Constraints on Low-Mass WIMP Signals from CDMS

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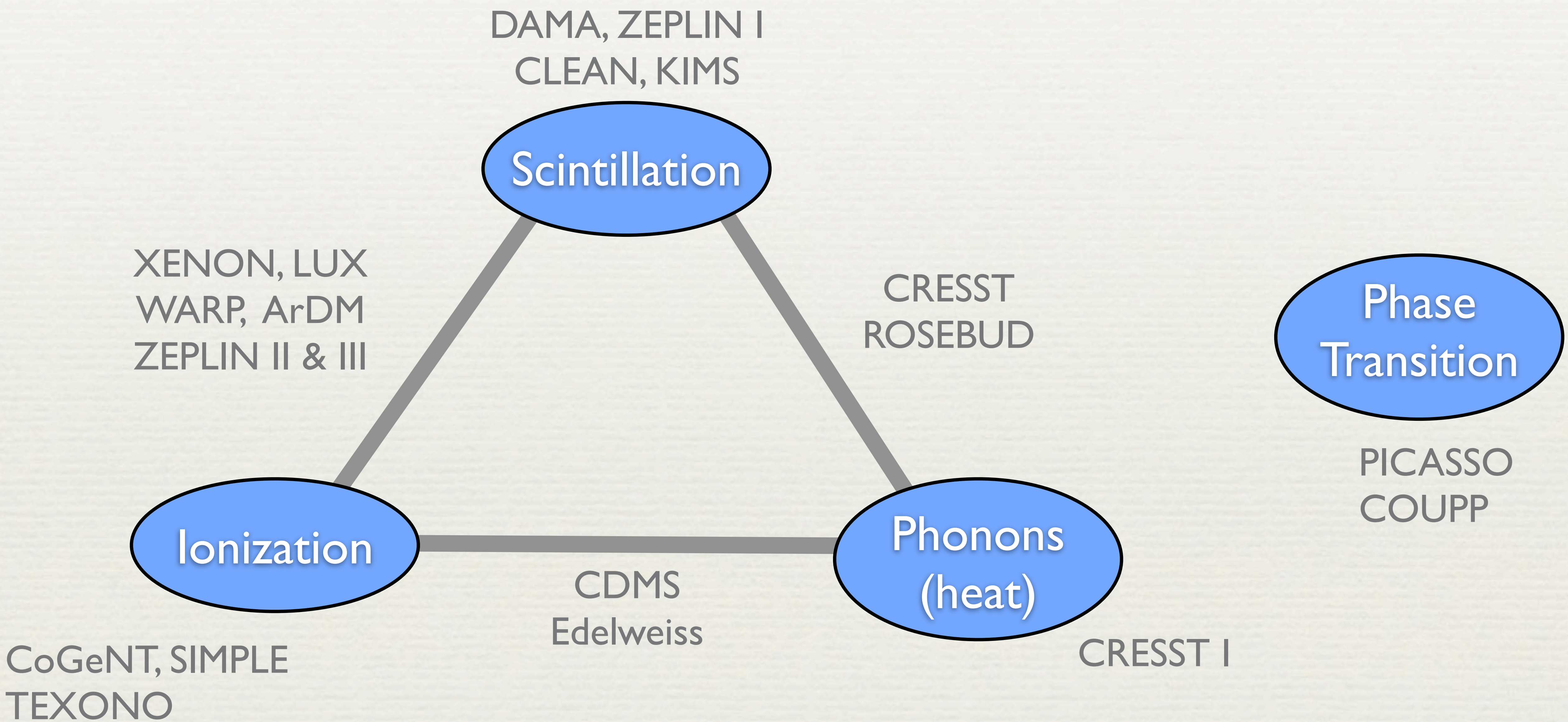
Our best wishes to those affected by the ongoing crisis

