

Snowmass LLP summary report

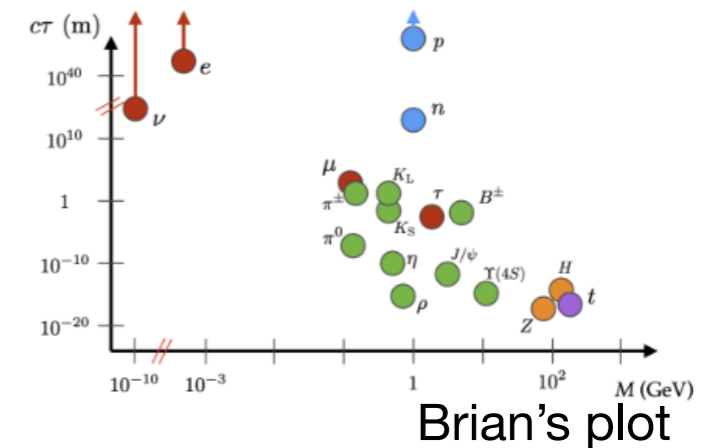


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Objectives

- Emphasize that LLPs are important
- Emphasize that LLPs cannot be taken for granted:
 - ◆ HL LHC upgrades are essential
 - ◆ Strong physics case for one or more auxiliary LLP detectors
 - ◆ Future detectors/accelerators must be designed with LLP's in mind
- Provide some illustrative benchmarks comparing existing and future facilities (non-exhaustive)
- Summarize LLP related snowmass submissions



Input to the big Energy Frontier summary

Outline

LLP's fall (mostly) under EF09: "More general explorations"

- New bosons and heavy resonances (R. Harris, F. Yu)
- New fermions (I. Lewis, J. Hogan)
- Long lived particles

(Also see EF02, EF08 and EF10)

Was merged with EF08 (models) and EF10 (dark matter) in one BSM summary report

IX. Long Lived Particles

A. Strategies and detector R&D

1. General detector requirements
2. Tracking detectors
3. Calorimeters
4. Timing detectors
5. Triggers
6. Alternative data taking strategies

B. Dedicated detectors for LLPs

1. Forward detectors
2. Central detectors
3. Detectors for charged LLPs
4. Detectors at future colliders

C. Signatures & models

1. Charged LLPs
2. Low mass displaced vertices
3. High mass displaced vertices
4. Dark showers

Outline

IX. Long Lived Particles

A. Strategies and detector R&D

1. General detector requirements
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6. Alternative data taking strategies



What makes a good LLP detector?

B. Dedicated detectors for LLPs

1. Forward detectors
2. Central detectors
3. Detectors for charged LLPs
4. Detectors at future colliders



What are dedicated detectors and why do we need them?

C. Signatures & models

1. Charged LLPs
2. Low mass displaced vertices
3. High mass displaced vertices
4. Dark showers



Some example sensitivity plots

Strategies and detector R&D

Examples of things we highlighted:

- Particle ID capabilities are extremely valuable (e.g. dE/dx , time-of-flight etc)
- Vertex resolution near IP is a priority (e.g. VELO)
- Dedicated triggers for LLP's are essential, *especially* at hadron and muon machines. Hardware needs to be designed accordingly
- Aside from EW vs Strong production, not all colliders are born equal for LLPs: Hadron and muon machines will be MUCH more challenging than e^+e^-
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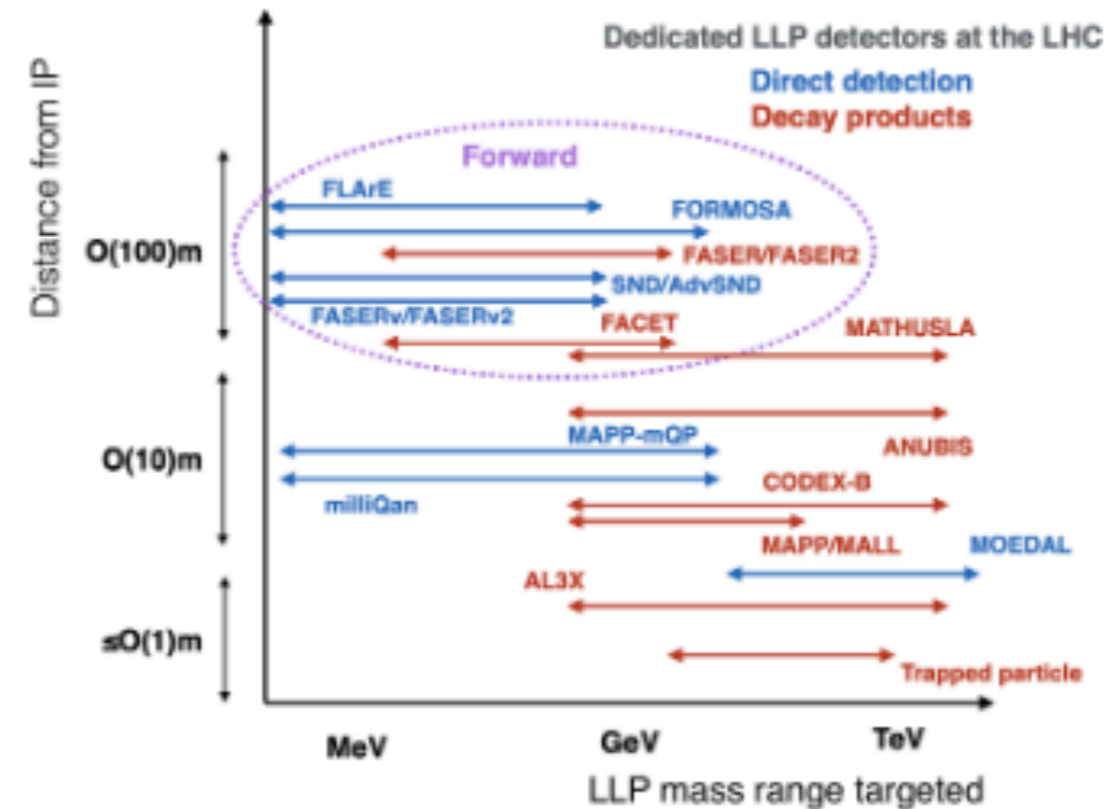
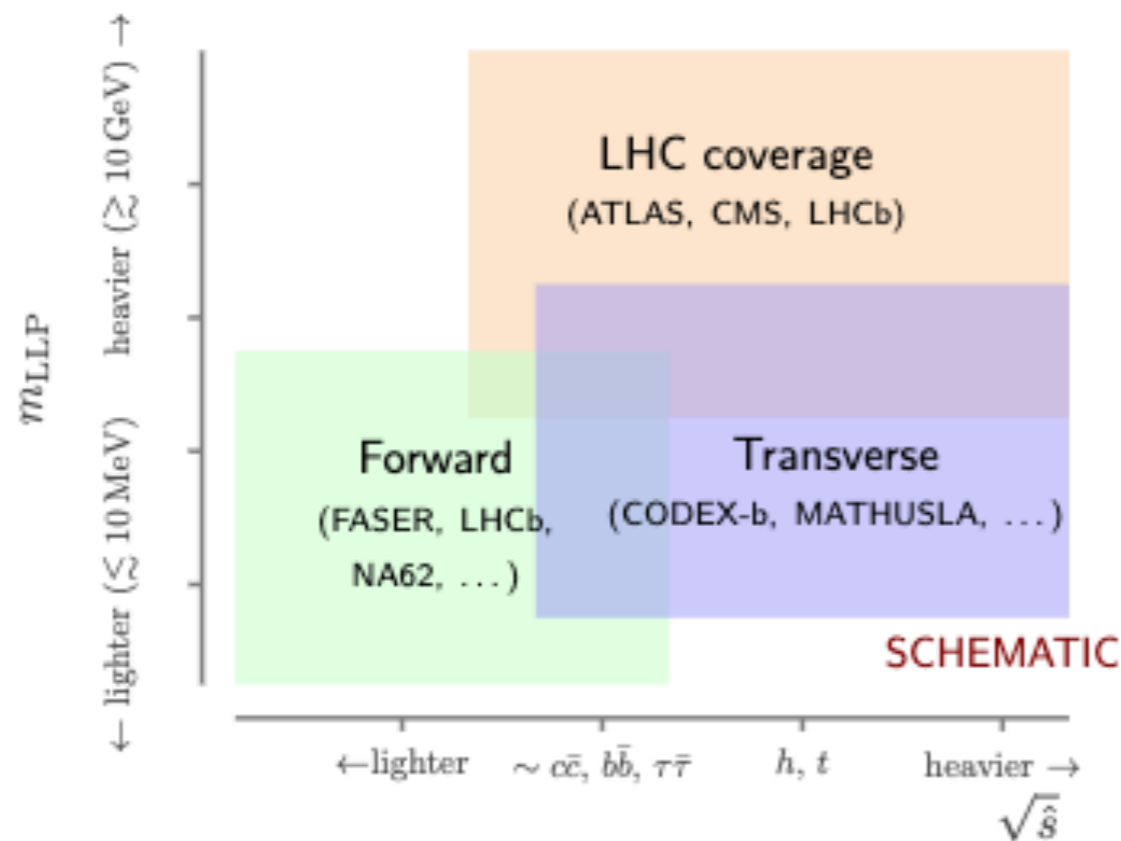
Everything likely obvious to LLP community

