CDMS-II at Soudan Mine

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Fermilab Director's Review of

Soudan Mine Operations

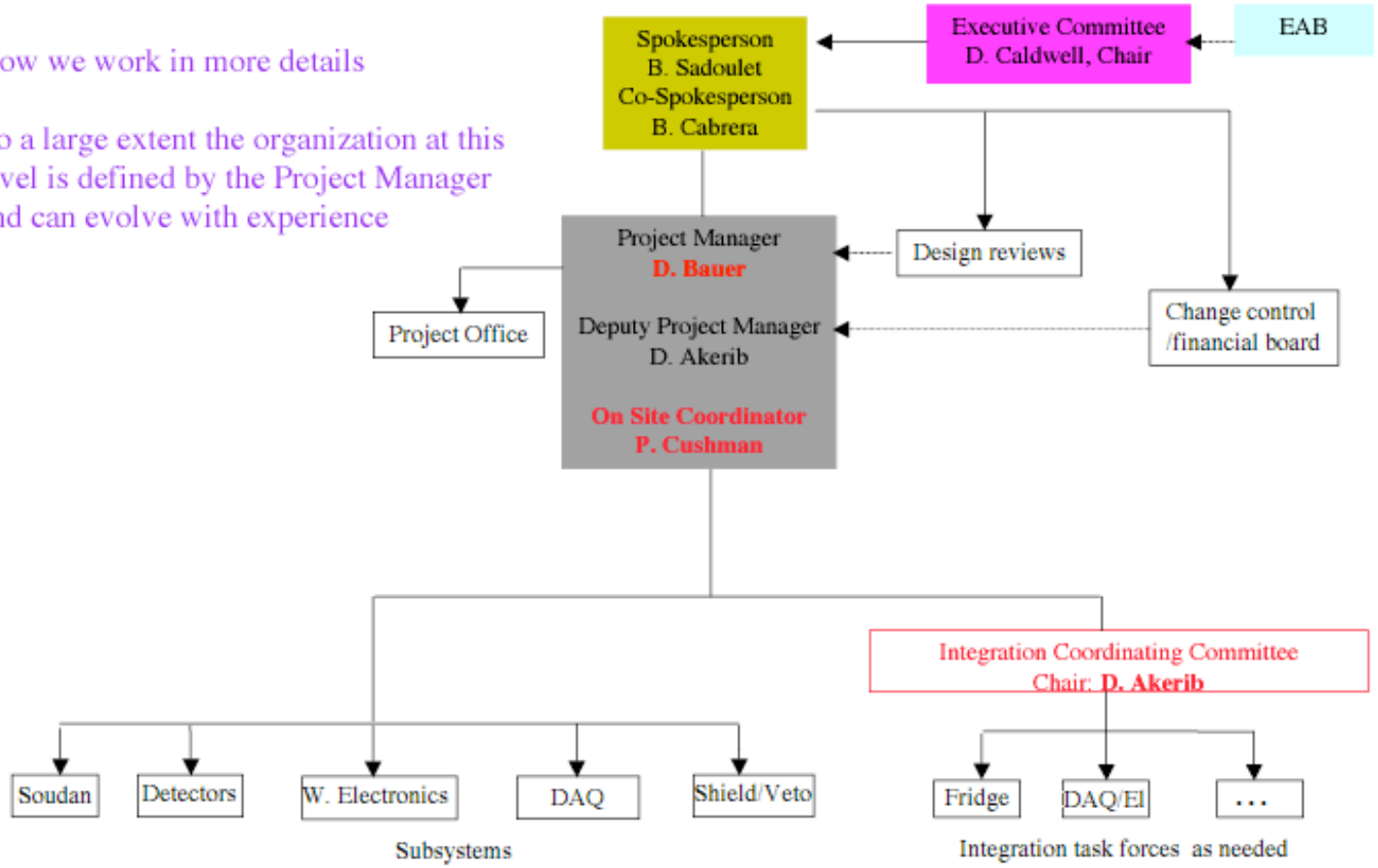
14 May 2003


UC Berkeley, Stanford, LBNL, UC Santa Barbara,
Case Western Reserve U, FNAL, Santa Clara U,
NIST, U Colorado Denver, Brown U, U Minnesota

Organizational Structure

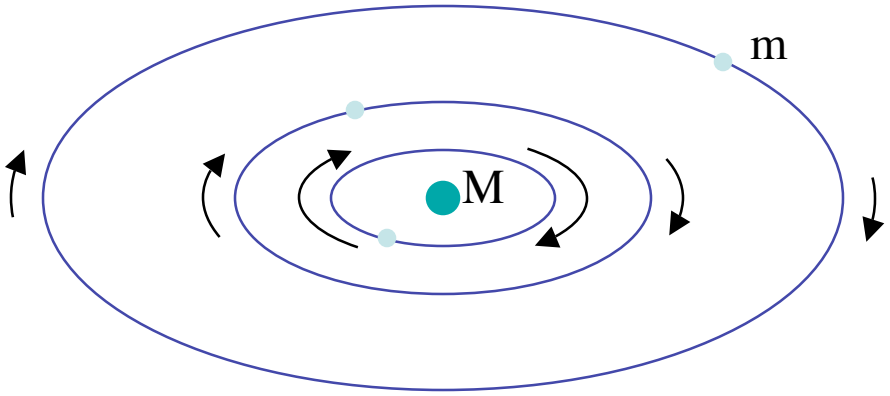
How we work in more details

To a large extent the organization at this level is defined by the Project Manager and can evolve with experience



Rotation Curves and Galactic Dark Matter

- Solar System obeys Kepler laws

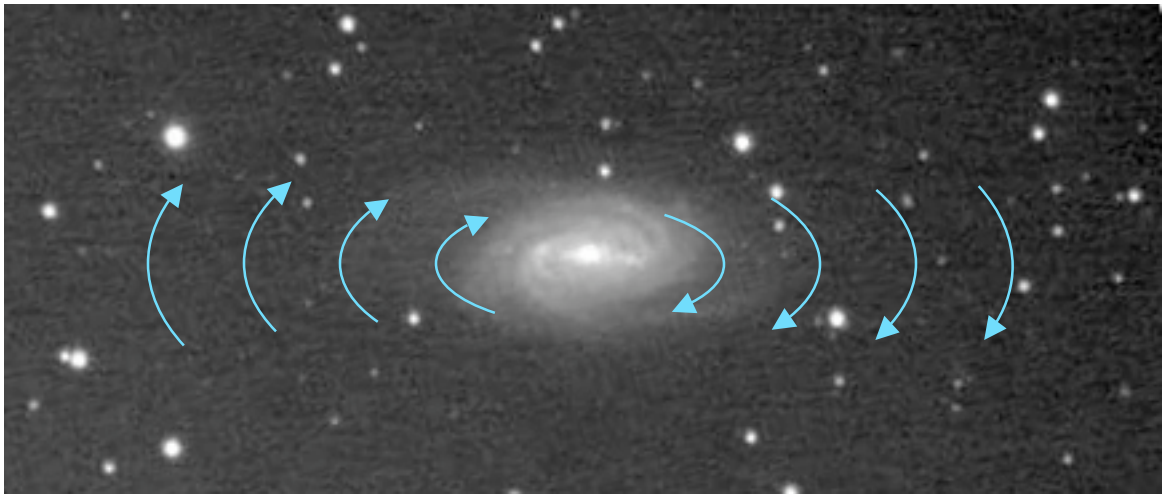


$$\vec{F} = -\frac{GMm}{r^2}\hat{r}$$

$$= -m\frac{v^2}{r}\hat{r}$$

$$v = \sqrt{\frac{GM}{r}}$$

- Galaxies have constant rotation curves



For :

