Virgo Gravitational Wave Master Classes

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Maastricht University

GW master classes

In early 2021, a great deal of prior discussion was done on the educational and scientific goals of the Master Classes

Main key points:

* Teachers and students get introductory material on gravitational wave science
* Proceed with an online exercise using Virgo resources
* ..followed by discussion with scientists and comparing to other classes

In brief: become real scientists for a day!

https://wiki.virgo-gw.eu/Outreach/GW-Masterclasses

Master Class Exercises: from first example to fixed template

Plan: start with *one* Master Class Exercise to work out in detail and measure its effectiveness. Its form can next be used as a template for additional Master Class exercises.

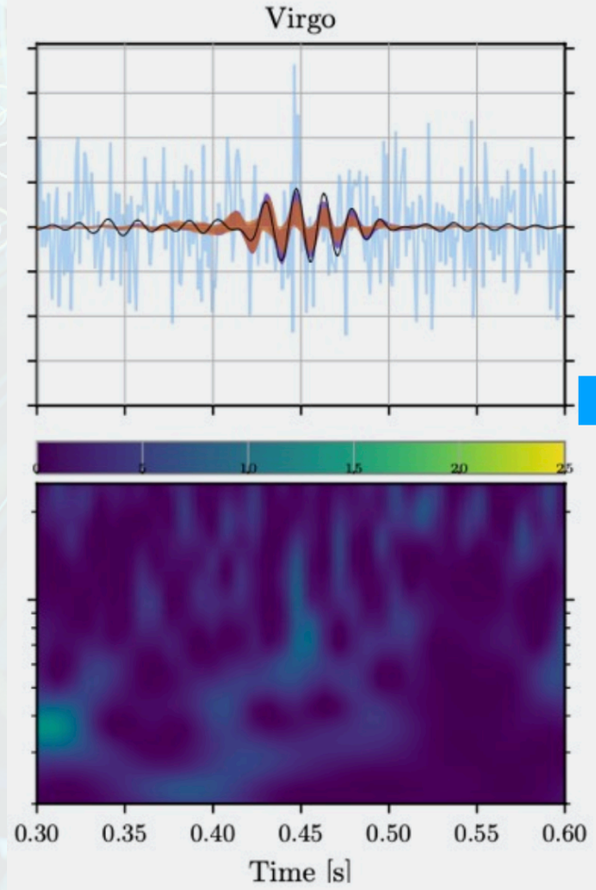
Possible topics:

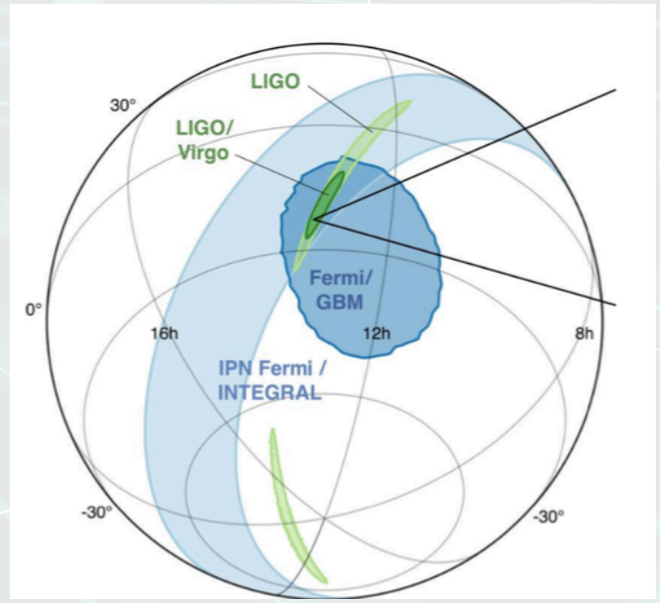
*** gravitational wave theory**

*** instrumentation**

*** data-analysis**

*** sky localisation**





Nicolas Arnaud made a 'skeleton version' of the way our first exercise should look:

see:

