



TRACK TRIGGERS FOR UNCONVENTIONAL SIGNATURES

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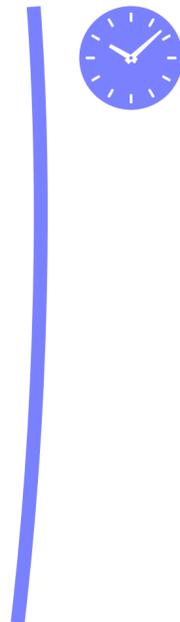
MOTIVATION

Tracks often most distinctive feature of exotic signatures

Challenge for ATLAS/CMS trigger
No tracking @L1
limited tracking @HLT

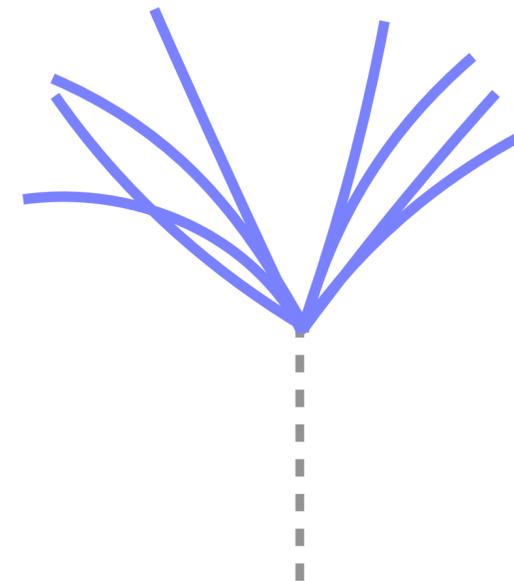
Will change at the HL-LHC!

Heavy Stable
Charged Particles
(HSCPs)



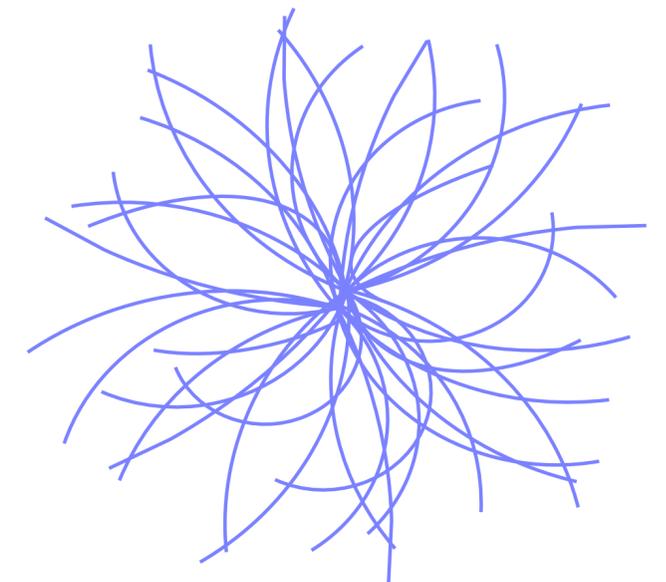
slow moving/
highly ionizing
prompt track

Long-lived particle
decays



displaced jets/
leptons

Soft-Unclustered
Energy Patterns
(SUEPs)



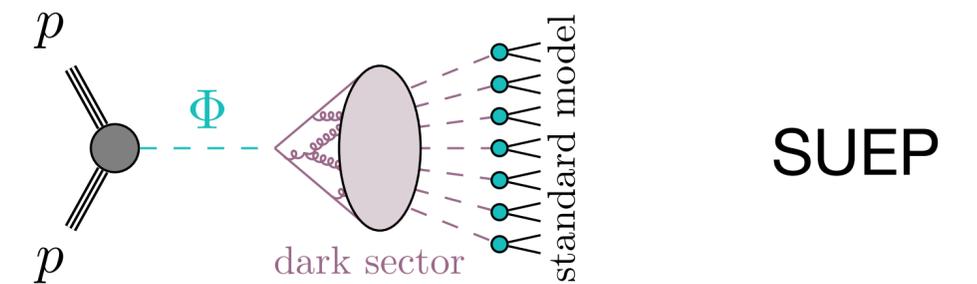
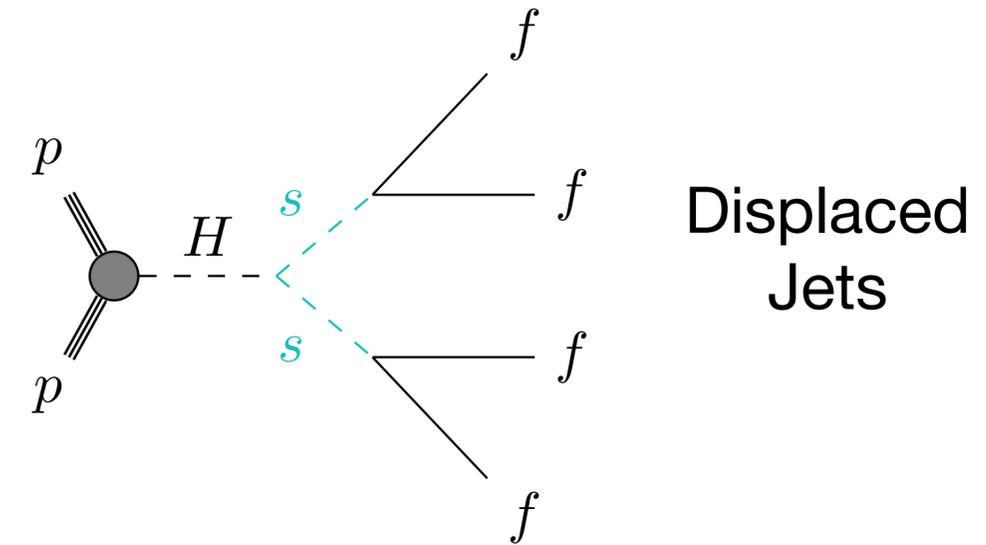
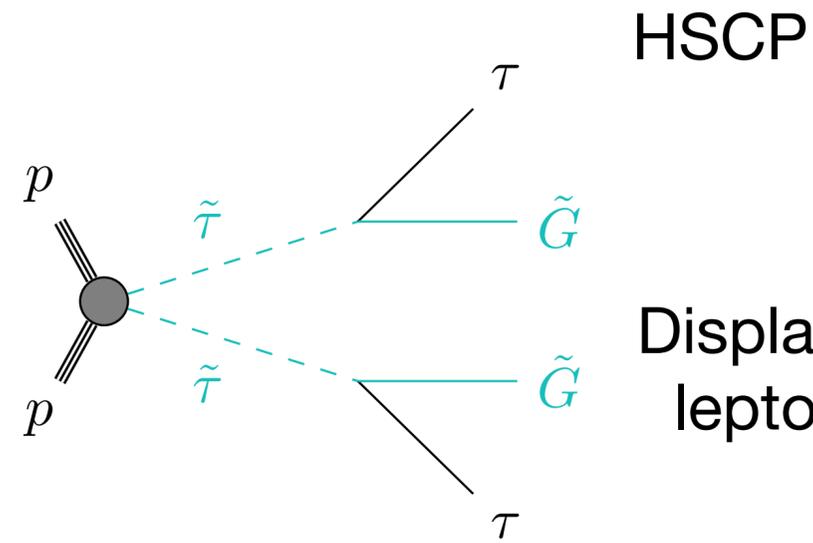
large multiplicity
of soft tracks

THIS STUDY

Goal: Determine best track-trigger parameters for wide range of exotic signatures

3 models \leftrightarrow 4 signatures

wide range of p_T , d_0 , n_{Track}



STRATEGY

Evaluate event-level efficiencies
for a range of track trigger
parameters

Truth-level accounting for
realistic effects

Assumes ATLAS/CMS
geometry

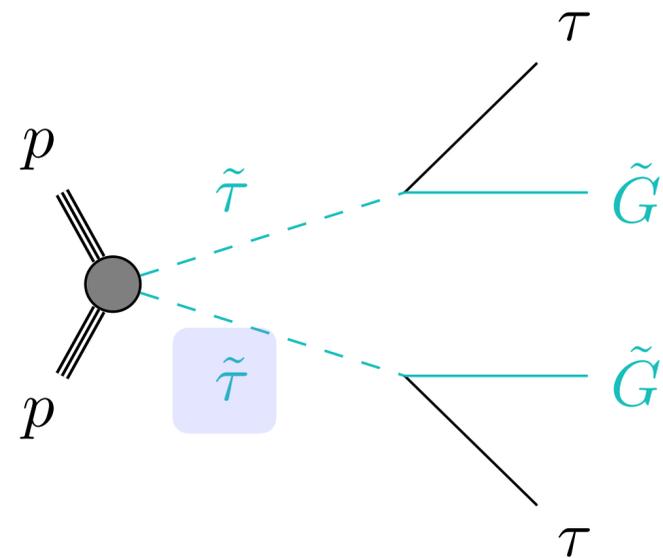
Per-event selection:

$$n_{\text{Track}} \geq X$$

Per-track selection:

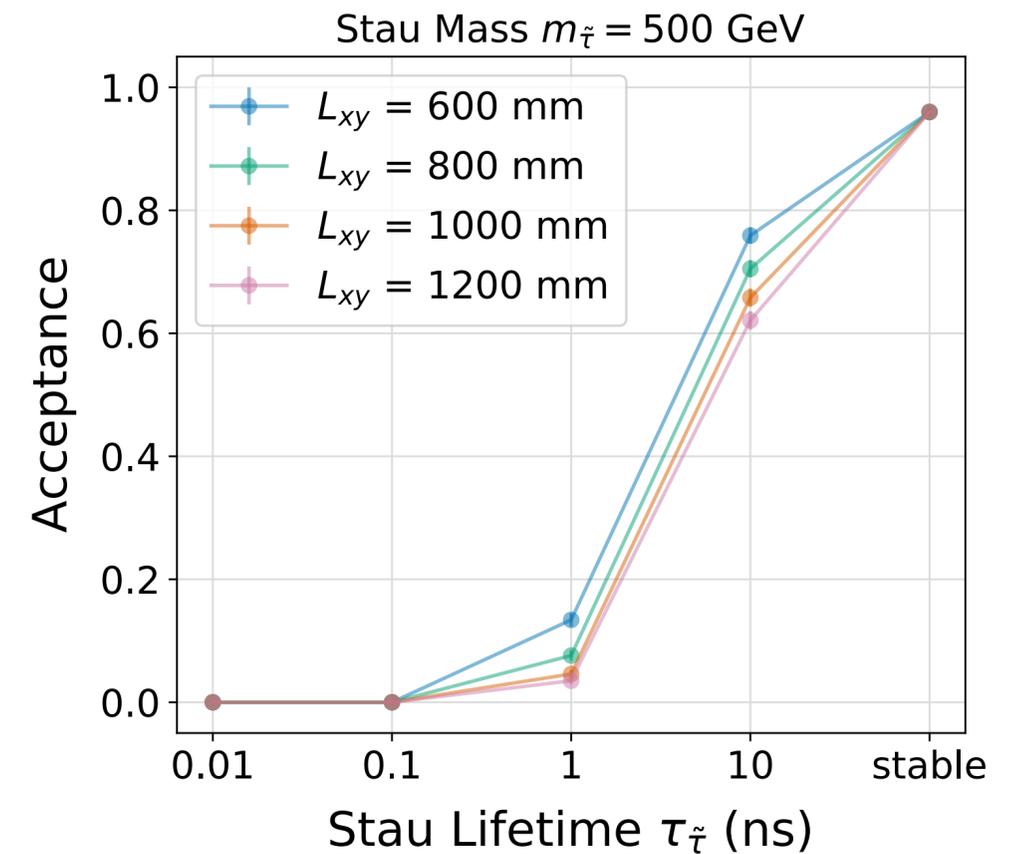
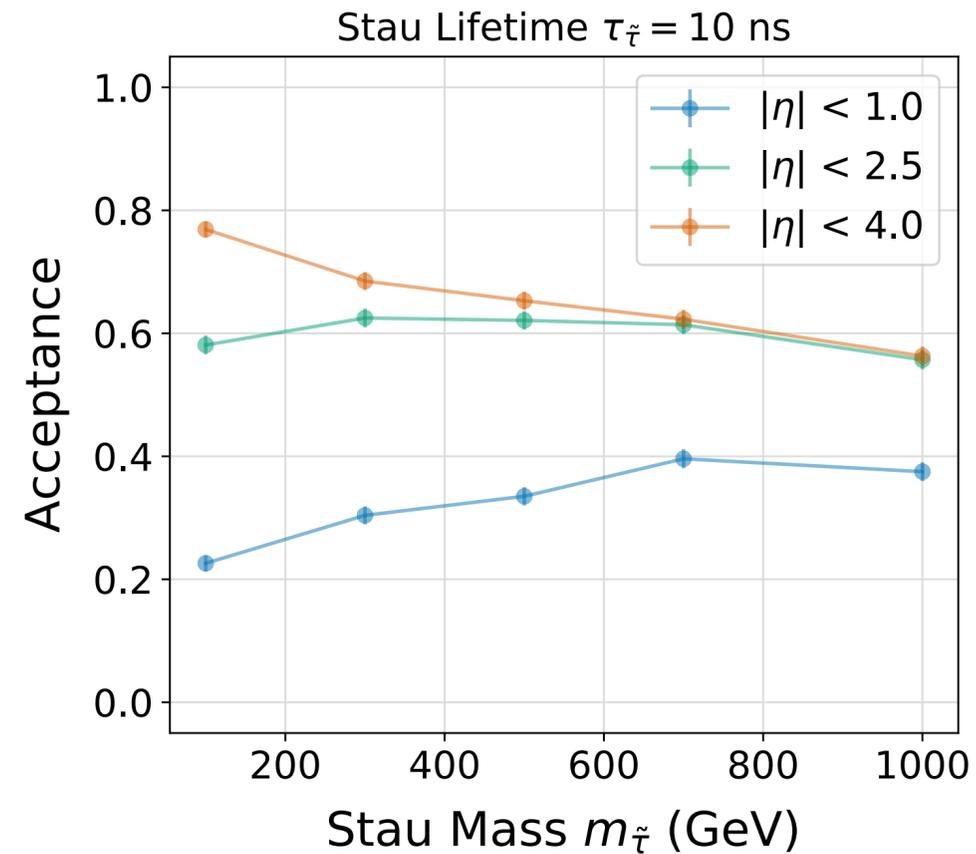
Acceptance	Charged
	Status = 1
	$ \eta < 1.0, 2.5, 4.0$
	Traverses sufficient n_{layers}
Efficiency	$p_T > 0.5, 1, 2, 5, 10 \text{ GeV}$
	$ d_0 < 10, 20, 50, 100 \text{ mm}$

