Search for Hadronic Resonances at CMS

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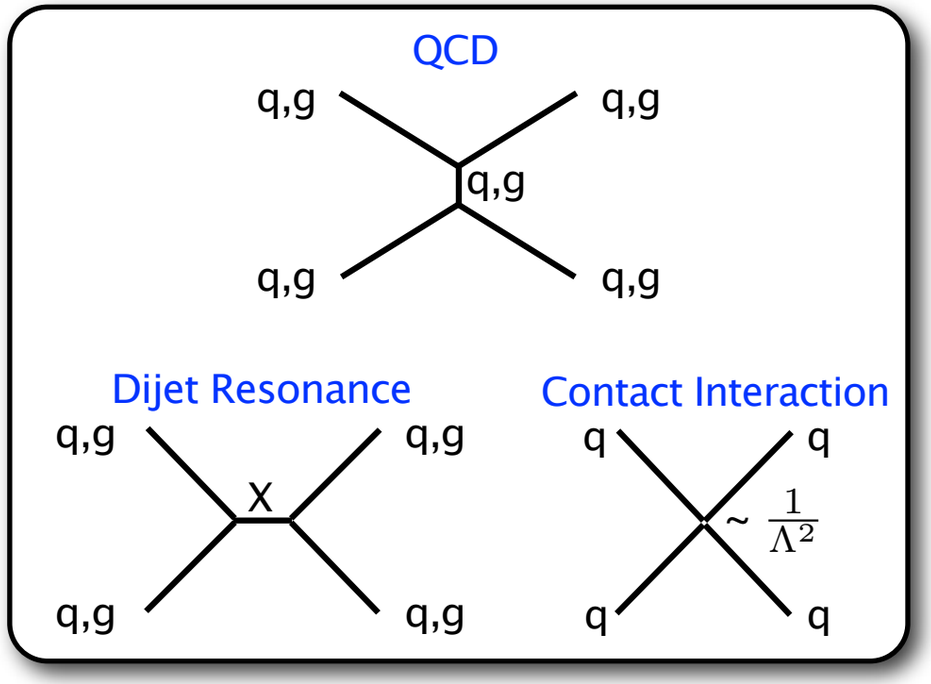
on behalf of the CMS Collaboration

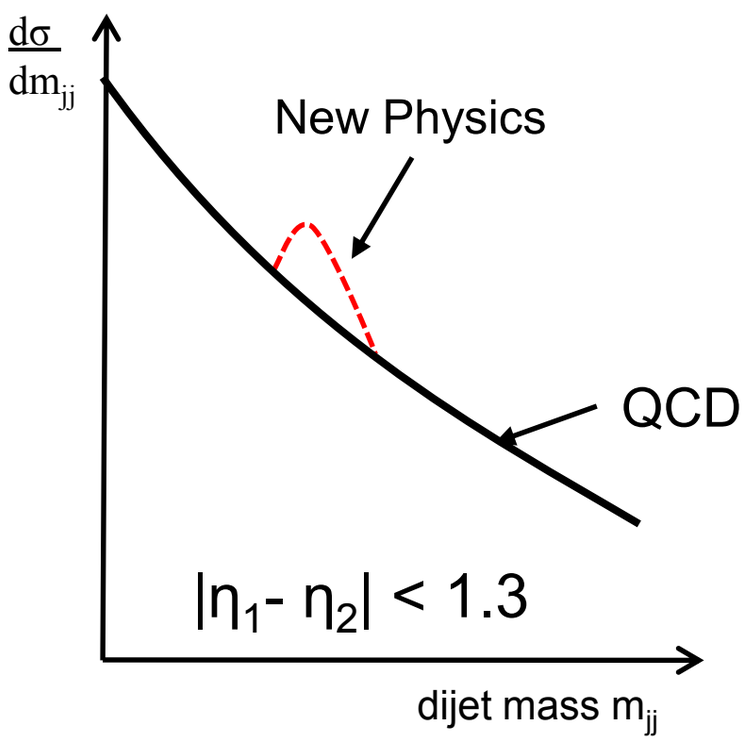
Outline

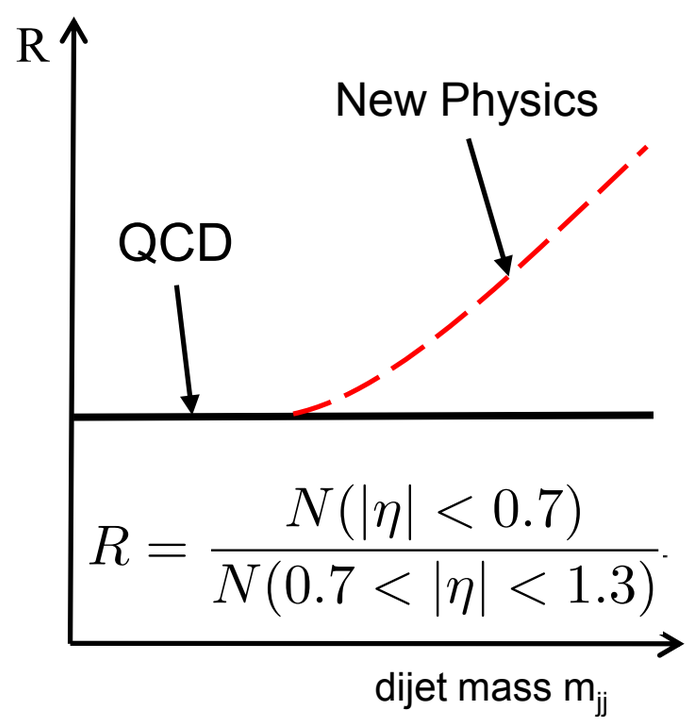
- ☑ Motivation
- ☑ The CMS Detector and Jet Reconstruction
- ☑ Dijet
  - ✓ Dijet Resonances
  - ✓ Dijet Centrality Ratio
  - ✓ Dijet Angular Distribution
- ☑ Multijet
- ☑ t-tbar
- ☑ Conclusion

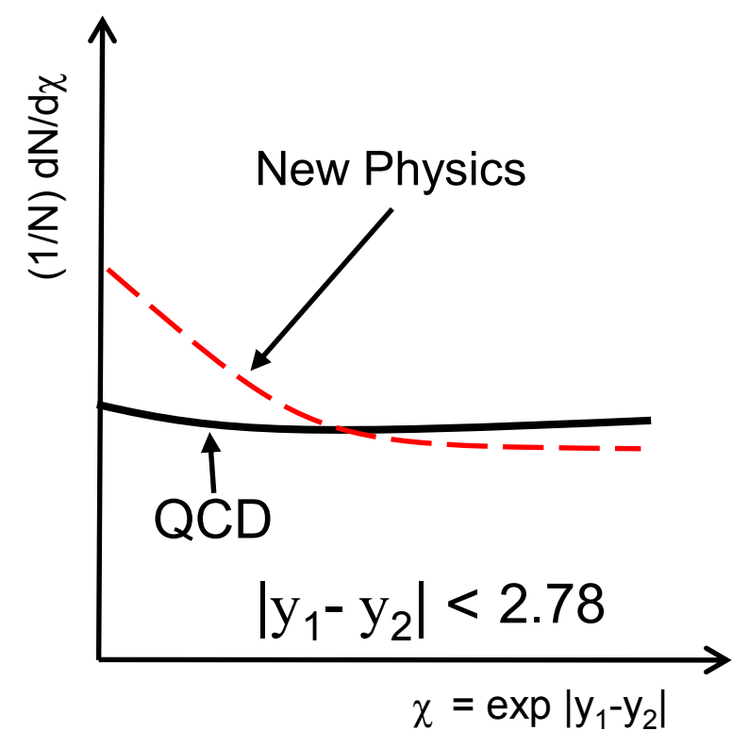
Motivation

- We search for new physics in hadronic final states.
- Dijet resonance in dijet mass (bump hunting).
  - ✓ String resonances, q*, axigluon, ...
- Dijet centrality ratio and Dijet angular distribution
  - ✓ Contact interaction.
  - ✓ Dijet centrality ratio also can confirm that a *"bump"* is not QCD fluctuation.
- In addition: RPV gluino in multijet channel and Z' in t-tbar channel.