https://wiki.virgo-gw.eu/pub/Outreach/GW-Masterclasses/20220531_GUIs.pdf

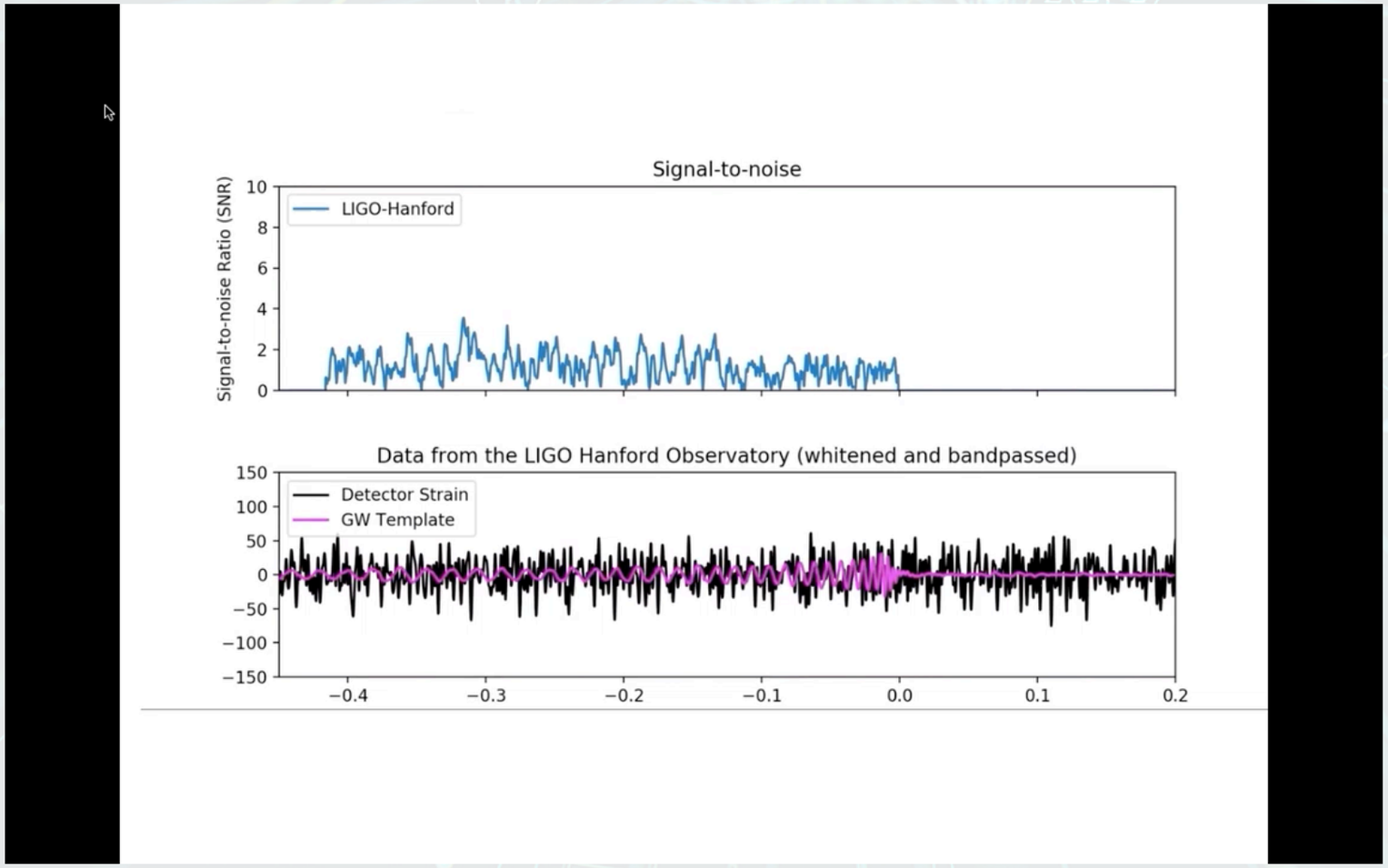
GW Data analysis: Matched filtering

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

→ $h(f)$ = what one looks for

→ $S_n(f)$ = how one is thwarted by the detector

Approach: Try out gravitational waveform *h(f)* for different values of the parameter space, look for parameters that have highest SNR.



