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Long Range Plans for Direct Dark Matter Searches

Short term plans (mostly high mass)

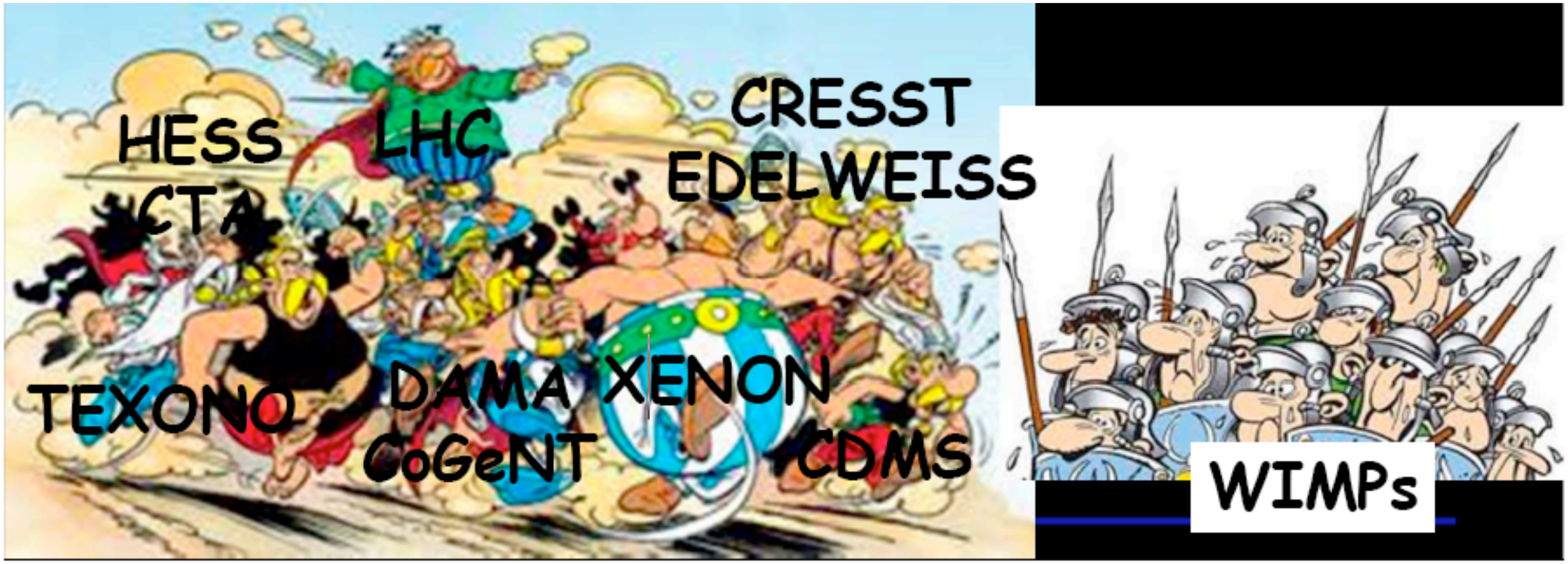
Cleaning up the low mass region

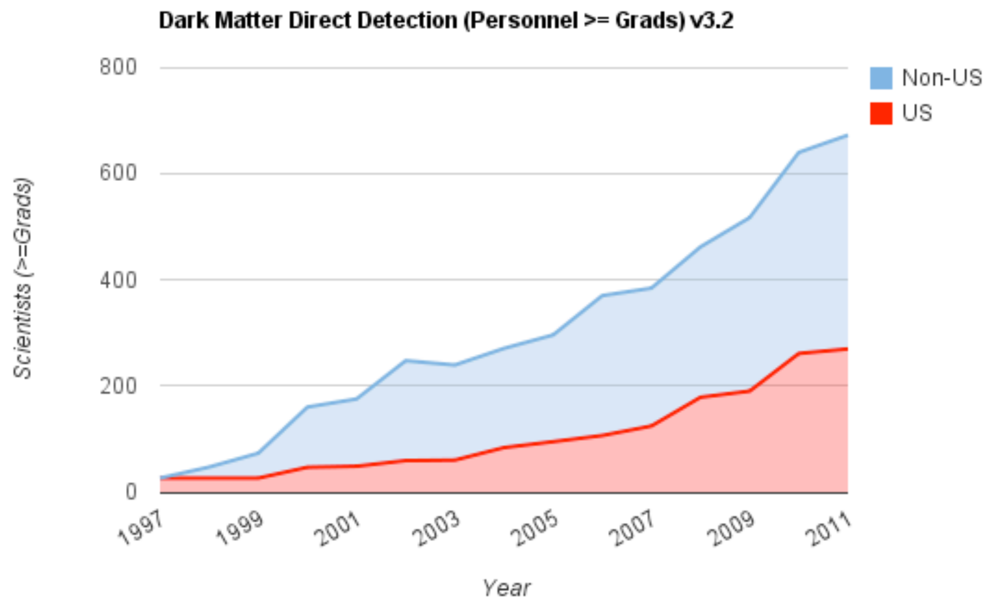
The medium term and long term

Disclaimer:
I am a member of CDMS

An Active Field

Credit: Joerg Jaeckel





Direct Detection
An expanding community

US≈ 270 physicists ≈70% FTE
≈ 40% of world

Detection Challenge

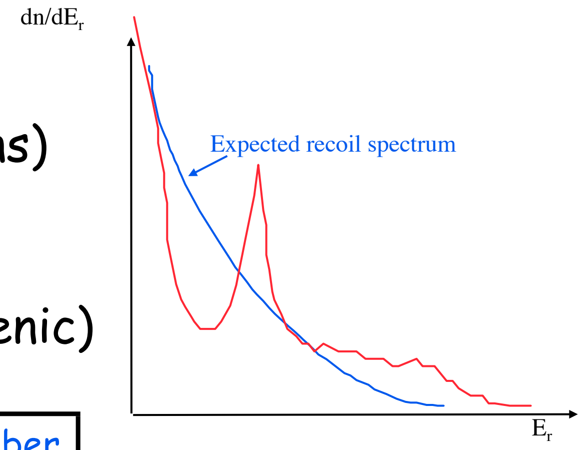
A variety of novel and exciting techniques

Exquisite energy sensitivity

3 D reconstruction=>fiducial cuts (self shielding, bad regions)

At least two measurements to distinguish nuclear recoil
from electron recoils => as much information as possible

Decrease neutrons to negligible level (radio-purity, cosmogenic)



	Liquid Xenon	Liquid Argon	Low temp. Ge	Bubble Chamber
Ionization	√	√	√	high density
Scintillation	√	√		
Phonons			√	
Other		Pulse shape	Pulse shape	Acoustic

+ 77K Ge, NaI

Challenges

10^{-47} cm^2/nucleon ≈ 1 evt/ton/year (e.g. 70 GeV/c^2, Ge, 10 keV threshold)

