Status and Plan for the Analyses of ttbar at threshold at the ILC

Akimasa Ishikawa

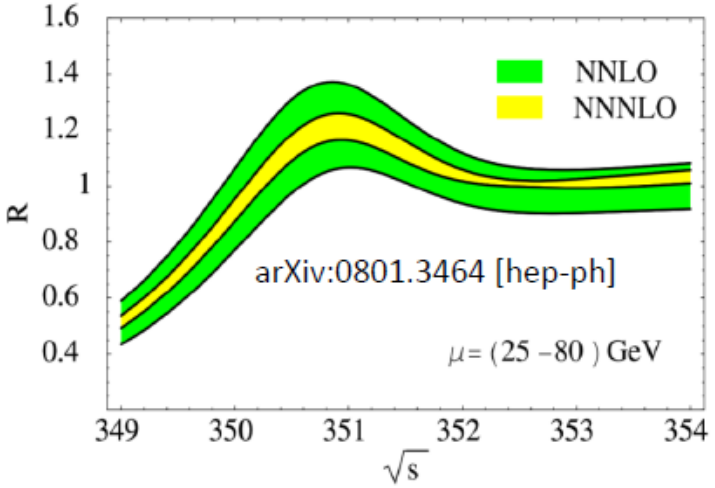
(Tohoku University)

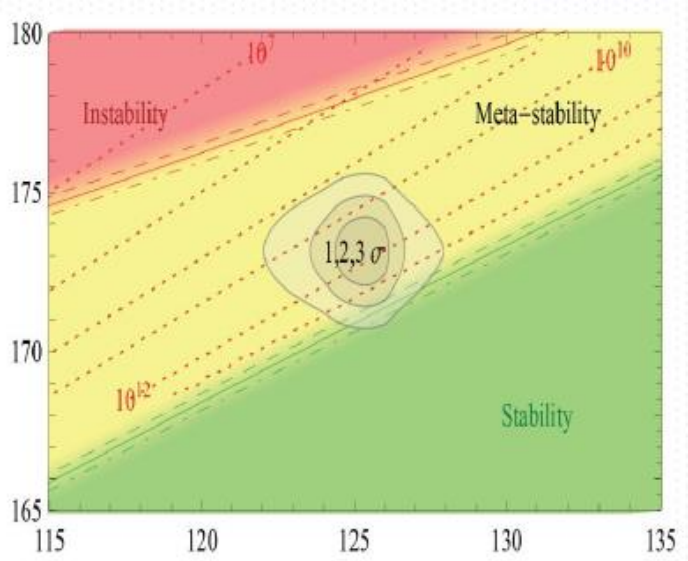
Analysis was done by T. Horiguchi

ttbar at threshold

- σ_{tt} VS √s is sensitive to
  - M_t
    - Theoretically well-defined running mass
    - Vacuum instability in the SM
  - Γ_t
    - Deviated from SM if new physics in decays
  - y_t
    - Higgs exchange diagram gives 9% enhancement
  - α_s
    - not yet done

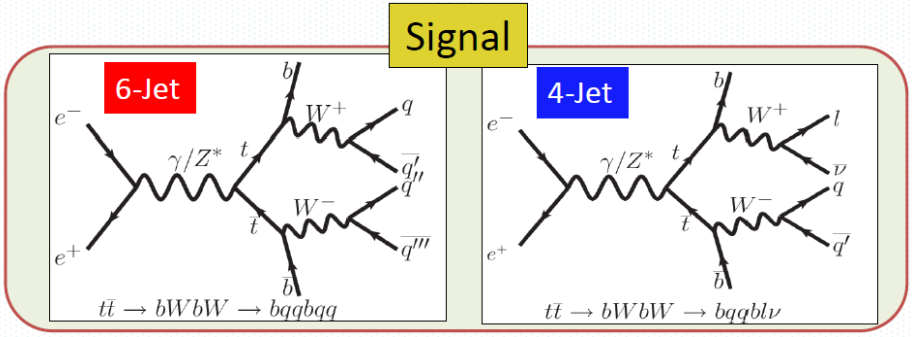
- Fit to σ_{tt} to obtain m_t, Γ_t and y_t simultaneously.





