CF1 Direct Detection overview

Focus here on Low-Mass Dark Matter (Sectors): past, present, and future in 10 mins

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Snowmass CPM, #127, Searches for Dark Sectors, Oct 6, 2020

[slide from Tongyan Lin]

CF1: Particle-like Dark Matter

Covers dark matter in the regime where it appears in experiments as individual quanta, rather than coherently via wave phenomena. Includes direct searches through its interaction with detector materials and indirectly from products of its annihilation.

- ➢ Distinguished from CF2 (Dark Matter: Wave-like) by focus on higher masses (roughly >1 eV)
- ➢ Distinguished from CF3 (Dark Matter: Cosmic Probes) by focus on particle signals of DM-SM interactions

CF1 activities: past and future

- Series of nine CF1 meetings through August and September (https://indico.fnal.gov/category/1193/)
- Dark matter is in all frontiers. We want to update our understanding of complementarity between different searches and techniques, including developments since last Snowmass
  - Session #150 at CPM is a start
  - Dedicated complementarity workshop early in 2021

Snowmass CF1 2013 report: one paragraph on DD of sub-GeV DM

1310.8327

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7.2 Other non-WIMP dark matter searches

In addition to axions, there are many classes of non-WIMP dark matter candidates that may be detected by experiments designed to search for WIMPs. These include searches for dark photons, inelastic dark matter, lightly ionizing fractionally charged particles (LIPs) and may more. Searches for these particles are distinct from the traditional WIMP search in that the WIMP interacts with the detector through a means other than elastic scattering off nuclei. This may include, but is not limited to, ionization, elastic scattering off electrons, or excitation of the molecular system. Often the resulting interaction is detected as an electron recoil. One set of models, lumped under the description of "sub-GeV dark matter" [79] includes the "WIMP-less" scenario, axinos, and gravitinos. XENON10 has published limits based on a search for particles that induce ionization of individual electrons and was able to set limits on particle interactions that produce one two or three electrons [80]. Ultra-low threshold detectors such as CDMS-lite are also expected to have excellent sensitivity to such models. Searches for LIPs require identification of minimum ionizing particles that produce a track within the detector or detecting array. In many cases these searches are complementary to searches at colliders, fixed target experiments or underground neutrino experiments.

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only a few papers on this topic in 2013…

We've come a long way since then!

Significant theory progress

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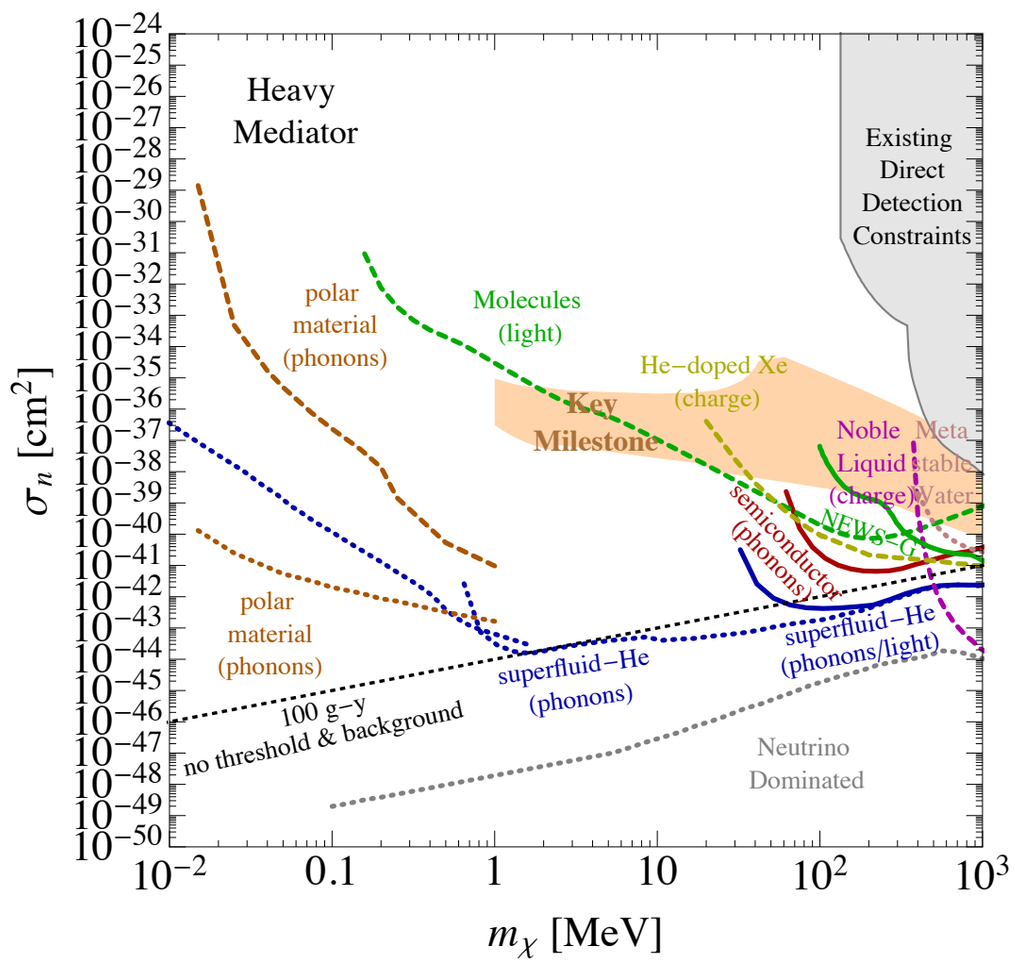
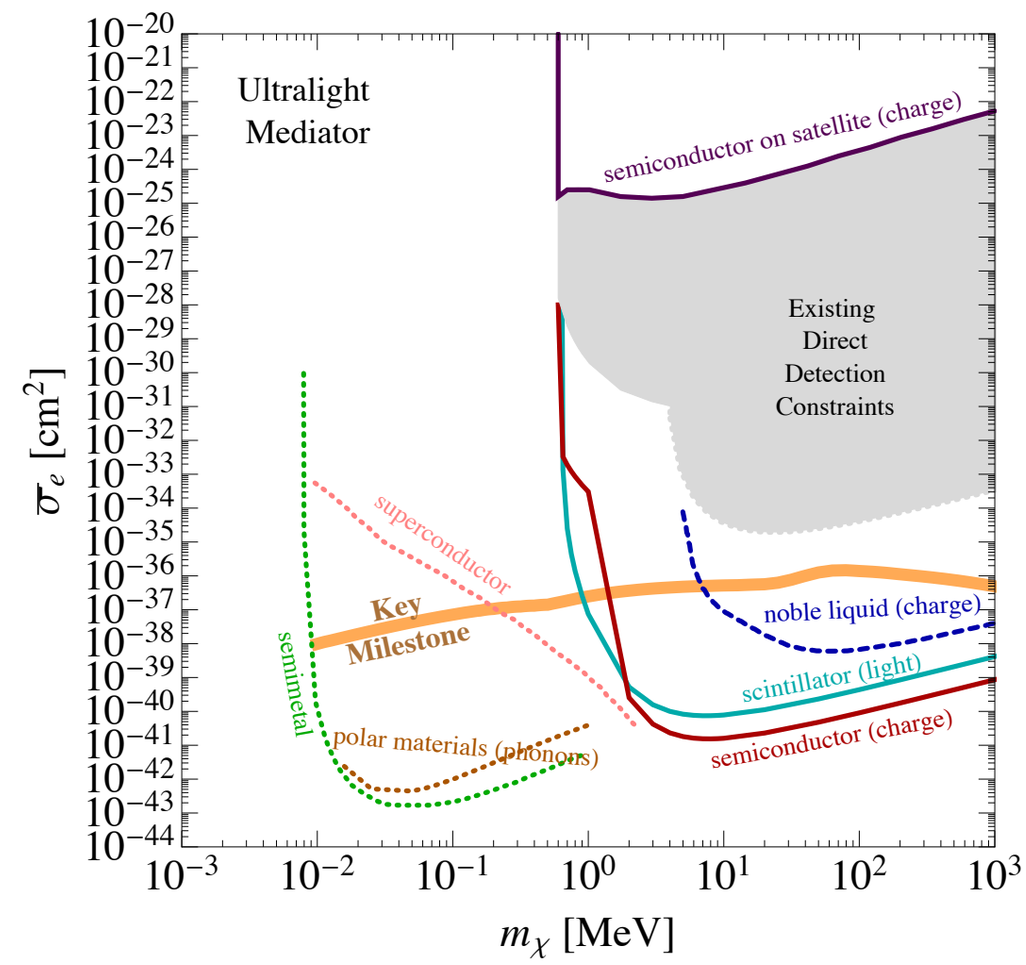
many ideas for probing

