W boson cross section measurement with the ATLAS experiment at LHC

Silvia Franchino Universita` & INFN Pavia- Italy

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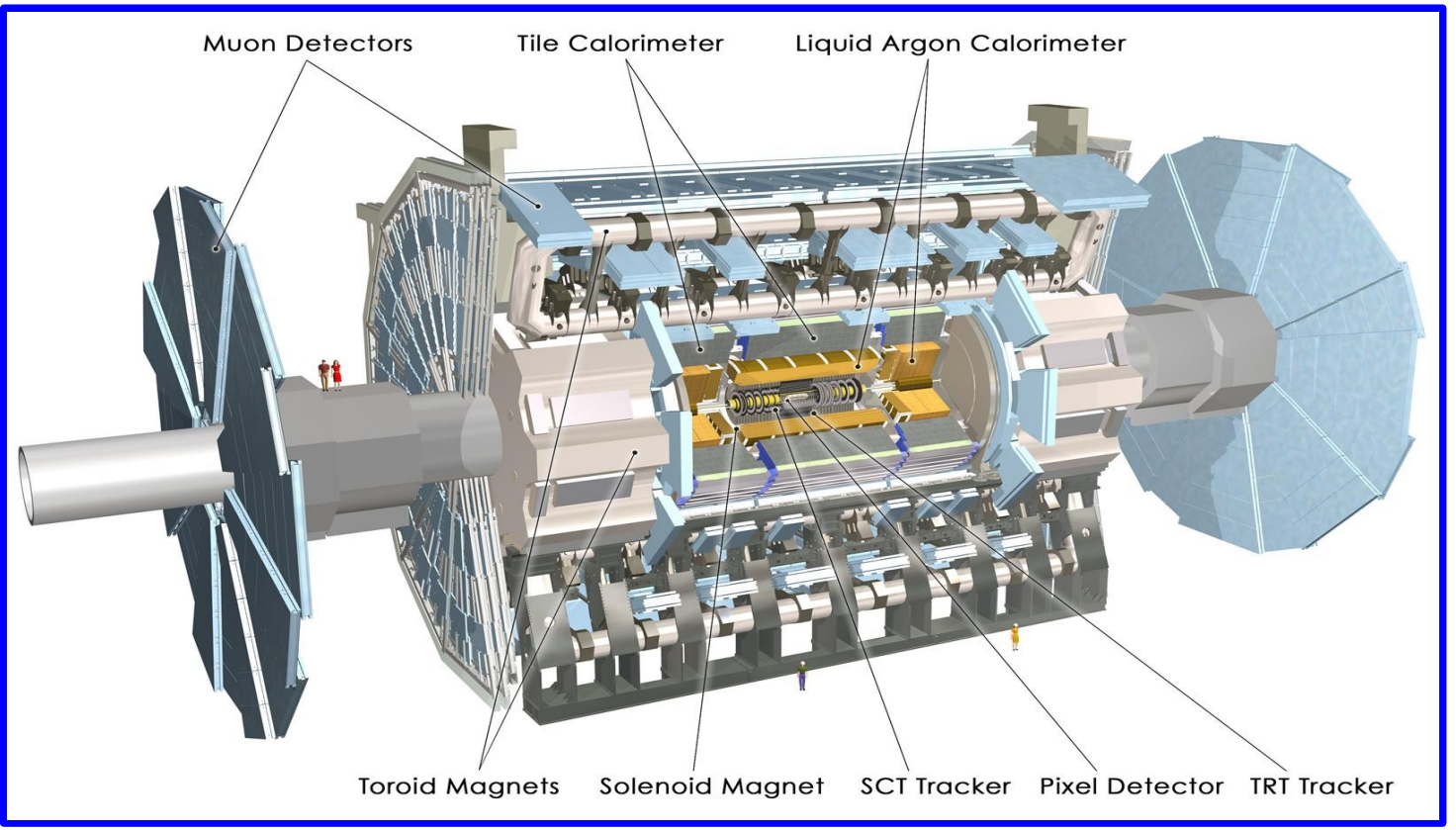
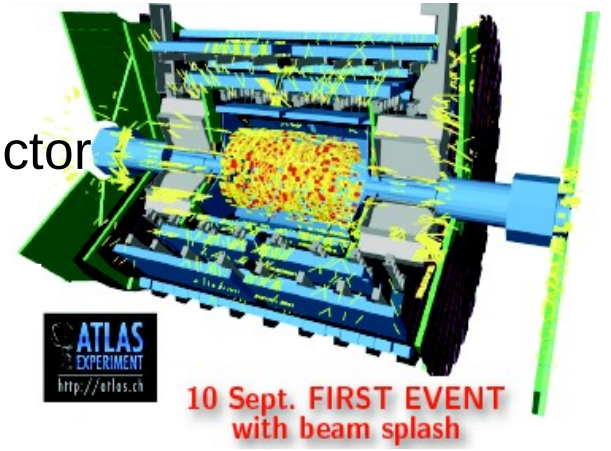
The ATLAS experiment



Detector is ready for data taking, waiting for LHC delivery of firsts collisions

- September 2008: First LHC “splash” events
- Since beginning 2008: cosmic rays commissioning, full detector
- Waiting for LHC collisions (November 2009)
- c.m.e. 7 TeV---> 10 TeV
- Data taking for full 2010 is foreseen



ATLAS early physics

Process	expected events in 100 pb^{-1} at 10 TeV (after cuts)
$J/\Psi \to ll$	$\sim 10^6$
$\Psi \to ll$	$\sim 5{\cdot}10^4$
$W \to l\nu$	$\sim 3{\cdot}10^5$
$Z \to ll$	$\sim 3{\cdot}10^4$
$t\bar{t} \to WbWb \to l\nu + X$	~ 350
Jet $p_T > 1$ TeV	~ 500
Gluinos, squarks m$\sim$ 1 TeV	~ 5

Goals in 2010

1) Commission and calibrate the detector in situ using well-known physics samples
   e.g. - Z → ee, μμ tracker, ECAL, Muon chamber calibration and alignment, etc.
   - tt → blν bjj jet scale from W → jj, b-tag performance, etc.

