

# A Naïve Result on B-L Model Using Contur

A full analysis can be found in arXiv: 1811.11452

---

Xu-Xiang Li

July 2, 2021

Peking University

# B-L Model

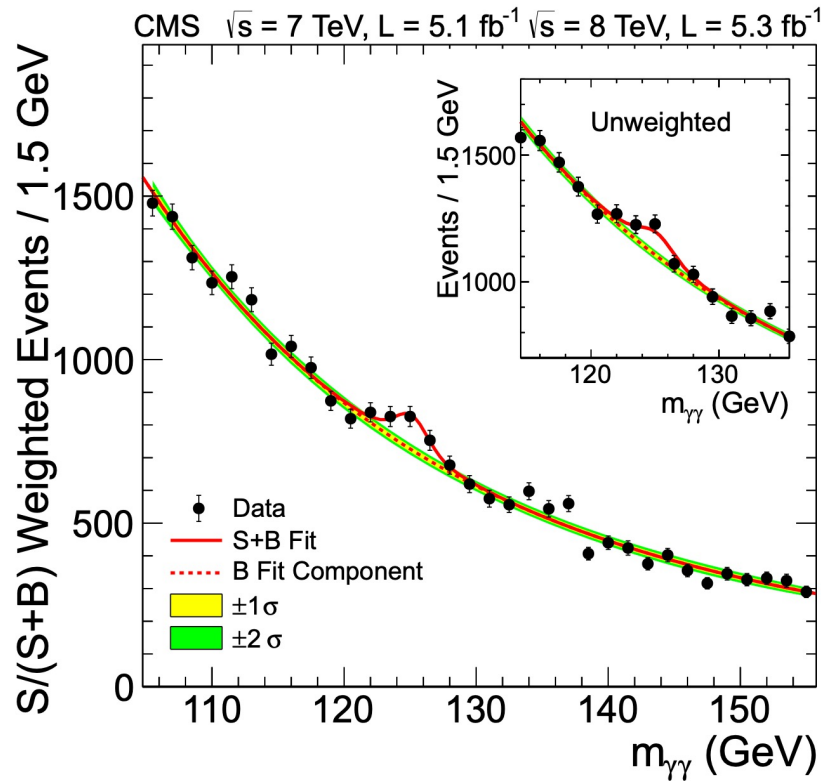
$$-\frac{1}{4}B_{\mu\nu}B^{\mu\nu} - \frac{1}{4}B'_{\mu\nu}B'^{\mu\nu} - \frac{1}{2}\epsilon B_{\mu\nu}B'^{\mu\nu}$$



$$D_\mu = \partial_\mu + ig_s \mathcal{T}_\alpha G_\mu^\alpha + ig T_a W_\mu^a + ig_1 Y B_\mu + i(\tilde{g}Y + g'_1 Y_{B-L})B'_\mu$$

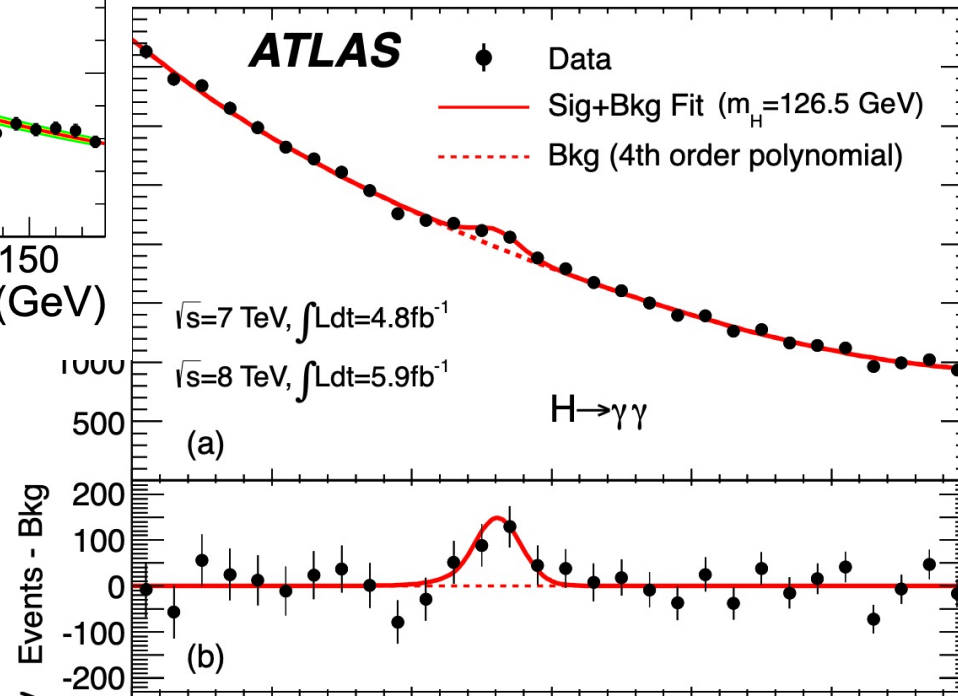
$\psi$	$q_L$	$u_R$	$d_R$	$\ell_L$	$e_R$	$\nu_R$	$H$	$\chi$
$SU(3)_C$	3	3	3	1	1	1	1	1
$SU(2)_L$	2	1	1	2	1	1	2	1
$Y$	$\frac{1}{6}$	$\frac{2}{3}$	$-\frac{1}{3}$	$-\frac{1}{2}$	-1	0	$\frac{1}{2}$	0
$B - L$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	-1	-1	-1	0	2

