Pierre Fest

The dark side of Antideuterons

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Once upon a time, at the dawn of a new century, armed with a deep conviction that good papers need strong motivations ...

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Since we do not find compelling signals of dark matter, why not invent a new undetectable signal? That would be fun!

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Antideuterons as a signature of supersymmetric dark matter

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Clearly this will never work: a simple back of the envelope calculation shows that the expected rate of antiD production is 4 orders of magnitude smaller than antiP production.

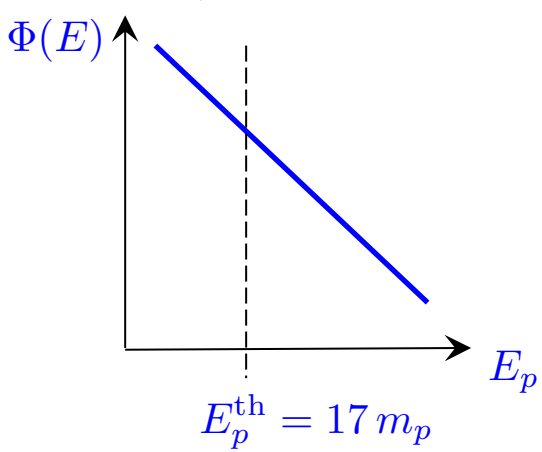
Ok: we are at the dawn on a new century, but still ...

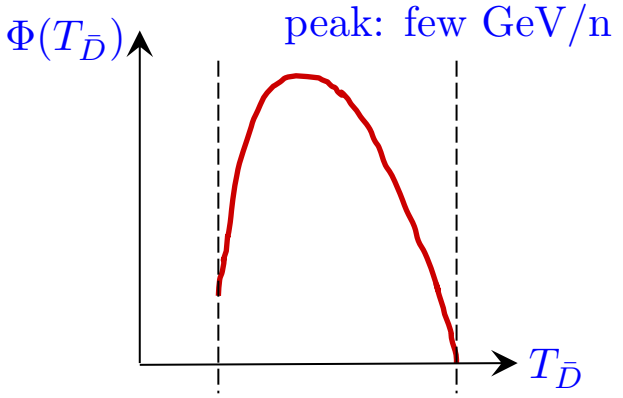
OK, wait

The low-energy window !

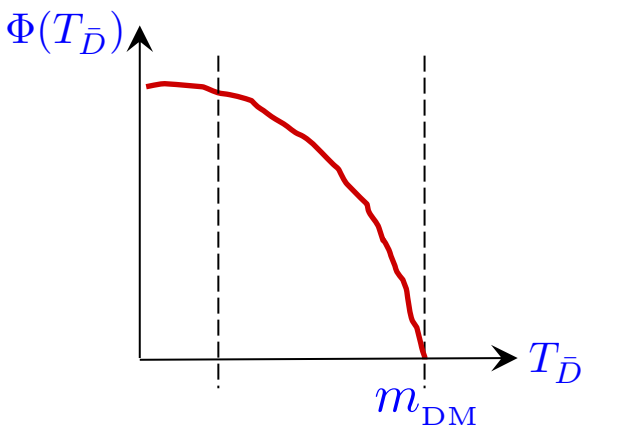
At production: background and DM have different kinematics and source spectra

Background: $p_{CR} + \overbrace{p_{ISM}}^{\text{at rest}} \longrightarrow \bar{p}\bar{n} + pn + pp$

