Search for Contact Interactions in Jet p_T
Status Report

Suma Beri[1], Suneel Dutt[2], and Harrison B. Prosper[3]

[1]Panjab University, [2]Shoolini University,
[3]Florida State University

Exotica Multijets Working Group Meeting

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Outline

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

Overview

Goal

- Use the measured inclusive jet p_T spectrum at 8 TeV to draw conclusions about possible new QCD-like interactions that can be modeled as contact interactions (CI).

Experimental Input

- Inclusive jet p_T spectrum in $|y| < 0.5$, $507 \leq p_T \leq 2500$ GeV (SMP-12-012, Sanmay Ganguly *et al.*)
- Jet response function (JRF)
- Jet energy scale (JES) uncertainty
- Jet energy resolution (JER) uncertainty

Overview

Theoretical Input

- PDFs (LHAPDF-6.1.4)

  CT10nlo, MSTW2008nlo68cl, NNPDF23_nlo

- Program to calculate QCD @ NLO

  fastnlo_toolkit-2.3.1pre-1871 + fnl3332y0.tab

- Program to calculate CI @ NLO

  CIJET-1.1

- Non-perturbative corrections (Sanmay Ganguly)

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

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

The QCD+CI cross section, @NLO, can be written as

$$\sigma = \sigma_{\text{QCD}} +$$

$$+ \lambda \sum_{i=1}^{6} \kappa_i [b_i + a_i g + a_i f]$$

$$+ \lambda^2 \sum_{i=1}^{6} \kappa_i^2 [b_{ii} + a_{ii} g + a_{ii} f]$$

$$+ \lambda^2 \sum_{i=1,3,5} \kappa_i \kappa_{i+1} [b_{ii+1} + a_{ii+1} g + a_{ii+1} f]$$

$$+ \lambda^2 \sum_{i=1,2,5,6} \kappa_i \kappa_4 [b_{i4} + a_{i4} g + a_{i4} f]$$

where $g = -\ln(\mu_0 \sqrt{k})$ and $f = \ln(\sqrt{(k / \lambda)})$

The CI sum comprises 57 coefficients

CI Cross Section Coefficients

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2. **Analysis Overview**
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Analysis Overview

Analysis Steps

1. For CT10, MSTW2008, generate 100 *randomly* sampled PDF sets. (Use recently released tool, hessian2replicas, in LHAPDF6). NNPDF random sample already provided.

2. For each of the randomly sampled PDF sets and 7 combinations of the renormalization and factorization scales, compute the QCD inclusive jet p_T spectrum.

3. Do the same for the 57 differential coefficients needed to compute the CI spectra for *arbitrary* values of κ and Λ.

Analysis Overview

Analysis Steps

4. Convolve each spectrum, $f(p_T) = d^2F/dp_T dy$ (either QCD or the 57 CI coefficients),

$$f_{obs}(p_T \mid x, y) = \int_0^\infty R(p_T \mid x, y, z)\, f(z)\, dz$$

with the jet response function R, for *randomly* sampled pairs (x, y) of zero mean, unit variance, Gaussian variates that account for uncertainty in the jet energy scale (JES) and jet energy resolution (JER), respectively, taking care to maintain the correlation across all bins and all spectra.

Analysis Overview

Jet Response Function (JRF)/JES

Use the jet response function (SMP-12-012, Sanmay Ganguly *et al.*)