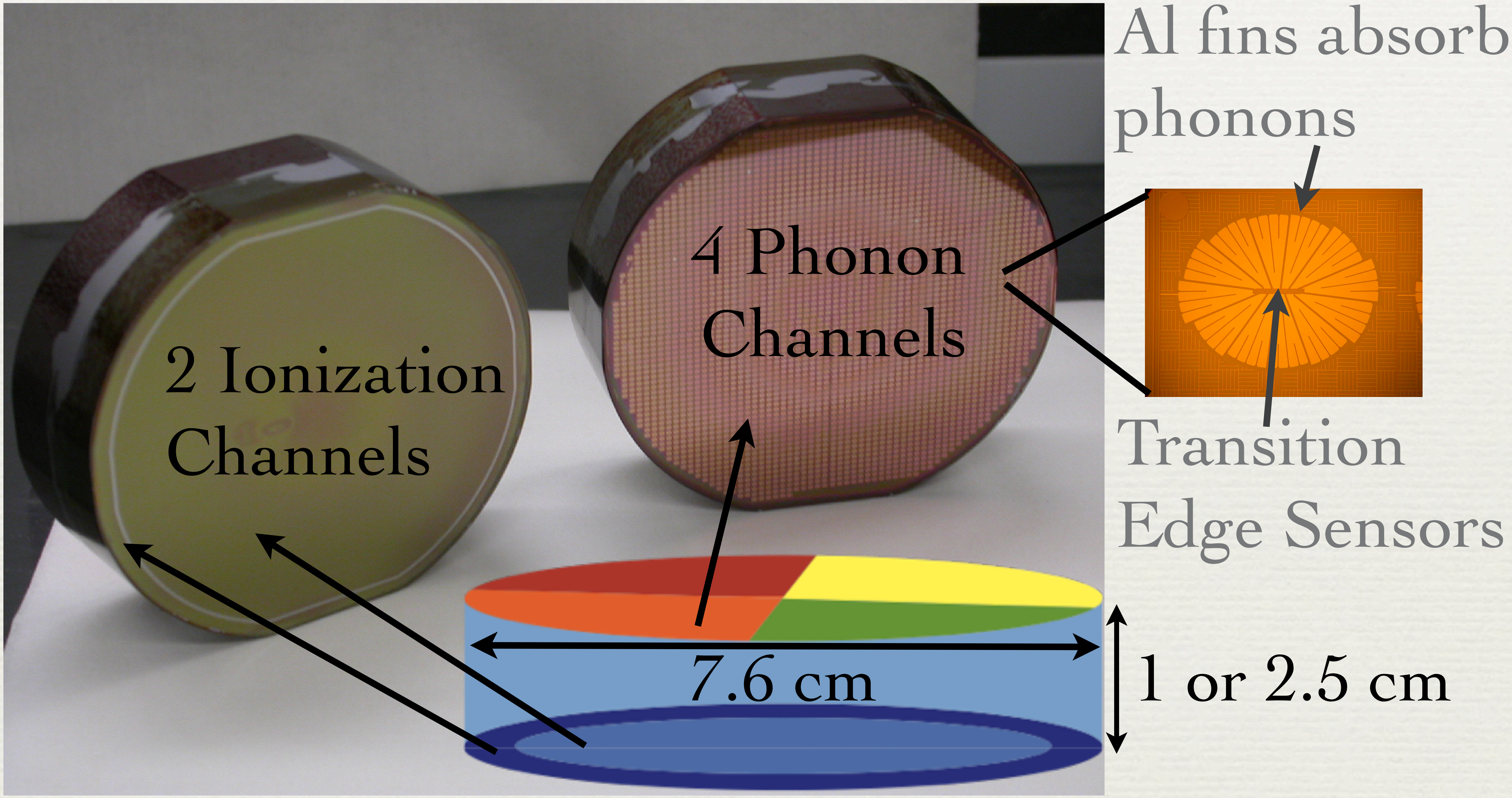
CDMS

The Cryogenic Dark Matter Search

Event Discrimination



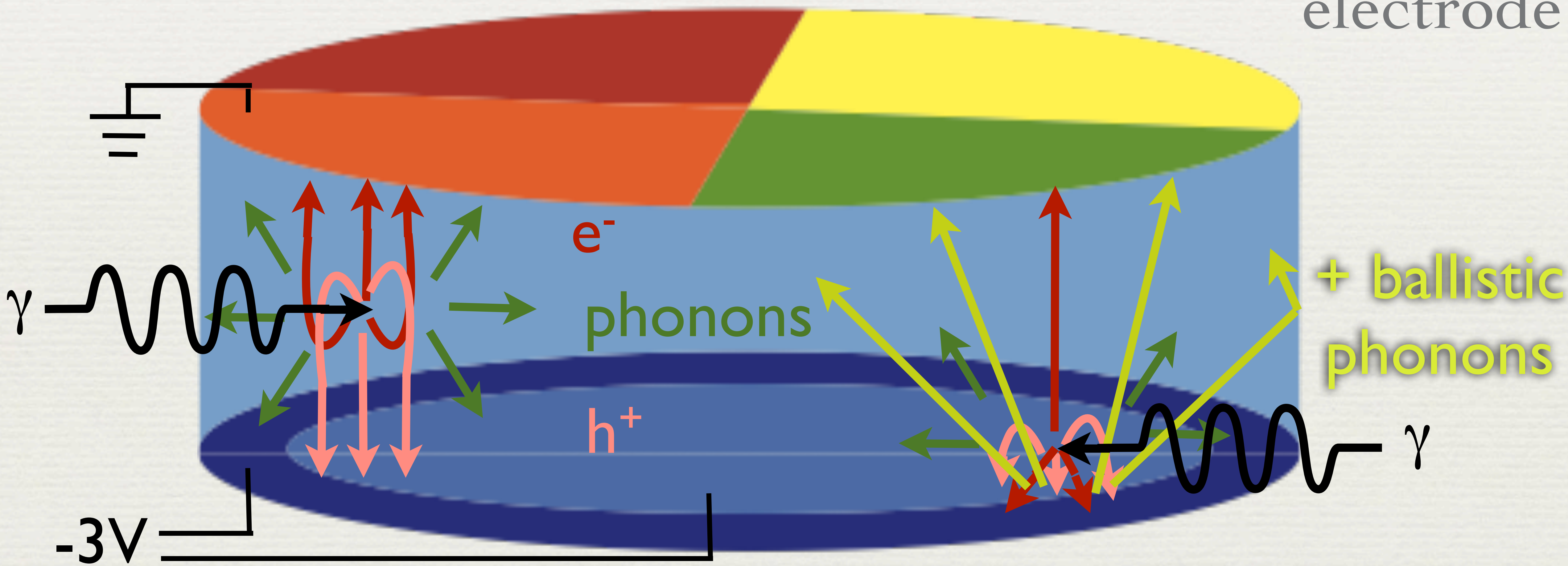
Instrumentation



Carrier Transient

Carriers (bulk events) go the right way

Carriers (surface events) injected into the wrong electrode

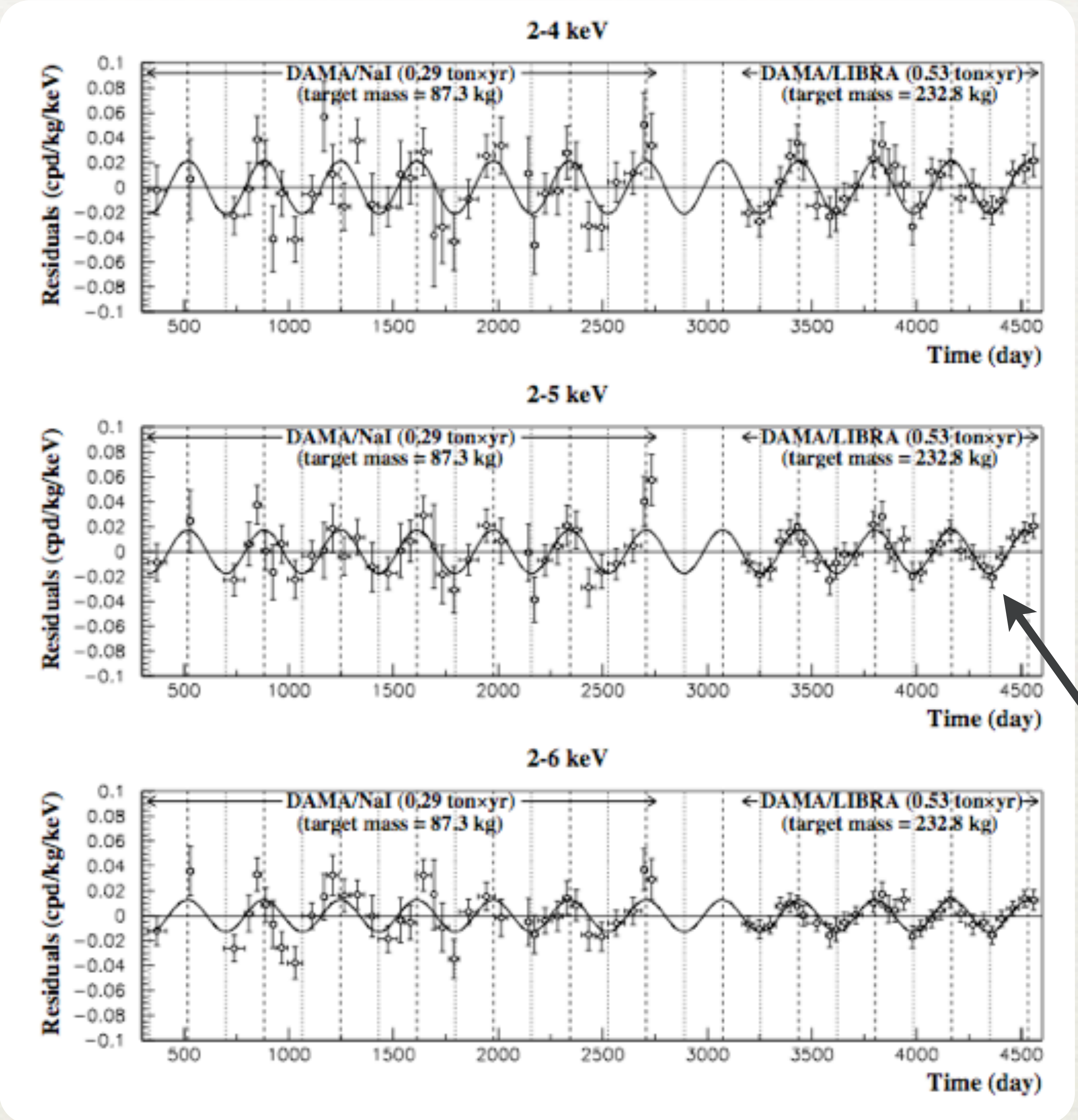


CDMS

Low Energy Analyses

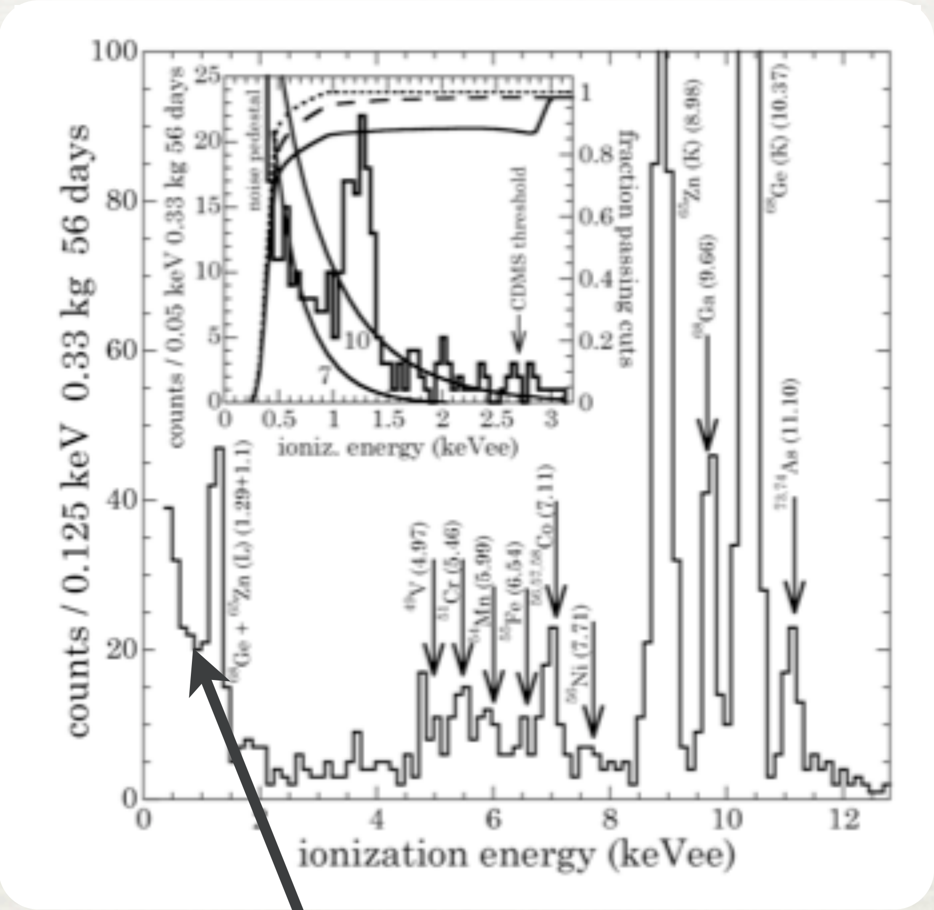
- Stanford Underground Facility
- Soudan

DAMA and CoGeNT



Bernabei et al.,
Eur. Phys. J. C 56 333 (2008), arXiv:0804.2741

annual
modulation

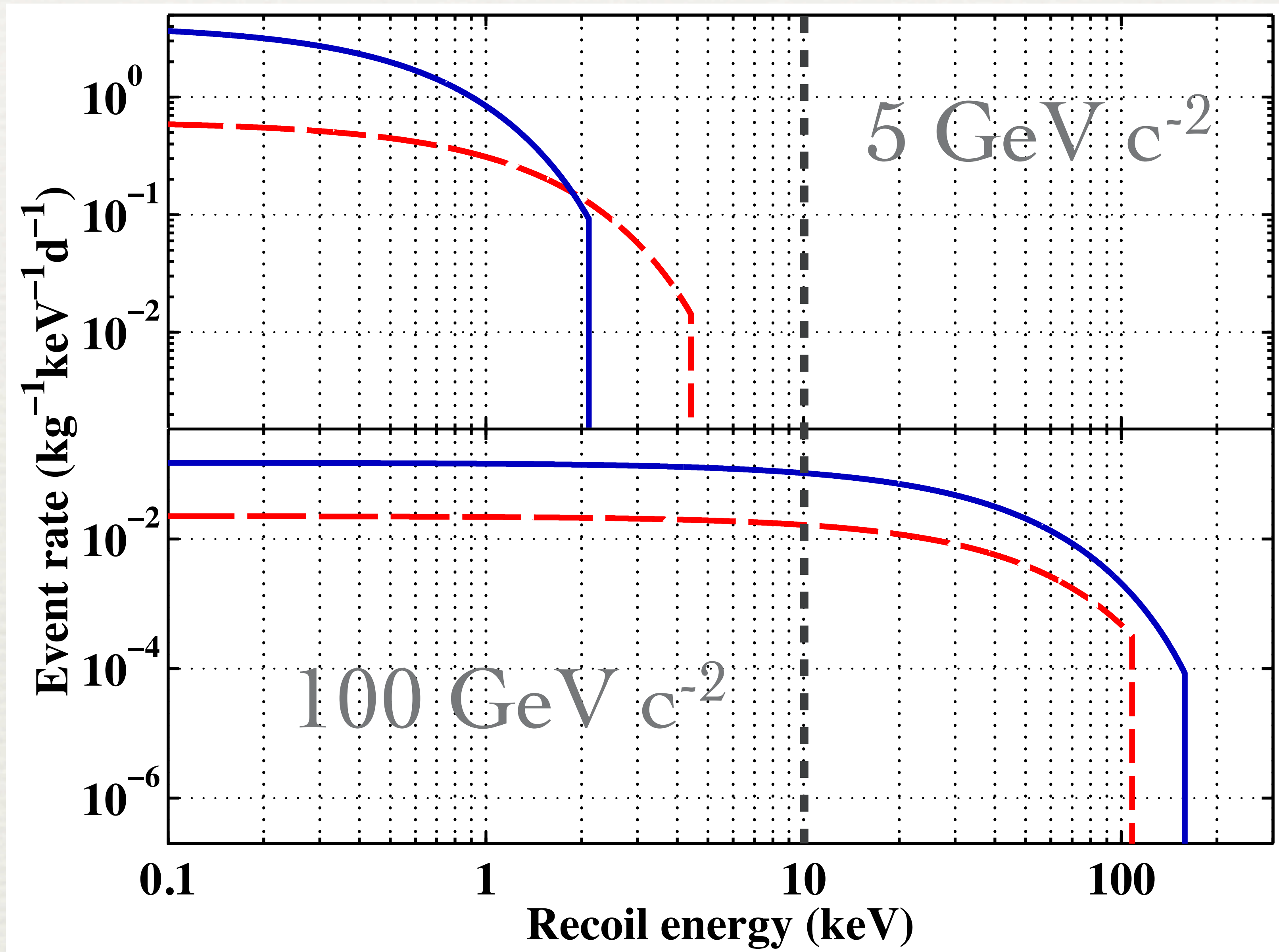


Aalseth et al.,
arXiv:1002.4703

WIMP-like
exponential
spectra

WIMP Event Rates

- 1×10^{-41} cm^2 cross section
- 544 km s^{-1} escape velocity
- 0.3 GeV cm^{-3} density



Ge
Si

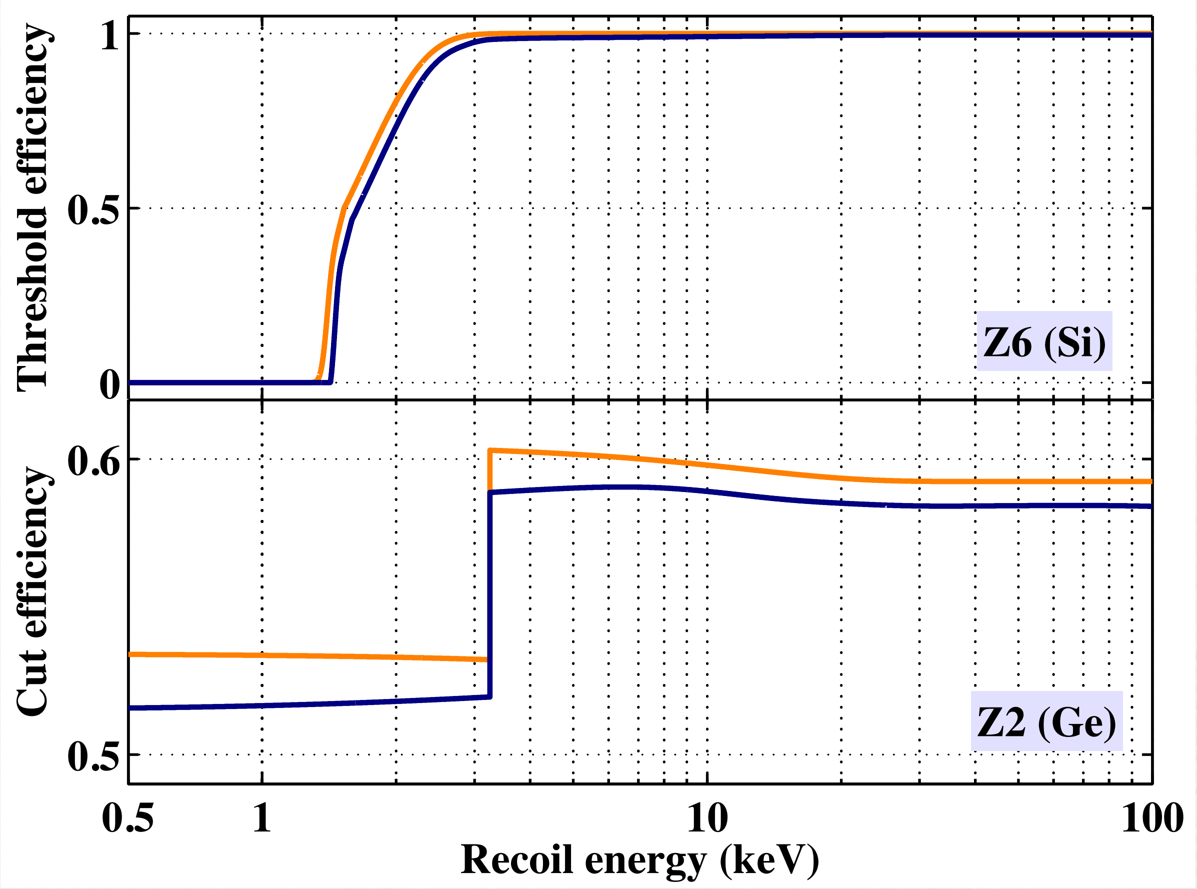
Stanford Result

Akerib et al, PRD **82**, 122004 (2010)

- Shallow site (17 m water equivalent overburden)
- 118 live days from Dec 2001 - June 2002
- 4×224 g Ge
  - $1 \times$ Ge not used due to high analysis threshold
  - $1 \times$ Ge sensitive to cryostat temperature, live time reduced
- 2×105 g Si

