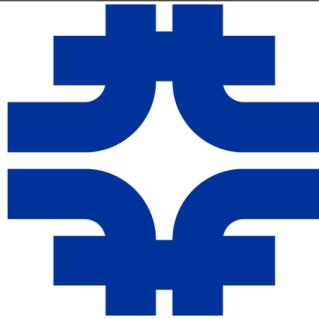


DiJet Mass

Konstantinos Kousouris
Fermilab

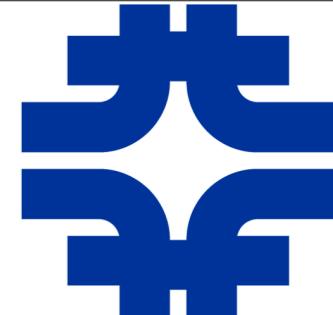
USCMS JTERM III



Outline

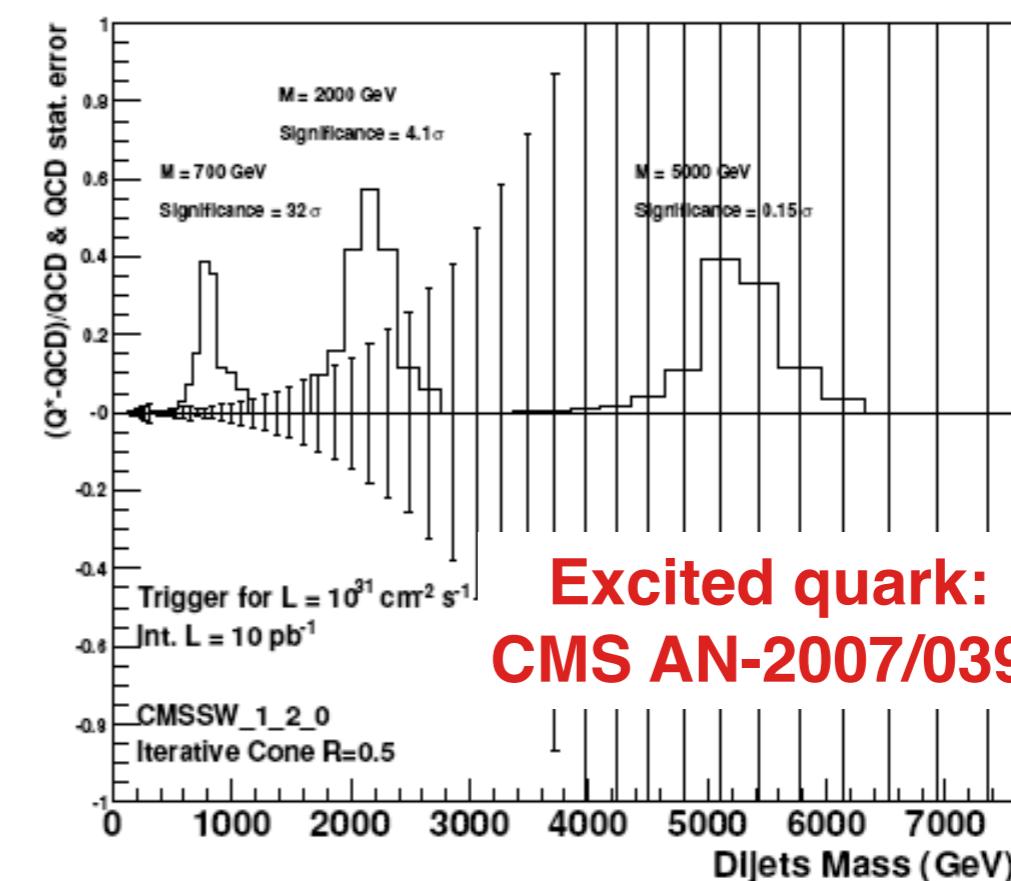
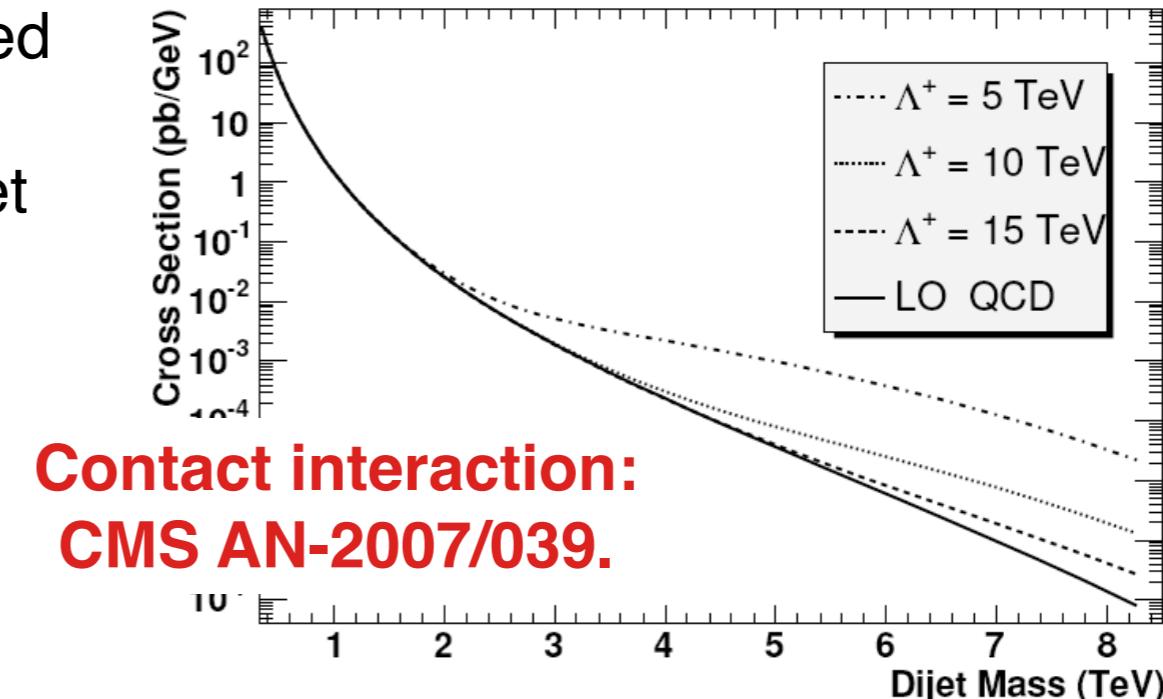
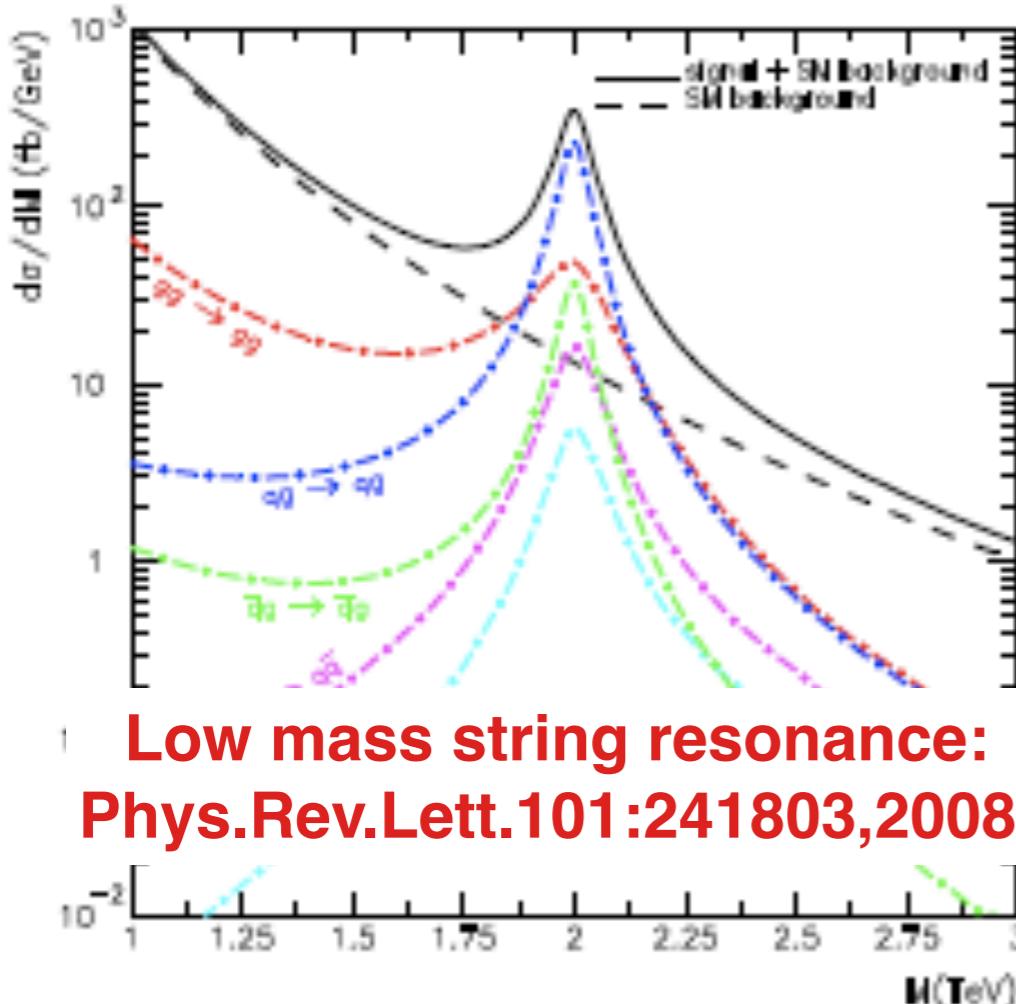
- Physics Motivation
- Spectrum Construction
- Unsmearing
- Comparison to Theory
- Summary



