LFV tau decays at Belle II

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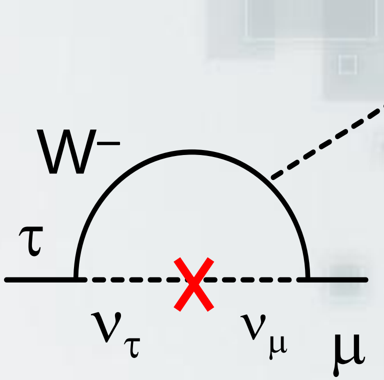
Introduction

Lepton flavor violation (LFV) in charged leptons

⇒negligibly small probability in the Standard Model (SM) even including neutrino oscillations:

→ $\mathcal{B}(\tau \rightarrow \mu\gamma) < O(10^{-54})$



Observation of LFV is a clear signature of New Physics (NP)

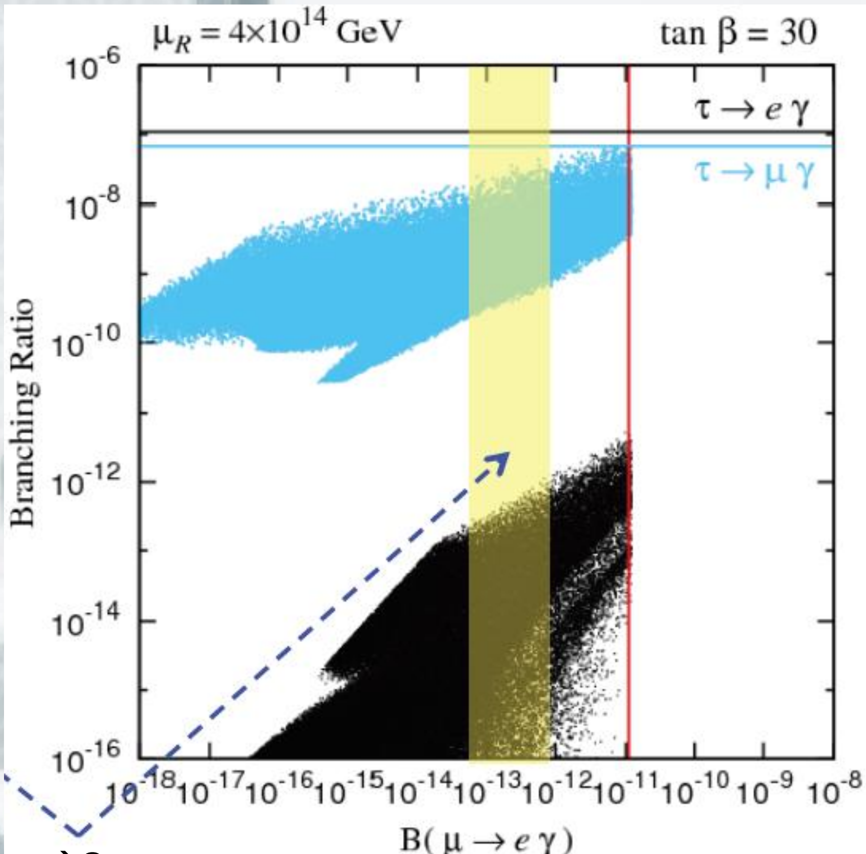
- Many extensions of the SM predict LFV decays.
  - These branching fractions could be enhanced as high as current experimental sensitivity. ($\sim 10^{-8}$)

Tau lepton = The heaviest charged lepton

- Expected strong coupling to NP
- Many possible LFV decay modes

τ→μγ vs μ→eγ

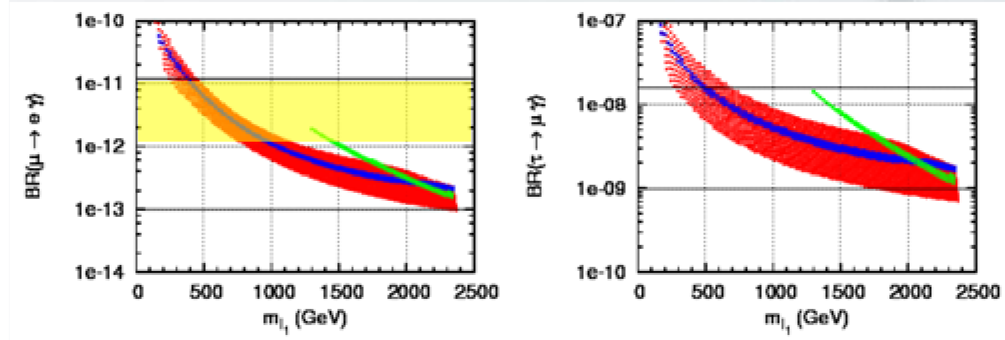
SUSY GUT SU(5)+νR,non-- - degenerate νR(I),normal Hierarchy



μ→eγ expected

Goto, Okada, Shindou & Tanaka
PRD77, 095010 (2008)

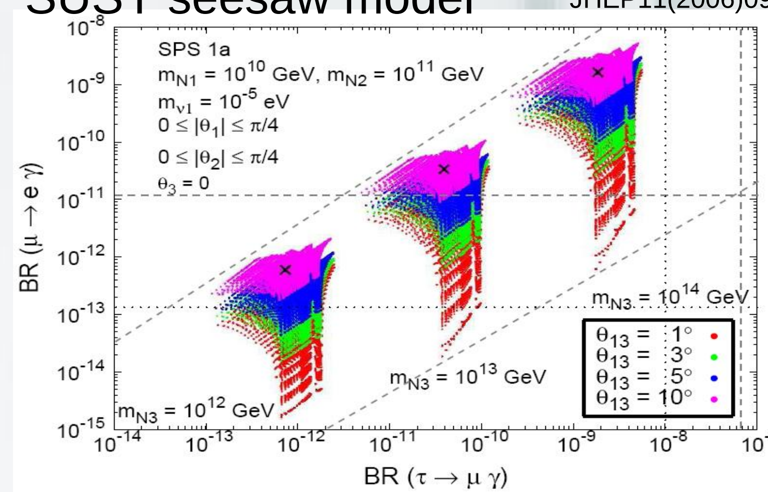
Lepton sector constraints in an SU(3)-flavored MSSM



Calibbi, Jones Perez, Masiero, Park, Porod & Vives arXiv:0907.4069v2

SUSY seesaw model

JHEP11(2006)090



These make us to expect Br(τ→μγ)~O(10^{-8--9}).

Even if μ→eγ has very small BF, some model predicts that τ→μγ can have sufficiently large BF to observe it experimentally.

