“Fisica elettrodebole nella regione in avanti a LHCb”

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Motivation

- **LHCb** offers a **complementary phase space region** for electroweak and jets measurements respect to ATLAS and CMS:
  
  - Unique acceptance: \(2 < \eta < 5\)
  - Cleanest LHC events: \(<\text{Pile-Up}> \sim 2\)
  - Very large bandwidth trigger for events with b jets and displaced vertices, efficient even at very low \(p_T\).

- Measurement in the forward region provide unique access to PDFs \((x,Q^2)\). Precision measurements of \(\sigma_{W(Z)}\) in this region are important tests of perturbative QCD and EWK theory.

\[
x_{1,2} = \frac{M}{\sqrt{s}} e^{\pm y}
\]
LHCb detector

**Vertex Locator and tracking system**: precise vertex (primaries and secondaries) and tracking reconstruction (direction, momenta, invariant masses)

- **IP resolution**: 20 μm
- **Δp/p** = 0.4 % at 5 GeV/c to 0.6 % at 100 GeV/c

**Particle ID performances**

- kaon ID efficiency: ~ 95 % for ~ 5 % π→K mis-id probability
- muon ID efficiency: ~ 97 % for 1-3 % π→μ mis-id probability

**Calorimeters performances**

- ECAL resolution: 1 % + 10 % / √(E[GeV])
- HCAL resolution: 9 % + 69 % / √(E[GeV])

**Not the best for jets physics...**
Forward W + b/c production at 7 and 8 TeV

- **Measurement:** $W (\rightarrow \mu\nu) + b/c$ jet production cross section, Phys. Rev. D 92, 052001 (2015)

- **Motivations:** Test perturbative QCD predictions. Probe the capability of LHCb to jets physics.

- **Data:** 1 fb$^{-1}$ and 2 fb$^{-1}$ respectively from pp collisions at 7 and 8 TeV

- **Selection:**
  - High PT muon (PT > 20 GeV) and at least one jet (PT > 20 GeV).
  - $\Delta R(\mu,\text{jet}) > 0.5$.
  - Veto on $Z \rightarrow \text{dimuon}$ events.

- **Benchmark measurement:**
  - Sensitive to proton PDF.
  - Constraints SM Higgs and BSM background.

- **Jet reconstruction and tagging:**
  - **Particle flow:** charged track and calo clusters.
  - **Anti – $K_t$** clustering algorithm, $R = 0.5$.
  - **b-tagging:** observables related to secondary vertices, reconstructed using tracks in the jet. **Excellent performances in LHCb thanks to precise SV reconstruction.**
Forward W + b/c production at 7 and 8 TeV

- **W (and Z) yield extraction:**
  \[ p_T(\mu)/p_T(\mu_{\text{jet}}) \] distribution fit

- **Simultaneous fit to the jet SV tag mass and track multiplicity to obtain the b and c yields:**

- **Measured W+b/c cross sections (normalized to W+jet)** are in good agreement with SM

<table>
<thead>
<tr>
<th></th>
<th>7 TeV Results</th>
<th>8 TeV Results</th>
<th>SM prediction 7 TeV</th>
<th>SM prediction 8 TeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \sigma(Wb) \times 10^2 ]</td>
<td>0.66 ± 0.13 ± 0.13</td>
<td>0.78 ± 0.08 ± 0.16</td>
<td>0.74±0.17−0.13</td>
<td>0.77±0.18−0.13</td>
</tr>
<tr>
<td>[ \sigma(Wc) \times 10^2 ]</td>
<td>5.80 ± 0.44 ± 0.75</td>
<td>5.62 ± 0.28 ± 0.73</td>
<td>5.02±0.80−0.69</td>
<td>5.31±0.87−0.52</td>
</tr>
</tbody>
</table>
First observation of top in the forward region


- **Motivations:**
  - The enhancement at forward rapidities of $t\bar{t}$ production via gg and qg scattering, respect to gg fusion, may result in a **large charge asymmetry**, sensitive to physics beyond the SM.
  - Forward $t\bar{t}$ events can be used to constraint PDFs at large momentum fraction.

- **Data:** 1 fb$^{-1}$ and 2 fb$^{-1}$ respectively from pp collisions at 7 and 8 TeV

- **Selection:** Same selection of the W + b/c sample!
First observation of top in the forward region

**Strategy:** Study the $W+b$ fitted yield and $W$ charge asymmetry in function of $PT(\muon +b) \rightarrow$ fit the top cross section

**Results:**

\[ \sigma(\text{top})[7 \text{ TeV}] = 239 \pm 53 \text{ (stat)} \pm 38 \text{ (syst)} \text{ fb} \]

\[ \sigma(\text{top})[8 \text{ TeV}] = 289 \pm 43 \text{ (stat)} \pm 46 \text{ (syst)} \text{ fb} \]

**Good agreement with SM prediction:** $180^{+51}_{-41}(312^{+83}_{-68}) \text{ fb at } 7(8) \text{ TeV}$
Moving on: search for $b \bar{b}$ resonances

- **Jet-capability** at LHCb demonstrated: $Z + b$ (JHEP 01 (2015) 064), $W + b/c$, forward-central $b\bar{b}$ asymmetry (LHCb-CONF-2012-014), $b\bar{b}$ cross section (LHCb-CONF-2013-002).

- $H \rightarrow b\bar{b}$ decay not yet “discovered” at ATLAS and CMS (significance < 3 σ)

- We can search for the $H \rightarrow b\bar{b}$ production in the forward region:
  - Higgs production associated to a vector boson in order to reduce the background

- Backgrounds studies ongoing:
  - $W^{\pm} b \bar{b}$
  - $Z b \bar{b}$
  - $t\bar{t}$
  - QCD combinatorial
Search for $b\bar{b}$ resonances

- The possibility to search for the inclusive $H \rightarrow b\bar{b}$ is currently under studying. LHCb not so much penalized in acceptance respect to General Purpose Detectors.

- In general, $b\bar{b}$ resonances are considered preferred channels in the search for New Physics.

- The first step is identify and reconstruct the $Z \rightarrow b\bar{b}$ decay. In this way we can validate the jet energy scale and improve if necessary.

- Peak resolution estimated on LHCb simulation ($\approx$ 11 GeV with $R=0.5$ and both jets $b$-tagged).
Conclusions

- LHCb is continuing with success its **electroweak program**.

- LHCb is able to **complement with ATLAS and CMS** for EW and QCD measurements.

- We are successfully branching into **jets physics**.

- The excellent performances of the **b-jet tagging** have been demonstrated.

- In the next months several preliminary measurements needed for **bb resonances searches** are expected.