Top quark related study at SDU

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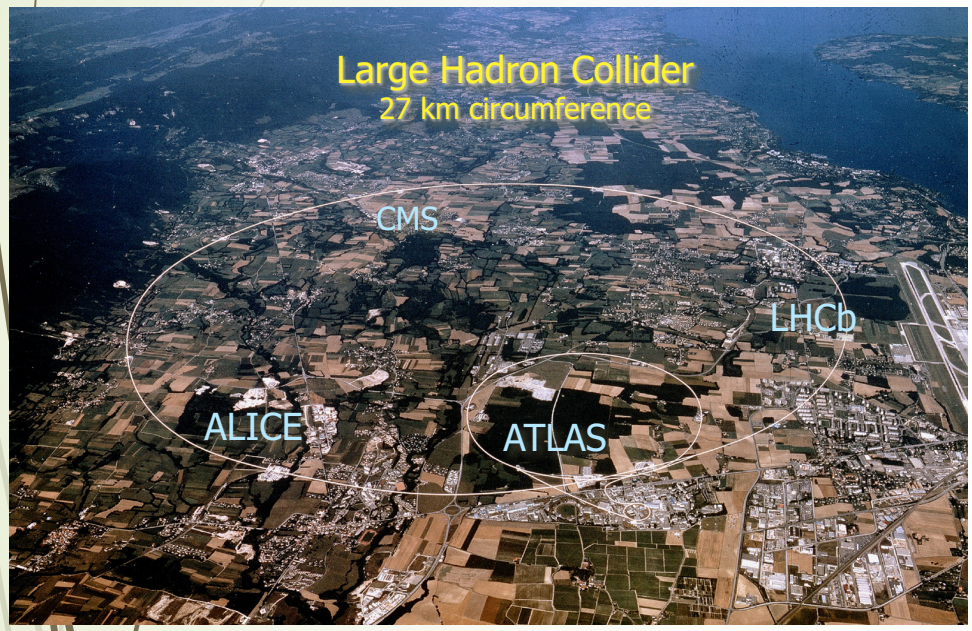
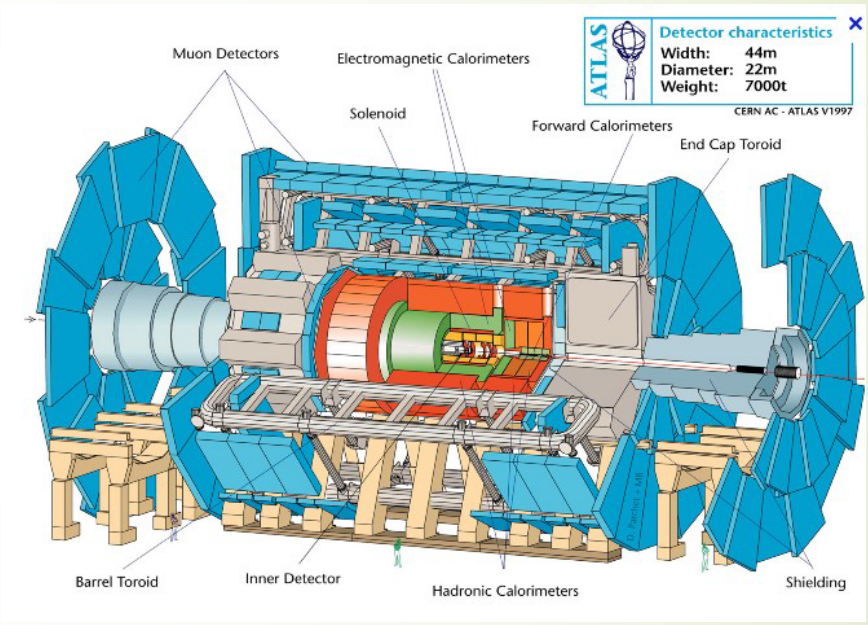
2017-12-01 卓越中心第五次会议

outline

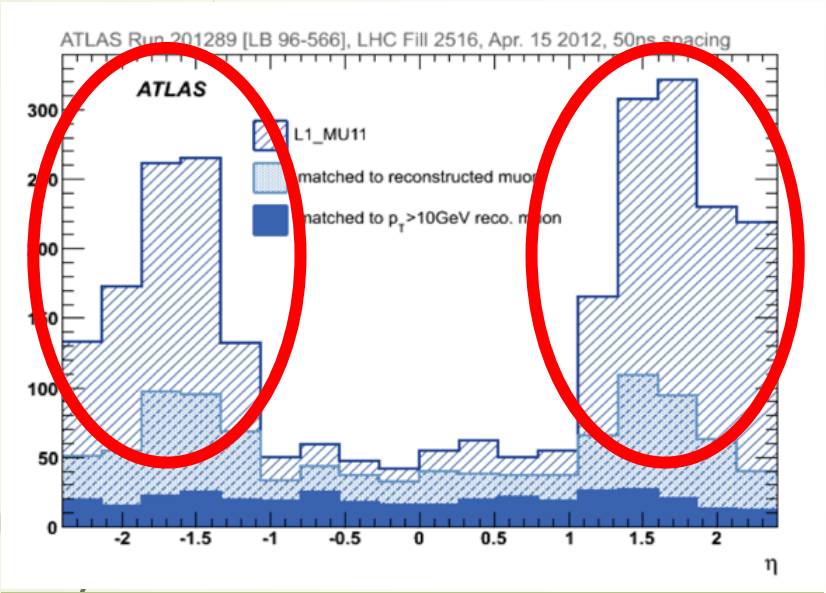
- The main work concentrated are relative measurements of top quark property and cross sections
- The main analysis which we contributed most are
  - Top pair spin correlations
  - W boson polzrizations
  - Single top Wt channel cross section measurement
  - Single top t channel cross section measurement
- All the analysis were published.

