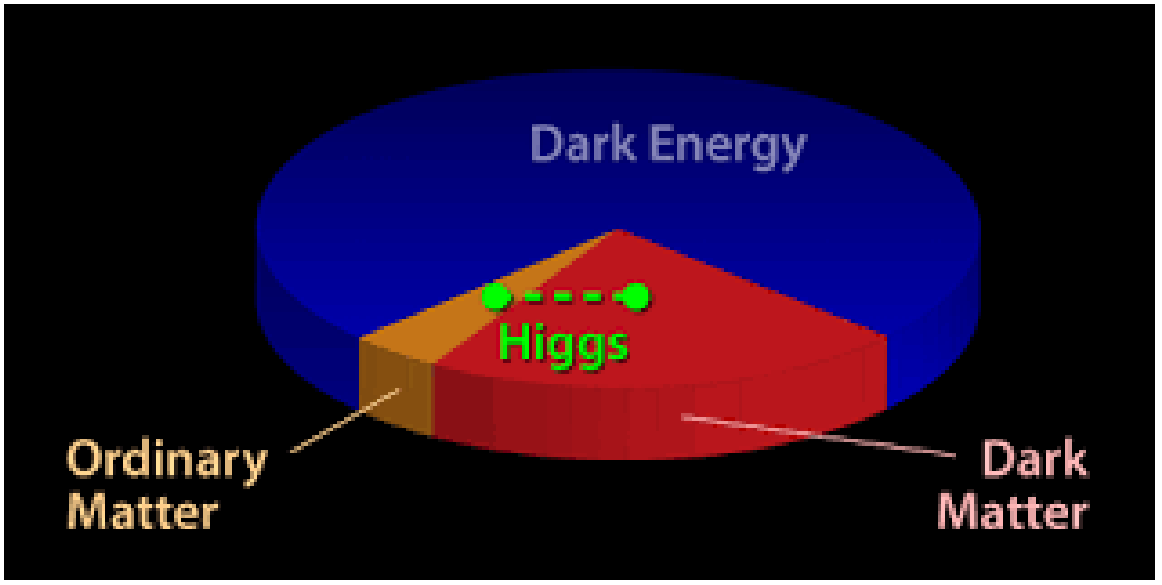


Dark Matter through the Higgs portal

Alexey Gladyshev (BLTP, JINR)

Dark Matter Workshop, October 22, 2020

In commemoration of Willem de Boer

The Supersymmetric interpretation of the EGRET excess of diffuse galactic gamma rays #1

W. de Boer (Karlsruhe U., EKP), C. Sander (Karlsruhe U., EKP), V. Zhukov (Karlsruhe U., EKP), A.V. Gladyshev (Dubna, JINR and Moscow, ITEP), D.I. Kazakov (Dubna, JINR and Moscow, ITEP) (Nov 14, 2005)

Published in: *Phys.Lett.B* 636 (2006) 13-19 • e-Print: hep-ph/0511154 [hep-ph]

pdf DOI cite 58 citations

Egret excess of diffuse galactic gamma rays as tracer of dark matter #2

W. de Boer (Karlsruhe U., EKP), C. Sander (Karlsruhe U., EKP), V. Zhukov (Karlsruhe U., EKP), A.V. Gladyshev (Dubna, JINR and Moscow, ITEP), D.I. Kazakov (Dubna, JINR and Moscow, ITEP) (Aug 29, 2005)

Published in: *Astron.Astrophys.* 444 (2005) 51 • e-Print: astro-ph/0508617 [astro-ph]

pdf DOI cite 156 citations

Egret excess of diffuse galactic gamma rays interpreted as a signal of dark matter annihilation #3

Wim de Boer (Karlsruhe U., EKP), C. Sander (Karlsruhe U., EKP), V. Zhukov (Karlsruhe U., EKP), A.V. Gladyshev (Dubna, JINR), D.I. Kazakov (Dubna, JINR) (2005)

Published in: *Phys.Rev.Lett.* 95 (2005) 209001 • e-Print: astro-ph/0602325 [astro-ph]

pdf DOI cite 47 citations

Excess of egret galactic gamma ray data interpreted as dark matter annihilation #4

