An abstract graphic on the left side of the slide consists of numerous thin lines radiating from a central point. The lines are colored in a gradient from dark blue at the bottom to bright yellow at the top, with some lines being white or light blue. The lines are of varying lengths and thicknesses, creating a starburst or particle collision effect.

COLLIDING LIGHT

To make dark matter at the LHC

International Conference on High Energy Physics
Poster session | 31 July 2020

Jesse Liu
University of Chicago

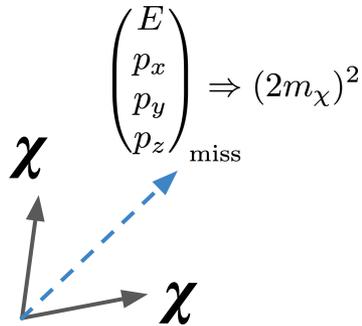


THE UNIVERSITY OF
CHICAGO

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



Reality



E and p_z
"immeasurable"

Consequence: at least 2 degrees of freedom lost

ATLAS SUSY Searches* - 95% CL Lower Limits
October 2019

ATL-PHYS-PUB-2019-044

ATLAS Preliminary
 $\sqrt{s} = 13 \text{ TeV}$

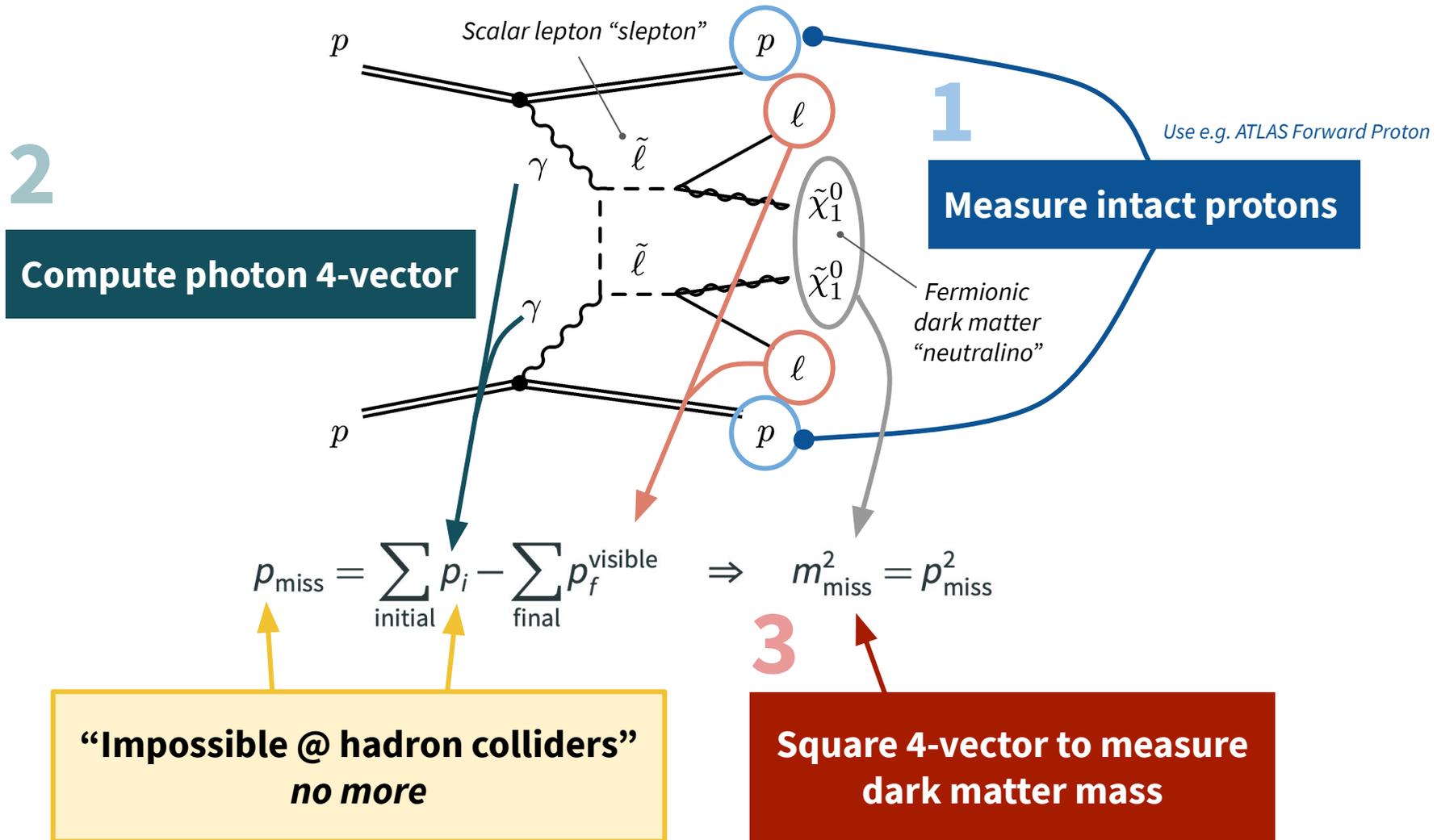
Model	Signature	$\mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	Reference			
Inclusive Searches	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow \tilde{q}\tilde{\chi}_1^0$	0 e, μ mono-jet	139 \tilde{q} [10x Degen] 36.1 \tilde{q} [1x, 8x Degen]	$m(\tilde{\chi}_1^0) < 400 \text{ GeV}$ $m(\tilde{q}) - m(\tilde{\chi}_1^0) = 5 \text{ GeV}$	ATLAS-CONF-2019-040 1711.03301		
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{g}\tilde{\chi}_1^0$	0 e, μ 2-6 jets	139 \tilde{g}	$m(\tilde{\chi}_1^0) = 0 \text{ GeV}$ $m(\tilde{g}) = 1000 \text{ GeV}$	ATLAS-CONF-2019-040 ATLAS-CONF-2019-040		
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{g}\tilde{\chi}_1^0 \ell\ell$	3 e, μ 4 jets	36.1 \tilde{g}	Forbidden	$m(\tilde{\chi}_1^0) < 800 \text{ GeV}$	1706.03731	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{g}\tilde{\chi}_1^0 WZ$	0 e, μ 7-11 jets	36.1 \tilde{g}	1.2	$m(\tilde{g}) - m(\tilde{\chi}_1^0) = 50 \text{ GeV}$	1708.02794	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{g}\tilde{\chi}_1^0$	SS e, μ 6 jets	139 \tilde{g}	1.15	$m(\tilde{g}) - m(\tilde{\chi}_1^0) = 200 \text{ GeV}$	1909.08457	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{g}\tilde{\chi}_1^0$	0-1 e, μ 3 b	79.8 \tilde{g}	2.25	$m(\tilde{g}) - m(\tilde{\chi}_1^0) = 200 \text{ GeV}$	ATLAS-CONF-2018-041 ATLAS-CONF-2019-015	
3 rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow \tilde{b}_1\tilde{\chi}_1^0$	Multiple Multiple Multiple	36.1 \tilde{b}_1 36.1 \tilde{b}_1 139 \tilde{b}_1	Forbidden Forbidden 0.58-0.82 Forbidden 0.74	$m(\tilde{\chi}_1^0) = 300 \text{ GeV}, \text{BR}(\tilde{b}_1) = 1$ $m(\tilde{\chi}_1^0) = 300 \text{ GeV}, \text{BR}(\tilde{b}_1) = \text{BR}(\tilde{t}_1) = 0.5$ $m(\tilde{\chi}_1^0) = 300 \text{ GeV}, \text{BR}(\tilde{b}_1) = 1$	1708.09266, 1711.03301 1708.09266 ATLAS-CONF-2019-015	
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow \tilde{b}_1\tilde{\chi}_1^0 \rightarrow \tilde{b}\tilde{\chi}_1^0$	0 e, μ 6 b	139 \tilde{b}_1	Forbidden	$\Delta m(\tilde{\chi}_1^0, \tilde{\chi}_1^0) = 130 \text{ GeV}, m(\tilde{\chi}_1^0) = 100 \text{ GeV}$ $\Delta m(\tilde{\chi}_1^0, \tilde{\chi}_1^0) = 130 \text{ GeV}, m(\tilde{\chi}_1^0) = 0 \text{ GeV}$	1908.03122 1908.03122	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow W\tilde{b}_k^0$ or $\tilde{t}_1\tilde{\chi}_1^0$	0-2 e, μ 0-2 jets/1-2 b	36.1 \tilde{t}_1	1.0	$m(\tilde{\chi}_1^0) = 1 \text{ GeV}$	1506.08616, 1709.04183, 1711.11520	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow W\tilde{b}_k^0$	1 e, μ 3 jets/1 b	139 \tilde{t}_1	0.44-0.59	$m(\tilde{\chi}_1^0) = 400 \text{ GeV}$	ATLAS-CONF-2019-017	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 b \nu, \tilde{t}_1 \rightarrow \tilde{t} G$	1 $\tau + 1 e, \mu, \tau$ 2 jets/1 b	36.1 \tilde{t}_1	1.16	$m(\tilde{\chi}_1^0) = 800 \text{ GeV}$	1803.10178	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{c}\tilde{\chi}_1^0 \ell\ell, \tilde{t}_1 \rightarrow \tilde{c}\tilde{\chi}_1^0$	0 e, μ 2 c	36.1 \tilde{t}_1	0.46 0.85	$m(\tilde{\chi}_1^0) = 0 \text{ GeV}$ $m(\tilde{t}_1, \tilde{t}_1) - m(\tilde{\chi}_1^0) = 50 \text{ GeV}$ $m(\tilde{t}_1, \tilde{t}_1) - m(\tilde{\chi}_1^0) = 5 \text{ GeV}$	1805.01649 1805.01649 1711.03301	