LHC and ATLAS

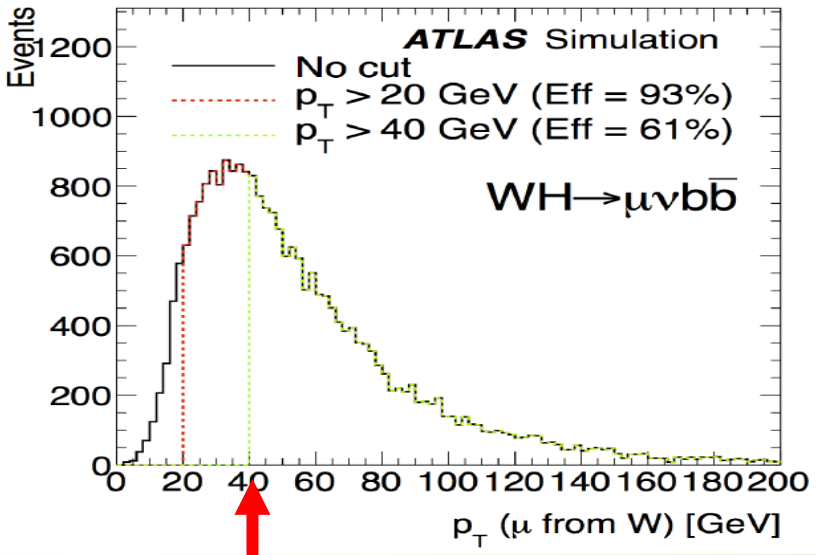




For HL-LHC,the allowed level-1 trigger will be **100kHz,** And **20kHz** for muon



90% Forward Muon trigger are fake, waste the bandwidth of the DAQ



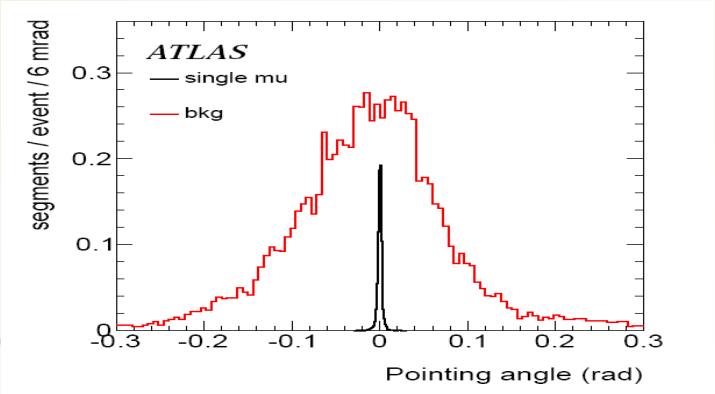
Increasing Pt cut lose lot of events

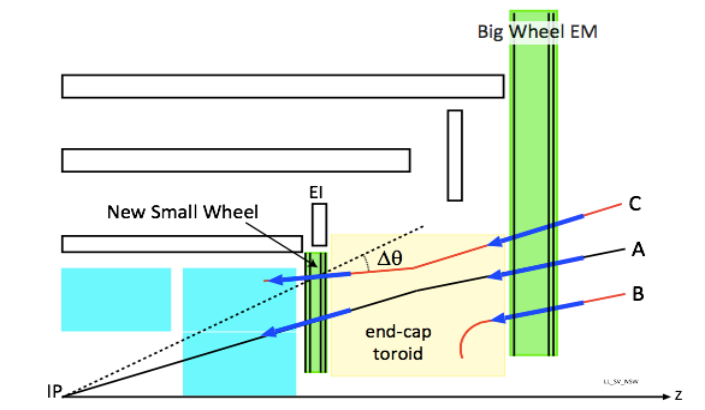
L1MU threshold (GeV)		Level-1 rate (kHz)
$p_T > 20$	$3x10^{34}cm^{-2}s^{-1}$	60 ± 11
$p_T > 40$		29 ± 5
$p_T > 20$ barrel only		7 ± 1

L1MU threshold (GeV)	$H \to b\bar{b}$ (%)	$H \to W^+W^-$ (%)
$p_T > 20$	93	94
$p_T > 40$	61	75
$p_T > 20$ barrel only	43	72

ATLAS-TDR-20-2013

Muon trigger upgrade strategy





1. $\Delta\theta$ distribution of real muon and background
2. Cut at $\Delta\theta$<7.5mrad highly suppress the background.

NSW principle: Reject tracks not from the IP.

B: created within the toroid

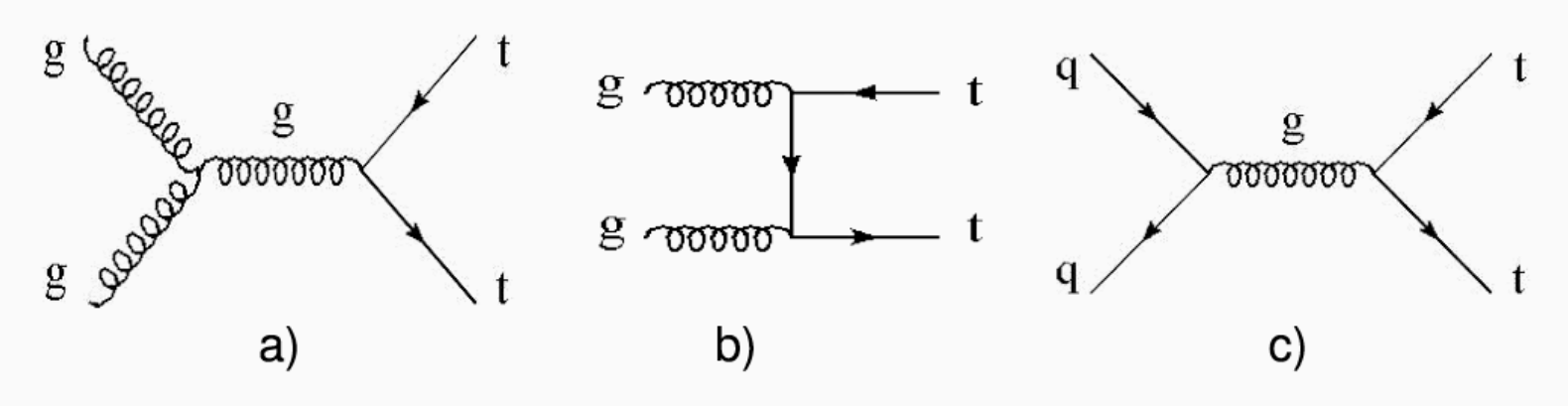
C: from the interations in the magnet system.