# Higgs Bump vs. Z' Bump

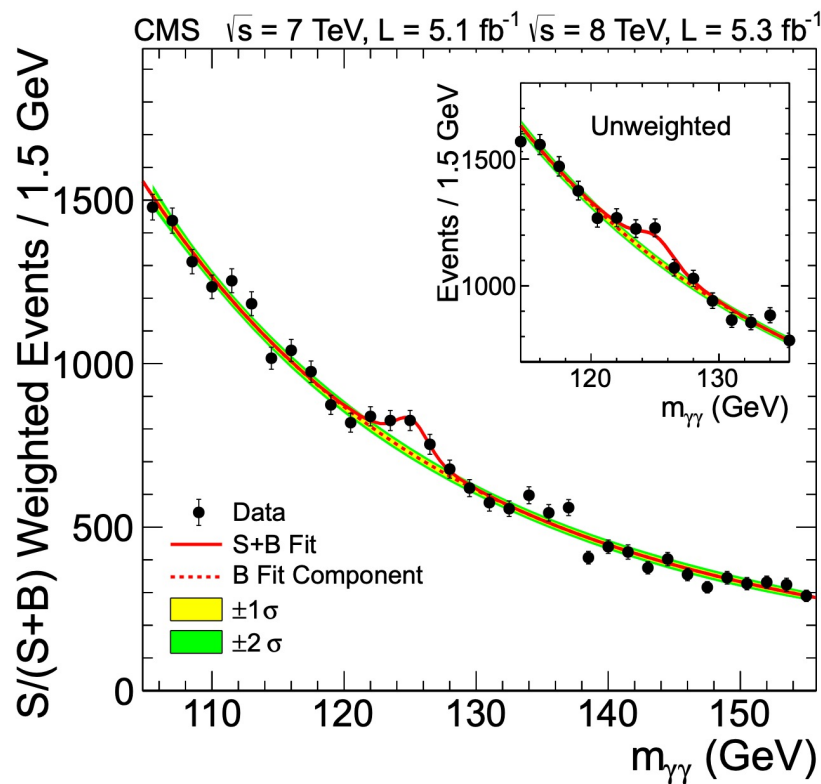


arXiv: 1207.7235

arXiv: 1207.7214

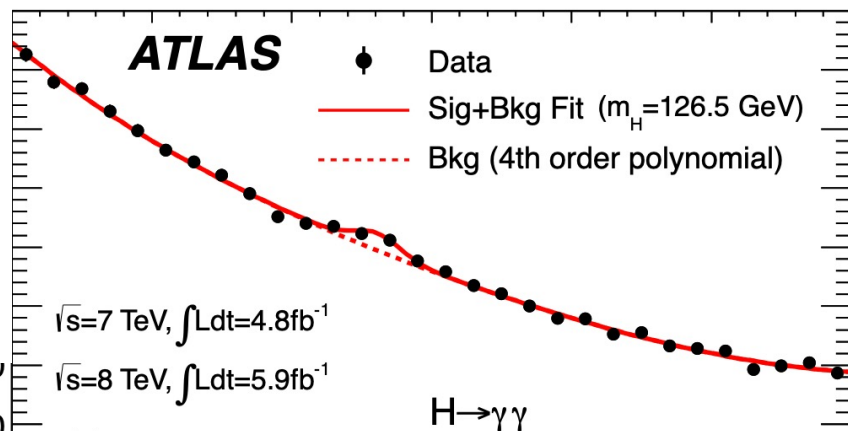