Liquid Xenon: Liquid purity, HV, radio-purity high enough for self-shielding

Liquid Argon: Liquid purity, HV, ^{39}Ar depletion

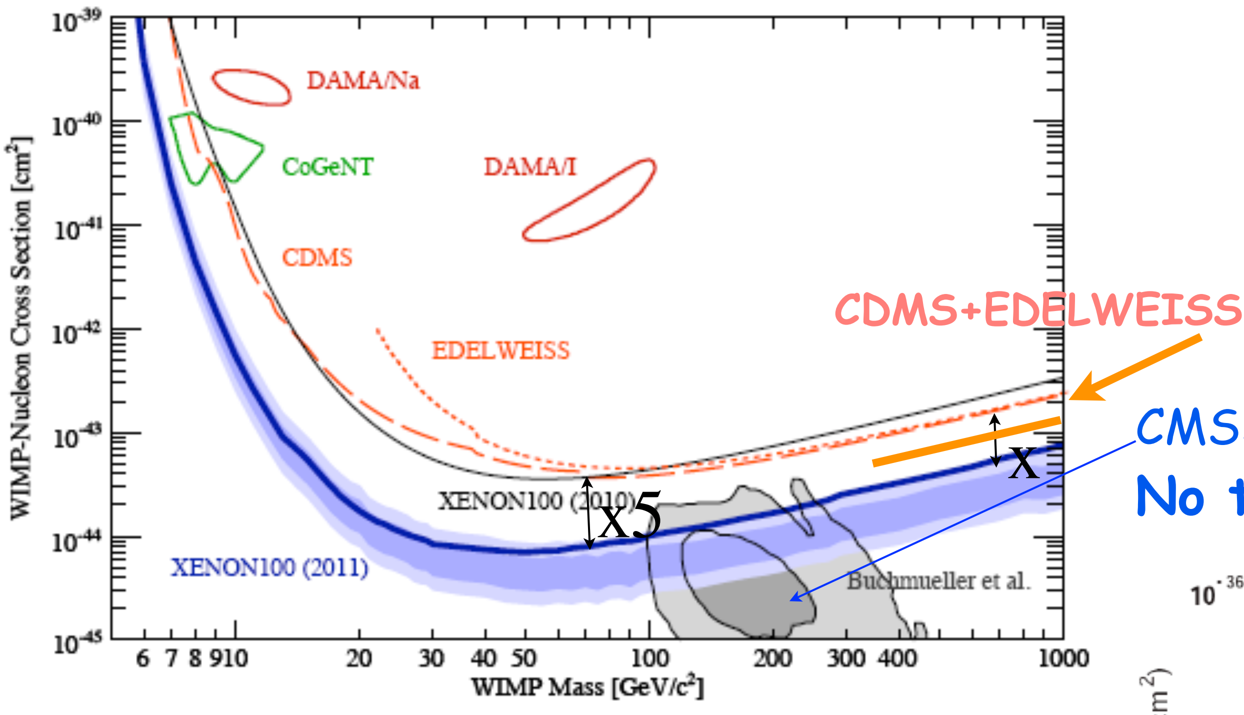
Low temp. Ge: Cost/yield for large # of detectors high Ø Ge

Bubble chamber: Liquid purity/stability, α acoustic rejection

Directionality: How to get large enough mass at reasonable cost?

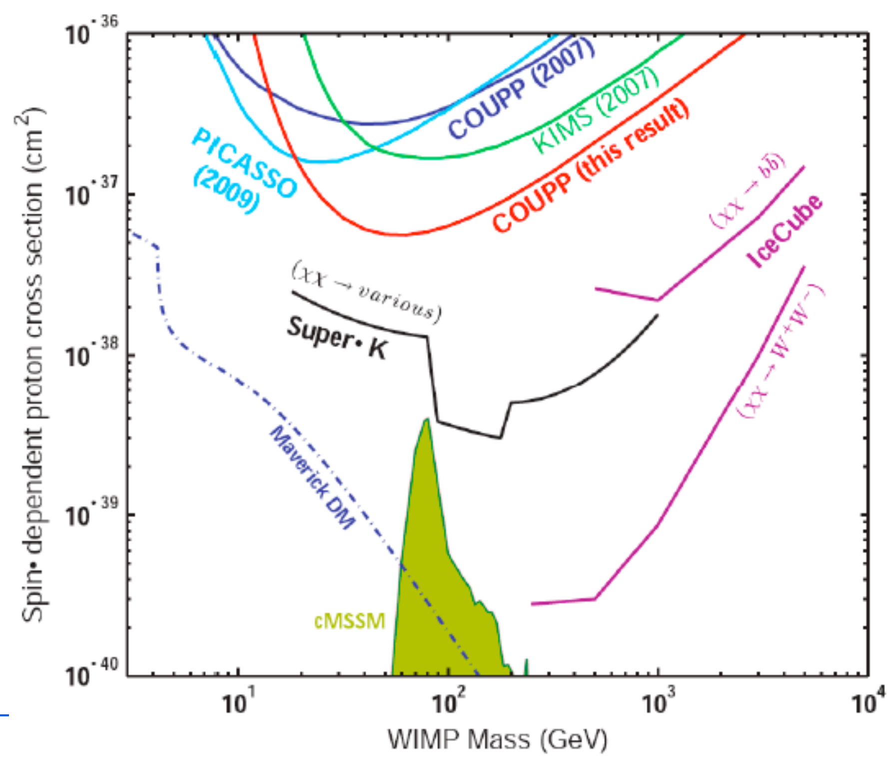
+ scale-up: engineering and safety

High Mass Region

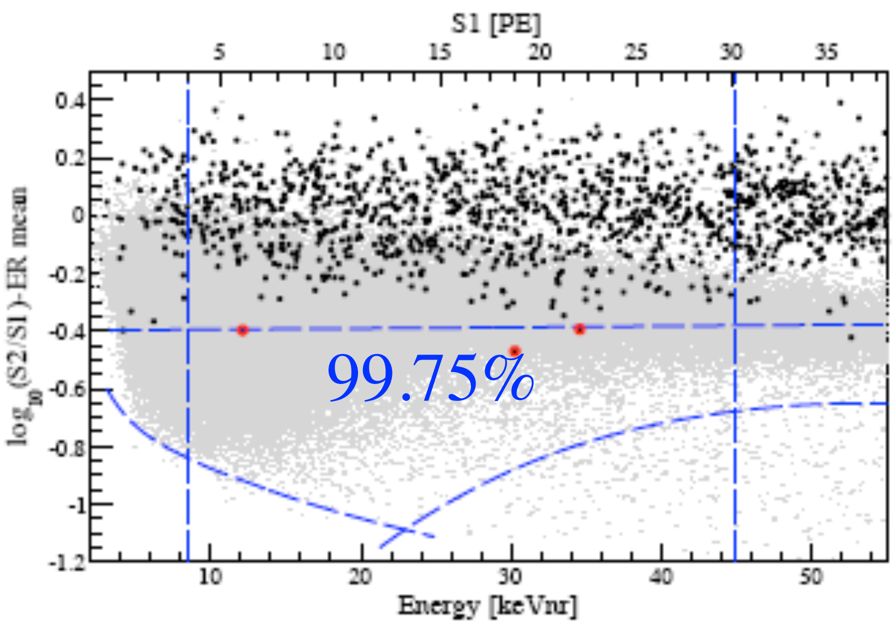


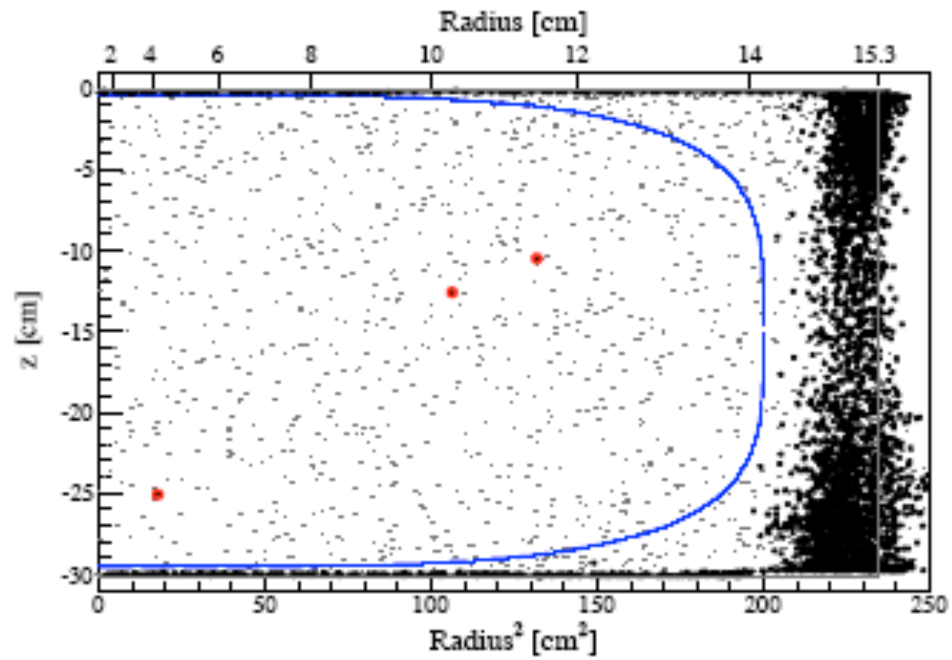
CMSSM≈mSUGRA Focal point region

No threshold for Direct Detection



Background!





