Search for Dijet Resonances in Dijet Mass

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Overview

- First pass at machinery for finding limits on dijet resonances,
  - ✓ Resonance shape as a function of mass,
  - ✓ Fitting of dijet mass “data” with background shape,
  - ✓ Calculating of likelihood vs. resonance cross section,
  - ✓ Finding 95% C.L. cross section upper limit and comparing with model cross section for mass limits

Resonance Shape Analysis

- CMSSW_2_2_3 was used.
- There different qstar samples were used.

Exotica Summer08 GEN-SIM-RECO.

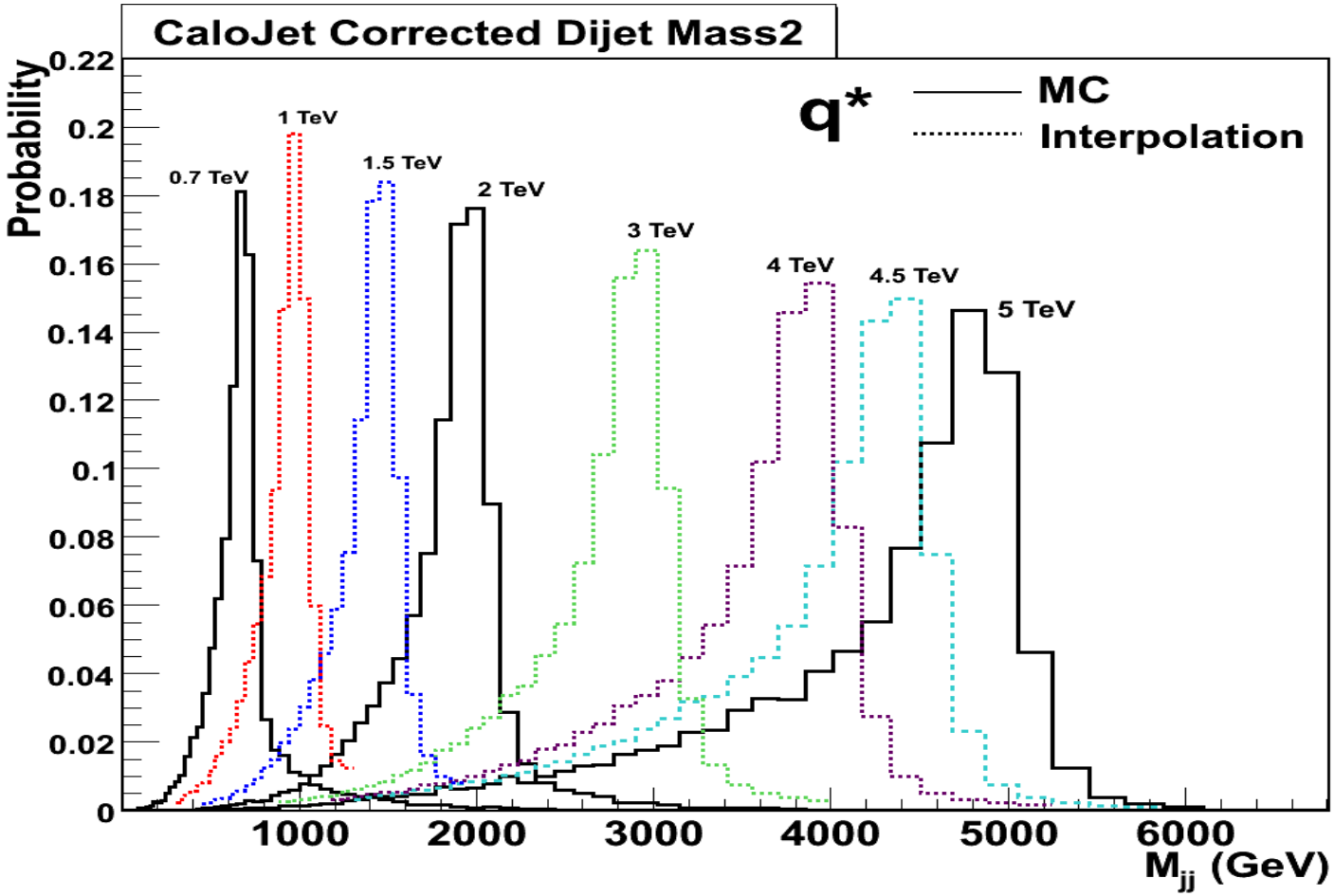
$$m_{q*} = \text{0.7 TeV, 2 TeV, 5 TeV}$$

$$q^* \longrightarrow qg$$

- SisCone R=0.7
- Pt and eta dependent jet correction were applied. (L2L3CorJets)
- Two leading jets with $|\eta_{jet}| < 1.3$ were selected.

Resonance Shapes

- A code is written which generate the resonance shape any resonance mass using interpolation technique.
- **Shape.h** and **Shape.C** can be found in CVS (UserCode/Sertac)



QCD Background Analysis

- QCD cross section from Summer 08 data sample, smoothed by fitting it to parameterization.

- Toy generator is written to produce random statistical fluctuation in smooth QCD background curve,

