

# **Toward A Consistent Picture For CRESST, CoGeNT and DAMA**

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# Current State of Direct Detection Experiments

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- Three dark matter direct detection experiments (DAMA/LIBRA, CoGeNT, and CRESST-II) have each reported signals which are not consistent with known backgrounds
- The signals do resemble that predicted for a dark matter particle with mass of  $\sim 10$  GeV and cross section with nucleons  $\sim 10^{-41}$ -  $10^{-40}$  cm<sup>2</sup>
- These signals are also faced but null results of several other experiments
- Can the signals of these experiments be explained by a single species of dark matter particle, without conflicting with the constraints of other experiments?

# What's going on with these surface events?



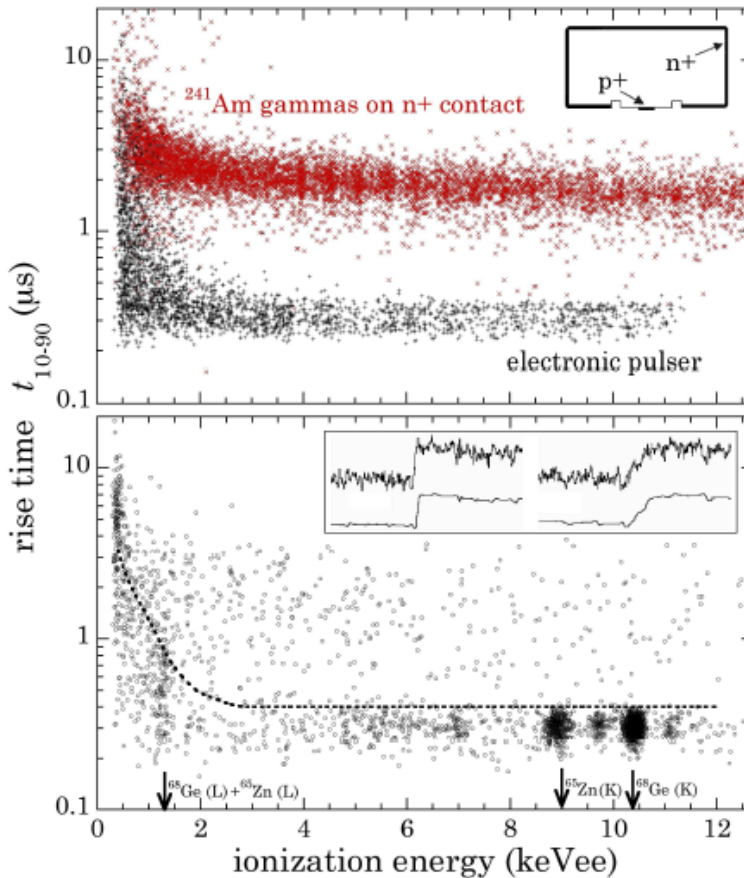
Optimist: A bit of a moving target is expected



"All our vehicles come with a 24-hour, round-the-block guarantee."

Pessimist: Replace vehicle by "signals"

# A theorist's understanding of surface events

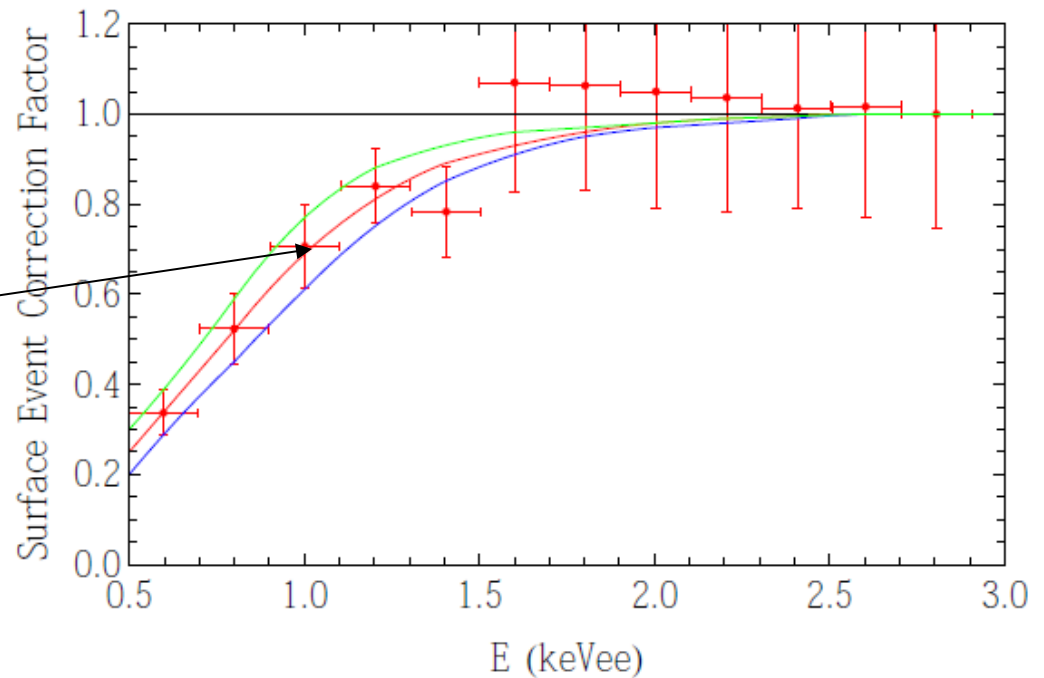
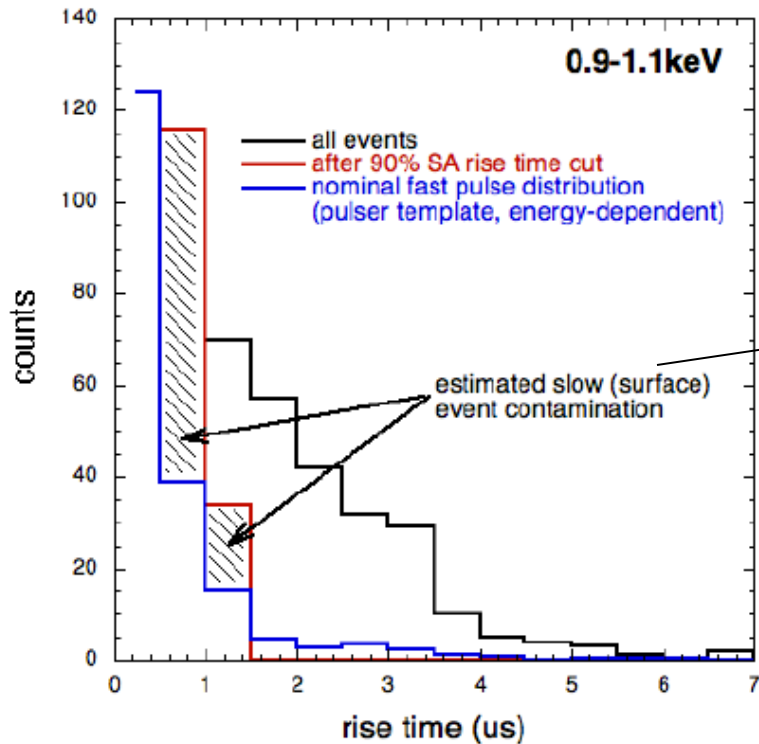


