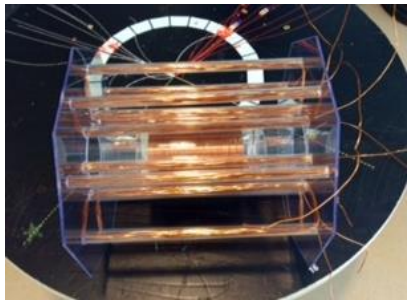
WORKING GROUP 4 – S'COOL LAB

THE PARTICLE DETECTOR

GIORGIO VACCHIANO
LEAH PEDDER
MARINA SILVA

THE ION TRAP

MAREK BALAZOVIC
MARKUS FRANSSON
HAMDAN DRAGHMEH



THE ATLAS MAGNET

LIZELLE SWANEPOEL
MIRIAM ROSENFELD
JULIA ALDEHOFF

SUPPORT: ALEXANDRA FEISTMANTL - VINCENT DARRAS - JULIA WOITHE

PARTICLE DETECTOR

HST 2015

GIORGIO VACCHIANO (IT)

LEAH PEDDER (USA)

MARINA SILVA (PT)

S'Cool LAB

SUBJECT

Particle camera MX-10 JABLOTRON

BASED ON PIXEL DETECTOR IN LHC

http://www.jablotron.com/en/about-jablotron-1/about-us/international-cooperation/jablotron-mx-10-1.aspx

- Characteristics
- Edu-kit

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JABLOTRON MX-10

The MX-10 Digital particle camera is a state-of-the-art educational tool for demonstrating radiation and analyzing radioactive sources.

It can record and recognize different kinds of ionizing particles (α,β,γ) and provides you with a lot of information to study. The accompanying Pixelman software, with easy installation on your PC, instantly displays and allows you to export all the acquired data.

Main features of MX-10

- instant display – unlike traditional quantum detectors (GM tubes, scintillators) , this device is virtually a digital radiation video camera
- clear recognition of particles - α, β, γ, MIP particles (e.g. muons from cosmic rays)
- easy-to-use in classroom experiments

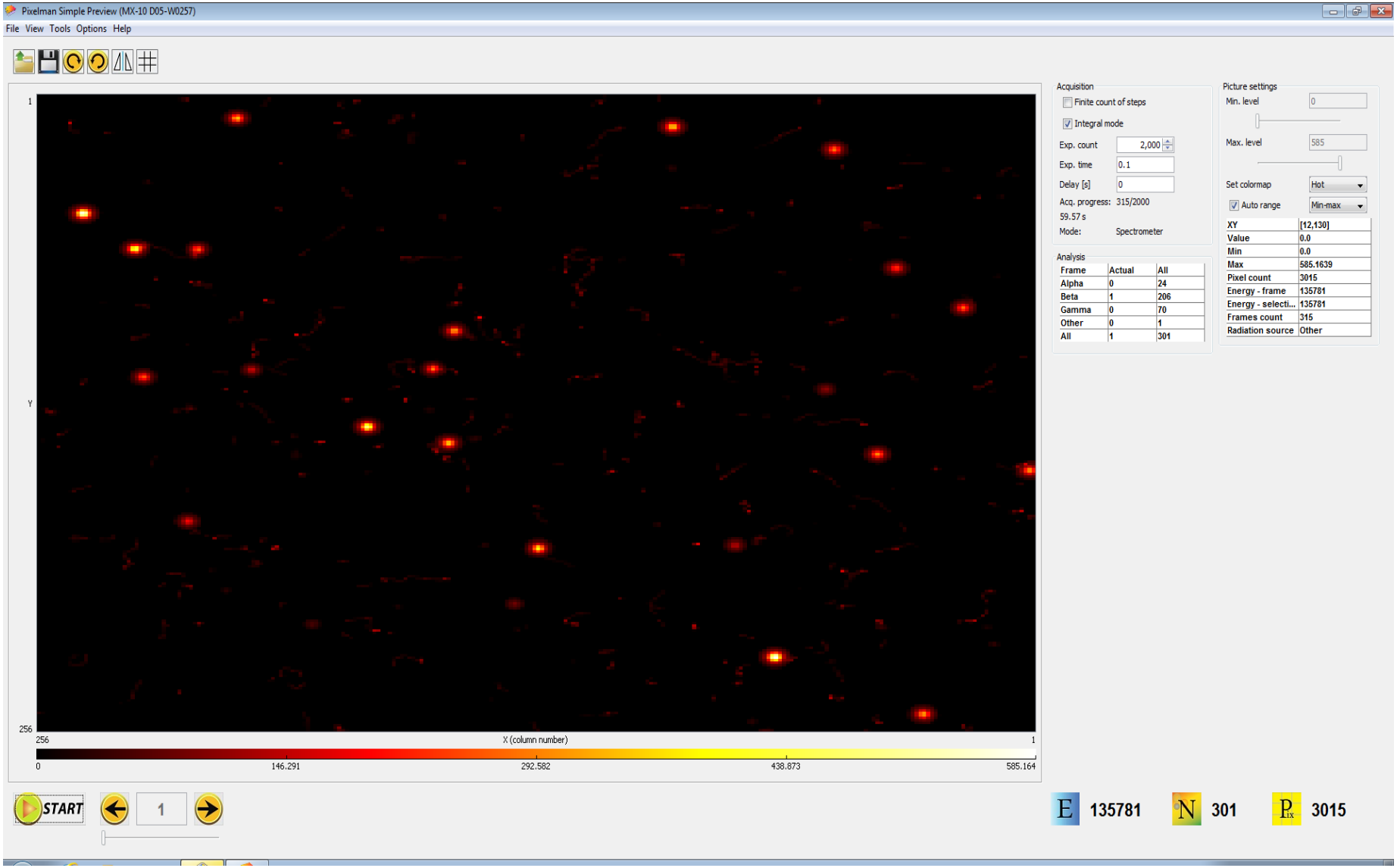
The basic MX-10 set

The basic MX-10 set contains:

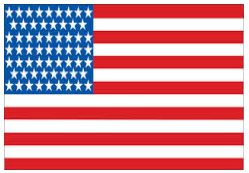
- MX-10 camera
- Pixelman software and Experiment Guide on a memory stick
- USB connecting cable

All packed in a hard case.

SOFTWARE


Pixelman Simple Preview (MX-10 D05-W0257)
File View Tools Options Help
Acquisition
Finite count of steps
Integral mode
Exp. count 2,000
Exp. time 0.1
Delay [s] 0
Acq. progress: 315/2000
59.57 s
Mode: Spectrometer
Picture settings
Min. level 0
Max. level 585
Set colormap Hot
Auto range Min-max
XY [12,130]
Value 0.0
Min 0.0
Max 585.1639
Pixel count 3015
Energy - frame 135781
Energy - selecti... 135781
Frames count 315
Radiation source Other
Analysis
Frame Actual All
Alpha 0 24
Beta 1 206
Gamma 0 70
Other 0 1
All 1 301
1
Y
256
256
X (column number)
1
0
146.291
292.582
438.873
585.164
START
1
E 135781
N 301
Pix 3015

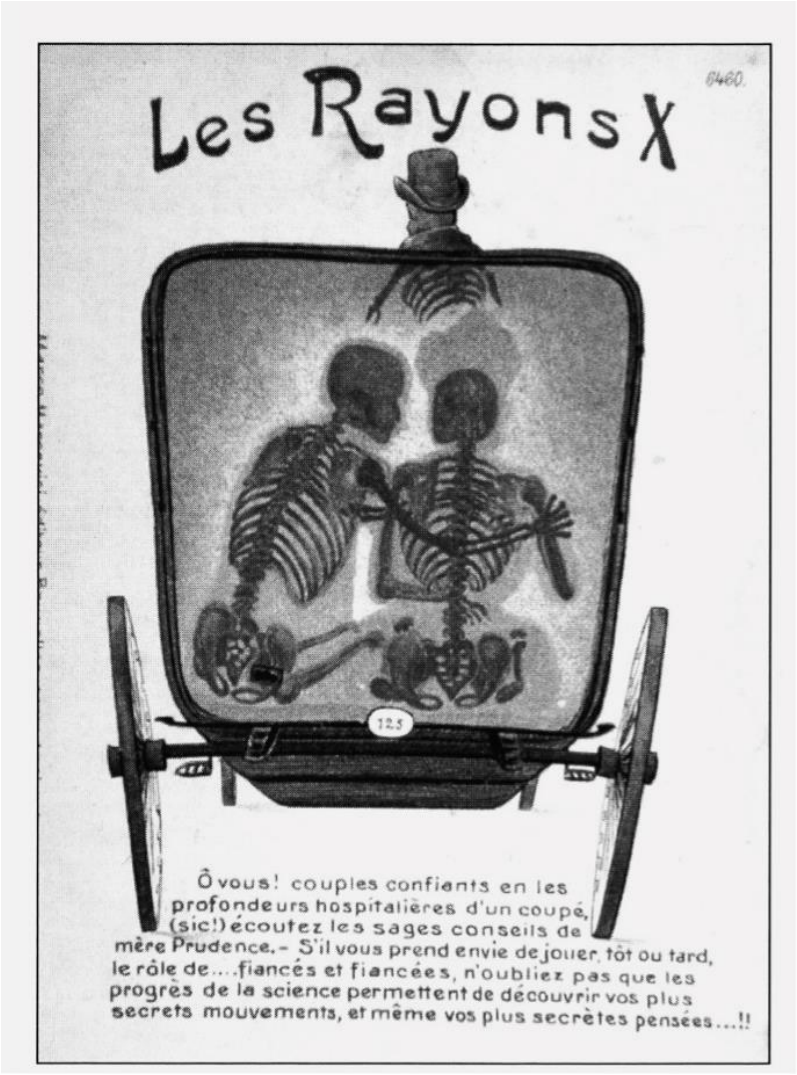
CURRICULA



	USA	PORTUGAL	ITALY
AGE	15-18	13-14	18-19
COMPULSORY	No	Yes	No
CONTENTS	Electromagnetic spectrum Energy Nuclear physics Modern physics	Electromagnetic spectrum Tecnology and equipment using radiation	Electromagnetic spectrum Nuclear physics Radioactivity

STUDENTS' CONCEPTIONS

- Don't know the meaning of "radioactivity", misunderstanding with radio waves
- "Radiation" has a frightening conotation
- No natural sources emit radiation, only the industrial because radiation is artificial
- There is no background radiation, we live in a free radiation environment
- Radioactivity is unstoppable
- Natural radiation is different from the one from radioactive sources
- Radiation is carried by the wind
- Radiation is danger because it is invisible
- Irradiation of objects results in radioactive objects



OUR PROPOSAL

Shielding test

- Al shielding
- Pb shielding
- Paper shielding
- Distance
- Thickness of Al

Tape X-rays

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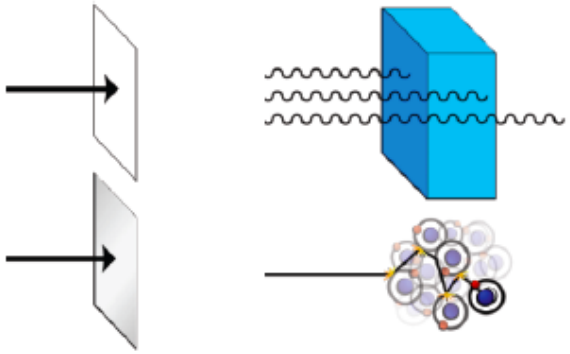
PROTOCOLS

MX-10 Particle Detector
Shielding Test



Theory	Experiment
• Make predictions using what you already know • Explain why you think what you do • Think about what makes sense to you	• Perform measurements • Record observations • Prove (or disprove) your predictions

If you notice that your predictions differ from what you see in your experiment, makes sure that you suggest why this might be the case.

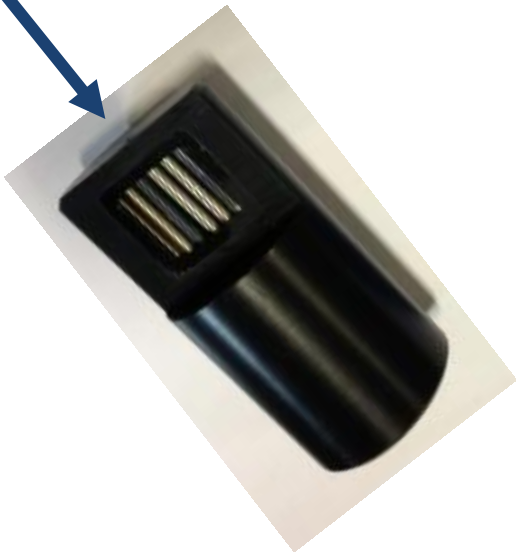
Prior Knowledge:

