750 GeV Diphoton Excess From Cascade Decay

In collaboration with

Fa Peng Huang, Chong Sheng Li, Ze Long Liu

arXiv: 1512.06732

Yan Wang

Institute of High Energy Physics

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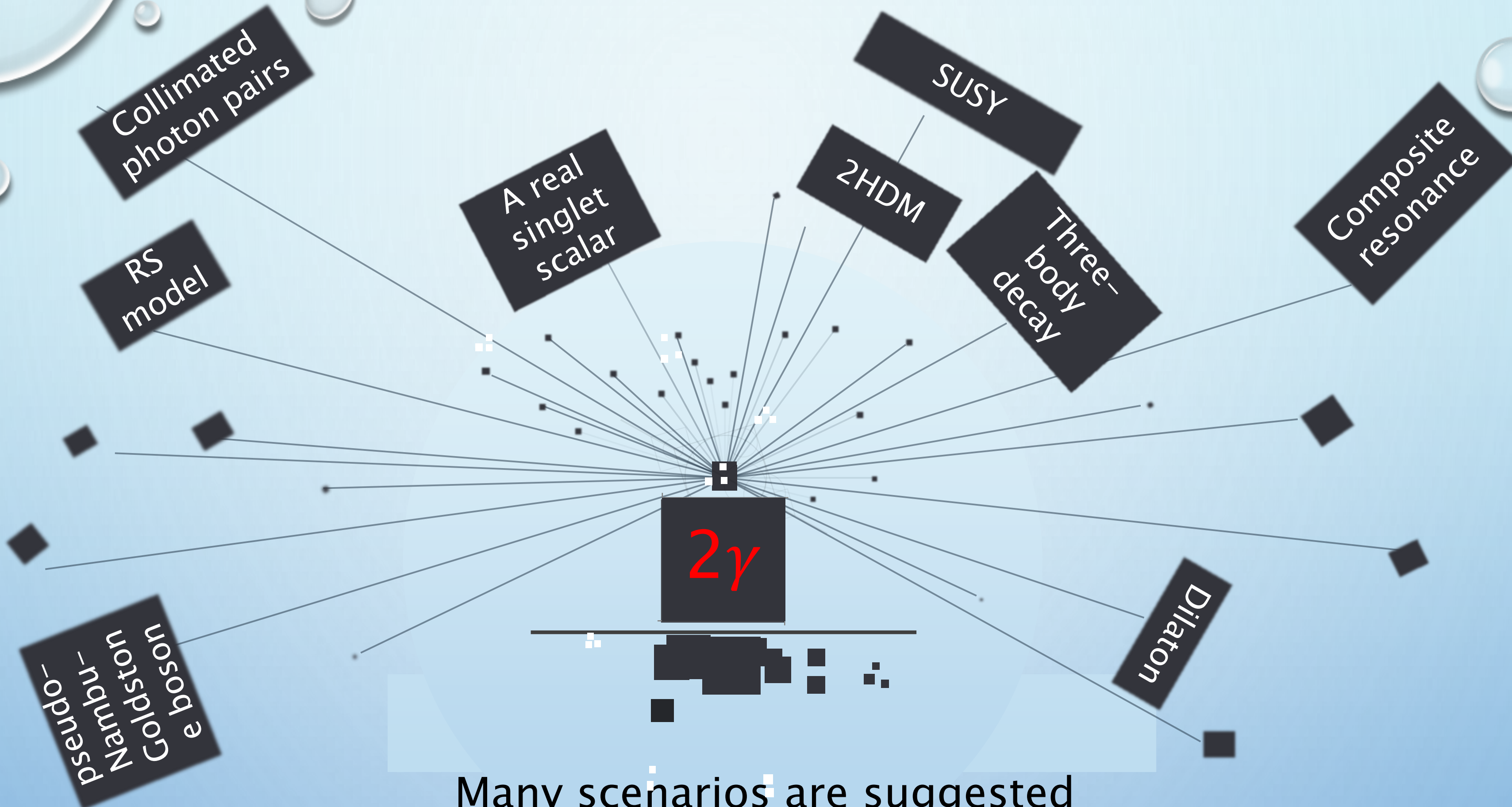
HAPPY NEW YEAR



Many scenarios are suggested

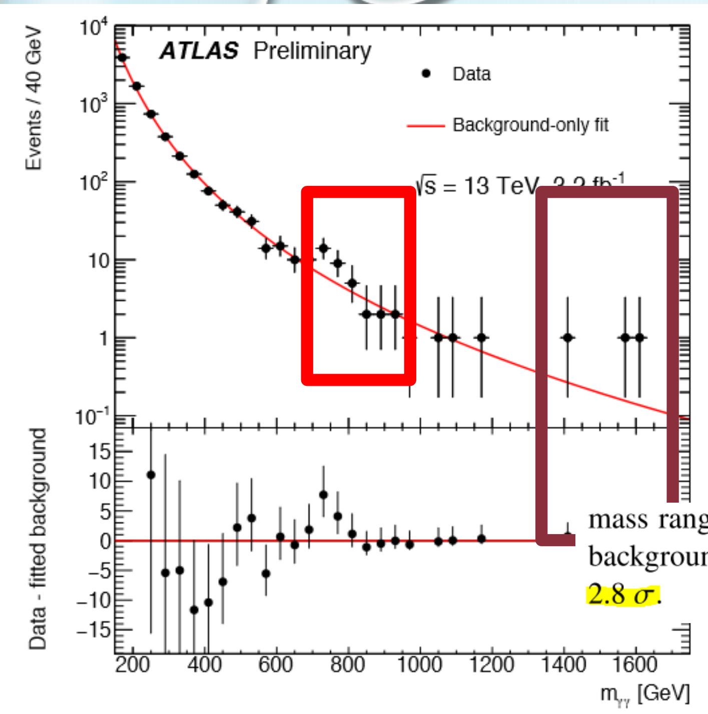
We propose a scenario can explain 750 GeV and 1.6 TeV diphoton excess, simultaneously

We also predict a 4γ excess at 1.6 TeV

What is 1.6 TeV excess ???

