

# The Hunt For Dark Matter Conference Summary

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# **An Exciting Time For Dark Matter... A New Kind of Dark Matter Meeting**

~20 Excellent plenary talks (only a few others)

~60 Parallel talks - very wide range of topics, from particle physics theory to technical aspects of detector technology

~170-180 Participants!

Quasi-equal emphasis on direct, indirect and collider searches

# **An Exciting Time For Dark Matter... A New Kind of Dark Matter Meeting**

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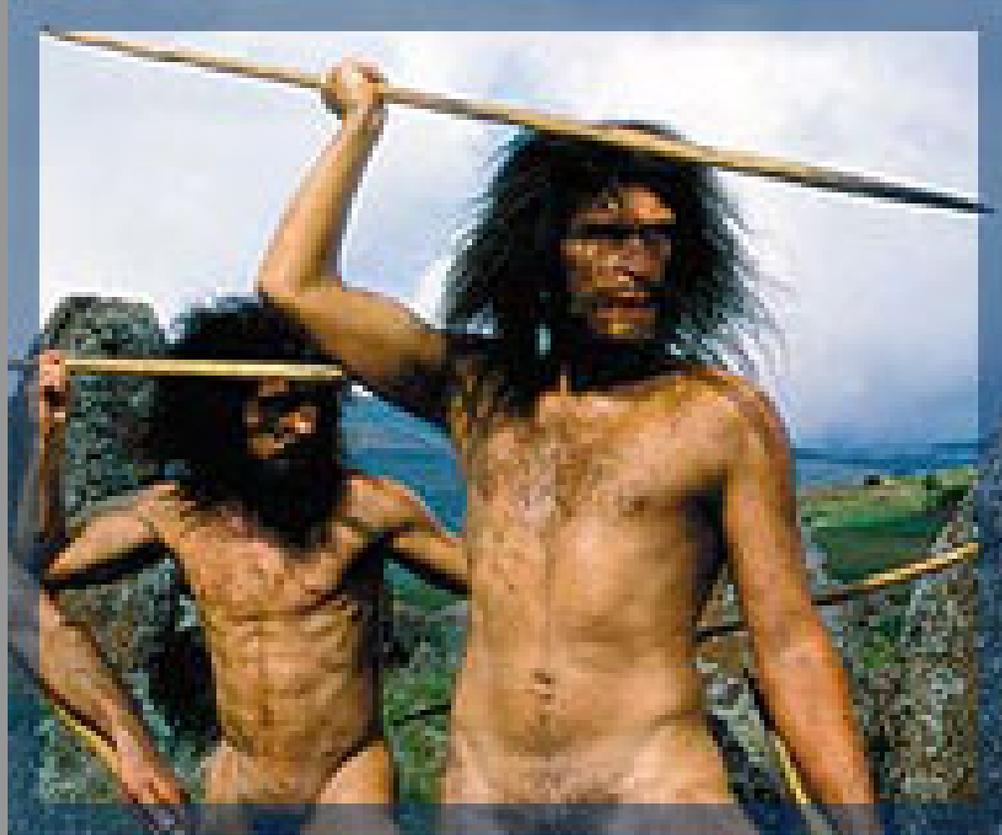
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Quasi-equal emphasis on direct, indirect and collider searches

