NNPDF
PLANS AND PROSPECTS

STEFANO FORTE
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PDF4LHC

DURHAM, SEPTEMBER 26, 2012

THE NNPDF TIMELINE

	8/2008	6/2009	2/2010	1/2011	7/2011	7/2012 (arXiv)
	NNPDF1.0	NNPDF1.2	NNPDF2.0	NNPDF2.1 NLO	NNPDF2.1 LO and NNLO	NNPDF2.2/2.3
DIS	✔	✔	✔	✔	✔	✔
Drell-Yan data	✘	✘	✔	✔	✔	✔
Jet data	✘	✘	✔	✔	✔	✔
LHC data	✘	✘	✘	✘	✘	✔
Independent param of the strange and anti-strange	✘	✔	✔	✔	✔	✔
Heavy Quark masses	✘	✘	✘	✔	✔	✔
NNLO	✘	✘	✘	✘	✔	✔

NNPDF2.3

- FIRST SET WITH SYSTEMATIC INCLUSION OF LHC DATA

- SOME METHODOLOGICAL IMPROVEMENTS (MINIMIZATION) MOSTLY AT NLO

- REDUCTION IN UNCERTAINTY ON PDFS, LUMINOSITY & STANDARD CANDLES, AT NLO IN EQUAL PROPORTION DUE TO METHODOLOGY & LHC DATA, AT NNLO MOSTLY DATA

- COLLIDER-ONLY FIT NOT YET COMPETITIVE

LHC 7 TeV

	$\sigma(W^+)$		$\sigma(W^-)$		$\sigma(Z^0)$	
	NLO	NNLO	NLO	NNLO	NLO	NNLO
NNPDF2.1	5.891 ± 0.133	6.198 ± 0.098	4.015 ± 0.091	4.213 ± 0.068	0.928 ± 0.018	0.972 ± 0.013
NNPDF2.3	5.854 ± 0.076	6.122 ± 0.078	4.057 ± 0.053	4.202 ± 0.059	0.931 ± 0.011	0.968 ± 0.012
NNPDF2.3 NOLHC	5.886 ± 0.082	6.198 ± 0.109	4.039 ± 0.066	4.218 ± 0.072	0.931 ± 0.012	0.974 ± 0.015
NNPDF2.3 COLLIDER	5.845 ± 0.104	6.127 ± 0.107	4.071 ± 0.074	4.234 ± 0.068	0.953 ± 0.016	1.000 ± 0.020

	$\sigma(W)/\sigma(Z^0)$		$\sigma(W^+)/\sigma(W^-)$	
	NLO	NNLO	NLO	NNLO
NNPDF2.1	10.678 ± 0.031	10.707 ± 0.034	1.467 ± 0.018	1.471 ± 0.021
NNPDF2.3	10.650 ± 0.022	10.669 ± 0.034	1.443 ± 0.009	1.457 ± 0.013
NNPDF2.3 NOLHC	10.662 ± 0.025	10.692 ± 0.026	1.457 ± 0.022	1.470 ± 0.020
NNPDF2.3 COLLIDER	10.403 ± 0.131	10.359 ± 0.124	1.436 ± 0.014	1.447 ± 0.015

	$\sigma(t\bar{t})$		$\sigma(H)$	
	NLO	NNLO	NLO	NNLO
NNPDF2.1	160.1 ± 5.4	158.6 ± 4.4	11.40 ± 0.18	15.22 ± 0.22
NNPDF2.3	158.3 ± 4.0	157.1 ± 4.2	11.46 ± 0.13	15.31 ± 0.20
NNPDF2.3NOLHC	158.4 ± 4.3	157.1 ± 4.7	11.48 ± 0.14	15.30 ± 0.17
NNPDF2.3–COLLIDER	151.2 ± 6.1	150.0 ± 5.3	10.80 ± 0.25	14.44 ± 0.27

