

Teilchenphysik aus dem 3D-Drucker

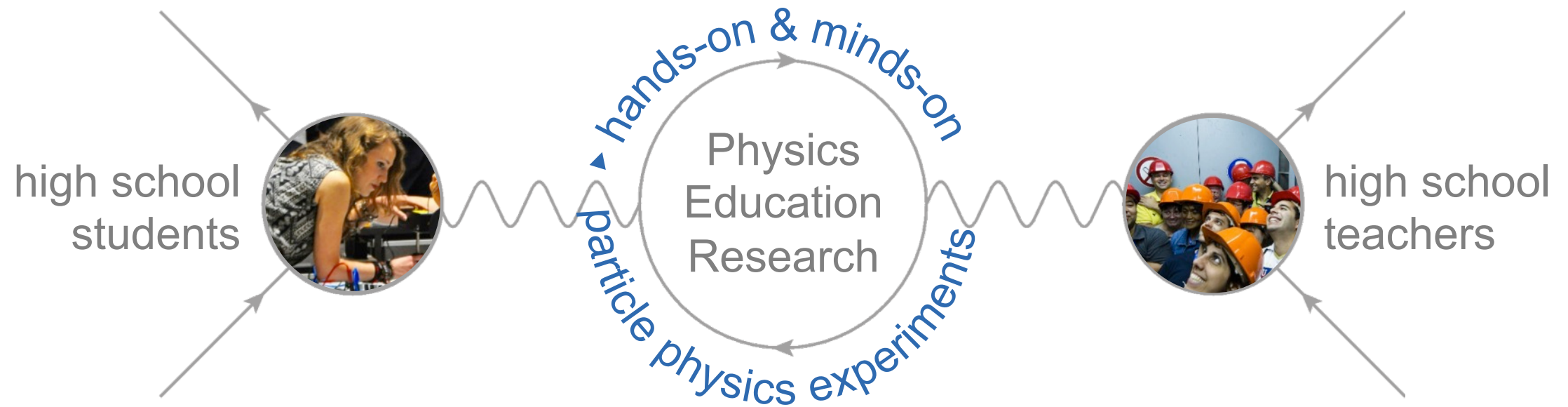
Particle physics & 3D printers

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CERN S'Cool LAB

a hands-on particle physics learning laboratory



experiments related to CERN physics, e.g. Pixel detectors, PET, superconductivity

approx. 5000 per year
from more than 30 countries
age group 16-19

cognitive & affective outcomes,
students' conceptions,
e-learning preparation

teachers' motivations for field
trips, **low-cost DIY experiments**
for classrooms

3D printable things & education

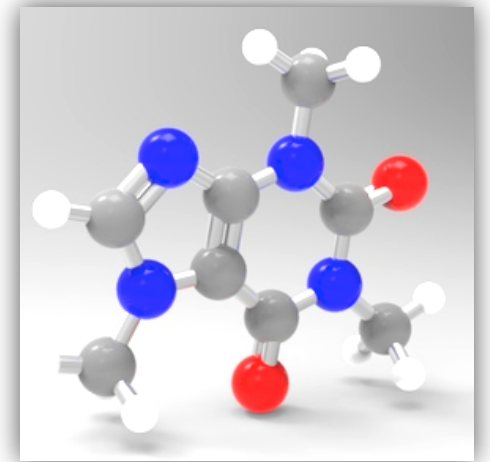


- More and more 3D printers & 3D printable things available
- e.g. www.thingiverse.com/education
- So far: many structural models
- Only a few functional model

