



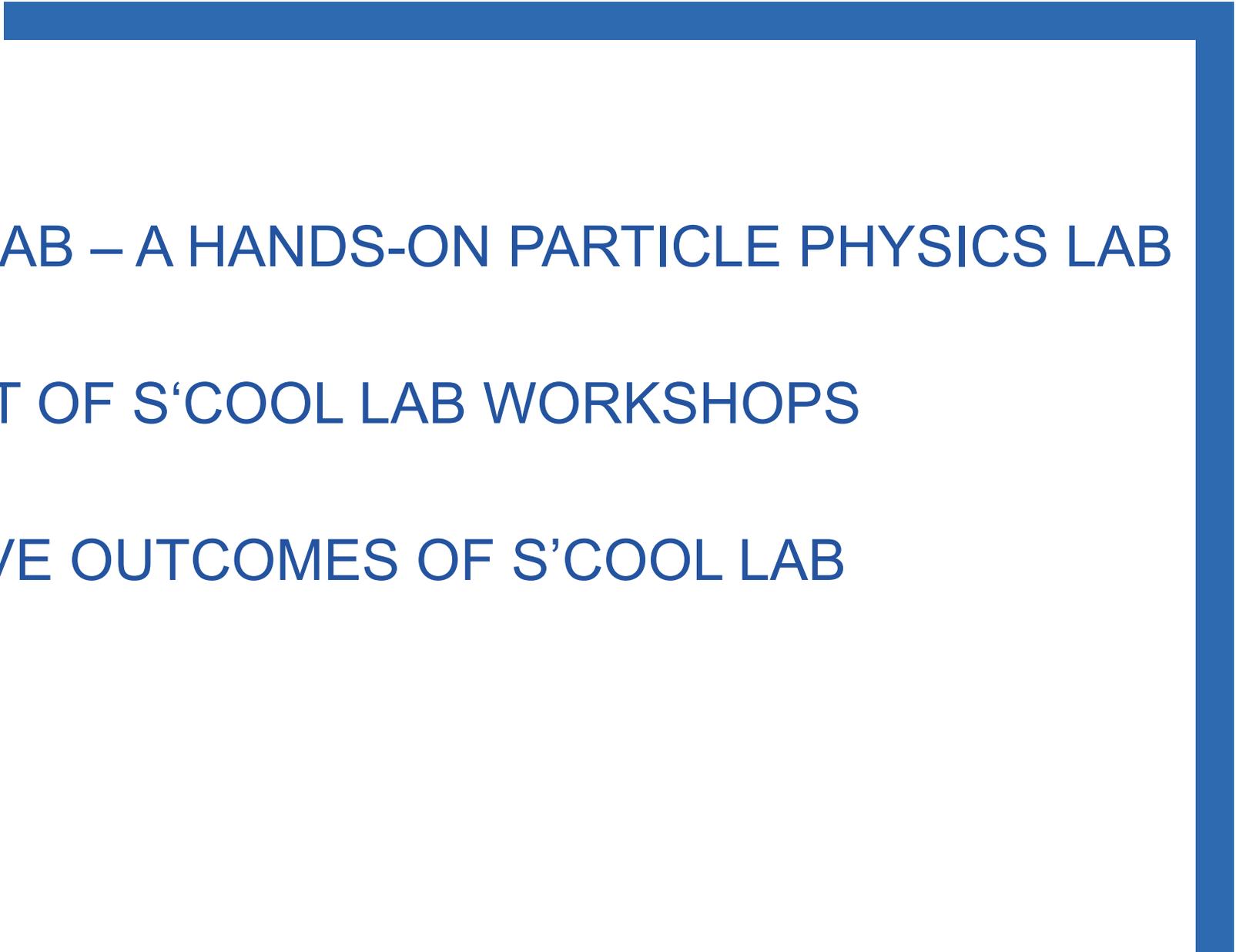
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Hands-on Particle Physics Experiments for High-school Students at S'Cool LAB / CERN

