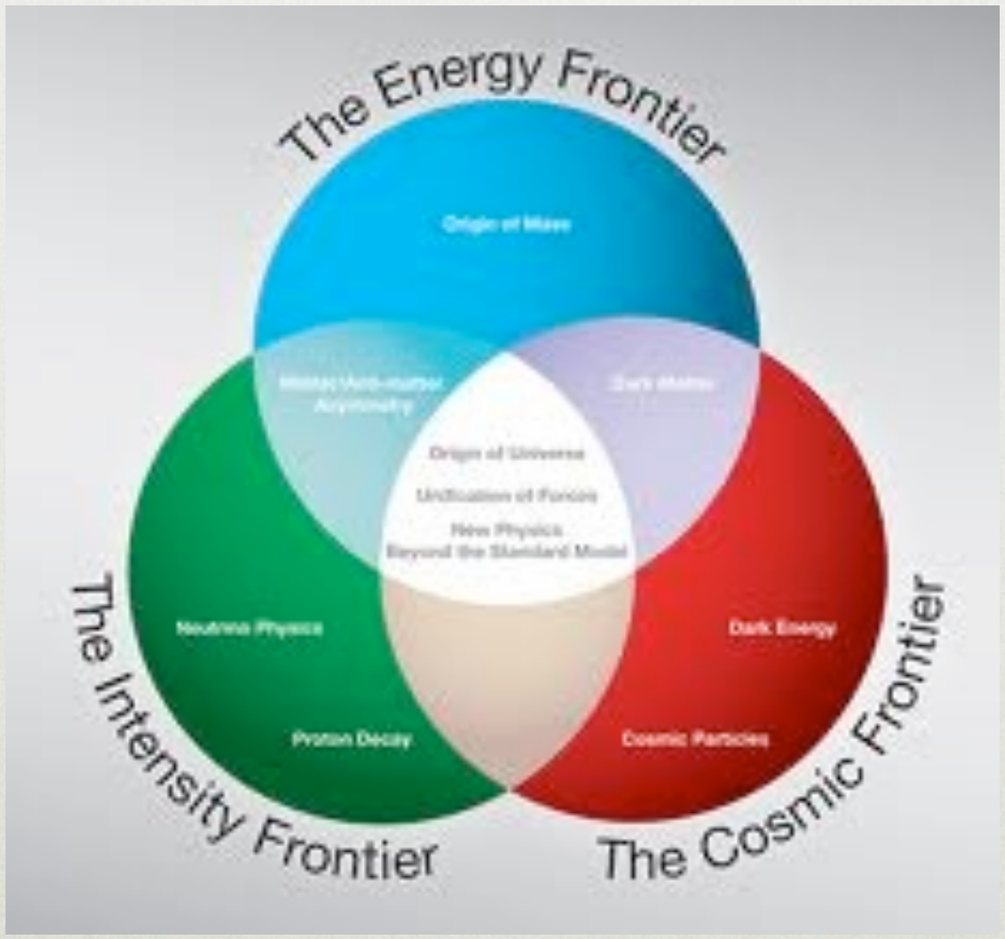
Physics at the Frontiers

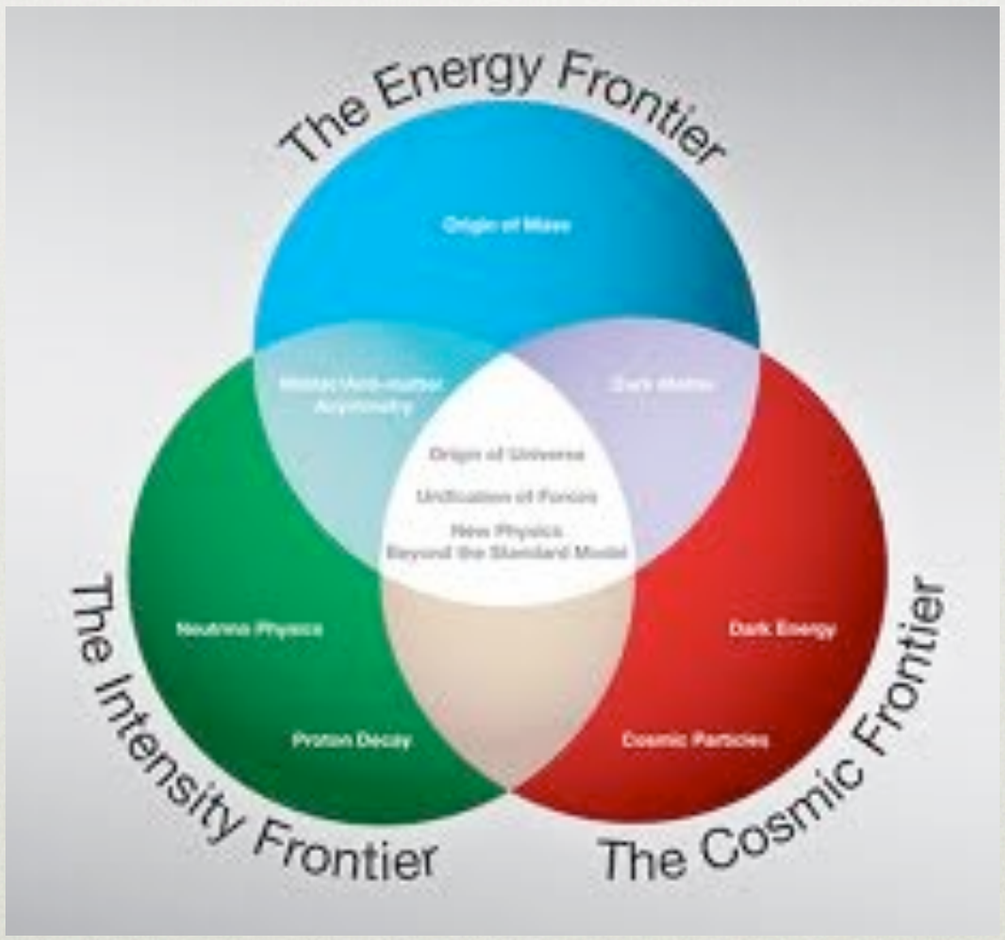
Kathryn M. Zurek
University of Michigan

Fermilab Frontiers



Watch (and Work) List

Top AFB
B physics anomalies
W + jets



MiniBooNe Anomaly
Cosmic Radiation Anomaly
MINOS $\nu/\bar{\nu}$ discrepancy

CoGeNT/DAMA anomalies
XENON and LUX below
Higgs pole
AMS and cosmic positrons

New Physics solutions require out-of-the-box models

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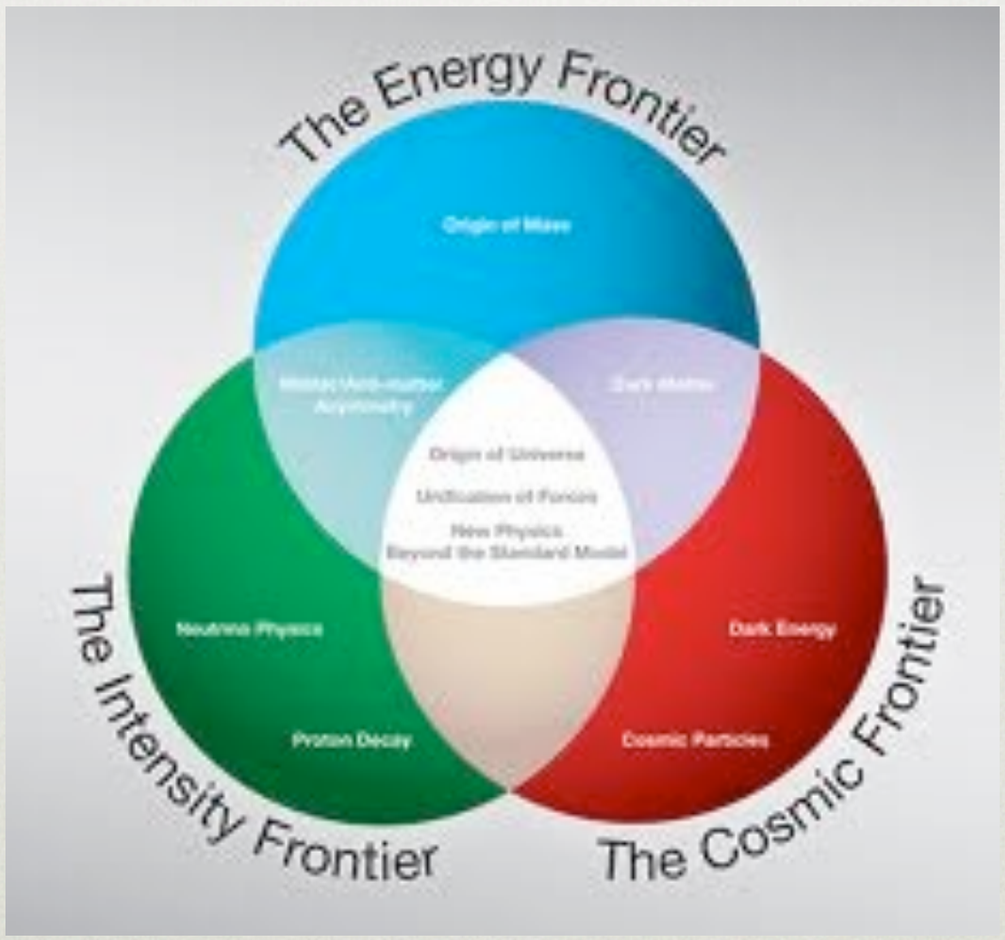

