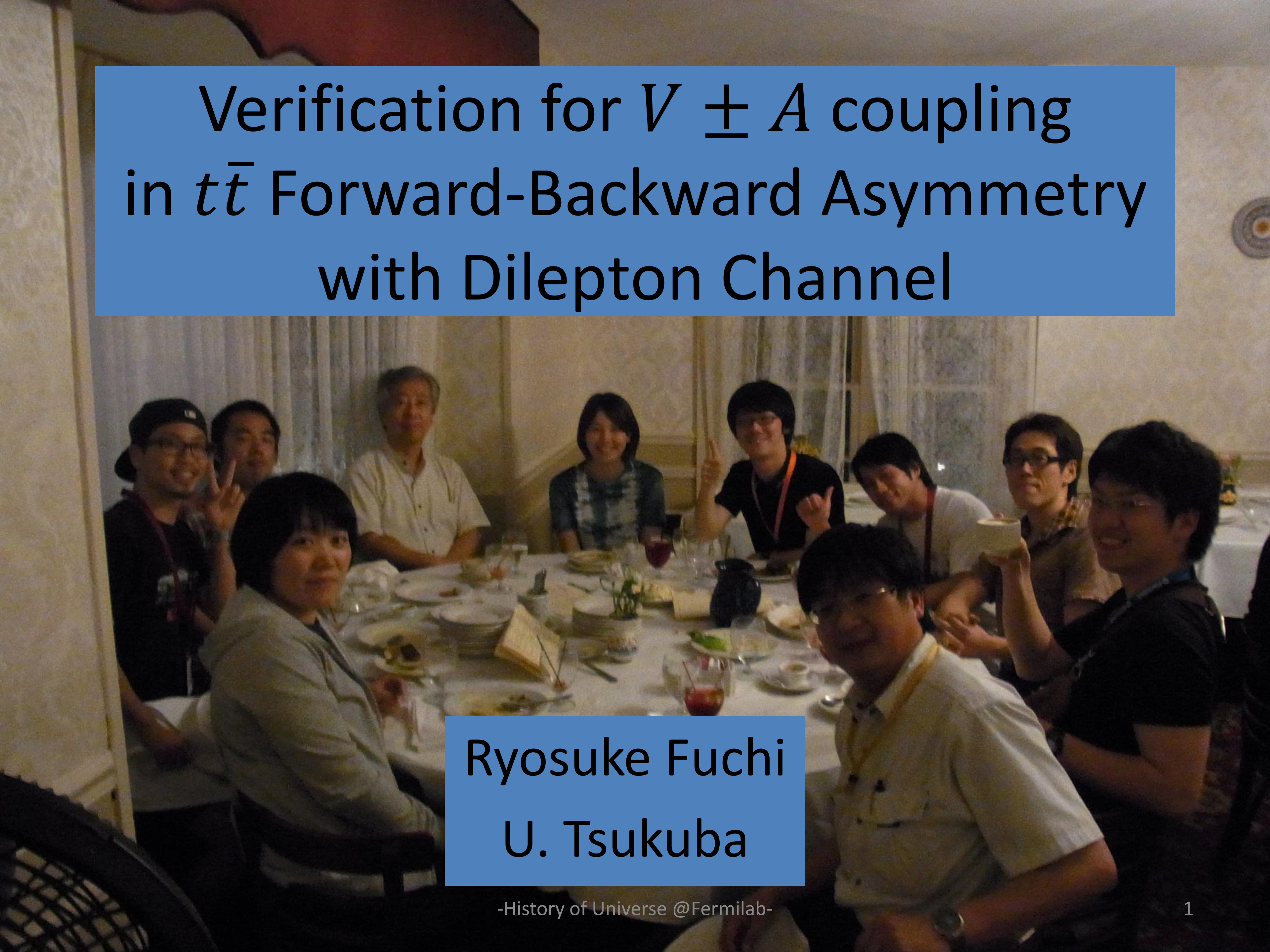

Verification for $V \pm A$ coupling in $t\bar{t}$ Forward-Backward Asymmetry with Dilepton Channel

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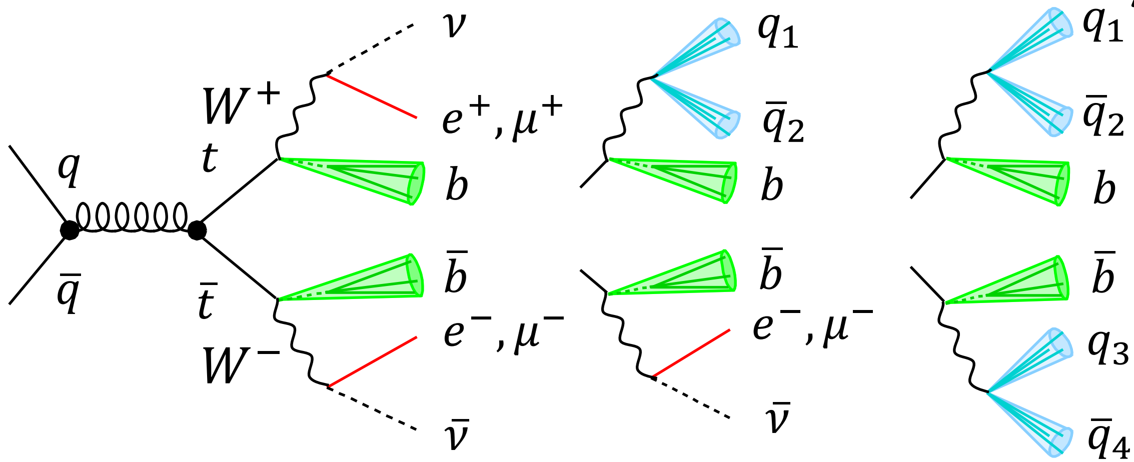
U. Tsukuba

