

Intro to LHC DM Working Group public meeting (18/12/2017)

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LHC DMWG ORGANISERS**

How the DMWG operates

LHC Dark Matter Forum / Working Group (2014-)

http://lpcc.web.cern.ch/lpcc/index.php?page=dm_wg

- Make the most of what little we know of DM
- Complement so far diverse collaborations between experiment and theory
- Pay attention to good ideas from theory, help make things happen in experiments

The DMWG so far has worked on **focused efforts:**

selected topics leading to arXiv write-ups

E.g. June 2016: choose new topic to develop towards our next public meeting

- open editing of a [google document](#) containing suggestions
- meeting with short presentations on some of the potential topics
- add suggestions and discussion to google doc
- jointly decide on topic(s) after discussion on contributors mailing list (*)
- develop topic in open meetings
- keep discussing on-list and in smaller groups of interested contributors
- **conclude and write up, with circulation and review on mailing list**

From now on: thinking about pursuing more than one topic at a time

Today: first discussion on what the community is interested in

More chances to discuss new topics on mailing lists (*)

(*) Discussion always encouraged on **mailing list:** lhc-dmwg-contributors@cern.ch

- higher volume list for day-to-day discussions in detail
- everyone registered with the mailing list has posting rights
- everyone is welcome to raise questions / issues to the attention of the group
- broader mailing list lhc-dmwg@cern.ch is only used for announcements and circulations

List of topics covered so far

Summer 2015

<https://arxiv.org/abs/1507.00966>

[Dark Matter Forum] Reach consensus on a **common set of benchmark models** for ATLAS and CMS early Run-2 searches

Winter 2015

<https://arxiv.org/abs/1603.04156>

Within the framework of the DMF simplified models, **present results and compare** Direct Detection (DD) / Indirect Detection (ID) / collider searches

Winter 2016

<http://arxiv.org/abs/1703.05703>

Agree on how to **present searches for mediators** of DM interactions in visible decays together with searches to DM particles, add lepton couplings to DMF benchmark models

Spring 2017

<https://arxiv.org/abs/1705.04664>

Arrive at a joint **estimation of theory uncertainties** for *precision DM searches* at colliders (e.g. mono-jet)

2017-early 2018

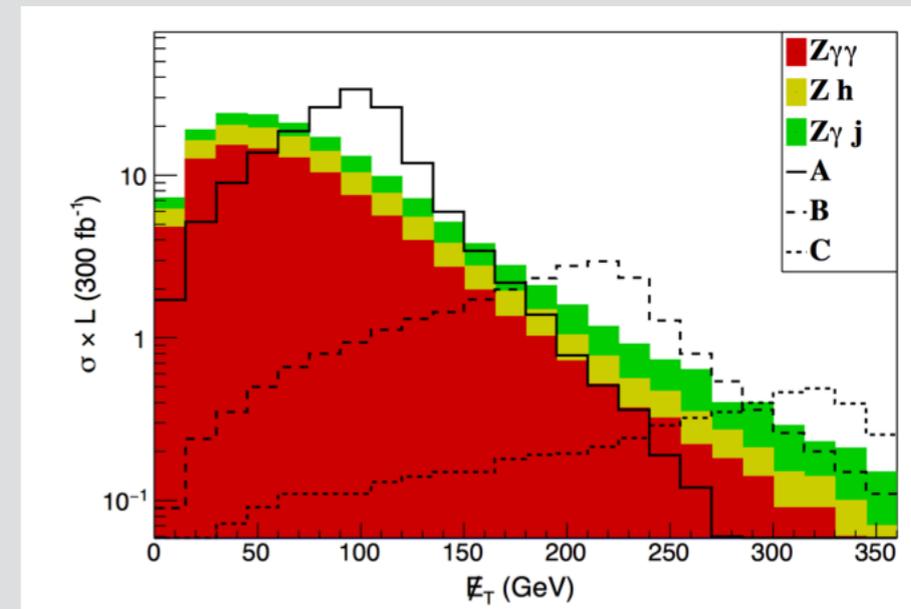
Develop **scalar sector** and **t-channel** benchmark models

