Study of Radiative B Meson Decays
$B \to \tau \nu$

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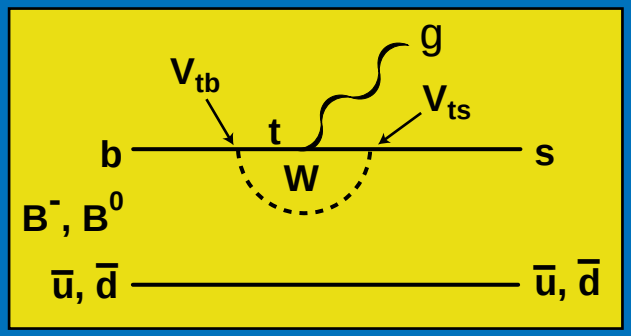
- **Radiative B decays at CLEO**
  - **$b \to s\gamma$ penguins, W exchange**
- **Exclusive measurements/searches**
  - **Branching fractions $B^0 \to K^{*0}(892)\gamma$,**
  - **$B^+ \to K^{*+}(892)\gamma$, $B \to K_2^*(1430)\gamma$, $B \to \rho/\omega\gamma$,**
  - **$B^0 \to D^{*0}\gamma$**
- **New upper limit on BR($B \to \tau\nu$)**

Radiative B decays

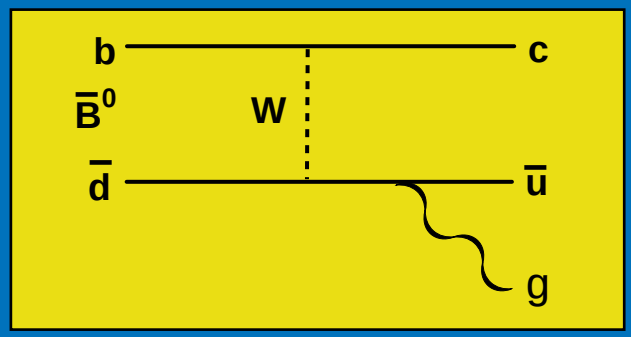


- b –> s g penguin
- First observed 1993 at CLEO

  B –> K* g

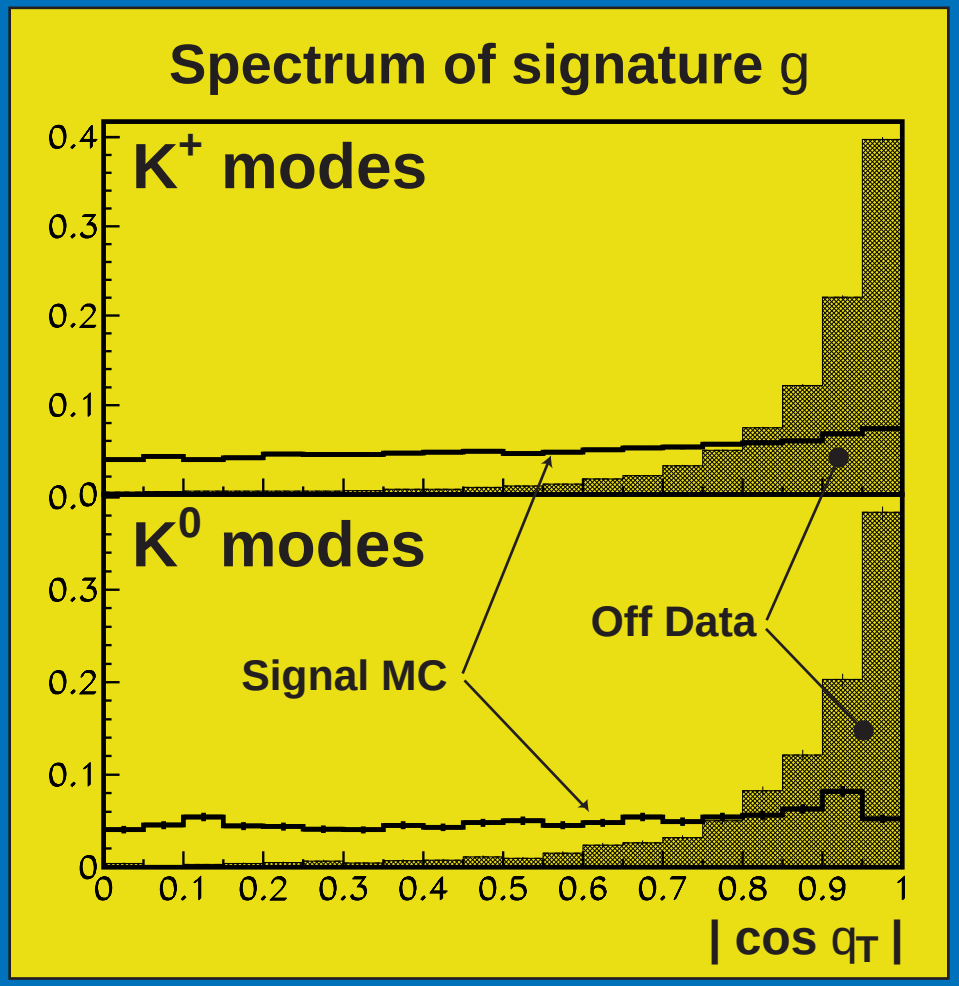
- No flavor changing neutral currents
- Loop dominated by t quark - V_{tb} V_{ts} (SM)
- Non-SM physics (loop)
- CP asymmetry (talk by V.Frolov)