EW direct	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 + h$	1-2 e, μ 4 b	36.1 \tilde{t}_1	0.32-0.88	$m(\tilde{\chi}_1^0) = 0 \text{ GeV}, m(\tilde{t}_1) - m(\tilde{\chi}_1^0) = 180 \text{ GeV}$	1706.03986	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 + Z$	1 e, μ 1 b	139 \tilde{t}_1	Forbidden 0.86	$m(\tilde{\chi}_1^0) = 360 \text{ GeV}, m(\tilde{t}_1) - m(\tilde{\chi}_1^0) = 40 \text{ GeV}$	ATLAS-CONF-2019-016	
	$\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$ via WZ	2-3 e, μ 0 e, μ	36.1 $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$ 139 $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$	0.205	$m(\tilde{\chi}_1^0) = 0$ $m(\tilde{t}_1) - m(\tilde{\chi}_1^0) = 5 \text{ GeV}$	1403.5294, 1806.02293 ATLAS-CONF-2019-014	
	$\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$ via WW	2 e, μ 0 e, μ	139 $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$ 139 $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$	0.42	$m(\tilde{\chi}_1^0) = 0$	1908.08215	
	$\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$ via Wh	1-1 e, μ 2 h/2 γ	139 $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$ 139 $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$	Forbidden 0.74	$m(\tilde{\chi}_1^0) = 70 \text{ GeV}$	ATLAS-CONF-2019-019, 1909.09226	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 \nu$	2 e, μ 2 τ	139 $\tilde{t}_1\tilde{t}_1$ 139 $\tilde{t}_1\tilde{t}_1$	1.0	$m(\tilde{\chi}_1^0) = 0$ $m(\tilde{t}_1) = 0.5(m(\tilde{\chi}_1^0) + m(\tilde{\chi}_1^0))$	ATLAS-CONF-2019-008 ATLAS-CONF-2019-018	
Long-lived particles	$\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 \nu$	0 jets ≥ 1	139 \tilde{t}_1 139 \tilde{t}_1	0.256 0.7	$m(\tilde{\chi}_1^0) = 0$ $m(\tilde{t}_1) - m(\tilde{\chi}_1^0) = 10 \text{ GeV}$	ATLAS-CONF-2019-008 ATLAS-CONF-2019-008	
	$\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 \nu$	0 e, μ ≥ 1	139 \tilde{t}_1 139 \tilde{t}_1	0.13-0.23 0.3	0.29-0.88	BR($\tilde{t}_1 \rightarrow hZ$) = 1 BR($\tilde{t}_1 \rightarrow Z\gamma$) = 1	1806.04030 1804.03602
	$\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 \nu$	0 e, μ 0 jets	36.1 \tilde{t}_1 139 \tilde{t}_1	0.46	Pure Wino Pure Higgsino	1712.02118 ATL-PHYS-PUB-2017-019	
	Direct $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$ prod., long-lived \tilde{t}_1	Disapp. trk 1 jet	36.1 $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$ 139 $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$	0.15	0.46		
	Stable \tilde{g} R-hadron	Multiple	36.1 \tilde{g}	2.0		$m(\tilde{\chi}_1^0) = 100 \text{ GeV}$	1902.01636, 1808.04095
	Metastable \tilde{g} R-hadron, $\tilde{g} \rightarrow \tilde{g}\tilde{\chi}_1^0$	Multiple	36.1 \tilde{g}	2.05 2.4			1710.04901, 1808.04095
RPV	LFV $\tilde{p}\tilde{p} \rightarrow \nu_e + X, \nu_e \rightarrow \nu_e \ell \mu \tau$	0 e, μ, τ	3.2 \tilde{p}	1.9	$A'_{111} = 0.11, A'_{133} = 0.07$	1607.09079	
	$\tilde{t}_1\tilde{t}_1\tilde{t}_1^* \rightarrow W\tilde{W}Z\ell\ell\nu\nu$	0 jets	36.1 $\tilde{t}_1\tilde{t}_1\tilde{t}_1^*$ [$A_{133} \neq 0, A_{133} \neq 0$]	0.82 1.33	$m(\tilde{\chi}_1^0) = 100 \text{ GeV}$	1804.03602	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{g}\tilde{\chi}_1^0, \tilde{g} \rightarrow \tilde{g}\tilde{q}\tilde{q}$	4-5 large-R Multiple	36.1 \tilde{g} [$A_{133} = 200 \text{ GeV}, 1100 \text{ GeV}$] 36.1 \tilde{g} [$A_{133} = 2e-4, 2e-5$]	1.05 1.9 2.0	Large A'_{133}	1804.03666	
	$\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 \nu$	Multiple	36.1 \tilde{t}_1 [$A_{133} = 2e-4, 1e-2$]	0.55	$m(\tilde{\chi}_1^0) = 200 \text{ GeV}, \text{bino-like}$	ATLAS-CONF-2018-003	
	$\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 \nu$	2 jets + 2	36.7 \tilde{t}_1 [$\nu\tilde{q}, A$]	0.42 0.61	$m(\tilde{\chi}_1^0) = 200 \text{ GeV}, \text{bino-like}$	ATLAS-CONF-2018-003 1710.07171	
	$\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{t}_1 \nu$	2 e, μ 1 μ	36.1 \tilde{t}_1 136 \tilde{t}_1	1.0	0.4-1.45 1.6	BR($\tilde{t}_1 \rightarrow h\nu$) = 20% BR($\tilde{t}_1 \rightarrow \nu\tilde{q}$) = 100%, $\cos\theta = 1$	ATLAS-CONF-2018-003 1710.05544 ATLAS-CONF-2019-006

