Study of ISR events with radiative return to Z resonance at ILC250GeV

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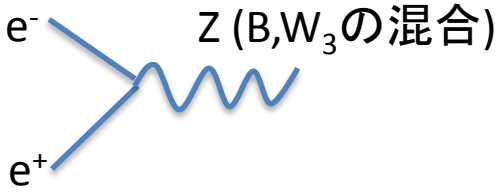
-Reference-

arXiv:1708.09079 arXiv:1708.08912
hep-ex/9810047 hep-ex/0509008

Motivation

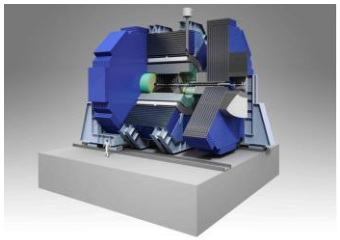
A^0_{LR}(Left-Right Asymmetry) の誤差を少なくする



- Current value -

$m_Z = 91.1875 \pm 0.0021$ GeV

$(A_{LR} + \Delta A_{LR} =) A^0_{LR} = 0.1514 \pm 0.0022$



-> These value comes from 17 million Z decays accumulated by
the ALEPH, DELPHI, L3 and OPAL experiments at LEP,
600 thousand Z decays by the SLD experiment using a polarized beam at SLC

The ILC is suitable for this study
because of Clean data & 250 GeV & Polarized beam

Expected precision at SiD is much better than SLD (SLC) and ALEPH (LEP)

Motivation

LEPにおけるビームエネルギーの精密測定

Motivation

The direct measurement of the W mass with an accuracy of 30-50 MeV at LEP2

=> A Precise Determination of the LEP center-of-mass energy (below 30 MeV)

Process

e^+e^- => Zγ => hadrons (2jets) √s ~ 181-184 GeV

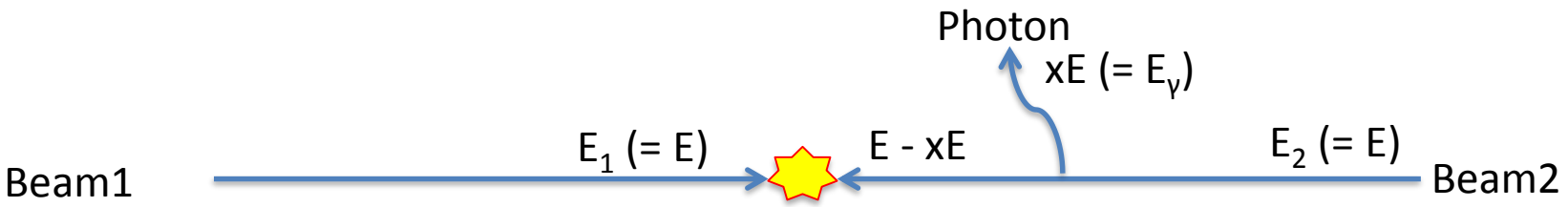
θ_1 and θ_2 are the polar angles of the 2 jets (measured values)

