# Early-data measurement of J/$\psi \to \mu^+\mu^-$ decays with the ATLAS detector at LHC

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**Summary.** — The approach for the observation of the first J/$\psi \to \mu^+\mu^-$ production using the ATLAS detector at the Large Hadron Collider will be presented. Given the large quarkonia cross sections, large sample of muons can be obtained with few pb$^{-1}$. These clear muon samples can be used to study the Muon Spectrometer in all his aspects, like detector alignment, trigger calibration and trigger efficiency. Events of interest can be triggered by requiring one or two isolated muons; offline selection can then be applied, consisting maily of muon pseudorapidity cuts and lepton transverse-momentum threshold.

## 1. – Introduction

The foreseen rate of J/$\psi$ resonance production on the bases of Standard Model prediction will be very high at Large Hadron Collider [1]. In particular, ATLAS detector [2] is expected to collect about 6000 J/$\psi$ per pb$^{-1}$ at $\sqrt{s}$= 7 TeV. Muons coming from the subsequent decays are naturally candidates in commissioning the ATLAS detector [2], in particular the Muon System [3], and in evaluating the Level 1 Trigger [4] efficiency. All the relevant information concerning trigger and muon reconstruction have been retrieved using a tool developed in the ATLAS software framework contest in order to perform these studies. J/$\psi \to \mu^+\mu^-$ decays have been observed [5] very recently by ATLAS Collaboration in $\sqrt{s}$ = 7 TeV collision data.

## 2. – The ATLAS Muon System

Final states containing high transverse momentum muons are the principal signatures in most of the research goals of LHC physics programme, so the ATLAS Muon Spectrometer [3] has been set-up in order to provide an independent trigger system and to perform standalone measurements in terms of muon transverse momentum ($p_T$), pseudorapidity ($\eta$) and azimutal angle ($\phi$). The three main detector technologies composing this system are the Thin Gap Chambers (TGC), the Resistive Plate Chambers (RPC), and the Multilayer Drift Tubes (MDT); TGCs and RPCs are mainly used for ATLAS Trigger [4] (RPCs for the barrel region, $|\eta| < 1.05$, and TGCs for the endcap region, 1.05 $< |\eta| < 2.4$), while MDTs provide precise coordinate measurement in the bending plane. The Muon System is capable to identify and reconstruct muons in the $|\eta| < 2.7$ range having a $p_T$ varying in a large spectrum (1-1000 GeV). Depending on the requirements on muon reconstruction quality, three categories of muons are foreseen: standalone, combined and tagged. The standalone muon reconstruction is entirely based on the tracks reconstructed in the Muon Spectrometer (MS) and extrapolated to the interaction point, taking into account multiple scattering and energy loss in the calorimeters; the combined muon reconstruction comes out from a statistical combination of both a standalone MS track and an Inner Detector (ID) track; finally tagged muons are formed by ID tracks extrapolated to the MS matching segments which are not associated with any other MS track.

**2**˙1. *The Level 1 Trigger*. – The ATLAS trigger [4] is divided into three levels of event selection: Level 1 (hardware-based), Level 2 and Event Filter (collectively referred to as the High Level Trigger or HLT and based on software algorithms). These three levels are designed to reduce LHC interaction rate of 1 GHz to 200 Hz. In particular the Level 1 must lower the initial rate to 75 kHz with a latency of 2.5 $\mu$s, and is based on two kinds of dedicated detectors (RPCs and TGCs) distributed over three stations placed at different distances with respect to the interaction point. In order to pass Level 1 trigger thresholds, events must have a time coincidence of hits in the different trigger stations within a predefined angular region, called a "road", from the interaction point through the detector. The width of the roads is strictly connected to the transverse momentum thresholds: the more the transverse momentum is high, the less is the bending of the muon in the magnetic field and the width of the road is accordingly reduced. The Level 1 trigger provides for each muon candidate the region where it was found, called the region of interest (RoI) and serve as seed for the HLT. Level 1 efficiency relative to offline muon reconstruction can be evaluated by selecting events using an independent trigger.

## 3. – J/$\psi \rightarrow \mu^+\mu^-$ observation in ATLAS

The large quarkonia production cross section allows resonances to be observed with a few $pb^{-1}$. At the time of writing these proceedings the decay of J/$\psi$ into di-muons has been observed in ATLAS data with a clear peak [5]. Data used have been collected in proton-proton collisions at $\sqrt{s}$ = 7 TeV in the period that goes from the end of March 2010 to the mid of May 2010 for a corresponding integrated luminosity of 6.4 $\pm$ 1.3 $nb^{-1}$. Events were selected by requiring Level 1 Minimum Bias Trigger[4] and, in order to select collision events, a minimum of three tracks associated with the same reconstructed primary vertex and satisfying some quality criteria on the number of ID hits has been required. In the events so obtained pairs of reconstructed muons having associated ID tracks satisfying the same quality criteria were searched; J/$\psi$ candidates were formed using combined and tagged muons by requiring at least one muon of the pair to be reconstructed as combined. The fit of the peak in the mass window (2,4) GeV using an unbinned maximum likelihood method is shown in fig. 1, solid line; points with error bars are data. Full circles representing opposite sign combination are superimposed to same sign (open circles) ones. The overall value for the invariant mass so obtained, 3.099 $\pm$ 0.007 GeV, is in agreement with the PDG value within statistical uncertainty. First studies on Level 1 trigger using J/$\psi$ candidates are also reported in the same work.

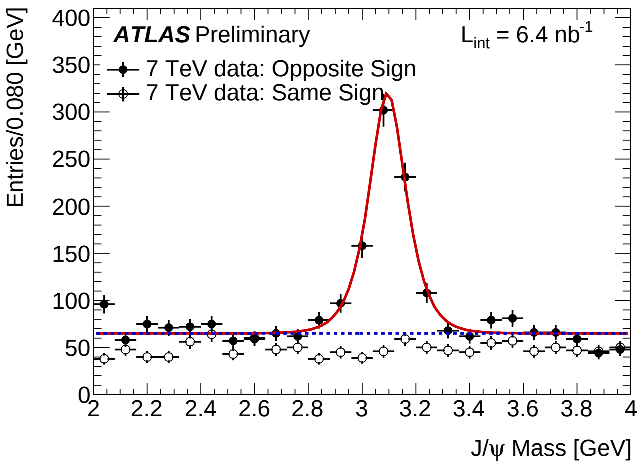


Fig. 1. – Invariant mass distribution of reconstructed J/$\psi \to \mu^+\mu^-$ candidates. The full circles represent opposite sign combinations while the open circle the same sign ones. The solid line is the result of maximum likelihood unbinned fit in the mass window (2,4) GeV.

## REFERENCES


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