CDMS II Status
+ CDMS I / III / CryoArray
Direct Detection of SUSY
Cold Dark Matter

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see information at
http://cdms.brown.edu/
http://gaitskell.brown.edu/

CDMS Collaboration

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University of Minnesota

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- 12 detectors - cold & checked out @ SOUDAN
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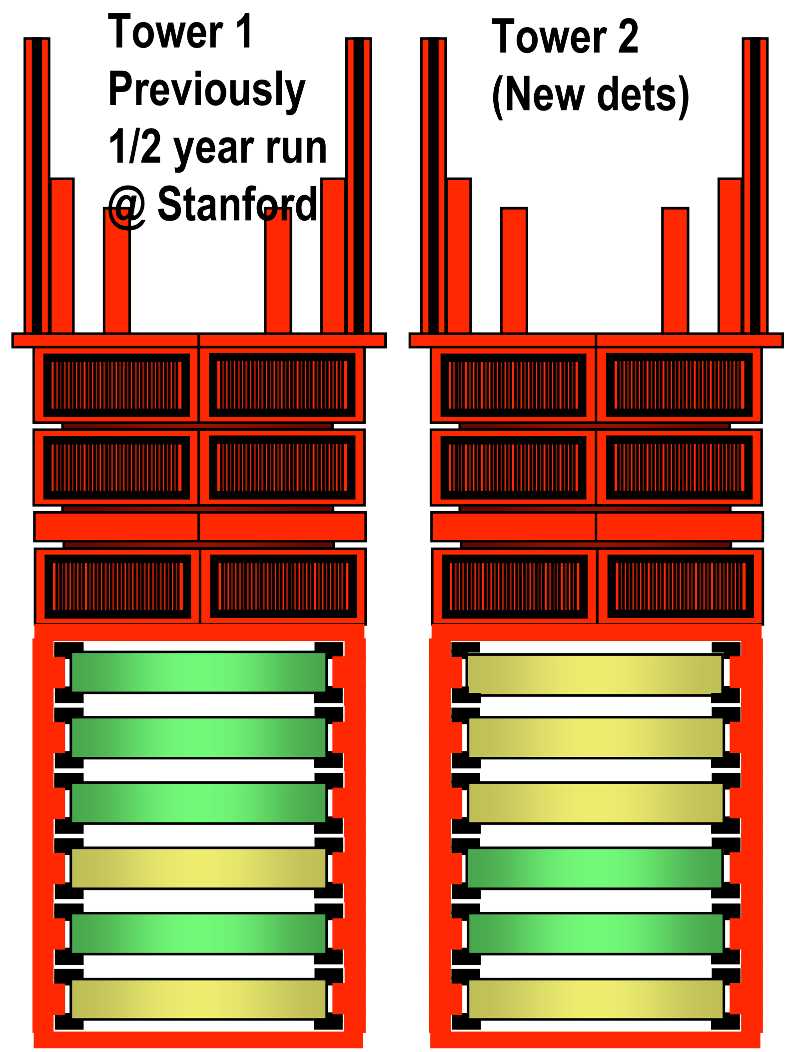
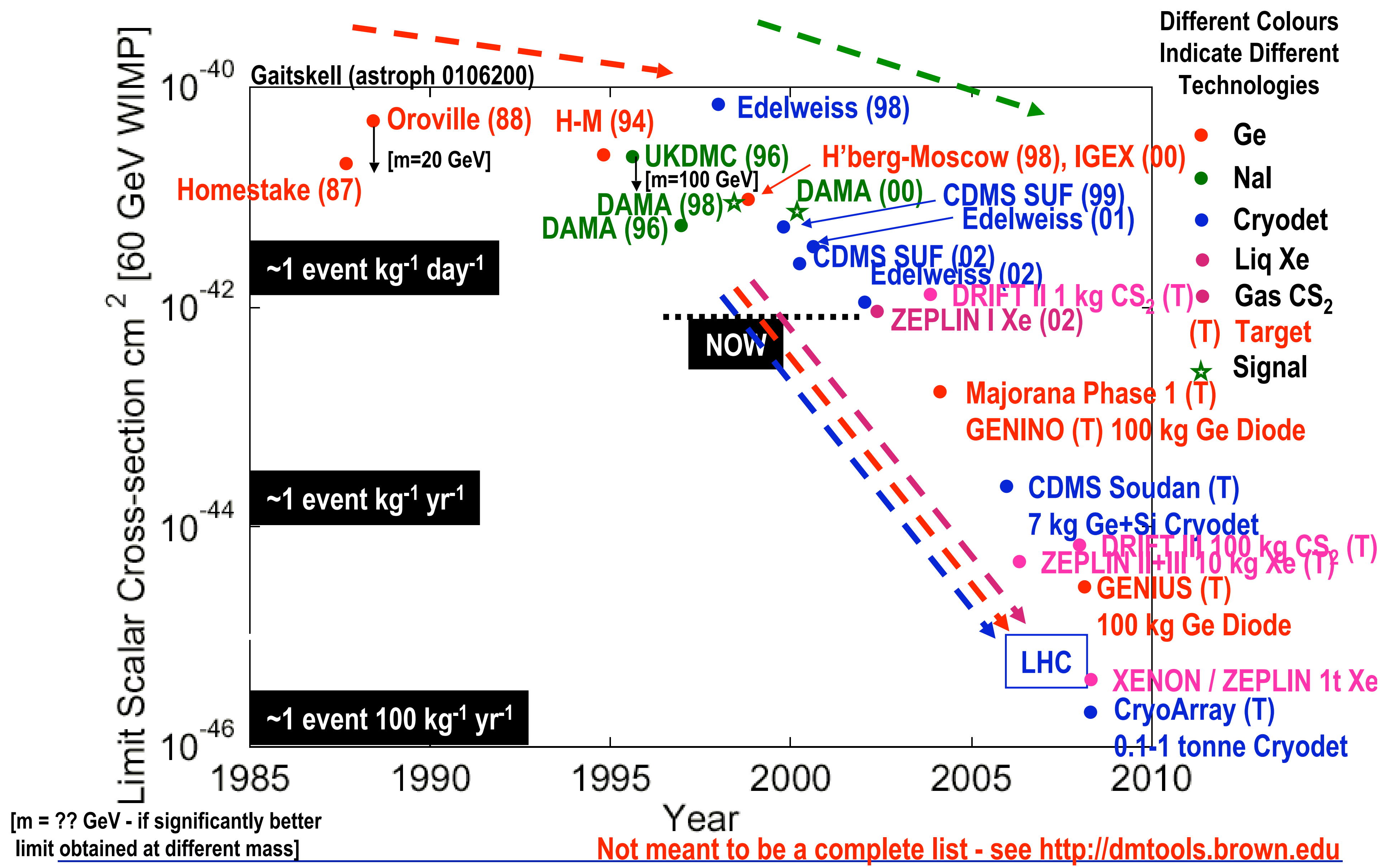