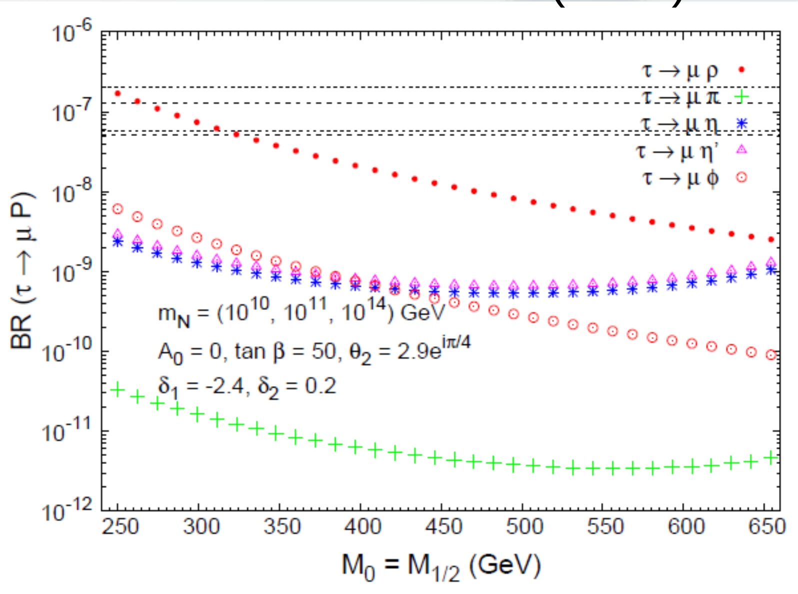
ex.) $SU(3)^3$ symmetry in SUSY model: arXiv:1204.0688v1 [hep-ph]

New Physics and τ LFV

If NP is found, as a next step, we like to know what mechanism induces NP.

ratio	LHT	MSSM (dipole)	MSSM (Higgs)
$\frac{\mathcal{B}(\tau^-\to e^-e^+e^-)}{\mathcal{B}(\tau\to e\gamma)}$	$0.4\ldots2.3$	$\sim 1\cdot10^{-2}$	$\sim 1\cdot10^{-2}$
$\frac{\mathcal{B}(\tau^-\to \mu^-\mu^+\mu^-)}{\mathcal{B}(\tau\to \mu\gamma)}$	$0.4\ldots2.3$	$\sim 2\cdot10^{-3}$	$0.06\ldots0.1$
$\frac{\mathcal{B}(\tau^-\to e^-\mu^+\mu^-)}{\mathcal{B}(\tau\to e\gamma)}$	$0.3\ldots1.6$	$\sim 2\cdot10^{-3}$	$0.02\ldots0.04$
$\frac{\mathcal{B}(\tau^-\to \mu^-e^+e^-)}{\mathcal{B}(\tau\to \mu\gamma)}$	$0.3\ldots1.6$	$\sim 1\cdot10^{-2}$	$\sim 1\cdot10^{-2}$
$\frac{\mathcal{B}(\tau^-\to e^-e^+e^-)}{\mathcal{B}(\tau^-\to e^-\mu^+\mu^-)}$	$1.3\ldots1.7$	~ 5	$0.3\ldots0.5$
$\frac{\mathcal{B}(\tau^-\to \mu^-\mu^+\mu^-)}{\mathcal{B}(\tau^-\to \mu^-e^+e^-)}$	$1.2\ldots1.6$	~ 0.2	$5\ldots10$

NUHM JHEP06(2008)079



Various LFV searches are important because they can distinguish NP models even if one LFV decay has been observed. →It is a strong advantage that τ has many kinds of LFV decays.

Search for τ LFV at Belle

KEKB/Belle

B-factory: E at CM = Υ(4S)

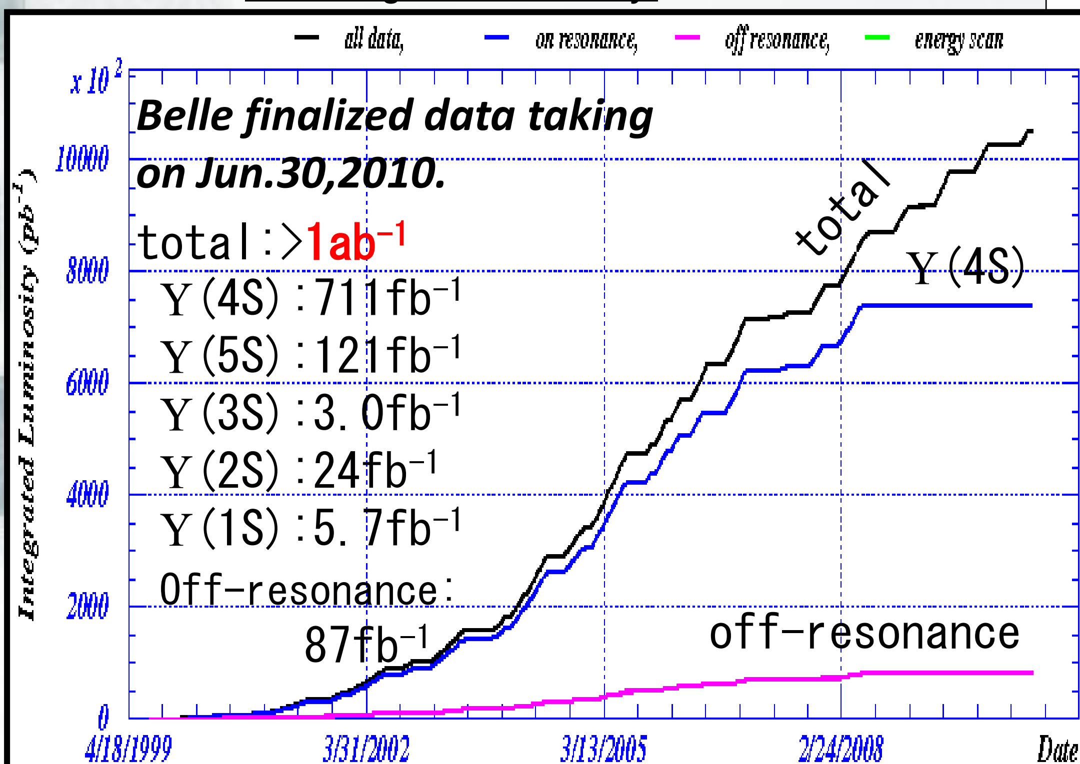
e^+(3.5 GeV) e^-(8 GeV)

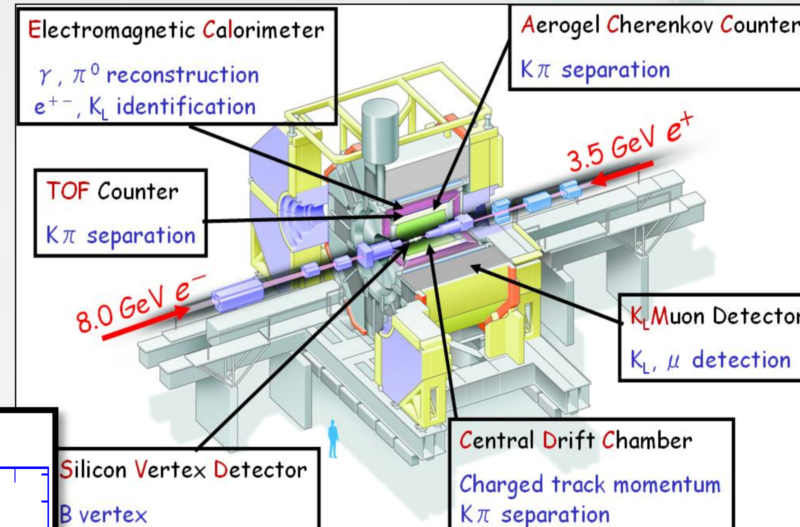
σ(ττ)~0.9nb, σ(bb)~1.1nb

A B-factory is also a τ-factory!