model of an animal cell
www.thingiverse.com/thing:689381

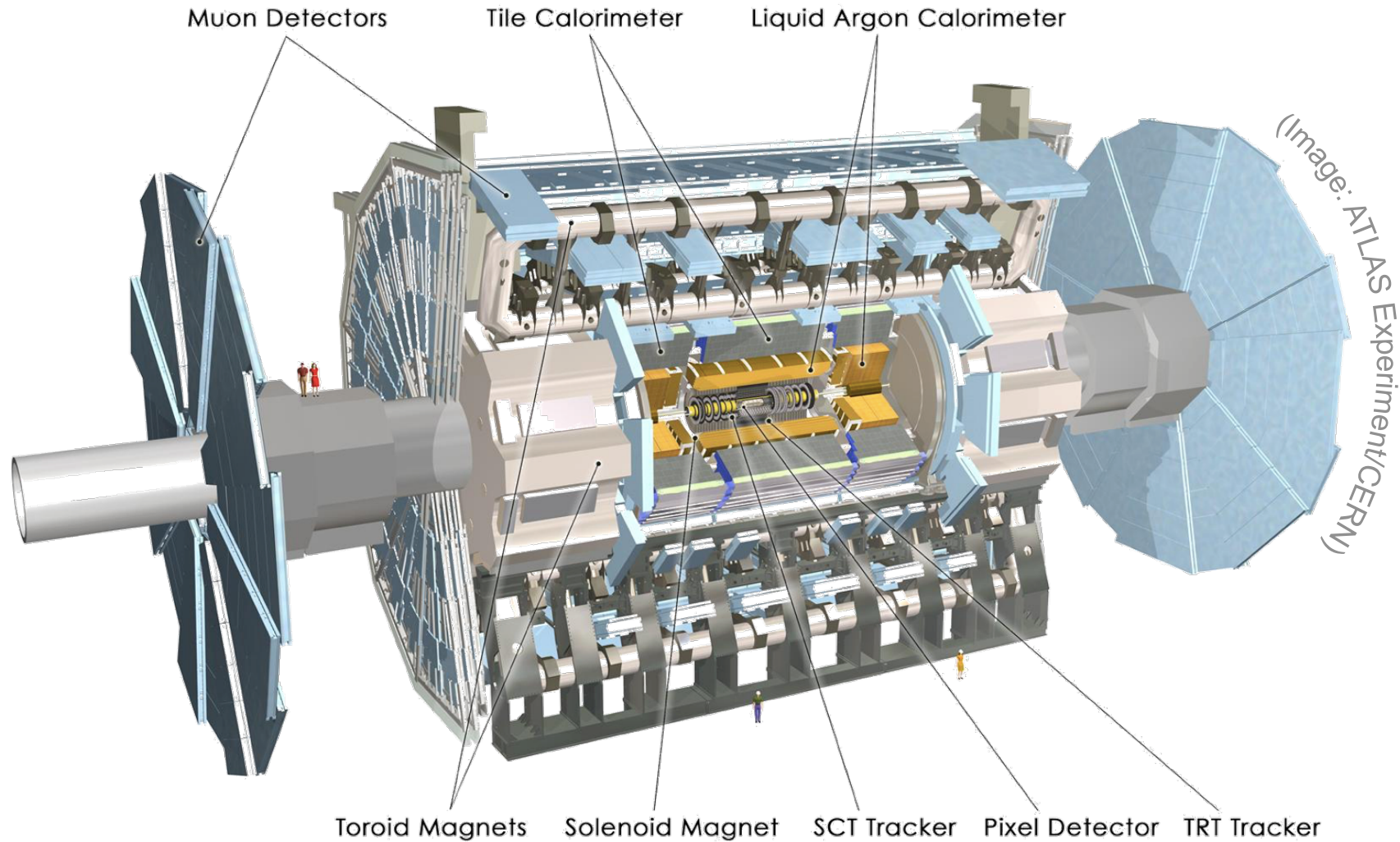


model of a caffeine molecule
www.thingiverse.com/thing:876224

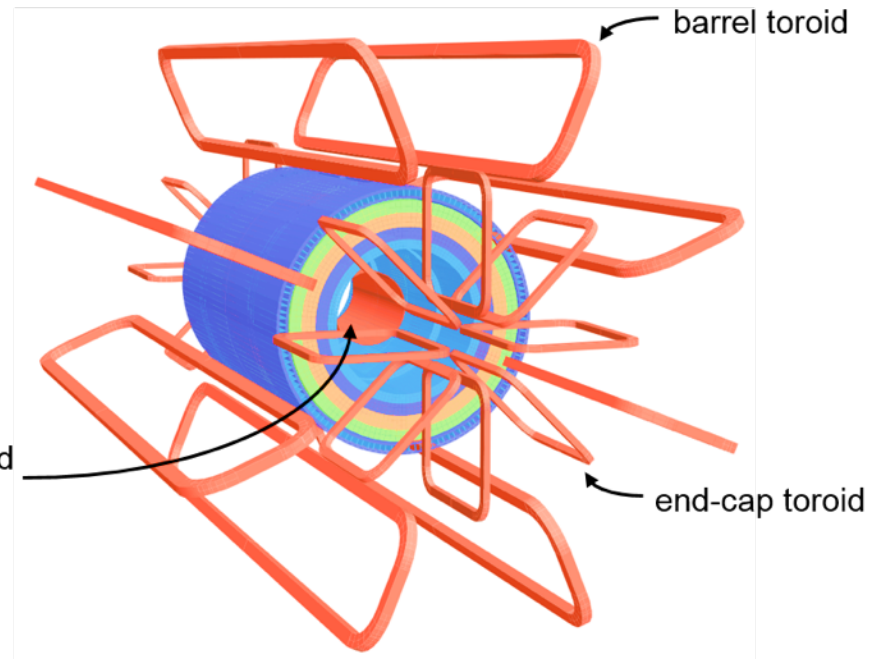


model of ALICE detector
http://cern.ch/alicematters/?q=ALICE_3D_models

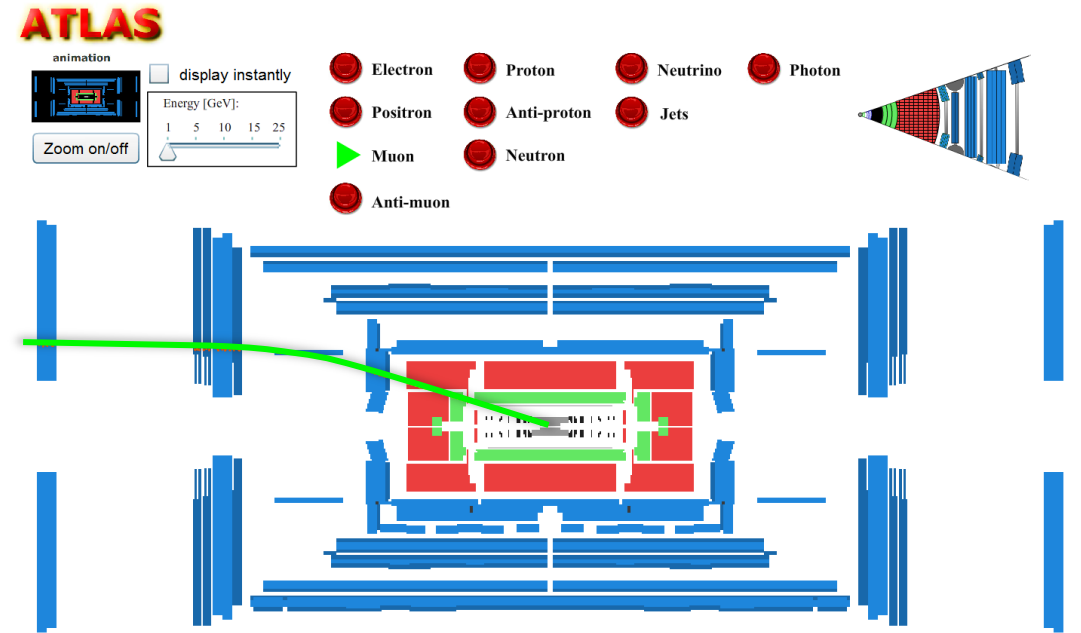