1. How is radiation[1] shielded?

2. Why do we need radiation shielding?

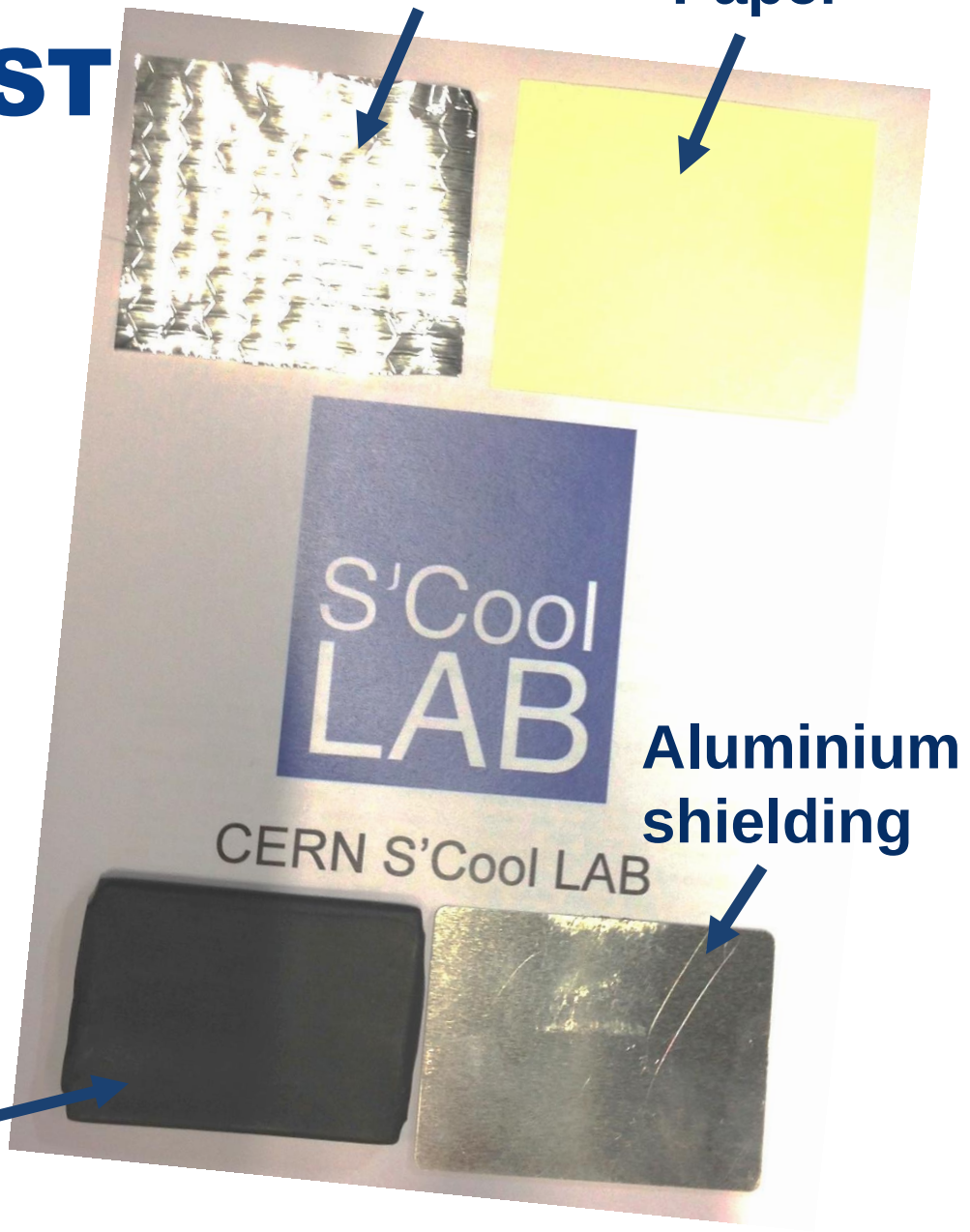
SHIELDING TEST

Radioactive source



Aluminium foil

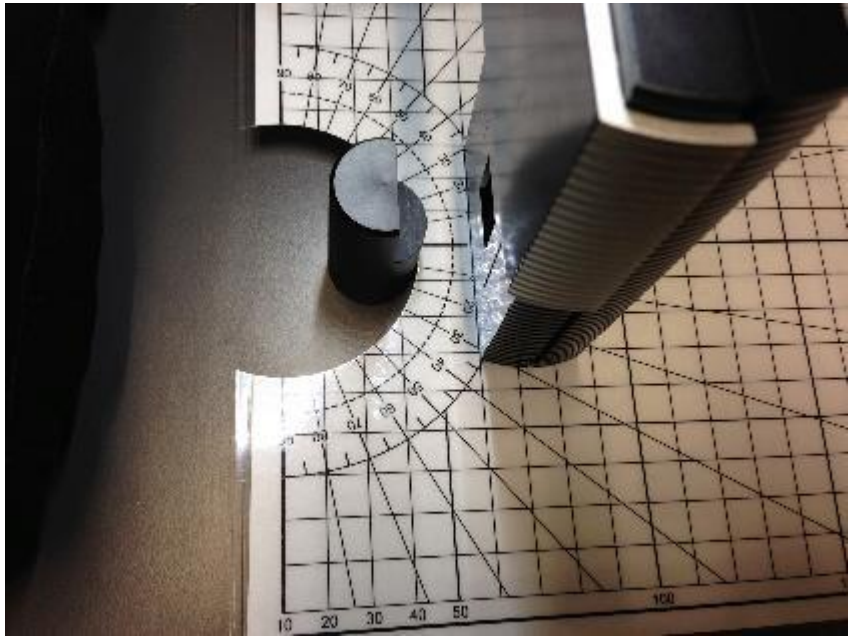
Paper



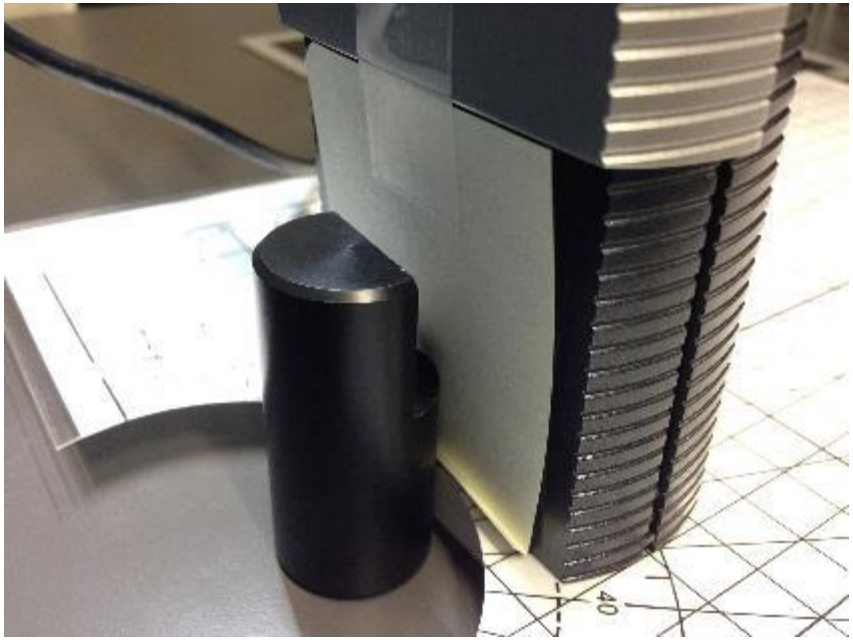
Aluminium shielding

Lead shielding

SHIELDING TEST

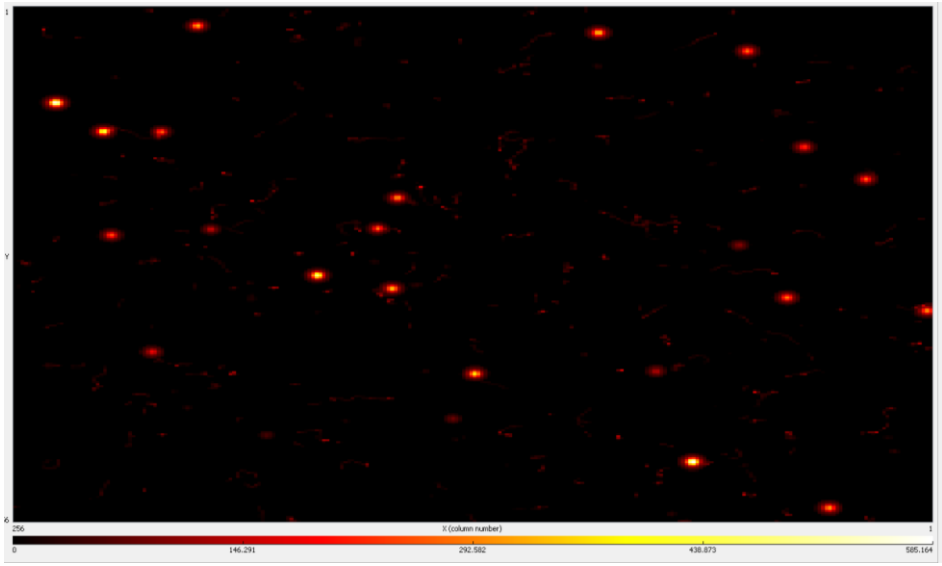


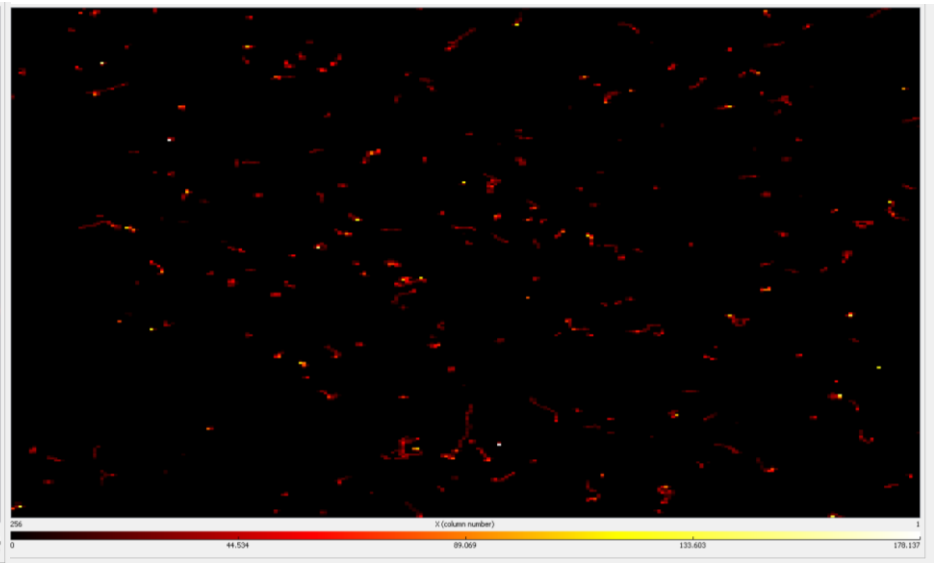
Without shielding



With shielding

SHIELDING TEST



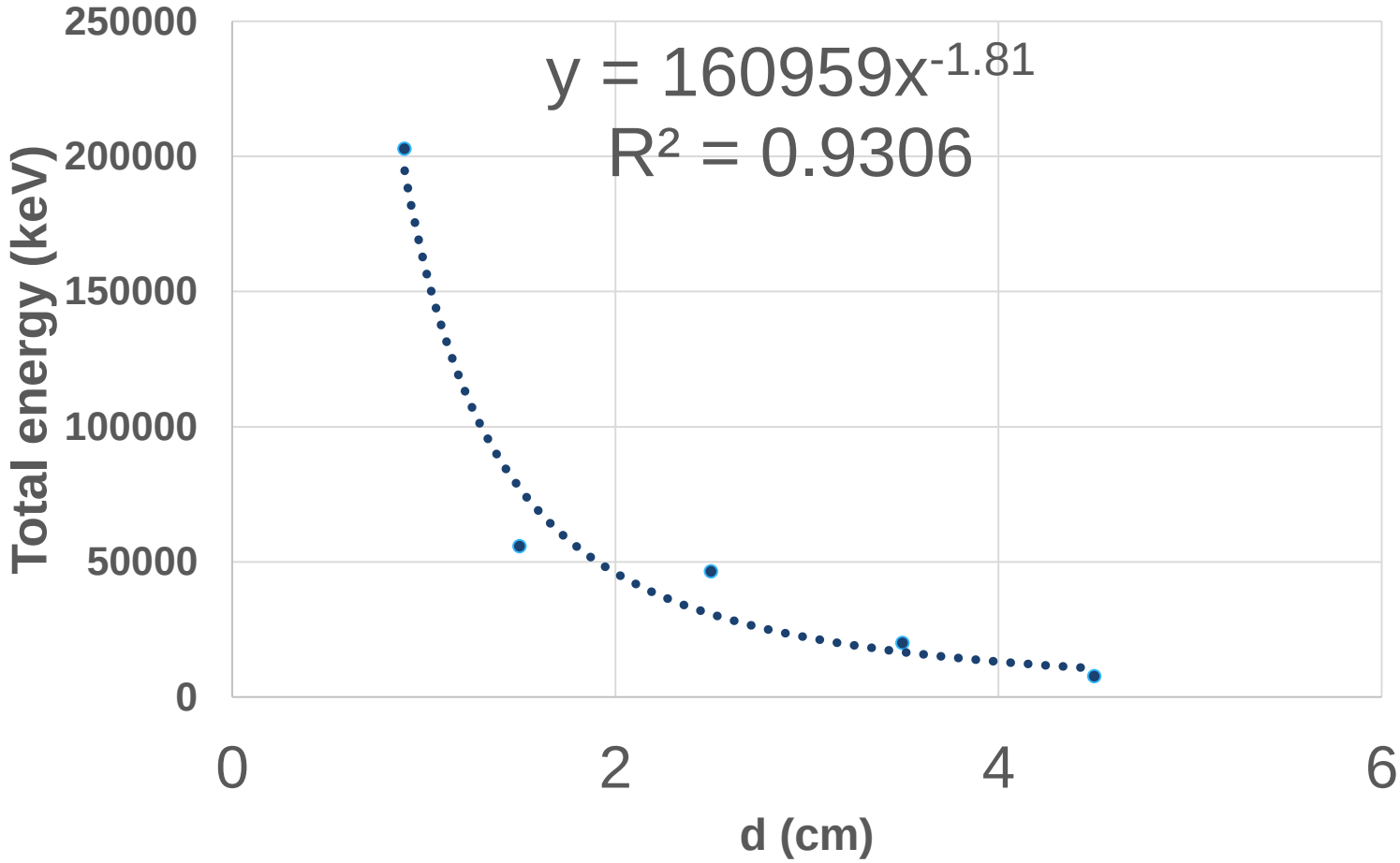


Without shielding

With paper shielding

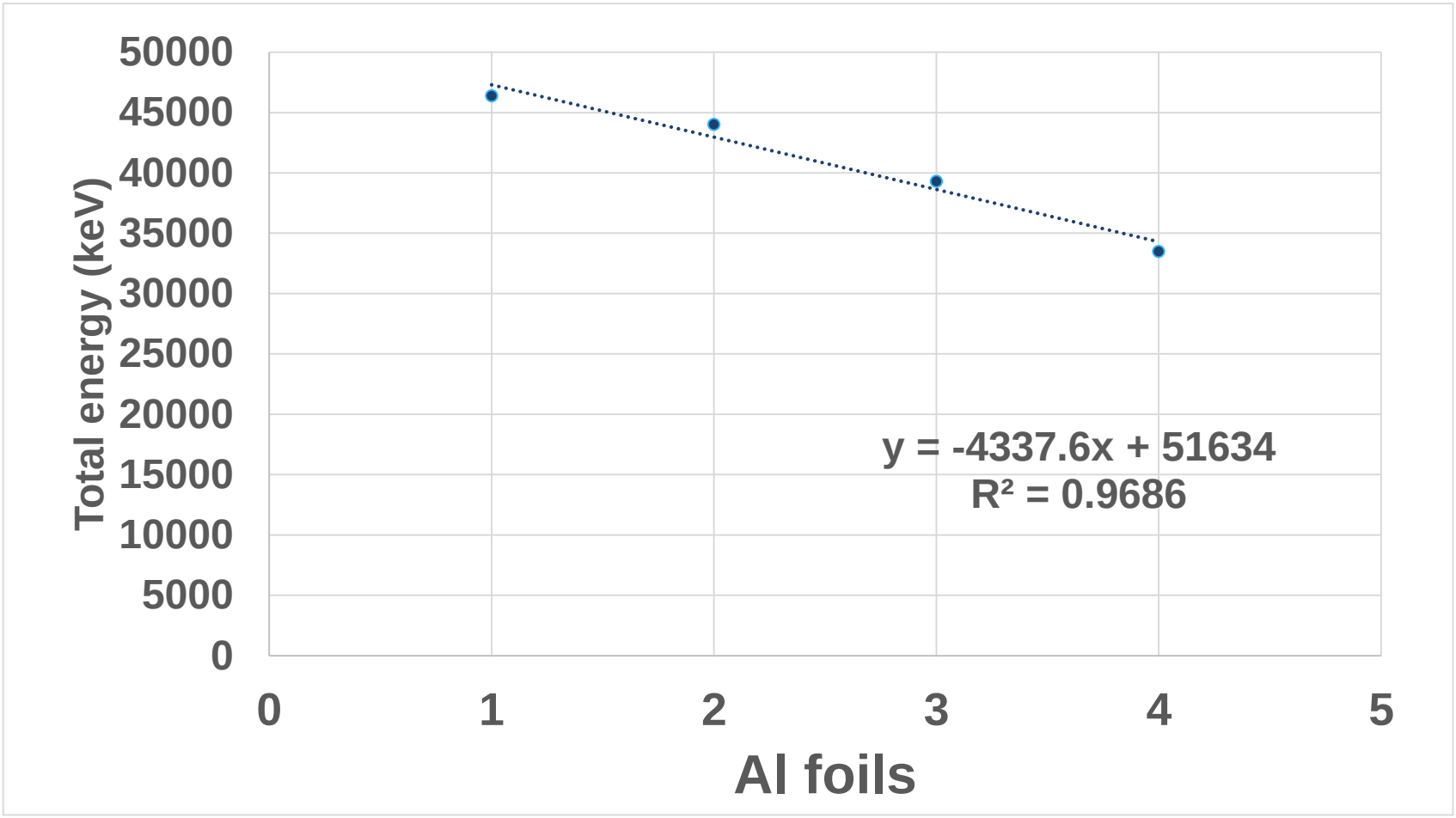
SHIELDING TEST

Total energy as function of distance to the source of radiation

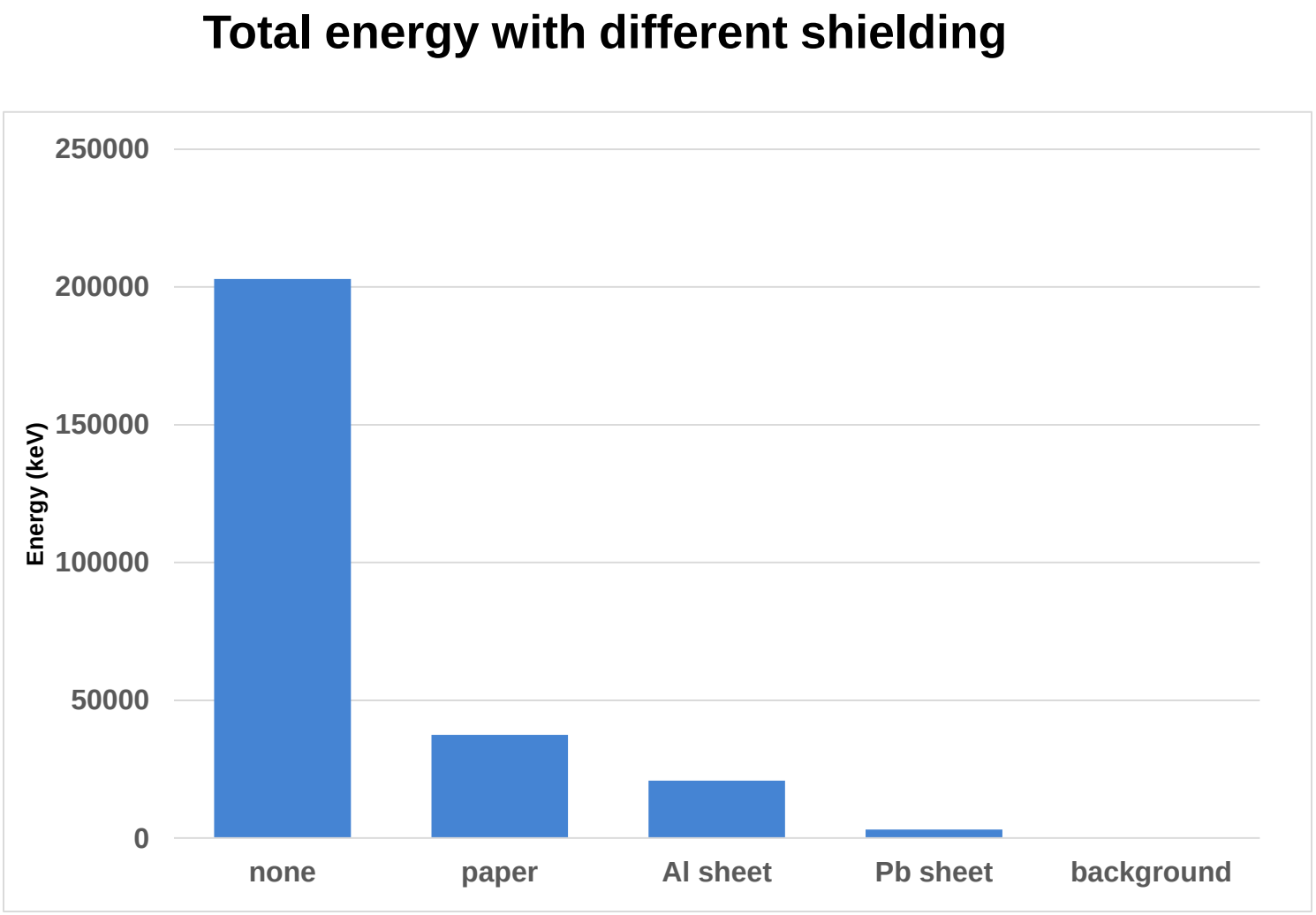


SHIELDING TEST

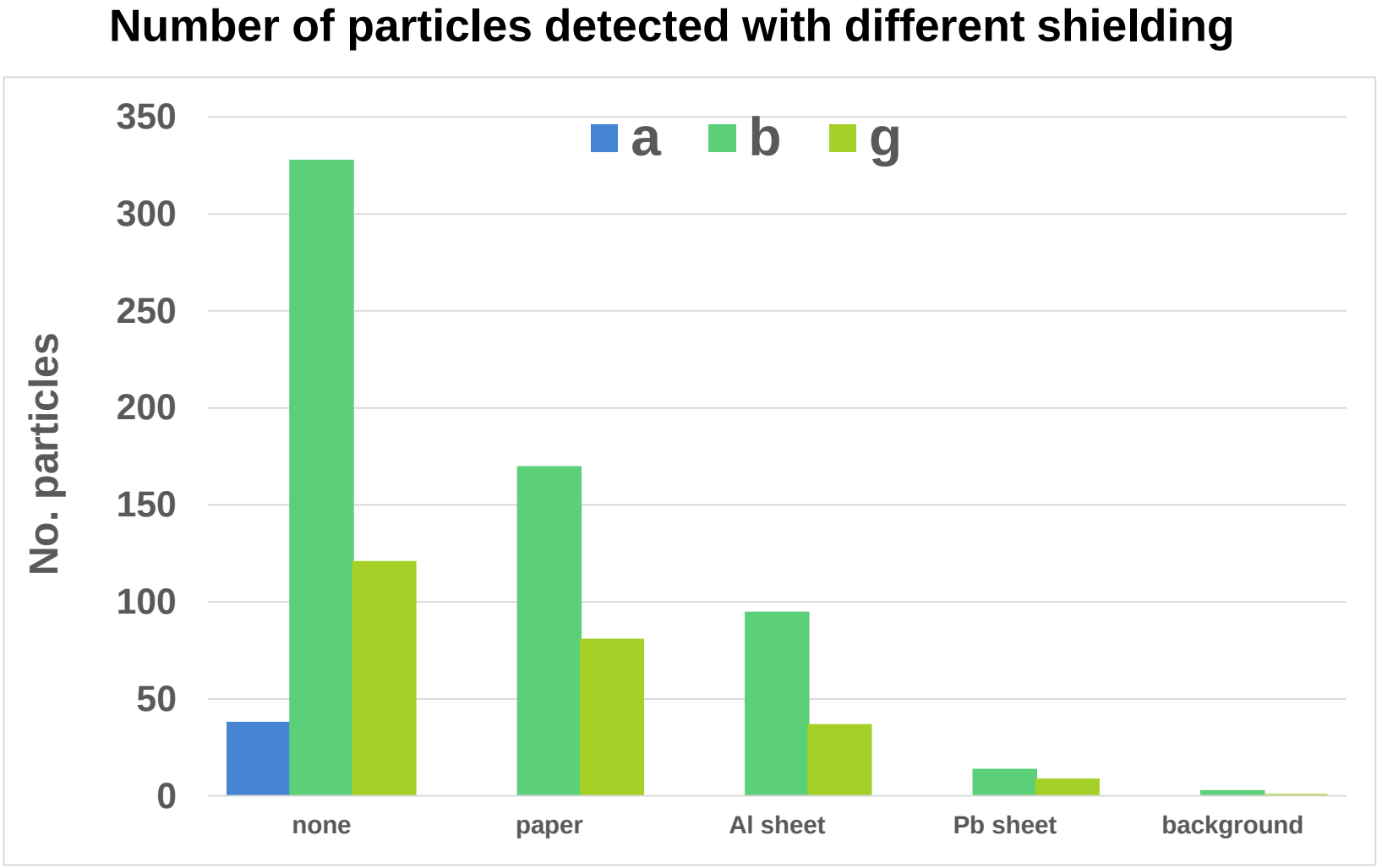
Total energy as function of thickness of aluminum foil



SHIELDING TEST



SHIELDING TEST

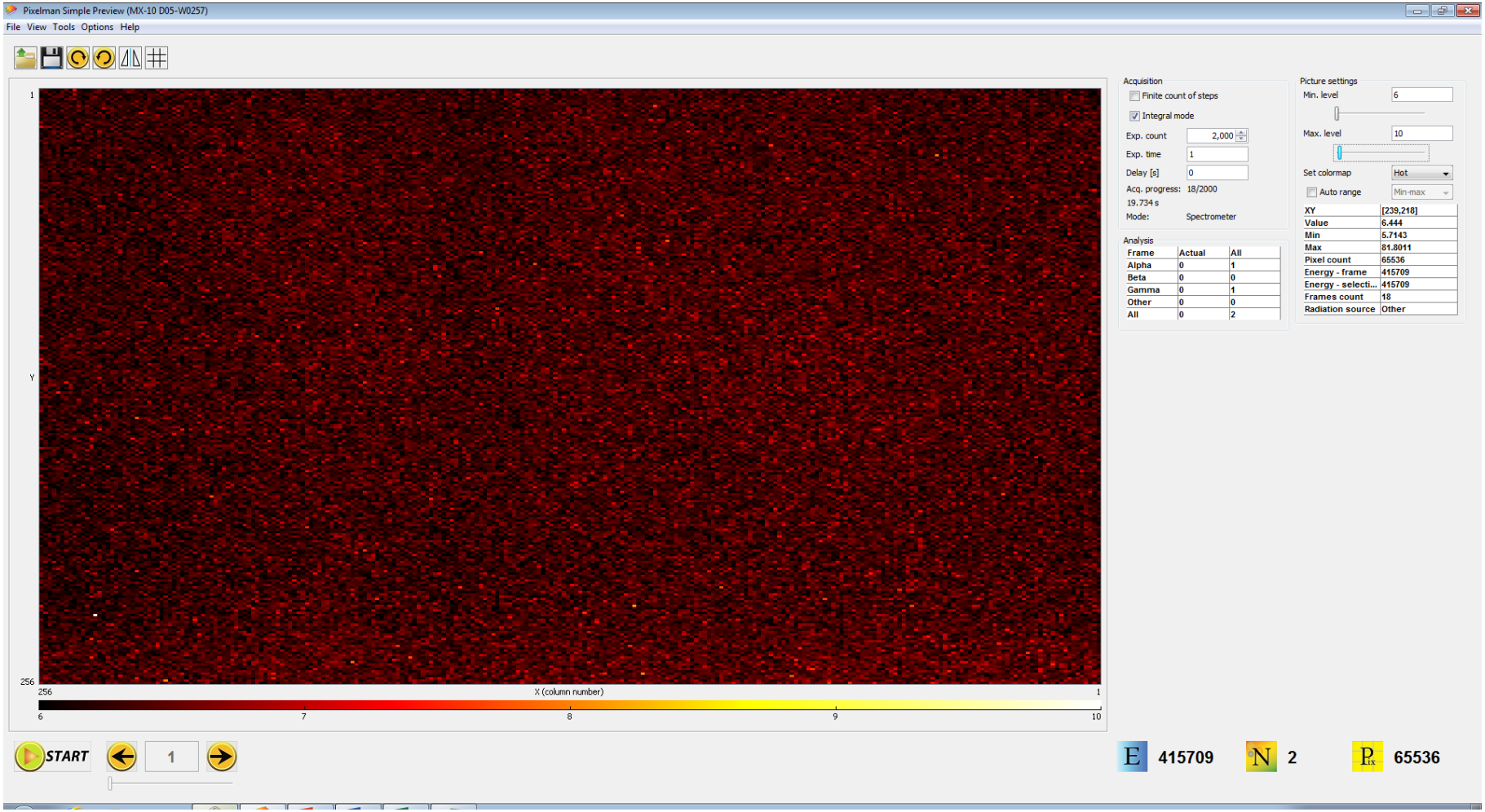


TAPE X-RAYS

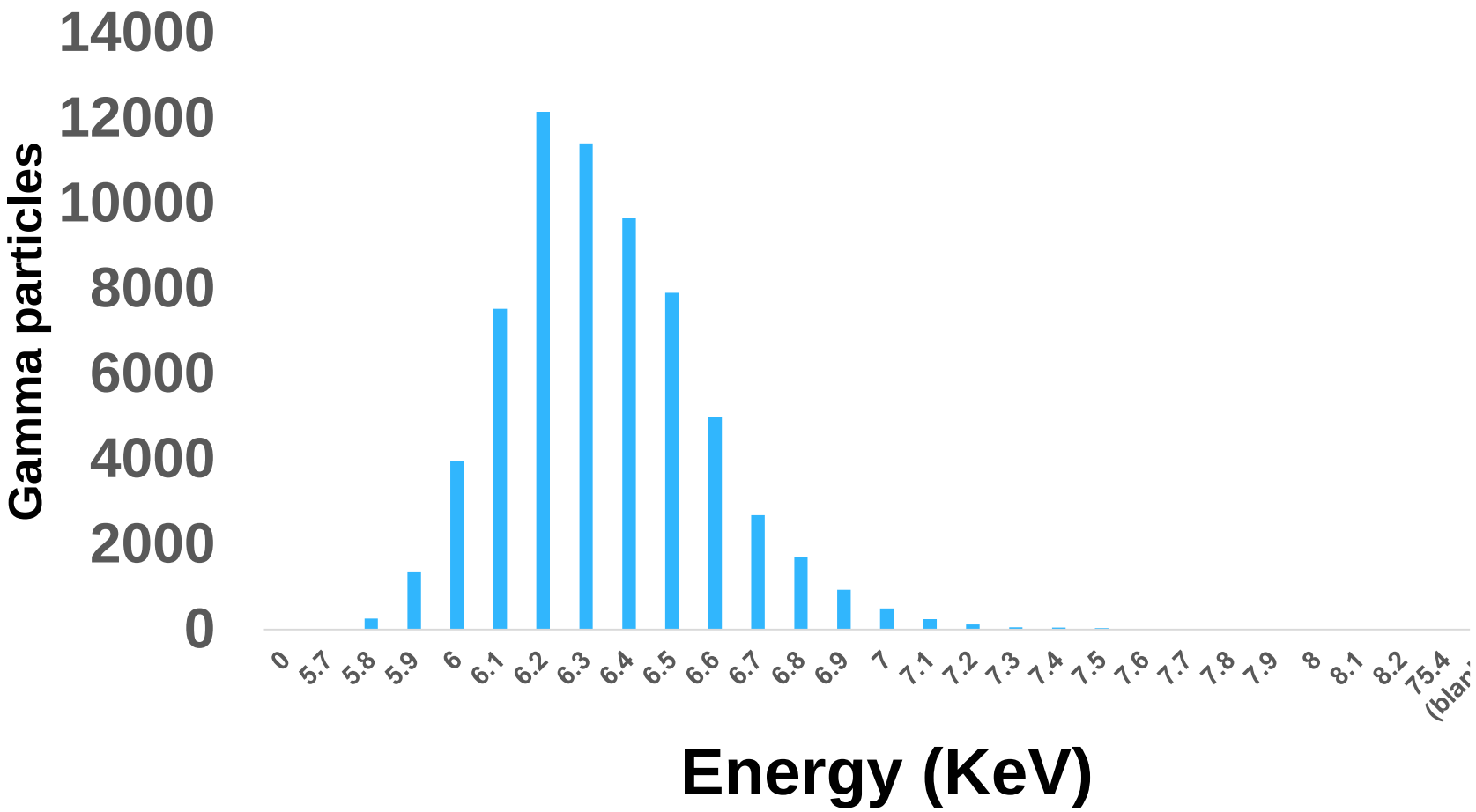

S'Cool
LAB
CERN S'Cool LAB


Scotch
Magic™
Recycled
cardboard*
Film made
from a natural
fibre resource**
8
19 mm x 33 m
Invisible
3M

TAPE X-RAYS


Pixelman Simple Preview (MX-10 D05-W0257)
File View Tools Options Help
Acquisition
Finite count of steps
Integral mode
Exp. count 2,000
Exp. time 1
Delay [s] 0
Acq. progress: 18/2000
19.734 s
Mode: Spectrometer
Analysis
Frame Actual All
Alpha 0 1
Beta 0 0
Gamma 0 1
Other 0 0
All 0 2
Picture settings
Min. level 6
Max. level 10
Set colormap Hot
Auto range Min-max
XY [239,218]
Value 6.444
Min 5.7143
Max 81.8011