Peak luminosity: 2.1×10^{34} $cm^{-2}s^{-1}$

World highest luminosity!





Belle Detector:

Good track reconstruction and particle identifications

Lepton efficiency:90%

Fake rate : O(0.1) % for e

O(1)% for μ

~9×10^8 ττ at Belle

analysis method

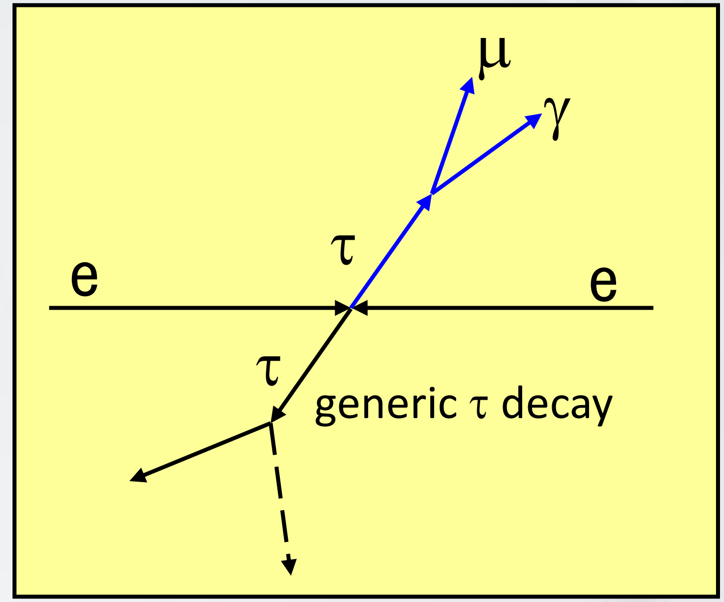
- $e^+e^- \to \tau^+\tau^-$

Br~85%

→ 1 prong + missing (tag side)

→ $\mu\gamma$ (signal side)

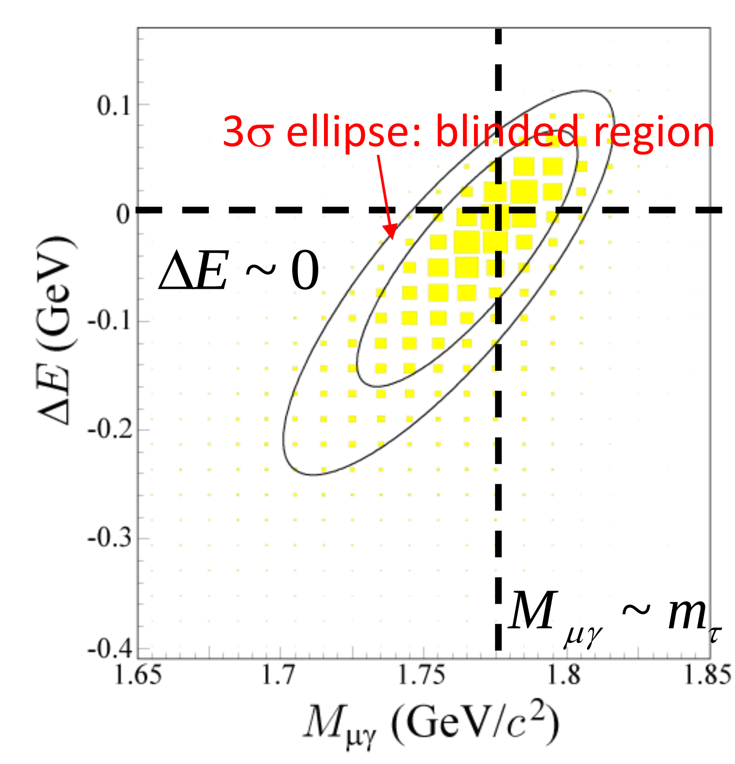
Fully reconstructed



Signal extraction: $M_{\mu\gamma}$–ΔE plane

$$M_{\mu\gamma} = \sqrt{(E_{\mu\gamma}^2 - p_{\mu\gamma}^2)}$$

$$\Delta E = E_{\mu\gamma}^{CM} - E_{beam}^{CM}$$

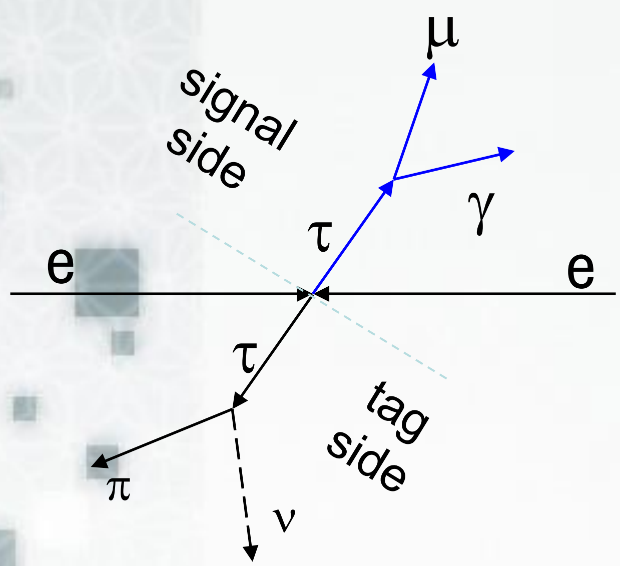


Blind analysis ⇒Blind signal region

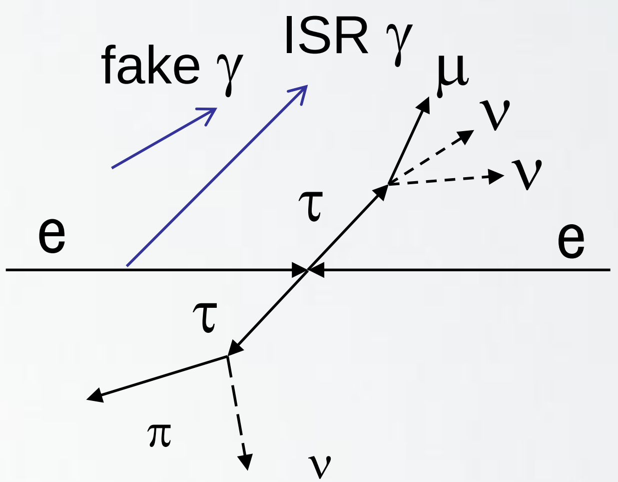
Estimate number of BG in the signal region using sideband data and MC

