$e^{\pm}\mu^{\mp}$ Lepton Flavour Violation and $\tau^{\pm}\mu^{\mp}$ Lepton Flavour Universality Studies at the Upsilon(3S) with BaBar

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November 29 - December 3, 2021, Bergen, Norway

BABAR
St. Francis Xavier University
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Outline of the Talk

- BABAR Detector
- Analysis-1: $\tau^{\pm}\mu^{\mp}$ Lepton Universality

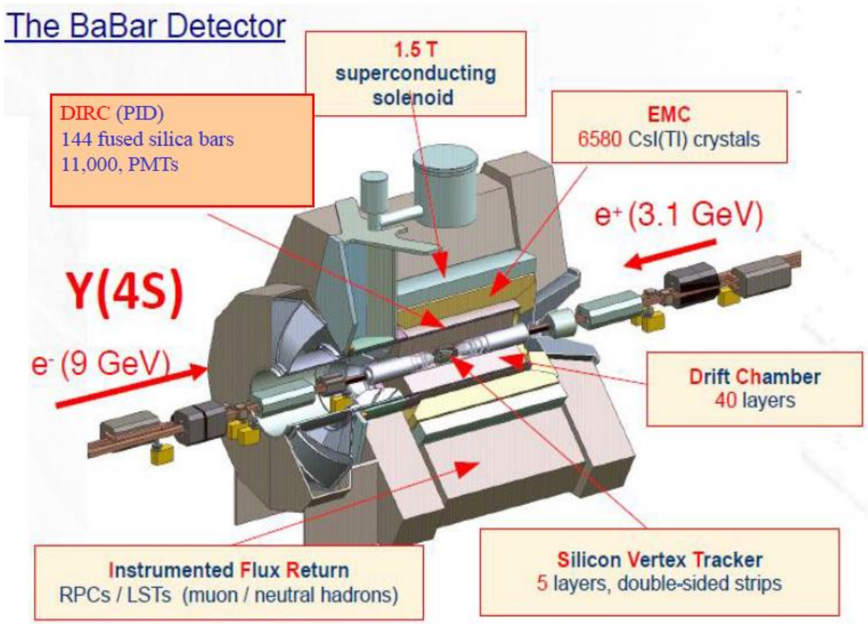
Phys. Rev. Lett. 125, 241801 (2020) by BaBar Collaboration.

- Analysis-2: $e^{\pm}\mu^{\mp}$ Charged Lepton Flavour Violation

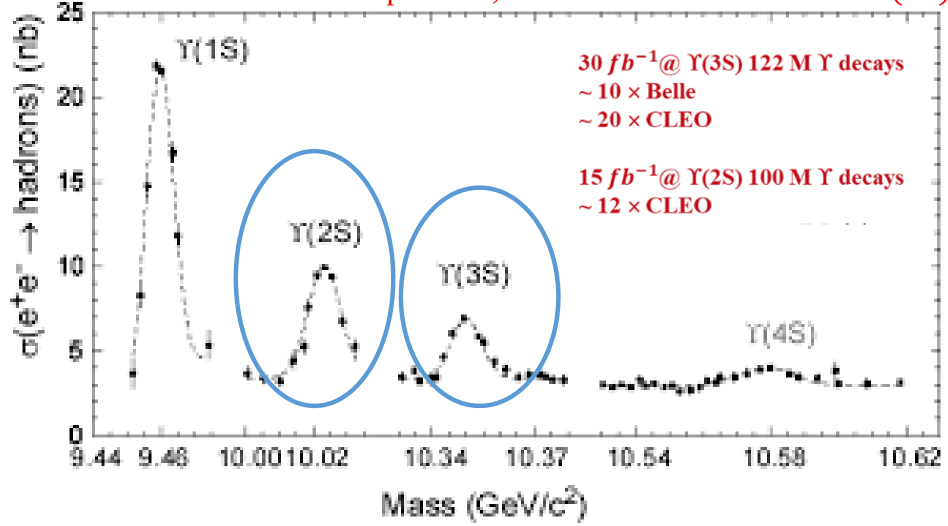
A journal paper has been submitted.

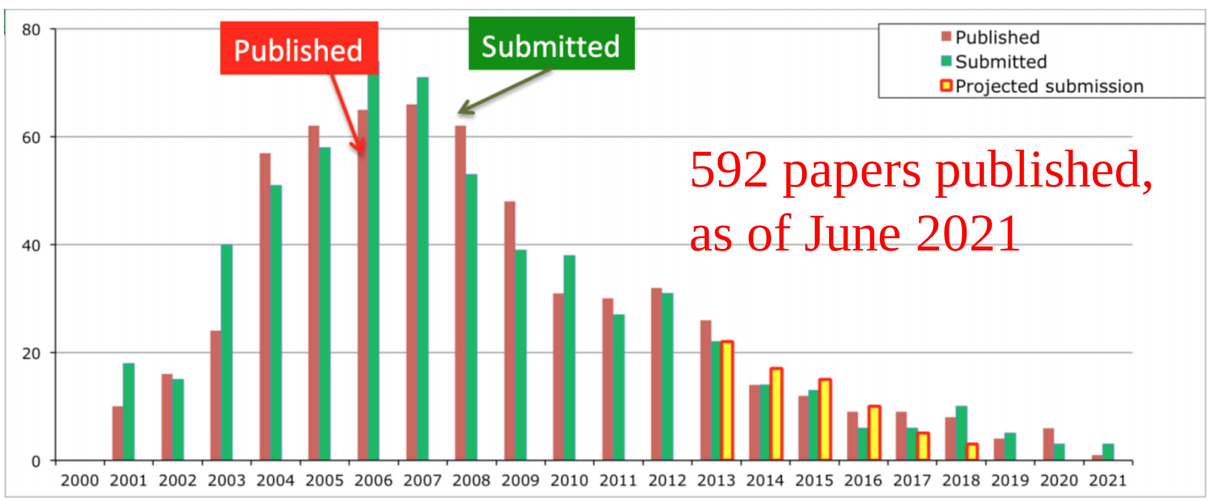
- Data and MC Samples
- Analysis Strategy
- Results
- Conclusion

BaBar Detector

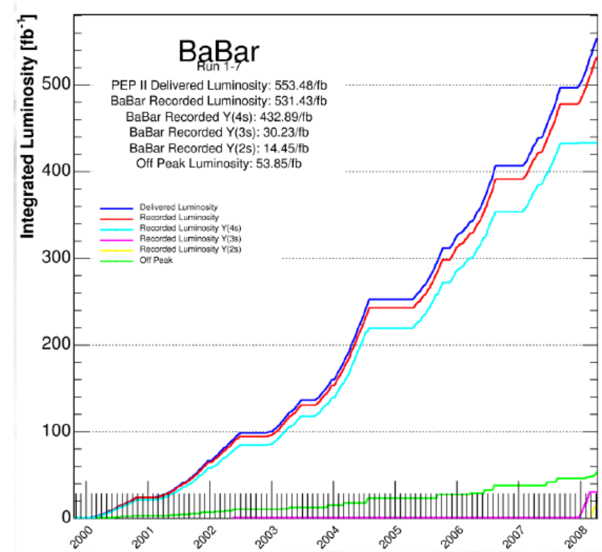


Between Dec. 2007 – Apr. 2008, BaBar collected data below $\Upsilon(4S)$





592 papers published, as of June 2021



Motivation: Lepton Universality

- In the SM, the branching fraction for the decay of

$$\Upsilon(nS) \to l^- l^+ (n = 1,2,3 \ \& \ l = e, \mu, \tau)$$

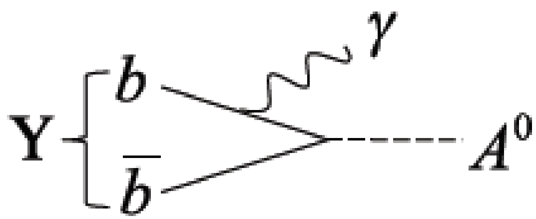
is independent of the flavour of l excluding a tiny lepton mass effect.