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Outline



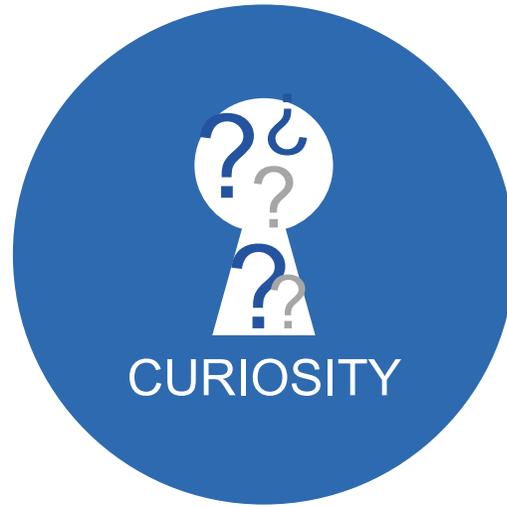
- ① S'COOL LAB – A HANDS-ON PARTICLE PHYSICS LAB
- ② CONCEPT OF S'COOL LAB WORKSHOPS
- ③ AFFECTIVE OUTCOMES OF S'COOL LAB

① S'COOL LAB – A HANDS-ON
PARTICLE PHYSICS LABORATORY
FOR HIGH-SCHOOL STUDENTS

Aims of S'Cool LAB



Give insights into the working methods, technologies and research of the world's largest particle physics laboratory



Spread CERN's spirit of science curiosity



Make CERN's physics and technologies understandable to students through hands-on experimentation

S'Cool LAB – conception

HANDS-ON PARTICLE PHYSICS LEARNING LABORATORY

For high-school students and teachers
International audience from more than 20 countries
Independent experimentation in small groups
Support by volunteering CERN scientists
S'Cool LAB days (1000 students p.a.) and
S'Cool LAB “light” (6000 participants p.a.)



S'Cool LAB – conception

200 m² MODULAR LABORATORY SPACE AT CERN

State-of-the-art IT equipment incl. videoconferencing
Experiments for schools linked to CERN's scientific
programme and technologies, e.g.



supercon-
ductivity

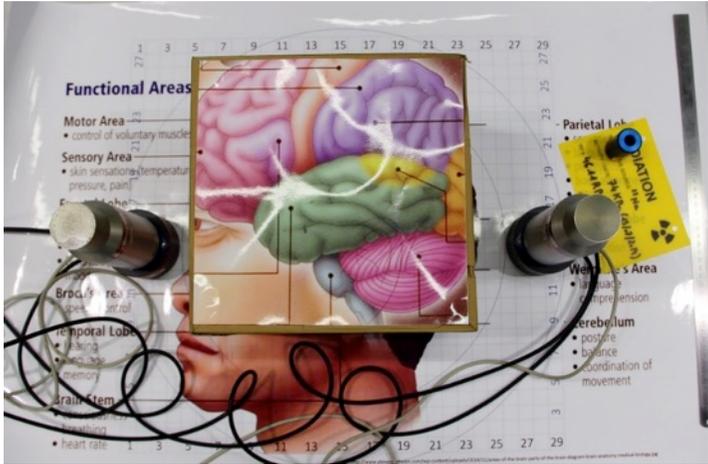


PET



cloud
chambers

Example: Positron-Emission-Tomography (PET)



Now you'll measure coincidences with the Na-22 preparation and the two detectors for different angular configurations (90° and 180°).
Which setup do you expect to have the larger count rate?
 Write down your predictions in the following table.

Prediction

Setup	Student 1	Student 2	Student 3	Student 4
Setup 1 90° 	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Setup 2 180° 	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Note down the reason for your prediction!



S'Cool LAB – conception

TEST BED FOR PHYSICS EDUCATION RESEARCH

Development and evaluation of student activities accompanied by research in physics education



PER in S'Cool LAB – design & research questions



Area of research 1: Affective outcomes of S'Cool LAB

e.g. Has S'Cool LAB the potential to raise students' **curiosity** towards particle physics?

