The CDMS Experiment: Status and Combined Limits with EDELWEISS

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CDMS:

Science 327, 1619, 2010
PRL 106 (2011) 131302, PRD 82 (2010) 122004
PRD 83 112002 (2011)

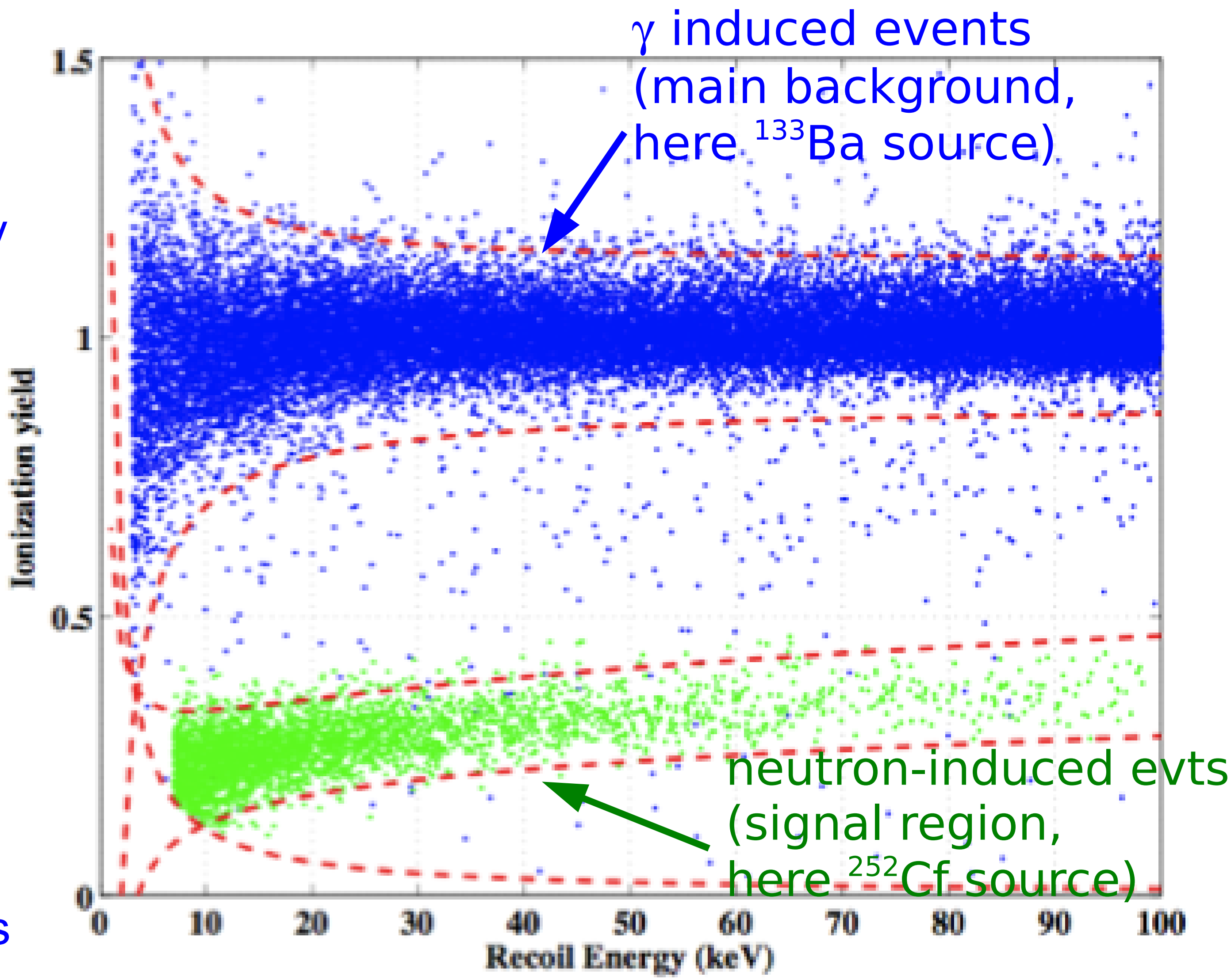
CDMS-EDELWEISS:

PRD 84 (2011) 011102(R), arXiv:1105.3377
see also S. Yellin, arXiv:1105.2928

The Dark Matter Mystery and Cryogenic Detectors

- Most of the matter in the Universe only visible via gravitational interactions (Zwicky 1933)
- Particle physics may provide a solution: Weakly Interacting Massive Particles (WIMPs)
- Many experiments trying to detect WIMPs directly, using many different techniques and targets: XENON, DAMA, COGENT, CRESST …
- Millikelvin Ge ionisation-phonon detectors (CDMS, EDELWEISS) have provided competitive limits on WIMPs over the past decade

- mK Ge has excellent background rejection:



