

Chicagoland and Midwest 1 day DM Workshop Summary

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The FNAL Workshop

- Exactly one week ago!
- <https://twindico.hep.anl.gov/indico/conferenceDisplay.py?confId=877>
- Featured summaries in the morning followed by extensive panel discussion in the afternoon

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Midwest Dark Matter Mini-workshop

Friday 06 April 2012
from 09:00 to 17:20UTC
at Fermilab (One West)
chaired by: *Karen Byrum (ANL)*

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Friday 06 April 2012

09:00	Theory Talk (45) (Slides)	Dan Hooper
09:45	Simulation Talk (30) (Slides)	Salman Habib
10:15	Break (15)	
10:30	Experimental Collider Laboratory Talk (30) (Slides)	Sarah Malik (CMS)
11:00	Experimental Direct Talk (30) (Slides)	Jeter Hall
11:30	Indirect Talk (30) (Slides)	Jim Buckley
12:00	Lunch (1h00)	
13:00	Panel Discussion (1h30) Panel Members: Rocky Kolb (moderator), Dan Bauer, Juan Collar, Francesc Ferrer, Carlos Wagner, Albrecht Karle, Alexander Paramonov	
14:30	Afternoon Break (15)	
14:45	Panel Discussion (continued) (1h15) (Location: Curia II)	

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Advertized to try to answer:

- What are the strengths and weaknesses of each approach to DM?
- Where do the different approaches complement each other in a way that provides more information than each individually?
- What are the prospects for making progress with each technique over the next decade?
- How can we build a larger community that can argue effectively for DM experiments leading up to the Snowmass 2013 meeting?

- Will try to structure this summary around to what extent these questions were answered in the FNAL workshop...
- Also will try to emphasize the discussion/comments that are not accessible through the indico agenda!

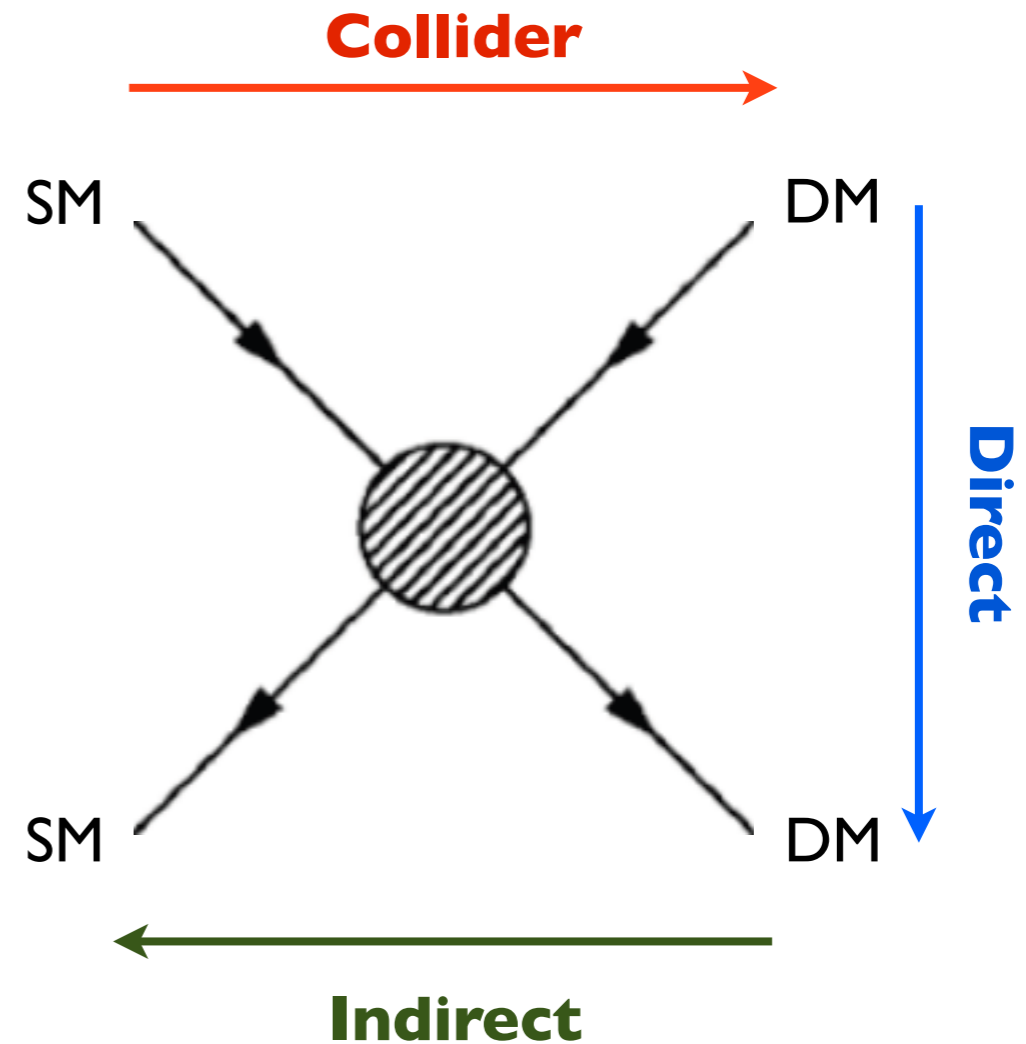
- Panel Members: Rocky Kolb (moderator), Dan Bauer, Juan Collar, Francesc Ferrer, Carlos Wagner, Albrecht Karle, Alexander Paramonov



Approaches?

