

# W POLARIZATION & TOP SPIN CORRELATION

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( Many thanks to the organizers )

# OUTLINE

- + Introduction
- + W polarization measurement
  - Semi-lepton channel
  - Di-lepton channel
- + Top spin correlation measurement
- + Summary

# INTRODUCTION

- + “top property group” in ATLAS
  - CPPM, SDU, IHEP in competing with
    - × Gottingen, LIP,
- + 1.04/fb 2011 data analyzed
  - Note prepared
- + 4.7/fb analysis in progress
  - spin correlation in preparation

# INTRO TO THE PHYSICS

## + Possible new physics in twb coupling

$$- \mathcal{L}_{twb} \sim \frac{gV_{tb}}{\sqrt{2}} \gamma^\mu (f_L P_L + f_R P_R) + \frac{g}{\sqrt{2}} \frac{iV_{tb}\sigma^{\mu\nu}}{m_W} q^\nu (g_L P_L + g_R P_R) + H.C.$$

$$- \frac{1}{\sigma} \frac{d\sigma}{d\cos\psi} = \frac{3}{8} [2 F_0 \sin^2\psi + F_L (1 - \cos\psi)^2 + 2 F_R (1 + \cos\psi)^2]$$

## + Possible new physics via top pair production

- Gluon contributions, NLO QCD, EW loops

× Virtual contribution from New physics like SUSY ... ?

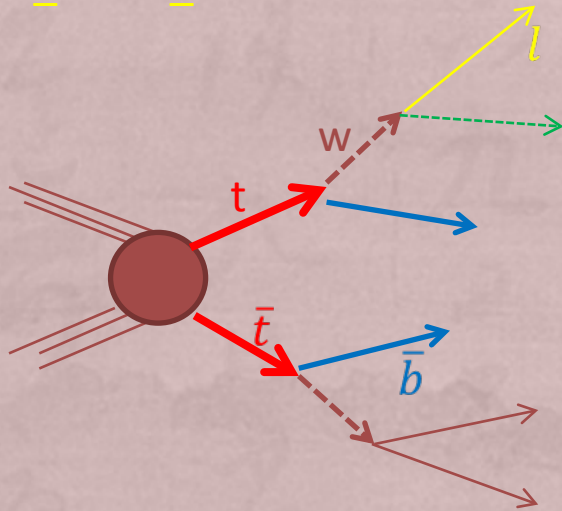
$$- \frac{1}{\sigma} \frac{d\sigma}{d\cos\vartheta_+ d\cos\vartheta_-} = \frac{1}{4} [1 + B_+ \cos\vartheta_+ + B_- \cos\vartheta_- - C \cos\vartheta_+ \cos\vartheta_-]$$

$$- \frac{1}{\sigma} \frac{d\sigma}{d\cos\phi} = \frac{1}{2} [1 + D \cos\phi]$$

## + Backgrounds : W+jets, multi-Jets, single top

# INTRO TO THE ANALYSES

EF\_e20\_medium/EF\_mu18  
 EF\_e22vh\_medium1  
 EF\_mu18\_medium



$\psi$

The angle between  
 lepton direction  
 in W ( top ) rest frame  
 and  
 W ( top ) direction  
 in top ( ttbar ) rest frame

## ≠ Leptons :

- PS :  $p_T \geq 25 \text{ GeV}$  ( $\mu 20$ ),  $|\eta| \leq 2.5$
- Tight\_PP / muID\_combined
- Isolation : Etcone & pTcone /dR\_jet

## + Jet

- $p_T \geq 25$ ,  $|\eta| \leq 2.5$ , JVF > 0.75
- AntiKt4\_EMTopo

## + B jet

- JetFitterCOMBNN/MV1 (0.602)
- 2 b jet required

## + MET : RefFinal\_em\_tightpp

- $M_T^W$  defined & utilized

# W POLARIZATION MEASUREMENT

## + Event reconstruction

- Pick 2 from  $\geq 2$  light jets for  $M_{jj} \triangleright M_W$
- pick 1 from  $\geq 2$  b jets for  $M_{jjb} \triangleright M_{top}$
- pick another b closest to lepton (smallest  $R_{bl}$ )
- Solve neutrino from  $M_{lv} \triangleright M_W$

