Working group I

Parton Density Functions

convenors:

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Open Issues

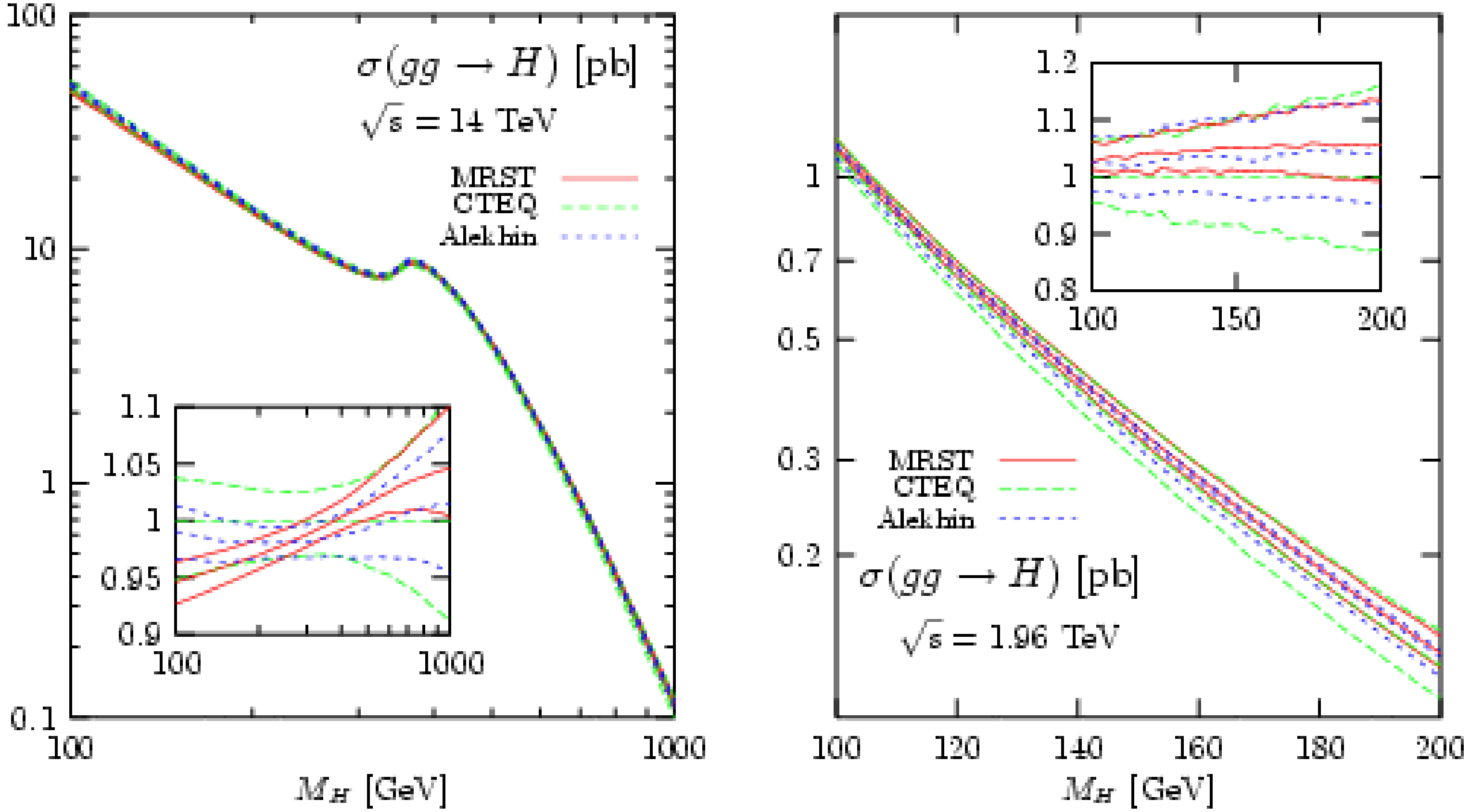
- PDF ERRORS COMPARABLE TO THEORY ERRORS Cacciari, Ferrag
- ERROR BANDS FOR PDF SETS COMPARABLE, BUT DO NOT OVERLAP Cacciari, Ferrag
- GLOBAL FIT VS. "CONSISTENT" SET OF DATA Chekelyan, Alekhin, Cooper-Sarkar
- ARE SMALL x RESUMMATIONS RELEVANT? Thorne, Pumplin, Ball, Colferai
- SATURATION IN F_2 AT SMALL x? Weigert, Munier
- DO WE NEED LARGE x RESUMMATIONS? Magnea, Grazzini, Gardi