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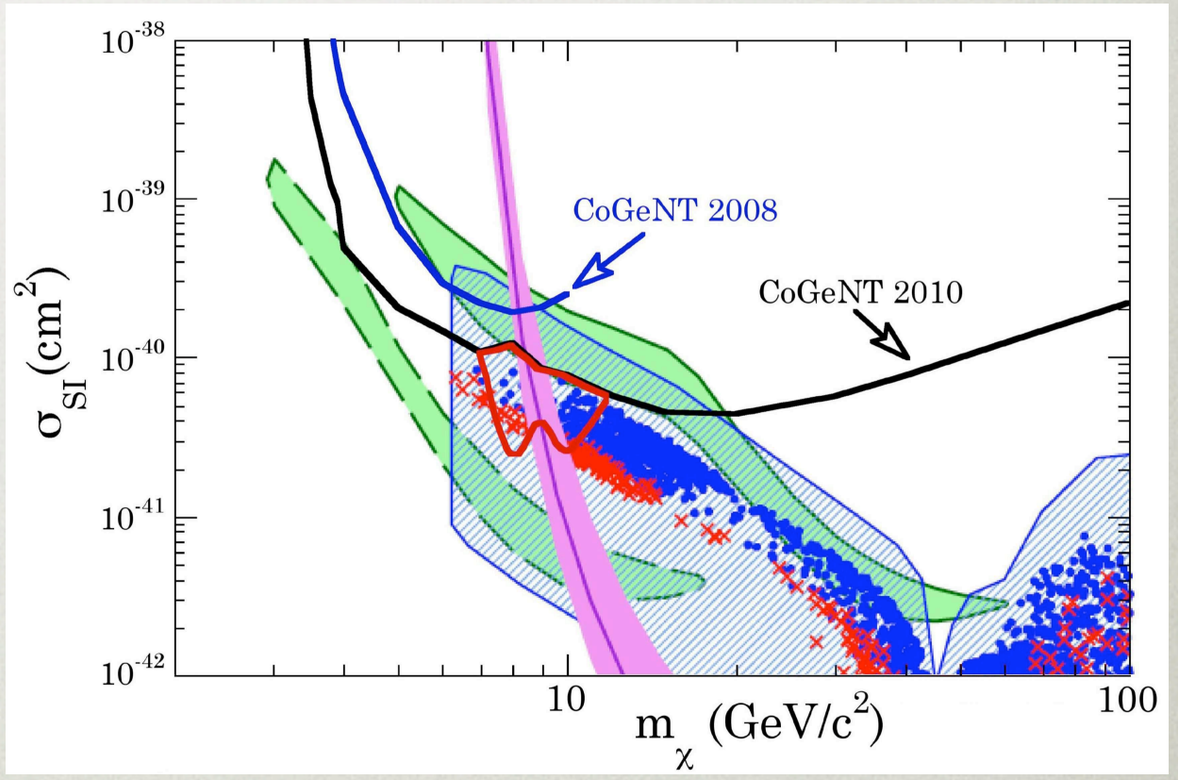
Cosmic Frontier

- "Discovery" of light dark matter

DAMA, NaI

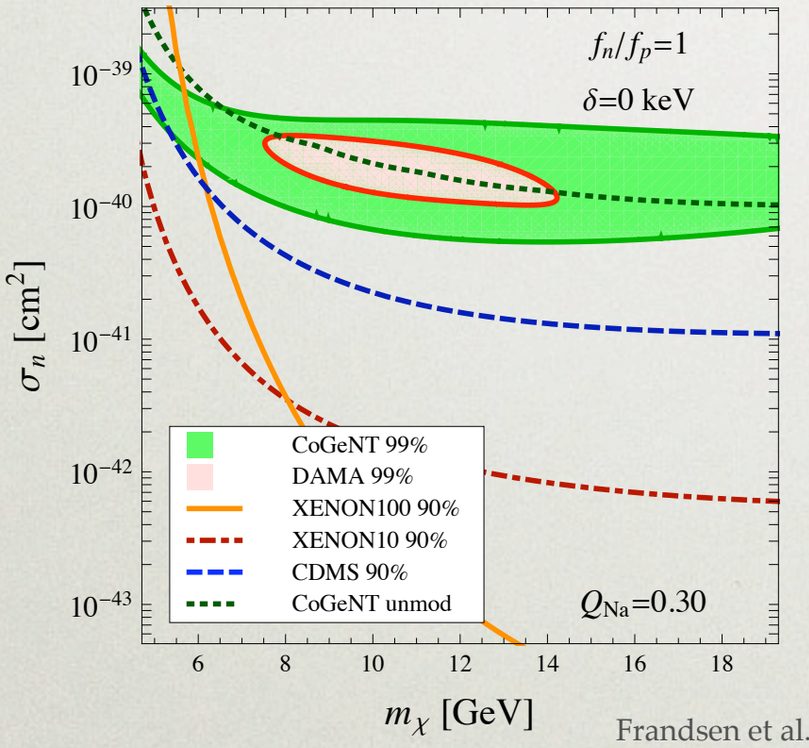
CoGeNT, Ge



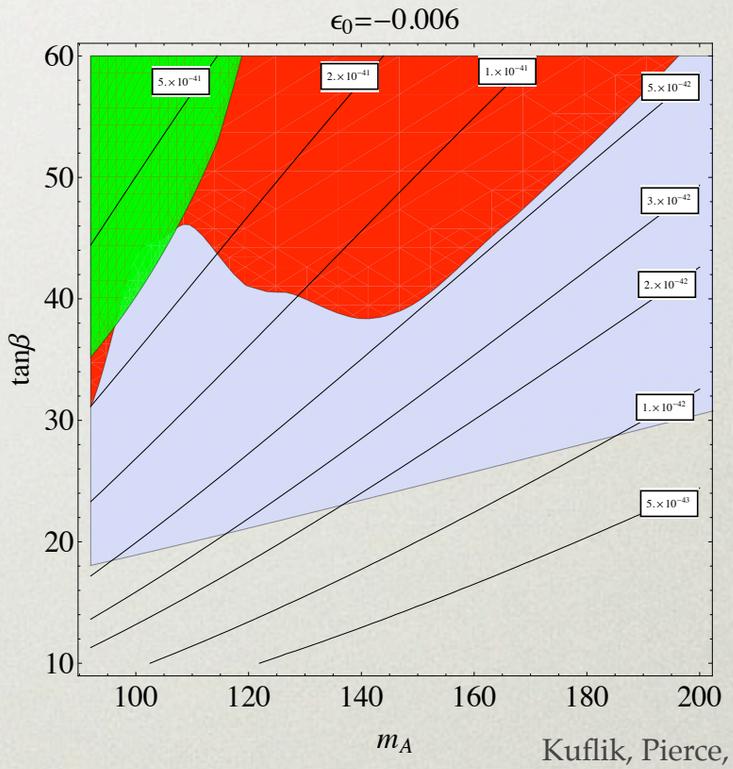
CoGeNT

Hunt for Dark Matter

- Direct conflict with CDMS Ge
- Neutralino from MSSM not viable



Frandsen et al.



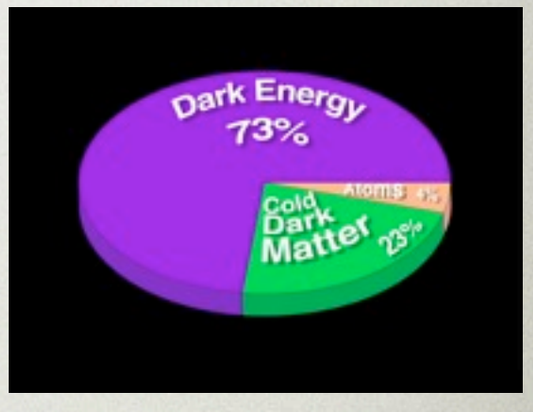
Kuflik, Pierce, KZ

- Is 5-7 GeV mass window suggestive of something else?

Dark Matter and the Baryon Asymmetry

- In standard picture, DM abundance set by thermal freeze-out

$$\Gamma_{ann} \lesssim H$$



- What if instead set by baryon density?

Experimentally, $\Omega_{DM} \approx 5\Omega_b$

Find mechanism $n_{DM} \approx n_b$

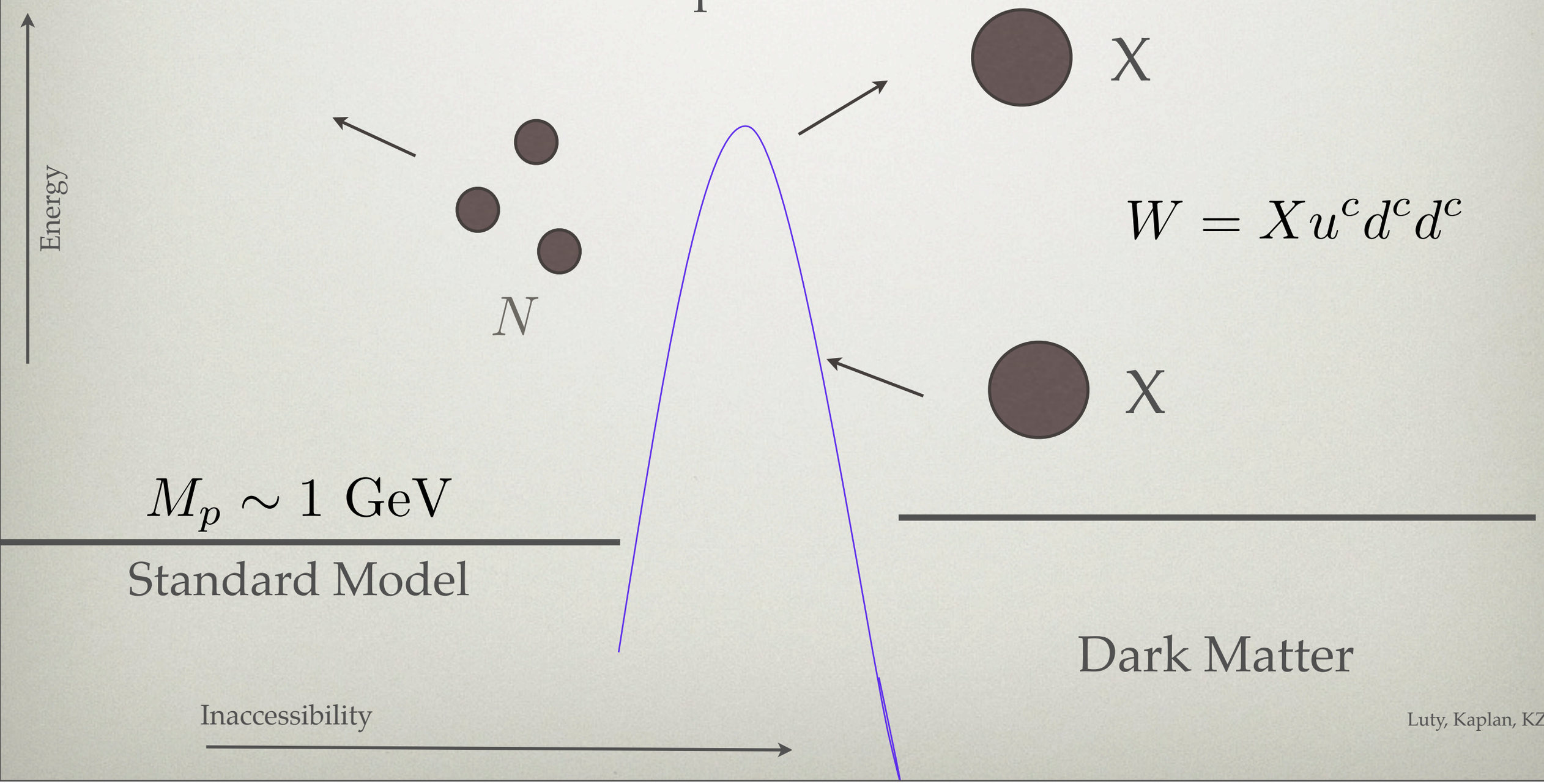
$$\Rightarrow \quad m_{DM} \approx 5 m_p$$

