ATLAS実験におけるトップクォーク測定のための多ジェット事象解析

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Analysis Motivation

✓ **ttbar in “1-lepton” and “2-lepton” modes are well measured.**

- In a physics sense, we should cover ALL decay modes from ttbar.
  → Also good feedback for future multijet trigger optimization.

✓ **Many interesting physics BSM in high pt Multi Jet Events**

- All hadronic analysis might be a probe for such new physics.
- We should understand complex multijet events more closely.

✓ **Largest Branching ratio, Large QCD Background**

- 44% of ttbar pair decay into 6 jets.
- Huge QCD background ! But basically the object is only “jets” !

The ttbar Xection Measurement in All hadronic mode is Very Challenging, but definitely we should do it !

Introduction

Concept : **“Try As Simple As Possible”**

-> Simple event selection
-> Data driven background modeling
-> 1D (mass chi2) fit for the measurement
-> # of Background is UNCONSTRAINED is the Fit

Still Lots of room to improve, but avoid any possible bias at the moment.

Data Set : **Full data Corrected by ATLAS**

-> **4 jet trigger (4th jet L2 pt threshold is 30 GeV)**
L1_4J15 -> L2_4j30 -> EF_4j35_NoEF
ttbar MC
-> Full Hadrnic dicay (PowHeg +Pythia)

The Final Integrated Luminosity is 36 pb $^{-1}$
(with systematic error of 3.4%)

Analysis Overview

- Background Model: Data Driven (i.e. Pretag→1b/2btag functions) Tag Rate functions (TR) derived from 5jet bin (to avoid trigger bias).

  → Then applied to other jet bins.

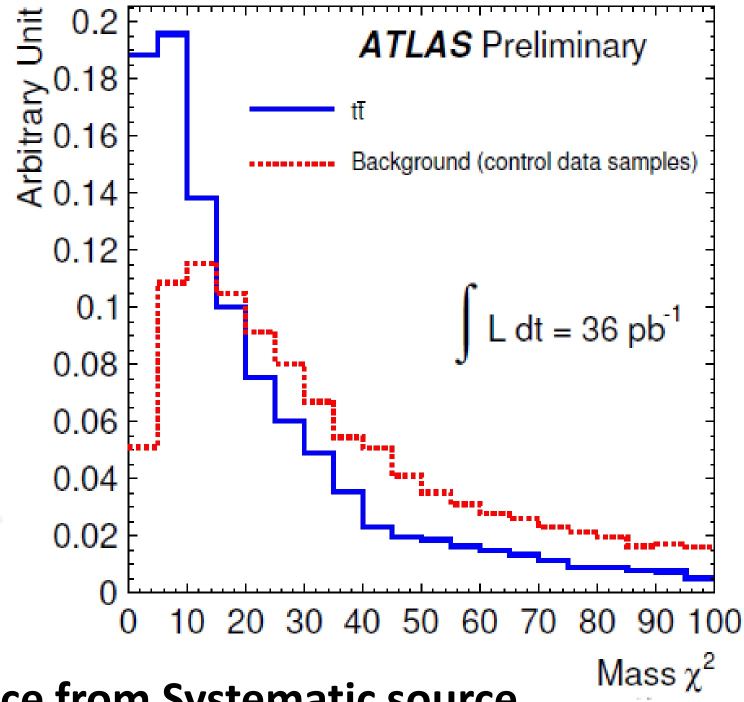
	4jet	5jet	>=6jet
1btag	CR	CR	CR
2btag	CR	CR	SIGNAL

(CR: Control Region)

- Fitting χ^2 distribution: For i^th comb.

$$\chi_i^2 = \sum_{k=1,2}\left(\left(\frac{\mathrm{M}_{3j}^{k} - \mathrm{M}_{\mathrm{top}}}{\sigma_{\mathrm{top}}}\right)^2 + \left(\frac{\mathrm{M}_{2j}^{k} - \mathrm{M}_{\mathrm{W}}}{\sigma_{\mathrm{w}}}\right)^2\right)$$

- Then take min. χ^2 out of 6 combinations.

