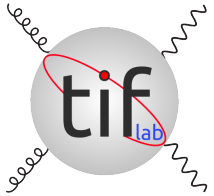
PDFs:

FROM RUN II TO RUN III

STEFANO FORTE
UNIVERSITÀ DI MILANO & INFN

UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI FISICA



CMS SM MEETING

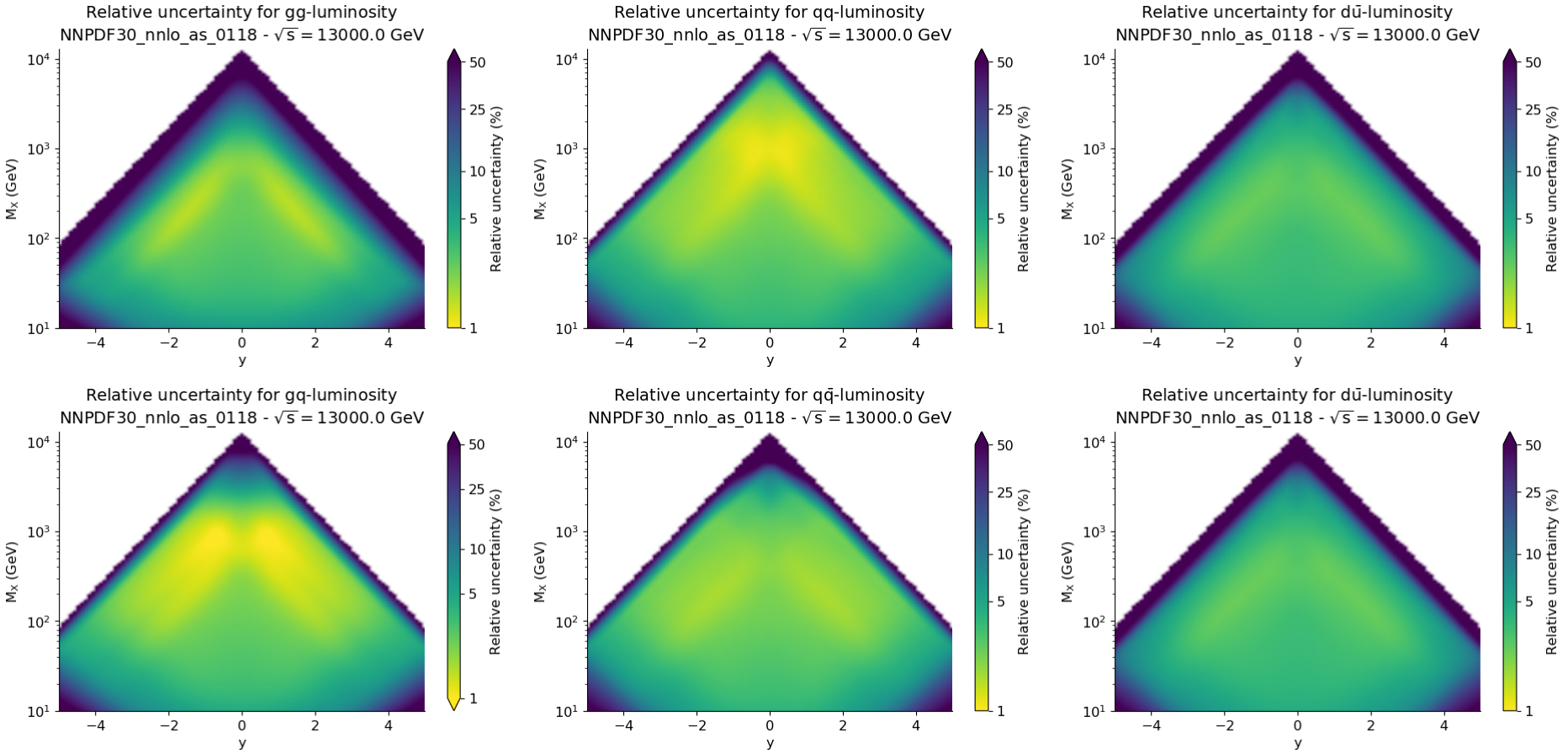
FEBRUARY 25, 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 740006

MOTIVATIONS: PRECISION

PDF4LHC PDFs (2014) NNPDF3.0 NNLO

GLUON SINGLET FLAVORS

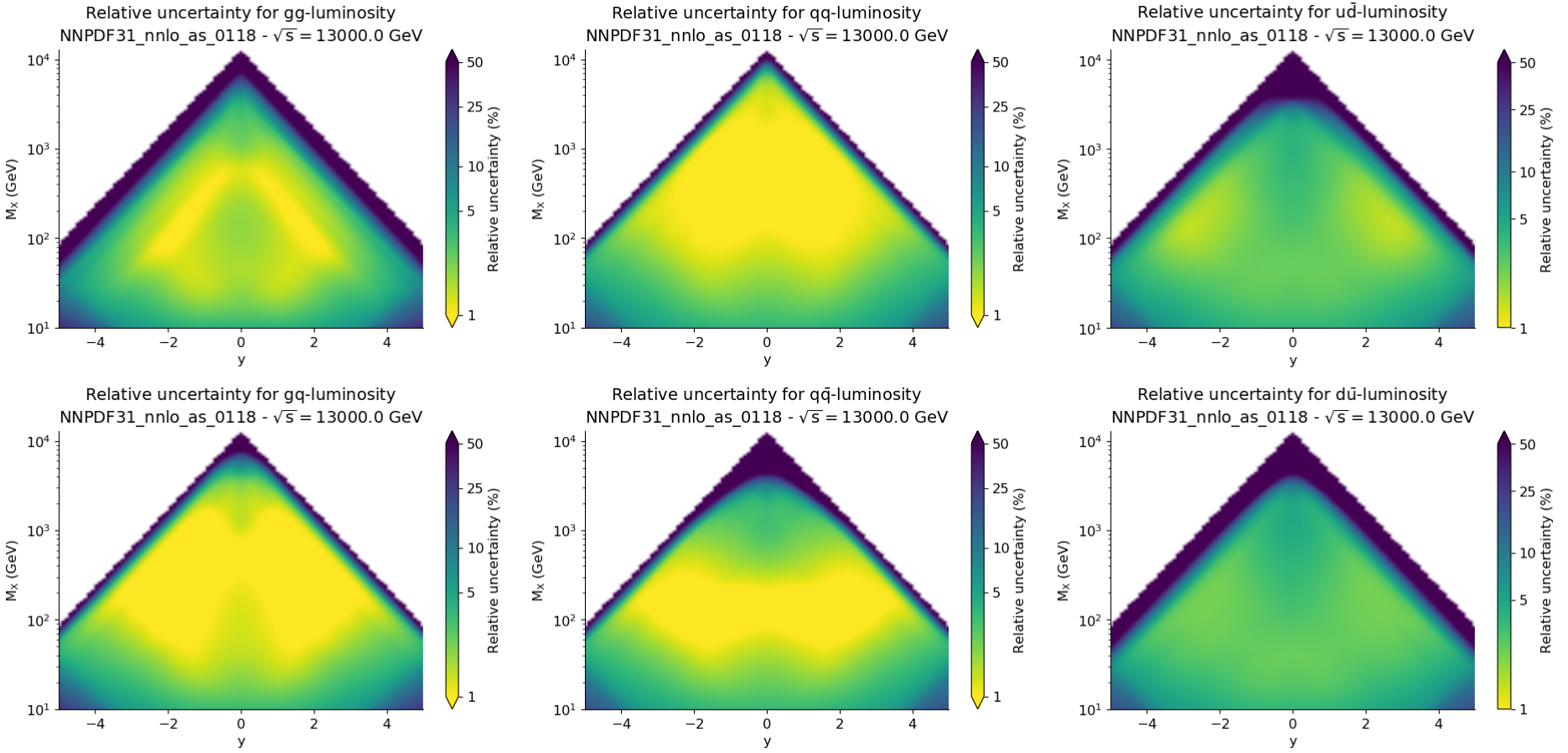


- GLUON BETTER KNOWN AT SMALL x, VALENCE QUARKS AT LARGE x, SEA QUARKS IN BETWEEN
- TYPICAL UNCERTAINTIES IN DATA REGION $\sim 3 - 5\%$
- SWEET SPOT: VALENCE Q - G; DOWN TO 1%
- UP BETTER KNOWN THAN DOWN; FLAVOR SINGLET BETTER THAN INDIVIDUAL FLAVORS

MOTIVATIONS: PRECISION

CURRENT PDFs (2017) NNPDF3.1 NNLO

GLUON SINGLET FLAVORS

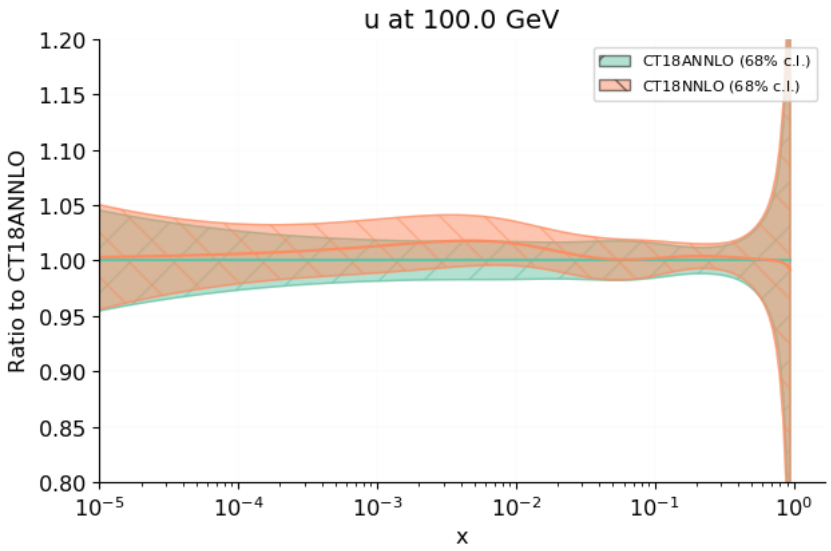


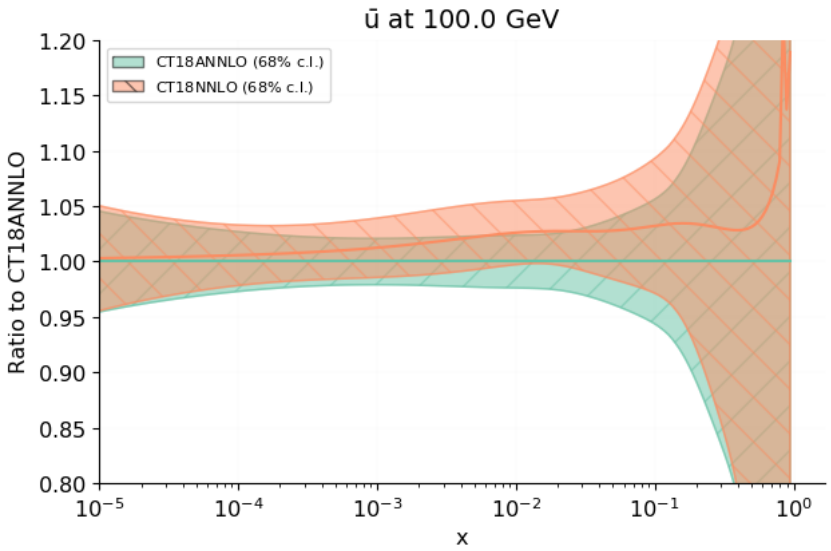
- GLUON BETTER KNOWN AT SMALL x, VALENCE QUARKS AT LARGE x, SEA QUARKS IN BETWEEN
- TYPICAL UNCERTAINTIES IN DATA REGION $\sim 1 - 3\%$
- SWEET SPOT: VALENCE Q - G; 1% OR BELOW
- UP BETTER KNOWN THAN DOWN; FLAVOR SINGLET BETTER THAN INDIVIDUAL FLAVORS

