CMS/LHC exp.: Data Analysis

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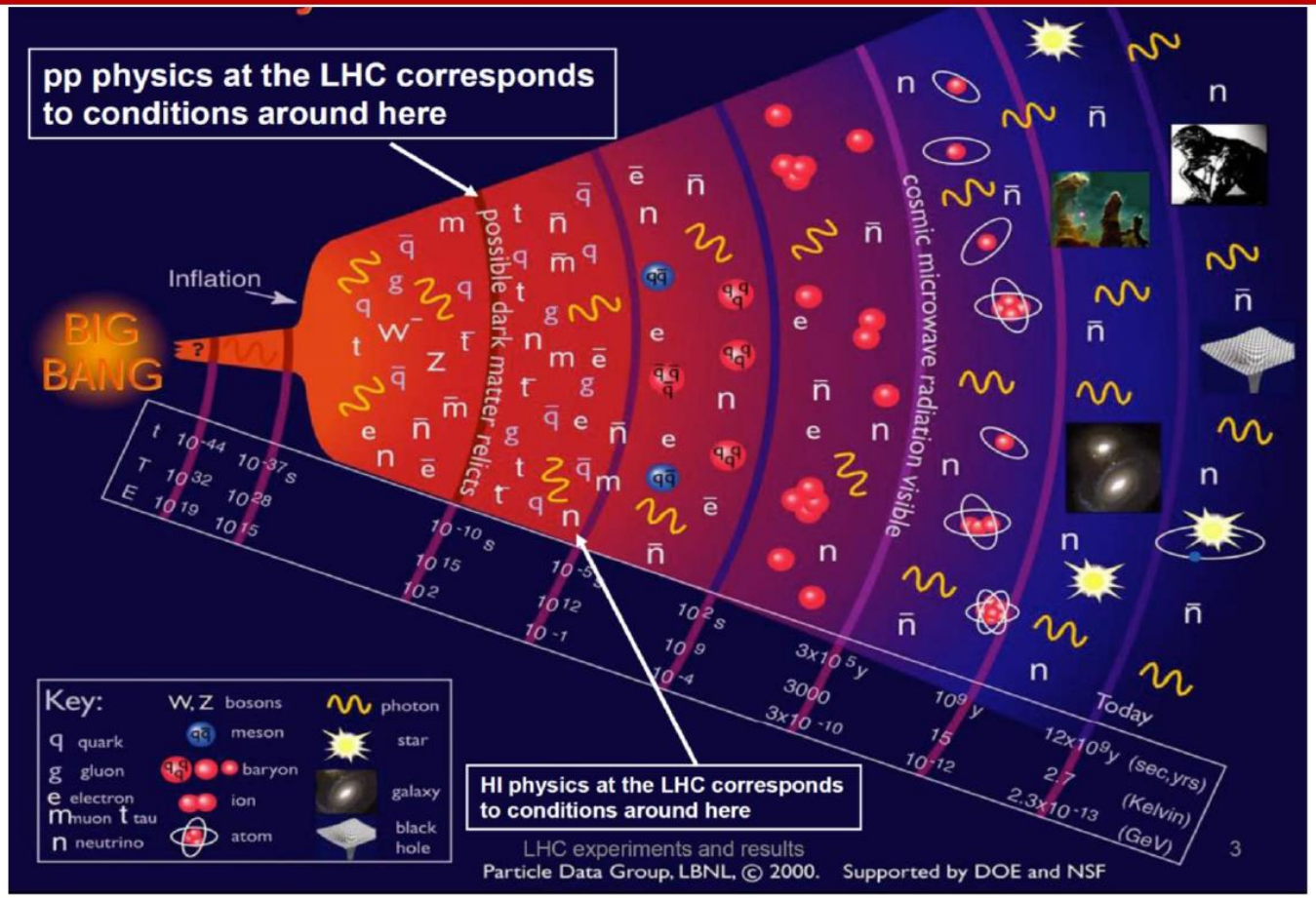
