New Physics - Theory

by

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Talk [a] outline

- SUSY
- Tools
- Non SUSY (xtra dim, Higgsless models...)
- Hadron/ILC flavours

[a] WARNING: incomplete

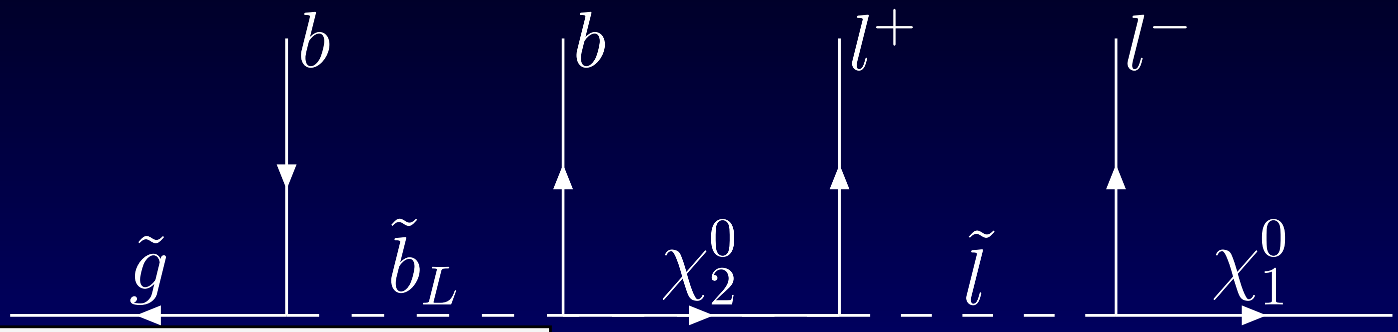
Subgroup Organisation

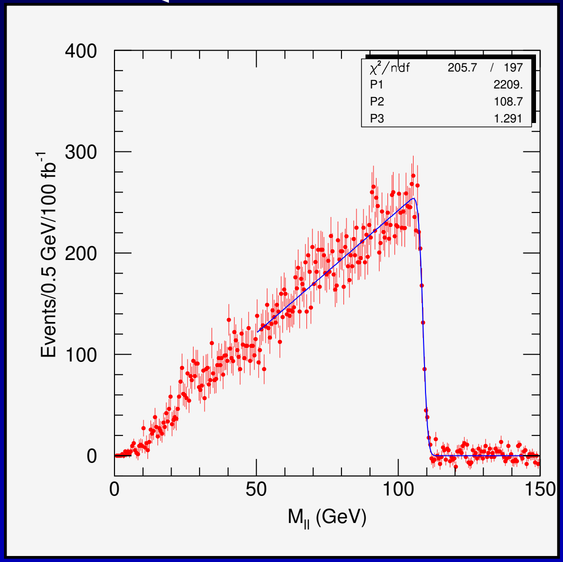
Beyond (disorganisation of) Standard Model (subgroup).
What Scott said! (3pm here [a]: We will suggest topics, get lists of names for each subtopic and then set up daily “slots” for meetings). *Check message board every time you walk past it! Certainly every morning*.
Convenors around this week are

- Filip Moortgat (CMS contact), Samir Ferrag (ATLAS contact), S Muanza (D0), Klaus Desch (ILC)
- Peter Skands (SLHA Tsar)
- Ben Allanach (SUSY theory), Christophe Grojean (extra dim/alternatives theory)