HSCP



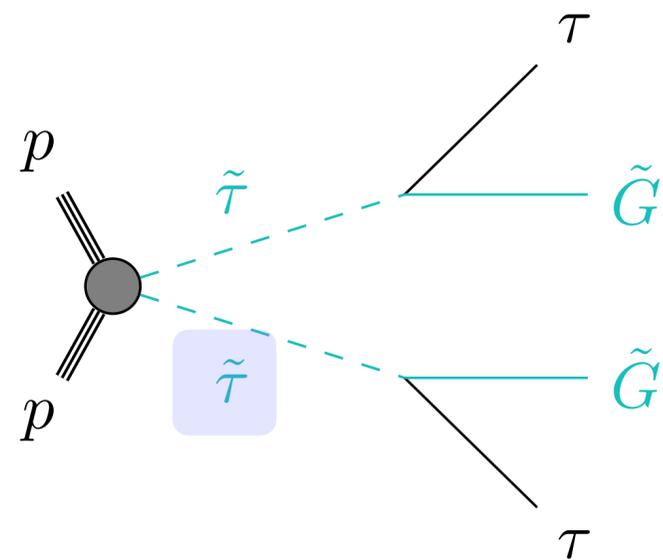
Signature:
 ≥ 1 prompt track

Geometric Acceptance



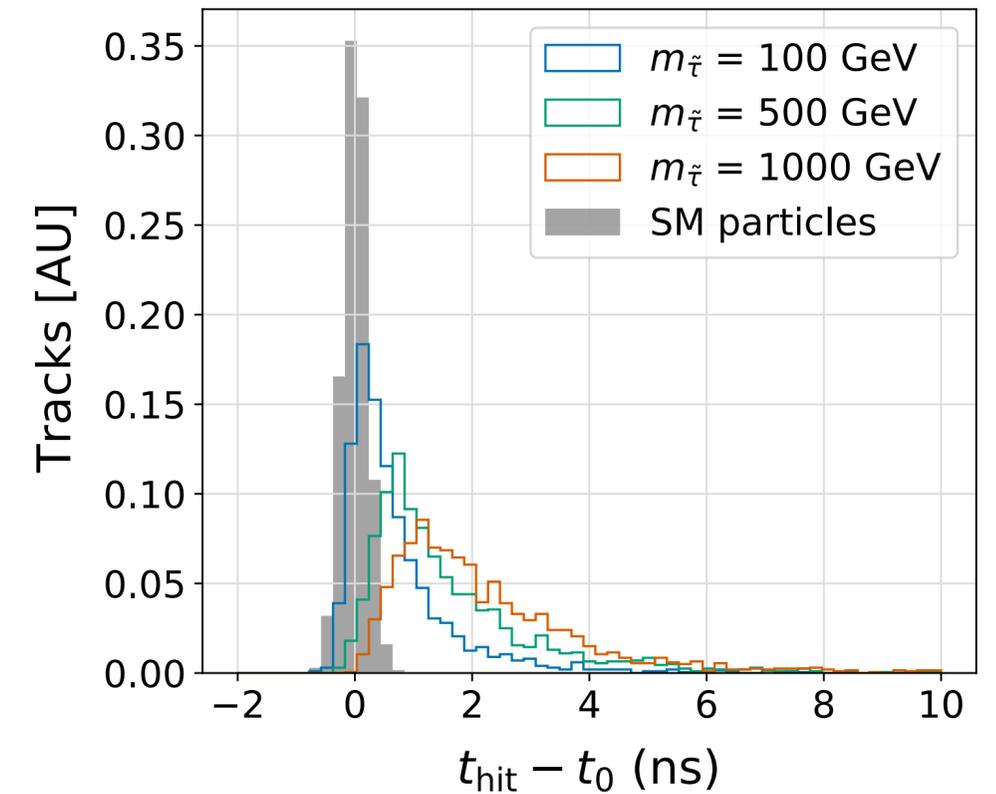
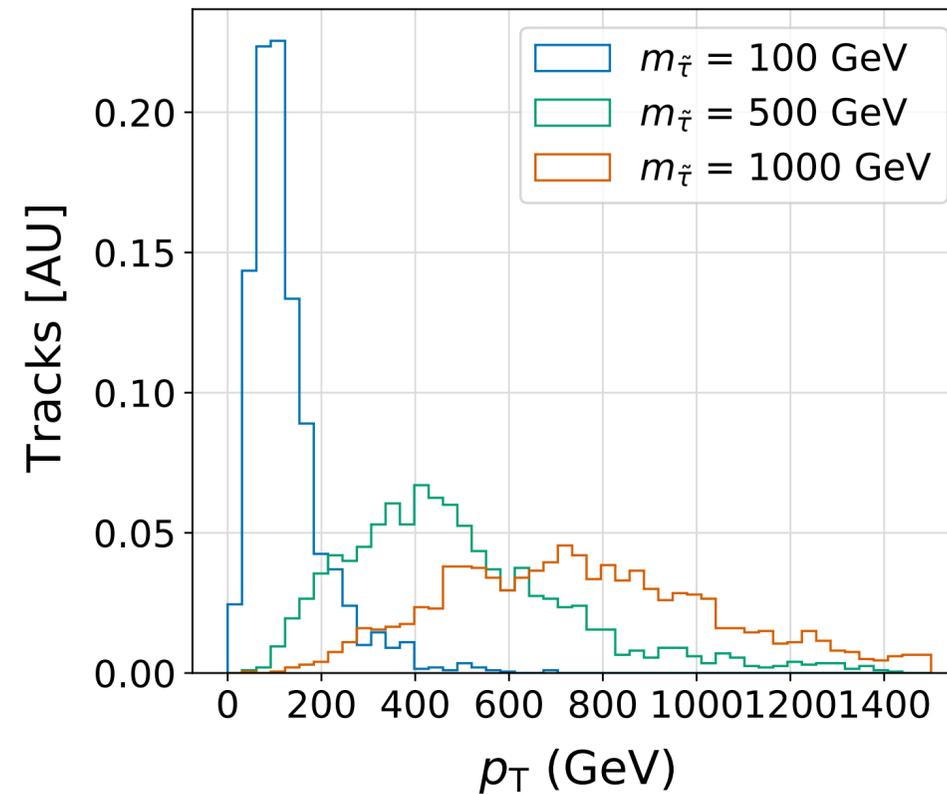
η = most important parameter
 reduce n_{Layers} : modest improvement for 1-10 ns lifetimes

HSCP



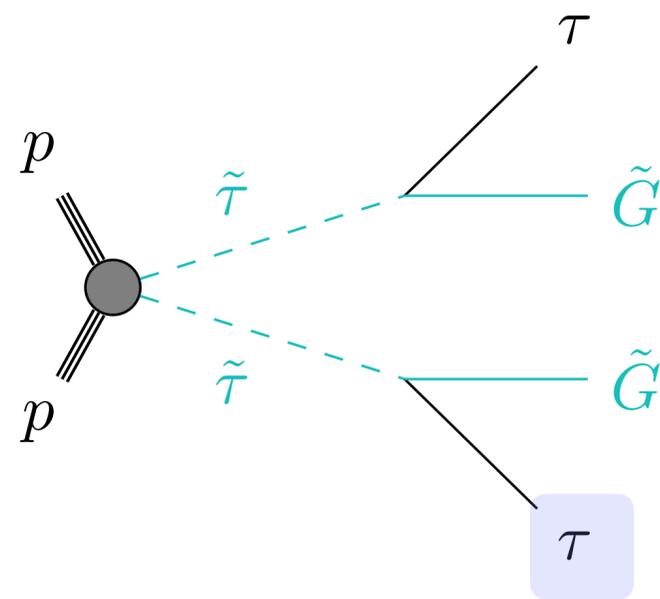
Signature:
 ≥ 1 prompt track

Highly efficient!



High $p_T \rightarrow$ negligible loss of efficiency
CMS-style timing layer = additional handle to reject background

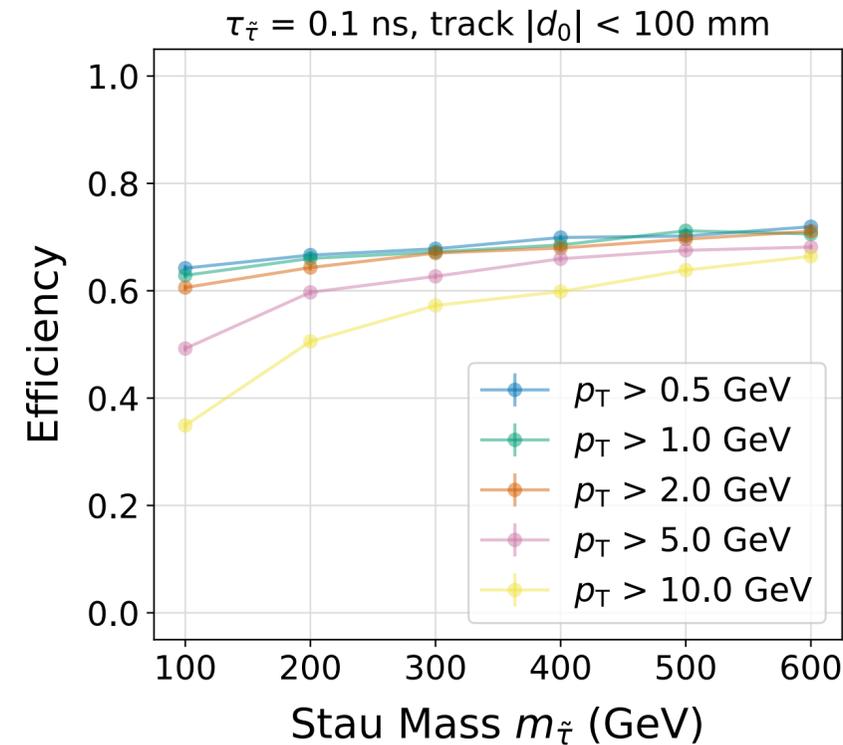
DISPLACED LEPTONS



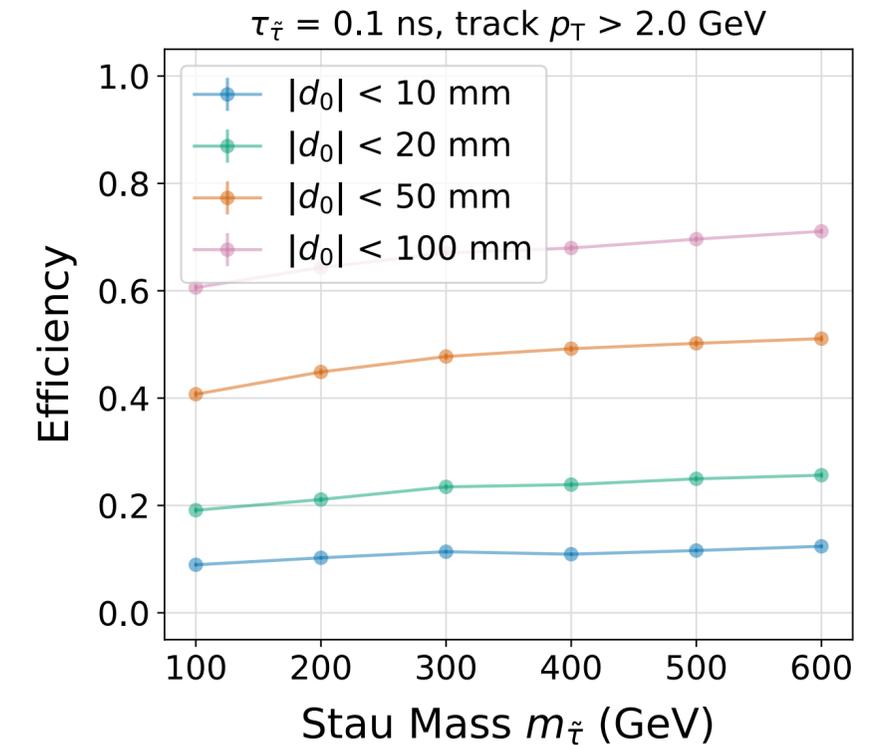
Signature:
 ≥ 1 or $\underline{2}$
 displaced tracks
 $|d_0| > 1 \text{ mm}$

