Search for Quark Substructure by Dijet Angular Distributions in $p\bar{p}$ Collisions at $\sqrt{s}$=1.96 TeV

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Run Periods

Period	Run No.	SAM	Lum(pb)	Sum	Dates		
0	138425-186598	0d	520	520	04-Feb-02	-	22-Aug-04
1	190697-195408	0h	130	650	07-Dec-04	-	18-Mar-05
2	195409-198379	0h	130	780	19-Mar-05	-	20-May-05
3	198380-201349	0h	100	880	21-May-05	-	19-Jul-05
4	201350-203799	0h	100	980	20-Jul-05	-	04-Sep-05
5	203819-206989	0i	150	1130	05-Sep-05	-	09-Nov-05
6	206990-210011	0i	120	1250	10-Nov-05	-	14-Jan-06
7	210012-212133	0i	50	1300	14-Jan-06	-	22-Feb-06
8	217990-222426	0i	210	1510	09-Jun-06	-	01-Sep-06
9	222529-228596	0i	200	1710	01-Sep-06	-	22-Nov-06
10	228664-233111	0i	290	2000	24-Nov-06	-	30-Jan-07
11	233133-237795	0j	260	2260	30-Jan-07	-	31-Mar-07
12	237845-241664	0j	180	2440	01-Apr-07	-	13-May-07

Data Summary

Quantities

- 2.4 fb^{-1} Integrated Luminosity
- 25 million Jet100 samples
- 10 nb constant trigger cross-section

Cuts

- $|\eta| < 2$
- $|Zvertex| < 60cm$
- Missing E_T Singnificance $< 5\ \sqrt{\mathrm{GeV}}$

QCD Subprocesses

all quarks massless, averaging over initial quark colors

$t = -s\,\sin^2(\theta/2),\ u = -s\,\cos^2(\theta/2)$

$$\frac{\partial\sigma}{\partial\Omega}(q\bar{q} \to q'\bar{q}') = \frac{\alpha_s^2}{9s}\,\frac{t^2+u^2}{s^2}$$

$$\frac{\partial\sigma}{\partial\Omega}(qq' \to qq') = \frac{\alpha_s^2}{9s}\,\frac{s^2+u^2}{t^2}$$

$$\frac{\partial\sigma}{\partial\Omega}(q\bar{q} \to q\bar{q}) = \frac{\alpha_s^2}{9s}\left[\frac{t^2+u^2}{s^2} + \frac{s^2+u^2}{t^2} - \frac{2u^2}{3st}\right]$$

$$\frac{\partial\sigma}{\partial\Omega}(qq \to qq) = \frac{\alpha_s^2}{9s}\left[\frac{t^2+s^2}{u^2} + \frac{s^2+u^2}{t^2} - \frac{2s^2}{3ut}\right]$$

$$\frac{\partial\sigma}{\partial\Omega}(q\bar{q} \to gg) = \frac{8\alpha_s^2}{27s}\left(t^2+u^2\right)\left(\frac{1}{tu} - \frac{9}{4s^2}\right)$$

$$\frac{\partial\sigma}{\partial\Omega}(qg \to qg) = \frac{\alpha_s^2}{9s}\left(s^2+u^2\right)\left(-\frac{1}{su} + \frac{9}{4t^2}\right)$$

$$\frac{\partial\sigma}{\partial\Omega}(gg \to q\bar{q}) = \frac{\alpha_s^2}{24s}\left(t^2+u^2\right)\left(\frac{1}{tu} - \frac{9}{4s^2}\right)$$

$$\frac{\partial\sigma}{\partial\Omega}(gg \to gg) = \frac{9\alpha_s^2}{8s}\left(3 - \frac{ut}{s^2} - \frac{su}{4t^2} - \frac{st}{4u^2}\right)$$

$$\chi = \frac{1+\cos\theta}{1-\cos\theta}, \quad \cos\theta = \frac{\chi - 1}{\chi + 1}$$

$$\frac{d\sigma}{d\chi} = \frac{2\pi}{(\chi+1)^2}\,\frac{d\sigma}{d\Omega}, \quad \frac{t}{s} = \frac{-1}{\chi+1}, \quad \frac{u}{s} = \frac{-\chi}{\chi+1}$$

QCD Subprocesses with Substructure Modeling

$$\frac{d\sigma}{d\Omega}(qq \rightarrow qq) = \frac{\alpha_s^2}{9s}\left[\frac{t^2+s^2}{u^2} + \frac{s^2+u^2}{t^2} - \frac{2s^2}{3ut}\right] + \frac{2\alpha_s}{9s}\frac{\eta}{\Lambda^2}\left[\frac{s^2}{t} + \frac{s^2}{u}\right] + \frac{2}{3s}\frac{s^2}{\Lambda^4}$$

$$\frac{d\sigma}{d\Omega}(q\bar{q} \rightarrow q\bar{q}) = \frac{\alpha_s^2}{9s}\left[\frac{t^2+u^2}{s^2} + \frac{s^2+u^2}{t^2} - \frac{2u^2}{3st}\right] + \frac{2\alpha_s}{9s}\frac{\eta}{\Lambda^2}\left[\frac{u^2}{t} + \frac{u^2}{s}\right] + \frac{2}{3s}\frac{u^2}{\Lambda^4}$$

$$\frac{d\sigma}{d\Omega}(q\bar{q} \rightarrow q'\bar{q}') = \frac{\alpha_s^2}{9s}\frac{t^2+u^2}{s^2} + \frac{1}{4s}\frac{u^2}{\Lambda^4}$$