$v \approx \text{constant}$

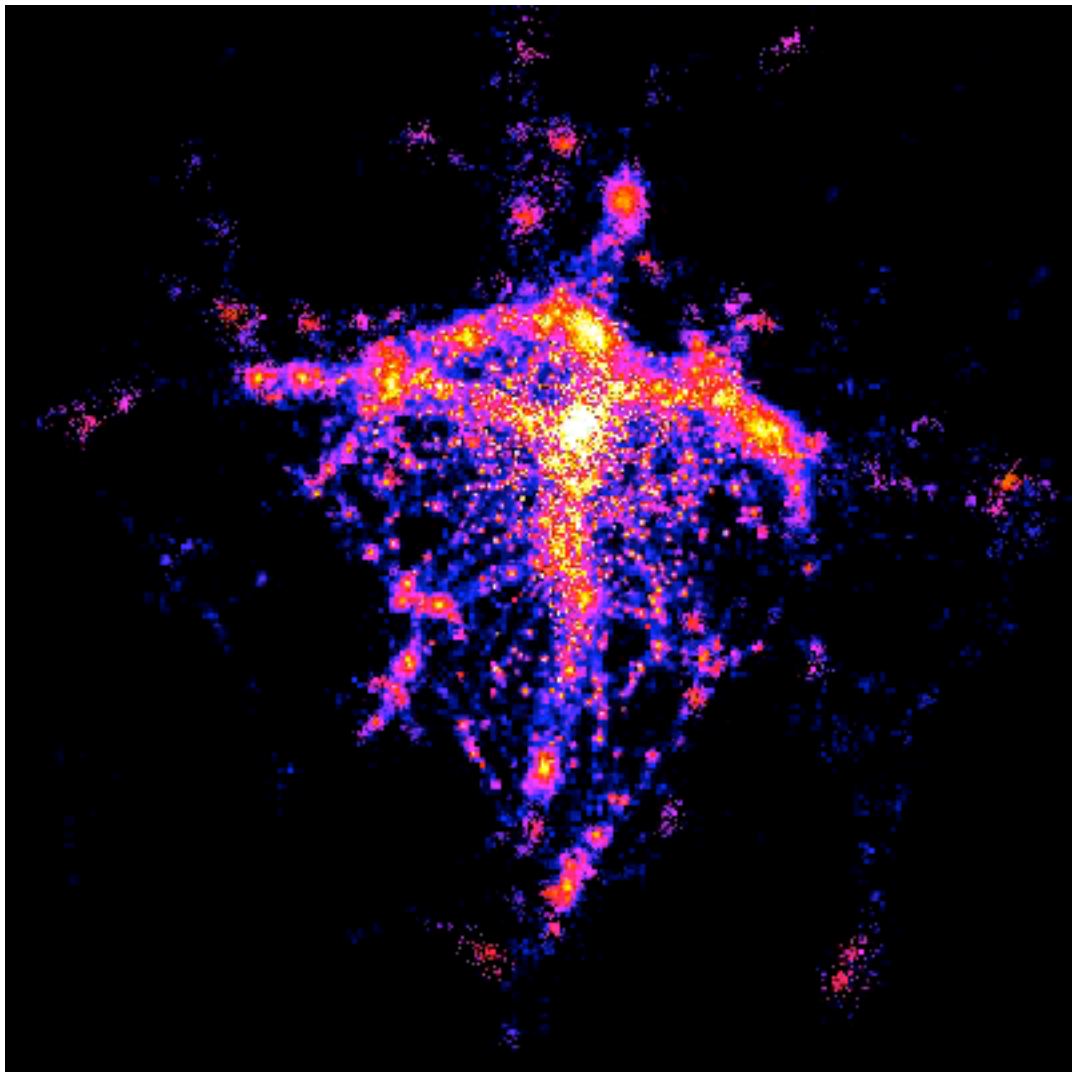
then :

$M(r) \quad r$

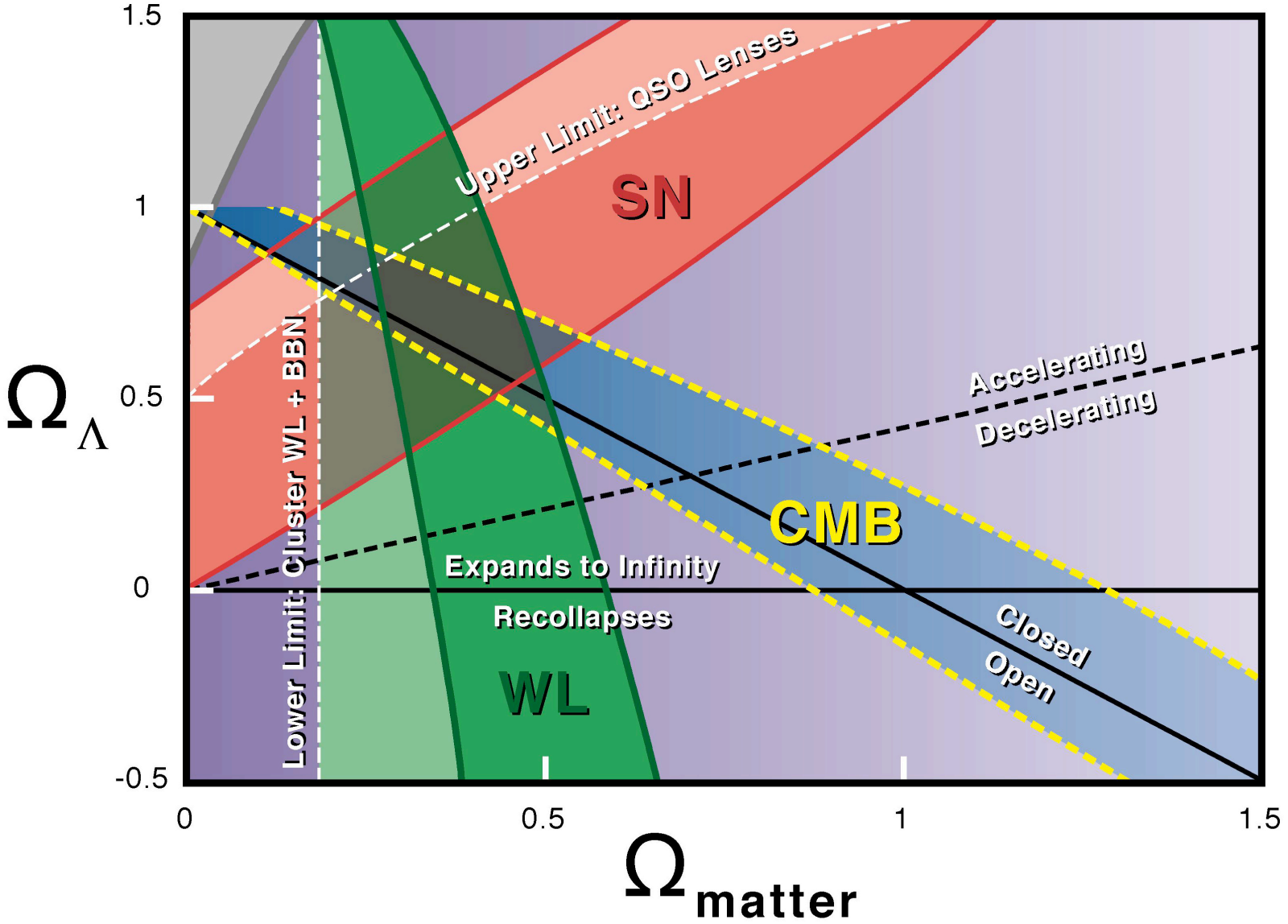
$M_{dark} \geq 10 M_{lum}$

Dark matter simulations

- B. Moore, Zurich
- Shows Virgo cluster like galaxy cluster and zooms in on dark matter distribution (brighter is more dark matter)

