DPF 2015

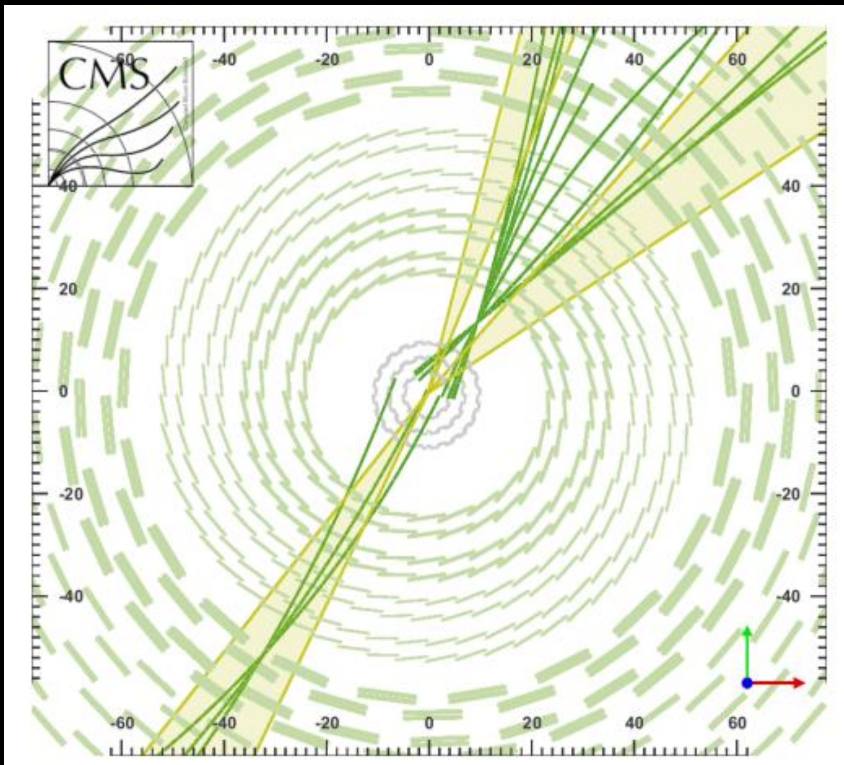
Long-Lived Superparticles with Hadronic Decays at the LHC

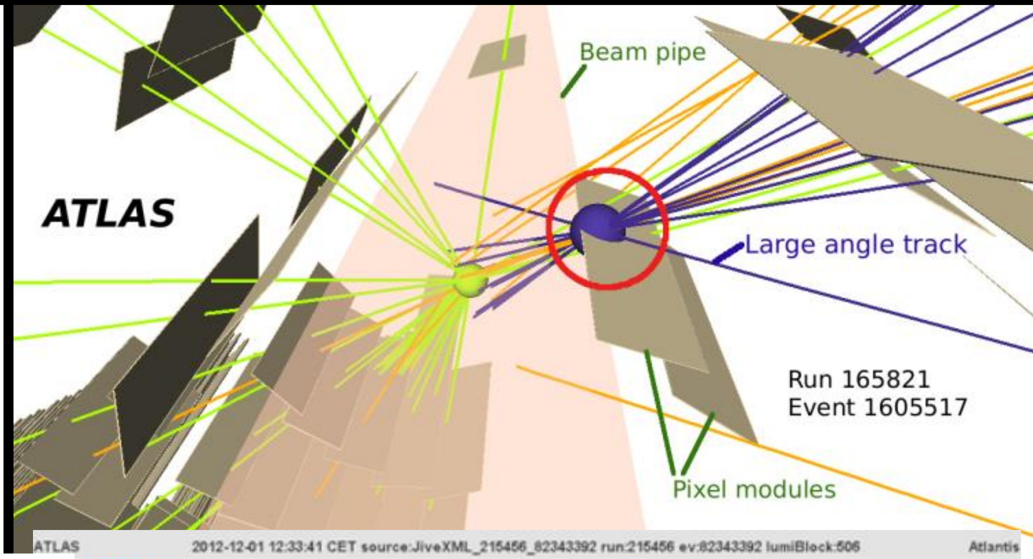
Zhen Liu

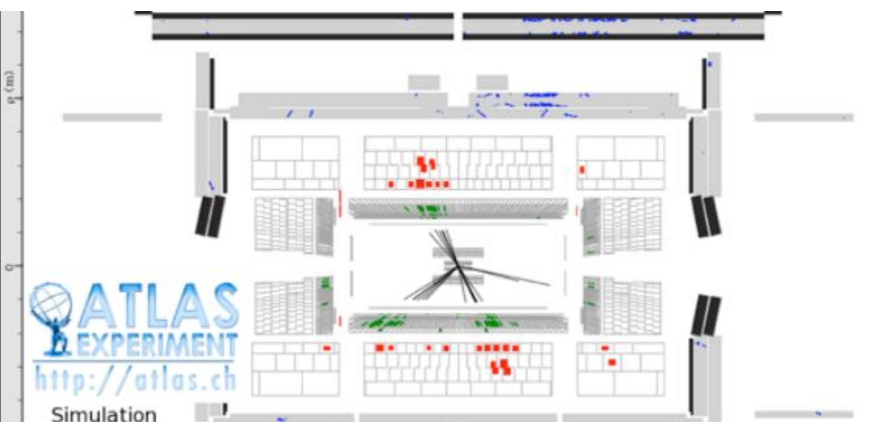
PITT-PACC, University of Pittsburgh
Fermi National Accelerator Laboratory

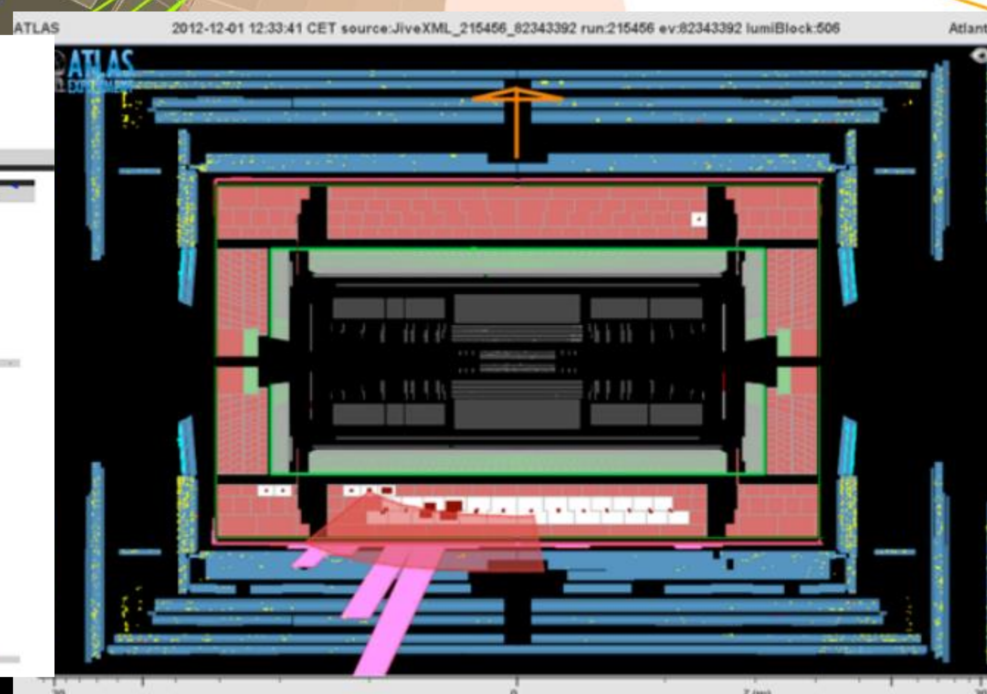
Talk based on work with B. Tweedie, arxiv:1503.05923

THINKING OUTSIDE THE BEAMPIPE









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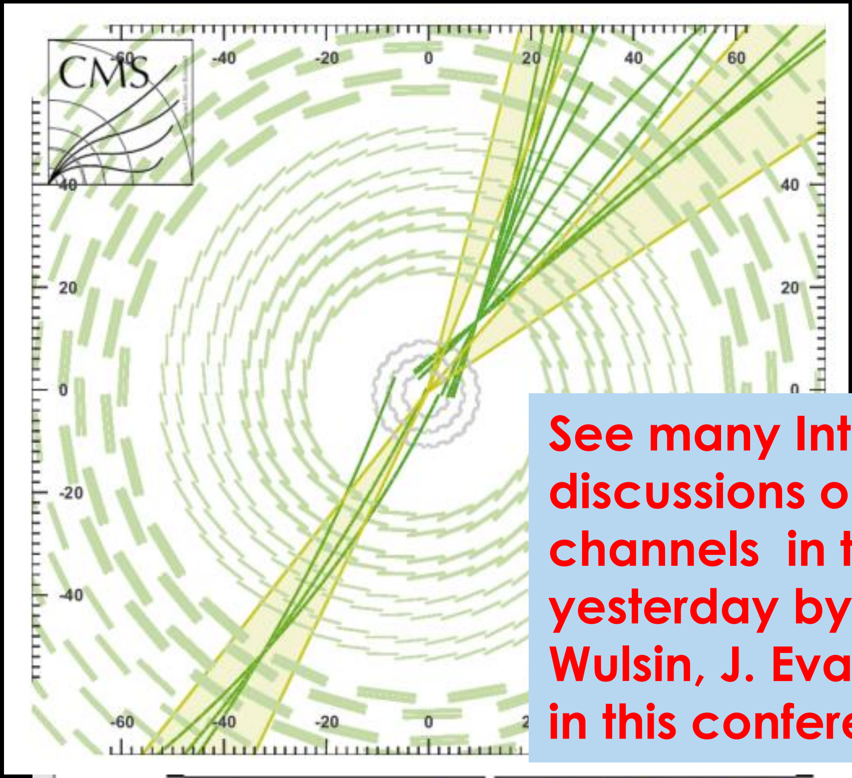
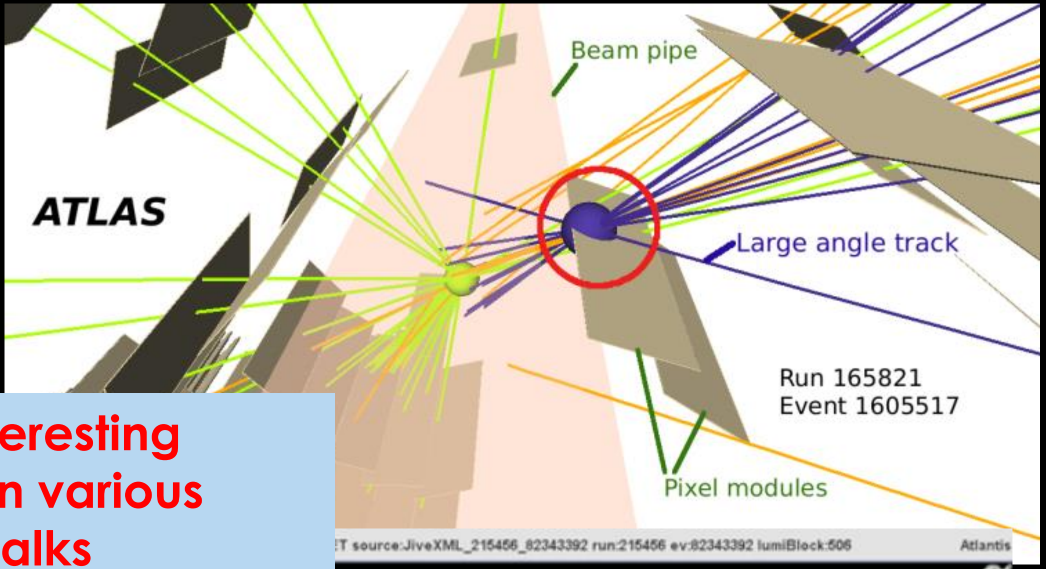
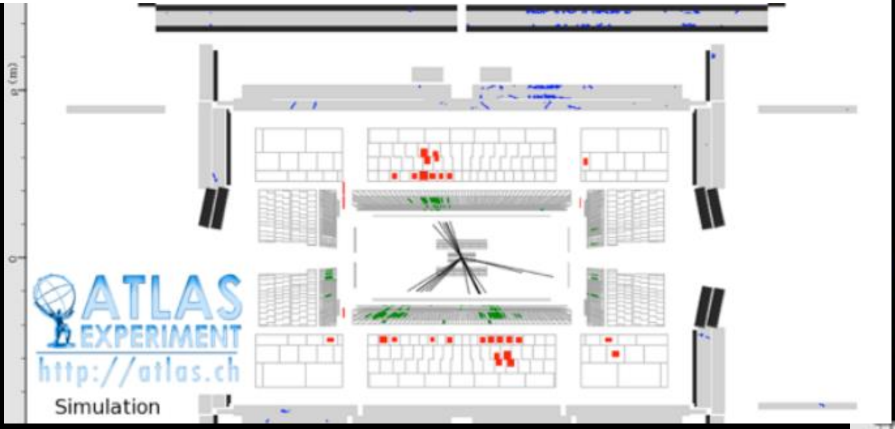
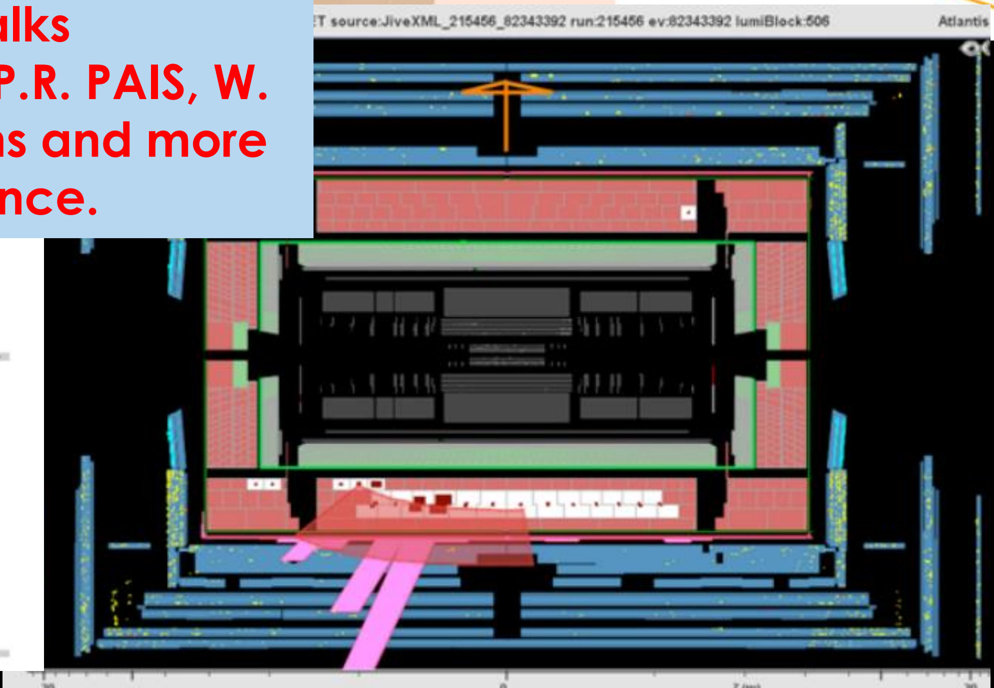




See many Interesting discussions on various channels in talks yesterday by P.R. PAIS, W. Wulsin, J. Evans and more in this conference.