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

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

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

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

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

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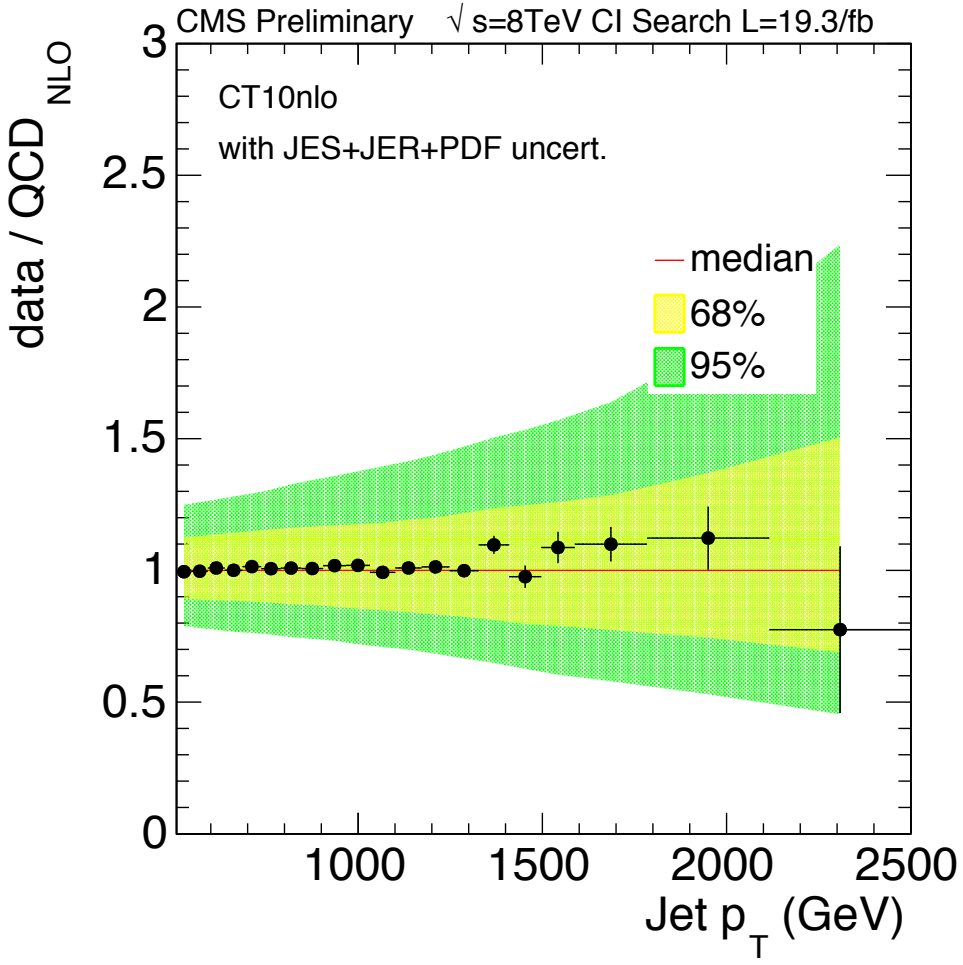
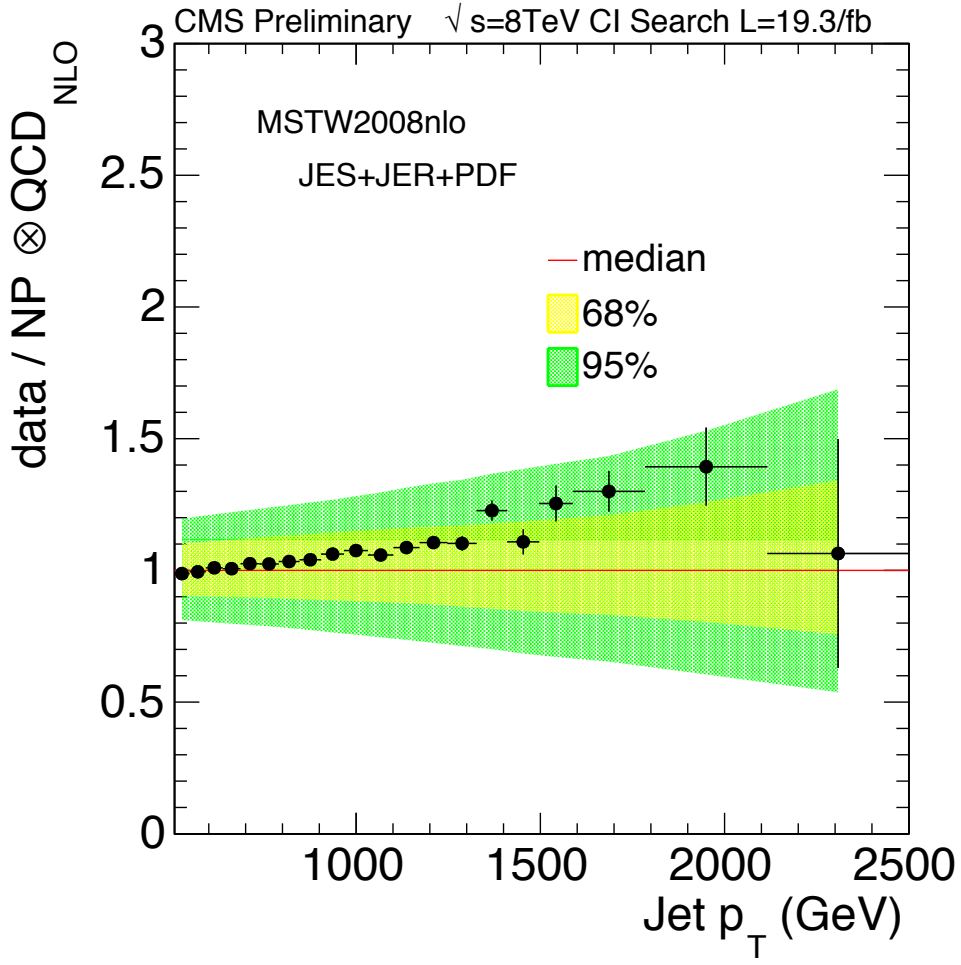
Status

1. All 3 x 100 x 7 QCD spectra have been calculated and smeared.
2. All 3 x 100 x 7 x 57 CI differential coefficients have been calculated.
3. All 100 x 7 x 57 CT10nlo CI differential coefficients have been smeared. The MSTW, NNPDF calculations will be done soon.
4. Limit setting code from the 7 TeV analysis has been revamped and tested in another analysis (SUSY razor boost). But the multinomial likelihood used for the 7 TeV analysis needs to be adapted to the more flexible calculation of the CI spectra before limits can be calculated.

