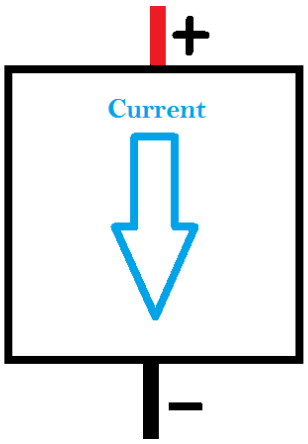
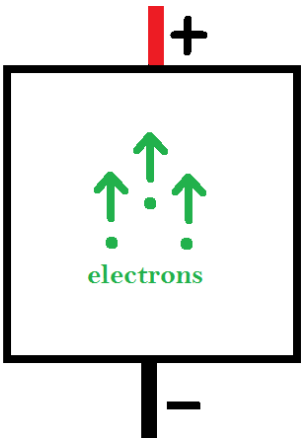
Classic Hall Effect primer for Quantum Hall Effect Experiment

The effect:

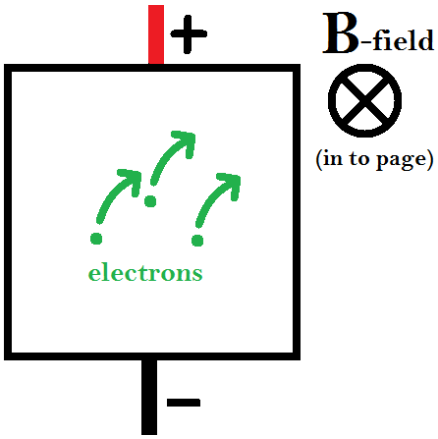
1.



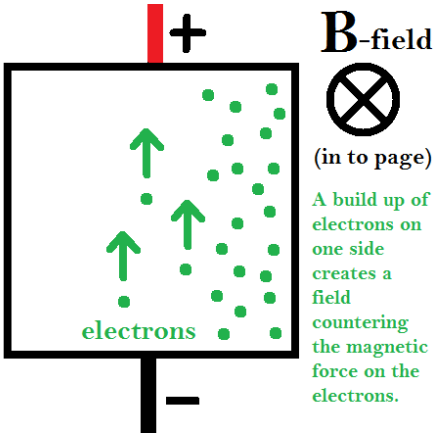
2.



3.

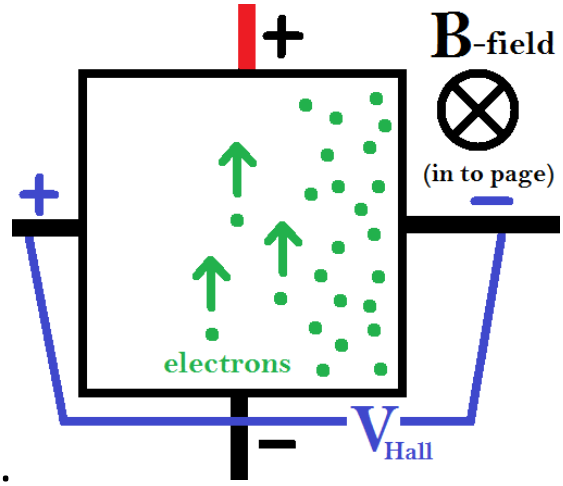


4.



A build up of electrons on one side creates a field countering the magnetic force on the electrons.

5.



Note: If the charge carriers are holes instead of electrons, the sign of the Hall voltage is reversed. Draw out how these pictures would be different to convince yourself of this. Thus, the classic Hall Effect can be used to determine the sign of the charge carriers!

The experiment:

The purpose of this primer experiment is to develop a better understanding of the Hall Effect and prepare for the Quantum Hall Experiment. The samples and equipment are similar to the equipment in the cryostat, but can be interacted with more directly.

Your task is to:

a) **Determine the carrier type of each sample (holes or electrons)**
b) **Estimate the carrier density of each sample.**

