

Multicomponent WIMP Dark Matter from Gauge Symmetries

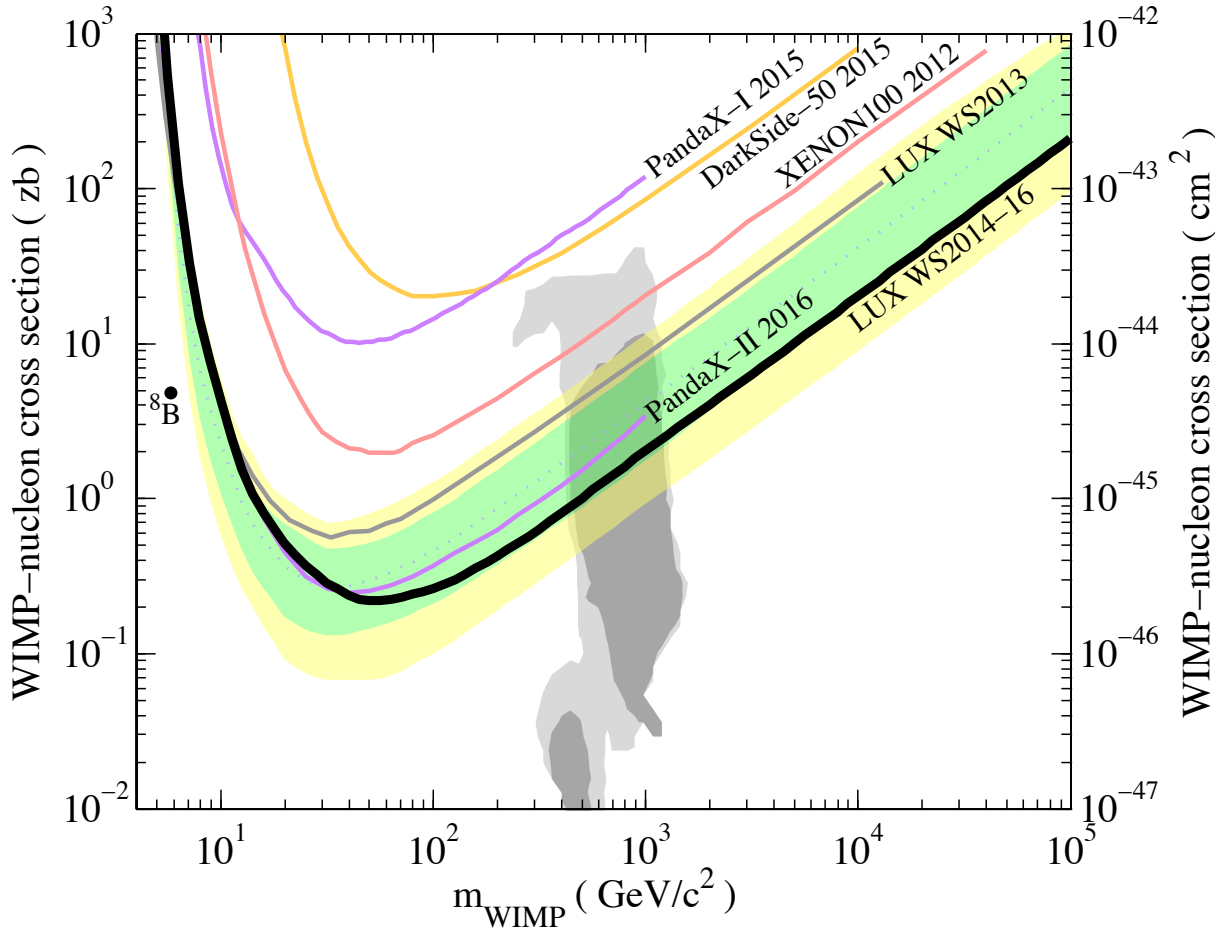
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28.9.16, DESY theory workshop, Hamburg

based on work to appear with G. Arcadi, O. Lebedev,
Y. Mambrini, S. Pokorski, T. Toma

