W^+/W^- and l^+/l^-

A Means to investigate PDFs

T. Schörner-Sadenius, G. Steinbrück
Hamburg University

HERA-LHC Workshop, CERN, October 2004

Idea, Motivation, Plan

… still to be worked on ;-)

- Find a means to investigate PDFs.
- Choose cross-section ratios because uncertainties and efficiencies may cancel to some extent. Choose channels with large statistics!
  - W^+/W^-
  - e^+/e^- (and μ^+/μ^-)
- Use of various MC models / calculations, latest PDFs:
  - MC@NLO
  - HERWIG / PYTHIA
  - CTEQ6 with 40 error sets
- Take into account detector effects:
  - Rough estimates of efficiencies, jet fake rates and charge miss-identification probabilities in macro running on hbook ntuples.
  - Later (starting now): Use of full CMS simulation/reconstruction chain at least for
    - central (CTEQ6m) signal scenario (to compare with `fast detector simulation')
    - Main background source(s) (large jet sample).
  - Try to estimate necessary luminosity/measurement precision and maximum tolerable miss-ID probabilities etc.

HERWIG

… central scenario for the time being …

- HERWIG 6.505
- With CTEQ6m and 40 error PDFs.
- Process ID 1499; selected only leptonic W decays.
- Full event simulation (parton shower, heavy particle decays, cluster formation, cluster decay, soft underlying event) → necessary for meaningful comparison with MC@NLO statements?

  ➔ slow! CPU is some limitation if going for full error evaluation.
- So far about 100k events for each PDF.
- For cross-checks also CTEQ6m sample (100k events) with only hard event generated.

  ➔ No parton shower generated; W has not p_T.

MC@NLO

… To estimate influence of higher orders….

- HERWIG 6.504
- With CTEQ6m
- Requires also full event generation chain → also slow.
- Generated so far 60k for both process IDs –1497 and –1498 (separately for W^+ and W^-).

Jet Fake Rate, Charge Miss-ID

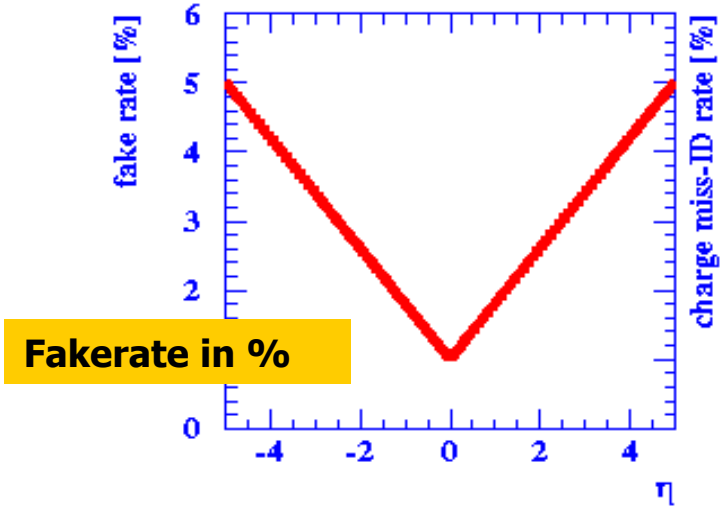
Just rough estimates so far …

- Fake rate:
  - Increasing from 1% (eta=0) to 5% (eta>=5).
  - Effect: Boson / lepton ratio = 1 !
- Charge miss-identification probability:
  - In eta: increasing from 0% (eta=0) to 10% (|eta|>=5)
  - In p_T: increasing from 0% (p_T=0 GeV) to 5% (p_T=100 GeV)
  - Sum both contributions.
  - Effect: Washes out boson / lepton ratios
- Fold both effects using
  - For e^+: fill e^+ histo with wtx*(1-chargemissidprob+fakerate)
fill e^- histo with wtx*(chargemissidprob+fakerate)
  - And vice versa for e^-.
  - Then divide e^+ histo by e^- hist.
- Efficiencies not considered

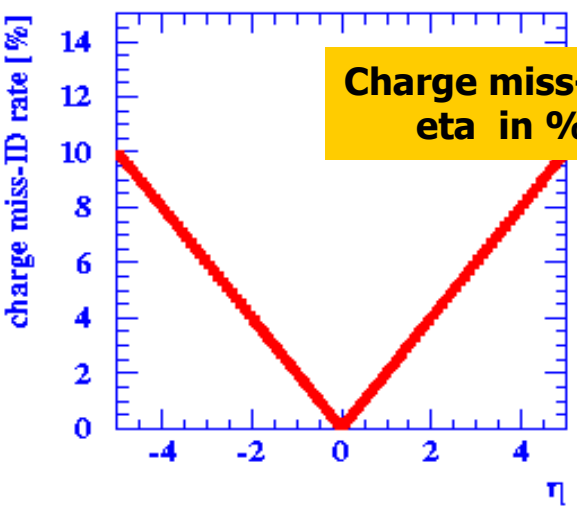
  ➔ Assume same efficiencies for both charges so that effects cancel (small error?).