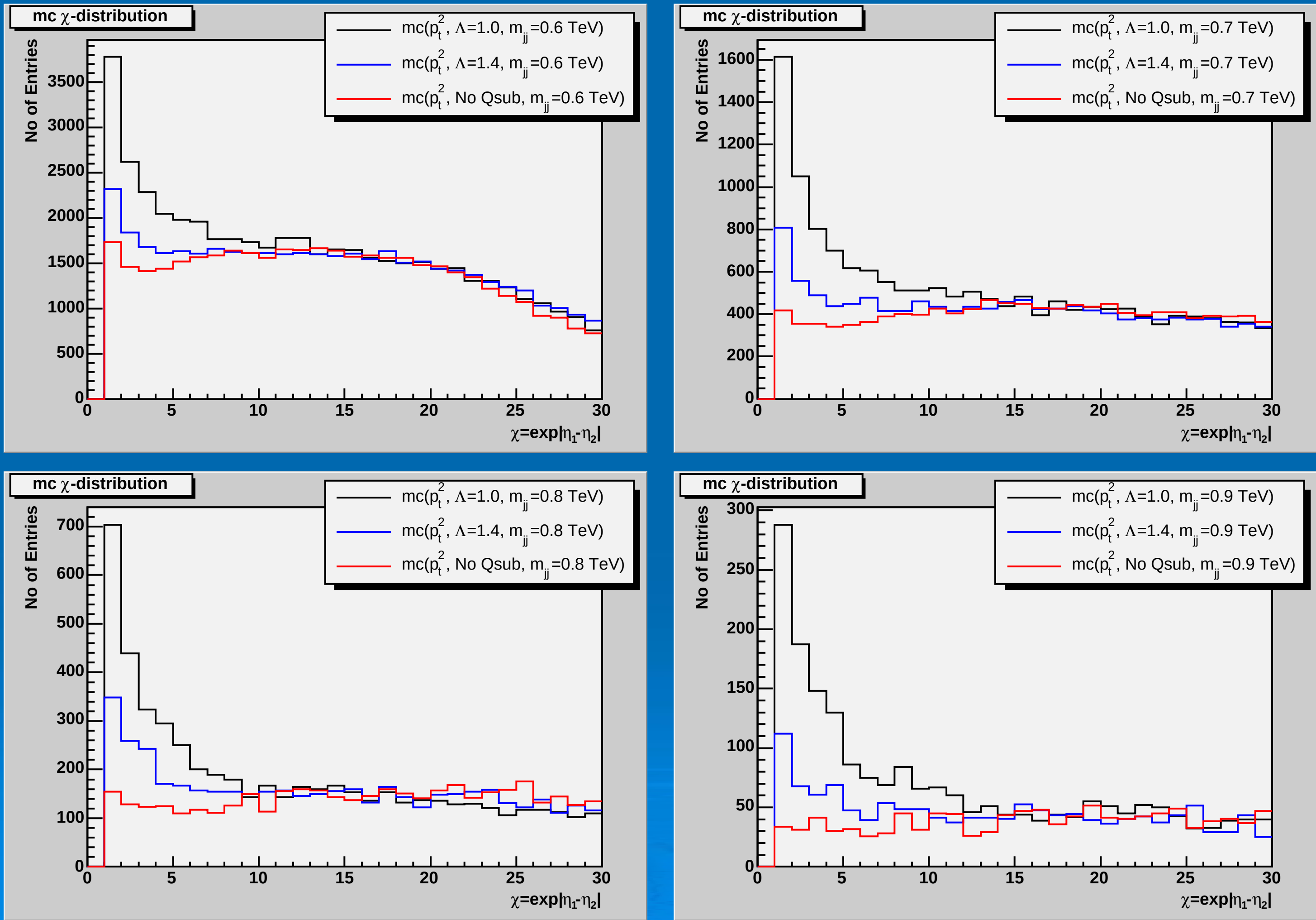
$$\frac{d\sigma}{d\Omega}(q\bar{q}' \rightarrow q\bar{q}') = \frac{\alpha_s^2}{9s}\frac{s^2+u^2}{t^2} + \frac{1}{4s}\frac{u^2}{\Lambda^4}$$

$$\frac{d\sigma}{d\Omega}(qq' \rightarrow qq') = \frac{\alpha_s^2}{9s}\frac{s^2+u^2}{t^2} + \frac{1}{4s}\frac{s^2}{\Lambda^4}$$