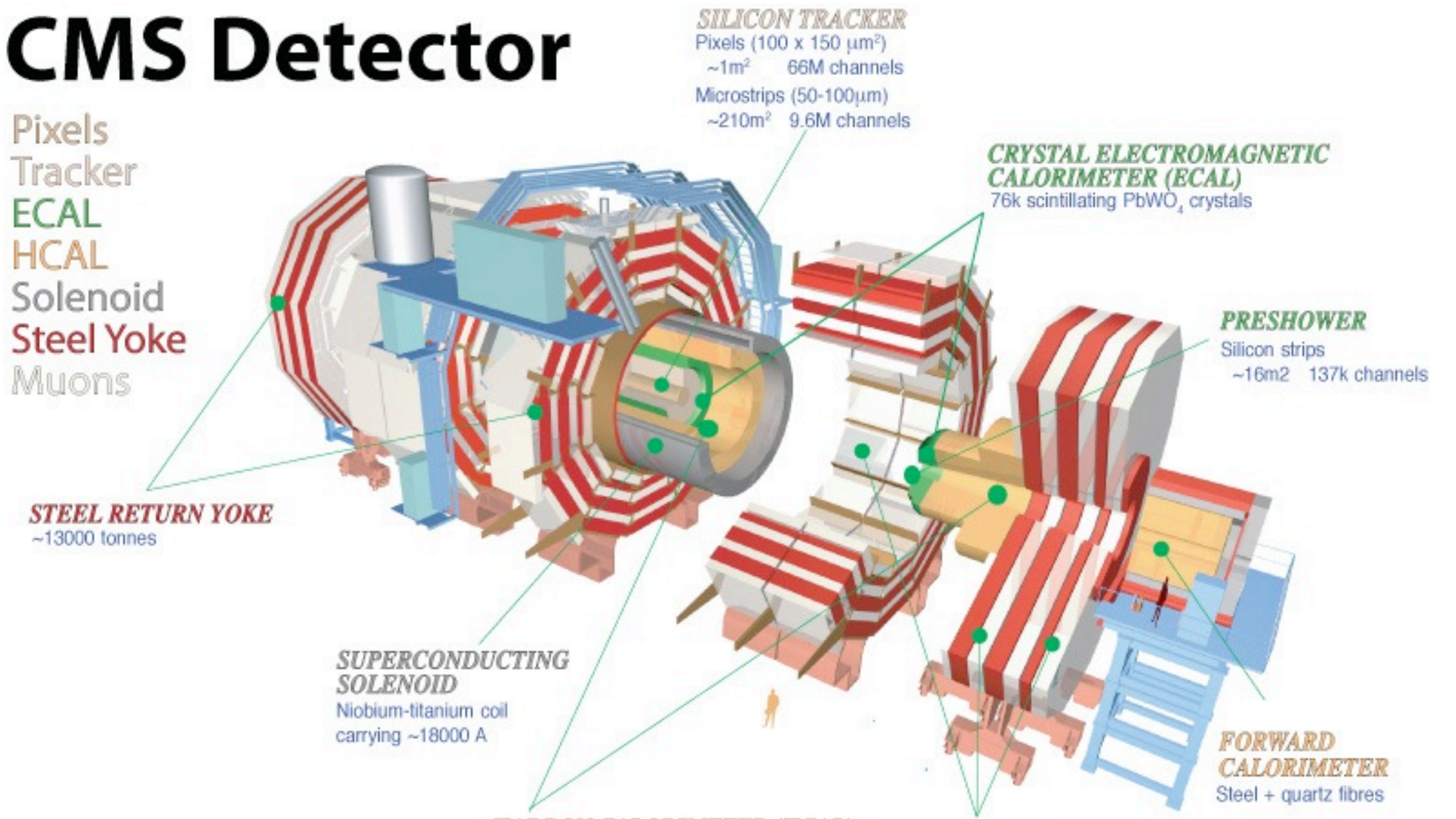






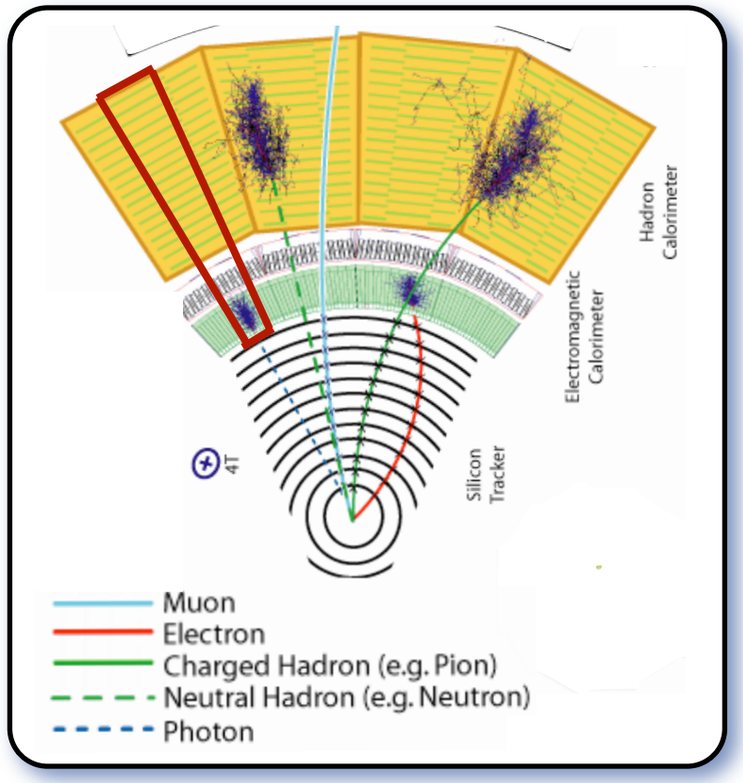


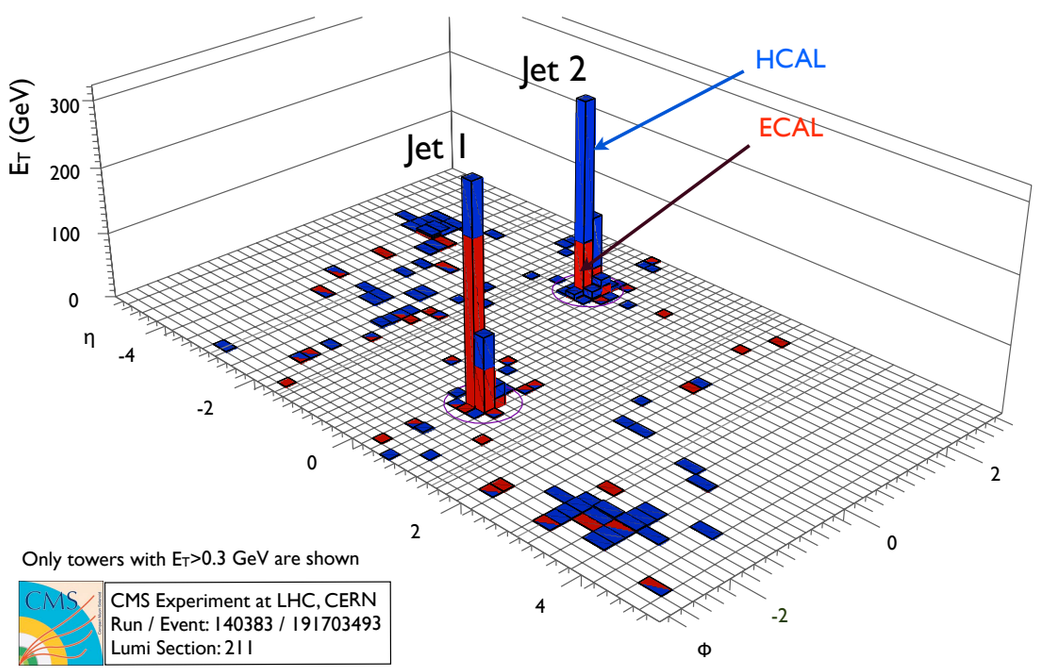
The CMS Detector



Total weight	: 14000 tonnes
Overall diameter	: 15.0 m
Overall length	: 28.7 m
Magnetic field	: 3.8 T

Jet Reconstruction



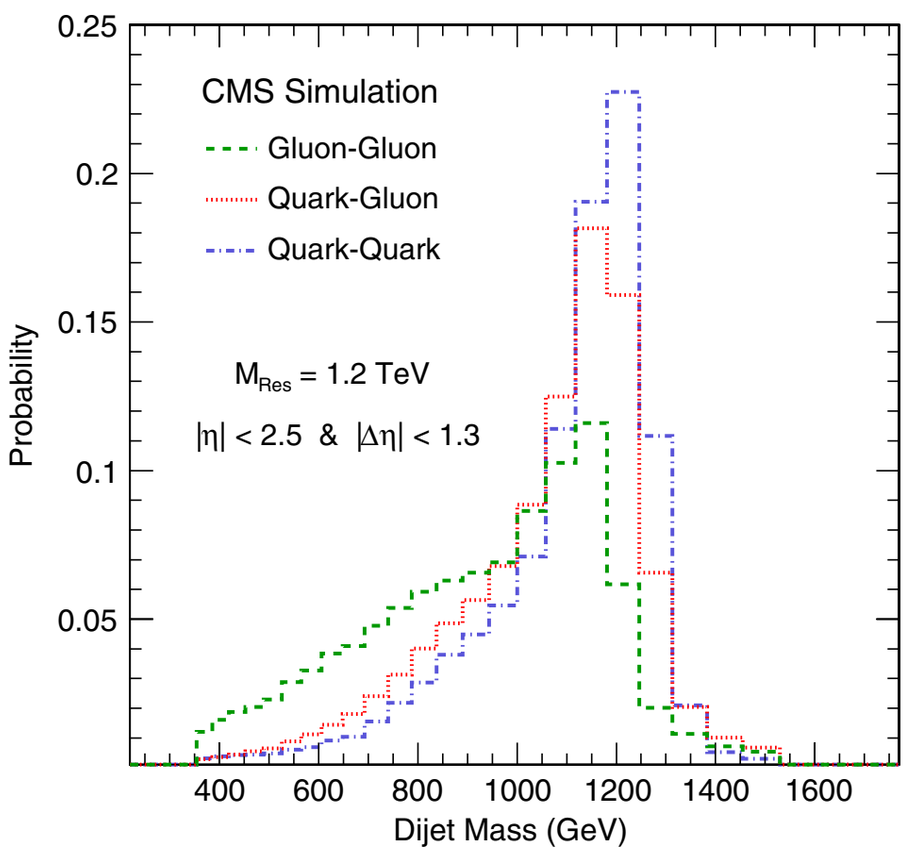


- Jet types:
  - ✓ Calorimeter Jets: reconstructed from energy deposits in the hadronic and electromagnetic calorimeters, grouped in projective calo towers.