*⇒ Makes writing a true summary talk a very difficult task*

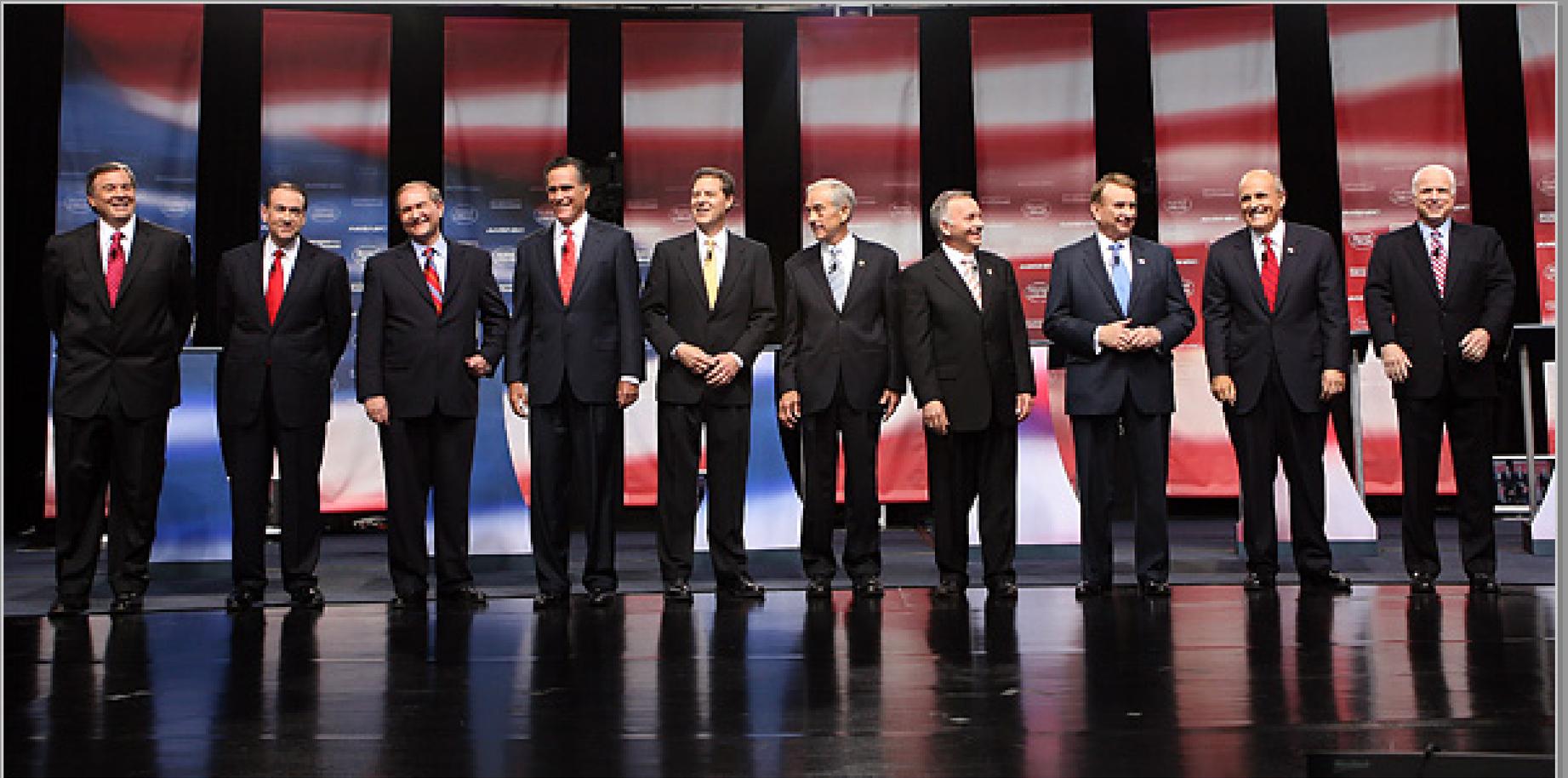
# Hunting For Dark Matter



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# The Field of Particle Dark Matter Candidates



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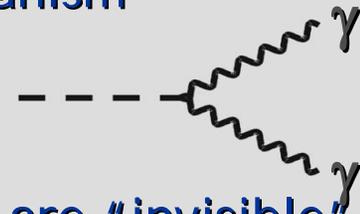
## Axions

CP conservation in QCD by Peccei-Quinn mechanism

→ Axions  $a \sim \pi^0$

$$m_\pi f_\pi \approx m_a f_a$$

For  $f_a \gg f_\pi$  axions are "invisible" and very light



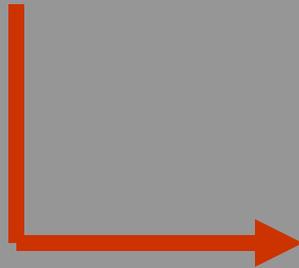
(Georg Raffelt's Talk)

(Jonathan Feng's Talk)

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(Tim Tait's Talk)

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# Direct Detection!!!

**XENON**

**10**

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**CDMS II**

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(See talks by D. McKinsey  
and S. Golwala)

# Direct Detection!!!

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# Direct Detection!!!

**New XENON 10 Limit (April APS Meeting)**

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# Direct Detection!!!

## XENON 10

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## CDMS II

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# Direct Detection!!!

**XENON**

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**CDMS II**



AP PHOTO

# Direct Detection!!!

XENON

10



CDMS II

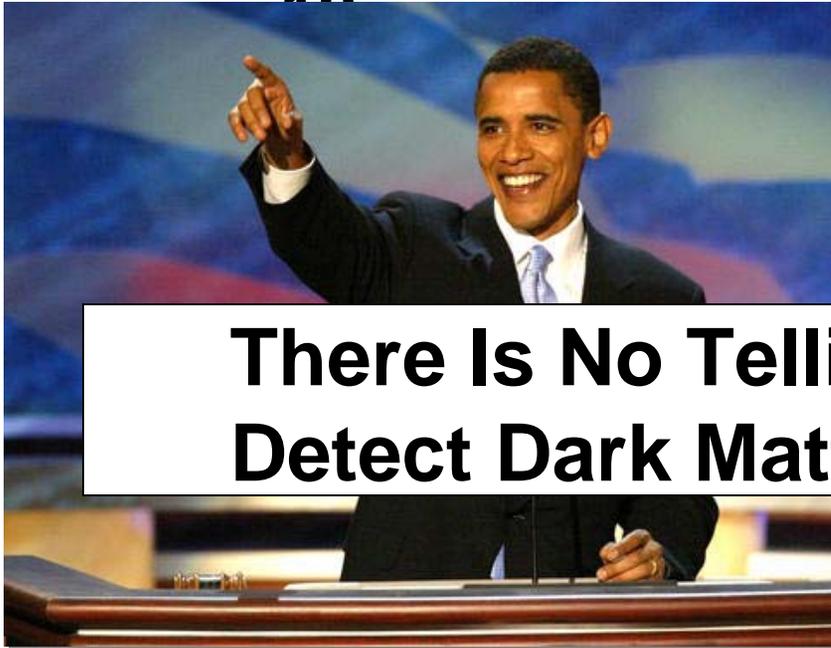


(AP PHOTO)

# Direct Detection!!!

XENON

10



CDMS II

**There Is No Telling Who Will  
Detect Dark Matter First**



(AP PHOTO)