- Non-penguin
- B^0 –> D^{*0} g



Exclusive decays: B –> K*g, r /w/ f g

- **Signature:**
  High energy g
  (2.1GeV < E_g < 2.7GeV)
- **Background: e^+e^- –> qq**
  g from ISR or p^0, h
- **Use only barrel calorimeter**
  | cos q_g | < 0.71
  for suppression of continuum background
- **q_T : angle between B thrust axis and rest of event**
- **Veto for p^0**



Exclusive decays: B –> K*g, r /w/ f g

- **Reconstruct**

  B^0 –> $K^{*0}(892)\gamma$, B^+ –> $K^{*+}(892)\gamma$, B –> $K_2^*(1430)\gamma$

  $K^+\pi^-$, $K_S^0\pi^0$, $K^+\pi^0$, $K_S^0\pi^+$ (+ C.C.)

  B –> r /w g

  ρ^0 –> $\pi^+\pi^-$, ρ^+ –> $\pi^+\pi^0$, ω –> $\pi^+\pi^-\pi^0$ (+ C.C.)

  B –> f g (non-penguin)

  ϕ –> K^+K^-

- **Suppress background**

  through event shape

  E_B cut: $\Delta E = | E_{Resonance} + E_\gamma - E_{beam} | < 300MeV$ ($K^*\gamma$)

