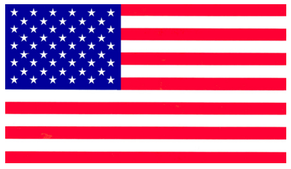
Computing and Data Analysis

CERN High School Teacher Programme 2023

Carol



Eva

Edward

Nikos

Sarina

Our Goal:

To capture our students attention
motivate our students from the beginning,
keep active their interest
with real-world examples.

I will find it for you. I will use many video filters. Like only videos with:

Green football pitches
Real Madrid games
CR7 games for Real Madrid
CR7 goals
Overhead Bicycle Kicks
.....

TRIGGERING

Finally, I will have to watch some possible appropriate videos and trim one for you.

ANALYSIS

And .....

✂ **RC7 Overhead Kick**

7 seconds · Clipped by Edward Csuka · Original video "CRISTIANO RONALDO OVERHEAD KICK FROM ALL ANGLES!! #GoalOfTheSeason" by UEFA

YouTube

Link

Data

Usually a huge amount

Triggering

A machine selects some of the data
depending our criteria

Analysis

Someone with the help of a machine (or not)
‘Watches ’ the selected data and keep the correct one

CERN does it every day

YOU do it every day when searching something on the internet (youtube, google, tiktok....)

Classroom and Curriculum

Excel with digital and analogue data collection

Sensor data collection and analyze using sensor software

Collaboration

Classroom and Curriculum

Dimensional analysis

Scientific notation vs standard notation

400 million collisions

= _____ collisions

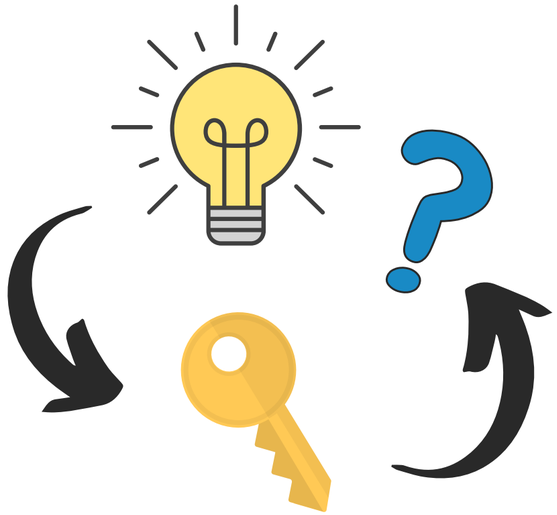
Coding

Key Ideas

CERN creates a massive amount of data in a short period of time

The computing technology doesn't match the needs

Triggers are necessary to make the data manageable



Related Challenges

Students' Math & Statistic Ability

Coding

Collaboration

Learning Resources

The Story of the Higgs Boson (2013 Nobel Prize)

New physics happens every day at the Large Hadron Collider (LHC) experiment taking place at the European Center for Nuclear Research (CERN) in Geneva, Switzerland. The LHC is a giant underground circular tube that accelerates two beams of protons in opposite directions and collides them together. These collisions result in a MASSIVE amount of data that needs to be filtered, computed and analyzed to make discoveries.

Part 1: Deluge of Data

The LHC produces 400 million collisions per second. Write this number in standard notation.