Gelmini, Hall, Lin, Barr, Kaplan, Kitano, Low, Farrar, Zaharijas, Fujii, Yanagida

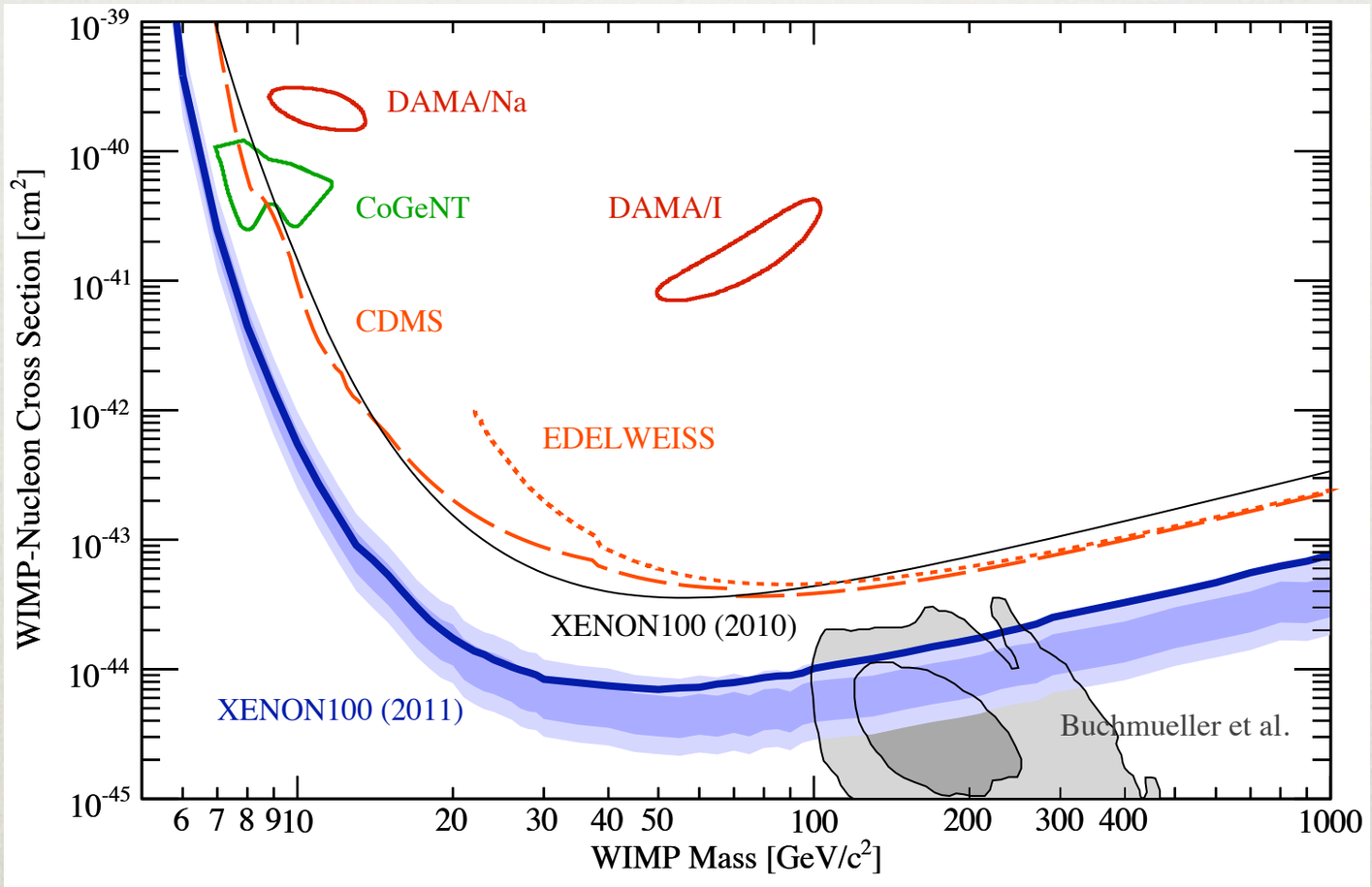
Many Examples of Asymmetric DM

Integrate out heavy state

Effective operators:

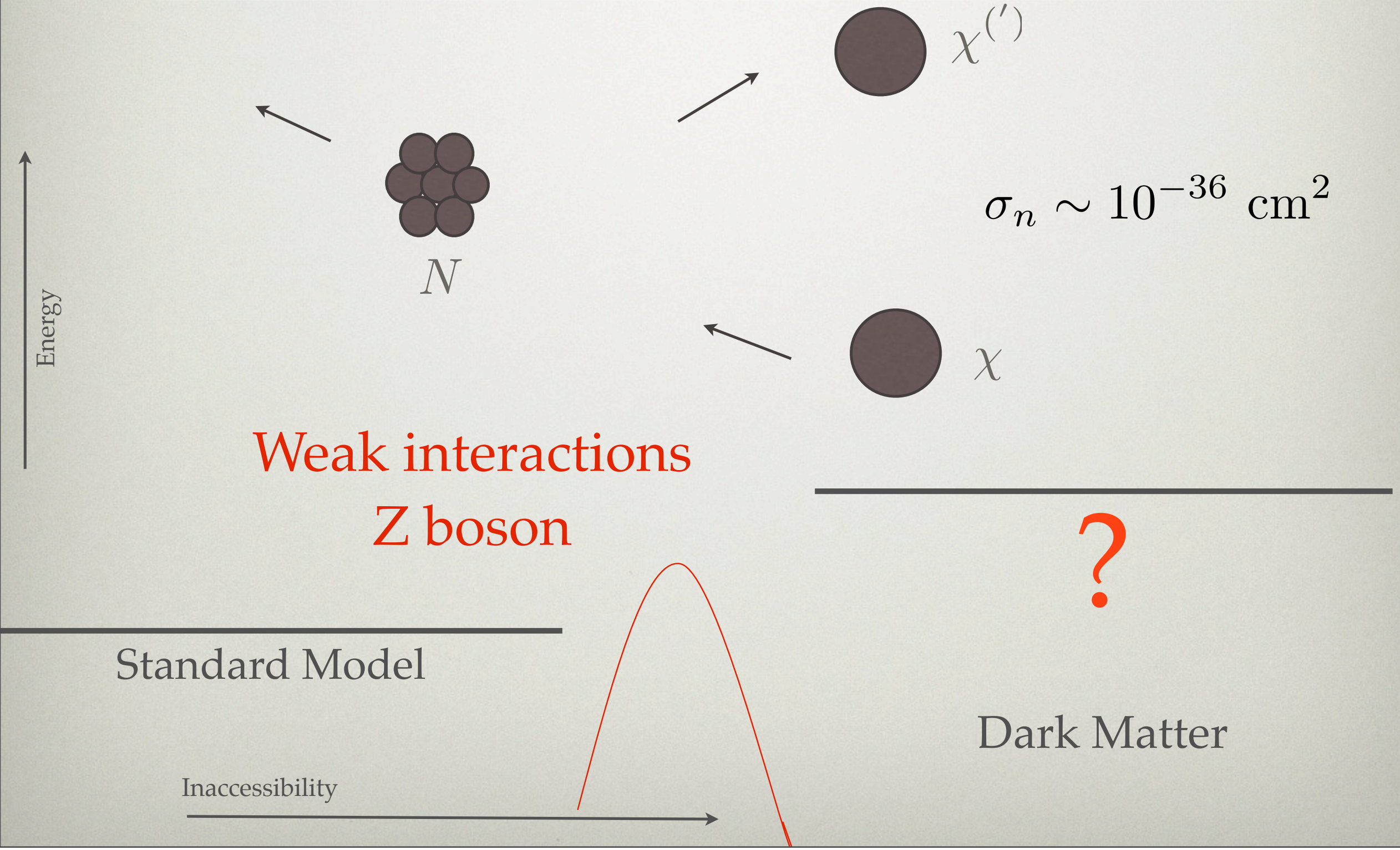


Sub-Weakly Interacting Massive Particles



XENON

Sub-Weakly Interacting Massive Particles



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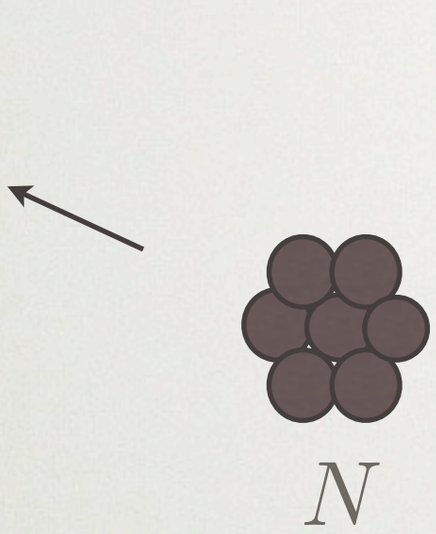
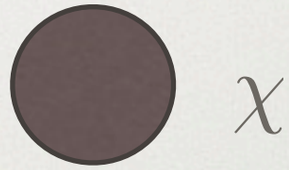