# Direct Detection!!!

**Many Other Experiments  
in the Running:**

Zeplin III, LUX, WARP,  
XMASS, CLEAN, DEAP,  
...and a few dozen others



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# Indirect Detection

VERITAS, HESS and MAGIC  
in operation

GLAST to launch late in 2007



(See Talk By Jim Buckley)

# Indirect Detection

HESS

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# Indirect Detection

**PAMELA's Launch- 480 million events!**

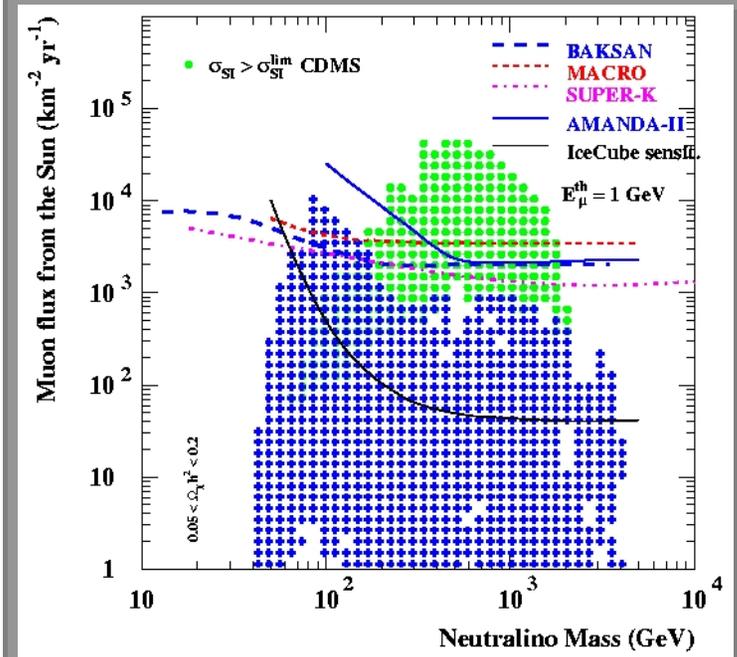
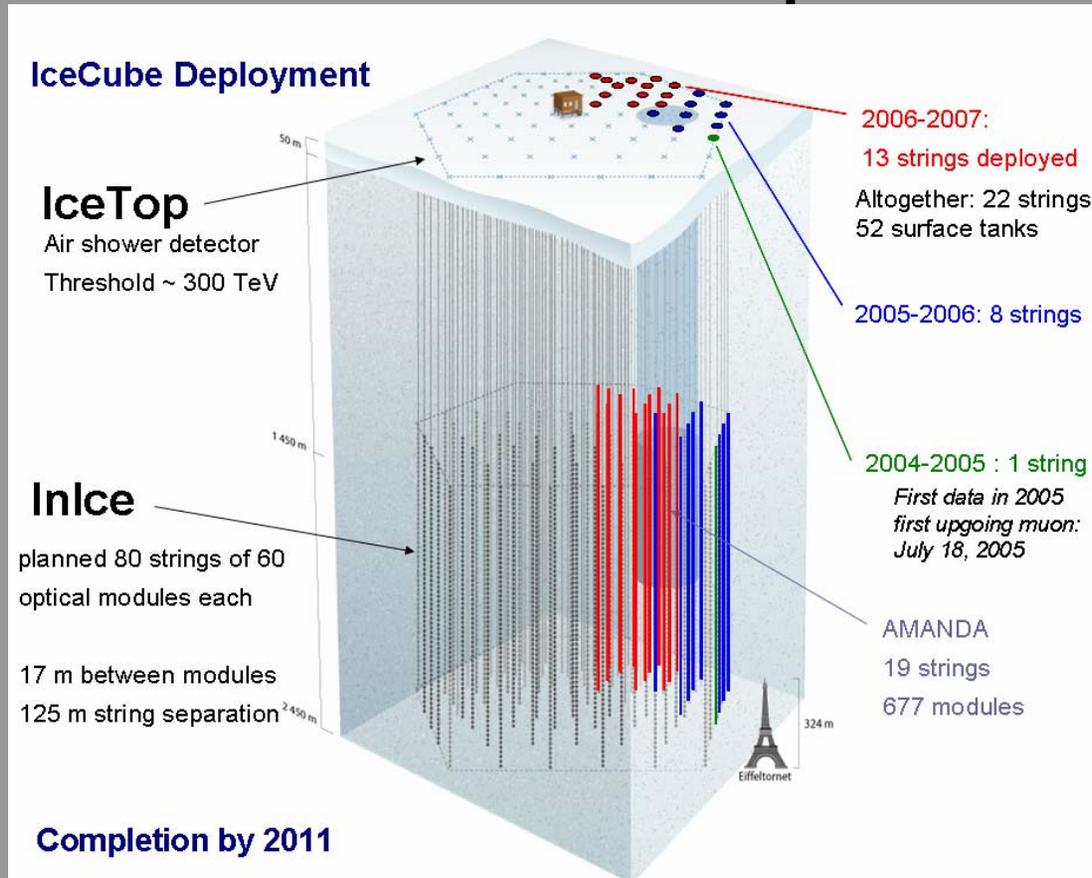
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Will dramatically improve measurement of cosmic  
positron and antiproton spectra (See Aldo Morselli's Talk)

# Indirect Detection

**IceCube is 22/80 completed!**



IceCube will test WIMPs with large spin-dependent scattering cross sections - complementarity to direct searches  
(See Francis Halzen's Talk)