ATLAS – A Toroidal LHC ApparatuS



Toroidal magnet system – the T in ATLAS



central solenoid

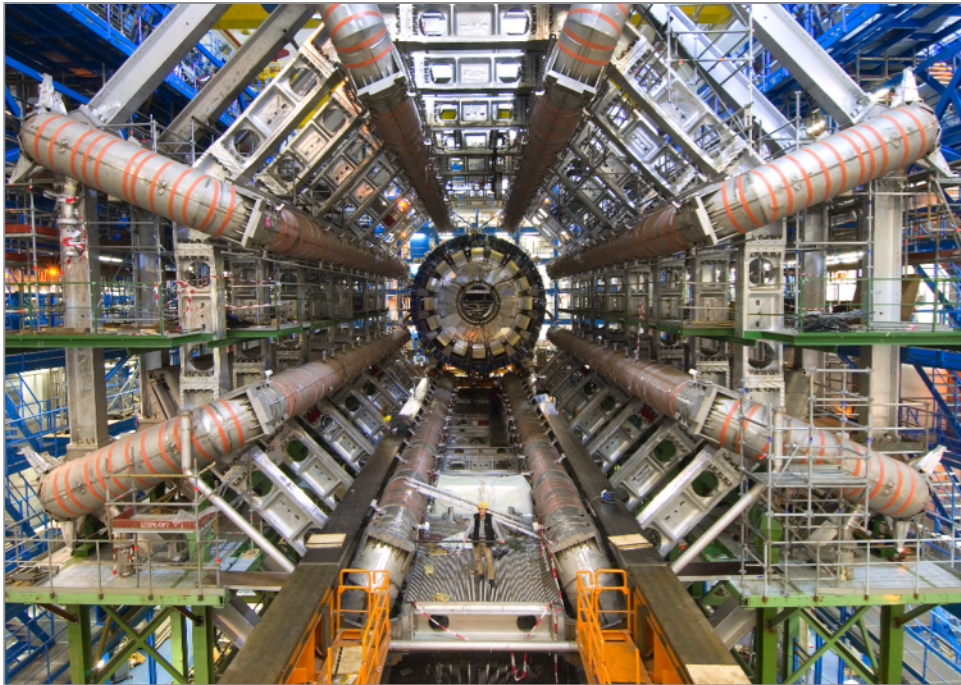


Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel

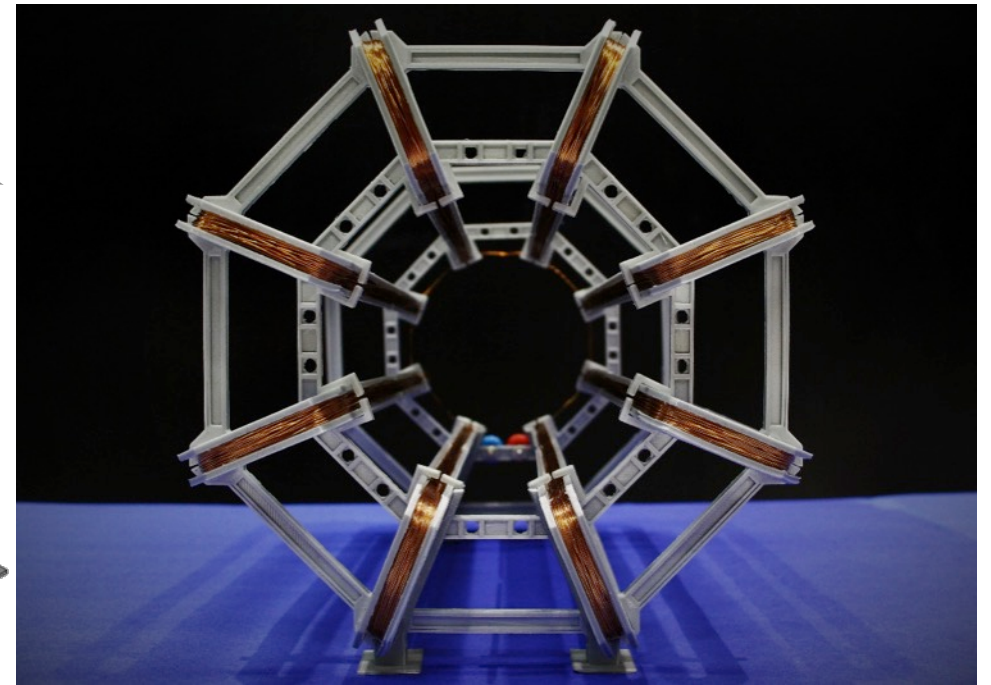
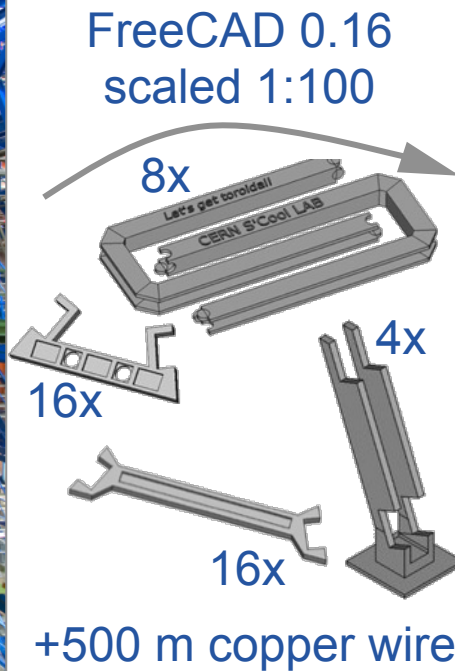
The ATLAS Collaboration (2008). The ATLAS Experiment at the CERN Large Hadron Collider. *Journal of Instrumentation*, 3, S08003
<http://cdsweb.cern.ch/record/1129811>

Herrmann, T., Jeřábek, O., Jende, K., & Kobel, M. (2012).
Interactive simulation of the ATLAS detector
http://atlas.physicsmasterclasses.org/en/wpath_teilchenid1.htm