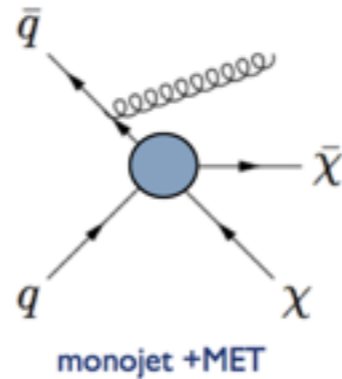
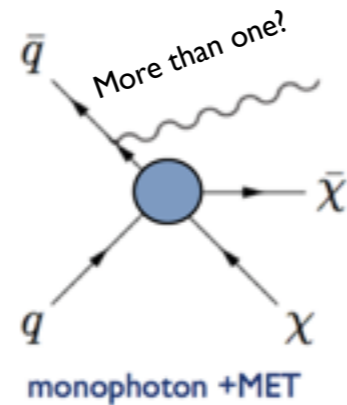
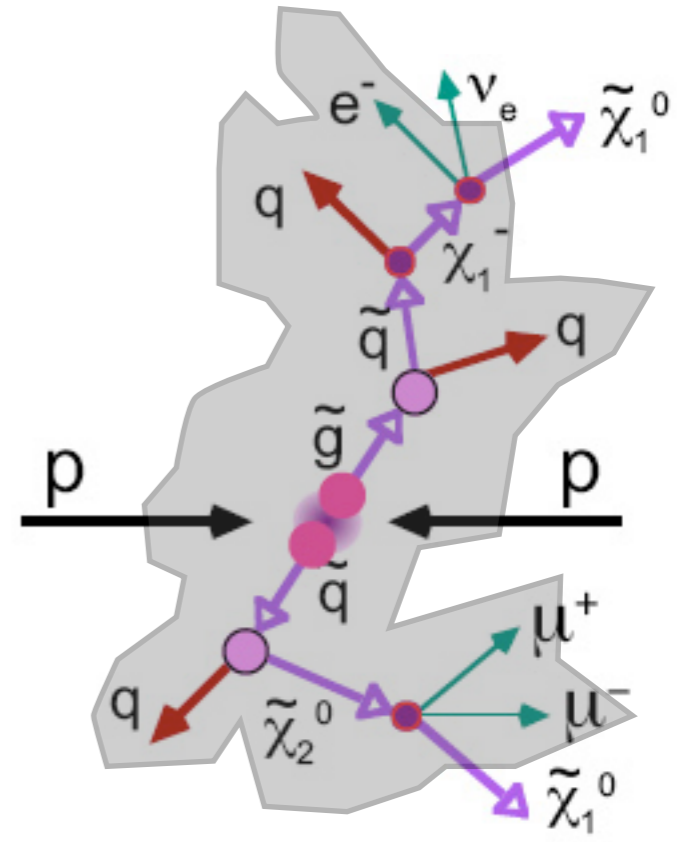
- What are the strengths and weaknesses of each approach to DM?

- Collider (Make some)
- Direct (Catch some)
- Indirect (Catch some leftovers)
- Also gravitational/astronomical observation (how we know DM is there in the first place) mentioned as a 4th approach to keep in mind.



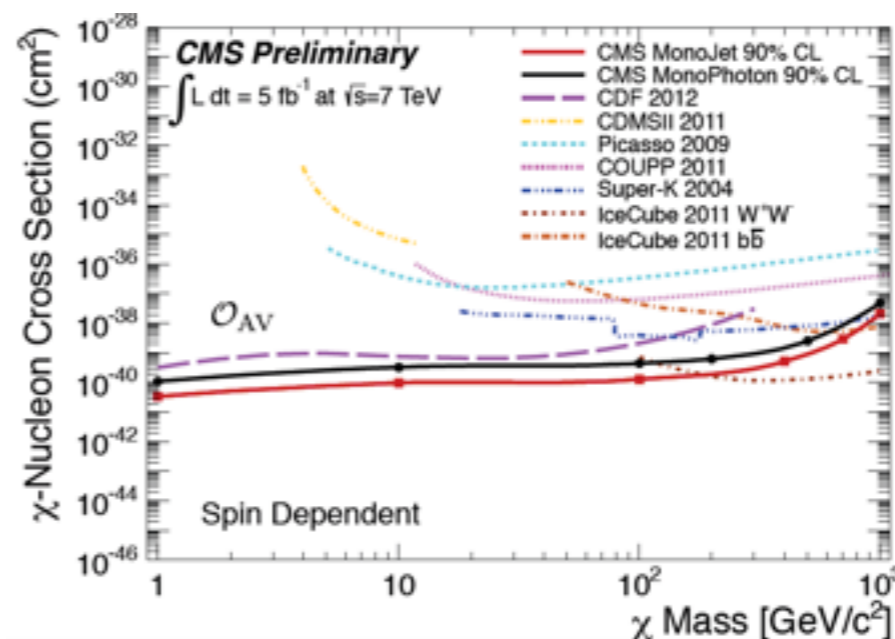
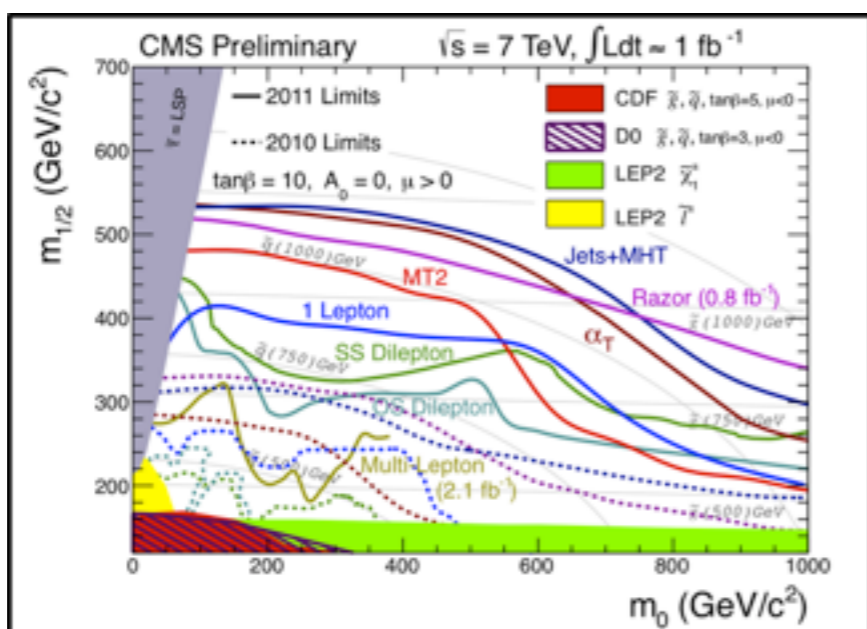
Collider I (LHC)

- Search approaches for SUSY like DM:
 - Strong production of more massive SUSY beasts, decays cascading down to a DM candidate LSP
 - Direct production of DM pair, catching through ISR/FSR photon or jet.