← surface events (calibration)

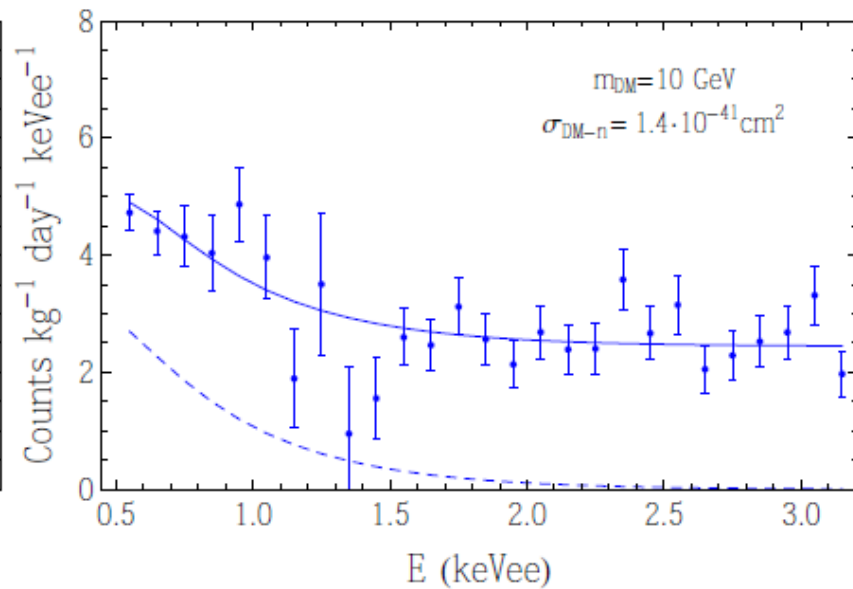
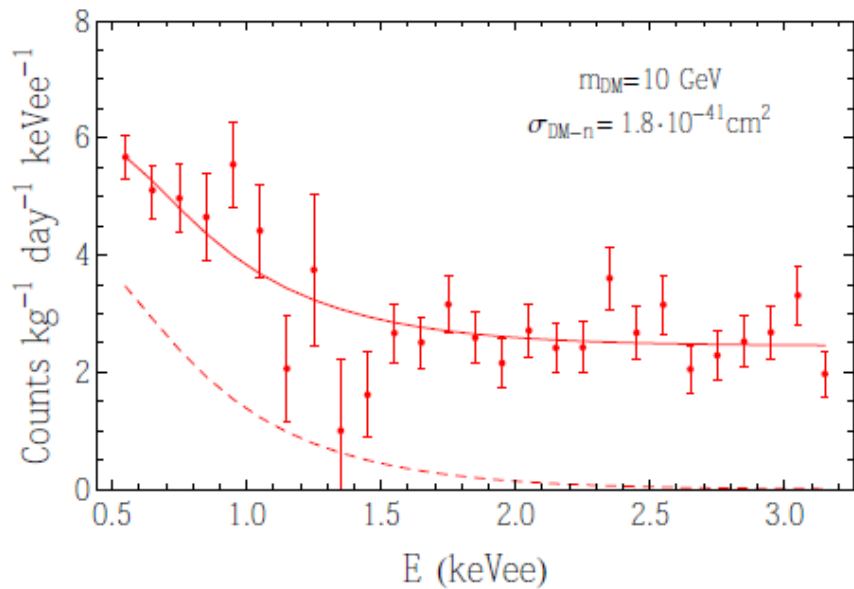
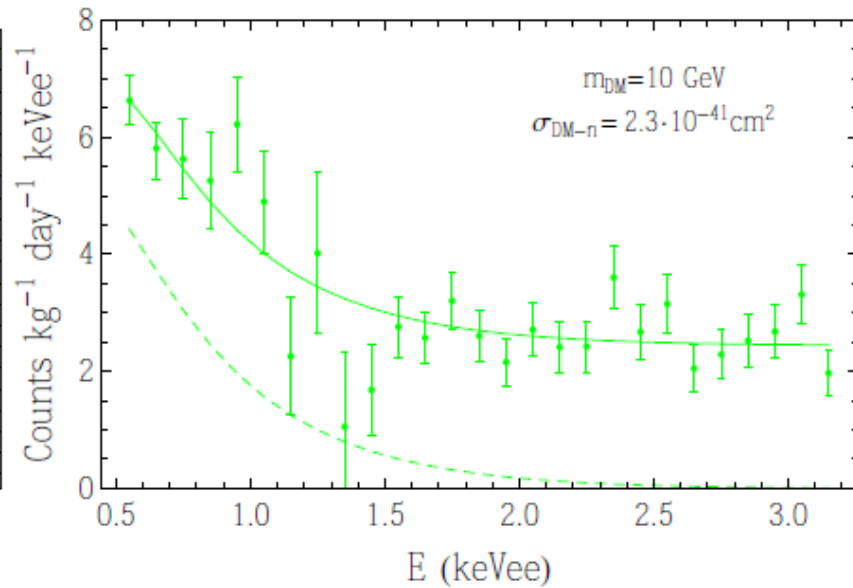
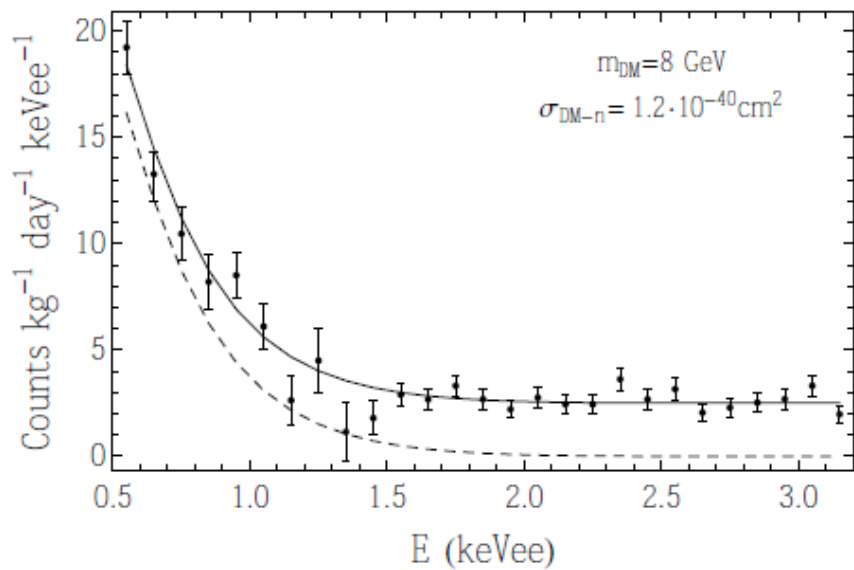
← bulk events

