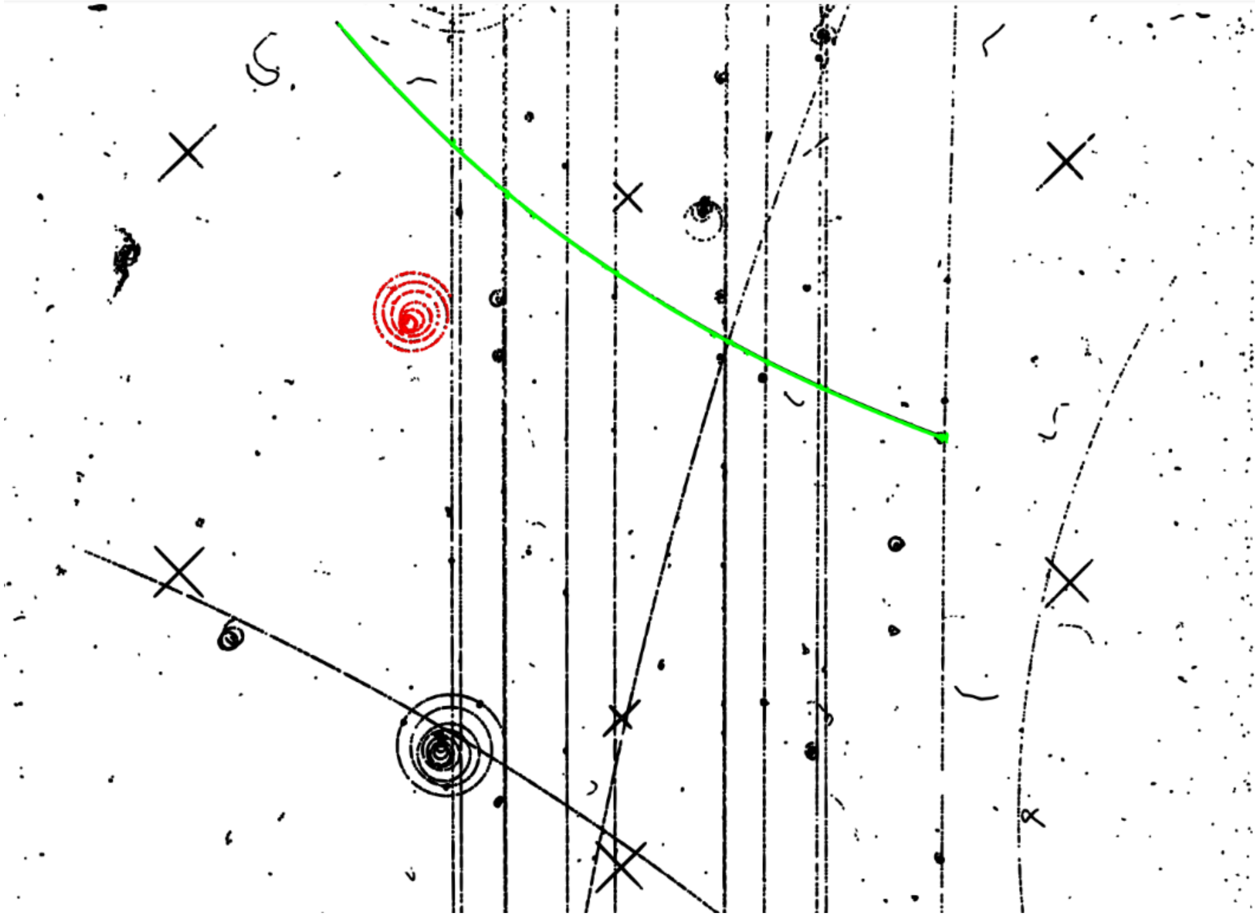
Bubble Chamber Educational Material

Sebastian Fabianski, Netzwerk Teilchenwelt/CERN

S'Cool LAB
CERN
TECHNISCHE UNIVERSITÄT DRESDEN
NETZWERK TEILCHENWELT

Bubble Chamber Educational Material



Interactive worksheets

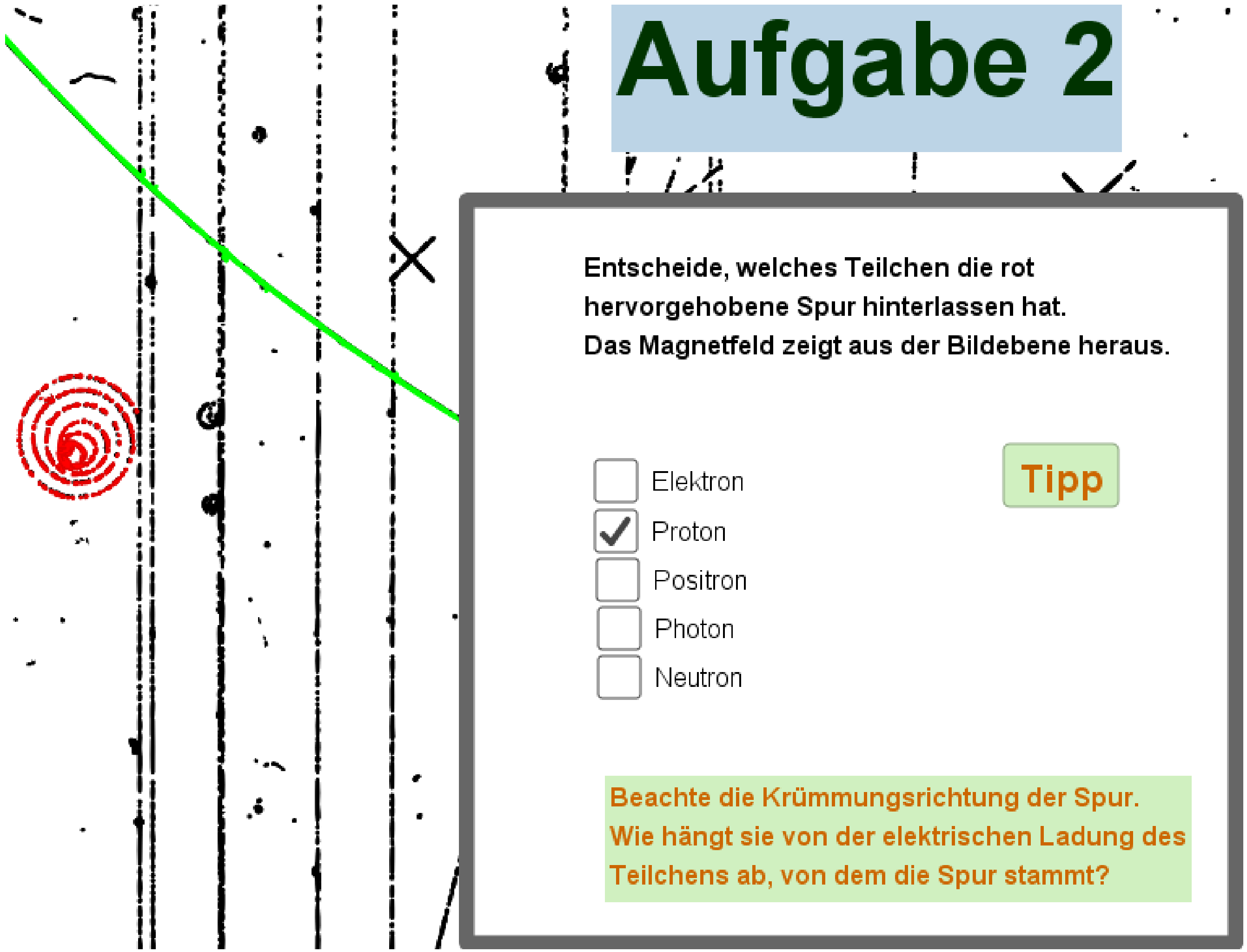
- Embedded in GeoGebra
- Developed by Rebecca Schmidt and Floria Naumann from „Netzwerk Teilchenwelt“ on different levels
- Available in German

Conception of materials

- Introduction in GeoGebra and in Bubble Chambers
- **Interactive worksheets(GeoGebra)**
- Additional, analog worksheets