Designing a 3D printable model

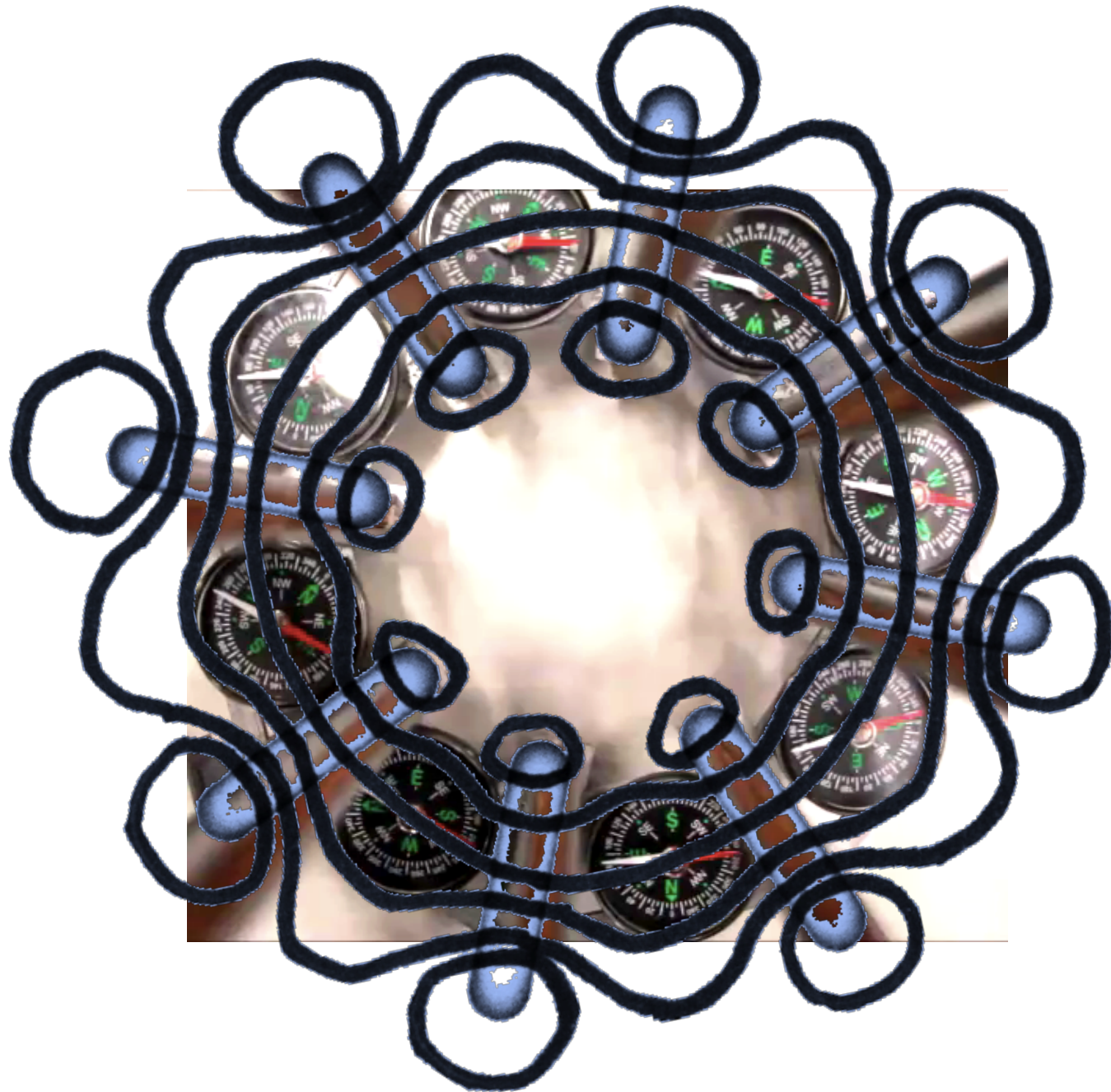