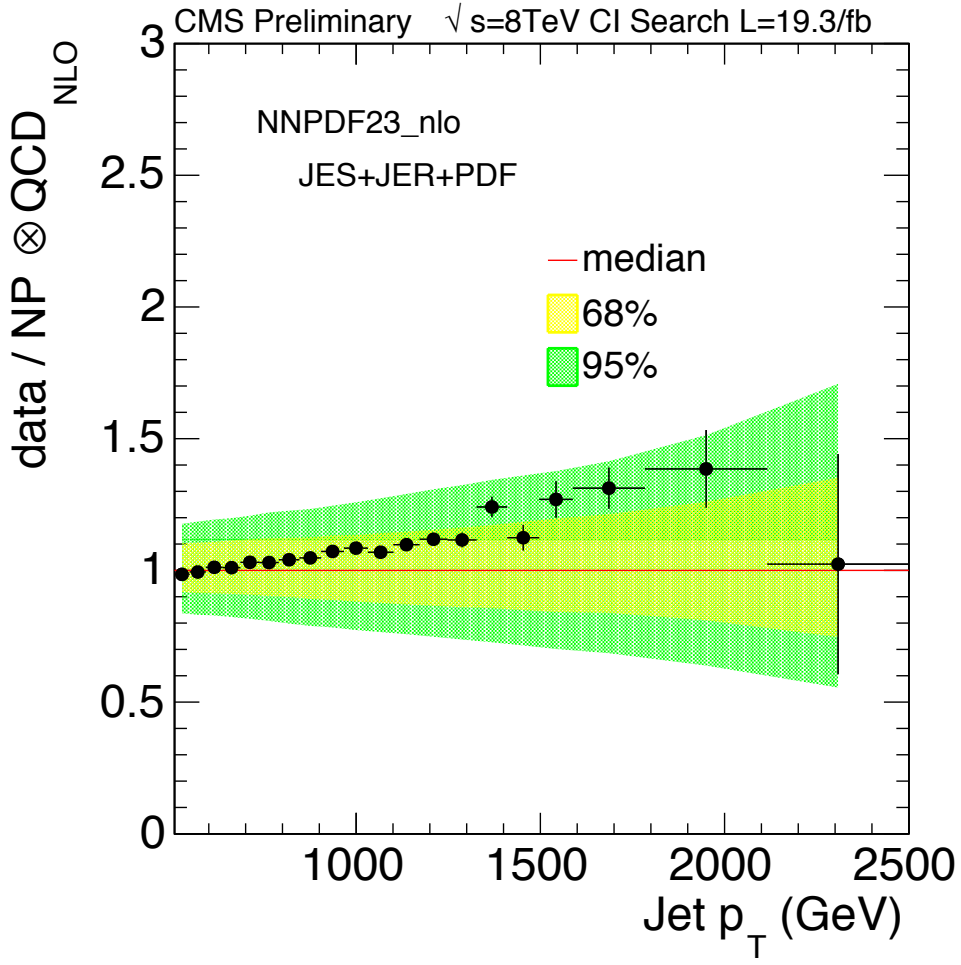
Status: Data/QCD with CT10nlo



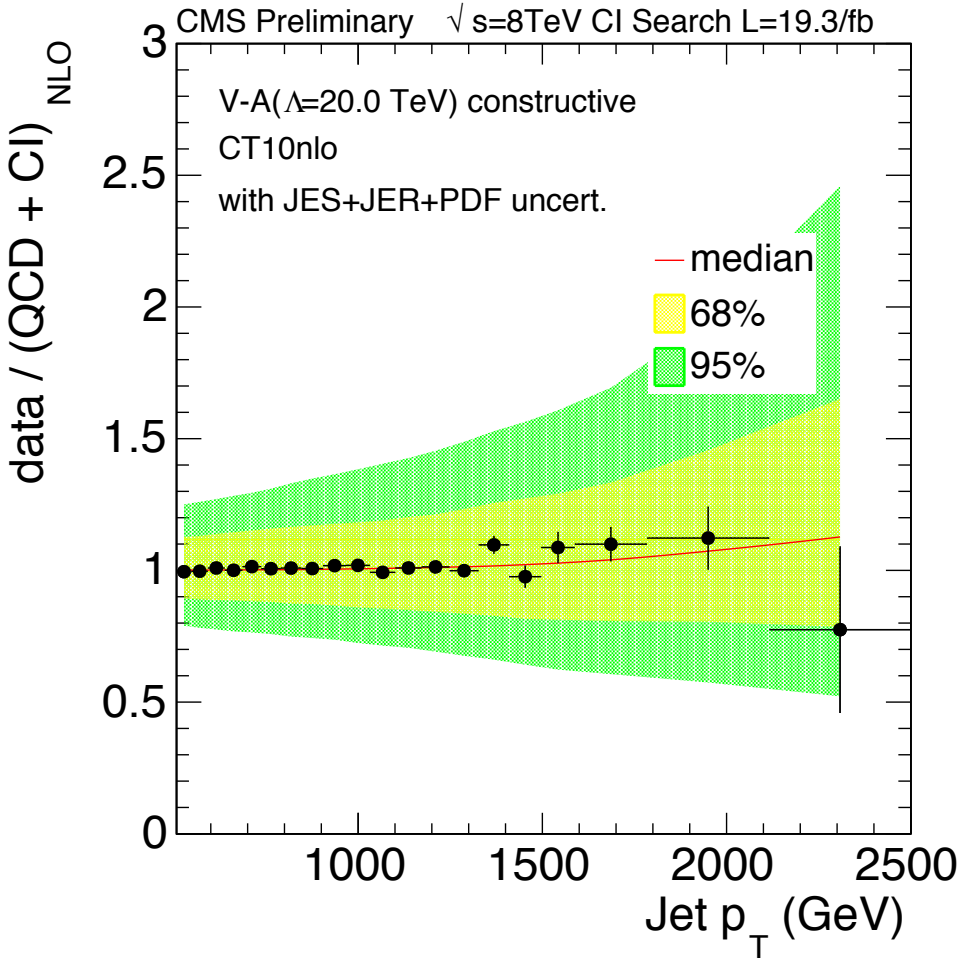
Status: Data/QCD with MSTW2008



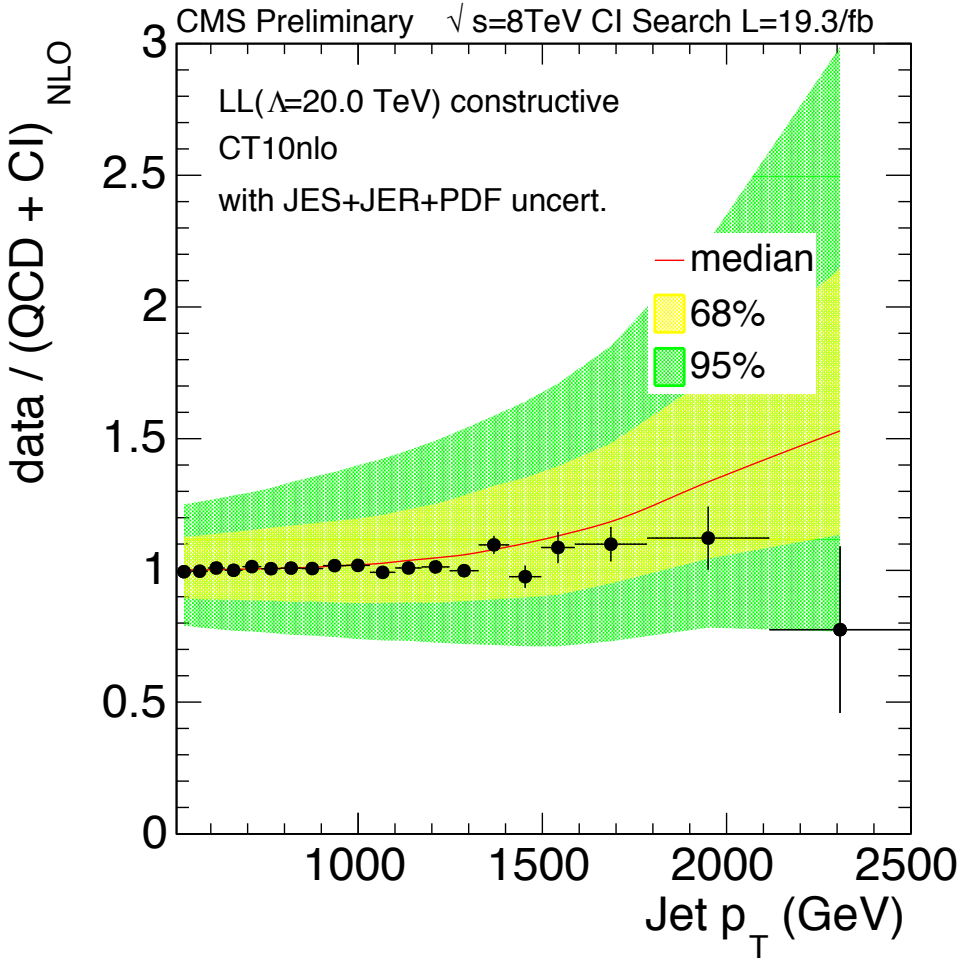
Status: Data/QCD with NNPDF23



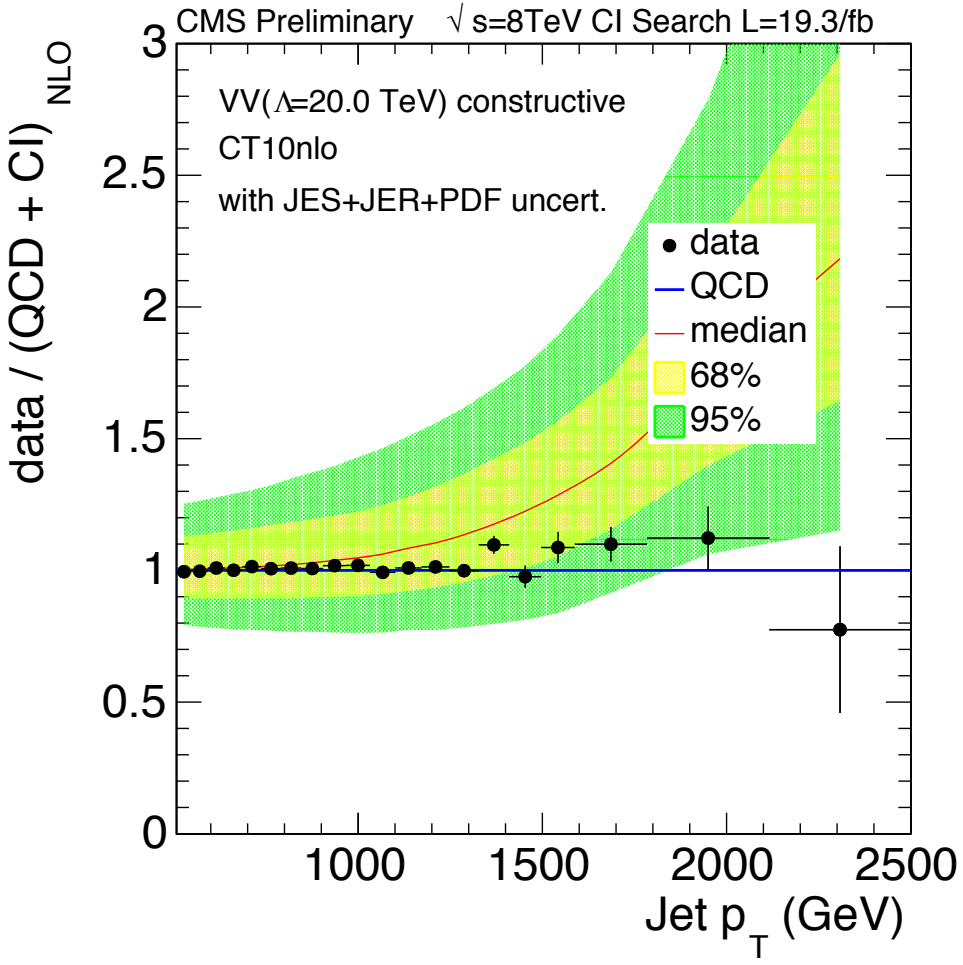
