La fisica accessibile durante il commissioning: spunti per la discussione

Misure che si possano fare a '*bassa*' luminosita', con statistica limitata e con una conoscenza incompleta del rivelatore:

- **Minimum bias/Underlying event**
- **Misura delle PDF dall'analisi del W (ulteriori commenti)**

C. Gemme – A.Ghezzi

Why studying Minimum Bias and Underlying Event

- Essentially all physics at LHC are connected to the interactions of *quarks* and *gluons* (small & large transferred momentum).
  - ***Hard processes (high-pT)***: well described by perturbative QCD
  - ***Soft interactions (low-pT)*** : require non-perturbative phenomenological models *(strong coupling constant, $\alpha_s(Q^2)$, saturation effects,…)*

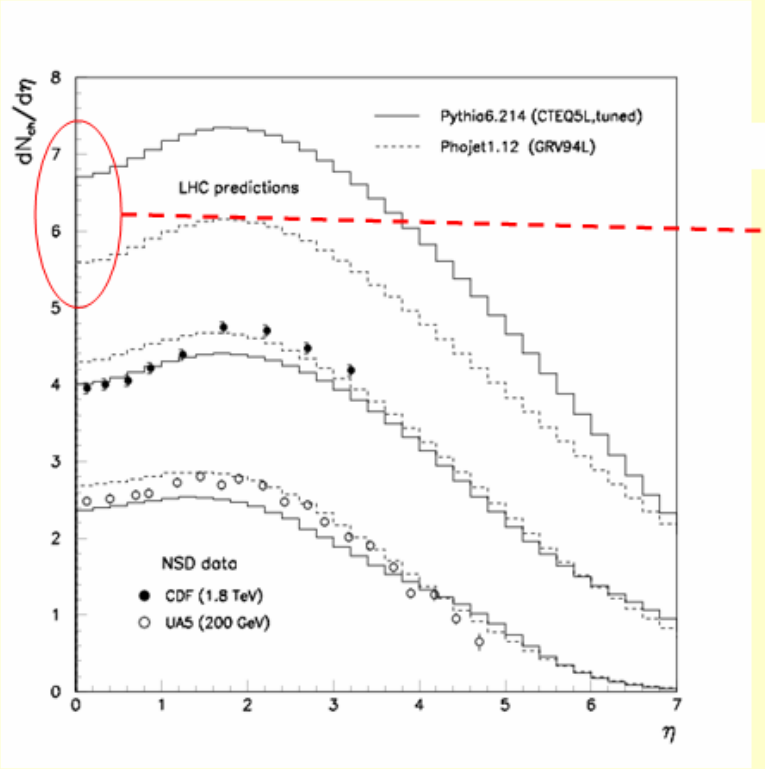
Minimum bias and the ***underlying event*** is dominated by ***"soft"*** partonic interactions.

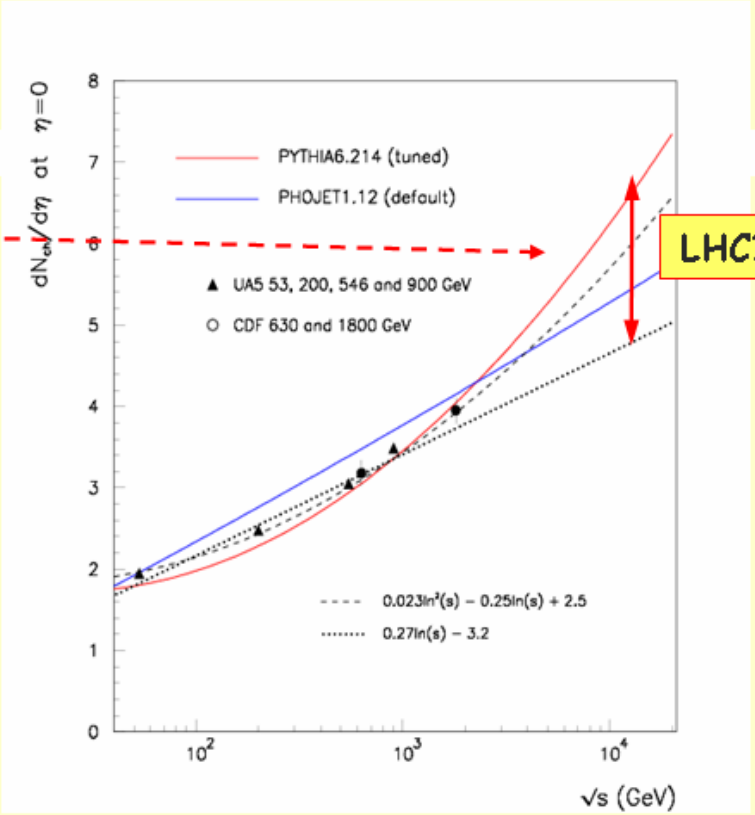
- Why should we be interested?
  - **Physics**: improve our understanding of QCD effects, multiple interactions (parton, Pomeron, etc.), total cross-section,…
  - **Experiments** : occupancy, pile-up, backgrounds,…

Early measurements with Min Bias data

- Large uncertainties in prediction at LHC energy
- Obvious first measurements with min-bias data are
  - $dN_{ch}/d\eta$, dN_{ch}/dp_T
  - dNch/dη at η = 0 requires only several thousand events and it is a robust measurement, not dependent on full ID reconstruction.

Charged particle density at $\eta = 0$





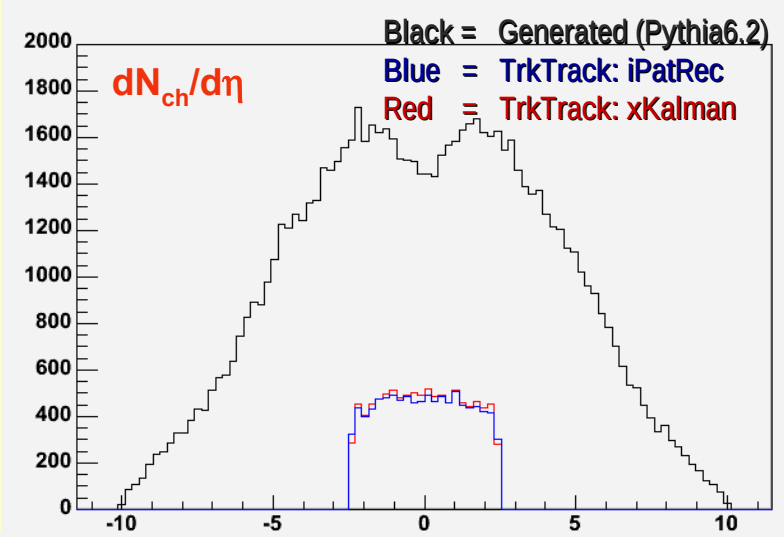
Large uncertainty in track densities!

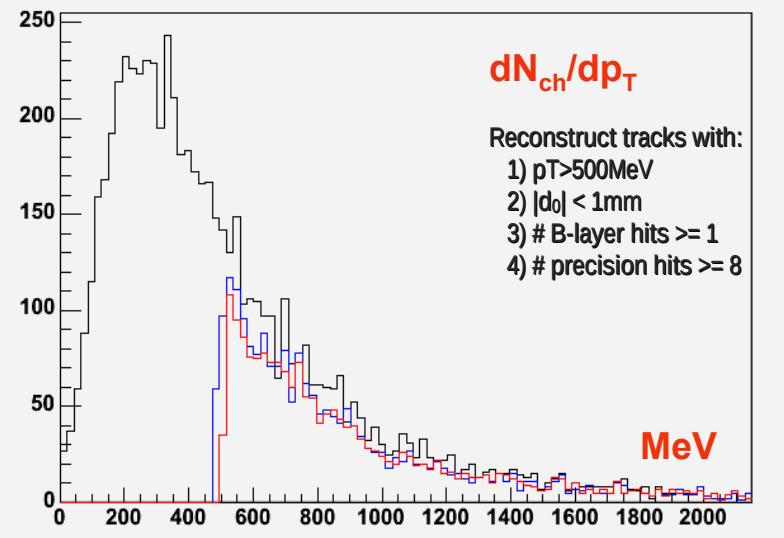
Multiple interaction model in PHOJET predicts a ln(s) rise in energy dependence. PYTHIA suggests a rise dominated by the $\ln^2(s)$ term.

Only need central inner tracker and a few thousand pp events

Charged particle densities

Generated vs reconstructed tracks (1000 events):





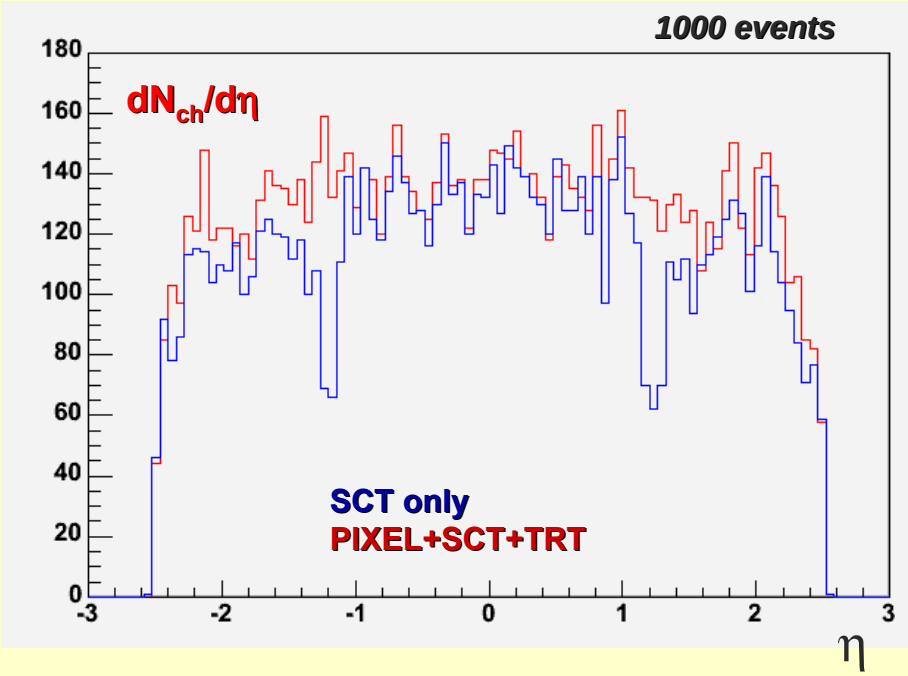
Full inner detector track reconstruction (InDetRecExample)

