S'Cool LAB group 1
Quadrupole Ion Trap & Beam Optics

Group Leaders: Lachlan, Fabian & Hector

1. Quadratic Ion Trap: Ayyaz, Thana, Susanna
2. Beam Optics: Bahareh, Kazuoki, Lidwina

Quadrupole Ion Trap

- Theory
- Setup
- Problems

Theory of Quadruple ion trap

•Observation of particle when isolated or without material walls

Types of traps

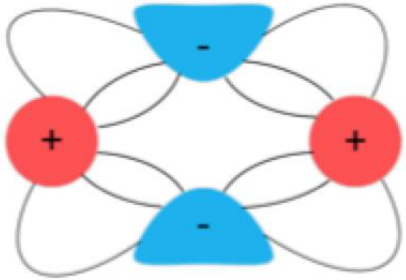
1.Penning traps, developed by Dehmelt and Penning, use static electric and magnetic fields,

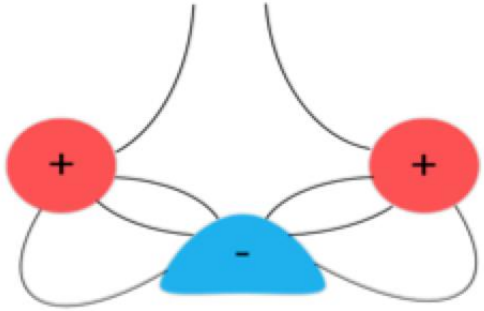
2.Paul traps, developed by Wolfgang Paul, are operated with alternating electric fields

Difference between ion trap and group work

1. Uses spores instead of ions

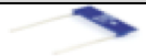
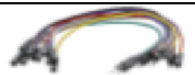
2. Three poles are used instead of four



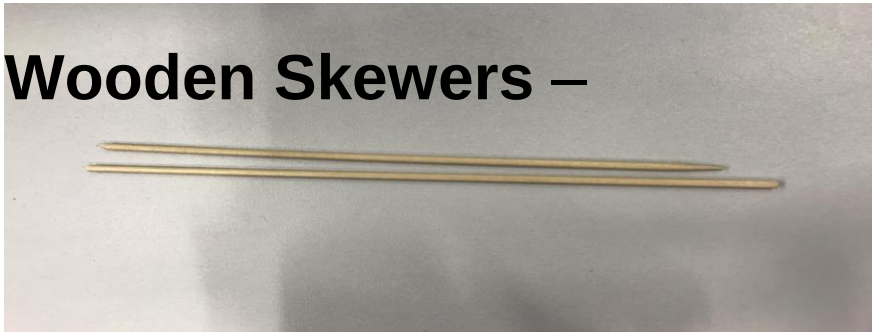


Equipment and Setup:

Materials:

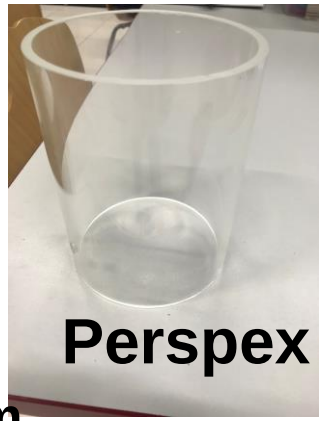
Description	Picture	Price
2 x Resistor (10 $M\Omega$)		8 €
Multi Contact 4mm Banana plug sockets		6 € for 2 pieces
1 × Toggle Switch On-Off-On*		25 € for 5 pieces
Male to Male Leads (9 required) Male to Female Leads (6 required)		5 € for packs of 10 (20 € total)
Electric Paint (Bare Conductive)		20 € for 50 ml
Breadboard		18 €
Capacitors 1 × 1 µF 1 × 10 µF		Come in packs of 4 for 2 € (4E)
Diode		Packs of 10 for 5 €
2 × NPN Transistor		Packs of 10 for 3 €
Resistors 1 × 100 Ω 2 × 10 Ω 1 × 8.2 kΩ 1 × 10 kΩ		Come in packs of 10 for 3 € (total 12 €)
10 kΩ Potentiometer		3 €
Battery Strap (Clip)		5 for 4 €
9V Battery		8 €
2 x High power LED		0.12 € per piece

Other materials required to perform experiment:

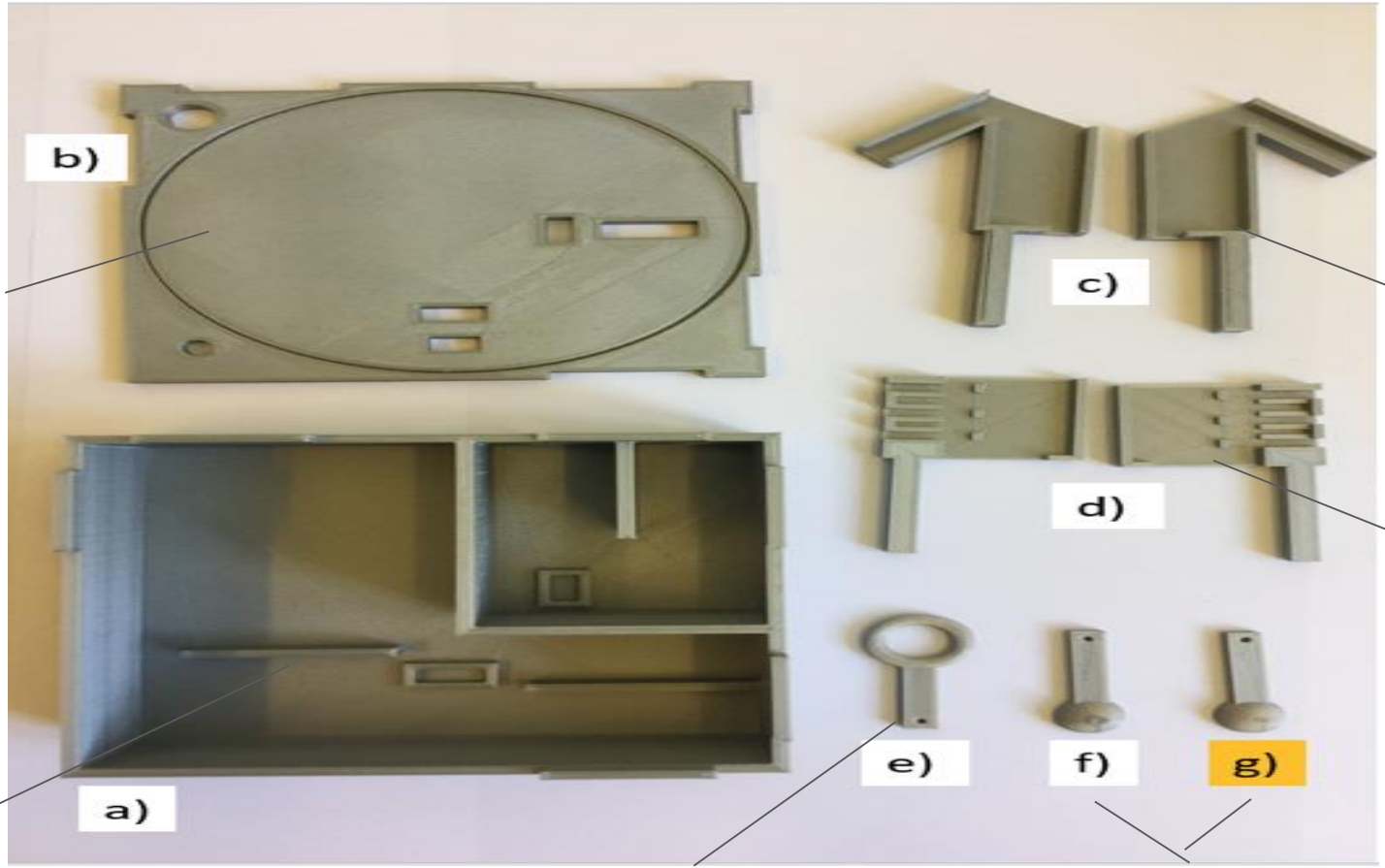


Power Source/Transformer

Spores (Lycopodium Powder)



Building Instructions: 3D printing:



Lid

LED Holder

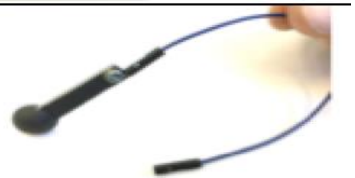
Electrode Stan

Base

Ring Electrode

Spherical Electrode

Building Instructions Cont'd

Description	Picture
Paint electrodes with conductive paint. Note: Conductive paint can be more difficult to apply than regular paint.	
Paint the ring on both sides. The paint is only required on one side of the shaft.	 
Paint only the top side of the endcap electrodes.	 
After the conductive paint has dried, attach the male end of the male-to-female leads to the electrodes. Do this by using M2.5x6 bolts and a washer. Note: Depending on how well the electrode is 3D printed, it may be difficult to screw the bolt. Note: you may not need all the supplied bolts.	  