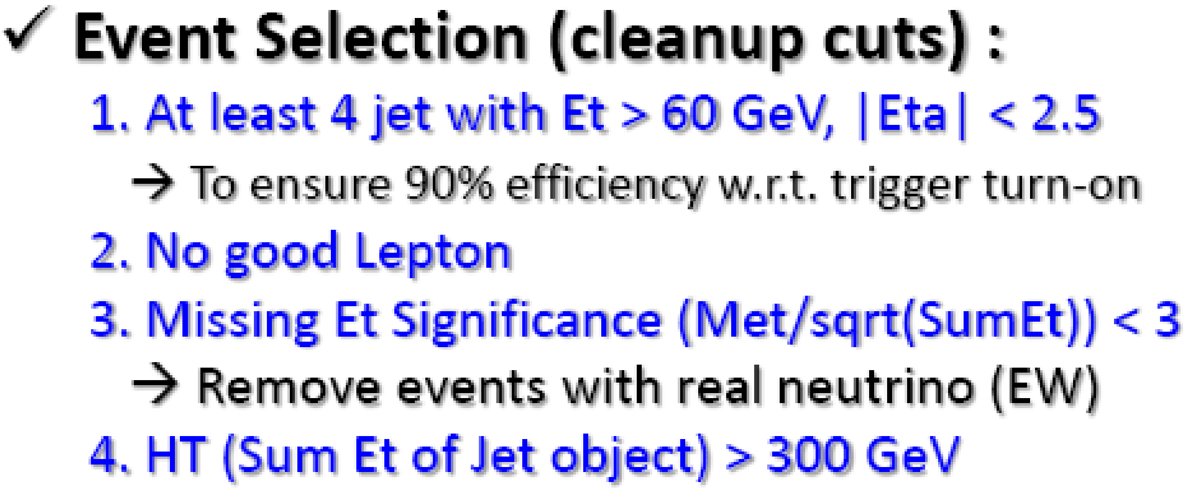


- Systematic Uncertainty

Signal Acceptance difference and Mass X^2 shape difference from Systematic source.

Objects and Event Selection

- ✓ **Jets : (Anti Kt)**
  - **Pt > 20 GeV, |eta| < 2.5**
- ✓ **B-Tag :**
  - **Secondaly vertex tag (SV0>5.85)**
- ✓ **Electron : (only used for veto)**
  - **Pt > 20 GeV, |eta| <2.47 (excluding [1.37, 1.52])**
- ✓ **Muon : (only used for veto)**
  - **Pt > 20GeV, |eta| < 2.5**



✓ **Event Selection (cleanup cuts) :**

1. At least 4 jet with Et > 60 GeV, |Eta| < 2.5
   → To ensure 90% efficiency w.r.t. trigger turn-on
2. No good Lepton
3. Missing Et Significance (Met/sqrt(SumEt)) < 3
   → Remove events with real neutrino (EW)
4. HT (Sum Et of Jet object) > 300 GeV

Signal efficiency is ~ 20%
(mainly due to 4th jet Pt cut ,
Others are not killing at all…)

B-tag Rate Function (1)

B-tag rates for first tag and second tag are different due to gluon splitting process (g→bbbar), hence the tag rate should be estimated for each (1b/2b).

> Tag Rate Function (TR) is defined as,

Event Basis

$$\mathrm{TR}_{\mathrm{jet}} = \boxed{\frac{\#\text{ of events with } \mathrm{nb}_{\mathrm{bin}} \text{ tag}}{\#\text{ of events in } \mathrm{nj}_{\mathrm{bin}}}} \times \frac{1}{{}_{\mathrm{nj}_{\mathrm{bin}}}\mathrm{C}_{\mathrm{nb}_{\mathrm{bin}}}}$$

A factor for jet by jet prob.