Status: Data/QCD for V-A model



Status: Data/QCD for LL model



Status: Data/QCD for VV model



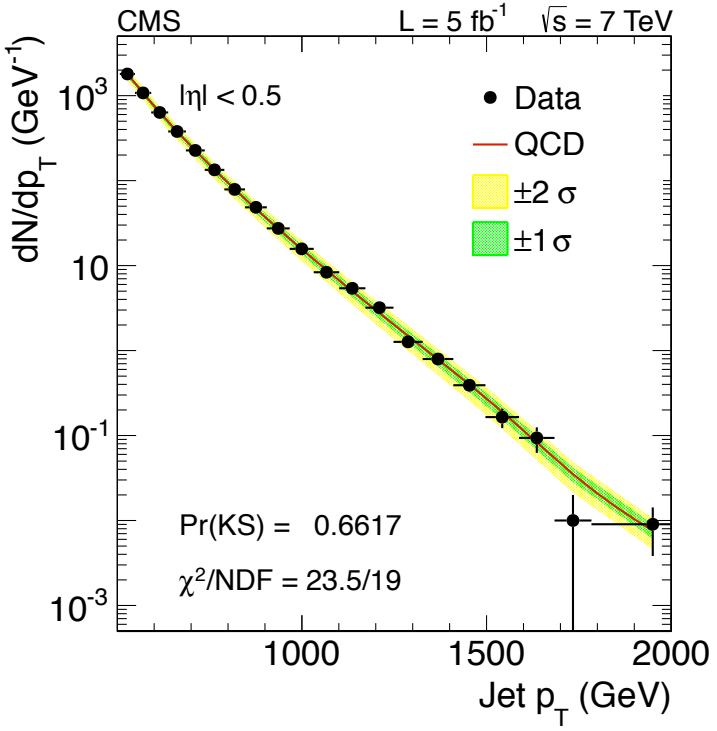
Plans

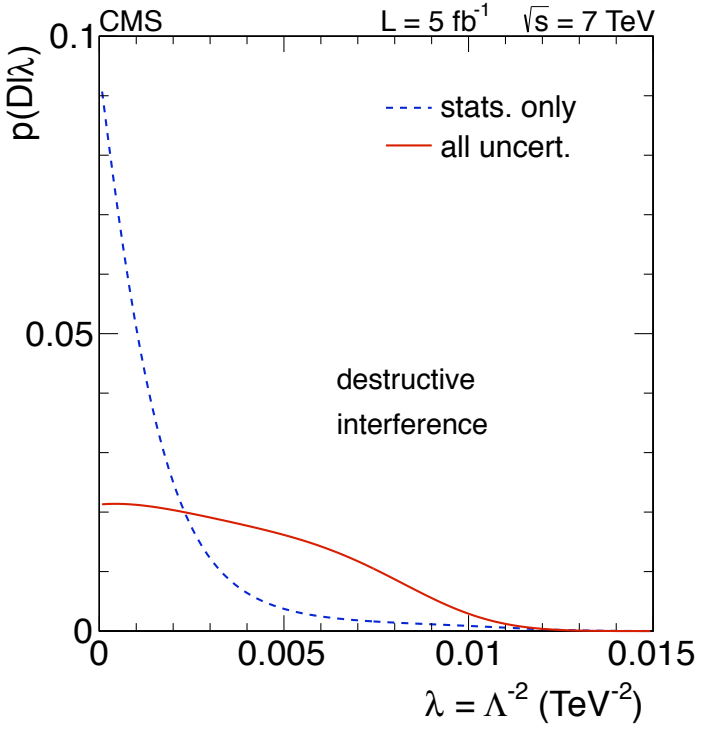
1. Complete CI calculations for MSTW and NNPDF