# Higgs Bump vs. Z' Bump

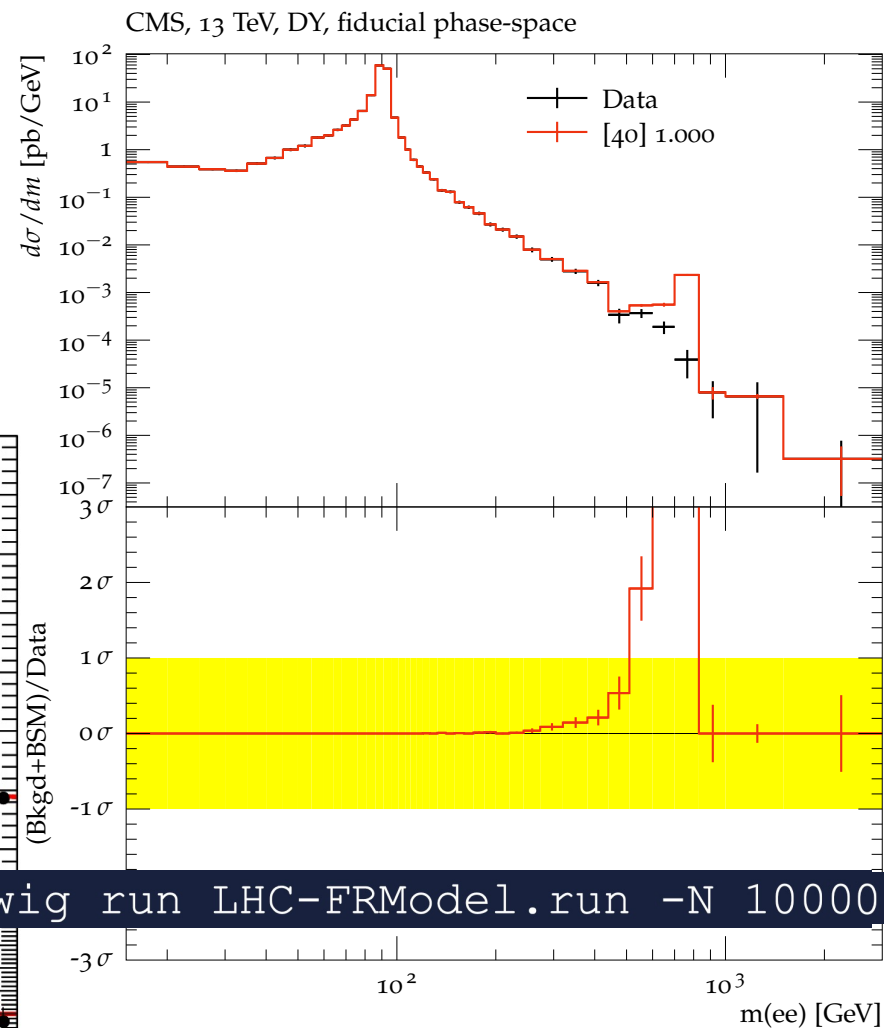
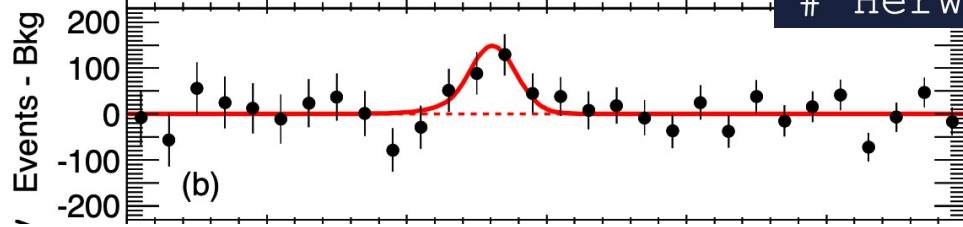


arXiv: 1207.7235

arXiv: 1207.7214

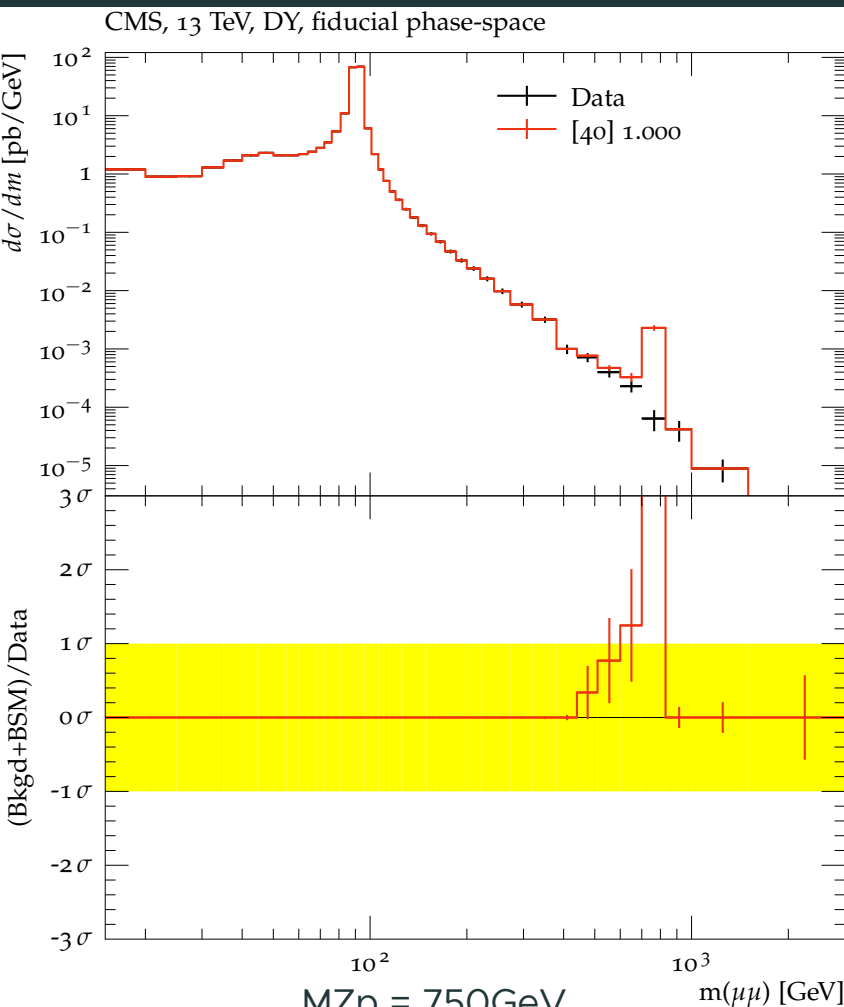


(a)

