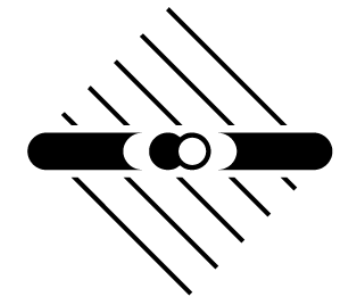
Connection of Indirect Detection to LHC

Stefan Vogl



Some Connections of Indirect Detection to LHC

The indirect connection

Do we probe the same physics?

- example: pseudoscalar mediators (coy dark matter)

$$\mathcal{L}_{int} = ig_\chi a\bar{\chi}\gamma_5\chi + ig_q\frac{m_q}{v}\bar{q}\gamma_5 q$$

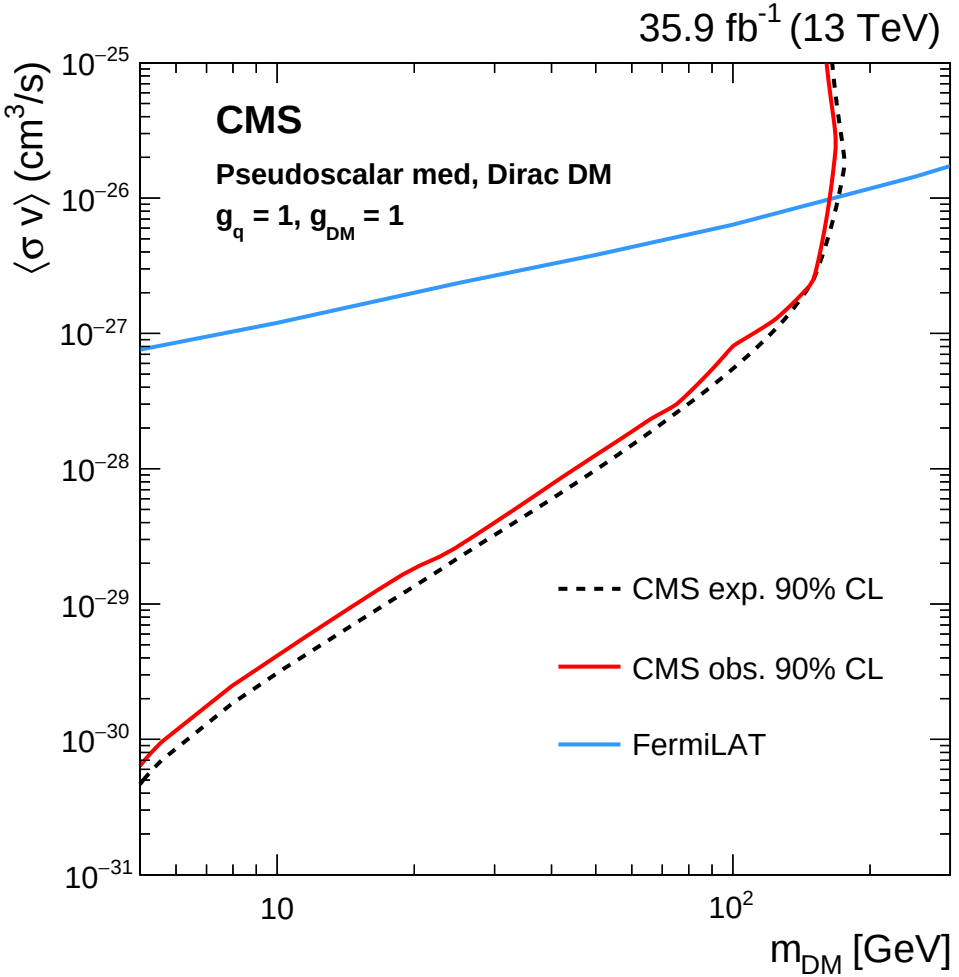
Indirect detection

- annihilation to heaviest accessible quark
  $\rightarrow$ promising candidate for galactic center excess
- annihilation to mediator pairs if $m_a \lesssim m_\chi$
  $\rightarrow$ "secluded" dark matter

LHC

- direct heavy quark luminosity: suppressed
- most relevant production from gluons (loop mediated)

