

Top pair threshold study

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Measurement of top momentum

- Top pair wave function

$$\left[-\frac{\nabla^2}{m_t} + V(r) - (E + i\frac{\Gamma_\theta}{2})\right]G(\mathbf{x}, E) = \delta^3(\mathbf{x})$$

Γ_θ : width of toponium

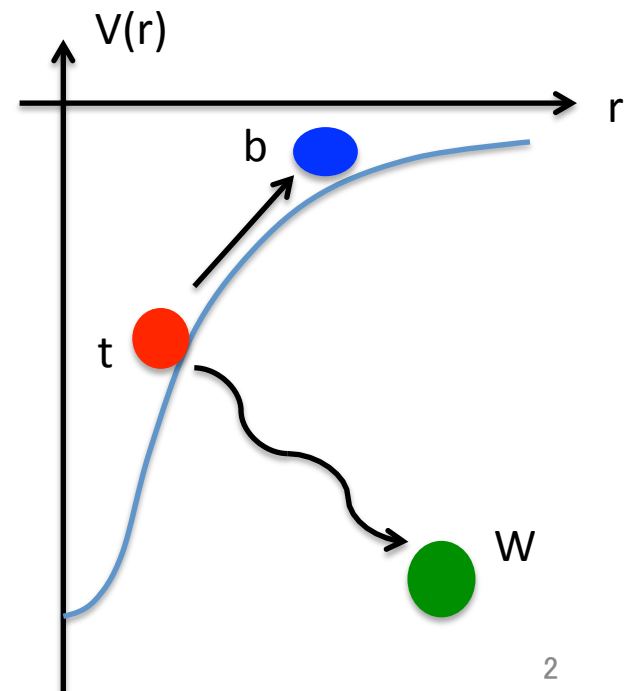
r : relative distance ($r = |\mathbf{x}|$)

potential $V(r) \sim -\frac{3}{4} \frac{\alpha_s(1/r)}{r}$

If Γ_t become bigger, the top decays before the top slows.

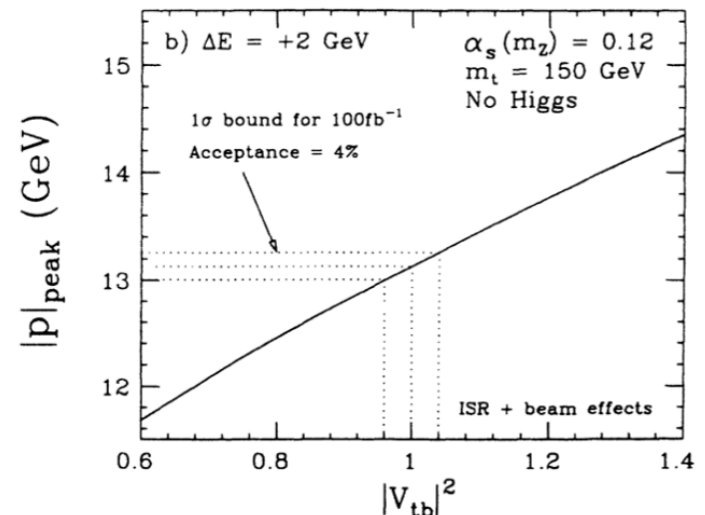
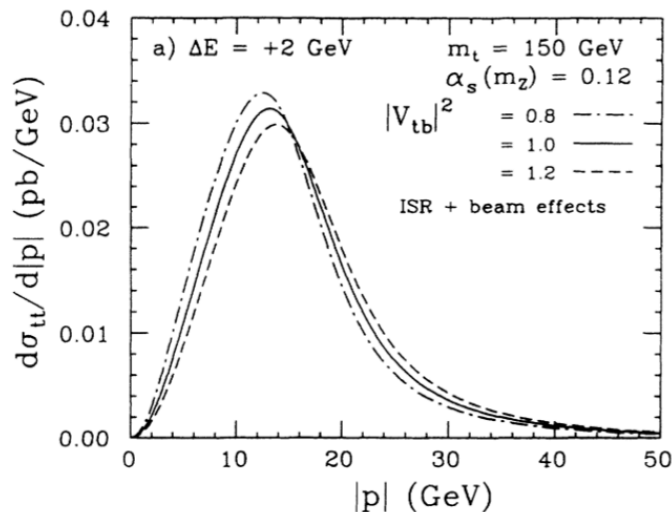


The top momentum is bigger.



Measurement of peak position

- Top width
 - If Γ_t become larger, the peak position of top momentum distribution become larger.
 - Γ_t is proportional to $|V_{tb}|^2$
 $(\Gamma_t \propto |V_{tb}|^2)$



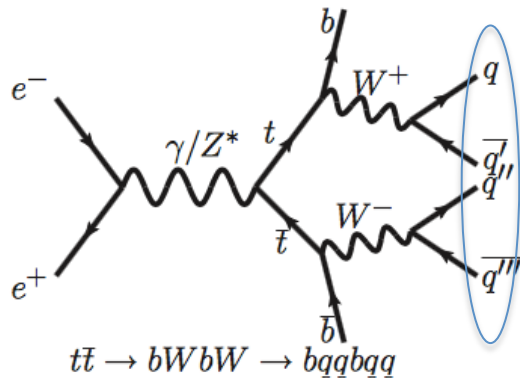
Estimate $|V_{tb}|^2$ by P_{peak} (α_s is fixed)