$$= \boxed{\frac{njet_{tag}}{njet_{all}}} \times \frac{nj_{bin}}{nb_{bin} \times {}_{nj_{bin}}C_{nb_{bin}}}$$

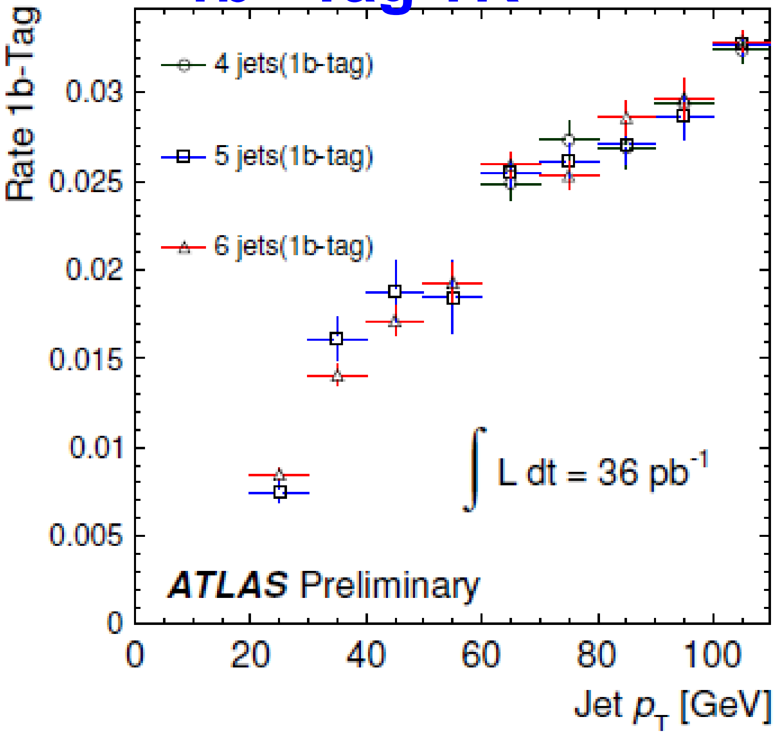
Jet Basis allows us to parameterize jet-pt and jet-eta.

Example 1) In 5jet bin and 1btag : $\mathrm{TR}_{\mathrm{jet}}(5\mathrm{jet}, 1\mathrm{btag}) = \frac{njet_{tag}}{njet_{all}} \times \frac{5}{1 \times {}_5C_1}$

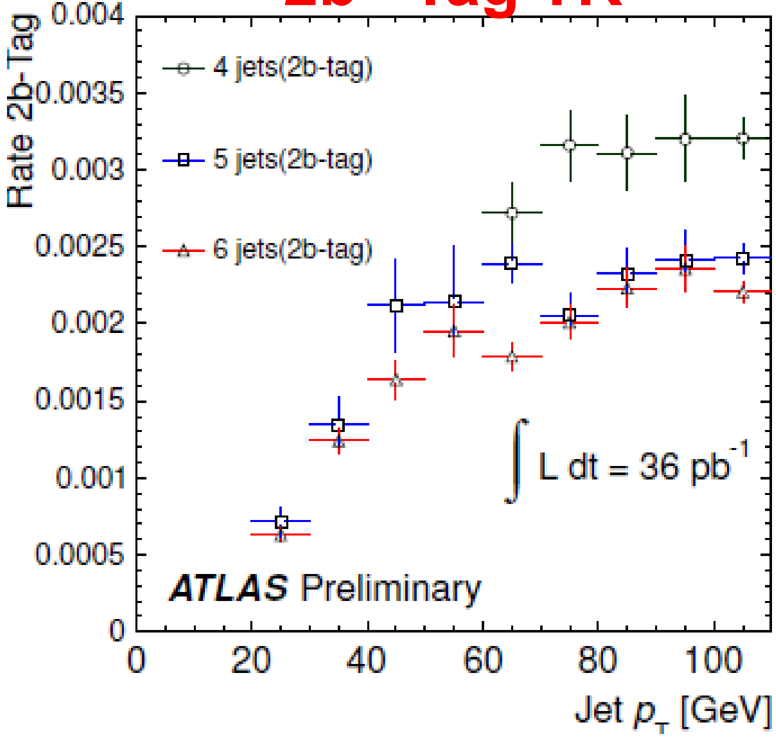
Example 2) In 5jet bin and 2btag : $\mathrm{TR}_{\mathrm{jet}}(5\mathrm{jet}, 2\mathrm{btag}) = \frac{njet_{tag}}{njet_{all}} \times \frac{5}{2 \times {}_5C_2}$