Not yet suitable for tonne size!

Purification to decrease ^{85}Kr

Did not present 200 day result by APS meeting in April 2012

Technical progress

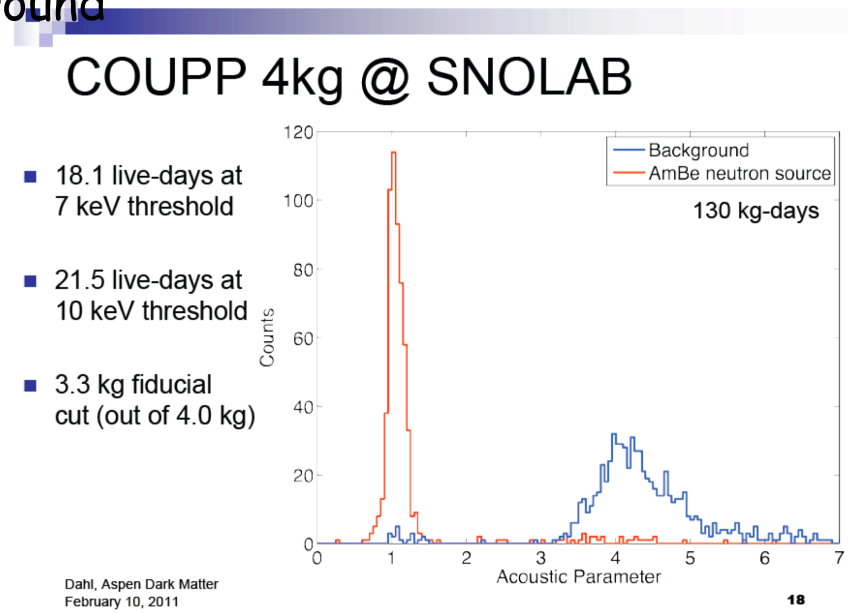
Super CDMS 10 kg running well at Soudan

8-> 5? 10^{-45} cm^2 depending on neutron background

COUPP 4kg at SNOLAB

Acoustic rejection of alphas
but neutrons due to PZT

60kg problems with CIF_3dissociation
solved -> SNOLAB



Liquid Xe

XMASS (800kg Xe)

first tests -> results at Japanese Physical Society meeting: background from Cu

LUX 350kg, successful tests at the surface -> underground this spring 2012

Xenon 2.4 tonne being reviewed US +Europe

Panda X 1 tonne China +US

Liquid Ar:

MiniCean (180kg), Deep/Clean

WARP->Dark Side in Borexino CTF

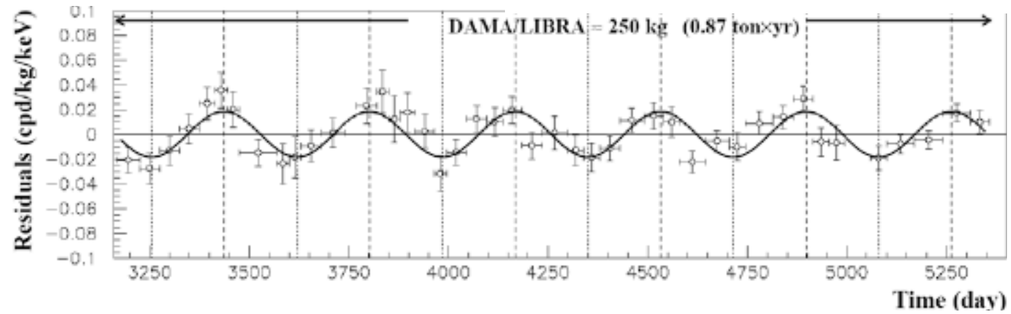
ArDM in Camfranc

A Low Mass WIMP?

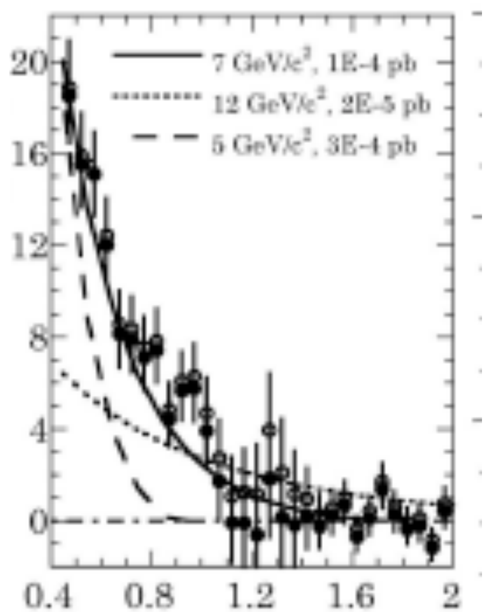
Experimental claims

DAMA (NaI)

Latest Princeton Nov 2010



CoGeNT (Ge)

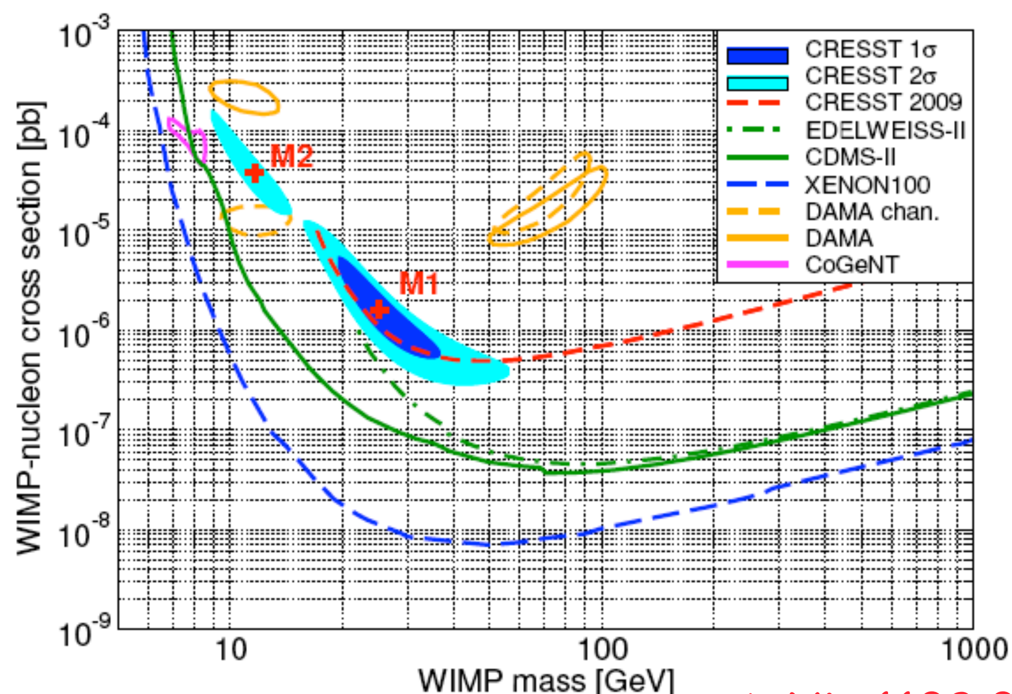


keV ee

Aalseth et al. ArXiv: 11060650

L X ray peak subtracted

CRESST (Ge)



ArXiv:1109.0702

A Low Mass WIMP?