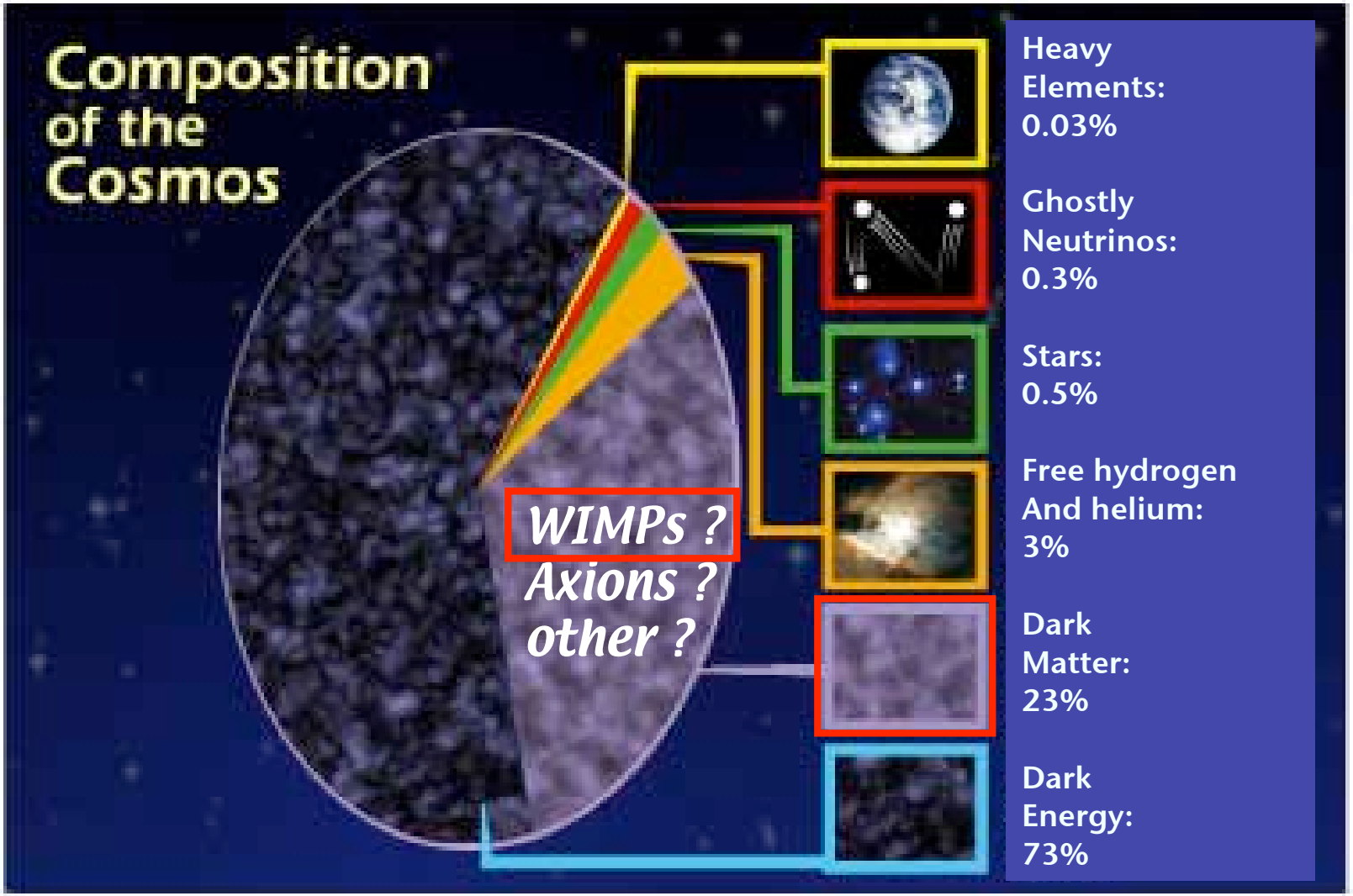


Dark Matter & Recent Cosmology Results

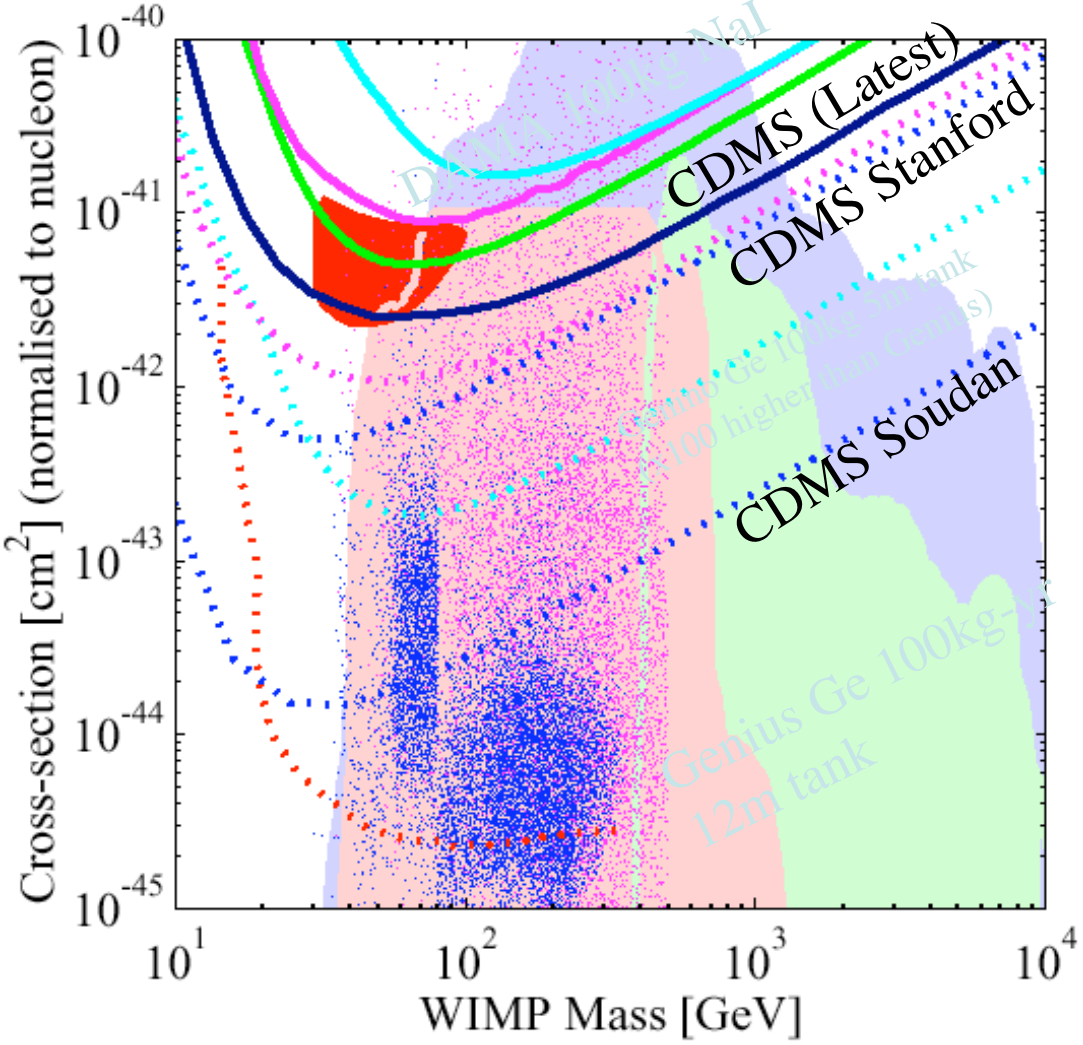


Components of Universe

$$\Omega_{\Lambda} + \Omega_{m} = 1$$

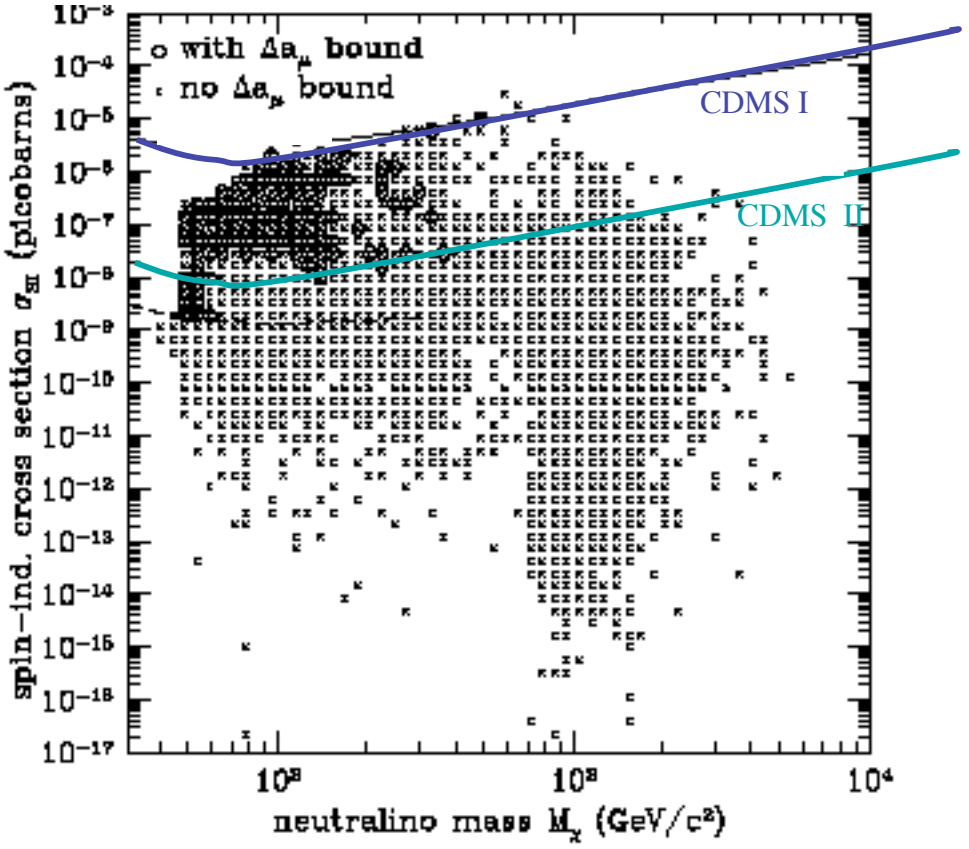


WIMP Search Projections



Pointers to Supersymmetry ?

