

Search for $b\bar{b}$ resonances at CDF and LHCb

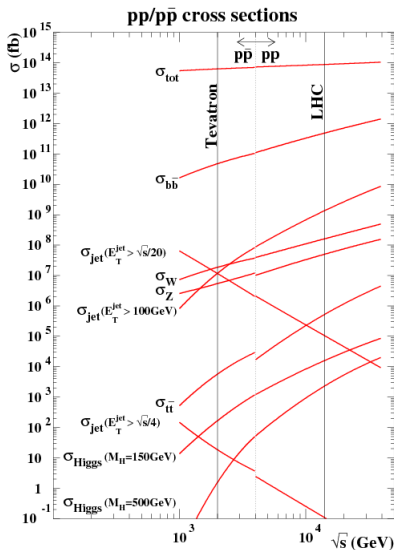
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The search for $b\bar{b}$ resonances

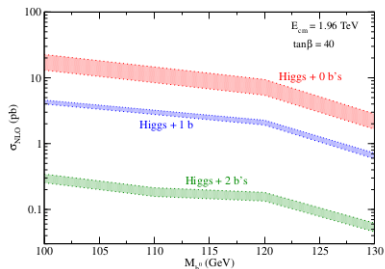
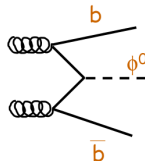
- ✓ High interest in particles decay into $b\bar{b}$ pairs
- ✓ Higgs boson decays predominantly in $b\bar{b}$
 $\mathcal{B} \approx 57.7\%$
- ✓ Numerous extensions to the standard model predict massive particles decay into dijet resonance
 - ▶ Z' , W' , Graviton, Axigluon, SuSy
- ✓ Overwhelming backgrounds from the multijet production from QCD interactions



Search for MSSM Higgs Bosons

✓ MSSM Higgs properties

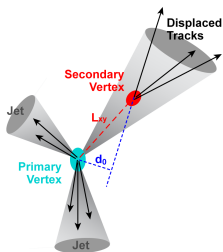
- ▶ Three neutral scalars: h, H, A : (generically ϕ)
- ▶ $\tan\beta$: ratio of down-type to up-type couplings
- ▶ At large $\tan\beta$, decays into $b\bar{b}$ (90%) and $\tau\tau$ (10%) dominate



✓ The 3b channel

- ▶ Search for the $bb\phi \rightarrow bbbb$ process
- ▶ Associated production $b\phi$ to reduce the large backgrounds
- ▶ Smaller cross section when requiring both bs to be high- p_T
- ▶ Look for the Higgs + 1b case

Identifying b jets



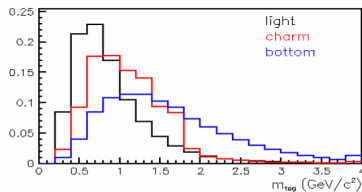
- ▶ B hadrons travel a finite distance in the detector $\sim 500 \mu\text{m}$, a secondary vertex is formed
- ▶ Tracks from secondary vertex have large impact parameter

Triggering on b-jets

- ▶ Secondary vertices reconstructed on-line at trigger level
- ▶ The **Silicon Vertex Trigger** (SVT) is a trigger processor that combines hits from silicon detectors with tracks reconstructed in the drift chambers
- ▶ It allows to measure the impact parameter with a resolution of $35 \mu\text{m}$ for $2 \text{ GeV}/c$ tracks
- ▶ Fast ($O(10\mu\text{s})$) and efficient ($\sim 40\%$) on-line b-tagging
- ▶ Key of the CDF outstanding high and low energy B-physics program

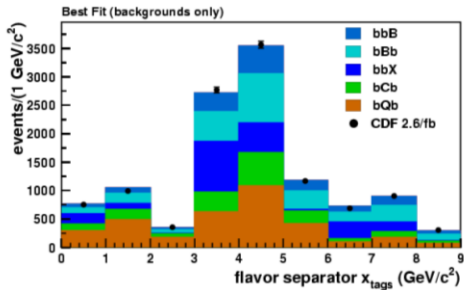
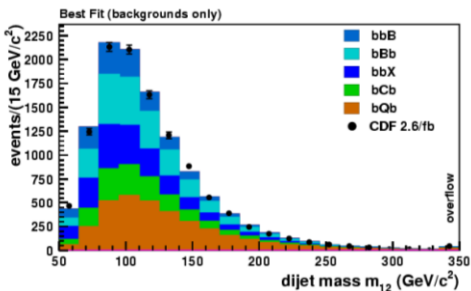
Search for Higgs bosons produced in association with b quarks Phys. Rev. D 85, 032005

- ✓ 3 b-Tagged jets sample, collected with a double on-line b-tagging jets trigger
- ✓ Signal: enhancement in the mass of the first 2 jet m_{12} spectrum
- ✓ Important backgrounds components are:
 - ▶ $bb + b$: bbb
 - ▶ $bb + X$: bbc, bbq
 - ▶ $bX + b$: bcb, bqb
- ✓ MC does not give a truthful representation of the various flavors components
 - ▶ Data-driven method, starting from double-tagged events
 - ▶ x_{tag} constructed from the invariant masses of the secondary vertices, sensitive to the flavor composition
 - ▶ Backgrounds templates are built weighting the events by the probability to tag the third jet if it were a b, c or a light-quark jet