ATLAS-CONF-2015-081

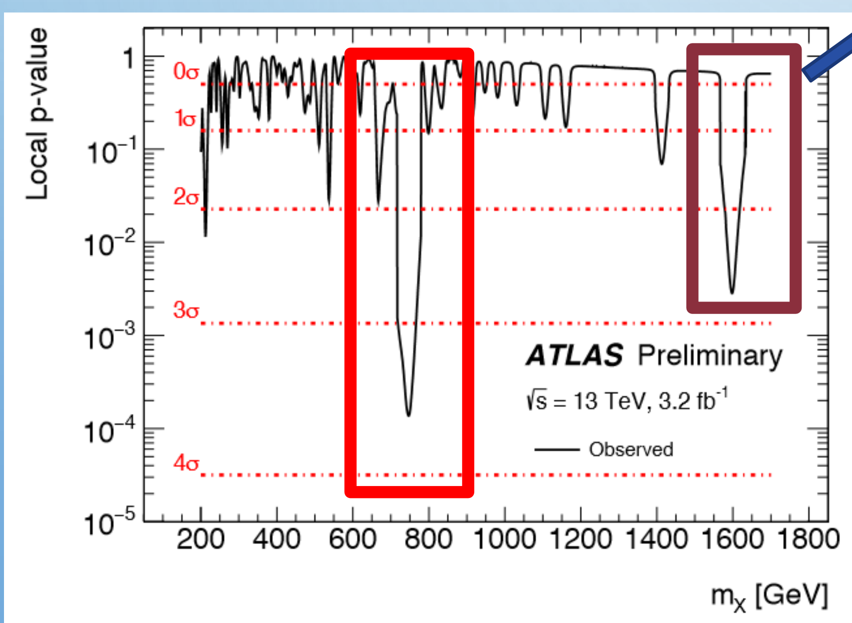
Diphoton Excess

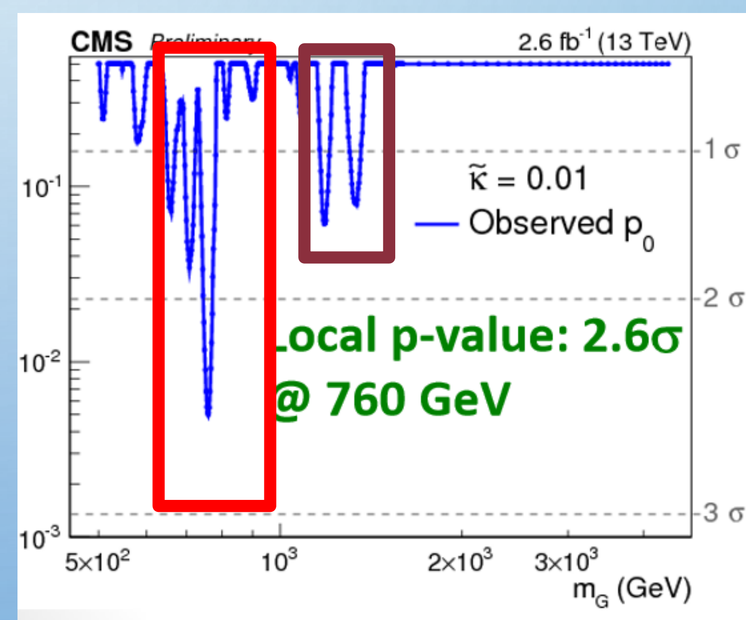


$$\sigma_{\rm excess} = (10 \pm 3)\ {\rm fb}\ ({\rm at\ 13\ TeV\ ATLAS}),$$
$$\sigma_{\rm excess} = (6 \pm 3)\ {\rm fb}\ \ ({\rm at\ 13\ TeV\ CMS}).$$

mass range $m_X \in [200 - 2000]$ GeV is accounted for. The second most significant deviation from the background-only hypothesis is found for a mass of about 1.6 TeV, corresponding to a local significance of 2.8 σ.

