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SuperCDMS in 10 Minutes

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New Perspectives 2018

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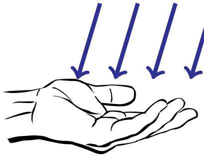
NORTHWESTERN UNIVERSITY

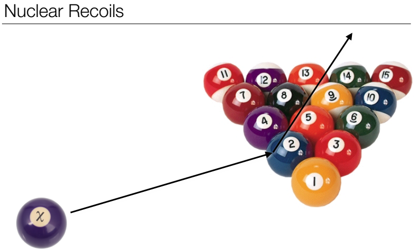
The Hunt for Dark Matter
AMS-02
CALET
FERMI,
Pamela,
ATTIC
DAMPE
GAPS
HESS, VERITAS,
Magic
IceCube
1.5 kilometers
2.5 kilometers
Indirect
Detection
ALICE
CMS
ATLAS
LHCb
LHC
Production in
Colliders
Direct
Detection
ADMX
B_0
Single
real
photon
a
Virtual
photon
T
CDMS
LUX
Astrophysics
Measurements

Dark Matter Direct Detection

- Dark matter passes through the earth all the time
  - About 20 million/hand/sec
    - Assuming O(10) GeV/c^2mass

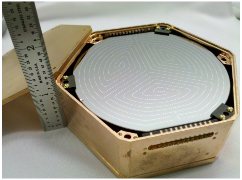


- Direct detection experiments measure them via their elastic scattering off target nucleus
  - Very rare
    - Or we would have seen it by now...
  - Expect very low-energy rec
    - Leave little to no trace
- Experimental requirement
  - Large exposure
  - Ultra sensitive detectors
  - Low backgrounds

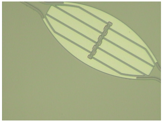


Direct Detection and SuperCDMS

- **C**ryogenic **D**ark **M**atter **S**earch
- Germanium and Silicon detectors
  - Tens of kilograms of detector mass next generation
  - Can scale up if needed

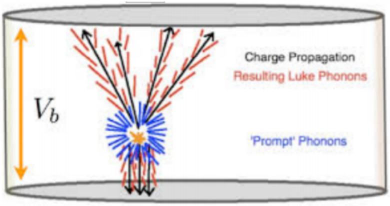


- Transition Edge Sensors (TES)
  - Operated at 60 mK or below
  - Down to O(10) eV sensitivity
  - Use state of the art cold electronics for the best signal to noise



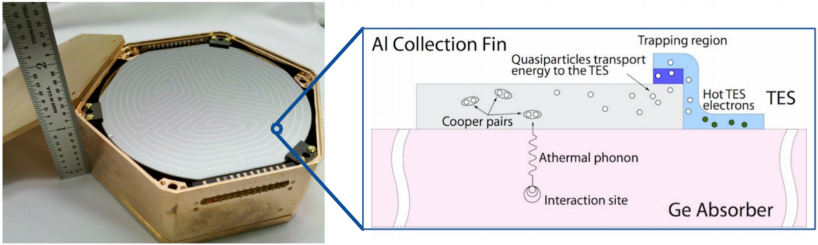
- Operate deep underground, with layers of shielding
  - SNOLAB, 2000 m underground
  - Meticulous choice of low radioactivity material and extra care to cleanliness
  - Robust shielding scheme
  - 0.1 background events /kg/keV/day

SuperCDMS Detector Principle

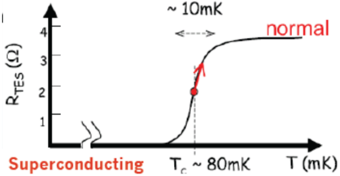


- Cool down Ge or Si crystal to near 0K
- Dark matter scatter off nucleus in the crystal
- Creates lattice vibration in crystals
  - Athermal phonons
- TES deposited on the crystal surface serves to detect phonons

TES as Phonon Detectors

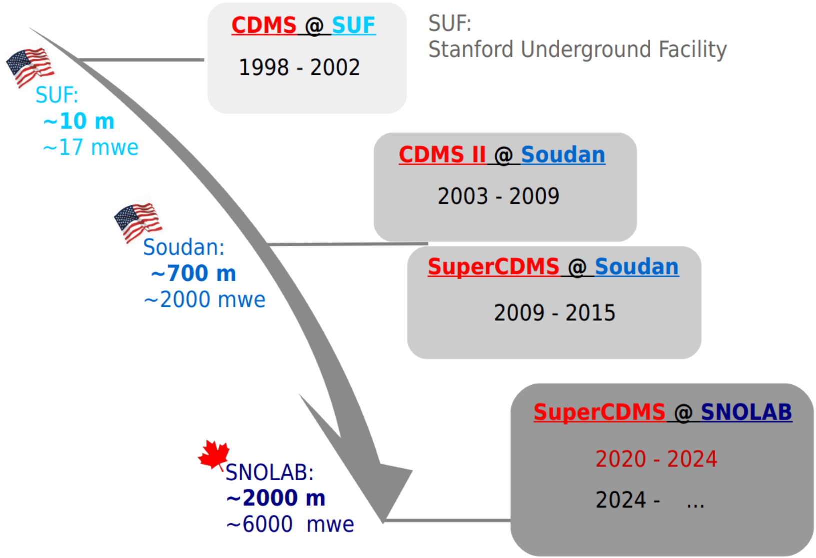


- Bring TES to the middle of its superconducting transition
- Collect phonons with Aluminum fins, then focus their energy towards the TES
  - Like an antenna