OBJECT

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Space of All Models

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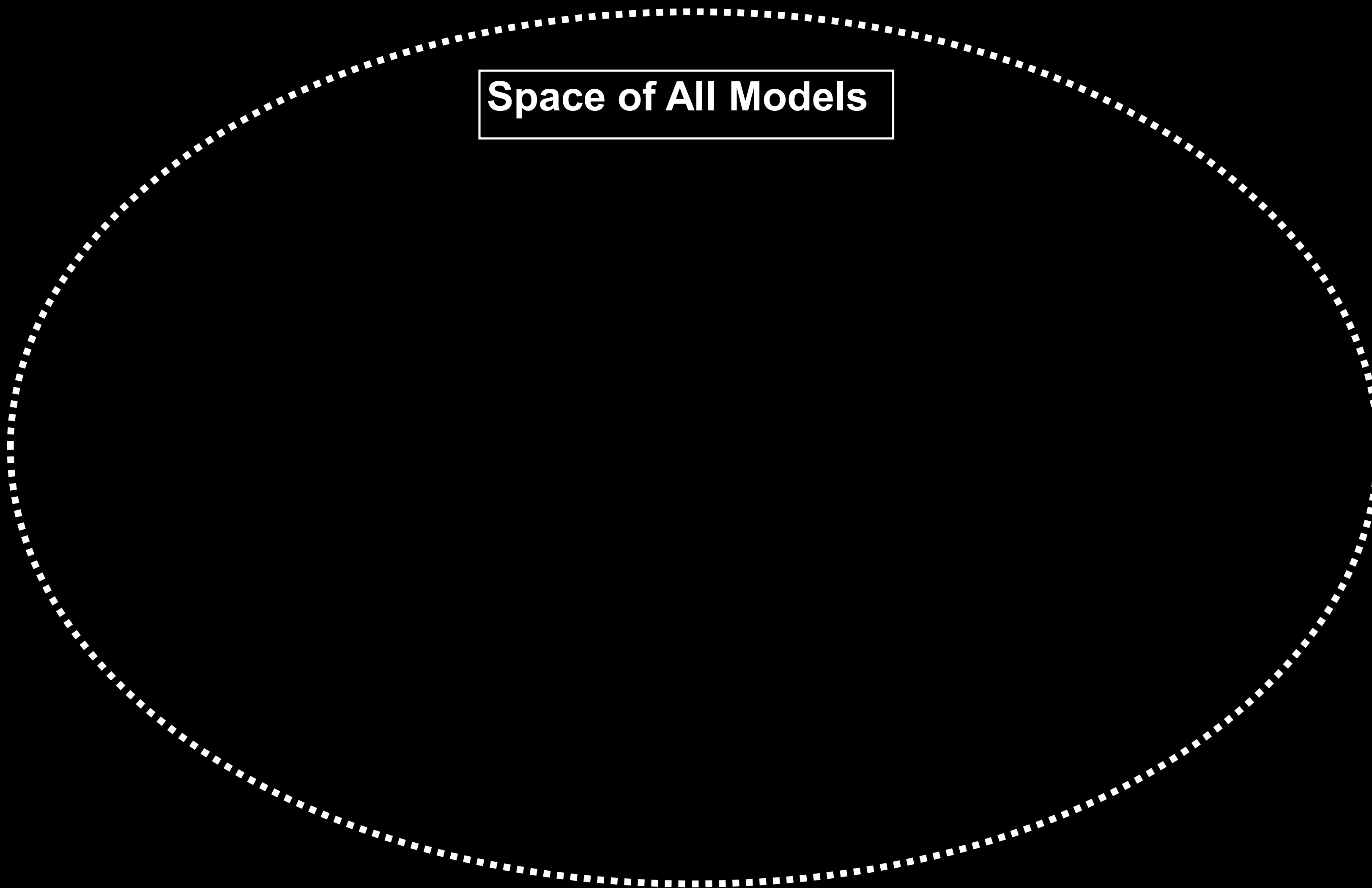

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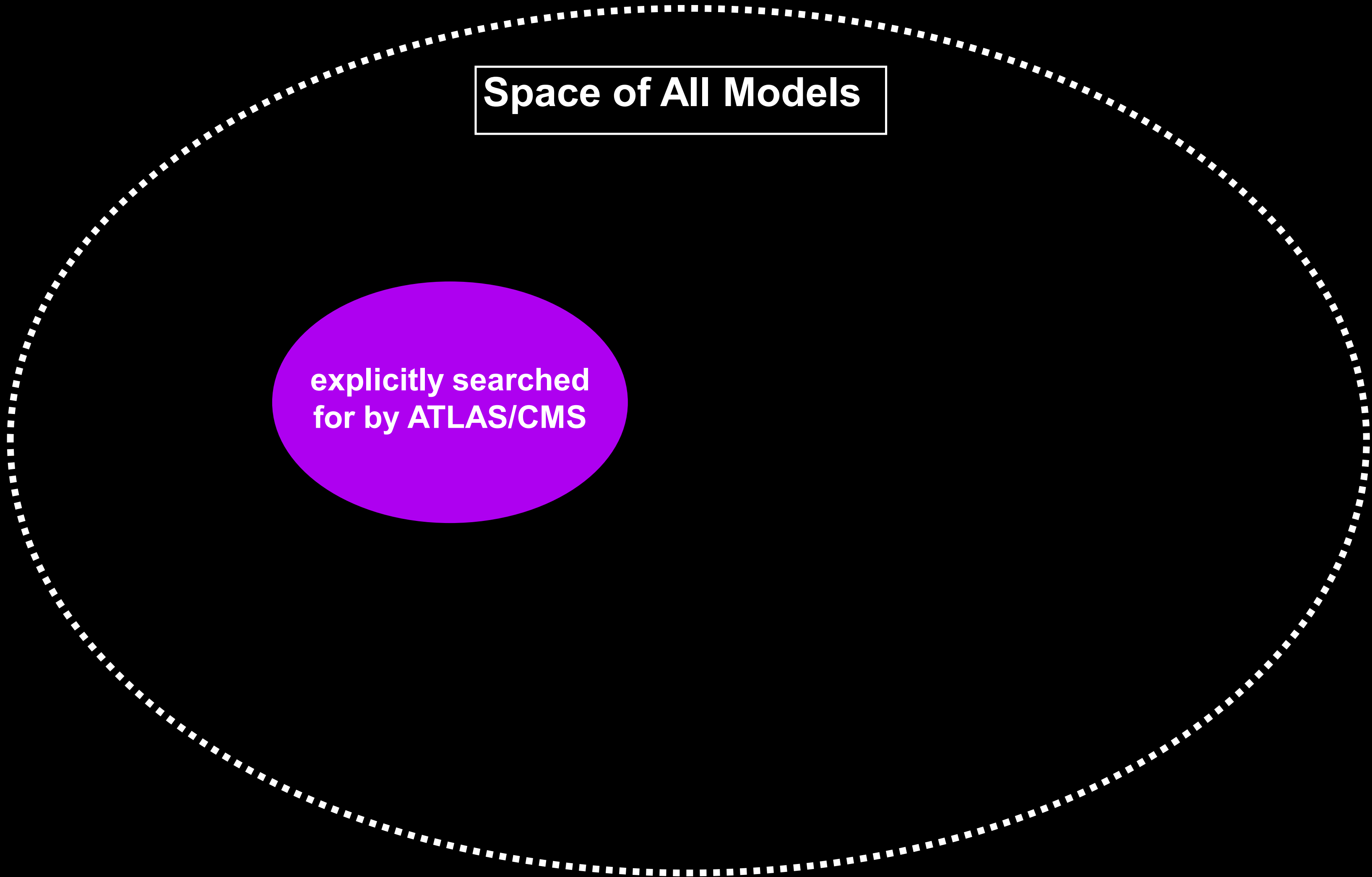

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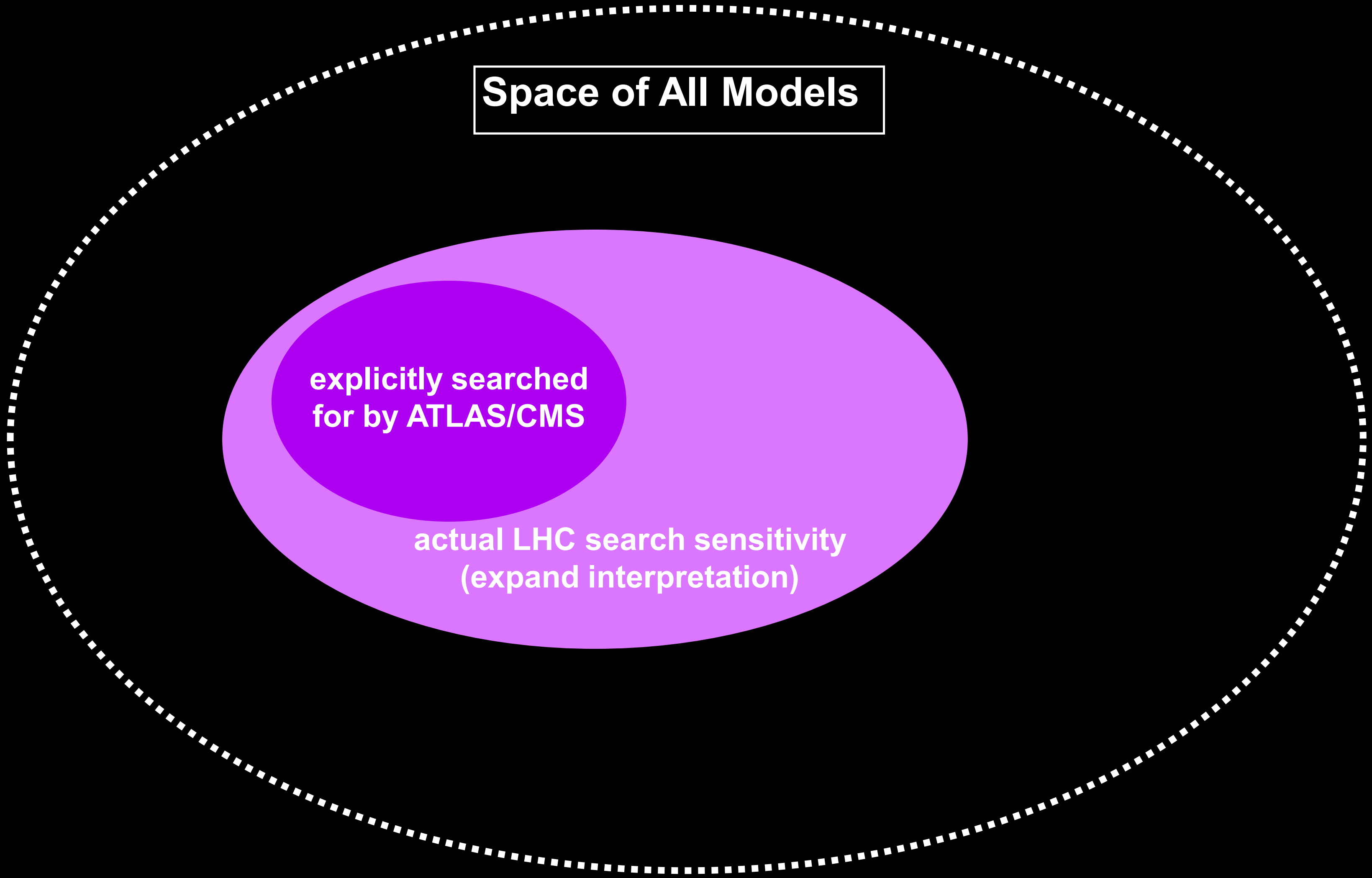
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explicitly searched
for by ATLAS/CMS
actual LHC search sensitivity
(expand interpretation)

