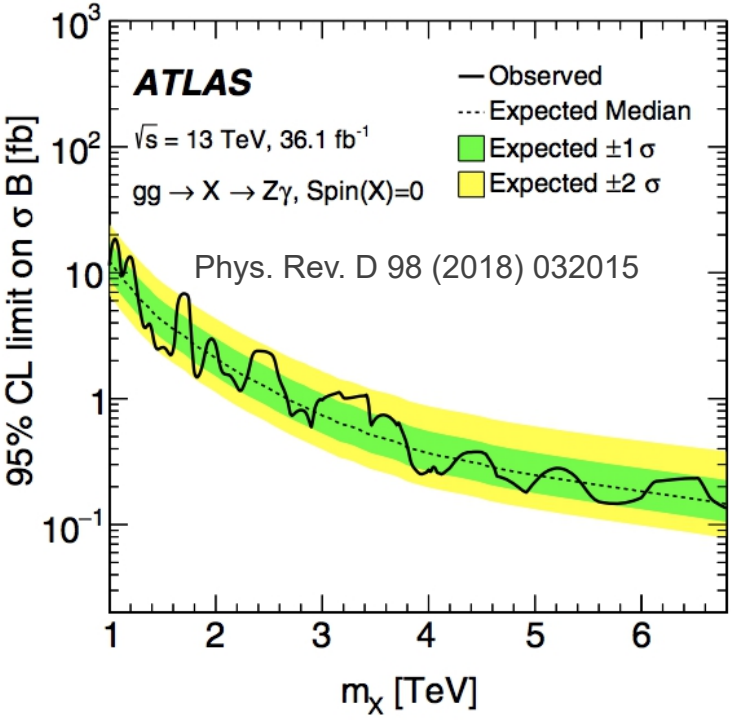
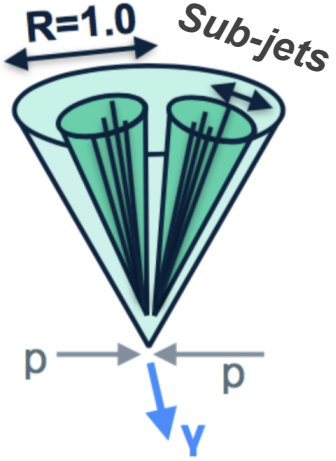
Search for heavy resonance decaying to an energetic photon and a W or Z boson in hadronic final state

Bo Liu
IHEP, CAS

Introduction

- Motivation: generic search for any BSM heavy resonance decaying to V+γ, where V decay hadronically
- Various signal hypotheses explored
  - spin=0/2 X→Z+γ
  - spin=1 X→W+γ





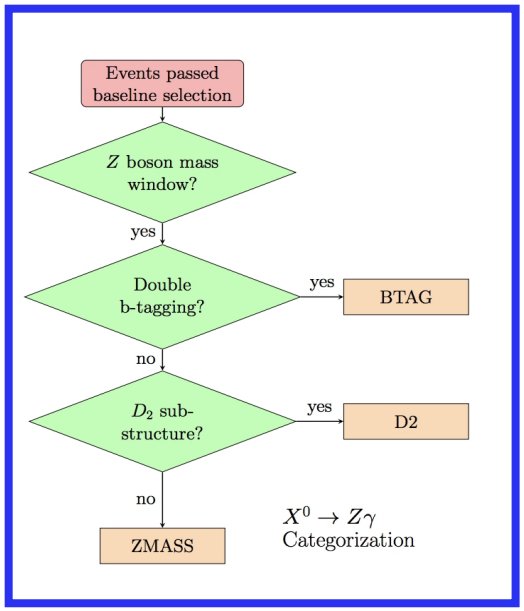
Physics objects:
1 high energy photon
1 large-Radius jet (fatjet)

- **Improvements:**
  - **Increase total luminosity to 139/fb**
  - **New fatjet definition, new subjet reconstruction method**
  - **Better W/Z boson tagger and b-tagger**
  - **Re-optimized selections**