Outline

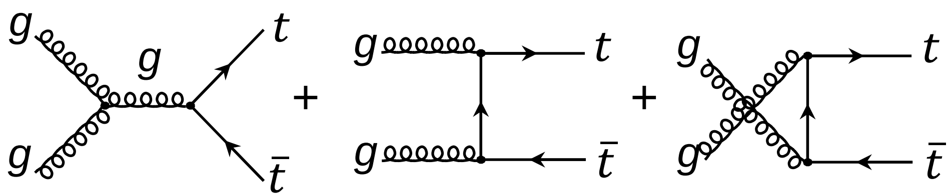
-Motivation
-Analysis Flow
-Weighting by Matrix Element
-Production Angle
-Δy for ttbar, $\Delta\eta$ for leptons asymmetry

ttbar Production & Decay

85%



15%



Dilepton
- 2 lepton
- 2 *b*-jet
- MET

Lepton+Jet
- 1 lepton
- 4 jet(2 *b*-jet)
- MET

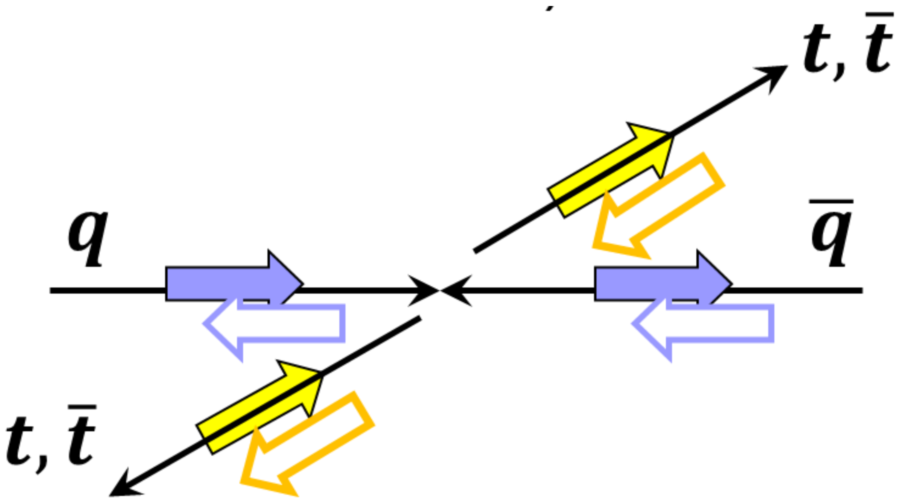
All Hadronic
- 6 jet(2 *b*-jet)

Categorize ttbar events into 3 decay types according to W decay mode

Production Angle of top quark (V)

assume " V " coupling

-spins in the initial state face in same direction
-spins in the final state also tend to face in same direction when they are relativistic
-ttbar don't have favorite direction



Production Angle ($V \pm A$)

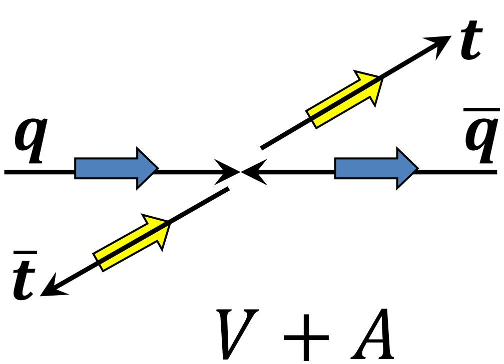
assume " $V \pm A$ " coupling

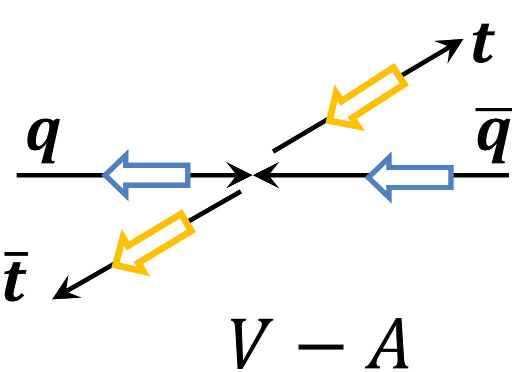
-proton direction is favored for top in both cases of $V \pm A$

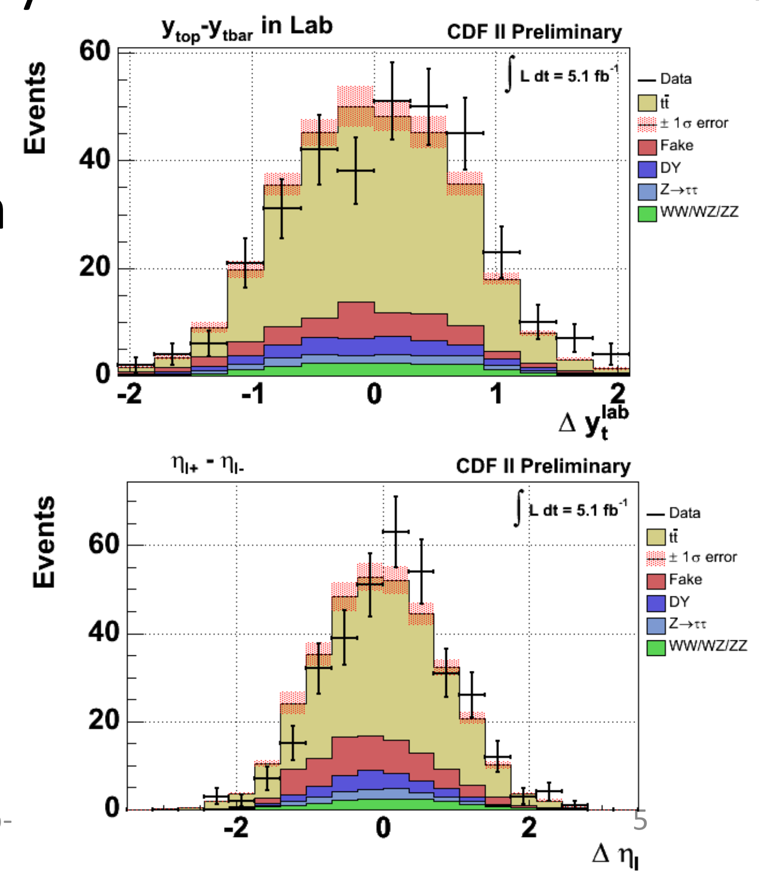
→"Positive Forward – Backward Asymmetry "

→ $\Delta y = y_t - y_{\bar{t}}$ has " + " bias

-CDF suggests larger positive asymmetry in Δy for tt, $\Delta\eta$ for ll







Analysis Flow

Determine ttbar's spinors from flight direction of a lepton

↓

Calculate the Matrix Elements of V, V-A and V+A coupling

↓

Generate events put event-by-event weight of $\frac{\Sigma_{qq}\left|\mathfrak{M}_{V,V\pm A}\right|^2}{\Sigma_{qqtt}\left|\mathfrak{M}_{V}\right|^2}$

↓

Evaluate the ttbar Asymmetry from the distribution of the Δy, $\Delta\eta$, distribution of flight direction of lepton