N

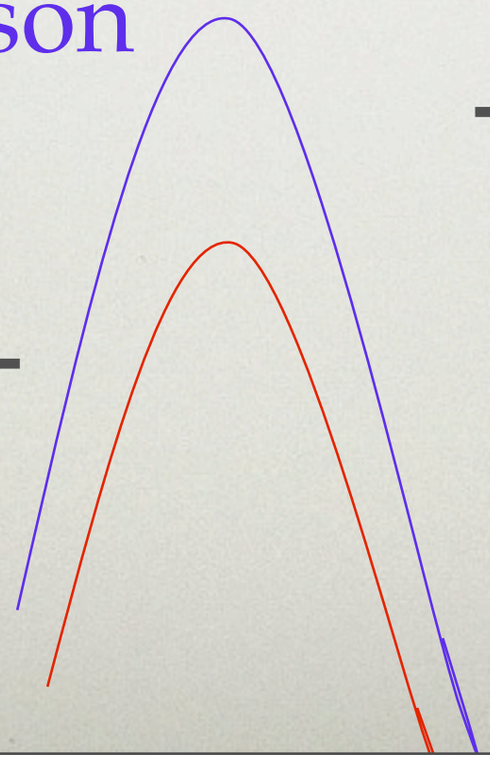
$\chi^{(\prime)}$

$\sigma_n \sim 10^{-45-46}$ cm^2



χ

Higgs boson



$M_p \sim 1$ GeV

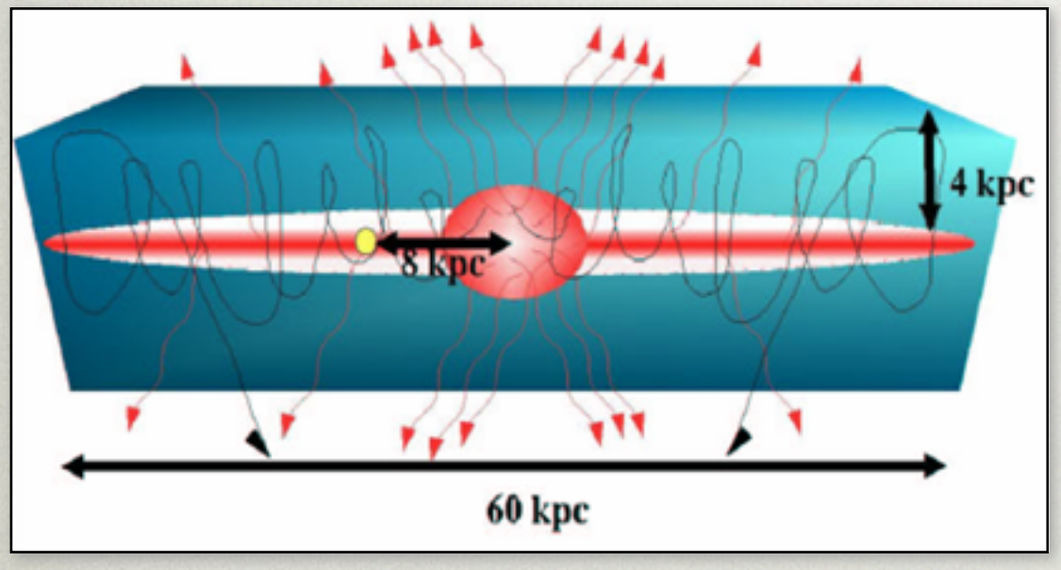
Standard Model

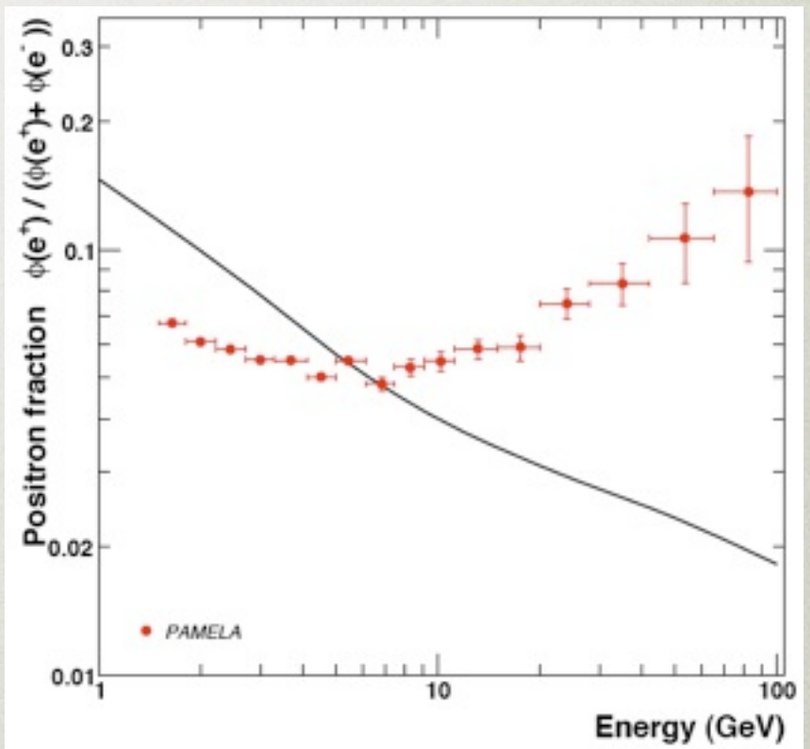
?

Dark Matter

Hunt for Dark Matter

- Indirect Detection
  - "Discovery" of weak scale dark matter

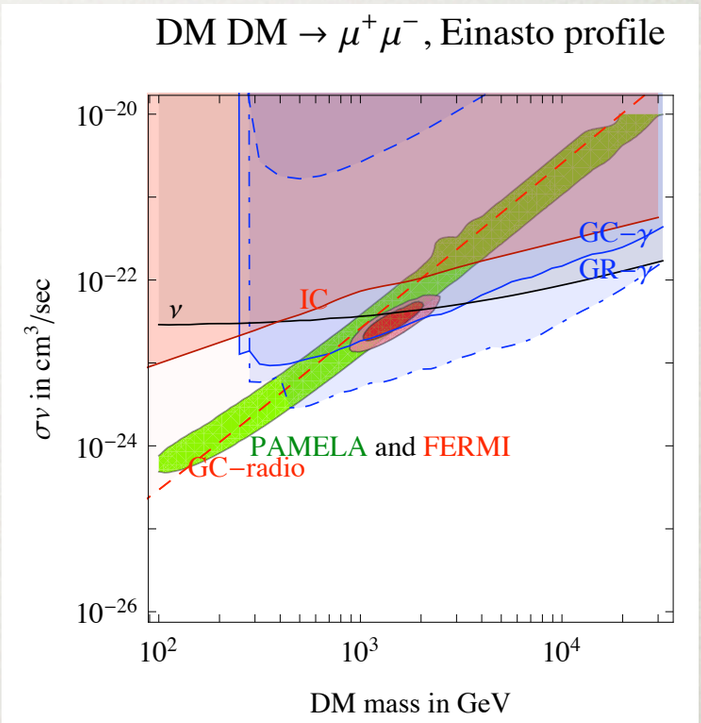




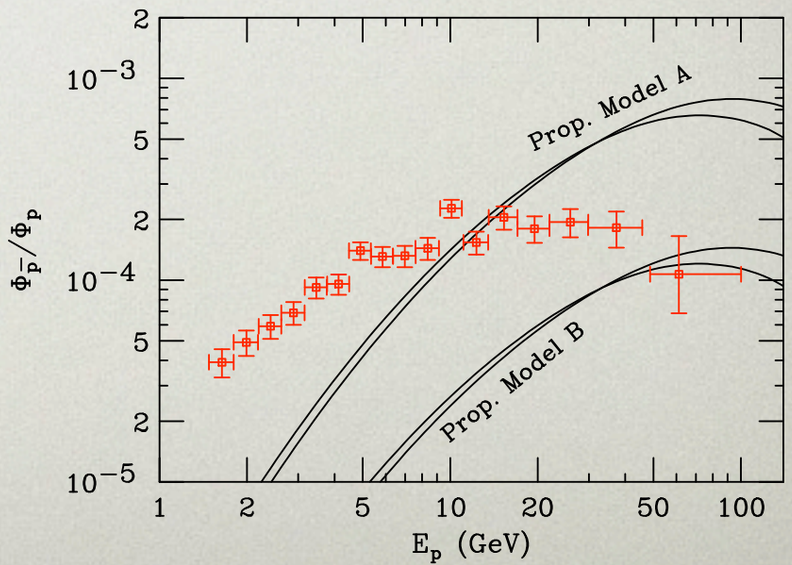
PAMELA

Indirect Detection

Meade, Papucci, Strumia, Volansky



- Recent Launch of AMS
- Improved constraints on propagation model --> better determination of particle physics



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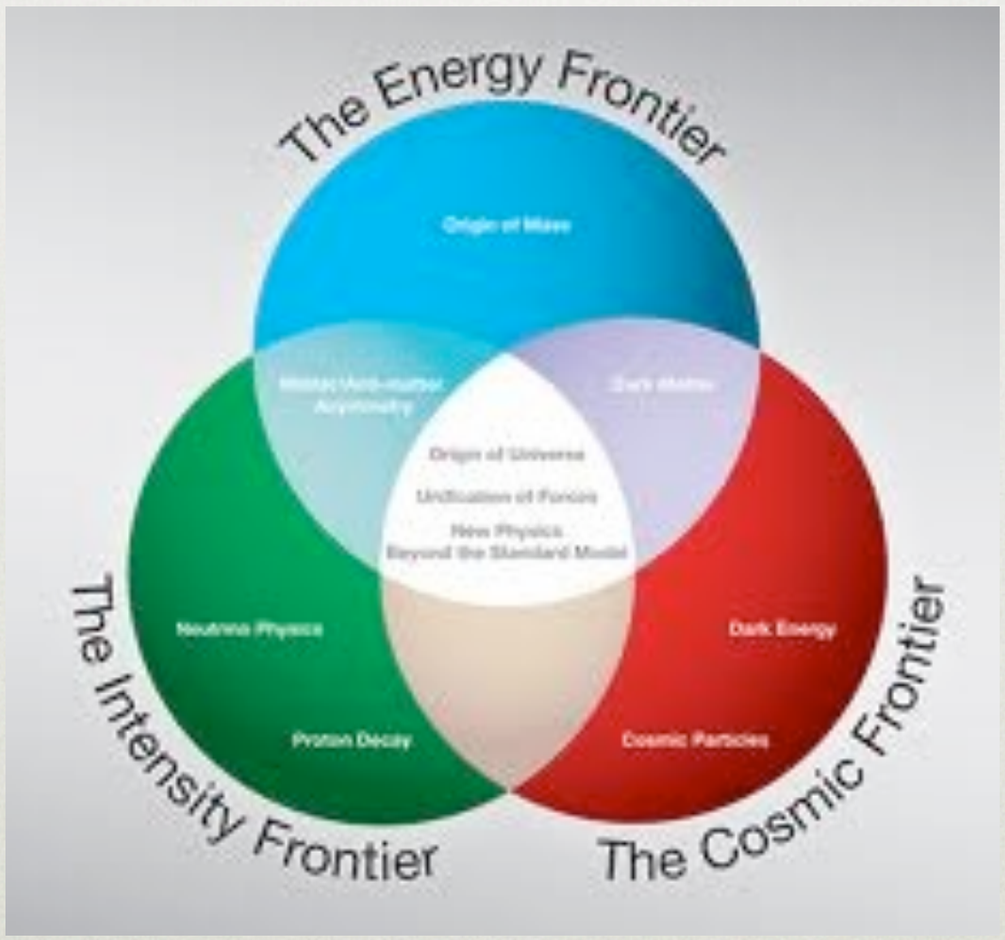