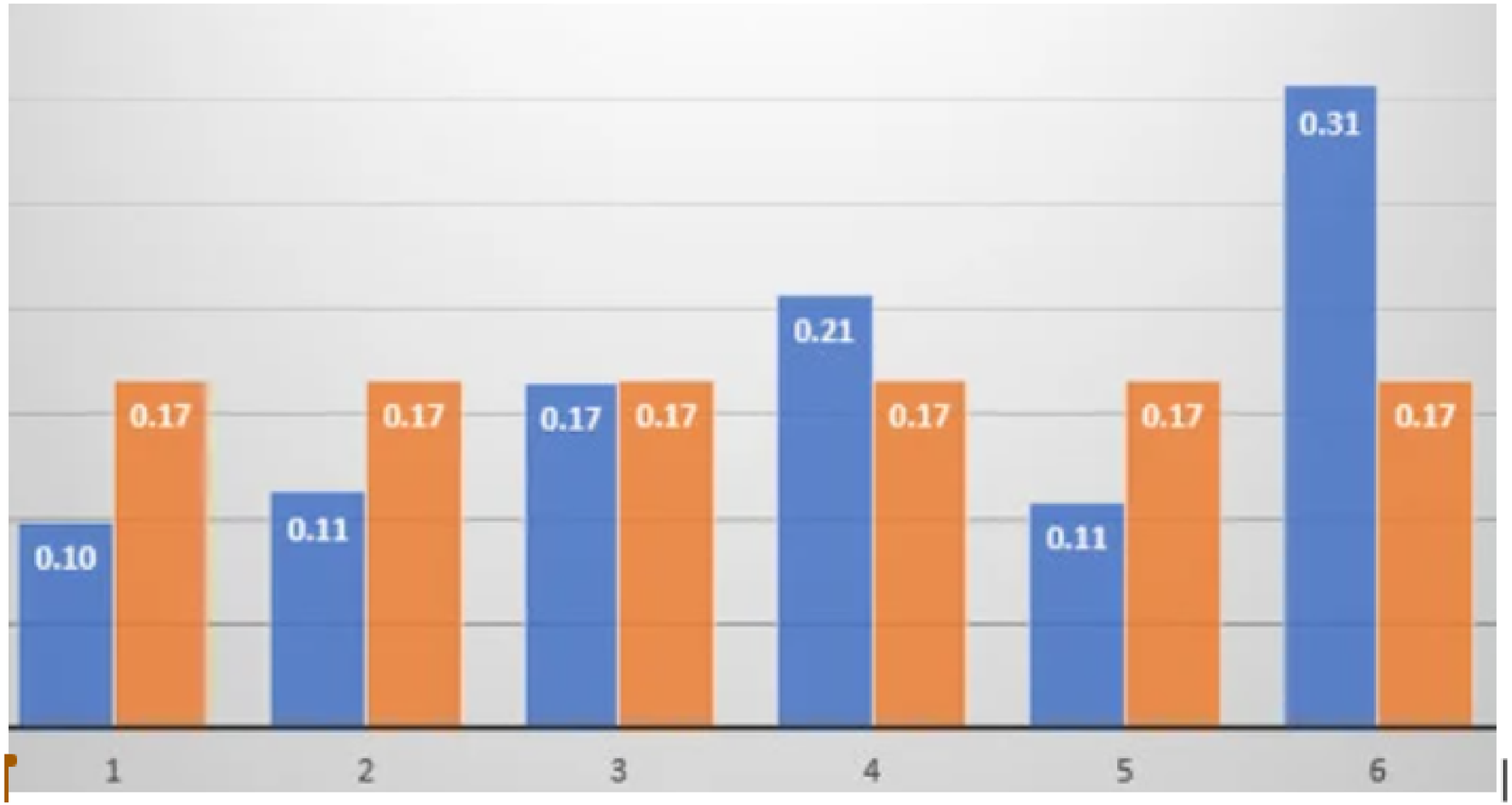
_____ collisions per second

Each collision results in 700 particles being produced. How many particles are produced each second at the LHC?

Link

Learning Resources

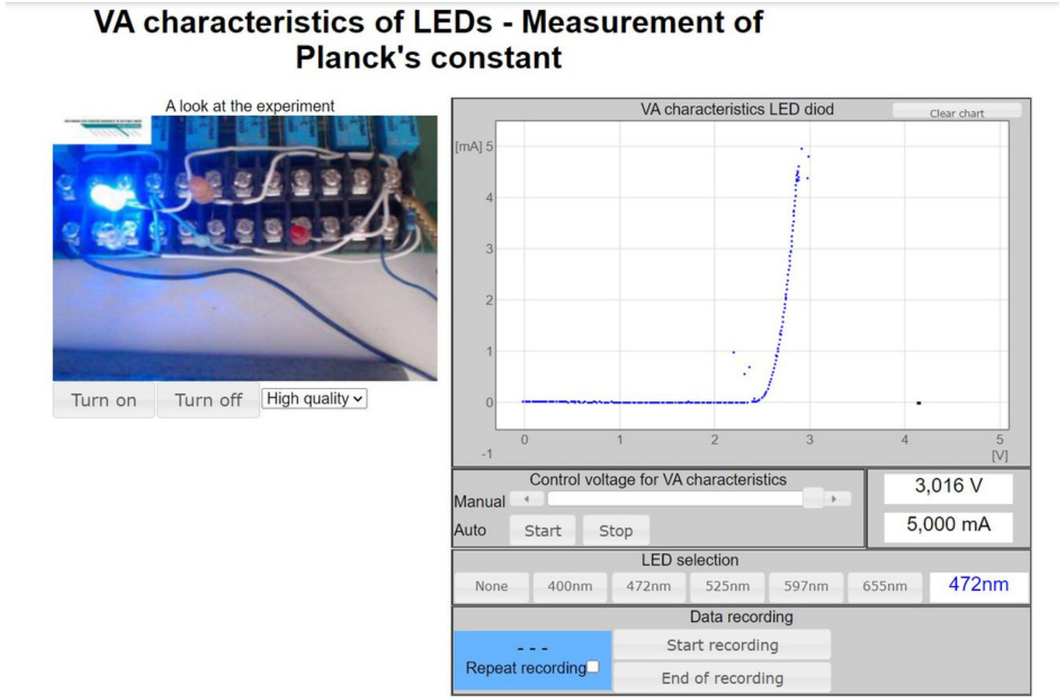
Using 6-sided dice to model products of proton proton collisions

