Z0 Production in Heavy Ion Collisions at LHC

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Introduction

The Z^0 boson is important probe to constrain initial nuclear matter effects in heavy ion collisions. Since the dominant contribution of Z^0 production is through quark and anti quark fusion, it is a unique probe to study the nuclear effect of quark pdf at very low x and up to very high Q^2. The Compact Muon Solenoid (CMS) detector, with its excellent muon detection capability in a wide range of momentum and rapidity, is perfectly suitable to study the Z^0 bosons through the decay muons. In this work we report, the reconstruction capability of the $Z^0 \to \mu^+\mu^-$ signal in heavy ion collisions, in the CMS detector. Z^0 is measured earlier by UA1 collaboration at $\sqrt{s}$ =0.546 TeV and 0.630 TeV [1], CDF collaboration at $\sqrt{s}$ = 1.8 TeV [2] and 1.96 TeV [3] and recently in CMS at 7 TeV [4] .

Z0 production cross section in Pb Pb collisions

Z^0 cross section multiplied by branching ratio ($Z^0 \to \mu^+\mu^-$) as measured by different experiments in pp and p$\bar{p}$ collisions are shown in table I . These cross sections are fitted with a second order polynomial as shown in figure 1. Using this parametrization we estimate Z^0 cross sections at various energies relevant for heavy ion collisions. Z0 cross section for Pb-Pb is calculated as
$\sigma_{AA}(Z^0 \to \mu^+\mu^-) = \sigma_{pp}(Z^0 \to \mu^+\mu^-) \times A^2$
where A is the mass number of Pb.

We estimate the total numbers of Z^0 expected for luminosities relevant for heavy ion run. Total 156 Z^0 are estimated with first year heavy ion run at $\sqrt{\text{s}} = 2.76$ TeV, for integrated luminosity $\int L\ dt = 10\ (\mu\ barn)^{-1}$. This number does not include initial state parton shadowing.

TABLE I: Measured cross section for Z0 at various energies in pp and p $\bar{p}$ collisions.

$\sqrt{s_{NN}}$ (TeV)	$\sigma \times BR(Z^0 \to \mu^+\mu^-)$ (p barn)
0.546	90.0±62.0(stat)±12.0(sys)[1]
0.63	61.0±17.0(stat)±6.0(sys)[1]
1.8	237.0±9.0(stat)±0.0(sys)[2]
1.96	248.0±5.9(stst)±7.6(sys)[3]
7.0	881.0±100.0(stat)±38.0(sys)[4]

TABLE II: Expected numbers of Z^0 in Pb Pb collisions

$\sqrt{s_{NN}}$ (TeV)	$\sigma_{pp} \times BR(\mu^+\mu^-)$ (p barn)	$\int L\ dt$ $(\mu\ barn)^{-1}$	Expected numbers
5.5	705.0	500.0	15250
5.5	705.0	10.0	305
4.0	522.0	10.0	225
2.76	361.0	10.0	156

Geometrical acceptance and reconstruction efficiency of Z^0 in CMS

Z^0 is produced using PYTHIA6.34 [5] with CTEQ6L1 parametrization (LO with LO α_s) [6] of Parton Distribution Function (pdf) at 2.76 TeV. One Z^0 is produced in each event and forced to decay in muon channel. These input distributions are then reconstructed using CMS software. Geometrical acceptance and reconstruction efficiencies are calculated. Total 80000 Z0 are generated using PYTHIA so that we have good statistics at high p_T. Reconstructed dimuon invariant mass is calculated using global muons. Global muons are best quality muons reconstructed in CMS.

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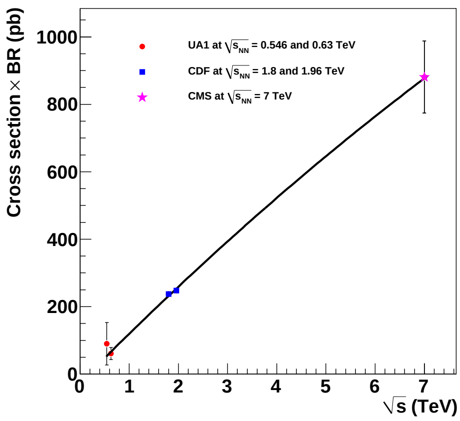

FIG. 1: $Z^0(\sigma \times BR(\mu^+\mu^-))$ in pp and p$\bar{p}$ collisions.

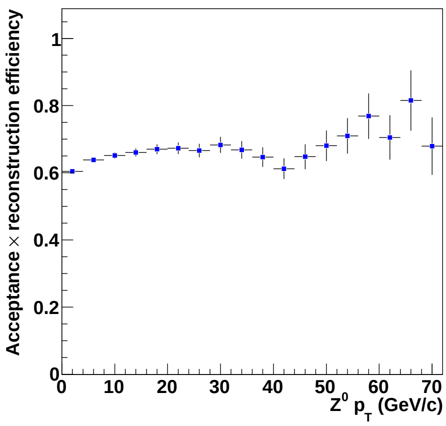

FIG. 2: Geometrical acceptance × reconstruction efficiency as a function of Z0 p_T

They have at least three hits in muon chambers with good match to track in tracker as well as in silicon pixel.
Geometrical acceptance × reconstruction efficiencies are found nearly 64% for Z0. We estimate nearly 100 Z0 will be detected in full CMS acceptance with first heavy ion run.

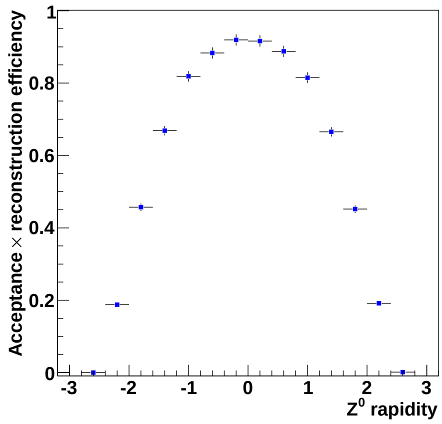

FIG. 3: Geometrical acceptance × reconstruction efficiency as a function of Z0 rapidity.

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