Search for the Lepton Flavor Violating B Decays $B^0 \to \tau$ and $B^0 \to e\tau$ at CLEO2

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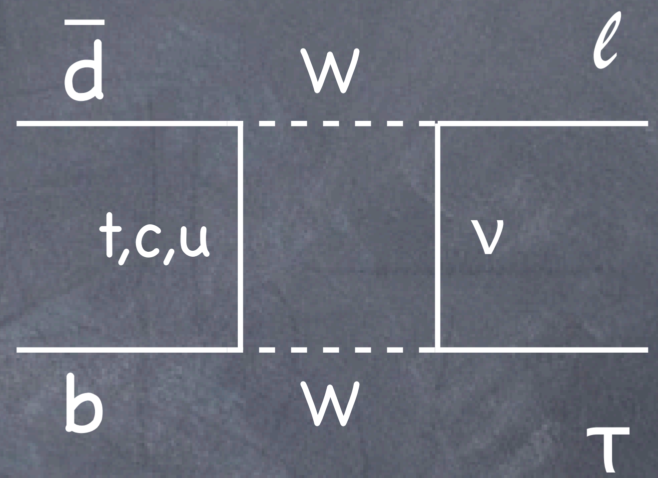
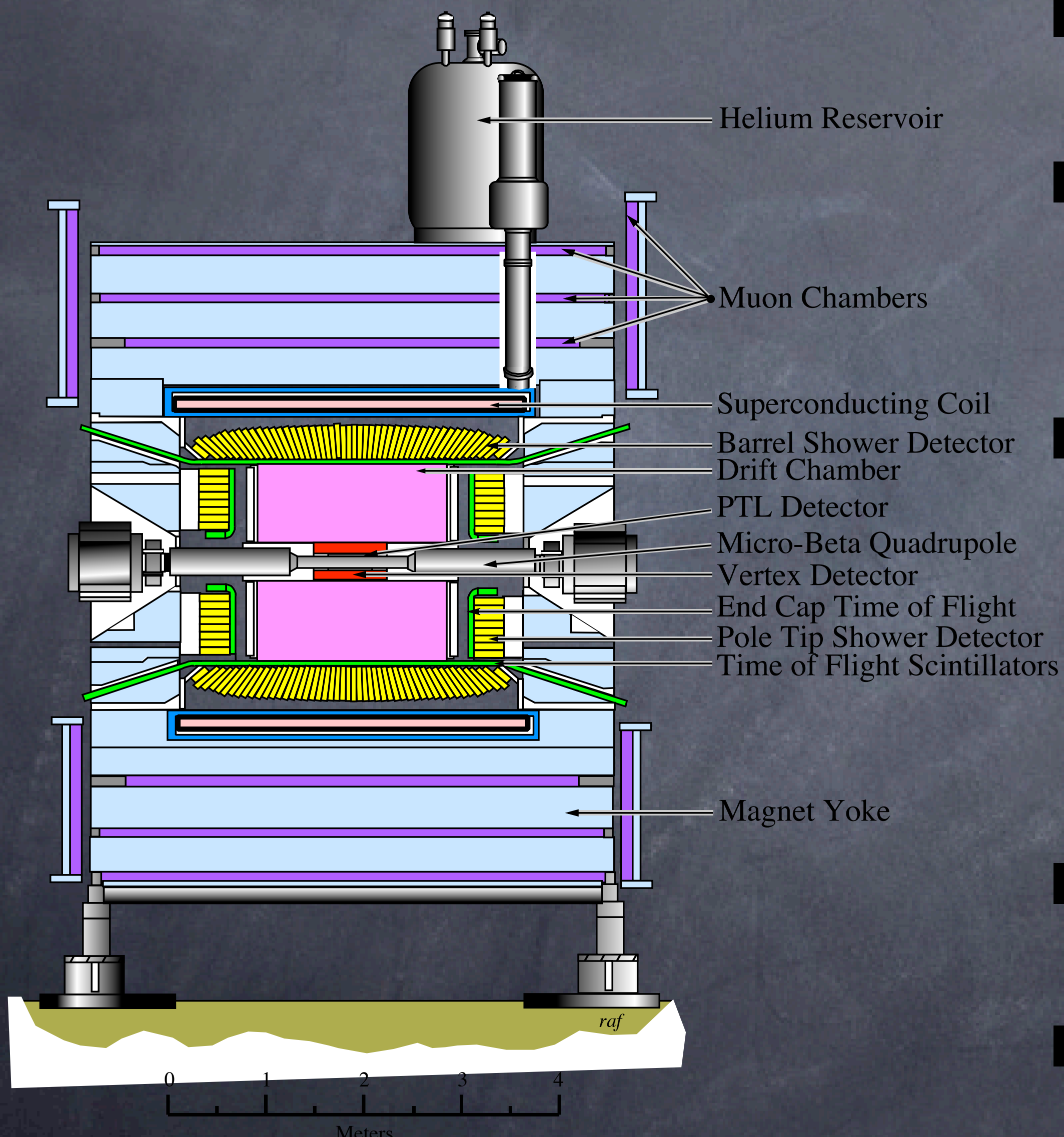
The Physics: $B \to \ell\, \tau$