CDMS: the Cryogenic Dark Matter Search

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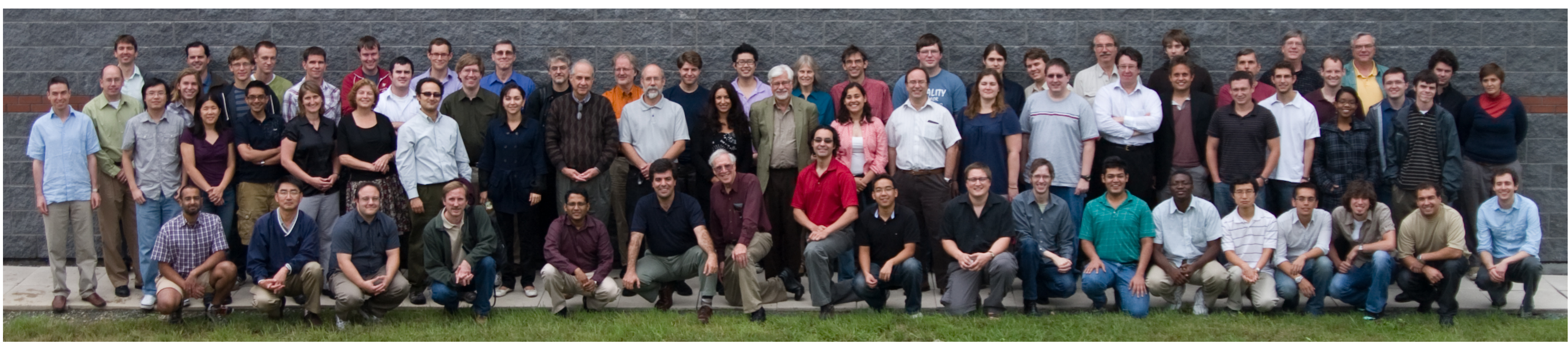
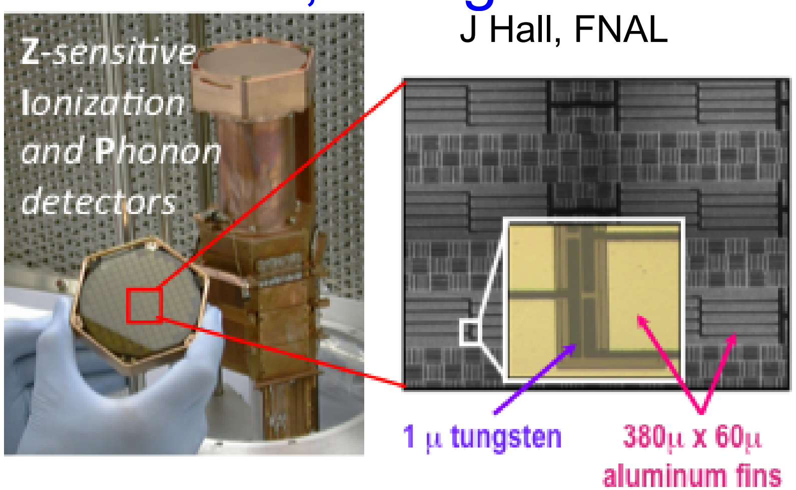
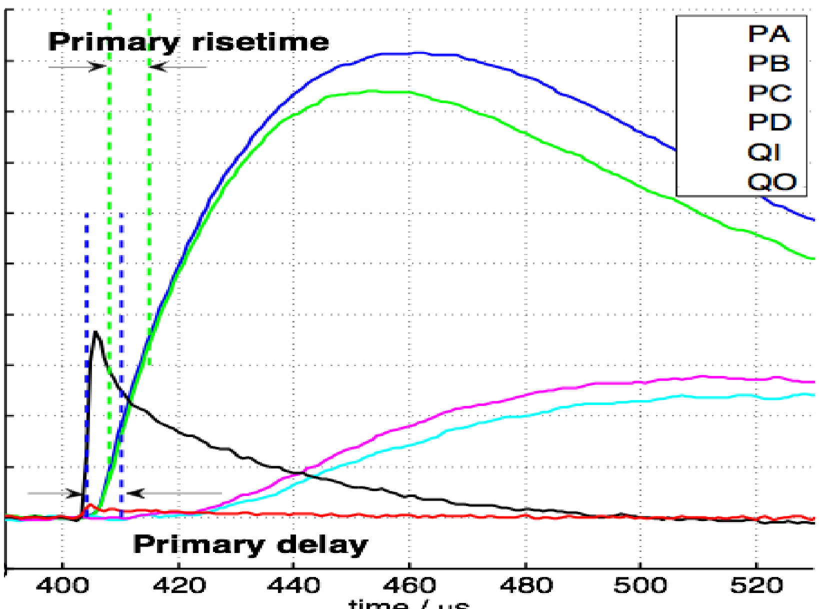


CDMS @ Soudan (2100 mwe)

