New Particles Subgroup Overview

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Outline

Many studies just getting underway...

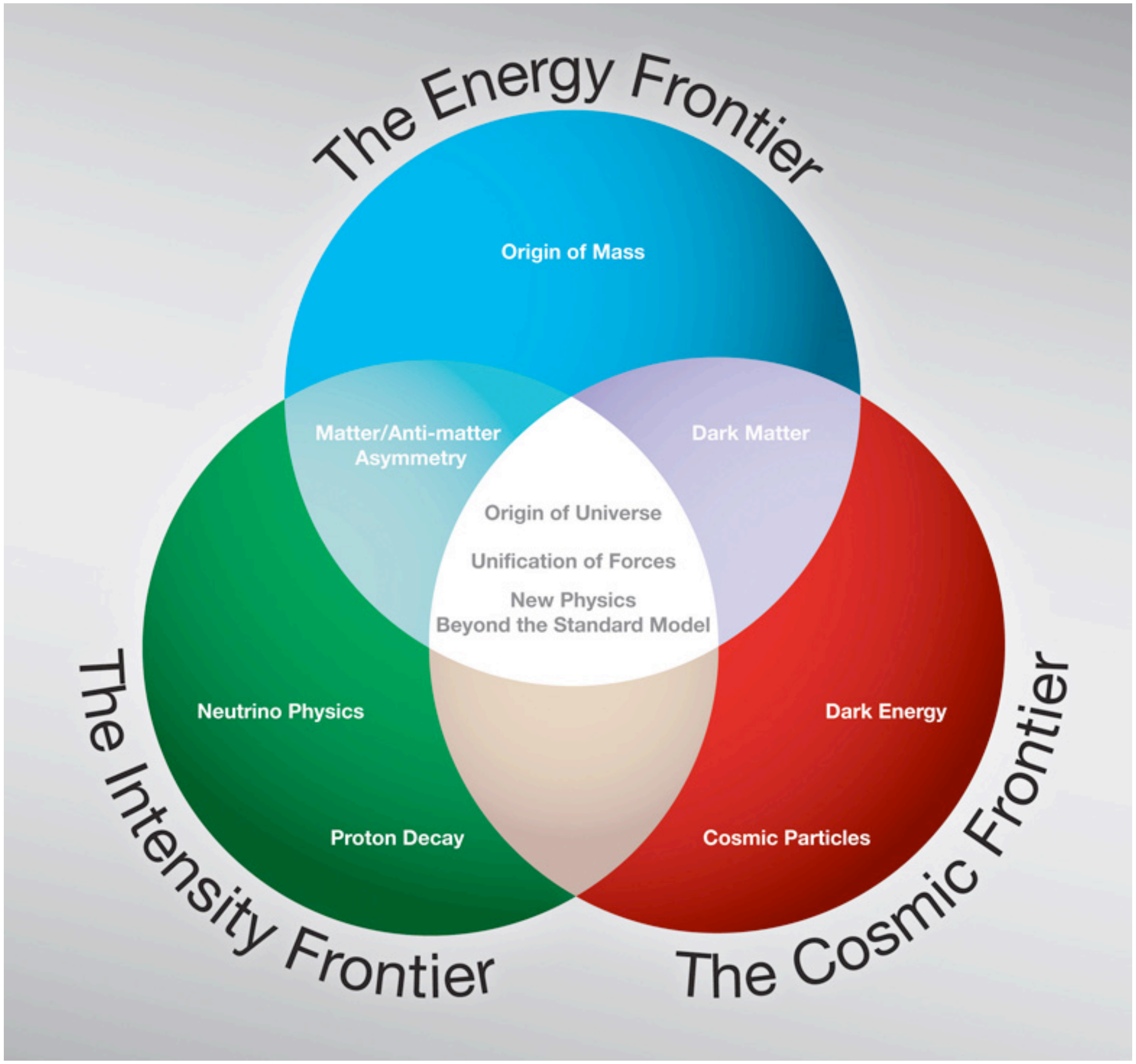
$\Rightarrow$ no final conclusions

Presented here:

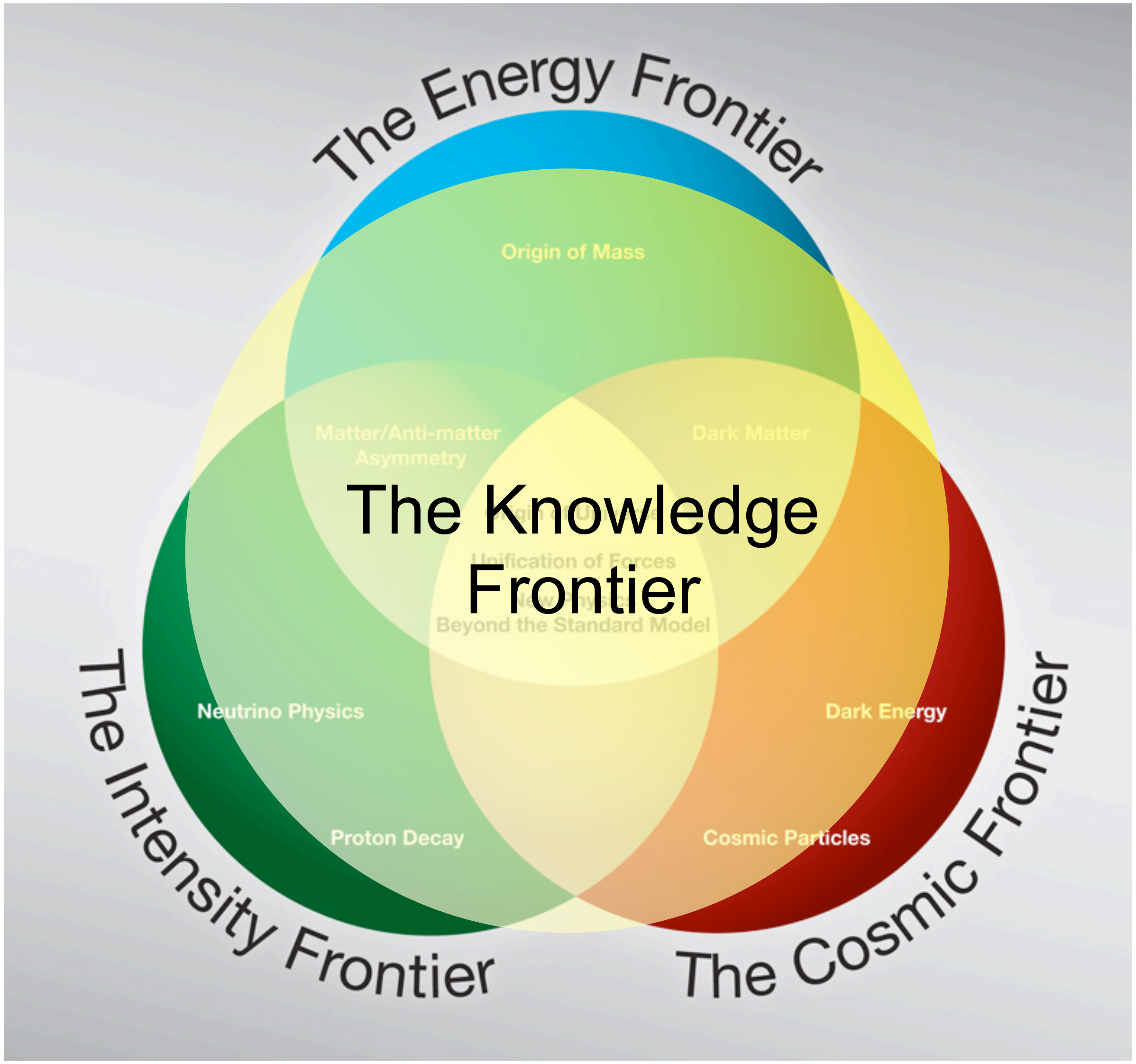
- Motivation/big picture
- Questions to be addressed in NP subgroup
- Overview of studies
- Discovery stories

Feedback/input wanted!

Three Frontiers



Three Frontiers



Three complementary approaches to discover new fundamental laws of nature

New Particles

Discovery and study of particles by direct production has been a primary driver of progress in fundamental physics

⋮	⋮
1983	W,Z discovery
1995	t discovery
2013	Higgs discovery
⋮	⋮

Strength of colliders:
direct search/study with multiple channels, high statistics