  - ✓ Particle Flow (PF) Jets: Use all detector elements to reconstruct particles, then cluster to jets.
- Anti-kt clustering algorithm with cone size of 0.5 and 0.7.
  - ✓ infrared and collinear safe.
- Jet energy corrections are determined either by using MC truth information or by employing data driven techniques.
  - ✓ Uncertainty on Jet energy scale is less than 5% .

Dijet Resonances Models

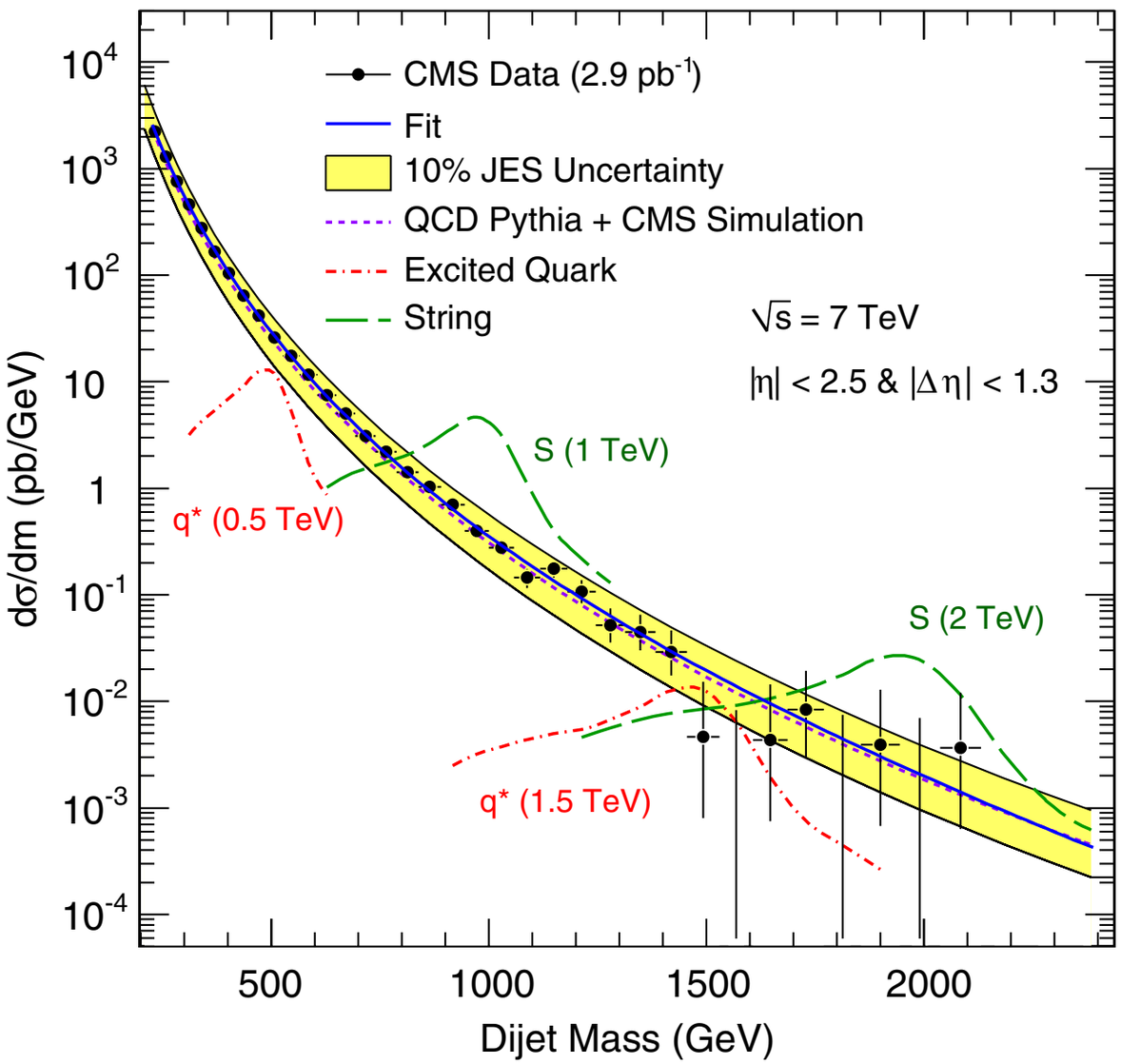
- Parton resonances decaying to dijets are predicted by various models:

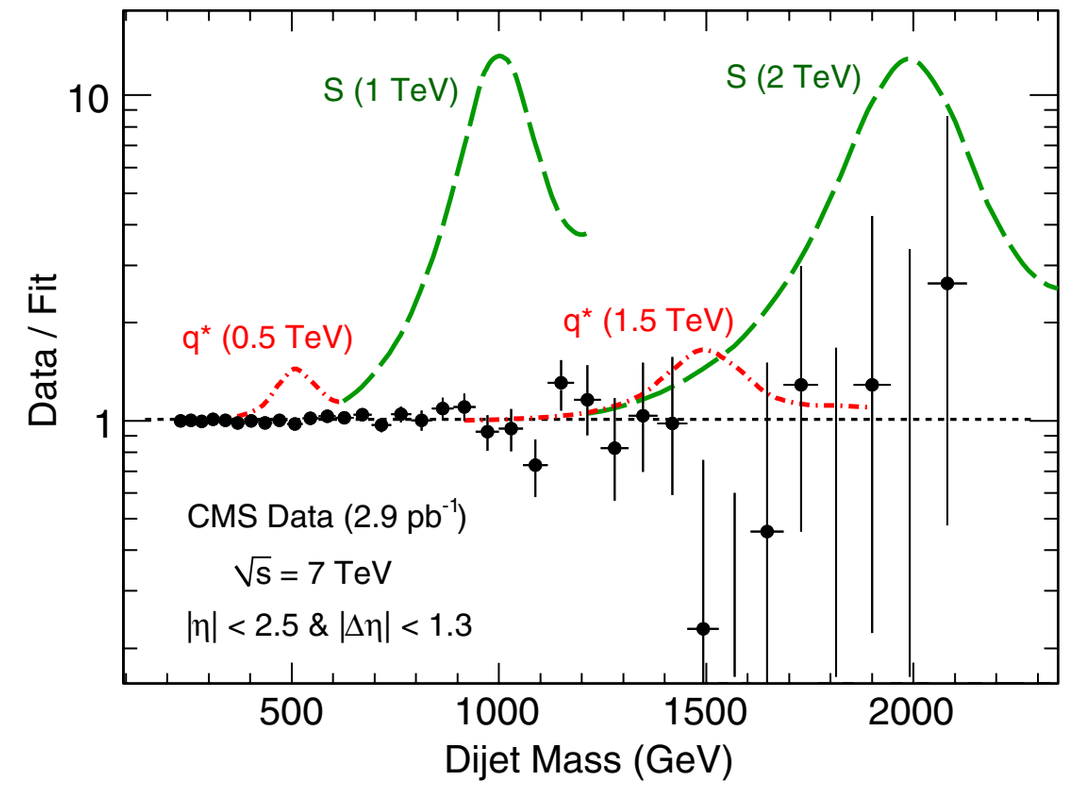
Model Name	X	Color	J^P	$\Gamma/(2M)$	Final-state Partons
String	S	mixed	mixed	0.003-0.037	qq, gg and qg
Axigluon	A	Octet	1^+	0.05	$q\bar{q}$
Coloron	C	Octet	1^-	0.05	$q\bar{q}$
Excited Quark	q*	Triplet	$1/2^+$	0.02	qg
E_6 Diquark	D	Triplet	0^+	0.004	qq
RS Graviton	G	Singlet	2^+	0.01	$q\bar{q}$, gg
Heavy W	W′	Singlet	1^-	0.01	$q\bar{q}$
Heavy Z	Z′	Singlet	1^-	0.01	$q\bar{q}$



- We searched for 3 generic types of narrow dijet resonances in the data.
  - ✓ qq, qg and gg resonances
  - ✓ differences mainly due to FSR.
  - ✓ Gaussian core of dijet mass resolution for qg resonances varies from 11% at 0.5 TeV to 6% at 2.5 TeV

