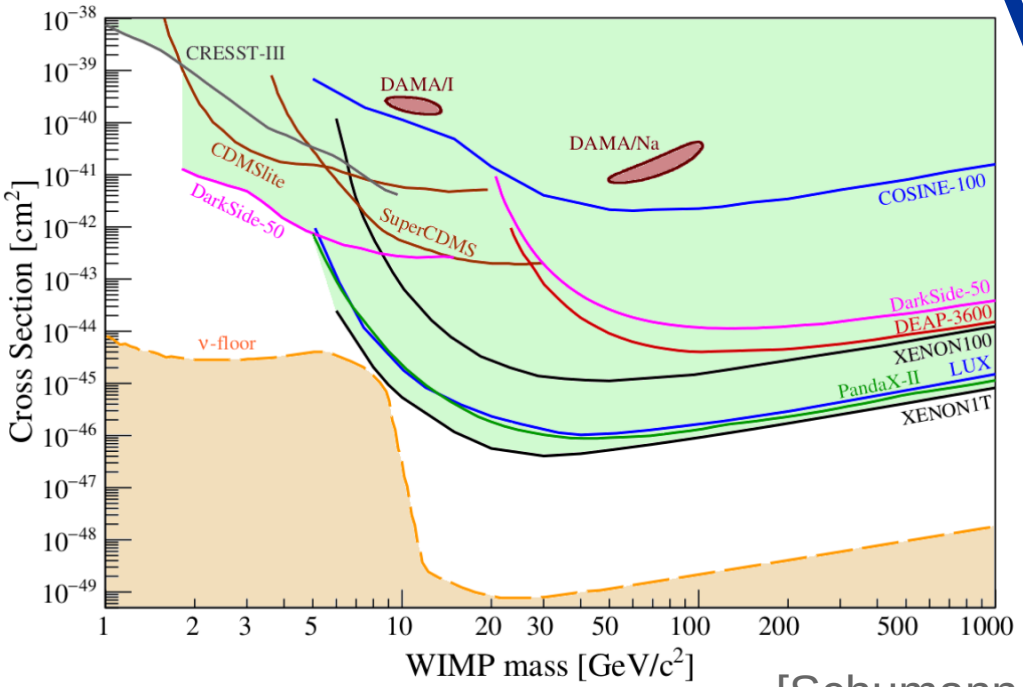
Inelastic Dirac Dark Matter

Sam Junius

Based on JHEP 06 (2022) 048

Direct detection puts strong bounds on thermal dark matter



[Schumann '19]

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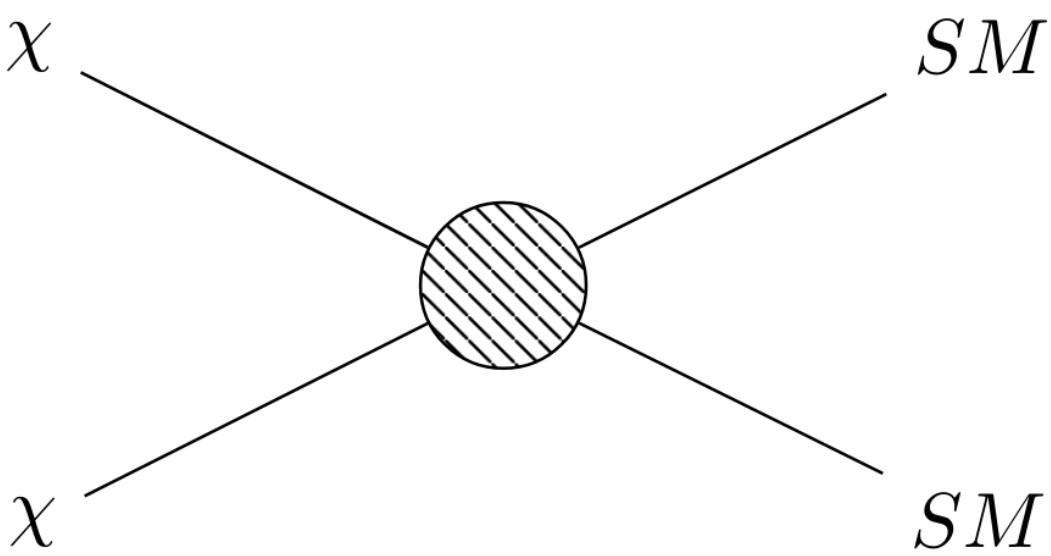
Self-annihilation

Elastic scattering



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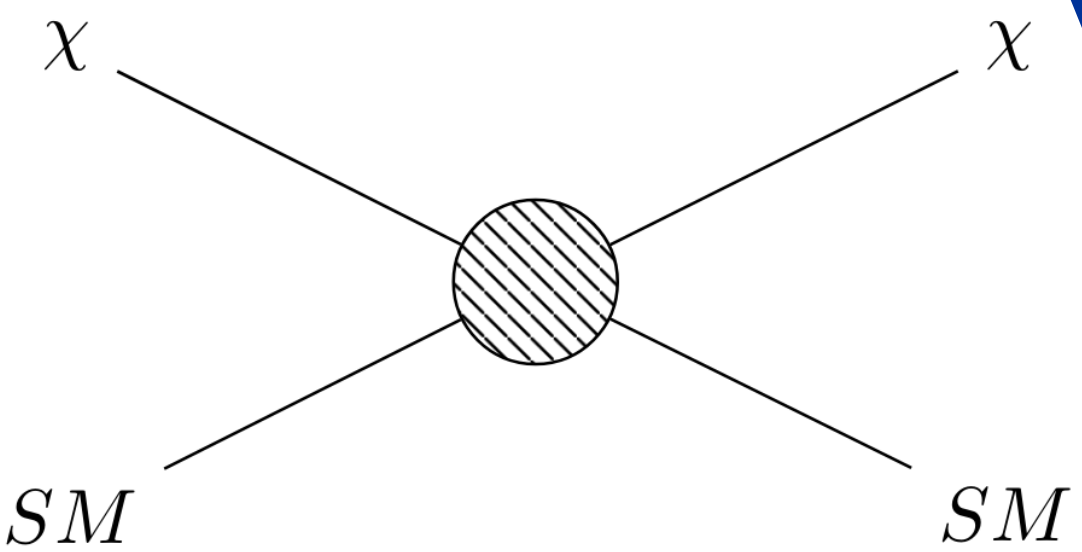
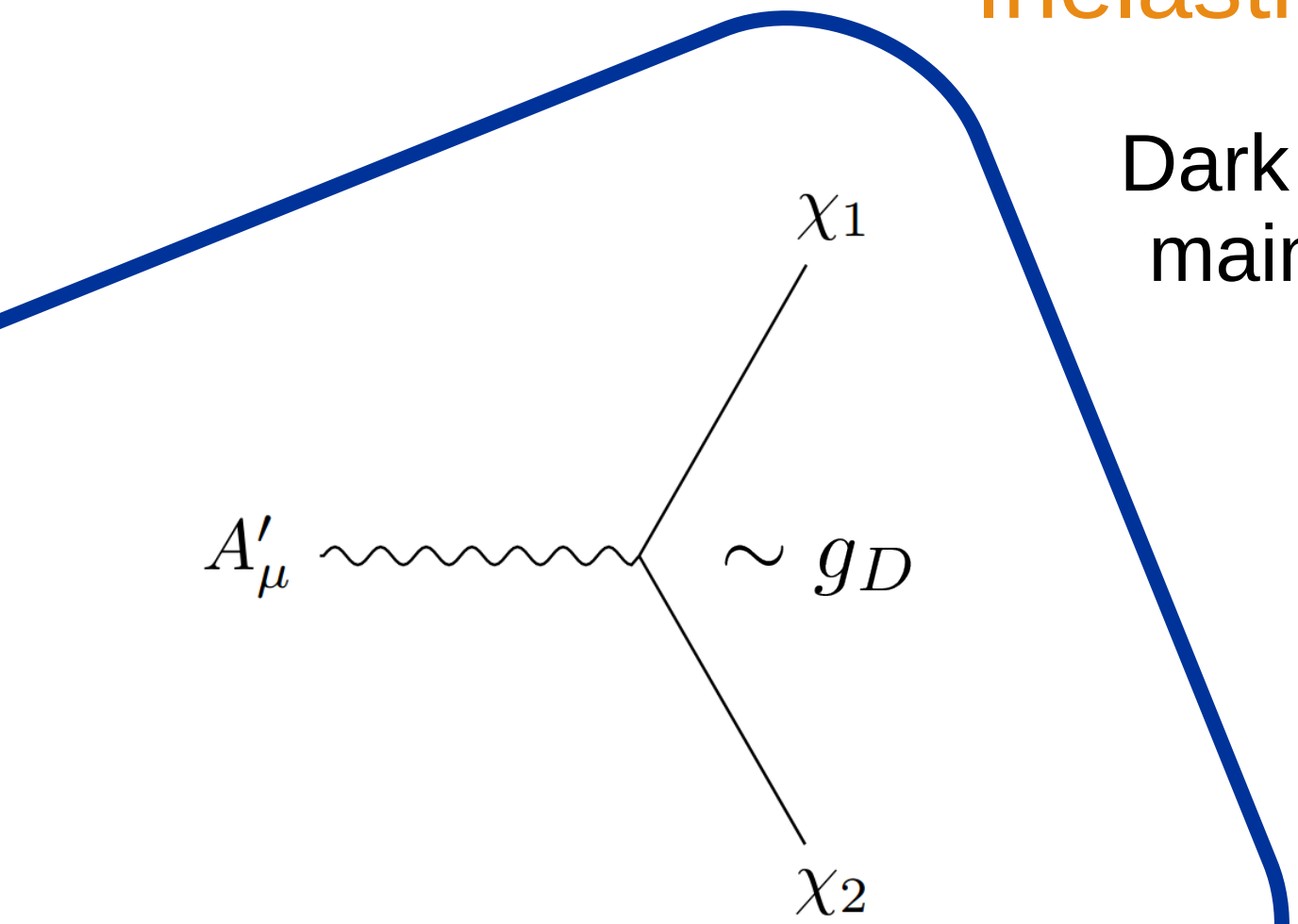