MOTIVATIONS: ACCURACY

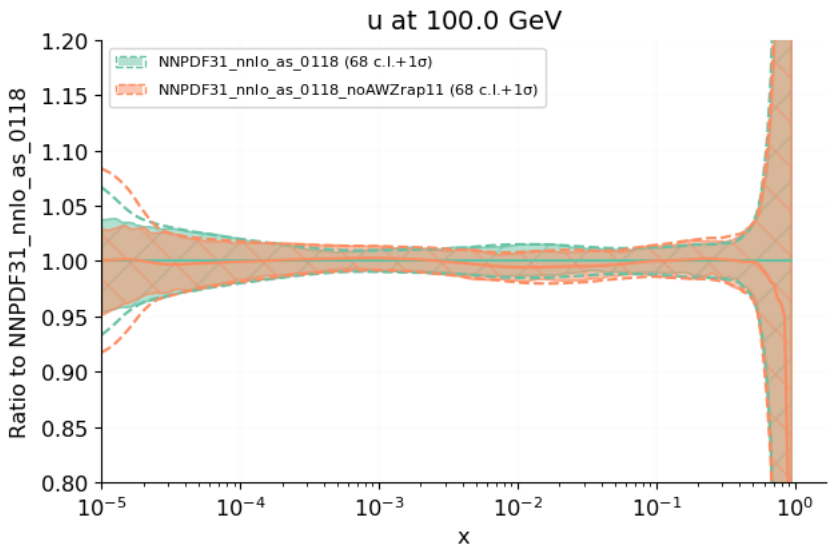
IMPACT OF ATLAS W/Z 7TEV DATA

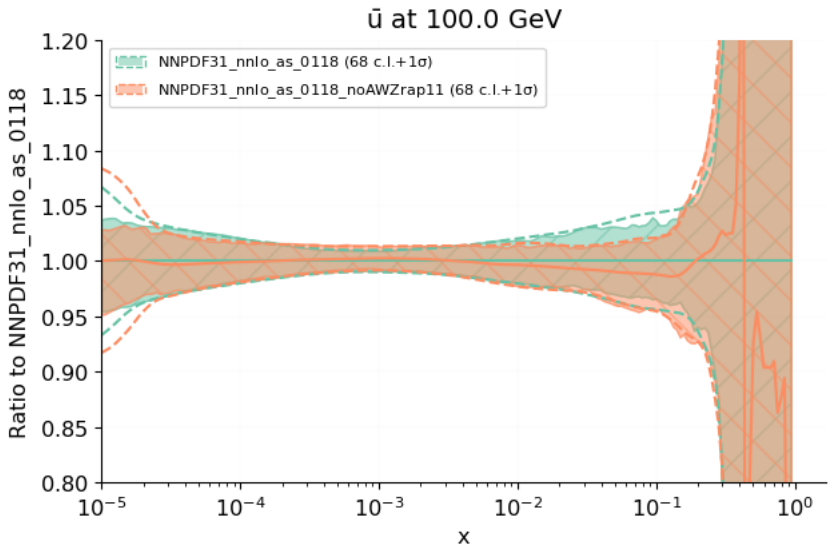
CT18





NNPDF3.1





- CT18: PDF SETS RELEASED WITH/WITHOUT ATLAS W/Z DATA INCLUDED
- NNPDF3.1: CONSISTENCY OF ALL DATASETS INCLUDED

SUMMARY

TOWARDS NNPDF4.0 (2020)

DATA

- THE NNPDF4.0 DATASET
- TOP PAIRS
- SINGLE TOP
- JETS

THEORY

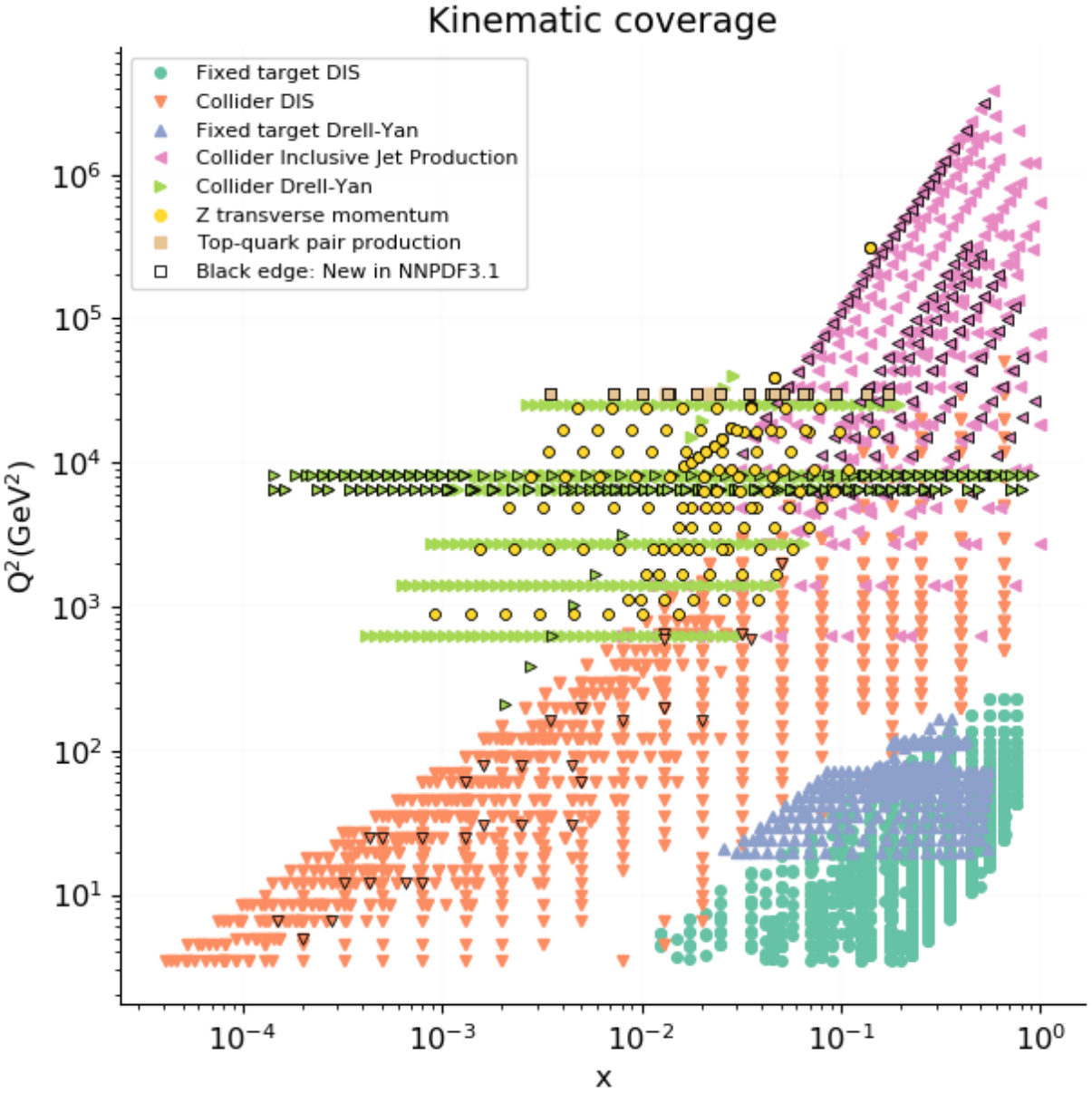
- ELECTROWEAK CORRECTIONS
- REGULARIZED COVARIANCE MATRICES
- THEORY UNCERTAINTIES

(METHODOLOGY)

DATA

DATASET WIDENING

NNPDF3.0 vs NNPDF3.1 (CT14 vs. CT18: similar)



NEW DATA: (black edge)

- HERA combined F_2^b
- D0 W lepton asymmetry
- ATLAS W, Z 2011, high & low mass DY 2011; CMS $W^{\pm}$ rapidity 8TeV LHCb W, Z 7TeV & 8TeV
- ATLAS 7TeV jets 2011, CMS 2.76TeV jets
- ATLAS & CMS top differential rapidity
- ATLAS Z p_T differential rapidity & invariant mass 8TeV, CMS Z p_T differential rapidity 8TeV

DATASET WIDENING
NNPDF4.0 SUMMARY (EXPECTED IN 2020)

1. OLD DATASETS WITH IMPROVED TREATMENT
   - ASSORTED DEBUGGING
   - CORRELATIONS IN ATLAS TOP DISTRIBUTIONS AT 8 TEV
   - CHOICE OF SCALE AND CORRELATION MODELS FOR SINGLE-JET DATA
   - MASSIVE CORRECTIONS TO NEUTRINO DIS DIMUON CROSS SECTIONS AT NNLO
   - NUCLEAR UNCERTAINTIES IN FIXED-TARGET DIS AND DY
2. NEW DATASETS FOR OLD PROCESSES
   - DIS c AND b PRODUCTION (HERA COMBINED)
   - SINGLE JET PRODUCTION (ATLAS, CMS)
   - TOP PAIR PRODUCTION (ATLAS, CMS)
   - COLLIDER DY/INCLUSIVE VECTOR BOSON PRODUCTION (ATLAS, CMS, LHCB)
   - COLLIDER VECTOR BOSON PRODUCTION IS ASSOCIATION WITH CHARM (CMS)
3. NEW DATASETS FOR NEW PROCESSES
   - ISOLATED PHOTON PRODUCTION (ATLAS)
   - SINGLE TOP PRODUCTION (ATLAS, CMS)
   - COLLIDER DIJET PRODUCTION (ATLAS, CMS)
   - DIS+JET(S) PRODUCTION (H1, ZEUS)
   - COLLIDER VECTOR BOSON PRODUCTION IS ASSOCIATION WITH JETS (ATLAS, CMS)

$\mathcal{O}(50)$ NEW/REVISED DATASETS

DISCUSSED IN THIS TALK

NEW DATASETS FOR OLD PROCESSES

- DIS c AND b PRODUCTION
  HERA COMBINED REDUCED CROSS SECTIONS (REPLACES H1 AND ZEUS DATA SETS)

- SINGLE-INCLUSIVE JETS
  ATLAS 8 TEV DOUBLE DIFFERENTIAL DISTRIBUTIONS (R=0.4; R=0.6) (IMPLEMENT CORRELATION MODELS)
  CMS 8 TEV DOUBLE DIFFERENTIAL DISTRIBUTIONS (R=0.7)(IMPLEMENT CORRELATION MODELS)

- TOP PAIR PRODUCTION
  ATLAS 8 TEV DIFFERENTIAL ABS. AND NORM. DISTRIBUTIONS; DILEPTON; $m_{t\bar{t}}$; $y_{t\bar{t}}$
  CMS 8 TEV DOUBLE DIFFERENTIAL NORM. DISTRIBUTIONS; DILEPTON; (p_T^t, y_t); $(m_{t\bar{t}}, y_t)$; $(m_{t\bar{t}}, y_{t\bar{t}})$
  CMS 13 TEV DIFFERENTIAL ABS. AND NORM. DISTRIBUTIONS; DILEPTON; p_T^t; y_t; $y_{t\bar{t}}$; $m_{t\bar{t}}$
  CMS 13 TEV DIFFERENTIAL ABS. AND NORM. DISTRIBUTIONS; LEPTON+JET; p_T^t; y_t; $y_{t\bar{t}}$; $m_{t\bar{t}}$
  CMS 5.02 TEV TOTAL CROSS SECTION

- COLLIDER DY/INCLUSIVE VECTOR BOSON PRODUCTION OR IN ASSOCIATION WITH CHARM
  ATLAS 13 TEV W^+, W^- AND Z TOTAL CROSS SECTIONS (INCLUDING CORRELATIONS)
  ATLAS 7 TEV W^+, W^- AND Z RAPIDITY DISTRIBUTIONS (INCLUDIG OFF-PEAK AND FORWARD)
  ATLAS 8 TEV DOUBLE-DIFFERENTIAL HIGH-MASS DY DISTRIBUTIONS (TO BE CHECKED)
  ATLAS 8 TEV TRIPLE DIFFERENTIAL DY DISTRIBUTION
  CMS 8 TEV DOUBLE-DIFFERENTIAL DY DISTRIBUTION
  CMS 13 TEV DY DIFFERENTIAL CROSS-SECTIONS (VARIOUS DISTRIBUTIONS, AMONG WHICH Zp_T)
  CMS 13 TEV $W + c$ DIFFERENTIAL DISTRIBUTIONS
  LHCB 8 TEV W AND Z RAPIDITY DISTRIBUTIONS, ELECTRON CHANNEL
  LHCB 13 TEV Z RAPIDITY DISTRIBUTIONS, DIELECTRON AND DIMUON CHANNELS

ALREADY IMPLEMENTED; ONGOING IMPLEMENTATION; TO DO

NEW DATA SETS FOR NEW PROCESSES

- ISOLATED PHOTON PRODUCTION
  ATLAS 8 TeV DIFFERENTIAL DISTRIBUTIONS, INCLUDING CORRELATIONS
  ATLAS 13 TeV DIFFERENTIAL DISTRIBUTIONS

- SINGLE TOP PRODUCTION, t-CHANNEL
  ATLAS TOP TO ANTITOP RATIO, 7, 8 AND 13 TeV
  ATLAS TOP AND ANTITOP ABS. AND NORM. DIFFERENTIAL DISTRIBUTIONS, 7 TeV, p_T; y
  ATLAS TOP AND ANTITOP ABS. AND NORM. DIFFERENTIAL DISTRIBUTIONS, 8 TeV, p_T; y
  CMS TOP AND ANTITOP TOTAL CROSS SECTION, 7 TeV
  CMS TOP TO ANTITOP RATIO, 8 AND 13 TeV