Takeaways

vary p_T



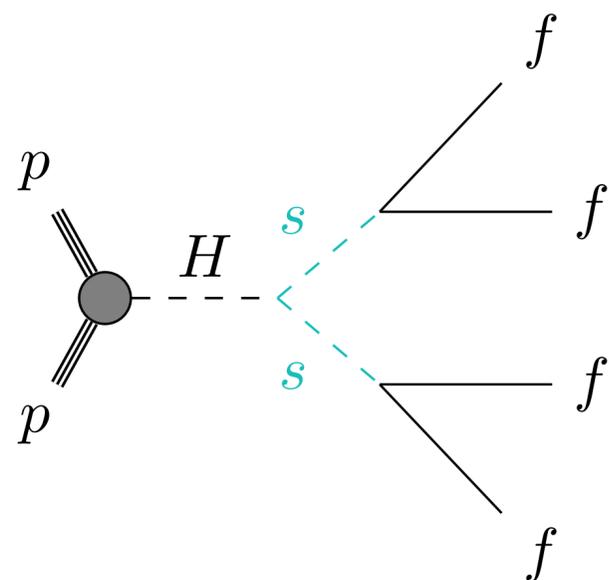
vary d_0



d_0 more impactful than p_T threshold

Consistent with expectations for high mass leptonic decay

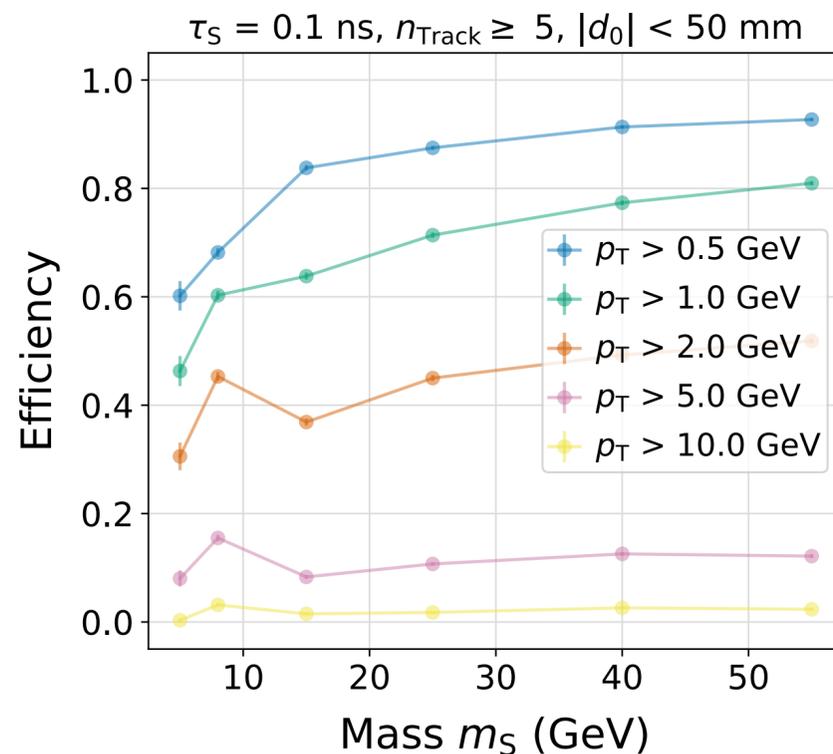
HIGGS PORTAL



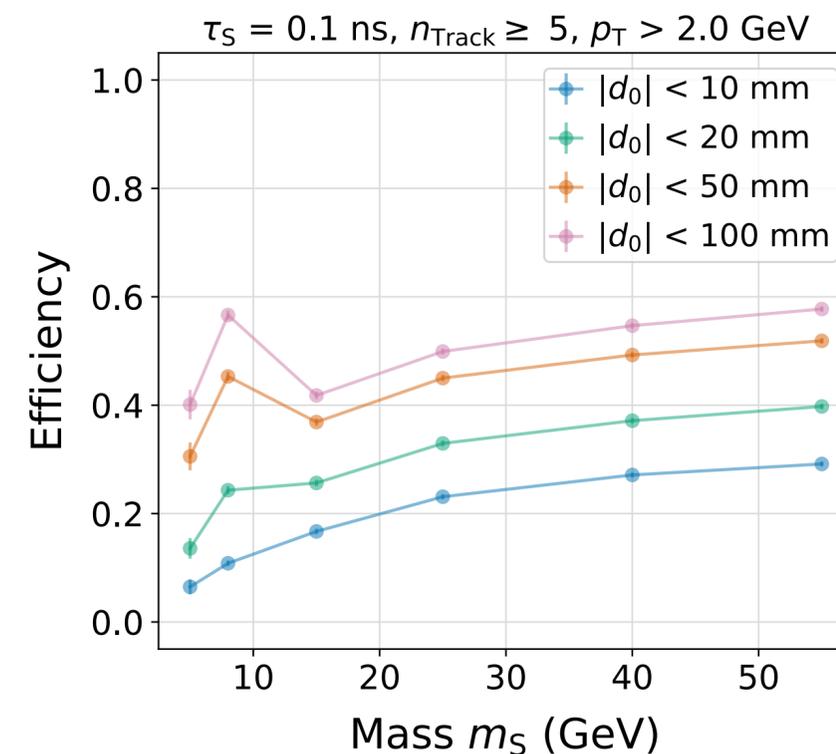
Signature:
 ≥ 2 or $\underline{5}$
 displaced tracks
 $|d_0| > 1 \text{ mm}$

Takeaways

vary p_T

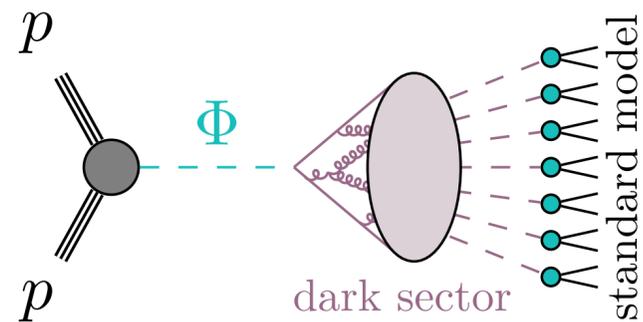


vary d_0



Most important: low p_T threshold with non-zero d_0 range
 Consistent with expectations for low mass hadronic decay

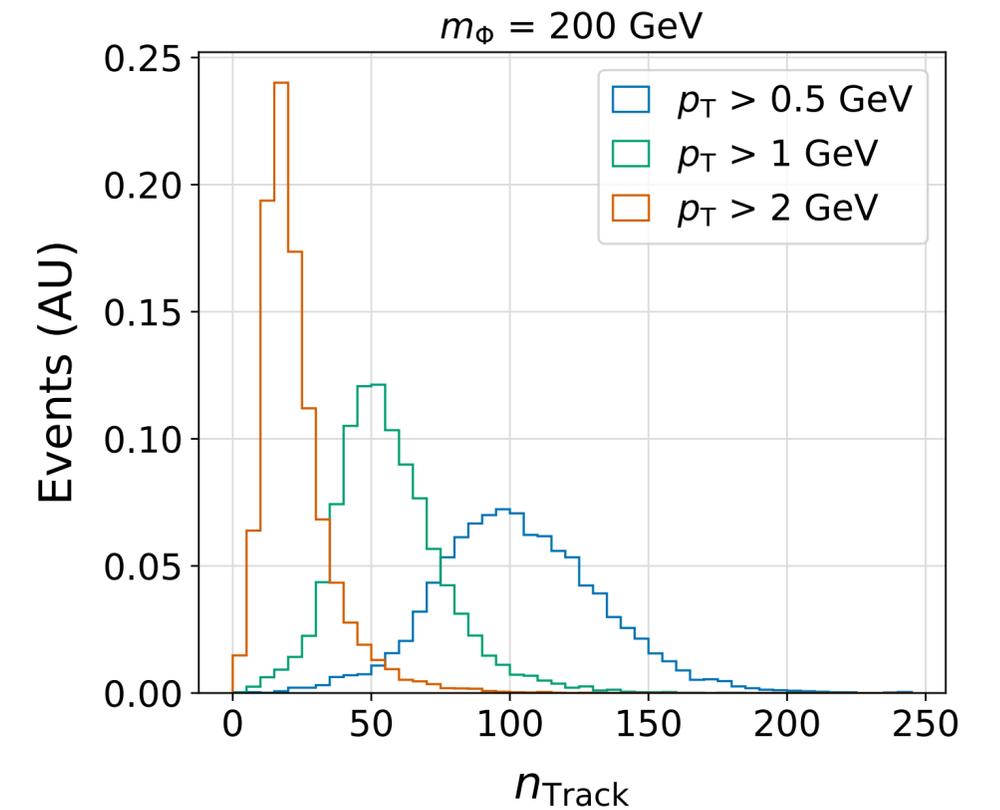
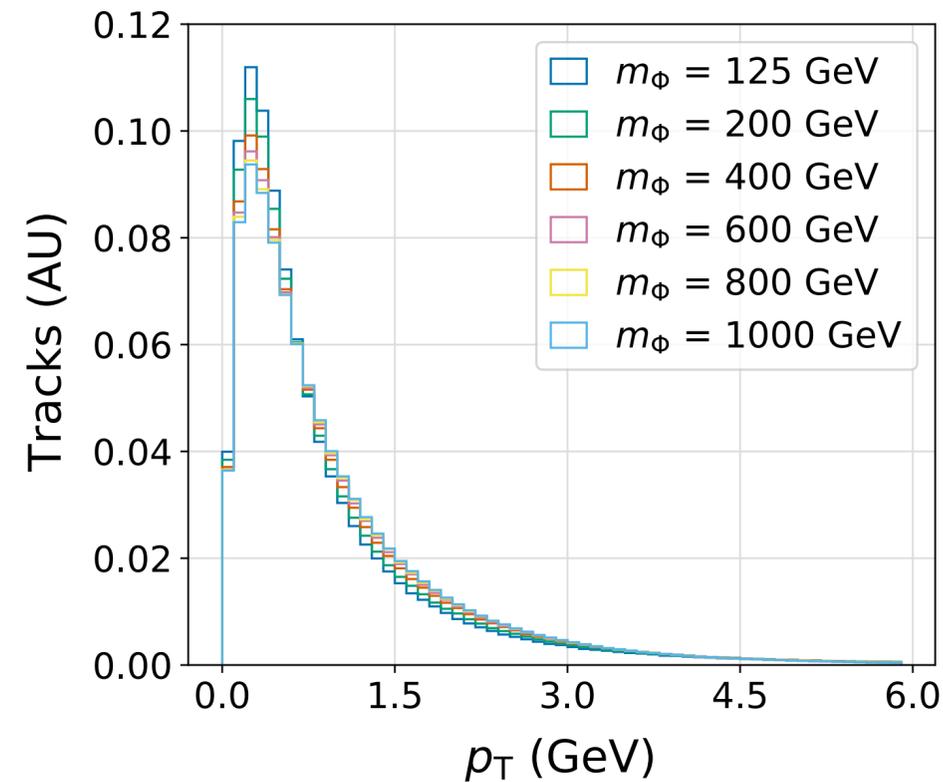
SUEPS



Signature:

High multiplicity of prompt tracks

Key features

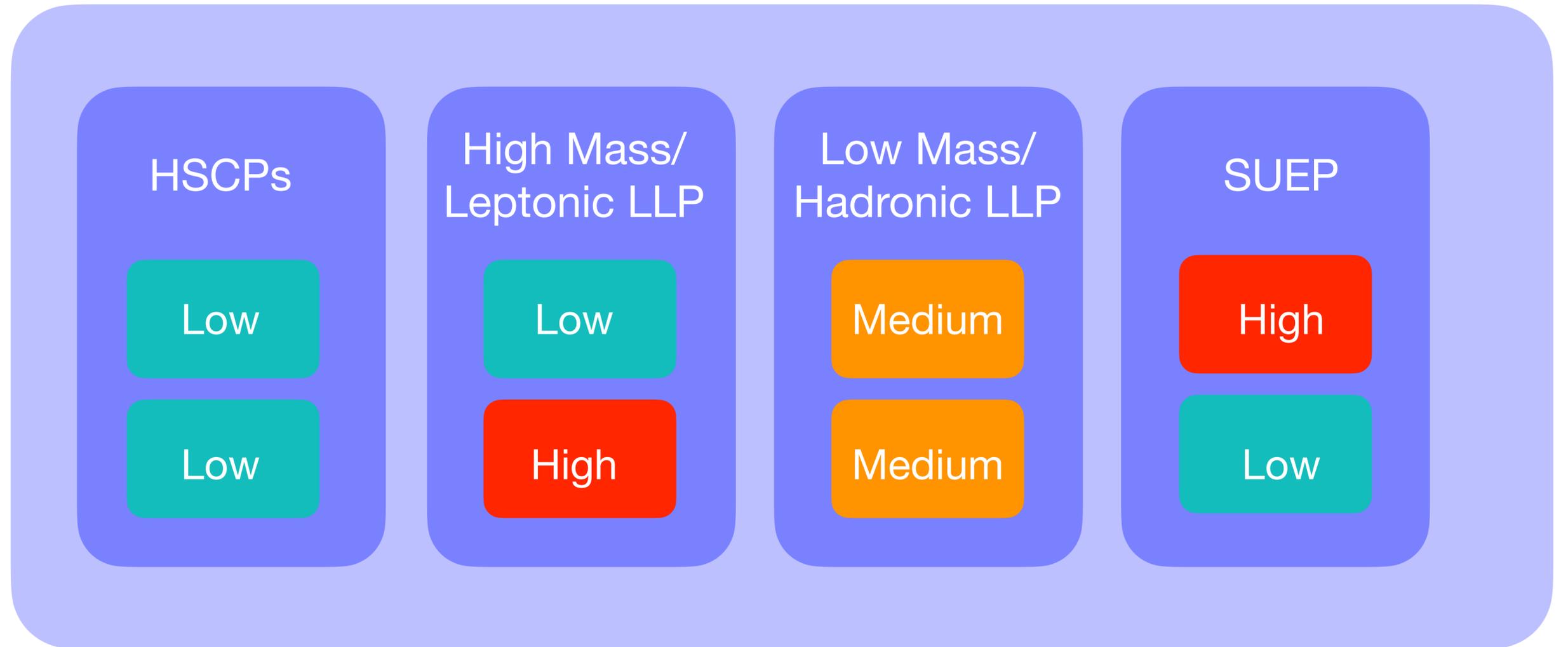


Most important: as low p_T threshold as possible
Other potential handles: characteristic event shape & H_T

