Search for lepton flavor violating τ decay into $\ell\eta$, $\ell\eta'$ and $\ell\pi^0$

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for the Belle Collaboration

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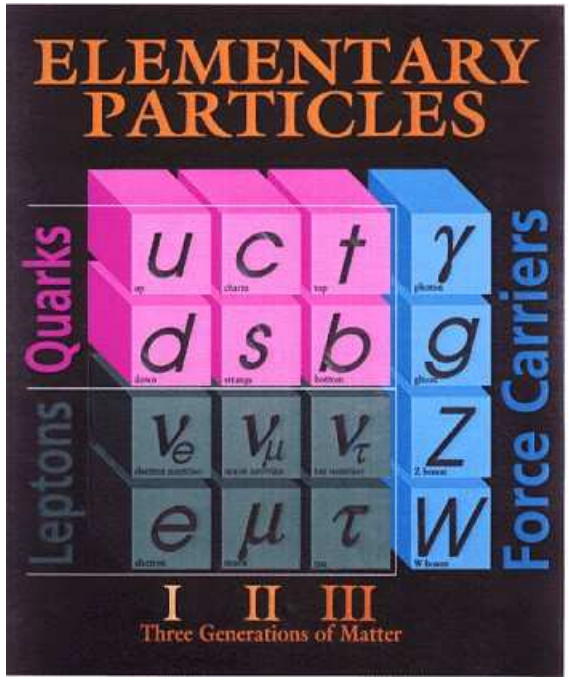
(Accepted by PLB (hep-ex/0703009))

Introduction (1)



- Quark mixing
  - Flavor mixing in quark sector have been studied well
  - Beautifully described by CKM matrix including CPV
- Neutrino mixing
  - Discovered
  - Provides hints of new physics beyond SM
- Lepton Flavor Violation (mixing) decays for charged lepton
  - Not observed yet
  - very small probability via neutrino oscillation.

  $\mathcal{B} \propto (\Delta m^2_\nu / m^2_W)^2 \simeq 10^{-49} \sim 10^{-52}$

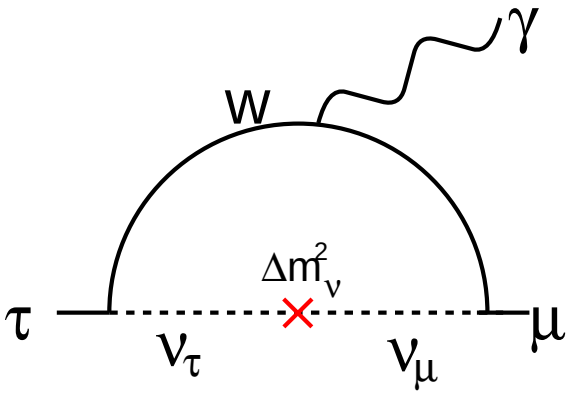
$\Rightarrow$ So, difficult to observe τ LFV at current experiment.

$\Downarrow$

If we observed LFV decays in charged lepton, they would be a clear signature of New Physics.

Many extensions of the SM predict LFV decays

$\Rightarrow$ SUSY(+Seesaw), Extra dimension etc.

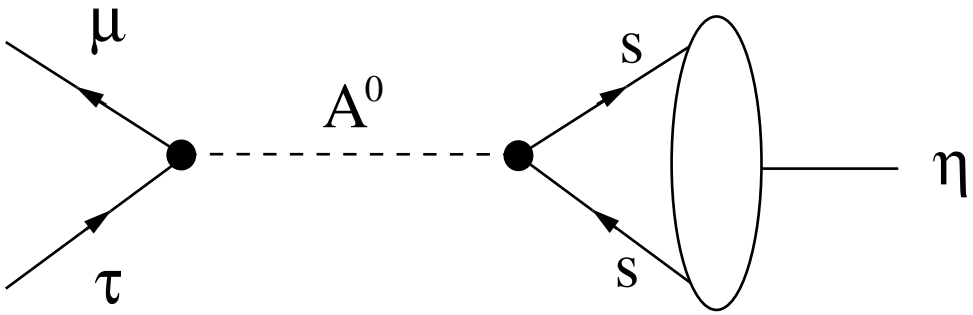


Introduction(2)

LFV in Higgs mediated model is sensitive to $\mu\eta$ and $\mu\mu\mu$ decay ($M_{\rm SUSY} >> M_{\rm Higgs}$)

$$\mathcal{B}(\tau \to \mu\eta) = 8.4 \times 10^{-7} \left(\frac{\tan\beta}{60}\right)^6 \left(\frac{100{\rm GeV}/c^2}{m_A}\right)^4$$

(M. Sher, PRD 66, 057301 (2002))



Comparison with $\mu\mu\mu$
- enhanced as $(m_s/m_\mu)^2$
- color ($\times$ 3)
- larger phase space than $\mu\mu\mu$ decay

$\Rightarrow \tau \longrightarrow \mu\eta$ is improved by factor of 8.4 compared $\tau \longrightarrow \mu\mu\mu$ decay.

$$\mathcal{B}(\tau \to \mu\eta) : \mathcal{B}(\tau \to \mu\gamma) : \mathcal{B}(\tau \to 3\mu) = 8.4 : 1.5 : 1$$

Previous analysis@ Belle

$\mathcal{B}(\tau \to \mu\eta) < 1.5 \times 10^{-7}$@154/fb (PLB B622, 218(2005))

Introduction (3)

SUSY

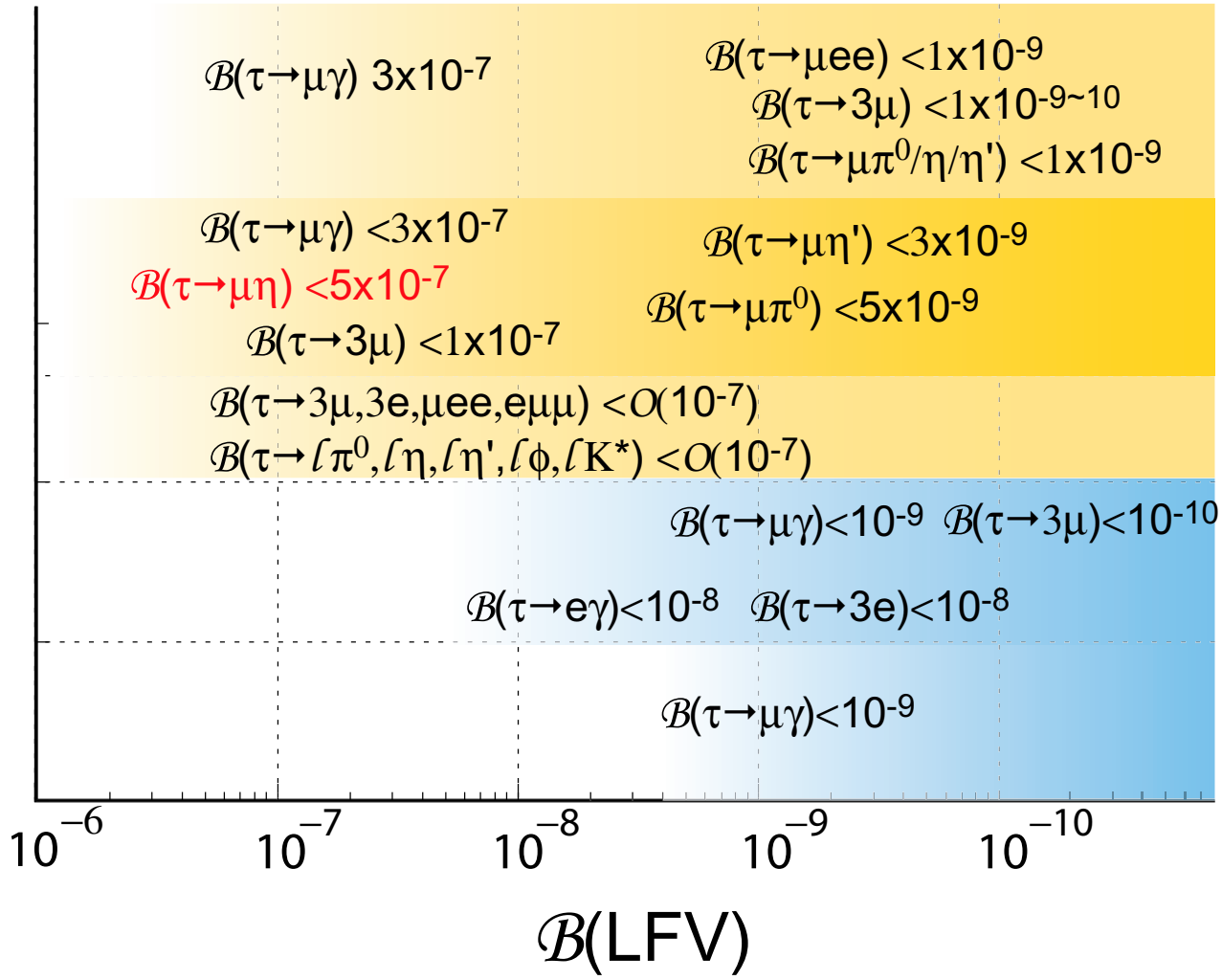
Gauge mediated (MSSM)

Higgs mediated (MSSM)

R-parity-V

SO(10) with ν_R

Extra dimension



$\Rightarrow$ Many extensions of the SM predict LFV $\tau \longrightarrow \ell\eta$ decays!!

Previou analysis

Search for τ decay into ℓ ($= \mu$ or e) + pseudoscalar meson (η, η' and π^0)

Previous results (PLB 622, 218 (2005) : 154 fb^{-1})

$\tau \to \mu\eta$ mode	Eff.	BG	Obs.	Upper limit
$\eta \to \gamma\gamma$	8.0%	3.9±1.5	1	2.3×10^{-7}
$\eta \to \pi^+\pi^-\pi^0$	7.2%	0.62±0.42	0	5.5×10^{-7}

$\tau \to \mu\eta < 1.5 \times 10^{-7}$ $\quad \tau \to e\eta < 2.4 \times 10^{-7}$

$\tau \to \mu\eta' < 4.7 \times 10^{-7}$ $\quad \tau \to e\eta' < 10 \times 10^{-7}$

$\tau \to \mu\pi^0 < 4.1 \times 10^{-7}$ $\quad \tau \to e\pi^0 < 1.9 \times 10^{-7}$

$\Downarrow$

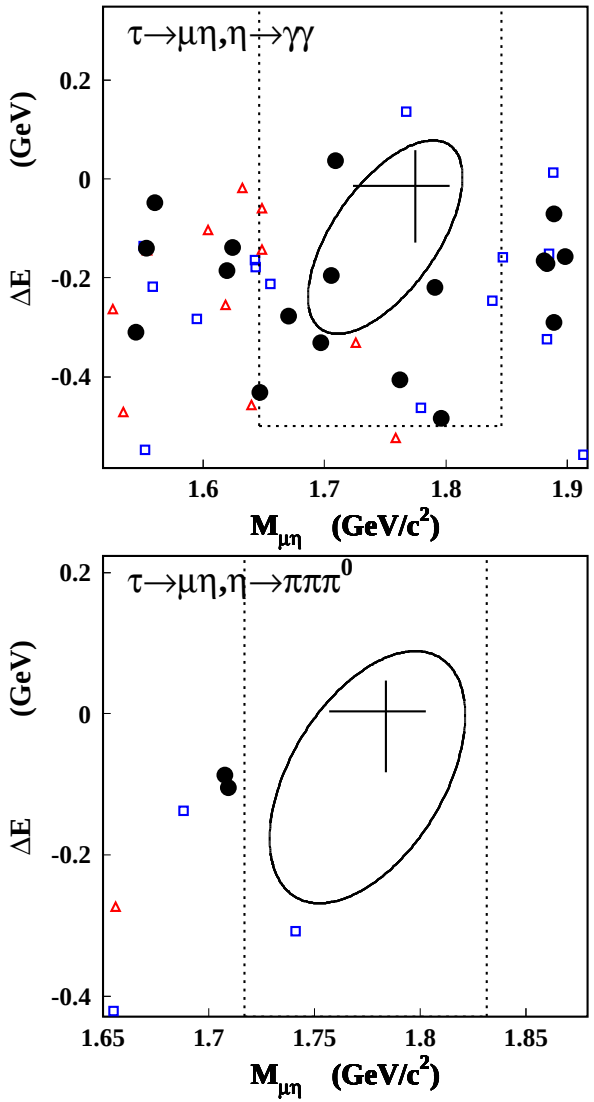
Update this search using 401 fb^{-1} data
(401/154 = 2.6 times)