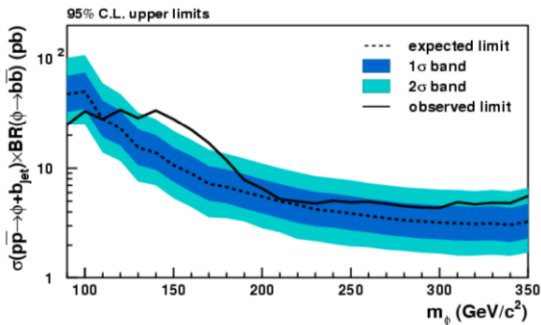
Fit backgrounds templates to data

- ✓ Templates are actually 2D histograms in both m_{12} and x_{tag}
 - ▶ Fit itself is also 2D
 - ▶ Only show projections for clarity



Results

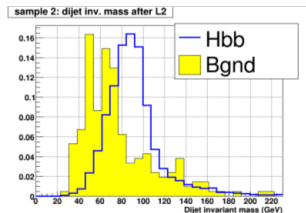
Analysis based on a data sample corresponding to an integrated luminosity of 2.6fb^{-1}



Max deviation from expected at $150 \text{ GeV}/c^2$
 Including the trials factor, $1 - CL_b = 2.5\%$ (1.9σ)
 Corresponds to $\sigma \times BR \sim 15\text{pb}$

Search for $b\bar{b}$ resonances in a new CDF sample

- ✓ Sample of data rich in b jets, still to be analyzed
- ✓ Special trigger developed for the data taking, exploiting CDF trigger upgrade

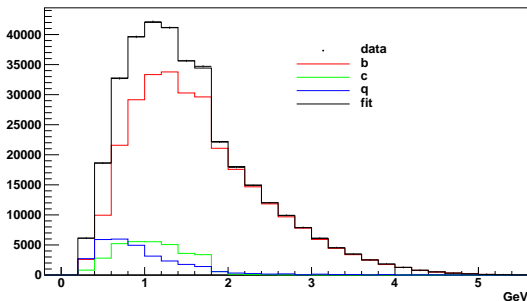


- ▶ A jet is formed starting from a seed tower in the calorimeter above a threshold (3 GeV)
- ▶ A new fixed cone cluster finding algorithm is used to reconstruct offline-like quality jets
- ▶ 3D tracks matched to one of the jets
- ▶ Two jets in the final states with low energy threshold (15 GeV) to avoid sizable bias on the dijet invariant mass distribution
- ▶ Only one on-line SVT b-tagged jet, smaller bias due to the on-line tagger
- ▶ $5.4fb^{-1}$ of integrated luminosity, plenty of $b\bar{b}$ pairs

Search for $b\bar{b}$ resonances in a new CDF sample

- ✓ Many physics analyses are possible:
 - ▶ $b\bar{b}$ and multi-b resonances
 - ▶ Extend the $\phi \rightarrow bbb$ search, this sample is orthogonal to the one used in the previous analysis
 - ▶ We can test the Standard Model with a $b\bar{b}$ asymmetry measurement, particularly at the Z pole

TagMass (+ or - tags)



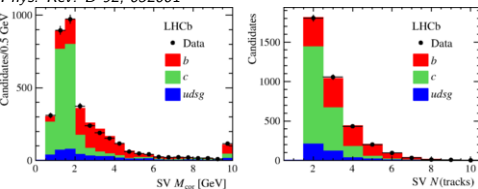
Flavor composition of the 1 on-line and off-line b-tagged jet. About 20% of contamination from c and light quark jets

Jets physics at LHCb

- ▶ LHCb is an one arm forward spectrometer designed for the study of hadrons with b and c quarks
- ▶ But it is becoming more and more a general purpose experiment
- ▶ It gives access to a complementary phase space region for electroweak and jets measurements respect to ATLAS and CMS
- ▶ Some jet analyses already published

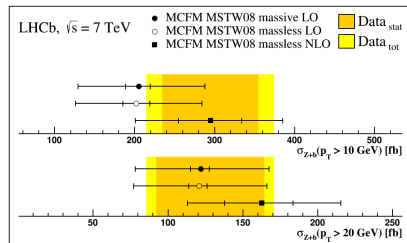
Forward $W + b/c$ production at 7 and 8 TeV

Phys. Rev. D 92, 052001



Measurement of the Z+b-jet cross-section in pp collisions at $\sqrt{s} = 7$ TeV in the forward region

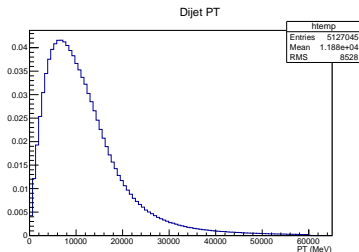
JHEP01(2015)064



$b\bar{b}$ resonances at LHCb

- ✓ LHCb is probably the most similar to CDF LHC experiment
- ✓ Controlled luminosity, extremely good tracking performance and particular forward acceptance
 - ▶ QCD background can be kept under control

- ✓ Idea: transfer all the technologies and skills developed at CDF, adapted to the new environment
 - ▶ First there is the need for a dedicated trigger for b-jets
 - ▶ Look for energy towers in the calorimeters to form the jet (anti-kt or cone algorithm)
 - ▶ Use the tracking information to search for tracks with high impact parameter \rightarrow displaced vertices
 - ▶ High multiplicity \rightarrow need for speed: GPU technologies for tracking under development



**Unique opportunity to search for low mass resonances at
LHC**

Backup

x_{tag} definition

- ▶ m_1 , m_2 and m_3 mass of the secondary vertex of the first, second and third jets
- ▶ The goal is to separate the backgrounds with:
 - ▶ high m_1+m_2 (bbB, bBb, bbC, bbQ) from those with lower m_1+m_2 (bCb, bQb)
 - ▶ high m_3 (bbB, bBb, bCb, bQb) from those with lower m_3 (bbC, bbQ)

