Dark Matter Searches at Future Colliders: The Unique Reach of the Muon Collider

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EF10 DM@Colliders 9/23/20

LOI Scope

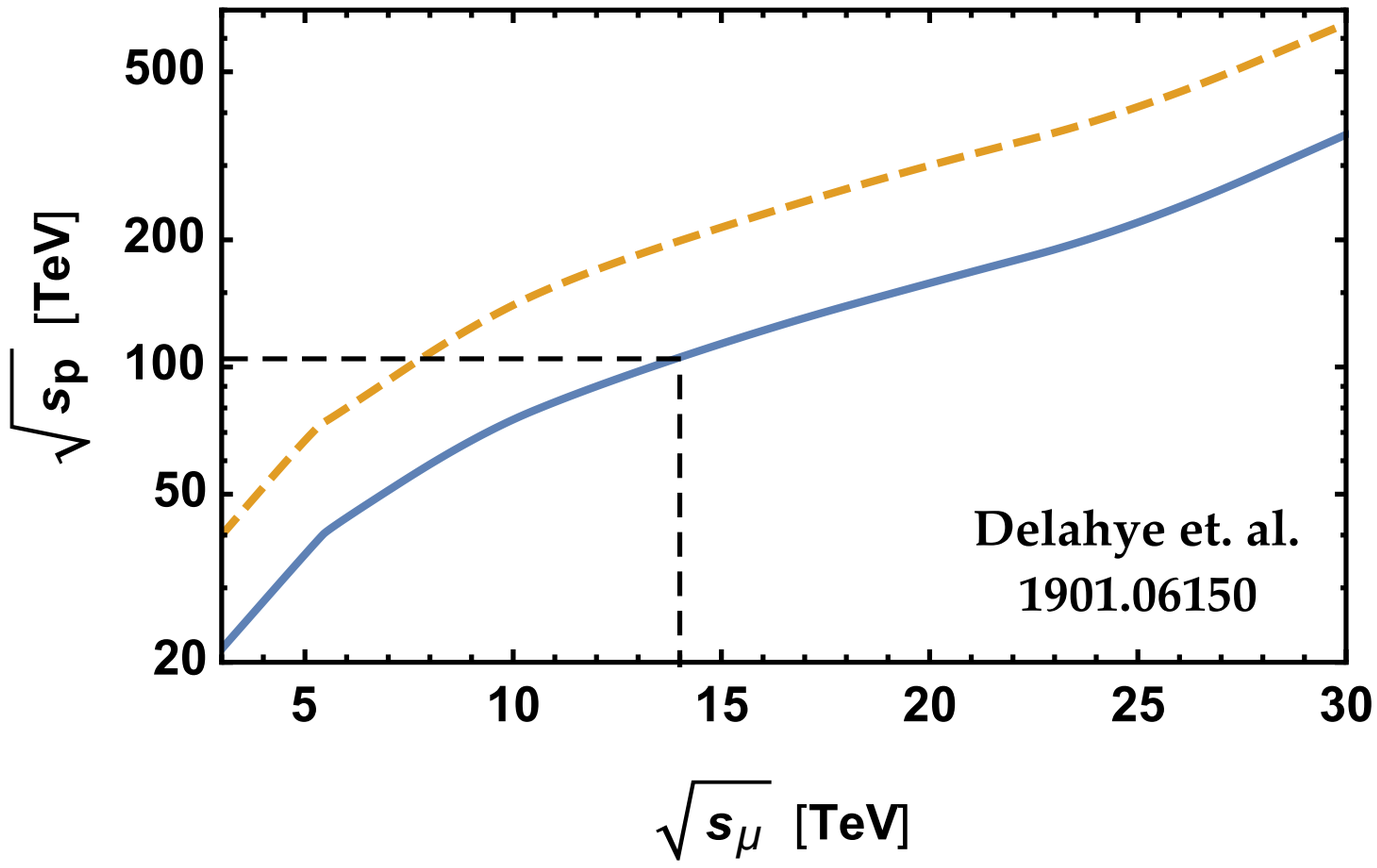
1) Electroweak Dark Matter

2) Muon Philic Dark Matter

3) TeV+ scale BSM for g-2

Muon Collider Basic Remarks

Equivalent proton CM energy



All processes electroweak (or BSM) $\sigma = \left(\frac{10\,\mathrm{TeV}}{\sqrt{s_\mu}}\right)^2 \cdot 1\,\mathrm{fb}$

Suppressed synchrotron radiation $(m_e/m_\mu)^4 \approx 10^{-9}$

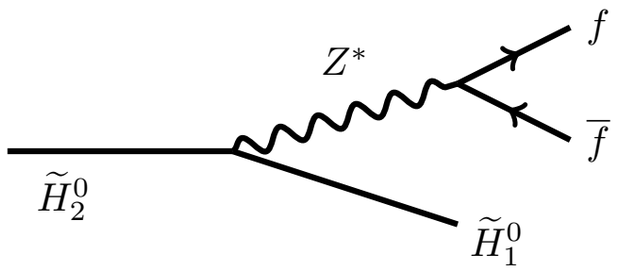
Novel issue: decaying beam particles (=BG?)