Pseudoscalar mediators



CMS-PAS-EXO-16-048

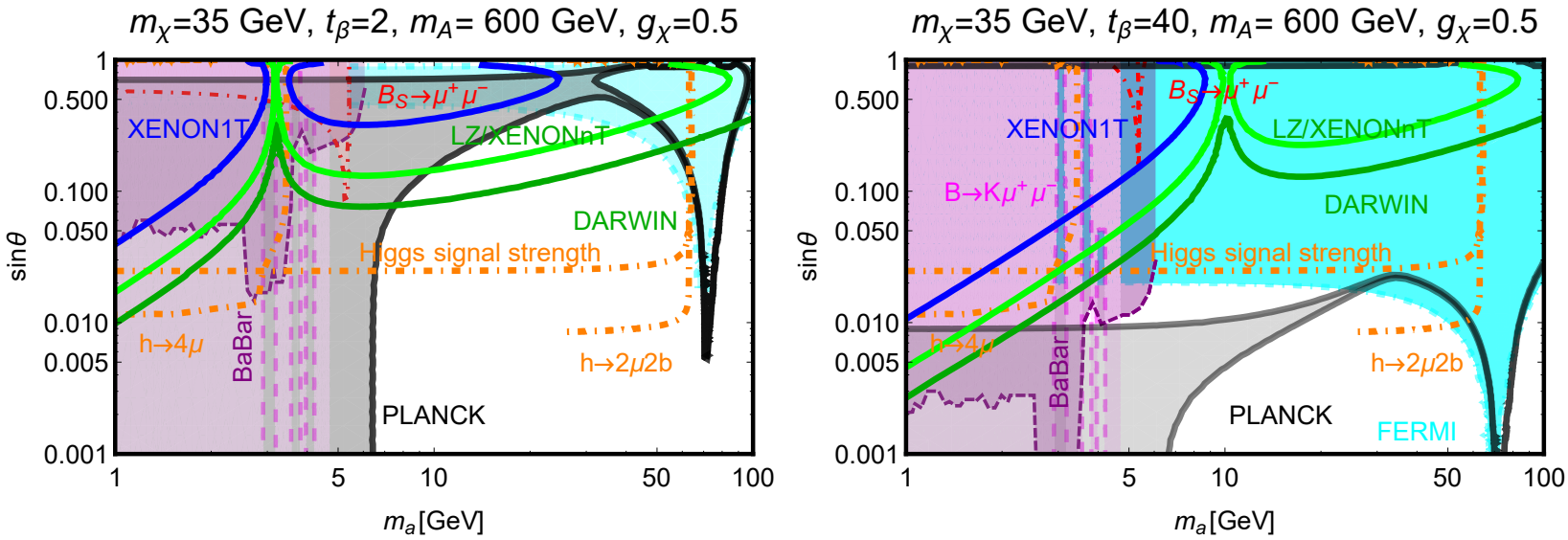
- good LHC sensitivity to small m_χ
- indirect detection more sensitive at large m_χ

Model dependence?

- Yukawa with quarks and with SM singlet dark matter $\rightarrow$ gauge invariance requires additional interactions
- possible fixes:
  - 2HDM + singlet doublet DM see for example Berlin+ 15
  - for singlet DM add new pseudoscalar (2HDM + a) see Ipek+ 14
- expect more parameters: tan β, θ, m_H ...

What is their impact on phenomenology?