Jet Fake Rate, Charge Miss-ID

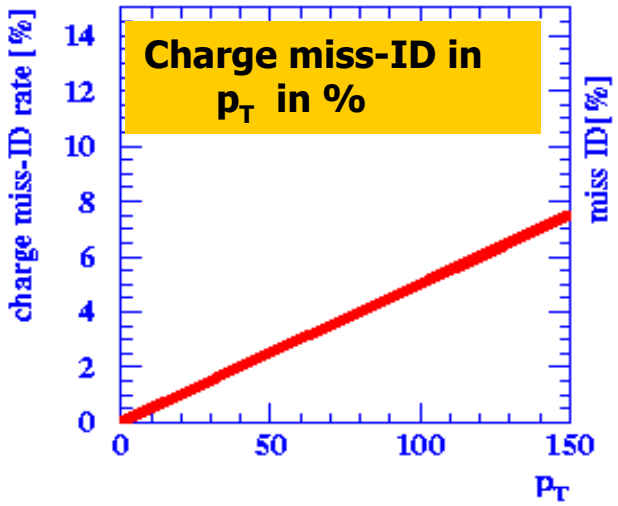
Just rough estimates so far …



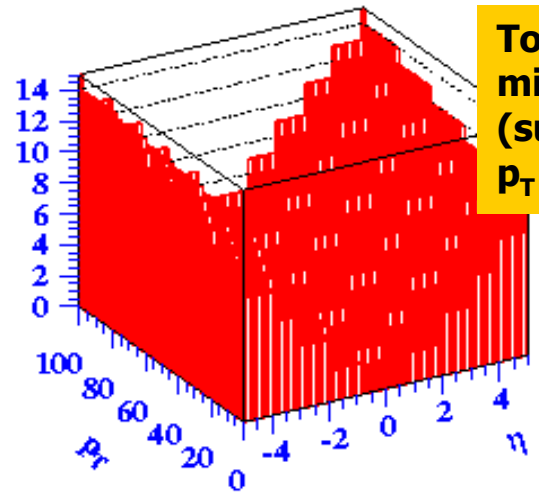
Fakerate in %



Charge miss-ID in eta in %



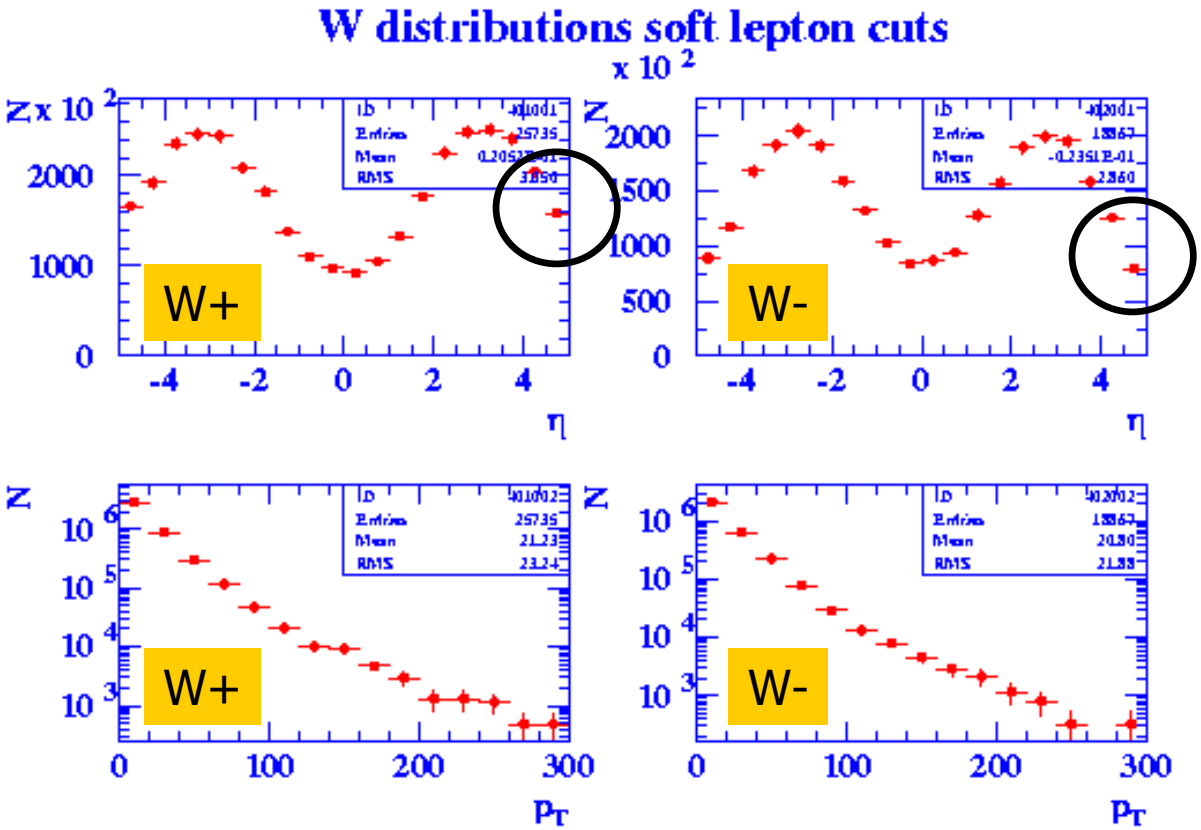
Charge miss-ID in p_T in %



Total charge miss-ID in % (sum of eta and p_T effects)