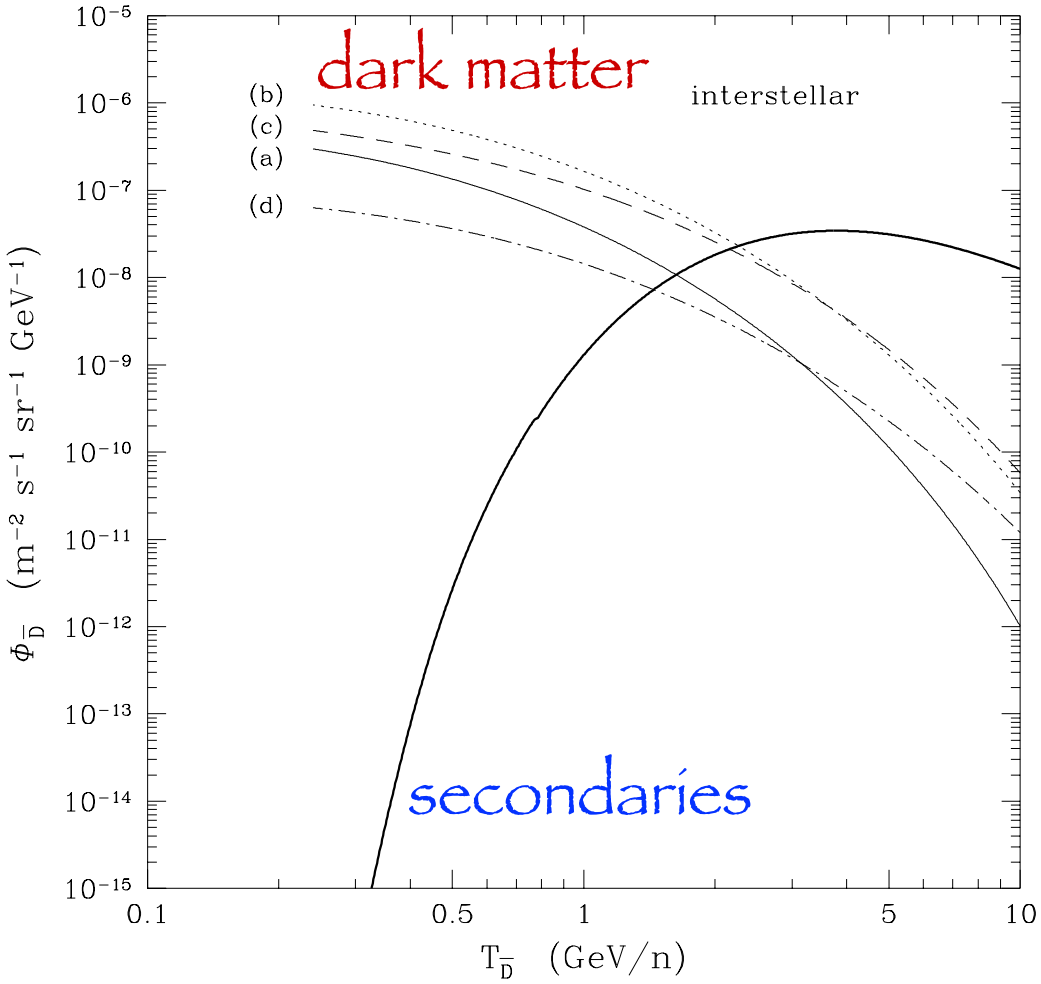




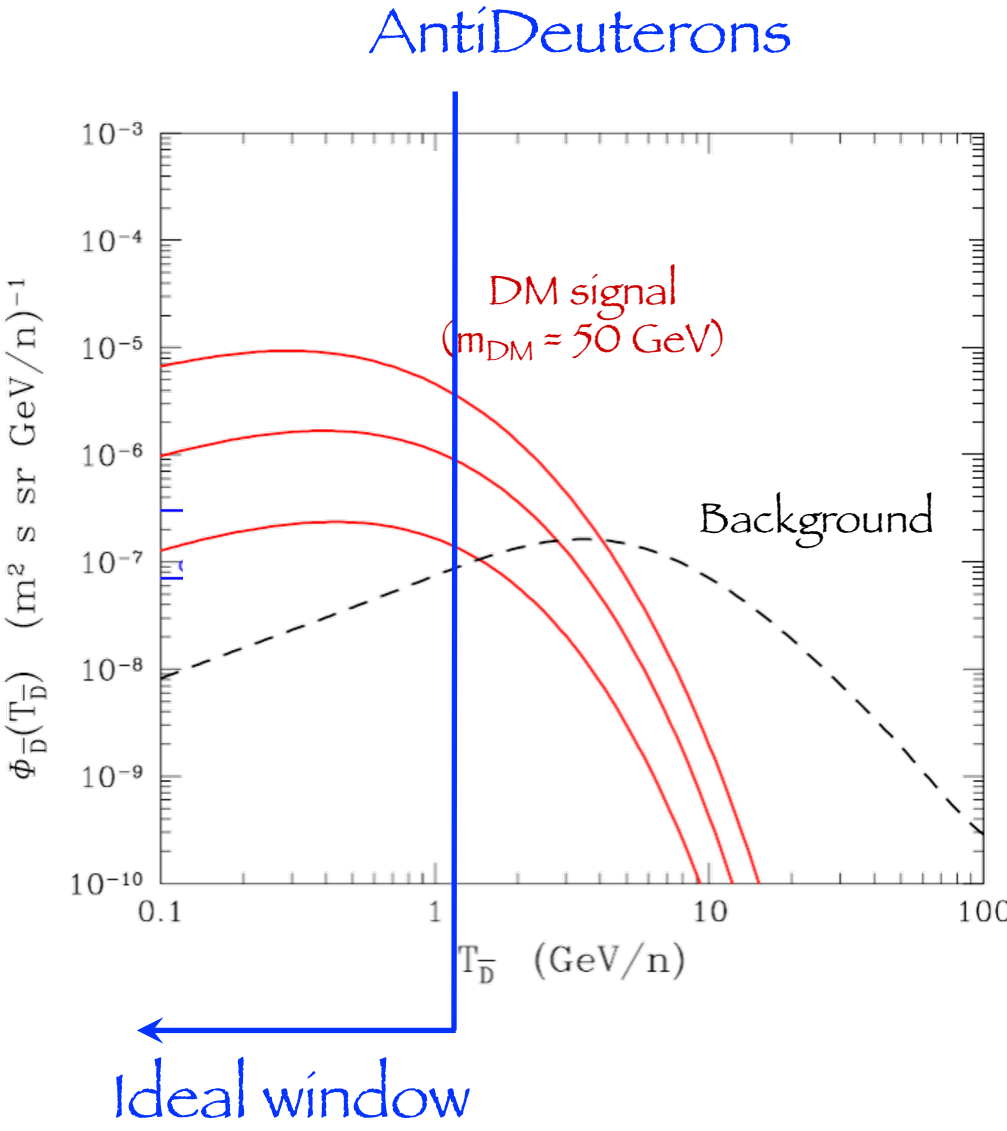
Signal: $\underbrace{\chi}_{\text{at rest}} + \overbrace{\chi}^{\text{at rest}} \longrightarrow \bar{p}\bar{n} + pn$



The low-energy window !

