Composite Higgs Phenomenology

Astrophysical Signals of Composite Dark Matter

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Mass: From the Higgs to Cosmology

Cargese 2018

Composite Higgs Models

- A compelling solution to the hierarchy problem:

$$\mu_{\text{EW}}^2/\Lambda_{\text{Pl}}^2 \sim 10^{-28}$$ 👎

- The Higgs (and possible *other scalars*) are **pseudo-Goldstone bosons**
- They emerge when $G \to H$ spontaneously
- G must be explictly broken to allow the generation of a potential for the pGBs

new physics!

$f \approx$ TeV

EW physics

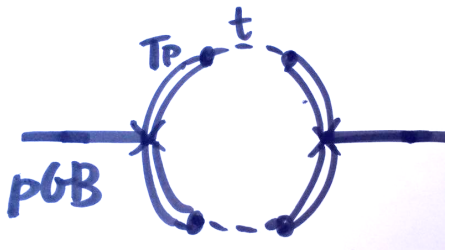
$v \approx 246$ GeV

Group theory constraints on **EWSB** and the **properties** of the new scalars

A Dark Matter Candidate?

Natural light scalars with a mass at the EW scale:

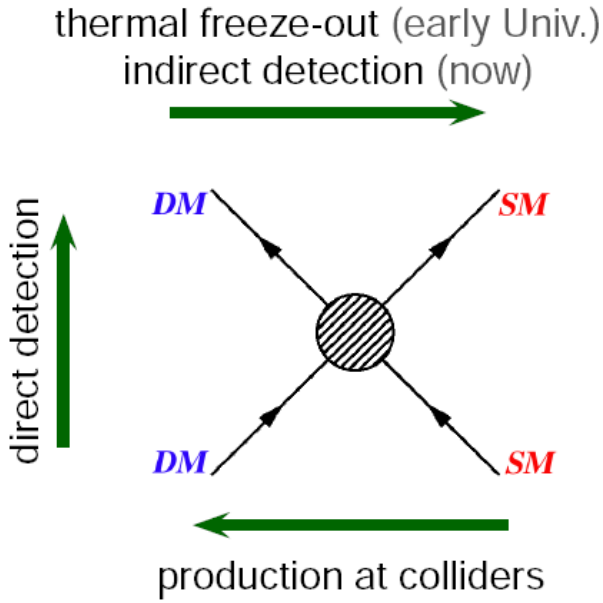
$$m^2 \sim \frac{y_q^2}{(4\pi)^2} f^2 \ , \quad f \sim \text{TeV} \ .$$



Justifies "for free" the
WIMP miracle:

$$\Omega h^2 \approx 0.1 \times \left(\frac{3 \times 10^{-26} \text{cm}^3 \text{s}^{-1}}{\langle \sigma v \rangle} \right)$$

$$\approx 0.1 \times \left(\frac{\alpha^2/(200 \text{ GeV})^2}{\langle \sigma v \rangle} \right) \ .$$



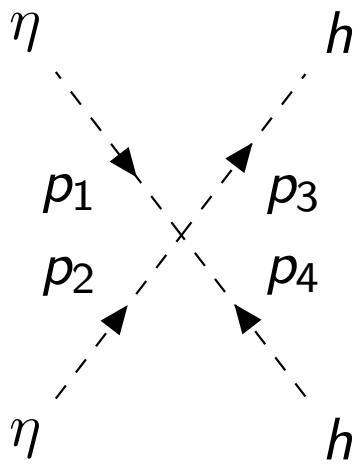
Minimal Model

The potential is dynamically generated:

$$V_{\text{eff}}(h,\eta) = \frac{1}{2}(\mu_h^2 h^2 + \mu_\eta^2 \eta^2) + \frac{\lambda_h}{4} h^4 + \frac{\lambda}{2} h^2 \eta^2 + \frac{\lambda_\eta}{4} \eta^4 + \mathcal{O}((h,\eta)^6)$$

- ✓ **Direct Searches** $\Rightarrow$ Small λ
- ✓ **Observed relic density** $\Rightarrow$ Not so small...