Cuts

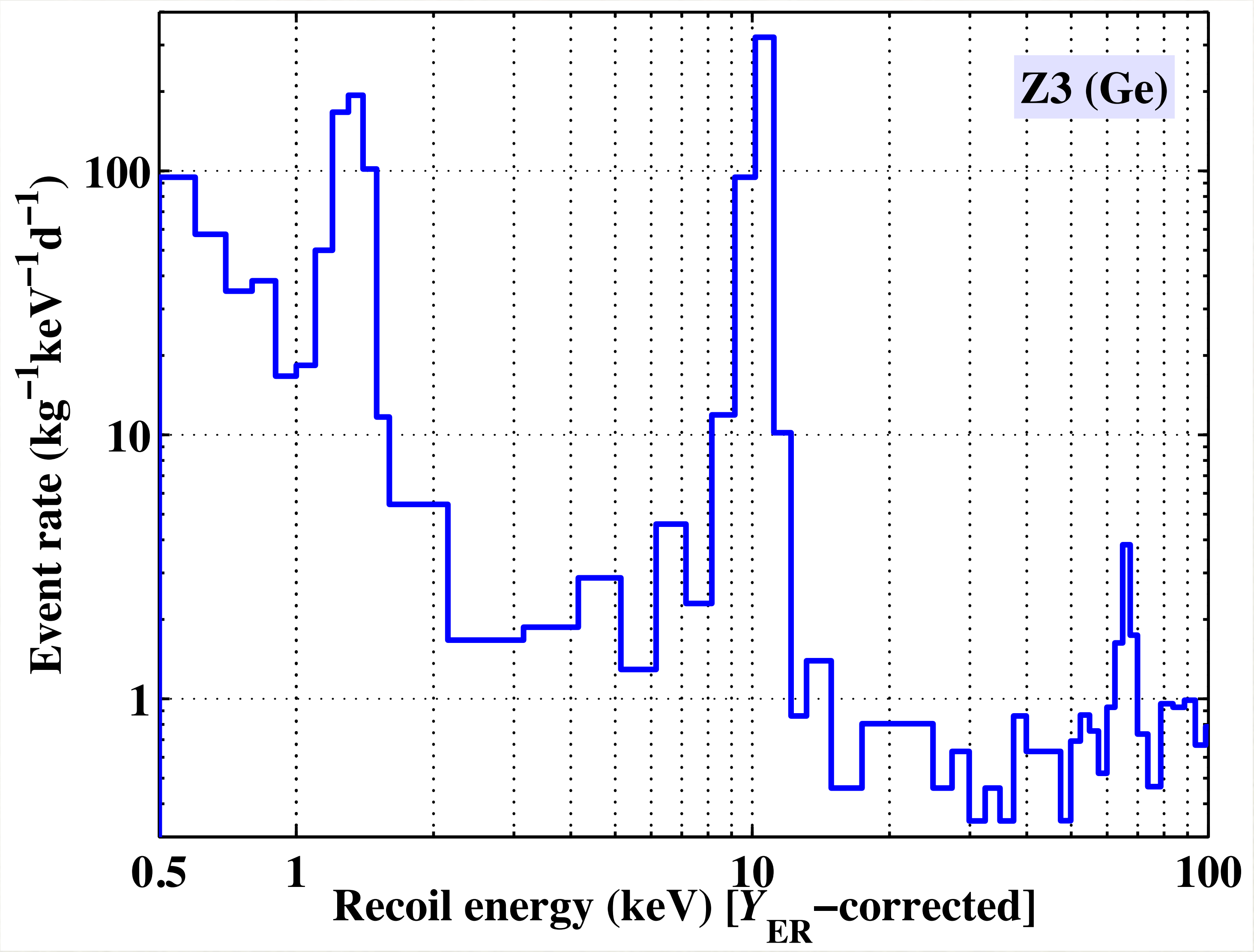
- Data Quality (No energy dependence, 99% efficiency)
  Noise
  Pileup
  Chi2
  Phonon and
    ionization pretrigger
    < 5 σ from mean
- Single scatter
  (100% efficiency)
- *no* Muon veto, 50-80 μs
  (67-78% efficiency)
- Inner electrode (83% eff)
- Nuclear recoil (93-96% eff)



mean
lower
limit

Energy Calibration

- Cosmic ray activated (Ge68) and neutron activated (Ge71) lines at 1.3 and 10.4 keV
- Cosmogenic (Ge73m) at 66.7 keV

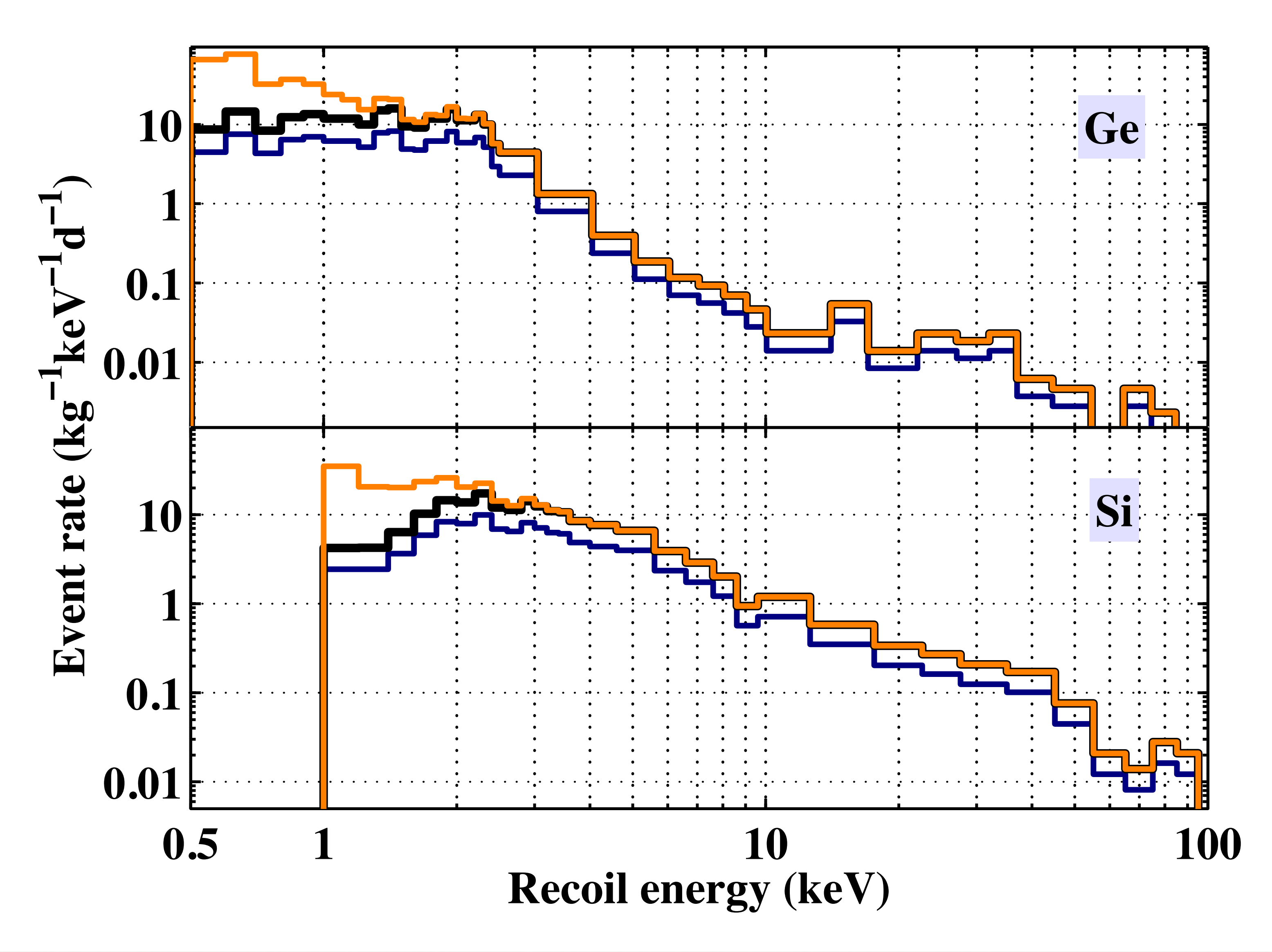


WIMP Candidates

cut and threshold adjusted event rate

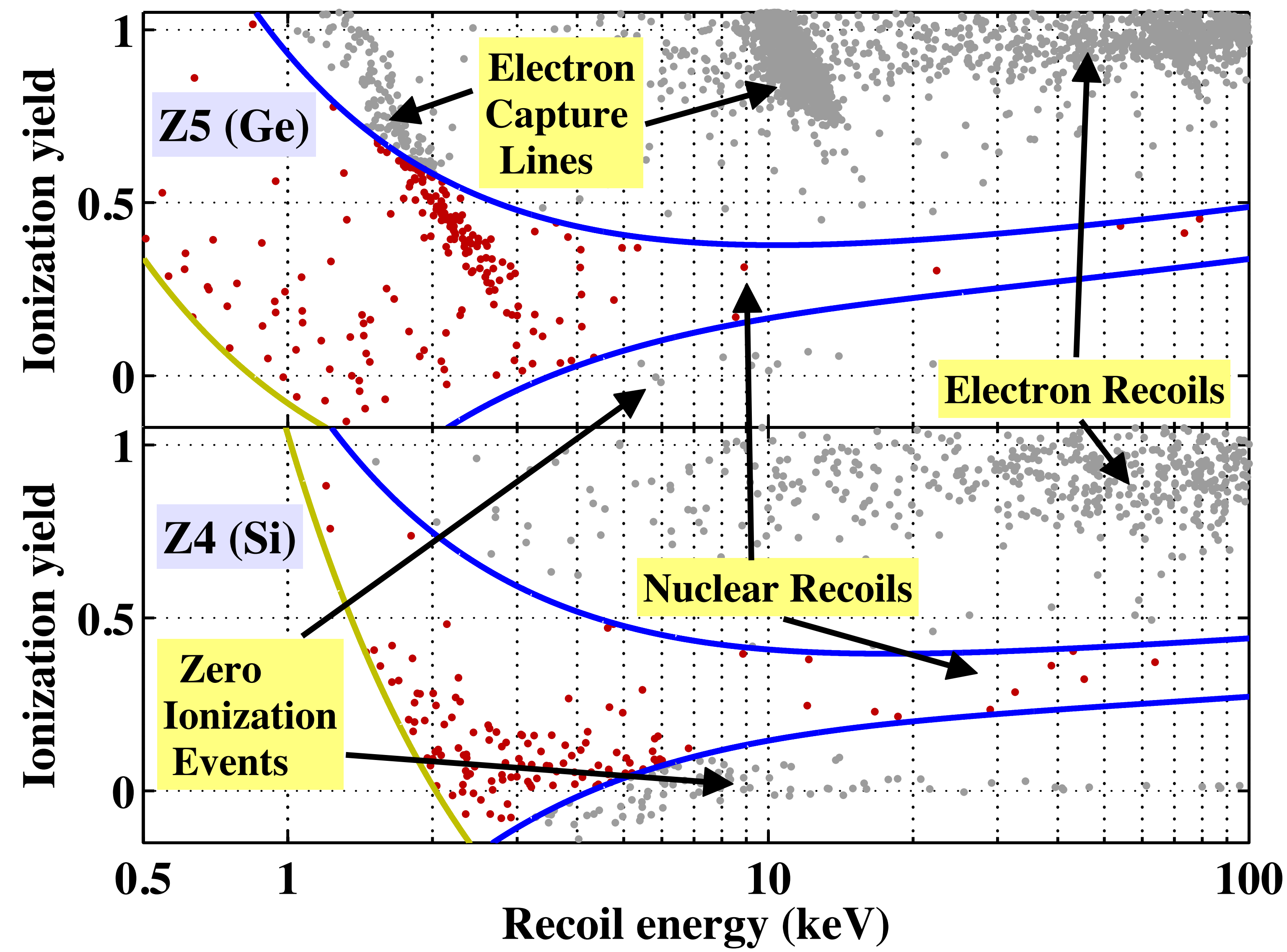
cut adjusted event rate

raw event rate



Ionization vs. Energy

	Ge	Si
Total	1080	970
Event Accounting (%)		
1.3 keV line	32	0
Zero-charge	30-40	30-40
14C betas	0	40
Compton	10-20	10-20
Cosmogenic	6	2
Other	2-22	0-18