$$|\beta| = |\sin(\theta_1+\theta_2)| / (\sin\theta_1 + \sin\theta_2)$$

$$x = 2|\beta| / (1+|\beta|)$$

arxiv.org/abs/hep-ex/9810047

Motivation



ISRなしの値　$s = 4E_1E_2 = 4E^2$

ISRありの値　$s' = 4E_1E_2 = 4E(E-xE) = 4E^2(1-x) = s(1-x)$

Radiative Return to the Z resonance

$\sqrt{s'} = 91.19$ GeV

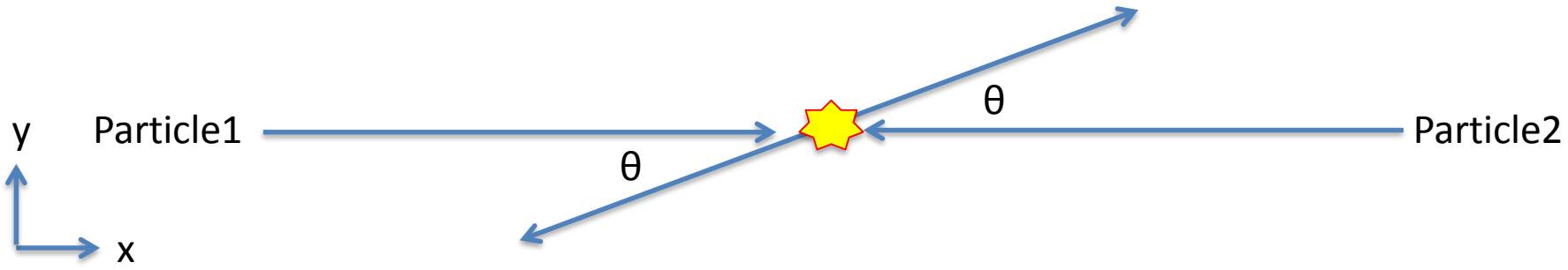
=> $x = 0.8670$

=> $E_\gamma = 108.4$ GeV

$|\beta| = P_{tot}/E_{tot} = E_\gamma/(E_1+E_2) = xE/[E+E(1-x)] = x/(2-x)$

$x = 2|\beta|/(1+|\beta|)$

Motivation



重心系

Particle1
$E_1 = E$
$P_{1x} = P\cos\theta$
$P_{1y} = P\sin\theta$

Particle2
$E_2 = E$
$P_{2x} = P\cos\theta$
$P_{2y} = P\sin\theta$

x direction Boost

慣性系

Particle1
$E_1' = \gamma E + \eta P\cos\theta$
$P_{1x}' = \eta E + \gamma P\cos\theta$
$P_{1y}' = P\sin\theta$

Particle2
$E_1' = \gamma E - \eta P\cos\theta$
$P_{1x}' = \eta E - \gamma P\cos\theta$
$P_{1y}' = -P\sin\theta$

$\sin\theta_1 = |P_{1y}'|/E_1'$
$\sin\theta_2 = |P_{2y}'|/E_2'$
$\cos\theta_1 = P_{1x}'/E_1'$
$\cos\theta_2 = P_{2x}'/E_2'$

$|\sin(\theta_1+\theta_2)|/(\sin\theta_1+\sin\theta_2) = \eta/\gamma = |\beta|$

Motivation

ALEPH Detector Strategy

①Number of charged tracks greater than 7

②Total visible invariant mass greater than 50 GeV

③$0.6 < x' < 0.8775$

where $x' = 2|\beta|/(1+|\beta|)$

$|\beta| = |\sin(\theta_1+\theta_2)|/(\sin\theta_1+\sin\theta_2)$

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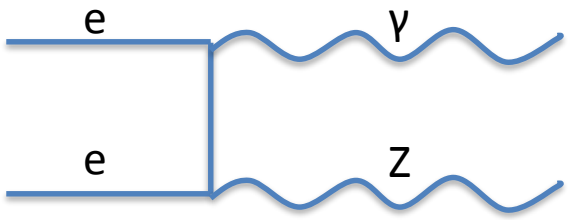
Setup



- Simulation setup

  - Event Generation : WHIZARD
    - Signal Process : e^+e^- => Zγ => hadrons or leptons
    - Model = SM_CKM
    - E_{cm} = 250 GeV
    - Beam Polarization : (P_{e-},P_{e+}) = (-0.8,+0.3)/(+0.8,-0.3)
    - Cut (2 ISR Photon Energy < 40 GeV, the third photon > 10 GeV)
    - ISR & Beamstralung : ON

  - Detector Simulation : DELPHES
    - DSiD : a fast simulation Delphes detector for the ILC
      based on the full simulation performance of the SiD

Signal

Z -> leptons (e,mu,tau)
Z -> quarks (u,d,c,s,b)
+ $86 \leqq$ Invariant Mass < 96

Invariant Mass = $\sqrt{4E^2(1-x')}$

Z -> leptons (e,mu,tau)
Z -> quarks (u,d,c,s,b)
+ $0.852544 \leqq x' < 0.881664$

θ_1 and θ_2 are the angles of the 2 jets (measured values)