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.



Only transverse measured but really desire missing momentum 4-vector

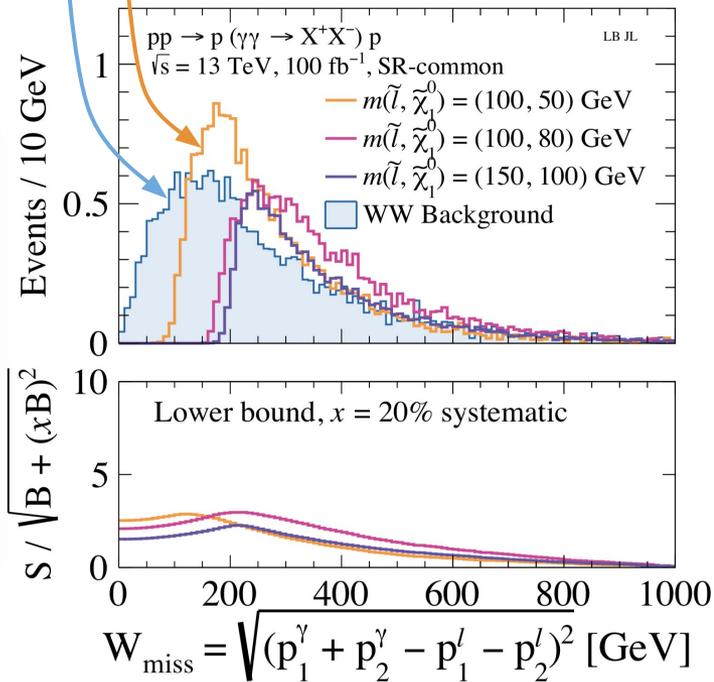
Solution: collide light & tag protons for 4-vector p_{miss}



Impact: turn light into dark matter this decade?