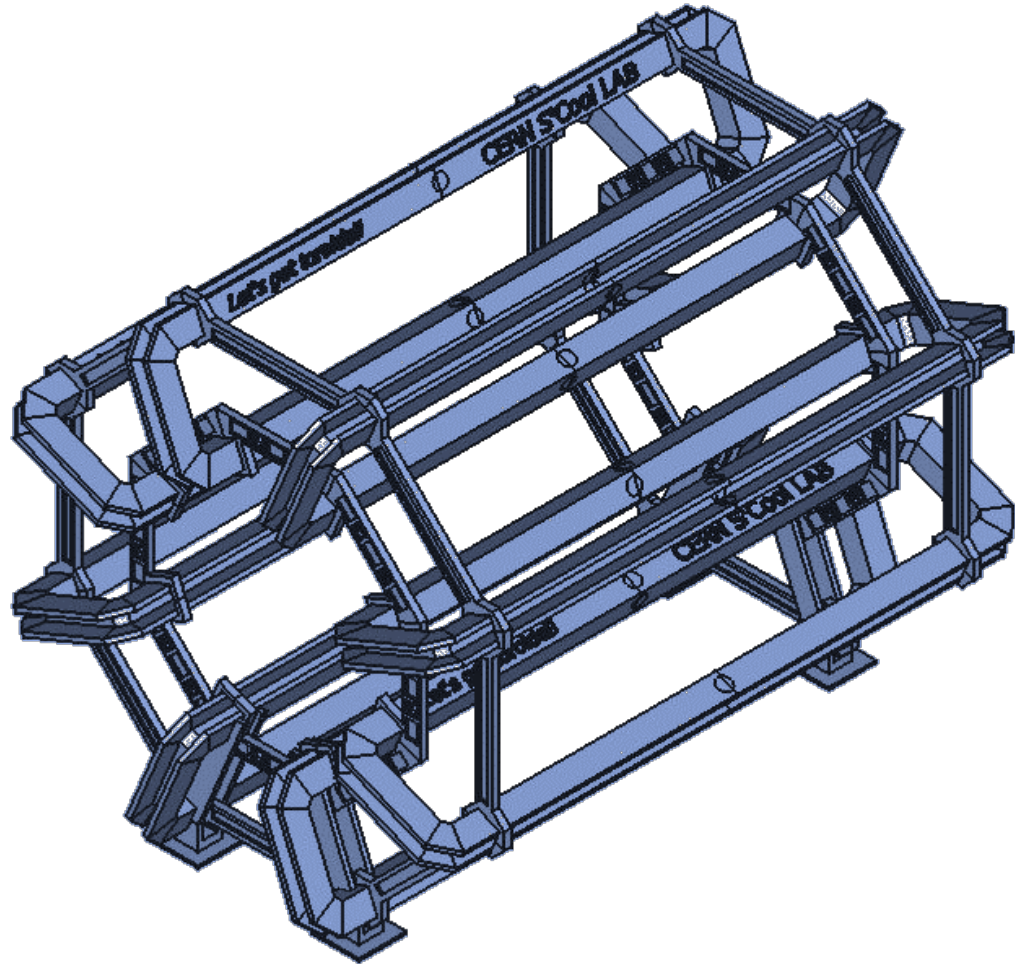


