COLLIDING LIGHT

To make dark matter at the LHC

International Conference on High Energy Physics

Poster session | 31 July 2020

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University of Chicago

THE UNIVERSITY OF CHICAGO

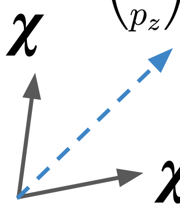
In collaboration with Lydia Beresford (University of Oxford)

Based on Phys. Rev. Lett. 123 (2019) 141801

Problem: LHC “MET+X” DM searches only use invisible 2-vector

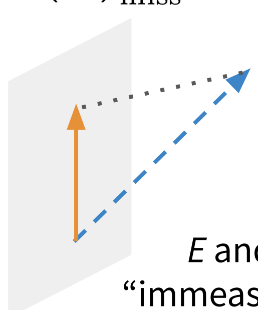
Dream

$$\begin{pmatrix} E \\ p_x \\ p_y \\ p_z \end{pmatrix}_{\text{miss}} \Rightarrow (2m_\chi)^2$$



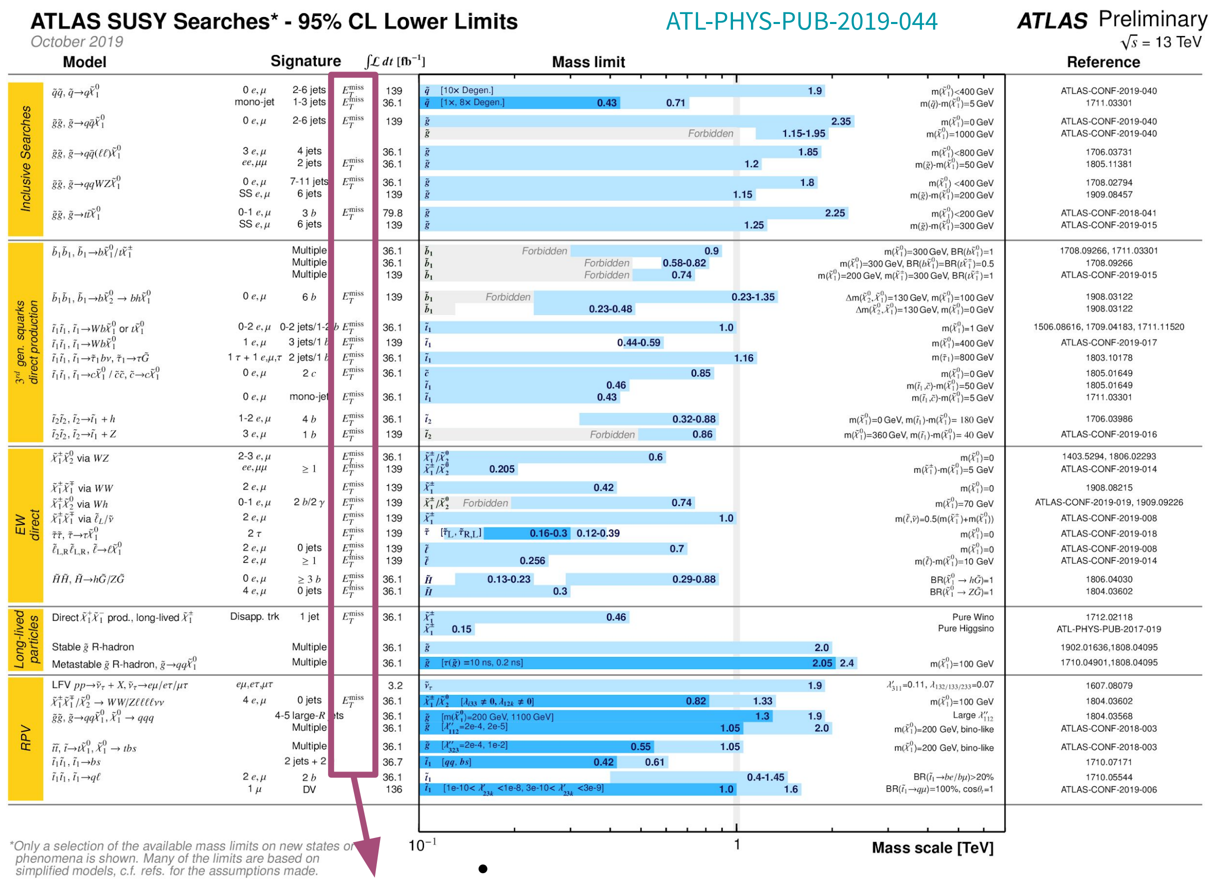
Reality

$$\begin{pmatrix} p_x \\ p_y \end{pmatrix}_{\text{miss}}$$ 2-vector



E and p_z
“immeasurable”