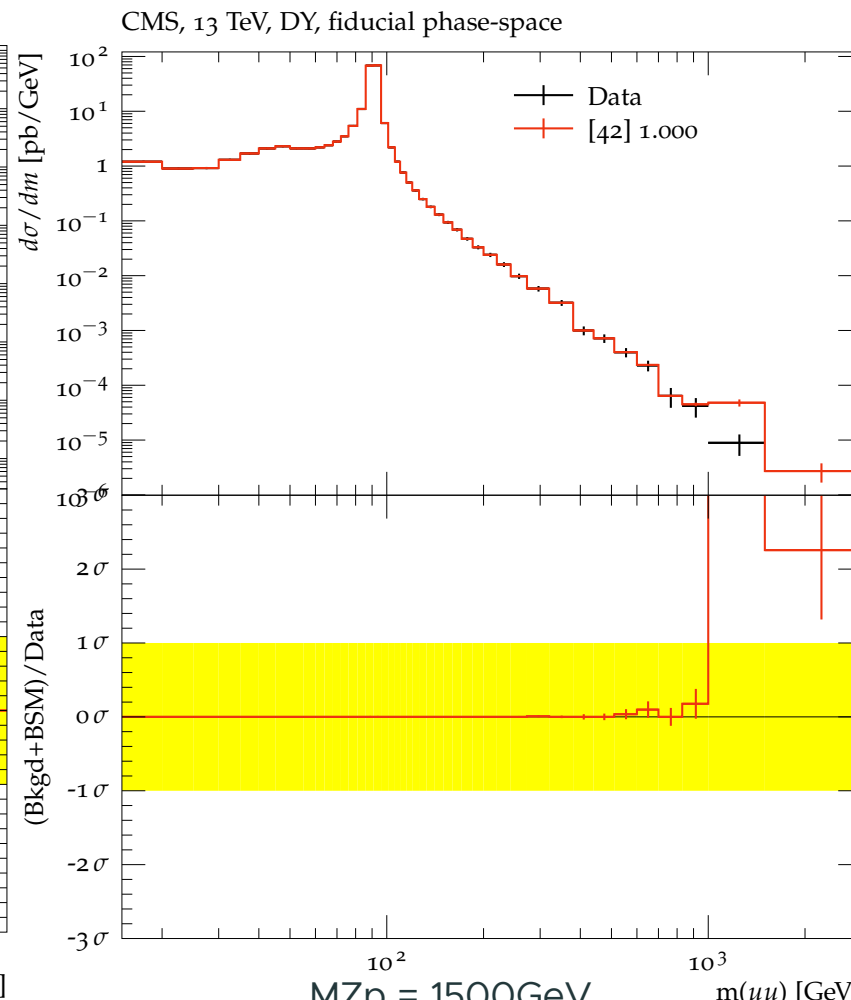


# Herwig run LHC-FRModel.run -N 10000

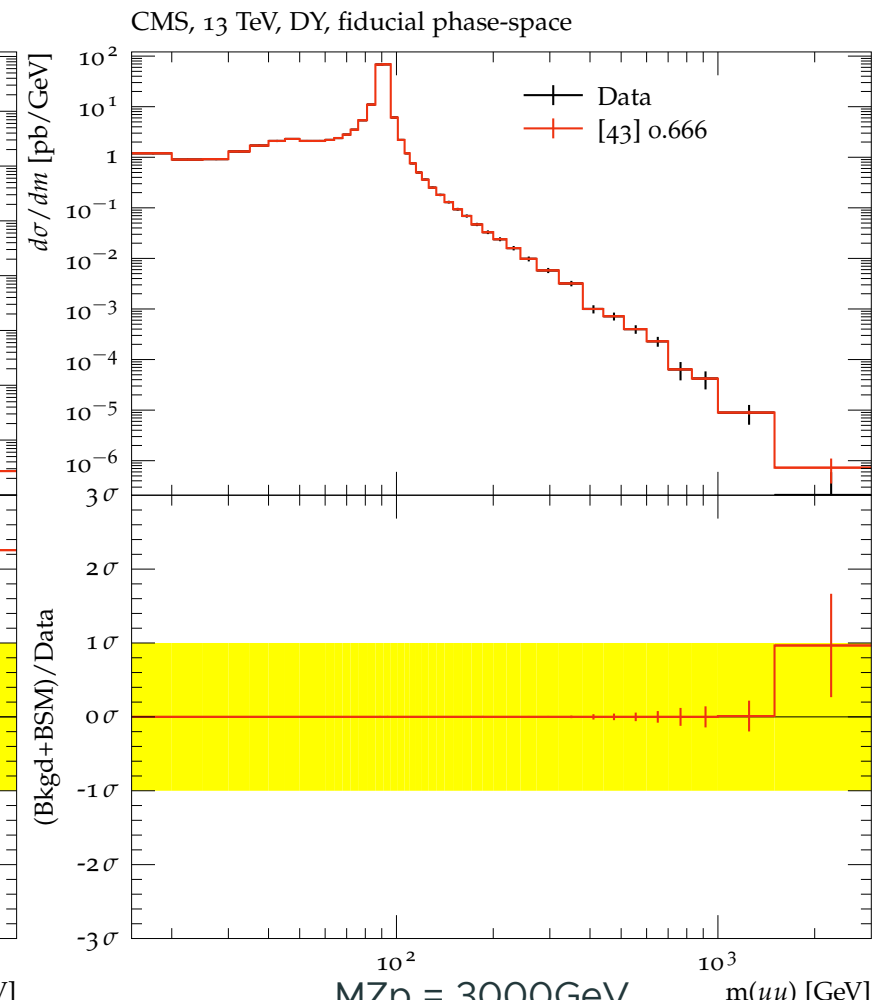
# Exclusion Under Different Situations



$MZp = 750\text{GeV}$   
 $MH2 = 450\text{GeV}$   
 $g1p = 0.2$   
 Exclusion: 100.00%