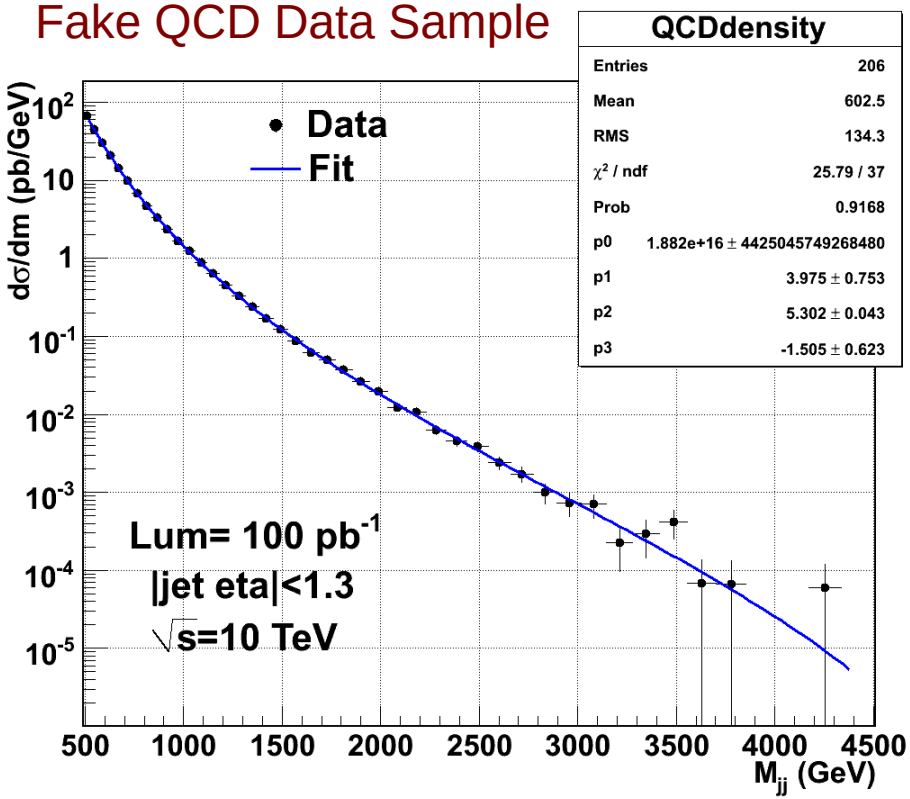
✓ Poisson fluctuation on tail,

✓ Gaussian fluctuation where n>25.

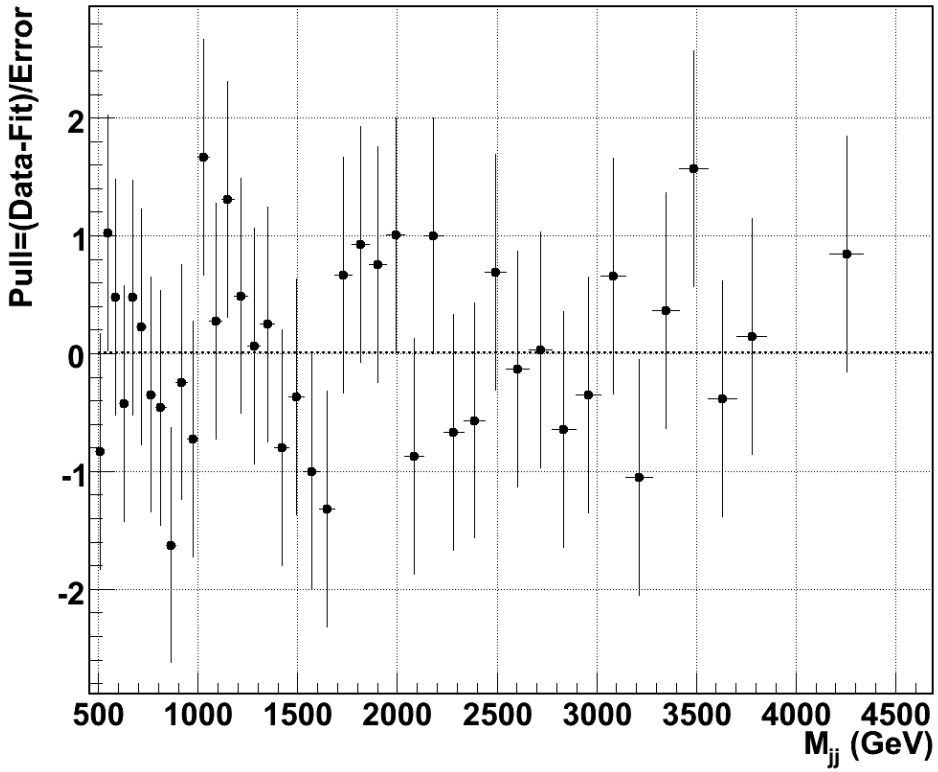
- Produce “data” sample with QCD background shape at 100 pb^{-1} of luminosity.