Analysis condition

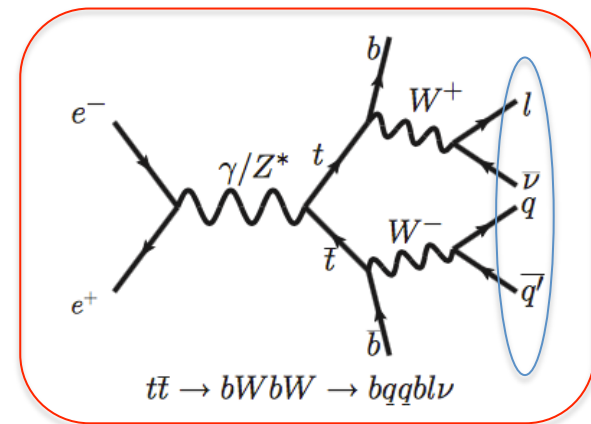
The top decay mode is dominant in 6-Jet and 4-Jet.

In 6-Jet, it is difficult to identify two top.

Thus, analysis 4-Jet mode.



6-Jet



4-Jet

- Analysis condition

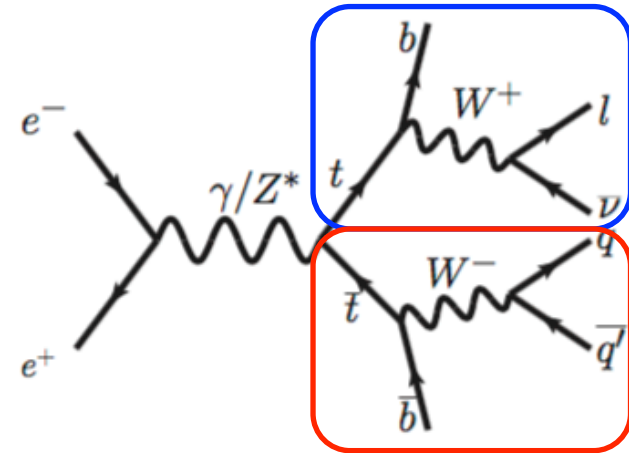
Energy	Luminosity	Polarization
$E_{\text{cm}} = 347\text{GeV}$ $m_t = 174\text{GeV}$	Each polarization 100fb^{-1}	$(e^-, e^+) = (\mp 80\%, \pm 30\%)$

Combinatorial BG

- Combination of jets is important to measure the top momentum exactly.
 –At this stage, top is reconstructed by

mass χ^2

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

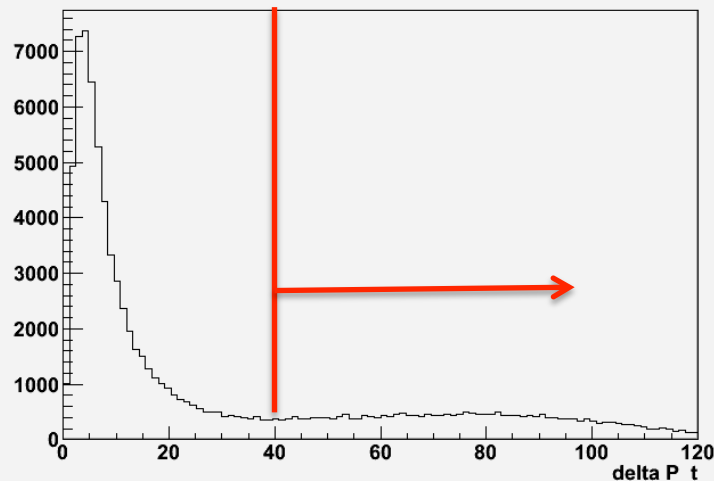


Semi-leptonic

Hadronic

$$t\bar{t} \rightarrow bWbW \rightarrow bqqlbv$$

- Introduce $|\Delta P|$ to check combinatorial BG.

