PROSPECTS
panel discussion

Ben Allanach
Marcus Berg
Kyle Cranmer

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Ben Allanach

Good Practice When You're Doing Scans

- Scan with different "priors", or axes functions (eg flat in parameters, flat in log parameters). It is good for posterior *or* profile likelihood to test robustness, to check that you have enough scanned points.

- Bear in mind that you don't always have to fix upper bounds on parameters in the prior: for example, you can use say (1/fine-tuning), for instance. If your fit region reaches the edge of one of your parameter limits, you know your fit is in trouble.

- In profile likelihood, use an afterburner to minimise the best fit point to find the absolute best fit point (eg with MINUIT or GAs etc)

- This brings up the issue of whether some of the differences between fits are due to the global minimum being not found, or whether the tails of the likelihood distribution (in the 2 parameters of interest on a 2D plot) have not been scanned sufficiently densely.

Good Practice When You're Doing Scans

- KEEP or PUBLISH (on a webpage) the SLHA file of the best-fit point. When someone else does a similar scan and differs with your results, you'll be able to swap SLHA files to perform checks and find out where the differences are.

- When doing Bayesian scans, produce distributions of the priors marginalised down to 1 or 2 D (but taking, say, the lack of physical regions into account)

Experimental Likelihoods

- We wish experimentalists to make their experimental likelihood functions available via some interface like RooStats. It will avoid just assuming it's Gaussian all the time.

- We will set up a web-site with this recommendation, and request signatures from people who think it's a good idea. There are difficulties in implementation, but it must be possible for these to be overcome.

- Encourage scanning package authors to get their codes ready to hook up to this interface: it will be necessary to add parameters which control experimental systematics (one will either marginalise over these, or maximise the likelihood over them in the profile likelihood case).

- There are different choices for likelihood penalties for dark matter relic density: you can impose that the neutralino is ALL of the dark matter, or instead that it might be some fraction of it, for instance. This is really a difference in prior.

Model Selection

- This is a difficult problem, and different ways of doing it. Evidence ratios are likely to remain prior dependent even after highly constraining data is available.

- One needs to perform frequentist model selection between two different models: hypothesis testing. Goodness of fit of one model on its own is not interpretable in a quantitative fashion, although it will give some sort of qualitative feeling.

Dark Matter Data

- If the LHC sees missing energy excesses, one wants to know if the particle found is the stuff that is (hopefully) being seen in dark matter detection experiments.

- One needs a *lot* of collider SUSY measurements in order to be able to constrain the relic density, unless some simple SUSY breaking model fits the signals. One could then check the number inferred *assuming some cosmology* against WMAP/LSS inferred relic densities. Does the mass scale measured by the LHC agree with that measured in direct detection experiments? This would be a hypothesis test that the particle is the same one as the one that is hanging around in the galaxy.

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Experimental Likelihoods

- Saw example from Fermi, mainly need to influence LHC and direct detection communities

- pre-processing to eliminate nuisance parameters chooses Bayesian vs. Frequentist and doesn't allow for correlated systematics

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GOODNESS OF FIT

- parameter contours typically assume model is correct
- initial question would be to know if the model is a good fit to the data
- minimum of unbinned likelihood is not a useful goodness of fit criteria
- difficult problem, easier to consider an alternative
- moves towards hypothesis testing and model selection

PROSPECTS panel discussion

Marcus Berg
(+Yann Mambrini)

Concrete questions for scans

- scan over *mediation scenarios*, e.g. gravity mediation (PMSB), gauge mediation (GMSB), anomaly mediation (AMSB), *mixed!* ...

In the defining papers, there are explicit formulas for your usual m_0, A_t etc. in terms of few parameter (like 4-5) – but motivated !

$$\{f_{\rm kin}, m_{3/2}, F, \tan\beta\}$$

$$E_F \sim \sqrt{F}, \text{e.g. } 10^{10} \text{ GeV for PMSB}$$

See also Ben's slides!

