Resonance search for new physics in the photon and jet final state at $\sqrt{s} = 13$ TeV

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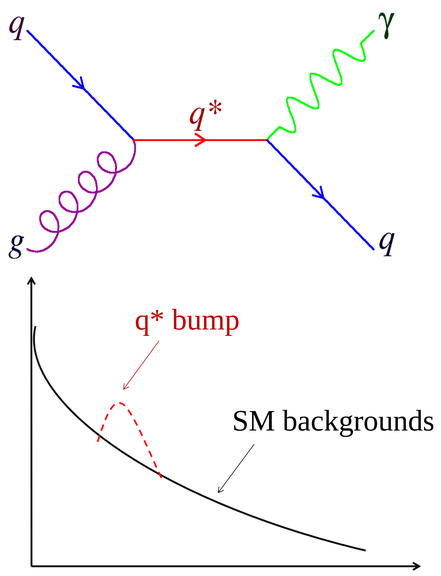
The poster presents a search for excited quarks (q*) decaying into a γ + jet final state in pp collisions at $\sqrt{s} = 13$ TeV. The search is done with the data taken by the CMS experiment[1] at the CERN LHC in 2015 corresponding to an integrated luminosity of 2.7 fb^{-1}. Results are presented in terms of 95% CL upper limits on cross section times branching fraction as a function of excited quark mass (M_{q^*}). Limits on excited quarks are presented as a function of their mass and coupling strength; masses below 4.37 TeV are excluded at 95% CL for coupling multipliers f=1.0.

Introduction

- Compositeness models: Possible explanation to mass hierarchy in quarks and leptons.
- Excited states → Signal of composite structure.
- The interaction of excited states with SM partners is given by the Lagrangian[2],

$$L_{int} = \frac{1}{2\Lambda}\,\bar{q}_R{}^{*}\,\sigma^{\mu\nu}\left[\sum_i g_i f_i T_i{}^{a} G_{i\mu\nu}{}^{a}\right] q_L + h.c.$$

- Λ – Compositeness scale.
- f_s, f, f' – Coupling multipliers to SU(3), SU(2) and U(1) gauge field-strength tensors.



What we expect?

Signal

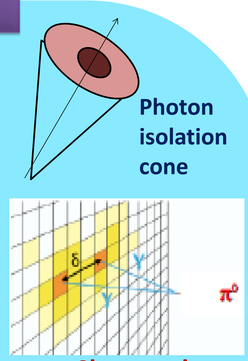
- ✓ Excited quarks ($q^* \rightarrow \gamma + jet$)
- ✓ Considered u* & d* only.
- ✓ Assumptions : Compositeness scale, $\Lambda = M_{q^*}$,
- ✓ $f_s = f = f'$
- ✓ Considered, f = 0.5 and 1.0 scenarios
- ✓ Excited quarks generated using LO Pythia6 event genertor.

Backgrounds

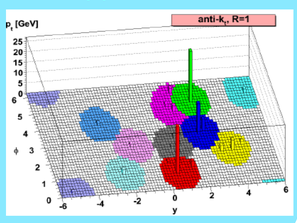
- ✘ SM γ + jet (Madgraph and NLO JetPHOX)
- ✘ Di-jet final state : jet faking photon (Pythia)
- ✘ γ + W/Z : W/Z decays to a pair of jets. (Madgraph)

Events we select

- $P_T{}^{\gamma} > 190$ GeV & $|\eta^{\gamma}| < 1.44$
- Photon identification & isolation:
  - H/E < 0.05
  - Energy weighted width, $\sigma_{i\eta i\eta} < 0.011$
  - Requirement on Σp_T of photons, charged and neutral hadrons around photon candidate.
- Anti-k_T (R = 0.4) Particle flow jets
- $\Delta R(\gamma, jet) > 0.5$
- $P_T{}^{jet} > 190$ GeV & $|\eta^{jet}| < 2.4$
- $M_{\gamma + jet} > 695$ GeV
- $\Delta\varphi(\gamma, jet) > 1.5$ & $\Delta\eta(\gamma, jet) < 1.8$