Kota Kasahara will talk

Generate $V, V \pm A$ Events

We use MC events of qqbar->ttbar in ttop25, where spin correlation is not taken into account. (correspond to $\Sigma_{qqtt}|\mathfrak{M}_V|^2$)

→put event-by-event weight of $\frac{\Sigma_{qq}\left|\mathfrak{M}_{V,V\pm A}\right|^2}{\Sigma_{qqtt}|\mathfrak{M}_V|^2}$

$$\mathfrak{M}_V \propto \left(\overline{v}_{\bar{q}}\gamma^{\mu}u_q\right)(\bar{u}_t\gamma^{\mu}v_{\bar{t}})$$
$$\mathfrak{M}_{V\pm A} \propto \left(\overline{v}_{\bar{q}}\gamma^{\mu}(1\pm\gamma^5)u_q\right)(\bar{u}_t\gamma^{\mu}(1\pm\gamma^5)v_{\bar{t}})$$

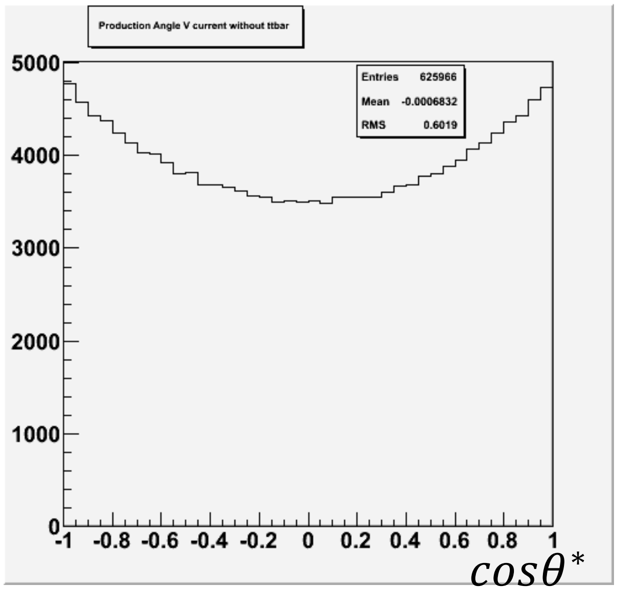
where $u_t = N_t\begin{pmatrix}\phi_t \\ \alpha\sigma_3\phi_t\end{pmatrix}, v_{\bar{t}} = N_{\bar{t}}\begin{pmatrix}-\alpha\sigma_3\chi_{\bar{t}} \\ \chi_{\bar{t}}\end{pmatrix}$

with $\phi_t(\theta_{\bar{l}},\phi_{\bar{l}}) = \begin{pmatrix}e^{-i\phi_{\bar{l}}/2}cos\frac{\theta_{\bar{l}}}{2} \\ e^{i\phi_{\bar{l}}/2}sin\frac{\theta_{\bar{l}}}{2}\end{pmatrix}, \chi(\theta_l,\phi_l) = \begin{pmatrix}-e^{-i\phi_l/2}cos\frac{\theta_l}{2} \\ -e^{i\phi_l/2}sin\frac{\theta_l}{2}\end{pmatrix}$

ttbar's spinors are determined from flight direction of leptons, and we can calculate ME using them at event-by-event

