PROCEEDINGS OF SCIENCE

$J/\psi \to \mu^+\mu^-$ from 7 TeV pp collisions in ATLAS: performance with first data

Andreas Korn* **for the ATLAS Collaboration**
Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720, USA
E-mail: Andreas.Korn@cern.ch

Starting early 2010 the Large Hadron Collider (LHC) has been colliding protons on protons at a center of mass energy of 7 TeV. These first 7 TeV collisions have been recorded by the ATLAS experiment, which is currently rediscovering the Standard Model processes. Among the particles produced are well known di-muon resonances like the J/ψ, the $\psi(2S)$ and the Υ family, which are standard candles that play an important role in detector commissioning and calibration. The observation of these resonances with the ATLAS experiment and first results on the performance of the ATLAS detector are reported here. The results indicate, that ATLAS is performing well. Within the available statistics no significant deviations of the reconstructed mass positions have been found and the observed resolutions are within expectations and well modeled by the detector simulation.

35th International Conference of High Energy Physics - ICHEP2010,
July 22-28, 2010
Paris France

*Speaker.

 http://pos.sissa.it/

PoS(ICHEP 2010)249

1. Introduction

The ATLAS detector is a general purpose experiment at the LHC designed to look for physics beyond the Standard Model. Before ATLAS can embark on searches for New Physics, the detector performance and Standard Model backgrounds have to be understood.

Narrow resonances, with well known mass positions, play an important role in detector commissioning. Di-muon resonances, like the J/ψ, the $\psi(2S)$ and the Υ family are examples of such "‘standard candles"’. The reconstruction of $J/\psi \to \mu^+\mu^-$ decays forms also an important corner stone of the ATLAS B-physics program and the first results have been reported at this conference [1]. These proceedings will concentrate on performance measurements.

2. The ATLAS Detector

The ATLAS detector has been described in detail elsewhere [2]. Here only a brief overview of those detector subsystems important to the di-muon analysis presented is given. Muon reconstruction in ATLAS relies on the Muon System (MS) and the Inner Detector (ID). The combined muon reconstruction matches and refits fully reconstructed track segments in both subsystem. A second algorithm tags ID tracks as muons by matching them to partially reconstructed muon segments.

The MS is located inside toroidal magnets with an average field of 0.5 T. It uses barrel layers of Resistive Plate Chambers and Thin Gap Chambers in the forward region to provide fast trigger information. Precision chambers of Monitored Drift Tubes and Cathode Strip Chambers are used to measure the momentum of the passing muon. The Muon System provides an excellent momentum resolution of $\sim 10\%$ at 1 TeV. Below 100 GeV the momentum measurement is dominated by the ID and the ID track parameters are used for the results presented. The expected ID momentum resolution can be parametrised as $\frac{\sigma_{pT}}{p_T} \sim 0.04\% p_T[\mathrm{GeV}] \bigoplus 1.5\%$ The ID is situated inside a 2 T magnetic field and composed of 3 tracking technologies: the Transition Radiation Tracker (TRT), the SemiConductor Tracker (SCT) and closest to the interaction point the Pixel Detector. The ID Barrel consists of 73 layers of TRT straw tubes, 4 double layers of silicon strips in the SCT and 3 pixel layers. Each of the two endcaps is made of 20 TRT wheels, with 8 straw layers each, followed by 9 SCT and 3 Pixel disks.

The events presented here have been collected with two different triggers. Early data were taken using the Minimum Bias Trigger Scintillators (MBTS) at the lowest trigger level. The MBTS planes are located perpendicular to the beam axis ± 3560 mm away from the interaction point and cover the pseudorapidity range $2.82 < |\eta| < 3.84$ and $2.09 < |\eta| < 2.82$. Later a single muon trigger was deployed, that uses coincidences in the fast muon trigger layers.

3. J/ψ reconstruction and performance

This analysis is based on an integrated luminosity of 78 nb^{-1}. Muons are required to have a total momentum of $p > 3$ GeV in order to reach the muon chambers. To ensure good track quality only tracks with at least 1 pixel and 6 SCT hits are kept. Di-muon candidates are formed using both tagged and combined muons. The candidates are refit to a common vertex.