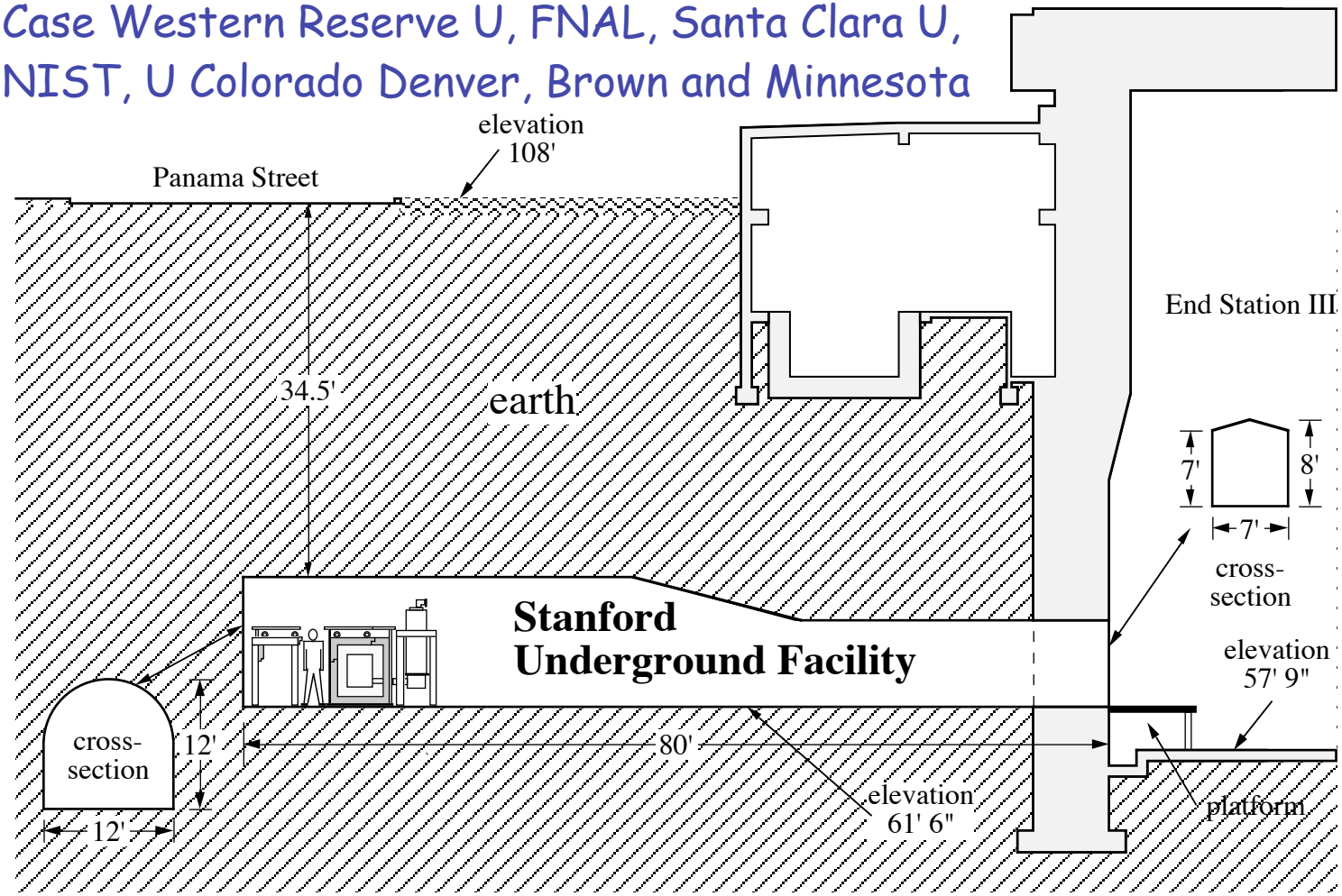
- The g-2 result from Brookhaven: **3.5 □ with new completed analysis and new input from theory**
- Together with constraint from LEP and Tevatron favor low mass and larger cross sections accessible to CDMS II



Baltz-Gondolo 01
But incomplete treatment
at large tan □

CDMS I - Stanford shallow site (SUF)

UC Berkeley, Stanford, LBNL, UC Santa Barbara,
Case Western Reserve U, FNAL, Santa Clara U,
NIST, U Colorado Denver, Brown and Minnesota



Stanford Underground Facility

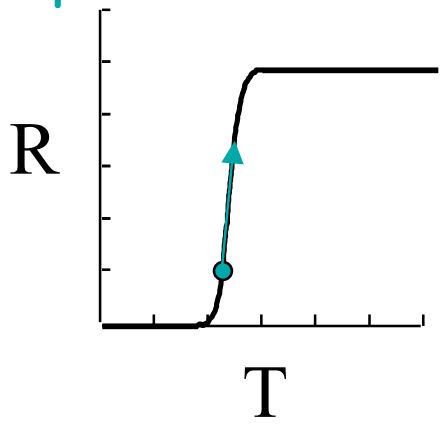
- CDMS-I operations 1996-1999, Runs 13-19 (PRL & PRD)
- CDMS-II operations 2000-2002, Runs 20-21 (PRL & PRD)
- CDMS-II operations 2003-2005, Soundan Laboratory

Date acquisition system

Icebox and shielding

Superconducting Transition Edge Sensors

- Steep Resistive Supeconducting Transition



- W T_c ~ 70 mK
- 10-90% <1 mK

unitless measure of transition width → $\alpha = \frac{dR}{dT}\Big/\frac{R}{T}$

- Voltage bias is intrinsically stable

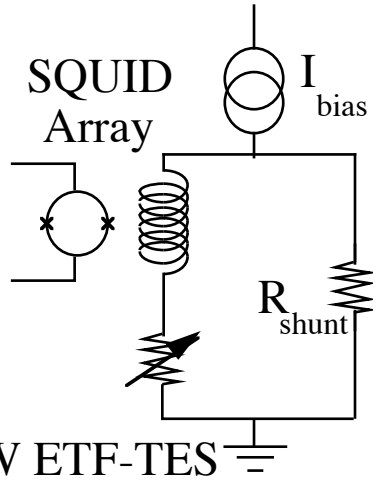
The Joule heating produced by bias

$$P_J = \frac{V_B^2}{R} \quad \Rightarrow \quad P_J \downarrow \text{ when } R \uparrow$$