TODAY'S MEETING FOCUS:

feedback on past work and suggestions for future topics

Less simplified models means richer parameter space

- Consensus on study of the UFO from <https://arxiv.org/pdf/1701.07427v1.pdf>
- Interesting kinematic distributions 
- Relative importance and phenomenology of different collider channels depends on Yukawa structure and parameters
- Two scalar doublets mean more parameters requiring careful evaluation, to understand:
 - where colliders are uniquely sensitive
 - how to simplify parameter space
- should account for additional constraints from Higgs / EW observables / flavour physics → model parameters from theory



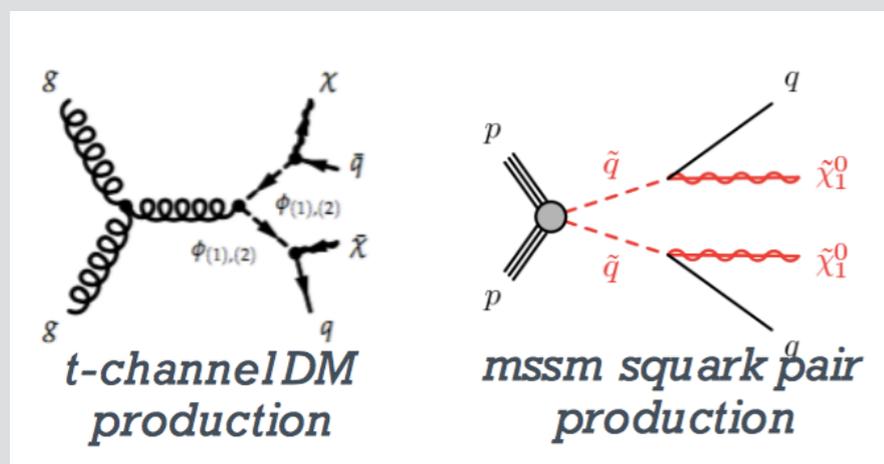
Completed DMWG tasks:

- discuss parameter space simplifications
- identify **kinematically distinct models** for future developments
- study **benchmarks** for Run 2 to represent range of complementary searches

Theory and experimental community driving development
of recommendations from bottom up,
now effort is on **writing up whitepaper** ([git repository](#))