Results: W^+ and W^- distributions

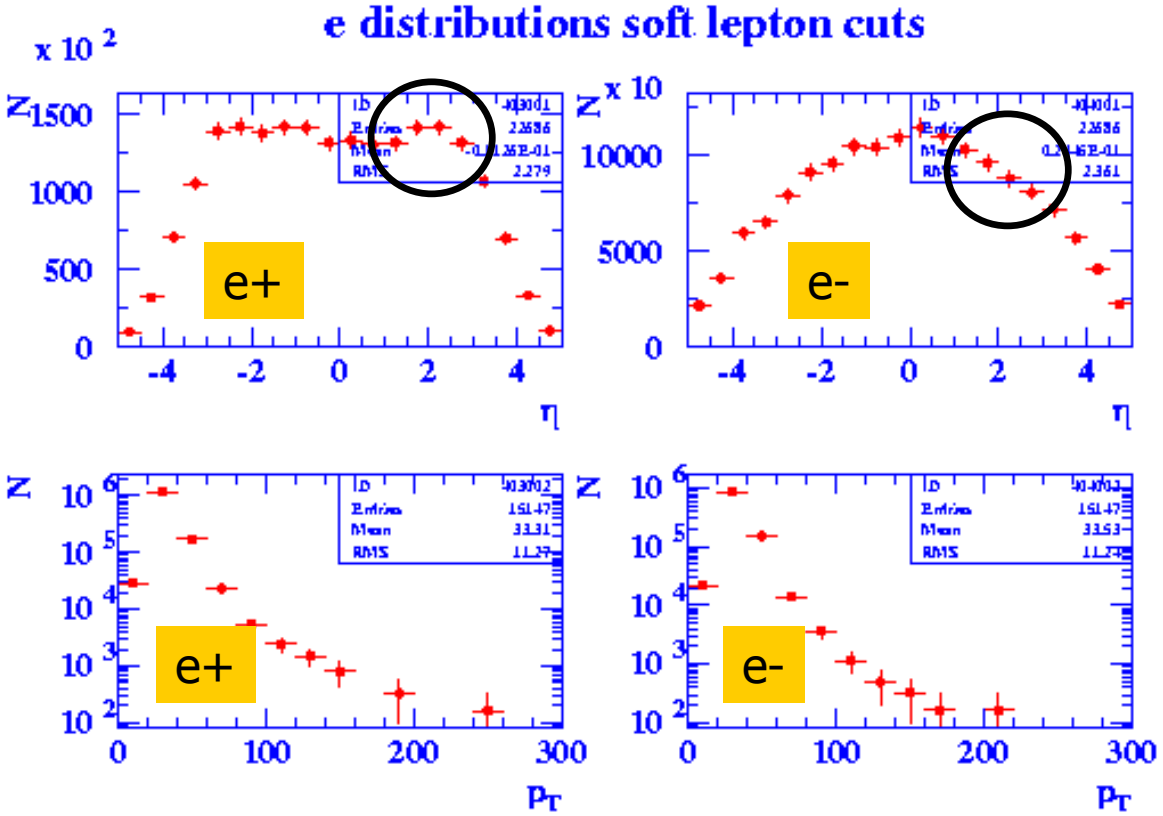
Not taking any fake rate effects etc. into account



- Soft lepton selection: p_T > 20 GeV, |eta|<2.5
- Clear shape differences between W^+ (left) and W^- (right) samples, especially in eta.