Implementation

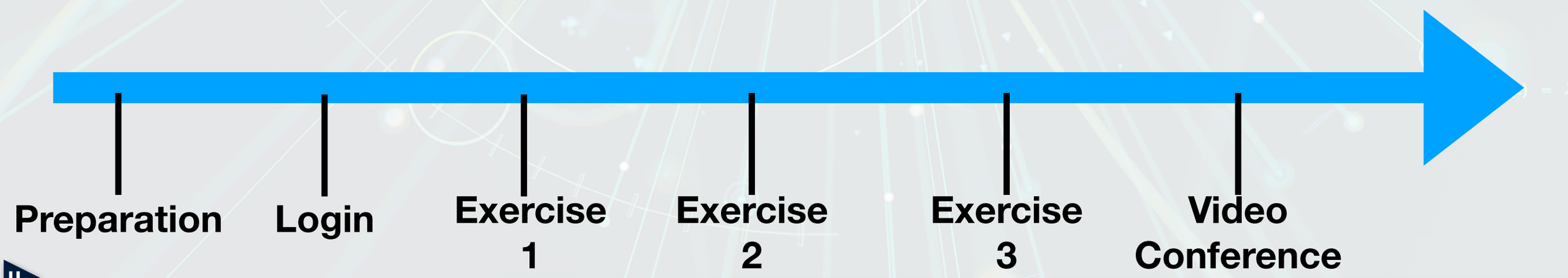
Key physics questions addressed:

* How is gravitational wave detection done?

* How is data pre-processed?

* How to do parameter estimation once a gravitational wave has been found in the data?

* What is the role of coincidences in sky-localisation?



Exercise 1 (40 minutes)

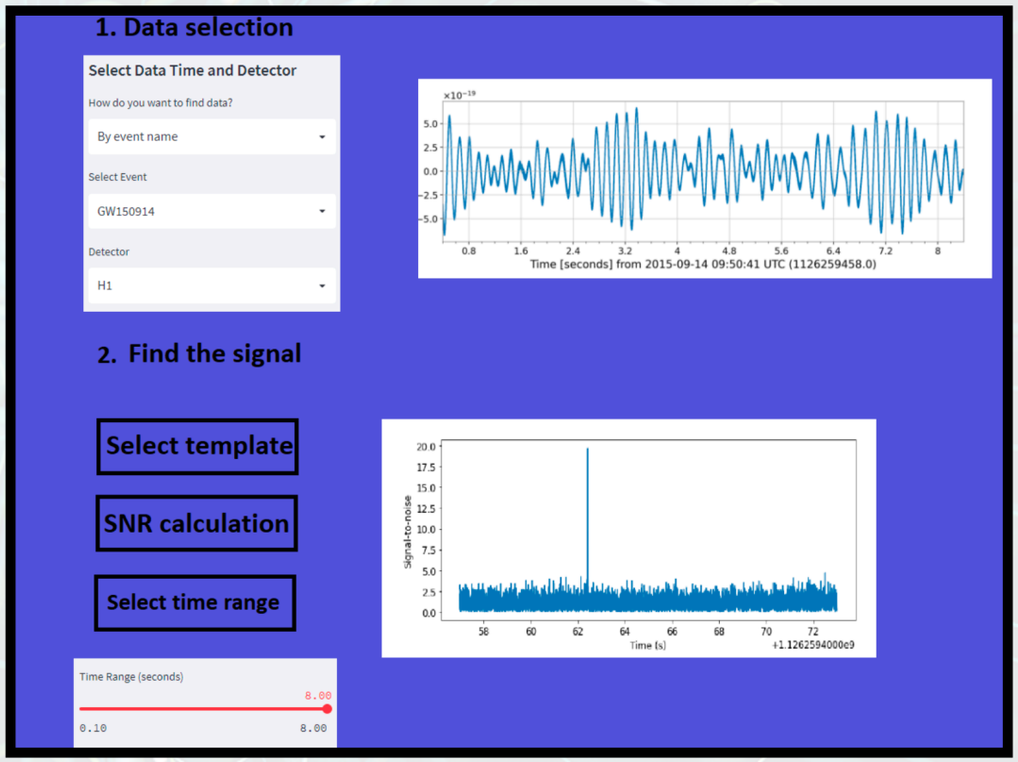
Training exercise on detecting gravitational waves and doing parameter estimation.

