Constraining/measuring gluon distribution in a proton in CMS detector using the process "Z+jet"

S.Banerjee, M.Dittmar, M.Guchait, Sangeeta Singh

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Presented by

M. Guchait

TIFR

Process:

$$PP \to Z + jet; \qquad Z \to \mu^+\mu^-$$

The subprocesses are:

$$qg \to Z + q$$
$$q\bar{q} \to Z + g$$

- These processes are very sensitive to gluon pdf, may be useful to constrain/measure gluon pdf in proton.
- Theoretical understanding of this process is very clear today, accurate calculations are available.
- Some preliminary studies have been carried out so far.

Strategy

- Need to construct obseravbles.

$$\frac{d\sigma}{d\eta_1 d\eta_2 dp_t^2} = \sum_{a,b}[x_a f_{x_a}^P(x_a, Q^2) x_b f_{x_b}^P(x_b, Q^2) + x_1 \leftrightarrow x_2]\frac{d\sigma}{d\hat{t}}($$

with

$$x_{a,b} = \frac{p_T}{\sqrt{s}}[exp(\pm\eta_1) + exp(\pm\eta_2)] \qquad (2)$$

where $a, b = q, \bar{q}, g, \eta_1 = \eta^Z, \eta_2 = \eta^j, P_T = P_T^Z$.

- Estimate the event rate for Z+jet process for different x and Q^2

- Inputting the knowledge of $f^P_{x_q}(x_q, Q^2), f^P_{x_{\bar{q}}}(x_{\bar{q}}, Q^2)$ possible to constrain out $f^P_{x_g}(x_g, Q^2)$

The lepton rapidity distributions from W^+ and W^- may provide the quark and anti-quark parton flux in proton.

- Main sources of backgrounds: mainly from QCD!!

PYTHIA level studies

- Event generation using PYTHIA in CMSSW_1_1_1 environment.

PYTHIA Setting :

`Processes:MSUB(15)` and `MSUB(30)`;

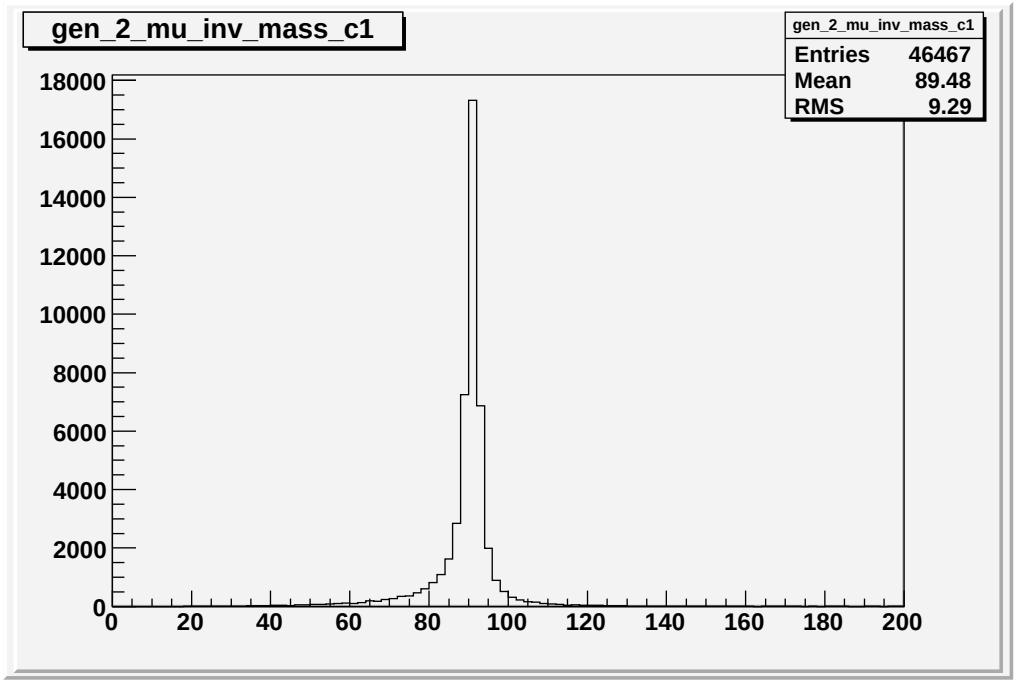
`MSTP(43)`=2 for on shell Z production;