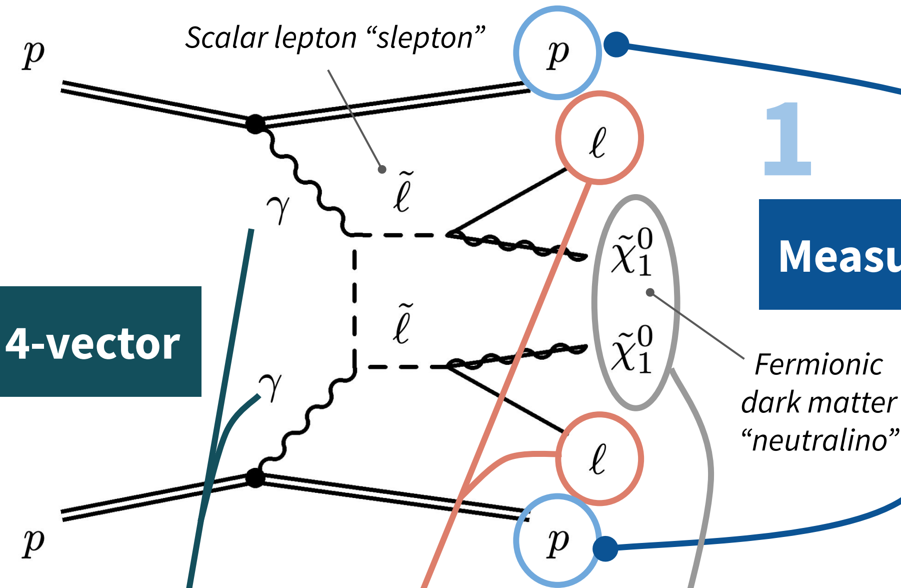
Consequence: at least 2 degrees of freedom lost



E_T^{miss}

Only transverse measured but really
desire *missing momentum 4-vector*

Solution: collide light & tag protons for 4-vector p_{miss}



1

Use e.g. ATLAS Forward Proton

Measure intact protons

2

Compute photon 4-vector

$$p_{\text{miss}} = \sum_{\text{initial}} p_i - \sum_{\text{final}} p_f^{\text{visible}} \Rightarrow m^2_{\text{miss}} = p^2_{\text{miss}}$$

3

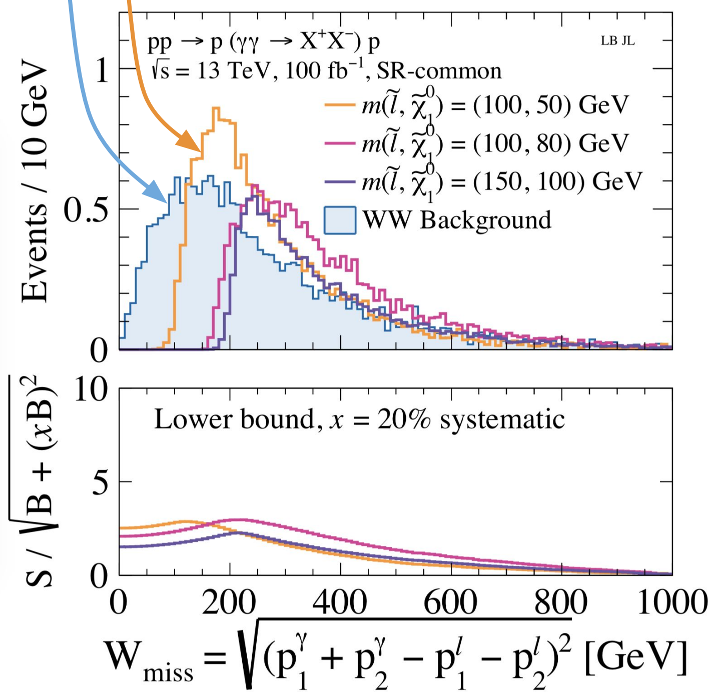
"Impossible @ hadron colliders"
no more

Square 4-vector to measure dark matter mass

Impact: turn light into dark matter this decade?

γγ → WW irreducible background

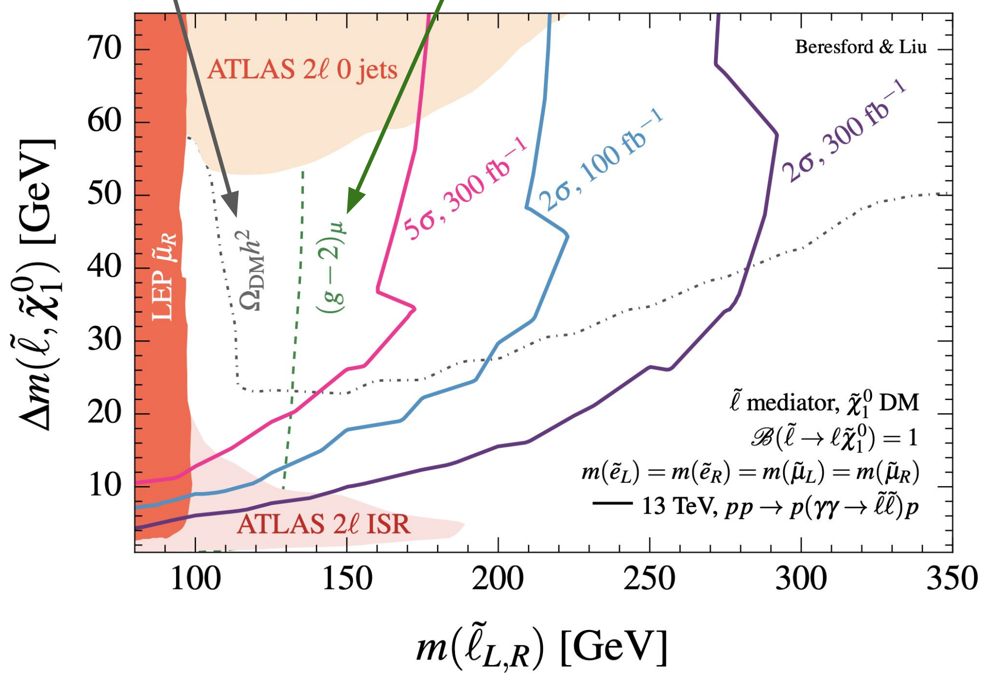
Sharp threshold at $2 \times m_{\mathrm{DM}}$