Inelastic Dark Matter

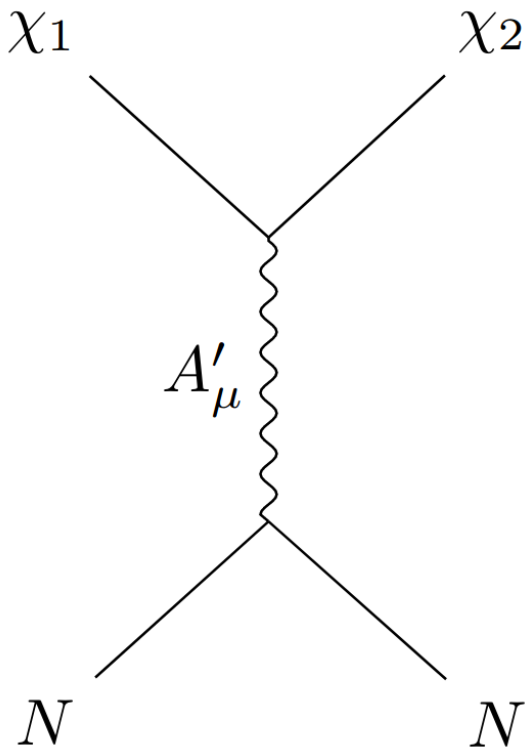


Dark fermions couple mainly off-diagonally with dark photon

Weaker direct detection bound

Thermal through co-annihilation

Inelastic Dark Matter



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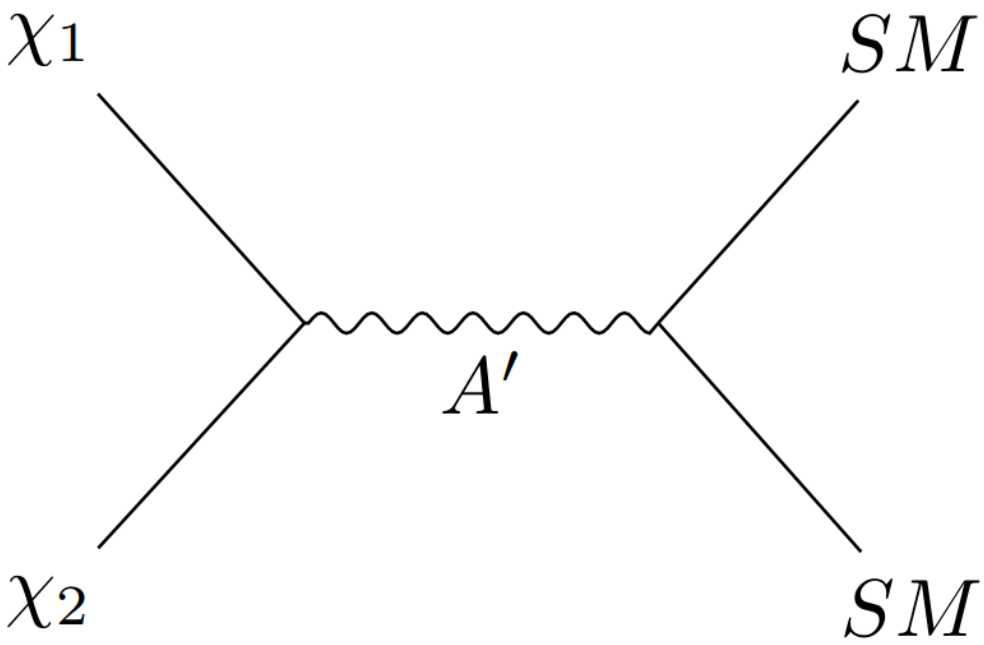

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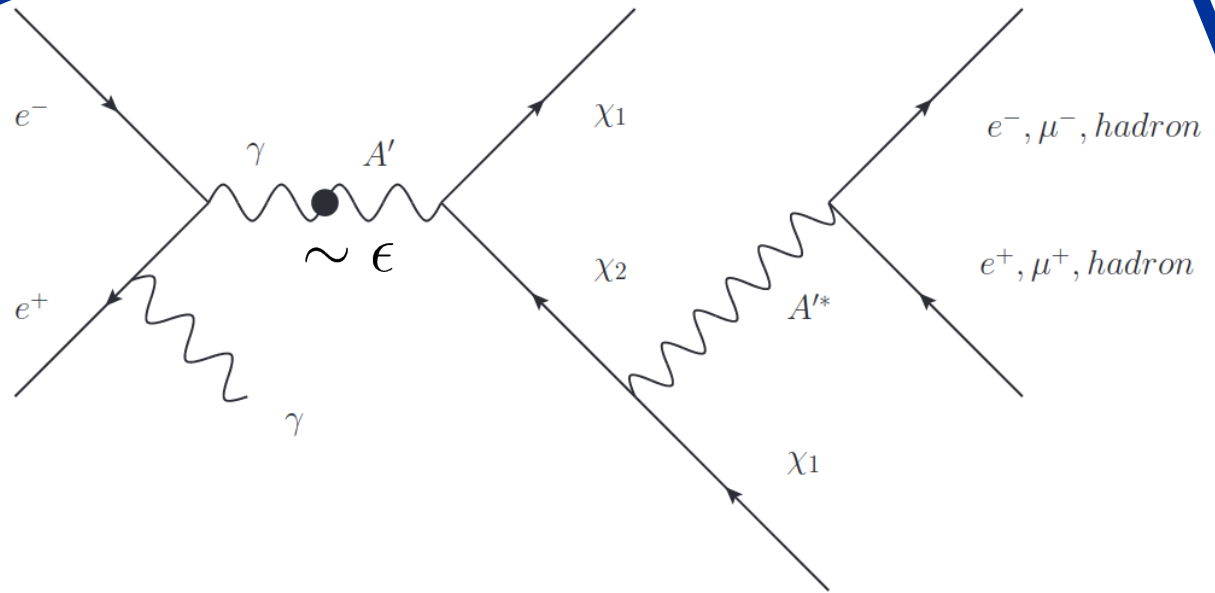
Inelastic DM detection