Motivation



[LUX, 2016]

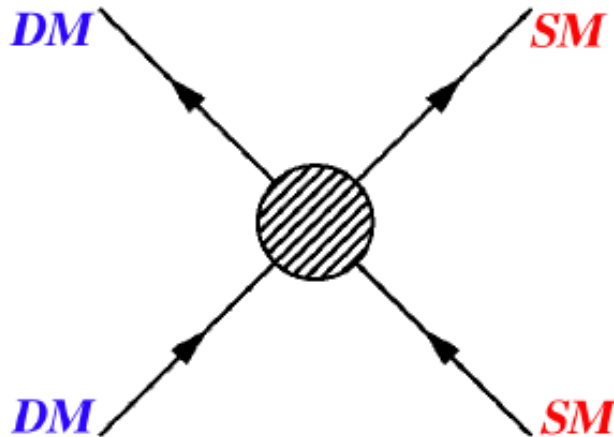
- Null results in DD already cut deeply into parameter space 'favored' by WIMPs
- still, WIMPs are attractive DM candidates
- tension in particular for simplest models

Motivation

thermal freeze-out (early Univ.)
indirect detection (now)



direct detection ↑



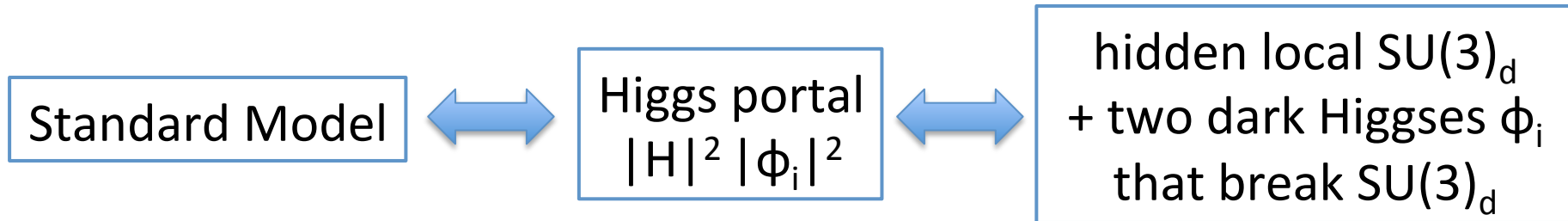
production at colliders



[image: www.mpi-hd.mpg.de/lm/research_DM.en.html]

- reason for tension:
DD limits require small coupling
→ small $\langle \sigma v \rangle$
→ WIMPs overabundant due to $\Omega \propto 1/\langle \sigma v \rangle$
- possible way out:
having multiple mediators and/or DM particles breaks the 'crossing' relation between DD and annihilation diagrams
- besides: visible sector is also multicomponent, so why not the dark one?

A UV complete model as case study: mixed spin 0/spin 1 DM from hidden SU(3)



[CG, Lebedev, Mambrini, 2016]

- this naturally leads to $Z_2 \times Z_2'$ symmetry \rightarrow 3 DM particles
- Extra states:
 - 3 scalars
 - 1 pseudoscalar χ
 - 8 massive vectors A^a
- DM can be:
 - either: 3 vectors A^1, A^2, A^3
 - or: A^1, A^2 (both have mass m_A) + pseudoscalar χ

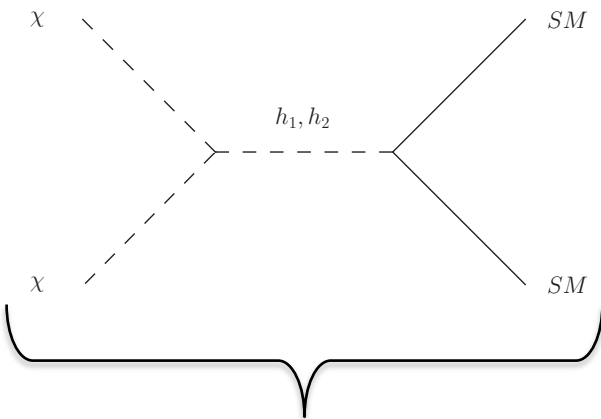
discussed
here! 