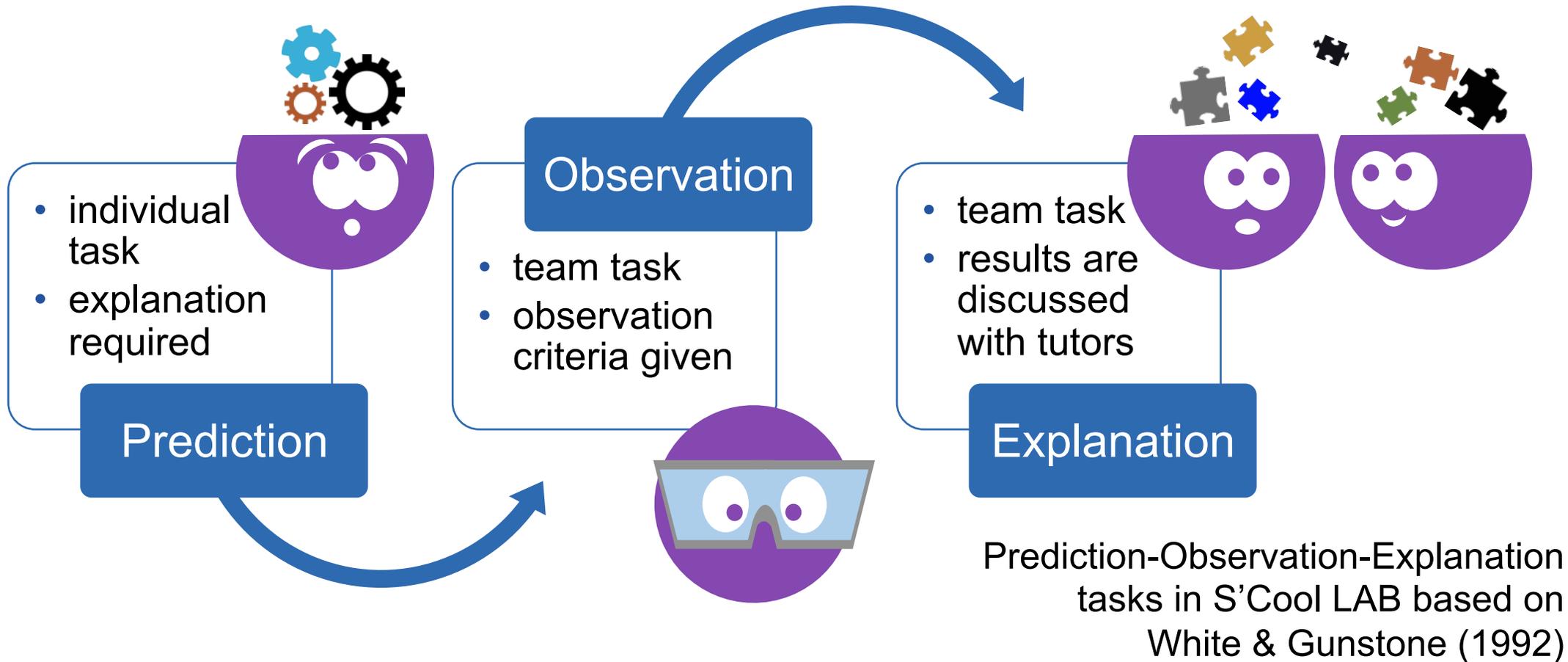
Area of research 2: Cognitive outcomes of S'Cool LAB

How much does students' **conceptual understanding** regarding the
e.g. conducted experiments improve in the framework of S'Cool LAB workshops?

② CONCEPT OF S'COOL LAB WORKSHOPS

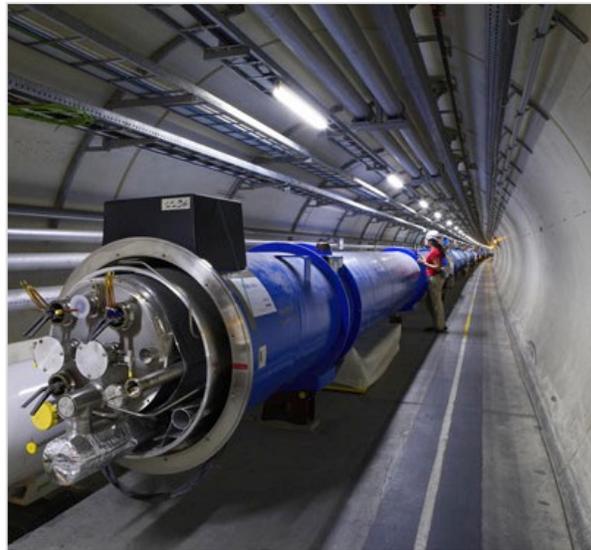
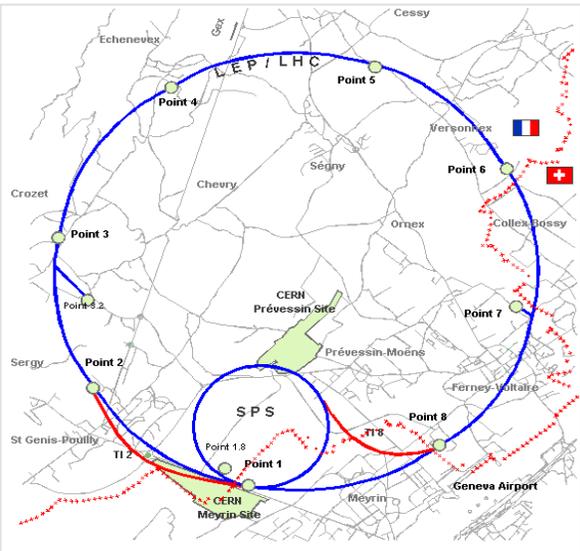
Students' conceptions and POE tasks