B-tag Rate Function (2)

1b –Tag TR



2b –Tag TR

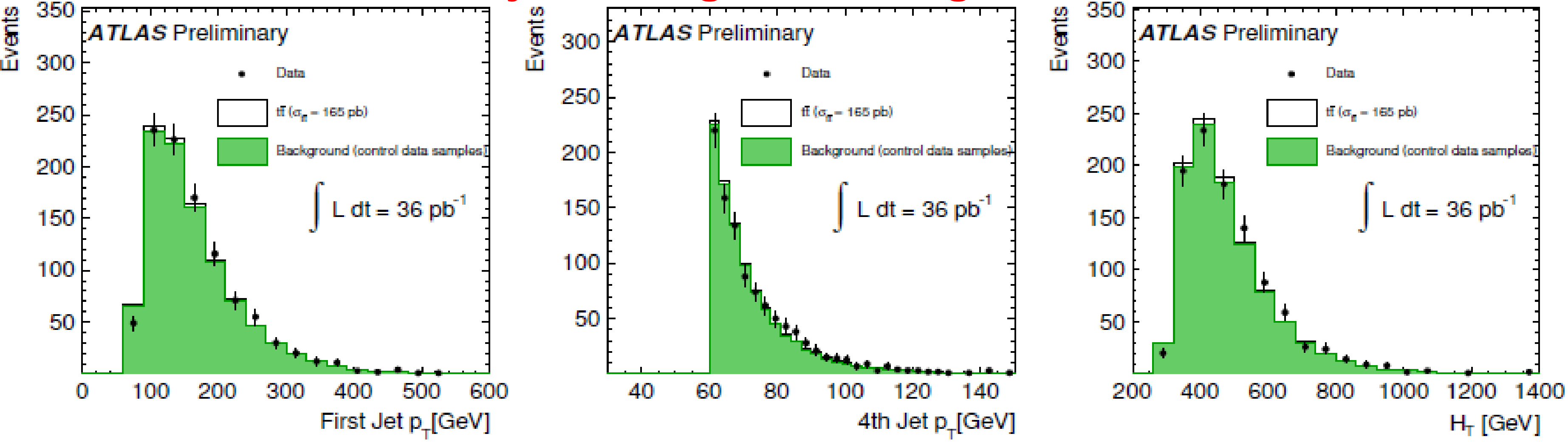


> 5jet TR is our default to be applied for other jet bin.
It looks almost consistent with 6jet TR, but 4jet TR looks different.
→ So we don't rely on TR for absolute normalization → unconstrained fit.
* The difference is assigned as a systematic uncertainty.