Results: e^+ and e^- distributions

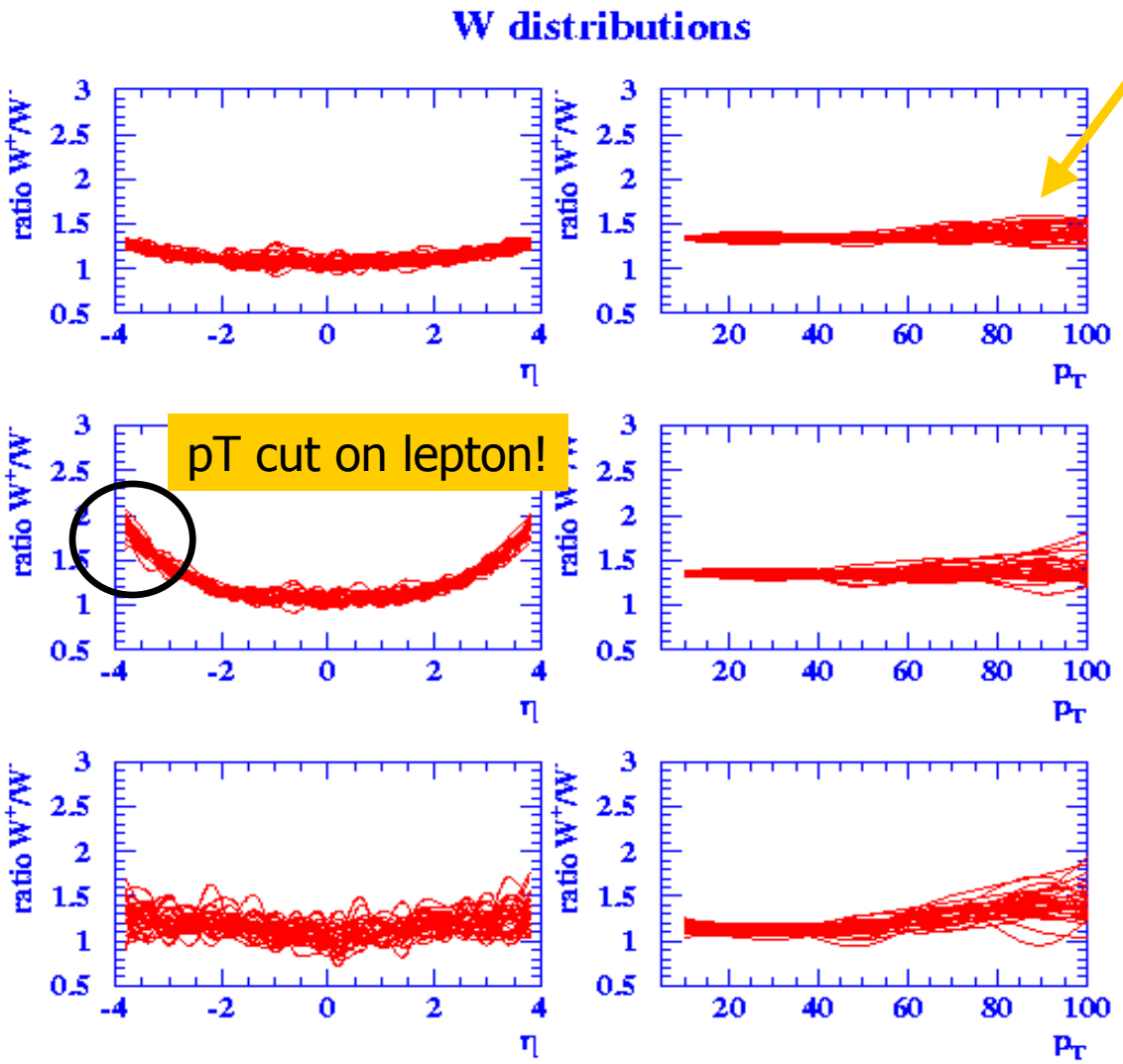
Not taking any fake rate effects etc. into account



- Soft lepton selection: p_T > 20 GeV, |eta|<2.5
- Clear shape differences between e^+ (left) and e^- (right) samples, especially in eta.

Results: W^+/W^- ratios

Not taking any fake rate effects etc. into account



CTEQ6m plus 40 error PDFs!

All semileptonic W without any sigificant lepton selection.