QCD Background

Fake QCD Data Sample



Pulls

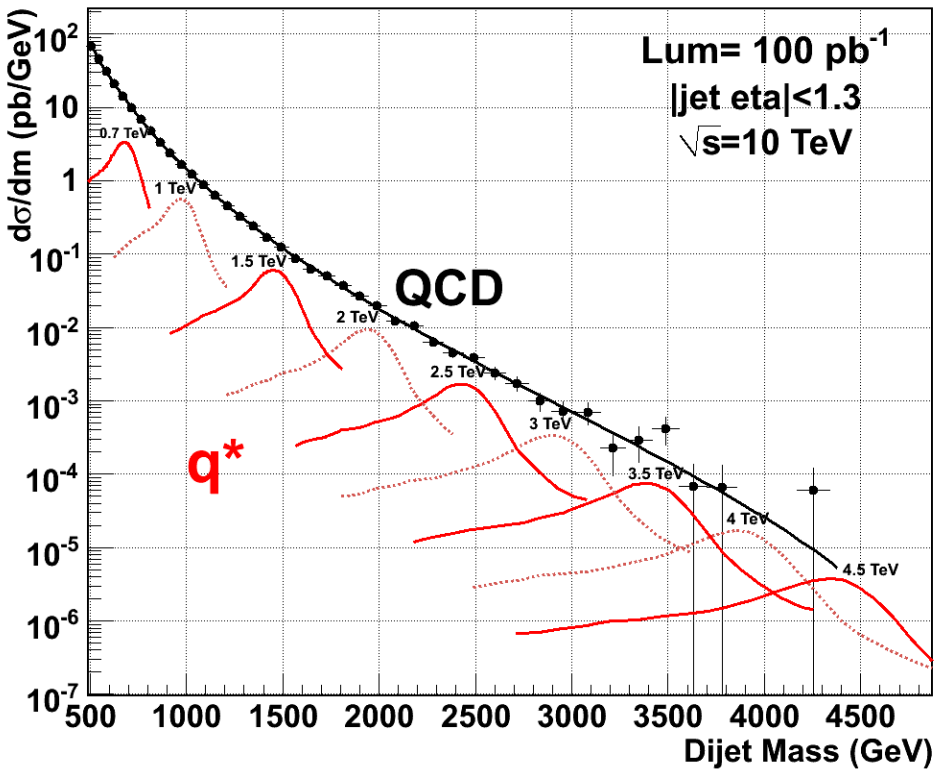


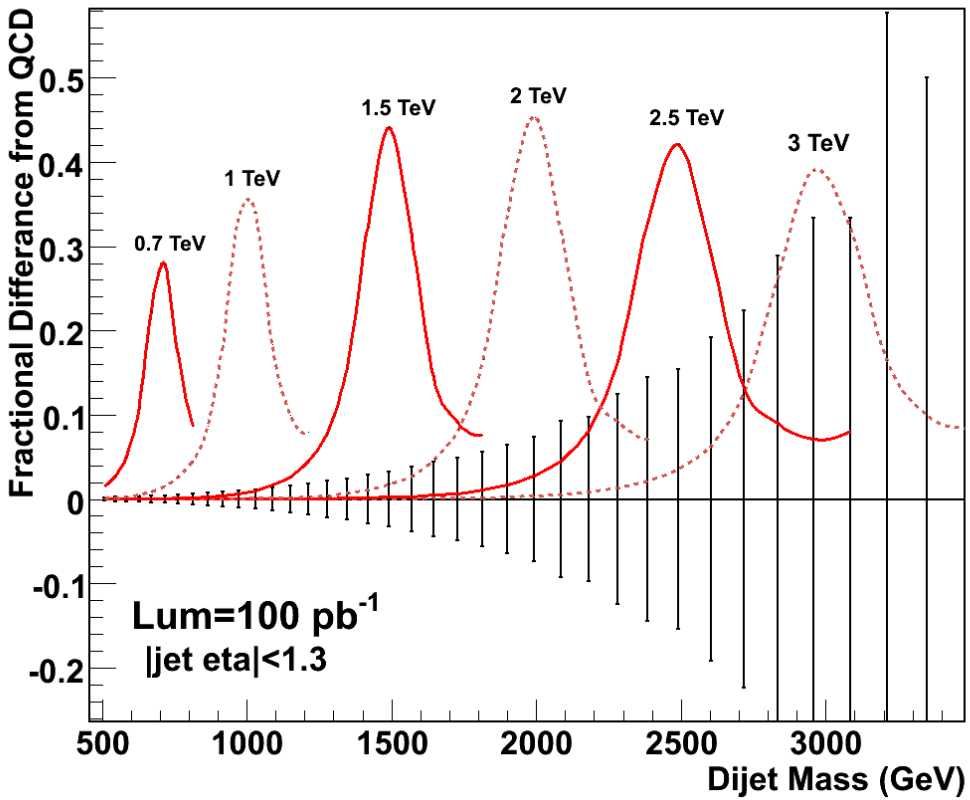
Fit Function

$$\frac{p_0\left(1-\frac{m}{\sqrt{s}}+\left(\frac{m}{\sqrt{s}}\right)^2 p_3\right)^{p_1}}{m^{p_2}}$$

The pulls are consistent with statistical fluctuations.

Background and Signal





➢The differential cross section as a function of dijet mass for the QCD background and the excited quark signal with variable masses.

Likelihood Distribution

To calculate the limits on new particle production decaying dijet, a binned likelihood method is used.

$$L = \prod_i \frac{e^{-\mu_i} \mu_i^{n_i}}{n_i!} \qquad \mu_i = \alpha N_i(S) + N_i(B)$$

measured # of events in data

# of events from signal

expected # of events from background

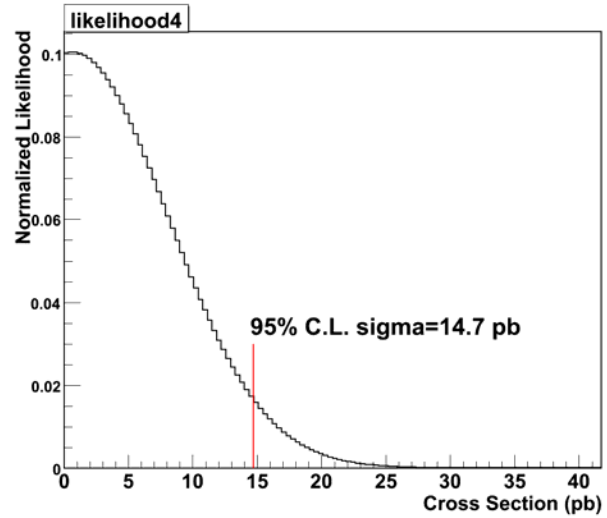
To help calculate signal, a function is created. QstarBinned.h (UserCode/Sertac)

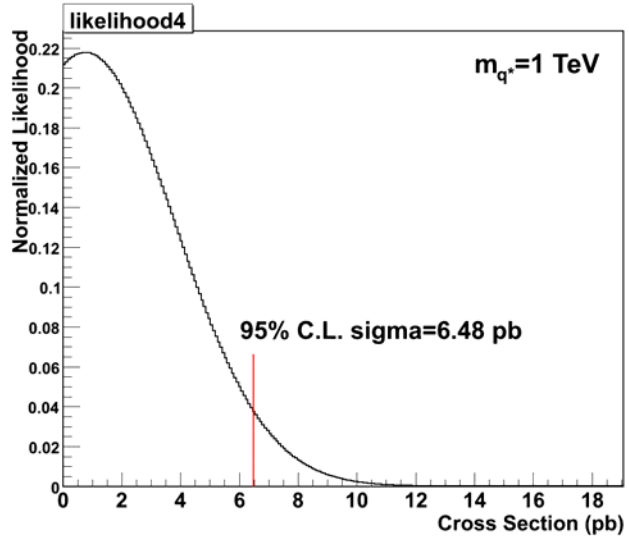
QstarBinnedProb (dijet mass, resonance mass)

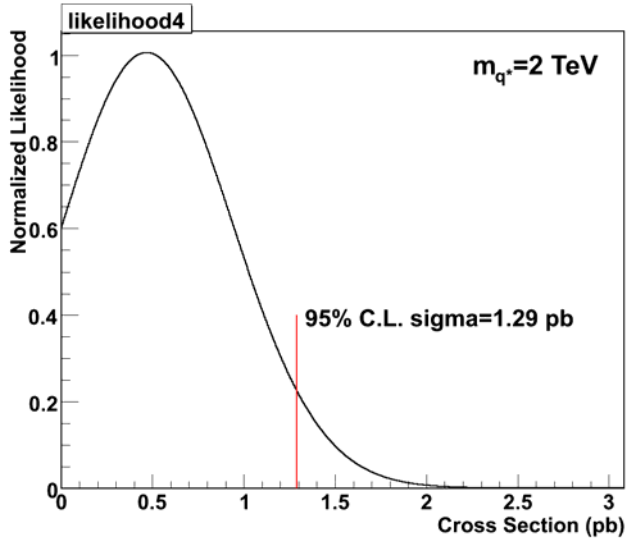
Returns **probability** in our bins of dijet mass for any resonance for 0.3*M<mjj<1.3*M.