  M_B cut: $M_B^2 = E_{beam}^2 - p_B^2$

  $5.2GeV < M_B < 5.3GeV$

Exclusive decays: B –> K*g

Yield: $88.3^{+12.2}_{-11.5}$

BF(90% c.l.) = $(4.55^{+0.72}_{-0.68} \pm 0.34) \times 10^{-5}$

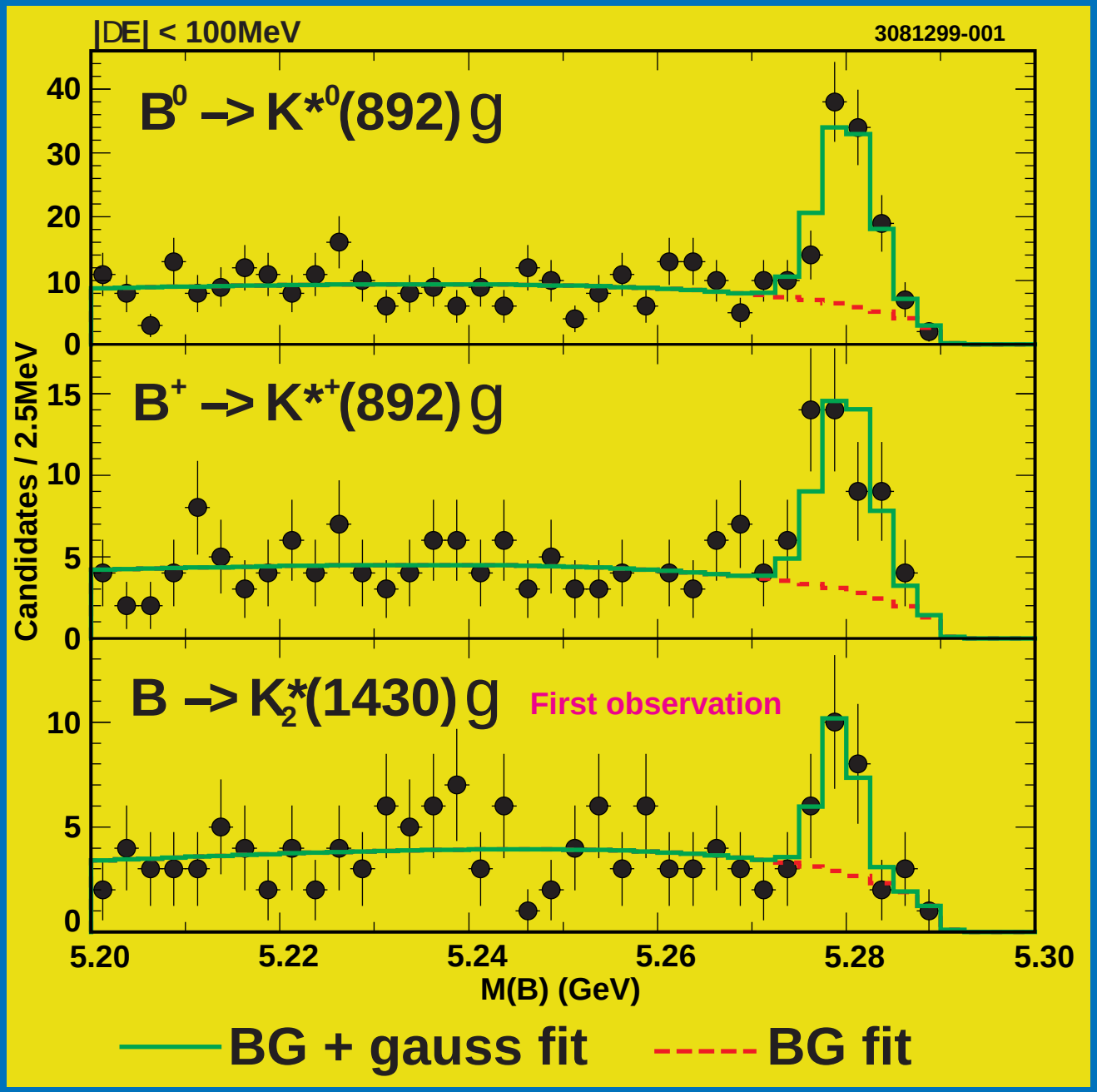
Yield: $36.7^{+8.3}_{-7.6}$

BF(90% c.l.) = $(3.76^{+0.89}_{-0.83} \pm 0.28) \times 10^{-5}$

Yield: $15.8^{+5.7}_{-5.1}$ (3.3σ)