- DM scattering: $m_\chi \gtrsim \mathrm{keV}$





BRN DM report

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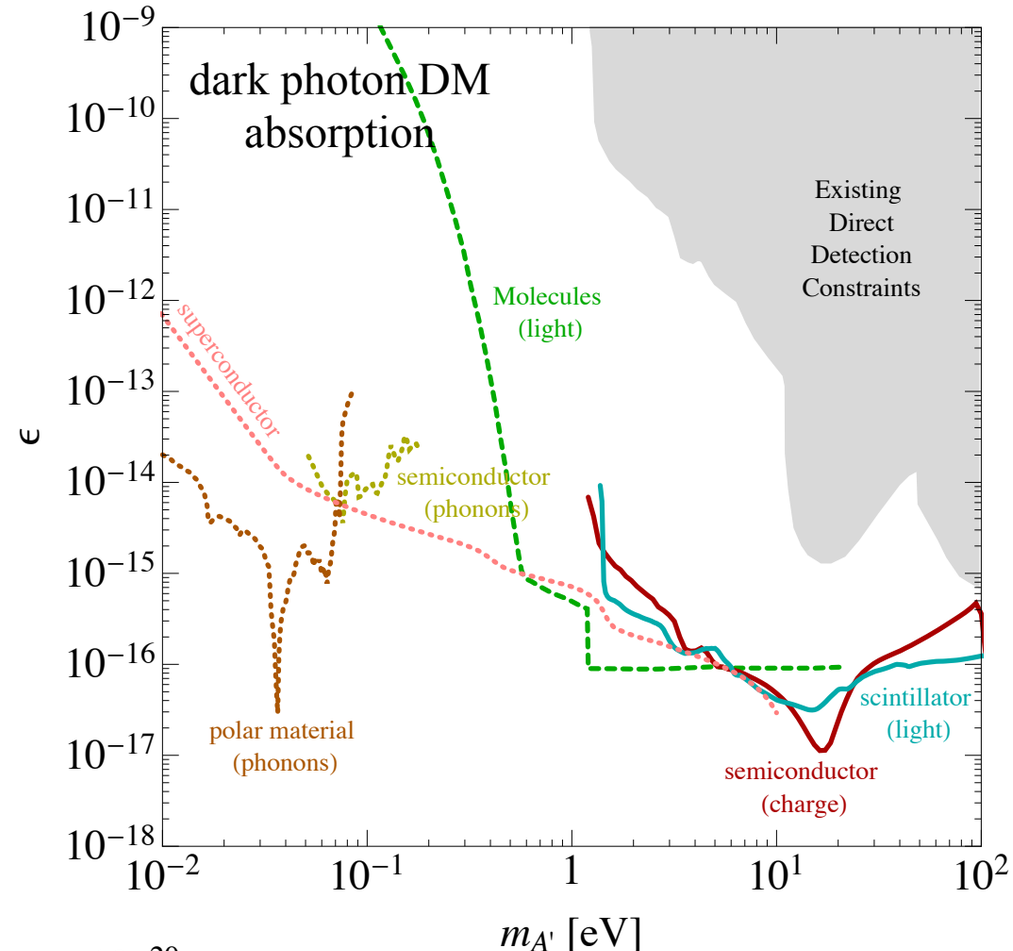

