Inaugural
US Muon Collider
Community Meeting

Searching Heavy Z' from $L_\mu - L_\tau$ model at *Muon collider*

Si Wang
University of Pittsburgh

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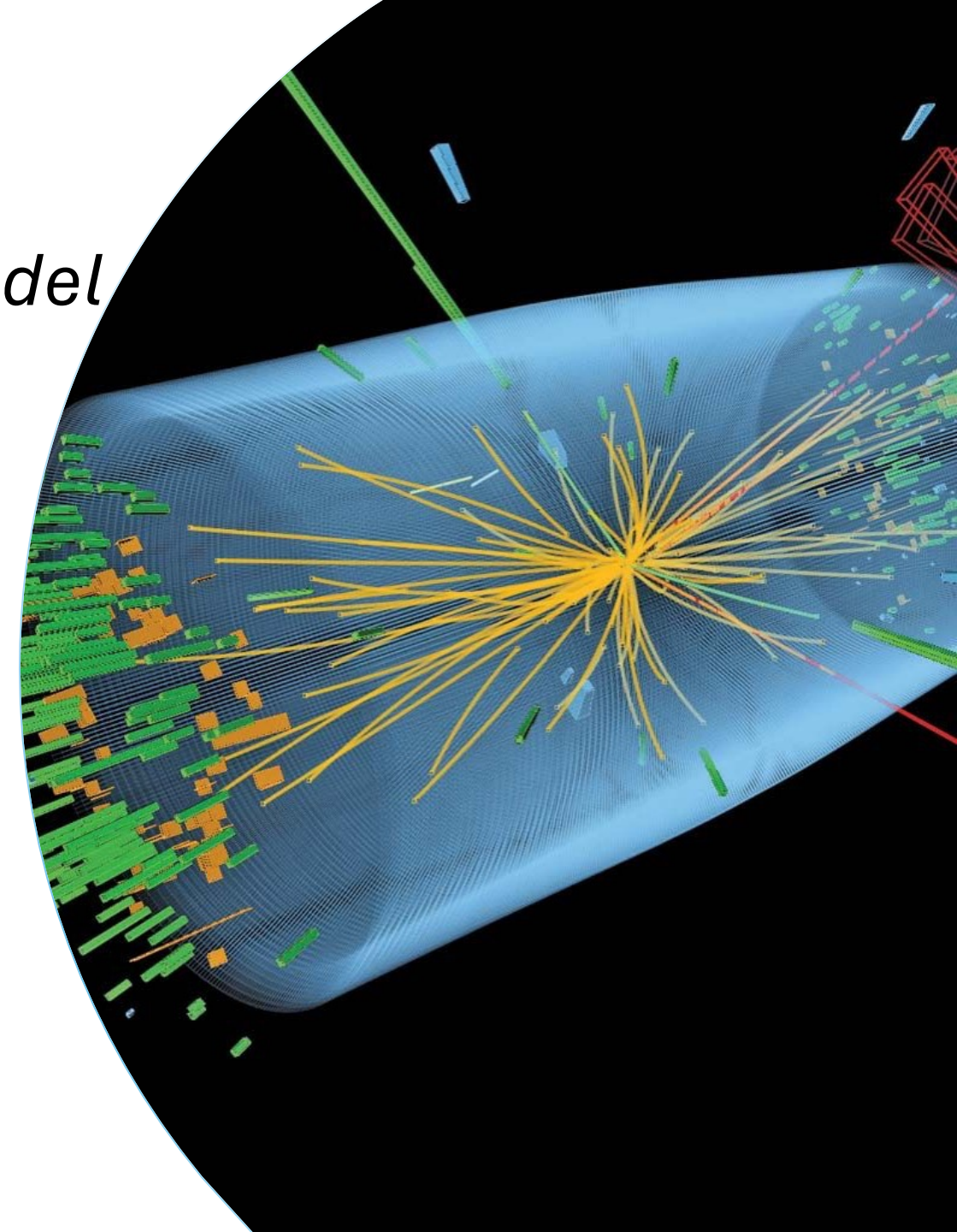
Collaborators:
A. Dasgupta, P.S. B. Dev, T. Han,
R. Padhan, K. Xie

arXiv: 2308.12804



$L_\mu - L_\tau$ Model

$SU(3)_C \times SU(2)_L \times U(1)_Y \times U(1)'$ ⟶ Z' Φ

Gauge group	L_e	L_μ	L_τ	e_R	μ_R	τ_R	H	Φ
$SU(3)_c$	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
$SU(2)_L$	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**1**
$U(1)_Y$	$-\frac{1}{2}$	$-\frac{1}{2}$	$-\frac{1}{2}$	-1	-1	-1	$\frac{1}{2}$	0
$U(1)_{L_\mu - L_\tau}$	0	1	-1	0	1	-1	0	2

$$\mathcal{L}_{\mu-\tau} = g' Z'_\nu (\bar{L}_\mu \gamma^\nu L_\mu - \bar{L}_\tau \gamma^\nu L_\tau + \bar{\mu}_R \gamma^\nu \mu_R - \bar{\tau}_R \gamma^\nu \tau_R) + \frac{1}{2} M^2_{Z'} Z'_\mu Z'^\mu$$

Why do we study this model? at Muon Collider ?