For more improvents of sensitivity, need

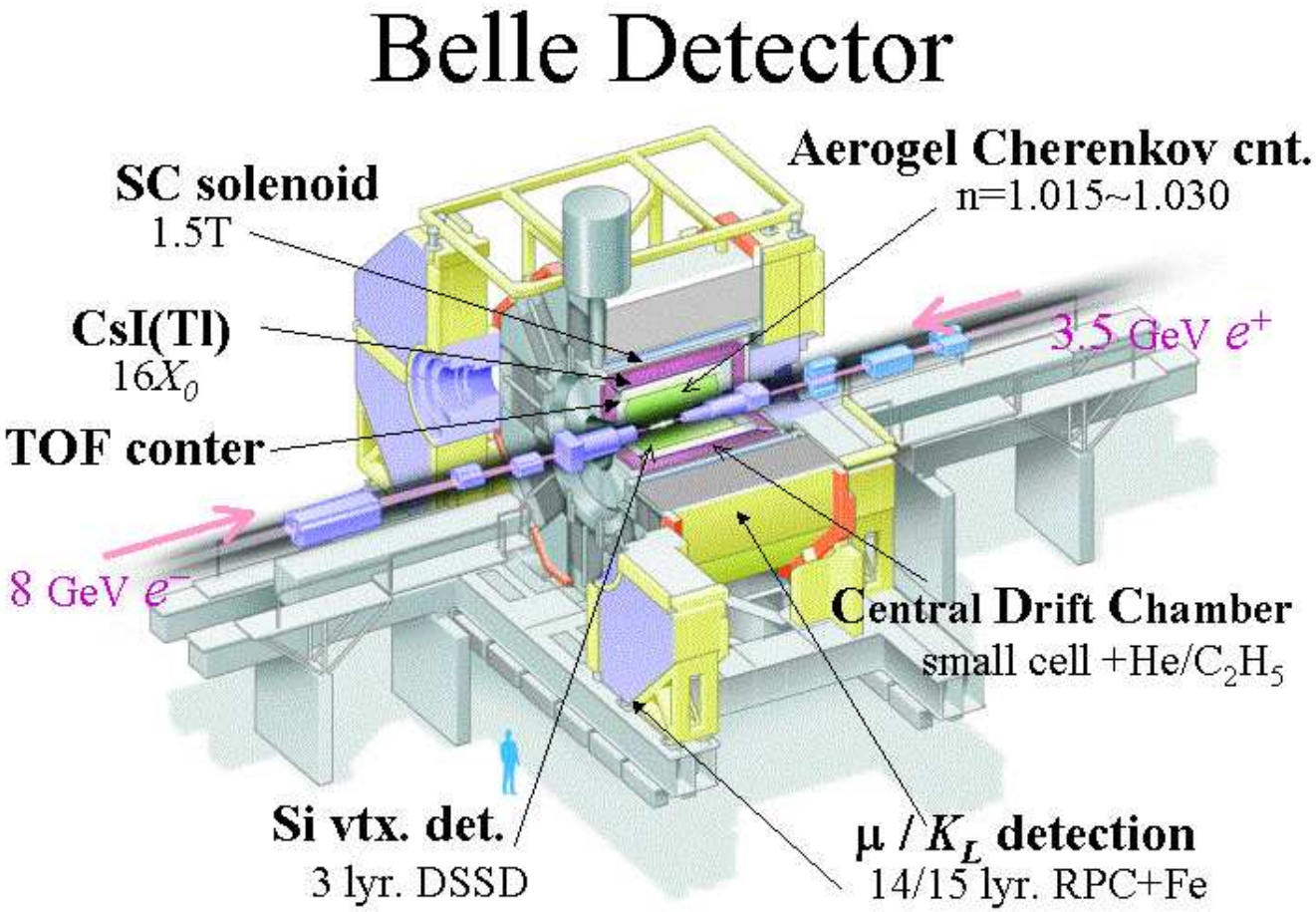
$\Rightarrow$ optimize event selections

$\Rightarrow$ reduce the background events

$\Rightarrow$ add more sub-decays



Belle Detector



F/B asymmetric detector

Good vertex resolutions and particle ID capablilities

KEKB:$e^+(3.5\text{GeV})e^-(8\text{ GeV})$

$\sqrt{s} = 10.58$ GeV

$\sigma(\tau\tau) \sim 0.9$ nb

$(\sigma(B\bar{B}) \sim 1.0$ nb)

B-factory is also τ factory!!!

Integrated luminosity:

>700/fb collected

$\Rightarrow 5.8\times10^8\tau^+\tau^-$

For these analysis,

Use 401/fb ($358\times10^6\tau^+\tau^-$)

For lepton ID

e efficiency 93%

μ efficiency 88%

Analysis method for LFV τ decay (1)

Procedure for LFV τ decay

— Select low multiplicity track events with a zero net charge

— Separate into two hemispheres using thrust axis

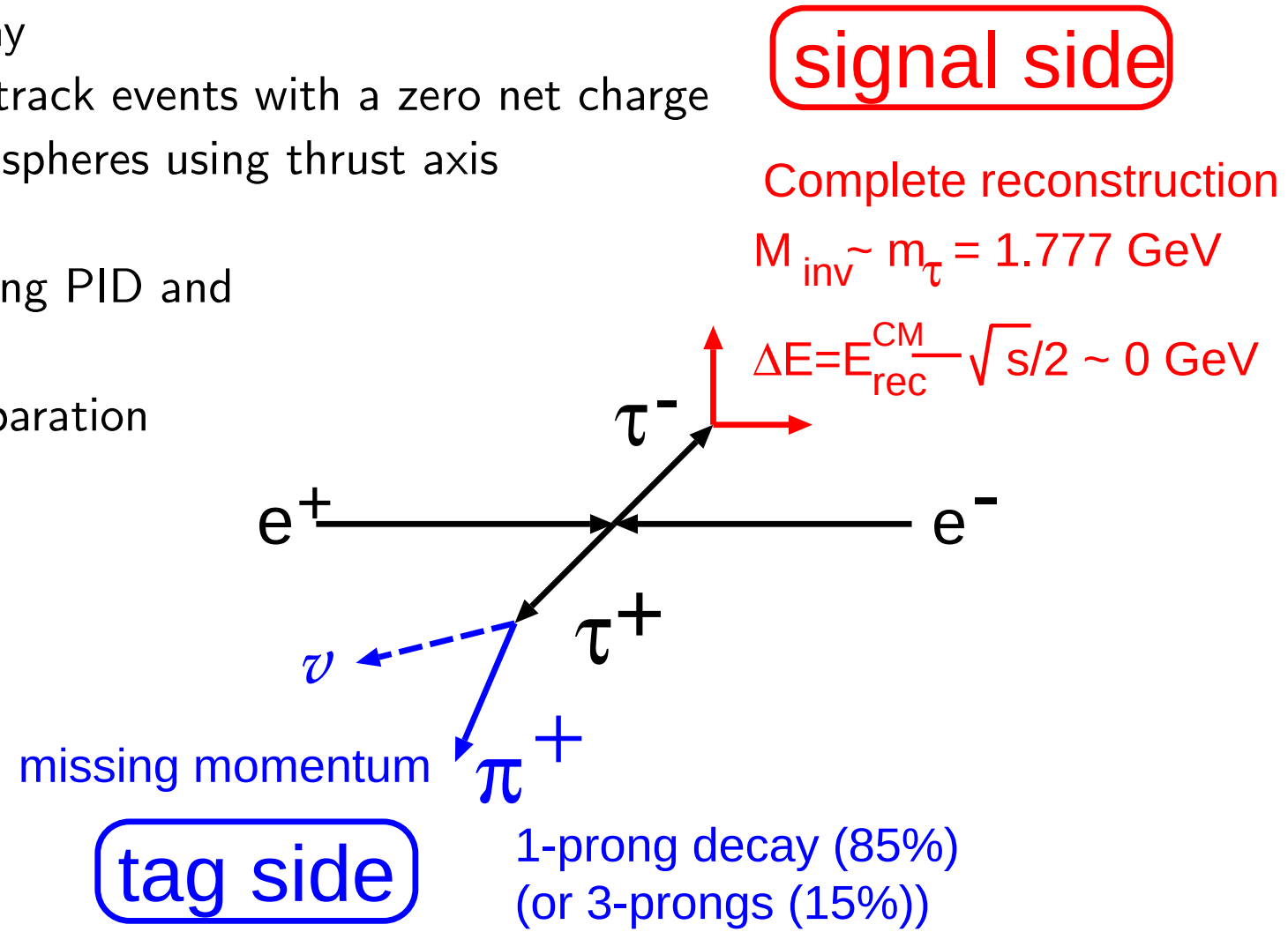
→ signal and tag

— Reduce background using PID and kinematic informations

— lepton ID, K/π separation

— missing momentum

— # of γ's etc.



Analysis method for LFV τ decay (2)

Signal extraction in $M_{\rm inv}$ and ΔE plane

- $M_{\rm inv} \sim m_\tau = 1.777$ GeV/c^2
- $\Delta E = E^{\rm CM} - E^{\rm CM}_{\rm beam} \sim 0$ GeV

Blind the signal region

— Estimate the background in signal region using sideband data

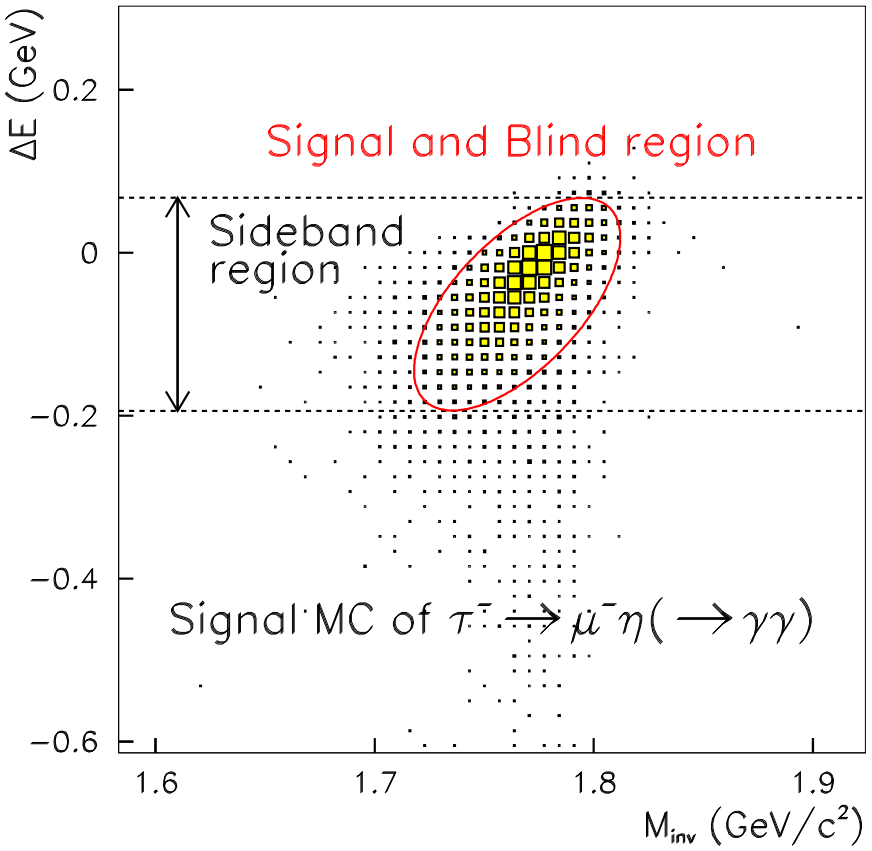
$\Downarrow$

After open the blinded region

— counting # of events in signal region.

Set an upper limits if no excess of signal events compared expected background.

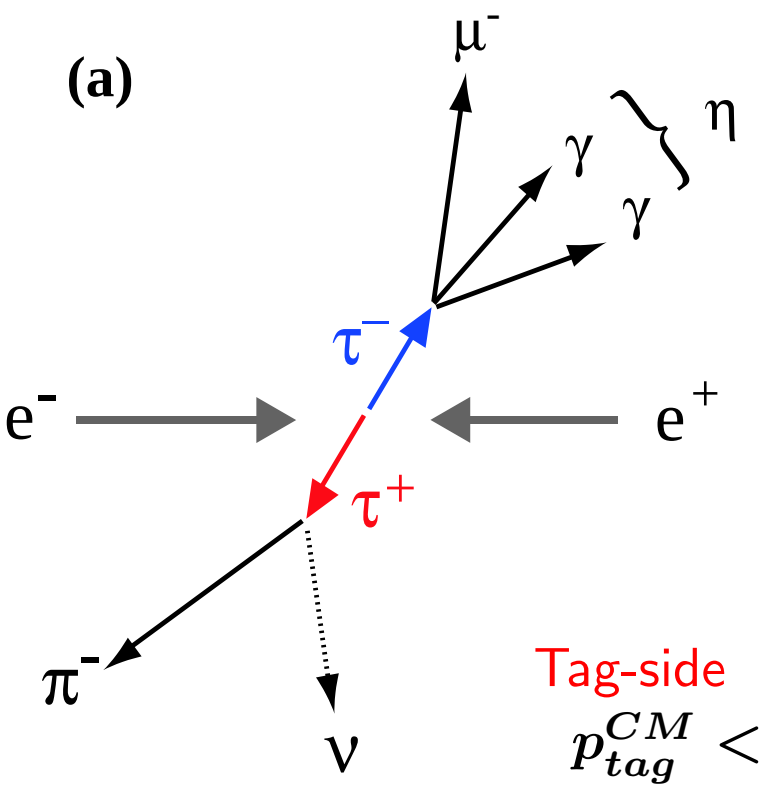
$$B(\text{LFV } \tau \text{ decay}) < \frac{s_{90\%C.L.}}{2\varepsilon N_{\tau\tau}}$$



$\pm 10\sigma_{M_{\rm inv}}$ and ΔE region

$\tau \to \ell\eta(\to \gamma\gamma)$ (1)

Event selection for $\tau \to \mu/e\eta(\to \gamma\gamma)$ (1prong − 1prong event)



Signal-side

Lepton selection with $p_{\mathrm{sig}} > 0.7$ GeV/c

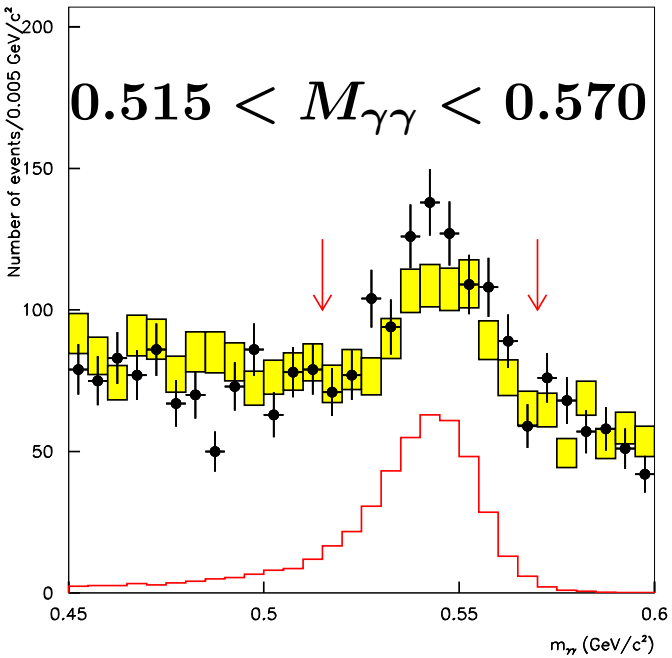
$\eta \to \gamma\gamma$ reconstruction

$E_{\gamma 1} > 0.6$ GeV, $E_{\gamma 2} > 0.25$ GeV ($E_{\gamma 1} > E_{\gamma 2}$)

π^0 veto for reducing fake η

$0.85 > \cos\theta^{CM}_{\eta\ell} > 0.5$

of $\gamma \leq 1$



Tag-side

p^{CM}_{tag} <4.5 GeV/c

p_{miss} >0.4 GeV/c

within the fiducial volume

$m_{tag} < 1.777\ \mathrm{GeV}/c^2$.

of $\gamma \leq 2$

$\tau \to \ell\eta(\to \gamma\gamma)$ (2)

Applying cut using correlation between
missing mass square (m^2_{miss}) and missing momentum (p_{miss})