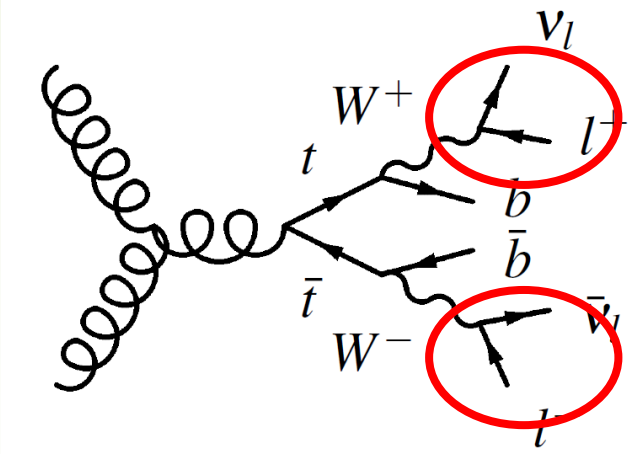
L1MU threshold (GeV)	Level-1 rate (kHz)
$p_T > 20$	60 ± 11
$p_T > 40$	29 ± 5
$p_T > 20$ barrel only	7 ± 1
$p_T > 20$ with NSW	22 ± 3
$p_T > 20$ with NSW and EIL4	17 ± 2

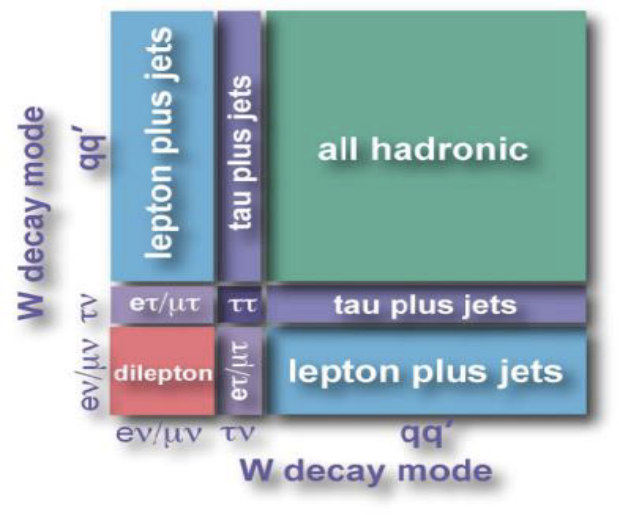
The level-1 trigger can be reduced to under 20kHz

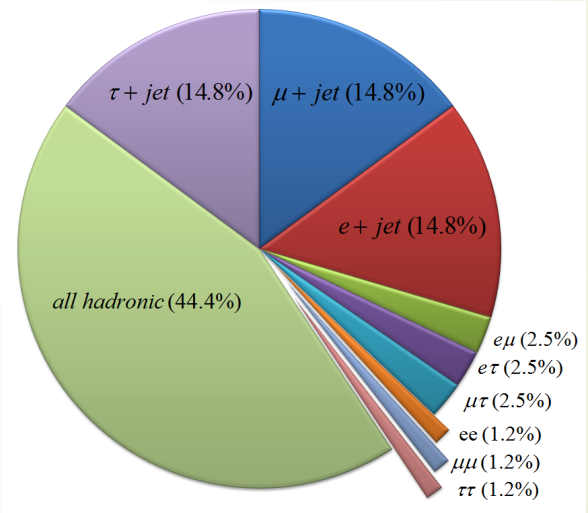
ATLAS-TDR-20-2013

- 6M $t\bar{t}$ evt @ 8 TeV & 25 fb^{-1}
- Decay before hadronization (best chance to probe a quasi-bare quark), Access to top properties through decay products
- Sensitive to new physics: polarization, Charge, FCNC…