Direct Detection: History & Future

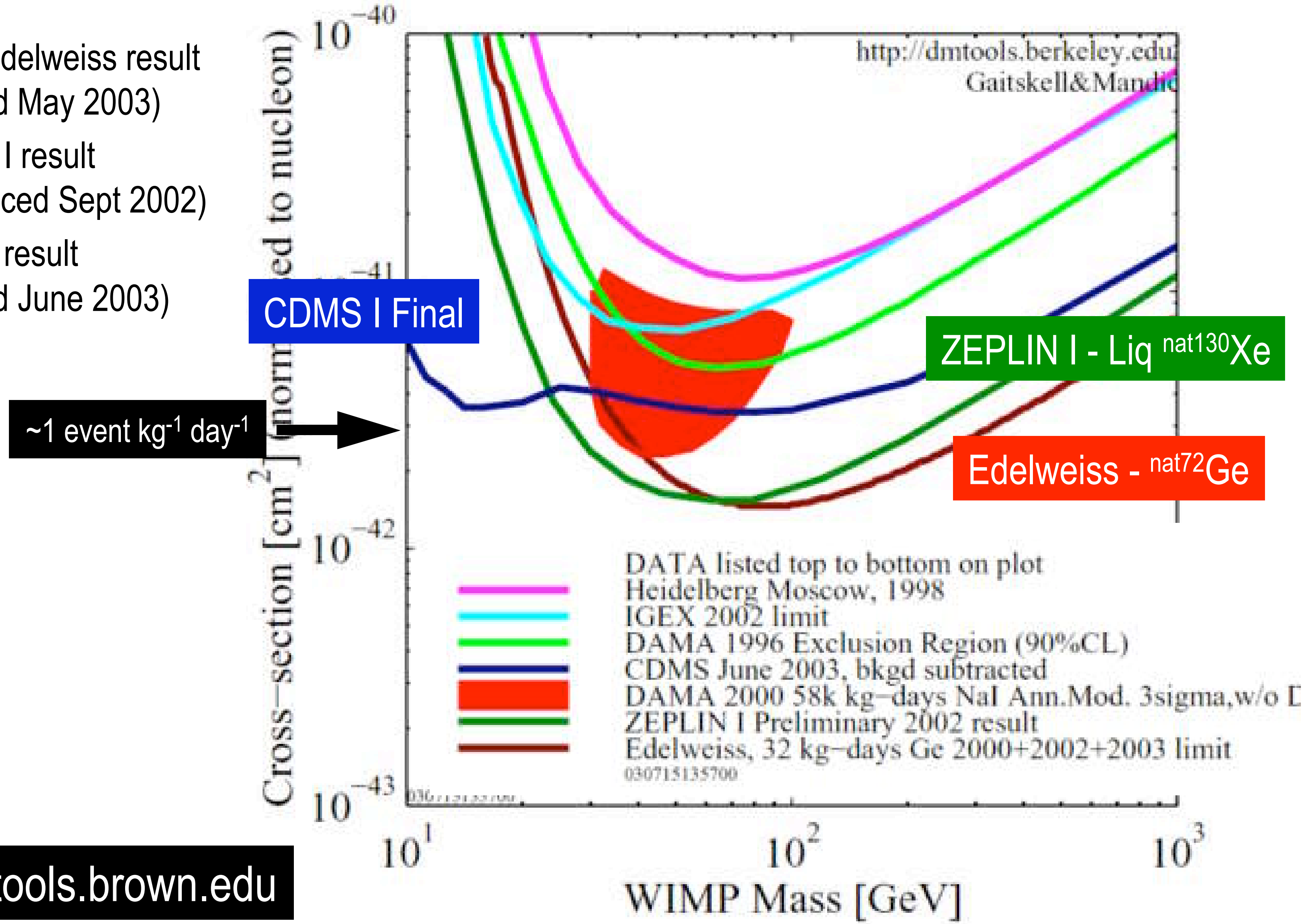
90% CL Limit on Cross section for 60 GeV WIMP (scalar coupling)



Not meant to be a complete list - see http://dmtools.brown.edu

Latest & Greatest Limits on Scalar C-S for WIMPs

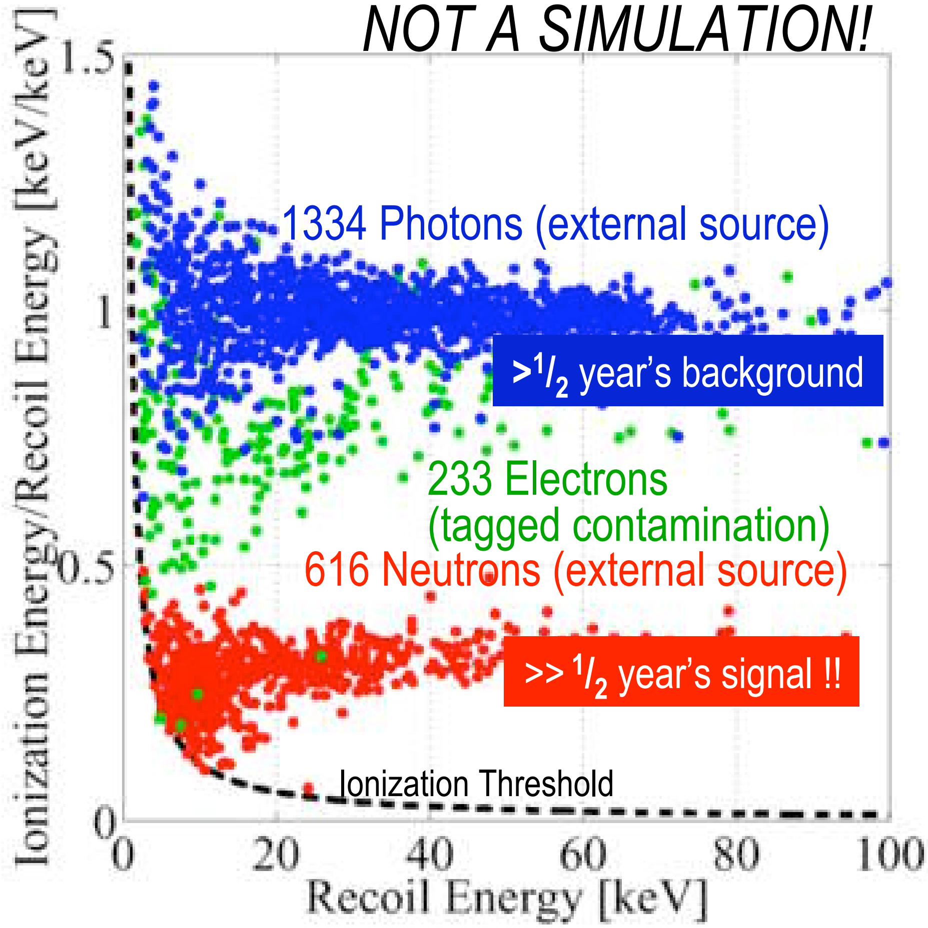
- Latest Edelweiss result (updated May 2003)
- ZEPLIN I result (announced Sept 2002)
- CDMS I result (updated June 2003)