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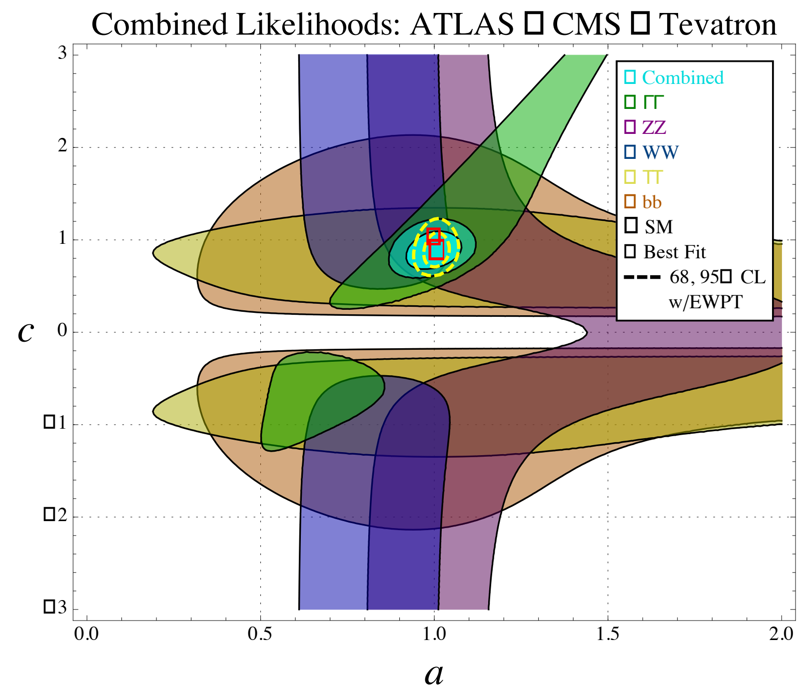


[Azatov, Galloway]

Strength of colliders:
direct search/study with multiple channels, high statistics

E.g. Higgs discovery...

Beyond the Higgs?

Higgs discovery ⇒ known interactions can be extrapolated to 10^{19} GeV!

An issue for all fundamental physics frontiers!

No guarantee of new physics.

This is normal in science.

$$\text{importance} \times \text{probability of discovery} \leq 1$$

Beyond the Higgs!

Strong motivation for new fundamental laws of physics that can be discovered and studied at the energy frontier

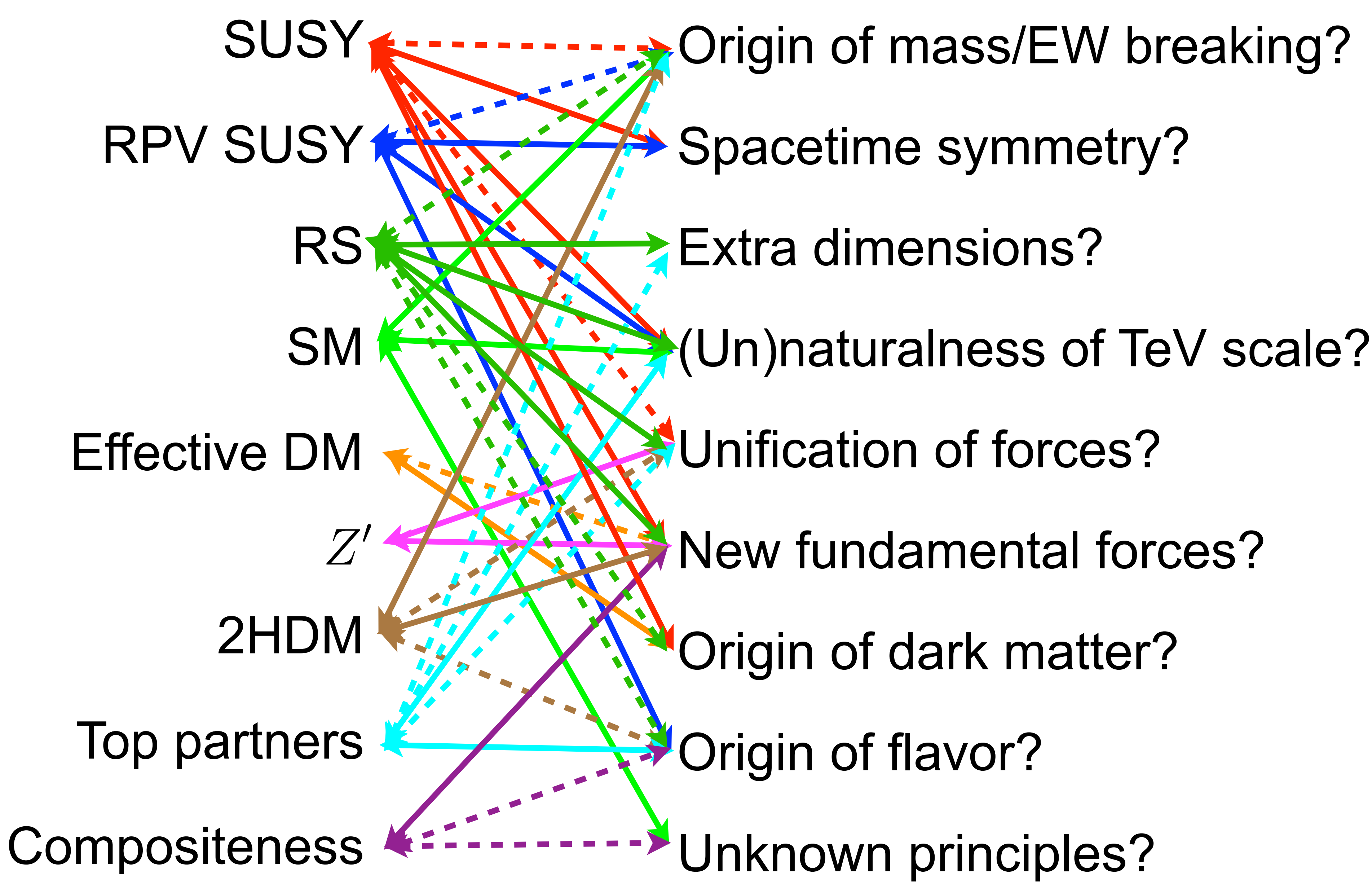
Questions:

- What is the nature of dark matter?
- Are fundamental parameters fine-tuned?
- Are there new fundamental forces in nature?
- What is the origin of flavor?
- Are “elementary” particles wholly or partially composite?

Ideas:

- Supersymmetry
- Extra dimensions
- Unification of forces
- Multiverse

Connections



NP Subgroup Questions

No prioritization of facilities, but make physics comparisons that impact decision process

Answers to these questions are our proposed conclusions

1) What is the role of the high-luminosity (3000/fb) LHC in addressing fundamental questions in physics?

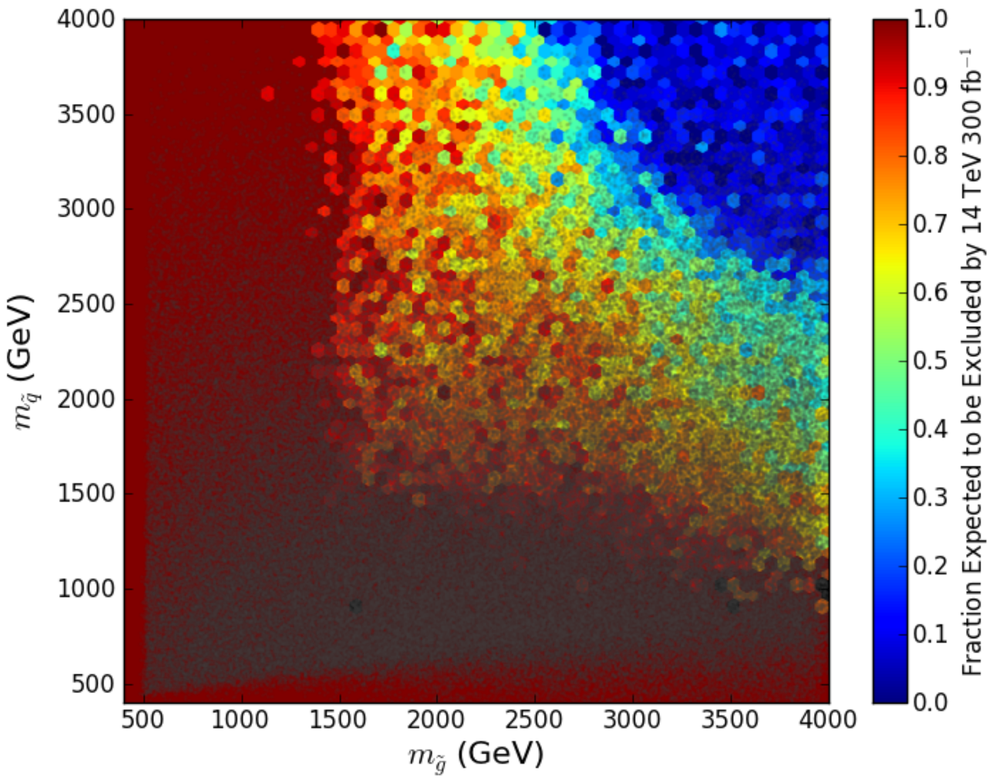
Preliminary results suggest an important role

- Discovery reach, especially for signals with large backgrounds and/or systematics
- Results impact case for future facilities