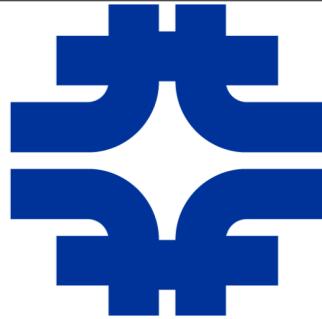


Physics Motivation

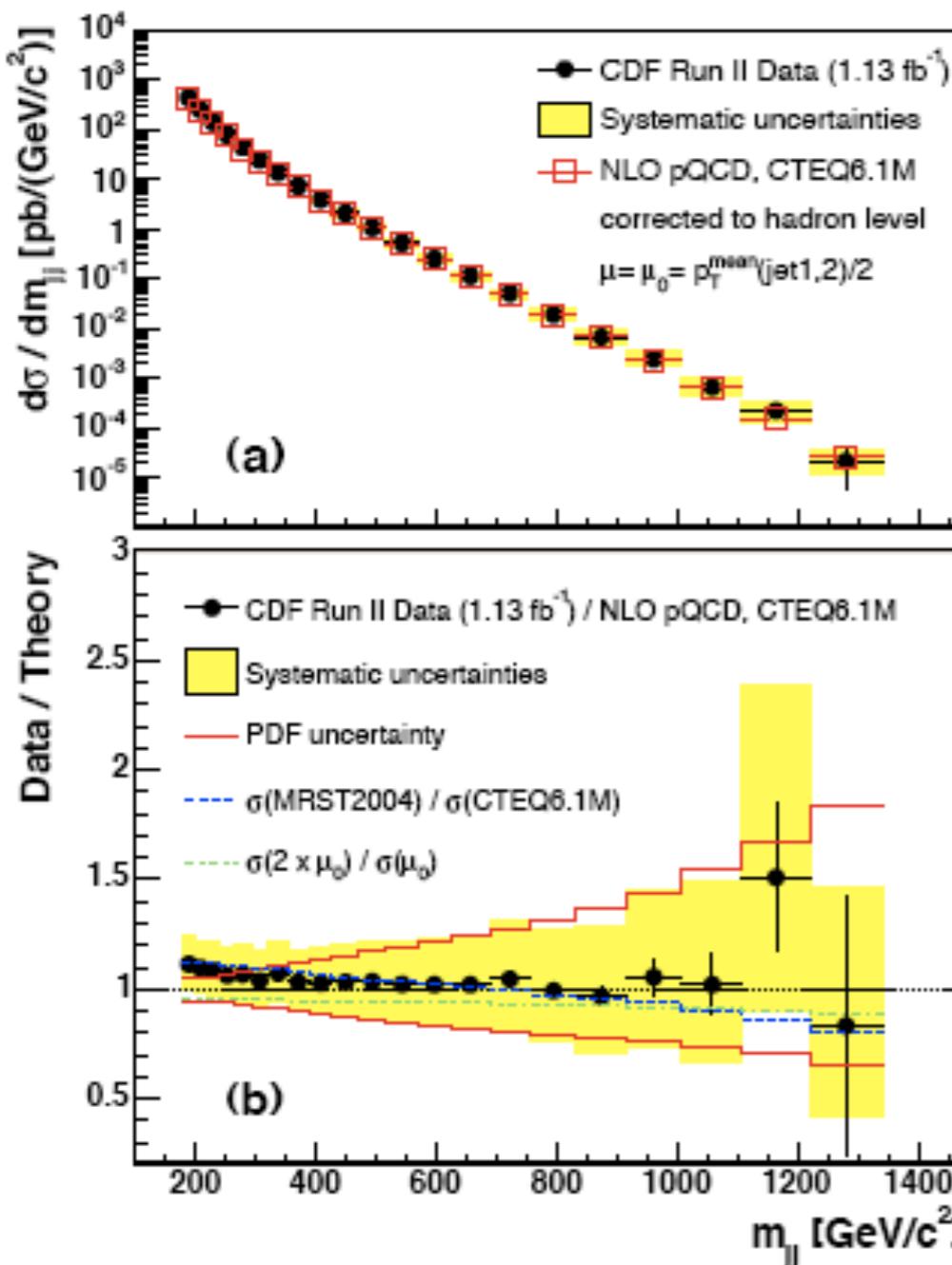
1. The Dijet mass cross section can be used to discover new Physics early on.
2. Sensitive to contact interactions and dijet resonances.
3. Can serve as a QCD precision measurement but only after the jet energy scale is well understood and constrained.



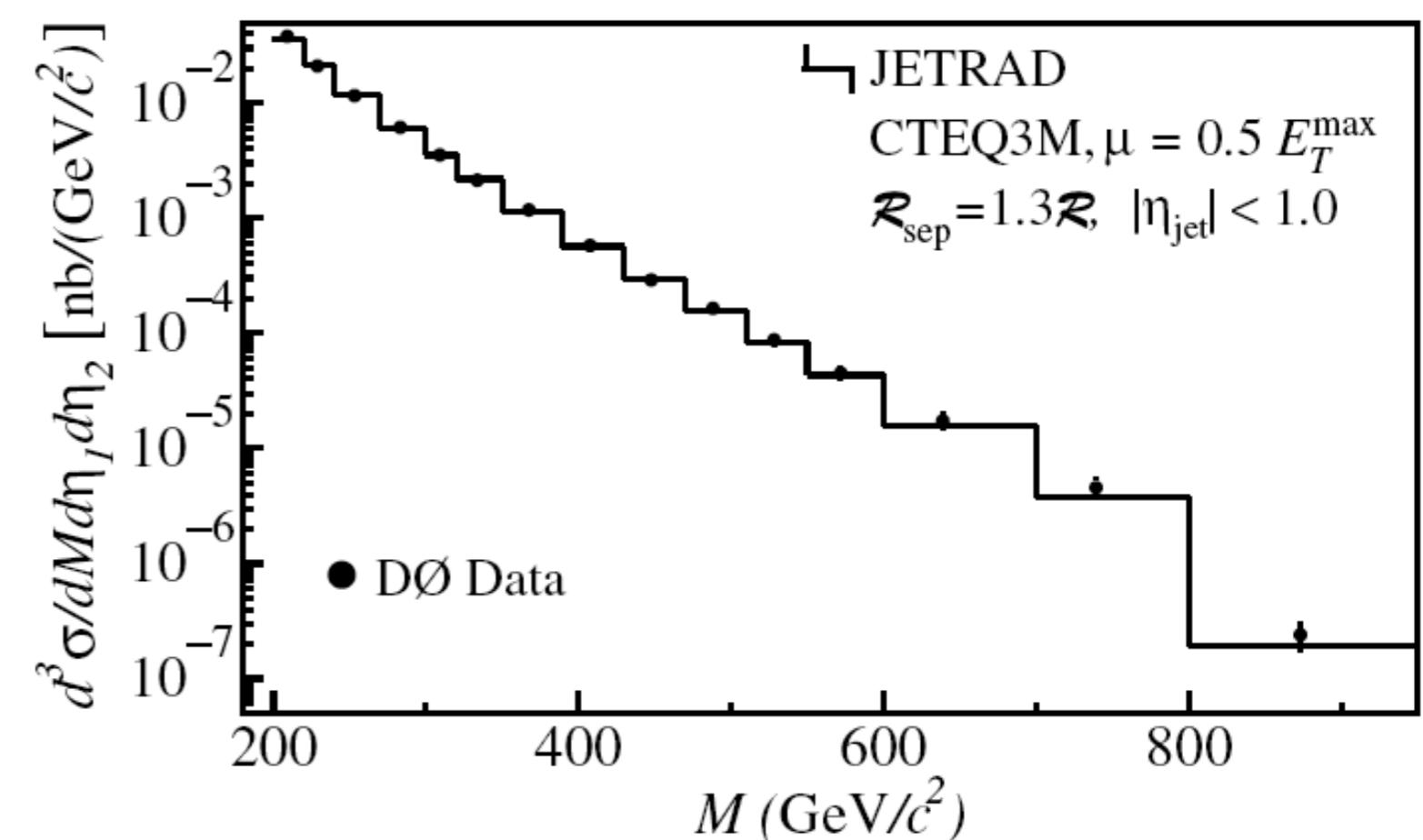
Tevatron Results



CDF Run II:
arXiv:0812.4036 [hep-ex]

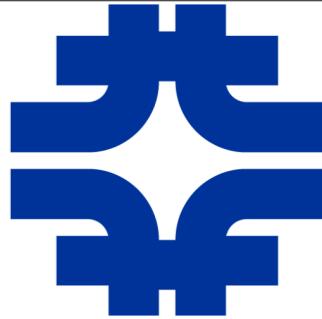


D0 Run I:
Phys.Rev.Lett.82:2457-2462,1999.



Tevatron Reach: $\sim 1.4 \text{ TeV}$





Sample

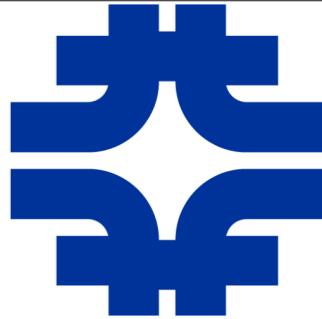
- ✓ Summer08 QCDDiJet (FullSim, 10 TeV CM energy).
- ✓ Jet Algorithm: SIScone R = 0.7.
- ✓ Assuming integrated luminosity L=10pb⁻¹
(~1.5 month @ 1E31cm⁻²s⁻¹ with 25% run efficiency).

/QCDDiJetPt * to *_IDEAL_V9_v*/GEN-SIM-RECO

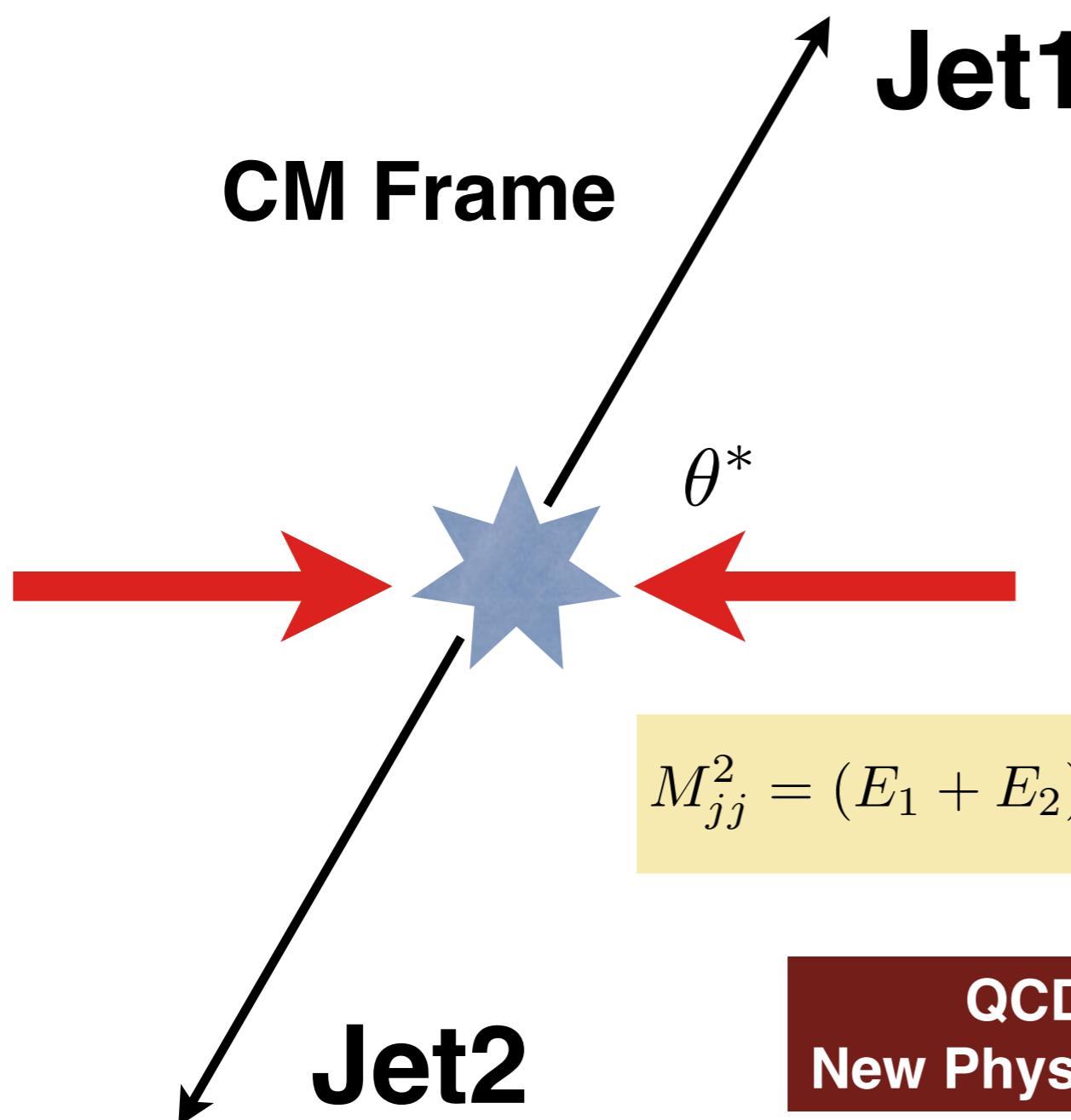
1E31cm⁻²s⁻¹

Trigger Path	Prescale	Events
HLT_L1Jet15	10,000	1.4E+05
HLT_Jet30	2,500	4.7E+05
HLT_Jet50	150	6.8E+05
HLT_Jet80	10	1.1E+06
HLT_Jet110	1	2.8E+06