http://dmtools.brown.edu

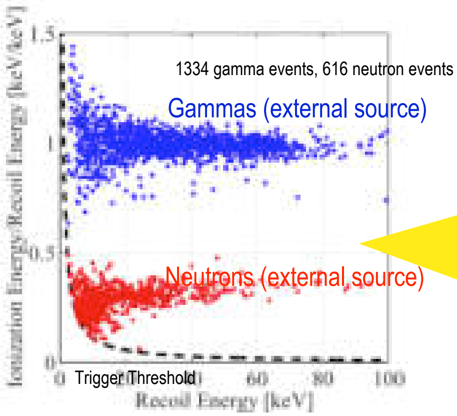
CDMS Background Discrimination
Explanation of basics (…On-going improvements in rejection)

- Ionization Yield (ionization energy per unit recoil energy) depends strongly on type of recoil
- Most background sources (photons, electrons, alphas) produce electron recoils
- Particles (electrons) that interact in surface "dead layer" of detector result in reduced ionization yield
- WIMPs (and neutrons) produce nuclear recoils

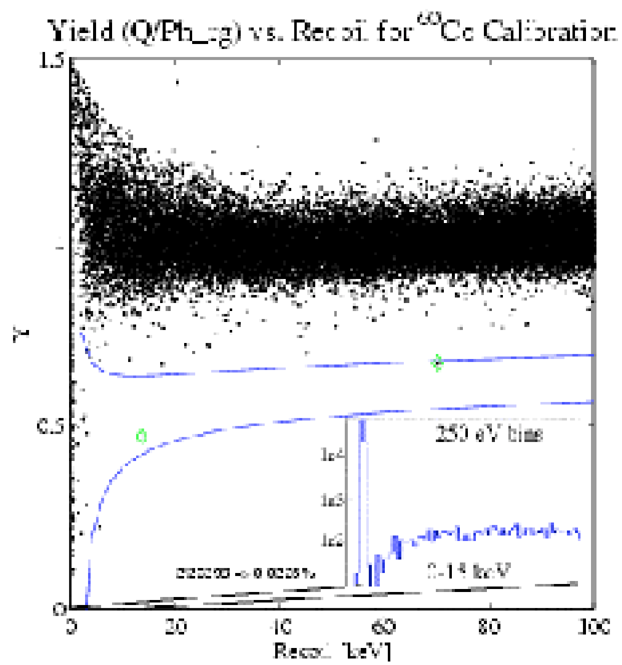


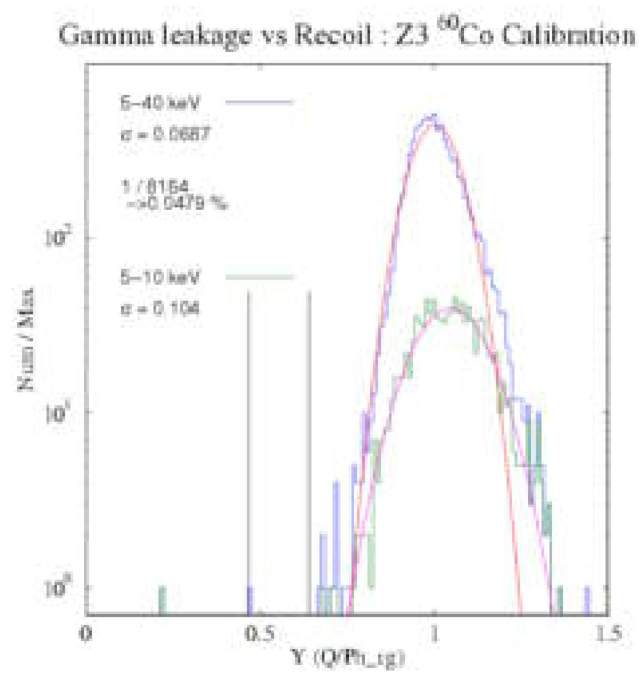
- Detectors provide near-perfect event-by-event discrimination against otherwise dominant bulk electron-recoil backgrounds , very good (> >98% against surface electron-recoil backgrounds

CDMS II - Calibrations at Stanford



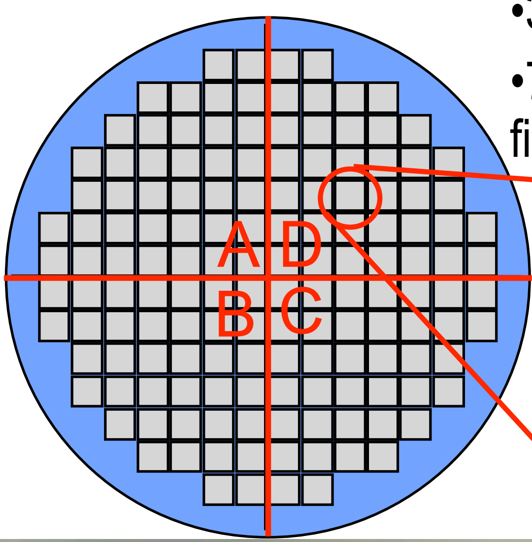
- ZIP Detector (250g Ge , or 100 g Si)
  - 20,400 gamma events (5-100 keV) ~ 1 week continuous calibration with ^{60}Co source
  - = ~one count in 12 years of gamma background (assuming project background level of 0.25 counts/keV/kg/day at CDMSII Soudan. Calibration still Poisson stats/neutron background limited)
  - Sensitivity better than 1 WIMP per year per detector

