W+3 Jet Production at Hadron Colliders:

NLO computations with BlackHat + SHERPA

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PHENO --- Madison --- May 2009

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In collaboration with: *C.F. Berger (MIT), Z. Bern (UCLA), L. Dixon (SLAC), D. Forde (SLAC), T. Gleisberg (SLAC), H. Ita (UCLA), D. Kosower (Saclay) and D. Maitre (Durham)*
arXiv:0803.4180 ; **arXiv:0808.0941** ; **arXiv:0902.2760**

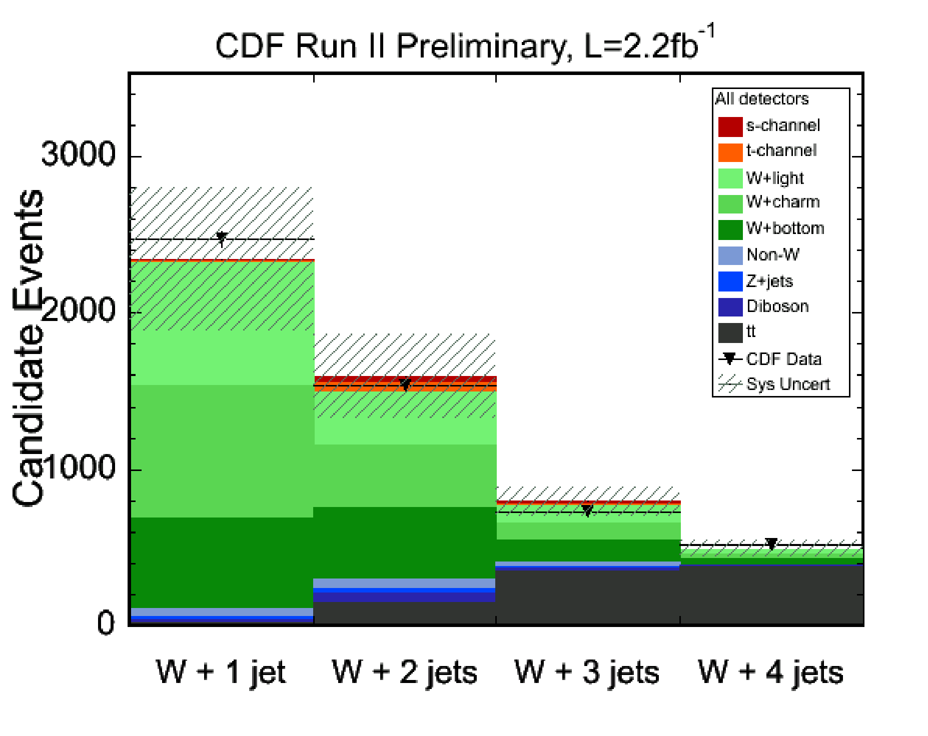
Messages

1. NLO QCD corrections necessary for hadron collider physic
    - First quantitative reliable predictions
    - Corrections not always amount to global rescaling: Change of distribution shapes!
2. Oncoming Automated NLO Corrections
    - NLO corrections with BlackHat+SHERPA
    - W+n jets (n=1,2,3) at NLO QCD

The Challenges of Hadron Collider Physics

Tevatron: Single Top Production

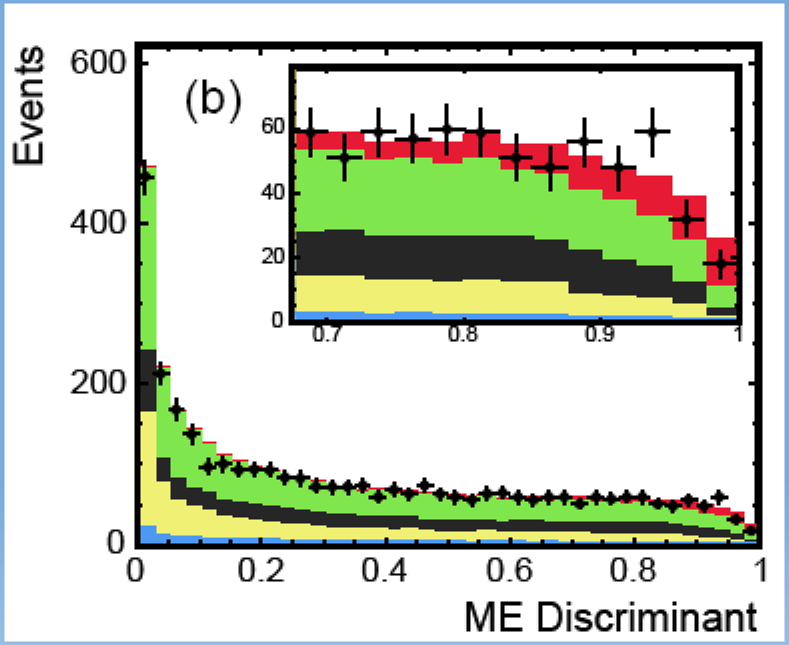
T. Aaltonen et al. [CDF Collaboration], arXiv:0809.2581