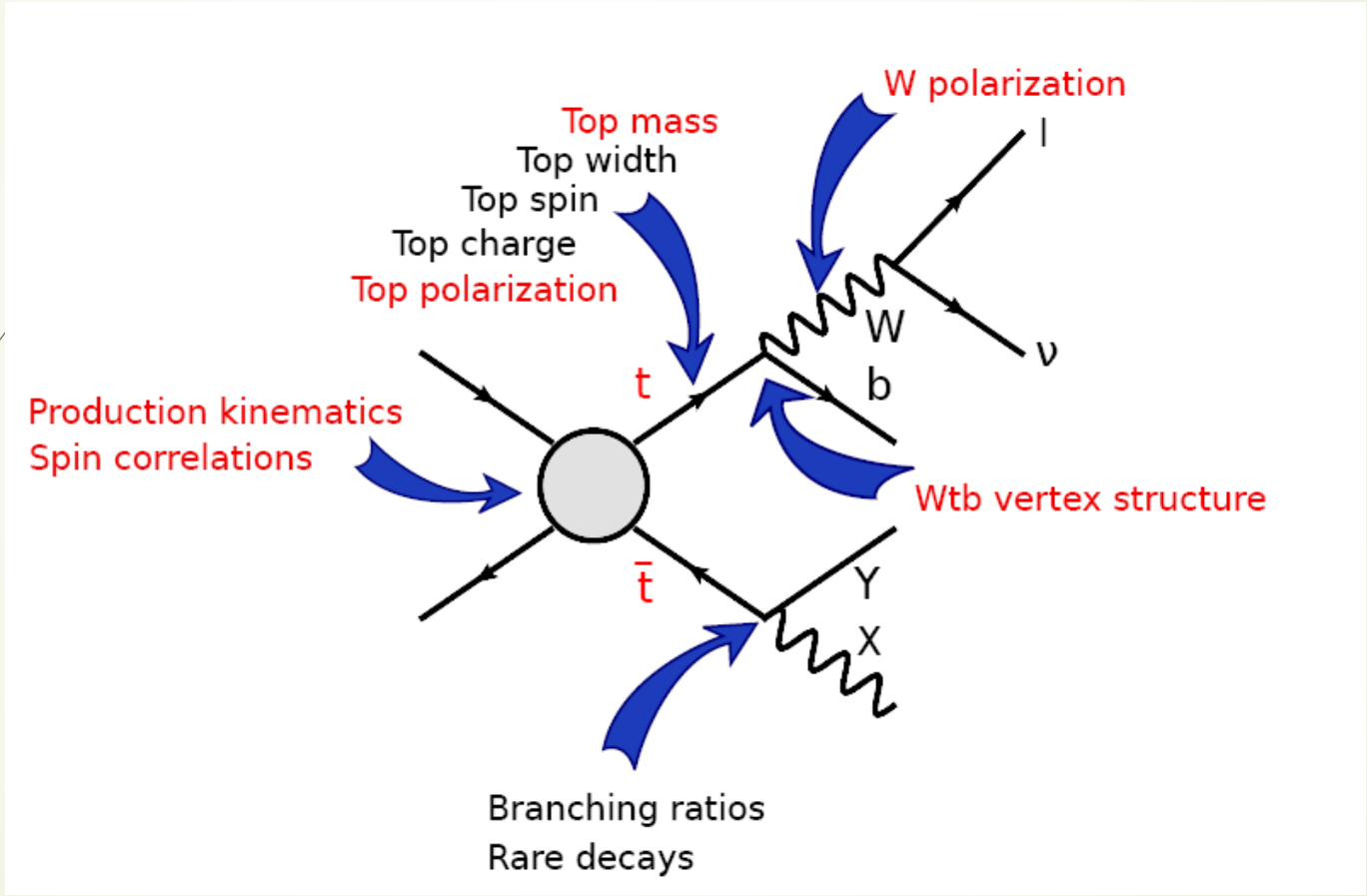






According to the decay mode of the W-boson, the tt channel are classified into di-lepton, single-lepton and fully-hardronic.

Top quark physics at LHC

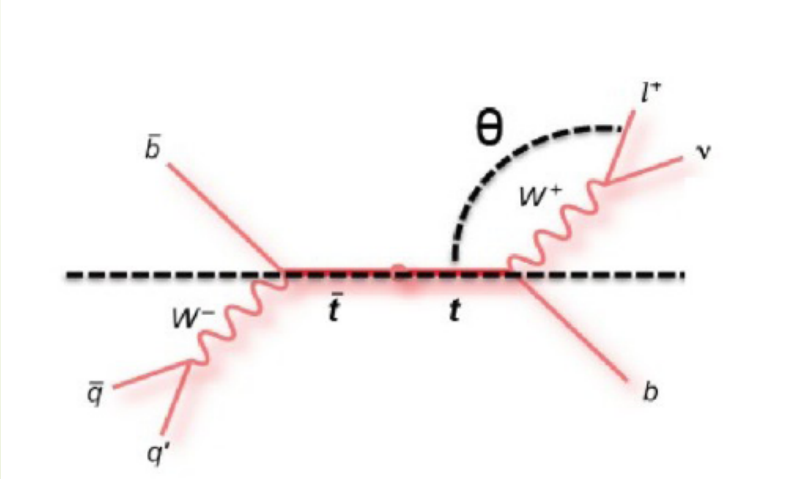


Spin correlations of top pairs

- As the lifetime of top quark is shorter than its de-polarization/hadronization time, it's possible to measure the effects of its spin.

- The angular distribution of top decay products correlate with the top spin according to

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta} = \frac{1}{2}(1+\alpha_i\cos\theta)$$

