A hands-on tour through particle physics on a small budget

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All material: cern.ch/s-cool-lab
CERN S‘Cool LAB
a hands-on particle physics learning laboratory

1. Simple hands-on activities for your classroom
2. See and experience some of our activities
3. Your opinion on future hands-on activities
Experiments: high-tech vs. low-cost

In S’Cool LAB: high-tech

For the classroom: low-cost
A hands-on tour through particle physics on a small budget

cern.ch/s-cool-lab/classroom-activities
Congratulations!

According to your answers, the particle which fits your personality best is a/an

Dark matter is called 'dark' because physicists have not been able to discover it directly, but astronomers can see the effect it has on galaxies. According to one of the best theories, dark matter is made of weakly interacting heavy particles, so called WIMPs.

cern.ch/identities
Quark puzzle
Scattering Experiment
Bubble Chamber Worksheets

24 GeV/c protons from CERN‘s PS
10/08/1972, 2m Bubble Chamber
3D-Printable Black Box
Ideas for (future) experiments

- How interesting do you think this experiment is for school use?
- How easy or difficult would it be for you to use the experiment in the physics classroom?
- Could you imagine to assemble the experiment from individual parts?
- Should the S'Cool LAB team pursue this idea further?
A 3D printable ATLAS magnet model

(Image: CERN)

FreeCAD 0.16
scaled 1:100

8x

16x

4x

16x

+500 m copper wire

S'Cool LAB www.thingiverse.com/thing:1722230
A 3D printable ATLAS magnet model
Interferometer
Interferometer

\[ \Delta s = s_2 - s_1 \]
## Interferometer

<table>
<thead>
<tr>
<th>No.</th>
<th>Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>13x</td>
<td>3D printed parts</td>
</tr>
<tr>
<td>5x</td>
<td>Mirror, Beam Splitter, Lens</td>
</tr>
<tr>
<td>1x</td>
<td>Laserpointer</td>
</tr>
<tr>
<td>1x</td>
<td>Steel baseplate</td>
</tr>
<tr>
<td>6x</td>
<td>Knurled screw</td>
</tr>
</tbody>
</table>

### Risks & Dangers
DIY Diode Detector

“a complete α and β spectrometer for 20 bucks”

- fits in a tin box for candies
- complete open source design
- output connected to soundcard/headset input
- simple enough for students to do the soldering
- detects α-particles and electrons: 33 keV – 8 MeV

publication pending, Oliver Keller
DIY Diode Detector

Columbite stone

KCl Potassium table salt

[Graph showing electron and alpha distributions]
## DIY Diode Detector

<table>
<thead>
<tr>
<th>No.</th>
<th>Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DIY Diode Detector</td>
</tr>
<tr>
<td>1x</td>
<td>Computer, Smartphone OR Oscilloscope</td>
</tr>
<tr>
<td>1x</td>
<td>Radioactive source or everyday objects</td>
</tr>
</tbody>
</table>

### Risks & Dangers

- Soldering 😊

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*No.* Part

1. DIY Diode Detector

1x Computer, Smartphone OR Oscilloscope

1x Radioactive source or everyday objects
Quadrupole Ion Trap
Quadrupole Ion Trap