$\gamma\gamma \rightarrow WW$ irreducible background

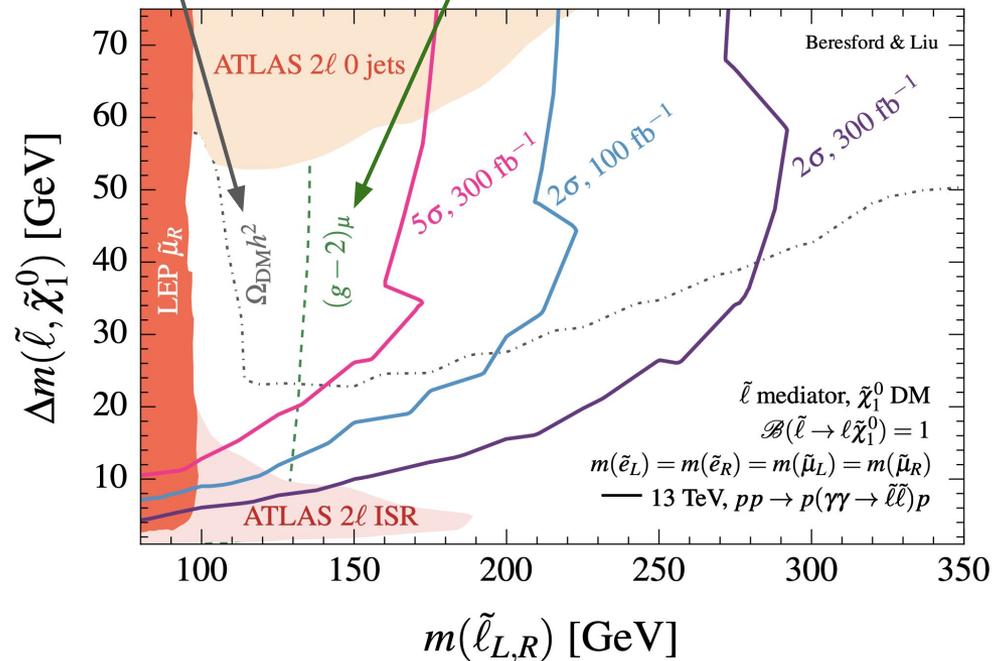
Sharp threshold at $2 \times m_{DM}$



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

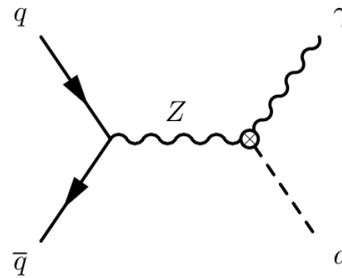
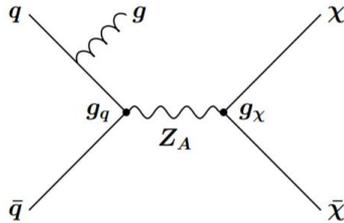
on behalf of the ATLAS Collaboration



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.

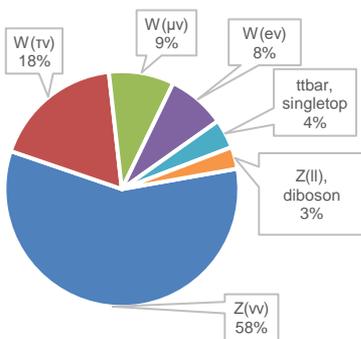
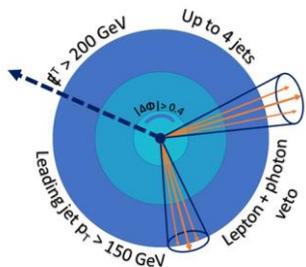


This diagram shows the production of an Axion Like Particle (ALP) in association of a photon through the mediation of a Z boson in the s-channel. If the ALP is considered invisible, the event can be identified with a single photon event with large momentum imbalance. These type of signatures are searched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

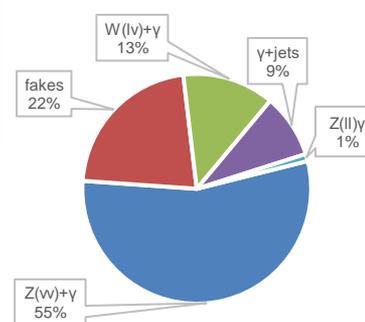
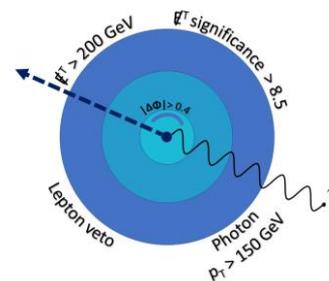
Monojet



- **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 E_T^{miss} and the 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.