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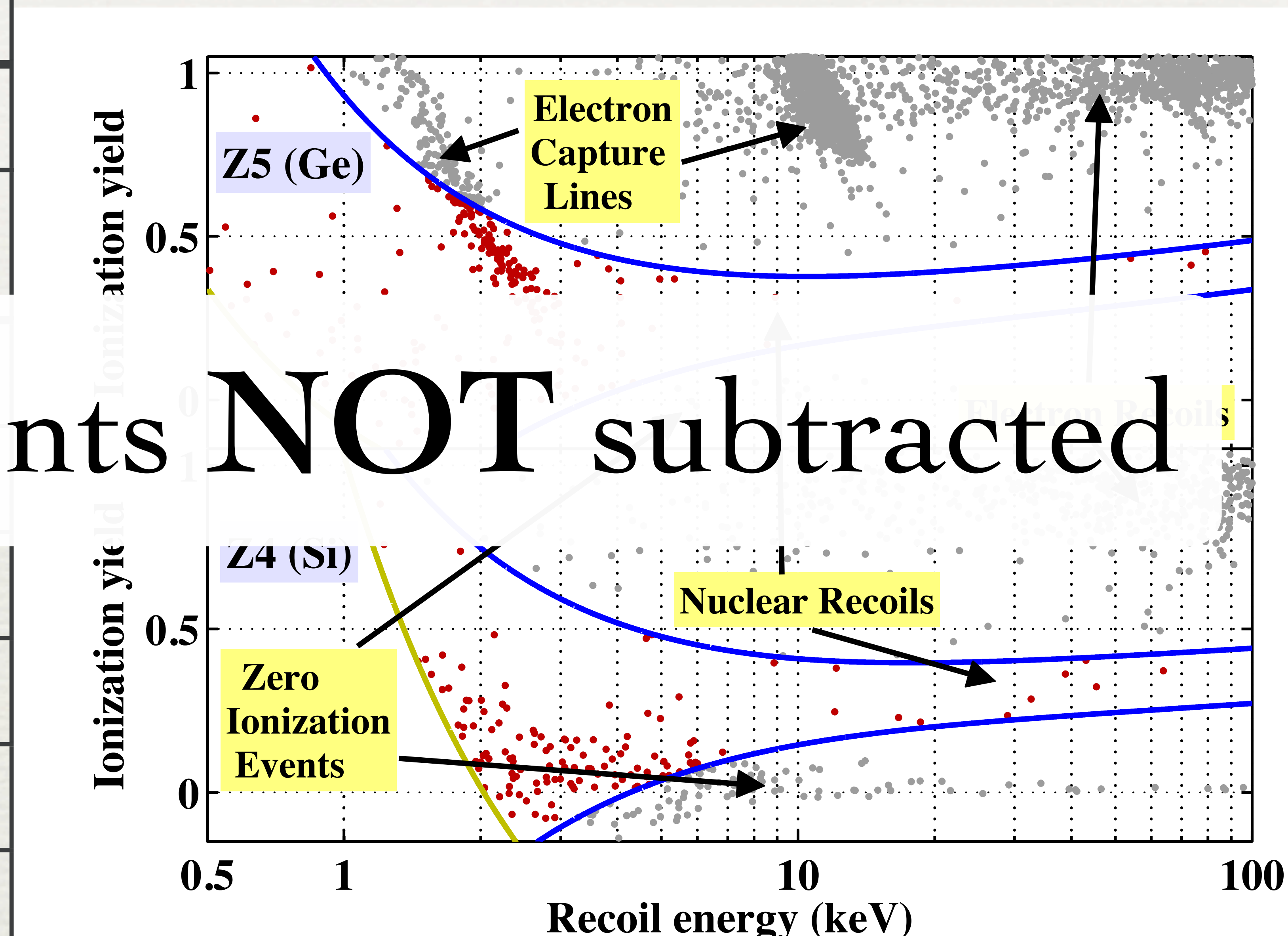
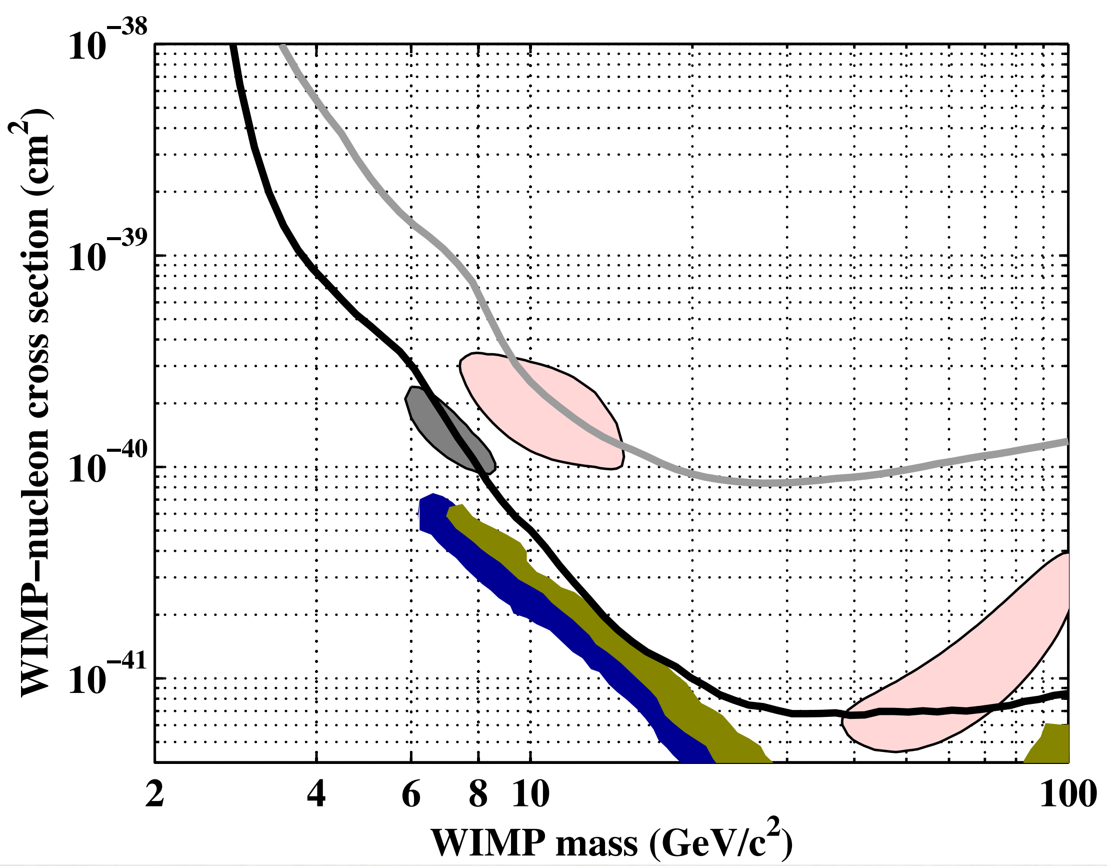


“Known” events NOT subtracted

WIMP-Nucleon 90% Exclusion Limits



XENON100 (scintillation eff.)

constant · decreasing -

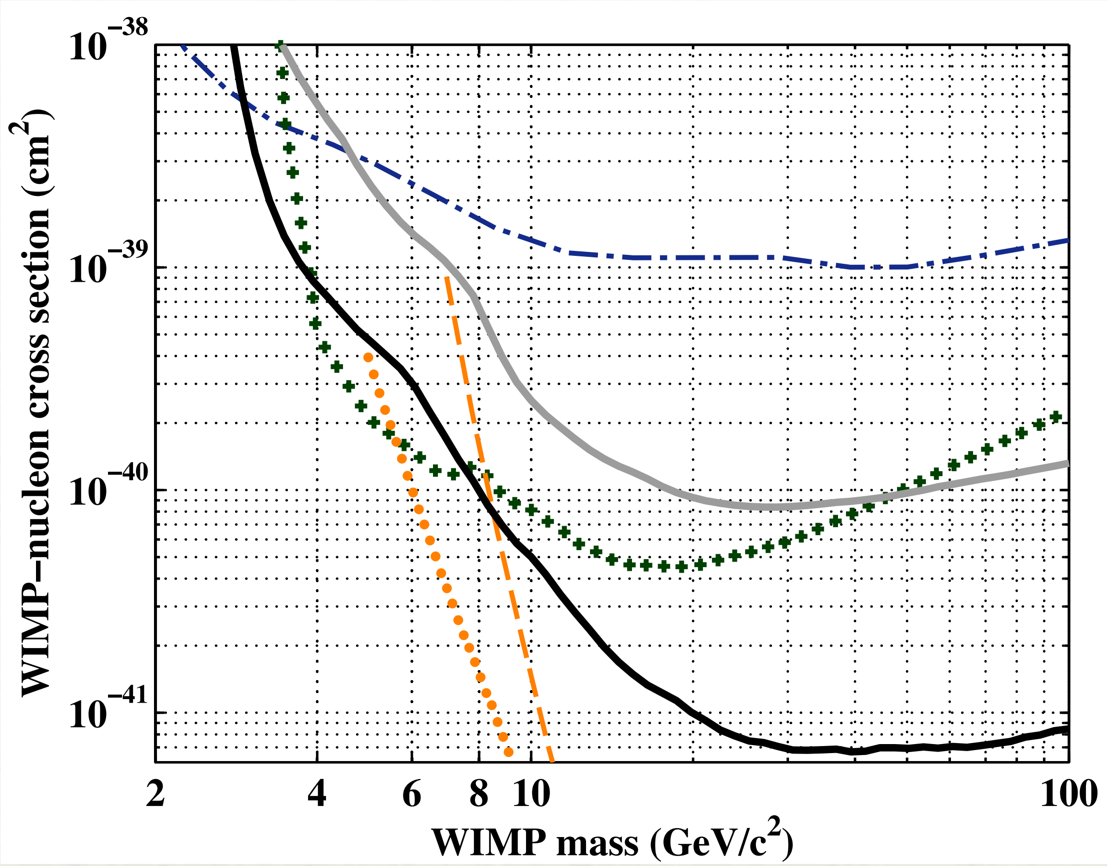
CoGent + CRESST -·

Si only

Ge

Si + Ge

(500 km s^{-1})



DAMA / LIBRA

DAMA / LIBRA + CoGeNT (600 km s^{-1})

C. Savage, et al, J. Cosmol. Astropart. Phys. 04 (2009) 010
C. Savage, et al, J. Cosmol. Astropart. Phys. 09 (2009) 036
C. Savage, et al, arXiv:1006.0972

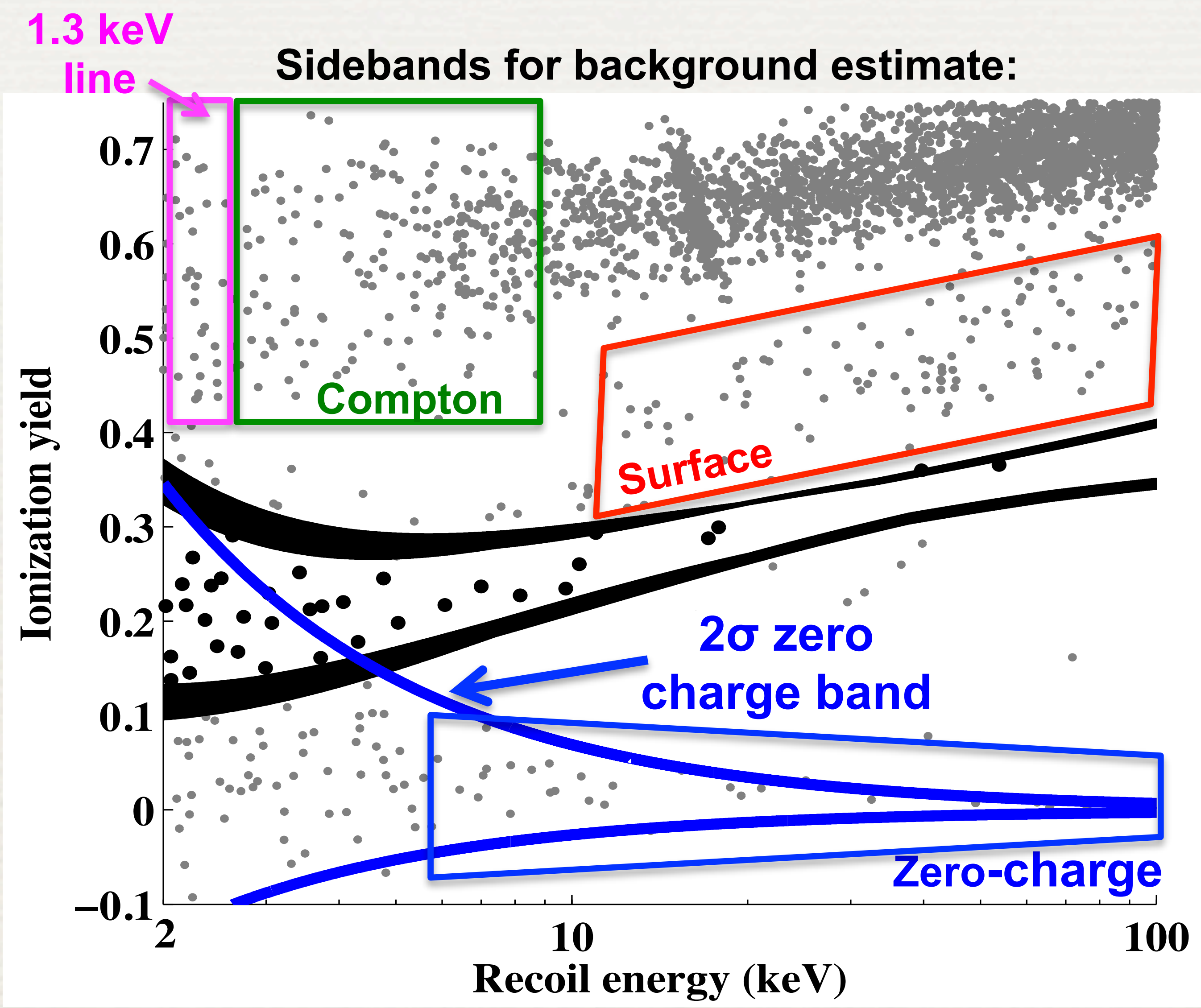
D. Hooper et al., Phys. Rev. D 82, 123509 (2010)
A. Bottino, et al, Phys. Rev. D 67, 063519 (2003)
A. Bottino, et al, ibid.68, 043506 (2003); 69, 037302 (2004)
G. Belanger, et al, J. High Energy Phys. 03 (2004) 012