Dijet Resonances Search

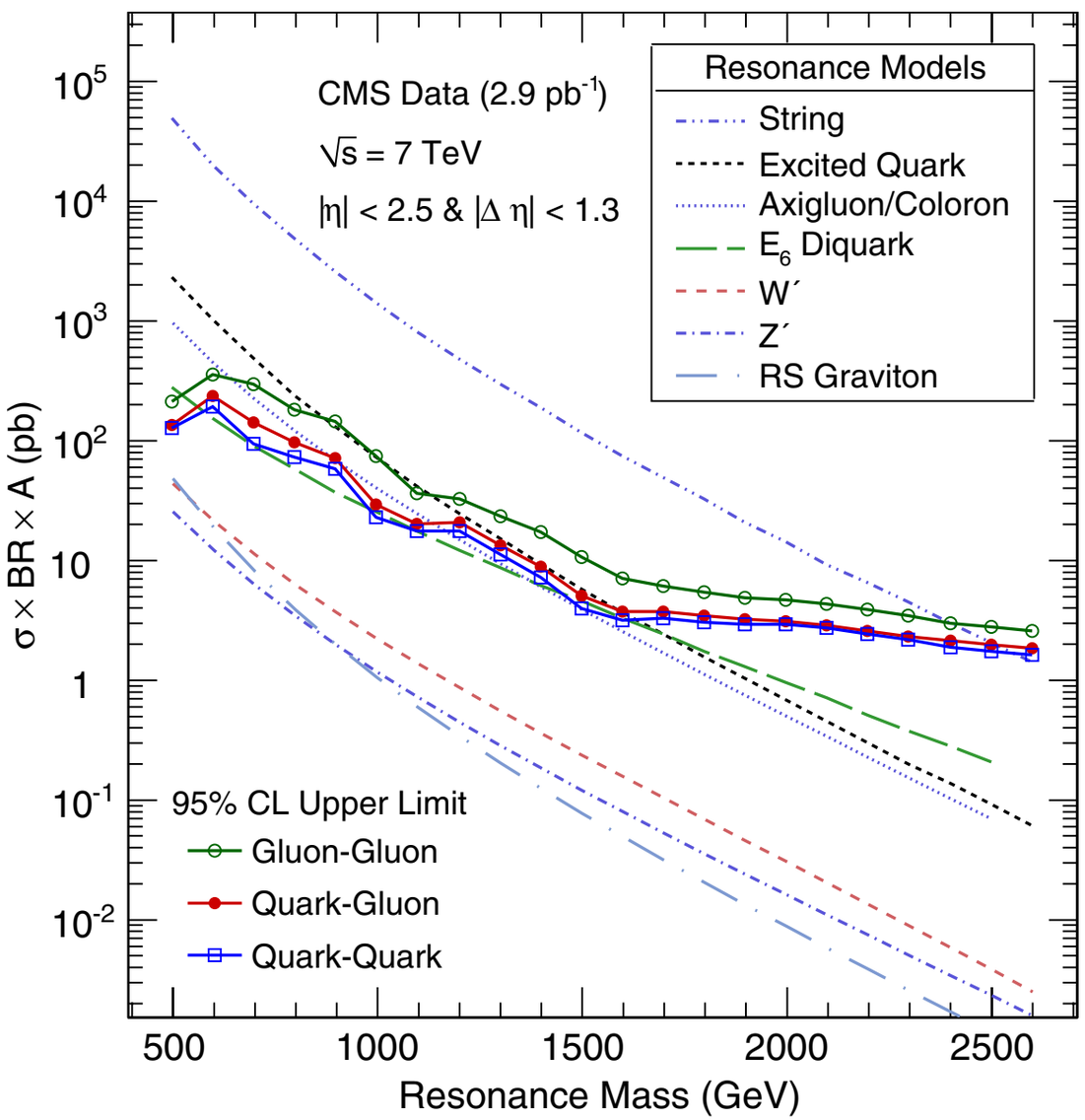




$$\frac{d\sigma}{dm} = p_0 \frac{(1-X)^{p_1}}{X^{p_2+p_3\ln(X)}} \qquad x = m_{jj}/\sqrt{s}$$

- Good fit ($\chi 2/ndf = 32/31$) with 4 parameter function.
- The data is in good agreement with the full CMS simulation of QCD from PYTHIA.
- No indication of new physics.

Dijet Resonance Limits



Phys. Rev. Lett. 105, 211801, 2010

- We have **generic, cross-section upper limits** on quark-quark, quark-gluon and gluon- gluon resonances.
- Observed Bayesian(*) limit at 95% CL.

String Resonances

- ✓ **0.50<M(S)<2.50 TeV**
  - ➡ M(S)<1.40 from CDF (1 fb^{-1})

Excited Quark

- ✓ **0.50<M(q*)<1.58 TeV**
  - ➡ 0.60<M(q*)<2.15 from ATLAS (36 pb^{-1})

Axigluon / Coloron

- ✓ **0.50<M(A)<1.17 TeV & 1.47<M(A)<1.52 TeV**
  - ➡ 0.12<M(A)<2.60 TeV from ATLAS (36 pb^{-1})

E6 Diquark

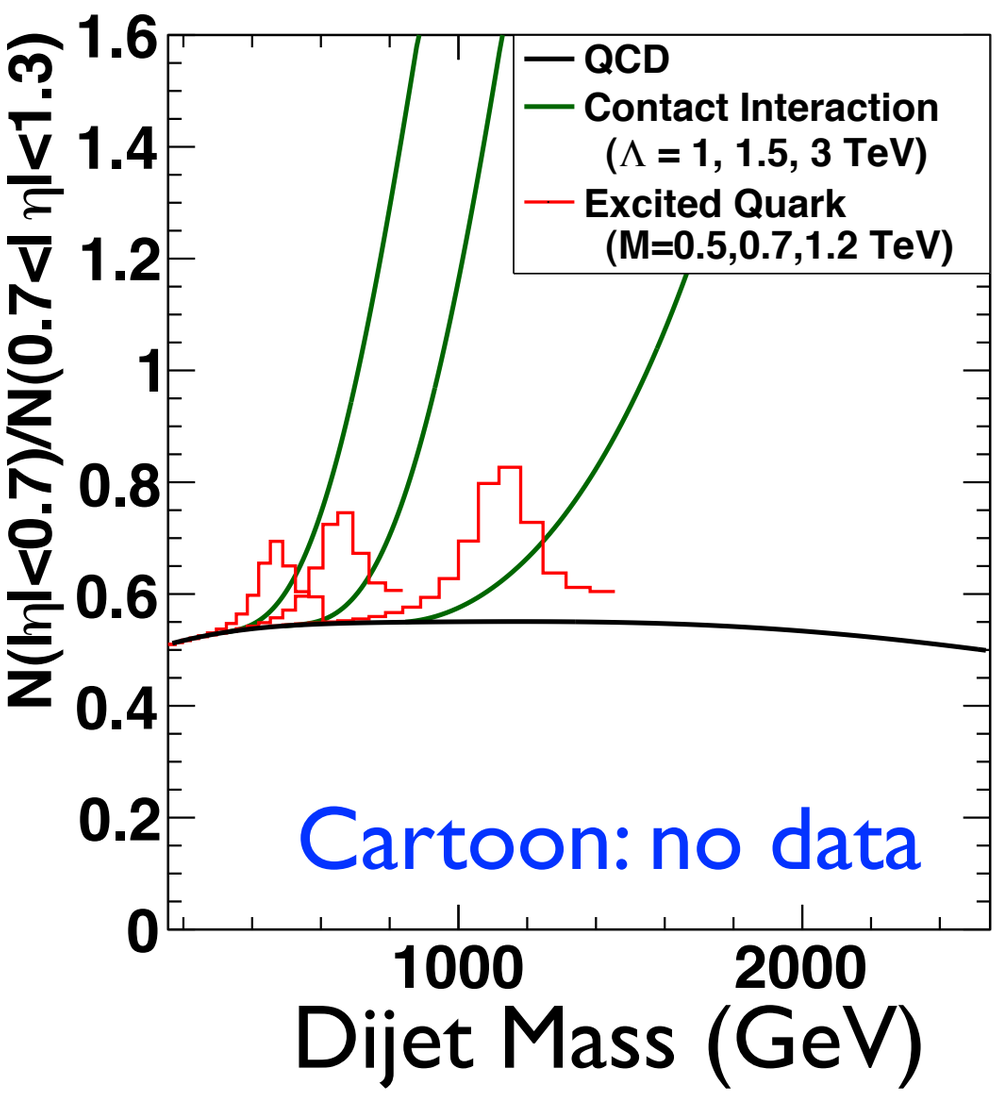
- ✓ **0.50<M(D)<0.58 TeV & 0.97<M(D)<1.08 TeV & 1.45<M(D)<1.60 TeV**
  - ➡ 0.29<M(D)<0.63 TeV from CDF (1 fb^{-1})

(*) with flat prior in signal strength.