- COLLIDER DI-JET PRODUCTION
  ATLAS 7 TeV DIJET DOUBLE DIFFERENTIAL DISTRIBUTIONS (R=0.4; R=0.6)
  CMS 5.02 TeV DIJET DOUBLE DIFFERENTIAL DISTRIBUTIONS
  CMS 7 TeV DIJET DOUBLE DIFFERENTIAL DISTRIBUTIONS (R=0.7)
  CMS 8 TeV DIJET TRIPLE DIFFERENTIAL DISTRIBUTIONS (R=0.7)

- DIS+JET(S) PRODUCTION
  H1 SINGLE- AND DI-JET DIFFERENTIAL DISTRIBUTIONS
  ZEUS SINGLE- AND DI-JET DIFFERENTIAL DISTRIBUTIONS

- COLLIDER VECTOR BOSON PRODUCTION IN ASSOCIATION WITH JETS
  ATLAS 8 TeV W+JET DIFFERENTIAL DISTRIBUTIONS

ALREADY IMPLEMENTED; ONGOING IMPLEMENTATION; TO DO

TOP PAIR PRODUCTION

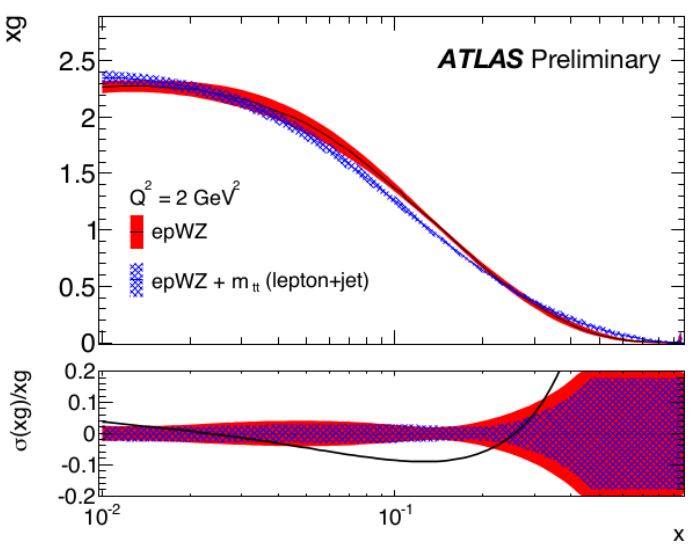
(PAST RESULTS)

CONSISTENCY OF DIFFERENT OBSERVABLES

TOP PRODUCTION AND THE GLUON

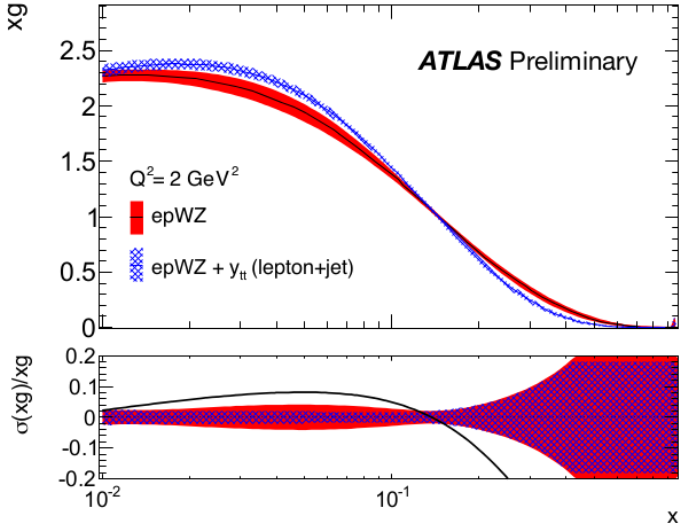
INCLUSION OF ATLAS TOP DATA IN HERA+TOP FIT (XFITTER)

HQ PAIR RAPIDITY DISTN



(a)

INVARIANT MASS DISTN.

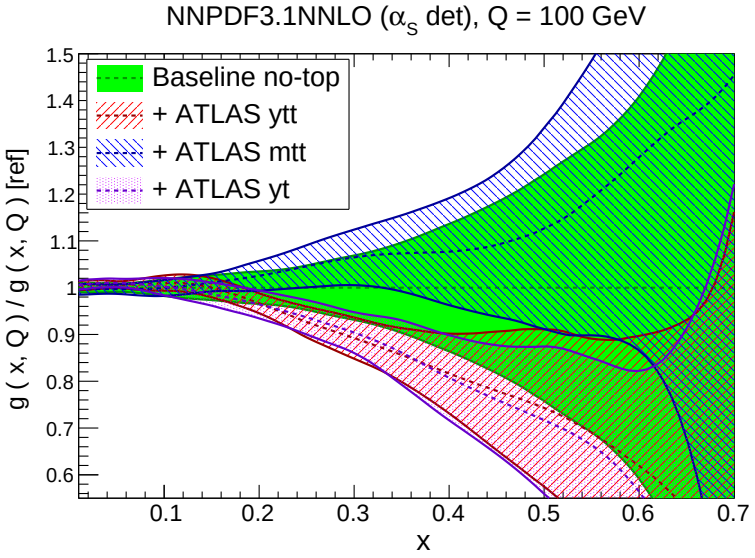


(a)

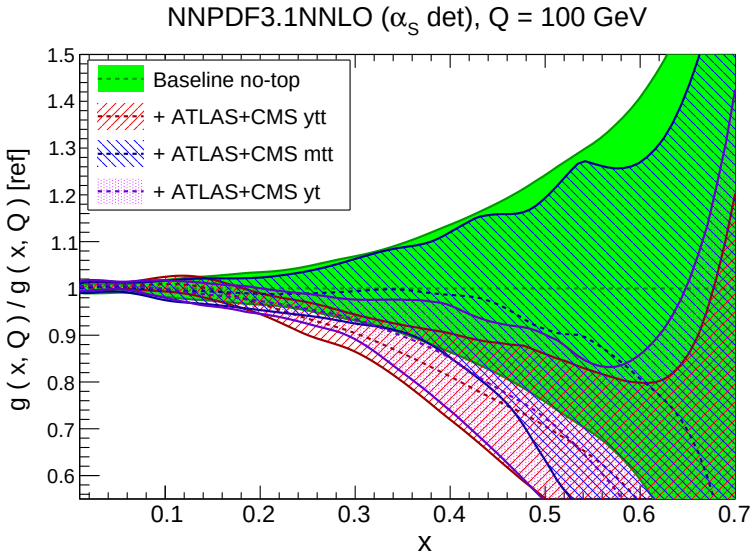
INCONSISTENCY?

TOP PAIR PRODUCTION
(PAST RESULTS)
TOP PRODUCTION AND THE GLUON
INCLUSION OF ATLAS TOP DATA IN NNPDF3.1-LIKE FIT

ATLAS ONLY



ATLAS+CMS



- FOR ATLAS m_{tt} & y DISTRIBUTIONS PULL IN OPPOSITE DIRECTION
  $\Rightarrow$ COMPATIBLE WITHIN UNCERTAINTIES
- m_{tt} HAS MUCH LESS PULL
- FOR CMS, BOTH m_{tt} & y PULL IN THE SAME DIRECTION

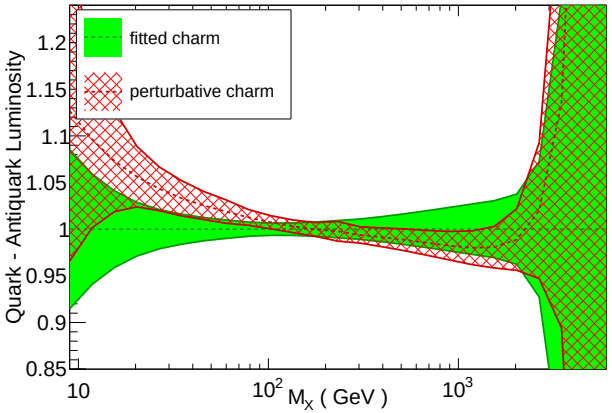
CONSISTENCY!

ASIDE: THE CHARM PDF FROM DATA
IMPACT ON LIGHT QUARK PDFS

- TRADITIONALLY CHARM PERTURBATIVELY GENERATED FROM (LOW-ORDER) MATCHING CONDITIONS
- NNPDF3.1: CHARM FITTED

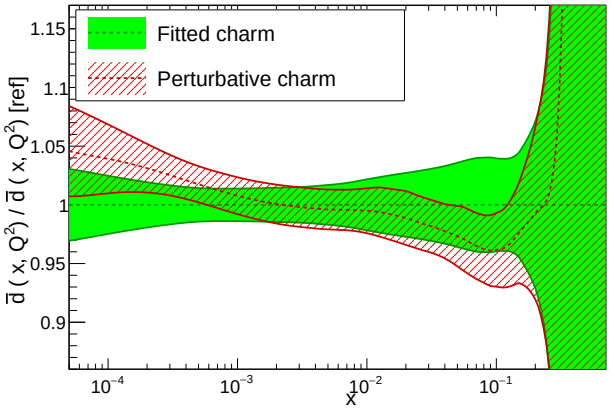
QQBAR LUMI

LHC 13 TeV, NNLO

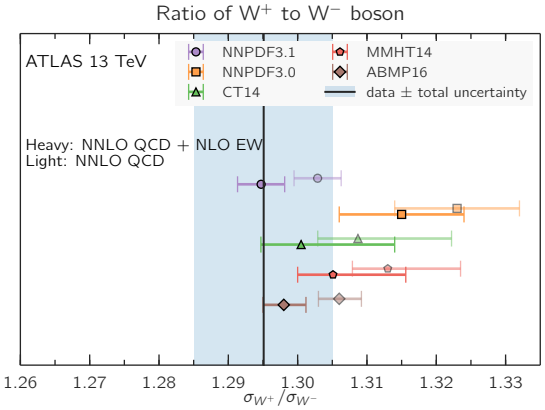


FITTED VS. PERTURBATIVE CHARM ANTIDOWN PDF

NNPDF3.1 NNLO, Q = 100 GeV



W^+/W^- XSECT RATIO



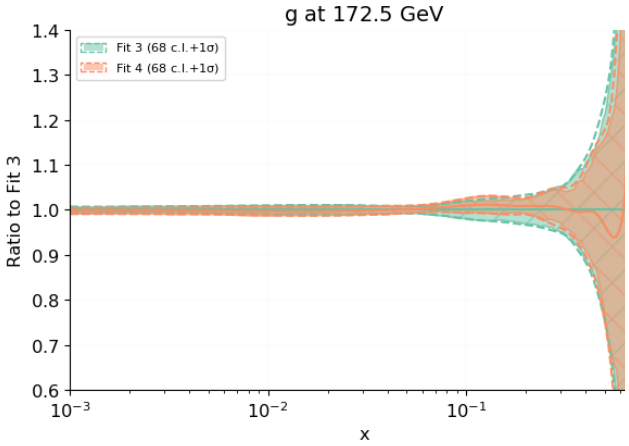
- QUARK (ESPECIALLY QUARK-ANTIQUARK) LUMI AFFECTED
- FLAVOR DECOMPOSITION ALTERED
- NECESSARY FOR AGREEMENT OF 13TeV PREDICTED CROSS-SECTIONS

TOP PAIR PRODUCTION
(NEW RESULTS)

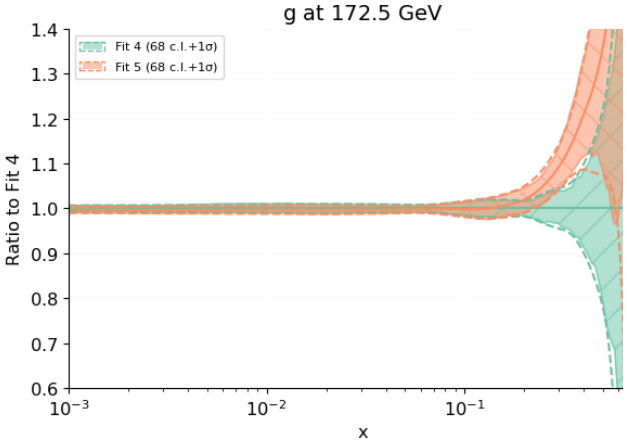
(S.F., E. Nocera, J. Rojo, subm. to Les Houches 2019)

- WHAT IF WE FIT ALL DISTRIBUTIONS AT ONCE?
  CORRELATIONS $\Rightarrow$ NOW POSSIBLE
- NORMALIZED VS. ABSOLUTE DISTRIBUTIONS?
- FITTING CHARM? (NEEDED FOR GOOD FIT TO ATLAS W/Z IN NNPDF3.1)