Signal and BG topology for $\tau \to \mu\gamma$

signal event

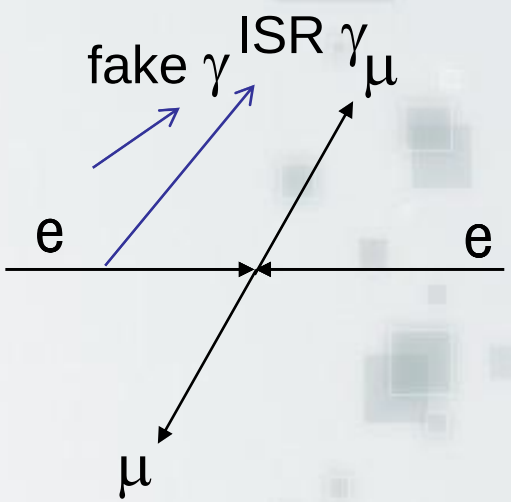


SM $\tau\tau$ event+ISR or beam BG: $\tau \to \mu\nu\nu$ in signal side



3 or 4 neutrinos: missing momentum helps to reject.

$\mu\mu$ event with ISR or beam BG



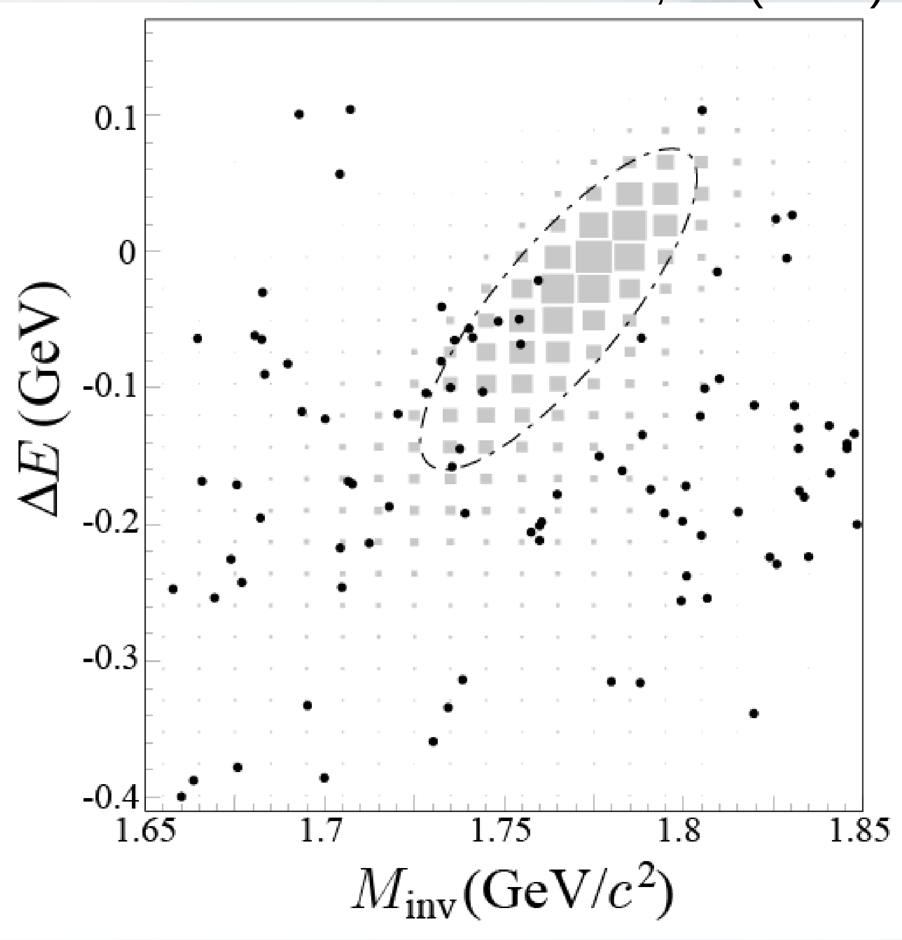
muon-veto in tag side

Result for $\tau \rightarrow \mu\gamma$ search

PLB 666, 16 (2008)

- 545 fb^{-1} Belle data sample
- 94 events are found while (88.4±7.4) BG events are expected in 5σ region and
- the detection eff. is 6.1%.

- Upper Limits are evaluated
- by 2d UEML fit on M-ΔE plane.
- Expected UL: 7.8×10^{-8} @90%CL
- Obtained UL: 4.5×10^{-8} @90%CL



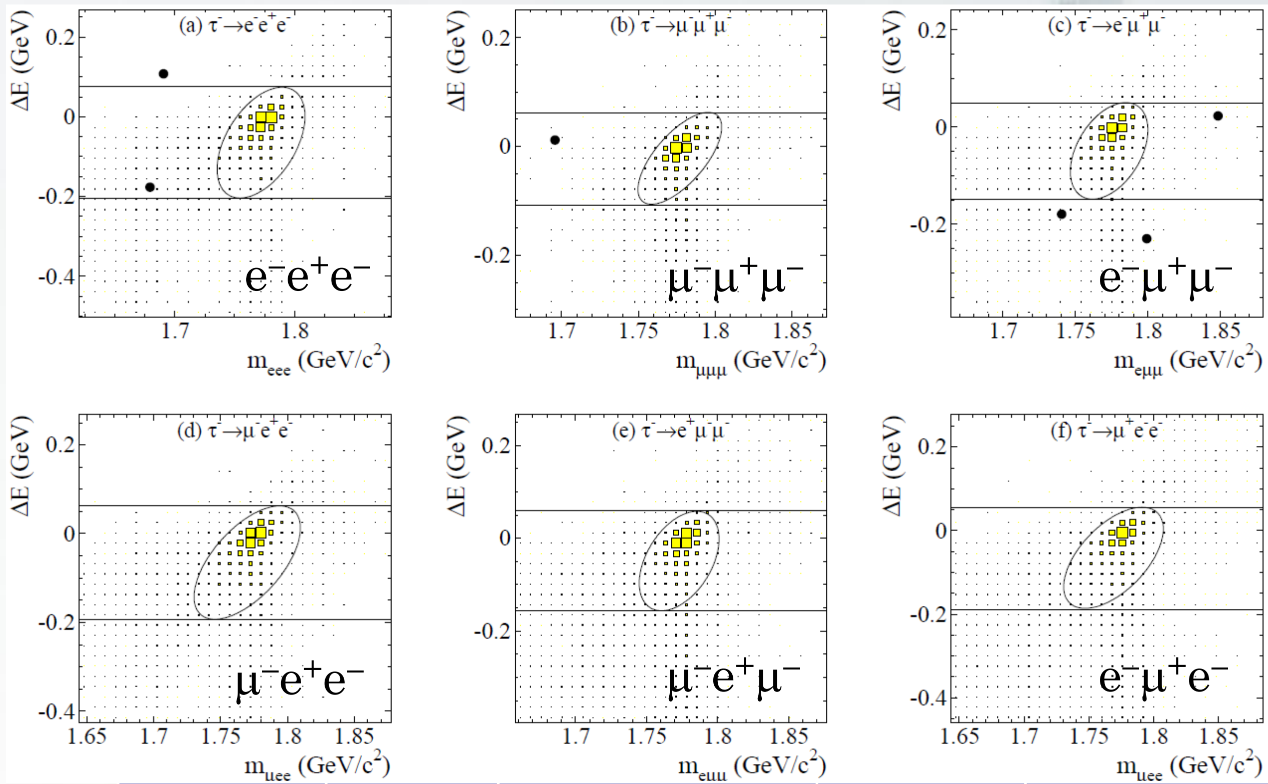
UEML=Unbinned Extended Maximum Likelihood fit