BF(90% c.l.) = $(1.66^{+0.59}_{-0.53} \pm 0.13) \times 10^{-5}$

sum of K_2^{*+} and K_2^{*0}



Exclusive decays: B –> K*γ

▼ **Theory:**

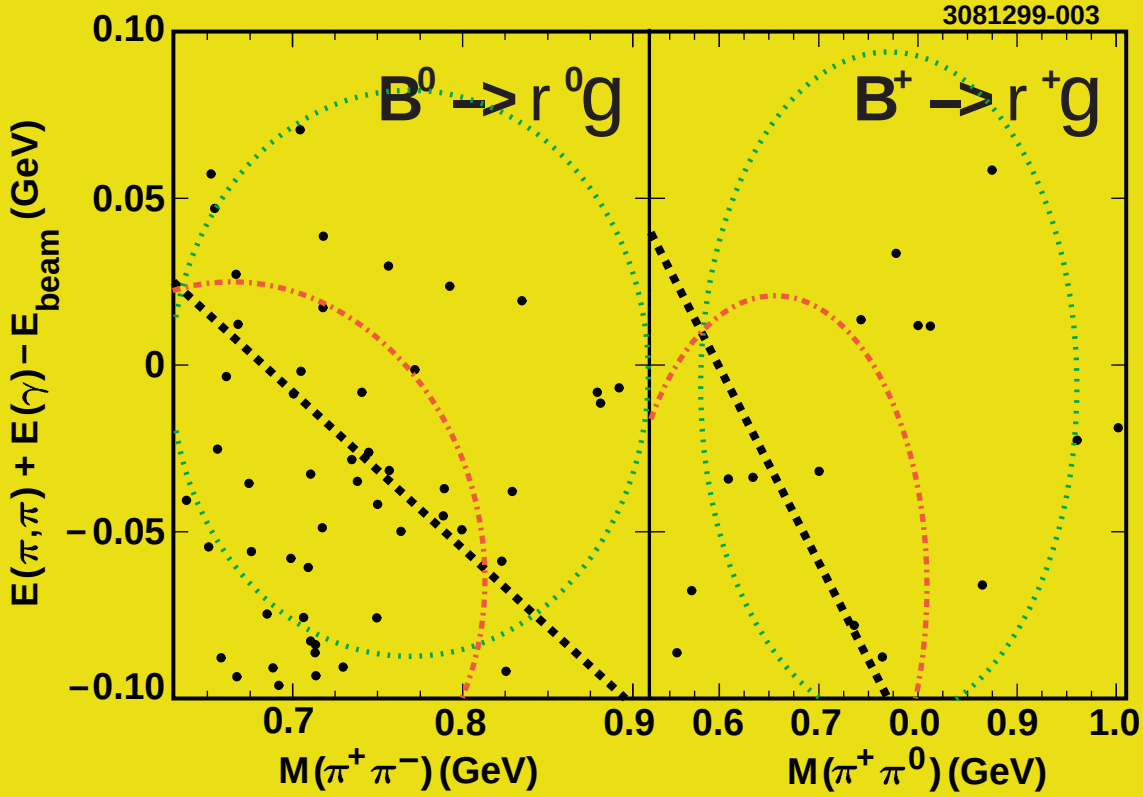
$$\frac{BF(B \to K^*_2(1430)\gamma)}{BF(B \to K^*(892)\gamma)}$$

CLEO meas.	prediction
$0.39^{+0.15}_{-0.13}$	0.37 ± 0.10 (Phys. Lett. B 367 1996, 309)
	3.0 -- 4.9 (Phys. Lett. B 298 1993, 195)

Exclusive decays: B –> r g

▼ Background

B –> r g: continuum, B –> K*g (id K^+ as p^+)