# Colliders - The Tevatron

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Also, very interesting  
results from squark/gluino  
and sbottom/stop searches  
(see Jane Nachtman's Talk)

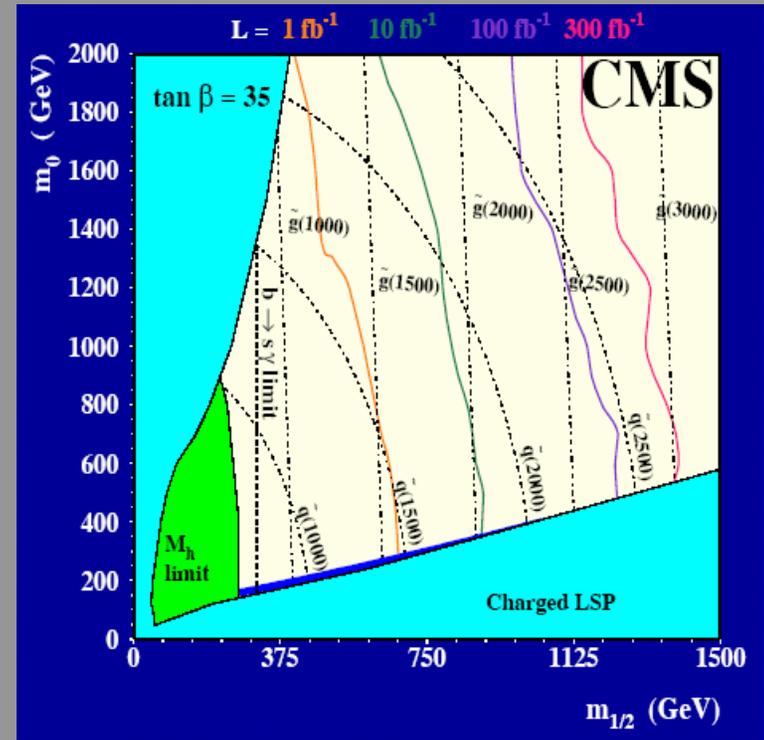
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# Colliders - The LHC

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(see talks by Michael Schmitt  
and Xerxes Tata)

# Colliders - The LHC

- The LHC is a discovery machine
- Precision measurements are much more difficult



(see talks by Michael Schmitt, Xerxes Tata and Ted Baltz)

mass/mass splitting	LCC4 value		LHC
$m(\tilde{\chi}_1^0)$	169.1	±	17.0
$m(\tilde{\chi}_2^0)$	327.1	±	49.
$m(\tilde{\chi}_2^0) - m(\tilde{\chi}_1^0)$	158.0	±	-
$m(\tilde{\chi}_3^0) - m(\tilde{\chi}_1^0)$	370.6	±	-
$m(\tilde{\chi}_1^+)$	327.5	±	-
$m(\tilde{\chi}_1^+) - m(\tilde{\chi}_1^0)$	158.4	±	-
$m(\tilde{\chi}_2^+) - m(\tilde{\chi}_1^+)$	225.8	±	-
$m(\tilde{e}_R) - m(\tilde{\chi}_1^0)$	243.2	±	-
$m(\tilde{\mu}_R) - m(\tilde{\chi}_1^0)$	243.0	±	-
$m(\tilde{\tau}_1)$	194.8	±	-
$m(\tilde{\nu}_1) - m(\tilde{\chi}_1^0)$	25.7	±	-
$m(h)$	117.31	±	0.25
$m(A)$	419.3	±	1.5 *
$\Gamma(A)$	14.8	±	-
$m(\tilde{u}_R), m(\tilde{d}_R)$	944., 941.	±	94.
$m(\tilde{s}_R), m(\tilde{c}_R)$	941., 944.	±	97.
$m(\tilde{u}_L), m(\tilde{d}_L)$	971., 975.	±	141.
$m(\tilde{s}_L), m(\tilde{c}_L)$	975., 971.	±	146.
$m(\tilde{b}_1)$	795.	±	40.
$m(\tilde{b}_2)$	862.	±	86.
$m(\tilde{t}_1)$	716.	±	(> 345)
$m(\tilde{g})$	993.	±	199.

**Benchmark LCC4**  
**Baltz, Battaglia, Peskin and**  
**Wizansky**

**But, our hunt does not end with  
discovery...**

# But, our hunt does not end with discovery...

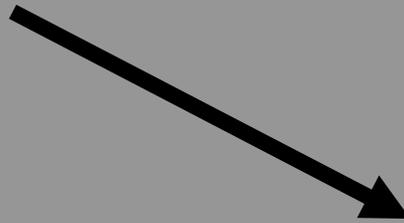


Collider discovery of a long-lived, neutral particle

# But, our hunt does not end with discovery...



Collider discovery of a long-lived, neutral particle



Direct/indirect detection needed to confirm the particle is cosmologically stable and abundant

