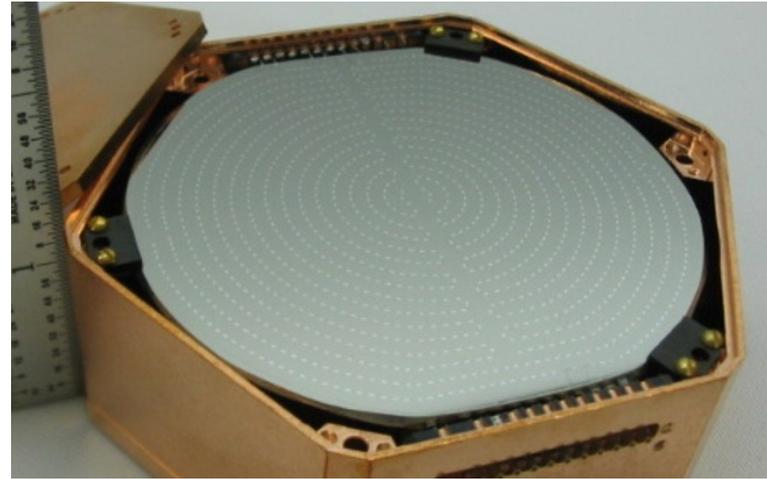


CDMS



Don Holmgren
SCD Projects Meeting
June 19, 2013

Outline

- Introduction (dark matter)
- Online
- Soudan to FNAL data movement
- Offline (from Ben Loer)
- SuperCDMS at SNOLAB (CDMS G2)

A quick introduction to dark matter

- Slides copied from Lauren Hsu's talks
- For more information, see:
 - Lauren's [Fermilab Colloquium](#) Oct 31, 2012
 - Lauren's [FPCA Seminar](#) Feb 9, 2012
 - Jeter Hall's [FPCA 2010 Retreat Talk](#)
 - SuperCDMS [website](#)
 - Dan Bauer's [G2 Briefing](#) for the Directorate

An old puzzle...

1933:

Fritz Zwicky analyzes velocity dispersion in Coma Cluster



Individual galaxies move too fast for a bound system...



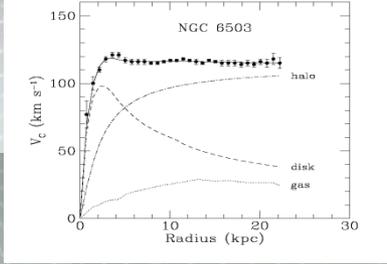
Coma Galaxy Cluster
(SDSS)

*was the cluster more massive than deduced from
luminous material?*

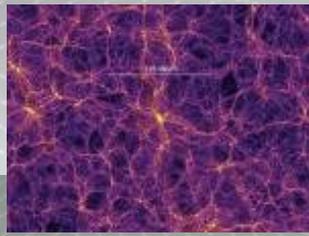
...becomes an established problem



Zwicky discovers missing mass in Coma Cluster



Galactic rotation curves measured with 21cm suggest dark matter on galactic scales



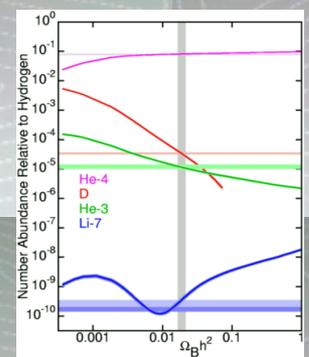
N-body simulations reproduce large scale structure if DM is cold



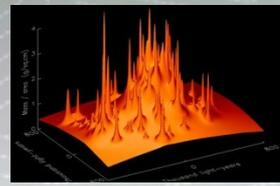
Bullet Cluster shows separation between baryonic matter and center of gravity



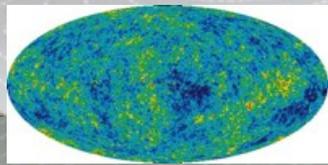
Astrophysical data tell us much about dark matter but we still don't know its fundamental properties!