~90% of B –> r g

~90% of B –> K*g

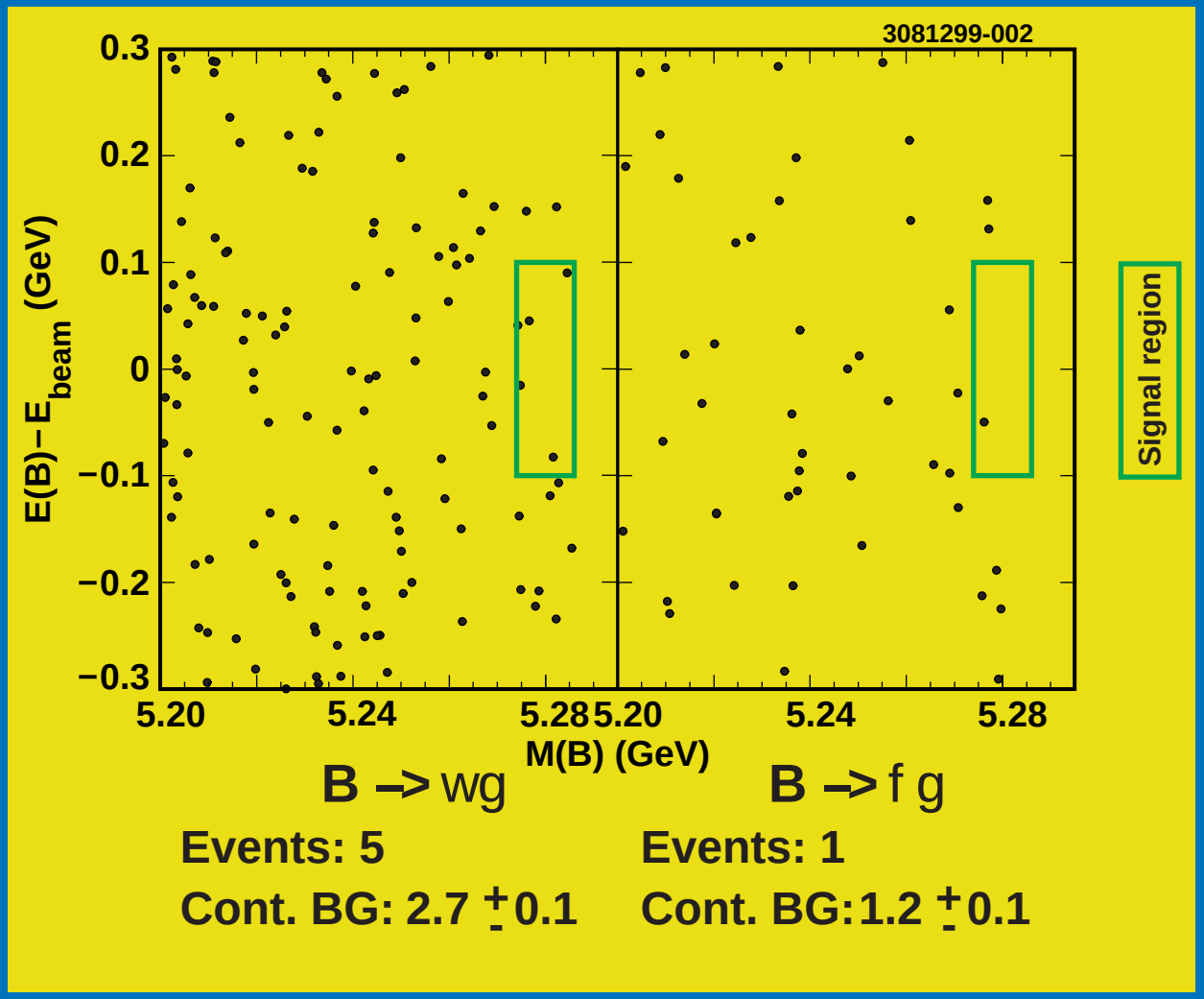
..... Event selection

Events: 24
Cont. BG: $9.3^{+0.6}_{-0.5}$
K* BG: 5.4 ± 0.8

Events: 10
Cont. BG: 5.2 ± 0.4
K* BG: 2.6 ± 0.6

BF(B^0 –> r ^{0}g) < 1.7×10^{-5}
BF(B^0 –> r $^+$g) < 1.3×10^{-5}
(90% c.l.)

Exclusive decays: B –> w/f g



- Background only continuum
- Upper limits:

$BF(B^0 \to \omega\gamma) < 0.92 \times 10^{-5}$

$BF(B^0 \to f\gamma) < 0.33 \times 10^{-5}$

(90% c.l.)

Exclusive decays: B –> r /w/f g

- $|V_{td}/ V_{ts}|$

$$\frac{BF(B \to r\,g)}{BF(B \to K^*\,g)} = x\,|V_{td}/ V_{ts}|^2$$

x = form factor ratio (r /K*): 0.58 < x < 0.91 (models)