Collider II

- This time last year we were sitting on about $\sim 36/\text{pb}$ (possibly had doubled that by this point)
- At this time were expecting to accumulate $1/\text{fb}$ in the 2011 run
- **In the end recorded 5x that!**
(Already this past \sim week have recorded about $300/\text{pb}$ at 8 TeV!)
- “Low berries” first searches based on “simple” final states, and based on models tuned for early signal detection.
- Need input from theorists (models, SLHA/LHE files) to help map searches into DM space!



Collider III

Advantages

- The strongly coupled scenario has potentially large cross sections, perhaps improving the chances of observing evidence of a weakly interacting LSP at the end of a decay cascade.
- Potential to observe more of the underlying particle physics (i.e. other particles in the SUSY cascades)
 - Distributions can tell us things like masses, rates cross sections

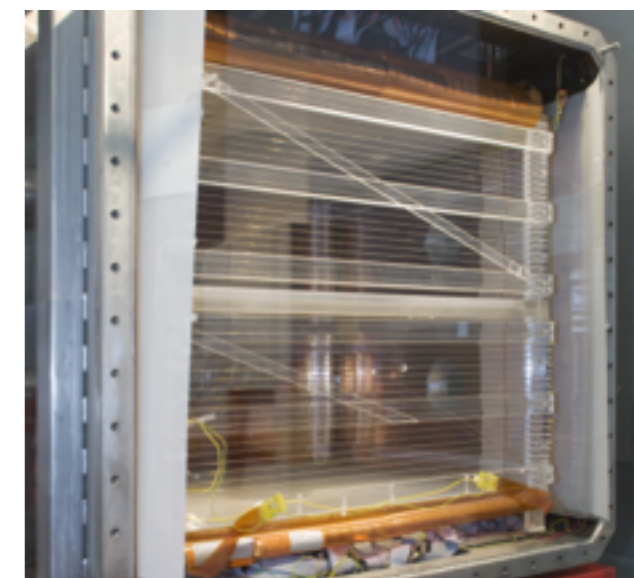
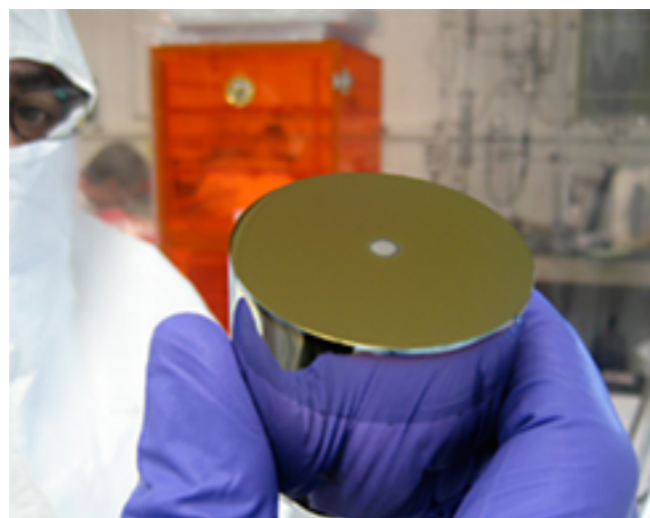
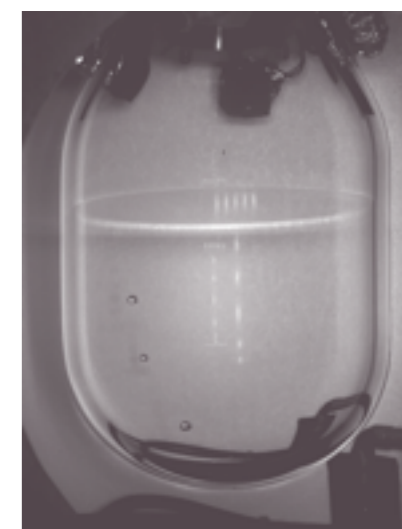
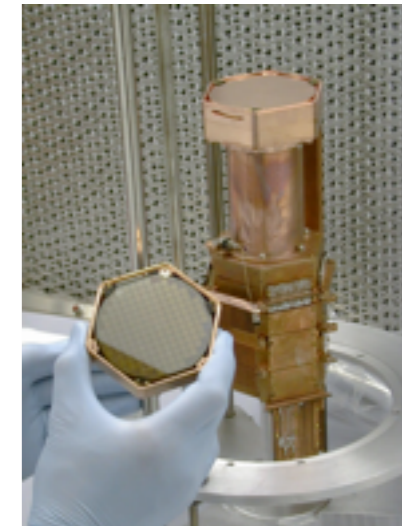
Weaknesses

- Model dependence -- an observation could be interpreted as SUSY, UED, ...
- What if not strong interacting -- only weakly produced?
- Suppose we do observe a signal with MET? How do we connect that back to DM?
 - How can we know that the thing making MET is the stable thing we would need?