3 questions

Can this be the results of experimental issues?

A lot of discussions DAMA e.g. Nygren

CoGeNT: Collar

Eventually, if no convergence, an independent group will have to repeat the experiment on same material

DM Ice at the South Pole (also KIMS ANAIS, Princeton)

How to make it compatible with CDMS and Xenon?

Can this be unified (Hooper,Collar)?

Hooper, Collar, Hall, McKinsey arXiv 1007.1005

Theory: very natural for asymmetric dark matter

dark matter ≠ anti dark matter (K. Zurek, L. Randal ...)

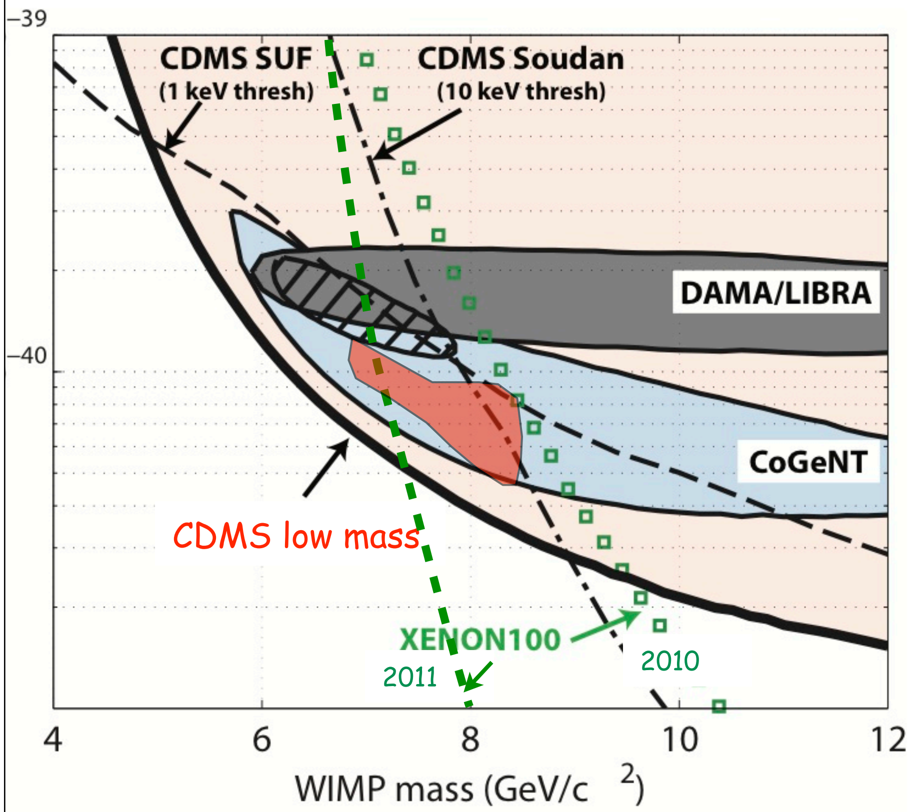
if baryon asymmetry coupled to dark matter asymmetry ≈ equal

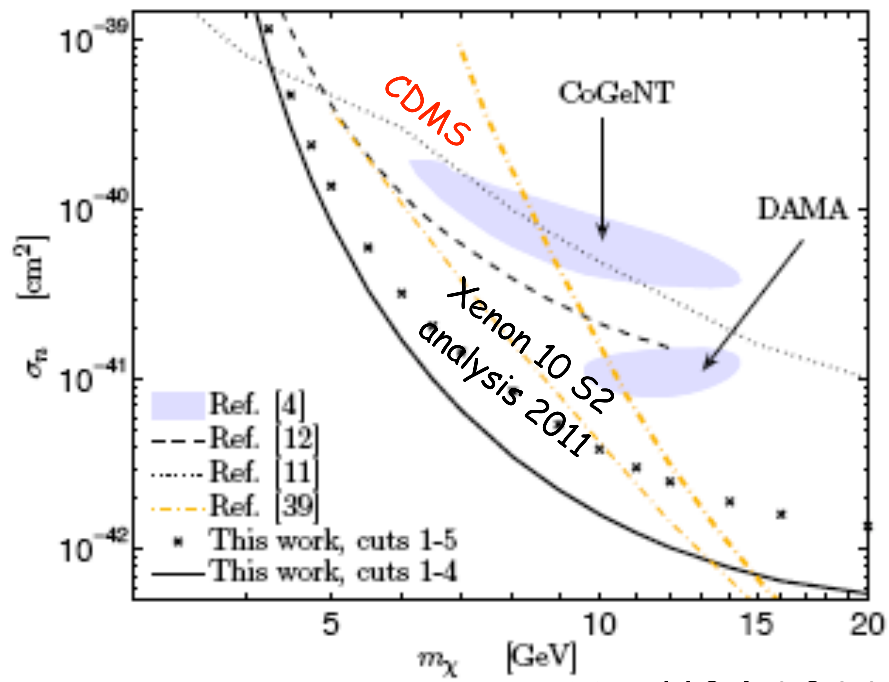
7 times more dark matter -> 7 GeV scale

Scattering through Higgs -> weak scale ????

How do you naturally have enough annihilation to wipe out the symmetric component?

Compatibility with other experiments with CoGeNT original "claim"





Xenon 10 S2 Analysis ArXiv:1104.3088
1 electron sensitivity level

Ahmed et al ArXiv:1011.2482
Very robust
Same material as CoGeNT

Collar: arXiv:1106.0653 still excessive sensitivity to calibration especially at few (5) electrons level

But CoGeNT shifting !

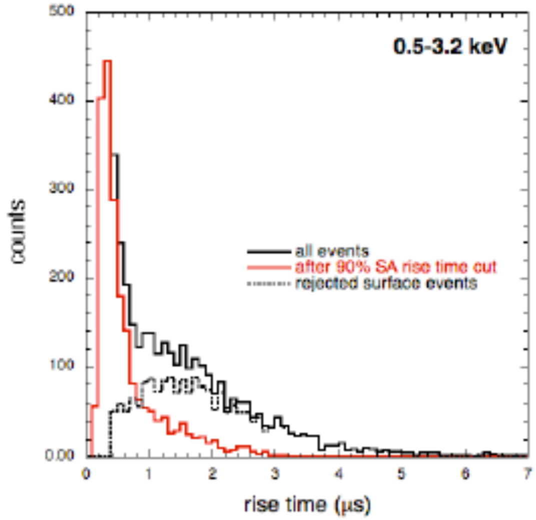
2/3 of events are surface events. Why not 100%?