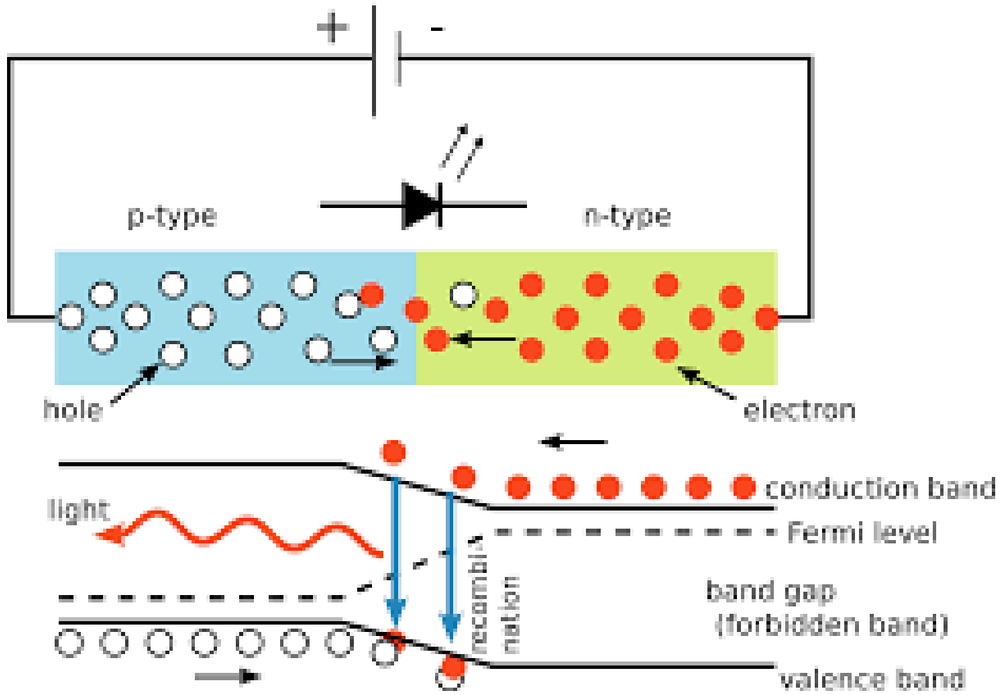


Learning Resources

QuarkNet

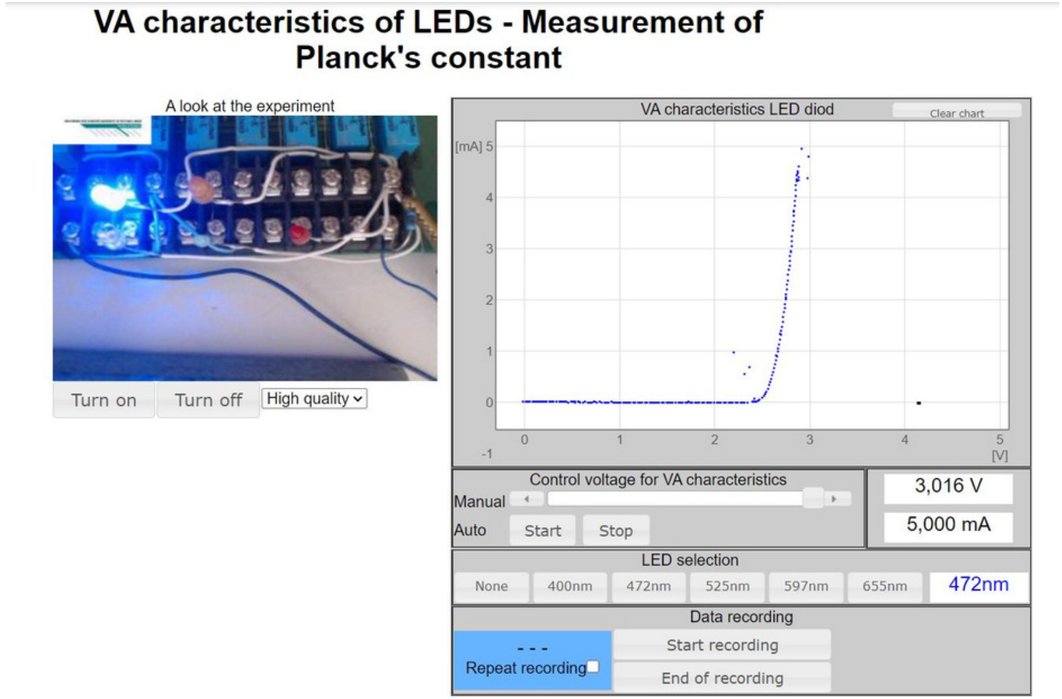
Best Practice: Determine Planck's Constant