W. de Boer, M. Herold, C. Sander, V. Zhukov, A.V. Gladyshev et al. (Aug 19, 2004)

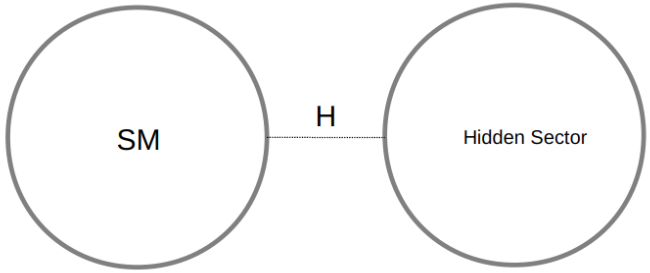
e-Print: astro-ph/0408272 [astro-ph]

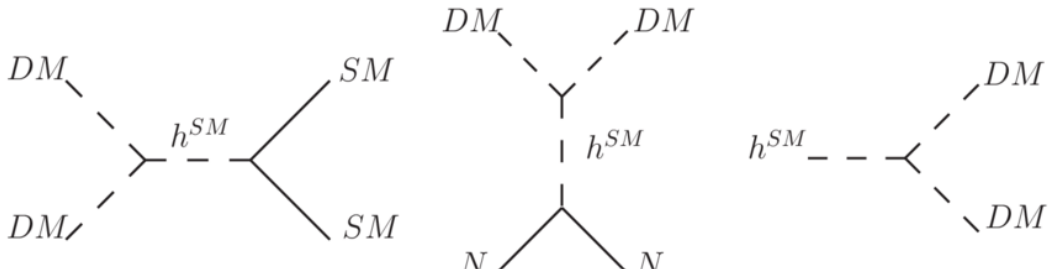
pdf cite 49 citations

Willem de Boer
11/02/1948 - 13/10/2020

The Higgs-portal: Definition

The Higgs-portal scenarios/models are scenarios in different models of particle physics in which the particles that account for the DM in the Universe interact only through their couplings with the Higgs sector of the theory.





The DM can be detected in annihilation processes, nucleon scattering in direct detection experiments, or in invisible Higgs decays.

The Higgs-portal: The Standard Model scenario

The simplest Higgs–portal scenario is when the Higgs sector is kept minimal postulated in the SM: the single doublet Higgs field that leads to the unique H boson which has been observed so far.

The DM particle in the SM can have three possible spin assignments:

- spin–0 or scalar particle;
- spin–1 vector boson;
- Dirac or Majorana spin–1/2 fermion;

  (a spin–2 DM state has been also proposed → NR / effective theories).

The Higgs-portal: The SM with extended H sector

The Higgs sector of the 2H model has 5 physical states after EWSB:

- 2 CP–even neutral ones which have properties of the SM H;
- CP–odd or pseudoscalar neutral H;
- 2 charged H states with properties different from those of the SM H.

The presence of additional particles leads to a rich phenomenology and interesting new signatures.

Further extesion of SM H sector: additional singlet Higgs field.

The Higgs-portal: SUSY extensions of the SM

The H sector of the MSSM again involves 5 physical states after EWSB:

- 2 CP–even neutral ones that mix and have properties of the SM H;
- CP–odd or pseudoscalar neutral H;
- 2 charged H states with properties that are completely different from those of the SM H boson.

SUSY extensions imply the existence of fermionic partners to Higgses.

There is an ideal candidate for WIMP which can form the CDM: the LSP, a neutralino, a mixture of the partners of the neutral gauge and Higgs bosons. It is stable if a symmetry called R–parity is conserved.

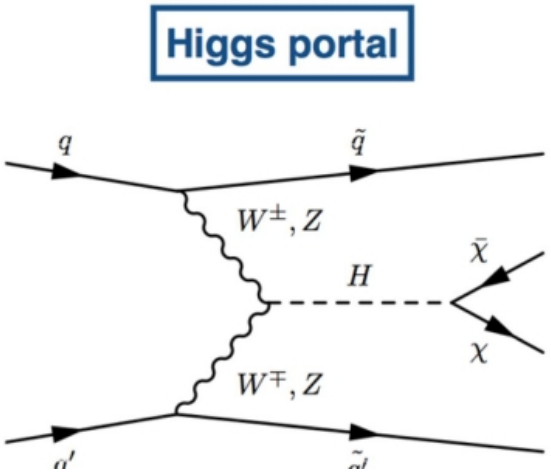
The Higgs-portal: SUSY extensions of the SM