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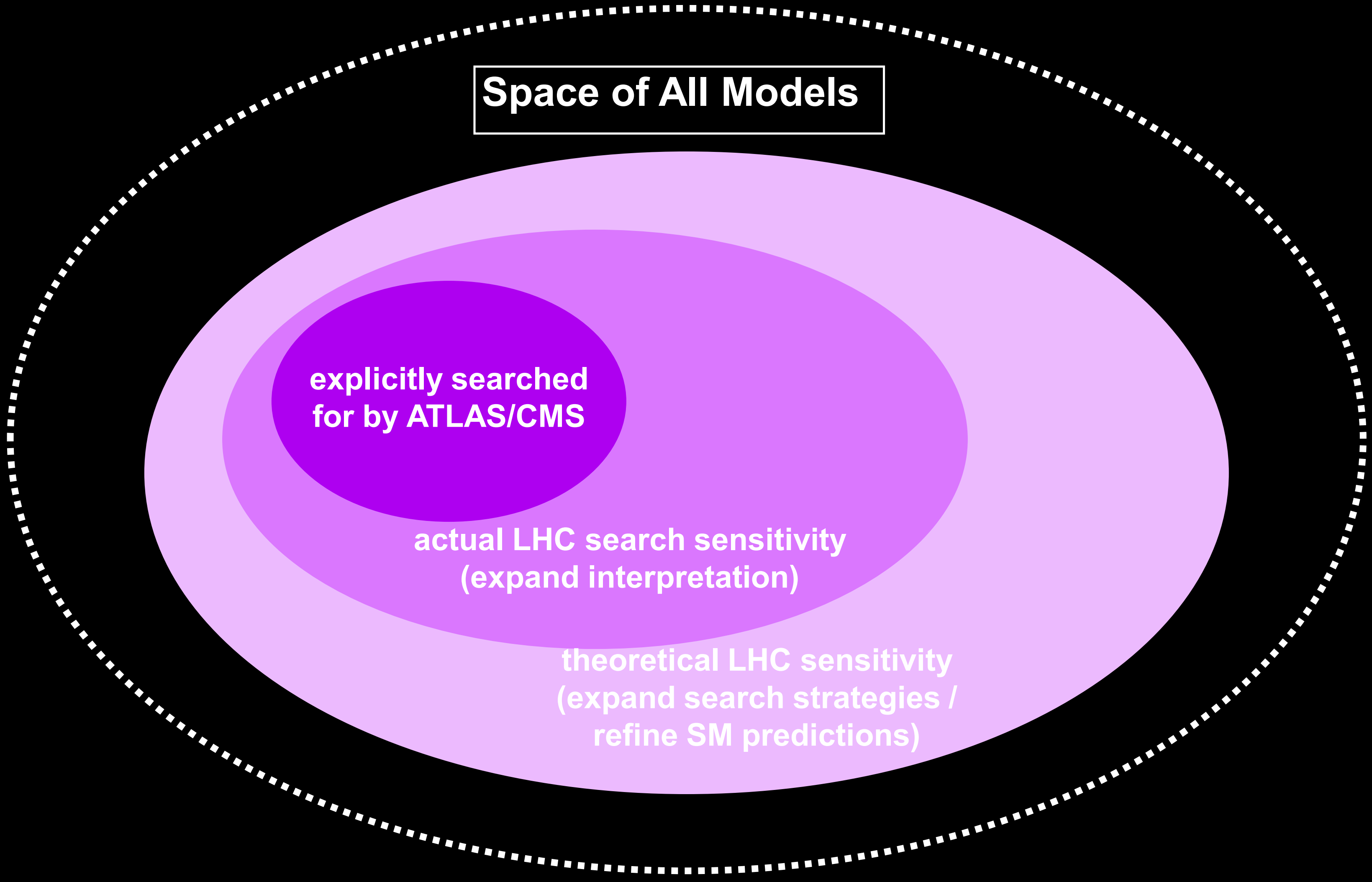
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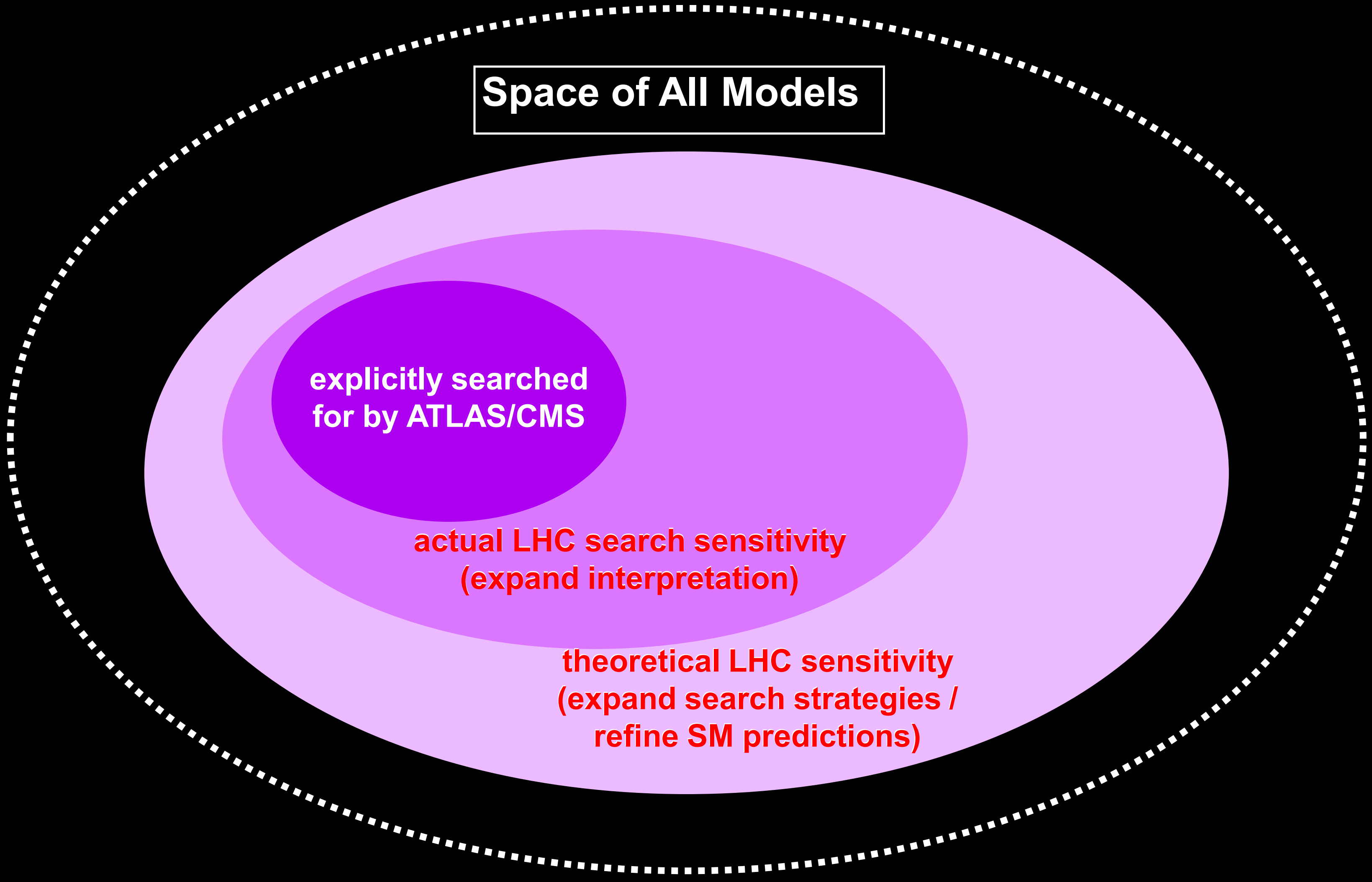
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OVERVIEW OF OUR STUDY

Applied to all models

- CMS displaced dijets (tracker)
- ATLAS low-EM jets (HCAL)
- ATLAS muon spectrometer vertices*
- CMS charged stable particles

Applied to models with leptonic decays

- CMS displaced dileptons
- CMS displaced electron & muon
- ATLAS displaced muon + tracks

* 7 TeV, 2 fb^{-1}

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Hadronic R-parity violation

- $\tilde{t} \to \bar{d}_i \bar{d}_j$ via baryonic RPV including $\tilde{t} \to \bar{b}\bar{b}$
- $\tilde{g} \to u_i d_j d_k$ via baryonic RPV
- $\tilde{H} \to u_i d_j d_k$ (+soft) via baryonic RPV

gauge mediation

- $\tilde{q} \to q\,\tilde{G}$ in GMSB
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Our selection of signals covers a large range of displace decay topologies, including 1j+MET, 2j+MET, 3j+MET, 2j, 3j, as well as heavy flavors, making it easy for theoretists to estimate exclusions for their own models in concern.

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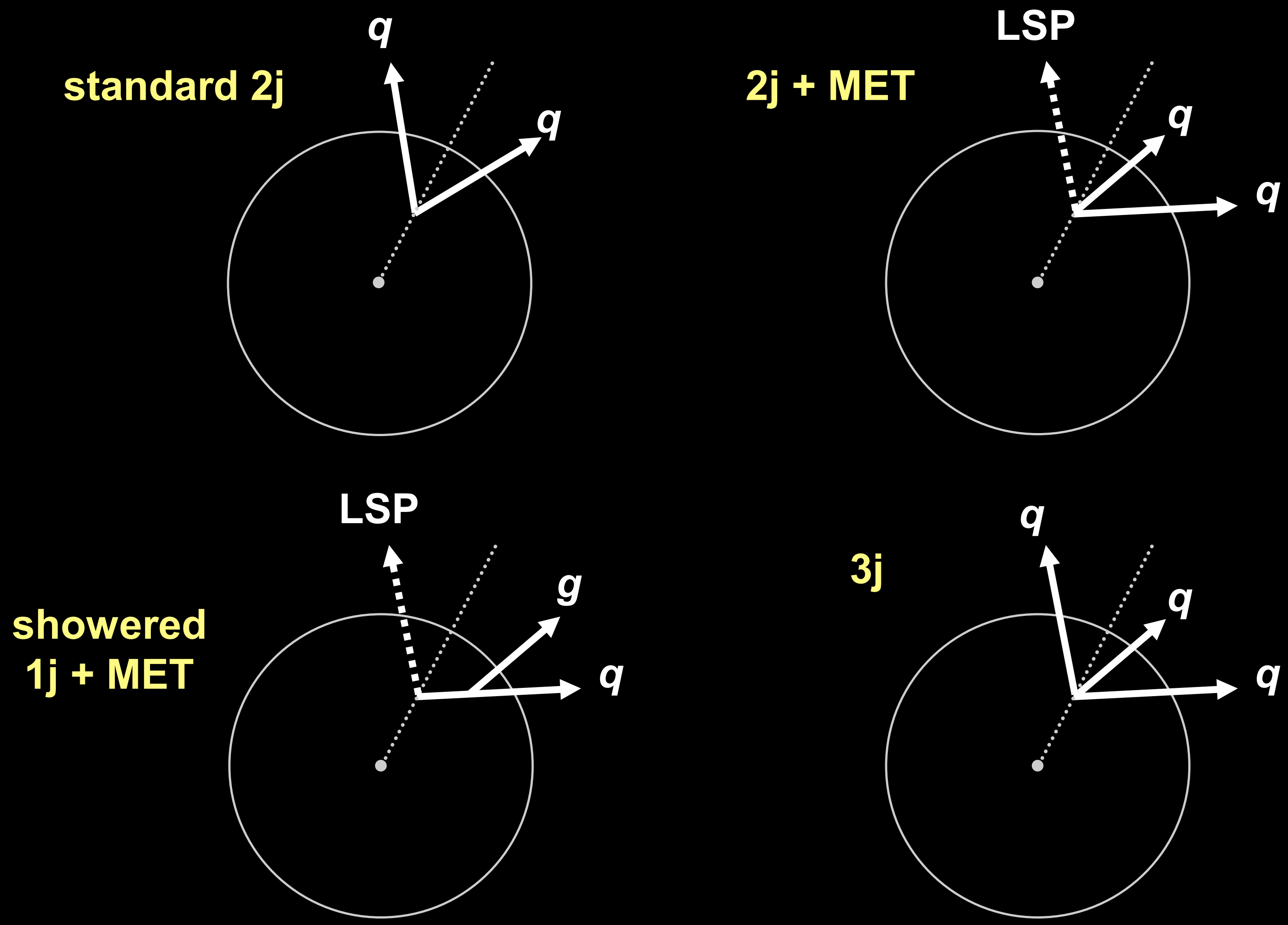
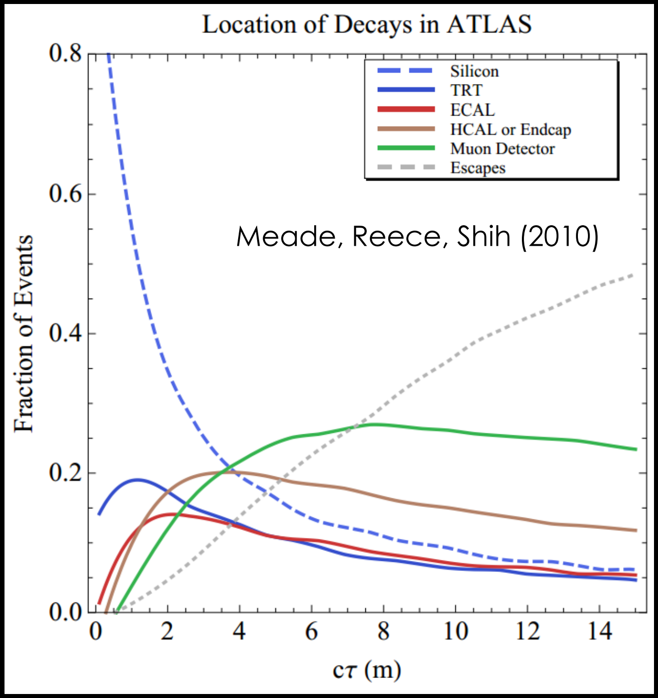
A EXAMPLE OF DISPLACED DIJET



A TYPICAL EFFICIENCY MAP



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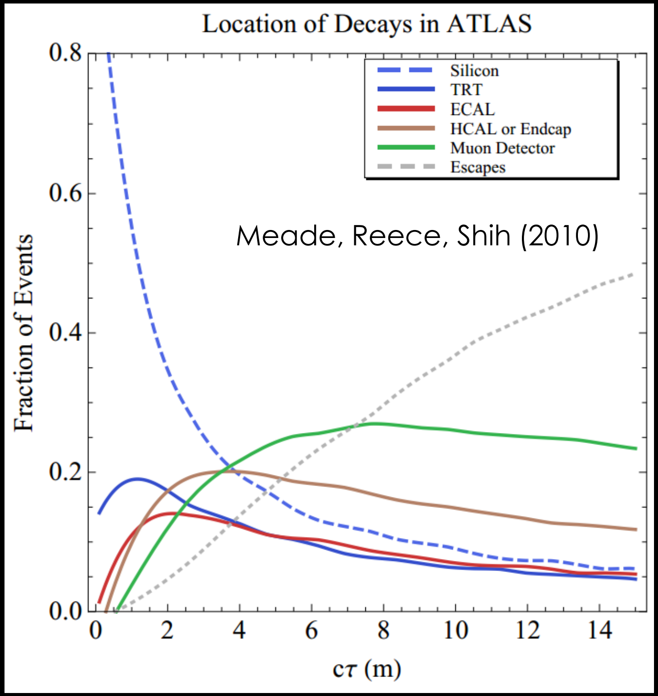

Depend on lifetime, how is the particle being produced (How Lorentz factor distributes), the decay distributes shape differently at different layers of the detector.