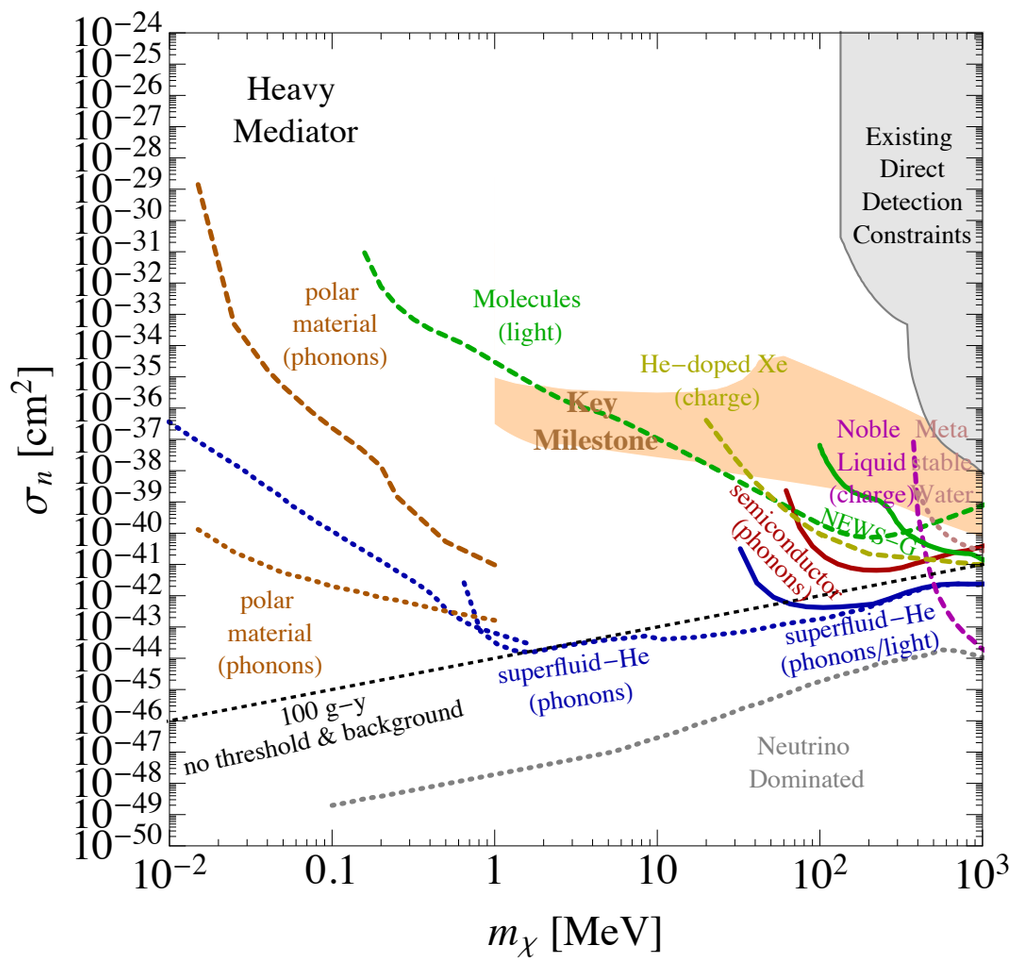

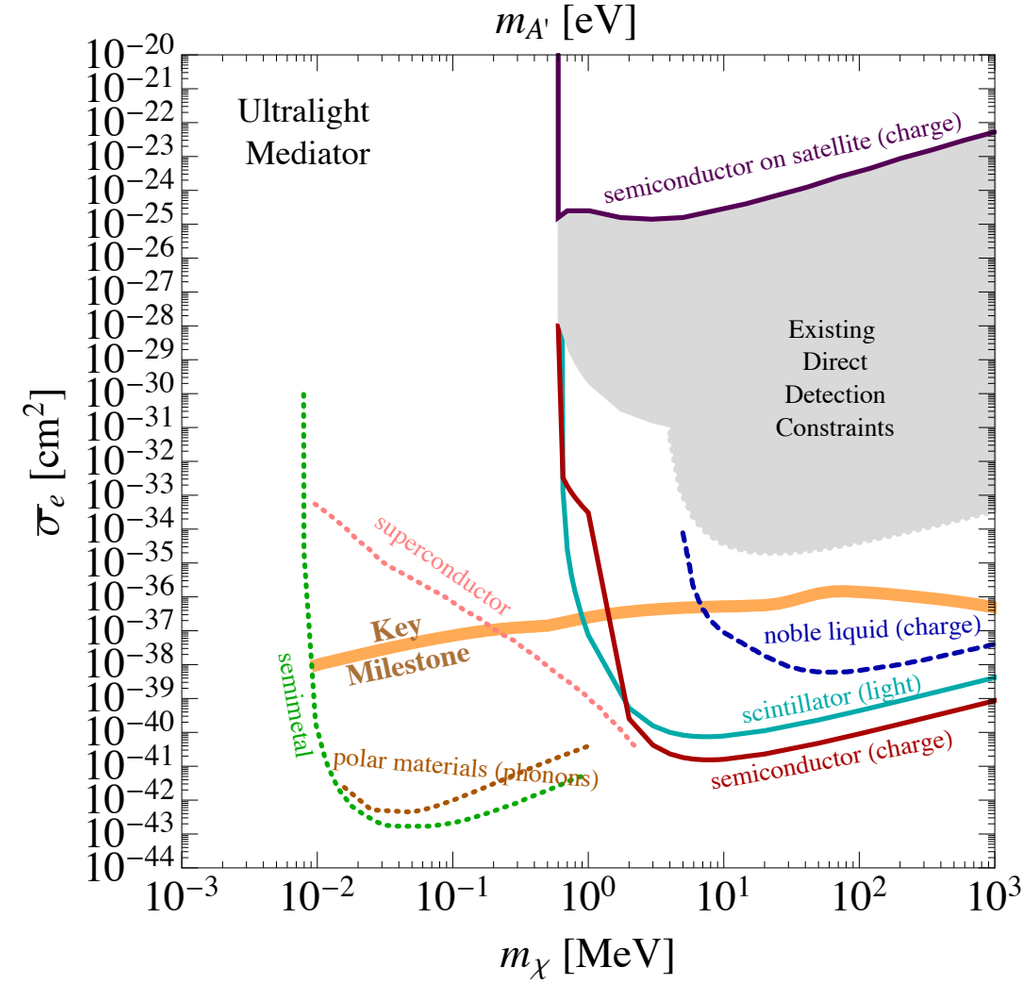

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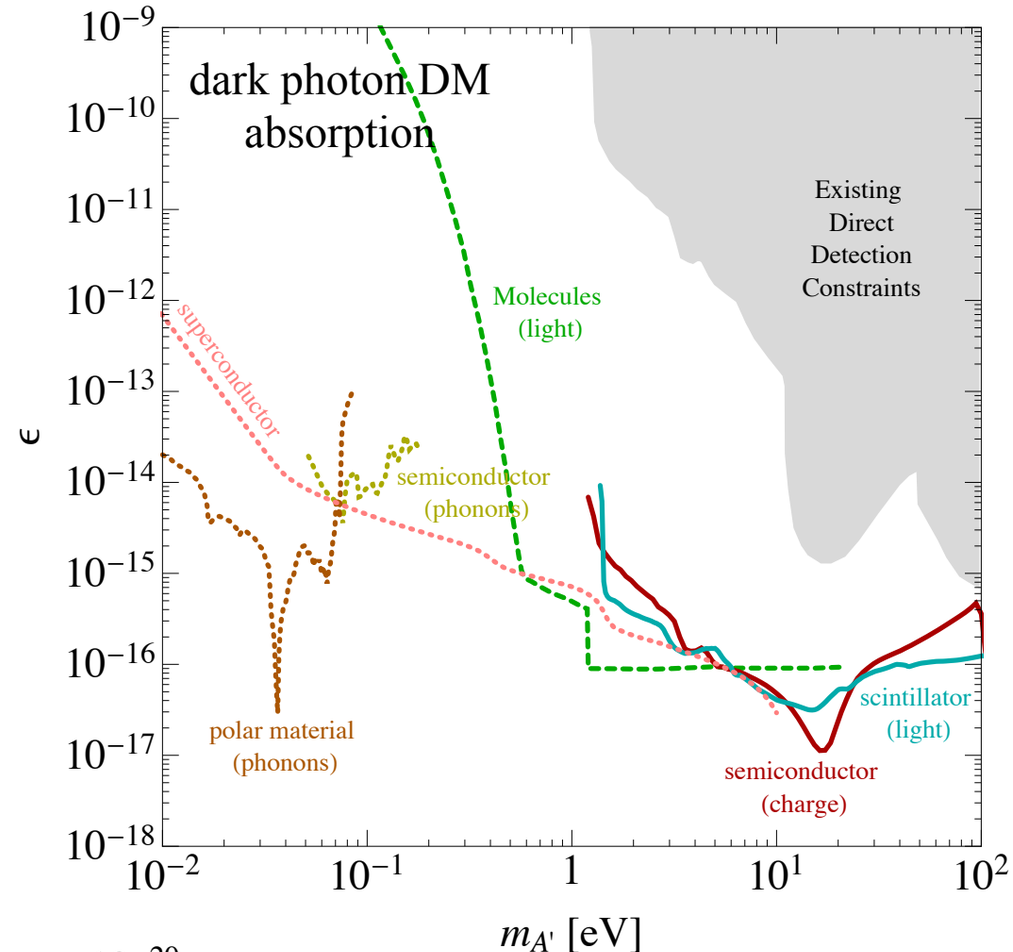