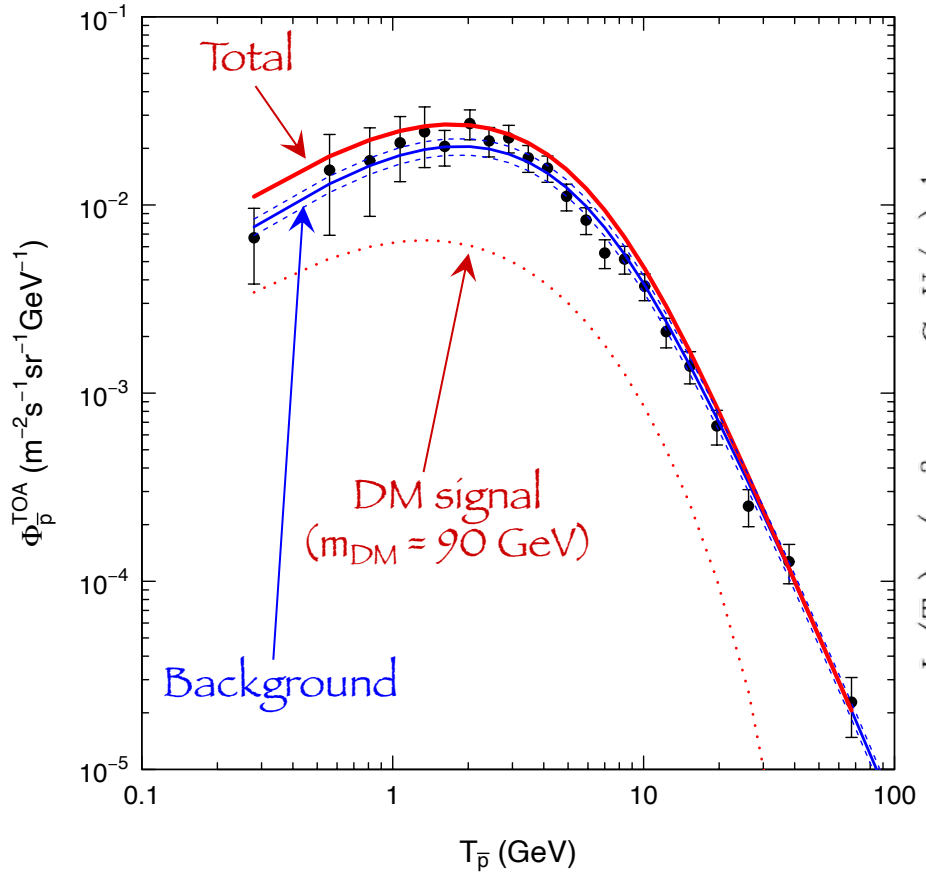


The low-energy window !