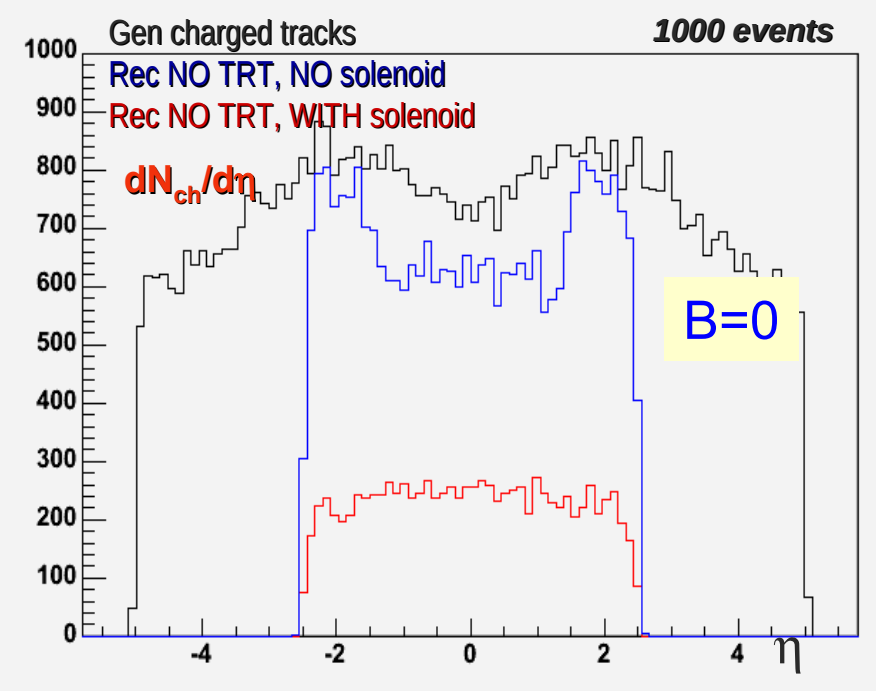
Only a small fraction of tracks reconstructed:

- Limited rapidity coverage
- Can only reconstruct track p_T with good efficiency down to ~500 MeV, and most particles in MB events have p_T <500 MeV

During commissioning phase

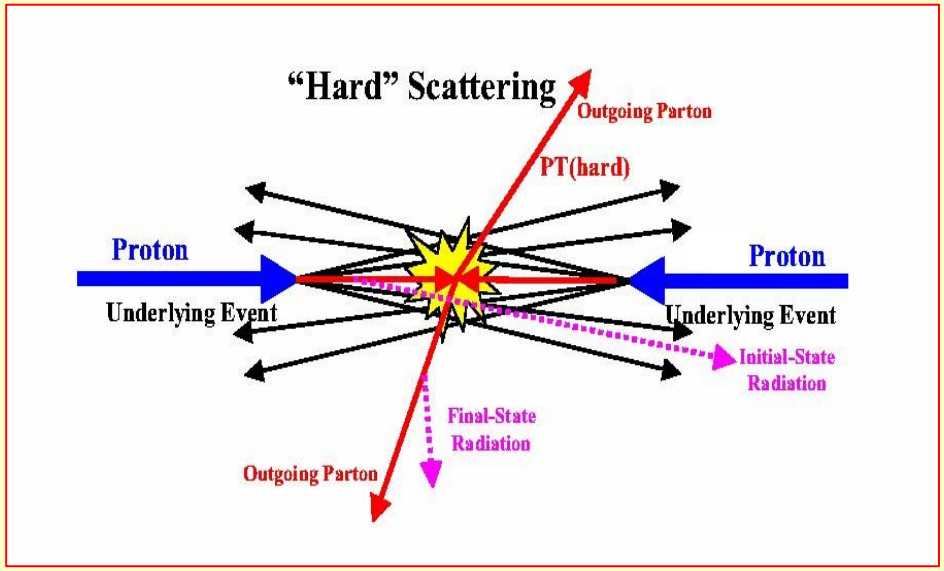
- With commissioning in mind, interesting to compare measurements of $dN_{ch}/d\eta$ for different ID subsystems.
- For example, here is a comparison of "SCT only" with "Pix+SCT+TRT"
  - In the central rapidity region there is little difference in number of tracks reconstructed.
- One way to reconstruct tracks down to lower p_T's would be to take some data with a reduced solenoid field (or even zero, don't need track p_T for $dN_{ch}/d\eta$)
- Probably better to look at reduced field scenarios (eg 1 T), so that we can get dN_{ch}/dp_T measurement with same data.

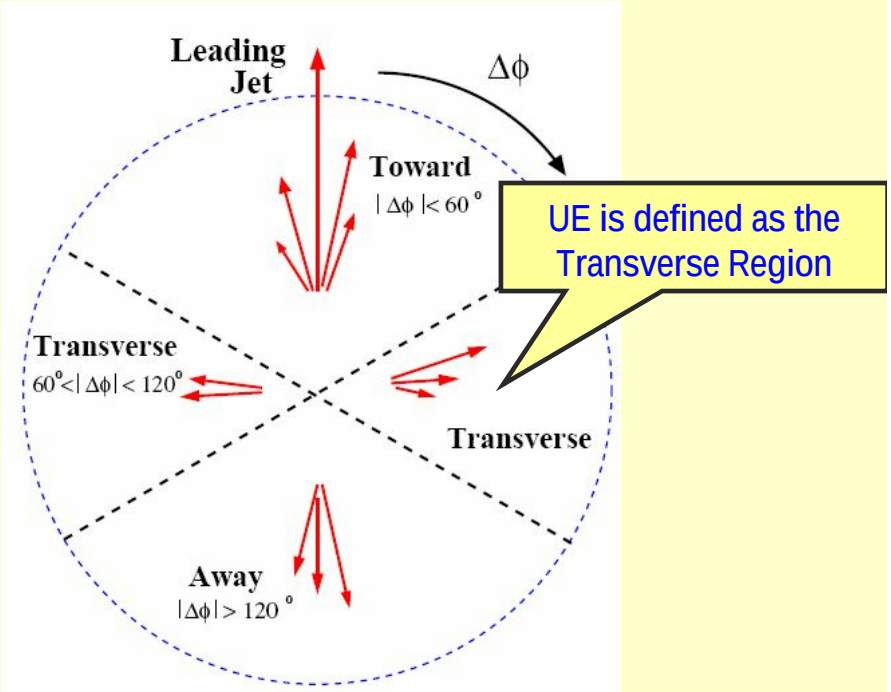




The Underlying Event in jet physics

- The underlying event is defined as ***everything in the collision except the hard process***.
  - ***It is not*** a minimum bias event!
- The underlying event has ***hard*** (multiple "semi-hard" parton scatterings, ISR and FSR) and ***soft*** components (mainly beam-beam remnants).





$\Delta\phi = \phi - \phi_{jet}$ **azimuthal angle between charged part and the leading charged jet**

LHC predictions: pp collisions at $\sqrt{s}$ = 14 TeV

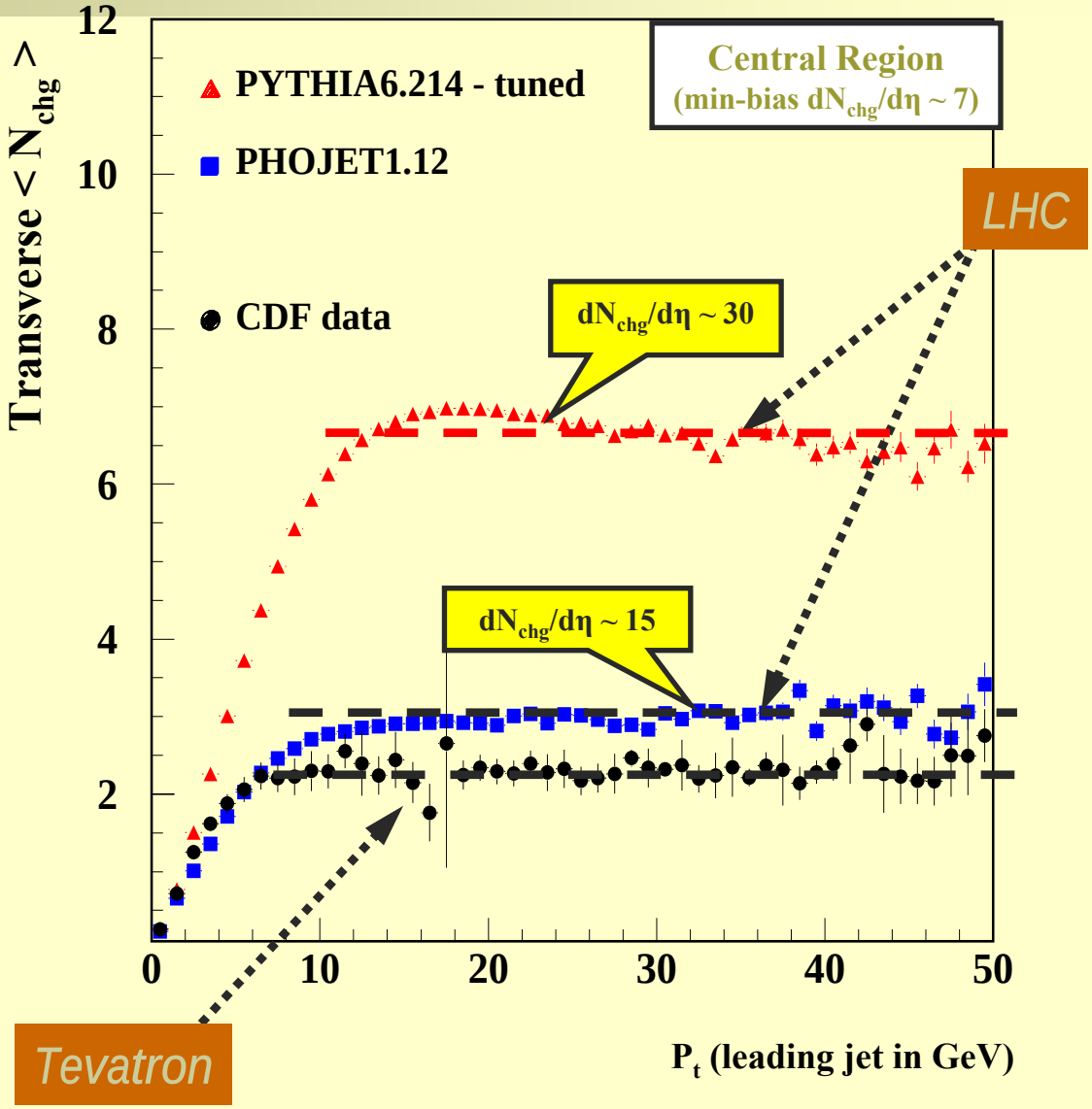
Charged particles:

p_t>0.5 GeV and $|\eta|$<1

Cone jet finder:

$$R=\sqrt{(\Delta\eta)^2+(\Delta\phi)^2}=0.7$$

UE particles come from region transverse to the leading jet.



Triggering considerations

I. Min-bias trigger

- Scintillators mounted on front face of LAr endcap cryostat: 20cm < R < 130cm
- Use during early running when **luminosity very low**
- Need to study triggering efficiency etc.
- Use random trigger when luminosity above 10^{32} cm^{-2} s^{-1} ?

II. Jet trigger

- Selecting jet events: **low luminosity**

Trigger (LVL1): single jet, E_T^{jet} >200 GeV

σ_{jet} ~ 70nb → ~10^9 events / 20 fb^{-1}
→ ~100 events / s

Few hours of data taking (low luminosity) should provide enough statistics!

It would be certainly interesting to lower the jet trigger E_T threshold during commissioning.