2) "Rediscover" and measure Standard Model at $\sqrt{s}$ ~ 10 TeV: W, Z, tt, QCD jets …
   (also because omnipresent backgrounds to New Physics)

3) Early discoveries ? Potentially accessible: Z', SUSY, …. surprises ?

W,Z inclusive cross section measure

$$\sigma_{V\to ll} = \frac{(N_{obs} - N_{bkg})}{\int \mathcal{L}dt \cdot A \cdot \epsilon}$$

★ N_{obs} = number of measured events

★ N_{bkg} = background events in the candidate W sample (estimated from MC)

★ $\int \mathcal{L}dt$ = integrated luminosity (depends from LHC, initial uncertainty 10-20%)

★ ε = trigger and reconstruction efficiency (estimated from data)

★ A = acceptance for experimental selections (estimated from MC)

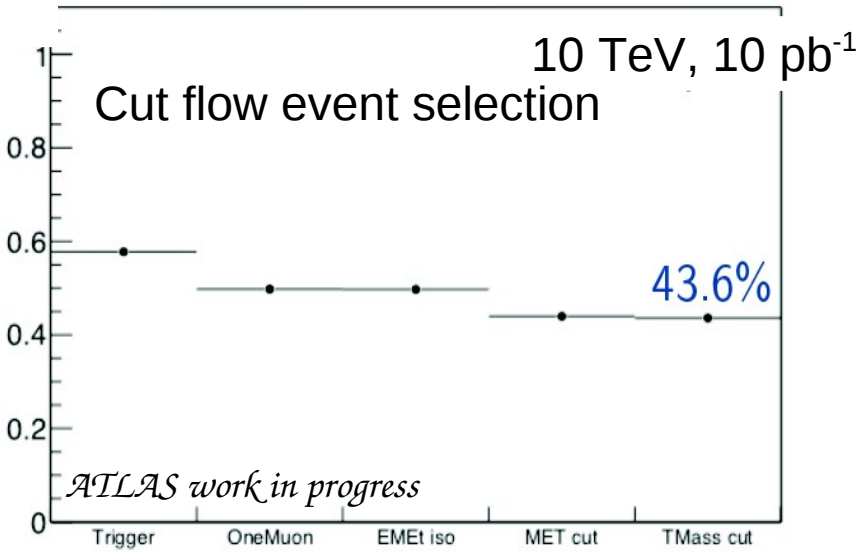
The inclusive W,Z cross sections will be one of the first LHC measurements

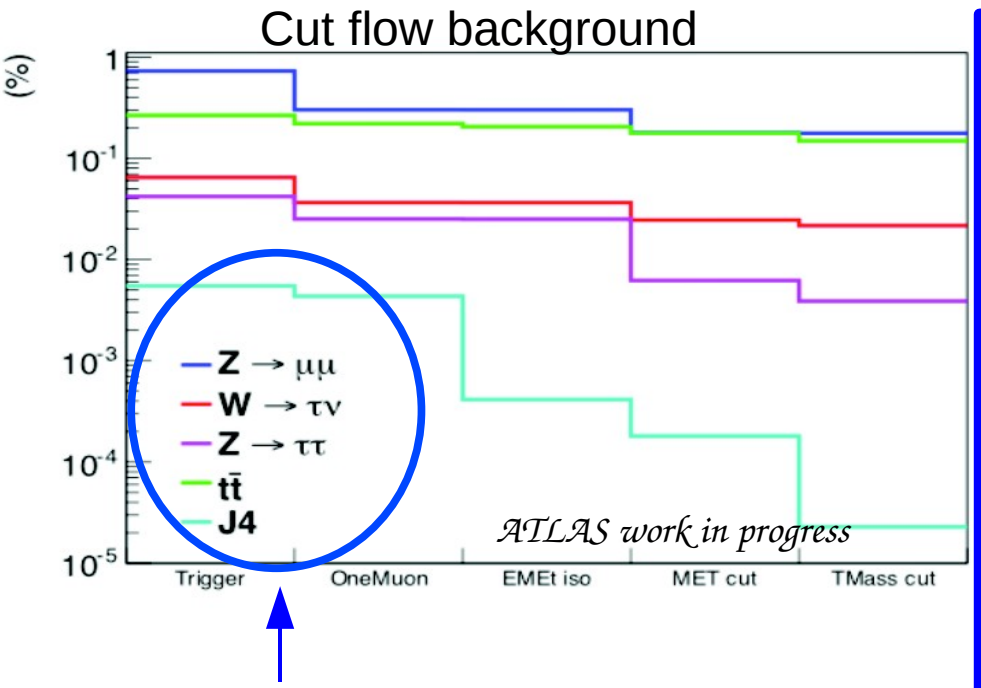
- Cross section ratio σ(W)/σ(Z) indirect measurement of Γ(W)
- With higher integrated luminosity, taking theoretical prediction as input, possible use for collider luminosity monitor and PDF's constraint analysis