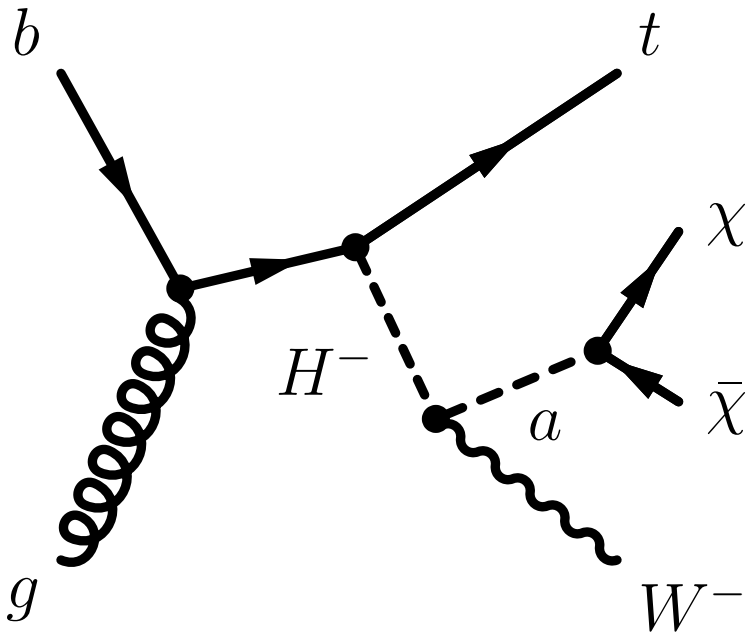
tan β dependence

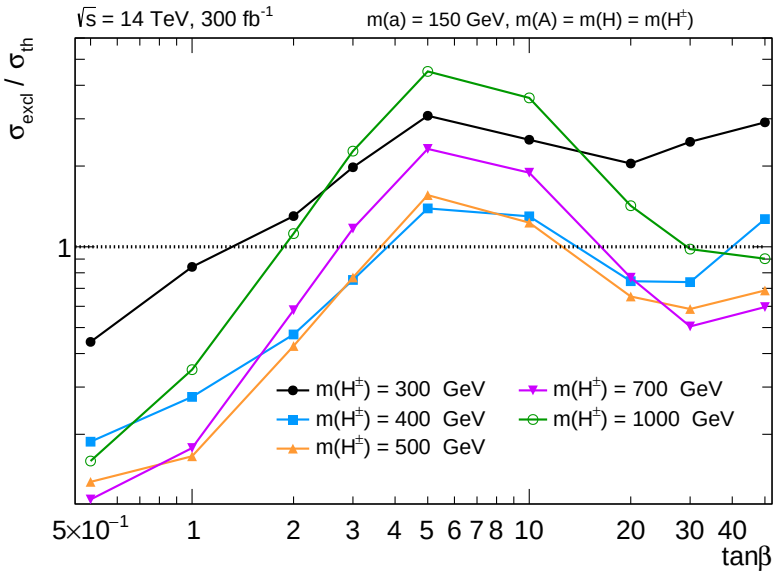


Arcadi,SV,+ 17

- annihilation cross section and other observables have different dependence on parameters

New States → New Signatures





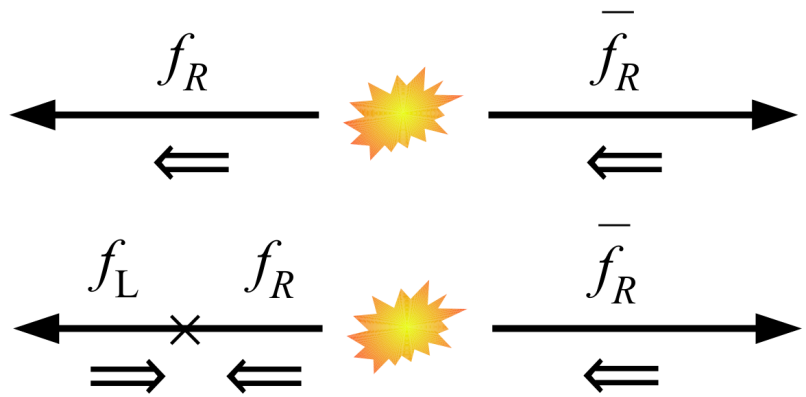
Pani, Polesello 17

- additional states lead to alternative signatures
- LHC and Indirect detection probe different physics