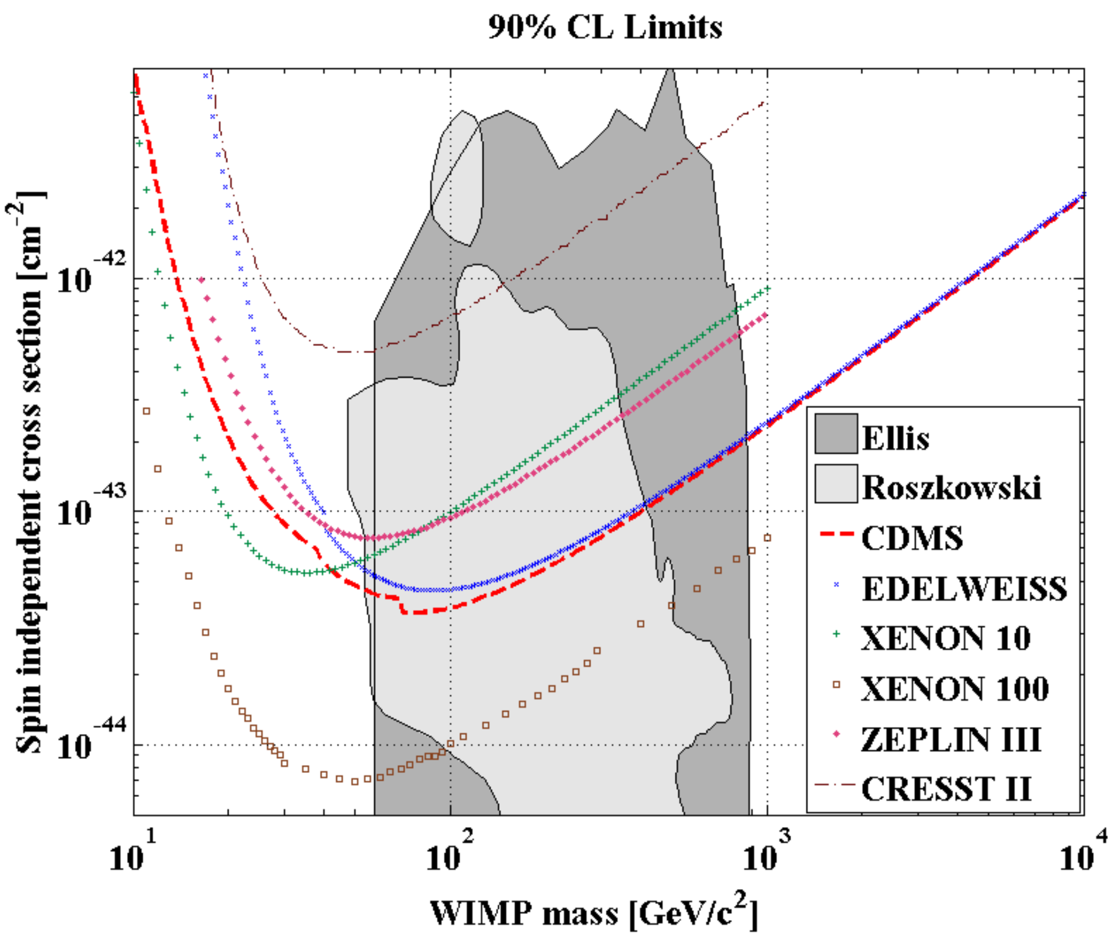
- Up to 19 Ge ionisation-phonon detectors, 230 g each:



- Athermal phonons to reject surface events:

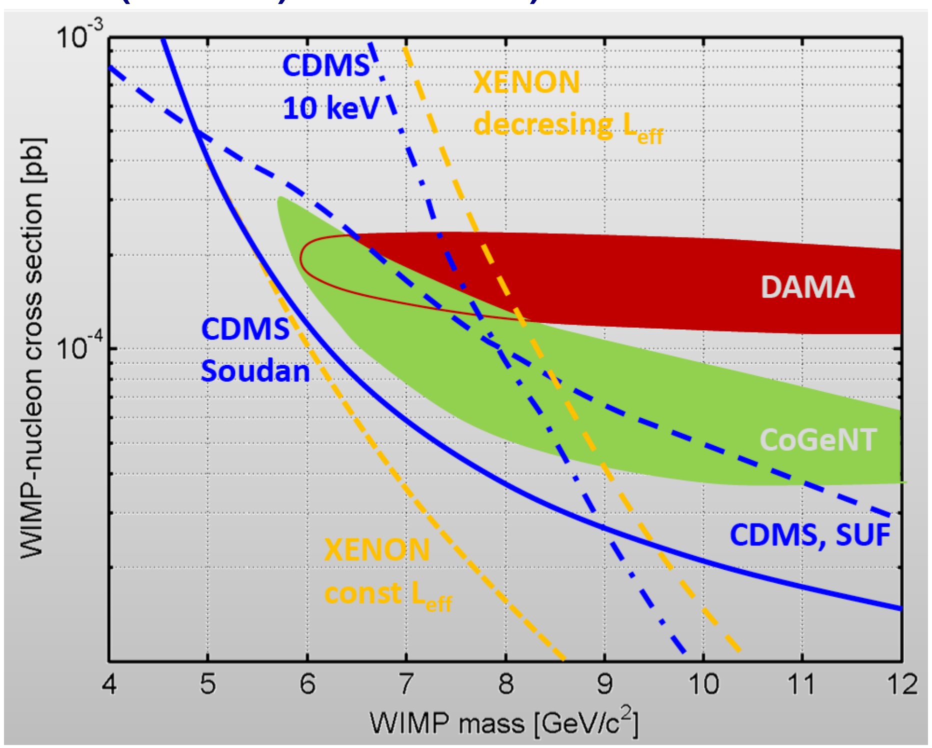


- Total (Science 327, 1619, 2010):
  - Max expos. 379 kg.d, thresh. 5 keV
  - Blind analysis
  - 4 candidate evts, 2 expected from bckgd