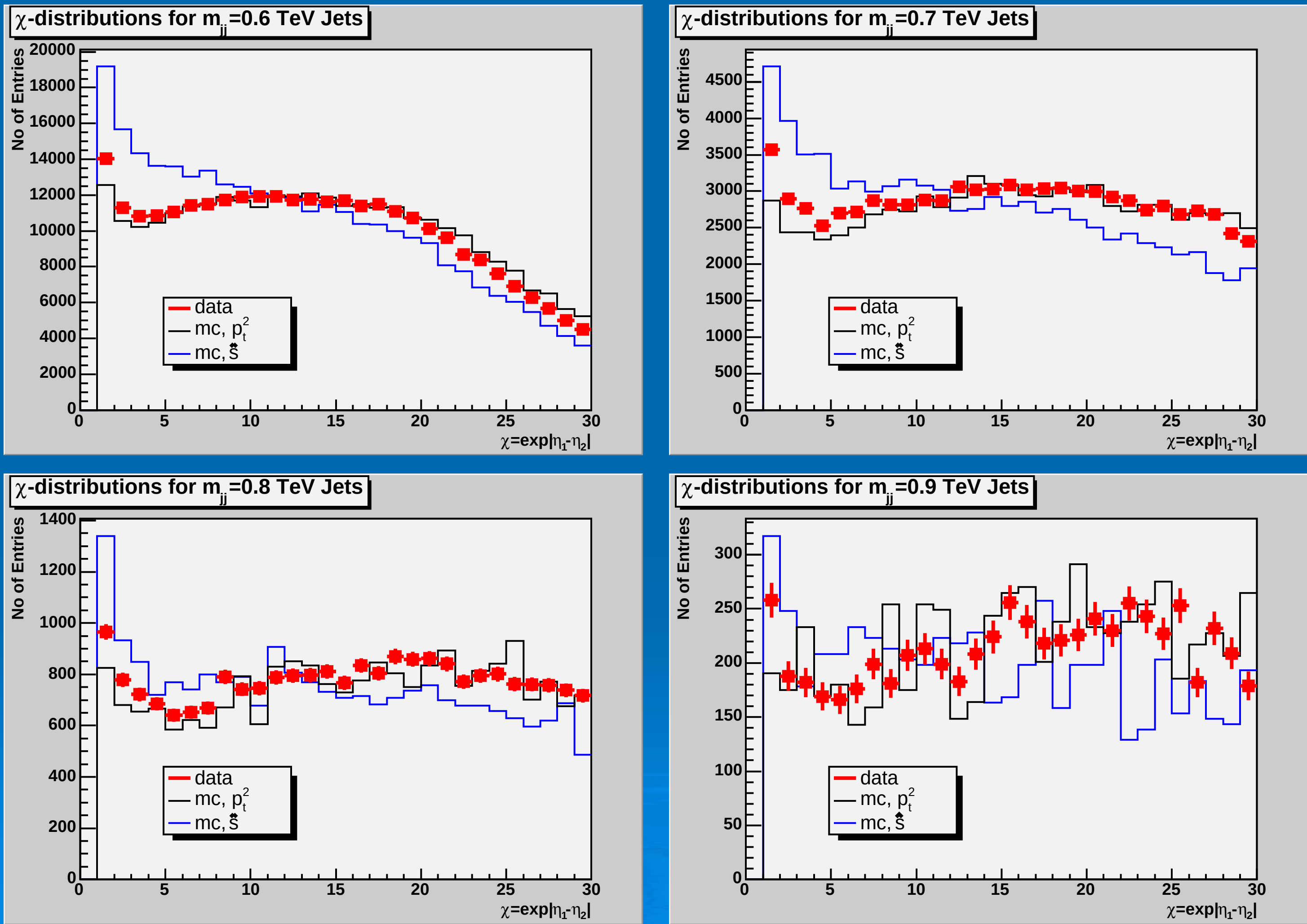
The interference term $\left(\frac{\eta}{\Lambda}\right)$ *is small,* $\eta = \pm 1$.

$\frac{d\sigma}{d\Omega}$*(Rutherford)* $\sim \frac{1}{s}$, $\frac{d\sigma}{d\Omega}$*(compositeness)* $\sim \frac{s}{\Lambda^4}$