Result for $\tau \rightarrow$3leptons search

- Data: 782fb^{-1}
- No event is found in the signal region.
- **Almost BG free**
  - Expected # of BG: 0.01-0.21
  - Because of good lepton ID
- Br<(1.5-2.7)x10^{-8} at 90%CL.

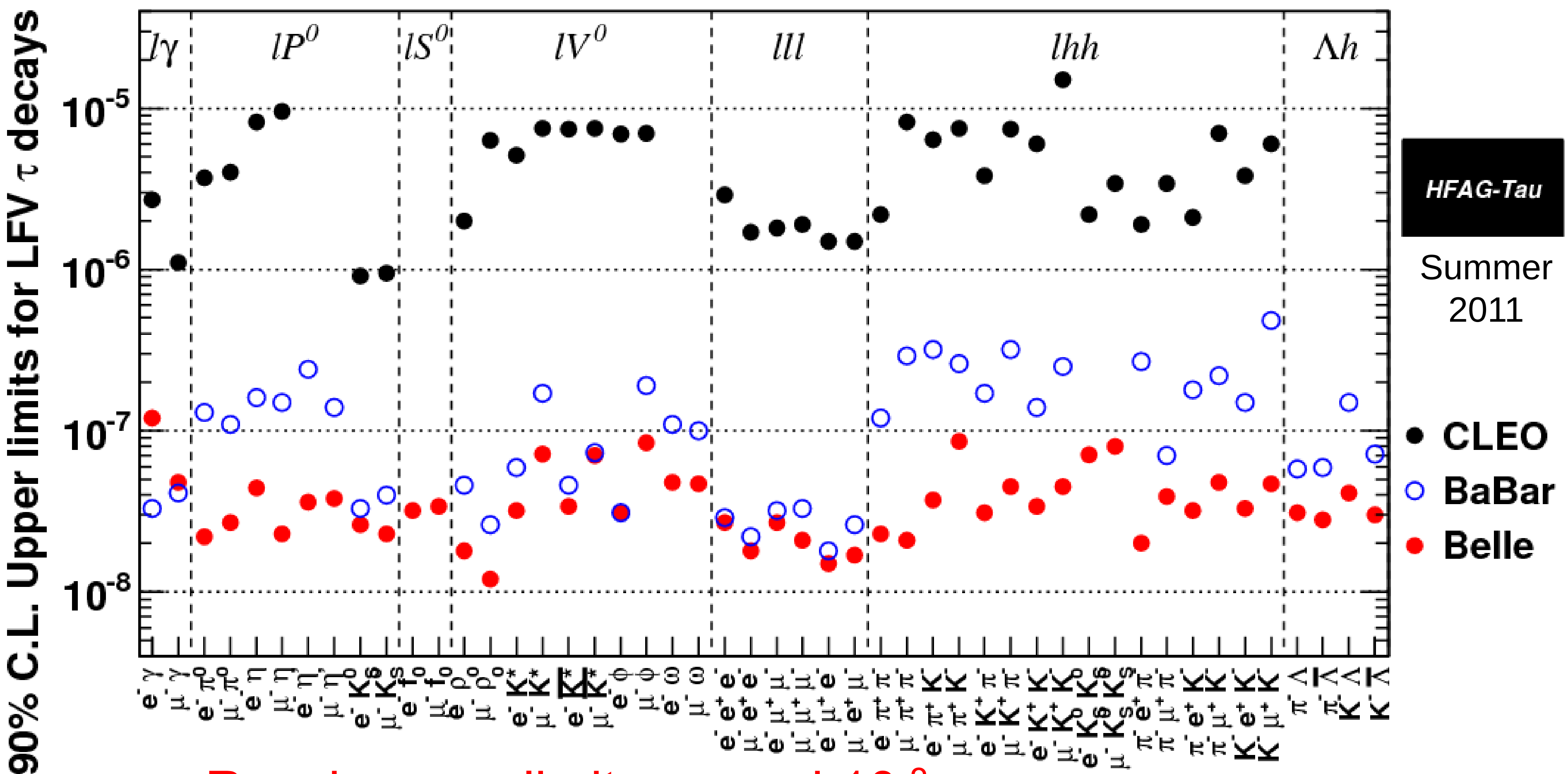
→most sensitive results

Phys.Lett.B 687,139 (2010)



Mode	ε (%)	N_{BG}^{EXP}	σ_{syst} (%)	UL (x10^{-8})
$e^- e^+ e^-$	6.0	0.21±0.15	9.8	2.7
$\mu^- \mu^+ \mu^-$	7.6	0.13±0.06	7.4	2.1
$e^- \mu^+ \mu^-$	6.1	0.10±0.04	9.5	2.7
$\mu^- e^+ e^-$	9.3	0.04±0.04	7.8	1.8
$\mu^- e^+ \mu^-$	10.1	0.02±0.02	7.6	1.7
$e^- \mu^+ e^-$	11.5	0.01±0.01	7.7	1.5