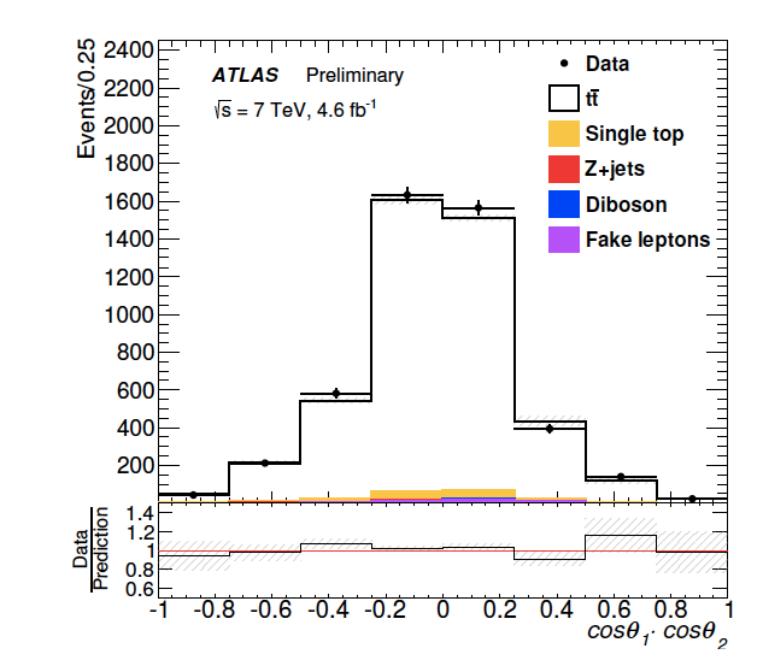


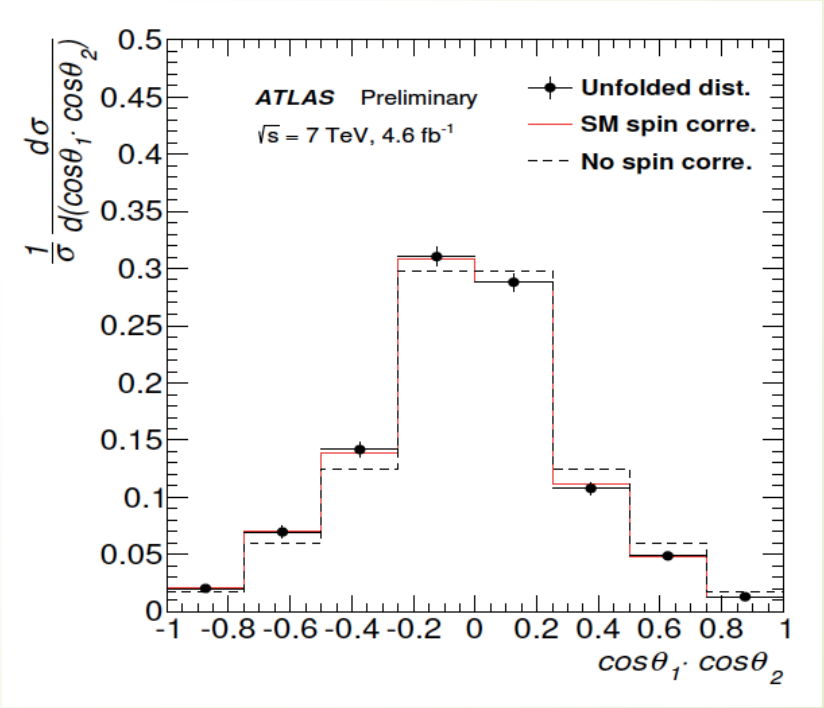
the angle defined between the top product in top rest frame and spin axis.

Motivations of the analyses

- New physics models beyond the SM (BSM) can alter the top polarization and the spin correlation strength by modifying the production mechanism of the tt pair, or the top decay, for example:
  - If tt pair is produced via a heavy Z boson [hep-ph/9911288] or via a heavy Higgs boson[PRD58, 114031 (1998)].
  - in supersymmetric models if a top quark decays into a charged Higgs boson, which then decays into a lepton and a neutrino [EPJC 66, 261 (2010)].
  - Models predicting top pair charge asymmetry introduce top polarization, as well.
  - Stop exiting will also correct the spin correlation strength by the loop corrections.

Unfolding of distributions and compared to theory predictions.

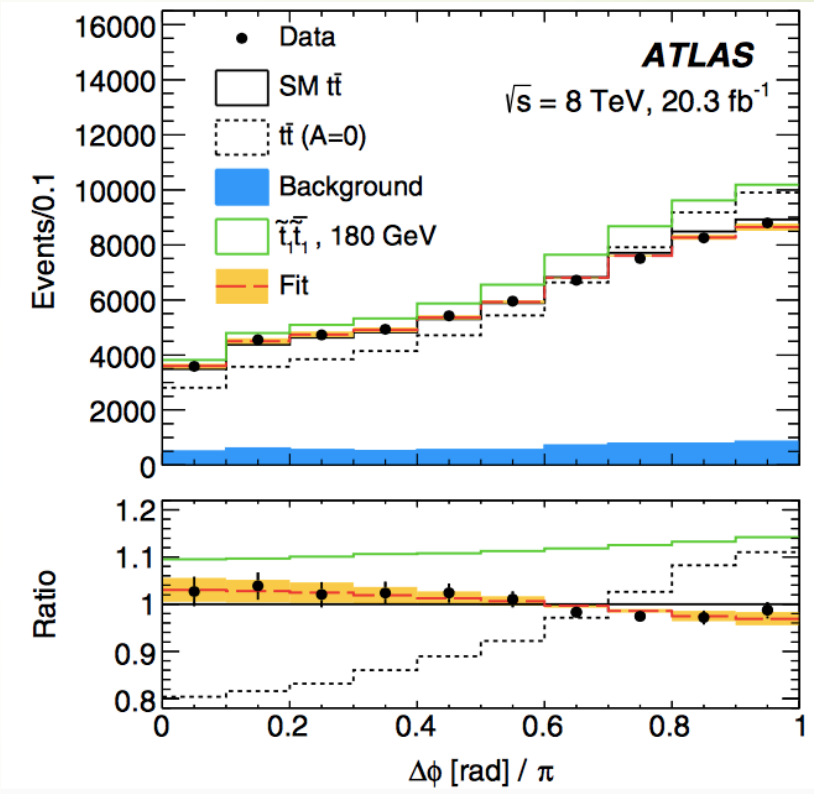




8TeV $\int Ldt$=20.2fb^{-1}

The azimuthal opening angle, between the momentum directions of the top quark decay products in the laboratory frame $\Delta\phi$.

$f_{SM} = 1.20 \pm 0.05(\text{Stat}) \pm 0.13(\text{Syst})$



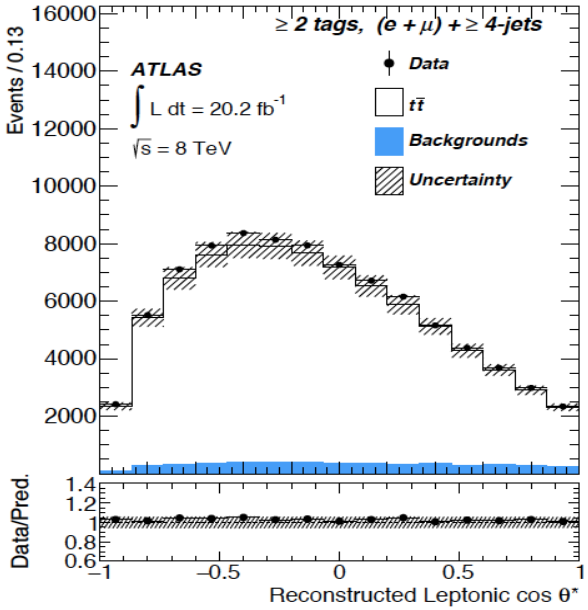
[PRL 114, 142001 (2015)]

W polarization

8TeV $\int Ldt$=20.2fb^{-1}

$$\frac{1}{\sigma}\frac{d\sigma}{d\cos\theta^*} = \frac{3}{4}(1-\cos^2\theta^*)\,F_0 + \frac{3}{8}(1-\cos\theta^*)^2\,F_L + \frac{3}{8}(1+\cos\theta^*)^2\,F_R$$

Single lepton channel: the angle between the W decay product and the b-jet in the W boson rest frame is measured