$|\beta| = |\sin(\theta_1+\theta_2)|/(\sin\theta_1+\sin\theta_2)$

$x' = 2|\beta|/(1+|\beta|)$

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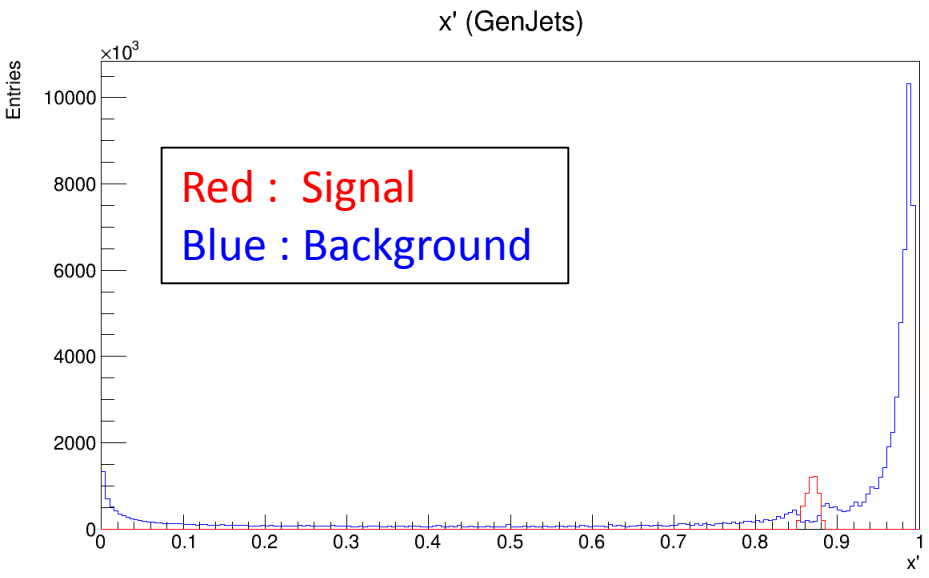
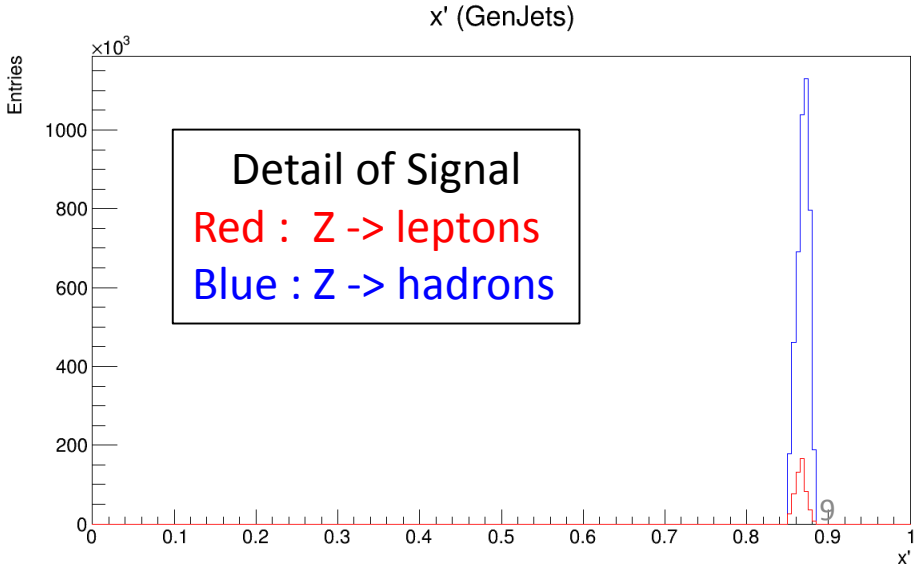
x'