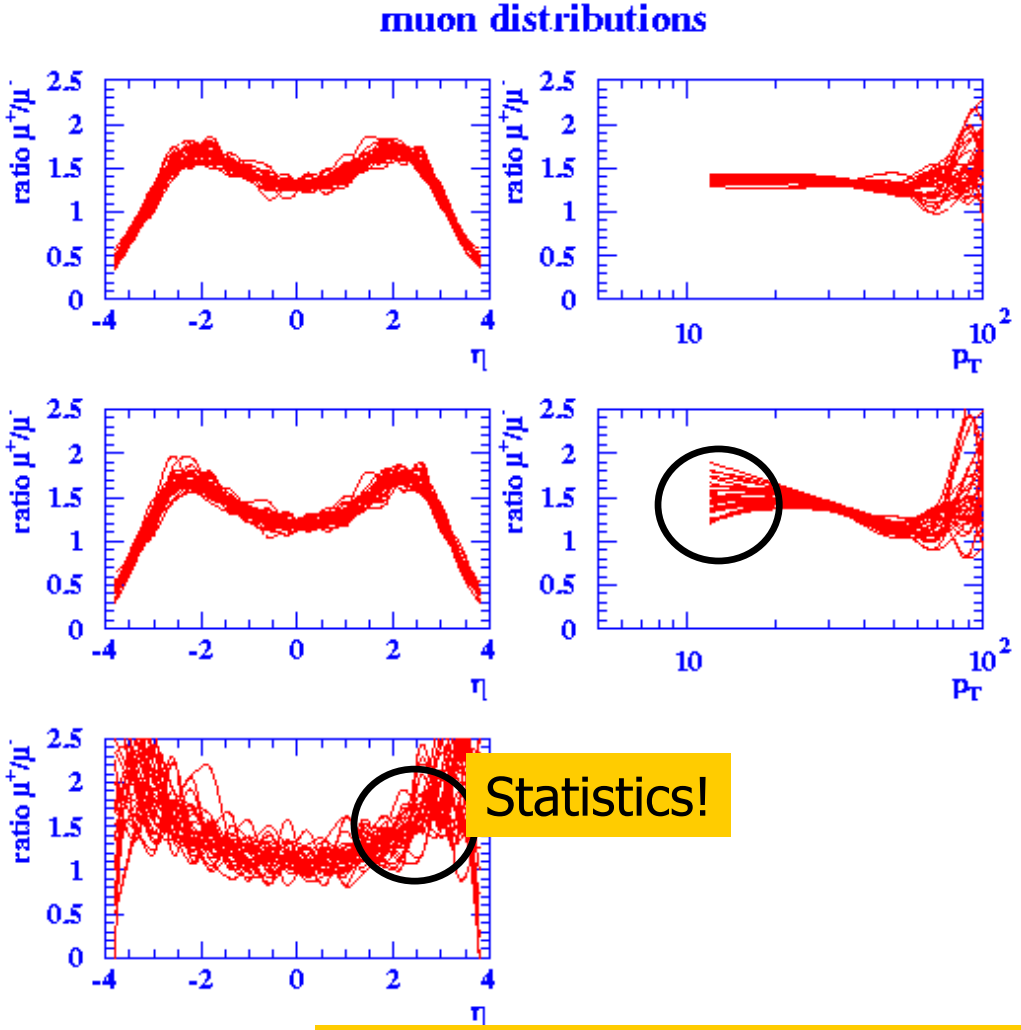
pT cut on lepton!

Soft lepton selection:
p_T > 20 GeV, |eta|<2.5

Hard lepton selection:
p_T > 40 GeV, |eta|<2.5
(and $E_{T,miss}$ > 20 GeV)

Results: Ratio μ^+/μ^-

Not taking any fake rate effects etc. into account



All leptons from semileptonic W decays without any sigificant lepton selection.

Soft lepton selection:
p_T > 20 GeV, |eta|<2.5
(and $E_{T,miss}$ > 20 GeV)

Statistics!

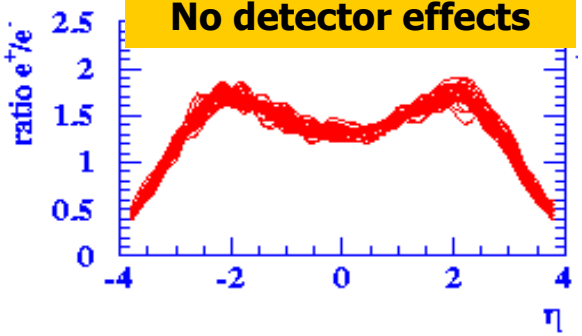
Hard lepton selection:
p_T > 40 GeV, |eta|<2.5
(and $E_{T,miss}$ > 20 GeV)

Nice sensitivity to PDF especially at low p_T.