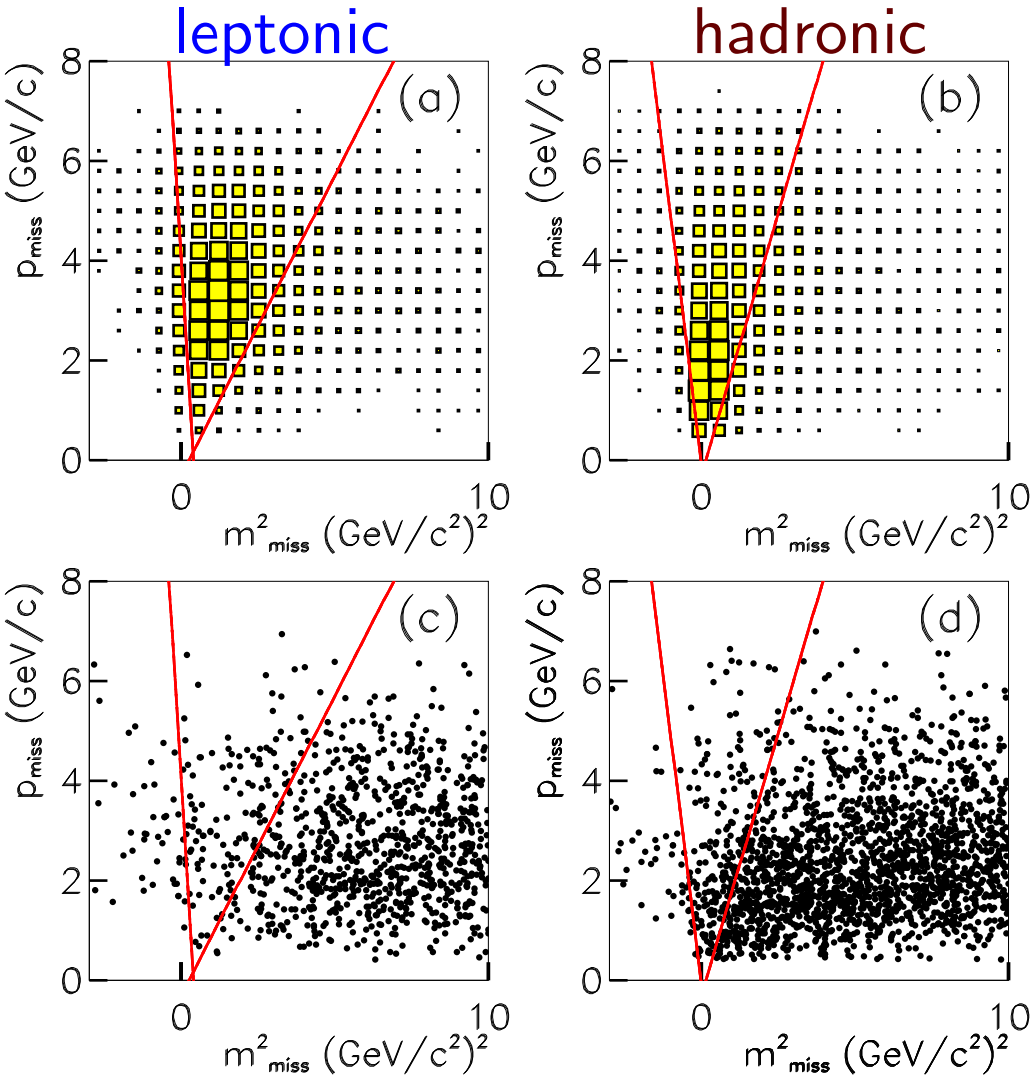
Separate two types in tag-side informations

– leptonic decay (including 2ν)

$$p_{\rm miss} > -10m^2_{\rm miss} - 4$$
$$p_{\rm miss} > 1.1m^2_{\rm miss} - 1$$

– hadronic decay (including 1ν)

$$p_{\rm miss} > -5m^2_{\rm miss} - 0.25$$
$$p_{\rm miss} > 2.1m^2_{\rm miss} - 0.3$$



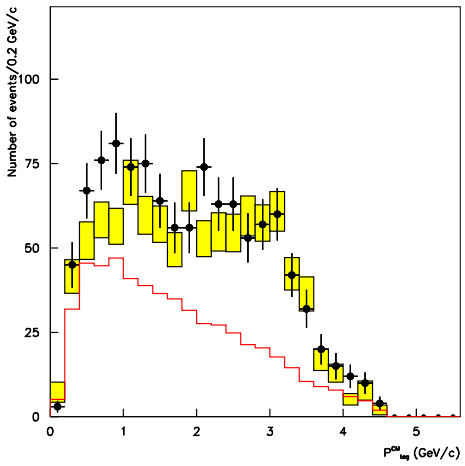
$\tau \to \ell\eta(\to \gamma\gamma)$ (3)

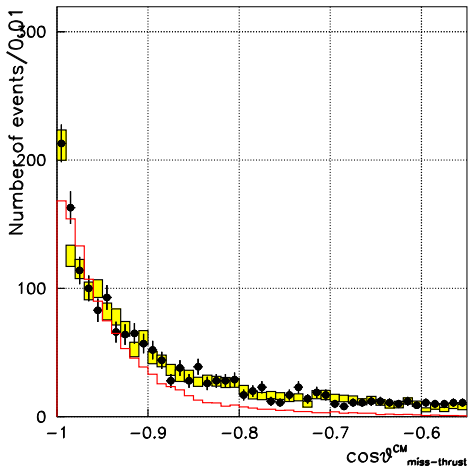
Applying cut using correlation between $p_{\rm tag}^{\rm CM}$ and $\cos\theta_{\rm miss-thrust}^{\rm CM}$

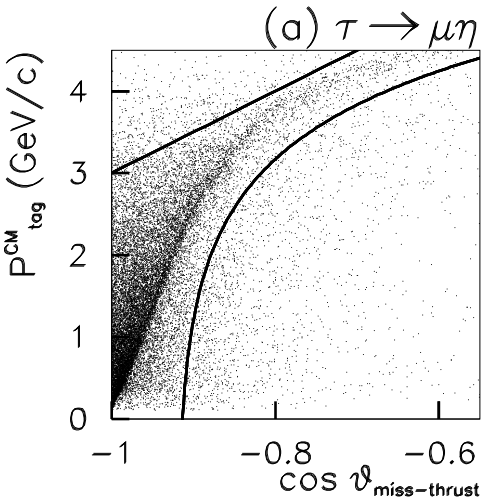
$$p_{\rm tag}^{\rm CM} > 1.1\log(\cos\theta_{\rm miss-thrust} + 0.92)) + 5.5$$
$$p_{\rm tag}^{\rm CM} < 5\cos\theta_{\rm miss-thrust} + 7.8$$

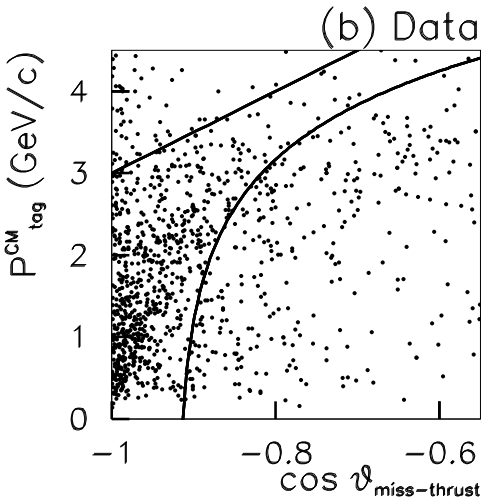
$\Downarrow$

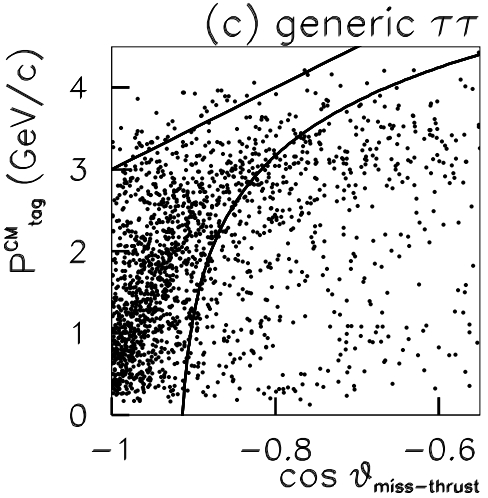
This cut is effective to reduce
$\tau\tau$ and $\mu\mu$ background

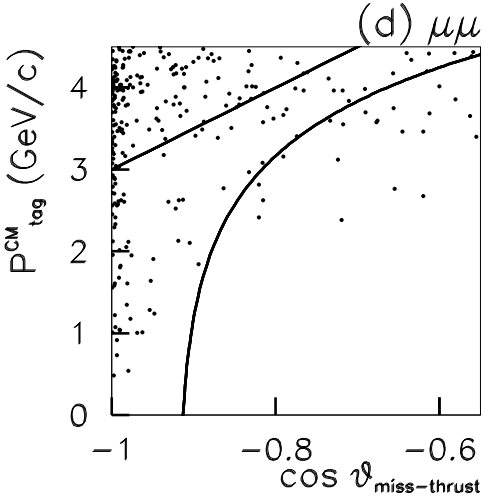












$\tau \to \ell\eta(\to \gamma\gamma)$ (4)

Signal region:

— Elliptical region which contain 90% of signal MC after all cuts.

Background estimation:

— Use sideband data

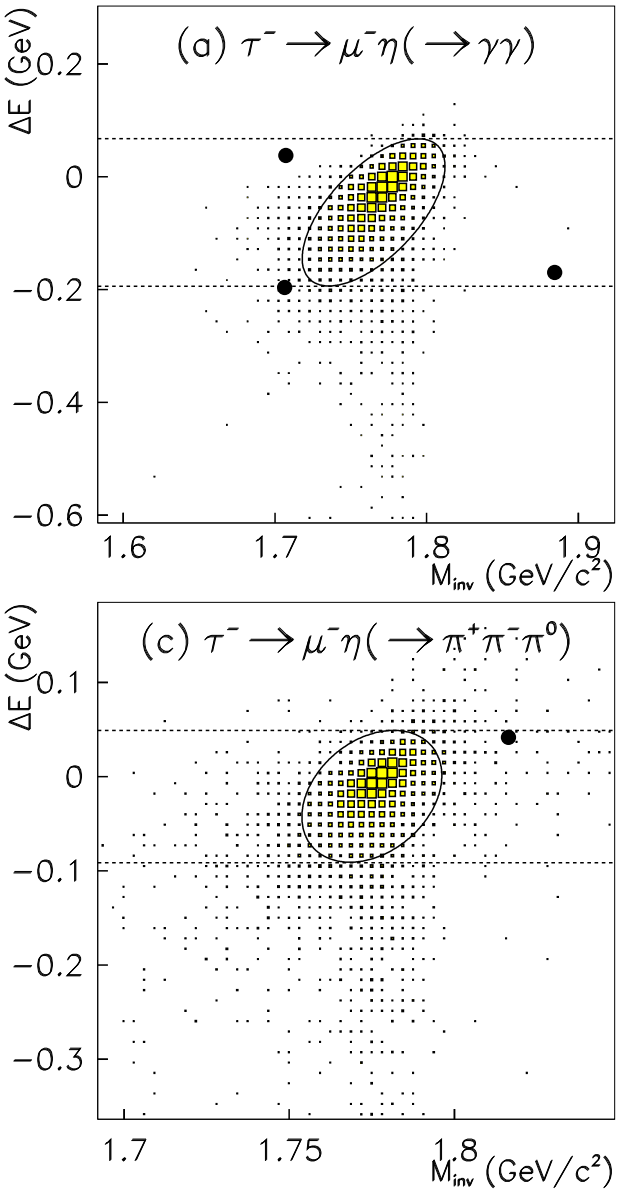
$$\mathcal{B}(\tau \to \mu\eta) < \frac{s_{90}}{2N_{\tau\tau}\varepsilon Br(\eta \to \gamma\gamma)}$$

New results @401/fb				
	Eff.	Expected BG	observed data	Limit.
$\mu\eta(\to \gamma\gamma)$	6.42%	0.40 ± 0.29	0	$< 1.2 \times 10^{-7}$
$e\eta(\to \gamma\gamma)$	4.57%	0.25 ± 0.25	0	$< 1.7 \times 10^{-7}$
Previous results @154/fb				
$\mu\eta(\to \gamma\gamma)$	8.03%	3.9 ± 1.5	1	$< 2.3 \times 10^{-7}$
$e\eta(\to \gamma\gamma)$	5.68%	0.23 ± 0.16	0	$< 4.0 \times 10^{-7}$

$\Rightarrow$ Reduce background by introducing new event selections

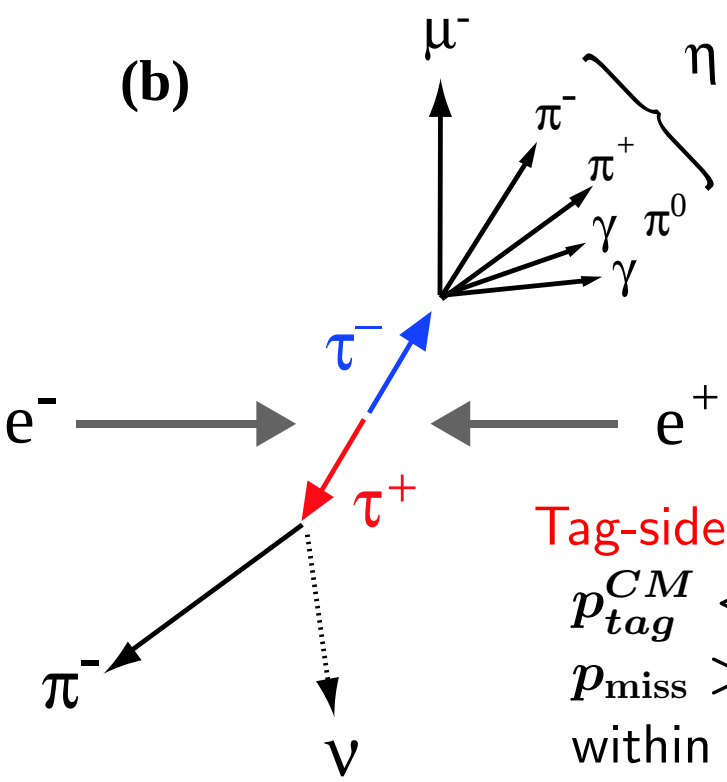
$\Downarrow$

Improve a factor of ~ 2 compared with previous results



$\tau \to \ell\eta(\to \pi^+\pi^-\pi^0)(1)$

Event selection for $\tau \to \mu/e\eta(\to \pi^+\pi^-\pi^0)$ (3−1 prong events)