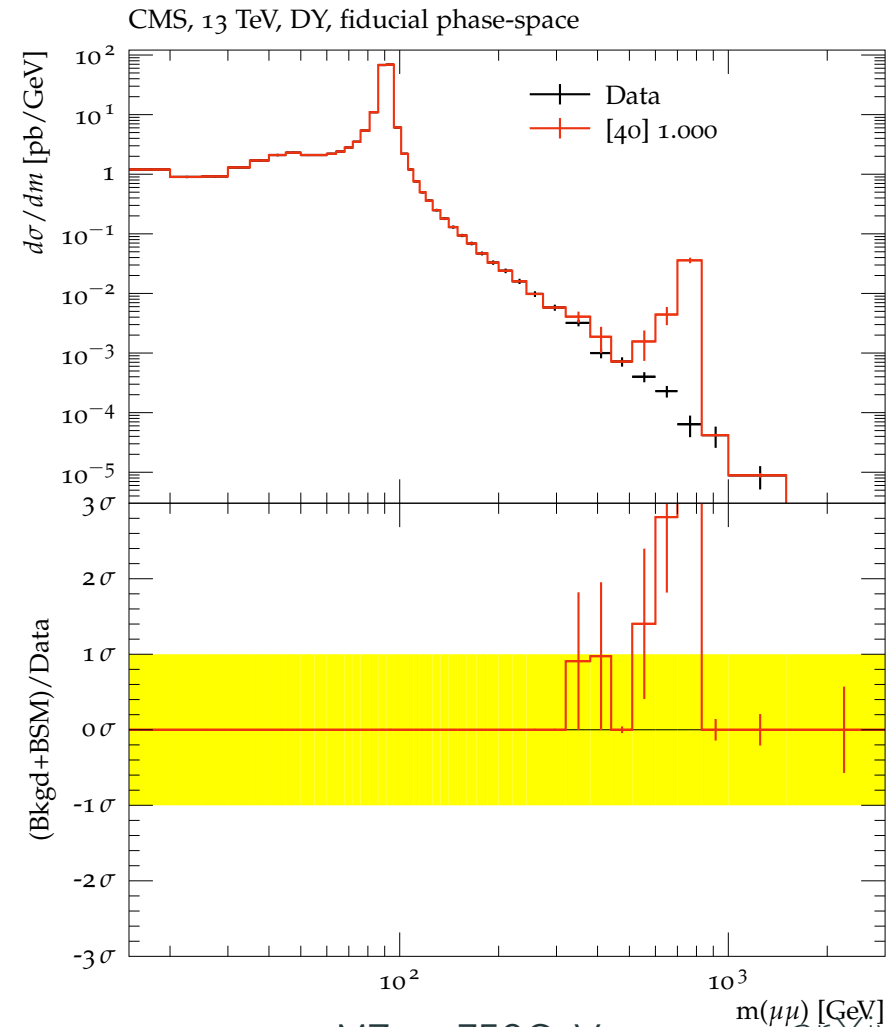
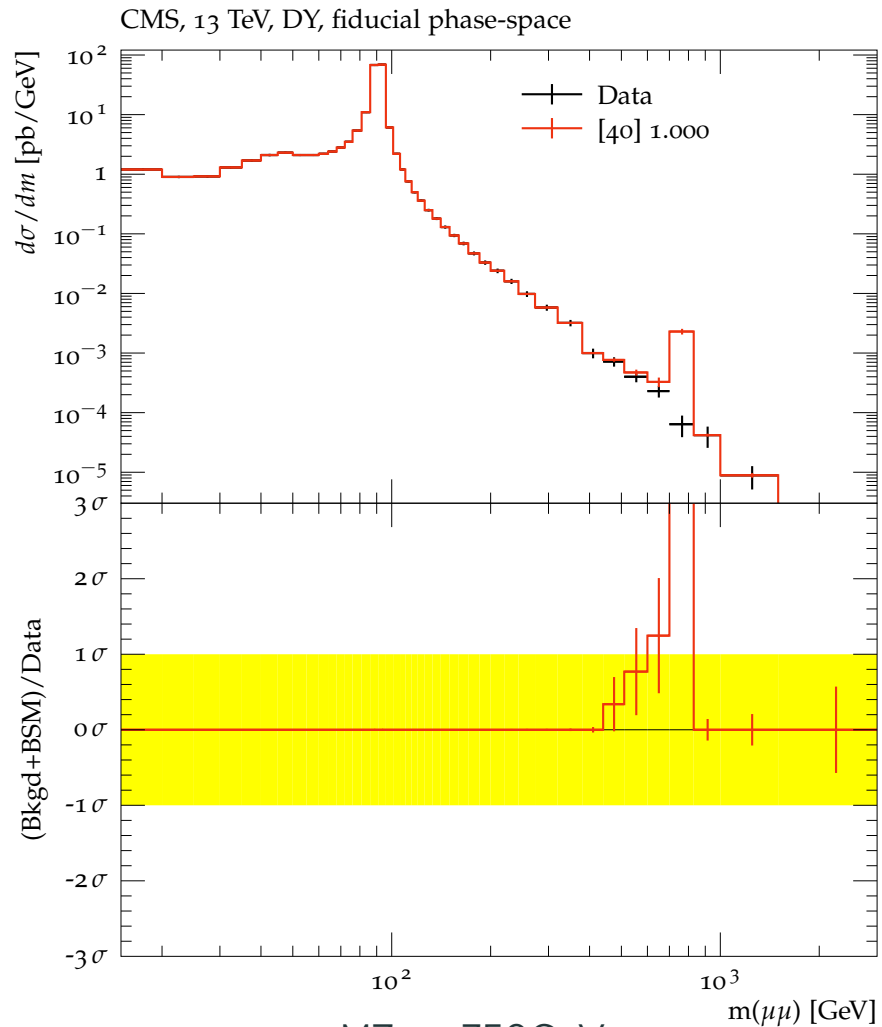