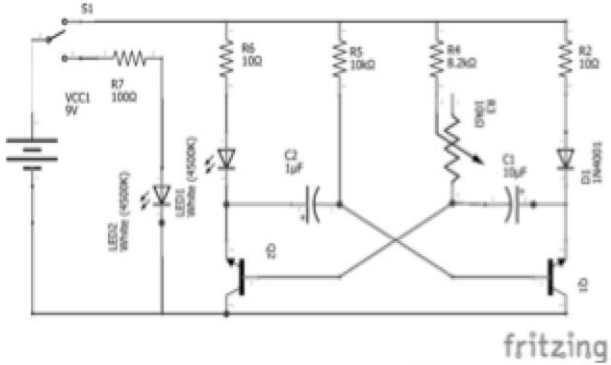


Figure 2 Circuit Diagram of Astable Multivibrator

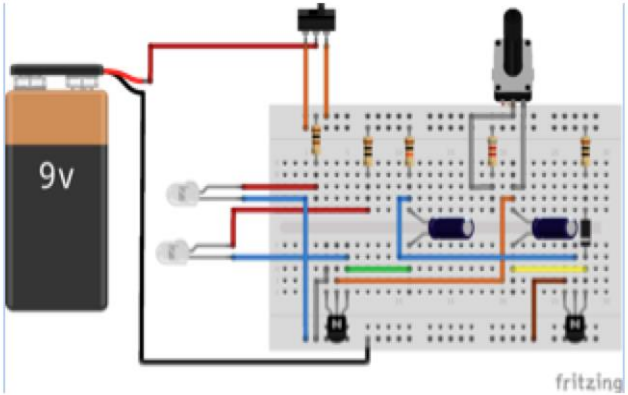
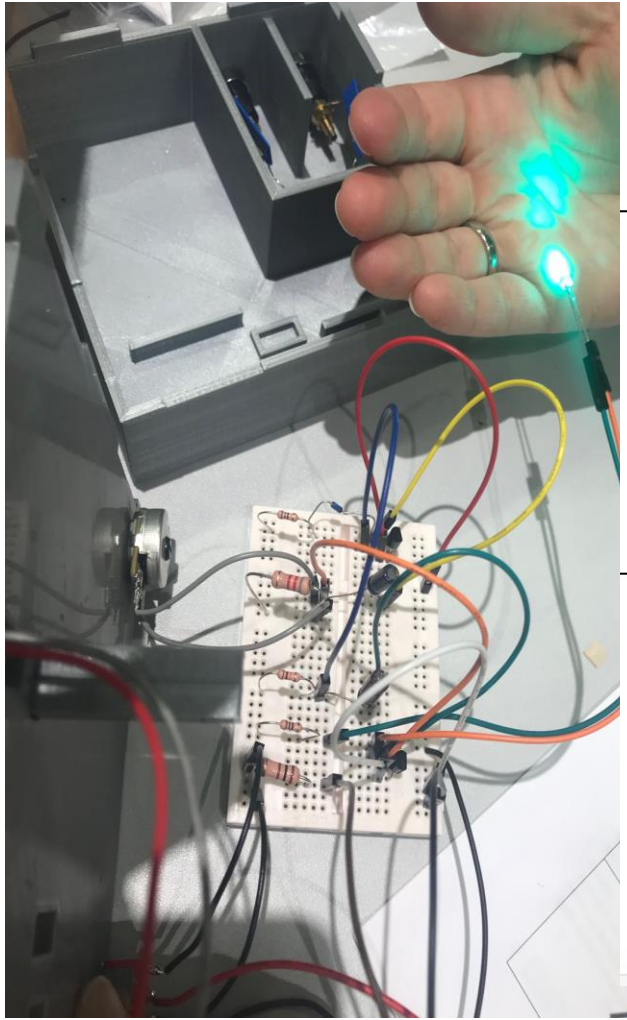
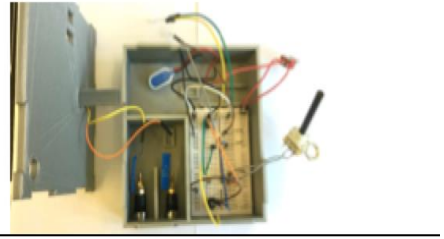
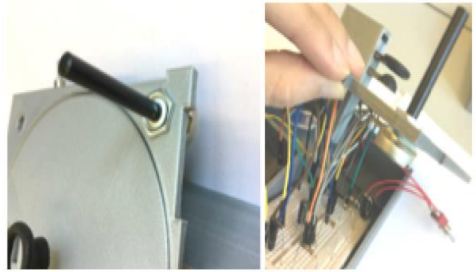
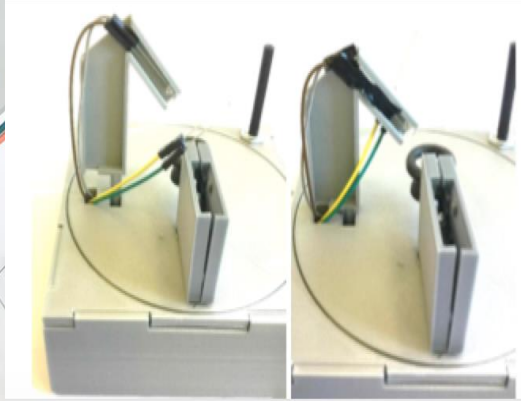


