Cryogenic Dark Matter Search (CDMS)

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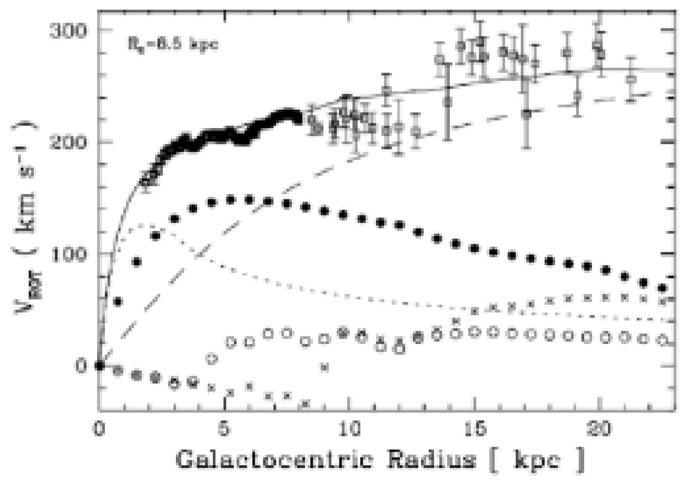
Abstract

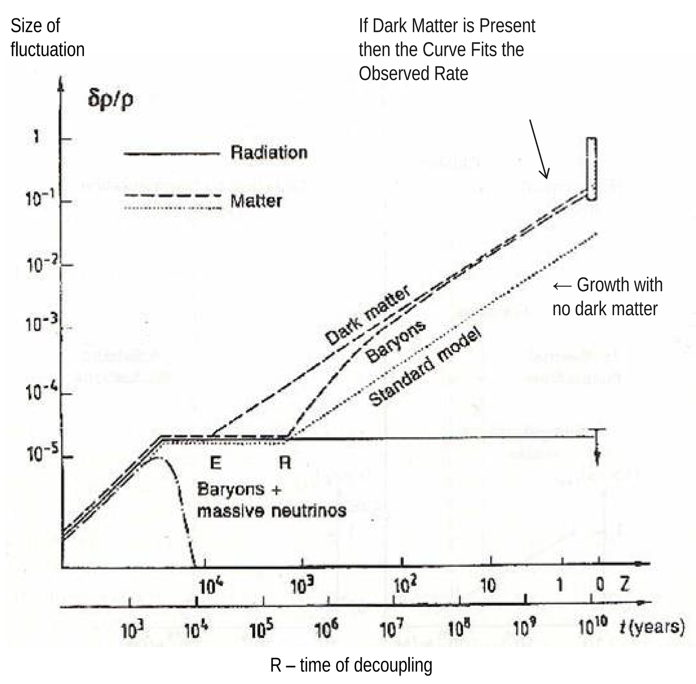
The Cryogenic Dark Matter Search (CDMS) research team at Texas A&M University is a small part of a large collaboration consisting of upwards of 18 international institutions. CDMS is attempting to directly detect Weakly Interactive Massive Particles (WIMPS). Current CDMS detectors production is slow and has a low detector yield. The experimental sensitivity of the detector is proportional to the product of the number of target nuclei and the time. Texas A&M University is working on increasing the production rate, along with improving the reproducibility of results of the CDMS detector by industrializing the method of production. In the ground state of the operation, four inch silicon substrates are coated with tungsten and aluminum. As for summer of 2010, the CDMS group at Texas A&M University is further pursuing their goals by bringing online a second laboratory. The second laboratory serves as a space for etching the coated substrates. The substrates are etched to form microscopic circuits with the goals of detecting nuclear recoils, all while rejecting background events.

Dark Matter Introduction:

Dark matter was first proposed by Fritz Zwicky in 1935. The idea was at first discarded and labeled foolish. Facts were soon proposed, and the idea reconsidered. Fritz Zwicky was an astronomer that focused on large galaxy interactions. The idea of dark matter is a possible explanation for the inexplicable rotational velocities of galaxies across the universe.