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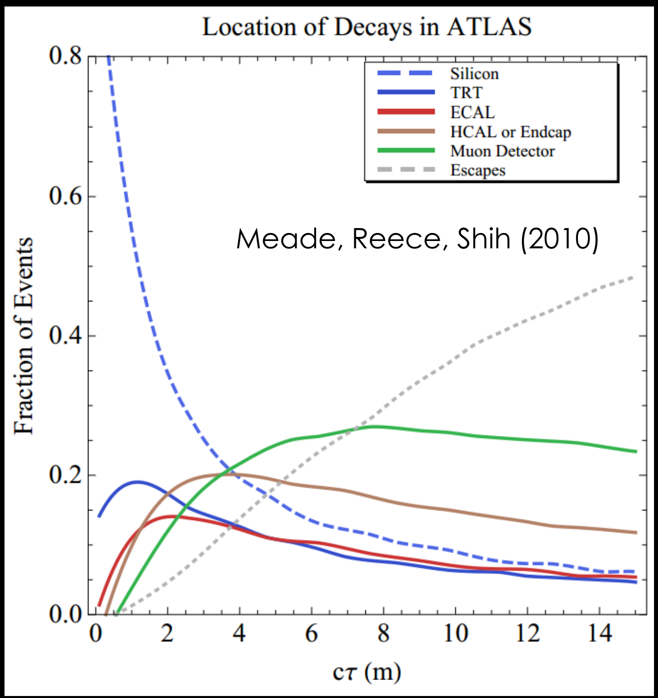

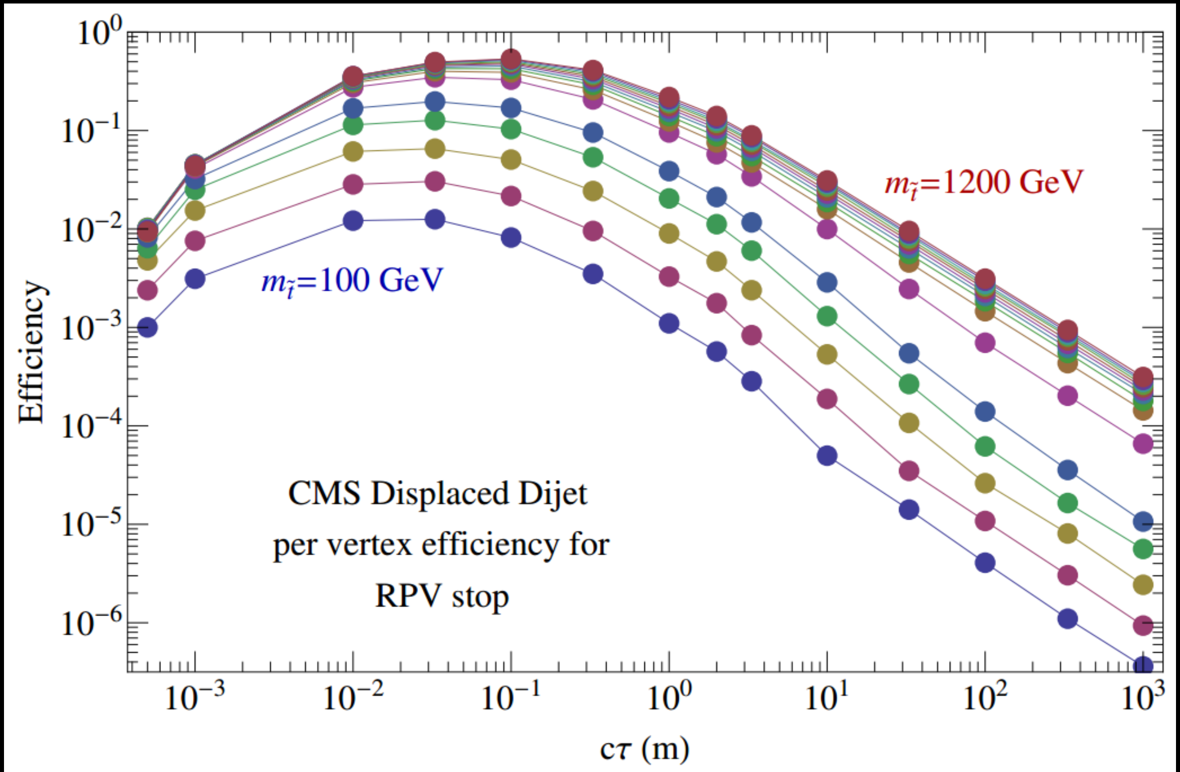

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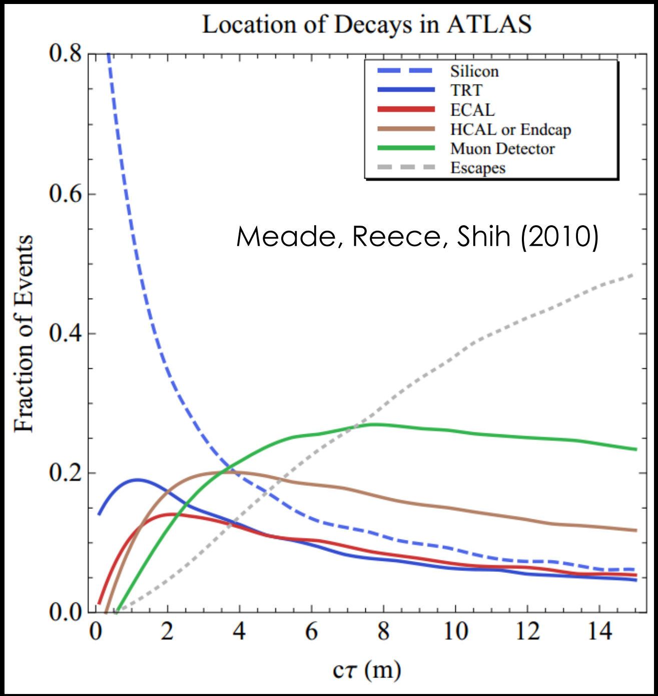

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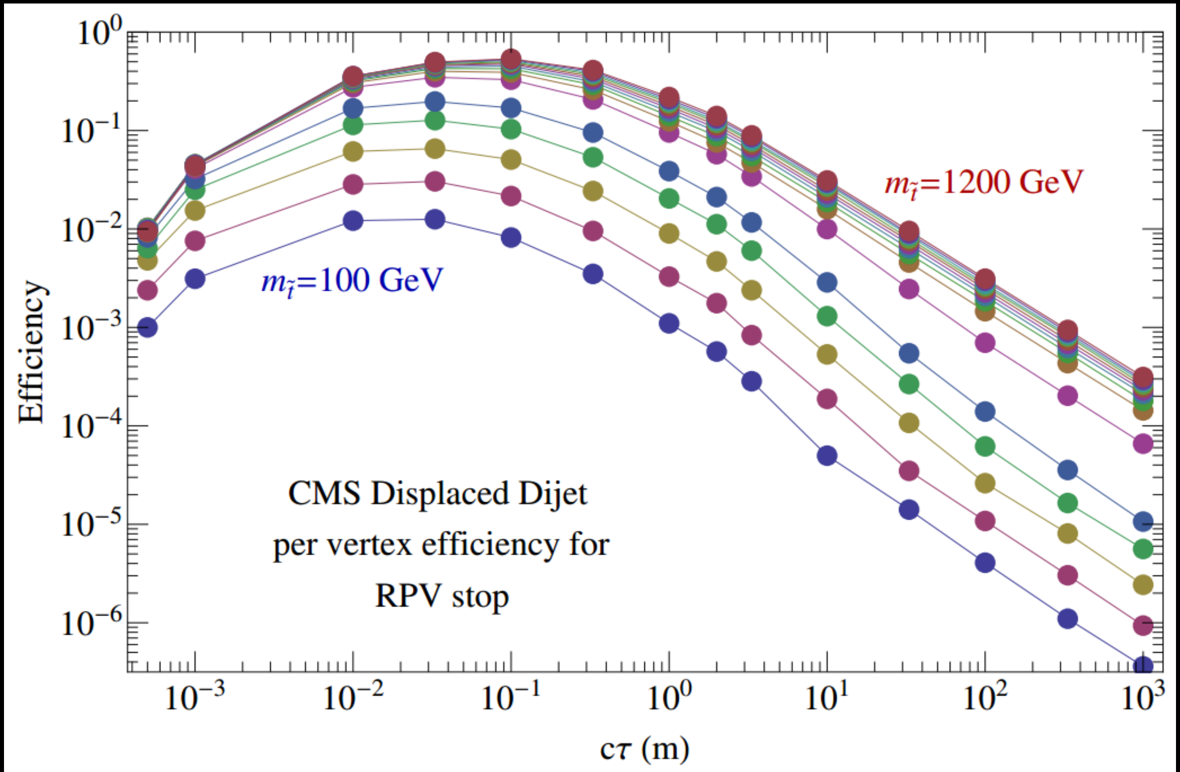

Efficiency map for RPV stop decays into light jet pairs in the CMS displaced dijet analysis.

- Lines at increase of 100 GeV
- Low mass suffers more for cuts on jet energy
- High mass approaches constant efficiency shape
- Low efficiency at low lifetime (cut to remove SM)
- (Shift in peak due to Lorentz Factor)

EXAMPLE 1: GMSB STOP

With detailed simulation and our own modeling of the displacement, after carefully calibrating with existing searches, we can derive the limits from many search of our simplified models.

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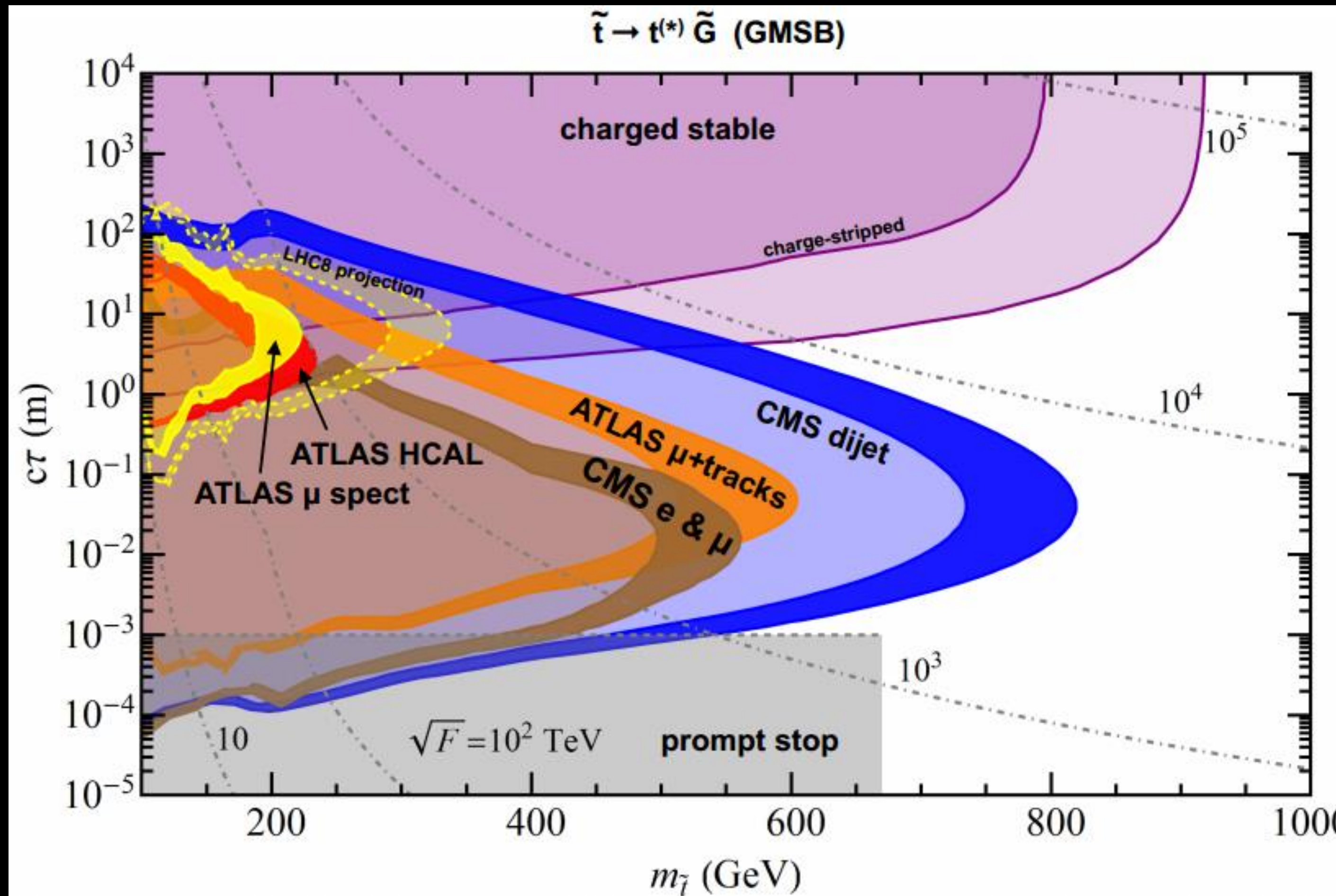

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GMSB Stop → Top$^{(*)}$ + Gravitino

