Measurement of the W-boson helicities in top decays at CMS/LHC

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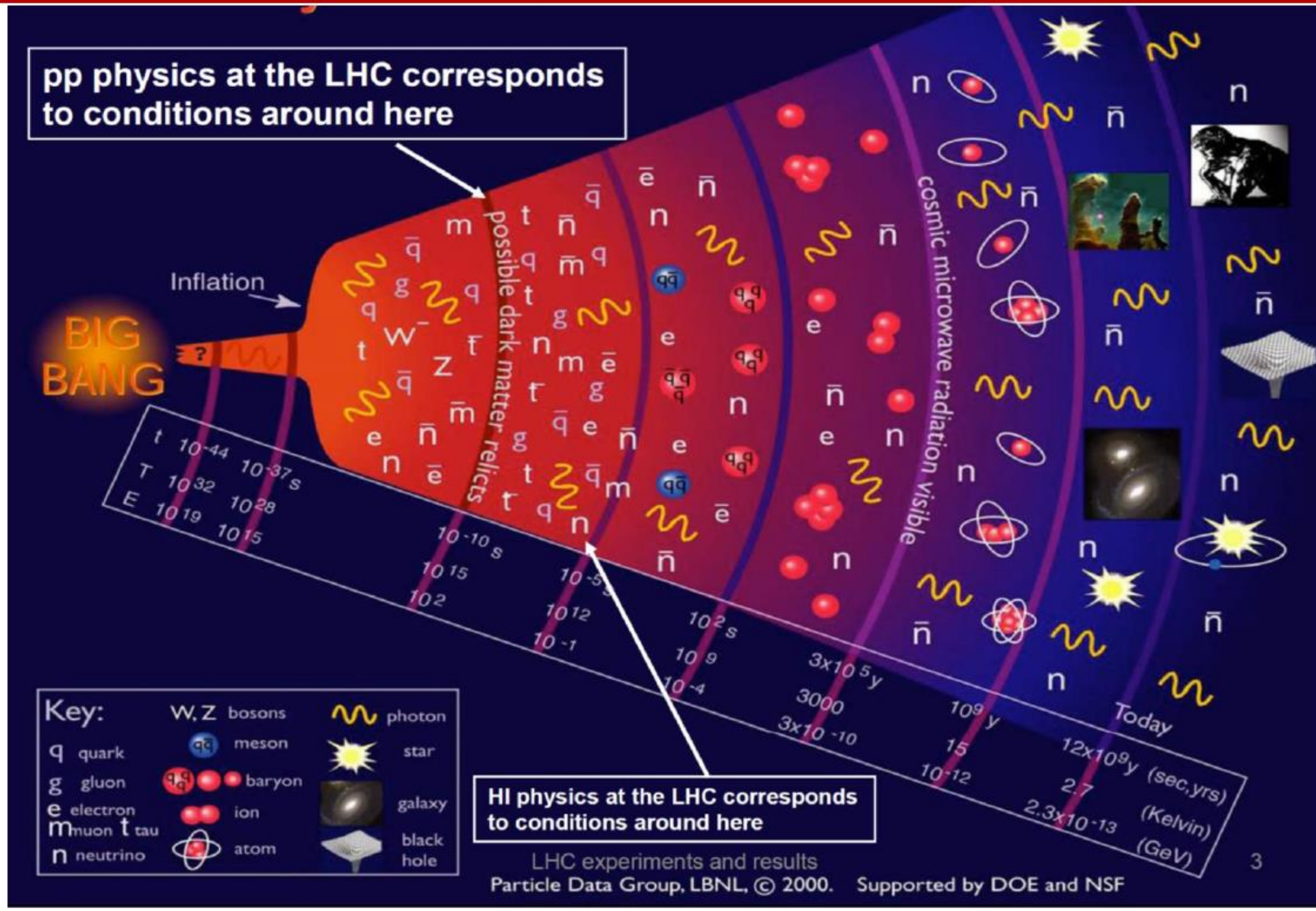
