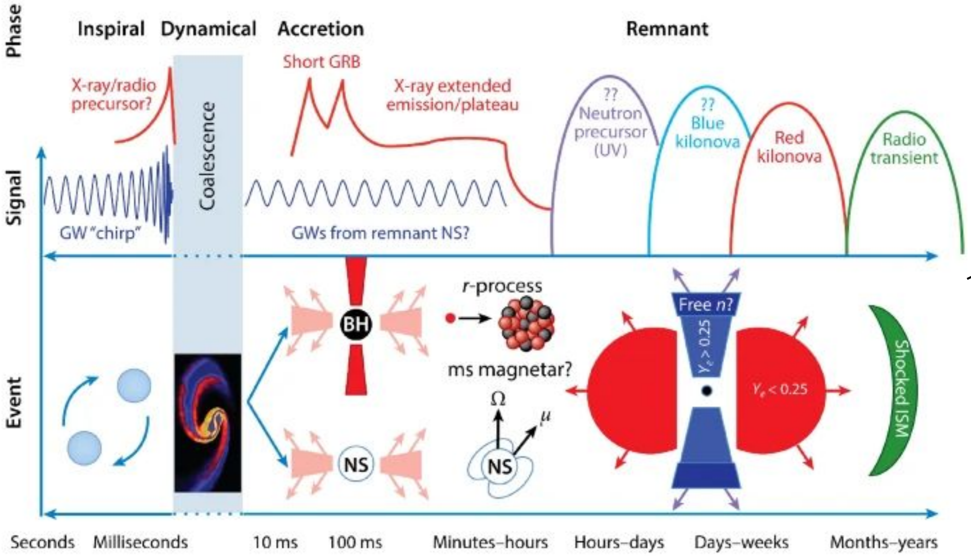
Improvement of multi-messenger research with gravitational waves and short gamma ray bursts



Supervisors : Marion Pillas and Tito Dal Canton

Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis

Multimessenger search



Messengers emission from BNS and NSBH mergers as a function of time from Fernández and Metzger (2016)

Search of coincidence between Fermi GBM and LVK observatories surveys

Expected impacts : better understanding of

- ultrarelativistic jet
- mergers systems
- Hubble tension
- heavy elements formation
- etc….

The objective

We have to rank GRB/GW coincidences

$$\Lambda = \frac{I_{\Delta t} I_{\Omega}}{1 + \boxed{Q_g} + Q_\gamma + \boxed{Q_g} Q_\gamma}$$

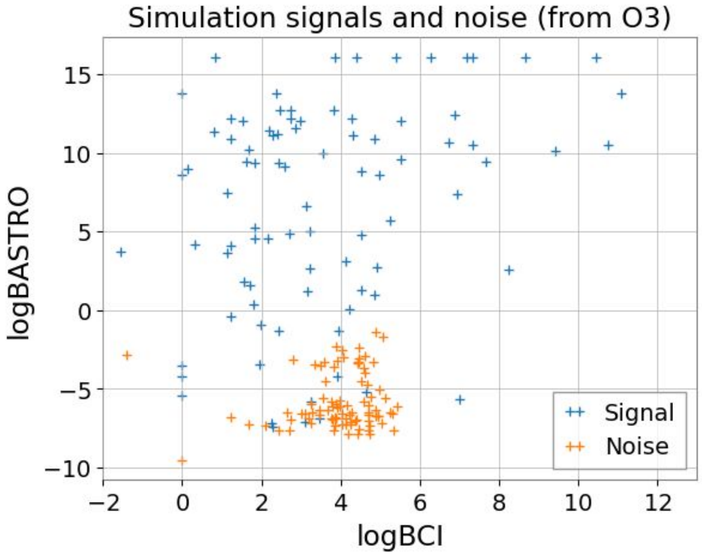
The ranking statistic used

Q_g = $P(D_G|\text{Noise})/P(D_G|\text{Signal})$

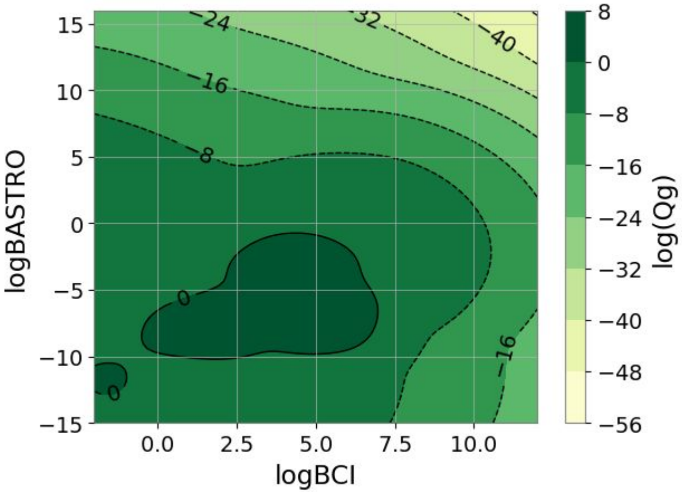
distributions with BCI ⟶ not efficient enough

KDE 2D with BCI and P_{astro}

Calculation of the Qg

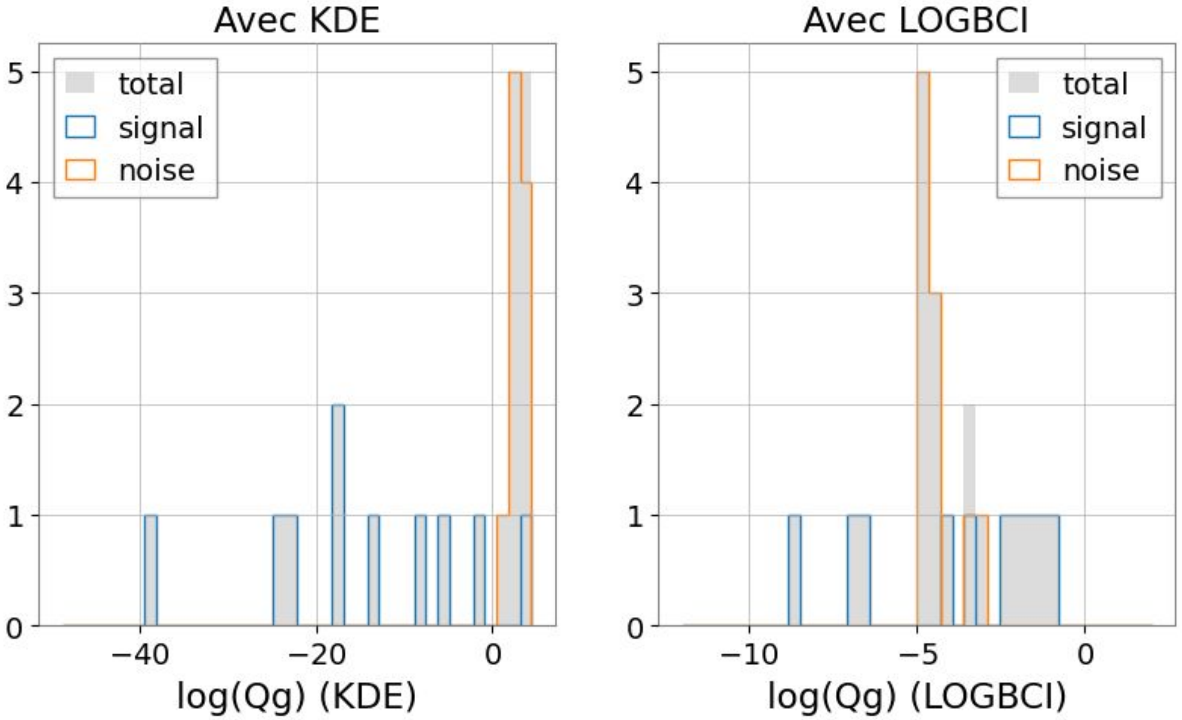


Signals simulated from PyCBC (blue) and noise from LIGO detections in O3 dataset (orange)



$$Q_g = \log(PDF_{noise}/PDF_{signal})$$

Results



New Q_G is much better than the former one !