The reconstructed mass position and resolution are extracted from an unbinned maximum likelihood fit to the resulting mass distribution. The fit uses a Gaussian to model the signal and a linear function to describe the background. The J/ψ is a narrow resonance and the reconstructed width is dominated by detector resolution. The best mass resolution of $\sigma = 34 \pm 1_{(stat.)}$ MeV is achieved in the barrel region ($|\eta| < 1.05$). As shown in Fig. 1 and 2 this resolution degrades in the forward region to $\sigma = 79 \pm 2_{(stat.)}$ MeV. The mass is determined to $3095 \pm 1_{(stat.)}$ MeV, which is in agreement with the world average. The reconstructed mass position is sensitive to energy loss, alignment and the overall B-field scale. Within the statistics used for this analysis no deviations of the mass position have been found.

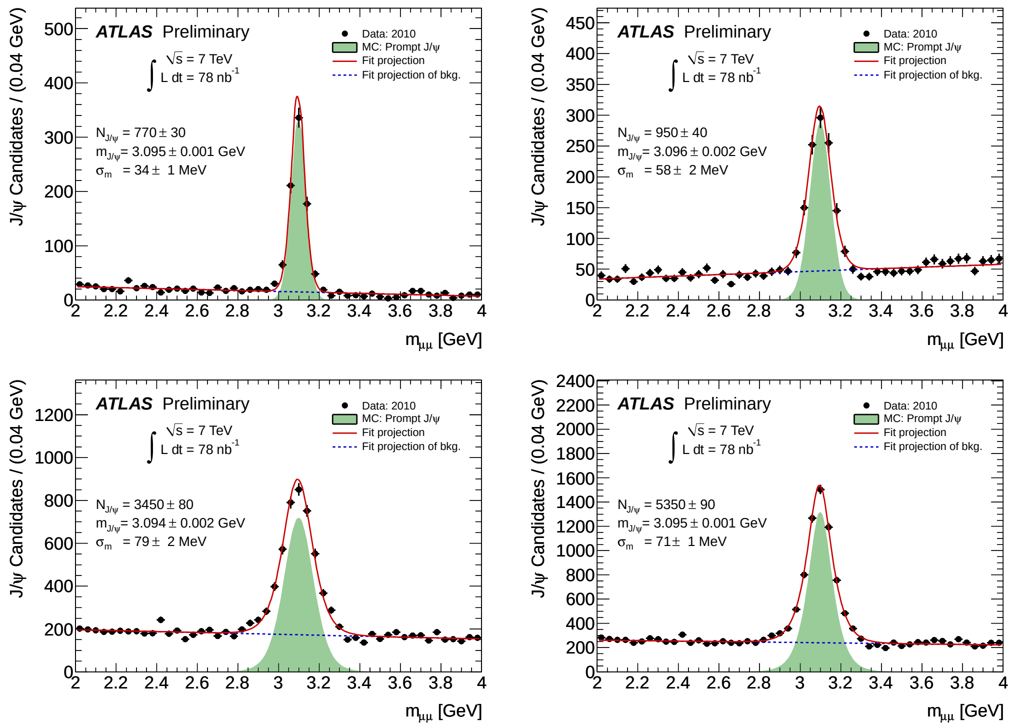

Figure 1: Invariant mass of $J/\psi \to \mu\mu$ candidates in three muon pseudorapidity categories: both muons in the barrel ($|\eta| < 1.05$) (*top left*), one muon in the barrel, second in the endcap ($1.05 < |\eta| < 2.5$)(*top right*), both muons in the endcap (*bottom left*) and all candidates (*bottom right*). The solid lines illustrate the results of the unbinned maximum likelihood fit to all di-muon pairs in the mass window 2–4 GeV, the dashed lines are the result for background only in the same fit. The solid area in each case represents the Monte Carlo prediction, from prompt J/ψ only. Uncertainties shown, are statistical only.