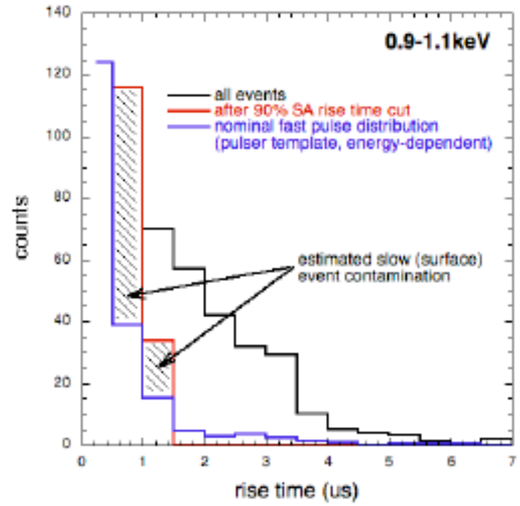
CoGeNT Shift

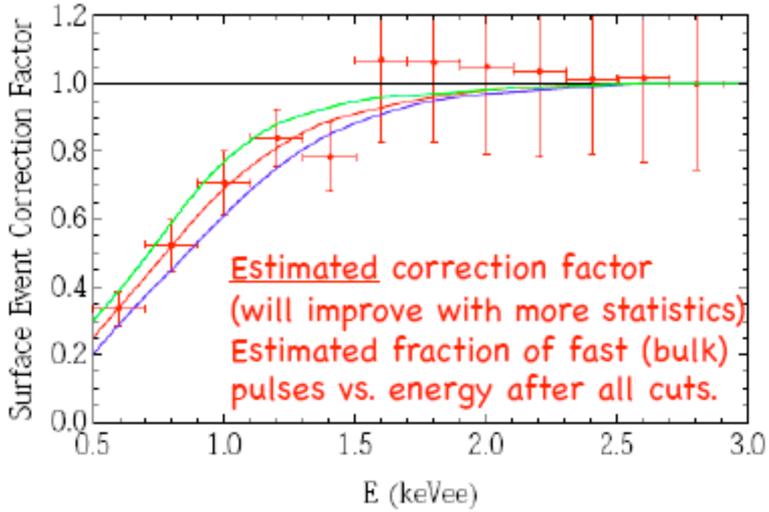
CoGeNT uncertainties (e.g., surface event rejection next to threshold)

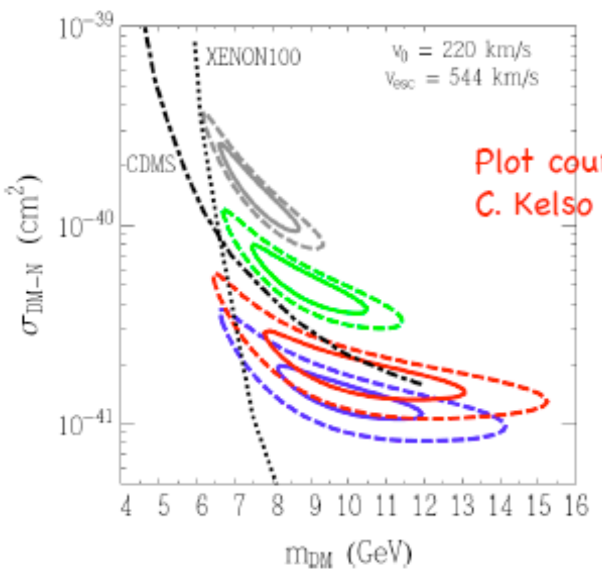
PRELIMINARY (work in progress, not an exact science yet)

from Juan Collar







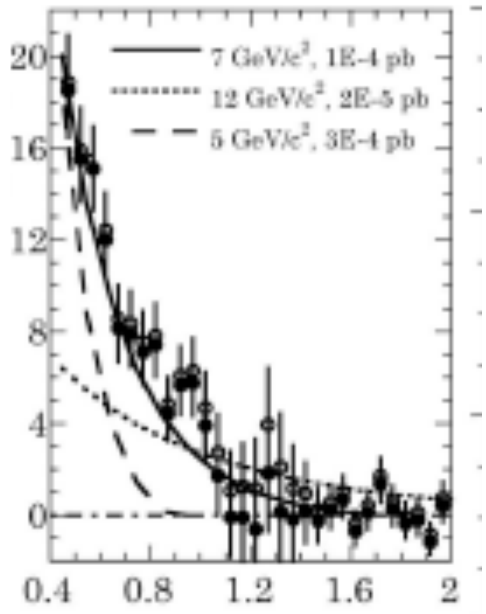


Plot courtesy
C. Kelso

Modulation?