Thank you for your listening !!

Extraction of GW signals from the ET-MDC

Victor Glorieux
24/06/2025

Supervisor : **Adrian Macquet**
Postdoctoral researcher, IJCLab.

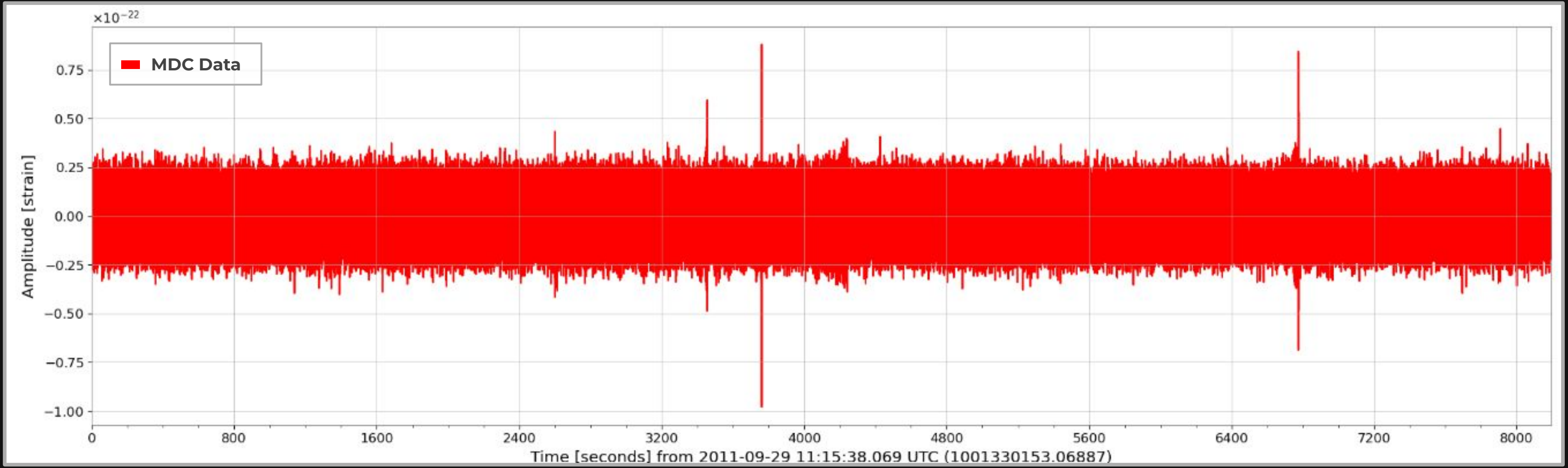
Senior supervisor : **Tito Dal Canton**
Research officer, IJCLab.

Outline

- **Introduction**
  - **Goals**
- **Methodology**
  - **PySTAMPAS**
  - **Likelihood maximization**
- **Results**

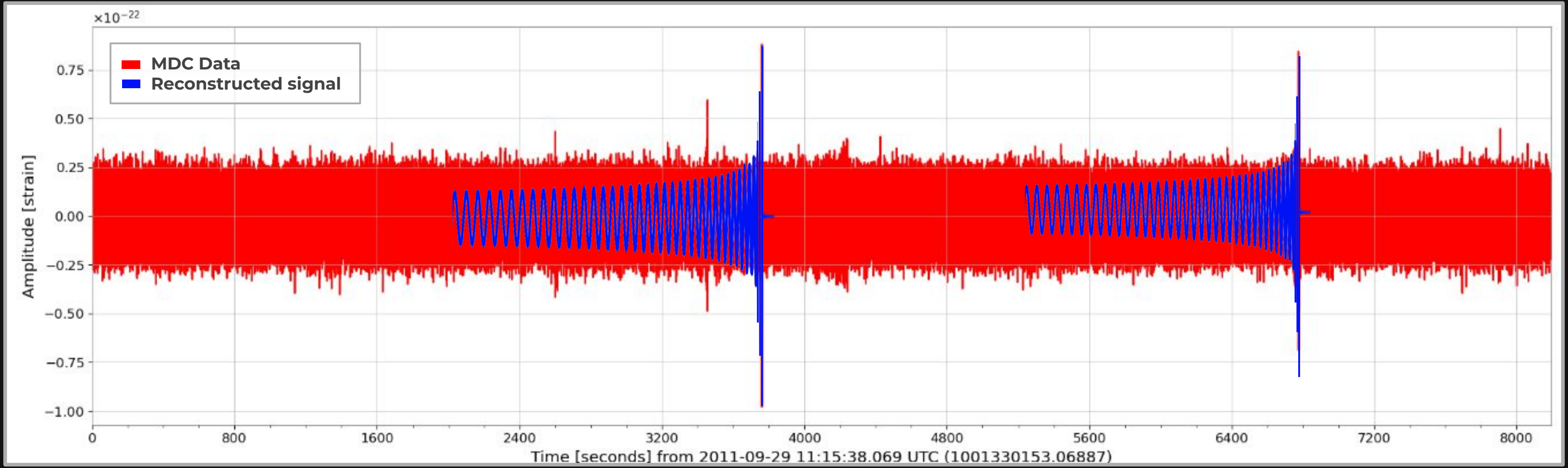
Introduction : Goals

- **Hierarchical approach**



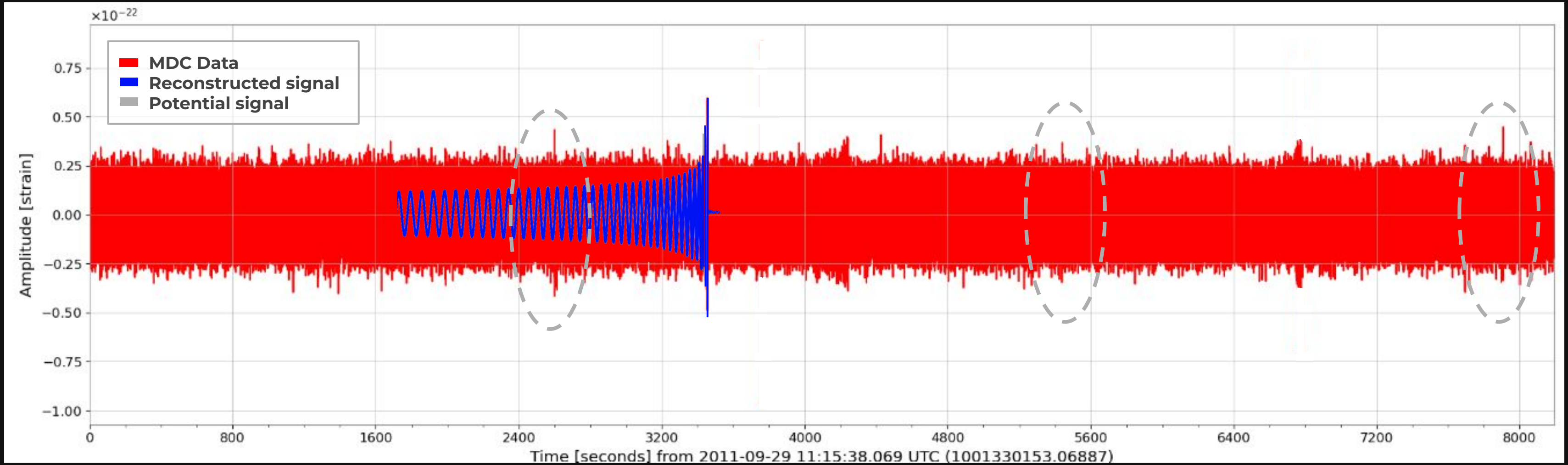
Introduction : Goals

- **Hierarchical approach**



Introduction : Goals

- **Hierarchical approach**



Outline

- Introduction
  - Goals
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  - PySTAMPAS
  - Likelihood maximization
- Results

Methodology

Pystampas

Signal detection :

- List of triggers for candidate GW events.