note: $m_A > m_\chi$

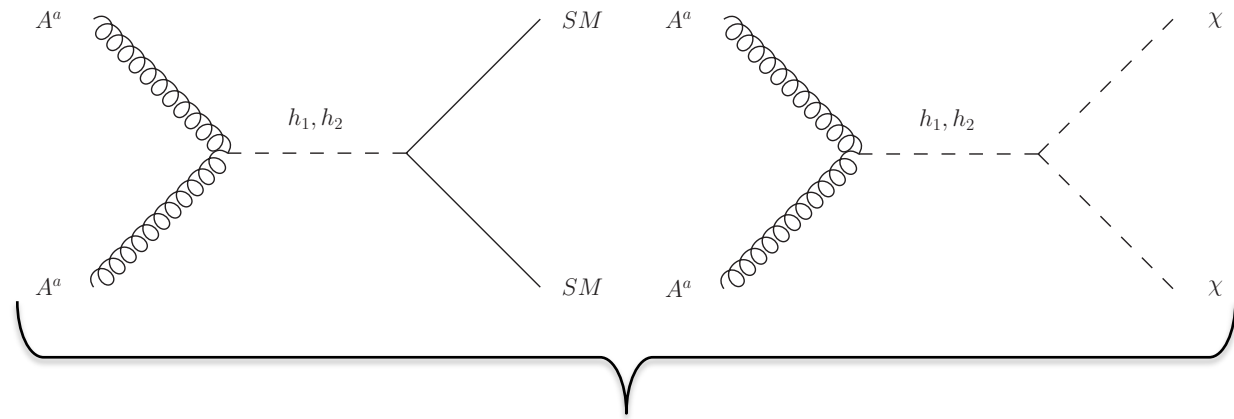
DM annihilation

- we consider the (simplified) case where part of the states are heavy and only the following ones play a role:*
 - DM states χ, A^1, A^2
 - extra scalar h_2
- NP parameters: m_A, m_χ, m_{h_2} , dark gauge coupling g , Higgs mixing $\sin\theta$