Assume

$BF(B \to r\,g) = BF(B^+ \to r^+ g) = 2BF(B^0 \to r^0 g) = 2BF(B^0 \to w\,g)$

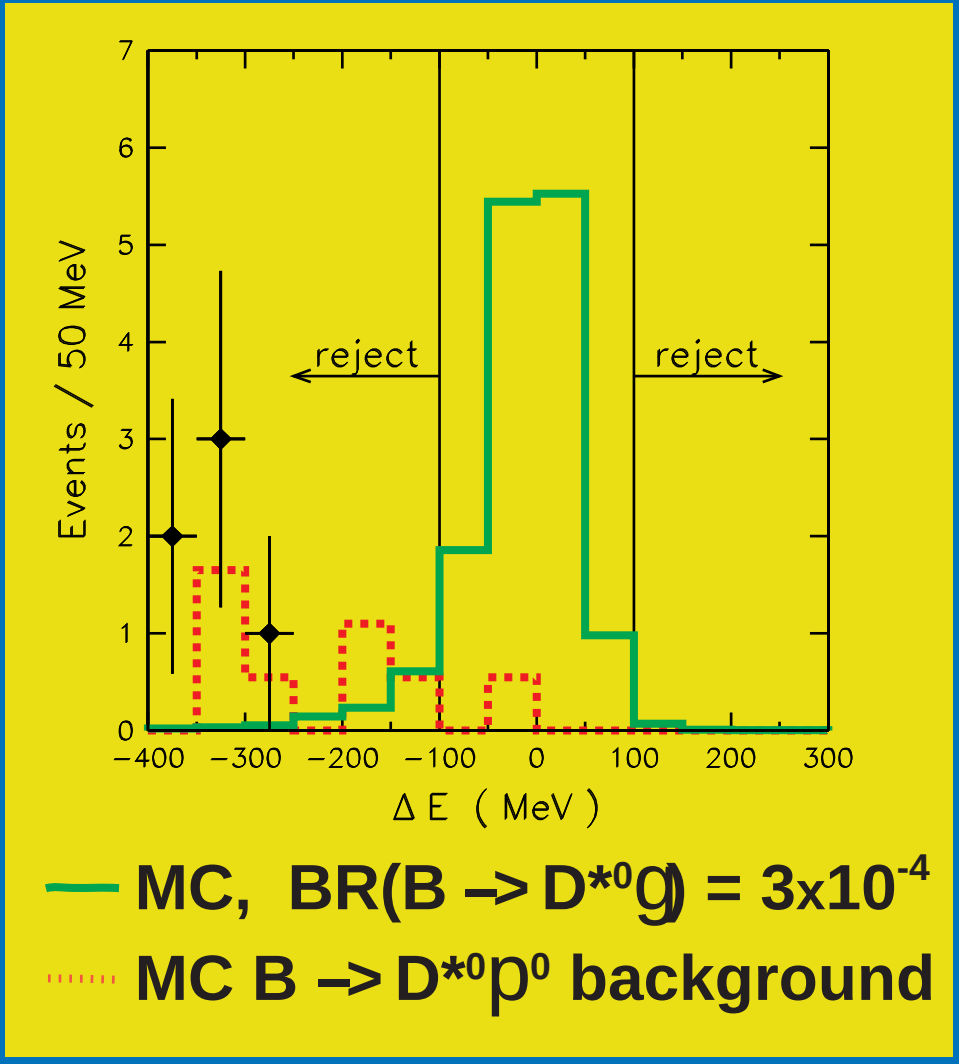
–> Limit: $|V_{td}/ V_{ts}| < 0.79$ (95% c.l.)

Current best limit (LEP/SLD/CDF): $|V_{td}/ V_{ts}| < 0.24$ (95% c.l.)

Wait for CLEO III!

Exclusive decays: $B^0 \to D^{*0}\gamma$

- Analysis similar to $B \to K^*\gamma$
- Reconstruct
  $D^{*0} \to D^0\pi^0, D^0\gamma$
  $D^0 \to K^+\pi^-, K^-\pi^+\pi^0, K^-\pi^+\pi^-\pi^+$
- Background: continuum, $B \to D^{*0}\pi^0$
- $BF(B \to D^{*0}\gamma) < 5.0 \times 10^{-5}$ (90%)
- Together with
  $BF(B^0 \to f\gamma) < 0.33 \times 10^{-5}$
  Indication that radiative B decays are dominated by $b \to s\gamma$.