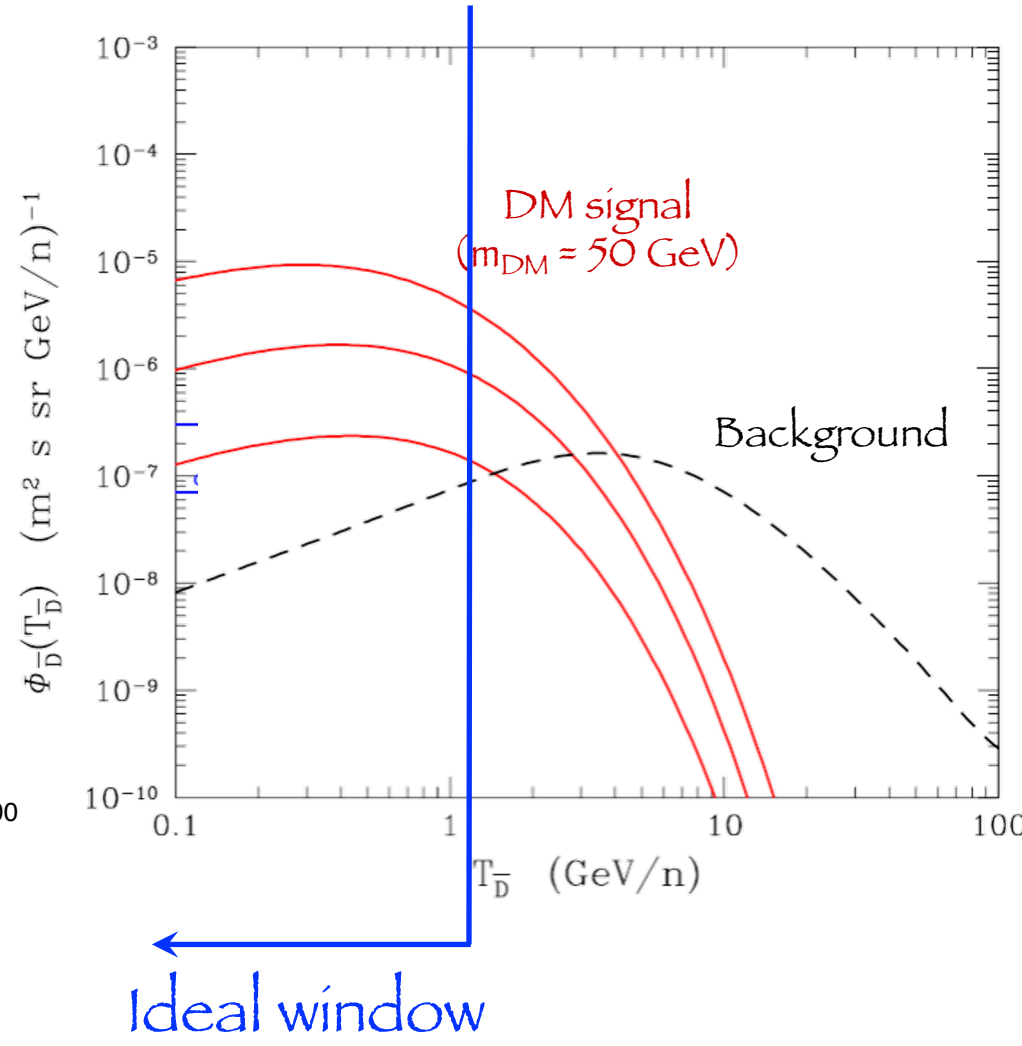


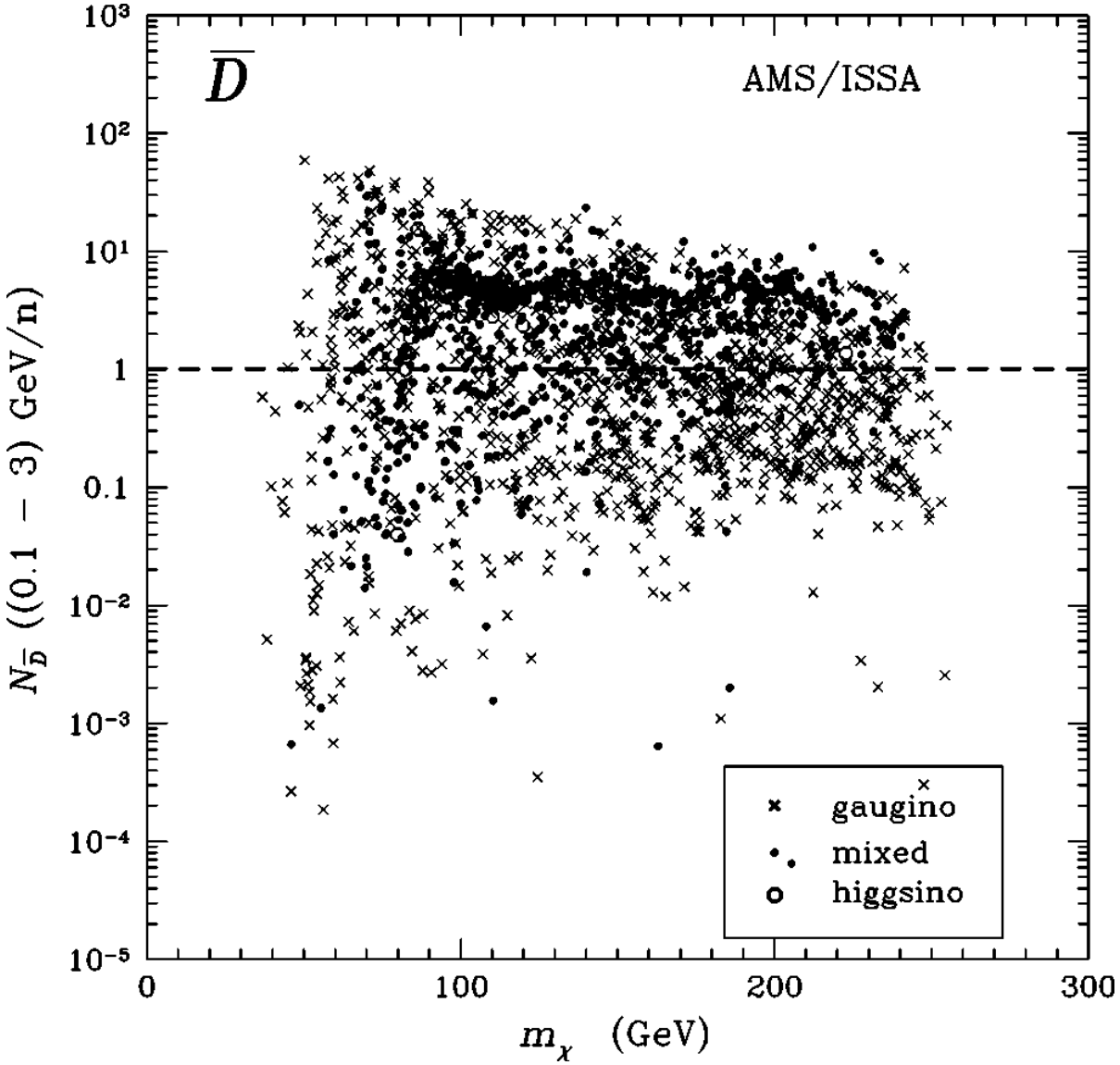
Antiprotons vs. Antideuterons

AntiProtons



AntiDeuterons




$\overline{D}$
AMS/ISSA