Likelihood

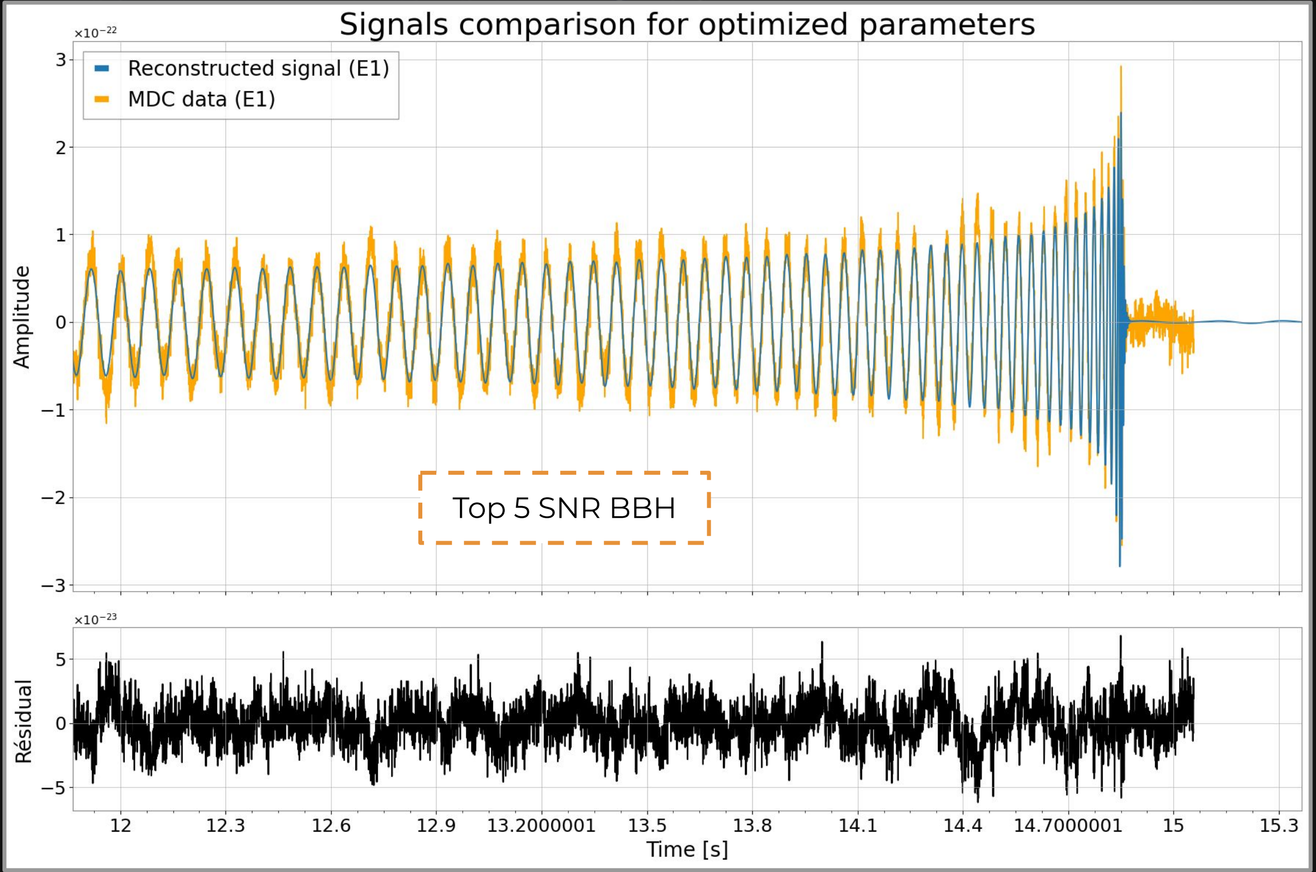
Signal modelisation :

- PyCBC and GwPy models.
- Maximization of the likelihood ratio to obtain the best parameters for each signals.

Outline

- Introduction
  - Goals
- Methodology
  - PySTAMPAS
  - Likelihood maximization
- Results

