

Long-Lived Particle Searches at B Factories:

Improving Discovery Prospects for Hidden Sectors

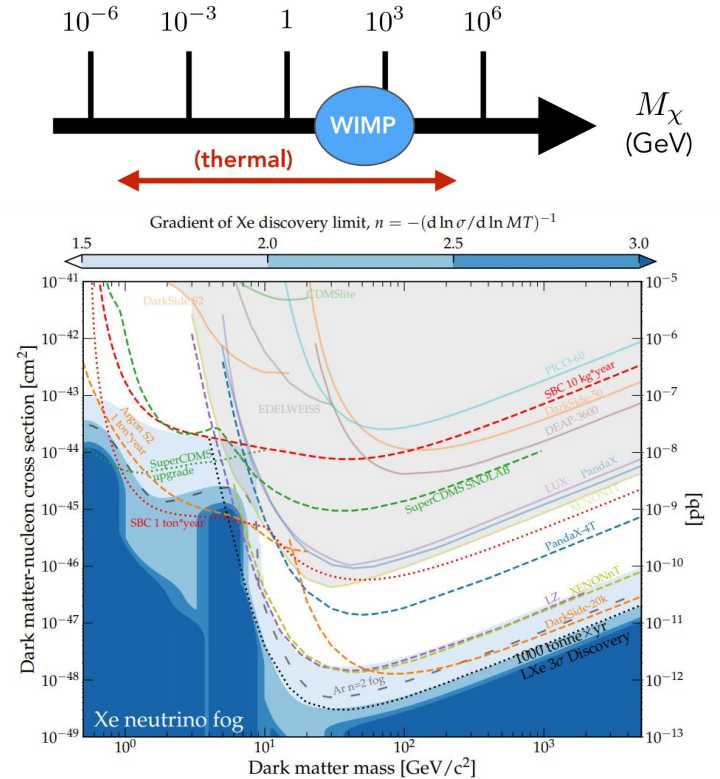
Albany Blackburn

Harvey Mudd College

International Conference on Interconnections Between
Particle Physics and Cosmology

Based on work with M. Acevedo, N. Blinov, B. Shuve, M. Stone, 2105.12744,
JHEP 09 (2021) 154.

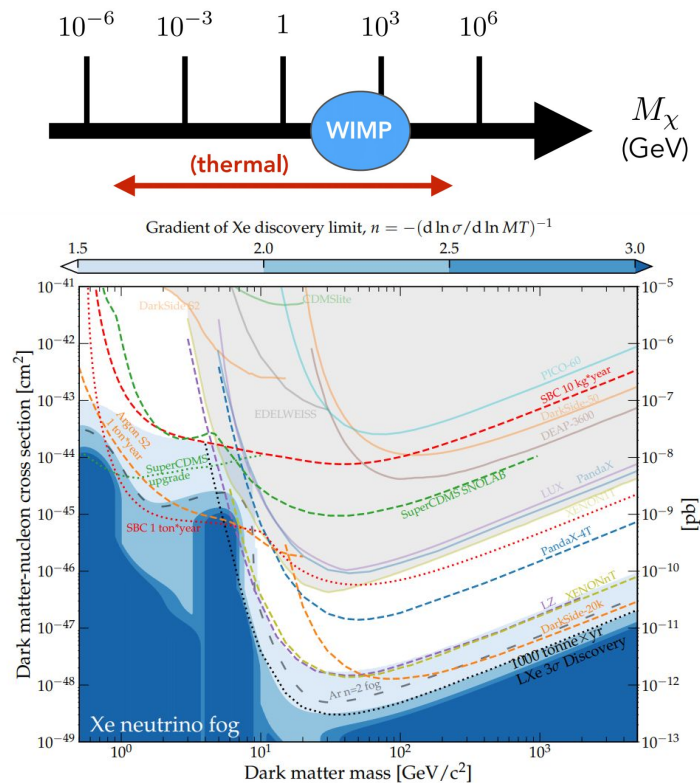
The Search for Hidden Sectors



The Search for Hidden Sectors

High Mass DM Models

- No positive signals yet
- Highly constrained parameter space

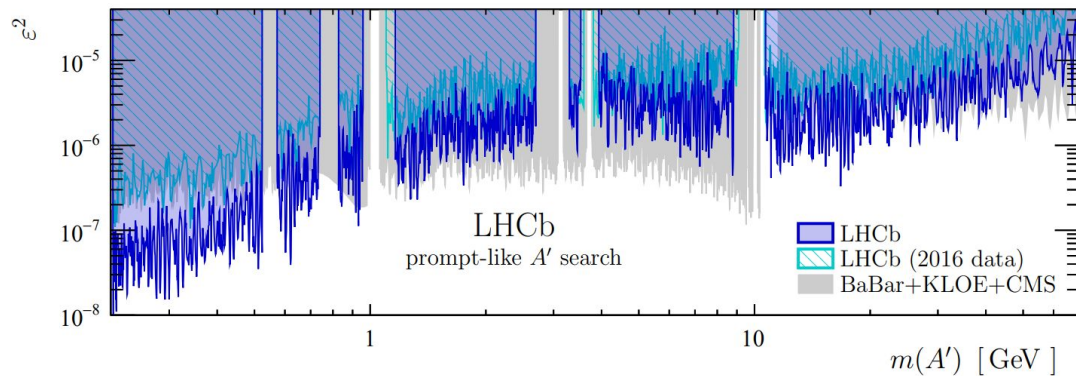


Exclusive Searches

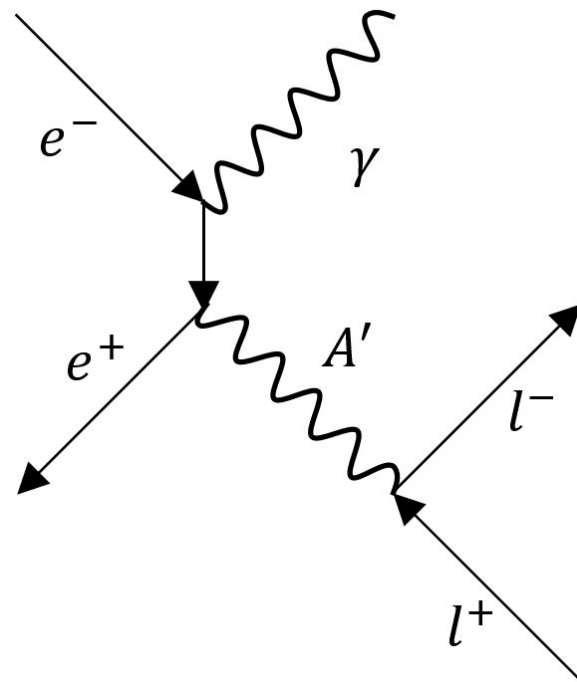
Optimized for certain production and decay modes for a given hidden sector particle