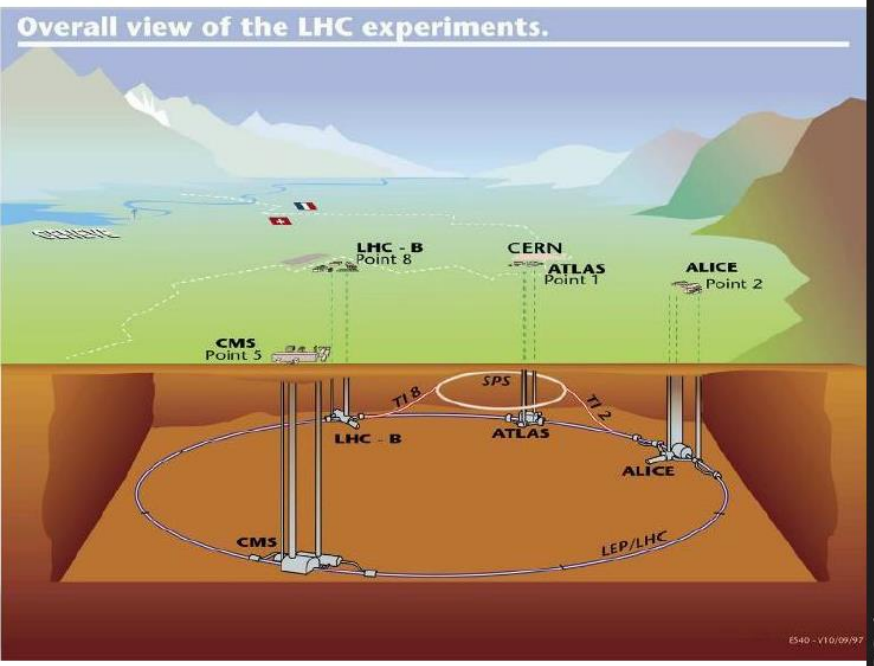
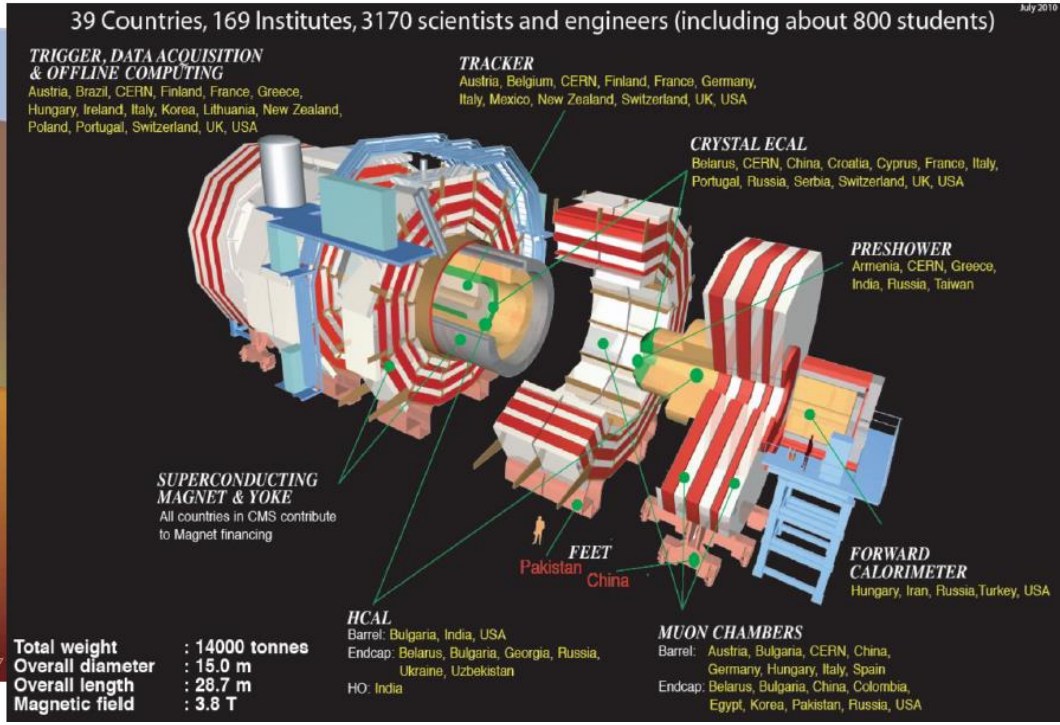
2η ΗΜΕΡΙΔΑ ΕΝΗΜΕΡΩΣΗΣ ΦΟΙΤΗΤΩΝ ΤΟΥ ΔΠΜΣ
‘ΦΥΣΙΚΗ ΚΑΙ ΤΕΧΝΟΛΟΓΙΚΕΣ ΕΦΑΡΜΟΓΕΣ’