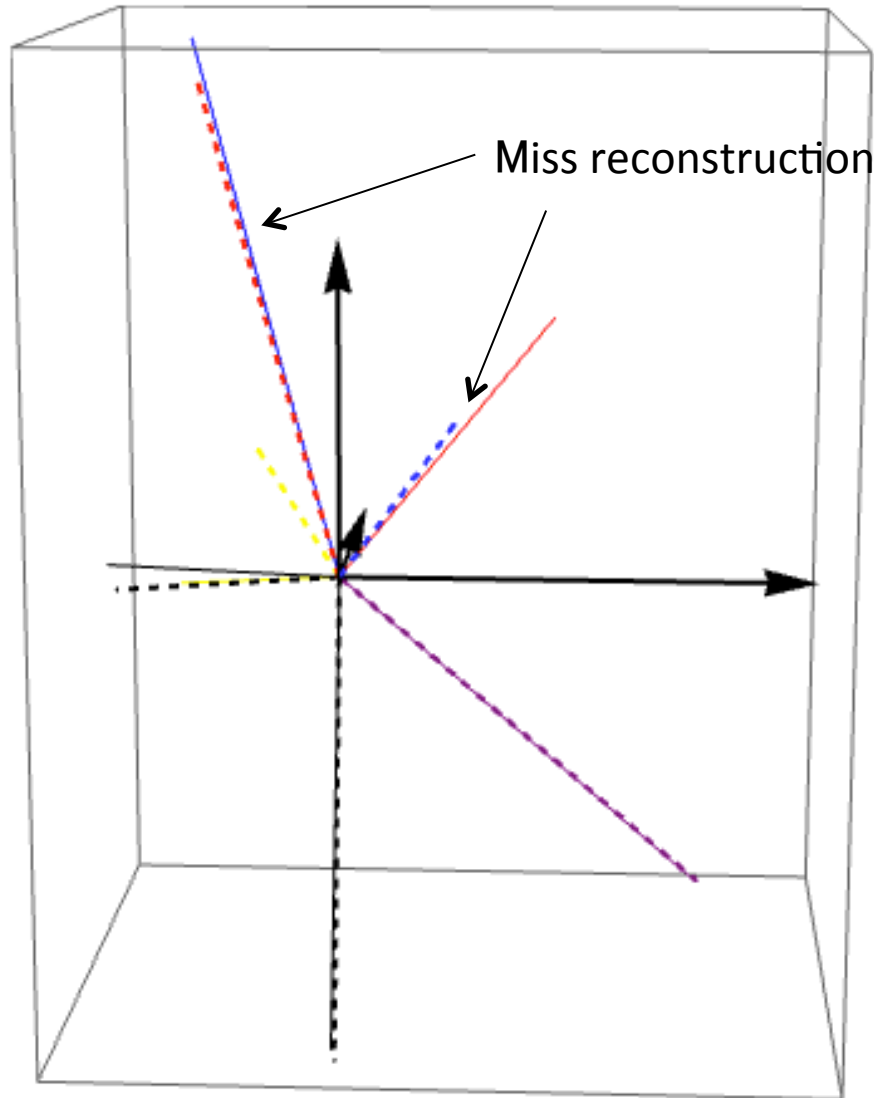


$$|\Delta P| = |\vec{P}_{rec} - \vec{P}_{MC}|$$

Check the $|\Delta P| > 40\text{GeV}$ event.

