

FCC SUSY Section Plan

CERN

Oct 5th 2015

Matthew McCullough

With Mike Hance and Filip Moortgat



This Talk:

What I will try to cover:

- Section titles and scope
- Analyses from pheno/exp
- ...

Please comment on:

- Analyses we may not be aware of
- Overlap with other sections
- Appropriateness of contents
-

Snapshot of analyses:

[arXiv.org](#) > [hep-ph](#) > [arXiv:1502.05044](#)

High Energy Physics – Phenomenology

Neutralinos in Vector Boson Fusion at High Energy Colliders

[Asher Berlin](#), [Tongyan Lin](#), [Matthew Low](#), [Lian-Tao Wang](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1312.1802](#)

High Energy Physics – Phenomenology

Gaugino physics of split supersymmetry spectrum at the LHC and future proton colliders

[Sunghoon Jung](#), [James D. Wells](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1406.4512](#)

High Energy Physics – Phenomenology

Boosting Stop Searches with a 100 TeV Proton Collider

[Timothy Cohen](#), [Raffaele Tito D'Agnolo](#), [Mike Hance](#), [Hou Keong Lou](#), [Jay G. Wacker](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1311.6480](#)

High Energy Physics – Phenomenology

SUSY Simplified Models at 14, 33, and 100 TeV Proton Colliders

[Timothy Cohen](#), [Tobias Golling](#), [Mike Hance](#), [Anna Henrichs](#), [Kiel Howe](#), [Joshua Loyal](#), [Sanjay Padhi](#), [Jay G. Wacker](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1412.4789](#)

High Energy Physics – Phenomenology

The Relic Neutralino Surface at a 100 TeV collider

[Joseph Bramante](#), [Patrick J. Fox](#), [Adam Martin](#), [Bryan Ostdiek](#), [Tilman Plehn](#), [Torben Schell](#), [Michihisa Takeuchi](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1404.0682](#)

High Energy Physics – Phenomenology

Neutralino Dark Matter at 14 and 100 TeV

[Matthew Low](#), [Lian-Tao Wang](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1503.03099](#)

High Energy Physics – Phenomenology

LHC constraints on Mini-Split anomaly and gauge mediation and prospects for LHC 14 and a future 100 TeV pp collider

[Hugues Beauchesne](#), [Kevin Earl](#), [Thomas Gregoire](#)

(Submitted on 10 Mar 2015 (v1), last revised 27 Aug 2015 (this version, v3))

[arXiv.org](#) > [hep-ph](#) > [arXiv:1410.6287](#)

High Energy Physics – Phenomenology

Prospects for Electroweakino Discovery at a 100 TeV

[Stefania Gori](#), [Sunghoon Jung](#), [Lian-Tao Wang](#), [James D. Wells](#)

(Submitted on 23 Oct 2014)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1506.02644](#)

High Energy Physics – Phenomenology

Reaching for Squarks and Gauginos at a 100 TeV p-p Collider

[Sebastian A. R. Ellis](#), [Bob Zheng](#)

Snapshot of analyses:

[arXiv.org](#) > [hep-ph](#) > [arXiv:1410.1532](#)

High Energy Physics – Phenomenology

Prospects for observing charginos and neutralinos at a 100 TeV proton–proton collider

[Bobby S. Acharya](#), [Krzysztof Bozek](#), [Chakrit Pongkitivanichkul](#), [Kazuki Sakurai](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1408.1961](#)

High Energy Physics – Phenomenology

Superpartners at LHC and Future Colliders: Predictions from Constrained Compactified M–Theory

[Sebastian A.R. Ellis](#), [Gordon L. Kane](#), [Bob Zheng](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1407.5066](#)

High Energy Physics – Phenomenology

Squark and gluino production cross sections in pp collisions at $\sqrt{s} = 13, 14, 33$ and 100 TeV

[Christoph Borschensky](#), [Michael Krämer](#), [Anna Kulesza](#), [Michelangelo Mangano](#), [Sanjay Padhi](#), [Tilman Plehn](#),
[Xavier Portell](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1402.5419](#)

High Energy Physics – Phenomenology

Prospects for constrained supersymmetry at $\sqrt{s} = 33$ TeV and $\sqrt{s} = 100$ TeV proton–proton super–colliders

[Andrew Fowlie](#), [Martti Raidal](#)