Event-background estimation

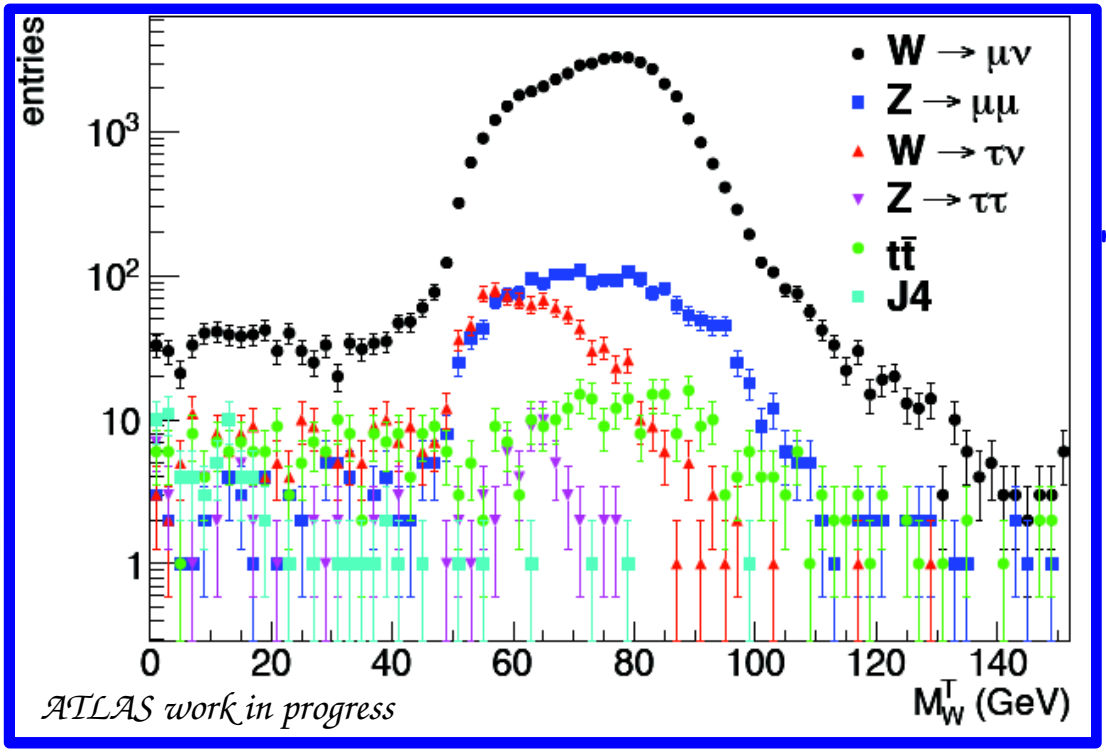
W--> μν selection

Acceptance	at least one muon within $\|\eta\| < 2.8$ and $p_T > 5$ GeV
Trigger	mu20 EF trigger selection
OneMuon	at least one muon (Staco) within $\|\eta\| < 2.5$ and $p_T > 25$ GeV
Isolation	EM isolation within a 0.4 cone ($\Sigma p_T < 5$ GeV)
MET	$E_T^{miss} > 25$ GeV
WTMass	$M_T > 40$ GeV