Pixel count 65536
Energy - frame 415709
Energy - selecti... 415709
Frames count 18
Radiation source Other
1
256
X (column number)
256
1
6
7
8
9
10
START
1
E 415709
N 2
Pix 65536

TAPE X-RAYS


Gamma particles
14000
12000
10000
8000
6000
4000
2000
0
0
5.7
5.8
5.9
6
6.1
6.2
6.3
6.4
6.5
6.6
6.7
6.8
6.9
7
7.1
7.2
7.3
7.4
7.5
7.6
7.7
7.8
7.9
8
8.1
8.2
75.4
Energy (KeV)

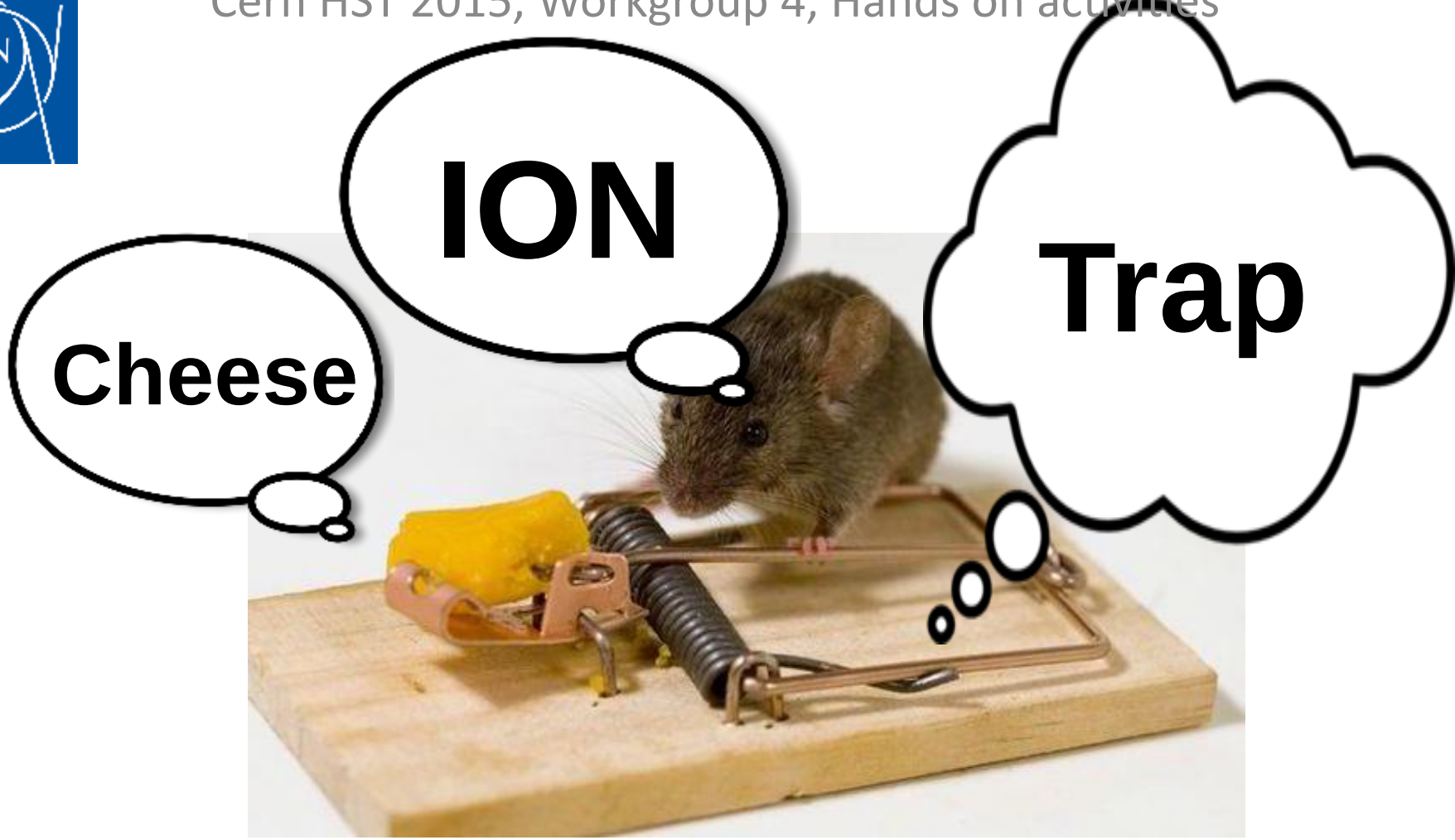
ALTERNATIVE

- **Android app for comic rays detection**
  - http://wipac.wisc.edu/deco
- **App with built in particle detector**
  - https://youtu.be/9ibceYbzScw

SOURCES

- **Sticky tape generates X-rays, Nature, 22-oct-2008**
  - http://www.nature.com/news/2008/081022/full/news.2008.1185.html
- **Becky Parker**
  - You're never too young to be a research scientist
  - TEDxCERN
  - https://www.youtube.com/watch?v=MTv1N-BLTiM
- **Eijkelhof, H. (1990), Radiation and risk in physics education**
  - http://rpd.oxfordjournals.org/content/68/3-4/273.full.pdf+html
- **Neumann, S. (2014). Three Misconceptions About Radiation – And What We Teachers Can Do To Confront Them. *The Physics Teacher*, 52, doi:10.1119/1.4893090**
  - http://scitation.aip.org/docserver/fulltext/aapt/journal/tpt/52/6/1.4893090.pdf?expires=1437573291&id=id&accname=2098973&checksum=8E4CFEB927CAA55165B5947116D63681
- **Rego, F. & Peralta, L. (2006). Portuguese students' knowlodge of radiation physics. *Physics Education*, 41 (3).**
  - http://iopscience.iop.org/0031-9120/41/3/009/pdf/0031-9120_41_3_009.pdf

DISCUSSION TIME 1!