Interactive worksheets

- AB 2644



Interactive worksheets

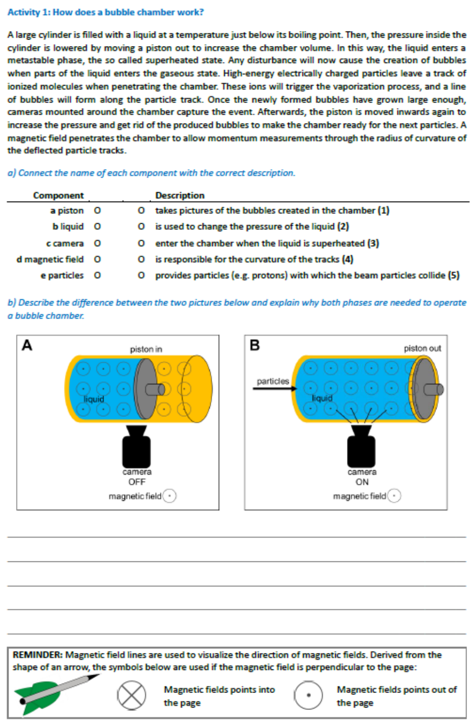
- AB 2644

Translation of the material

- On this basis Julia Woithe from S‘Cool Lab at CERN developed analog worksheets in English

Bubble Chamber materials

- Needs not much pre-knowledge



Activity 1: How does a bubble chamber work?

A large cylinder is filled with a liquid at a temperature just below its boiling point. Then, the pressure inside the cylinder is lowered by moving a piston out to increase the chamber volume. In this way, the liquid enters a metastable phase, the so called superheated state. Any disturbance will now cause the creation of bubbles when parts of the liquid enters the gaseous state. High-energy electrically charged particles leave a track of ionized molecules when penetrating the chamber. These ions will trigger the vaporization process, and a line of bubbles will form along the particle track. Once the newly formed bubbles have grown large enough, cameras mounted around the chamber capture the event. Afterwards, the piston is moved inwards again to increase the pressure and get rid of the produced bubbles to make the chamber ready for the next particles. A magnetic field penetrates the chamber to allow momentum measurements through the radius of curvature of the deflected particle tracks.

a) Connect the name of each component with the correct description.

Component			Description
a piston	O	O	takes pictures of the bubbles created in the chamber (1)
b liquid	O	O	is used to change the pressure of the liquid (2)
c camera	O	O	enter the chamber when the liquid is superheated (3)
d magnetic field	O	O	is responsible for the curvature of the tracks (4)
e particles	O	O	provides particles (e.g. protons) with which the beam particles collide (5)

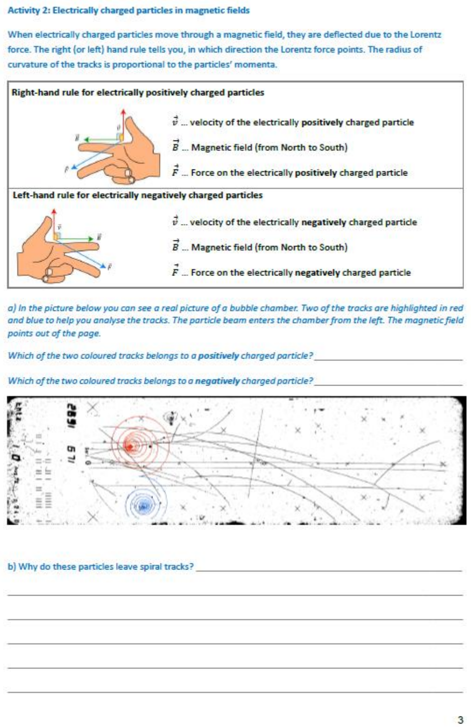
b) Describe the difference between the two pictures below and explain why both phases are needed to operate a bubble chamber.

REMINDER: Magnetic field lines are used to visualize the direction of magnetic fields. Derived from the shape of an arrow, the symbols below are used if the magnetic field is perpendicular to the page:

Magnetic fields points into the page

Magnetic fields points out of the page

2



Activity 2: Electrically charged particles in magnetic fields

When electrically charged particles move through a magnetic field, they are deflected due to the Lorentz force. The right (or left) hand rule tells you, in which direction the Lorentz force points. The radius of curvature of the tracks is proportional to the particles' momenta.