Exclusive Searches

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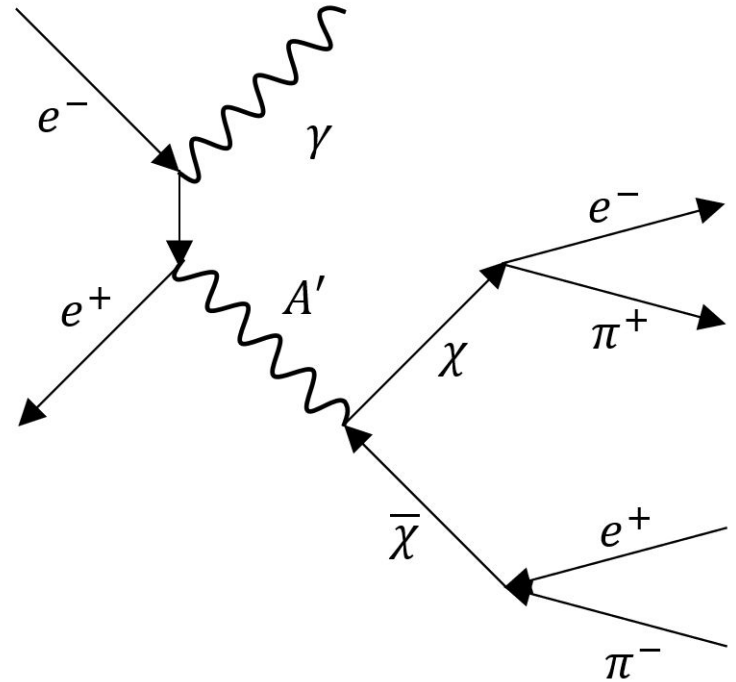
LHCb, 1910.06926 [PRL]



Exclusive Searches: Limitations

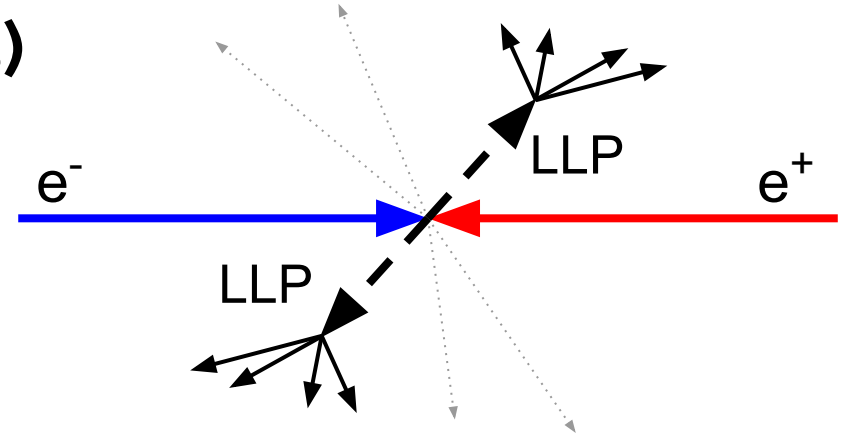
Optimized for certain production and decay modes for a given hidden sector particle

Broad range of hidden sectors could be missed/would require many searches



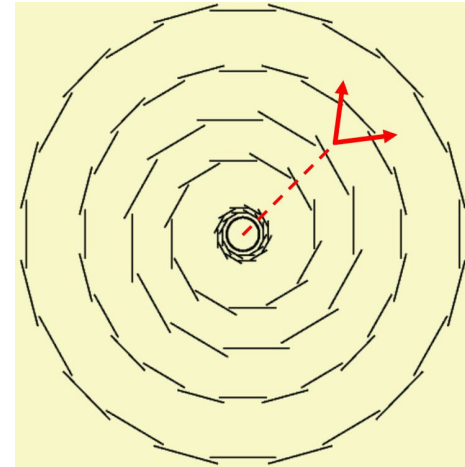
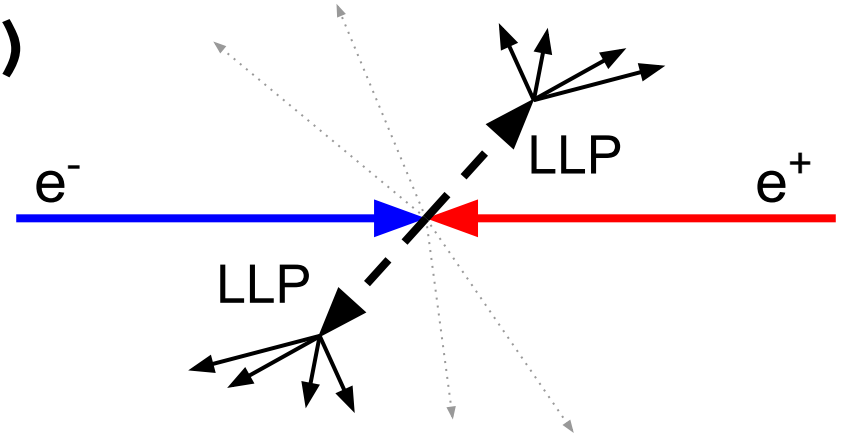
Long-Lived Particles (LLPs)

Decay sufficiently far away from collision point that the decay point can be reconstructed



