

# Measurement of top quark momentum at the ILC near the threshold of top pair production

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# Introduction

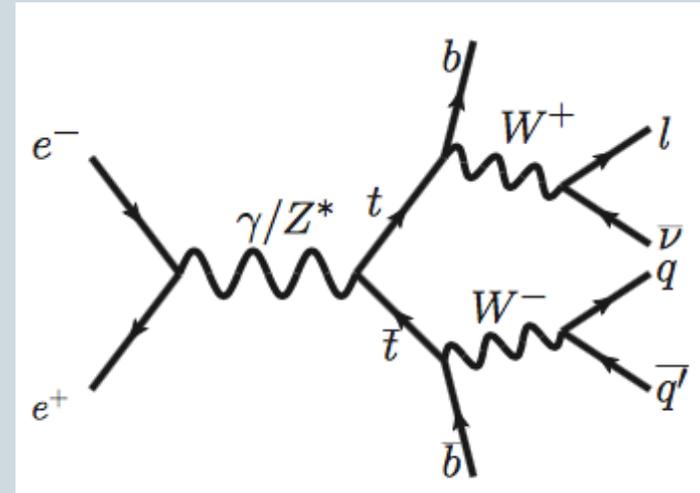
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- Top quark is the heaviest particle in the standard model.
- The mass of top quark is very large, therefore top quark has large decay width.
- Top quark decay into b quark and W boson before hadronization.
- We expect the precise measurement of top quark at the ILC.
- Measuring the top momentum, we can estimate the top decay width.

# Simulation Set Up

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- $m_{\text{top}} = 174 \text{ GeV}$
- $\sqrt{s} = 347 \text{ GeV}$
- ILD simulation
- 4-jet mode ( $ee \rightarrow tt \rightarrow bWbW \rightarrow bqqbl\nu$ )
- $L_{\text{int}}[\text{eL}(-80), \text{pR}(+30)] = 100 \text{ fb}^{-1}$
- $L_{\text{int}}[\text{eR}(+80), \text{pL}(-30)] = 100 \text{ fb}^{-1}$



# Reconstruction

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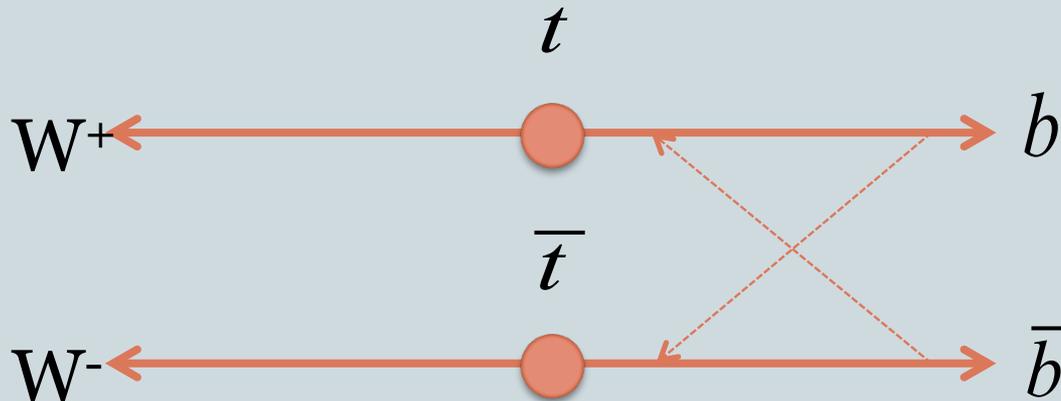
- Isolated Lepton Tag (# of lepton = 1)
- Jet reconstruct (# of jet = 4)
- b quark tag (most likely b and second most likely b)
- reconstructing  $W^-$  and  $W^+$  (One is residual 2-jet and the other is Isolated Lepton + missing 4 momentum)
- reconstructing top (from  $W^+$  boson + b quark) and reconstructing anti-top (from  $W^-$  boson + anti-b quark)

# Analysis

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- wrongly reconstructed top quark