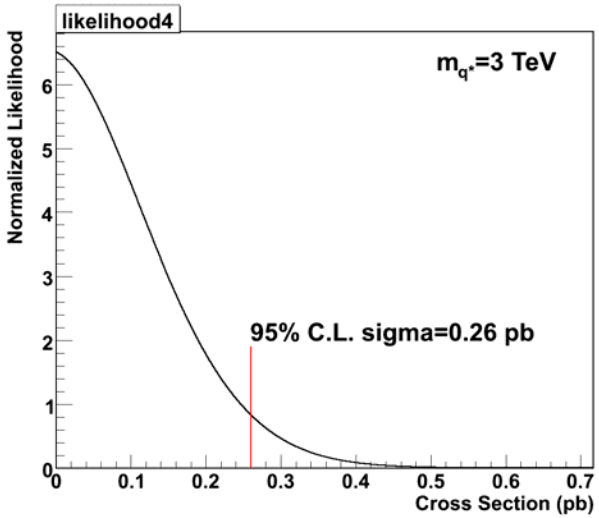
For background the parameterized QCD fitting used.

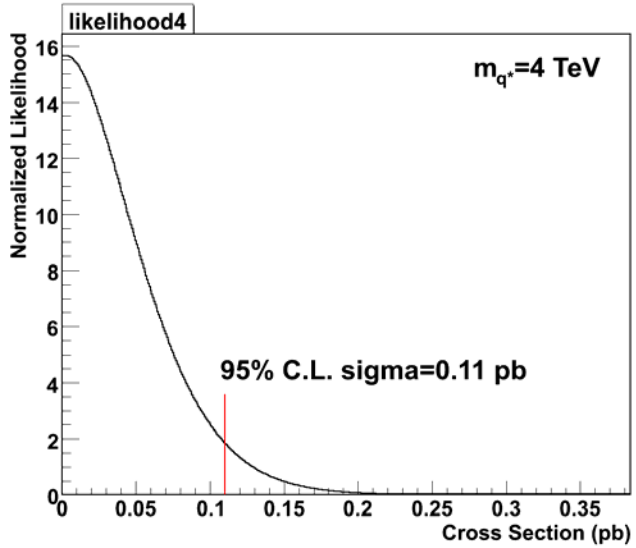
Likelihood Distributions at Various Resonance Mass