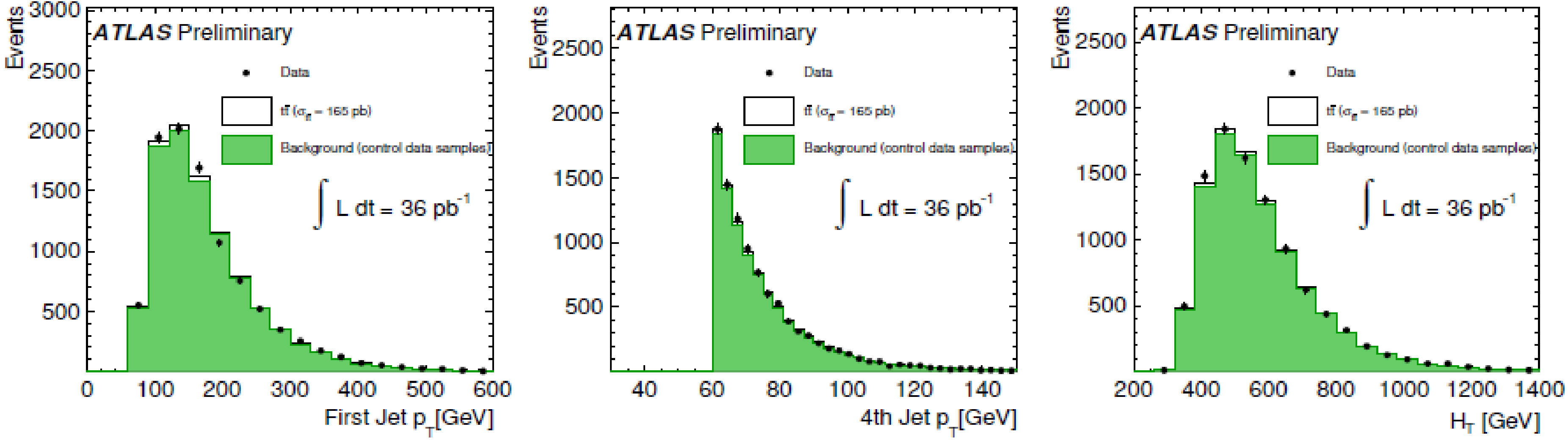
> In the future, more parameterizations would help.
- e.g. Ntrk, SumEt, Nvtx etc, but statistically hard at this moment.

Kinematic Check

5 jet 2 b-tag control region



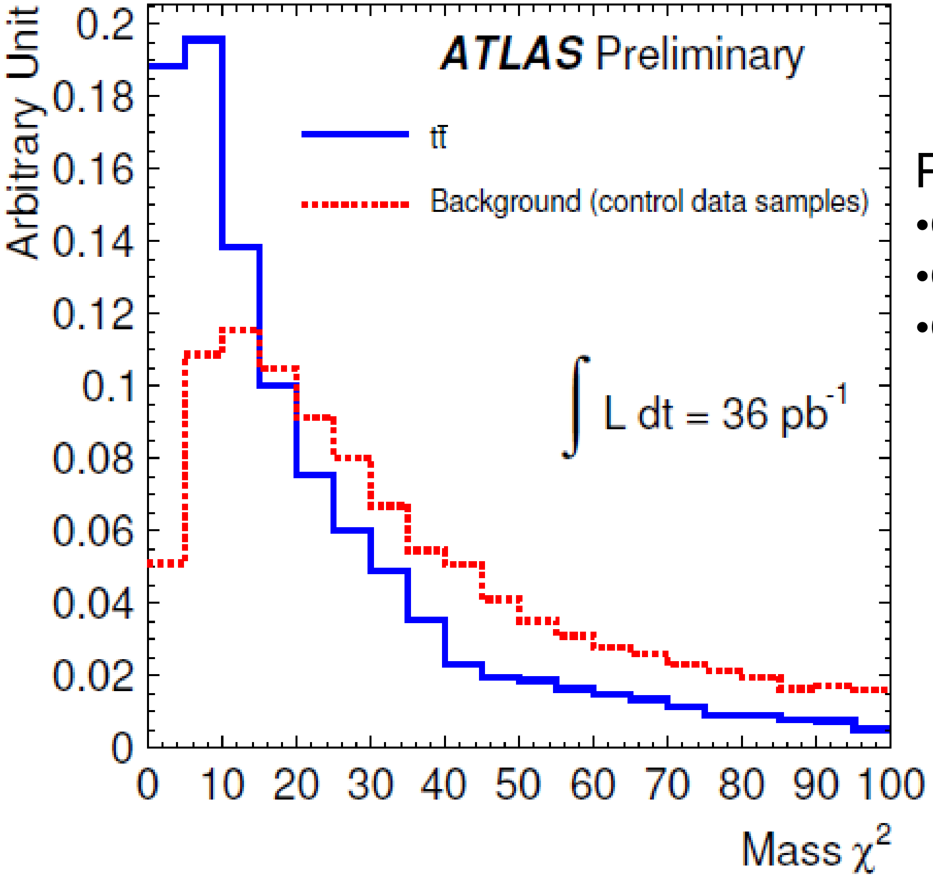
6 jet 1 b-tag control region



Good agreements !

