A final word on Minimal Dark Matter

We consider SU(2) n-plets

We require STABILITY + CALCULABILITY

We are left with a very short list of cases:

n = 3 stable because of matter-parity

n = 5 stable accidentally

n = 7 stable if a millicharge is assigned

n = 9 already not calculable…

Key Question:

Can we probe all the Minimal Dark Matter WIMPS @ future colliders?

To do List:

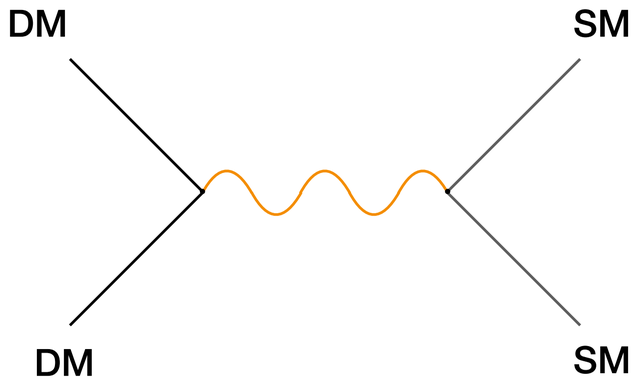
1. **Mass predictions from Freeze-out**

2. **Reach at future colliders for different C.O.M energies**

Extra:

comparison with future indirect detection prospects…

Freeze-out

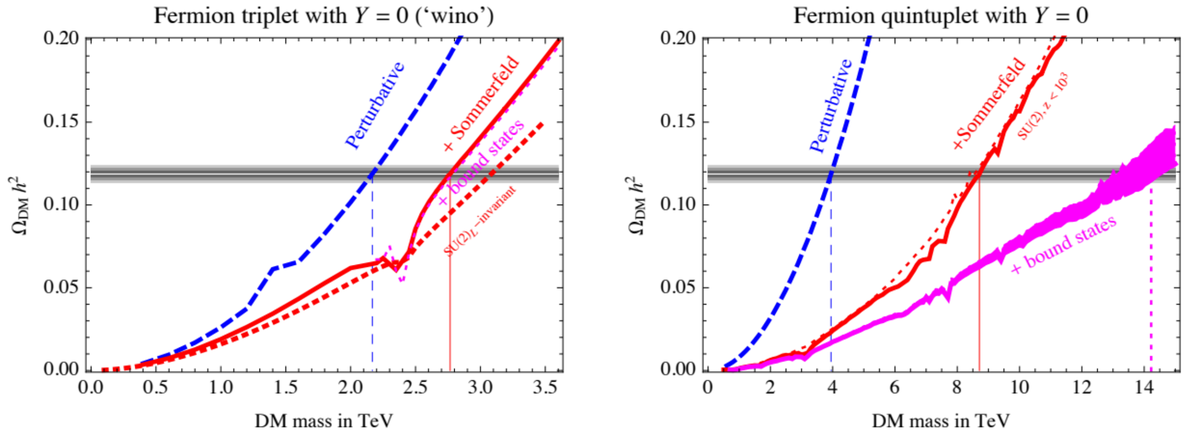


$$\sigma_{\rm ann}(\mathrm{DM}+\mathrm{DM}\leftrightarrow\mathrm{SM}+\mathrm{SM})\propto\frac{g^4}{M^2}n^3 \quad \xrightarrow[\sigma_{\rm ann}=\sigma_{f.o.}]{} \quad M\propto n^{3/2}$$

Low-velocity corrections modify substantially $\sigma_{\rm ann}$

- *Sommerfeld enhancement*
- *Bound-state formation (large corrections for n ≥ 5)*

taken from Mitridate, Redi, Smirnov, Strumia 2018



Summary of the WIMPs mass predictions

n = 3 (thermal Wino)

Perturbative: $M_3 = 2.2$ TeV

w/ Sommerfeld: $M_3 = 2.8$ TeV

No bound state formation!

n = 5

Perturbative: $M_5 = 4$ TeV

w/ Sommerfeld: $M_5 = 9.4$ TeV

w/ Bound-states: $M_5 = 14.4$ TeV

?

n = 7

Perturbative: $M_7 = 9$ TeV

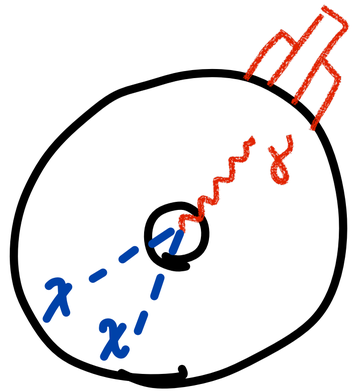
Sommerfeld: $M_7 = 23$ TeV
(in SU(2)-invariant limit – 1512.03332)

No calculation of bound-state effects yet!