Missing mass spectrum @ LHC

Favoured by dark matter abundance

Favoured by muon g – 2 tension



Sensitivity to challenging parameter space

Search for new phenomena in mono-X final states using pp collision data collected in Run-2 by the ATLAS experiment at the LHC

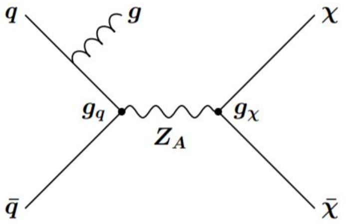
Sergio González Fernández
IFAE, Barcelona

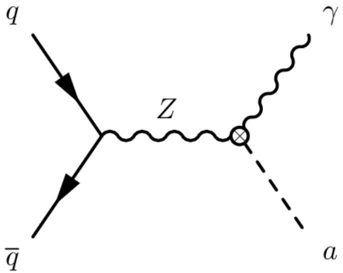
on behalf of the ATLAS Collaboration

Introduction

- Cosmological and astrophysical observations point to the existence of a form of matter known as **Dark Matter** (DM) that accounts for about 27% of the total mass-energy of the Universe.
- If DM interacts with the Standard Model, it can be produced at the LHC and **detected indirectly** via initial state radiation (ISR) of the incoming particles or by identifying some Standard Model (SM) particles produced in association with DM.
- Searches focused in these type of signatures are commonly known as **mono-X** searches. For the rest of this presentation mono-X will refer to **monojet** and **monophoton** searches.

Diagram for the pair-production of weakly interacting massive particles (WIMPs) χ, with an exchanged mediator Z_A in the s-channel. In this process, the DM particles escape the detector as invisible but can be detected indirectly with an ISR gluon that will hadronize yielding an event with a jet and large momentum imbalance. These type of signatures are searched in the **monojet** analysis.



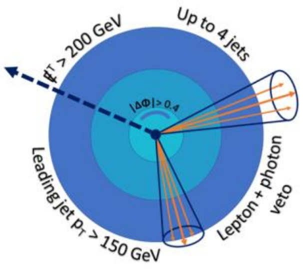


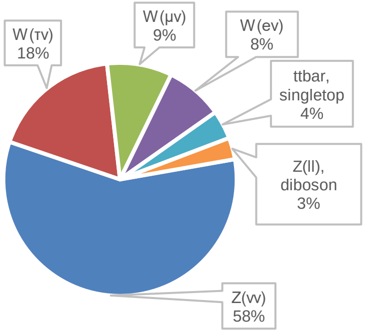
This diagram shows the production of an Axion Like Particle (ALP) in association of a photon through the mediation of a Z boson in the s-channel. If the ALP is considered invisible, the event can be identified with a single photon event with large momentum imbalance. These type of signatures are searched in the **monophoton** analysis.

- Many theoretical models for new physics propose candidates for Dark Matter. These include simplified WIMP models, SUSY interpretations, Large Extra Dimensions and Axion Like Particles.

Analyses overview

Monojet



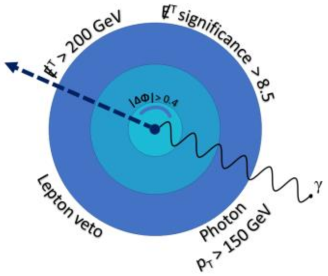


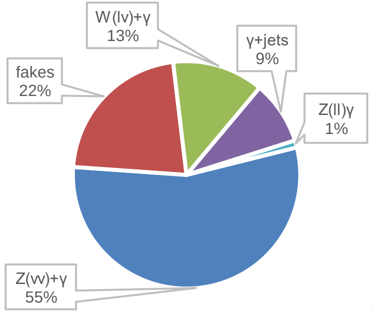
- **Monojet** and **monophoton** searches focus on signatures with large missing transverse momentum associated to jets or photons, respectively.
- The signal region in both analyses focuses on cutting the $\boldsymbol{E_T^{miss}}$ and the $\boldsymbol{p_T}$ of the associated particle (**jets**/**photon**). Both apply a lepton veto.
- In both analyses the jet/photon is expected to be **recoiling** of the dark matter particles so a $\Delta\phi$ cut to the E_T^{miss} is also applied.
- The **dominant background** arises from events with a **Z boson decaying into neutrinos**. If jets or photons are produced in ISR the event becomes indistinguishable from a monojet/photon signal event.
- The **background contamination** in the signal region is computed using **Control Regions**, which are defined in an orthogonal but similar way as the Signal Region.

- Theoretical prescriptions for reweighting **V+jets** processes yield **NNLO (QCD) and NLO+Sudakov logs (EWK) precision.**

- A cut on $\boldsymbol{E_T^{miss}}$ **significance** is introduced to help **reduce** the contamination from the $\boldsymbol{\gamma}$**+jets** background.