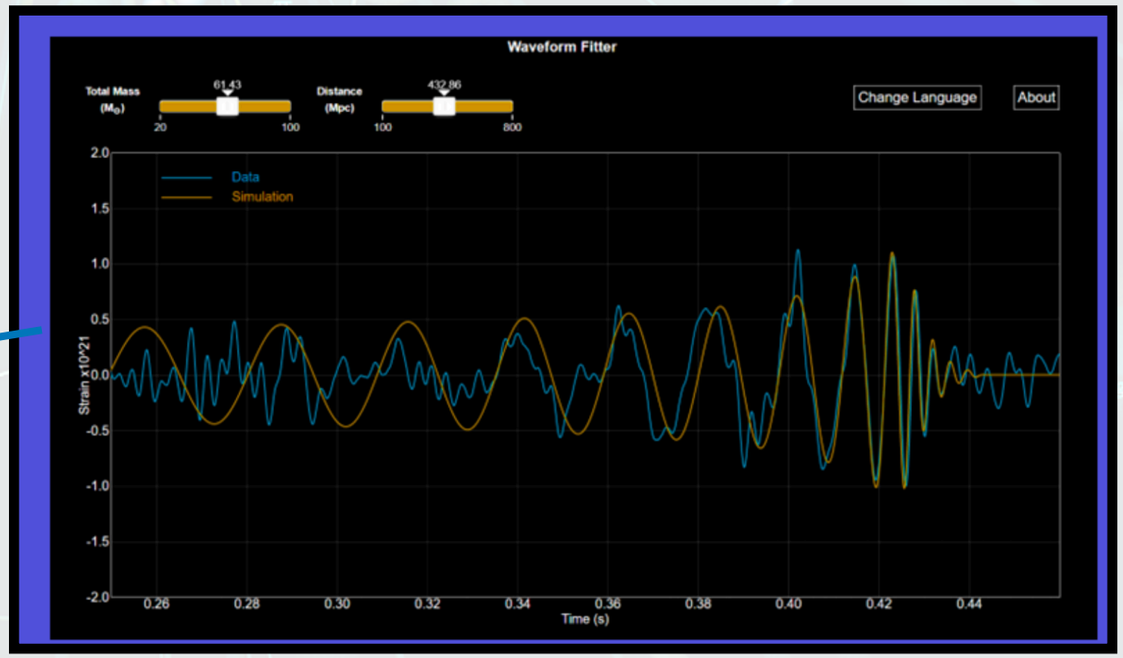
Step 1:
Students do a series of trial exercises on triangular and Gaussian gravitational wave signals.

Step 2:
Students select a (real) data stretch from a GW detector, a template, and perform an SNR calculation