Results : Likelihood maximization

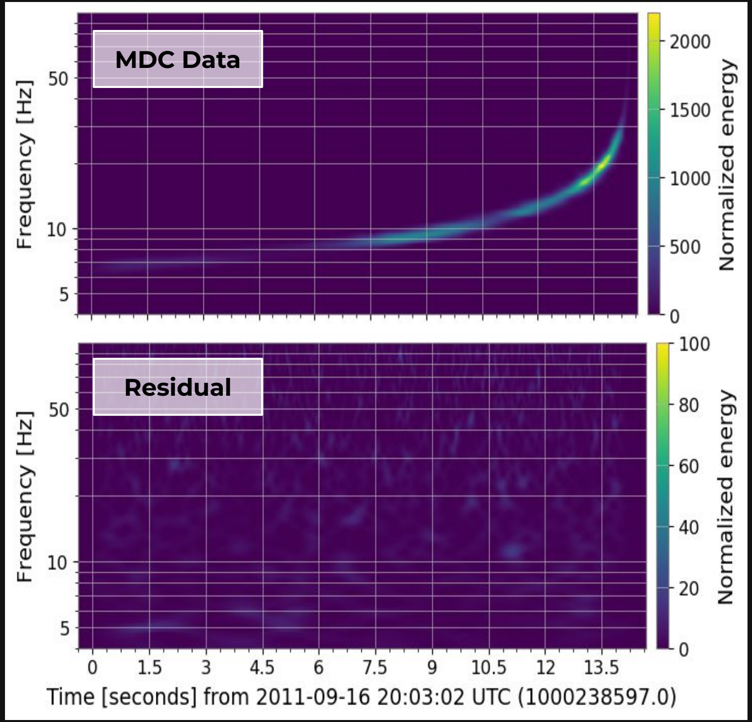


BBH

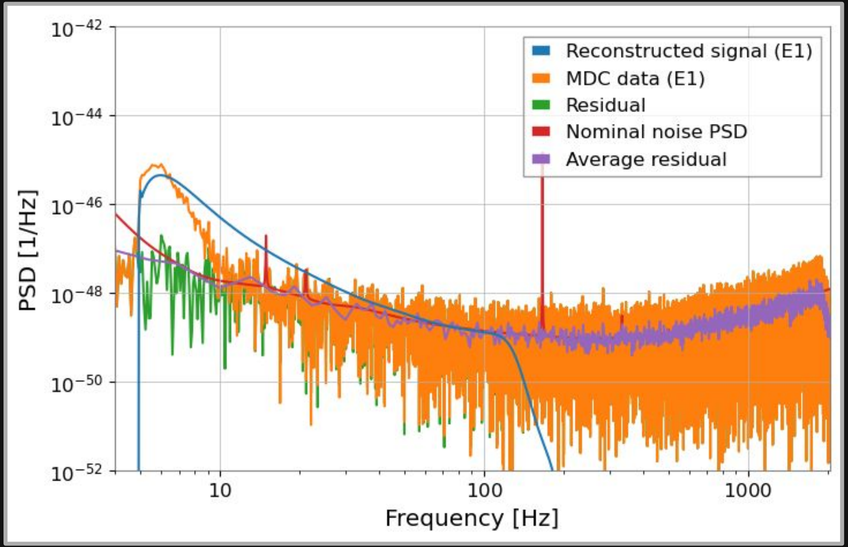
BH/NS

BNS

Results : q-transforms



Top 5 SNR BBH



Top 10 SNR BBH

Thank you

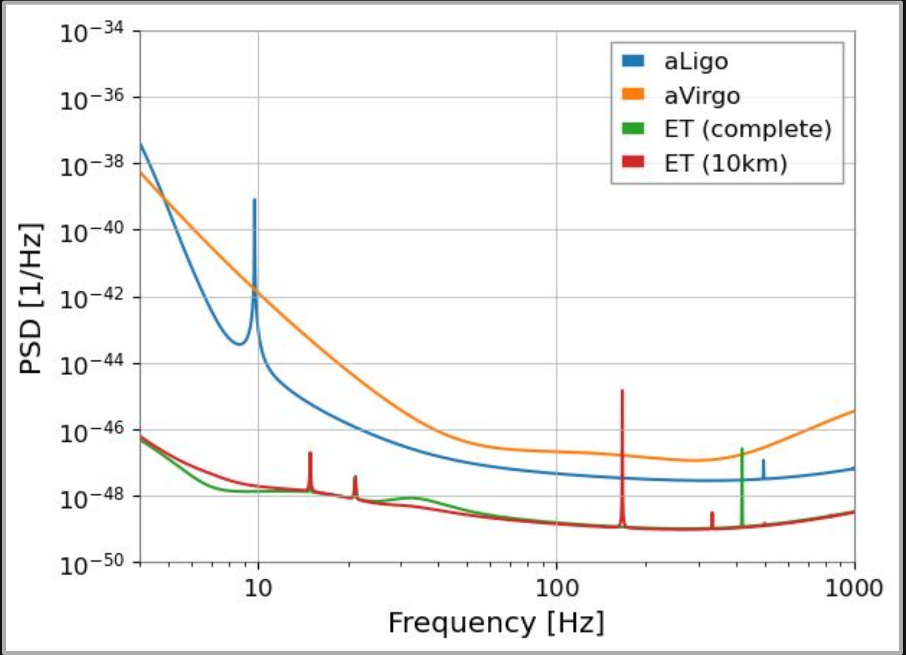
References

Image slide 1 : [source] : Simulated image of 2 black holes : SXS Lensing.

Image end slide : [source] : Black hole picture : Interstellar movie.

Backup slide : ET-MDC

- **Einstein Telescope : Mock Data Challenge**



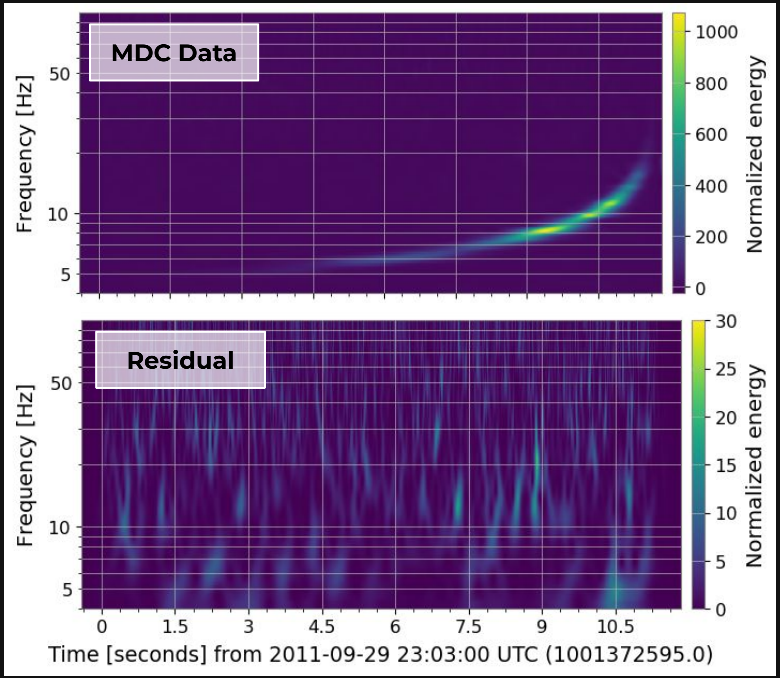
Einstein Telescope (ET) :

- 3 detectors : E1, E2 and E3
- 10 km arms

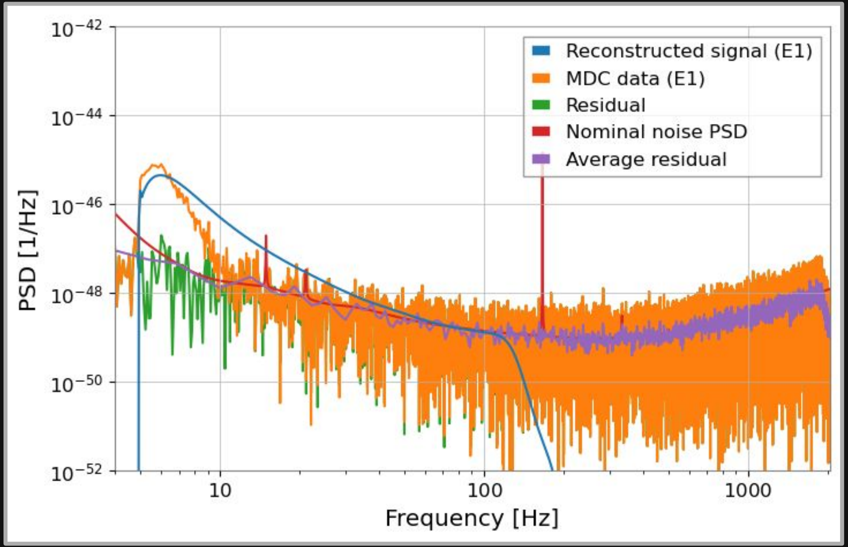
MDC :

- 31 days of ET simulated observations
- Around 70 000 CBC

Backup slide : q-transform top 10 SNR BBH



Top 10 SNR BBH



Top 10 SNR BBH

Study of variable finesse cavity for Einstein Telescope

Jiuyi LI

M1 General Physics

université PARIS-SACLAY | FACULTÉ DES SCIENCES D'ORSAY

Advisor: Angélique Lartaux

Study of variable finesse cavity for Einstein Telescope

Why we do this ?

How we do this ?

What have we got ?

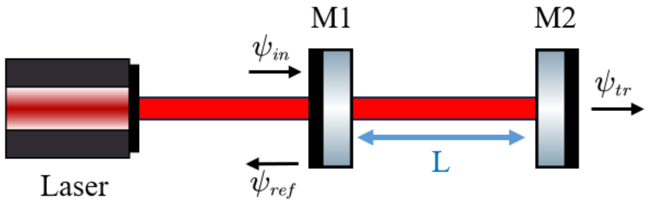
Jiuyi LI

M1 General Physics

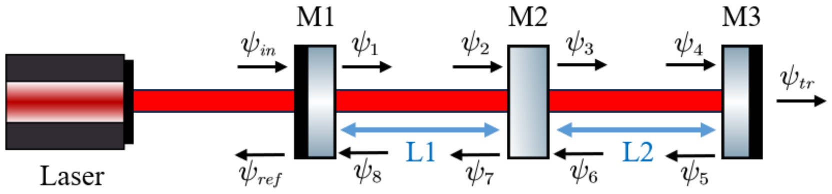
Advisor: Angélique Lartaux

Why we do this ?

In gravitational-wave detection, the filter cavity provides a frequency-dependent phase rotation to the squeezed state, thereby helping to suppress quantum noise.



Fabry–Perot Cavity



Three Mirror Caivty

Advantages

- Variable Finesse
- Supporting for more complex operations with ET - Further increase in sensitivity

Sources: Classical and Quantum Gravity, 28(9):094013, April 2011.

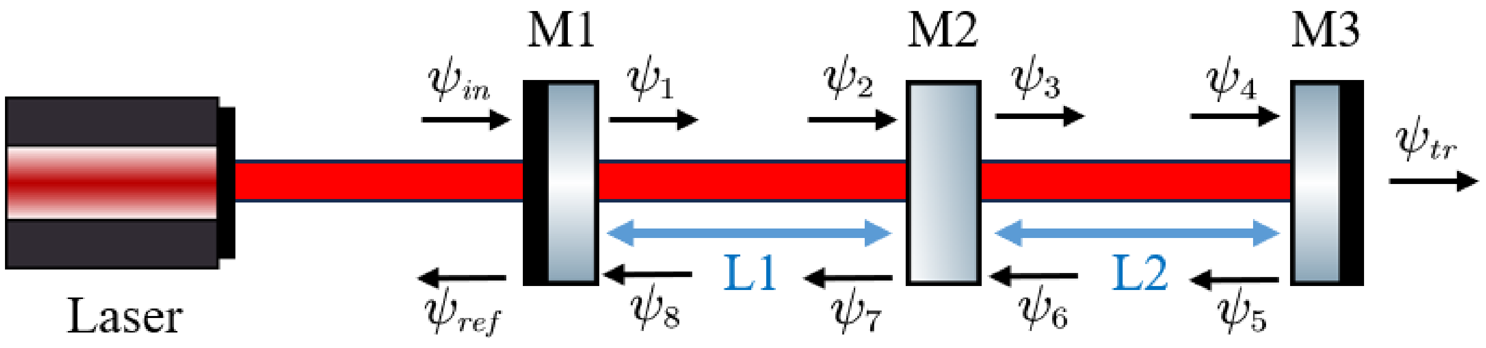
How we do this & What have we got ?

