LHCb Higgs Plans

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Physics at the High-Luminosity LHC

Luminosity and Detector

- projected luminosity (G. Wilkinson (2016) Theatre of Dreams)
  - assume $\mathcal{L} = 2 \times 10^{33}$ cm^{-2}s^{-1}, ≈ 7.5 fb^{-1} per year

LHC era				HL-LHC era	
Run 1(a) 2011	Run 1(b) 2012	Run 2 2015 - 2018	Run 3 2021 - 2024	Run 4 2027 - 2030	Run 5 2031 - 2034?
1 fb^{-1}	2 fb^{-1}	5 fb^{-1}	20 fb^{-1}	30 fb^{-1}	30? fb^{-1}

- LHCb upgrade during LS 2
  - LHCb-PUB-2014-040
  - replacement of ring imaging Cherenkov detectors
  - replacement of tracking detectors
  - **full software trigger**, see LHCB-TDR-016
    - currently limited by hardware readout at 1 MHz
    - upgrade will read out entire detector at 40 MHz
- improve detector even further during LS 3?

LHCb Advantages and Disadvantages

- significantly lower luminosity, $\approx 100\text{fb}^{-1}$?
- reduced acceptance, $\lesssim 5\%$
- not a hermetic detector
- ECAL saturation

- very flexible trigger
- low pile-up
- excellent secondary vertex resolution
- complementary forward region

- **LHCb should focus on channels which utilize strengths**
  - exclusive charm final states
  - τ final states with secondary vertices
  - inclusive c and b-jet decays

LHCb Higgs Studies

- **no dedicated HL-LHC Higgs studies yet . . . but will aim for October**
  - $H[\tau\tau]$ limits published with Run 1 2011 data
  - analysis underway on Run 1 with $W[\ell\nu]H[Q\bar{Q}]$ final state
  - some internal pheno studies on $H[c\bar{c}/b\bar{b}]$ with VBF and VH

- numbers today are **very** rough, mix of calculations from Pythia, Mcfm, PowhegBox, MadGraph, and LHCHXSWG
- assume detector performance similar to Run 1
  - muon and jet reconstruction $\approx 95\%$
  - b-jet tagging $\approx 65\%$, c-jet tagging $\approx 25\%$
  - hadronic τ reconstruction $\approx 50 - 60\%$
  - **trigger efficiency equivalent to selection efficiency!**

$H[c\bar{c}]$ and $H[b\bar{b}]$

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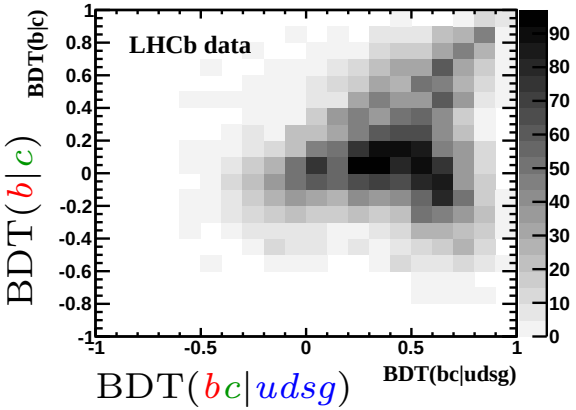
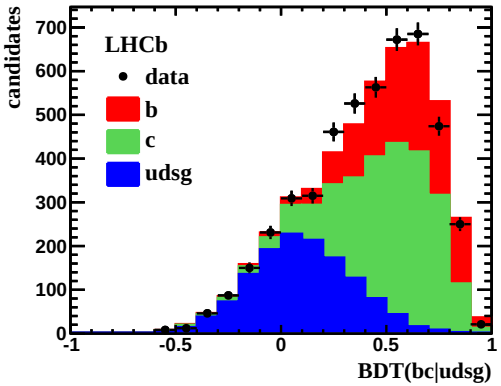
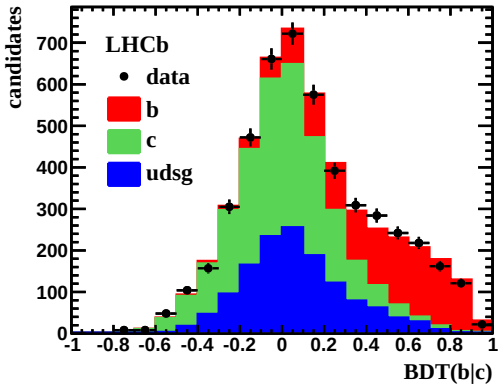
data distribution



BDT($bc|udsg$) proj.