- Displaced searches (dijet, μ+tracks, $e + \mu$, HCAL, μ spectrometer) covers mid-lifetime Heavy charges
- stable particle searches (pink; CHAMP) covers long lifetime
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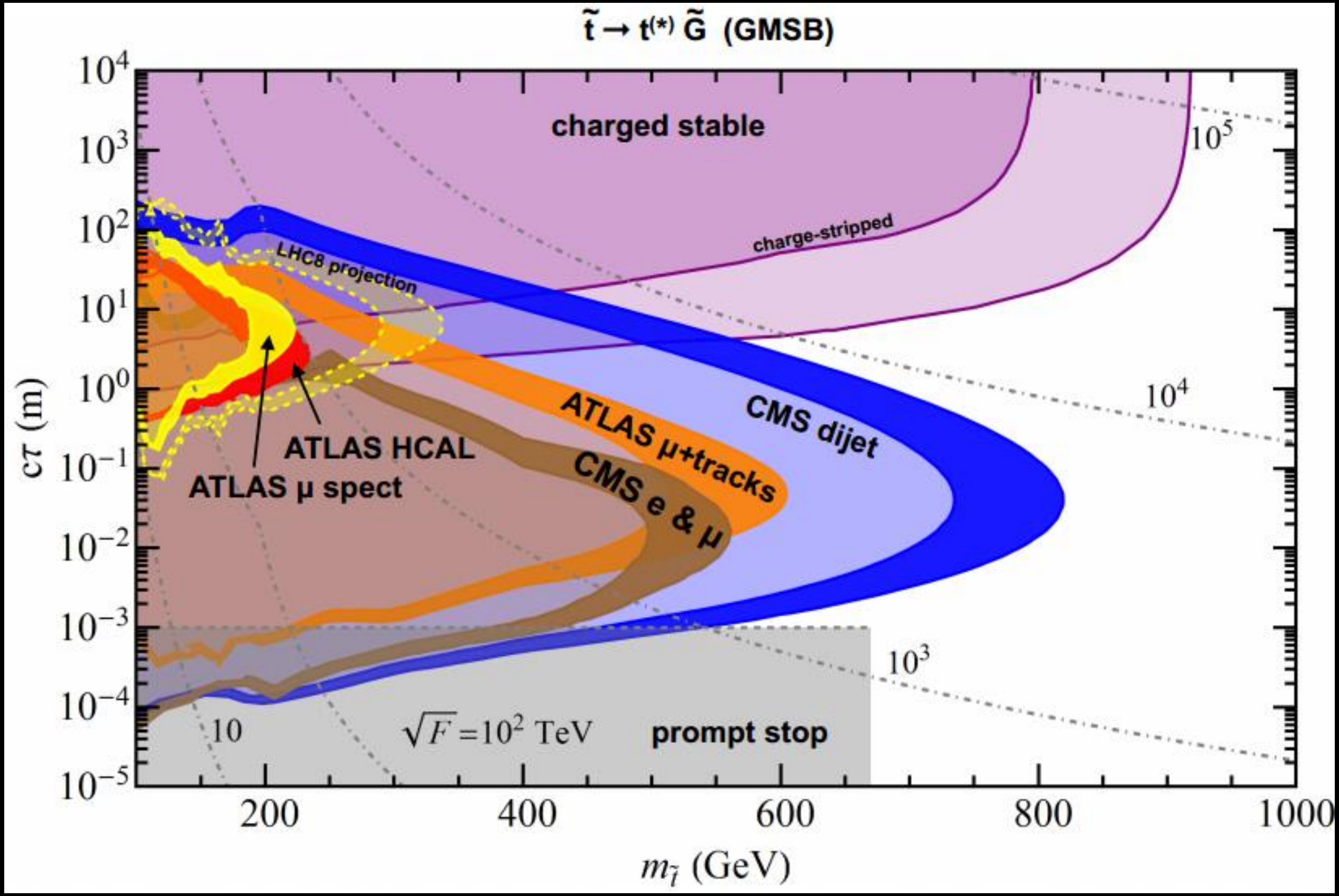

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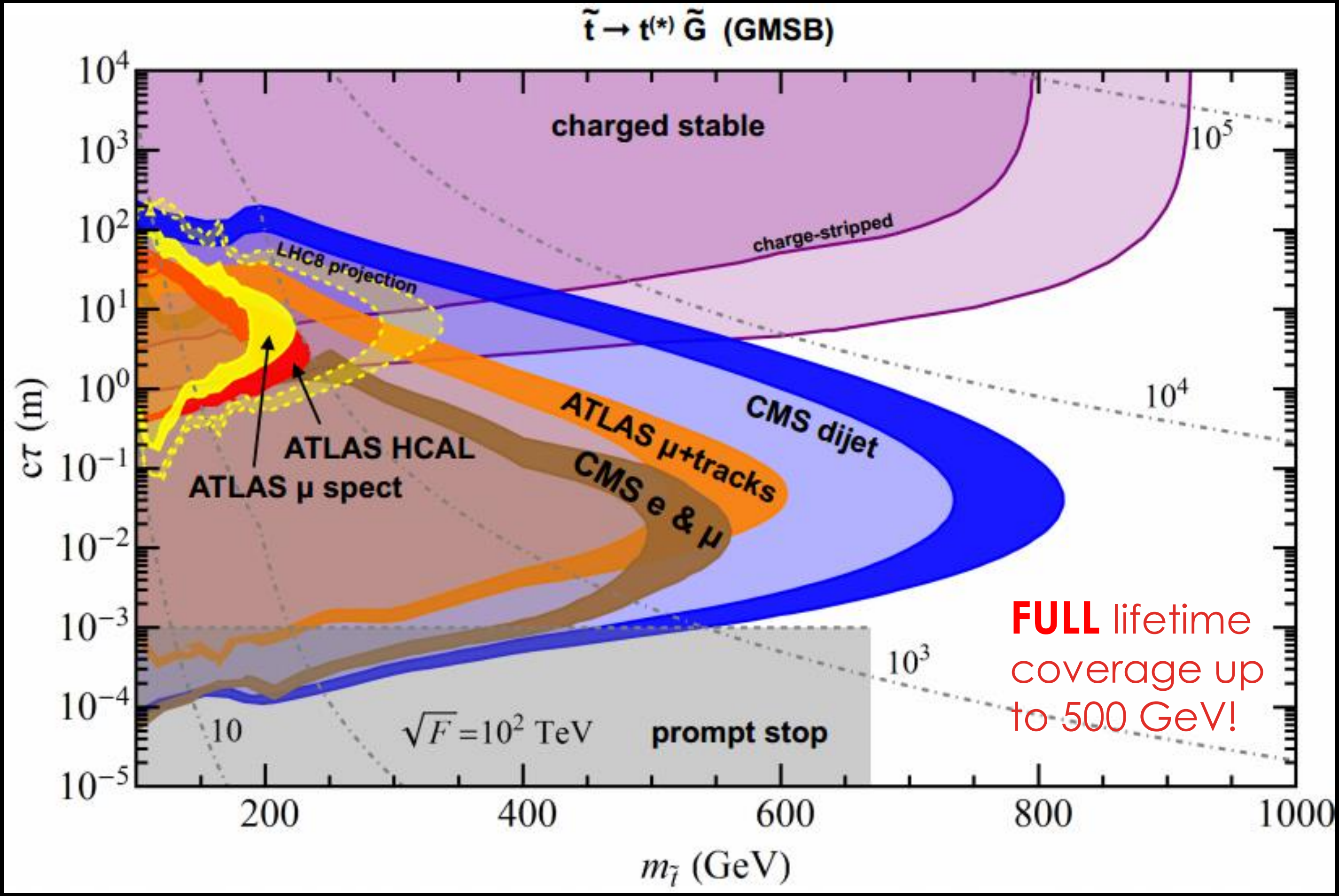

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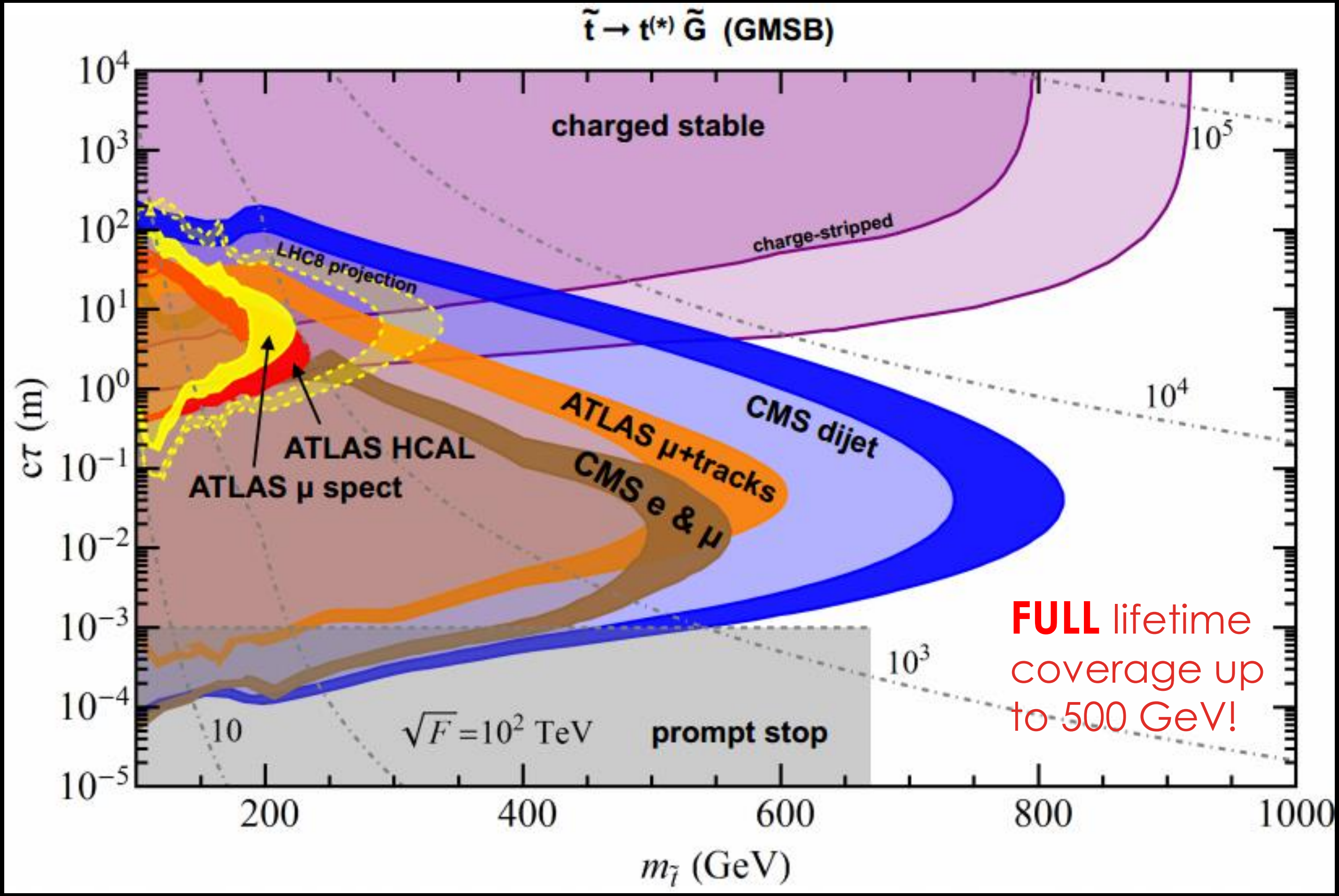

Dijet search has very good sensitivity reach, lepton plus tracks searches also sensitive to leptonic top- and b-decays. HCAL and muon spectromeater searches sensitive to higher lifetimes but so far suffers large efficiency cost. Optimization may provide additional information, e.g., heavy neutral displaced particles.

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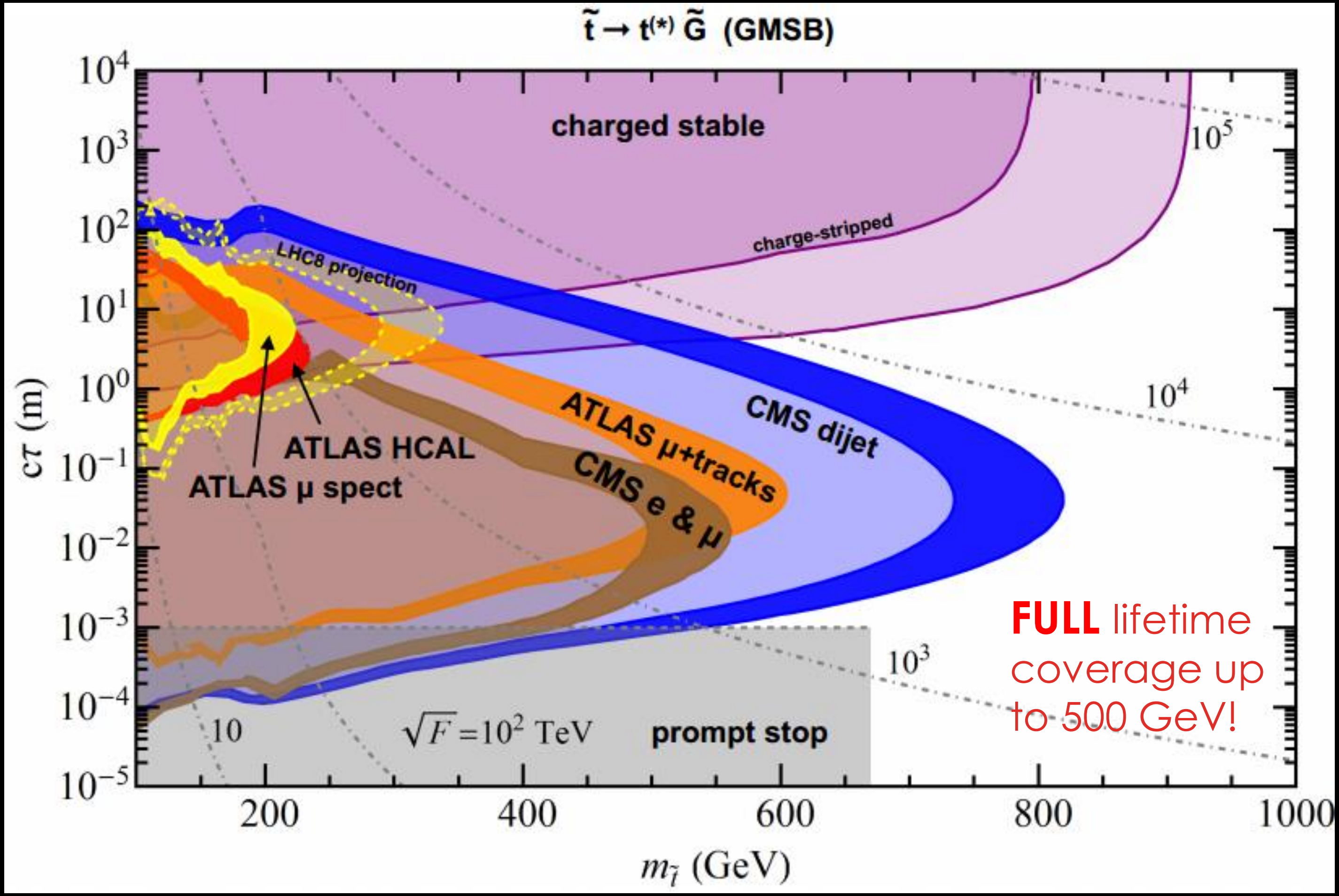

FULL lifetime coverage up to 500 GeV!

