Explaining CoGeNT and DAMA with Backgrounds

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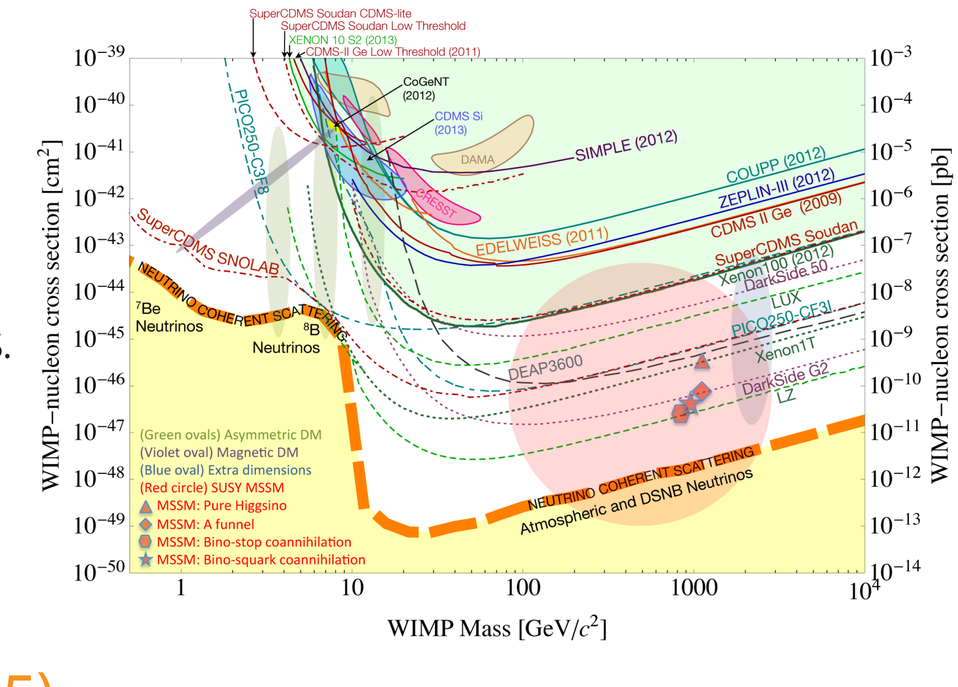
Direct Detection

Direct Detection experiments aim to detect Dark Matter originating in the galactic halo. Recently there have been claims of tension between experiments claiming discovery and those setting limits.

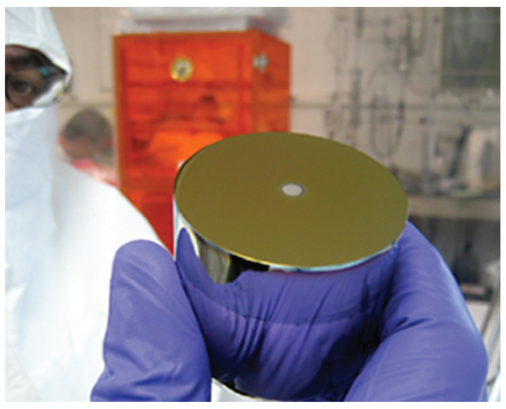
The CoGeNT collaboration claimed until recently to observe a low-energy rise in their data, which was not compatible with known backgrounds. This fit well to a Dark Matter recoil signal, but required a mass and cross section incompatible with other experiments such as LUX and SuperCDMS.

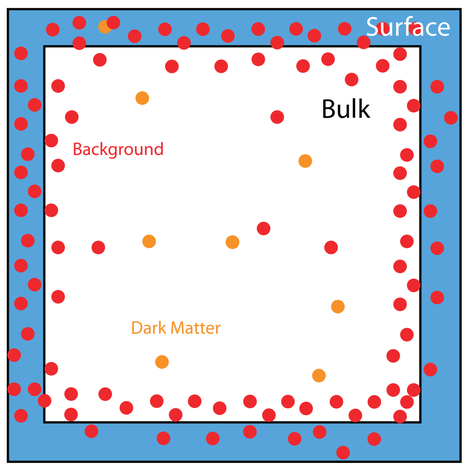
The DAMA/LIBRA experiment observes an annual modulation at 9.2 sigma, which peaks in late May. This is consistent with expectation from Dark Matter with a maximum day on June 2nd, however such a signal requires a mass and cross section incompatible with other experiments.