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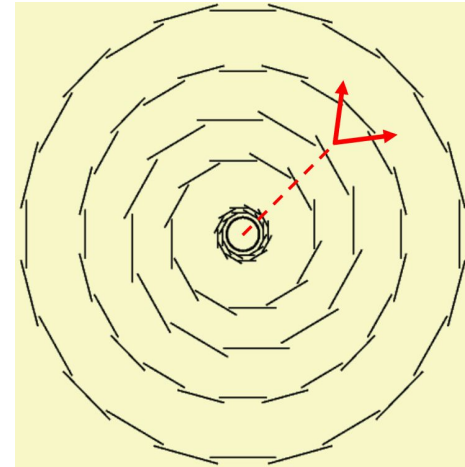
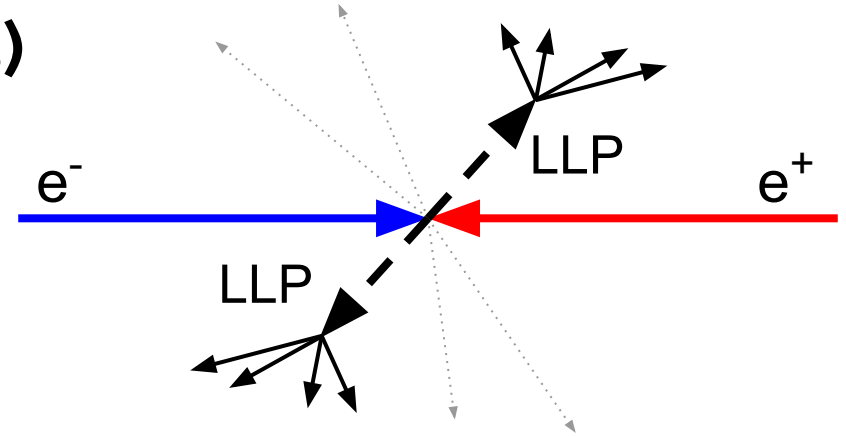
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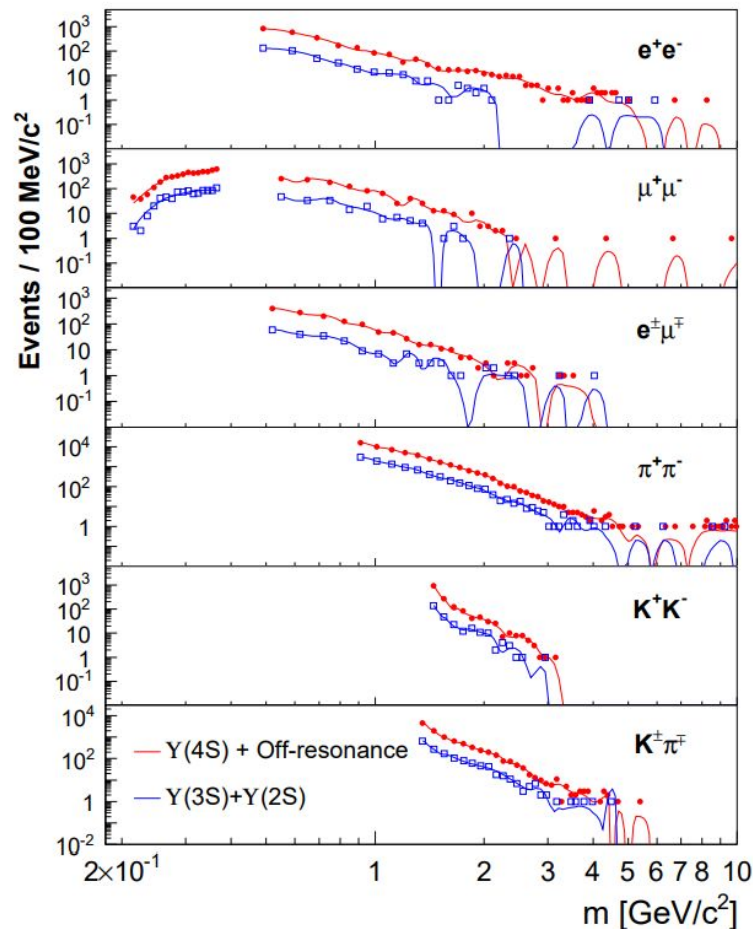
Decay sufficiently far away from collision point that the decay point can be reconstructed

Daughter particle trajectories used to create displaced vertex



BaBar LLP Search

- Inclusive with respect to LLP production mode
- Requires reconstruction of LLP invariant mass



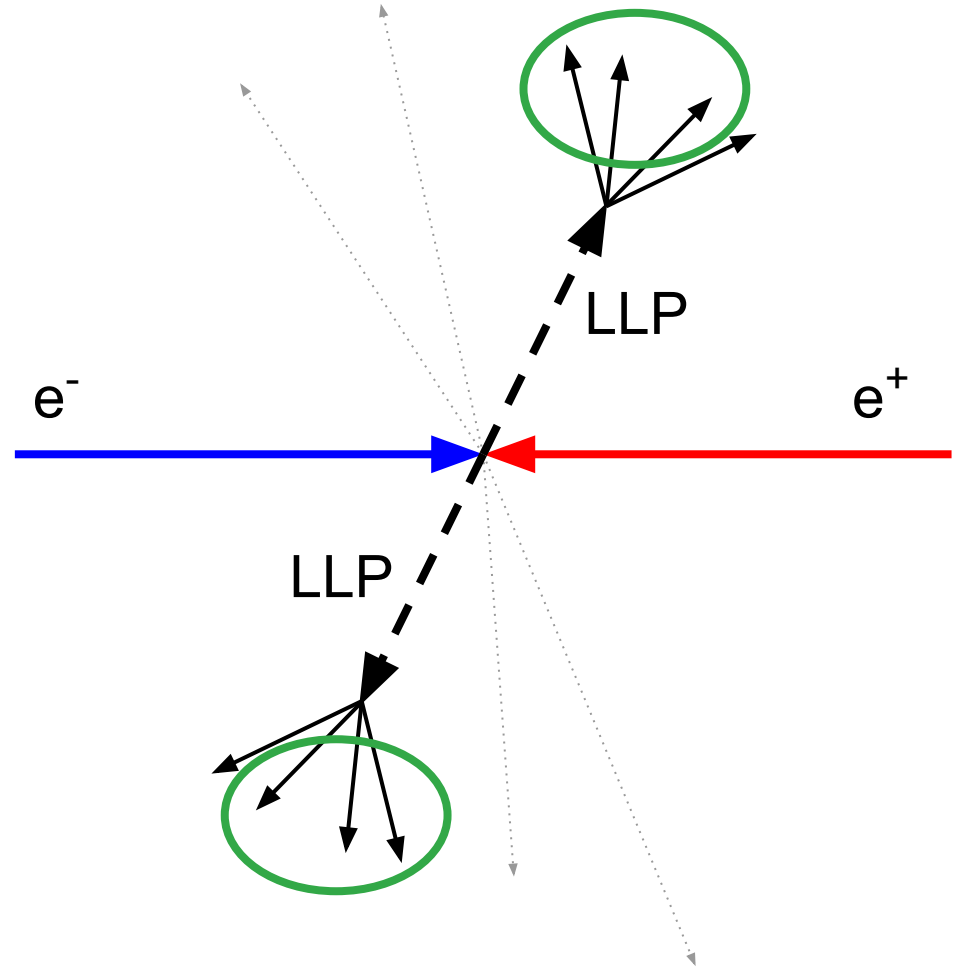
Our Search Strategy

Search for one or more displaced vertices and/or two or more tracks from the vertex