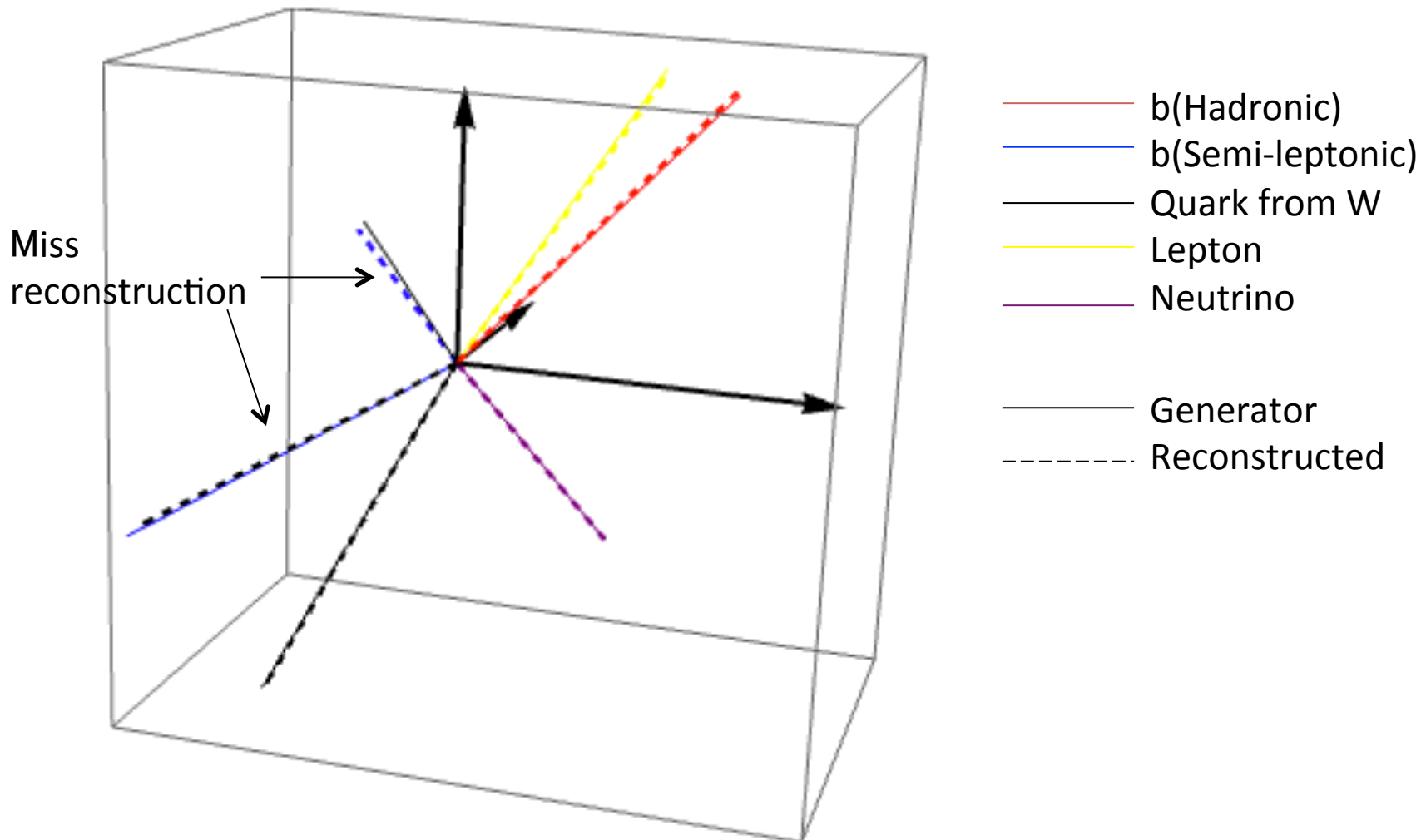
And check what kind of combinatorial BG

① Wrong b and b



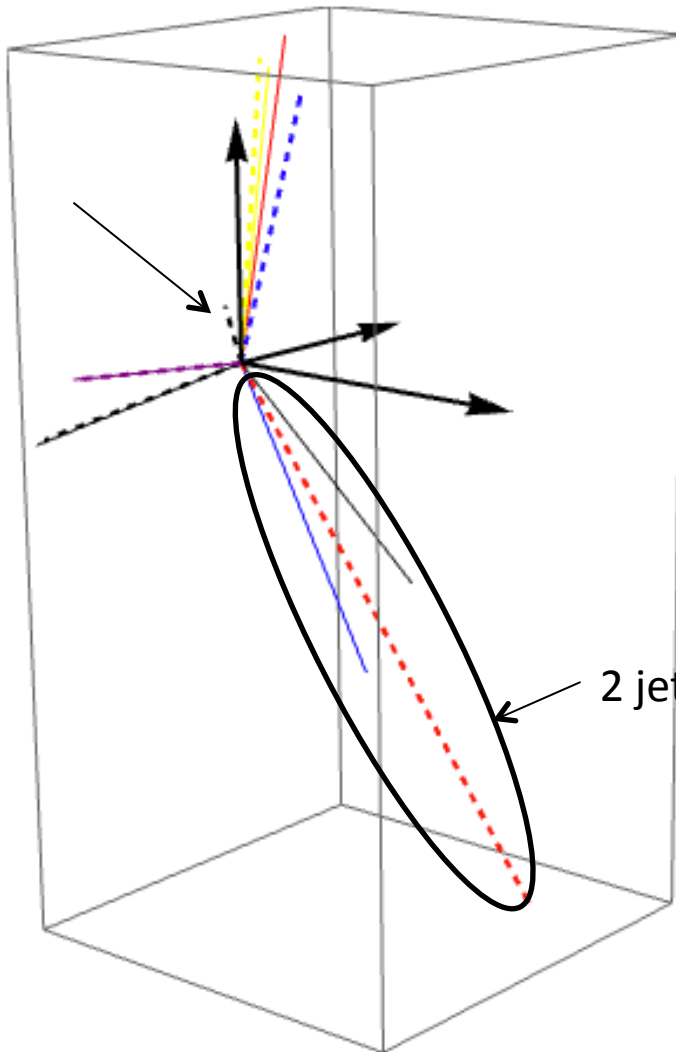
- b(Hadronic)
- b(Semi-leptonic)
- Quark from W
- Lepton
- Neutrino
- Generator
- Reconstructed

② Wrong b and q from W



③ 2 jets reconstructed 1jet

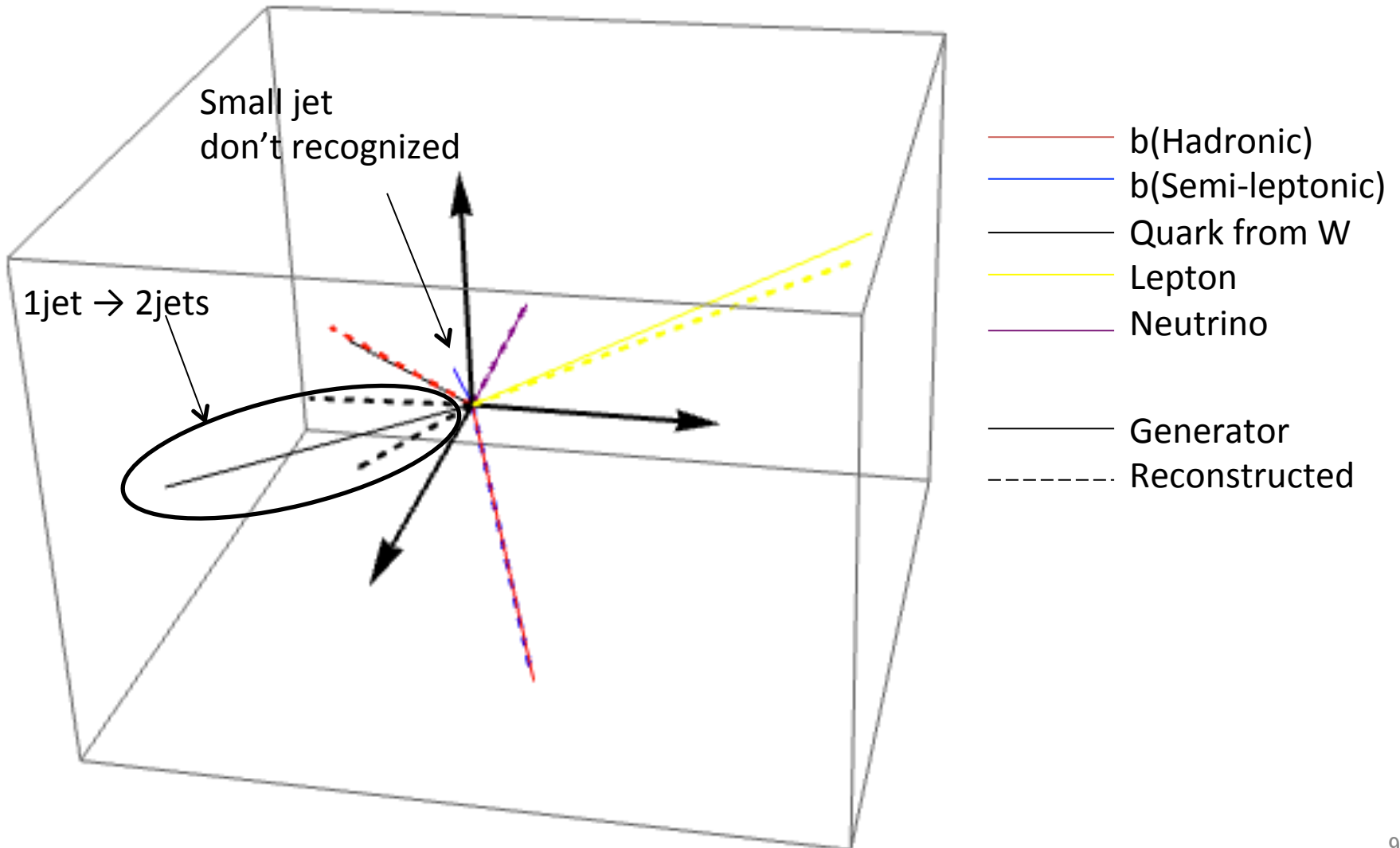
Small jet
is made.



