A first look at $B \to \overline{D}\mu\mu$

Theory, Data and Selection

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Introduction

Progress:

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Topics:

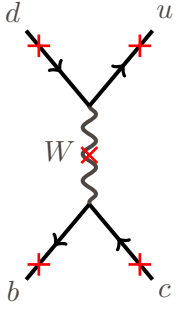
- → Theory (Diagram, Predictions)
- → Dataset (Stripping, Blinding)
- → Selection (Preselection, Classification)

Theory

- Paper by *Evans et al.* (2000)
- OPE and Heavy Quark Expansion
- Result depends on matrix elements β and β_8
- A few crude assumptions made (in absence of Lattice QCD)
- Prediction:

$$\mathrm{Br}(\overline{B}^0 \to D^0 e^+ e^-)|_{q^2>1\ \mathrm{GeV}} = 2.6 \times 10^{-9}$$
$$\mathrm{Br}(\overline{B}^0 \to D^* e^+ e^-)|_{q^2>1\ \mathrm{GeV}} = 1.4 \times 10^{-8}$$

- Might be enhanced if assumptions unjustified
- Idea: Also look at D^*

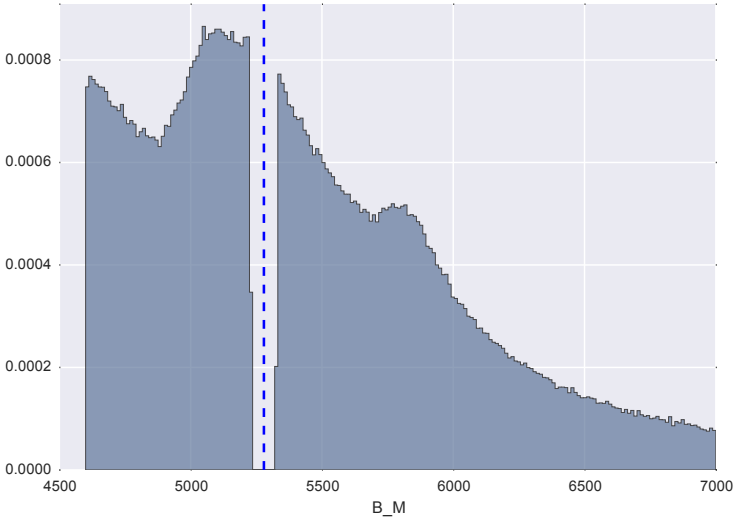


Dataset: Stripping

- → Stripping line: `Dimuon/B2XMuMu_Line`
- → Data from 2011 and 2012 (3 fb^{-1})
- → Slightly over 10^6 events

Candidate	Selection
B	IP $\chi^2 < 16$(best PV)
	4600 MeV/c^2 $< M <$ 7000 MeV/c^2
	DIRA angle $<$ 14 mrad
	flight distance $\chi^2 > 121$
	vertex χ^2/ndf < 8
$\mu^-\,\mu^+$	$m(\mu^-\mu^+) <$ 7100 MeV/c^2
	vertex χ^2/ndf < 9
	`isMuon`
	DLL$_{\mu\pi} > -3$
D^0	ADAMASS(D^0) $<$ 100 MeV/c^2
	vertex $\chi^2 < 10$
tracks	ghost prob $<$ 0.4
	min IP $\chi^2 > 9$
GEC	SPD Mult. < 600