"Students' prior knowledge can interfere with how they observe and remember lecture demonstrations" (Miller, Lasry, Chu, & Mazur 2013)

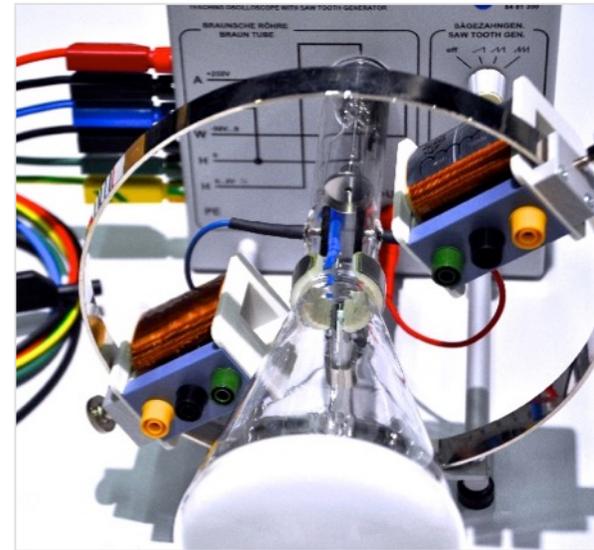


Example: electron gun – particle acceleration

CERN's Large Hadron Collider
6.5 TeV protons, 27 km circumference

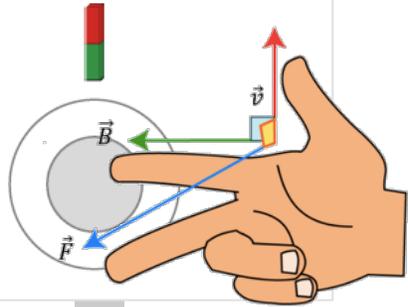


Electron tube in S'Cool LAB
300 eV electrons, 30 cm length



 **Prediction:** Mark your prediction for the 3 magnet positions below.

Magnet position 1



The diagram shows a hand pointing to a circular magnet. The magnet has a vertical bar with a red top and a green bottom. A velocity vector \vec{v} is shown pointing upwards. A magnetic field vector \vec{B} is shown pointing to the left. A force vector \vec{F} is shown pointing downwards and to the left. The hand is pointing to the magnet with its index finger.

③ AFFECTIVE OUTCOMES OF S'COOL LAB

Appreciation of S’Cool LAB and the experiments

- pilot phase from May to June 2016:
 - 96 students
 - 35% female / 65% male
 - avg. age 16.8 years (grades 9 – 12)
 - students from Germany, Spain, Sweden, The Netherlands, and Turkey
 - Avg. Math grade 77%, avg. Physics grade 75%
- Students filled out (online) questionnaires before and after their visit

We are interested in your opinion!

Evaluation – S’Cool LAB Day overall

How did you like your S’Cool LAB day at CERN?

9 • The guided tour at CERN not at all very much

10 • Working on the experiments in S’Cool LAB not at all very much

11 • The whole day at CERN including S’Cool LAB not at all very much

How do you feel about the durations?

12 • The guided tour at CERN too short too long

13 • Working on the experiments in S’Cool LAB too short too long

14 • The whole day at CERN including S’Cool LAB too short too long

15 • We had enough time to work on the experiments on our own in S’Cool LAB. completely disagree completely agree

How much did you learn?