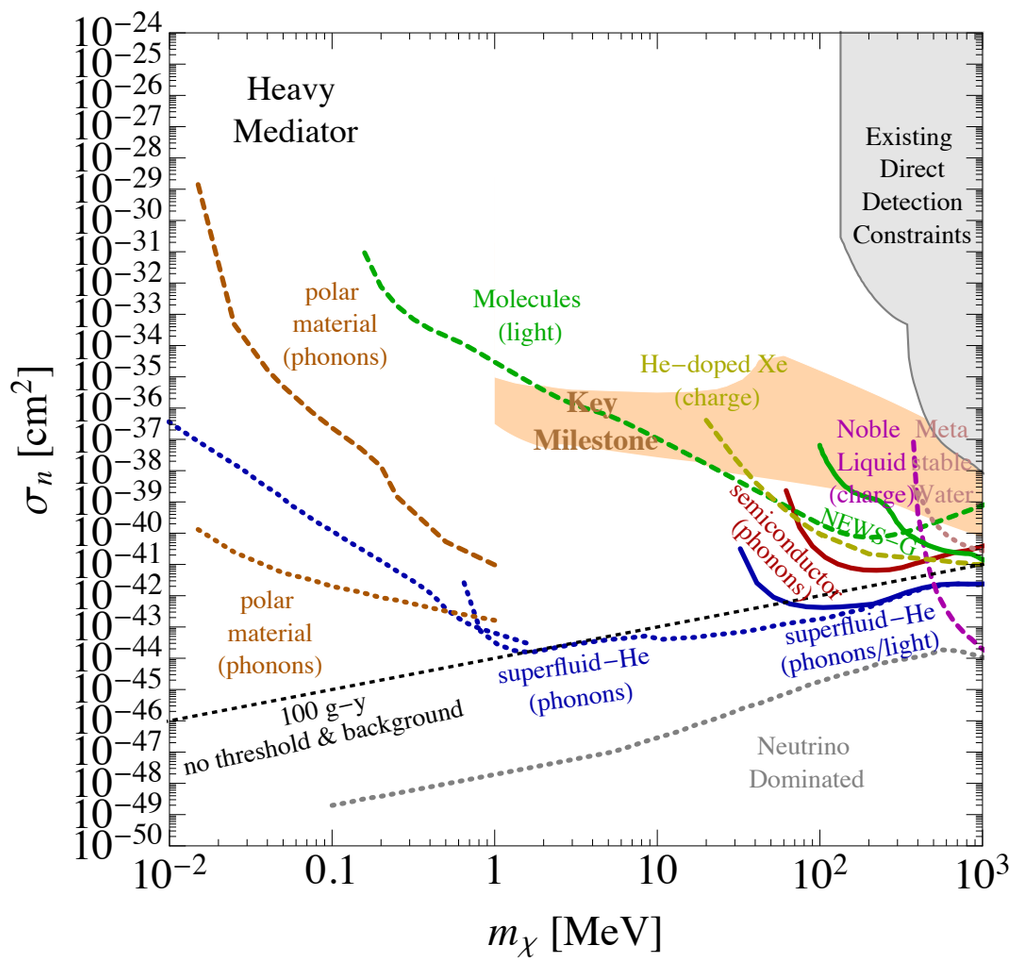

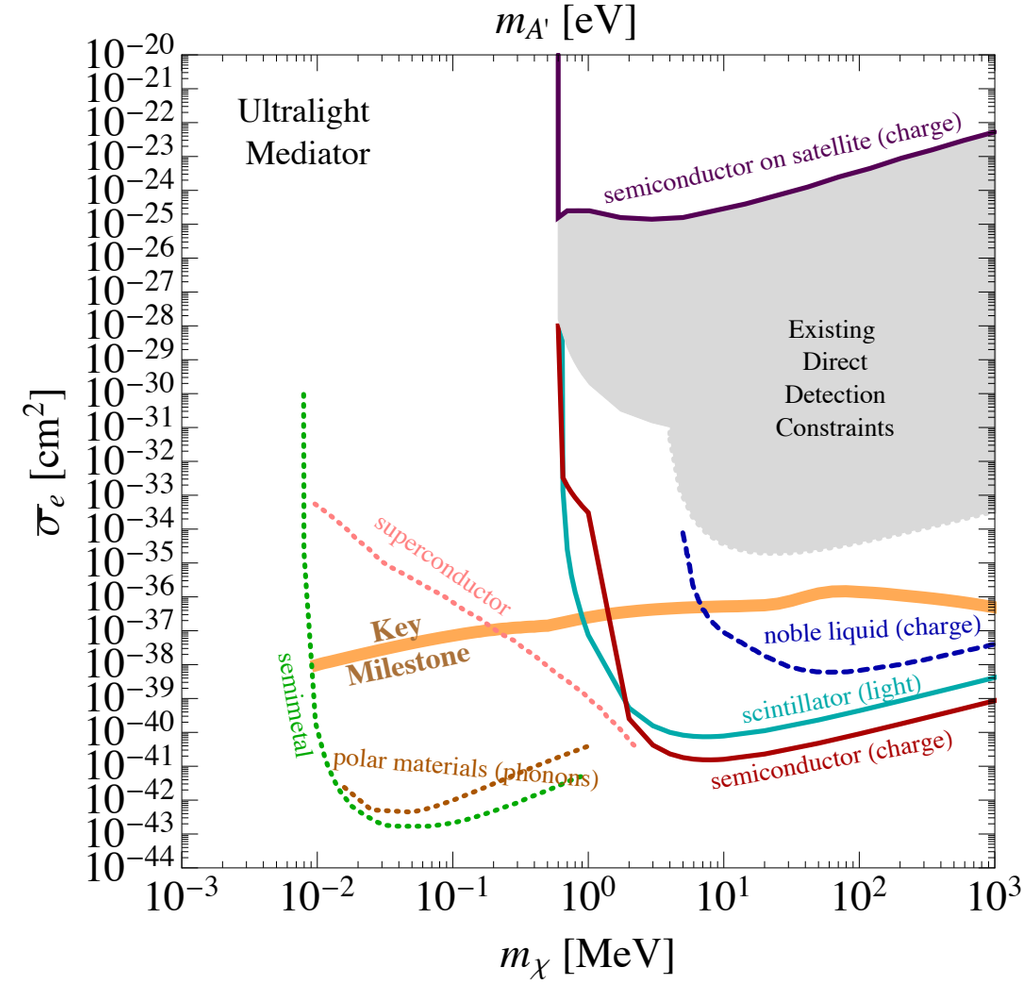

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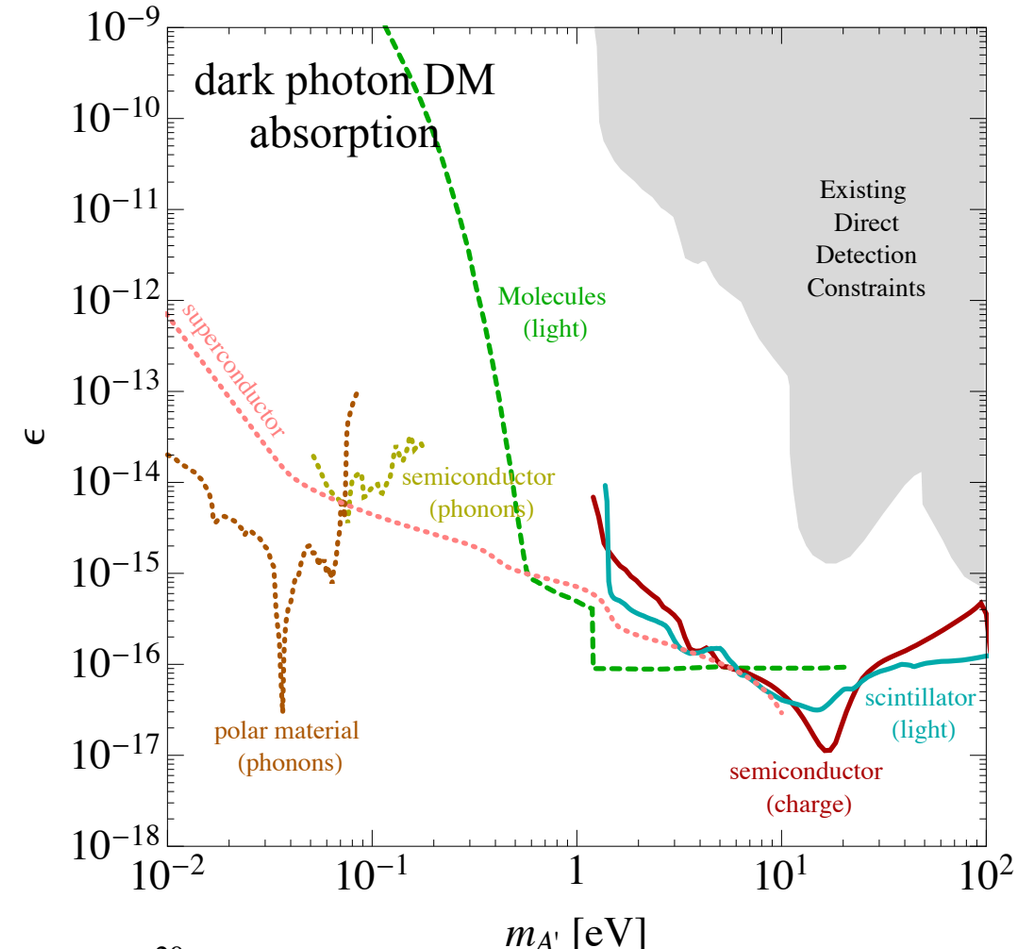

