Dark Matter and Underground Facilities:

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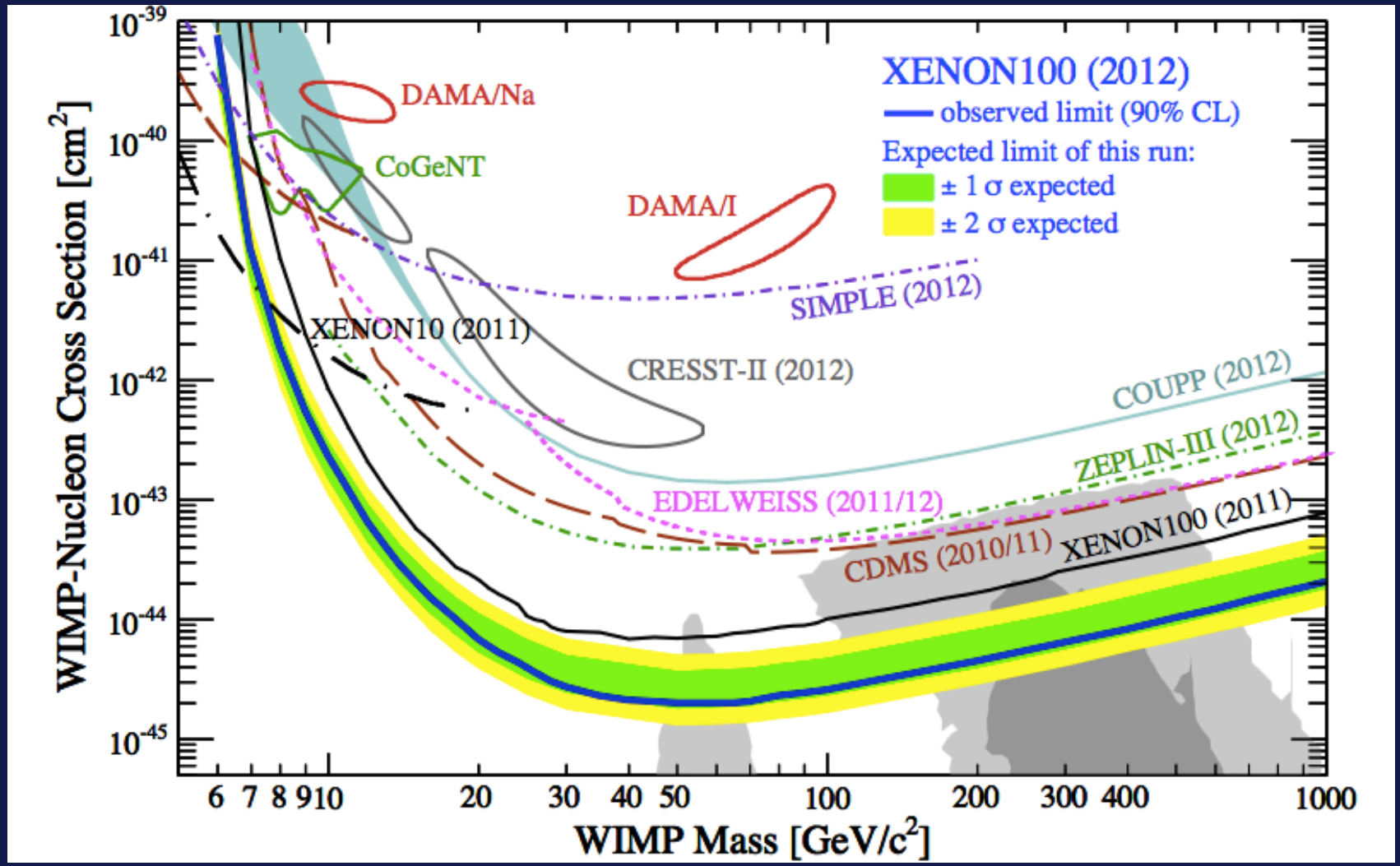
The Dark Matter Campaign