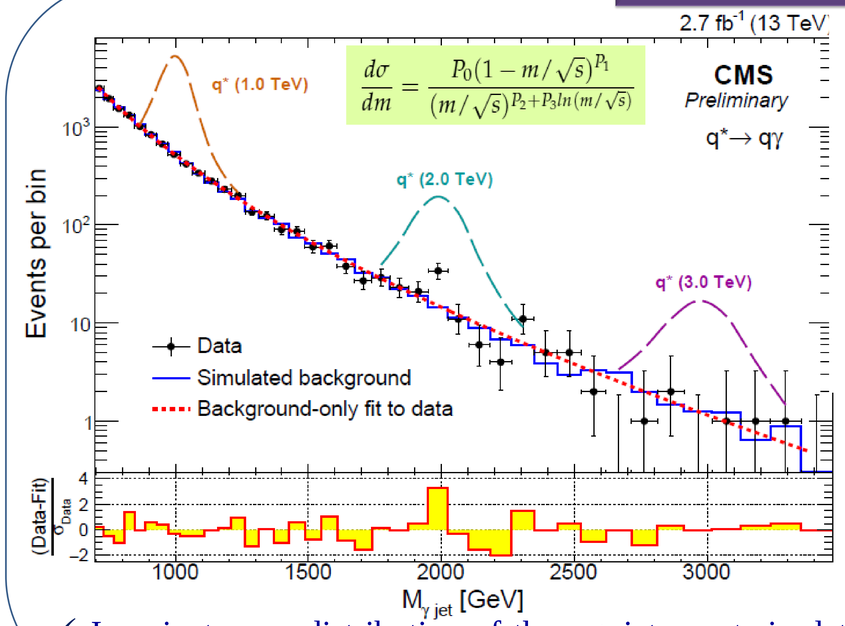


$\sigma_{i\eta i\eta}$, Shower shape

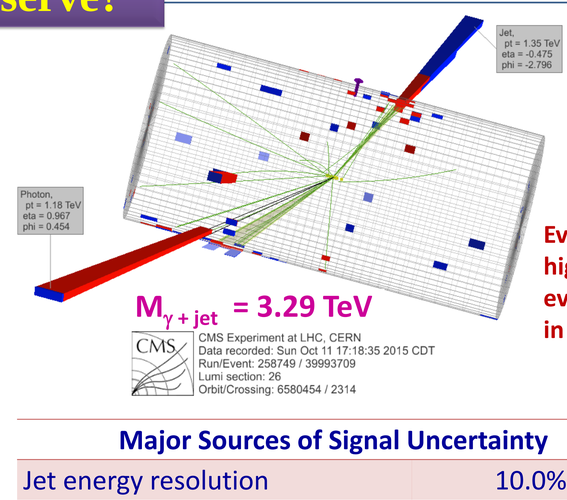


Anti-k_T jets in detector

What we observe?



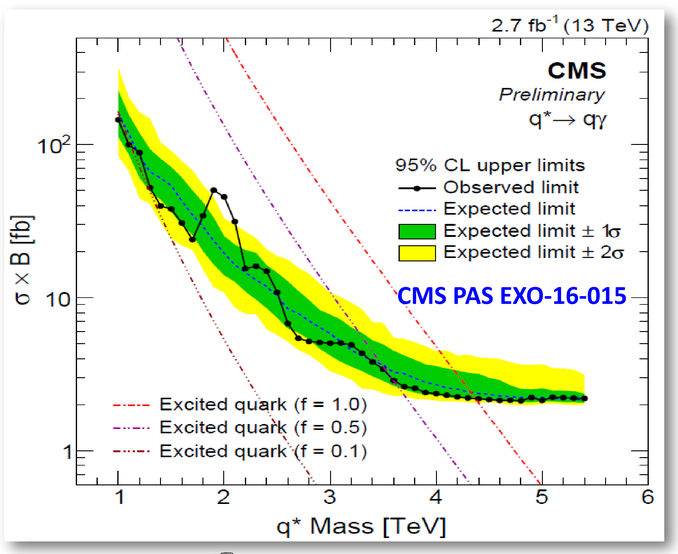
✓ Invariant mass distribution of the γ + jet events in data and comparison to MC simulations after final selection.

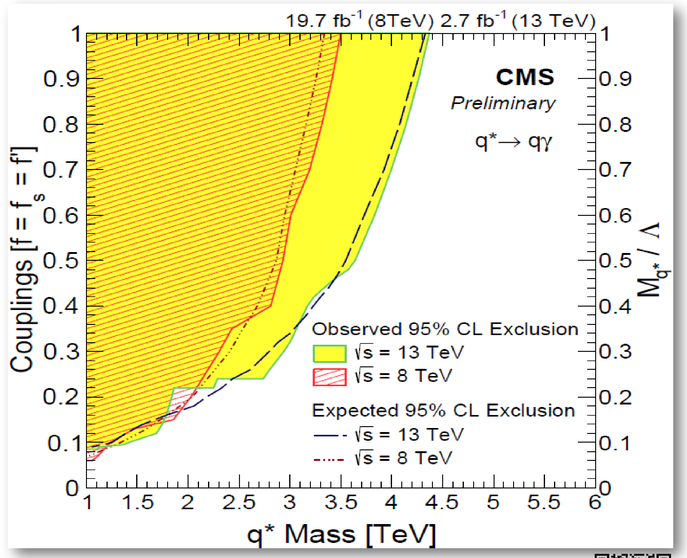


Event Display of highest mass event observed in data

Major Sources of Signal Uncertainty

Jet energy resolution	10.0%
Photon energy resolution	0.5%
Jet energy scale	0.5-0.8%
Photon energy scale	1.0%
Photon ID	2.0-4.0%
Luminosity	2.7%





Summary

- A search for q* decaying to a γ and jet is presented.
- Set 95% CL upper limits on σ × BR for $q^* \rightarrow \gamma + jet$.
- We exclude $1.0 < M_{q^*} < 4.37$ TeV for $f = 1.0$ and $1.0 < M_{q^*} < 1.36$ TeV for $f = 0.1$ at $\sqrt{s} = 13$ TeV with $\int L dt = 2.7\ fb^{-1}$.
- Present exclusion at 95% CL as function of coupling strength and q* mass.

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[1] JINST 3 (2008) S08004 | [2] CMS PAS EXO-16-015