Core work: Experimentally, precisely measuring the cavity's phase delay on the light.

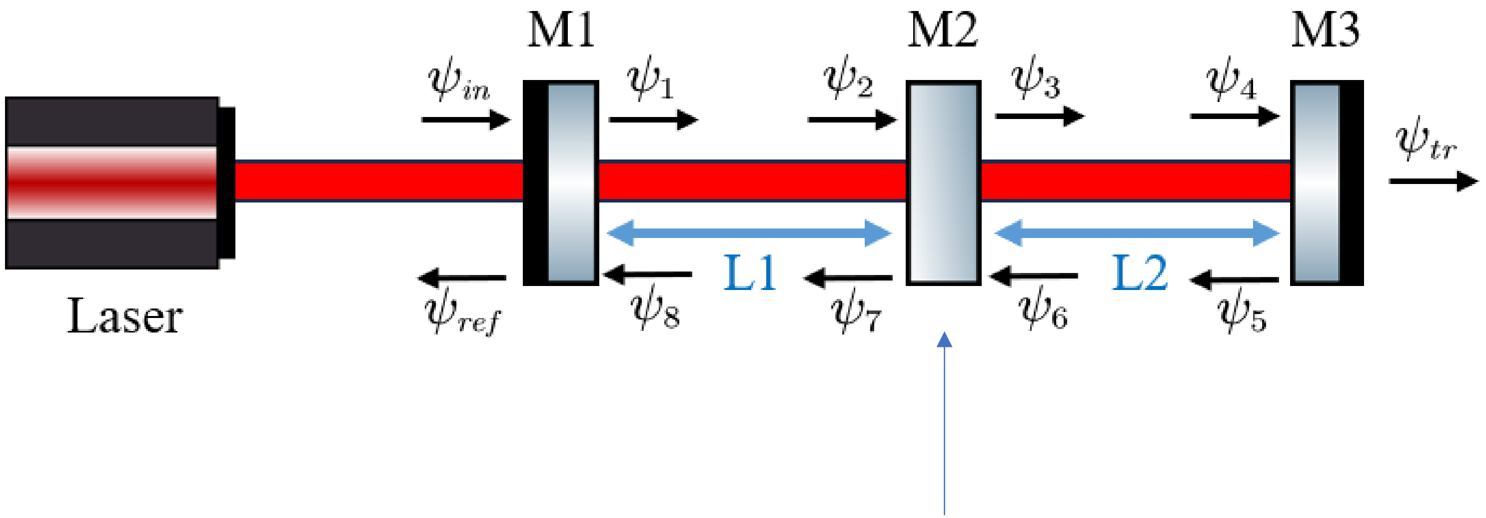
Geometry of the Three mirror cavity → Design Targets

→ Optical Design → Platform Setup → Measurements

Geometry of the Three mirror cavity → Design Targets → Optical Design → Platform Setup → Measurements



Geometry of the Three mirror cavity → **Design Targets** → Optical Design → Platform Setup → Measurements



Size of the light spot: 330 um

Geometry of the Three mirror cavity → Design Targets

→ **Optical Design** → Platform Setup → Measurements

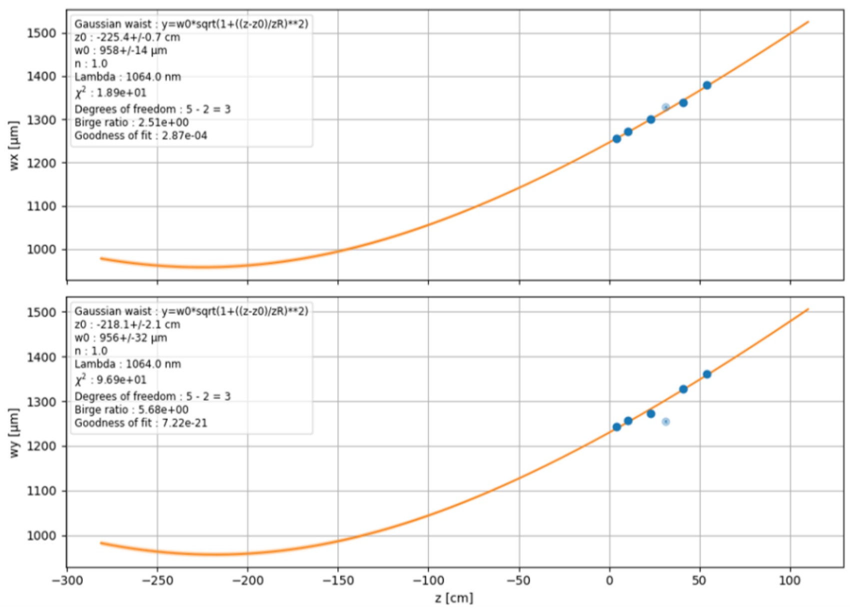


Fig. Fiber-laser beam parameters measured with a beam analyzer

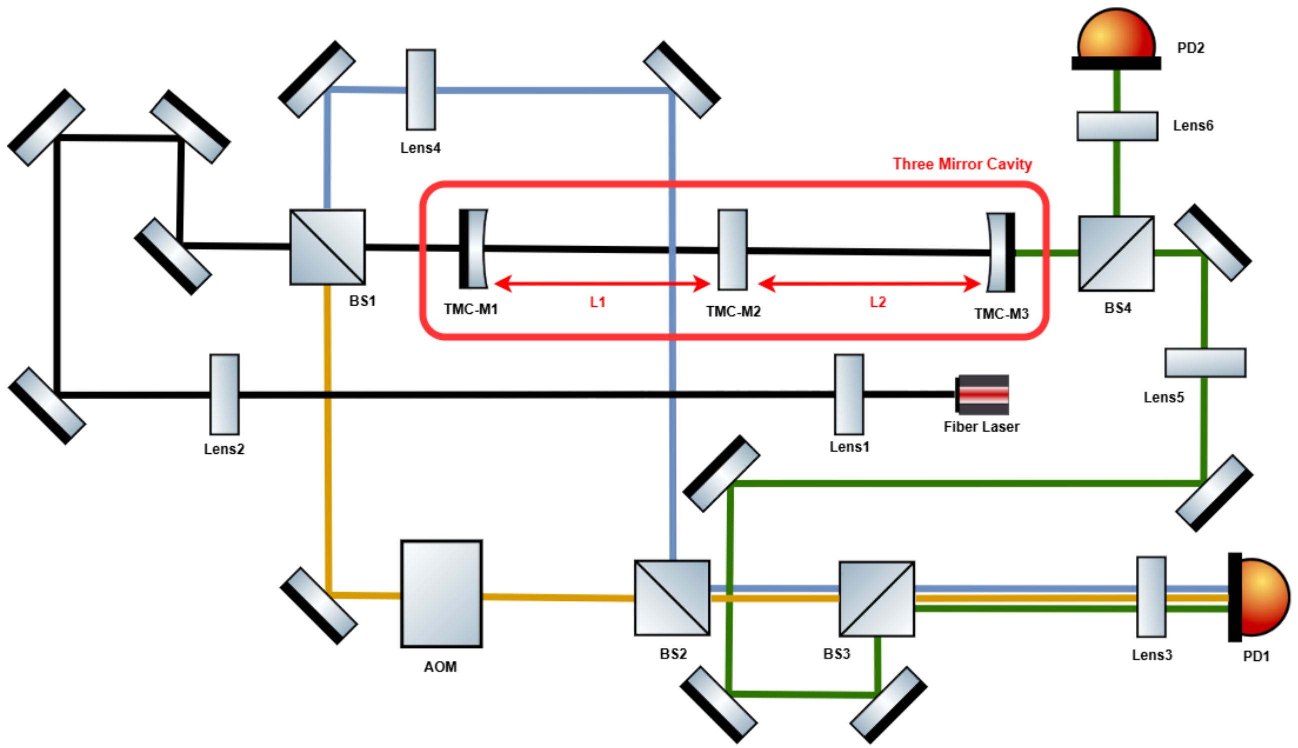


Fig. Optical schematic of the three-mirror cavity setup

Geometry of the Three mirror cavity → Design Targets → Optical Design → **Platform Setup** → Measurements