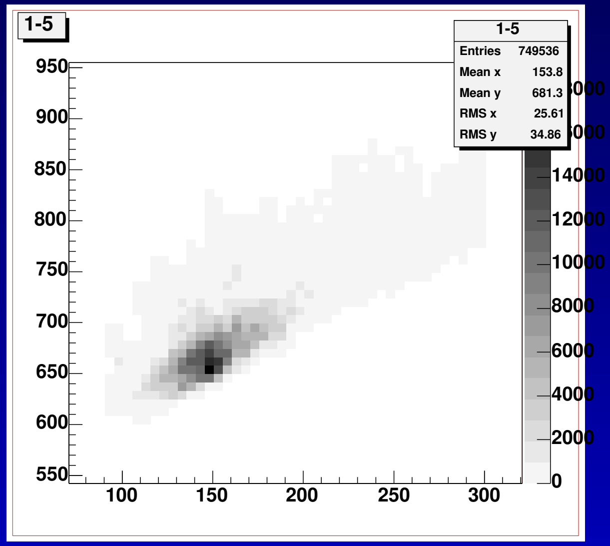
[a] Convenors in library at 2pm

Hadronic SUSY Measurements





$m_{\tilde{g}}$



$m_{\chi_1^0}$

$$\#D = 5(m) + 4(p_{\chi_1^0}) - 5(p^2 = m^2) = 4 \text{ for 1 event.}$$

$\#D = 5(m) + 4n(p_{\chi_1^0}) - 5n(p^2 = m^2) = 5 - n$ for n events, an *overconstrained* system for $n > 5$ [a]

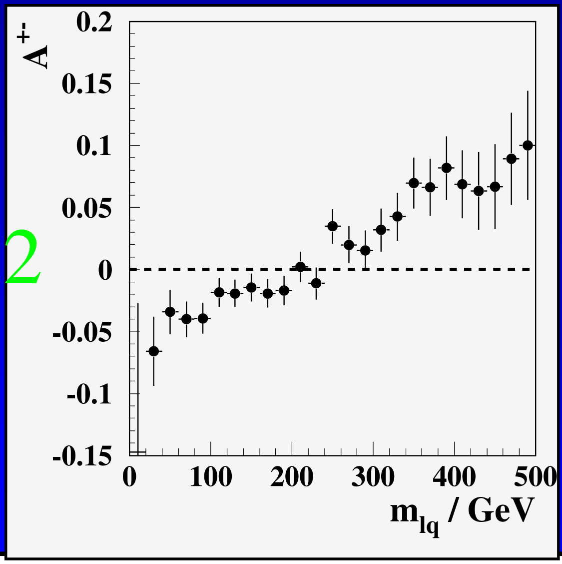
[a] Nojiri, Polesello and Tovey; Lester, Les Houches proceedings 03

Spins at LHC

Crucial check of SUSY is spin (cf UED). Consider $\tilde{q}_L \rightarrow q l \tilde{l}$: $m \equiv m_{ql}/m_{ql}(max) = \sin\theta/2$

$$\frac{dP(l^+q/l^-\bar{q})}{dm} = 4m^3, \qquad \frac{dP(l^-q/l^+\bar{q})}{dm} = 4m(1-m^2),$$

whereas pure PS is always $2m$. Seems hopeless, since we cannot tag quarks vs anti-quarks (average is PS). pp collider leads to spin-generated lepton charge asymmetry



$$A^{+-} = \frac{m_{jl^+} - m_{jl^-}}{m_{jl^+} + m_{jl^-}}$$

Barr, hep-ph/0405052

$$\mathcal{L} = 150 pb^{-1}$$

SUSY Higgs

Standard direct SUSY Higgs production well studied, including $\tan\beta$ measurement from $gg \to b\bar{b}H/A$ where $H/A \to \tau^+\tau^-$ [a]. Higgs production in SUSY cascade decays less well studied: contact with SMH group: look to exhaust interesting possibilities [b]

$$
\begin{aligned}
pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{q}^*, \tilde{q}\tilde{g} &\to \chi_2^\pm, \chi_3^0, \chi_4^0 + X \\
&\to \chi_1^\pm, \chi_2^0, \chi_1^0 + h, H, A, H^\pm \; + X \\
pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{q}^*, \tilde{q}\tilde{g} &\to \chi_1^\pm, \chi_2^0 + X \\
&\to \chi_1^0 + H^\pm, h, H, A \; + X
\end{aligned}
$$