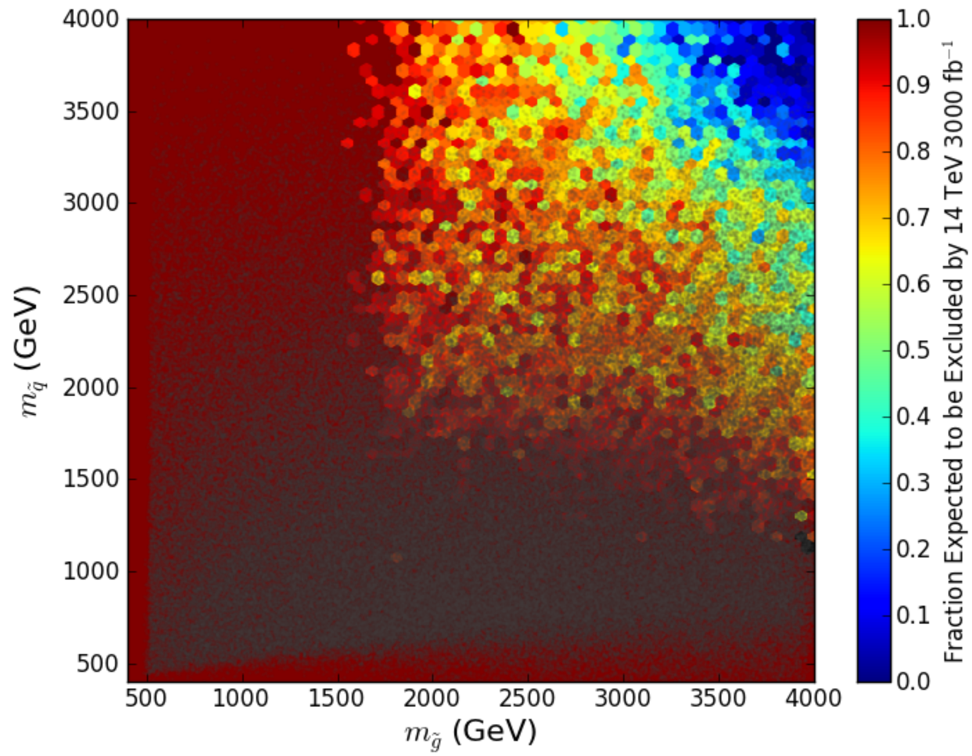
Example: pMSSM

M. Cahill-Rowley, J. Hewett, A. Ismail, and T. Rizzo

300 fb $^{-1}$



3 ab $^{-1}$



NP Subgroup Questions

2) What more can be learned from future energy frontier facilities?