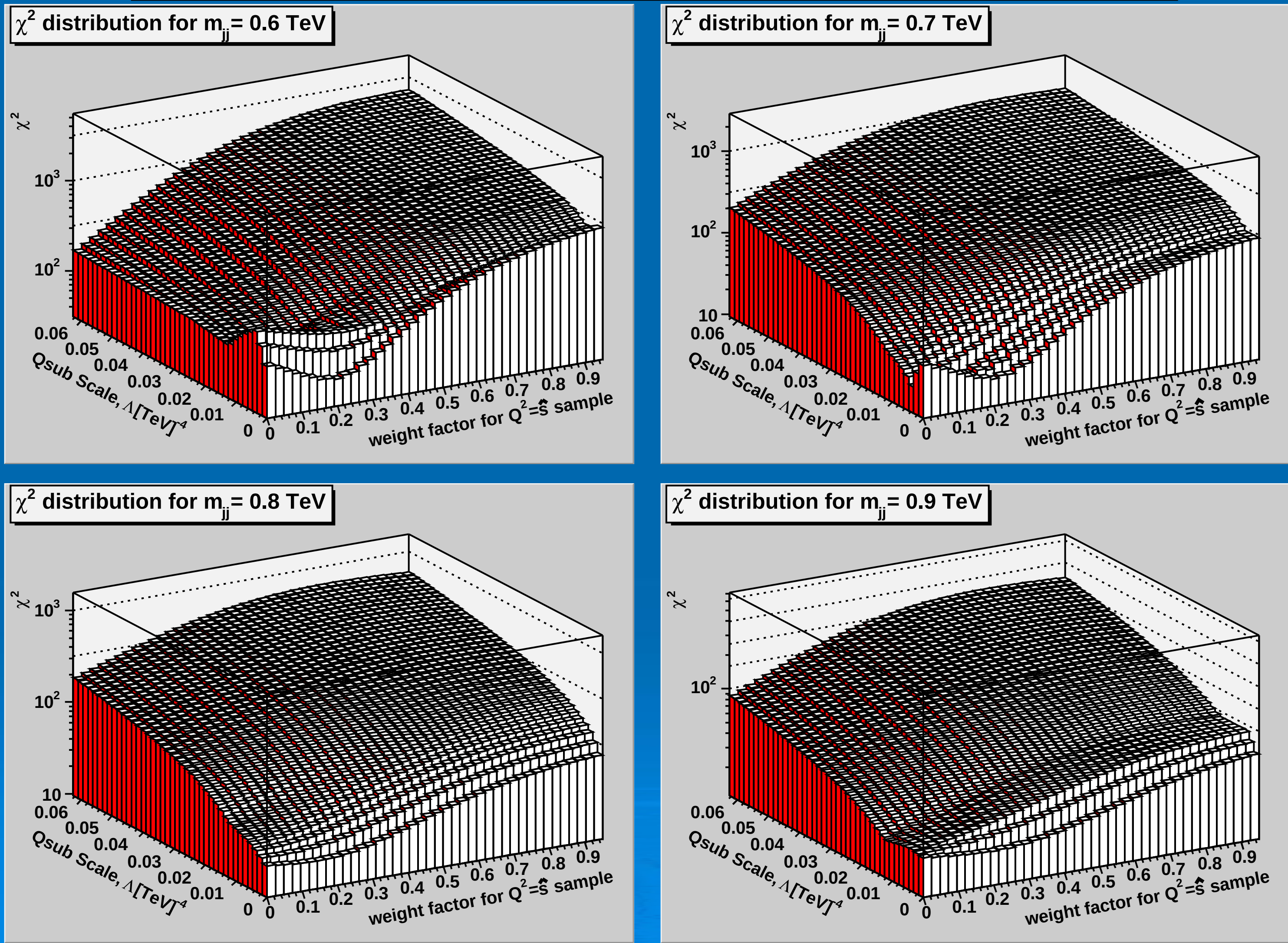
QSub effects on mc χ-dsitribution



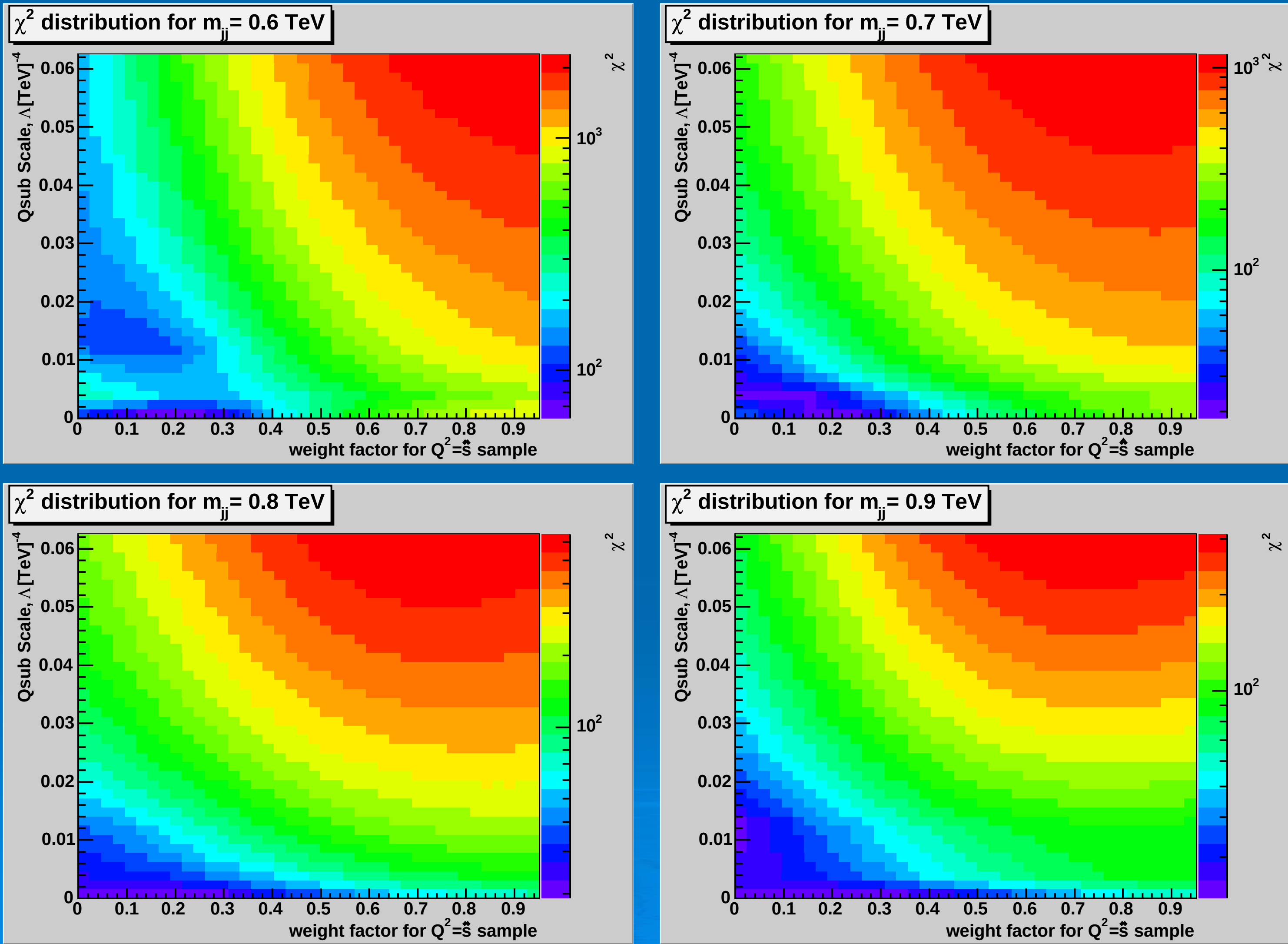
Data χ-Distribution Compared to no-qsub



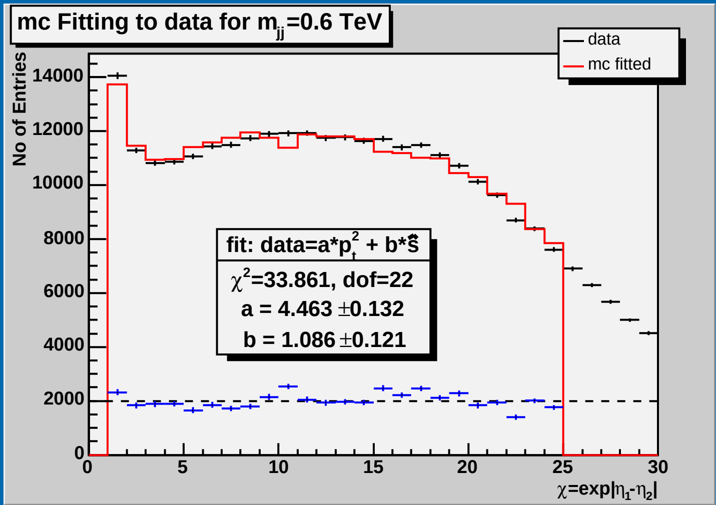
χ^2-Distribution of varying Λ and Q^2-mix

