Search for Contact Interactions @ 8 TeV
Status Report

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Exotica Multijets Working Group Meeting

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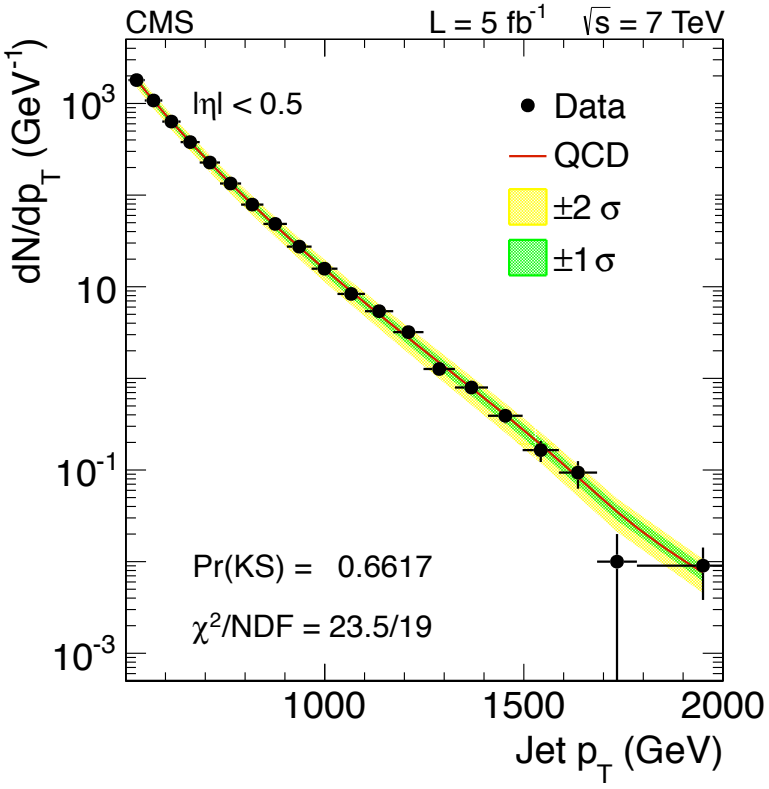
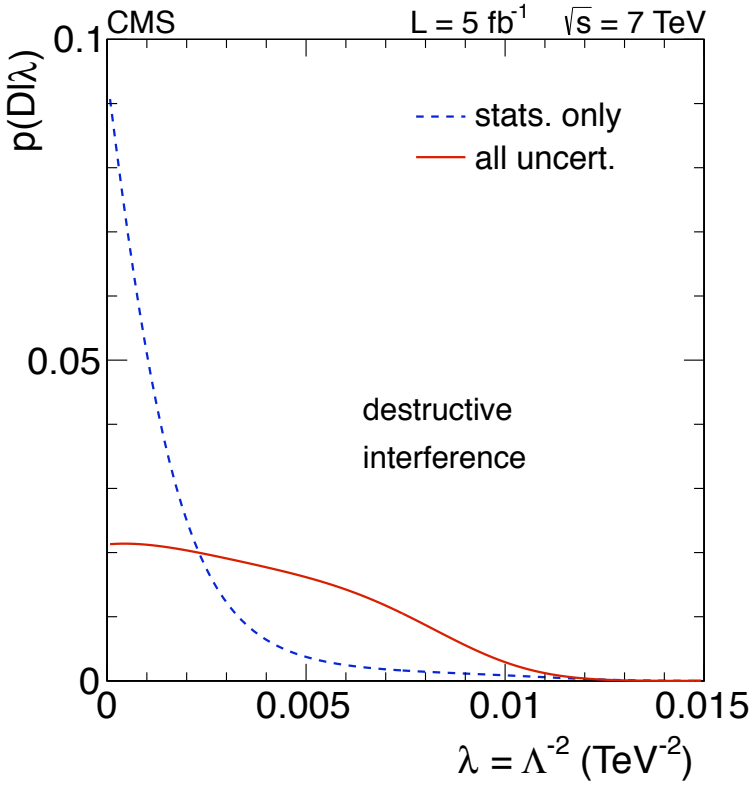
Contact Interaction (CI) Search @ 7 TeV





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Search for contact interactions using the inclusive jet p_T spectrum in pp collisions at $\sqrt{s} = 7$ TeV

S. Chatrchyan *et al.**
(CMS Collaboration)

(Received 21 January 2013; published 26 March 2013)

Outline

1. Overview
2. Analysis Overview
3. Status
4. Plans

Overview

Goal

- Compare the inclusive jet p_T spectrum at 8 TeV of $|y| < 0.5$ jets to QCD+CI models computed at NLO accuracy, and draw conclusions about possible new QCD-like interactions, modeled as contact interactions.

Experimental Input

- Measured inclusive jet p_T spectrum above 500 GeV where trigger efficiency is flat
- Jet response function (JRF)
- Jet energy scale (JES) uncertainty
- Jet energy resolution (JER) uncertainty

Overview

Theoretical Input

- Program to calculate QCD @ NLO

  fastNLO (v2.1.0-1360 + fnl3323y0.tab)

- Program to calculate CI @ NLO

  CIJET (v1.0, Gao, arXiv:1301.7263v1)

Overview: Models

At next-to-leading order, the effective Lagrangian describing QCD-like interactions may be written as

$$L = L_{QCD} + 2\pi\lambda \sum_{i=1}^{6} \kappa_i O_i$$

where $\lambda = 1/\Lambda^2$ and κ_i are free parameters and each O_i is a sum over dim-6 operators:

$$O_{1,2} \sim \bar{u}_L \gamma_\mu u_L \; \bar{u}_L \gamma^\mu u_L$$
$$O_{3,4} \sim \bar{u}_L \gamma_\mu u_L \; \bar{u}_R \gamma^\mu u_R$$
$$O_{5,6} \sim \bar{u}_R \gamma_\mu u_R \; \bar{u}_R \gamma^\mu u_R$$

Overview: Models

Following CMS paper arXiv:1202.5535v1, we consider CI models defined by specific values of $\kappa_1 \ldots \kappa_6$, namely,

Model	η_{LL}	η_{RL}	η_{RR}
LL	± 1	0	0
RR	0	0	± 1
VV	± 1	± 1	± 1
AA	± 1	∓ 1	± 1
V-A	0	± 1	0

where $\eta_{LL} = \kappa_1$, $\eta_{RL} = \kappa_3/2$, $\eta_{RR} = \kappa_5$, and $\kappa_2 = \kappa_4 = \kappa_6 = 0$.