- b(Hadronic)
- b(Semi-leptonic)
- Quark from W
- Lepton
- Neutrino
- Generator
- - - - Reconstructed

2 jets reconstructed 1jet

④ 1 jet reconstructed 2jets

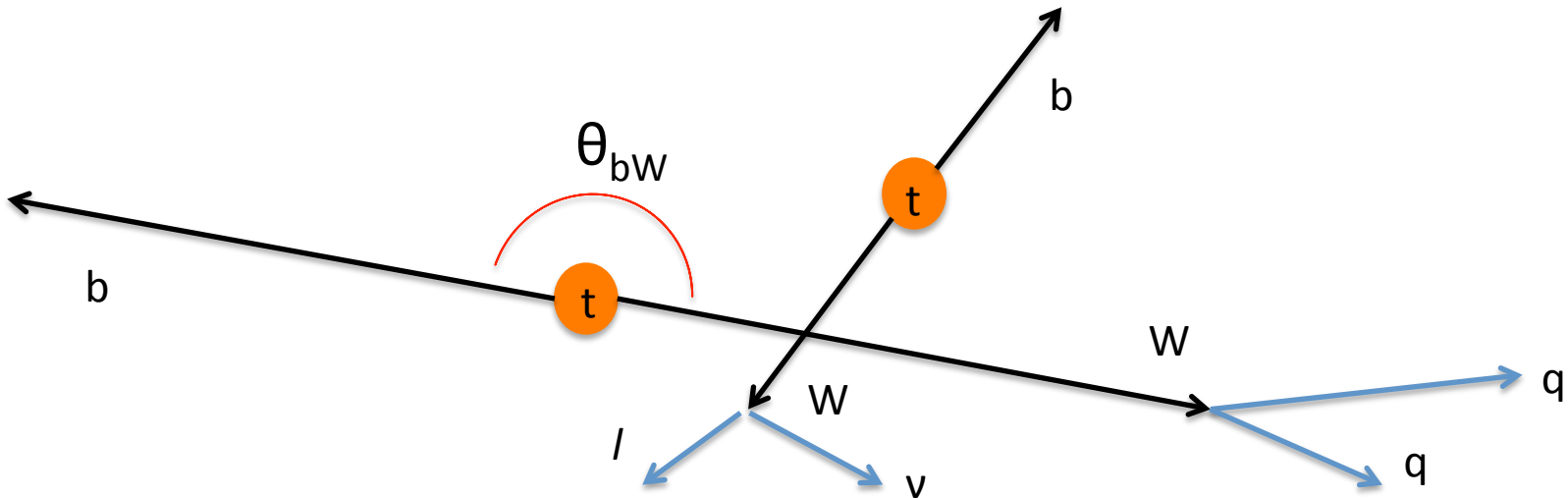


Count of the wrong events

- 100 events at $|\Delta P| > 40\text{GeV}$.