4. Other di-muon resonances

The J/ψ meson provides a high statistics sample to map out the detector, but produces as decay products predominantly muons with lower momentum. Higher mass resonances like the $\psi(2S)$ and the Υ family, but also the Z, can be used to extend the momentum reach.

The signal to background ratio is less favorable in the case of the $\psi(2S)$ and Υ. Di-muon candidates are required to have at least one combined muon. A cut on the transverse momentum of $p_T > 4$ GeV was placed on the leading muon and $p_T > 2.5$ GeV was required for the second muon.

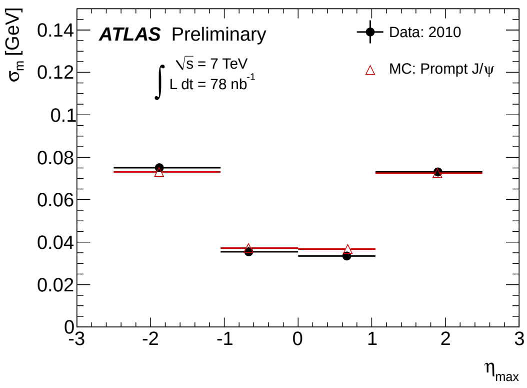

Figure 2: Mass resolution of $J/\psi \rightarrow \mu\mu$ candidates versus the maximum pseudorapity probed.

The resulting mass distributions are shown Fig. 3, using an integrated luminosity of 290 nb^{-1} for the $\psi(2S)$ and the full available 2010 data sample of 41 pb^{-1} for the Υ . The $\psi(2S)$ mass is reconstructed as $3686 \pm 6_{(stat.)}$ MeV. The reconstructed masses are consistent with the world average.

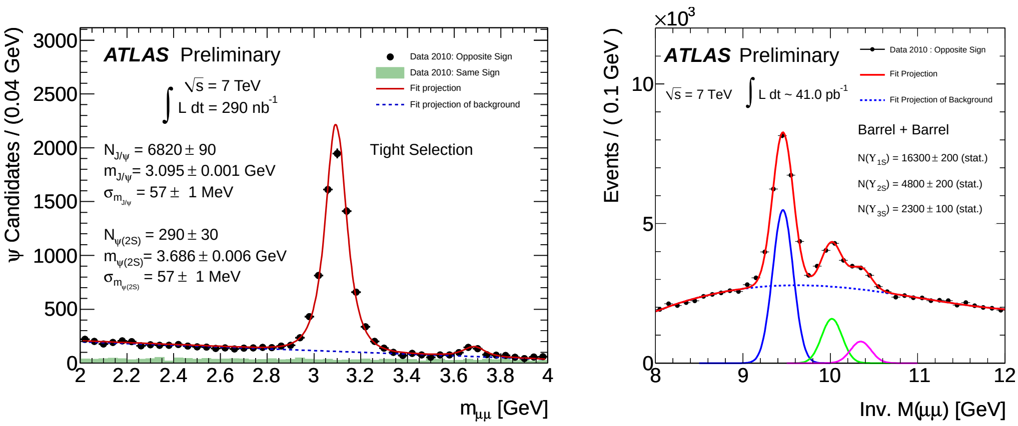

Figure 3: Shown on the left invariant di-muon mass of J/ψ and $\psi(2S)$ candidates. Shown on the right is the invariant mass distribution of $\Upsilon \rightarrow \mu^+\mu^-$ candidates in the barrel region using the full statistics available at the end of the 2010 run. Overlaid is a fit to the data using three Gaussians to model the signal. The peak separations are fixed to the world average. Uncertainties shown, are statistical only.

References

[1] Julie Kirk, Andrew Nelson, these proceedings

[2] [ATLAS Collaboration], "The ATLAS Experiment at the CERN Large Hadron Collider", JINST **3** S08003 (2008)

[3] [ATLAS Collaboration], "J/ψ performance of the ATLAS Inner Detector", ATLAS-CONF-2010-078 (2010)