Monophoton

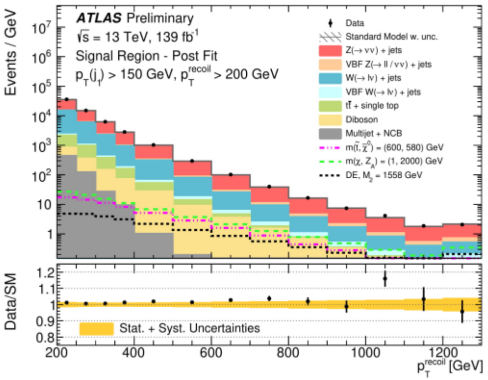


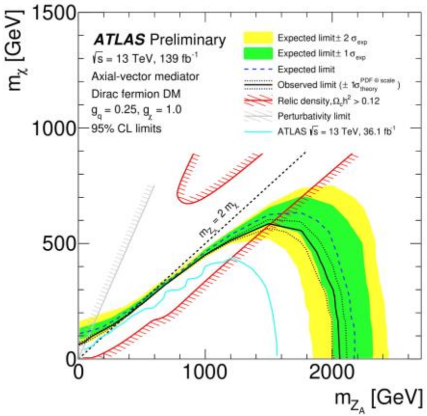


Results and Interpretations

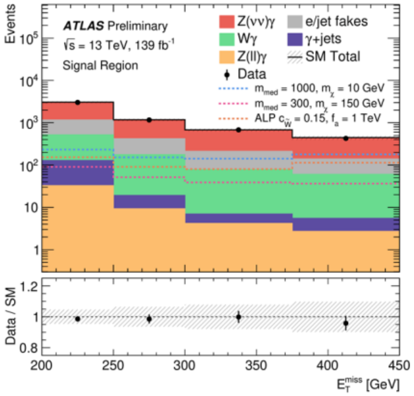
- No significant deviations to the Standard Model predictions is observed and the results are translated into **exclusion limits** for a variety of models with a DM candidate, such as simplified models.

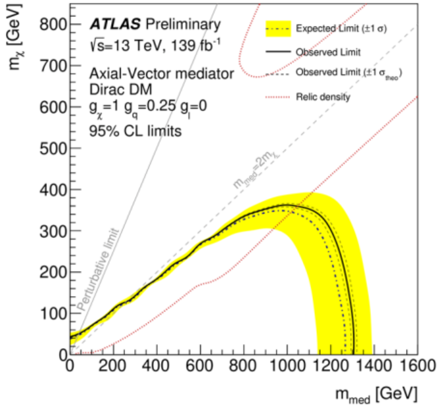
Monojet





Monophoton





- Both analyses consider for the first time setting exclusion limits on a model that describes Axion Lile Particles interactions with the Standard Model.
- The monojet analysis also provides exclusion limits in models related to SUSY, Dark Energy, Large Extra Dimensions and Higgs boson decays to WIMPs.

Institute for Research in Fundamental Sciences

School of Particles and Accelerators; Institute for Research in Fundamental Sciences (IPM)

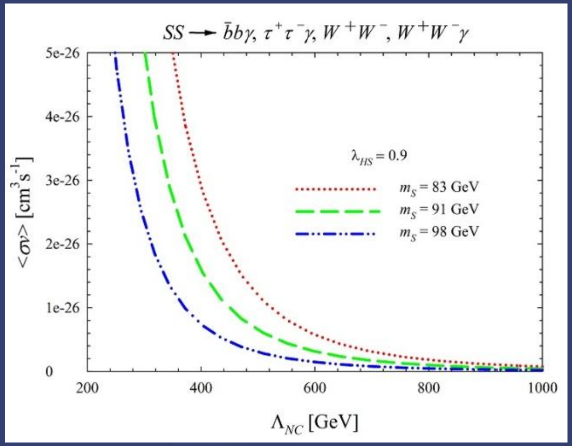
Title:

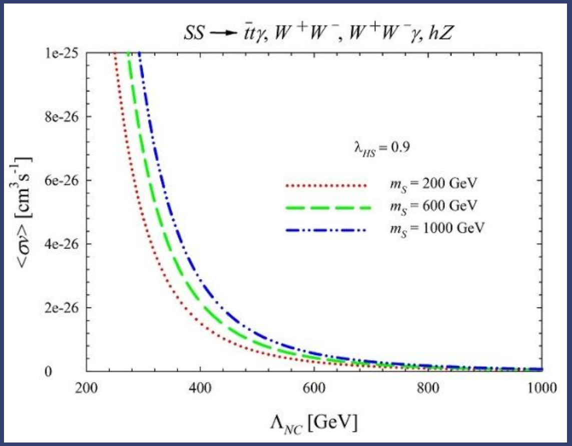
Non-commutative space-time: a viable hypothesis to explain the gamma-ray excess in the galactic center [arXiv:2007.01501]