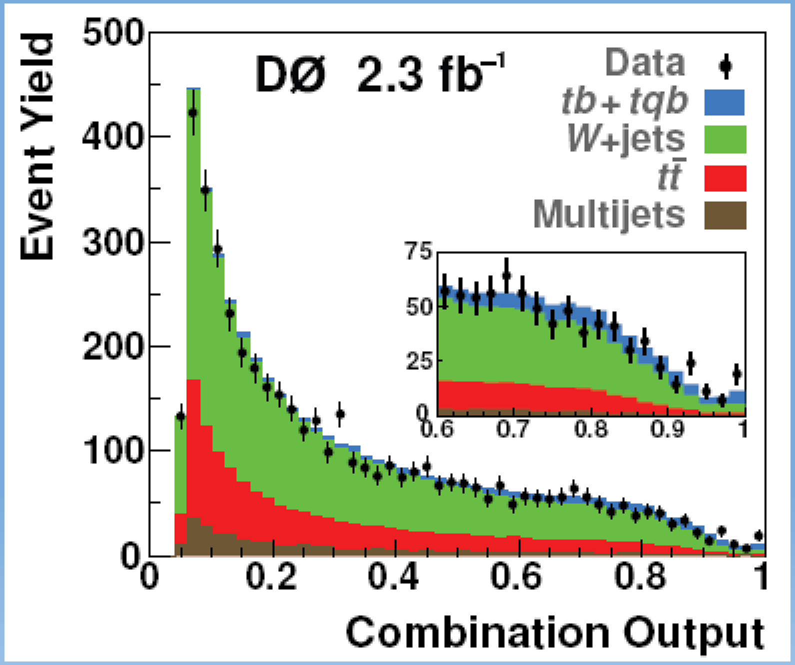


But we should not limit the physics reach of our experiments by restricting them only to "counting" analyses:

For example the matrix element method uses full information of LO matrix elements to pull the signal out of background.

Tevatron: Single Top Production





CDF 5 sigma discovery!

D0 5 sigma discovery!

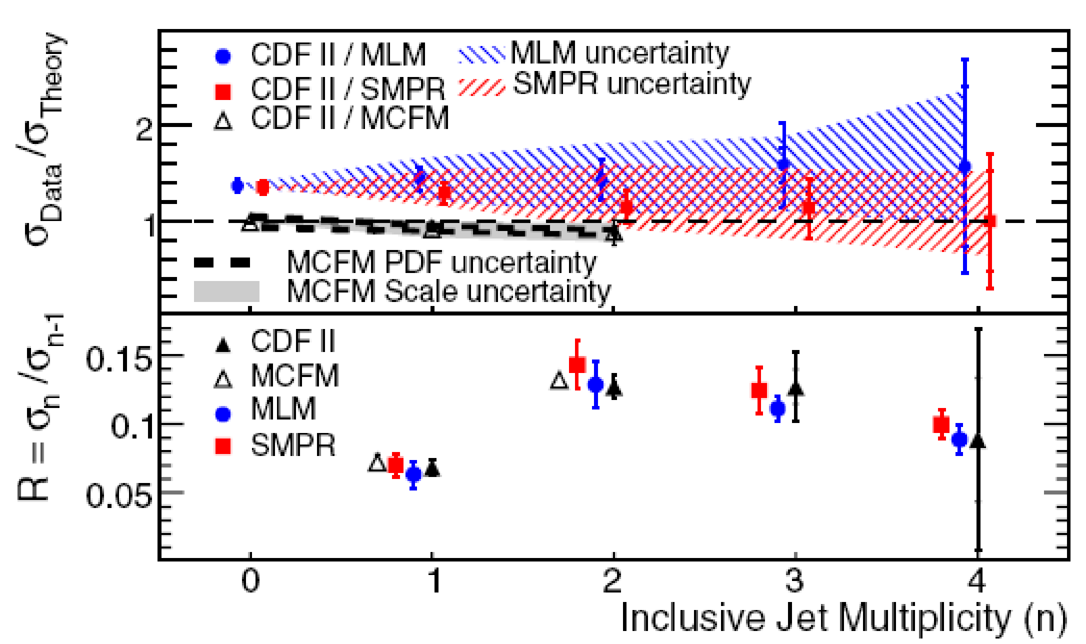
arXiv:0903.0885

arXiv:0903.0850

It should be possible to do better by using NLO matrix elements.
The goal is to provide experimenters with necessary theoretical tools for a wide variety of processes.

Comparing tools

T. Aaltonen et al. [CDF Collaboration], arXiv:0711.4044



Wanted: LHC studies with extra jets:

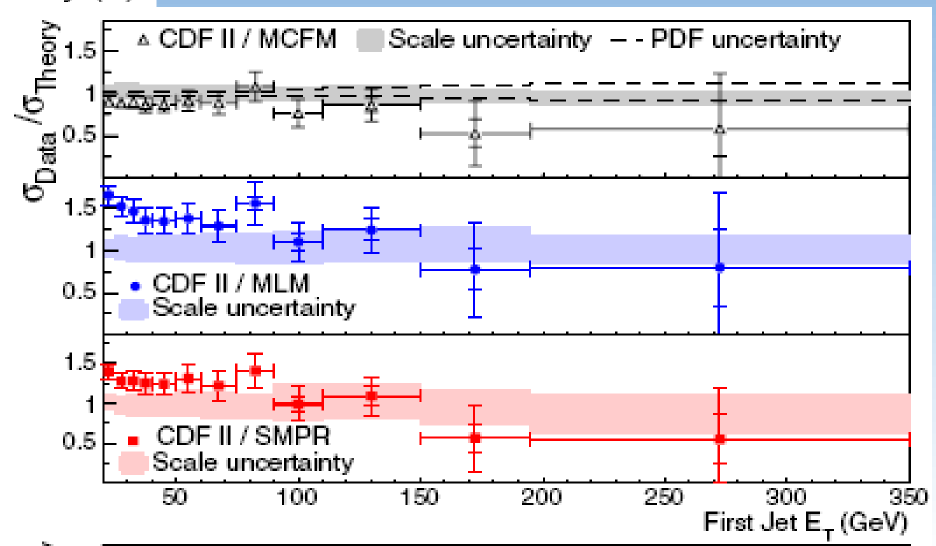
data from $320pb^{-1}$

SMPR-model: Madgraph+Pythia
MLM-model: Alpgen+Herwig

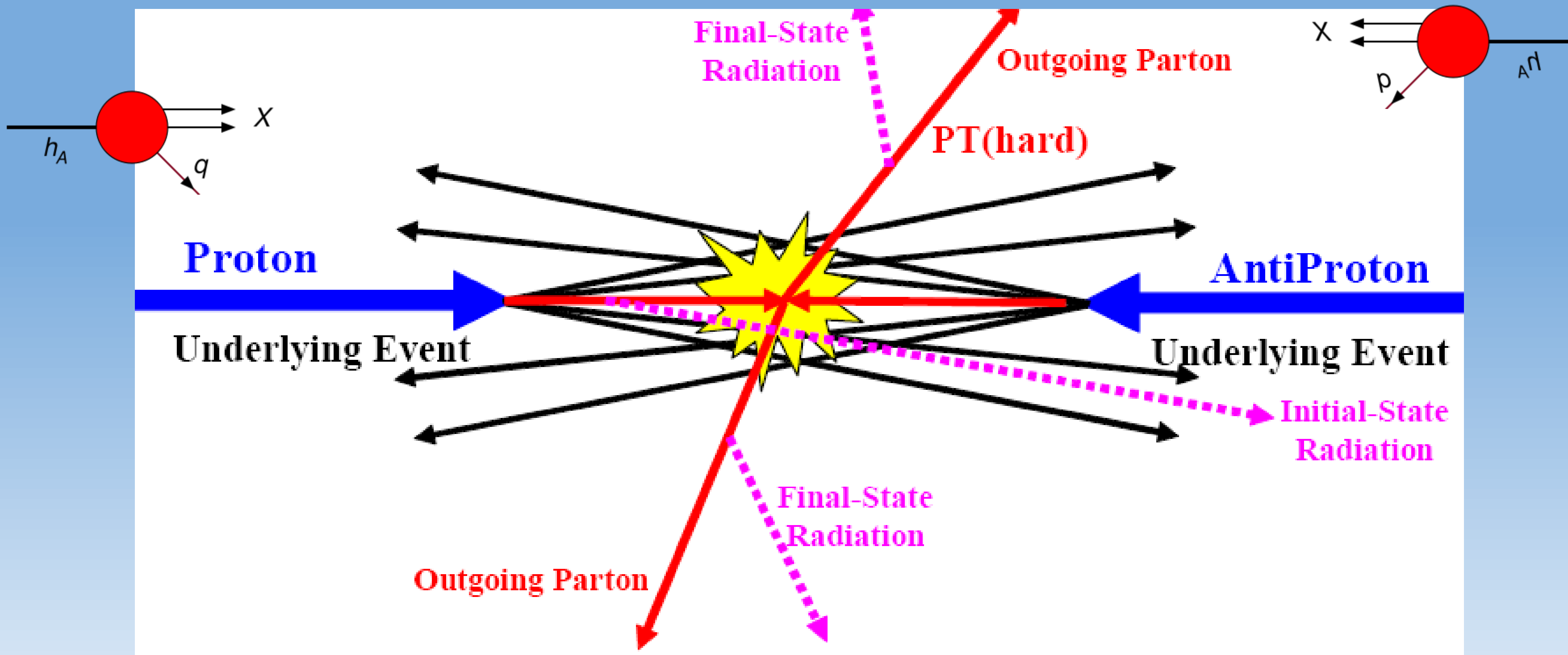
LO,

MCFM; parton level; including Bern, Dixon, Kosower, Weinzierl 1-loop matrix elements; Full NLO by Campbell and Ellis

NLO.



Scattering processes at hadron colliders:
A multi-layered problem



taken from Rick Field

(C.F. Berger, Z. Bern, L. Dixon, FFC
D. Forde, T. Gleisberg, H. Ita,
D. Kosower and D. Maitre)

W+n j (n=1,2,3) at NLO

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See talks by:

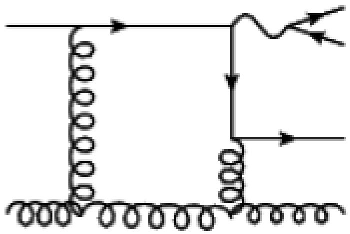
- *Carola F. Berger*
- *Frank Krauss*

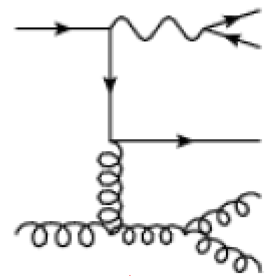
NLO Quantum Corrections

one loop amplitudes interfered with the Born

real contributions with one extra parton in the final state

W+2 :





BlackHat:

Automating the computation of one loop matrix elements

(arXiv:0803.4180 ; arXiv:0808.0941)

Sherpa:

Within AMEGIC++ automates the Catany-Seymour Dipole substraction for real corrections

(T. Gleisberg, F. Krauss, 2007)

More Activity in Automating NLO Computations:

- Real pieces:
  - MadDipole Frederix, Gehrmann, Greiner
  - Seymour, Tevlin
  - Hasegawa, Moch, Uwer
  - …
- Virtual pieces:
  - CutTools   Ossola, Papadopoulos, Pittau
  - Rocket   Ellis, Giele, Kunszt, Melnikov, Zanderighi
  - Lazopoulos
  - Giele and Winter
  - …

W+Jets at the Tevatron: CDF Analysis

T. Aaltonen et al. [CDF Collaboration], arXiv:0711.4044, 320 pb^-1

	Cut
Electron Et	20 GeV
Electron eta	1.1
Missing Energy	30 GeV
W Transverse Mass	20 GeV
Jet Et	20 – 25 GeV
Jet eta	2
Delta R	0.4

We employ the SISCone Jet Algorithm

Salam, Soyez arXiv:0704.0292

CTEQ pdfs, and a dynamical factorization/renormalization scale (sqrt(Mw^2+pt_W^2)) for comparison with data

W+n jets: Comparing Rates

number of jets	CDF	NLO
1	53.5 ± 5.6	$57.8^{+4.4}_{-4.0}$
2	6.8 ± 1.1	$7.62^{+0.62}_{-0.86}$
3	0.84 ± 0.24	$0.882(5)^{+0.057}_{-0.138}$