Summary

Estimate of 2-sigma (?) uncertainties

PDFs / Scales		Tevatron	LHC
Bottom	PDFs	±10-15%	±15-20%
	Scales	±35%	±40%
Top	PDFs	±5-10%	±3-6%
	Scales	±5%	±12%

Impact on the Higgs production: gluon fusion



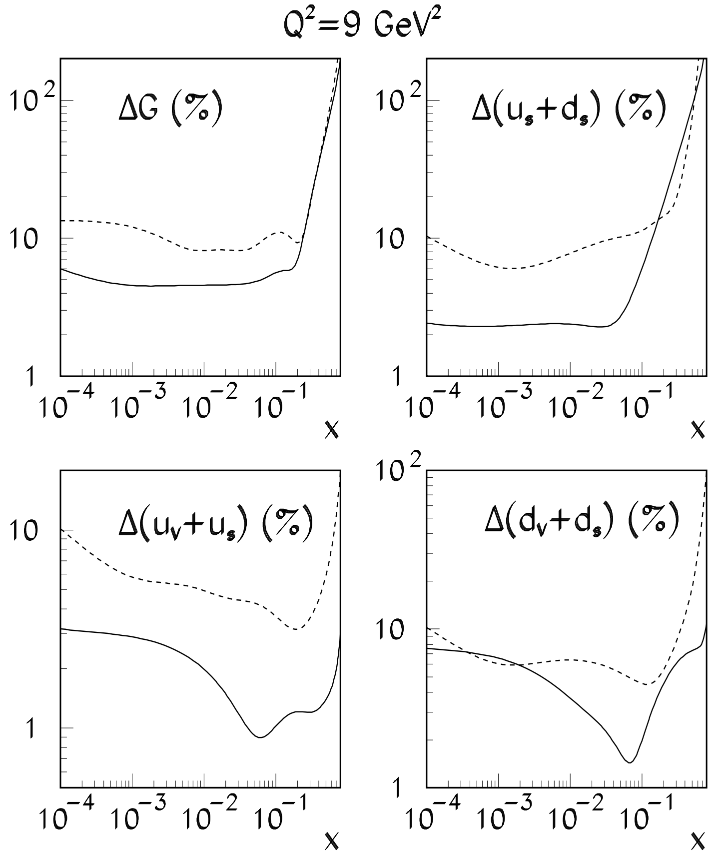
LHC: smoothly oscillating (intermediate *x*) and increasing (high *x*)

~ 4-3% to 11% (100-1000 GeV)

Tevatron: increasing (high *x* gluons), ~ 7% to 15% (100-200 GeV)

