"Whither WIMPs:"
Direct Detection of SUSY Cold Dark Matter
One Tonne - Have we got what it takes?
Has NUSEL got what we need?

WORKING GROUP LEADERS:
Rick Gaitskell (Brown University)
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useful information at
http://www.physics.umd.edu/ness02/
- follow working group link
http://gaitskell.brown.edu/physics/NeSS2002/web_darkmatter/

Dark Matter Working Group

Thanks to the working group

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Alexander Kusenko, UCLA
Kirk MacDonald, Princeton
Jeff Martoff, Temple
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Nigel Smith, RAL

Andy Warhol - Pop Artist 1960's - "Exactly"

Gerald M. Edelman *Bright Air, Brilliant Fire* (1992)

The pop artist Andy Warhol once approached me at a party and told me that he collected scientific journals, but he couldn't understand them.

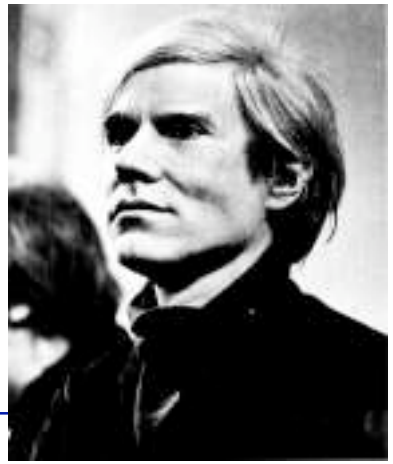
He drifted away, then came
"Do you mind if I ask you a cience take so long?"

I said, "Mr. Warhol, when yo n Monroe, does it have to be exactly like her, as clo an make it?"

He said, "Oh no."

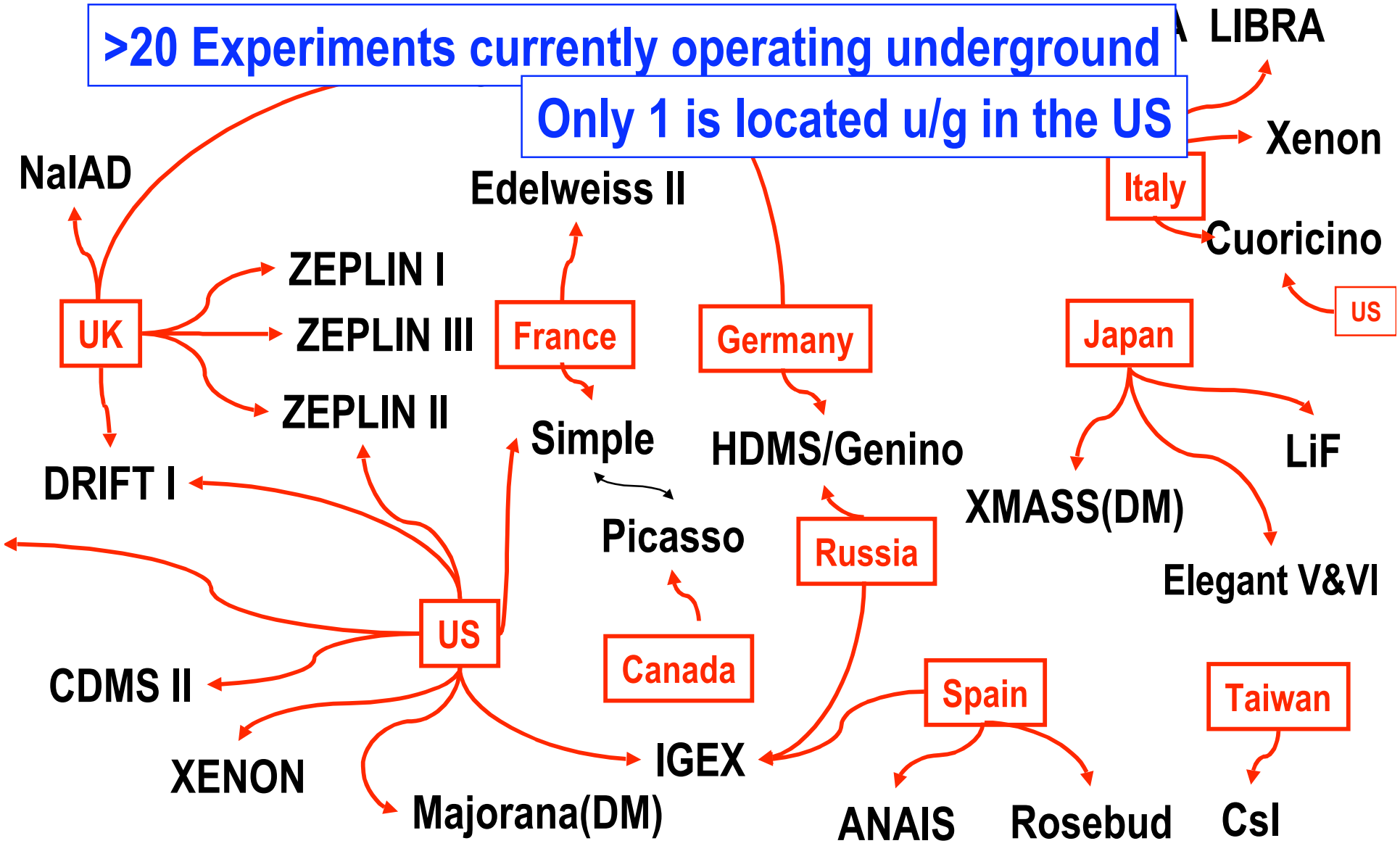
I said, "Well, in science it ha Γ as you can make it."