Reduction in Scale Dependence

Number of jets	LO	NLO
1	16%	7%
2	30%	10%
3	42%	12%

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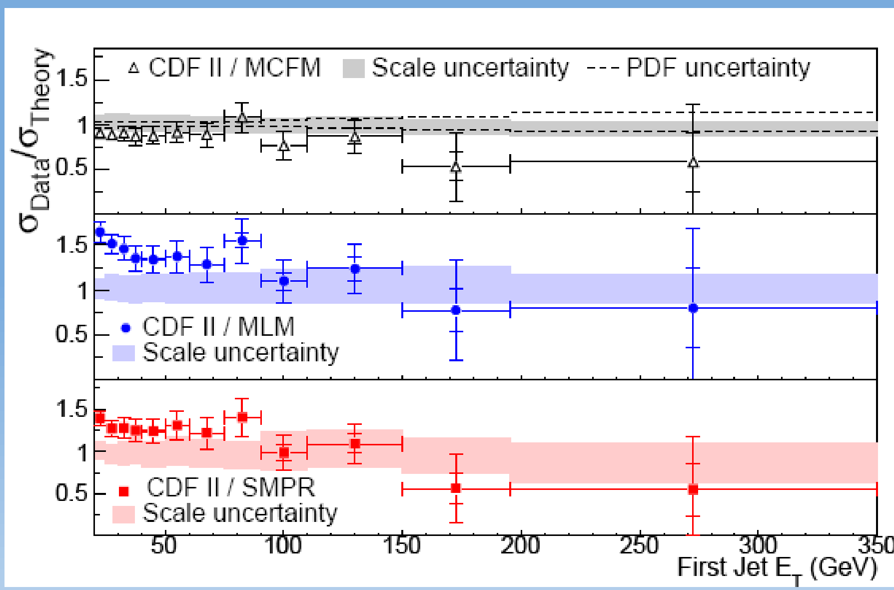
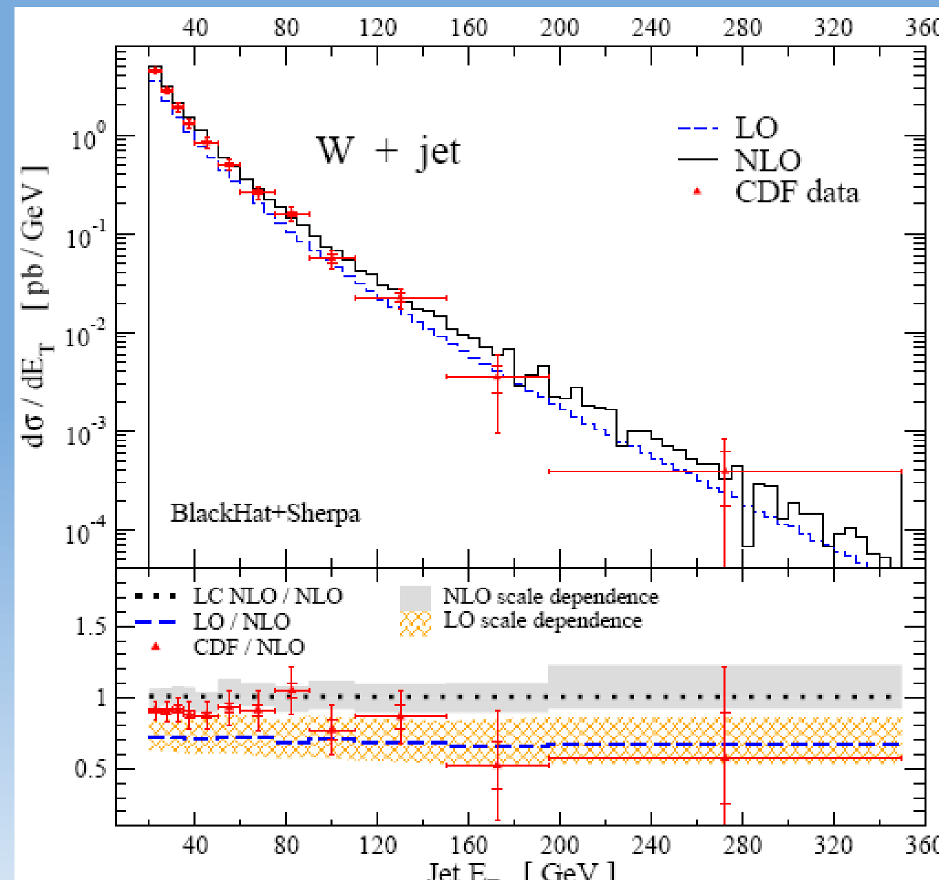
W+ jet +X at the Tevatron





