Hunting for Dark Matter with the CDMS Experiment

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Cryogenic Dark Matter Search

Sebastian Arrenberg
University of Zürich
for the CDMS Collaboration
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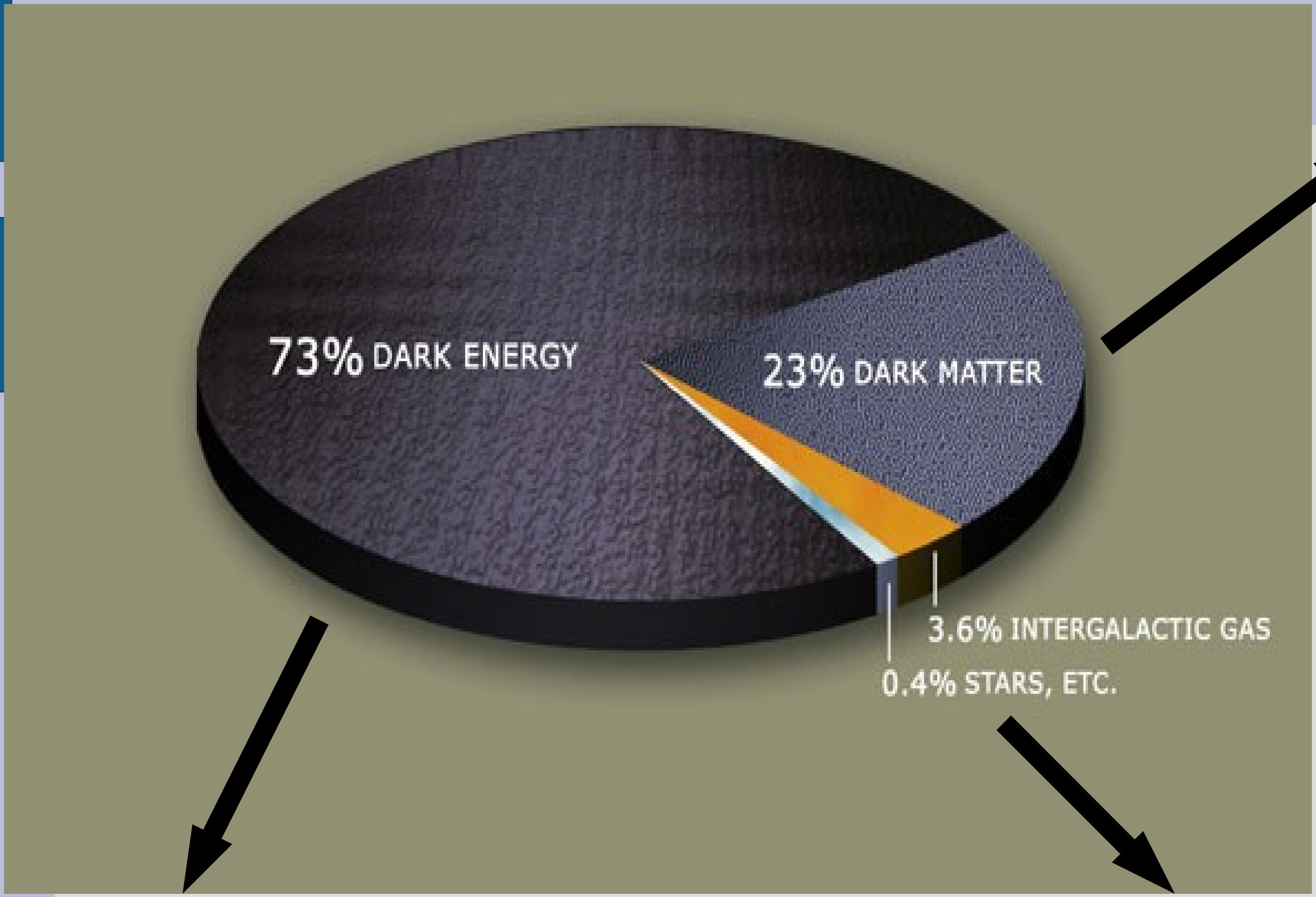
Ely, Minnesota

What is the universe made of ?



Necessary for structure formation.

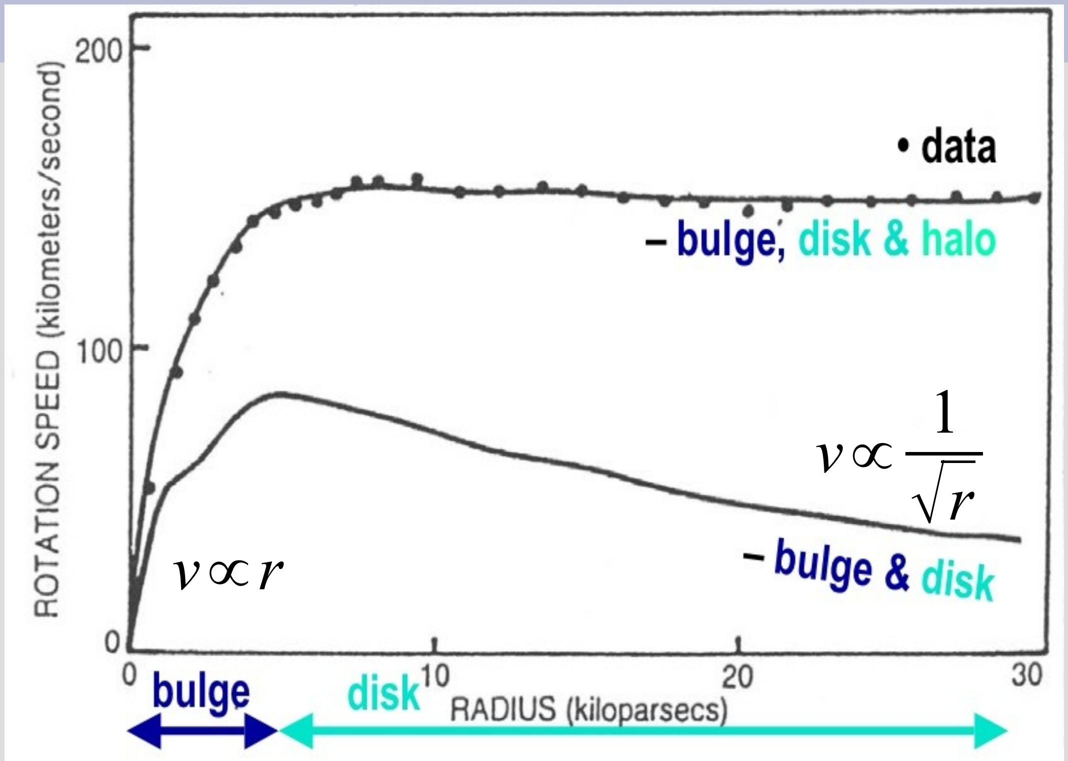
Probably a new kind of particle.