In **CHMs**:



$$= -2i\lambda - \frac{i}{f^2}(p_1 + p_2)\cdot(p_3 + p_4)$$

New derivative interactions

Non-Minimal CDM Phenomenology

Case of heavier extra pGBs: *ArXiv 1801.06537*

Complementary Case: work in progress

- Wide region of the parameter space **still to be tested**:

$$\text{DM DM} \to \kappa\ \kappa \to \text{SM SM}\ ;$$

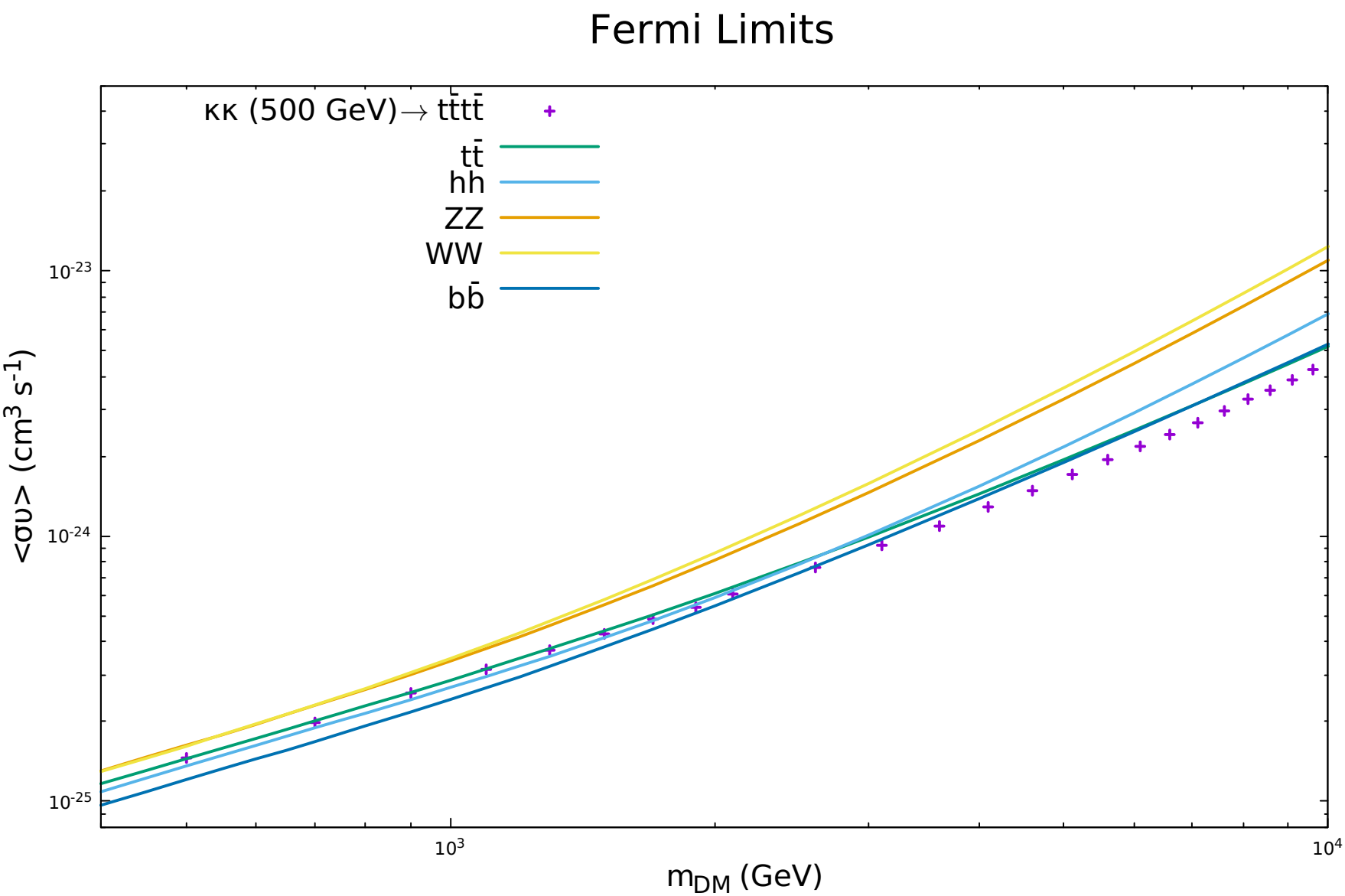
- The new channel **evades current constraints** ;
- In some models, it can even have a **large annihilation rate** ;
- Emerging of a large number of extra pGBs (>SM scalars) ;
- *Limiting Case:*

$$\lambda \approx \left(\frac{m_\eta}{f}\right)^2 \ ,$$

in DM DM $\to$ hh (WW; ZZ), so that the **new channel dominates**.