Overview: Models

At NLO, the cross section per jet p_T bin is of the form

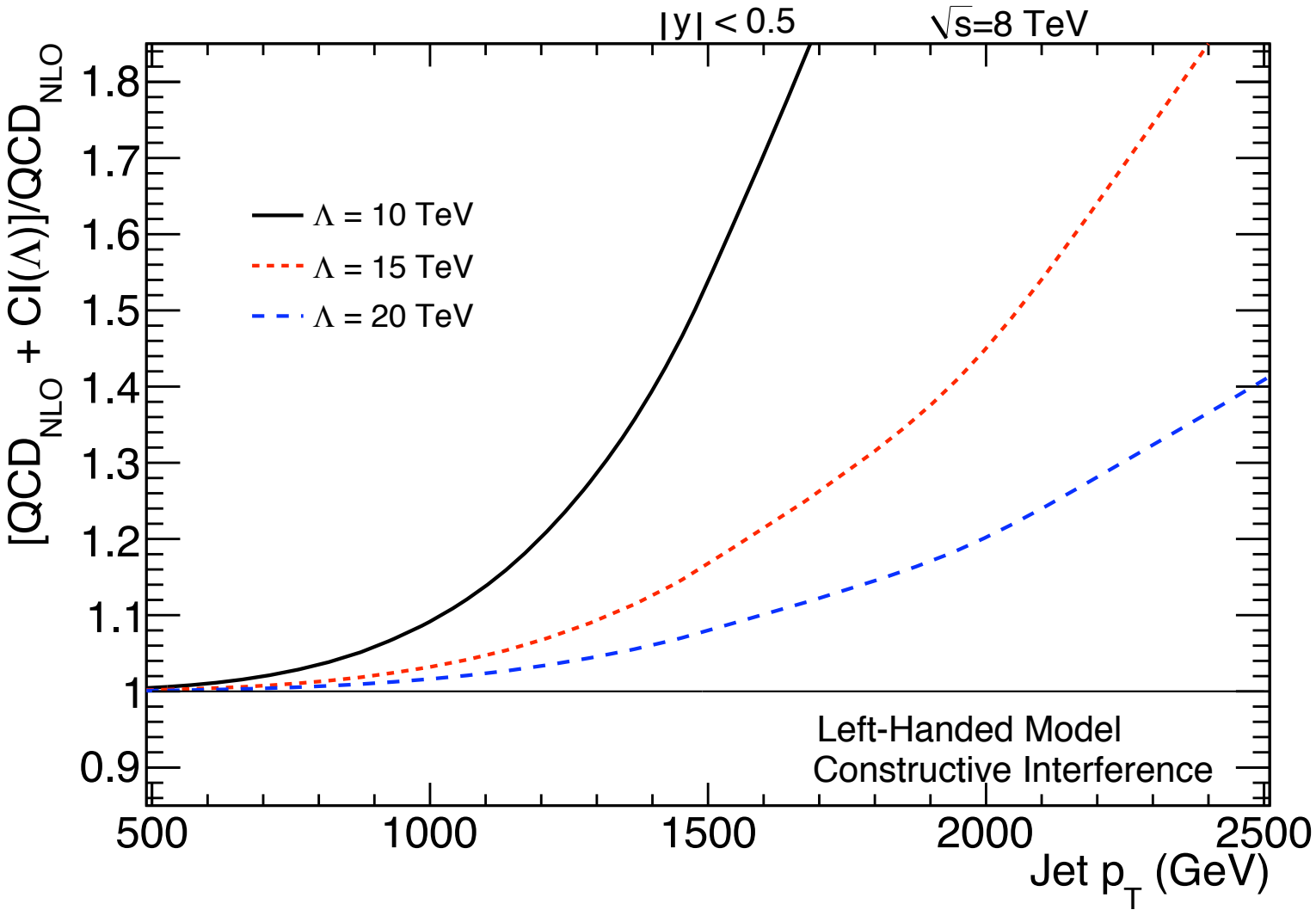
$$\sigma = \sigma_{QCD} + [b + b' \ln \Lambda - b' \ln \mu_0] \frac{1}{\Lambda^2} + [a + a' \ln \Lambda - a' \ln \mu_0] \frac{1}{\Lambda^4}$$

where σ_{QCD} is the SM QCD cross section @ NLO.