(Image: CERN)



S'Cool LAB www.thingiverse.com/thing:1722230

The final model

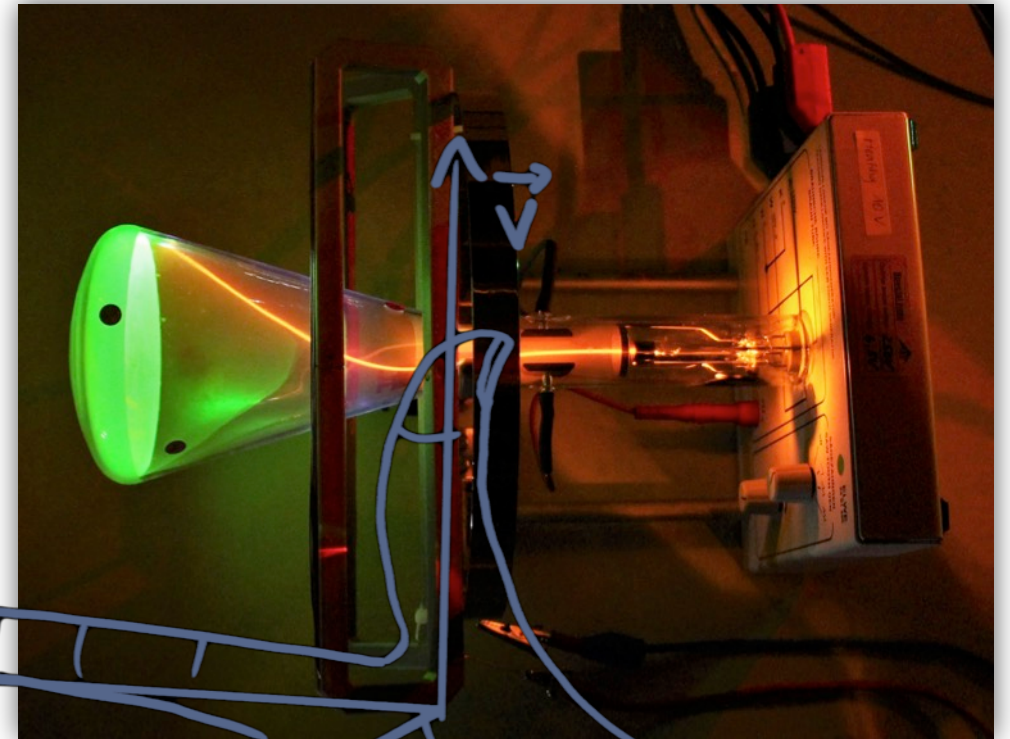
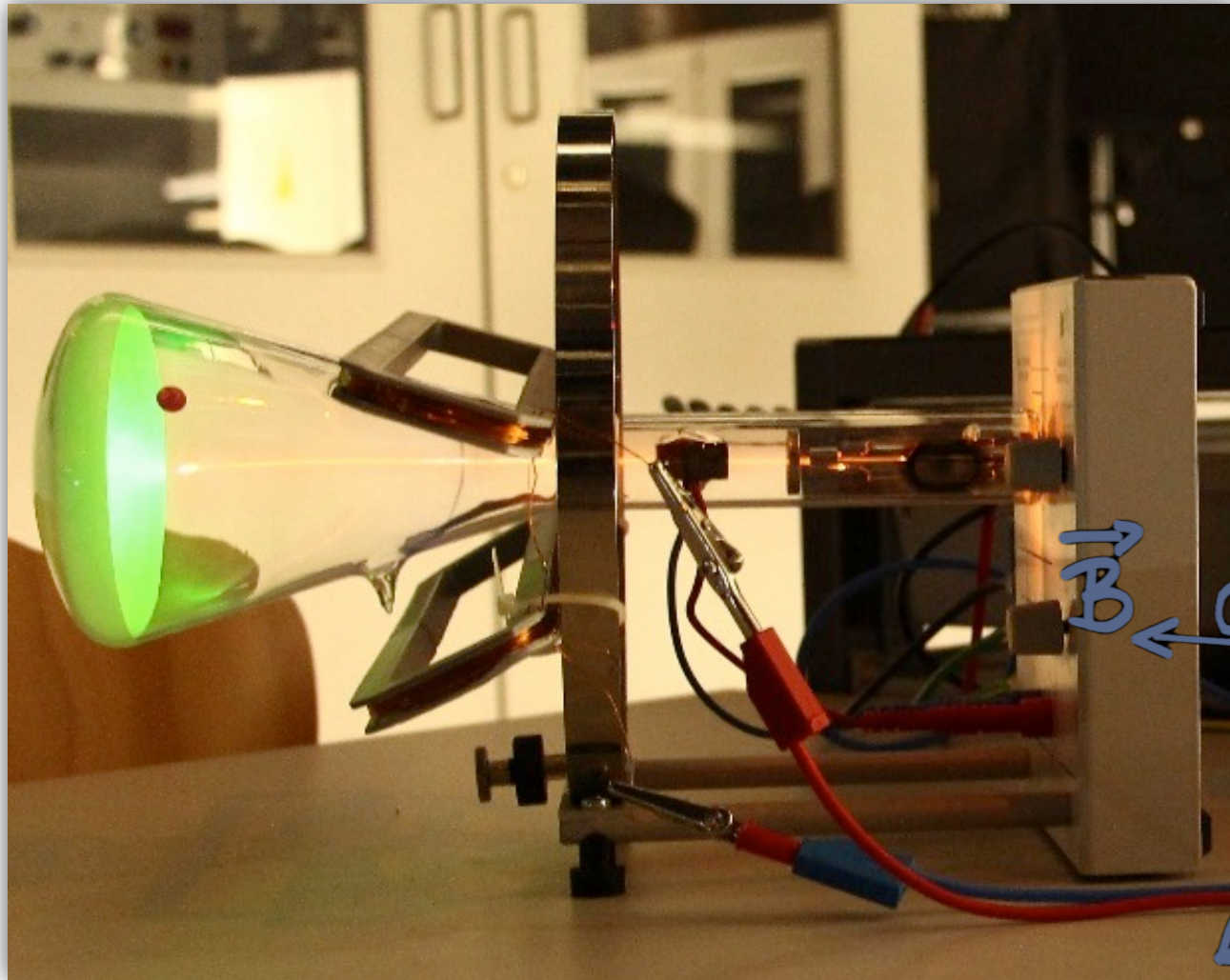