Colliders

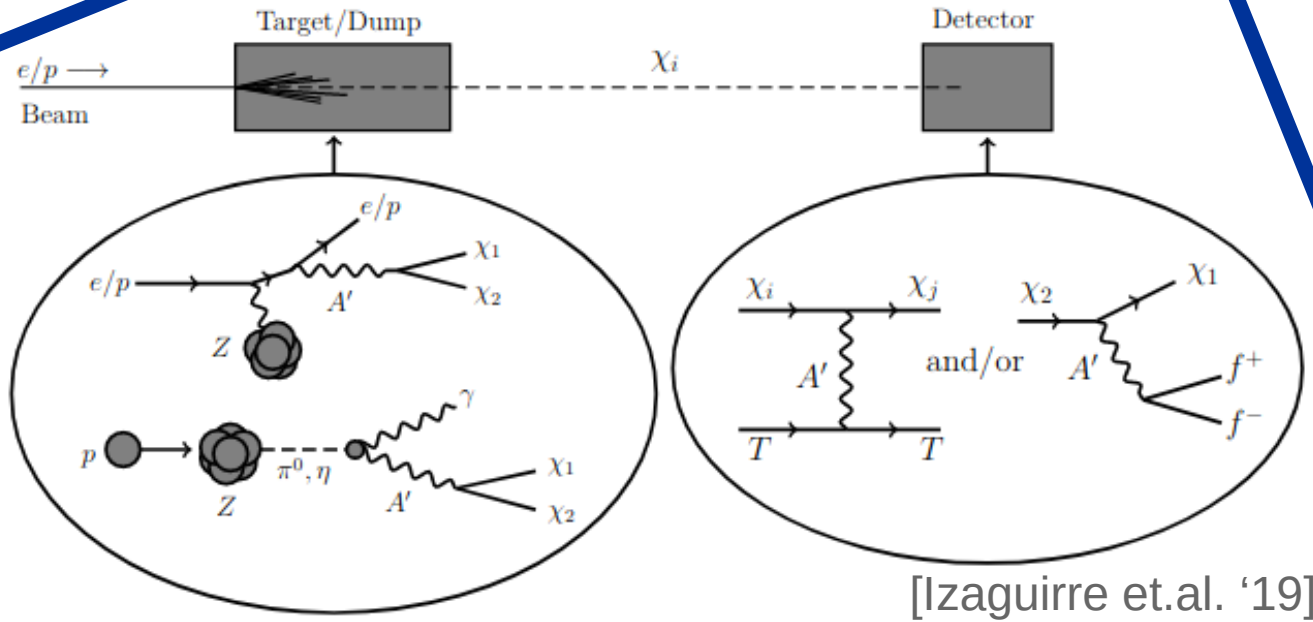
- Displaced signature
- Mono-photon

Inelastic DM detection

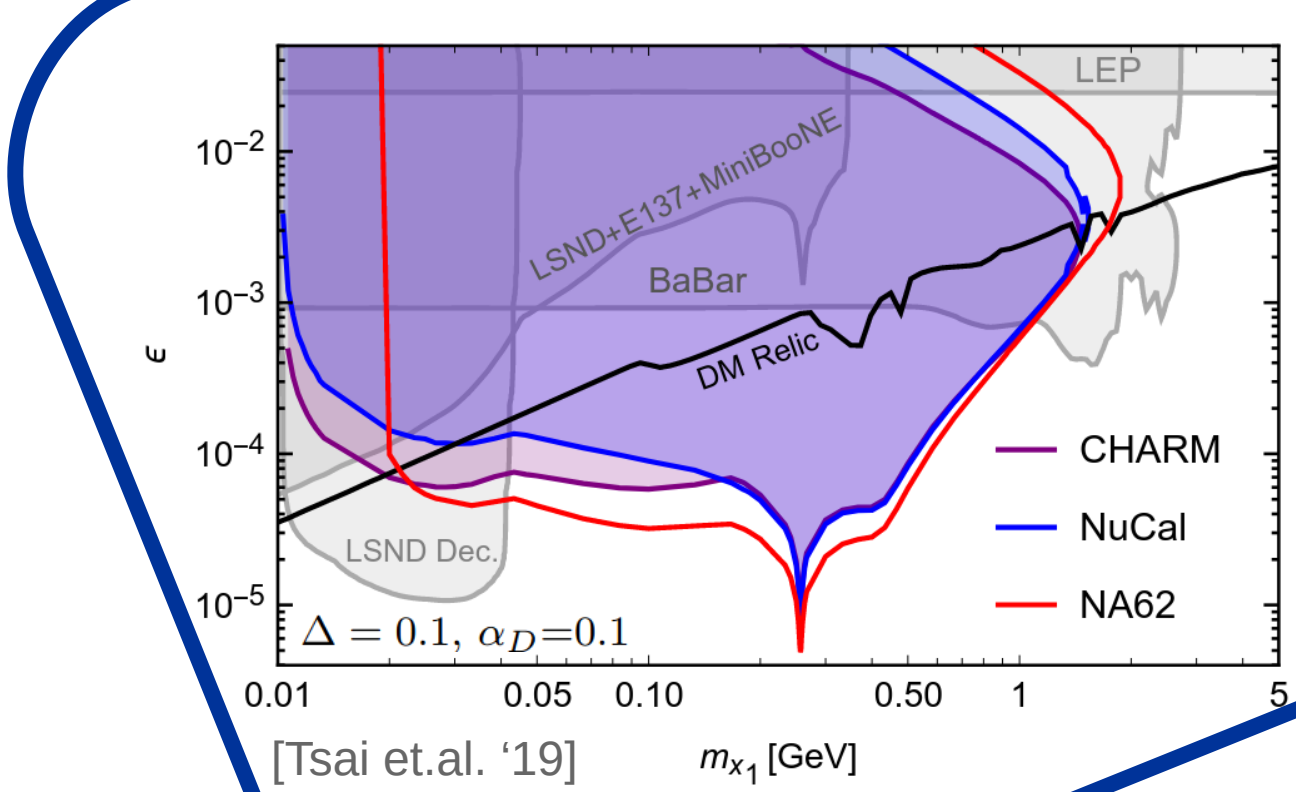
Colliders

Beam-dump

- Scattering
- Decay



[Izaguirre et.al. ‘19]



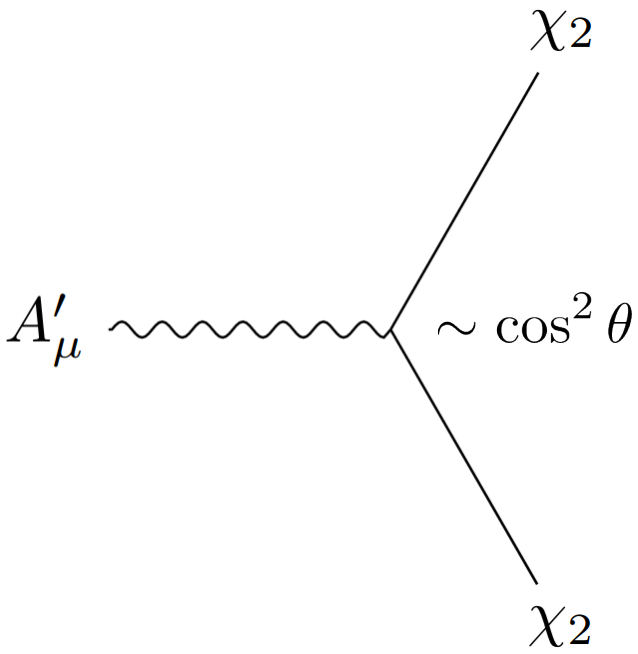
[Tsai et.al. '19]

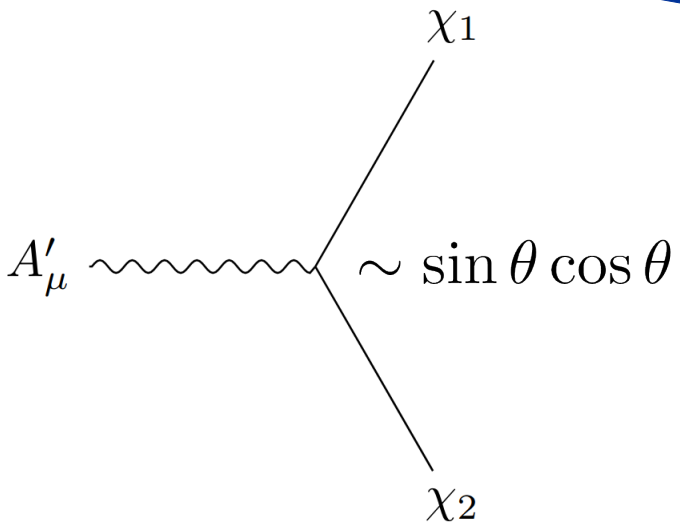
iDM is highly constraint
by beam-dump experiments

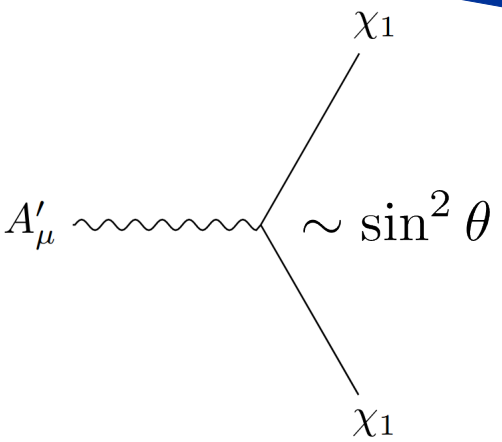
Inelastic Dirac Dark Matter (i2DM)