Kinematic Definitions



$$\eta^* = \frac{1}{2}(\eta_1 - \eta_2)$$

$$\eta_{boost} = \frac{1}{2}(\eta_1 + \eta_2)$$

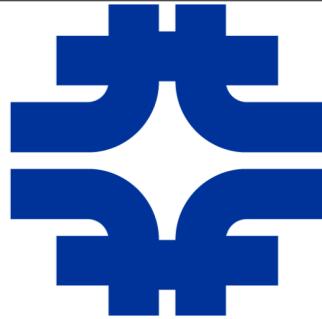
$$\cos \theta^* = \tanh \eta^*$$

$$\chi = \frac{1 + \cos \theta^*}{1 - \cos \theta^*}$$

$$M_{jj}^2 = (E_1 + E_2)^2 - (\vec{p}_1 + \vec{p}_2)^2 = 2p_{T,1}p_{T,2} (\cosh \Delta\eta - \cos \Delta\phi)$$

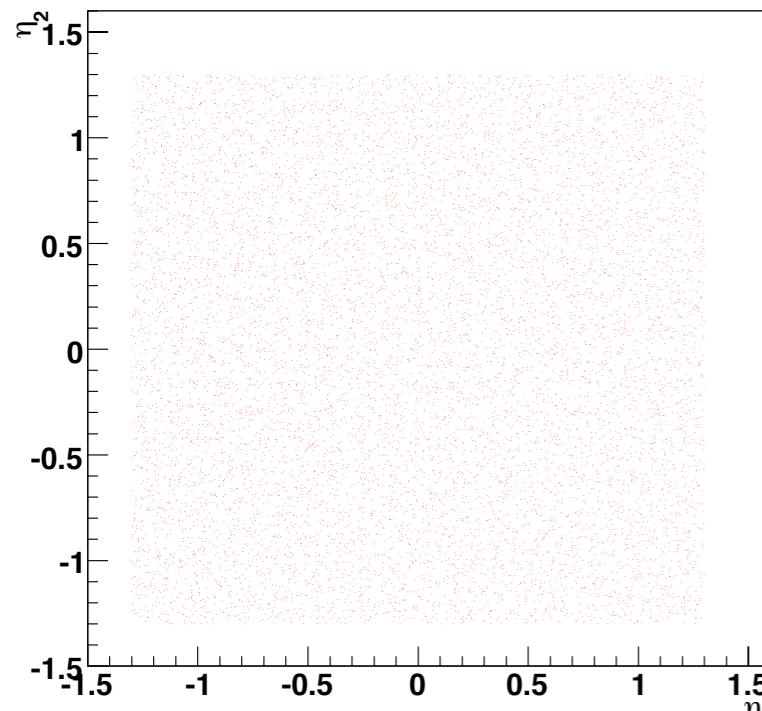
QCD: $\cos\theta^* \sim 1$ (t-channel scattering)
New Physics: uniform θ^* (s-channel scattering)



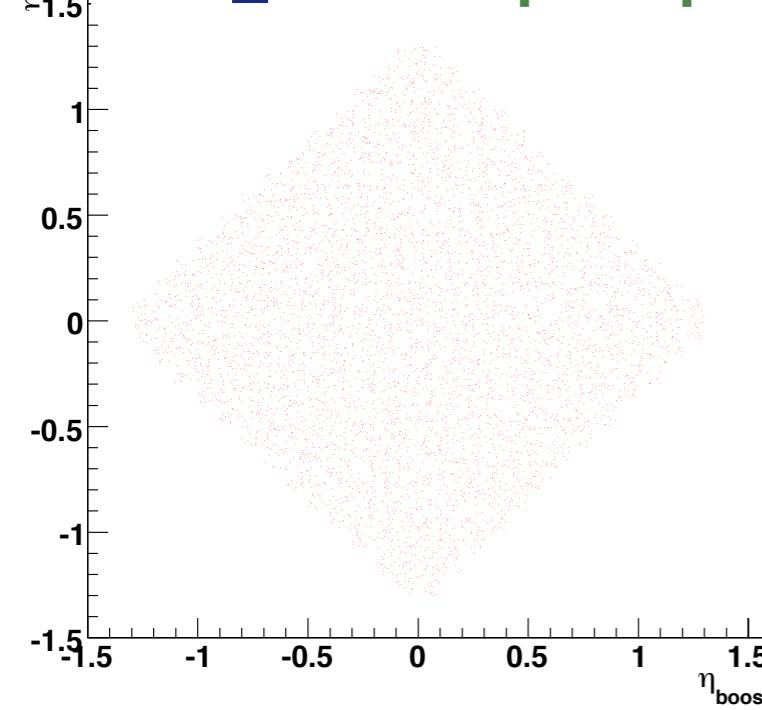


Basic Kinematic Distributions (I)

HLT_Jet110 η_1 vs η_2

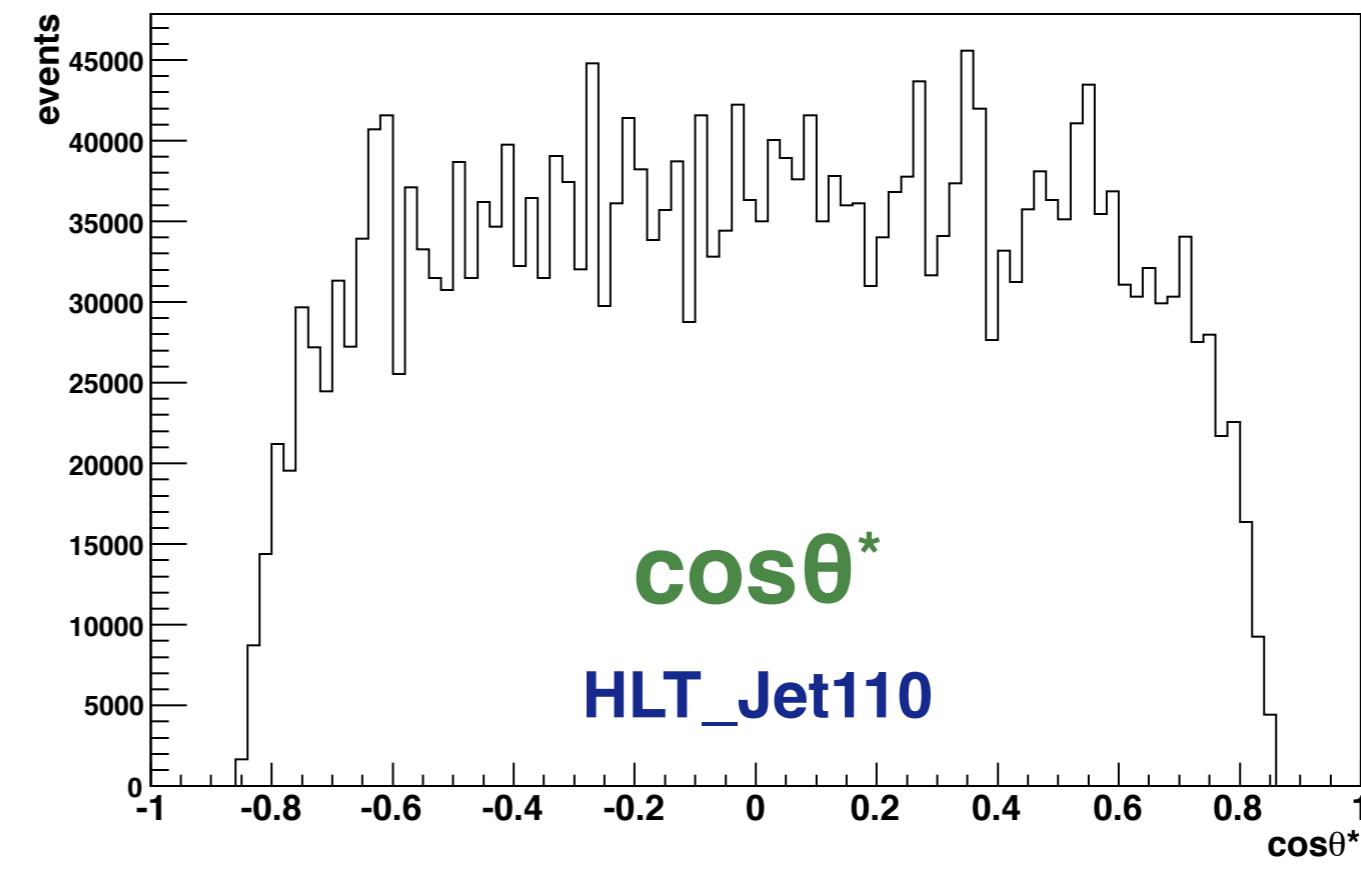


HLT_Jet110 η^* vs η_{boost}



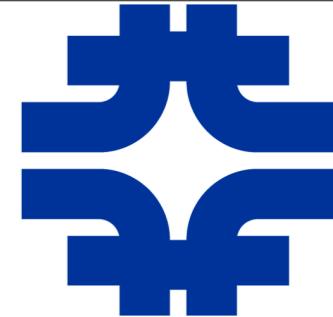
Event selection:
At least two jets with $|\eta_1|, |\eta_2| < 1.3$

Constrain the measurement in the Barrel
(better understood detector, higher
sensitivity to new physics).

