Some Comments on Theory/Experiment in Z cross-section

(Ronan McNulty)

A number of issues arose in the preceding work which have been discussed at some length with Robert, and might usefully be brought to this forum....

Z could be used to measure the luminosity

1. What is theoretical precision (from PDF) ?
2. Can (PDF) precision be improved?
3. How should the error bands be interpreted?
4. Is the procedure that produces them consistent?

What is theoretical precision on Z (from PDF) ?

- NNLO calculation better than 1%
- Statement has been made many times that σ_Z is known to ~3-4%
- Statistical uncertainty on σ_Z coming from PDFs (any model) is ~ 1% when constrained fit made to $d\sigma/dy$
- Model dependence is much bigger.
- Given that σ_Z changes by 0/-4/2 % for MSTW/CTEQ/Alekhin, is my overall uncertainty

$\Delta, \Delta/2, 2\Delta$? It makes a difference!

Can PDF precision be improved ?

- If we can move from 4% uncertainty to 1% it makes a huge difference to luminosity measurement.
- From quality of fit to $d\sigma/dy$ it may be possible to distinguish Alekhin/CTEQ/MSTW.
- What are model differences giving σ_Z variations?
- Are these objective differences that can be resolved?
- Or are these just due to a different approach?

How should the error bands be interpreted?

- Error bands as measure of uncertainty on PDF hopefully allow me say: “In 90% of repeated fits to such global data, the true value would be within the band”
- With some added assumptions of a Gaussian like distribution, I can derive a 67% 1σ range.
- Constrained fits to find $d\sigma/dy$ are well defined and 1σ from PDF propagates to 1σ on $d\sigma/dy$ (basically Hessian approach – see review Watt PDF4LHC Feb 08)
- If such a fit is a valid fit, it also has produced valid improved values for the eigenvectors.
- If you trust my luminosity derived in this way, you should trust my eigenvector values too.

Is the procedure that produces PDFs consistent?

- BUT – my eigenvector values are more precise than values that would be given by the global fit.
- Or to put it another way, (as has been asked at these meetings before), what is the statistical implications of defining errors from $\Delta\chi^2$=50 or 100?
- Effectively my data is deweighted by factor 4-6 (Cousins PDF4LHC Feb08)
- So should my luminosity estimate also be deweighted by factor 4-6? Should I magnify my error bars?
  1% statistical precision -> 4-6% ?
- Choices in, and understanding of global fit, critical to interpretation of uncertainties on σ_Z

Is the procedure that produces PDFs consistent?

- I think $\Delta\chi^2$=50 or 100 hides bad global data and model systematics. So confidence level interpretation of error band may be valid, but assuming a Gaussian behaviour within this envelope is not.
- Constrained fit for $d\sigma/dy$ possibly invalid.
- **So how should experimental data interact with theory?**
- New MSTW c.l. approach probably a more accurate and consistent statement of situation (see Watt PDF4LHC Feb 08)
- But need to think how to use this information correctly when measuring σ_Z experimentally.

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Getting to 1% uncertainty on σ_Z requires:

1. Understanding model dependence
2. Understanding methodology of experimental and theoretical fitting procedures.