`CKIN(3)`=10 GeV, Z is forced to decay to, $Z \rightarrow \mu^+\mu^-$; PDF `CTEQ5L`

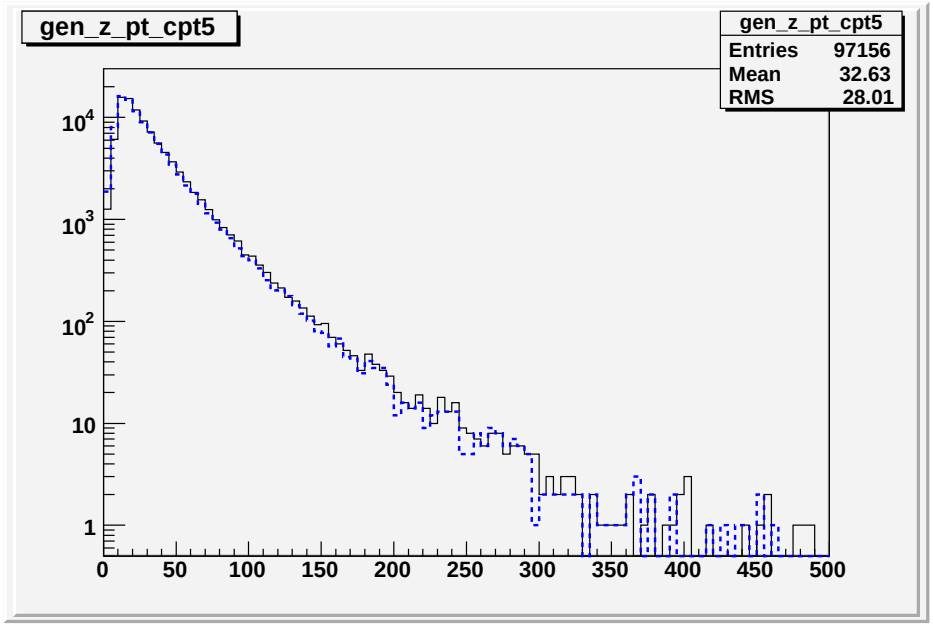
For Jet reconstruction: `JetReco`,cone alogorithm, taking ΔR=0.5

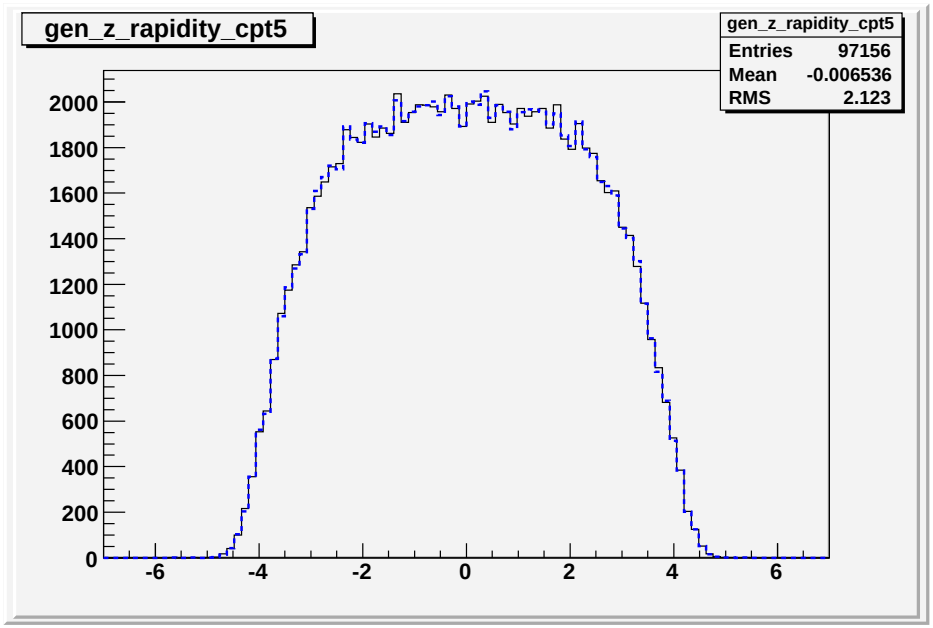
Muon reconstruction: Generator level informations, from particle id

Production Cross section is high $\sim 10^3 pb$:



$m_{\mu^+\mu^-}$ w/cut
$p_T > 10\ GeV$ and $|\eta| < 2.4$

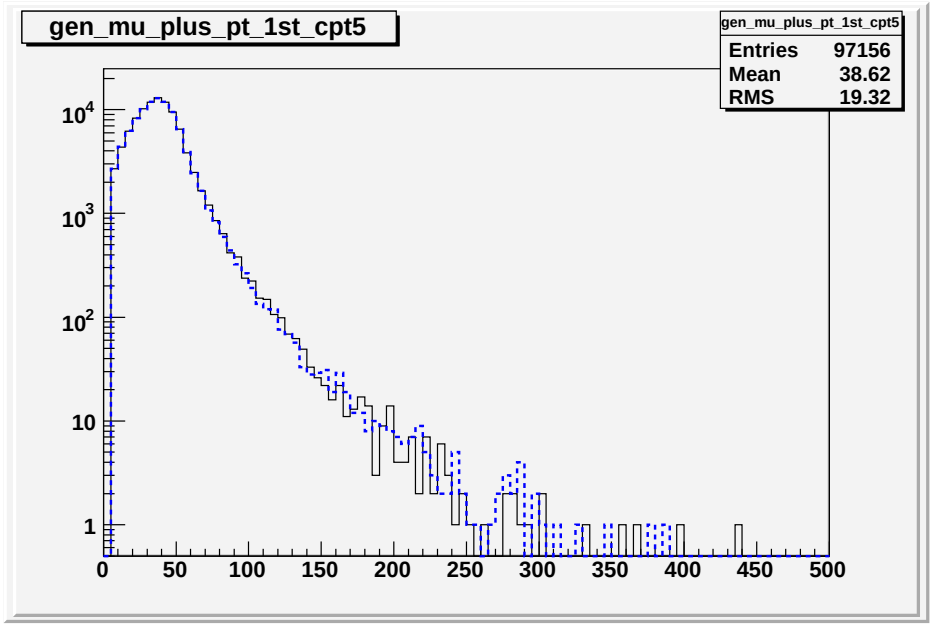


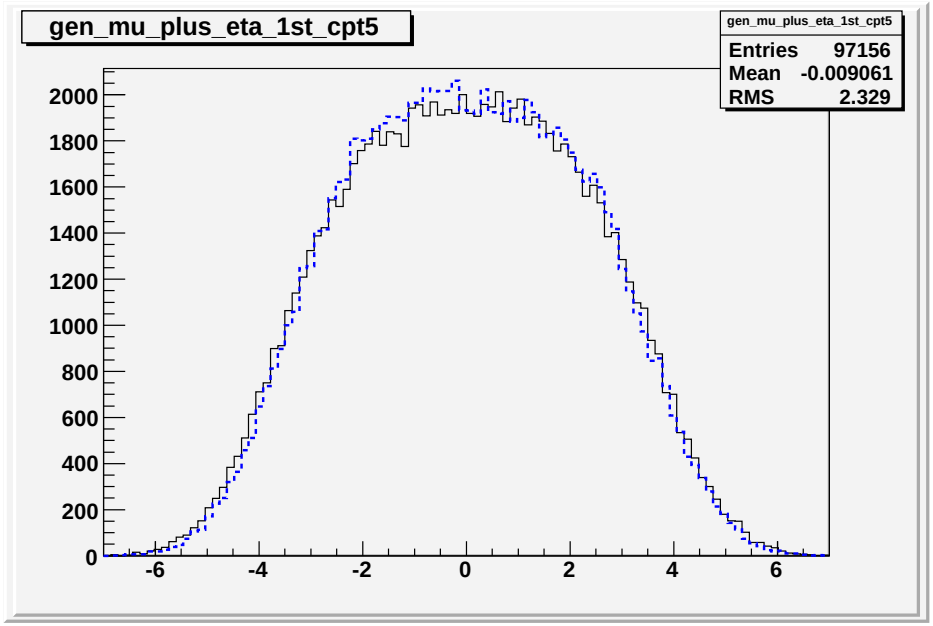


p_T and $rapidity$ of
Z(solid) and Z_{rec}(dashed)