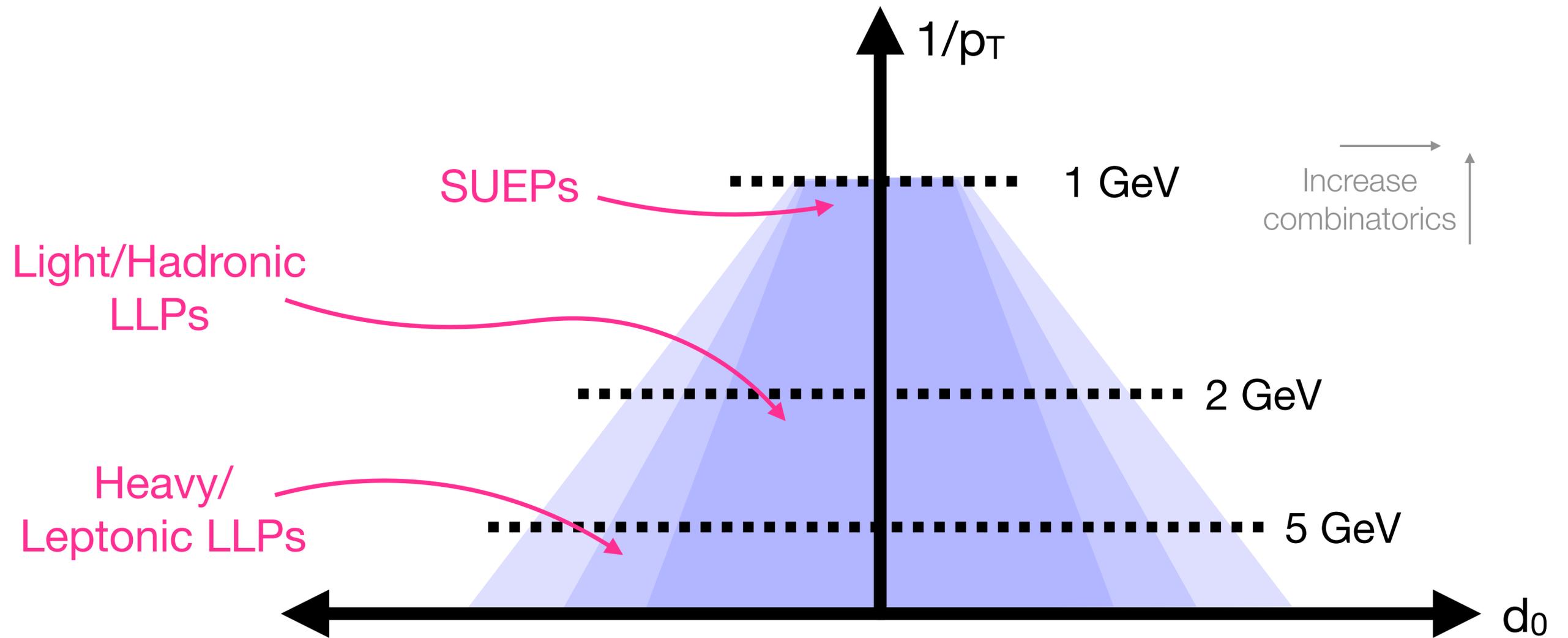
TRENDS

Sensitivity to p_T

Sensitivity to d_0

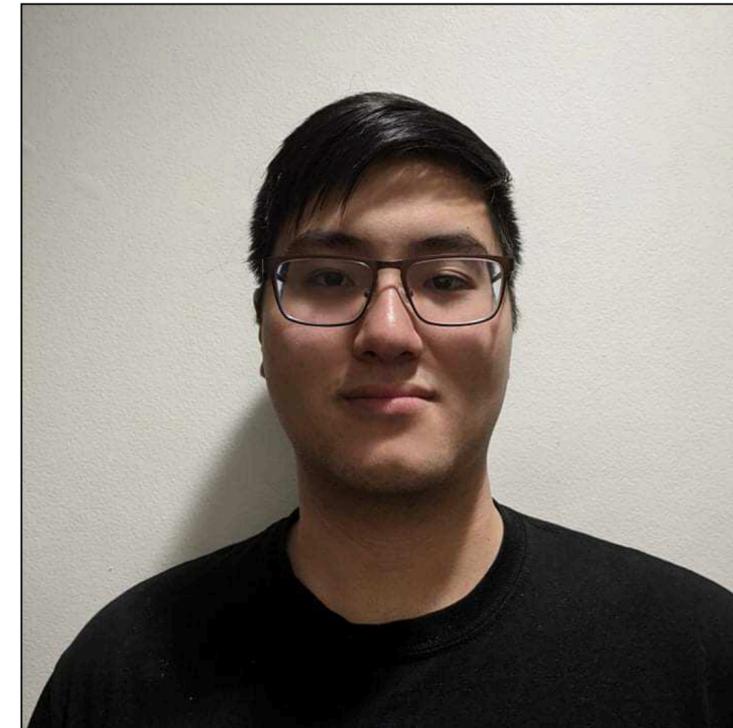
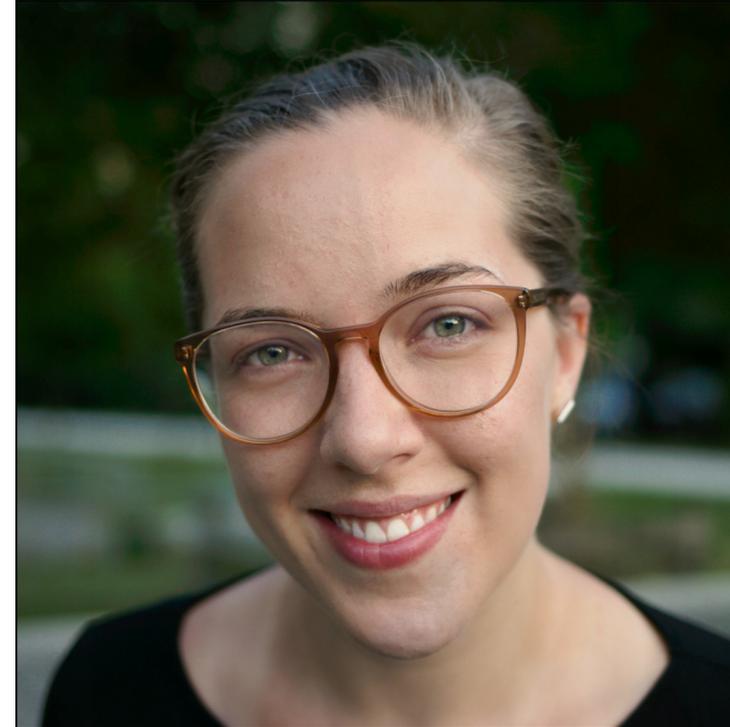


CONCLUSIONS



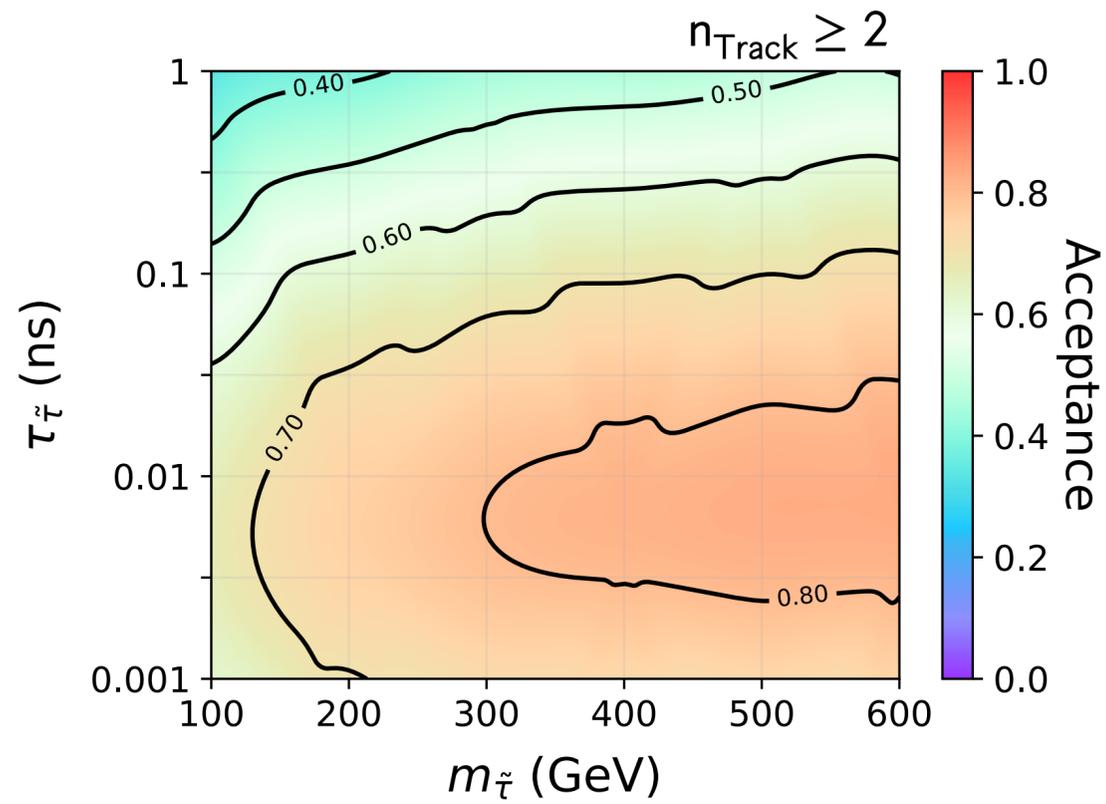
Possible to cover a wide range of unconventional signatures given realistic constraints!

THANK
YOU!