Mixed Dirac states
one charged one neutral under $U(1)_D$

A'_μ couples mainly to χ_2







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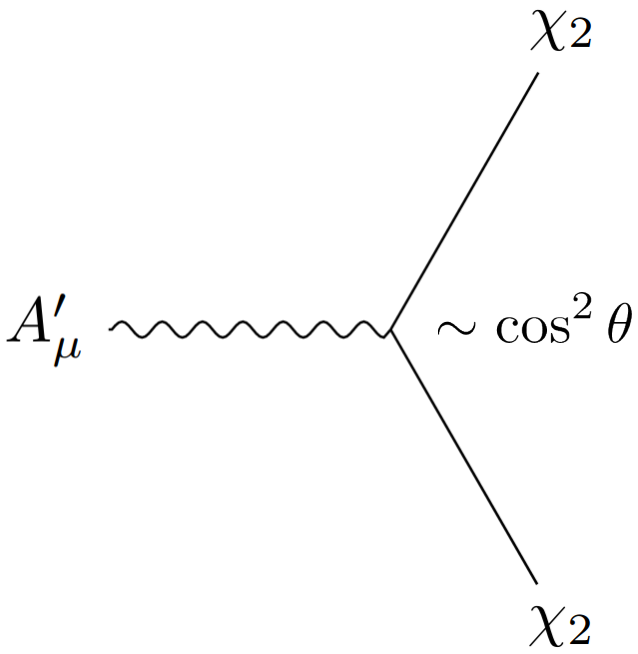
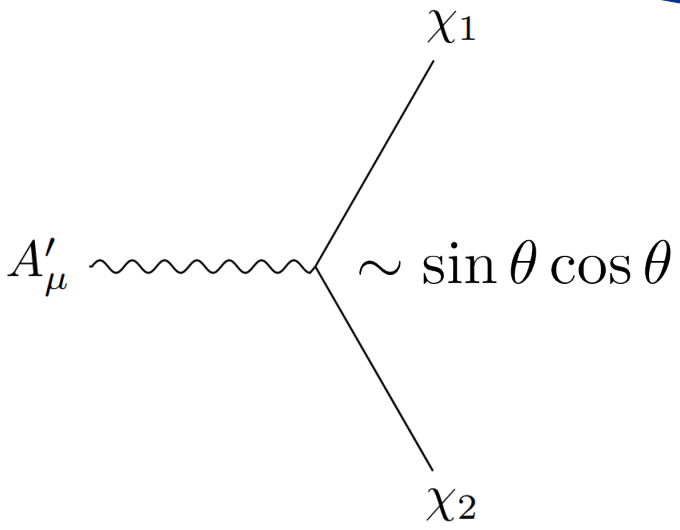
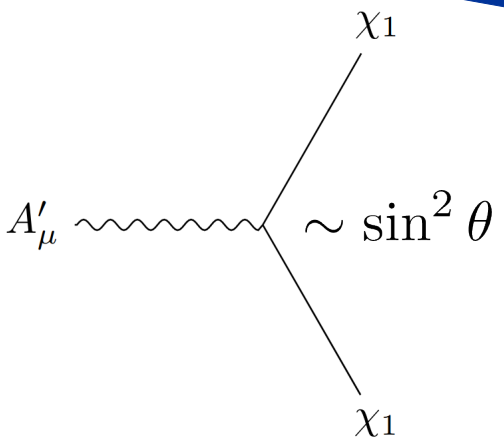
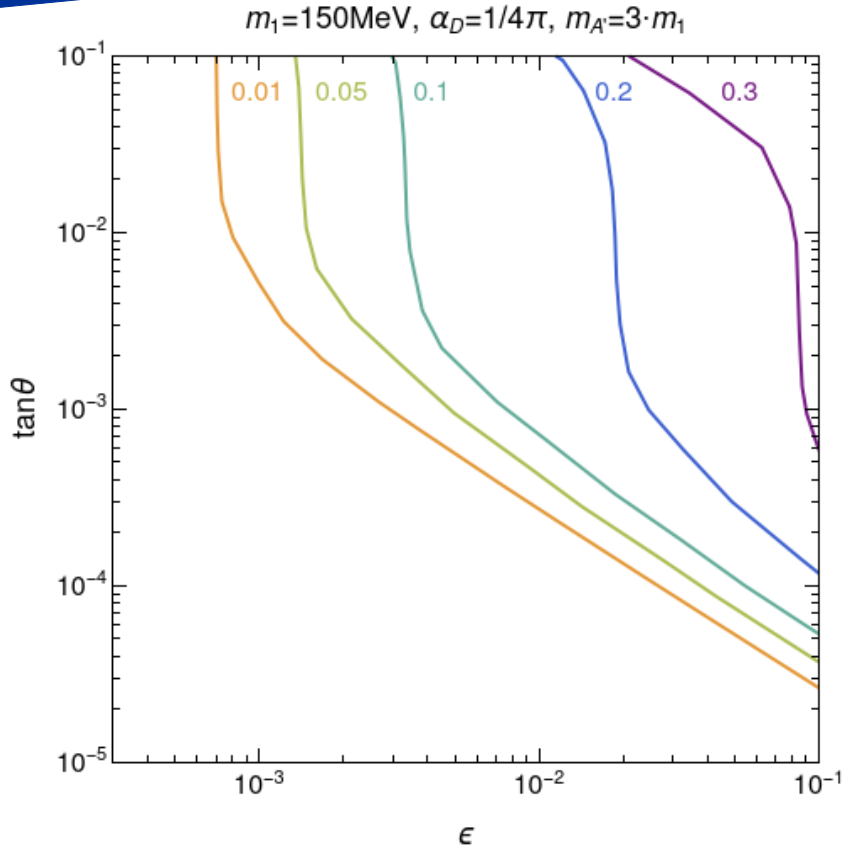






Larger viable DM parameter space



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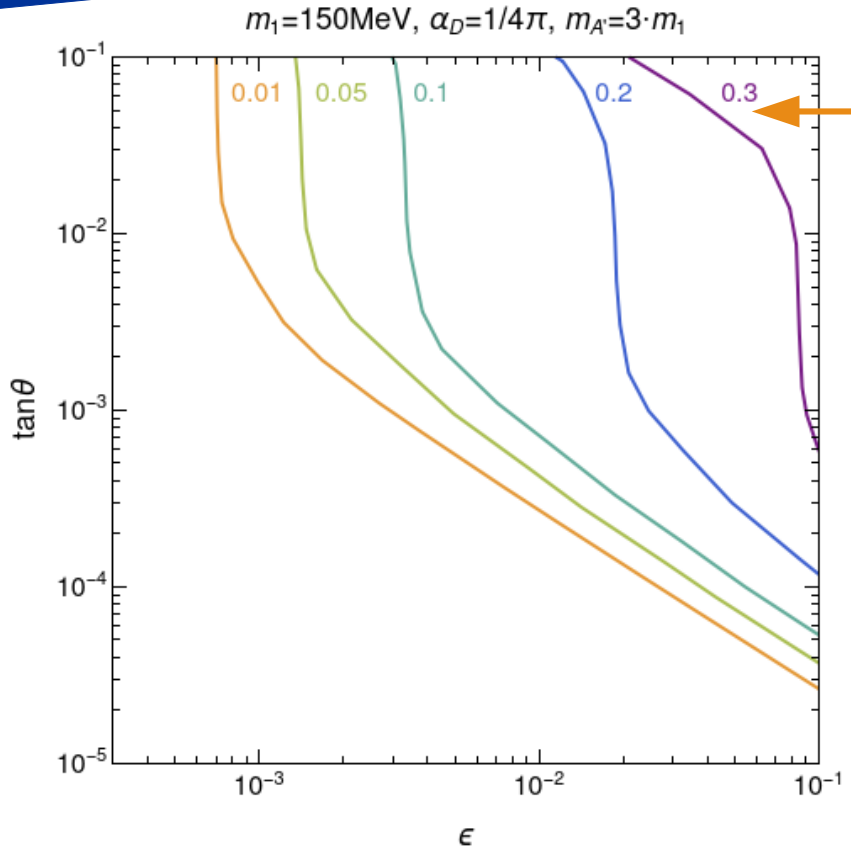
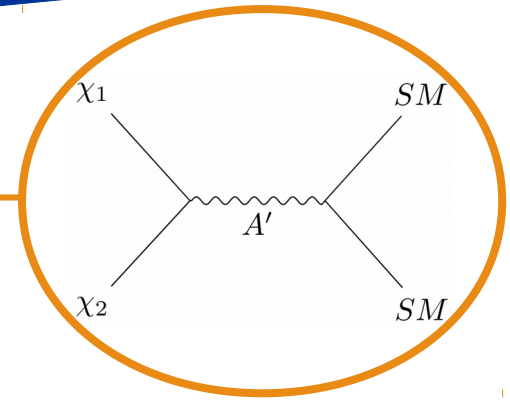
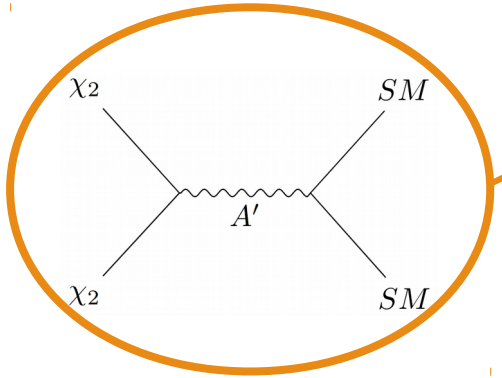