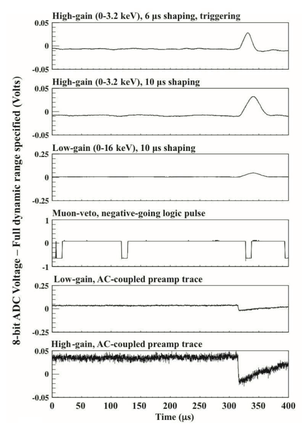
CoGeNT

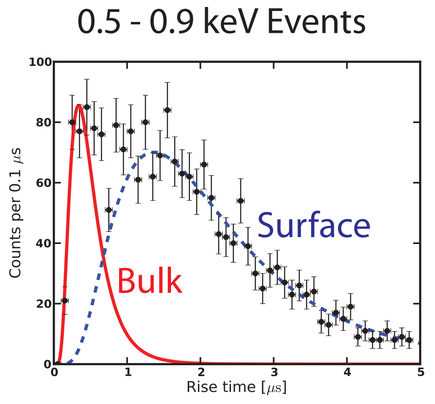
Based on Davis, McCabe and Boehm (arXiv:1405.0495)

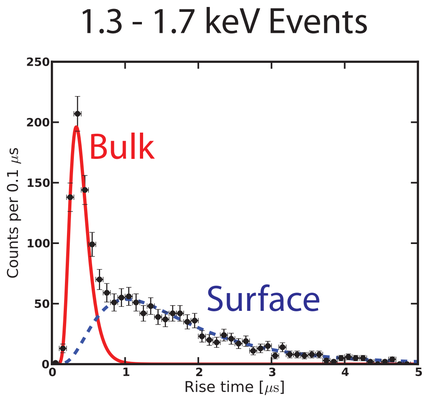




1. Events are measured in either the surface or bulk of the detector. Those on the surface are dominated by background and so must be removed. The surface of CoGeNT is the `transition region' where events are measured with lower energies, and so their spectrum mimics that of Dark Matter recoils.

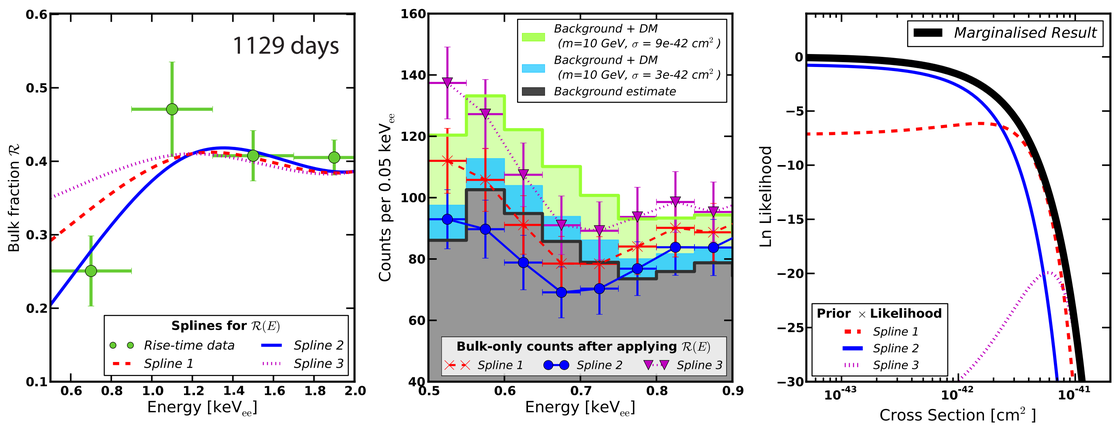






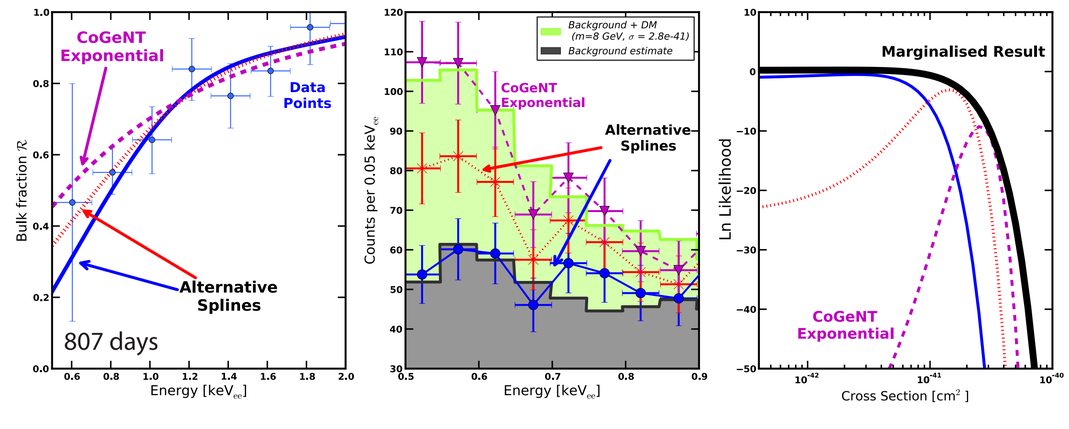
2. Events in CoGeNT are composed of rapid changes in the measured voltage. The size of the voltage difference gives the energy while the duration is quantified as the rise-time.