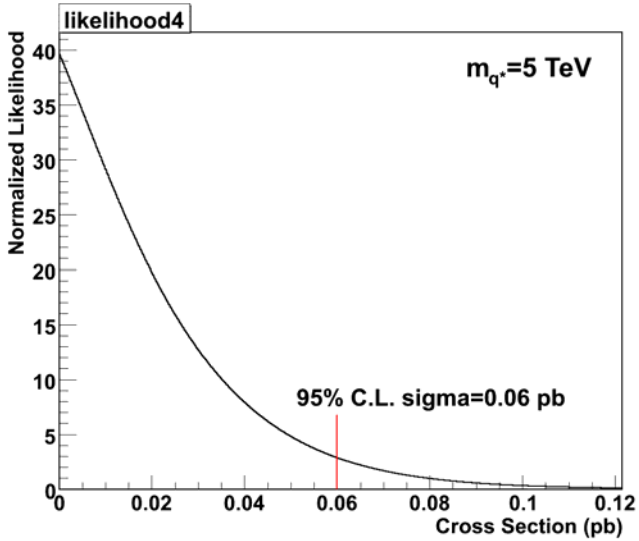






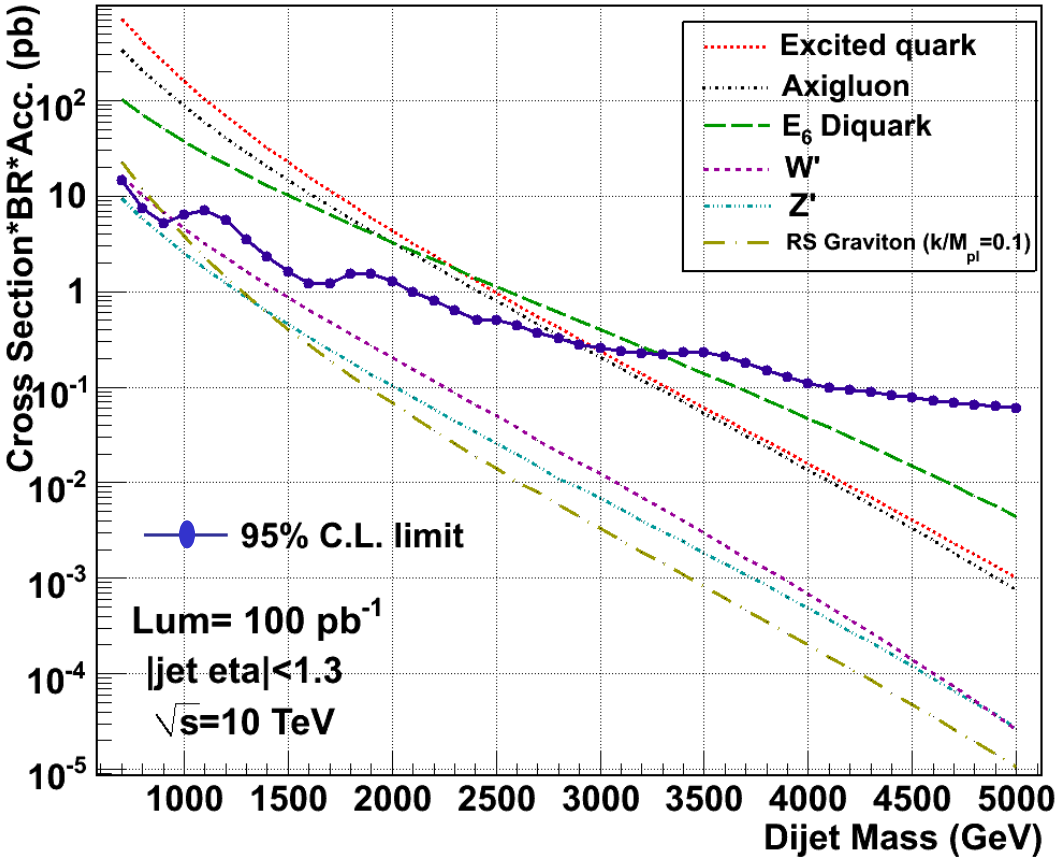






Dijet Resonance Sensitivity

Dijet Resonance Sensitivity for excited quark at 100 pb^{-1}



- 95% CL is compared to the cross section for various resonance models,
- Here we used q* shape for all resonances,
- Mass limit for excited quark from the fake sample is about 3 TeV.
- Limits for $\sqrt{s}$ =14 TeV and |jet eta|<1 with stat errors only was 3.8 TeV, limit from Tevatron with 1 fb^{-1} of data was 0.87 TeV.

Conclusions and Plans

- We are preparing to search for resonances in early CMS data,

- We have presented basic machinery for setting limits on dijet resonance,

- CMS should be sensitive to an excited quark up to ~3 TeV at 95% CL with 100 pb^{-1},

- Future plans are,

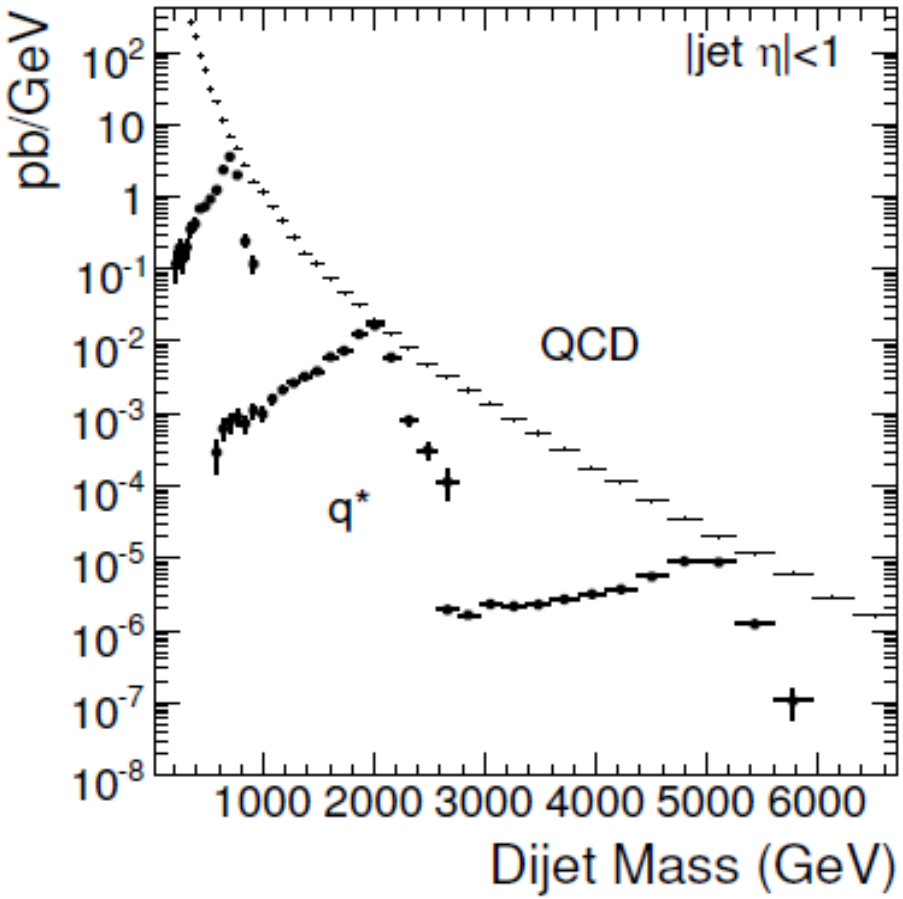
✓ Signal significance estimates from likelihood ratio,

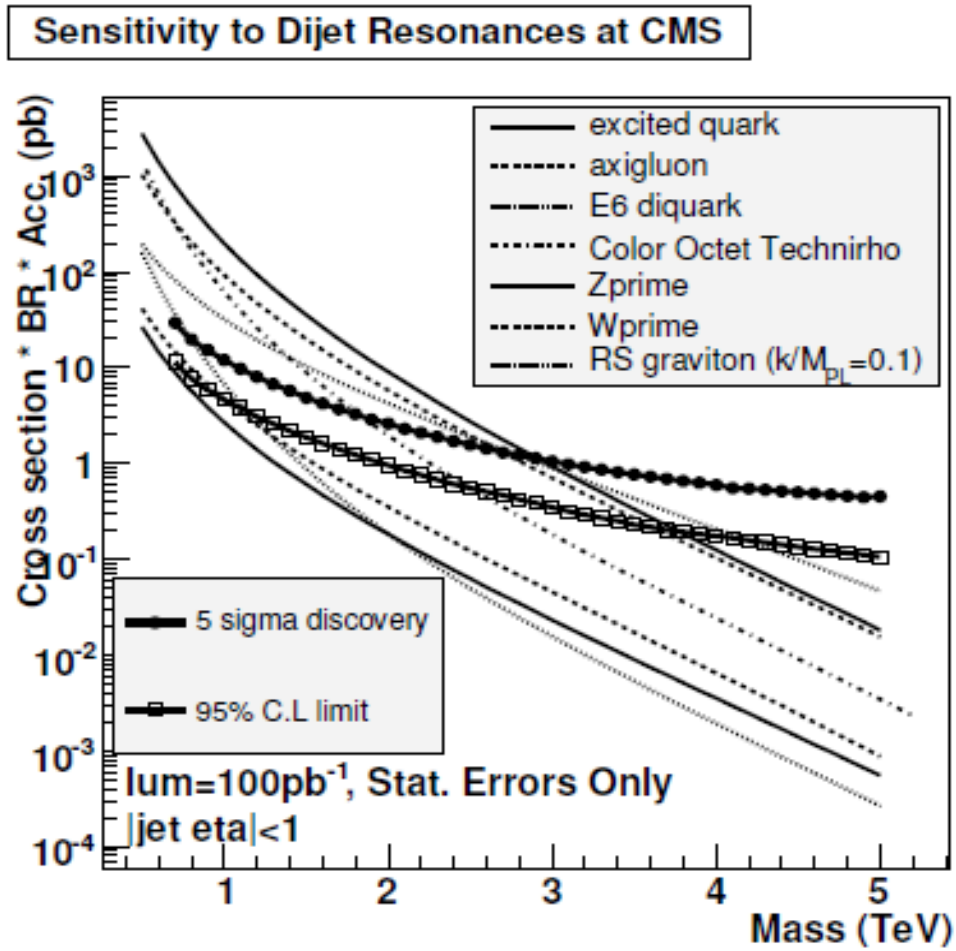
✓ Cross section measurements for resonances,