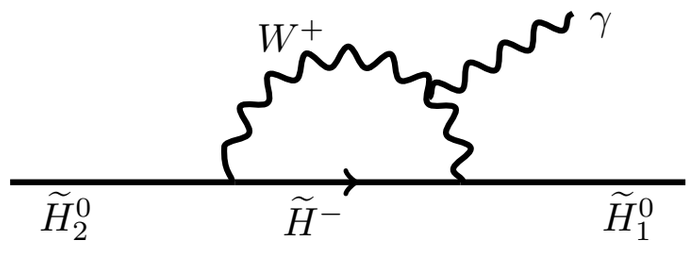
Electroweak Dark Matter

Existing work studied muon collider reach for mono-X channel

χ / m_χ [TeV]	DM	HL-LHC	HE-LHC	FCC-100	CLIC-3	Muon-14
$(1,2,1/2)_{\rm DF}$	1.1	–	–	–	0.4	0.6
$(1,3,\epsilon)_{\rm CS}$	1.6	–	–	–	0.2	0.2
$(1,3,\epsilon)_{\rm DF}$	2.0	–	0.6	1.5	0.8 & [1.0, 2.0]	2.2 & [6.3, 7.1]
$(1,3,0)_{\rm MF}$	2.8	–	–	0.4	0.6 & [1.2, 1.6]	1.0
$(1,5,\epsilon)_{\rm CS}$	6.6	0.2	0.4	1.0	0.5 & [0.7,1.6]	1.6
$(1,5,\epsilon)_{\rm DF}$	6.6	1.5	2.8	7.1	3.9	11
$(1,5,0)_{\rm MF}$	14	0.9	1.8	4.4	2.9	3.5 & [5.1, 8.7]
$(1,7,\epsilon)_{\rm CS}$	16	0.6	1.3	3.2	2.4	2.5 & [3.5, 7.4]
$(1,7,\epsilon)_{\rm DF}$	16	2.1	4.0	11	6.4	18

SM representation — Di Luzio Grober, Panico 1810.10993 — Mass reach (TeV)





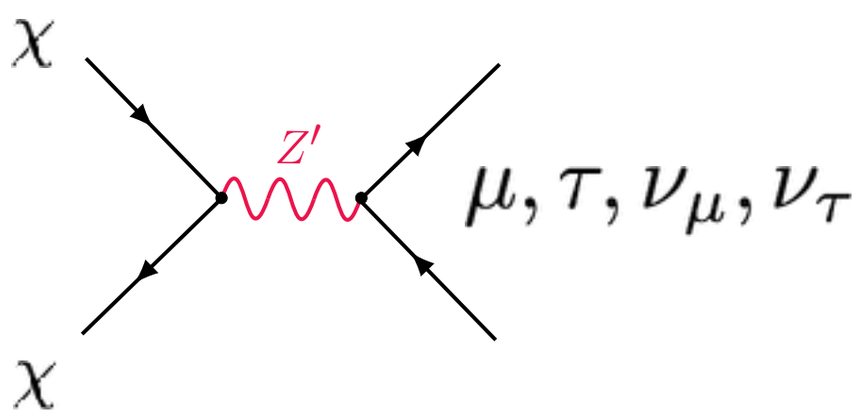
Goal: exploit displaced vertices with "realistic" muon collider setup to improve reach

Goal: how does ISR VBF change the reach? Constantini et.al. 2005.10289

Muon Philic DM

Q: Why haven't we discovered DM thus far?