Signal-side

Lepton selection with $p_{\rm sig} > 0.7$ GeV/c

$\eta \to \pi^+\pi^-\pi^0$ reconstruction

of $\gamma \leq 1$

$0.85 > \cos\theta^{CM}_{\eta\ell} > 0.5$

Tag-side

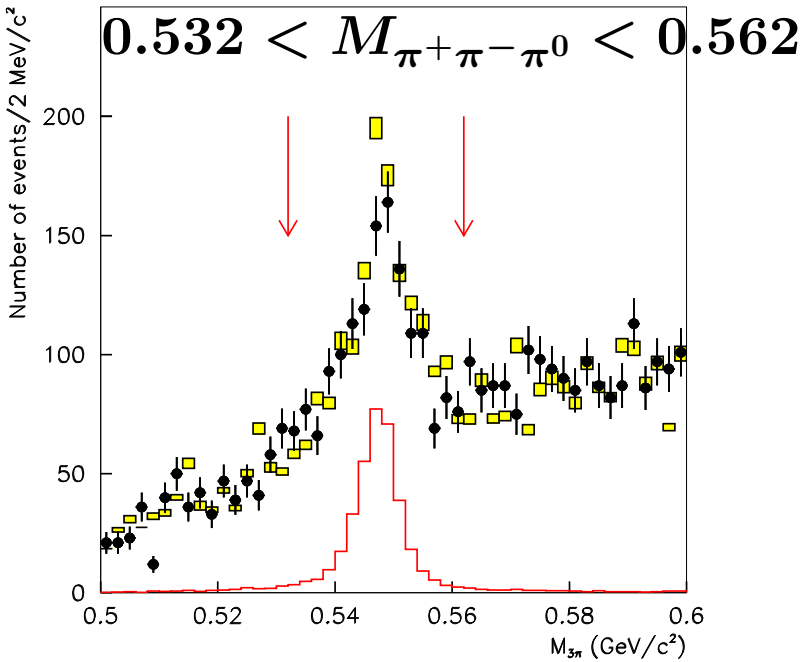
p^{CM}_{tag} <4.5 GeV/c

$p_{\rm miss}$ >0.4 GeV/c

within the fiducial volume

$m_{tag} < 1.777\ {\rm GeV}/c^2$.

m^2_{miss} vs. p_{miss} cut



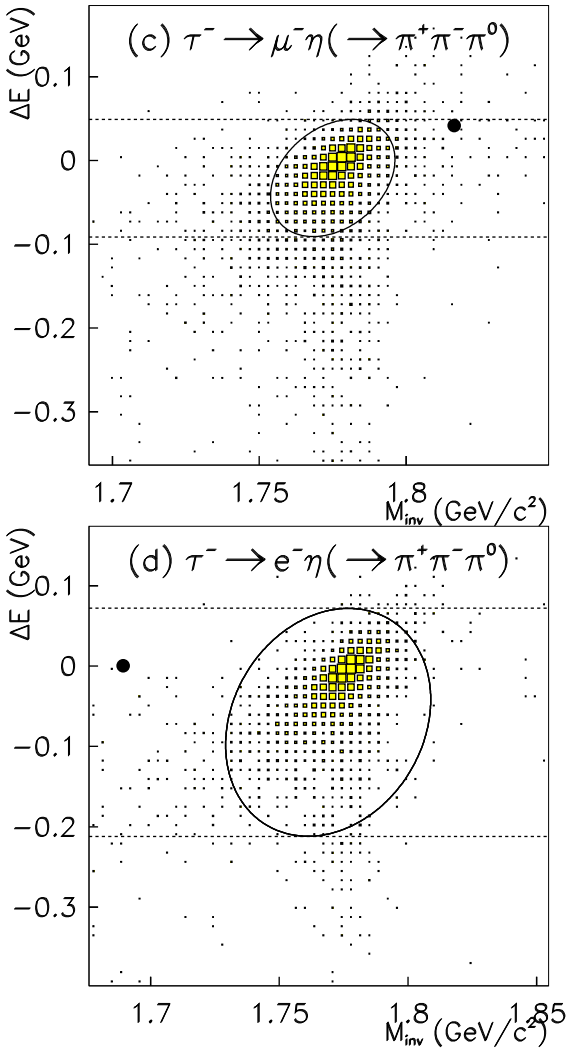
$\tau \to \ell\eta(\to \pi^+\pi^-\pi^0)(2)$

Signal region and Background estimation:

– Same methods as $\tau \to \ell\eta(\gamma\gamma)$

New results @401/fb				
	Eff.	Expected BG	observed data	Limit.
$\mu\eta(\to \pi^+\pi^-\pi^0)$	6.84%	0.24 $\pm$ 0.24	0	$< 2.0 \times 10^{-7}$
$e\eta(\to \pi^+\pi^-\pi^0)$	4.72%	0.53 $\pm$ 0.53	0	$< 2.9 \times 10^{-7}$
Previous results @154/fb				
$\mu\eta(\to \pi^+\pi^-\pi^0)$	7.15%	0.60 $\pm$ 0.42	0	$< 5.5 \times 10^{-7}$
$e\eta(\to \pi^+\pi^-\pi^0)$	6.84%	0.23$\pm$0.23	0	$< 5.8 \times 10^{-7}$

$\Rightarrow$ Improve a factor of $\sim$ 2 compared with previous results!!



Combined limit for $\tau \to \ell\eta$

Combined with $\eta \to \gamma\gamma$ and $\eta \to \pi^-\pi^+\pi^0$

μ mode	$\mathcal{B}(\eta \to XX) \times$ Eff.	BG	Sys. Unc.
$\eta \to \gamma\gamma$	0.3943× 6.4%	0.40±0.29	7.1%
$\eta \to \pi^+\pi^-\pi^0$	0.226×6.8%	0.24±0.24	5.6%
Combined	4.1%	0.64±0.38	6.5%

$\Rightarrow$Combined limits: $< 6.5\times10^{-8}$

$(< 1.5\times10^{-7}$@154/fb)

e mode	$\mathcal{B}(\eta \to XX) \times$ Eff.	BG	Sys. Unc.
$\eta \to \gamma\gamma$	0.3943× 4.6%	0.25±0.25	7.1%
$\eta \to \pi^+\pi^-\pi^0$	0.226×4.7%	0.53±0.53	5.6%
Combined	2.9%	0.78±0.59	6.5%

$\Rightarrow$Combined limits: $< 9.2\times10^{-8}$

$(< 2.3\times10^{-7}$@154/fb)

$\Rightarrow$ These results improve the previously published limits set by factors of 2.3 and 2.5, respectively.

$\tau \to \ell\eta'$ (1)

Previous results (PLB 622, 218 (2005) : 154 fb^{-1})

$Br(\tau^- \to \mu^-\eta') < 4.7 \times 10^{-7}$

$Br(\tau^- \to e^-\eta') < 10 \times 10^{-7}$

In previous analysis,

use only $\eta' \to \eta(\to \gamma\gamma)\pi^+\pi^-$ mode

$\Downarrow$

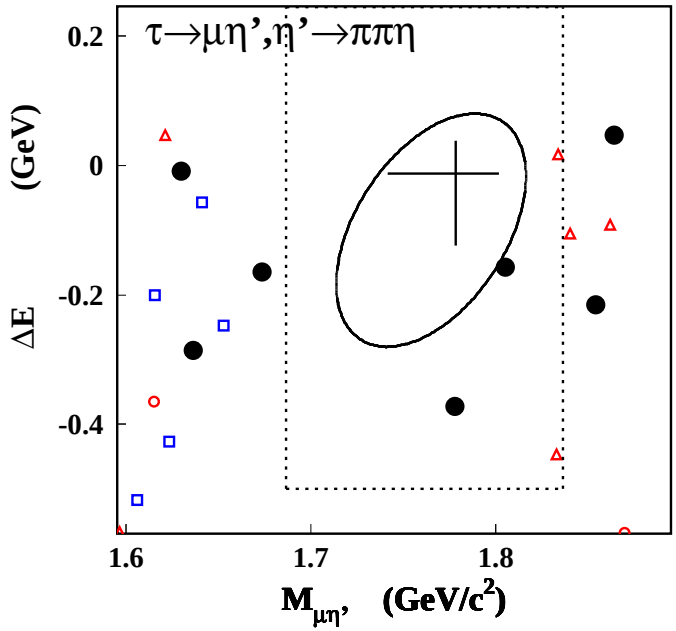
I use two modes as $\eta' \to \eta\pi^+\pi^-$ and $\eta' \to \rho\gamma$

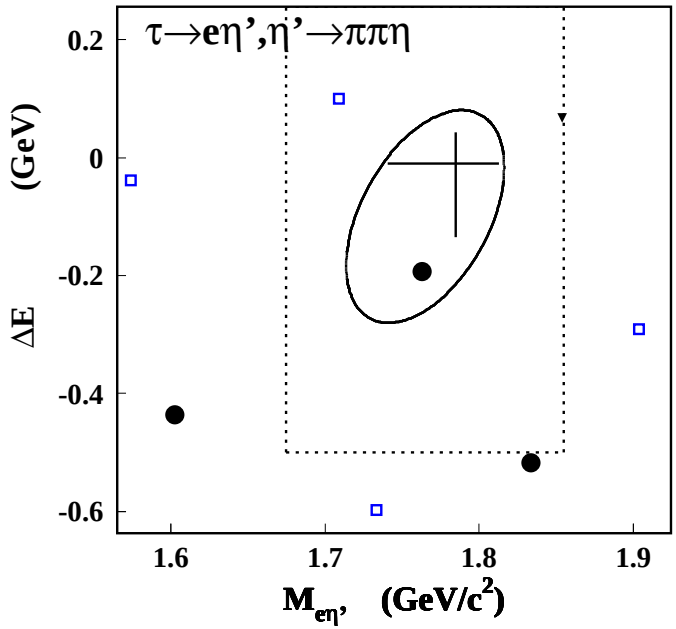
We can obtain more sensitivity by

– increase of luminosity ($\times$ 2.6)

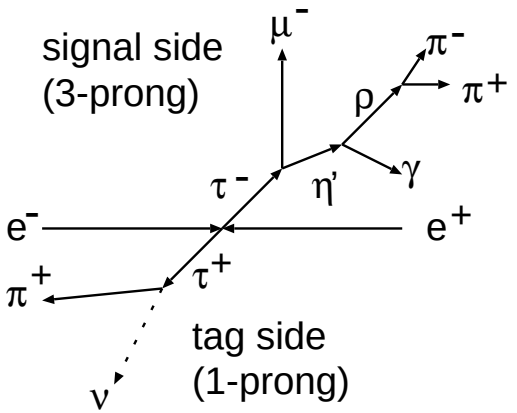
– adding $\eta' \to \rho\gamma$ mode ($\mathcal{B}(\eta' \to \rho\gamma)$=29.5%)

($\mathcal{B}(\eta' \to \eta(\to \gamma\gamma)\pi^+\pi^-)$=17.5%)





$\tau \to \ell\eta'$ (2)



Apply similar events selections as $\tau \to \ell\eta(\pi^-\pi^-\pi^0)$

Signal-side

Lepton selection with $p_{\rm sig} > 0.7$ GeV/c

η' reconstruction

$\to \eta' \to \rho(\pi^+\pi^-)\gamma$

ρ :: $0.550 < M_{\pi^+\pi^-} < 0.900\ \mathbf{GeV}/c^2$

η' :: $0.930 < M_{\rho\gamma} < 0.970\ \mathbf{GeV}/c^2$

$\to \eta' \to \eta(\to \gamma\gamma)\pi^+\pi^-$

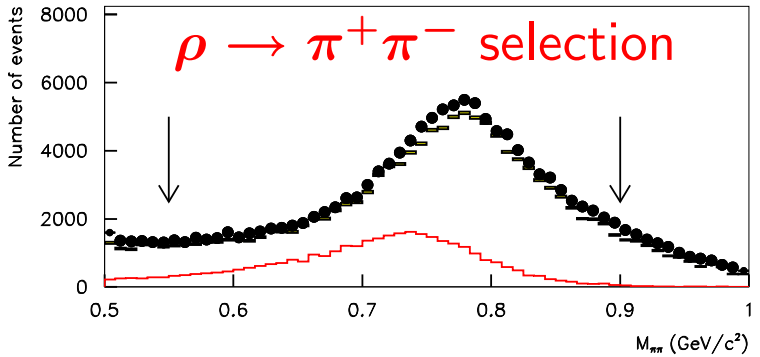
η :: $0.515 < M_{\gamma\gamma} < 0.570$

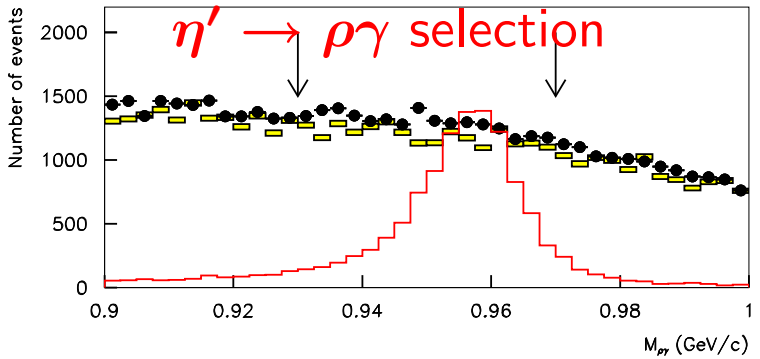
η' :: $0.920 < M_{\eta\pi^+\pi^-} < 0.980$

$0.85 > \cos\theta^{CM}_{\eta'\ell} > 0.5$

of $\gamma \leq 1$

m^2_{miss} vs. p_{miss} cut





No η' peak

$\Rightarrow$ due to no observation of $\tau \to \eta' X \nu$

(Expected very small branching ratio)

$\tau \to \ell\eta'$ (3)

No events in blind region for all modes

So, we set combined upper limits as

$\mathcal{B}(\tau \to \mu\eta') < 1.3\times10^{-7}$

(Previous limit: $< 4.7\times 10^{-7}$)

$\Rightarrow$ improved by a factor of 3.6

$\mathcal{B}(\tau \to e\eta') < 1.6\times10^{-7}$

(Previous limit: $< 10\times 10^{-7}$)