Hopefully nothing shocking/surprising



Dedicated detectors

- Important for exhaustive coverage of low mass LLPs in particular
- Emphasized complementarity:
 - ✦ Forward vs central detectors
 - ✦ Charged vs neutral LLPs



Dedicated detectors

- B. Dedicated detectors for LLPs
 1. Forward detectors
 2. Central detectors
 3. Detectors for charged LLPs
 4. Detectors at future colliders

- Forward: FASER, FPF, FACET, MOEDAL-MAPP
- Central: MATHUSLA, CODEX-b, ANUBIS, (AL3X)
- Charged LLPs: MOEDAL, MILIQAN, FORMOSA
- At future colliders: lepton & hadron colliders, some general thoughts

Roughly a paragraph per detector, space is limited...

Signatures and Models

C. Signatures & models

1. Charged LLPs
2. Low mass displaced vertices
3. High mass displaced vertices
4. Dark showers

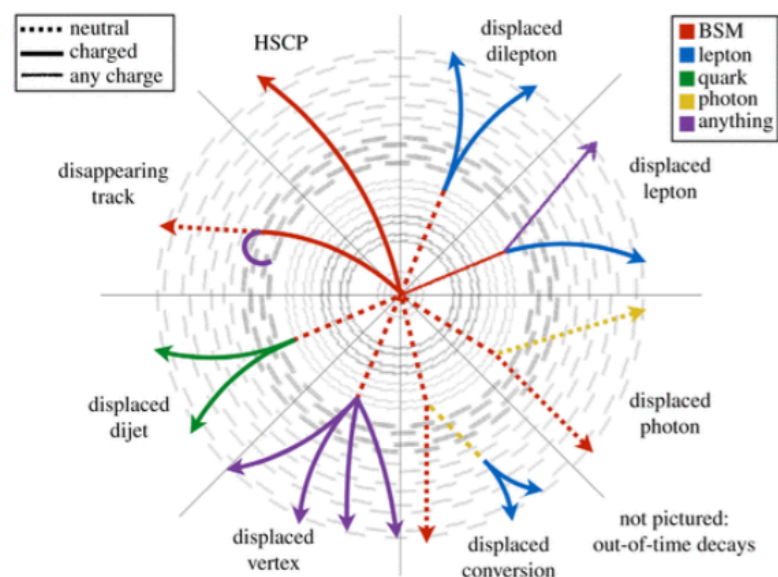
Really had to pick a handful examples, sorry if your favorite model or search is not represented

E.g. For light LLPs, restricted to stuff made in Higgs decays

(Also featured in Higgs working group)