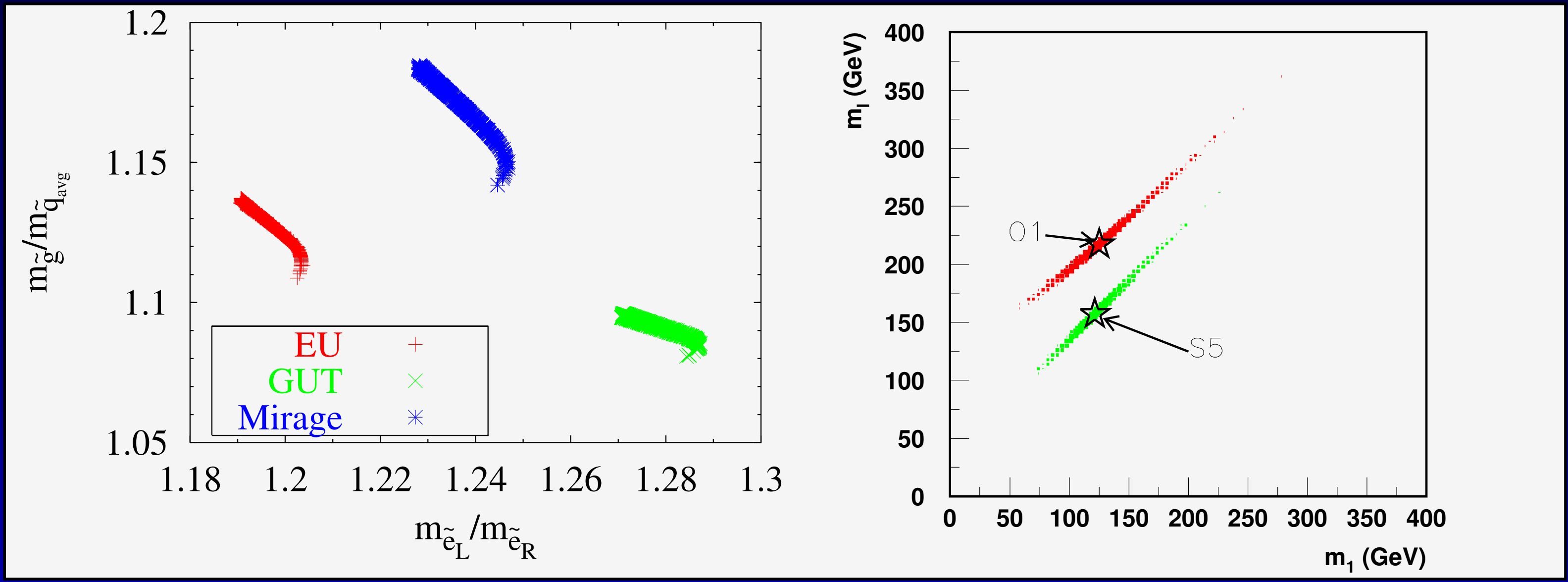
[a] Kinnunen *et al*, hep-ph/0503075

[b] Datta, Djouadi, Guchait, Moortgat, hep-ph/0305095

Model Discrimination

$\mathcal{Q}$: How much accuracy on sparticle masses do we need?

$\mathcal{Q}$: Which are the most sensitive observables [a]?



Different approach [b] with more inclusive signatures: $\not{E}_T$, 3l, OS 2l, . . . excess over SM *without* cuts.

[a] BCA, D Grellscheid, F Quevedo, JHEP 0205 (2002) 048

[b] Binetruy *et al*, `hep-ph/0312248`

Model Discrimination

τ polarisation from $\tilde{\tau}$ decay can help us pin down stau mixing parameters