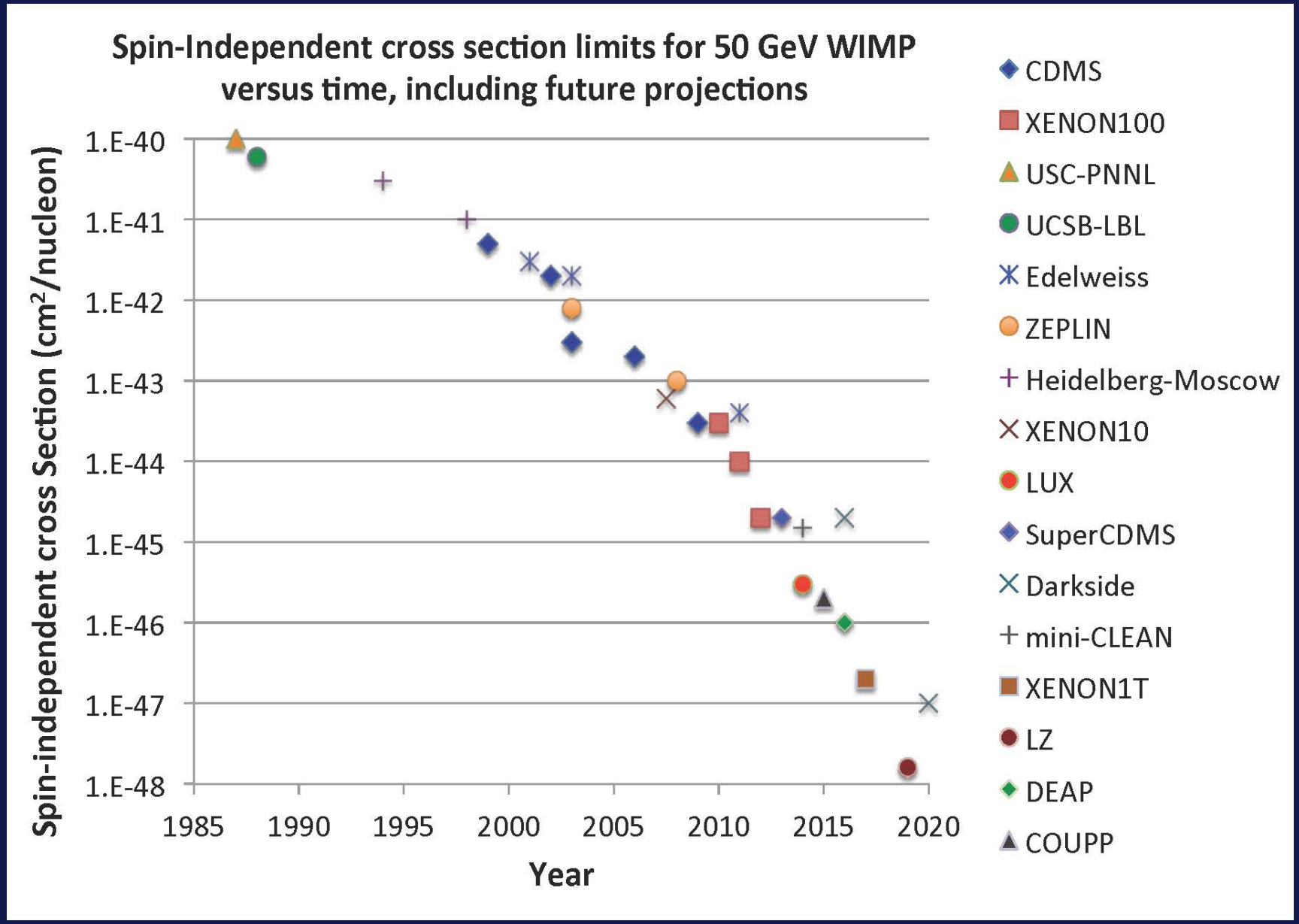
- An Assessment of the Science Proposed for the Deep Underground Science and Engineering Laboratory (Lankford Report, National Research Council, 2011)
  - "The direct detection of dark matter would provide a crucial experimental connection between particle physics and cosmology.
  - To be definitive, their signature signals would need to be significantly above the background and would need to come from different experiments….
  - The program in dark matter detection will by necessity involve a number of G2 experiments that will coalesce into a smaller number of highly sophisticated and massive G3 detectors."

The Dark Matter Landscape



There could be a discovery at any time.

The campaign is advancing to the G2 experiments.