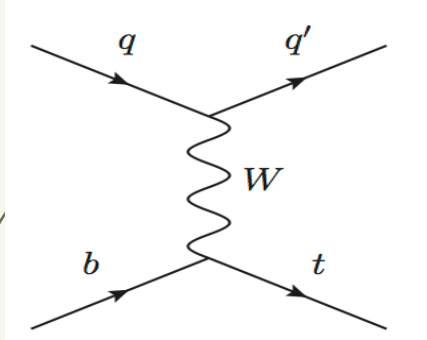


The most precise measurement to date is
$F_0 = 0.709 \pm 0.019$, $F_L = 0.299 \pm 0.015$, $F_R = -0.008 \pm 0.014$
consistent with SM predictions

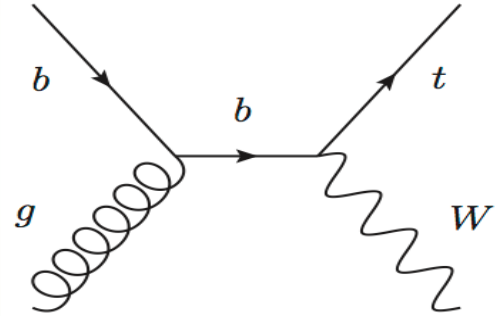
[Eur. Phys. J. C (2016) 76: 432]

Single top production

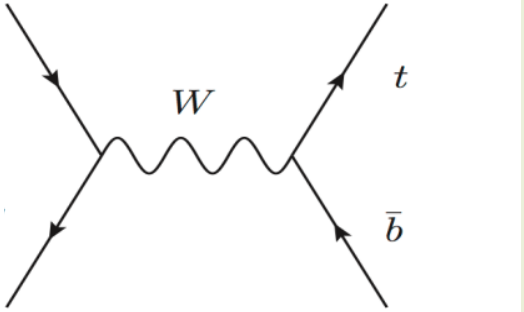
- Direct probe of the W-t-b coupling
- Precision test of the standard model



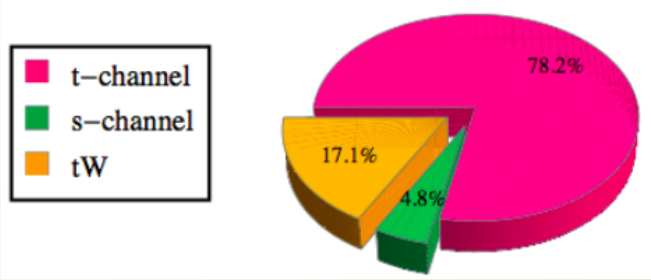
t channel



Wt channel



s channel



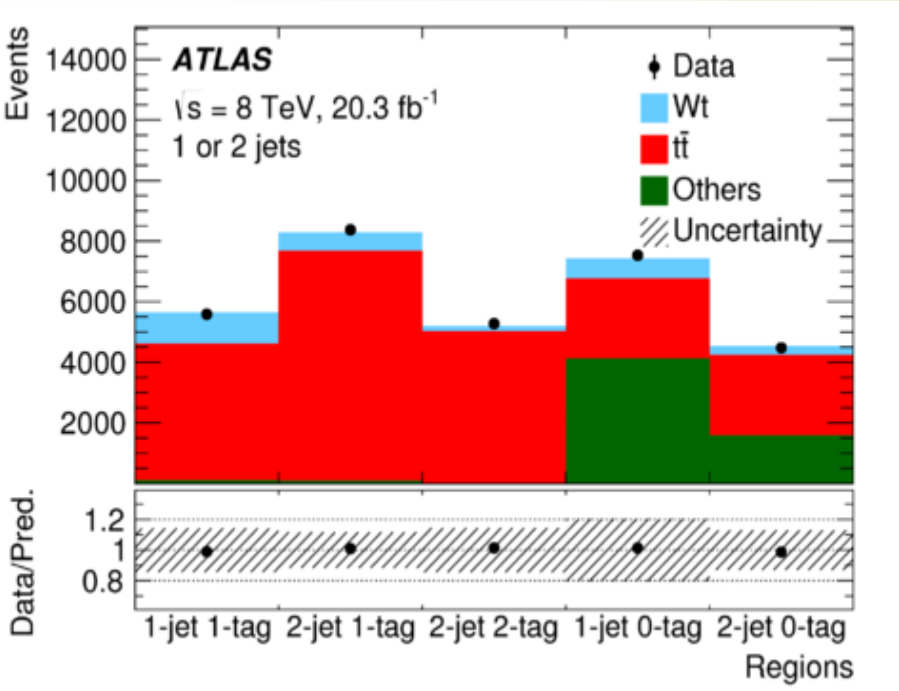
8TeV $\int Ldt$=20.2fb^{-1}

Single top Wt production at 8TeV

arXiv:1510.03752

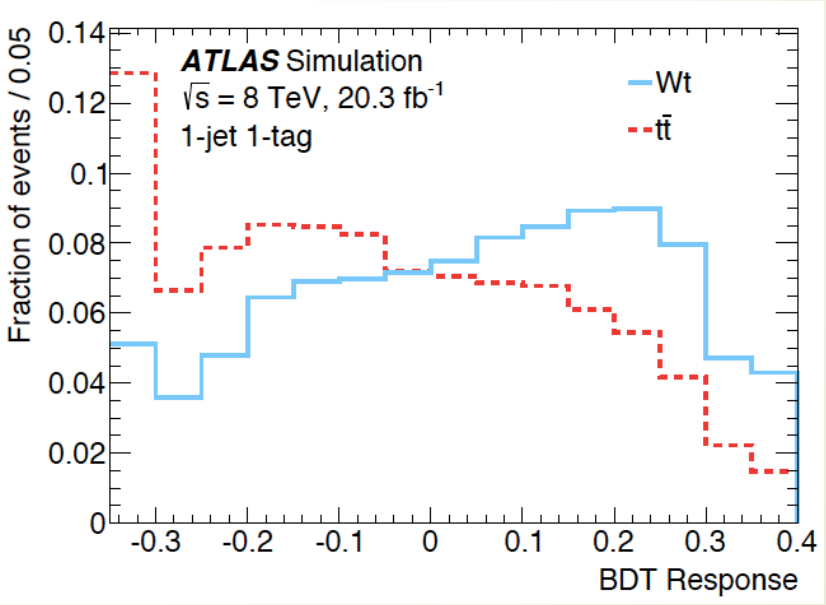
- Dilep decay events
- 1 signal region with 1-jet b-tagged:
  (1-jet 1-tag)
- 2 regions enriched in top pair:
  (2-jet 1-tag) and (2-jet 2-tag)
- 2 regions enriched in other BGs:
  (1-jet 0-tag) and (2-jet 0-tag)
  only used for control the BG

The BDTs are trained separately in three regions, 1-jet 1-tag, 2-jet 1-tag and 2-jet 2-tag, using simulated Wt events as signal and simulated $t\bar{t}$ events as background.