He looked at me with sympathy and said, "Isn't that terrible?"



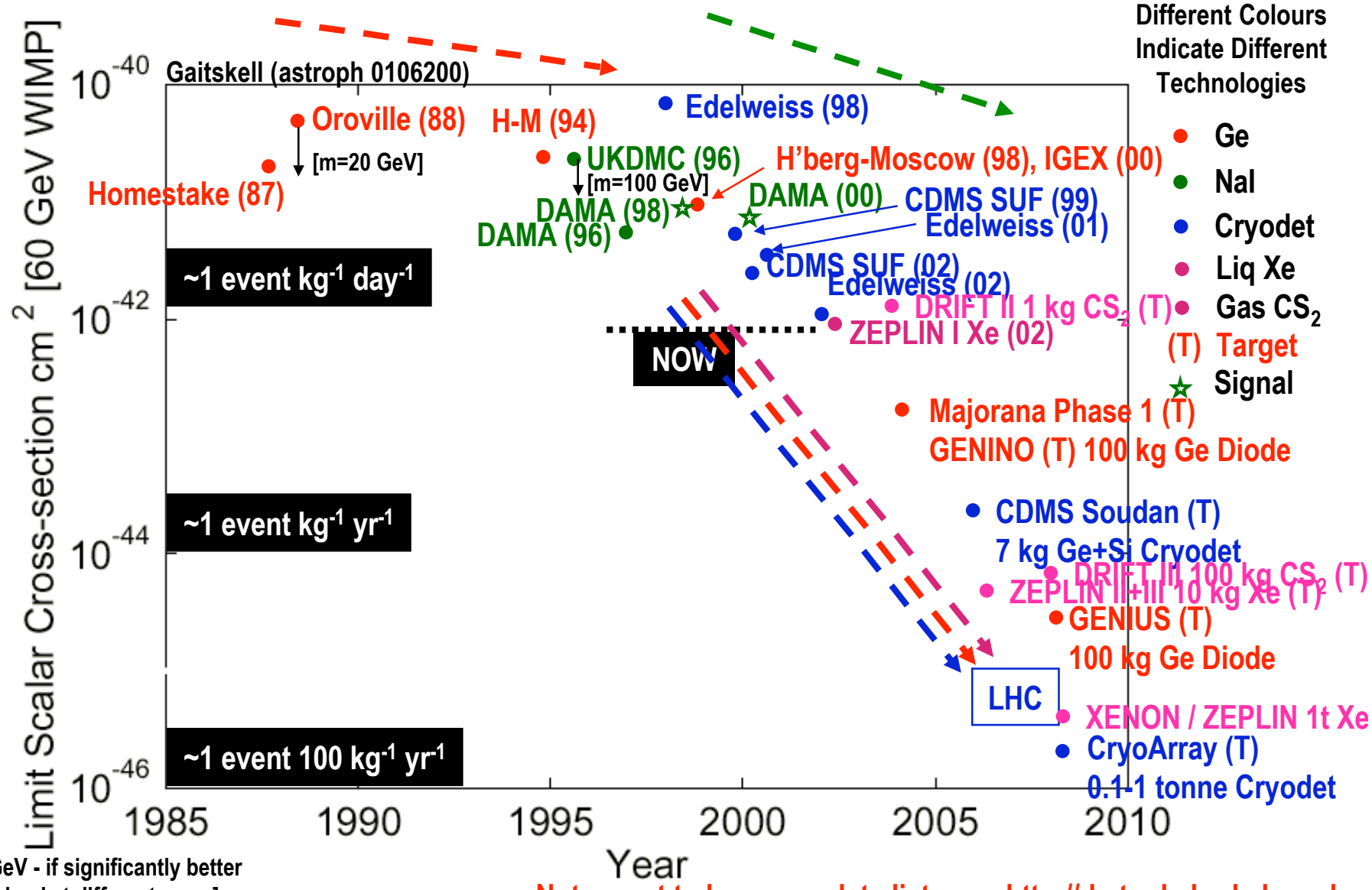
Dark Matter Experiments (Worldwide/affiliations)