Quantifying overlap with SUSY

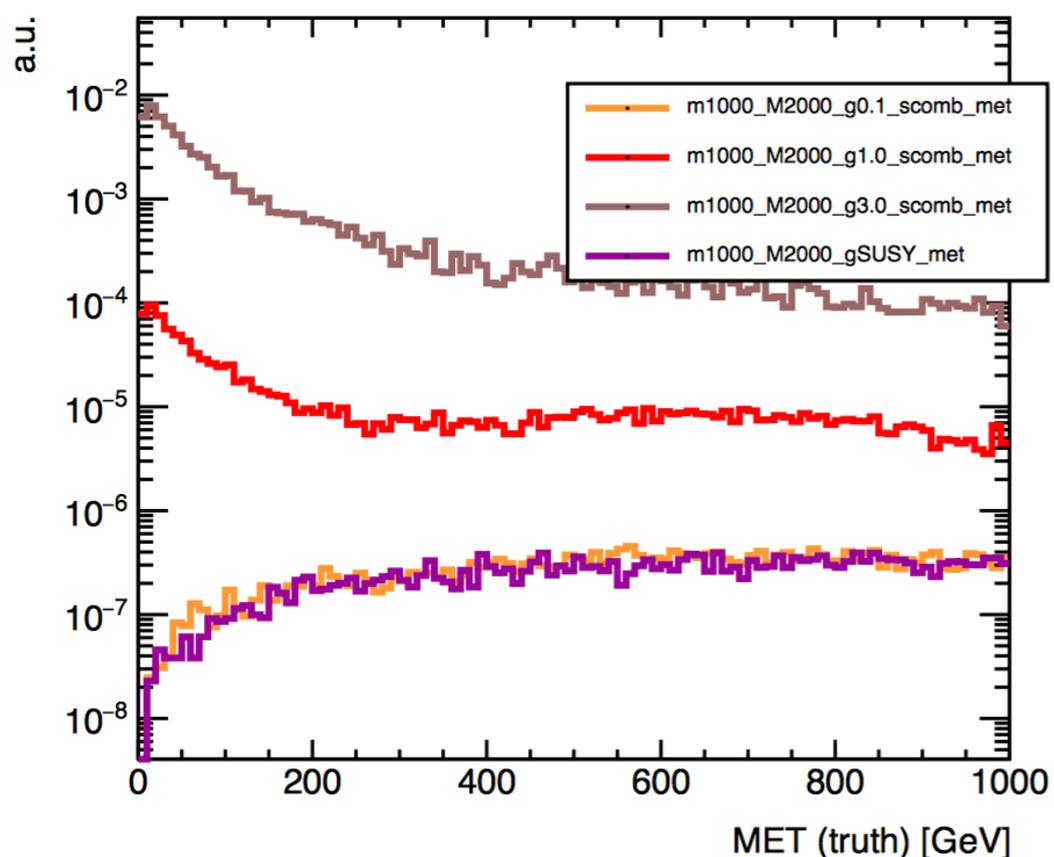
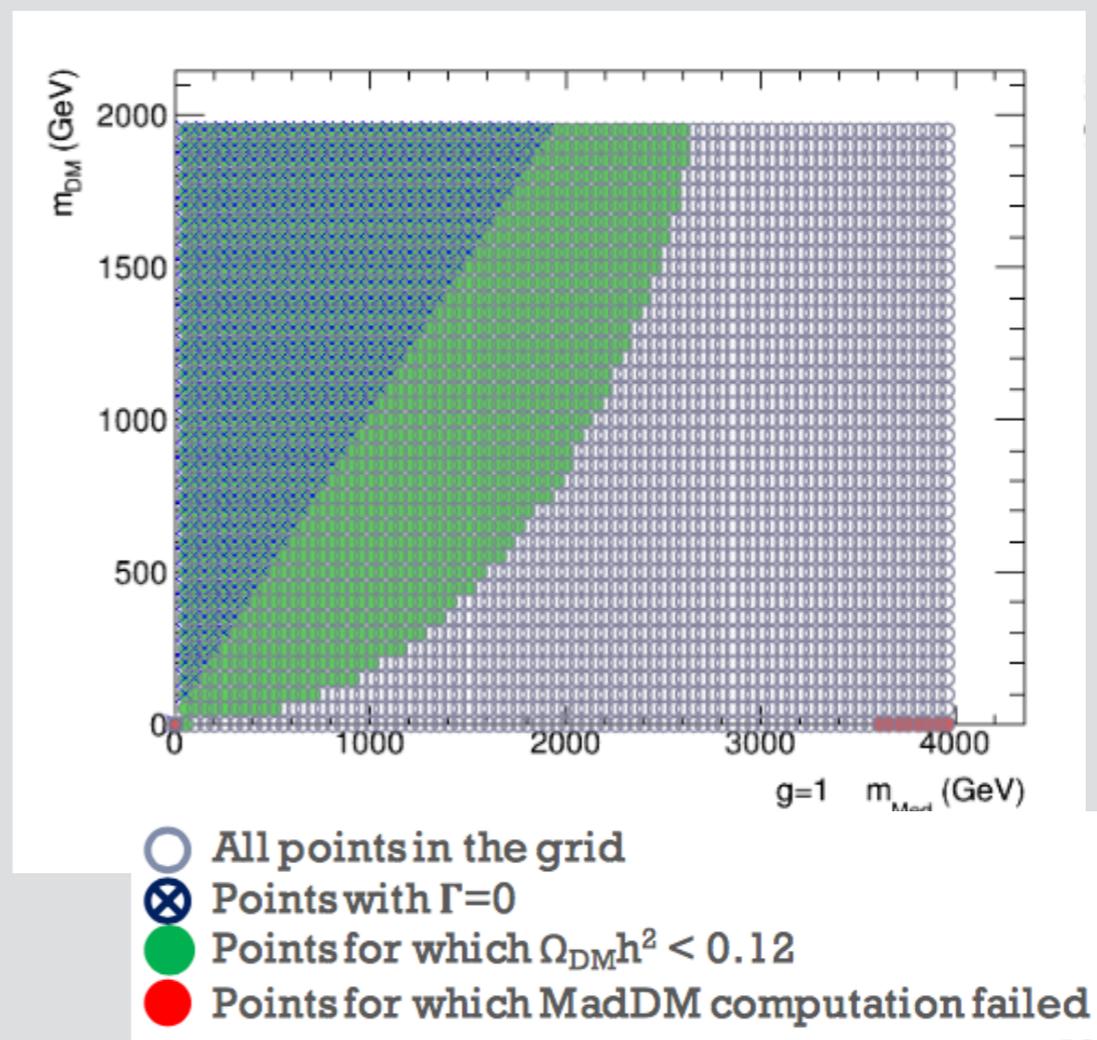
- Kinematics changes with larger coupling