- Searching New Particles

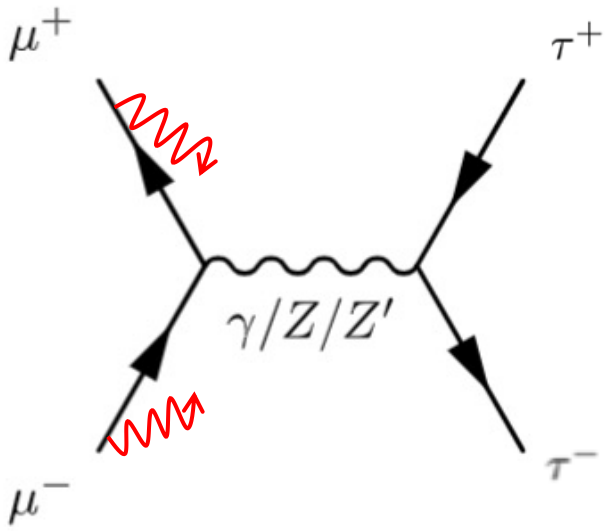
- Direct Z' Production

- Anomalous Magnetic Dipole Moment $(g-2)_\mu$

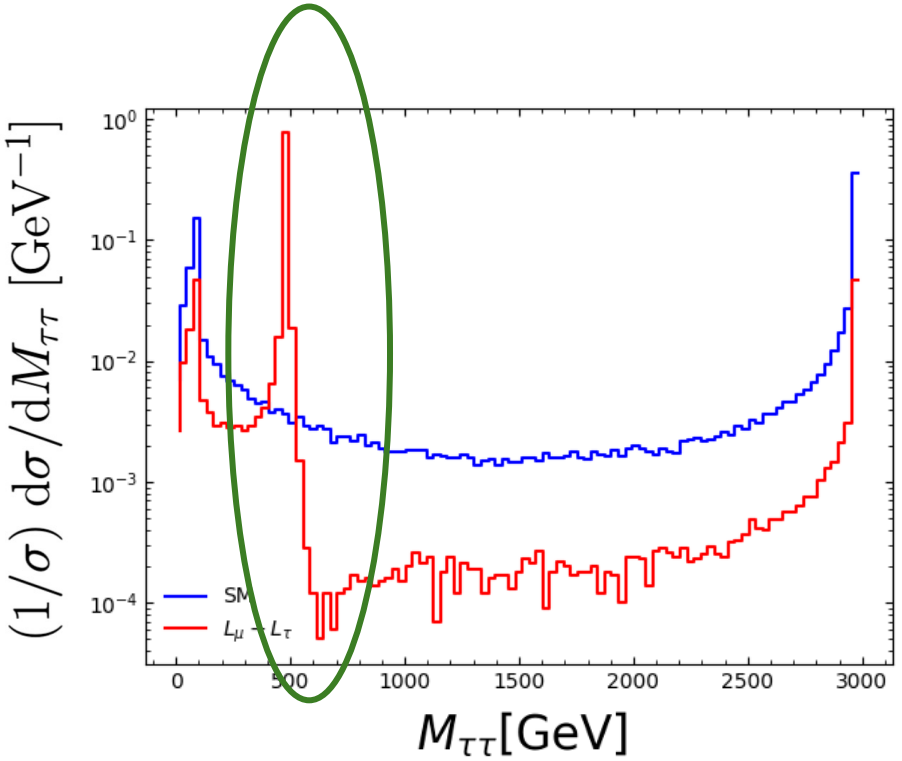
  [P. Fayet, arXiv:hep-ph/0702176]

On-Shell Z' Particle Production Resonance

$\mu^+\mu^- \to \tau^+\tau^-$ With Initial State Radiation (ISR)