The LHC purpose

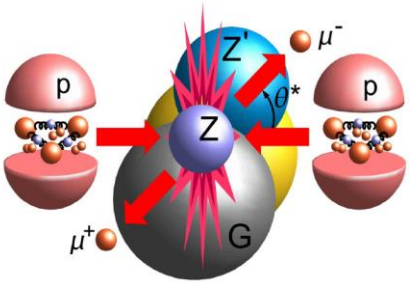


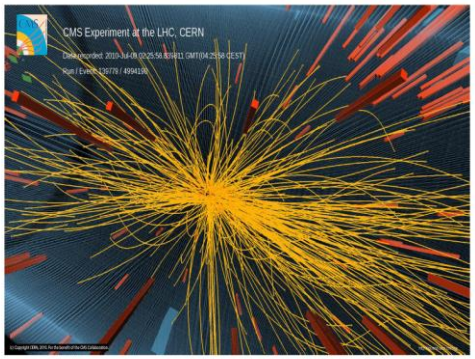
CERN Accelerator & Experiments





$E = mc^2$



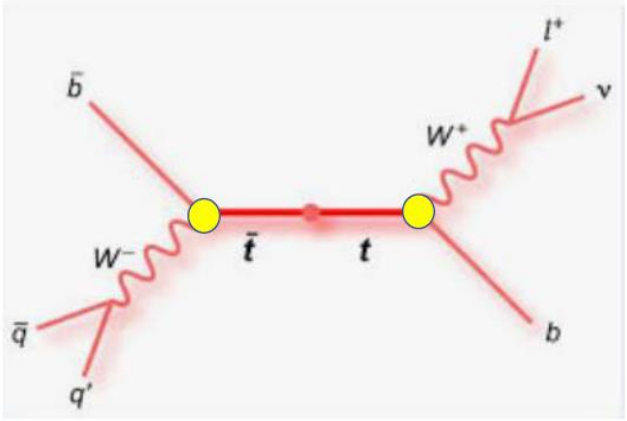


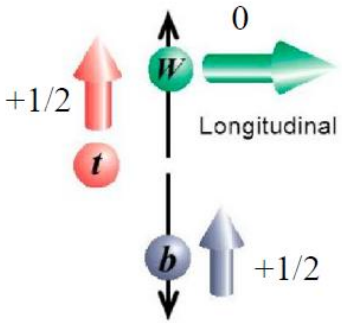
TOP : W helicities from ttbar events

Motivation:

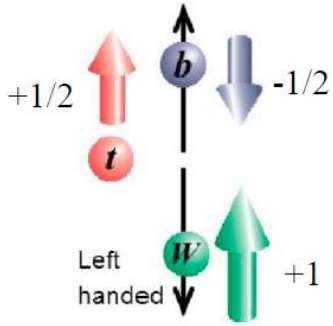
The measurement is sensitive to the Wtb vertex structure;