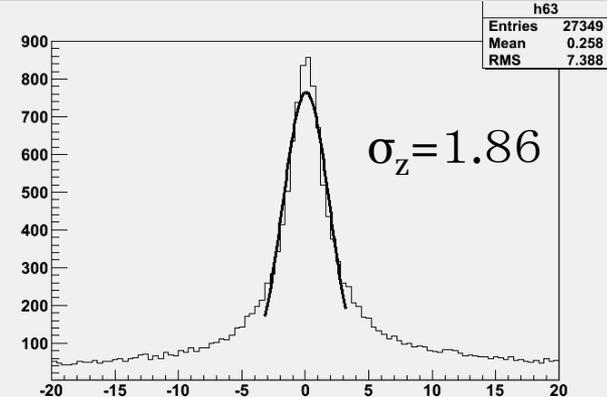
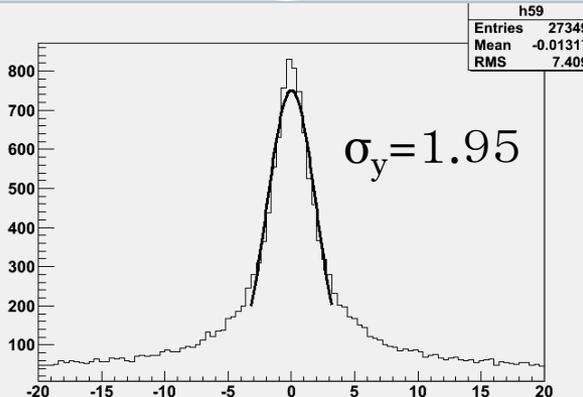
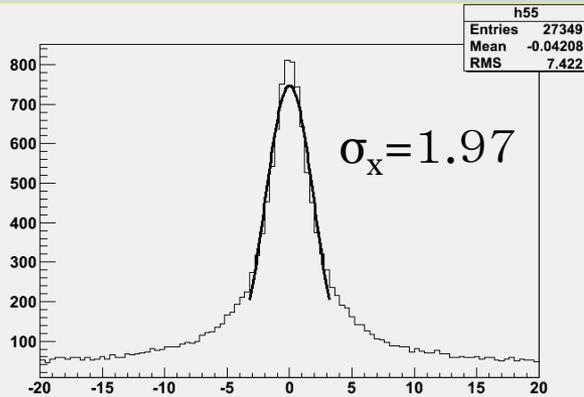
$t(W^+ + \bar{b})$  and  $\bar{t}(W^- + b)$



To decrease the wrong combination, we check the three components of b and anti-b quark momentum

# Correct Assignment

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Pbbar\_x\_rec-Pbbar\_x\_MC

Pbbar\_y\_rec-Pbbar\_y\_MC

Pbbar\_z\_rec-Pbbar\_z\_MC

$$\text{Pbbar\_x\_MC} - 5\sigma_x < \text{Pbbar\_x\_rec} < \text{Pbbar\_x\_MC} + 5\sigma_x$$

$$\text{Pbbar\_y\_MC} - 5\sigma_y < \text{Pbbar\_y\_rec} < \text{Pbbar\_y\_MC} + 5\sigma_y$$

$$\text{Pbbar\_z\_MC} - 5\sigma_z < \text{Pbbar\_z\_rec} < \text{Pbbar\_z\_MC} + 5\sigma_z$$

We confirm that six components( $b_x, b_y, b_z, \text{bbar}_x, \text{bbar}_y, \text{bbar}_z$ ) satisfy these conditions.