The surprisingly direct connection

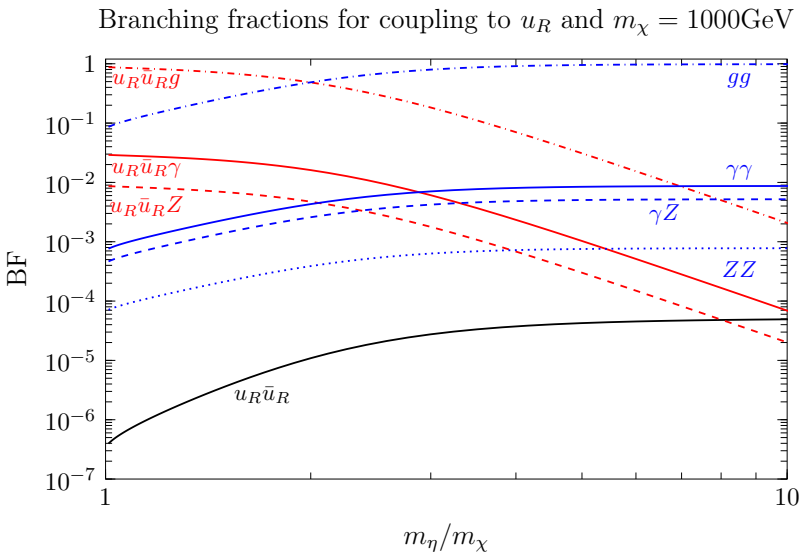
$\chi\chi \to q\,\bar{q}$

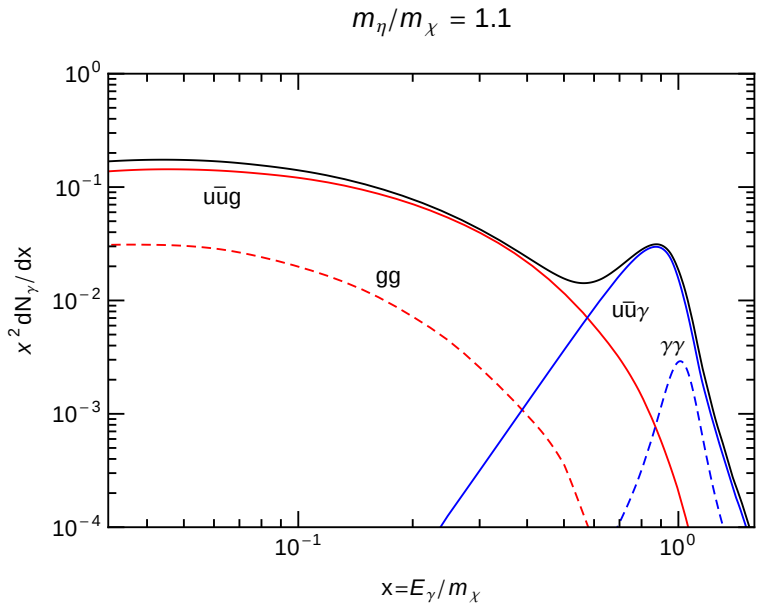
- s-wave annihilation of Majorana dark matter suppressed by helicity m_f^2/m_χ^2