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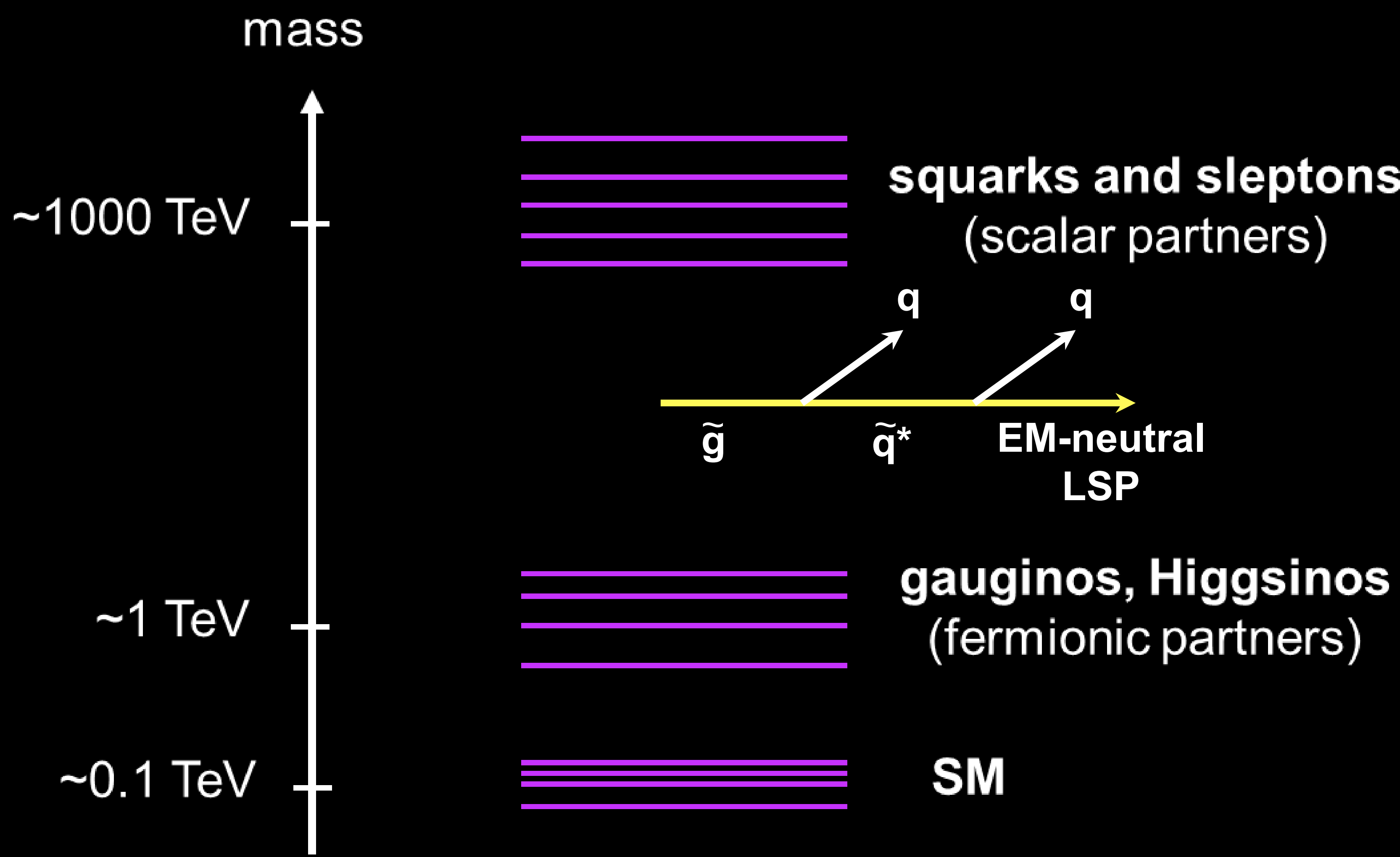

Arkani-Hamed & Dimopoulos (2004)
Arvanitaki, Craig, Dimopoulos, Villadoro (2012)
Arkani-Hamed, Gupta, Kaplan, Weiner, Zorawksi (2012)

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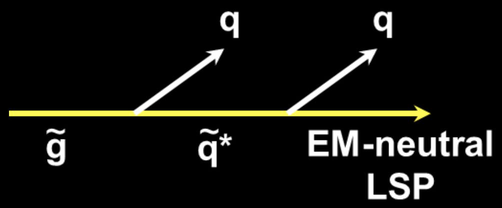

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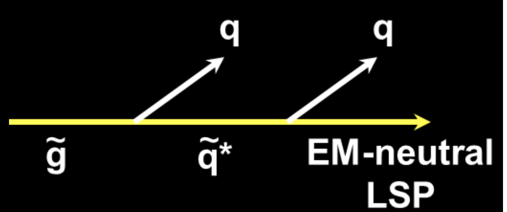

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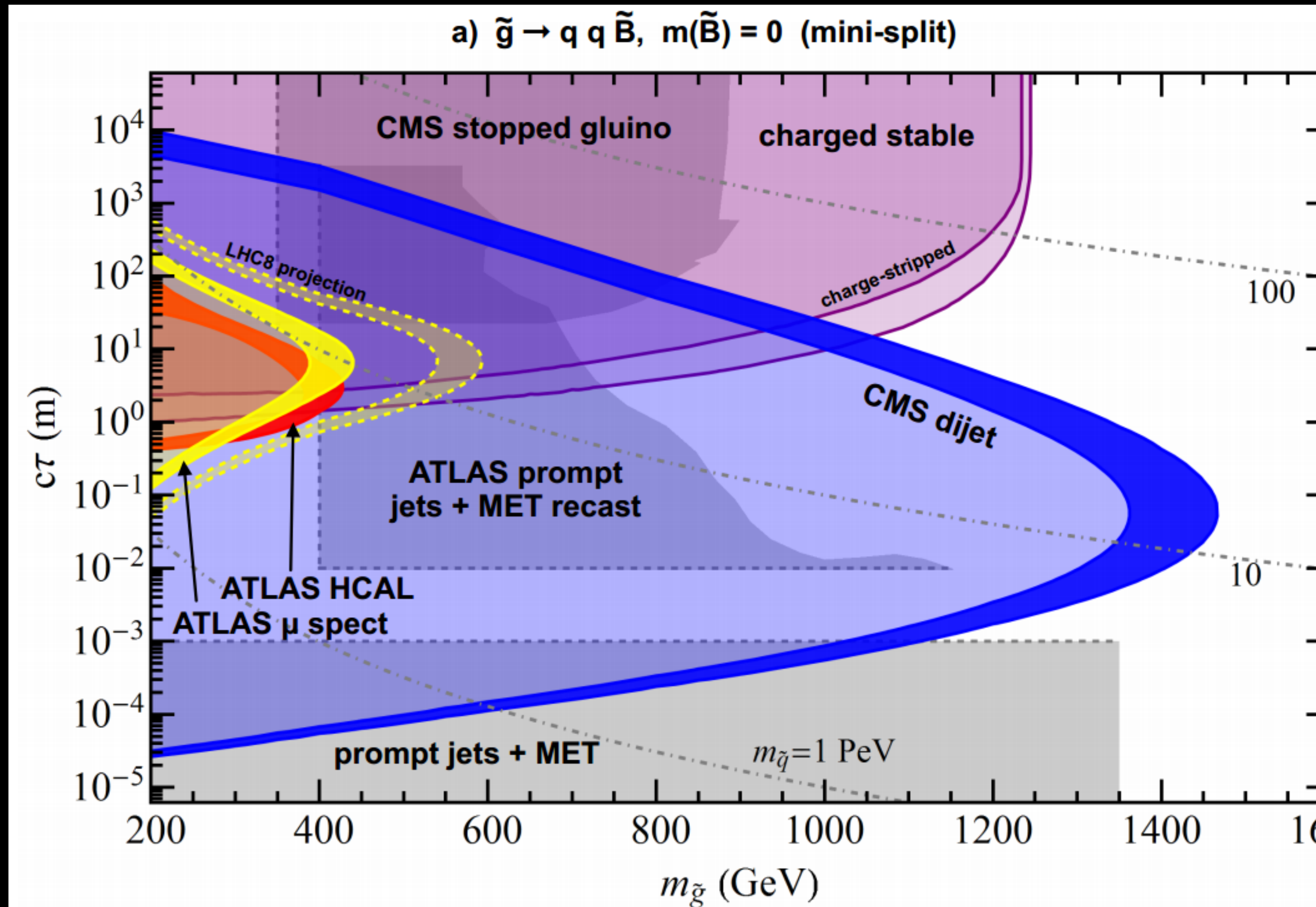

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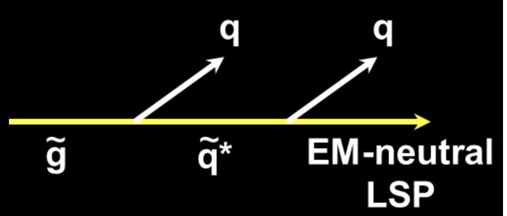

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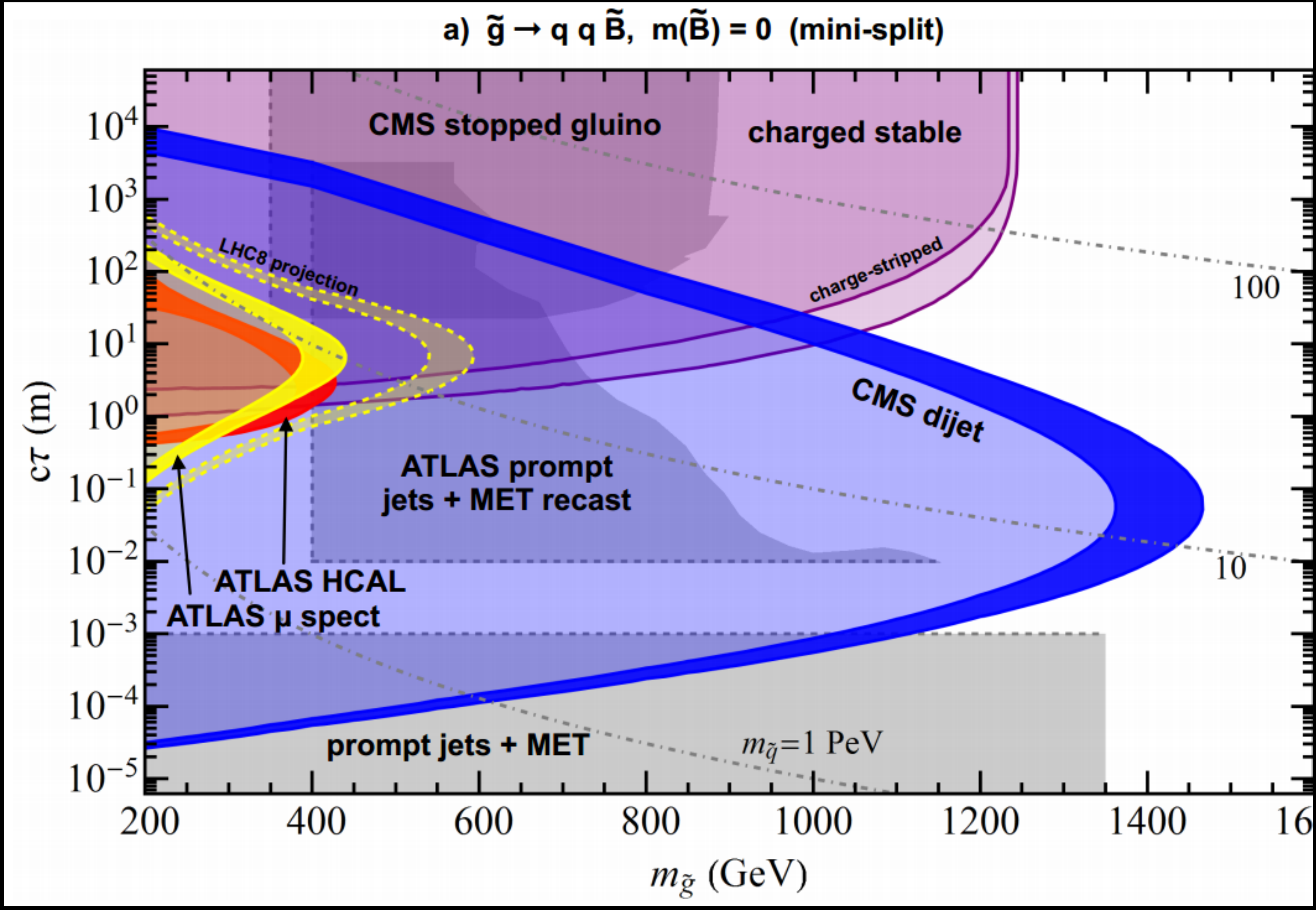