3. Bulk events are faster on average than surface events, leading to two distinct populations in rise-time. Both can be fit to log-normal (or Pareto) distributions however the large overlap at low-energy introduces uncertainty into the fits.



4. Use the fits to the rise-time data to determine the Bulk Fraction: the fraction of events which are from the bulk, as a function of energy.

5. Fit cubic splines to the bulk fraction (left panel) to parameterise its energy dependence. Each of these leads to a different bulk-only spectrum (central) e.g. spline 3 has a low-energy excess while spline 2 does not. Hence each spline gives a different Likelihood (right). Marginalise over all splines to integrate out this uncertainty. This leads to less than one sigma evidence for Dark Matter.



6. We also analyse the 807 live days data, which was used by CoGeNT to derive their `region of interest' in the Dark Matter parameter space.

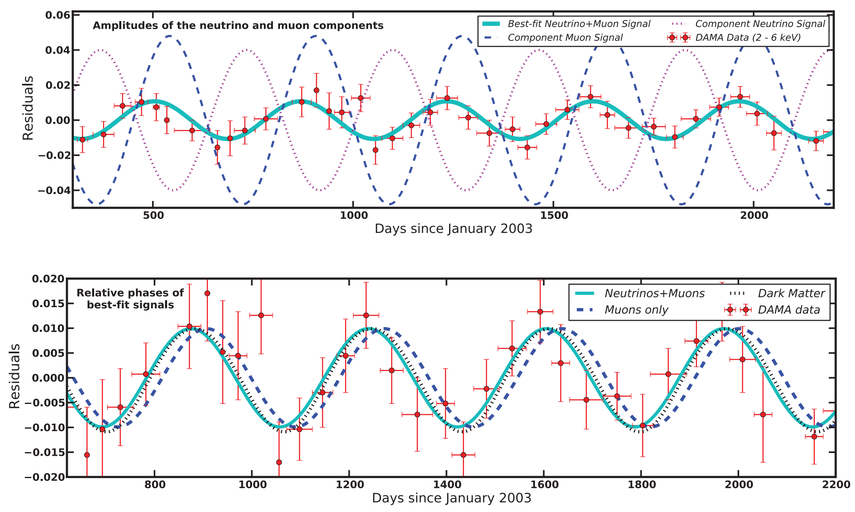
7. CoGeNT used only a one-parameter exponential without theoretical basis. We label this as `CoGeNT Exponential'. However this does not capture the measured uncertainty at low-energies and the cubic splines are other plausible choices for the bulk fraction. The central panel shows that the presence of a low-energy excess depends strongly on the choice of bulk fraction. Hence when marginalising the significance for Dark Matter vanishes and so the `region of interest' resulted from a bias introduced by the choice of exponential function.

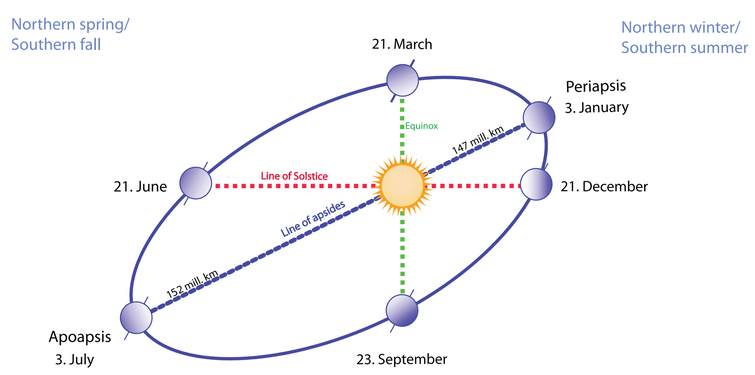
DAMA

There are other potential sources of modulation in DAMA. Muon-induced neutrons are correlated with the temperature of the atmosphere, but due to this they peak about 30 days too late.

Solar neutrinos are also capable of stimulating neutron emission in targets around DAMA. Their flux varies with the Earth-Sun distance and so is largest in early January.

Combining the two allows for a modulation which fits that observed by DAMA as well as Dark Matter.





DAMA: R. Bernabei et al., Eur.Phys.J. C73, 2648 (2013), 1308.5109.
CoGeNT: C. Aalseth et al., Phys.Rev. D 88, 012002, 1208.5737 and arXiv:1401.3295
Direct Detection Figure: Snowmass Report at arXiv:1310.8327
Earth Orbit Figure: http://en.wikipedia.org/wiki/Earth's_orbit#mediaviewer/File:Seasons1.svg

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