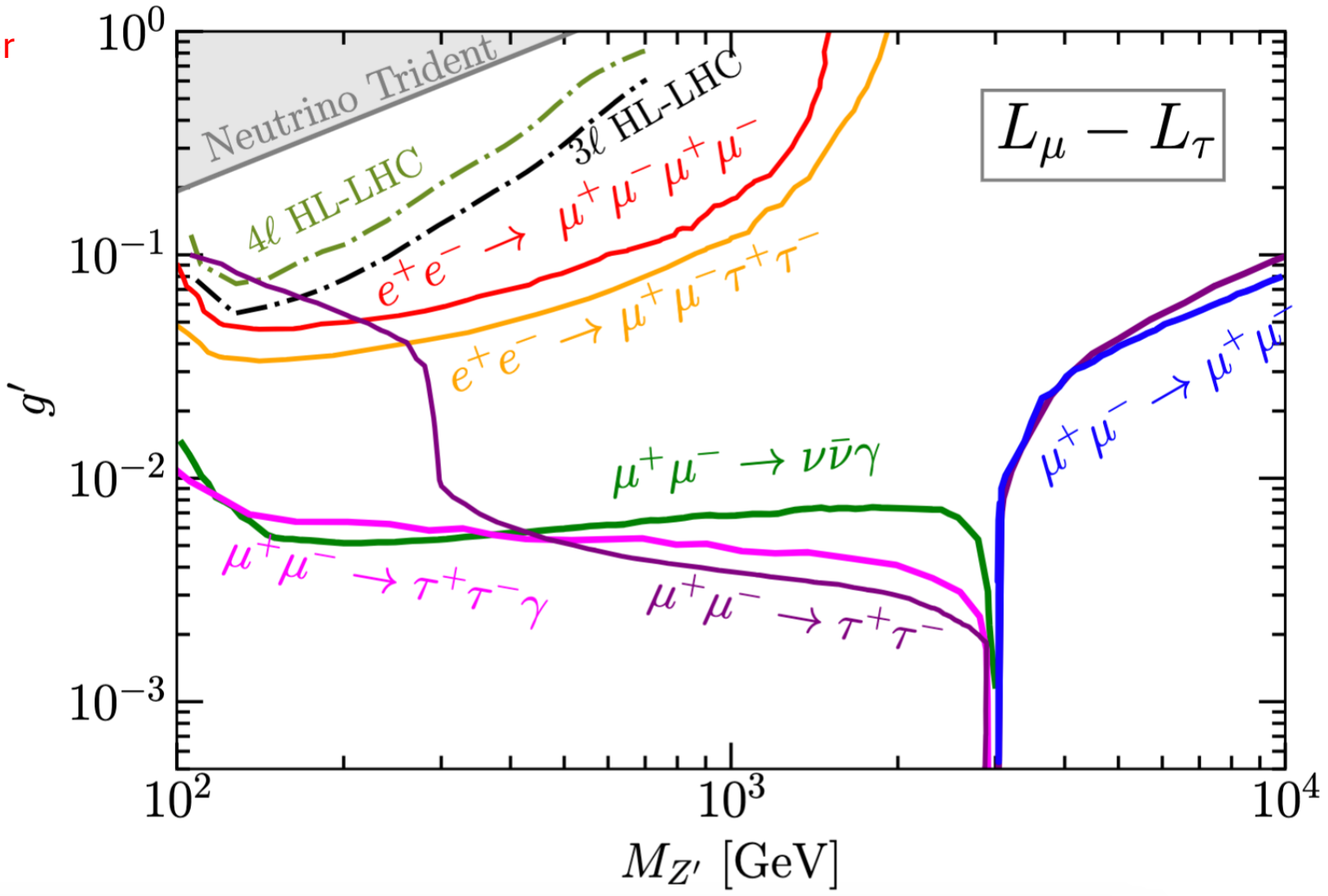
$\sqrt{s} = 3$ TeV
$M_{Z'} = 500$ GeV
g'=0.2



