Measurement of the top charge asymmetry and top polarization

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Presentation

Of Myself

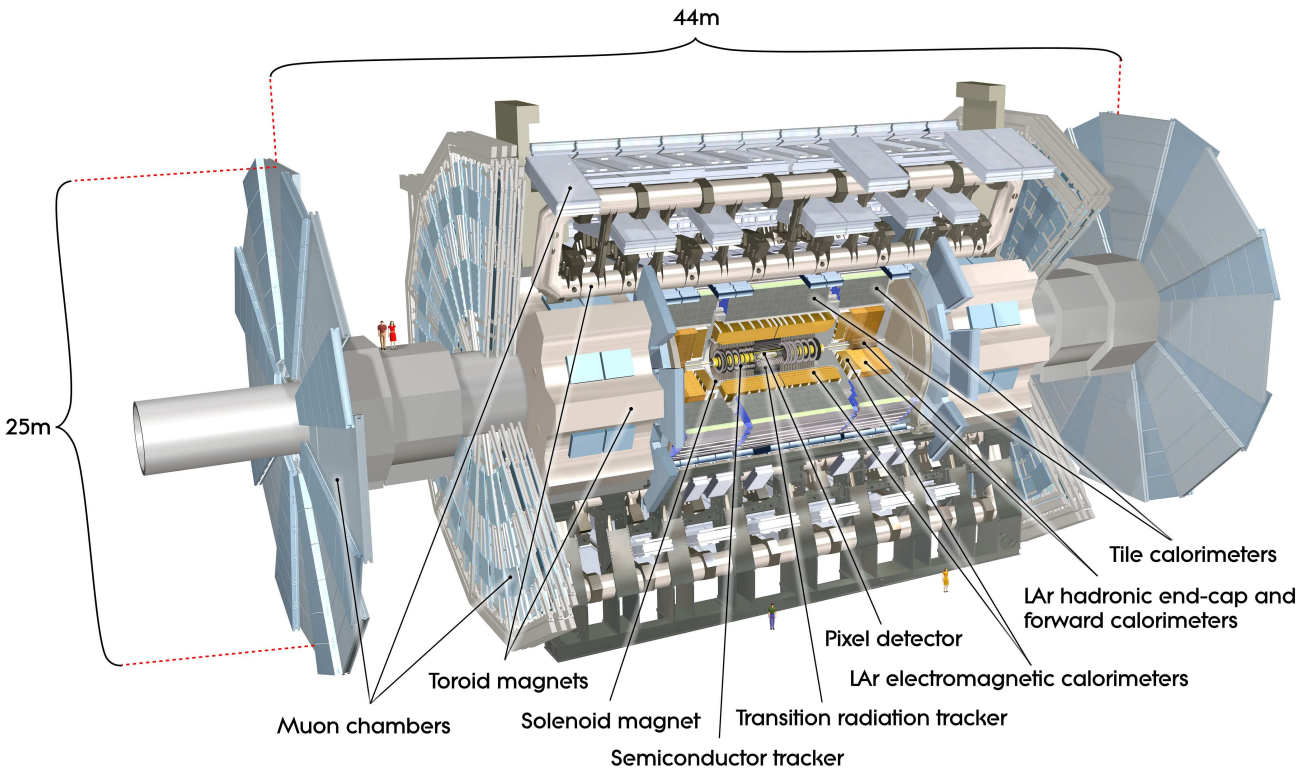
- started working at CEA-Saclay, Irfu/SPP last week
- come from Slovenia
- work experience: undergraduate degree in galactic dynamics (RAVE collaboration data analysis), PhD and postoc (DESY) experimental particle physics (ATLAS collaboration)
- main fields of work: Monte Carlo generators and tuning and experimental top quark physics
- responsibilities: 2010-2011 ATLAS top group MC contact, 2011- ATLAS top group systematics contact, 2007- ATLAS Monte Carlo group Pythia responsible, 2011 Summer Conference $t\bar{t}$ + jets note editor ....