is stable whereas for current bias

$$P_J = I_B^2 R \quad \Rightarrow \quad P_J \uparrow \text{ when } R \uparrow$$

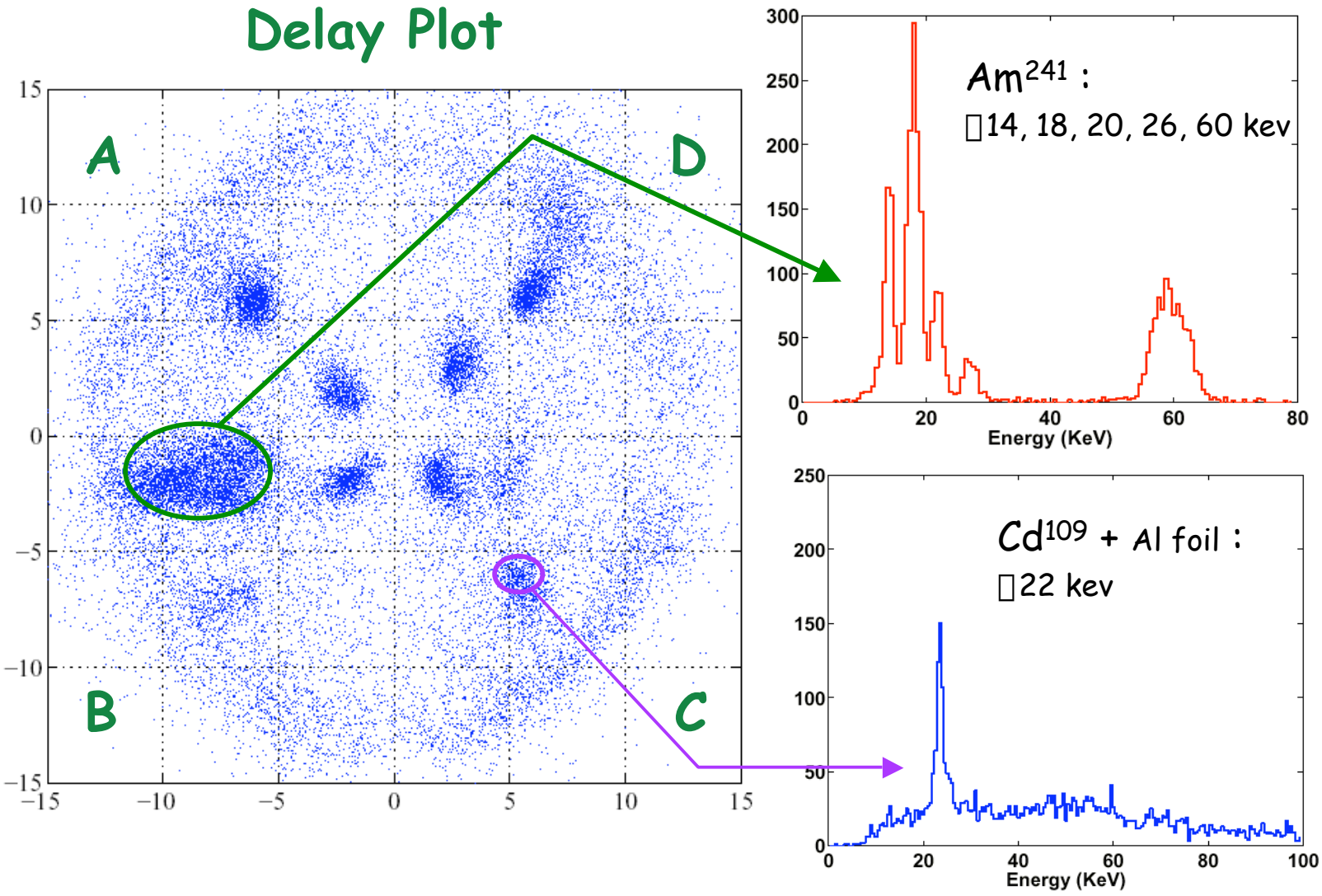
which is intrinsically unstable



CDMS-II Si & Ge ZIP Modules

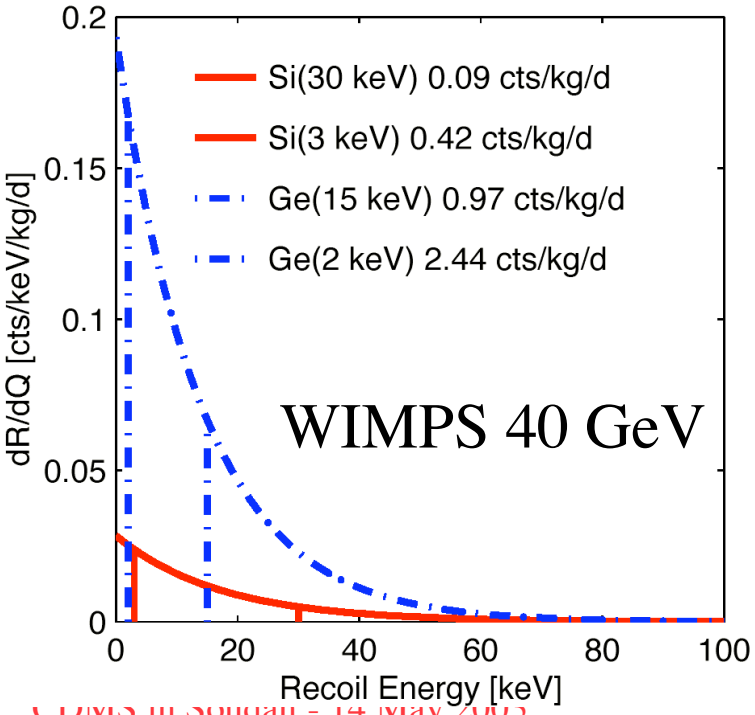
- Simultaneous readout of ionization and phonon signal to discriminate electron recoils from nuclear recoils

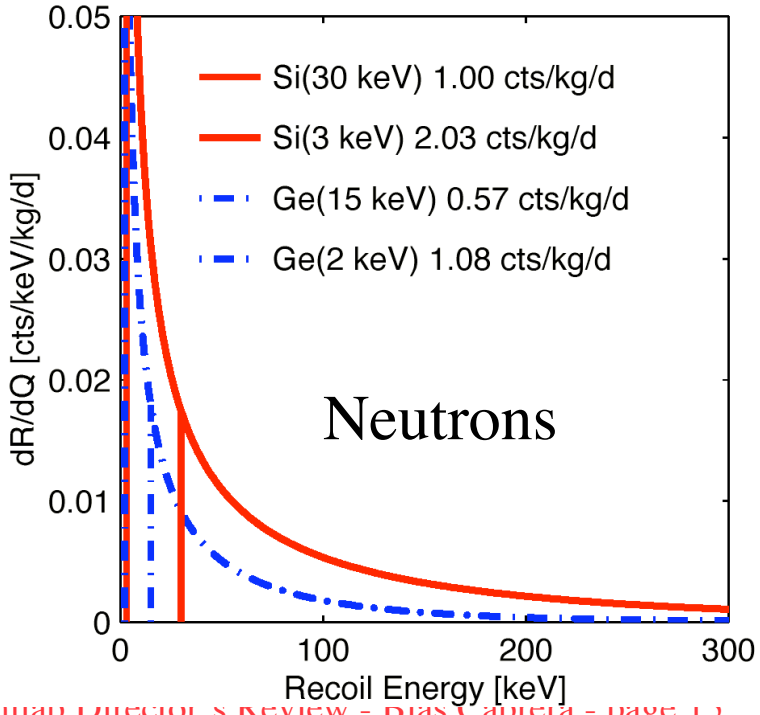
ZIP Phonon Position Sensitivity



WIMP vs Neutron Sensitivity of Si and Ge

- Jan-Jun 1998 Si ZIP Run at Stanford Underground Facility
  - For neutrons 50 keV - 10 MeV
    Si has ~2x higher interaction rate per kg than Ge
  - For WIMPs
    Si has ~6x lower interaction rate per kg than Ge