- Any deviation from the unity for the ratio of branching fractions would indicate the new physics

- Lepton Universality, therefore, is an excellent test of the SM prediction

- Leptonic decays of the $\Upsilon(nS)$ mesons are also important in search for phenomena beyond the SM

for example:



$A^0 \to CP - odd\ Higgs$

Analysis Dataset: Lepton Universality

$$\mathcal{B}(\Upsilon(3S) \to \tau^+\tau^-)/\mathcal{B}(\Upsilon(3S) \to \mu^+\mu^-)$$

Data sample for signal

- 27.96 fb^{-1} $\Upsilon(3S)$ on-peak data

Control data samples

- 78.3 fb^{-1} $\Upsilon(4S)$ on-peak data and
- 7.75 fb^{-1} $\Upsilon(4S)$ off-peak data (40 MeV below the on-peak) and
- 2.62 fb $^{-1}$ $\Upsilon(3S)$ off-peak data (40 MeV below the on-peak)

- Control samples are used to evaluate properties of background, to study systematic sffects, and to calculate corrections to MC based efficiencies

Lepton Universality

$\mathcal{B}(\Upsilon(3S) \rightarrow \tau^+\tau^-)/\mathcal{B}(\Upsilon(3S) \rightarrow \mu^+\mu^-)$ **Phys. Rev. Lett. 125, 241801**

Monte Carlo (MC) samples:

- Continuum: $\tau^+\tau^-, \mu^+\mu^-, Bhabhas, uds, c\bar{c}(\sqrt{s} = m_{\Upsilon(3S)}\ and \sqrt{s} = m_{\Upsilon(4S)})$
- $\tau^+\tau^-, \mu^+\mu^-$ -- KKMC (with radiative effects)
- Bhabhas –BHWIDE
- Hadronic continuum and generic $\Upsilon(3S)$ – EvtGen (PHOTOS)

Signal Events

- $\Upsilon(3S) \rightarrow \tau^+\tau^-, \mu^+\mu^-$ KKMC (ISR turned off)
- Signal MC sample is about three times the size of the data sample
- GEANT4 for detector acceptance

Event Selections:

- two oppositeley charged tracks (each in one hemisphere)

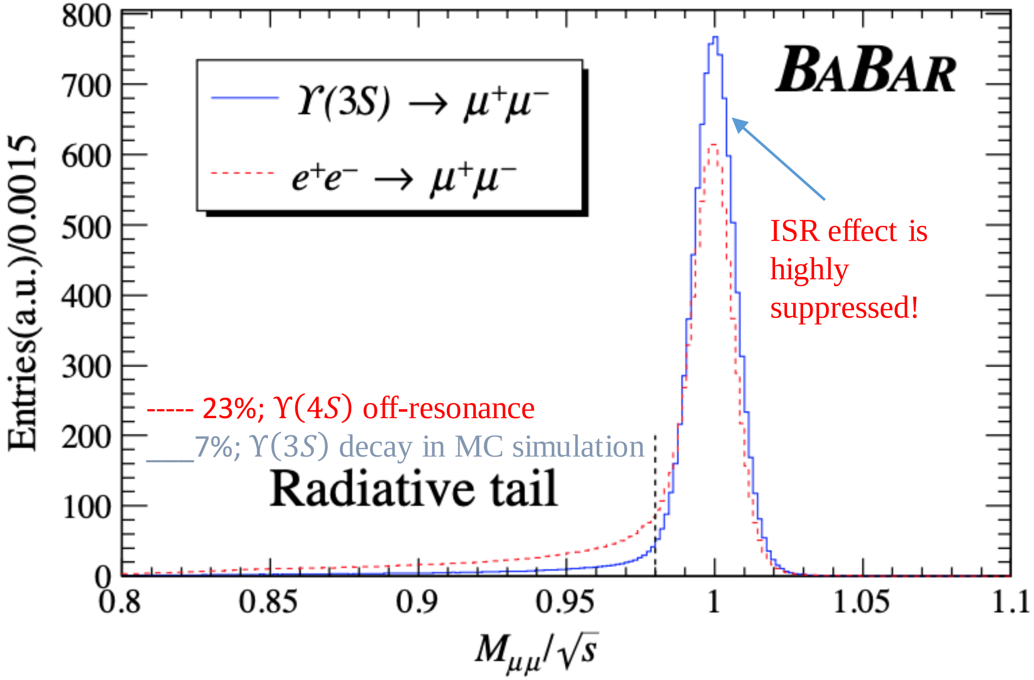
$\boldsymbol{\mu^+\mu^-}$	$\boldsymbol{\tau^+\tau^-}$
▪ At least one μ hit IFR (suppressing Bhabha) ▪ $0.8 < M_{\mu\mu}/\sqrt{s}$ <1.1 ▪ 99.9% purity	▪ One track is required to be identified as an electron (based on PID) and the other doesn't ▪ Angle between two track in the center-of-mass > 110° ▪ $\lvert cos\theta_{miss}\rvert < 0.85$ in the center-of-mass frame ▪ 98.9 % purity

Lepton Universality

$\mathcal{B}(\Upsilon(3S) \to \tau^+\tau^-)/\mathcal{B}(\Upsilon(3S) \to \mu^+\mu^-)$ **Phys. Rev. Lett. 125, 241801**

❑ Analysis

- Off-resonance data ($\Upsilon(4S), \Upsilon(3S)$) are used to correct the differences between MC and data ($\tau^+\tau^-/\ \mu^+\mu^-$) selection efficiency ratios
- Continuum modeling:



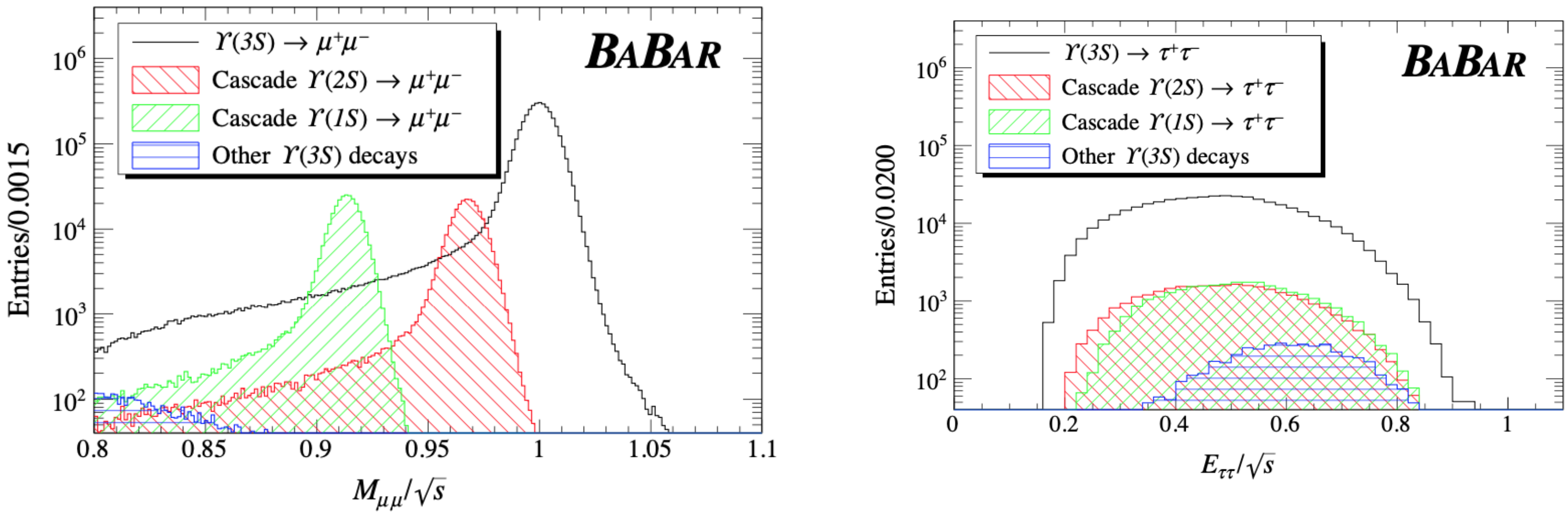
- For the $\tau^+\tau^-$ events the total reconstructed event energy scaled to the center-of-mass energy $E_{\tau\tau}/\sqrt{s}$ is plotted
- Cascade decays are considered (via radiative and hadronic transitions)

Lepton Universality

$\mathcal{B}(\Upsilon(3S) \to \tau^+\tau^-)/\mathcal{B}(\Upsilon(3S) \to \mu^+\mu^-)$ **Phys. Rev. Lett. 125, 241801**

Analysis: Fitting

- To extract the ratio $\mathcal{R}_{\tau\mu}^{\Upsilon(3S)}$, a binned maximum likelihood fit is employed on $M_{\mu\mu}/\sqrt{s}$ and $E_{\tau\tau}/\sqrt{s}$
- $\Upsilon(3S) \to \mu^+\mu^-$ and $\Upsilon(3S) \to \tau^+\tau^-$ are taken from KKMC (no ISR)
- $\Upsilon(2S) \to l^+l^-$, $\Upsilon(1S) \to l^+l^-$, and $\Upsilon(nS) \to hadrons$ are from EvtGen MC



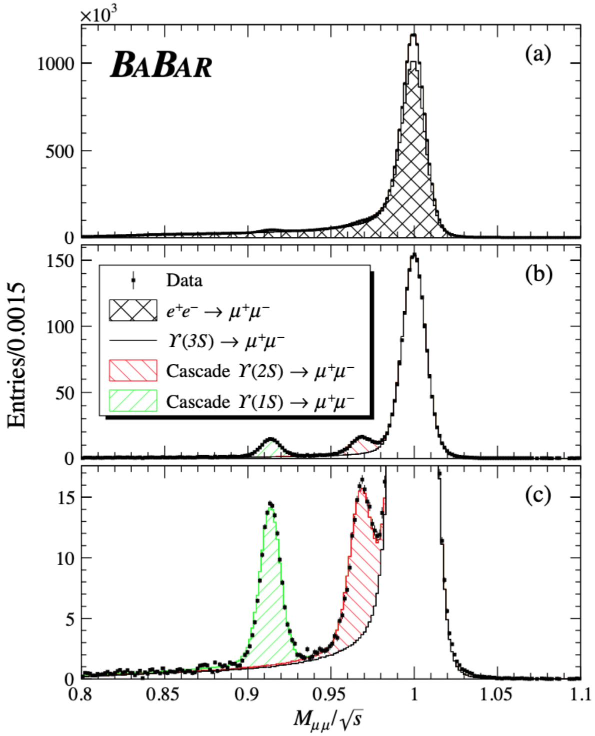
- Cascade decays are clearly separated in dimuon events and nearly indistinguishable in $\tau^+\tau^-$ events.
- Continuum templates then use data control samples: $\Upsilon(4S)$ Run6 data

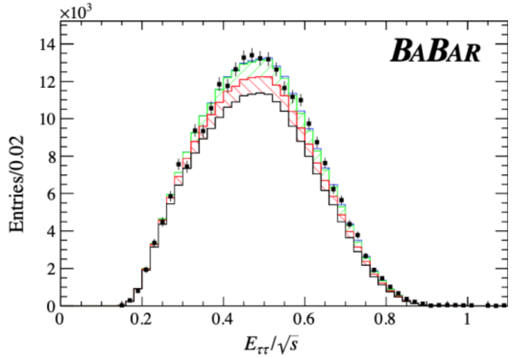
Lepton Universality

$\mathcal{B}(\Upsilon(3S) \to \tau^+\tau^-)/\mathcal{B}(\Upsilon(3S) \to \mu^+\mu^-)$ **Phys. Rev. Lett. 125, 241801**

❑ Analysis: Fit Result

- $M_{\mu\mu}/\sqrt{s}$ and $E_{\tau\tau}/\sqrt{s}$ are simultaneously fit using MC and data derived templates
- The free parameters of the fit are the number of $\Upsilon(3S) \to \mu^+\mu^-$ events $N_{\mu\mu}$ and the raw ratio $\tilde{R}_{\tau\mu} = \frac{N_{\tau\tau}}{N_{\mu\mu}}$





Systematics:

Source	Uncertainty (%)
Particle identification	0.9
Cascade decays	0.6
Two-photon production	0.5
$\Upsilon(3S) \to$ hadrons	0.4
MC shape	0.4
$B\bar{B}$ contribution	0.2
ISR subtraction	0.2
Total	1.4

Lepton Universality

$\mathcal{B}(\Upsilon(3S) \to \tau^+\tau^-)/\mathcal{B}(\Upsilon(3S) \to \mu^+\mu^-)$ **Phys. Rev. Lett. 125, 241801**

❑ Analysis: Fit Result

$$\mathcal{R}_{\tau\mu}^{\Upsilon(3S)} = \tilde{R}_{\tau\mu} \frac{1}{C_{\mathrm{MC}}} \frac{\varepsilon_{\mu\mu}}{\varepsilon_{\tau\tau}} (1 + \delta_{B\bar{B}})$$

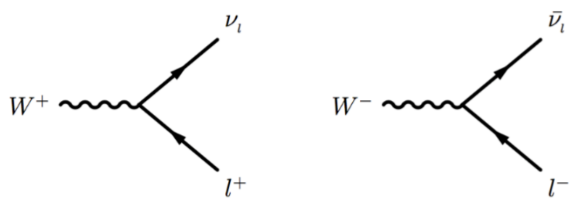
- $\tilde{R}_{\tau\mu}$ is the fit result, C_{MC} is the data/MC correction, $\varepsilon_{\mu\mu}/\varepsilon_{\tau\tau}$ is the MC selection efficiency, and $\delta_{B\bar{B}}$ is the correction from $B\bar{B}$ events
- Using $\Upsilon(3S)$ data with $\Upsilon(4S)$ and off-resonance control samples BaBar measures the ratio of the leptonic branching fractions of the $\Upsilon(3S)$ meson is:

$$\mathcal{R}_{\tau\mu}^{\Upsilon(3S)} = \frac{\mathcal{B}(\Upsilon(3S)\to\tau^+\tau^-)}{\mathcal{B}(\Upsilon(3S)\to\mu^+\mu^-)} = 0.966 \pm 0.008_{stat} \pm 0.014_{syst}$$
$$= 0.966 \pm 0.016_{tot}$$