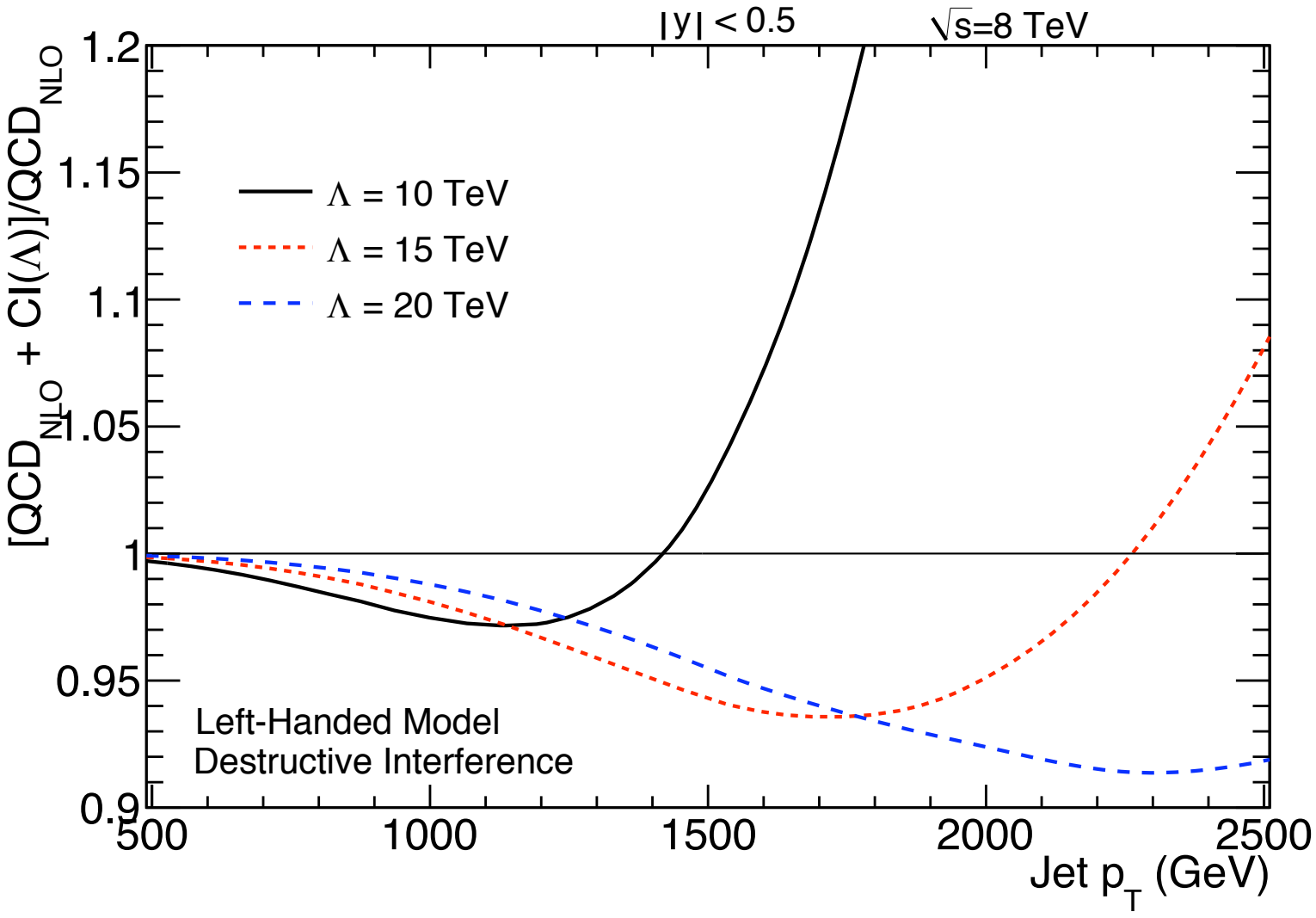
At LO, the primed terms vanish.

(In the 7 TeV analysis, we considered the *ad hoc* model $\sigma = \sigma_{QCD} + b/\Lambda^2 + a/\Lambda^4$, with σ_{QCD} at NLO.)

