

# Status and Prospect of Search for Long-Lived Particles

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## <u>What are Long-Lived Particles (LLPs)?</u>

LLPs in this parlance: Beyond-Standard-Model (BSM) particles that travel macroscopic distances, compared to the detector resolution

## LLP searches: Motivation

Longer particle lifetimes (not a rare occurrence) may arise in both SM & (naturally in) BSM from  $\Gamma \sim y^2 \left(\frac{m}{M}\right)^n m$ 

hierarchy of scales

- Massive Mediators  $\cap$
- Small Phase Space Ο
- Small coupling Ο
- We may miss out on "New Physics" if we exclude the LLP search regimes

 $m \ll M$ 

- May answer many questions related to hierarchy and naturalness
- Calls for dedicated approach for triggering, reconstruction, background mitigation, etc, in the detector side.



#### LLP searches: Detector Caveats

- Standard Tracking: noise prone, Large Radius Tracking better suited
- Basic reconstruction algorithms may not be efficient to detect BSM LLPs or backgrounds from non p-p collisions.
- Constrained by detector dimensions
- Imperfect background mitigation/estimation

#### LLP Lifetimes in Standard Model



Most LLP decay searches are sensitive to the white band region between 1µm and 20m.

### <u>Aodel</u>

#### Signature Based Detection



<u>arXiv:1810.12602</u> gives a good summary of direct and indirect collider based LLP search methods.

You may also refer to Fig1 in arXiv:2212.03883



### Lifetime Limits: ATLAS LLP Searches



### Lifetime Limits: CMS LLP Searches

#### **Overview of CMS long-lived particle searches**

RPV

SUSY

SUSY RPC

Higgs+Other



#### **RECENT LLP SEARCHES**









Model-independent limits are set on the contribution from new phenomena to the signal-region yields.











## In Conclusion

- Multiple LLP search scenarios
  - Both ATLAS & CMS have set exclusion limits in multiple Run 2 analysis
  - Gives us a clear idea of regions to explore
- RUN-3 data incoming as we speak
  - More search regions would be covered
- Novel triggers, taggers, background estimation techniques & ML based algorithms are being developed
  - Ŵill increase acceptance in challenging regimes
- Need to focus on better detector design specs, minimize beam spread
- Large Radius Tracking in ATLAS is globally active in Run 3
  - Gives the ability to reconstruct displaced tracks
  - Increases numbers of signatures in non-prompt cases
- SUSY gives us some easily explorable LLP search scenarios in the current detector energy scales
- Many other results, both from ATLAS & CMS in the works (not included here)



## BACKUP







Cross Section view of The ATLAS Inner Detector



Cross Section of The CMS detector