- We search for the decays $B^0 \to \ \tau$ and $B^0 \to e\tau$ in all charge combinations
- This decay is forbidden in the Standard Model with massless neutrinos
- With massive (eV) neutrinos, and mixing, it is still expected to be suppressed
- Observation would indicate interesting new physics



CLEO2 Data and Detector



- Data is from CLEO2
- 9.6×10^{6} $B\bar{B}$ from $\Upsilon(4s)$ resonance
- 4.5 /fb 60 MeV below resonance for continuum, 2 photon background
- Use Lumi/E^2 scaling
- Use missing momentum cut for 2photon bgd

Analysis Technique

- Search for final states $(e)^+ \tau^-$, $(e)^- \tau^+$
- Use τ decay modes: $\tau \rightarrow \ \nu\nu$ and $\tau \rightarrow e\nu\nu$
- Denote modes by (l,l′) for $B \rightarrow l\tau$, $\tau \rightarrow l' \nu\nu$
- In B rest frame, primary l is monoenergetic
- In lab frame, 2.2 GeV < P(l) < 2.5 GeV
- Secondary l′ required to have p(e)> 0.6 GeV or P( )> 1.0 GeV for PID
- $P_{\nu\nu}$ is event missing E,P - use E(beam)
- Use 2 Neural Nets: NN_{BB} and NN_{cont}

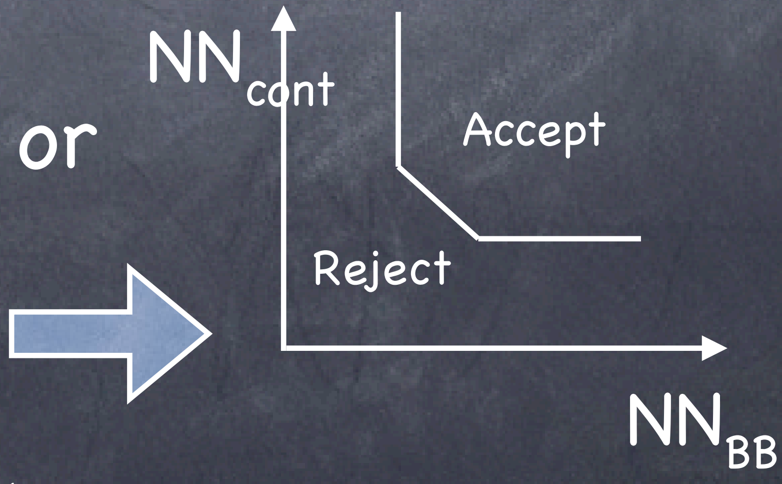
Continuum Suppression

- Continuum Suppression NN_{cont}
  - Input: R2 (ratio of 2nd and 0th Fox Wolfram Moments)
  - Input: Event Sphericity
  - Input: Event Thrust
  - Input: cos of angle between p(l)-p(l′) and thrust axis of rest of event
  - Input: cos of angle between neutrino pair and lepton pair
  -
- Train with Signal and generic Continuum MC