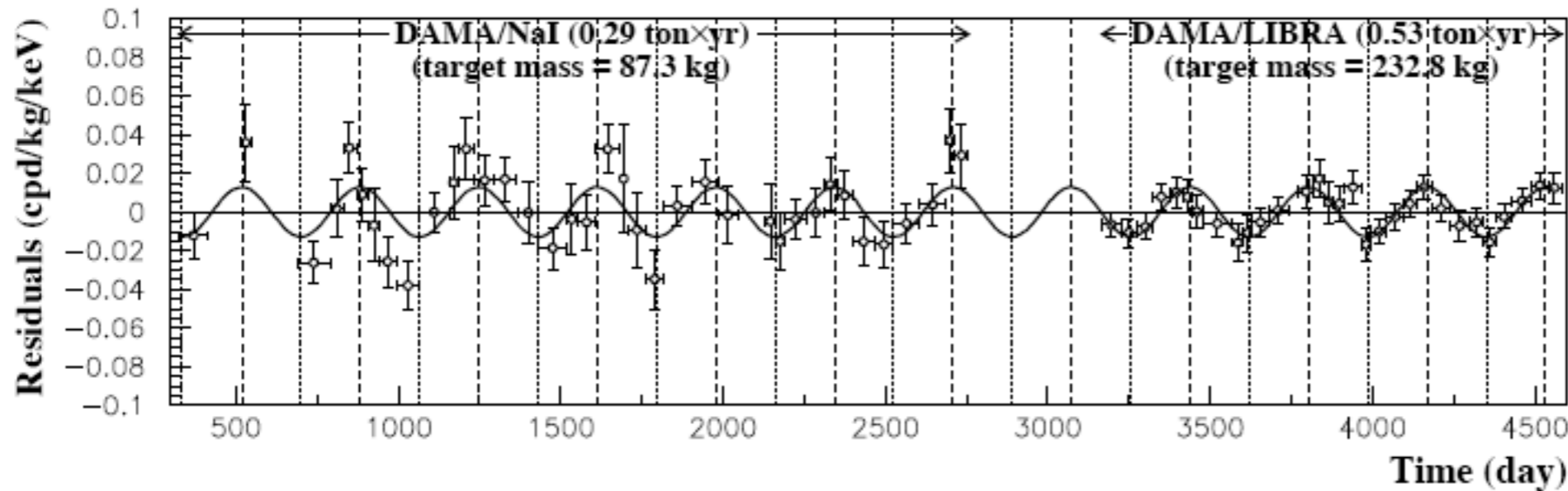


Direct I

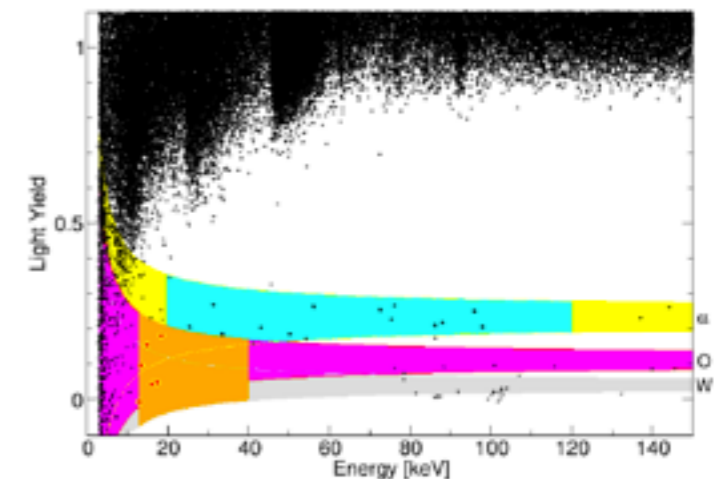
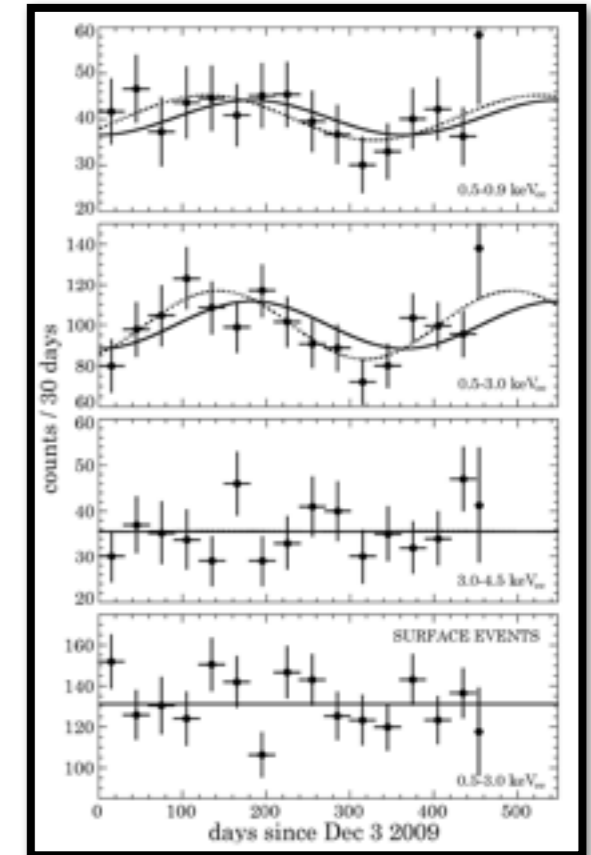
- Detecting interaction between $> \text{GeV}$ WIMP and nucleus in a material
- Name of game is to reduce backgrounds due to things like thermal fluctuations, radioactive decays, cosmic rays...
 - recoil energies 1-100 keV
- Many experiments, employing many detector technologies and as a result different nuclear targets
 - phonons, superheated fluids (bubble chambers), scintillators, ionization chambers



Direct II



- DAMA/Libra, CoGeNT, CRESST-II appear to have seen signals that can be interpreted as DM -- ~ 10 GeV WIMP
- Though not without controversy -- are we sure we understand the backgrounds as well as we think we do?
- Comment that we should have experiments in both north & south hemispheres to counter weather dependent effects