2.8 σ

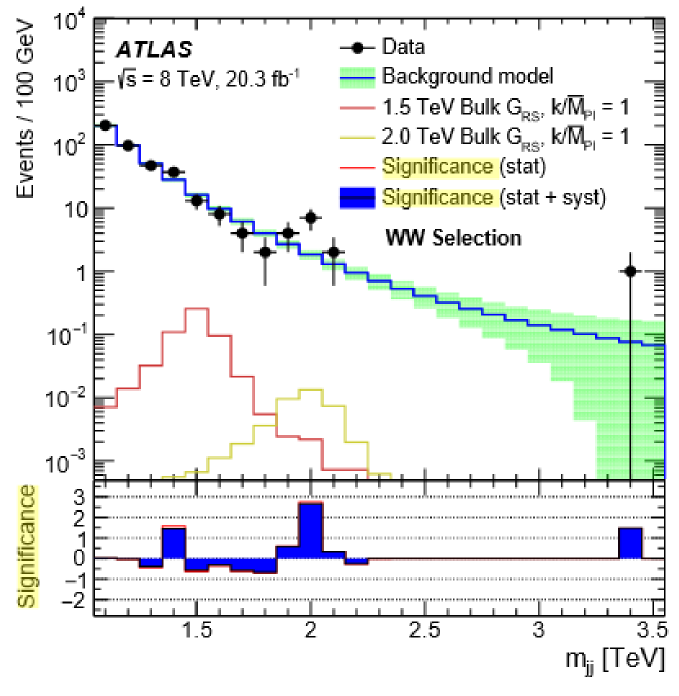




CMS PAS EXO-15-004

8 TeV diboson by ATLAS

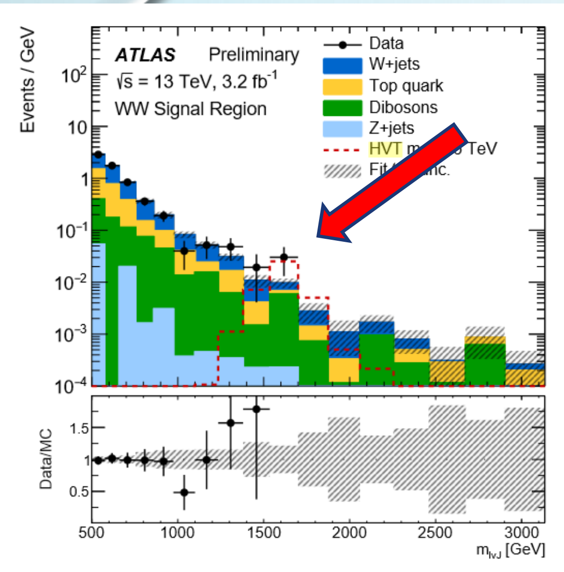
in the region around 2 TeV in figures 5(a), 5(b) and 5(c), lead to small p_0 values near that mass. The smallest local p_0 values in the *WZ*, *WW*, and *ZZ* channels correspond to significances of 3.4 σ, 2.6 σ, and 2.9 σ respectively.



(b)

arXiv: 1506.00962

Some Hints @ 1.6 TeV



(a) *WW* Signal Region

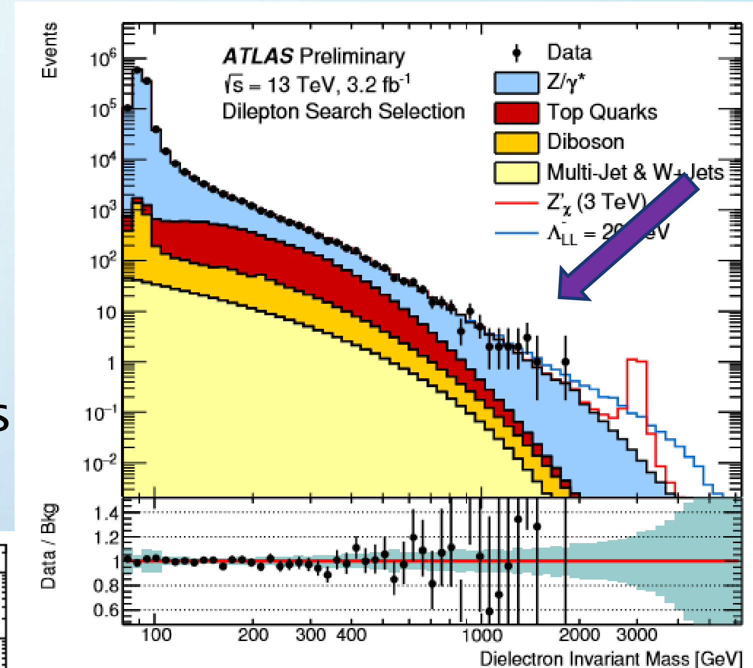
new resonances decaying to WW or WZ final states at 13 TeV LHC

Whether or not, 1.6 TeV resonance is needed?

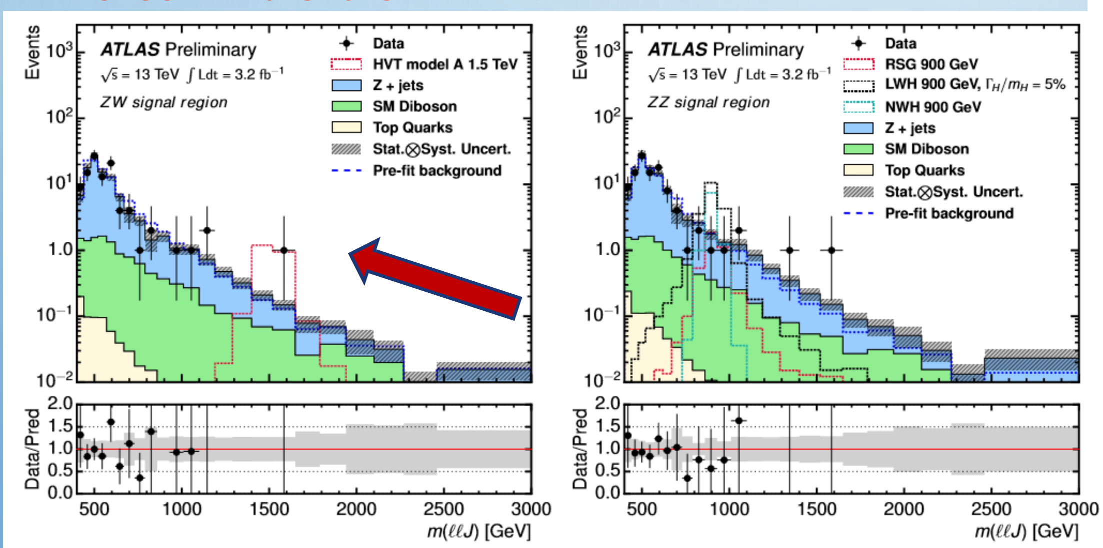
How to explain the two diphoton excess simultaneously?

