

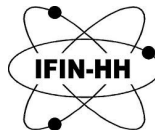
# High Energy Physics Measurements, Status and Prospects

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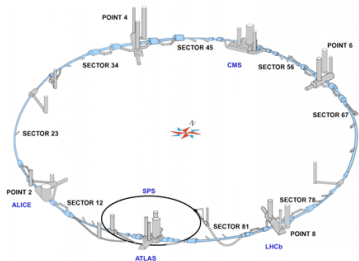
*Workshop on Sensors and High Energy Physics (SHEP 2016)*

October 21st, 2016

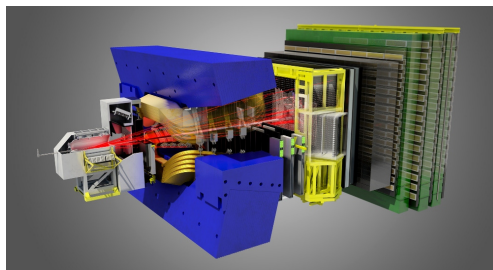


# Introduction

- 1 Present Standard Model of fundamental particles
- 2 Future: New Physics, but at what energy scale
- 3 13-14 TeV proton-proton energy at LHC, close to cosmic ray knee (see talk of Alex ENE)
- 4 LHC energy a far compared with Planck scale  $10^{28}$  eV, by a factor of 2 ... in power index.



LHC and spectrometers (courtesy of CERN)

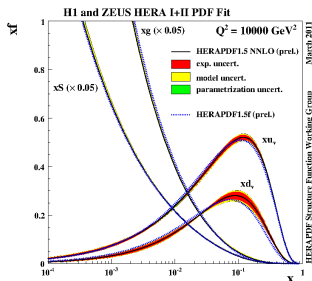


LHCb single-arm and forward spectrometer

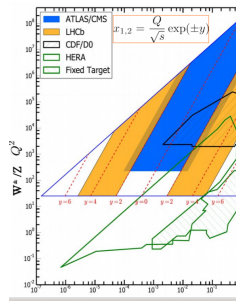


# LHC experiments

- 1 LHC accelerates protons and collides bunches of particles with unprecedented center of mass energy at 13 TeV since 2015,
- 2 Luminosity of  $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  and 100s of  $\text{fb}^{-1}$  integrated luminosity by the end of RUN II.
- 3 ATLAS and CMS are General Purpose Detectors:
  - large Luminosity, 20 times more than LHCb, Looking for direct evidence of New Physics, Colliding partons at large  $Q$  and  $x$ .



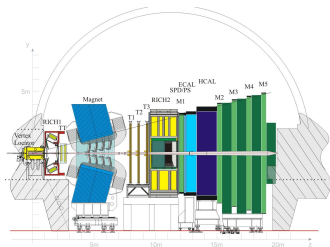
parton PDF for  $Q^2$  of 10000  $\text{GeV}^2$  (courtesy of H1 and ZEUS collaborations) HERAPDF



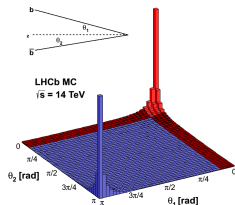
LHCb single-arm and GPD  $xQ$  phase-space

# LHCb Detector

## 2D cross-sectional view of LHCb



## $b\bar{b}$ production LHCb

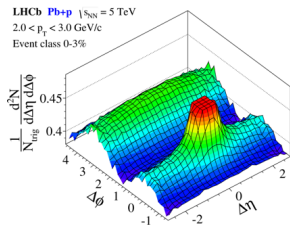


- 1 Single arm spectrometer,  $\eta \in [2, 5]$ .
- 2 Stations:
  - Vertex LOcator (VELO);
  - 4 tracker stations;
  - 4 Tm integrated field;
  - Calorimeters;
  - RICH detectors;
  - Muon system.
- 3 Precise measurements:
  - Impact parameter resolution  $\approx 20 \mu\text{m}$  for high- $p_T$ .
- 4 Excellent Particle IDentification (PID) and tracking in a unique pseudorapidity range.

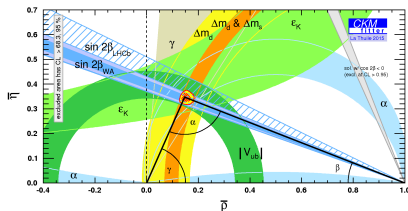
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# Physics so far at LHC

- Possible Higgs discovery at CMS and ATLAS for a particle of 128 GeV.
- States consistent with charmonium pentaquarks observed at LHCb
- LO Penguin transitions for rare decays, CP asymmetries and CKM unitarity is consistent with Standard Model.
- New Physics remains elusive, though new LHCb data is being processed, so far precision tests of Standard Model have not revealed significant disagreements.
- Also ALICE and LHCb programs of proton-Lead collisions have produced some surprising results, e.g. near-side ridge



Lead-proton collisions with near side ridge implying long range correlations with produced jets.



CKM triangle unitarity tests:  $\beta$  angle measurement

- CP-violating asymmetries in charm sector;
- Photon polarization measurements in b-hadron radiative decay (penguin).
- Exotic tetra-quark states without light flavors,
- Other CKM angle measurements
- $W/Z/\gamma^*$  production in forward direction
- QCD measurements, including the b-hadron production cross-sections at various collision energies at LHC
- $B_s \rightarrow \mu^+ \mu^-$
- $B^0 \rightarrow K^* \mu^+ \mu^-$  puzzle.
- etc

# Measurements prospects at LHC Detectors following Upgrades

- LHCb hopes to reach  $50 \text{ fb}^{-1}$  or more integrated luminosity in the LHC RUN III.
- expect 20-40 increase in sensitivity for key measurements: e.g. rare LO-penguin loop transitions.
- Other LHC detectors expect at least a 10 factor increase in luminosity.
- Find new observables which might be measured with the increased luminosity and better sensitivity in trigger phase.
- Look for Physics beyond Standard Model.