S. Ferrag

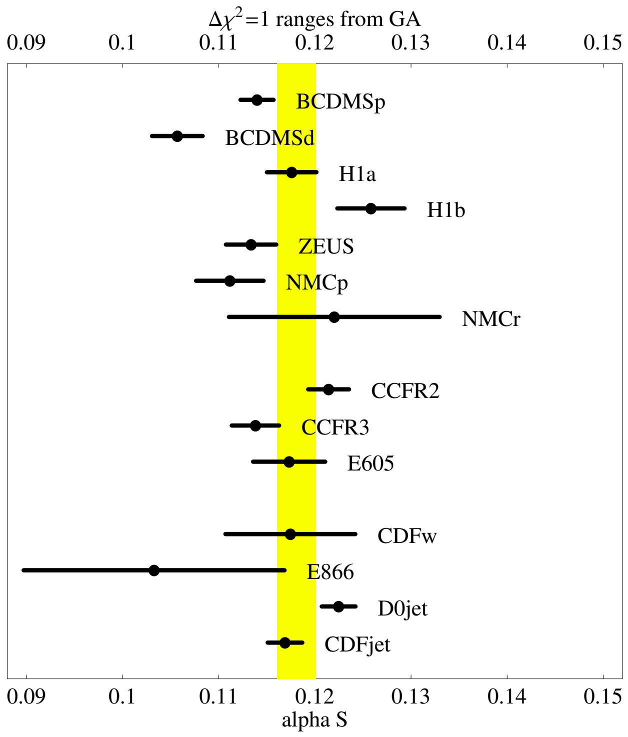
Comparison to the global fit

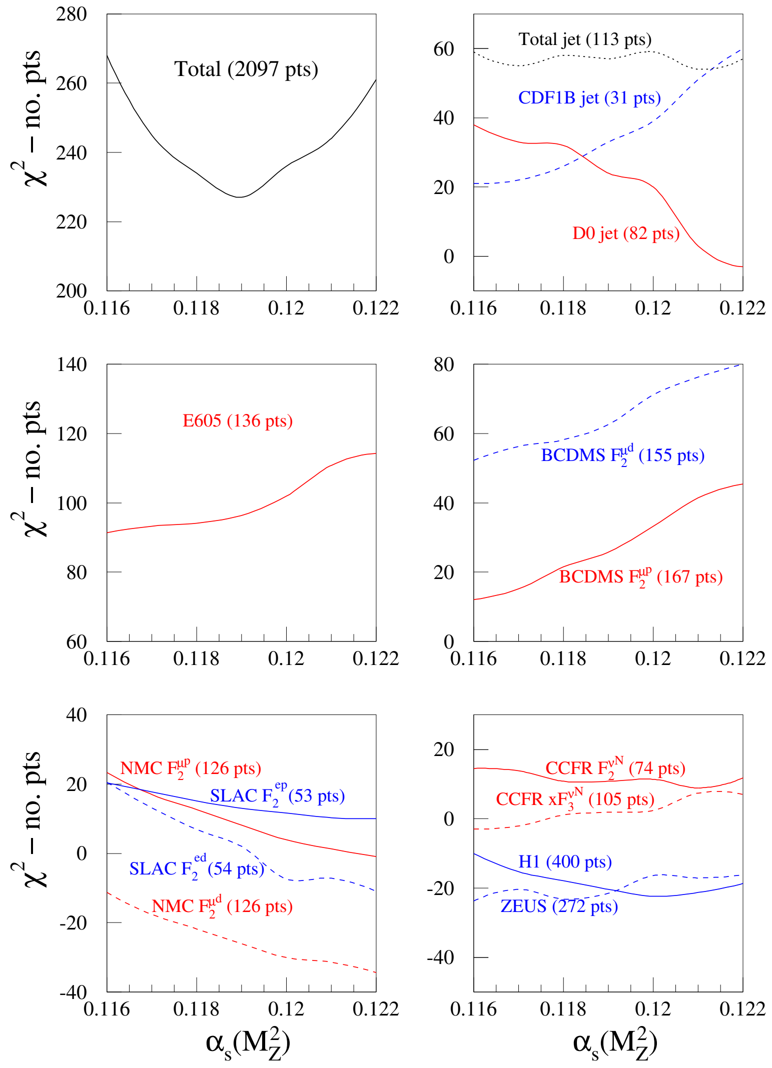


Addition of more data is useless if you do not control additional sources of theoretical uncertainties

Full: A02; dashes: CTEQ6

In full **global** fit art in choosing "correct" $\Delta\chi^2$ given complication of errors. Ideally $\Delta\chi^2 = 1$, but unrealistic.