(Running/Active Collaboration)



Direct Detection: History & Future

90% CL Limit on Cross section for 60 GeV WIMP (scalar coupling)



[m = ?? GeV - if significantly better limit obtained at different mass]

Not meant to be a complete list - see http://dmtools.berkeley.edu

Some of Current (2001-) and Projected Experiments (2005-)

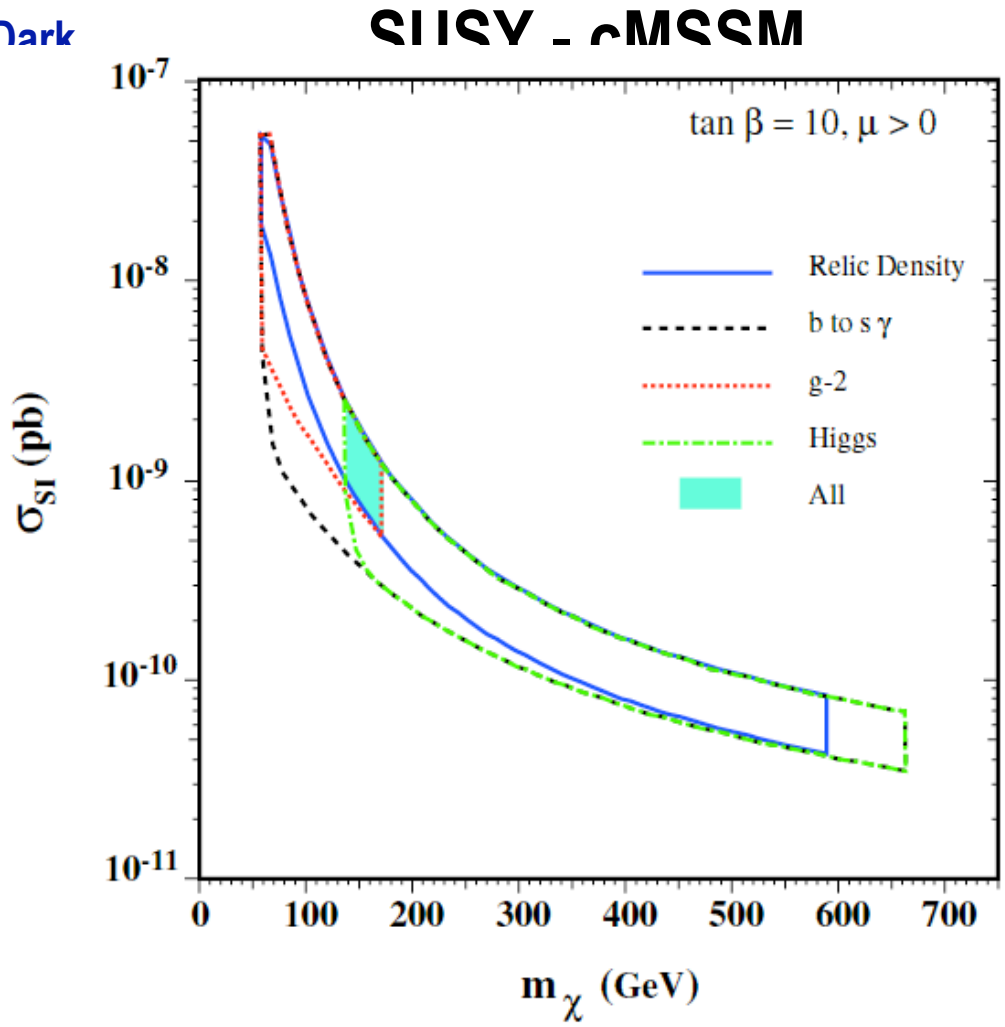
**** Not a complete list, experiments reported at meeting ***

Technology /Collab. Name	CURRENT Fiducial Mass Goal / (Now)	(2001–) Funding source	Location	PROJECTED Mass Goal	(2005–) Location
Liquid Xe					
XENON	100 kg (-)	US	**	1000 kg	**
ZEPLIN	30 kg (3 kg)	UK/US	Boulby,UK	1000 kg	Boulby,UK
XMASS	20 kg (1 kg)	Japan	Kamioka,Japan	1000 kg	**
Cryogenic (T<1K)					
CDMS/CryoArray	7 kg (1 kg)	US	Soudan,US	1000 kg	**
EDELWEISS	7 kg (0.7 kg)	France	Frejus,France	35 kg	Frejus,France
EuroCryo Collab		Europe	**	1000 kg	**
Gas TPC					
DRIFT	1 kg (0.2 kg)	US/UK	Boulby,UK	100 kg	**
HP Ge					
MAJORANA	40 kg (2 kg)	US	**	500 kg	**
GENIUS	40 kg (5 kg)	Europe	Gran Sasso,Ity	1000 kg	Gran Sasso,Ity