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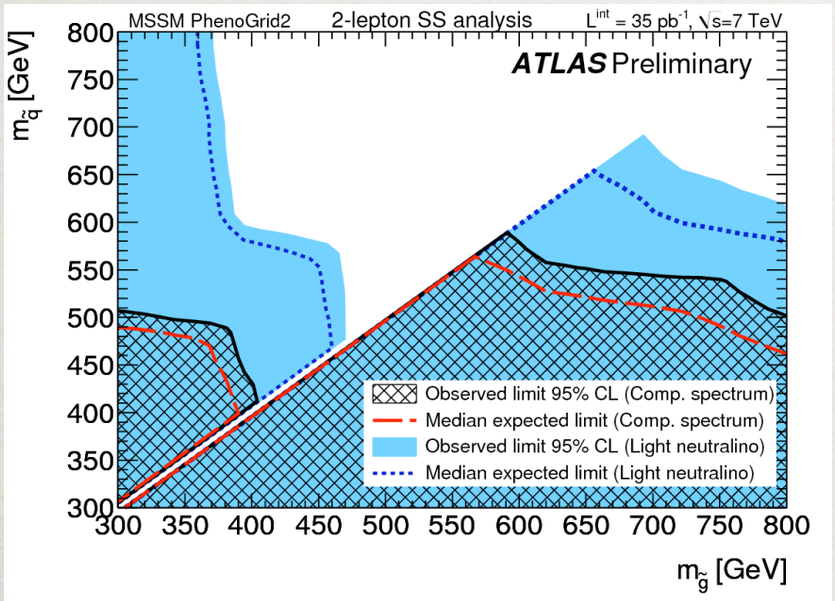
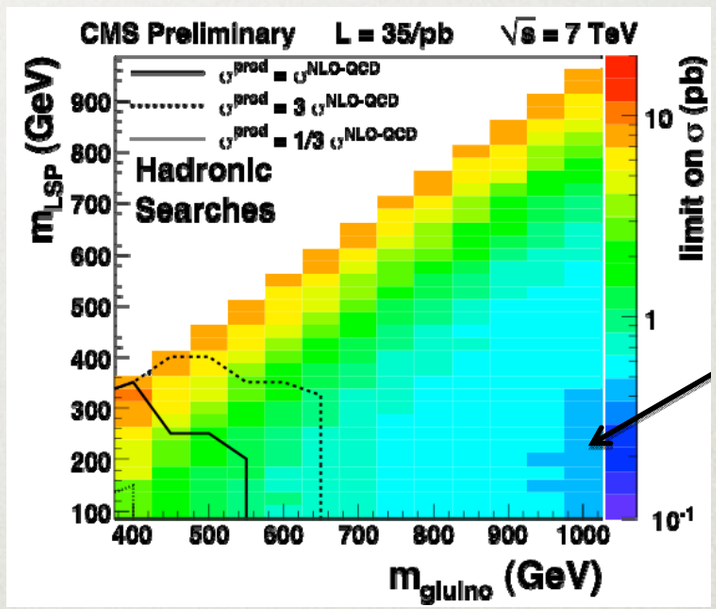
Energy Frontier

- Search for Higgs and supersymmetry takes front stage





- Likely to push supersymmetric states up just below a TeV

Energy Frontier

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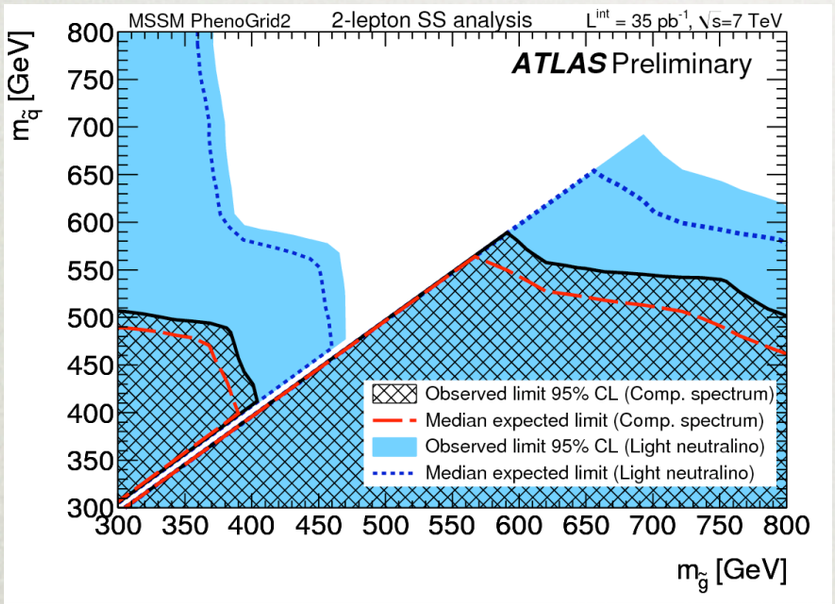
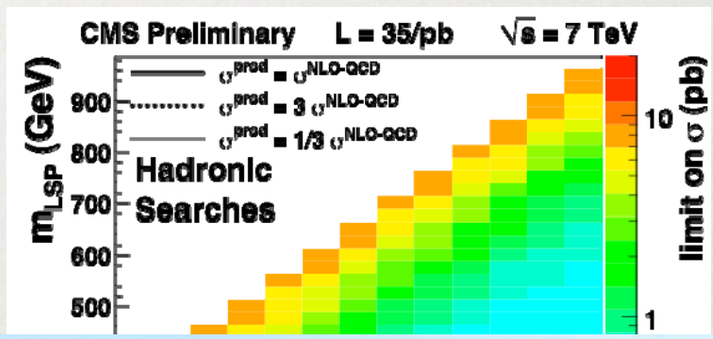
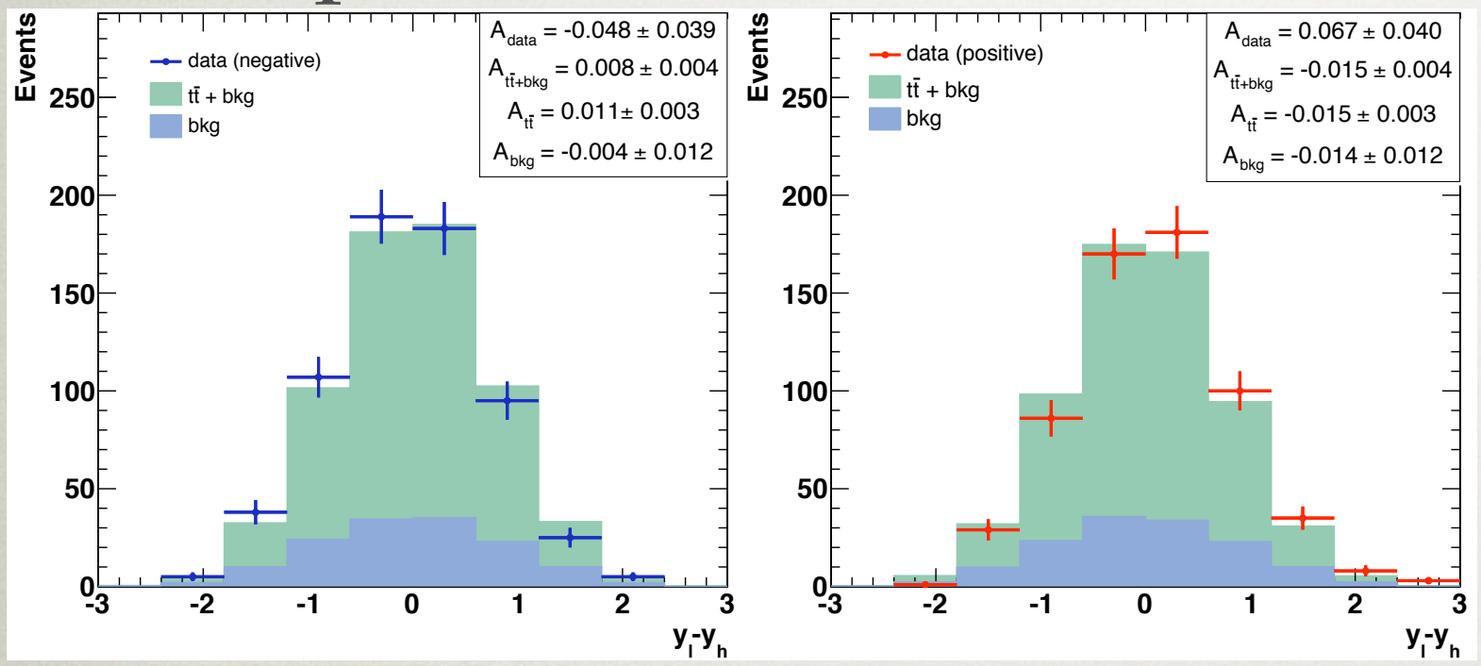