8 weeks of data, 3 months  
after entering Soudan

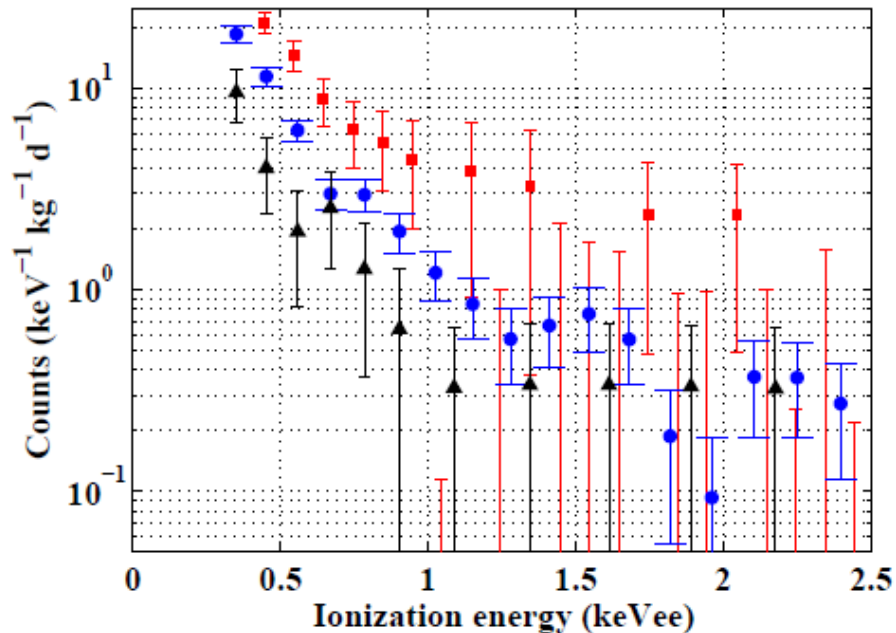
# A theorist's understanding of surface events



From Juan's talk



# Is the spectrum consistent with CDMS?

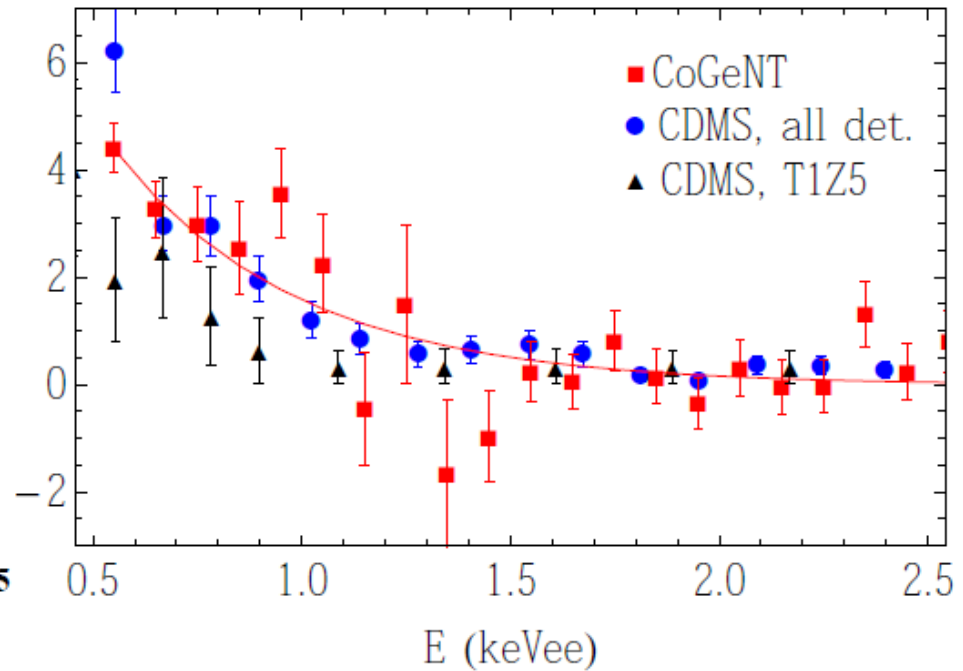
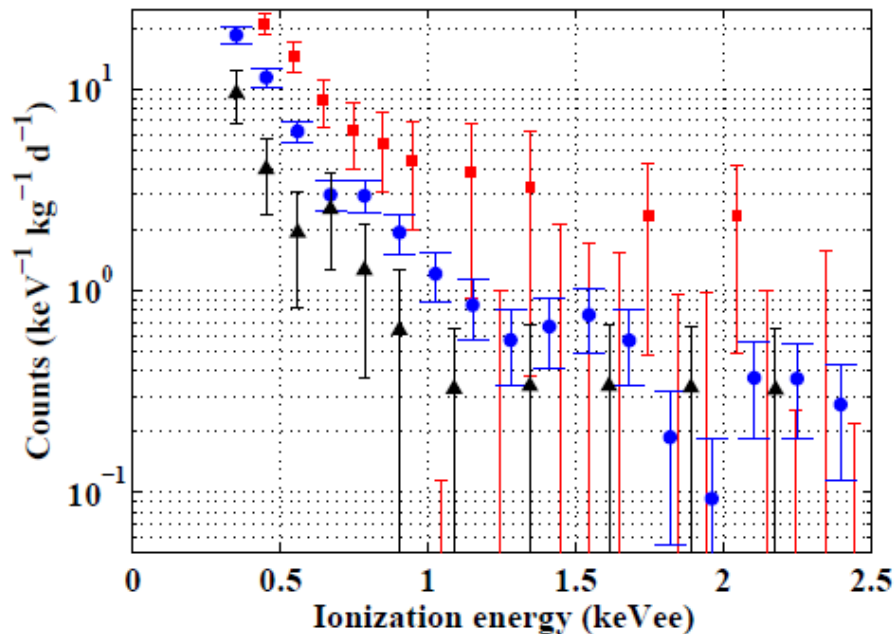