new physics from anomalous Wtb couplings

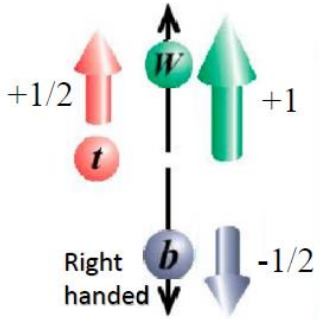




F_0



F_L



F_R

V-A suppressed

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

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

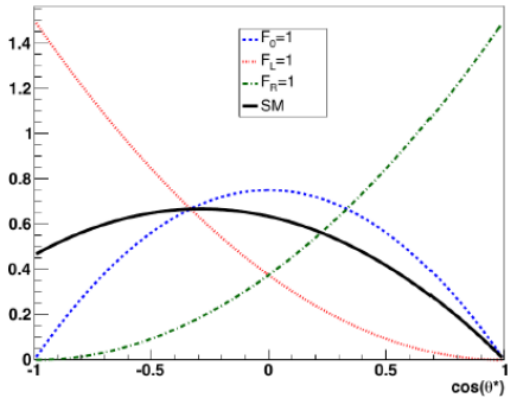
F_0 = 0.687±0.005, F_L = 0.311±0.005, F_R = 0.0017±0.0001
(Phys. Rev. D **81** (2010) 111503) , mt = 172.8 1.3 GeV

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.

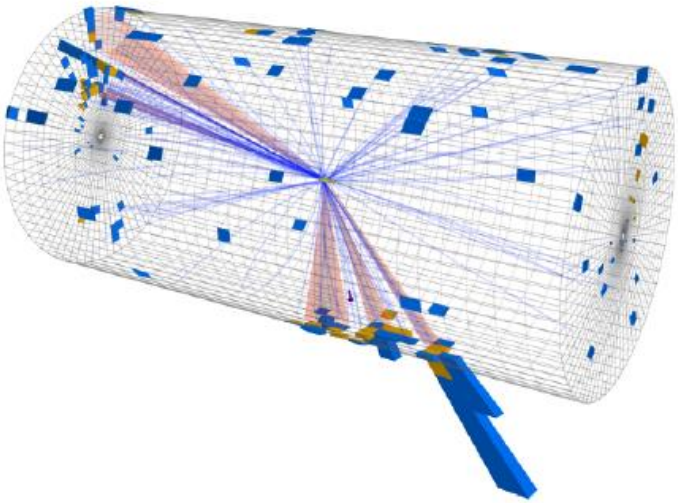
W helicities TOPICS

- 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

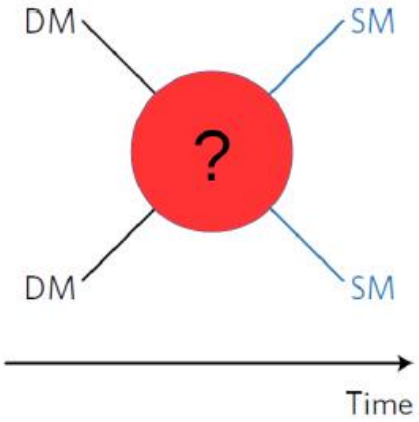
Why should I do it?

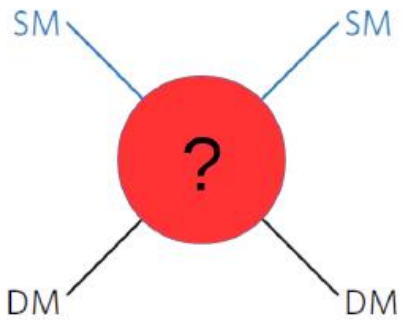
- Get in touch with the real **Particle Physics** World
- Analyze **LHC data**
- Search for **New Physics** / Measure the **Standard Model**
- Learn advanced **analysis techniques** & **tools**

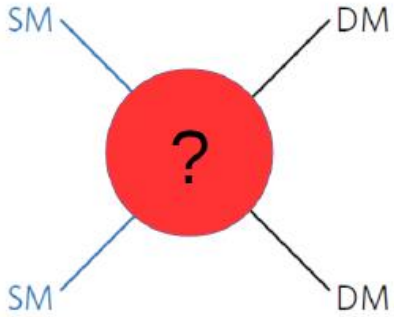
Searching for Dark Matter @ LHC
Does it matter?