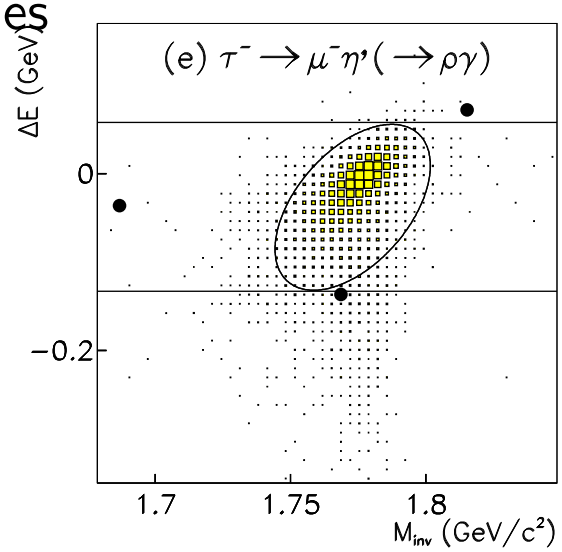
$\Rightarrow$ improved by a factor of 6.3

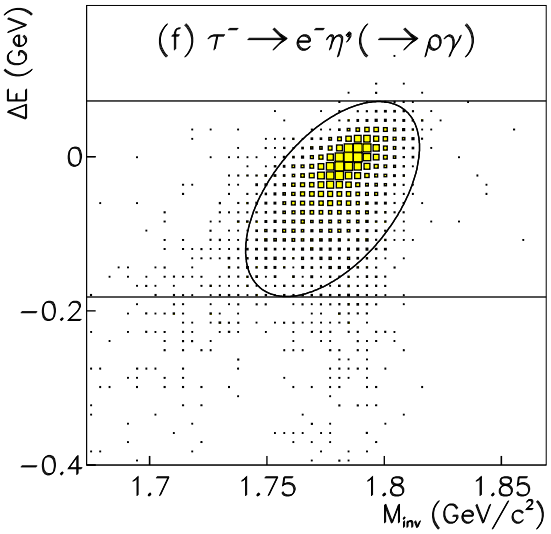
$\Downarrow$

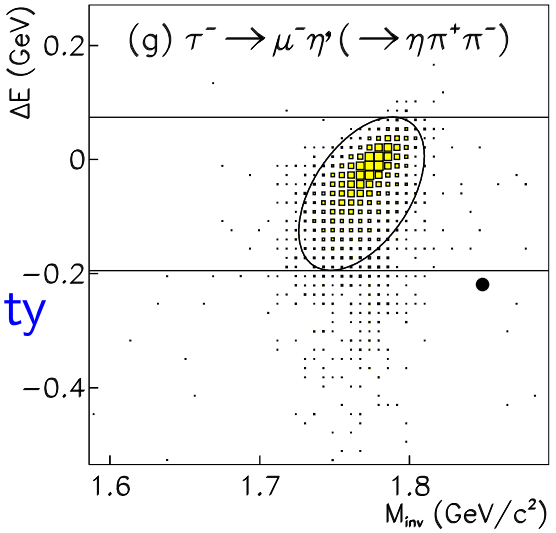
By adding $\eta' \to \rho\gamma$ modes,

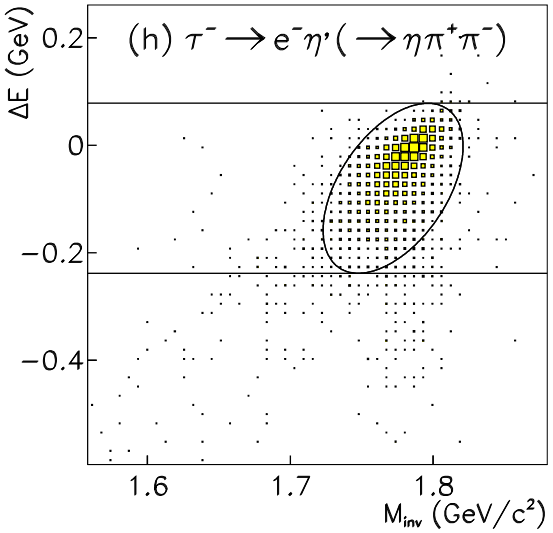
we obtain more improvements in

the factor of the increase of luminosity

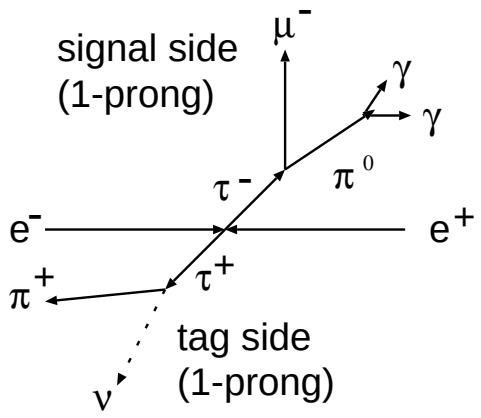








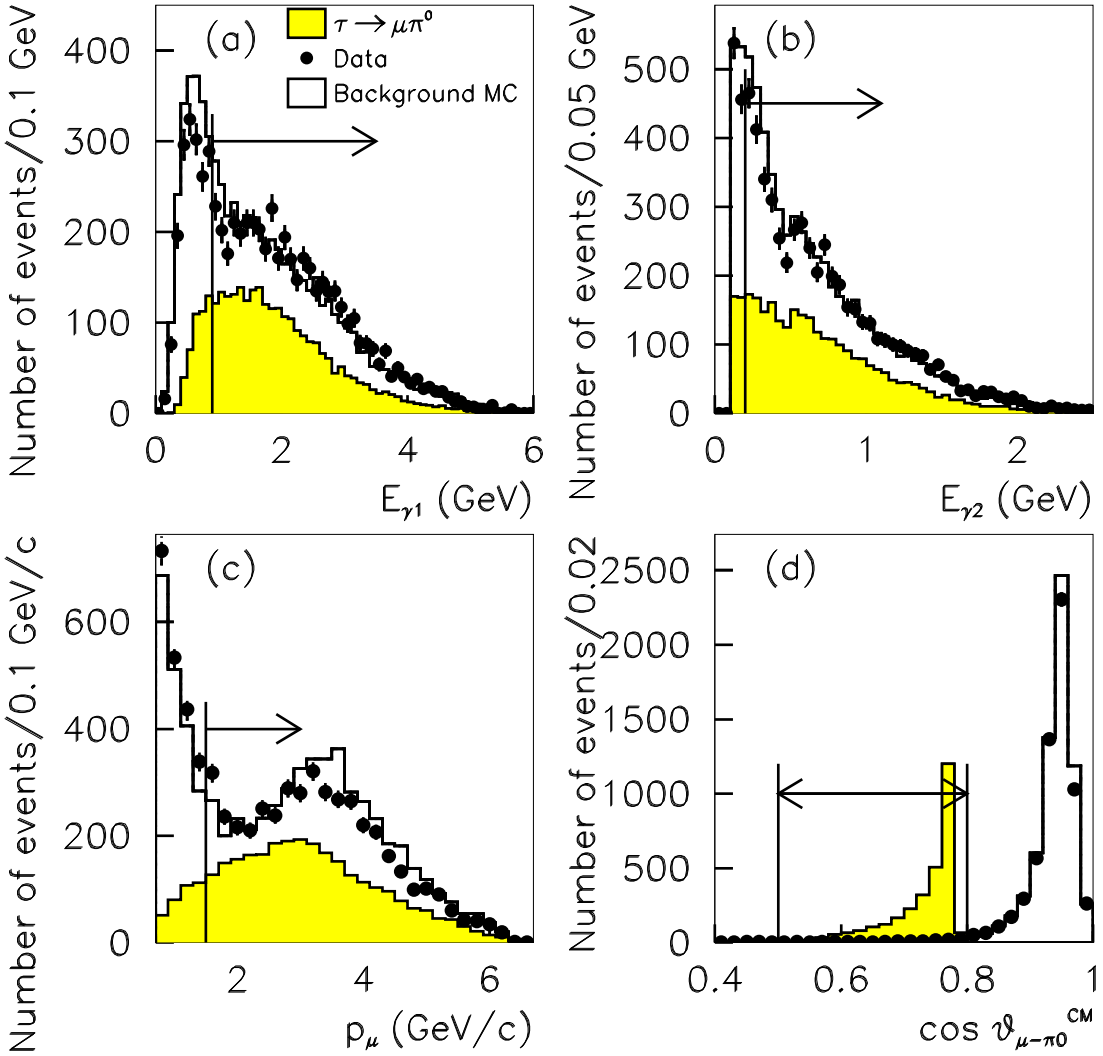
$\tau \to \ell\pi^0$ (1)



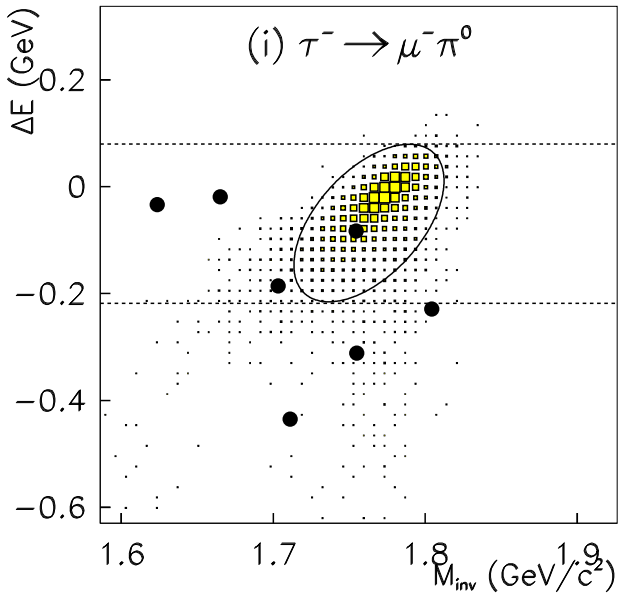
Apply similar events selections as $\tau \to \ell\eta(\to \gamma\gamma)$

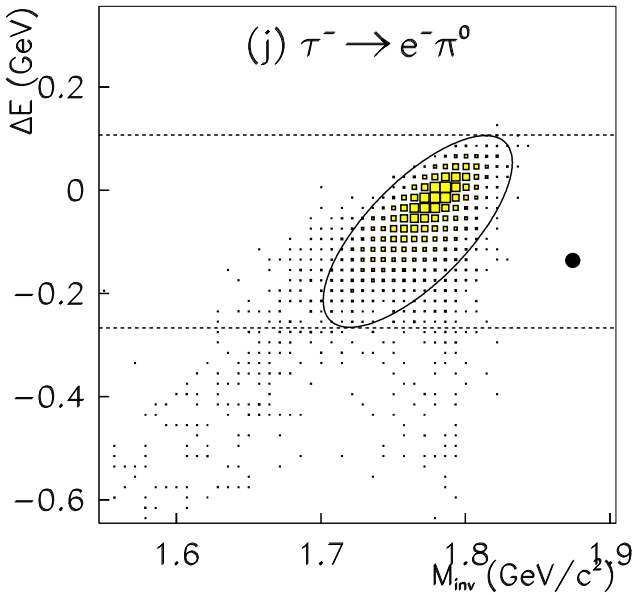
Large background from $\tau \to \pi^-\pi^0\nu$, we apply more stringent event selection as

- $E_{\gamma 1} > 0.90$ GeV
- $E_{\gamma 2} > 0.20$ GeV
  $(E_{\gamma 1} > E_{\gamma 2})$
- $p_\mu > 1.5$ GeV/c
- $0.80 > \cos\theta^{CM}_{\mu\pi 0} > 0.5$



$\tau \to \ell\pi^0$ (2)





Mode	$\tau^- \to \mu^-\pi^0$	$\tau^- \to e^-\pi^0$
expected BG	0.58±0.34	0.20±0.20
observed events	1	0
Efficiency	4.5%	3.9%
Upper limit	$< 1.2 \times 10^{-7}$	$< 8.0 \times 10^{-8}$
Improved factor from 154/fb analysis	3.4	2.4

Summary of upper limits on $\mathcal{B}$ at 90% C.L.

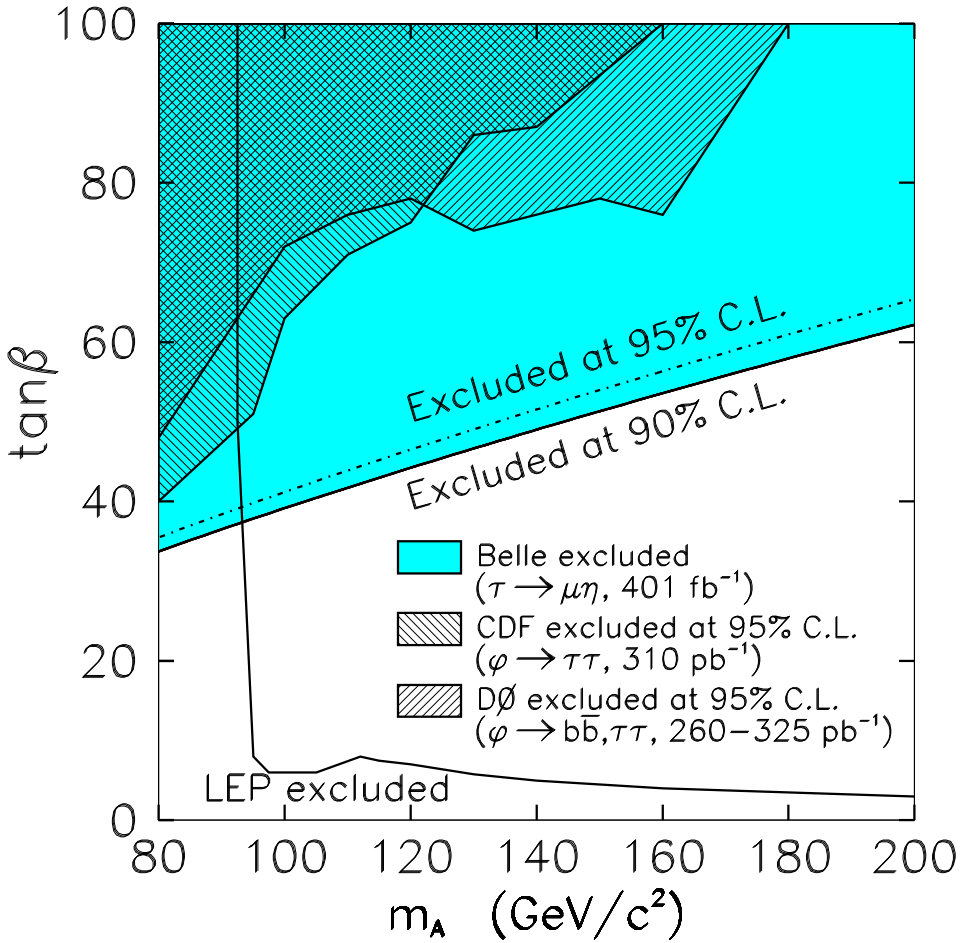
Mode	M^0 subdecay mode	Upper limit at 90% C.L.
$\tau^- \to \mu^- \eta$	$\eta \to \gamma\gamma$	$<1.2\times10^{-7}$
	$\eta \to \pi^+\pi^-\pi^0$	$<2.0\times10^{-7}$
	Combined	$<6.5\times10^{-8}$
$\tau^- \to e^- \eta$	$\eta \to \gamma\gamma$	$<1.7\times10^{-7}$
	$\eta \to \pi^+\pi^-\pi^0$	$<2.6\times10^{-7}$
	Combined	$<9.2\times10^{-8}$
$\tau^- \to \mu^- \eta'$	$\eta' \to \rho\gamma$	$<1.9\times10^{-7}$
	$\eta' \to \eta\pi^+\pi^-$	$<4.1\times10^{-7}$
	Combined	$<1.3\times10^{-7}$
$\tau^- \to e^- \eta'$	$\eta' \to \rho\gamma$	$<2.5\times10^{-7}$
	$\eta' \to \eta\pi^+\pi^-$	$<4.7\times10^{-7}$
	Combined	$<1.6\times10^{-7}$
$\tau^- \to \mu^- \pi^0$	$\pi^0 \to \gamma\gamma$	$<1.2\times10^{-7}$
$\tau^- \to e^- \pi^0$	$\pi^0 \to \gamma\gamma$	$<8.0\times10^{-8}$

These results improve upon our previously published upper limits by factors from 2.3 to 6.3.