Our Search Strategy

Example requirements:

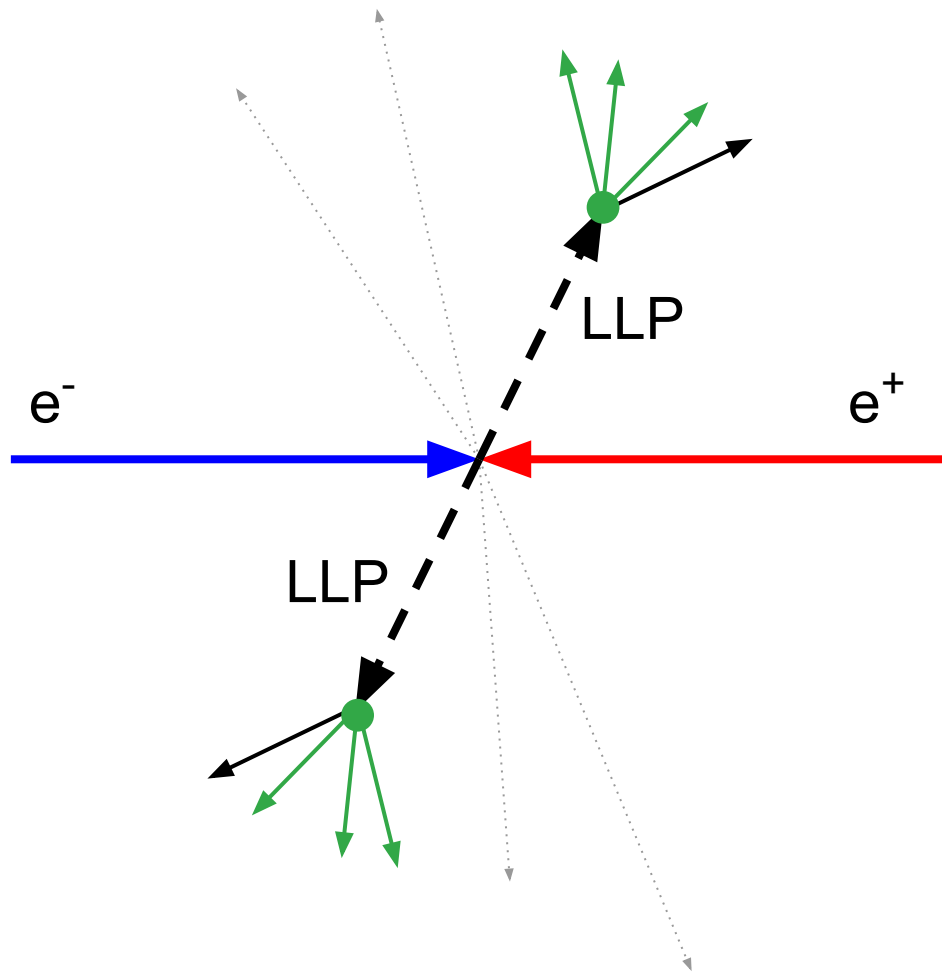
- 2 vertices
- 3 tracks/vertex



Our Search Strategy

Example requirements:

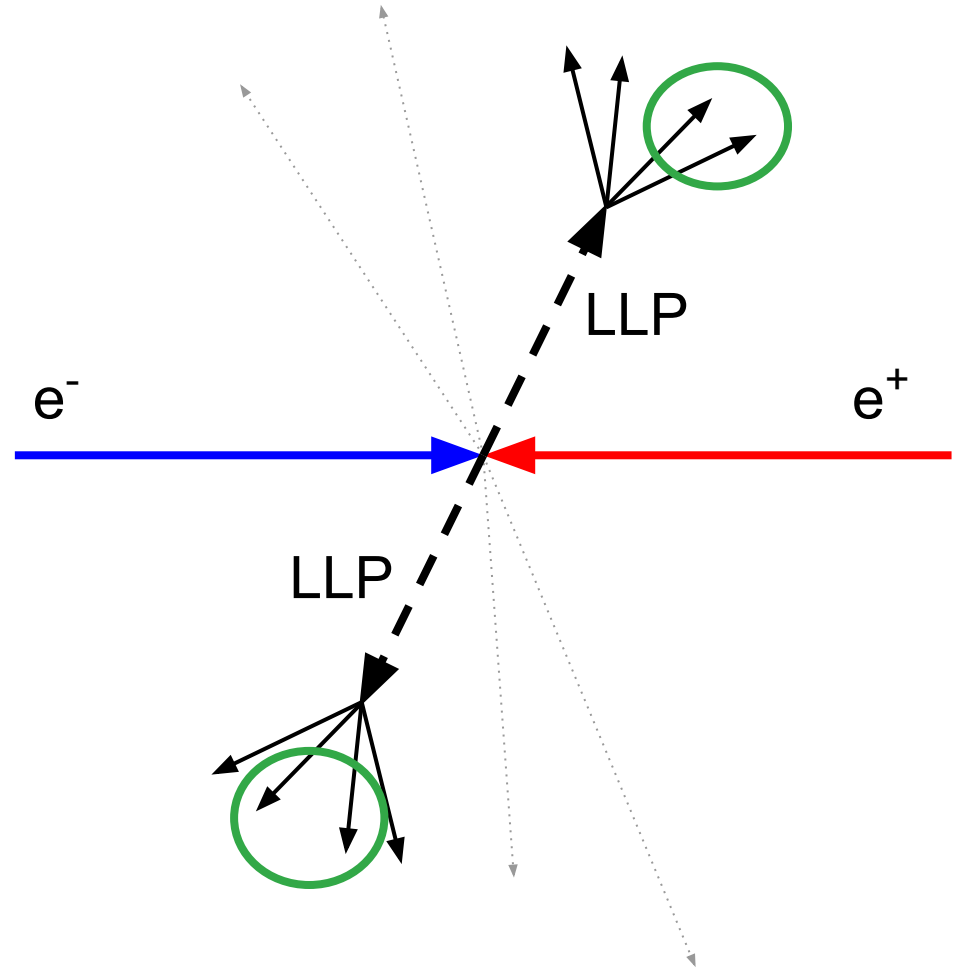
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Our Search Strategy