$MZp = 1500\text{GeV}$   
 $MH2 = 450\text{GeV}$   
 $g1p = 0.2$   
 Exclusion: 100.00%



$MZp = 3000\text{GeV}$   
 $MH2 = 450\text{GeV}$   
 $g1p = 0.2$   
 Exclusion: 77.71%

# Exclusion Under Different Situations



arXiv: 1106.4462

# UFO Files

```
# tree $CONTUR_ROOT/data/Models/ -d
/contur/data/Models/
|-- 2HDM
|   |-- Gildener-Weinberg
|   |   `-- G-W
|   |-- InertDoublet
|   |   `-- InertDoublet_UFO
|   `-- KL-LH2017
|       `-- 2HDM_K1_UFO_final
|-- ALP
|   `-- ALP
|-- B-L
|   `-- B-L-3
```

# UFO Files

## # User-defined parameters.

```
g1p = Parameter(name = 'g1p',
                 nature = 'external',
                 type = 'real',
                 value = 0.2,
                 texname = 'g_p',
                 lhablock = 'BLINPUTS',
                 lhacode = [ 1 ])

MH2 = Parameter(name = 'MH2',
                 nature = 'external',
                 type = 'real',
                 value = 450.,
                 texname = '\\text{MH2}',
                 lhablock = 'BLINPUTS',
                 lhacode = [ 2 ])

Sa = Parameter(name = 'Sa',
               nature = 'external',
               type = 'real',
               value = 0.1,
               texname = '\\text{Sa}',
               lhablock = 'BLINPUTS',
               lhacode = [ 3 ])
```

```
MZ = Parameter(name = 'MZ',
               nature = 'external',
               type = 'real',
               value = 91.1876,
               texname = '\\text{MZ}',
               lhablock = 'MASS',
               lhacode = [ 23 ])
```

```
MZp = Parameter(name = 'MZp',
                 nature = 'external',
                 type = 'real',
                 value = 3000,
                 texname = '\\text{MZp}',
                 lhablock = 'MASS',
                 lhacode = [ 9900032 ])
```

parameters.py

```
Zp = Particle(pdg_code = 9900032,
              name = 'Zp',
              antiname = 'Zp',
              spin = 3,
              color = 1,
              mass = Param.MZp,
              width = Param.WZp,
              texname = 'Zp',
              antitexname = 'Zp',
              charge = 0,
              BL = 0,
              GhostNumber = 0,
              LeptonNumber = 0,
              Y = 0)
```

```
ghZp = Particle(pdg_code = 9000005,
                 name = 'ghZp',
                 antiname = 'ghZp~',
                 spin = -1,
                 color = 1,
                 mass = Param.MZp,
                 width = Param.WZp,
                 texname = 'ghZp',
                 antitexname = 'ghZp~',
                 charge = 0,
                 BL = 0,
                 GhostNumber = 1,
                 LeptonNumber = 0,
                 Y = 0)
```

particles.py

# UFO Files

```
# propagator for the incoming fermion # the one for the outcoming is computed on the flight
```

```
F = Propagator(name = "F",  
              numerator = "complex(0,1) * (Gamma('mu', 1, 2) * P('mu', id) + Mass(id) * Identity(1, 2))",  
              denominator = denominator  
            )
```

```
# massive vector in the unitary gauge, can't be use for massless particles
```

```
V1 = Propagator(name = "V1",  
              numerator = "complex(0,1) * (-1 * Metric(1, 2) + Metric(1,'mu')* P('mu', id) * P(2, id) / Mass(id)**2 ",  
              denominator = denominator  
            )
```

```
V_283 = Vertex(name = 'V_283',  
              particles = [ P.e__plus__, P.e__minus__, P.Zp ],  
              color = [ '1' ],  
              lorentz = [ L.FFV1 ],  
              couplings = {(0,0):C.GC_14})
```

```
V_284 = Vertex(name = 'V_284',  
              particles = [ P.mu__plus__, P.mu__minus__, P.Zp ],  
              color = [ '1' ],  
              lorentz = [ L.FFV1 ],  
              couplings = {(0,0):C.GC_14})
```

```
V_285 = Vertex(name = 'V_285',  
              particles = [ P.ta__plus__, P.ta__minus__, P.Zp ],  
              color = [ '1' ],  
              lorentz = [ L.FFV1 ],  
              couplings = {(0,0):C.GC_14})
```

propagators.py

```
GC_14 = Coupling(name = 'GC_14',  
                value = '-(complex(0,1)*g1p)',  
                order = {'QED':1})
```