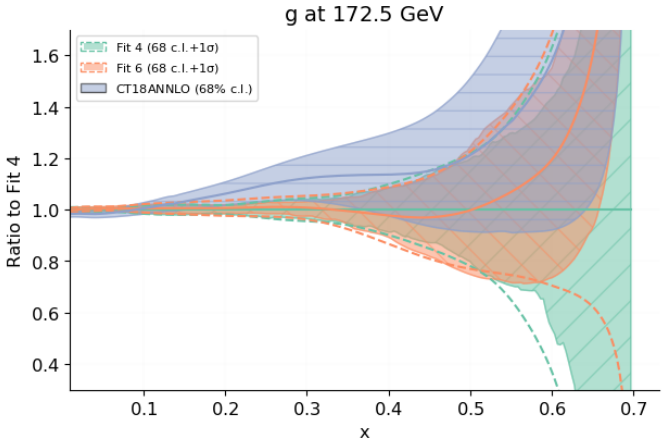
t RAPIDITY VS. ALL



ALL NORM. VS. ABSOLUTE



ALL NORM FIT. VS. PERT. CHARM

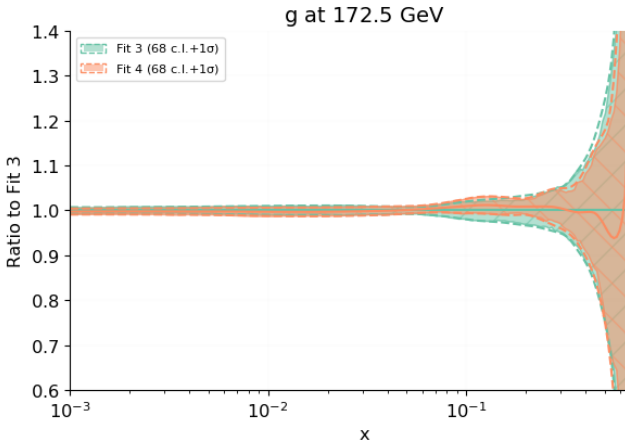


TOP PAIR PRODUCTION
(NEW RESULTS)

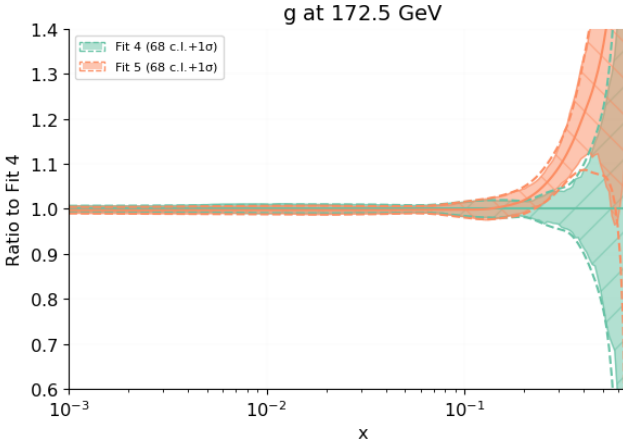
(S.F., E. Nocera, J. Rojo, subm. to Les Houches 2019)

- WHAT IF WE FIT ALL DISTRIBUTIONS AT ONCE? $\Rightarrow$ NO EFFECT!
  CORRELATIONS $\Rightarrow$ NOW POSSIBLE
- NORMALIZED VS. ABSOLUTE DISTRIBUTIONS? $\Rightarrow$ BIG EFFECT!
- FITTING CHARM? $\Rightarrow$ SIZABLE EFFECT!

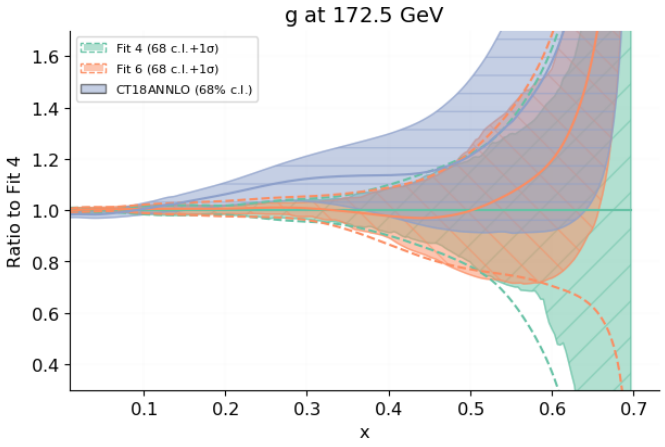
t RAPIDITY VS. ALL



ALL NORM. VS. ABSOLUTE



ALL NORM FIT. VS. PERT. CHARM

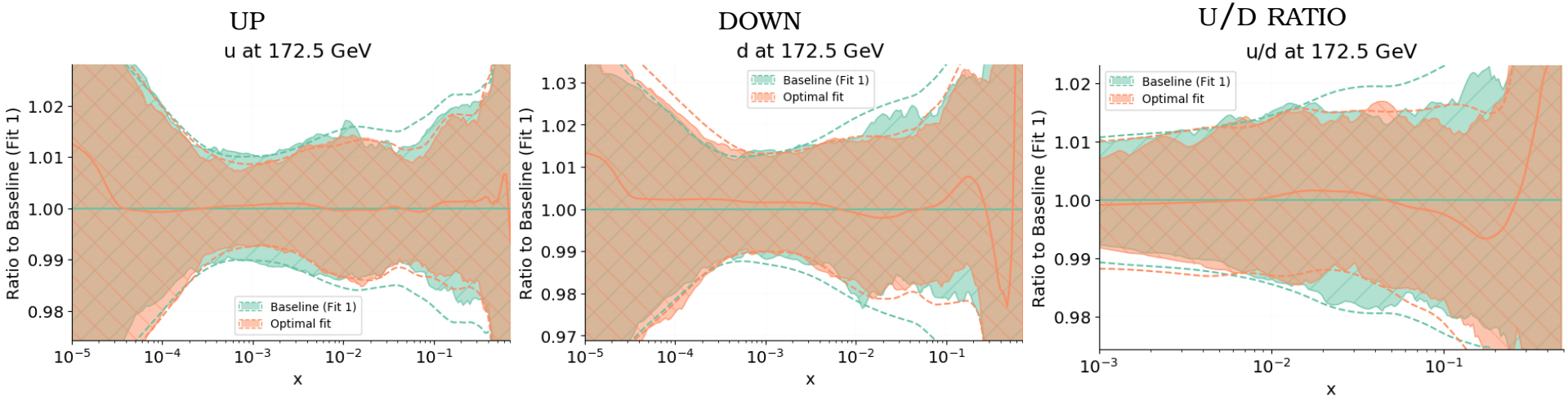


- DIFFERENT DISTRIBUTIONS CONSISTENT (BUT p_t BAD FIT)
- ABSOLUTE PATHOLOGICAL (BAD FIT, INCONSISTENT GLUON)
- FITTED CHARM NEEDED FOR CONSISTENCY WITH GLOBAL DATASET

SINGLE TOP PRODUCTION (t-CHANNEL)

(E. Nocera, M. Ubiali, C. Voisey, `arXiv:1912.09543`)

- CANNOT USE MULTIPLE OBSERVABLES (NO CORRELATION)
- OPTIMAL SET $\Rightarrow$ XSECT RATIOS (ATLAS, CMS), TOTAL XSECT (CMS) + NORMALIZED RAPIDITY DISTRIBUTION (ATLAS)
- SEVERAL PROBLEMATIC DATA: p_T DISTRIBUTIONS, ATLAS XSECT RATIOS



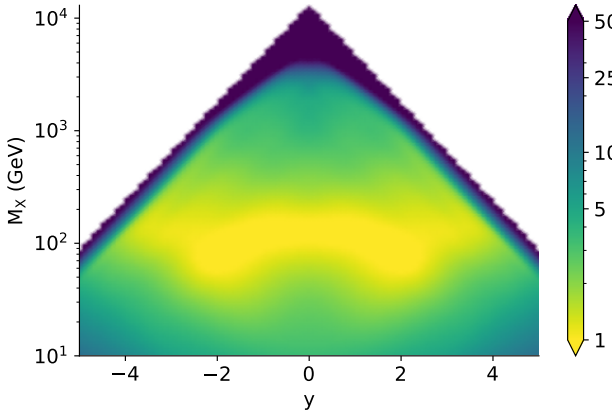
- CENTRAL VALUES UNCHANGED
- SLIGHT REDUCTION OF UNCERTAINTY ON LIGHT QUARKS

SINGLE TOP PRODUCTION(t-CHANNEL)
IMPACT ON PHENOMENOLOGY

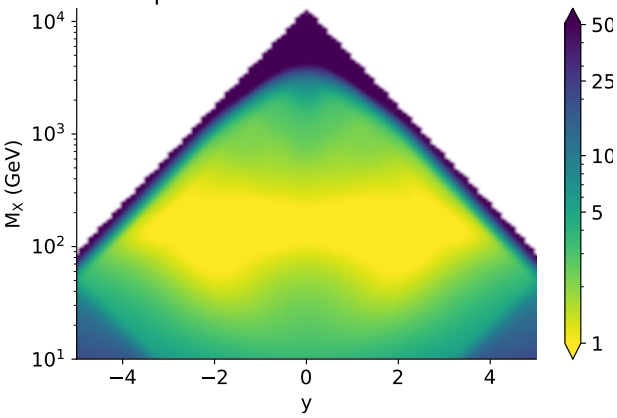
- MOST PRECISE REGION FOR $q\bar{q}$ LUMI SOMEWHAT EXTENDED
- UNCERTAINTY ON W^+/W^- HARDLY REDUCED

QUARK-ANTIQUARK LUMINOSITY

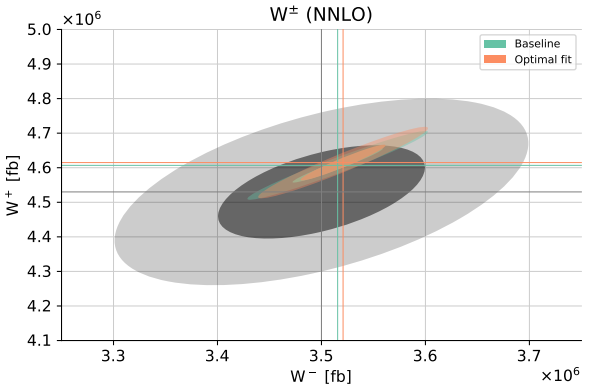
BASELINE



BASELINE+SINGLE TOP



W^+/W^- RATIO



- WHAT'S WRONG WITH THE ATLAS 8TEV XSECT RATIO?
- WHAT'S WRONG WITH THE p_T DISTRIBUTIONS?
- CORRELATIONS BETWEEN OBSERVABLES?

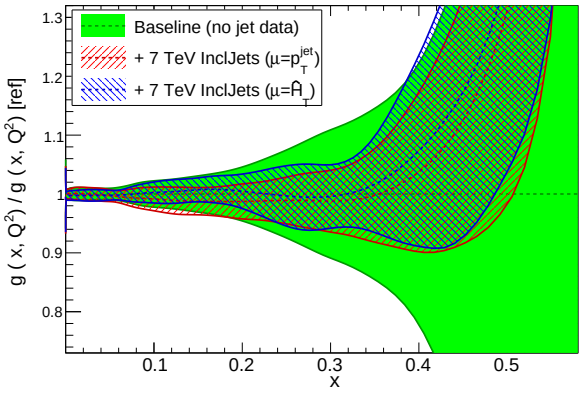
JETS:
SINGLE-INCLUSIVE: NNPDF3.1 DATASET

NNPDF+NNLOJET++, in preparation

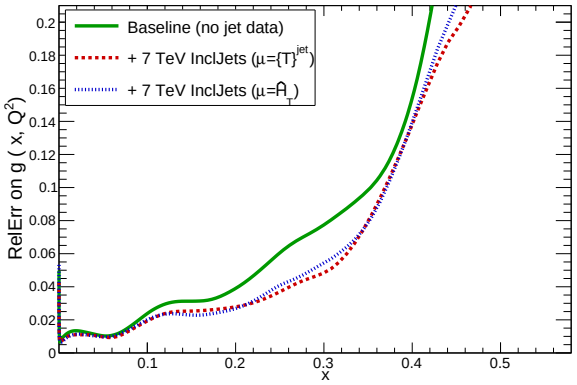
- IMPACT ON GLUON UNCERTAINTY AT LARGE x
- SERIOUS ISSUES WITH THE ATLAS 7 TEV COVARIANCE MATRIX
- $\hat{H}_T$ BETTER FIT AT NLO VS p_T, NO DIFFERENCE AT NNLO
- MODERATE IMPACT OF EW CORRNS ON PDFS, BUT BETTER FIT