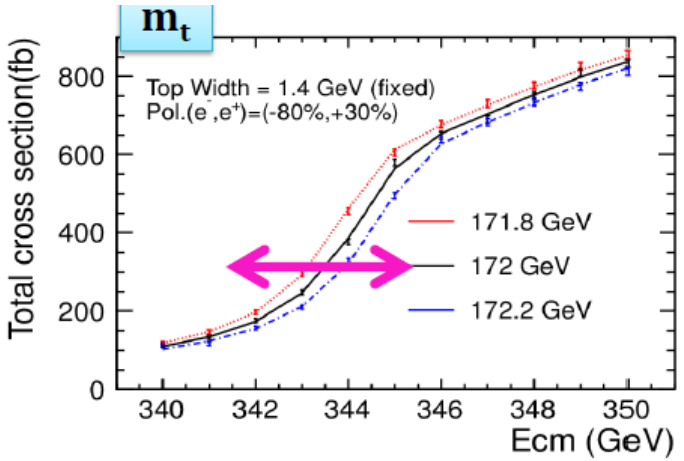
Simulation Setup

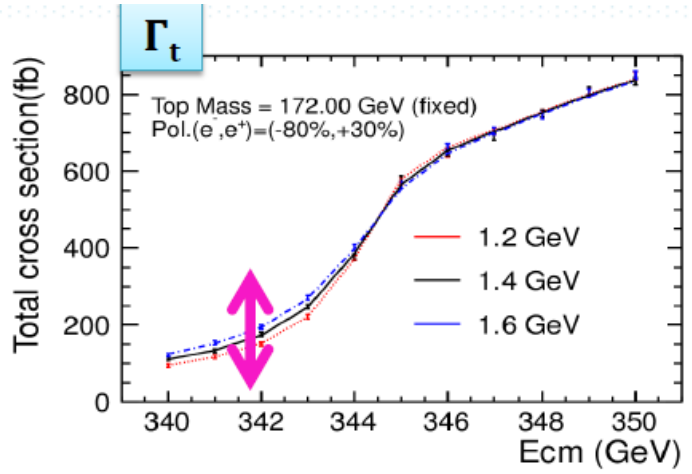
Top quark mass	174 GeV
$\sqrt{s}$ (threshold scan)	341 - 350GeV (every 1 GeV, 10 points)
Polarization	$p(e^+, e^-) = (-30\%, +80\%), (+30\%, -80\%)$ (In this talk, I call them "Right" and "Left")
Integrated Luminosity	5 fb^{-1} (each $\sqrt{s}$ & pol, total 100fb^{-1})
Event Generation	Physsim (LO ,QCD enhancement, on ISR/ beamstralung/beam energy spread)
Simulation	ILD_01_v05 (DBD ver.)



Fitting with templates

- fit to σ_{tt} with template to extract three variables, m_t, Γ_t and y_t simultaneously.
  - Two dimensional template (m_t, Γ_t)
  - y_t from normalization
  - α_s is fixed at 0.12
- Template is made from
  - Theoretical $\sigma_{tt}(s)$ from Kiyo-san (NLO calc)
  - Efficiency from Physsim (LO) and DBD setup





Results

Stat. Error (m_t , Γ_t :MeV/y_t:%)	6-Jet			4-Jet		
	m_t^{PS}	Γ_t	y_t	m_t^{PS}	Γ_t	y_t
Left(50fb^{-1})	47	65	9.6	52	71	11
Right(50fb^{-1})	68	94	14	75	106	16
Left (50fb^{-1}) + Right(50fb^{-1})	**39**	**53**	**7.9**	**43**	**59**	**9.1**

Combined ALL

m_t^{PS}(GeV)	Γ_t(GeV)	y_t
172±0.029	1.4±0.039	5.9 %

- German group estimated systematics to m_t from beam spectrum is ~80MeV. From theory is 100MeV
- y_t uncertainty from theory (error on total cross section ~4%) is 22%

Comparison with (2+1) and 3

- (2+1) par fit : m_t and Γ_t simultaneously. y_t from normalization
- 3 par fit : all simultaneously
- Mt worse than (2+1) fit
- Simultaneous fit gives correct error matrix