Results: Ratio e^+/e^-

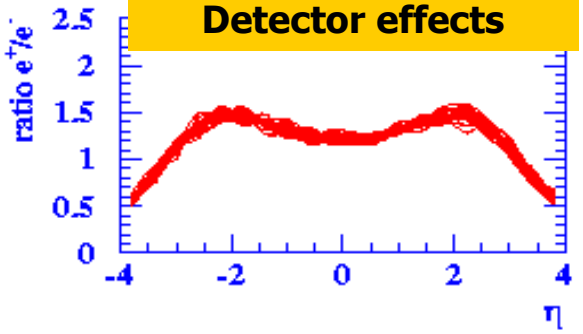
... as function of eta

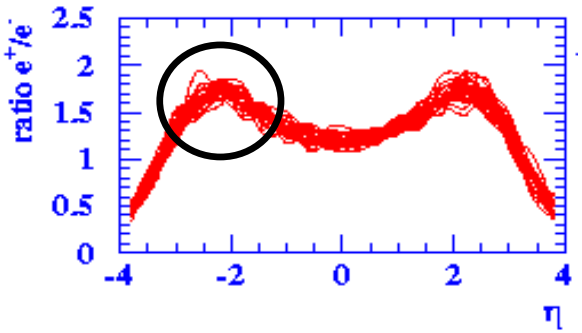
No detector effects



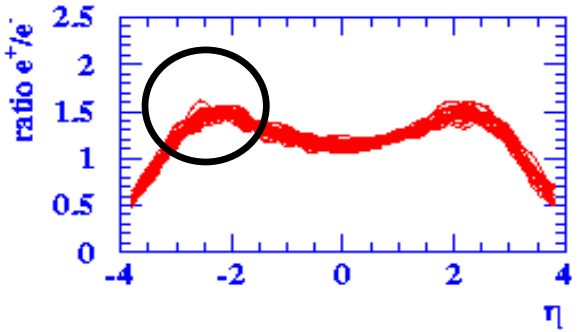
All leptons from semileptonic W decays without any sigificant lepton selection.