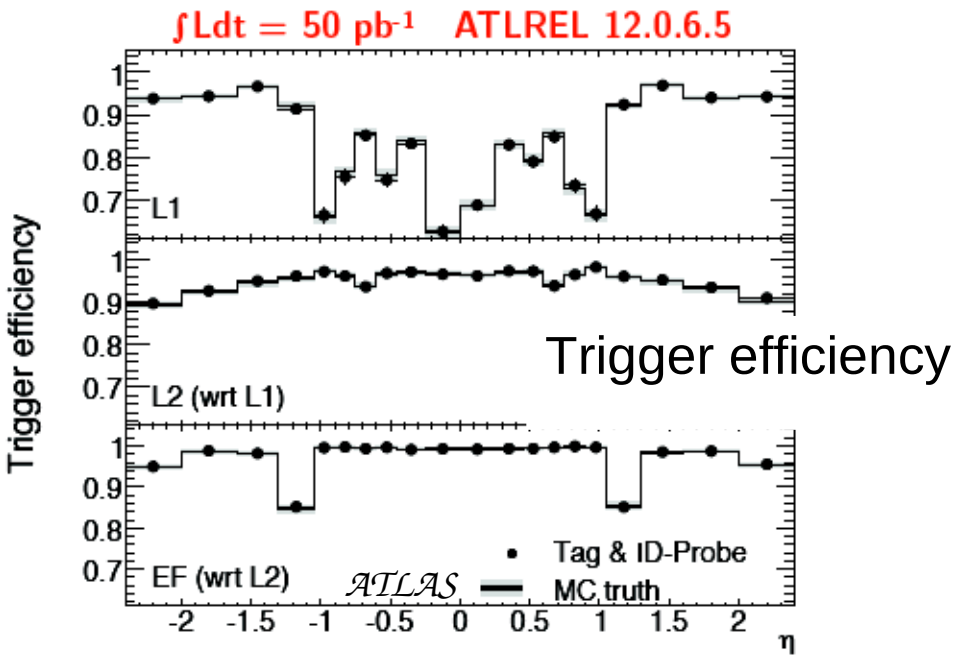


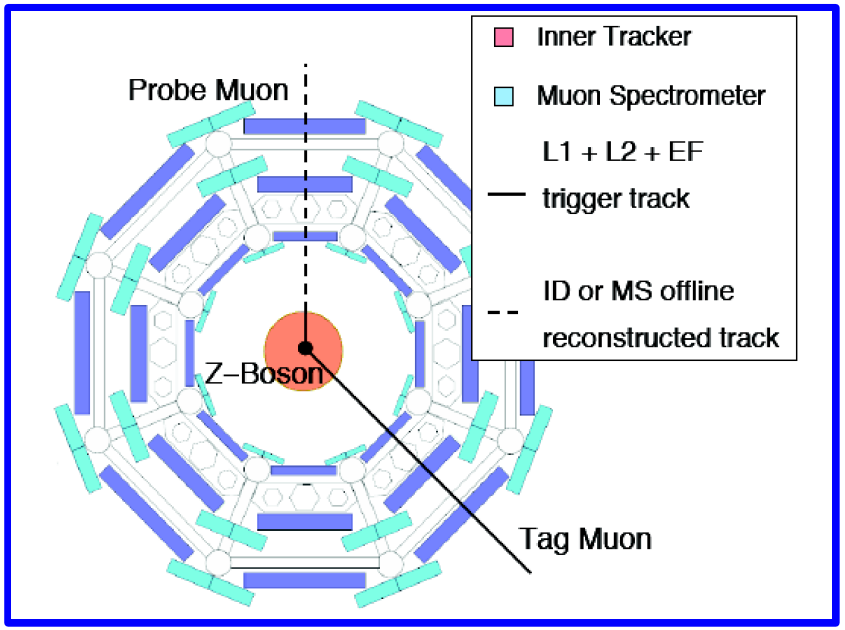
Main background

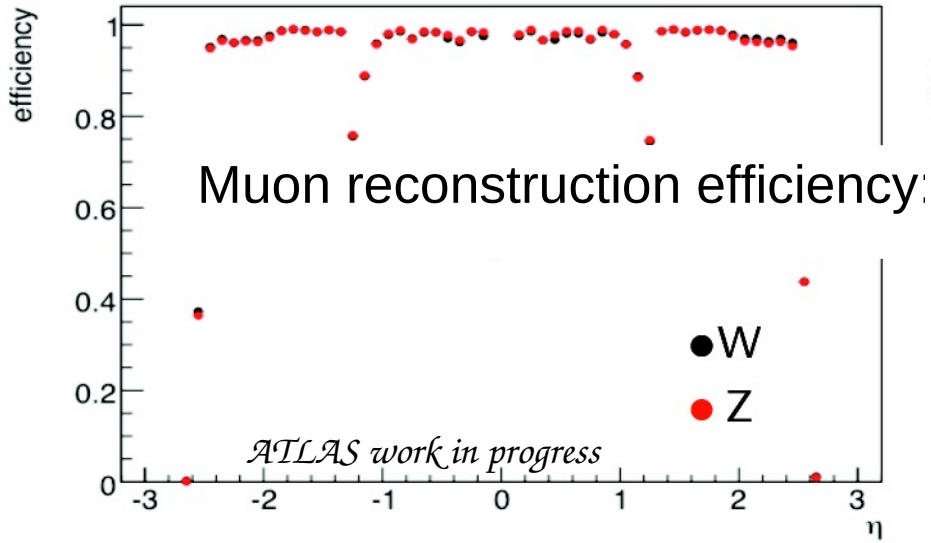


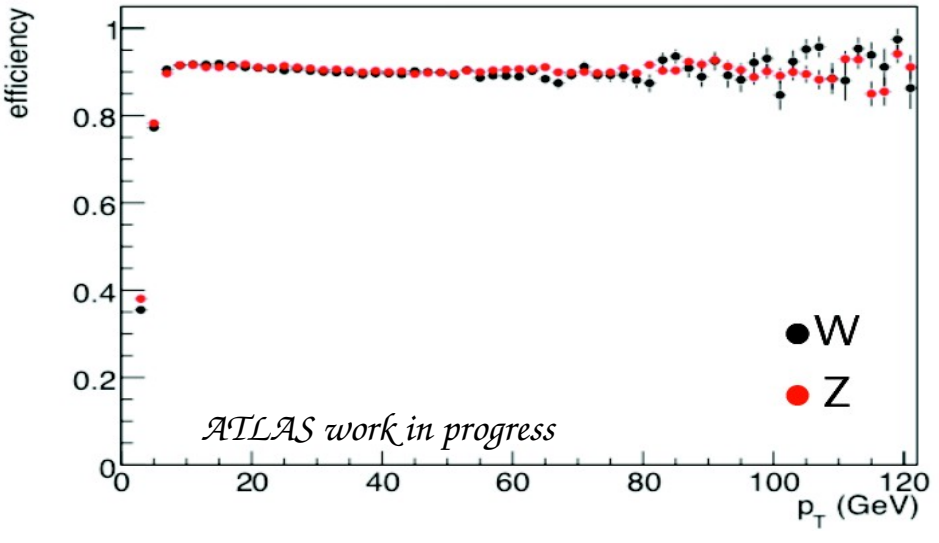
Efficiency

Includes the trigger selection efficiency and the one of offline reconstruction;
Calculated from data (Z--> μμ samples) with the ***tag & probe method***