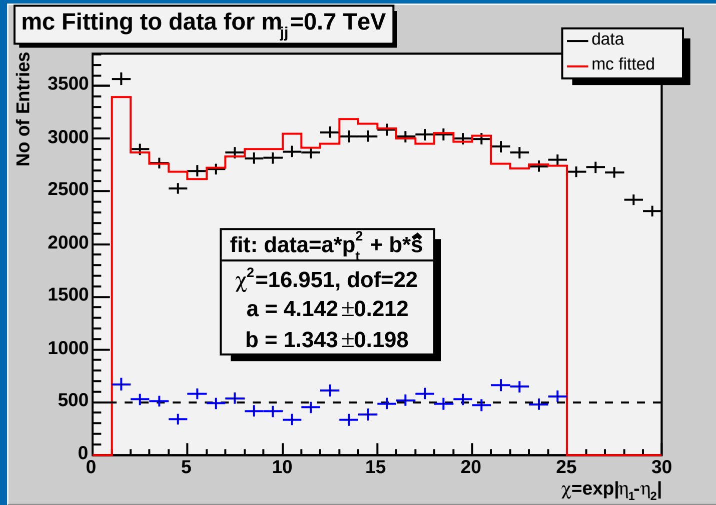


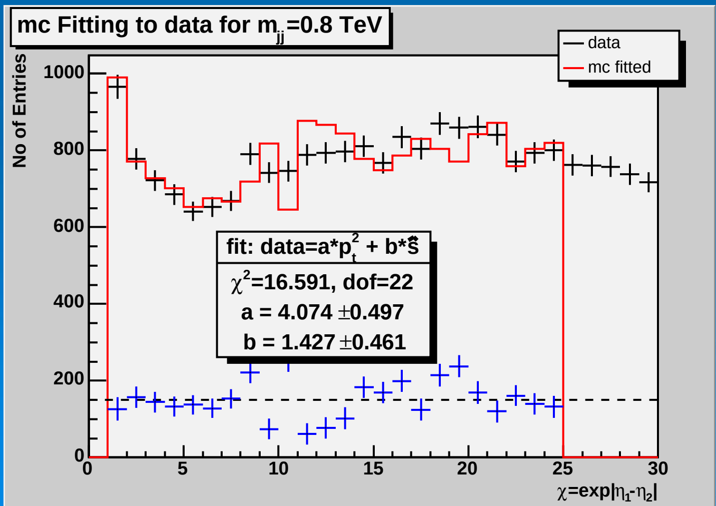
χ^2-Distribution of varying Λ and Q^2-mix