NNPDF2.3
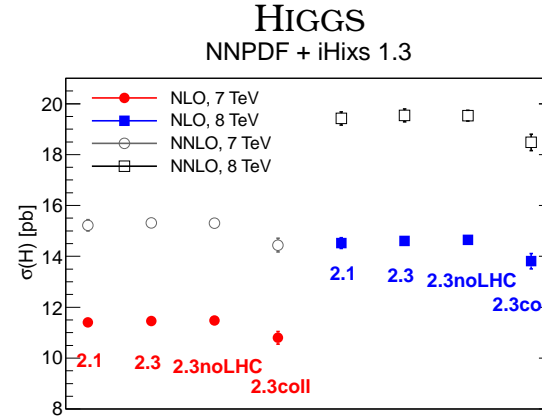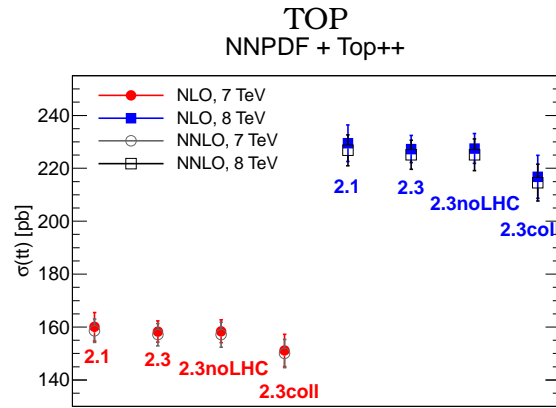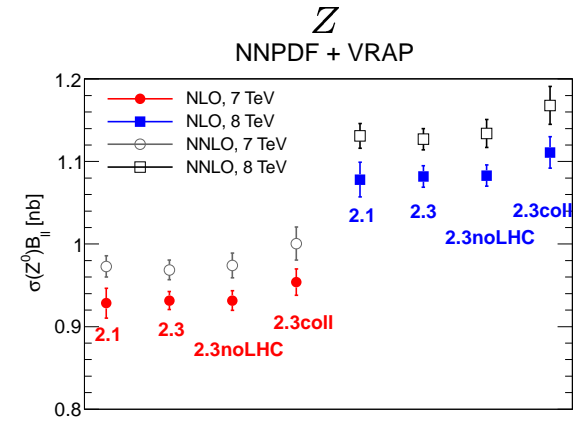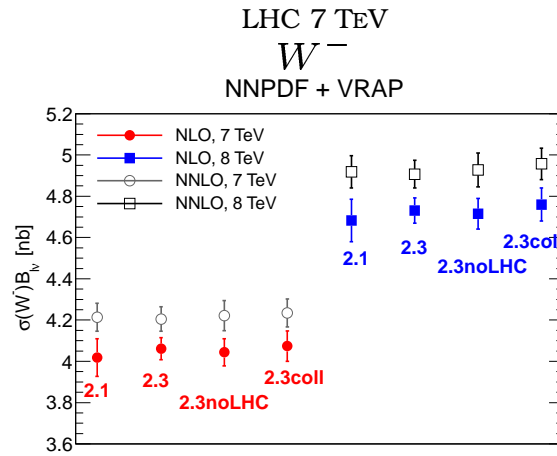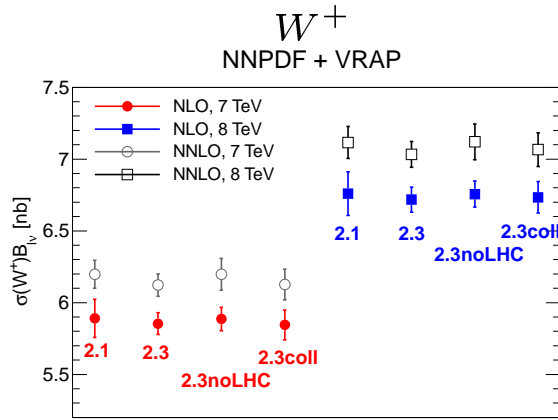
CODE DEVELOPMENT: MIGRATION TO C++
MOTIVATIONS

- MODULAR, FLEXIBLE CODE; FASTER & EASIER TO DEBUG

- BETTER INTEGRATION WITH LIBRARIES (`ROOT, BLAS, GSL`)

- PARALLEL COMPUTATION (CPU/GPU CLUSTERS)

- PUBLIC CODE?

