# ATLAS Single Top Studies

## Collaboration Shandong University - LPSC Grenoble

Benoît Clément[1], Thomas Delemontex[1] (PhD), Julien Donini[1,3],
Cunfeng Feng[2], Peng Ge[2], Annick Lleres[1], Arnaud Lucotte[1],
C. Monini[1] (PhD), Xiaohu Sun[1,2] (PhD), Jin Wang[1,2] (PhD)

[1] LPSC Grenoble
[2] Shandong University
[3] LPC Clermont-Ferrand

FCPPL Workshop - Annick Lleres

21/03/2012

# Single top production at LHC

o Production via weak interaction involving a W-t-b vertex

o Three sub-processes:

- Exchange of a virtual W-boson in t-channel and s-channel
- Associated production with an on-shell W-boson
- t-channel is the dominant process: 65 pb at 7 TeV

➢ Measurements focalized on t-channel and considering leptonic decay modes (W→lν)

➢ t-channel signature:

- Exactly one isolated high $p_T$ charged lepton (e or μ)
- Large missing transverse energy (undetected ν)
- 2 or 3 high $p_T$ jets
- One jet originating from a b-quark
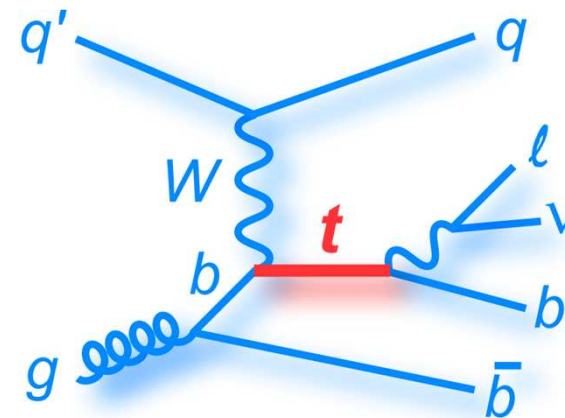
# Motivations for single top measurements

➢ **Single top production provides a direct probe of the Standard Model W-t-b coupling:**

  ○ Measurement of cross section determines the $V_{tb}$ matrix element without any assumptions

  ○ Measurement of polarization observables tests the left-handed nature of the charged-current interaction

➢ **Single top production is sensitive to many models of new physics and in particular to new top couplings:**

  ○ Modifications of the SM top weak interactions: anomalous t-W-b couplings

  ○ Non standard neutral currents changing the flavor: FCNC couplings t-Z-c, t-$\gamma$-c, t-g-c

  ○ Looking for deviations w.r.t SM predictions in measured cross sections and polarization observables gives access to new physics