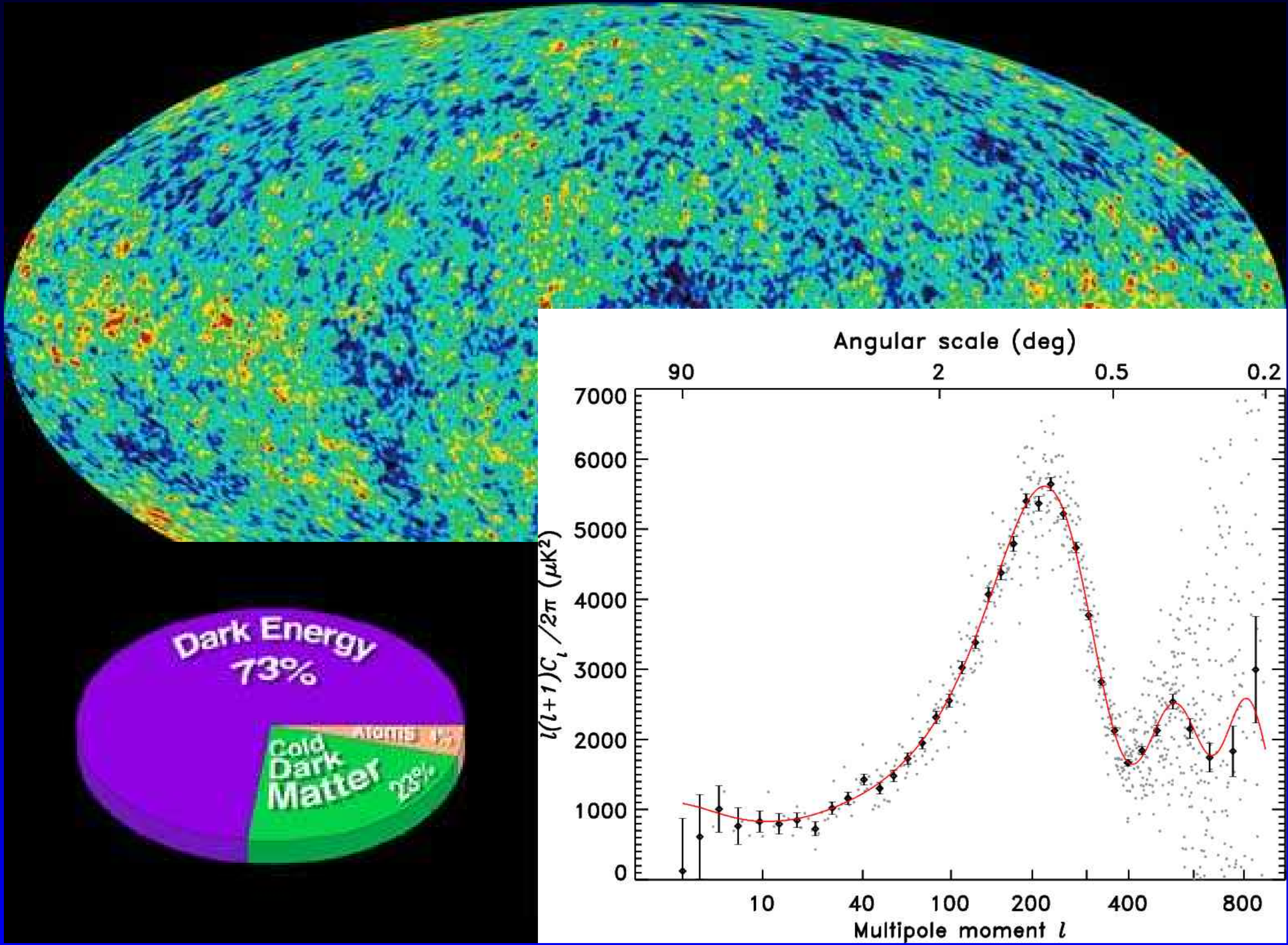
- AMSB: -1 (Wino LSP)
- mSUGRA: +1
- GMSB/non-universal models: intermediate

Polarisation determined from π energy distributions in hadronic decays. Polarisation affected by CP violating phases, “mixes up” the information so have to combine with other measurements.