Pattern of wrong rec	Wrong b and b	Wrong b and q	2jet→1jet	1jet→2jet	Others
# of events	85	21	22	15	20

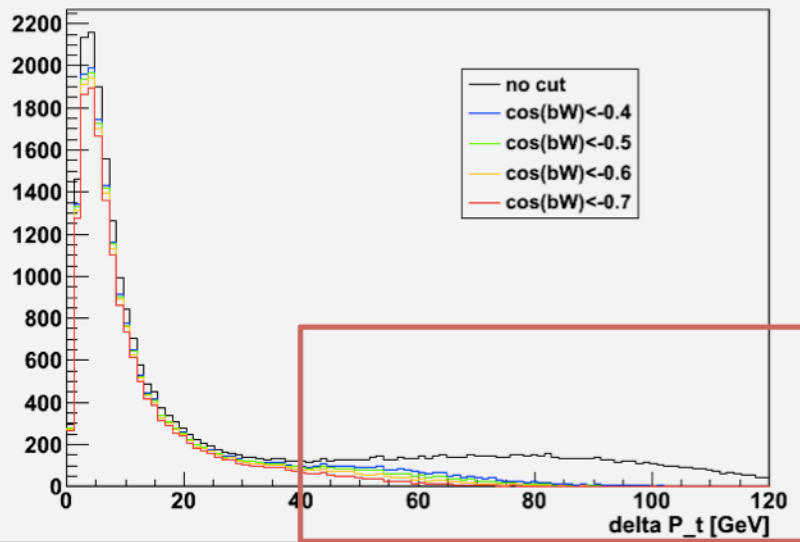
- In the threshold region, b and W are created back to back.



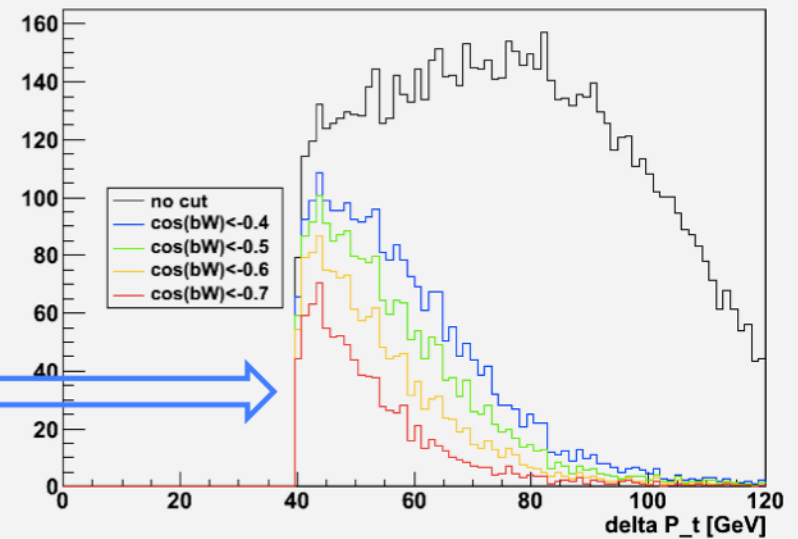
→ Cut $\cos\theta_{bW}$ to reduce wrong b and b.

$$\cos\theta_{bW}$$

- $|\Delta P|$ with $\cos\theta_{bW}$ cut



$\Delta P > 40$



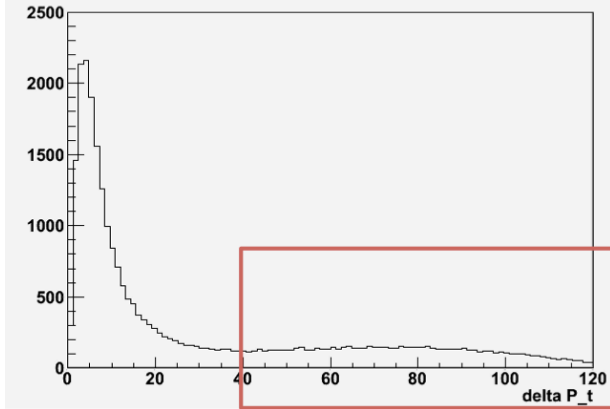
	$\cos\theta_{bW} < -0.4$	$\cos\theta_{bW} < -0.5$	$\cos\theta_{bW} < -0.6$	$\cos\theta_{bW} < -0.7$
Rate of event at $ \Delta P > 40 \text{ GeV}$	12.7%	10.4%	8.01%	5.46%
# of event at $ \Delta P < 40 \text{ GeV}$	17152	16935	16599	16001