Figure 3 Breadboard Schematic of Stable Multivibrator



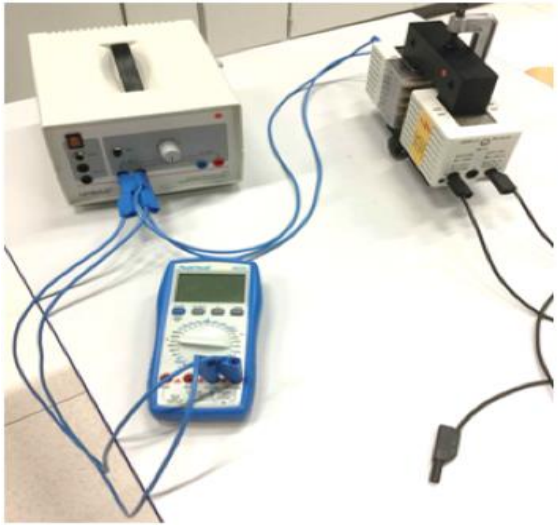




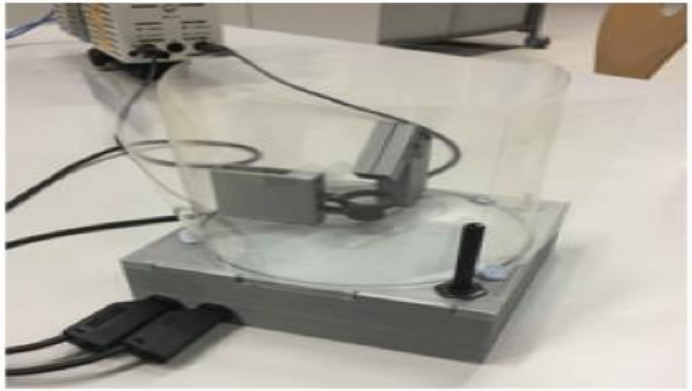


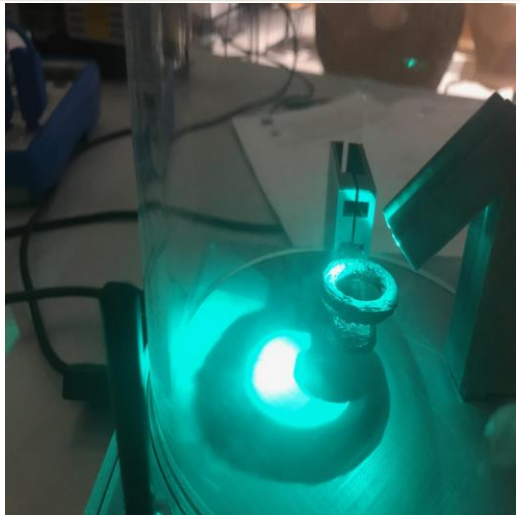
Operation Instructions

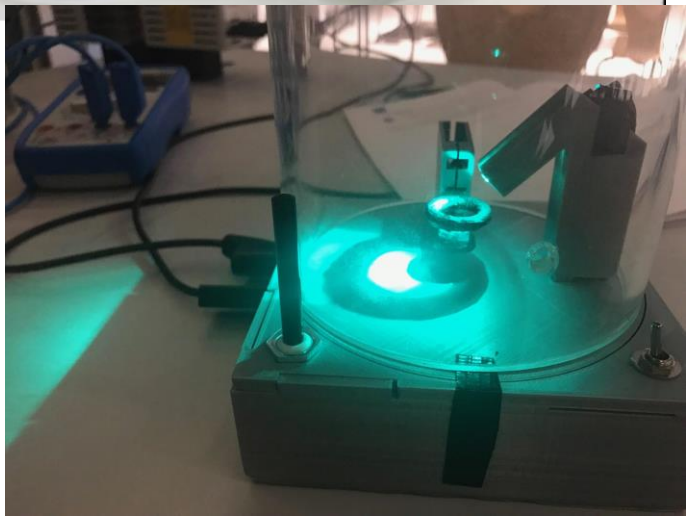
- **Safety Notes**
- **Trapping Spores**



Operation Instructions Cont’

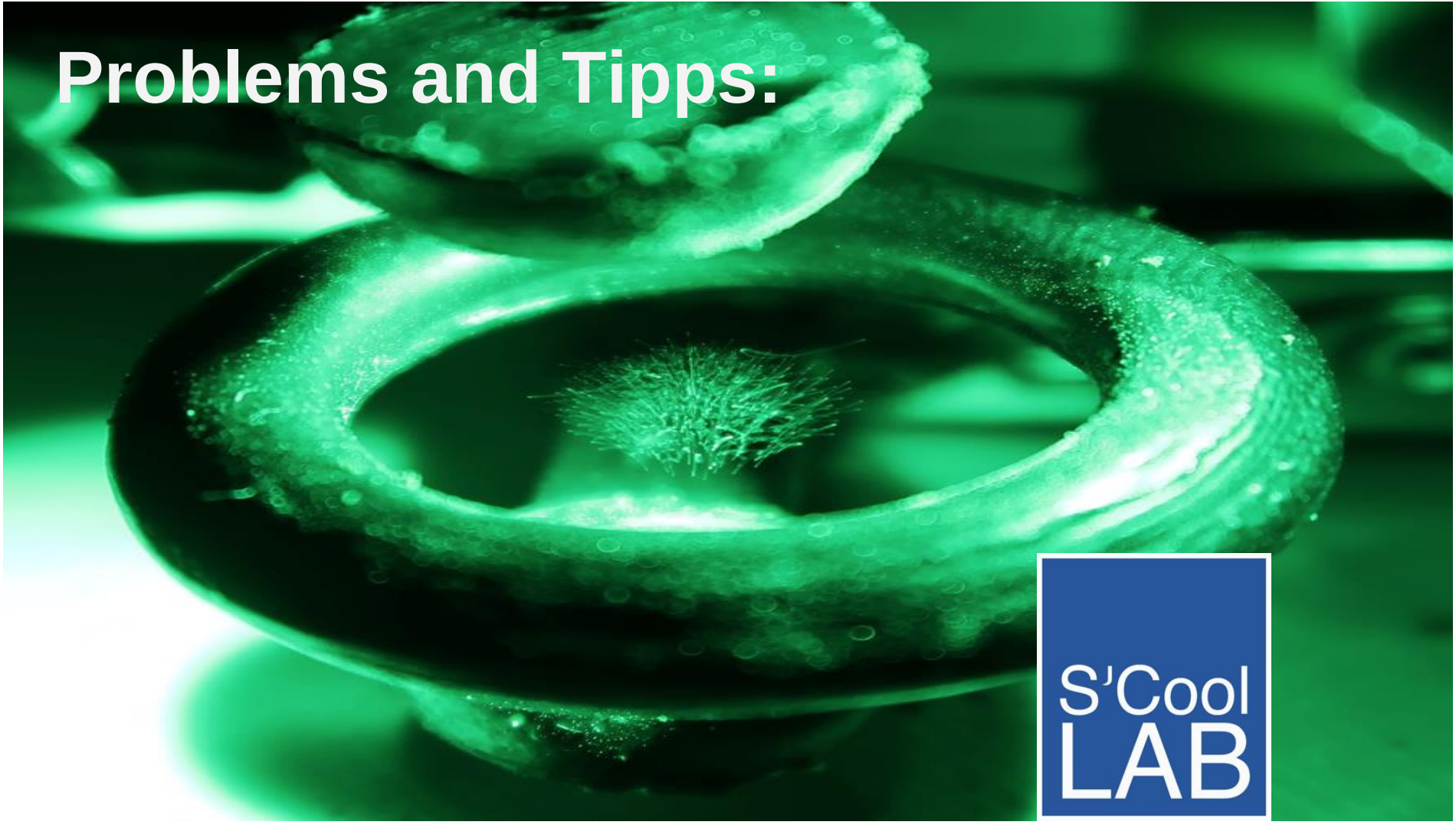






SOURCE[heyitscaspian.tumblr.com](heyitscaspian.tumblr.com)

Problems and Tipps:



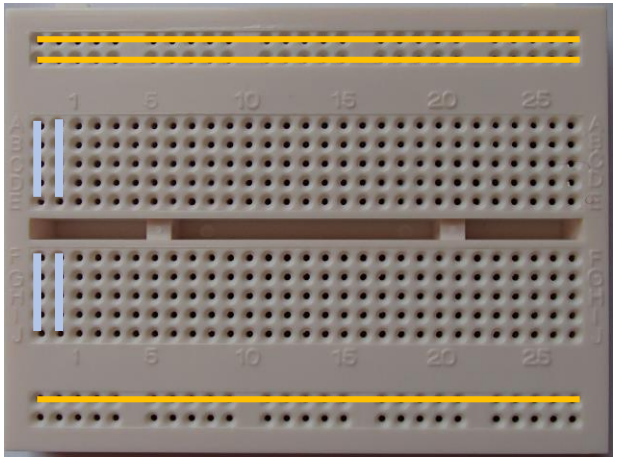
Painting

Have you ever painted with glue? We did.

TIP: Use a brush with stiff hair.

Project Board

The dots on the outer side connect horizontally.



The dots in the middle connect vertically.

TIP: Stick the electric components deep into the board. Otherwise they are not connected properly.