Upper limits for τ LFV searched for at Belle

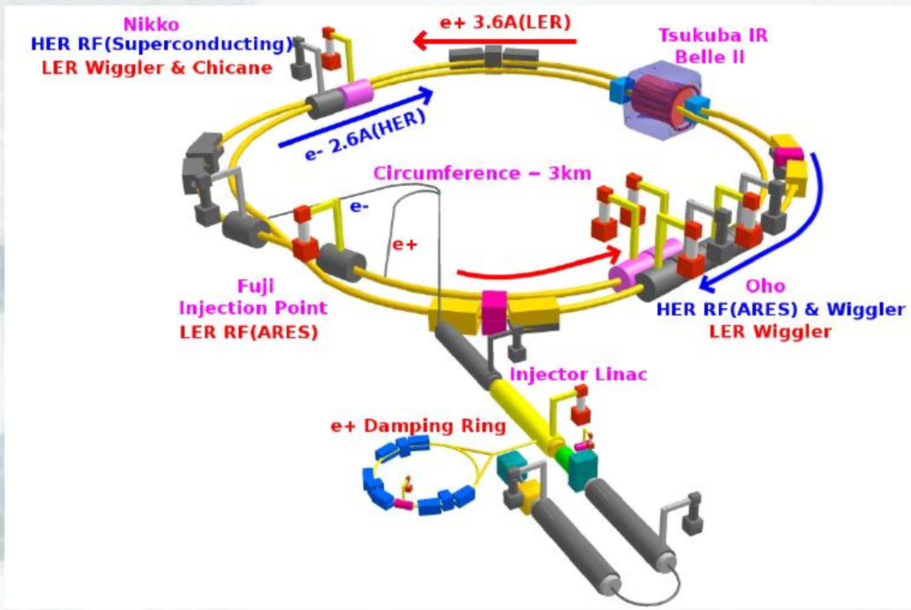


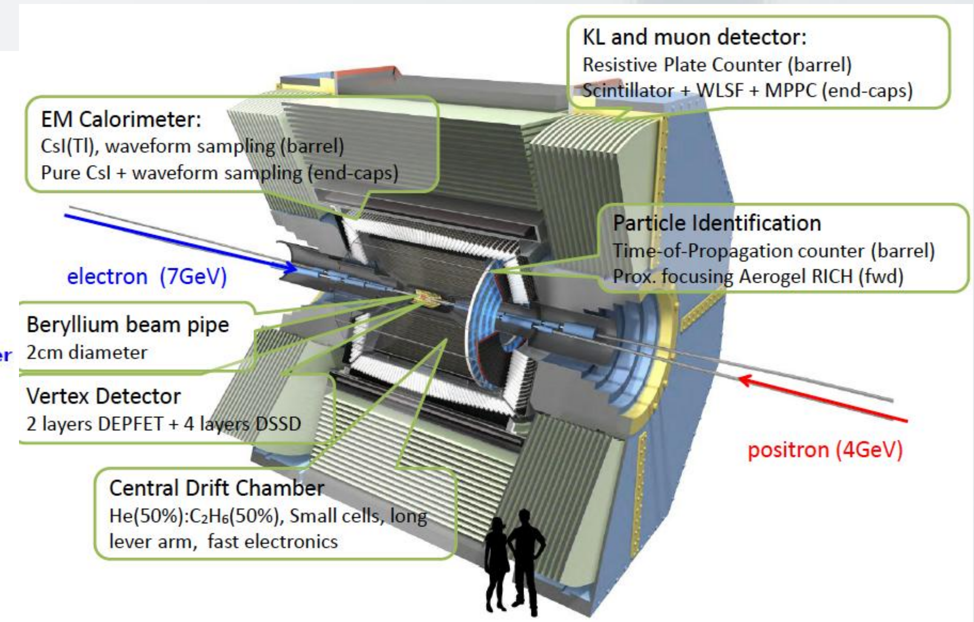
Reach upper limits around 10^{-8} ~100x more sensitive than CLEO

Update using full data samples will be finalized soon!