2. Complete adaptation of 7 TeV likelihood to new CI model
3. Compute limits (using a Bayesian method)
4. Document analysis (analysis note already started)
5. Ask for an ARC etc.

Timescale for obtaining results ~ one month if all goes well.

BACKUP

Contact Interaction (CI) Search @ 7 TeV





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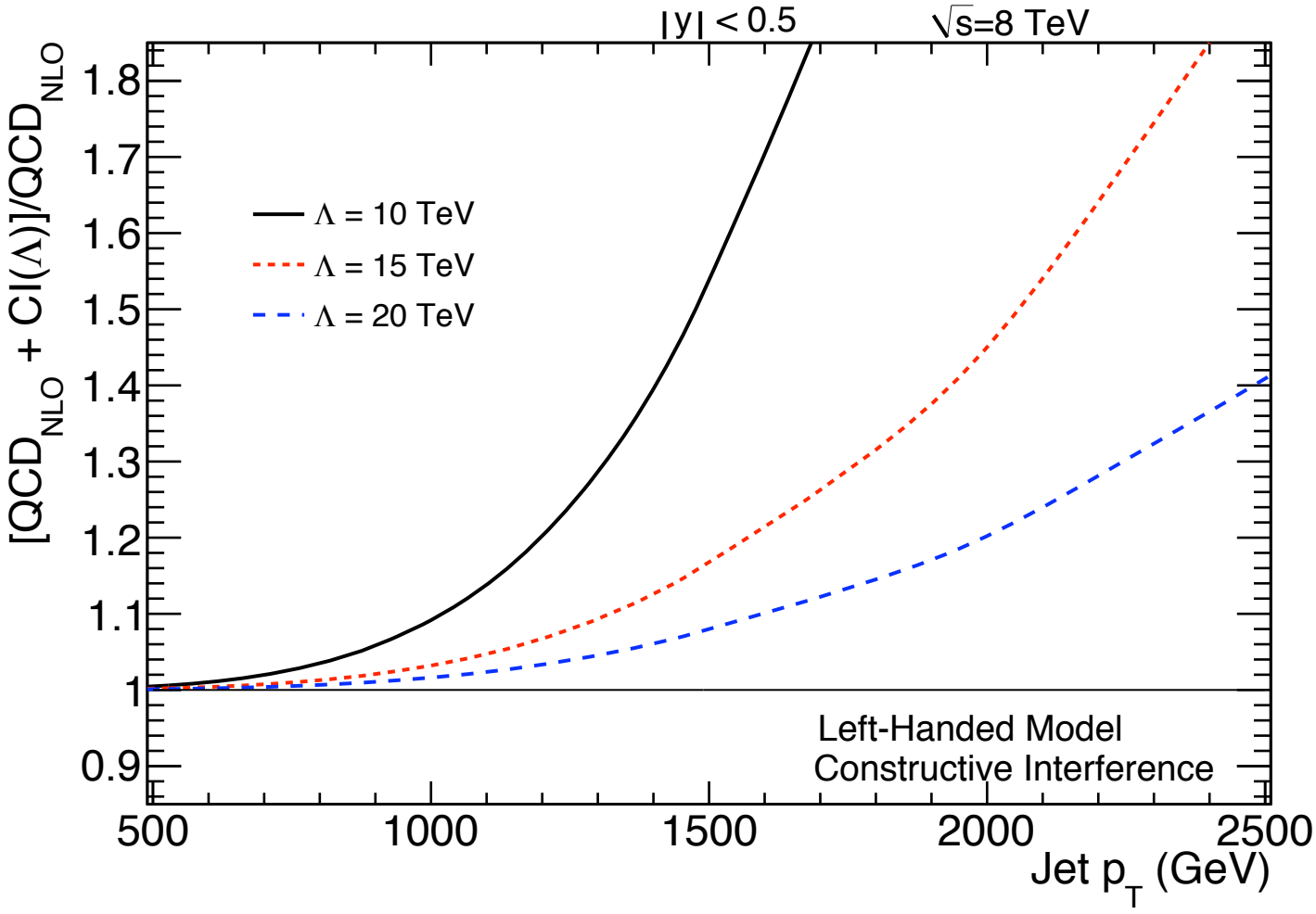
Search for contact interactions using the inclusive jet p_T spectrum in pp collisions at $\sqrt{s} = 7$ TeV