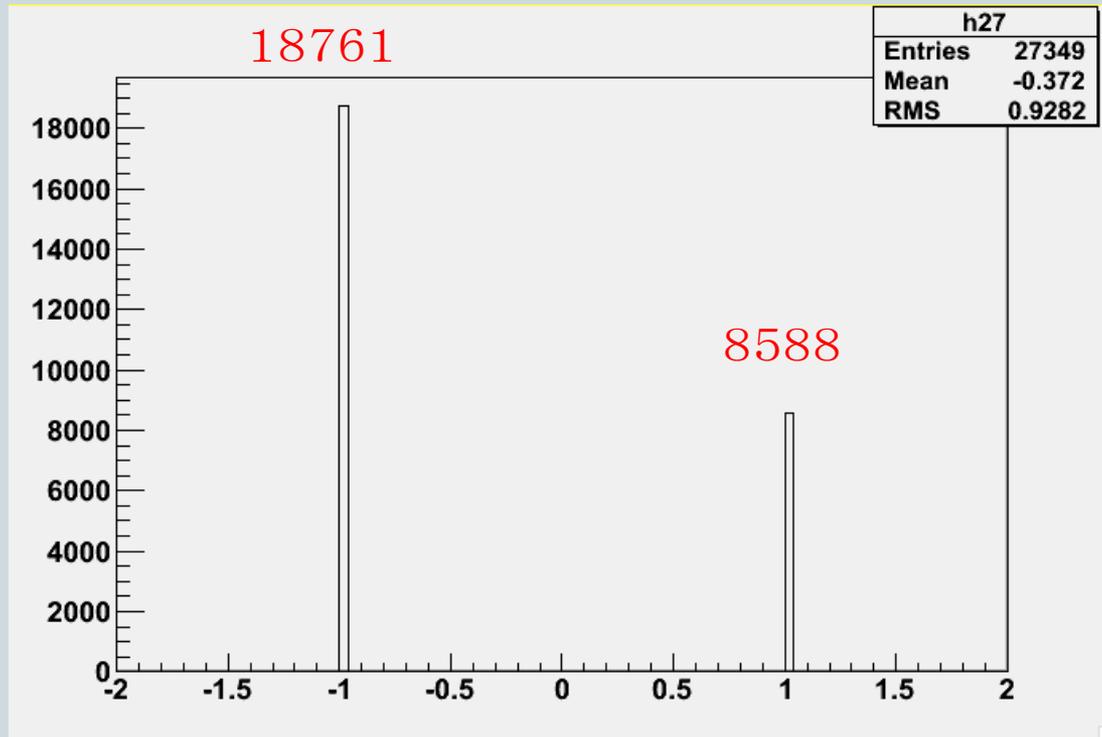
If so, Correct Assignment(CA)=+1.