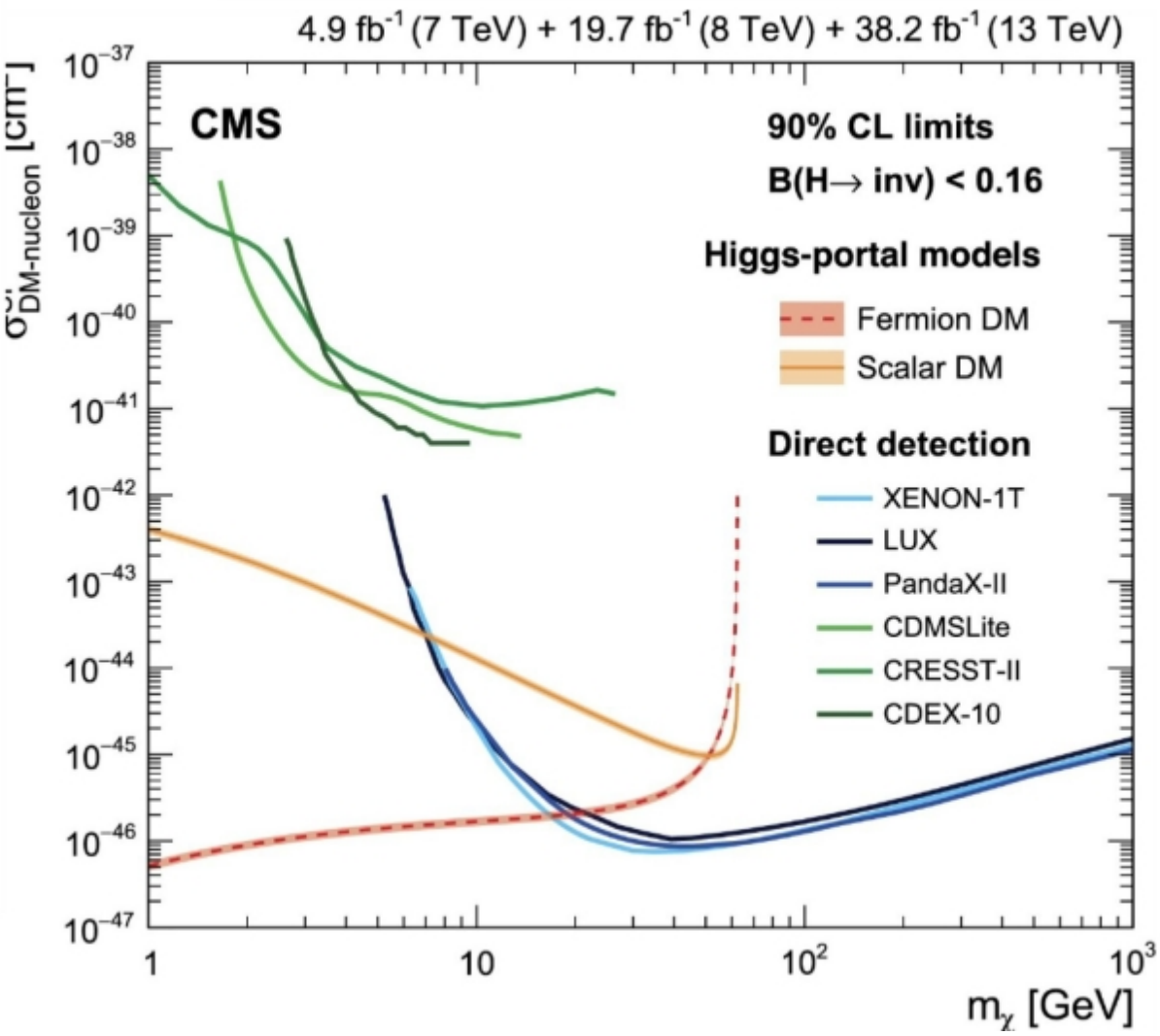
Further extension of the MSSM H sector is becoming popular by now, is the so–called NMSSM in which a complex singlet field is added to the 2H doublet model giving extra CP–even and CP–odd H particles.

When the partners of the fermions are very very heavy as we know from the LHC data, the neutral states of the H sector are the privileged portals to the DM neutralino in a large area of the parameter space.