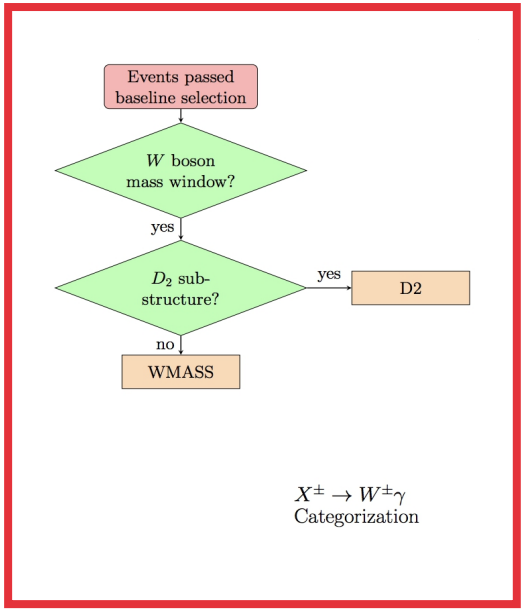
Event Selection and Categorization

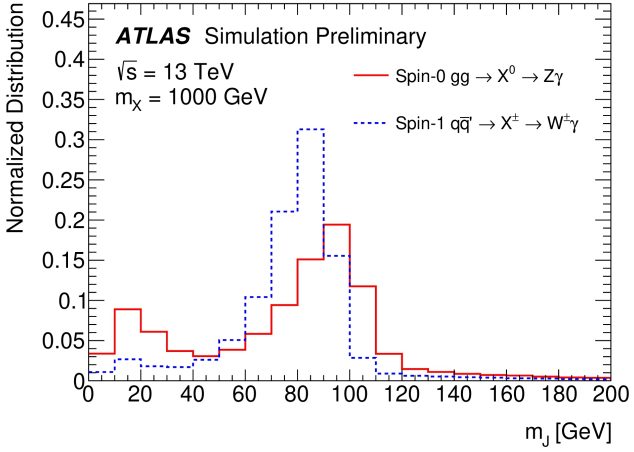
- **Baseline selection**
  - Trigger: photon with p_T>140 GeV
  - Tight-Isolated Photon: p_T>200 GeV, |η|<1.37
  - Large-R jet (**Antikt10 TCCjets**): p_T>200 GeV, |η|<2.0, removal overlap with photon
  - **VR subjet** reconstruction method for btagging
- **Categorization**
  - Boson tagger based on jet mass and D_2 and also subjet btagging information
  - Additional optimizations for pT of the photon and jet are performed for different categories