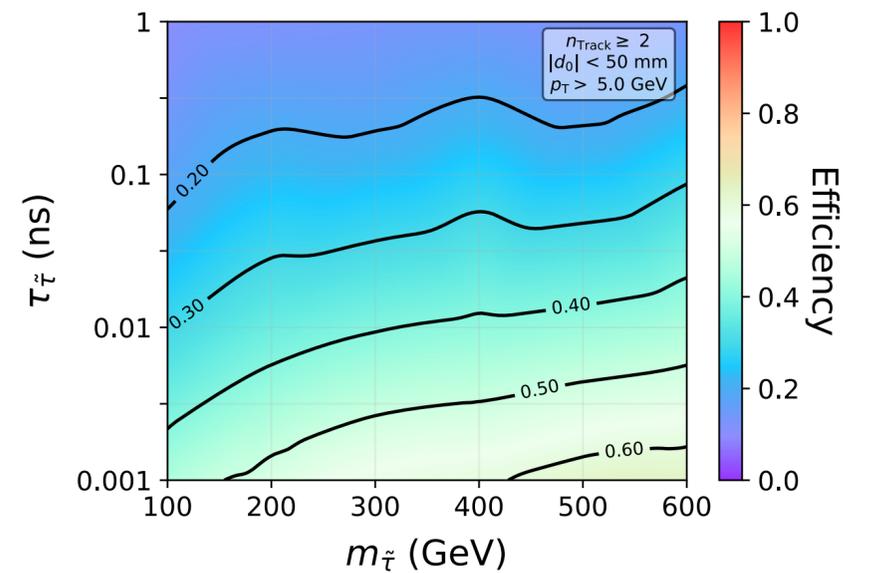
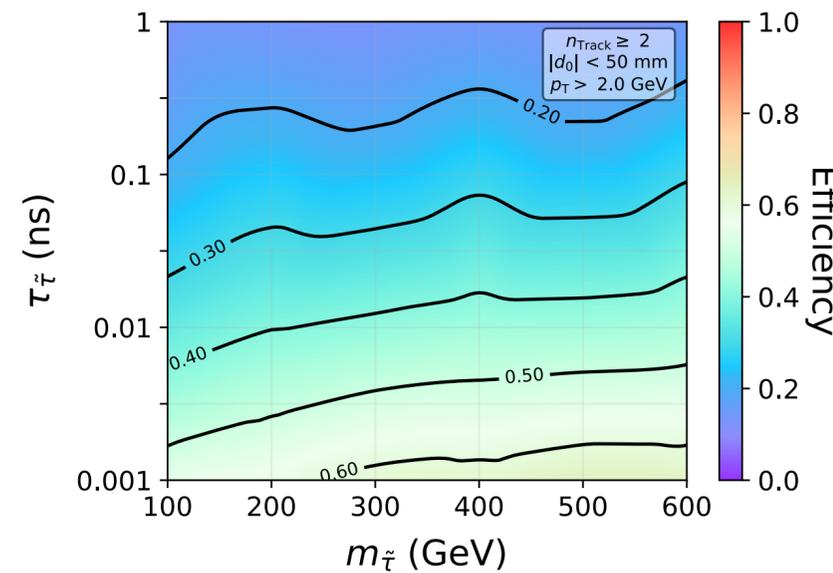
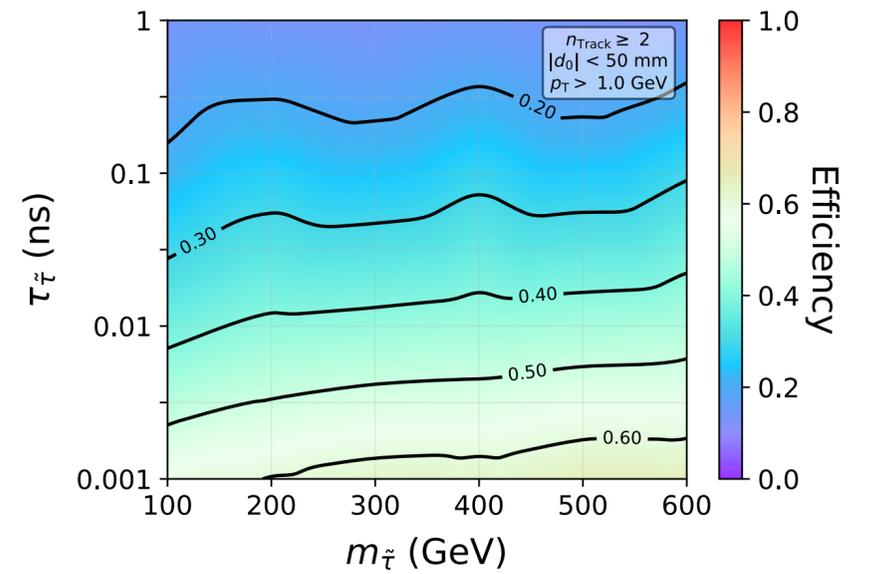
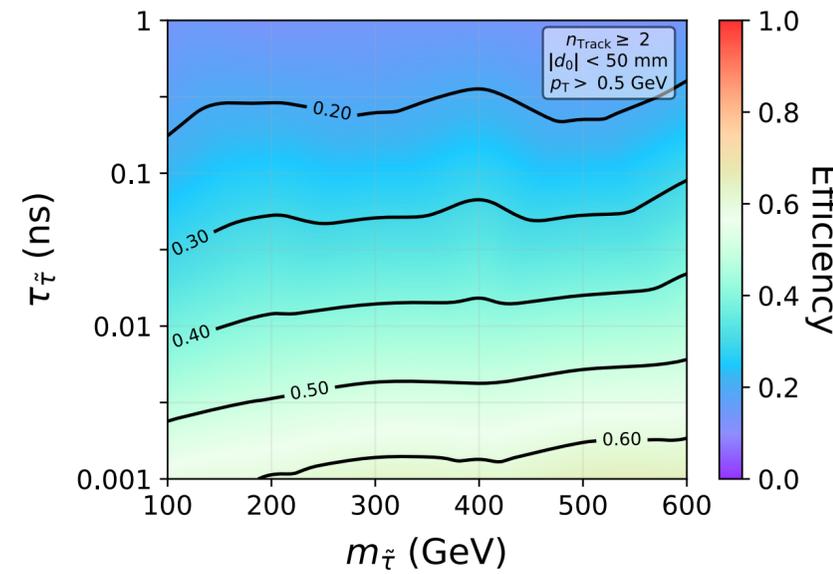


BACKUP

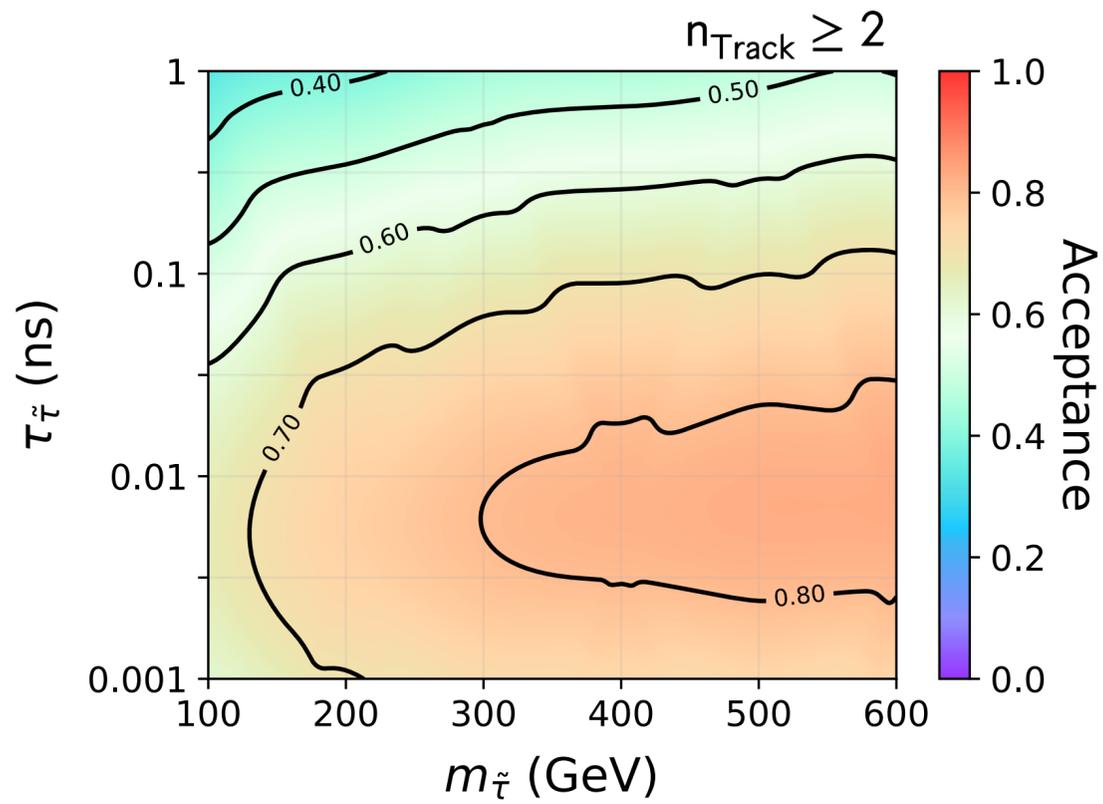
DISPLACED LEPTONS



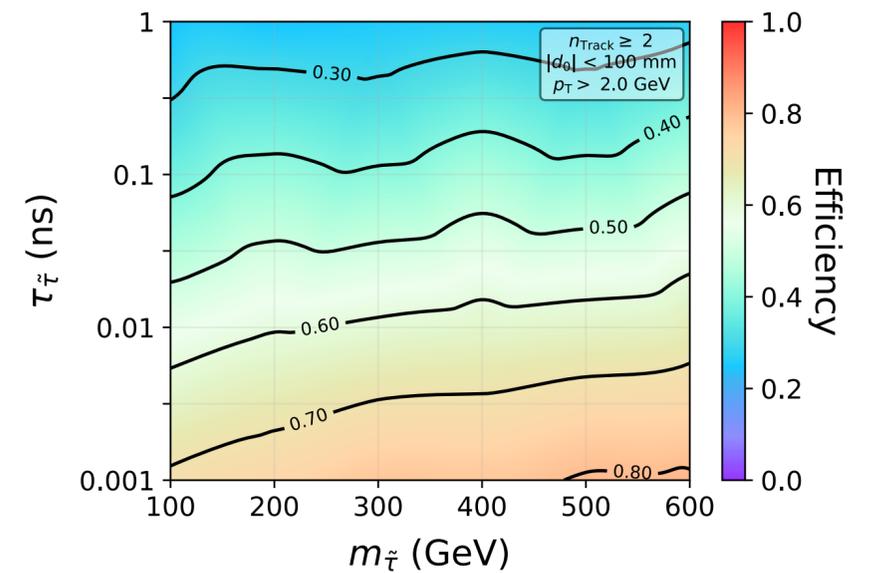
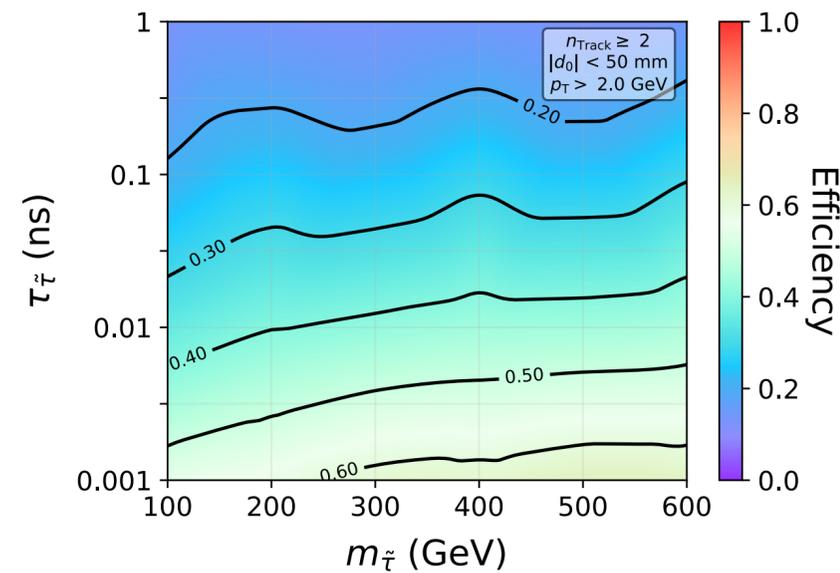
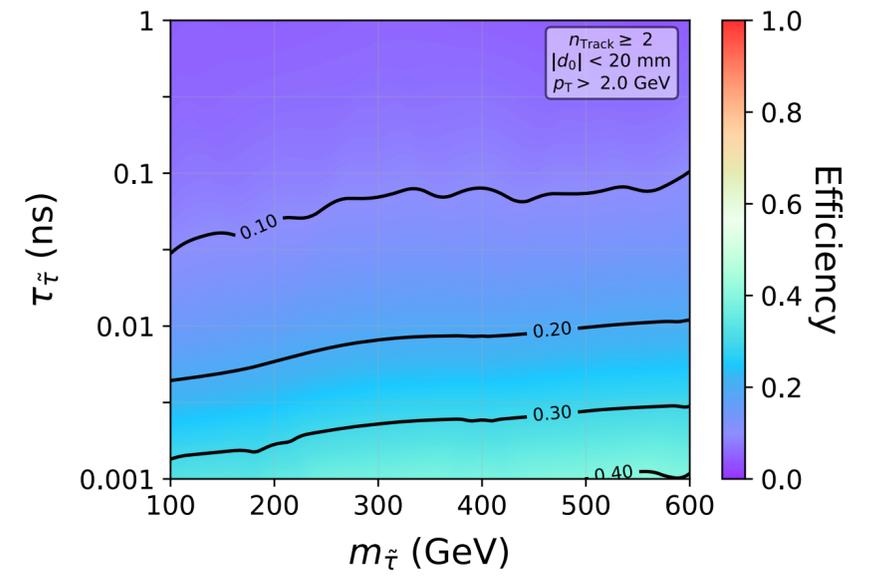
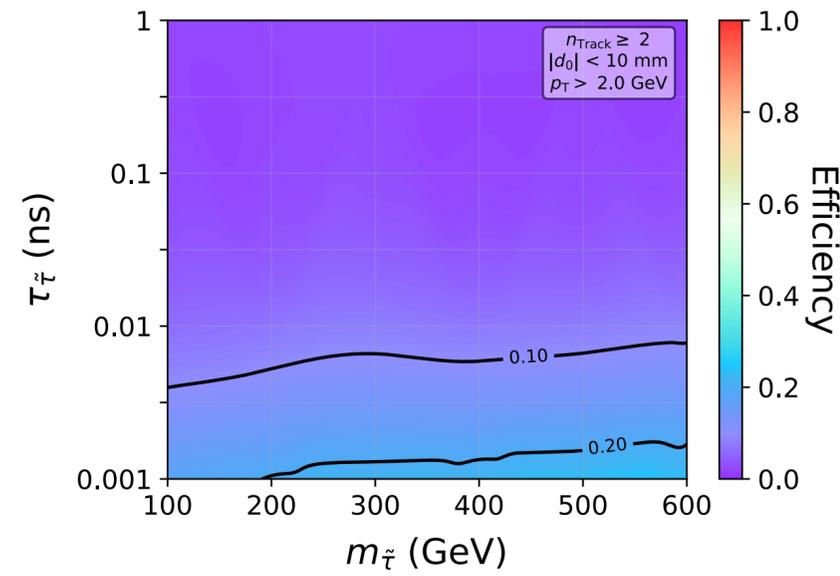
Vary p_T