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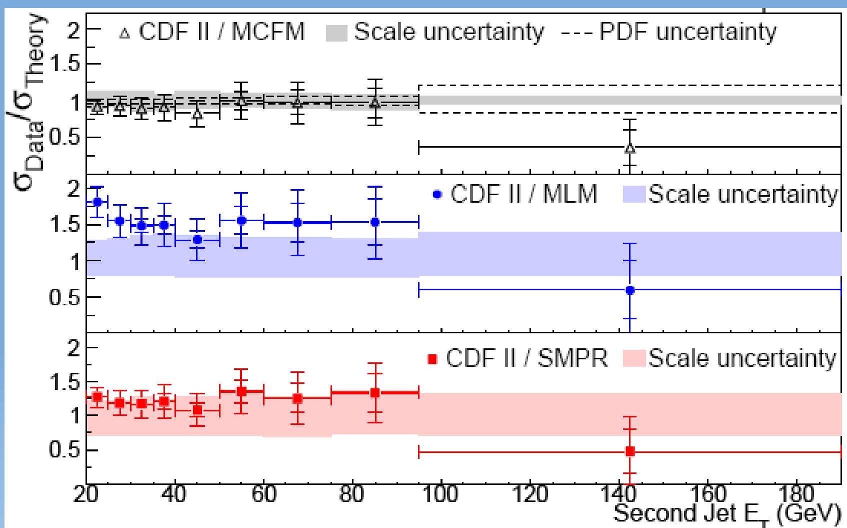
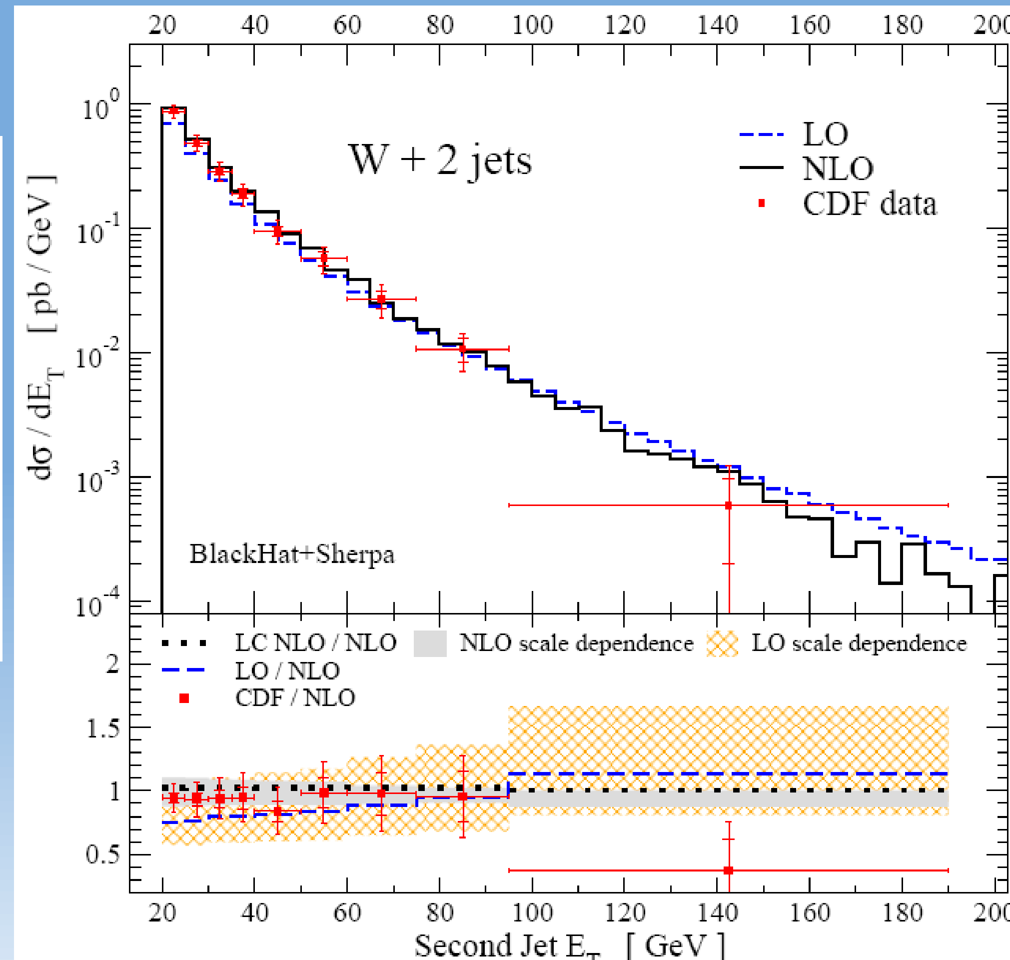
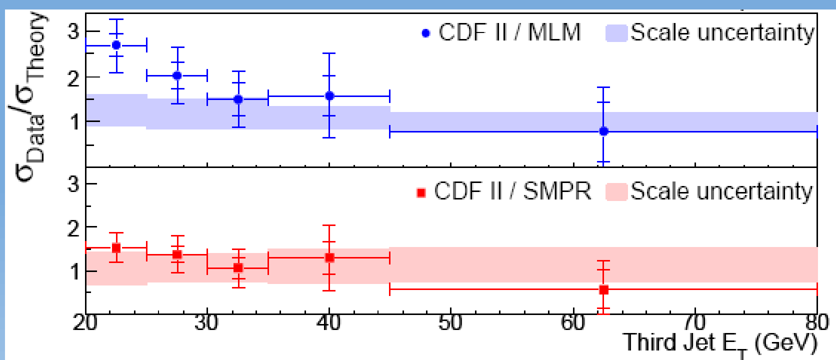
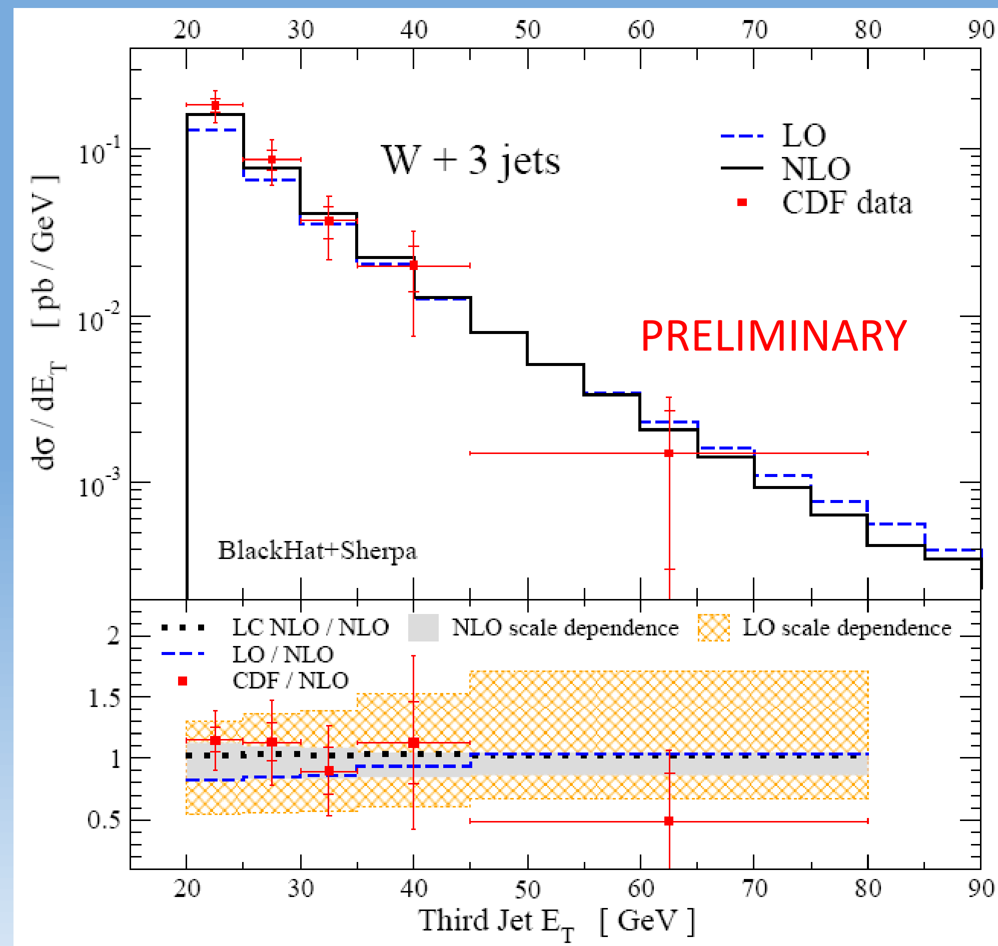
W+2 jets + X at the Tevatron