# But, our hunt does not end with discovery...



Collider discovery of a long-lived, neutral particle

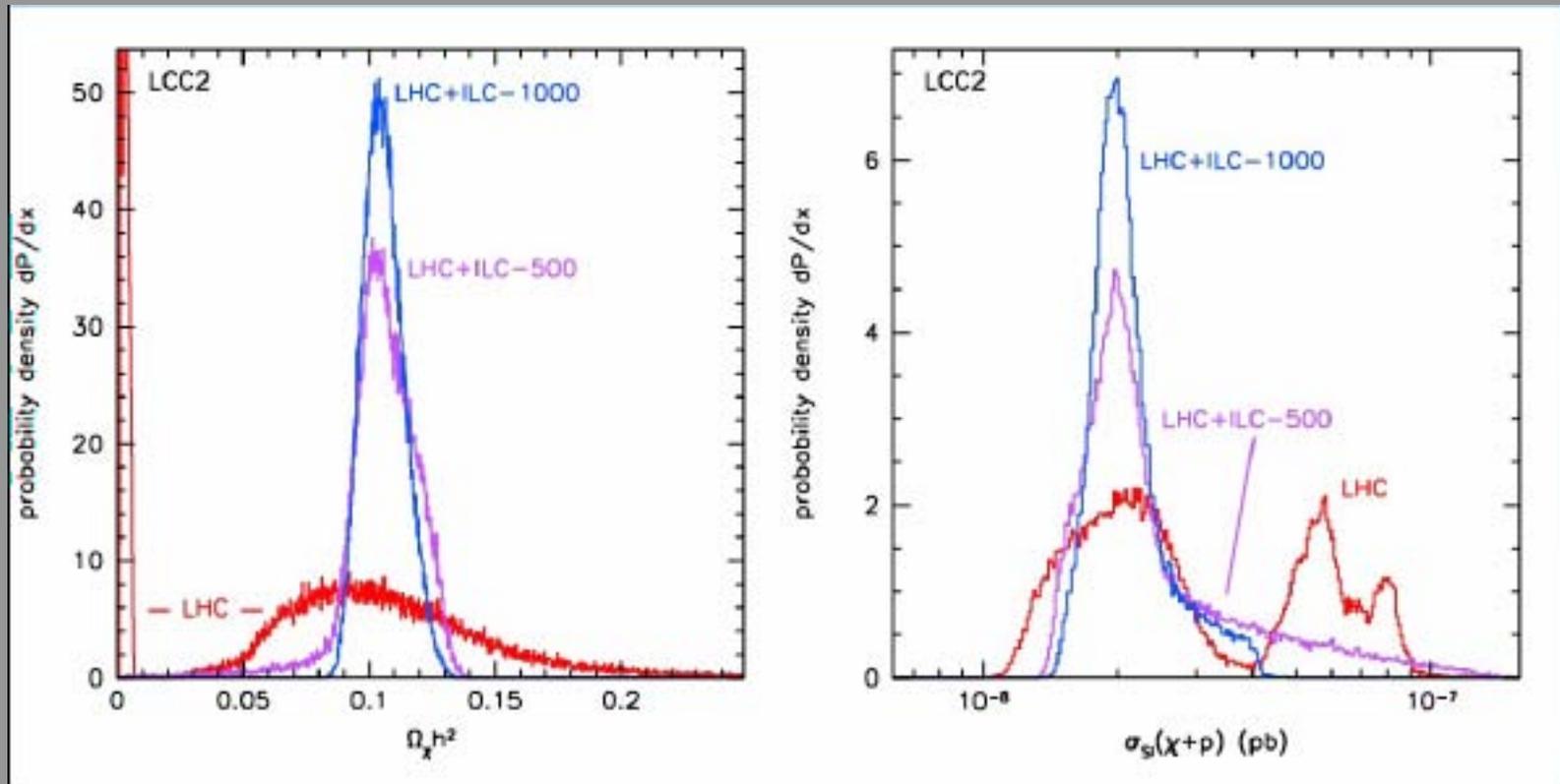


Direct/indirect detection needed to confirm the particle is cosmologically stable and abundant

But will the discovery stand at the supreme court of the ILC?



# Confirmation At The ILC Is Essential!



(See Ted Baltz and Marco Battaglia's talks)

# Confirmation At The ILC

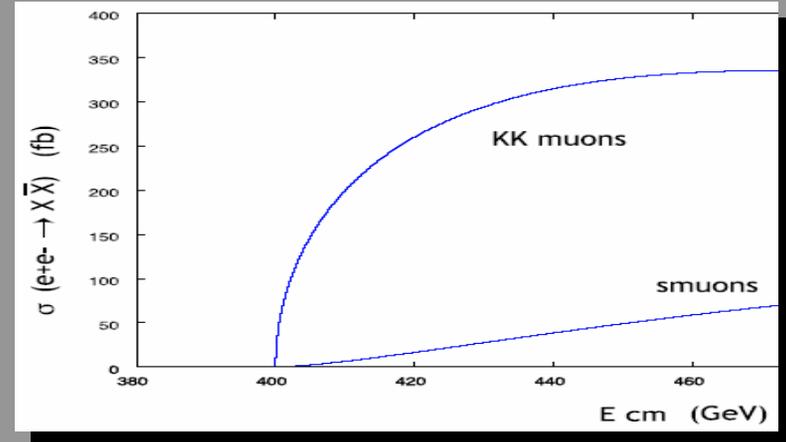
UED phenomenology

$$e^+e^- \rightarrow \mu_1^+\mu_1^- \rightarrow \mu^+\mu^-\gamma_1\gamma_1$$

closely resembles SUSY;