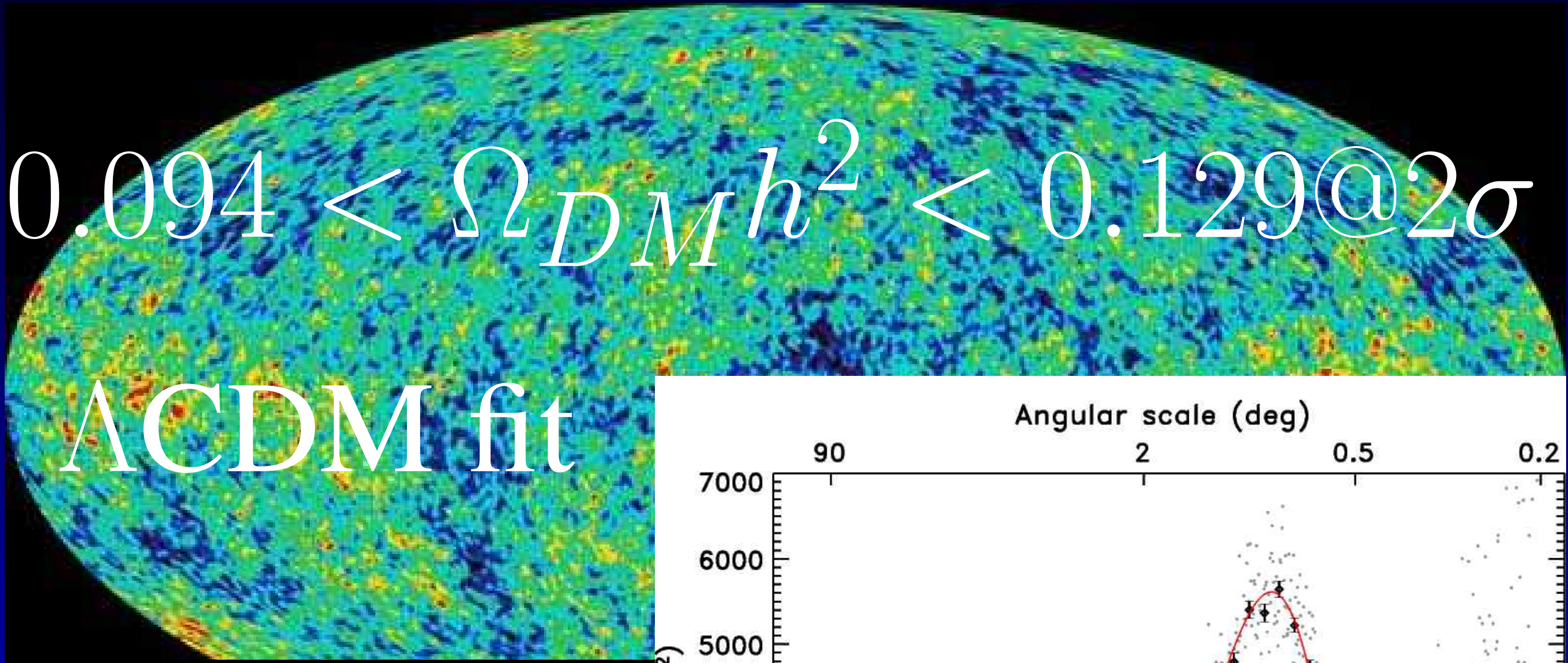
Tools

- SUSY Les Houches Accord '03 very successful: interfaces spectrum generators, decay packages, event generators, DM calculators. Time for *SLHA II*: $R\!\!\!/_p$, $C P\!\!\!/$, higher loops/effective couplings
- `HERWIG` implementation of SLHA I. *SUSPECT?*
- Flavour physics and BSM discussion day: May 16th
- Discussion of SM backgrounds, new physics tools needed (`CHARYBDIS`, ADD, RS, . . .)