Concrete questions for scans

- Modelling (fake) future data

  let's say we see *a)* WIMP at XENON 1 ton

  and *b)* some gamma-ray line at FERMI

  and *c)* perhaps some hints at LHC

  - SM won't fit
  - Maybe MSSM will fit
  - Maybe fit will favor *more restricted* SUSY model (mediation scenario)
  - Maybe we will need *more general* SUSY model to fit well at all (beyond MSSM models)

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Two examples for illustration

Brignole, Casas, Espinosa, Navarro, '03
Casas, Espinosa, Hidalgo '03

Example 1: Beyond the MSSM (BMSSM)

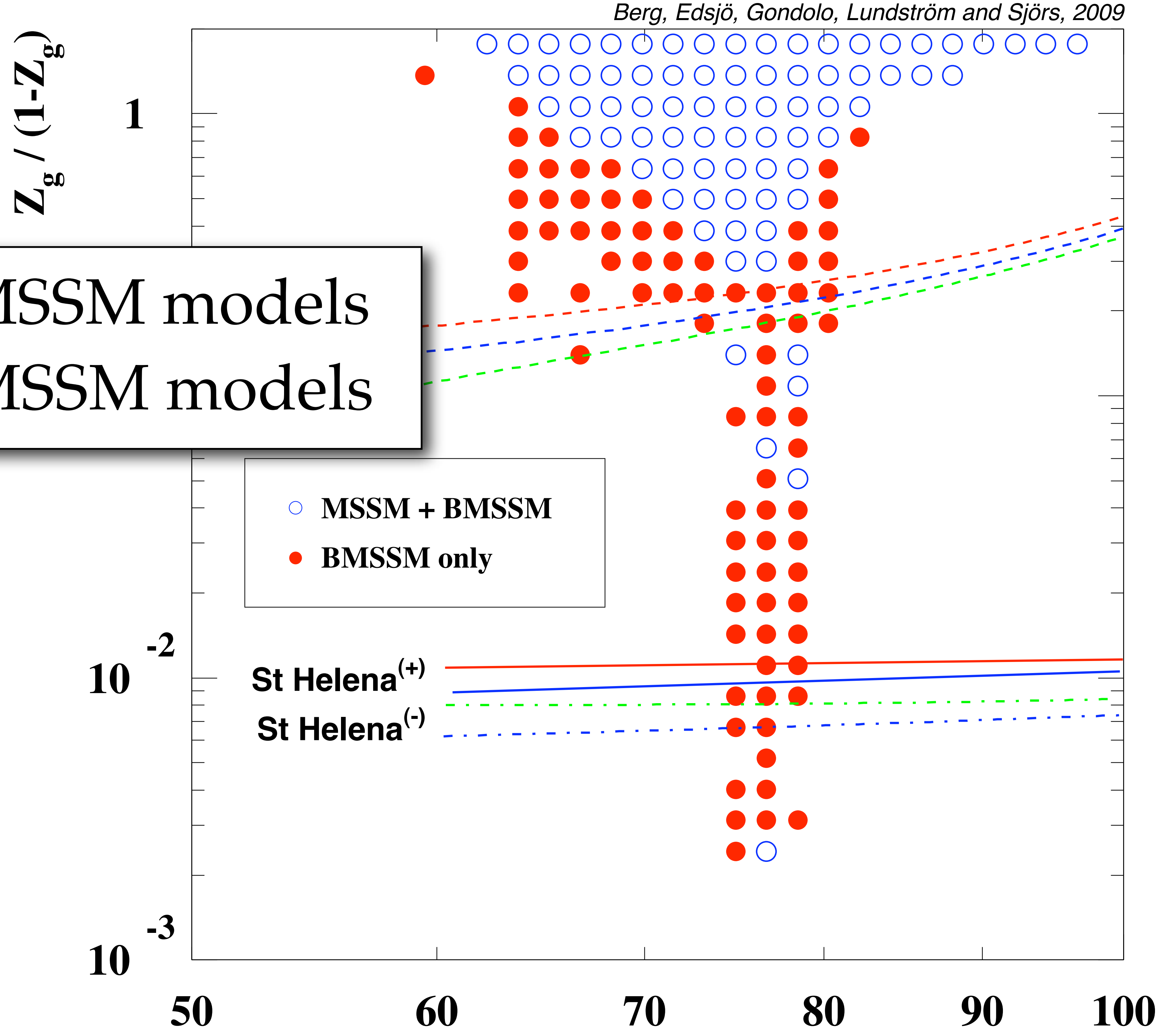
...
Dine, Seiberg, Thomas '07 (Seiberg at STRINGS07)
...