- Six times more precise than the CLEO measurement [PRL 98, 052002 (2007)]
- The final ratio is with 2σ of the SM value 0.9948 [J. High Energy Phys. 06 (2017) 019]

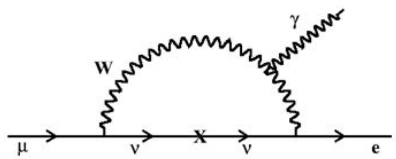
Motivation: Charged Lepton Flavour Violation

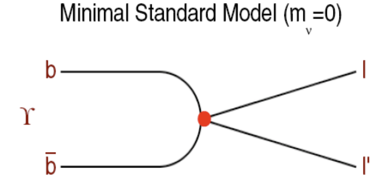
- Charged Lepton Flavour Violation (CLFV) is a transition among e, μ, τ that doesn't conserve lepton family number.
- In Standard Model, Lepton Flavour is conserved for zero degenerate **ν** masses and now we have clear indication that $\boldsymbol{\nu}$**'**s have finite mass.



Example of **lepton flavour conservation** is a muon decay: $\mu^- \to e^- \overline{\nu_e} \nu_\mu$

Opportunity for New Physics !!!





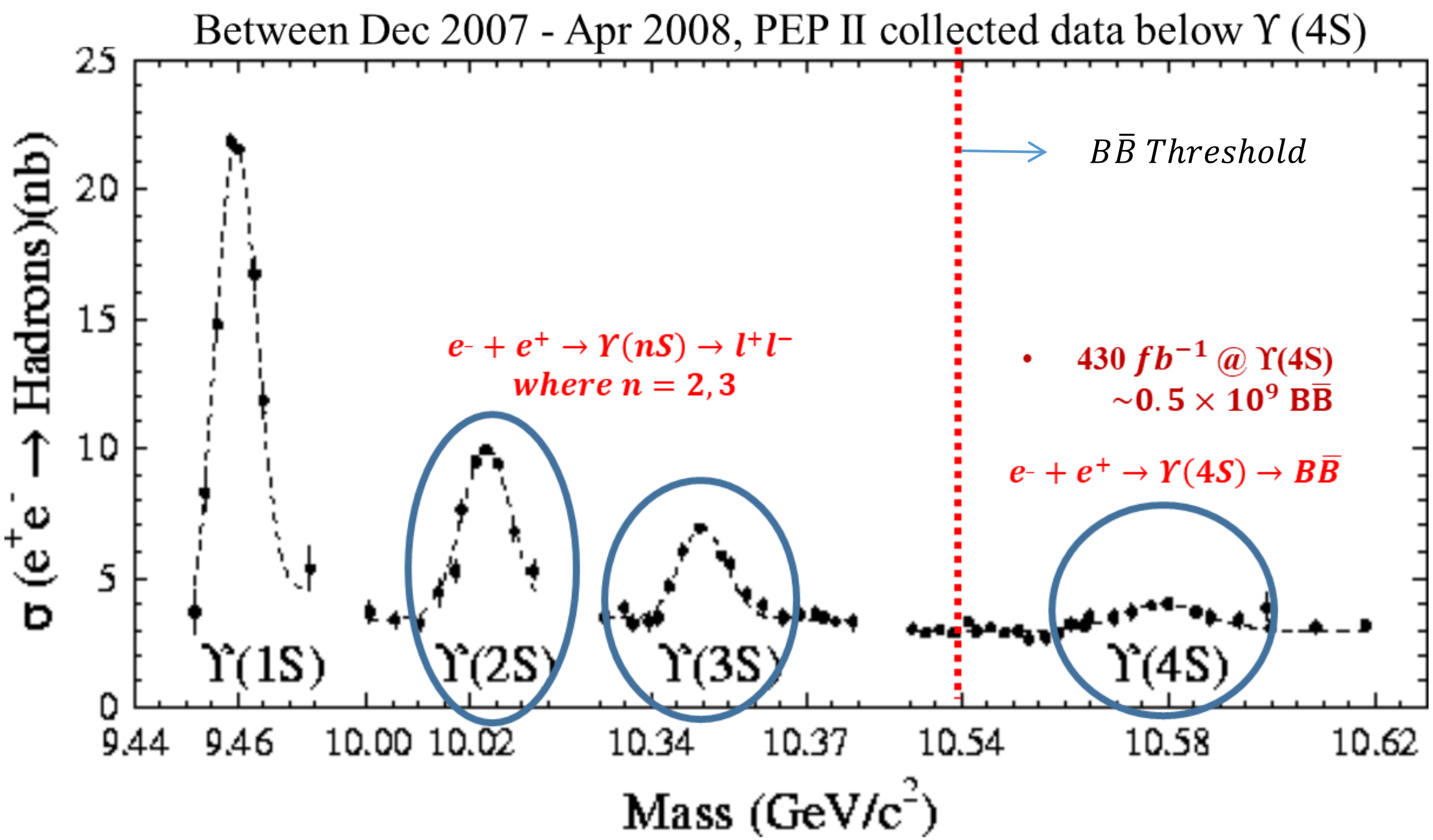
$l_\alpha \to l_\beta \approx \boldsymbol{O}(\mathbf{10^{-54}})$

Example of **charged lepton flavour violation** is a neutrinoless muon decay: $\mu^- \to e^- \gamma$

- In the charged lepton sector, **Lepton Flavor Violation** is **heavy suppressed** in the Standard Model.

- Various BSM models such as Supersymmetry, Compositeness, Heavy neutrino, Leptoquarks, Heavy Z', Anomalous boson Coupling, Higgs/top loops etc. are the predicted CLFV.

Charged Lepton Flavour Violation in Upsilon Decays



- **30 fb^{-1}@ Υ(3S) 122 M Υ decays**
  ~ 10 × Belle
  ~ 20 × CLEO

- **15 fb^{-1}@ Υ(2S) 100 M Υ decays**
  ~ 12 × CLEO

Dramatic Increase in sensitivity to rare decays: $\Gamma_{\Upsilon(4S)}/\Gamma_{\Upsilon(nS)} \approx 10^3$

Upsilon System: **CUSB detector, CLEO Collaboration**
T. Bohringer et al., Phys. Rev. Lett. 44, 1111 (1980) and P. Finocchiaro et al., Phys. Rev. Lett. 45, 222 (1980)

Theoretical Expectations and Experimental Limit

S.Nussinov, et. al. estimated that the contribution of the virtual $\Upsilon(3S) \to e^{\pm}\mu^{\mp}$ to the $\mu \to eee$ rate would be reduced by approximately $M^2_{\mu}/(2M^2_{\Upsilon})$ leading to a recalculated indirect bound: **BF($\Upsilon(3S) \to e^{\pm}\mu^{\mp}$) < 1×10^{-3}**

$$[BR(\mu\to 3e)]_{V-exch} \approx \frac{[\Gamma(V\to e^+e^-)][\Gamma(V\to e^\pm\mu^\mp)]}{[\Gamma^2(W\to e\nu)]}\left(\frac{M_W}{M_V}\right)^6 \quad [1]$$