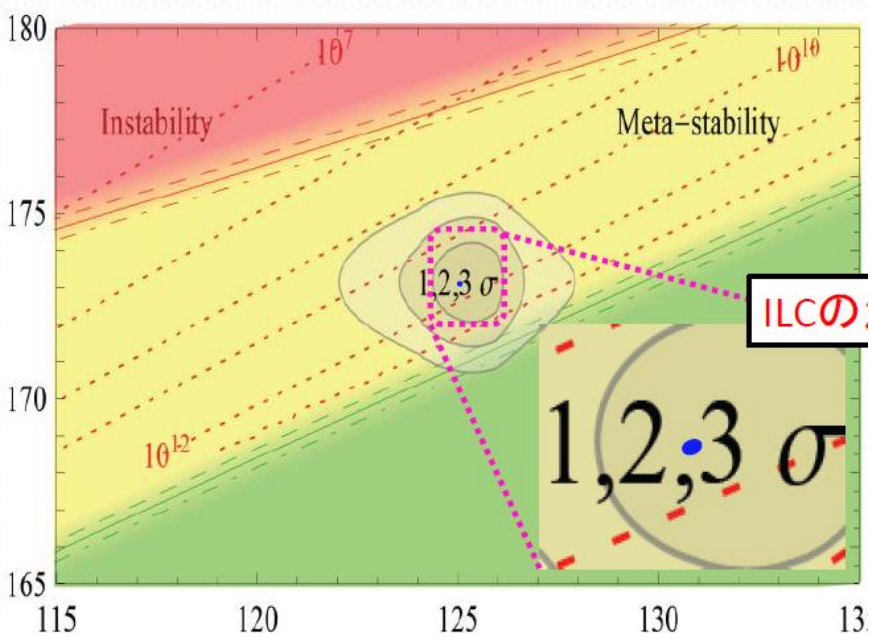
	(2 + 1) param fit	3 param fit
m_t	19 MeV	29 MeV
Γ_t	38 MeV	39 MeV
y_t	4.6%	5.9%

Correlation coefficients

	(2 + 1) param fit	3 param fit
m_t vs Γ_t	0.52	0.57
m_t vs y_t	-	0.72
Γ_t vs y_t	-	0.33

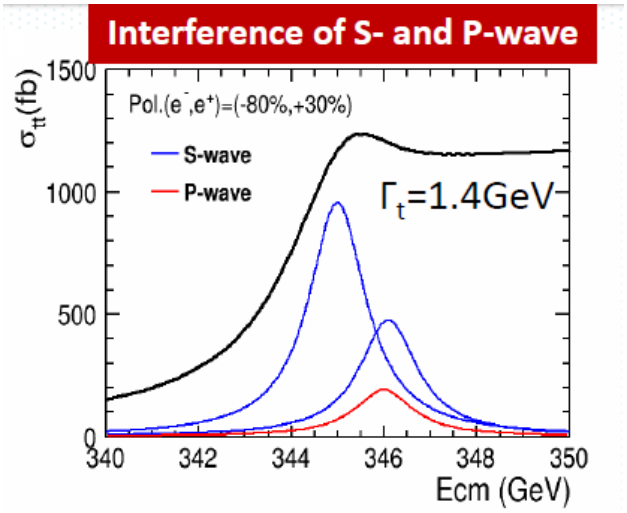
Vacuum instability

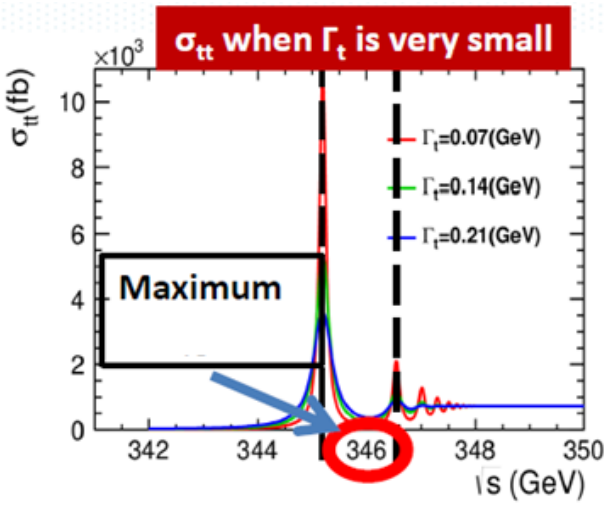
- Only stat error



Forward-Backward Asymmetry

- From S and P waves interference, A_{FB} is generated at threshold which is sensitive to Γ_t and α_s which controle the overlap of S and P waves.