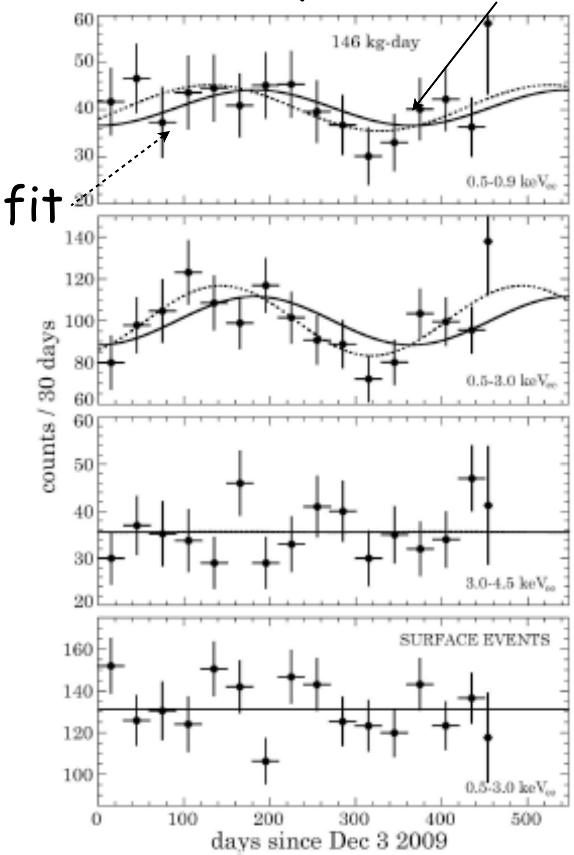
Aalseth et al. ArXiv: 11060650

Modulation appears larger 0.9-3keV where there are very few events



Expected modulation

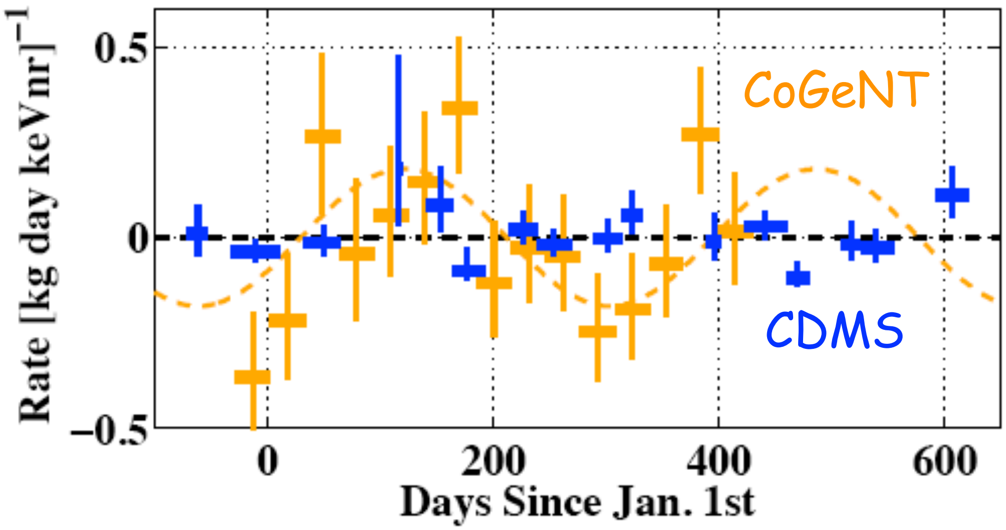
Best fit

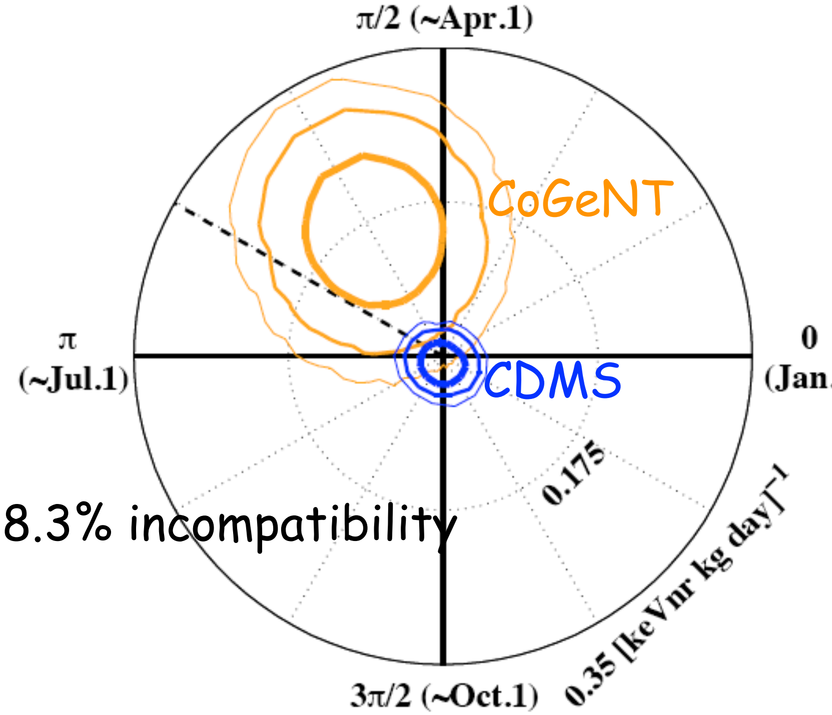


CDMS (Marina del Rey)

5 keV-11.9 keV nuclear recoil:

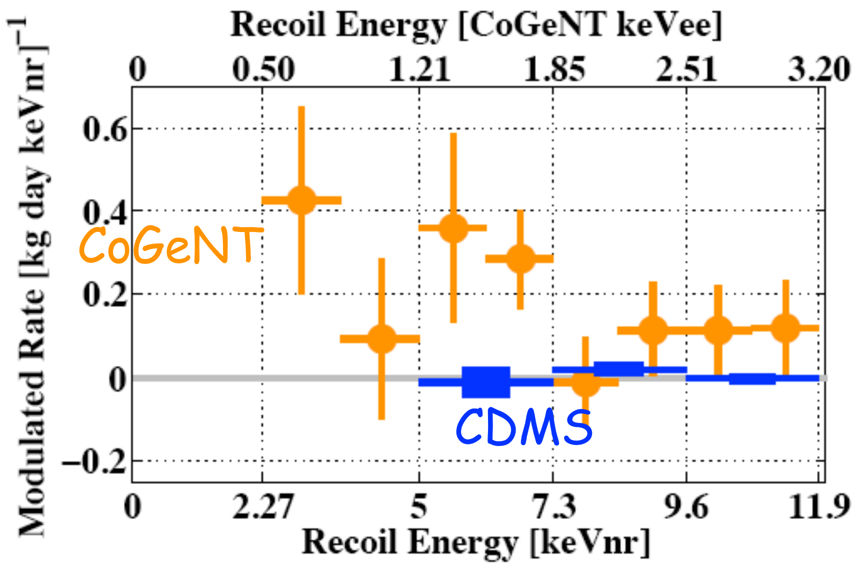
arXiv:1203.1309



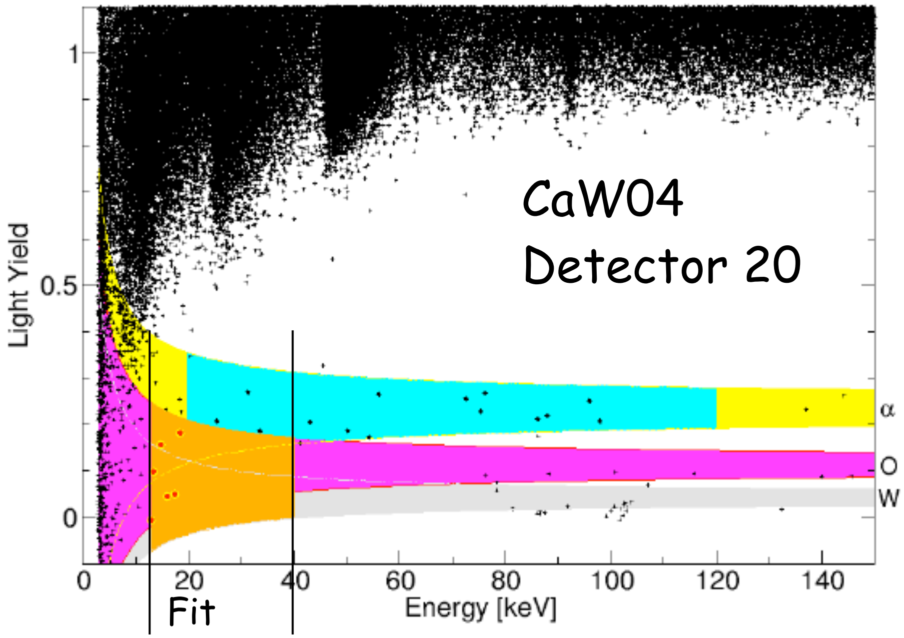


We are of course looking at lower energy

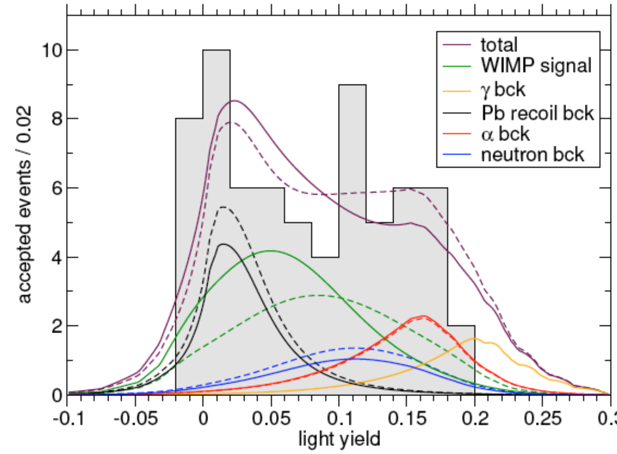
Hope to have a solid result at lower energy soon!

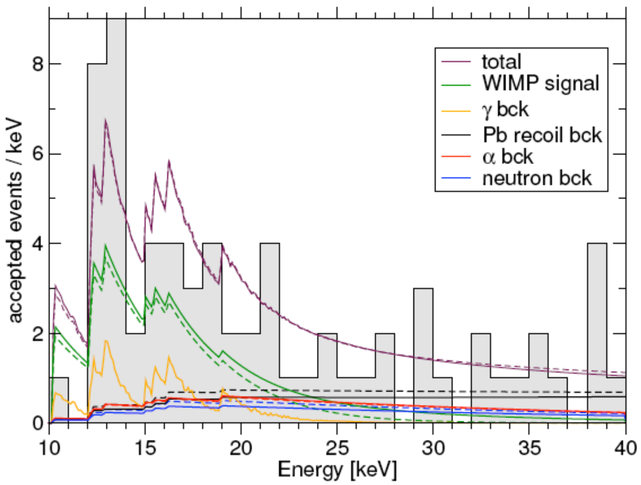


CRESST (1109.0702)



Detailed fit of recoil energy and scintillation distributions + multiplicity (neutrons)





Claim >4 σ ≠ rest of field

But 42-47 background, 29-24 signal Evts

Maximum likelihood notoriously sensitive to assumed functional forms!