W+3 jets + X at the Tevatron





W+3 Jets at the LHC

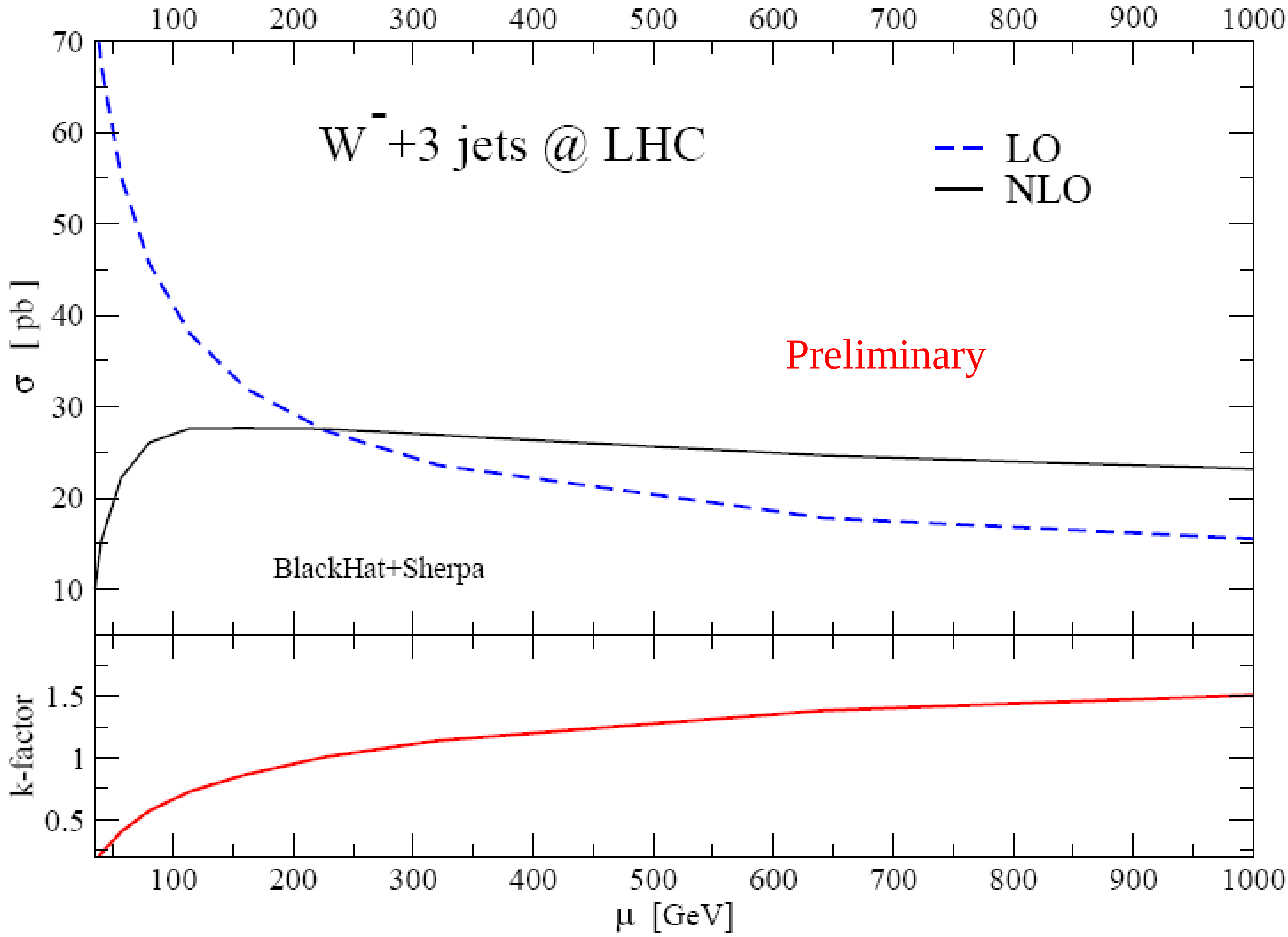
PRELIMINARY

	Cut
Electron Et	20 GeV
Electron eta	2.5
Missing Energy	30 GeV
W Transverse Mass	20 GeV
Jet Et	30 GeV
Jet eta	3
Delta R	0.4