$N_{\bar{D}}$ ((0.1 − 3) GeV/n)
m_χ (GeV)
gaugino
mixed
higgsino
10^3
10^2
10^1
1
0.1
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
100
200
300

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A NOVEL ANTIMATTER DETECTOR BASED ON X-RAY DEEXCITATION OF EXOTIC ATOMS

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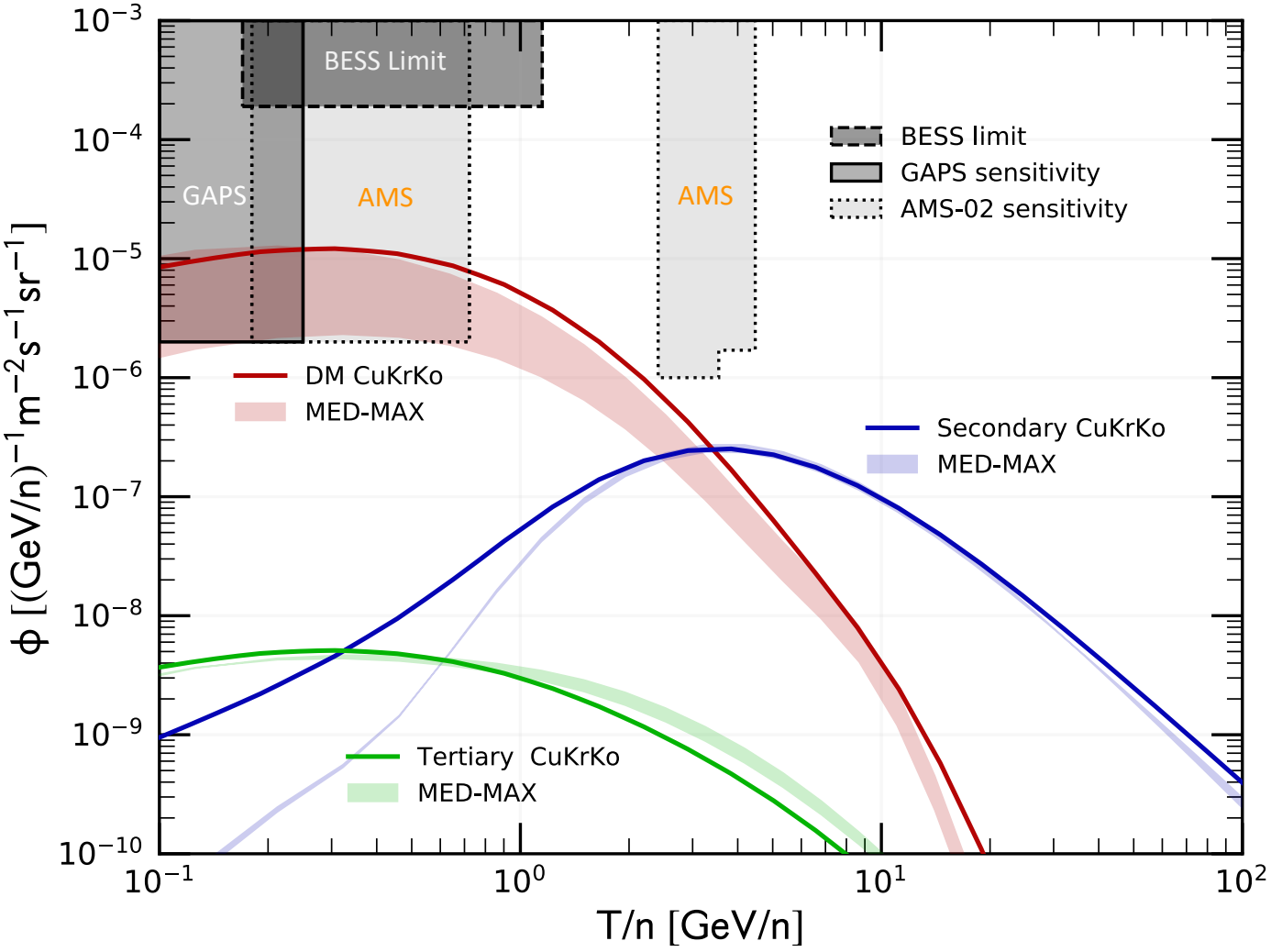
ABSTRACT