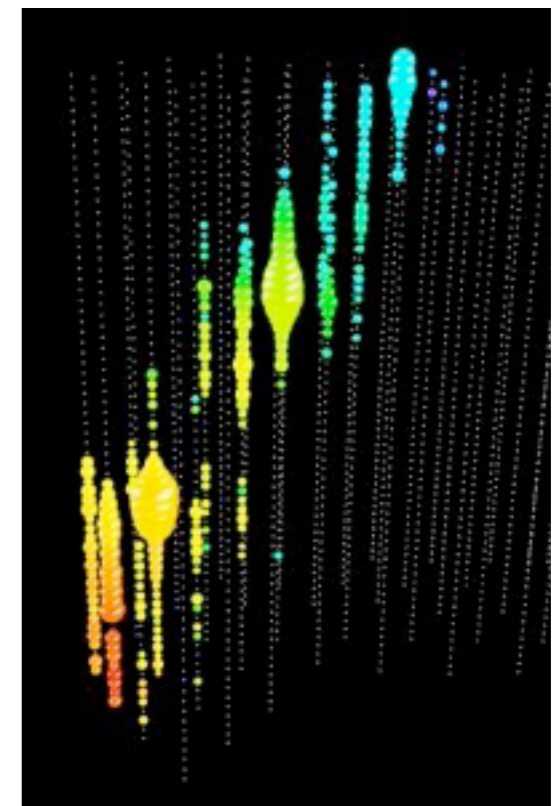
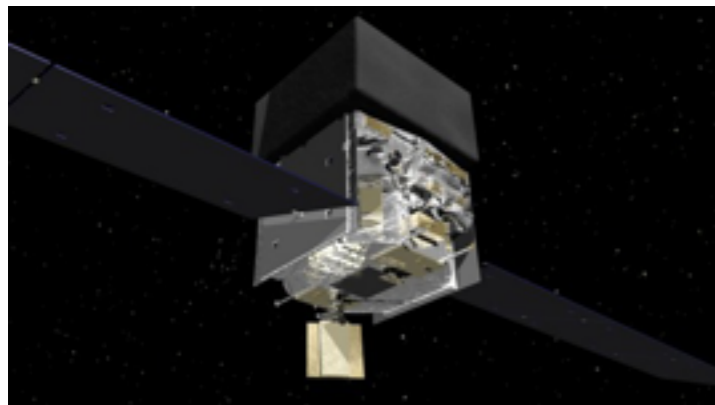
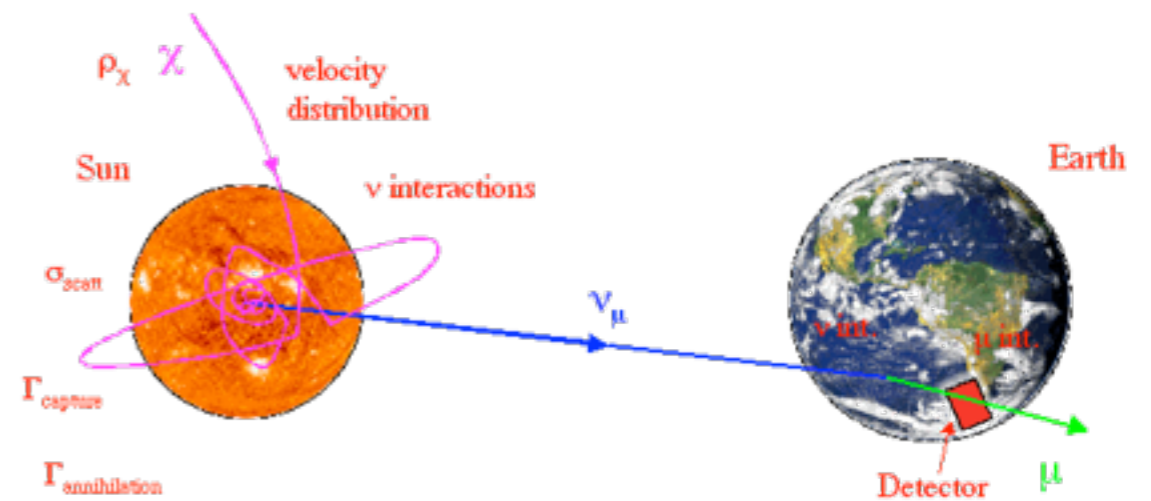
Direct III

- Advantages
 - Diversity -- many experiments
 - Many different methods whether just looking for the recoil energy, measuring annual or daily direction modulation
 - Can give you mass assuming you understand velocity distributions and scattering cross sections
- Disadvantages
 - Diversity?
 - Don't know what the thing might have been you've detected or to what extent it would make up DM



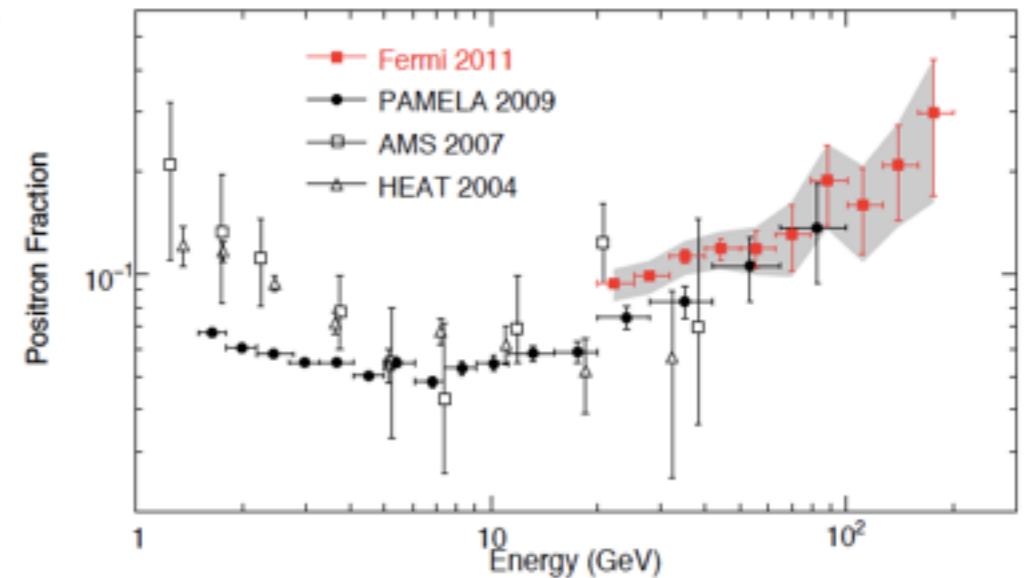
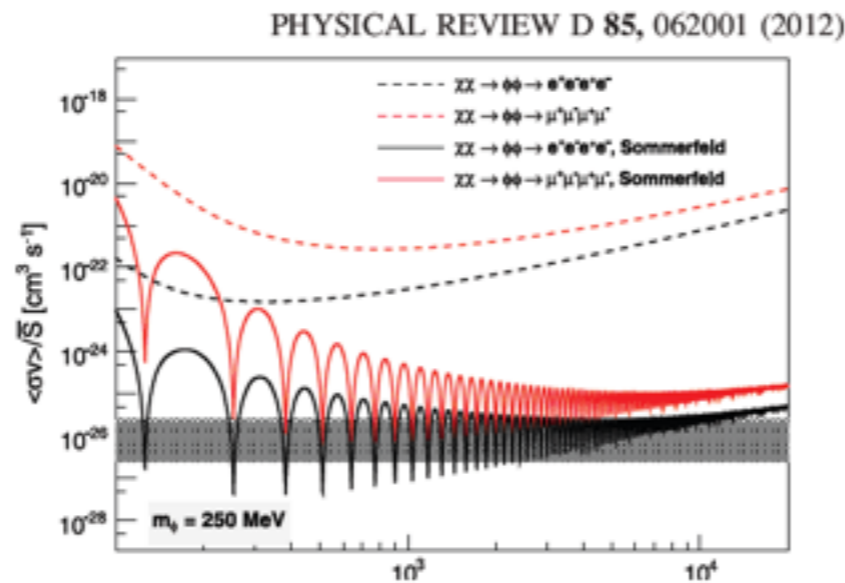
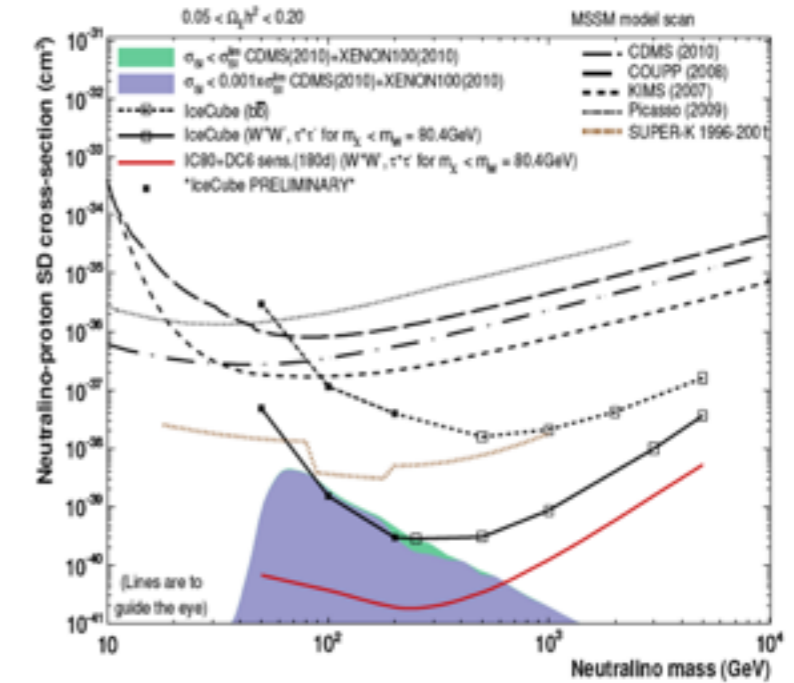
Indirect I