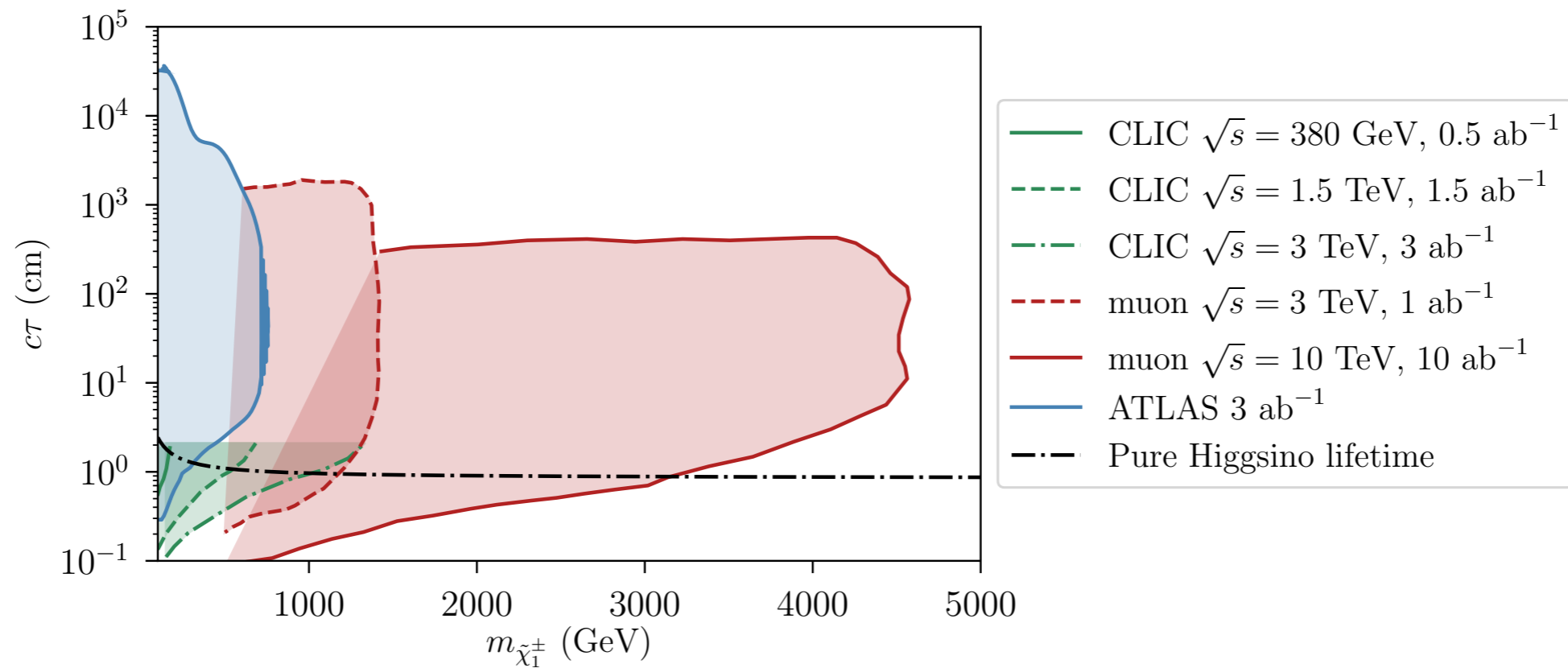
Dark photons, HNL, etc etc are mentioned, but sensitivity plots are featured in RF06 report (See Stefania's talk).

(We will of course cross reference)