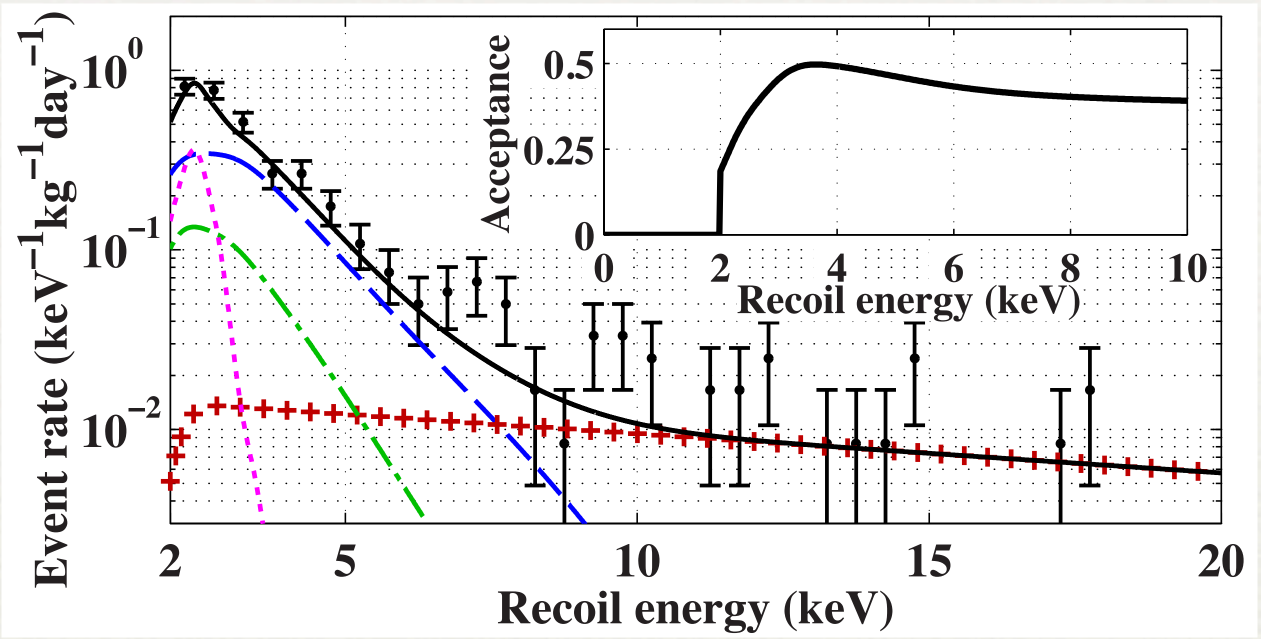
Soudan Result

Ahmed et al, PRL (accepted), arXiv:1011.2482

- Oct 2006 - Sept 2008
- 241 kg days
- 8 × 230 g Ge with lowest-detector thresholds of 2 keV
- NR band $(+1.25,-0.5)\sigma$
    - Maximizes sensitivity to nuclear recoils while minimizing expected backgrounds