Pairing

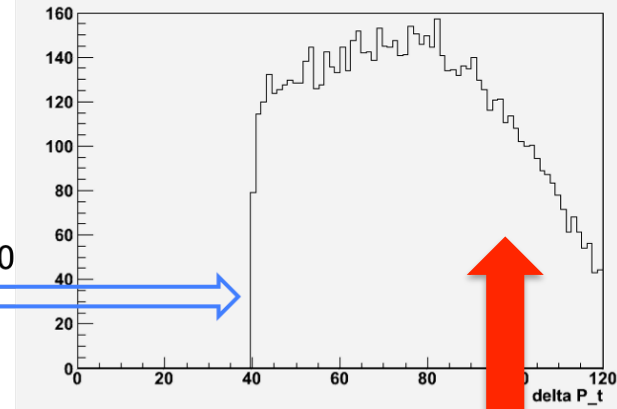
Mass χ^2

Chang method of pairing

$\cos\theta_{bw}$

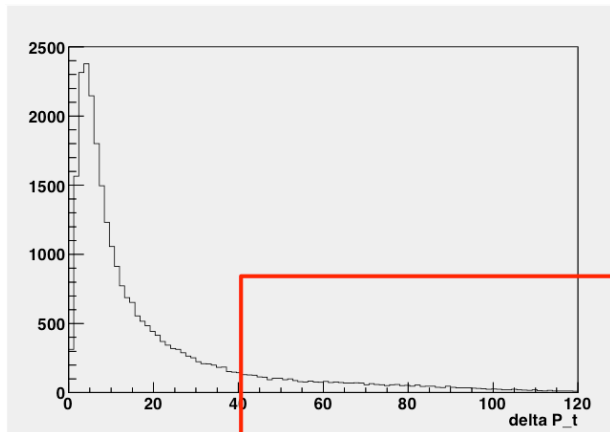


$\Delta P > 40$

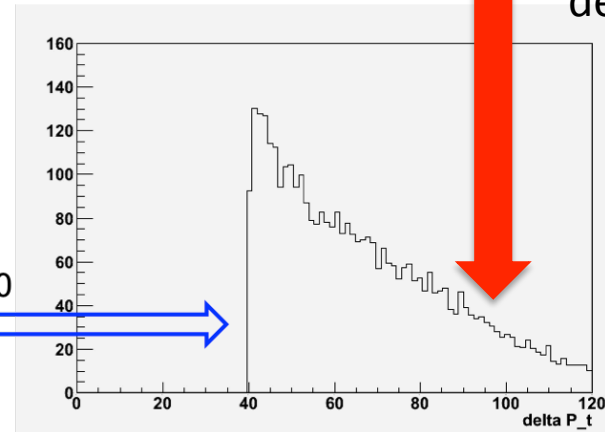


Pairing by mass χ^2

Wrong events decrease



$\Delta P > 40$

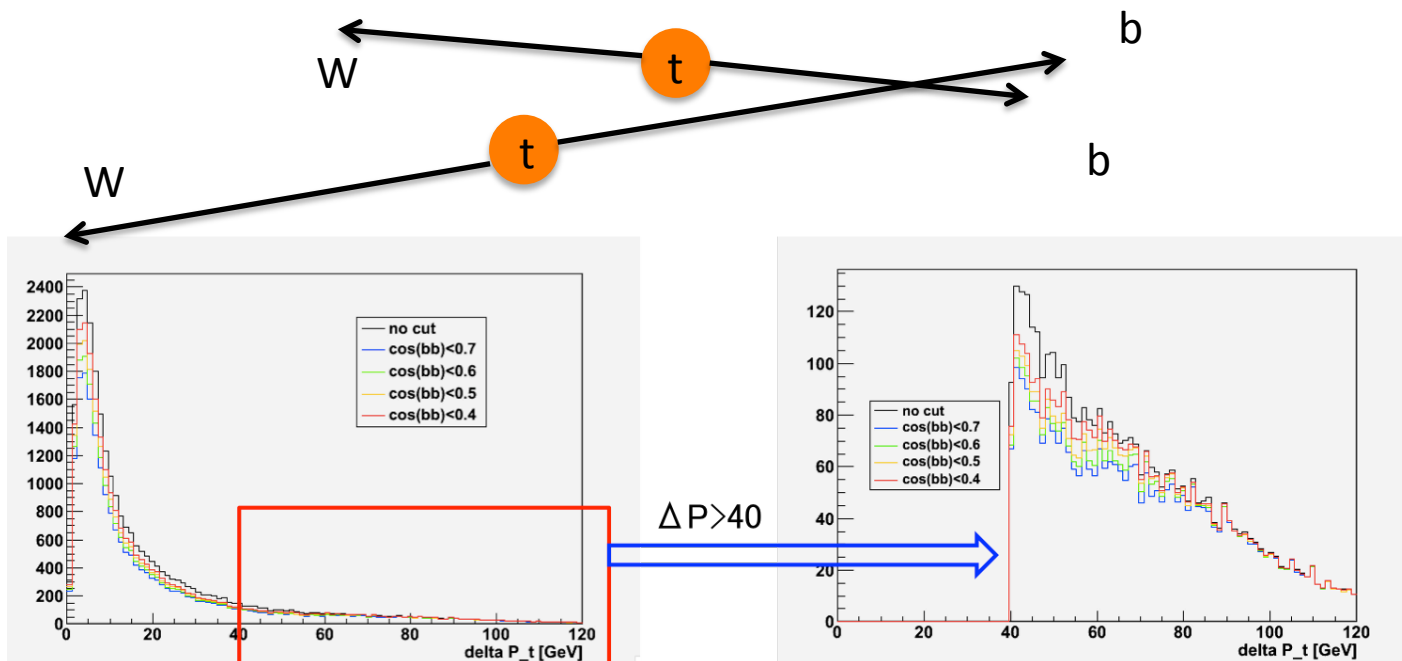


Pairing by $\cos\theta_{bw}$

$\cos\theta_{bb}$

- If b is near another one, it is more likely to be wrong

→ Cut $\cos\theta_{bb}$



	$\cos\theta_{bb} < 0.7$	$\cos\theta_{bb} < 0.6$	$\cos\theta_{bb} < 0.5$	$\cos\theta_{bb} < 0.4$
Rate of event at $ \Delta P > 40 \text{ GeV}$	14.8%	15.0%	15.3%	15.6%
# of event at $ \Delta P < 40 \text{ GeV}$	20837	19749	18653	17532

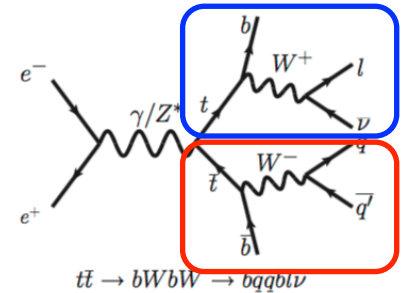
$\cos\theta_{bb}$ is not sensitivity combinatorial BG.