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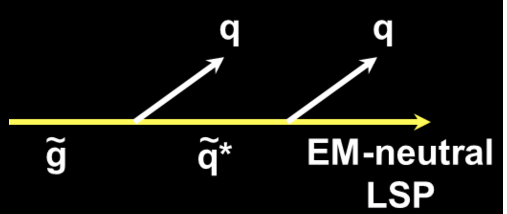

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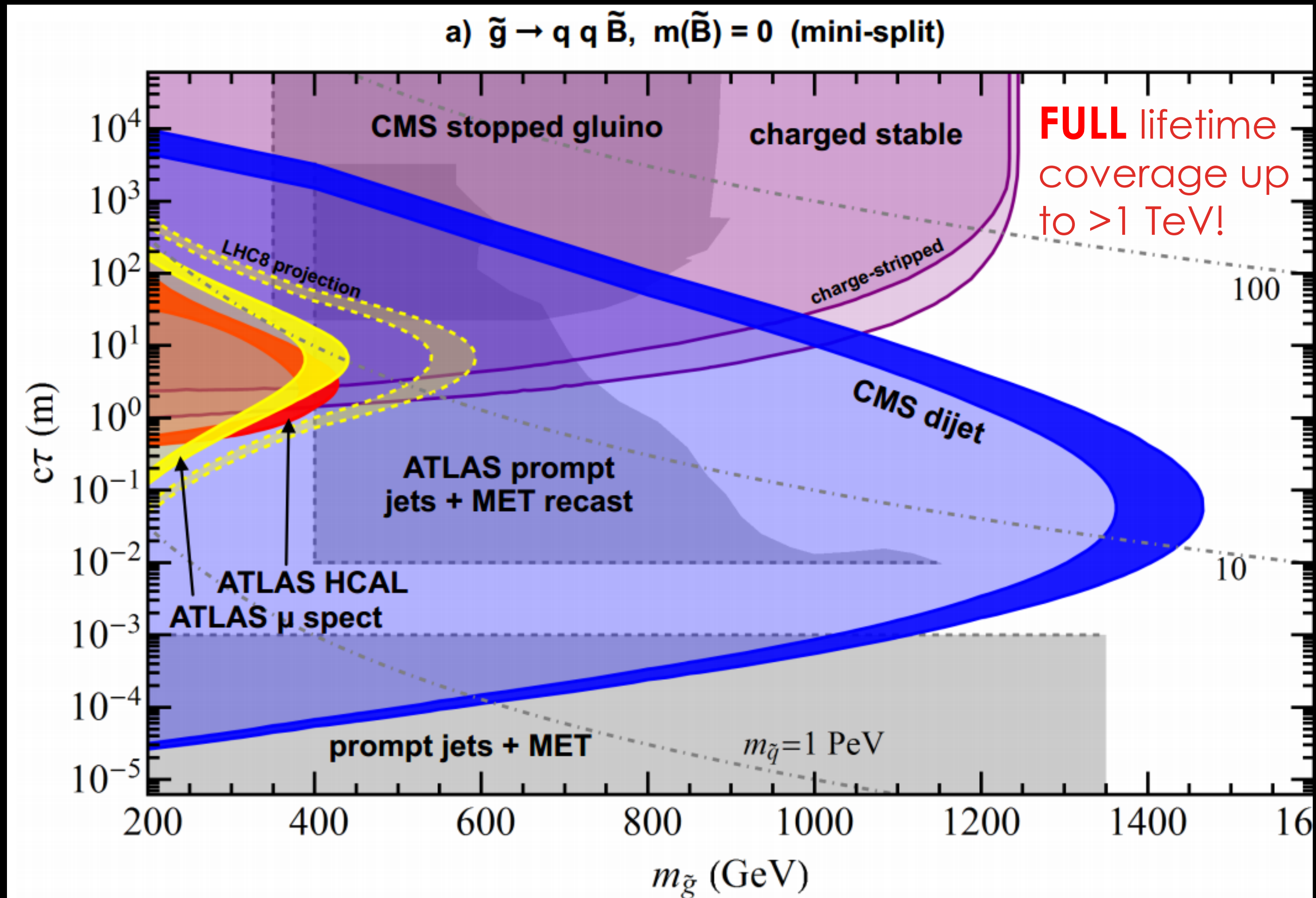

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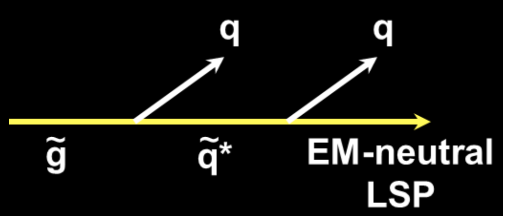

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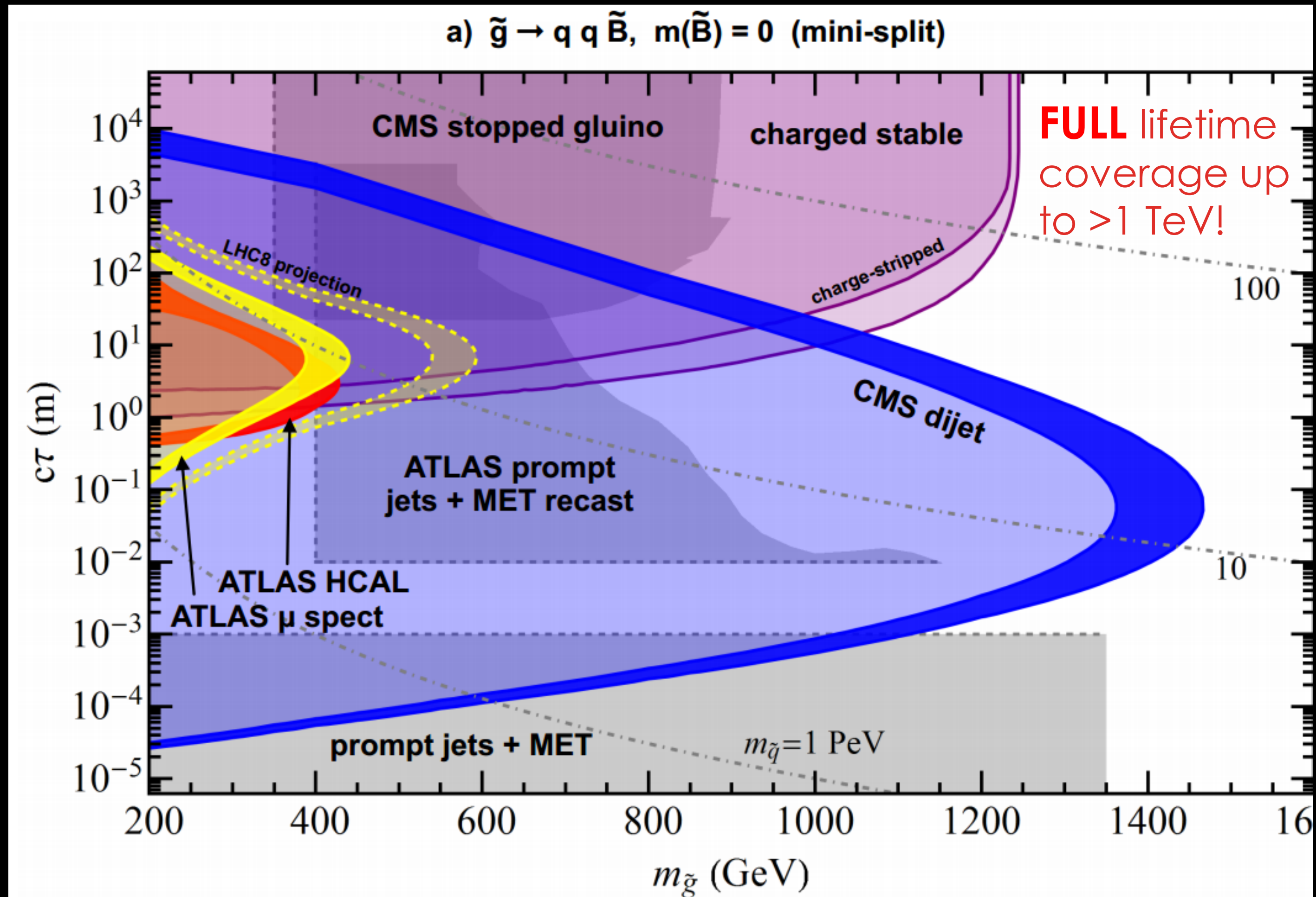

This figure shows one extreme case with large mass splitting between the LSP and NLSP. How about a bit compressed?

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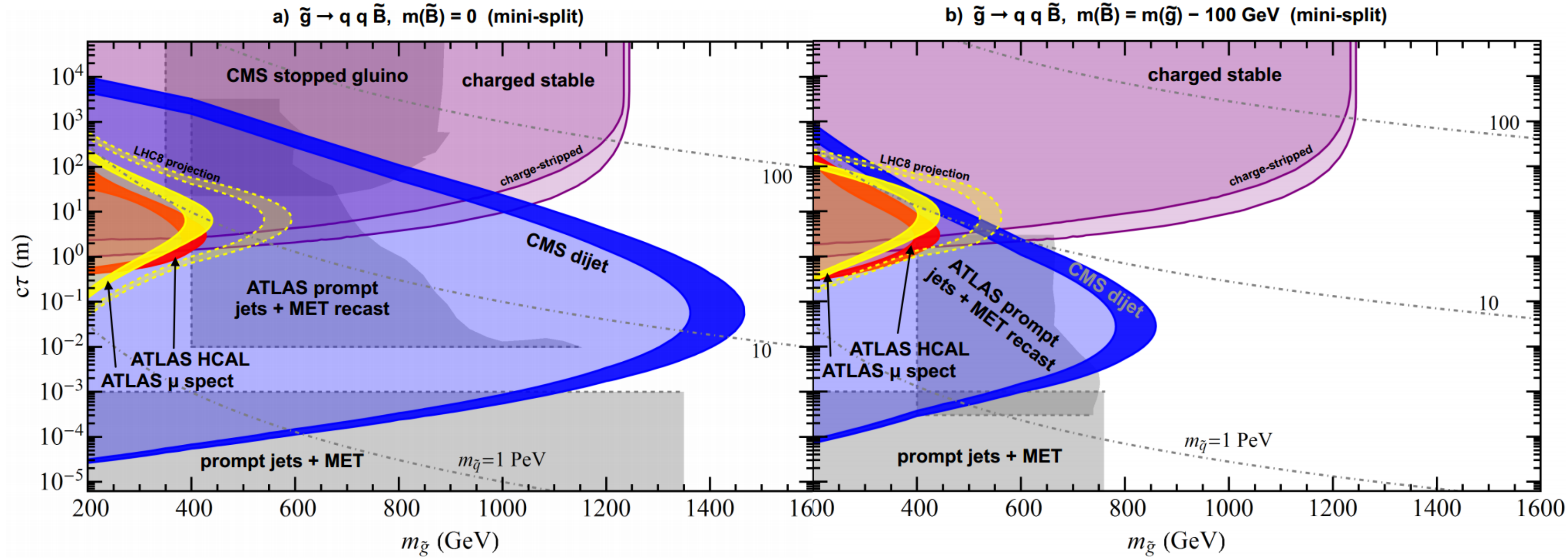

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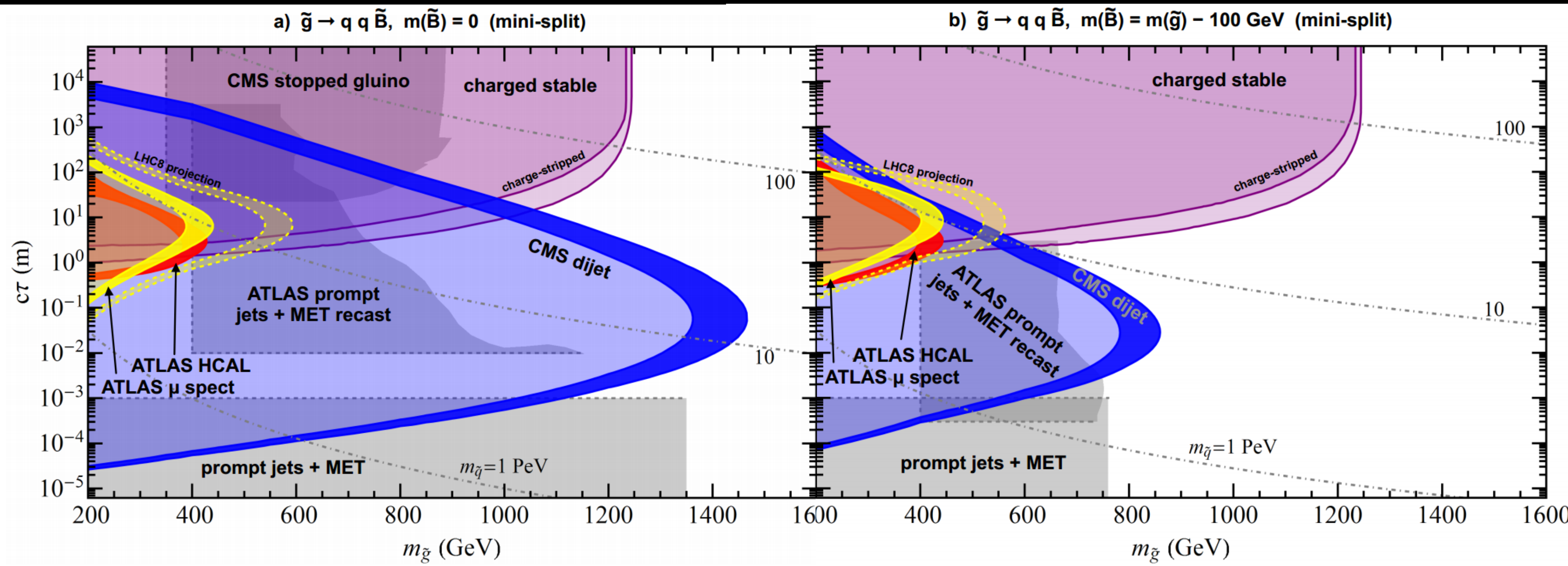