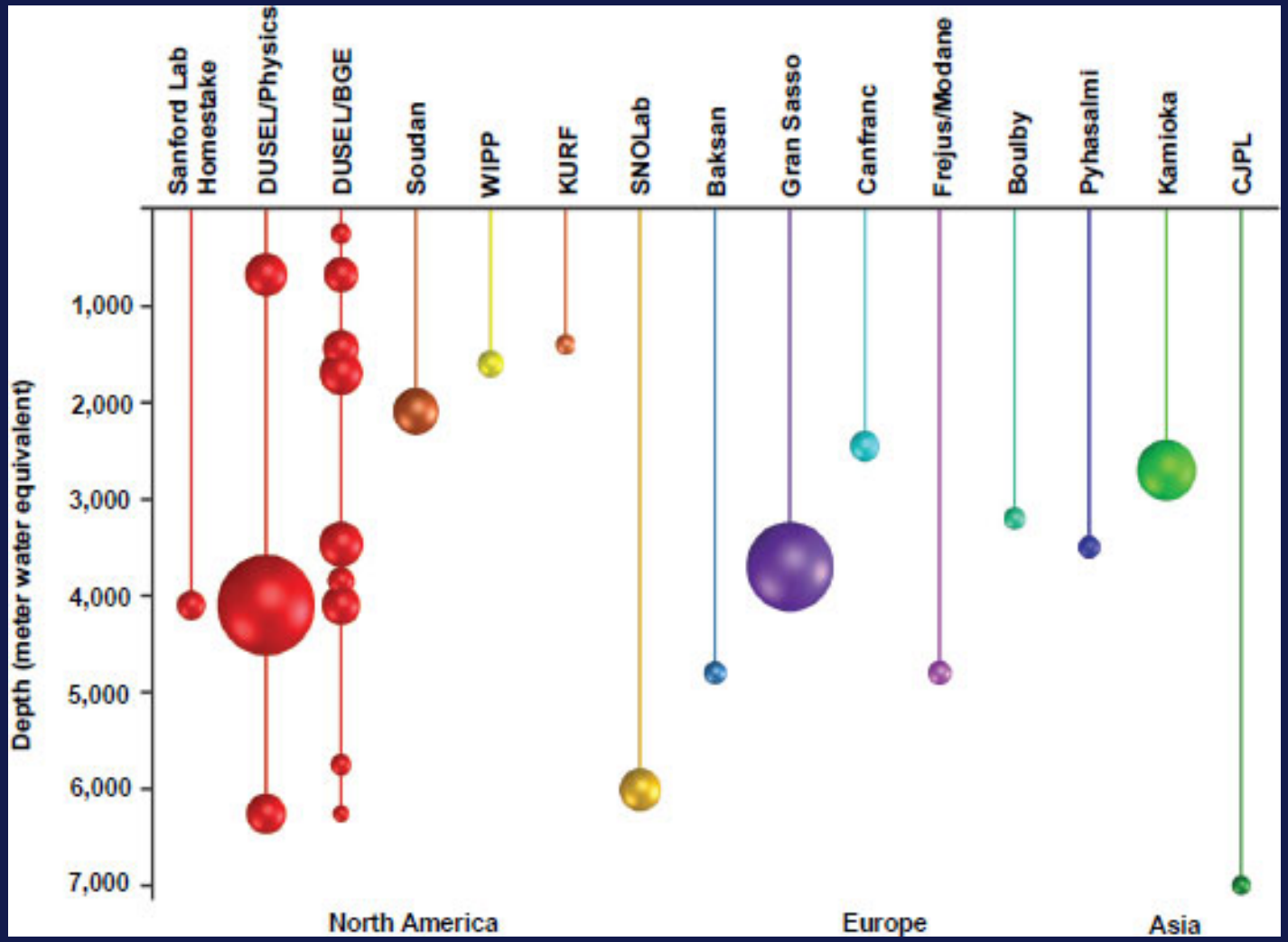
Facilities for the G2 experiments

- The current underground facilities can meet the needs of the G2 experiments.
  - Sanford Laboratory (SURF) – LZ
  - SNOLAB – SuperCDMS, COUPP, DEAP
  - Gran Sasso Laboratory (LNGS) – XENON1T
  - China Jin-Ping Underground Laboratory – PandaX II
- The experiments will make excellent use of the facilities through about 2019.
- It is critical that these facilities continue to operate throughout the operating period for the experiments.

G3 experiments

- Experiments beyond the G2 round are considered to be G3.
  - Fiducial mass 5-10x greater than the corresponding G2 experiment.
  - The number of G3 experiments willl be smaller than of G2 experiments.
- If all growth plans for existing facilities are realized, and none are closed, sufficient space may well exist for G3 experiments.
- It is important that DM experiments are given appropriate priority in allocation of this space.

Depth



- The G2 sites range in depth from 3600-7000 m.w.e.

Are present sites deep enough for G3 experiments?

- All of the G2 sites may well be deep enough to host a G3 experiment.
  - Cosmogenic neutrons do not dominate the present experiments.
  - Advanced veto/shield systems reduce backgrounds.
  - Solar pp neutrinos are likely to be the dominant source of backgrounds for G2 experiments.

– The experience of G2 experiments with advanced veto/shield systems will determine the depth at which backgrounds from cosmic muons are smaller than other background.

Are present deep sites large enough for G3 experiments?

- The shield/veto systems needed to reduce backgrounds in a multi-ton G3 experiment determines the size of the hall needed.
- Only a few of the largest of the existing and planned underground halls can accommodate such an experiment.
- Housing a G3 experiment in the U.S. would require additional excavation at SURF.

The International Program

- Experiments in the U.S. DM program are deployed in U.S., Asia, Canada, Europe, and Antarctica.
- This arrangement has arisen naturally from the international nature of particle physics collaborations.
- It is critical than an open access policy – like those now in place at major underground facilities – continue to be followed.

US role in future facilities

- The U.S. will continue to take a strong leadership role in the worldwide dark matter campaign through the G3 era.
- The best way for the governments to support the international system of underground experiments is for each major country (or region) to support at least one major underground laboratory capable of hosting the forefront experiments.
- It is not clear whether it would be possible to sustain this international support if one country chose to take a major role in the research without supporting any facility.

Conclusions I

- All the next generation (G2) dark matter experiments can be accommodated by existing and planned underground facilities, assuming no reduction in these facilities.
- Most G2 experiments are at facilities outside the U.S.
- U.S. physicists are participating in most G2 experiments around the world, and are leading many of them.
- A G3 experiment is likely to be 5-10x the volume of the G2 experiment of similar technology and mass reach.

Conclusions II

- It seems likely that all the G2 facilities will have sufficient depth for a G3 experiment.
- The U.S. does not now have an underground hall large and deep enough to house a large G3 experiment.
- It is premature to develop plans for a facility dedicated to a large directional experiment.