Underlying event

- On fully simulated jet samples (60K events) compare reconstructed and generated multiplicity.

Select jet events:

Njets > 1

|ηjet| < 2.5

ETjet >10 GeV

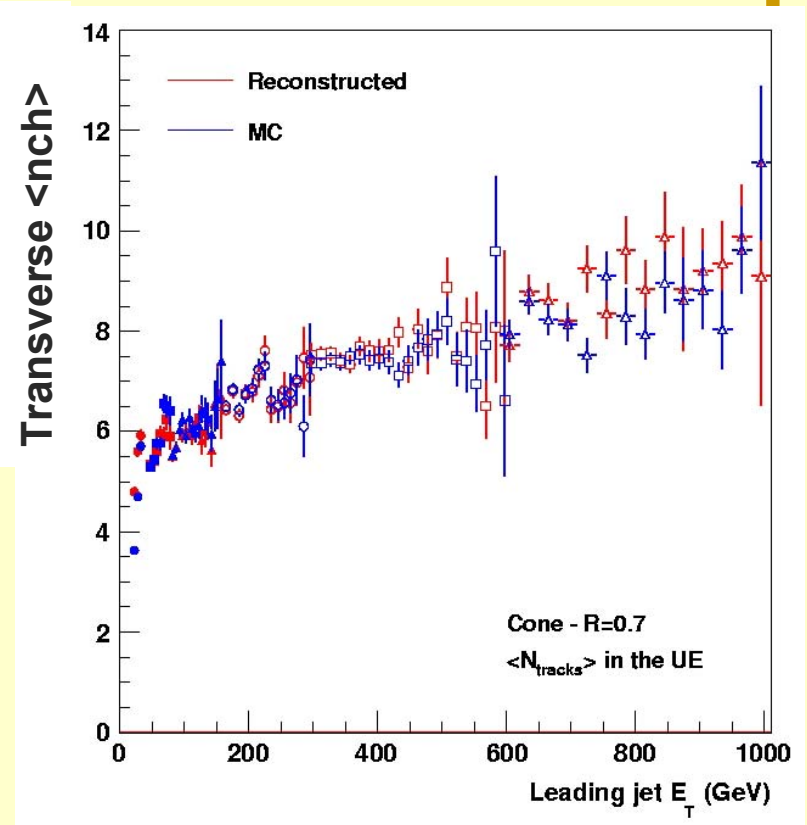
Select UE:

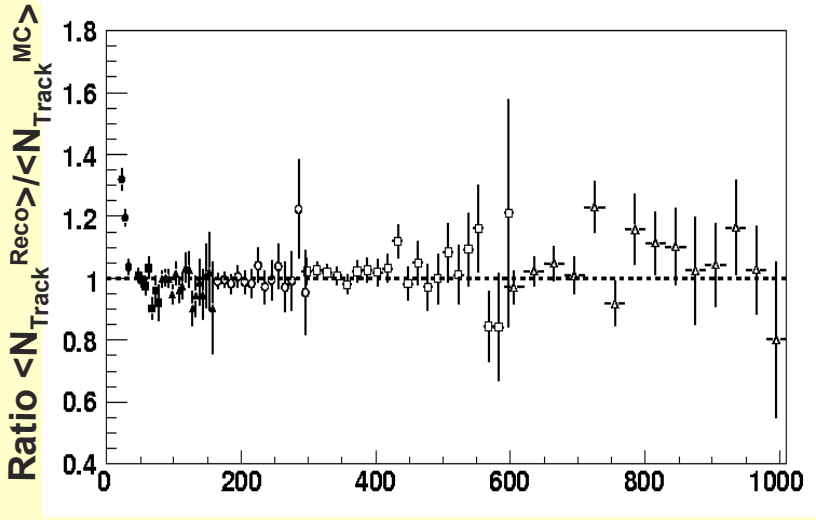
|ηtrack | < 2.5,

pTtrack > 1.0 GeV/c

$60^0 < |\Delta\phi| < 120^0$

- Good agreement reconstructed/generated UE
- Early measurements of jet events can measure UE and allow tuning of MC models
  (100 events/s -> few hours)





UE: Triggering considerations

Jet trigger

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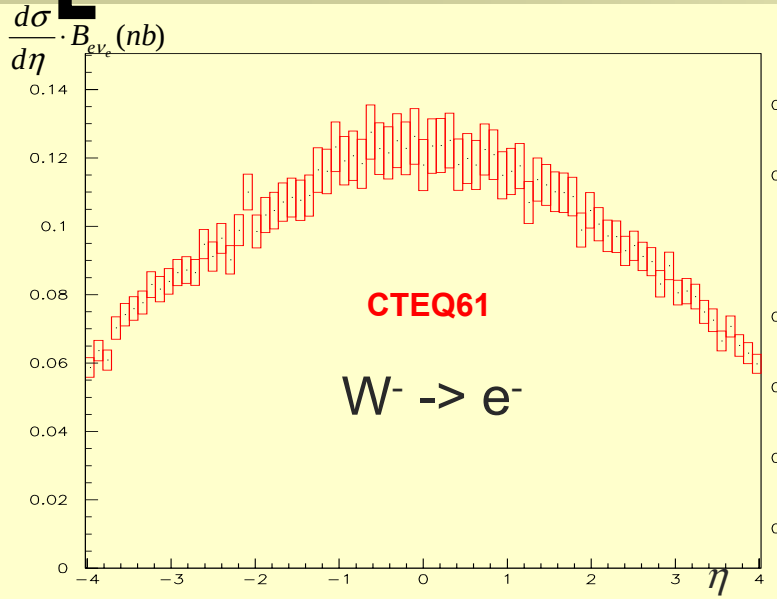
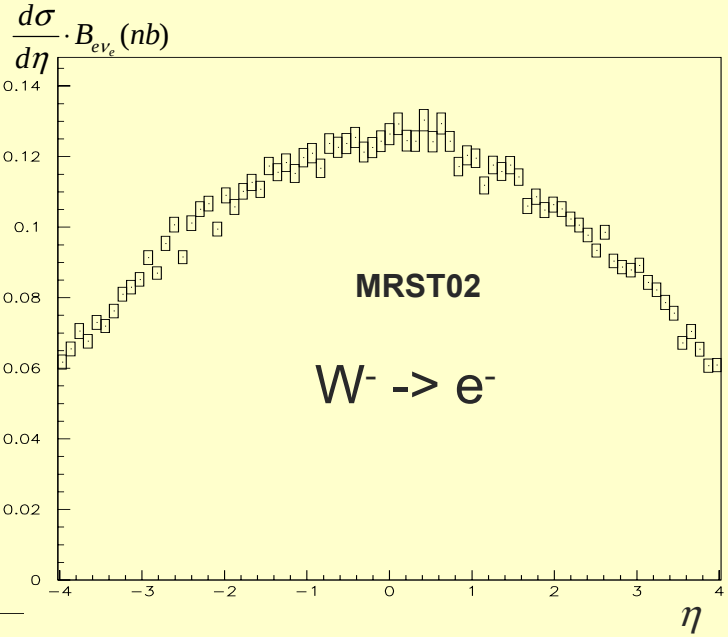
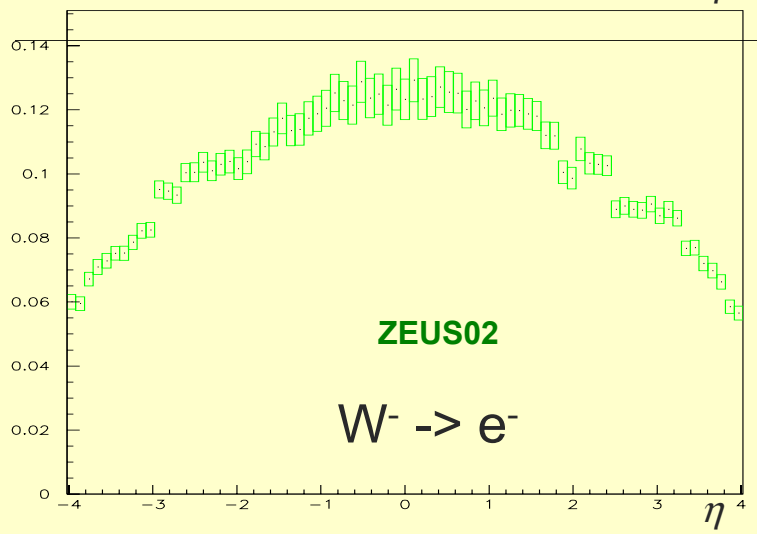
PDFs determination using W bosons

- Measurement of W → lepton rapidity distribution can increase our knowledge of the PDFs useful for many other measurements .
  - W->e Rapidity distributions at GEN and DET Level **To Discriminate PDF Sets**
  - W->e Asymmetry and Ratio at GEN and DET Level **To possibly Minimise PDF Errors** (under investigation)
- **How accurate we need to be?**
  - Sensibility of the lepton pseudorapidity distributions to the PDFs
  - Detector level distributions
  - Systematic uncertainties: first study on misidentification but more sources need studies (detector misalignments and efficiency, backgrounds…)

$W^- \rightarrow e^- \eta$ Distributions at *Generator Level*







For the W^{+-} we will actually observe the leptons from the decays

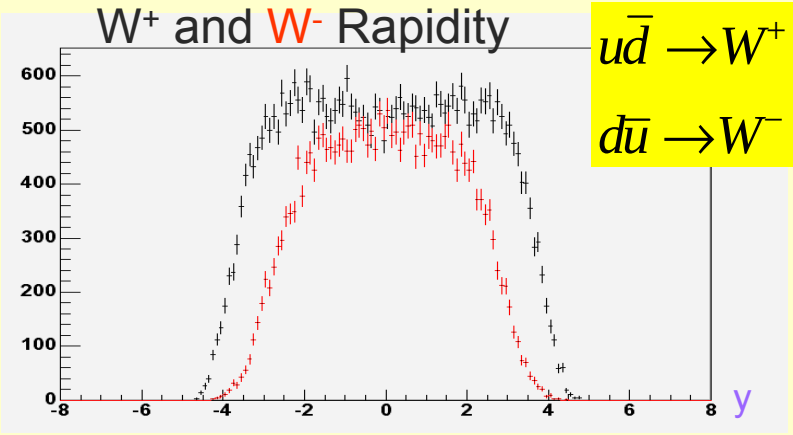
Error boxes are the full PDF Uncertainties

W- -> e- events generated with HERWIG with different PDFs (CTEQ61,MRST02,ZEUS02))

At y=0 the total uncertainty is
~ ±6% from ZEUS
~ ±4% from MRST01E
~ ±8% from CTEQ6.1
ZEUS to MRST01 central value diff. ~5%

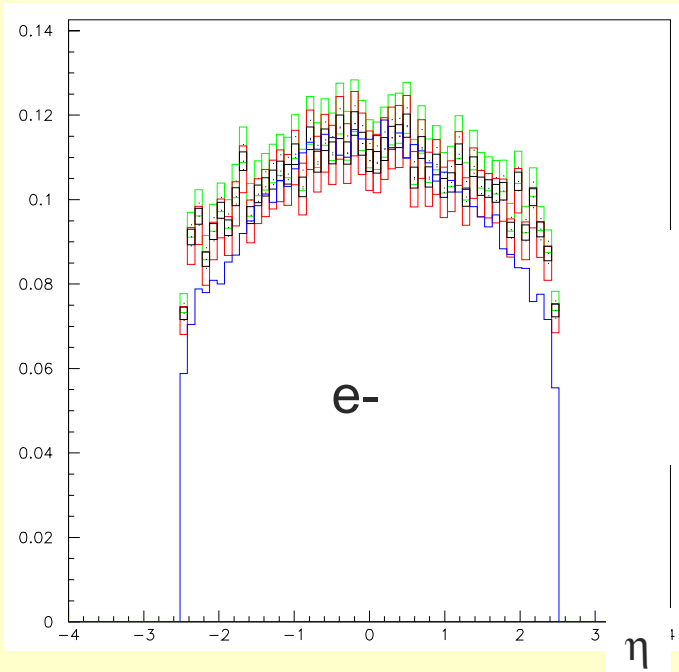
We NEED to be more accurate than **~3%**

ATLAS detector simulation (AtlFast)



- Uncertainty in PDFs transferred to sizeable variation in rapidity distribution of electrons
- Limited by **systematic uncertainties**

To discriminate between conventional PDF sets we need to achieve an **accuracy ~3%** on rapidity distributions.