By:
S. Peyman Zakeri

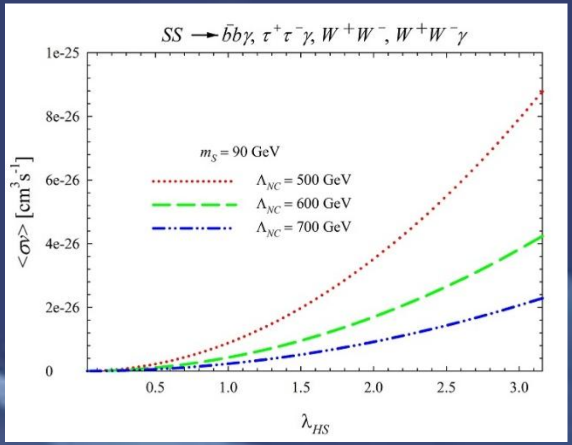
ICHEP 2020

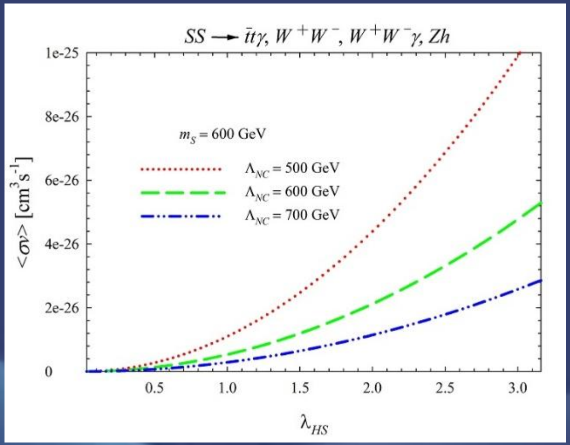
July 2020





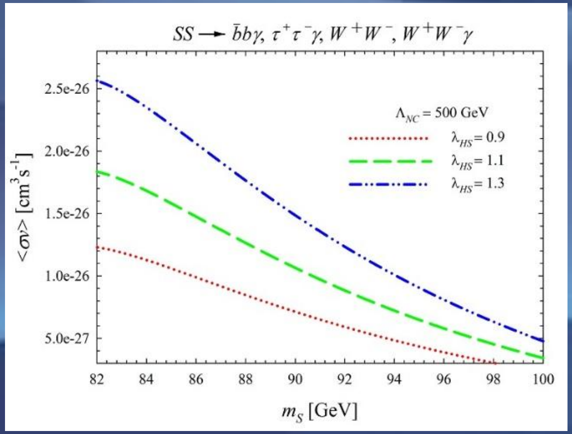
DM annihilation cross-section

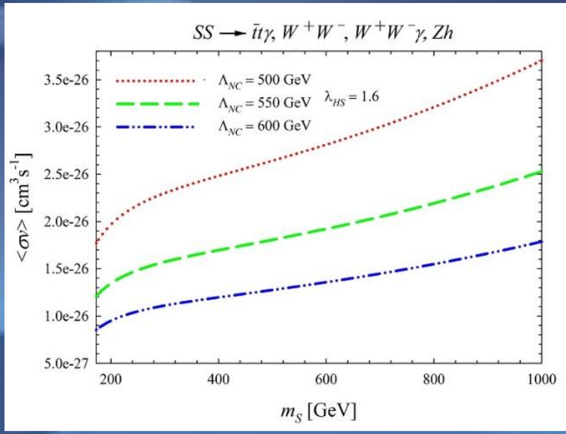




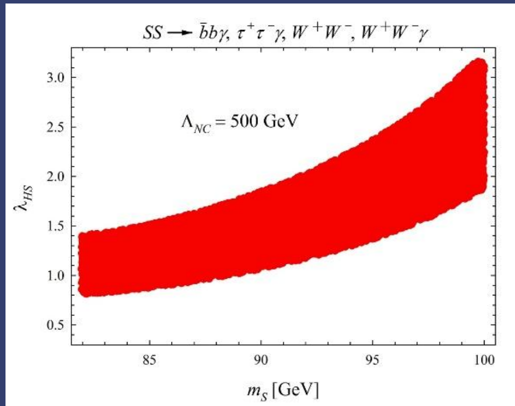
Λ_{NC}:
non-commutative energy scale

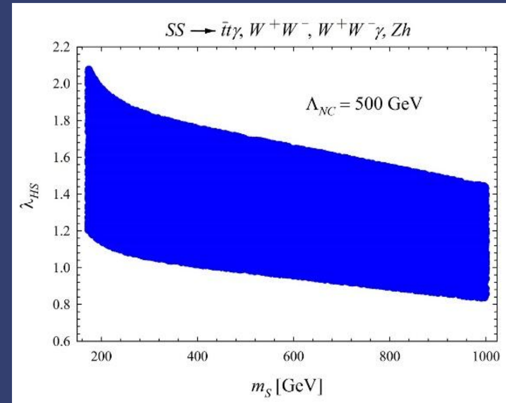
λ_{HS}:
Higgs – DM coupling

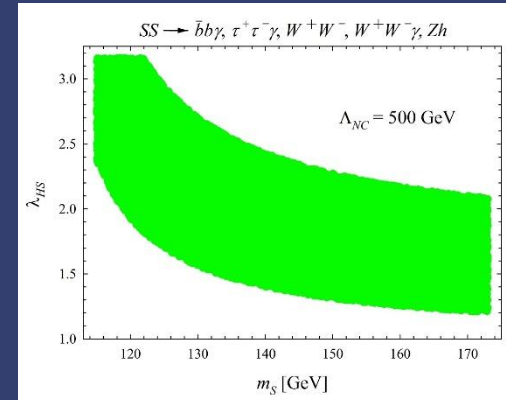




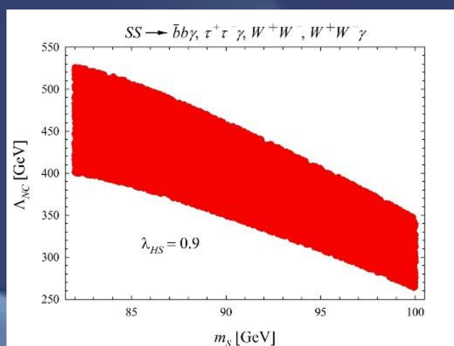
m_S:
DM mass

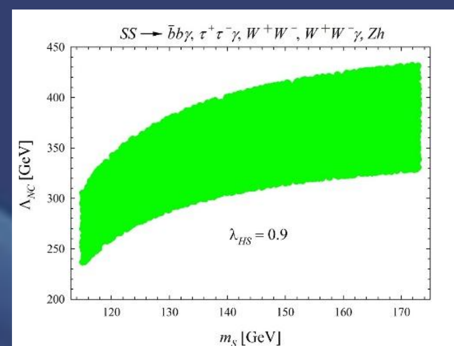


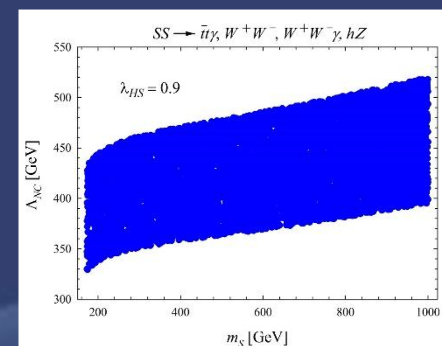


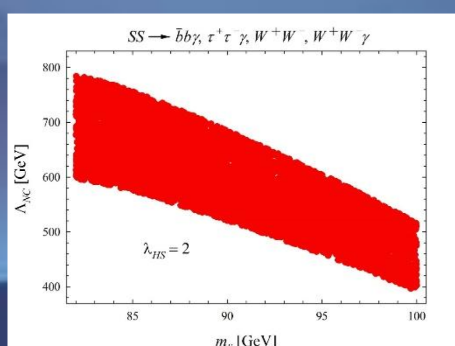


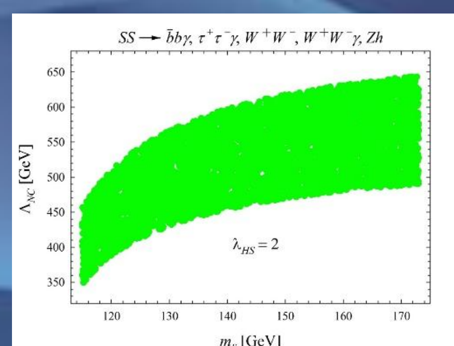