## + KLFitter as a cross check

- Breitwigners against JetEnergy/MET resolution
- Tagged b is necessary

## + Corrections from Performance groups

# W-POLA YIELDS

ele	Standard selection	Standard selection	+ reconstruction
	1 b-tagged	2 b-tagged	2 b-tagged
$t\bar{t}$ signal	$4383.2 \pm 1006.3$	$2245.5 \pm 584.3$	$1338.9 \pm 328.0$
W + jets	$865.5 \pm 417.0$	$107.6 \pm 62.2$	$76.0 \pm 50.0$
Z + jets	$140.2 \pm 69.4$	$24.3 \pm 18.4$	$16.7 \pm 12.3$
di boson	$12.9 \pm 3.4$	$1.5 \pm 0.5$	$1.0 \pm 0.4$
single $t$	$233.4 \pm 50.1$	$83.2 \pm 24.0$	$48.0 \pm 13.4$
Multi-jets	$220 \pm 220$	$122 \pm 122$	$55 \pm 55$
Total expected	$5855.1 \pm 1087.2$	$2584.3 \pm 603.1$	$1535.9 \pm 339.0$
Collision data	5830.0	2482.0	1474.0

muo	Standard selection	Standard selection	+ reconstruction
	1 b-tagged	2 b-tagged	2 b-tagged
$t\bar{t}$ signal	$6494.7 \pm 1808.2$	$3344.8 \pm 1065.9$	$2130.7 \pm 644.2$
W + jets	$1393.6 \pm 683.7$	$172.9 \pm 102.3$	$109.0 \pm 72.6$
Z + jets	$143.4 \pm 67.2$	$22.7 \pm 13.6$	$17.3 \pm 10.2$
di boson	$22.3 \pm 6.5$	$3.0 \pm 1.2$	$2.2 \pm 0.7$
single $t$	$346.2 \pm 86.0$	$126.5 \pm 42.6$	$85.3 \pm 27.2$
Multi-jets	$509 \pm 509$	$249 \pm 249$	$113 \pm 113$
Total expected	$8909.2 \pm 1970.4$	$3918.9 \pm 1104.4$	$2457.4 \pm 661.2$
Collision data	9120.0	3791.0	2454.0

- + W+jet : 2-b tag MC-effi multiplied to DD scale
- + Mjets : DD-extracted faking multiplied to loose-control
- + Others : MC simulation

# W-POLA FIT

- + Unfolding method
  - Each 1/3 polarization has its own response
  - 3 PROTOS samples simulated/prepared
  - Unfolding function extracted for each polarization
- + Fit data with  $F_0$  &  $F_L$ 
  - Response functions convoluted
  - Backgrounds shapes superposed
  - Consistency from Iterating procedure



# W-POLA RESULT

	$e+jets$	$\mu+jets$	combined
$F_0$	$0.62 \pm 0.12 \pm 0.11$	$0.66 \pm 0.06 \pm 0.10$	$0.65 \pm 0.05 \pm 0.09$
$F_L$	$0.30 \pm 0.06 \pm 0.06$	$0.31 \pm 0.05 \pm 0.05$	$0.30 \pm 0.04 \pm 0.06$
$F_R$	$0.08 \pm 0.06 \pm 0.07$	$0.03 \pm 0.03 \pm 0.06$	$0.05 \pm 0.04 \pm 0.05$