Marek Balazovic, Markus Fransson, Hamdan Draghmeh

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What is an iontrap?

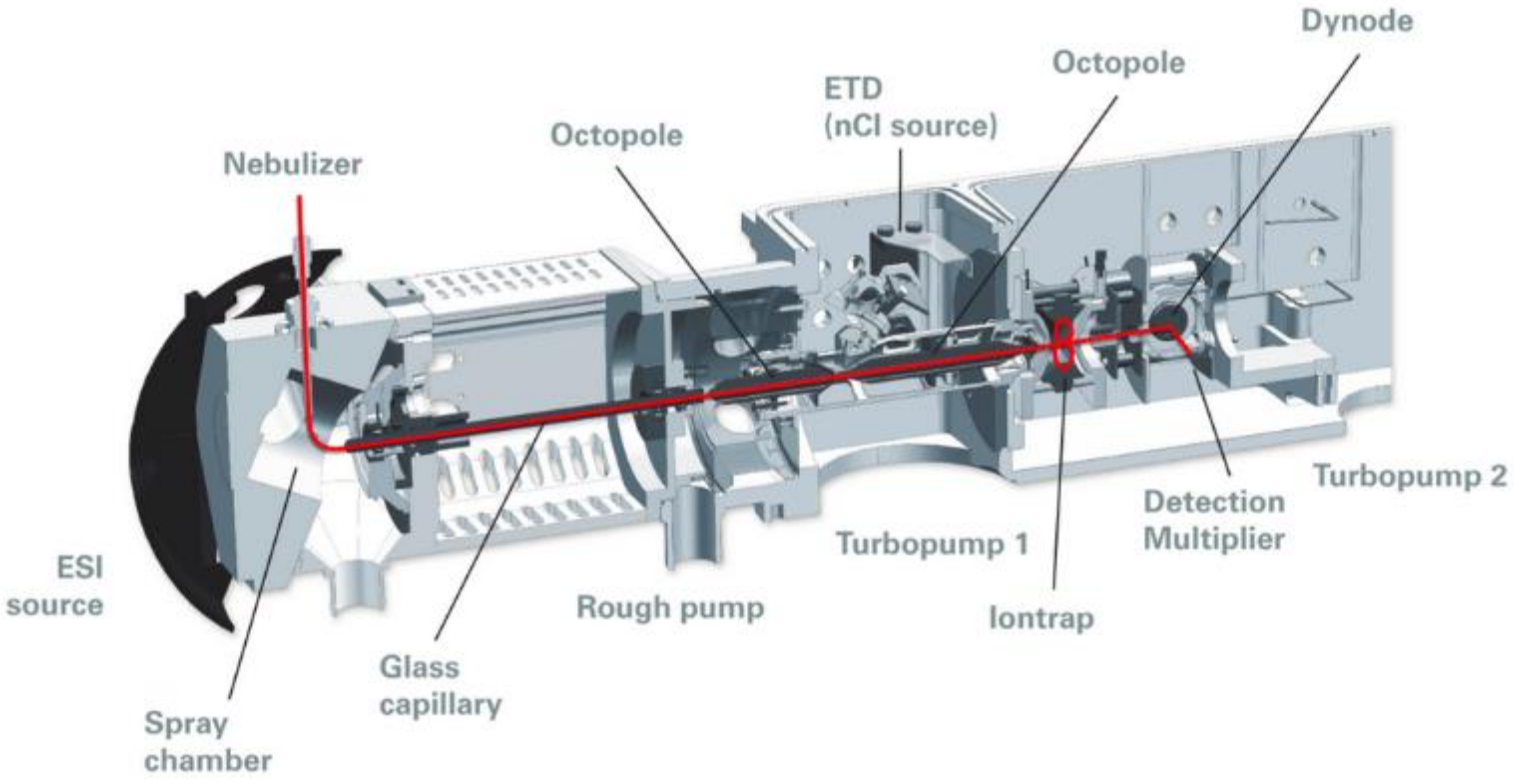
A quadrupole ion trap

Its also called "Paul" traps in honor of Wolfgang Paul.

Shared the Nobel Prize in Physics in 1989 for this work

Applications

Iontrap had been used in Mass spectrometry (MS)

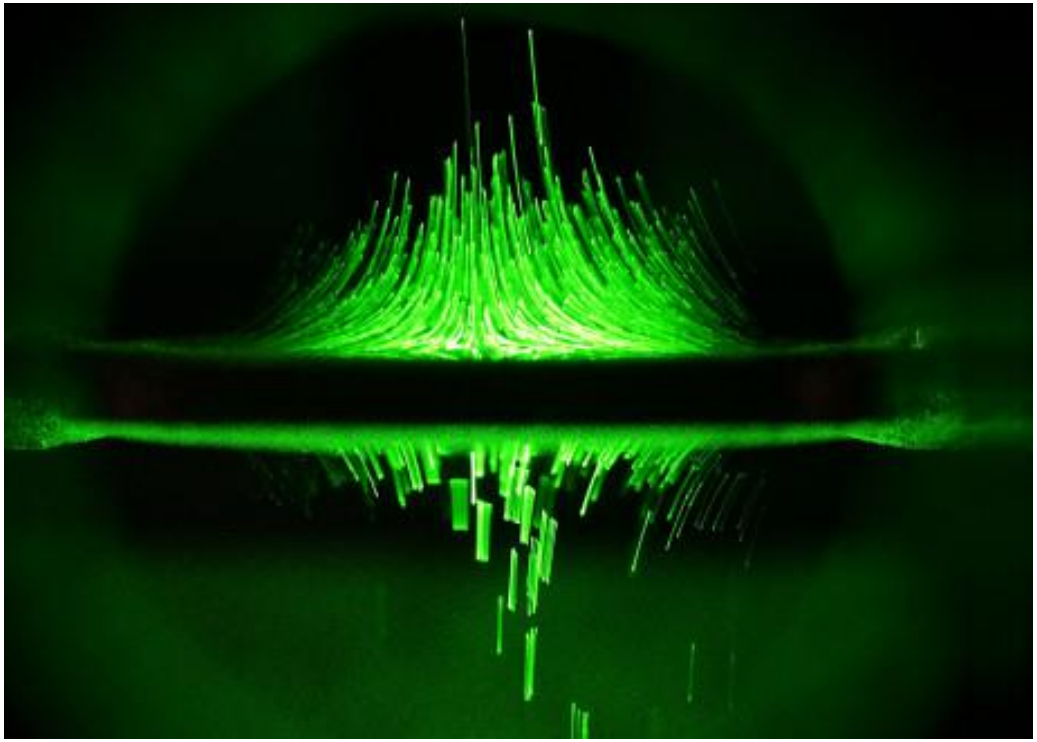


Trapping antimatter

In CERN experiments such as ATHENA and ALPHA. Iontrap was evolved to capture and trap the antimatter.

Demonstration example

Why our project?



(www.newtonianlabs.com)

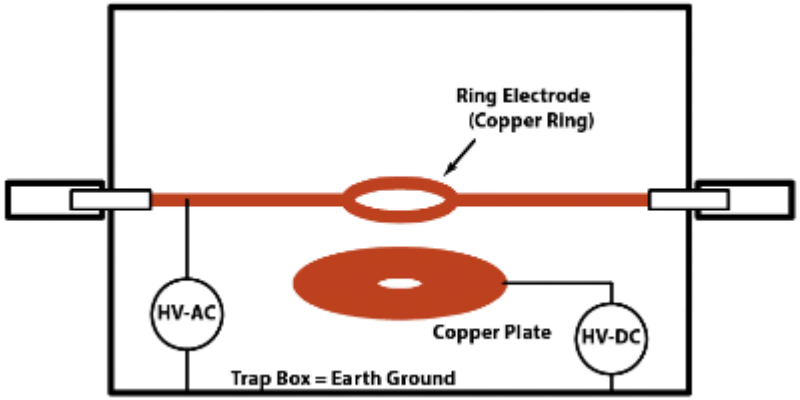
$ 7490…

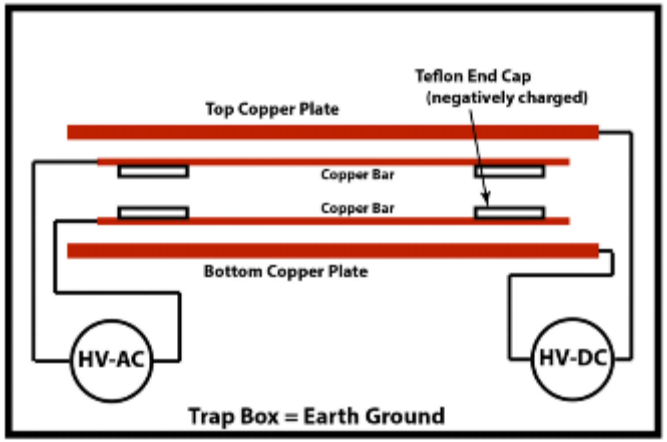
Why our project?

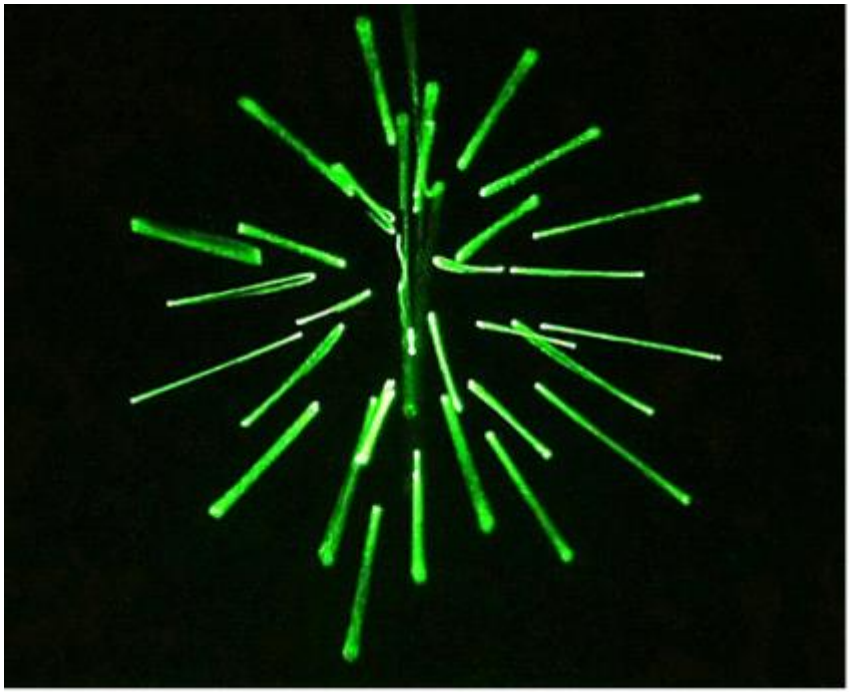
Make this cheap and visible and easy to build