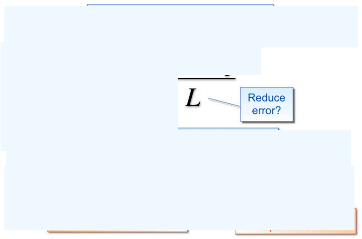
Many approaches use $\Delta\chi^2 \sim 1$. CTEQ choose $\Delta\chi^2 \sim 100$ (conservative?). MRST choose $\Delta\chi^2 \sim 20$ for $1-\sigma$ error.

Goals

- need tool for error propagation
- need to understand dependence on rapidity and p_T spectrum$\rightarrow$ acceptance cuts
- need a list of 'gold-plated' processes
- assess relative size of expt. and th. uncertainties @ LHC
- need to understand interplay of PDF errors with montecarlos/event generators
- need tools to assess impact of resummations or non-GLAP effects

SUGGESTIONS

- REFERENCE PROCESSES AT LHC:
  - W, Z production as luminosity monitor
  - W, Z rapidity and p_t distn. constrain PDF shape
  - W^+/W^- constrain flavor decomposition
  - use γ (W, Z) + jet to constrain the gluon (use also high mass DY?)
- REFERENCE PROCESSES AT HERA:
  - high precision F_2
  - F_L as probe of gluon & non-GLAP effects
  - lower proton energy → intermediate-large x
  - deuteron running → flavor decomposition



Luminosities...

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- After all, the pp-Lumi is expected to be (only) known at 5%...

Alternative : use W/Z counting as luminosity monitor   Dittmar et al,

$$N_{pp\sigma\ Z} = L_{pp}\ \sigma PDF(x_1,x_2,Q^2)\ \sigma\sigma_{q,\bar{q}\sigma\ Z}(+\mathrm{HO})$$

count   extract   as inputs

or better : normalize processes to number of Zs (parton-parton luminosity)

$$N_{pp\sigma\ WW} = N_{pp\sigma\ Z}\ \sigma\frac{\sigma_{q,\bar{q}\sigma\ WW}}{\sigma_{q,\bar{q}\sigma\ Z}}\ \sigma\frac{PDF(x_1',x_2',Q'^2)}{PDF(x_1,x_2,Q^2)}$$

$\Delta L_{pp} = 0!$

Calculate ratios.
Reduced uncertainties(?)
Extend also to gluon-quark case....