Ionization vs. Energy





Total

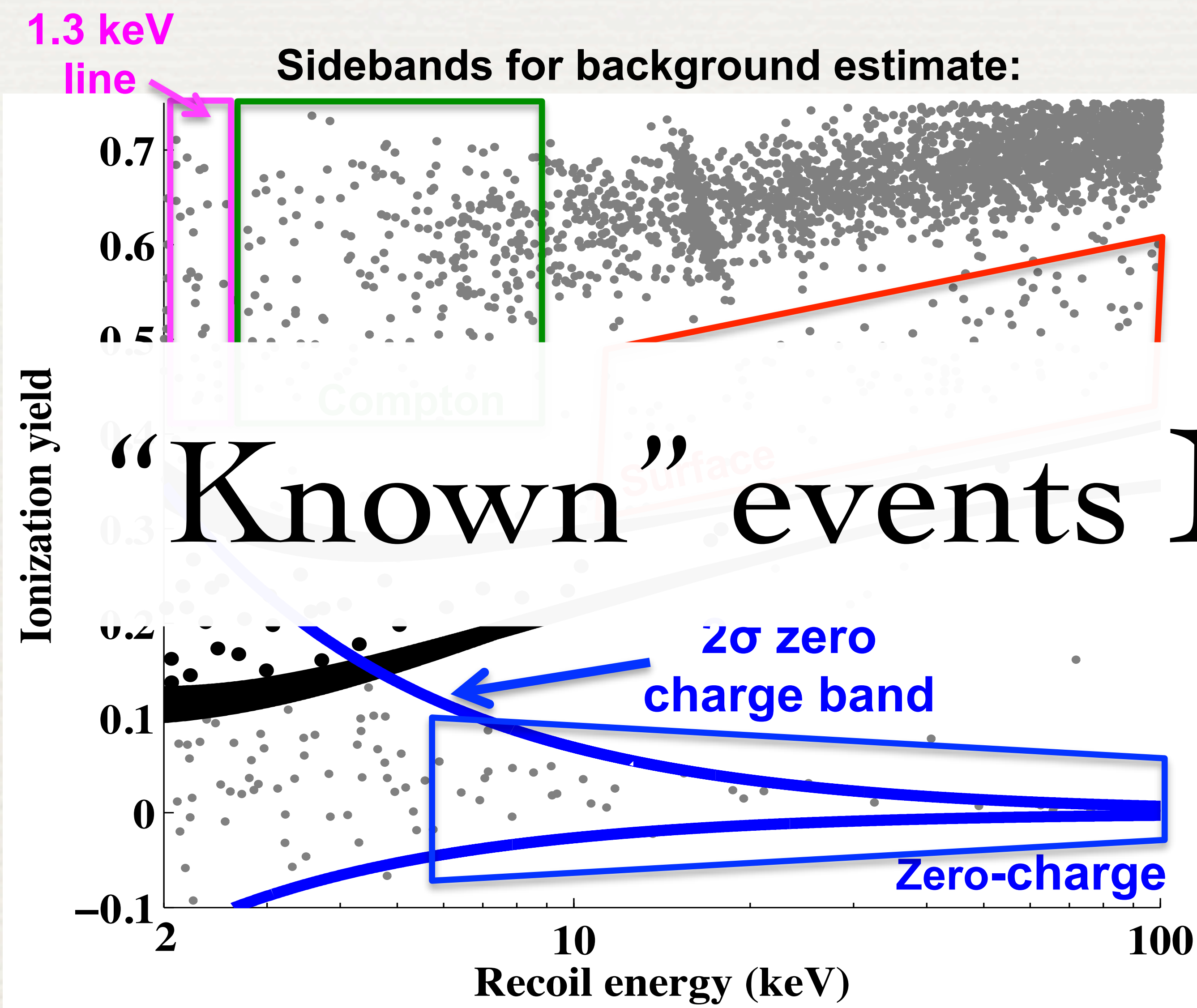
Zero-charge

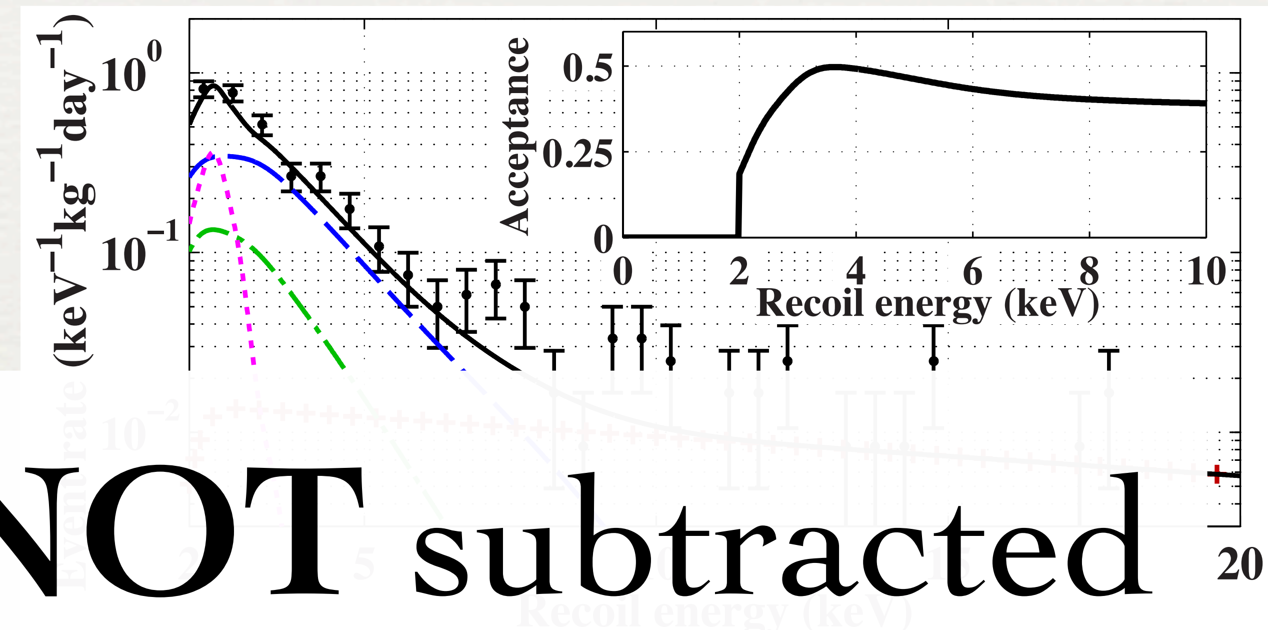
Surface

Bulk

1.3 keV

Ionization vs. Energy





“Known” events NOT subtracted

Total

Zero-charge

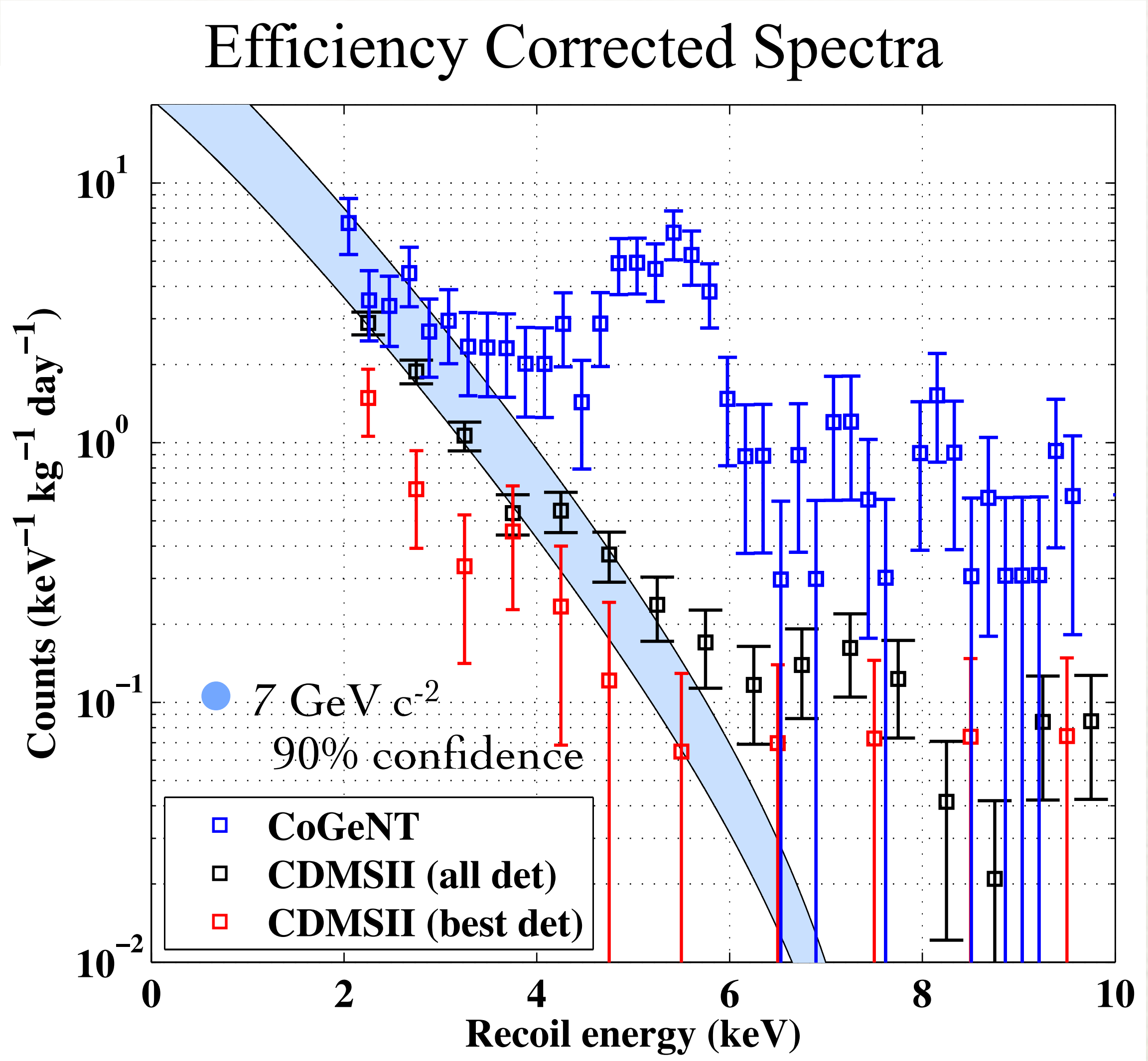
Surface

Bulk

1.3 keV

CDMS and CoGeNT

- Both use Ge detectors
- Signal in CoGeNT not seen in CDMS



7 GeV c^{-2} 90% confidence

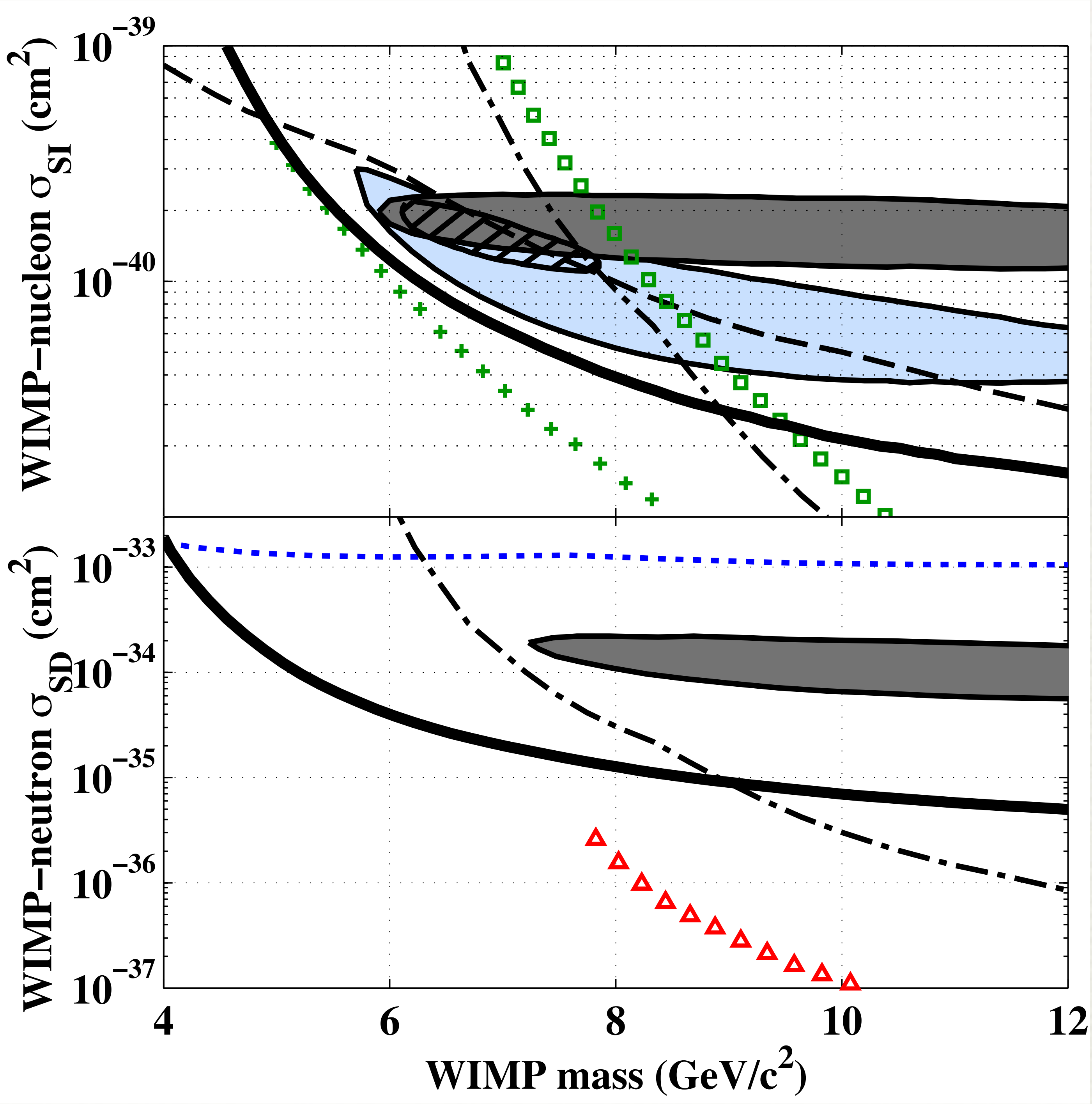
Hooper et al.,
Phys. Rev. D 82, 123509 (2010),
arxiv:1007.1005

WIMP-Nucleon 90% Exclusion Limits

CDMS Stanford 1 keV --
CDMS Soudan 2 keV —
CDMS Soudan 10 keV -·
XENON100 □ +

DAMA / LIBRA ●
CoGeNT ●
DAMA + CoGeNT ▨

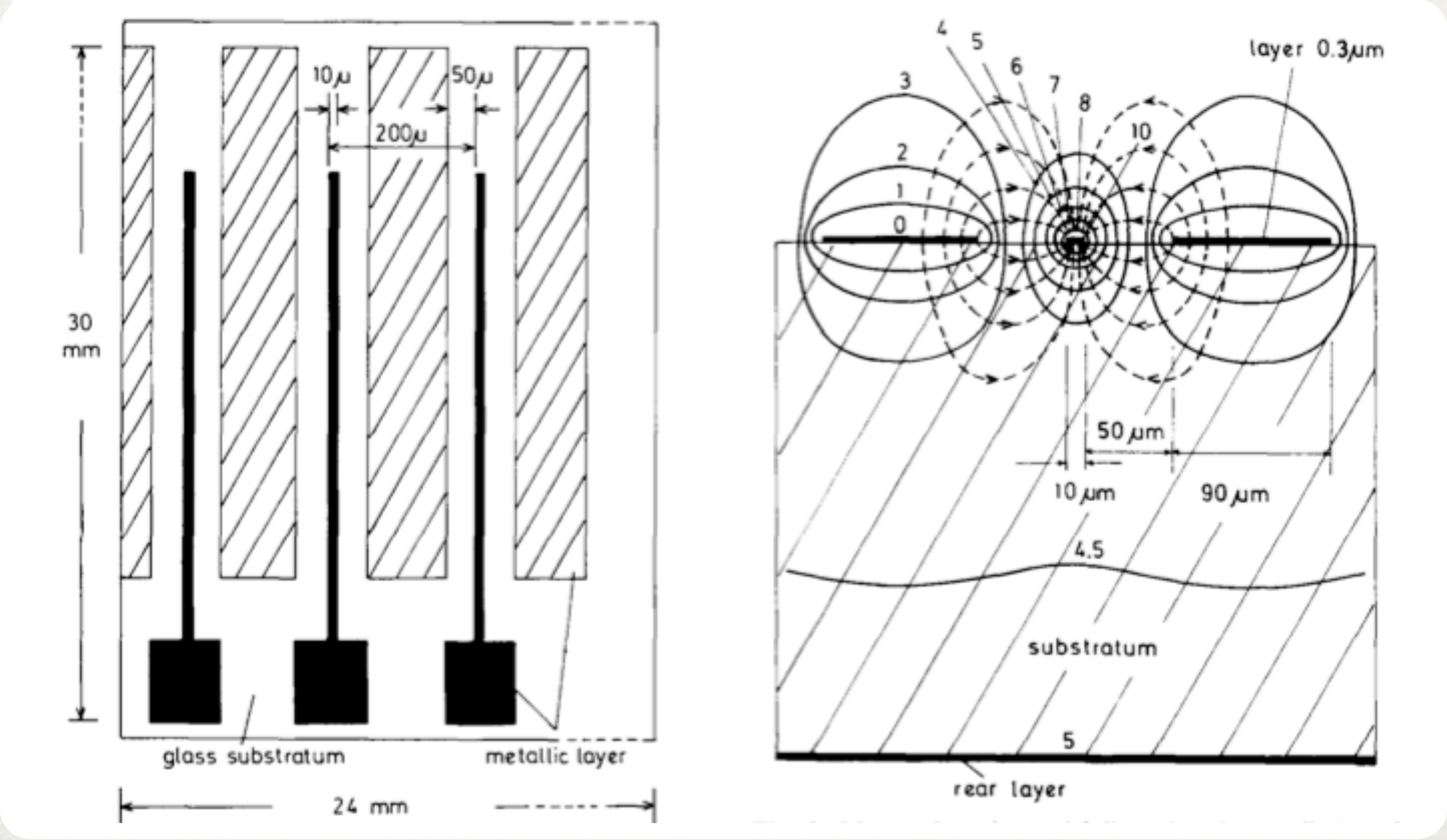
CDMS Soudan 10 keV -·
CRESST --
XENON10 △