?

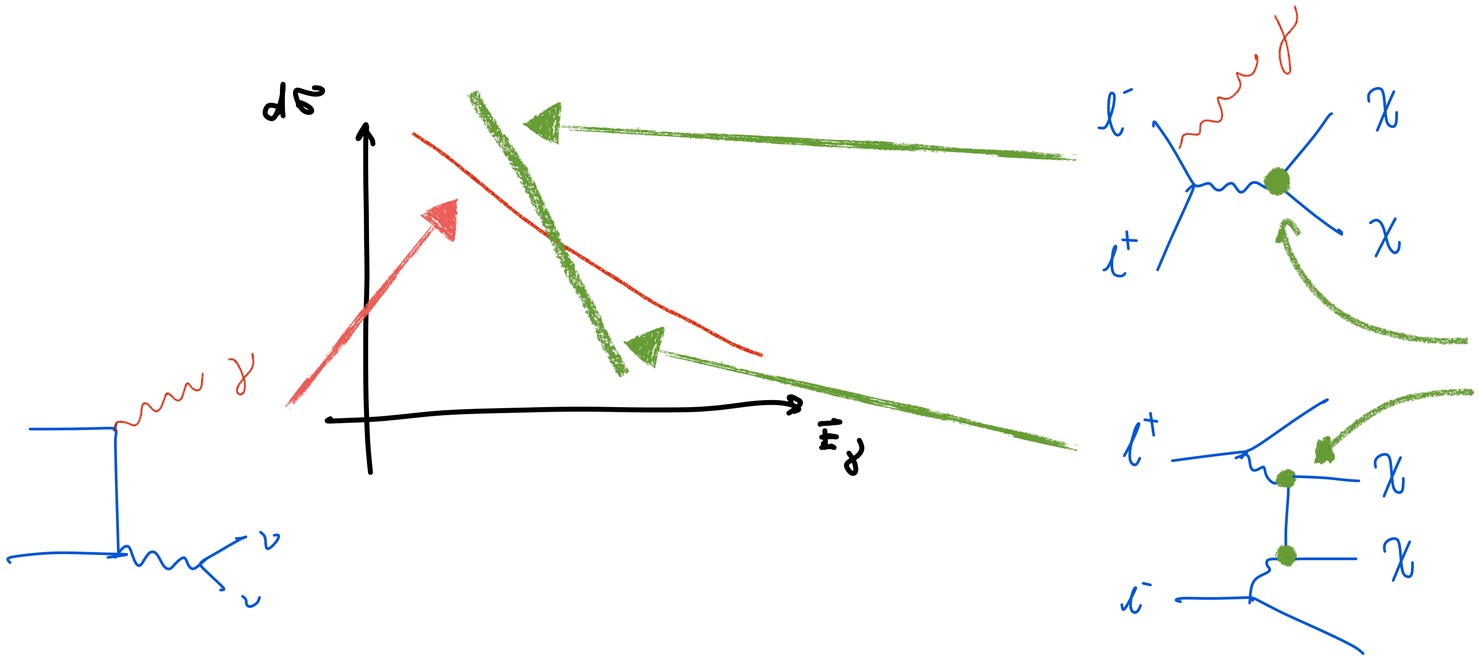
FUTURE COLLIDER REACH

Recoil on “nothing”



GENERIC

SEARCH INTERPRETED FOR DARK MATTER



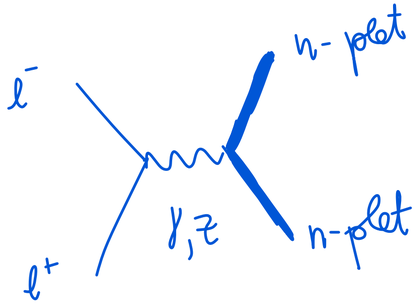
Possible large enhancement due to multiplicity of states and size of couplings

Degenerate EW multiplets

STUB-TRACKS

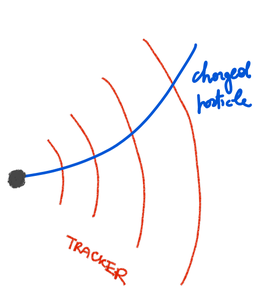
EXTRAPOLATION FROM CLIC

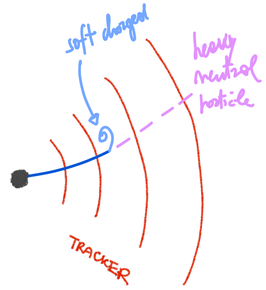
- Heavy n-plet of SU(2)
- Mass splitting ~ $\alpha_W m_W$ ~ 0.1 GeV - GeV