- **Funding Profile - current experiments (investment in det R&D >10 yr)**
  - **Construction Capital 5-15M$; Operating 2-4M$/yr , Personnel FTE 15-40**
- **Funding Profile - Projected Experiments (1 tonne)**
  - **Construction Capital 20-50+M$; Operating 4-8M$/yr , Personnel FTE 30-60**

WIMP Dark Matter Physics

- Physics Motivation
  - Cosmology: Need for Non-Baryonic Dark Matter
    - $\Omega_{\text{unknown matter}}$=0.27+/-0.04) [Turner]
  - Particle Physics: Naturally generates solution
    - SUSY [Ellis]
    - Non-Pointlike DM [Kusenko]
    - Kaluza-Klein Extra Dimensions [Feng
- Existing Direct Detection Experiments
  - Testing some models
  - As sensitivity improves - will continu test more models
- Recent/current accelerator constraint shrinking SUSY bounds
  - Mainly constrained UPPER bound of cross-section
  - g-2 [BNL] can provide constraint on LOWER bound (for μ>0) if tentative disagreement is due to SUSY



Greatest Experimental Challenges

- Construction & Operation of Detector Arrays Underground
  - Many of experiments experiencing "delays" associated with construction/operation
    - "Project Risk"
  - All Groups would benefit greatly from infrastructure/support of Underground Lab
    - Knowledgeable Technical/Engineering Assistance
- Achieving Detector Discrimination Performance (free of systematics)
  - Demanding Background Discrimination >>99%)
- Improvements needed in Screening Facilities
  - Dark Matter has new concerns, beyond those of Current Low Background Experiments
    - 0-100 keV & Surface Contamination
  - To reduce internal radioactivity
    - Experiments >2005 clearly demand access to systems beyond simple HPGe screening
      - 10^{-12} g/g U/Th
    - Surface/low energy radioactivity screening (Providing Input to NUSL -> Screen Fac Initiative)
      - 1 m^{-2} day^{-1}
  - Scale of "intermediate" collaboration has difficulty meeting all screening requirements
- Fabrication of some target/construction materials underground
  - Ge crystal growth / Electroformed Cu
- Purification / Isotopic enrichment of target materials (e.g. Xe)

Dark Matter Depth Requirements

- **Site Depth Requirement**
  - Dominated by need to reduce high energy neutrons (50-600 MeV), generated by muons, that cannot be moderated directly using poly
  - Shallow ~1700 mwe (1 muons/m^2/minute)
    - Just satisfactory for 10 kg scale experiments (σ~10^{-8} pb)
    - 1 tonne experiments would require large additional active shield (>1 m thick)
      - >99% veto Risk associated with systematic misidentification
  - Intermediate ~3800 mwe
    - Factor ~50x reduction in muons/HE neutrons compared to shallow
    - Additional comfort factor, general consensus that 1 tonne experiments can function comfortably wrt to HE neutrons from muons (σ~10^{-10} pb)
    - Depth may be necessary for gas target given much large surface area to shield
    - Satisfactory for cosmogenic activation
    - Muons passing through detector array can be vetoed by simple muon veto (>99% being achieved)
  - Deep ~6000 mwe (Further factor ~50x reduction in muon/HE neutrons)
    - Does not appear to be necessary for 1 tonne (σ~10^{-10} pb), but eliminates any risk, and will allow next-next generation

WIMP SUSY Dark Matter Conclusion

- Planned Projects for sensitivity -> 1 event /100 kg/year (~10^{-46} cm^2)
  - Target masses of 1 tonne
  - Data from existing round of detectors will be used to inform design
- Support of Underground Laboratory will be vital for their successful construction and operation
  - "Intermediate Scale Experiments
  - Significant extra burden bringing full resource requirements to hole in ground
- Next Generation 2005-: complementary TeV / LHC SUSY signal
- If signal is discovered then range of large detectors can be used to do WIMP astronomy and study SUSY / Dark Matter physics
  - Different target materials
    - study coupling / kinematics on different nuclei
  - Directional Detectors
    - WIMP Velocity distribution
  - SUSY Parameters that can't be determined in accelerators (R-Parity)
  - Tests models of particle generation in Big Bang