SuperCDMS

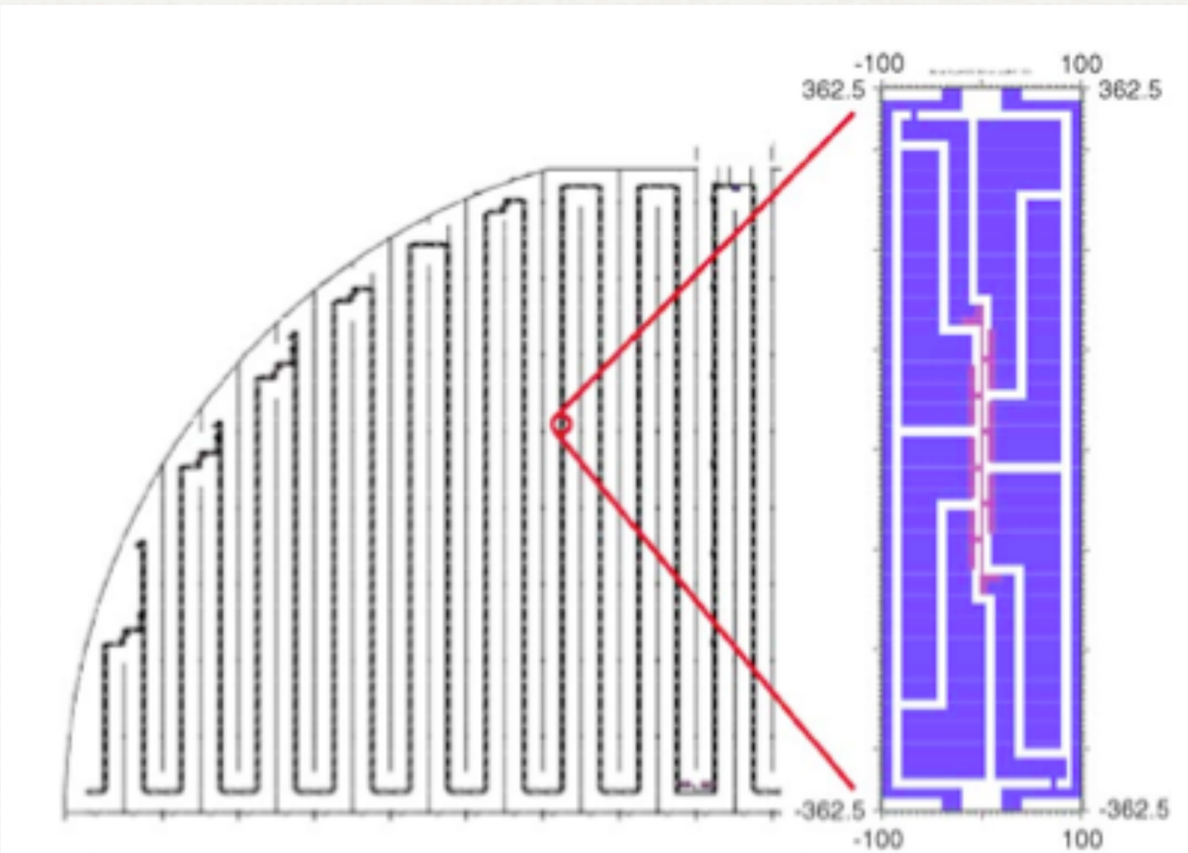
Interleaved Detectors

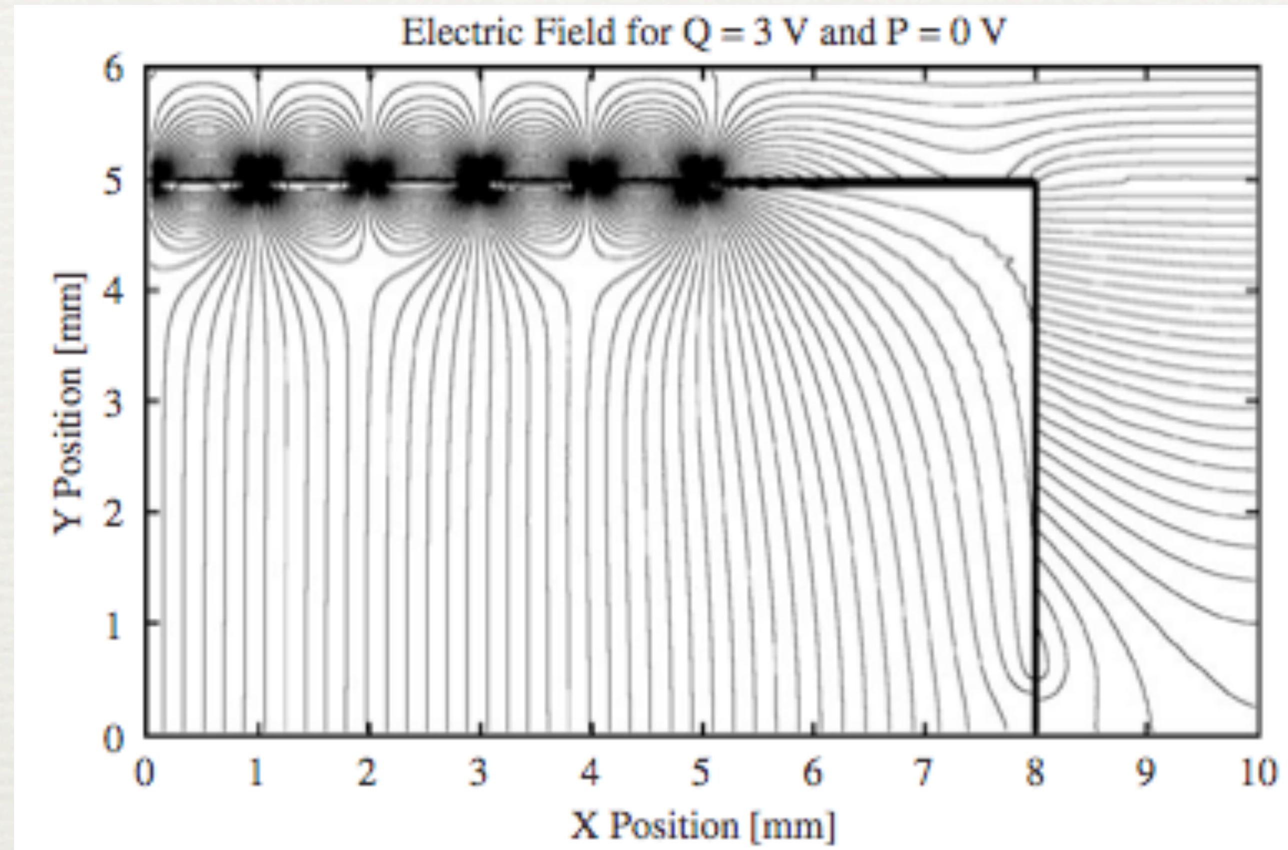
Microstrip Gas Chamber



- A. Oed 1988 NIM A 263 (1988) 351-359

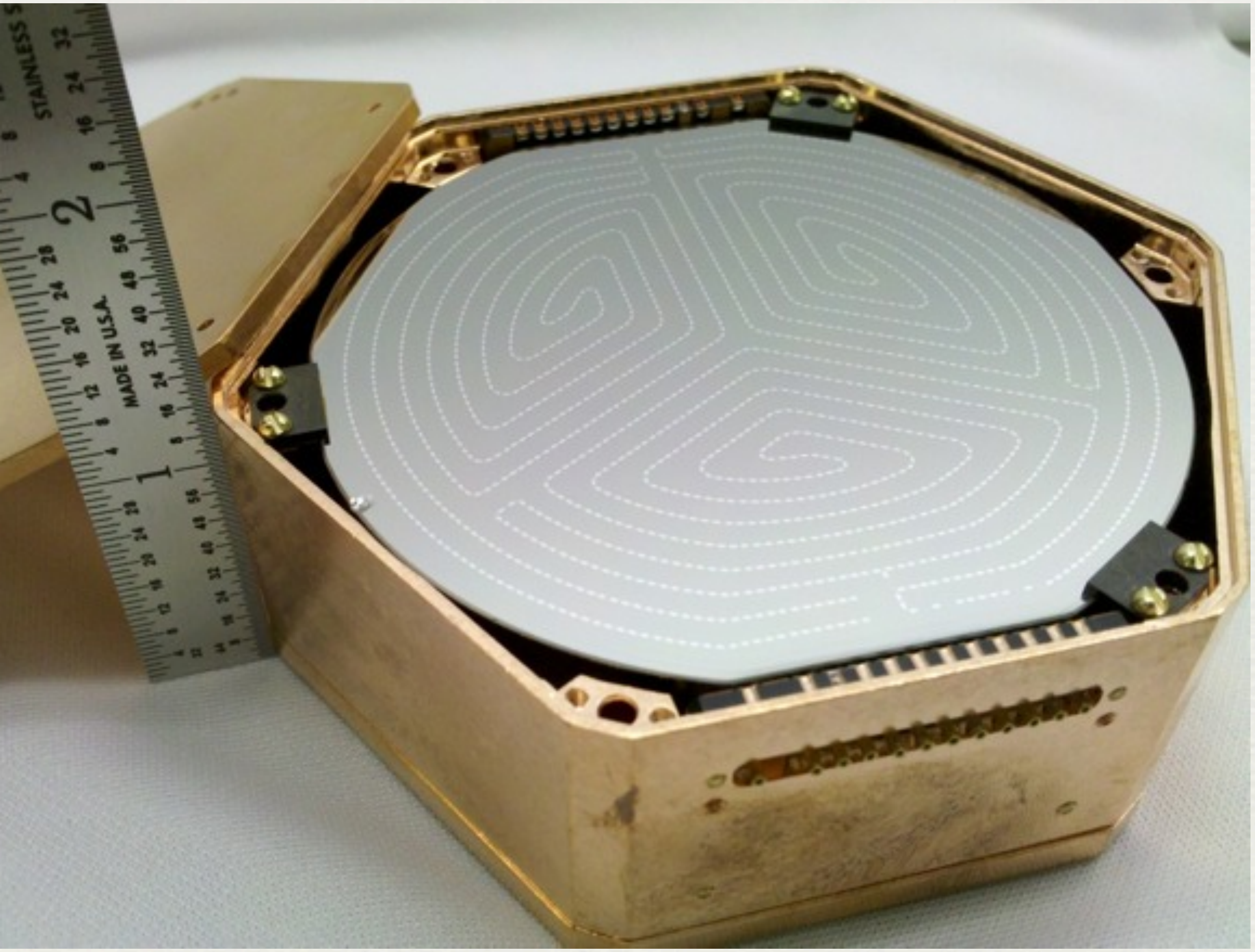
SCDMS iZip Detectors

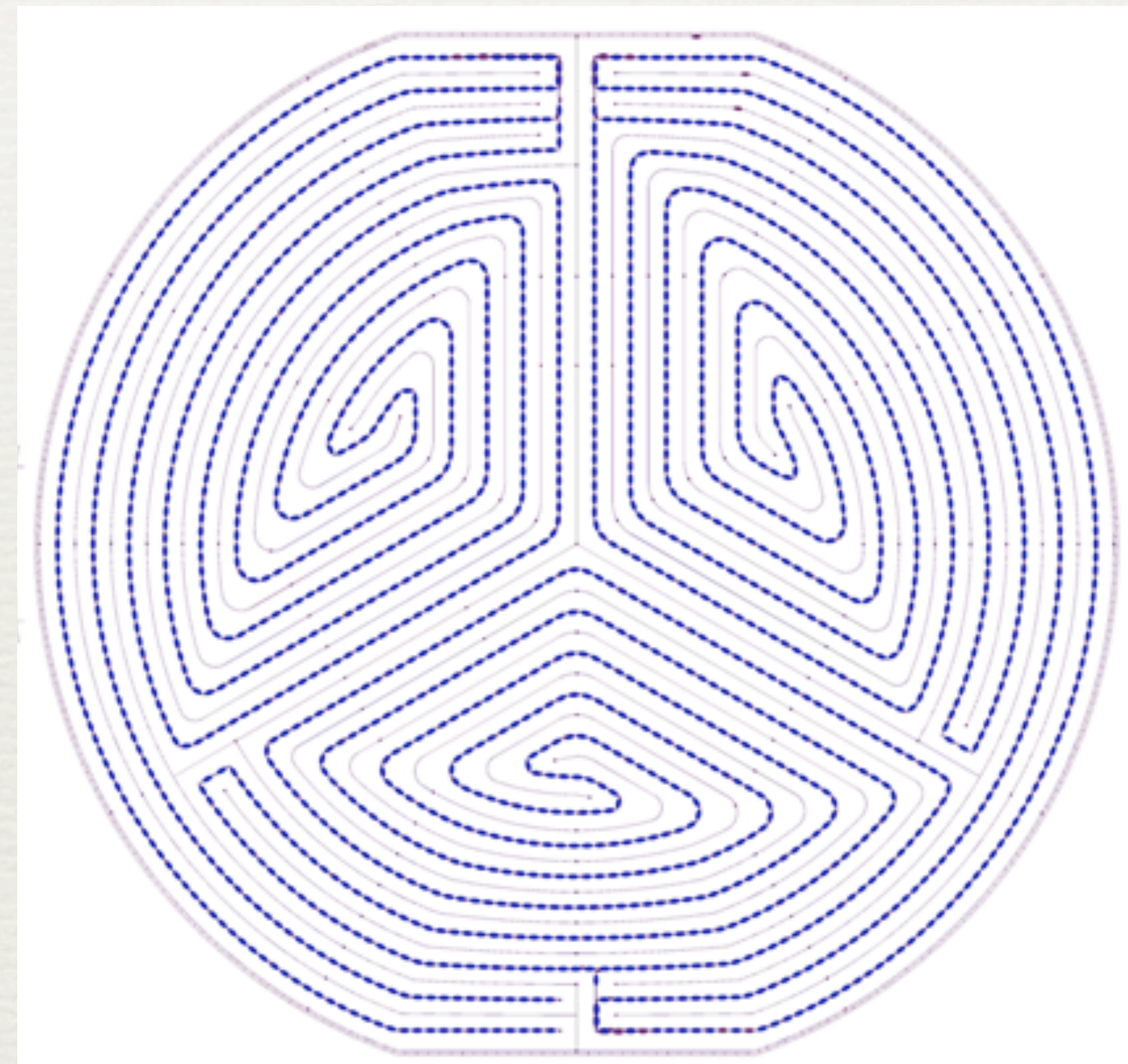




- MSGC concept extended to CdZnTe, P. Luke Appl. Phys. Lett. **65** (22) 1994
- SCDMS, P. Brink et al NIM A 559 (2006) 414 - 416