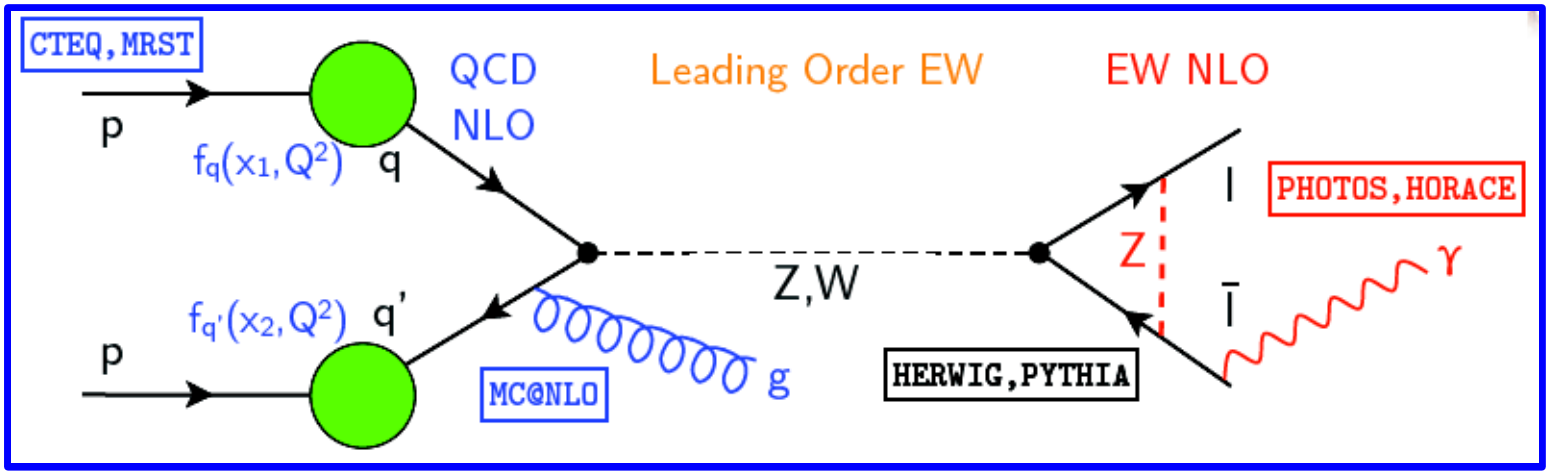






Acceptances

Fraction of events satisfying the geometrical and kinematic detector constraints
Calculated from MC generators



- Elementary interaction simulated through various MC generators: matrix element, parton showers, hadronization code, ...

★ ***LO*** Pythia, Hervig (Jimmy for u.e.) + parton showers QCD, QED (PHOTOS), EW (HORACE)
★ ***NLO*** QCD (MC@NLO), EW (HORACE)
★ ***PDF***'s matching with Matrix Element generators (CTEQ, MRST in LO or NLO calculations)

Test differences in acceptances varying MC to verify the detector sensitivity.

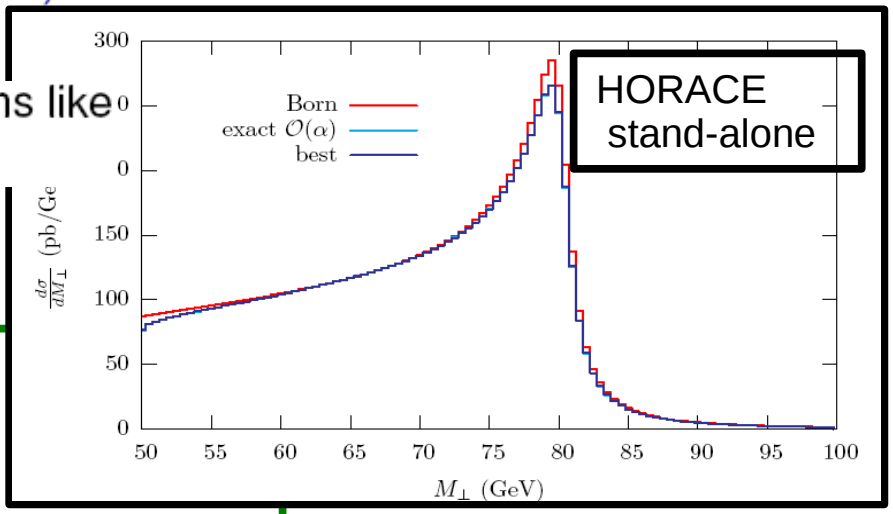
- Needed also a detailed simulation of the detector response to such events

NLO electroweak corrections (1)

HORACE (Higher Order RAdiative CorrEctions) MC event generator implementing EW corrections to DrellYan processes (C.M. Carloni Calame, G. Montagna, O. Nicrosini, A. Vicini, JHEP 0710:109,2007 & incl.ref.)

- ⋆ exact $\mathcal{O}(\alpha)$ RC, consistently matched with
- ⋆ multi-photon radiation (h.o. QED corrections)
- ⋆ and including photon-induced processes

easy interface to QCD showering & hadronization programs like **HERWIG** and **PYTHIA**



In this analysis:
HORACE NLO EW corrections
+ HERWIG parton shower
in the ATLAS Athena framework (c.m.e. 10 TeV)

- Evaluation of EW effects at the generator level (in part covered by QCD HERWIG PS)
- Then simulation of events through ATLAS detector (ATLFAST II)
- The goal is the evaluation of EW effects after smearing and intrinsic cuts of the detector

Horace + HERWIG --> Corrections of ~%
Is this % effect still visible after reconstruction ?

NLO electroweak corrections (2)

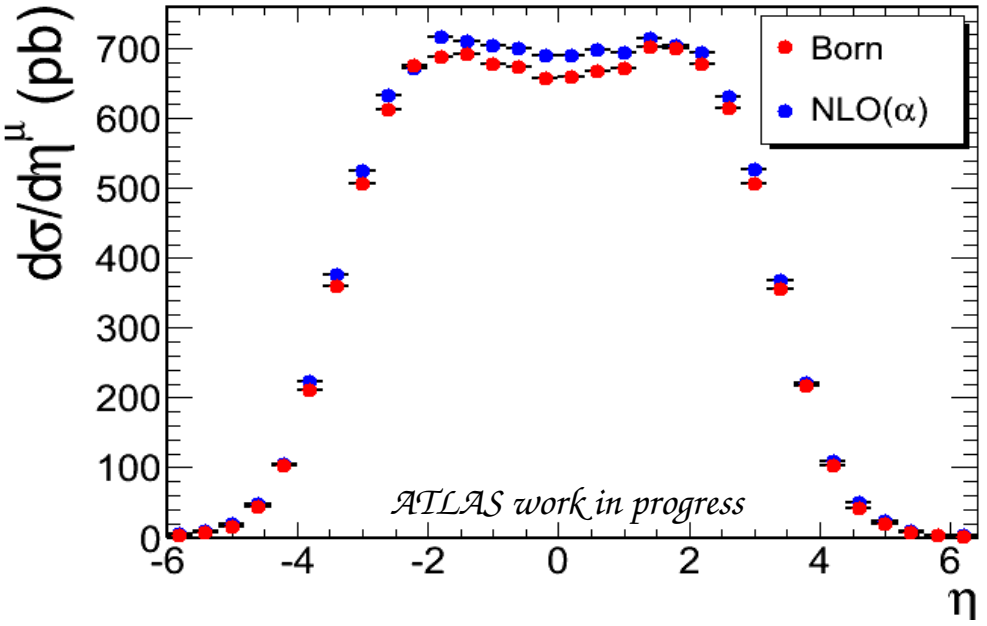
To evaluate the effects of EW correction comparison between