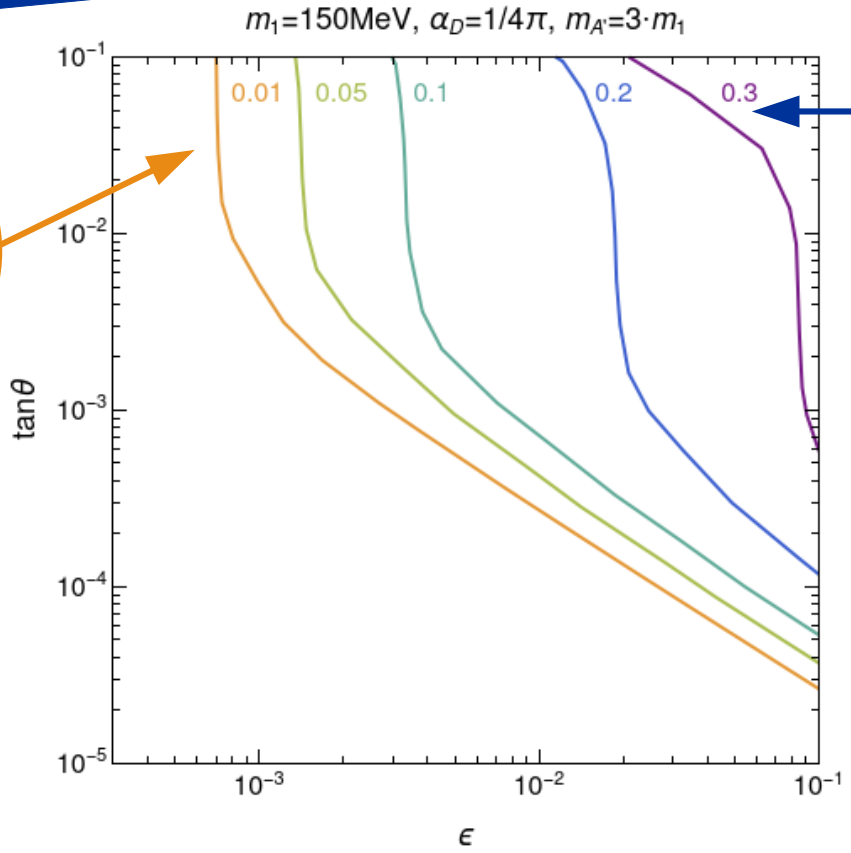


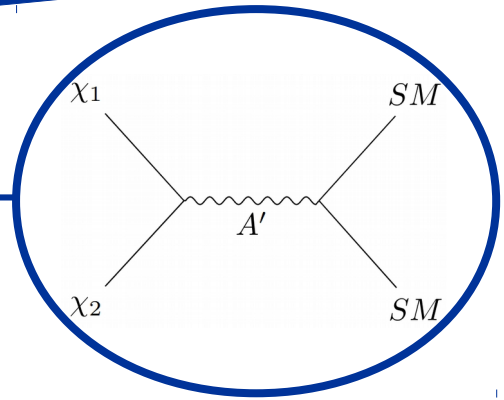
Co-annihilation

Larger viable DM parameter space



Mediator Annihilation





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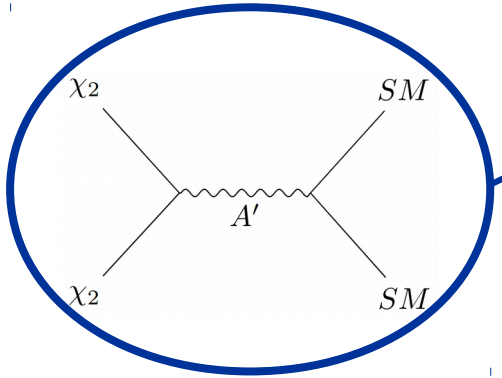
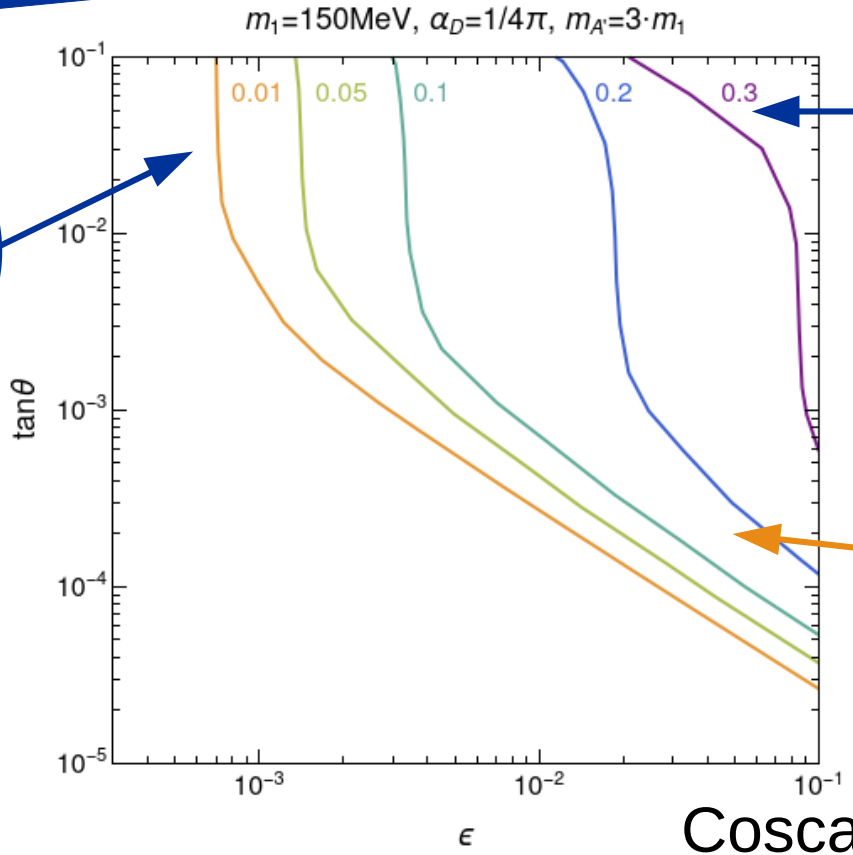
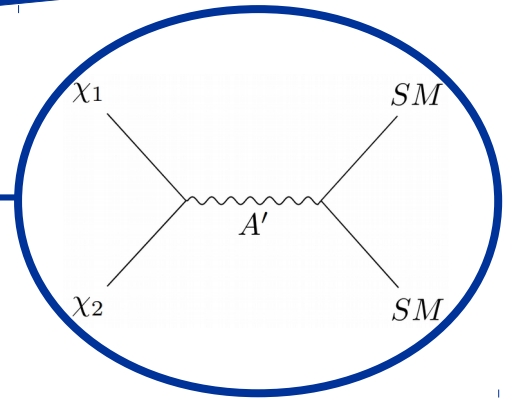
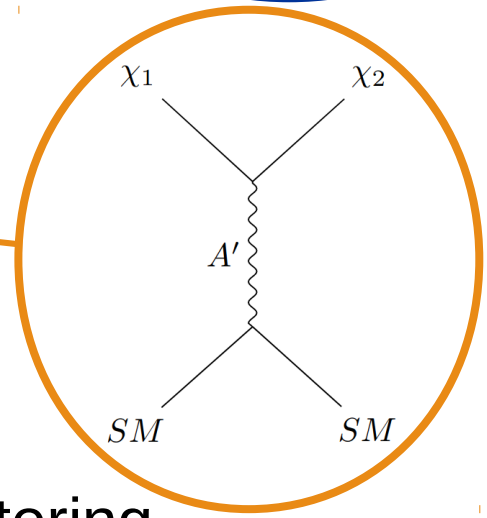