Don´t kill the LED!

9 Volt will kill the LED – always use the resistor!!

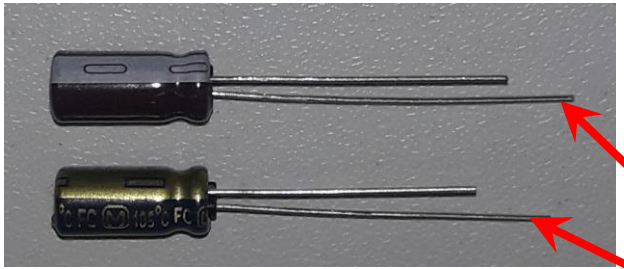
Tip:

The **short end** of most electronic devices must be connected with the **negative pole** of the battery.

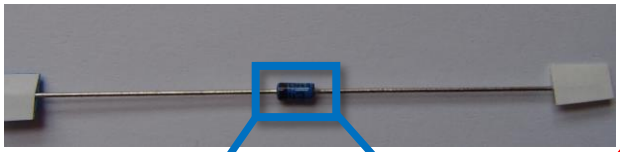
How can you remember this:
You want the **negative** experiences in life to last a **short** time!

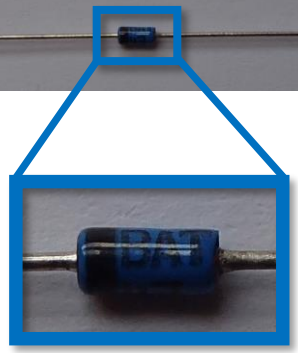
Connect the capacitors and the diode correctly!

Capacitors:



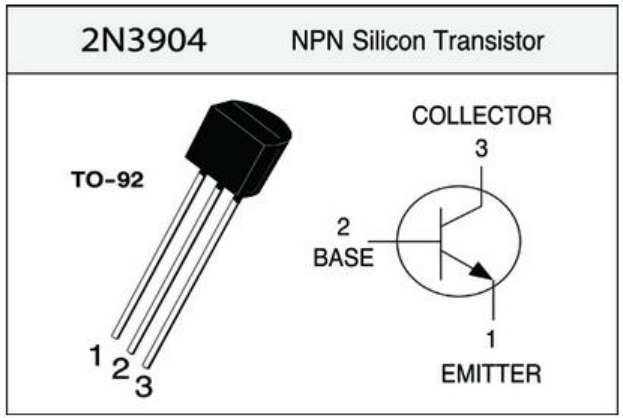
Diode:

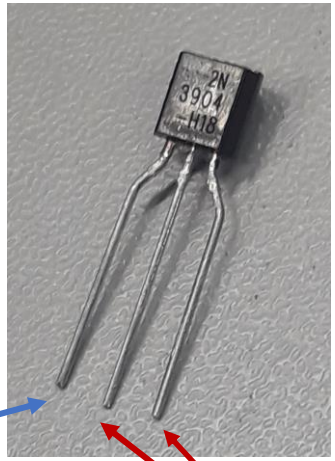




The black ring is the negative connection.

Put the 2 transistors the right way!





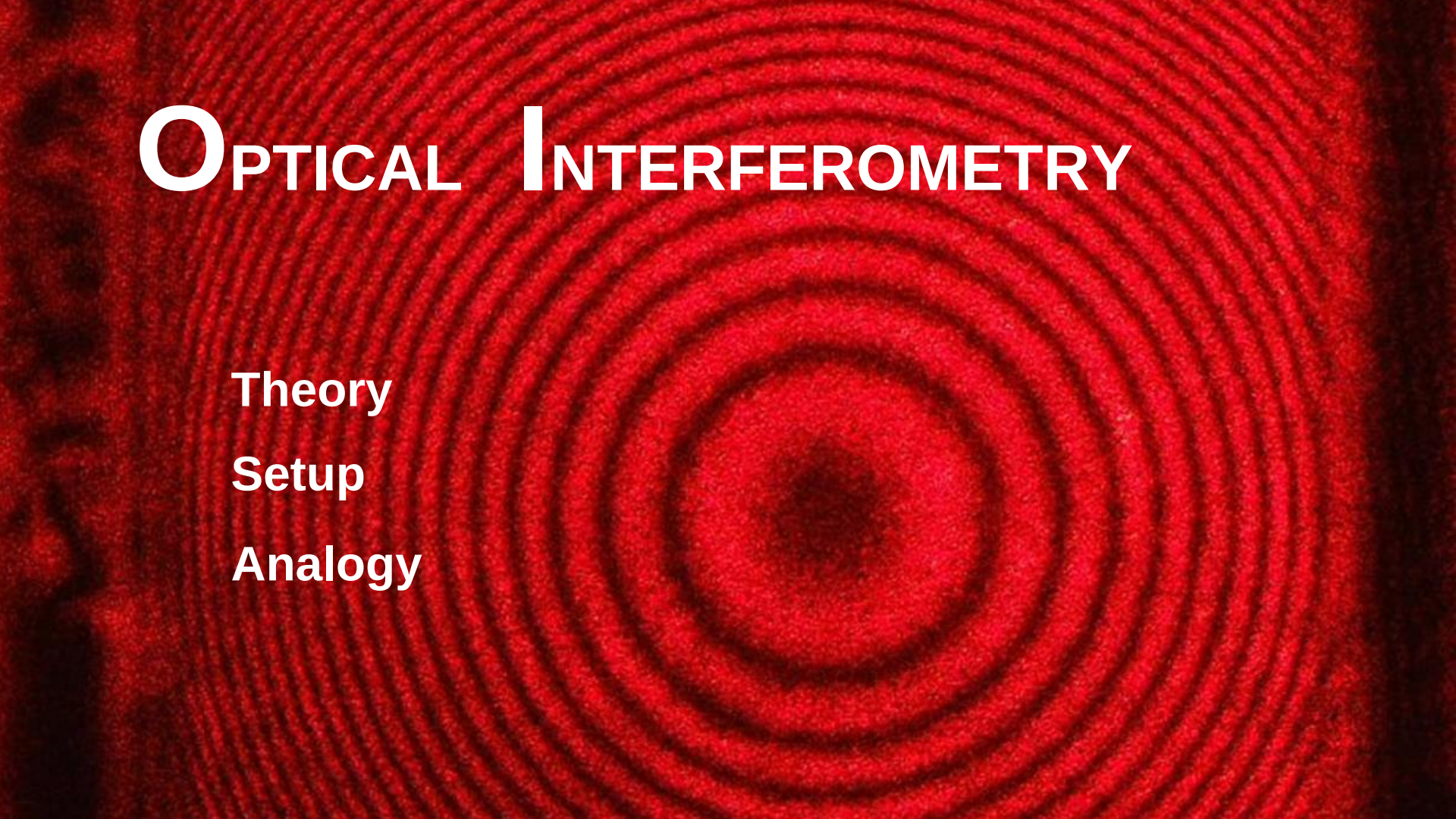
This goes to the **negative pole**.

These go to the **positive pole**.

Don´t mix up the resistors!

100Ω 8.2kΩ 10Ω 10Ω 10kΩ

GOOD LUCK!!