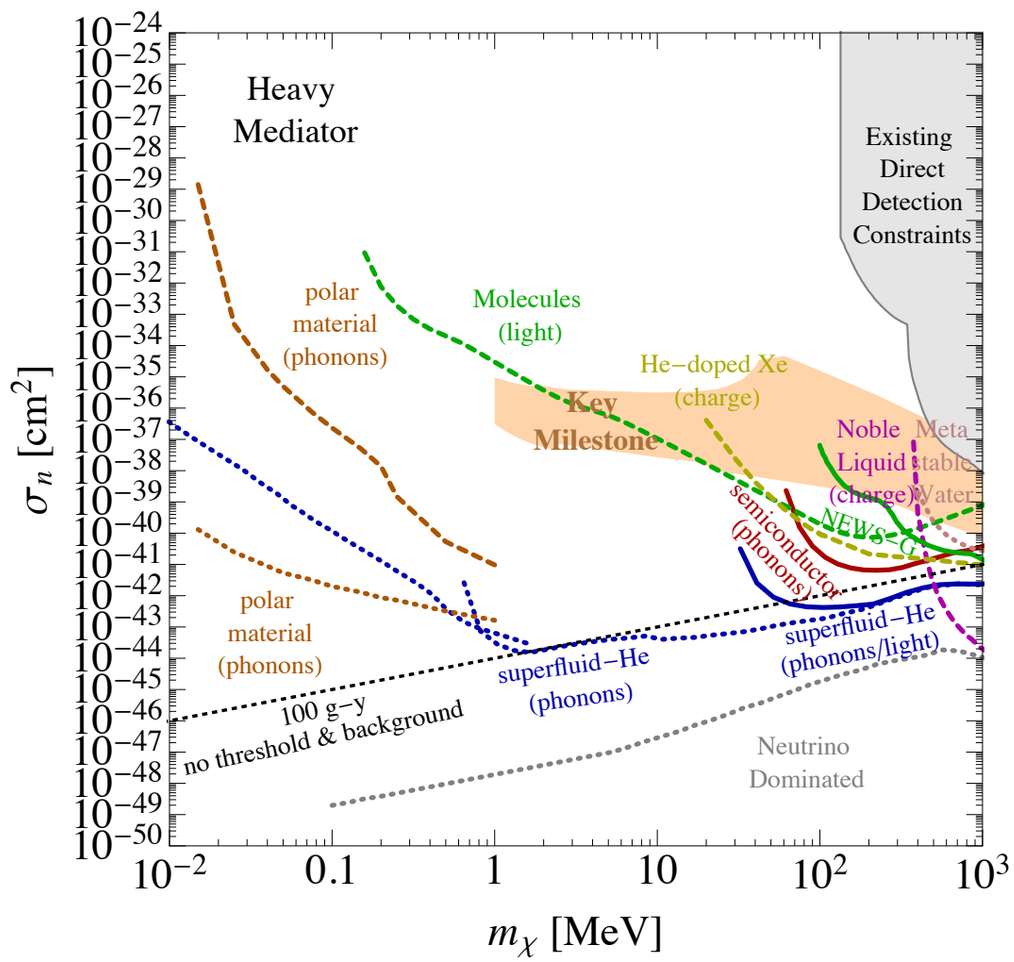

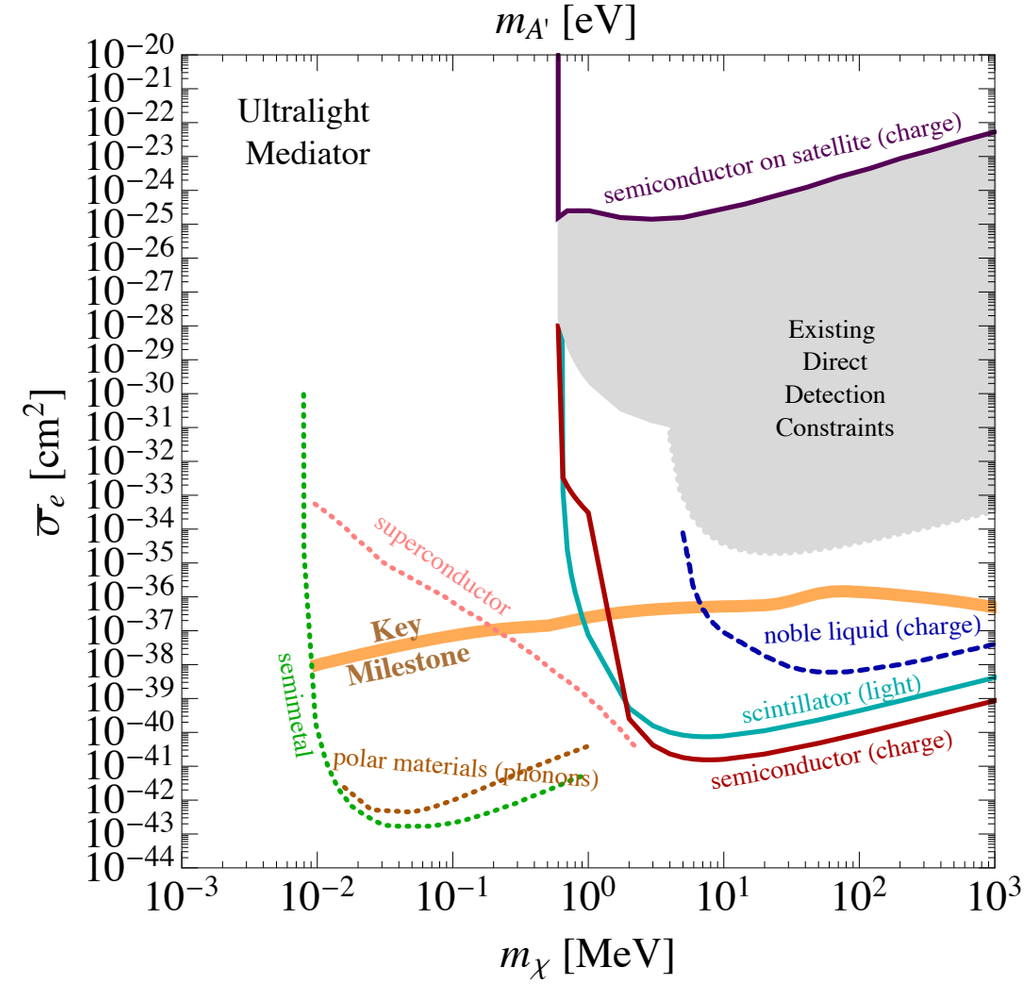

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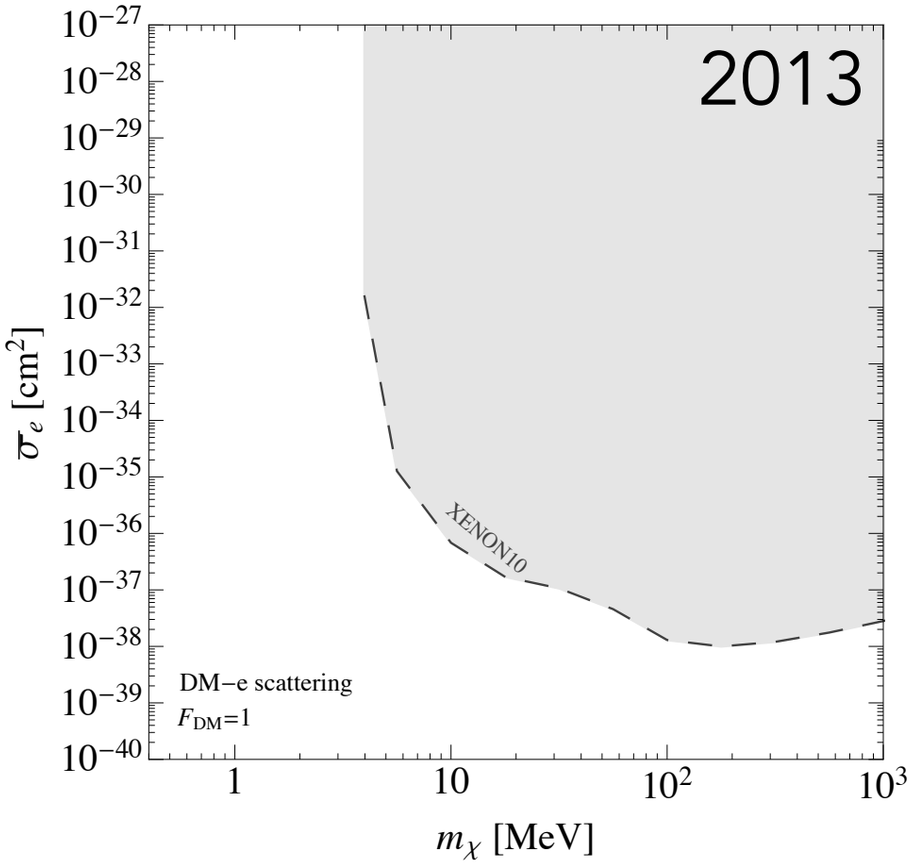
Exciting experimental progress



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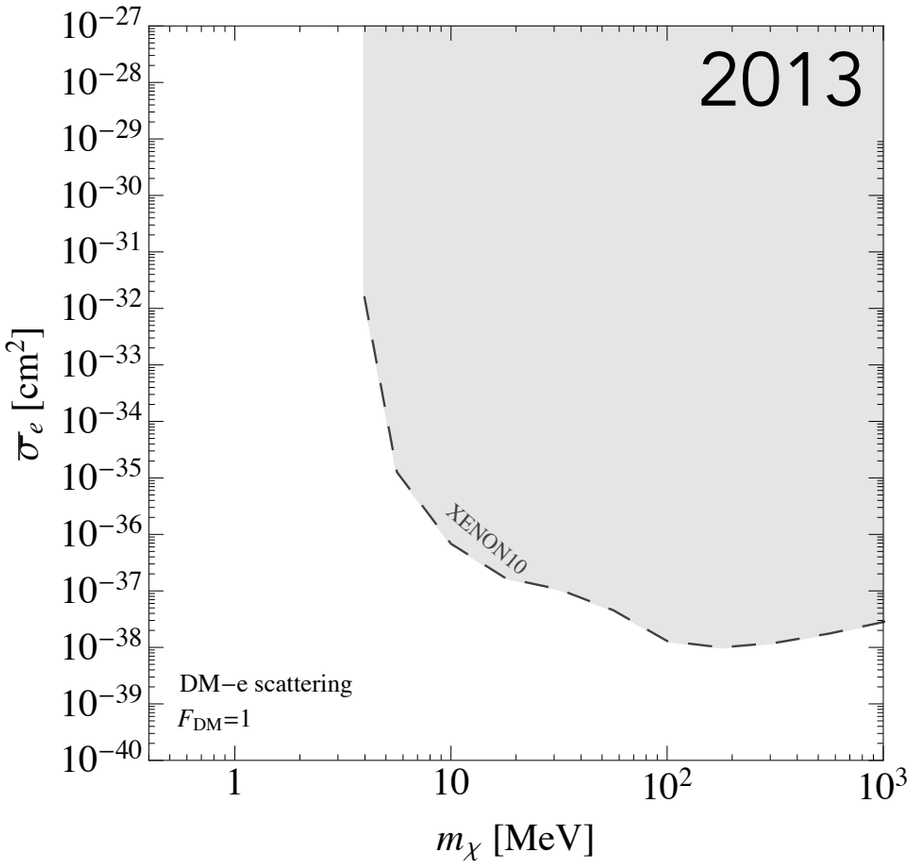