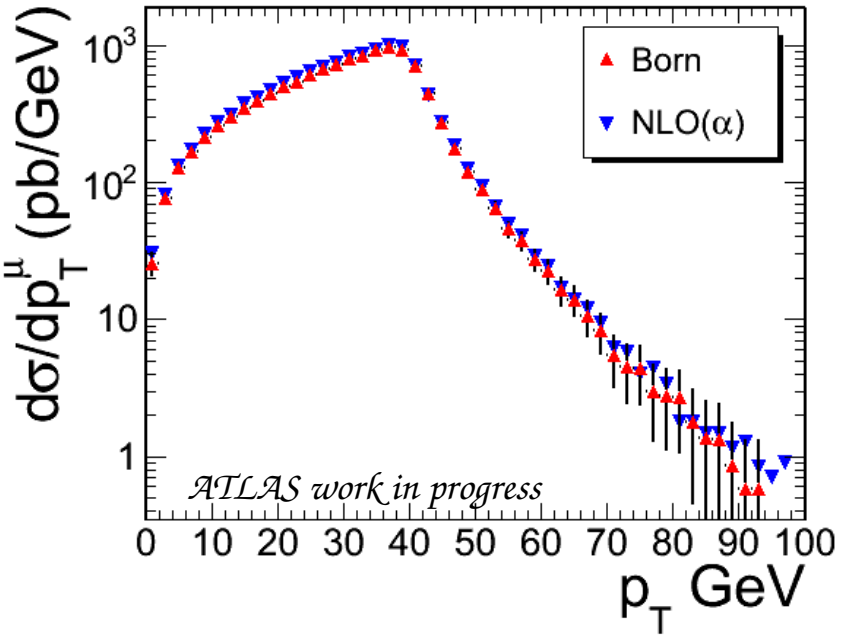
Horace-BORN+ HERWIG PS σ(W->μν)=**11800 pb**

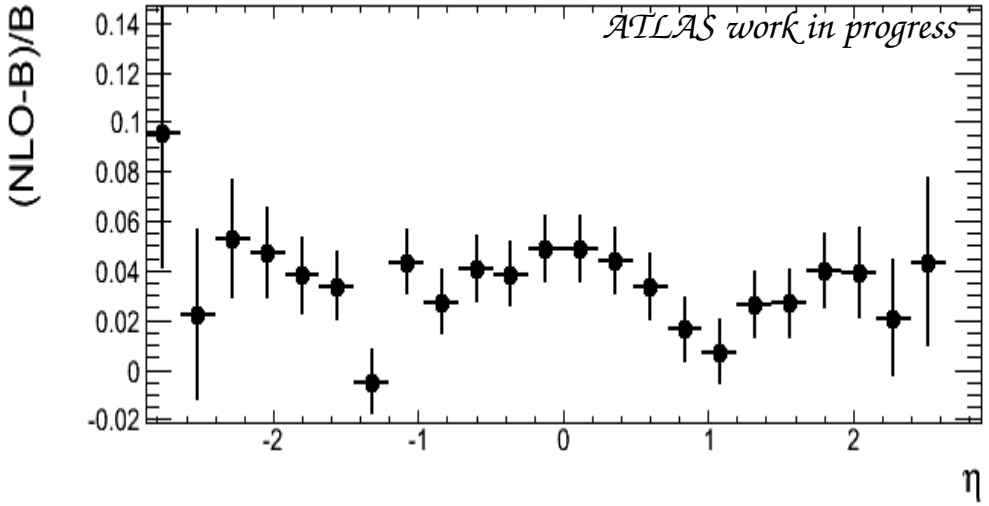
Horace-NLO(α)+ HERWIG PS σ(W->μν)=**12300 pb**

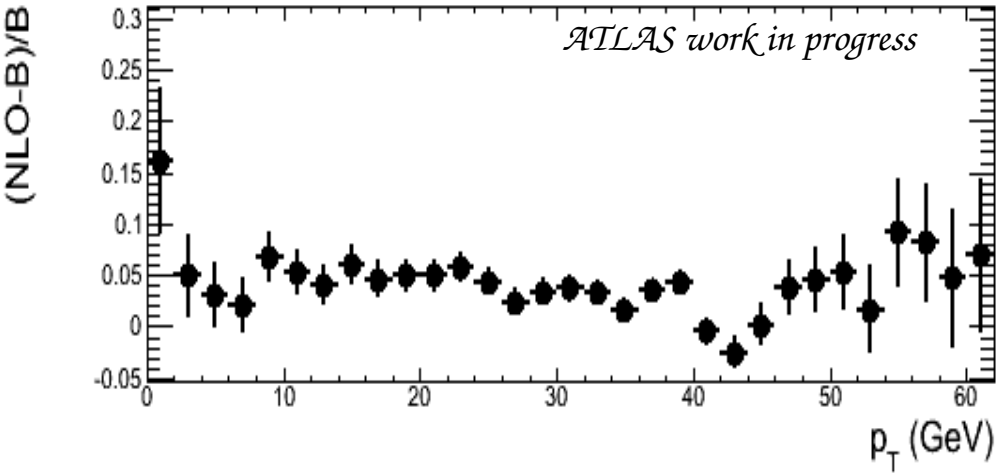
~4 %

Full inclusive pseudorapidity and tranverse momentum distributions of muons (evgen)