BB Suppression

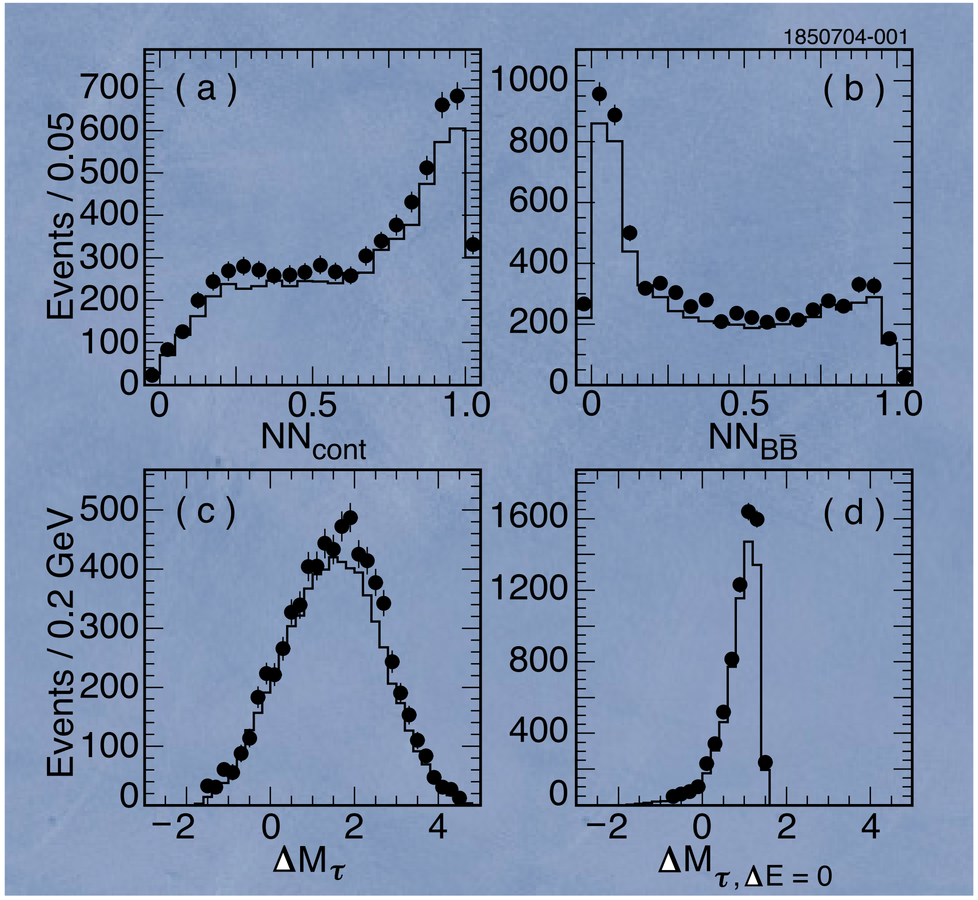
- BB suppression NN_{BB}
    - Input: Beam Constrained B candidate Mass
    - Input: Missing Candidate B energy
    - Input: cos of angle between l and -(momentum of non Candidate B)
- Train with Signal and BB generic Monte Carlo

For each mode, accept or reject in Neural Net plane



SideBand Data/MC Check

- Use Primary Lepton Sidebands (2.0<p(l)<2.2 GeV, 2.5<p(l)<2.7 GeV)
- Plot off resonance subtracted Data, B Generic MC
- ΔM_τ is τ mass diff using $P_{\nu\nu}$
- $\Delta M_{\tau,\,\Delta E=0}$ is beam constrained τ mass diff
- Good Match