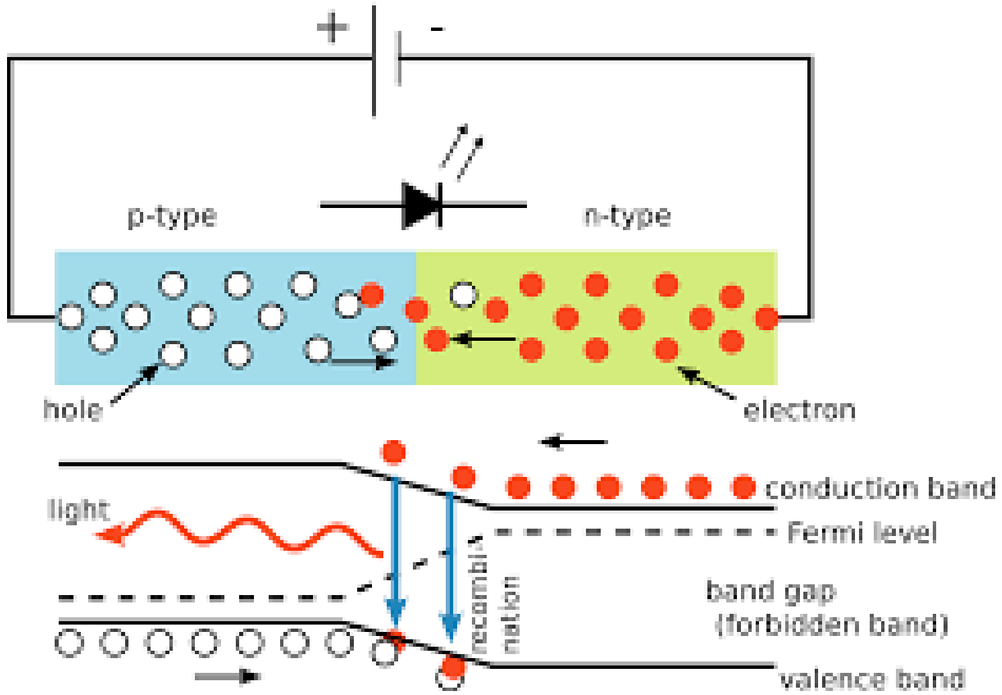




Link to the Best Practice

Best Practice: Determine Planck's Constant



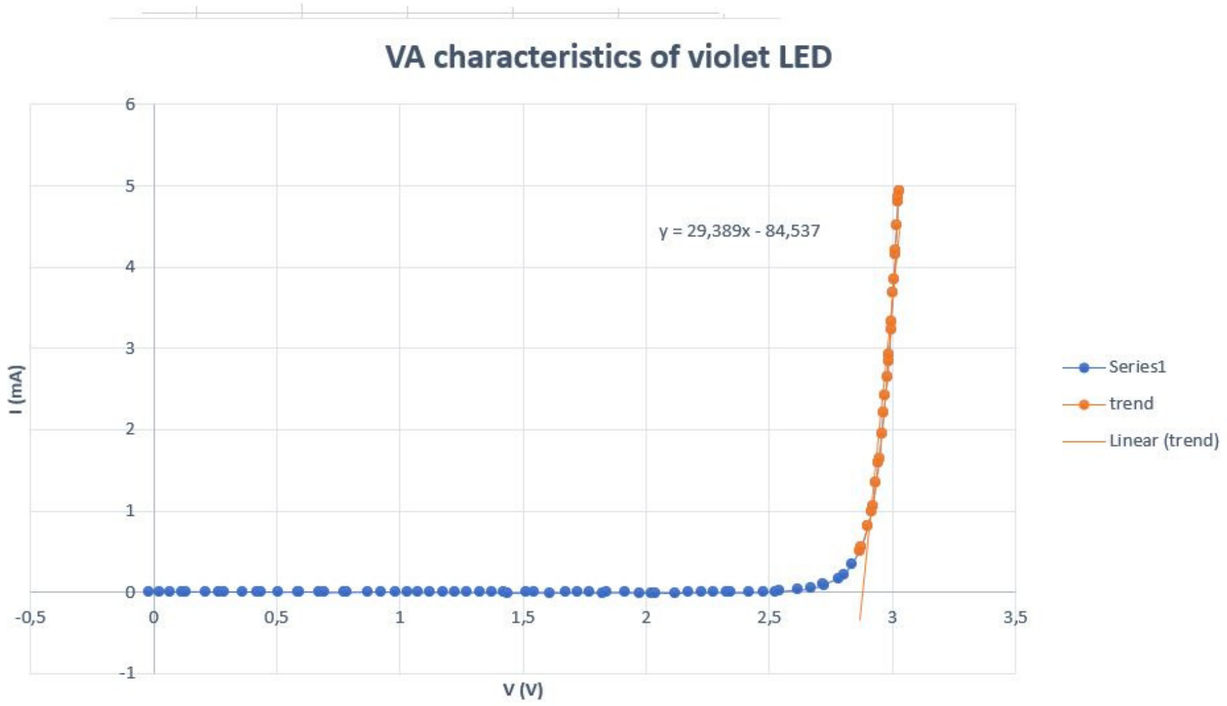


Link to the Best Practice

Best Practice: Determine Planck's Constant

	A	B	C
	0,023	0,008	
5	0,066	0,008	
6	0,113	0,011	
7	0,131	0,011	
8	0,209	0,009	
9	0,264	0,008	
0	0,285	0,008	
1	0,36	0,008	
2	0,422	0,007	
	0,437	0,006	
	0,504	0,005	
	0,585	0,004	
	0,592	0,008	
	0,671	0,004	
	0,692	-0,003	
	0,773	0,003	
	0,784	0,001	
	0,872	0,005	
	0,926	0,005	
	0,985	0,003	
	1,028	0,002	
	1,076	0,001	
	1,124	0,002	
	174	0,002	
	12	0,002	
		-0,002	
		0,001	

$V_{threshold}$=84,537/29,389=2,876



Link to the Best Practice

With LEDs, we can measure the voltage at which the LED first emits lights, V(threshold). This voltage is related to the energy gap by

$$E_{gap} = eV_{threshold} \qquad (5)$$

where e is the charge on the electron. Thus, the frequency of the brightest light emitted by the LED and the threshold voltage are related by:

$$eV_{threshold} = hf_{light} = \frac{hc}{\lambda_{light}}$$

Solving for Planck's constant,

$$h = \frac{eV_{threshold}}{f} = \frac{eV_{threshold}\,\lambda}{c}$$

Link to the Best Practice

From measured $V_{threshold}$ and inverse wavelength, we make a graph of the dependence $V_{threshold}$ on 1/lambda. Trendline -slope-calculation of h from energy equation.

$$h.f = e.V_{threshold}$$

$$h\frac{c}{\lambda} = eV_{threshold}$$

$$V_{threshold} = \frac{h.c}{e}\frac{1}{\lambda}$$

h(measured)	absolute error	relative error
6,14314E-34	4,82864E-35	7,29%
6,05129E-34	5,74712E-35	8,67%
6,52804E-34	9,79568E-36	1,48%
6,63894E-34	1,29443E-36	0,20%
5,07153E-34	1,55447E-34	23,46%
5,07714E-34	1,54886E-34	23,38%
6,50412E-34	1,2188E-35	1,84%
6,32034E-34	3,05656E-35	4,61%

$$slope = \frac{h.c}{e}$$

$$h = \frac{slope.e}{c}$$

e = charge of the electron=1,602.10^{-19} C, c = velocity of the light in vacuum= 3.10^{8} m/s.

Question ?