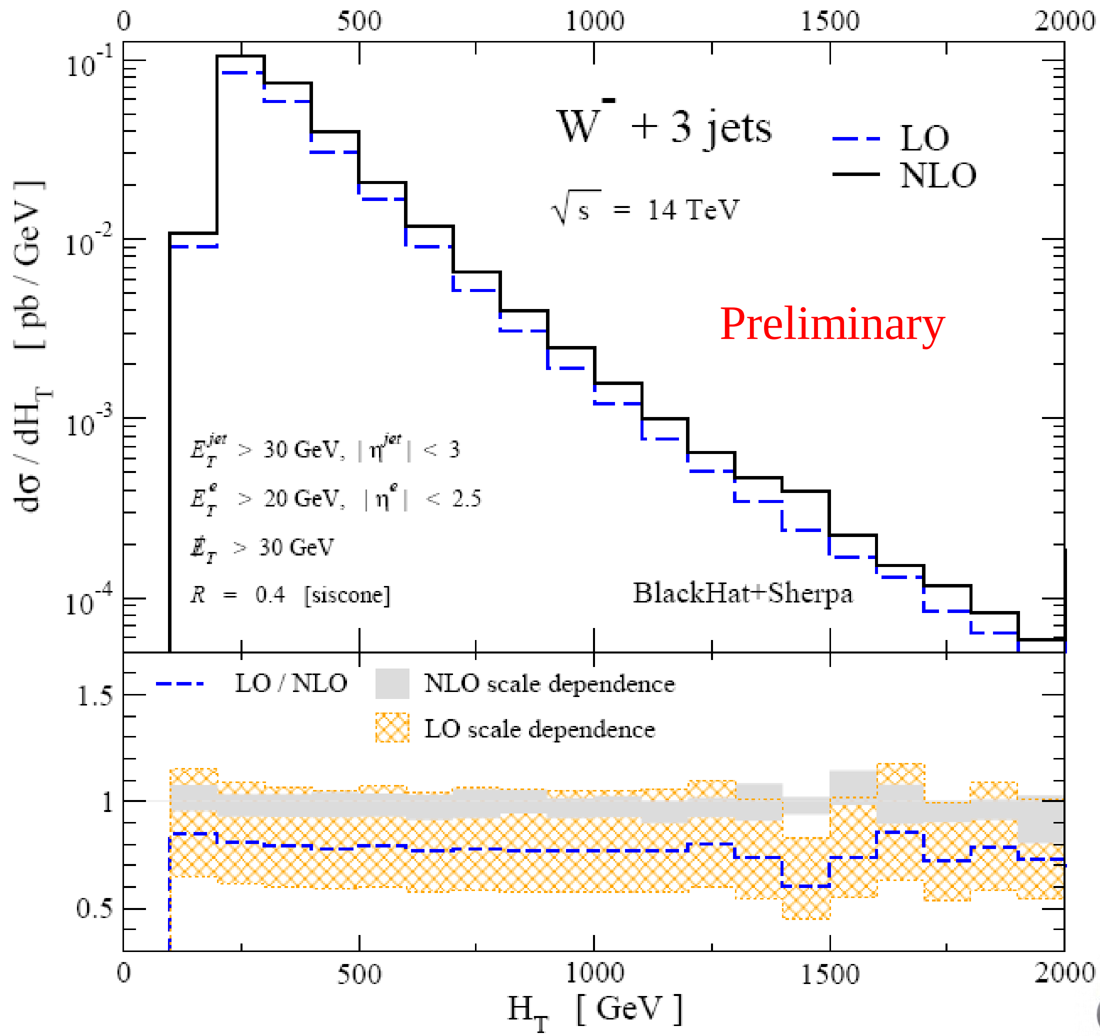
$$E_{CM} = 14\ \text{TeV}$$

SISCone

LHC total cross section



$H_T = \sum_j E_{T,j}^{\text{jet}} + E_T^e + \not{E}_T$ distribution



mu = H_T

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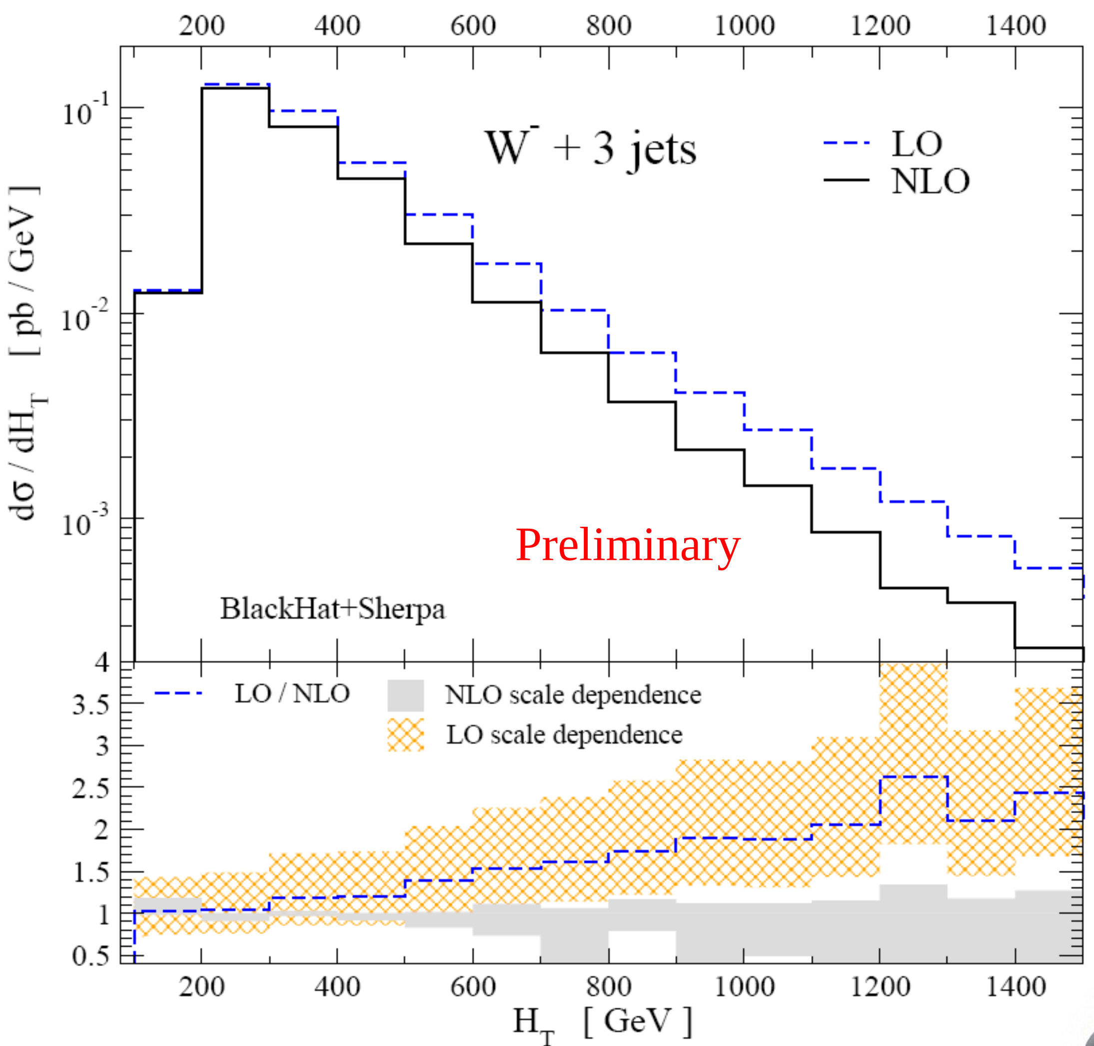
$H_T = \sum_j E_{T,j}^{\text{jet}} + E_T^e + \not{E}_T$ distribution