SM  
0.695  
0.304

Dominant uncertainty

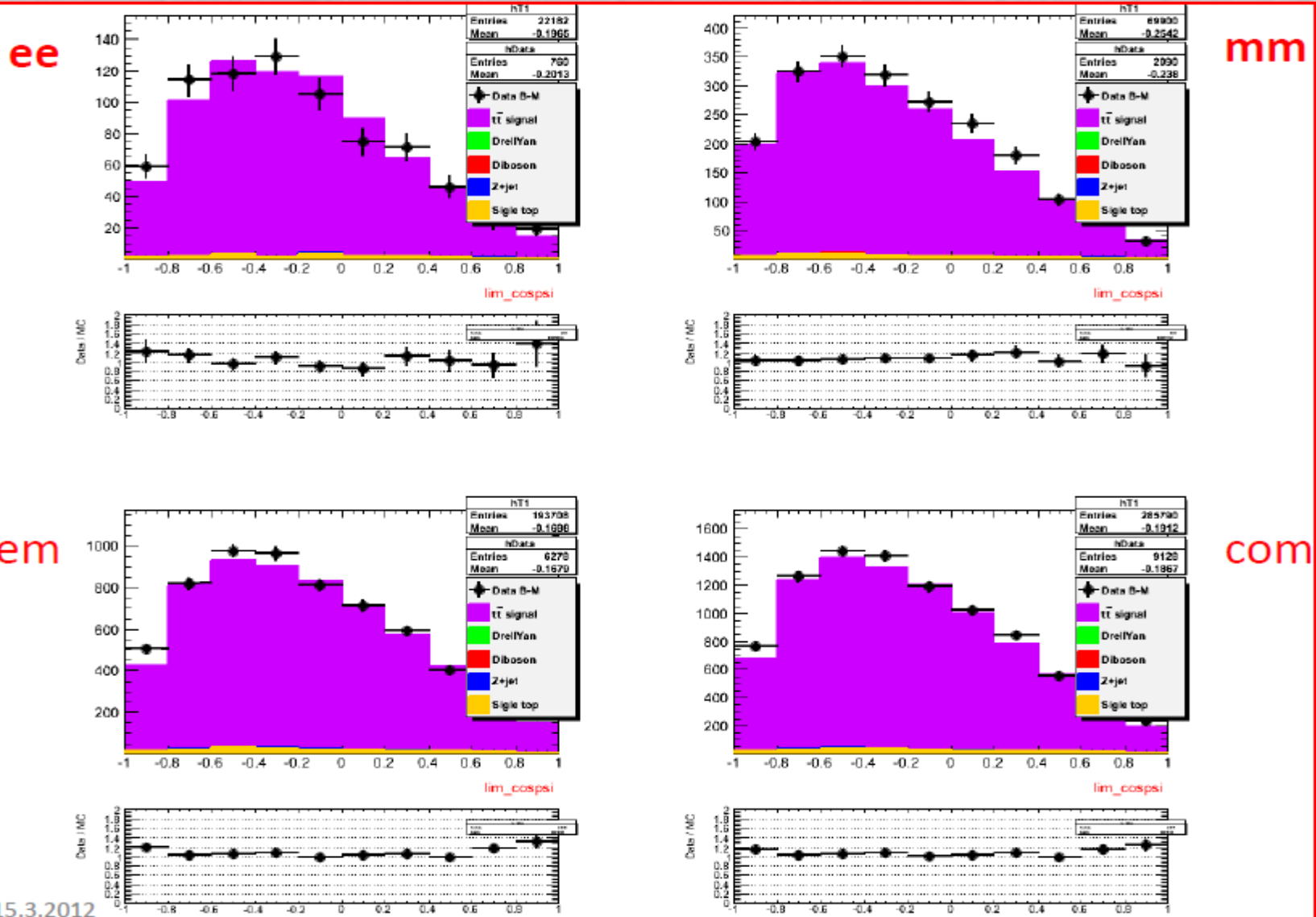
uncert	F0 em	FL em	F0 mu	FL mu	F0 comb	FL comb
ISR/FSR	0.054	0.030	0.033	0.019	0.040	0.018
JER	0.045	0.020	0.020	0.025	0.035	0.011
Btag	0.028	0.014	0.024	0.015	0.030	0.022
JES	0.022	0.003	0.019	0.007	0.017	0.005
LHC ?	0.036	0.016	0.013	0.013	0.032	0.018
LRE	0.016	0.007	0.029	0.006	0.027	0.028

In addition to ATLAS-Conf notes, The Editor Board has approved the paper draft on 1/fb result

# W-POLA DI-LEPTON

- + Extra backgrounds : Z+jets, di-boson
  - $M_{ll} > 15\text{GeV}$ ,  $|M_{ll} - 91\text{GeV}| > 10\text{GeV}$
- + Tagged  $b \geq 1$  for more yields
- + A little difficulty in Event topology
  - 2 components of MET
  - 2 mass of W, 2 mass of tops
  - Numerical searching/scanning
  - Many set of solutions from 2 quadratic equations
  - 73% success

# DI-LEP DISTRIBUTION



5.3.2012

# PRELIMINARY DI-LEPTON

380/3139/1045 events in ee/em/mm channel

After rec.	F0 (0.695)	FL (0.304)	FR (0.001)
ee	0.500 +/- 0.090	0.459 +/- 0.048	0.0407 +/- 0.0889
mumu	0.668 +/- 0.054	0.270 +/- 0.025	0.0618 +/- 0.0538
emu	0.564 +/- 0.030	0.400 +/- 0.017	0.0349 +/- 0.0297
combine	0.590 +/- 0.025	0.376 +/- 0.013	0.0343 +/- 0.0249

Systematics in progress, many thanks to Liming CHEN

# TOP SPIN CORRELATION(TSC)

+ Share many with W pola analysis

- Objects/event selection
- Event topology reconstruction

+ Angles Product instead of Double differentials

$$\frac{1}{\sigma} \frac{d\sigma}{d\cos\vartheta_+ d\cos\vartheta_-} = \frac{1}{4} [ 1 + B_+ \cos\vartheta_+ + B_- \cos\vartheta_- - C \cos\vartheta_+ \cos\vartheta_- ] \triangleright \frac{d\sigma}{\sigma d[\cos\vartheta_+ \cos\vartheta_-]}$$