Model parameter-space

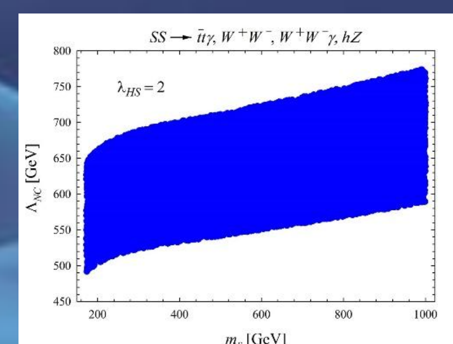




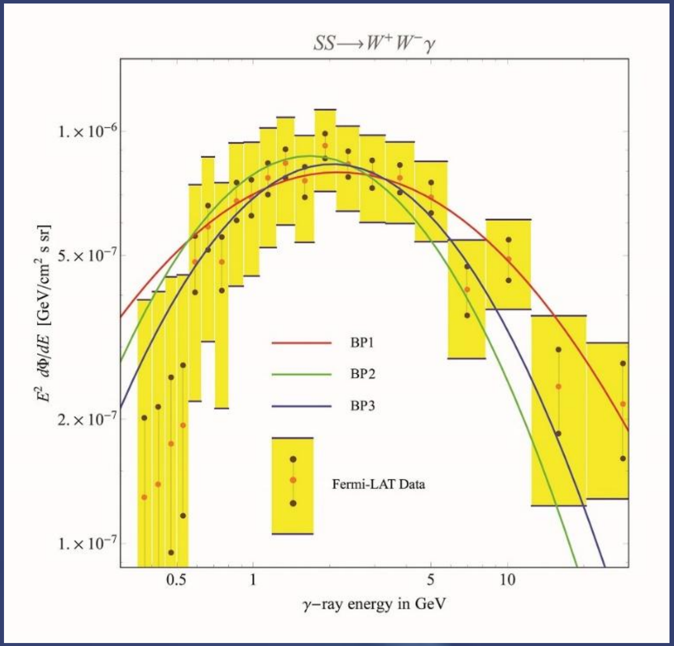


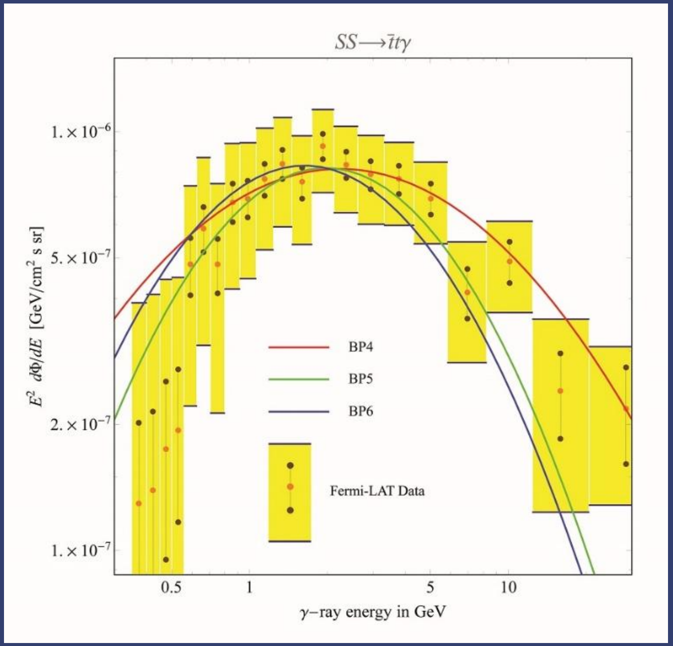


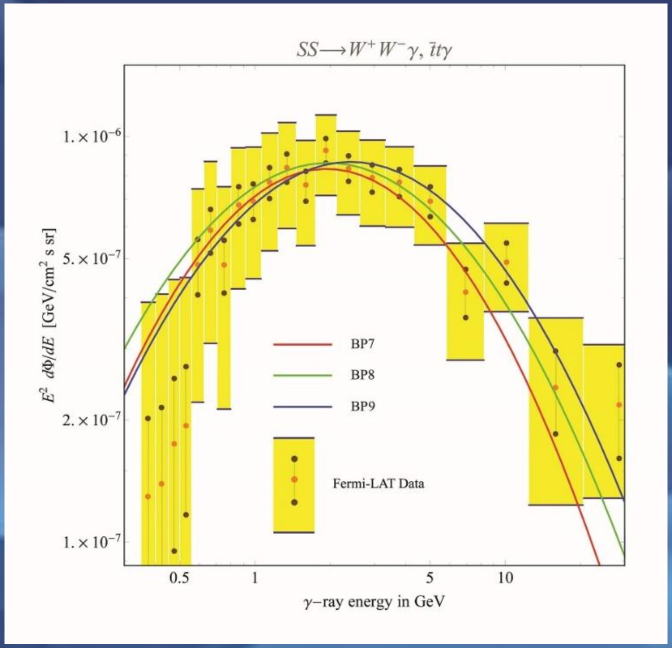


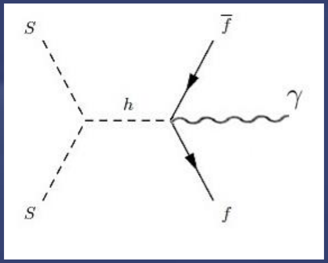


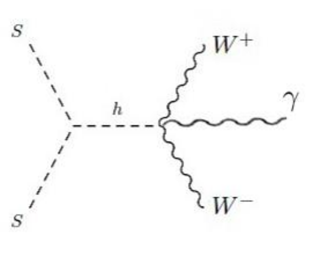
Gamma-ray flux











** differences in gender, race, sexual orientation, socio-economic status, ability, religious belief*
*** the actions we can make to ensure that each difference is given **an equal opportunity to do good physics***

Diversity* + Inclusion** at Belle II:

Who we are, what we've done and where we want to be

Shanette De La Motte

