Engaging the youth in programming and physics through an online educational activity

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Key objectives

- To inspire high school students around the world with a fun e-learning experience introducing basic concepts in programming and high energy physics

- To empower teachers and educators, around the world, with a tool to introduce STEM education in their classrooms and beyond

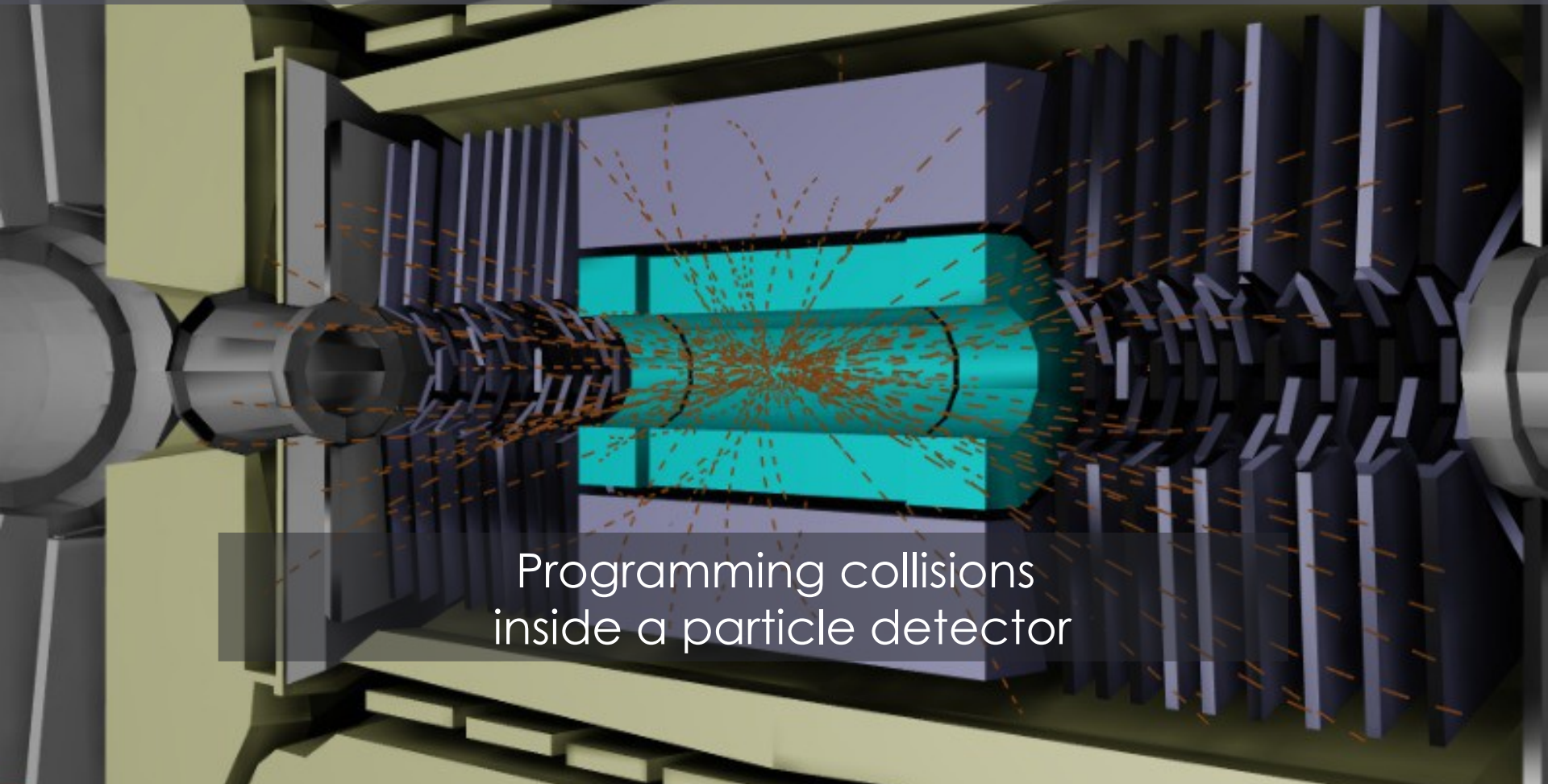
Development phases

- **Phase 1:** Proof-of-Concept
  - one step of the tutorial
  - can be used on its own (quite advanced)

Phase 2 and 3 depend on funding

- **Phase 2:** Full development (in English)
  Additional steps (for less/more advances audience)
  - Enhanced functionalities (e.g. adaptations for tablets, sign-in to save progress)
  - Certificate
- **Phase 3:** Translations