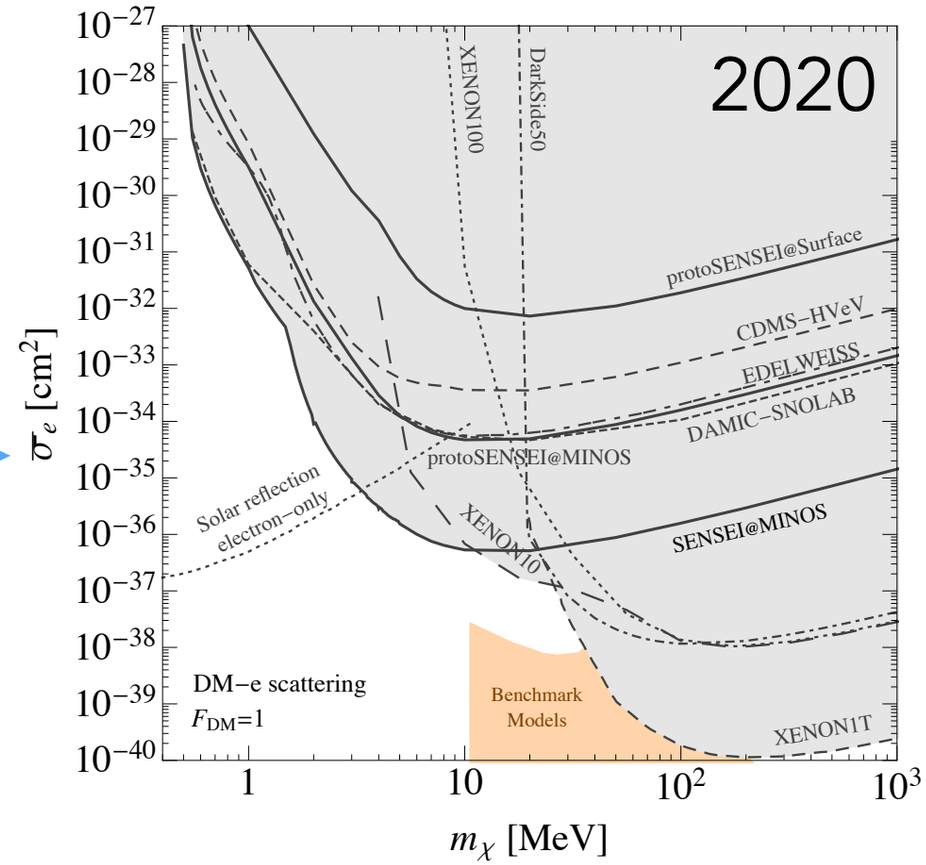

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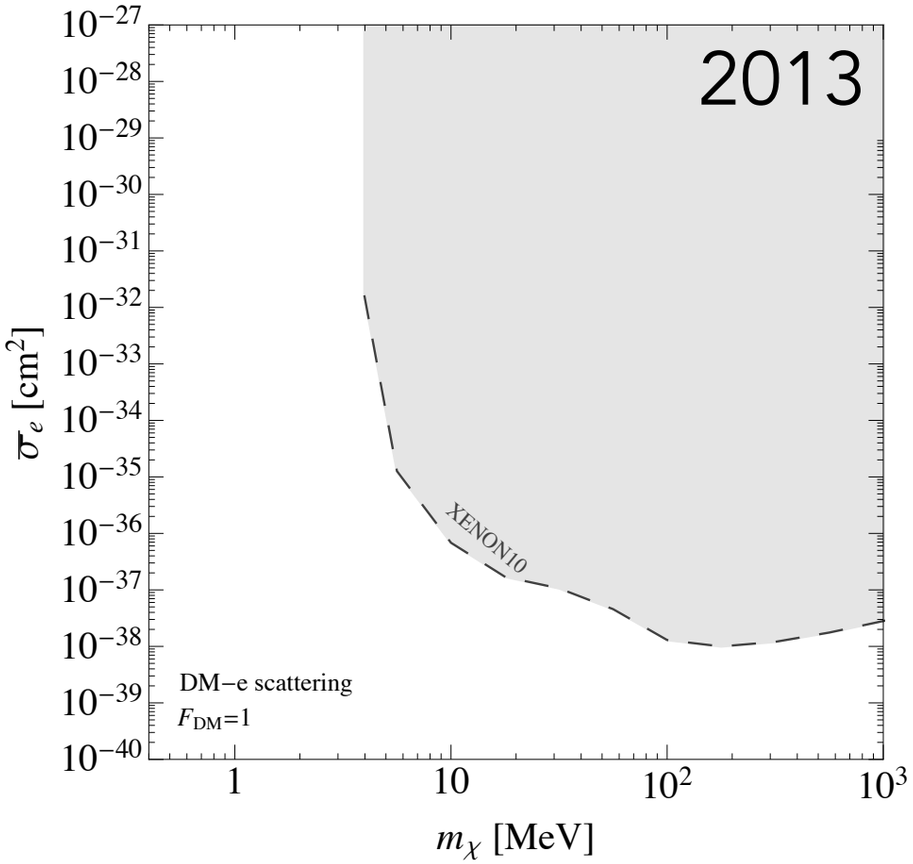