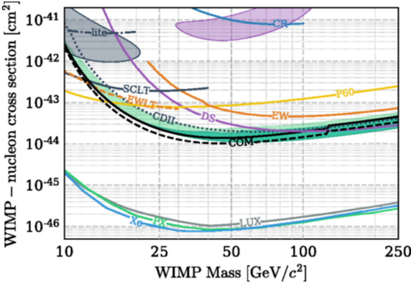
- Small change in temperature → measurable change in resistance → Great signal to noise

Past and future of SuperCDMS

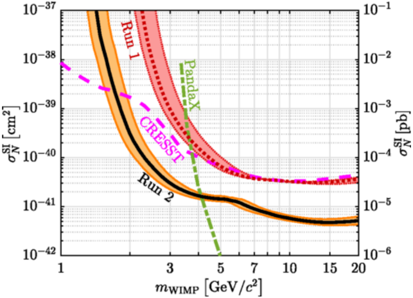


SuperCDMS Soudan Results

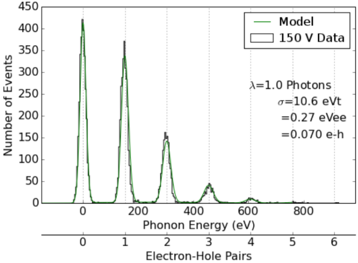
PRL 120, 061802 (2018)



PRD 97, 022002 (2018)

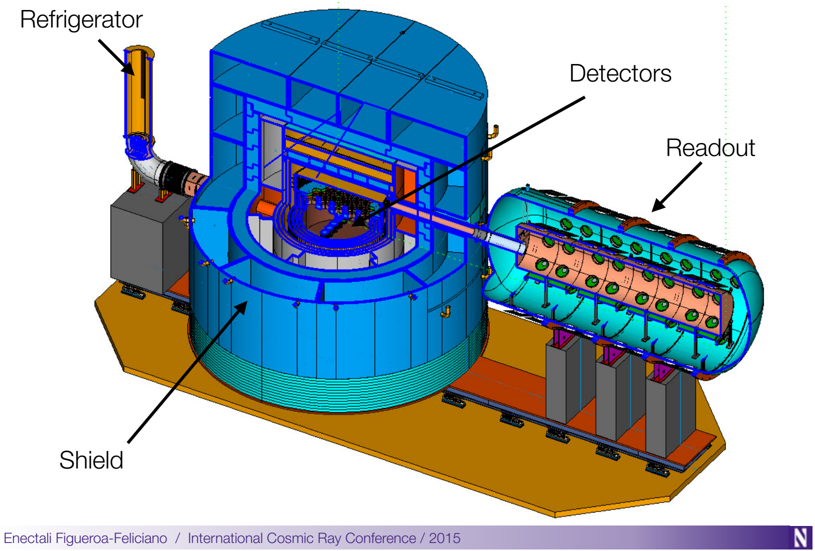


arXiv:1804.10697



- Many great results from SuperCDMS Soudan
- Recent results show sensitivity of O(10) eV

SuperCDMS SNOLAB @ the Ladder Lab



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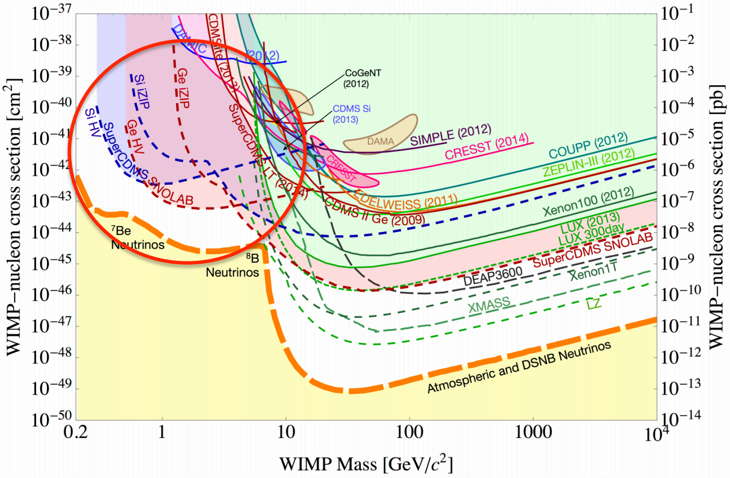
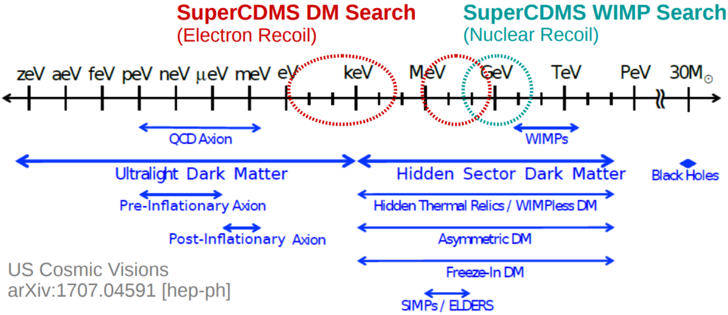


CDMS SNOLAB focused on low mass DM region
er three orders of magnitude better sensitivity

SuperCDMS Electron Recoil



- SuperCDMS is also sensitive to sub-GeV dark matter through electron recoil signal search

Conclusions

- Dark matter direct detection helps identify dark matter properties
- SuperCDMS looking for lower mass dark matter
  - Below 10 GeV/c^2
- Employs germanium and silicon crystals equipped with transition edge sensors
  - Ultra high sensitivity and low energy threshold
- Many great results from previous operations
- Moving to SNOLAB
  - At the forefront of dark matter direct detection over its previous runs at Soudan.
  - Expect turning on in 2020
- Stay tuned

Backup Slides

Backup slides