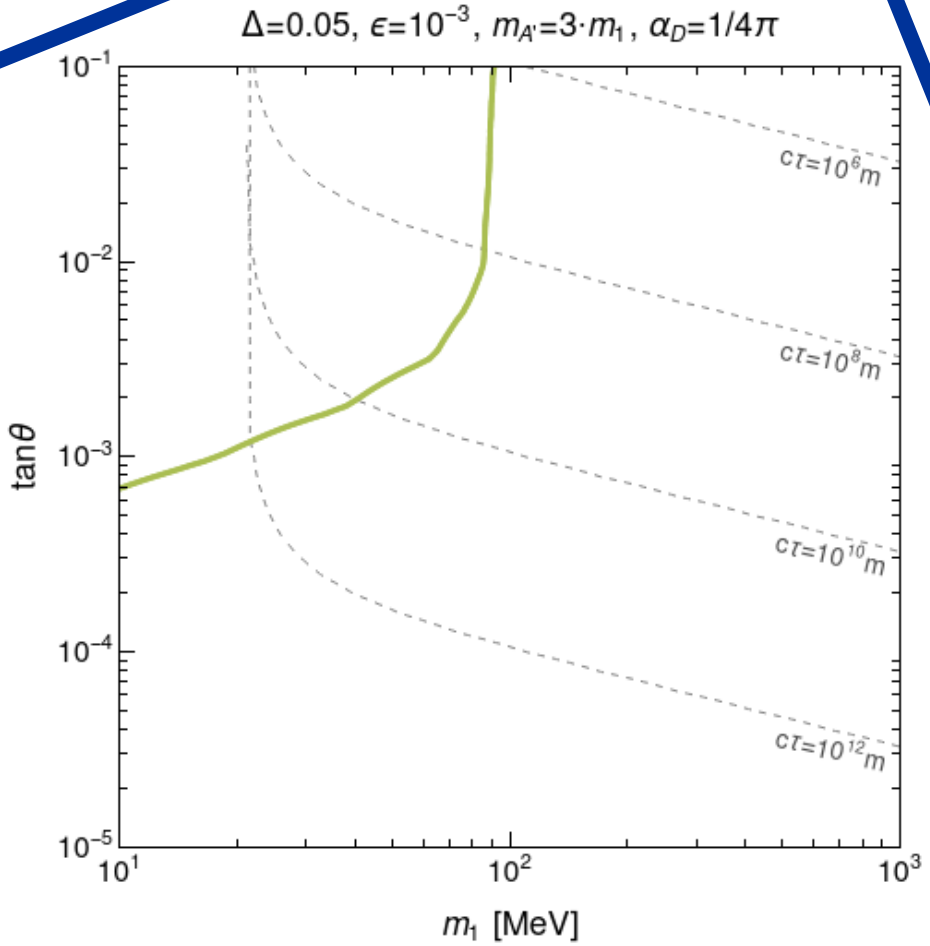






Coscattering

i2DM Detection

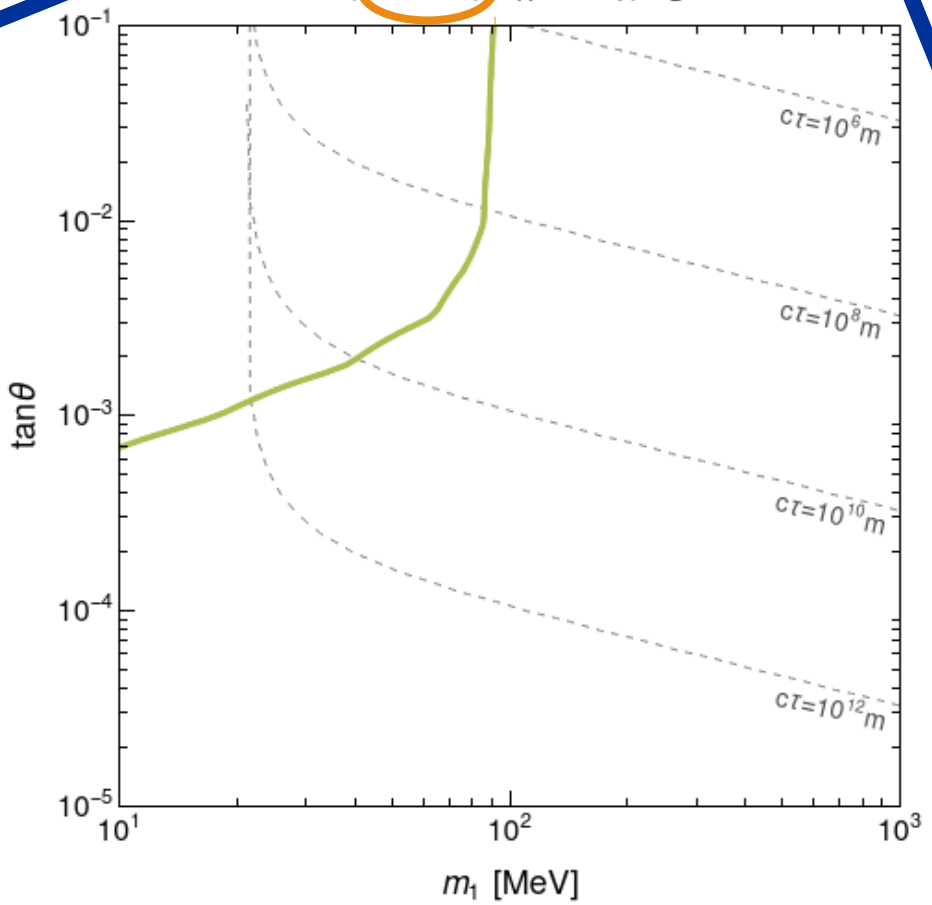


BaBar limit on ϵ

Charm and LSND probing decay and scattering

Near-future bounds

i2DM Detection



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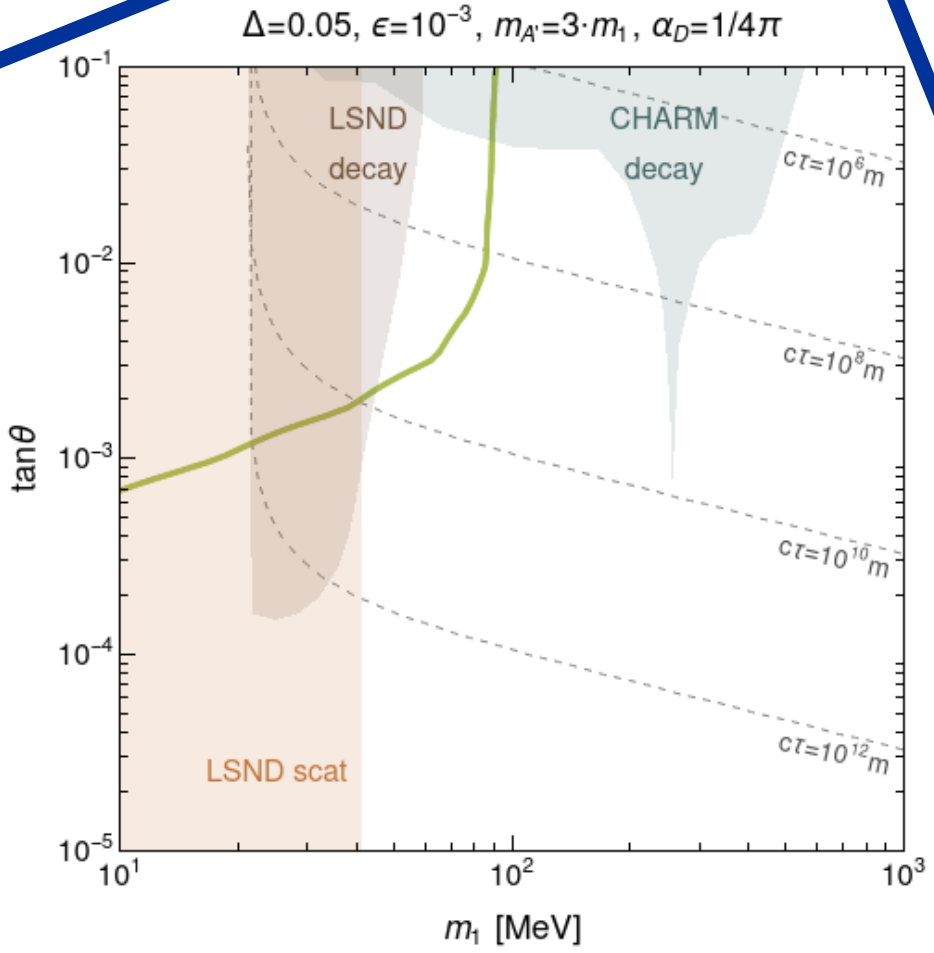