BF($\mu \to eee$) <1.0×10^{-12} [2]

BF($\Upsilon \to ee$) =2.18×10^{-2} [3]

Existing Measurements	Results	CL (%)	Collaboration
BF($\Upsilon(3S) \to e^{\pm}\tau^{\mp}$)	< 4.2×10^{-6}	90	J.P. Lees et al. PR D89 111102 [BaBar Collaboration]
BF($\Upsilon(3S) \to \mu^{\pm}\tau^{\mp}$)	< 3.1×10^{-6}	90	
BF($\Upsilon(3S) \to \mu^{\pm}\tau^{\mp}$)	< 20.3×10^{-6}	95	Love et al. PRL 101, 201601 [CLEO Collaboration]

[1] S.Nussinov, et. al. PRD 63 (2001)

[2] Bellgardt, et al., Nucl.Phys. B299 (1988)

[3] P.A. Zyla et al. (Particle Data Group)

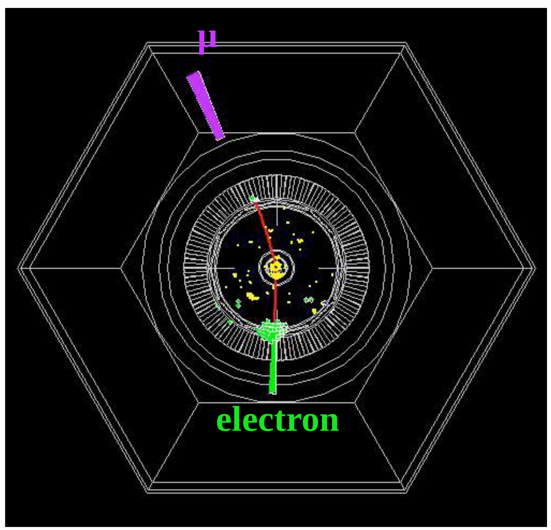
- **We report a limit several orders of magnitude more sensitive than this indirect limit.**

CLFV: Data, MC Sample

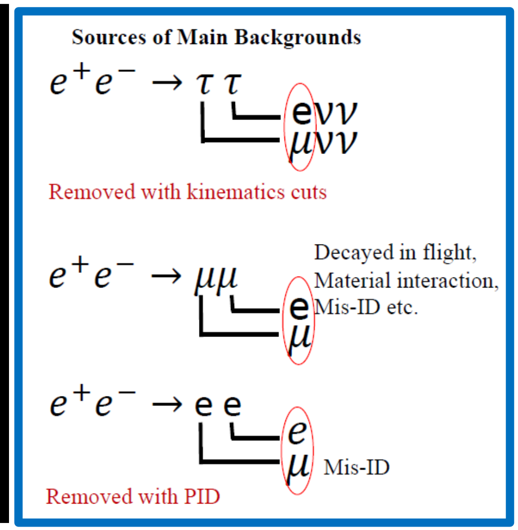
Data Sample	**On resonance (fb^{-1})**	**Off resonance (fb^{-1})**
Run 7 $\boldsymbol{\Upsilon(3S)}$ **(Data)**	27.9 = 27.0 + 0.93	2.62 To validate the systematic study
Run 6 $\boldsymbol{\Upsilon(4S)}$ **Data driven continuum background**	78.31 Systematic study pre-selected as $e^{\pm}\mu^{\mp}$and $\mu^{\pm}\mu^{\mp}$	7.75 To validate the systematic study
MC signal: $e^+e^- \rightarrow \Upsilon(3S) \rightarrow e^{\pm}\mu^{\mp}$: 103000 events		

CLFV: Signal and Background Characteristics

- $\boldsymbol{\Upsilon(3S)} \rightarrow \boldsymbol{e^{\pm}\mu^{\mp}}$: Required two primary track signal of $\boldsymbol{e^{\pm}}$ ***and*** $\boldsymbol{\mu^{\mp}}$
- CM Momentum: $\boldsymbol{p_{e^{\pm}}} \sim \frac{\sqrt{s}}{2} \sim \boldsymbol{E_B}$ and $\boldsymbol{p_{\mu^{\pm}}} \sim \frac{\sqrt{s}}{2} \sim \boldsymbol{E_B}$ where $\boldsymbol{E_B}$=Beam Energy in Centre of Mass System
- Angle between the two lepton tracks must satisfy $\theta_{12}^{CM} > 179^{\circ}$ to emerged as back to back.
- Energy deposit by $\boldsymbol{\mu^{\mp}}$ track on the Electromagnetic Calorimeter > 50 MeV
- EMC acceptance $24^{\circ} < \theta_{Lab} < 130^{\circ}$ etc.



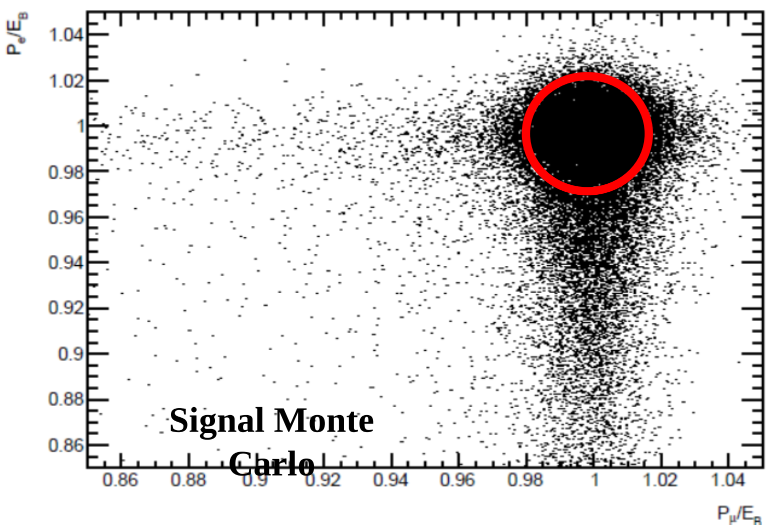
Sample Background event
$\boldsymbol{e^{-}e^{+} \rightarrow \tau^{\pm}\tau^{\mp} \rightarrow e^{\pm}\mu^{\mp} + 4\nu}$