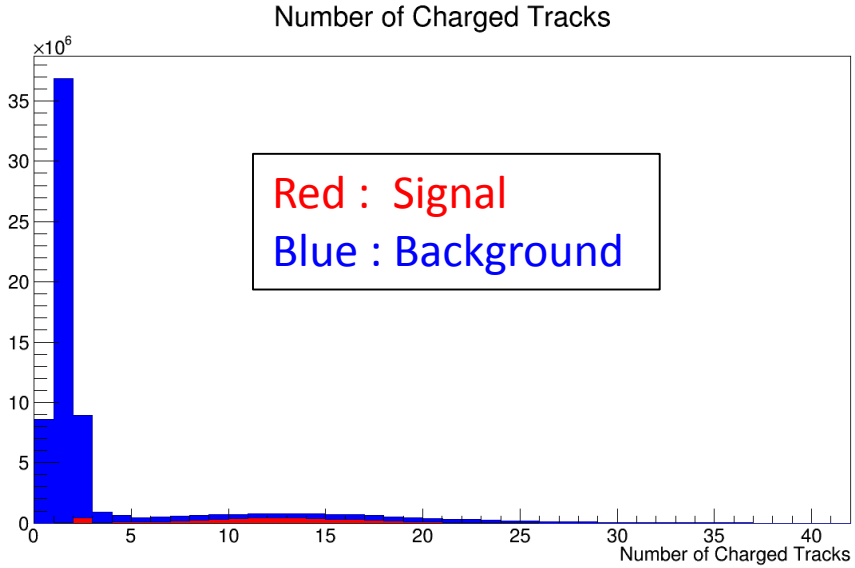
Signal VS Background





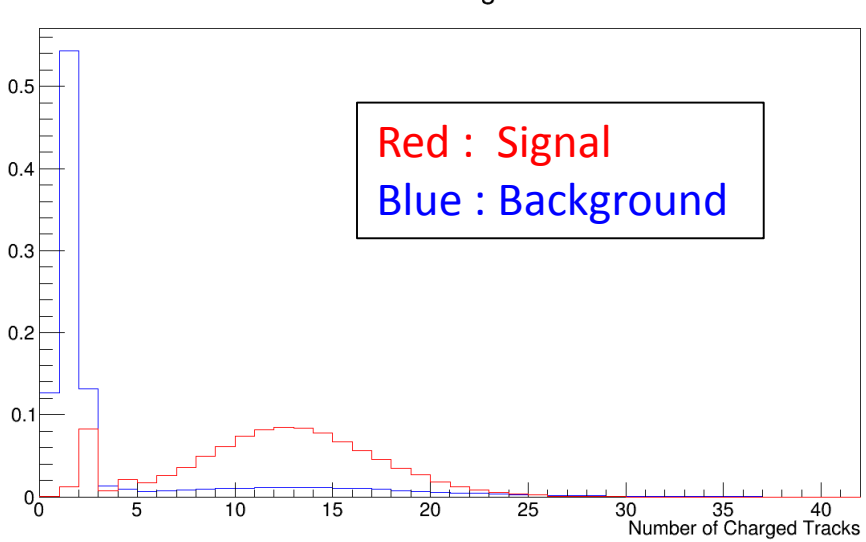
σ(Z -> hadrons)/σ(Z -> leptons) ~ 7

Number of Charged Tracks



Signal VS Background

Signal VS Background
(Normalized)