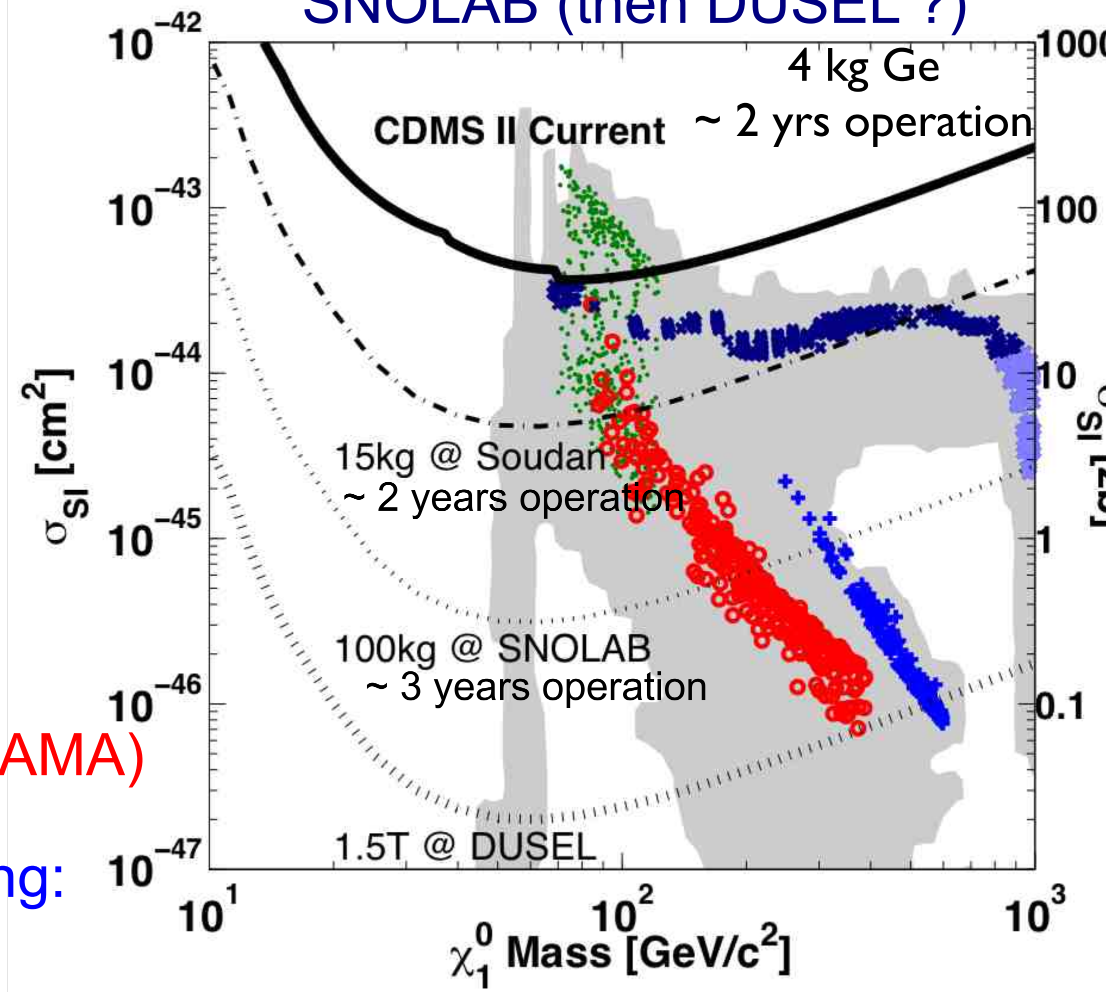


From CDMS to SuperCDMS

- CDMS and light WIMPs (PRL 106 (2011) 131302, PRD 82 (2010) 122004)



- SuperCDMS:
  - Improved detectors (also use charge to ID surface evts)
  - Larger, deeper experiment at SNOLAB (then DUSEL ?)



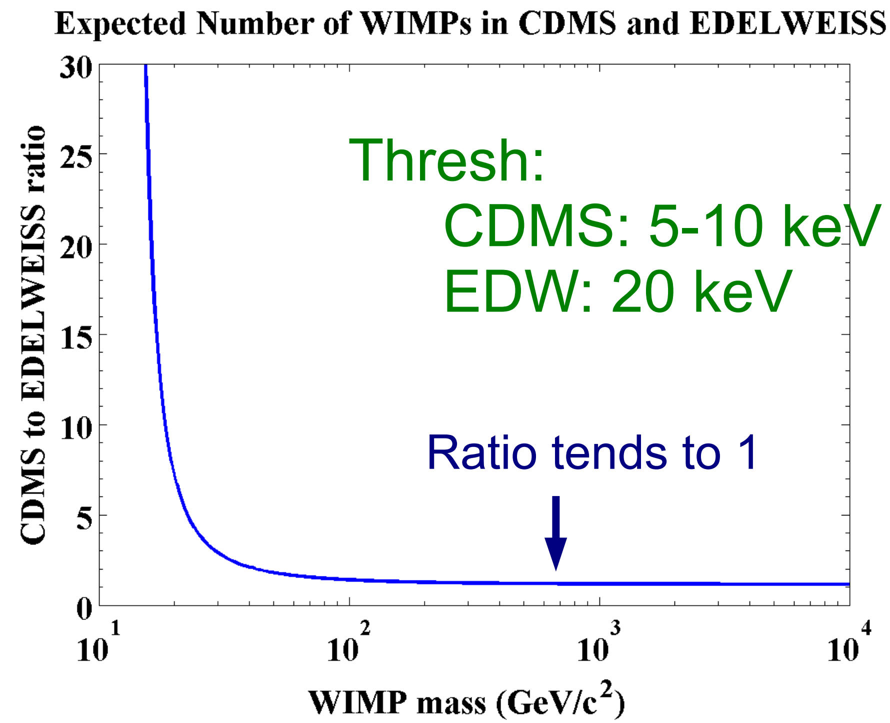
Tension between results of (CDMS, XENON) and (COGENT, DAMA)