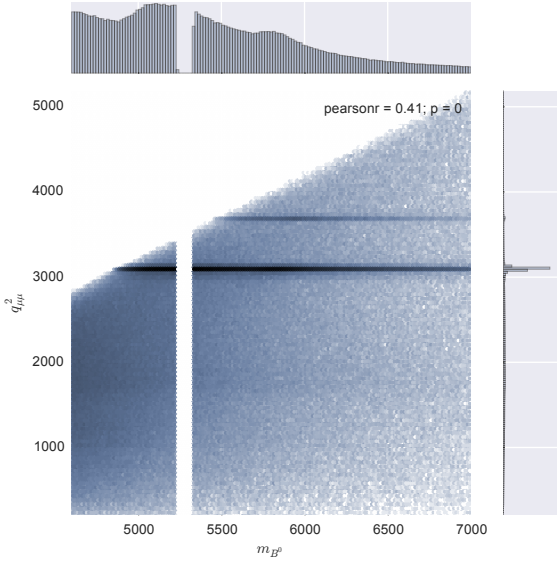
Dataset: Blinding

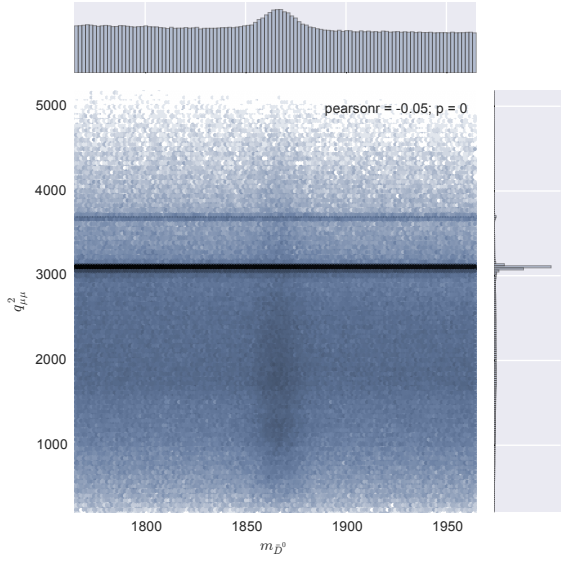


Dataset: Trigger lines

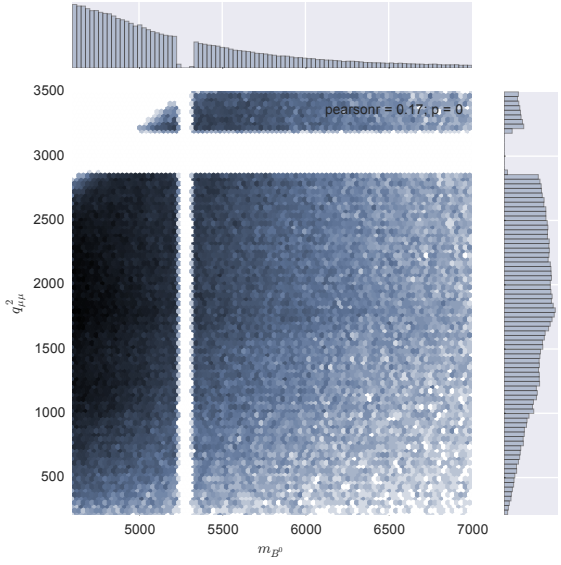
Trigger lines
B_L0MuonDecision
B_Hlt1TrackAllL0Decision
B_Hlt1TrackMuonDecision
B_Hlt2Topo{2,3,4}BodyBBDTDecision
B_Hlt2TopoMu{2,3,4}BodyBBDTDecision
B_Hlt2SingleMuonDecision
B_Hlt2DiMuonDetachedDecision

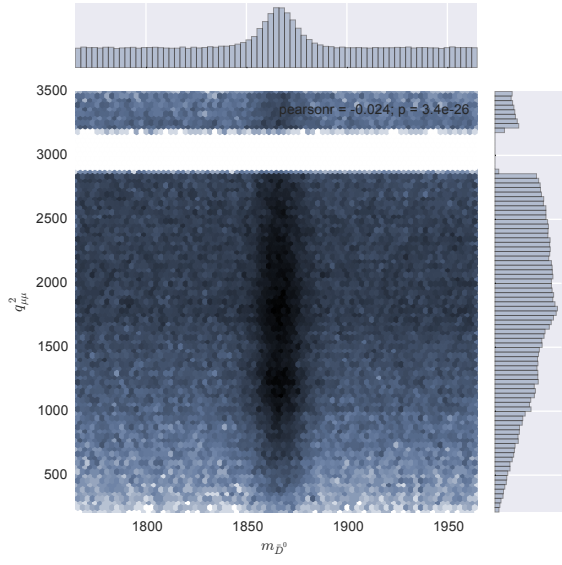
Dataset


pearsonr = 0.41; p = 0
5000
4000
3000
2000
1000
$q^2_{\mu\mu}$
5000
5500
6000
6500
7000
m_{B^0}


pearsonr = -0.05; p = 0
5000
4000
3000
2000
1000
$q^2_{\mu\mu}$
1800
1850
1900
1950
$m_{\overline{D}^0}$