* A^3 can't be decoupled but usually plays no crucial role



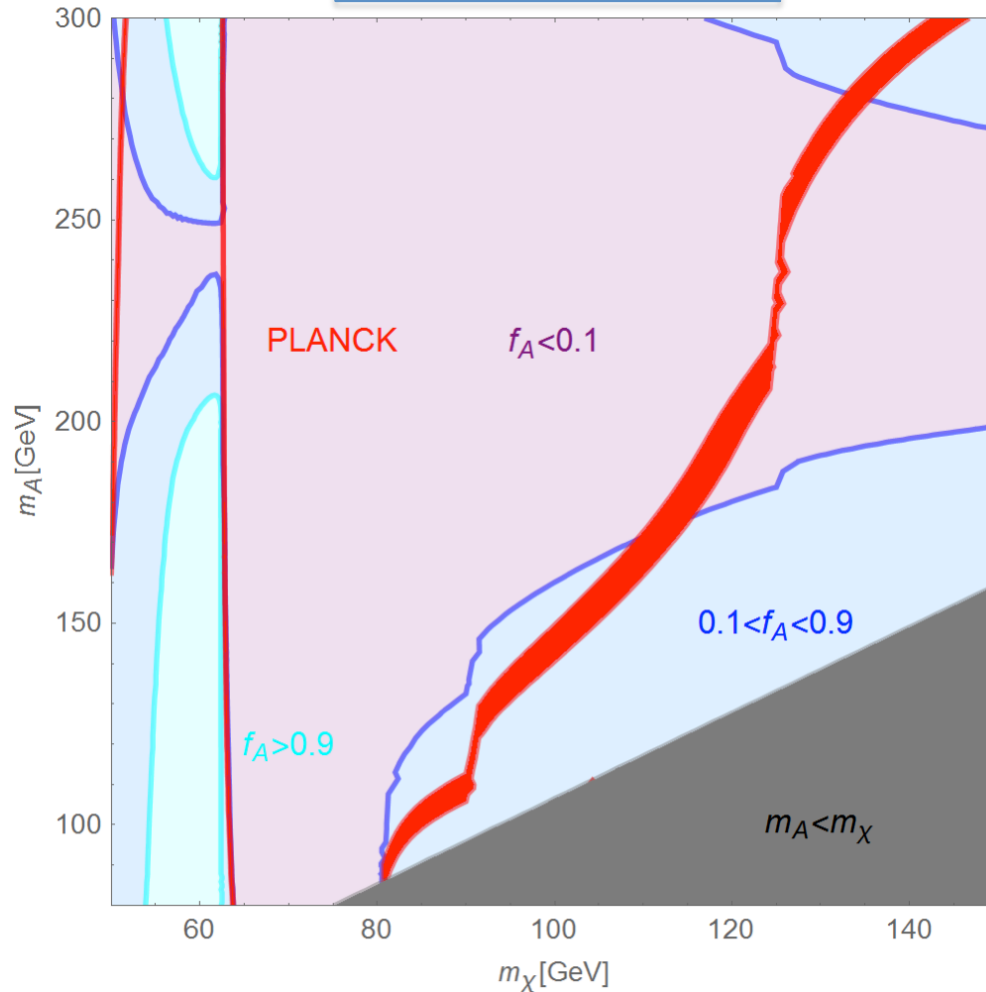
pseudoscalar DM annihilation to SM states



for the heavier DM component A , annihilation to SM, as well as dark annihilation to χ is relevant!