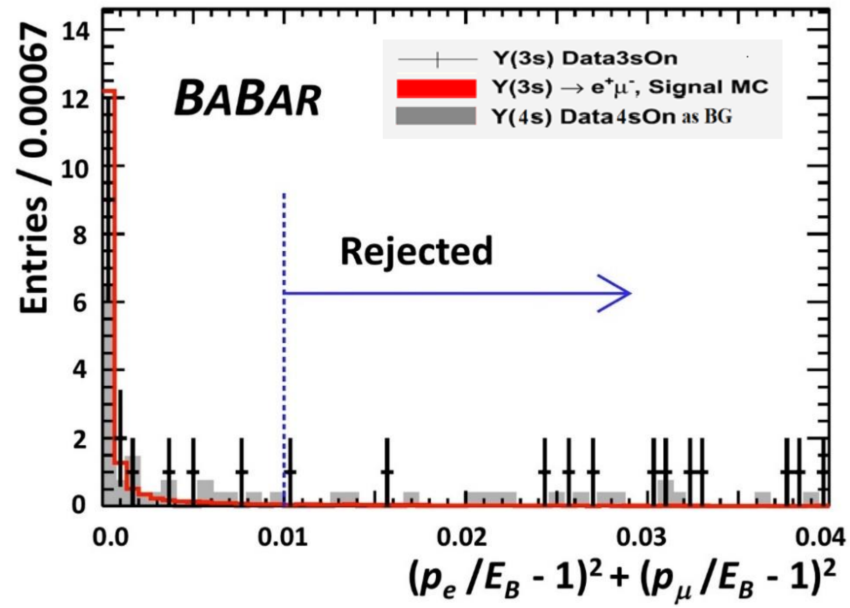
Different Sources of Background

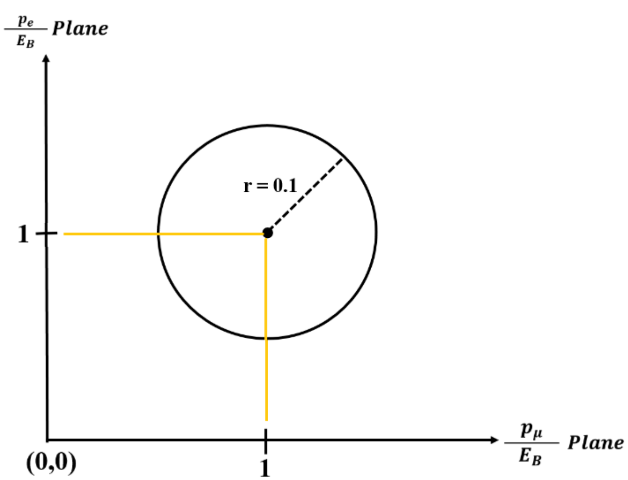
CLFV: Final Selection Criterion

***BABAR* Preliminary**



***BABAR* Preliminary**



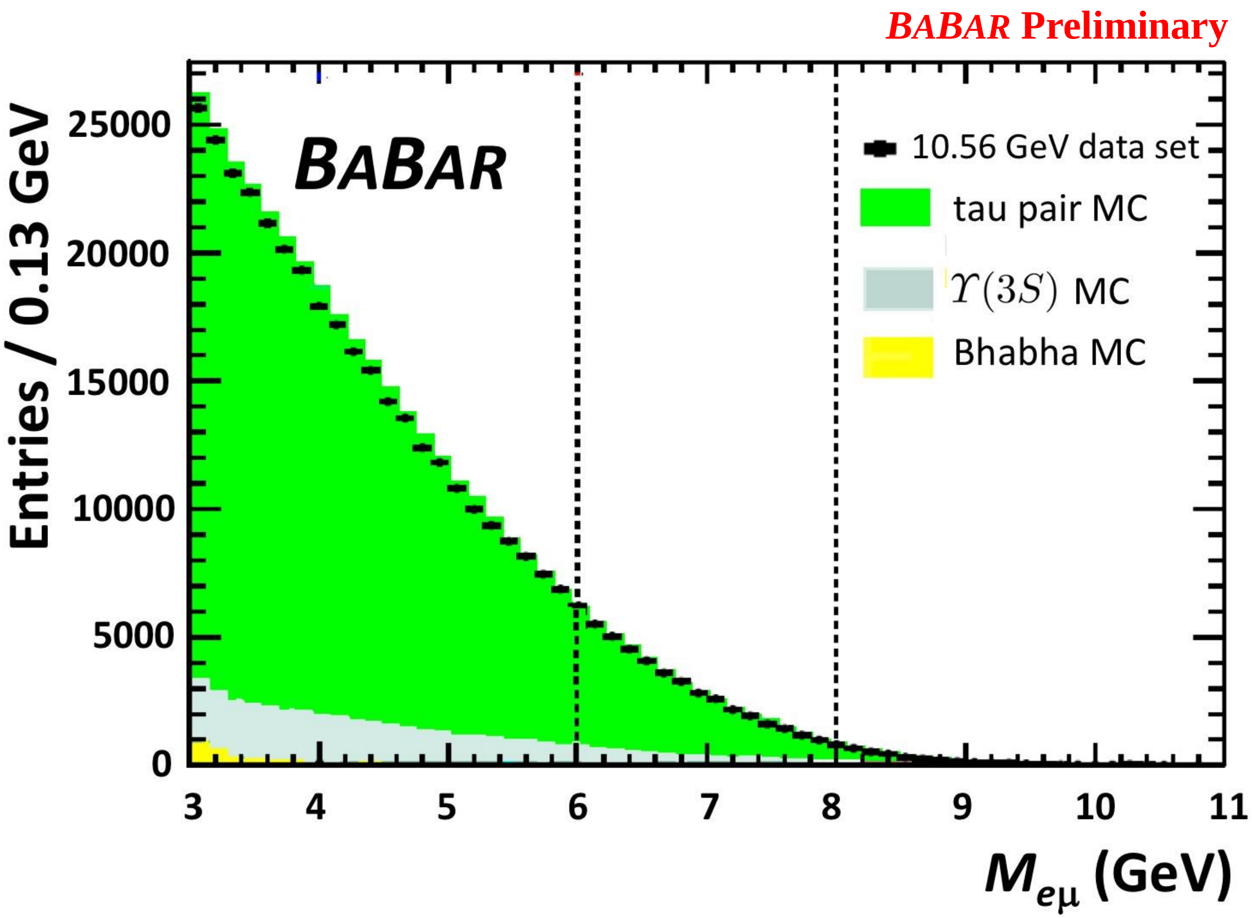


Selection Criteria: The lepton momenta must satisfy the condition which is defining a circle of radius

$$\left(\frac{p_e}{E_B} - 1\right)^2 + \left(\frac{p_\mu}{E_B} - 1\right)^2 = (0.1)^2 = 0.01$$

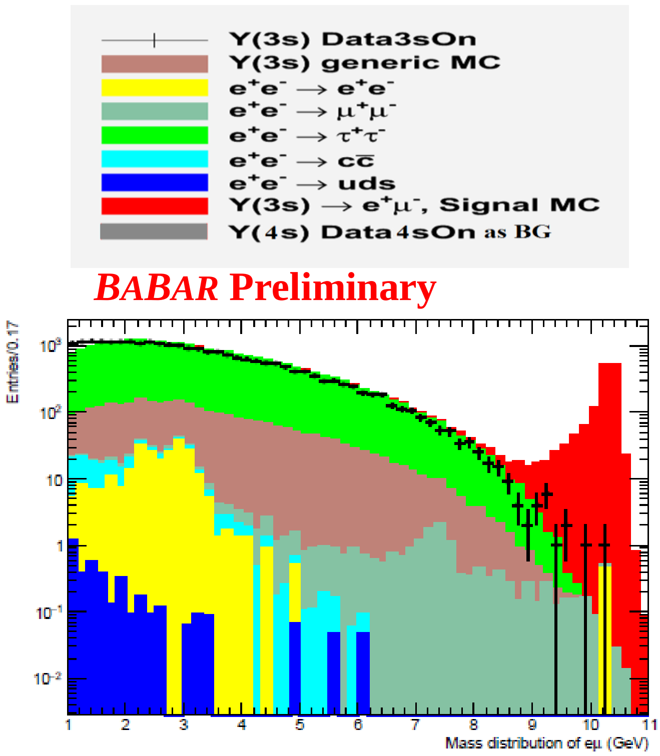
Where, $p_{e^\pm,\mu^\pm} \sim \frac{\sqrt{s}}{2} \sim E_B$