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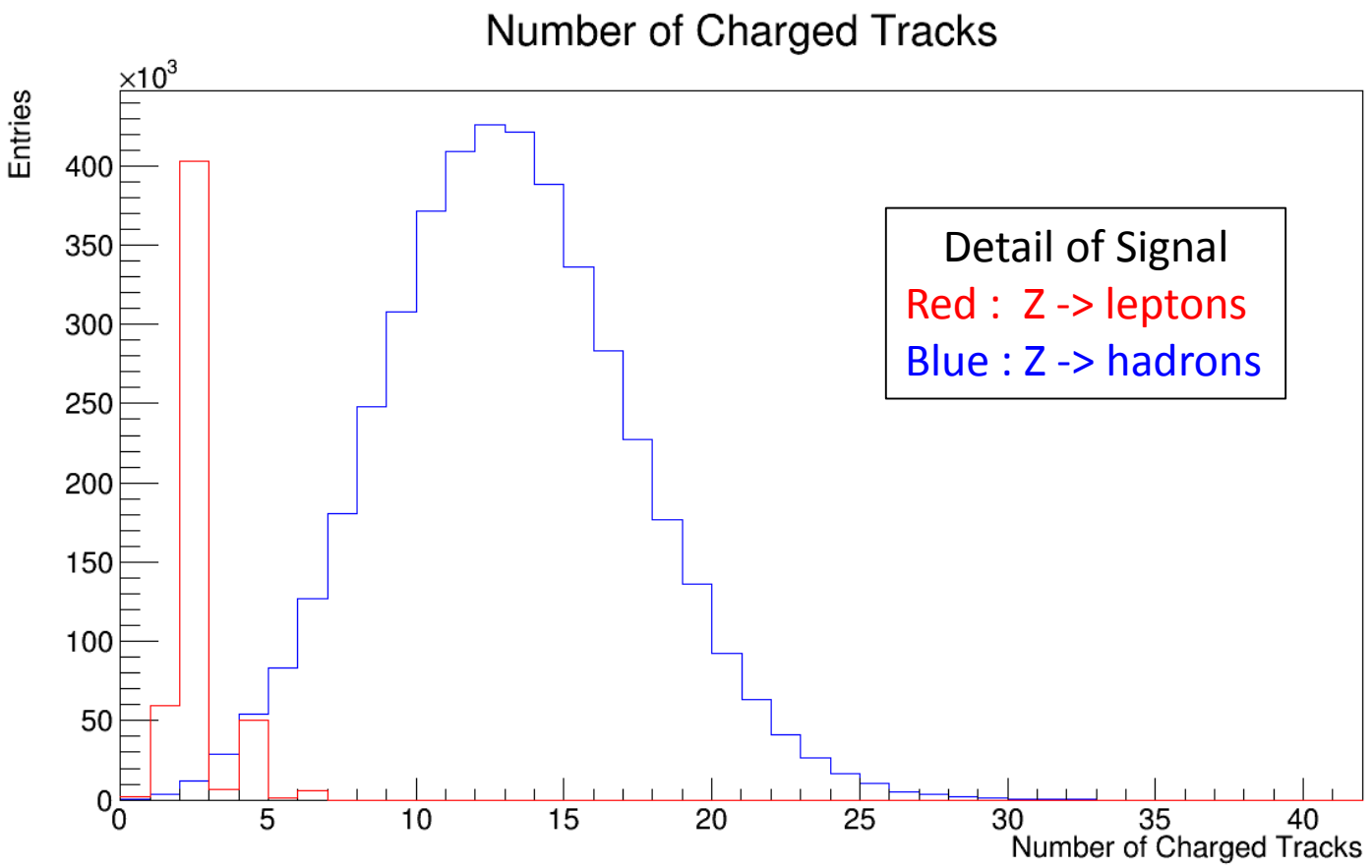