BBN sets bound on baryonic matter content of the universe



Gravitational lensing tomography supports existence of DM

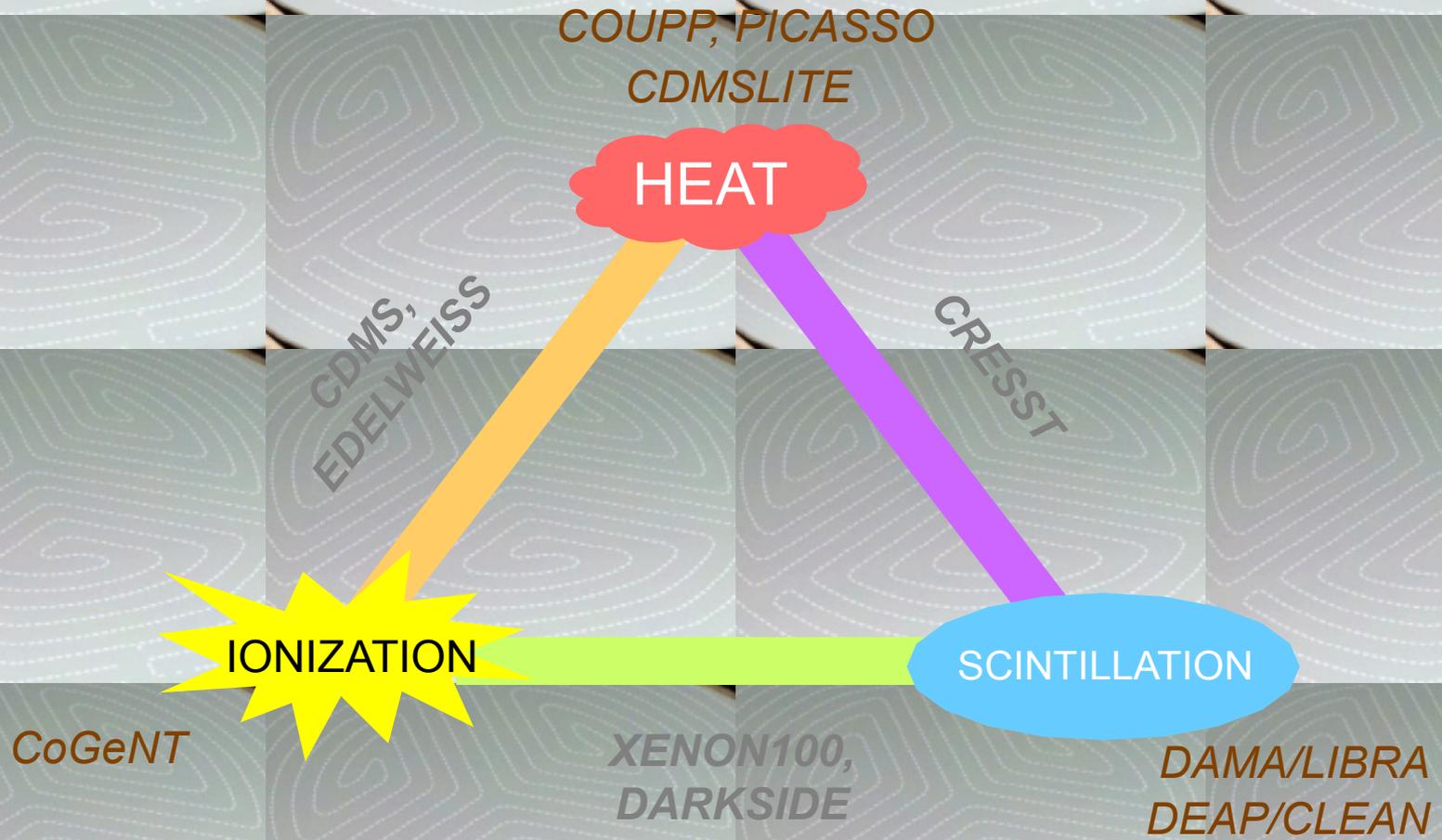


CMB tells us that DM is ~85% of all matter in the Universe, and $\Omega_{CDM} = 23\%$