Deserves a proper study!

Preliminary Plots — Indirect Detection



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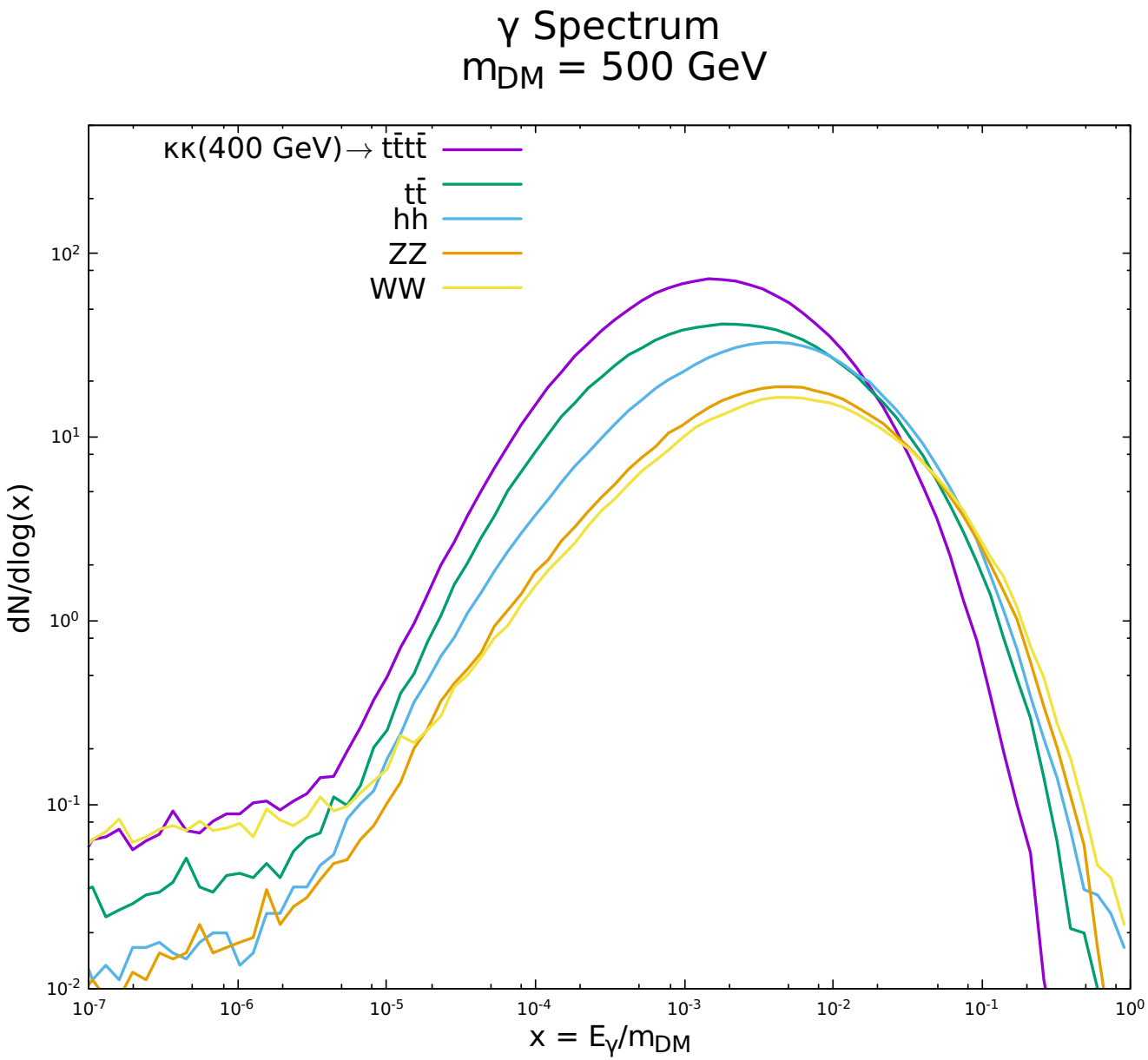

Continuing to investigate new signatures...

Thank you for your attention!

*(special thanks to **LIP** and **COST Action** for the financial support)*