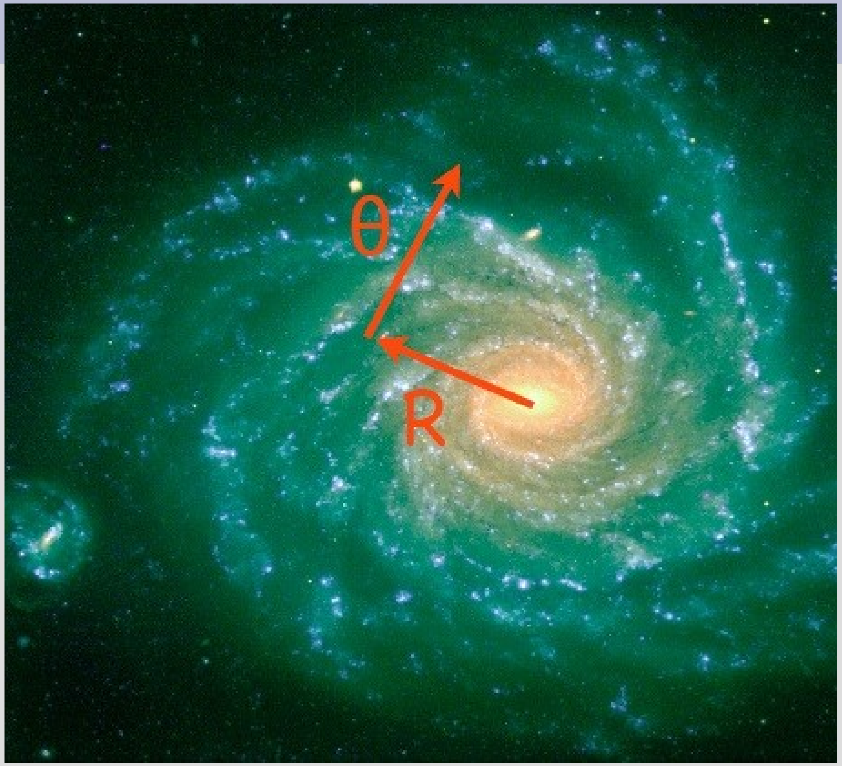
That's what CDMS is trying to detect.

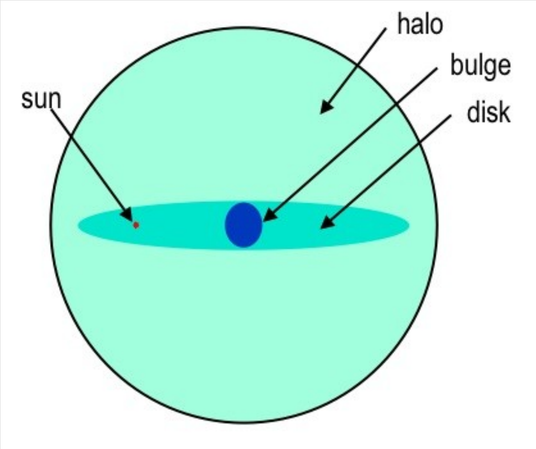
Accelerating the expansion of the universe?

Everything you can see in the sky.