The original CoGeNT excess spectrum (that included the surface event contamination) was larger the spectrum measured at CDMS.

This is difficult to explain any way other than with detector systematics.

# Is the spectrum consistent with CDMS?

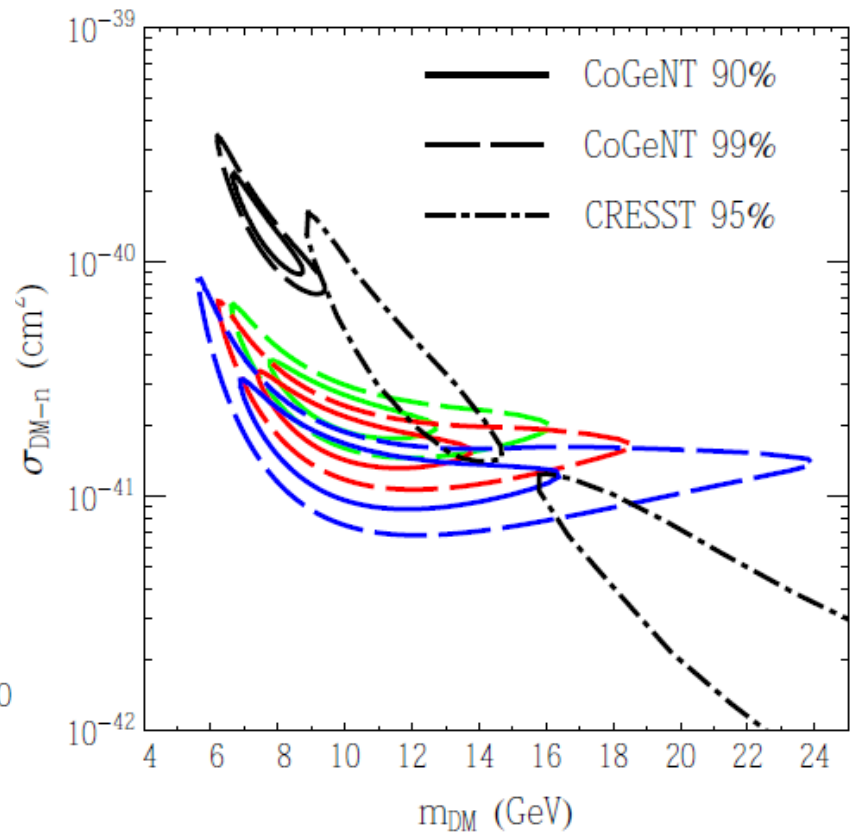
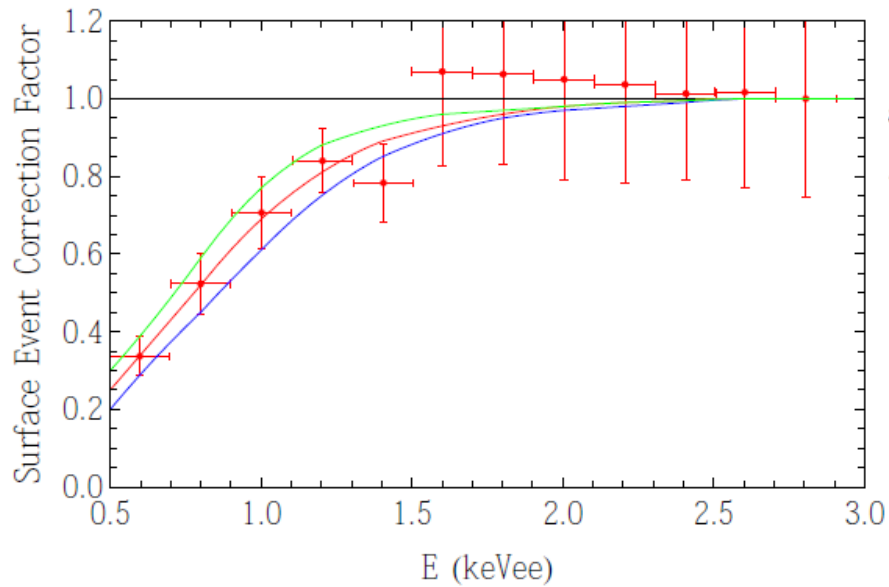
## CDMS?