CLFV: Systematic Uncertainty on Signal Efficiency



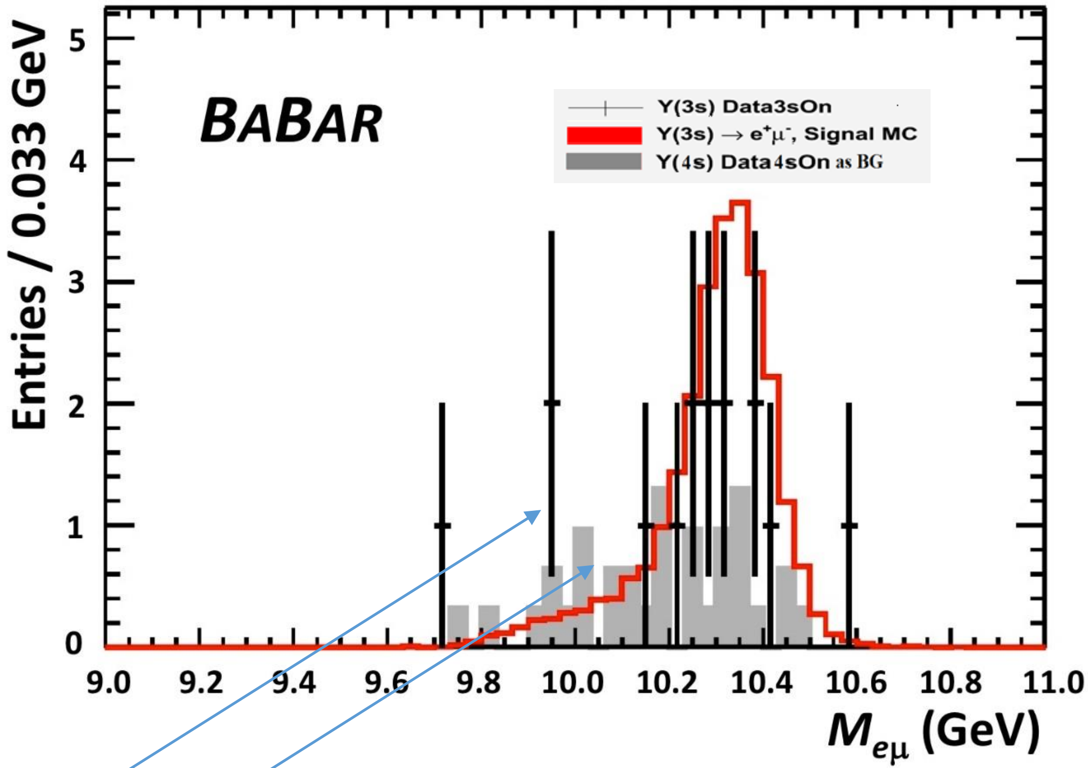
- Controlled Sample: A data set where two major cuts were reversed to check the data/MC agreement.
- Disagreement arises due to uncertainties in PID, Tracking, kinematics, trigger etc.
- Uncertainty in "Side Bands": 1.2%

CLFV: Invariant Mass Distribution of $e^{\pm}\mu^{\mp}$



Before final selection criteria were applied (3% unblinded preselected data)

Candidate Events:15 (black)
Data Driven Estimated Background : 12.2 (grey)



After all selection criteria are applied

Summary: Background, Uncertainty, Candidate

Source of Background	**Data Driven Continuum Background $\Upsilon(4S)$**	**Peaking Background from Generic $\Upsilon(3S)$ MC**
Tight PID selection	12.2 ± 2.1	0
Loosen PID selection	N/A	1.80 ± 0.9

Values	**Uncertainties** ***BABAR*** **Preliminary**
ε_{SIG} (systematics) • In the "Lepton Momentum" cut • In the "Back to back" cut • In all other cuts on the "Side bands"	 0.029 (2.9%) 0.011 (1.1%) 0.012 (1.2%)
ε_{SIG} (total)	$0.2342 \pm (0.0077_{SYST} \pm 0.0013_{STAT})$ $0.2342 \pm 0.0078_{TOTAL}$ (3.3%)
N_{Υ} (27.0 fb^{-1})	$(117.7 \pm 1.18) \times 10^{6}$ (1.02%) [Phys. Rev. Lett. 104, 151802.(2010)]
Total Background (equivalent to 27.0 fb^{-1})	**12.2 ± 2.3** (18.9%)
Candidate Seen in Data Sample	**15**

CLFV: Result

***BABAR* Preliminary**

- **Data**: $(27.0\ fb^{-1})$
- **Branching Fraction:**

$$\frac{N_{\text{Candidate}} - N_{BG}}{\varepsilon_{sig} \times N_{\Upsilon}} \qquad (1.0 \pm 1.4_{stat(N_{Candidate})} \pm 0.8_{syst}) \times 10^{-7}$$

- **Upper Limits with Confidence Level of 90%:** $< 3.6 \times 10^{-7}$ **CLs Method**

[J.Phys.G 28 (2002) 2693-2704]

CLFV: New Physics

BABAR **Preliminary**

- Lepton flavour violating decays are predicted by many beyond SM processes. Thus a clear experimental signature = "New Physics"
- A measurement of BF(Υ (3*S*) $\rightarrow e^{\pm}\mu^{\mp}$) can be used to place constraints on $\frac{g^2_{NP}}{\Lambda_{NP}}$ of new physics processes that include lepton flavour violation.

$$\textbf{\textit{where}},\ \frac{g^2_{NP}}{\Lambda_{NP}} = \frac{\textbf{effective coupling of the new physics}}{\textbf{energy scale of the NP, given by the mass of the NP propagator.}}$$

- Place constraints on $\frac{g^2_{NP}}{\Lambda_{NP}}$ of new physics processes that include lepton flavor violation using

  BF(Υ (3*S*) $\rightarrow e^{\pm}\mu^{\mp}$) < 3.6 × 10^{-7} @90%CL

$$\left(\frac{g^2_{NP}}{\Lambda_{NP}}\right)^2 \Big/ \left(\frac{4\pi\alpha_{QED}Q_b}{M_{\Upsilon(3S)}}\right)^2 = \frac{BF(\Upsilon(3S)\to e\mu)}{BF(\Upsilon(3S)\to \mu\mu)}$$

$$\Lambda_{NP}/g^2_{NP} \geq 80\ \text{TeV} \qquad @90\%\ \text{CL}$$

Conclusion

- BABAR has made a significant contribution to Lepton Universality search by $\mathcal{B}(\Upsilon(3S) \to \tau^+\tau^-)/\mathcal{B}(\Upsilon(3S) \to \mu^+\mu^-)$ and verify the SM prediction

→ the result is six times precise than the only previous measurement by CLEO.
→ result published in **Phys. Rev. Lett. 125, 241801**

- No significant evidence for Charged Lepton Flavor Violation in $\Upsilon(3S) \to e^\pm\mu^\mp$ decay and an upper limit has been set.

$$\boldsymbol{\Upsilon(3S) \to e^\pm\mu^\mp < 3.6 \times 10^{-7}}$$ **@ 90% C.L.** ***BABAR*** **Preliminary**

- Our reported result is several orders of magnitude lower than this limit according to the ref [S.Nussinov, et. al. PRD 63, 016003 (2001)].