Monophoton

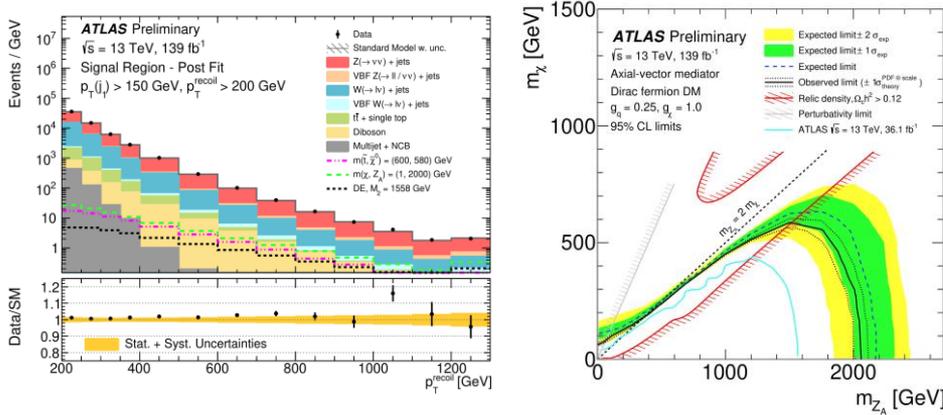


- A cut on E_T^{miss} **significance** is introduced to help **reduce** the contamination from the γ +jets background.

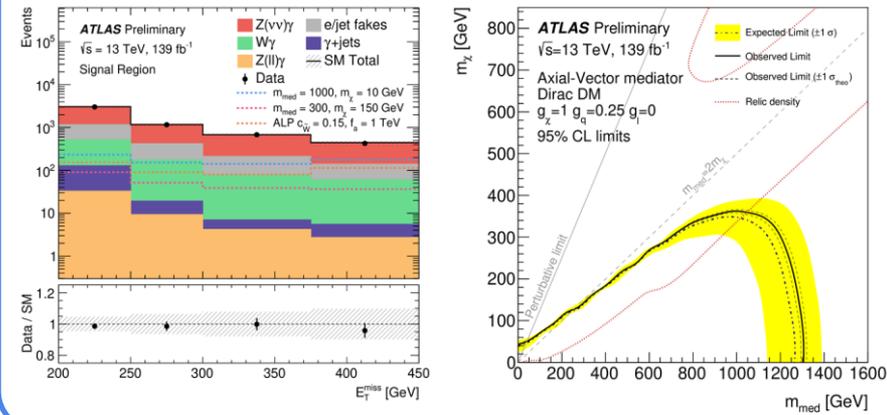
Results and Interpretations

- 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 Like 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]**

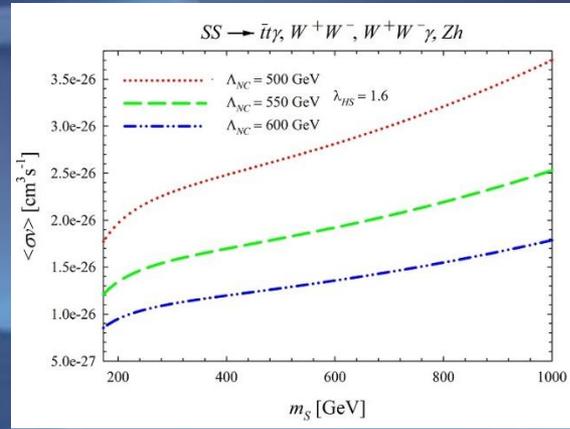
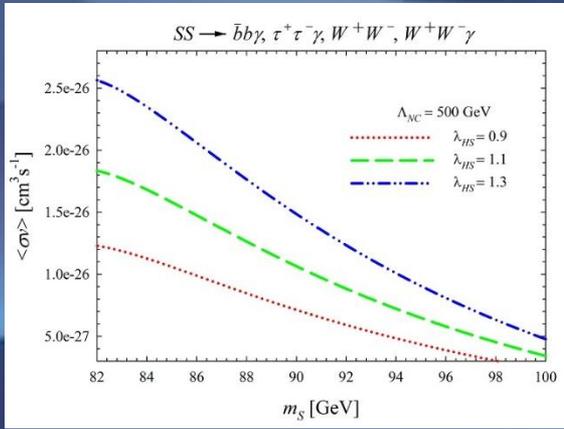
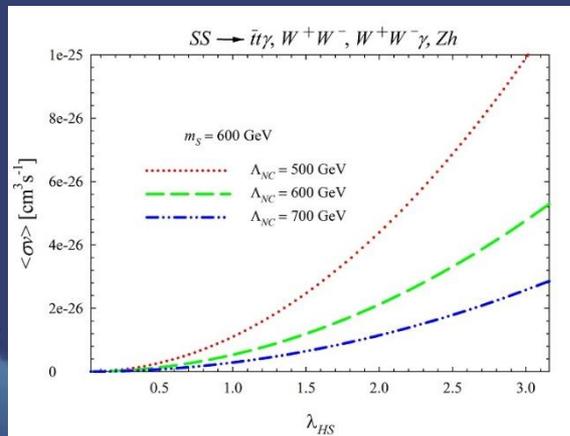
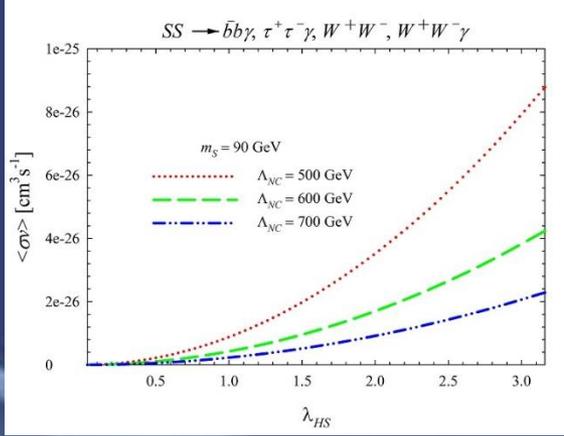
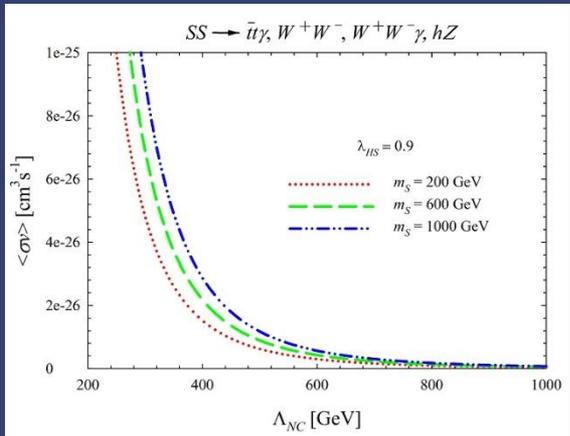
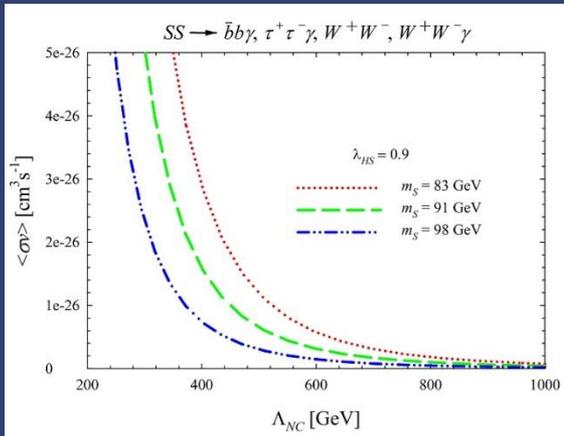
By:

S. Peyman Zakeri

ICHEP 2020

July 2020

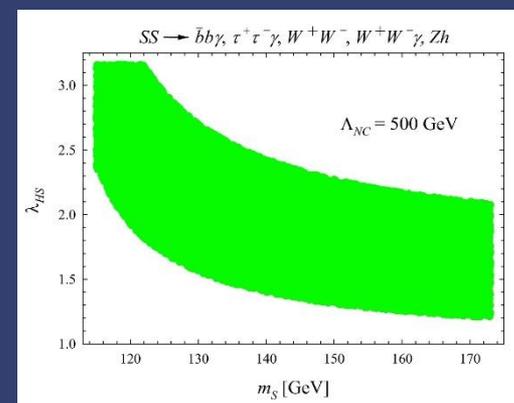
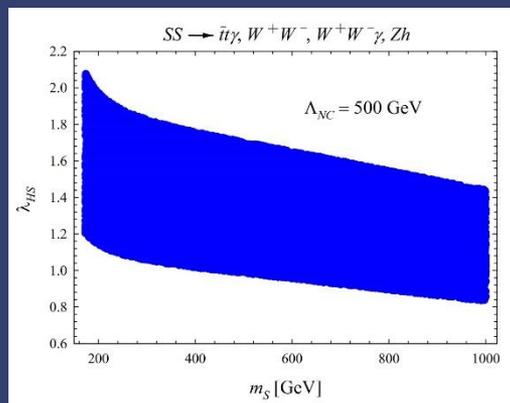
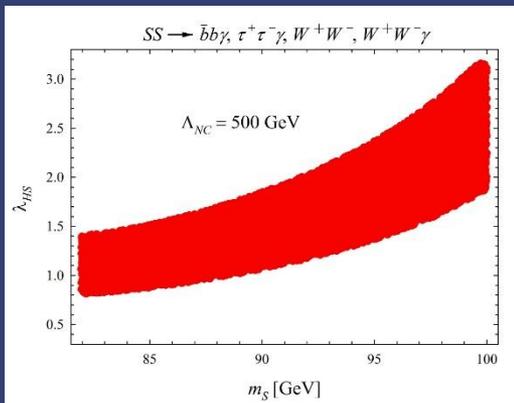
DM annihilation cross-section