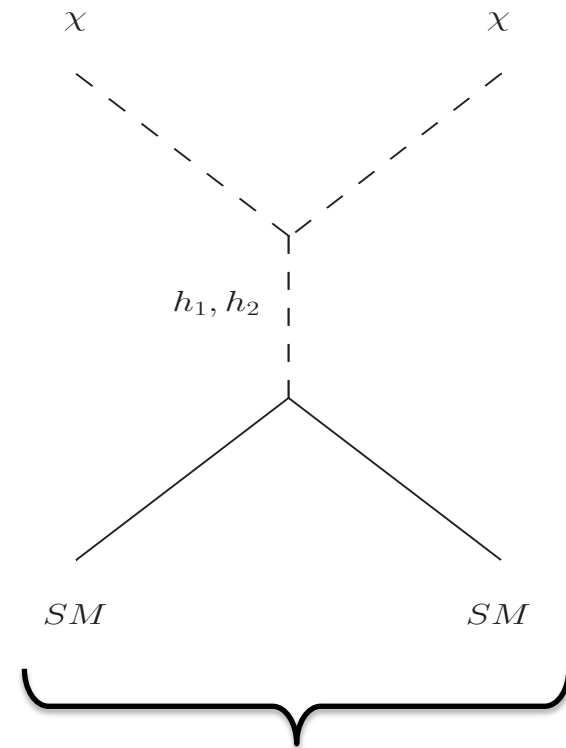
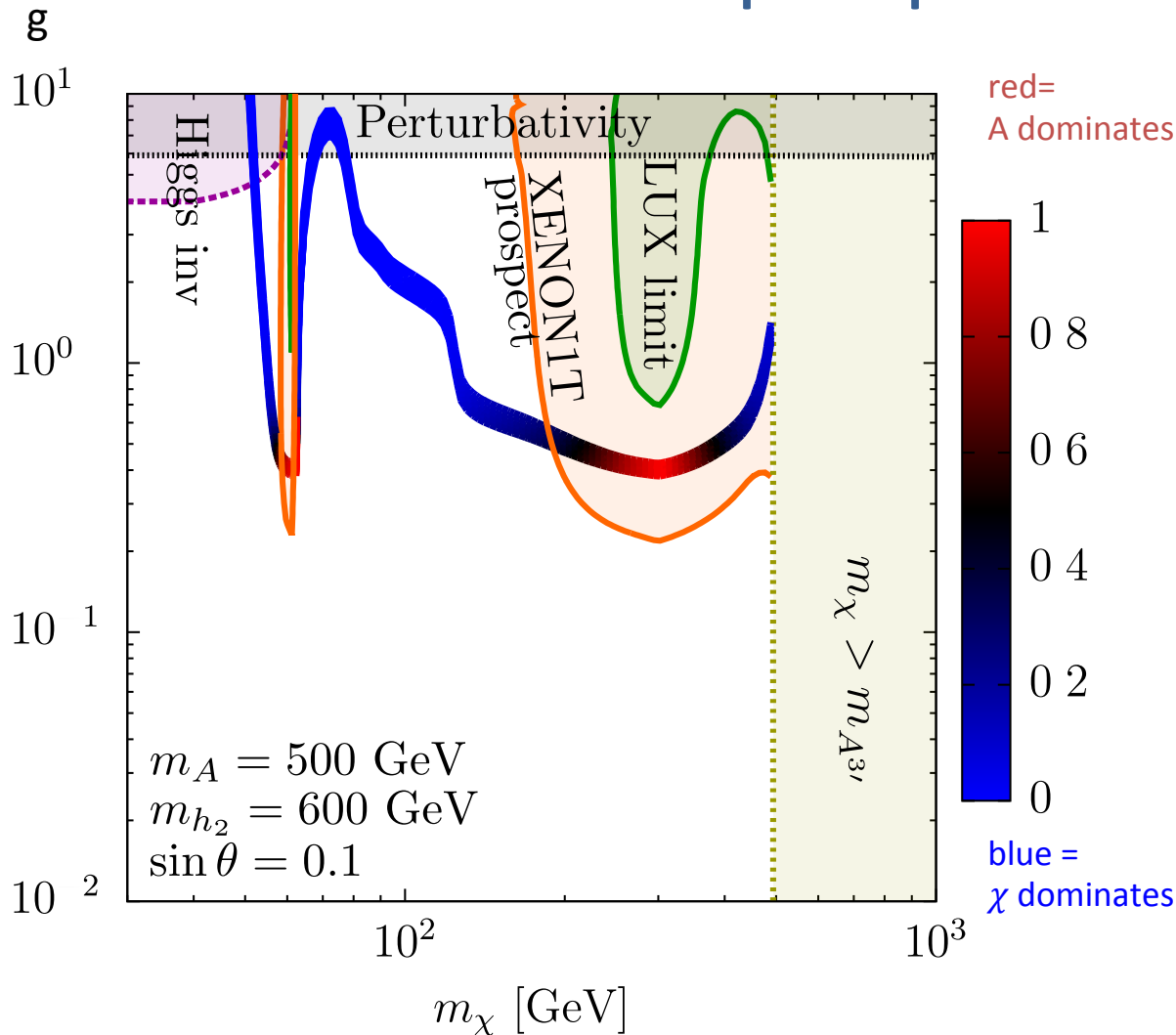
Both components may be dominant, depending on parameters:

$\tilde{g}=1, \sin\theta=0.1, m_{h_2}=500 \text{ GeV}$



- shown: relative contribution of vector DM to total DM:
 $f_A = \Omega_A / \Omega_{\text{total}}$
- since, very roughly,
 $\Omega_{\text{total}} \propto 1 / \langle \sigma v \rangle_A + 1 / \langle \sigma v \rangle_\chi$
 component with smaller $\langle \sigma v \rangle$ dominates
- this explains e.g. behaviour when one of the components annihilates resonantly
- red: correct relic density