If not so, CA=-1

# Correct Assignment( $\chi^2$ )

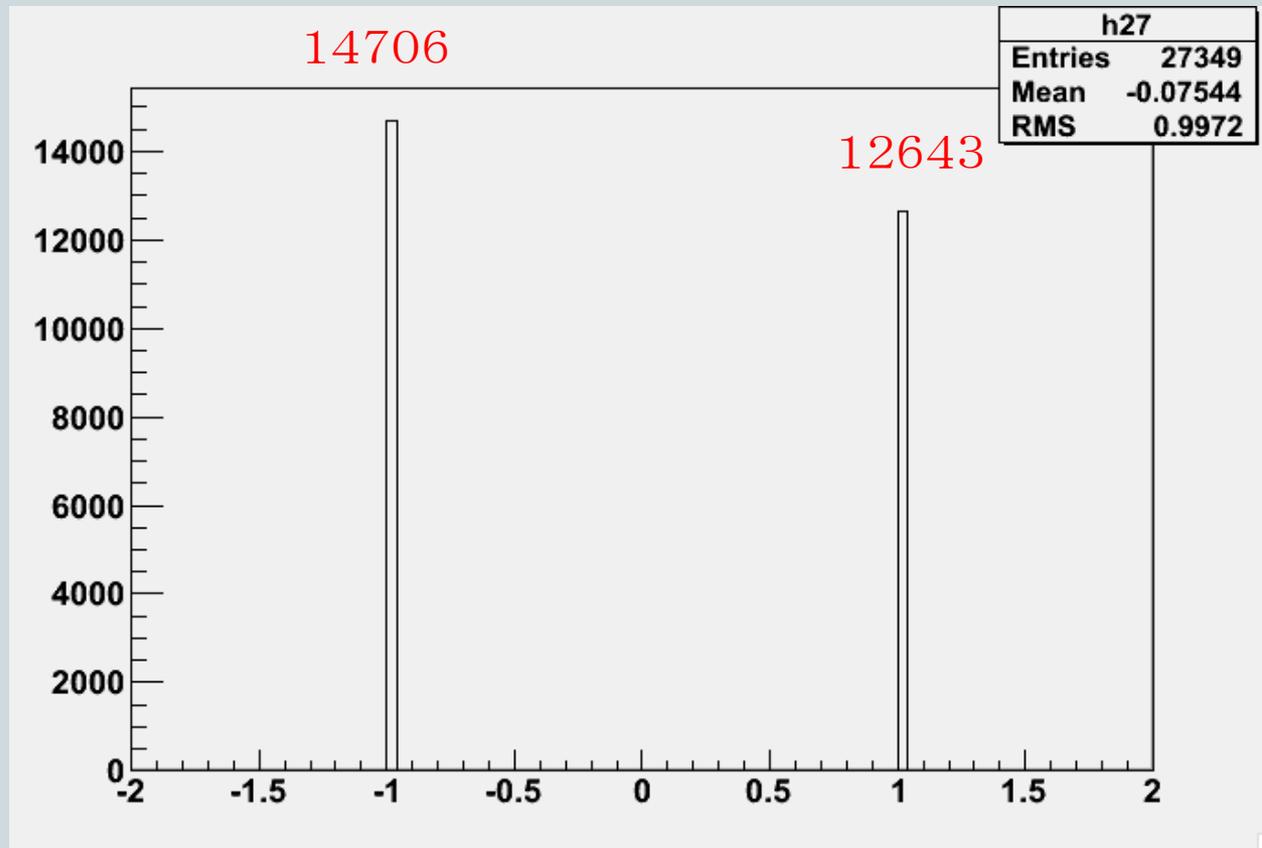
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$$\chi_{4\text{-Jet}}^2 = \frac{(m_t - m_{3jet})^2}{\sigma_{m_t}^2} + \frac{(m_w - m_{2jet})^2}{\sigma_{m_w}^2} + \frac{(m_t - m_{j+l+\nu})^2}{\sigma_{m_t}^2}$$



# Correct Assignment( $\cos\theta_{bW}$ is minimum)

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Correct events increase 14.8%

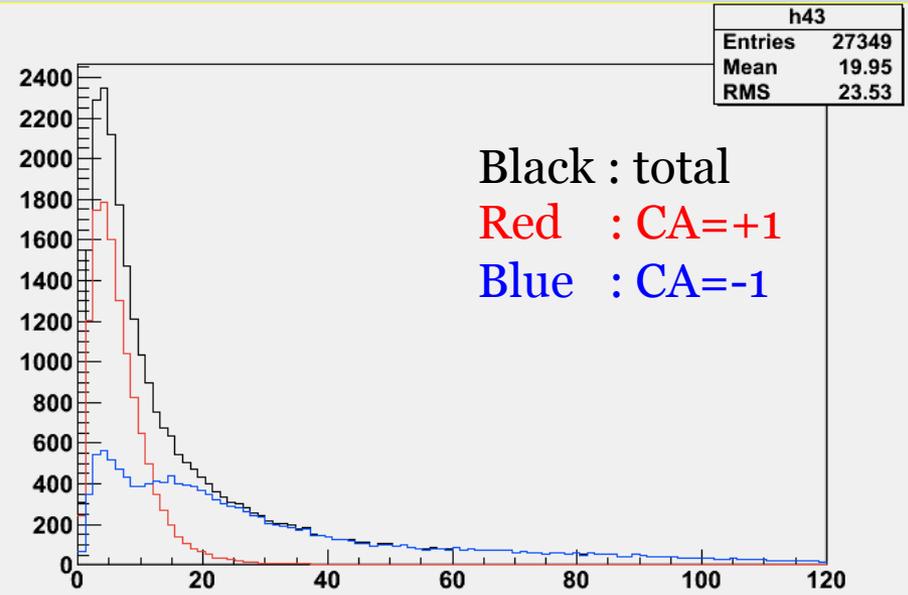
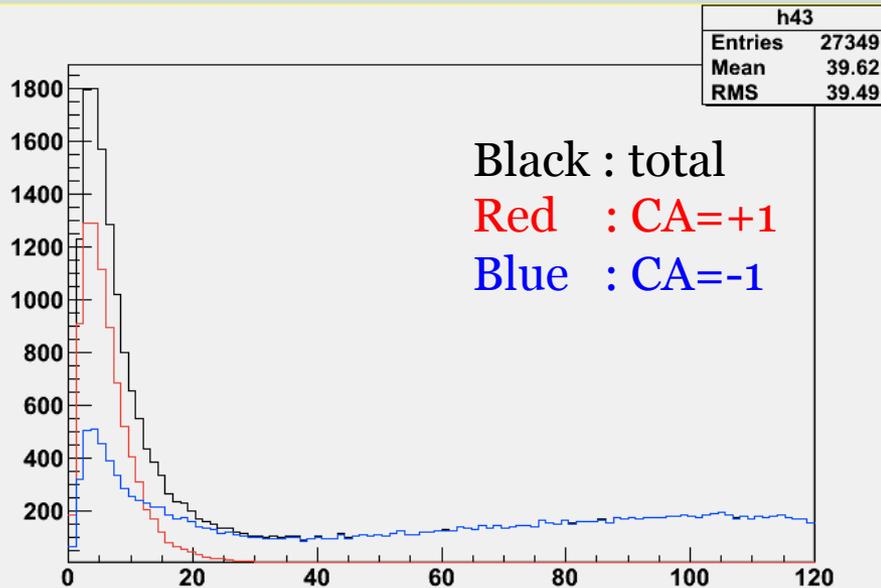
$$\Delta Pt = |Pt\_rec - Pt\_MC|$$