Example requirements:

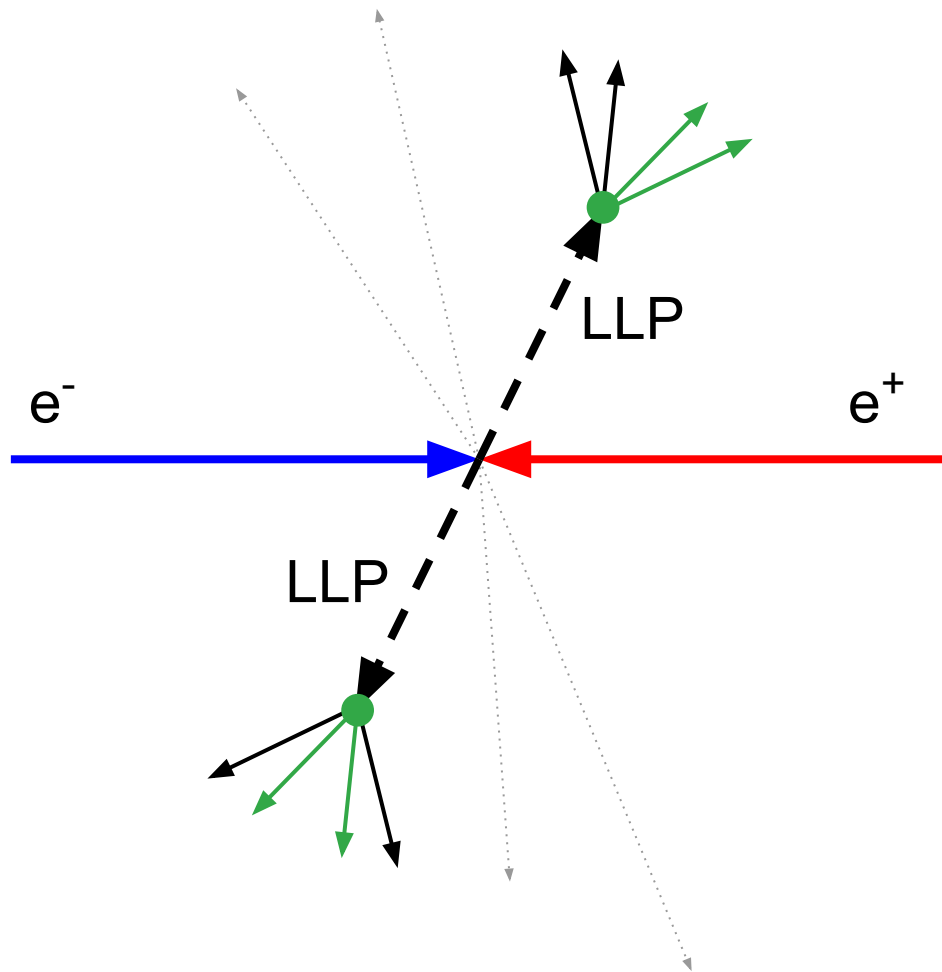
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Our Search Strategy

Example requirements:

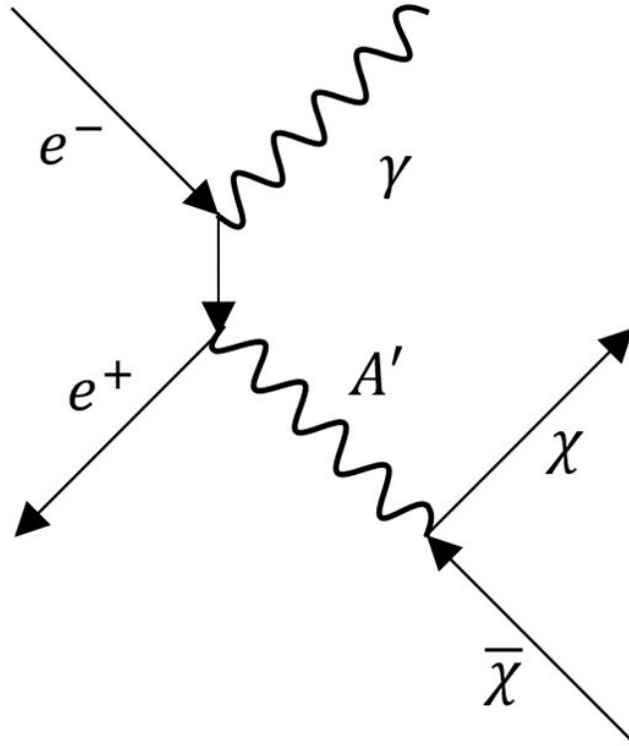
- 2 vertices
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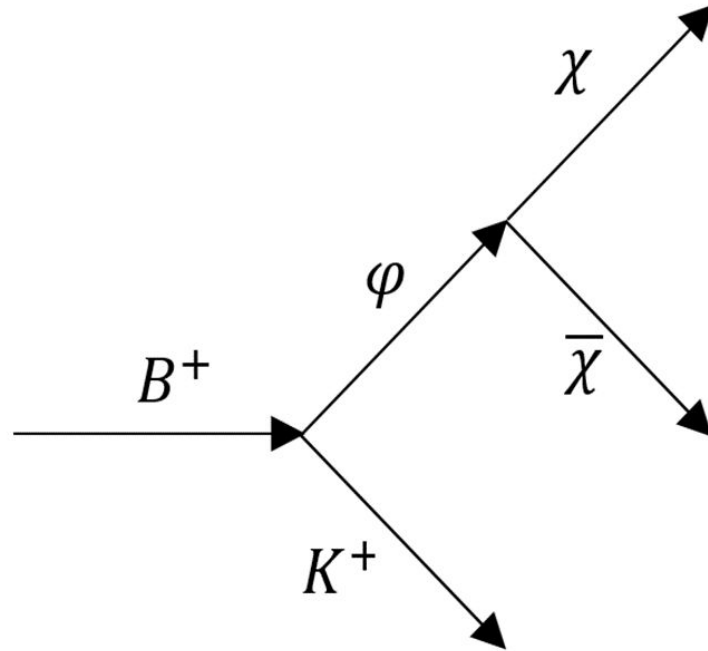
Analysis