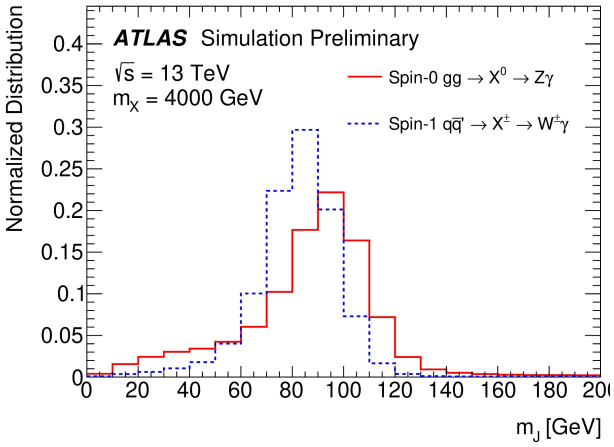
Zy channel

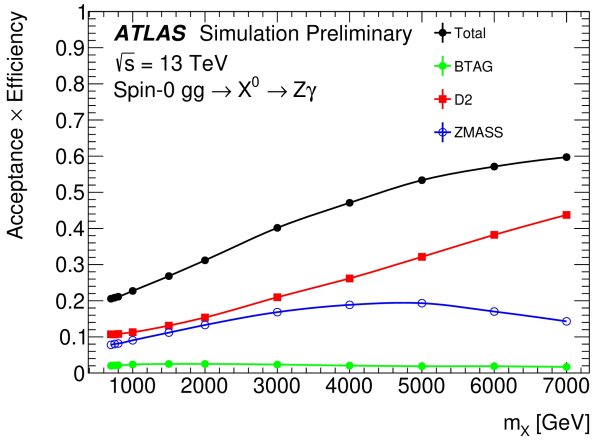


Wy channel









Signal and Backgrounds

- Double-sided Crystall ball function is used to parametrize signal shape

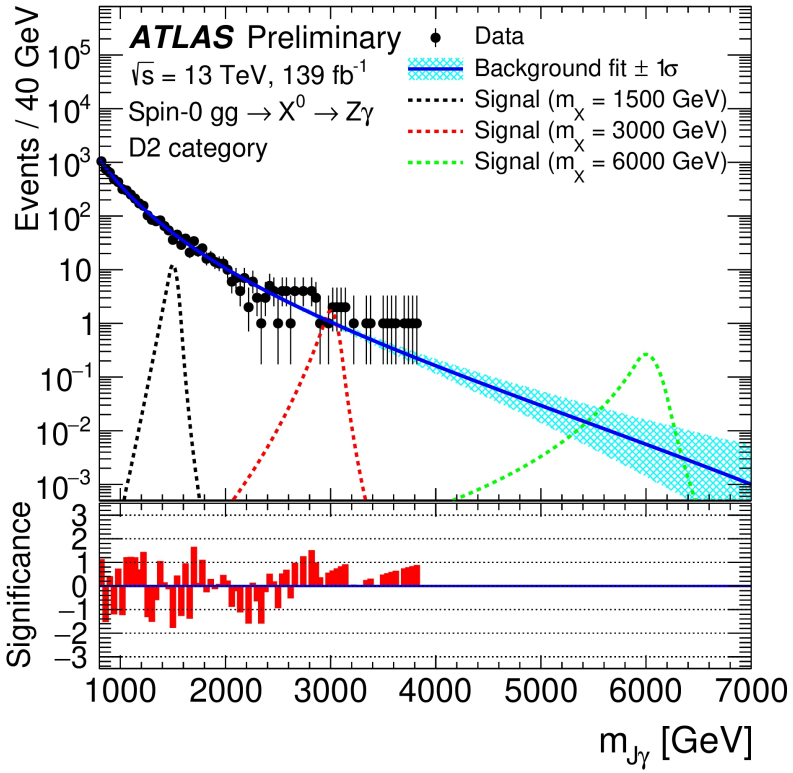
$$DSCB(m; N, \mu, \sigma, \alpha_1, n_1, \alpha_2, n_2) =$$

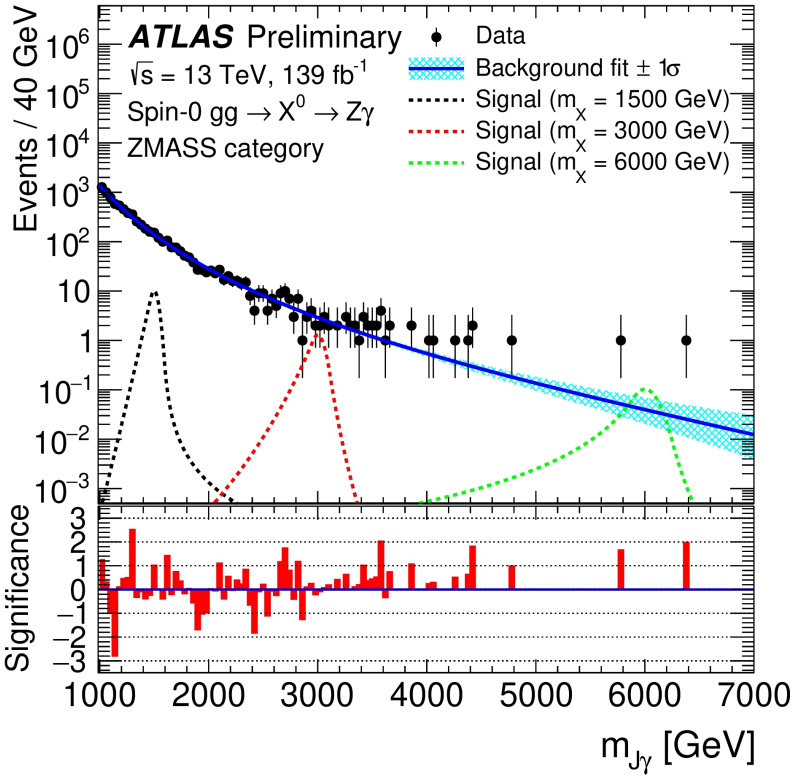
$$N \cdot \begin{cases} \left(\frac{n_1}{|\alpha_1|}\right)^{n_1} \exp\left(-\frac{|\alpha_1|^2}{2}\right)\left(\frac{n_1}{|\alpha_1|} - |\alpha_1| - \frac{m-\mu}{\sigma}\right)^{-n_1} & \frac{m-\mu}{\sigma} \le -\alpha_1 \\ \exp\left(-\frac{(m-\mu)^2}{2\sigma^2}\right) & -\alpha_1 < \frac{m-\mu}{\sigma} \le \alpha_2 \\ \left(\frac{n_2}{|\alpha_2|}\right)^{n_2} \exp\left(-\frac{|\alpha_2|^2}{2}\right)\left(\frac{n_2}{|\alpha_2|} - |\alpha_2| + \frac{m-\mu}{\sigma}\right)^{-n_2} & \alpha_2 < \frac{m-\mu}{\sigma} \end{cases}$$