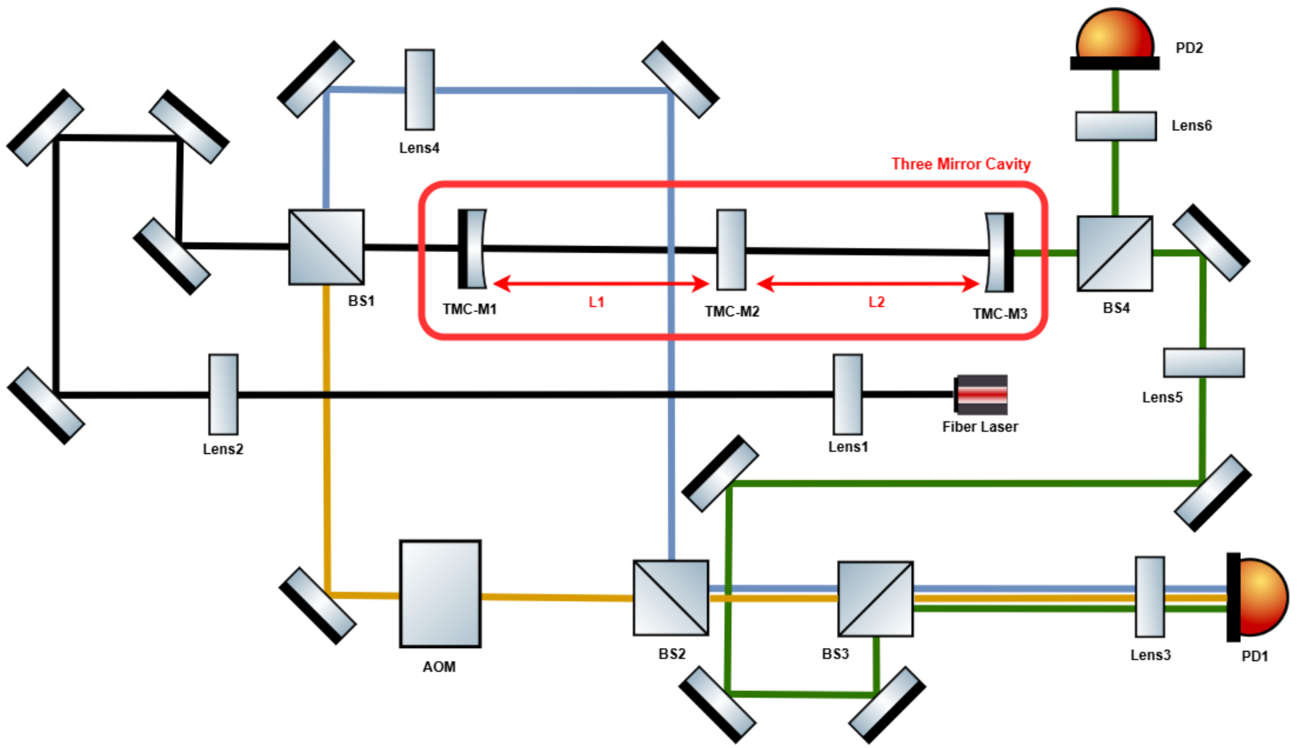


Fig. Optical schematic of the three-mirror cavity setup

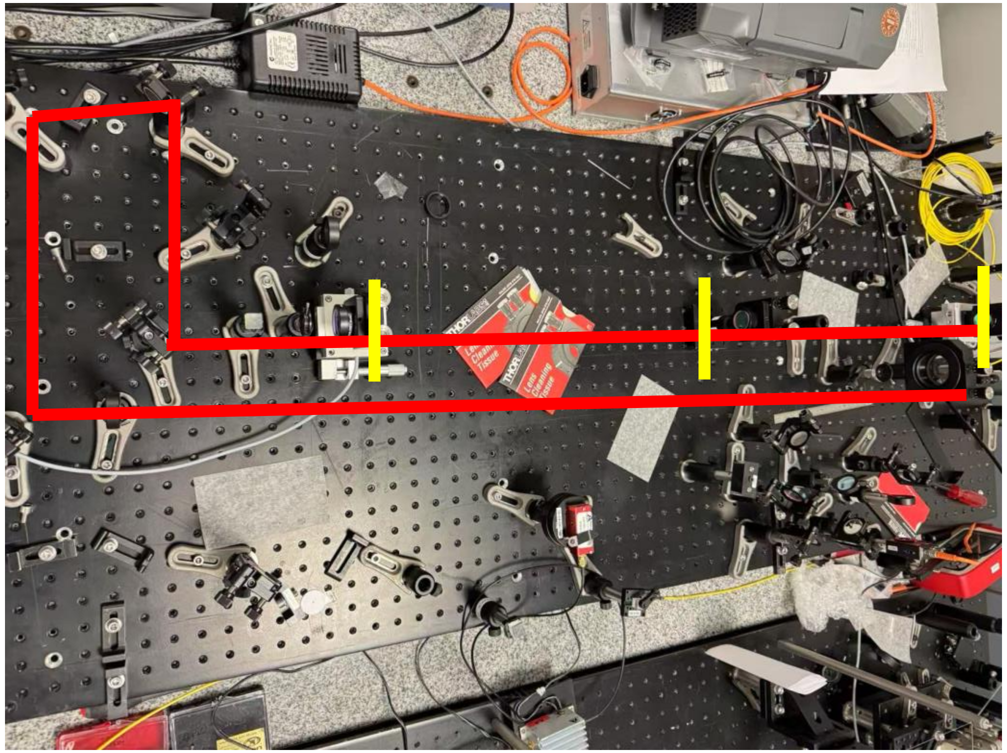


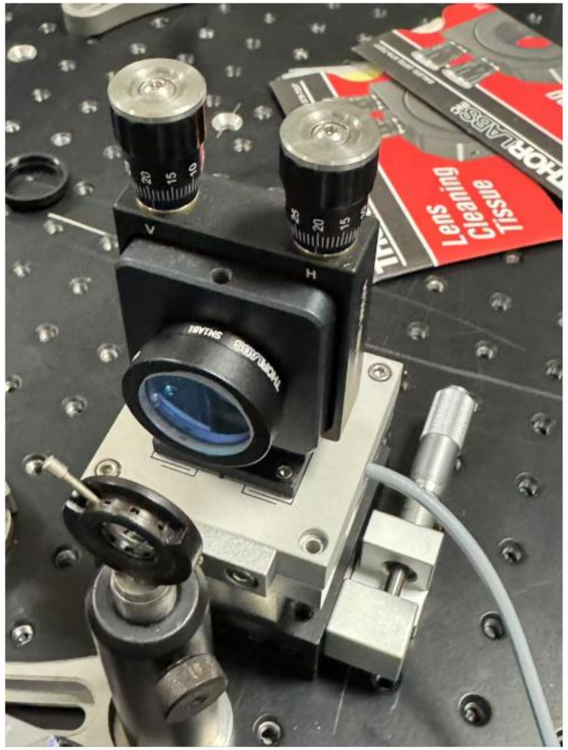
Fig. Platform Setup

Geometry of the Three mirror cavity → Design Targets

→ Optical Design → Platform Setup → **Measurements**

(a) Rigol DG4102 generator

(b) PiezoConcept controller



(c) Piezoelectric platform

Fig. Instruments used for piezo platform control

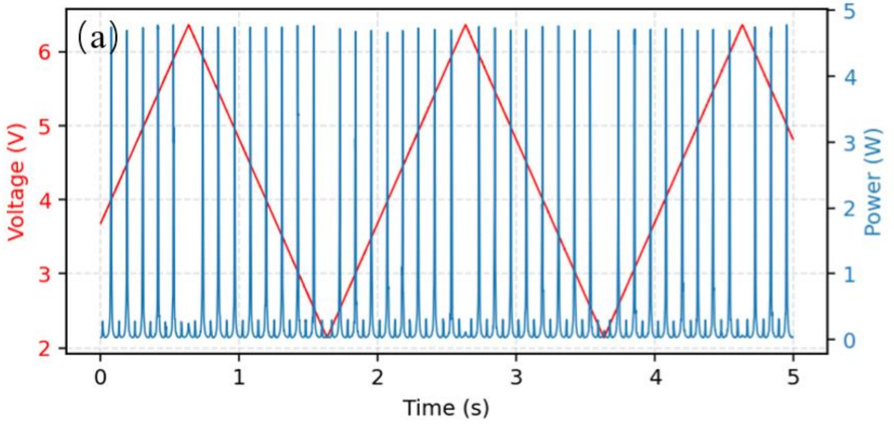


Fig. Drive voltage (red, left axis) and detected power (blue, right axis) during a single triangular ramp