✓ Refinements to limits including other resonance shapes, systematic, other improvements to produce.

BACKUP SLIDES

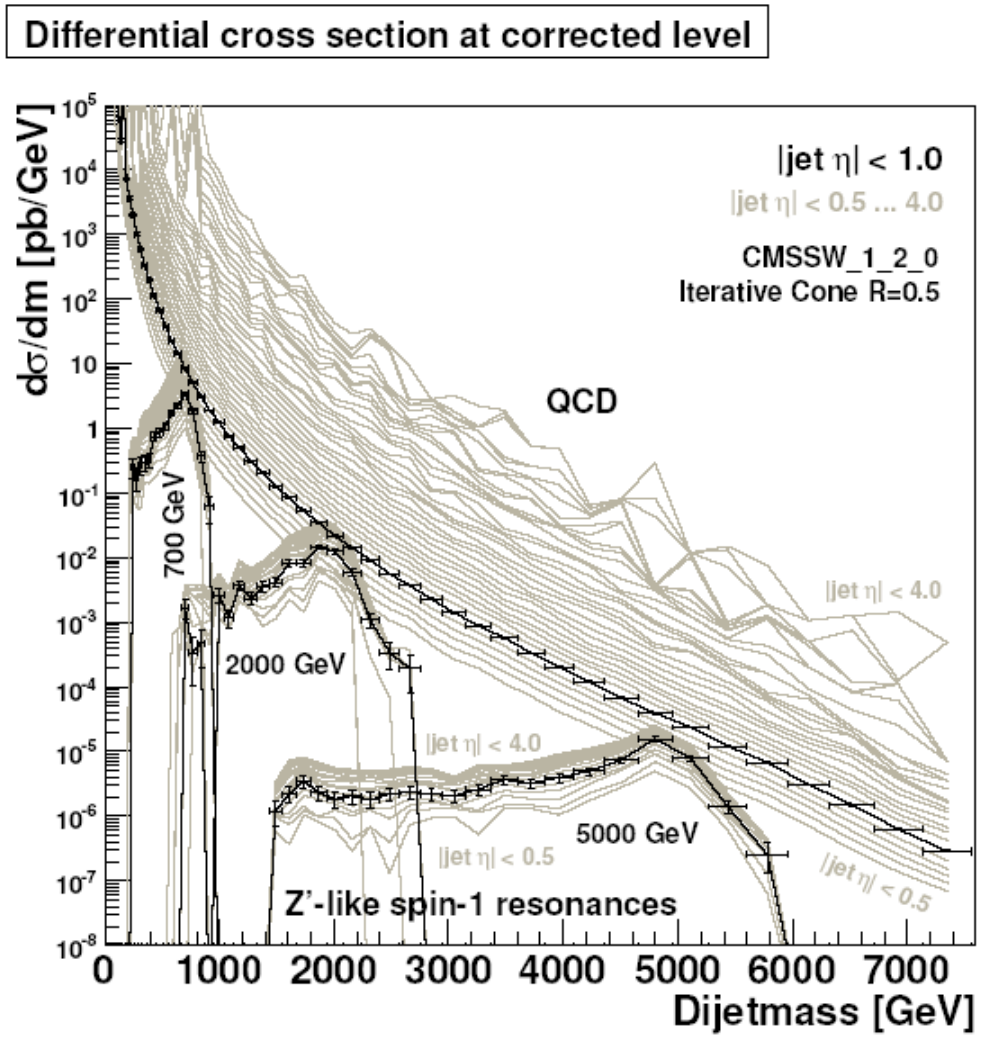
Dijet Resonance Sensitivity from Previous Study