- Simulate data according to Belle II parameters
 - MadGraph5 LLP production and decay based on custom models
 - Pythia8 showering and hadronization (where relevant)
- Attempt to reconstruct displaced vertex/vertices
 - Displaced vertex distance ($0.2 \text{ cm} < r < 60 \text{ cm}$ with varying efficiency)
 - Daughter particle momentum ($p_T > 100 \text{ MeV}$)
- Calculate sensitivity for specific LLP parameters

Dark Photon Production Mode

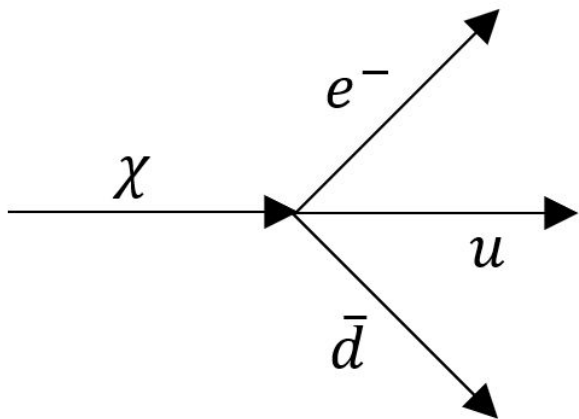


Dark Higgs Production Mode



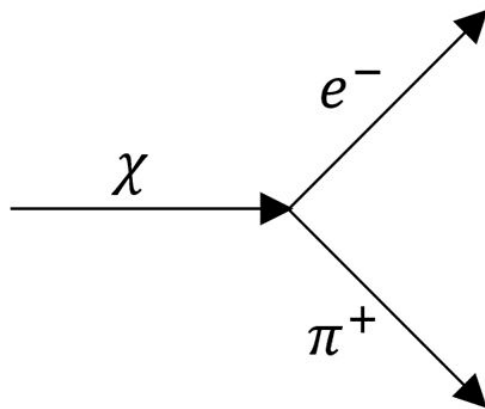
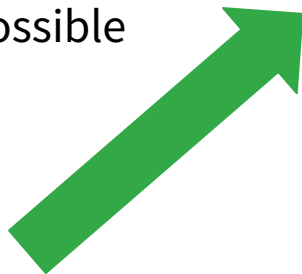
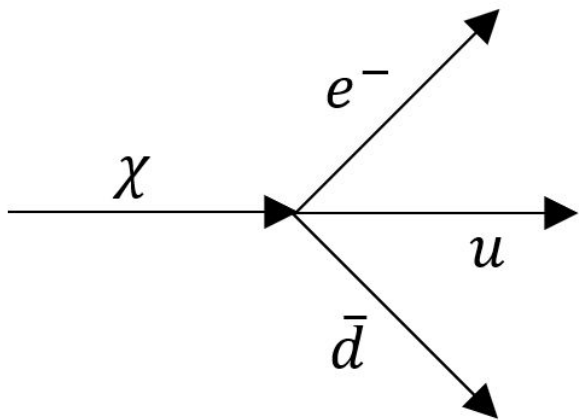
LLP Decays

- EFT to categorize possible decays
- Neutral LLPs decay to at least 2 charged particles, but additional states possible



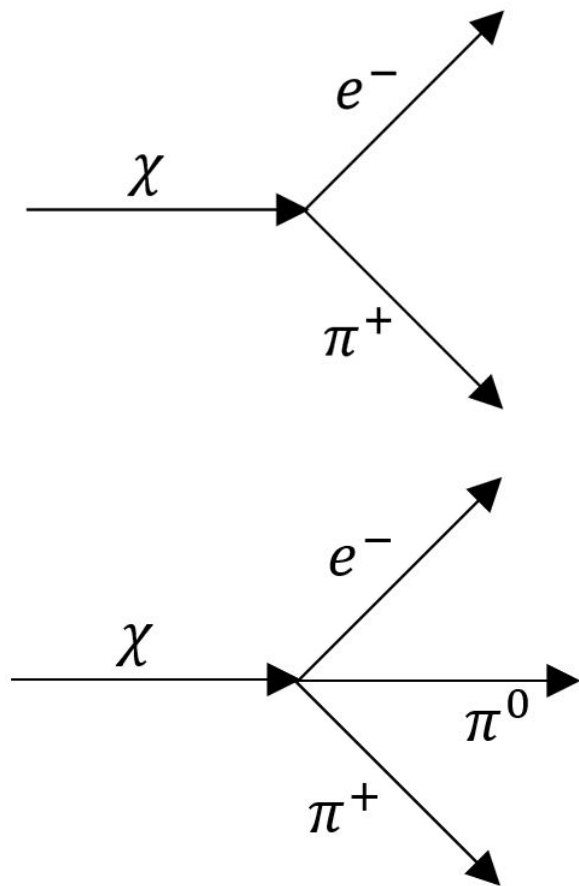
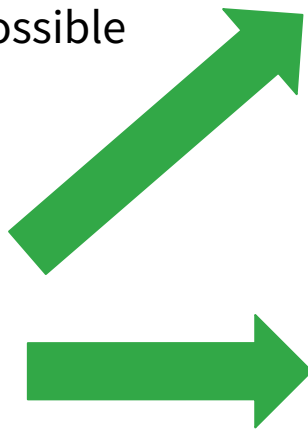
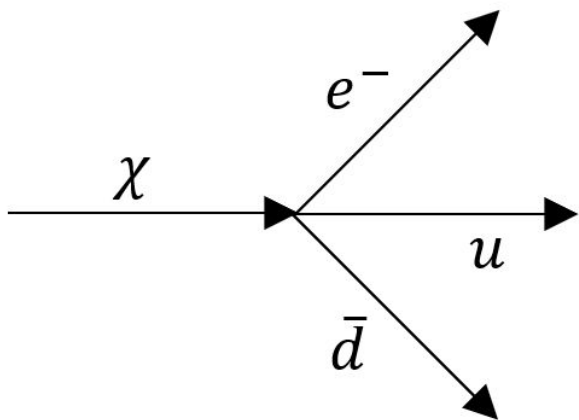
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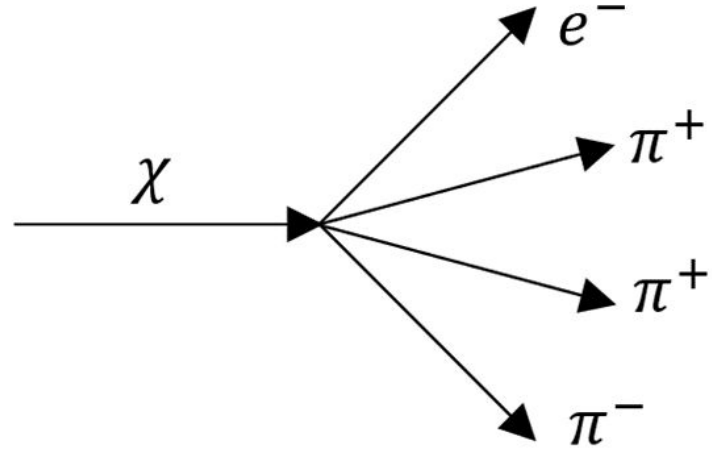
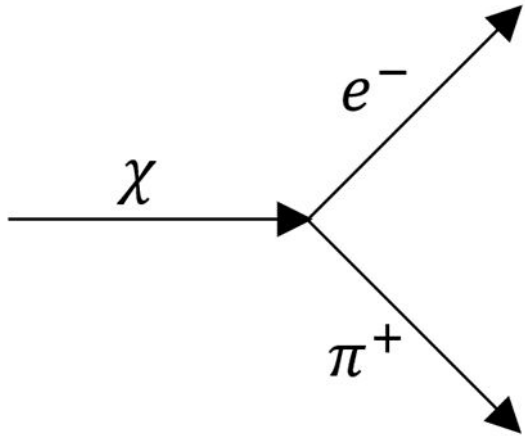