Leptonic decays: $B^+ \to \tau^+ \nu_\tau$

- **Motivation:**

$$BF(B^+ \to l^+ \nu_l) = \frac{G_F^2 m_B m_l^2}{8\pi} (1 - m_l^2/m_B^2) f_B^2 |V_{ub}|^2 \tau_B$$

m_l = lepton mass

  - BF largest for τ
  - Extract $f_B |V_{ub}|$

- **Full reconstruction of charged B**

  $D^0, D^{*0} (n\pi)^+$, n = 1-5

  D^0 : 8 $K\pi$ modes –> net efficiency ~16%

  D^{*0} : $D^0\pi^0$, $D^0\gamma$, constraint on D^{*0} mass

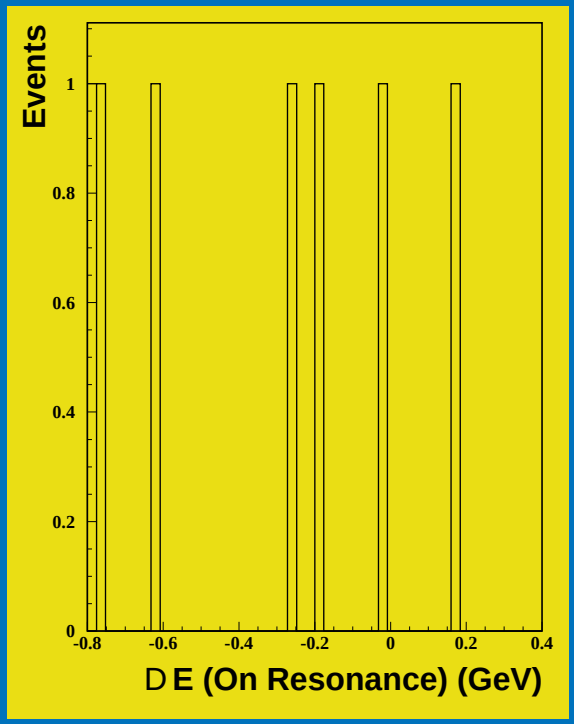
- τ **reconstruction**

  $\tau \to (e\nu_e, \mu\nu_\mu, \pi)\nu_\tau$ (46% of BF)

  Require single charged track

Leptonic decays: $B^+ \rightarrow t^+ \nu_t$

- Background suppression
  - q^2 cut (signal has small q^2 = invariant mass^2 of $(n\pi)^+$)
  - $|\cos \theta_{thrust}|$ cut
    - (continuum background dominates at large values)
- No charged tracks left (besides τ track)
- little leftover shower energy
  - E_{rest} < 400-600 MeV, π^0 veto
- Find 6 events on resonance
- Likelihood fit: 0.96 signal events
- BF($B^+ \rightarrow t^+ \nu_t$) < 8.4 x 10^{-4} (90% c.l.)
  - still above SM prediction (2-10 x 10^{-5})



Summary

- New measurements

  $BF(B^0 \to K^{*0}(892)\gamma) = (4.55^{+0.72}_{-0.68} \pm 0.34) \times 10^{-5}$

  $BF(B^+ \to K^{*+}(892)\gamma) = (3.76^{+0.89}_{-0.83} \pm 0.28) \times 10^{-5}$

  $BF(B \to K^*_2(1430)\gamma) = (1.66^{+0.59}_{-0.53} \pm 0.13) \times 10^{-5}$ first observation

- $A_{CP}(B \to K^*\gamma) = 0.08 \pm 0.13$
- No evidence for $B \to \rho\gamma$, $B^0 \to \omega\gamma$, $B^0 \to \phi\gamma$, $B^0 \to D^{*0}\gamma$
- $|V_{td}/V_{ts}| < 0.79$ (95% c.l.)
- radiative B decays dominated by $b \to s\gamma$
- New analysis of $B^+ \to \tau^+\nu_\tau$

  $BF(B^+ \to \tau^+\nu_\tau) < 8.4 \times 10^{-4}$ (90% c.l.)

- New opportunities with CLEO III