[arXiv.org](#) > [hep-ph](#) > [arXiv:1309.1514](#)

High Energy Physics – Phenomenology

Reach in All Hadronic Stop Decays: A Snowmass White Paper

[Daniel Stolarski](#)

[arXiv.org](#) > [hep-ex](#) > [arXiv:1307.5327](#)

High Energy Physics – Experiment

Sensitivity of future collider facilities to WIMP pair production via effective operators and light mediators

[Ning Zhou](#), [David Berge](#), [Tim M.P. Tait](#), [LianTao Wang](#), [Daniel Whiteson](#)

Snapshot of analyses:

arXiv.org > hep-ph > arXiv:1502.05044

High Energy Physics – Phenomenology

Neutralinos in Vector Boson Fusion at High Energy Colliders

Asher Berlin, Tongyan Lin, Matthew Low, Lian-Tao Wang

arXiv.org > hep-ph > arXiv:1312.1711

High Energy Physics – Phenomenology

Gaungino physics of a future proton collider

Sunghoon Jung, James D. Wells

arXiv.org > hep-ph > arXiv:1406.4512

High Energy Physics – Phenomenology

SUSY Simplified Model

Timothy Cohen, Tobias Wacker

arXiv.org > hep-ph > arXiv:1410.6287

High Energy Physics – Phenomenology

Neutralino

Matthew Low, Lian-Tao Wang

arXiv.org > hep-ph > arXiv:1410.6287

High Energy Physics – Phenomenology

Prospects for Electroweakino Discovery at a 100 TeV

Stefania Gori, Sunghoon Jung, Lian-Tao Wang, James D. Wells

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High Energy Physics – Phenomenology

Reaching for Squarks

Sebastian A. R. Ellis, Bob Zheng

arXiv.org > hep-ph > arXiv:1406.4512

High Energy Physics – Phenomenology

100 TeV Proton Collider

Yi-Lin Lou, Jay G. Wacker

Mediation and
Collider

Collider

There are many papers
considering 100 TeV
without mentioning
explicitly in title/abstract.
Holler if you see something
missing!

FCC SUSY Section Plan

2 Supersymmetry

2.1 Introduction

2.2 Stops

2.3 Gluinos

2.4 Neutralinos

2.5 Squarks

2.6 Exotic Signatures

2.7 Indirect Probes

2.8 Mini-Split SUSY

FCC SUSY Section Plan

- The motivation for SUSY is naturalness of the weak scale.
- No clear UV-based structure has emerged (gravity/gauge/anomaly-mediated etc). We thought
 - A) Break structure up by the particles
 - B) Order sections initially by relevance to hierarchy problem
- We feel this “bottom up” structure may be most useful to reader, but also useful for spreading information: generic sparticle reach may be easily found in document.

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FCC SUSY Section Plan

Introduction

- The motivation for SUSY is the hierarchy problem, so this must be the focus of introduction. Make argument clear, and gather opinion.
- “At present the indication is that Nature does not too much care about our notion of naturalness. Still the argument for naturalness is a solid one and we are facing a puzzling situation.” Altarelli, 2013
- Other possibilities out there, but relative to them SUSY still very attractive.
- Synergies. E.g. between Higgs mass and SUSY predictions: If high-ish $\tan(\beta)$ stops probably in 100 TeV reach!

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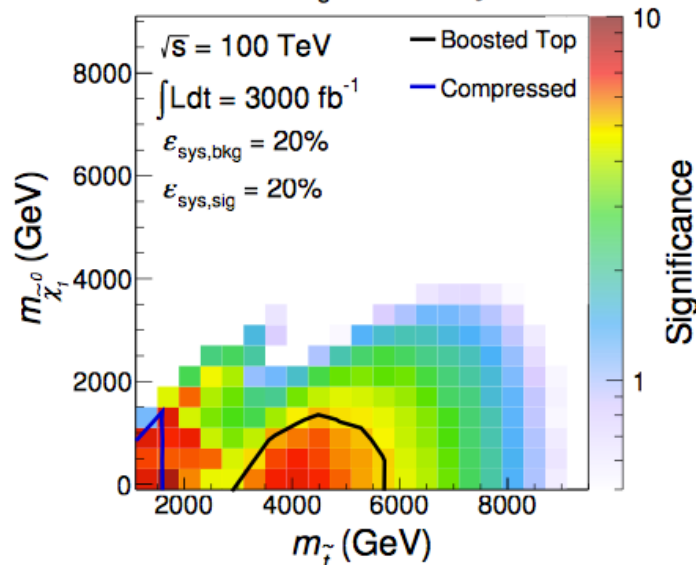
2.8 Mini-Split SUSY

FCC SUSY Section Plan

Stops

- Cornerstone of SUSY.
- Direct production searches
 - Decay to LSP

CL_s Discovery



1406.4512:

- Production from gluino decays

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**To keep in mind
during document
preparation:**

Which search
projections are out
there already?