Dilepton invariant mass

ATLAS-CONF-2015-070



ATLAS-CONF-2015-075



(a) (b)

heavy resonances decaying into a WZ or ZZ pair

ATLAS-CONF-2015-071

Story @ 1.6 TeV

Our simplified model

$$\mathcal{L}_{\rm eff} = \frac{c_{rgg}}{\Lambda_1} G^b_{\mu\nu} G^{b\mu\nu} r + c_{r\alpha\alpha}\Lambda_2 r\alpha\alpha + \frac{c_{\alpha\gamma\gamma}}{\Lambda_3} F_{\mu\nu}F^{\mu\nu}\alpha + c_{\alpha aa}\Lambda_4 aa\alpha,$$

$$\Lambda_1 = \Lambda_2 = \Lambda_3 = \Lambda_4 = \Lambda = 10^4 \text{ GeV}$$

r and α are scalars

$M_r \sim 1.6\ TeV$

$M_\alpha \sim 750\ GeV$

a is a DM candidate

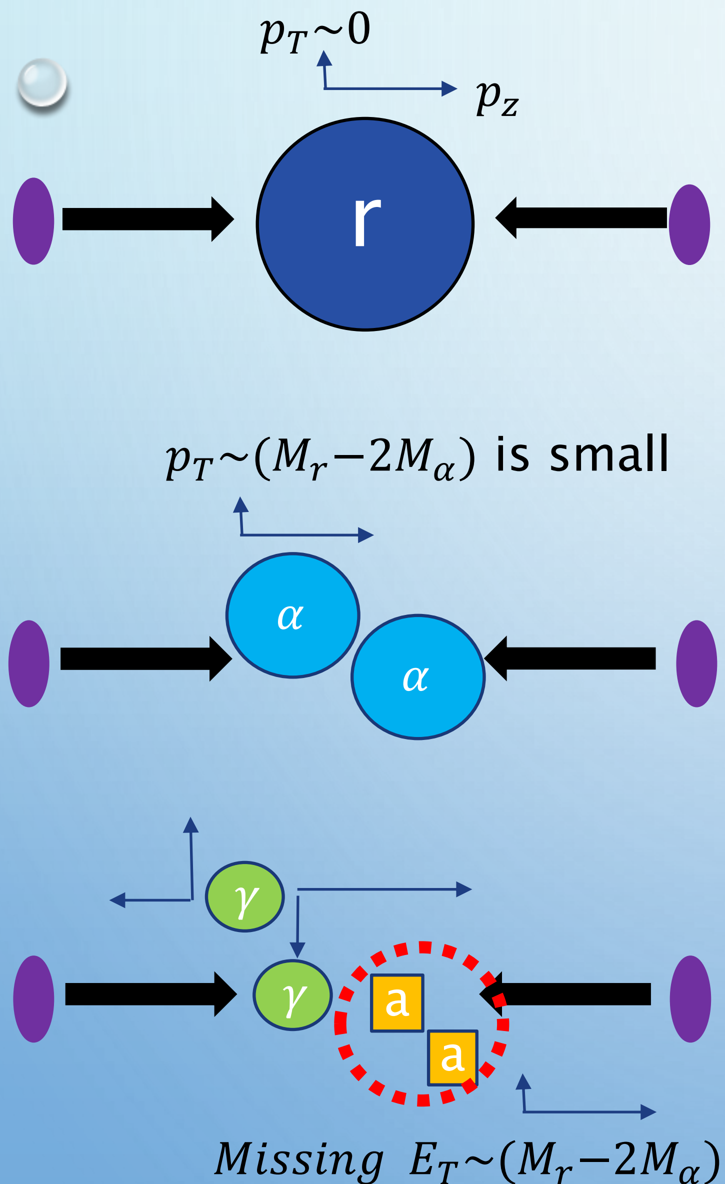
Three channel

$\sigma\,(pp \to r \to (\alpha \to aa)(\alpha \to aa))$ *dominate*

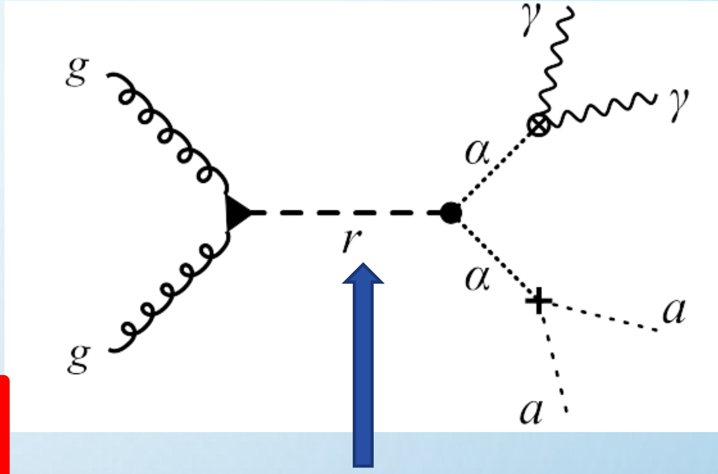
$\sigma_{excess}(pp \to r \to (\alpha \to aa)(\alpha \to \gamma\gamma))$ *excess* $\sim 10\ fb$

$\sigma_{signal}(pp \to r \to (\alpha \to \gamma\gamma)(\alpha \to \gamma\gamma))$ *predicted signal*

Diphoton Excess



We need $M_r \sim 2M_\alpha$



M_r is very heavy, the production rate is suppressed by PDF.
The constraints from the 8 TeV's LHC data can be naturally evaded

We can only resolve the large enough missing transverse energy (met) of aa pair, so only *diphoton* is detected

Simplify Parameters

$$N_r = \frac{\Gamma(r \to \alpha\alpha)}{\Gamma(r \to gg)}$$
$$N_\alpha = \frac{\Gamma(\alpha \to aa)}{\Gamma(\alpha \to \gamma\gamma)}$$

$$\sigma_{\rm excess} = \frac{1}{M_r S_{c.m.}} f_{gg}\Gamma(r \to gg)\frac{N_r}{N_r+1}\frac{N_\alpha}{(N_\alpha+1)^2}$$