DM Direct Detection Assumptions

- Dark matter particles ...
 - Neither absorb nor emit light (no charge, no EM interactions)
 - Interact with ordinary matter via gravity (infer from astronomical observations) and the weak force (so will cause nuclear recoils)
 - Have large masses compared to standard particles
- Candidate: **WIMPs** (Weakly Interactive Massive Particles)
- Detect via recoils of suitable target nuclei
 - CDMS detectors operate at low temperature (0.090K) because predicted recoil energies are tiny (10-100 KeV)
 - Operate underground to shield from cosmic ray background (background rejection is everything)

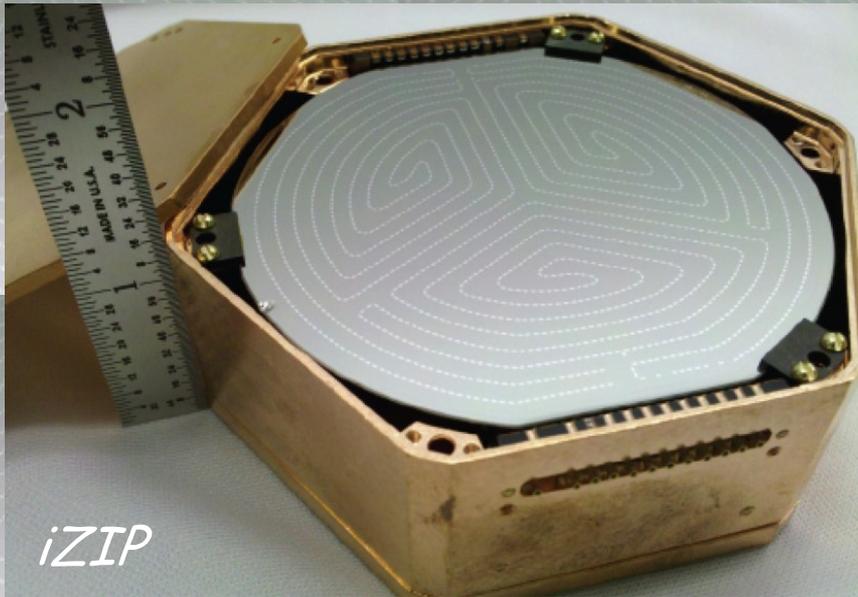
WIMP detection techniques



SuperCDMS Soudan

10 kg of Ge arranged in 5 towers

iZIP = "interleaved Z-sensitive Ionization and Phonon" detector

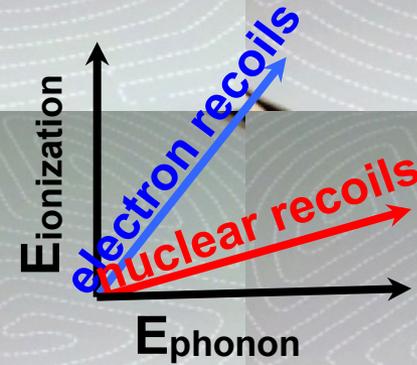
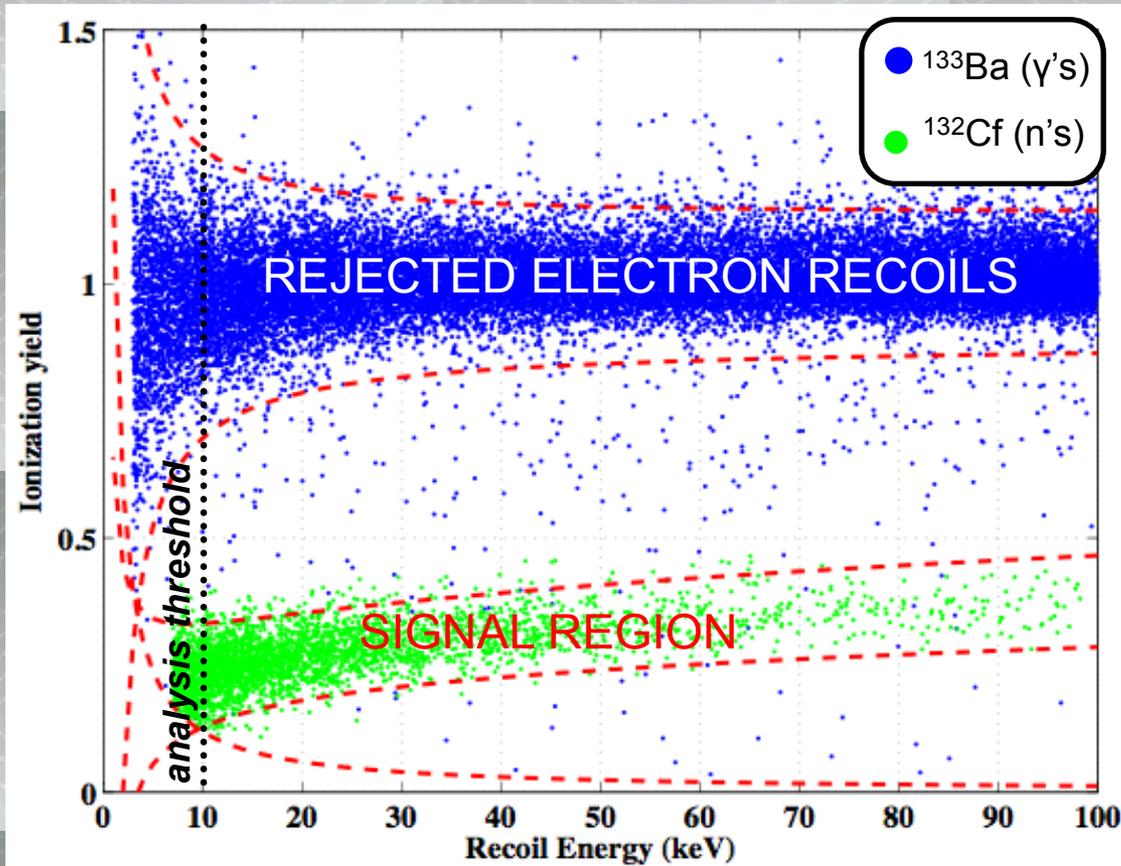


*2.5 cm
(thickness of Ge crystals)*

0.6 kg per detector

iZIP: 2.5-cm thick, double-sided phonon and charge sensors

How it works for CDMS



$$\text{ionization yield} = \frac{E_{\text{ionization}}}{E_{\text{phonon}}}$$

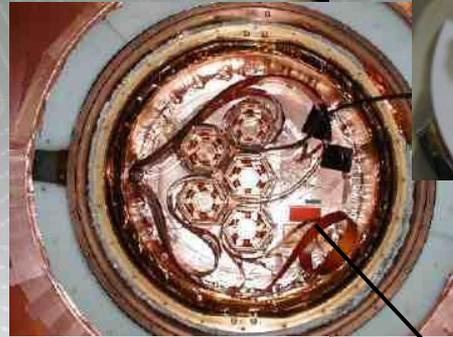
1:10⁴ rejection of gammas based on ionization yield alone...