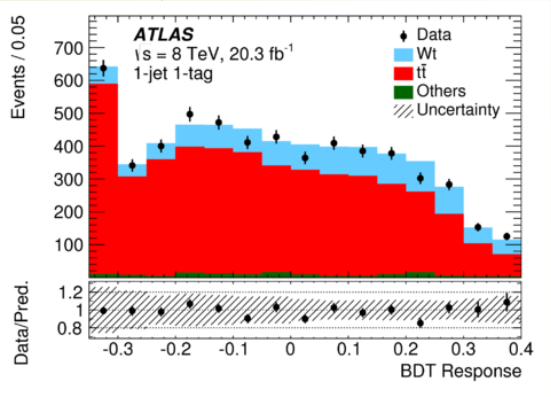
Variable	1-jet, 1-tag	2-jet 1-tag	2-jet 2-tag
$p_{\mathrm{T}}^{\mathrm{sys}}(\ell_1, \ell_2, E_{\mathrm{T}}^{\mathrm{miss}}, j_1)$	1		
$p_{\mathrm{T}}^{\mathrm{sys}}(\ell_1, \ell_2, j_1)$	7		
$p_{\mathrm{T}}^{\mathrm{sys}}(\ell_1, \ell_2)$	13		
$p_{\mathrm{T}}^{\mathrm{sys}}(j_1, j_2)$		10	1
$p_{\mathrm{T}}^{\mathrm{sys}}(\ell_1, \ell_2, E_{\mathrm{T}}^{\mathrm{miss}})$		12	2
$p_{\mathrm{T}}^{\mathrm{sys}}(\ell_1, \ell_2, E_{\mathrm{T}}^{\mathrm{miss}}, j_1, j_2)$		13	
$p_{\mathrm{T}}^{\mathrm{sys}}(\ell_1, j_1)$			13
$\sigma(p_{\mathrm{T}}^{\mathrm{sys}})(\ell_1, \ell_2, E_{\mathrm{T}}^{\mathrm{miss}}, j_1)$	4	5	
$p_{\mathrm{T}}(j_2)$			8
$\Delta p_{\mathrm{T}}(\ell_1, \ell_2)$	8		
$\Delta p_{\mathrm{T}}((\ell_1, \ell_2, j_1), (E_{\mathrm{T}}^{\mathrm{miss}}))$	9		
$\Delta p_{\mathrm{T}}(E_{\mathrm{T}}^{\mathrm{miss}}, j_1)$		9	
$\Delta p_{\mathrm{T}}(\ell_1, \ell_2, E_{\mathrm{T}}^{\mathrm{miss}}, j_1)$		16	
$\Delta p_{\mathrm{T}}(\ell_2, j_2)$			14
$\Delta R(\ell_1, j_1)$	2		5
$\Delta R(\ell_2, j_1)$		4	10
$\Delta R(\ell_2, j_2)$		6	
$\Delta R(\ell_2, j_1)$		11	
$\Delta R(\ell_1, \ell_2)$		14	
$\Delta R((\ell_1, \ell_2), j_2)$			9
$m(\ell_2, j_1)$	10	3	3
$m(\ell_1, j_2)$		1	4
$m(j_1, j_2)$		2	
$m(\ell_2, j_2)$		7	7
$m(\ell_1, j_1)$		8	6
$m(\ell_1, \ell_2)$		15	
$m(\ell_2, j_1, j_2)$			11
$m(\ell_1, \ell_2, j_1, j_2)$			15
$m_{\mathrm{T}}(j_1, E_{\mathrm{T}}^{\mathrm{miss}})$	5		
m_{T2}	11		
$E/m(\ell_1, \ell_2, j_2)$			16
$\sum E_{\mathrm{T}}$	3		
Centrality(ℓ_1, ℓ_2)	6		
Centrality(ℓ_1, j_1)	12		
Centrality(ℓ_2, j_2)			12

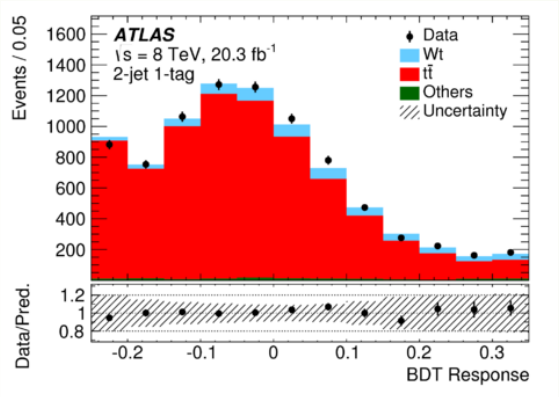
- Three BDT(Boosted Decision Trees) discriminants used for 3 b-tag regions respectively
  - ✓ 13 variables for (1-jet 1-tag)
  - ✓ 16 variables for (2-jet b-tagged)

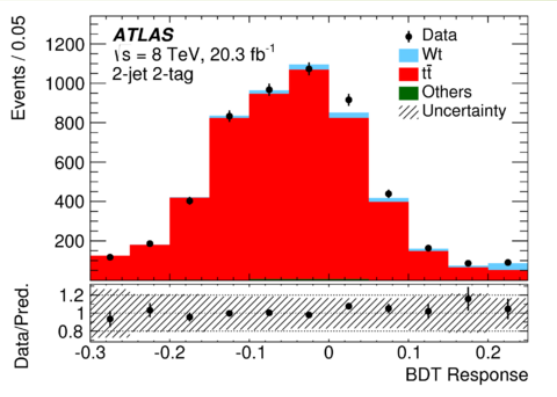


BDT response for 1-jet 1-tag. events.