- corrections to annihilation cross section relevant

Color charged t-channel mediator

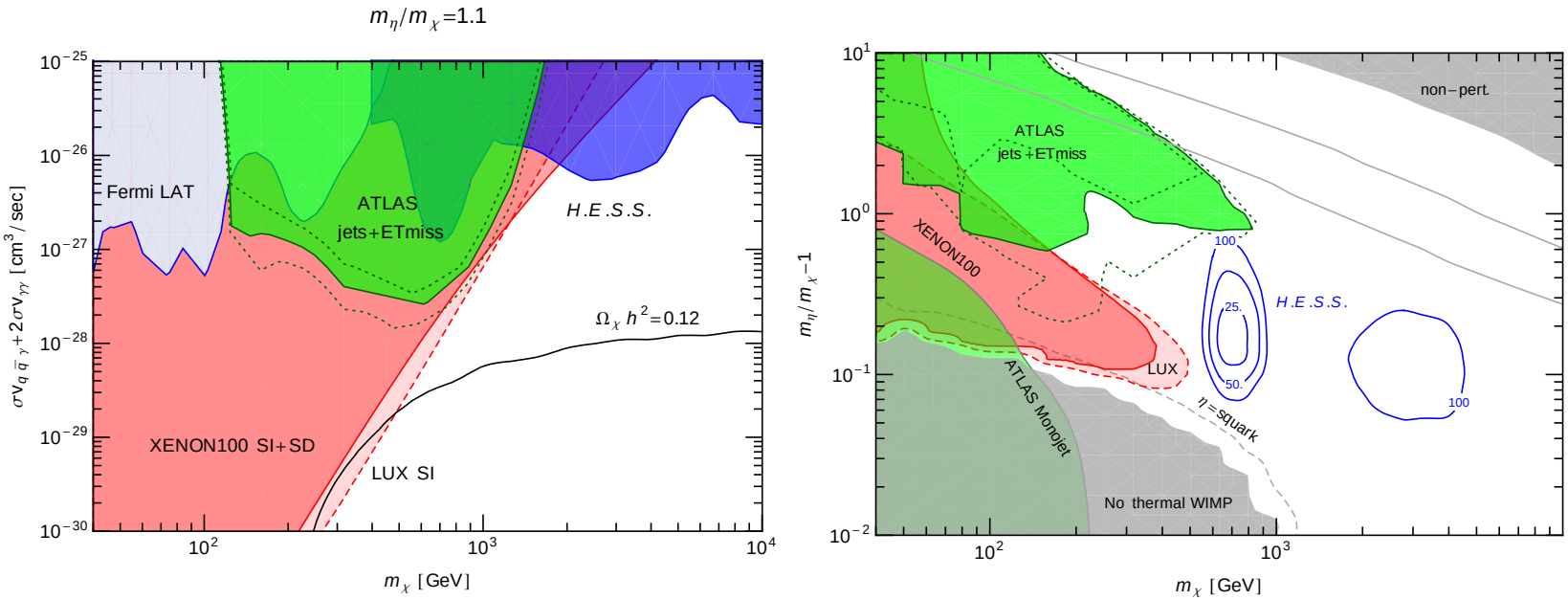




Garny, SV + 15

- dominant annihilation to $u\bar{u}$ gluon or $u\bar{u}\gamma$
- very similar to mono-X signature
- superior sensitivity to line-like gamma feature

Line searches and the LHC



Garny, SV+ 14

- line search competitive at high m_χ
- future CTA sensitivity?

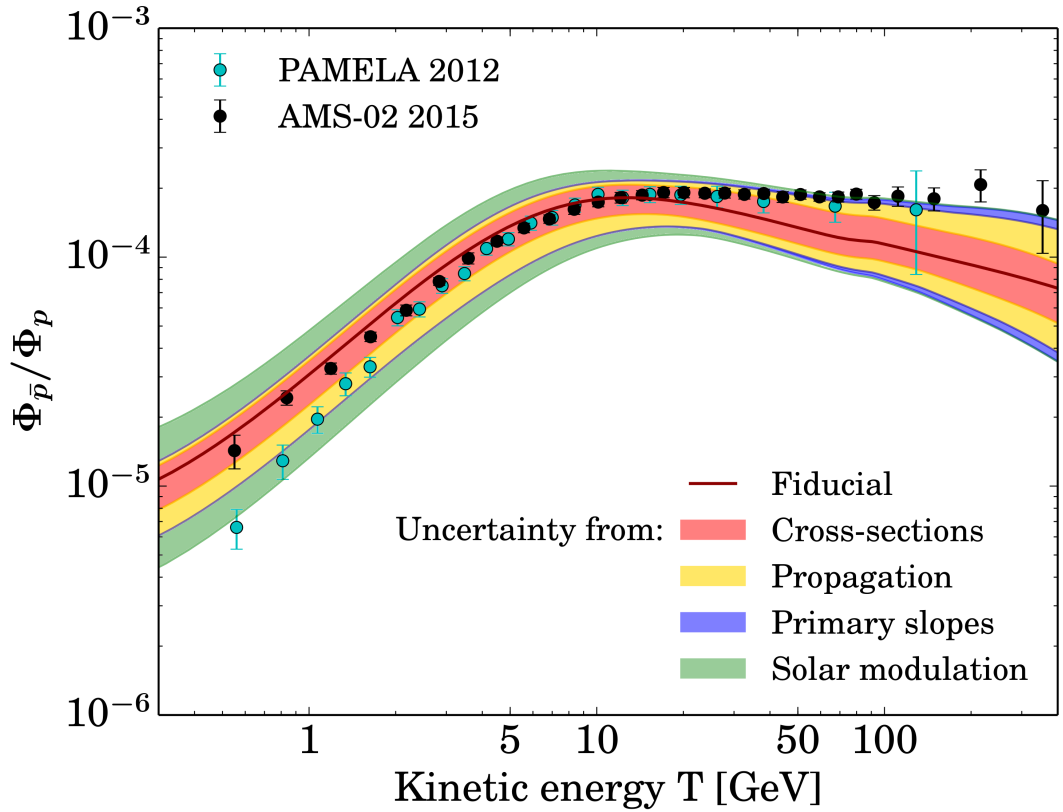
The forgotten connection

Backgrounds and signals

- indirect detection needs to overcome astrophysical backgrounds
- predicting backgrounds with high confidence is challenging
- accurate description of astrophysics required
- good understanding of relevant particle physics processes