$\sigma_{theo} = PDF(x_1, x_2, Q^2) \otimes \hat{\sigma}_{hard}$

constrain, define uncertainties

HO calculations, implement in MC

Constraining PDFs

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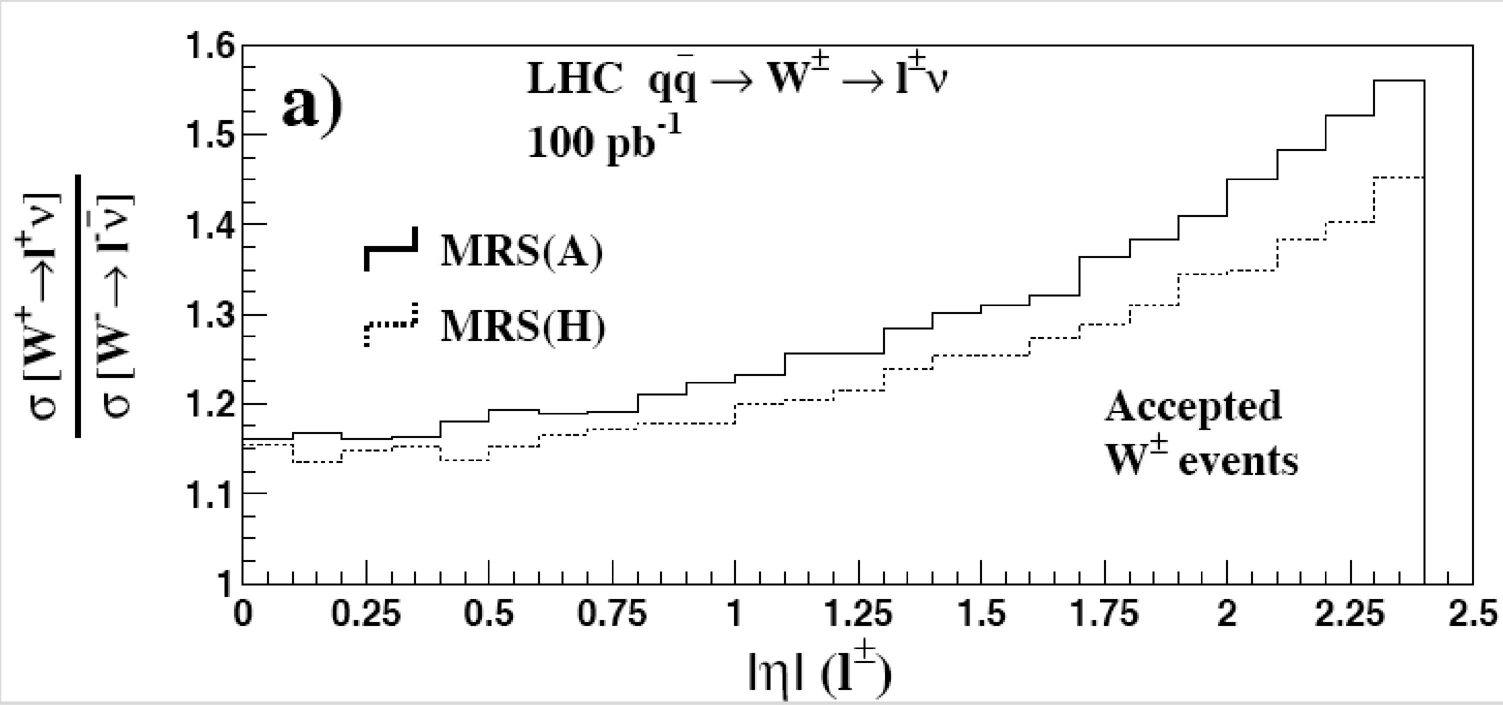
- W/Z (rap. and p_T distr.) very useful to constrain PDFs
- particularly well suited: W^+/W^- cross section ratio ~u(x)/d(x)
- even small PDF differences observable

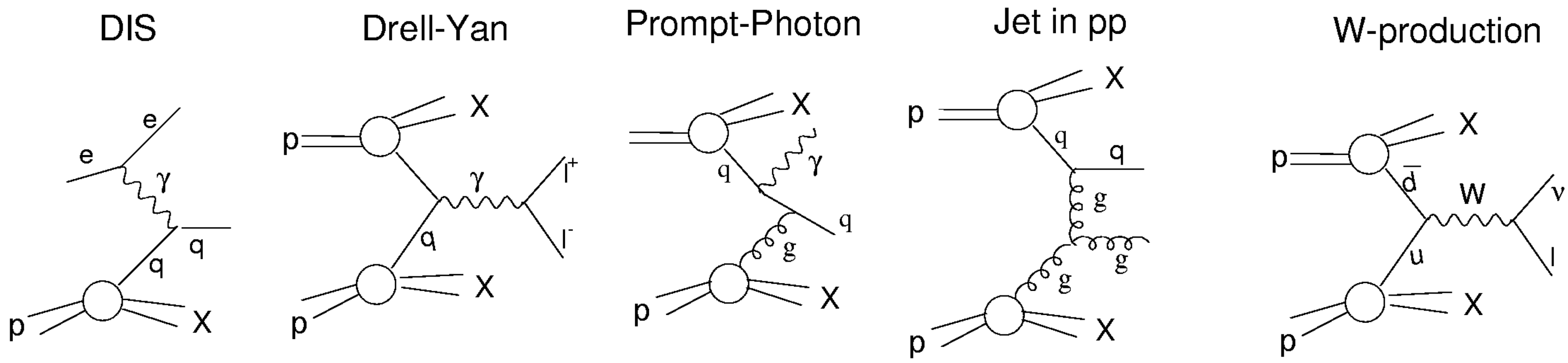


Dittmar et al.