- Detecting annihilation products of WIMPS expected to have collected within massive things, sun, galaxy clusters, etc.
- Electron/positron measurements (satellites, i.e. PAMELA, Fermi LAT)
- Neutrino detectors (ground based) IceCube/DeepCore, Amanda, SuperK
- Gamma ray telescope arrays (ground MILAGRO, VERITAS, HESS, MAGIC)



Indirect II

- IceCube compared to direct measurements for spin dependent WIMP-nucleon xsec limits (right)
- PAMELA/Fermi see excess of positrons rising with energy, but not with antiprotons -- can explain with leptophilic models
- But perhaps constrained by VERITAS (wiggly curve below)



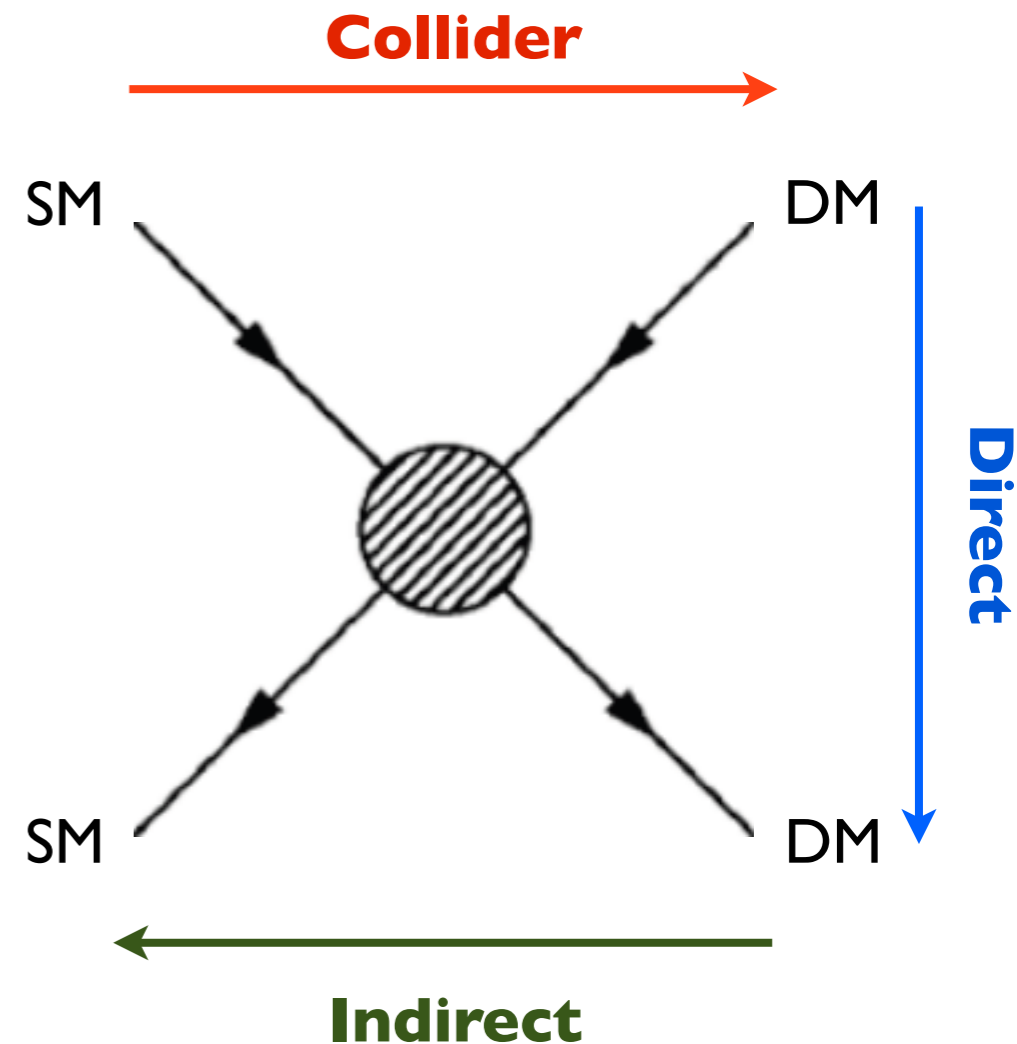
Indirect III

- Advantages
 - Many experiments targetting different annihilation signatures/particles
 - Identify particles with a cosmic source,
 - Could get a handle on mass and possibly cross section
- Disadvantages
 - Don't know to what extent a DM candidate would make up what fraction of DM
 - Don't necessarily know what the things are that made what you're detecting



Synergy?