The NNPDFWizard

- It's also available a graphical interface wizard that creates easily configuration files compatibles with NNPDF++.
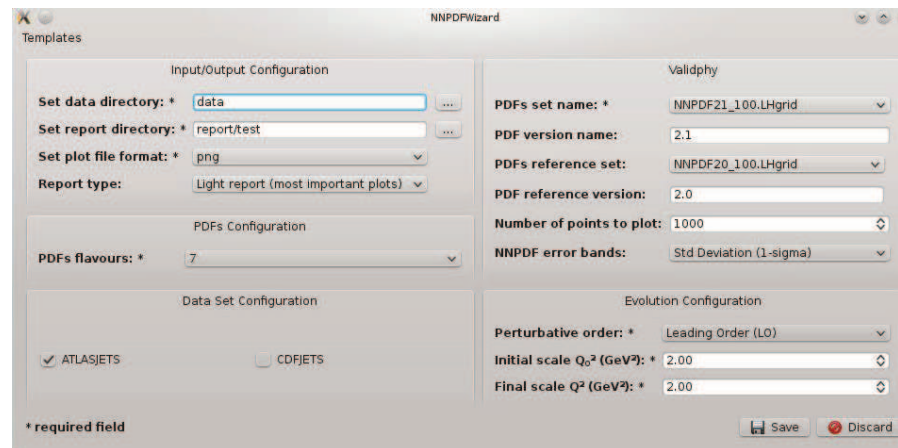

Figure: Example of GUI available to create configuration files.