Selection: J/ψ cuts





Selection: PID cuts

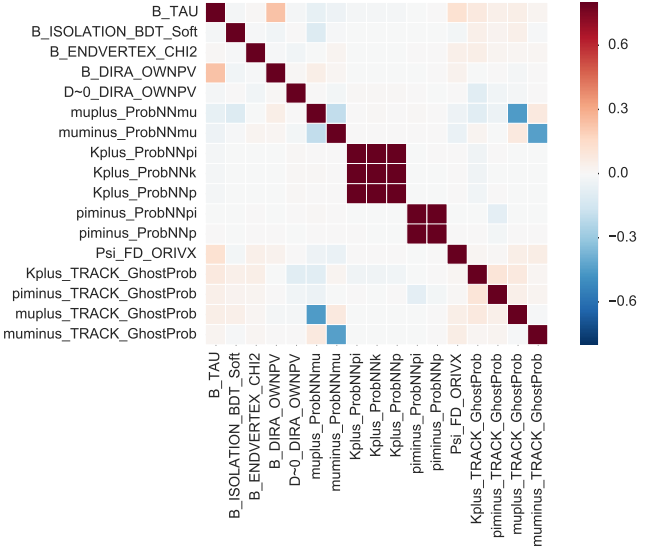
Selection: Classifier

- Classifier: AdaBoost
- Trained on
  - upper B^0 mass sideband (background)
  - $B^0 \to \overline{D}^0 \mu\mu$ PHSP Monte Carlo (signal)
- Feature set can still be improved (see rhs)

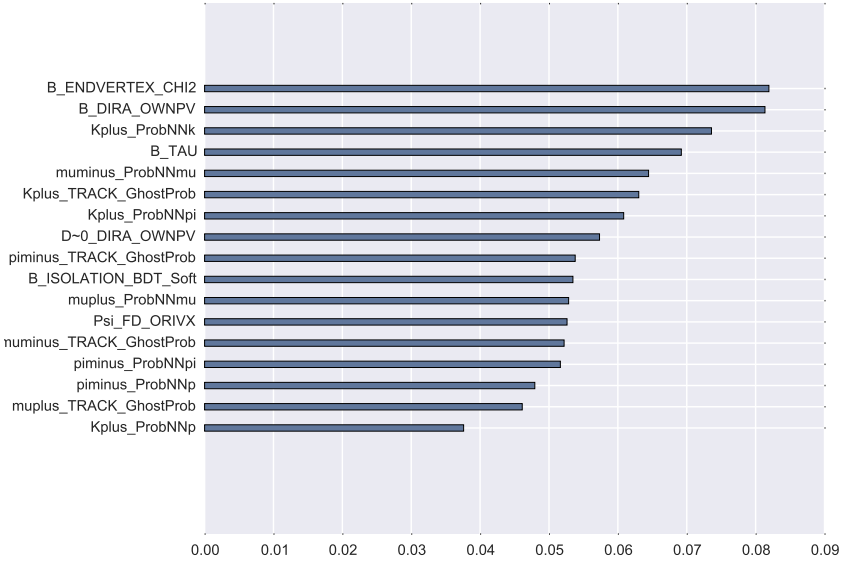
Variables
B_TAU
B_ISOLATION_BDT_Soft
B_ENDVERTEX_CHI2
B_DIRA_OWNPV
D~0_DIRA_OWNPV
Kplus_ProbNNpi
Kplus_ProbNNk
Kplus_ProbNNp
piminus_ProbNNk
piminus_ProbNNp
piminus_ProbNNpi
muplus_ProbNNmu
muminus_ProbNNmu
*_TRACK_GhostProb

Classifier: Feature correlation matrix

- → Data mostly unprepared
- → No transformations applied (log/acos)
- → Error values left in (idea: impute)

