Frequently Asked Questions Regarding CDMSII

1. Why use germanium and silicon for the CDMSII detector?
   These materials are both semi-conductors, used in the making of integrated circuits for electronics. Very pure crystals of these materials can be grown and the semi-conductor industry has developed techniques for placing tiny electrodes on their surfaces. We use these techniques to install sensitive, superconducting thermometers on our detectors in order to sense the tiny pulse of heat liberated by a WIMP.

2. How does the detector work, i.e. once a particle hits the detector, how is the data transmitted?
   Sensors on the surface of the detectors pick up both the charge and heat liberated by a particle interacting in the detector. Tiny superconducting wires transmit these signals up the sides of the detector tower to electronics mounted at the top. After conversion to voltages, these signals are sent on stripline cables to room-temperature electronics for further amplification and conversion to digital signals, which are then recorded by computers and written to hard disks and magnetic tape.

3. How does the electric "cable" work in the CDMSII experiment?
   They contain copper traces on a flexible Kapton (plastic) strip. Essentially they are like tiny wires embedded in plastic. These copper wires transmit signals from the detectors to room-temperature amplifiers and recorders, Since copper conducts heat very well, and since these striplines connect room temperature to the cold detector towers, we have to minimize the amount of copper and intercept the heat at several points along their length.

4. How close to absolute zero does the CDMSII experiment get?
   On the Kelvin temperature scale, absolute zero is 0K (-293 Celsius, -460 Fahrenheit). At absolute zero, all molecular motion ceases. The coldest part of the CDMS experiment reaches 0.02 K, or 2/100ths of a degree above absolute zero. At that temperature, molecules are moving at an average speed of only about 9 miles/hour, comparable to the running speed of a human. At room temperature, molecular speeds average about 1100 miles/hour, about twice as fast as a jet airplane.

5. What process is used to get the detector that cold, i.e. how are gases used?
   One must employ several methods in combination to reach such cold temperatures. First, two layers of vacuum ensure that heat from the outside is not transmitted inwards. Second, a layer of liquid nitrogen (77K, -216 Celsius, -383 Fahrenheit) surrounds the inner parts of the refrigerator. Third, a bath of liquid Helium (4K, -289 Celsius, -456 Fahrenheit) maintains the inner parts of the refrigerator and the tops of the detector towers at 4K. [These cryogens are liquefied by compressors and delivered to Soudan by a vendor in Virginia, MN.] The remainder of the temperature decrease is achieved using the dilution refrigerator, which pumps one Helium isotope (3He) gas from another (4He) as a liquid and then condenses the 3He back into the

4He. This is very similar to the process used in normal refrigerators except the refrigerant is Helium instead of Freon (or one of its modern replacements).

6. What evidence do you have that WIMPS exist? How did you know to be looking for them in the first place?
We know that dark matter exists, because we can directly see its gravity affecting galaxies and clusters of galaxies. We also know that dark matter cannot be made up of known particles, because these would produce other detectable effects that have not been seen. However, particle physics has produced a theory, called Supersymmetry, that predicts the existence of a new class of particles that are massive, neutral, and stable. These WIMPS would have been produced in sufficient quantity during the Big Bang to explain the current abundance of dark matter.

7. How will you know when you a see a WIMP, if they are hypothetical particles?
Since WIMPS have masses at least as large as atomic nuclei, but have no electric charge, they can only interact with normal matter by scattering off nuclei like billiard balls (elastic scattering). The signature of WIMP elastic scattering in CDMS is the release of heat in the detectors, without very much charge. Only neutrons, among normal matter particles, can mimic this signature. We are deep underground to avoid neutrons, but can also distinguish them from WIMPS because they scatter much more frequently in our detectors. For example, about 50% of neutrons will leave energy in at least two of our detectors but WIMPS interact so rarely that they will never cause more than one detector signal.

8. How many towers are in the CDMS detector? How many do you plan to put in the detector? How many "pucks" are in each tower?
We are currently operating 5 towers of detectors in the CDMS II experiment, each of which contains 6 detector 'pucks'. We will be building seven new towers of larger 'pucks' for the next version of CDMS.

9. Where is CDMSI located? Is there a CDMSIII or CDMSIV? What other similar experiments are happening around the world?
CDMS I was run at the Stanford Underground Facility, on the Stanford University campus in California, from 1996-2002. This facility was a shallow tunnel and the experiment was limited by backgrounds due to cosmic ray particles. That is why CDMS II was constructed in the Soudan Underground Laboratory at a depth of 2341'. After 2-3 more years at Soudan, we will likely again be limited by the small rate of cosmic ray particles penetrating to this depth. So the next phase of the experiment, which we call SuperCDMS, is planned for the Sudbury Inco nickel mine in Ontario, Canada, at a depth of approximately 6800'.

10. Can you provide a timeline for the development of CDMS research – when first start, where first start, advancements, who were the first physicist involved in the research, etc.
The concepts for using cryogenic detectors to detect dark matter originated in an experiment conducted by UC Berkeley, UC Santa Barbara and Lawrence Berkeley

Laboratory in the 1980's. The Berkeley team was led by Bernard Sadoulet and the UCSB team by David Caldwell. The CDMS collaboration formed in the early 1990's with the addition of Stanford University, led by Blas Cabrera. Development of the first detectors and the complicated cryogenics system resulted in the first CDMS data run in 1996. Although data taken by CDMS I did not lead to discovery of WIMPs, it became clear by 1998 that backgrounds would limit the first experiment and that the detectors could be considerably improved. This formed the basis of the proposed CDMS II experiment, which was funded in 1999, and includes 12 university groups and two national laboratories . Construction began at Soudan in that same year and continued until the first data were collected in 2003-2004 with two towers of detectors. We have just begun collecting data with five towers of detectors.

11. What happens if you do not detect a WIMP?
    Although we would be disappointed, scientific research progresses with both positive and negative results. If we do not detect WIMPS, we will conclude that the current explanations for dark matter are not correct and new theories are needed. Accelerators are also searching for WIMPS, including the collider at Fermilab and the new LHC machine that will soon be commissioned at CERN (Geneva, Switzerland).

12. What is the enclosure called in which the detector sits? Why use this type of enclosure?
    It is technically called a class-10000 RF-shielded clean room. Even small amounts of radioactivity can compromise our search for WIMPS and all dust contains traces of radioactive elements. So the clean room is needed to keep such dust away from our detectors. For the same reason, we must wear special clothing inside this room. Class-10000 just means that there are fewer than 10000 dust particles of a certain size within a cubic foot of air in the room. Electrical noise can also adversely affect our detectors, so the room has a metal skin and special grounding to reduce high-frequency noise.

13. Could you explain how the wiring (the item that looks like film footage) works? The person also wanted to know if the wiring was like fiber optics?
    I mentioned these 'striplines' in a previous answer. We do not use light to carry our signals, as fiber optic cables do, although that is a possible approach for the future to minimize the amount of heat carried in via these cables.

14. Another person was wondering how (if at all) CDMS was related to the string theory.
    Not directly. String theory postulates that all particles are really made up of tiny strings of energy and requires something like Supersymmetry to explain the particles seen in nature. However, if CDMS does detect WIMPS, it will not be able to determine whether they are made of strings because the size of these strings is much too small. Accelerator experiments may be able to determine whether WIMPS seen by CDMS are the same as particles predicted by Supersymmetry.