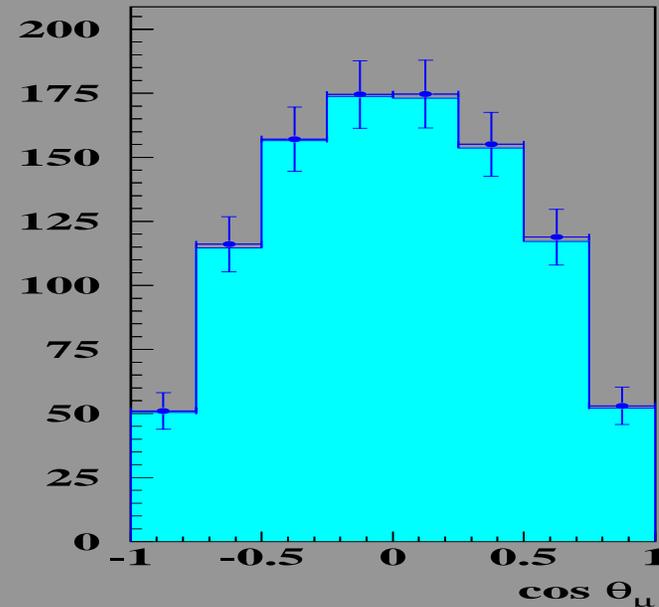
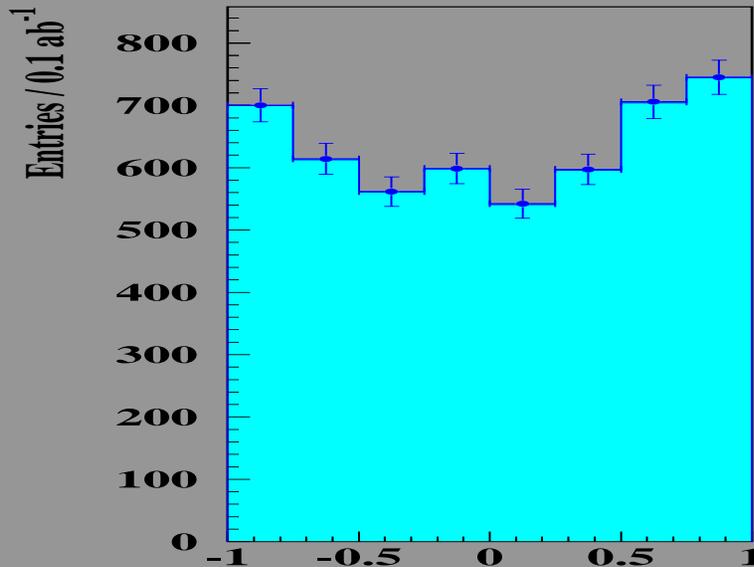
$$e^+e^- \rightarrow \tilde{\mu}^+\tilde{\mu}^- \rightarrow \mu^+\mu^-\tilde{\chi}_1^0\tilde{\chi}_1^0$$

Nature of new particles can be clearly identified by a spin analysis, based on production properties and decay angles.



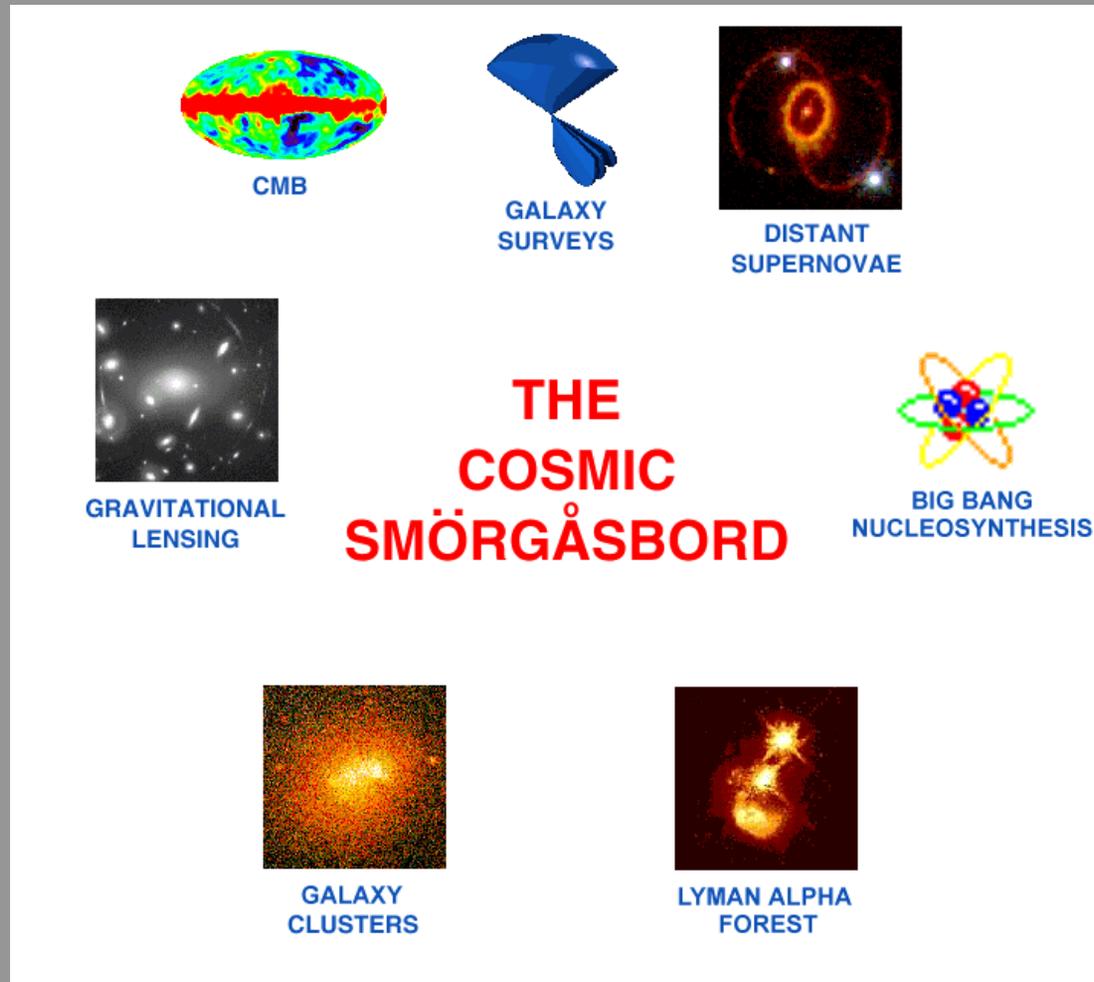
$$\left(\frac{d\sigma}{d\cos\theta}\right)_{UED} \sim 1 + \cos^2\theta$$