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$\chi^2_{4\text{-jet}}$  is minimum

$\cos\theta_{bW}$  is minimum ( $\theta \sim 2\pi$ )

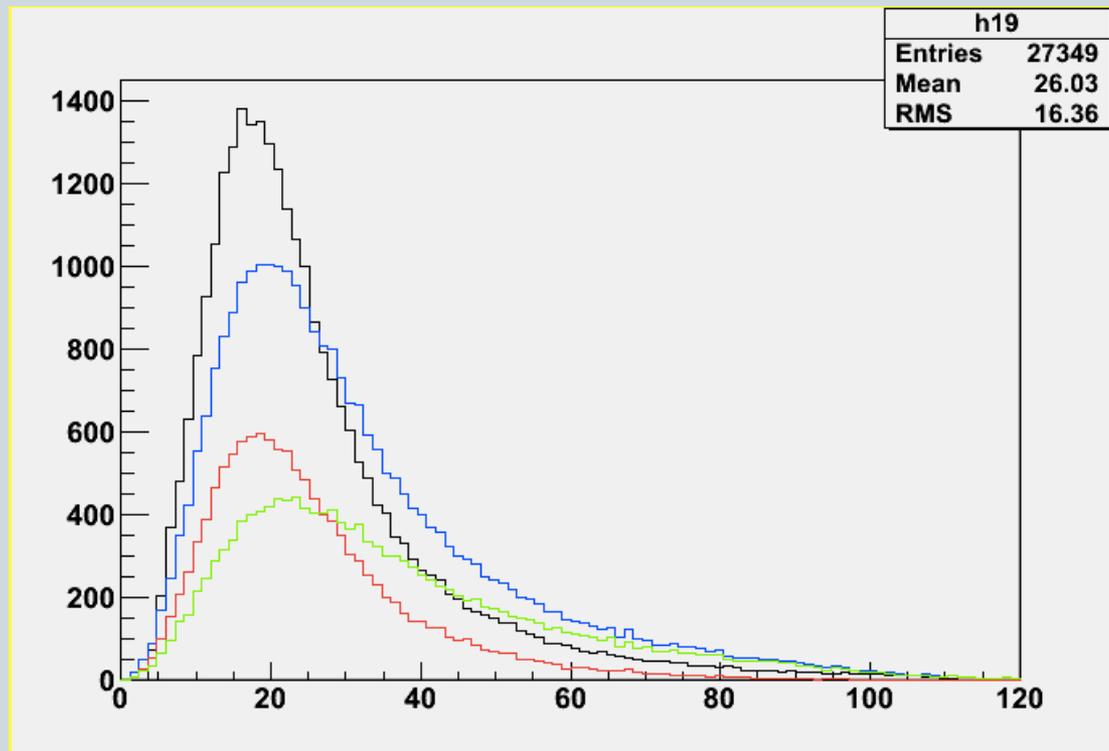
$$\chi^2_{4\text{-Jet}} = \frac{(m_t - m_{3jet})^2}{\sigma_{m_t}^2} + \frac{(m_w - m_{2jet})^2}{\sigma_{m_w}^2} + \frac{(m_t - m_{j+l+\nu})^2}{\sigma_{m_t}^2}$$