Error boxes: The full PDF Uncertainties

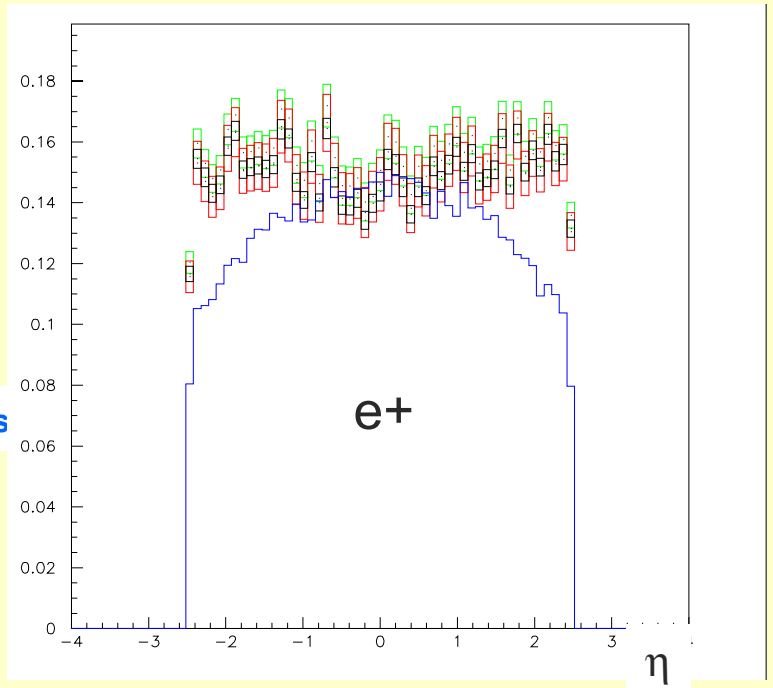
CTEQ61 (MC@NLO)

MRST02 (MC@NLO)

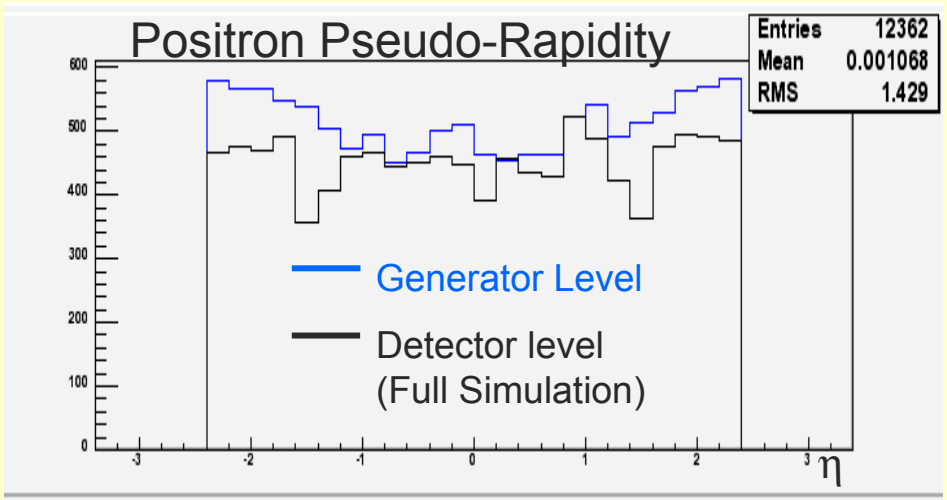
ZEUS02 (MC@NLO)

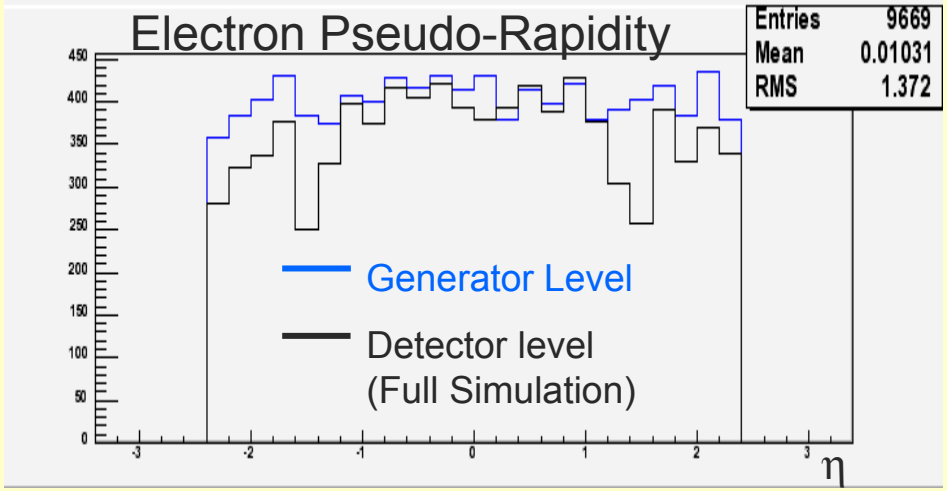
MRST03 (Herwig+k-Factors

Stat ~6 hours at low Lumi.



W^{+-} -> e^{+-} Full Simulation: *Detector and Generator levels Comparison*





67K fully simulated events

Signal Selection Efficiency
(DET-AfterCuts / GEN-AfterCuts)

W+ -> e+ $|\eta| < 1$: 0.94 +- 0.03
W+ -> e+ $|\eta| > 1$: 0.84 +- 0.02

W- -> e- $|\eta| < 1$: 0.97 +- 0.03
W- -> e- $|\eta| > 1$: 0.85 +- 0.02

Back up for MB and UE

Triggering considerations

Min-bias trigger

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→ ~100 events / s

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It would be certainly interesting to lower the jet trigger E_T threshold during commissioning.

UE: Reconstructed jet events

- Jet samples used for this analysis *(reconstructed with 10.0.1)* :
  - J1 – J8: QCD jets in p_T bins (17 – 35GeV, 35 – 70GeV, 70 – 140 GeV, 140 – 280GeV, 280 – 560GeV, 560 – 1120GeV, 1120 – 2240GeV and p_T > 2240GeV) ;
  - Available from:

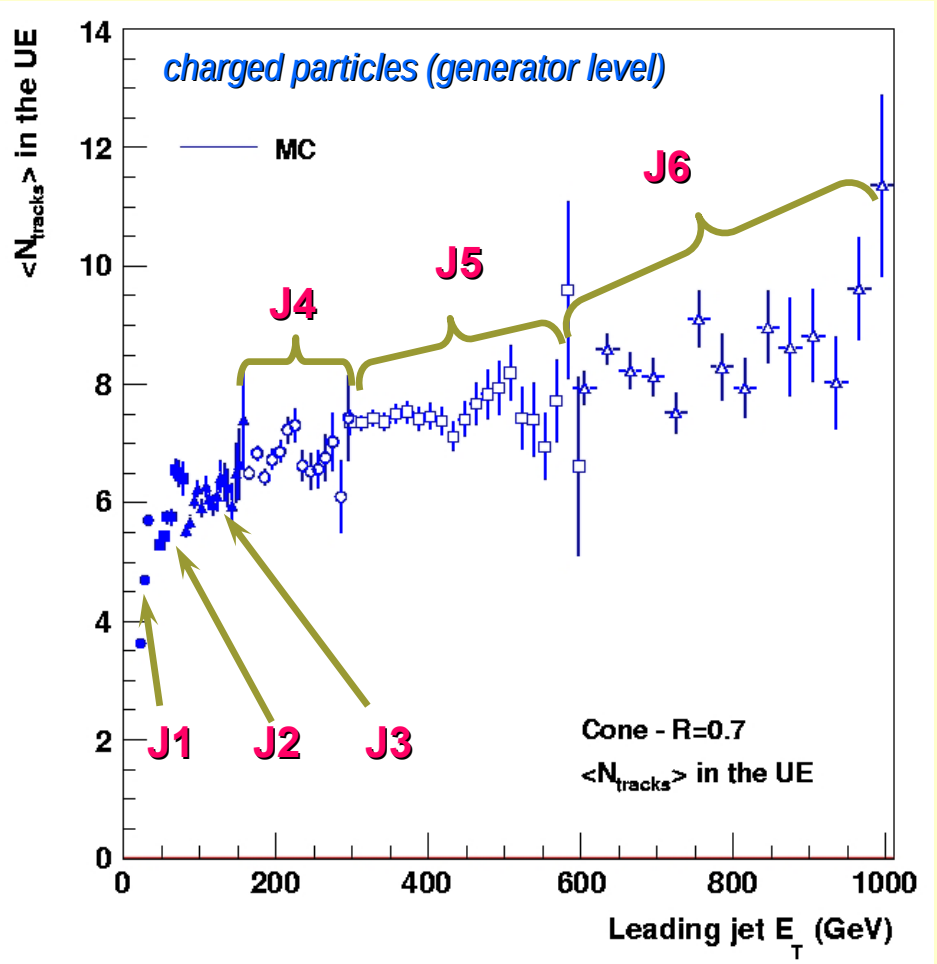
/castor/cern.ch/grid/atlas/datafiles/rome/recov10/