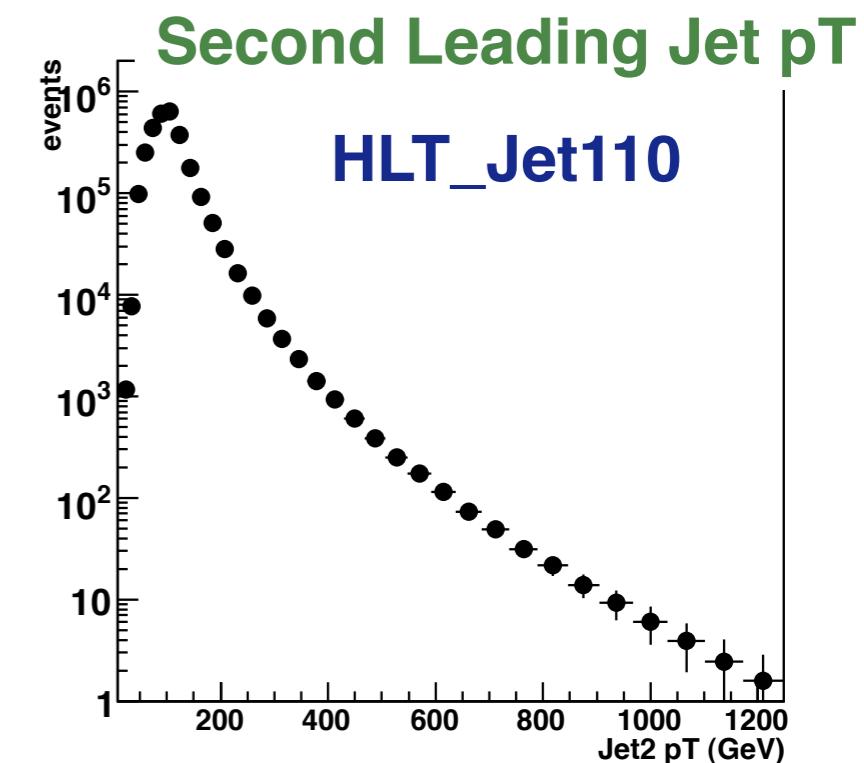
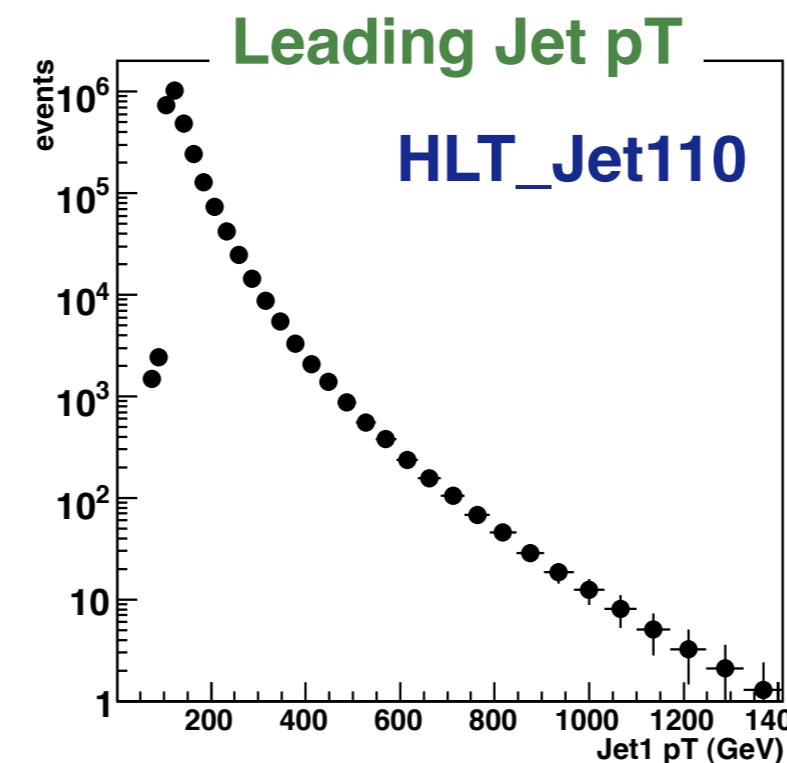
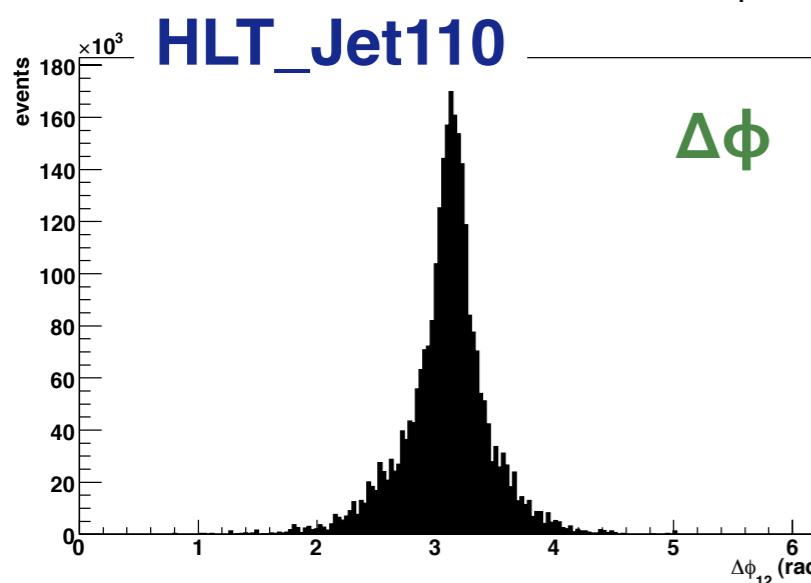
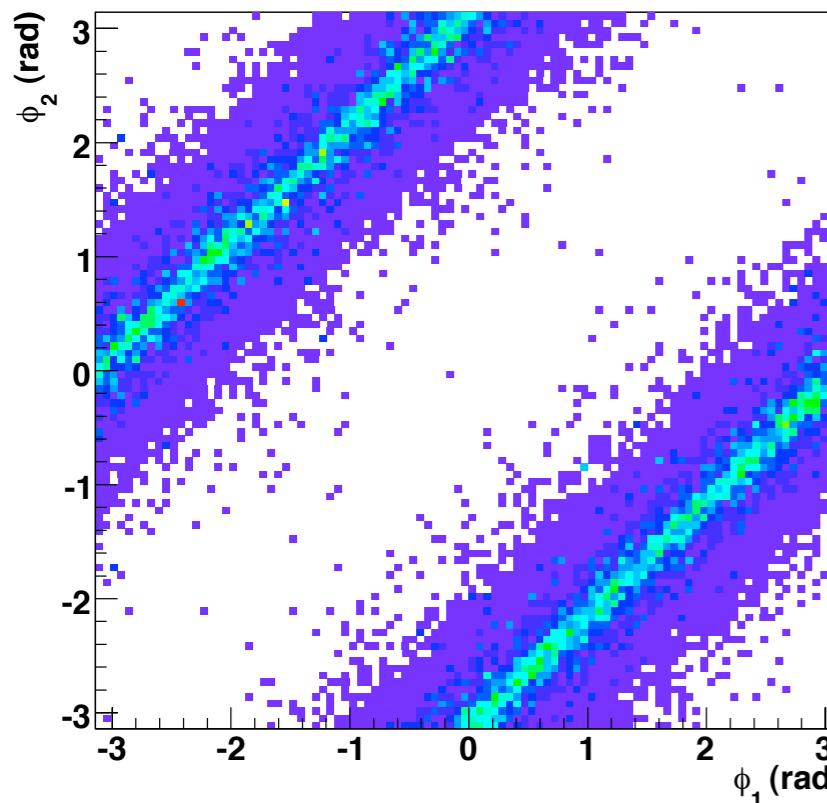


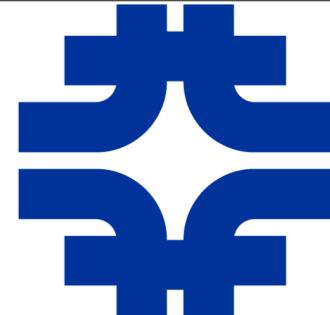


Basic Kinematic Distributions (II)