Z_{rec} is the reconstructed Z
out of two muons, μ^+ and μ^-

$p_T^{\mu} > 5\ GeV$

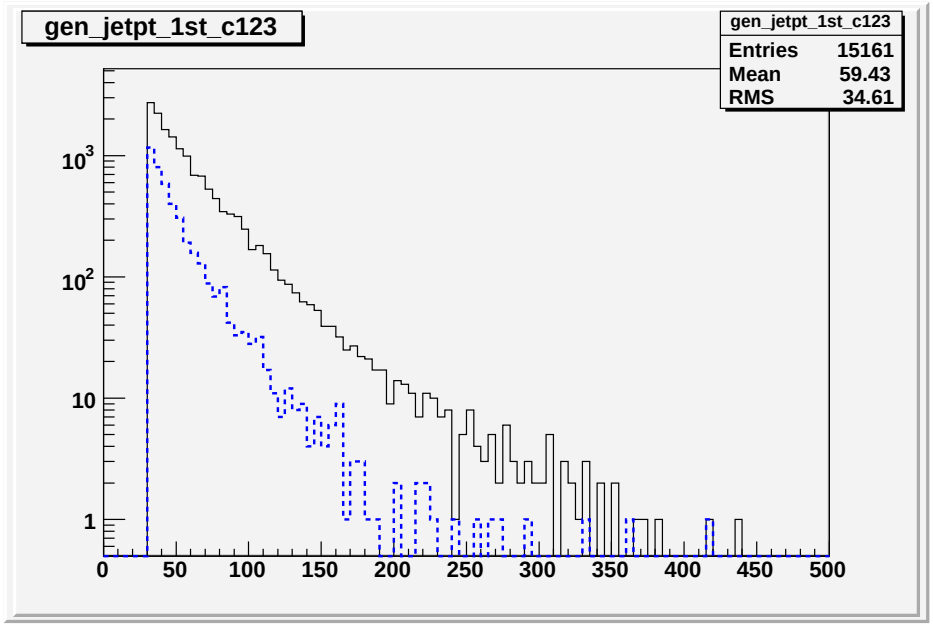


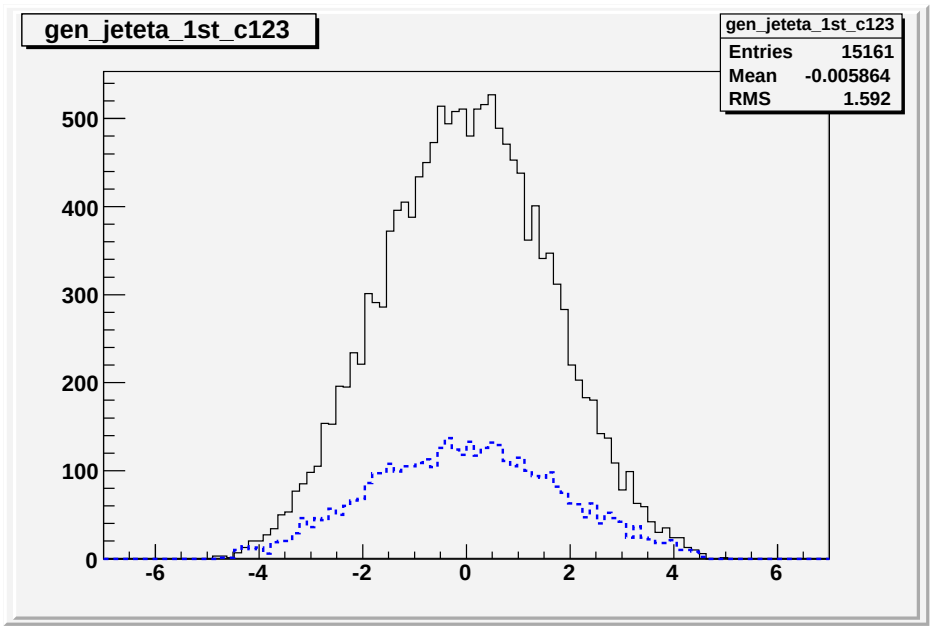


p_T and $|\eta|$ of μ^+ and μ^-

$p_T > 5\ GeV$

A good fraction of muons are in forward direction!