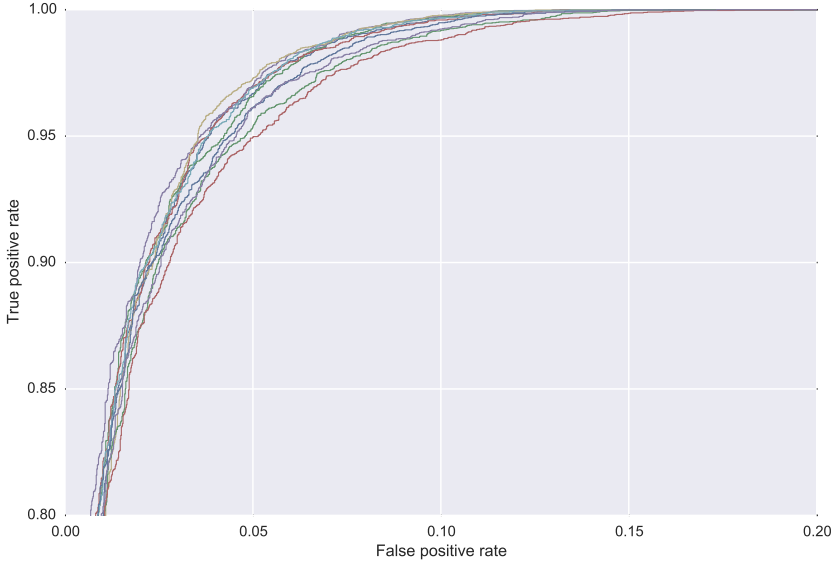


Classifier: Feature importance

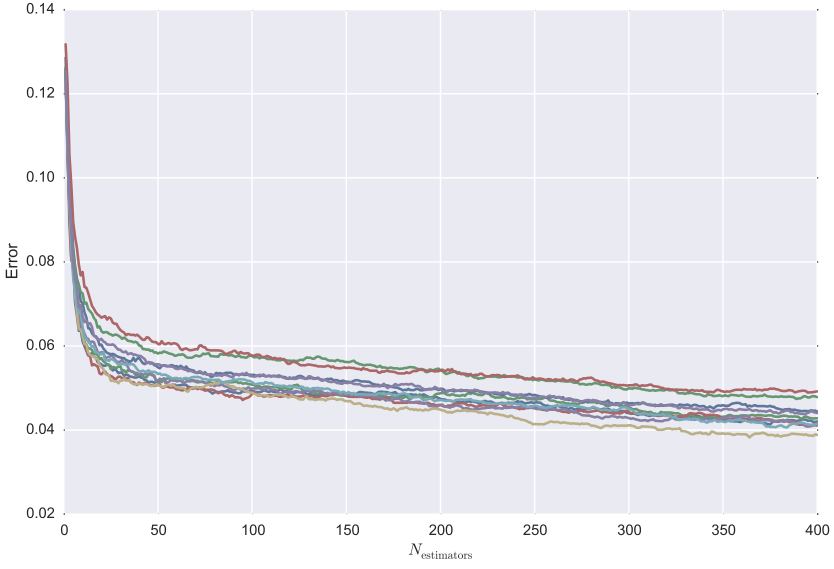


Classifier: ROC curve

→ 10-fold cross validation



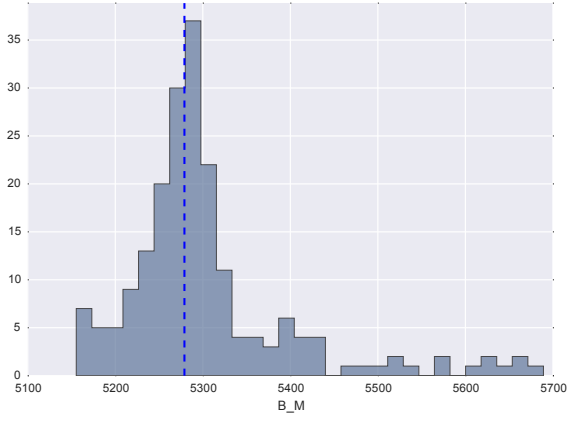
Classifier: Choice of $N_{\text{estimators}}$



Classifer: Test on $B \to K^* \mu\mu$

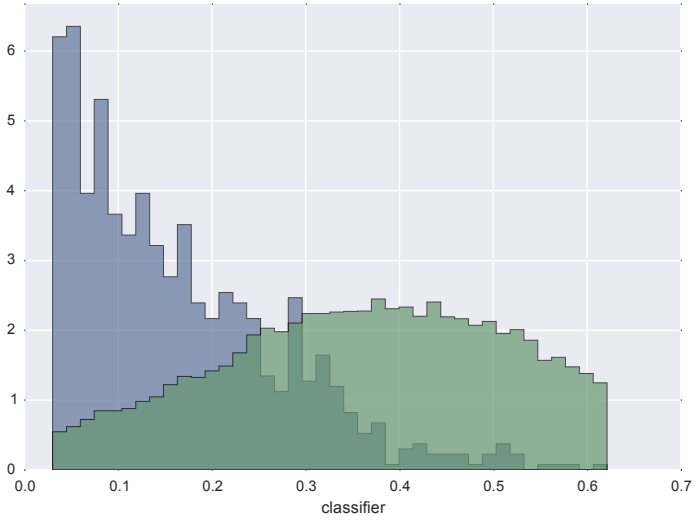
- → Monte Carlo is unreliable (PHSP) and signal is blinded