- Modeling based on the ***dijet*** family of functions

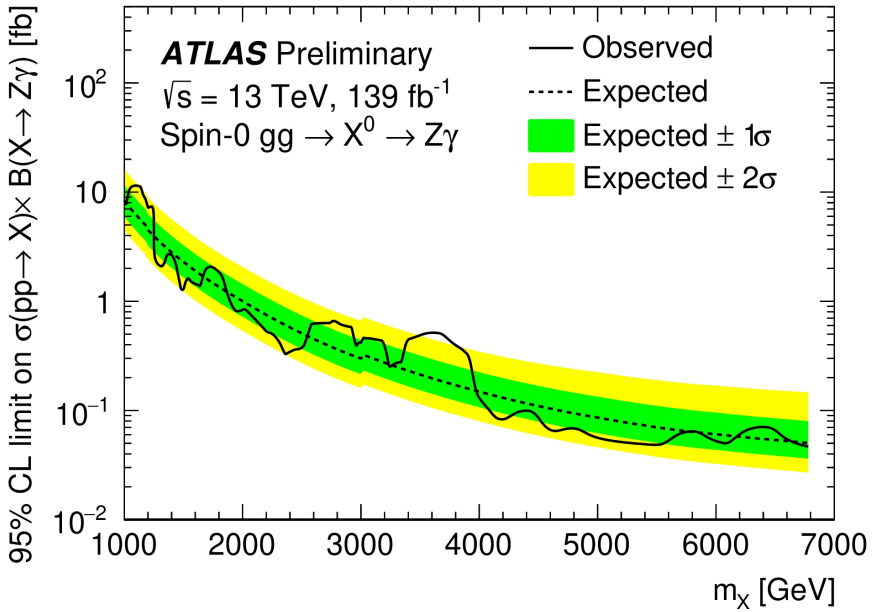
$$B(m_{J\gamma}; p_i) = (1-x)^{p_1} x^{p_2 + p_3 log(x) + p_4 log^2(x) + \dots},$$

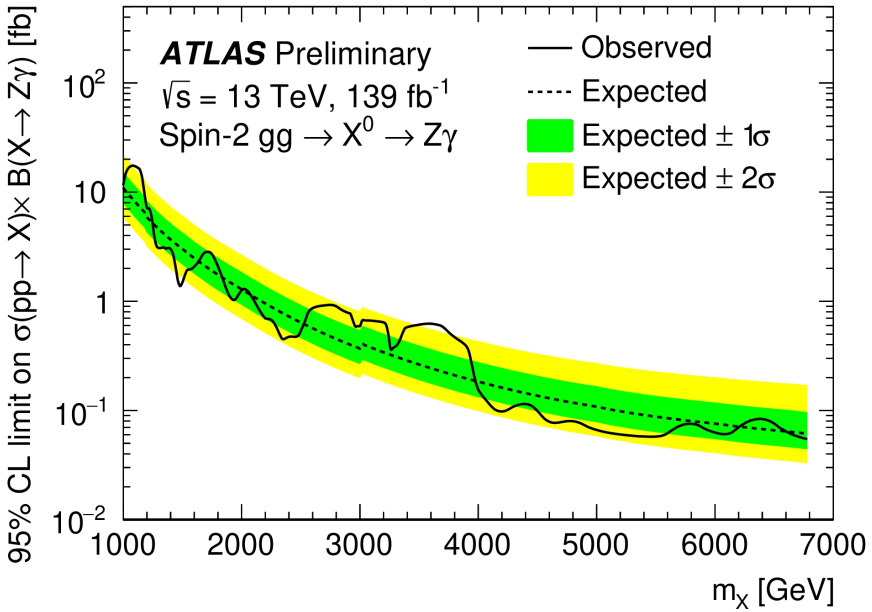
$$x = m_{J\gamma}/\sqrt{s},\ p_i, i = 1,2,3,\dots$$