DISPLACED LEPTONS

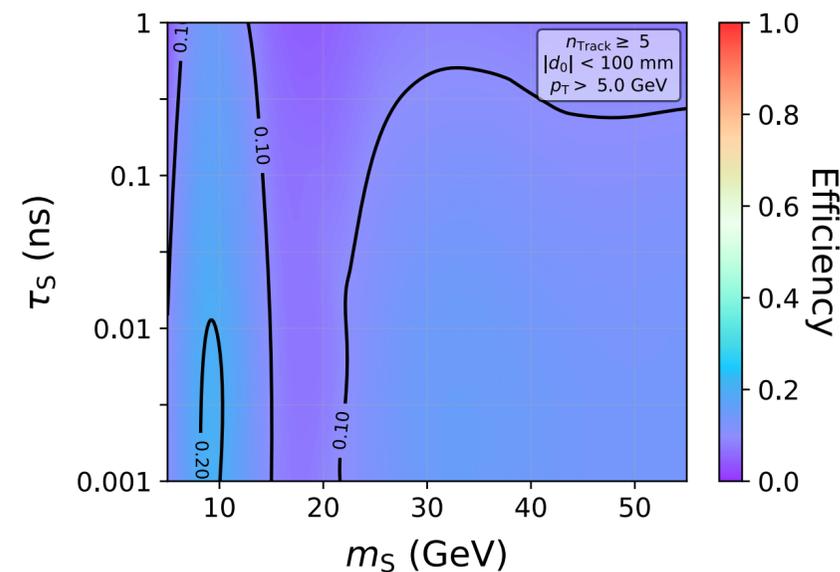
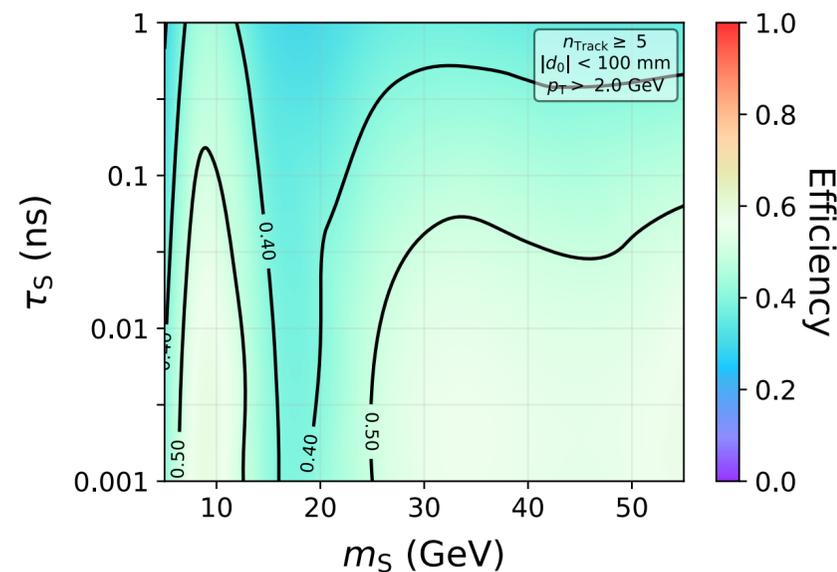
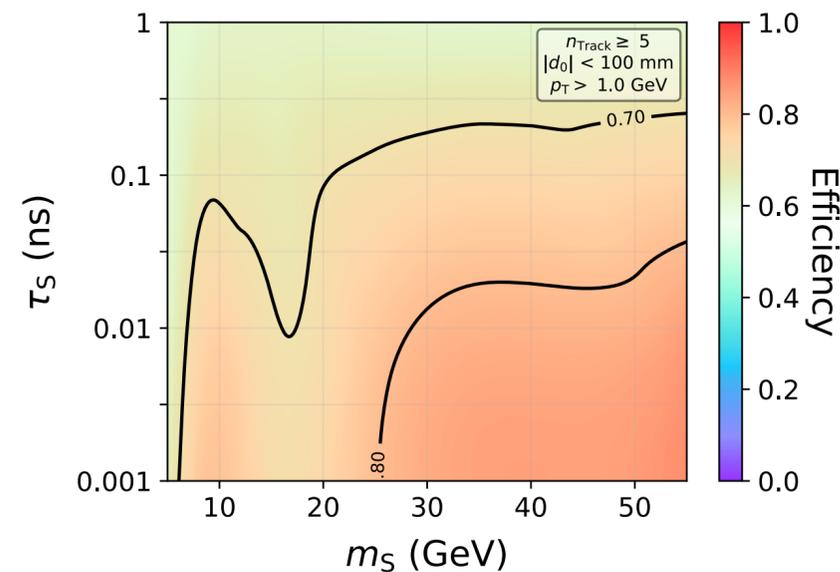
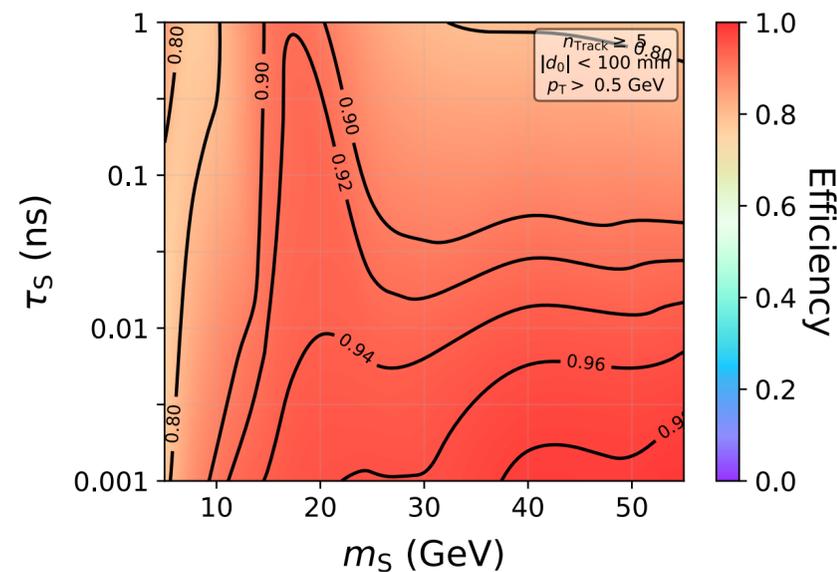
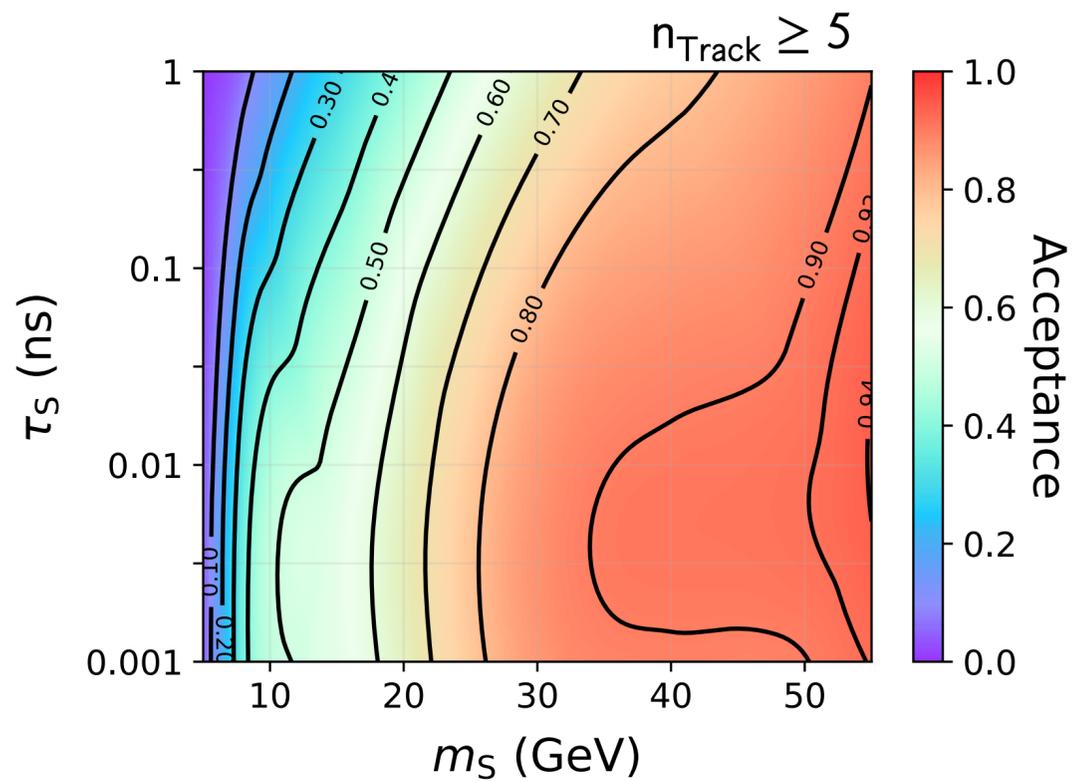