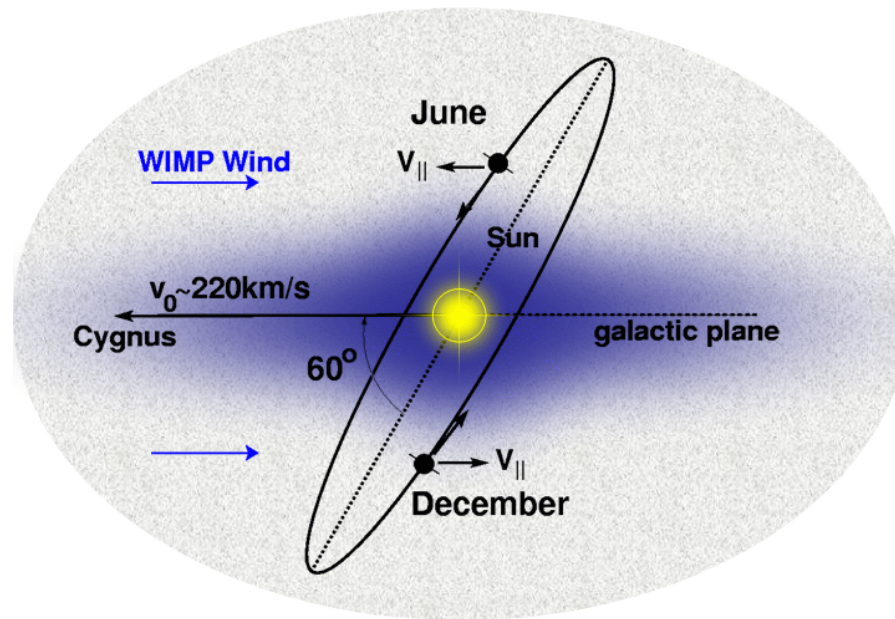
Excluding these additional surface events in CoGeNT brings the two spectra into much better agreement



# CoGeNT and CRESST

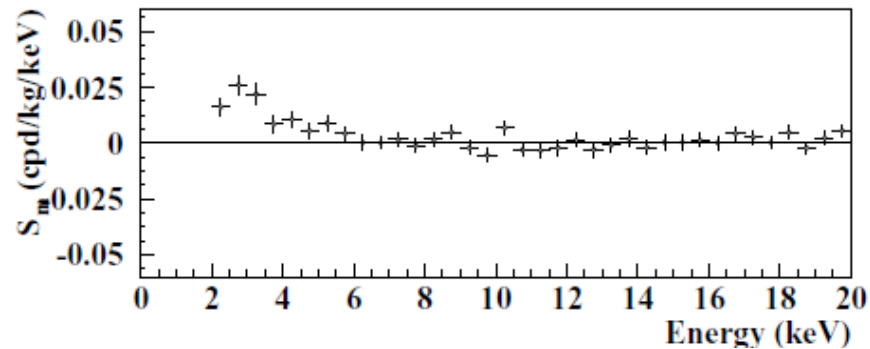
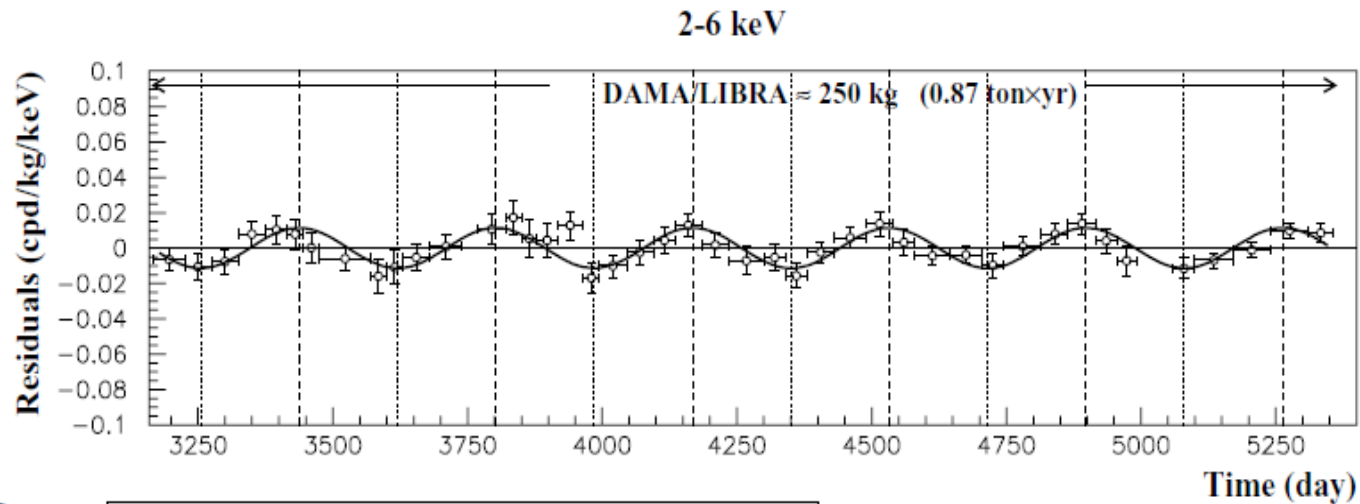