High voltage 3 kV
# Quadrupole Ion Trap

## Risks & Dangers

<table>
<thead>
<tr>
<th>Description</th>
<th>Picture</th>
<th>Price</th>
<th>Online Shop</th>
<th>Stock Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x Resistor (10 kΩ)</td>
<td></td>
<td>8 €</td>
<td></td>
<td>2960572</td>
</tr>
<tr>
<td>Multi Contact 4mm Banana plug sockets</td>
<td></td>
<td>6 € for 2 pieces</td>
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<td>404-200</td>
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<tr>
<td>1 x Toggle Switch On-Off-On*</td>
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<td>25 € for 5 pieces</td>
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<td>448-0753</td>
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<tr>
<td>Male to Male Leads (9 required)</td>
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<td>5 € for packs of 10 (20 € total)</td>
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<td>701-6463, 701-6454</td>
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<tr>
<td>Male to Female Leads (6 required)</td>
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<td></td>
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<tr>
<td>Electric Paint (Bare Conductive)</td>
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<td>20 € for 50 ml</td>
<td>RS Components</td>
<td>835-2693</td>
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<tr>
<td>Breadboard</td>
<td></td>
<td>18 €</td>
<td></td>
<td>102-9147</td>
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<tr>
<td>Capacitors</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>1 x 1 μF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 x 10 μF</td>
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</tr>
<tr>
<td>Diode</td>
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<tr>
<td>Packs of 10 for 5 €</td>
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<td>251-3025</td>
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<tr>
<td>2 x NPN Transistor</td>
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<tr>
<td>Packs of 10 for 3 €</td>
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<td></td>
<td></td>
<td>739-0442</td>
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<tr>
<td>Resistors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 x 100 Ω</td>
<td></td>
<td></td>
<td></td>
<td>707-8583, 707-8227, 707-8902, 707-8300</td>
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<tr>
<td>1 x 8.2 kΩ</td>
<td></td>
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<td></td>
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<tr>
<td>1 x 10 kΩ</td>
<td></td>
<td></td>
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<tr>
<td>10 kΩ Potentiometer</td>
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<td>3 €</td>
<td></td>
<td>408-8705</td>
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<tr>
<td>Battery Strap (Clip)</td>
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<td>5 for 4 €</td>
<td></td>
<td>489-021</td>
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<tr>
<td>9V Battery</td>
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<td>8 €</td>
<td></td>
<td>841-7002 (or 386-9997)</td>
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<tr>
<td>2 x High power LED</td>
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<td>0.12 € per piece</td>
<td>Reichelt Elektronik</td>
<td>LED 3-5000L GN</td>
</tr>
</tbody>
</table>
Linear Accelerator / Salad Bowl Accelerator
Linear Accelerator
Linear Accelerator / Salad Bowl Accelerator

- Plastic tube
- Aluminium foil
- High voltage
- Styrofoam
- Cables, clips
- Conducting paint
- Ping pong ball
Now it is your turn to explore the lab

Enjoy your discoveries!
What do you think?

Tell us your opinion!

• How interesting do you think this experiment is for school use?
• How easy or difficult would it be for you to use the experiment in the physics classroom?
• Could you imagine to assemble the experiment from individual parts?
• Should the S'Cool LAB team pursue this idea further?
Plasma electron gun

Simple Vacuum Pump

High Voltage Power Supplies
Plasma electron gun
# Plasma electron gun

<table>
<thead>
<tr>
<th>No.</th>
<th>Part</th>
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<tbody>
<tr>
<td>2x</td>
<td>3D printed cap</td>
</tr>
<tr>
<td>1x</td>
<td>Perspex tube</td>
</tr>
<tr>
<td>2x</td>
<td>High Voltage Power Supply</td>
</tr>
<tr>
<td>1x</td>
<td>Vacuum Pump</td>
</tr>
<tr>
<td></td>
<td>Screws, washers</td>
</tr>
</tbody>
</table>

## Risks & Dangers

- Vacuum
S‘Cool LAB programmes

S’Cool LAB PLUS+

A half-day programme for high school students (aged 16-19) which includes cloud chambers, + one additional experiment, + participation in PER projects. approx. 700 participants per year

Cloud Chamber WS

A 90-minute hands-on particle physics workshop for high school students (aged 14 and above) and high-school teachers. approx. 6000 participants per year (5000 students & 1000 teachers)
Peltier Cloud Chamber
Peltier Cloud Chamber

https://www.instructables.com/id/Make-a-Cloud-Chamber-using-Peltier-Coolers/

- Peltier Coolers 2x
- Power Supply #1 12V / at least 8 A
- Power Supply #2 5 V / at least 2.5 A
- CPU Cooler / Fan
- Small Plastic Container
- Arctic Silver 5 Thermal Compound
- Alcohol
- Misc. electrical connectors to hook stuff up
- LED flashlight

Risks & Dangers
Spark chamber

https://www.youtube.com/watch?time_continue=91&v=-8GlzUjYazs
Spark chamber

Risks & Dangers