- Likely to push supe
up just below a TeV

Top AFB

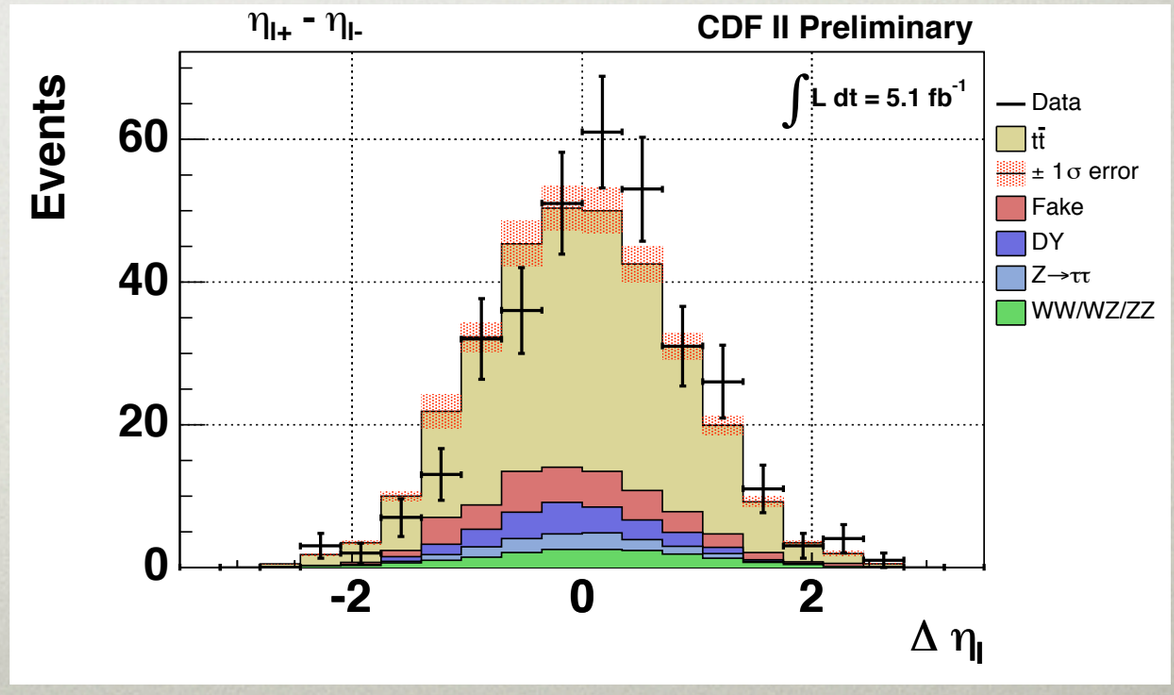
Semileptonic



$$A_{FB} = 0.110 \pm 0.039$$

CDF 5.3 fb^-1

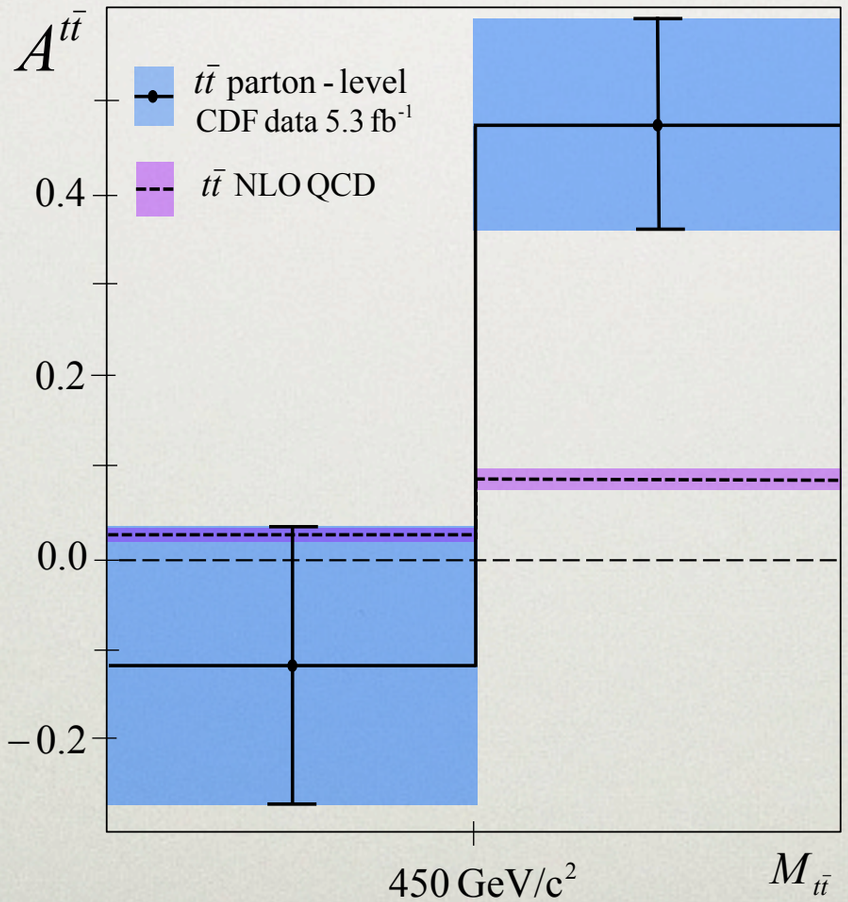
Fully Leptonic



$$A_{FB} = 0.14 \pm 0.05$$

Top AFB

- Mass Dependence

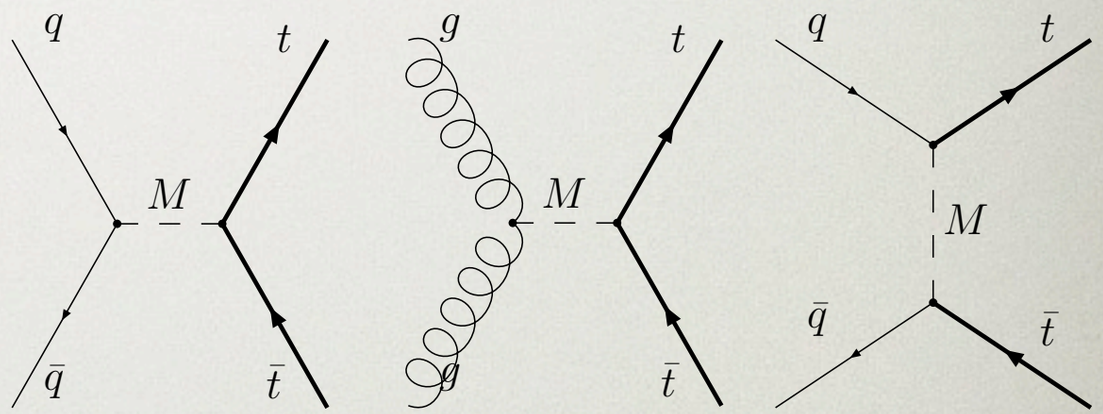


Models to Generate

- s-channel or t-channel
  - s-channel: axigluon

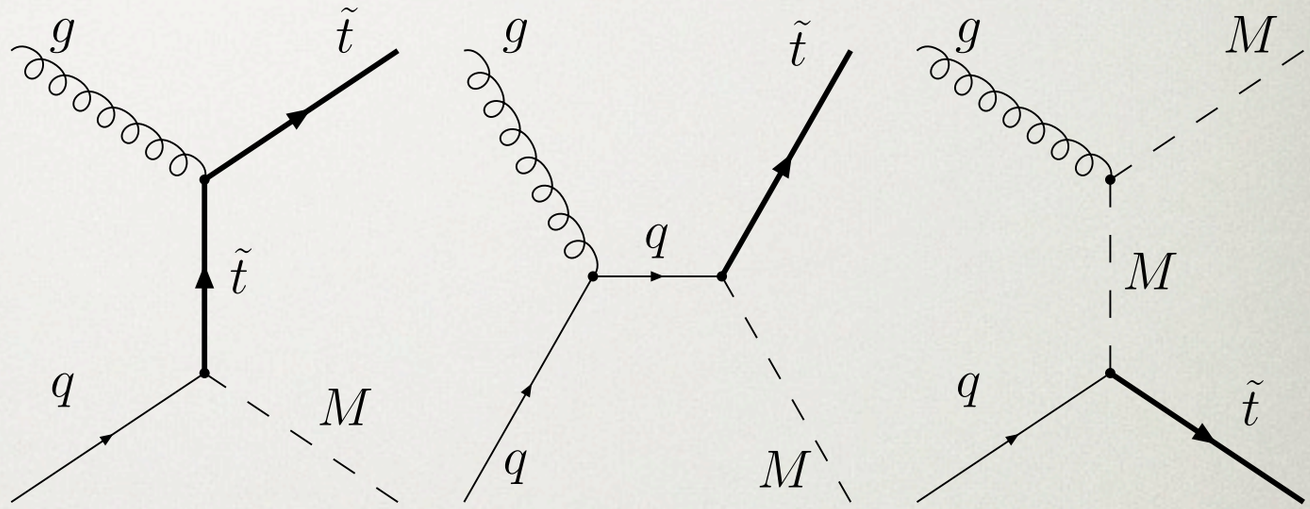
    Ferrario and Rodrigo
  - t-channel: flavor violating vector or scalar

    Jung, Murayama, Pierce, Wells
    Shu, Tait, Wang
    Ligeti, Schmaltz, Tavares
    Grinstein, Kagan, Trott, Zupan

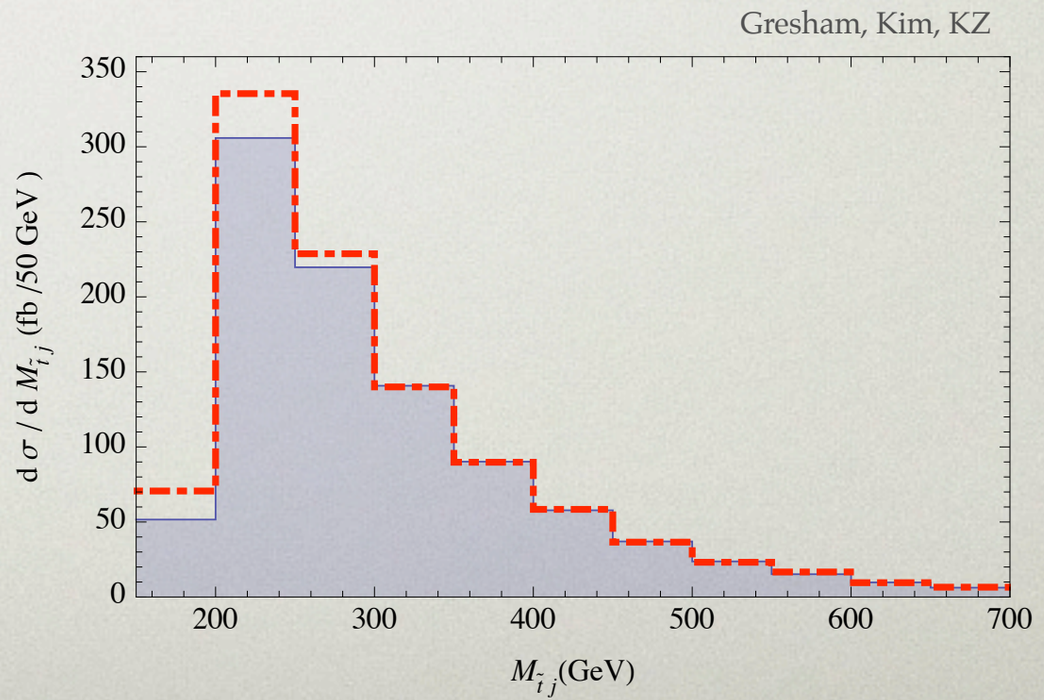


To Watch

- Top-flavor violating resonances
- (M -> tj)
- Single Top
- (M -> jj)