Vary d_0

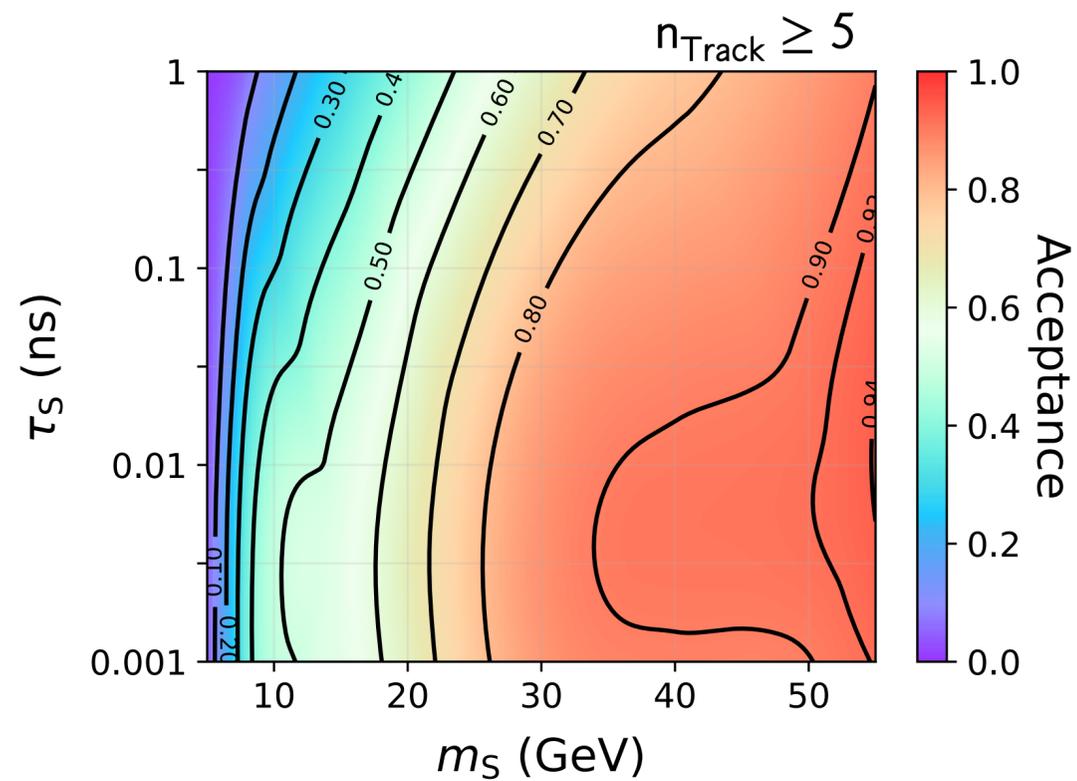


HIGGS PORTAL

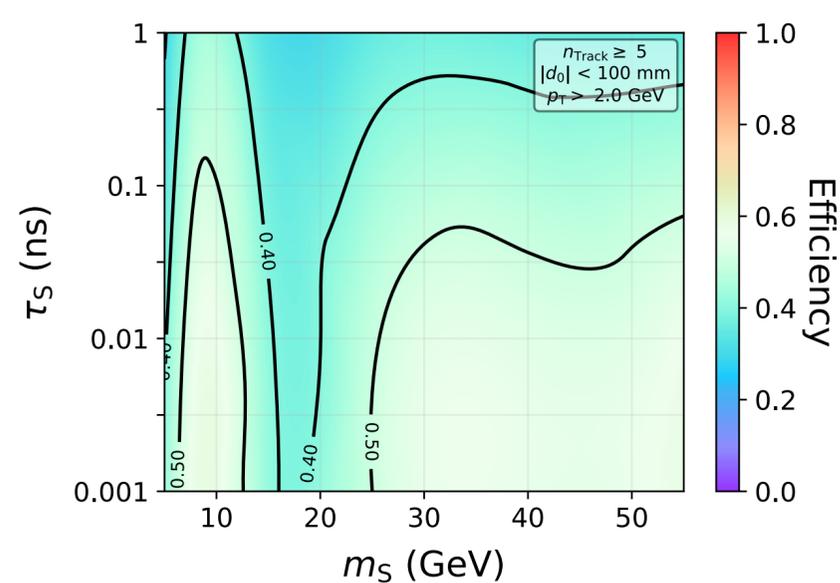
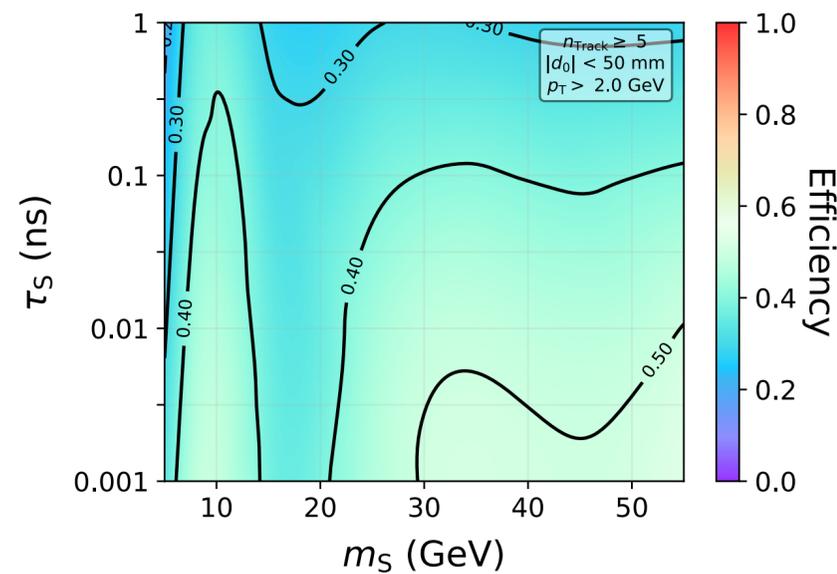
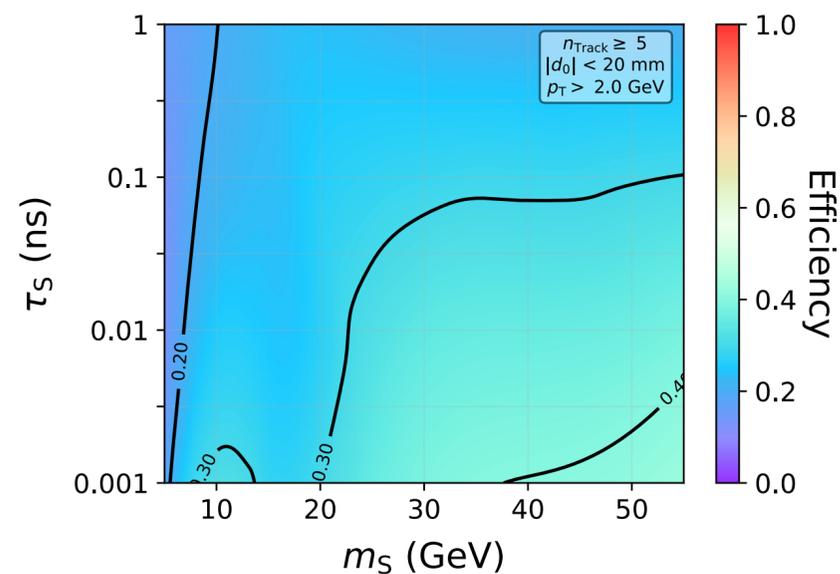
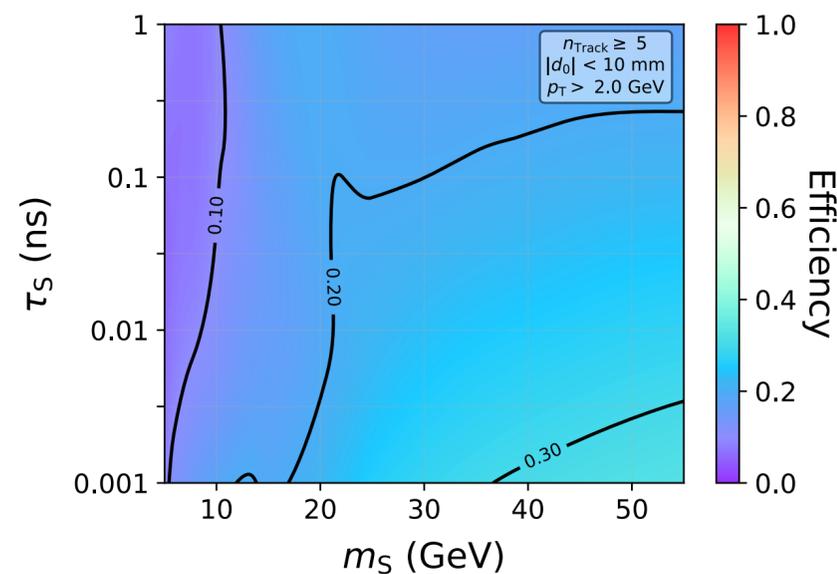
Vary p_T



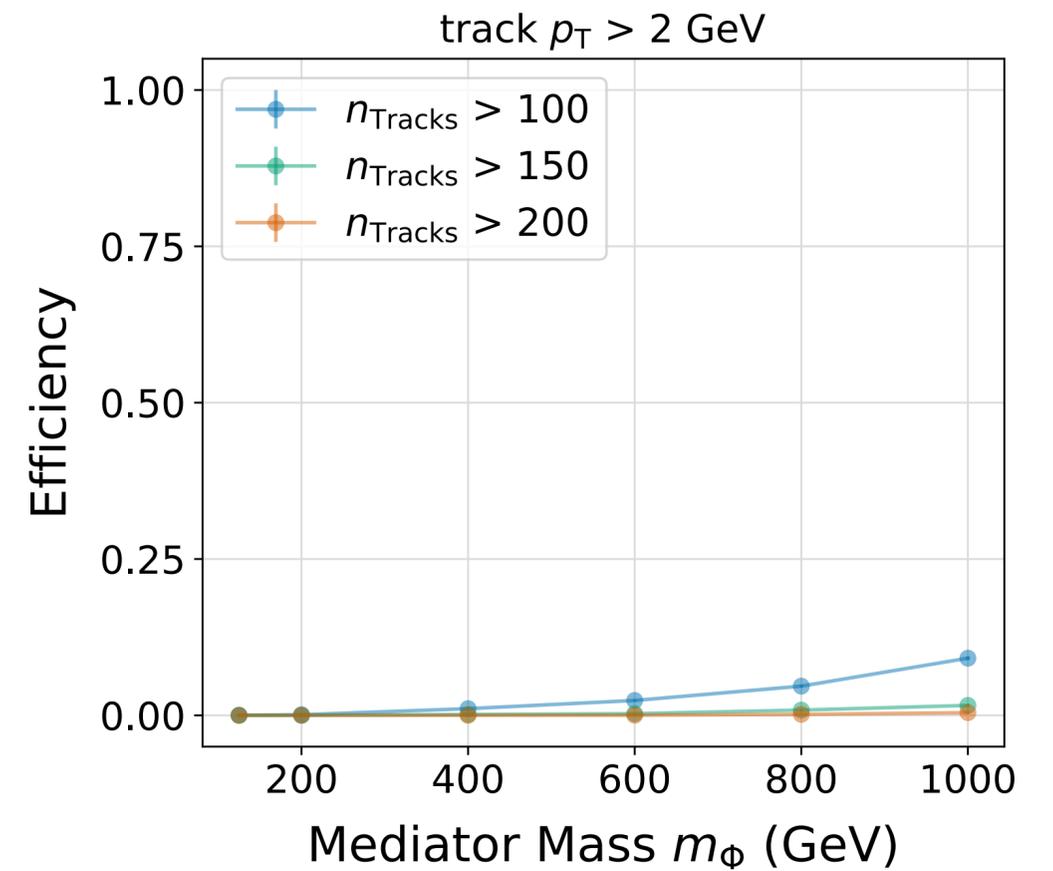
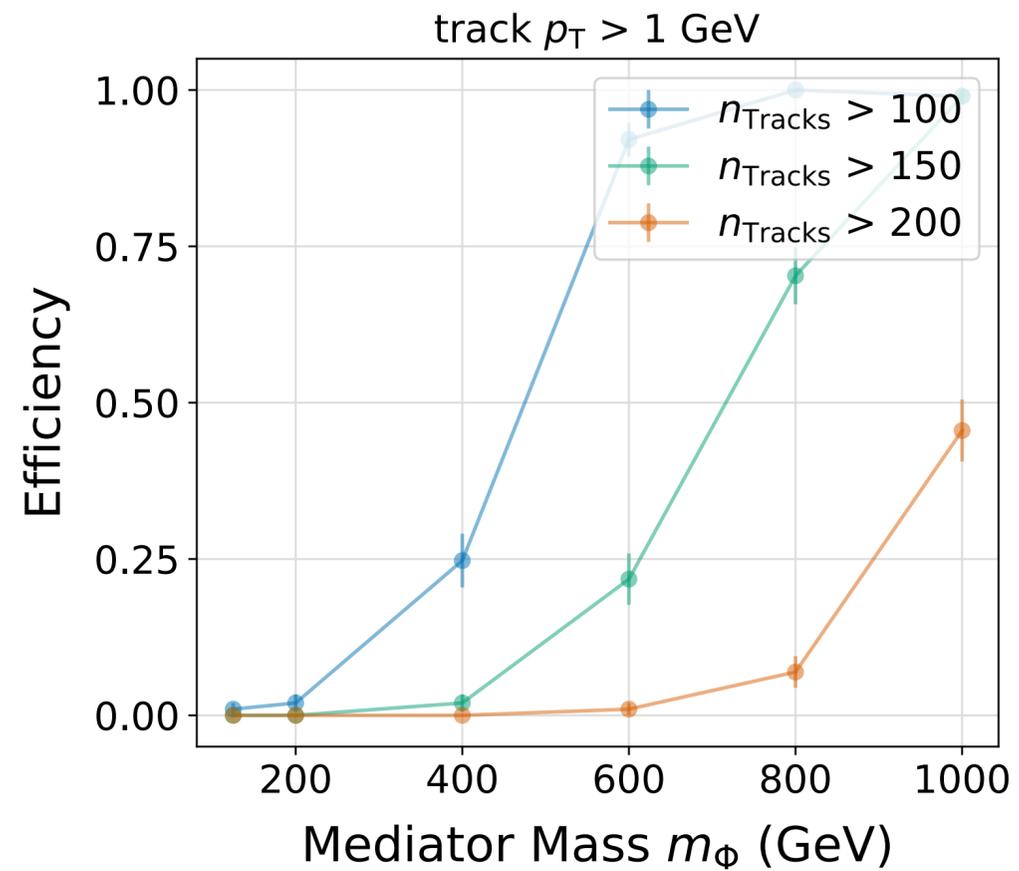
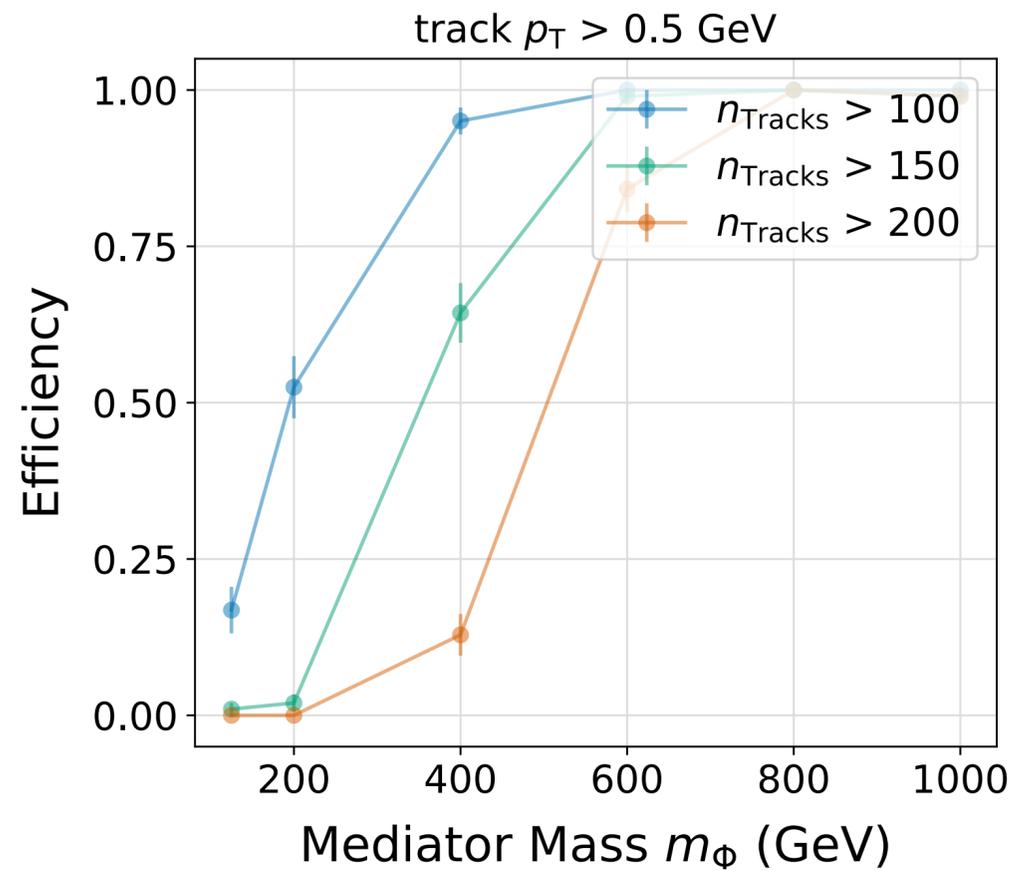
HIGGS PORTAL



