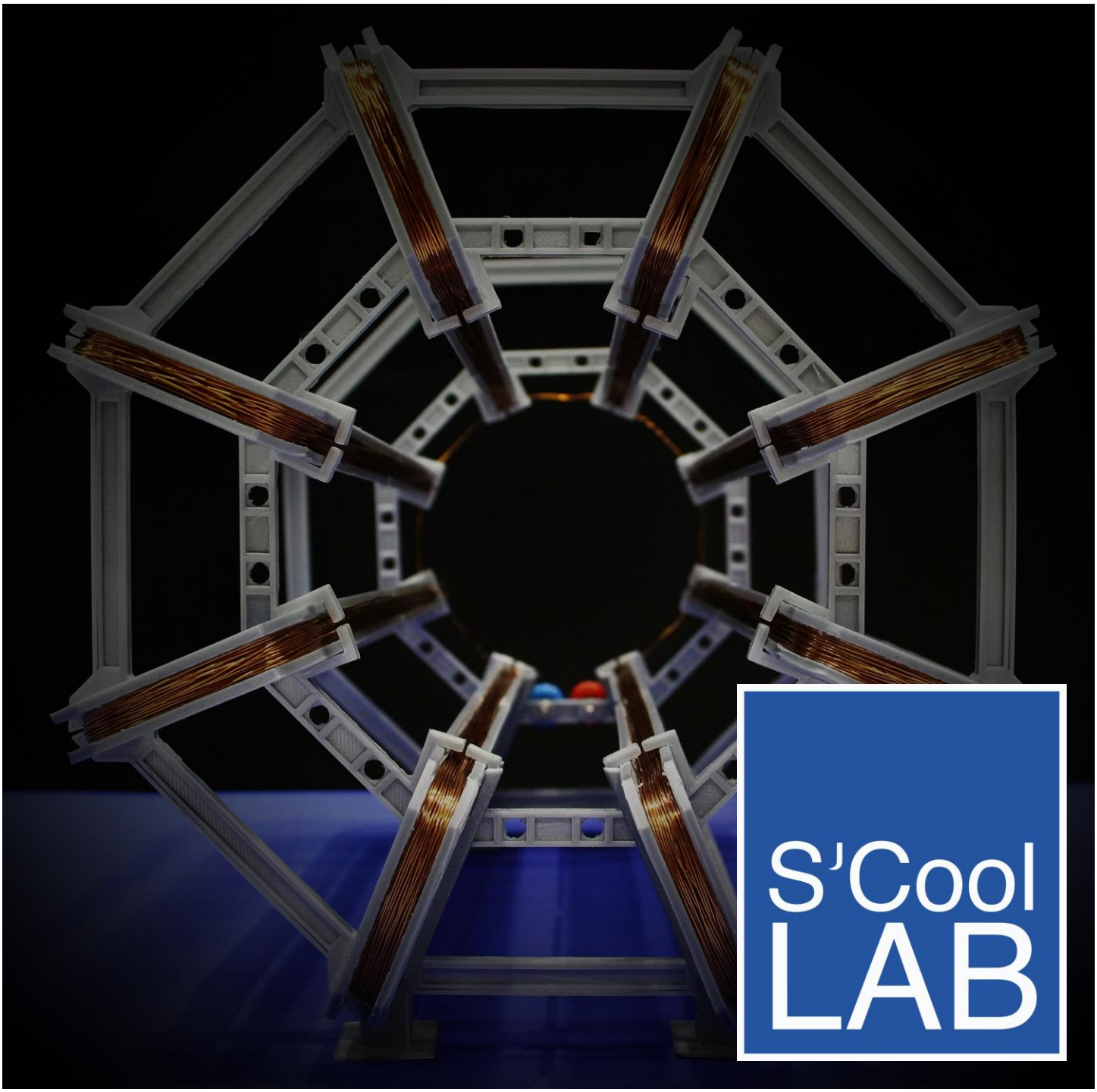

3D Model of ATLAS Toroidal Magnet system

Student worksheet

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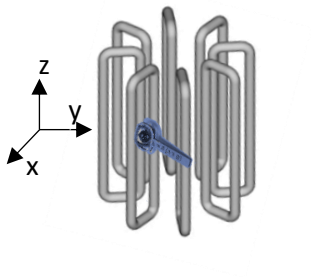
Worksheet for the model of the ATLAS magnet system

With the help of the following worksheet you will not only explore the magnetic field of the ATLAS magnet model, but also make a prediction of the results before the measurements. Remember what you already know and explain your prediction! Perform accurate measurements, note down your observations and try to explain if your predictions differ from you observations!

For all measurements performed in this worksheet:

a) The sketches show one / two or more coils always from above. So in the xy-plane of the picture on the right.
b) In the following tasks you will be exploring magnetic fields, and you will always measure the field at a certain "height". This height should correspond approximately to the z = 0 plane in the picture one the right.



Compare your model with the real toroidal magnet system of the ATLAS detector!
Use the following sources together with your measurements on your final model und fill out the table below.

[1] ATLAS Collaboration (2008): The ATLAS Experiment at the CERN Large Hadron Collider In: J. Instrum. 3 (2008) S08003 https://cdsweb.cern.ch/record/1129811
[2] The ATLAS Experiment © 2011 CERN (2011): ATLAS Fact Sheet. https://cds.cern.ch/record/1457044/files/ATLAS%20fact%20sheet.pdf

	feature	ATLAS toroid	Modell toroid
Size and mass	Inner diameter		
	Outer diameter		
	length		
	mass		
coils	Number of coils		
	material		
	Operating temperature		
	Turns per coil		
	Total length of conductor		
	Nominal current		
	Voltage		
	Resistance		
	Average magnetic field		

1. Exercise 1 – work in pairs

Prediction

1.1 We start with one of the coils. First of all, think about what the magnetic field of only one coil will look like. Sketch magnetic fields line in the figure below to visualise the predicted magnetic field!