IMPACT ON THE GLUON

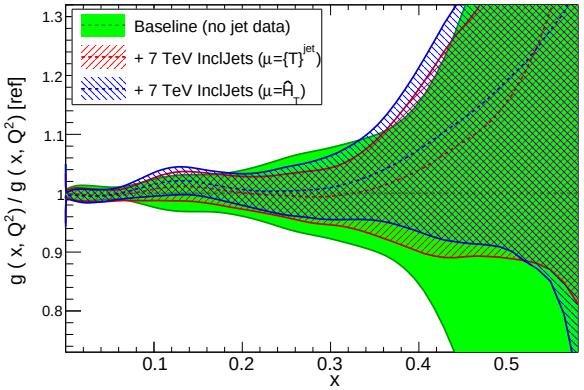
NLO



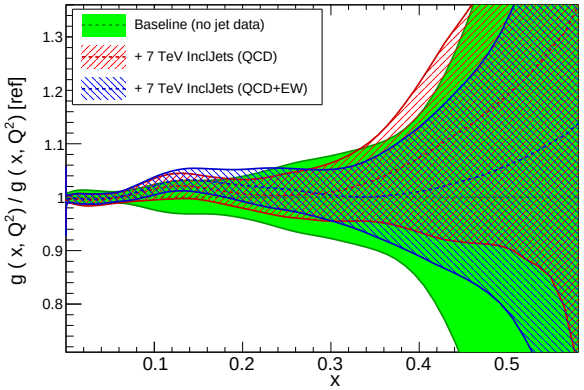
NNLO UNCERTAINTY



NNLO



EW CORRECTIONS



JETS

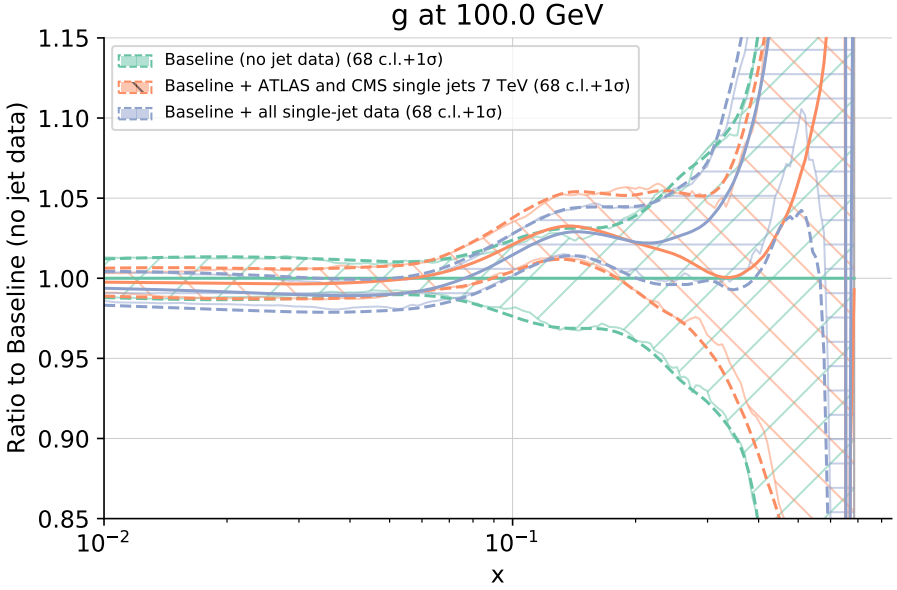
SINGLE-INCLUSIVE: FULL DATASET

NNPDF+NNLOJET++, in preparation

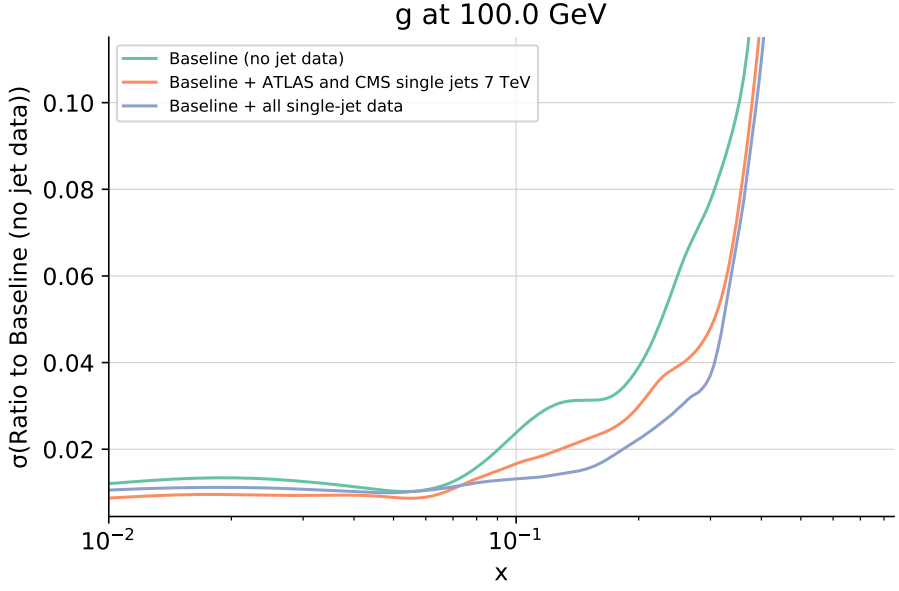
- CMS, ATLAS, 7, 8 TeV DATSETS CONSISTENT ⇒ UNCERTAINTY REDUCTION
- 8 TeV DATA ⇒ LARGE x GLUON AFFECTED

IMPACT ON THE NNLO GLUON

PDF



UNCERTAINTY



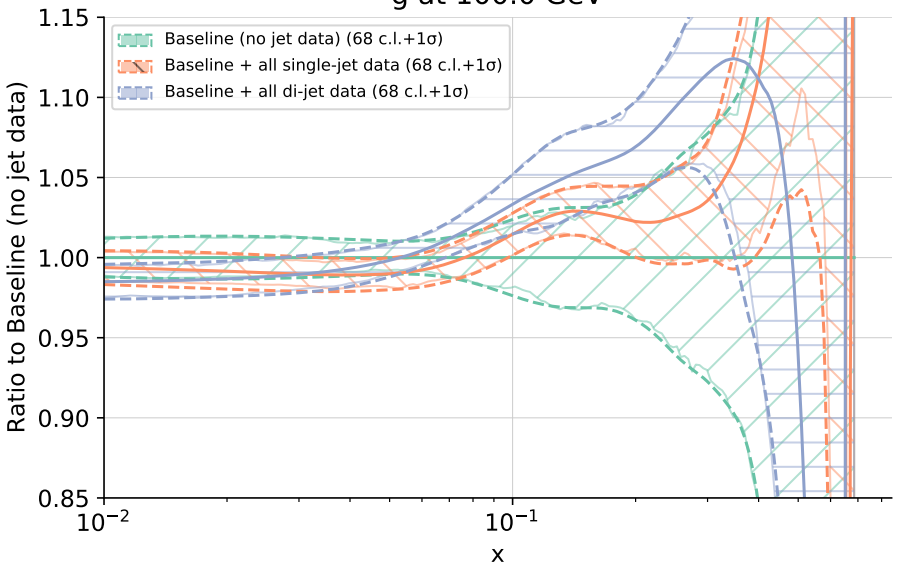
JETS:
SINGLE-INCLUSIVE VS. DIJETS

NNPDF+NNLOJET++, in preparation

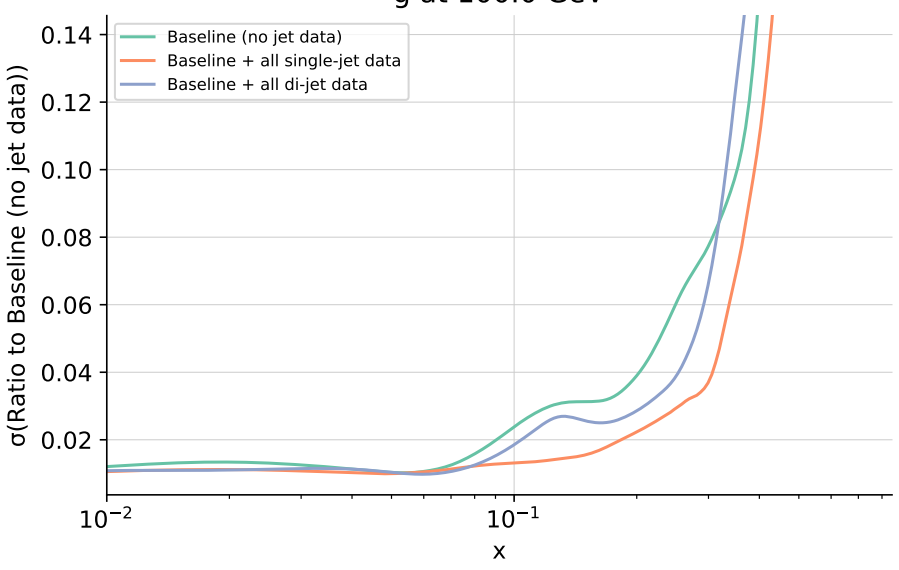
- CANNOT USE BOTH BECAUSE OF MISSING CORRELATIONS
- DIJETS BETTER FIT QUALITY

IMPACT ON THE GLUON

PDF



UNCERTAINTY



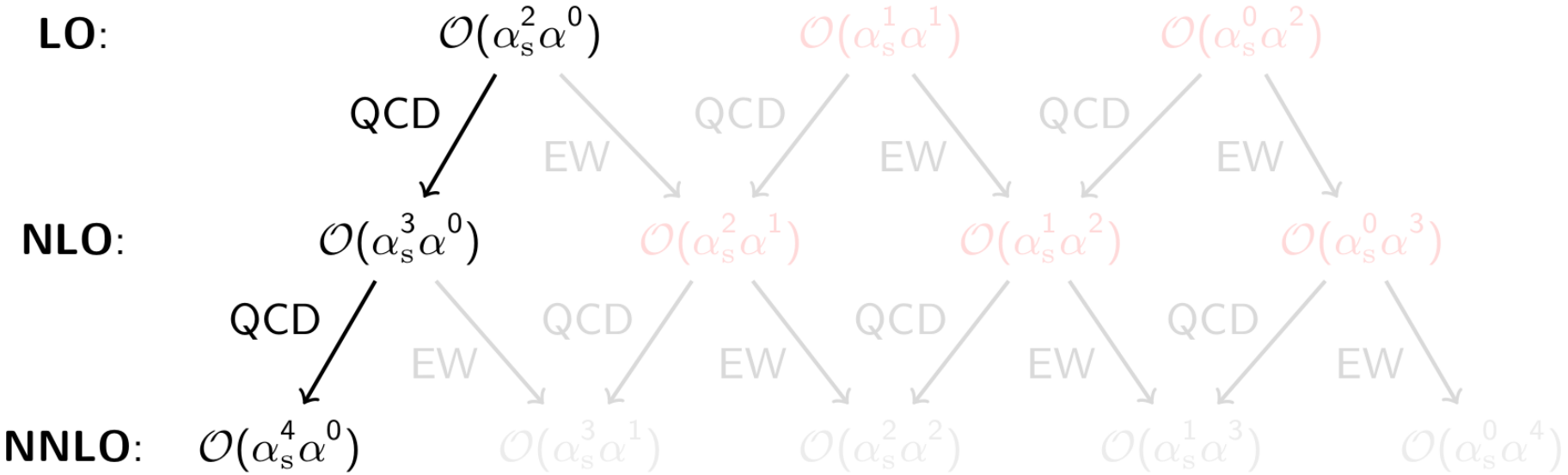
- SMILAR IMPACT OF EITHER OBSERVABLE
- SINGLE-INCLUSIVE $\Rightarrow$ SMALLER UNCERTAINTY (BUT MORE DATA)
- DIJETS $\Rightarrow$ (MORE) LARGE x ENHANCEMENT
- NEED FULL DATASET TO FIGURE OUT THE FINAL PRECISE PDF SHAPE