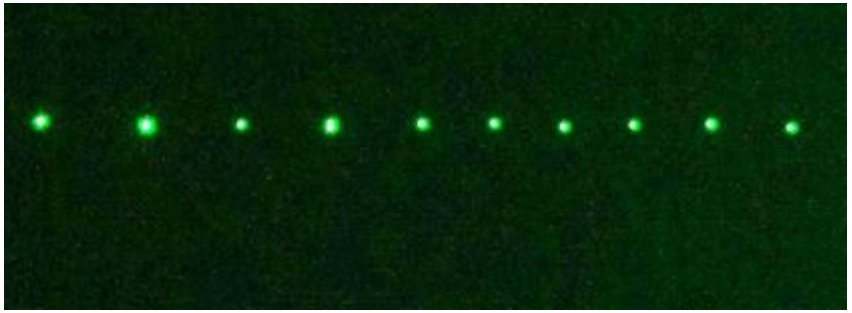
Types of simple traps

- The RING trap
- The LINEAR trap

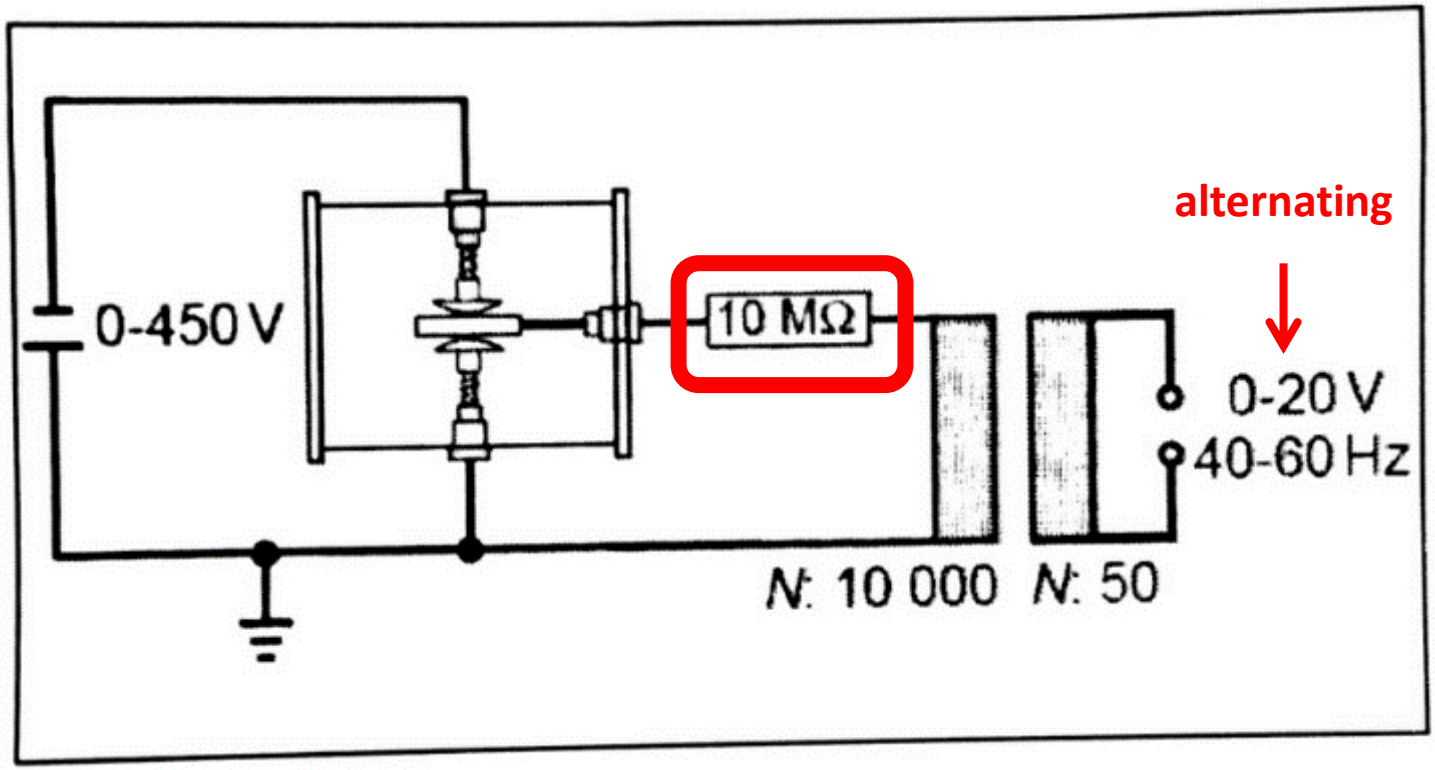








Our setup



1 mA => slight tingle

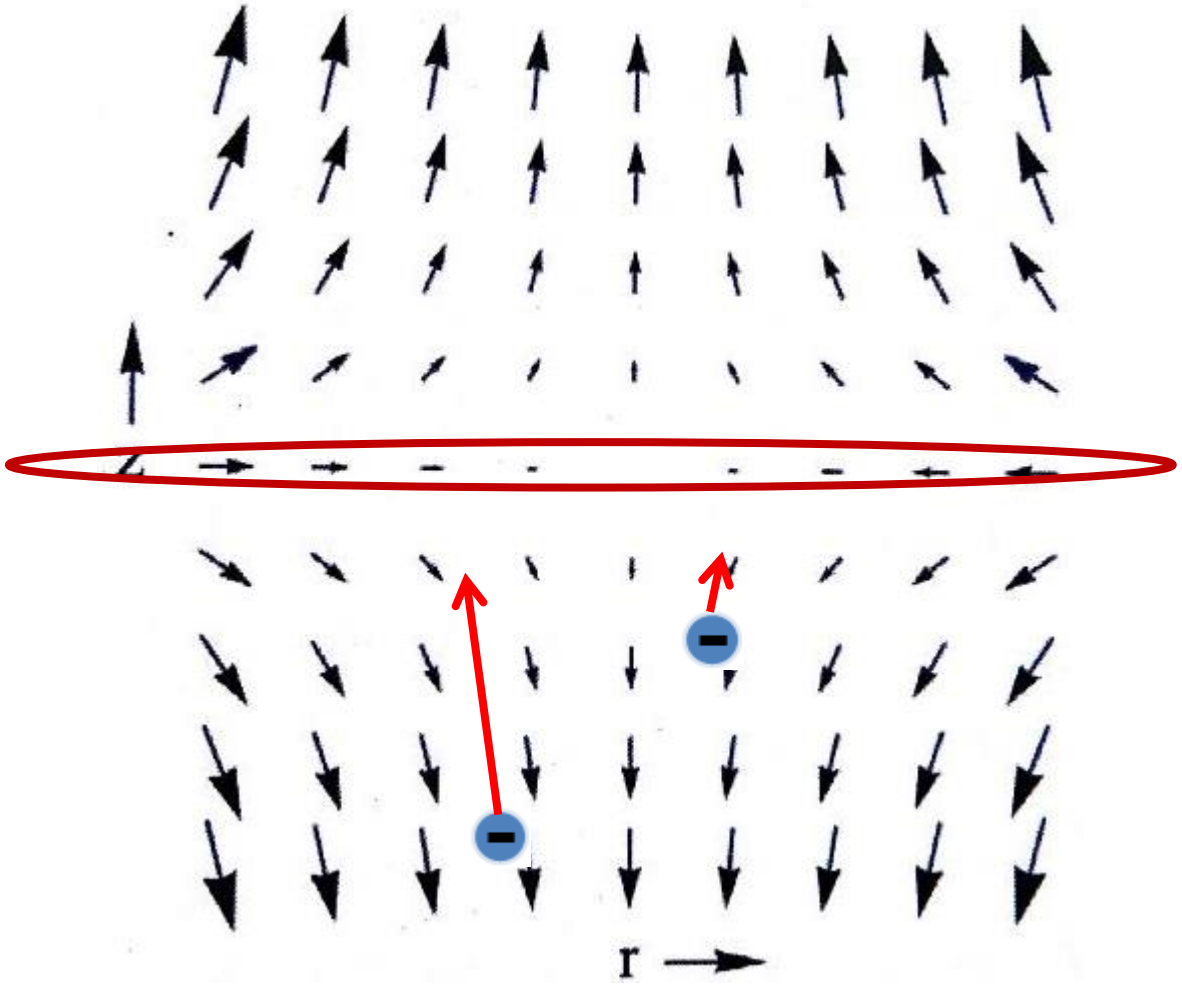
10 mA => respectable shock

$$I = \frac{4\ kV}{10\ M\Omega} = 0,4\ mA$$

100 mA => possibly lethal

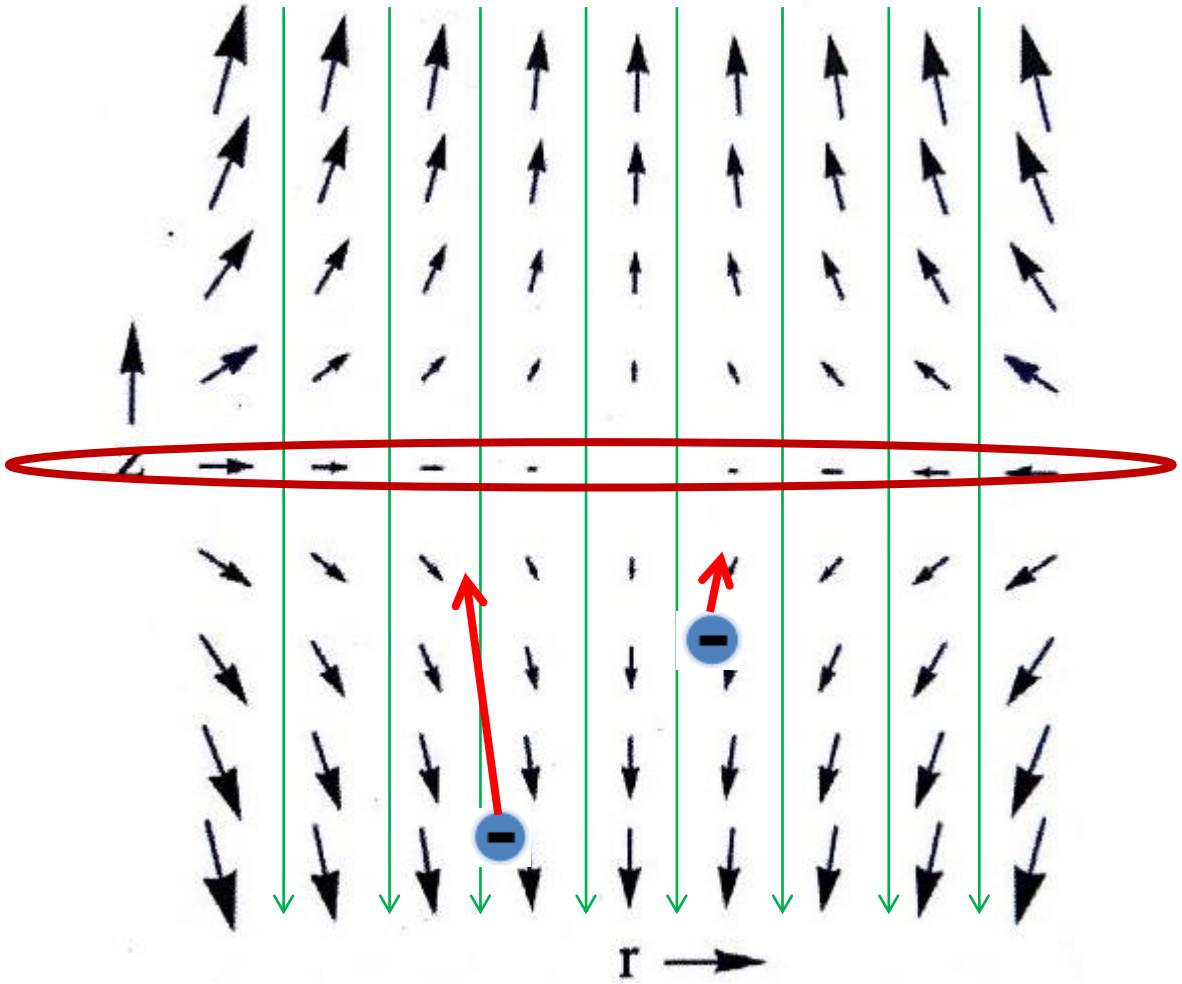
Our setup

Physical principle $F = E * q$



Physical principle $F = E * q$

Almost homogeneuos electric field to balance gravity



Results

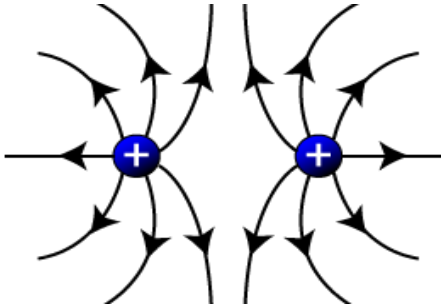
Results

Questions/Tasks for students

Connections with Curriculum

- *Electric field*

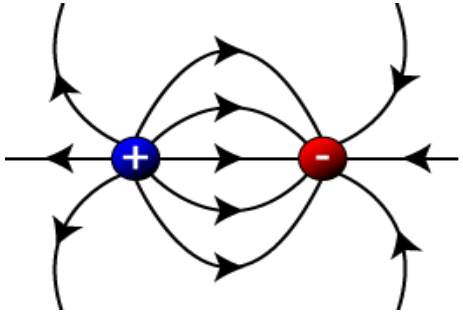
Basic characteristics of electric field, electric charge, electric force, electric lines



- *Harmonic oscillation*

- *Modern physics*

Antimatter, Mass-spectroscopy




FAILA

METHODS

- Interactive demonstrations
- Students project

Questions/Tasks for students

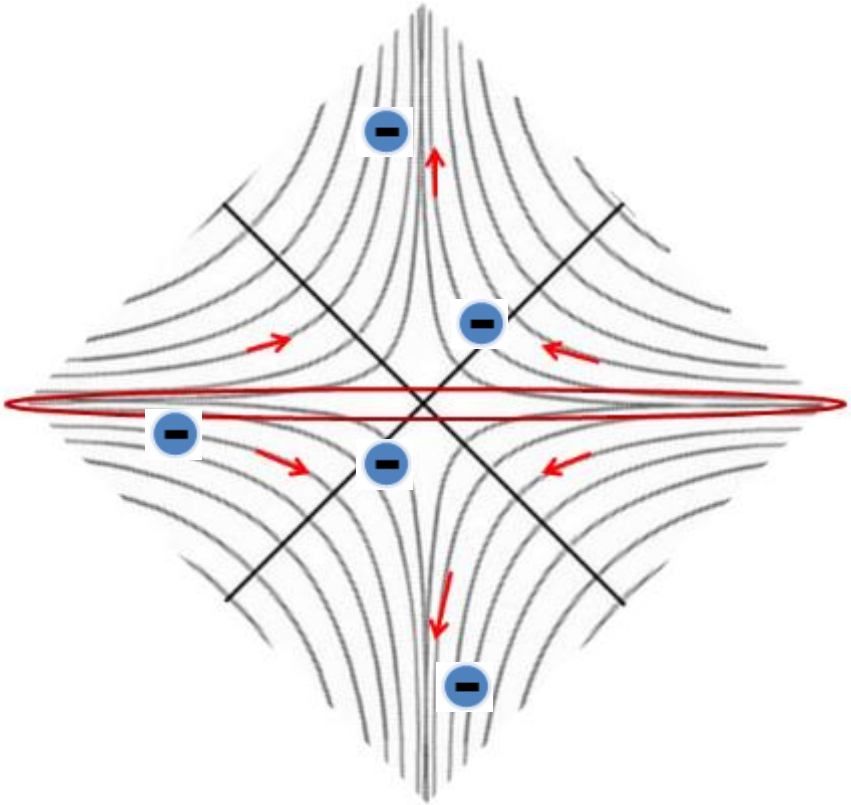
- Measure the weights of the spores
- What do you see in the trap? (points or lines) Why?
- How does the HV/AC affects the movement of the particles?
- What would happen if the
  i) Diameter of the ring is increased?
  ii) Voltage [DC] is increased?
  iii) DC supply is switched off?
  iv) frequency of AC is increased/decreased?
- How can particles sometimes move slow?

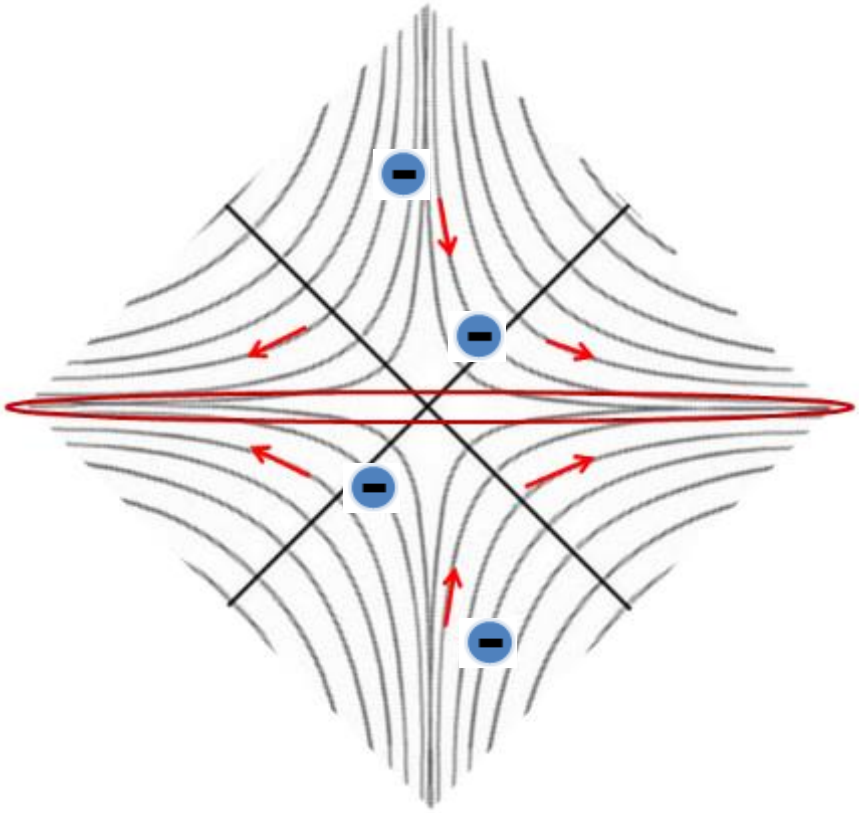
And that´s all for this HST!

DISCUSSION TIME 2!