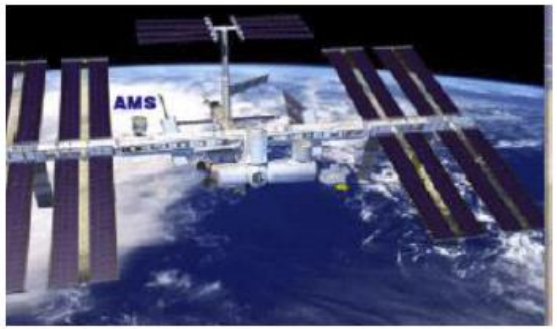


How to search for dark matter?

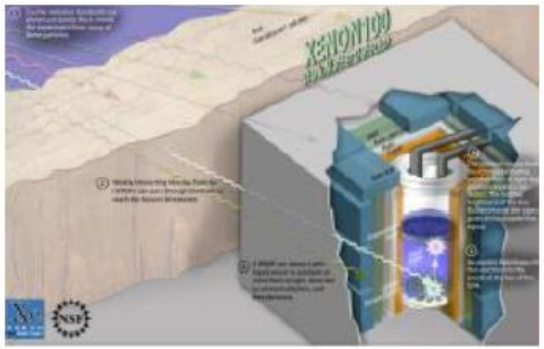








Indirect searches,
annihilation of DM into SM

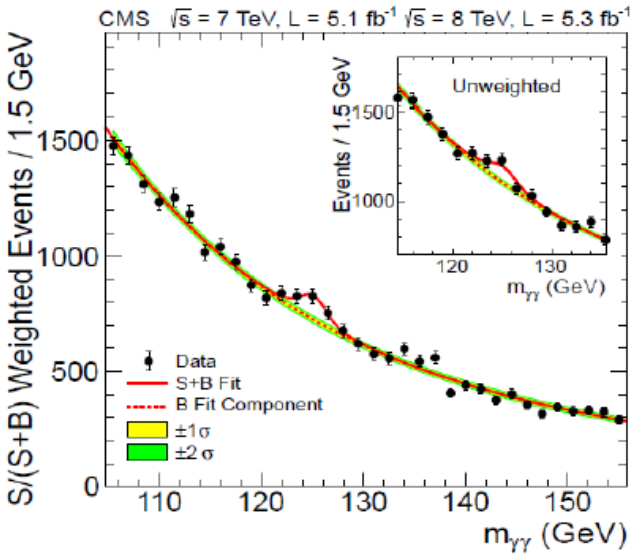


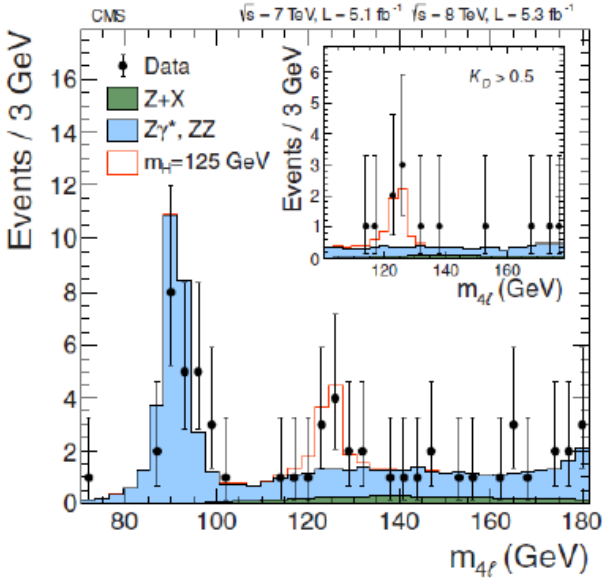
Direct searches,
DM scattering from SM

Collider searches,
SM collisions to DM

How to search for dark matter @ the LHC?