Vary d_0

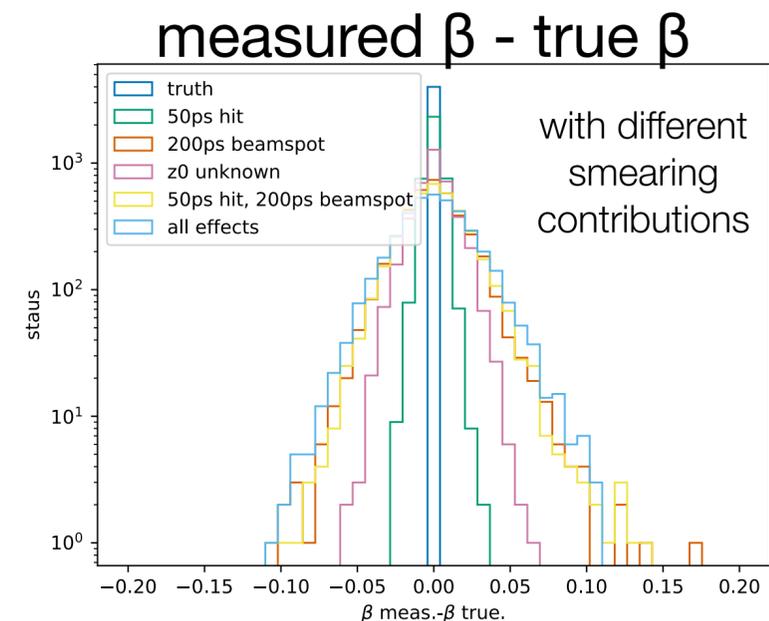
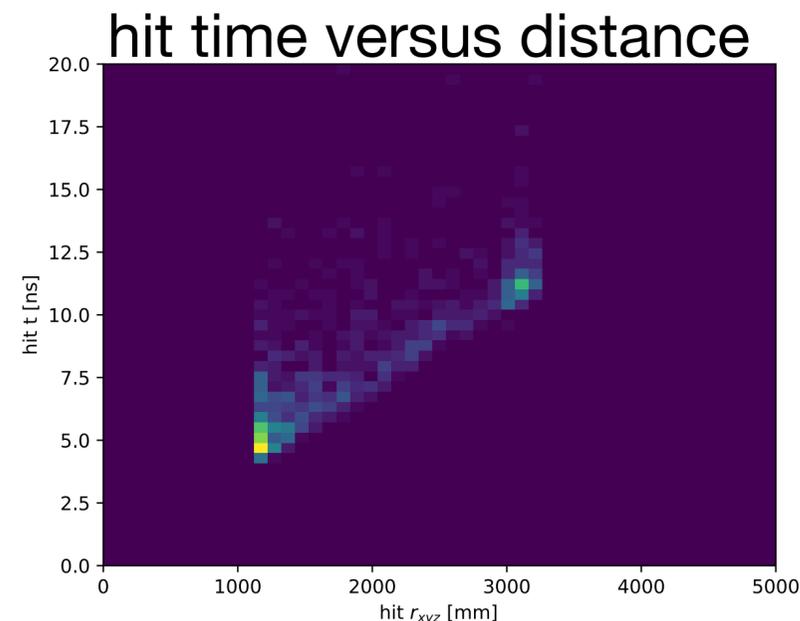
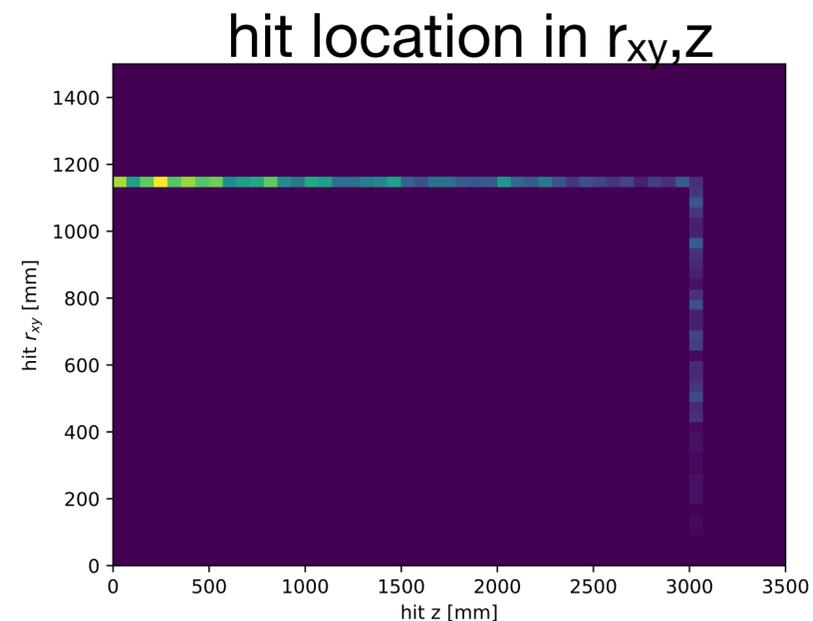


SUEP EFFICIENCIES



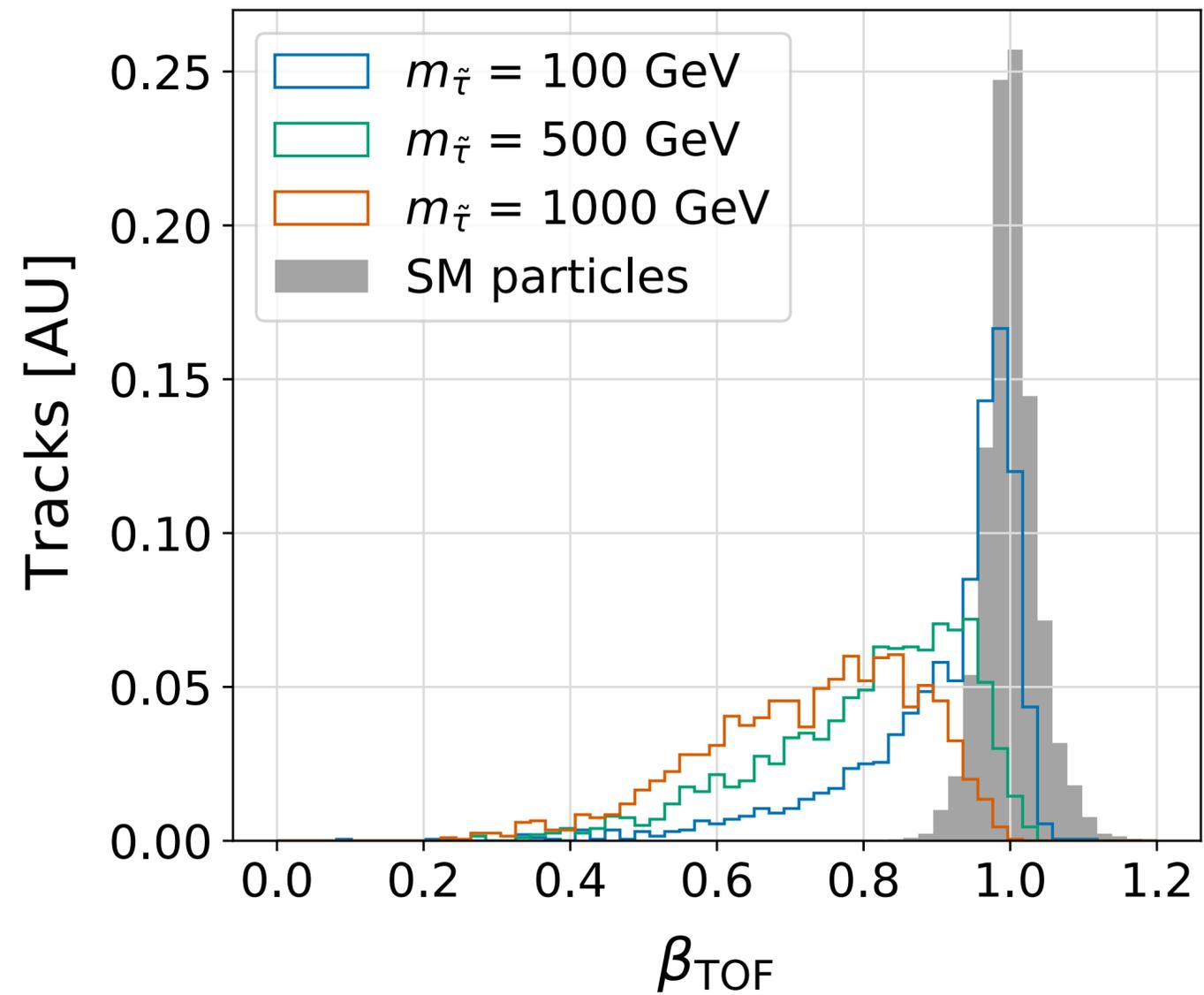
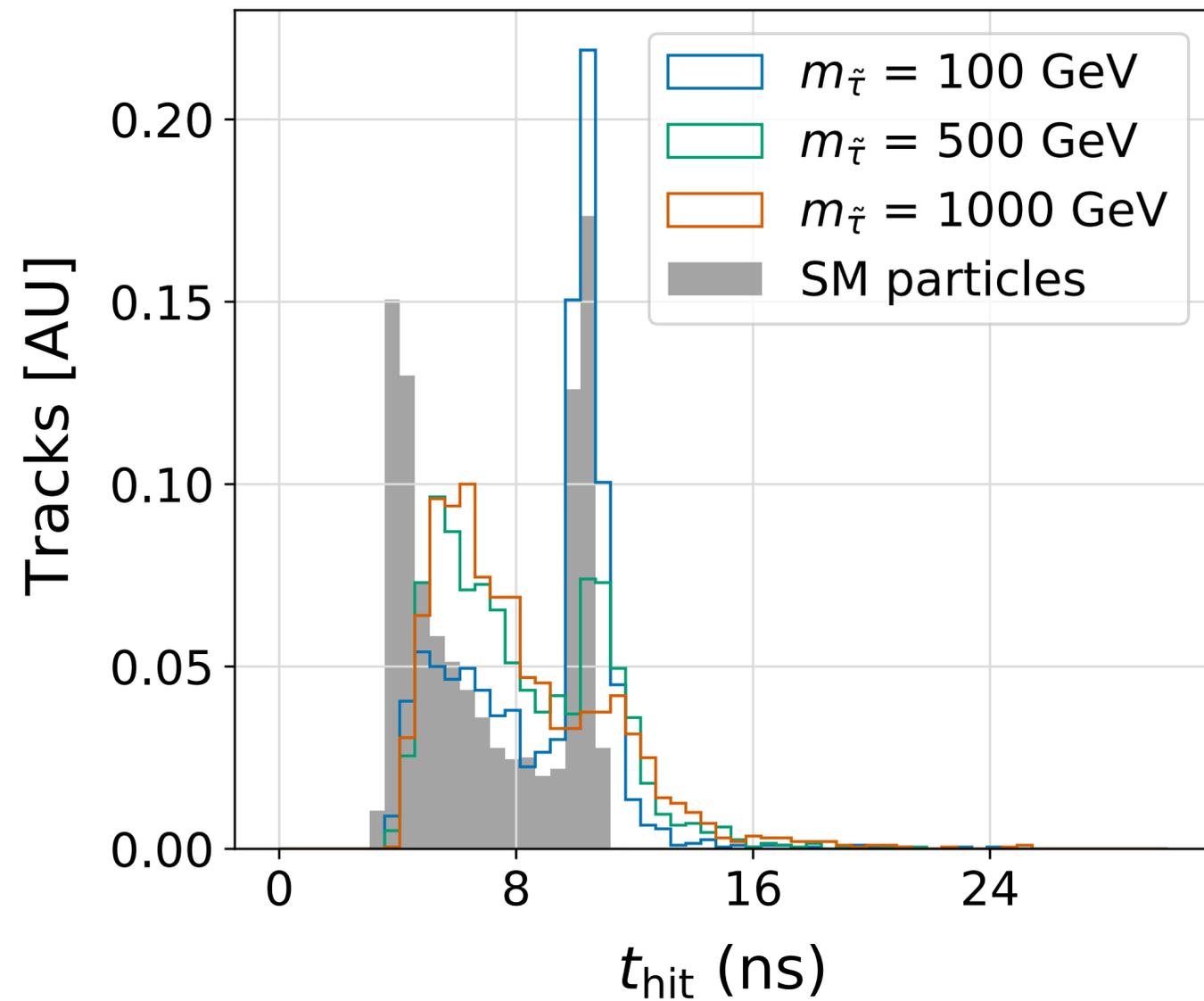
CMS STYLE TIMING LAYER

- ▶ Use PV position & 4-vector to find hit location & hit time
- ▶ Ignore path length from B-field (safe for tracks with $p_T > 10$ GeV)
- ▶ Smear to account for different contributions to hit & origin timestamps



beamspot time: gaussian with $\sigma = 200$ ps (dominant)
beamspot z_0 : gaussian with $\sigma = 50$ mm
timing hit resolution: gaussian with $\sigma = 50$ ps

HSCP TIMING



Our assumption: know track z_0 but not origin (time of pp-collision)