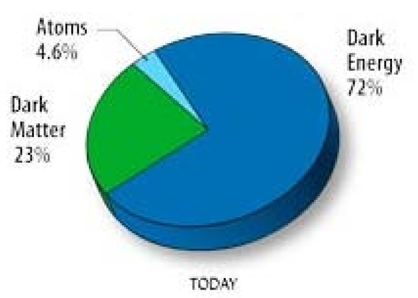
(Graph-1)



(Graph-2)

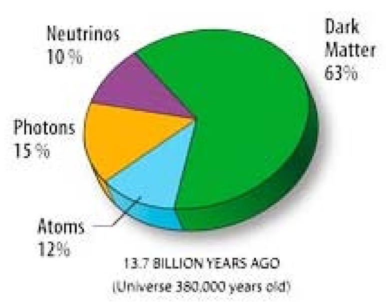
The decoupling effect observed in Graph-2 was also a primary contributing argument to the dark matter case. Dark matter is said to be decoupled at a much sooner point in time. With only visible matter present, the decoupling time line does not fit the observed approximation. If both dark matter and visible matter are observed then the curve is as seen in Graph-2. Weakly Interactive Massive Particles (WIMPS) is the favorite candidate for explaining the observed curve.

Many experiments, as well as approaches, have been proposed to help aide the search for dark matter, but the jury is still out on the best approach. One thing is for certain, the progress of particle physics, as well as the understanding of both the origins and possible conclusions of the universe as we know it may very well lay in the comprehension of dark matter.



(Chart-1)

Understood science has brought us as far as today, but further understanding lays in the future of the unknown. Of the understood particles of today, the proportion of the known to unknown is shockingly insufficient.

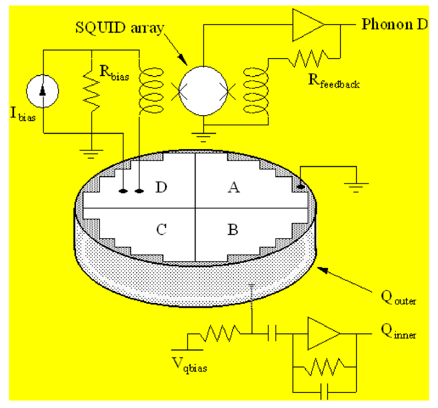


(Chart-2)

Imagine what awaits us in the future with the discovery of dark matter.

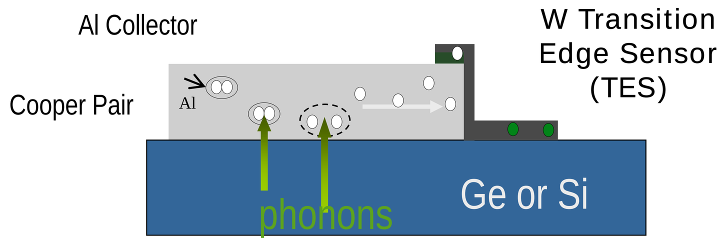
CDMS Approach:

Cryogenic Dark Matter Search (CDMS) is one of many attempts to isolate a WIMP event. The CDMS detector is designed to detect WIMP interactions by means of elastic collisions. The design of the detector as viewed in Diagram-1 presents a 4-quadrant detector with various background exclusion properties. Within each of the four quadrants is an etched microscopic circuit. Each circuit is focused on assessing interactions between 10 and 100 KeV.



(Diagram-1)

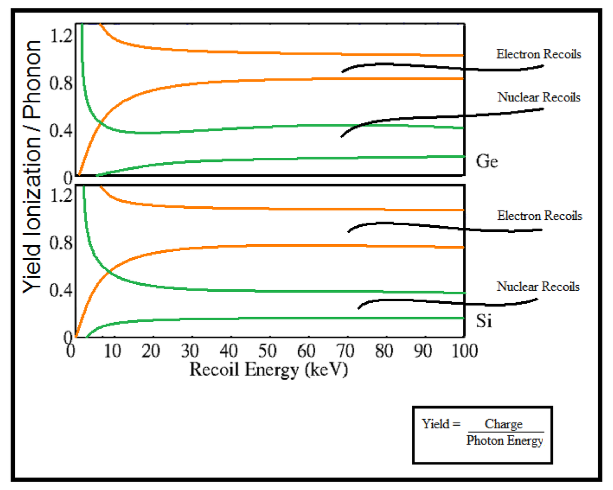
The detectors are composed of Ge and Si. Each detector is coated with Al and W and etched to form each circuit. The sensor designed by the etching process may be seen in Diagram-2. Also in Diagram-2 is the desired process for detection.