# Monte Carlo generator validation

### Cunfeng Feng and Peng Ge

**Validation of Monte Carlo generators for the three sub-processes:**

- Validation of POWHEG+Herwig/Pythia and McAtNlo+Herwig++ vs McAtNlo+Jimmy

- Comparison of the kinematic distributions ($p_T$, $\eta$) of the hard process objects and decays
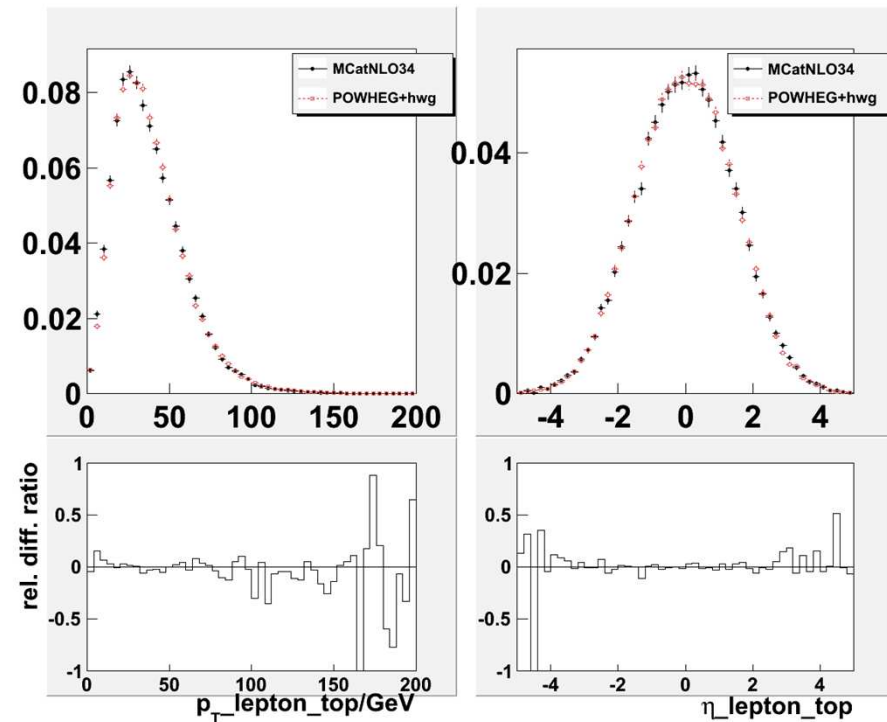


POWHEG+Herwig t-channel validation plots

# Measurement of t-channel cross section

Jin Wang

**t-channel cross section measurements via Boosted Decision Tree analyses**

o  The most discriminating variables (signal vs backgrounds) determined from Monte Carlo simulations are used as inputs of the BDT event classifier

o  Cut on the BDT output weight: value chosen to minimize statistical and systematic uncertainties on the measured $\sigma$