If we choose the CA=+1, large  $\Delta Pt (> 20\text{GeV})$  events decrease.

# Top Quark Momentum Distribution( $e_L-80, p_R+30$ )

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**Black** : MC truth (27349)

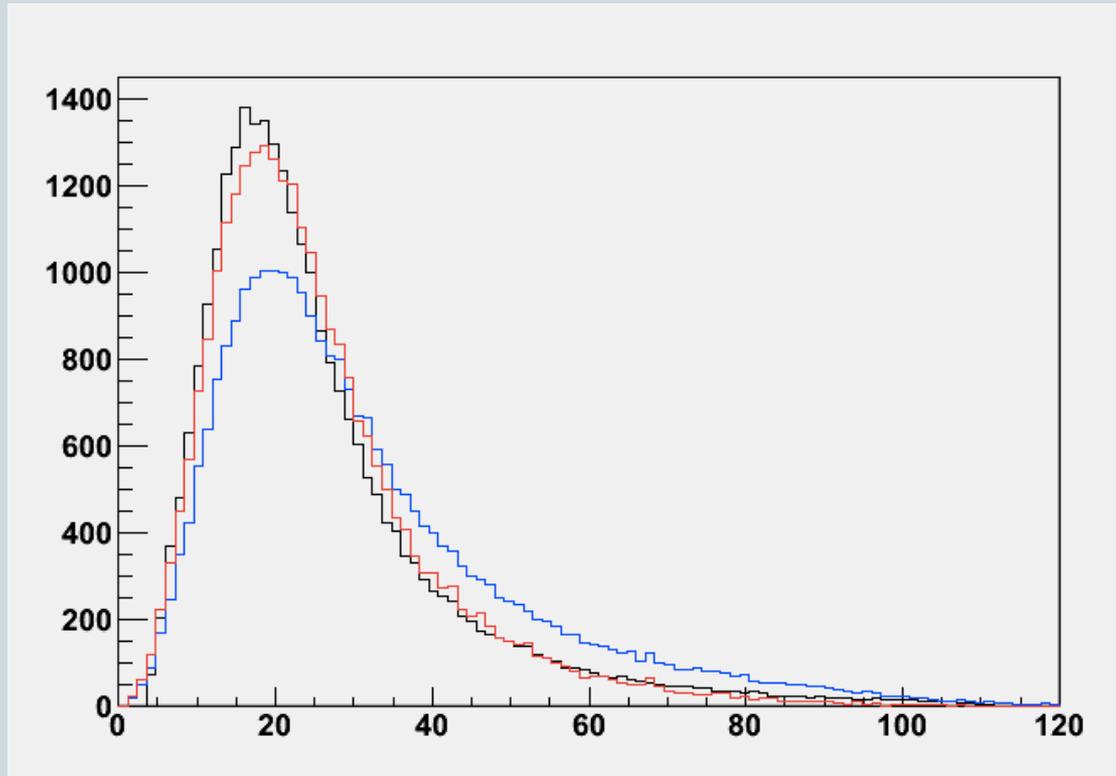
**Blue** : Reconstruct(Ozawa-san's result) (27349)