WMAP Results

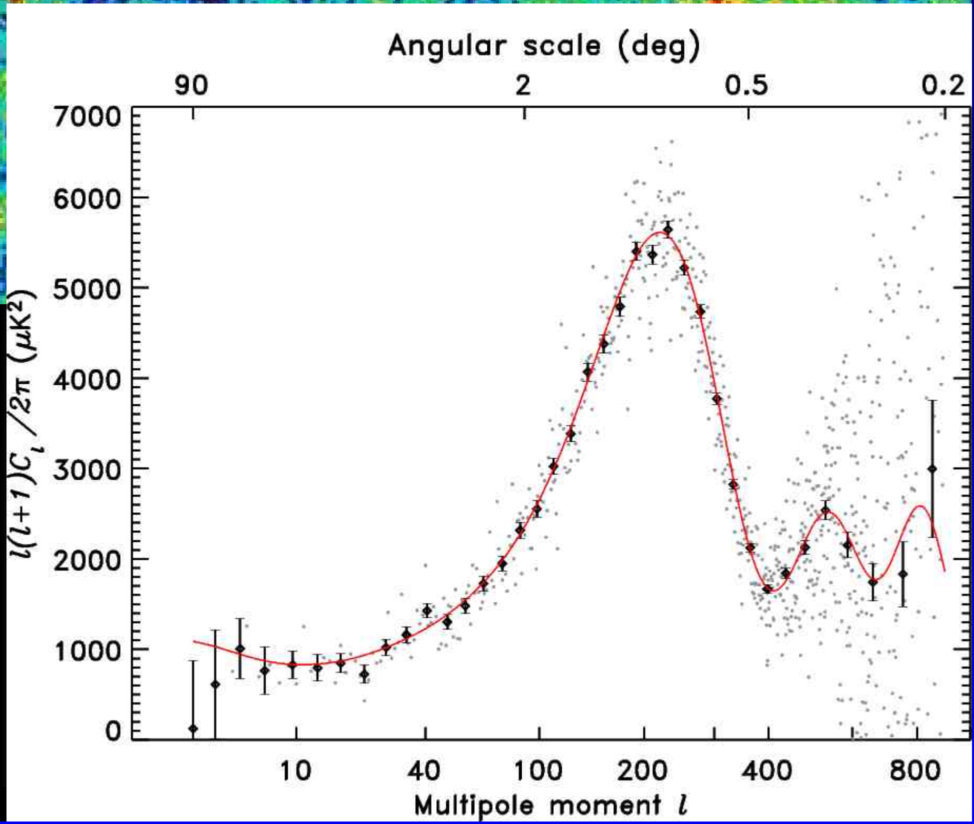


WMAP Results



$$0.094 < \Omega_{DM} h^2 < 0.129 @ 2\sigma$$

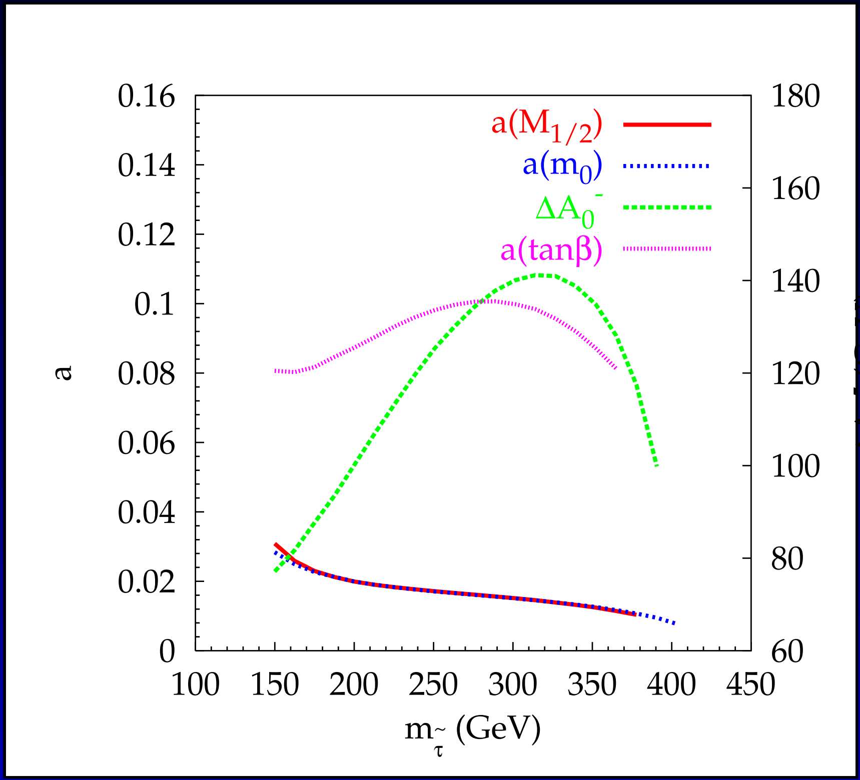
ΛCDM fit



Caveats

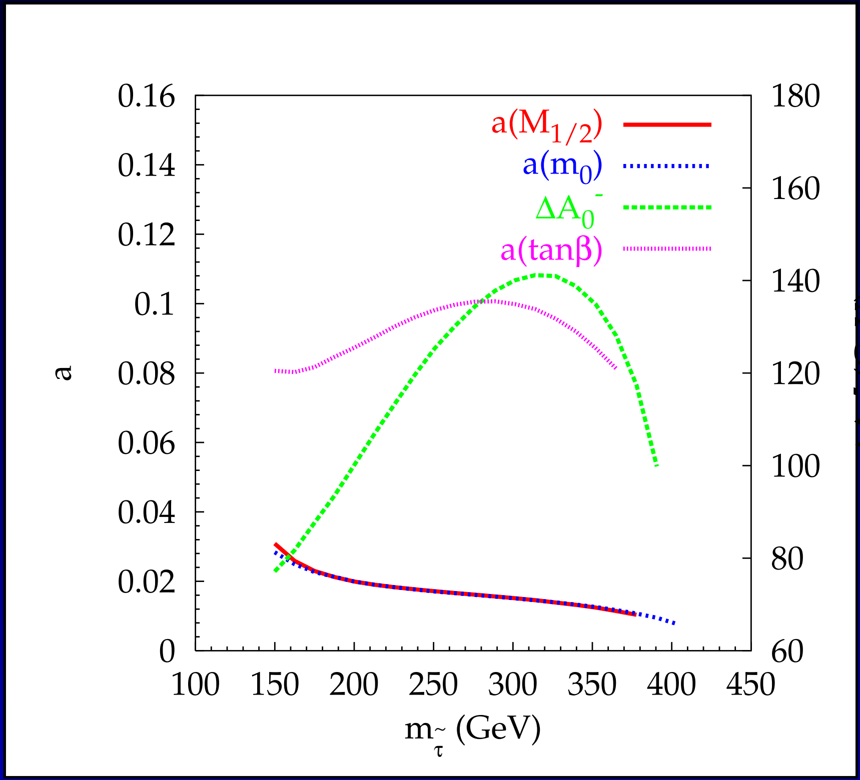
- Implicitly assumed that LSP constitutes *all* of dark matter
- Assumed radiation domination in post-inflation era. No clear evidence between freeze-out+BBN that this is the case (t_{eq} changes).
- Examples of non-standard cosmology that would change the prediction:
  - Extra degrees of freedom
  - Low reheating temperature
  - Extra dimensional models
  - Anisotropic cosmologies
  - Non-thermal production of neutralinos (late decays?)

mSUGRA Coannihilation Uncertainties



$a(m_0) \approx a(M_{1/2})$ comes from the sensitivity to $\exp[-(m_{\tilde{\tau}} - M_{\chi_1^0})]$

mSUGRA Coannihilation Uncertainties

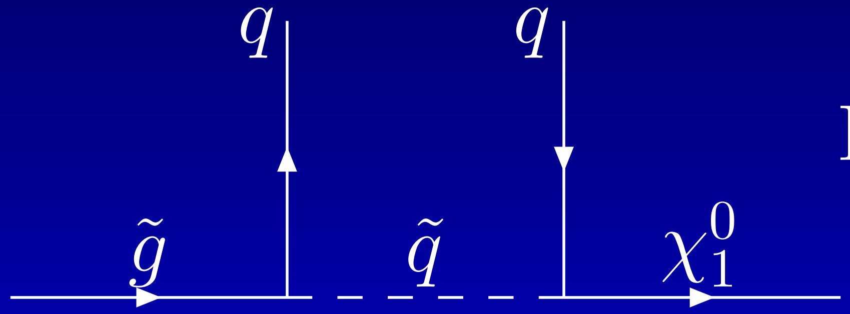


Unknown whether accuracies can be reached - but it looks difficult : $\Delta\Omega h^2 \sim .03$ in ruled out bulk region.

Polesello, Tovey, JHEP05 (2004) 071

Split SUSY

$\mathcal{Q}$: Is technical hierarchy problem a red herring like Λ?
Very heavy scalars. Still solves: dark matter, gauge unification, SUSY flavour problem ameliorated.
Gluinos are *quasi-stable* and form $R-$hadrons: neutral or charged .



$$\Gamma \propto \frac{1}{m_{\tilde{q}}^4}$$

Look like a slow heavy muon that loses some of its energy in interactions with the detector.
Charginos/neutralinos decay through *mixing effects*.

Kilian *et al*, hep-ph/0408088, Kraan `hep-ex/0404001`

Alternative EWSB

- SUSY models with a heavy Higgs
- Higgs as a Goldstone Boson
- Higgs as gauge fields
- Higgsless models
- Invisible Higgs and CPV in the Higgs sector
- Talks Mon 9:00-9:45: G. Cacciapaglia, "Higgsless theories"
- 9:45: M. Perelstein, "Collider signatures of Little Higgs and Higgsless theories"
- 11:00: G. Servant, "Kaluza-Klein Dark Matter"
- 11:45: B. Dobrescu, "Light Z' and new massless gauge bosons"

Conclusion

We hope to have lots of fun preparing for the new colliders, which *are* coming. And we hope the goats will keep quiet.