Step 3:
Students whiten and bandpass their data around their signal

Step 4:
Students perform parameter estimation

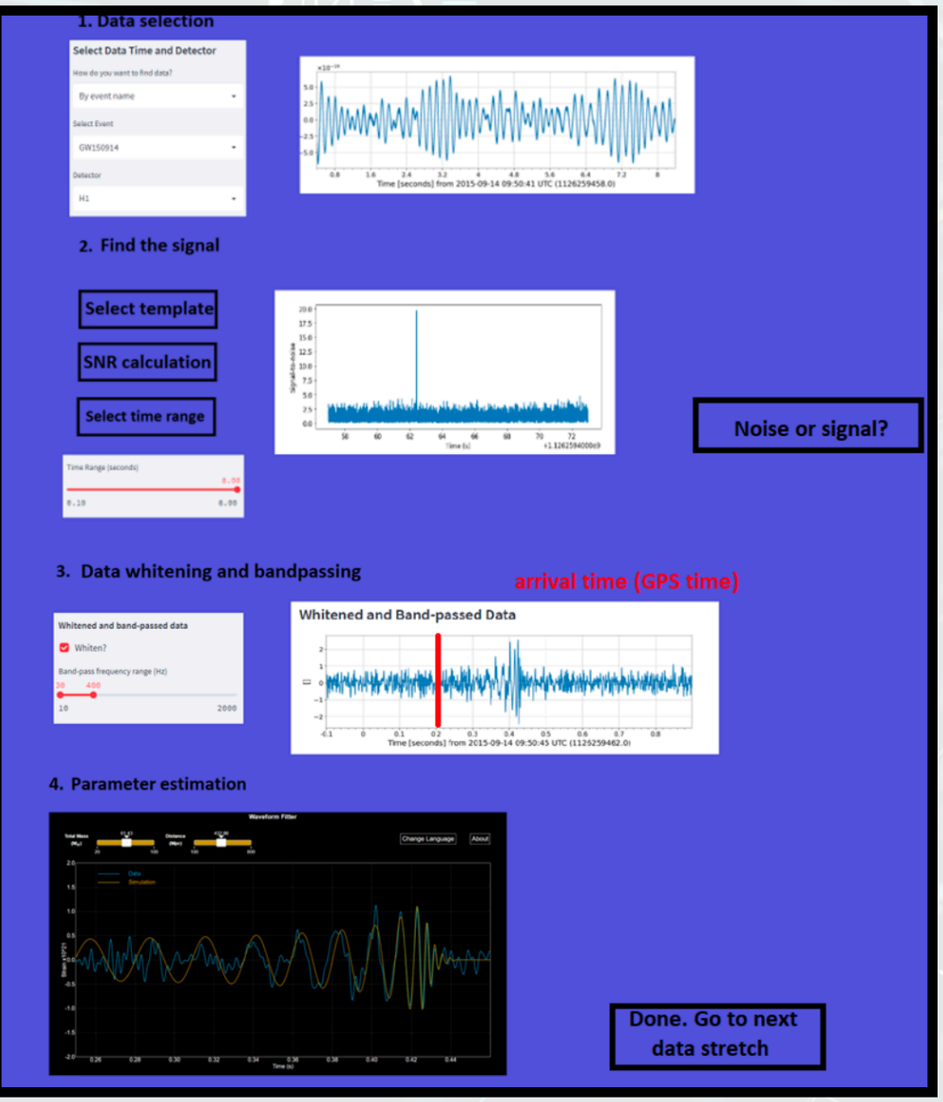




Exercise 2 (60 minutes)

Repeating detecting gravitational waves and doing parameter estimation.

This time, it is not known beforehand that there is a GW hidden in the data, and the timing of the GW is to be determined by the students themselves.



	Nickname	Detector	Data stretch	Arrival time	Time range	Frequency range	Total mass	Distance	chisquare
Group name	Nickname 1	Detector 1	GWabc	GPS time 1	Time range 1	Freq. range 1	M1	d1	x^2_1
	Nickname 2	Detector 2	GWabc	GPS time 2	Time range 2	Freq. range 2	M2	d2	x^2_2
	Nickname 3	Detector 3	GWabc	GPS time 3	Time range 3	Freq. range 3	M3	d3	x^2_3

Between each two groups of students:

Determine trigger window between their detectors

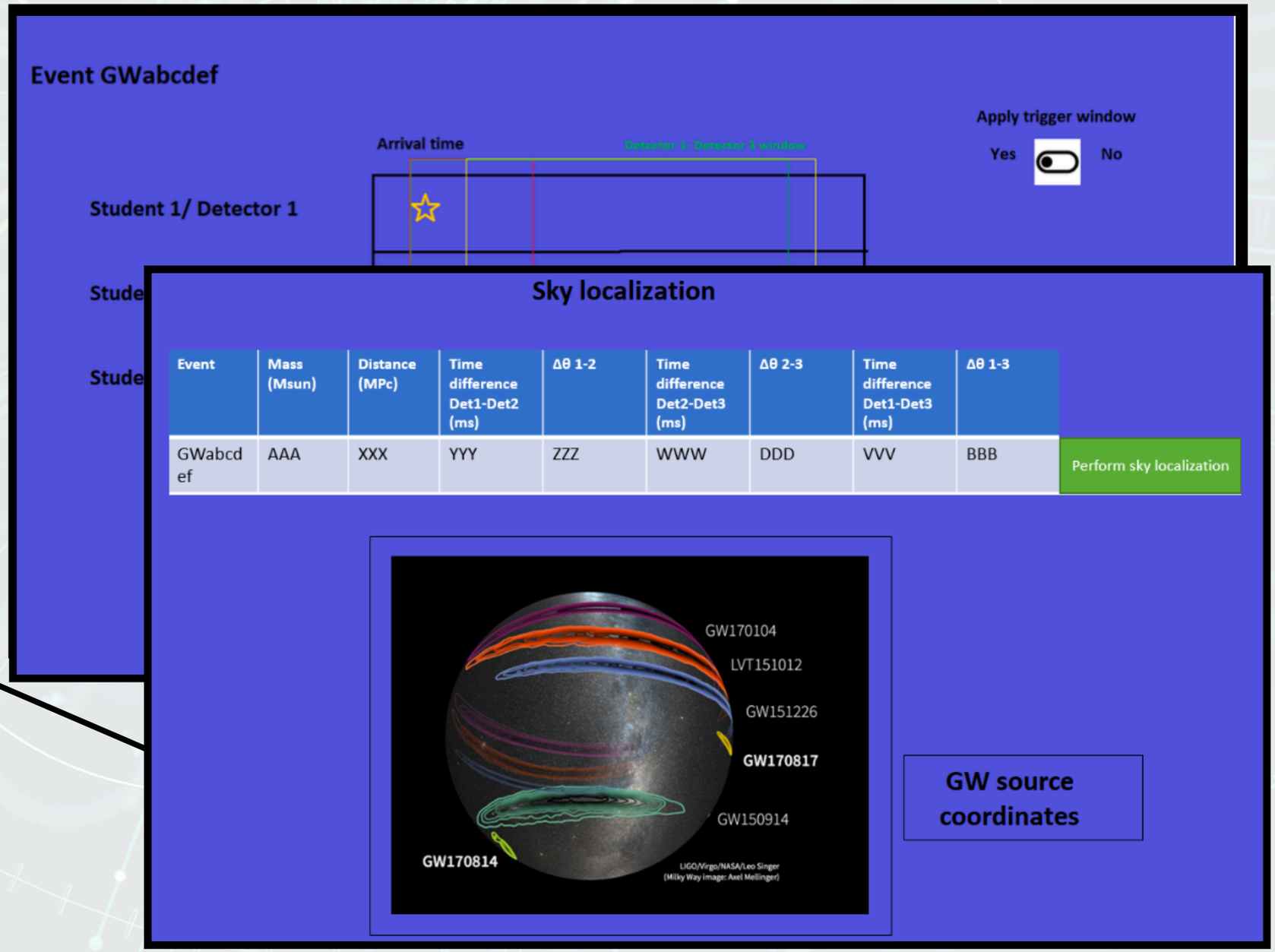
Exercise 3 (45 minutes)