Fig. Drive voltage (red, left axis) and detected power (blue, right axis) during a single triangular ramp

More measurements to be measured …

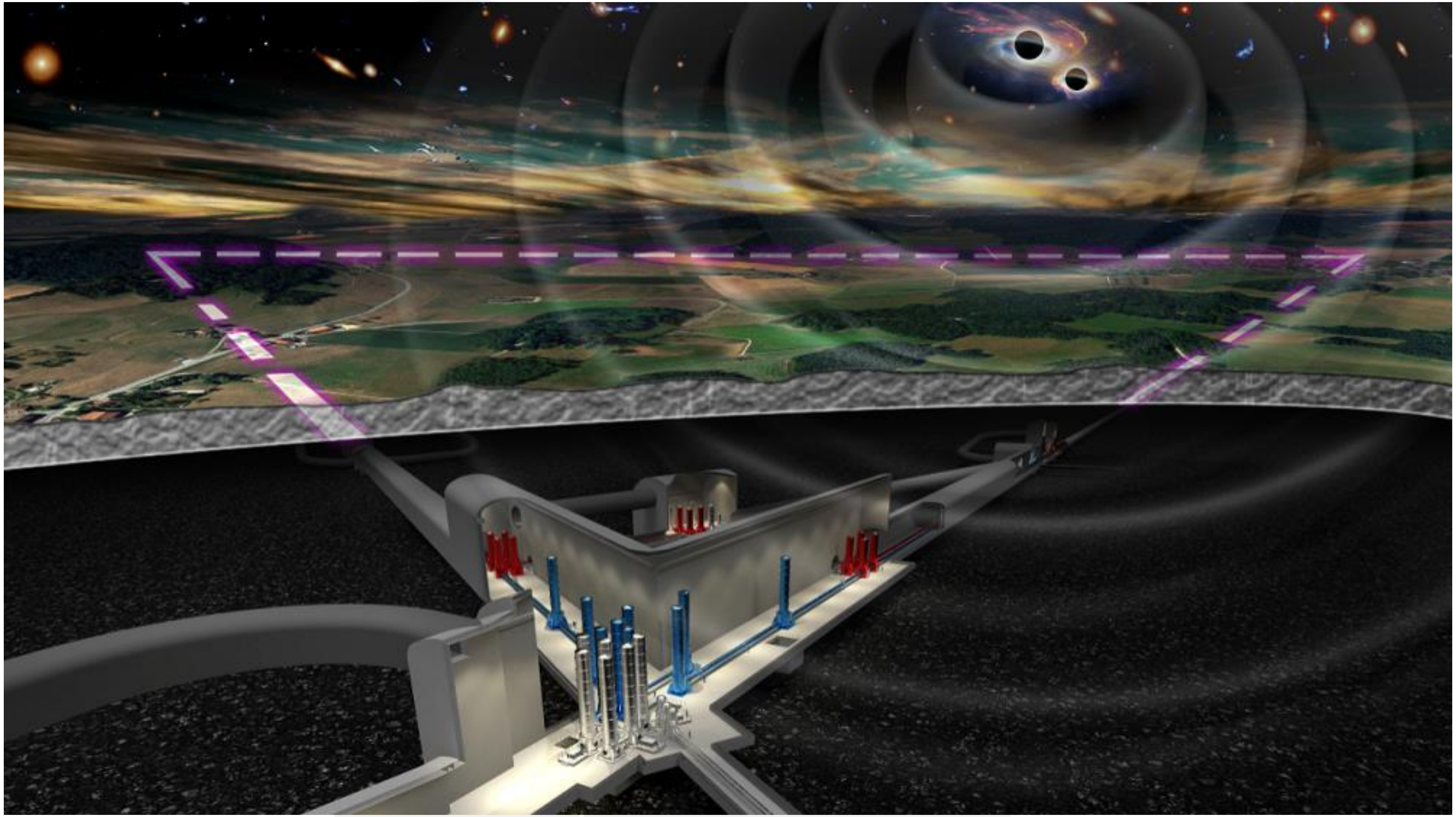
Geometry of the Three mirror cavity → Design Targets → Optical Design → Platform Setup → **Measurements**

More measurements to be taken…

Thank you!

Jiuyi LI
Advisor: Angélique Lartaux
24/6/2025

In the Gravitational Wave group ! ! !



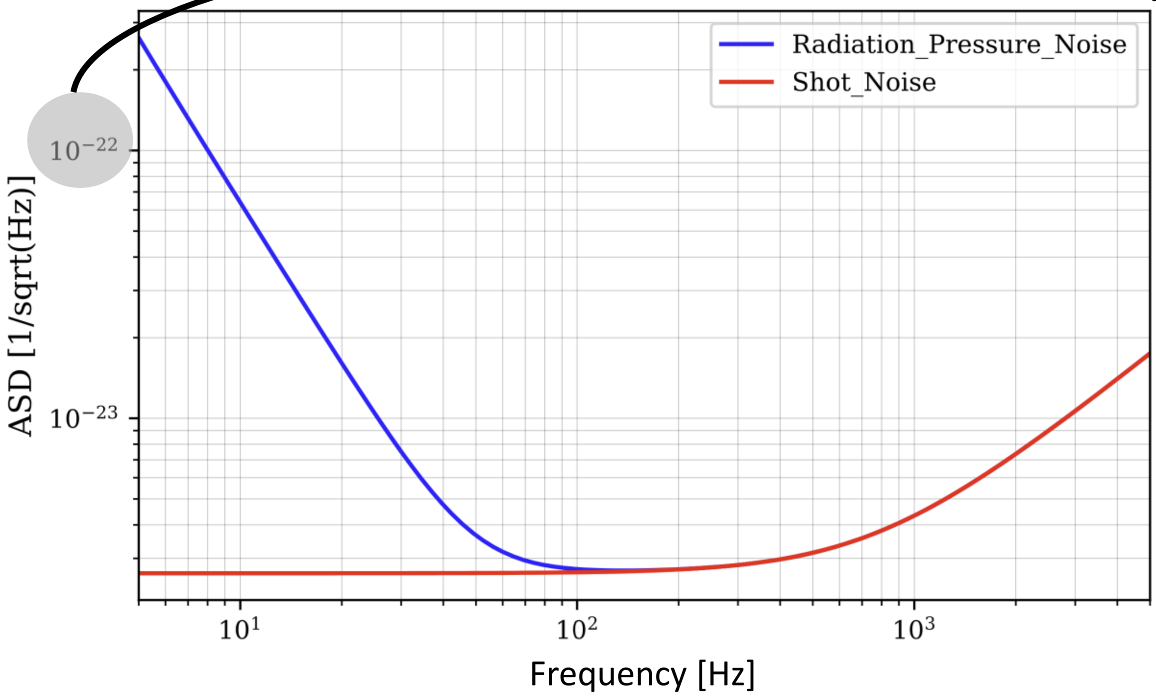
About me: Mauritius (Île Maurice) → U.S. → France

