>>> Constraints on $U(1)_{l_\mu - l_\tau}$ from LHC Data
>>> Improvements for arXiv:1811.12446[†]

Name: ZHANG, Zhongyi 中一[‡]

Date: August 14, 2019

[†]Manuel Drees, Meng Shi, Zhongyi Zhang
[‡]zhongyi@th.physik.uni-bonn.de

>>> Contents

$U(1)_{l_\mu - l_\tau}$ extension of Standard Model

(Anomaly Free, Survive from LEP data)

($g_\mu - 2$, Lepton Universality Violation)

(2μ, 3μ, 4μ, $\mu\tau_h$, $2\tau_h$, $3\tau_h$, $4\tau_h$ ...)

(> 30 analysis with > 300 SRs from LHC)

>>> Lagrangian and Feynman Diagrams for Signals

* The Lagrangian for Signals

$$\begin{aligned}\mathcal{L}_{\rm new} &= (D_\mu \phi_{\rm DM})^* D^\mu \phi_{\rm DM} - m_{\rm DM}^2 \phi_{\rm DM}^* \phi_{\rm DM} \\ &- \frac{1}{4} \mathcal{Z}'_{\mu\nu} \mathcal{Z}'^{\mu\nu} + \frac{1}{2} m_{Z'}^2 Z'^\mu Z'_\mu \\ &+ g_{\mu\tau} (\bar{\mu} \not{Z}' \mu + \bar{\nu}_\mu \not{Z}' \nu_\mu - \bar{\tau} \not{Z}' \tau - \bar{\nu}_\tau \not{Z}' \nu_\tau).\end{aligned}$$

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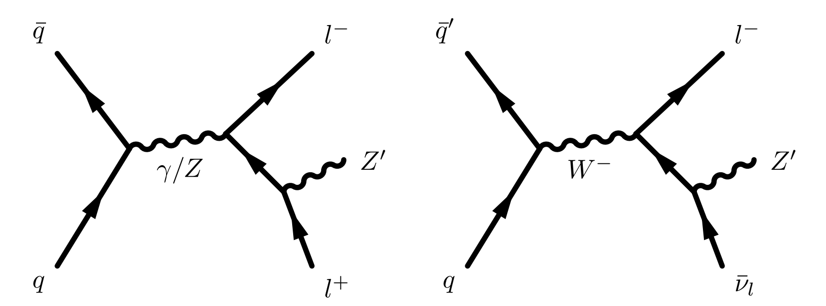
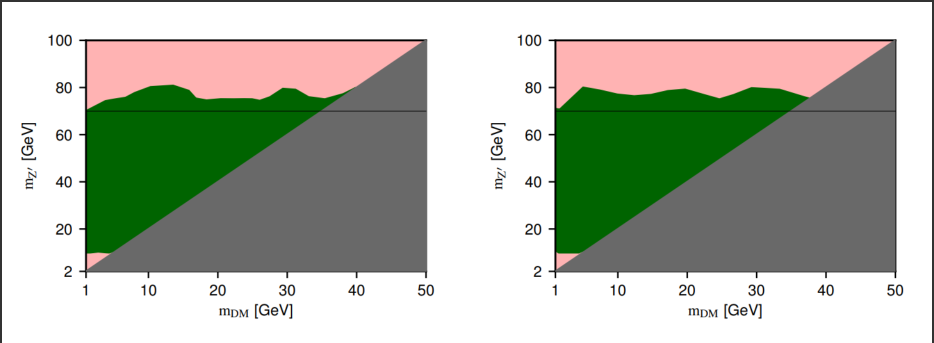
* Feynman Diagrams for Signals

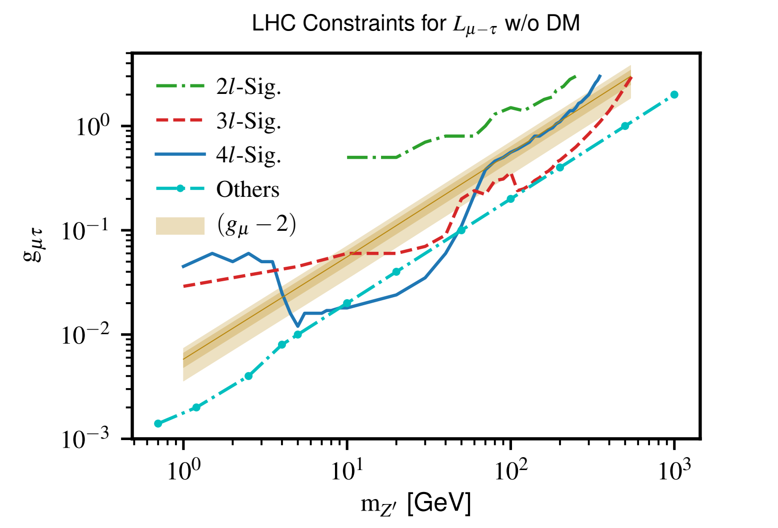


>>> Results from $2l$, $3l$ and $4l$ Final States in ATLAS and CMS



* Left (Charge of DM = 1), Right (Charge of DM = 2)
* $3l + 4l > 2l$, while only $2l$ relates to DM.
* ~~Dark Matter Phenomenology~~