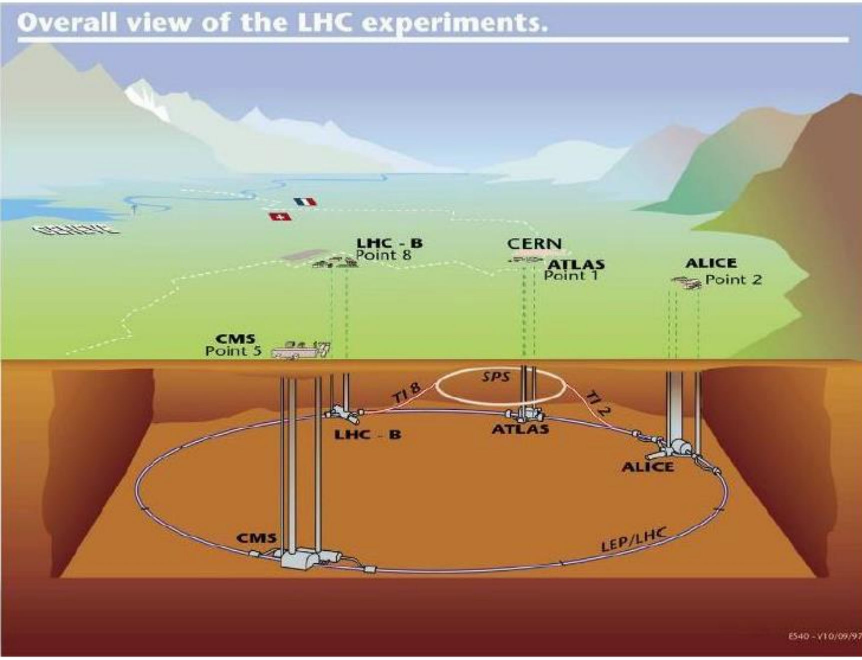
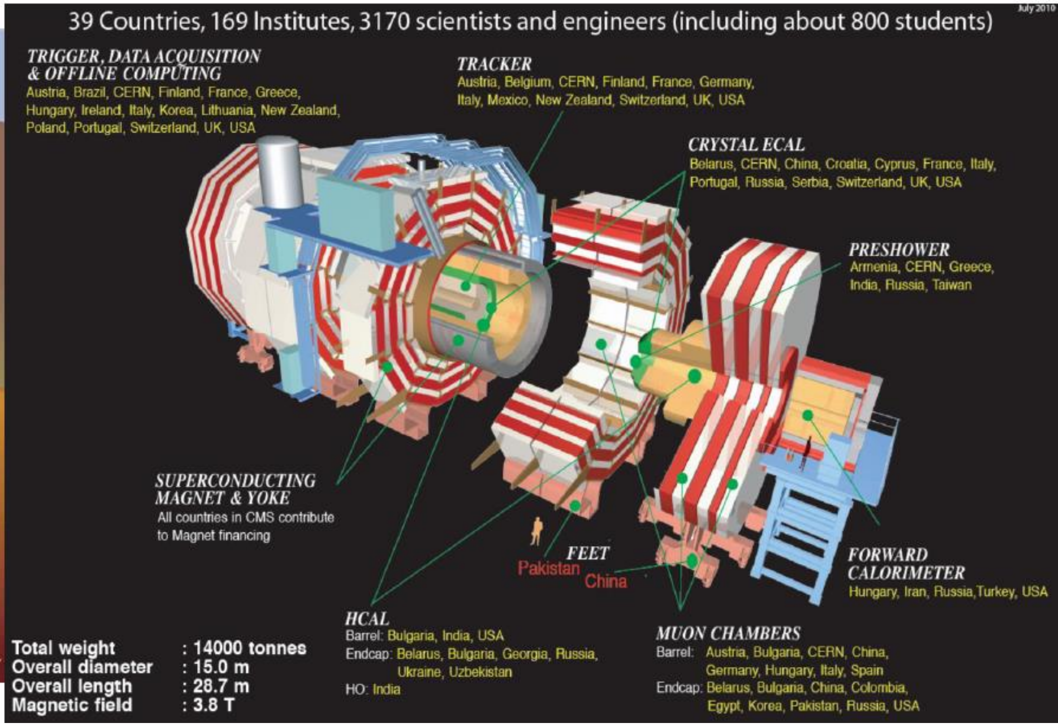
4η ΗΜΕΡΙΔΑ ΕΝΗΜΕΡΩΣΗΣ ΦΟΙΤΗΤΩΝ ΤΟΥ ΔΠΜΣ
‘ΦΥΣΙΚΗ ΚΑΙ ΤΕΧΝΟΛΟΓΙΚΕΣ ΕΦΑΡΜΟΓΕΣ’