Evidence for Dark Matter
Rotation curves of Galaxies



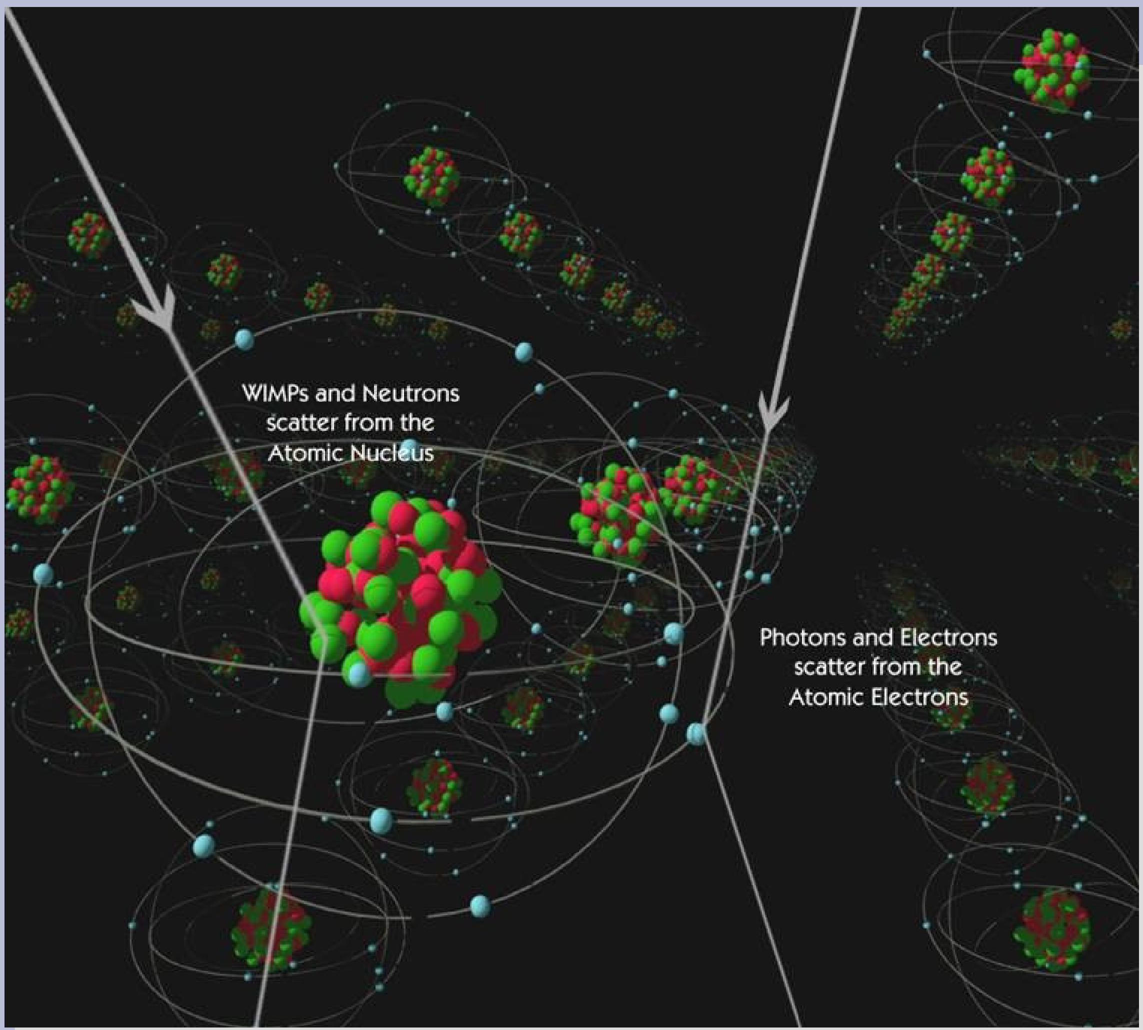




Isothermal spherical Halo of Dark Matter

Good candidate: Weakly Interacting Massive Particle (WIMP)

Direct Detection of WIMPs



Expected recoil energies: 1 - 100 keV

Expected event rates: 1/(day kg) – 1/(century kg)

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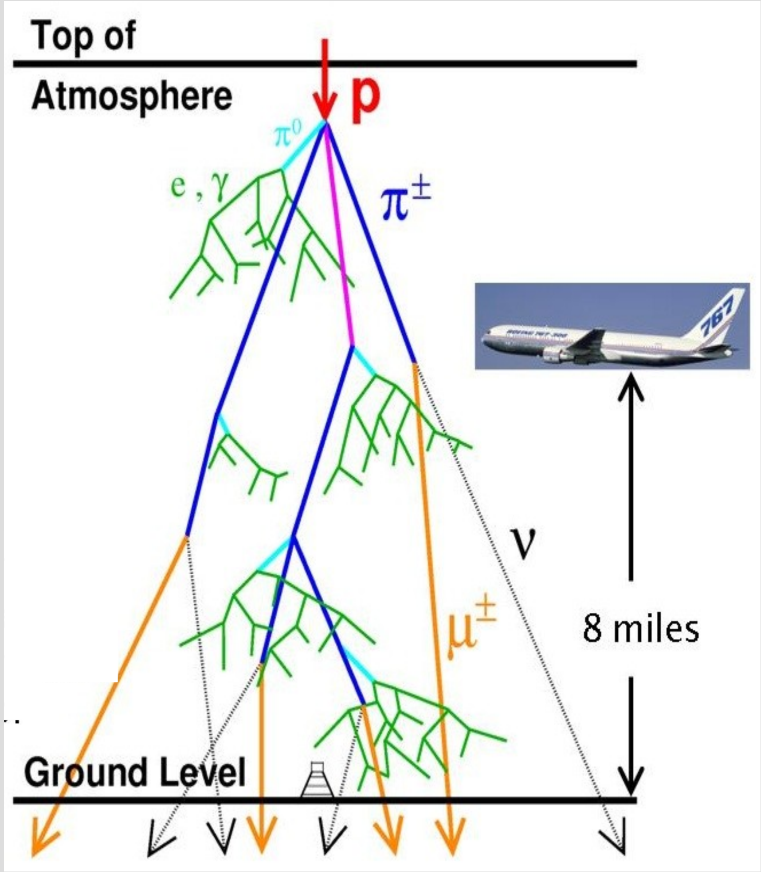
Possible Signal is very difficult to detect.

Most important problem: Reduce all background as much as possible !!!