**Red** : Correct Assignment = +1 (12643)

**Green** : Correct Assignment = -1 (14706)

# Uniforming the Event Number (#=27349)

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Black : MC truth

Red : CA=+1

Blue : Ozawa-san's result

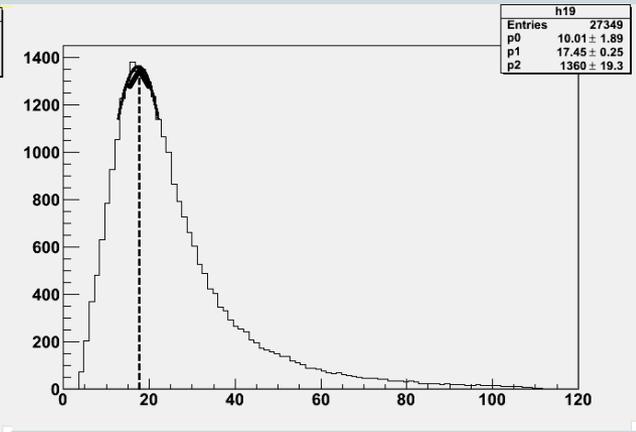
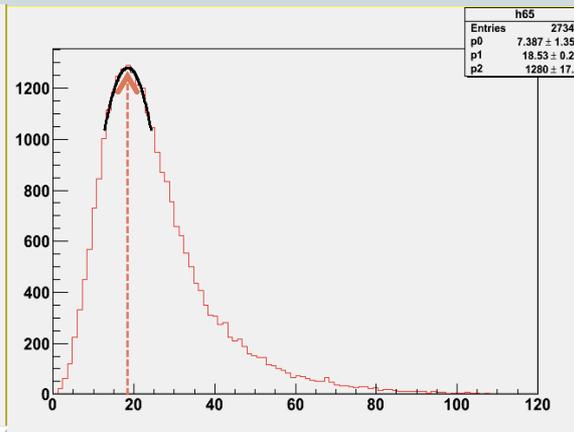
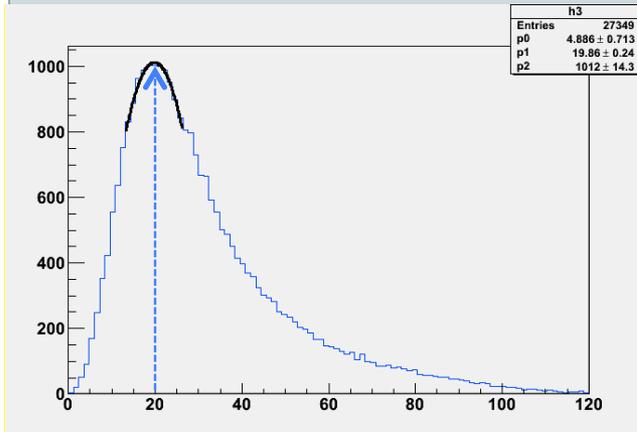
# Peak Position of Momentum Distribution

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Ozawa-san's result

CA=+1

MC truth



P\_peak =  $19.9 \pm 0.243$  GeV

P\_peak =  $18.5 \pm 0.248$  GeV

P\_peak =  $17.5 \pm 0.250$  GeV

The value of peak position closes to MC truth, but statistic uncertainty is not so good.

Peak :  $19.9 \rightarrow 18.5$

Statistic uncertainty :  $0.243 \rightarrow 0.248$

# Summary

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- We expect the precise measurement of top quark at the ILC in the threshold region of top pair production.
- Measuring the top momentum distribution and fitting the distribution into the distribution function which parameter is the top decay width, we can estimate the top decay width.
- If we define the Correct Assignment (CA) and require  $CA=+1$ , we can decrease the wrongly reconstructed top quark.
- If we require the  $CA=+1$ , The value of peak position closes to MC truth, but statistic uncertainty is not so good.

# Plan

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- I will explore the event of  $CA=-1$ , and I will check what is wrong.
- I will try to fit the top momentum distribution for all range, using the distribution function  $[f_{\text{momentum}}(\Gamma_{\text{top}})]$ .