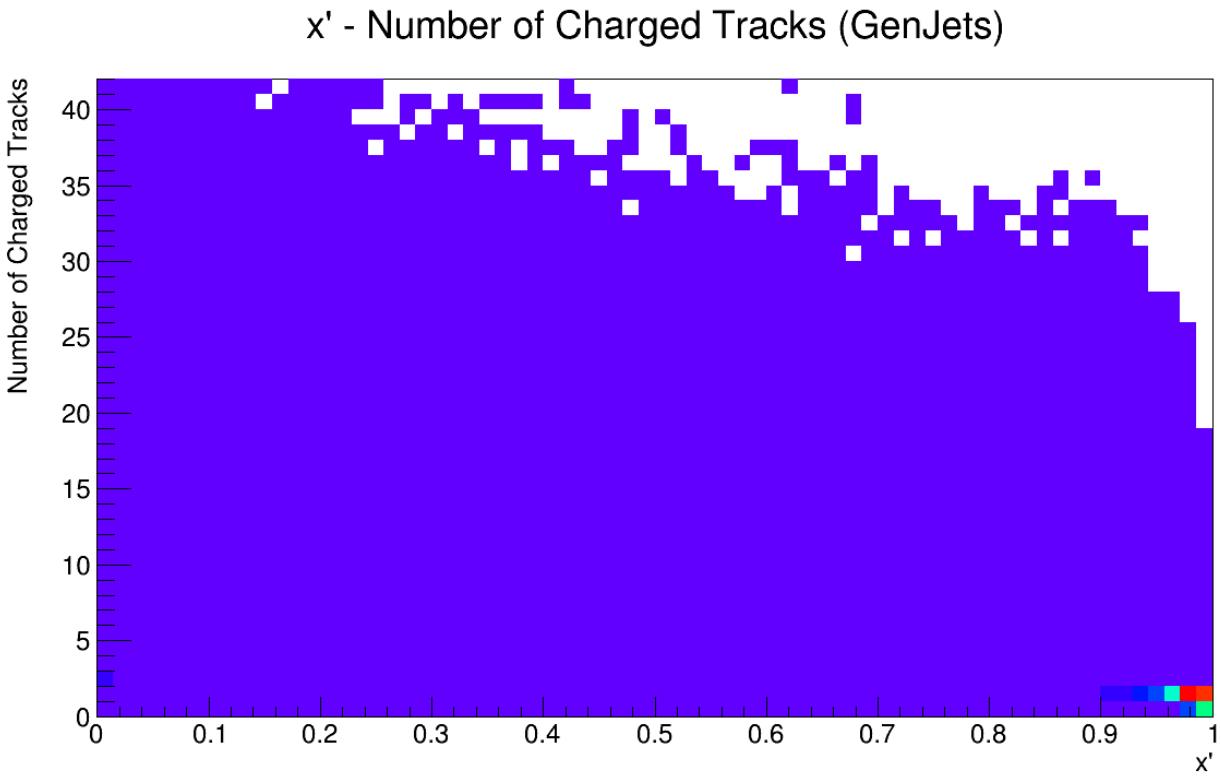
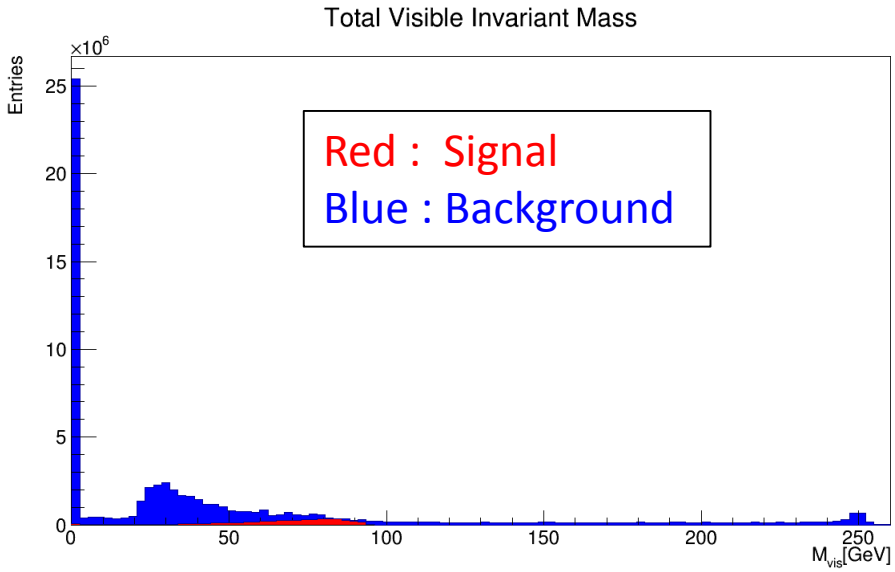