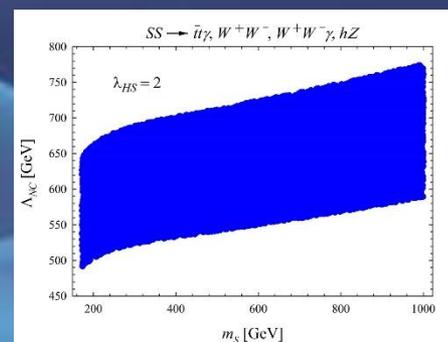
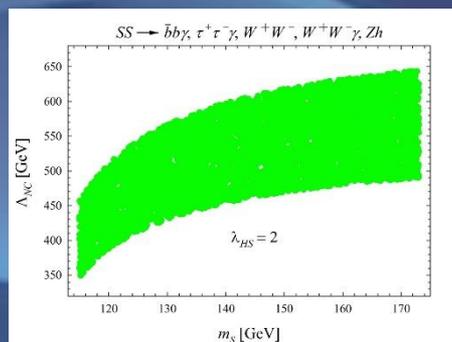
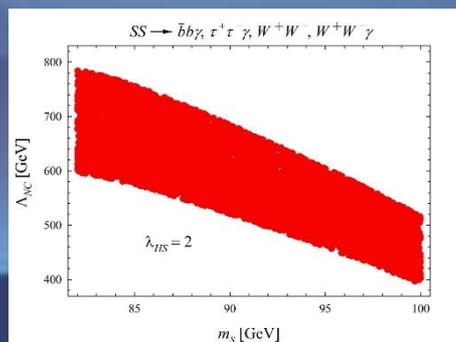
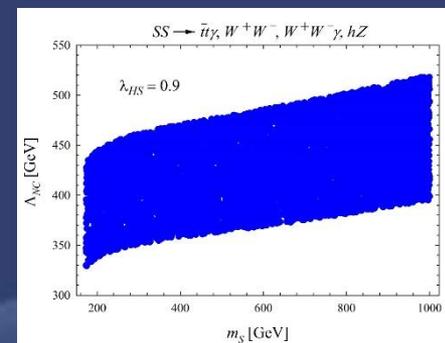
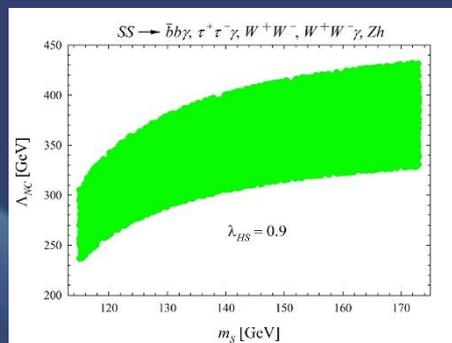
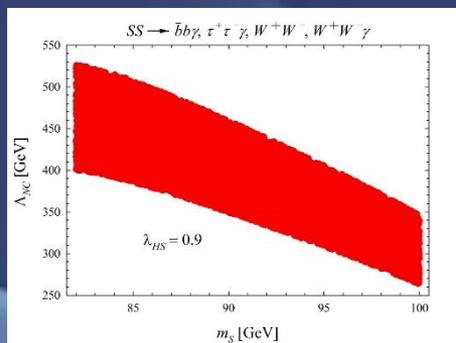
Λ_{NC} :
non-commutative energy scale

λ_{HS} :
Higgs – DM coupling

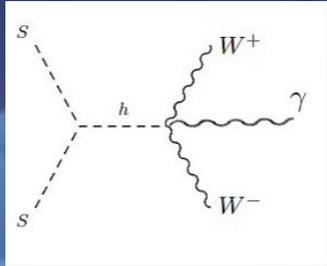
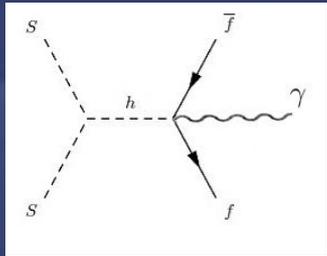
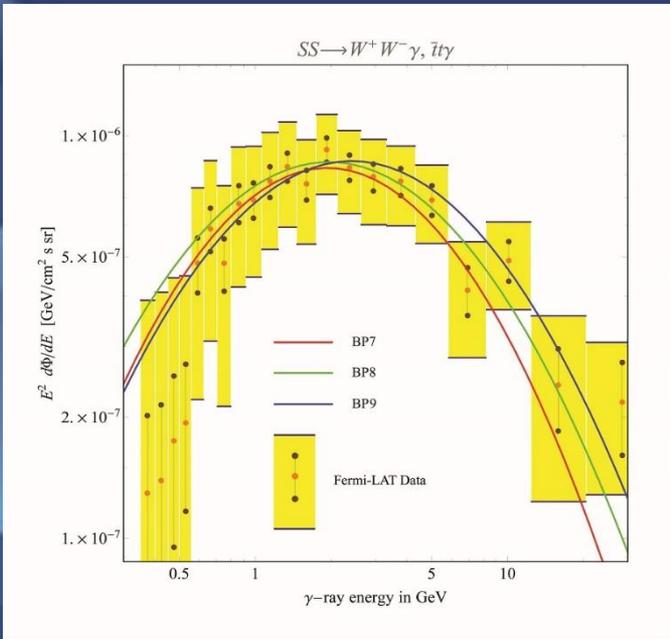
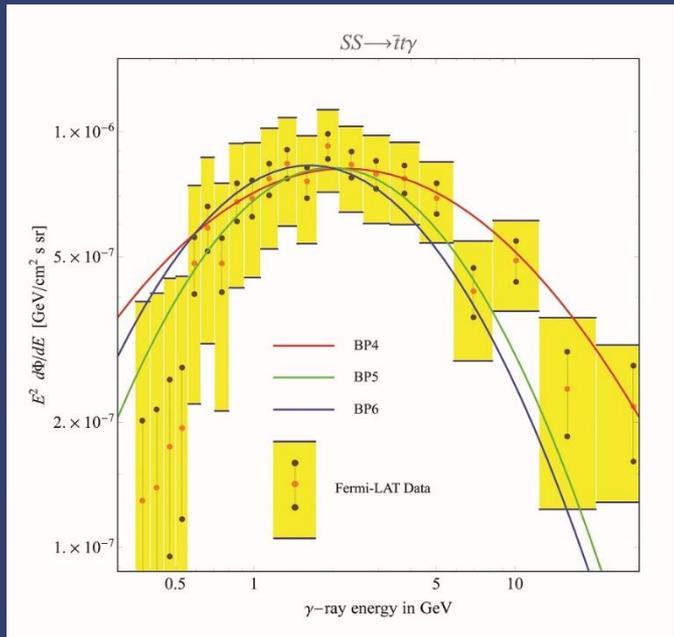
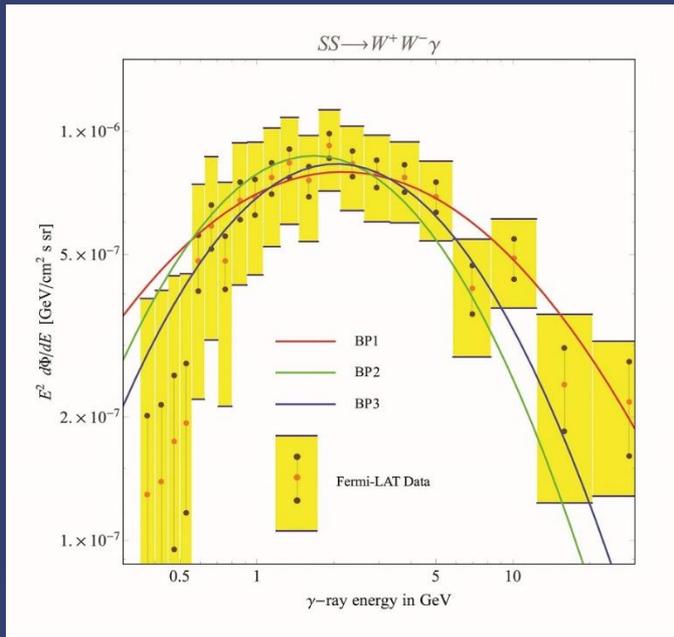
m_S :
DM mass