BETTER THAN 1:10⁶ rejection of gammas and betas w/ phonon pulse shape (in CDMSII)

Soudan setup

Lead, poly and scintillator provide additional shielding

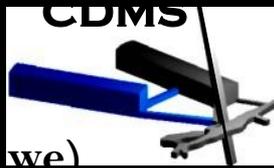
Array of 15 Ge detectors reside in the "icebox"



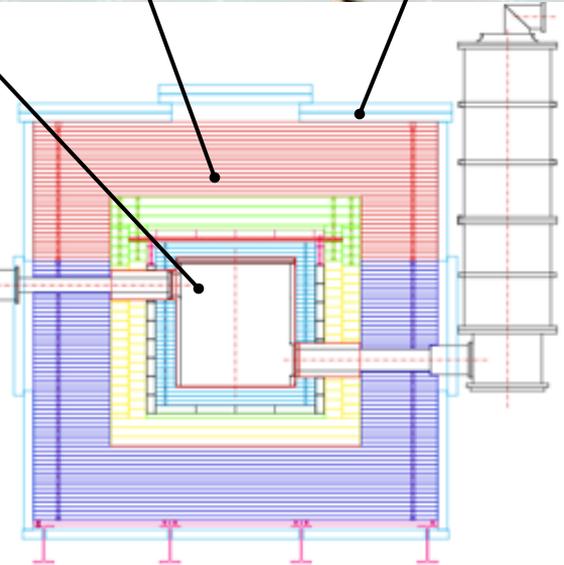
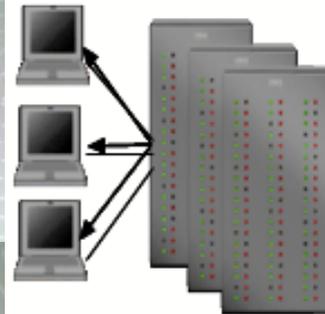
Surface



Deep underground site significantly reduces cosmogenic background



DAQ



Cryogenic system cools detectors to ~50 mK, needed for phonon detection

DAQ (*running since Dec 2003*)

- CDMS events consist of digitized traces from the phonon and charge channels from the iZIPs
 - Background running (WIMP-search) also includes digitized muon-veto PMT traces
 - Digitizers are VME-based, as are signal history buffers and GPS clock data
 - Other electronics are in NIM crates, or in CDMS 9U detector and trigger crates
 - Fast readout (“event builder”) is *CDMSR2DM*, based on Luciano Piccoli’s *R2DM* Run II software
 - Dependencies on ACE, ITC, thread_util, ORBacus
 - Underpinnings have been frozen since RedHat 7, all running on private network

DAQ (cont'd)

- Slow control is Java-based
 - RMI is used for inter-server communications
 - CORBA is used to interact with the event builder, and for various event channels (monitoring, error, state)
- Shifters use a data quality monitoring and reporting framework implemented in Tomcat
- DAQ and other computers at Soudan
 - 7 for event building and slow control
 - 3 disk servers (about 100 TB) for raw data, online processing (data quality system)
 - 3 Windows systems for control of cryogenics

A sophisticated data checking tool

Lets try a live demo: <http://cdmsmini.cdms-soudan.org:8080/DQDiagnostics.jsp>

Summary Page Search Tool

Data Summary Table - Hover Over A Cell For More Info

Series	Run	Type	Dets	Events	Run Time	Process Status	Operator Selection	Trig. Rate OK?	Phonons OK?	Veto On?	Comments	DQ Diagnosis
01120208_1034	133	Test	15	NA	02:41	waiting t...	?	✗	✗	✓	1V Ba...	✗
01120208_0836	133	Test	3	141744	01:39	done	✓	✓	✓	✓	2V bia...	✓
01120207_1436	133	Test	13	6624	00:04	done	✗	✓	✓	✓	DAQ t...	✗
01120207_1259	133	Test	13	0	00:40	NA	✗	✓	✓	✓	EB ne...	✗
01120207_1138	133	Test	13	74052	01:08	done	✓	✓	✗	✓	2V bia...	✓
01120207_1106	133	Test	13	4642	00:11	done	✓	✓	✗	✓	2V bia...	✗
01120207_0938	133	Test	13	127351	01:17	done	?	✓	✓	✓	2V bia...	?
01120206_2034	133	Test	13	172957	12:21	done	✓	✓	✗	✓	2V bia...	✗
01120206_1544	133	Test	15	25844	00:19	done	✓	✓	✗	✓	mislab...	✗
01120206_1457	133	Test	15	21673	00:33	done	✗	✓	✗	✓	2V bia...	✗
01120206_0728	133	Test	15	155284	04:05	done	?	✓	✗	✓	1V bia...	✗
01120205_1733	133	Test	15	79443	00:46	done	?	✓	✗	✓	1V bia...	✗
01120205_1726	133	Test	15	606	00:01	failed	✗	?	✓	✓	1V bia...	✗
01120205_1550	133	Test	3	121686	01:24	done	✓	✓	✓	✓	2V bia...	✓
01120205_1401	133	Test	2	117806	01:43	done	✓	✓	✓	✓	2V bia...	✓
01120205_1214	133	Test	3	175415	01:43	done	?	✓	✓	✓	2V bia...	?