Appendix

1. Draw E-field Forces on ions!





2. What will the motion be like?

The time-dependent electric force on the particle is $F(t) = qE(t) = qE_0 \cos \omega t$, so the motion of the particle in the z direction is described by the equation of motion ($F = ma$)

$$m\ddot{z} = qE_0 \cos \omega t$$

To solve this equation, we try a solution of the form $z = A \cos \omega t$, giving

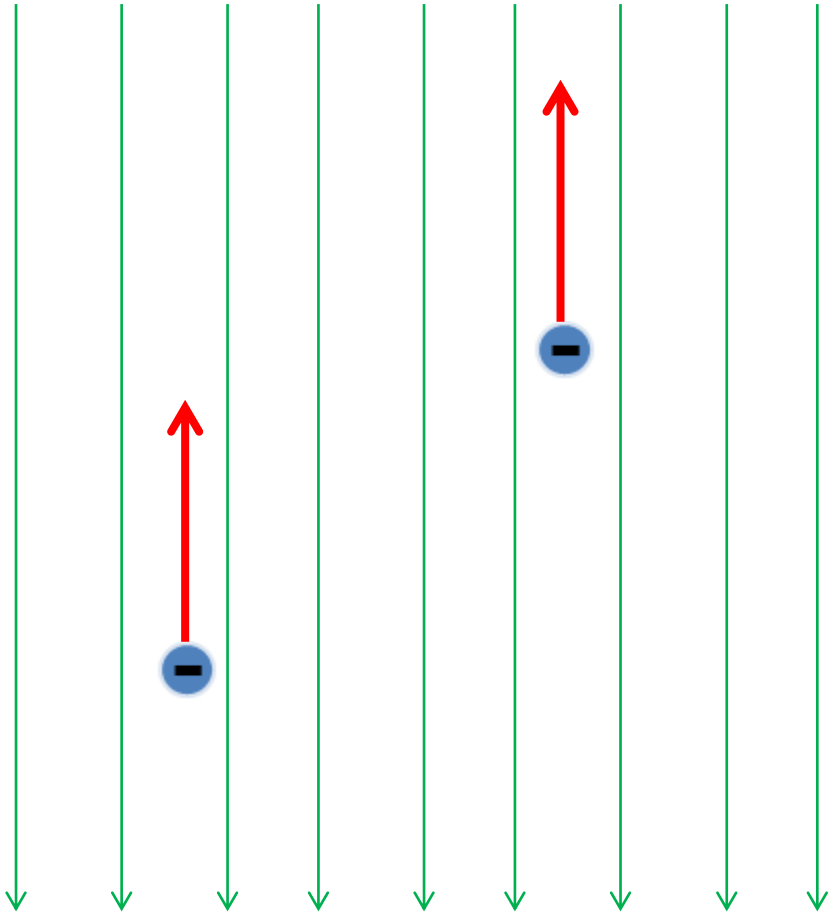
$$\begin{aligned} \dot{z} &= -\omega A \sin \omega t \\ \ddot{z} &= -\omega^2 A \cos \omega t \\ -m\omega^2 A \cos \omega t &= qE_0 \cos \omega t \\ &\Longrightarrow \quad A = -\frac{qE_0}{m\omega^2} \end{aligned}$$

and this gives the full solution

$$z(t) = z_{init} + v_{init} t - \frac{qE_0}{m\omega^2} \cos \omega t \tag{1}$$

where z_{init} is the initial position of the particle and v_{init} is its initial velocity. Note that this solution works in various

Physical principle



$$F = E * q$$

ATLAS magnetic field model

Lizelle Swanepoel
Miriam Rosenfeld
Julia Aldehoff

Workgroup

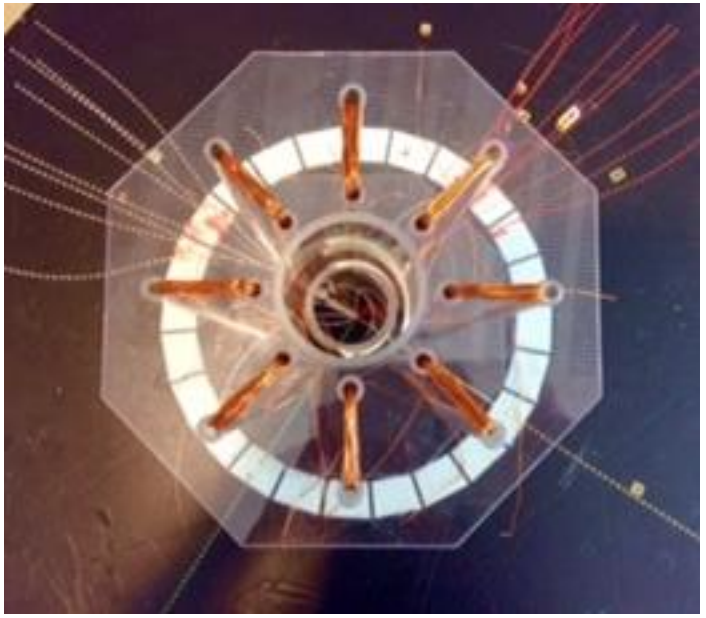
Ingredients

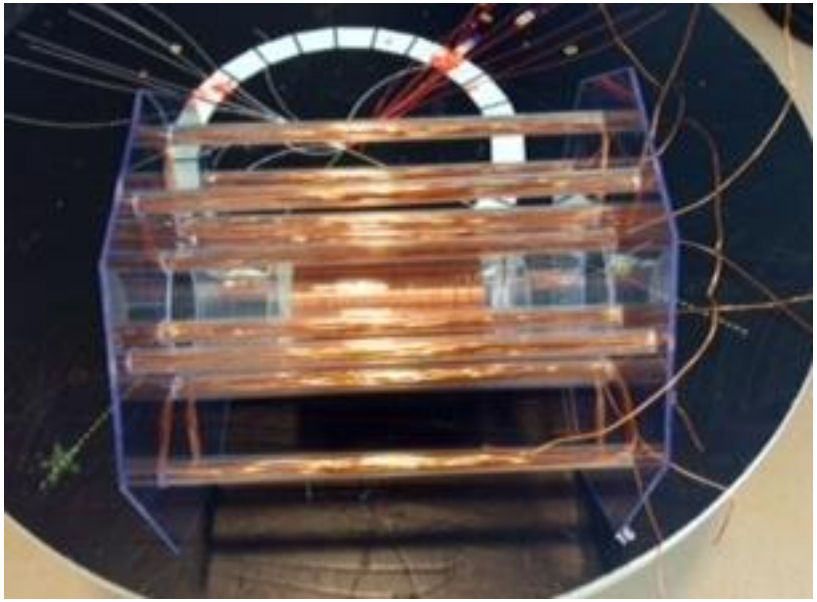
- We built a 1:100 model of the Atlas magnet system

- Coppe r wire
- Plexiglass cutouts
- 16 plexiglass tubes (1x25 cm)
- 1 plexiglass tube (7.5x25 cm)
- 1 plexiglasstube (6x15 cm)
- Compass needles
- Cables
- Transformer
- Connectors

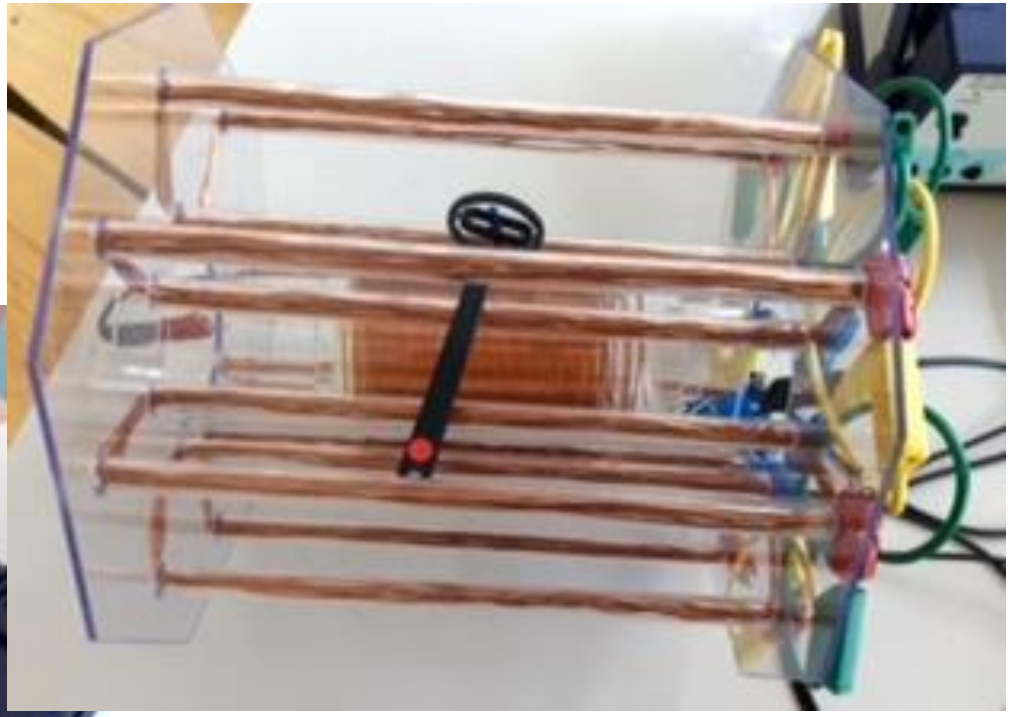
Working

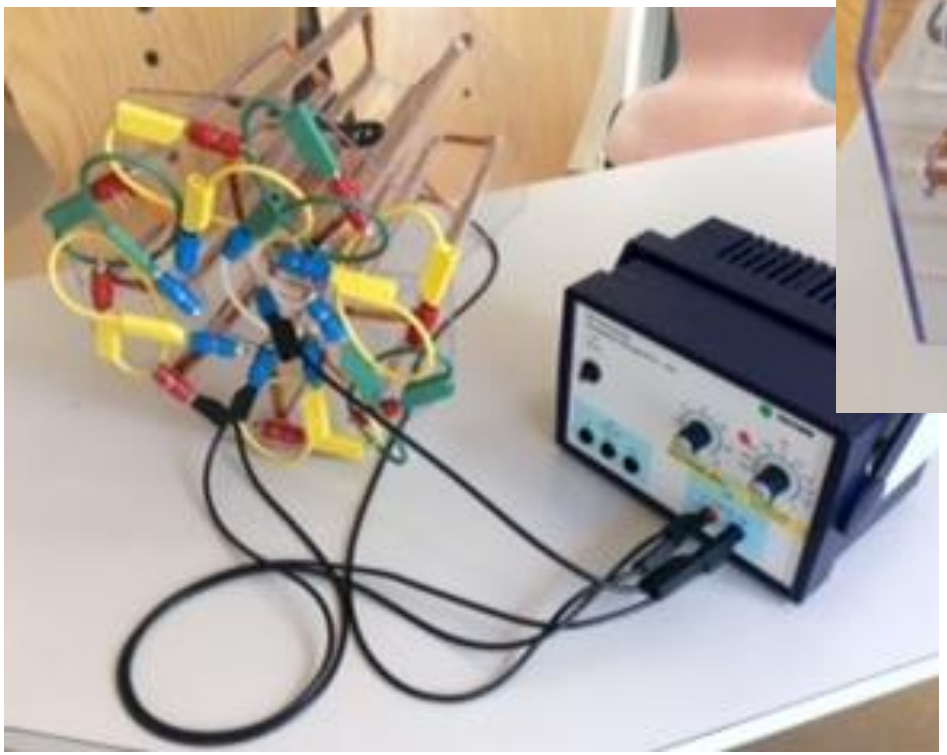
Magnetic components





The final model





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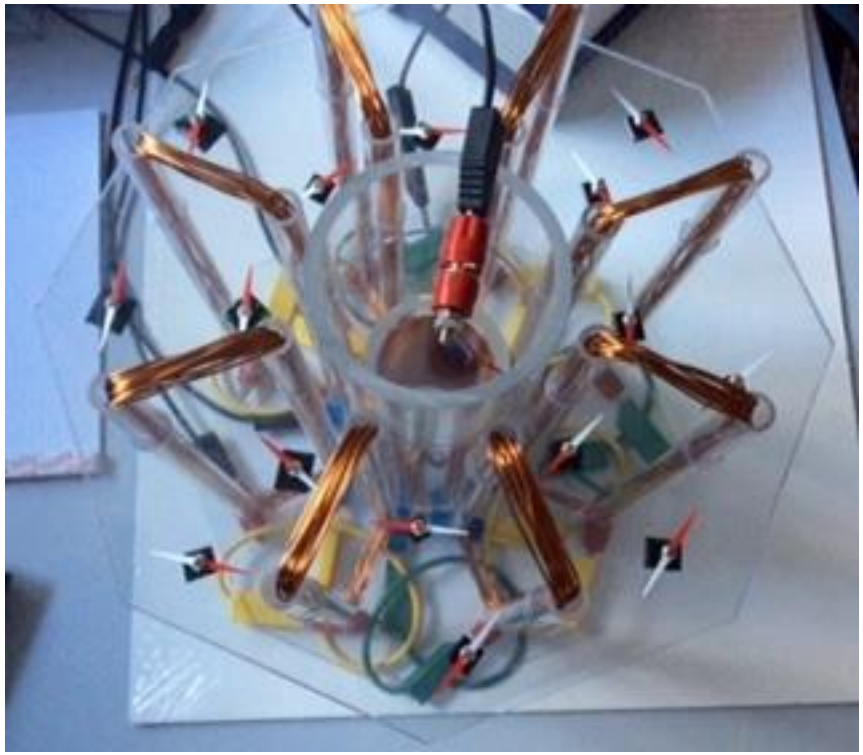

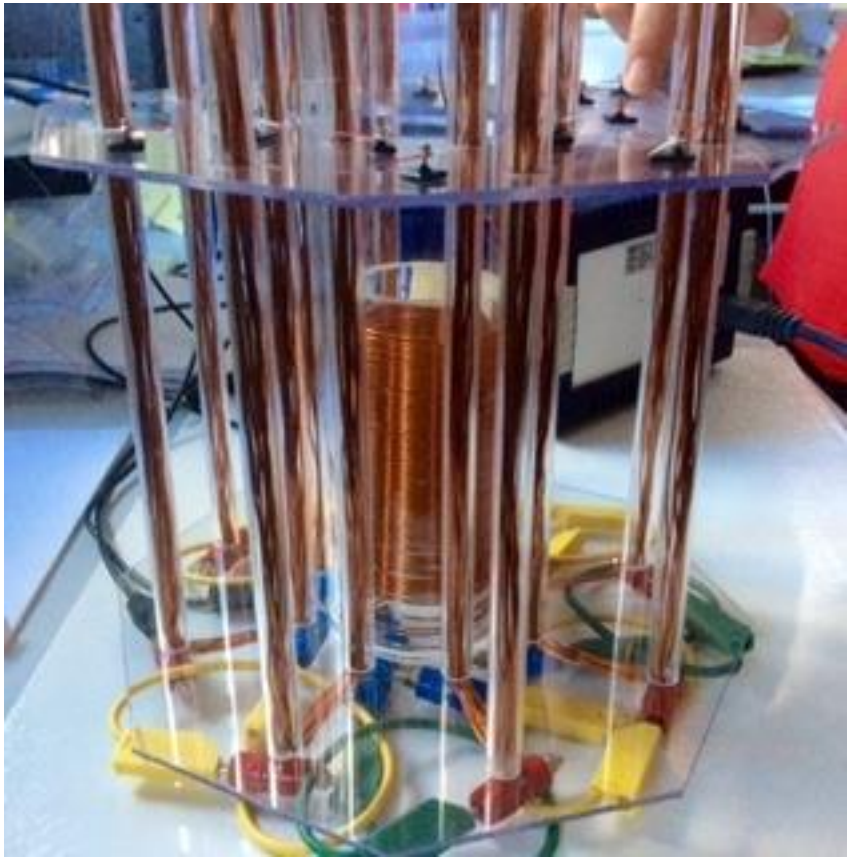

Introducing the activity

The www.independent.co.uk

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INDEPENDENT

HOMOPHOBIA, HIP-HOP, AND THE STAR WHO CAME OUT
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THE L'OREAL FILES: COULD SARKOZY GO DOWN?
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MURRAY ONE MATCH FROM THE FINAL
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EUREKA!

It has taken nearly 50 years and cost £2.6bn. Now, at last, the Higgs boson particle has been found – and a new chapter in our understanding of the universe can begin

A computer-generated image, above, shows proton collisions expected from the decay of a Higgs boson; Peter Higgs, below right EPA/CERN AFP

By STEVE CONNOR
Science Editor

It was a breakthrough that took almost half a century of deep thought, more than 30 years of painstaking experimentation and a massive £2.6bn machine. Yesterday, scientists said they believed they had found the subatomic particle that confirms our understanding of how the universe works.

Discovering the so-called "Higgs boson" particle would be one of the greatest achievements in science, rivalling the discovery of the structure of DNA in 1953 and the Apollo Moon landings of the 1960s and 1970s. It can explain why some particles have mass, but why others, such as photons of light, do not.

Although the discovery is consistent with such a particle – first postulated half a century ago by the retired British physicist Peter Higgs – scientists at the European Organisation

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Diamond: I'm sorry (but not sorry enough to give up his pay-off)

By OLIVER WRIGHT and JAMES MOORE

Bob Diamond, the former Barclays chief executive, indicated that he would fight to keep his multimillion-pound pay-off after stepping down in the wake of the interest rate-fixing scandal, despite admitting that he was in charge of bankers whose "behaviour... was reprehensible".

Questioned by MPs on the Treasury Select Committee, Mr Diamond said he was "sorry, disappointed and angry" but repeatedly failed to waive his pay-off of up to £30m, claiming it is a matter "for the Barclays board". He said he only found out about the rigging of the London Interbank Offered Rate (Libor) when he saw the Financial Services Authority's report, and that he was "physically ill" when he read emails from Barclays traders discussing the fixing.

Last night, the Chancellor claimed former Labour ministers were "clearly involved" in the scandal.