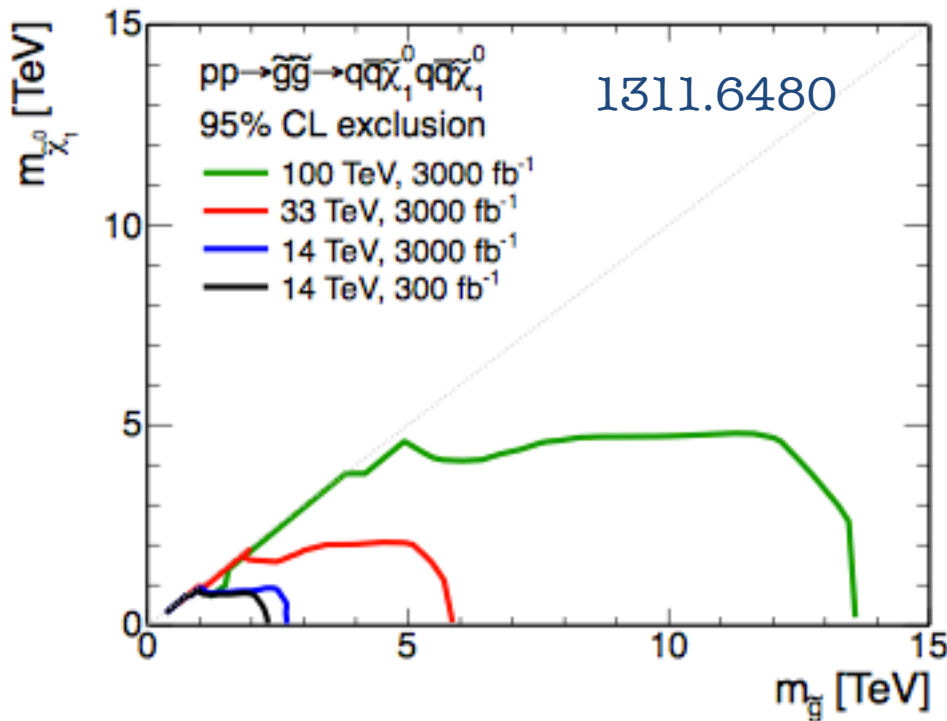
Which are coming?

Which have been
overlooked?

FCC SUSY Section Plan

Gluinos

- Keystone of SUSY.



- Studies already showing significant reach. 1312.1802, 1506.02644.

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Neutralinos (and Charginos)

- Capstone of SUSY.
- Must discuss dark matter possibility
 - Number of studies already: 1412.4789, 1410.6287, 1502.05044, 1404.0682.
 - Reach into few- TeV range seems typical!
- Avoid overlap, i.e. not “Mono-X” searches
- Focus on SUSY-specific signatures, including chargino production.
- Could perhaps subsume gravitino/goldstino pheno into here as well?