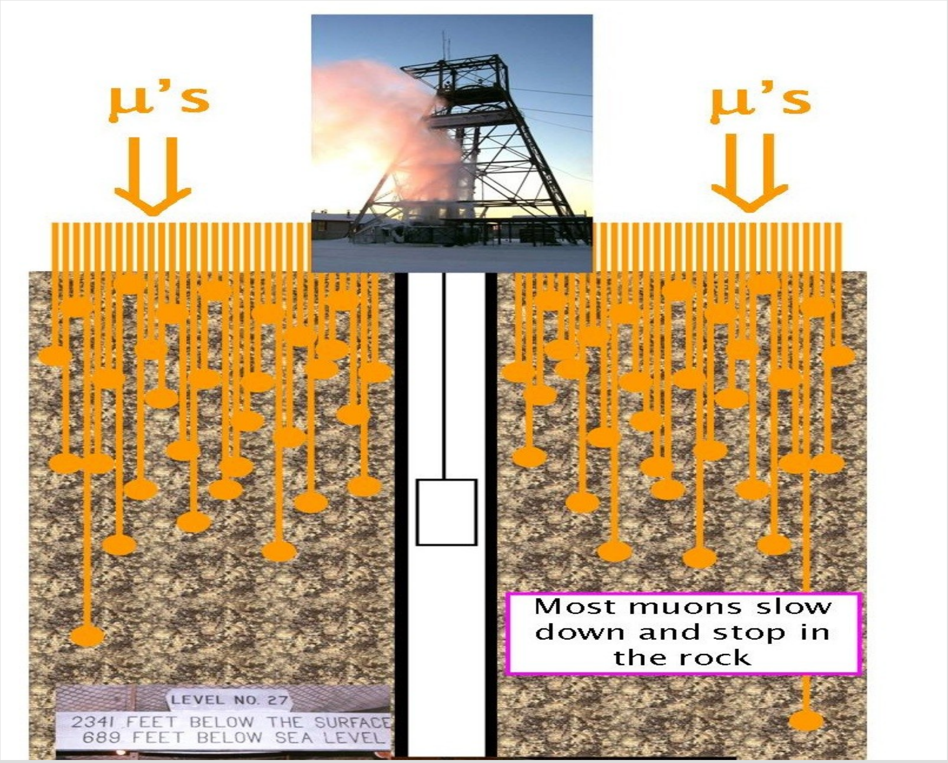
Therefore, go underground...

Cosmic protons start avalanches of particles.



Most important: Muons

Main background at first CDMS run at Stanford Underground Facility.

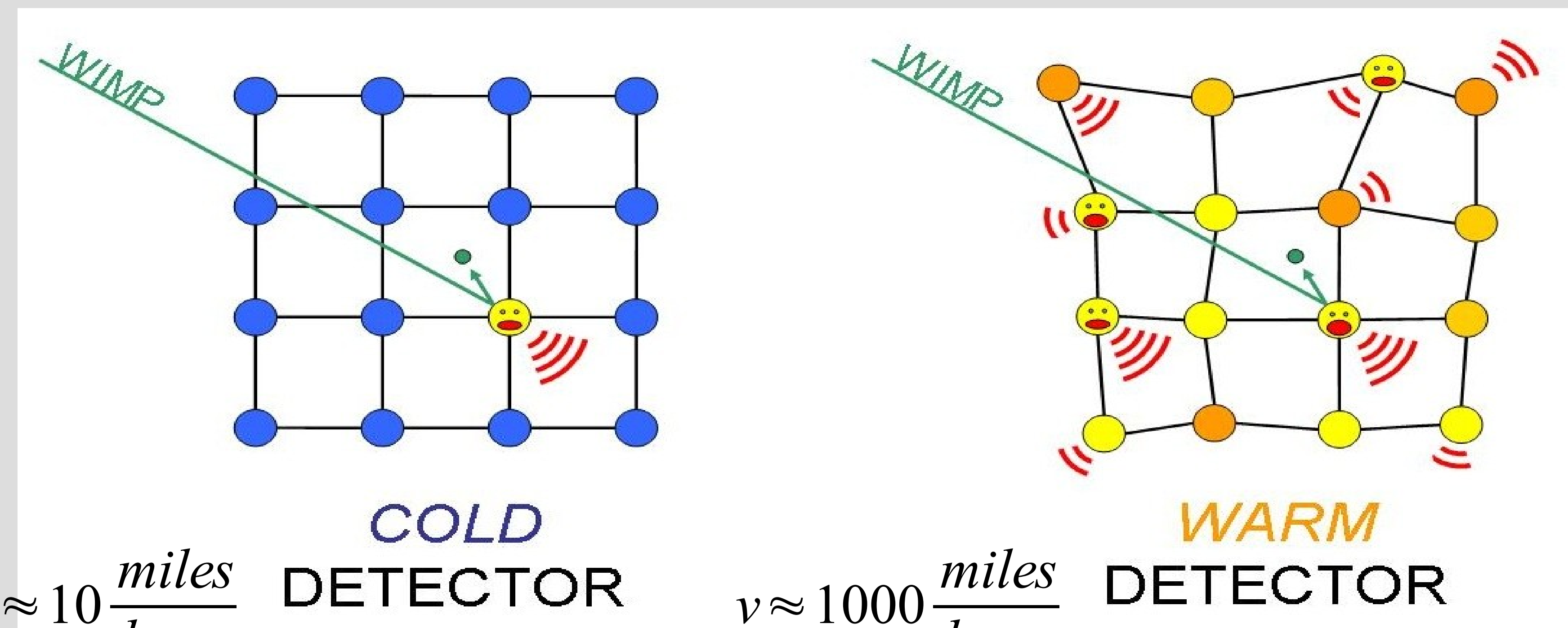


780 m of rock reduce the Muon flux by a factor of 10^5.

...and make it cold.

At room temperature: Random thermal motion would cover up any tiny vibration caused by a particle hitting an atom.