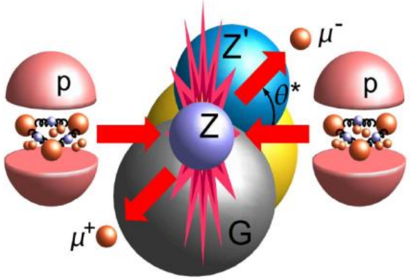
The LHC purpose

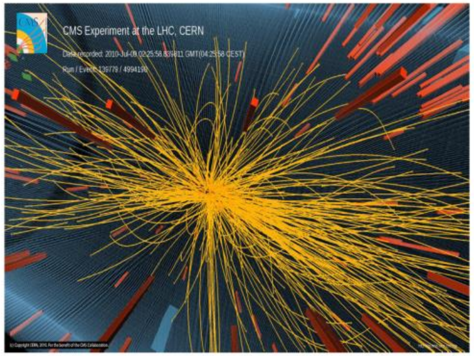



Overall view of the LHC experiments.
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC


39 Countries, 169 Institutes, 3170 scientists and engineers (including about 800 students)
July 2010
TRIGGER, DATA ACQUISITION & OFFLINE COMPUTING
Austria, Brazil, CERN, Finland, France, Greece, Hungary, Ireland, Italy, Korea, Lithuania, New Zealand, Poland, Portugal, Switzerland, UK, USA
TRACKER
Austria, Belgium, CERN, Finland, France, Germany, Italy, Mexico, New Zealand, Switzerland, UK, USA
CRYSTAL ECAL
Belarus, CERN, China, Croatia, Cyprus, France, Italy, Portugal, Russia, Serbia, Switzerland, UK, USA
PRESHOWER
Armenia, CERN, Greece, India, Russia, Taiwan
SUPERCONDUCTING MAGNET & YOKE
All countries in CMS contribute to Magnet financing
FEET
Pakistan
China
FORWARD CALORIMETER
Hungary, Iran, Russia,Turkey, USA
HCAL
Barrel: Bulgaria, India, USA
Endcap: Belarus, Bulgaria, Georgia, Russia, Ukraine, Uzbekistan
HO: India
MUON CHAMBERS
Barrel: Austria, Bulgaria, CERN, China, Germany, Hungary, Italy, Spain
Endcap: Belarus, Bulgaria, China, Colombia, Egypt, Korea, Pakistan, Russia, USA
Total weight : 14000 tonnes
Overall diameter : 15.0 m
Overall length : 28.7 m
Magnetic field : 3.8 T