Combining results from various groups and performing joint data-analysis to do sky localisation of the source of the gravitational wave signal.

Step 1:
Students watch video on sky localisation techniques.

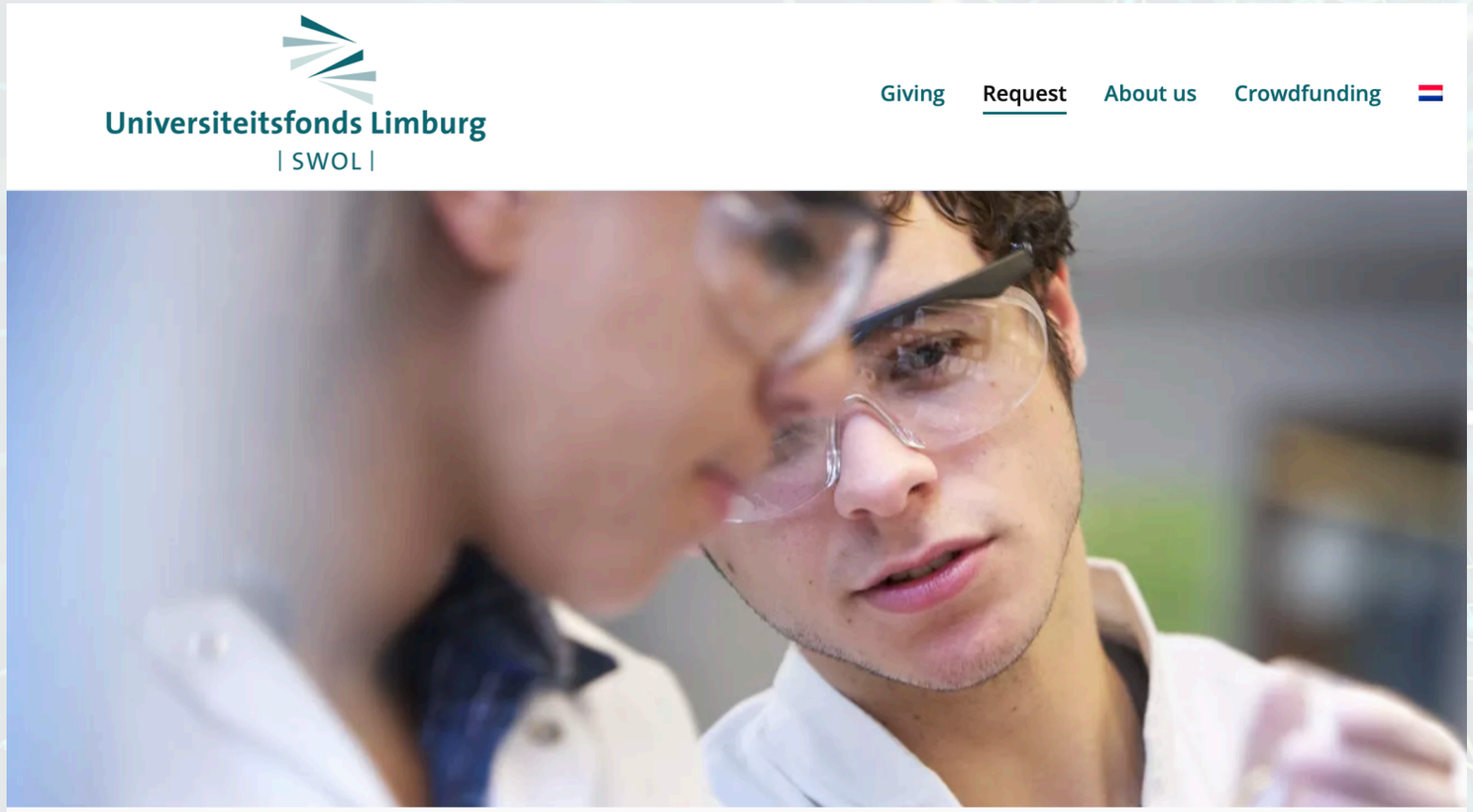
Step 2:
Students look for coincidences between their data sets, and manually select whether a GW coincidence has been found