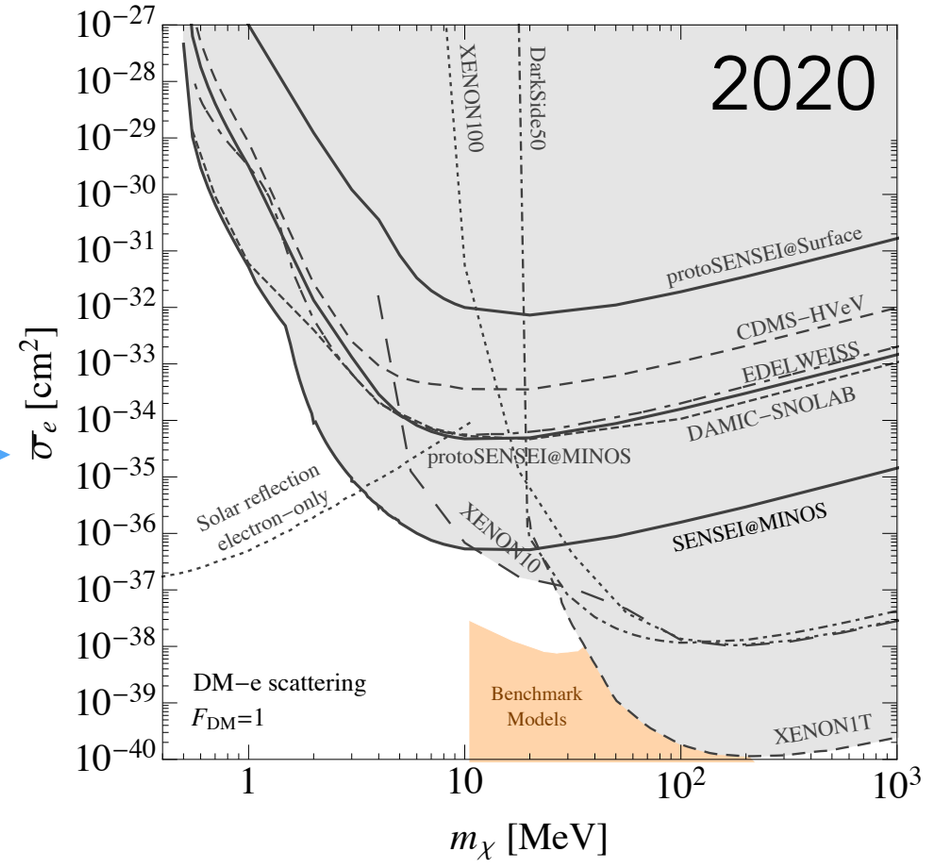

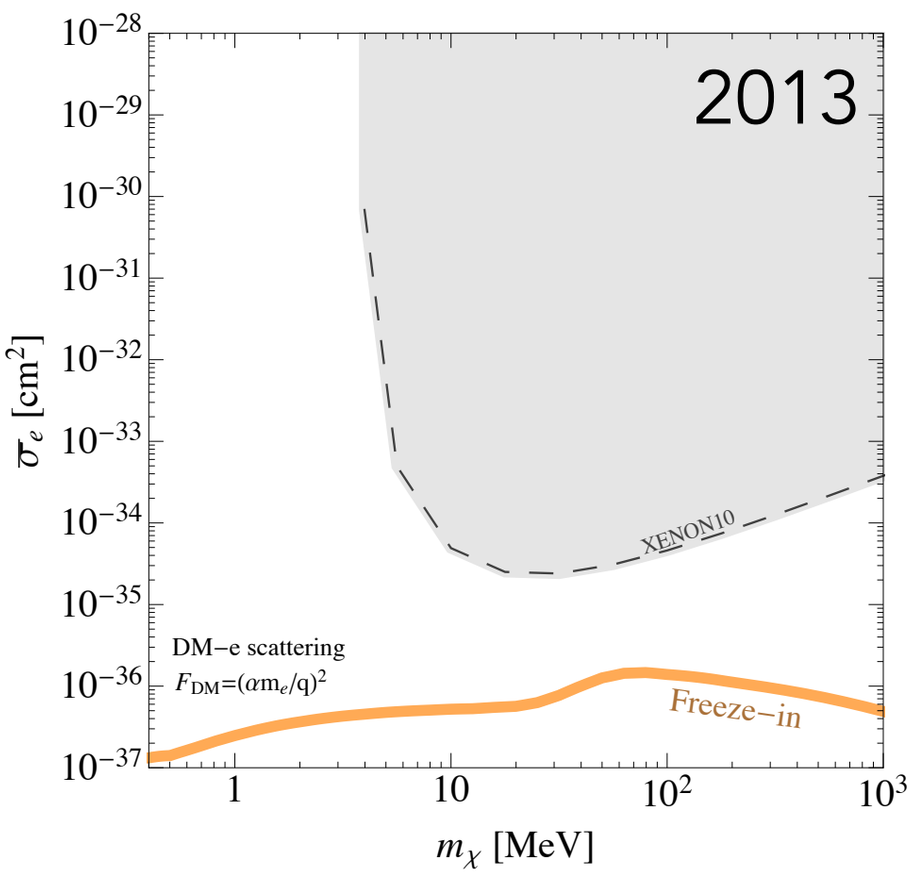

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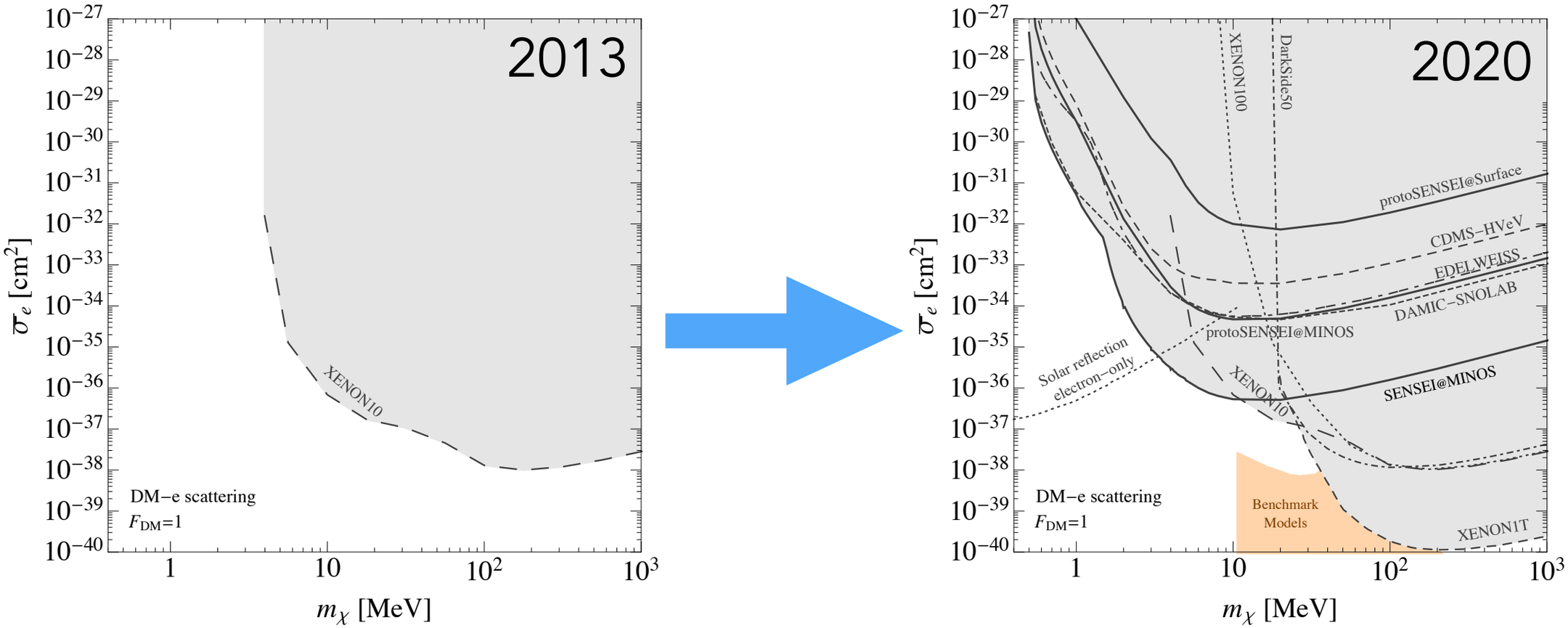

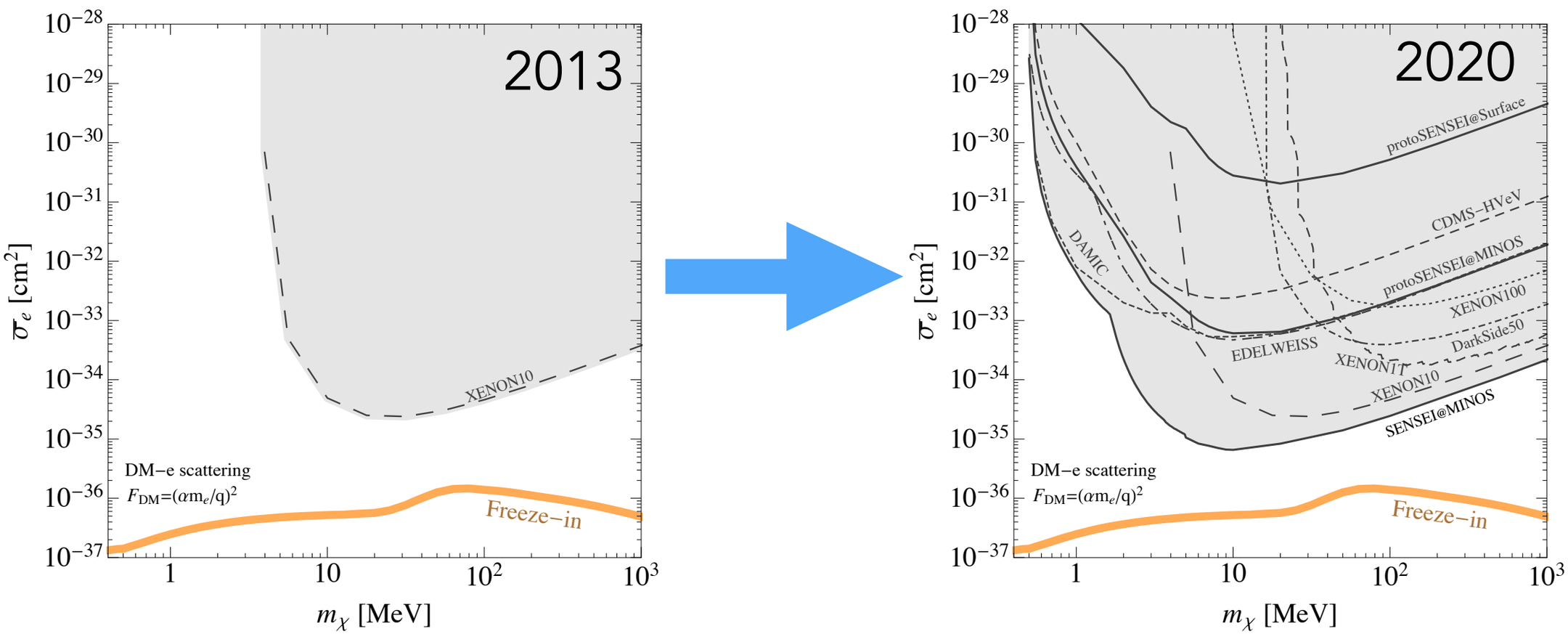

[slide from Tongyan Lin]

CF1 letters of interest

147 LOIs cross listed with CF1 - the most of any topical group!

Around 70 LOIs related to this session:

- ~21 LOIs on theory of dark sectors and searches (cross listed with TF)
- ~24 LOIs on R&D and experiments for direct detection of sub-GeV dark matter (cross listed with IF)
- ~21 LOIs on dark sector searches with neutrino experiments, sterile neutrino dark matter searches, and proposed accelerator experiments (cross listed with AF, RF, and NF)
- ~10 LOIs on astro probes (many others within CF3)

Several community "summary" reports available

Valuable resources for new Snowmass reports on "dark sectors", including particle-like DM, wave-like DM, and accelerator probes of DM + dark sectors:

- Fundamental Physics at the Intensity Frontier 2012 1205.2671
- Working Group Report: New Light Weakly Coupled Particles 2013 1311.0029
- Dark Sectors 2016: Community Report 1608.08632
- US Cosmic Visions: New Ideas in Dark Matter 2017 1707.04591
- DOE Basic Research Needs for:
  - DM Small Projects New Initiatives Report 2019
  - High Energy Physics Detector Research and Development Report 2020

https://science.osti.gov/hep/Community-Resources/Reports

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5. Understand, characterize, and mitigate low-energy backgrounds

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If challenges are overcome — and I strongly believe they will be — the next 10 years will probe particle-like DM over multiple orders of magnitude in (several) coupling vs mass parameter spaces

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By showcasing incredible breadth of detection concepts, technologies, and experimental progress, Snowmass report will make it easy for P5 to argue again for the importance of R&D & a small projects portfolio

Many thanks to the conveners for all their efforts!!