$b \to s\gamma$

- Why is it important?
  - "Penguin" loop diagram
  - SM: dominated by t quark, probes V_{ts}
  - Non-SM: via loop amplitude; interference on SM and non-SM may result in observable direct CP violating effects manifest in charge asymmetry of $B \to K^*\gamma$

Issues

- Theoretically prefer to measure inclusive decay $B \rightarrow X_s \gamma$
  - But harder experimentally…
- Experimentally measure exclusive decay $B \rightarrow K^* \gamma$
  - But harder theoretically …

Ref	Expt	#particles	Decay	#events	BR(x10^{-5})
C7	CLEO	2×10^6 $B\bar{B}$	$B\to X_s\,\gamma$	263±104 110±26	23.2 ±5.7 ±3.5
C2	CLEO	9.7×10^6 $B\bar{B}$	$B^0\to K^{*0}\,\gamma$	88±12	4.55 ±.7 ±.3
C2	CLEO	9.7×10^6 $B\bar{B}$	$B^+\to K^{*+}\,\gamma$	37 ±8	4.76 ±.8 ±.3
C2	CLEO	9.7×10^6 $B\bar{B}$	$B\to K^*_2\,\gamma$	16 ±6	1.66 ±.6 ±.1
C5	CLEO	3.3×10^6 $B\bar{B}$	$b\to s\,\gamma$	92±10 ±6	31.5±3.5±3.2±2.6
Ba2	BaBar	8.6×10^6 $B\bar{B}$	$B^0\to K^{*0}\,\gamma$	48 ±7	5.4 ±.8 ±.5
Be1	Belle	6.1×10^6 $B\bar{B}$	$B\to X_s\,\gamma$	107 ±17	33.6±5.6±4.2±5
Be1	Belle	6.1×10^6 $B\bar{B}$	$B\to K^*\,\gamma$	?	3.8
A1	Aleph	4×10^6 Z	$b\to s\,\gamma$	70 ±20	31.4±8.3±5.3
A1	Aleph	4×10^6Z	$B\to K^*\,\gamma$	5	?
A2?	Aleph	4×10^6Z	$B\to X_s\,\gamma$	?	33.8±7.4±8.5
L1	LHCb	?	$B^0\to K^{*0}\,\gamma$	26,000/10^7 sec; S/N=1	?

Experimental Systematics

- CLEO (C2): total of 6.8% dominated by background shape (5%)
- BaBar (Ba2): total of 8.6% dominated by tracking efficiency (5%)
- Belle (Be1): total of 12.4% dominated by photon reconstruction (5.3%) and charged track reconstruction (4.7%). They also show separate 15% model error for extrapolating over the full X_s mass range.

SM Theory $b \to s\gamma$

Reference	BR x 10-5
Hewett & Wells (PRD 55, 5549 (1997)	32.5±3 ±4
Chetyrkin et al (PLB 400, 206(1997); erratum PLB 425, 414 (1998)	32.8±2.2 ±2.5

- 1st error: Large dependence on scale μ (for $m_b/2<\mu<2m_b$)
  - LO ~25%
  - NLO ~5-10% (need NNLO?)
- 2nd error: Next largest dependence on m_c/m_b
  - ~5%

Beyond SM

- Many authors…
  – Bobeth et al NP B567, 153 (2000)
    - Calculation where SUSY contribution is of the order of 10% of SM value
- Present SM theory error (~10%) is about the same size as the non-SM contribution
- Experiment is at 15% errors now

Conclusions?

- Need better SM theory predictions (NNLO?) to probe deviations from SM
  - Need to reduce errors from present 10% to 1%?
  - What about m_c/m_b error of 5%, can it be reduced?
- Experiment by the end of LHCb, BaBar, Belle should be at least systematics dominated (presently 5-10%), but it looks as if those systematics could be reduced? A few percent?
  - Maybe means that experiment at the end of LHC era will have achieved the necessary experimental precision?

Still missing…

- Need crisp predictions (including systematics) for
  - BaBar, Belle, BTeV, LHC(b)
  - Could not find in the literature…
- Better understanding of reasonable expectations for the reduction in the SM theory error

References

- C2 (CLEO): hep-ex/9912057 "Study of exclusive radiative B Meson decays"
- C5 (CLEO): CONF98-17; ICHEP98 1011 "Improved measurement of B(b->s gamma)"
- C7 (CLEO): PRL74, 2885 (1995) "First measurement of the rate for the inclusive radiative penguin decay b-> s gamma"
- Ba2 (BaBar): SLAC-PUB-8534;hep-ex/0008055 "A measurement of the branching fraction of the exclusive decay B^0->K^{*0} gamma"
- Be1 (Belle): KEK 2001-3; hep-ex/0103042 "A measurement of the branching fraction for the inclusive B0->Xs gamma decays with Belle"
- A1 (Aleph): Williams thesis-99-017 "A measurement of the inclusive branching ratio for b->s gamma with the Aleph detector at LEP"
- A2 (Aleph): PLB429, 169(1998)
- L1 (LHC): CERN-TH/2000-101; hep-ex/0003238 "B Decays at the LHC"