<http://cern.ch/e-scoollab>

Enjoyment & perceived learning gain

Full-day programme: guided tour vs. S'Cool LAB

Dependent t-test results

- significant difference between hands-on workshops in S'Cool LAB and guided tour

- **Enjoyment**

$t(95) = 4.81, p < .001^{**}$,
Cohen's $d^1 = 0.49$

- **Perceived learning gain**

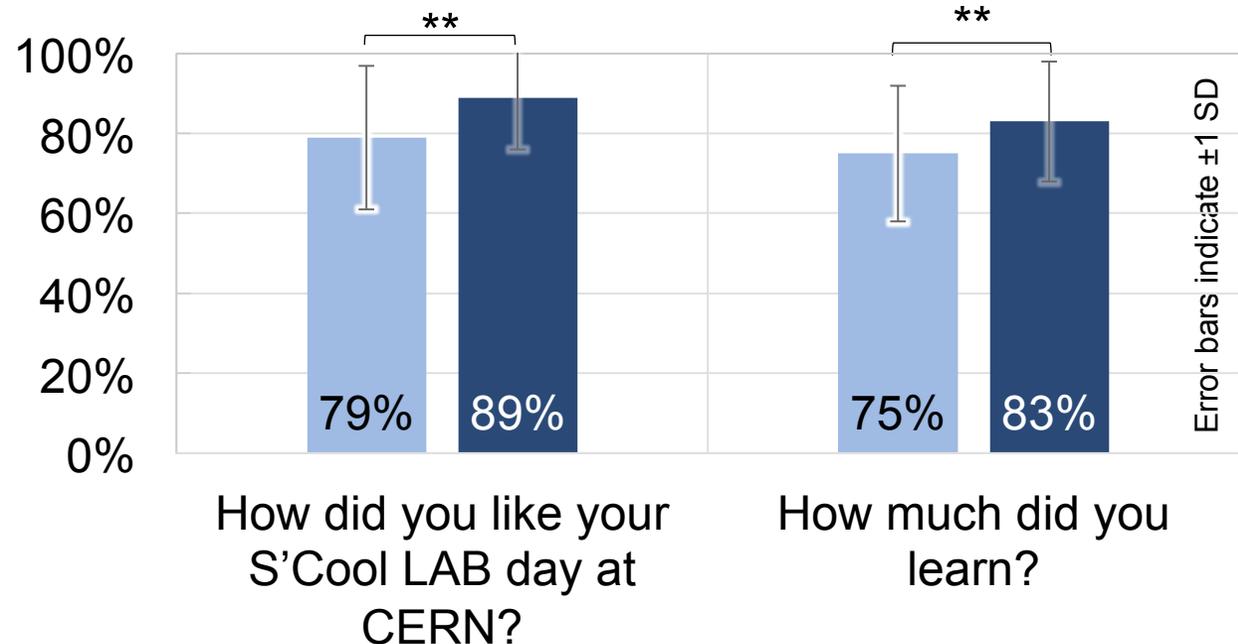
$t(95) = 3.45, p < .001^{**}$,
Cohen's $d^1 = 0.39$

¹ calculated according to Dunlop, Cortina, Vaslow & Burke (1996, p. 171)

- Students enjoy both parts of their full-day programme at CERN and report that they have learned a lot during the day
- Students like S'Cool LAB more than the tour

Enjoyment & perceived learning gain

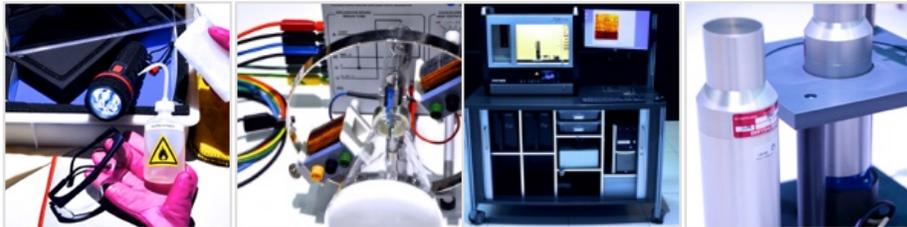
- The guided tour at CERN
- Working on the experiments in S'Cool LAB