Significance Plot

Muon Collider

$\sqrt{s} = 3$ TeV
$\mathcal{L} = 1\ ab^{-1}$

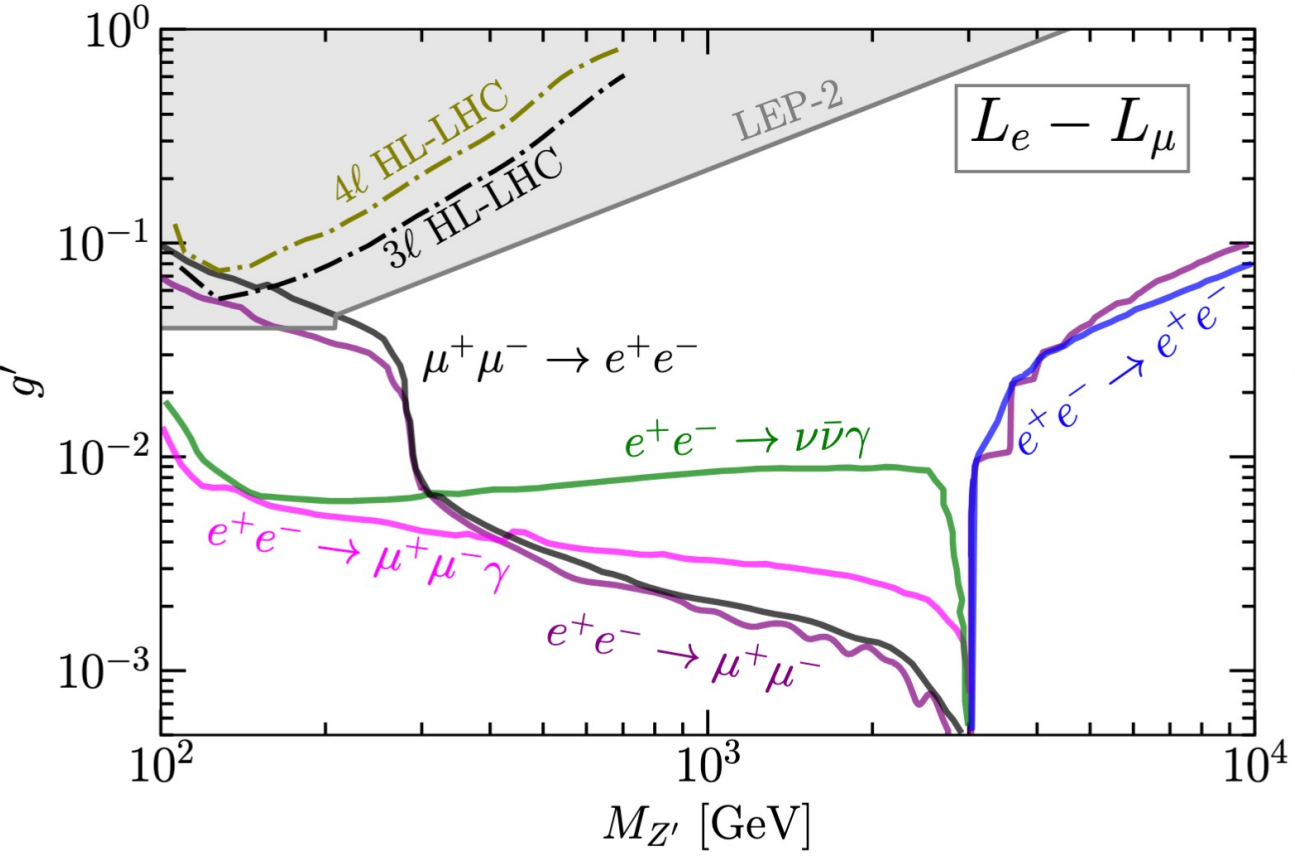


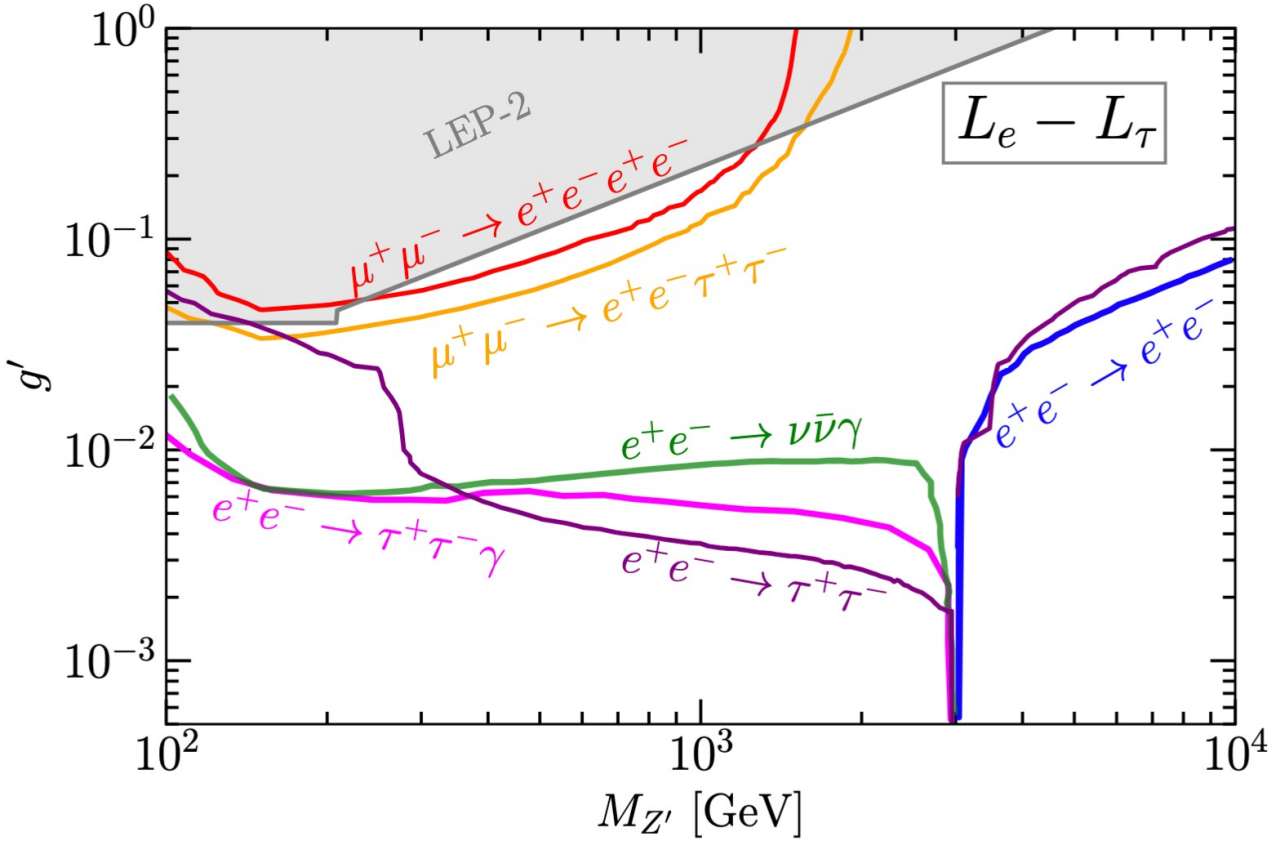
Back Up

Final Constraints

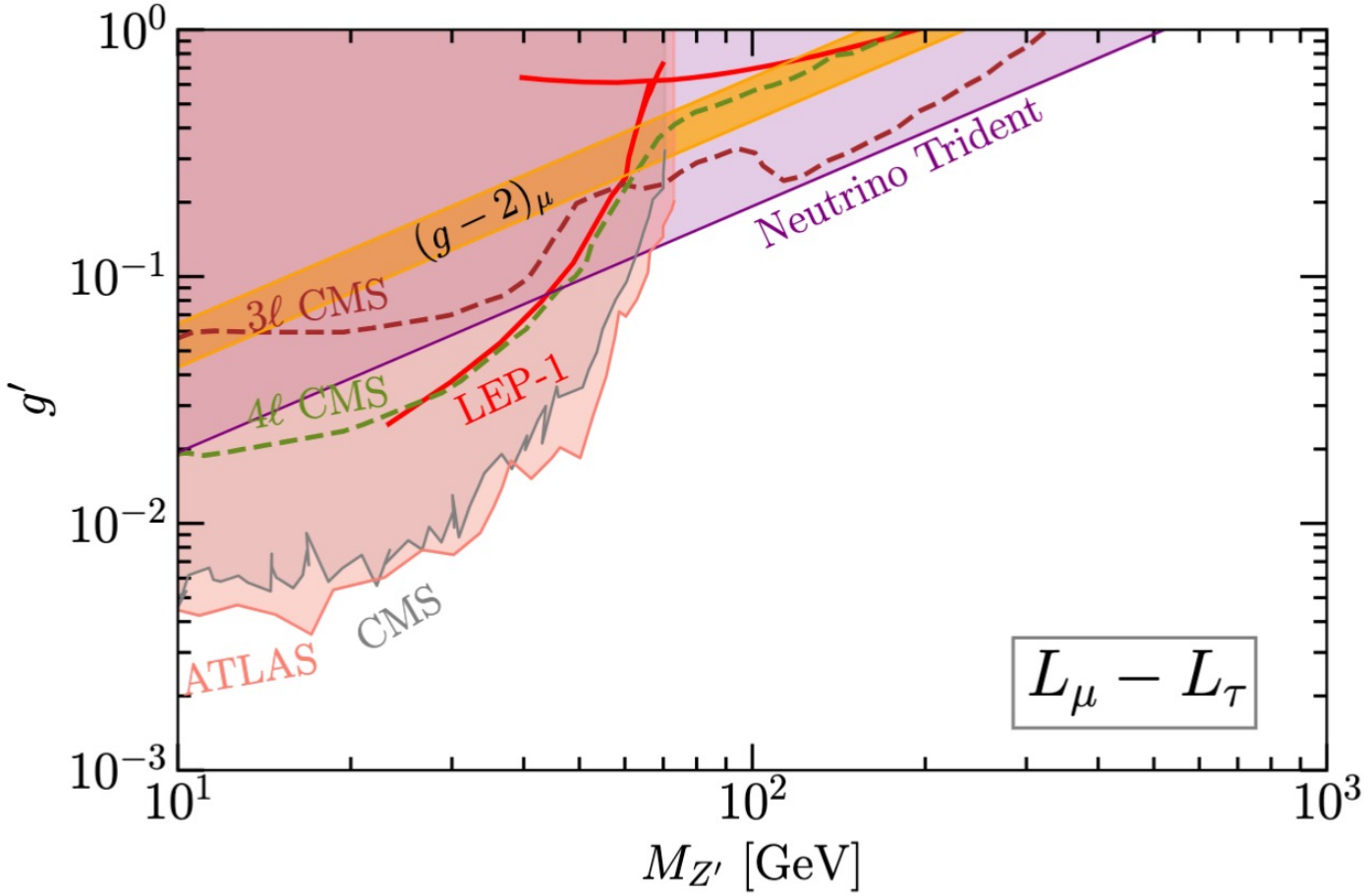
Electron Collider

$\sqrt{s} = 3$ TeV