Phase 1: Proof-of-Concept

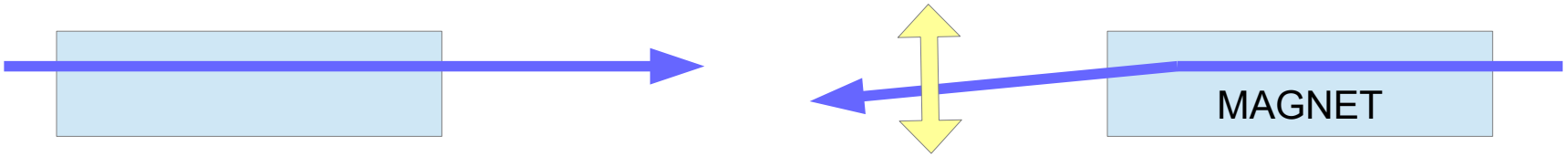


Programming collisions
inside a particle detector

Phase 1: Proof-of-Concept

- A simple exercise focusing on one element: aligning beams colliding inside a particle detector

  Reduced to a simple 1-dimensional problem:
  - One beam is assumed to already be optimally aligned
  - The user has control over a dipole magnet steering the other beam (in one plane, the other plane is ignored for simplicity)
  - Looking at how many collisions are produced, the user (or algorithm) has to find the optimal magnet current



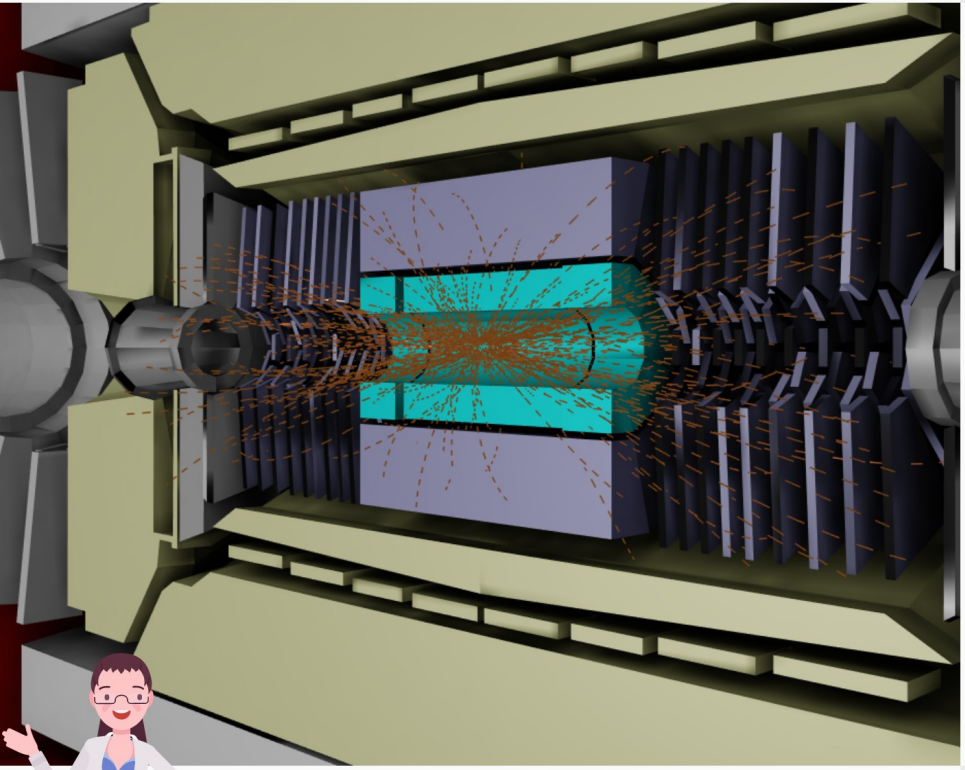
Under the hood

- The magnet current can be varied in a 0-100 range
- The optimal value (let's call it “X” - perfect alignment) is picked at random by the application
- The user can “run the accelerator” after setting the magnet current and check how many collisions were recorded
  - The number will depend on how close the magnet current is to the optimal value, giving up to a maximum of 1000
  - The user can hunt around the 0-100 range, looking for the maximum