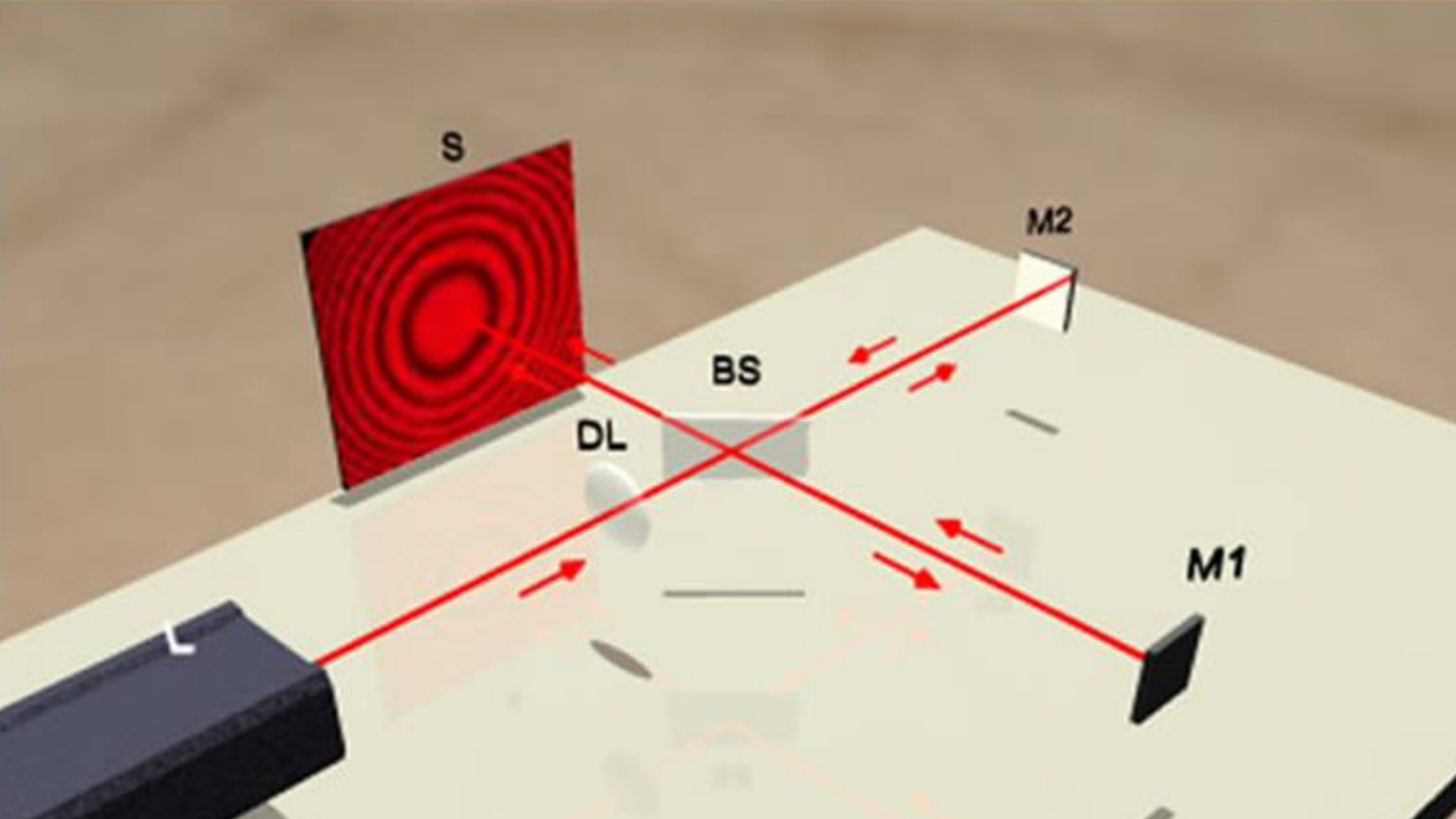


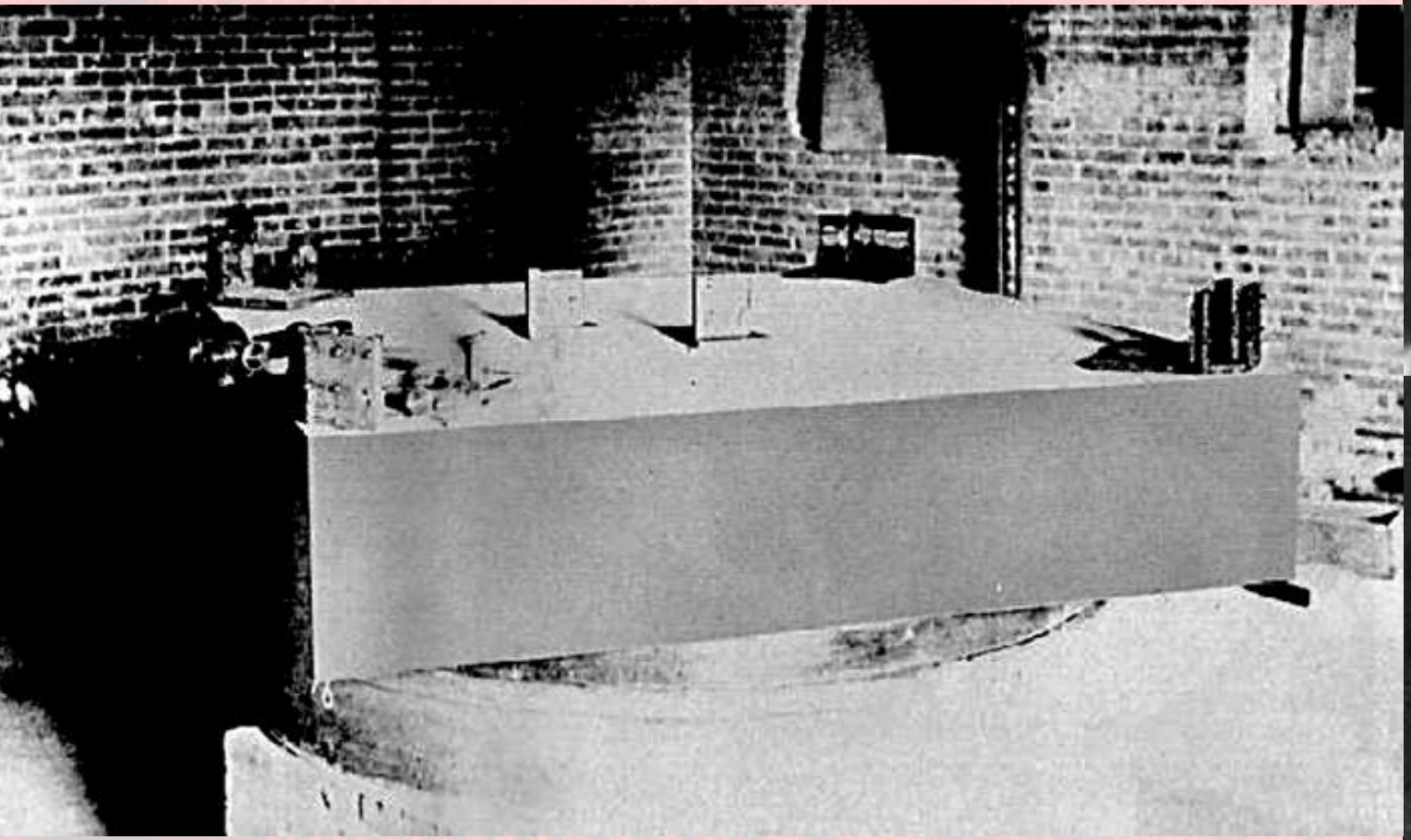
Optical Interferometry

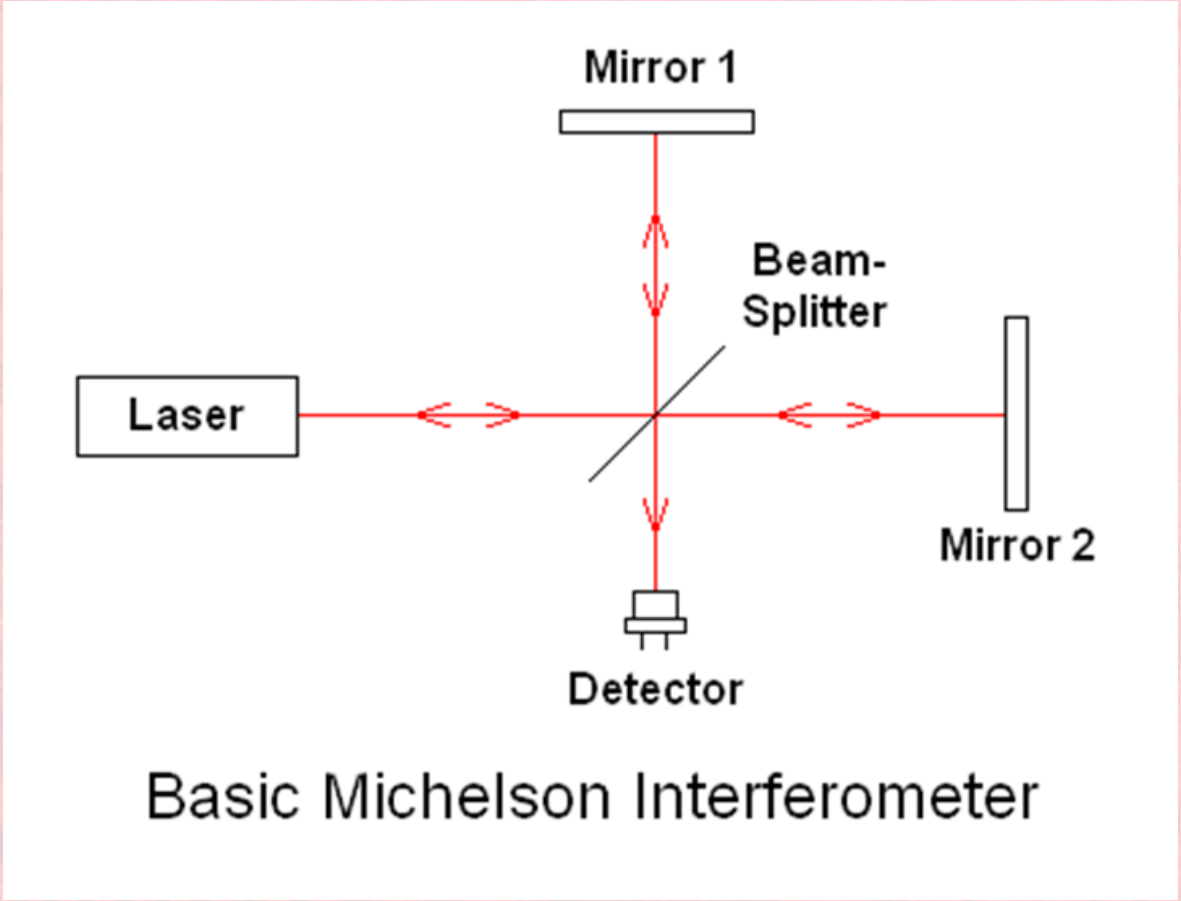
Theory

Setup

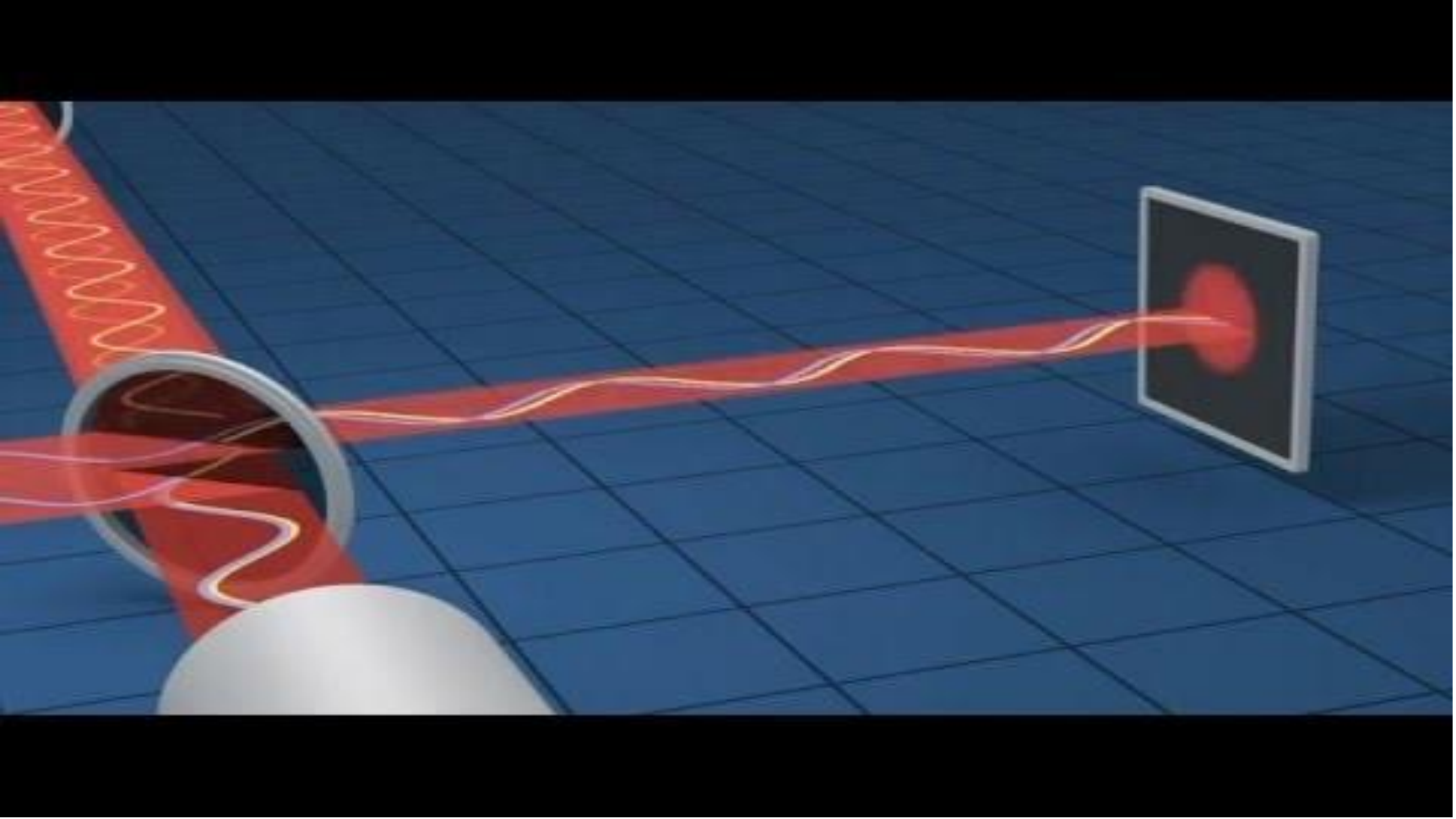