o  Statistical analysis to extract the cross section

o  Result $\sigma=90\pm30$ pb for an integrated luminosity of 1.04 fb$^{-1}$. A parallel neural network analysis gives $\sigma=83\pm20$ pb. (TOPQ-2011-14)
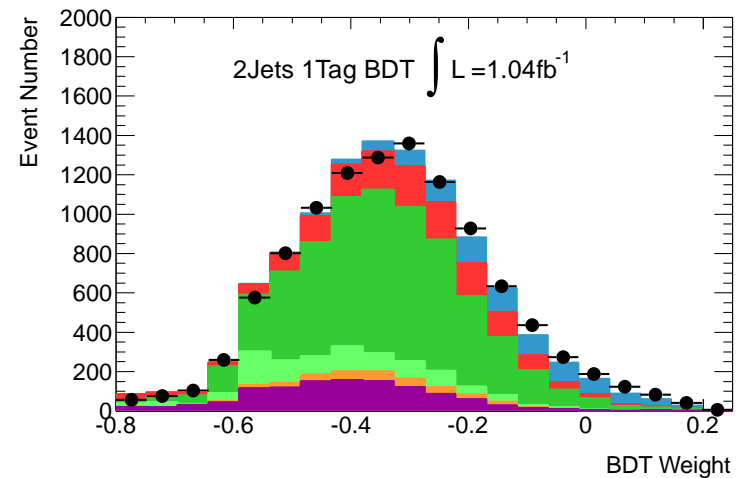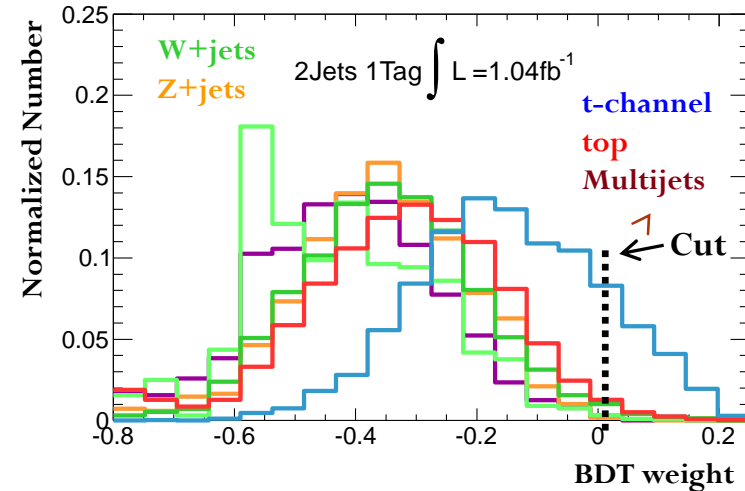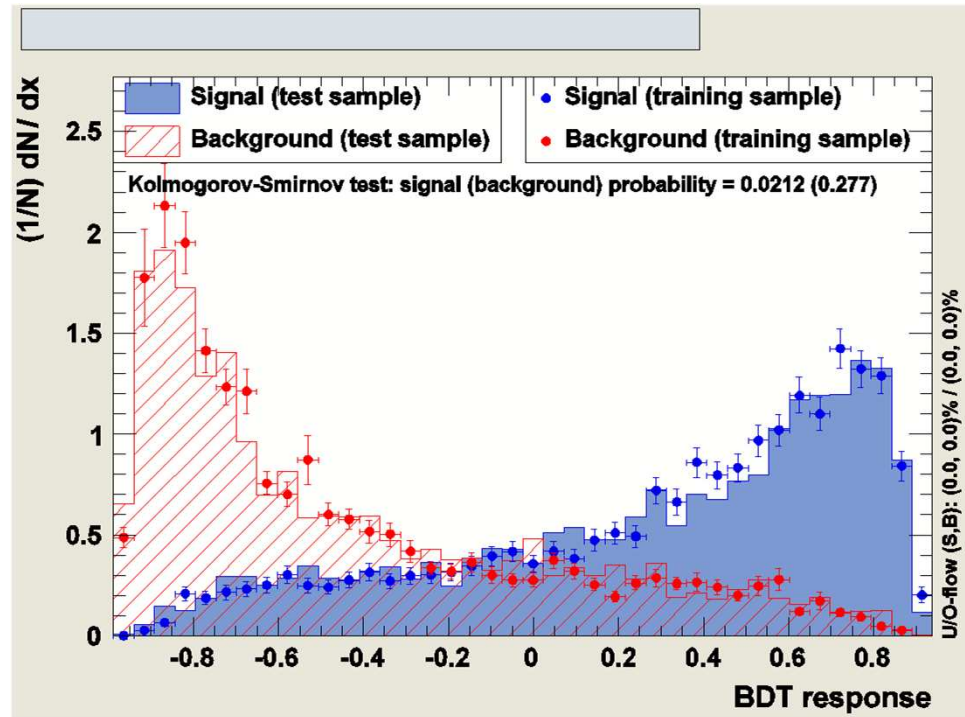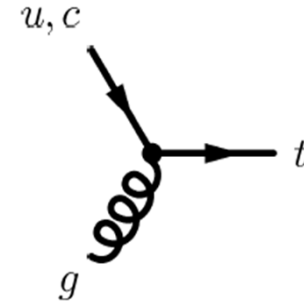
# Search for FCNC single top production

Xiaohu Sun

**Search for FCNC process:** $qg \rightarrow t$

- Same signature as t-channel for lepton and missing transverse energy

- Exactly one jet produced by hadronisation of a b-quark



- BDT analysis and extraction of the cross section limit

- Upper (very preliminary) limit for the cross section is 24.9 pb for a luminosity of 2.05 fb$^{-1}$. A neural network analysis leads to a limit of 3.9 pb (arXiv:1203.0529)

- Optimization of the BDT analysis and analysis of the full luminosity (5 fb$^{-1}$) will be done in the future

# Measurement of top-quark polarization

Xioahu Sun and Annick Lleres

**Measurement of top polarisation from angular correlations between the charged lepton and top spin axes appropriatly chosen**