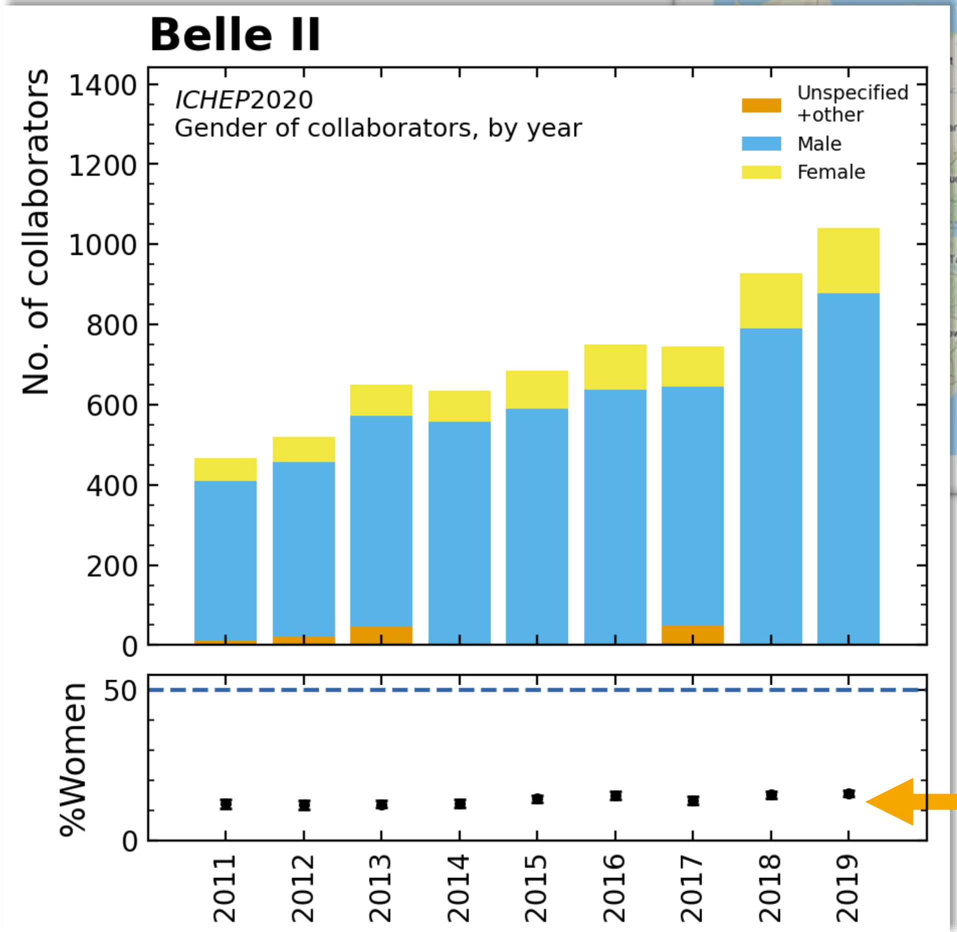
ICHEP 2020 | @SubatomicSADLM

THE UNIVERSITY of ADELAIDE

*I **acknowledge** and pay my respects to the Kaurna people, the traditional custodians whose ancestral lands the University of Adelaide is located on.*

Belle II

Region	#People	%People(in Collab.)	#Women	%Women(in Region)
Japan	169	16.23	28	16.57
Asia (excl.Japan)	202	19.4	43	21.29
E.Europe	90	8.65	14	15.56
Mediterannean	144	13.83	19	13.19
N.America	176	16.91	16	9.09
N.Europe	230	22.09	37	16.09
S.Hemisphere	30	2.88	5	16.67



2011: 12.2±1.5% women
2019: 15.5±1.1% women

...who we are

git branch -m master main

Confluence More Search ...