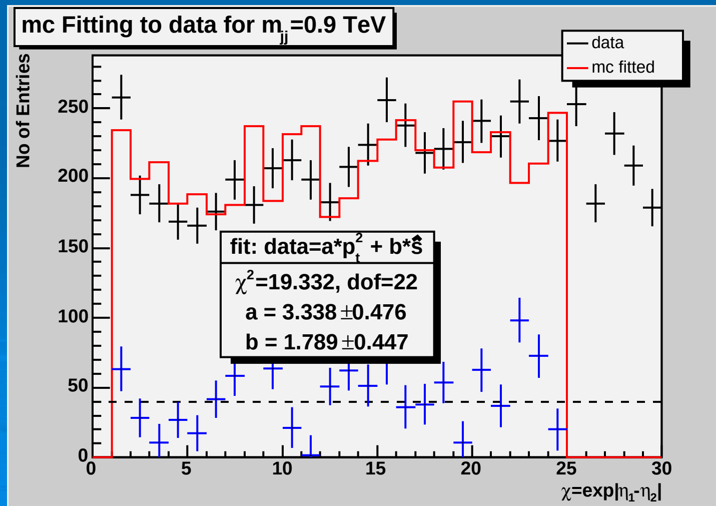


Least χ^2 Fit

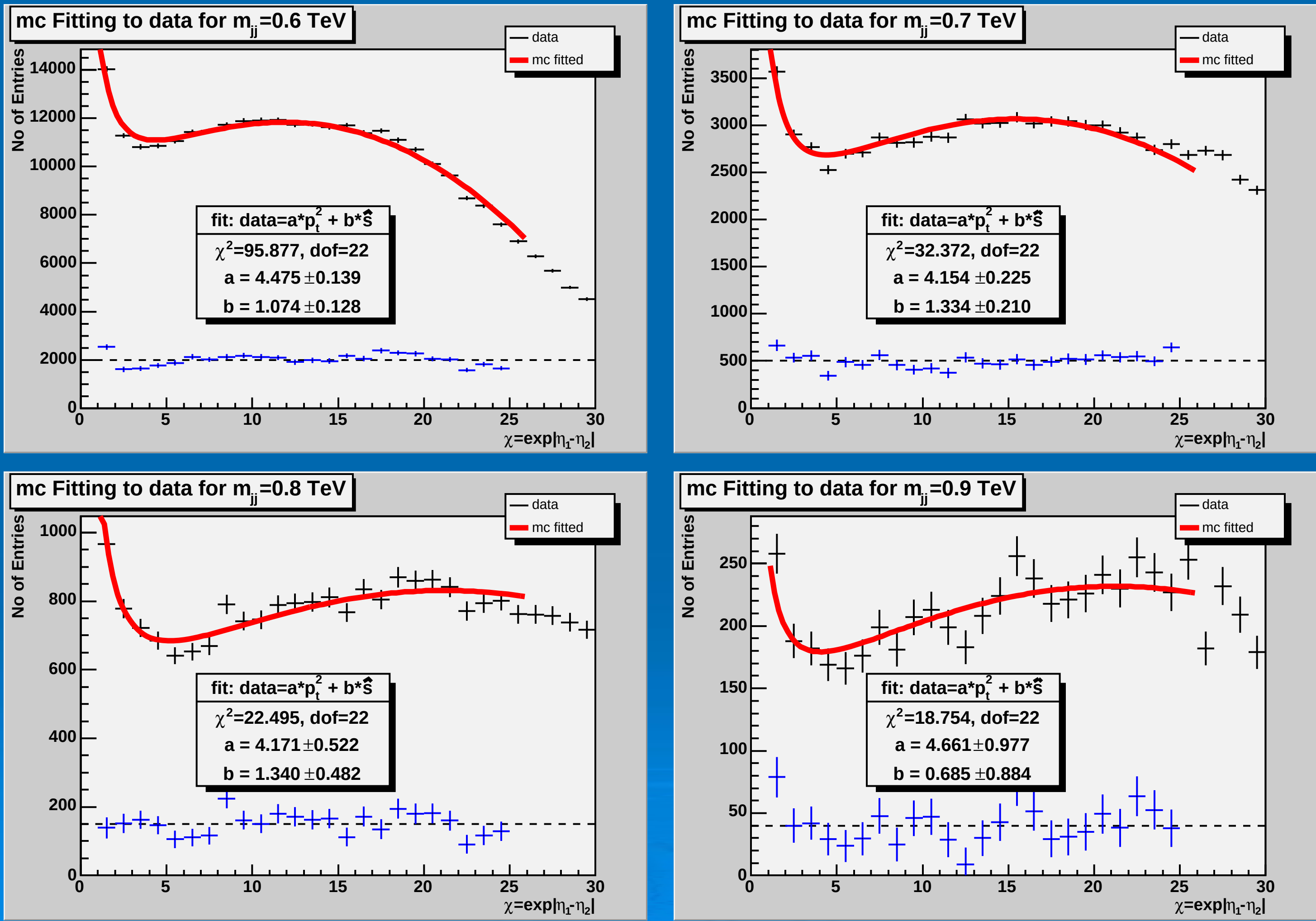




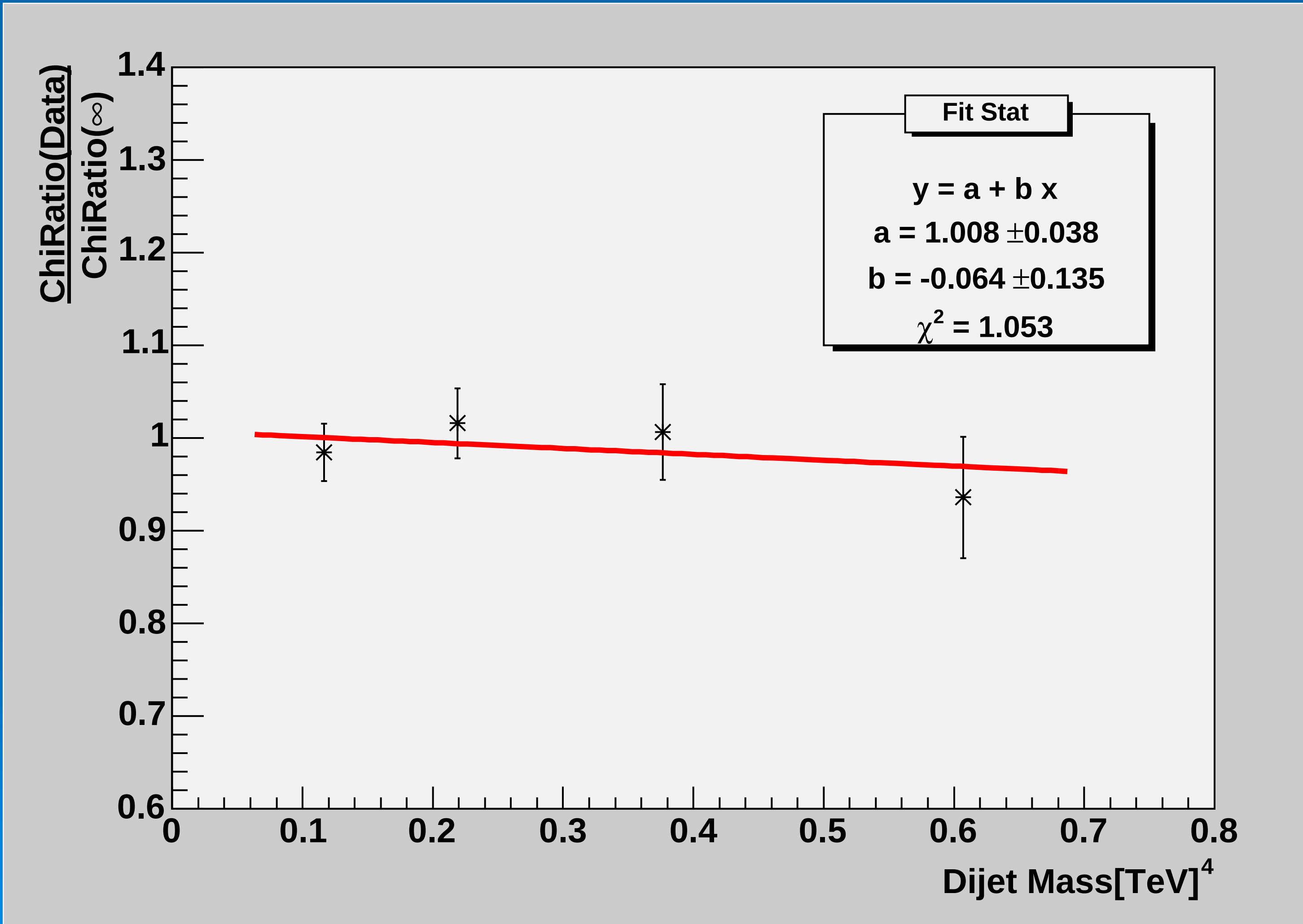




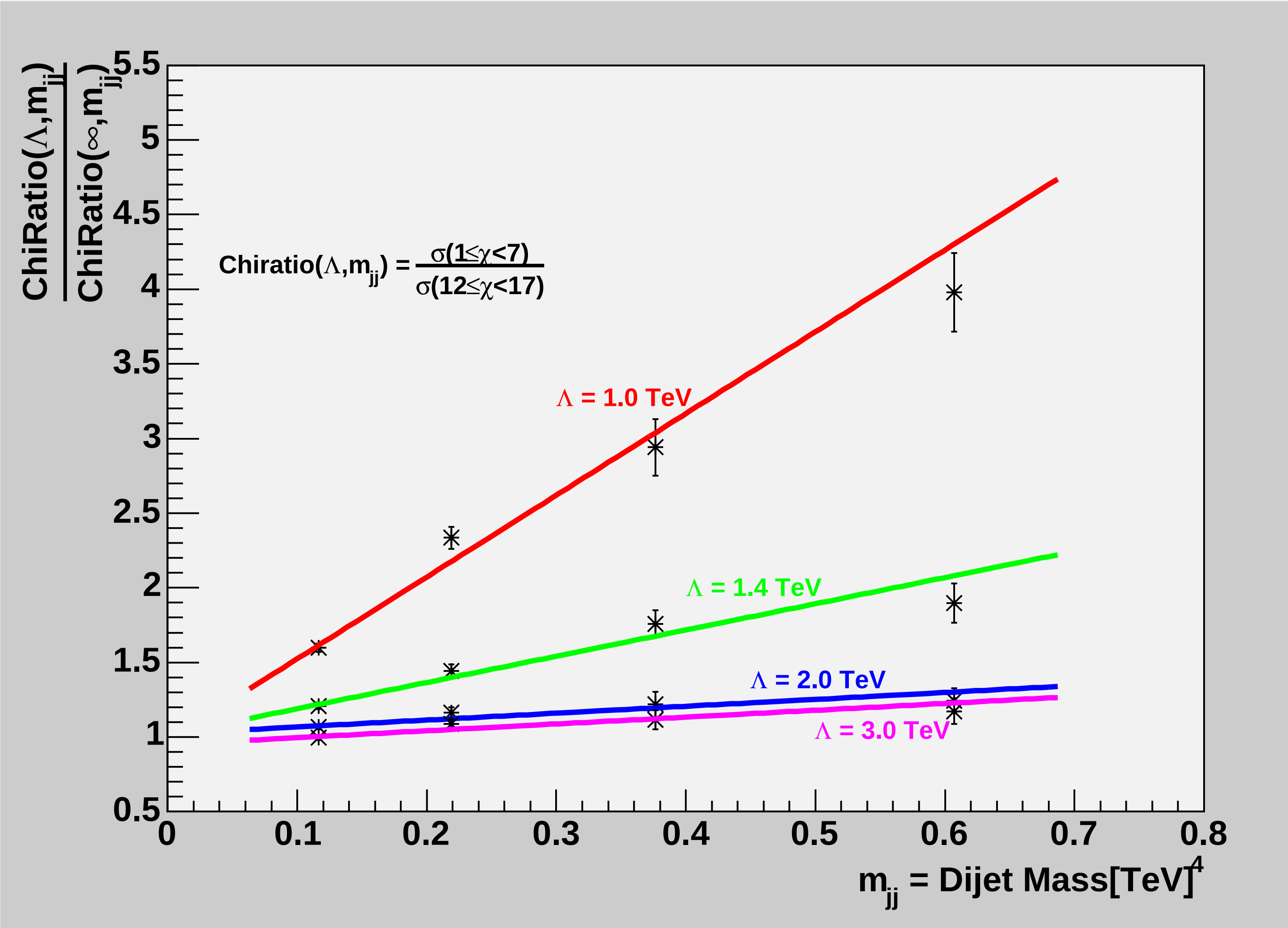
Least χ^2 Fit with Templates