Analogy


S
M2
BS
DL
M1
L

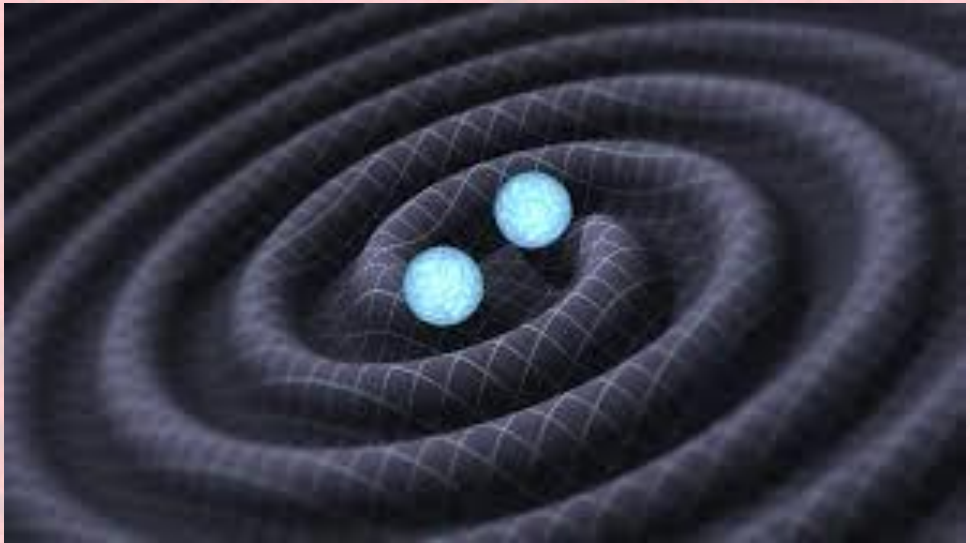




Basic Michelson Interferometer



https://www.youtube.com/watch?v=UA1qG7Fjc2A



Set up (Equipments)