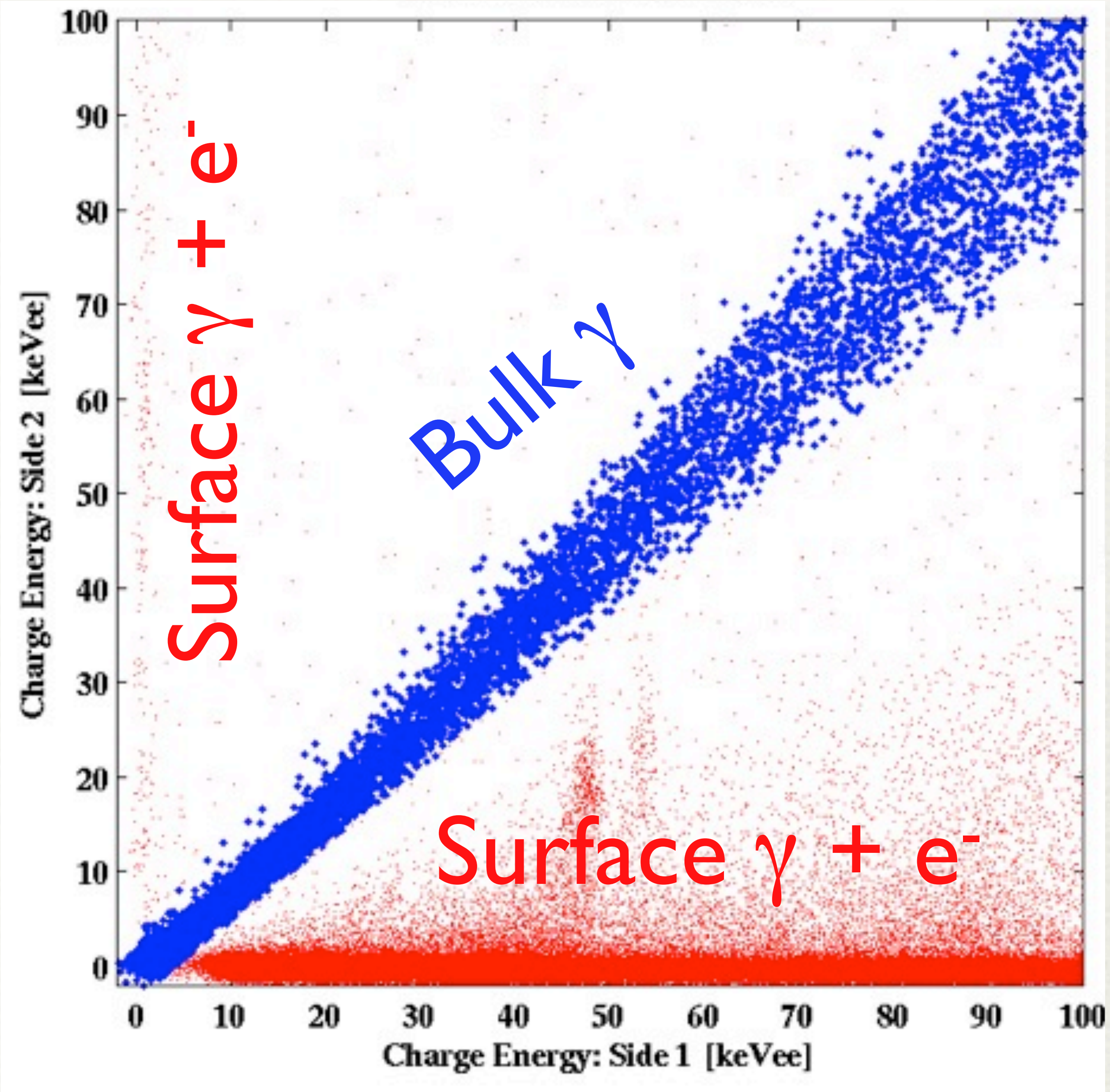
SCDMS iZip Detectors



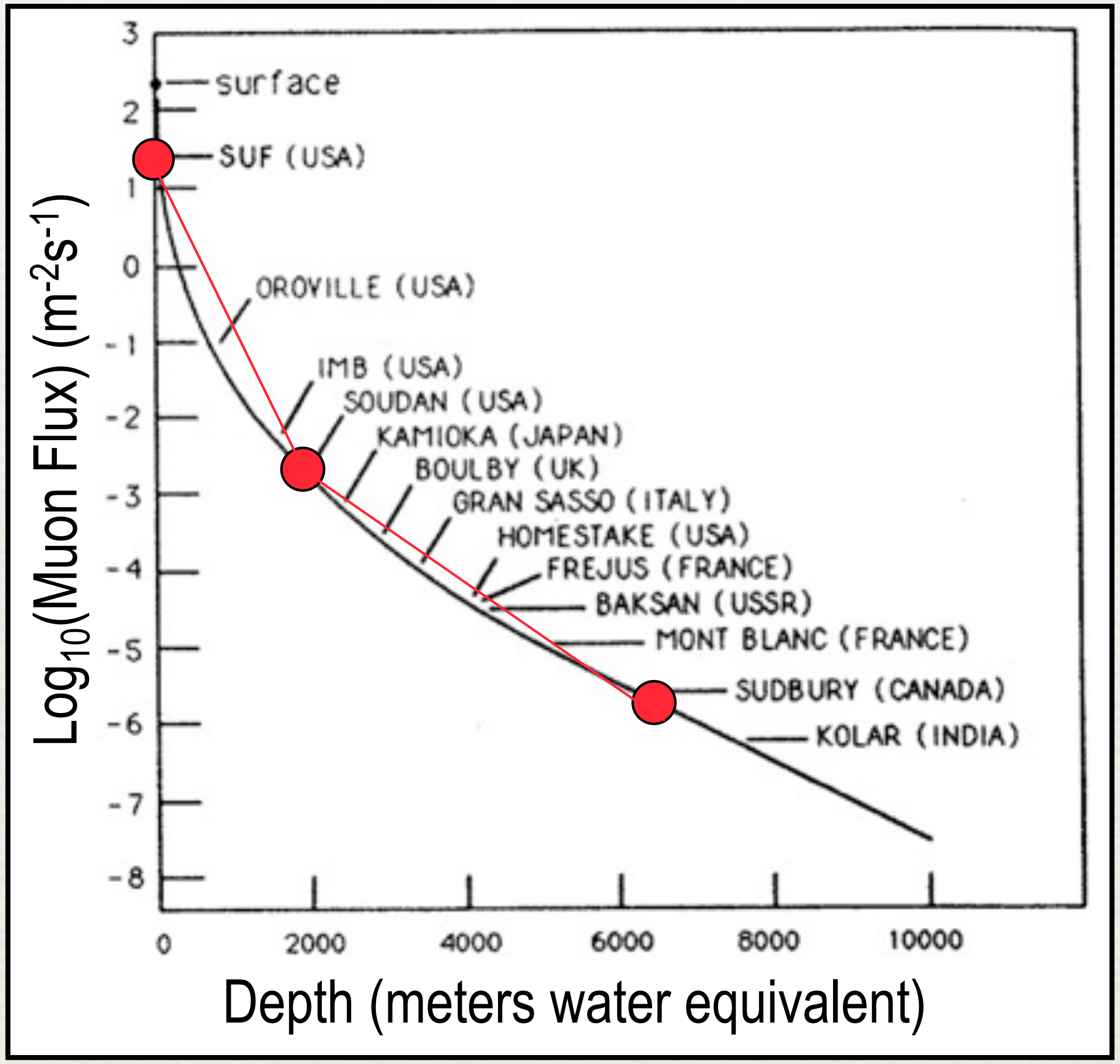


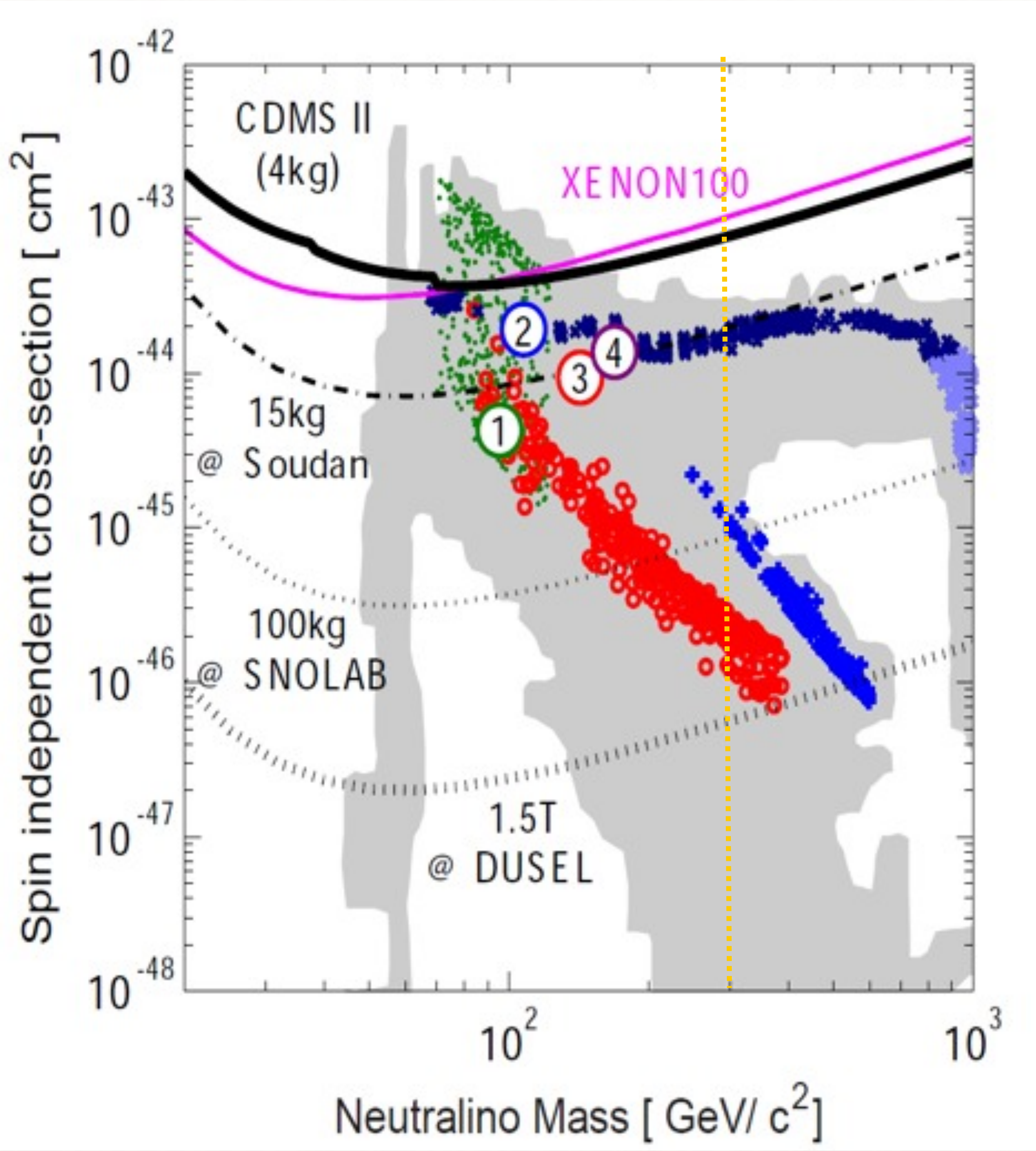
Surface Discrimination

$1:10^4$ surface discrimination from ionization signal



Future Limits





Backup Slides

Inner Charge Cut

- Area_qi = 83%
- Cf-252 passage = 81 - 83%
- Energy dependence
  - 84% (4 keV) - 79% (100 keV)
  - <4 keV, qi and qo indistinguishable, linearly extrapolate to 100% passage

Search Complementarity

Direct
- bulk
- focus point

Production
- coannihilation
- bulk

Indirect
- coannihilation
- Higgs funnel