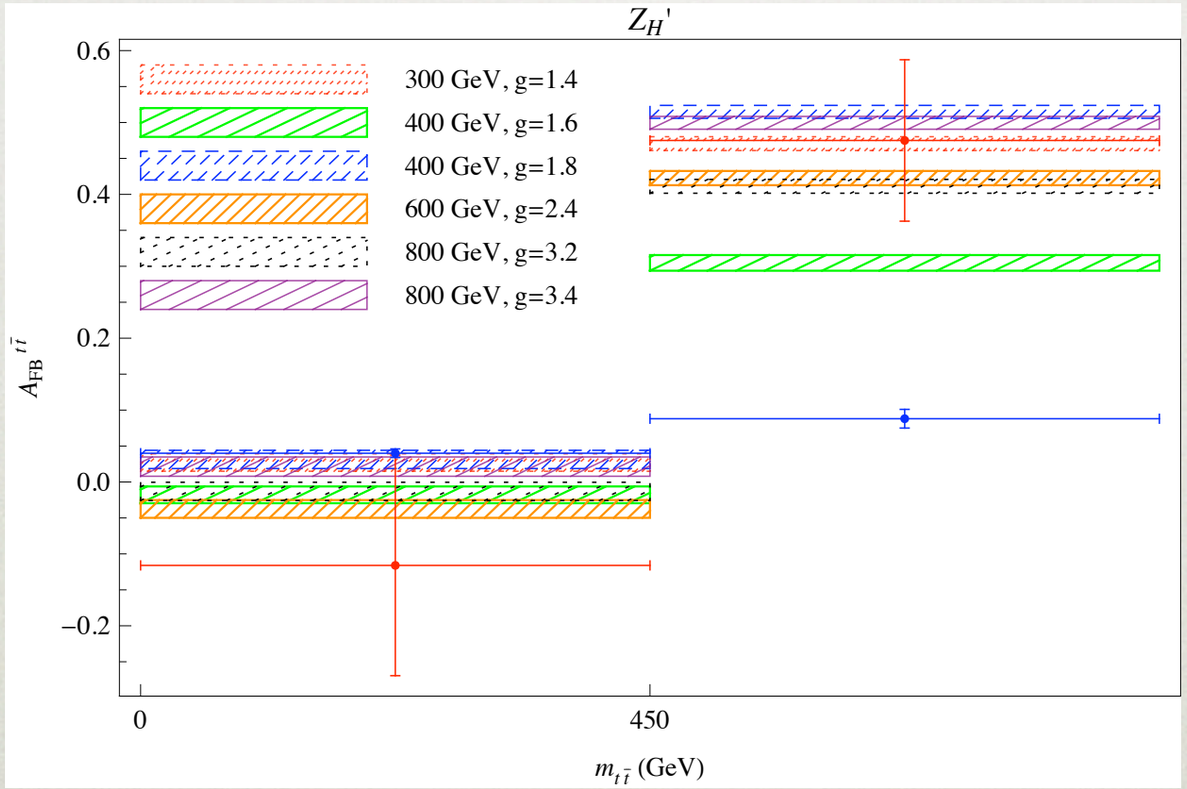


Gresham, Kim, KZ



Early LHC

- Large couplings to top --> LHC7 search with 1 fb^-1!



Gresham, Kim, KZ

B-physics Anomalies

- Tevatron like-sign muons

$$a^b_{sl} = -(8.5 \pm 2.8) \times 10^{-3} \qquad b\bar{b} \to \mu^+\mu^+ X$$

- B_s mixing in $\Delta\Gamma_s$ and $S_{\psi\phi}$

- Less significant:

  - measurement of $\sin 2\beta$ in $B_d \to \psi K$ and penguin dominated $b \to sq\bar{q}$

- Maybe there is something flavorful brewing?

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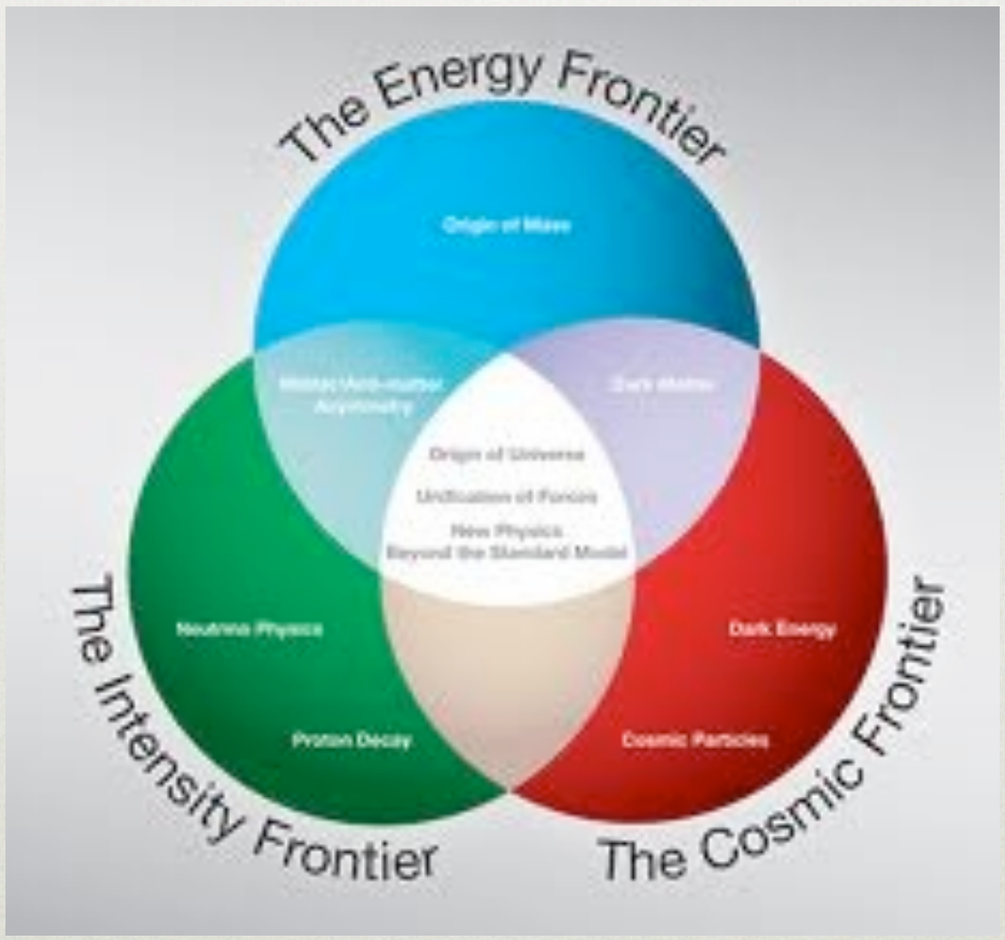

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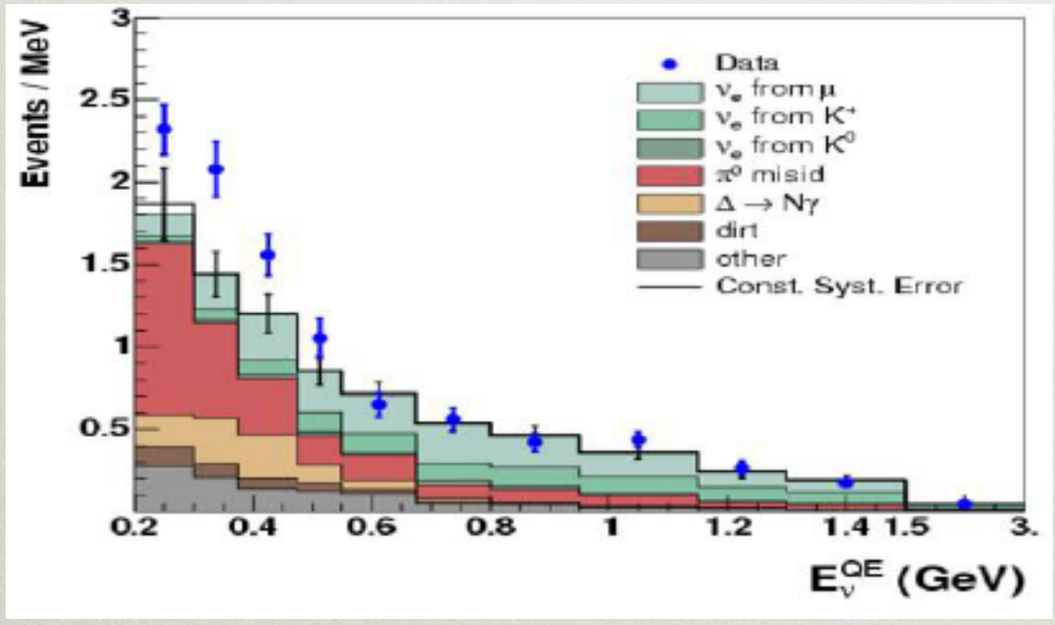
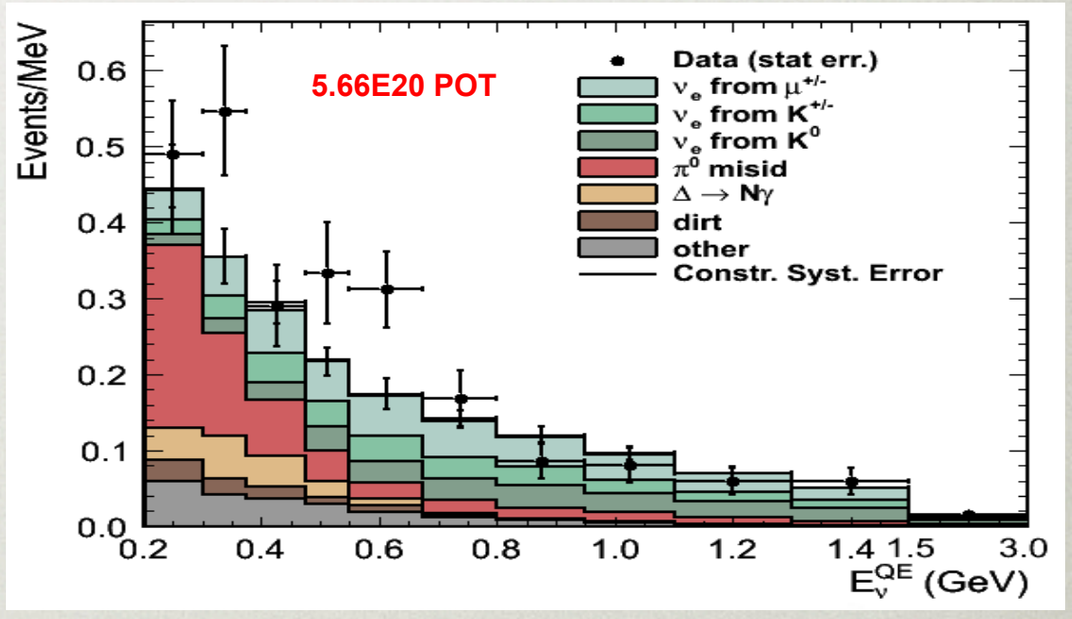
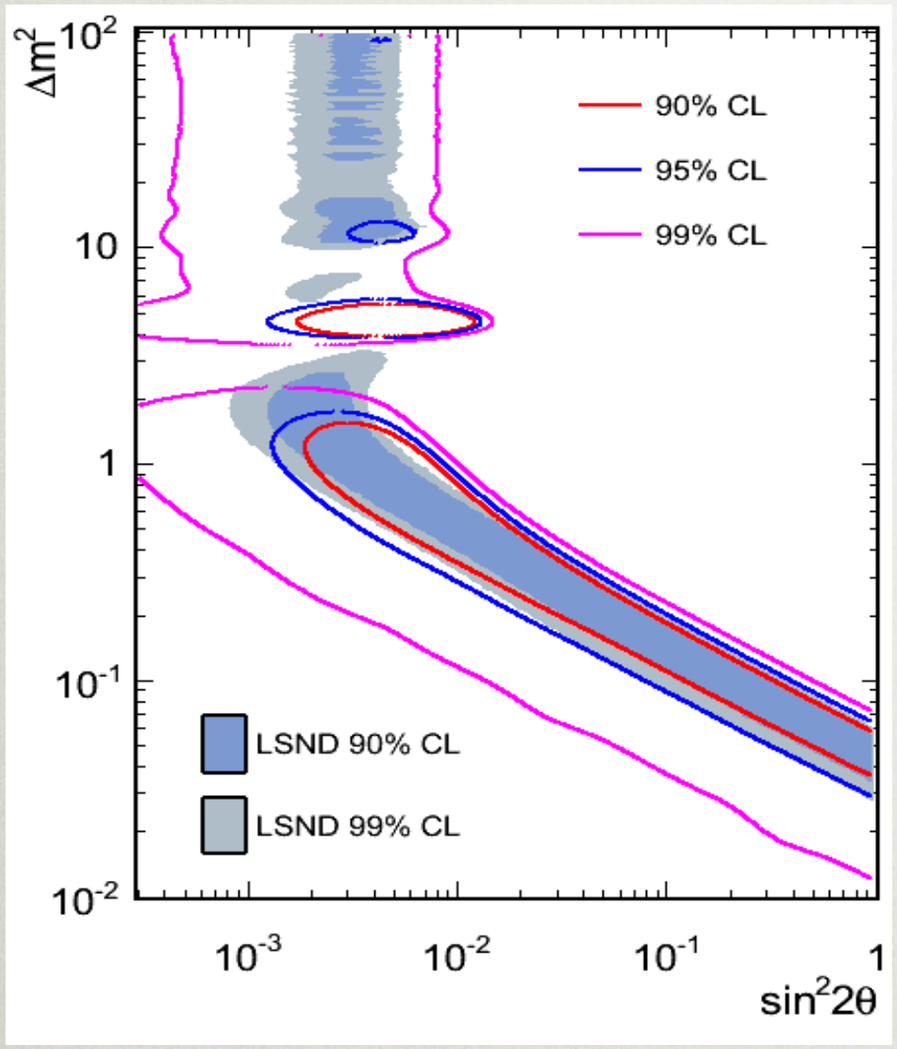
Intensity Frontier