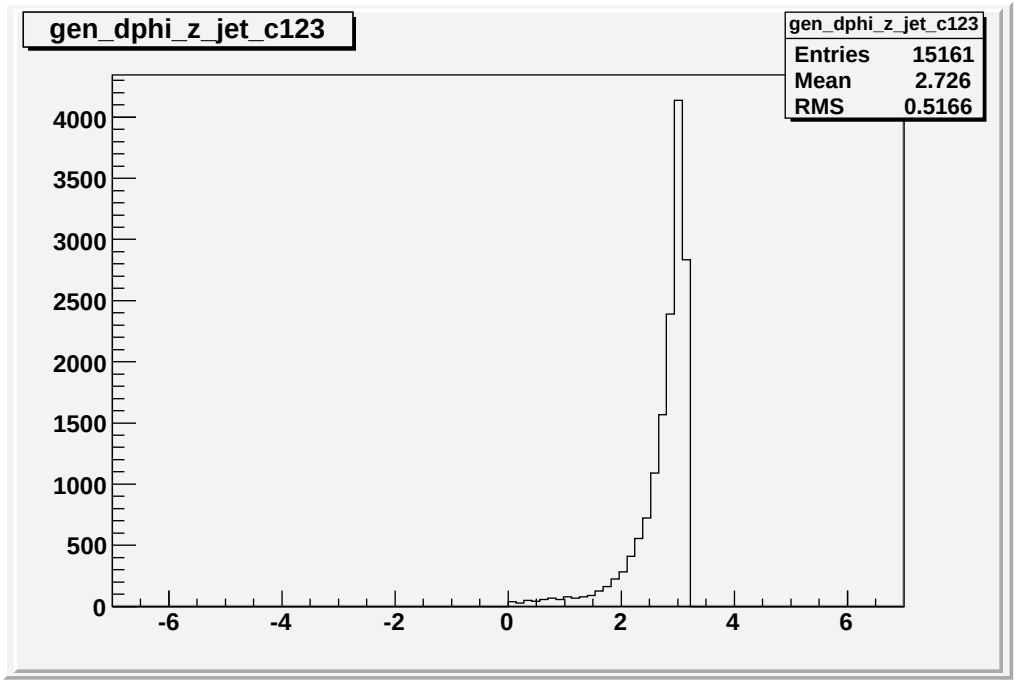




p_T and $|\eta|$ of
1st(solid) and 2nd Jet(dashed)

$p_T^\mu > 10\ GeV, |\eta_\mu| < 2.4.$
$p_T^j > 30\ GeV,\ |\eta^j| < 4.5.$
$|m_Z - m_{\mu\mu}| < 5\ GeV.$

2nd Jet is compartively
very soft



$\Delta\phi(Z_{rec}, 1stjet)$ w/cut

$p_T^\mu > 10\ GeV, |\eta_\mu| < 2.4.$
$p_T^j > 30\ GeV,\ |\eta^j| < 4.5.$
$|m_Z - m_{\mu\mu}| < 5\ GeV.$

Z_{rec} and 1st Jet is almost back-to-back.

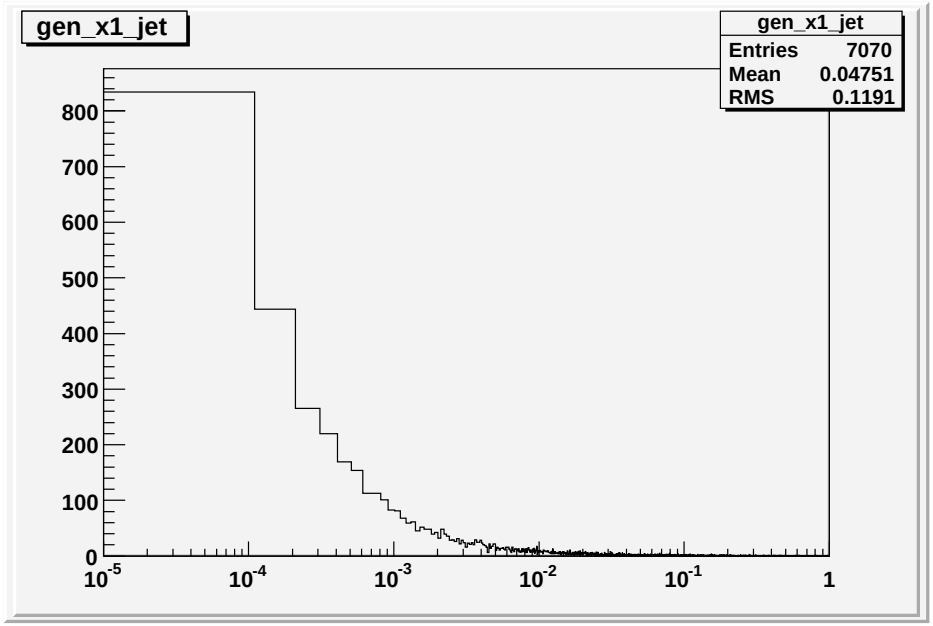
•To begin with, looking at the distributions, we decide following set of cuts for event selection:

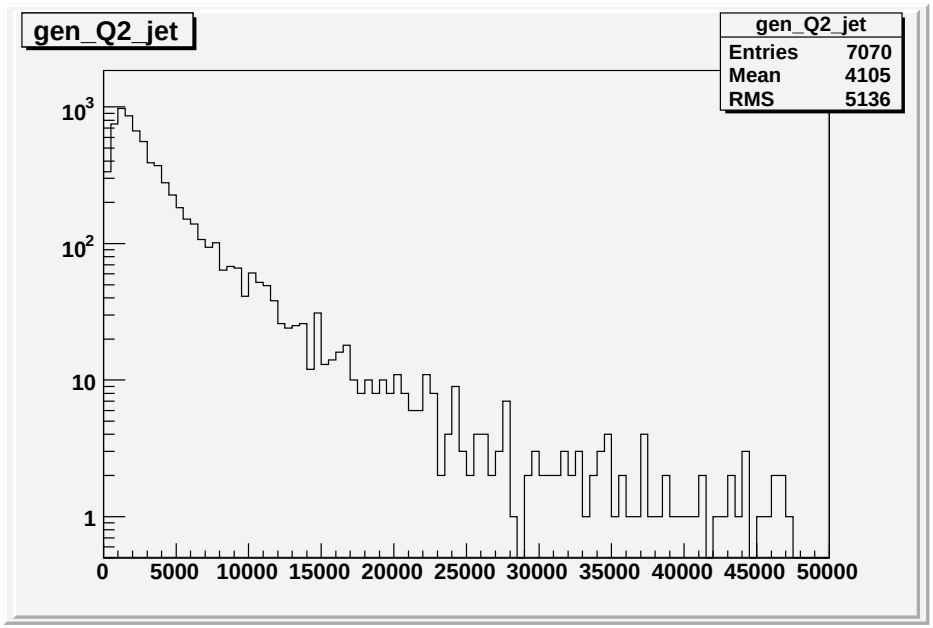
1. Muons $p_T > 10\ GeV$ and $|\eta| < 2.4$.
2. Jets with $p_T > 30\ GeV$ and $|\eta| < 4.5$.
3. $|m_Z - m_{\mu\mu}| < 5\ GeV$.
4. Number of jets $= 1$.
5. $|\phi(Z_{Rec} - Jet) - 180^o| < 15^o$.

(Z_{rec} is the reconstructed Z out of two muons, μ^+ and μ^-)

$|\eta^\mu|$ <2.4 kills ∼ 40%

Selection of Cuts	Cummulative eff.
Muon,$p_T^\mu > 10\ GeV$,$\|\eta^\mu\| < 2.4$.	0.47
No. of jets > 0 with $p_T > 30\ GeV$,$\|\eta\| < 4.5$	0.20
$\|m_Z - m_{\mu\mu}\| < 5\ GeV$.	0.15
Number of jets $= 1$.	0.10
$\|\phi(Z_{Rec} - Jet) - 180^o\| < 15^o$	0.07