STRUCTURE OF NNPDF CODE & STATUS
CODE MODULES

- `buildmaster`: COLLECTS DATA & PUTS THEM IN COMMON FORMAT   DONE

- `filter`: ENFORCES CUTS, CONSTRUCTS COVARIANCE MATRIX AND ITS INVERSE, GENERATES PSEUDODATA   DONE

- `evfactinter`: COMPUTES FK EVOLUTION TABLES   EXTERNAL FORTRAN MODULE

- `nnsinglet`: FIT PDFs TO DATA   TO DO

- `validphys`: COMPUTES FINAL PREDICTIONS, STATISTICAL ESTIMATORS, PRODUCES PLOTS & REPORT   DONE

- `plotpdf`: PRODUCES CATALOGUE OF PLOTS (INCLUDING BENCHMARKS)   DONE

FLOW-CHART FOR NNSINGLET
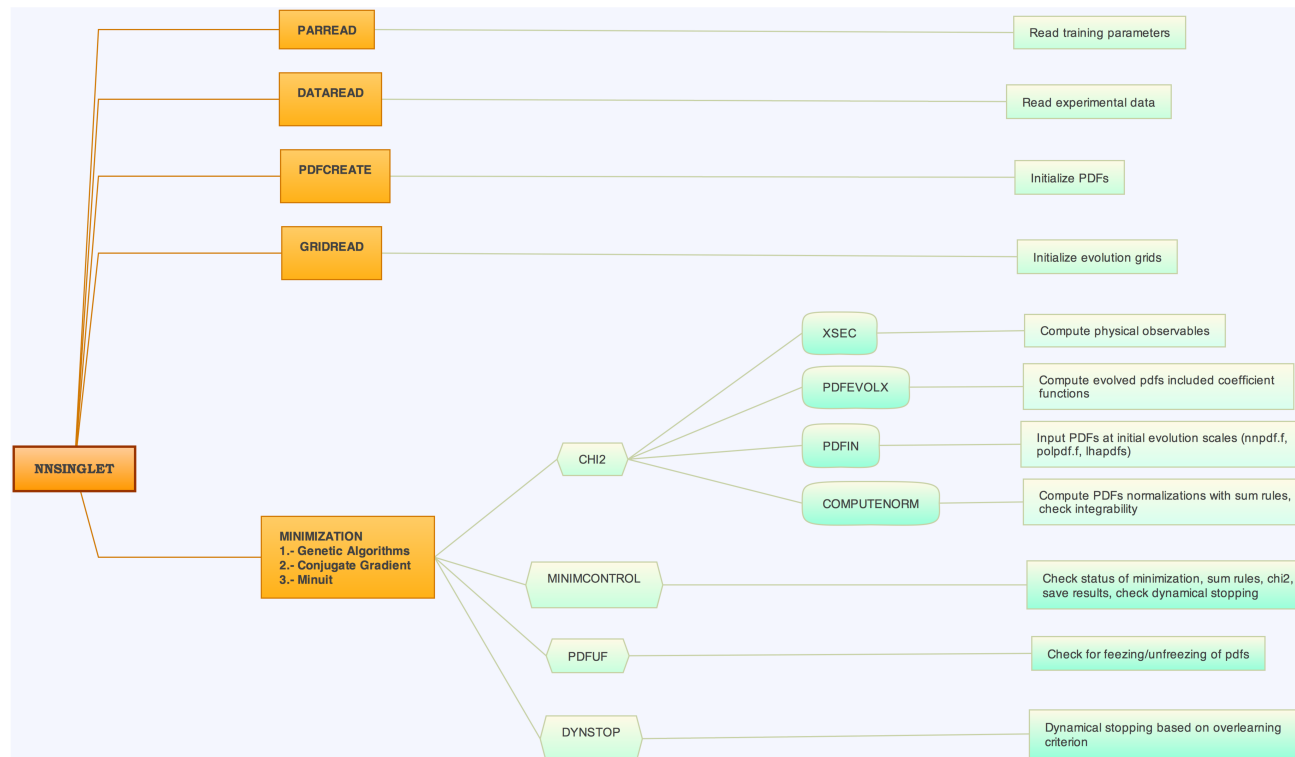
METHODOLOGICAL IMPROVEMENTS

GOALS:

- MINIMIZE PARAMETER-TUNING AND
  REMOVE DEPENDENCE OF RESULTS ON IT
  EXAMPLE: CHOOSE PREPROCESSING BASED ON OBJECTIVE CRITERIA &
 VERIFY INDEP. OF RESULTS ON IT

- OBTAIN STATISTCALLY SOUND RESULTS

  EXAMPLE: χ^2 MUST FOLLOW A χ^2 DISTRIBUTIONS; CAN THEN DETERMINE
 $\Delta\chi^2$ CRITERION

PREPROCESSING CONSISTENCY

- **PREPROCESSING**: $f(x) = x^{\alpha}(1-x)^{\beta}NN(x)$; α, β RANDOMIZED IN RANGE USED TO SPEED TRAINING, SHOULD NOT AFFECT RESULTS

- DETERMINE EFFECTIVE EXPONENTS: E.G.
  $\alpha_{\mathrm{eff}}(x, Q^2) \equiv \lim_{x \to 1} \ln\left(\Delta q(x, Q^2)\right)/\ln\left(1-x\right)$