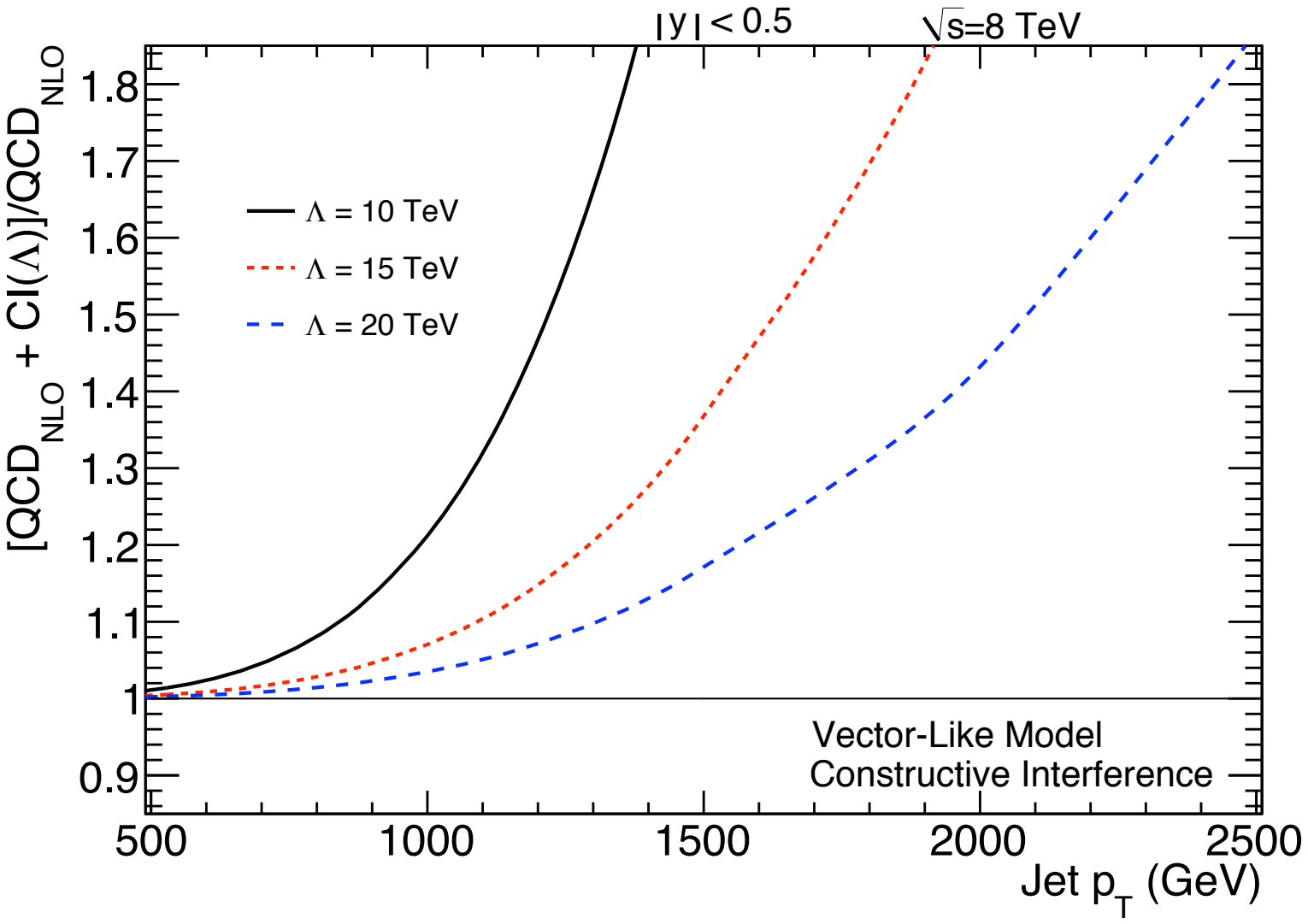
Left-Left (LL) Model



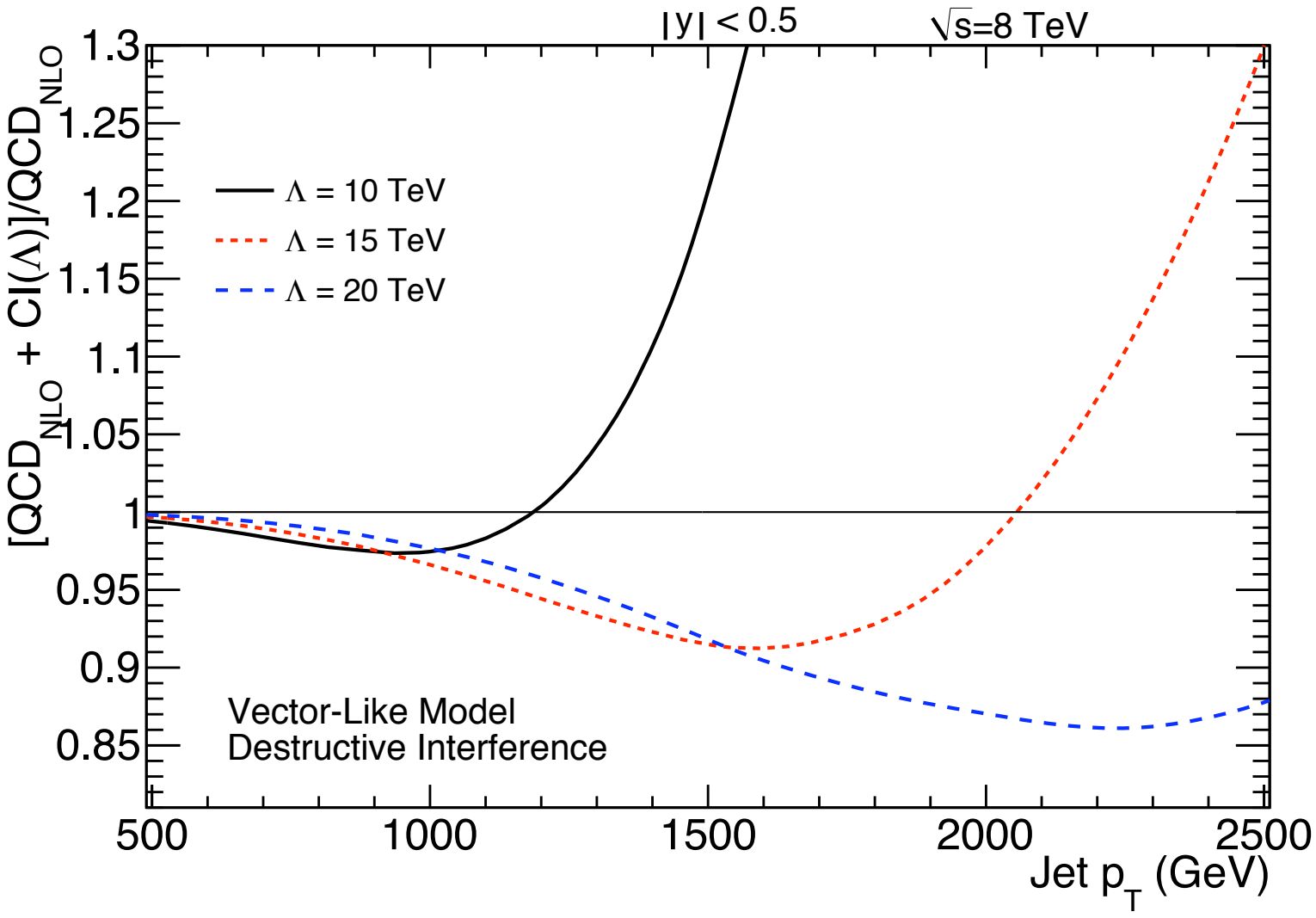
Left-Left (LL) Model



Vector (VV) Model



Vector (VV) Model



Analysis Overview

Analysis Steps

1. For a given CI model, *randomly* sampled PDF set, renormalization (μ_R) scale, and factorization (μ_F) scale, calculate σ_{QCD} and all CI coefficients bin-by-bin. Interpolate into smooth differential densities $f(p_T) = dF/dp_T$.