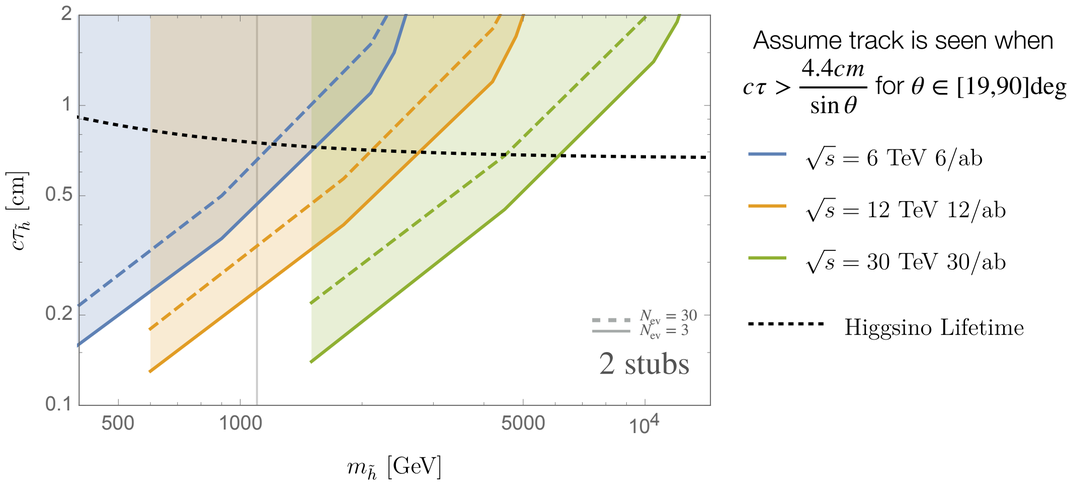


LARGE RATES, BUT NEEDS TO LIGHT UP THE DETECTOR IN A DISCERNIBLE WAY

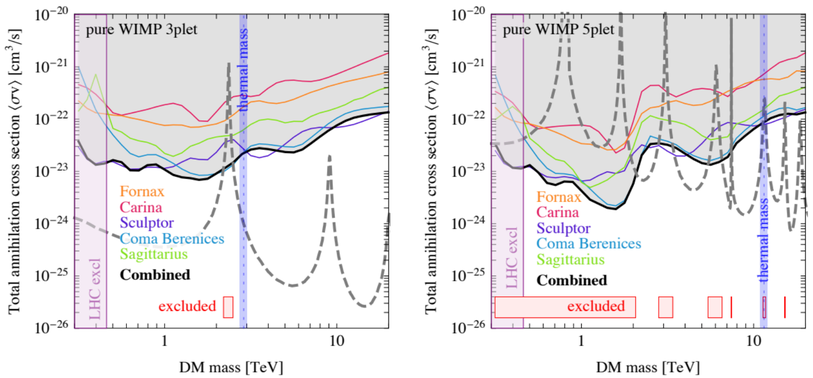
- Heavily subject to detector design issues
- Even in CLIC needs full detector simulation





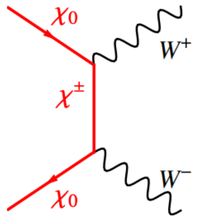


Indirect Detection

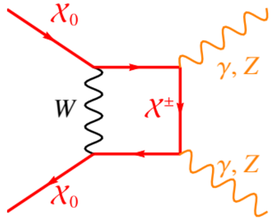


H.E.S.S. 2018

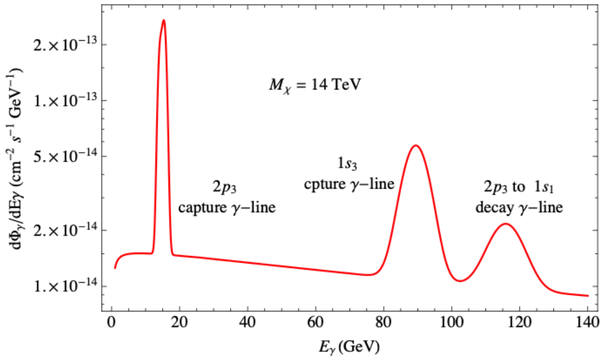
High energy gamma rays in dwarf Spheroidal galaxies



tree-level continuum



loop-induced lines



Mitridate, Redi, Smirnov, Strumia 2018

$$\chi_0\chi_0 \to B\gamma$$

extra gamma ray lines from bound state formation!