Depending on four parameters: c_{rgg}, N_r, N_α, $c_{\alpha\gamma\gamma}$

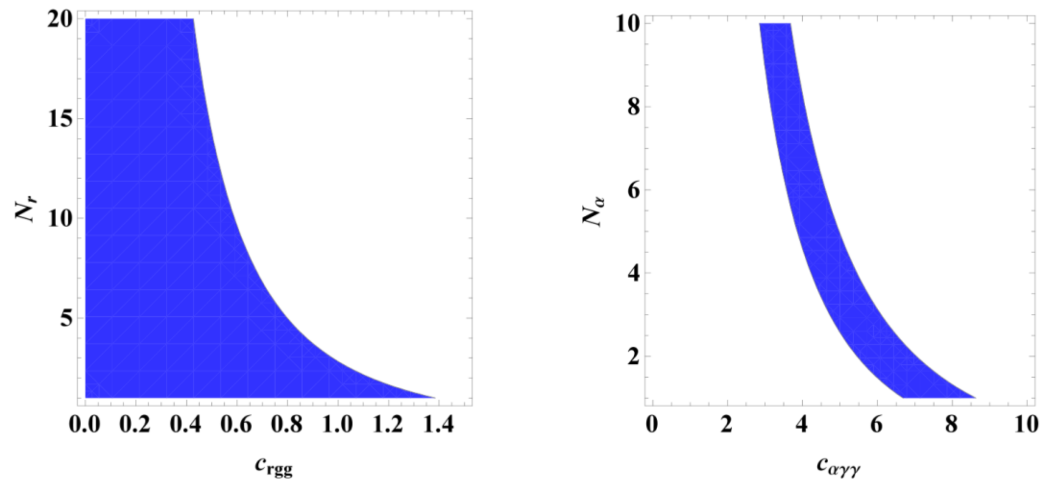
The basic constraints

$10 > N_r > 1, \qquad 10 > N_\alpha > 1$

$pp \to r \to gg \cong \dfrac{45\Gamma(r \to gg)}{N_r+1} < 100\ fb$

$\Gamma_r = (N_r+1)\Gamma(r \to gg) < 100\ \text{GeV}$

$30\ \text{GeV} < \Gamma_\alpha < 50\ \text{GeV}$



Benchmark Point

$$B1: \quad N_r = 1, \quad N_\alpha = 1 \qquad B2: \quad N_r = 1, \quad N_\alpha = 10$$

$$B3: \quad N_r = 10, \quad N_\alpha = 1 \qquad B4: \quad N_r = 10, \quad N_\alpha = 10$$

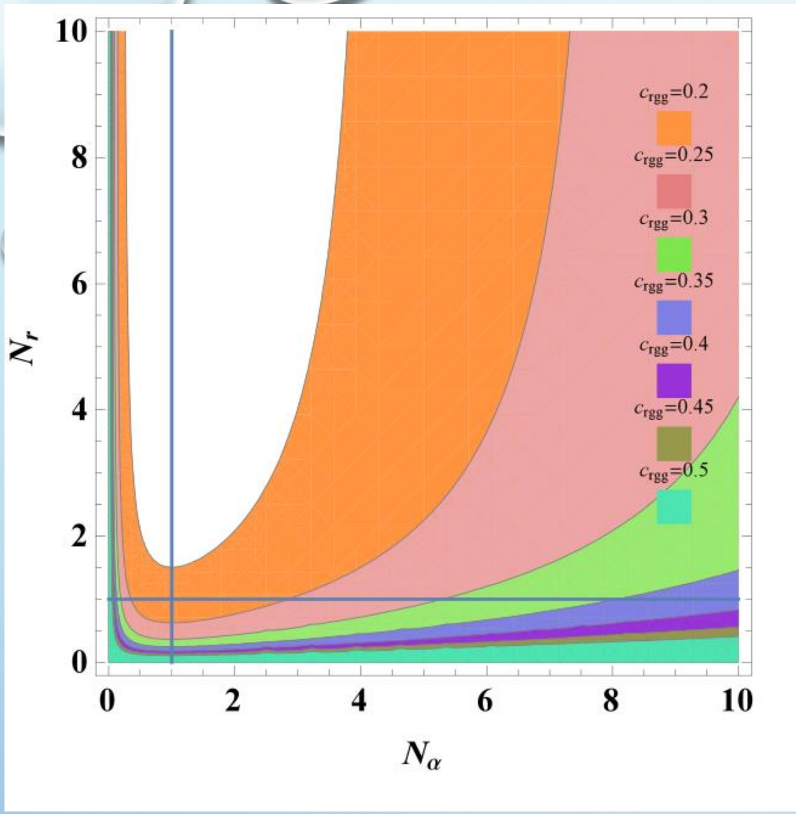
$$B5: \quad N_r = 8, \quad N_\alpha = 5.$$