  $\Rightarrow$ Let's run the classifier on $B \to K^* \mu\mu$!
- → Idea: Use this sample to investigate partial dependence

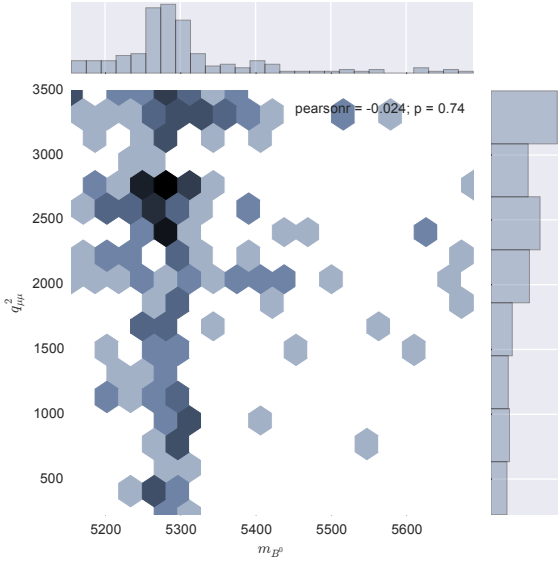


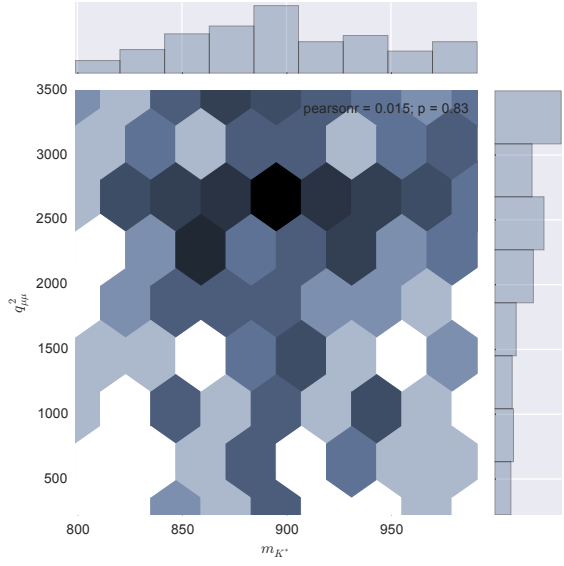
Thanks for listening!

Backup (K^* decision function)

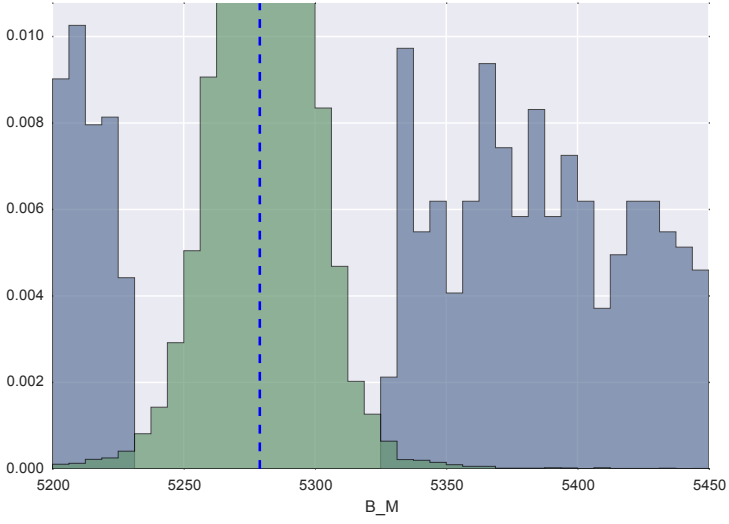


Backup (K^* masses)





Backup


0.010
0.008
0.006
0.004
0.002
0.000
5200
5250
5300
5350
5400
5450
B_M

Backup (D^0 decision function)