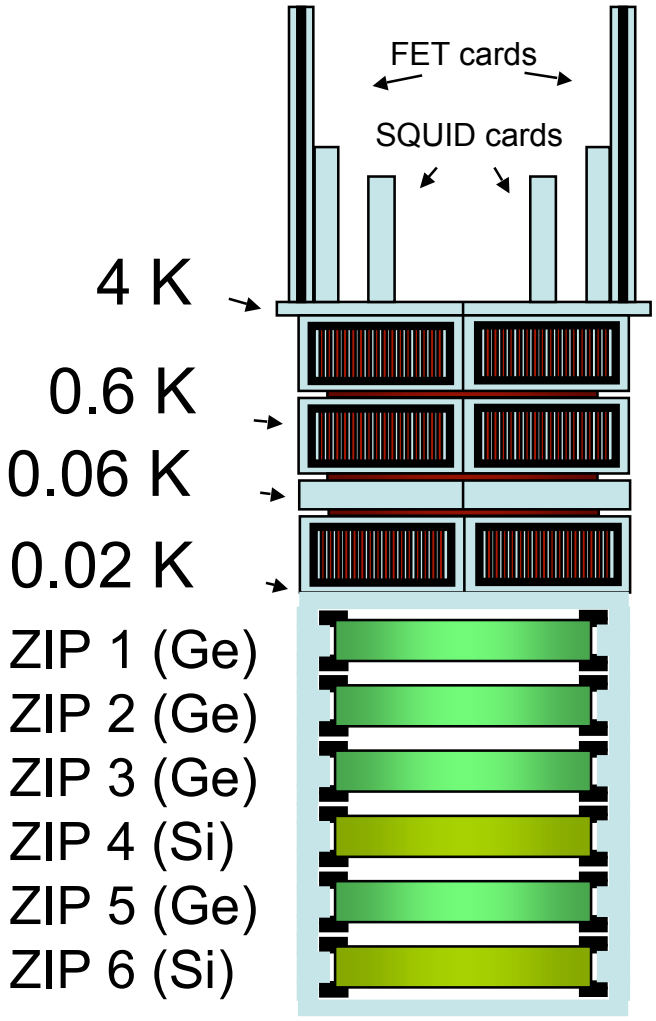




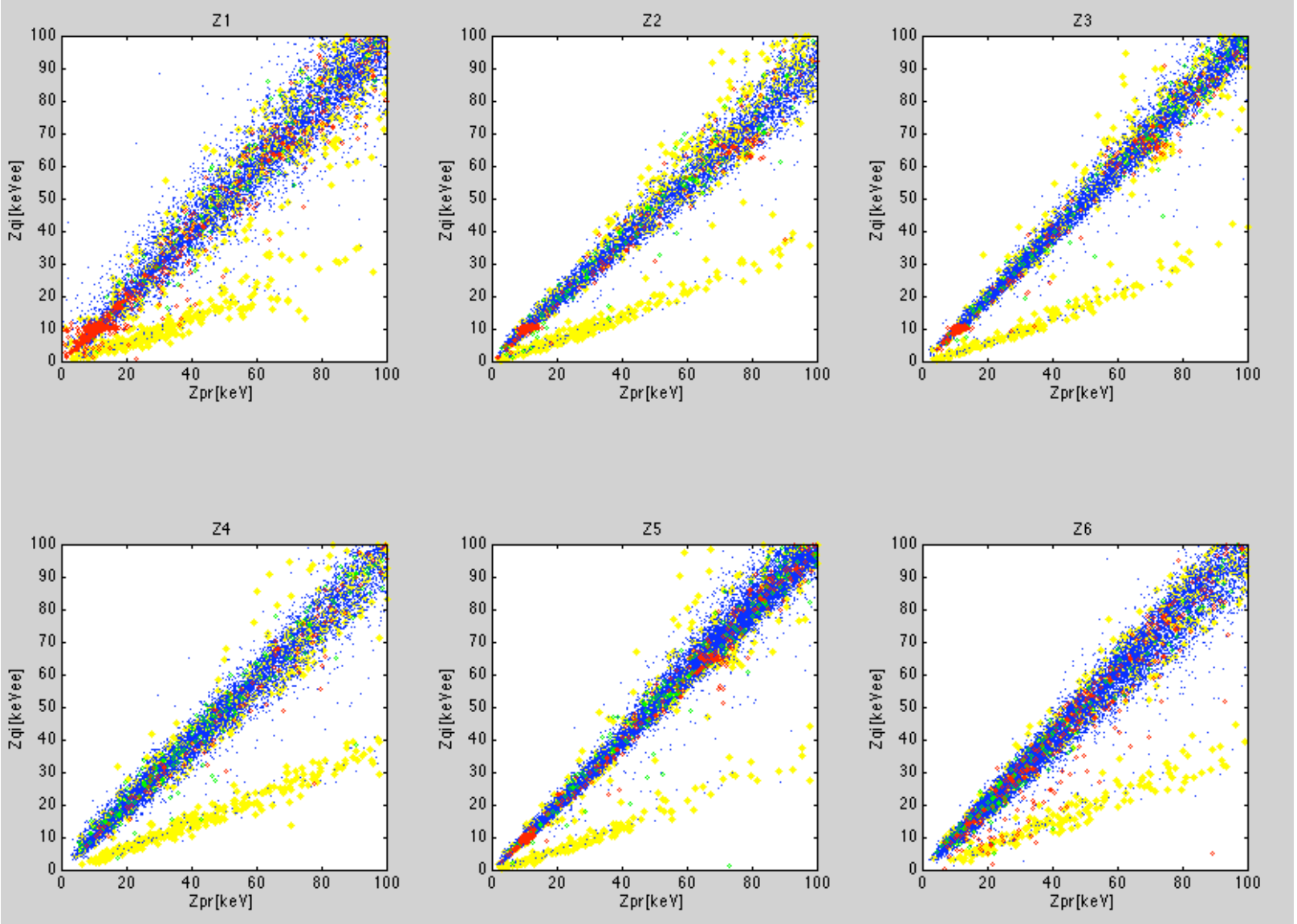
SUF Icebox Assembly

The SUF Run 21 Tower

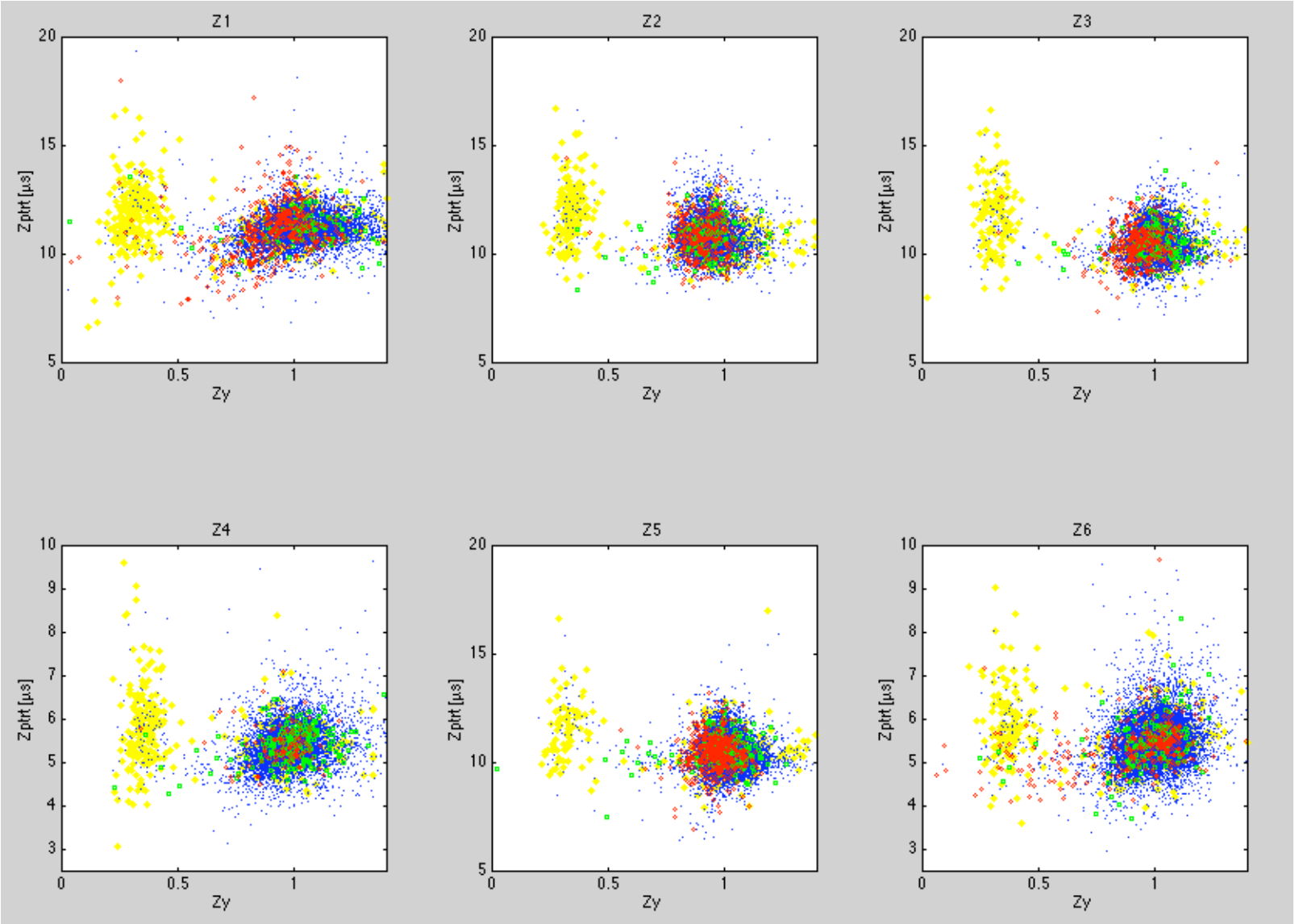
- The Soudan Tower I is now cold and taking data at SUF
  - Goals :
    - Establish the contamination levels of the detectors before their installation at Soudan
    - Measure gamma and beta rejection efficiencies
    - Measure the muon anit-coincident flux at SUF simultaneously with Si & Ge ZIPs
    - Test Monte Carlo predictions of neutron suppression rates due to addition of internal polyethelyne.
  - Detector fabrication for Tower II is almost complete



Recoil [keV] vs Charge [keVee]

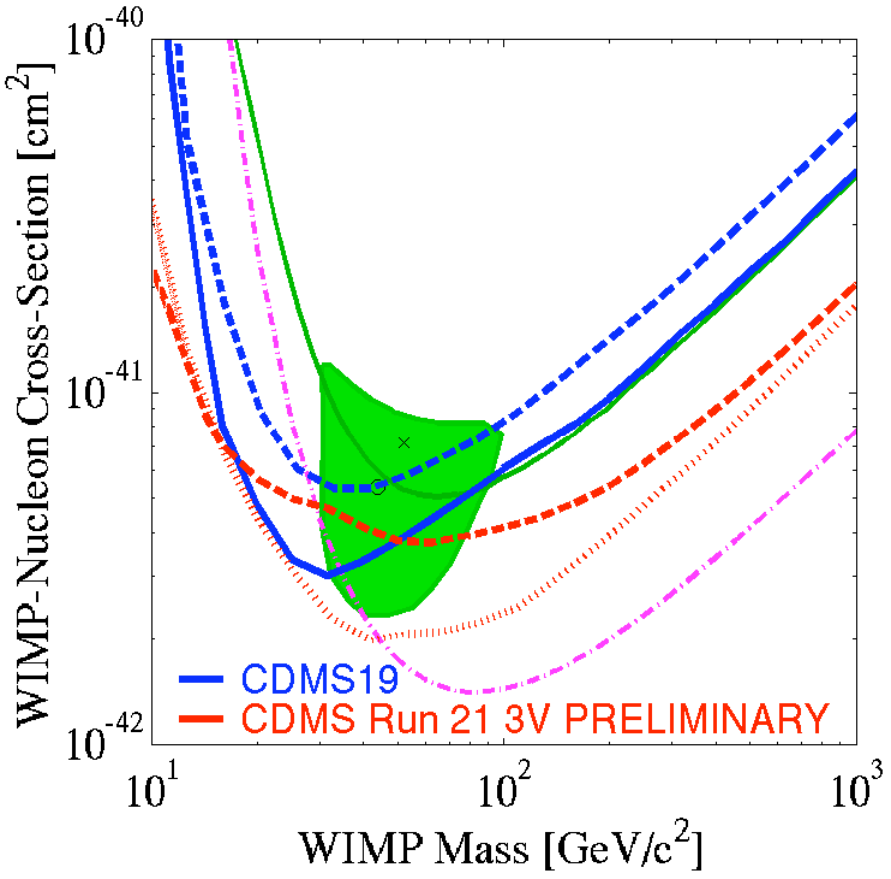


Yield [Charge/Recoil] vs Risetime [μs]