Dijet Centrality Ratio

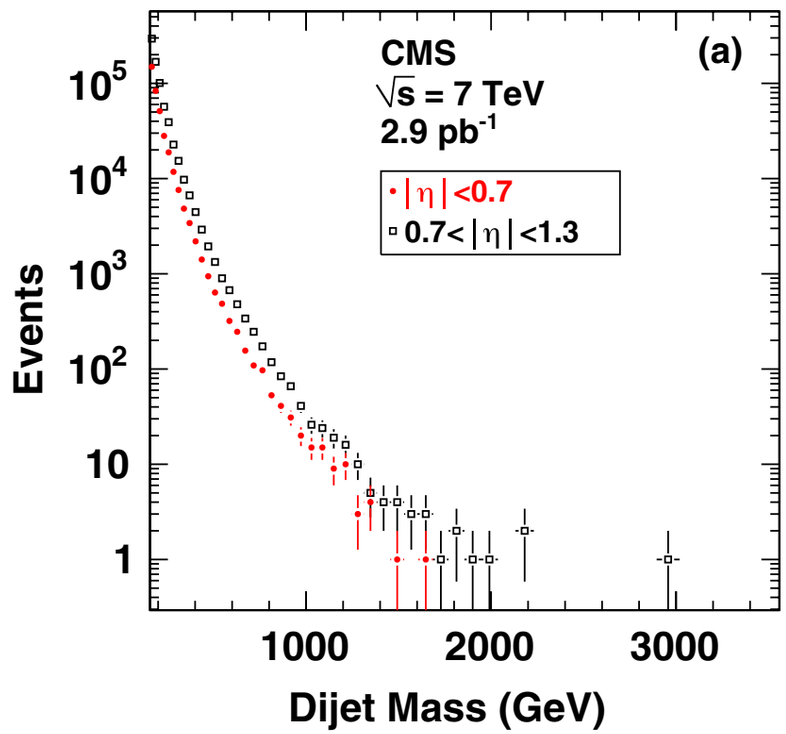
$$R = \frac{N(|\eta| < 0.7)}{N(0.7 < |\eta| < 1.3)} = \frac{N(\text{inner})^{*}}{N(\text{outer})}$$

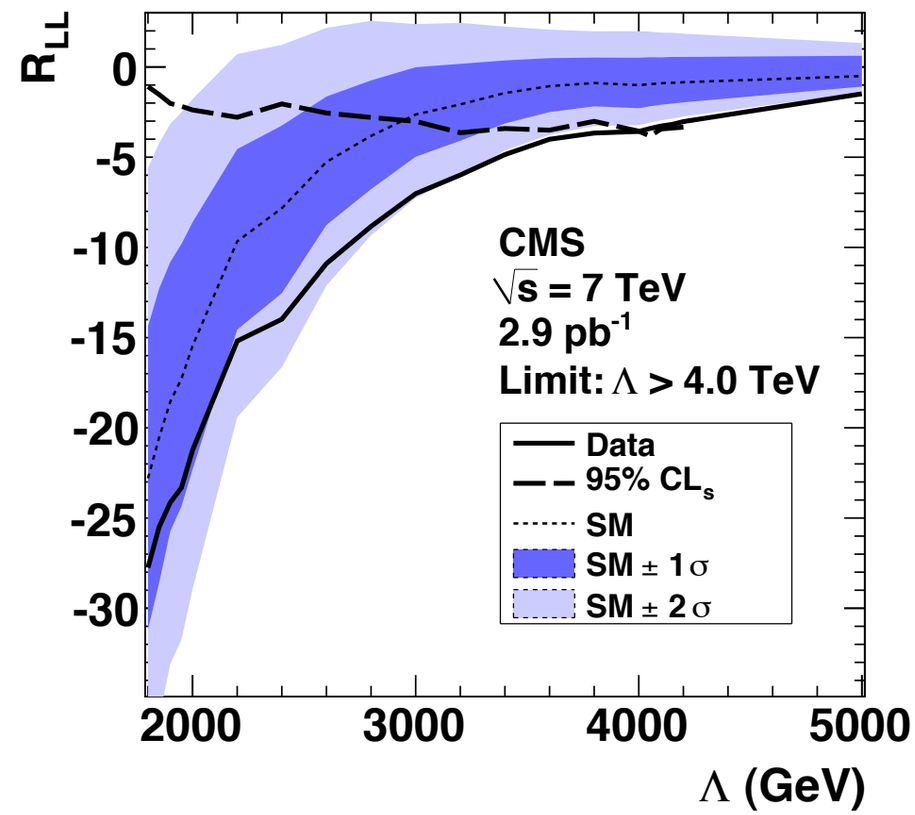
*Both jets inner or outer.

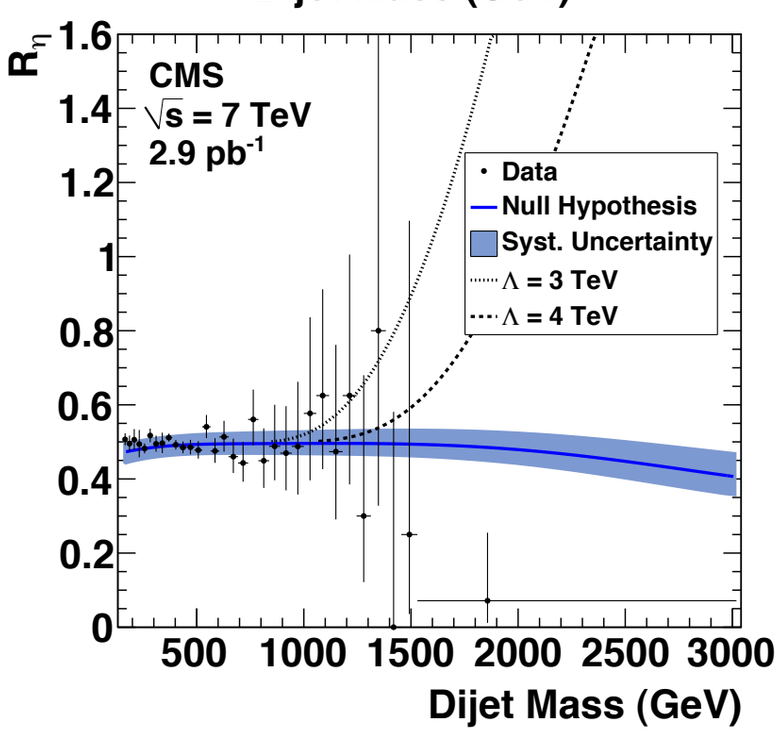


- Quantifies the centrality of the dijet angular distribution at a given dijet mass.
  - both leading jets are required to lie in the same η range.
- Important experimental uncertainties cancel because of the ratio (absolute jet energy scale, luminosity).
- "t-channel" scattering for QCD vs "s-channel" for most new Physics models
  - roughly flat vs dijet mass for QCD.
  - rises vs dijet mass for contact interactions.
  - "bumps" in dijet mass for dijet resonances.