2. Convolve the differential densities $f(p_T)$ with the jet response function for *randomly* sampled pairs (x, z) of scale factors that account for uncertainty in the jet energy scale (JES) and jet energy resolution (JER),

$$f_{obs}(p_T \mid x,z) = \int_0^\infty \text{Gaussian}(p_T \mid x p'_T, z\sigma(p'_T))\, f(p'_T)\, dp'_T$$

Analysis Overview

Jet Response Function (JRF)/JES

Use the jet response function (SMP-12-012, Sanmay Ganguly)

$$\sigma_{p_T} / p_T = C_{Data} \sqrt{\frac{N^2}{p_T^2} + \frac{S^2}{p_T} + C^2},$$

$$C_{Data} = 1.12, N = 6.130\text{GeV}, S = 0.949\text{GeV}^{1/2}, C = 0.031$$

https://indico.cern.ch/event/271240/material/slides/0?contribId=7

and the (33!) jet energy scale (JES) uncertainty components documented at

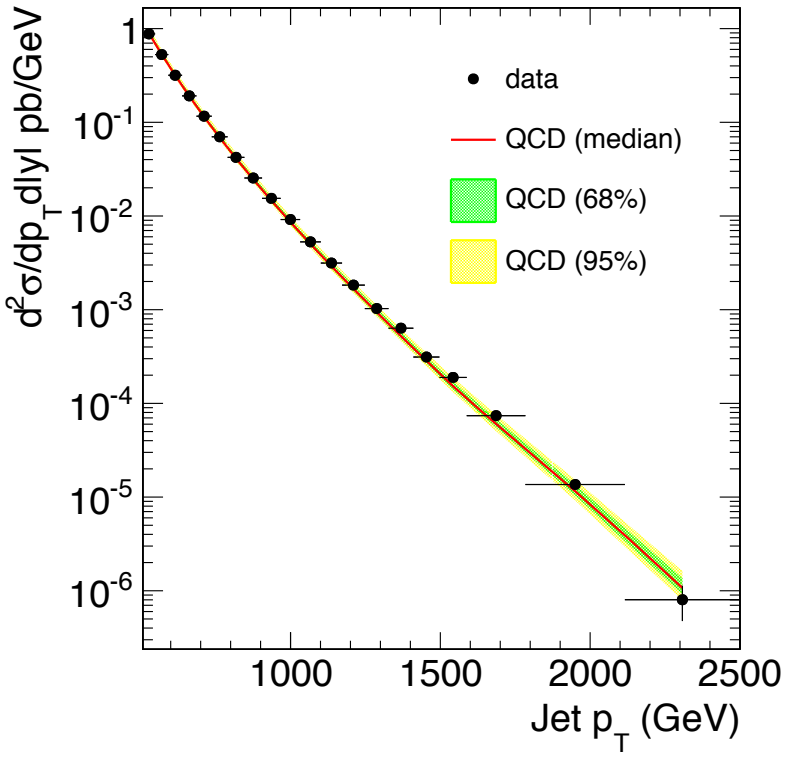
https://twiki.cern.ch/twiki/bin/viewauth/CMS/JECUncertaintySources?topic=JECUncertaintySources

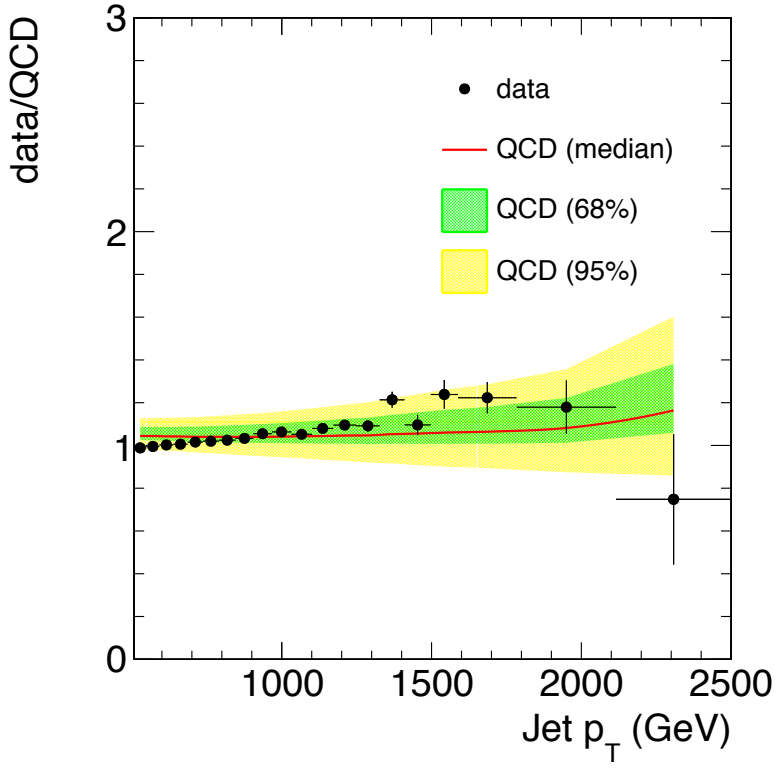
Status

We have:

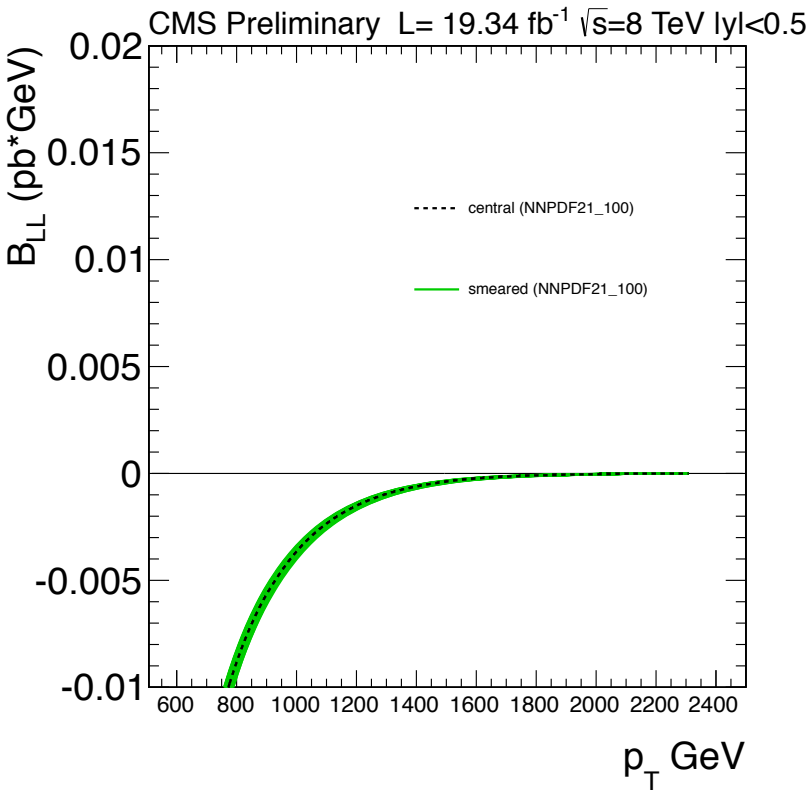
1. For the LL model, with destructive interference and using NNPDF21, calculated an ensemble of 100 QCD and CI coefficient spectra, smeared each with the jet response function using randomly sampled JES and JER scale factors.
2. Built a RooFit/RooStats model of the CI likelihood (a multinomial distribution over 20 bins).
3. Built a RooFit/RooStats model of likelihood averaged over PDF, μ_F, μ_R, JES, and JER variations.
4. Calculated the posterior density without and with the inclusion of systematic uncertainties.

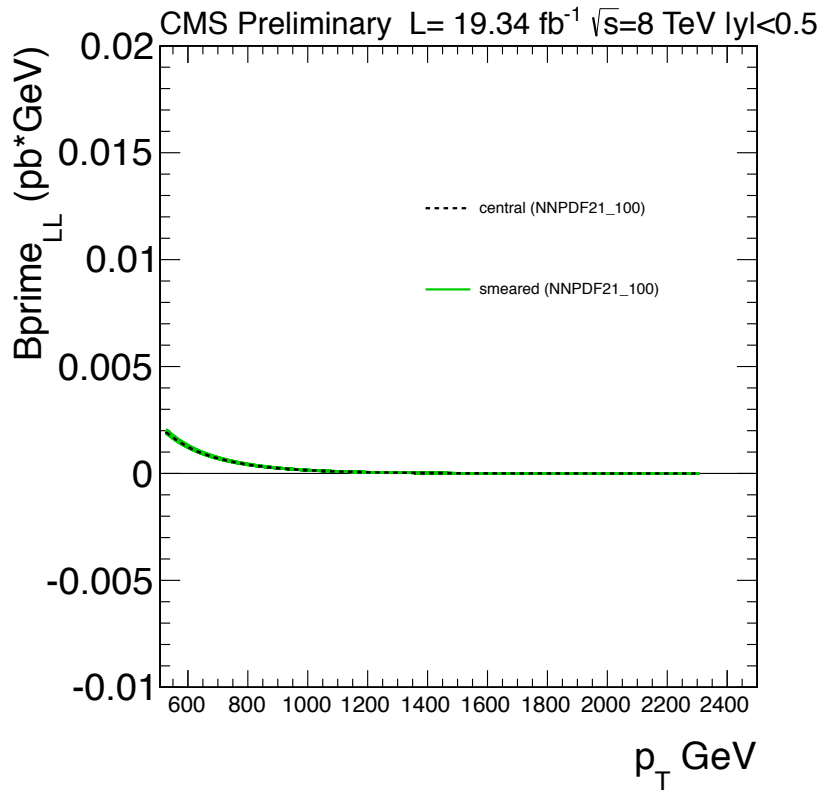
Data vs QCD


data
QCD (median)
QCD (68%)
QCD (95%)
$d^2\sigma/dp_T dly|$ pb/GeV
Jet p_T (GeV)

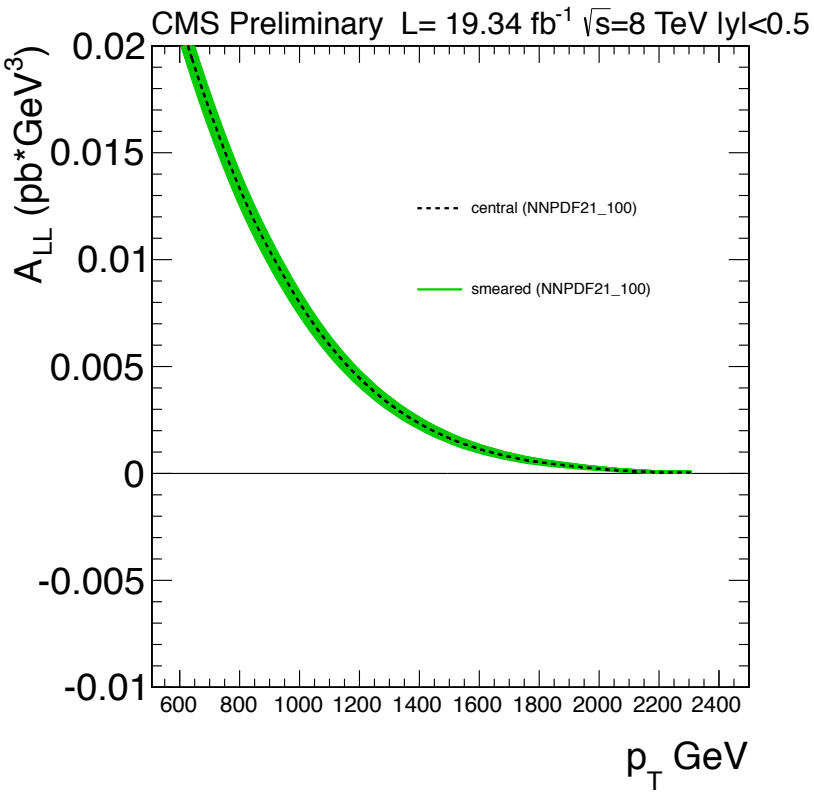

data
QCD (median)
QCD (68%)
QCD (95%)
data/QCD
Jet p_T (GeV)