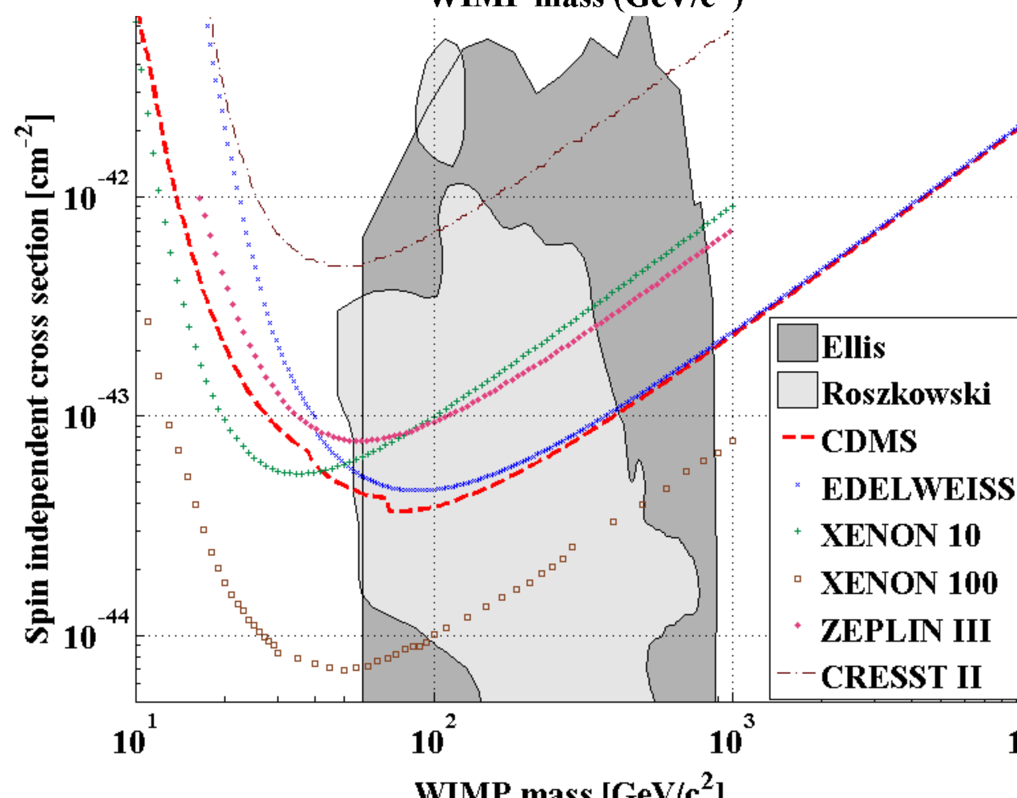
- Also results on inelastic scattering: PRD 83 112002 (2011)

Combining Data from CDMS and EDELWEISS

(See also J. Gascon's talk and arXiv:1103.4070v2)

- Both experiments use same target (Ge) and similar technology (ionisation-phonon)
- Results combined to study, WIMPs, backgrounds
- Formal agreement
  - Authorship, procedures …
  - Combination method
  - Make data public on arXiv
- Exposures similar
  - CDMS: 4 evts (expect ~ 2)
  - EDW: 5 evts (expect <= 3)