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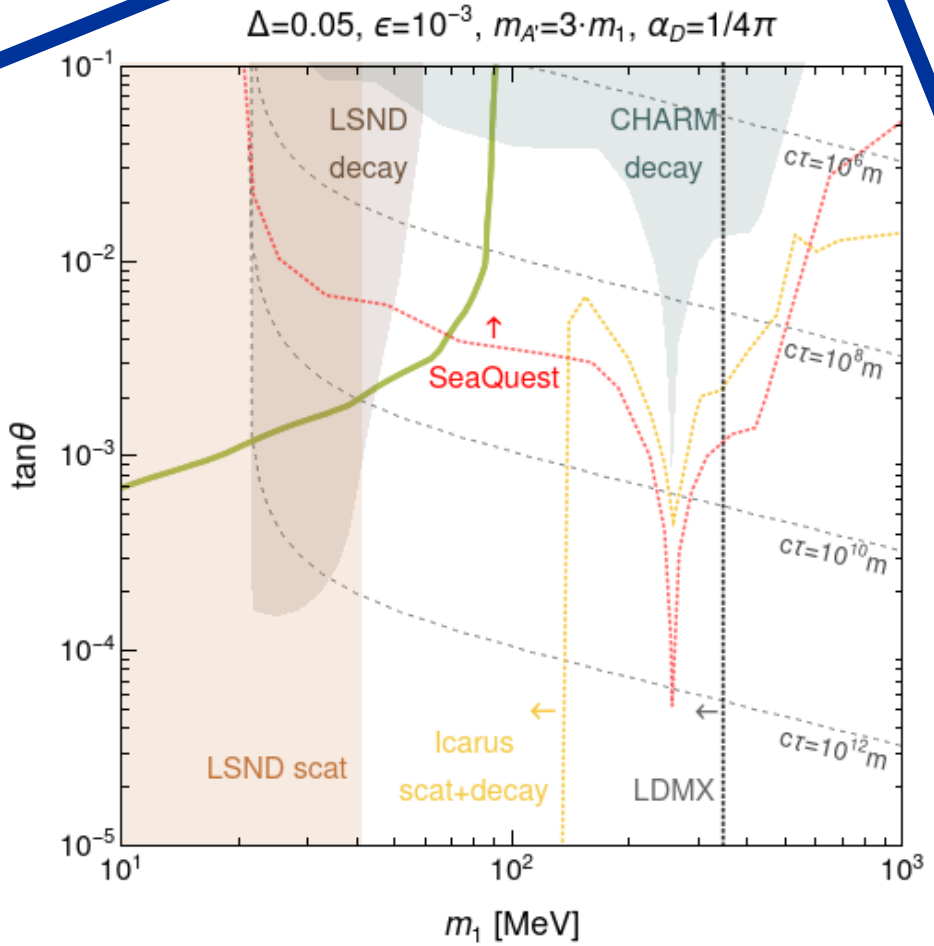

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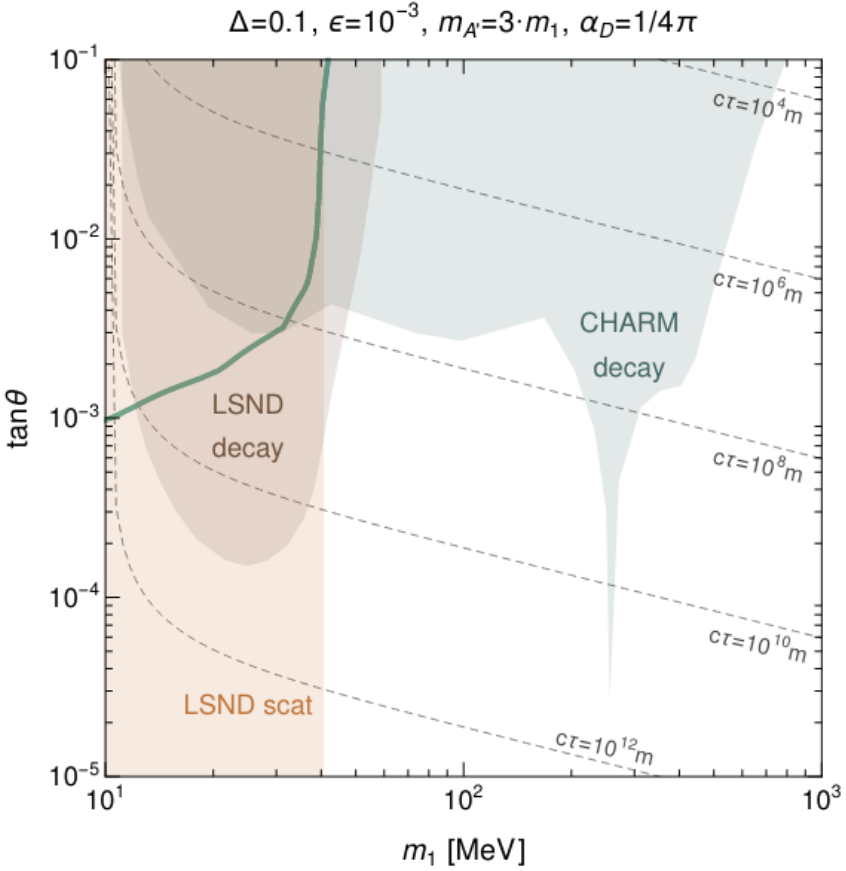
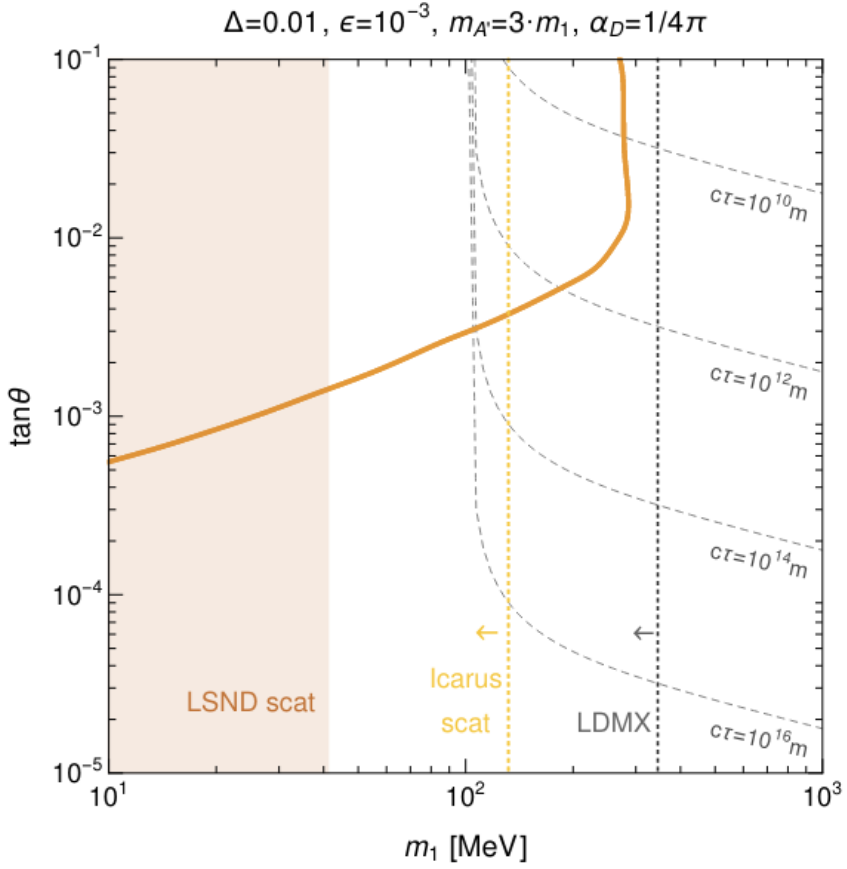
Conclusion