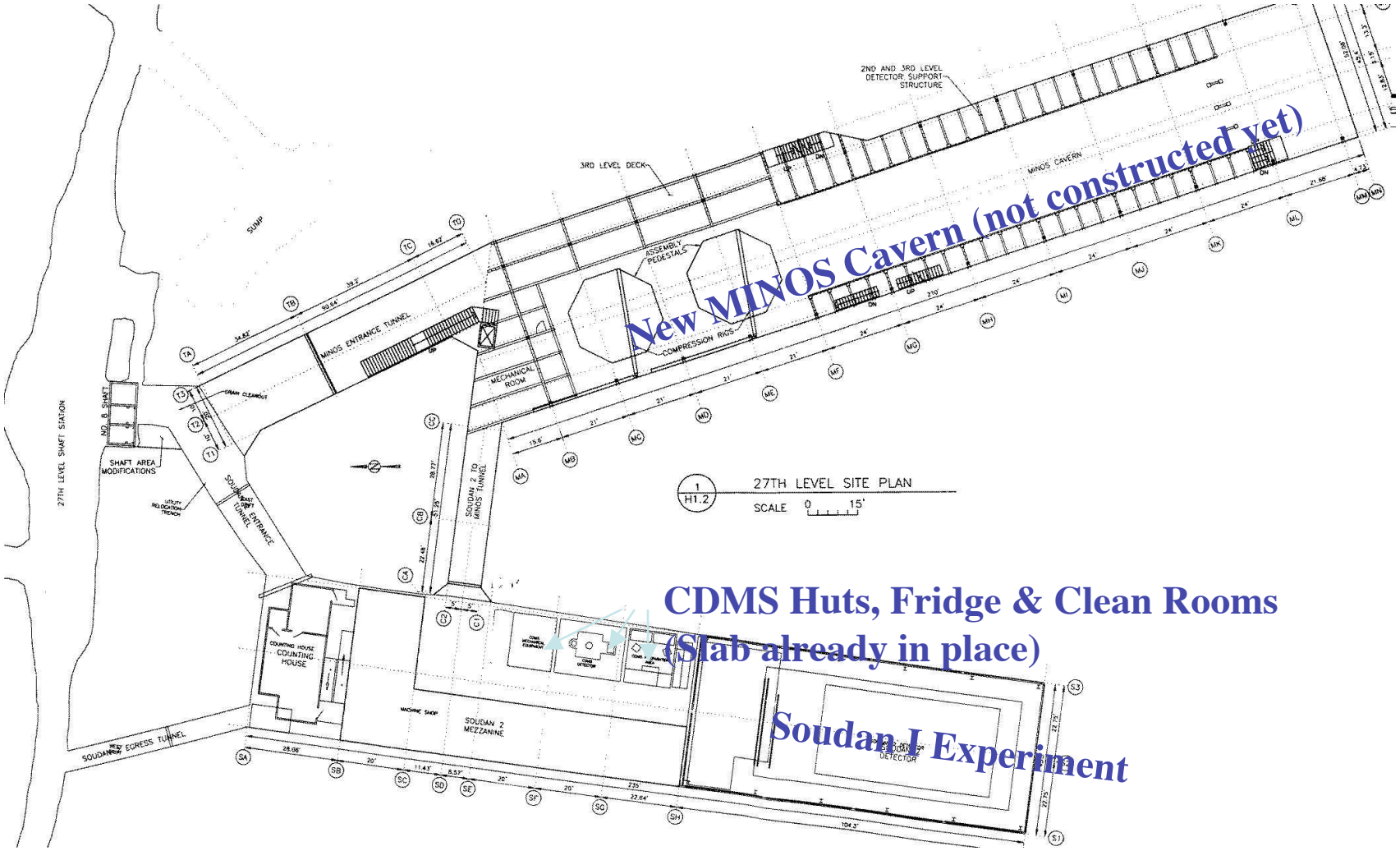
Status of CDMS (Run 21b)

- Dark red dotted line is CDMS most recent NO subtraction limit
- Light red dotted line is CDMS estimated sensitivity for just completed run
- After completing analysis will be between