$\mathcal{L} = 1\ ab^{-1}$





Current Exclusion Bounds

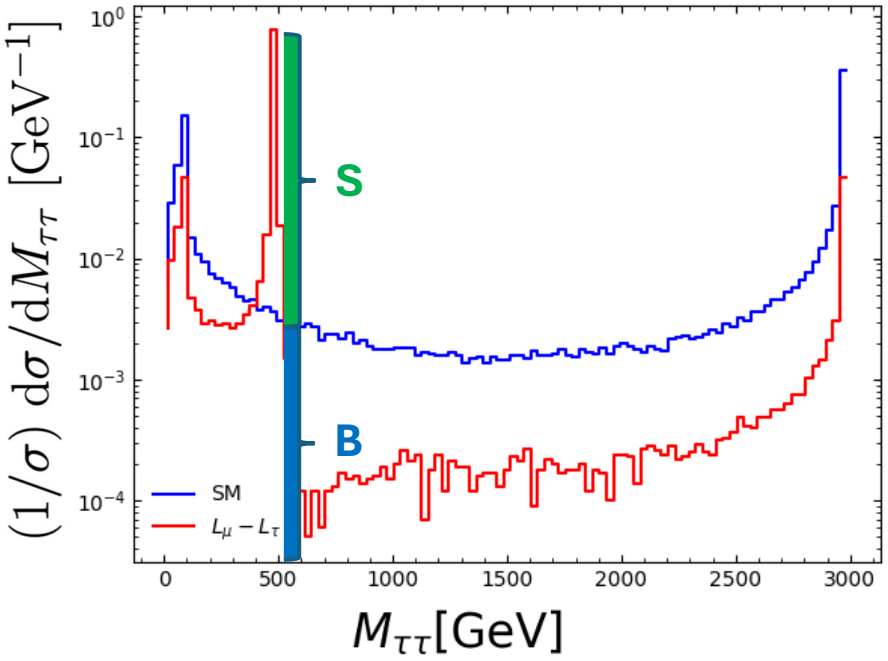


Current: LHC: ATLAS, CMS
Neutrino scattering
$(g-2)_l$

Future: Muon Collider, CLIC, ILC, CEPC, FCC,

On-Shell Z' Particle Production Method