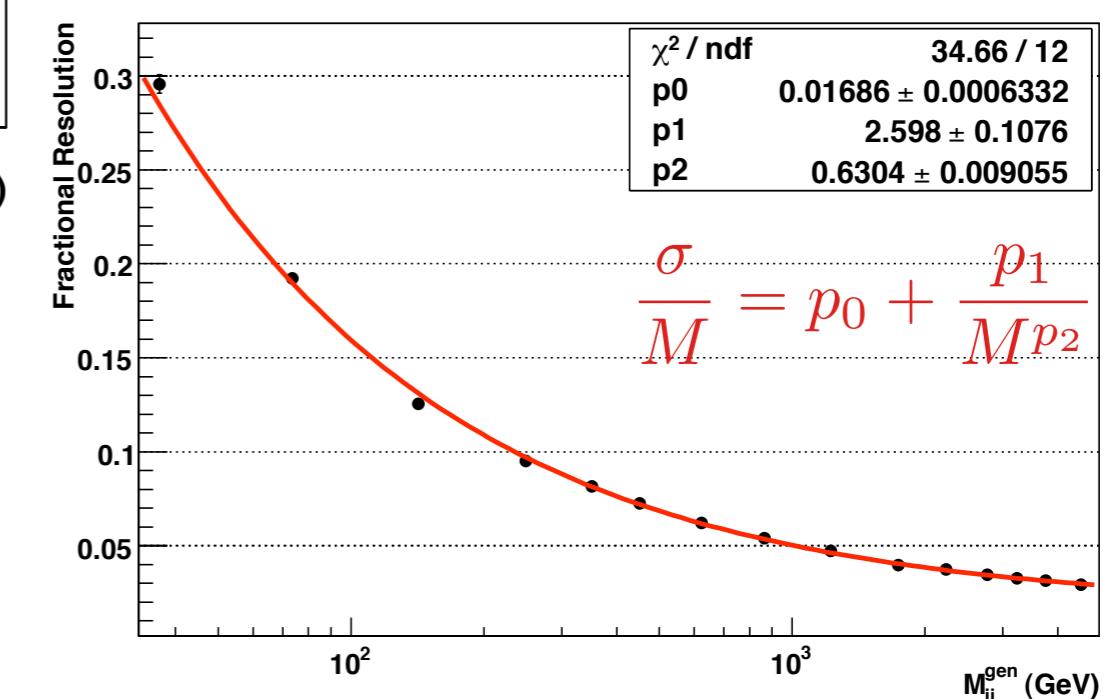
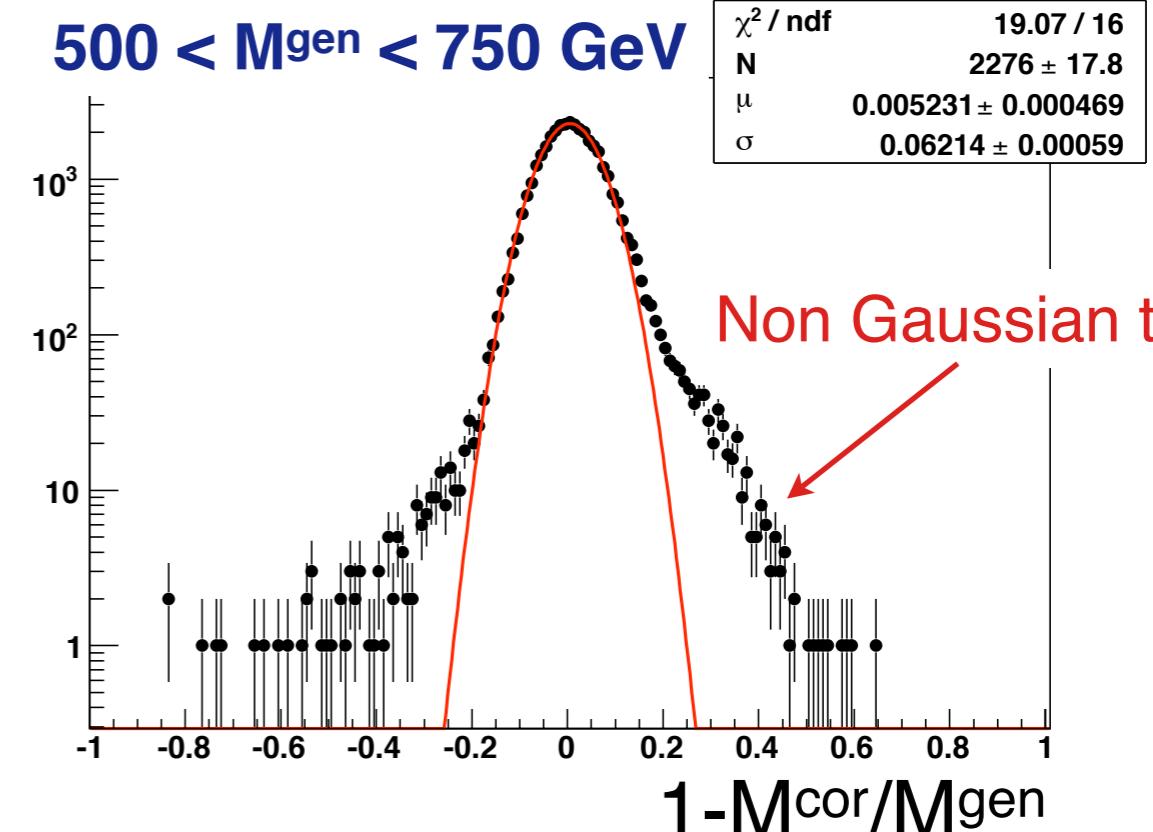
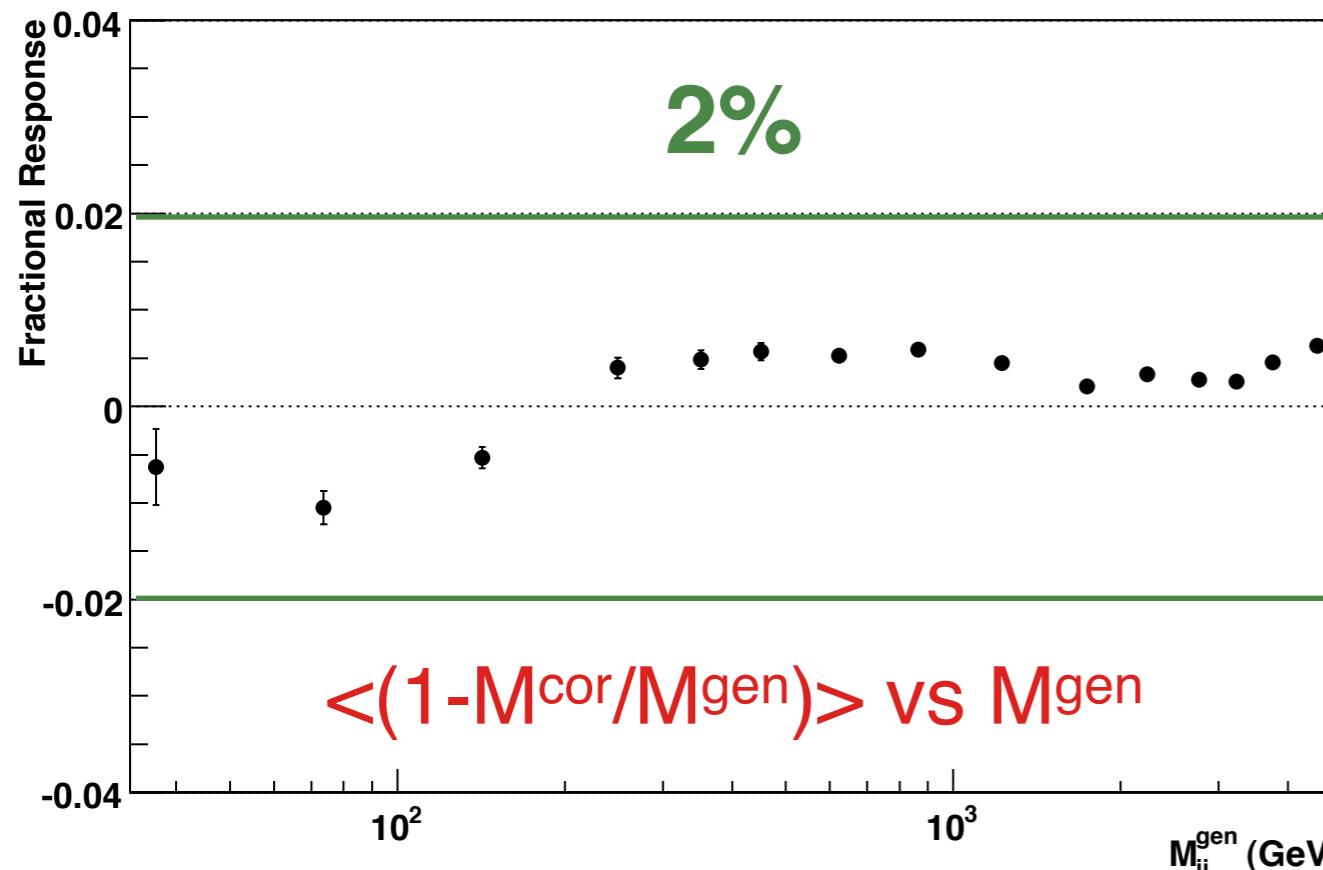
HLT_Jet110 ϕ_1 vs ϕ_2

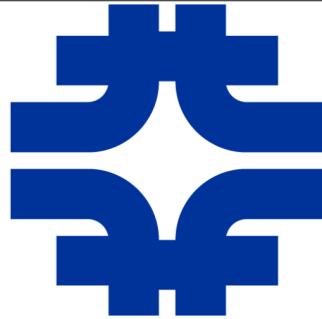




Mass Resolution

Default Summer08 L2+L3
Jet Corrections applied.





Measurement

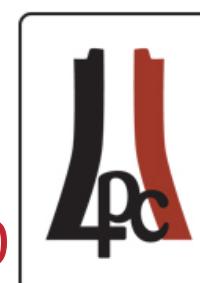
Event counting in
bins of dijet mass.

unsmeared
correction

differential cross
section

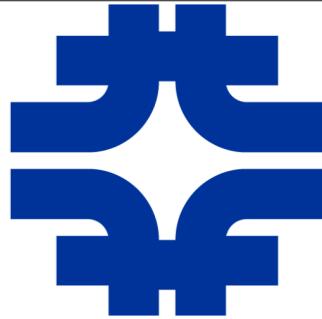
$$\frac{d\sigma}{dM} = \frac{C_{uns}}{\mathcal{L} \cdot \epsilon} \cdot \frac{N_{dijets}}{\Delta M}$$