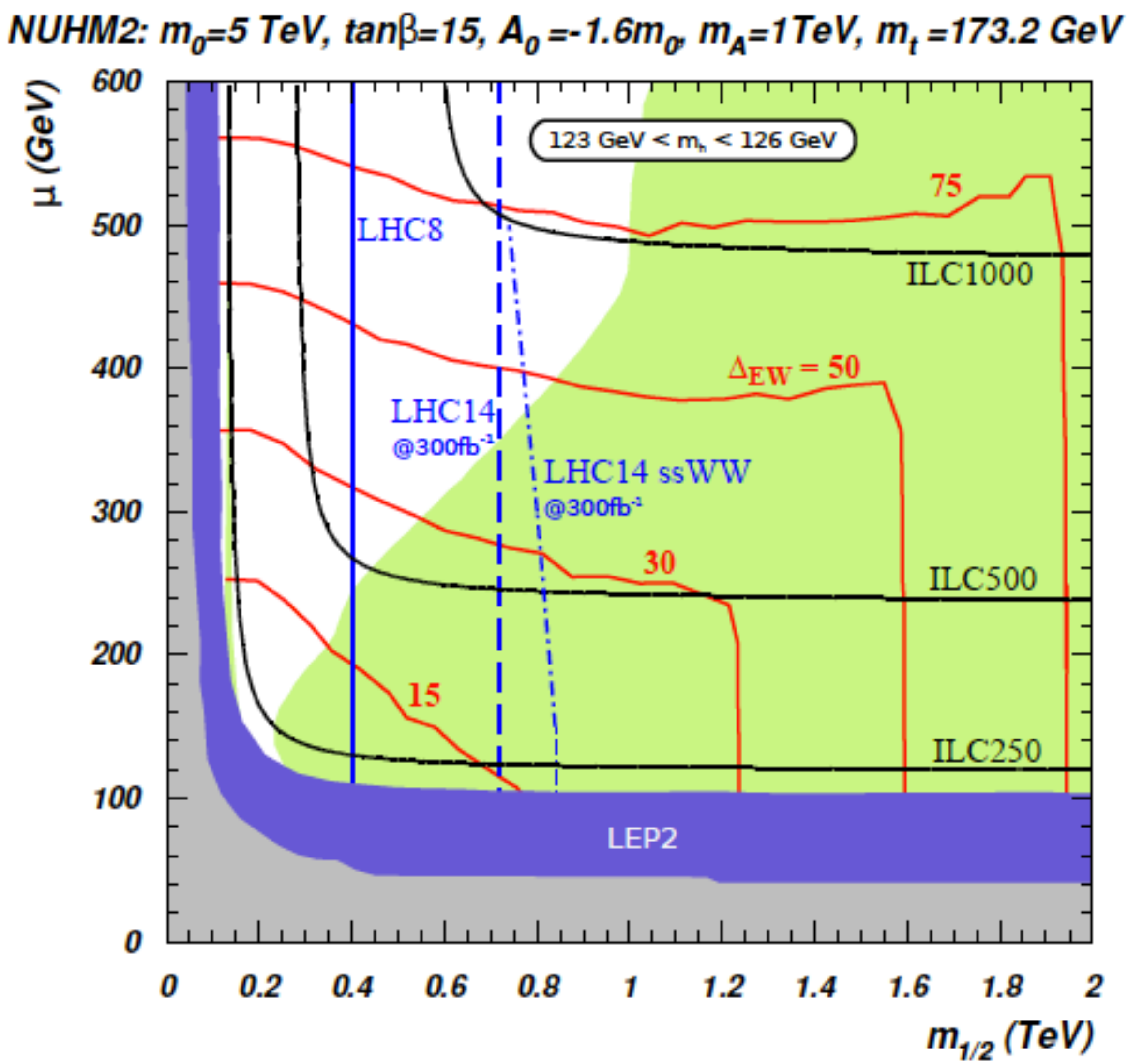
- ILC
- TLEP
- CLIC
- hadron collider @ 33 TeV, 100 TeV
- muon collider 6 TeV

How do discoveries or non-discoveries in near-term experiments impact the case for these facilities?

- 14 TeV LHC 300/fb, 3000/fb
- Dark matter searches
- Flavor physics, neutrino physics,...