# Dark Matter Should Have Annual Modulation



<http://www.hep.shef.ac.uk/research/dm/intro.php>

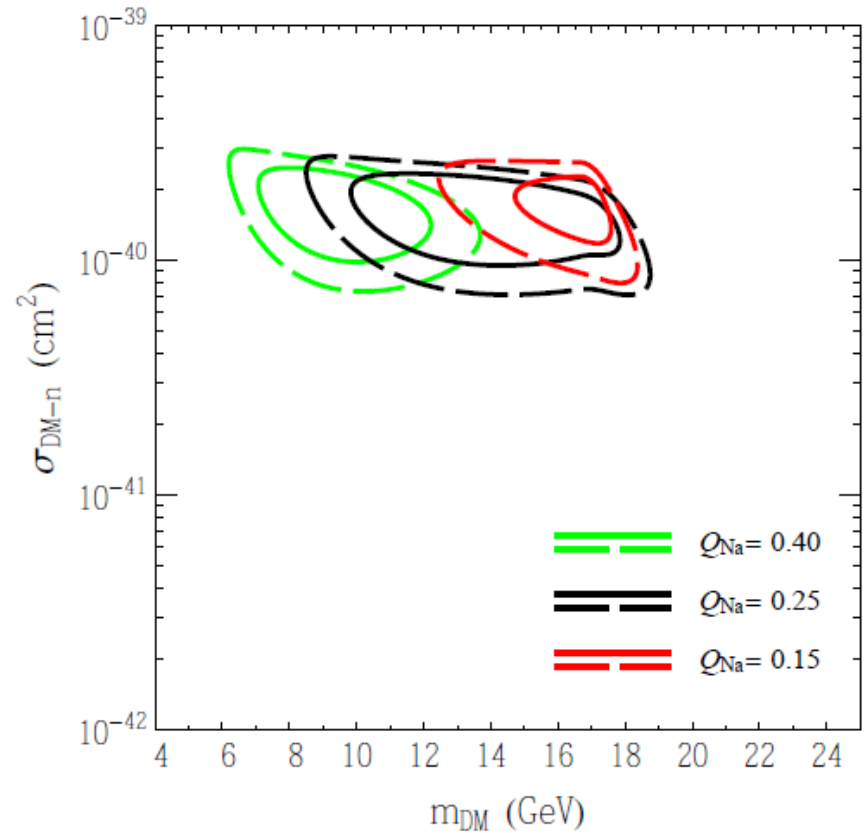
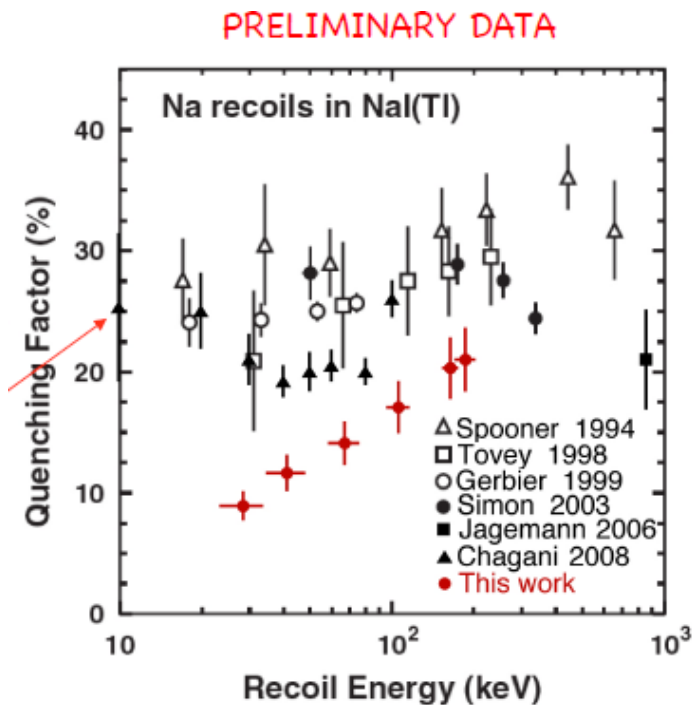
# DAMA (NaI) Claim



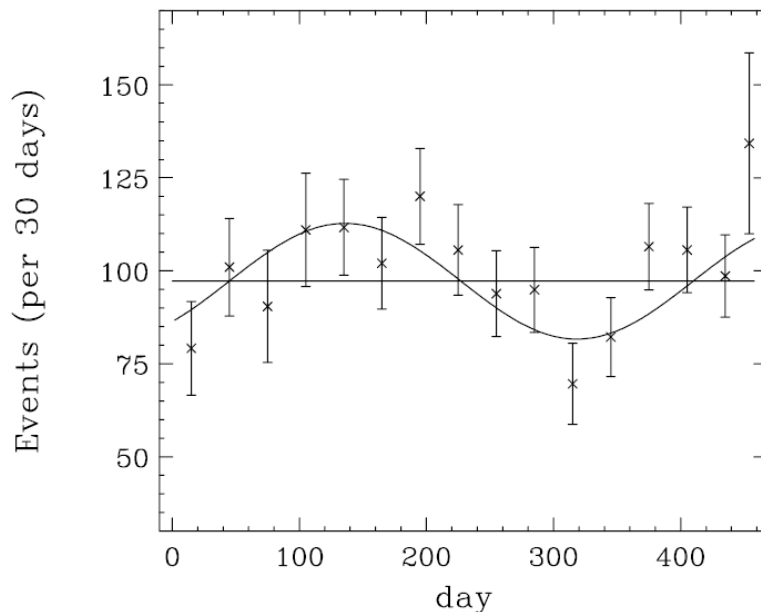
Rita Bernabeia, et. al.

Nuclear Physics B (Proc.  
Suppl.) 212–213 (2011)  
307–314

# Quenching factor for Na

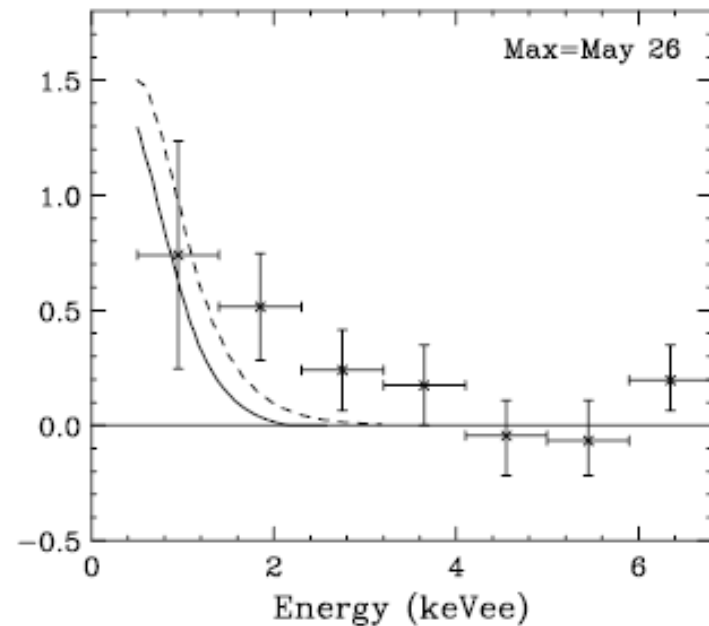
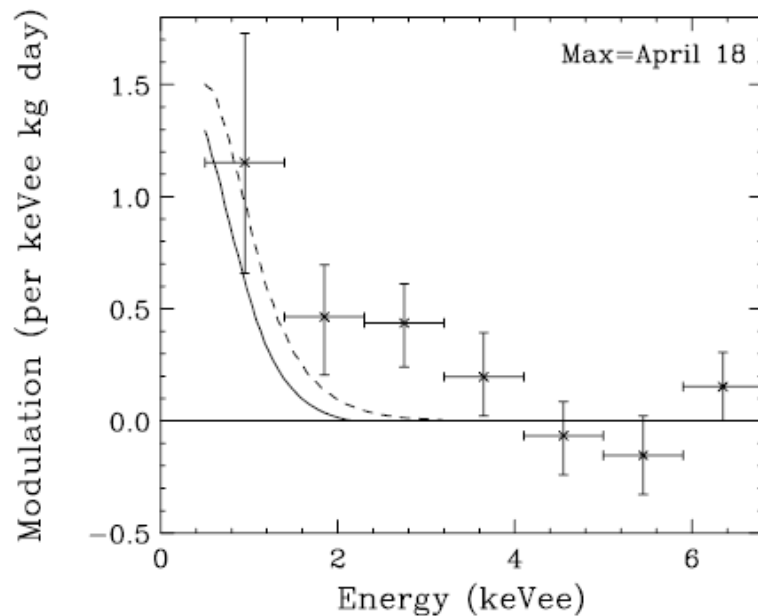