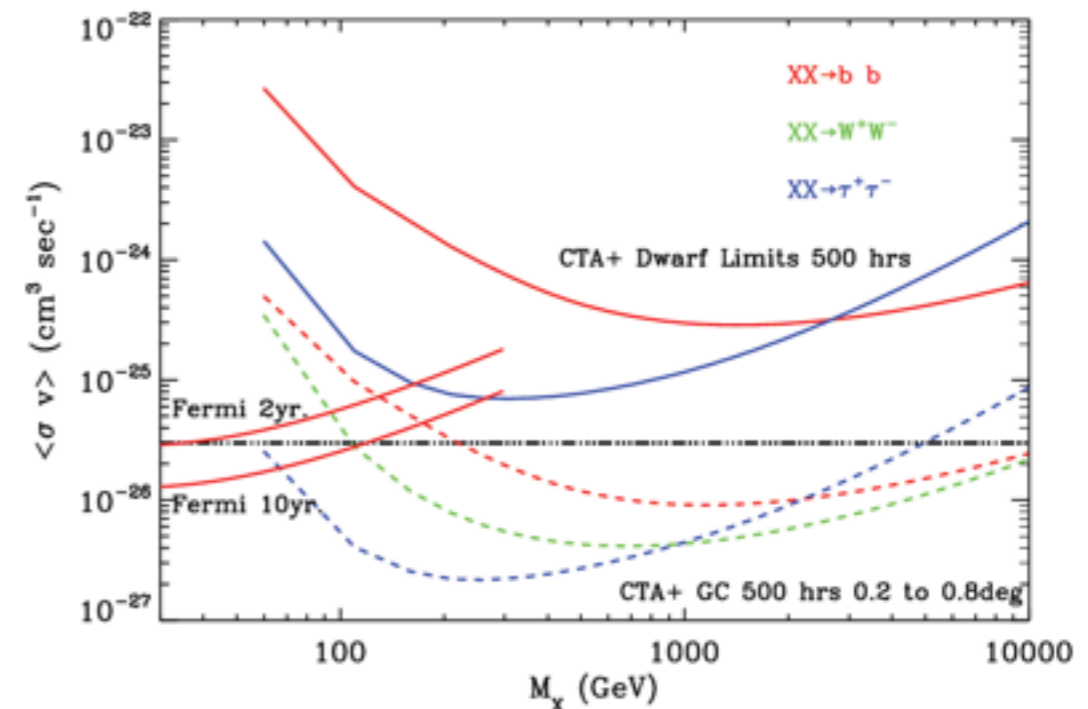
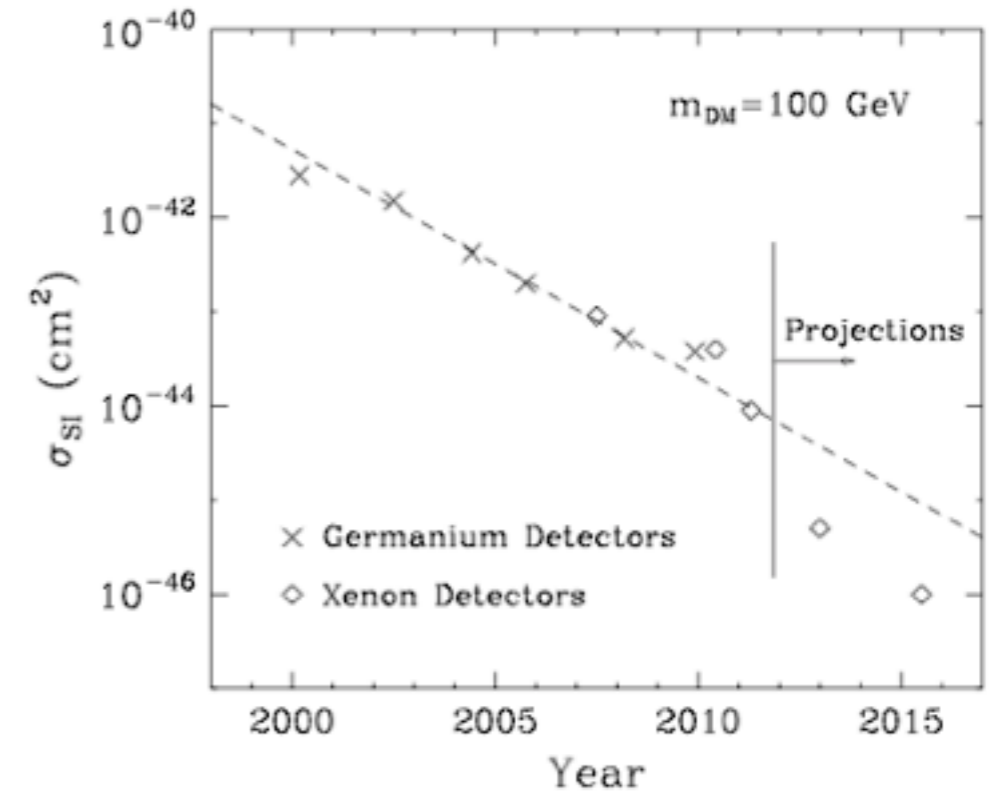
- Where do the different approaches complement each other in a way that provides more information than each individually?
- Again keep in mind the cartoon:
 - In principle we're all looking at the same process albeit through model dependent transformations
- Interesting panel discussion comment:
 - Given what evidence we have in hand, what would you consider conclusive, what would you need to say "we saw it"?
 - A: Need to see in more than one approach
 - "Need to see in collider" was more or less agreed one of the necessary approaches to have had seen evidence of DM
- If we see something in all 3 how sure can we be that its DM? What would we need to measure?