In case of compressed spectra (right panel)

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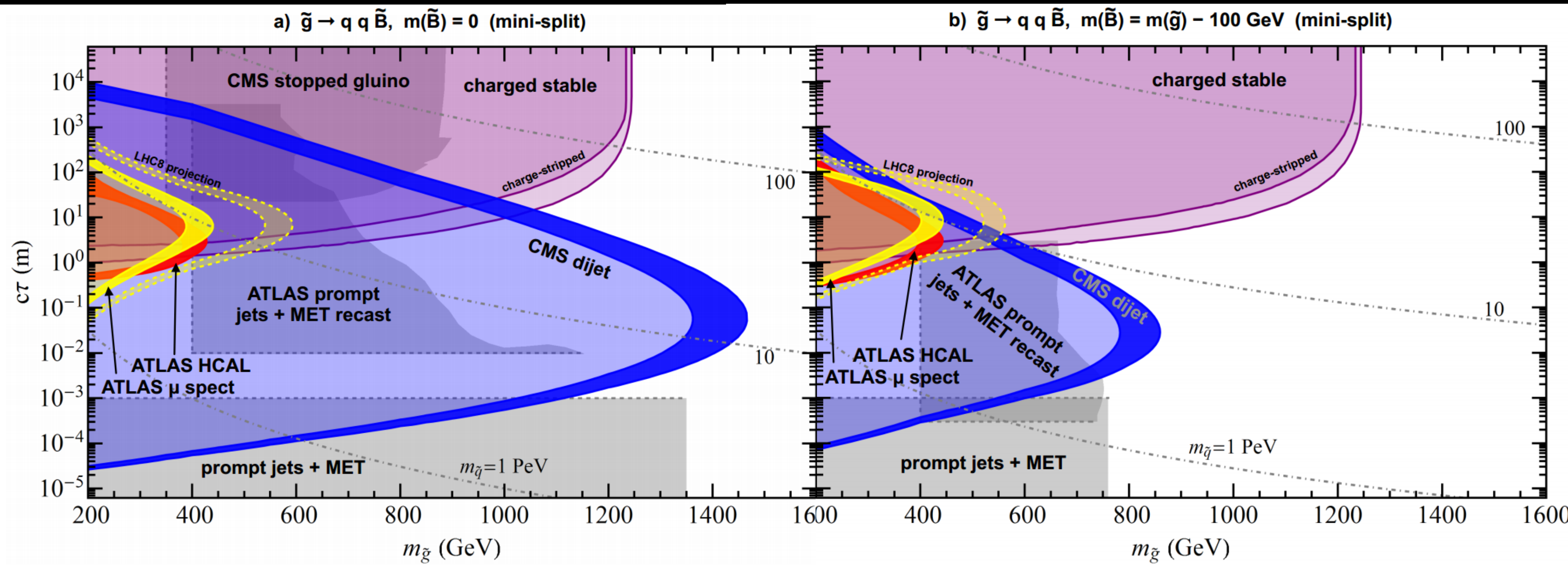

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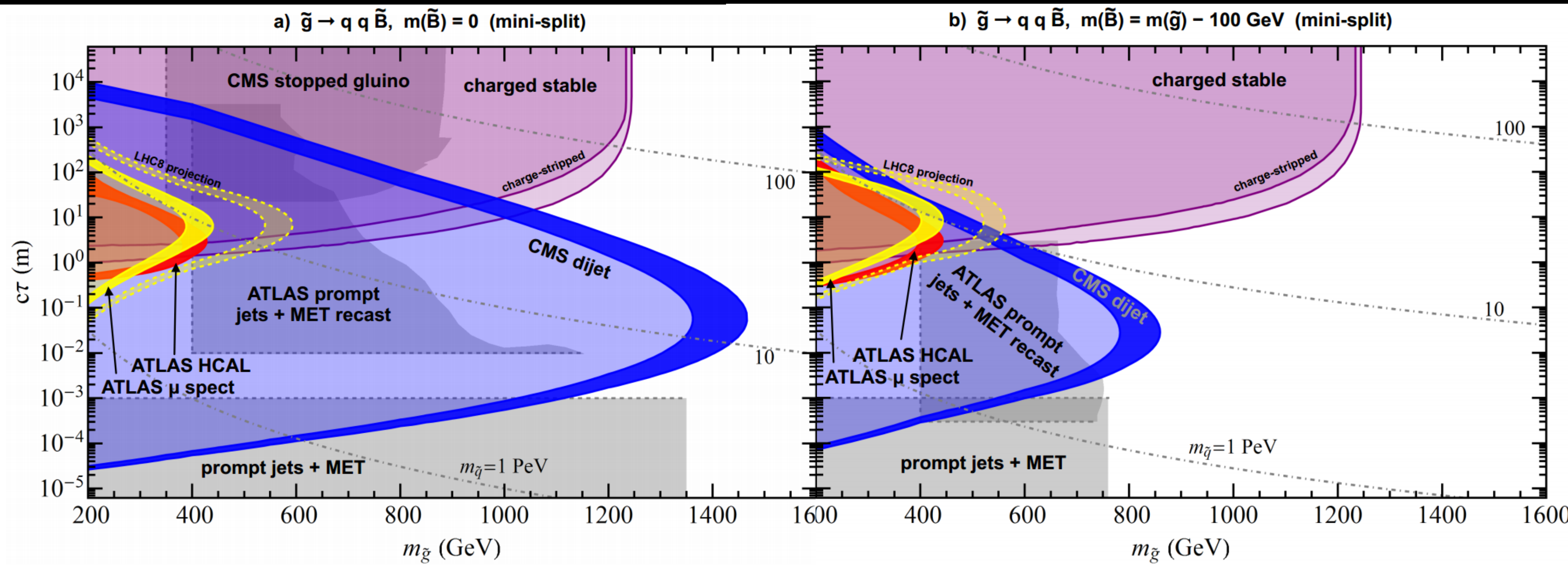

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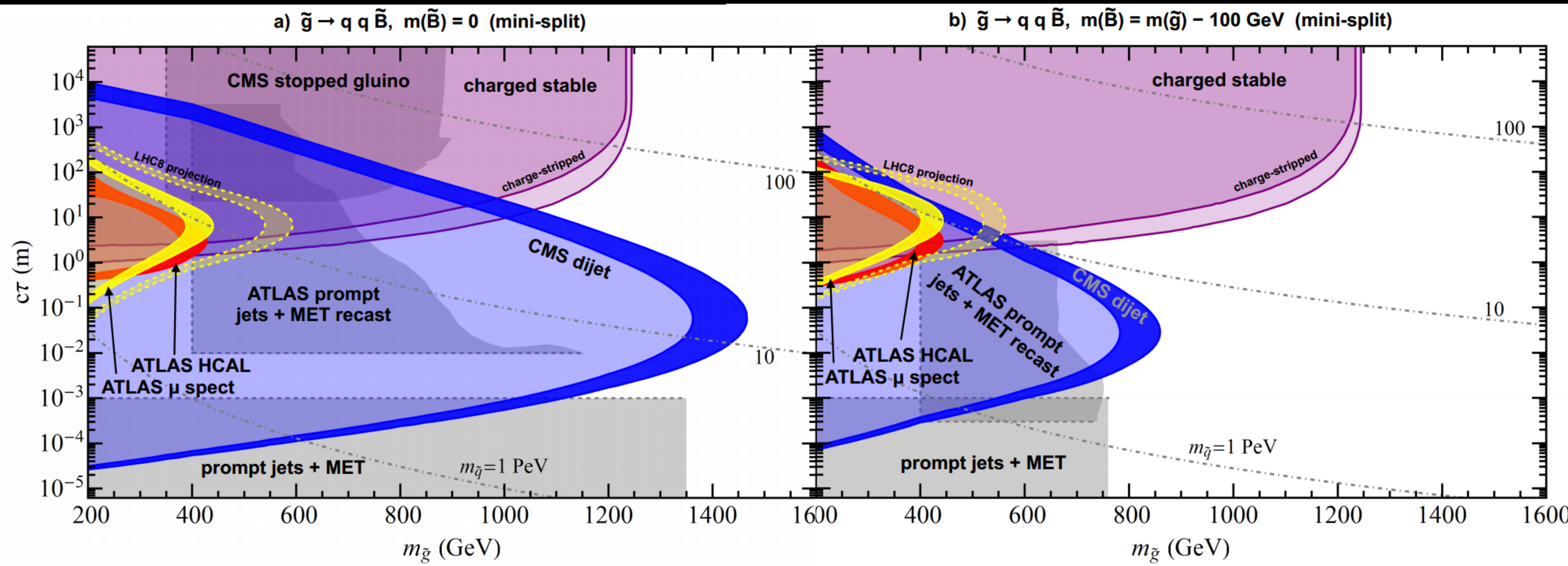

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- Different displaced search channels are more complementary, more important.

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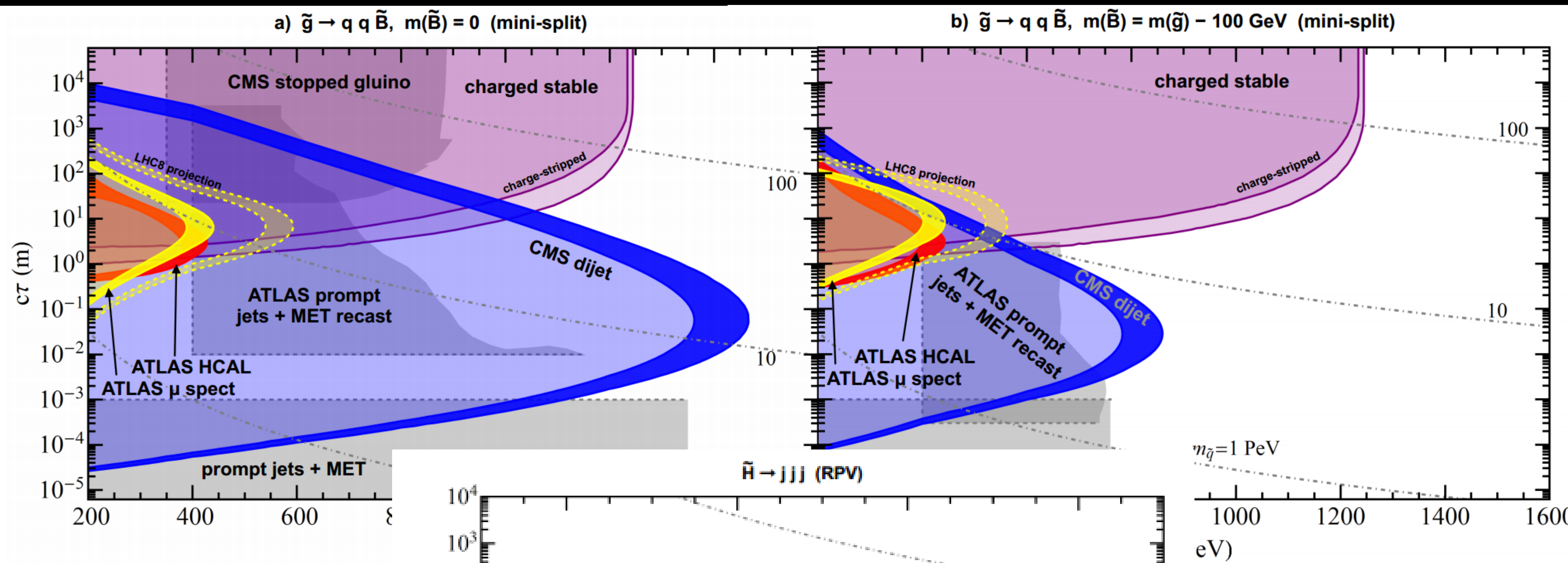

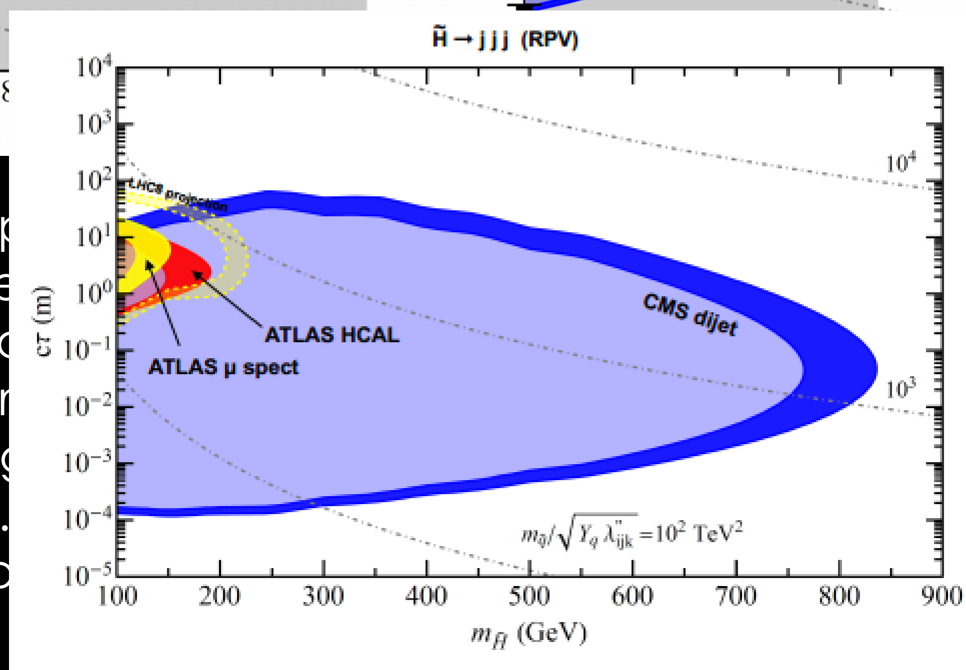

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