No new particles! Only modifies Lagrangian.
Our BMSSM subset = MSSM +

$$\begin{aligned}\delta\mathscr{L} &= -\delta V_1 - \delta V_2 + \delta\mathscr{L}_3 \\ &= -\left(2\epsilon_1 (H_u H_d)(H_u^\dagger H_u + H_d^\dagger H_d) + \text{ h.c.}\right) - \left(\epsilon_2 (H_u H_d)^2 + \text{ h.c.}\right) \\ &+ \left[\frac{\epsilon_1}{\mu^*}\left(2(\widetilde{H}_u \widetilde{H}_d)(H_u H_d) + 2(H_u \widetilde{H}_d)(\widetilde{H}_u H_d) + (\widetilde{H}_u H_d)^2 + (H_u \widetilde{H}_d)^2\right) + \text{ h.c.}\right]\end{aligned}$$

- modifies Higgs sector, but also charginos and neutralinos (hence modifies dark matter, if Higgsino)
- scaling dimension 4 and 5
- can give 20-30 GeV contribution to Higgs mass, allows light top squark

Light Higgsino Dark Matter



110 000 MSSM models
11 000 BMSSM models

also see e.g.
Bernal, Goudelis '09: "Dark Matter Detection in the BMSSM" (XENON-like, ...)

Example 2: "Anomalous U(1)" models (not really anomalous)