Number of Charged Tracks

Background

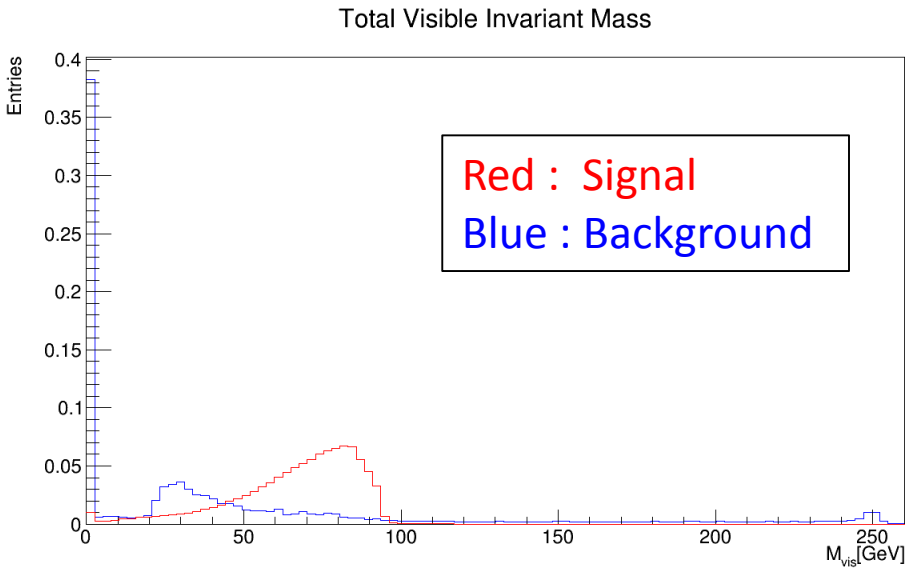


Total Visible Invariant Mass



Signal VS Background

Signal VS Background
(Normalized)