THEORY

ELECTROWEAK CORRECTIONS

EXAMPLE: TOP PAIR PRODUCTION

NNPDF3.1

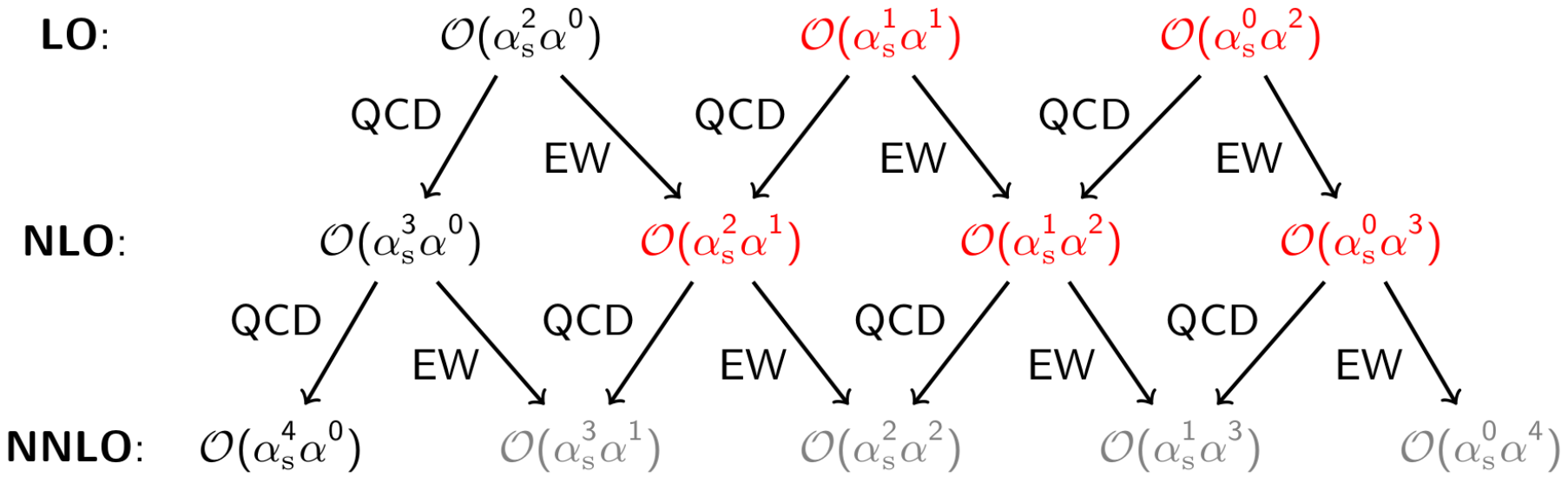


ELECTROWEAK CORRECTIONS

EXAMPLE: TOP PAIR PRODUCTION

NNPDF4.X

S. Carrazza, E. Nocera, C. Schwan, M. Zaro, in preparation



ELECTROWEAK CORRECTIONS

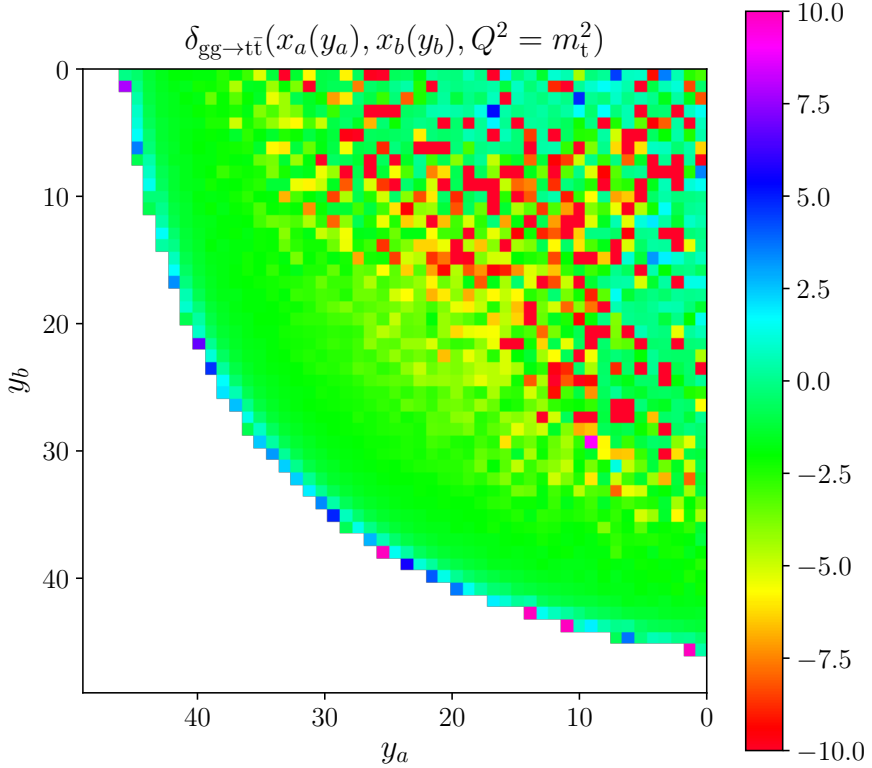
EXAMPLE: TOP PAIR PRODUCTION

NNPDF4.X

S. Carrazza, E. Nocera, C. Schwan, M. Zaro, in preparation

- TOOLCHAIN BASED ON `mg5_aMC`, `aMCblast`, `APPLgridEW` INTERFACED TO NNPDF THROUGH `APFELcomb`
- GRIDS COMPUTED AND TEST FITS PERFORMED FOR SELECTED PROCESSES

EXAMPLE: GLUON-GLUON GRID FOR $t\bar{t}$ 8 TeV



- $\Delta = \mathcal{O}(\alpha_s^\alpha)/\mathcal{O}(\alpha_s^2)$; $y_i(x) = -\ln x_i + 5(1 - x_i)$
- CORRECTION TYPICALLY $\sim 5\%$

ELECTROWEAK CORRECTIONS

THE DOUBLE-COUNTING PROBLEM

CONTRIBUTIONS SOMETIMES SUBTRACTED BY EXPERIMENT

EXAMPLE: ATLAS 7 TeV HIGH-MASS DY IN $Z, \gamma \to e^+e^-$ CHANNEL

- PHOTON-INDUCED SUBTRACTED AT LO (BUT NOT PHOTON-QUARK)
- THREE DATASETS DEFINED:
  - BORN LEPTONS: NO FINAL-STATE RADIATION (OK FOR QCD)
  - BARE LEPTONS: FINAL-STATE RADIATION
  - DRESSED LEPTONS: FINAL-STATE RADIATION + RECOMBINATION WITHIN GIVEN RADIUS (OK FOR QCD+EW)

DESIDERATA

- NEED DATASETS BOTH AT THE BARE & DRESSED LEVEL ✔
- PLEASE DO NOT SUBTRACT PHOTON INDUCED! (WHY WOULD YOU?) ✗

THE COVARIANCE MATRIX PROBLEM

- FOR SEVERAL DATSETS, FULL CORRELATED χ^2 POOR EXAMPLES:
- ATLAS 8 TeV $t\bar{t}$ ABSOLUTE DISTRIBUTIONS: $\chi^2/N_{\rm dat} \sim 6$, DECORRELATING OBSERVABLES $\chi^2/N_{\rm dat} \sim 2$
- ATLAS 2011 7 TeV SINGLE-INCLUSIVE JETS: $\chi^2/N_{\rm dat} \sim 2.5$, DECORRELATING RAPIDITY BINS $\chi^2/N_{\rm dat} \sim 1 \Leftrightarrow$ IF ONLY ONE BIN FITTED, ALL BINS PREDICTED WITH $\chi^2/N_{\rm dat} \sim 1$
- ATLAS W/Z 2011 7 TeV: $\chi^2/N_{\rm dat} \sim 2$

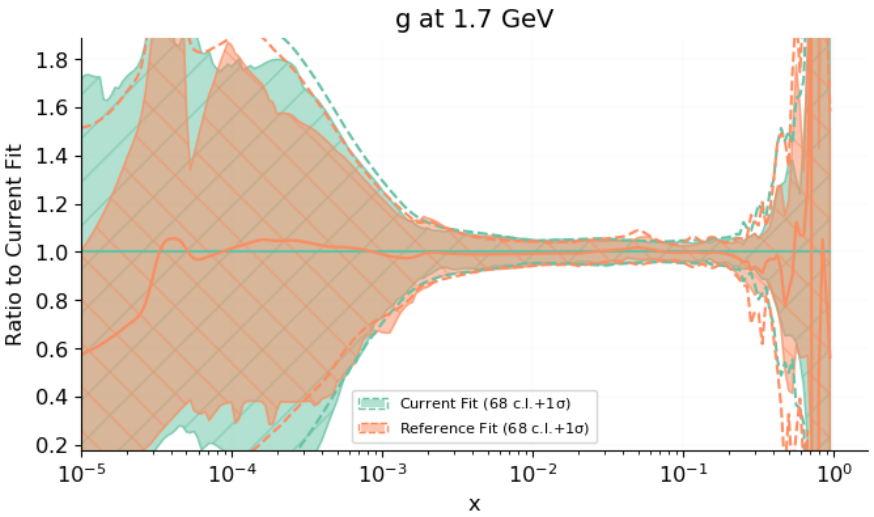
THE COVARIANCE MATRIX PROBLEM

EXAMPLE: THE ATLAS JETS

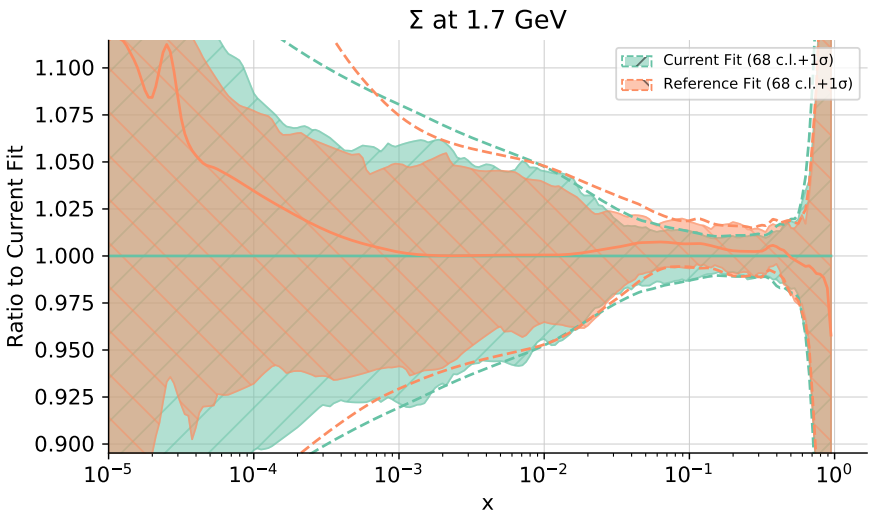
- ONLY CENTRAL RAPIDITY BIN $\Rightarrow \chi^2 \sim 1$, ALL BINS $\chi^2 \sim 2.5$
- BUT PDFS UNCHANGED!

PDFS: CENTRAL BIN VS ALL BINS

GLUON

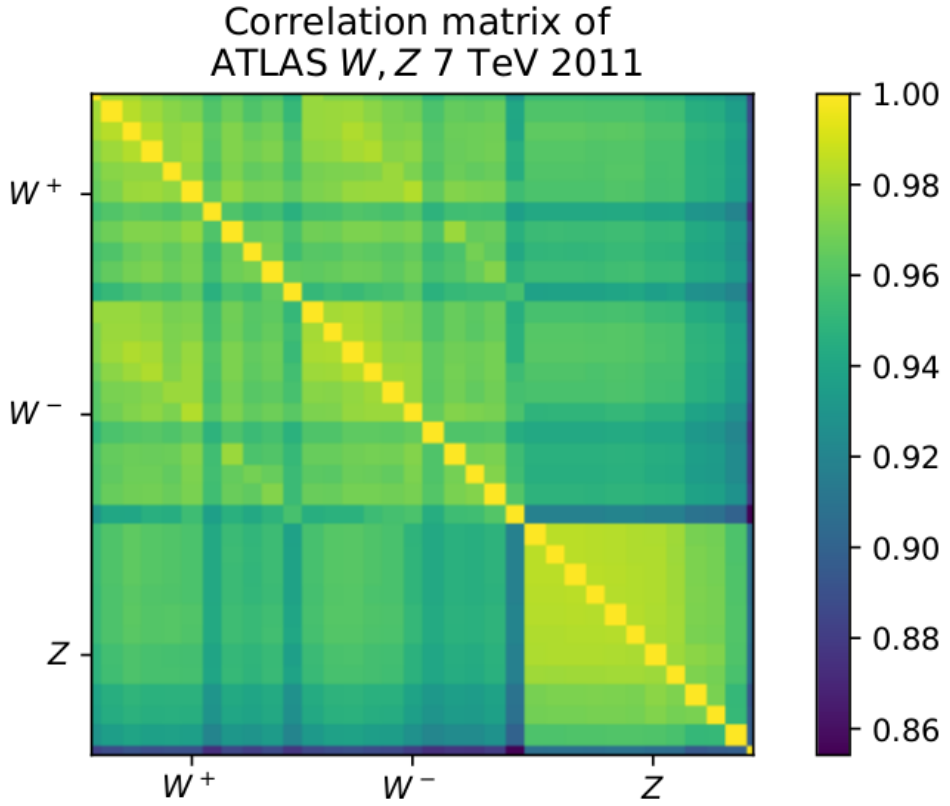


QUARK SINGLET



THE COVARIANCE MATRIX PROBLEM

ATLAS W/Z 2011 7 TeV CORRELATION MATRIX



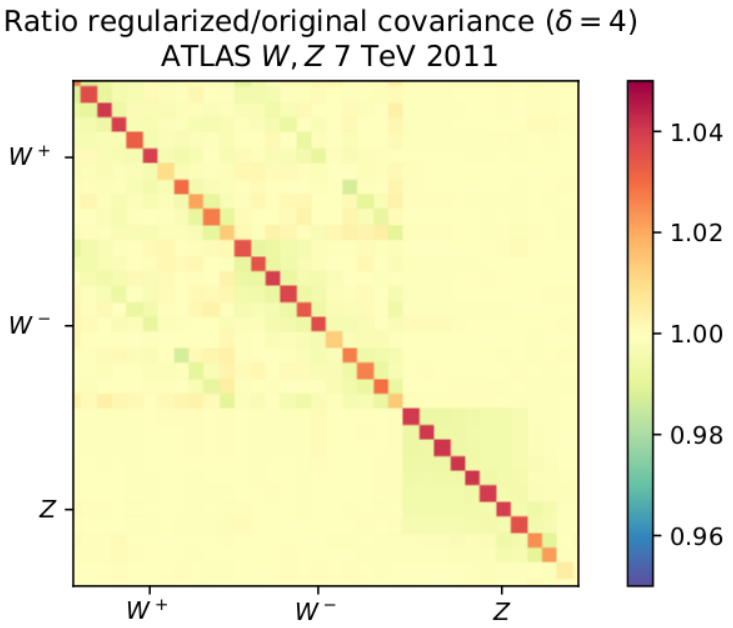
- POORLY CONDITIONED MATRIX: ONE (OR MORE) VERY SMALL EIGENVALUES
- GENERIC SITUATION WITH SMALL UNCORRELATED UNCERTAINTIES AND ONE ALMOST FULLY CORRELATED UNCERTAINTY