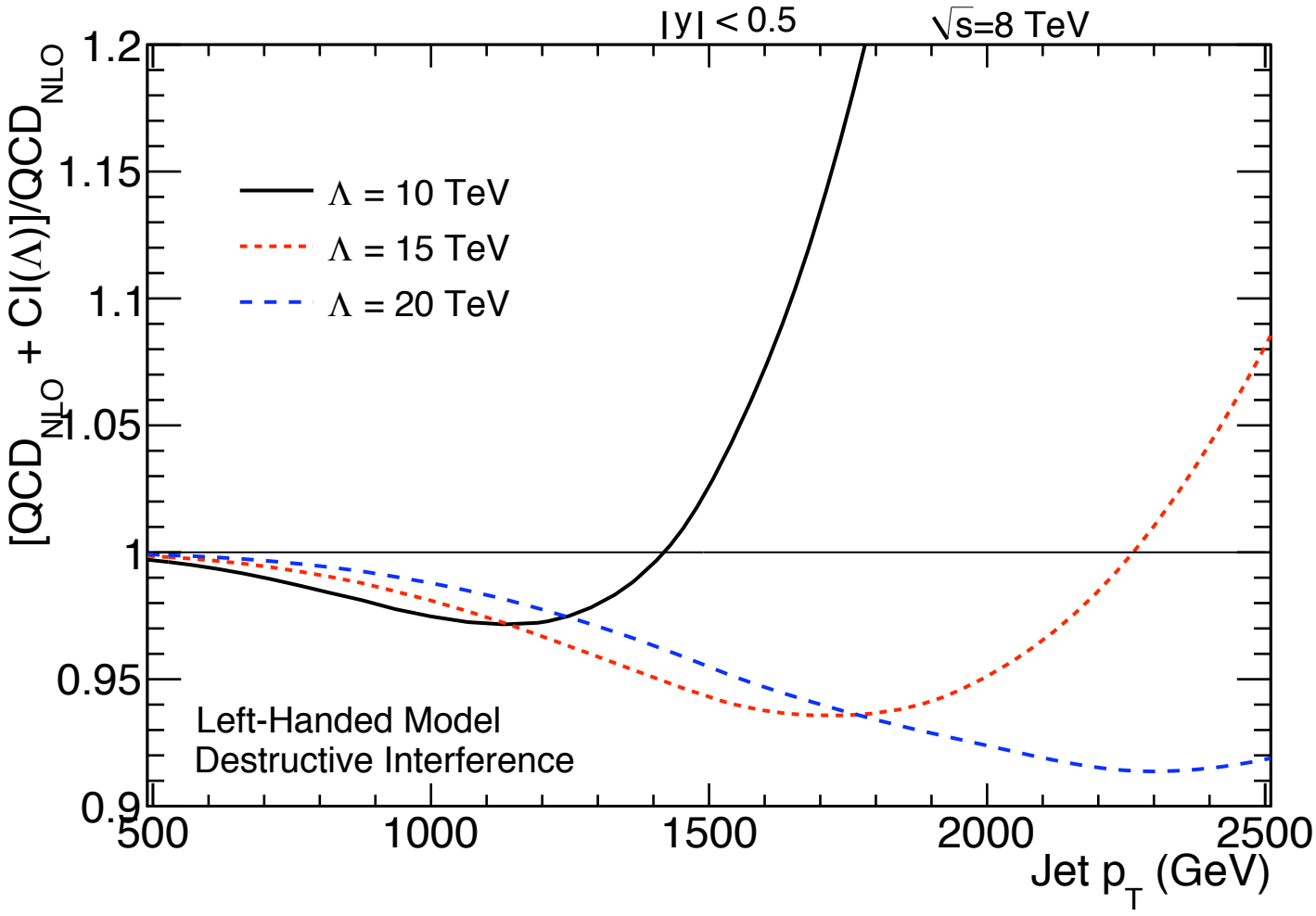
S. Chatrchyan *et al.**
(CMS Collaboration)