Peak position

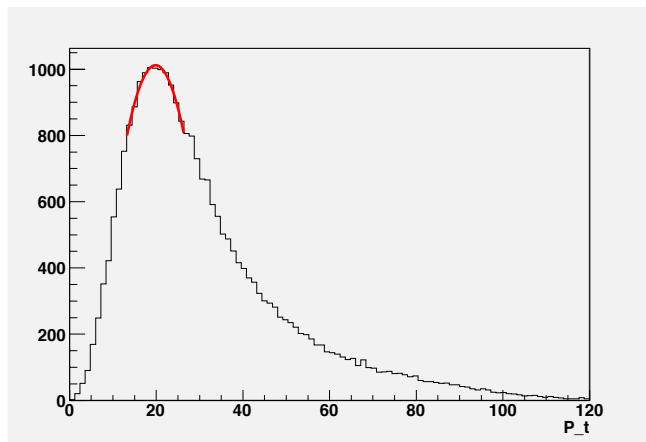
- Estimate peak position of the top momentum distribution by the $\cos\theta_{bw}$ pairing.

→ Because neutrino is reconstructed by missing 4-momentum, the momentum of leptonic and hadronic have correlation.

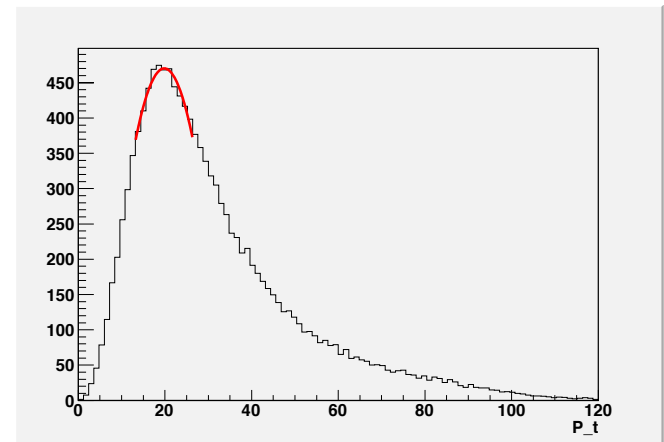
→ Estimate only the hadronic.



Left



Right



- Fit peak position by $\alpha(x - \beta)^2 + C$

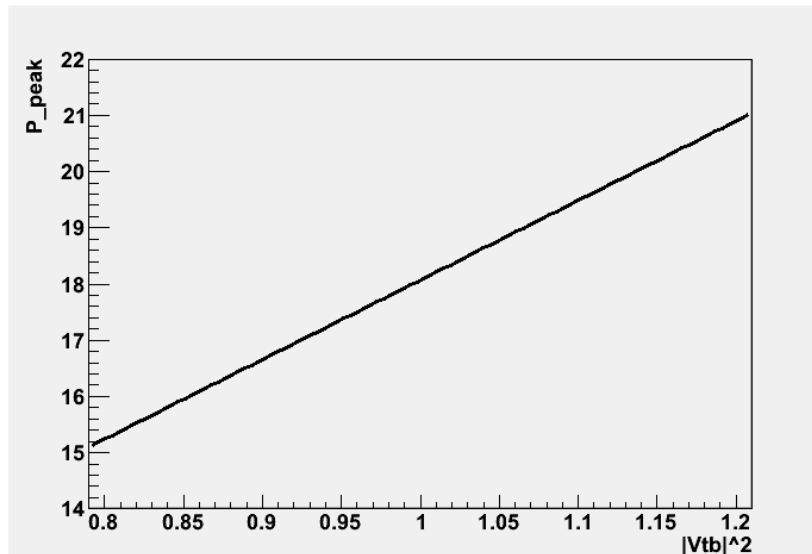
Left $P_{\text{peak}} = 19.9 \pm 0.243 \text{ GeV}$

Right $P_{\text{peak}} = 19.9 \pm 0.347 \text{ GeV}$

(100fb⁻¹)

Width

- Estimate the top width by the peak position.
→ Following figure shows Peak position vs $|V_{tb}|^2$ made by PhysSim.



P_{peak} vs $|V_{tb}|^2$

- Estimate statistic error by $\Gamma_t \propto |V_{tb}|^2$

Left $\delta\Gamma_t = 24 \text{ MeV}$
Right $\delta\Gamma_t = 34 \text{ MeV}$

Total cross section study
 $\delta\Gamma_t = 59 \text{ MeV}$

Summary

- Improved the pairing of jets method and estimate statistic error of peak position of top momentum distribution and top width.

Left $\delta\Gamma_t = 24 \text{ MeV}$
Right $\delta\Gamma_t = 34 \text{ MeV}$

- Future problem
 - ✓ Correction of peak position of measurement and generator.
 - ✓ Analysis at the plural energy point.
 - ✓ Study of systematic error.

back up

Measurement of top momentum

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Γ_θ : width of toponium

r : relative distance ($r = |\mathbf{x}|$)

potential $V(r) \sim -\frac{3}{4} \frac{\alpha_s(1/r)}{r}$

If Γ_t become bigger, the top decays before the top slows.



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