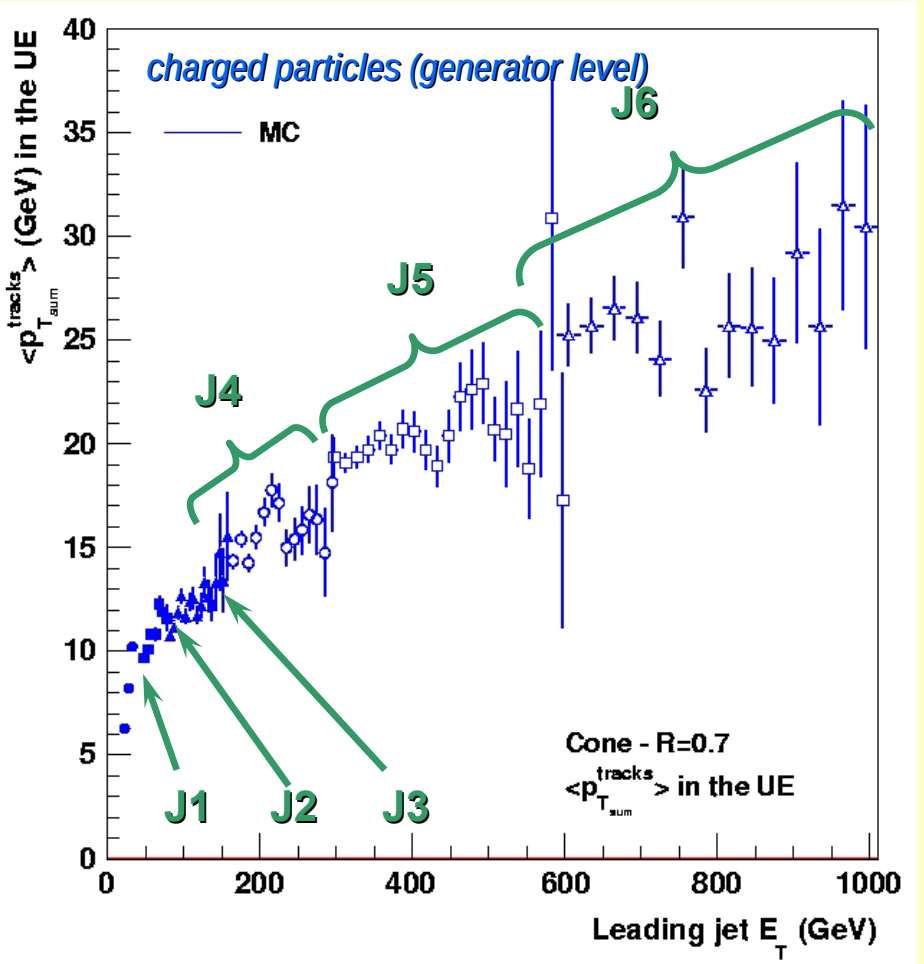
http://phyweb.lbl.gov/AOD/10.0.1/

  - Number of events used: J1 – J5: 40K events; J6, J7 and J8: 20K events.

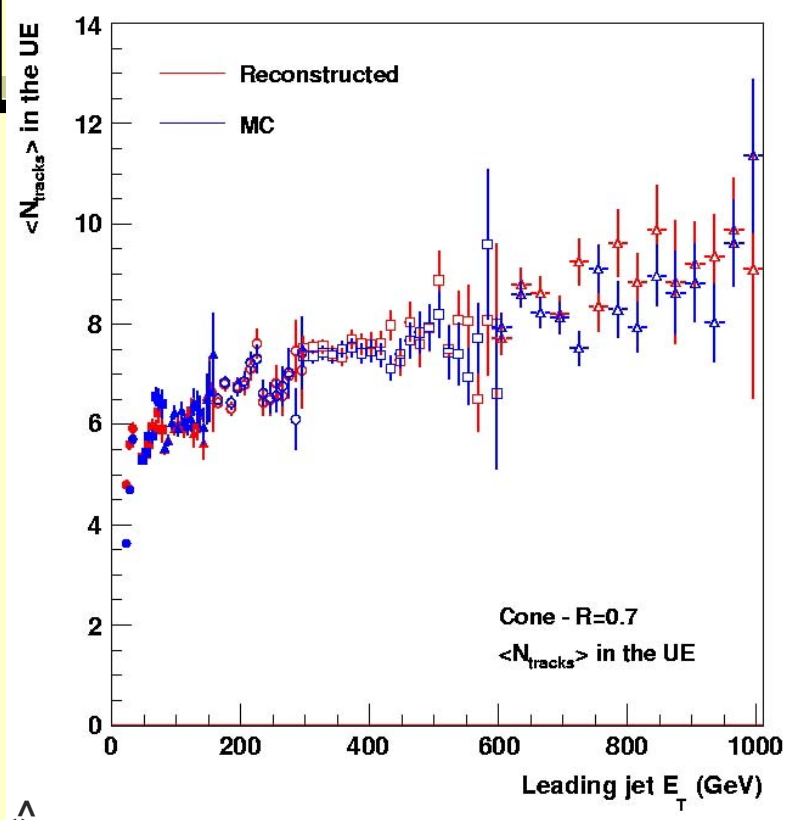
UE: MC event generator jet samples

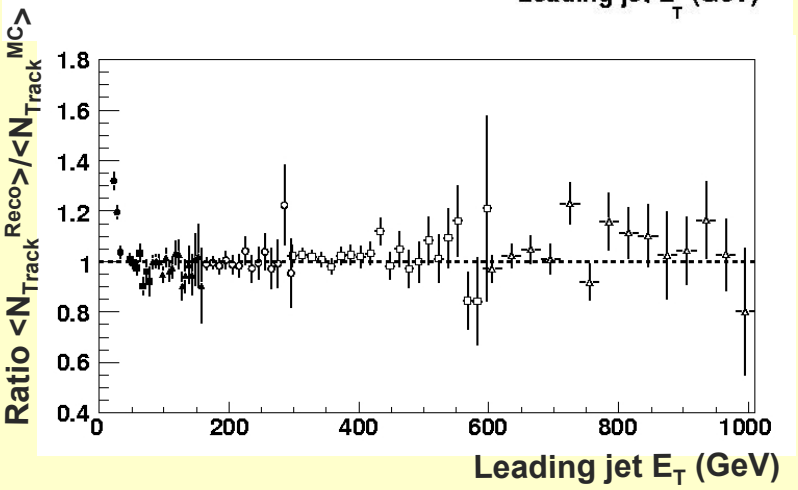
2) Selecting the underlying event: $N_{jets} > 1$, $|\eta_{jet}| < 2.5$, $E_T^{jet} > 10$ GeV, $|\eta_{track}| < 2.5$, $p_T^{track} > 1.0$ GeV/c