- This result can be interpreted as a limit on NP: $\Lambda_{NP}/g^2_{NP} \geq 80\ \mathrm{TeV}$ ***BABAR*** **Preliminary**

- Thanks to PEP II Colleagues for accelerator operations

Thanks and Questions

Backup (CLFV): Theoretical Upper Limit (Indirect)

Nussinov, Peccei, Zhang [1]

- Assume coupling of Υ to eμ looks like: $L_{eff} = gV_{e\mu}\bar{\mu}\gamma_{\alpha}eV^{\alpha}$
- Through Fig 1. this coupling contributes to $A\ (\mu \rightarrow 3e)$

$$A(\mu \to 3e) = (\bar{u}_\mu(p)\gamma^\alpha u_e(k_3))(\bar{v}_e(k_1)\gamma_\alpha u_e(k_2))\frac{g_{V_{e\mu}} g_{V_{ee}}}{M_V^2 - S} \quad \text{----(1)}$$

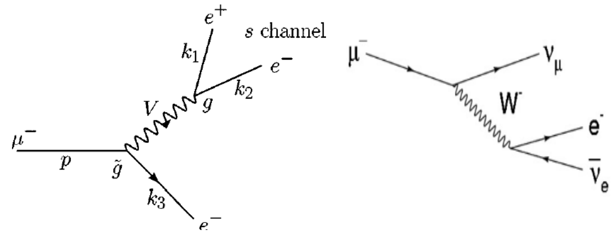
$$\frac{[\Gamma(\mu \to 3e)]_{V-exch}}{[\Gamma(\mu \to e\nu\bar{\nu})]} \approx \frac{g^2 V_{e\mu} g^2 V_{ee}}{M_V^4} / \frac{g_W^4}{M_W^4} \quad \text{----(2)}$$

Since $[\Gamma(V \to e^+e^-)] \sim g^2\ V_{ee}\ M_V$ and $[\Gamma(V \to e^\pm\mu^\mp)] \sim g^2\ V_{e\mu}\ M_V$, while $[\Gamma(W \to e\nu)] \sim g_W^2\ M_W$

$$[BR(\mu \to 3e)]_{V-exch} \approx \frac{[\Gamma(V \to e^+e^-)][\Gamma(V \to e^\pm\mu^\mp)]}{[\Gamma^2(W \to e\nu)]}\left(\frac{M_W}{M_V}\right)^6 \quad \text{----(3)}$$

$$BR(\Upsilon \to e\mu) = BR(\mu \to eee)\frac{\Gamma(W \to e\nu)^2}{\Gamma(\Upsilon)\Gamma \to ee}\left(\frac{M_\Upsilon}{M_W}\right)^6 \quad \text{----(4)}$$

$$\mathrm{BR}(\Upsilon(3S) \to e^\pm\mu^\mp \leq 2.5 \times 10^{-8}.$$



(Left) A vector exchange diagram contributing to $\mu \rightarrow 3e$
(Right) Ordinary muon decay, $\mu \rightarrow e\nu\bar{\nu}$, which proceeds via W exchange.

- $\mathrm{BF}(\mu \to eee) \leq 1.0 \times 10^{-12}$
- $\mathrm{BF}(\mu \to e\nu\bar{\nu}) \simeq 100\ \%$
- $\mathrm{BF}(W \to e^+\nu) \simeq (10.71 \pm 0.09)\ \%$
- $\mathrm{BF}(\Upsilon(3S) \to l^+l^-) \simeq (2.18 \pm 0.21)\ \%$
- $\Gamma(\Upsilon(3S) = (20.32 \pm 1.85)\ keV$
- $\Gamma(W) = (2.046 \pm 0.049)\ GeV$

S.Nussinov, et. al. estimate that the contribution of the virtual $\Upsilon\ (3S) \rightarrow e^{\pm}\mu^{\mp}$ to the $\mu \rightarrow eee$ rate would be reduced by approximately $M^2_{\mu} / (2\ M^2_{\Upsilon})$ leading to a re-calculated indirect bound:
$\mathrm{BF}(\Upsilon\ (3S) \rightarrow e^{\pm}\mu^{\mp}) < 1\times 10^{-3}$

[1] Nussinov, et. al. PRD 63, 016003 (2001)

Back Up (CLFV): Impact of each component of the selection on the signal efficiency, background and data.

- The first row provides information on the pre-selection.
- The last row provides information after applying all selection criteria.
- Rows 2-7 provides information when all requirements are applied except the criterion associated with the particular row. The luminosity-normalized expected number of events in the third and forth columns are for the background events from the $e^+e^- \to \Upsilon(3S)$ EvtGen MC and the data-driven continuum background events estimated from the $e^+e^- \to \Upsilon(4S)$ sample, respectively.
- The last column represented the number of events in the 27.02 fb^{-1} data sample after unblinding.

Selection Criterion	**Efficiency** $\varepsilon_{e\mu}$	$\Upsilon(3S)$ **BG**	**Continuum BG**	**Events in Data**
Pre-Selec.	0.8020 ± 0.0012	75516 ± 180	725003 ± 500	945480
Optimized PID	0.5074 ± 0.0015	5178 ± 49	320911 ± 333	358322
2 tracks in final state	0.2354 ± 0.0013	0	14.1 ± 2.2	18
Lep. Mom.	0.2684 ± 0.0012	86.5 ± 6.3	253.3 ± 9.4	302
Back-to-back	0.2402 ± 0.0013	0.46 ± 0.46	36.2 ± 6.0	39
EMC Accept.	0.2495 ± 0.0013	0	13.5 ± 2.2	17
Energy on EMC	0.2452 ± 0.0013	0	16.9 ± 2.4	19
All Criteria	0.2342 ± 0.0013	0	12.2 ± 2.1	15

Abstract

We report on the first search for electron-muon lepton flavor violation (LFV) in the decay of a b quark and b antiquark bound state. We look for the LFV decay $\Upsilon(3S) \to e^{\pm}\mu^{\mp}$ in a sample of 118 million (3S) mesons from 27/fb of data collected with the BABAR detector at the SLAC PEP-II $e^{+}e^{-}$ collider operating with a 10.36 GeV center-of-mass energy. No evidence for a signal is found and we set a limit on the branching fraction (BR) $\Upsilon(3S) \to e^{\pm}\mu^{\mp} < 3.6 \times 10^{-7}$ at 90% CL. This result can be interpreted as a limit on $\frac{\Lambda_{NP}}{g^{2}_{NP}} > 80\ TeV$ on the energy scale $\frac{\Lambda_{NP}}{g^{2}_{NP}}$ of relevant new physics. We also report on a precision measurement of the ratio BR($\Upsilon(3S) \to \tau^{\pm}\tau^{\mp} / \Upsilon(3S) \to \mu^{\pm}\mu^{\mp}$). The ratio is measured to be $0.966 \pm 0.008\ (stat) \pm 0.0014$(sys) and is in agreement with the Standard Model prediction of 0.9948 within 2 standard deviations. The uncertainty is almost an order of magnitude smaller than the only previous measurement.