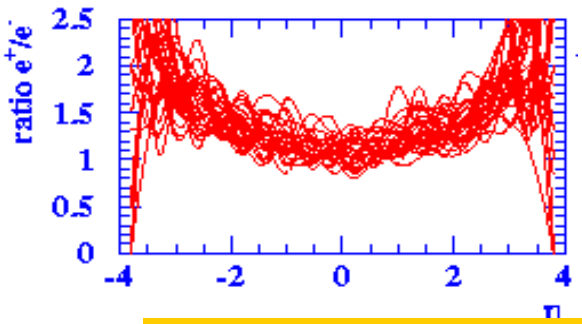
Detector effects



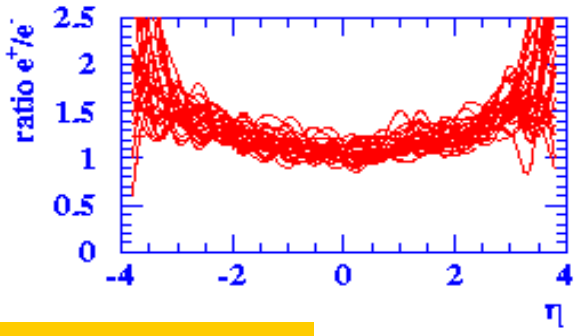


Soft lepton selection:
p_T>20GeV, $E_{T,miss}$>20GeV





Hard lepton selection:
p_T>40 GeV, $E_{T,miss}$>20GeV

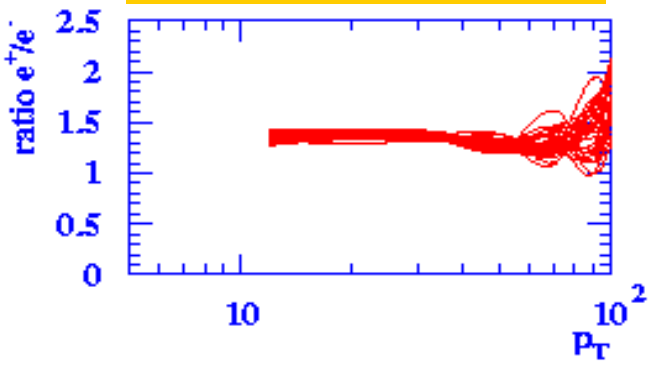


With detector effects: Less spread between PDFs, lower ratios

Results: Ratio e^+/e^-

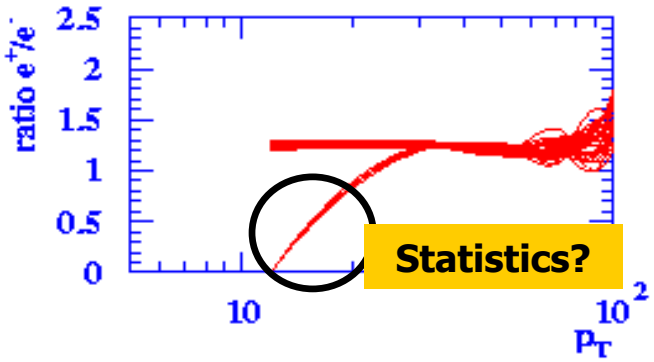
... as function of p_T

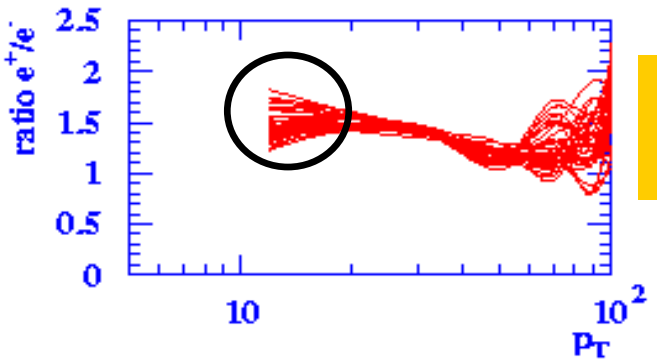
No detector effects



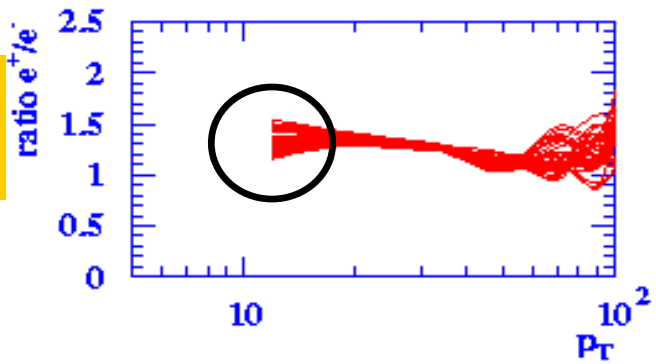
All leptons from semileptonic W decays without any sigificant lepton selection.

Detector effects





Soft lepton selection: |eta|<2.5, $E_{T,miss}$>20GeV

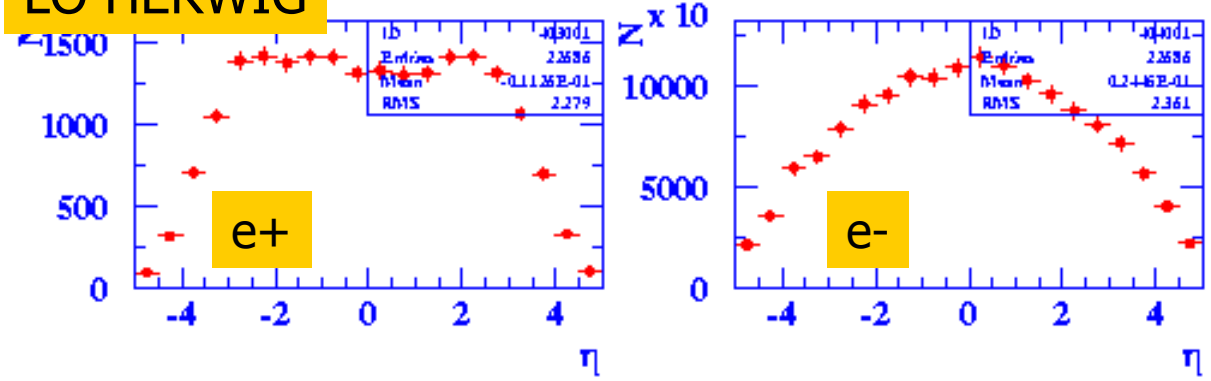


With detector effects: Less spread between PDFs, lower ratios

Effect of NLO: e^+ and e^- in eta

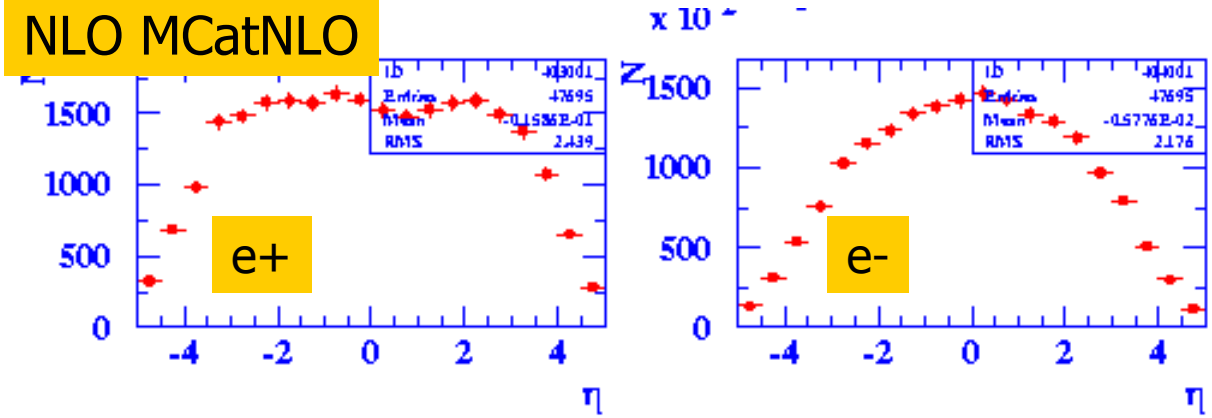
Not taking any fake rate effects etc. into account