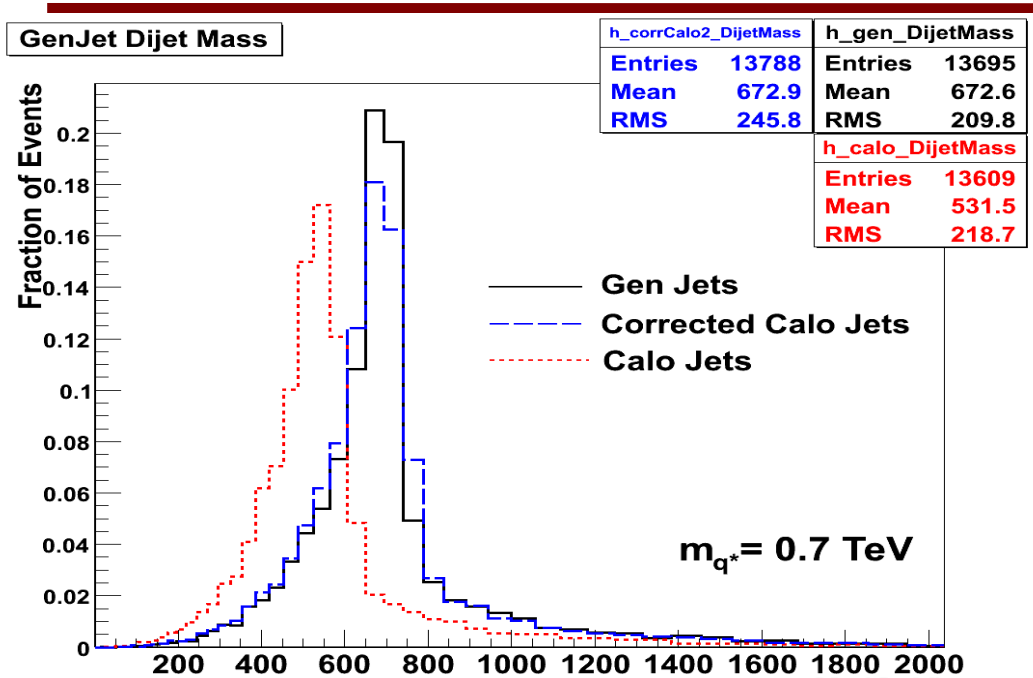
CMS NOTE 2006/070 , K.Gumus

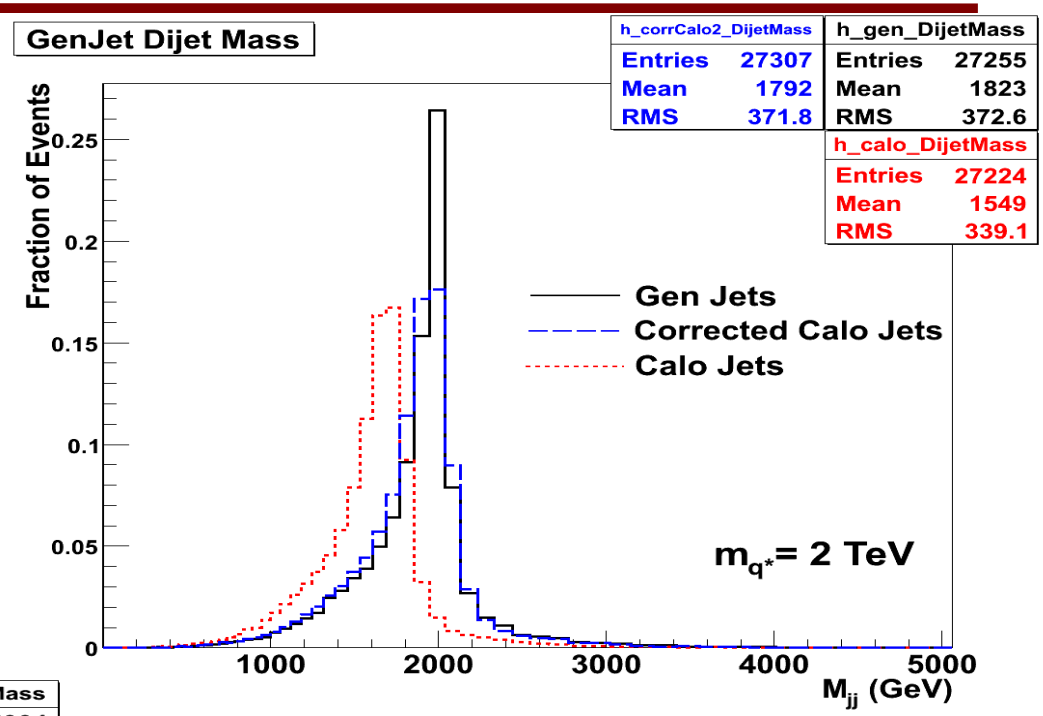
Differential Cross Section at Different eta Cuts