- Z' with generalized "Chern-Simons"(CS) terms

- seem very awkward and contrived at first,

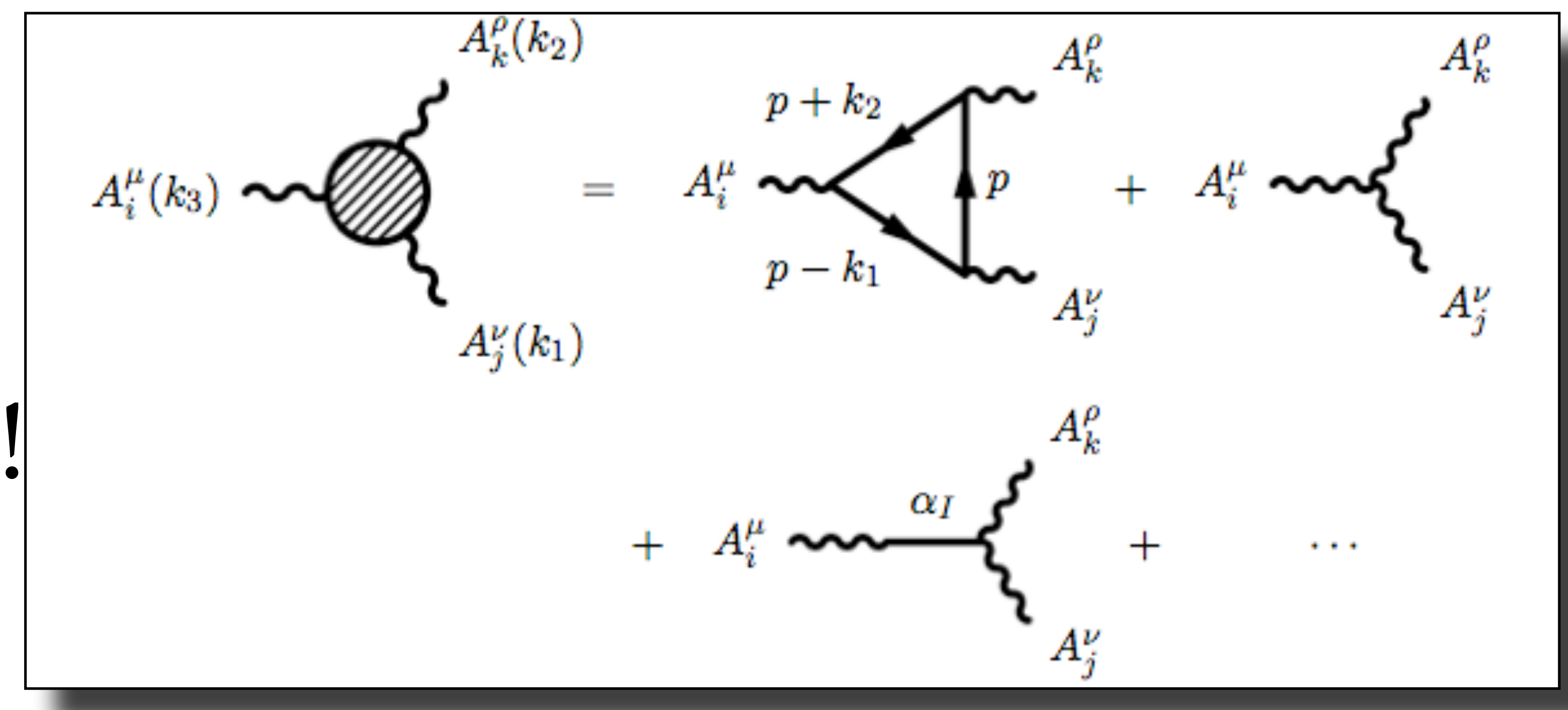
natural and necessary in string theory

- These Z′ particles are hard to produce at LHC

(WW fusion) but

easier in DM

setting (lineshape)!



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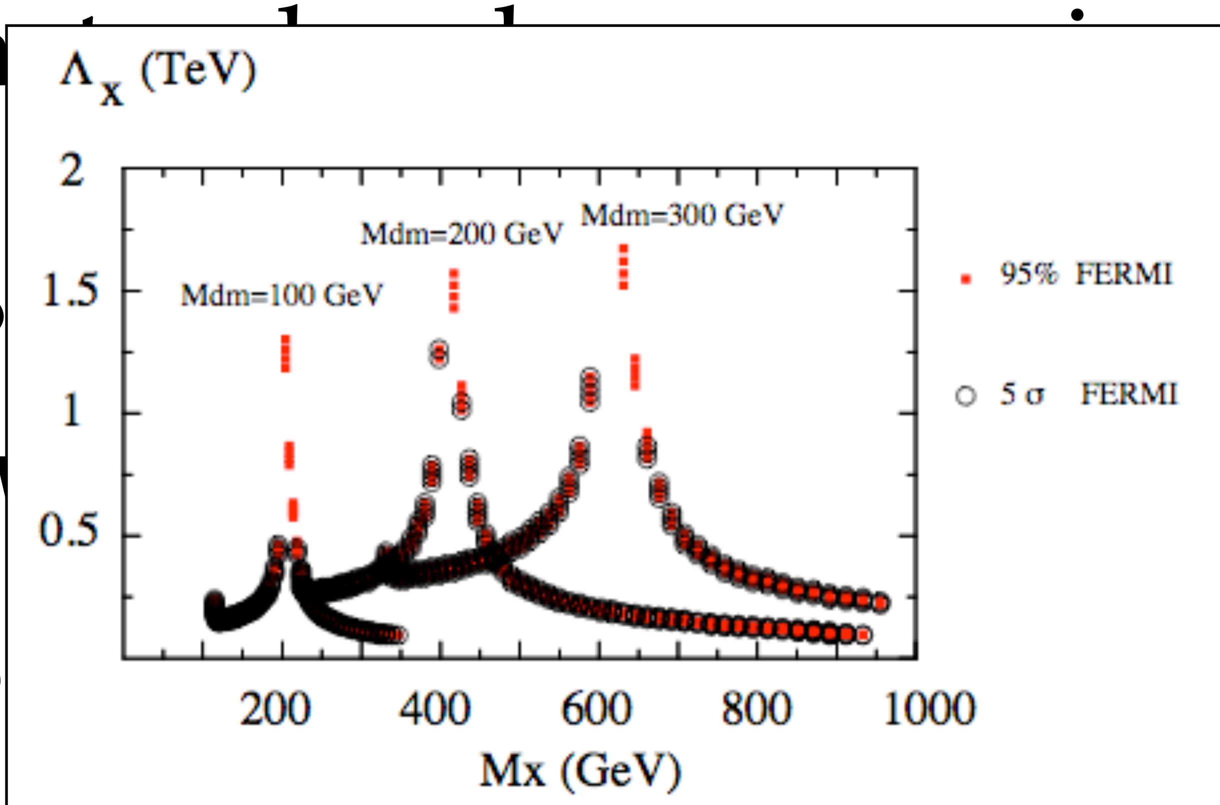