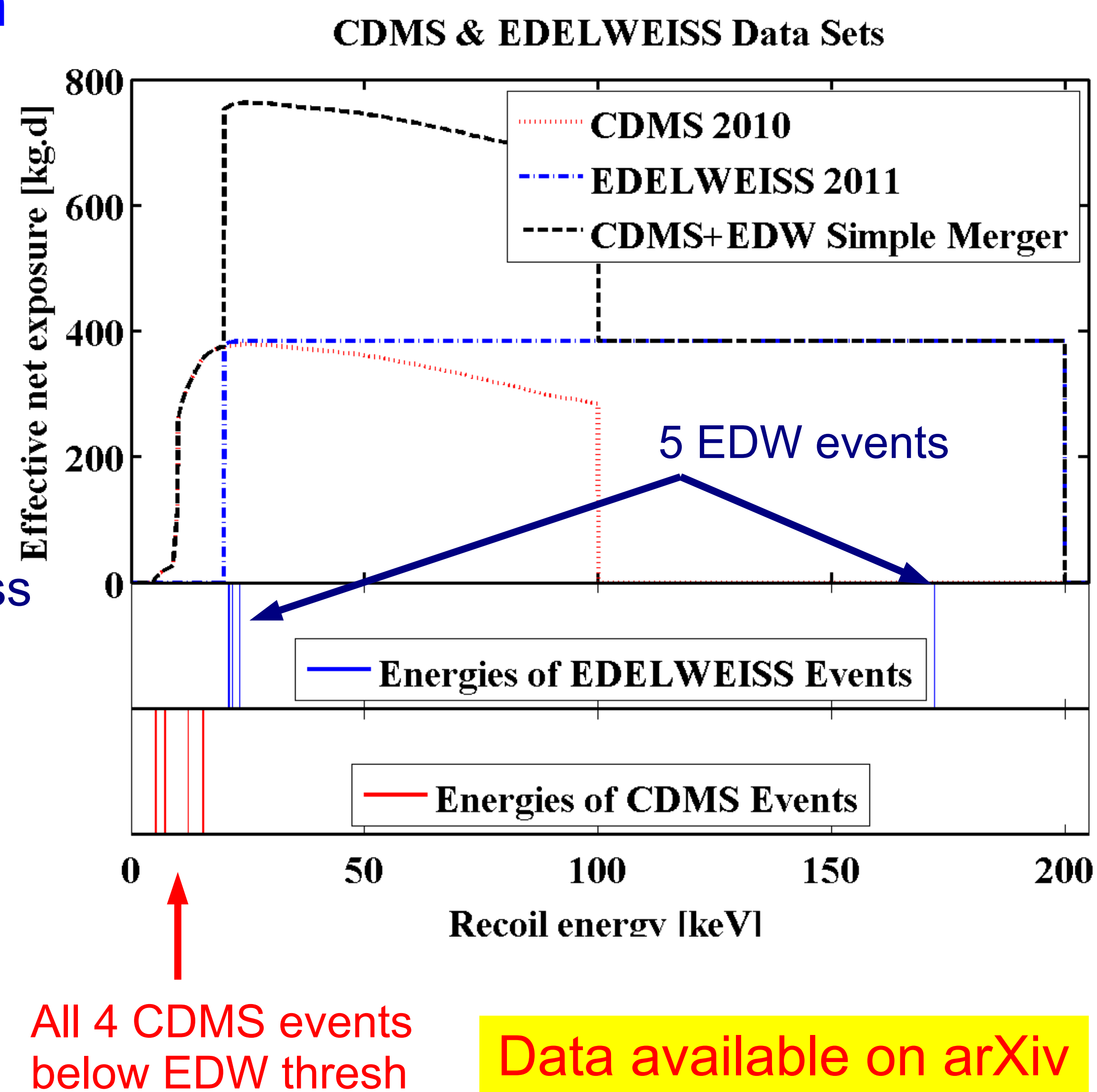




Simple Merger (S. Yellin, arXiv:1105:2928)

- Agreed upon before data were exchanged between experiments
- Official result of collaboration
- Method:
  - Sum exposure-weighted efficiencies
  - Combine events, regardless of experiment of origin
  - Apply standard “optimum interval” limit procedure (S. Yellin, PRD 66 032005 2002)
- What most experiments already do with their individual detectors, runs ...

- Data:



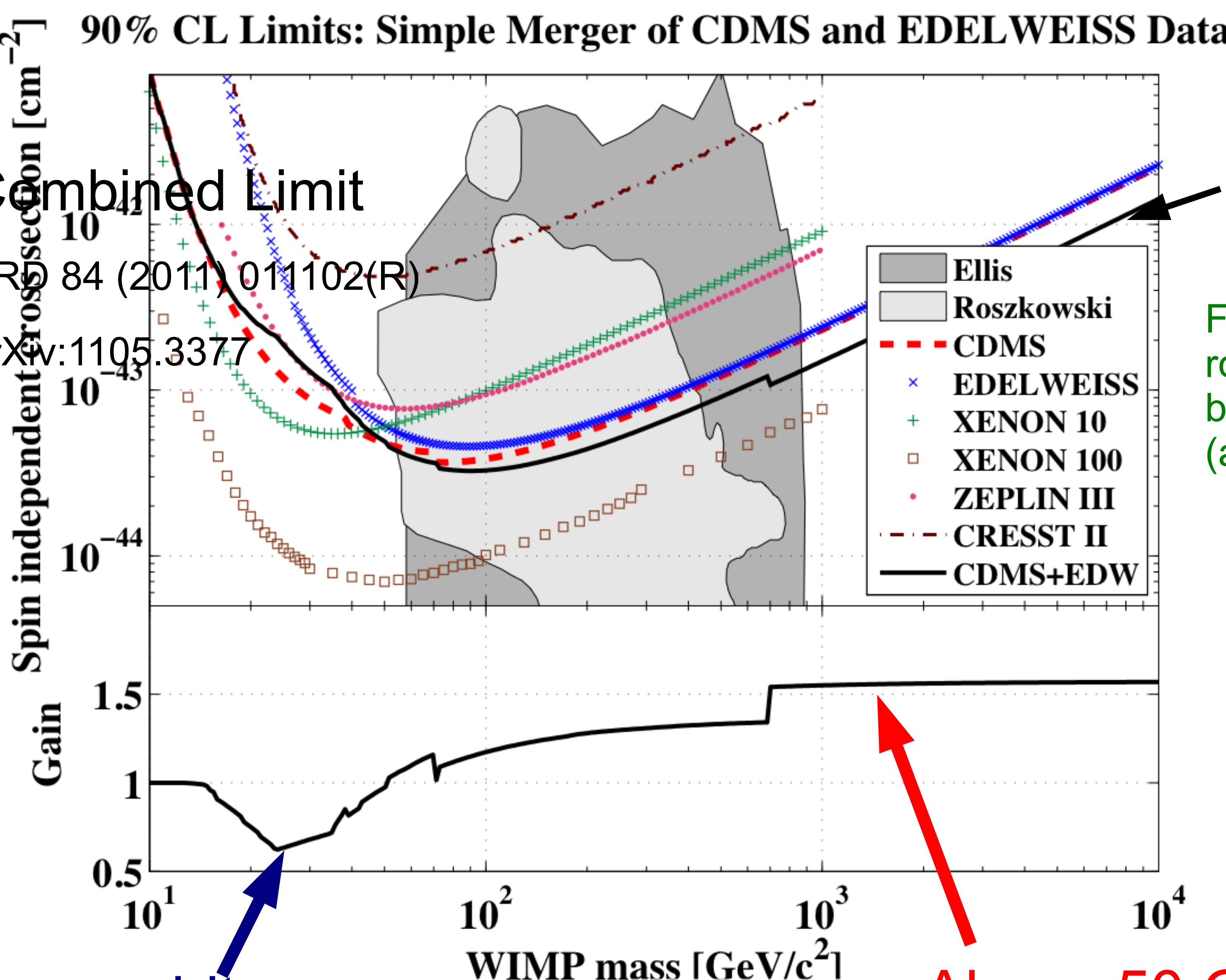
Data available on arXiv

Result

Combined Limit

PRD 84 (2011) 011102(R)

arXiv:1105.3377



For heavy WIMPs, roughly factor 2 behind XENON (arXiv:1104.2549)

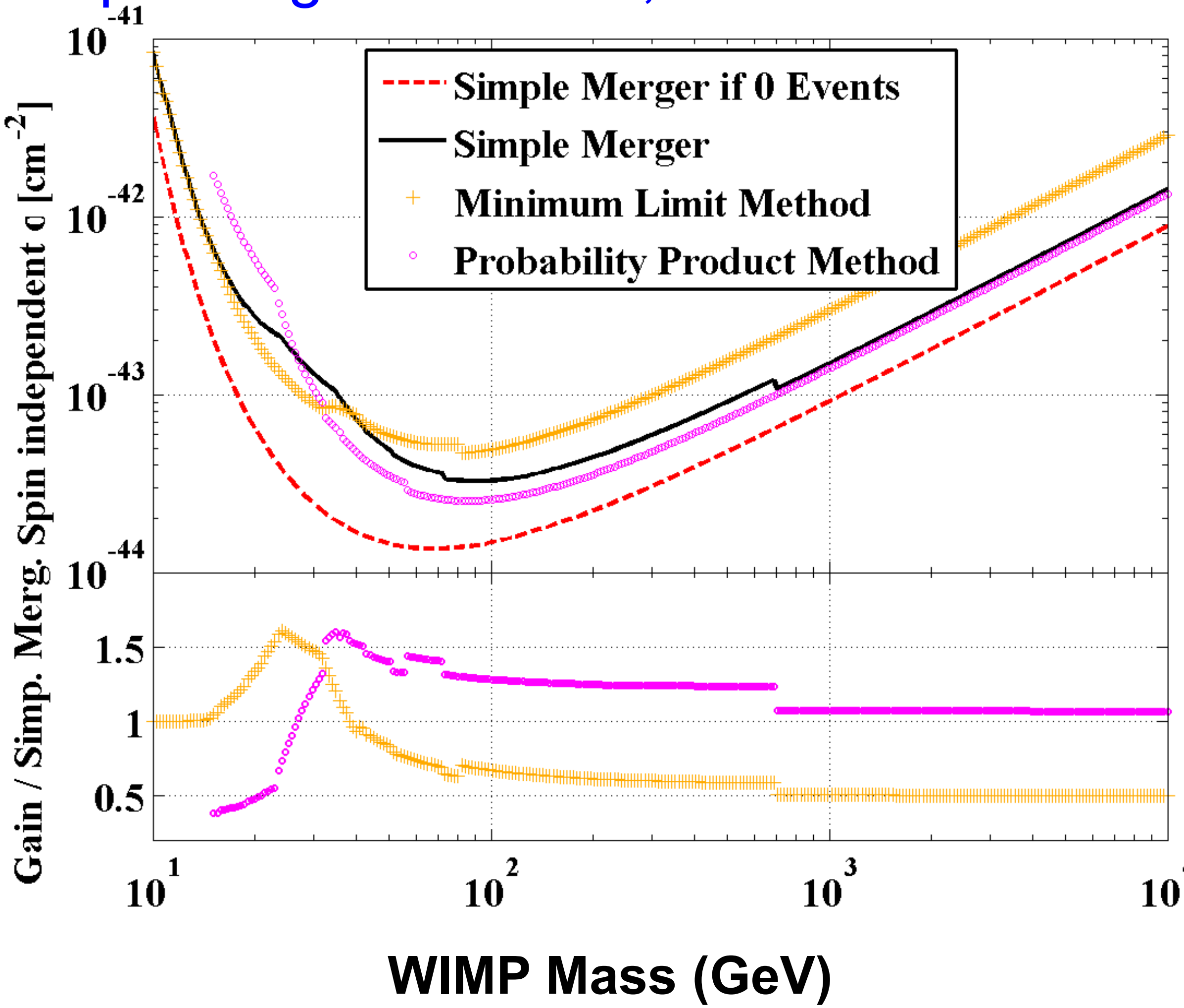
Lose a bit for light WIMPs

Above 50 GeV, improve up to factor 1.6

Alternative Methods (S. Yellin arXiv:1105.2928)