The Higgs-portal: Invisible Higgs decays (exp)

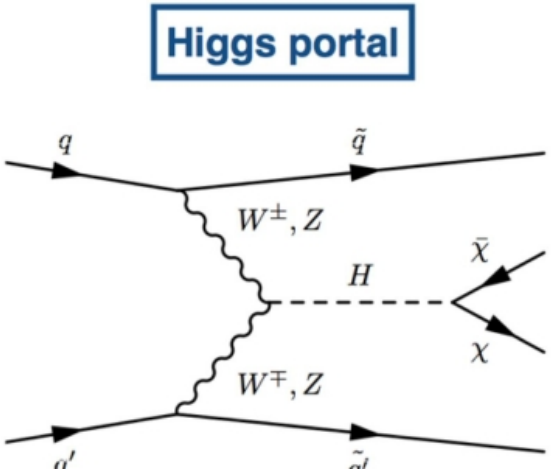
- CMS @ LHC

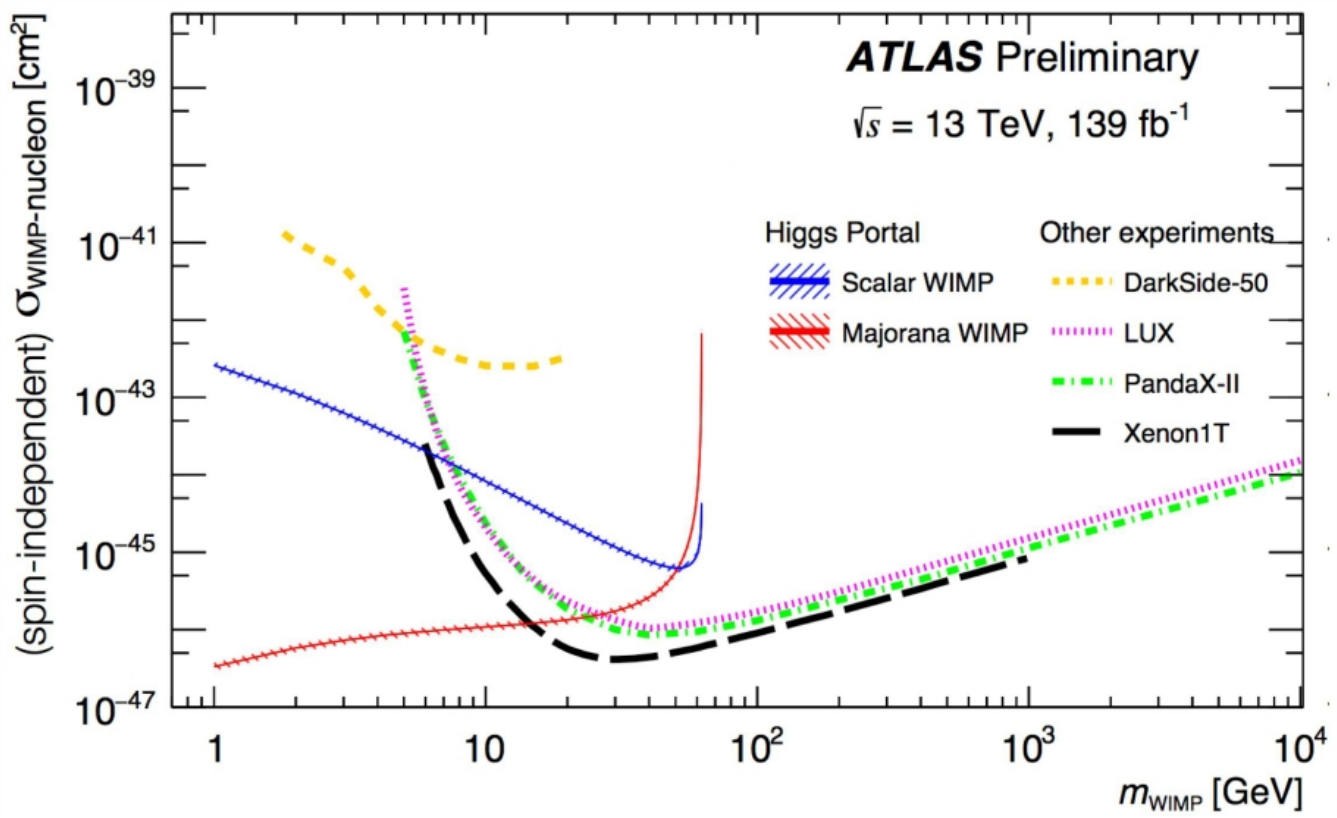




The Higgs-portal: Invisible Higgs decays (exp)

- ATLAS @ LHC





The Higgs-portal: Summary

- Dark Matter exists, properties are not known completely.
- There exist a lot of models of particle physics with Higgses.
- The most popular are the SM, 2HD SM, 2HD+S SM, MSSM, NMSSM, ...
- The presence of new particles leads to interesting new signatures.
- The properties of the Higgs boson discovered at the LHC can put stringent constraints on DM models.
- The collider searches for the DM means probably the searches for invisible Higgs decays.
- Physics Reports, Volume 842, 3 February 2020, Pages 1-180