

# Rare and Exotic B decays

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# Section Outline

Originally presented at  
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## 1.1 B physics

Initial page  
guestimates

...

### K. Leptonic Decays and $B^+ \rightarrow D^{(*)} \tau^+ \nu$

I. General theory overview and motivation

(short)

II.  $B^+ \rightarrow l^+ \nu$  ( $l = e, \mu, \tau$ )

II.i Theory

(2)

II.ii  $B^+ \rightarrow \tau^+ \nu$  measurements

(3)

II.iii  $B^+ \rightarrow l^+ \nu$  ( $l = e, \mu$ ) measurements

(2)

II.iv  $B^+ \rightarrow l^+ \nu \gamma$  measurements

(1)

II.v Interpretation of results

(2)

III.  $B \rightarrow D^{(*)} \tau^+ \nu$

III.i Theory

(3)

III.ii Methodology and experimental results

(7)

IV. Discussion, interpretation and future prospects

(2)

← Radiative/EW section here?

### L. Rare, Exotic and Forbidden Decays

I. Motivation and theory overview

(short)

II. Methodology

(short)

III.  $B^0 \rightarrow l^+ l^-$  ( also  $\tau^+ \tau^-$  and  $l^+ l^- \gamma$  )

(3)

IV.  $B^0 \rightarrow \gamma \gamma$

(maybe in radiative/EW section?)

(1)

V.  $B^0 \rightarrow$  invisible

(1)

VI. Lepton number/flavor violating modes

(2)

# Relation to other sections



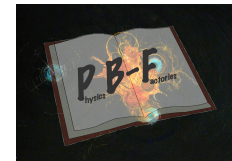
“Rare” section is catch-all for modes which don't naturally fit into other sections

- Connection to “Radiative and electroweak penguin decays” and Charm physics
- Discussion of whether  $B^0 \rightarrow \gamma\gamma$  should be here or in Radiative section; should be together with  $B_s^0 \rightarrow \gamma\gamma$
- Some recent rare charm decay results (where do these live???)

14.9	<i>CP</i> violation . . . . .	1
14.10	Radiative and electroweak penguin decays . .	1
14.11	Leptonic decays, and $B \rightarrow D^{(*)}\tau\nu$ . . . . .	1
14.12	Rare, exotic, and forbidden decays . . . . .	1
	14.12.1 Motivation and theory overview . . . . .	1
	14.12.2 Methodology . . . . .	1
	14.12.3 $B^0 \rightarrow \ell^+\ell^-(\gamma)$ . . . . .	1
	14.12.4 $B^0 \rightarrow \gamma\gamma$ . . . . .	1
	14.12.5 $B^0 \rightarrow$ invisible . . . . .	1
	14.12.6 Lepton number and/or flavor violating modes . . . . .	1
14.13	Baryonic $B$ decays . . . . .	2
15	Quarkonium physics . . . . .	2
	15.1 Conventional charmonium . . . . .	2
	15.2 Exotic charmonium-like states . . . . .	2
	15.3 Bottomonium . . . . .	2
16	Charm physics . . . . .	2
	16.1 Charmed meson decays . . . . .	2
	16.2 $D$ -mixing and $CP$ violation . . . . .	2
	16.3 Charmed meson spectroscopy . . . . .	2
	16.4 Charmed baryon spectroscopy and decays . .	2
17	Tau physics . . . . .	2
18	OED and initial state radiation studies . . . . .	2

# Status/plans

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Most analyses will be stand-alone descriptions in the text (i.e. one-off measurements by either BABAR or Belle)

- No issues with averaging, no need to coordinate text contributions between BABAR/Belle

Basic description of physics motivation (with theory references), description of methodology and discussion of results and sensitivity

- No text yet in SVN (soon!), but anticipate that writing will be straightforward
- Some recent new results; will be included

# $B^0 \rightarrow l^+ l^-$ and related modes



- III.  $B^0 \rightarrow l^+ l^-$  ( also  $\tau^+ \tau^-$  and  $l^+ l^- \gamma$  )
- IV.  $B^0 \rightarrow \gamma \gamma$
- V.  $B^0 \rightarrow$  invisible
- VI. Lepton number/flavor violating modes

$B^0 \rightarrow l^+ l^-$  is most stringent constraint, but new physics reach superseded by Tevatron/LHC  $B_{(s)}^0 \rightarrow l^+ l^-$

- 2008 BABAR  $B^0 \rightarrow l^+ l^-$  publication “almost” competitive with CDF

BABAR refs:

PRD 77, 032007 (2008)	$B^0 \rightarrow l^+ l^-$	full dataset
PRD-RC 77, 011104 (2008)	$B^0 \rightarrow l^+ l^- \gamma$	full dataset
PRL 96, 241802 (2006)	$B^0 \rightarrow \tau^+ \tau^-$	old result, but will not be updated

Belle refs:

PRD 68, 111101(R) (2003)	$B^0 \rightarrow l^+ l^-$	very old!
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# Other rare modes



$B^0 \rightarrow \gamma\gamma$  and  $B^0 \rightarrow$  invisible sections will be fairly short

- Only a handful of result available and methods are straightforward

BABAR references:

PRL 87, 241803 (2001) now superseded

**NEW!**

PR D83 (2011) 032006  $B^0 \rightarrow \gamma\gamma$  full dataset

PRL 93, 091802 (2004)  $B^0 \rightarrow$  invisible with SL tag

$B^0 \rightarrow$  invisible with hadronic tag (won't be ready)

$B^0 \rightarrow$  invisible with SL tag update to full dataset (probably won't be ready)

Belle references:

PRD 73, 051107 (2006)  $B^0 \rightarrow \gamma\gamma$

$B^0 \rightarrow$  invisible study in progress; in time for book?

# Other rare modes



LFV modes mostly published with related modes (e.g.  $B \rightarrow K e^+ \mu^-$ ). For these, we will not repeat analysis description presented in other section, but will mention them in this section for completeness

- Basically, just a big table

Some modes published separately:

BABAR references:

PRD-RC 77, 091104 (2008)  $B^0 \rightarrow l^+ \tau^-$  (essentially full dataset)

PRL 99, 201801 (2007)  $B^+ \rightarrow K^+ \tau^+ \mu^-$  update in progress

**NEW!**

PRD-RC D83, 091101 (2011)  $B^+ \rightarrow \Lambda_{(c)} l^+$  published last year

**NEW!**

$B^+ \rightarrow h l^+ l^+$  ( $h=K, \pi$ ) should be ready in time for book

Belle references:

**NEW!**

PRD 84, 071106(R) (2011)  $B^+ \rightarrow D^- l^+ l^+$  recent paper from Belle