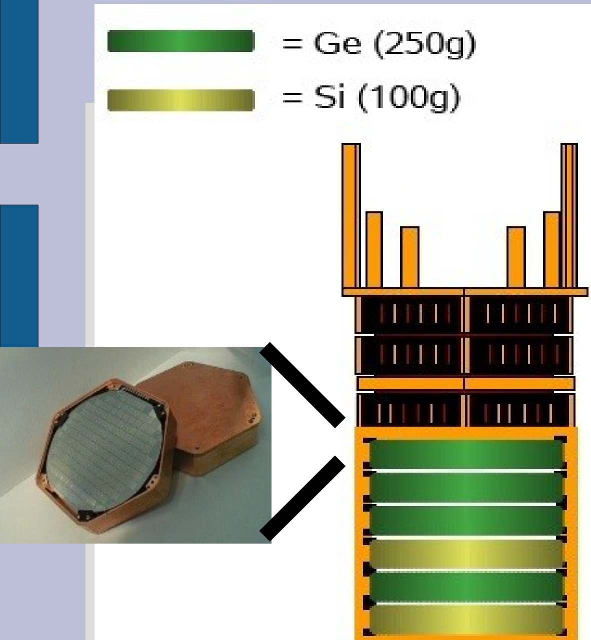
Detectors are cooled down to ~ 40 mK!

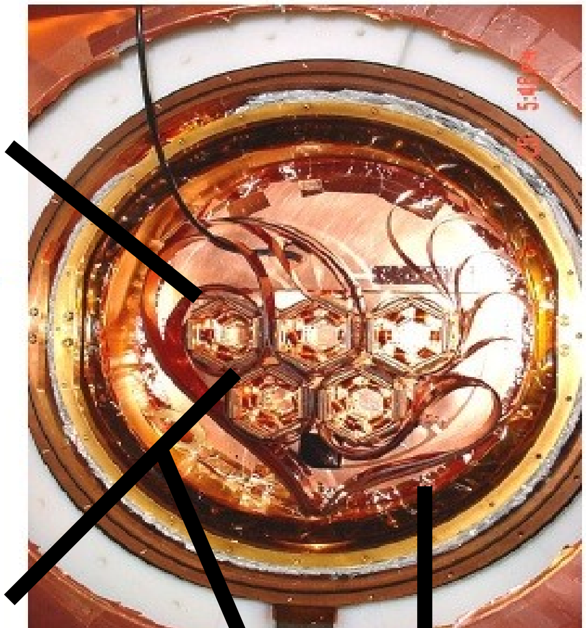


$v \approx 10 \frac{miles}{hour}$

$v \approx 1000 \frac{miles}{hour}$

The CDMS Setup

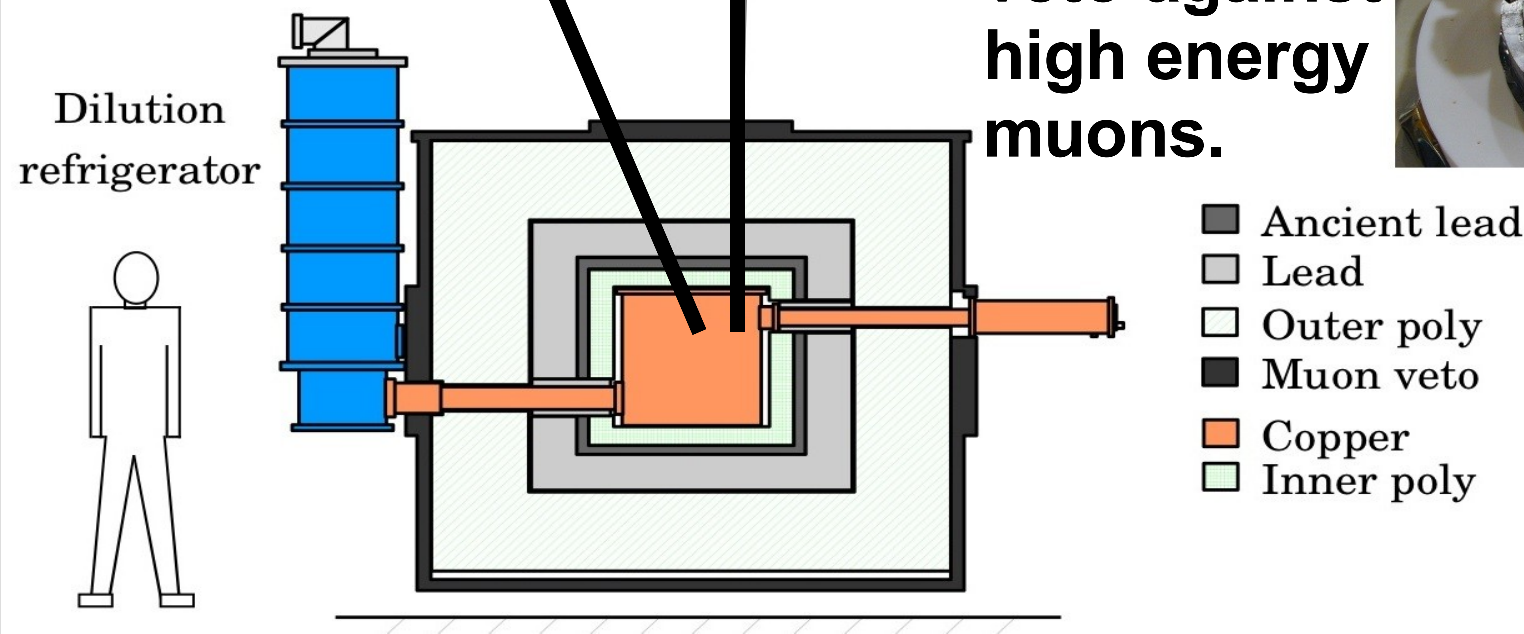




5 towers with 6 detectors each

Provide passive shielding against environmental radioactivity.