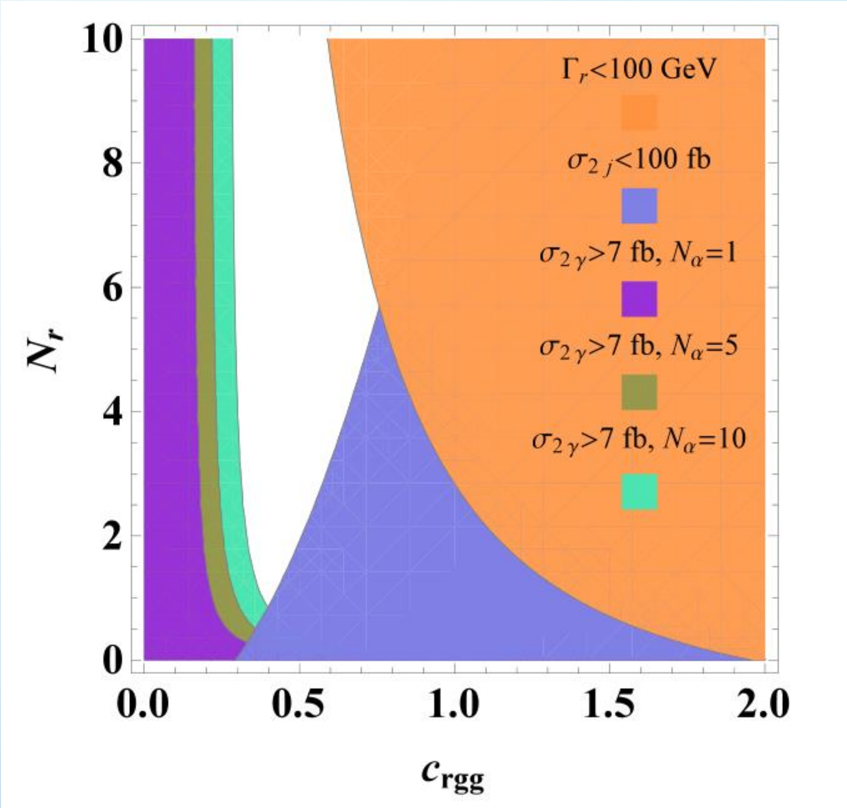
Parameter spaces satisfy the strict constraints

1. the basic constraints.
2. $\sigma_{\text{excess}}(pp \to r \to (\alpha \to aa)(\alpha \to \gamma\gamma)) \cong 10 \pm 3$ fb

	B1	B2	B3	B4	B5
c_{rgg}	[0.22, 0.30]	[0.38, 0.41]	[0.16, 0.22]	[0.28, 0.38]	[0.22, 0.30]
$c_{\alpha\gamma\gamma}$	[6.68, 8.63]	[2.85, 3.68]	[6.68, 8.63]	[2.85, 3.68]	[3.85, 4.98]

c_{rgg} varies from 0.2 to 0.4, *$c_{\alpha\gamma\gamma}$ only depends on N_α.*



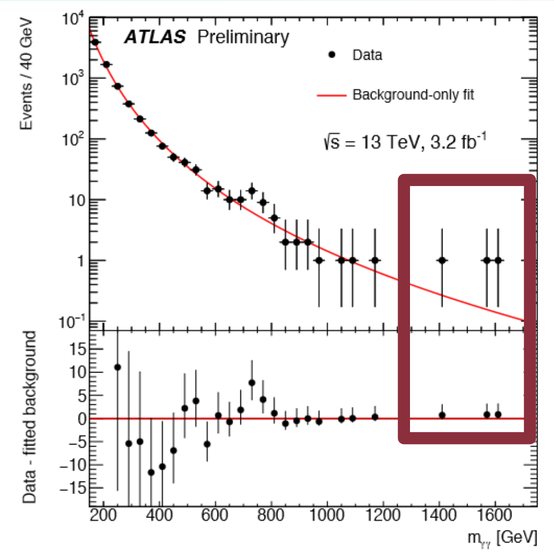


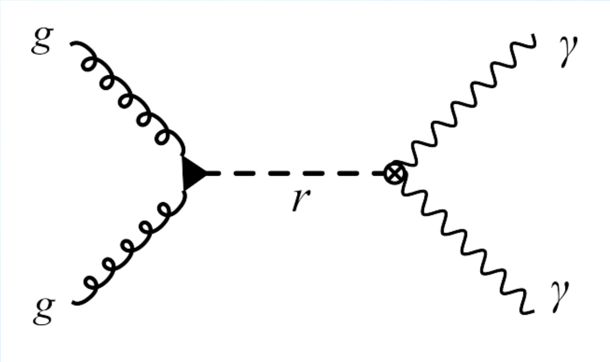
The colored band stand for $\sigma_{excess} < 7\ fb$

When c_{rgg} ↘,
N_r needs to ↗ and N_α needs to ↘.

When N_α is fixed, the excess only depend on the production of r

Our Prediction → Diphoton @ 1.6 TeV





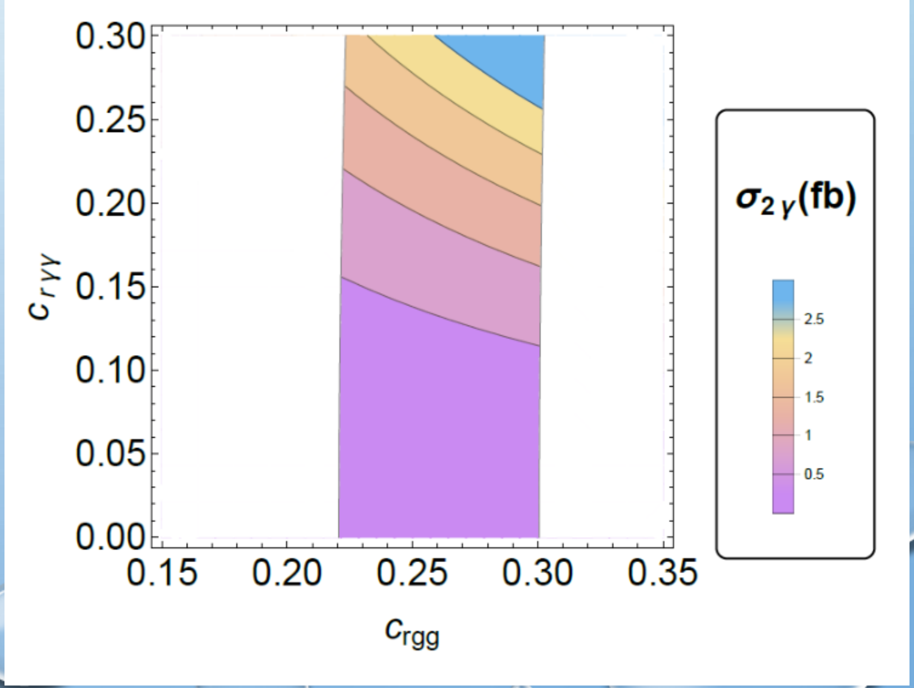
- Adding another effective operator

$$\delta\mathcal{L}_{eff} = \frac{c_{r\gamma\gamma}}{\Lambda_5} F_{\mu\nu}F^{\mu\nu} r$$