- Measurement of the degree of polarization ($P = \frac{N_+ - N_-}{N_+ + N_-}$) in the spectator basis. The top spin axis is the spectator jet momentum in the top rest frame

- **Highly polarized tops are produced in single top t-channel** (P = 0.90)

$$\frac{1}{\Gamma}\frac{d\Gamma}{dcos\theta_l} = \frac{1}{2}(1 + P\alpha_l cos\theta_l)$$    $\alpha$ spin analysing power (SM $\alpha_l = 1$)
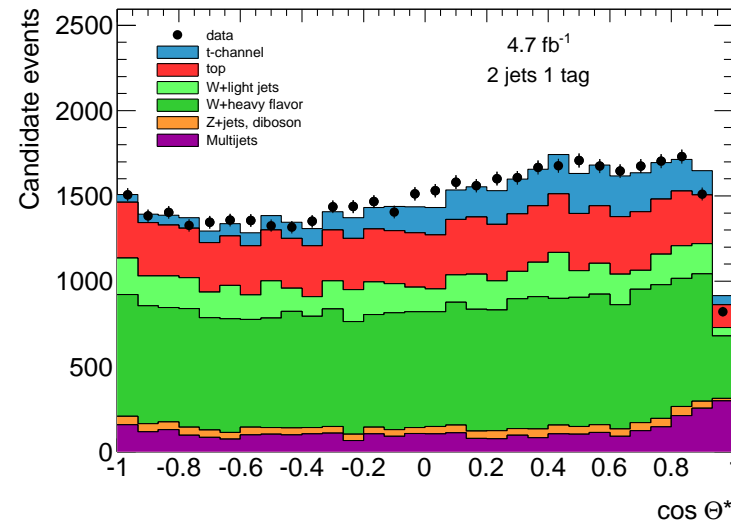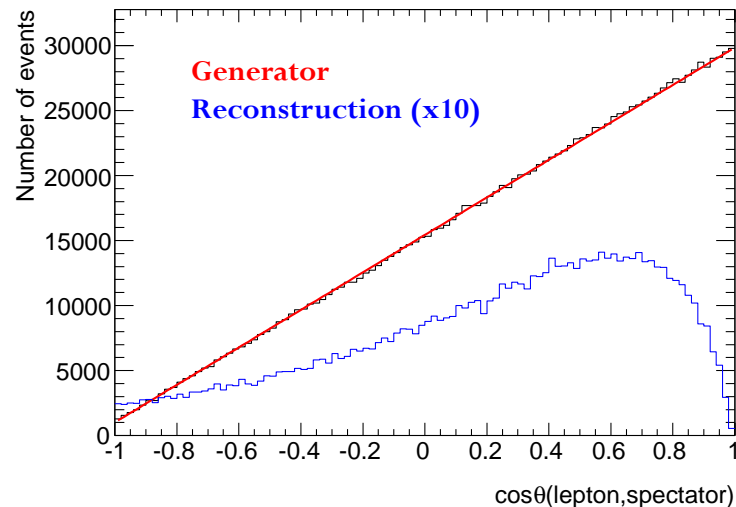
# Summary and Plans

- Fruitfull collaboration between the SDU and LPSC Grenoble groups

  - t-channel cross section measurement using a BDT method: Jin Wang's thesis (June 2012) – contribution to a paper to be submitted for publication (TOPQ-2011-14)

  - Search for FCNC coupling in single top production: Xiaohu Sun's work

  - First studies of the top polarization in single top production: Xiaohu Sun's thesis (Summer 2013)

- SDU-LPSC project for 2012-2013

  - Analyses will be focalized on polarization measurements to test the Standard Model W-t-b coupling and to look for anomalous couplings – W-boson polarization observables will also be studied: helicity, normal and transverse polarization fractions

  - Will continue studies to search for new couplings (FCNC)

  - s-channel studies are starting (PhD student 1st year)