- Neutrino physics anomalies
- MiniBooNE



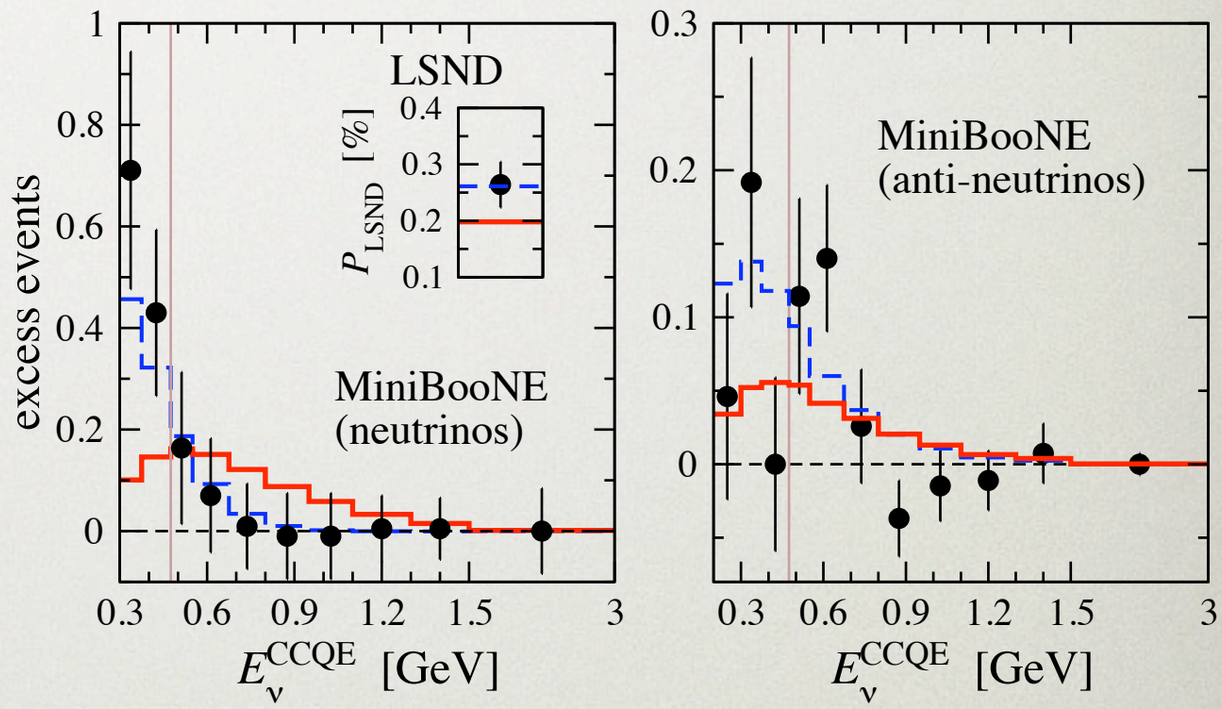


LSND/MiniBooNE



MiniBooNE

Kopp, Maltoni, Schwetz

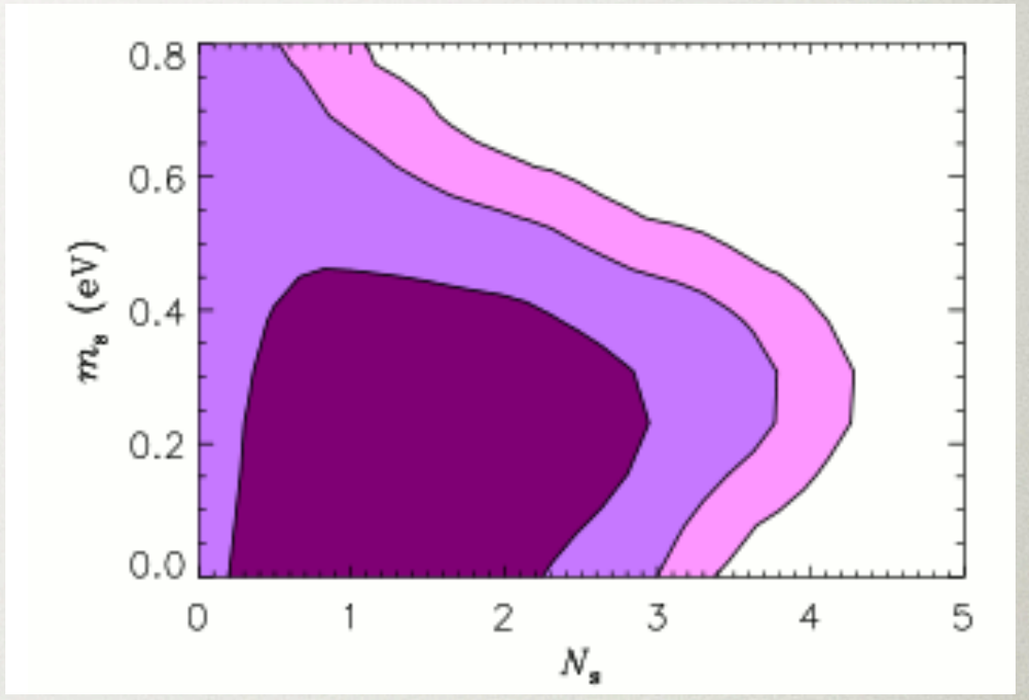


Hard to fit disappearance experiments with 3 + 2 light steriles

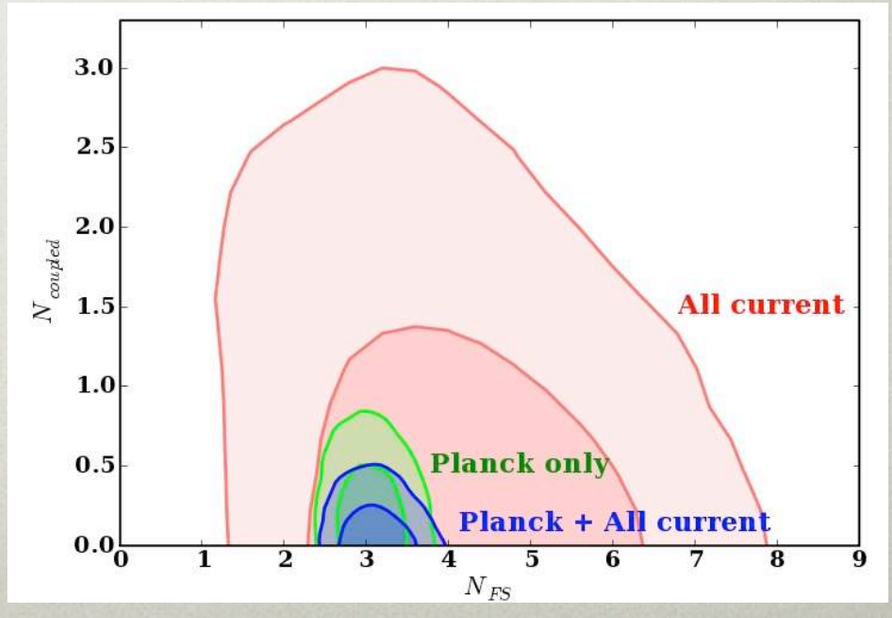
Cosmic Anomalies

- Current data:

Hamann et al.



- To watch: Planck experiment



Bashinsky, Friedland, KZ

Summary

- Next 2-3 years promise to be action-packed!
- Look to all frontiers for progress
- With current path, likely to re-shape theory
- Need “outside-the-box” theoretical ideas