Sensitivity Study

Pseudo-experiments(PE) are performed to check the fitting procedure



Fit the mass chi2 distribution

Performed 3000 PE from the templates

•Center value of N total = B obs = 1179

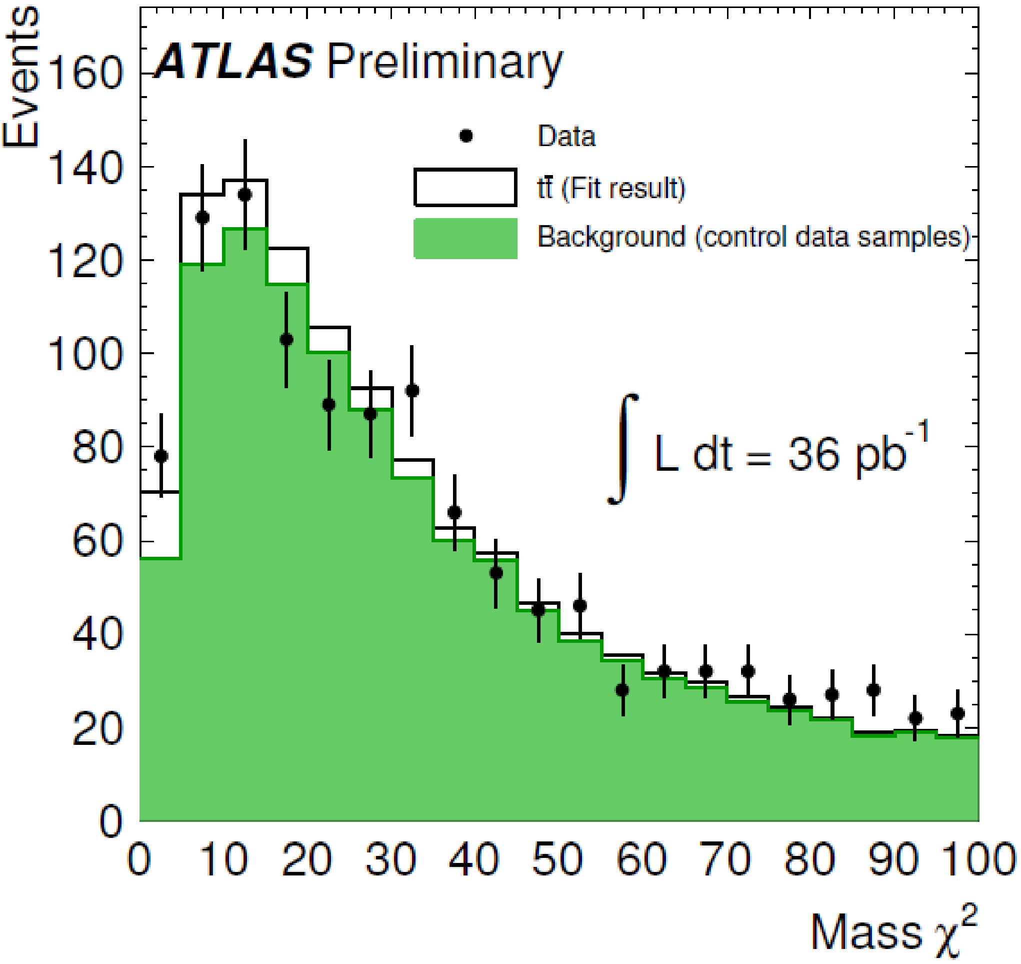
•Center value of N signal is based on σ=160 pb