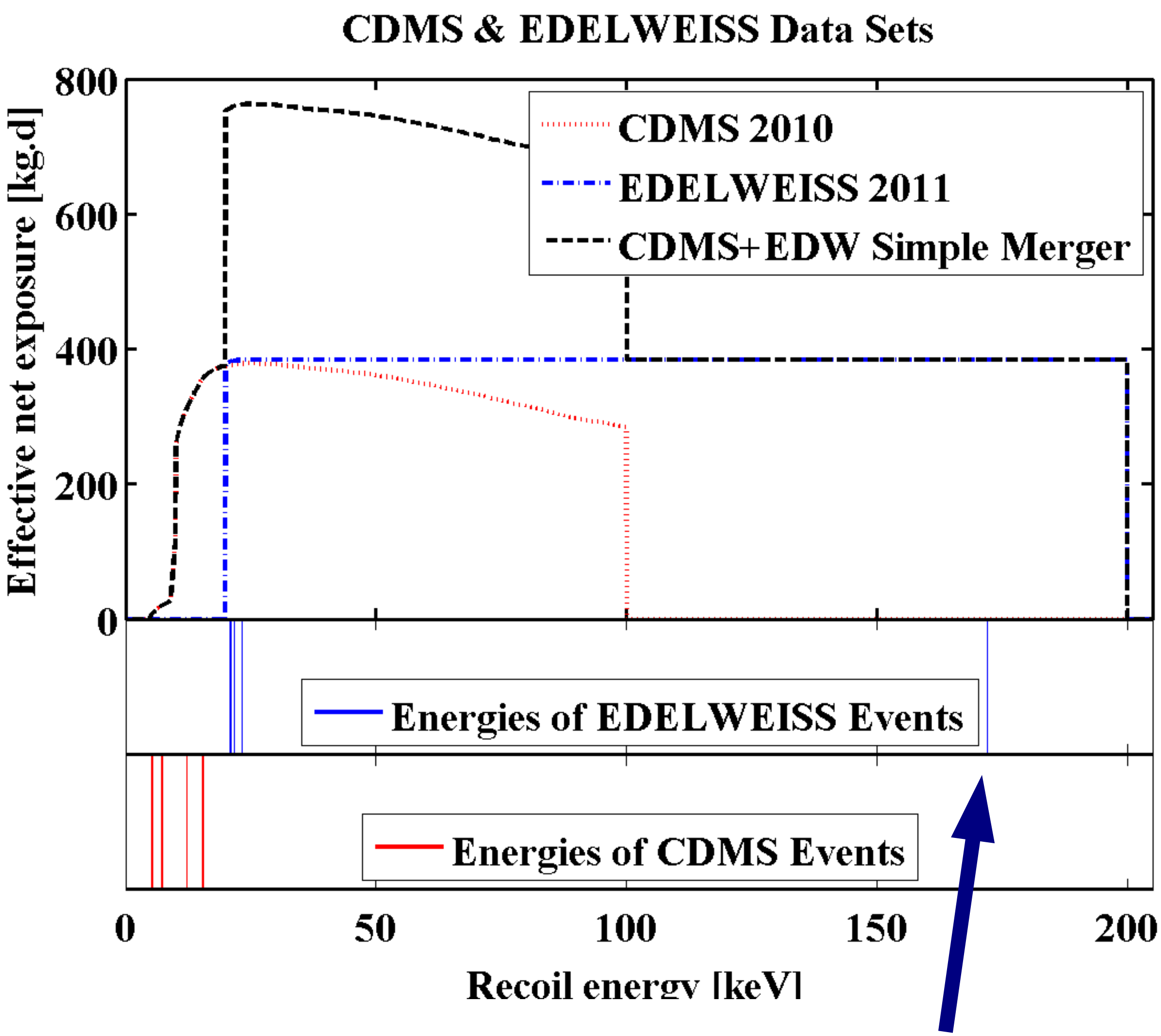
- Other methods that exploit the provenance of events are possible
- E.g. different ways to combine the probabilities of the optimum interval method applied to individual experiments
  - "Minimum Limit": Choose most constraining expt, but pay statistical penalty – appropriate for background limited cases
  - "Probability Product": - appropriate for low background cases

- Constraints can be stronger/weaker depending on method, WIMP mass



- Method should be chosen based on what is known of backgrounds a priori

Insight into Backgrounds



172 keV EDW outlier
considered background ab initio

- Independent likelihood test to CDMS, EDW separately:
  - WIMP mass most likely to cause events is <= 17 GeV in both cases,
  - but cross sections (rates) very different
- Likelihood ratio test of CDMS, EDW, CDMS+EDW:
  - No background hypothesis rejected at > 99.8%CL
  - Robust to variations in halo model

A la Recherche de la Matière Perdue

- CDMS has set strong constraints on WIMPs in past decade
- SuperCDMS ~ 10 kg set to start this quarter at Soudan:
  - Sensitivity goal: ~ 7.10^{-45} cm^2 with little or no background
  - Search for low-mass WIMPs
  - Qualify new detectors
- Intend to start running 100 kg at SNOLAB 2015
- CDMS and EDELWEISS have produced a common analysis of their results
  - At high masses improves constraints from cryogenic detectors by ~ 1.6
  - Method can also be applied to other experiments, targets

Towards LHC-size author lists ?

Combined Limits on WIMPs from the CDMS and EDELWEISS Experiments

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