Of The project

- joint experimental and theory project
- main goals: measurement and interpretation of the top charge asymmetry and top polarization at the LHC
- more in the following slides

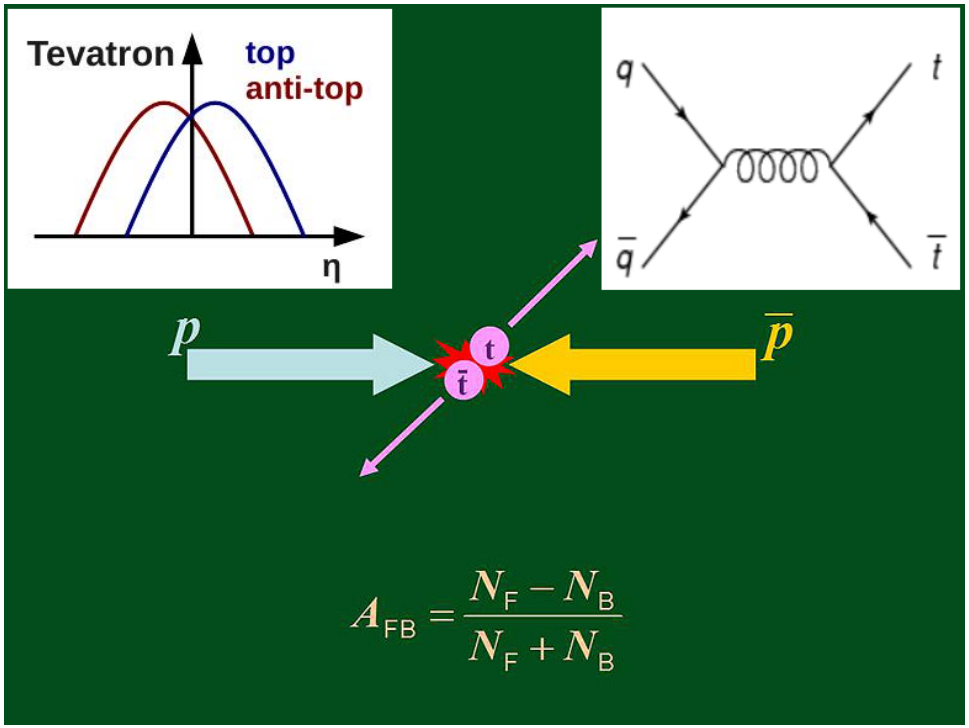
The ATLAS Collaboration and Detector

- top quark = the SM quark with the **largest** mass
- measurements done at the **L**arge **H**adron **C**ollider at CERN
- collision products detected with **A** **T**oroidal **L**HC **A**pparatu**S**
- **Large detector**: 25 m high, 44 m long, m=7t.
- **Large collaboration**: $\sim$ 3000 physicists



Top measurements and forward-backward asymmetry at TeVatron

- top discovered by CDF and D0 collaborations at TeVatron in 1995
- TeVatron (1987 - 2011) : $p - \bar{p}$ collider with highest $\mathrm{E_{cm}}$=1.96 TeV
- enough top quarks have been collected to measure many top quark properties
- **forward-backward asymmetry in $t\bar{t}$ production**:
  the (anti)top quark is predicted to be emitted preferably in the direction of the incoming (anti)quark