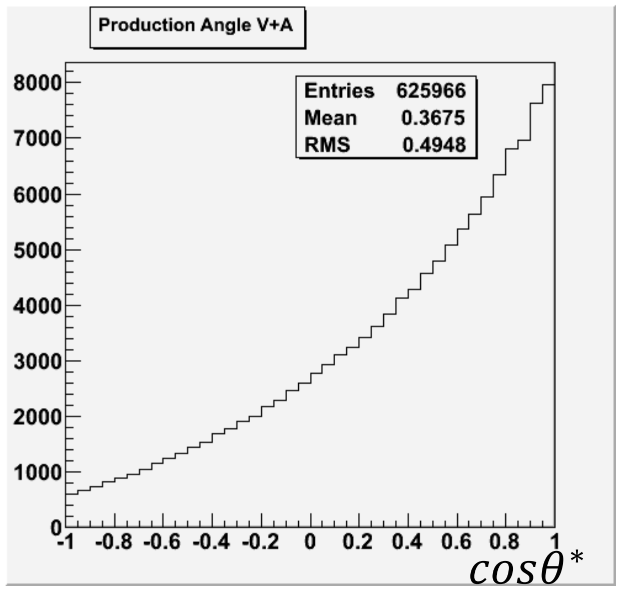
Production Angle of Top quark

V



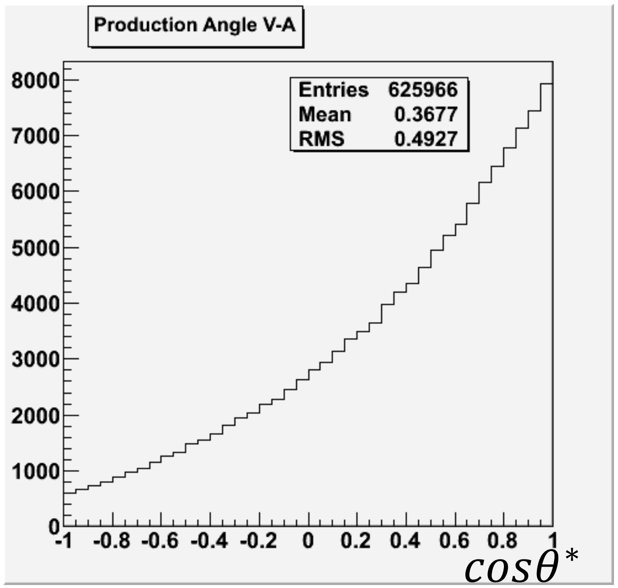
no favorite direction

V+A

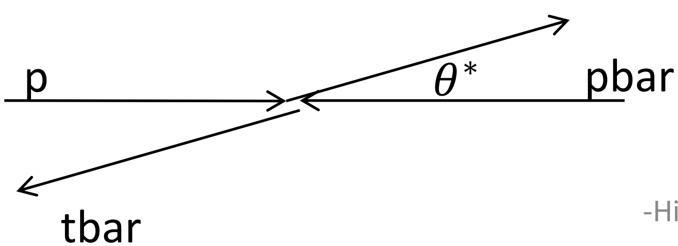


same as direction of proton

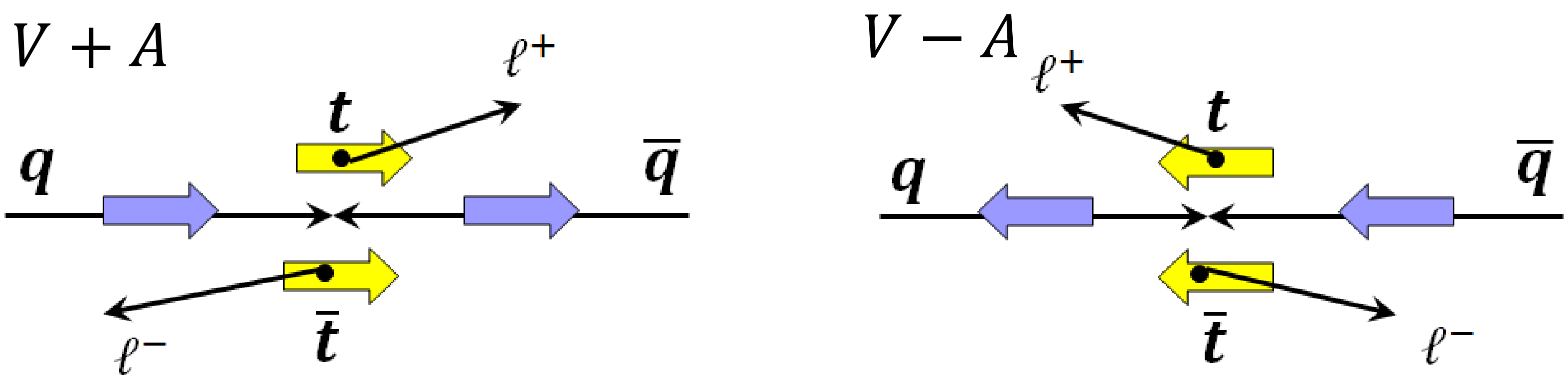
V-A



same as direction of proton



$\Delta\eta$ for leptons



$\Delta\eta$ asymmetry for leptons

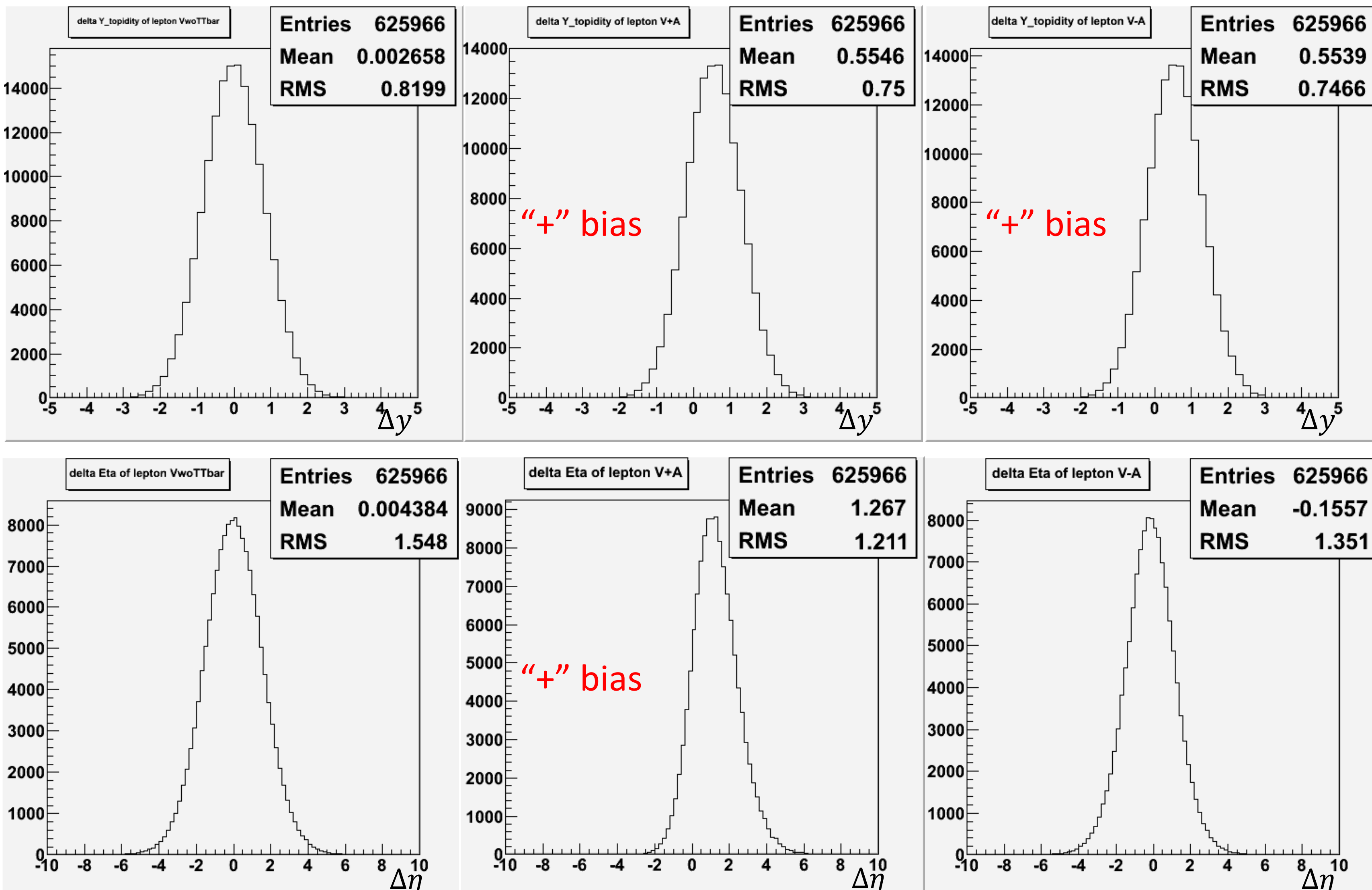
in case of V+A, A($\Delta\eta$) inheriting from A(Δy_t) is enhanced
in case of V-A, A($\Delta\eta$) inheriting from A(Δy_t) is suppressed

Δy and $\Delta \eta$ distribution

V V+A V-A

Δy

$\Delta \eta$



Δy , $\Delta\eta$ Asymmetry

$$Asymmetry \equiv \frac{N_+ - N_-}{N_+ + N_-}$$

	V	V+A	V-A
Δy	-0.002 ± 0.003	0.538 ± 0.002	0.541 ± 0.002
$\Delta\eta$	0.001 ± 0.003	0.722 ± 0.002	-0.095 ± 0.002

MC.Stat.Only

for V+A, A$(\Delta\eta)$ is enhanced,

for V-A, A$(\Delta\eta)$ is suppressed

Same positive A(Δy) in both cases of V+A and V-A

Production Angle after E.S.