M. G. Ratti

Understanding relic density

- "Compatible" region depends on coupling/mass of DM mediator, but still viable in many parameter scenarios



Technical points:

- Optimal split/merging/matching scheme

We would like to kick-off the efforts on white paper to conclude this study

Today's agenda

09:00 → 09:30 Introduction and scope of the meeting: Introduction



09:30 → 10:30 Discussion of results: LHC DM results with 2015+2016 data



09:30 CMS summary

Speaker: Livia Soffi (Cornell University (US))

20m



09:50 ATLAS summary

Speaker: Francesca Ungaro (University of Melbourne (AU))

20m



10:10 Discussion

20m



10:30 → 11:00 Coffee break

30m

11:00 → 12:15 New ideas: Morning



11:00 LLP Community ideas towards dark sector benchmarks and search

20m



11:40 Simplified likelihoods

Speaker: Matthew Daniel Citron (Univ. of California Santa Barbara (US))

20m



12:00 Tools for relic density calculations in freeze-in scenarios

Speakers: Andreas Goudelis (CNRS), Mr. Bryan Zaldivar (LAPTh, Annecy), Genevieve Belanger

10m



12:15 → 13:30 Lunch break

1h 15m

13:30 → 14:30 New ideas: Afternoon short talks



13:30 Dark matter studies for HL-LHC and HE-LHC

Speaker: Monica D'Onofrio (University of Liverpool (GB))

DM_HLHELHC.pdf

10m



13:45 Simplified models for LLP searches

Speaker: Tien-Tien Yu (CERN)

10m



14:00 DM phenomenology at the LHC with decays outside the detector

Speaker: Doojin Kim (CERN)

10m



14:15 Comparisons to ID for Vector and Axial Vector models

Speaker: Linda Carpenter (Ohio State University)

10m



14:30 → 16:00 Scalar sector: Conclusion of 2HDM work, t-channel studies



14:30 Comparison to scalar model

Speaker: Giorgio Busoni

10m



14:45 Conclusion of 2HDM

Speaker: Janna Katharina Behr (Deutsches Elektronen-Synchrotron (DE))

20m



15:10 2HDM and single top

Speaker: Priscilla Pani (CERN)

10m



15:25 2HDM for $t\bar{t}$ resonances and interference

Speaker: Janna Katharina Behr (Deutsches Elektronen-Synchrotron (DE))

5m



15:35 Summary of t-channel models

Speaker: Kenji Hamano (University of Victoria (CA))

20m



DMWG_20171218...

16:20 → 16:45 New ideas: Afternoon



16:20 LHCb dark sector results

Speaker: J Michael Williams (Massachusetts Inst. of Technology (US))

20m



16:45 → 17:00 Conclusions: Conclusions and next steps





CERN-LPCC-2017-XX

Dark Matter Working Group recommendation for Two Higgs Doublet Model (draft title)

Authorlist to be compiled; Antonio Boveia,^{3,*}
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Abstract. Draft abstract.

1. Introduction
2. The model
3. The model parameters
4. Parameter grid
 1. Mono-Higgs
 2. Mono-Z
 3. $t\bar{t}$ +MET
 4. Other signatures (e.g. monojet)
5. Relic density calculation
6. Comparison to ID/DD

Experimental input is in these sections

Whitepaper - Introduction

1 Introduction

Reasoning behind this effort

- Simplified models only one signature at a time, sometimes not gauge invariant
- One step beyond this: less-simplified models
- Compare and confront different search sensitivity
- Combinations among different signatures
- Find new kinematic regimes / improve searches by exploring different signatures
- Still keeping the choice of model generic enough that this is reusable for theorists

Reasoning behind the choice of this model

- Highlights more than one signature at a time, depending on parameters
- Leaves room for new unexplored kinematic signatures within existing searches (left for future work)
- Complete enough, still simplified so that one can choose grid planes
- Existing theory effort (HXSWG)

Main responsables:

1. DMWG organizers
2. Martin Bauer, Uli Haisch
(authors of original paper)

2 The model

Description of the model

- Citations: [1–5]
- Particles, masses, couplings, mixing angles

Comparison with existing models How does the model compare with other 2HDMs/scalar models (with and without DM).