$$E = mc^2$$


p
p
Z'
Z
G
θ*
μ⁻
μ⁺

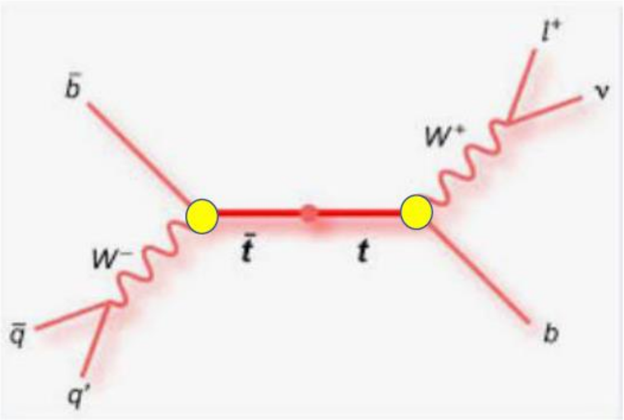

CMS Experiment at the LHC, CERN

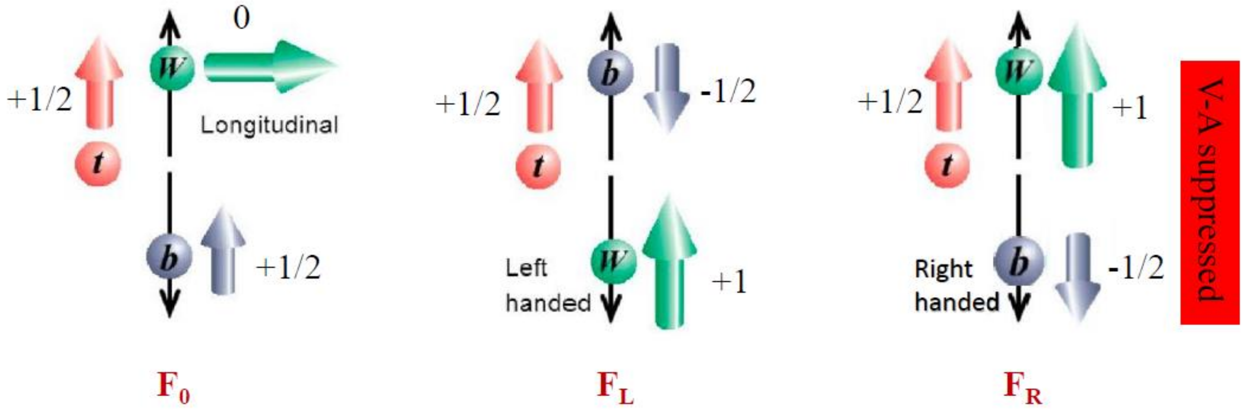
TOP : W helicities from ttbar events

Motivation:

The measurement is sensitive to the Wtb vertex structure;

new physics from anomalous Wtb couplings





CMS (8 TeV)

Phys. Lett. B 762 (2016) 512

F_0 = 0.681 ± 0.012 (stat) ± 0.023 (syst),
F_L = 0.323 ± 0.008 (stat) ± 0.014 (syst), and
F_R = -0.004 ± 0.005 (stat) ± 0.014 (syst)

ATLAS (8 TeV)

Eur. Phys. J. C 77 (2017) 264

F_0 = 0.709 ± 0.019 (stat+syst),
F_L = 0.299 ± 0.015 (stat+syst), and
F_R = -0.008 ± 0.014 (stat+syst)

TOP : W helicities from ttbar events

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

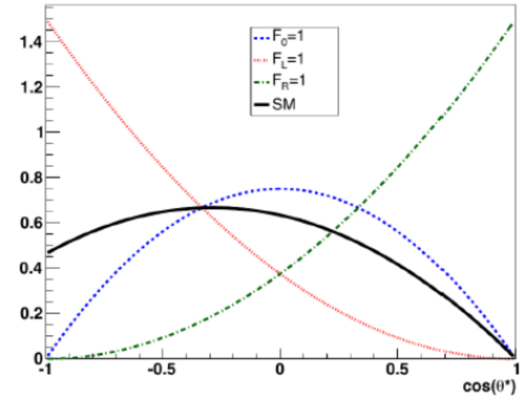
$F_0 = 0.687 \pm 0.005$, $F_L = 0.311 \pm 0.005$, $F_R = 0.0017 \pm 0.0001$
(Phys. Rev. D **81** (2010) 111503) , mt = 172.8 1.3 GeV

Can we do better by changing the 'sensitive variable' ?

- We propose a different approach to extract the W-helicity
  1. $\Delta\Phi(\ell, \text{jet})$
  2. $M_{\ell b}$

Previous Measurements

- Based on $\cos(\theta^*)$ → Strong discriminant power



- $\cos(\theta^*)$ needs the reconstruction of the top process ($t\bar{t}$ or single top)
- $t\bar{t}$ kinematic fit introduces a dependency of top mass.