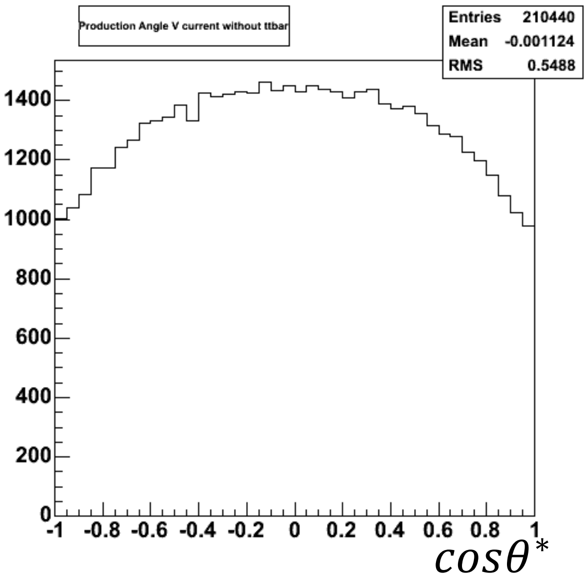
Event Selection

$leptons; P_t \geq 20\ GeV\ , |\eta| \leq 1.0$

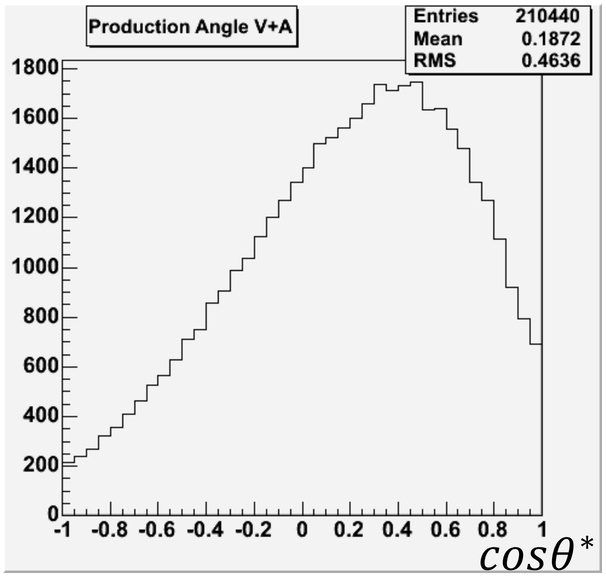
$b\ jets; P_t \geq 15\ GeV, |\eta| \leq 2.5$