Prospects for τ LFV search at Belle II

SuperKEKB/Belle II



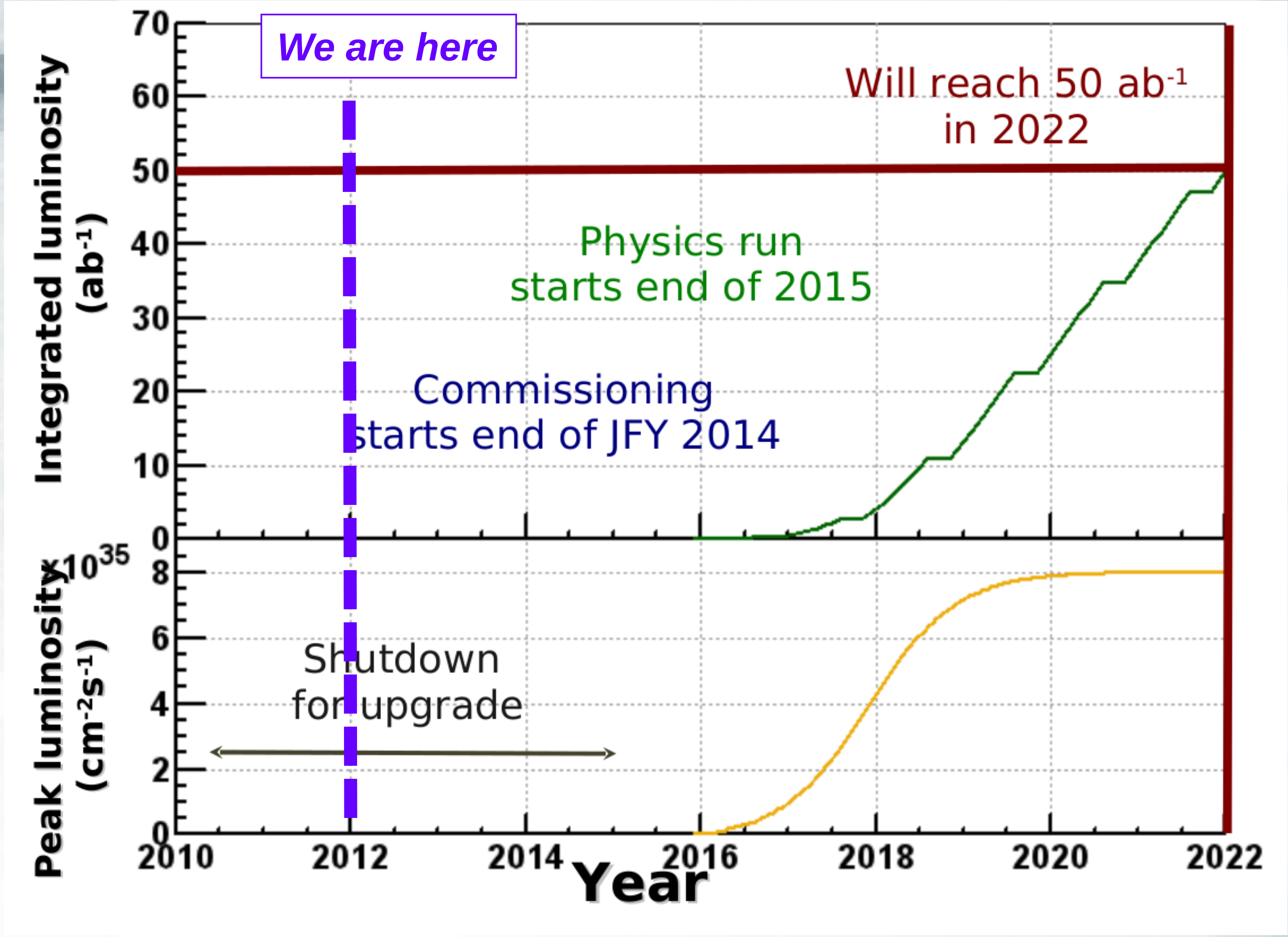


	KEKB		superKEKB	
Vertical β function:	5.9 mm	→	0.27/0.30 mm	(x20)
Beam current:	1.7/1.4 A	→	3.6/2.6 A	(x2)

→ L = 2×10^{34} $cm^{-2}s^{-1}$ → 8×10^{35} $cm^{-2}s^{-1}$ (x40)

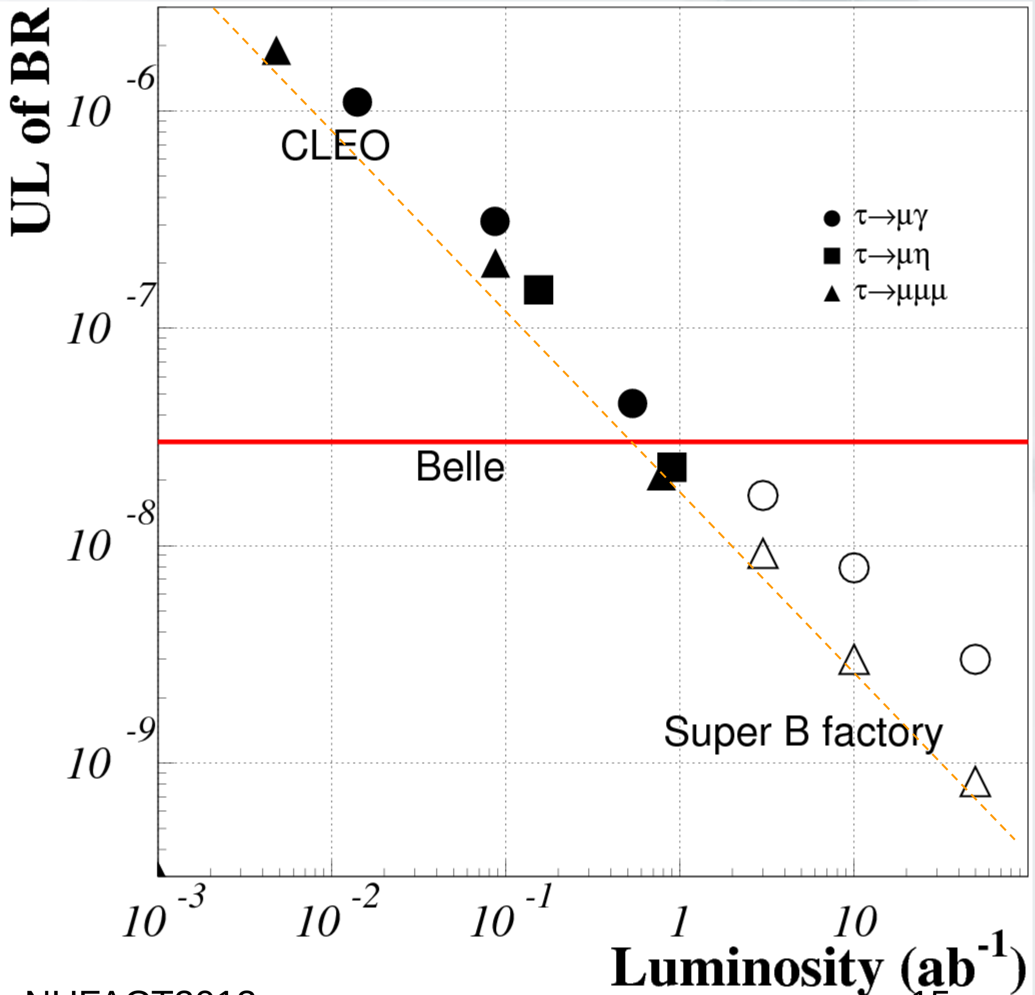
SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling, pure CsI for end-caps
KLM: RPC → Scintillator +SiPM (end-caps)

Expected luminosity on SuperKEB

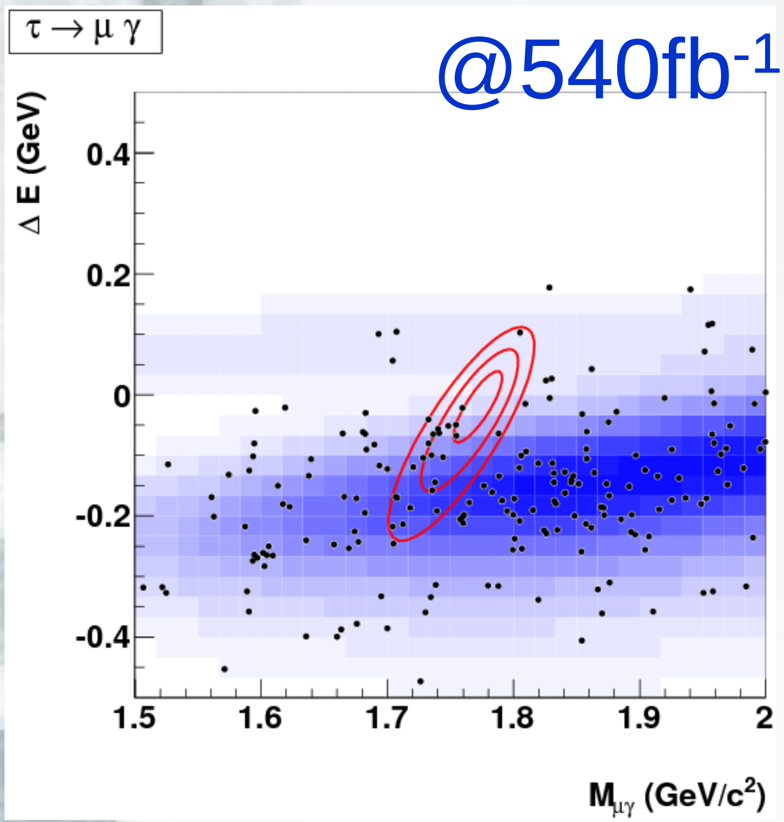


Future prospect on tau LFV

- Belle-II will collect ~10^{11} tau leptons. (=$50ab^{-1}$)
- Sensitivity depends on BG level.
  - Recent improvement of the analysis (BG understanding, intelligent selection)
    → Improve achievable sensitivity
- $\mathcal{B}(\tau \rightarrow \mu\gamma)$~O($10^{-9}$) and $\mathcal{B}(\tau \rightarrow \mu\mu\mu)$~O($10^{-10}$) at $50ab^{-1}$
  - Improvement of BG reduction is important.
    - Beam BG
    - Signal resolution