# Modulation in the CoGeNT data



- We find modulation of  $16\pm 5\%$  at the 2.7 sigma level
- The best fit to the peak is found to be at April  $18\pm 16$  days
- DAMA peak is May  $16\pm 7$  (2-4 keVee range) or May  $26\pm 7$  (2-6 keVee range)
- N-body simulations of galaxy formation find 68% of models have a peak within 20 days of late May/early June

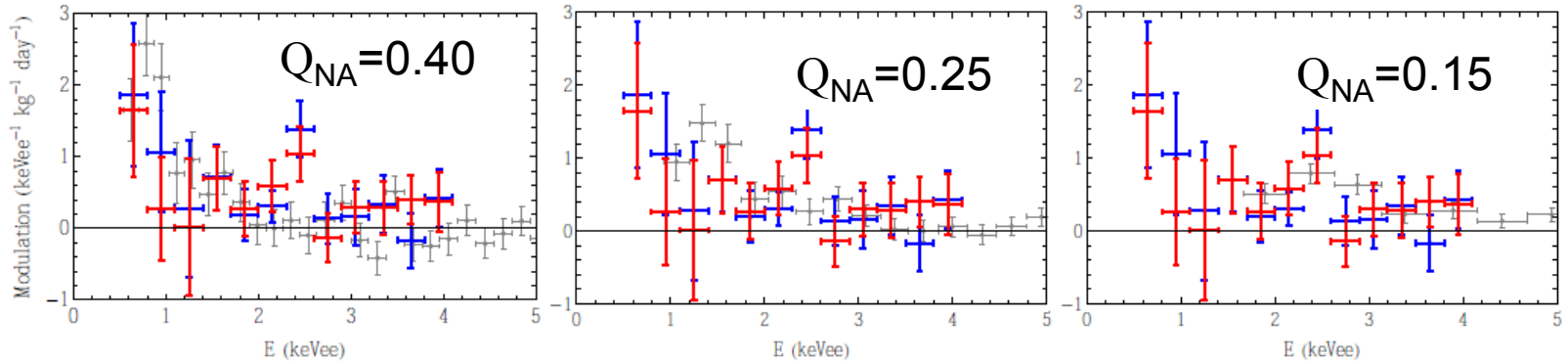
# Spectrum of Modulation



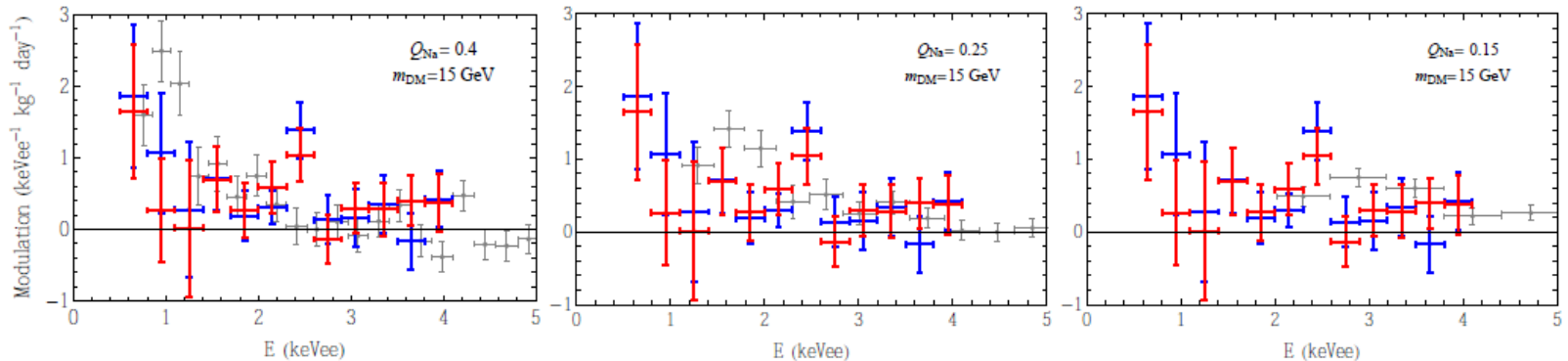
There is more modulation at higher energies than predicted in the standard halo model

# CoGeNT and Dama modulation amplitudes are consistent

10 GeV  
WIMP



15 GeV  
WIMP



Independent of astrophysical uncertainties, the gray error bars are the what the DAMA signal would look like at the CoGeNT detector

Red error bars are the CoGeNT modulation for maximum phase May 26 (~SHM).

Blue error bars are the best fit maximum phase for CoGeNT (April 18).