Change difficulty: EASY

Large Hadron Collider at CERN

WORKSPACE CODE RESULTS



Magnet Current

22

Collisions

955.9974818331

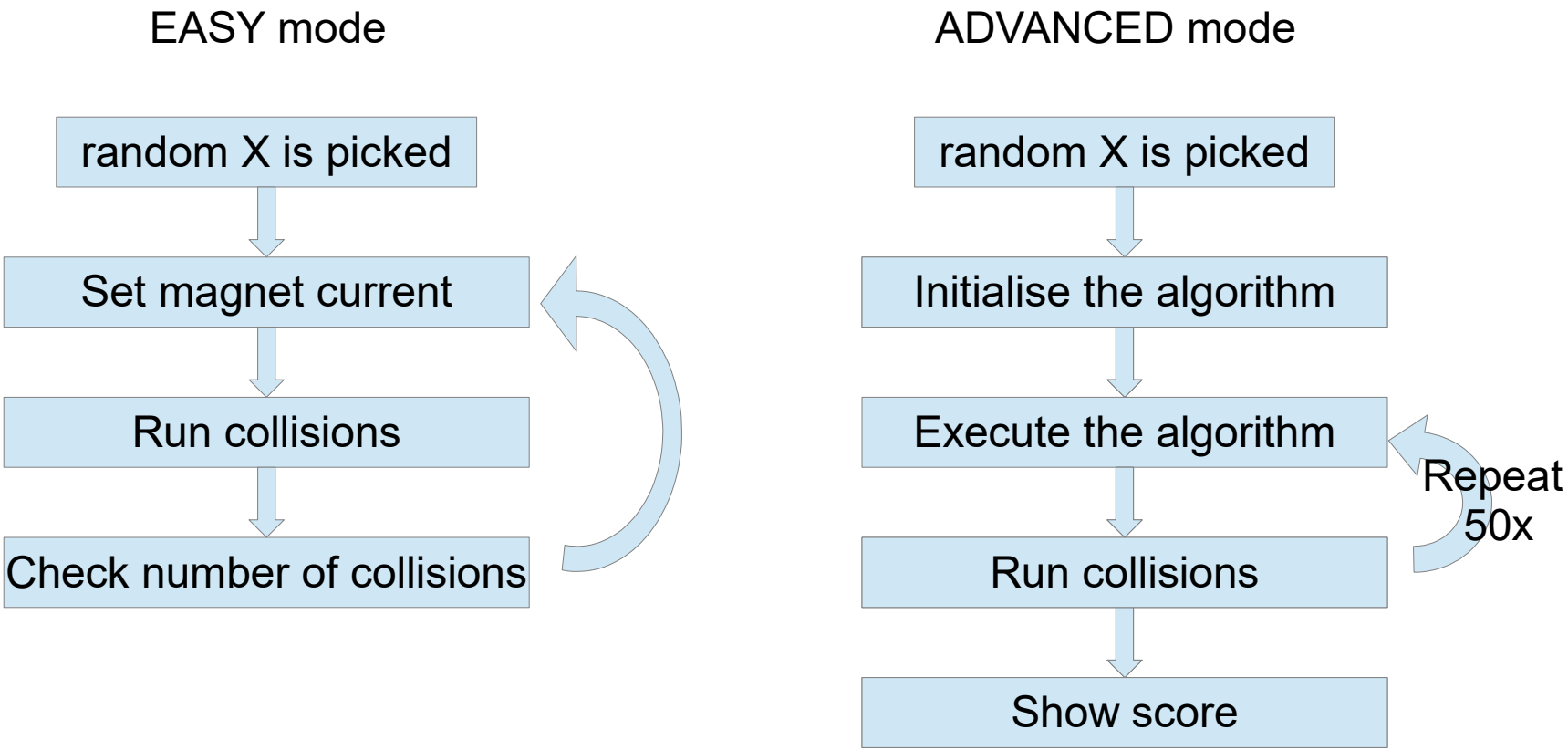
Hey, let's program collisions inside a particle detector at the Large Hadron Collider (LHC) at CERN!