Theory & Phenomenology ideas

- EIGENFUNCTION METHOD TO TURN CONVOLUTIONS INTO PRODUCTS Carli
- CHANGE Q^2, W^2 ANS x CUT $\Rightarrow$ "CONSERVATIVE PARTONS" Thorne
- HESSIAN METHOD TO STUDY CONSISTENCY OF GLOBAL FIT Pumplin
- FAST EVOLUTION Whalley
- USE RESUMMATION TO REWEIGHT GENERATED EVENTS Grazzini
- NNLO CALCULATIONS Blümlein, Moch

Proposal



- Study sensitivity of basic SM processes at LHC to parton densities and strong coupling
- Set-up grid for coefficient functions using NLO programs -> can be easily shared
- See what is the combination of best observables (including HERA F_2)
  to constrain

  PDFs & strong coupling & luminosity

  in the best way:
  - investigate theoretical uncertainties (minimise by clever choice of observable)
  - investigate how well observable can be measured (detector uncertainties)
- strong impact of LHC physics program in first 1-2 years: “commissioning”
- large amount of work, but work can be shared:
  - set-up of combined fit (including DGLAP evolution)
  - jets: inclusive jets, dijets, 3/2-jet rate
  - leptons: from W/Z-production, Drell-Yan
- can be tested on Tevatron data: -> write papers !

Alternative approach.

In order to investigate real quality of fit and regions with problems vary kinematic cuts on data.

Procedure – change W^2_{cut}, Q^2_{cut} and x_{cut}, re-fit and see if quality of fit to remaining data improves and/or input parameters change dramatically. Continue until quality of fit and partons stabilize.

For W^2_{cut} raising from $12.5\mathrm{GeV}^2$ to $15\mathrm{GeV}^2$ sufficient.

Raising Q^2_{cut} from $2\mathrm{GeV}^2$ in steps there is a slow continuous and significant improvement for higher Q^2 up to $> 10\mathrm{GeV}^2$ (cut 560 data points) – suggests any corrections mainly higher orders not higher twist.

Raising x_{cut} from 0 to 0.005 (cut 271 data points) continuous improvement. At each step moderate x gluon becomes more positive.

$\rightarrow$ MRST2003 conservative partons. Should be most reliable method of parton determination ($\Delta\chi^2 = -70$ for remaining data), but only applicable for restricted range of x, Q^2. $\rightarrow \alpha_S(M_Z^2) = 0.1165 \pm 0.004$.

Hessian Method to Study consistency of the global fit

(Work in progress)

Partition the data into two subsets:

$$\chi^2 = \chi_I^2 + \chi_{II}^2$$

where subset I might be, for example,

- any single experiment
- all of the jet experiments
- all of the low-Q data points (to look for higher twist effects)
- all of the low-x data points (to look for BFKL effects)
- all experiments that use deuteron corrections

Using the freedom to make an additional orthogonal transformation after the total χ^2 has been diagonalized, it is always possible to write

$$\chi^2 = \chi_0^2 + \sum_i z_i^2$$

$$\chi_I^2 = A + \sum_i B_i z_i + \sum_i c_i z_i^2$$

By simple algebra, this can be written as

$$\chi_I^2 = \sum_i \left(\frac{z_i - p_i}{q_i} \right)^2 + \text{const}$$

$$\Rightarrow z_i = p_i \pm q_i$$

In this way we can answer the question "How many parameters are significantly determined by any given data set?"