integrated luminosity jetID & event cleanup efficiency

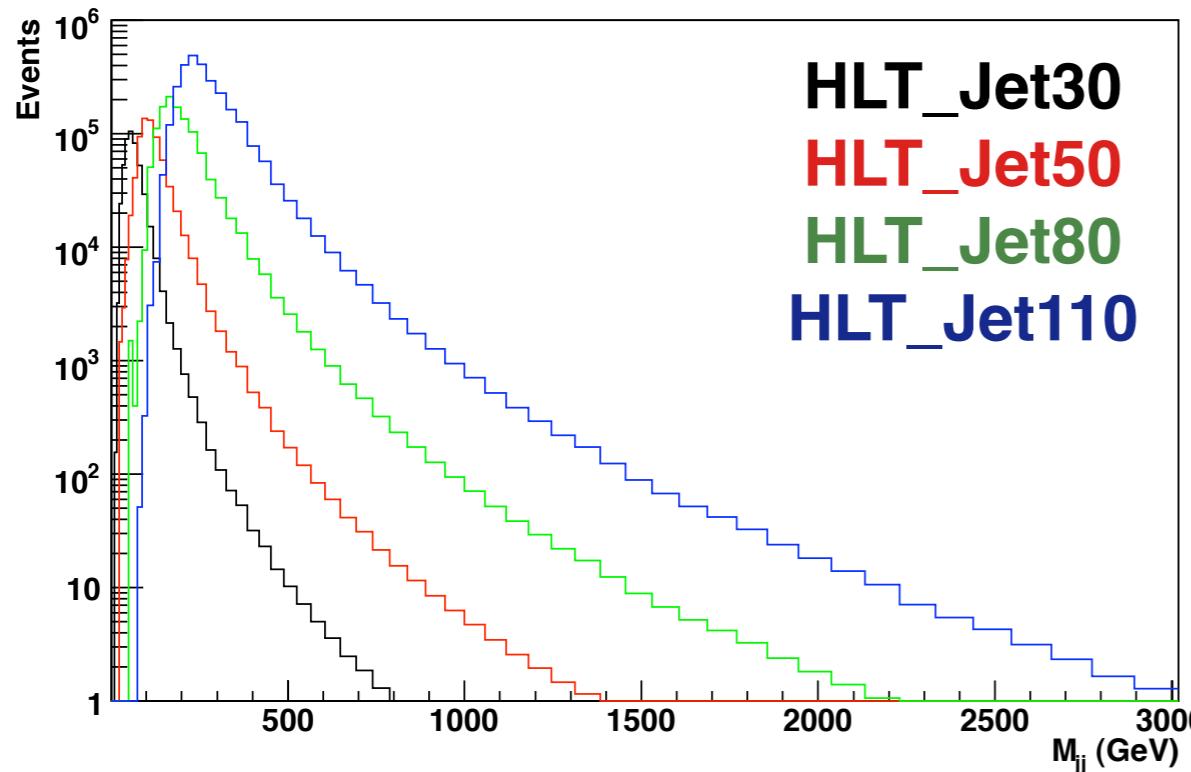




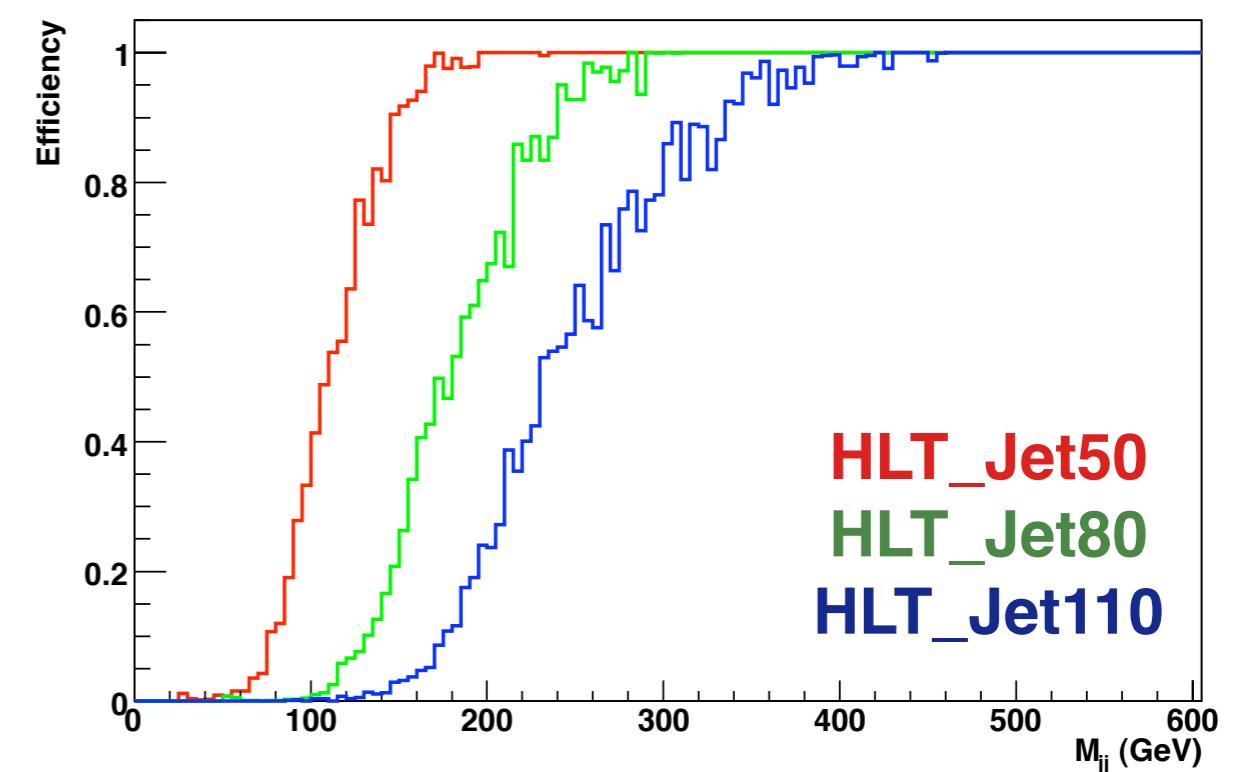
Spectrum Construction (I)



Trigger Yield vs Mass



Trigger efficiency vs Mass



99% efficiency points

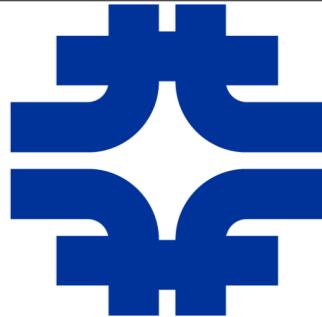
Trigger	Mass (GeV)
HLT_Jet30	97
HLT_Jet50	203
HLT_Jet80	308
HLT_Jet110	426

MC values!!! Need to
be calculated again
from data!!!

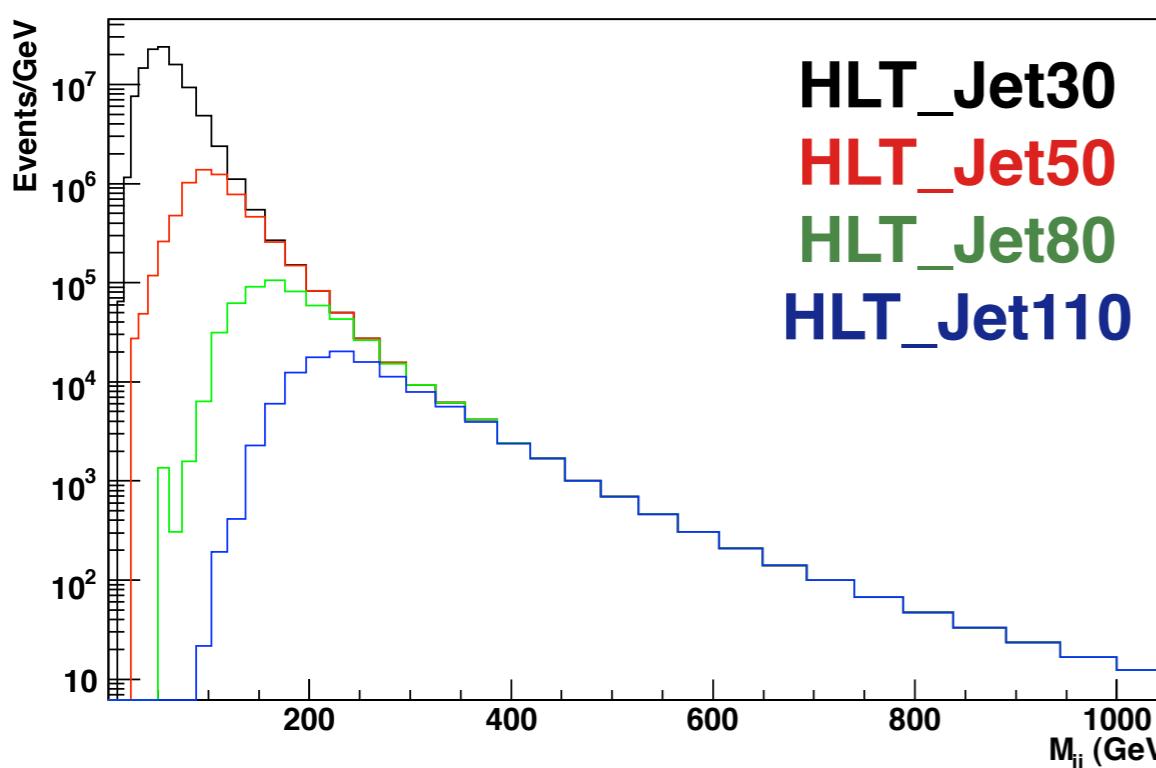




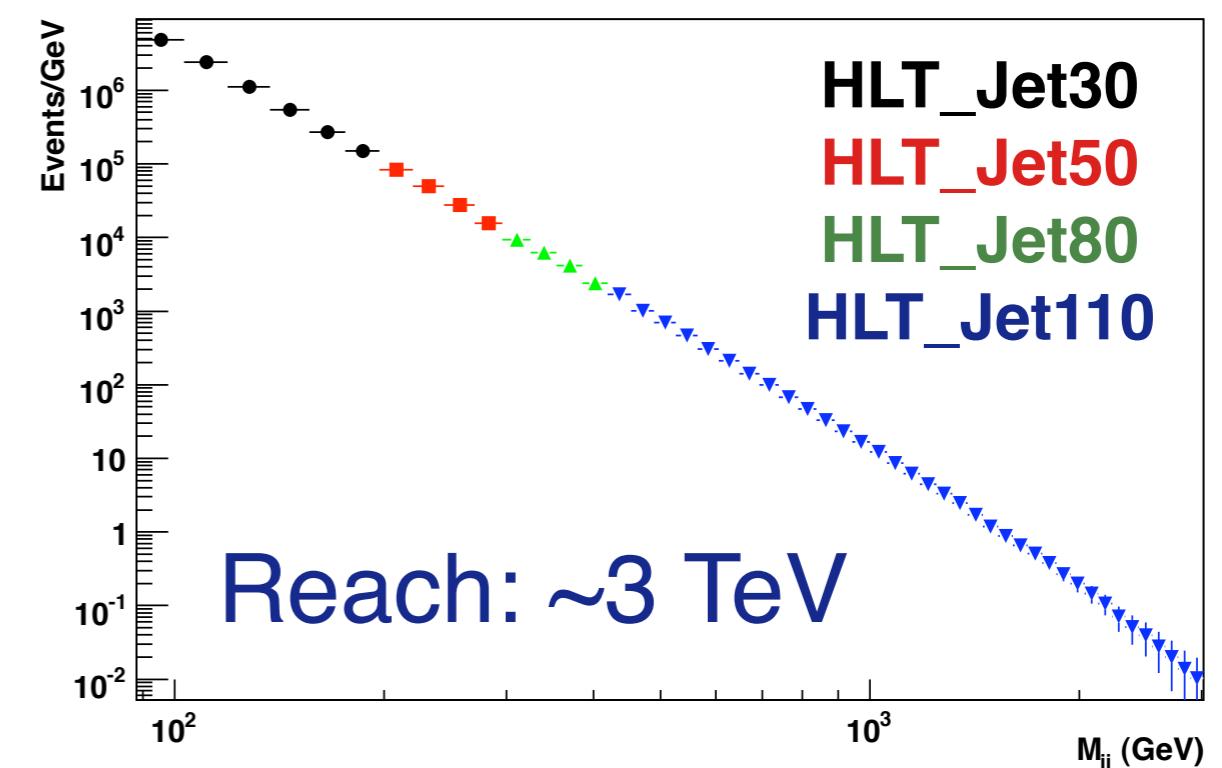
Spectrum Construction (II)



Normalized Spectra,
corrected for Prescale



Combined Spectrum

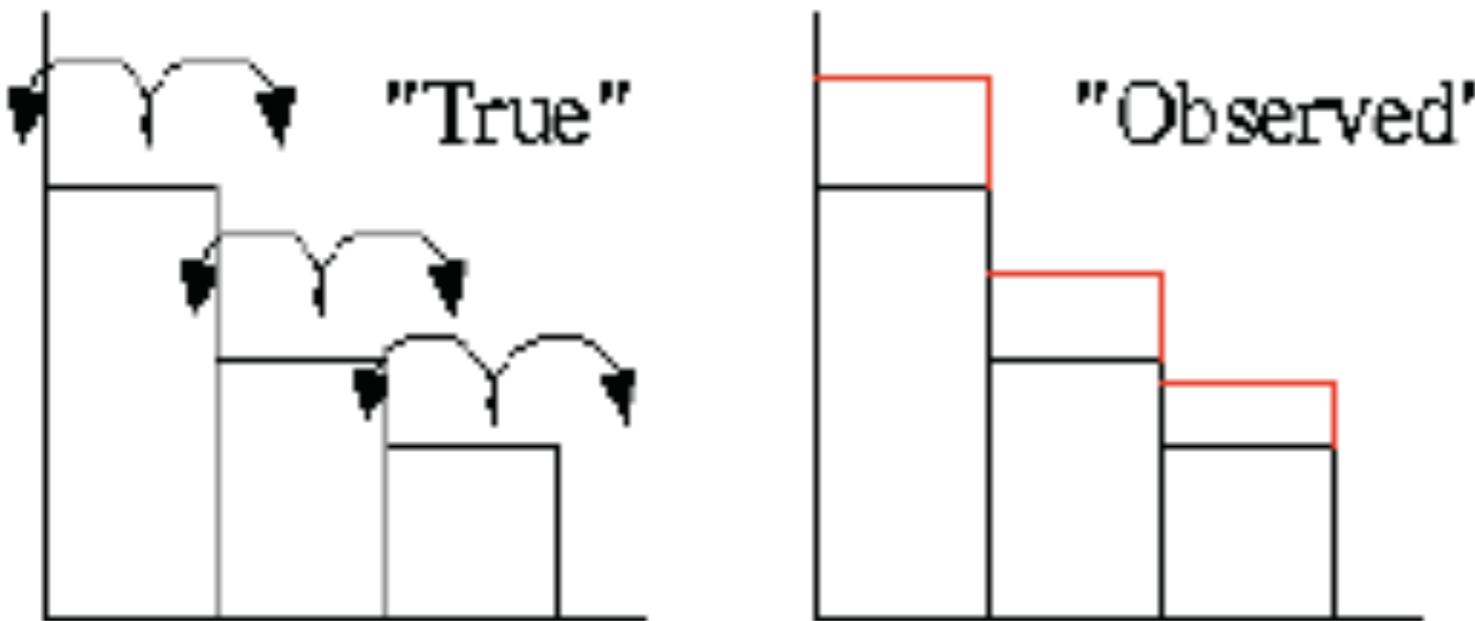
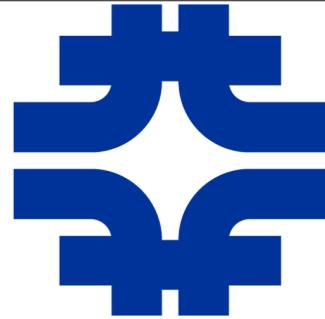


Each mass bin is populated by only
one trigger (the highest fully efficient).