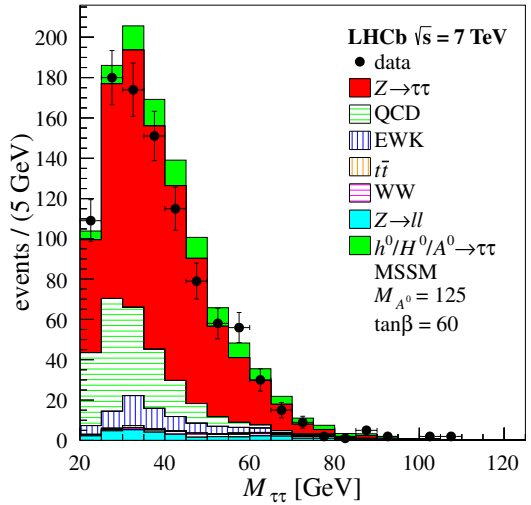


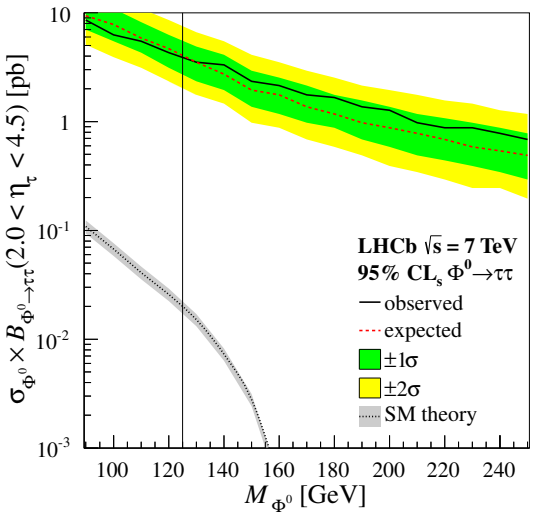
BDT($b|c$) proj.



- require two tagged jets and a lepton with $p_{\mathrm{T}} > 20, 2 < \eta < 5$
  - $H[b\bar{b}]\,W[\mu\nu] \approx 4$ fb
  - $H[c\bar{c}]\,W[\mu\nu] \approx 4 \times 10^{-2}$ fb
- with 300 fb^{-1} we could reach $\approx 8\times$ SM for $H[c\bar{c}]$
- with 1000 fb^{-1} and improvements we could reach $\approx 2\times$ SM
  - double c-tag efficiency and electron efficiency
- VBF could roughly double the stats

- used $\mu\mu$, μe, μh, and eh final states
- 7 TeV expectation
  - $\approx 3 \times 10^{-1}$ fb (signal)
  - ≈ 1000 fb (background)
- 14 TeV expectation
  - ≈ 3 fb (signal)
  - ≈ 1600 fb (background)
  - assume background scales proportionally to Z cross-section
- what about 3π final state with secondary vertex?
  - ≈ 1 fb without efficiencies
  - backgrounds (charm)?





$H[VV]$ and Conclusions

- assume electron efficiency similar to muon
- $H[Z[\ell\ell]Z[\ell\ell]]$ with $p_{\mathrm{T}} > 1$ GeV, $2.0 < \eta < 5.0$, and $115 < m < 135$ GeV
  - $\approx 1 \times 10^{-1}$ fb (signal)
  - $\approx 3 \times 10^{-1}$ fb (background from ZZ)
- $H[W[\mu\nu]W[e\nu]]$ with $p_{\mathrm{T}} > 1$ gev and $2.0 < \eta < 5.0$
  - ≈ 10 fb (signal)
  - ≈ 160 fb (background from WW)

- depending on performance and luminosity, LHCb could contribute to Higgs physics
- further study needed with a focus on LHCb strengths