- To identify the charge, 4jets+lepton mode is used.
- We choose the √s=346GeV which gives the maximum interference

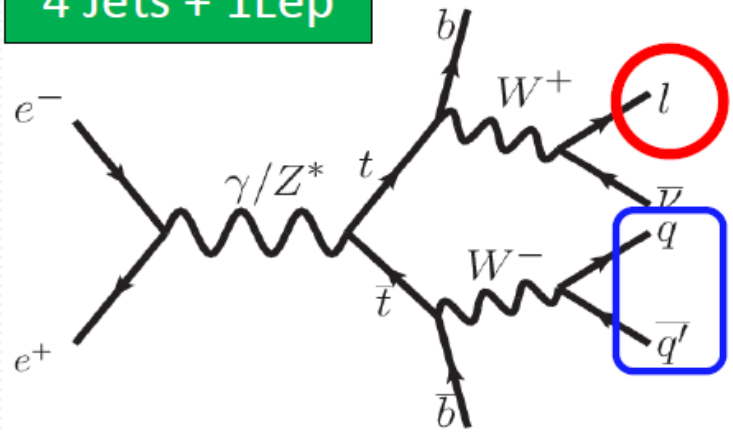
Setup

√s = 346 GeV (between S- and P- wave)

$\mathcal{L}$ = 50fb^{-1} (e+,e-) = (+0.3, -0.8)

$\mathcal{L}$ = 50fb^{-1} (e+,e-) = (-0.3, +0.8)