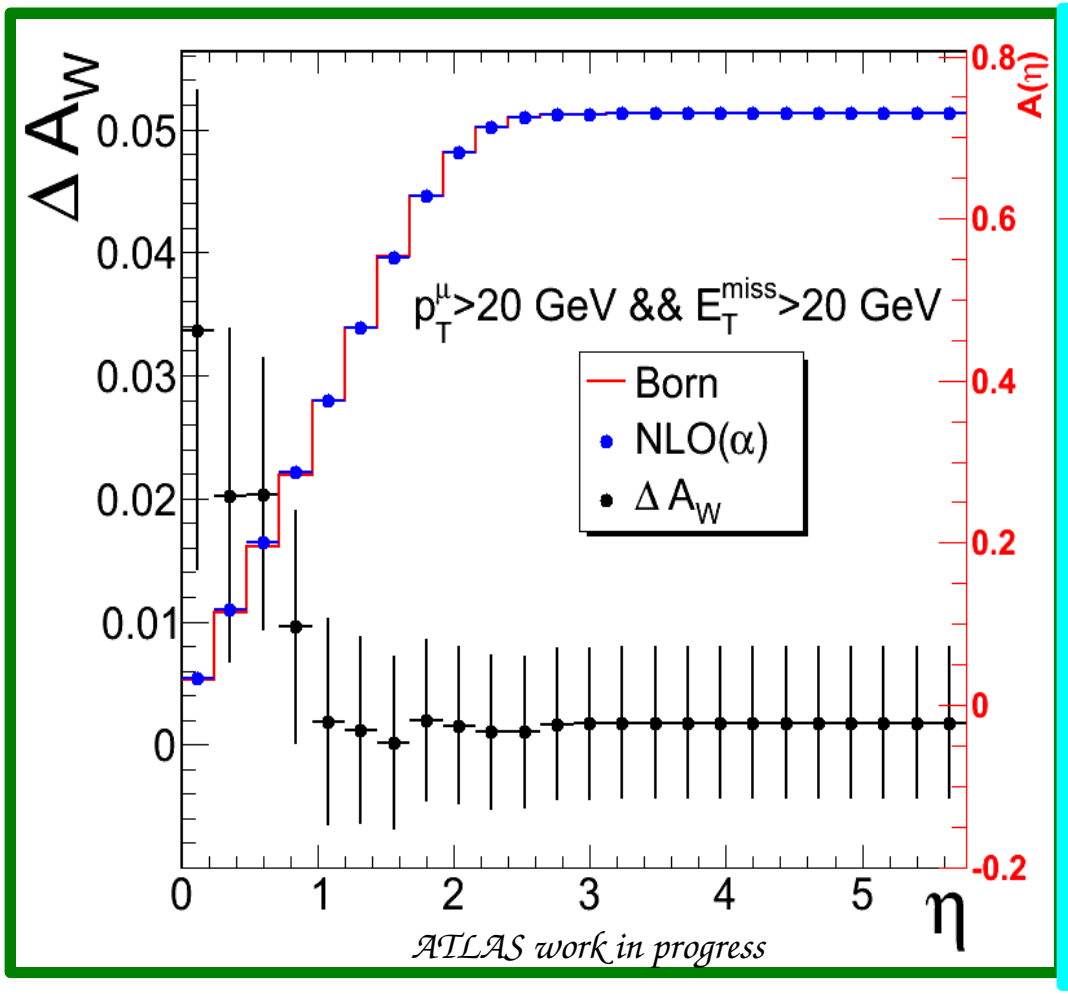


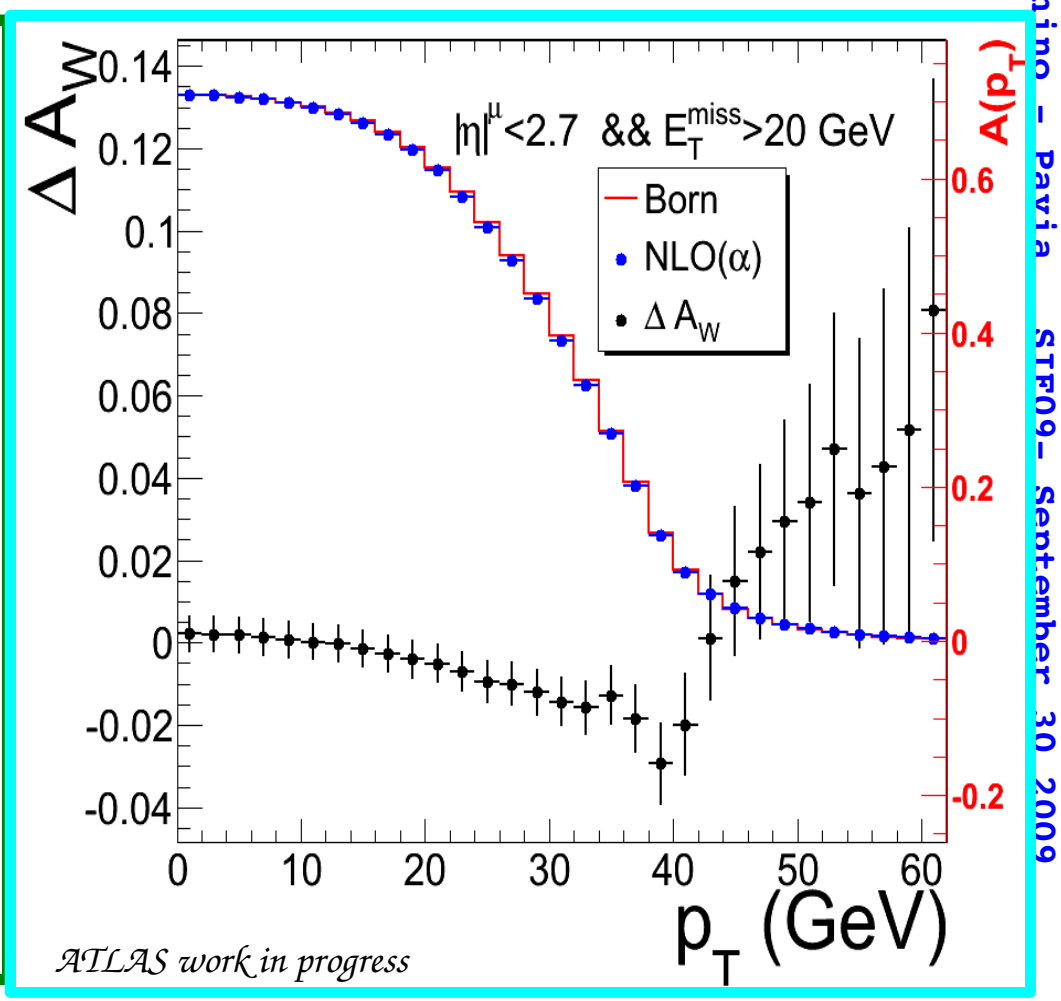


EW effects on acceptances

$$A_W(\eta_W(max)) = \frac{1}{\sigma_{tot}} \int_0^{\eta_\mu(max)} d|\eta_\mu| \frac{d\sigma}{d|\eta_\mu|}$$

$$A_W(p_W^T(min)) = \frac{1}{\sigma_{tot}} \int_{p_\mu^T(min)}^{\sqrt{s}/2} dp_\mu^T \frac{d\sigma}{dp_\mu^T}$$



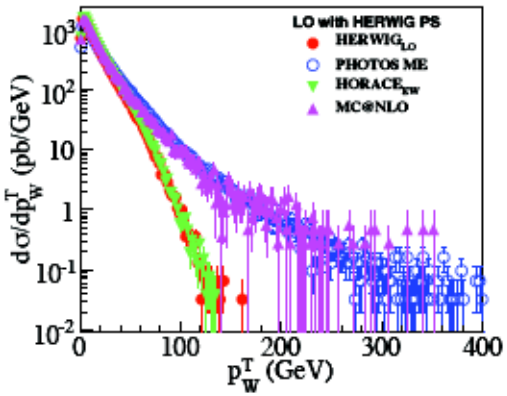


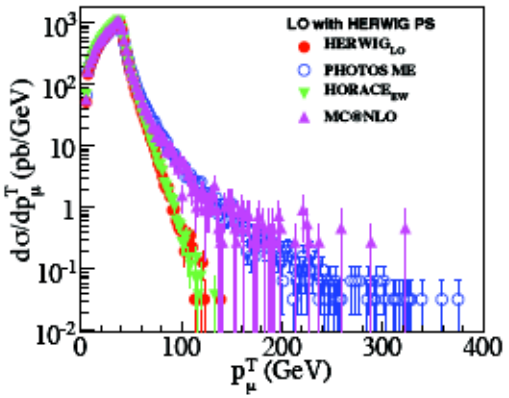
Conclusions

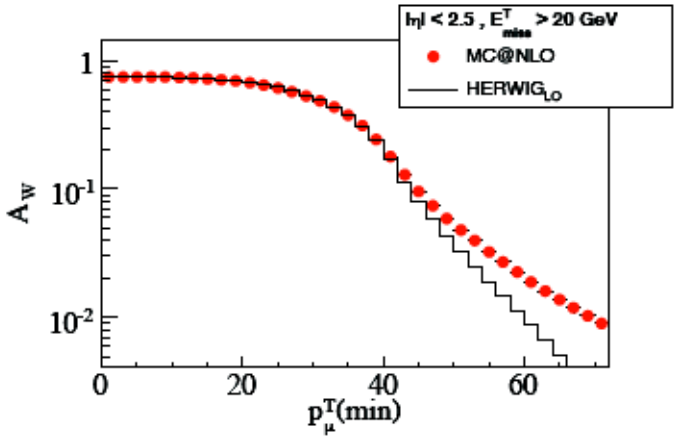
- LHC should start at the end of the year.
- W/Z physics will be used as “standard candle” in order to calibrate and understand and calibrate the detector (first pb^{-1}).
- Inclusive W/Z cross section measurements will be among the first analyses.
- The ultimate goal is to measure W cross section to a few %.
- To this end it's very important to understand systematic errors.
- Kinematic and geometrical acceptances are evaluated from MC. It is crucial to evaluate the best theoretical model that describes the interactions.
- NLO -EW effects contribute up to 5%. They have to be included.
- Horace (NLO EW effects) event generator has been used.
- Work still in progress on the evaluation of detector simulation of EW corrections.

ADDITIONAL SLIDES

- Acceptance corrections due to geometrical coverage of detector and trigger system
  - ★ Comparisons of MC@NLO, Photos and Horace generators with Herwig parton shower
  - ★ A quantitative estimation is ongoing







- Transverse momentum and pseudo-rapidity cumulative curves
  - ★ LO and NLO comparisons
  - ★ QCD corrections effect up to 2%
  - ★ lower impact from EW corrections (<1%)
  - ★ need to estimate impact of mixed EW-QCD NLO corrections

- Measurements of Electroweak observables
  - ★ **W,Z cross sections**
  - ★ **W mass** and width, $\sin^2\theta_{eff}$, A_{FB}
  - ★ W charge asymmetry $A(\eta_l)$ and differential cross sections
  - ★ Di-Boson productions
  - ★ to search for new physics looking at high invariant mass tail, ...

- Single W/Z boson production is a clean processes with large cross section useful also for
  - ★ **"Standard candle" for detector calibration/understanding**
  - ★ **constrain PDFs** looking at σ_{TOT}, W rapidity, ...
  - ★ monitor collider luminosity