They are also somewhat better than the recent results from BaBar ($<$1.1-2.4$\times10^{-7}$@339/fb) and are the most stringent limits on these modes to date.

Constraint on $\tan\beta$ and M_A

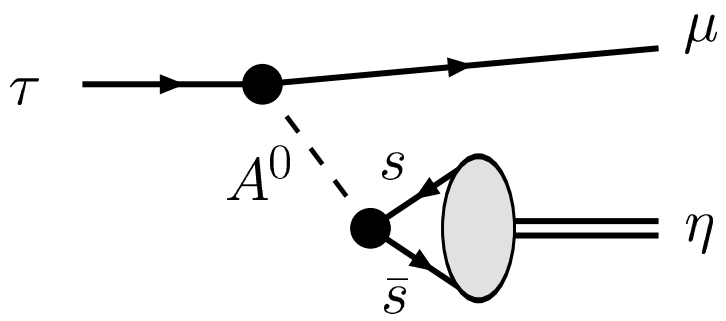
Constraint on $\tan\beta$ and M_A by our $\tau \longrightarrow \mu\eta$ result



Prediction with MSSM with seesaw

$$\mathcal{B}(\tau \longrightarrow \mu\eta) = 8.4 \times 10^{-7} \left(\frac{\tan\beta}{60}\right)^6 \left(\frac{100\mathrm{GeV}/c^2}{m_A}\right)^4$$

(M. Sher, PRD 66, 057301 (2002))



(CDF and DØ results: $p\bar{p} \longrightarrow h/H/Ab\bar{b} \longrightarrow b\bar{b}b\bar{b}$ from RUN II)

(LEP results: LEP Higgs Working Group)

Summary

We have searched for lepton-flavor-violating τ decays with a pseudoscalar meson (η, η' and π^0) using 401 fb^{-1} of data collected with the Belle detector at the KEKB.

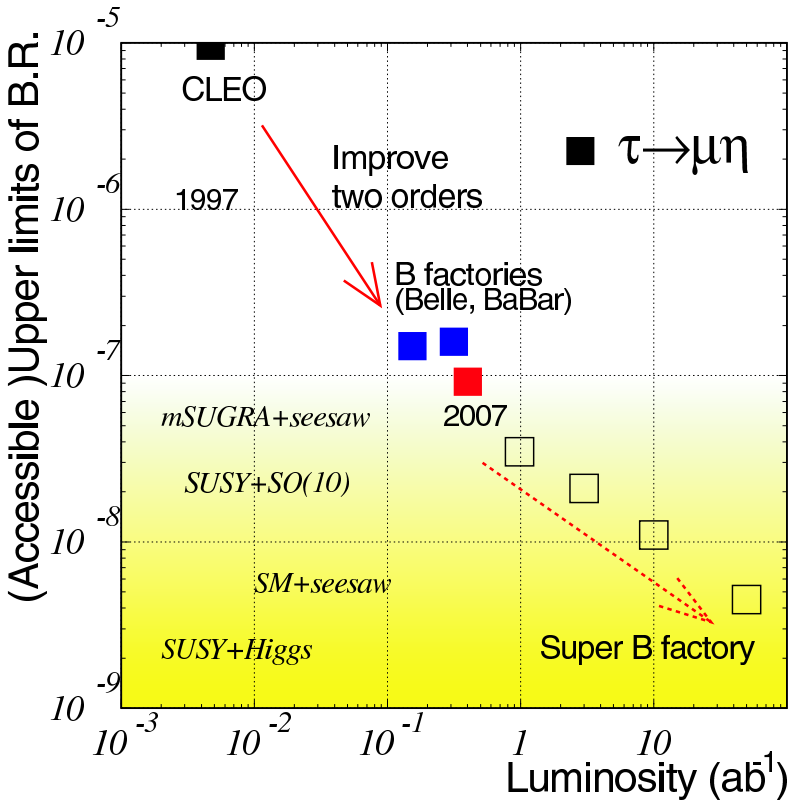
No signal is found and we set the following upper limits on branching fractions at the 90% confidence level as

$$\mathcal{B}(\tau \to \ell\eta, \ell\eta', \ell\pi^0) < (6.5 - 16) \times 10^{-8}$$

These results improve upon our previously published upper limits by factors from 2.3 to 6.3.

$\Rightarrow$ These limits help to constrain new physics scenarios beyond the Standard Model.

$\Rightarrow$ These results are submitted accepted by PLB.



Backup

Lepton Flavor Violation τ Decays

Many extensions of the SM predict LFV decays
$\Rightarrow$ SUSY(+Seesaw), Extra dimension etc.

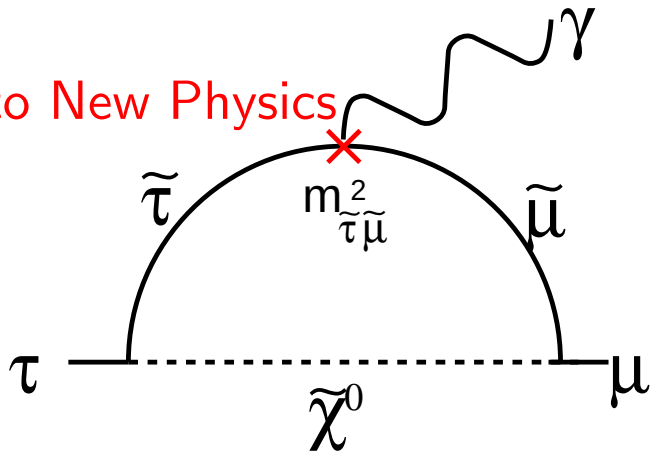
$$(m_{\tilde{\ell}})^2_{ij} = \begin{pmatrix} m^2_{\tilde{e}\tilde{e}} & m^2_{\tilde{e}\tilde{\mu}} & m^2_{\tilde{e}\tilde{\tau}} \\ m^2_{\tilde{\mu}\tilde{e}} & m^2_{\tilde{\mu}\tilde{\mu}} & m^2_{\tilde{\mu}\tilde{\tau}} \\ m^2_{\tilde{\tau}\tilde{e}} & m^2_{\tilde{\tau}\tilde{\mu}} & m^2_{\tilde{\tau}\tilde{\tau}} \end{pmatrix}$$

– SUSY-GUT or SUSY-Seesaw model –
Charged lepton mixing would occur through
the mixing of slepton mass matrix

$$\mathcal{B} \propto ((m^2_{\tilde{L}})_{ij})^2$$

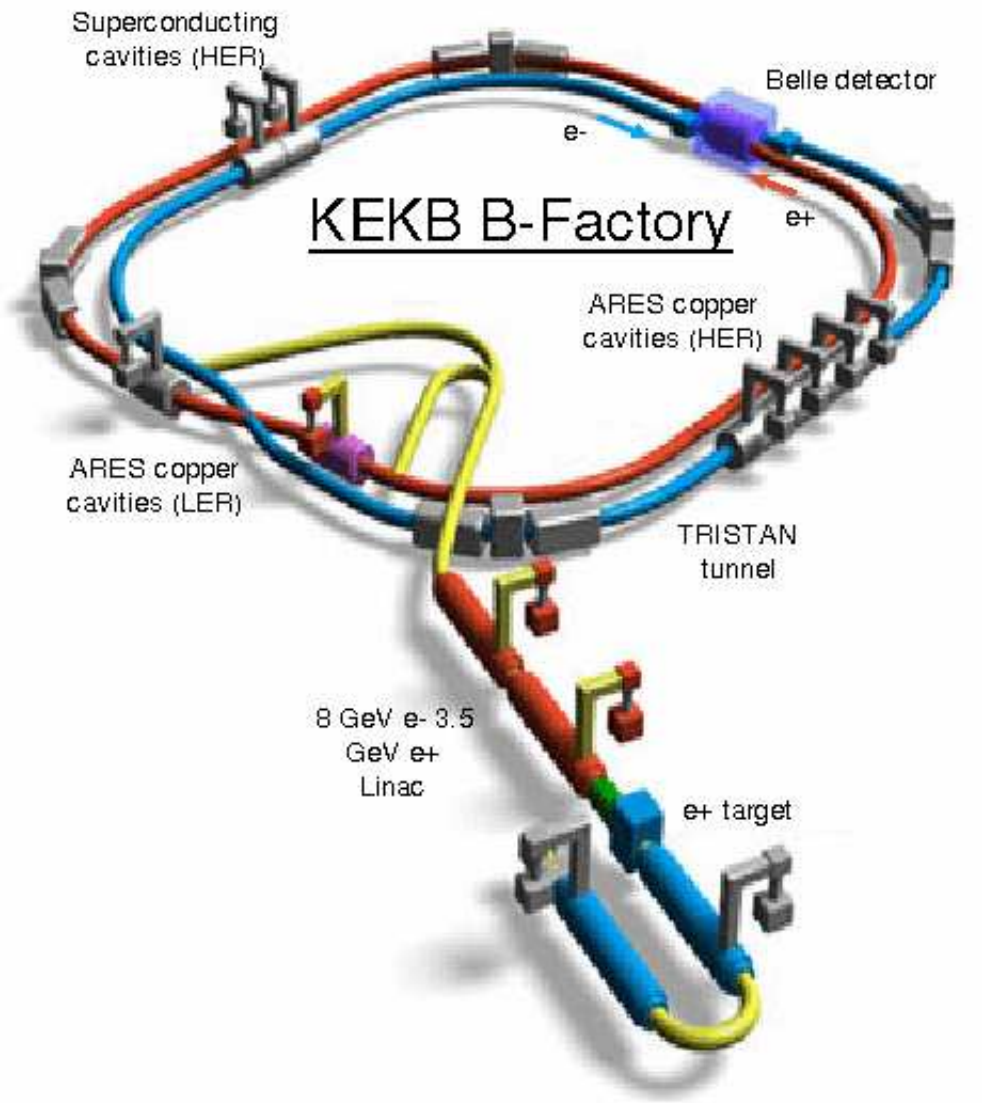
$\Rightarrow$ enhanced up to the current experimental sensitivity

LFV depends on the some powers of lepton mass $(m_\ell)^n$
$\Rightarrow$ τ is the heaviest lepton and have strongly couplings to New Physics



Previous experimental results for LFV τ decays
CLEO sensitivities on $\mathcal{B}$ <O(10^{-6})