- CHECK WHETHER RANGE OF PREPROCESSING WIDER THAN ONE-SIGMA EFFECTIVE EXPONENT RANGE

- IF NOT, WIDEN RANGE AND CHECK STABILITY OF RESULTS

SINGLET PREPROCESSING

STANDARD
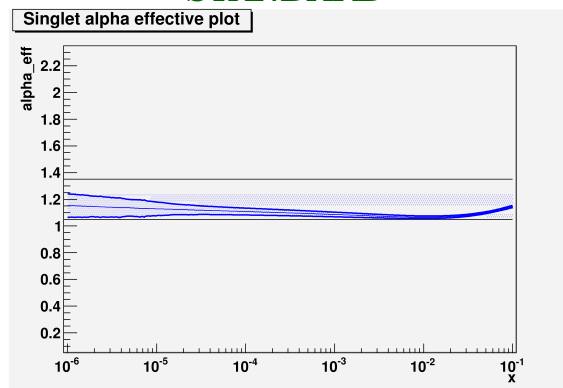
EXTENDED
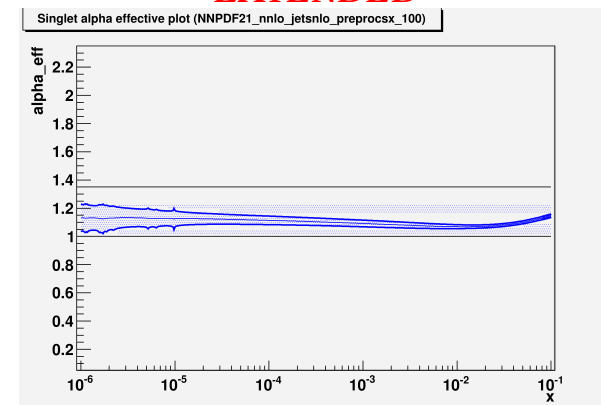
MINIMIZATION WITH WEIGHT PENALTY

- OPTIMAL FIT CURRENTLY DETERMINED BY CROSS-VALIDATION: DATA RANDOMLY DIVIDED IN TWO SETS, χ^2 OF FITTED (TRAINING) DATASET KEEPS DECREASING BUT χ^2 OF NON-FITTED (VALIDATION) DATASET STARTS INCREASING

- MUST INTRODUCE THRESHOLDS FOR INCREASE & DECREASE BASED ON TYPICAL χ^2 FLUCTUATIONS

- ALTERNATIVE IDEA: INTRODUCE A MEASURE OF THE COMPLEXITY OF THE j-TH NN: $\Delta_j = \sum_{i=1}^{N_w} (w_i^j)^2$

- THEN ADD TO χ^2 A WEIGHT-PENALTY $f(w_i) = \sum_{j=1}^{N_{pdfs}} \alpha_j \Delta_j$ AND MINIMIZE χ^2

- CONSTANTS α_j DETERMINED BY EXPECTED COMPLEXITY OF THE j-TH NETWORK BASED ON PREVIOUS FIT

- FITS STOPS WHEN NETWORKS FIT THE DATA BUT ARE NOT TOO COMPLEX

PLOTS VS TRAINING LENGTH OF

j-TH WEIGHT-PENALTY $\qquad\qquad\qquad\qquad\qquad \chi^2$
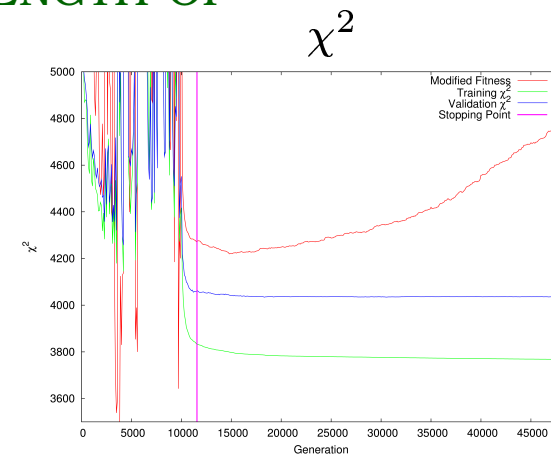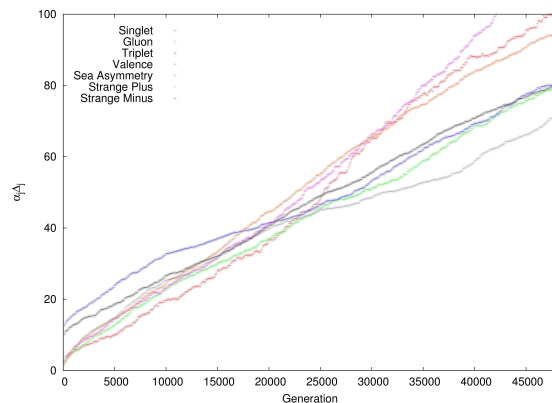
NEW DATA