Step 3:
Students have the software perform the sky localisation



Implementation

Resources have been collected



https://www.ufl-swol.nl/en/

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University Funding Scheme,
Aimed at science and education,
Dispenses funds based on private donations,
Funds requests up to €8000.

About the fund

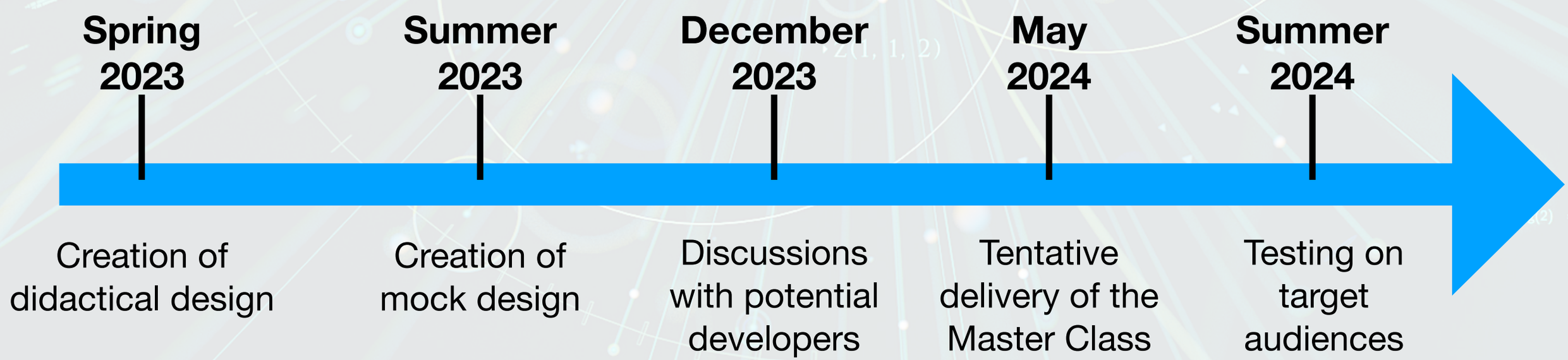
University Fund Limburg/SWOL aims to support scientific research and education at Maastricht University. Science is a crucial building block to achieve a better future for next generations.

The Fund also seeks to foster good and mutually beneficial relationships between the university and the local community, as well as between itself and these parties. To achieve these objectives, the Fund is focused on the continued development of UM, the acquisition of financial resources from companies, government, funding bodies and private donors and the promotion of international activities among students and academic staff. In addition, the Fund works to strengthen ties between Maastricht University and its alumni, the business community and relevant civil society organisations.

I wrote a proposal for the grant and was awarded it last year summer.

Timeline and next steps

* **Didactical design: fully finalised**
* **Necessary scientific resources (templates, stretches of data, widgets): collected**
* **Funds: requested and received**
* **Current status: discussion with developers for the coding/ implementation of Master Classes**



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