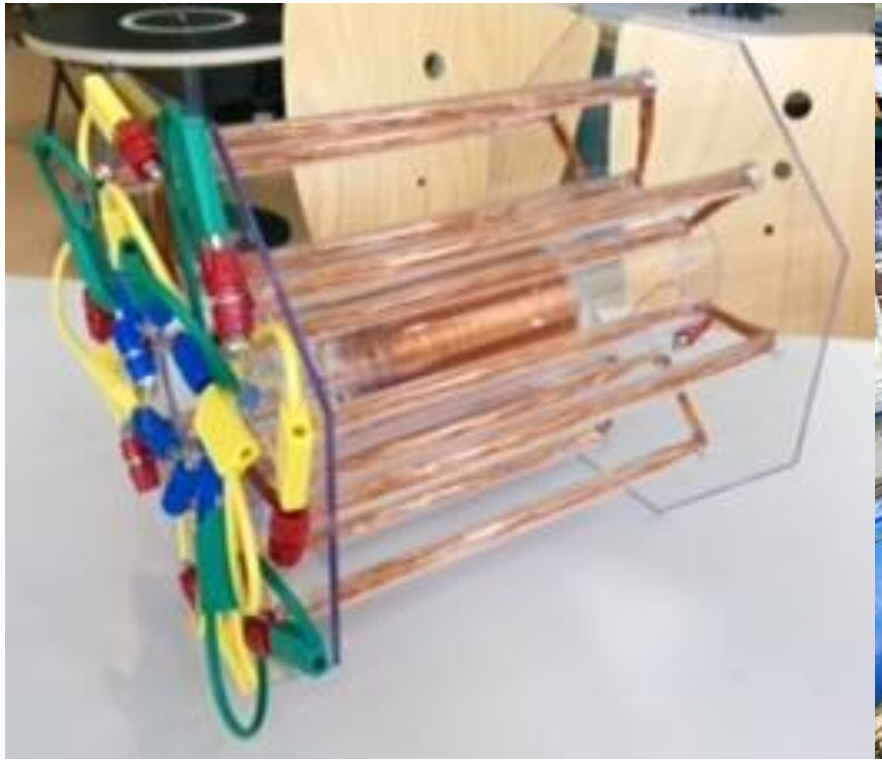
Diamond may get a £30m pay-off

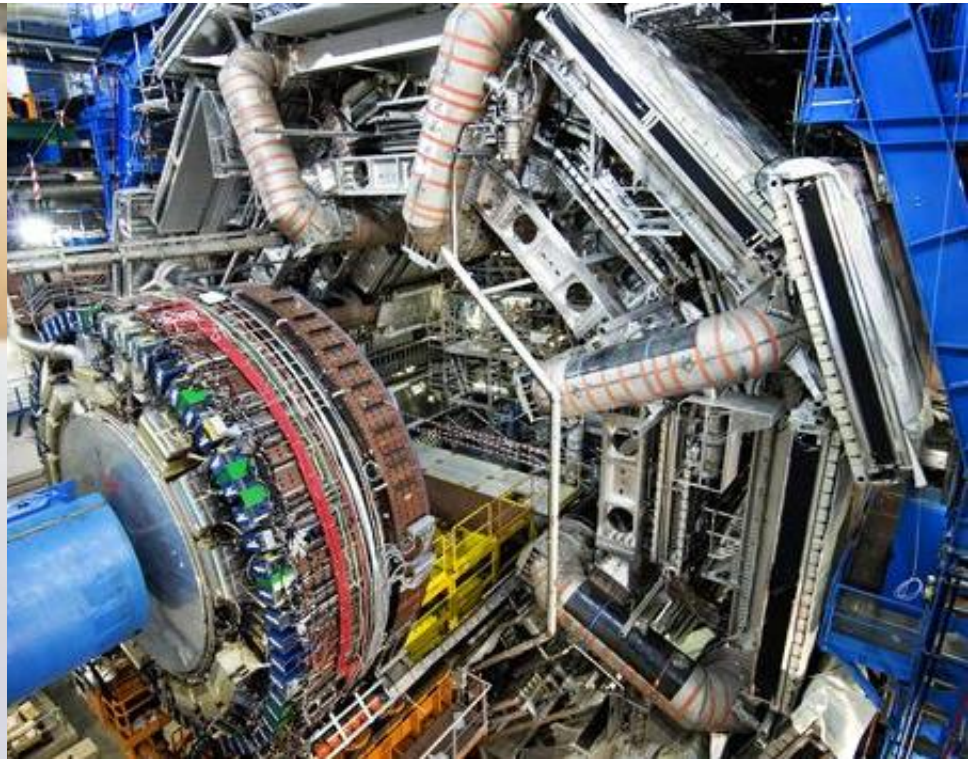
Further reports PAGES 4-6

http://www.voxeurop.eu/files/the_independent.750.jpg

http://www.atlas.ch/photos/lhc.html

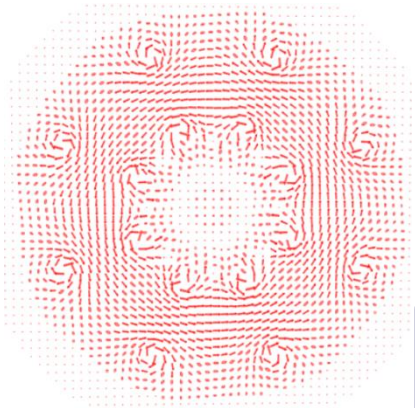
Model vs. reality





Picture from Bernhard Holzer‘s presentation

Lab circus to study magnetic fields



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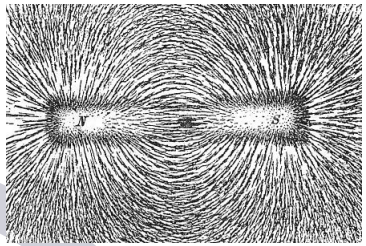
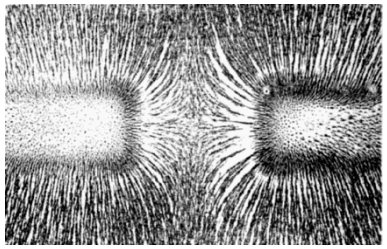
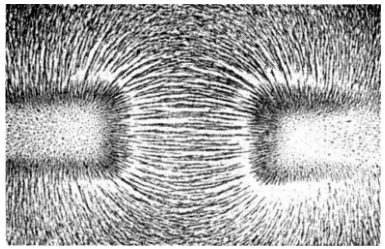
1 bar magnet



https://commons.wikimedia.org

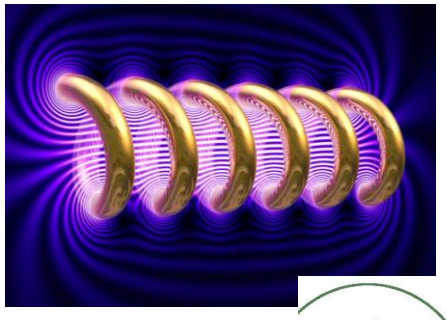


2 bar magnets



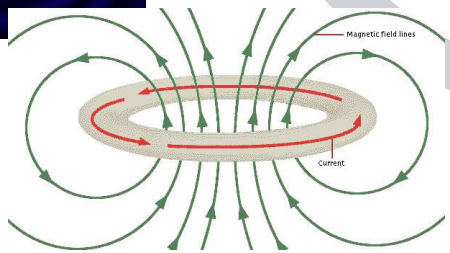
https://commons.wikimedia.org

Solenoid model



http://www.cibermitanios.com.ar/2008/05/10-simulaciones-fisicas-asombrosas.html

1 coil

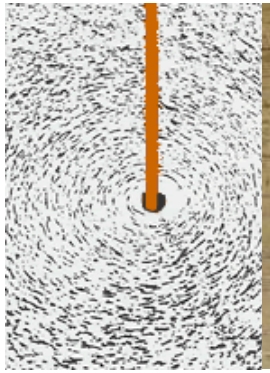


http://www.askamathematician.com

1 loop of wire

https://commons.wikimedia.org

1 wire

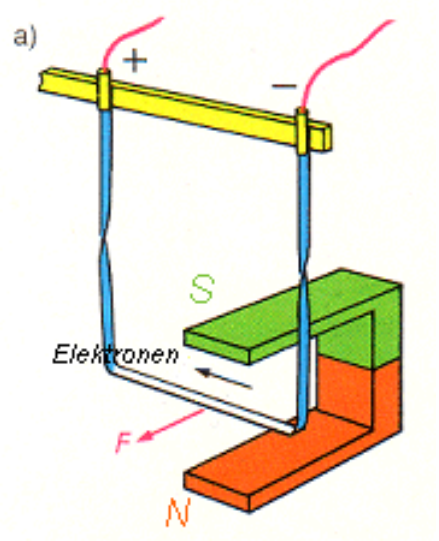


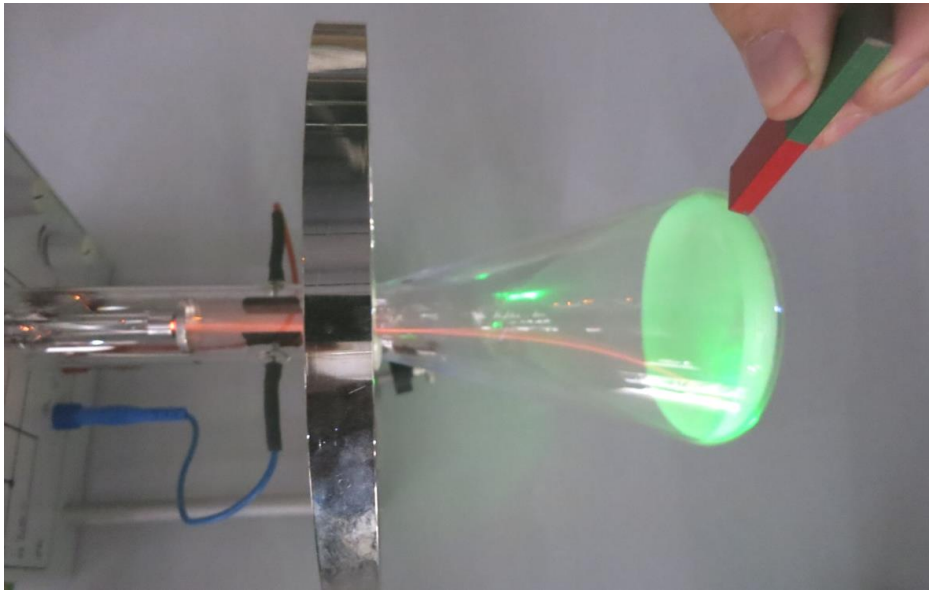
http://www.physics.ucla.edu

http://www.trincoll.edu/~cgeiss/stuff/the%20rocky%20road/ch_1/ch1_p1.htm

Advanced experiments

- 2 experiments to show how charged particles (e^-) react in a magnetic field
- these illustrate the fundamental principle of deflection using appropriate hand rules

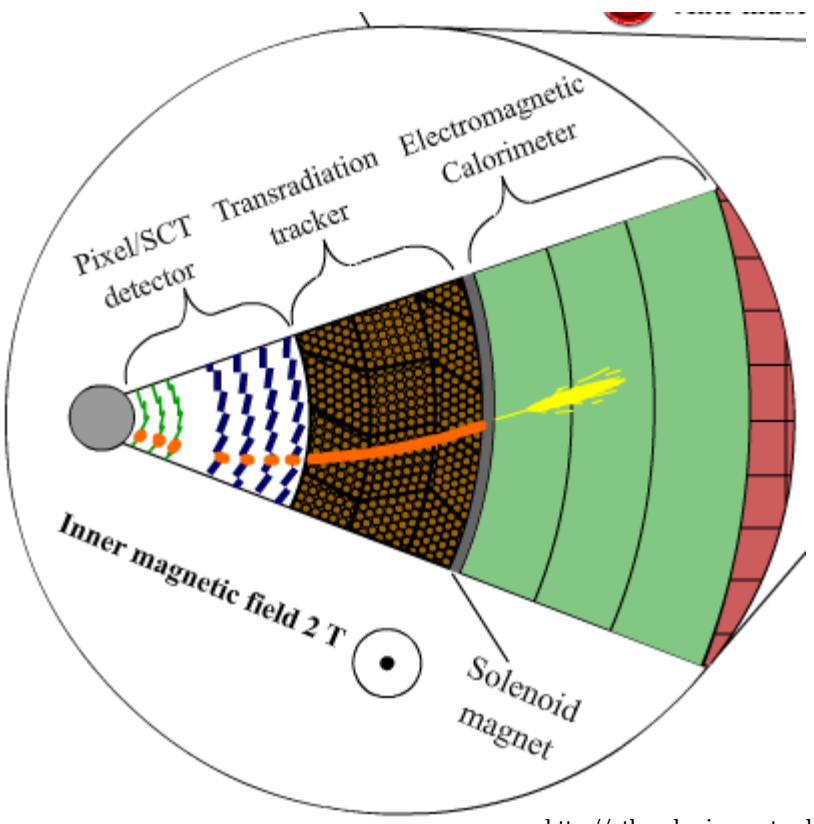


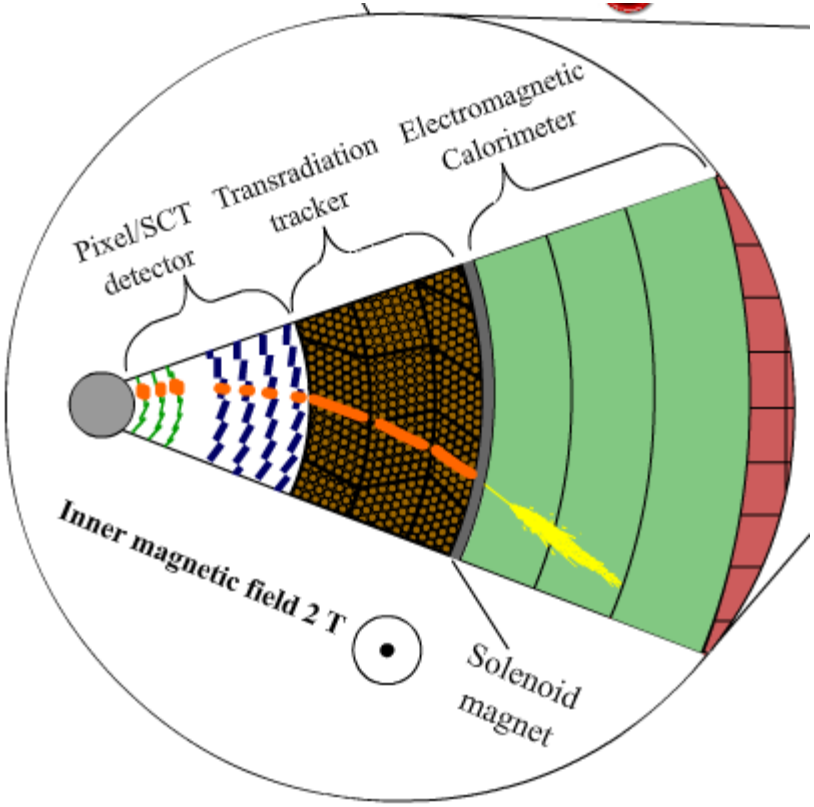


http://www.dieter-heidorn.de/Physik/VS/StrukturMaterie/K08_Elektronen/K08_Elektronen.html