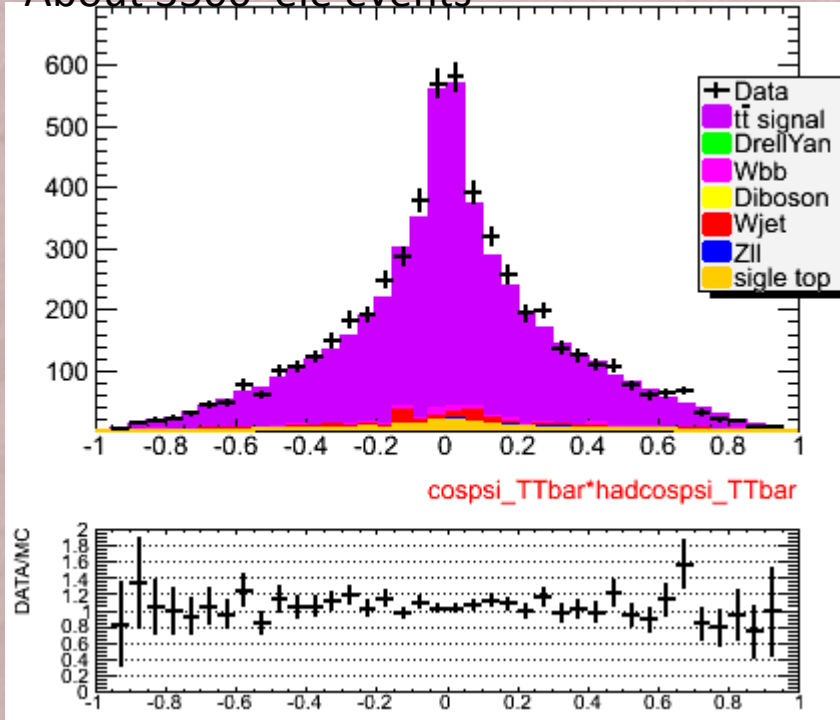
- + Linear term contribute null once well-corrected and integrated over PS
- + QCD conserve parity, other contribution is small/negligible, ignore B terms
- +  $C = -9 \langle \cos\vartheta_+ \cos\vartheta_- \rangle$

+ Iterated fit against unfolding function

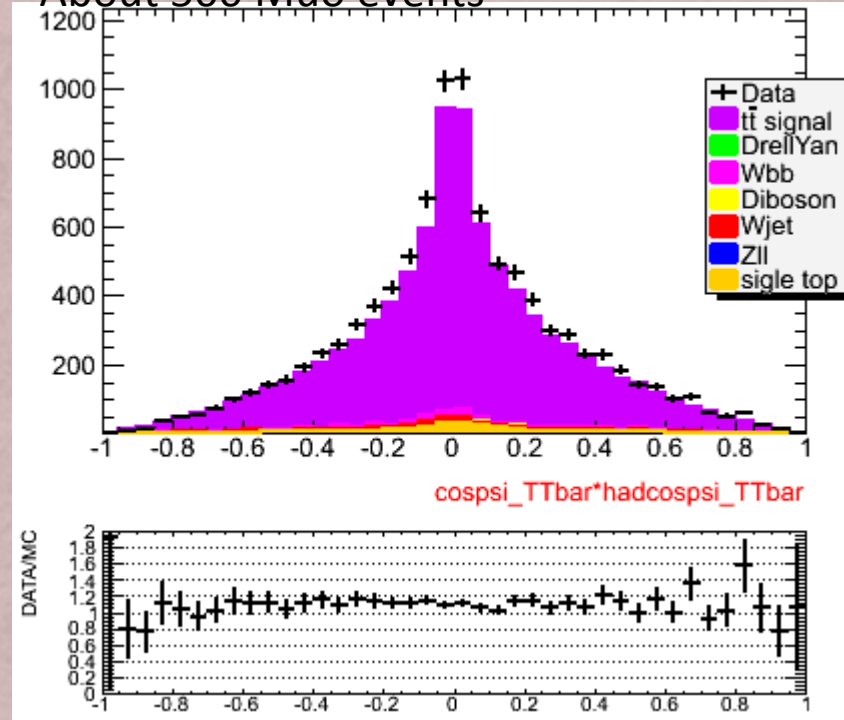
- The Mixing between the correlated and UNcorrelated samples

# ANGLE PRODUCT DIST

About 3500 ele events



About 500 Muo events



+  $C = 0.42$  ( SM 0.32 )

+ Systematics ongoing, many thanks to Bo LI

# SUMMARY

- + Good progress
- + Work more for better precision
- Thanks !