Charged LLPs

Disappearing track (Higgsino) sensitivity estimates, as function of lifetime

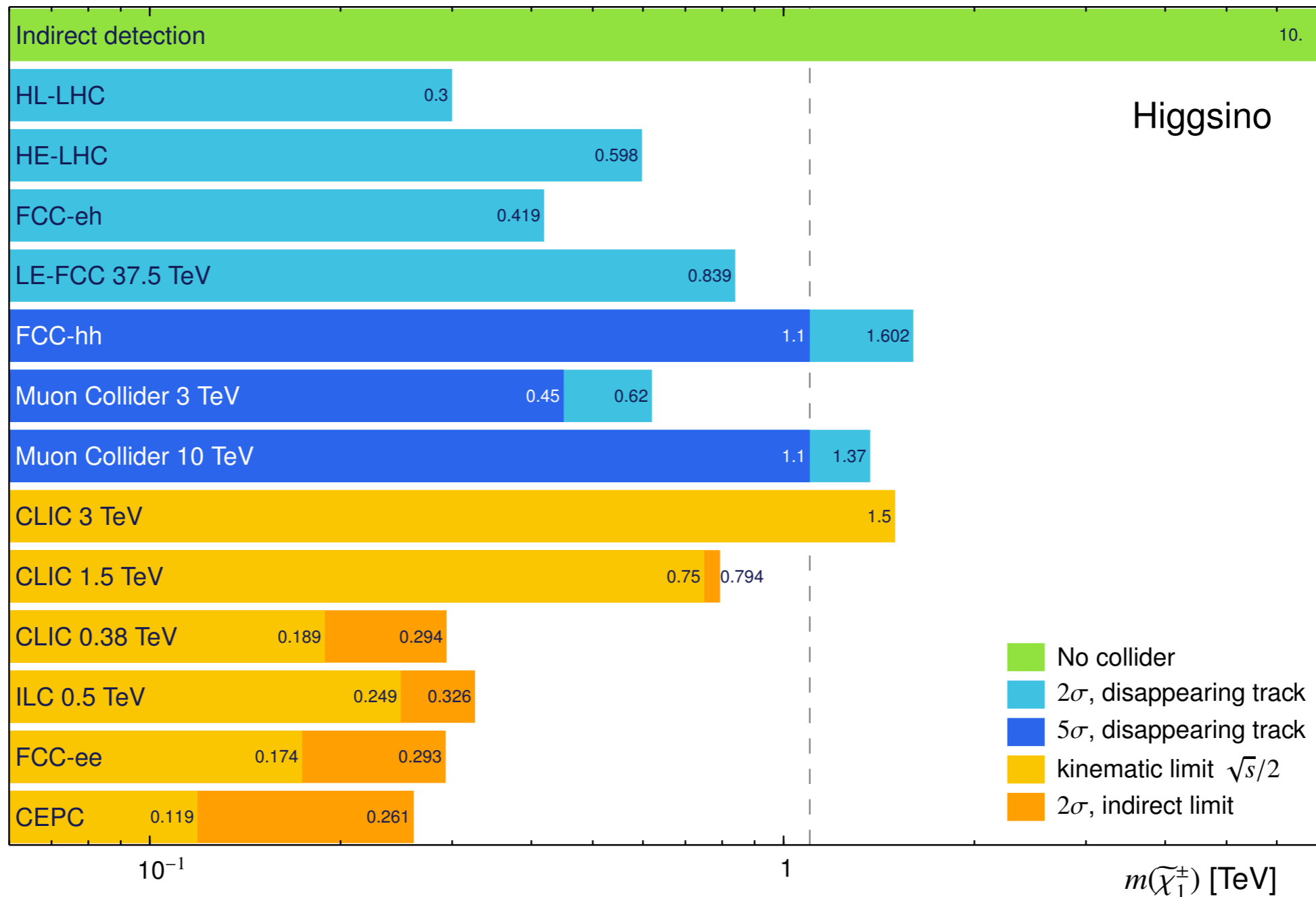


NEW

Charged LLPs

Disappearing track sensitivity estimates, assuming pure Higgsino

Capdevilla et al 2102.11292

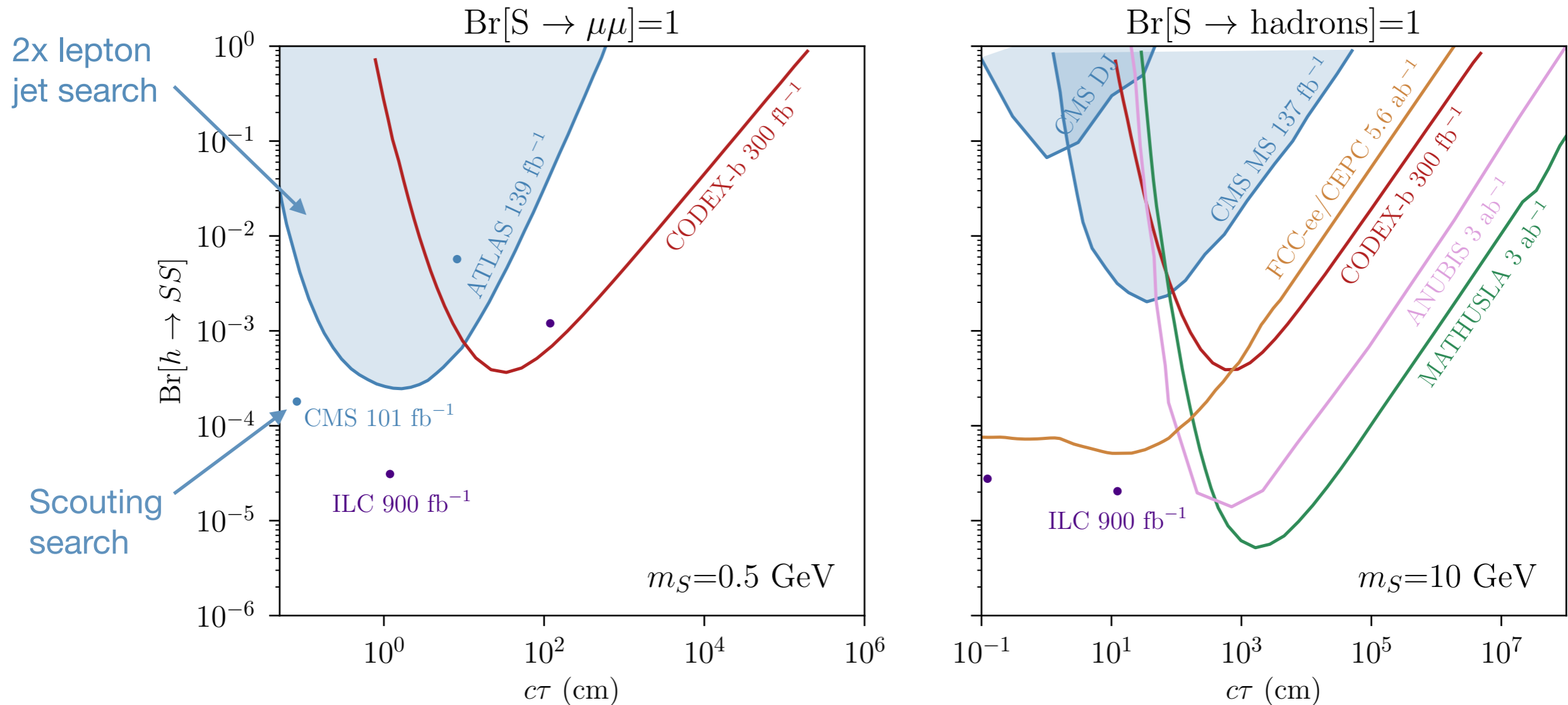


Caveats to the green indirect detection bar are explained in the text