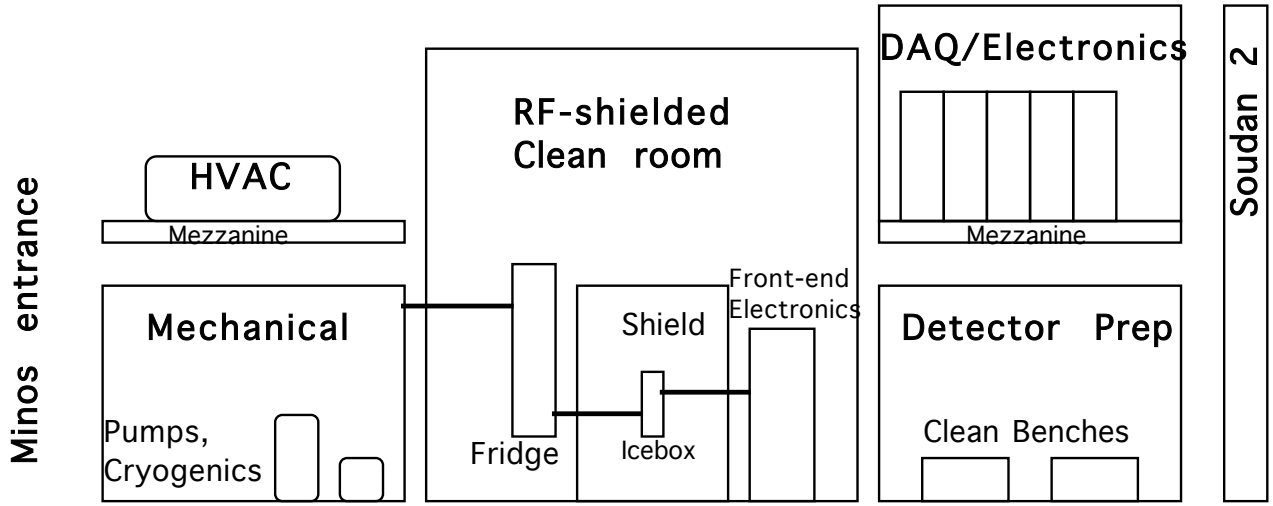



Soudan, Minnesota :
The CDMS II Deep Site

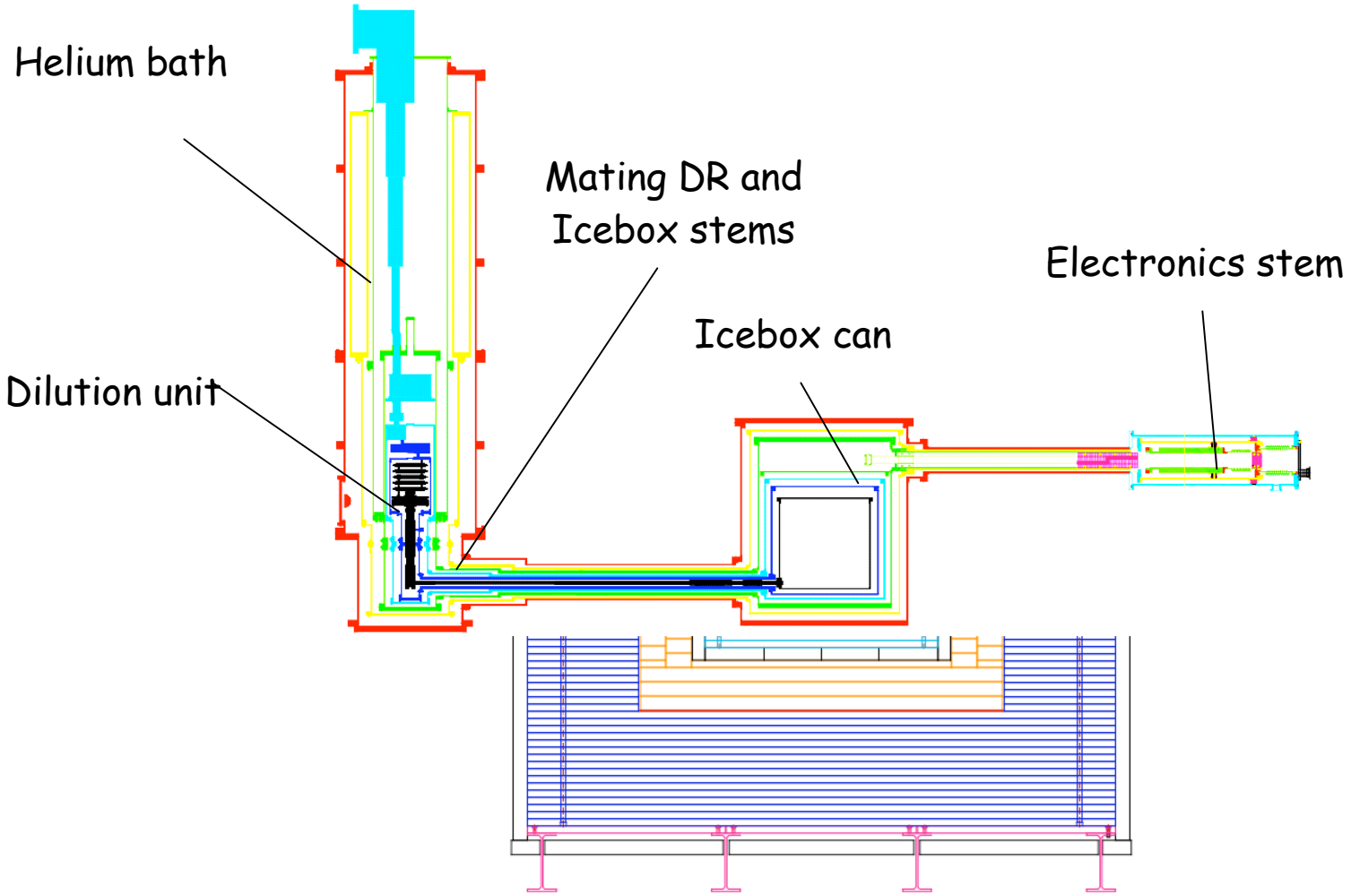
CDMS-II Soudan Mine Installation



CDMS II Experimental Enclosure



Soudan Cryo-System



Sept 2002 - May 2003 Soudan Progress

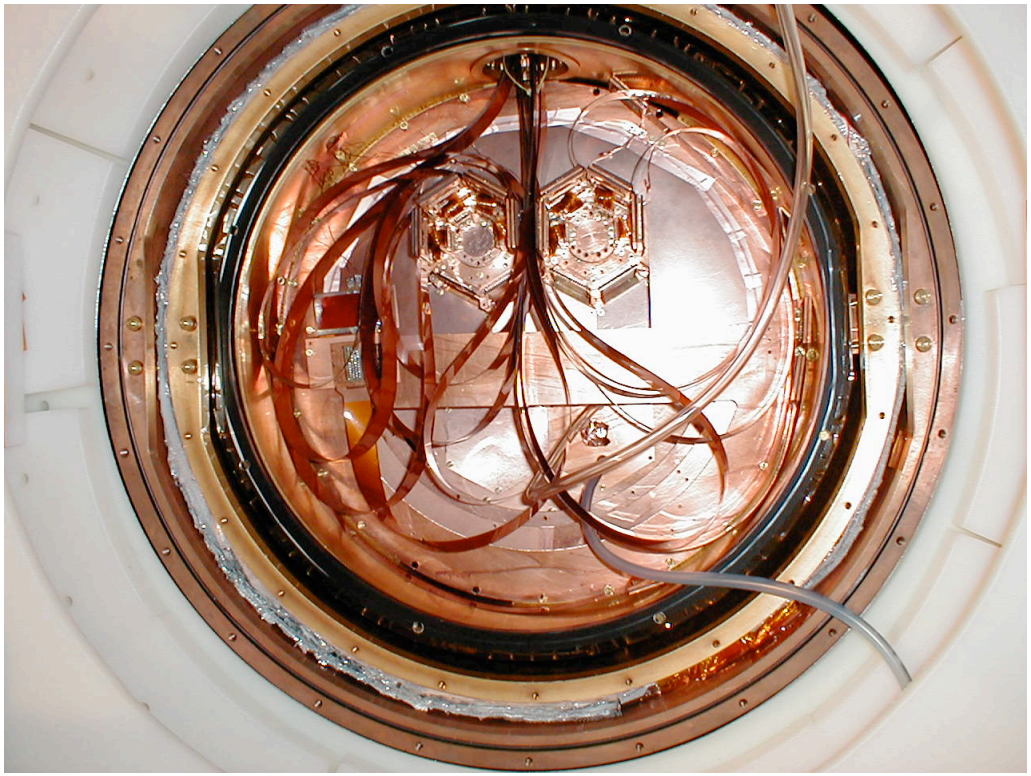
Detector Installation at Soudan

Two towers of Ge/Si detectors installed March, 2003

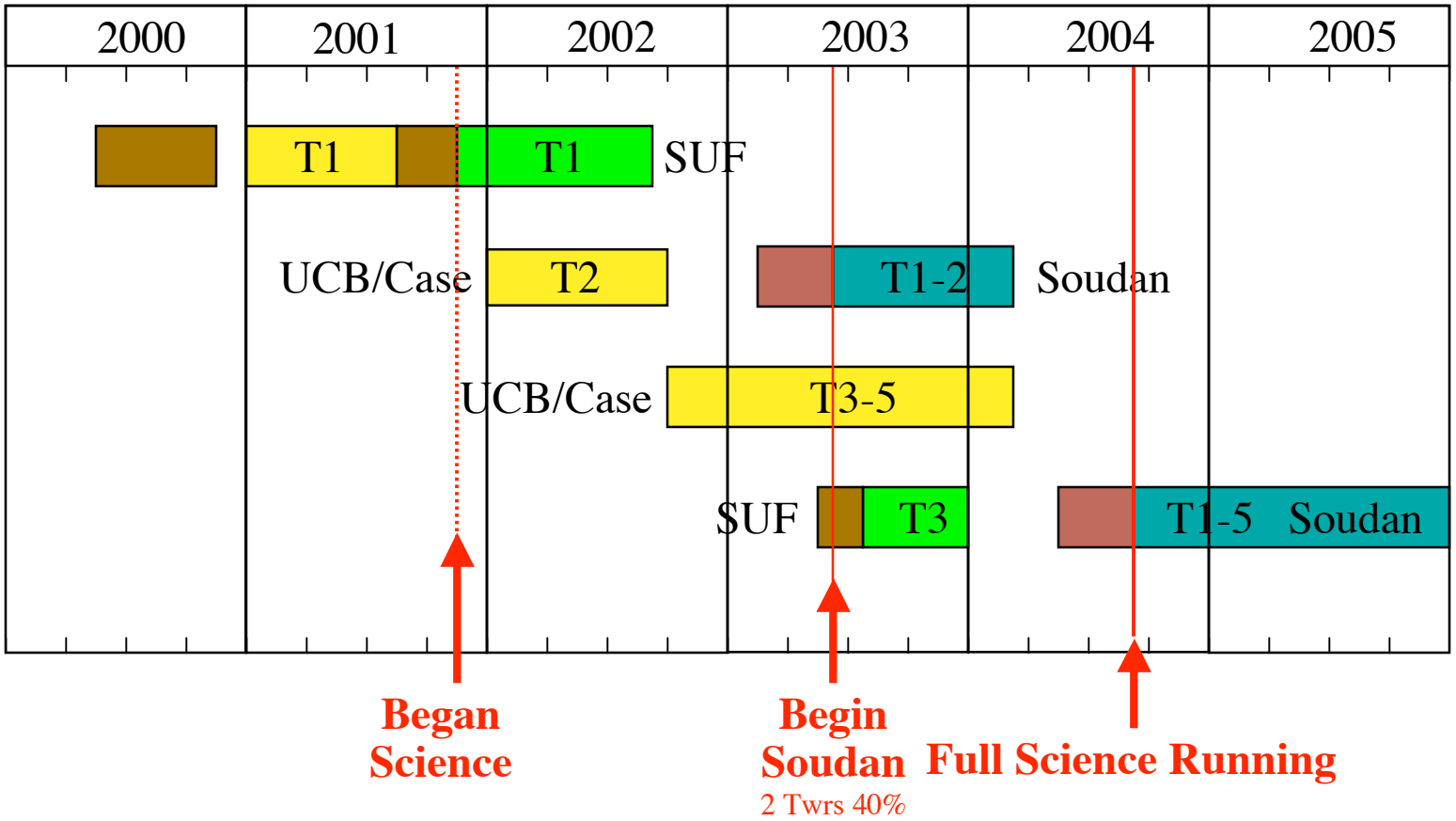
Cooled to base temperature April 17, 2003

First pulses April 26, 2003; commissioning/calibration

First “low-background” data in June, 2003



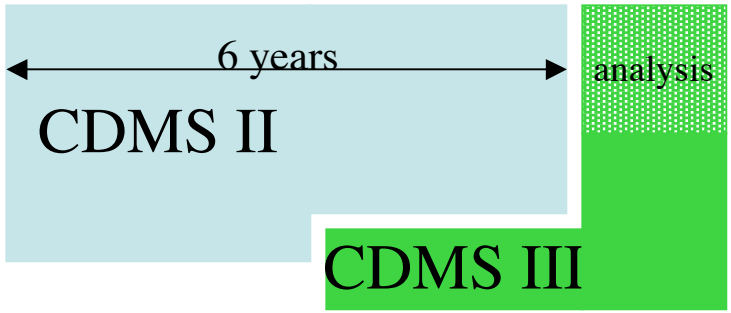
Soudan CDMS-II Plan with 5 Towers



This plan achieves science goals for originial proposal. We will submit proposal to complete Towers 6-8 as follow on with improved science reach.

Case for Upgrade after CDMS-II

- A possible scenario



For example:

- Cleaner towers 6,7…
- More advanced technology
- Further analysis

- Scientific justifications
  - Cleaner tower and better understanding of detectors
  - Possible hint for a signal

Replacement of a few towers can have a major impact

- Scientific strategy
  - Maintain US capability in cryogenic technology
    - Now detector production capability disappears in 2003/2004
  - Test bed for 3rd generation experiments
  - Maintain US leadership in dark matter search

Summary

- CDMS-II well underway
  - Tower 1 has been operated in SUF
  - Livedays (~65) x3 greater than PRL exposure
  - Inner polyethylene reduced neutrons x2-3
  - Gamma rejection far exceeds specification (>99.9%)
  - Beta contamination & rejection exceeds specifications
- Soudan installation nearing completion
  - Tower 1 & 2 (no SUF) in Soudan Mar, 2003
  - System cooled to base in April, 2003
  - First pulses in April, 2003
- Dark Matter operations by June, 2003