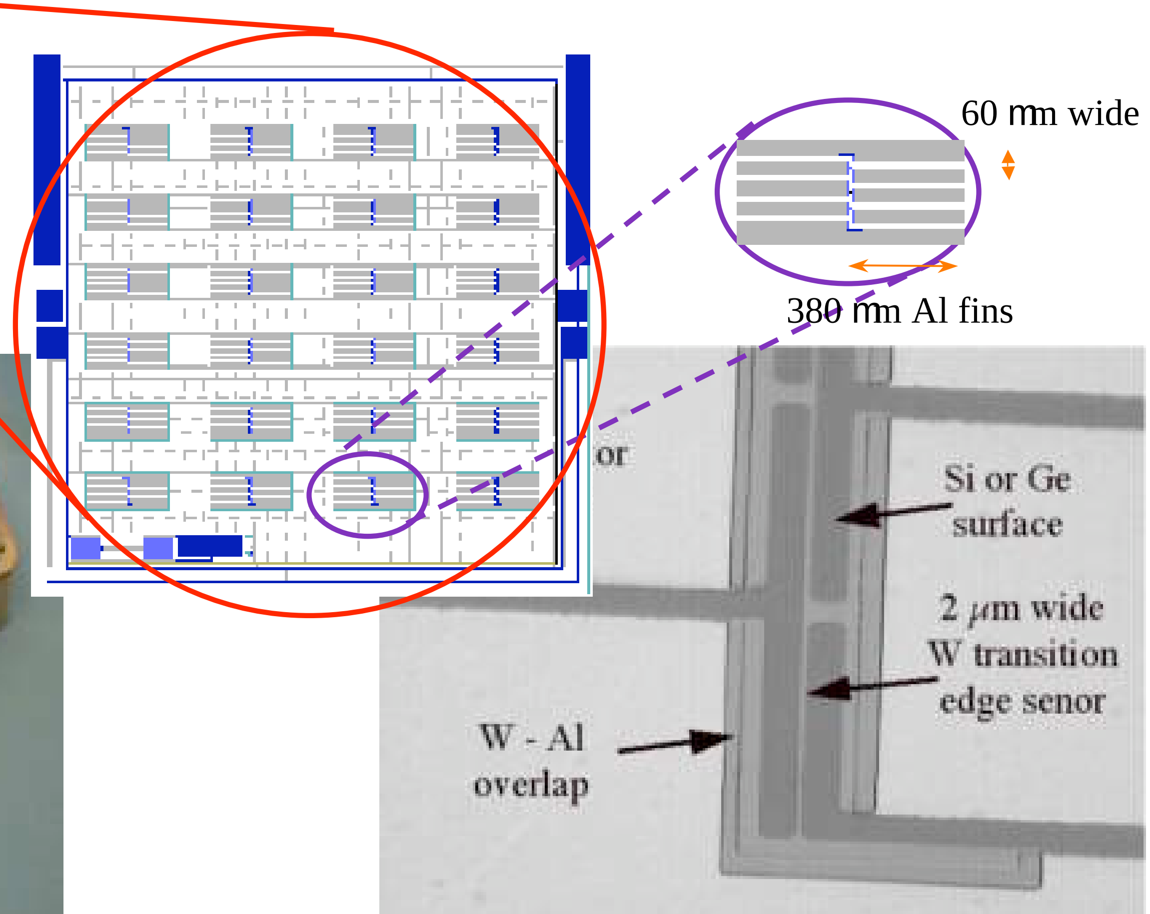




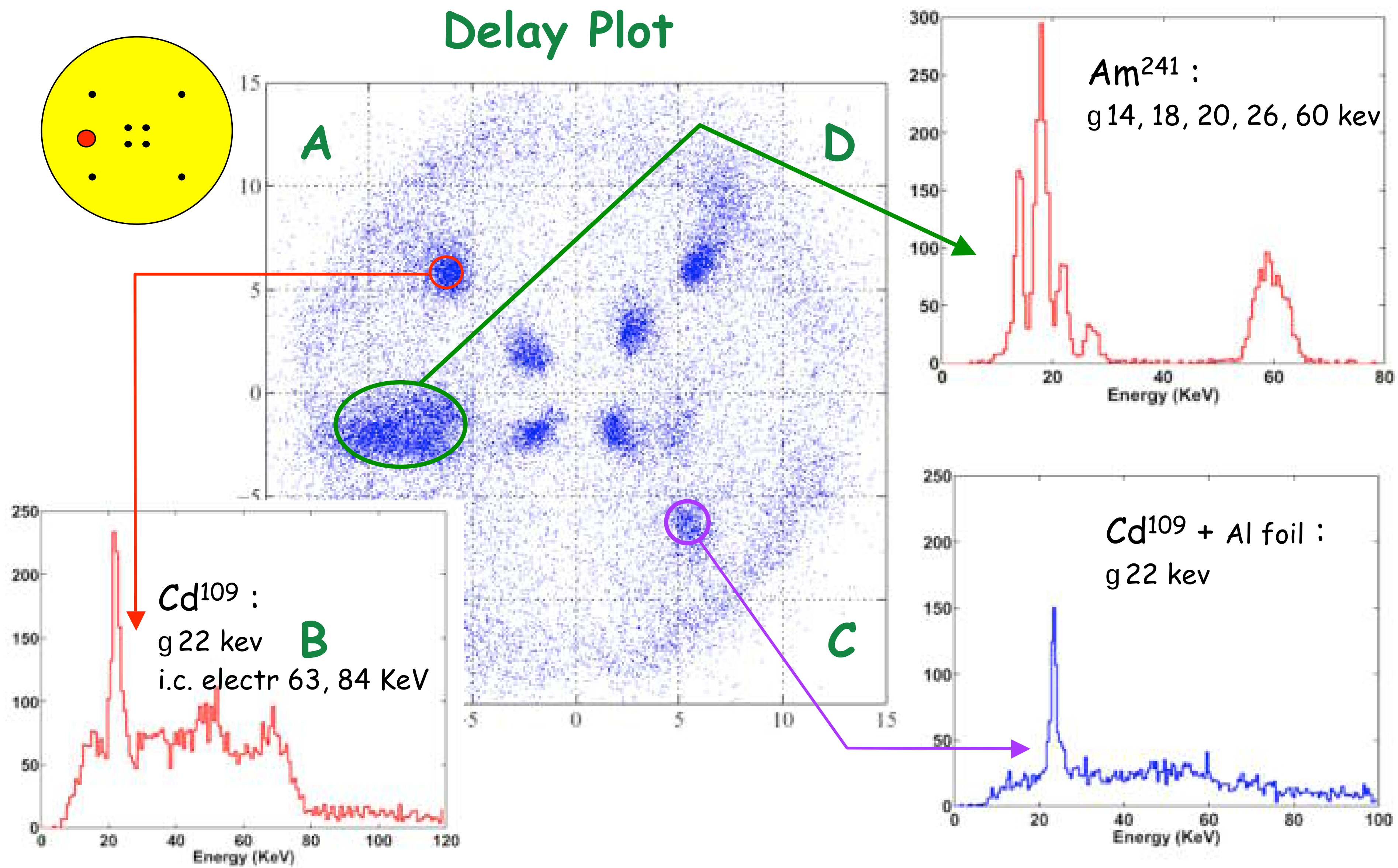
ZIP Detector Phonon Sensor Close-up

- Photolithographic patterning like CMOS but 1 big chip
- 37 cells per quadrant
- 7x4 array of W transition-edge