$MET \geq 20\ GeV$

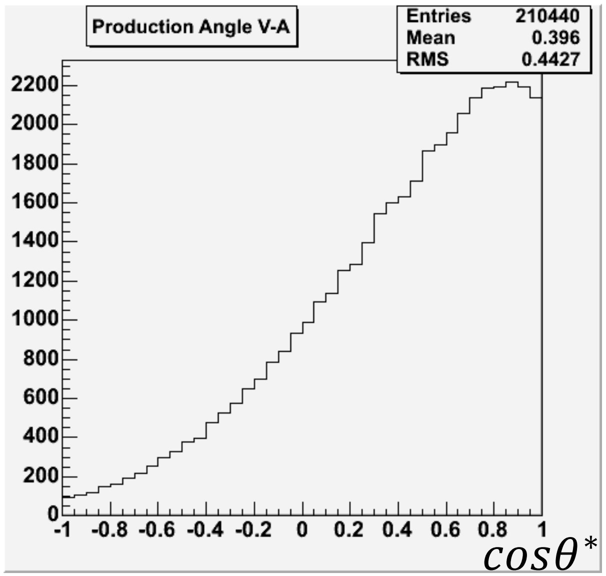
V



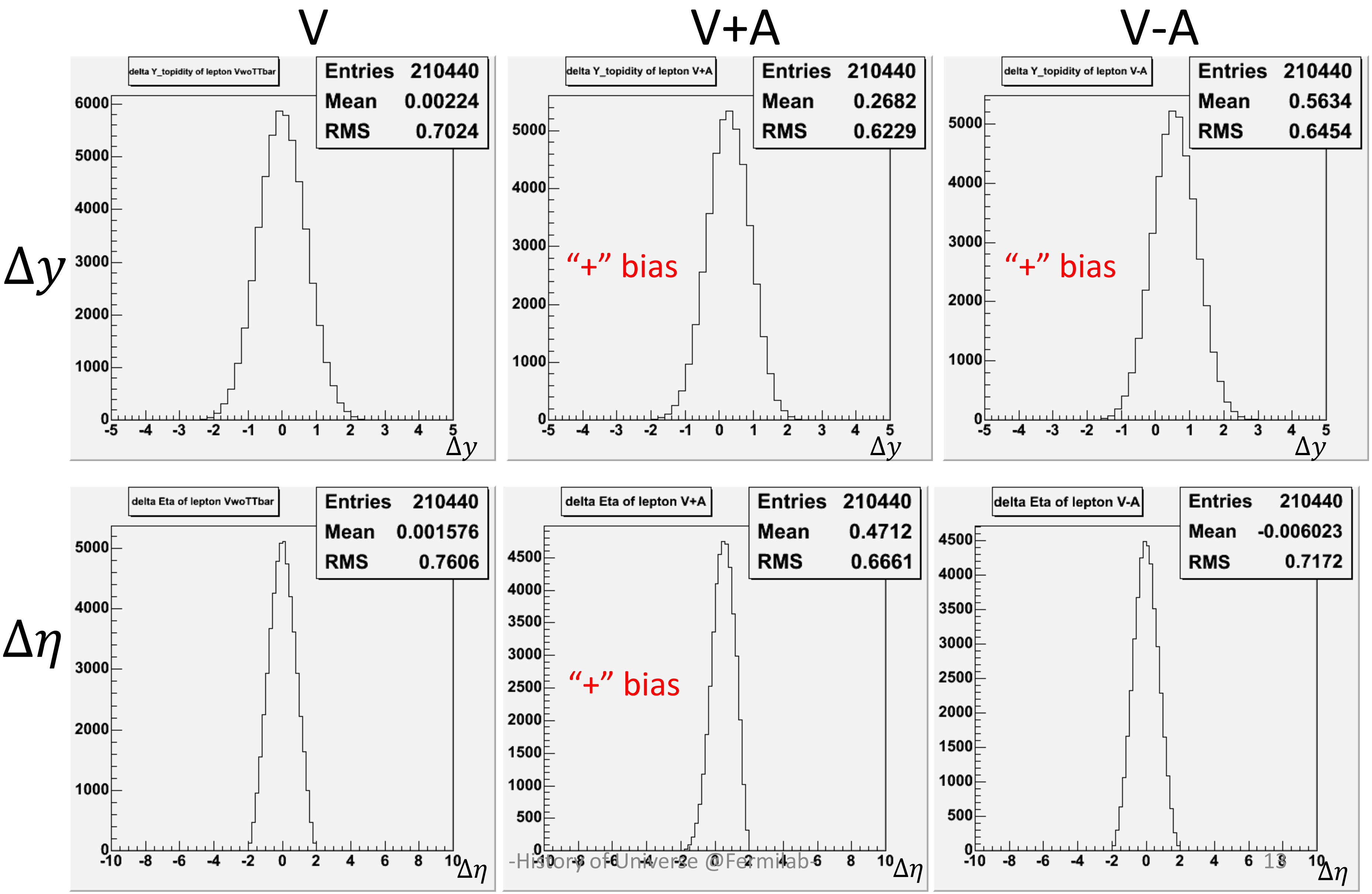
V+A



V-A



Δy and $\Delta\eta$ distribution after E.S.



Δy and $\Delta\eta$ Asymmetry after E.S.

$$Asymmetry \equiv \frac{N_+ - N_-}{N_+ + N_-}$$

	V	V+A	V-A
Δy	-0.003 ± 0.004	0.332 ± 0.005	0.614 ± 0.004
$\Delta\eta$	0.000 ± 0.004	0.517 ± 0.004	-0.001 ± 0.005

MC.Stat.Only

for V+A, A$(\Delta\eta)$ is enhanced,
for V-A, A$(\Delta\eta)$ is suppressed
positive A(Δy) in both cases of V+A and V-A

Summary

-can be measured “POSITIVE” A(Δy) if V-A or V+A coupling
-can be measured “POSITIVE” A($\Delta \eta$) if V+A coupling
(for V-A, A$(\Delta \eta)$ is suppressed)

Plan

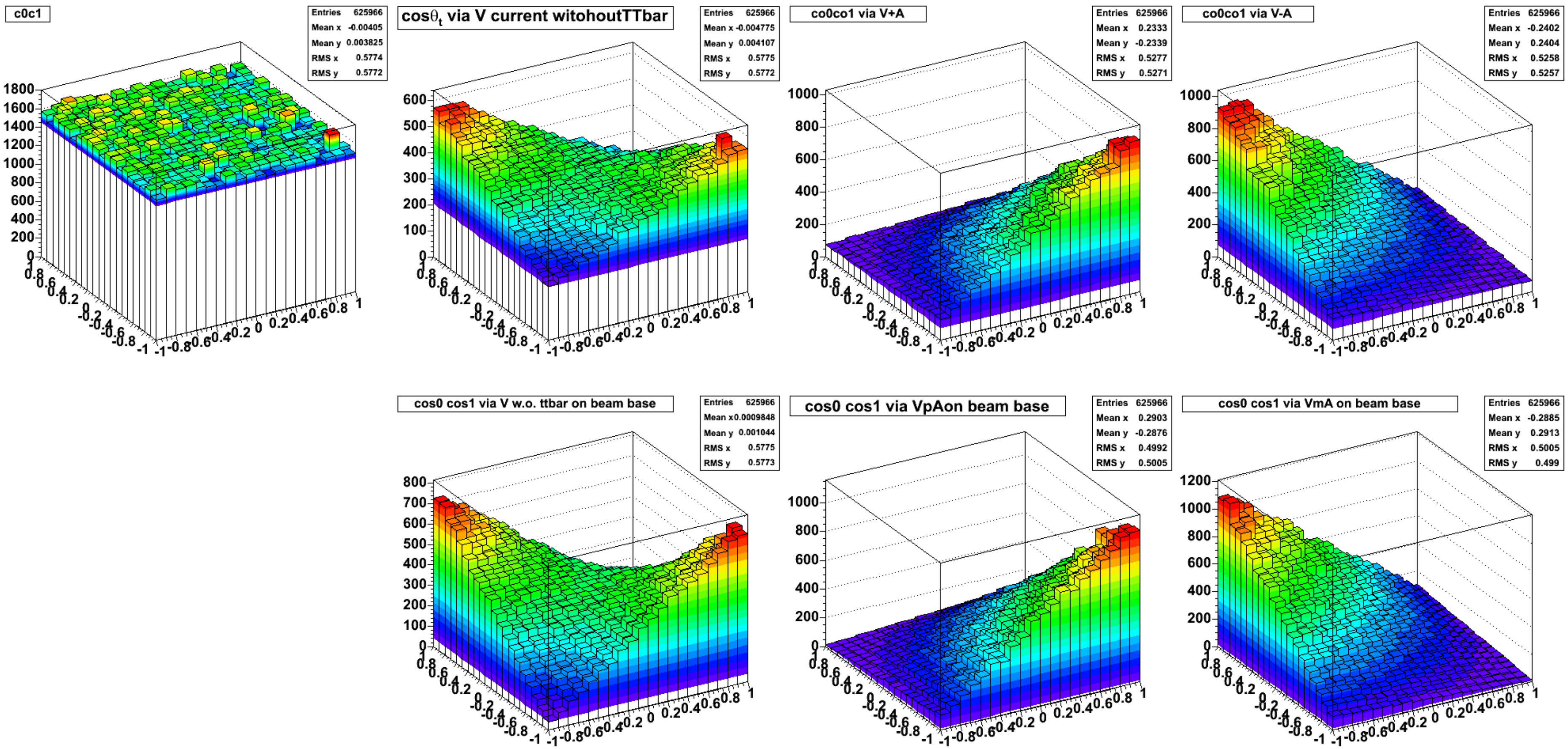
-take into account the detector acceptance