INSTRUCTION RESET RUN CODE

Two complexity levels

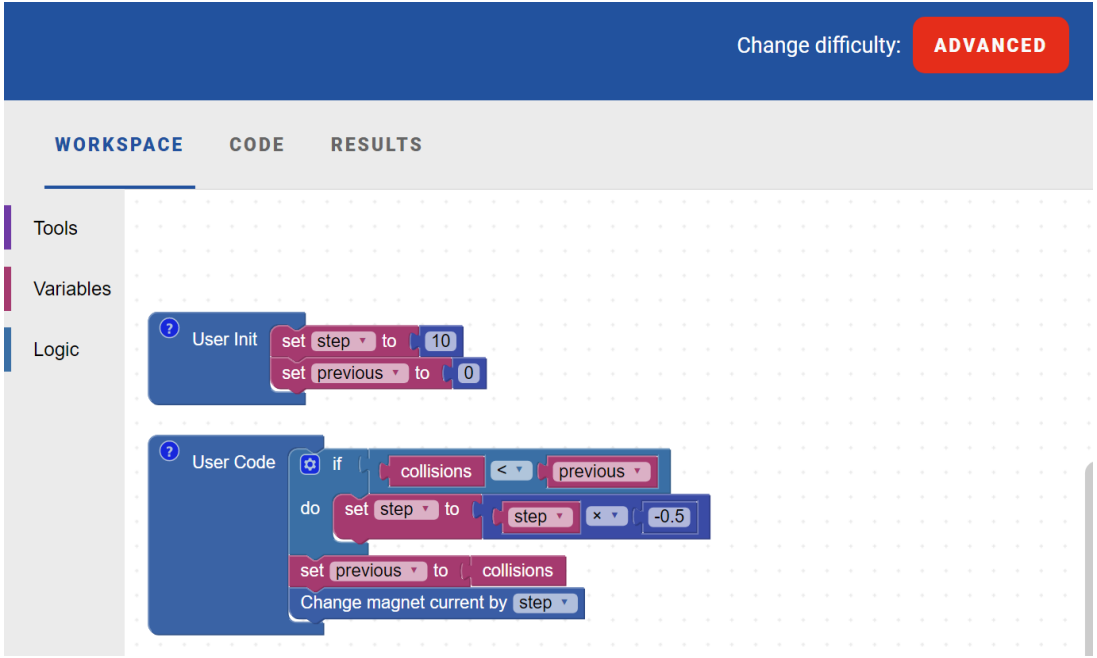
- The application has two modes – Easy and Advanced
- The idea behind this is simple:
  - In the Easy mode there's no coding – the user does all the work: sets the magnet current, runs collisions and repeats
  - In the Advanced mode the user has to write a simple program that searches for the maximum.
    - The program can check the number of collisions, set the magnet current, use variables, conditional statements etc
    - The idea is for the user to try reproducing their thought process from the Easy mode using an algorithm in the Advanced mode
    - A final score is shown at the end of running, based on the total number of collisions accumulated after 50 iterations

Flowchart


EASY mode
random X is picked
Set magnet current
Run collisions
Check number of collisions
ADVANCED mode
random X is picked
Initialise the algorithm
Execute the algorithm
Run collisions
Show score
Repeat 50x