sensors per cell, with Al “collector” fins covering only fraction of surface





Demonstration of xyZIP Position Sensitivity



Working at Soudan

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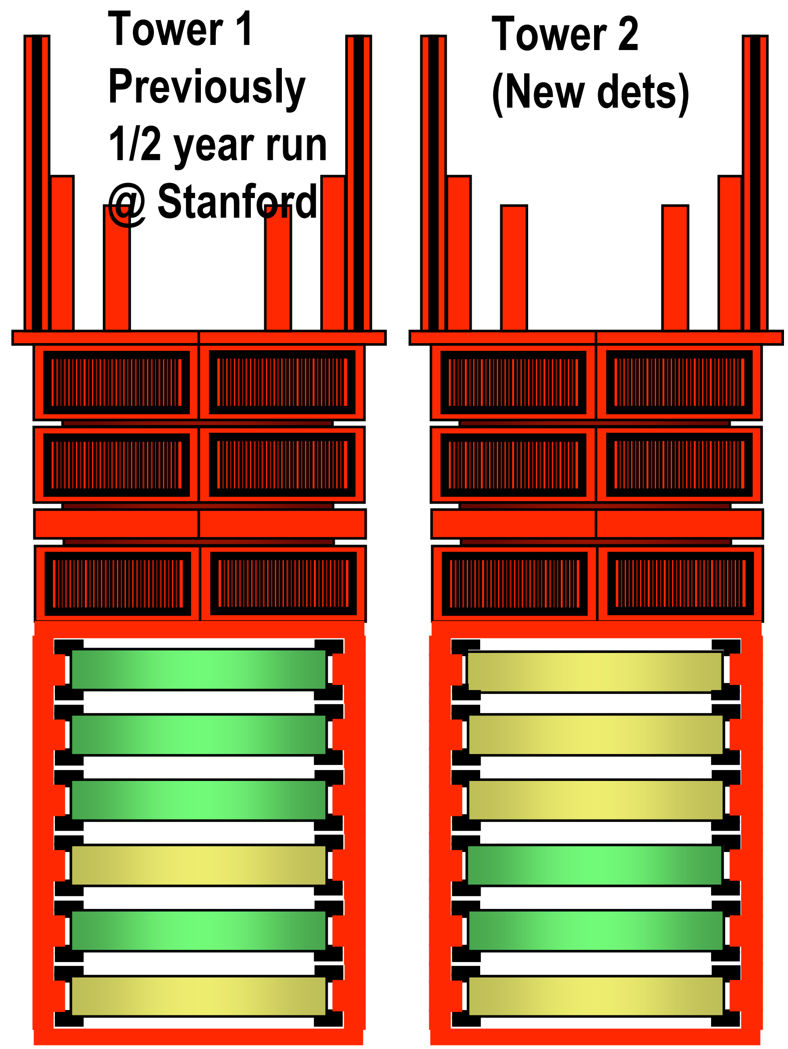