- The inclusive Wt production cross-section is measured from a simultaneous profile likelihood fit to the three BDT classifiers







$$\sigma_{Wt} = 23.0 \pm 1.3\,(\text{stat.})^{+3.2}_{-3.5}\,(\text{syst.}) \pm 1.1\,(\text{lumi.})\ \text{pb}$$

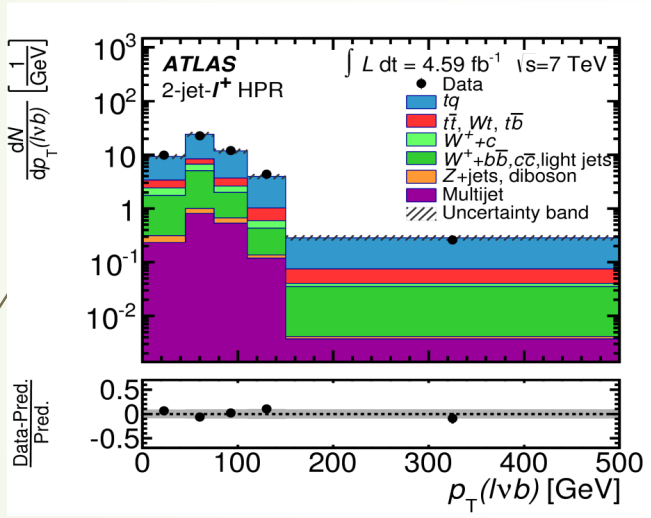
Total uncer. $^{+16}_{-17}$% Significance: 7.7σ (6.9σ exp.)

The measured value of $|f_{LV}V_{tb}|$ is 1.01 ± 0.10, and the corresponding lower limit on at the 95% confidence level is 0.80.

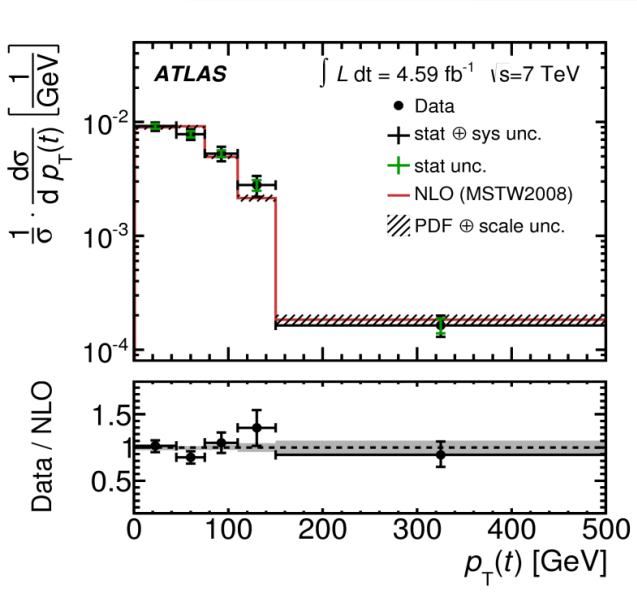
t-channel @7TeV: Differential cross section

arXiv:1406.7844

Measured 2-jet channel in high purity region of NN output



Measured distribution of the top-quark pT, distorted by detector effects and acceptance effects.



Normalized differential cross section of pT, agreement with the QCD NLO calculation.

Good agreement with NLO prediction

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t-channel @7TeV: ratio top/anti-top

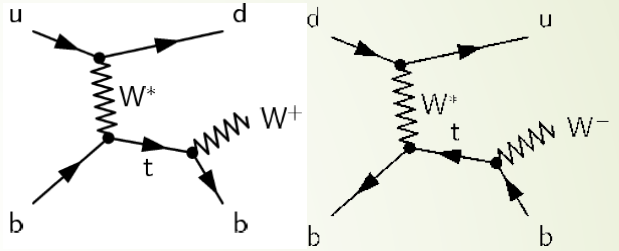
arXiv:1406.7844, accepted by PRD

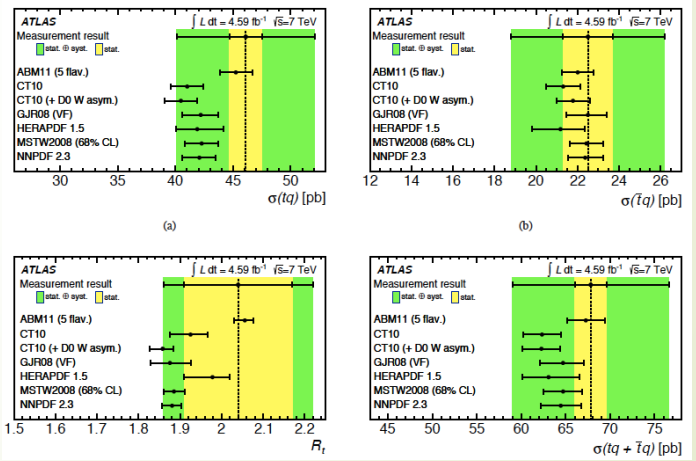
- Top and anti-top quark production asymmetric in t-channel
- Ratio R_t is sensitive to the ratio of u/d quark PDF

$$R_t = \frac{\sigma_t(t)}{\sigma_t(\bar{t})}$$

- Smaller uncertainties due to partial cancelations of common uncertainties

- Signal sample simulated with POWHEG(4F)+Pythia6,CT104f
- Two neural networks training for each 2-jet and 3-jet channel
- Extracted XS by binned maximum-likelihood fit to NN out distribution





Summary

- Relative analysis relative to top quark were done and pulished:
  - Top pair spin correlations
  - W boson polzrizations
  - Single top Wt channel cross section measurement
  - Single top t channel cross section measurement