(all with covariance matrix info, either already available or in next few weeks/months)

TO BE INCLUDED ASAP
(no new development needed)

- HERA-II ZEUS & H1 INCLUSIVE DIS STRUCTURE FUNCTIONS

- HERA II COMBINED F_2^c

- CMS W ASYMMETRY (FINAL 2011 FULL DATASET)

- CMS DRELL-YAN DOUBLE DIFFERENTIAL DISTRIBUTIONS

TO BE INCLUDED SOON
($\sim$January 2013: minor work needed)

- CMS 2011 INCLUSIVE JETS (FASTNLO/APPLGRID INTERFACING)

- CMS $W + c$ (APPLGRID/MCFM INTERFACING)

- ATLAS+CMS TOP DIFFERENTIAL DISTRIBUTIONS (APPLGRID INTERFACE)

TO BE INCLUDED LATER
($\sim$Spring 2013 or later: substantial work needed)

- Z LEPTON p_T DISTRIBUTIONS (INTERFACE TO GRAZZINI'S NNLO+RESUMMED CODE REQUIRED)

- DIPHOTONS (INTERFACE TO DEFLORIAN'S NNLO CODE REQUIRED)

- PROMPT PHOTONS (INTERFACE TO JETPHOX-NLO: VERY HARD)

THEORY IMPROVEMENTS

SHORT-TERM PROJECTS
($\sim$January 2013: either already implemented, or minor work needed)

- INTRINSIC CHARM (ALREADY IN CODE)

- $\overline{\text{MS}}$ MASSES (ALREADY IN CODE)

- QED EVOLUTION, REDUCED VERSION WITH PHOTON PDF ONLY PARAMETRIZED & ISOSPIN VIOLATION DYNAMICALLY GENERATED (ALMOST DONE)

- HIGHER TWISTS INCLUDED USING ABM FIT (TO DO, STRAIGHTFORWARD)

LONG-TERM PROJECTS
(after $\sim$Spring 2013: substantial work needed)

- THRESHOLD RESUMMATION, SMALL x RESUMMATION & DOUBLE RESUMMATION (CODE BY BONVINI ET AL. BEING DEVELOPED, MUST INTERFACE)

- THEORY ERRORS (GUFFANTI WORKING ON CACCIARI-HOUDEAU METHOD WITH NBI STUDENT, SCALE VARIATION WILL REQUIRE MORE WORK)

- MC PDFs (MAY BE PROJECT FOR STUDENT)

PARALLEL PROJECTS
(being pursued by subgroups)

- NUCLEAR PDFs (GUFFANTI+ALICE NBI GROUP) (IN PROGRESS)

- POLARIZED PDFs (WITH RIDOLFI & NOCERA: PRELIMINARY RESULTS PRESENTED AT DIS2012)

FUTURE PLANS

NEXT MAJOR RELEASE (NNPDF3.0) SUMMER 2013
WILL INCLUDE

- AS MANY LHC DATA AS POSSIBLE

- REQUIRED METHODOLOGICAL IMPROVEMENTS AND SOME THEORY IMPROVEMENTS

SOME INTERMEDIATE STUDIES: END 2012-EARLY 2013

- NNPDF2.3QED

- PDF SET WITH INTRINSIC CHARM (NNPDF2.4?)