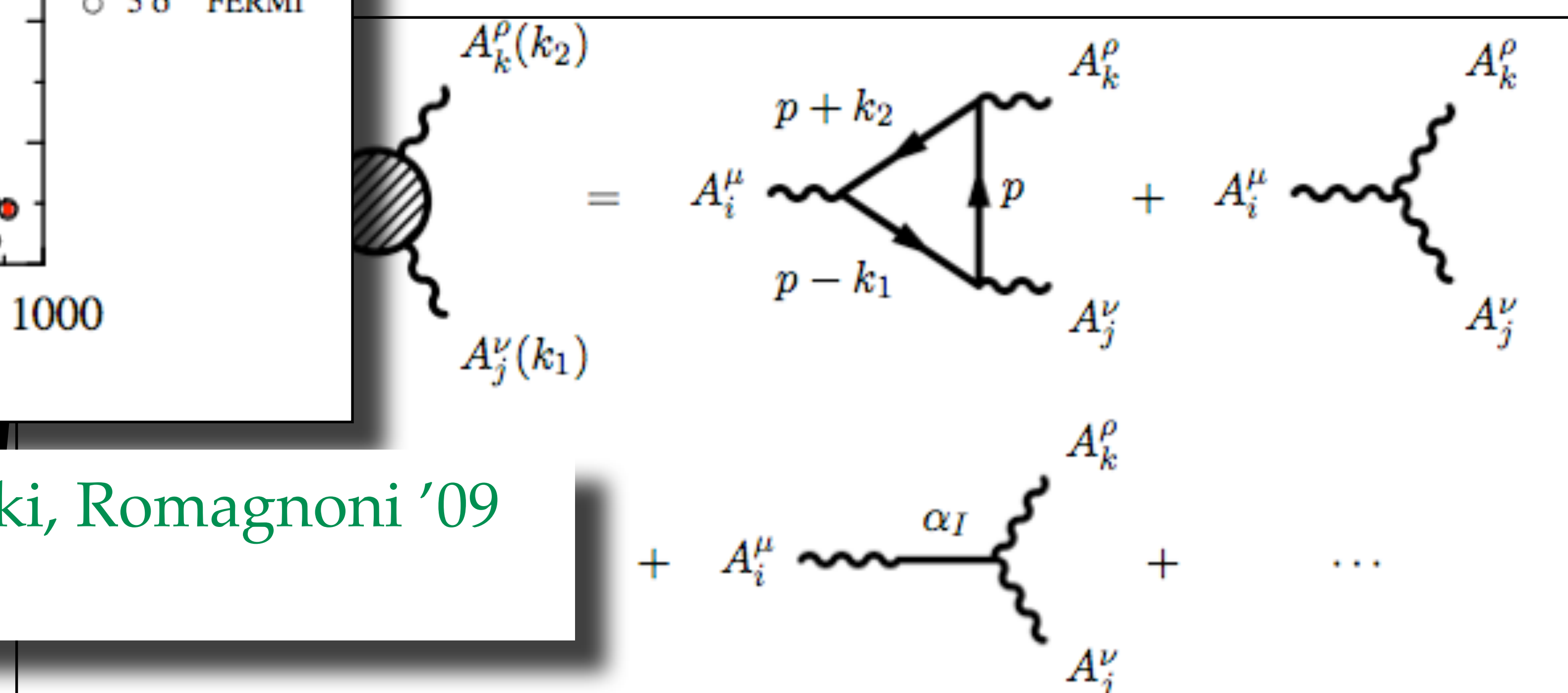

e.g. Dudas, Mambrini, Pokorski, Romagnoni '09
Mambrini '09

- Modelling (fake) future data

  let's say we see WIMP at XENON 1 ton

  and some gamma-ray line at FERMI

  and perhaps some hints at LHC

  Q: If we had enough data (and computer power) to scan over 5 parameters, should we scan

CMSSM-5	Good Choice
BMSSM-3+2	Arguably Bad Choice

  If we had data (and computer power) to scan over 19 parameters, should we scan

MSSM-19	Arguably Bad Choice
BMSSM-17+2 ?	Good Choice
MSSM+CS-17+2 ?	Good Choice

END