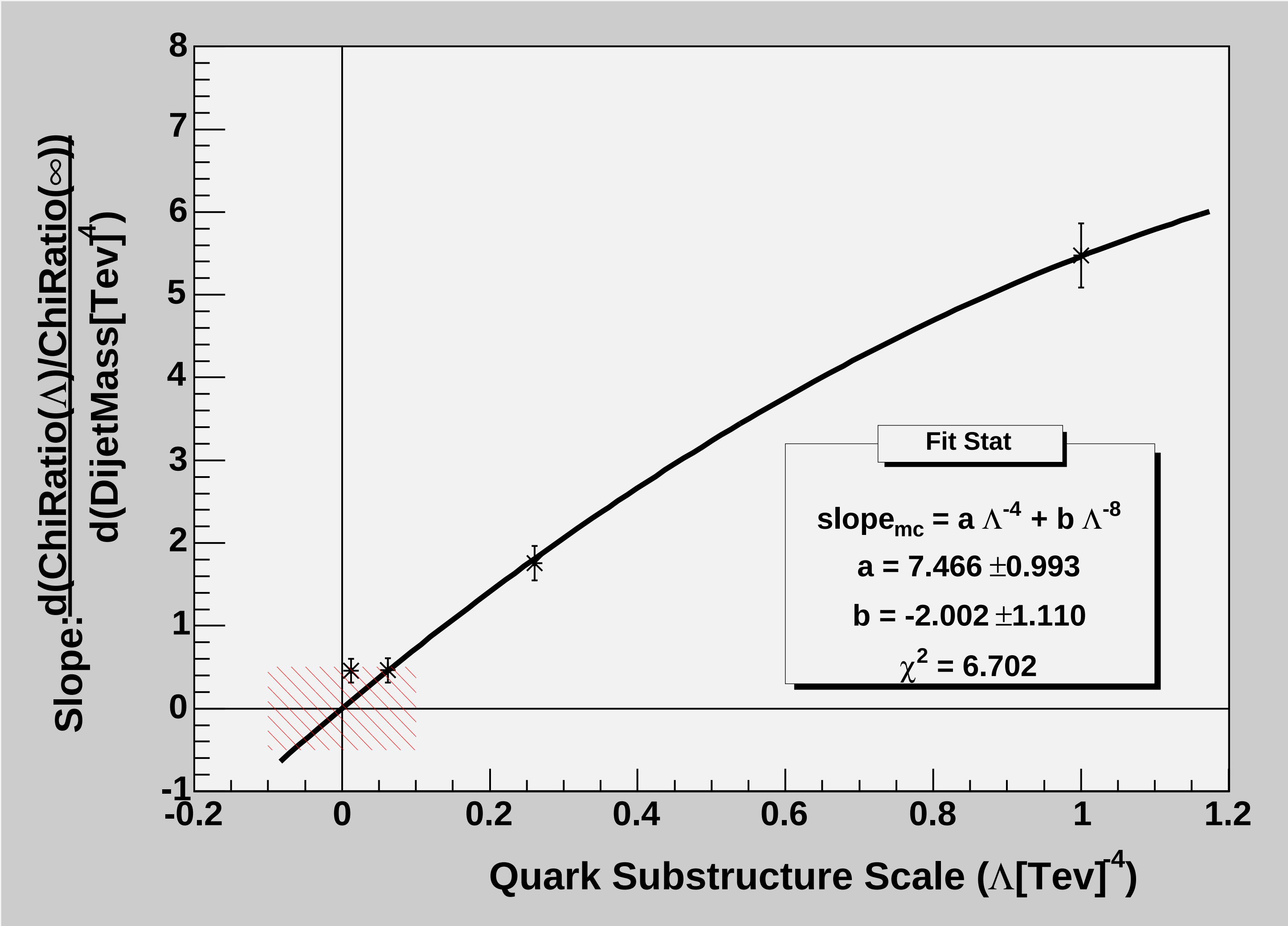
R ratio vs (jet-jet mass)^4 for Data



R ratio vs (jet-jet mass)^4

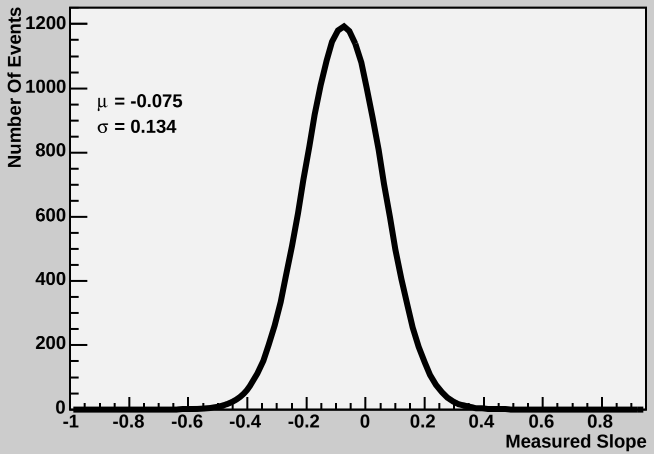


The Slopes vs 1/Λ^4

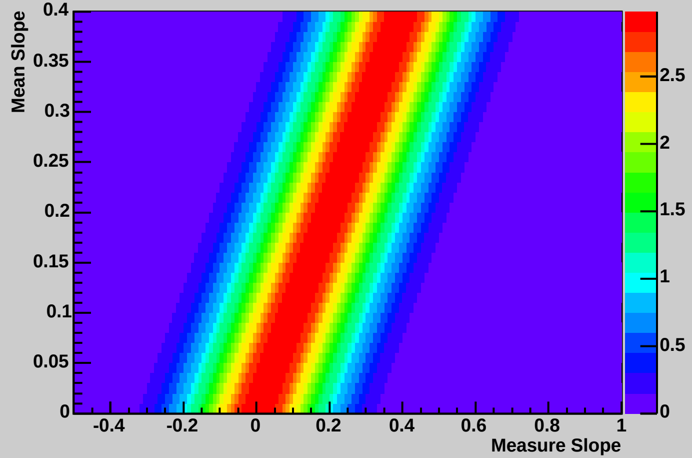


Psuedo Experiment w/ Feldman Cousins