A: Maybe because it couples more to higher generations

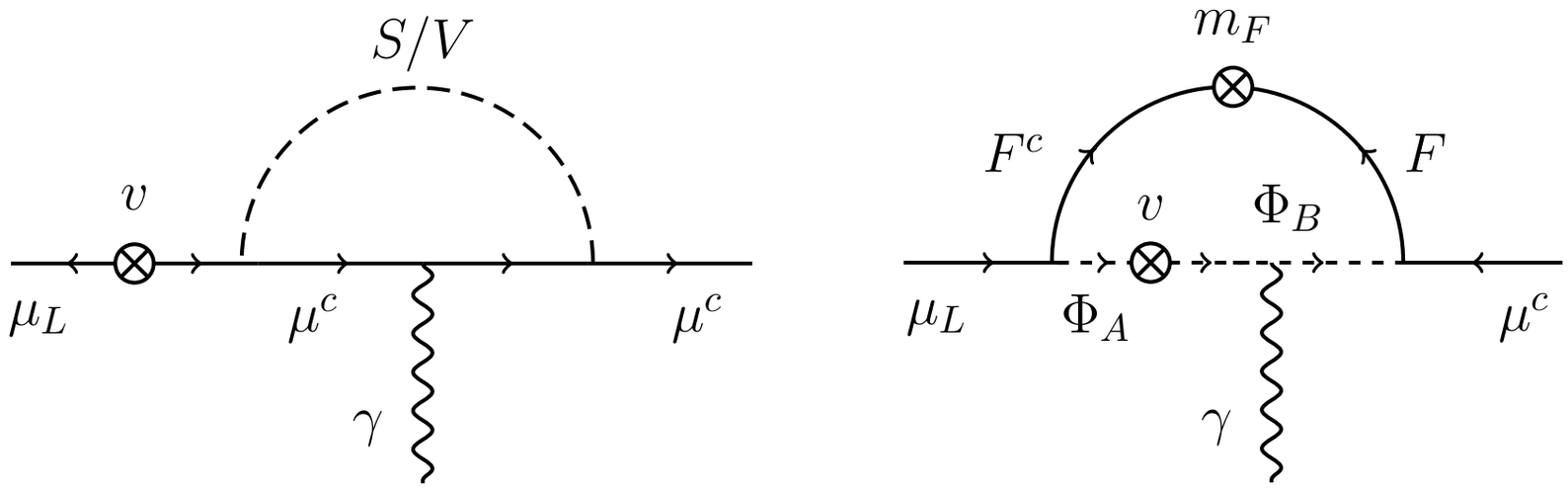


Example: gauged $L_\mu - L_\tau$ Interaction

Possible connection to muon g-2 anomaly
Compatible parameter space for freeze-out

Goal: study muon complementarity for these otherwise elusive models

TeV+ scale BSM for g-2

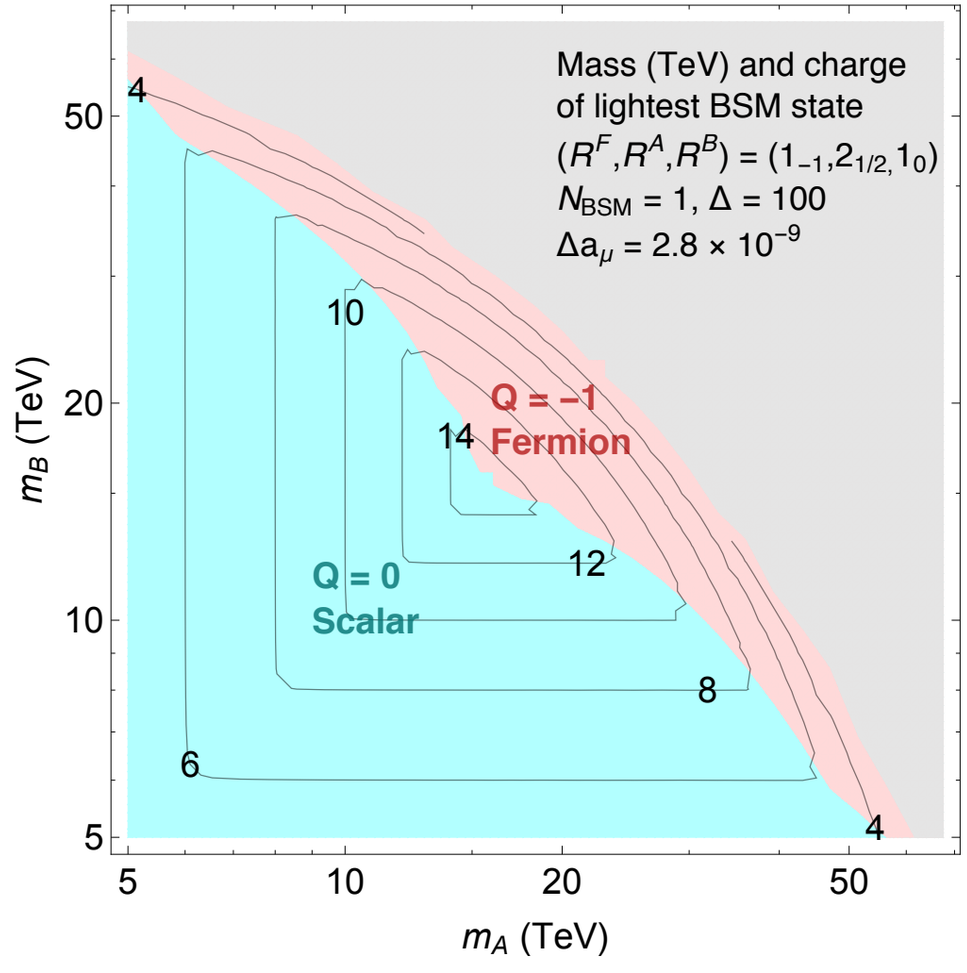


What's the heaviest BSM with unitary couplings that can explain g-2?

Recent study finds ~ few 10s TeV
"worst case scenario"

LOI goal: collider simulation
Quantify design parameters

Capedevilla, Curtin, Kahn, GK 2006.16277



Thanks!