Right-hand rule for electrically positively charged particles

$\vec{v}$ ... velocity of the electrically **positively** charged particle

$\vec{B}$ ... Magnetic field (from North to South)

$\vec{F}$ ... Force on the electrically **positively** charged particle

Left-hand rule for electrically negatively charged particles

$\vec{v}$ ... velocity of the electrically **negatively** charged particle

$\vec{B}$ ... Magnetic field (from North to South)

$\vec{F}$ ... Force on the electrically **negatively** charged particle

a) In the picture below you can see a real picture of a bubble chamber. Two of the tracks are highlighted in red and blue to help you analyse the tracks. The particle beam enters the chamber from the left. The magnetic field points out of the page.

*Which of the two coloured tracks belongs to a **positively** charged particle?* ____

*Which of the two coloured tracks belongs to a **negatively** charged particle?* ____

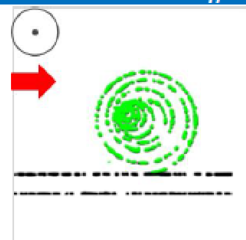
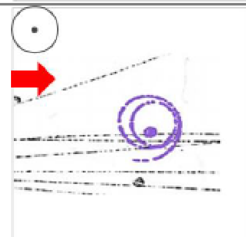
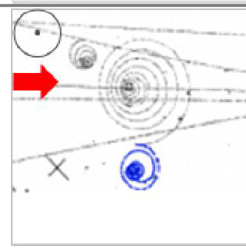
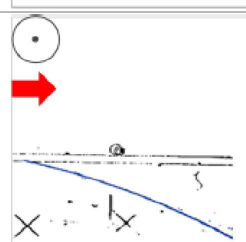
b) Why do these particles leave spiral tracks? ____

3

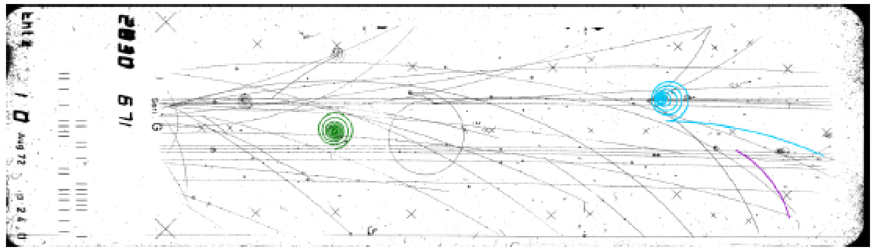
Activity 3: Particle identification and properties

Different types of particles leave different signatures in a bubble chamber due to their electric charge and their mass. In the following images, the particle beam enters the chamber from the left (➡). The magnetic field points out of the page (⊙).

a) Cut out the explanation puzzle pieces on page 9 and assign them to the correct picture of a track.

Bubble chamber track (coloured for better visibility)		Identified particle	Interaction process and particle signature in a bubble chamber
Picture 1			
Picture 2			
Picture 3			
Picture 4			

b) Identify the coloured tracks in the picture below:



	electron	positron	proton	explanation
green track	☐	☐	☐	
upper blue track	☐	☐	☐	
lower blue track	☐	☐	☐	
purple track	☐	☐	☐	

c) Which process was responsible for the two blue tracks? Explain!

____

____

d) Which of the two blue tracks belongs to the particle with the higher momentum? Explain!

____

____

e) Use a ruler to estimate the following measures.

Radius of curvature of upper blue track in m: $r_{image} =$ ____________

Length of the visible area in m: $l_{image} =$ ____________

In reality, the visible area of this bubble chamber was 2 metres long, what was the real radius of curvature of the upper blue track?

____

____

$r_{real} =$ ____________

Testing of the Materials

- Used in different schools and in teacher trainings
- Positive feedback and small changes made

Access to the materials

German materials:

https://www.geogebra.org/m/VAK3P8ar

Worksheets by J. Woithe:

https://scoollab.web.cern.ch/classroom-activities/bubble-chamber

Article about materials (English, French, Italian, Portugese):

https://www.scienceinschool.org/fr/content/comment-suivre-les-particules-subatomiques-%C3%A0-la-trace

Thanks for your attention!

Conclusion

- Interactive Bubble Chamber Education Material for GEoGebra developped by Netzwerk Teilchenwelt in Dresden

- Translated material in English available now