B.Sc. in ***Optics***, University of Rochester, Rochester, NY U.S

Research background: THz wave generation and detection, laser-plasma, spatiotemporal control

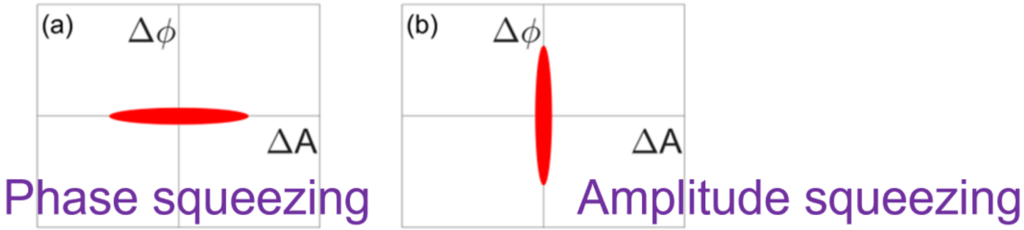
Hobbies: Cardistry & card magic, photography, learn new languages (to a lesser extent)

GW Detectors and Quantum Noise



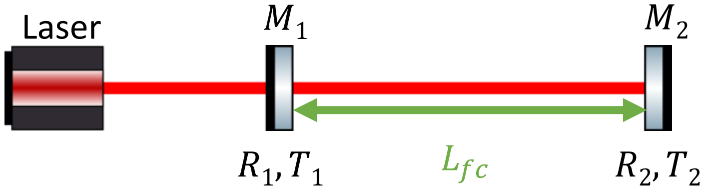
$\Phi_{atom} = 1$ Å

$L_{Earth-Sun} \cong 100\ million\ km$



$\theta_{sq} = 0$ $\theta_{sq} = \pi/2$

→Make θ_{sq} frequency dependent !!



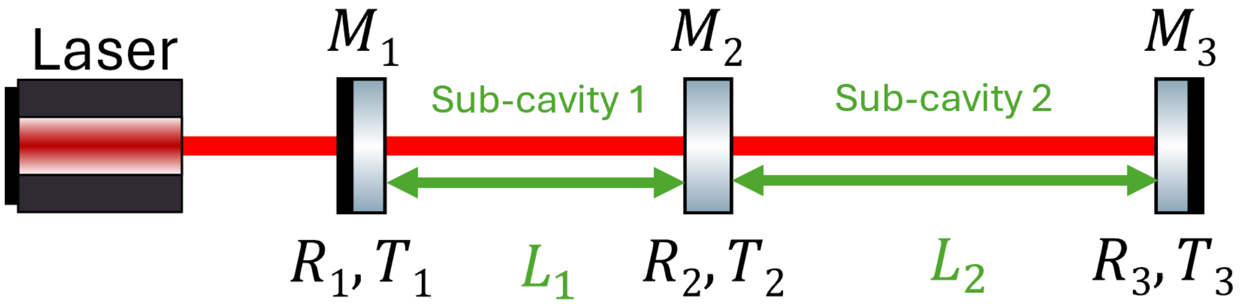
BUT!! Squeezing susceptible to power loss and fluctuations

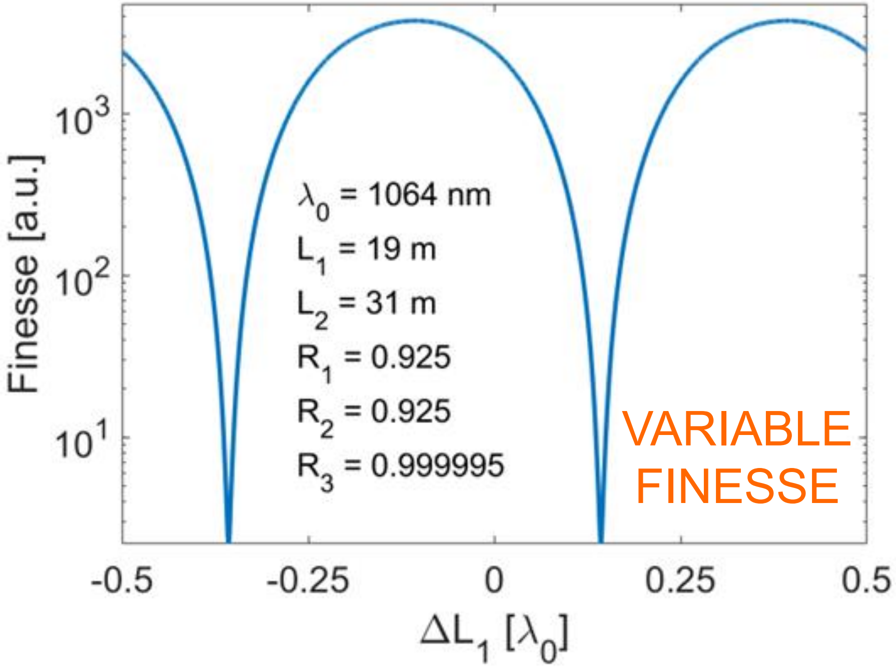
Radiation pressure noise=Amplitude noise ΔA

Shot noise=Phase noise $\Delta\phi$

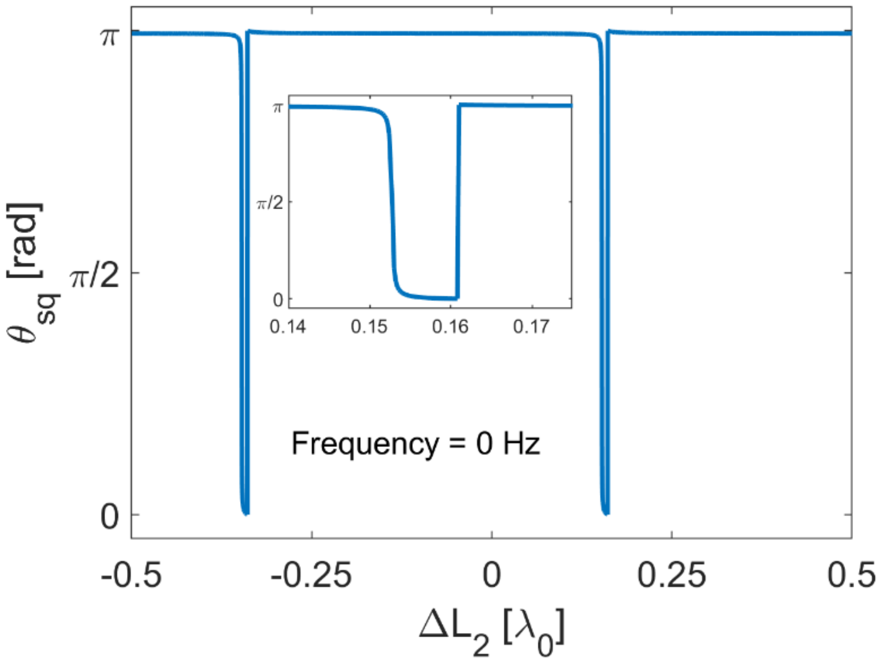
Solution: Squeezing → $\Delta\phi\Delta A \geq 1$

The internship: Linear 3-Mirror Cavity for Frequency-Dependent Squeezing in GW Detectors





VARIABLE FINESSE



Quantum noise propagation?