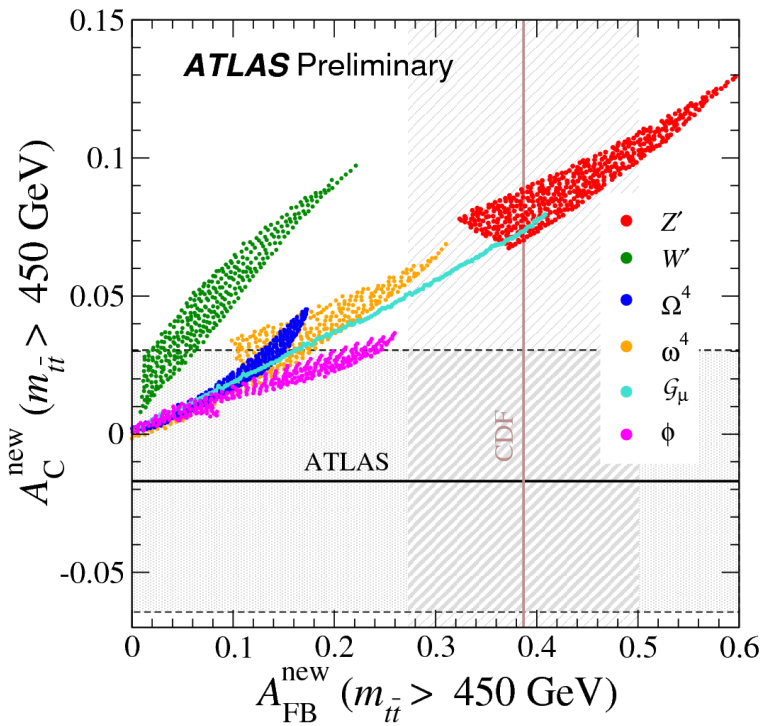


Asymmetry notably ($\sim 2 - 3\sigma$) larger than predicted by the SM.

Top charge asymmetry and polarization at the LHC

Asymmetry:

- pp collisions, $\mathrm{E_{cm}}$=7(8)TeV in 2011(2)
- **do we observe asymmetry excess at the LHC as well?**
- so far LHC experiments (ATLAS and CMS) asymmetry measurements compatible with the Standard Model
- **LHC results already useful**; limits on BSM physics models proposed to explain the TeVatron asymmetry excess



Polarization: not measured yet!

Project tasks

Top charge asymmetry:

- **a lot of work remains yet to be done;**
- refining the measurements: exploring phase-space dependence of the asymmetry, look for other observables and other decay channels
- using new (larger) data samples becoming available at the LHC

Top quark polarization:

- perform **first measurement** of the observable
- **sensitive to new physics**
- BSM physics models that can explain TeVatron forward-backward asymmetry may or may not also predict non-trivial net polarization at the LHC
- **in combination with the charge asymmetry** the top quark polarization has a **good constraining power** for these models .

In collaboration with the theorists working on the project we aim to address (and hopefully answer) the question whether or not new physics processes can be observed for the LHC top charge asymmetry and top polarization.

Additional Slides

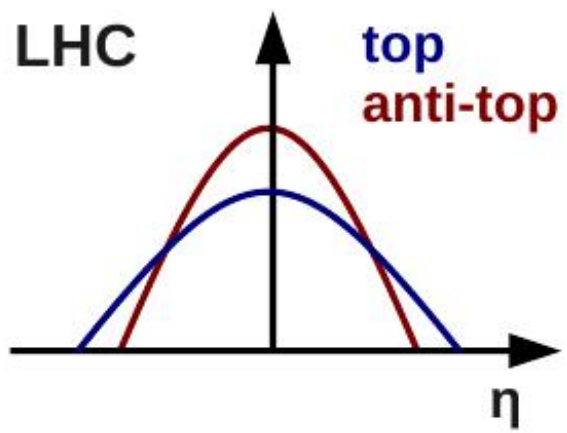
Charge asymmetry in $t\bar{t}$ production, arXiv:1203.4211

- $\boxed{\mathcal{L}_{\rm int} = 1.04\ \mathrm{fb}^{-1}}$
- The measurement is particularly interesting since the **Tevatron experiments report 2-3 σ excess in forward-backward asymmetry (A_{FB}) in $t\bar{t}$ events.**
- at LHC the physics effects responsible for Tevatron (A_{FB}) are manifest in charge asymmetry defined as:

$$A_C^{pp} = \frac{N(\Delta|y| > 0) - N(\Delta|y| < 0)}{N(\Delta|y| > 0) + N(\Delta|y| < 0)},$$

  where $\Delta|y| = |y_t| - |y_{\bar{t}}|$

- SM value [1] of $A_C^{pp} = 0.006 \pm 0.002$.