Comparison between the ATLAS barrel toroid and the functional 3D-printed model

	Feature	ATLAS toroid ¹	Modell toroid
Dimensions	Inner diameter	9.4 m	9.3 cm
	Outer diameter	20.1 m	20.1 cm
	Length	25.3 m	24.7 cm
	Mass	830 t	860 g
Coils	Number of coils	8	8
	Material	Niobium-Titanium	Enamelled copper wire
	Operating temperature	4.5 K	Room temperature
	Turns per coil	120	80
	Total length of conductor	56 km	500 m
	Voltage	16 V	12 V
	Nominal current	20.5 kA	0.4 A
	Resistance	0.16 mΩ	31 Ω
	Average magnetic field	0.5 T	0.8 mT

¹ The ATLAS Collaboration (2008). The ATLAS Experiment at the CERN Large Hadron Collider. *Journal of Instrumentation*, 3, S08003 <http://cdsweb.cern.ch/record/1129811>

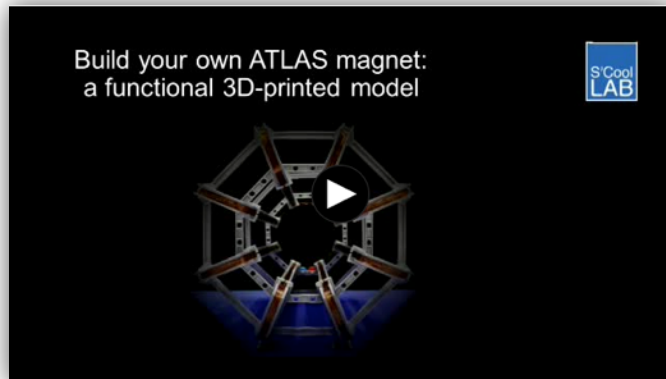
250 eV electron beam & model coils



More about the ATLAS magnet model

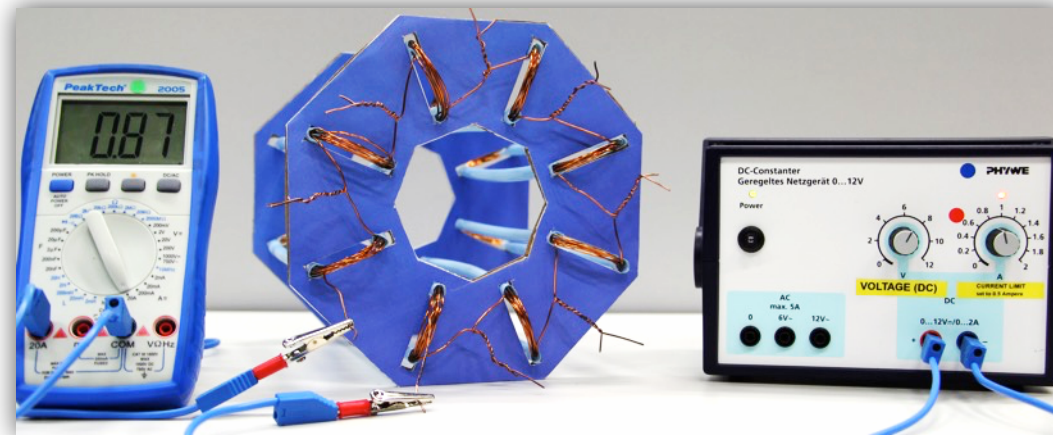
S'Cool LAB Website

<http://cern.ch/s-cool-lab/classroom-activities/atlas-model>



Video

<https://cds.cern.ch/record/2255117>



Model with straws: Feistmantl, A., Woithe, J. (2017). Elektromagneten der Teilchenphysik hands-on – das ATLAS-Magnetsystem. Praxis der Naturwissenschaften - Physik in der Schule, 66(1), 21-28 <https://cds.cern.ch/record/2244917>

Woithe, J., Feistmantl, A., Keller, O., Gonçalves, T. (submitted). Build your own ATLAS magnet: a functional 3D-printed model. *Physics Education*



Thank you for your attention!

Download our slides: cern.ch/s-cool-lab/publications

S'Cool LAB Website: cern.ch/s-cool-lab/classroom-activities/atlas-model

Send us pictures of your model: scool.lab@cern.ch