$$\left(\frac{d\sigma}{d\cos\theta}\right)_{SUSY} \sim 1 - \cos^2\theta$$



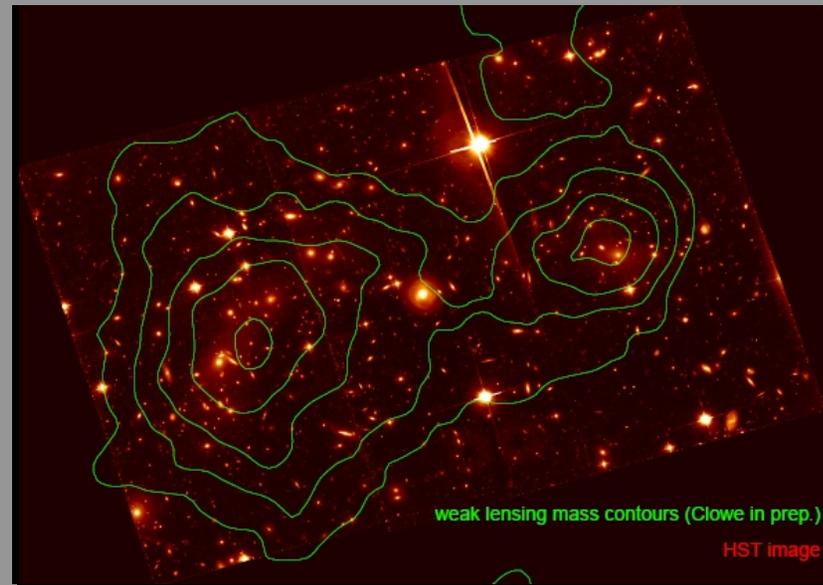
# Lots of Other Interesting Stuff...

-Cosmological Evidence (Max Tegmark)



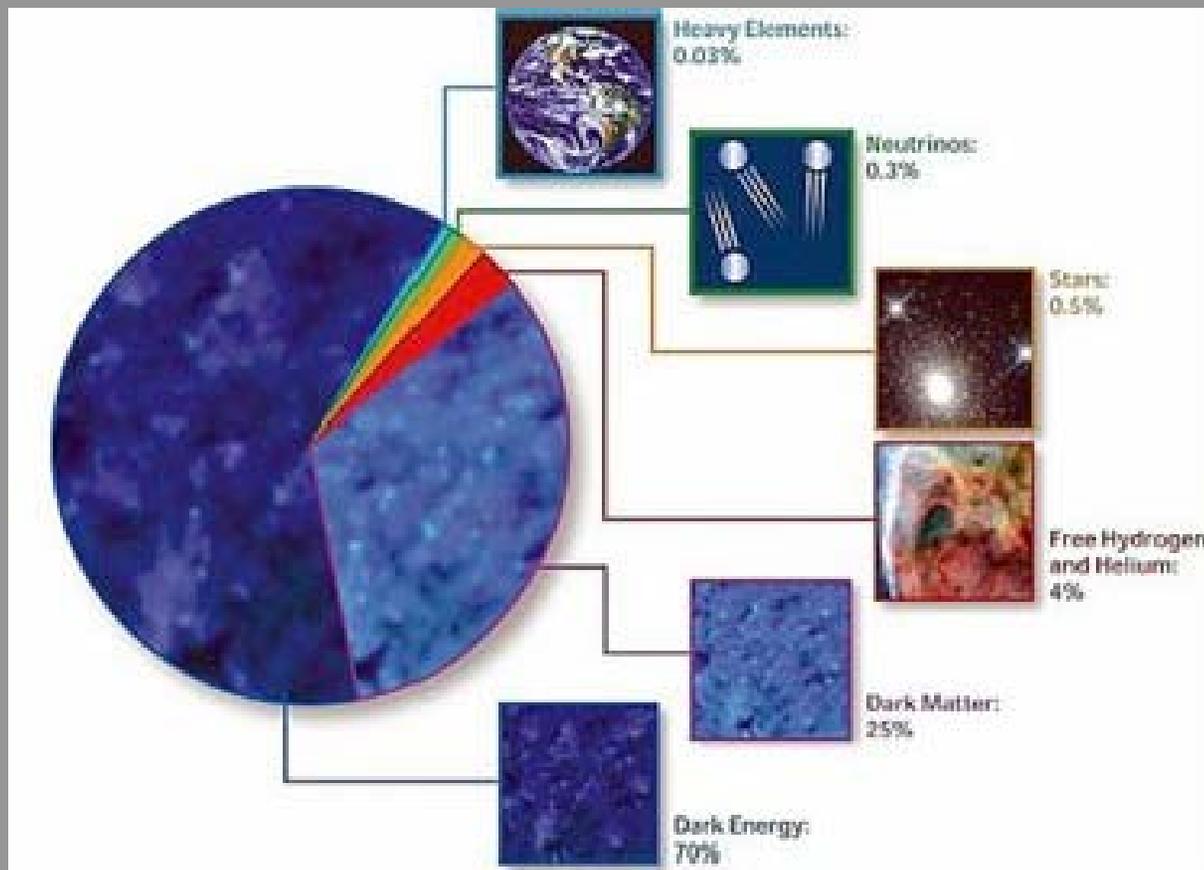
# Lots of Other Interesting Stuff...