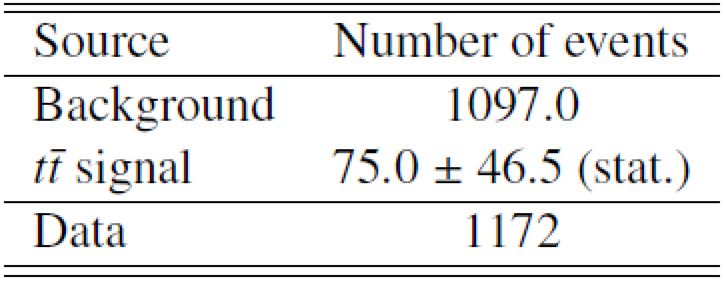
•Center value of B background = total – N signal

- Input vs output inearity = 1
- Pull width = 1
- **Expected Sensitivity with 36 pb^{-1}**
  2.2 σ (stat. Only)

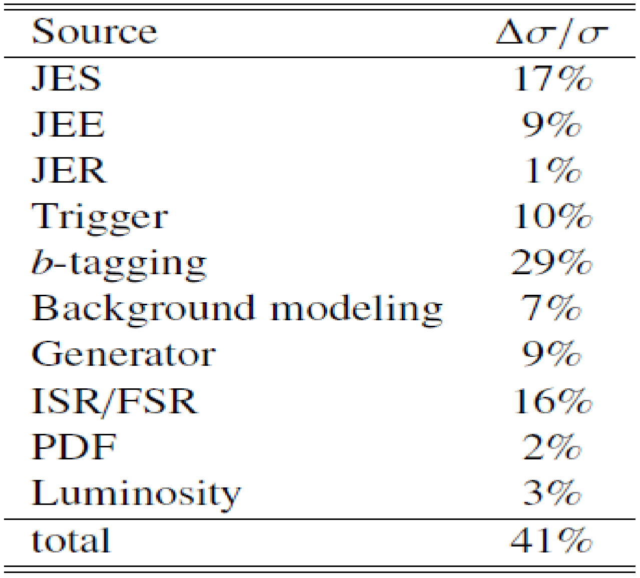
Although statistics is not enough to clear observation, a measurement of the cross section is performed given that top pair production has already been established.

Final Fit Results and Limit





Source	Number of events
Background	1097.0
$t\bar{t}$ signal	75.0 ± 46.5 (stat.)
Data	1172



Source	$\Delta\sigma/\sigma$
JES	17%
JEE	9%
JER	1%
Trigger	10%
b-tagging	29%
Background modeling	7%
Generator	9%
ISR/FSR	16%
PDF	2%
Luminosity	3%
total	41%

95% upper limit : $\sigma_{t\bar{t}} < 292\ \mathrm{pb}$

Fitted center value : $\sigma_{t\bar{t}} = 118 \pm 73\ (\mathrm{stat.}) \pm 48\ (\mathrm{syst.}) \pm 4\ (\mathrm{lumi.})\ \mathrm{pb}$

Summary

- 我々は多ジェット事象を用いて、トップクォーク対の生成を研究した。
- 今回使用したデータは36 pb-1であり、統計量が十分でなく、予想される精度は2 σ程度であるため、95% upper limit を求めた。

95% upper limit： $\sigma_{t\bar{t}} < 292 \text{ pb}$

- 統計誤差が大部分を占めているので、今後の高輝度ビームでのデータ収集に期待。
- 大きな系統誤差である b-tag, JES などは系統誤差に含まれているが、今後のデータ量に伴い、改善を期待できる。
- 今後のデータ量の増加により、精度が上がっていくが、高輝度ビーム用の多ジェット事象のトリガーがボトルネックになってくる。 あまりトリガーで高い運動量の要求をすると、信号分岐比が下がる。 つまりデータを増やしても精度があまり向上しない。
- 新しいトラッキングトリガー(FTK) など多角的なアプローチが重要になってくる。