Higgs discovery “easy”: mass peaks at predicted region:



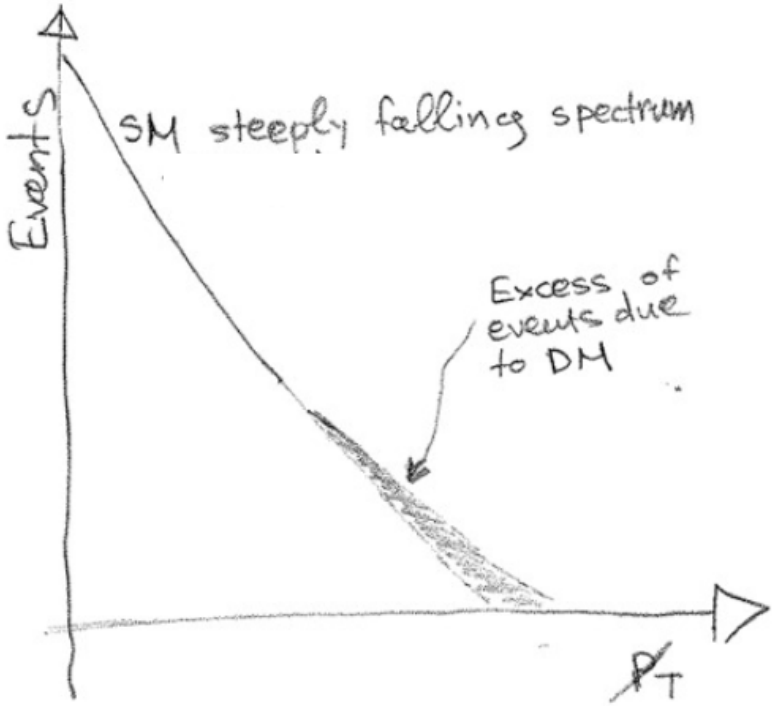


Many models with dark matter particles (e.g susy) have at least 2 invisible (undetectable) particles

use missing energy – like observables.

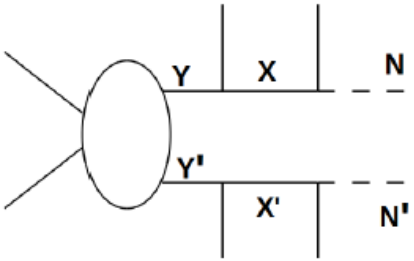
How to search for dark matter @ the LHC?

Discovery with missing energy difficult to be established (tail of a rapidly falling distribution).



Even if established what can we say about the model?

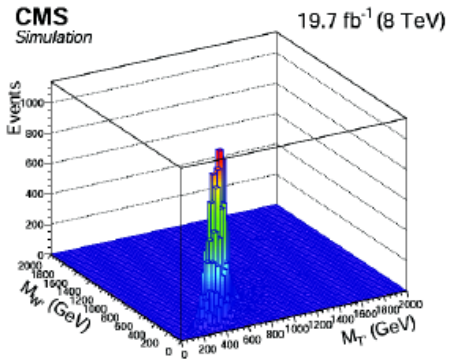
2-D mass reconstruction - What is it?



Topology

MET+
Visible particles
momenta

2 unknown masses
M_X & M_Y per event



- Needs the topology

- 2 invisible particles

G.Anagnostou,Model Independent Search in 2-Dimensional Mass Space, EPJ Web of Conferences, Vol 71, 2014.

Conclusions

Dark matter searches well motivated from both astrophysics and particle physics

LHC is the right place to search (we think). Main signature is missing energy.

Missing energy is currently used by many searches in both CMS & ATLAS.

The shape of MET distribution similar for signal and background processes

It is feasible to reconstruct particle masses in topologies with two invisible particles.

Method can help to understand the BSM physics (masses, parameters)