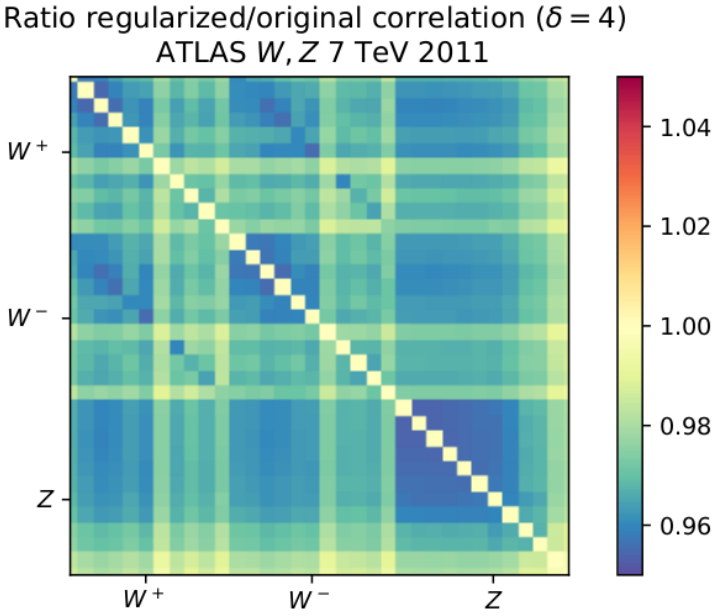
REGULARIZING $\Leftrightarrow$ DECORRELATING

Z. Kassabov, E. Nocera, M. Wilson, in preparation

- PERFORM SINGULAR-VALUE DECOMPOSITION
- REPLACE SMALLEST EIGENVALUES WITH CUTOFF $1/\delta$

ATLAS W/Z 2011 7 TeV CORRELATION MATRIX





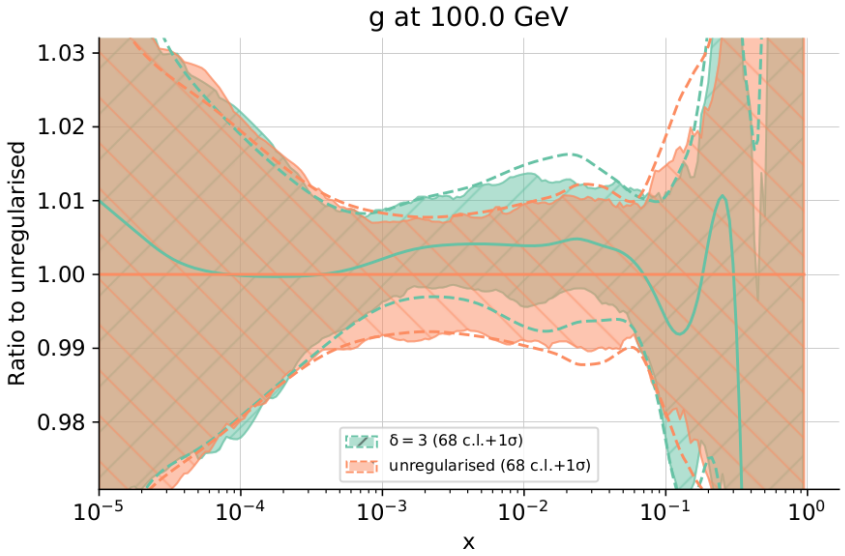
- EFFECTIVELY ADDS $1/\delta$ TO DIAGONAL OF COVARIANCE MATRIX
- CORRELATION MATRIX ALMOST UNCHANGED

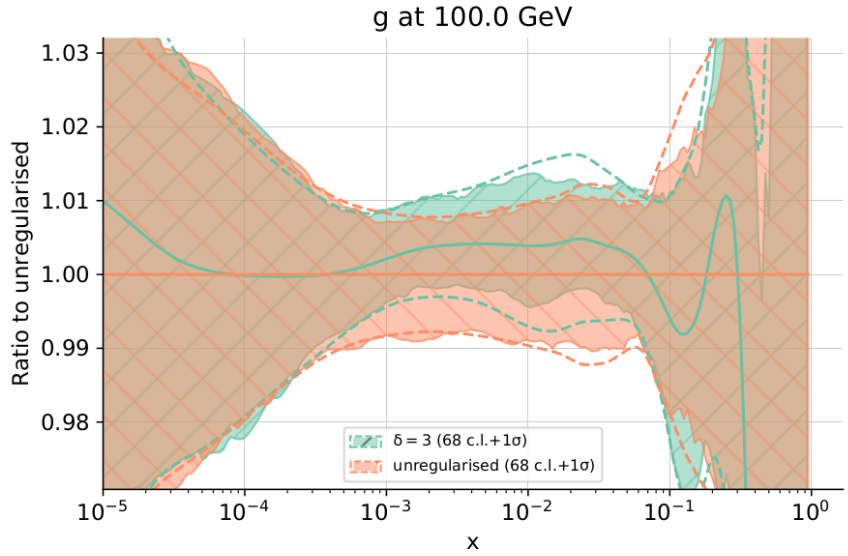
REGULARIZED FIT

Z. Kassabov, E. Nocera, M. Wilson, in preparation

- APPLY REGULARIZATION TO FULL NNPDF3.1 DATASET
- REFIT

RATIO OF REGULARIZED TO DEFAULT





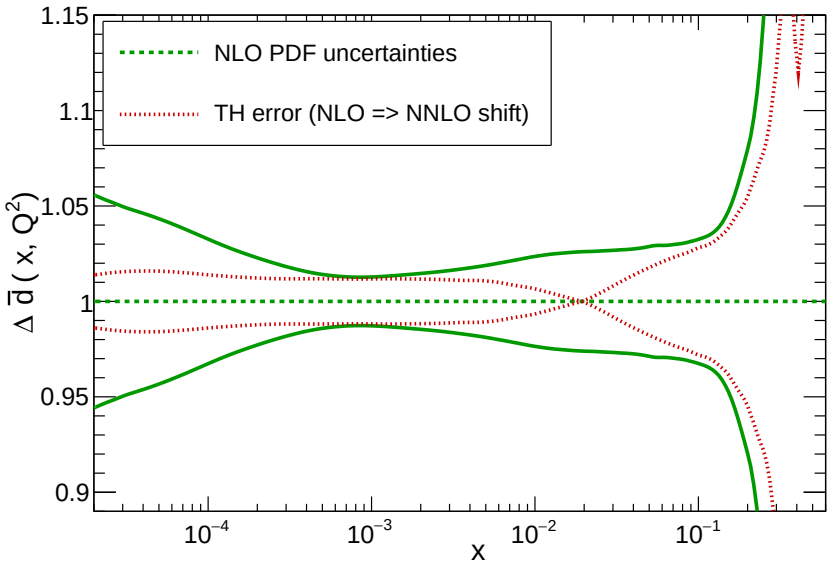
- χ^2 DOWN FROM 1.16 TO 1.0 FOR $\sim$ 4000 DATAPOINTS
- PDFs UNCHANGED

THE MISSING HIGHER ORDER UNCERTAINTY ON PDFS

NLO-NNLO SHIFT VS. NLO PDF UNCERTAINTY (NNPDF3.1)

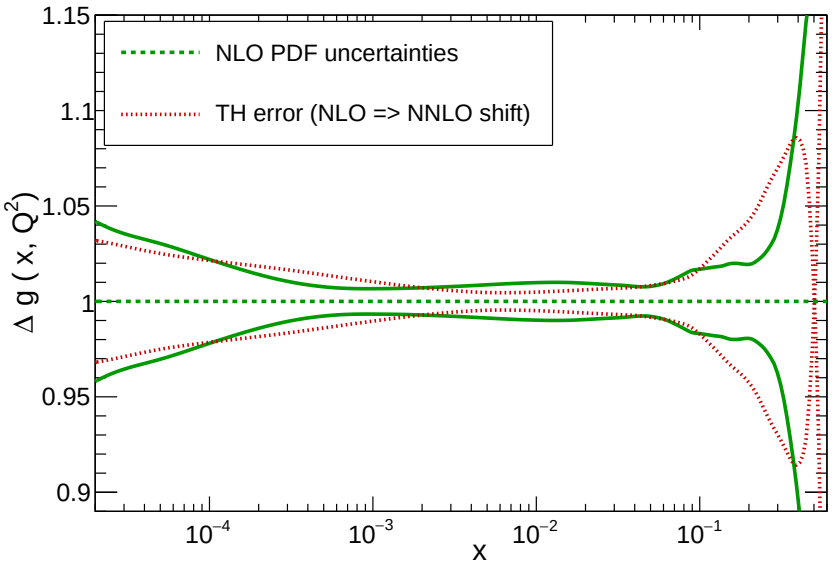
ANTIDOWN

NNPDF3.1, Q = 100 GeV



GLUON

NNPDF3.1, Q = 100 GeV



- NEVER INCLUDED IN CURRENT PDF SETS
- TODAY: NLO PDF & MHOU UNCERTAINTIES COMPARABLE
- NEAR FUTURE: SHOULD WE WORRY ABOUT NNLO MHOU?