Dijet Centrality Ratio



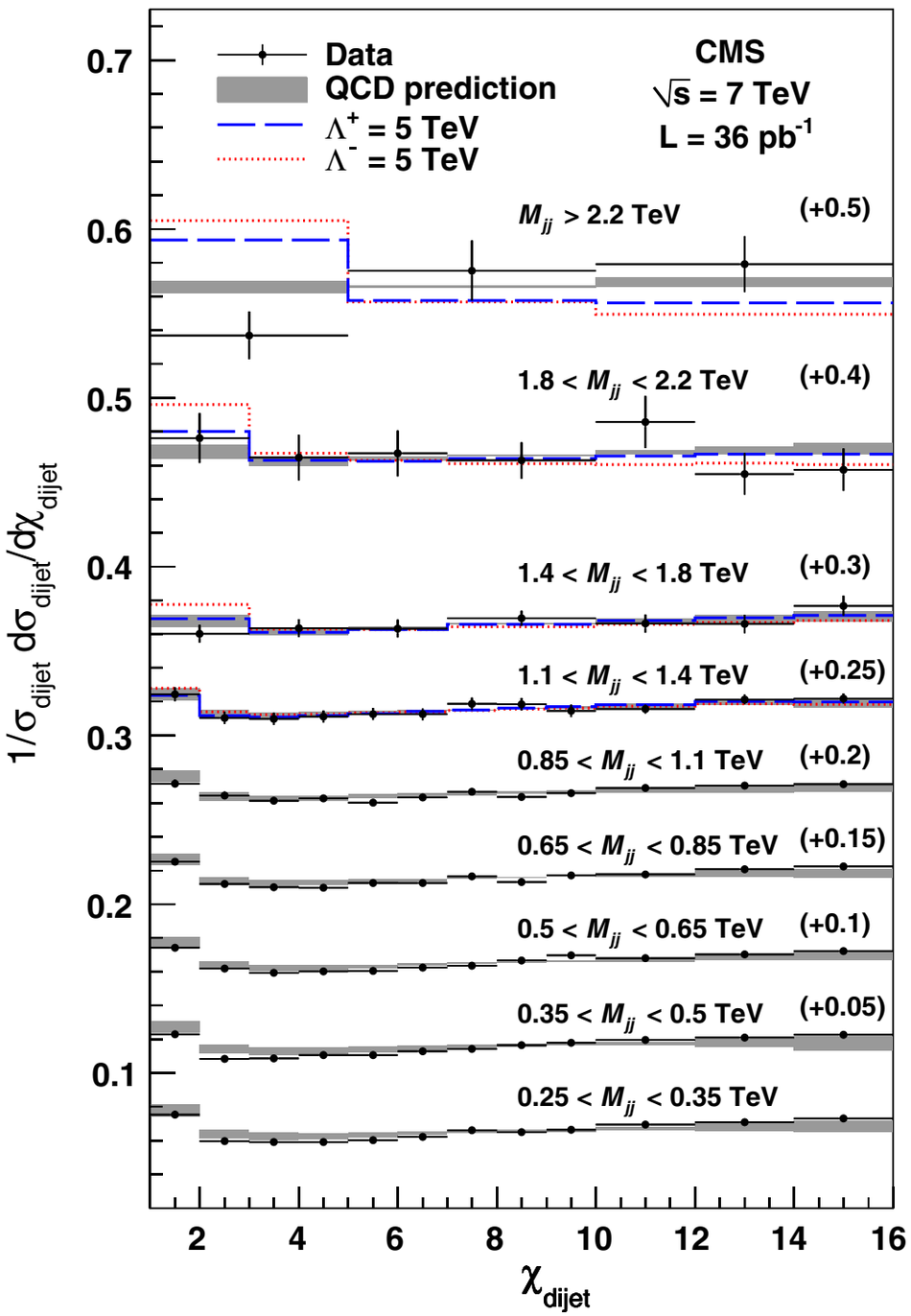




- ☑ Data is agree with the predictions of the standard model.
- ☑ Ratio is flat, no sign of new physics.
- ☑ Set limit on contact interaction scale Λ with CLs method.
- ☑ Contact interaction scale excluded for Λ<4.0 TeV at 95% CL.
  - ✓ Expected exclusion of Λ < 2.9 TeV.

Phys. Rev. Lett. 105, 262001 (2010)