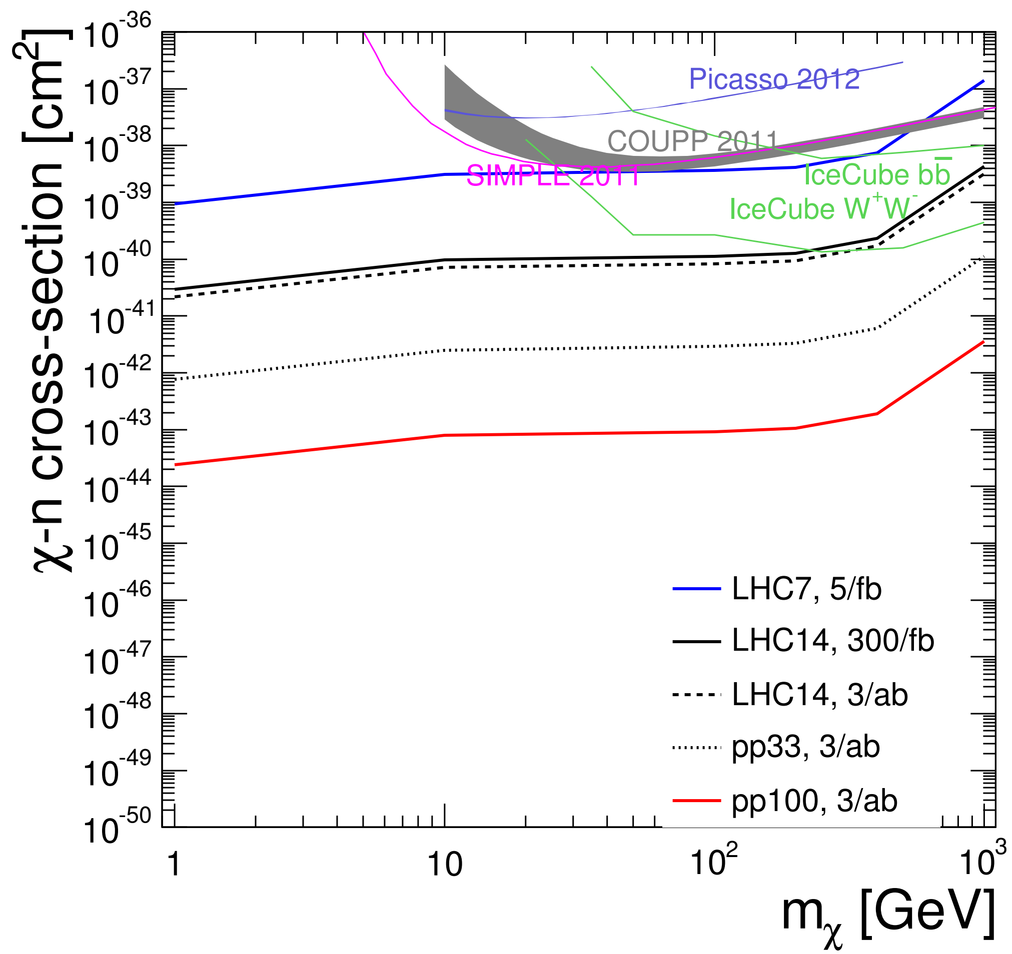
Example: “Natural” SUSY

H. Baer



Example: Effective DM

Ning Zhou, Daniel Whiteson, David Berge, Tim Tait, LianTao Wang



NP Subgroup Questions

More specific examples of these connections:

- How would a hint for SUSY at LHC impact the case for [VLHC, ILC, TLEP, CLIC,...]?

- How would a credible direct dark matter detection signal impact the case for [VLHC, ILC, TLEP, CLIC,...]?

- What is left for [VLHC, ILC, TLEP, CLIC, VLHC...] to discover if LHC and dark matter detection experiments see nothing?

- If LHC Higgs program is consistent with only standard model Higgs, what new physics can we hope to learn about with precision Higgs studies at lepton colliders?

Flagship Analyses

3) What are the flagship analyses for various new facilities?

- Lepton colliders:

  Electroweak-ino/dark matter?

  Slepton/stau?

  Higgs?

- High-energy hadron colliders

  Colored SUSY?

See discovery stories...

Whitepaper authors: we want YOU
to address these questions!

NP Whitepapers

27 whitepapers on many NP scenarios

- SUSY
- RS
- Resonances
- Phenomenological dark matter
- Long-lived particles
- “Hidden valley”

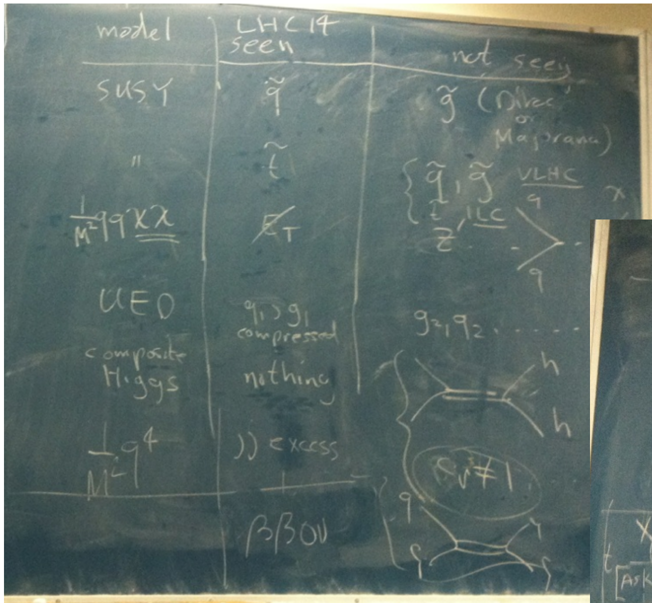
Reflects intellectual diversity and vigor of our field

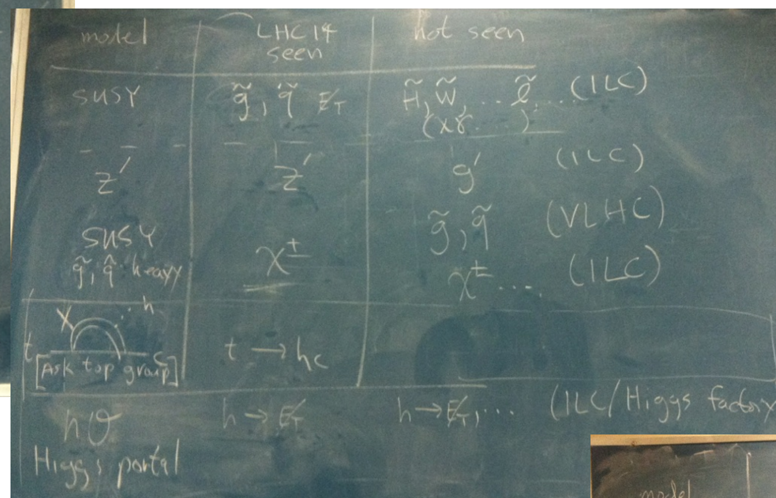
Most have preliminary results covered in talks here in Seattle Thank you!