$\mu = \sqrt{M_W^2 + p_T^2(W)}$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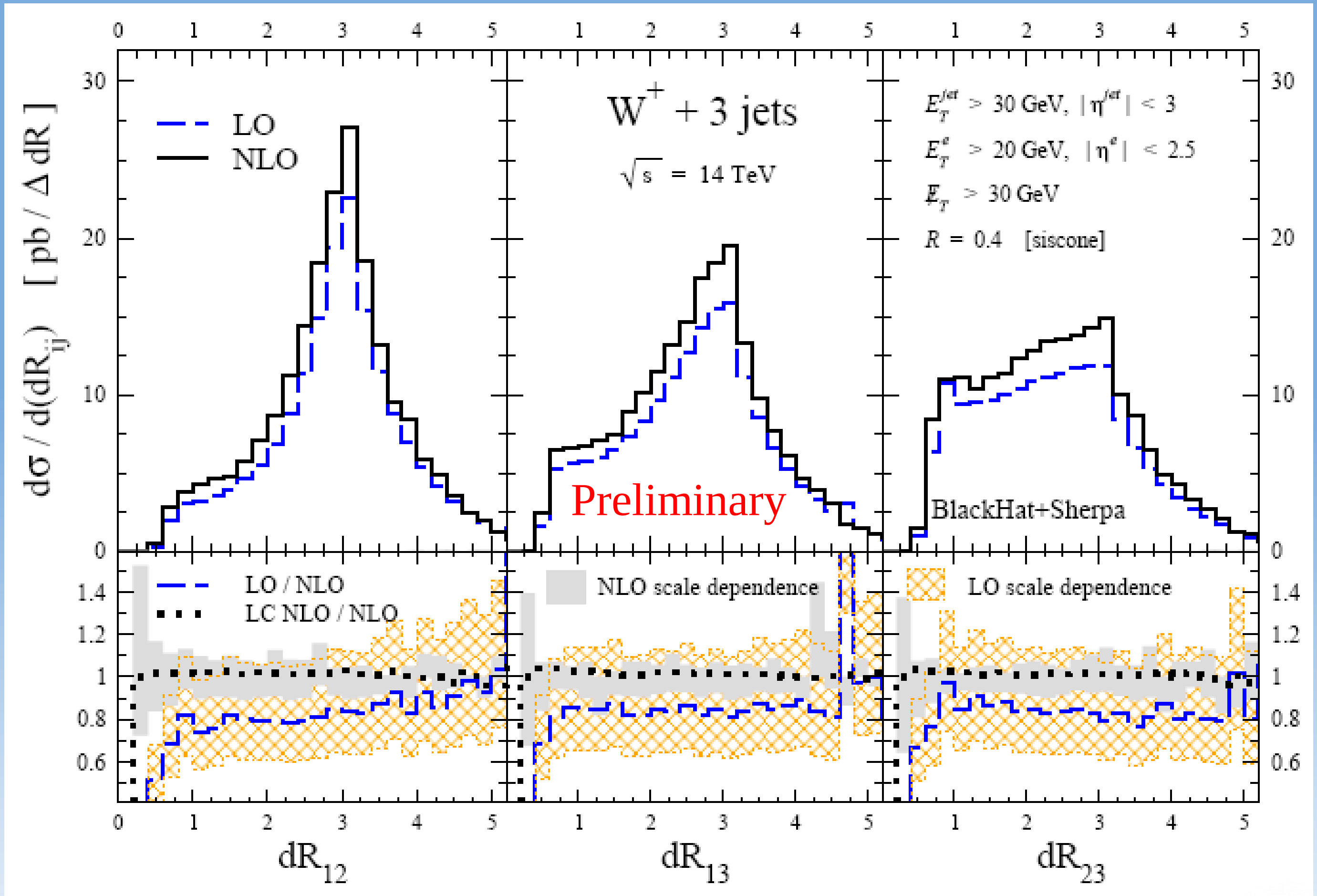
Jet dR Distributions



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Conclusions

- **NLO QCD corrections** are an important tool for hadron collider analyses: first reliable quantitative predictions
- ***Automated tools*** for computing loop quantum corrections are now on the horizon!
- Presented NLO QCD corrections to ***W+n jets (n=1,2,3)*** production at hadron colliders using ***BlackHat+SHERPA***: good description of CDF data
- ***Public Release*** of the codes is expected soon!