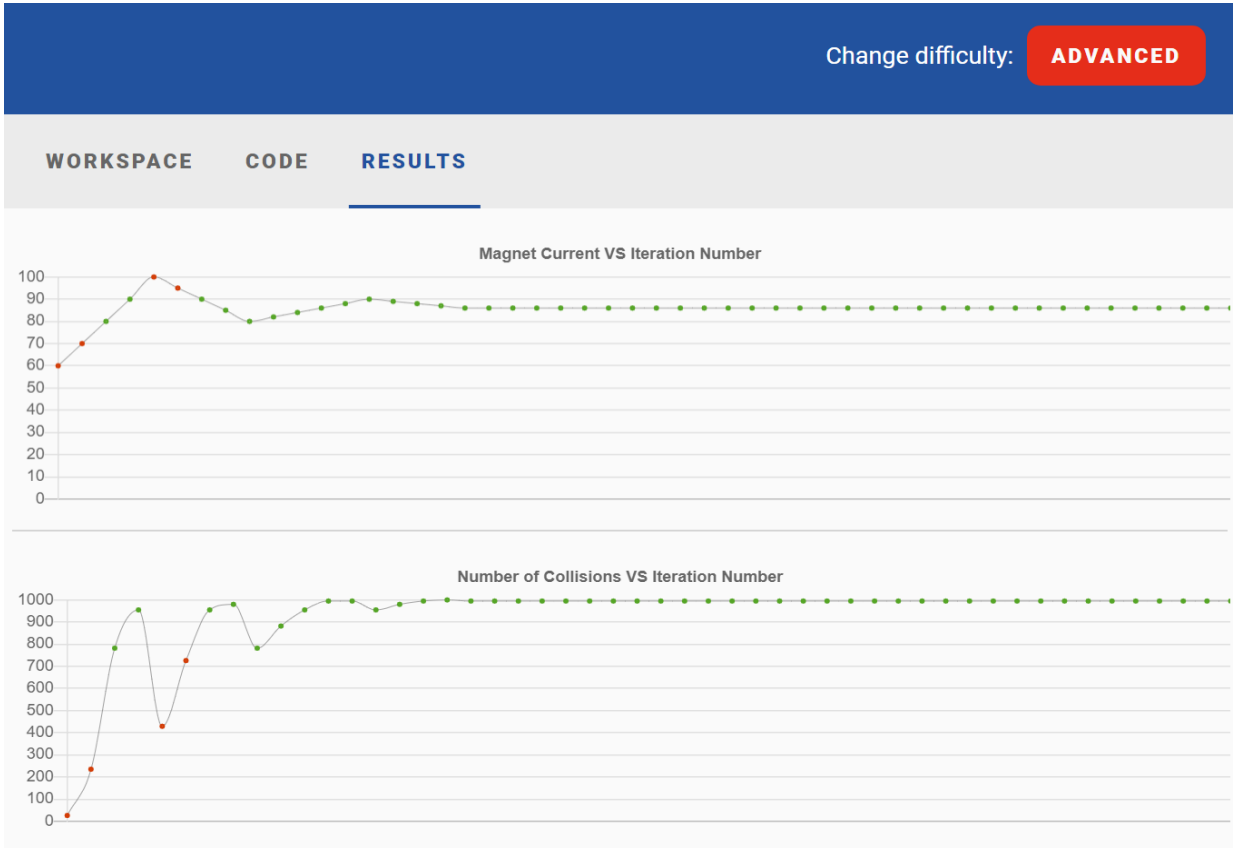
Writing algorithms

- All coding is done using Google's “blockly” open-source library



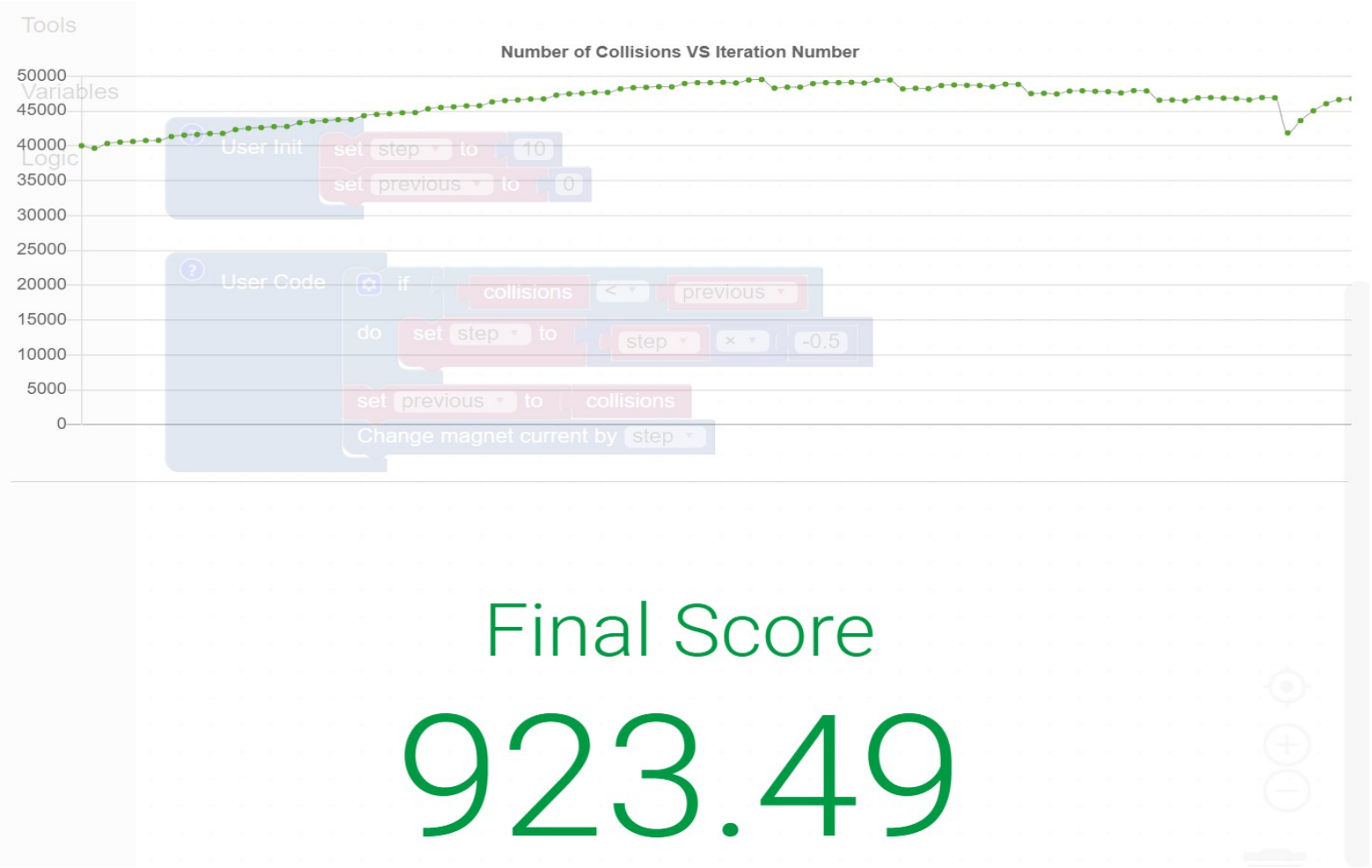
Algorithm results

- Result of running the code from the previous slide:



Final Score

- Running the code once or several times doesn't accurately show how well the user's algorithm performs
  - The “score” depends on the initial value of X (selected at random for each execution)
- To have an objective score allowing users to compare the performance of their algorithms, an extra “Final Score” mode was added
  - In this mode the 50-iteration algorithm run is performed 100 times, once for each possible value of X
  - The final score is a sum of scores from all 100 trials (normalized to 0-1000)


Tools
Variables
Logic