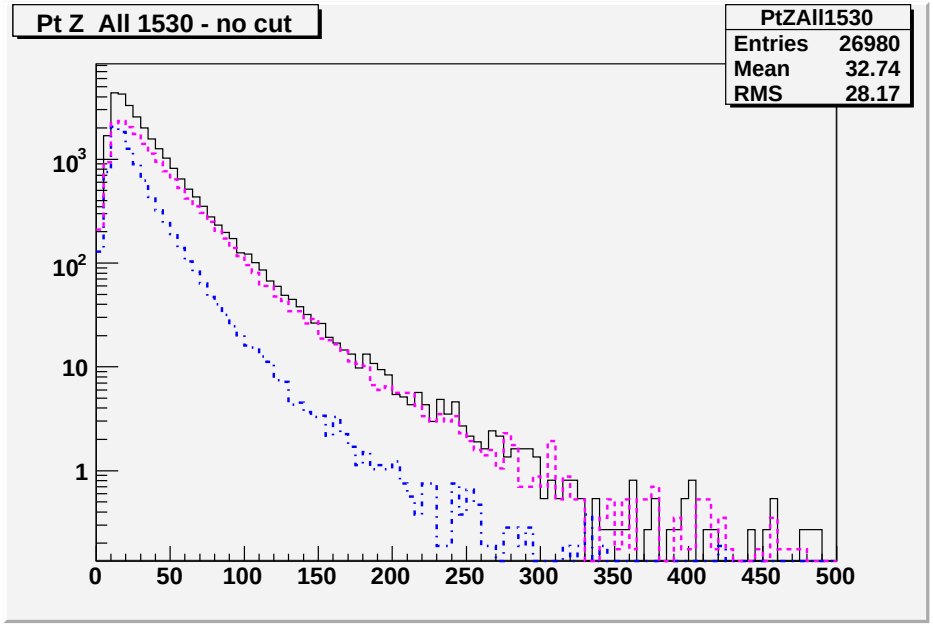


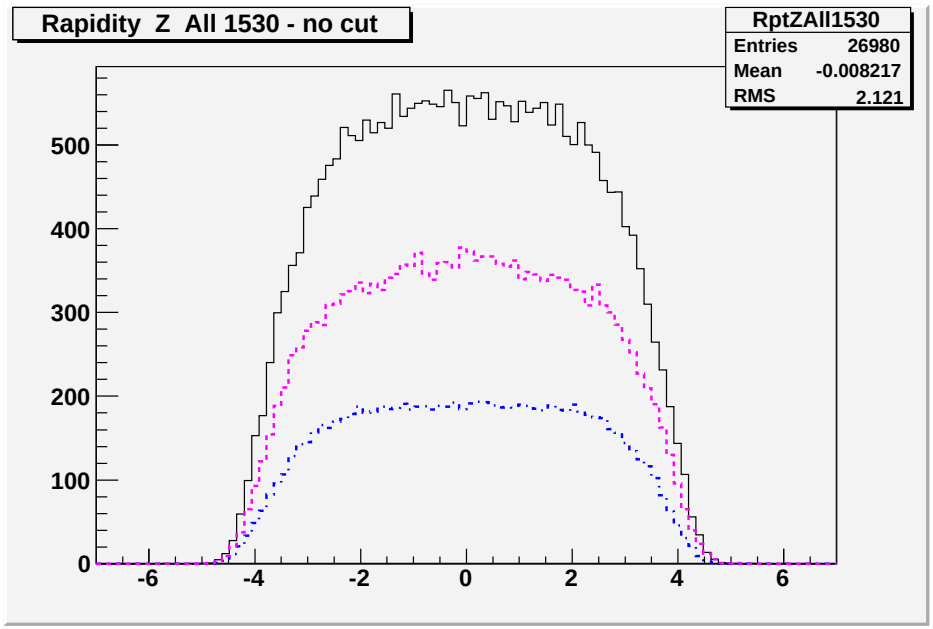


$$x_{1,2} = \frac{p_T^{Z_{rec}}}{\sqrt{s}}\left[e^{\pm\eta_{Z_{rec}}} + e^{\pm\eta^j}\right]$$

$$p_T^{\mu} > 10\ GeV, |\eta_{\mu}| < 2.4.$$
$$p_T^{j} > 30\ GeV,\ |\eta^j| < 4.5.$$
$$|m_Z - m_{\mu\mu}| < 5\ GeV.$$
Number of jets $= 1.$
$$|\phi(Z_{Rec} - Jet) - 180^o| < 15^o.$$

$Q^2 = (p_T^{Z_{rec}})^2$ distribution





These distributions are for individual subprocess and along with their sum

(Norm. by cross section(in pb))

p_T and $rapidity$ of Z

$q\bar{q}, qg \rightarrow Z + jet$(solid)

$qg \rightarrow Z + jet$(dashed)

$q\bar{q} \rightarrow Z + jet$(dot-dashed)

qg mediated process dominates, sensitive to gluon pdf, useful to find gluon pdf

Future Plan

- Need to study the variation with different pdfs.
(working at present. interfacing with LHAPDF)

- We may compare with ALPGEN, HERWIG.

- May be we can include $Z \rightarrow e^+e^-$ final state.

- Background(mainly QCD) need to be estimated.

- How do the distribution change with higher order effects? Study using `MCFM, MCNLO`.

- Upgrade CMSSW version to CMSSW_1_5_0 or which version..

- Use of CSA07 datasets.