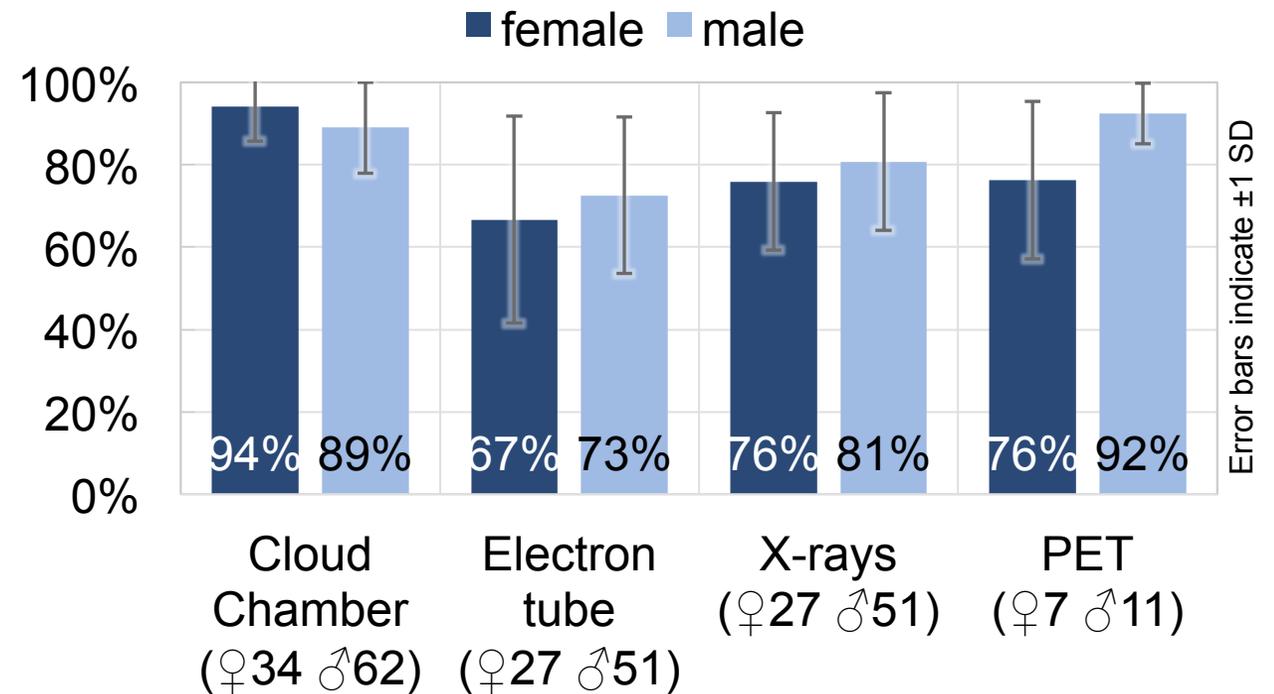
Evaluation S'Cool LAB experiments

Independent t-test results

- No significant difference in perception of experiments by girls and boys
- Favourite experiment: Cloud Chamber
- Very promising: PET experiment