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

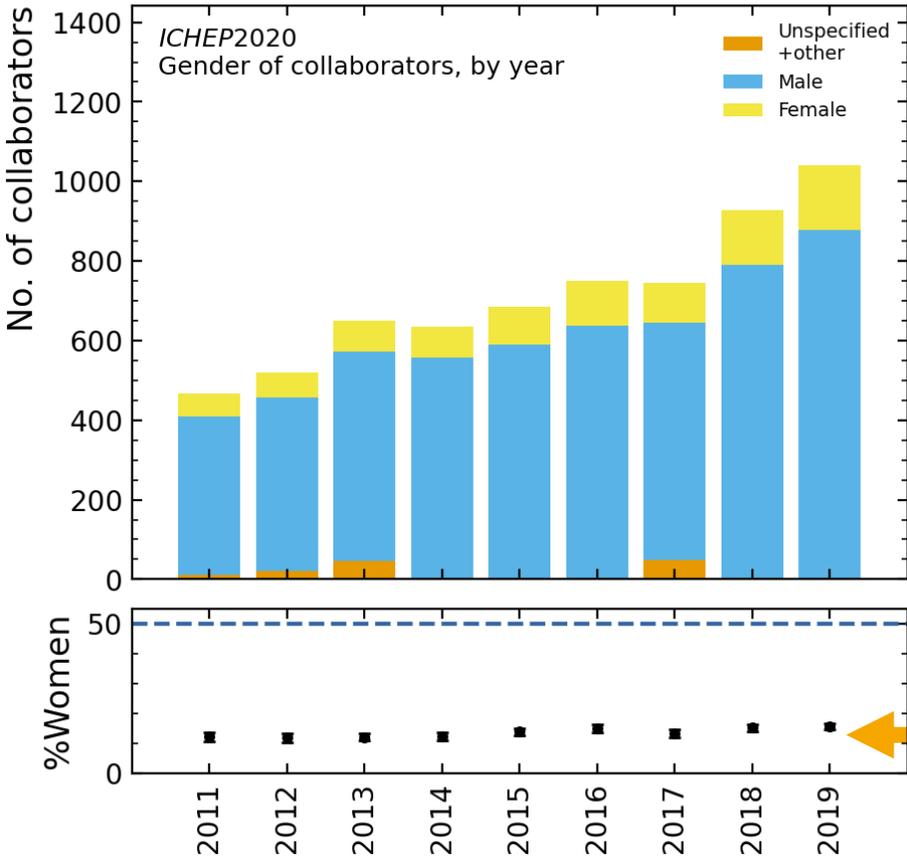
I acknowledge and pay my respects to the Kaurna people, the traditional custodians whose ancestral lands the University of Adelaide is located on.





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
Mediterranean	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

Belle II



2011: $12.2 \pm 1.5\%$ women
 2019: $15.5 \pm 1.1\%$ women

...who we are



git branch -m master main

Confluence

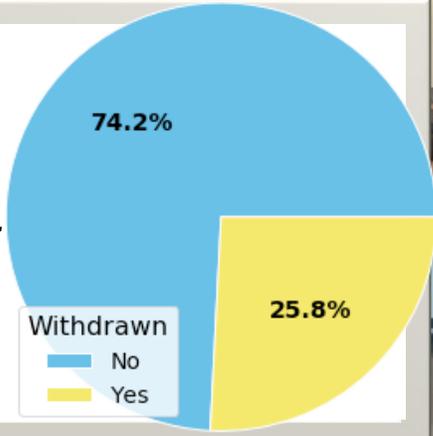
Dashboard / ... / Belle II Diversity

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 with colour blindness may be unable to distinguish between certain colours, with red-green colour blindness being the most common type. This can cause issues when, for example, looking at some of the displays...

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?"



Belle II
 International Women's Day
 #IWD2020
 #EachforEqual



~~manpower~~
peoplepower



Our Diversity Officers, Matt and Kay

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、および数値における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



...what we've done



"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!