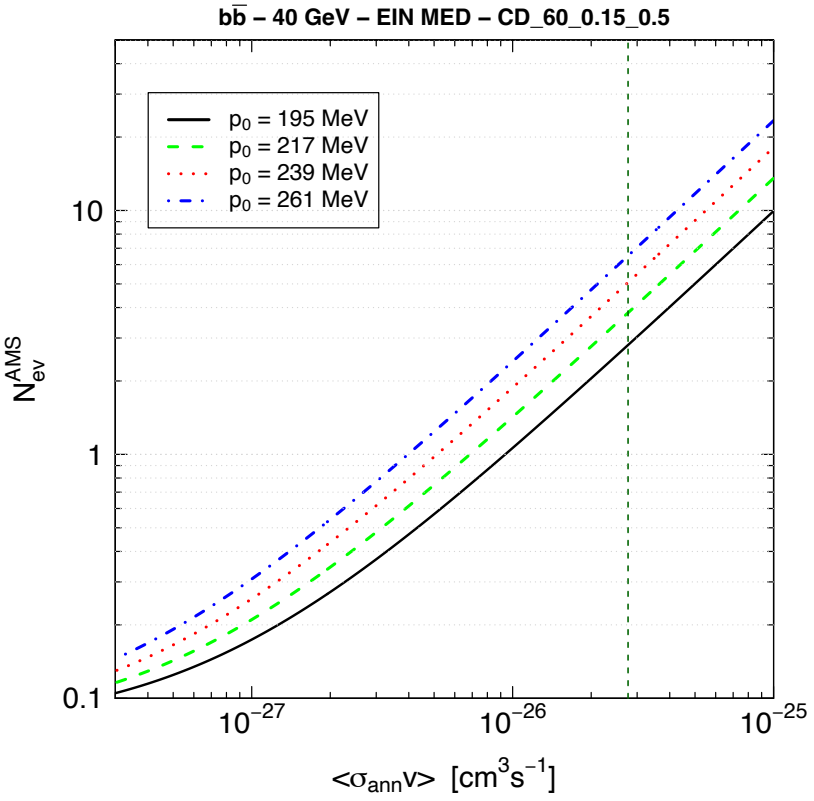
We propose a novel antiparticle detector. The gaseous antiparticle spectrometer (GAPS) effects particle identification through the characteristic X-rays emitted by antiparticles when they form exotic atoms in gases. GAPS obtains particularly high grasp (effective area–solid angle product) at lower particle energies, where conventional schemes are most limited in their utility. The concept is simple and lightweight, so it can be readily employed on balloon- and space-based missions. An extremely powerful potential application of GAPS is a space-based search for the neutralino through the detection of a neutralino annihilation by-product—the antideuteron. Paradoxically, this space-based search for the neutralino is capable of achieving comparable sensitivity to as yet unrealized third-generation, underground dark matter experiments. And GAPS can obtain this performance in a very modest satellite experiment. GAPS can also provide superior performance in searches for primary antiprotons produced via neutralino annihilation and black hole evaporation and in probing subdominant contributions to the antiproton flux at low energies. In a deep space mission, GAPS will obtain higher sensitivity for a given weight and power than BGO calorimeters.