Edit Save for later Watch

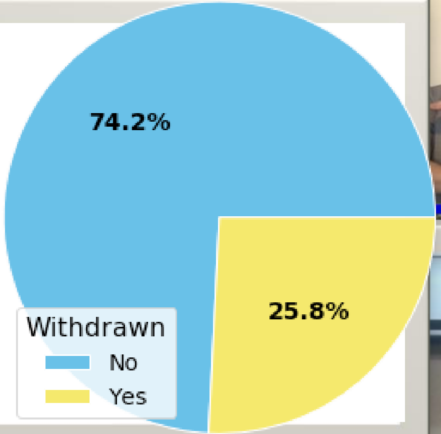
Dashboard /... / Belle II Diversity

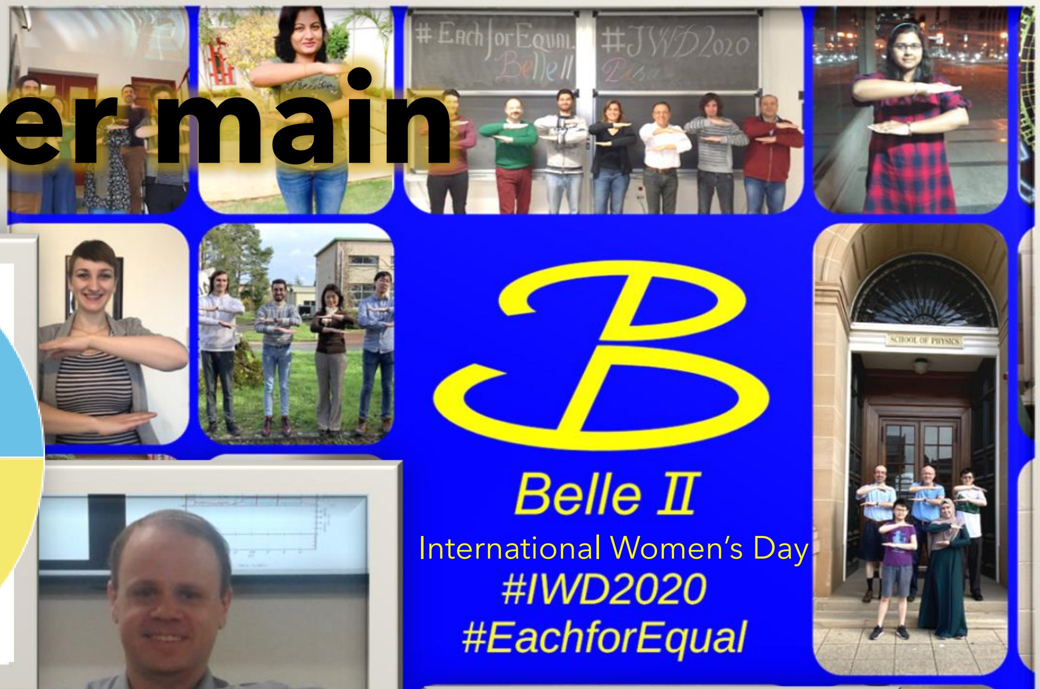
Colo(u)r Blind Friendly Plots and Displays

Matthew Barrett posted on 30. Jul. 2019 07:05h - last edited by Matthew Barrett 2019 04:26h

Colour (or Color) blindness, or more accurately colour vision deficiency, affects up to 8% of men and 0.5% of women. People colour blindness may be unable to distinguish between certain c hues, with red-green colour blindness being the most common type. This

Collab. Poll - "Have you ever withdrawn from consideration for a leadership role at Belle II (implicitly or explicitly) because of the impact it would have on your family life?"





~~manpower~~

peoplepower

Belle2実験
5 July 2019 ·

本日2019年7月5日は科学、技術、エンジニアリング、および数学における LGBT+Peopleの第2回国際デーです。

Belle IIコラボレーションは、この国際デーのオフィシャルサポーターであることを誇りに思っています。

私たちはLGBT+ コラボレーターを支持し評価します。そして私たちはBelle IIを人々の個性を大切にする安全ですべての人を受け入れるコラボレーションにすることを約束します。

#Belle2 #LGBTSTEMDay

@belle2collab

Our Diversity Officers, Matt and Kay

...what we've done

Belle II

"The Belle II collaboration is committed to fostering an open, diverse and inclusive working environment that nurtures growth and development of all, and believes that an array of values, interests, experiences, and cultural viewpoints enriches our learning and our workplace. Thus, members shall not engage in violent, harassing, sexist, racist, or discriminatory behaviour."

--Extract from the *Belle II Code of Conduct*

Support for under-represented groups... → **Leads to more diverse approaches in analysis...** → **And better Physics!**

Onwards, to equality for higher luminosity!

...and where we want to be!