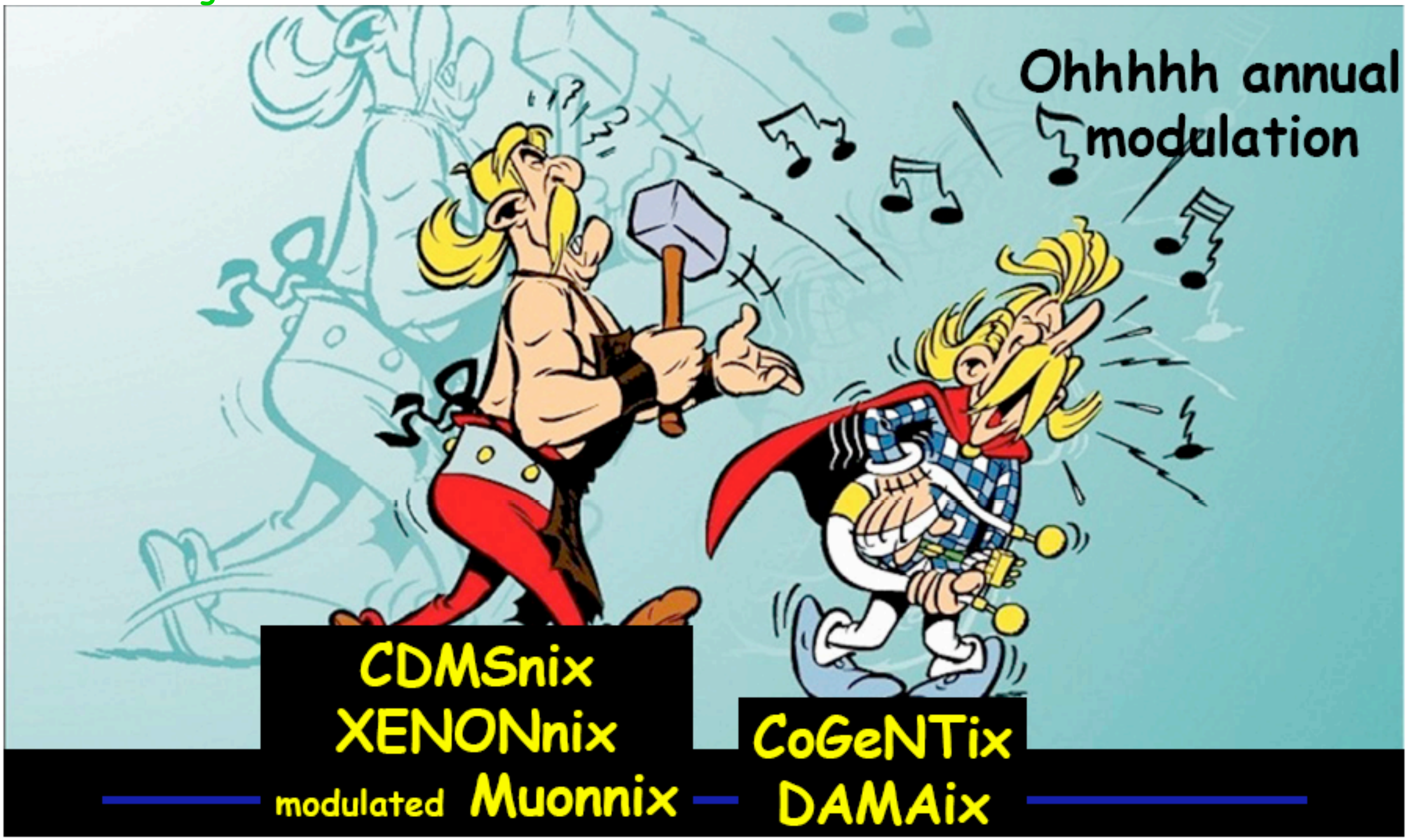
What if the shape assumed for the background is slightly wrong?

Not believable at this high level of background subtraction!

Team plans to reduce in next run!

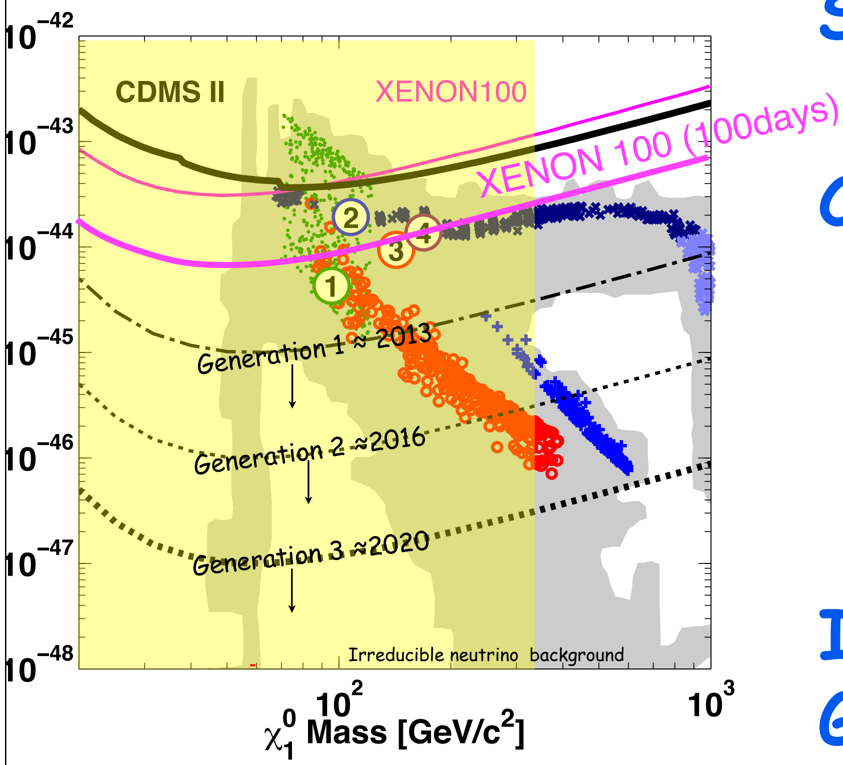
Lively discussion

Credit: Joerg Jaeckel



CRESSTix

Where do we go next?



Strong consensus

Sensitivity = Mass + background free.

Common roadmap

Generation 1 -> 10^{-45} cm^2 Exploration of technology + science (Supersymmetry)

Generation 2 -> 10^{-46} cm^2 Push the most promising technologies to their limit + science

Generation 3 -> <10^{-47} cm^2 2 (US) 3or4 worldwide -> detailed understanding of the physics

In US:

Generation 2:

Separate NSF (May 1) and DOE (July 8) competition for 1 year R&D.