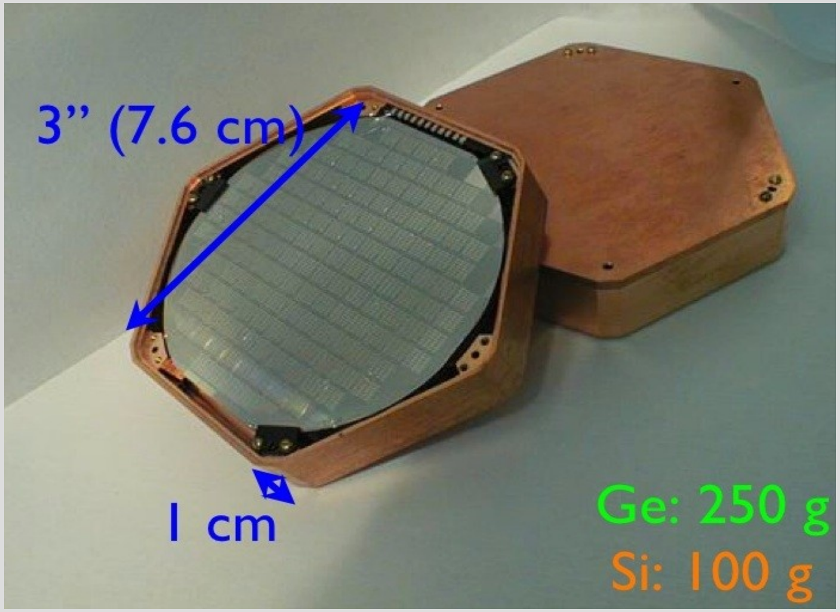
Use active veto against high energy muons.



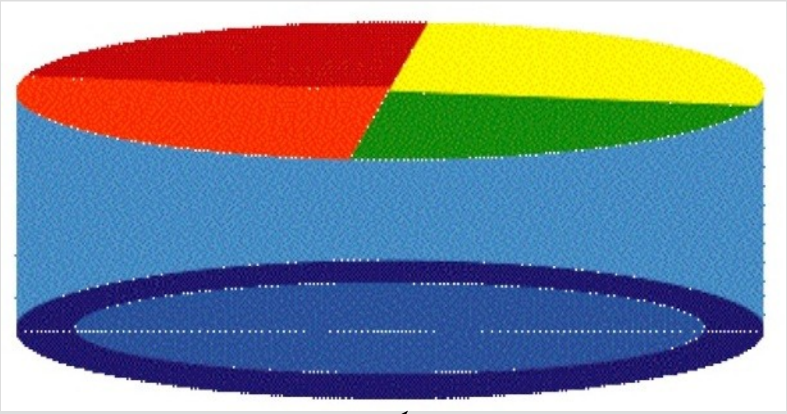
The CDMS Detectors

19 Ge and 11 Si semiconductor detectors.

2 signals from interaction (ionization and phonon) to provide event by event discrimination between electron recoils and nuclear recoils.



Phonon side:
4 quadrants of phonon sensors



Charge side:
2 concentric electrodes (Inner & Outer)

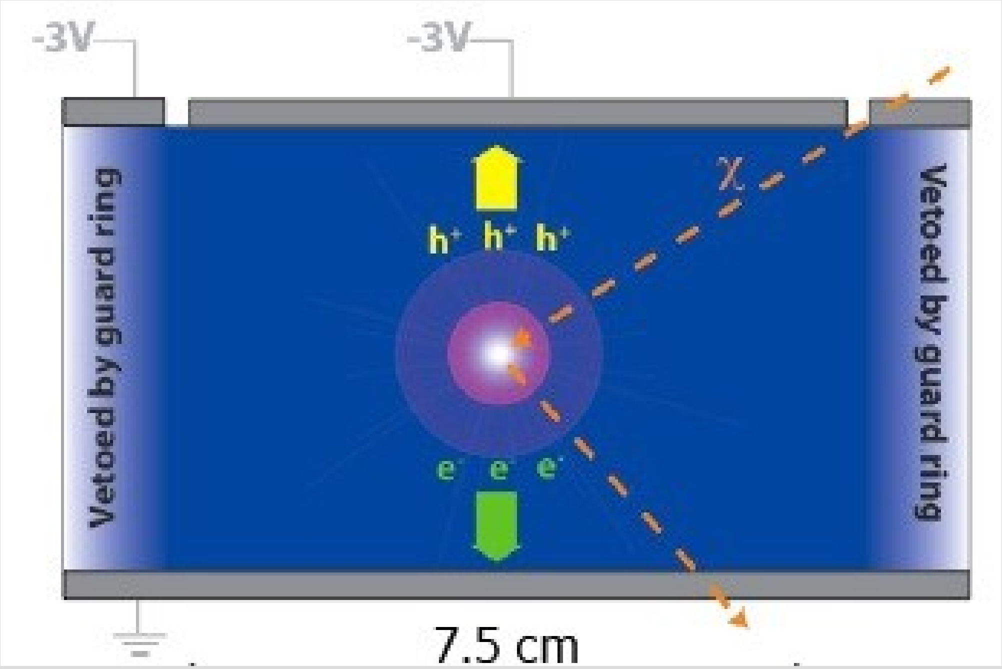
The Ionization Signal

An interaction breaks up the electron-hole pairs.

An electric field seperates the electrons and the holes. The charge is collected by the electrodes on the surface.