$\rightarrow$ LHC/collider input important for indirect detection

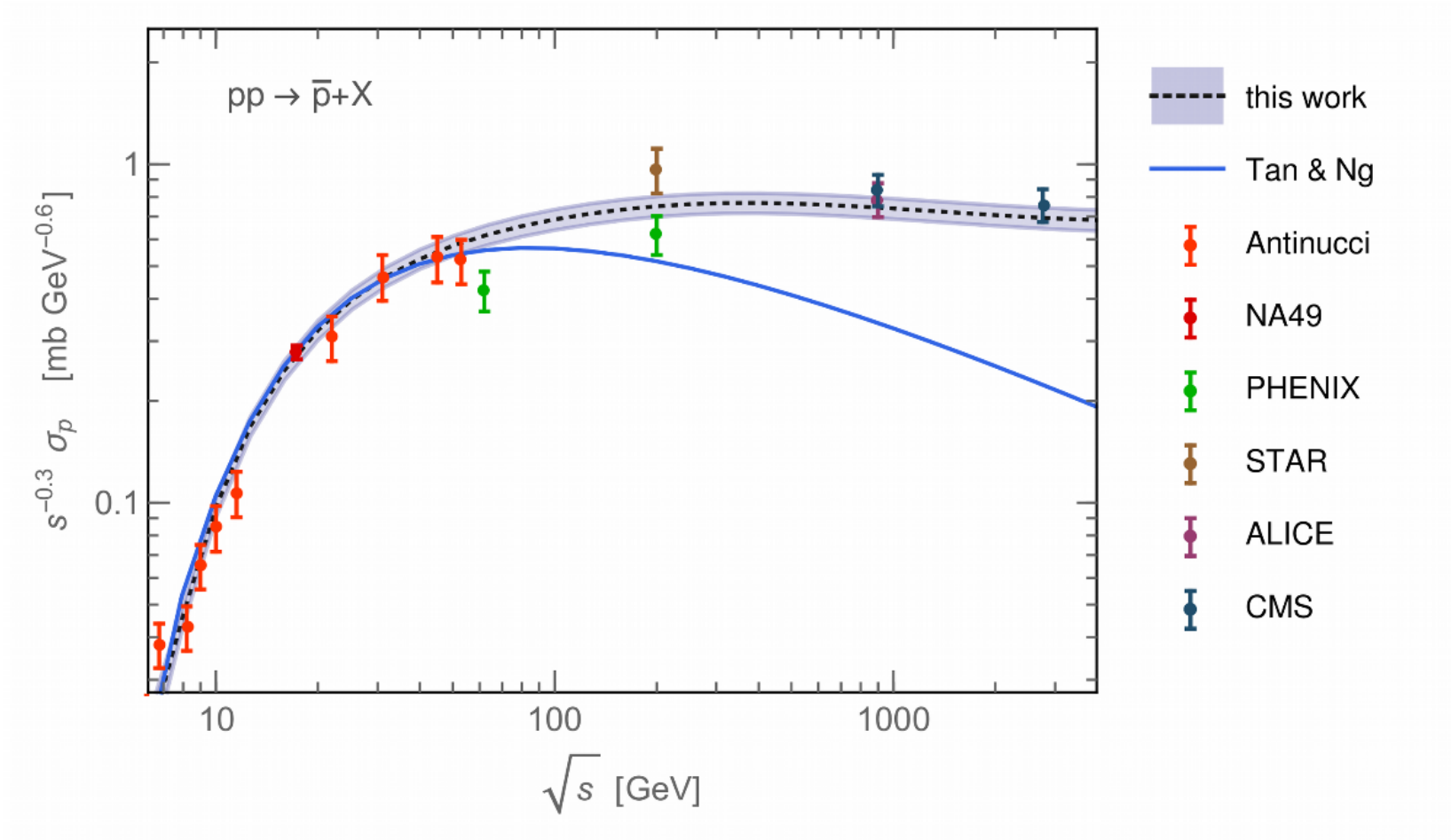
Example: AMS-02 antiprotons



Giesen+ 15

- AMS-02 data more precise than prediction for astrophysical flux
- How could we detect a signal here?