Unsmearing Basics

(The Ansatz function technique)



The observed spectrum is overestimated: due to the finite resolution and the steeply falling spectrum, more events migrate into a given mass bin. **Unsmearing correction** must be applied.

$$f(M) = N \cdot M^{-a} \cdot \left(1 - \frac{M}{\sqrt{s}}\right)^b \cdot \exp(-C \cdot M)$$

$$R(M, M^{gen}) = \frac{1}{\sqrt{2\pi} \sigma(M^{gen})} \cdot \exp\left[-\frac{(M - M^{gen})^2}{2\sigma^2(M^{gen})}\right]$$

$$F(M) = \int_0^\infty f(M^{gen}) \cdot R(M, M^{gen}) dM^{gen}$$

$$C_{bin} = \frac{\int_{bin} f(M) dM}{\int_{bin} F(M) dM}$$

Ansatz Function
(real spectrum)

Resolution model

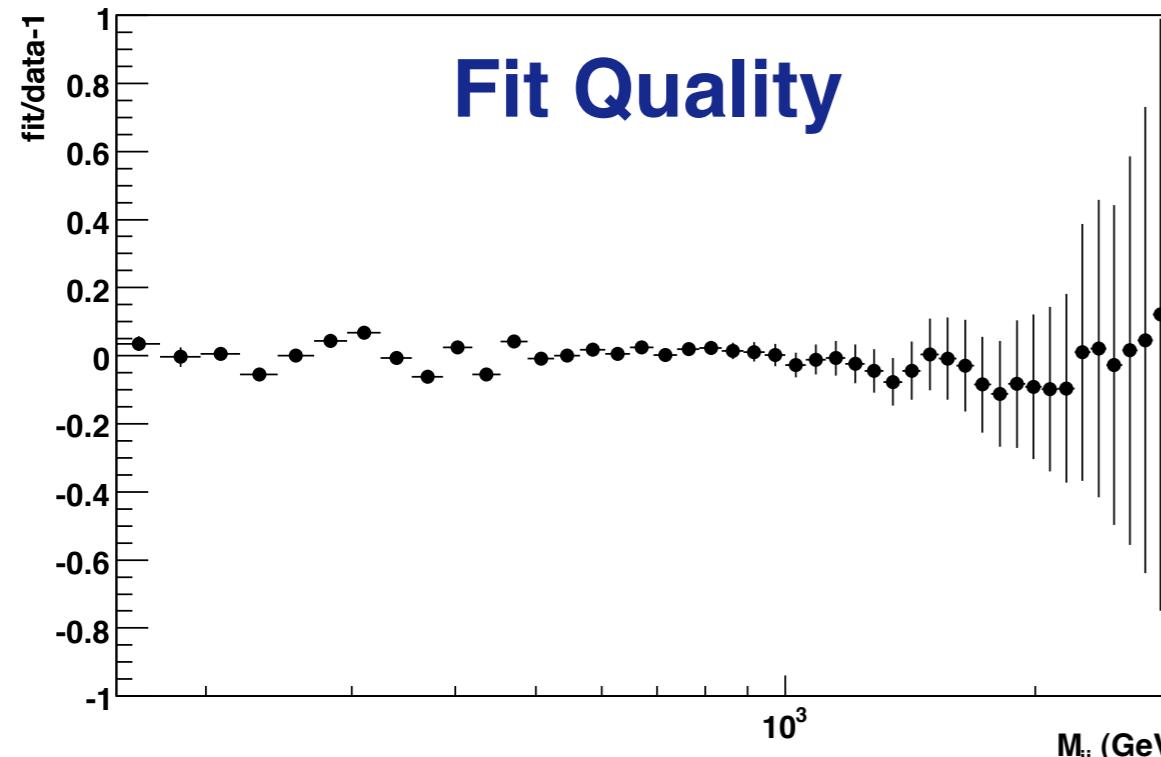
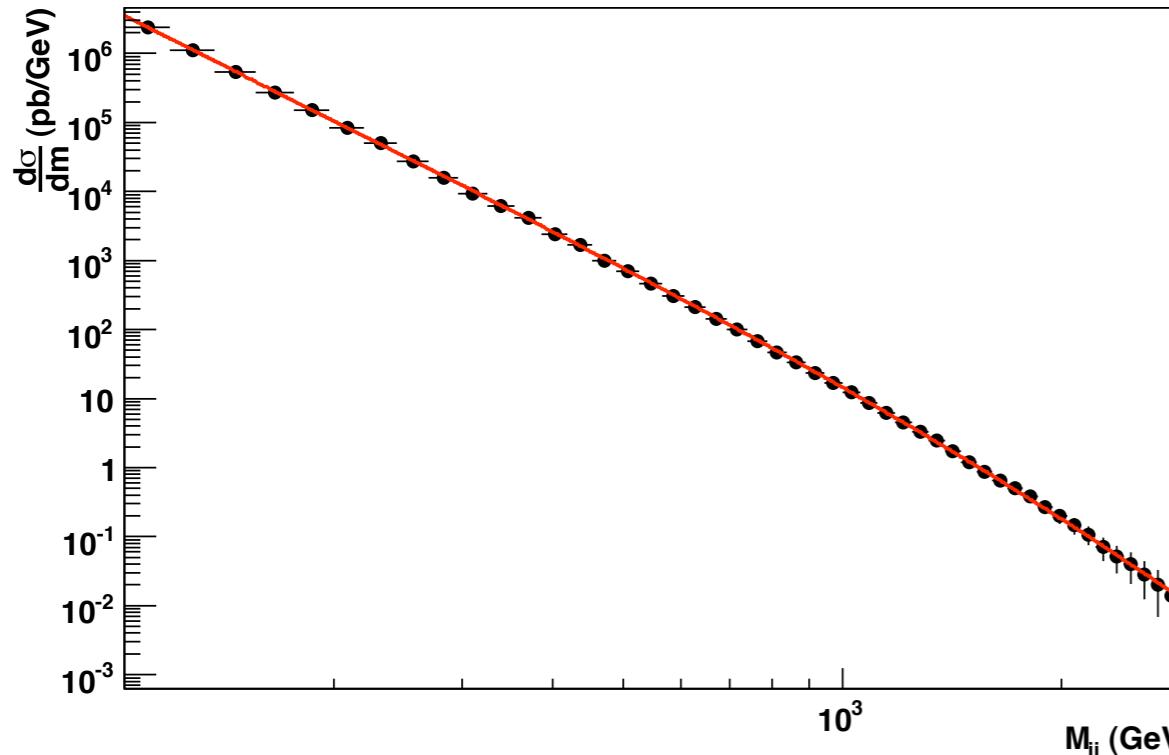
Fitting function
(fits the observed spectrum)

Unsmearing correction factor
(applied to data, bin by bin)