$\mu^+\mu^- \to \tau^+\tau^-$ With Initial State Radiation (ISR)



$\sqrt{s} = 3$ TeV
$M_{Z'} = 500$ GeV
g'=0.2

For $M_{Z'}$ from 100 GeV to 3TeV

Significance:

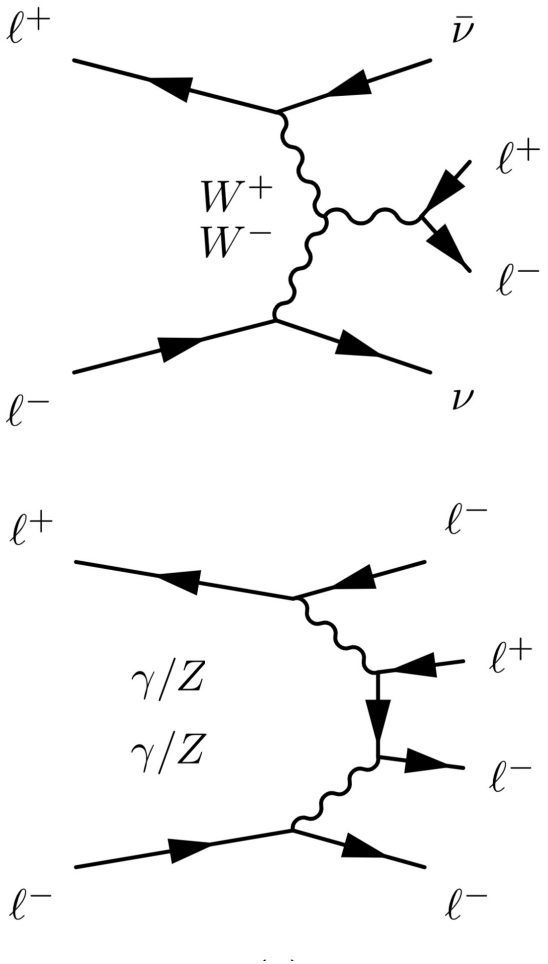
$$\mathcal{S} = \frac{S}{\sqrt{S + B + \delta^2 (S+B)^2}} = 2$$ (equivalent to 95% CL)