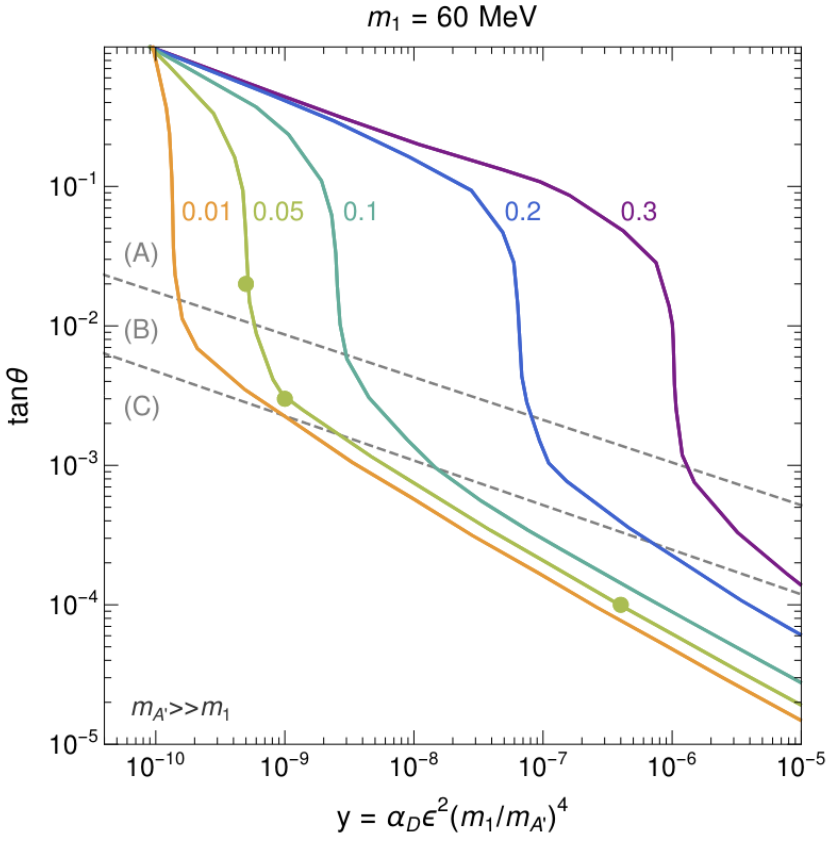
- Inelastic dark matter can evade direct detection
- Minimal iDM is highly constraint
- i2DM opens up viable DM parameter space due to extra mixing
- Near-future beam-dump experiments are very sensitive to i2DM

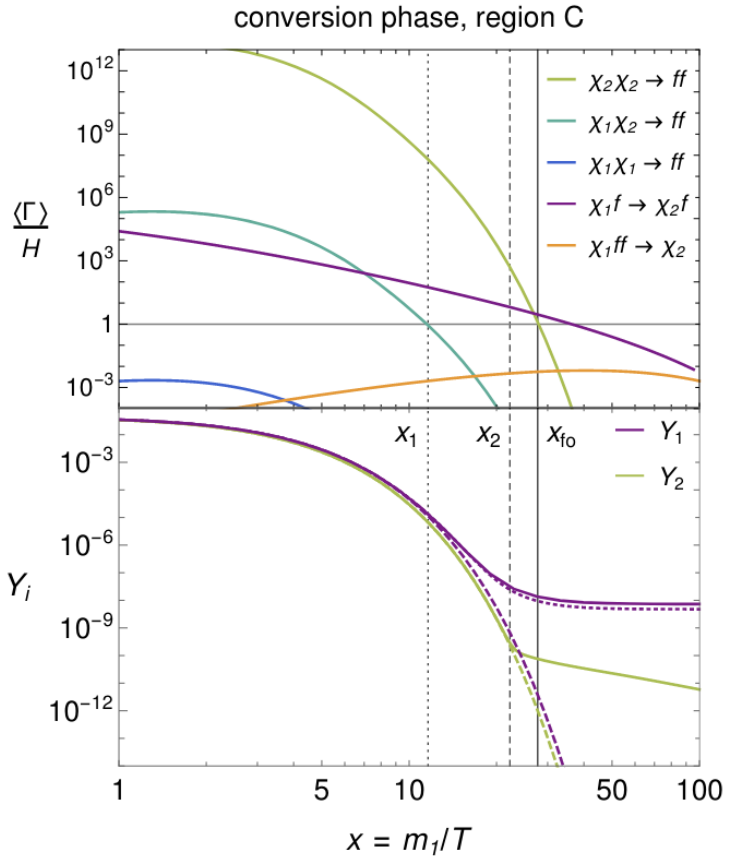
Results for different mass splitting





Kinetic equilibrium





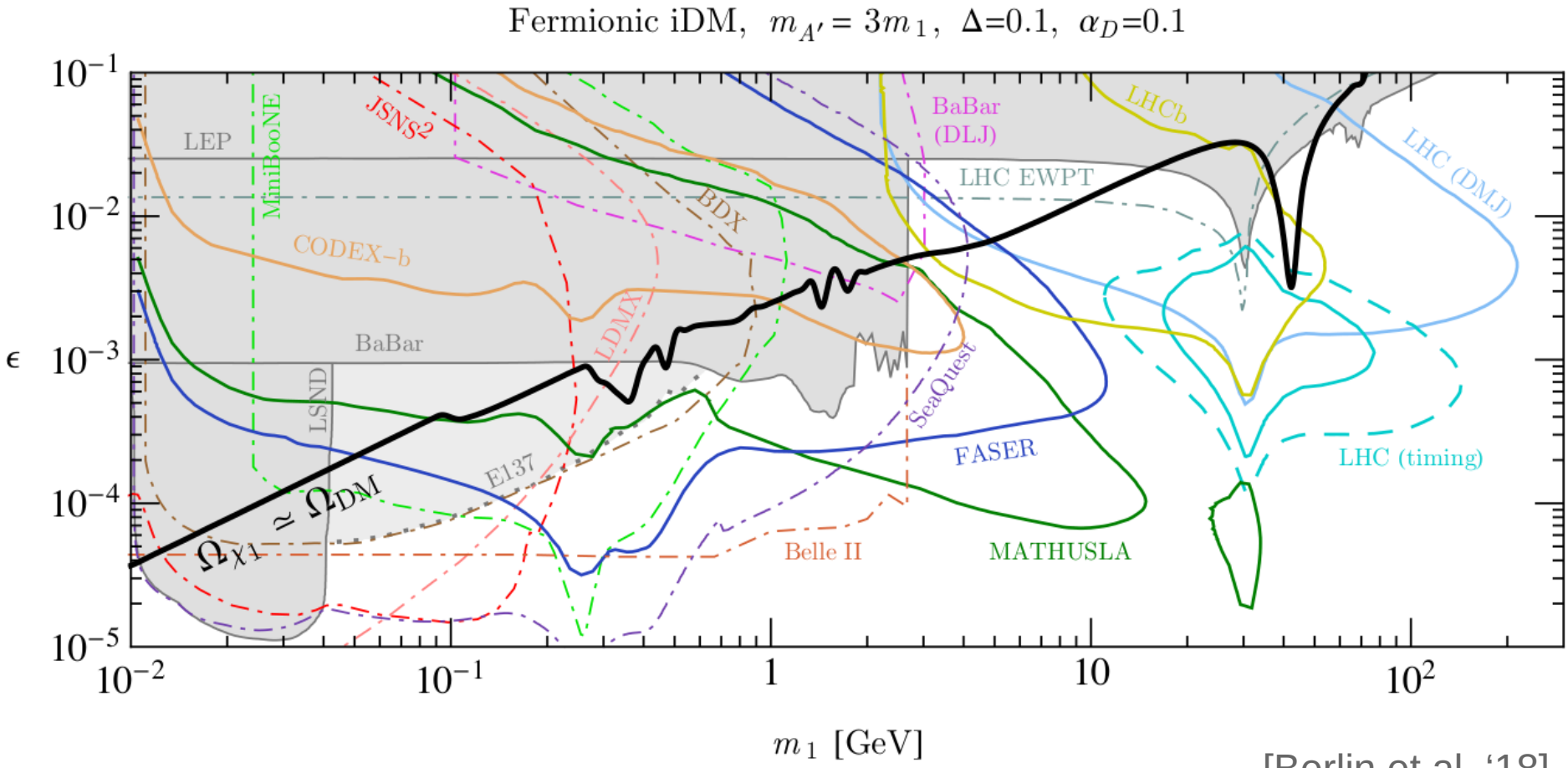
Beam-Dump experiments

- Current constraints:
  - LSND: 800Mev proton beam experiment with detector at 30m
  - CHARM: 400GeV proton beam experiment with detector at 480m
  - Ohters: MiniBooNE, NuCal, NA62 → less sensitive
- Near future experiments:
  - SeaQuest: 120GeV proton beam with decay volume from 5-12m
  - SBN: 8/120GeV proton beam with multiple detectors (SBND, MicroBooNE and Icarus)
  - LDMX: Electron beam dump looking for missing energy signal

Cosmological bounds

- For m>1GeV, QCD phase transition should be taken into account carefully
- For m<10MeV, strong bounds from ΔN_{eff}
- Within this range, other probes like CMB and BBN don’t reach parameter space where relic abundance is reproduced

Beam-Dump experiments



[Berlin et.al. ‘18]