Iron plate : 1

He-Ne laser source : 1
(λ= 632.8nm)

Iron stand : 1

Screen : 1

Mirrors* : 3

Lens* : 1

Beam splitter* : 1
(45% Reflection/45% Passing through)

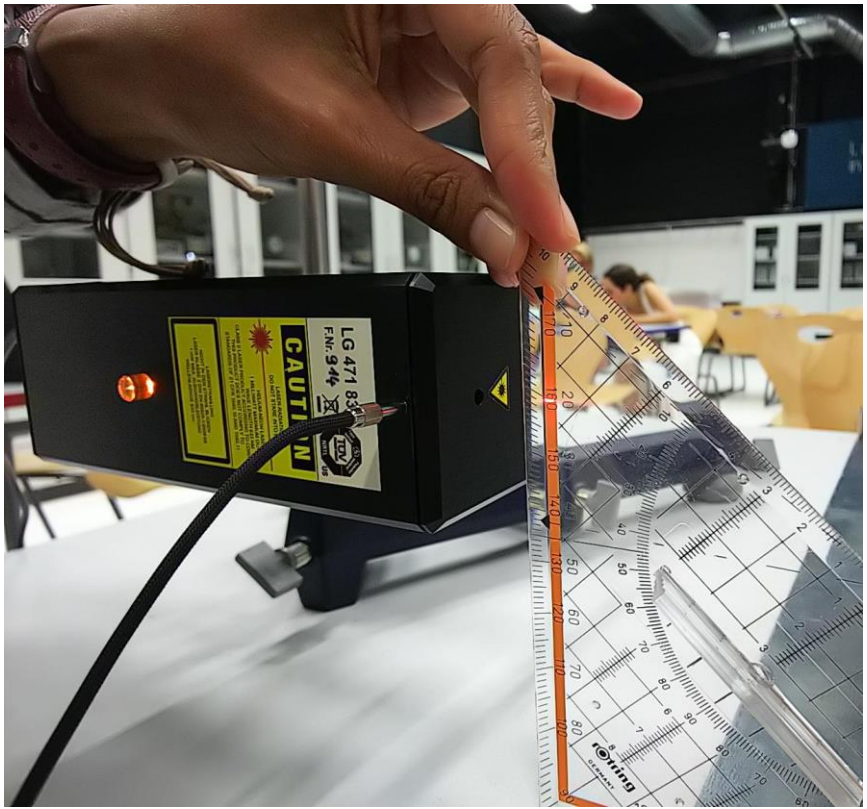
Neodymium magnet : 5

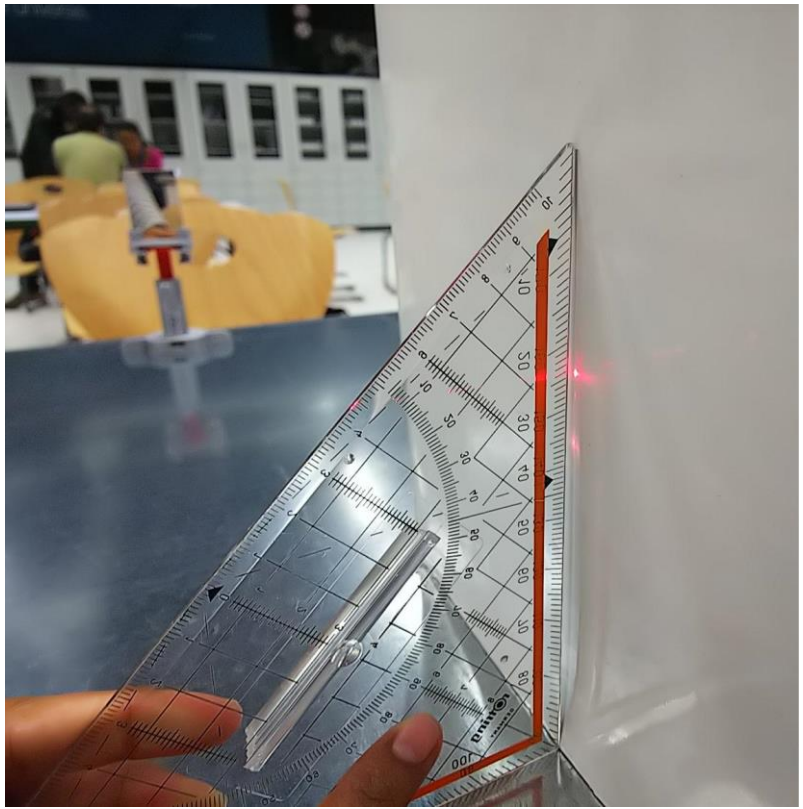
* = Mount them on a stands
made with a 3D printers

Set up

Set up

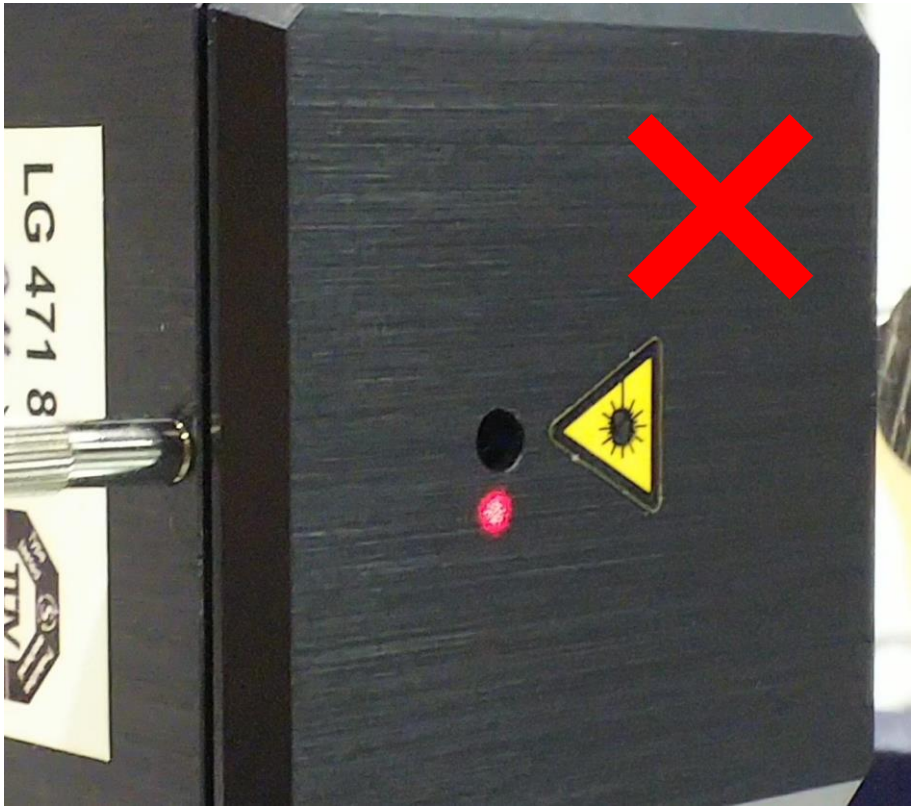
Set up (Alignment)