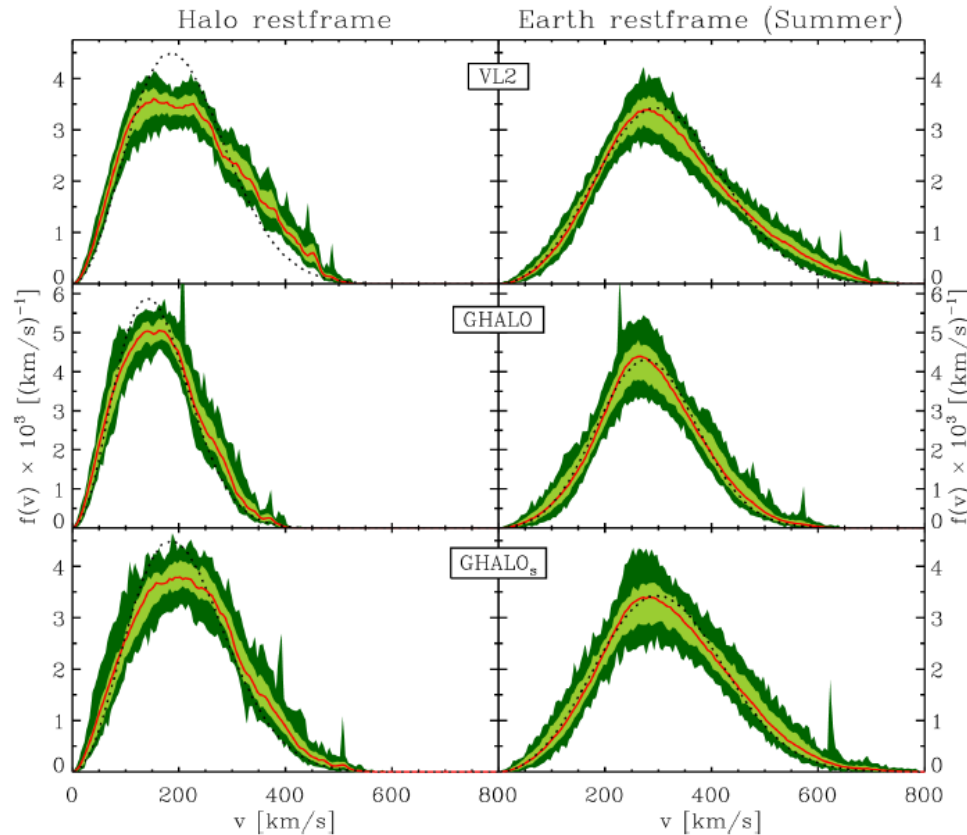
# Overall rate versus modulation

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- The simplest comparison between the overall spectra and the modulation spectra are discrepant by a factor of at least a few. What are the possibilities for reconciling this discrepancy?
- Particle Physics
  - Inelastic dark matter
  - Form Factor Dark Matter
  - Resonant Dark Matter
- Astrophysics
  - Substructure within the halo (streams)

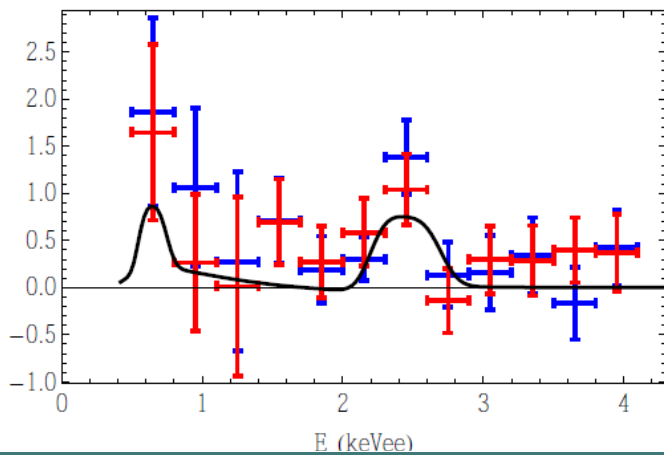
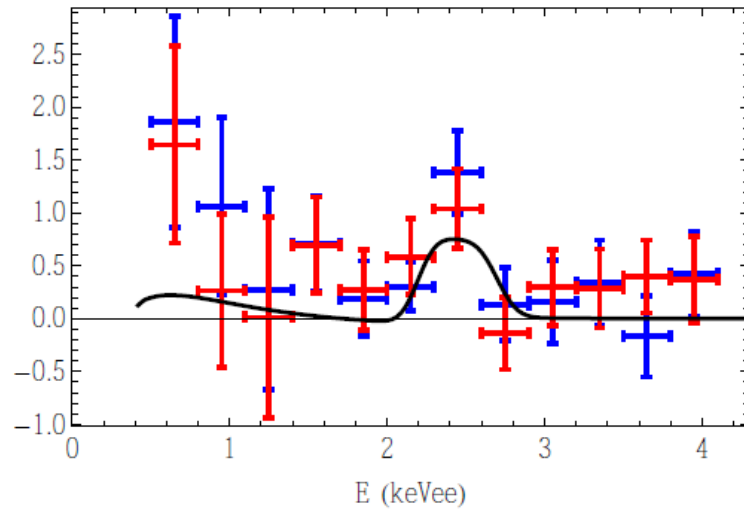
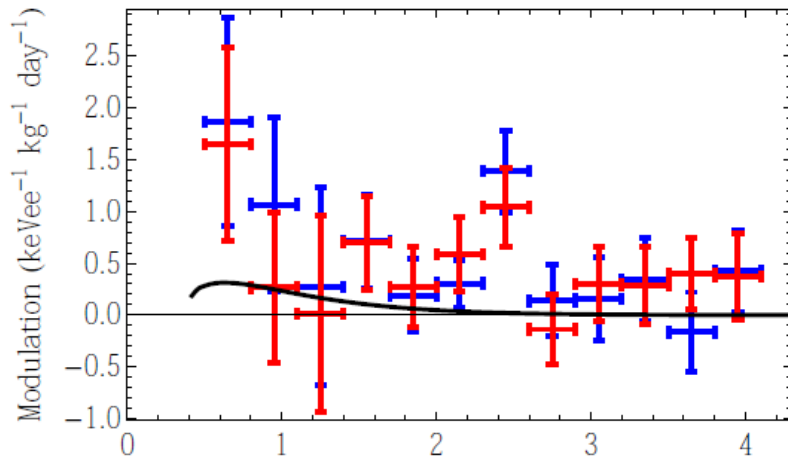


# Simulations of the Velocity Distribution of Dark Matter in Our Galaxy



Michael Kuhlen, Neal Weiner, Jurg Diemand, Piero Madau, Ben Moore, Doug Potter, Joachim Stadel, Marcel Zemp: **JCAP 1002 (2010) 030**

# Streams?



$m=10$  GeV

165 km/s, 15% of “smooth” halo

475 km/s, 24% of “smooth” halo

# Conclusions and Future Outlook

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- I am going to have disagree with Neal that to zeroth order, none of the experiments agree
- When considering reasonable uncertainties
  - CoGeNT and CRESST have similar overall spectra
  - CoGeNT and DAMA have similar modulation spectra
- CoGeNT is continuing to take data (after the fire) and we look forward to seeing if the modulation signal continues to increase in significance
- CDMS is undertaking an annual modulation analysis
- First C4 detector to be constructed soon