>>> Results from $2l$, $3l$ and $4l$ Final States in ATLAS and CMS



1. Tasks for Optimization

* Constraining $g_{\mu\tau}$ in $U(1)_{l_\mu - l_\tau}$ Signals
* Large Selection Efficiency for Stability
  $\Leftrightarrow$ Sensitivity = Recall = TP/(TP+FN)
* Large S/B Ratio after Selection for Stronger Bound
  $\Leftrightarrow$ Precision = TP/(TP+FP)

>>> Tasks and Algorithms for Optimization

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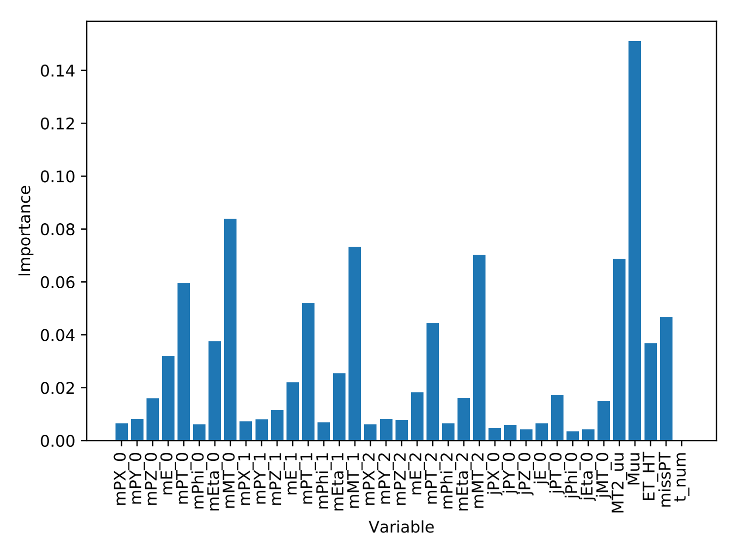
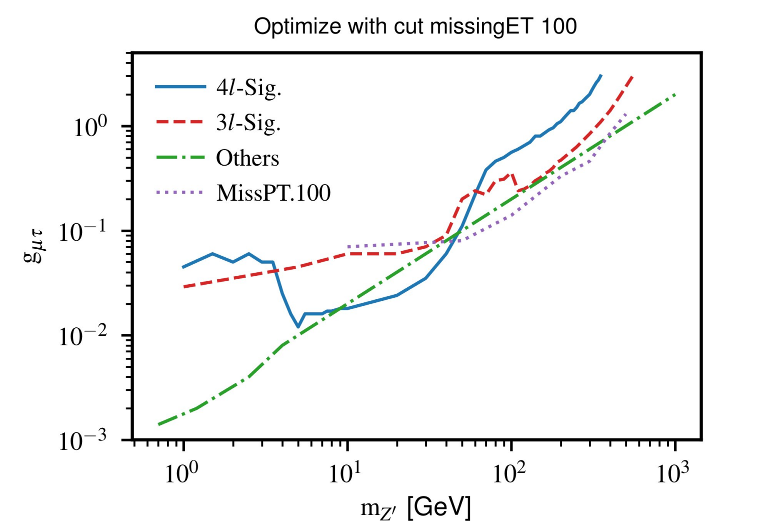
2. Algorithms for Optimization

* Traditional Cut Based Event Selection
  (Published ATLAS and CMS papers)
* kNN in the Metric Space for Events (arXiv:1902.02346)
  (Patrick T. Komiske, Eric M. Metodiev, Jesse Thaler)
* Machine Learning with Selected Features
  (SVM, RandomForest, AdaBoost, XGBoost, NN and etc)

>>> Feature Importance from XGBoost



>>> Recent Results from Machine Learning



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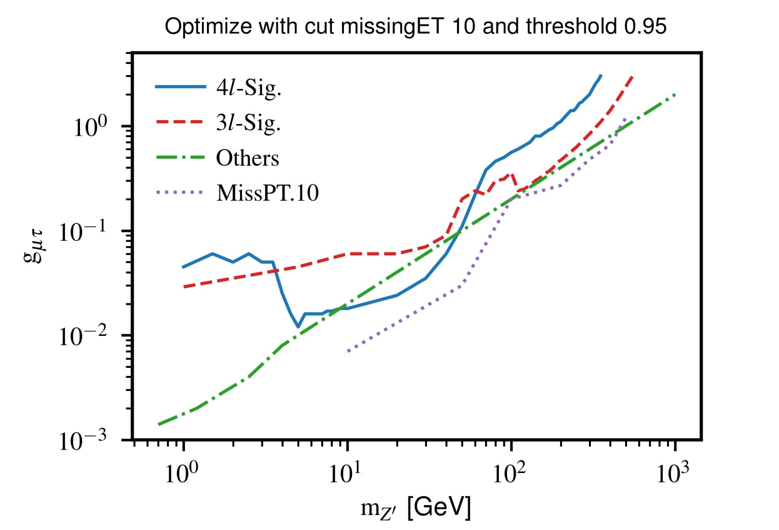

>>> Summary

1. LHC data cannot probe DM phenomenology for $U(1)_{l_\mu - l_\tau}$ extension.
   $\rightarrow$ Better classifiers are needed.

2. New classifiers may have the ability to probe more parameters in larger parameters space.
   $(g^V,\ g^A,\ g^S,\ m_{Z'} < 2m_{\rm DM},\ H_2\ \ldots)$

3. Information of feature importance decreases the calculating complexity and implies physical properties.

4. New Tools for Phenomenology Research?

Thanks