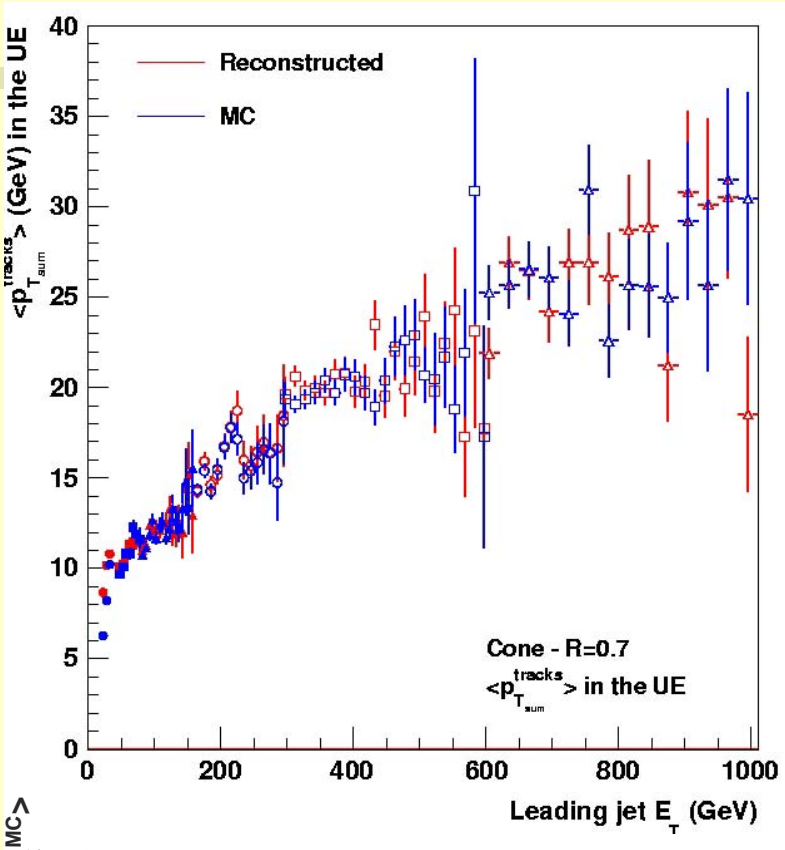


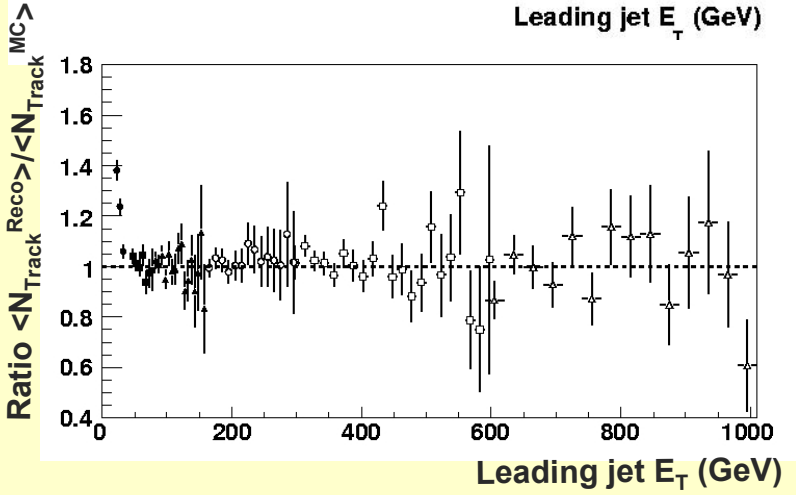


UE: MC event generator vs reconstructed jet samples







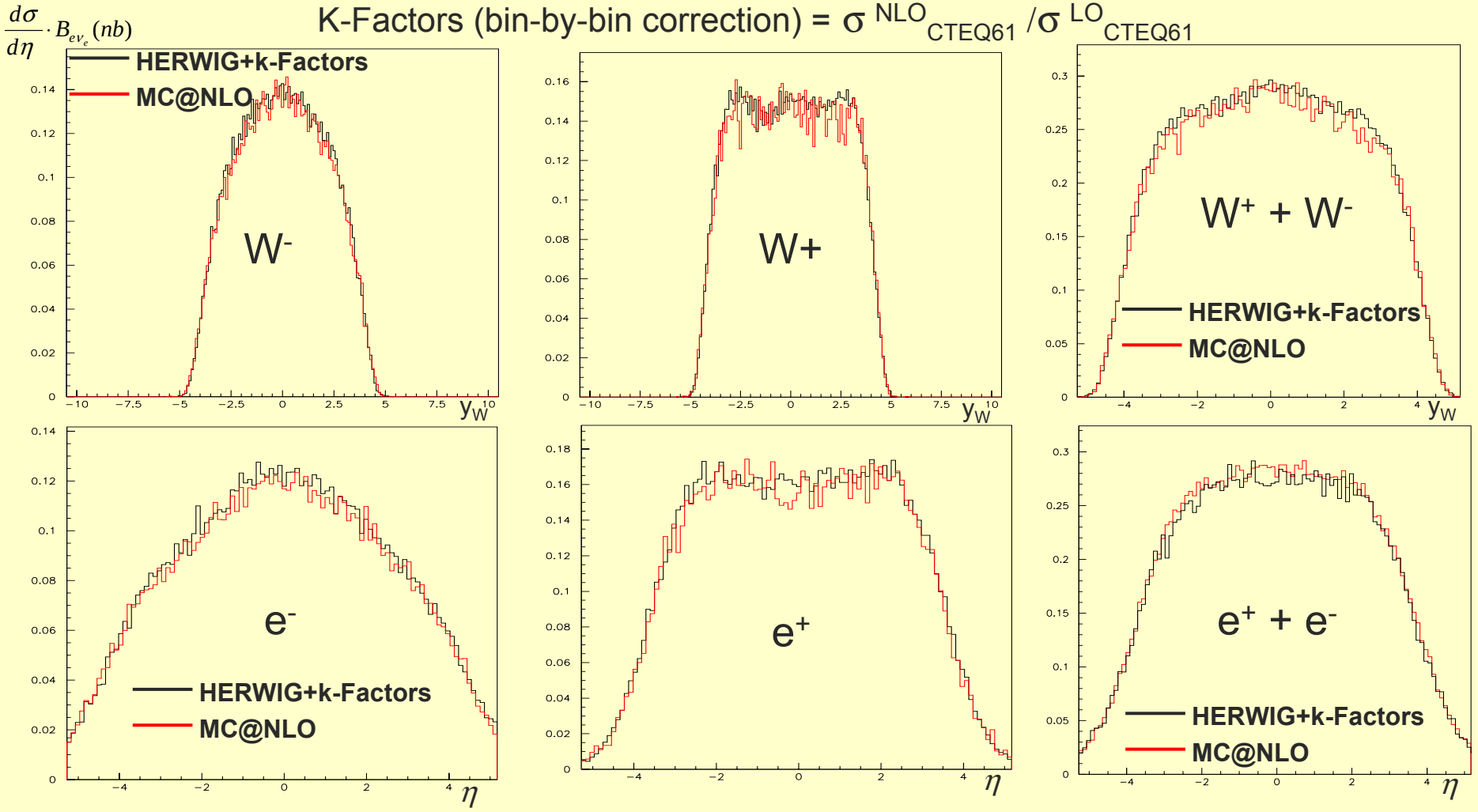


Back up for PDFs from Ws and Zs

Can we use *Herwig & K-Factors* to simulate NLO ?
– seems good enough for rapidity distributions

Events generated using **CTEQ61**

K-Factors (bin-by-bin correction) = $\sigma^{NLO}_{CTEQ61} / \sigma^{LO}_{CTEQ61}$

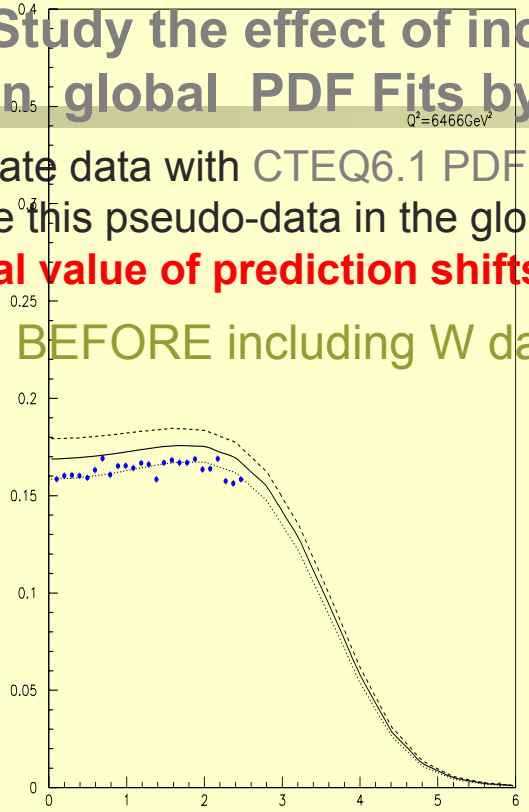


Study the effect of including the W Rapidity distributions in global PDF Fits by how much can we reduce the PDF errors?

Generate data with CTEQ6.1 PDF, pass through ATLFAST detector simulation and then include this pseudo-data in the global ZEUS PDF fit.

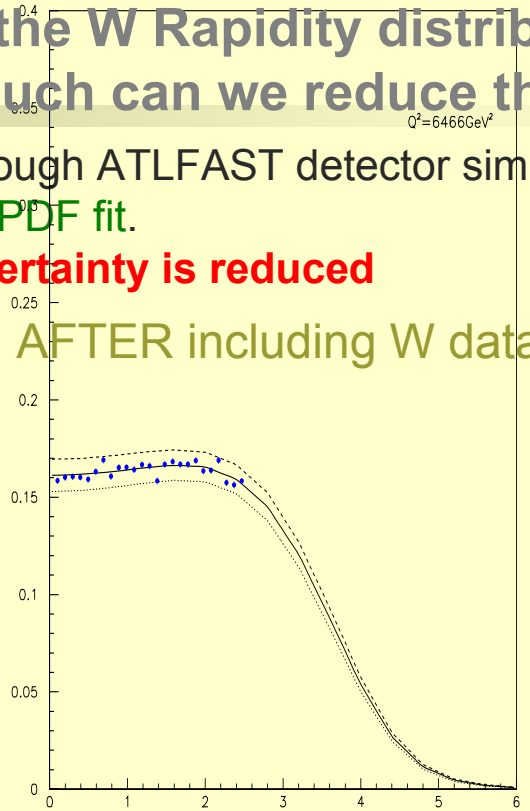
Central value of prediction shifts and uncertainty is reduced

BEFORE including W data



W^+ to lepton rapidity spectrum data generated with **CTEQ6.1 PDF** compared to *predictions* from **ZEUS PDF**

AFTER including W data



W^+ to lepton rapidity spectrum data generated with **CTEQ6.1 PDF** compared to *predictions* from **ZEUS PDF** AFTER these data are included in the fit

~1day of data-taking at low Lumi

Specifically the low-x gluon shape parameter λ, $xg(x) = x^{-\lambda}$, was $\lambda = -.187 \pm .046$ for the ZEUS PDF before including this pseudo-data. It becomes $\lambda = -.155 \pm .030$ after including the pseudo-data

Event Selection Criteria for $W^{+-} \rightarrow l^{+-} \nu_l$

(TDR selection cuts)

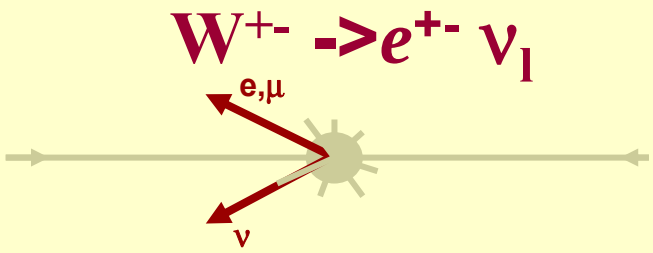
- **Electrons:** $|\eta| < 2.4$
  $Pt > 25$ GeV
- **Missing Et** > 25 GeV
- To *reject QCD bkg* & high Pt *W and Z* due to I.S.R. :

  No reconstructed **jets** in the event with $Pt > 30$ GeV

  Recoil on transverse plane should satisfy $|\vec{u}| < 20$ GeV

Background to $W^{+-} \rightarrow e^{+-} \nu_e$ with ATLFAST

Background Generation:

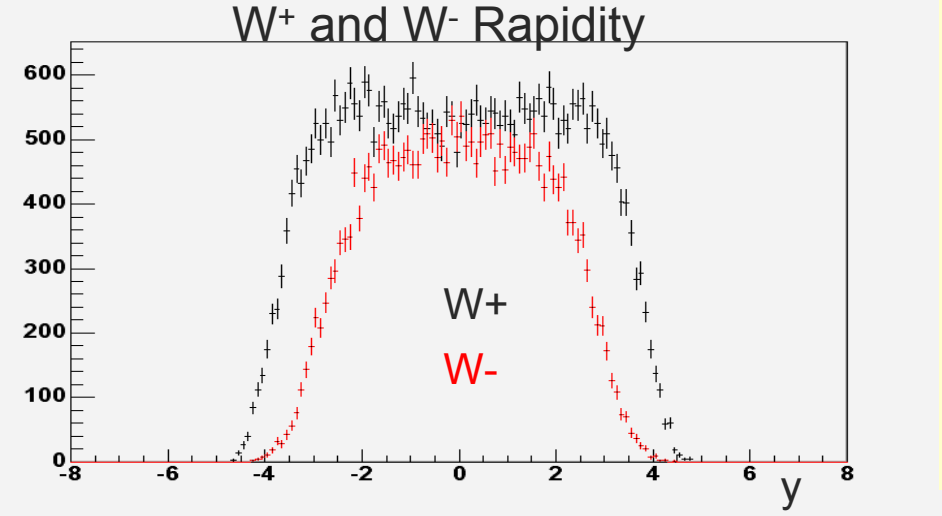


- 1M **W -> τν (-> eνν)** events
  with HERWIG + *CTEQ5L*
- 1M **Z -> $\tau^+\tau^-$ (-> $e^+ \nu\nu + e^- \nu\nu$)** events
  with HERWIG + *CTEQ5L*
- 1M **Z -> e^+e^-** events with HERWIG + *CTEQ5L*
- 600K **QCD** events with HERWIG + *CTEQ5L*:
  IPROC=1500
  all 2 -> 2 processes involving q,$\bar{q}$,g

  } Stat too little!!