TOP : W helicities from ttbar events

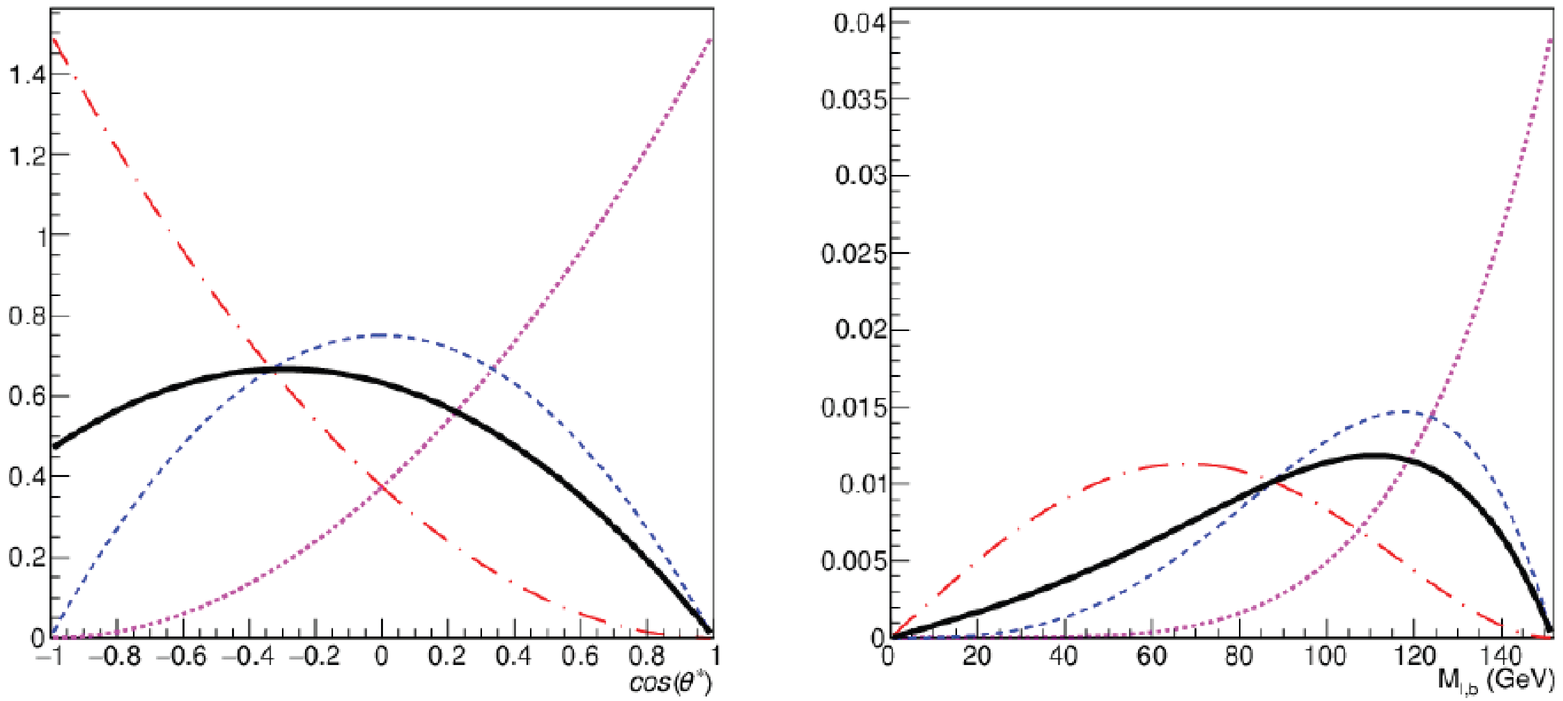


Figure 1: Predicted distributions for the different helicity fractions versus $\cos\theta^*$(left) and $m_{\ell b}$(right). The distributions for the helicity fractions F_0, F_R, and F_L are shown as dashed (blue), dotted (pink), and dash-dotted (red) lines, respectively. The sum of the three contributions according to the SM predictions is displayed as a solid line.

W helicities TOPICS

- Measure the W helicities with **different** sensitive variable
  - $\cos(\Theta^*)$
  - $\Delta\varphi\ (l, jet)$
  - M_{lb}
- Estimate basic backgrounds with data driven methods (Wjets & QCD)
- Investigate methods to reconstruct the ttbar system

Why should I do it?

- Get in touch with the real **Particle Physics** World
- Analyze **LHC data**
- Search for **New Physics** / Measure the **Standard Model**
- Learn advanced **analysis techniques** & **tools**