Number Of Rows To Display: 15 Number Of Recent Series To Fetch: 20 Get Most Recent Series Suppress DAQ Tests Renew My Last Query

6/19/2013

Soudan to FNAL Data Movement

- Data generation rates:
 - Background (WIMP search) – 0.6 MiB/sec
 - Calibration (Barium alpha) – 11 MiB/sec
 - Typical month (experiment runs 24 hours/day):
 - 30 calibration runs totaling 1.5 TiB
 - 210 background runs totaling 0.5 TiB
- Data movement scripts (all implemented in Perl)
 - Evolved from earlier tape archiving framework
 - Data are moved from event builder to online analysis server and copied to Soudan data archive
 - Data archive machine at FNAL pulls (via http) data from Soudan data archive
 - Original data files on the event builder are deleted once copies reside on both the Soudan and FNAL archives

CDMS Data at FNAL

- CDMS operates 10 servers in LCC-107
 - About 350 TiB of storage
 - Newer machines are used for interactive analysis (MATLAB, and ROOT-based)
 - All data taken at Soudan (2003 forward) is kept spinning, plus the outputs of various reprocessing campaigns
 - CDMS FermiGrid jobs pull data (rsync) from these servers
- Enstore
 - All raw data are written redundantly (2 copies, one each in FCC and GCC)
 - Roughly 64 TiB in each building (oldest data were not duplicated)
 - Monthly ingest is 1.9 TiB for each copy

Offline Slides

CDMS G2 (SuperCDMS at SNOLAB)

- (Planned) Improvements over Soudan SuperCDMS:
 - 9 Kg → 200 Kg
 - 3” Diameter iZIPs → 4” Diameter
 - 180 channels (120 phonon, 60 charge)
→ 1152 channels (864 phonon, 288 charge)
 - Lowered backgrounds through:
 - Deeper experiment
 - Active neutron veto
 - < 1 background event in 4 years of running!
 - New electronics (FNAL/SLAC) and new unified DAQ (“Midas” - UBC/PNNL)

CDMS G2 Challenges

- Data volumes
 - Naïvely, 6.4X the Soudan rate and data volume
 - Roughly 12 TiB per month if the same ratio of background to calibration data sets occurs
 - But, same or smaller network pipe (can't do 12 TiB per month) both out of the mine and to FNAL
 - Possible solutions:
 - Currently on-going iZIP analysis on Soudan data may justify taking much less calibration data
 - May need to do calibration analysis on computers at SNOLAB and only ship RQ files to the surface and FNAL
 - Back to shipping tapes??

CDMS G2 Challenges

- Extensive Soudan analysis software base exists, however:
 - Many opportunities for improvement, particularly implementation of a real data catalog
 - CDMS will explore ART
 - Too early to specify needs and schedule
 - Dependent on analysis of Soudan iZIP runs
 - New 4” detectors will need to be characterized to understand if digitization parameters will differ from Soudan iZIPs (sampling rate, trace lengths)
 - CDMS G2 depends on DOE down-select this year, and timing will further depend on budgets and continuing resolutions

The End