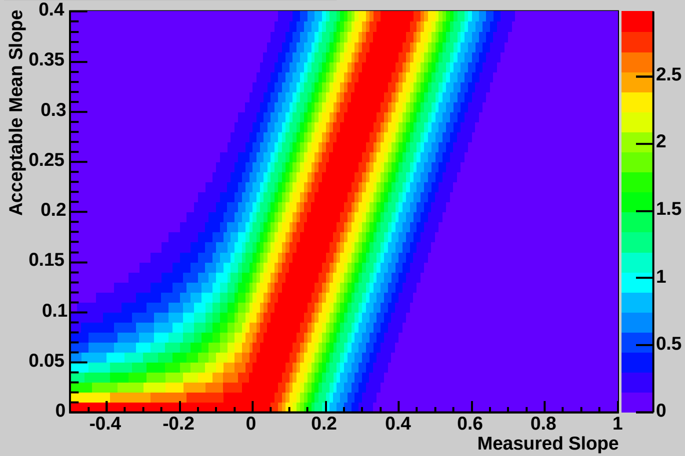
Result of Psuedo Experiment



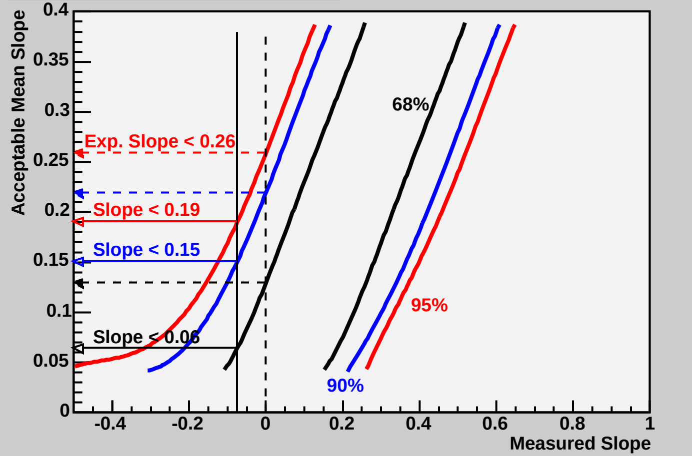
Signal vs Mean Distribution



Renormalized plot



Confidence Interval



Estimation of QSub Limit