- Scalar to SSM to 2HDM evolution
- Other models:
 - S. Ipek, D. McKeen, A. Nelson, [3]
 - Bell, Busoni, Sanderson, [2]
 - No, Goncalves, Machado, [4, 5]
 - Higgs Cross-section Working Group

3 Model parameters

- Motivate the choice of parameters in [1]
- Vacuum stability study: fix lambda parameters to 3

Main responsables:

1. Martin Bauer, Uli Haisch: authors of original paper
2. Bell, Busoni, Sanderson: comparison with scalar model in alignment limit, helped by F. Ungaro
3. Gori: comparison to HXSWG models
4. No, Goncalves Machado: vacuum stability study

Whitepaper - Experimental signatures

4 Signatures

Description of signatures and simplified cuts:

- mono-Higgs
- HF+MET
- mono-Z
- others

**Main responsables:
CMS+ATLAS analysers**

Rolling agenda for informal meetings/material of various signatures:

<https://indico.cern.ch/event/678491/timetable/#20171103.detailed>

5 Parameter grid

5.1 Parameter scans on masses, couplings and mixing angles

Logic of how we proceeded

- Starting from benchmark 3 of [1]
- Mapping the kinematics and sensitivity of the model by scanning some of the various parameters
- Checking whether other existing models can be rescaled

5.1.1 Results of studies

Each of the signatures should have the following plots in the planes of the final recommendation:

- efficiency at parton level with simplified, published cuts
- total and fiducial cross-section at parton level
- 2 - 3 kinematic plots of what has been scanned that are most representative for the analysis (here the analysers decide, then we harmonize at the end)

Signatures:

- Mono-Z (lep/had)
- MonoH \rightarrow bb
- Monojet
- ttbar+MET, with specific discussion about rescaling
- other signatures who have not yet presented at public meetings, in ATLAS and CMS

5.1.2 Final proposal for parameter scan

- a two-dimensional scan in the light pseudoscalar mass (m_a) - heavy pseudoscalar mass (m_A) plane where $m_a = m_A$, fixing $\tan\beta$ to 1.0, $\sin\theta$ to 0.35 and the Dark Matter mass (m_{DM}) to 10 GeV.
- a one-dimensional scan in DM mass from 1 GeV to 500 GeV for a point in the middle of the sensitivity range for the mono-V analyses at $m_A=600$, $m_a=250$ GeV, so the connection between this model and cosmology is clear as the measured relic density starts being satisfied at values of DM mass around 100 GeV

In order to explore changes in complementarity with different analyses and kinematics, this should be complemented by:

- a two-dimensional scan in the m_a $\tan\beta$ plane, for comparison with the $t\bar{t}+\text{MET}$ / $b\bar{b}+\text{MET}$ analyses. In this case, the charged Higgs mass ($m_{H^{\pm}}$), the heavy pseudoscalar mass (m_A) and the heavy Higgs mass (m_H) should be fixed to 600 GeV. This scan includes points: 50, 45, 40, 35, 30, 25, 20, 15, 10, 5 for $M(a)$ masses between 10 and 350 GeV. The high- $\tan\beta$ points would be of primary interest to the HF + DM searches. Uli's studies have shown that one can simply reweight the existing $t\bar{t}+\text{DM}/b\bar{b}+\text{DM}$ models from DMF to the new 2HDM+PS cross sections; full simulation of the newly proposed 2HDM+PS points is not required.
- two one-dimensional scans in $\sin\theta$ for the comparison of mono-Higgs and $b\bar{b}+\text{MET}$ analysis (it is expected that the $b\bar{b}+\text{MET}$ analysis will only have to rescale previous models/cross-sections) [2]:
 - $m_H = m_A = m_{H^{\pm}} = 600\text{GeV}$, $m_a = 200\text{GeV}$, $\tan\beta=1$
 - $m_H = m_A = m_{H^{\pm}} = 1000\text{GeV}$, $m_a = 350\text{GeV}$, $\tan\beta=1$

6 Connection with cosmology

Short section on the calculation of relic density for relic-aware grid, with plots and curves to be put in the repository.

Main responsables:

CMS+ATLAS analysers

Andreas Albert, Valerio Ippolito,
Emma Tolley

Timeline

October-December 2017: connect theory and experimental community, collect material and write white paper

18 December 2017: DMWG public meeting (see mailing list for details), status report from various groups

End of January 2017: DMWG internal peer-review of white paper

Would you like to become one of the referees?

Help welcome!