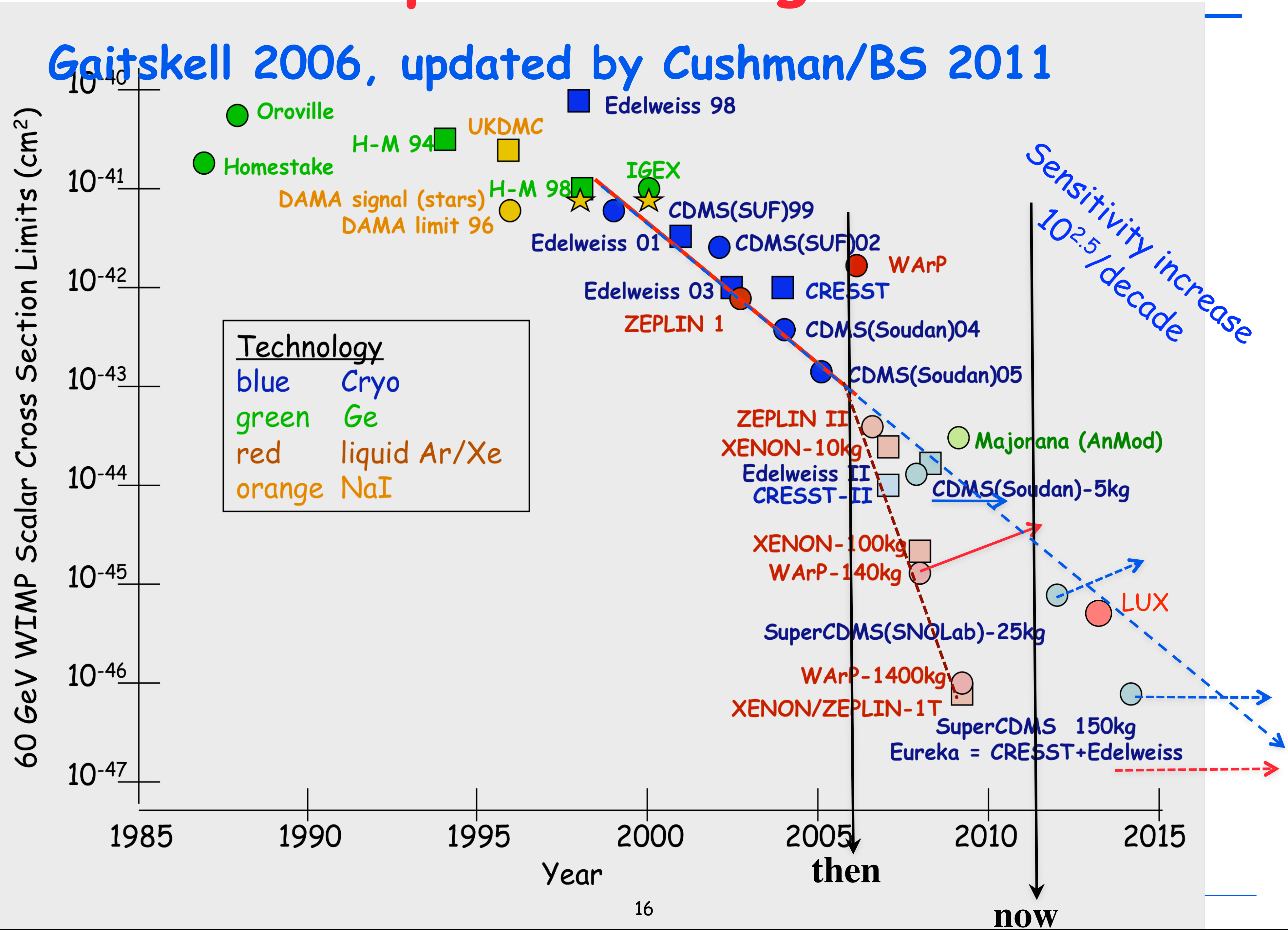
-> Project proposals to both agencies ≈ October 20, 2013 -> CD1,CD2,CD3a by Summer 2014.

Generation 3:

forming a Homestake Generation 3 Dark Matter Expt≈LBNE Converge to 2 technologies

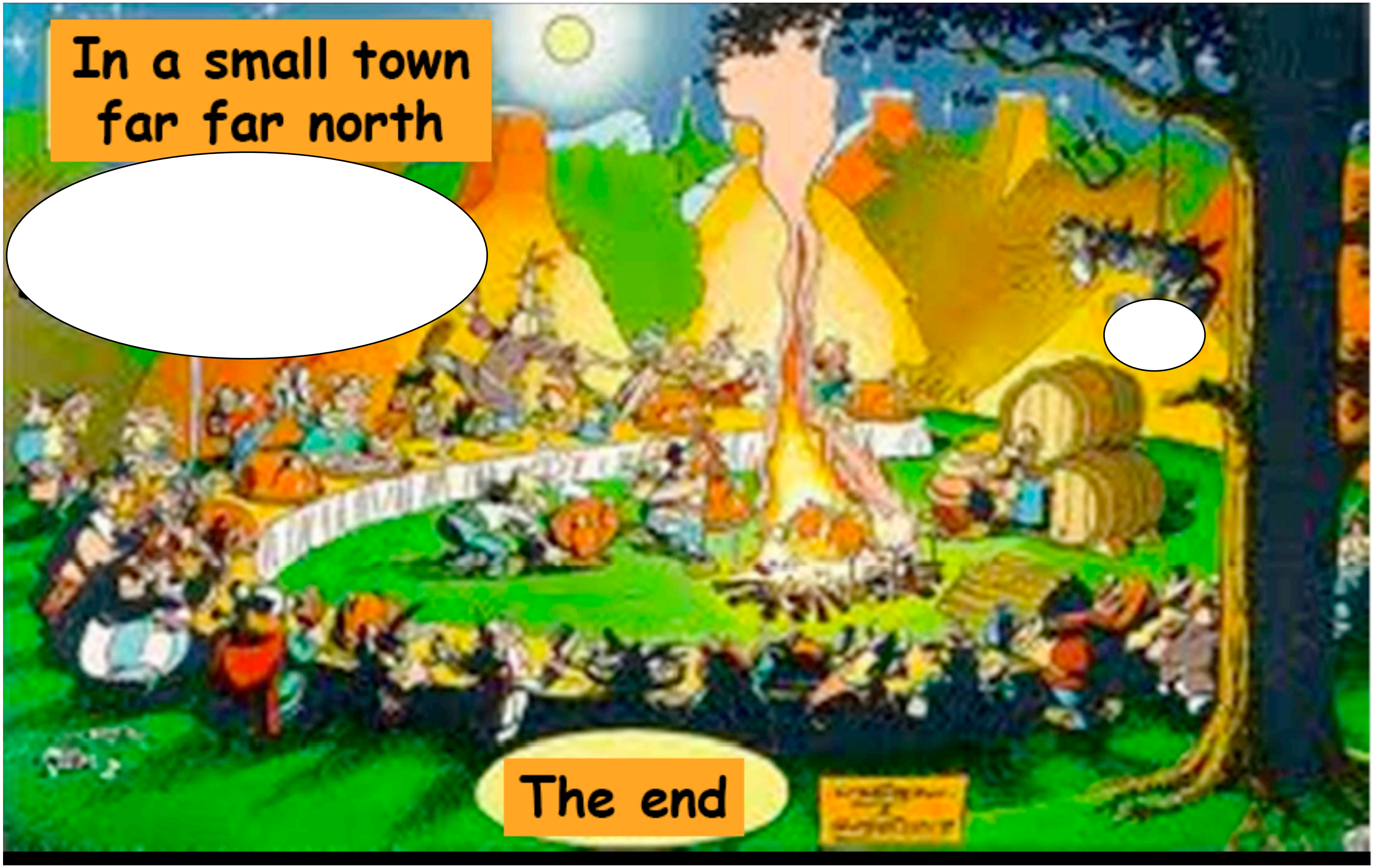
≈2015 technology choices for ≈2019 deployment

Hopes and Progress



Convergence of the community

Credit: Joerg Jaeckel



Conclusions and questions

Next few years will be very important

Direct Dark Matter:

- Establish at the current generation 1 the limits of the technologies
- Clean up our act at low mass
- Start in earnest on generation 2 in the US. Already Deep/Clean, XMass, and presumably Xe 1 tonne

LHC/Tevatron

- Input on fundamental physics: Higgs, minimum SUSY/other scenario compatible with data.
  - How strongly current data push to high mass scenarios (heavy squarks, gluinos)?
- Missing energy searches
- Monojets searches (e.g. for light WIMP)

Don't exclude the possibility of a discovery.

- A solid Higgs discovery would help!
- Direct and/or indirect essential to prove that the stuff is stable.
- Direct detection may help solving ambiguities (Baltz-Peskin-Vilanski 06)

Be careful not to send the wrong messages:

- Importance of "generic" conclusions with clear domain of applicability
  - The exclusion of MSSM/mSUGRA is not a lack of progress.
  - The feverish exploration of exotic models should no betray despair

Longer term

- Definitive results crossed checked across several experiments
- Large statistics with negligible background => astrophysics
- What are we missing in our program? How much emphasis on low mass?
- When do we give up?