The End

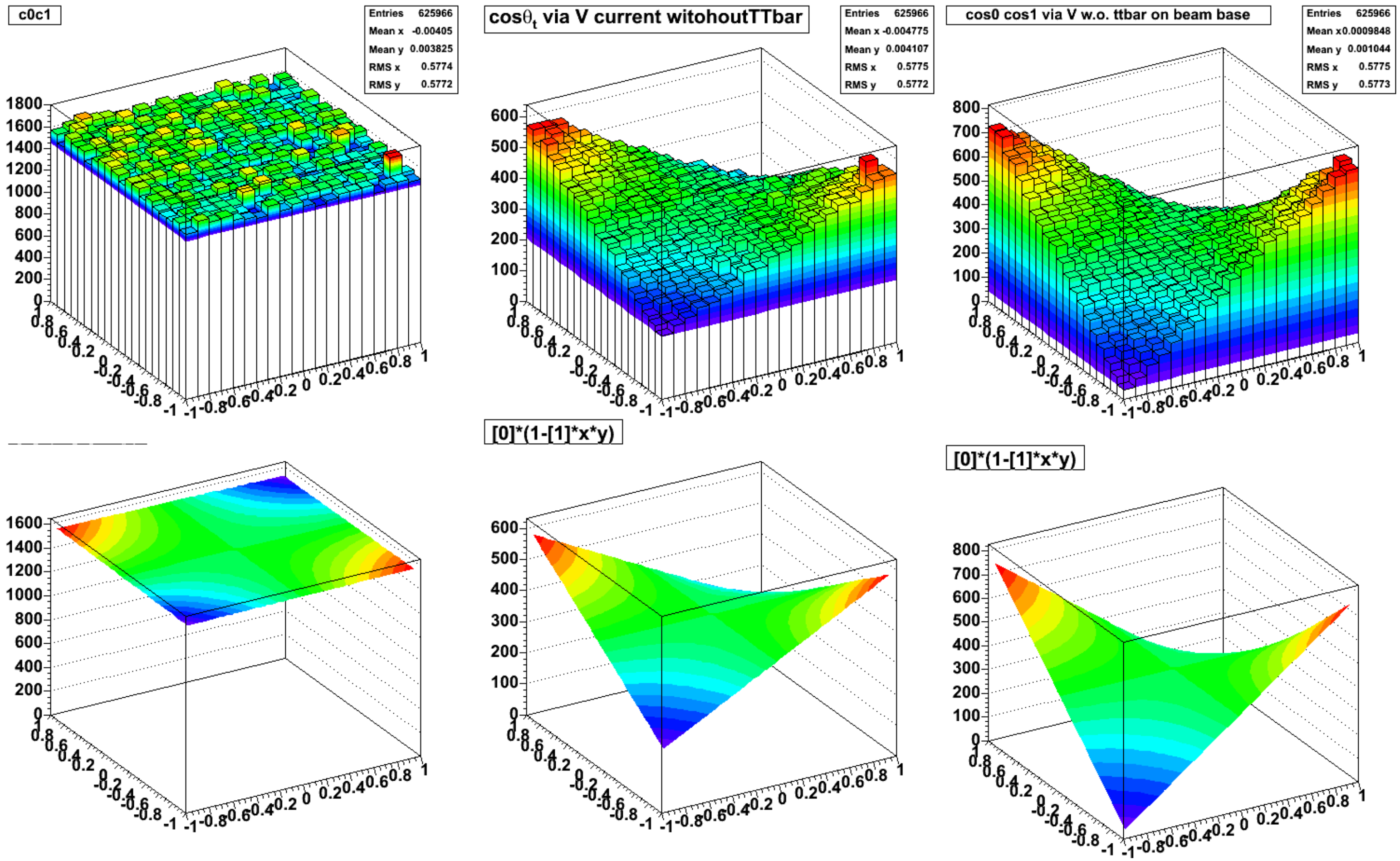
Thank you!!