(Received 21 January 2013; published 26 March 2013)

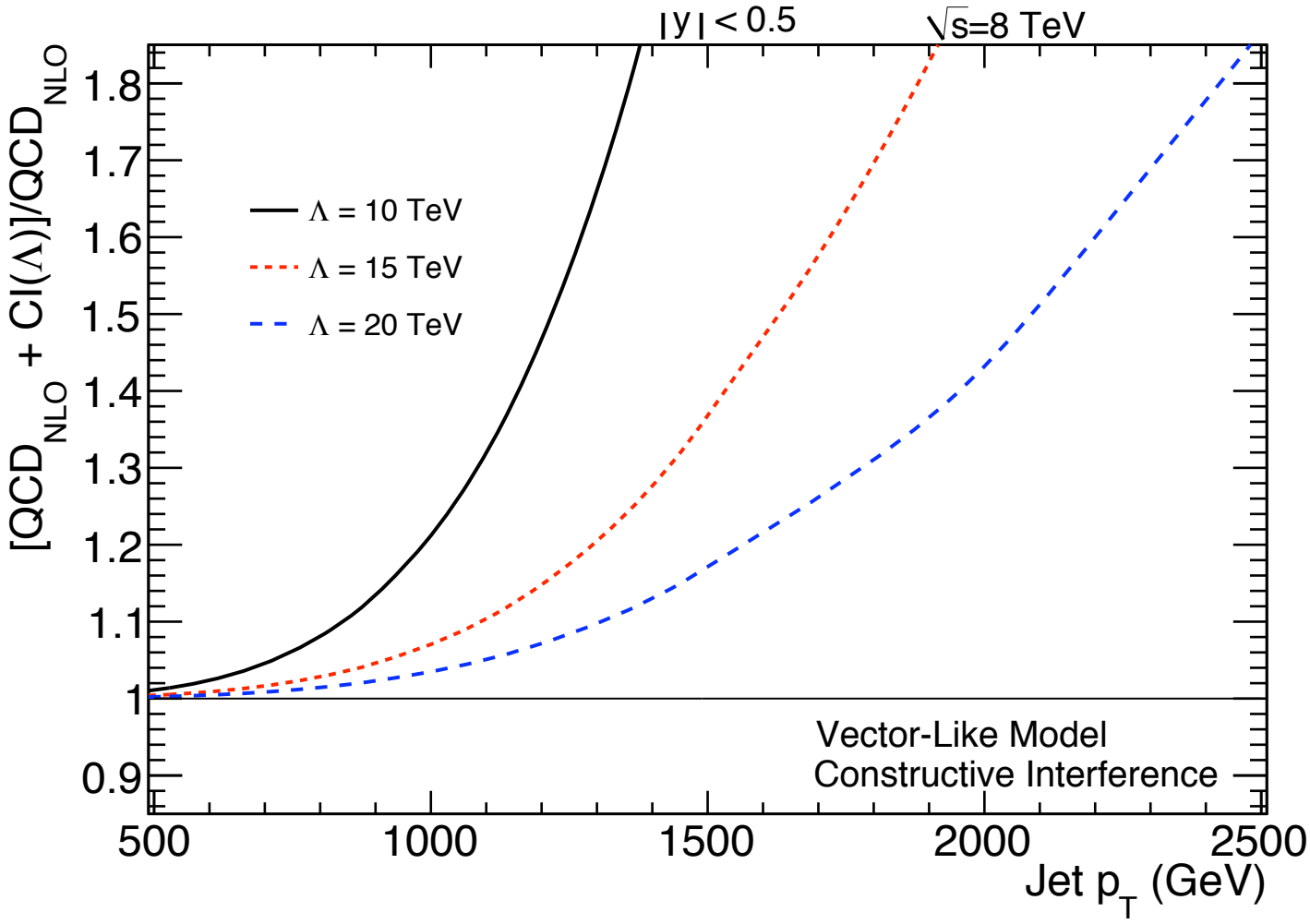
Left-Left (LL) Model



Left-Left (LL) Model



Vector (VV) Model



Vector (VV) Model