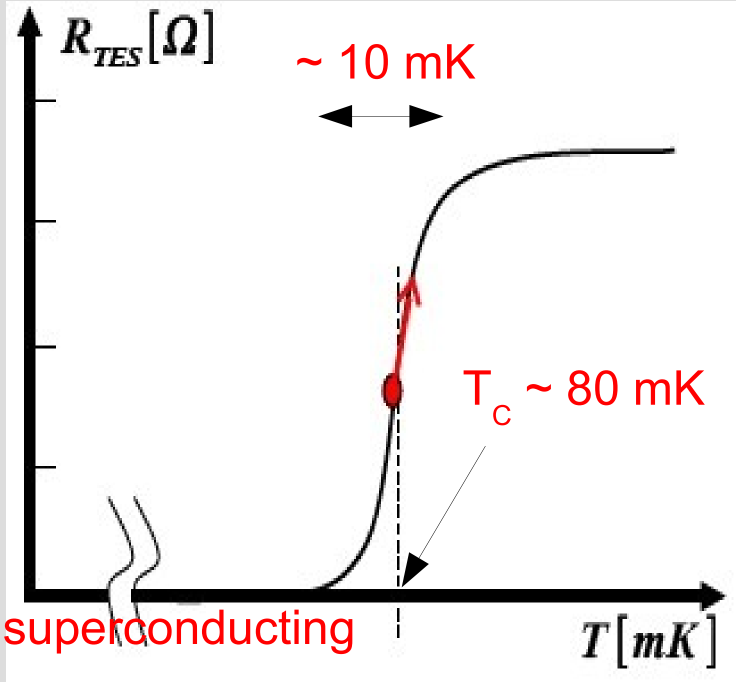
Since interactions at the crystal edge can have incomplete charge collection the outter electrode serves as a guard ring.

Events with significant contribution in the guard ring are omitted.



The Phonon Signal

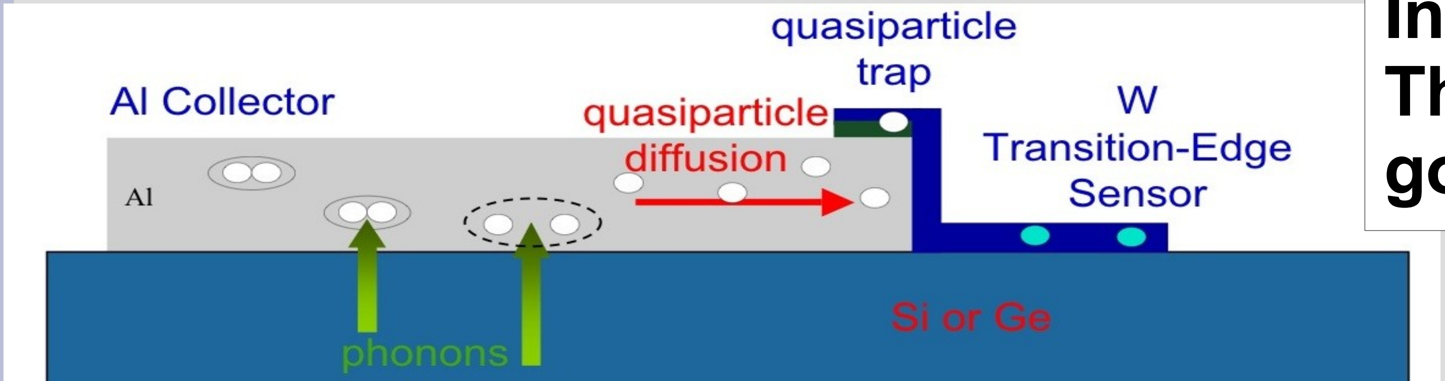
Tungsten strips are biased with a small voltage keeping them just at the edge of superconductivity.



Incoming particles “shake“ the lattice leading to the deposition of energy in the tungsten strips.

The temperature raises and the strips leave their state of superconductivity.

Thus the resistence increases dramatically lowering the current.



In other words: This is a really good thermometer.

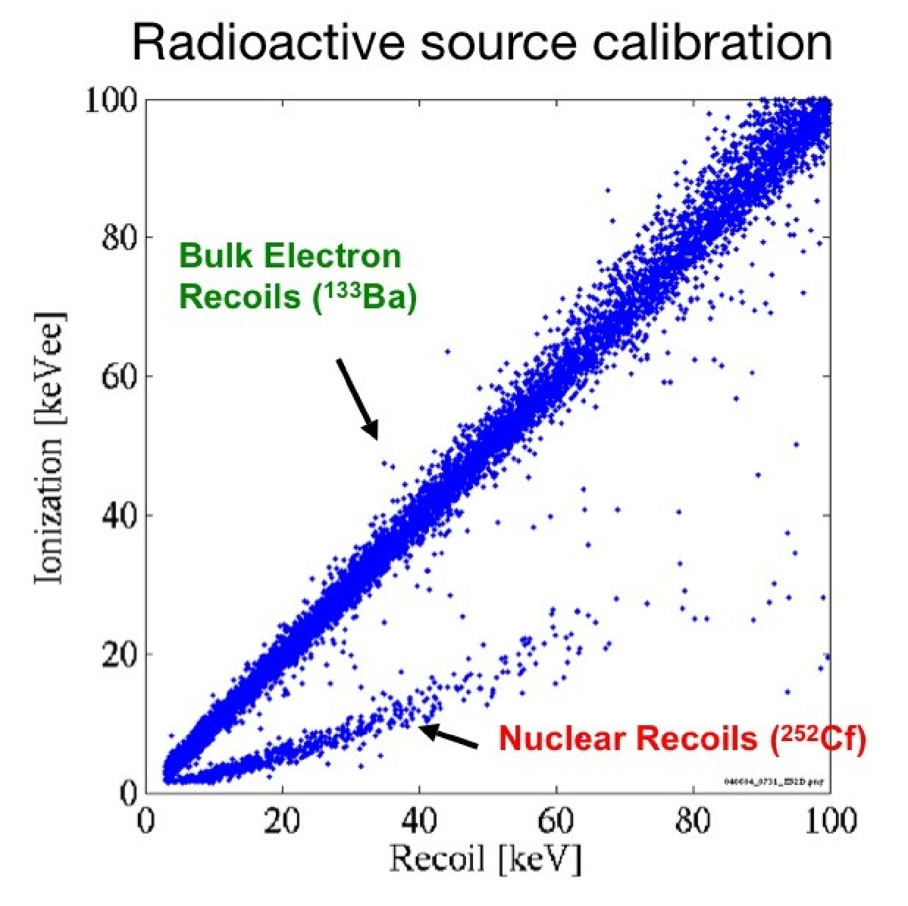
Background Discrimination

Ionization signal for nuclear recoils is suppressed.