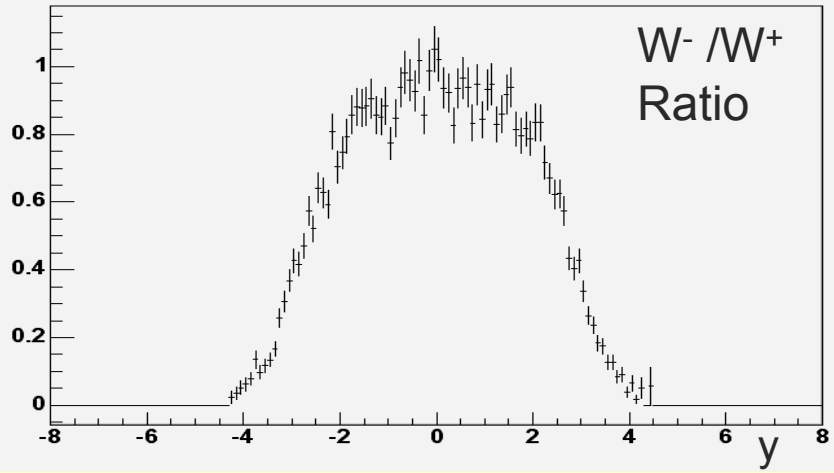
→ Also 1M **Signal** events: **W -> eν** with HERWIG + CTEQ6.1

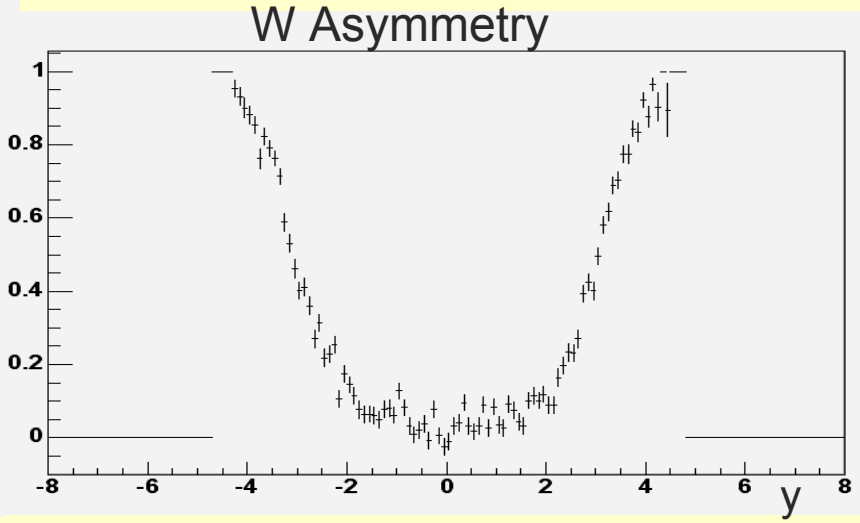
W^{+-} -> e^{+-} Full Simulation Generator Level for W's



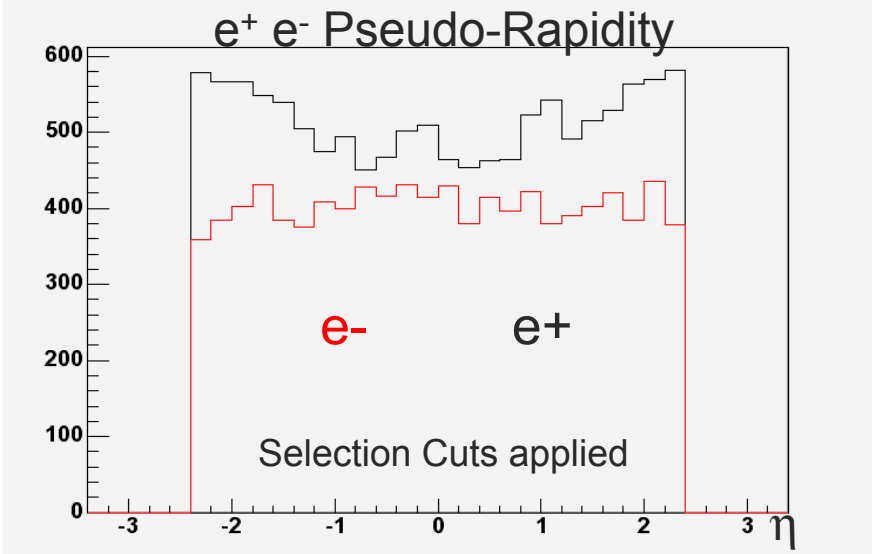
$$R_{\mp}(y_W) \equiv \frac{d\sigma / dy_W(W^-)}{d\sigma / dy_W(W+)}$$

$$A(y_W) \equiv \frac{d\sigma / dy_W(W^+) - d\sigma / dy_W(W^-)}{d\sigma / dy_W(W^+) + d\sigma / dy_W(W^-)}$$

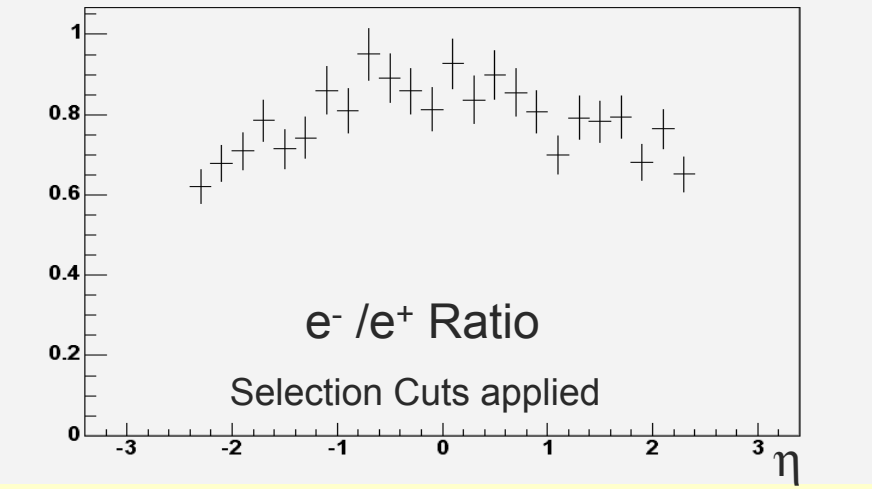


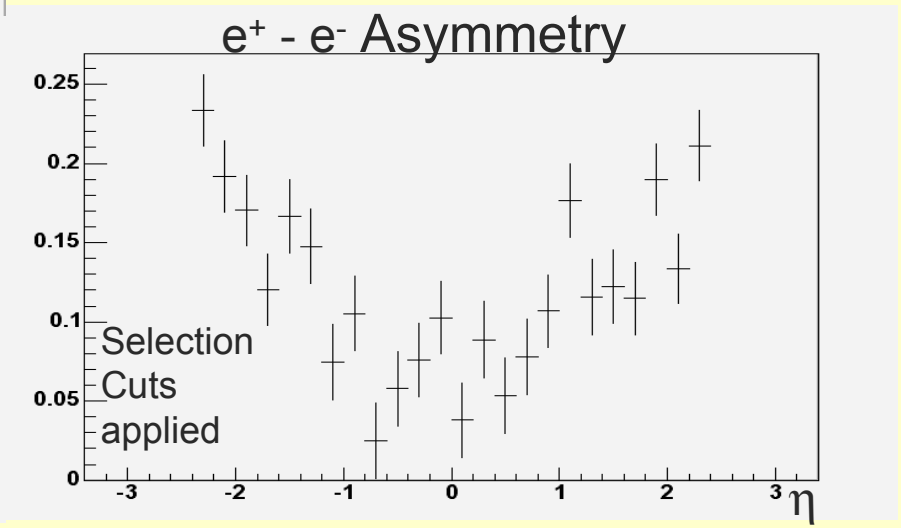


W^{+-} -> e^{+-} Full Simulation Generator level for e+ and e-

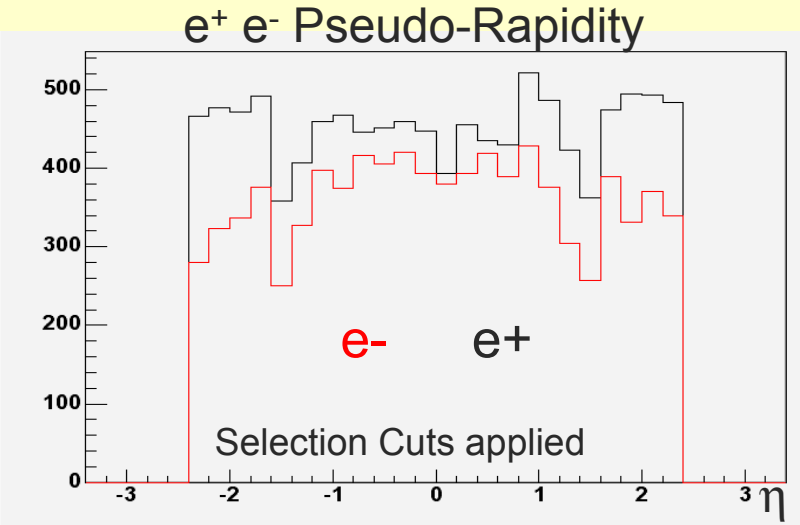


- TDR Selection Cuts:
  - Electrons: $|\eta| < 2.4$ $Pt > 25$ GeV
  - Neutrino $Pt > 25$ GeV
  - No reconstructed jets in the event with $Pt > 30$ GeV
  - Recoil on transverse plane $|u| < 20$ GeV

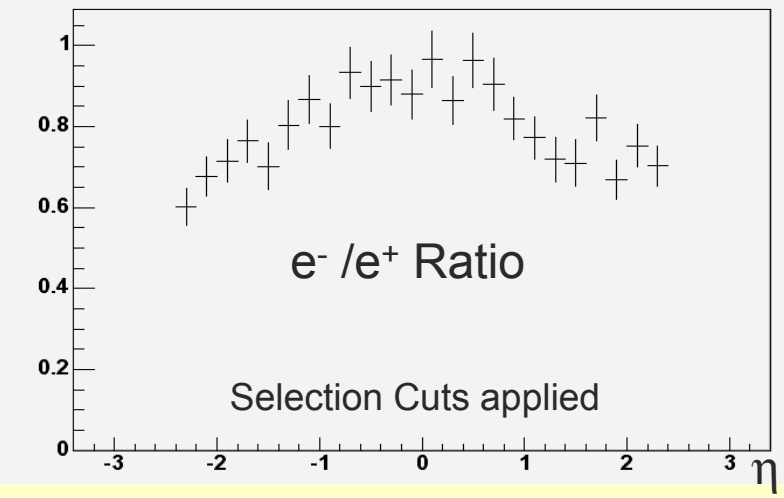


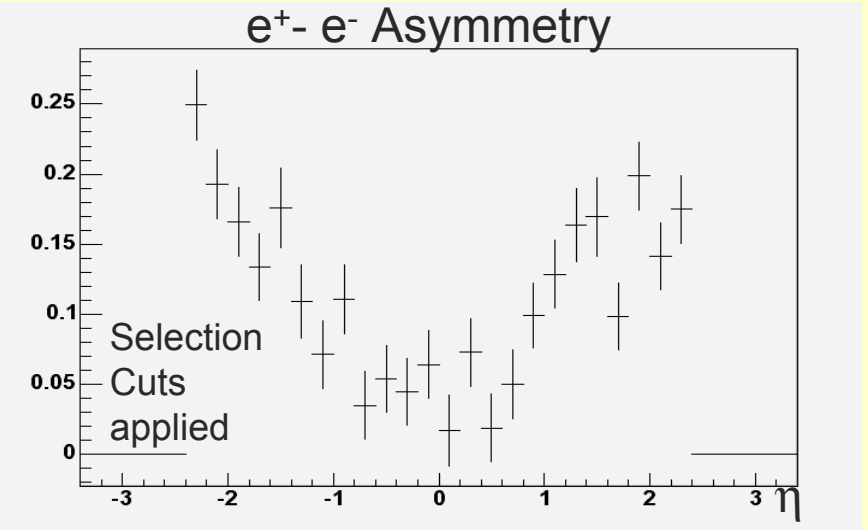


W^{+-} -> e^{+-} Full Simulation **Detector level**



- Standard Rome Electron Identification
- TDR Selection Cuts:
  - Electrons: $|\eta| < 2.4$ $Et > 25$ GeV
  - Missing $Et > 25$ GeV
  - No reconstructed jets in the event with $Pt > 30$ GeV
  - Recoil on transverse plane $|u| < 20$ GeV