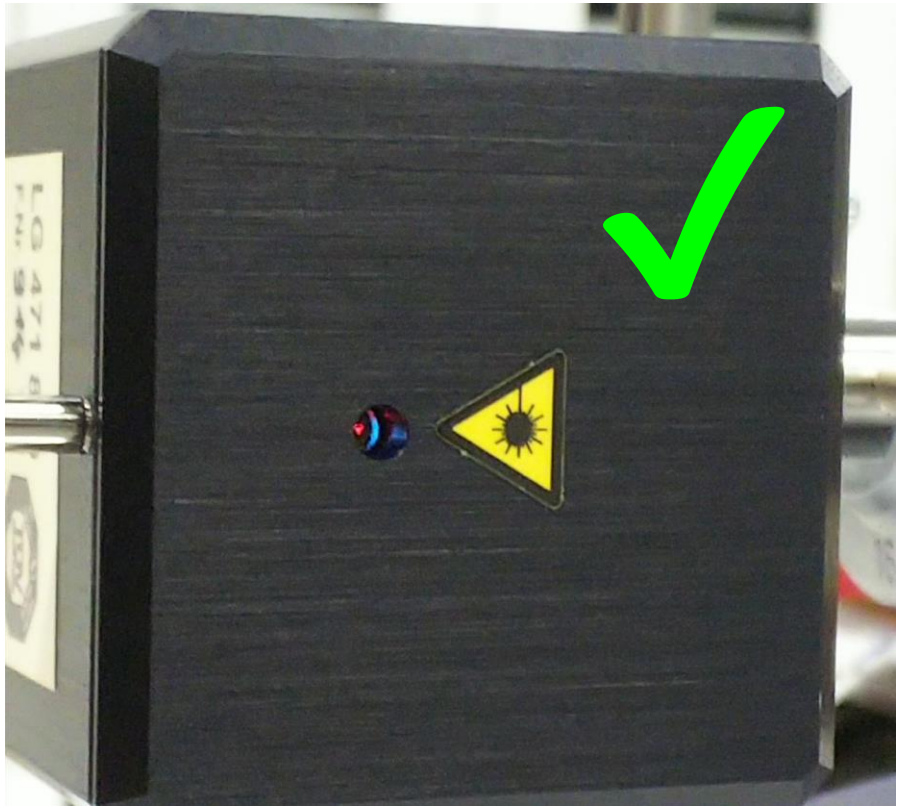




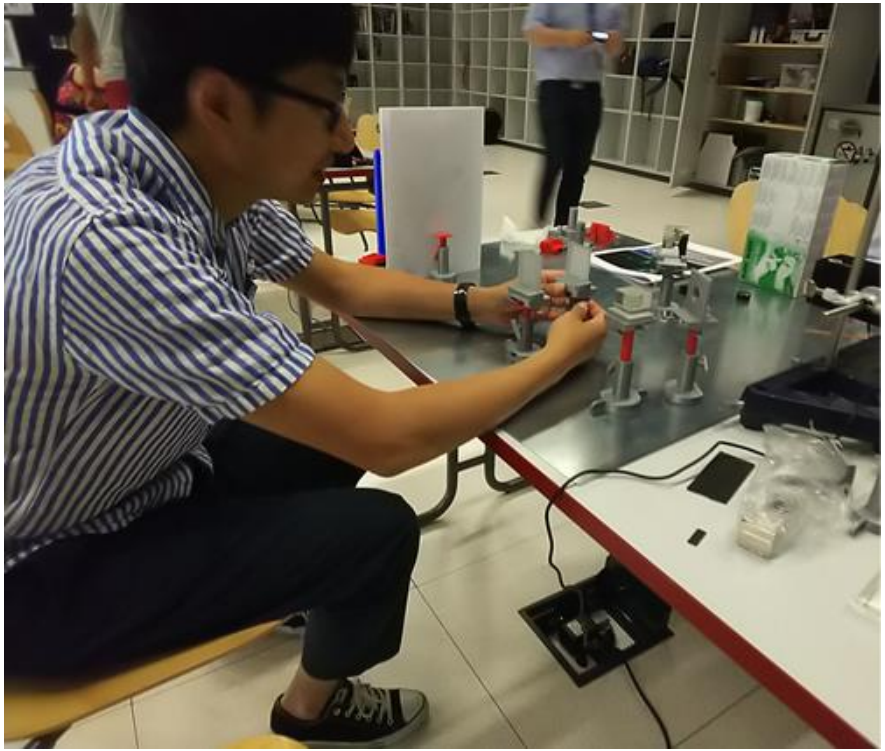
Set up (Alignment)

Set up (Alignment)

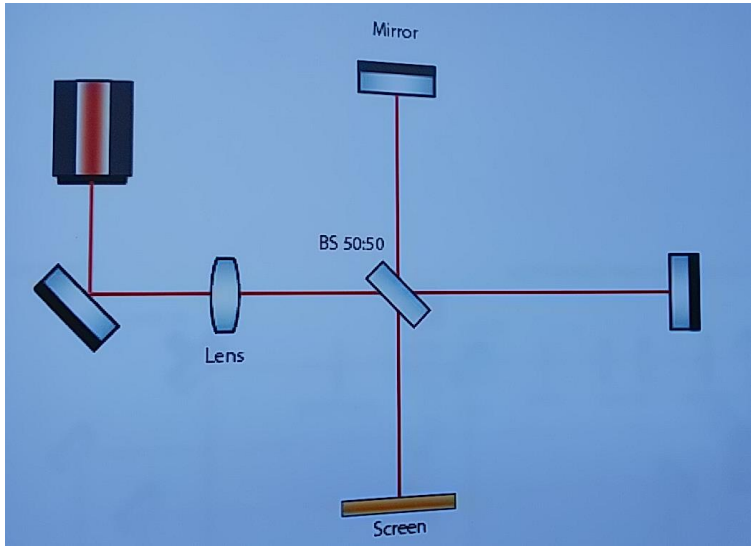


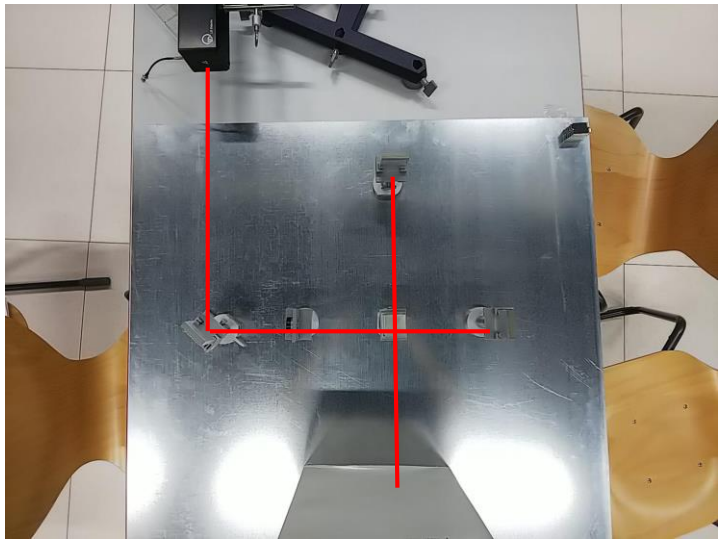


Set up (Alignment)

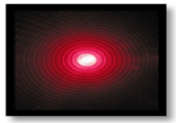


Set up





Analogy

- Optical Interferometry = LHC 
- Red Laser (photon) = Proton 
- Mirrors = Dipoles 
- Lenses = Quadrapoles 
- Screen = Detector 
- Interference = Collision 

Difficulties

- To make sure that all beams are in a line (need time)

- The interference effect might hard to produce or not to clear to see

Limitations

- Great amount of time (preparation and execution)
- Big size class is not recommended
- Need teacher’s supervision

Recommendation

It might be done at school, but...

- Teachers should do some preparations of the experiments before handing it out to students (for example, set up the magnets and the holders).
- For the base plate, it is better to use the grid one.
- Make it clear to students that LHC is a complicated tool, thus what they get here is a simple analogy.

Thank you :)