Particle deflection in ATLAS detector

- Simulation of the electron and positron
- Prediction with the Lorentz-force

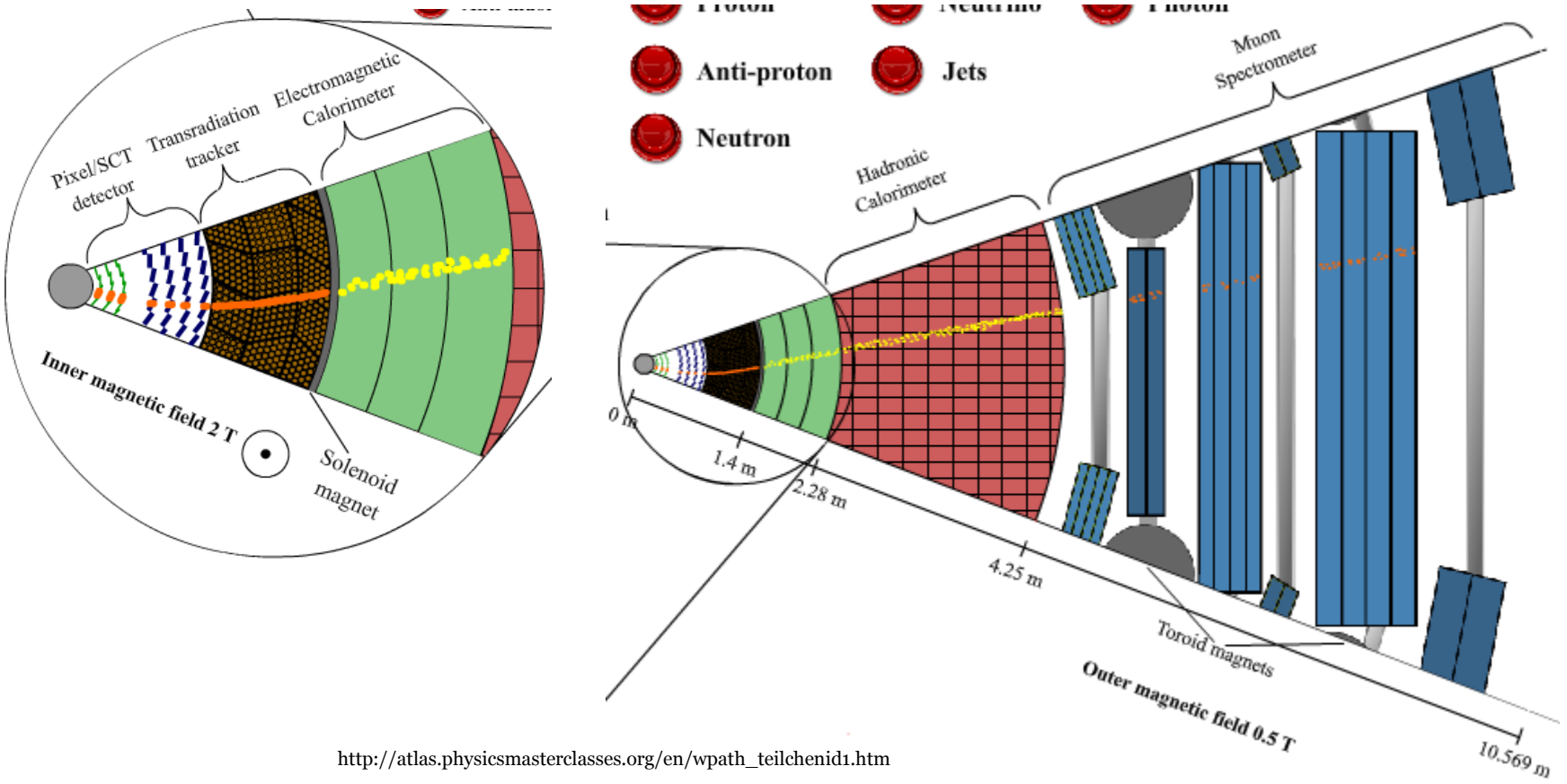




http://atlas.physicsmasterclasses.org/en/wpath_teilchenid1.htm

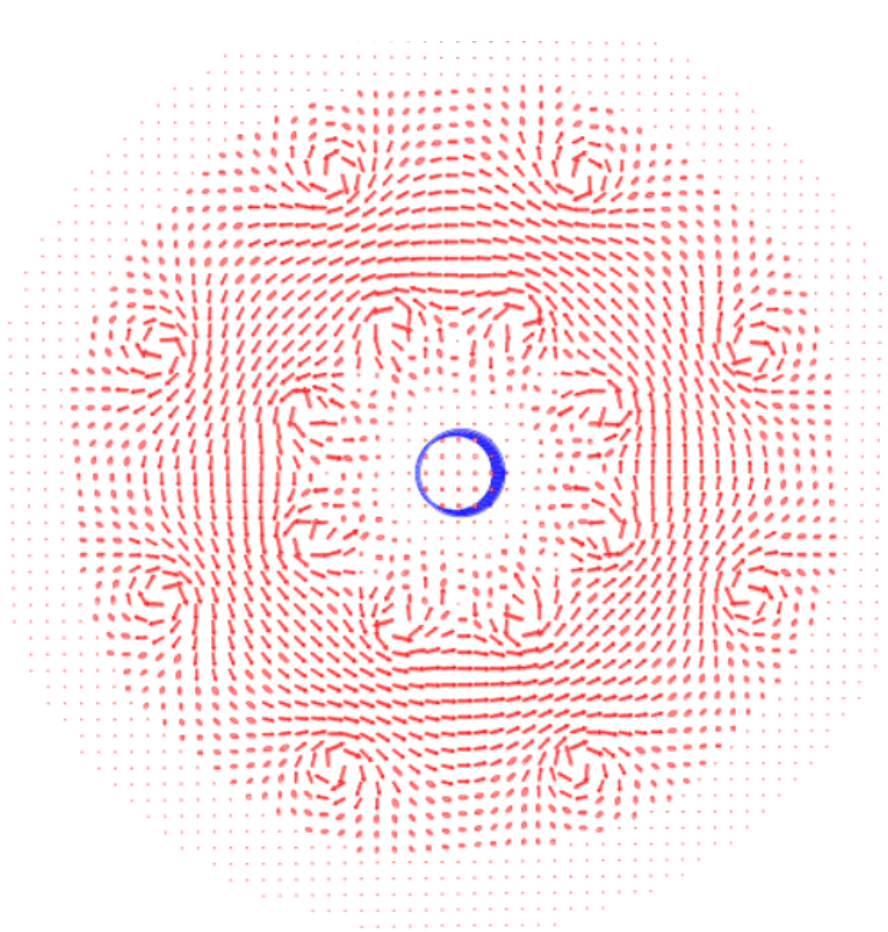
Particle deflection in ATLAS detector

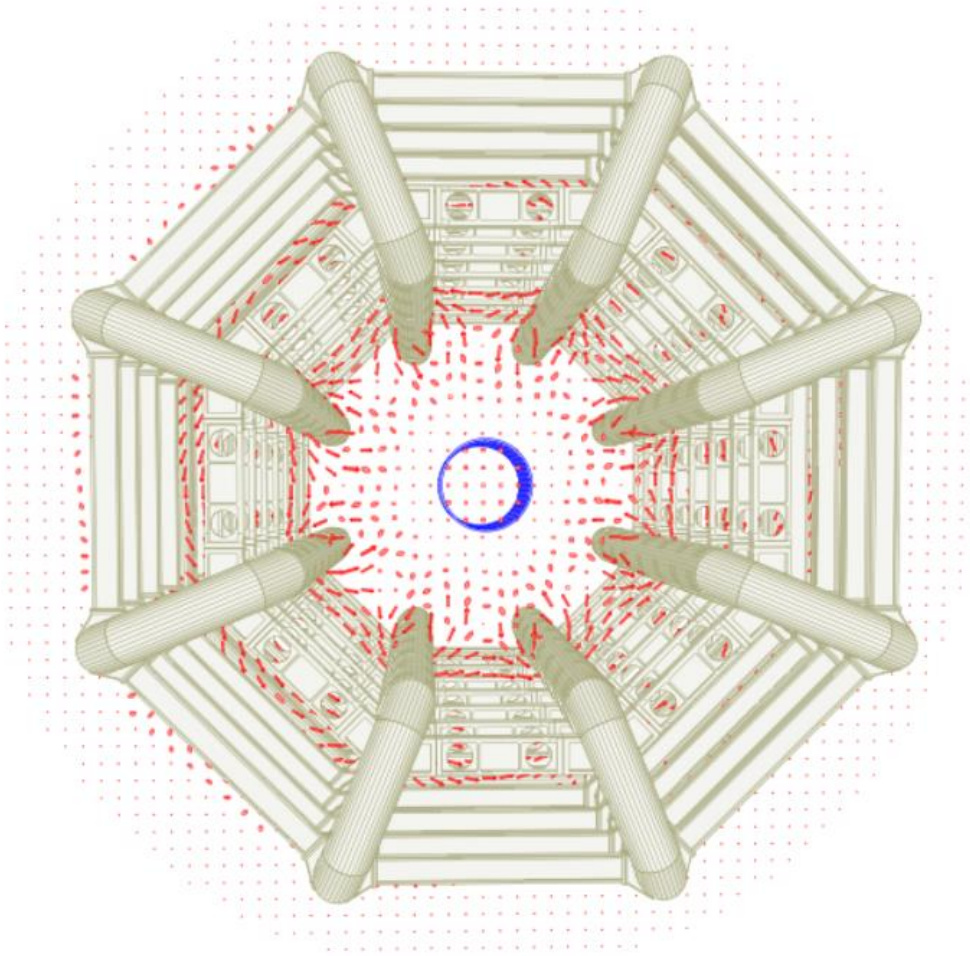
- Deflection of the muon is more complex



http://atlas.physicsmasterclasses.org/en/wpath_teilchenid1.htm

A simulation for the toroid field





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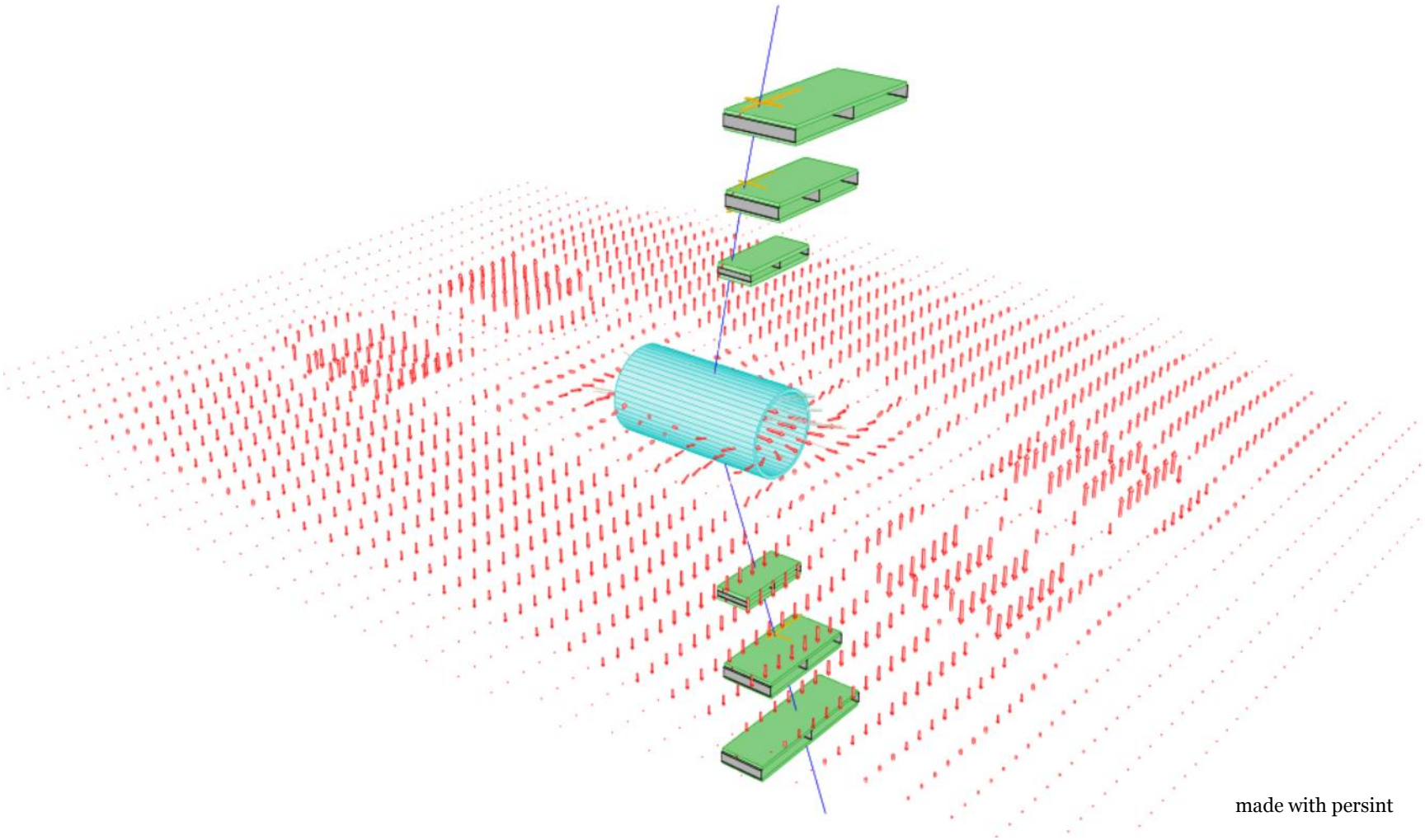
A simulation for the toroid field



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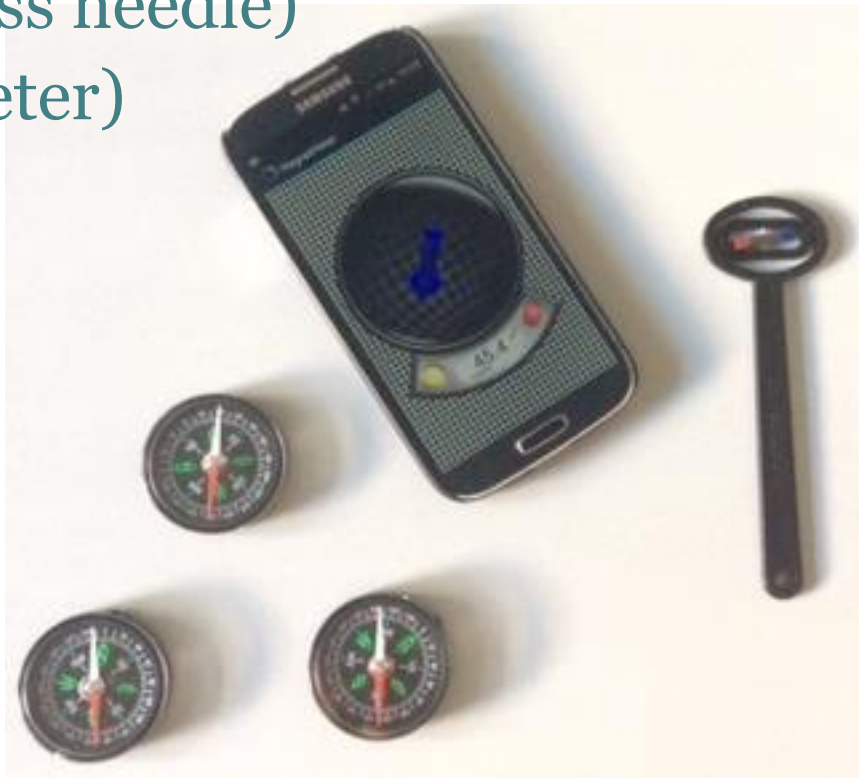
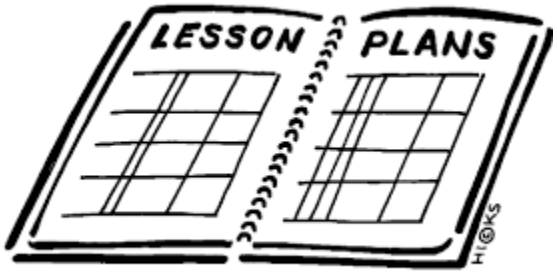
Measurement of the magnetic field

- Different methods to use:
  - Compasses
  - Magna Probe (3D-compass needle)
  - Smartphone app (teslameter)
  - Hall-Probe
    (exact magnetic field
    strength in Tesla)



Curricular context

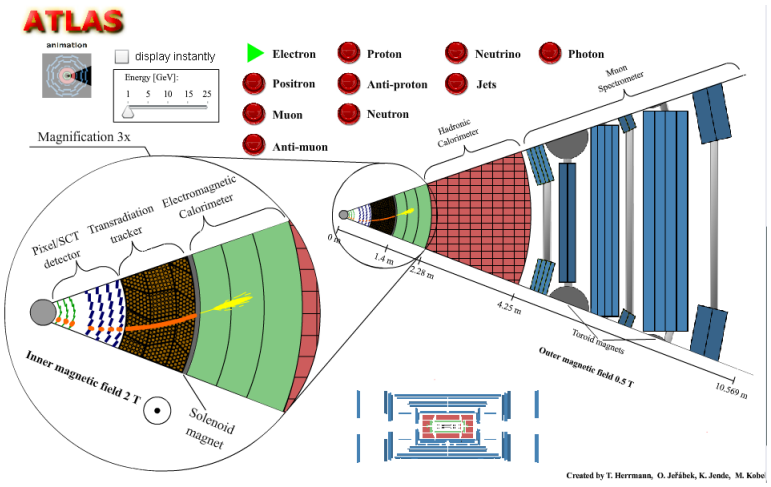
- Period
  - 11th or 12th grade
- Topic
  - Electrodynamics
  - particle physics
    (consolidating previous and extending knowledge)



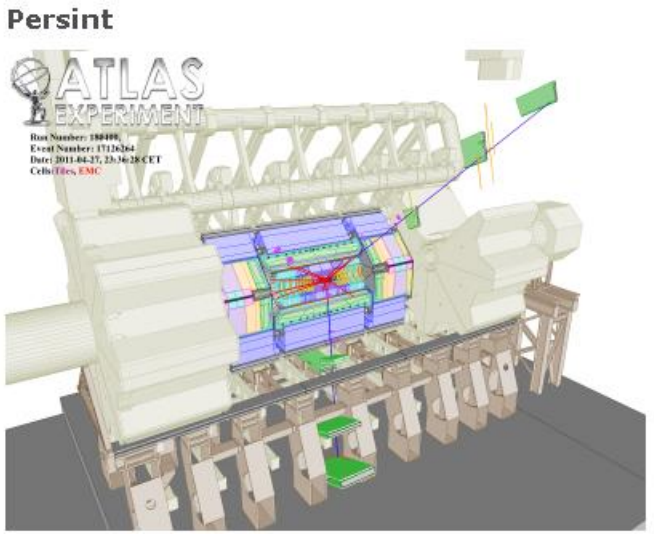
https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcSSZh4lNd9wvZvJcG3ytWFp4NHOj9hrrXDlH-PuGQns-KcDzlm7Rg

List of references

- ATLAS animation: http://atlas.physicsmasterclasses.org/en/wpath_teilchenid1.htm



- Persint: http://irfu.cea.fr/Phocea/Vie_des_labos/Ast/ast_sstechnique.php?id_ast=3113



Thank you for your attention!

Any questions?