-Modifications to Gravity (Pedro Ferreira)



# Lots of Other Interesting Stuff...

-Electroweak Baryogenesis (Carlos Wagner)



-EW Baryogenesis can naturally occur in low scale SUSY

-Within the MSSM, requires a light Higgs and a light stop (and LSP)

-Models with extended Higgs sectors (nMSSM, etc) are attractive

# Lots of Other Interesting Stuff...

-Simulations and Structure (Simon White)

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# **Lots of Other Interesting Stuff...**

**-About 60 parallel talks...**

# Thanks

## Organizers:

Dan Bauer  
Pasquale Serpico  
Andrew Sonnenschein  
Marcela Carena  
Karen Byrum  
Mark Jackson  
Fritz DeJongh  
DH

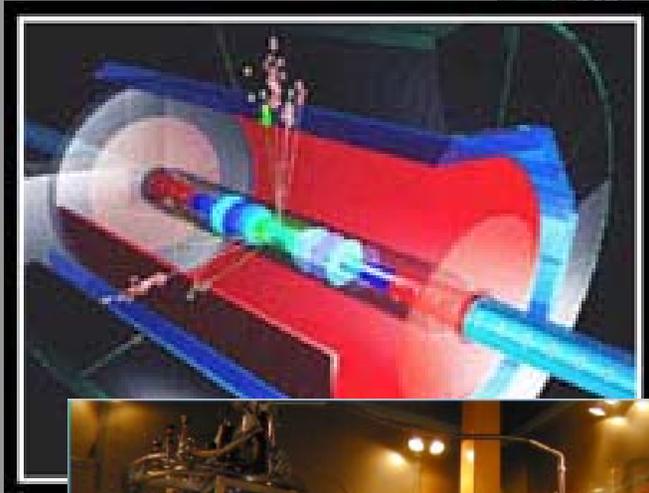
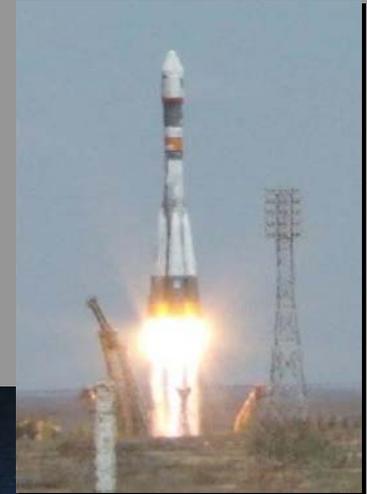
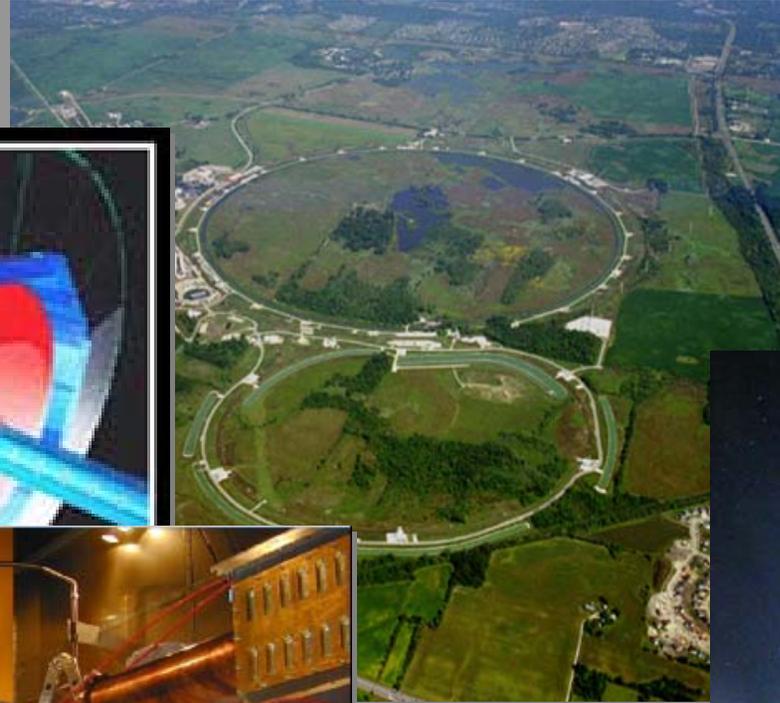
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# Thanks For Coming!





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Let's use all of the tools we have to solve the puzzle of dark matter!