LO HERWIG



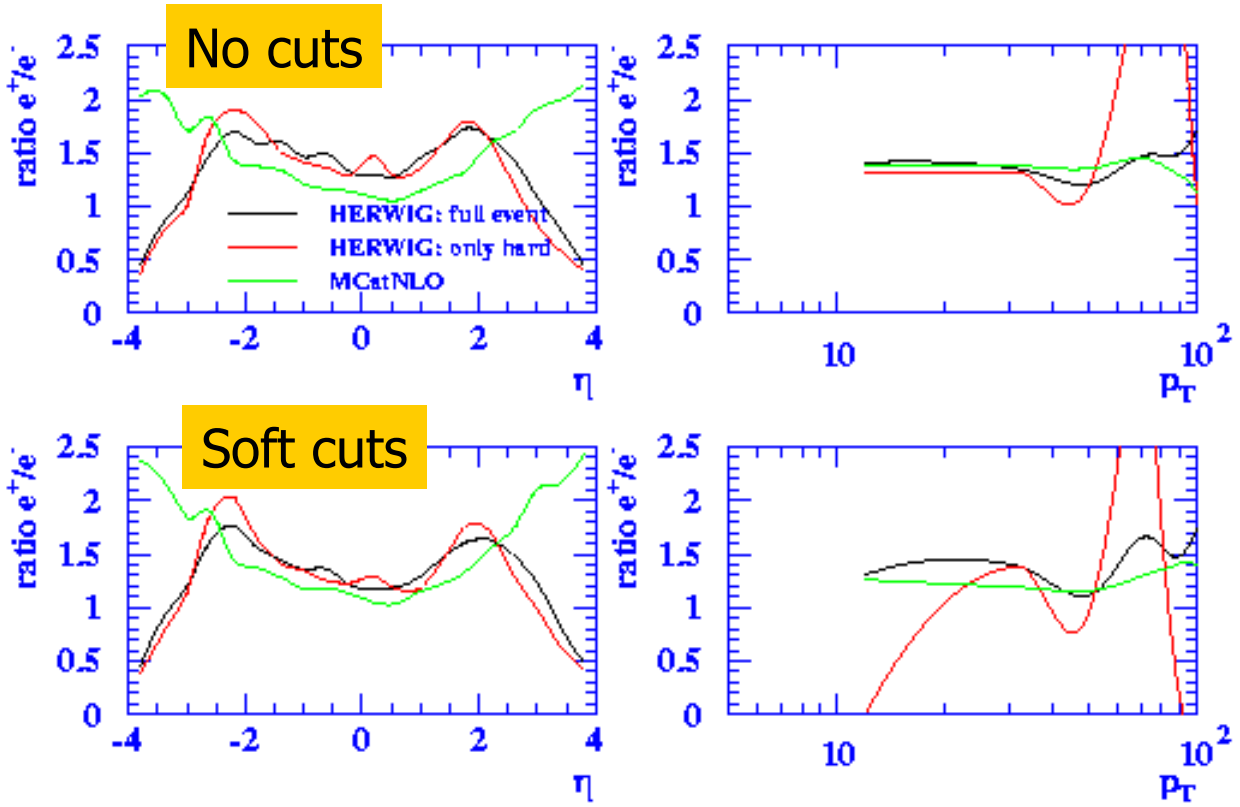
Hard to see difference, but ratio next page …

NLO MCatNLO



Results: MC@NLO for Ratio e^+/e^-

Without fake rates etc.



Very large effects of NLO corrections at large pseudorapidities.

Further Plans

… where to go from now?

- Discuss what we have done so far. Any suggestion is welcome.
- Try to get more MC statistics to get statistically more meaningful statements
  - Which statistics/precision do we need?
  - Which fake rates can we tolerate?
  - Which charge miss-ID?
  - Other effects?
- Try other observables?
- Propagate detector effects to W ratios.
- Try to get real CMS detector simulation (signal with one PDF, one background) ➔ judge on fake rates etc.

  G. Steinbrück is currently setting up the software to run on GridKa / grid computers at DESY.
- Your Feedback: Is it worthwhile going in this direction?

Summary

… where to go from now?

- Sensitivity to PDFs is large for some observables and cut scenarios. (medium cuts, low p_T)
- Effects washed out by detector effects.
- NLO seem to be big.
- ???????