Spectra from Primary Lepton Sideband regions (,e) mode

SideBand Data/MC Check 2

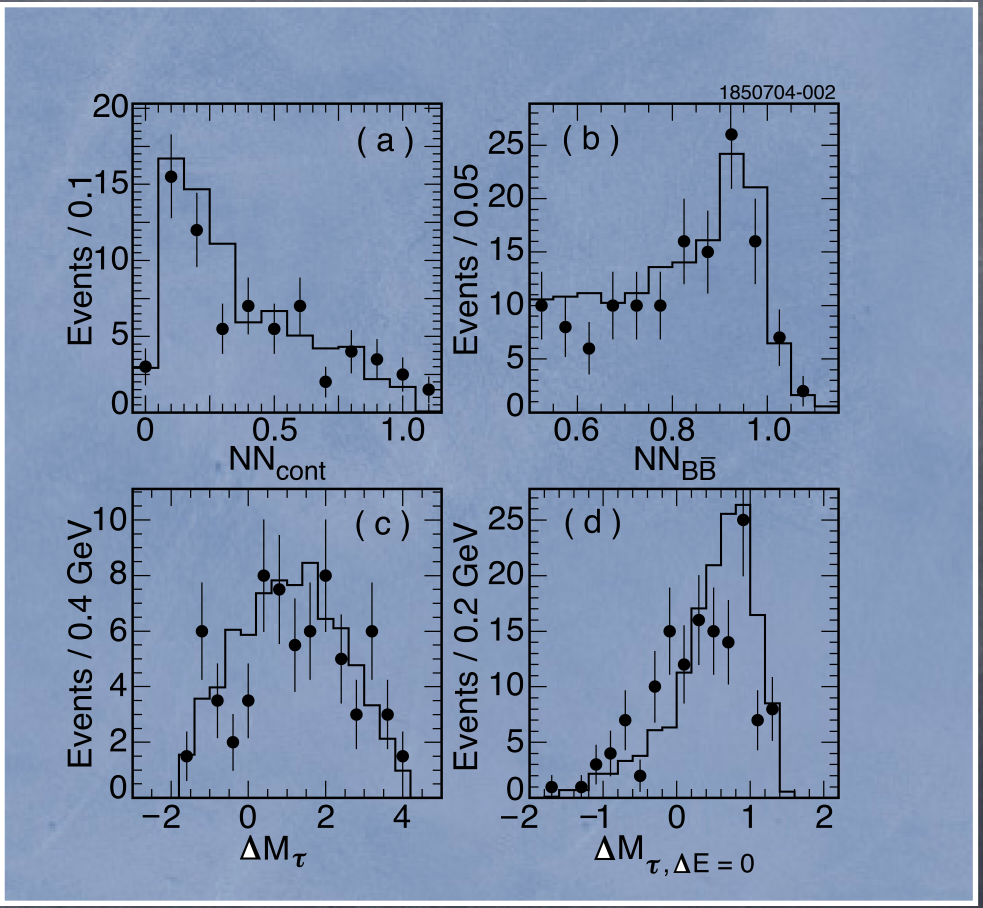
Use Primary Lepton Sidebands (2.0<p(l)<2.2 GeV, 2.5<p(l)<2.7 GeV)

Plot off resonance Data, Continuum Generic MC

In (e,e) mode data exceeds MC: 2 γ bgd

Scale MC in signal region by this ratio

Small error because we do on-off data substraction



Spectra from Primary Lepton Sideband regions (,e) mode

$B \rightarrow \ell \tau$

Results

- Subtract (scaled) Off Resonance Data from On Resonance Data, after cuts
- Compare to N(BB), N(Cont) scaled according to primary sideband estimation
- The rest would be signal

(l,l′)	(,e)	(,)	(e,e)	(e,)
N(on)	19	10	28	6
N(off)	2	3	7	0
N(obs)	15.0±5.2	4.0±4.7	14.0±7.5	6.0±2.4
<NBB>	23.7±2.7	9.0±1.4	11.6±1.4	5.1±0.8
<Ncont>	1.8±0.6	0.4±0.2	3.1±1.0	0.5±0.3

Results 2

- Dominant Systematics:
  - Lepton ID (3.5% for each lepton)
  - $P_{\nu\nu}$ uncertainties (5.4%)
  - Allow MC Scaling to vary by 1σ in least favorable direction for UL
- Limits including Systematics

(l,l′)	(,e)	(,)	(e,e)	(e,)
BR 90% UL (10^{-4})	0.55	0.87	1.64	1.46

Conclusions

- Combining Modes gives:
  - $B(B\to\ \tau) < 3.8\mathrm{x}10^{-5}$ @ 90%CL
  - $B(B\to e\tau) < 1.1\mathrm{x}10^{-4}$ @ 90%CL

Submitted to PRL

Limits are a factor of 22(5) better than previous lowest, also by CLEO

Results given are for unpolarized τ

For V-A ϵ -> ϵ+11%

For V+A ϵ-> ϵ-8%