Evaluation of the experiments



Motivation variables physics: Interest / Engagement and Self concept

Dependent t-test results

- significant difference between post and pre results

- **Interest / engagement**

$t(95) = 9.71, p < 0.001^{**}$

Cohen's $d^1 = 0.94$

- **Self concept**

$t(95) = 8.08, p < 0.001^{**}$

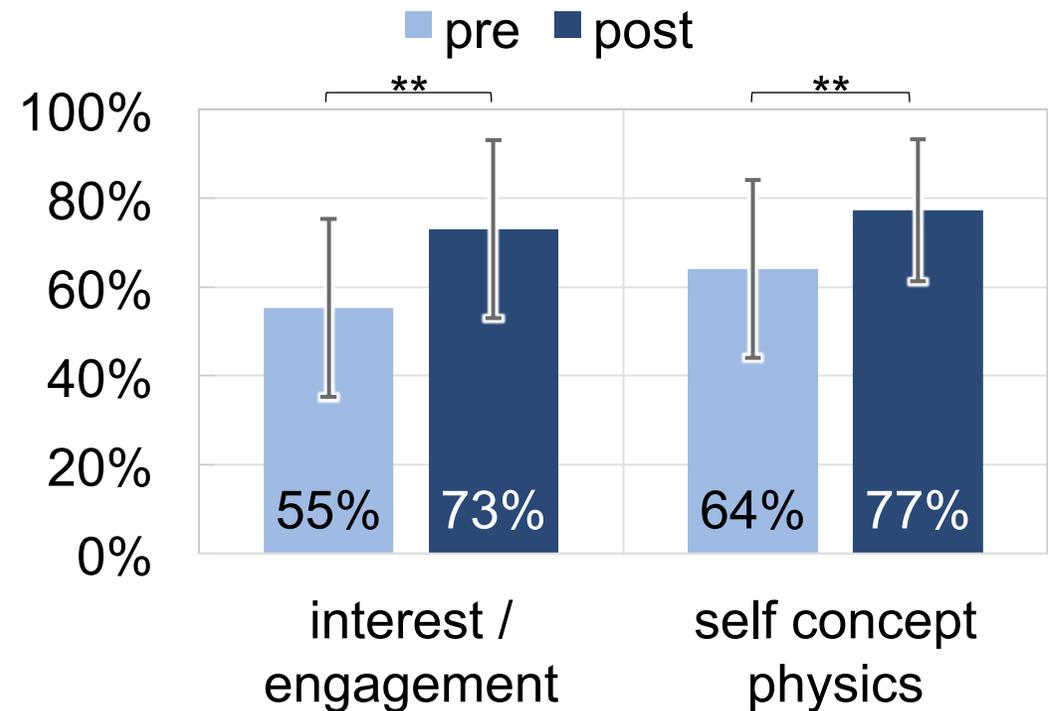
Cohen's $d^1 = 0.86$

→ High situational interest in S'Cool LAB

→ High self-concept in S'Cool LAB

¹ calculated according to Dunlop, Cortina, Vaslow & Burke (1996, p. 171)

Motivation variables pre / post

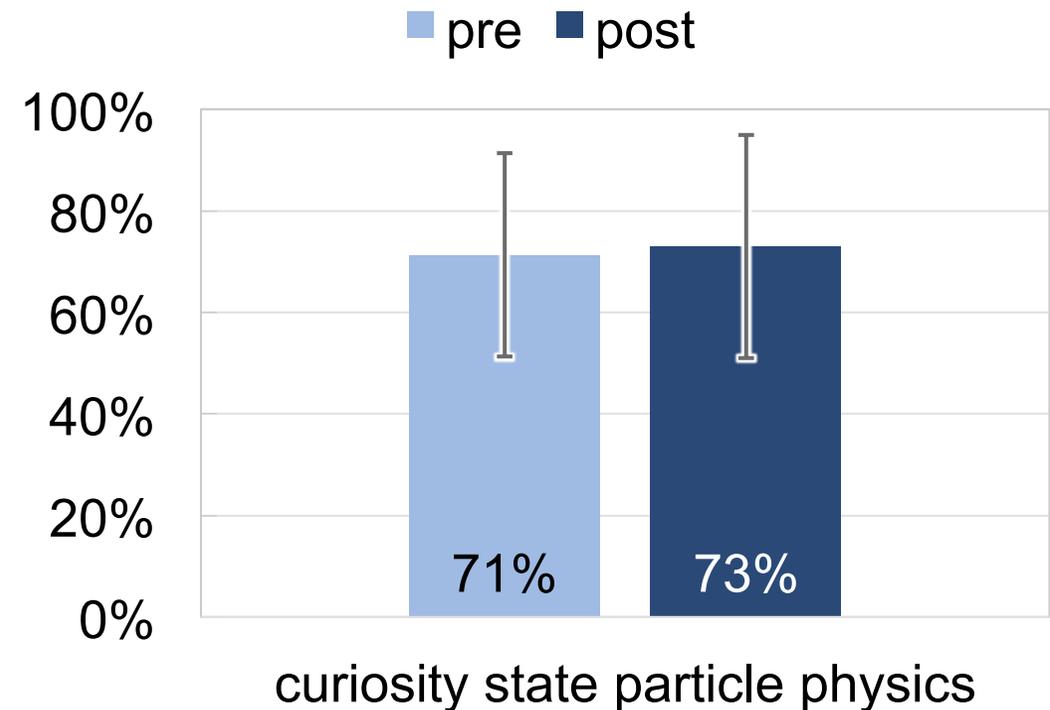


Curiosity state particle physics

Dependent t-test results

- No significant difference between post and pre results
 - $t(92) = 0.82, p = 0.414$
- Curiosity regarding particle physics is already high before the visit to S'Cool LAB

Curiosity state pre / post



“I had the idea of studying physics from before, but everyone kept telling me that it was crazy and it had pretty few professional exits. Thanks to your experiments I am convinced now that I want to at least try it.”

Student after S’Cool LAB workshop

Thank you for your attention!

Literature

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