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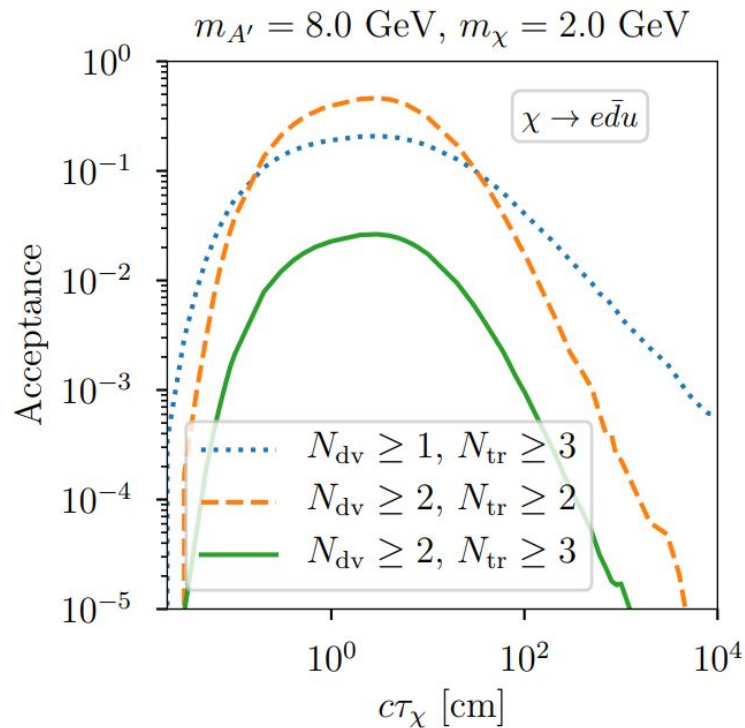
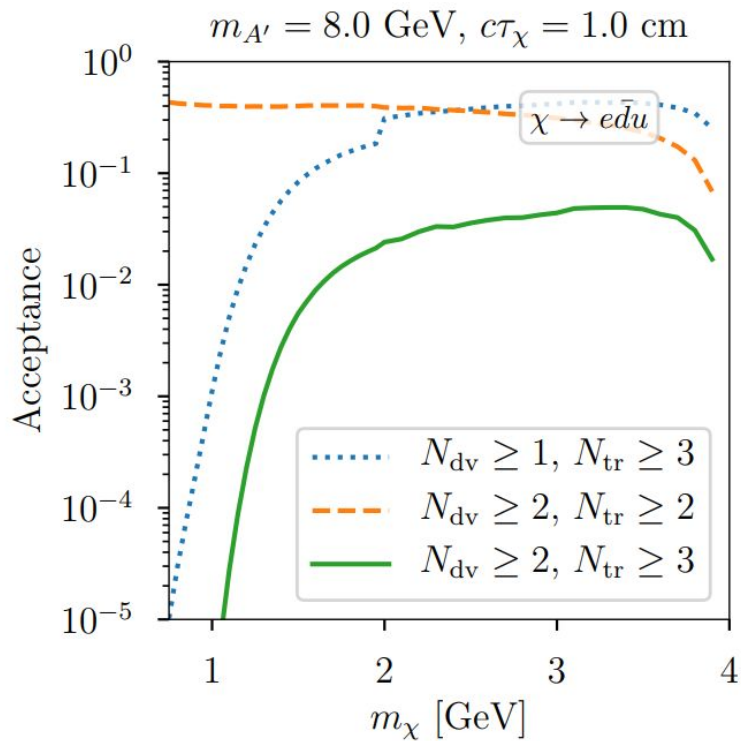
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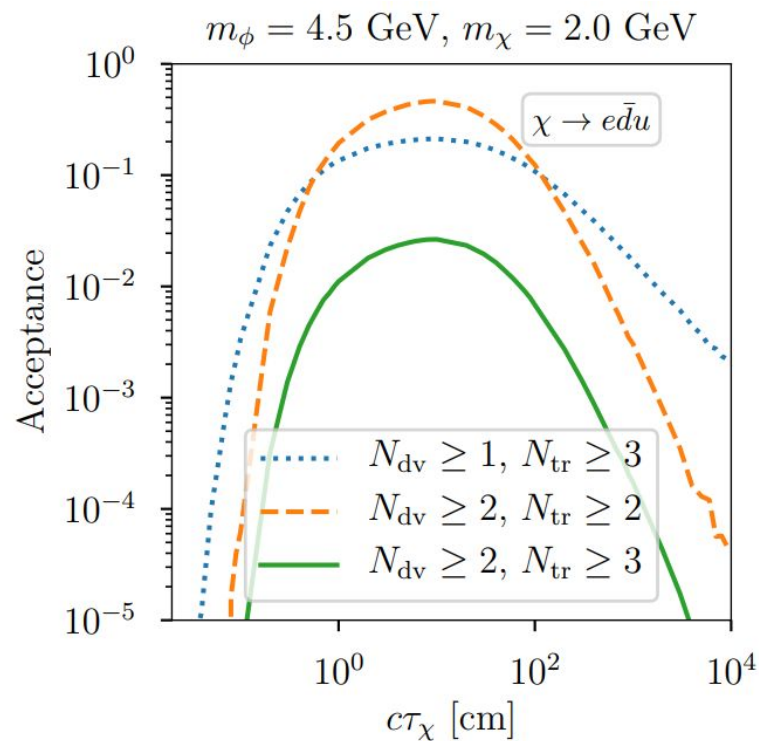
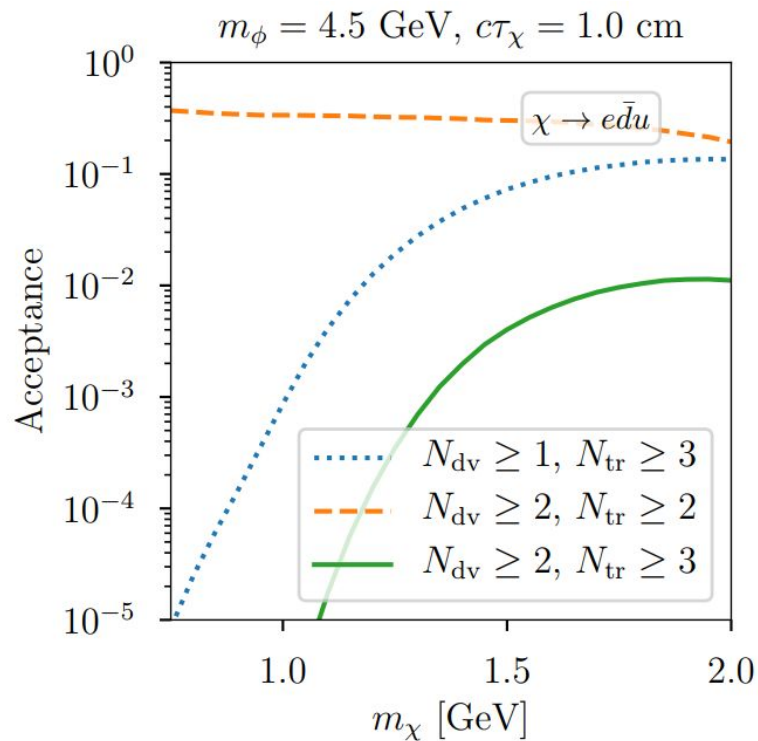
Semileptonic LLP Decay