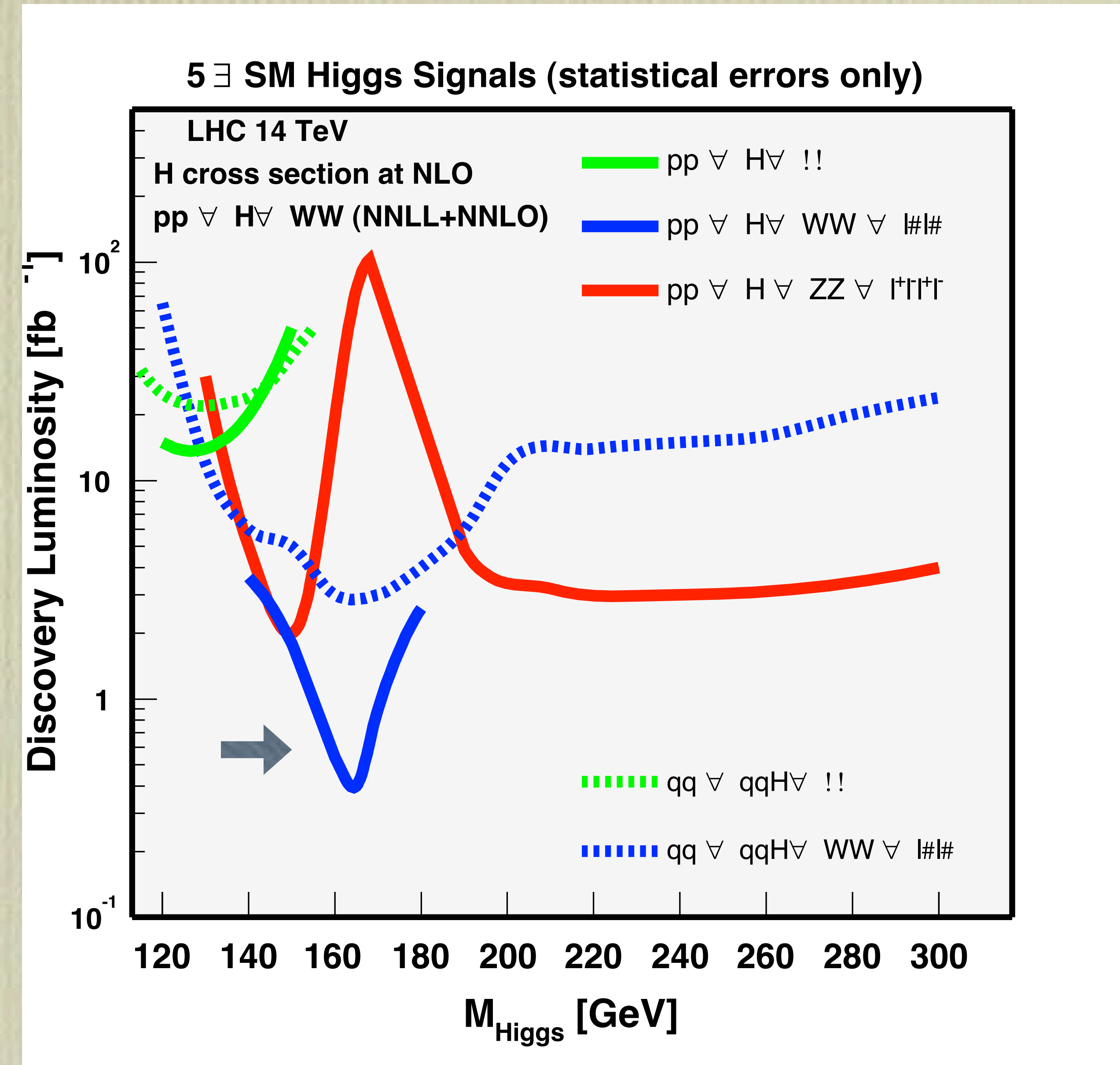
A recent application in $gg \to H \to WW \to l\nu l\nu$

G. Davatz, G. Dissertori, M. Dittmar, F. Pauss, MG (2004)

Use results for $gg \to H$ spectrum at NNLL+NLO to correct "reweight" events generated with PYTHIA

Apply the resummation formalism to WW pair production

NLL+LO results used to correct PYTHIA main background



Tasks

- list of interesting LHC reactions and assessment of their experimental and theoretical accuracy
- correlation of PDF uncertainty and determination of "standard candles"
- impact of determination of F_L on theoretical PDF uncertainties
- quantitative impact of small x and large x resummations on individual LHC observables