Need a context to discuss "are we ready"

Why do we need LHC to understand nature more deeply?

What form might physics take in the best of all possible string vacua?

Gordy Kane

Susy06

➢ We do not know why or even how the EW symmetry is broken. The form the Higgs physics takes will point the way to extending the SM.

➢ Cosmology and astrophysics ➔ the universe is composed of matter but not antimatter, but they *cannot* tell us *why*.

➢ Cosmology and astrophysics ➔ a quarter of the universe is dark matter, but they *cannot* tell us what the dark matter *is*.

➢ Cosmology and astrophysics ➔ the universe began with three space dimensions growing rapidly, but they *cannot* tell us what physical effect caused that inflation, what the inflaton was.

IF NATURE IS SUPERSYMMETRIC, WE CAN ADDRESS THESE QUESTIONS, AND LHC DATA CAN PROVIDE ESSENTIAL CLUES

I think I live in a string theory ground state, vacuum

In a supersymmetric world we can test string theory predictions at the LHC, and study the implications of LHC data for string theory

An optimist can make a defendable argument that LHC data could lead to testing and establishing string theory and to learning many "why's"

ARE WE READY TO TAKE ADVANTAGE OF THESE OPPORTUNITIES?

"LHC Inverse Problem"

The stakes are high

LHC INVERSE PROBLEM(s)

- Is there a signal beyond the SM? Experimenters plus SM theorists will get this right.

- Is it supersymmetry?
    - Can we learn what superpartners are produced at the LHC?
    - Can we distinguish susy from …at the LHC?
    - Can we distinguish susy from something we haven't even thought of at the LHC?
    - Can we measure superpartner spins at the LHC?

- Can we learn enough about the LSP (combining LHC info with experiments that detect it in the laboratory or in space) to compute the relic density and see how much of the dark matter it is?

- Can we deduce the weak scale effective Lagrangian?

- Can we deduce the unification scale effective Lagrangian?

- Can we deduce the underlying string theory?

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  (handwritten: I think so)

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  (handwritten: Wang & Yavin)

  (handwritten: LHC OLYMPICS)

  (handwritten: Will have early test from spin–σ relation for given measured mass)

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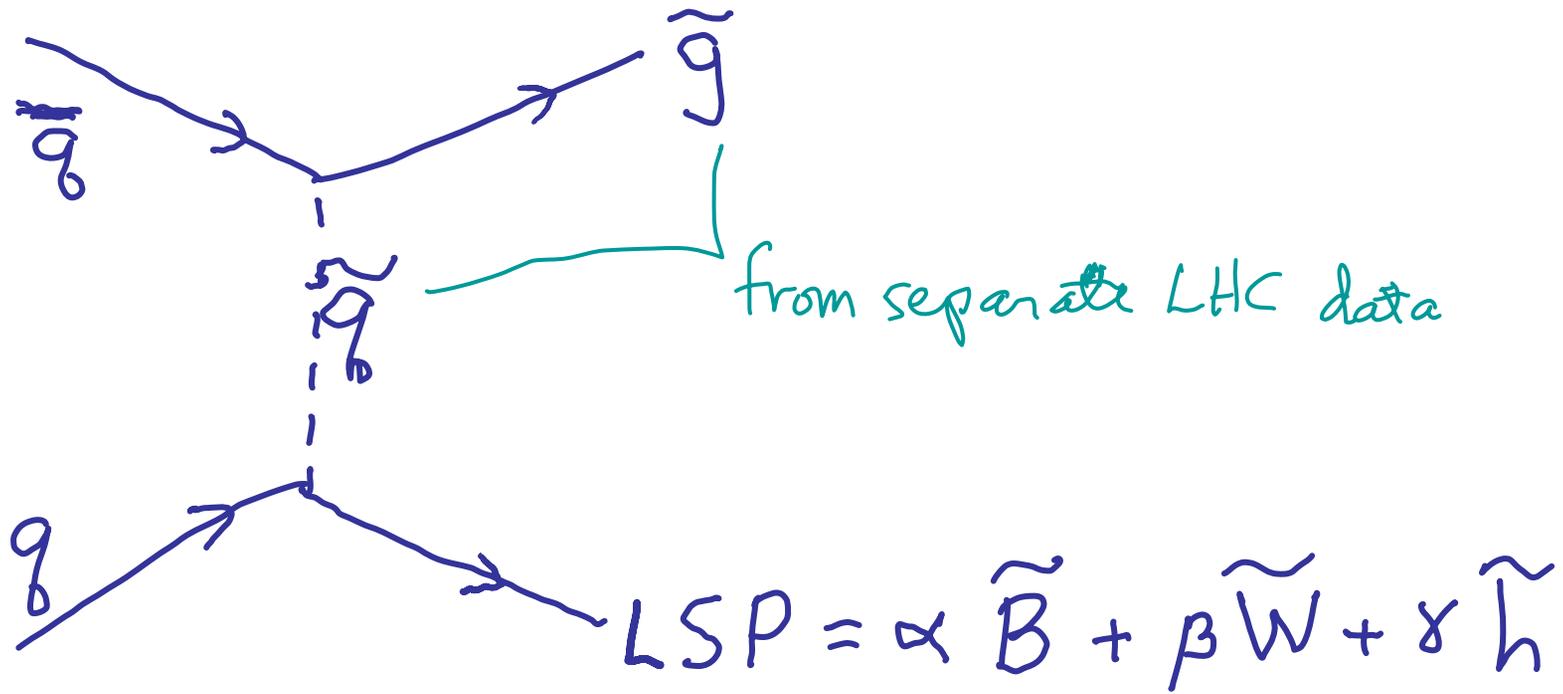
  (handwritten: Very difficult)

- Can we deduce the underlying string theory? *(handwritten: Maybe)*

Collider information needed to learn the relic density:

from separate LHC data

$$LSP = \alpha \, \widetilde{B} + \beta \, \widetilde{W} + \gamma \, \widetilde{h}$$

- $\widetilde{B}, \widetilde{W}, \widetilde{h}$ couple differently to $q\tilde{q}$
- So study this at Tevatron, LHC

Usual method "forward" – study models, hope to recognize them in what is observed

It *is* possible to construct a model where the superpartners can be identified and masses reconstructed

It *is* possible to construct a model where the LSP can be identified and calculated to give the relic density

But – how might one generate models to see if they are generic? – can use string theory – then Snowmass Benchmark models are rare, probably rather misleading

But – Degeneracies!

> ► different models, with different LSPs and different relic densities, different high scale structure, have same LHC signatures

Can we solve the LHC Inverse problems now?

NO

OBSTACLES:

- Degeneracies

- Intermediate scale matter

- S

- Phases

- More parameters than useful observables

- Etc

- Insufficient tools

Need better tools so many more people can participate and work faster

- Extend existing tools to include phases and flavor, and more general RGE running *up*
- Join and synthesize tools to more flexible, reliable, easy to use
- Complete packages to go from parton → shower → detector

Data challenges very good -- for experimenters to find signals and not find ones that are not there – for theorists to learn to interpret

IF YOU CAN'T SUCCEED WITH A DATA CHALLENGE OR BLACK BOX, YOU WON'T BE ABLE TO DO IT IN THE REAL WORLD

Much clever work needed to be able to figure out what LHC signals can tell us

If nature is supersymmetric we are not ready to take advantage of what we can learn from LHC --- but we could be