- In Exp, 1 event/40 GeV @3.2 fb^{-1}

So when taking benchmark point 5, and $c_{rgg} = 0.27, c_{r\gamma\gamma} = 0.18$

$$\sigma(gg \to r \to \gamma\gamma) \cong 1\, fb$$

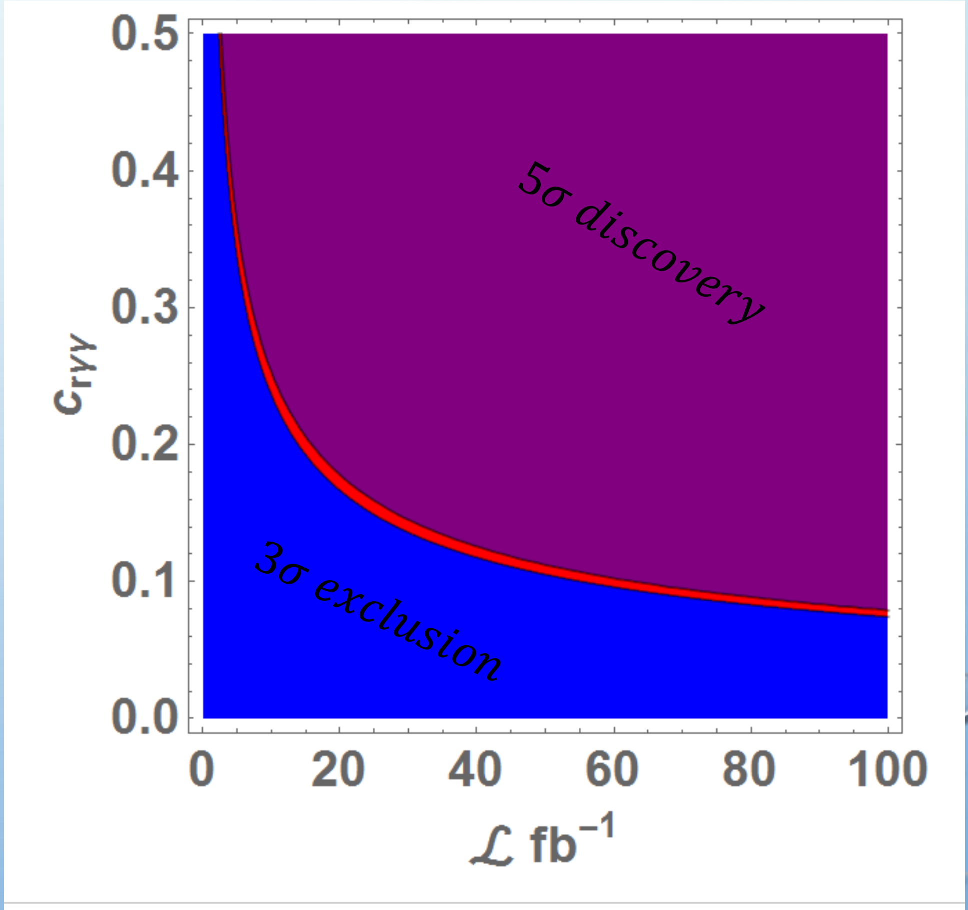


Our Prediction → Diphoton @ 1.6 TeV

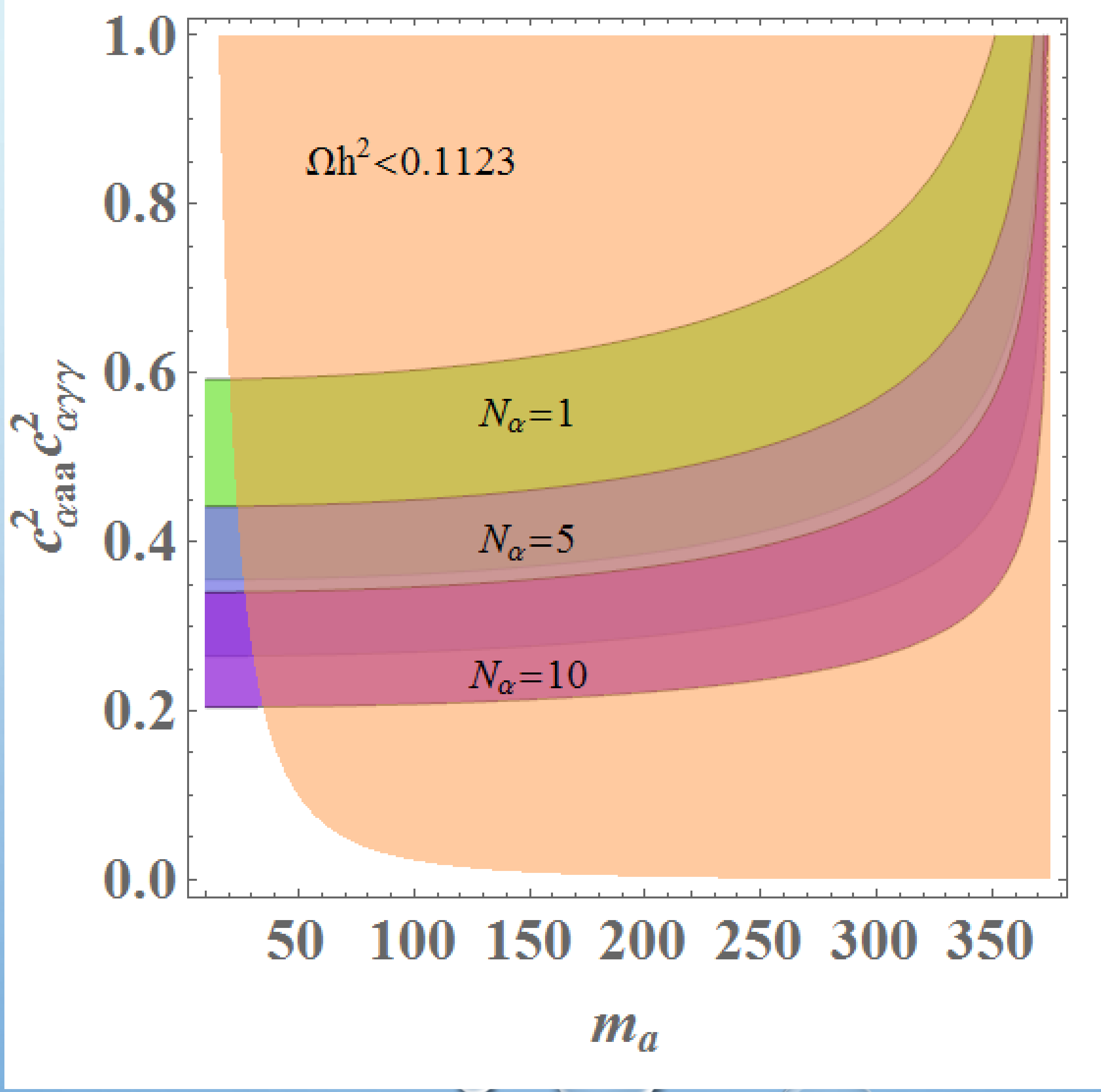
When $\mathrm{N}_r = 8$, $c_{rgg} = 0.27$,