Excellent rejection of electron recoil events.

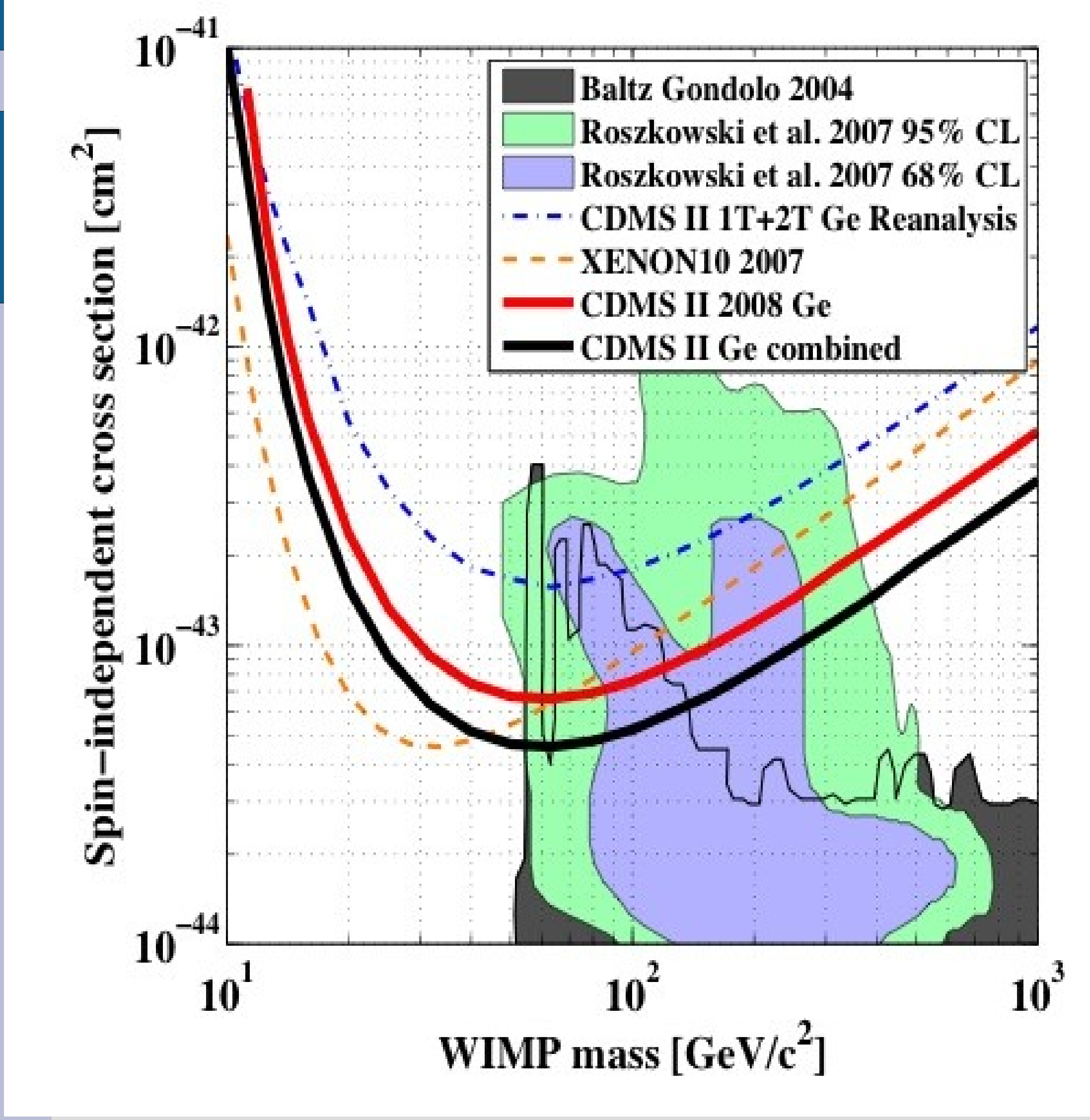
Neutrons usually scatter in more than one detector.

Remaining most important background:
electron recoil events near the surface (~ 10 µm) which have reduced charge collection can mimic nuclear recoils.



Use timing properties of phonon signal:
Surface electron recoils are faster in timing than nuclear recoils events.

Recent CDMS Results



Analysis of Ge detectors.

After all analysis cuts:
No events observed!

World leading exclusion limit on spin-independent interactions for masses > 42 GeV.

Result restricts some of the favored supersymmetric extensions of the Standard Model.

Conclusion

The CDMS experiment uses high-end technology in the search for Dark Matter.

CDMS is one of the worlds leading Dark Matter direct detection experiments.

The amount of data currently in the analysis pipeline will improve the limit by a factor of ~2.

Exciting time for direct detection of Dark Matter experiments since they start probing significant parts of the parameter spaces of, e.g. supersymmetric models and models with extra space dimensions.