Signal
4 Jets + 1Lep

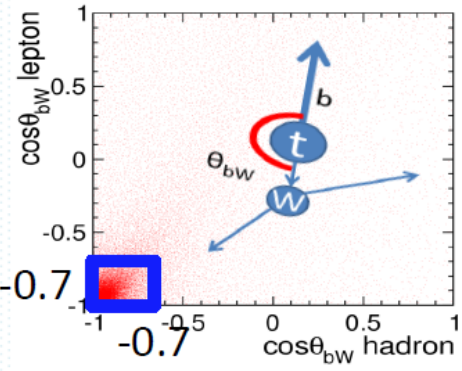


$t\bar{t} \rightarrow bWbW \rightarrow bqqbl\nu$

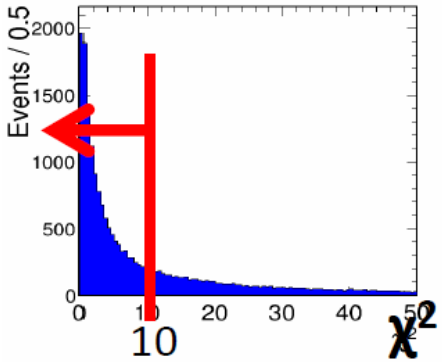
Reconstruction

- To get correct combination, several selections are applied.
- 38% efficiency

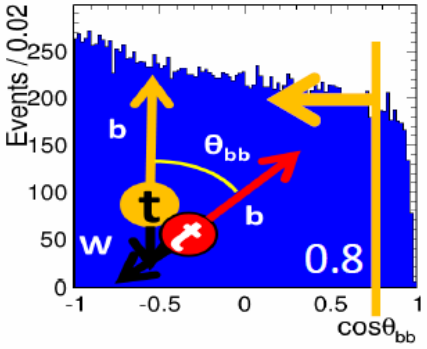
Angle of b and W at rest frame



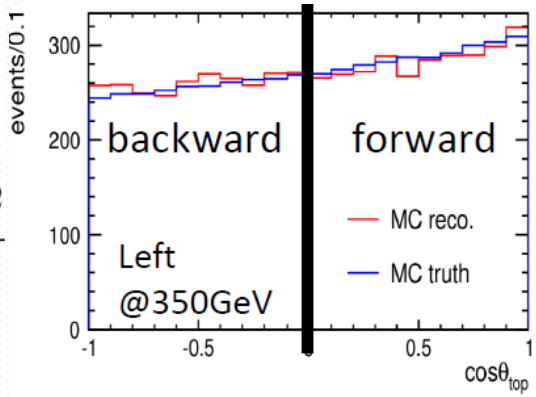
X² from mass

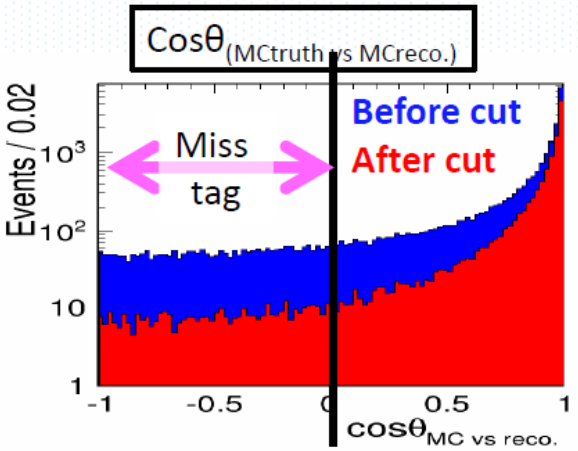


Closeness of 2 b quarks



Angle distribution after the selections.





$$\chi^2 = \frac{(m_t - m_{3j})^2}{\sigma_t^2} + \frac{(m_t - m_{jl\nu})^2}{\sigma_t^2} + \frac{(m_w - m_{2j})^2}{\sigma_w^2}$$

Cut for top ID

$\cos\theta_{bW} < -0.7$, $X^2 < 10$, $\cos\theta_{bb} < 0.8$

Misreconstruction is reduced.

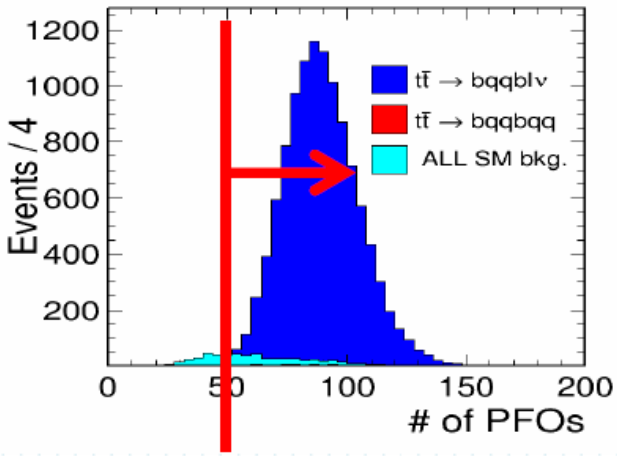
13% ⇒ 3.7 %

Cut flow tables

- For maximizing the significance (S_{top}), bkg. are rejected.

$$S_{top} = \frac{N_{signal}}{\sqrt{N_{signal} + N_{bkg.}}}$$

- # of PFOs is used except top tagging cut (previous page).



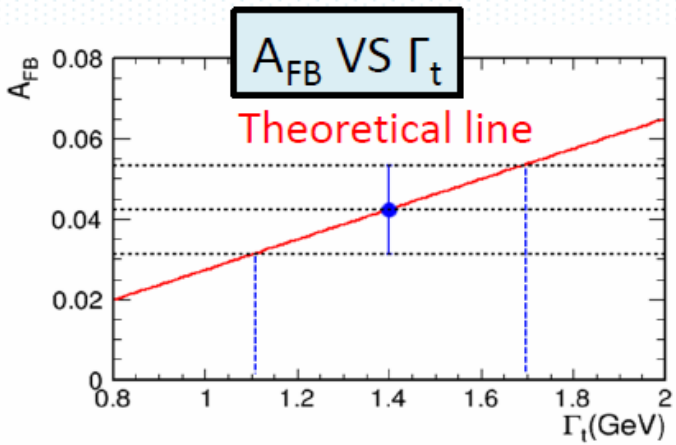
Left 50fb^{-1}	tt4j	tt6j	tt2j	SM bkg.	S_{top}	Efficiency
Gen.	12619	13101	3039	1 M	12.2	100
# of l_{iso} = 1	9648	418	909	0.3M	16.9	76.5
$\cos\theta_{bW}$<-0.7	8989	397	834	0.2M	18.4	71.2
X^2<10	6856	65	164	13134	48.2	54.3
$\cos\theta_{bb}$<0.8	4881	3	6	271	67.9	38.7
# of PFOs > 50	4872	3	4	182	**68.5**	**38.6**