Light LLPs

NEW

LLPs produced in Higgs decays

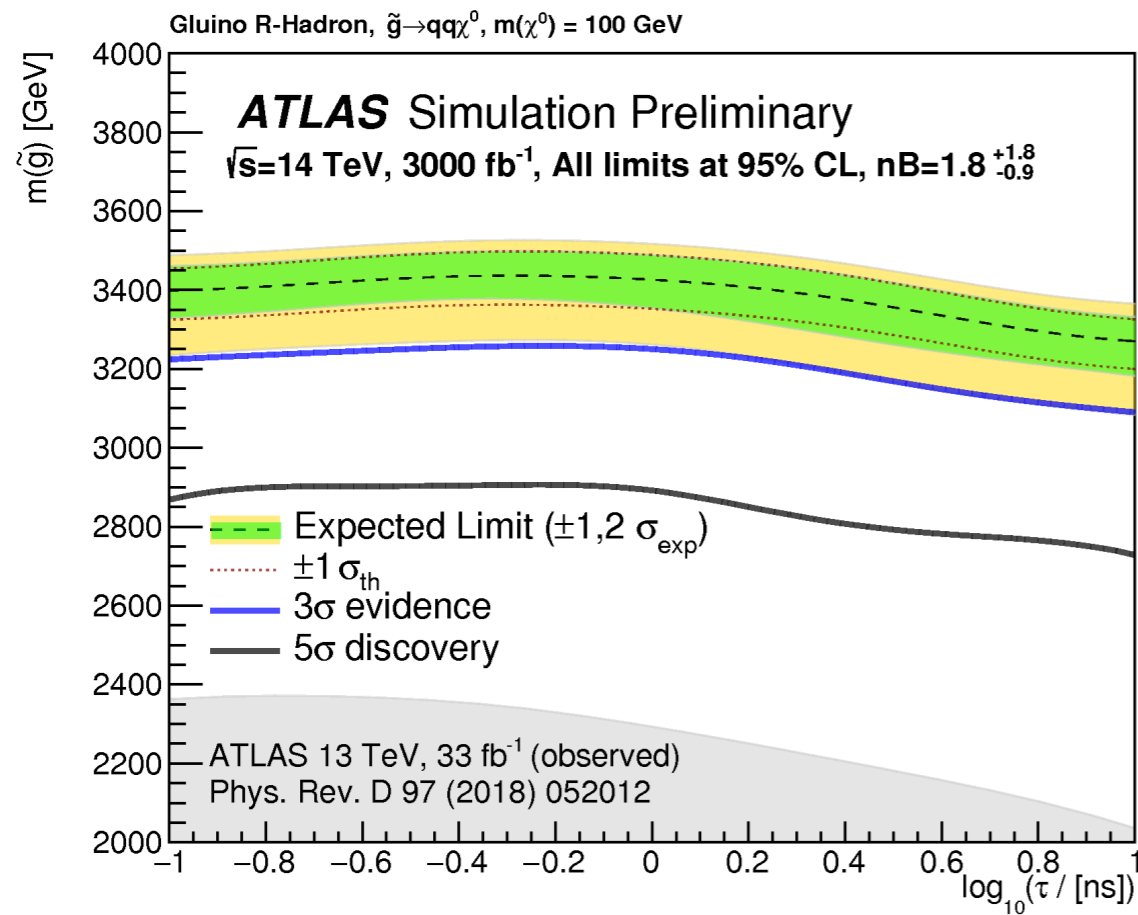


- Included strongest searches that we were comfortable extrapolating
- Sometimes only two lifetime points were available
- MATHUSLA study for left hand panel under way
- Several HL LHC projections available, but already outperformed by existing analysis