couplings.py

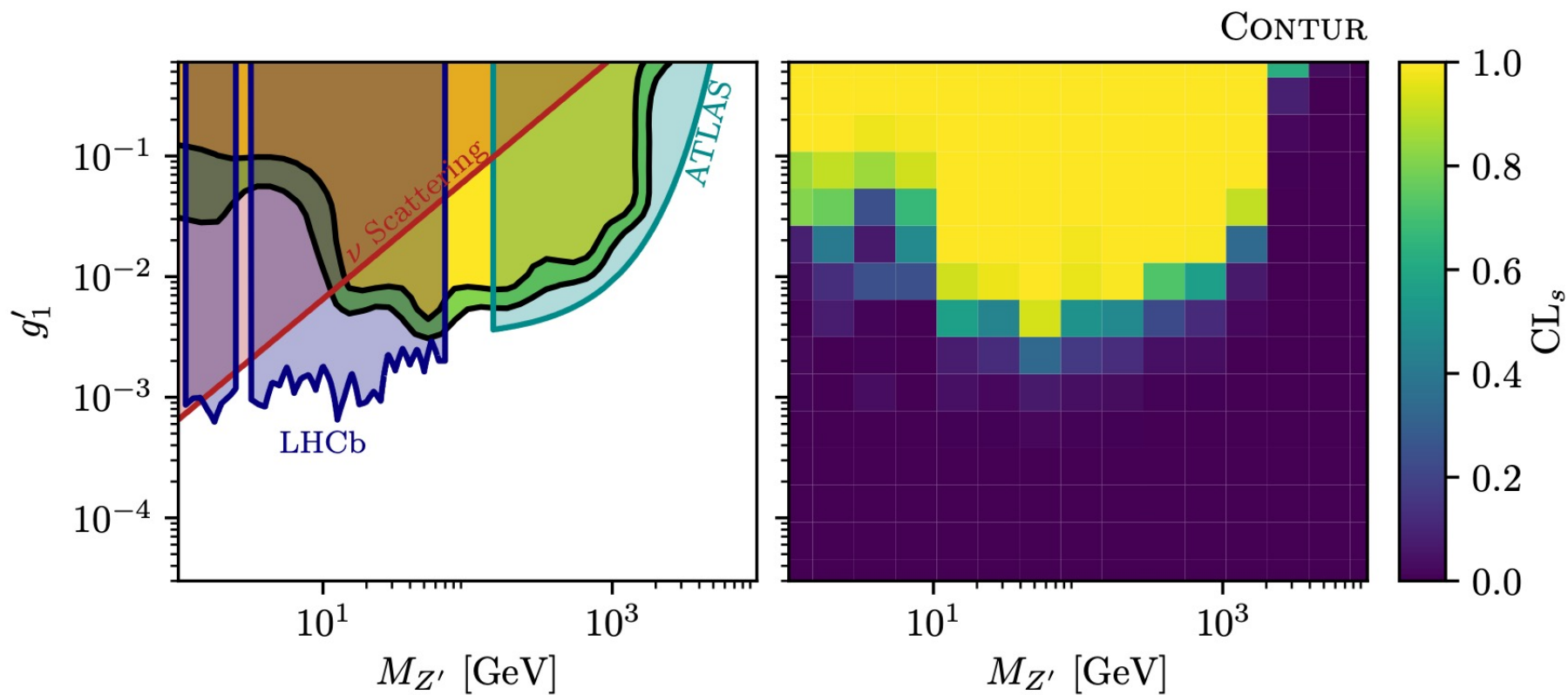
vertices.py

More on arXiv: 1108.2040

**Thank you!**

---

# Constraints on B-L Model



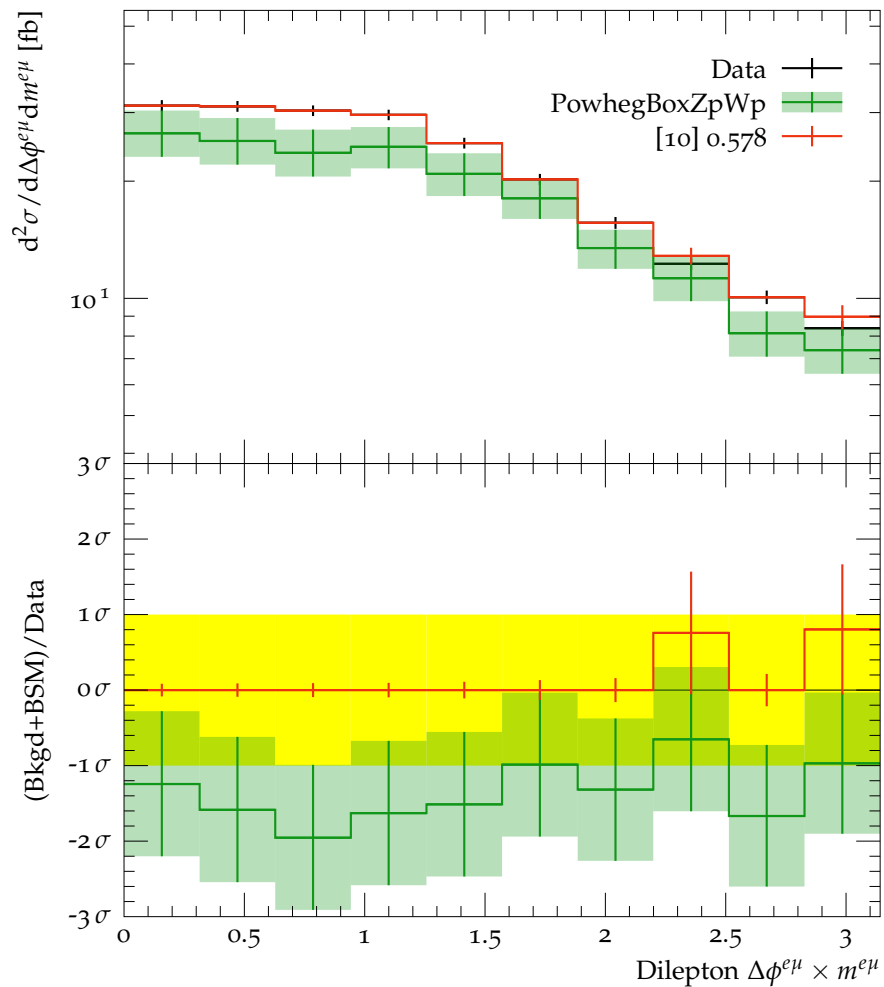
(a)