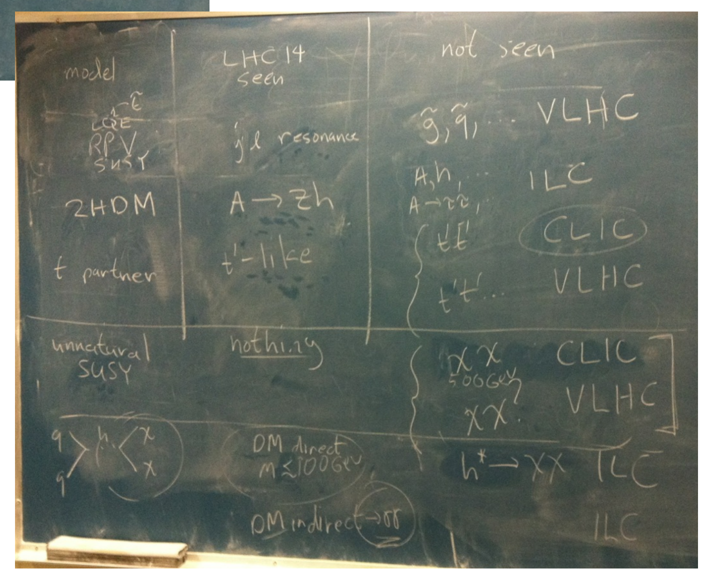
http://www.snowmass2013.org

Discovery Stories

12 of them....







UC Irvine Snowmass workshop

1/15/2003

Discovery Stories

1) Excess in jets + MET consistent with MSSM

LHC signal will give approximate mass scales

→ SUSY

→ ILC: electroweak-ino/LSP

photons + LSP (GMSB)

→ VLHC: superpartner spectrum

Discovery Stories

2) Excess in tt + MET

→ SUSY with light stop

→ top partner (e.g. little Higgs)

→ VLHC: search for remaining superpartners
top partner coupling to Higgs

Discovery Stories

3) Excess in leptons + MET

→ SUSY with light electroweak-inos

→ VLHC: colored superpartner spectrum

→ ILC: electroweak-ino study

4) Resonance in jet + lepton

→ SUSY with QDL R-parity violation

→ VLHC: superpartner spectrum

Discovery Stories

5) Everything consistent with the SM

$\longrightarrow$ High scale SUSY?

$\longrightarrow$ Composite Higgs?

$\longrightarrow$ Just the SM?

$\longrightarrow$ ILC: precision study of Higgs

$\longrightarrow$ CLIC/muon: EW-ino discovery (SUSY)

VV, Vh, hh resonances (composite Higgs)

$\longrightarrow$ VLHC: Colored SUSY

Not the “nightmare scenario” please!

Discovery Stories

6) Dark matter direct detection consistent with >10 GeV

→ Dark matter coupling to colored particles

→ VLHC: Direct dark matter production

7) Monojet excess

→ Dark matter production via qqXX or Z’

→ VLHC: Direct study of mediator

→ ILC/CLIC/muon: Direct study of Z’?

Discovery Stories

8) Dilepton resonance

→ Z'

→ ILC/CLIC: precision study

9) Evidence for h → MET from Higgs fit, MET excess

→ Higgs portal interaction $H^2 X$

→ ILC: study of h → MET

other h decays

Discovery Stories

10) Zh resonance

→ Nonmiminal Higgs model A → Zh

→ ILC/CLIC/muon: Detailed study of Higgs sector

11) Excess in t' search

→ Top partners, composite/little Higgs

→ VLHC/CLIC/muon: study of top partners

12) Excess high pT dijet events

→ qqqq effective operator from resonance

→ VLHC: study of resonance

Conclusions

• No guarantees, we are exploring the unknown...

• ...but addressing multiple important fundamental questions guided by evidence for new physics and compelling theoretical ideas.

• Many fundamental ideas can be tested at the TeV scale, many paths to discovery.


Keep exploring!