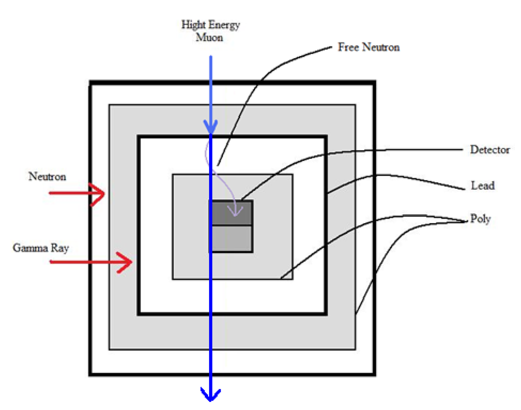
(Diagram-2)

Excluding Backgrounds:

A primary focus of any dark matter experiment is excluding all possible background events. This is done through a series of cuts and/or techniques. CDMS alone has a vast number of cuts applied to each detector. The single most important concept of CDMS is the idea of separation of nuclear recoils from electron recoils. Nuclear recoils represent an elastic collision between the nucleus of an atom, whether it be Ge or Si, and a dark matter particle (aka a WIMP). This interaction, labeled a 'Bulk Event' results in more phonon detection and less charge. Electron interactions occur when an electron is disturbed by an outside particle. The electron recoil events are quickly discarded as background. Graph-3 displays the data that might be found as calibration data for a Ge or Si detector. The graph displays both nuclear recoils (in green), and electron recoils (in orange).



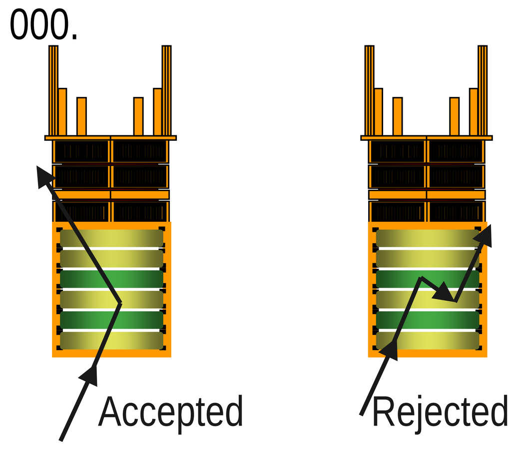
(Graph-3)



(Diagram-3)

Also amongst the cuts is simple shielding known as a VETO cut. The shielding consist of two layers of poly separated by a single layer of lead. Also surrounding these layers is a layer of panels that covers approximately 98% of the detector. These Panels are designed to exclude high energy muons. These panels along with miles of earth above the detector decrease the amount of muons that interact with detector by 50 000.

Also, by placing detectors in series, CDMS is able to exclude backgrounds by understanding collision properties that a WIMP possesses. WIMPs may only scatter once. While Background matter may scatter several times as it makes its way through a detector. Multiple detectors are needed to make this process valid.



(Diagram-4)

Texas A&M University's Process:

One drawback to CDMS in the past has been the production rate, and reproducibility of results. All detectors of the past have been handcrafted in time intensive R&D facilities. The experimental sensitivity of the detector is proportional to the product of the number of target nuclei and the time. Texas A&M University is working on increasing the production rate, along with improving the reproducibility of results of the CDMS detector by industrializing the method of production using Silicon Valley production techniques. The mass production of detectors increases the sensitivity of the experiment., and with any luck, the success of the experiment along with it.

The process at Texas A&M University begins in the Dry Lab with the coating of substrates. The process continues with the Wet Lab where the coated substrates are examined and etched. Here at A&M the process is still in the ground stages, but accelerating rapidly towards a bright and promising future. A&M hopes to continue making strides towards a bright and promising future, all while obtaining a larger role in the search for dark matter.

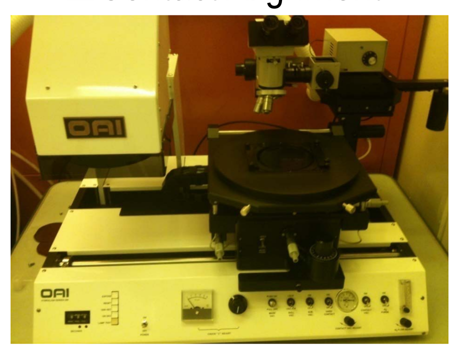
Contributions:

- Installation of Three Switch Ventilation Control Box
- Installation of Ventilation Ducts to Reroute Air as Necessary
- Plumbing Out the Wet Bench
- Plumbing the Wafer Wash

Skills Acquired:

- Dektack

- Contact Alignment



- Spin Coater

- Sputtering System

Upcoming Progress:

- Repair Sputtering System
- Find Recipe To Match Desired Results
  - Possibly Introduce Oxygen
  - Possible Introduce Other Gas Components
- Bring Online Polisher
  - Acquire More Space
- Continue to bring online second laboratory:
  - Acquire and Install Spin Coater
  - Automate Oven Operation
  - Harness Contact Alignment Skill
  - Gain Further Knowledge of Etching Process
- Continue on to Thicker Substrates.

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