# Inert Doublet Model

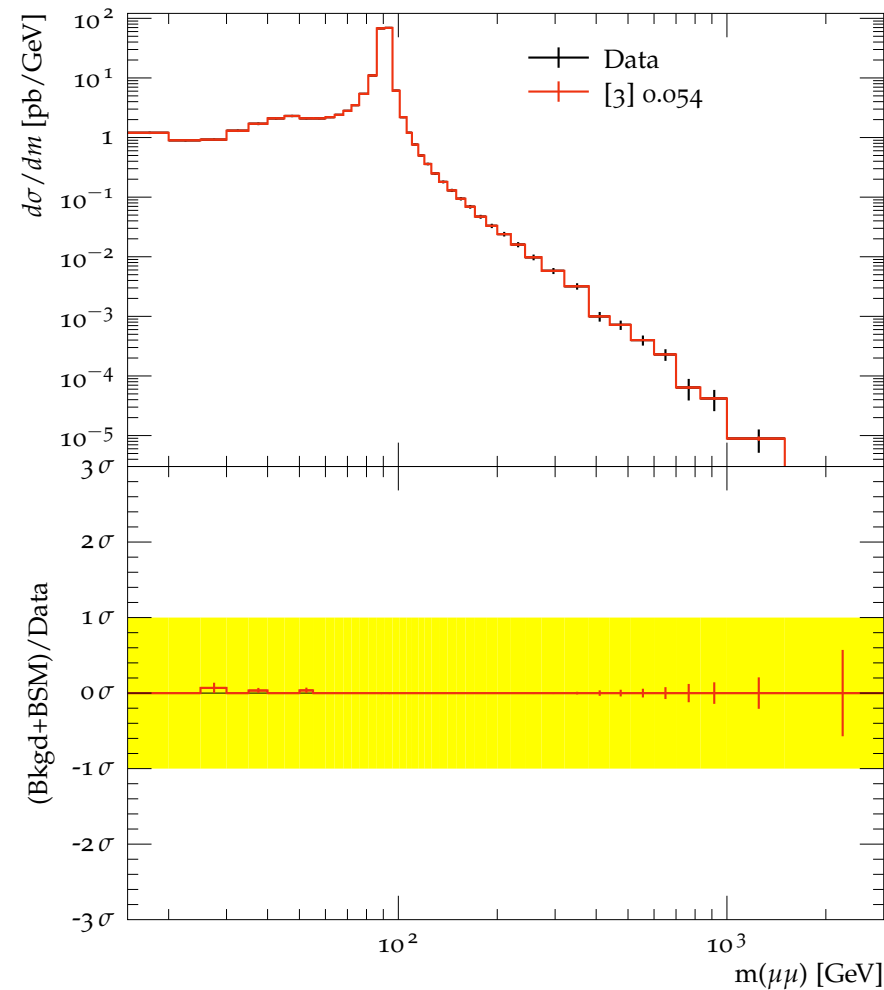
ATLAS\_13\_L1L2METJET pool: unlike dilepton plus missing transverse momentum and jets

Exclusion from this pool alone: 57.84%

MH0 = 70TeV  
 MA0 = 120TeV  
 MH+ = 200TeV



CMS, 13 TeV, DY, fiducial phase-space



# B-L Model

$$\mathcal{L} \supset (D^\mu H)^\dagger (D_\mu H) + (D^\mu \chi)^\dagger D_\mu \chi - \mathcal{V}(H, \chi),$$

# B-L Model

- Default **Alert Example**
- **Bold**
- Equations

$$a^2 + b^2 = c^2$$

$$\mathcal{L} \supset (D^\mu H)^\dagger (D_\mu H) + (D^\mu \chi)^\dagger D_\mu \chi - \mathcal{V}(H, \chi),$$

# Fonts

- Regular
- *Italic*
- **Bold**
- ***Bold Italic***
- Light
- *Light Italic*

# Table

**Table 1:** Largest cities in the world

City	Population
Mexico City	20,116,842
Shanghai	19,210,000
Peking	15,796,450
Istanbul	14,160,467

# Blocks

## Default

Block content.

## Alert

Block content.

## Example

Block content.