$(cos\theta_0, cos\theta_1)$ distribution

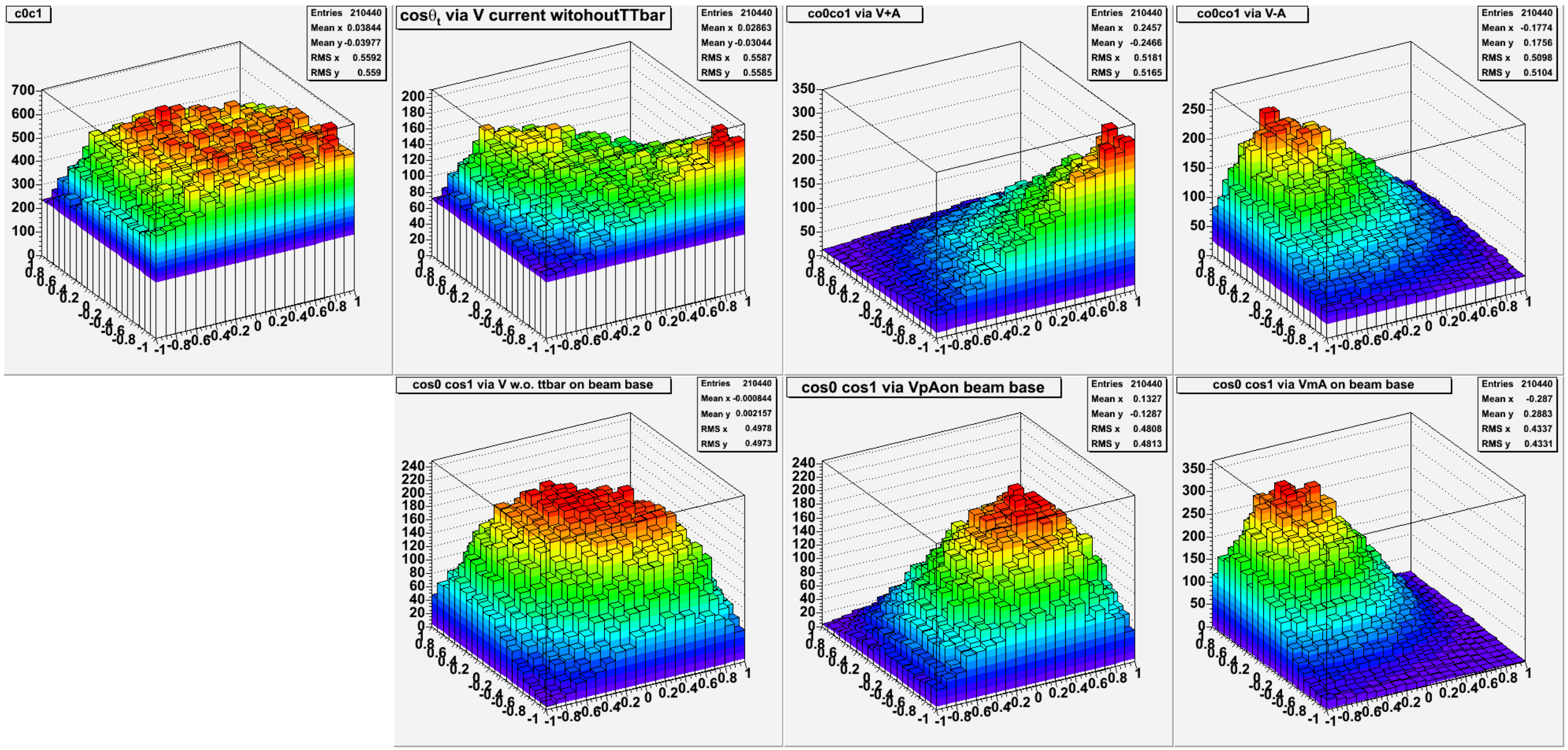
Vqqtt V V+A V-A



Fit


c0c1
Entries 625966
Mean x -0.00405
Mean y 0.003825
RMS x 0.5774
RMS y 0.5772
cosθ$_t$ via V current witohoutTTbar
Entries 625966
Mean x -0.004775
Mean y 0.004107
RMS x 0.5775
RMS y 0.5772
cos0 cos1 via V w.o. ttbar on beam base
Entries 625966
Mean x 0.0009848
Mean y 0.001044
RMS x 0.5775
RMS y 0.5773
[0]*(1-[1]*x*y)
[0]*(1-[1]*x*y)

$(cos\theta_0, cos\theta_1)$ distribution after E.S.



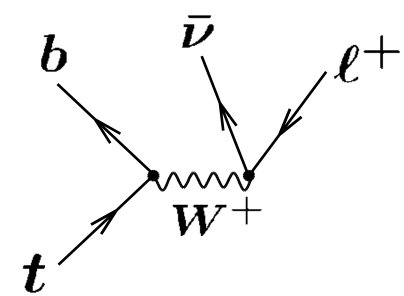
Back Up

top spinor

for top

$$\{\bar{u}_b \gamma_\mu (1-\gamma^5) u_t\}\{\bar{u}_\nu \gamma^\mu (1-\gamma^5) v_{\bar{l}}\} = -2\{\bar{u}_b (1+\gamma^5) u_\nu^C\}\{\bar{v}_{\bar{l}}^C (1-\gamma^5) u_t\}$$

$$v_{\bar{l}} = N_{\bar{l}}\begin{pmatrix}\sigma\cdot\hat{\bar{l}}\,\chi_{\hat{\bar{l}}}\\ \chi_{\hat{\bar{l}}}\end{pmatrix} \qquad u_l = N_l\begin{pmatrix}\phi_l\\ \sigma\cdot\hat{l}\,\phi_l\end{pmatrix} \qquad u_t = \begin{pmatrix}\varphi_t\\ 0\end{pmatrix} \qquad v_{\bar{t}} = \begin{pmatrix}0\\ \chi_{\bar{t}}\end{pmatrix}$$



$$= 2\{\bar{v}_b (1+\gamma^5) u_\nu^C\}\left\{\left(i\sigma_2\chi_{\bar{l}}^*\right)^\dagger \left(1+\boldsymbol{\sigma}\cdot\hat{\bar{\boldsymbol{l}}}\right)\phi_{\bar{t}}\right\}$$

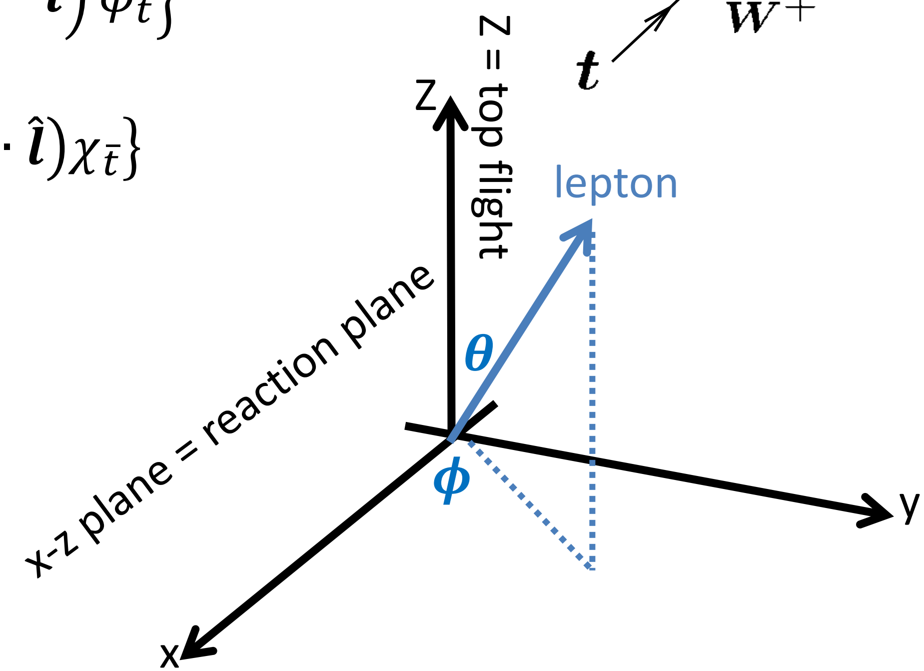
for anti-top, similarly

$$= 2\{\bar{u}_b (1+\gamma^5) u_\nu^C\}\{(i\sigma_2\phi_l^*)^\dagger(1+\boldsymbol{\sigma}\cdot\hat{\boldsymbol{l}})\chi_{\bar{t}}\}$$

If take the quantizing axis of top along with the lepton flight direction

$$1+\sigma\cdot\hat{\bar{l}} = 1+\sigma\cdot\hat{l} = 1+\sigma_3 = \begin{pmatrix}2 & 0\\ 0 & 0\end{pmatrix}$$

$$\phi_t = \chi_{\bar{t}} = \begin{pmatrix}1\\ 0\end{pmatrix}$$



Rapidity; $y = \tanh^{-1}\left(\frac{P_Z}{E}\right)$

$$\Delta y = \frac{2\left(e^{\frac{P_Z}{E}} + e^{-\frac{P_Z}{E}}\right)}{e^{\frac{P_Z}{E}} - e^{-\frac{P_Z}{E}}}$$

same direction of proton's; $P_Z > 0 \rightarrow \Delta y > 0$

against direction of proton's; $P_Z < 0 \rightarrow \Delta y < 0$

Pseudo Rapidity; $\eta = -lntan\left(\frac{\theta}{2}\right)$