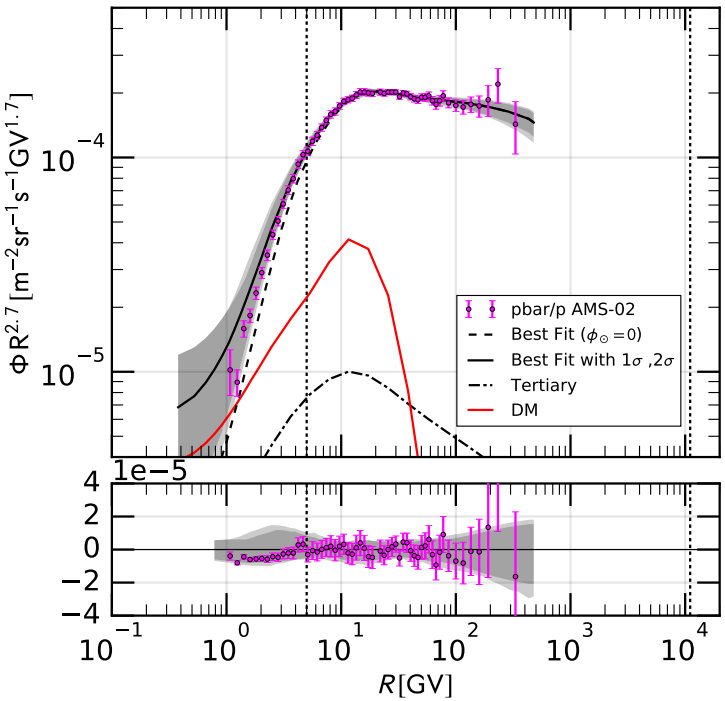
Collider measurements



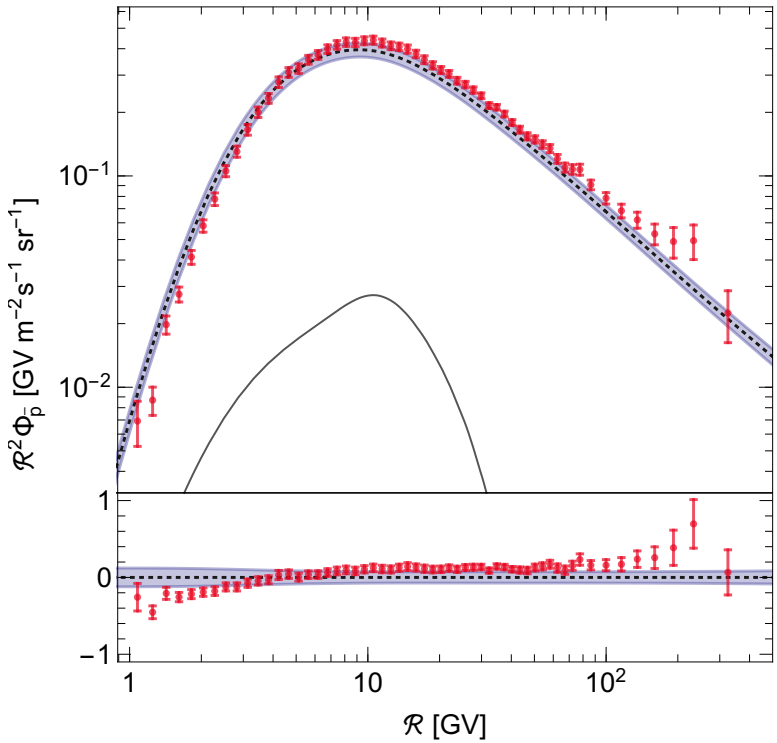
Winkler 17 and Reinert, Winkler 17

- antiproton production needs to be determined across wide range of energies
- LHC experiments contribute crucial information

Antiproton signal?



Cuoco+ 16



Reinert, Winkler 17

- reached the level of precision to search for (and argue about) a subleading antiproton signal in the AMS-02 data

Conclusion

- LHC and indirect detection often sensitive to different physics $\rightarrow$ opportunity to test different aspects of new physics
- indirect detection unique tool to test high mass dark matter
- LHC as a utility: collider measurements of cross section etc. crucial for indirect detection