Number of Collisions VS Iteration Number
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
User Init
set step to 10
set previous to 0
User Code
if collisions < previous
do set step to step × -0.5
set previous to collisions
Change magnet current by step
Final Score
923.49

Phase 1 tests

Students from Riga Technical University - Engineering High School

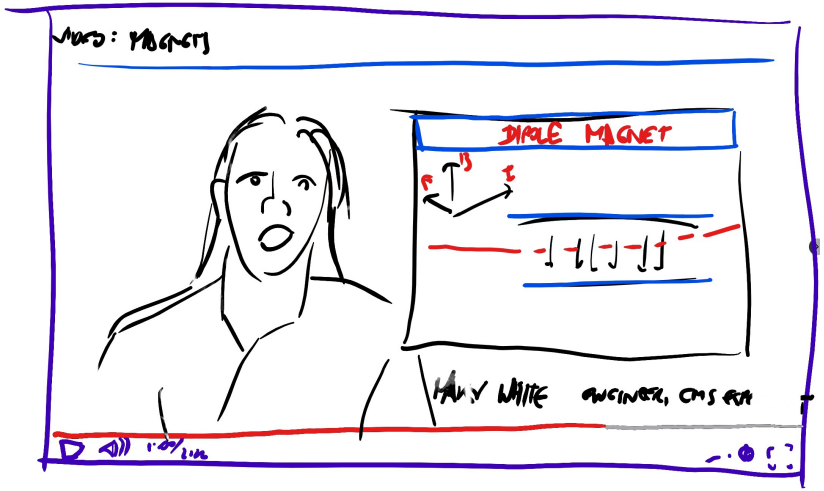
Phase 1 tests

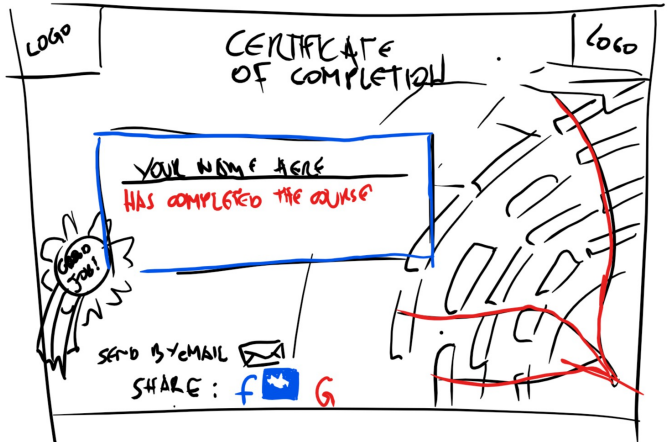
Students from Riga Technical University - Engineering High School

Future plans - Phase 2

(depends on funding)

- Adding more steps
- Adding video with explanations
- Adding a certificate





Test it

Try it out yourself:

http://cms-coding-tutorial.web.cern.ch

Send us your feedback:
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Thank you!