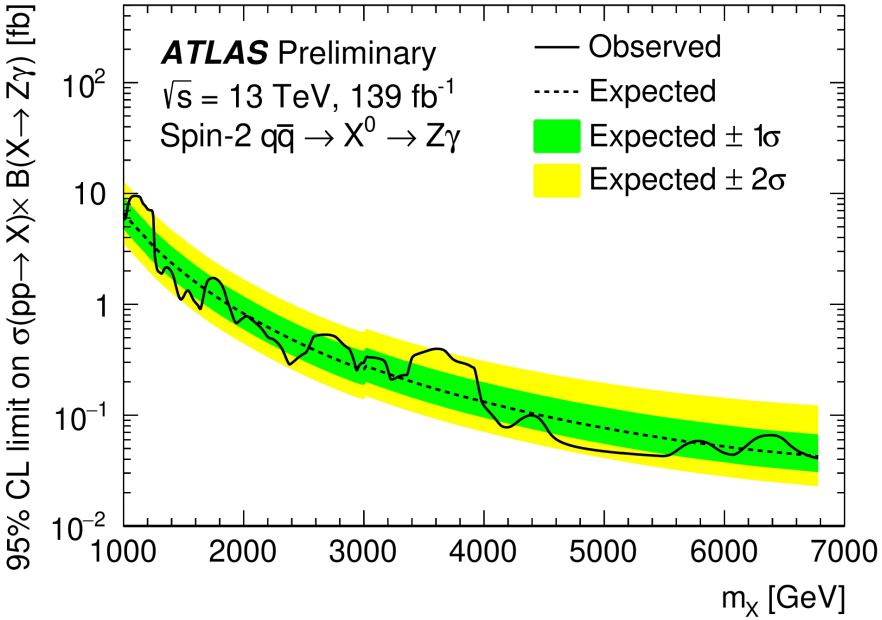


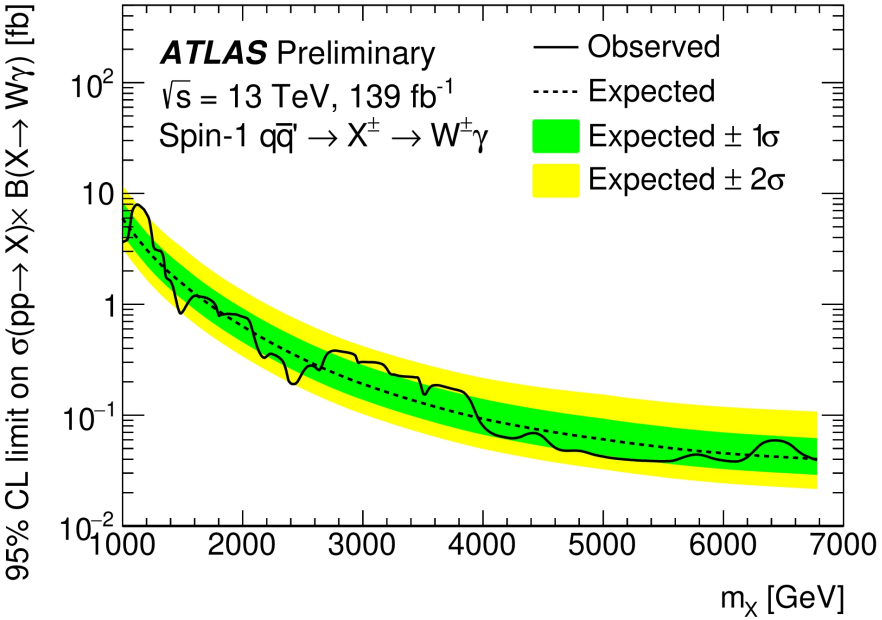


Results


ATLAS Preliminary
√s = 13 TeV, 139 fb-1
Spin-0 gg → X0 → Zγ
Observed
Expected
Expected ± 1σ
Expected ± 2σ
95% CL limit on σ(pp→ X)× B(X→ Zγ) [fb]
mX [GeV]


ATLAS Preliminary
√s = 13 TeV, 139 fb-1
Spin-2 gg → X0 → Zγ
Observed
Expected
Expected ± 1σ
Expected ± 2σ
95% CL limit on σ(pp→ X)× B(X→ Zγ) [fb]
mX [GeV]


ATLAS Preliminary
√s = 13 TeV, 139 fb-1
Spin-2 qq̄ → X0 → Zγ
Observed
Expected
Expected ± 1σ
Expected ± 2σ
95% CL limit on σ(pp→ X)× B(X→ Zγ) [fb]
mX [GeV]


ATLAS Preliminary
√s = 13 TeV, 139 fb-1
Spin-1 qq̄' → X± → W±γ
Observed
Expected
Expected ± 1σ
Expected ± 2σ
95% CL limit on σ(pp→ X)× B(X→ Wγ) [fb]
mX [GeV]

Summary

- **Search for resonance decaying to a Z/W boson and an energetic photon**
  - About 4x luminosity gain compared 36.5 fb^{-1}
  - Involved new techniques for both large-R jet and subjets reconstruction to improve the performance in high-pT
    - ✓ *TCC large-R jets have better substructure performance on high-pT region*
  - Optimize p_T selection for various resonance mass to improve sensitivity
  - Analytic functions for signal and background modelling
  - Analysis is unblinded
    - ✓ *No significant excess observed in mass distribution*
    - ✓ *Largest local significance is found below 3σ*

More detail: ATLAS-CONF-2021-041