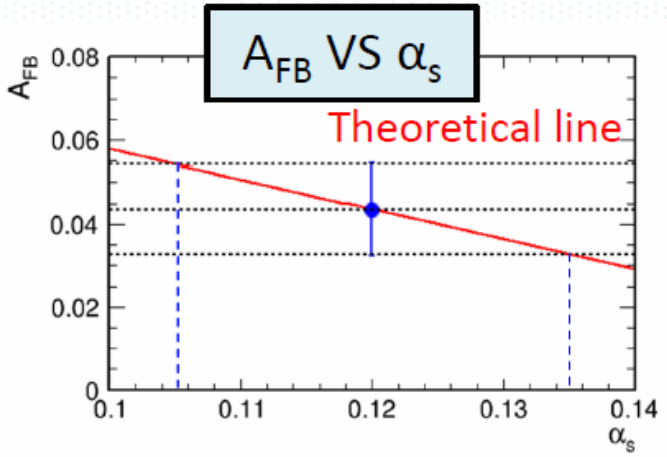
Results

From the 1σ error, we estimate the accuracy of Γ_t and α_s.

Center value is A_{FB}= 0.0427

50 fb^{-1}	# of events (NNLO)	δA_{FB}
Left handed	5537	0.013
Right handed	2564	0.020
Left + Right (100 fb^{-1})	8101	0.011





Red lines show theoretical line assuming polarization of (e^+, e^-)=(0,0).
Theoretical calculation for polarized case is not calculated.
In the future when ILC will be built, theorists will calculate it.

$\mathcal{L}$ = 100 fb^{-1} $\delta\Gamma_t$ = 290 MeV, $\delta\alpha_s$ = 0.015

Summary

- We measured m_t, Γ_t and $y\tau$ from cross section VS $\sqrt{s}$
  - δm_t = 29MeV
  - $\delta \Gamma_t$ = 39MeV
  - δy_t = 5.9%

- We also measured AFB to extract α_s and Γ_t
  - $\delta \Gamma_t$ = 39MeV
  - $\delta \alpha_s$ = 0.015 (not so sensitive)

  - We need some improvement

Plan

- Publication. Horiguchi is preparing the paper drafts.

- Systematic error from beam spectrum
  - Which is also important for m_H (and m_W) measurement.
- Crosssection fit to extract four parameters simultaneously
  - M_t, Γt , Y_t and α_s
  - strong correlation btw Γt and α_s?
- Improvement of Forward-Backward Asymmetry
  - Inclusion of 2jet+dilepton (and 6jets?) channel with charge ID.
- Top momentum measurement
  - Γ_t
- Coupling measurements
  - Angular analysis with polarized beam

backup

Selection Table @ √s= 350GeV

Table : 6-Jet Left handed

$$\int \mathcal{L}(t)dt = 5(\mathrm{fb}^{-1}) \quad S = \frac{N}{\sqrt{N_{Sig}}}$$

(e+,e-)=(+30,-80%)	tt6j	tt4j	tt2j	SM bkg.	S_{6j}	ε_{6j}
Generated	1643	1583	381	0.13M	4.4	10
# of lepton = 0	1590	353	18	0.11M	5.0	96
btag > 0.09 × 2	1499	330	17	19336	10.3	91
Thrust<0.825	1439	285	11	2447	22.3	87
Evis>300 GeV	1424	61	0	1092	28.0	86
m_t>107 GeV × 2	1383	37	0	492	31.6	84
# of pfos>84	1376	33	0	442	32.0	83
y45> 0.0012 y56 >0.0006	1362	31	0	392	32.2	82
Sphericity>0.22	1347	24	0	329	**32.7**	**82.**

√s=350 GeV	$S_{n\text{-Jet}}$	$\varepsilon_{n\text{-Jet}}$
6-Jet (e+,e-)=(-30, +80%)	23.5	84.6
4-Jet (e+,e-)=(+30, -80%)	31.0	66.3
4-Jet (e+,e-)=(-30, +80%)	21.9	68.2