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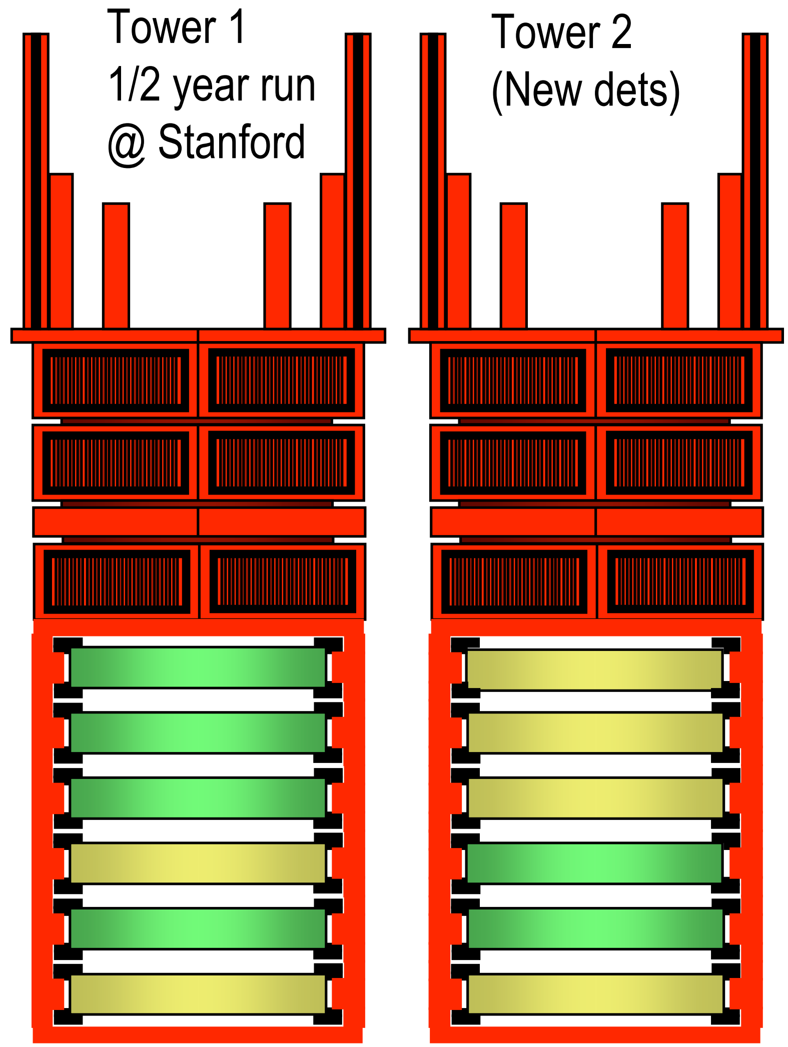
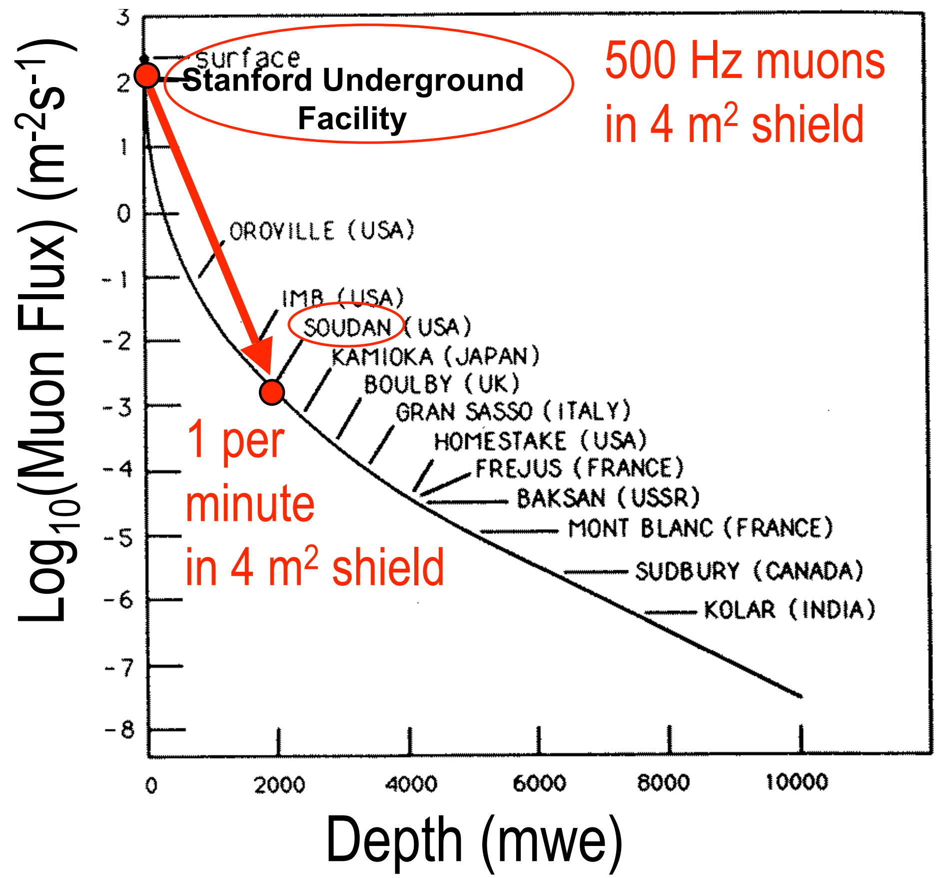


Expected Backgrounds for CDMS II at Soudan

On track for 0.0003 events/kg/keV/day at 15 keV?

- Depth of 2000 mwe reduces neutron background from ~1 / kg / day to ~1 / kg / year ☺
  - Also better neutron shielding



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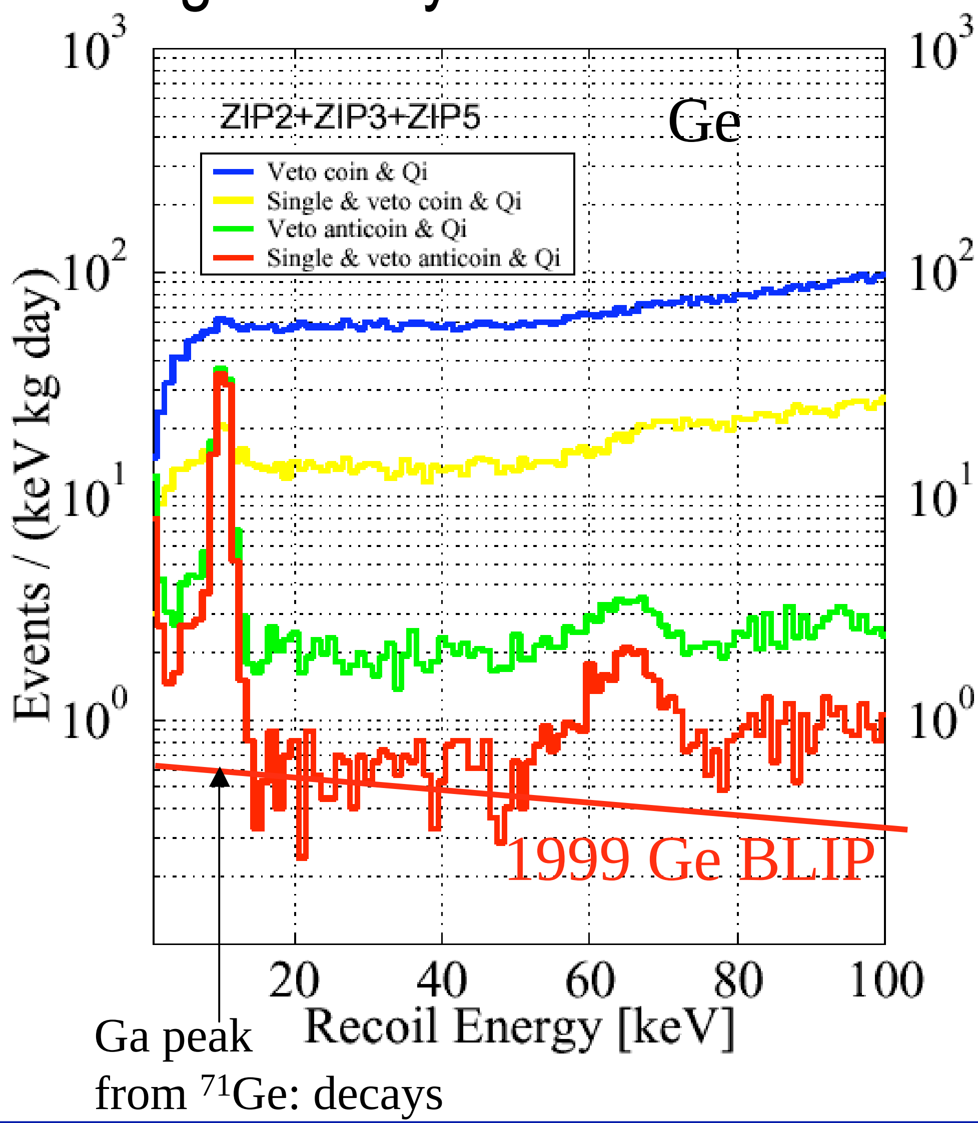
- Photon background is already 0.7 events /(kg keV day) x 10^{-3} expected leakage, despite the shallow site (good enough with background subtraction) ☺