Direct detection prospects

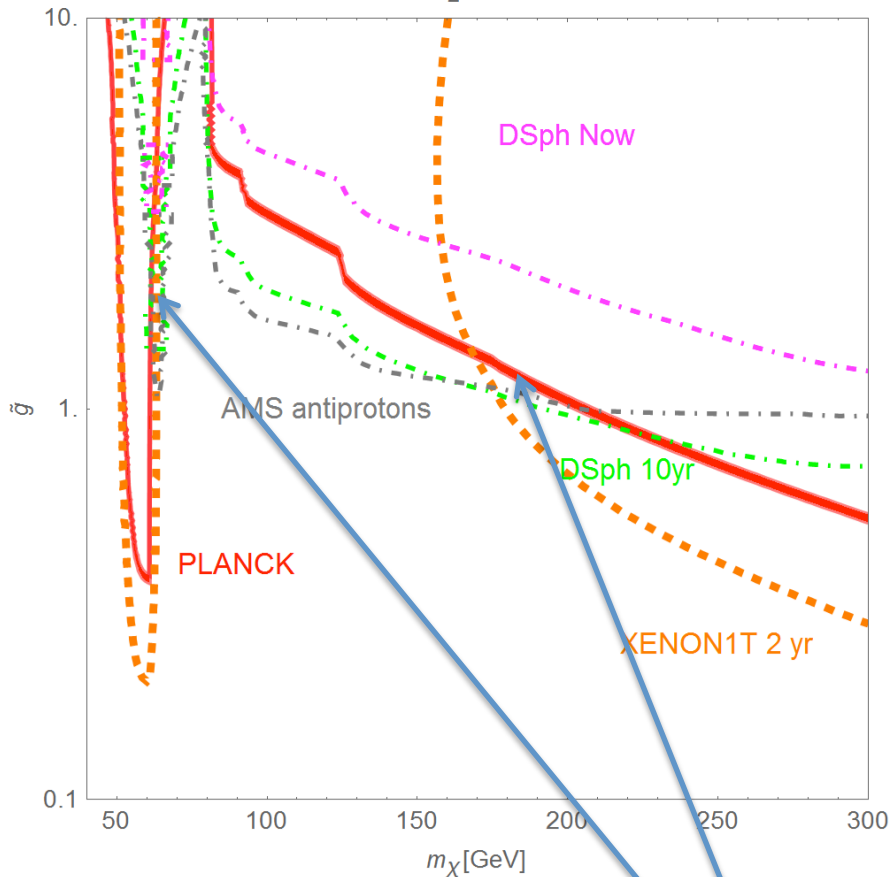


couplings lead to perfect cancellation in scattering of χ -DM on nuclei!

- WIMP DM can be completely invisible in DD! (if χ dominates)
- even if A-DM dominates: DD is suppressed since there is additional dark annihilation channel $A A \rightarrow \chi \chi$

Could see one component in indirect detection, the other in direct detection

$m_A=450 \text{ GeV}, m_{h_2}=850 \text{ GeV}, \sin\theta=0.1$



two regions where testing this scenario might be possible with future data

basic point:

- χ is invisible in DD, but might be observable in ID (if its DM fraction is large enough)
- on the other hand: vector component could be visible in DD, but is hardly visible in ID because main annihilation (often) into dark sector ($A A \rightarrow \chi \chi$)

Summary

- DM models with multiple WIMPs and/or messengers can alleviate constraints from direct detection and lead to an interesting phenomenology
- A hidden sector consisting of spontaneously broken $SU(3)$ gauge symmetry offers a UV complete framework which naturally has multicomponent DM consisting of spin-0 and spin-1 states
- The direct detection cross section is much suppressed in large regions of parameter space, often beyond the level of sensitivity of XENON1T