The blue region → 3σ exclusion limits to $c_{r\gamma\gamma}$, when luminosity increasing.

The purple region → 5σ discovery sensitivities to $c_{r\gamma\gamma}$ coupling



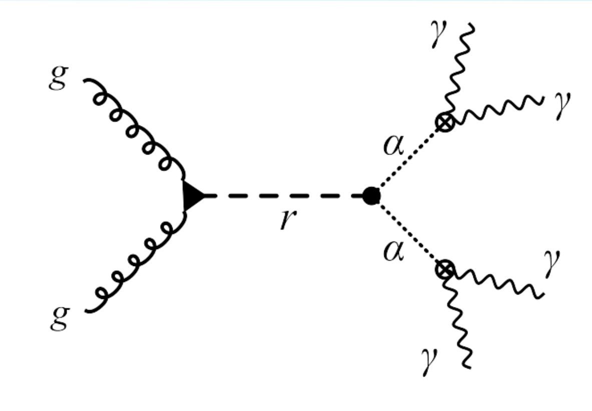
DM Relic Density



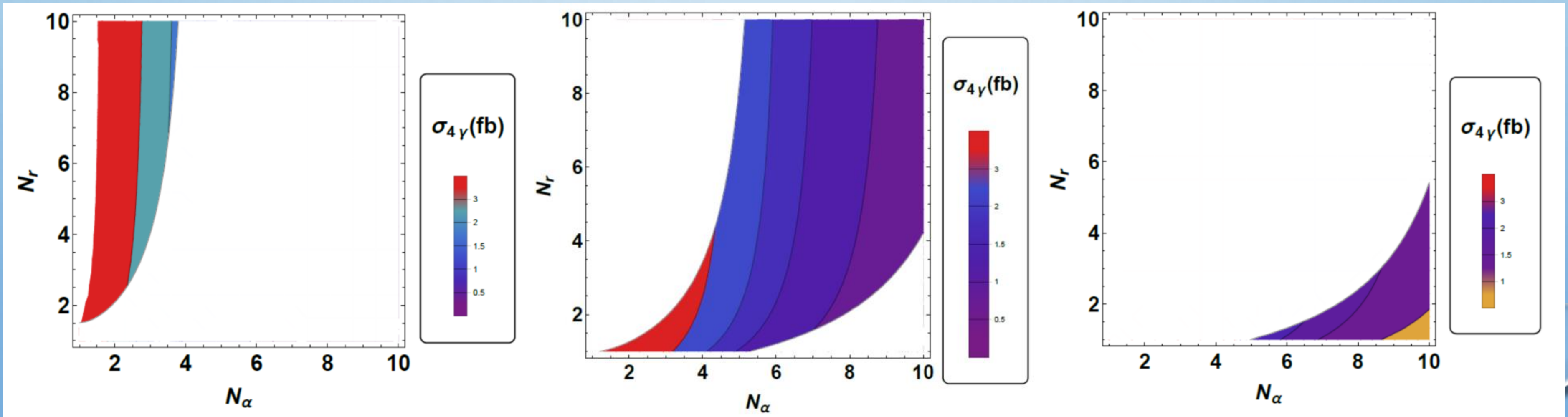
Our Prediction → Four Photons @ 1.6 TeV

The SM background is negligible
Can be tested directly at high luminosity LHC

$$\sigma_{4\gamma} \cong \frac{\sigma_{excess}}{N_\alpha} \cong \frac{10}{\mathrm{N}_\alpha} \ fb$$



Parameter spaces satisfy the strict constraints



$c_{rgg} = 0.2$ $c_{rgg} = 0.3$ $c_{rgg} = 0.4$

CONCLUSION

- Introduce two scalars α and r to explain 750 GeV diphoton excess and 1.6 TeV diphoton deviation from the background, simultaneously
- Compatible with current LHC Run I and Run II data
- Suggest a dark matter candidate a, which is compatible with the observed value of the relic density
- Predict 4 γ excess at 1.6 TeV, which can be tested at high luminosity LHC

Thanks for your attention!