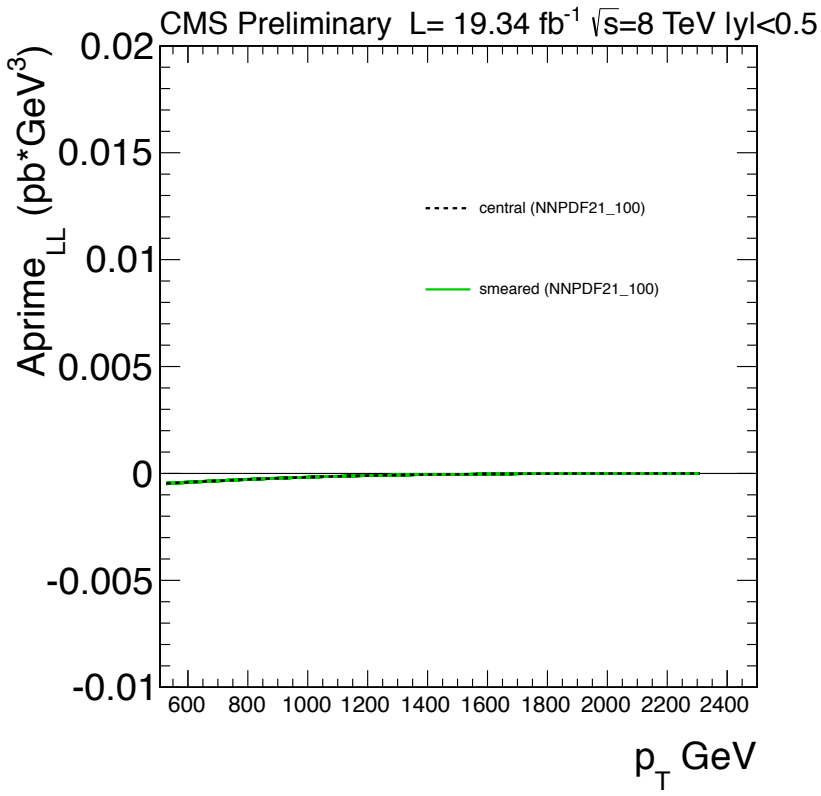
LL Model Coefficients – 1



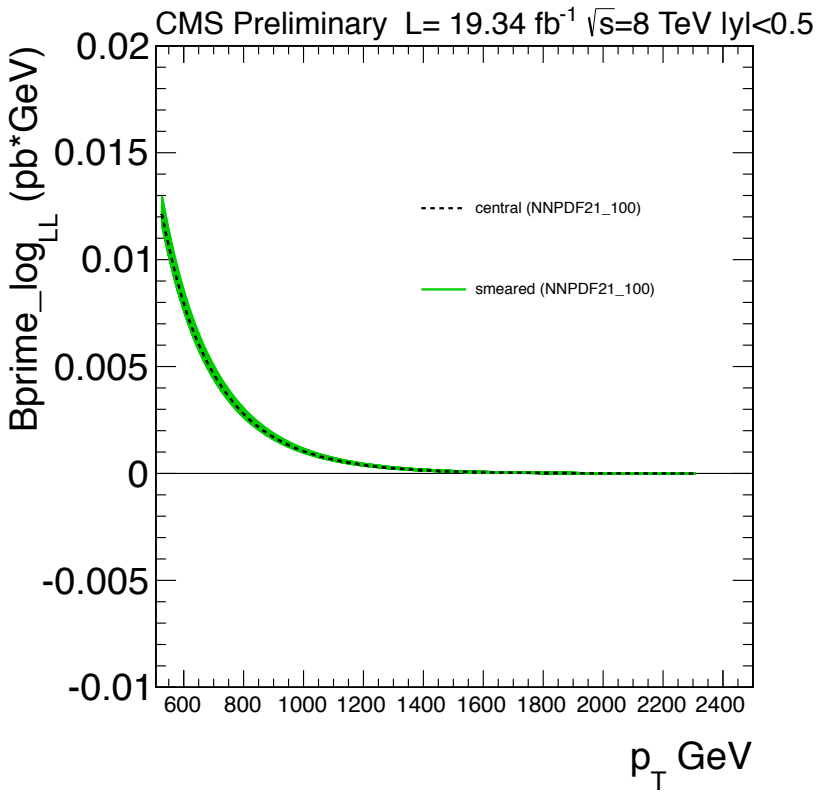


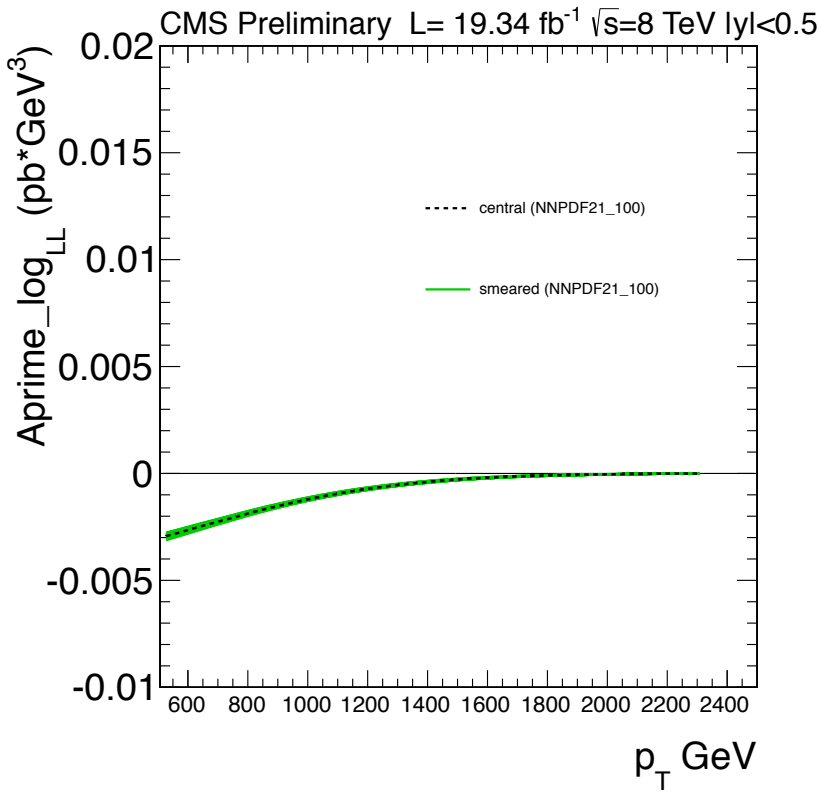
LL Model Coefficients – 2





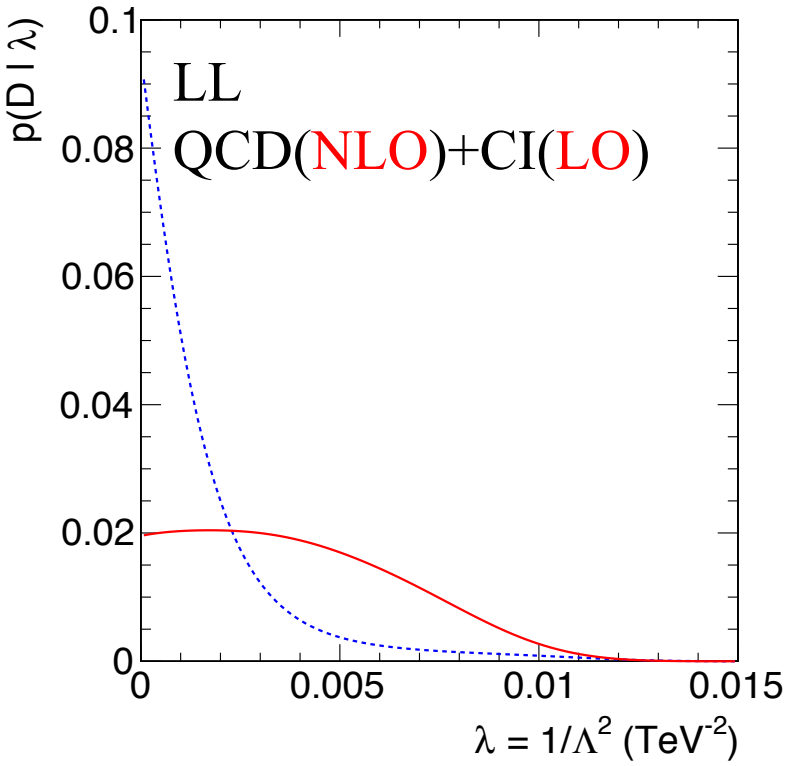
LL Model Coefficients – 3



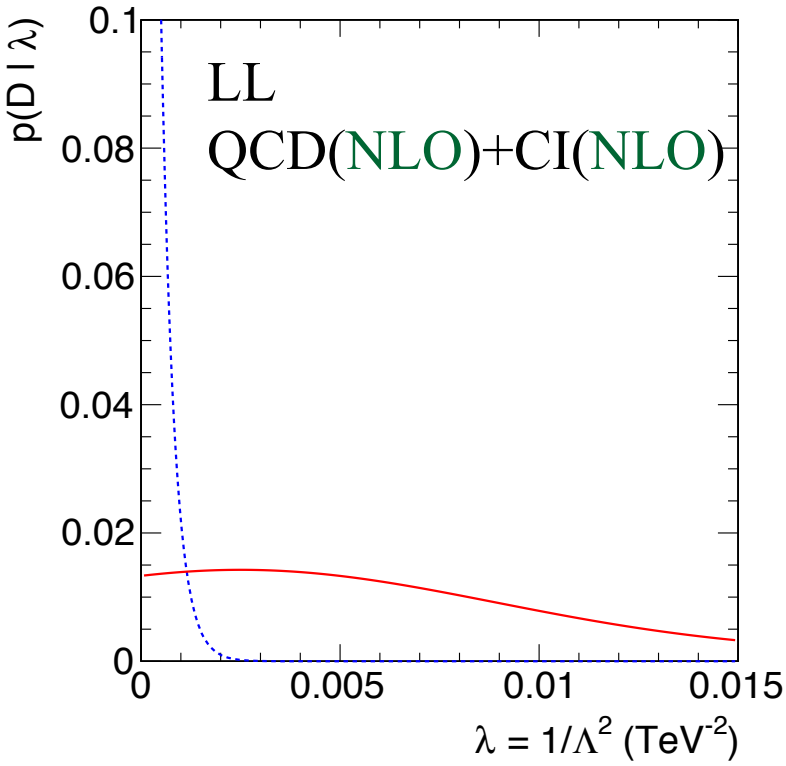


First Attempt at 8 TeV Likelihood

Warning: Here, we are comparing red apples with green ones!



L = 5fb^{-1} @ 7 TeV



L = 19.34fb^{-1} @ 8 TeV

Plans

1. Add MSTW2008
2. Include non-perturbative corrections
3. Repeat using all 10 CI models
4. Compute limits (using a Bayesian method)
5. Document analysis
6. Ask for an ARC etc.

Wish 1: Results presented at *some* conference this summer.

Wish 2: Publish results within 6 months.