Dijet Angular Distribution



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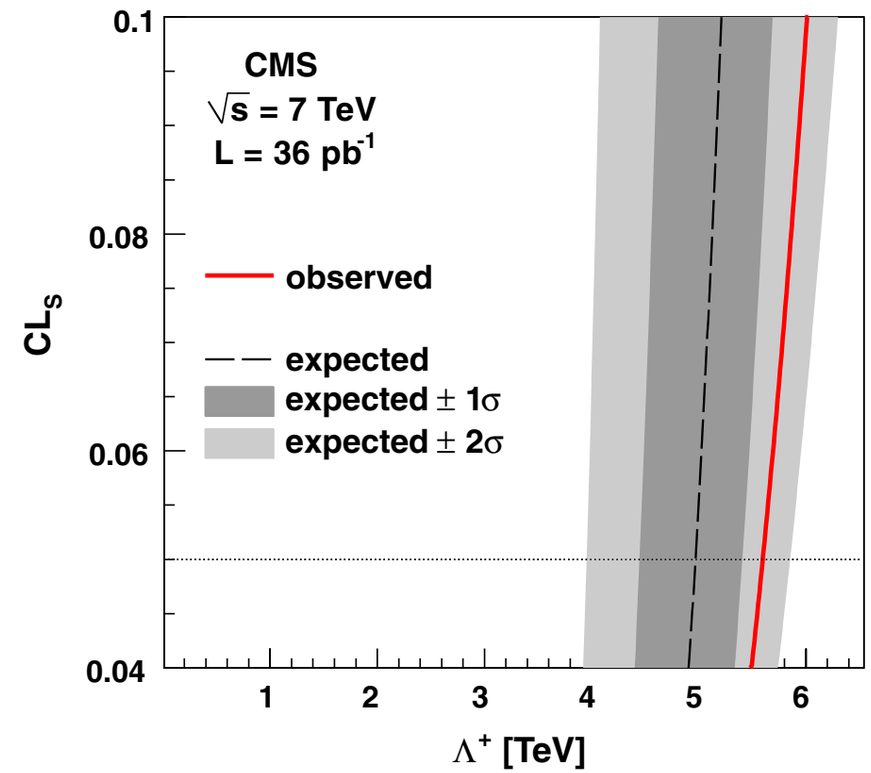
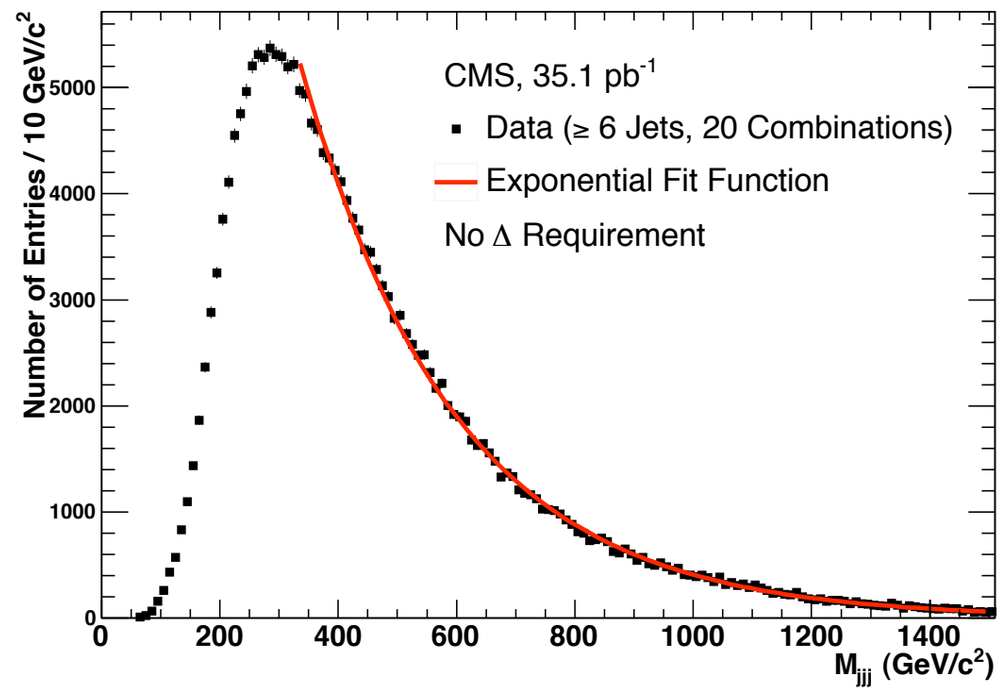
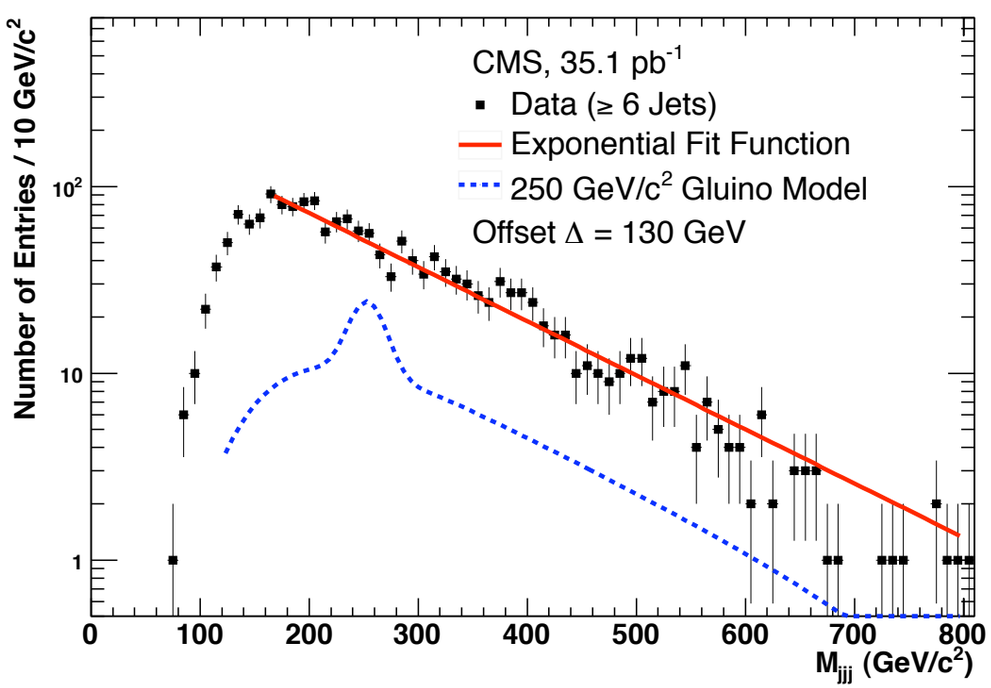


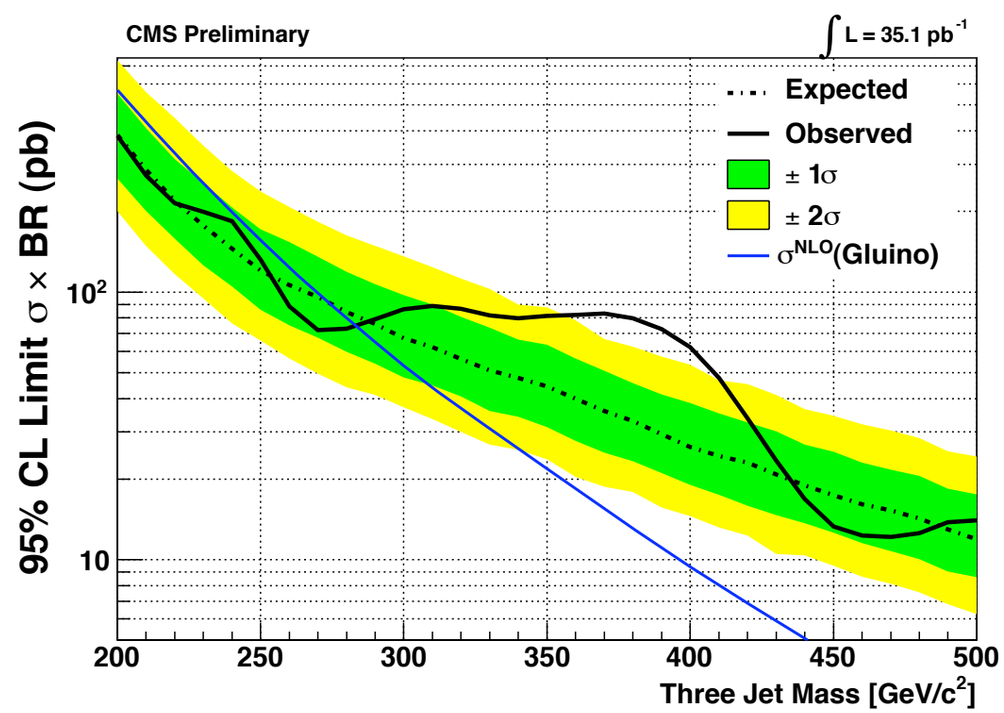
- Good agreement with NLO QCD predictions in 0.25 < Mjj < 2.2 TeV.
- Slight downward fluctuation at low χ in highest mass bin Mjj > 2.2 TeV.
- No evidence of quark substructure.
- Limit on Contact Interaction scale of Λ^+>5.6 TeV (Λ^->6.7 TeV) at 95% CL.

Multijet Resonances

- Studying pp → QQ → 3j + 3j = 6 jets
  - R-Parity violating Supersymmetric (RPV) gluino (No Missing ET)
- $M_{jjj} < \sum_{i=1}^{3} |p_T^{jet}|_i - \Delta$
  - to reduce background and optimize signal sensitivity
- Good agreement between the data and the expected QCD background.
- Excluded mass limit of RPV gluino at 95% CL is between 200 GeV and 280 GeV
  - the first limit from pp collisions.







t-tbar Resonances

☑ content will be added

Summary and Conclusions

- ☑ CMS hadronic resonance searches have been presented based on 2010 data.
- ☑ The CMS analysis have been performed to search for new physics in hadronic final states.
- ☑ No evidence for new physics yet.
- ☑ Many Tevatron results superseded and new limits have been published.
- ☑ 2011 data expected to quick supersede 2010 results, leaving ample space for discoveries.

Backup