Progress?

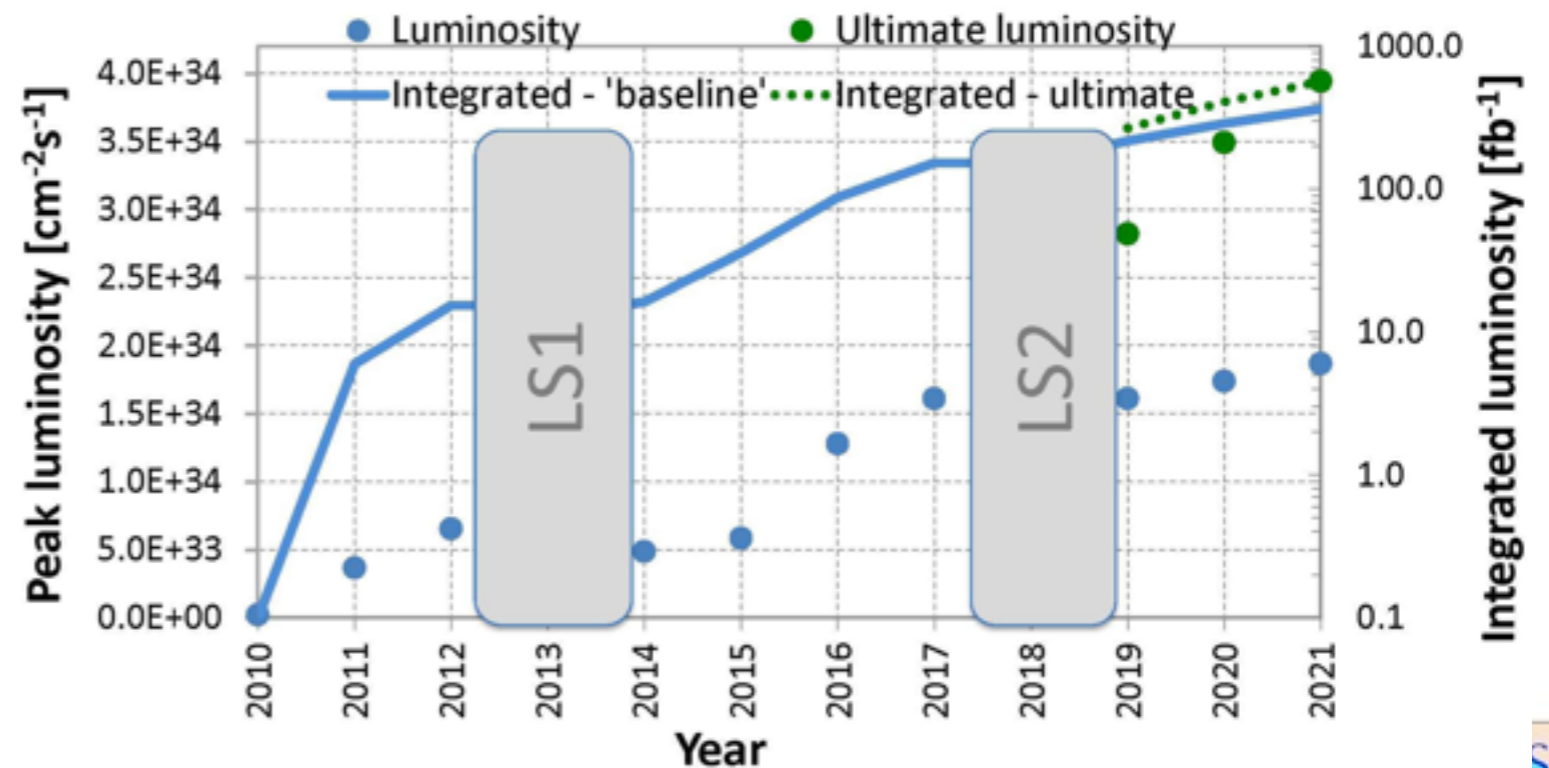
- What are the prospects for making progress with each technique over the next decade?

- In general barring funding worries, optimistic
- LHC at 8 TeV, close to 20 /fb expected this year, 14 TeV later
- Many improvements in direct detectors background understandings and new experiments coming online DEAP/CLEAN, LUX, CDMS bigger
- ICECUBE adding strings, DEEPCORE, proposed future projects like Cherenkov Telescope Array (CTA)



LHC

- Datataking at 8 TeV already frantically underway for this year at LHC
- Duplicate 2011 Int lumi by summer? 4x by end of run?
- Beyond that move to 14 TeV in ~2015
- SUSY searches reaching into 1 TeV masses now, expect to roughly double that after 14 TeV and ~100/fb.



Community?

- How can we build a larger community that can argue effectively for DM experiments leading up to the Snowmass 2013 meeting?



Community Discussion

- General consensus that definitively finding dark matter candidate requires observation within multiple realms (Collider/Direct/Indirect, Of those collider seemed required)
- This implies a need for a community spanning those realms
- Noting: workshops this summer and fall (DOE in August, DPF in October) with strong future funding implications.
 - Also noting possible (probable) dismal funding situation post US election
 - And targetting a SNOWMASS 2013
 - Will we learn anything in the next ~year that would imply waiting before making decisions? LHC? IceCube? ...
- Discussion included strong caution AGAINST “over organization” from panel members with experience with the European system -- where experiment participation decisions are made at the national/funding agency level.
 - Diversity/freedom to try ideas out with small projects being a strength of the US program.



Some questions posed in the discussions

- What if the LHC Higgs disappear -- and we don't see something new this year? What if we do? -- how do these change the DM search strategy?
- How do we prioritize experiments -- i.e. what do we do if asked to stage experiments ala LBNE?
- How well do we know the collection of experiments in the Collider/ Indirect/Direct realms don't leave holes in coverage? That we wouldn't miss a discovery?
- Is there a role for the Intensity Frontier here? Fixed target DM production?