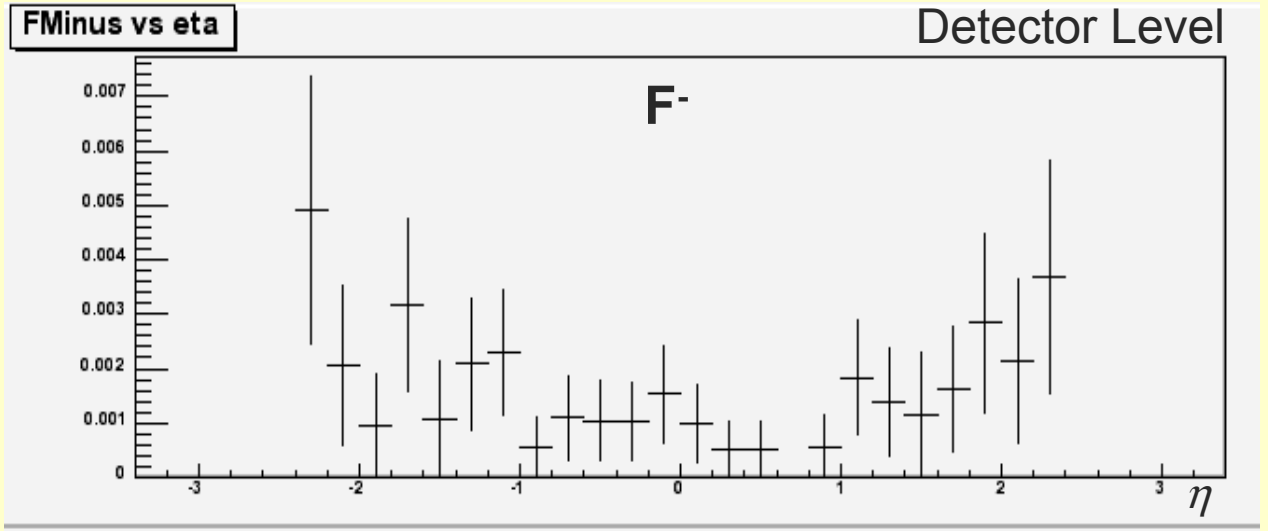
Systematic Uncertainties using Full Simulation: Charge Misidentification

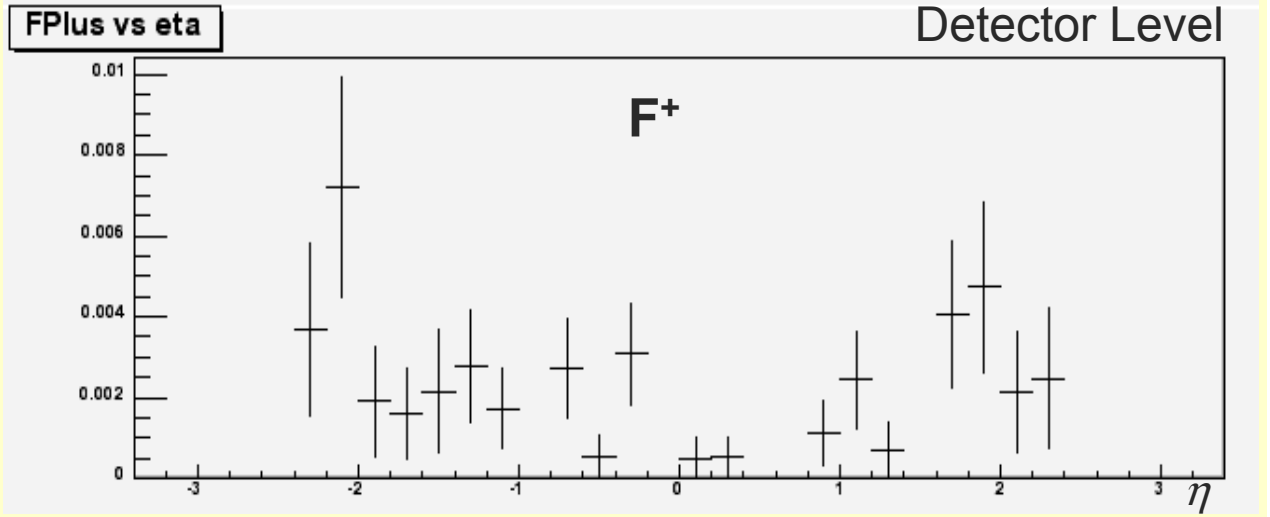
- **Charge Misidentification dilutes the Charge Asymmetry**
  - Correction:

$$A^{TRUE} \equiv \frac{A^{RAW} - F^- + F^+}{1 - F^- + F^+}$$

A^{RAW} = Measured Asymmetry
A^{TRUE} = Corrected Asymmetry
F^- = rate of *true* e^- misidentified as e^+
F^+ = rate of *true* e^+ misidentified as e^-

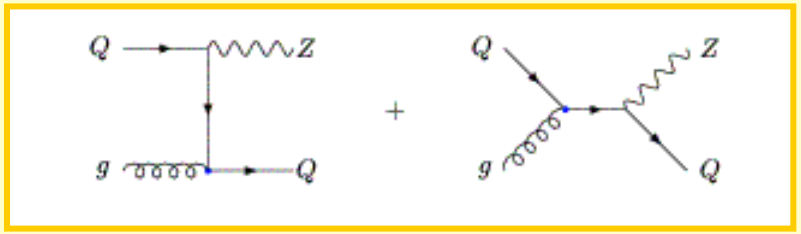
- **Use Z -> e+e-** sample from ATLAS Full Simulation Rome production ~98K events, Herwig+CTEQ5L **data-like analysis** (No use of MC-Truth)
  - **Mis-ID rate negligible?**



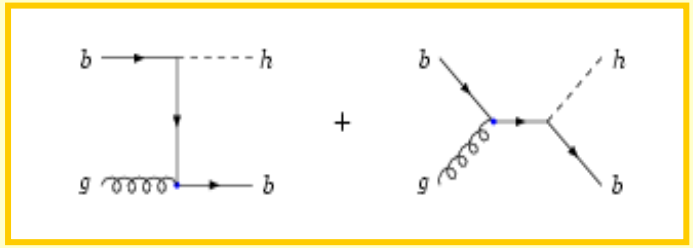


Motivations for Z+b study

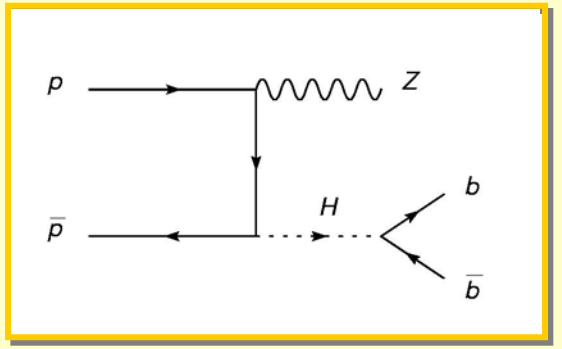
- Measurement of the b-quark PDF
  - Process sensitive to b content of the proton
    (J.Campbell et al. Phys.Rev.D69:074021,2004)



- Background to Higgs search
  - In models with enhanced σ(h+b) and BR(h->μμ)
    (J.Campbell et al. Phys.Rev.D67:095002,2003)

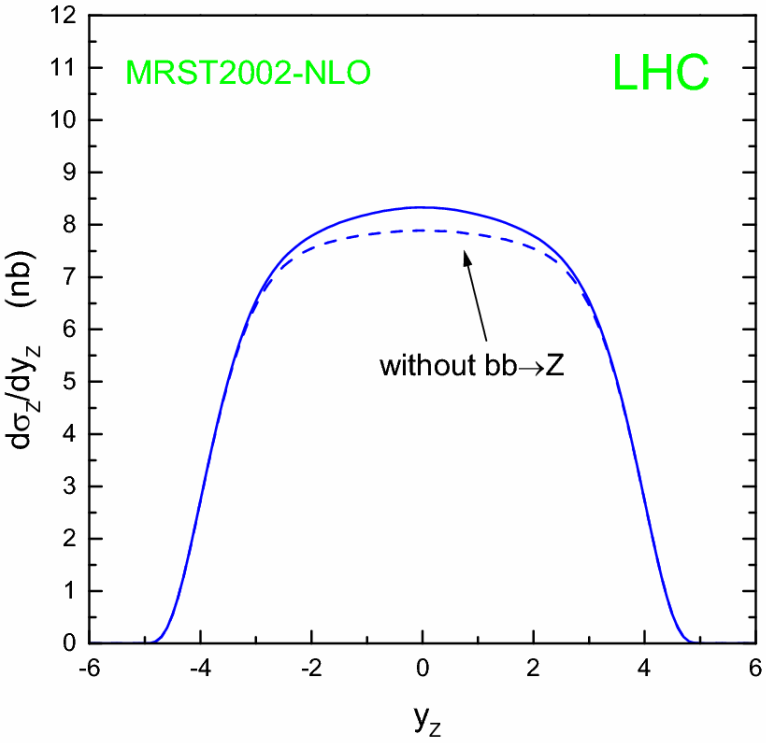


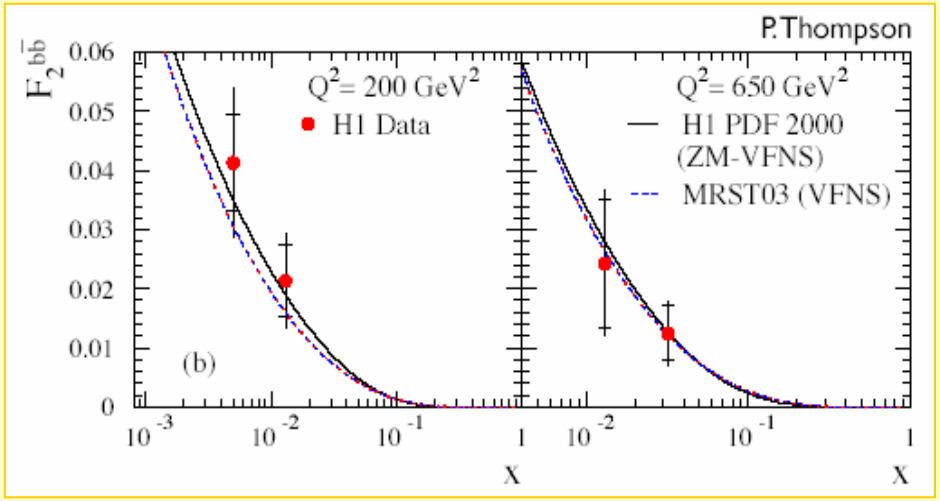
- Background to MS Higgs search
  - In models where pp → ZH con H → bb



Why do we measure the b PDF?

- bb->Z @ LHC is ~5% of entire Z production
- Knowing σ_Z to about 1% requires a b-pdf precision of the order of 20%





Now we have only HERA measurements, far from this precision

Z+b with different PDF sets

MRST5NLO, CTEQ5M1, Alehkin1000

(with LHAPDF in Herwig)

- Differences in total Z+b cross-section are of the order of 5%
- Some sensitivity from differential distributions: jet energy calibration crucial
- Other PDF sets predict larger differences

  (e.g., MRST5NNL0 >10%)