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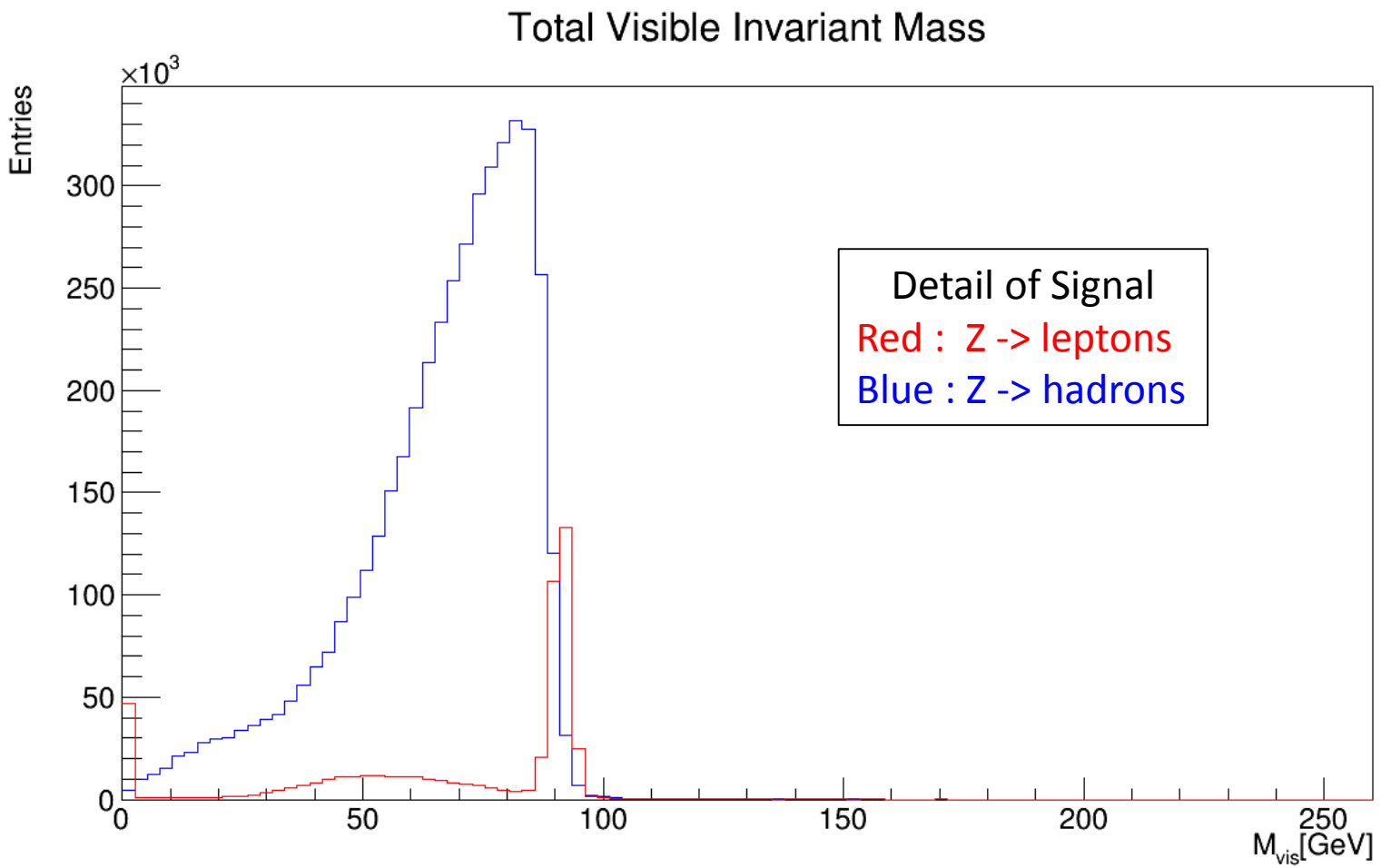
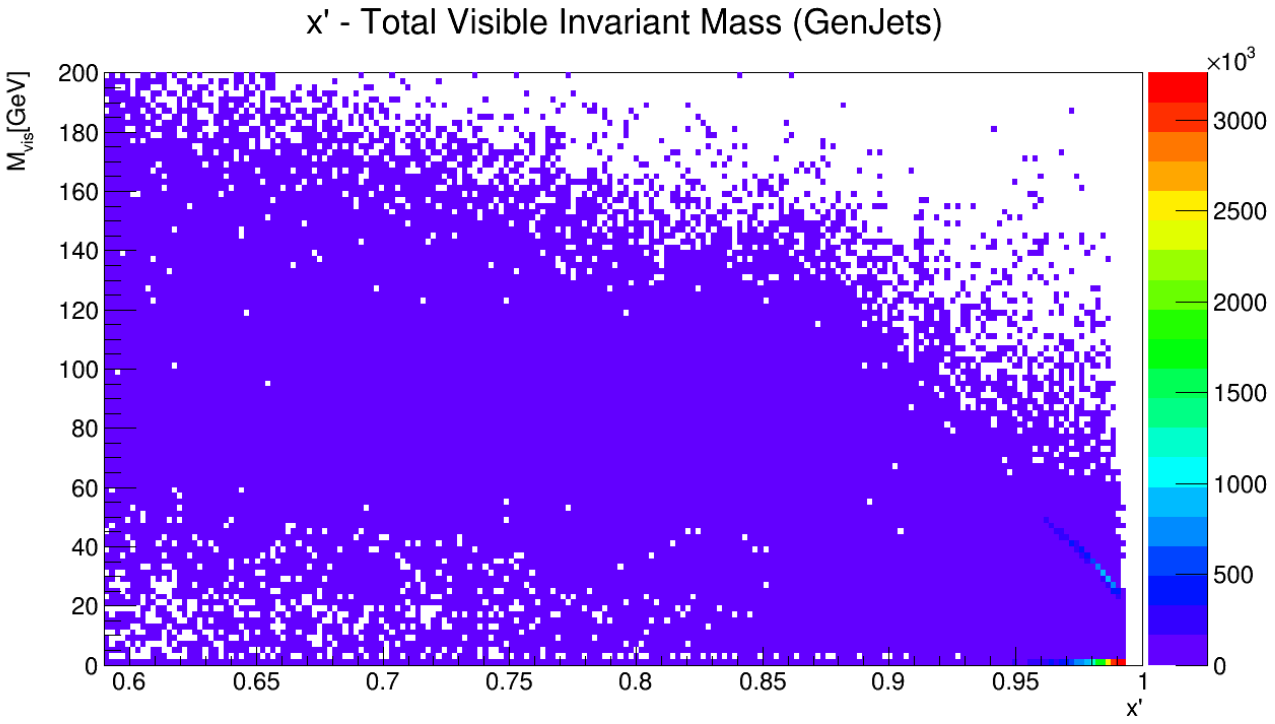


x’ vs Total Visible Invariant Mass

Background



Next Step

・Z -> hadrons と Z -> leptons のそれぞれについてefficiencyが最大になるような Total Visible Invariant Mass, Number of Charged Tracks の Cut を考える

・Full SimulationにおいてHit Pointに関するCutを考える

・A^0_{LR}の誤差を見積もる（ワインバーグ角の誤差を見積もる）