Acceptance: Dark Photon Model



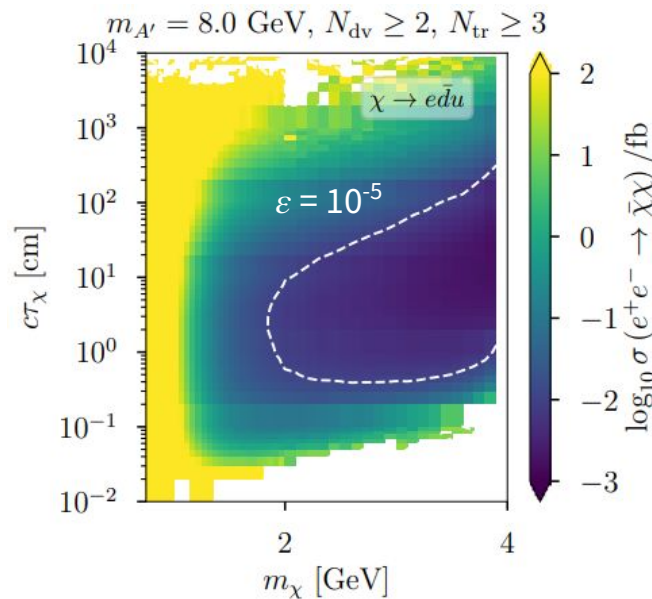
Acceptance: Dark Higgs Model



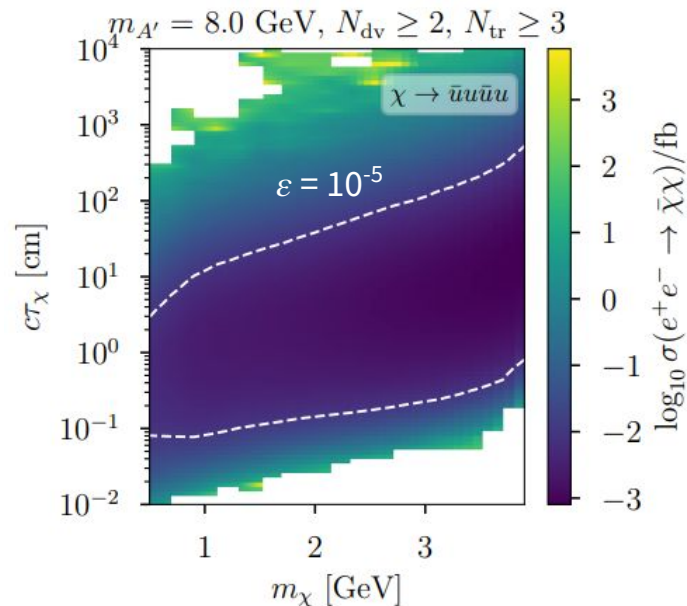
Cross Section Sensitivity Plots

10 event sensitivity, 50/ab at Belle II

Semileptonic



Fully Hadronic



Conclusion

- Excellent sensitivity to a variety of production and decay modes
 - Exciting prospects for results at Belle II
- Future work investigating search strategy on BaBar data
 - BaBar group at HMC focused on hidden-sector searches