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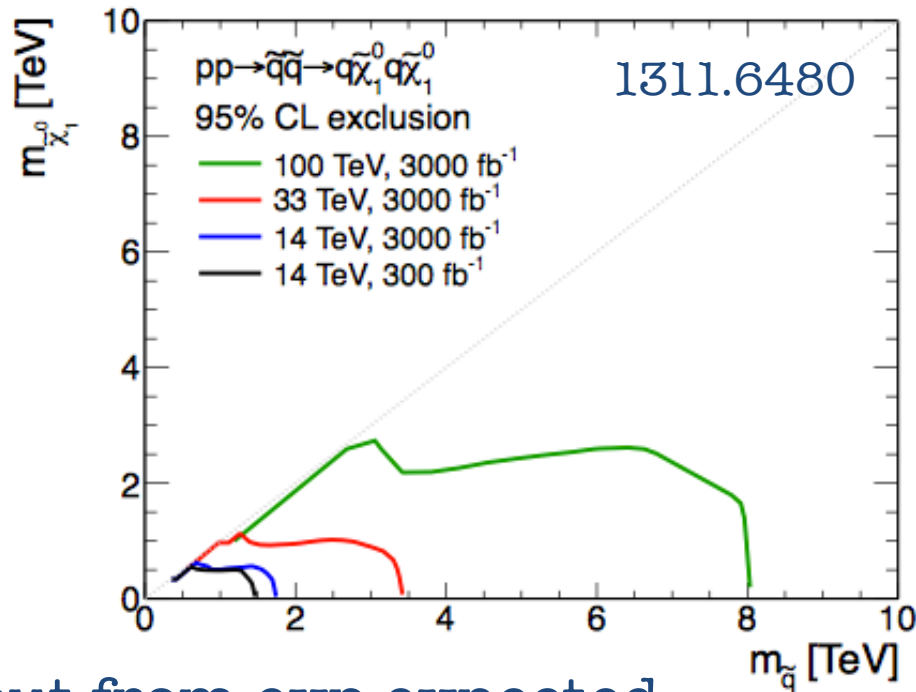
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FCC SUSY Section Plan

First two generation squarks

- “Vanilla” searches likely to have a significant reach.



- Input from exp expected.

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FCC SUSY Section Plan

Other SUSY Partners/Exotic Signatures

- Slepton discussion in here, or separate?
- Consider “Stealth” and “Compressed” spectra. RPV decays. Vanishing tracks.
- Displaced vertices.
 - Personal comment: Low background (rare) signatures like D-Vs could be very promising for 100 TeV. Relative to 14 TeV production cross sections may grow significantly, while background possibly staying low. Potentially significant leap in reach for 100 TeV.
- These considerations may motivate detector performance goals.

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FCC SUSY Section Plan

Indirect probes

- Precision Higgs coupling measurements inform our picture of sparticle spectra (hGG, $g\gamma\gamma$, 2HDM, di-Higgs).
- Flavour and CP-violation, precision observables also inform of structures above the weak scale.
- Other precision SM measurements also useful, e.g. precision top constraints stops.

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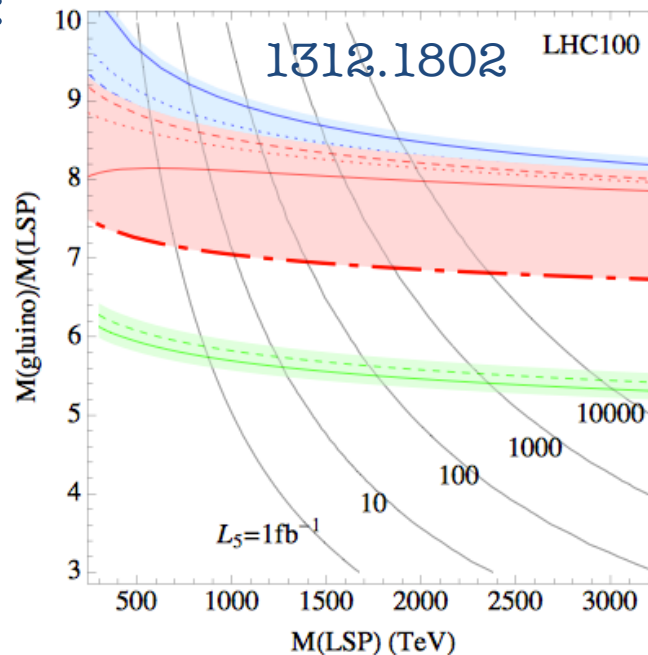
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Which have been overlooked?

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Mini-Split SUSY

- Mini-Split scenarios embrace the tuning of weak scale.* However still interesting due to:

- Higgs Mass
- Dark Matter
- Unification?



- Could 100 TeV offer comprehensive coverage, from gaugino production?
- Interplay with indirect dark matter searches?

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* See however: 1509.00834

FCC SUSY Section Plan

Conclusions

- **Discover:** Summarize the ground that could be covered with a 100 TeV collider.
- **Investigate:** If LHC saw emerging evidence during HL-LHC, could 100 TeV fully explore the new physics?
- **Constrain:** If no signs for SUSY emerged at 100 TeV, would we be convinced that a SUSY resolution of hierarchy problem was not realised in nature?

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