KEKB



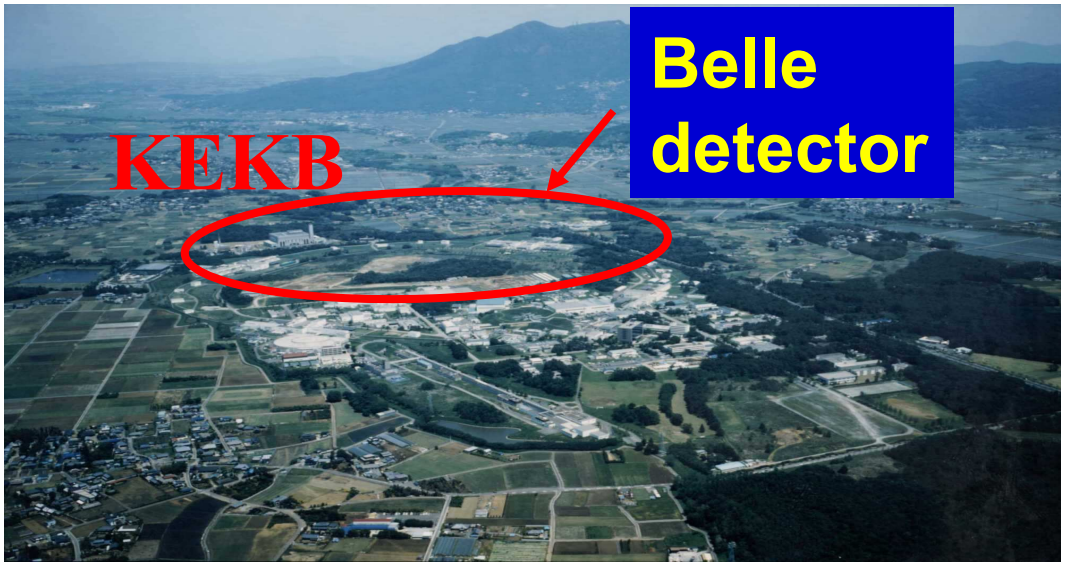
– High luminosity

– Asymmetric energy collider

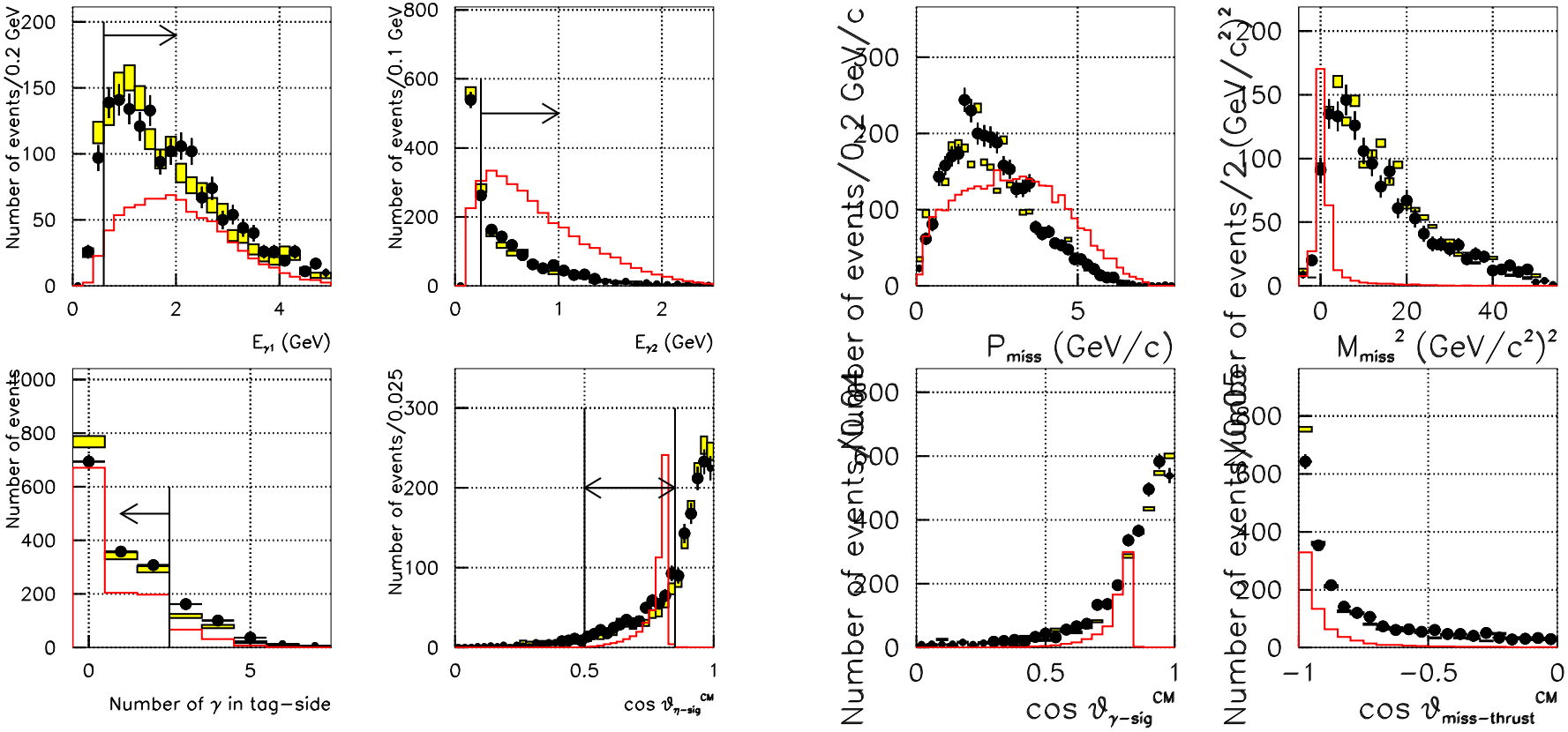
e^- 8 GeV/ e^+ 3.5 GeV

$\sqrt{s} = 10.58$ GeV (Υ(4s))

Integrated lum. > 700/fb @ 2007/3



Some distributions for $\tau \longrightarrow \mu\eta(\longrightarrow \gamma\gamma)$ and $\tau \longrightarrow \mu\eta(\longrightarrow \pi^+\pi^-\pi^0)$



Summary for the comparison between new and previous cut for $\tau \longrightarrow \ell\eta(\longrightarrow \gamma\gamma)$

Apply looser cuts than previous analysis

Previous cut		New cut
Muon veto @ tag-side	$\longrightarrow$	Muon veto @ tag-side with $10 > E^{CM}_{total} > 8.5$ GeV

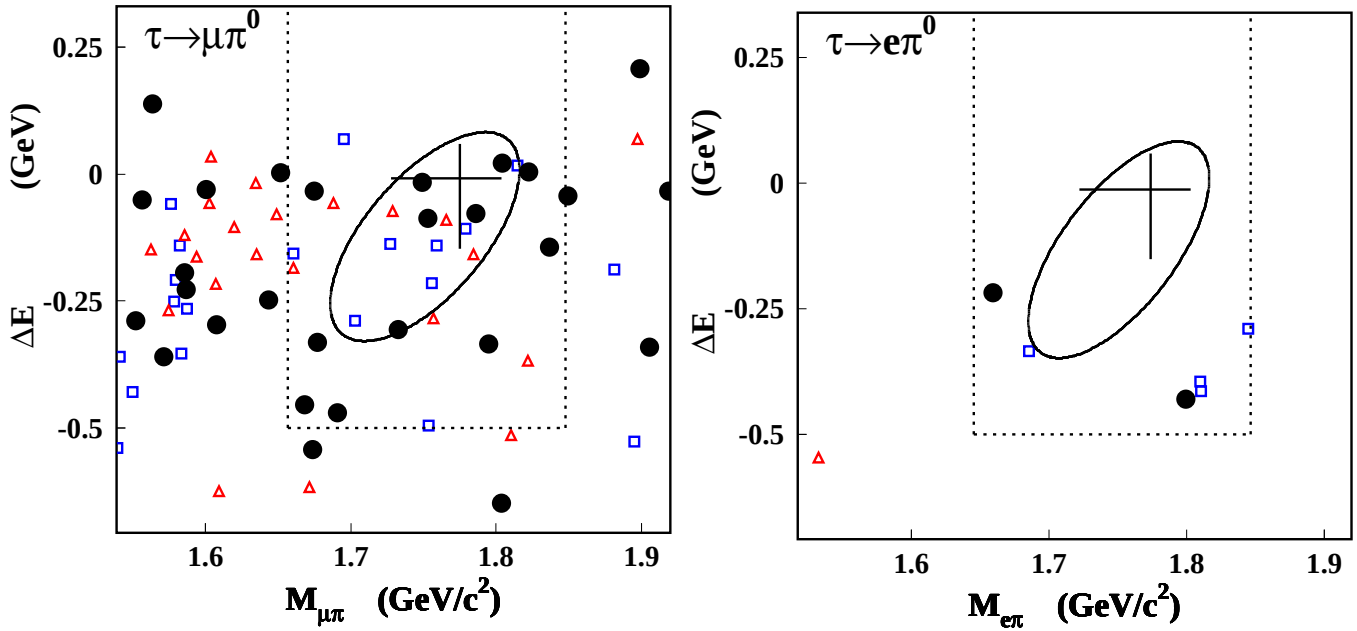
Apply tighter (similar) cuts than previous analysis

# of $\gamma <= 2$ in tag-side if tag-track is lepton	$\longrightarrow$	# of $\gamma <= 2$ in tag-side
$E_\gamma > 0.22$ GeV in η candidate	$\longrightarrow$	$E_{\gamma 1}(E_{\gamma 2}) > 0.60$ (0.25)GeV in η candidate
Correlation m^2_{miss} and p_{miss}	$\longrightarrow$	Separate using tag track information (lepton or hadron)
$0.95 > \cos\theta_{\eta-\mu} > 0.5$	$\longrightarrow$	$0.85 > \cos\theta^{CM}_{\eta-\mu} > 0.5$

Apply new cuts

N.A.	$\longrightarrow$	Correlation $\cos\theta^{CM}_{thrust-miss}$ and p^{CM}_{tag}

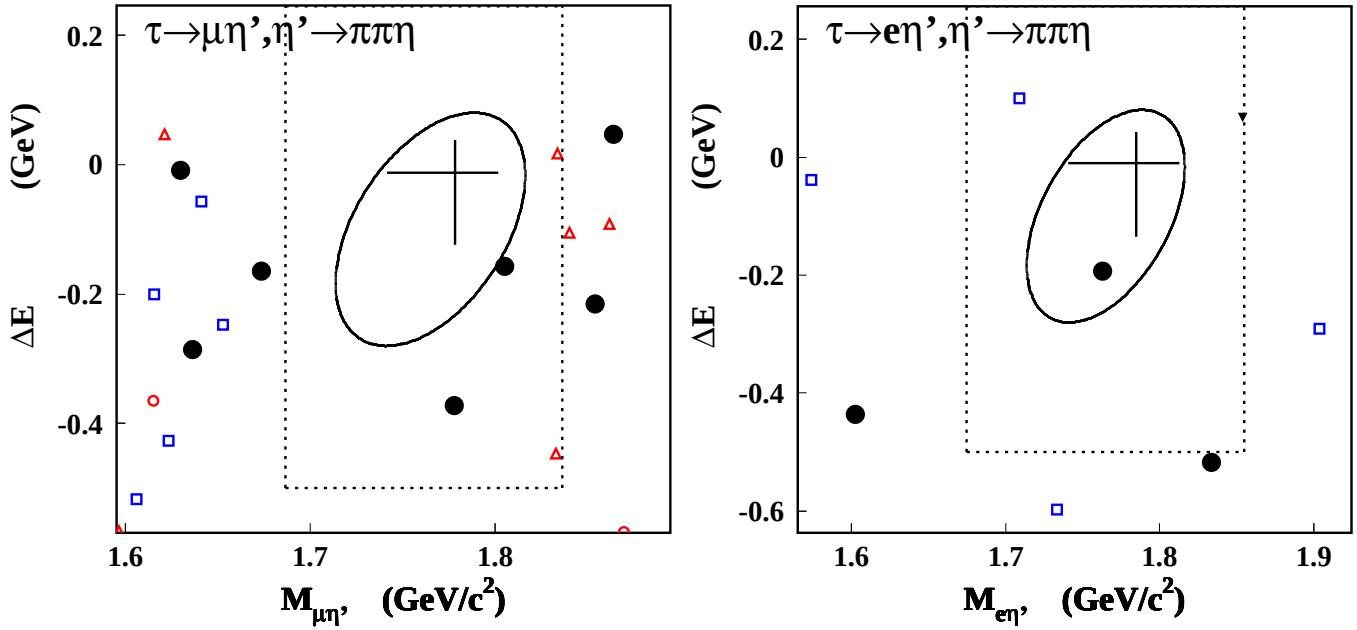
Previous results



Previous results (PLB 622, 218 (2005) : 154 fb^{-1})

Mode	$\tau^- \to \mu^- \pi^0$	$\tau^- \to e^- \pi^0$
expected BG	2.95±0.82	0.0±0.0
observed events	7	0
Efficiency	6.4%	4.7%
Upper limit	$< 4.1 \times 10^{-7}$	$< 1.9 \times 10^{-7}$

Previous results



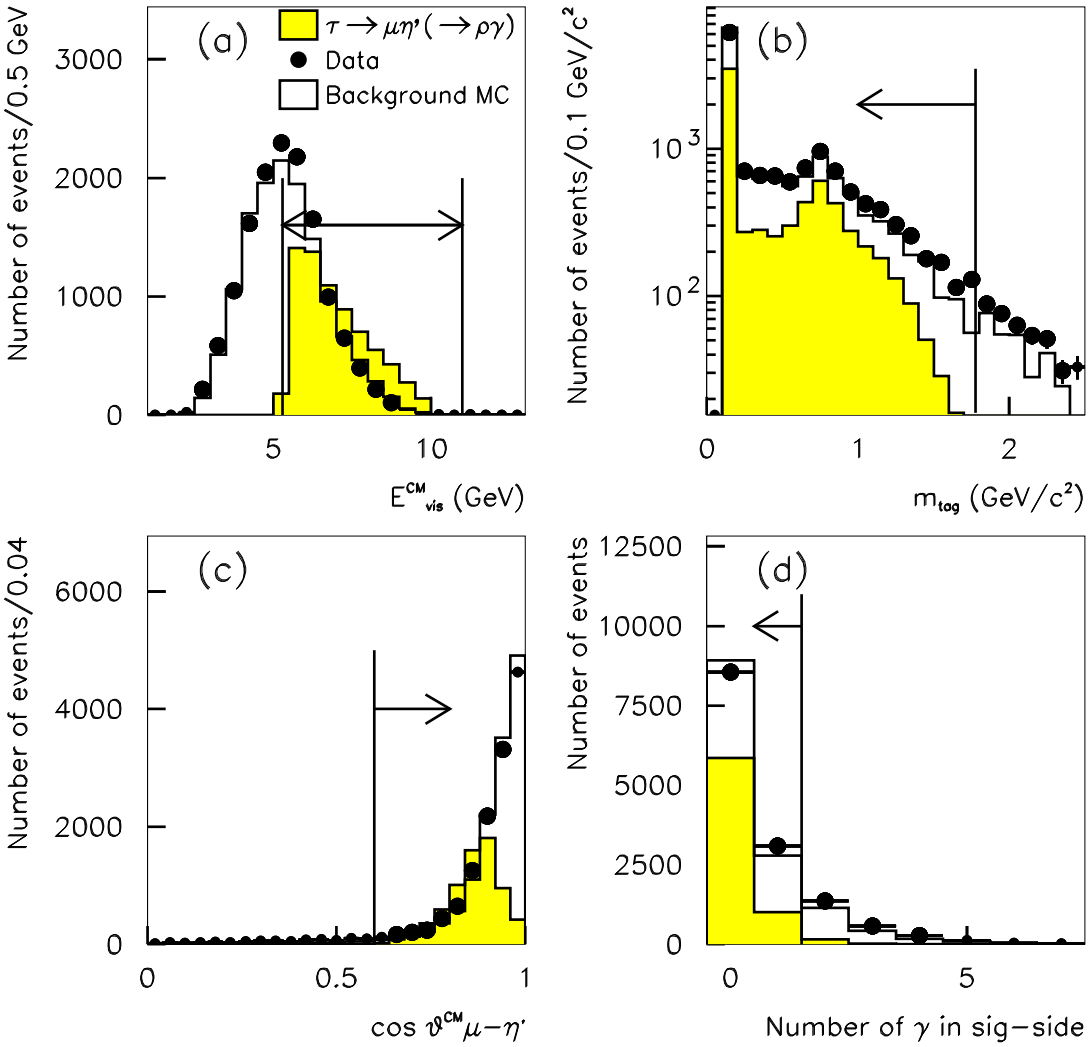
Previous results (PLB 622, 218 (2005) : 154 fb^{-1})

Mode	$\tau^- \to \mu^- \eta'$	$\tau^- \to e^- \eta'$
expected BG	0.94±0.42	0.28±0.20
observed events	0	1
Efficiency	8.41%	8.51%
Upper limit	$< 4.7 \times 10^{-7}$	$< 10 \times 10^{-7}$