Observation

1.2 Connect one coil to a power supply and explore the magnetic field. Sketch again magnetic field lines to visualise your observation.

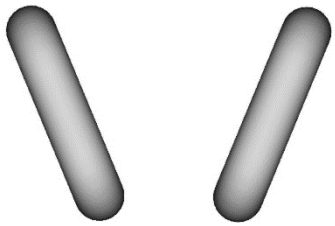
Explanation

1.3. Is there a difference between your prediction in 1.1 and your observation in 1.2? If the sketches are different, what could be the reason?

2. Exercise 2 – group work (2 students)

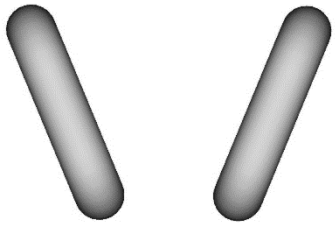
Prediction

2.1 In the next step you will use two coils. You will arrange them as shown in the figure below. How will the magnetic field look like now? Sketch your prediction.



Observation

2.2 Now, connect the coils, and connect them to a power supply. Explore the field and sketch again magnetic field lines visualising the magnetic field.



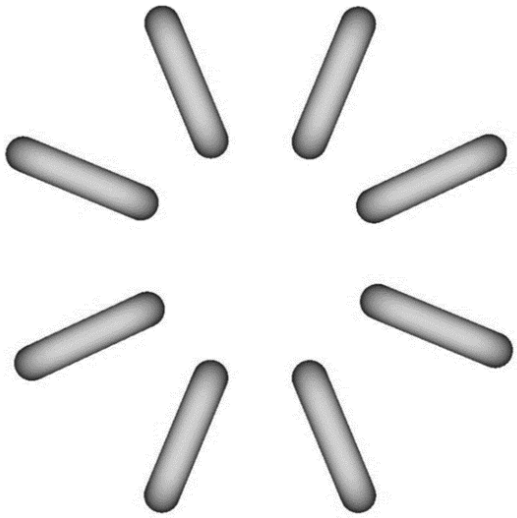
Explanation

2.3. Is there a difference between your prediction in 2.1 and your observation in 2.2? If the sketches are different, what could be the reason?

3 Exercise 3 – group work (8 students)

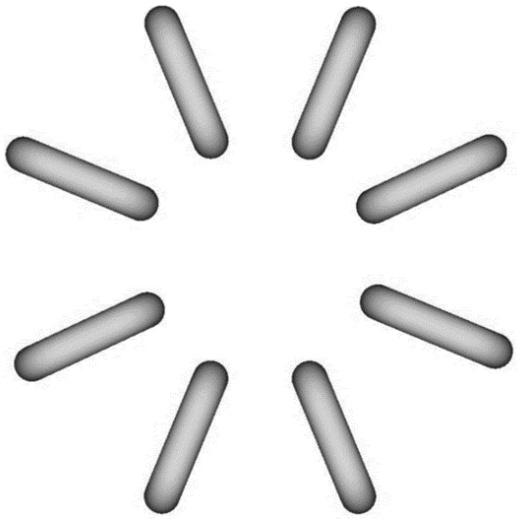
Prediction

3.1 Now, think about how the magnetic field of all 8 coils will look like. Sketch your prediction.



Observation

3.2 First you have to connect all coils and use glue to fix them. Then, connect the model to a power supply. Explore the field and sketch again magnetic field lines visualising the magnetic field.



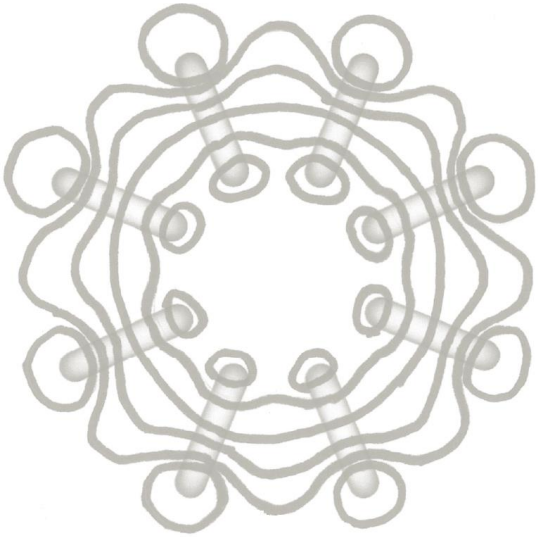
Explanation

3.3. Is there a difference between your prediction in 3.1 and your observation in 3.2? If the sketches are different, what could be the reason?

Congratulations! You have built your own 3D model of the ATLAS magnet system! Although the real toroidal magnet is 100 times bigger, its magnetic field looks very similar.

Solutions

If all eight coils are connected to the voltage supply, the magnetic field lines should look like in the drawing below. A circular magnetic field should be produced between the coils. In the outer regions around the coils the magnetic field is very inhomogeneous.



Comparison between the model and the real ATLAS toroid

The exact values for the model depend on several factors, however, the order of magnitude should be the same as in the table below.

	feature	ATLAS toroid	Modell toroid
Size and mass	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	Niob-Titanium	Enamelled copper wire
	Operating temperature	4.5 K	Room temperature
	Turns per coil	120 per coil	80 per coil
	Total length of conductor	56 km	500 m
	Nominal current	20.5 kA	0.4 A
	Voltage	16 V	12 V
	Resistance	0.160 mΩ	31 Ω
	Average magnetic field	0.5 T	0.8 mT