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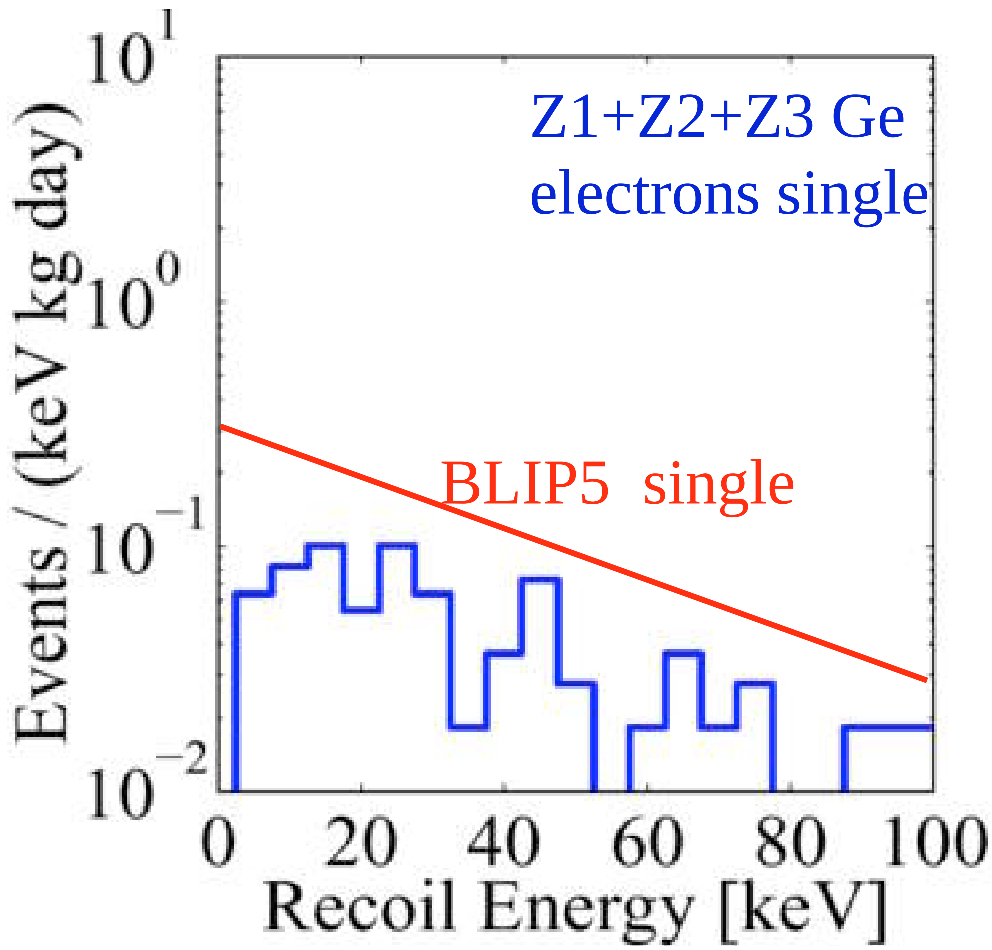
- Depth of 2000 mwe reduces neutron background from ~1 / kg / day to ~1 / kg / year ☺
  - Also better neutron shielding
- Photon background is already 0.7 events /(kg keV day) x $<10^{-3}$ expected leakage, despite the shallow test site ☺