S = $N^{SM+Z'} - N^{SM} = \epsilon\, \mathcal{L}\, (\sigma^{SM+Z'} - \sigma^{SM})$

B = $N^{SM} = \epsilon\, \mathcal{L}\, \sigma^{SM}$

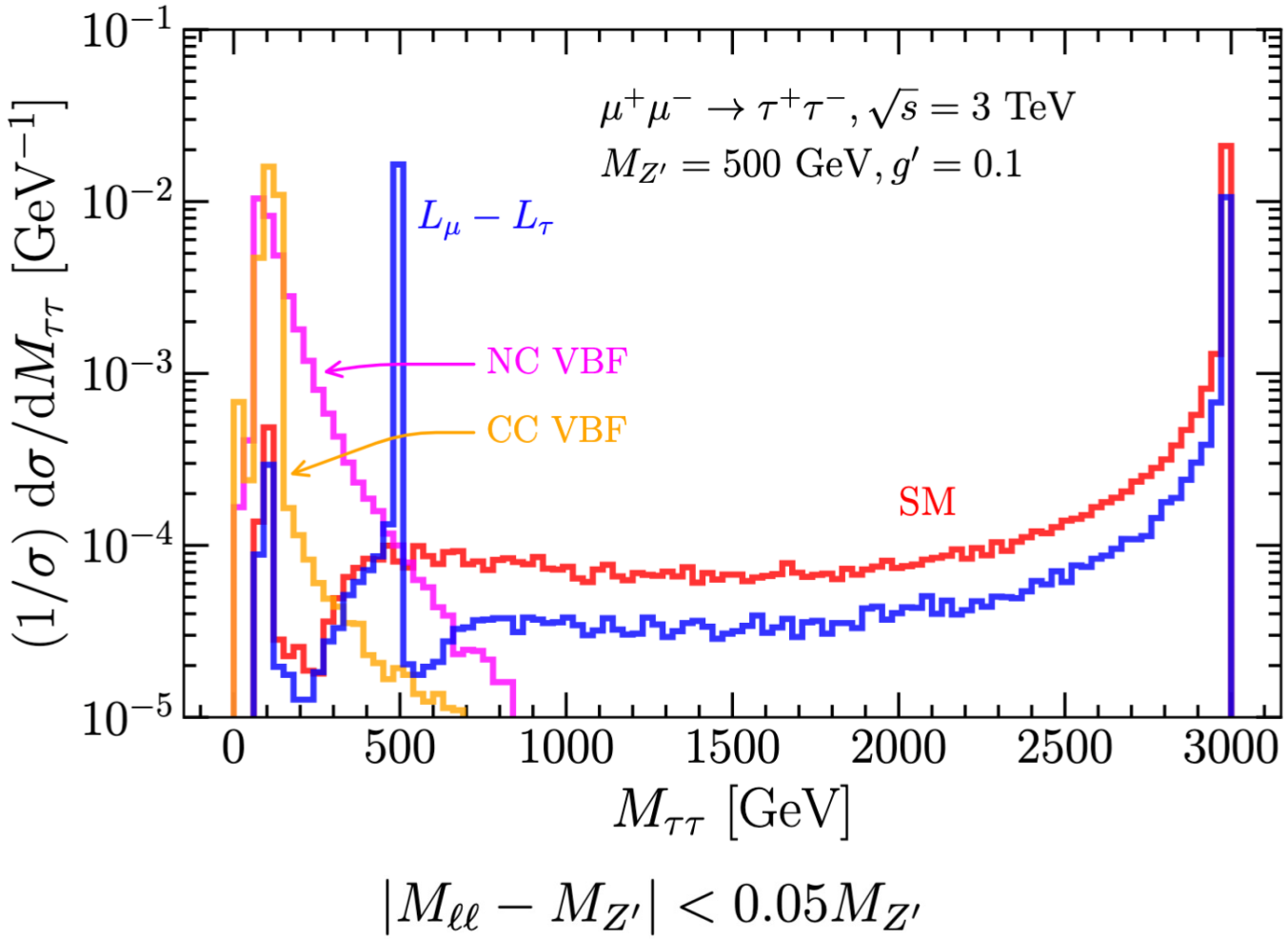
Whizard

Vector Boson Fusion (VBF) Background



(CC)