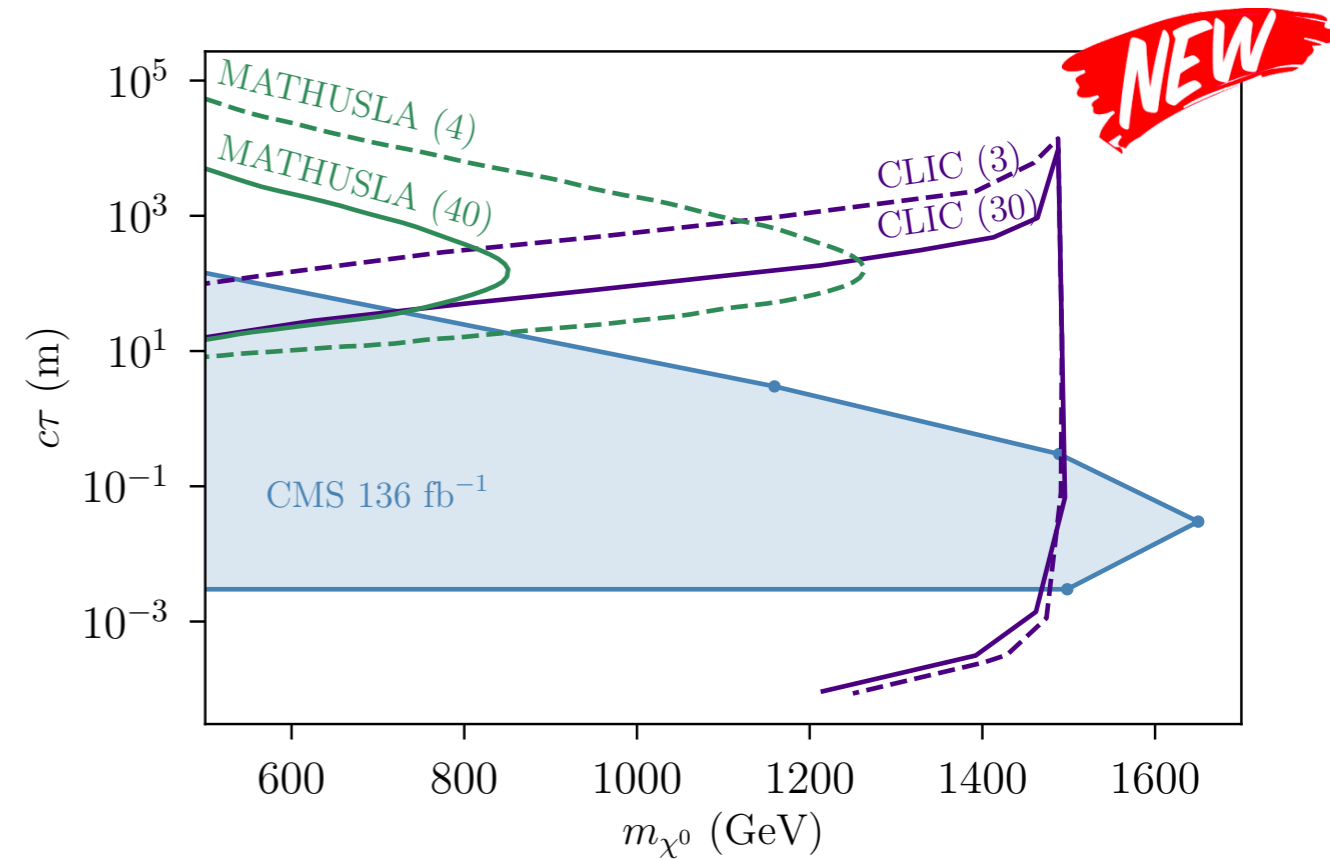
Heavy LLPs

1 colored & 1 EW example

Glauino

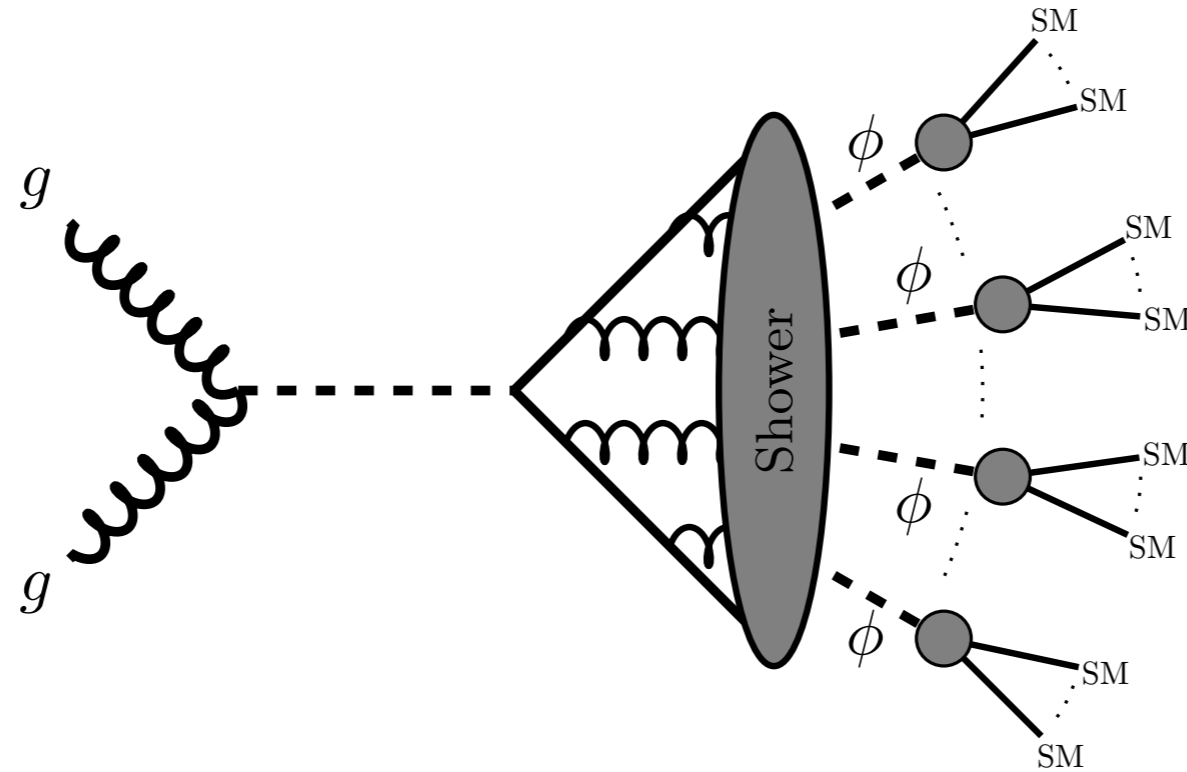


Higgsino



Dark Showers

Explain the challenges and motivation for dark showers



(Very brief, two paragraphs)

Conclusion

You can find the draft of the full BSM report here

https://snowmass21.org/energy/start#final_reports

We welcome suggestions, comments etc. Please bare in mind that we only have ~ 12 pages, an exhaustive summary is impossible.

You can leave your comments in the shared document linked on the webpage. Please identify yourself, so that we can get in touch if we have questions.

Feedback ideally before Seattle meeting (Mid July)