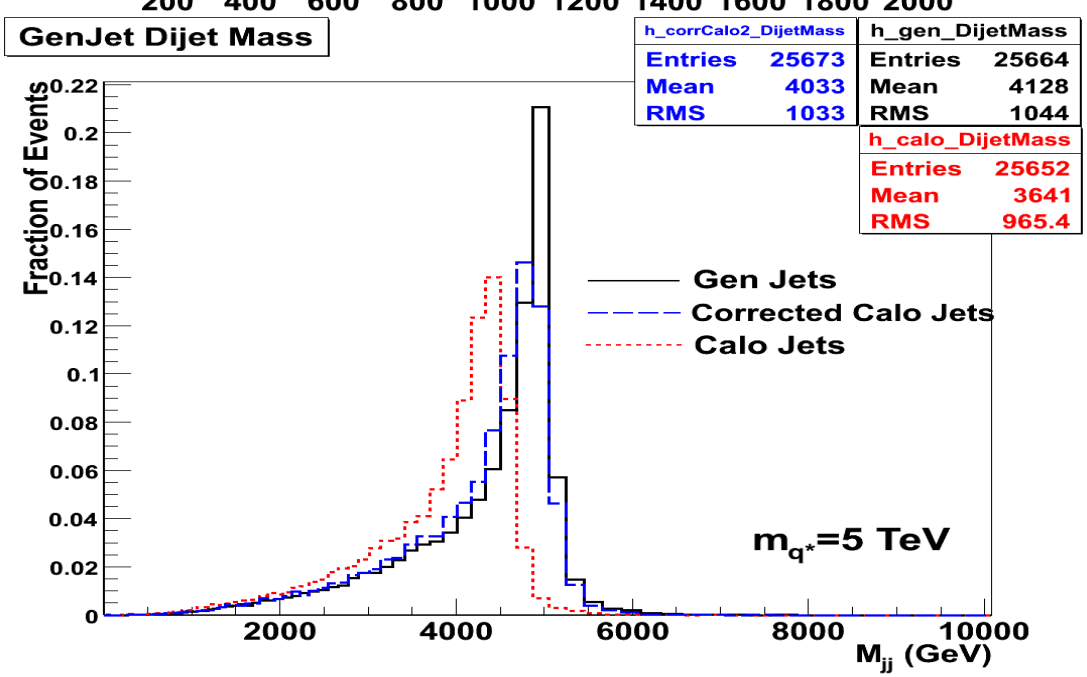


CMS Analysis Note 2007/016, Marco Cardaci

Q* Resonance Shapes





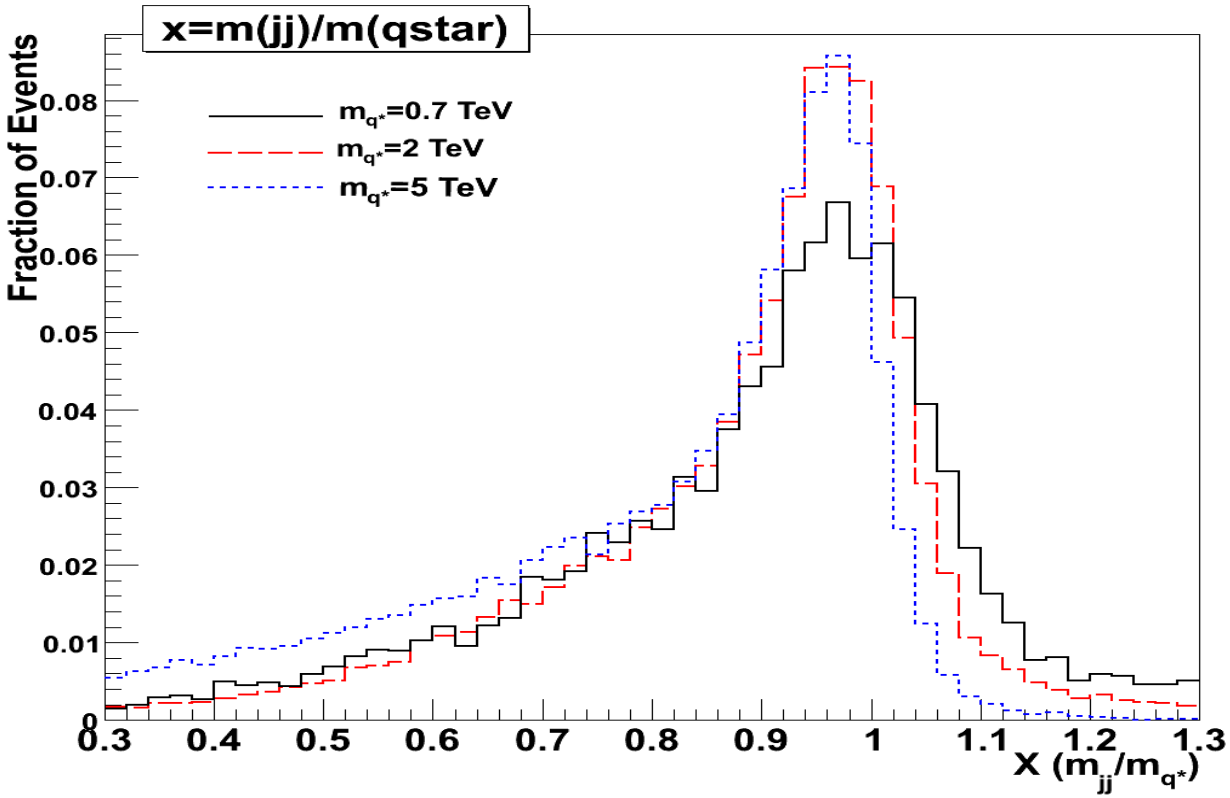


- Peaks are at expected resonance mass.
- Used same mass bins as dijet mass analysis.

Dijet Resonance at any M_{q*}

- We want to get shape of Dijet Resonance for any qstar mass value from the MC samples we have at 0.7, 2, 5 TeV.
- A new parameter (X) is determined in terms of qstar mass value.

$$X = \frac{M_{jj}}{M_{q*}}$$



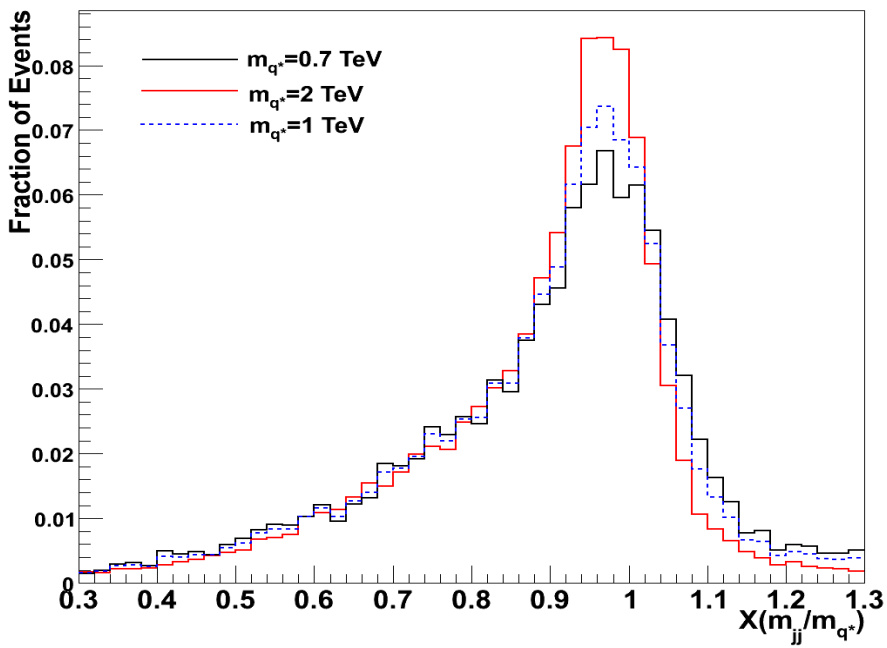
- Resonances look very similar in X.

Dijet Resonance at any M_{q*}

- Interpolation technique was used. For example,

$$700\ GeV < m_{q*} < 2000\ GeV$$

$$\Pr ob_{m_{q*}}(x) = \Pr ob_{700}(x) + \left[\Pr ob_{2000}(x) - \Pr ob_{700}(x)\right] \cdot \frac{m_{q*} - 700}{2000 - 700}$$



- Resonance shape at m_{q*}=1 TeV from interpolation is between the shape for m_{q*}=0.7 TeV and m_{q*}=2 TeV as it should be.