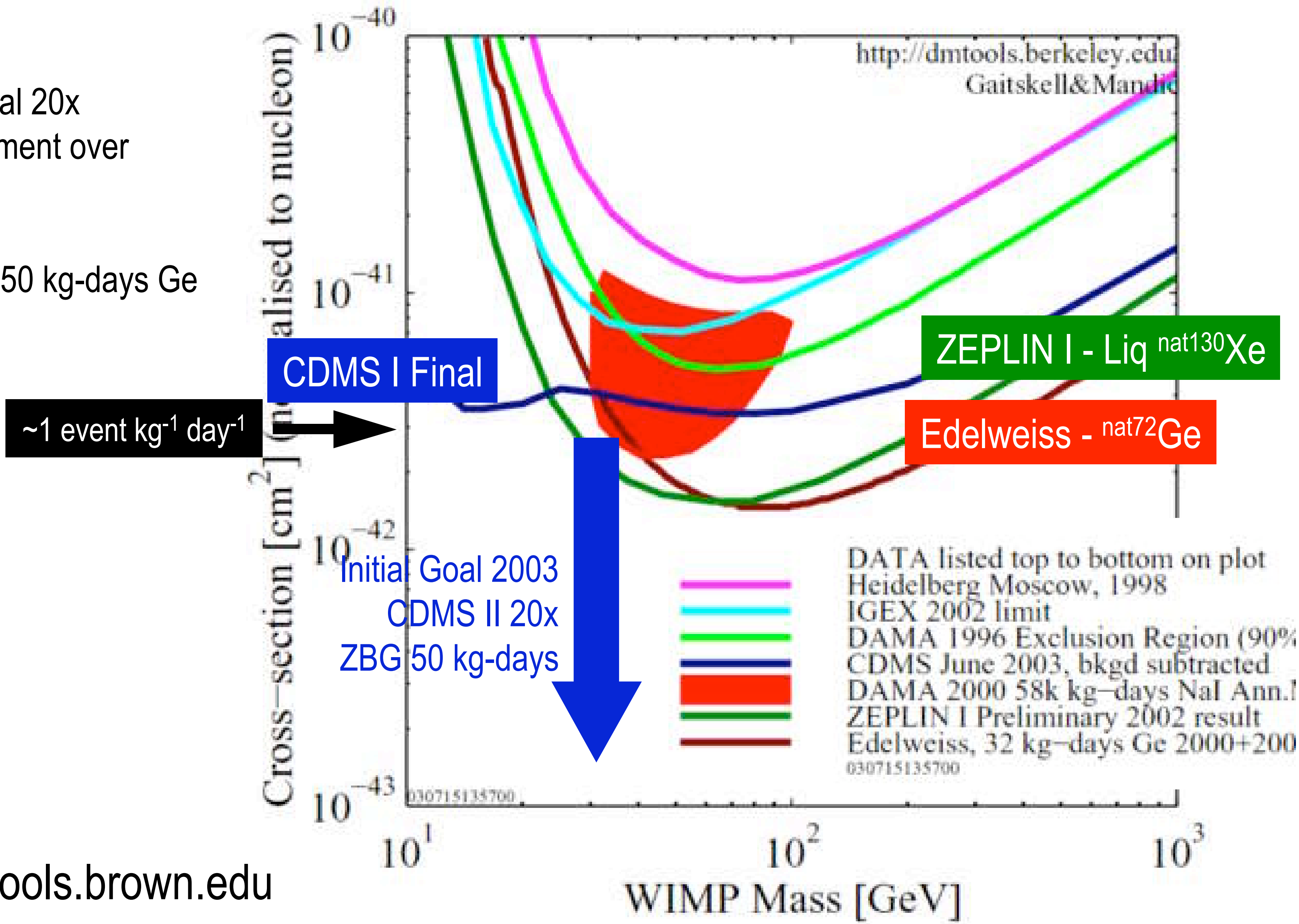


- Electron background is 0.1 events /(kg keV day) x ~0.04 expected leakage, despite the shallow site (need ~2x ☺☹ improvement from depth, or better surface screening/cleaning)

Latest & Greatest Limits on Scalar C-S for WIMPs

- CDMS II
  Initial goal 20x improvement over CDMS I

  ZeroBG 50 kg-days Ge



http://dmtools.brown.edu

CDMS Conclusions

R. Abusaidi *et al*., Phys. Rev. Lett. 84, 5699 (2000).
D.Abrams *et al*., Phys. Rev. D astro-ph/0203500 v3
D.Akerib et al. Phys. Rev Lett. hep-ex/03060001 - Final Stanford Analysis

- **CDMS I (1995-2001)**
  - SI upper limits now eclipsed by EDELWEISS, Zeplin I except at low WIMP mass.
  - CDMS data are incompatible with DAMA signal for standard WIMPs & halo.
  - Sensitivity limited by neutrons from muons interacting in surrounding rock.
- **CDMS II (2000-2005)**
  - 12 detectors (1.5 kg Ge, 0.6 kg Si) cold @ Soudan
    - Stanford discrimination tests of 6 dets exceeded performance expectations.
    - Stanford b/g testing showed expected reduction of neutron background by factor of ~2.3 due to installation of internal moderator (agreement with MC predictions.)
  - "First Dark" achieved Apr 2003.
    - Initial Goal ~50 kg-days Ge (similar to previous run @ Stanford, but no neutrons!)
- **CryoArray (2006 - 2017 or so…)**
  - Sensitivity to study WIMP physics down to s~10^{-46} cm^2 (many events if higher s).
  - Modest improvements over current results (shared):
    - Discrimination: g already good enough, b within factor few.
    - Backgrounds: x20 reductions vs CDMS II, 2-3x vs best current IGEX, H-M

Backup Slides Q&A
(Not Used in Talk)

CryoArray: A 3rd Generation Experiment

- Based on extrapolation of CDMS technology/strategy
- Basic parameters/goals
  - 1000 kg x 2 (live) years
  - ~100 WIMPs at 10^{-45}cm^2
    - ~10 WIMPs at 10^{-46}cm^2
  - ~10's background events

10^4 – 10^5 increase over present limits

10^2 – 10^3 increase over expts under construction

- Excellent discrimination so need little background reduction
  - Internal (g, b) and external (n)
- Main challenge:
  - Increase mass (~100x) and manufacturability of detectors/cryo package
  - Maintain Performance
- Possible sites
  - Soudan (CDMS II) among shallower sites (n background problematic)
  - National Underground Facility
    - Depth
    - Shared resources (vetos, assembly, materials screening, fabrication???)

Background Projections - CryoArray (1 ton)

Energy Range 15-45 keV

	Site	Depth (mwe)	Event Rate (mdru)	Exposure (1000 kg day)	Raw Events (#)	Rejection Efficiency	After Reject (#)	After Subtraction (#)	After Subtraction (mdru)
Photons									
CDMS I	SUF	16	800	0.016	384	99.96%	0.1	0	0
CDMS II	SUF	16	800	0.04	960	99.97%	0.3	0	0
CDMS II	Soudan	2080	260	2.50	19500	99.97%	6.5	5	0.07
CryoArray			13	500	195000	99.97%	65	15	0.001
Electrons									
CDMS I	SUF	16	300	0.016	145	95.00%	7	7	15
CDMS II	SUF	16	80	0.04	96	95.00%	5	5	4
CDMS II	Soudan	2080	20	2.50	1500	95.00%	75	15	0.2
CryoArray			1	500	15000	99.50%	75	15	0.001

- Photon background is very manageable
  - Current lower limit on discrimination already good enough if raw rate reduced to 13 mdru, ~2-3 times better than best levels reached so far (by IGEX, H-M)
    - achieve via materials selection and simplification of structures (little mounting material)
  - Screening to 10^{-10} g/g can reveal contamination source of such a background
- Electron background more worrisome, but certainly tractable
  - Need to screen & clean surfaces to 2.5 x 10^{-2} counts/ (keV m^2 day), or to 10x better if rejection remains only 95% -- novel but appears to be doable

dru = 1 event keV^{-1} kg^{-1} day^{-1}

see Schnee, Gaitskell & Akerib astro-ph/0208326