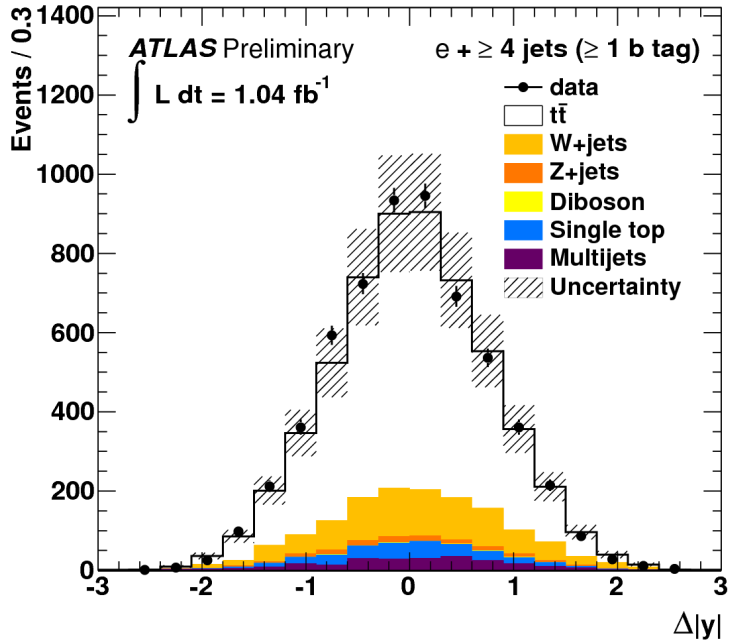


[1] for the analysis kinematics cuts, using MC@NLO

Charge asymmetry in $t\bar{t}$ production, arXiv:1203.4211

Analysis strategy:

- single lepton (e,μ) channel
- full $t\bar{t}$ system reco.; charge of the $t(\bar{t})$ follows from the charge of the final state lepton
- two inv. mass bins: $m_{t\bar{t}} < 450$ GeV and $m_{t\bar{t}} > 450$ GeV
- unfolding for theory comparisons



Result:

$A_C = -0.018 \pm 0.028\ (\text{stat}). \pm 0.023\ (\text{syst}.)$ [a]

- **consistent with the SM value** of $A_C^{pp} = 0.006 \pm 0.002$
- **sensitivity can be improved; reducing syst. uncertainty, using different kinematics region**
- **limits on allowed A_C(LHC) and A_{FB}(Tevatron) regions** can constrain some models proposed to explain the Tevatron A_{FB}

[a] $A_C = -0.053, -0.008 \pm 0.070, 0.035\ (\text{stat}). \pm 0.054, 0.032\ (\text{syst}.),\ m_{t\bar{t}} < 450\ \text{GeV},\ m_{t\bar{t}} > 450\ \text{GeV}$

Charge asymmetry in $t\bar{t}$ production, arXiv:1203.4211

Limits on allowed A_C(LHC) and A_{FB}(Tevatron) regions:

- Z': flavour-changing boson with right-handed couplings, exchanged in the t-chan. in $u\bar{u} \longrightarrow t\bar{t}$
- W': boson with right-handed couplings contributing to $d\bar{d} \longrightarrow t\bar{t}$
- $\Omega_4(\omega_4)$, charge=4/3 scalar colour-sextet(triplet) contributing to u-chan. $u\bar{u} \longrightarrow t\bar{t}$
- G_μ: heavy axigluon exchanged in s-chan.
- Φ: scalar doublet with the same quantum numbers as the SM Higgs

Figure details:

- coloured areas = mass and coupling scans (consistent with exp. data)
- solid(dashed) lines = experimental measurement(uncertainty)
- SM value is substracted from A_C,A_{FB} values