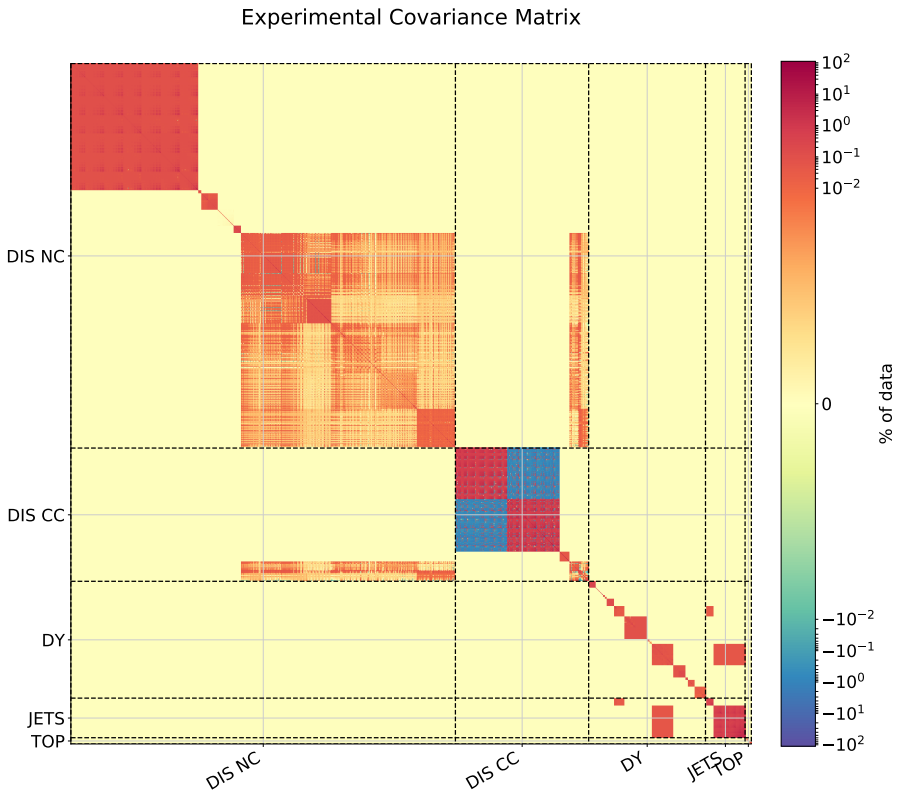
THE THEORY COVARIANCE MATRIX FROM SCALE VARIATION

NNPDF, 2019

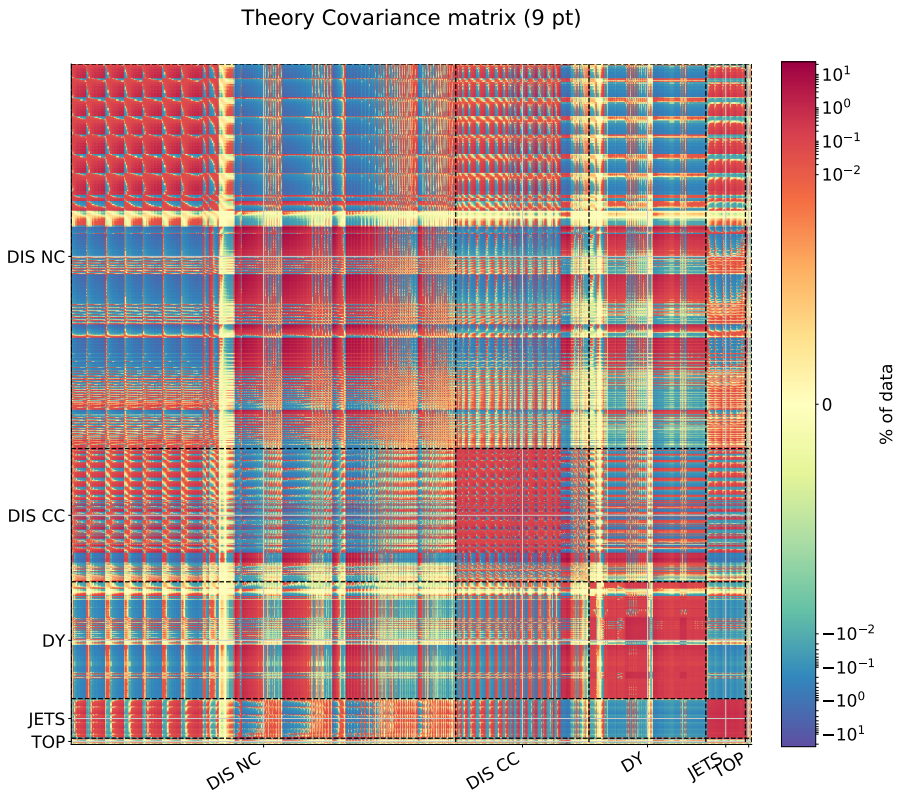
- INDEPENDENT NUISANCE PARAMETERS $\Rightarrow$ TH. AND EXP. ERRORS COMBINE IN QUADRATURE
  $\chi^2 = \sum_{i,j=1}^{N_{\rm dat}} \left(D_i - T_i^{(0)}\right) [S+C]_{ij}^{-1} \left(D_i - T_i^{(0)}\right)$
- REN. SCALE $\Rightarrow$ CORRELATIONS INDUCED BETWEEN EXPERIMENTALLY UNRELATED MEASUREMENTS OF SAME PROCESS
- FACT. SCALE $\Rightarrow$ CORRELATIONS INDUCED BETWEEN DIFFERENT PROCESSES

THE COVARIANCE MATRIX

EXPERIMENT

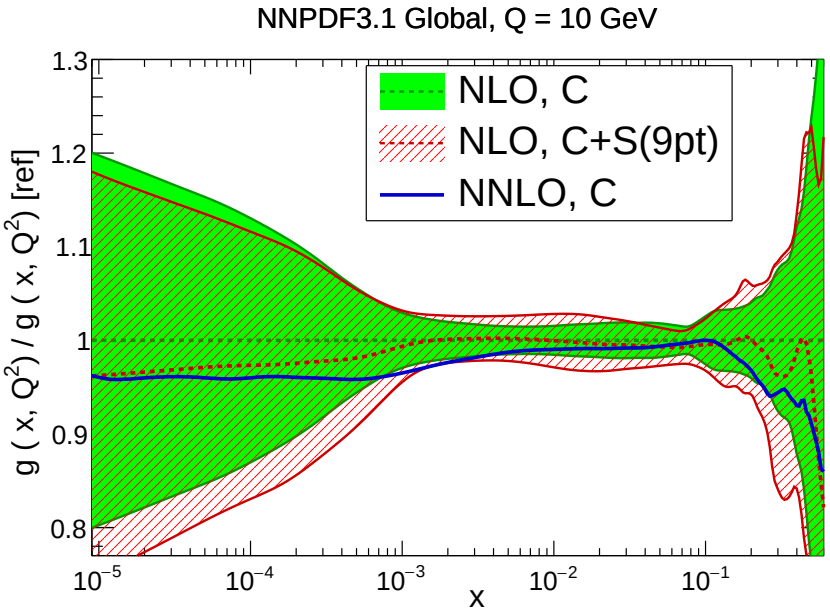


THEORY (9 PT)

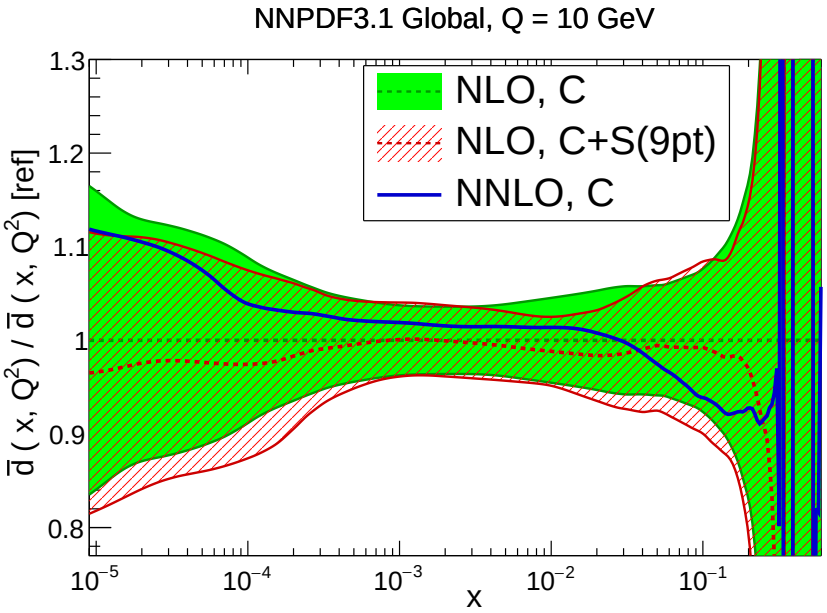


PDFs WITH THEORY UNCERTAINTIES

GLUON



ANTIDOWN



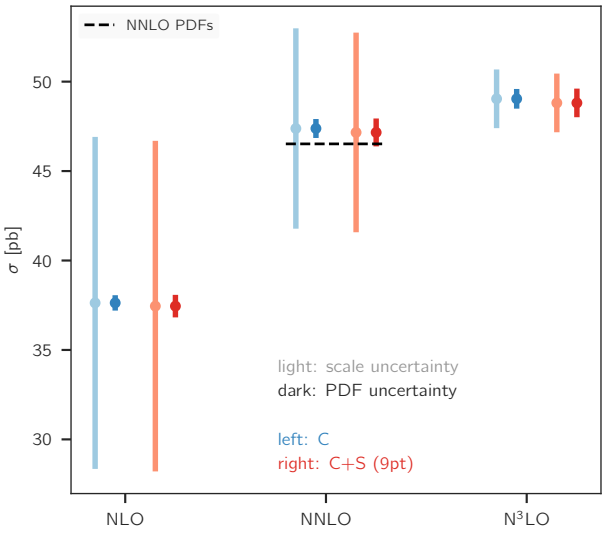
	C	$C + S^{(9\mathrm{pt})}$
χ^2	1.139	1.109
ϕ	0.314	0.415

- FIT QUALITY χ^2 IMPROVES
- RELATIVE ERROR ϕ ON PREDICTION MILDLY INCREASED
- CENTRAL VALUE MOVES TOWARDS KNOWN NNLO

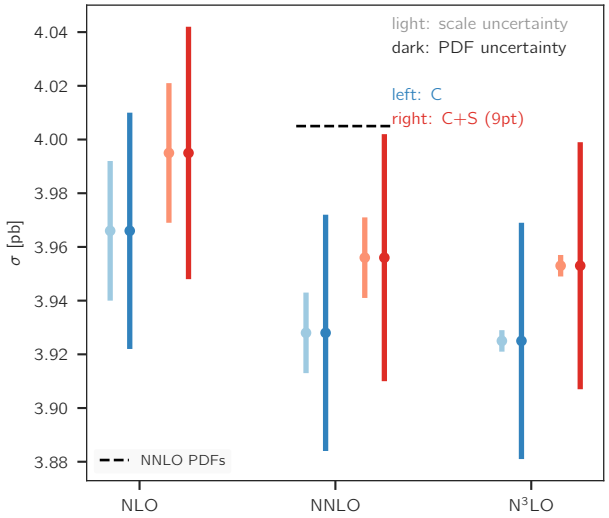
EQUALLY PRECISE BUT MORE ACCURATE RESULT!

PHENOMENOLOGY (LHC 13)

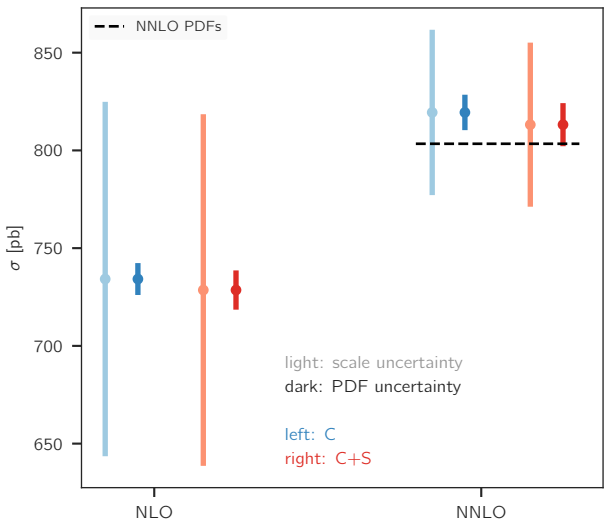
HIGGS GG



HIGGS VBF



TOP PAIRS



USAGE: JUST COMPUTE PDF ERROR AS USUAL &
COMBINE WITH MHOU ON HARD MATRIX ELEMENT COMPUTED WITH YOUR PREFERRED RECIPE

- GLUON FUSION, TOP
  - NO EFFECT ON CENTRAL VALUE
  - VISIBLE INCREASE OF UNCERTAINTIE
- VBF
  - MODERATE EFFECT ON UNCERTAINTIES
  - VISIBLE SHIFT OF CENTRAL VALUES
- ALL: TRUE NNLO NOW WITHIN NLO ERROR BAND

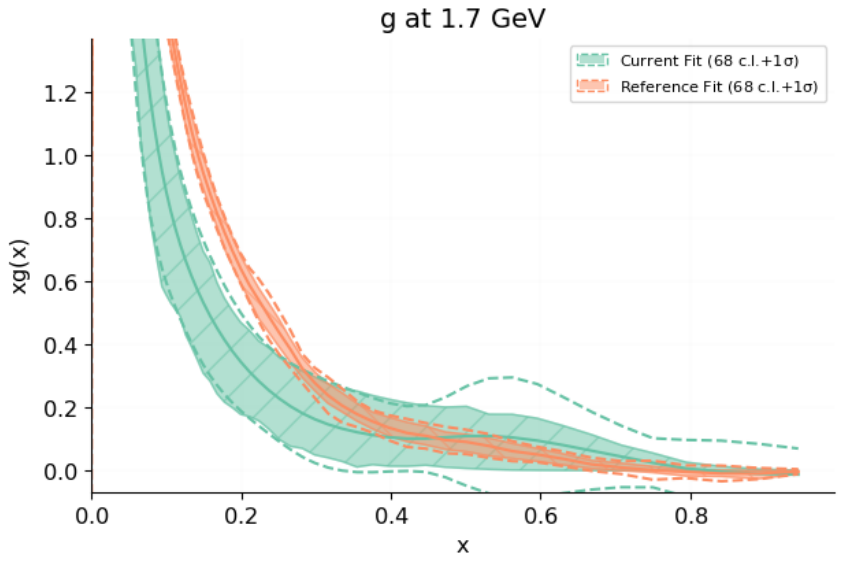
METHODOLOGY

NNPDF4.0: N3FIT

S. Carrazza, J. Cruz-Martinez, NNPDF, 2020

- FIRST PDF SET BASED ON DEEP LEARNING MODELS: HYPEROPTIMIZED METHODOLOGY
- CLOSURE TESTED
- "FUTURE" TESTED

PREDICTED VS TRUE GLUON
ONLY PRE-HERA DATA USED



NNPDF4.X HIGHLIGHTS

- BASED ON DEEP-LEARNING & CLOSURE TESTED
- VERY LARGE DATASET: ~ 50 NEW DATA, SEVERAL NEW PROCESSES
- THEORY UNCERTAINTIES ACCOUNTED FOR
- ELECTROWEAK CORRECTIONS INCLUDED UP TO NLO

THE WORK OF MANY PEOPLE

NNPDF collaboration and N^3PDF team meeting,

Varenna, Italy, September 2019