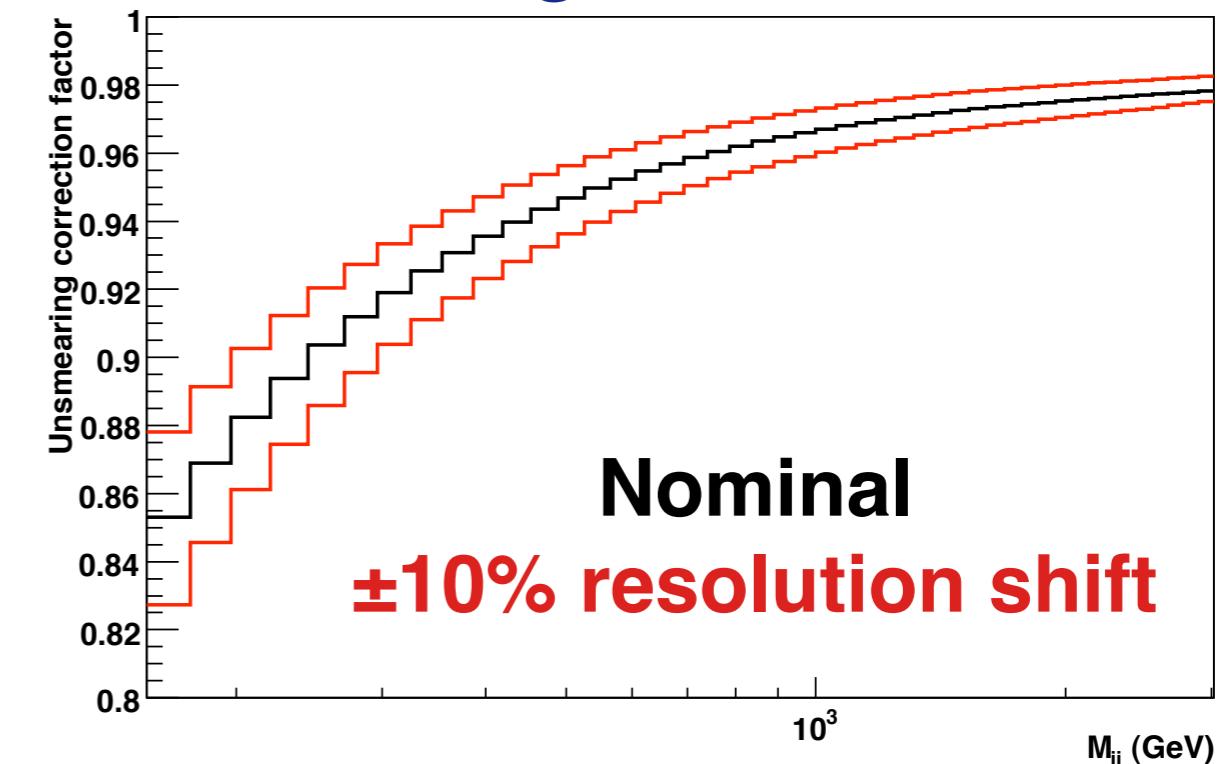


Unsmearing Results

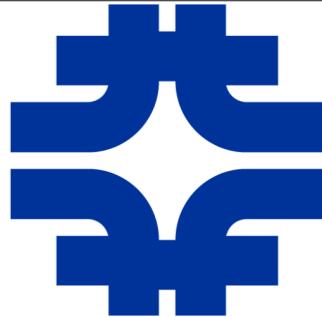
Fitted measured spectrum



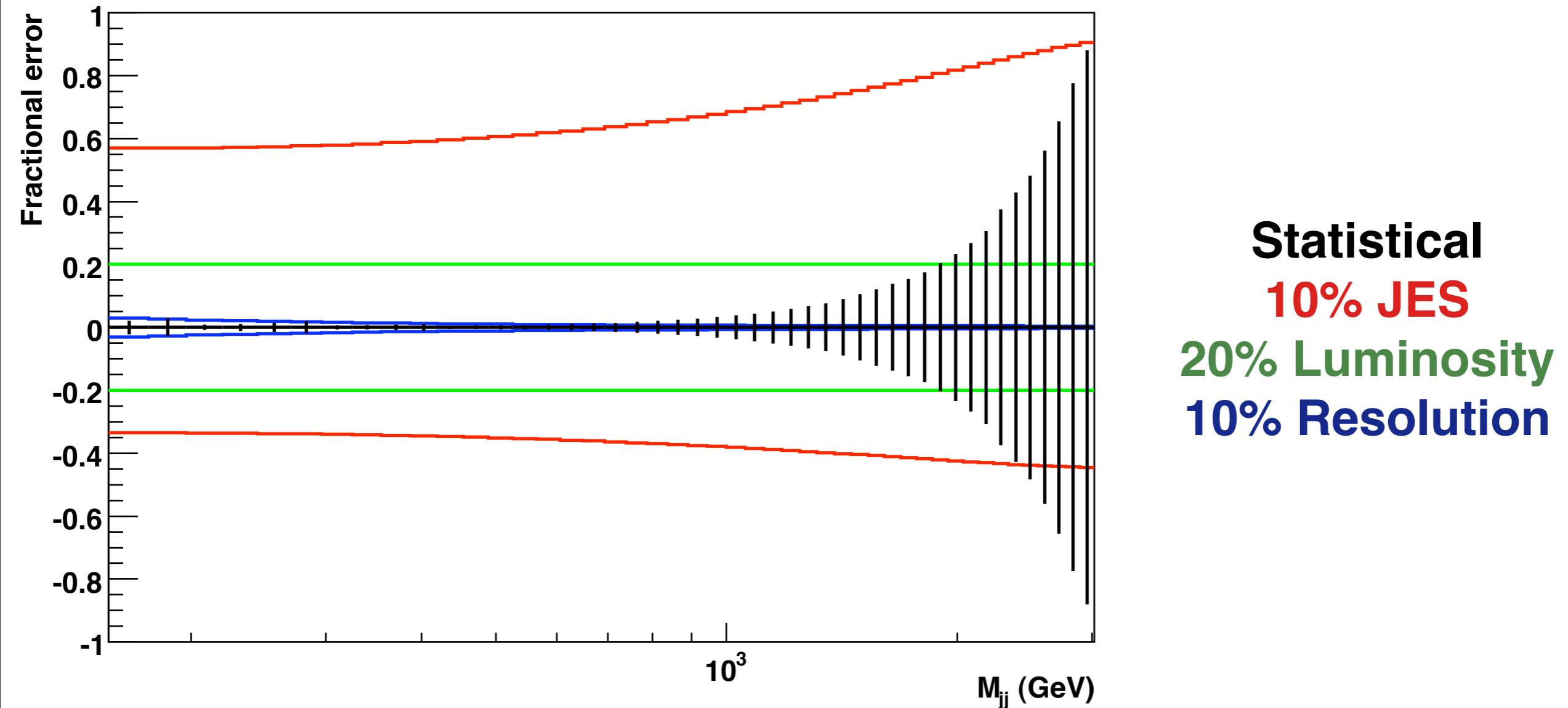
Unsmearing correction factor



The unsmearing correction is moderately sensitive to the resolution uncertainty. However, the inadequate modelling of the resolution tails can largely affect the low mass region.



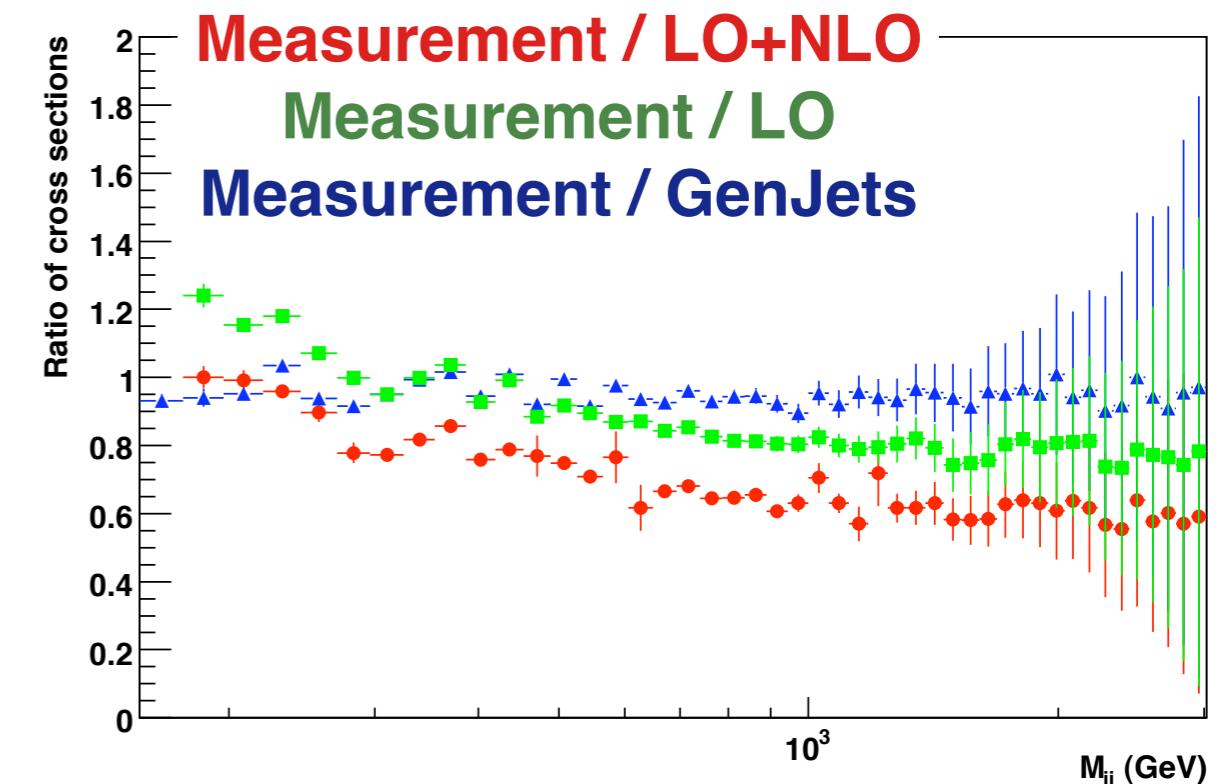
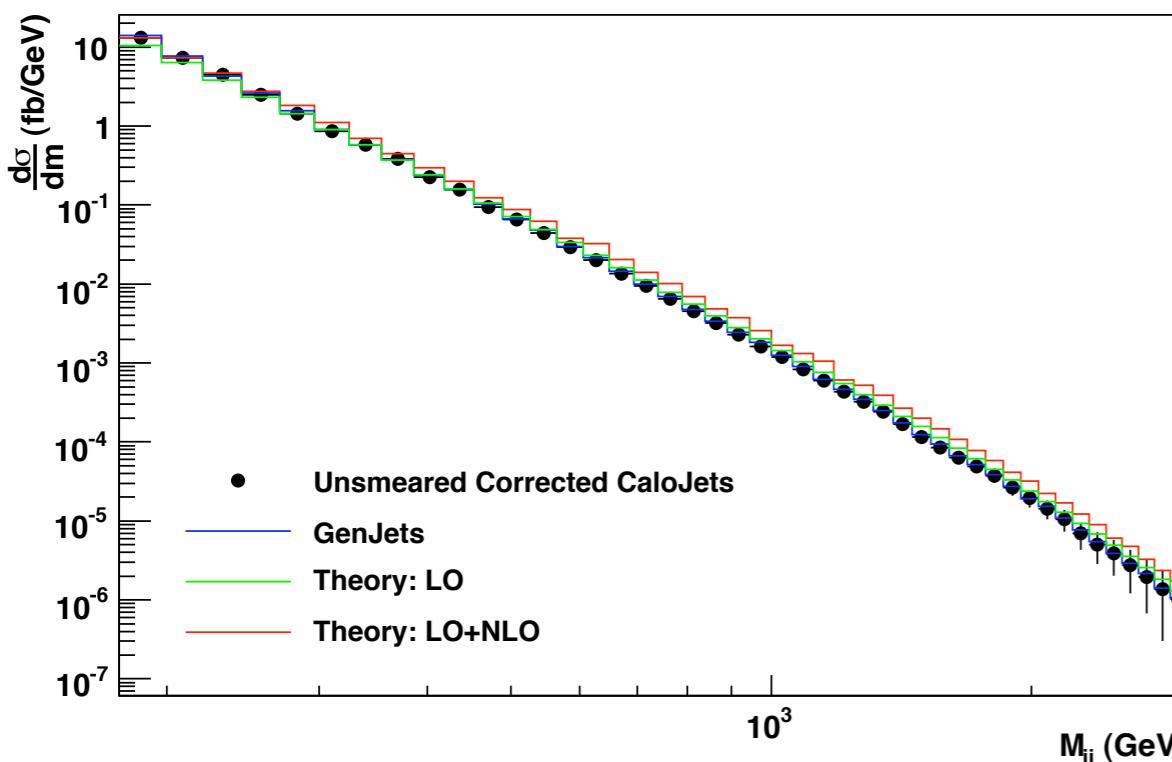
Experimental Uncertainties



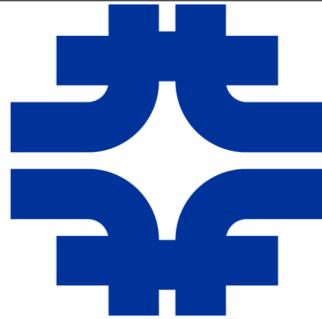
The JES uncertainty is dominant !!! Due to the steeply falling mass spectrum, a small shift of the jet energy leads to large shift of the cross section.



Comparison to Theory



1. The unsmeared corrected jet spectrum is in good agreement (within 5%) with the particle jet spectrum.
2. The LO and NLO predictions (parton level) are not directly comparable with the measured spectrum (particle level). An additional hadronization correction needs to be applied to the theory calculations.
3. The better agreement of LO to the measurement than the NLO is expected (The MC data are produced with PYTHIA which is a LO generator).



Summary

- The Dijet mass cross section is sensitive to new physics (contact interactions, dijet resonances) even with early data.
- A small amount of data ($\sim 10\text{pb}^{-1}$ @ 10 TeV collisions) is enough to allow a measurement far beyond the Tevatron reach.
- A precise workflow for the dijet mass cross section measurement has been determined and practised while anticipating the collision data.
- The sensitivity to the major experimental uncertainties has been investigated: the JES uncertainty dominates.
- NLO pQCD calculations have become available (by K.Hatakeyama) for comparison to the data.
- Next steps: estimation of the hadronization correction, investigation of the theoretical uncertainties.