The relevant Hall Effect equation is:

$$V_H = -\frac{IB}{net}$$

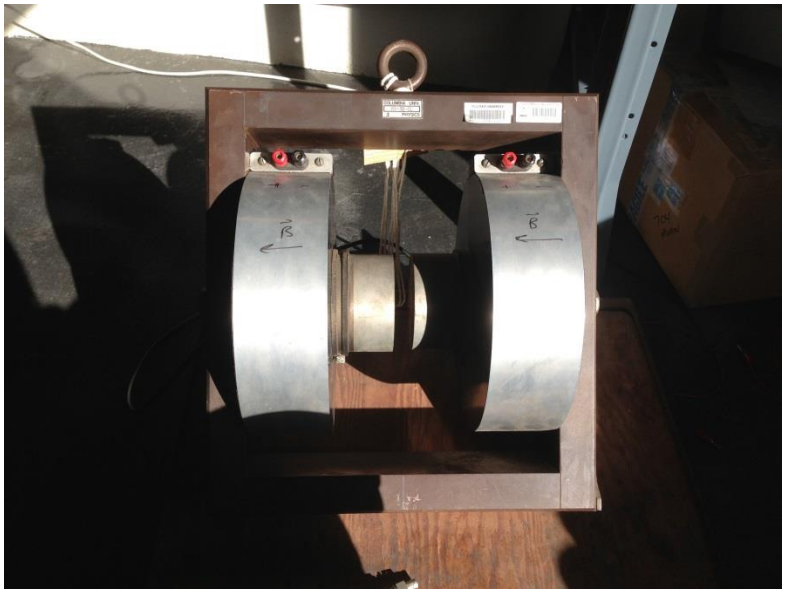
I is current, *B* magnetic field, *n* current density of carrier electrons, *e* is electron charge, *t* is sample thickness. Technically, this equation is for simple metals with one carrier type. Our samples are doped Si, which is a semiconductor containing both carrier types, though for this experiment we will assume one carrier type dominates. Though, for our samples, you will find that you cannot directly measure the Hall voltage, as there is a current dependent offset.

$$V_\perp = V_H + V_{offset}(I)$$

Thus, measuring *n* will require that you measure $V_H(B)$ for a fixed current. **What do you think the source of $\boldsymbol{V_{offset}(I)}$ is? How does $\boldsymbol{V_{offset}(I)}$ depend on I?** Note that this offset will be different depending on which pair of leads is used.

The equipment:

MAGNET:



The direction of the field is labeled for current traveling in the direction of RED to BLACK. This direction is important for finding the sign of the charge carriers. This magnet is composed of two solenoids with iron cores to boost the field. Connect the current to the magnet so that it travels in one side and then the other in series.

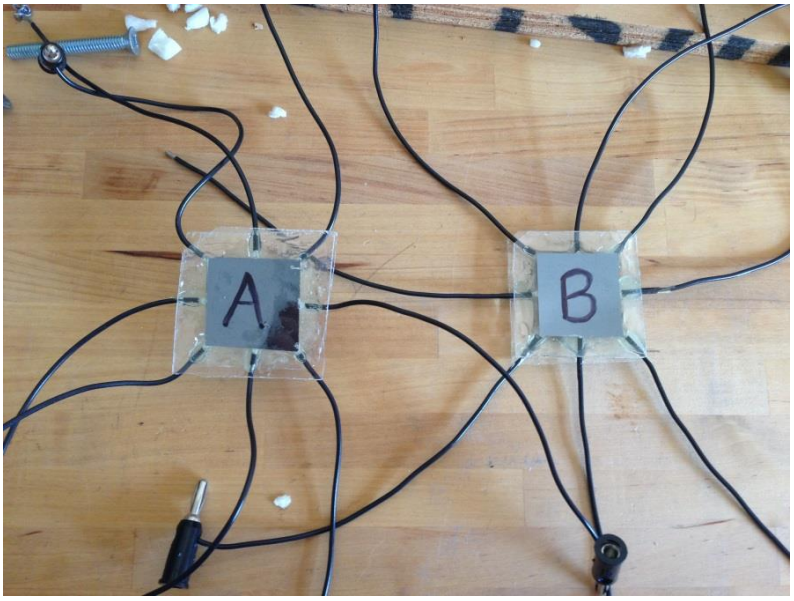
MAGNET CURRENT SUPPLY:

Connect the Red (+) to the Red lead of the magnet and Black (-) to Black. Use this to read the current through magnet. You can measure the magnetic field using the probe from the Nuclear Magnetic Resonance (NMR) experiment. Is the field linearly dependent on current?

SAMPLE CURRENT SUPPLY:

Use this to send current through the Si samples. **If the sample gets hot lower the current!**

THE SAMPLES:



Measure both samples. It is up to you to decide which leads to use, they are equivalent. The geometry of these devices mimics that of the GaAs devices you will use in the main Quantum Hall Experiment.

VOLTAGE PROBE:

Measure the voltages using the same equipment you will use to measure Hall voltage in the Quantum Hall Experiment.