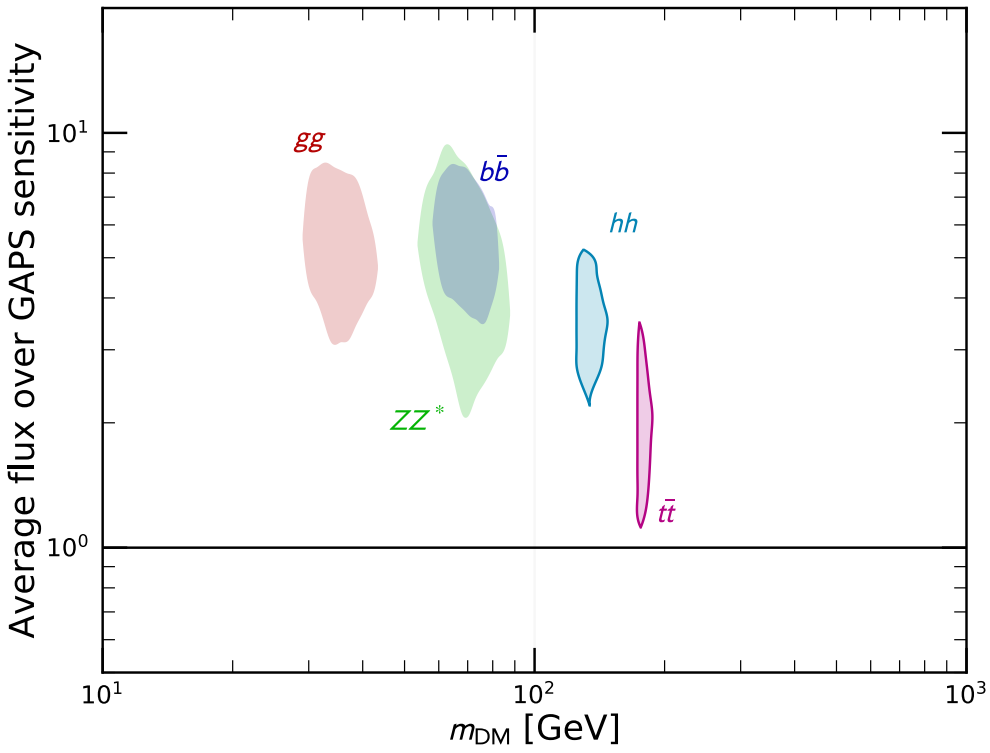
Subject headings: atomic processes — cosmic rays — dark matter — techniques: spectroscopic

The promise of indirect detection techniques to search for the neutralino has changed markedly in the last year. Theoretical calculations predict a flux of primary antideuterons in the cosmic rays due to the annihilation of the neutralino (Donato, Fornengo, & Salati 2000).

This flux is large enough that the GAPS technique, when employed in a modest space-based experiment, has competitive and possibly superior sensitivity to as yet unrealized third-generation direct detection experiments.


BESS Limit
GAPS
AMS
AMS
BESS limit
GAPS sensitivity
AMS-02 sensitivity
DM CuKrKo
MED-MAX
Secondary CuKrKo
MED-MAX
Tertiary CuKrKo
MED-MAX
ϕ [(GeV/n)$^{-1}$m^{-2}s^{-1}sr^{-1}]
T/n [GeV/n]
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-1}
10^{0}
10^{1}
10^{2}





DM signal: up to about 10 events

Background: 0.07 events

Thank you, Pierre, for the great fun working together, your inspiration and friendship!

And much more to come!