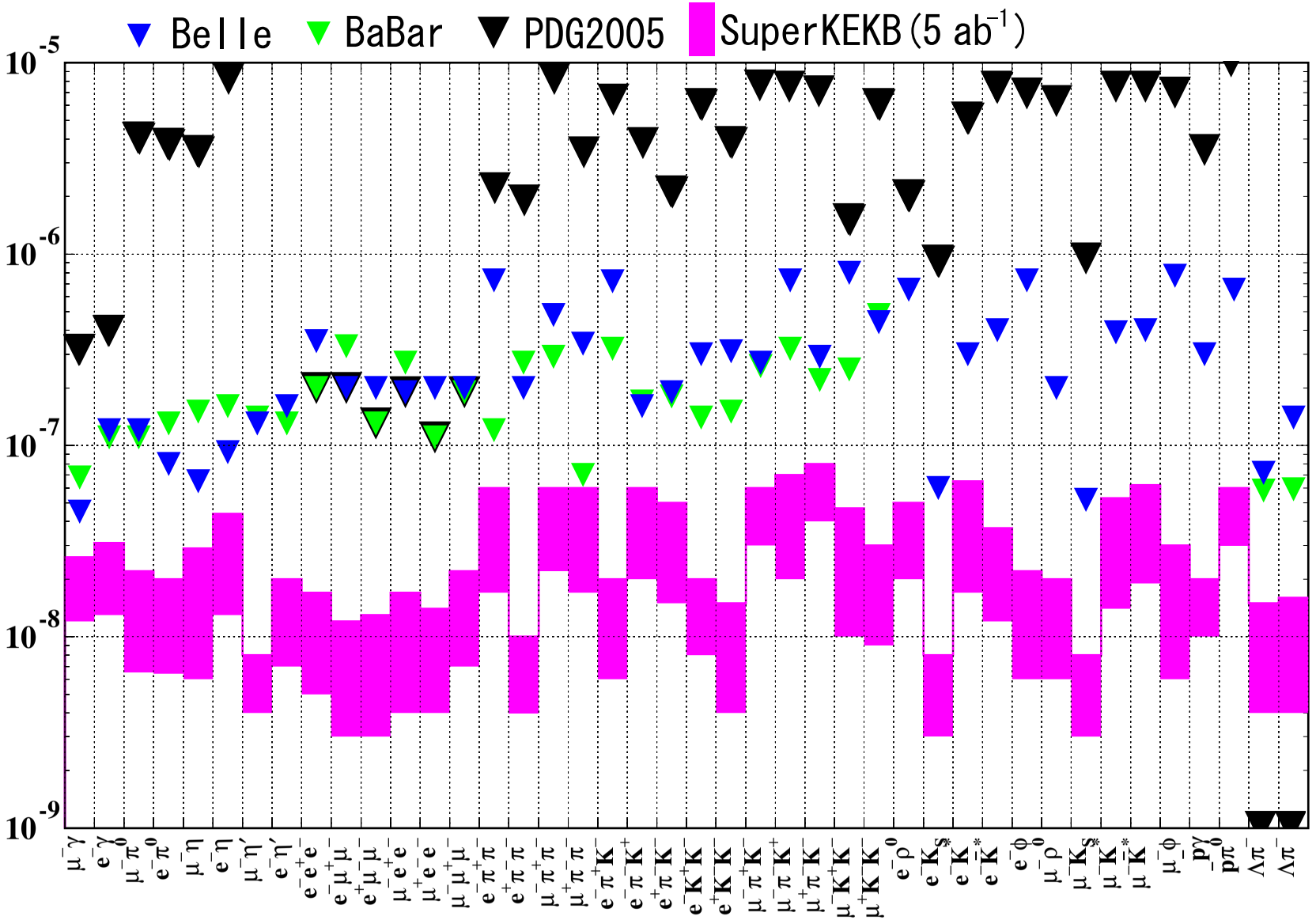
Results of the final event selection for the individual modes

Mode	$\mathcal{B}_{M^0}$	ε (%)	b_0	s	Total Sys. (%)	s_{90}
$\tau \to \mu\eta(\to \gamma\gamma)$	0.3938	6.42	0.40±0.29	0	7.1	2.1
$\tau \to \mu\eta(\to \pi^+\pi^-\pi^0)$	0.227	6.84	0.24±0.24	0	5.6	2.2
$\tau \to e\eta(\to \gamma\gamma)$	0.3938	4.57	0.25±0.25	0	7.1	2.2
$\tau \to e\eta(\to \pi^+\pi^-\pi^0)$	0.227	4.72	0.53±0.53	0	5.6	2.0
$\tau \to \mu\eta'(\to \rho\gamma)$	0.294×1.0	5.40	0.23±0.23	0	6.8	2.2
$\tau \to \mu\eta'(\to \eta\pi^+\pi^-)$	0.445×0.3943	4.92	$0.0^{+0.23}_{-0.0}$	0	8.3	2.5
$\tau \to e\eta'(\to \rho\gamma)$	0.294×1.0	4.76	$0.0^{+0.33}_{-0.0}$	0	6.8	2.5
$\tau \to e\eta'(\to \eta\pi^+\pi^-)$	0.445×0.3943	4.27	$0.0^{+0.24}_{-0.0}$	0	8.3	2.5
$\tau \to \mu\pi^0(\to \gamma\gamma)$	0.98798	4.53	0.58±0.34	1	4.5	3.8
$\tau \to e\pi^0(\to \gamma\gamma)$	0.98798	3.93	0.20±0.20	0	4.5	2.2

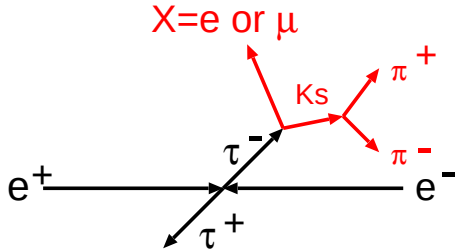
$\tau \to \mu\eta'(\to \rho\gamma)$



Lepton Flavor Violation τ Decays



$\tau \to \ell K^0_S$ (1)



1-prong decay

$\tau \to \ell K^0_S$ (where $K^0_S \to \pi^+\pi^-$)
Dataset for this analysis @ 281 fb^{-1}

Event selection

- $p_{\rm miss} > 0.4$ GeV/c
  within the fiducial volume
- $10 > E^{CM}_{total} >$ 5.29GeV
- $\cos\theta^{CM}_{tag-miss} > 0.0$
- # of γ in signal side ≤ 1
- # of γ in tag side ≤ 2
- $\cos\theta_{\ell K^0_S}$ vs. $p_{\ell K^0_S}$ cut

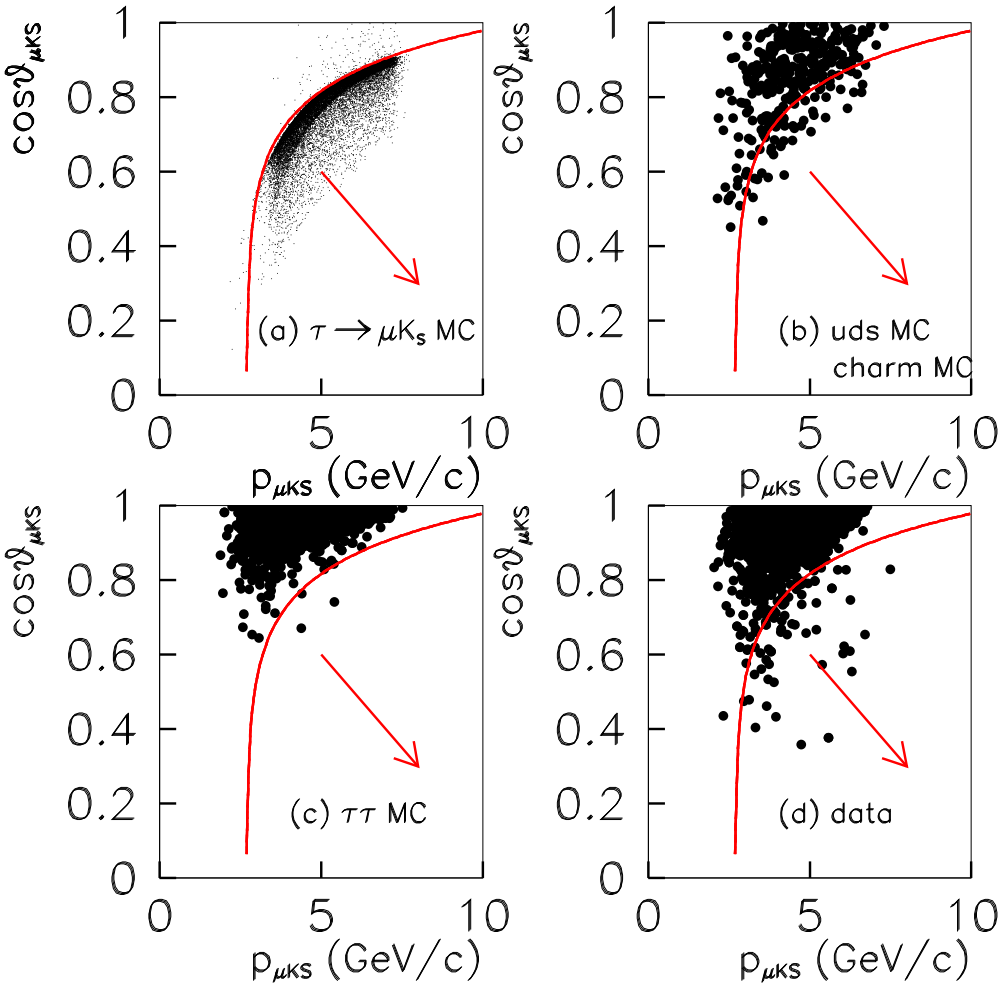
$\Rightarrow$ See plot on the right

$\cos\theta_{\ell K^0_S} < 0.14\log(p_{\ell K^0_S} - 2.7) + 0.7$ cut

Eff. of $\cos\theta_{\ell K^0_S}$ vs. $p_{\ell K^0_S}$ cut for each MC

Signal 99%

$\tau\tau$ 0.7%, uds 16%



$\tau \to \ell K^0_S$ (2)

After events selections

$\varepsilon = 11.8\%$ for eK^0_S

$\varepsilon = 13.5\%$ for μK^0_S

Background:

$D^{(*)\pm} \to \ell^\pm \nu K^0_S$

$\pi^\pm K^0_S$

In signal region

– Expected background

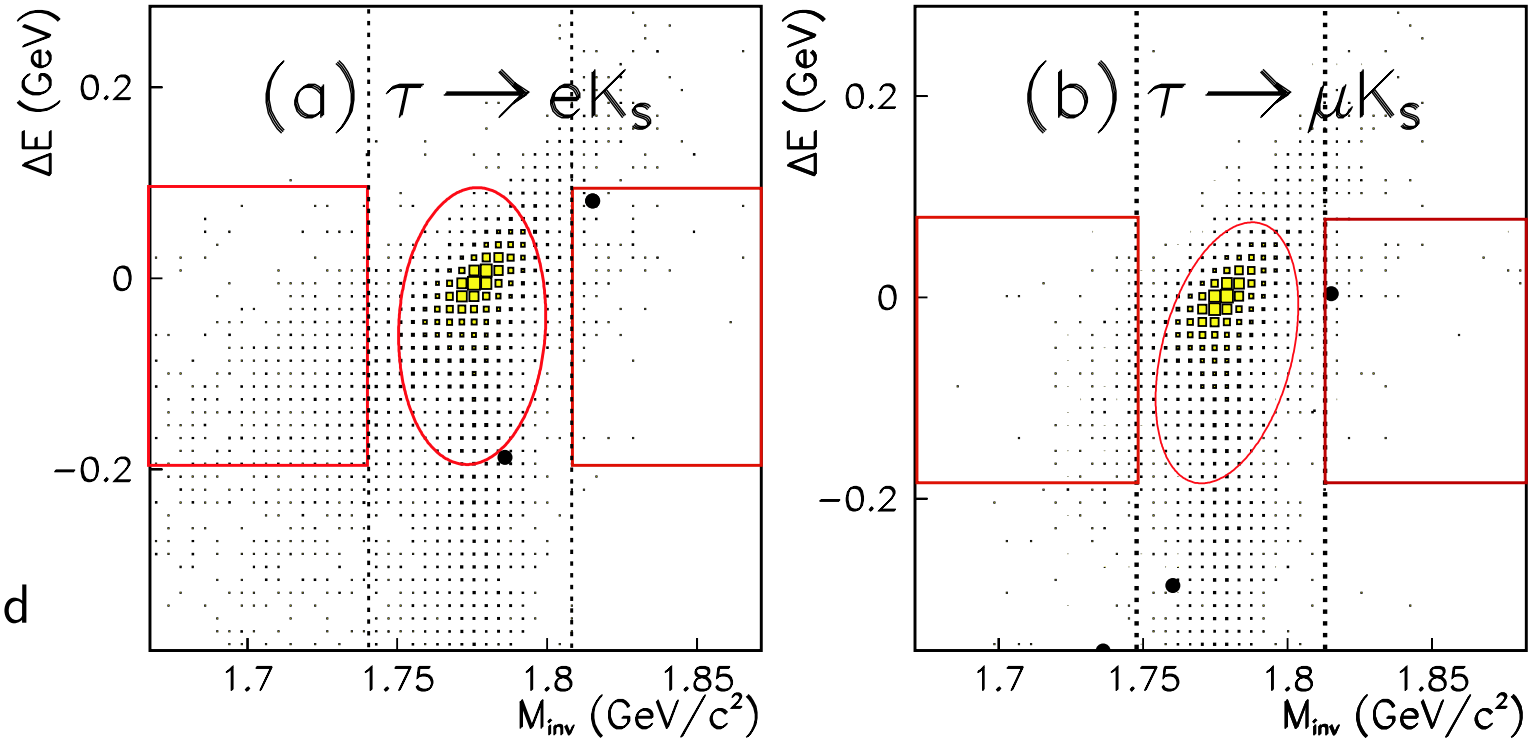
0.2 ± 0.2 events

– Data

No events in either mode

$\Downarrow$

Set upper limits on branching fraction at 90% C.L.



$\mathcal{B}(\tau \to eK^0_S) < 5.6\times10^{-8}$ $\mathcal{B}(\tau \to \mu K^0_S) < 4.9\times10^{-8}$

(PLB369, 159(2006)

Improved by a factor of 16 and 19 compared with CLEO

(Previous upper limits: $9.1(9.5)\times10^{-7}$ for $eK^0_S(\mu K^0_S)$)