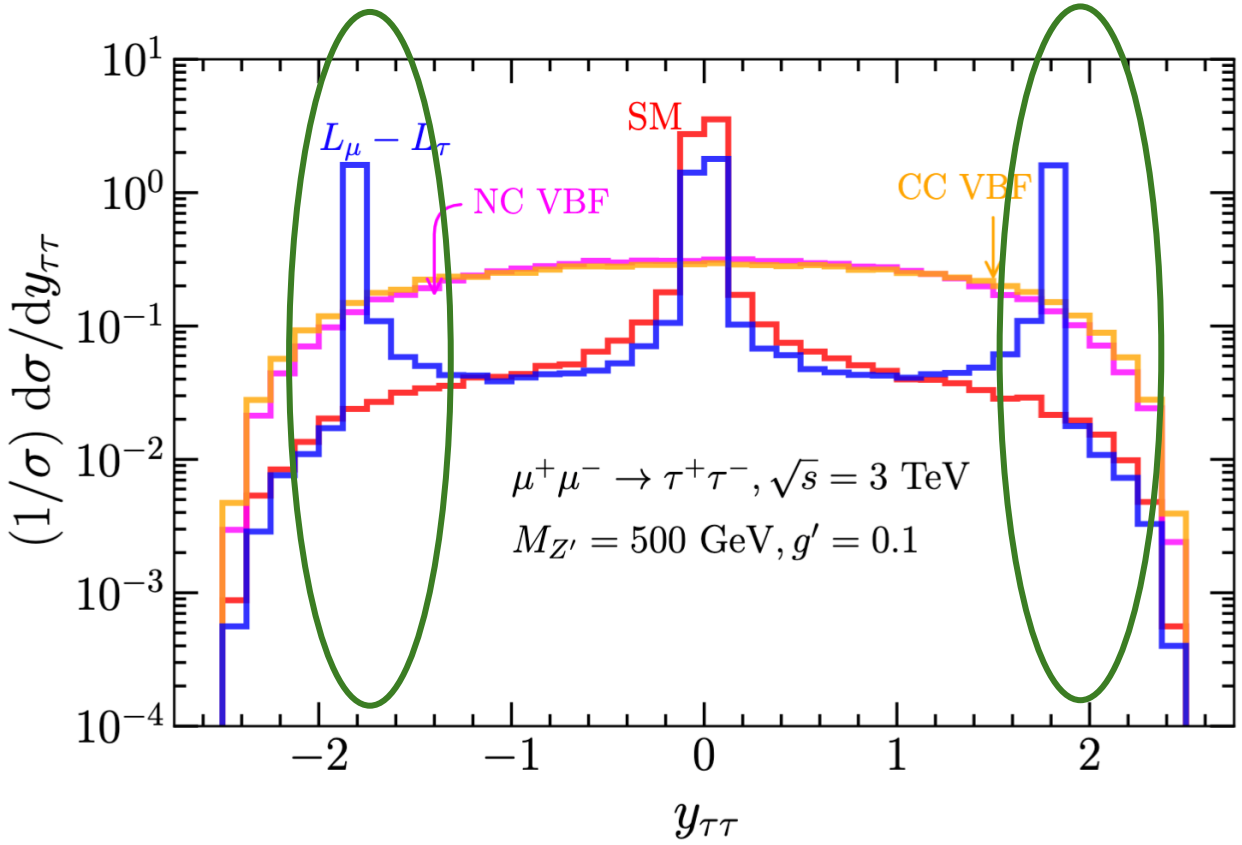
(NC)

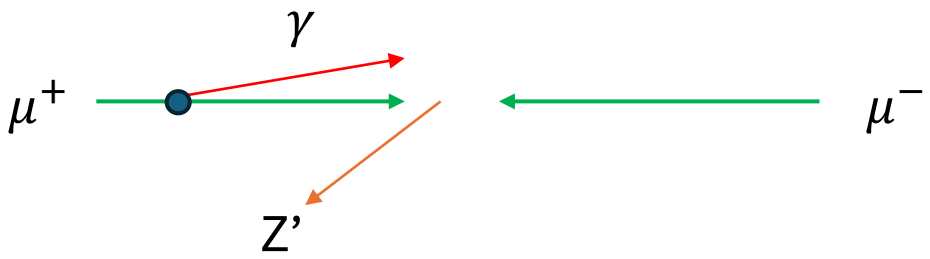


$$|M_{\ell\ell} - M_{Z'}| < 0.05 M_{Z'}$$

On-Shell Z' Particle Production

System Rapidity Cut





Additional Optimization Cuts:

$$|y_{\tau\tau} \pm y_{Z'}| < 0.2$$