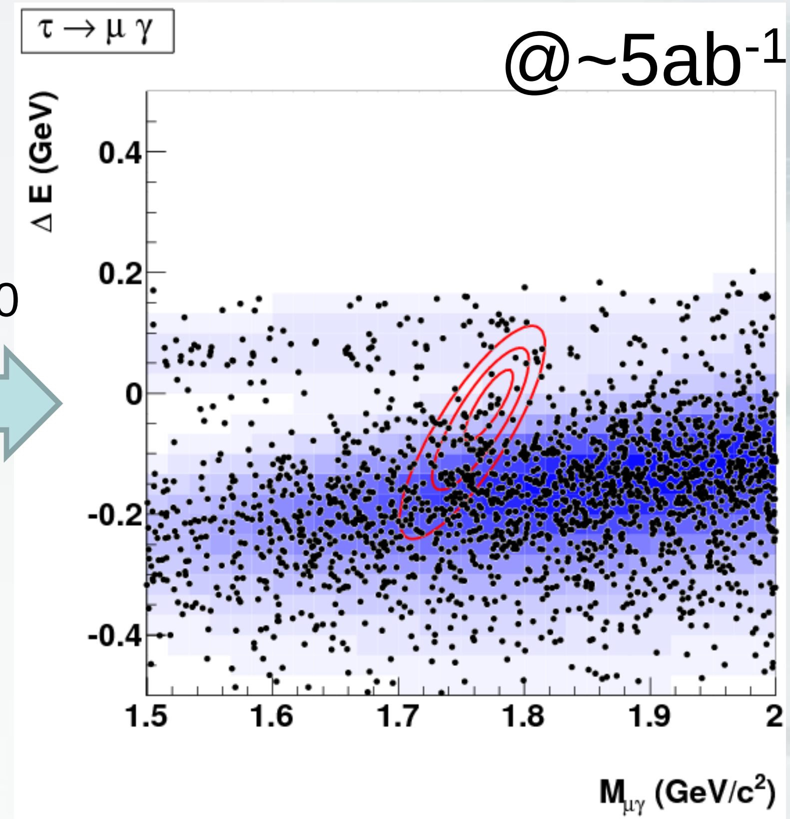


$\tau \to \mu\gamma$ @5ab^{-1}, 50ab^{-1}



~180BG events in total

x10

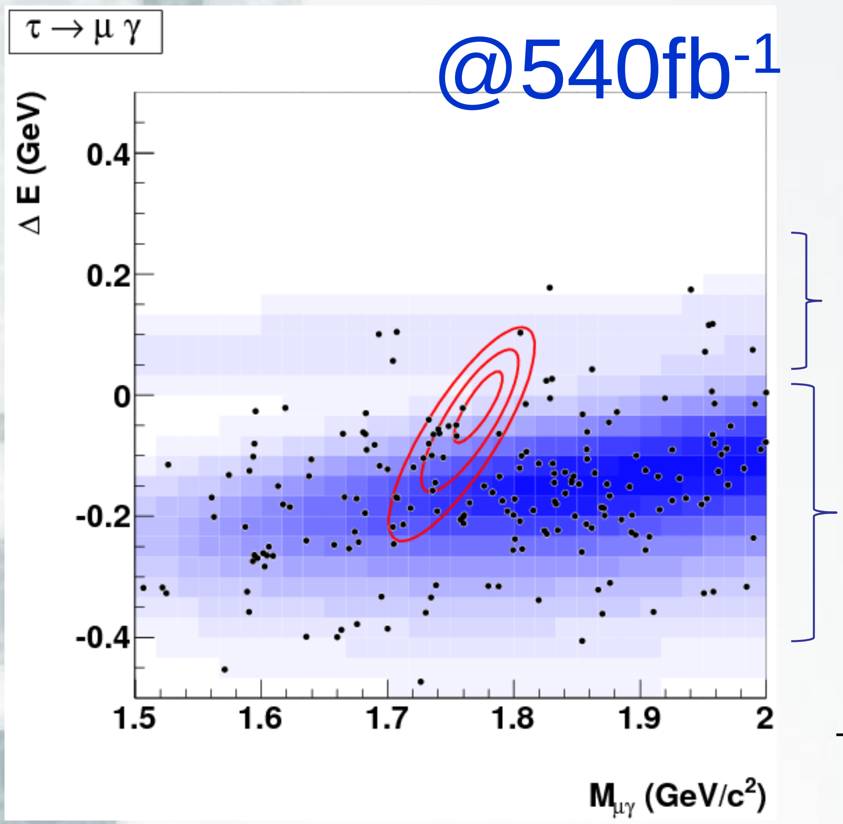


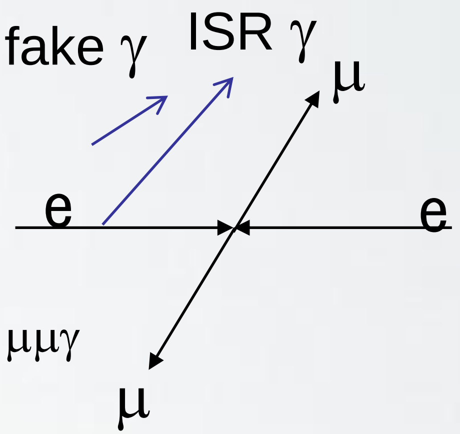
~1800BG events in total

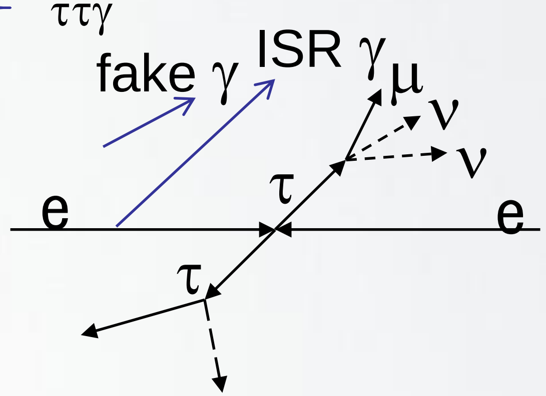
x100

?

$\tau \to \mu\gamma$ BG components







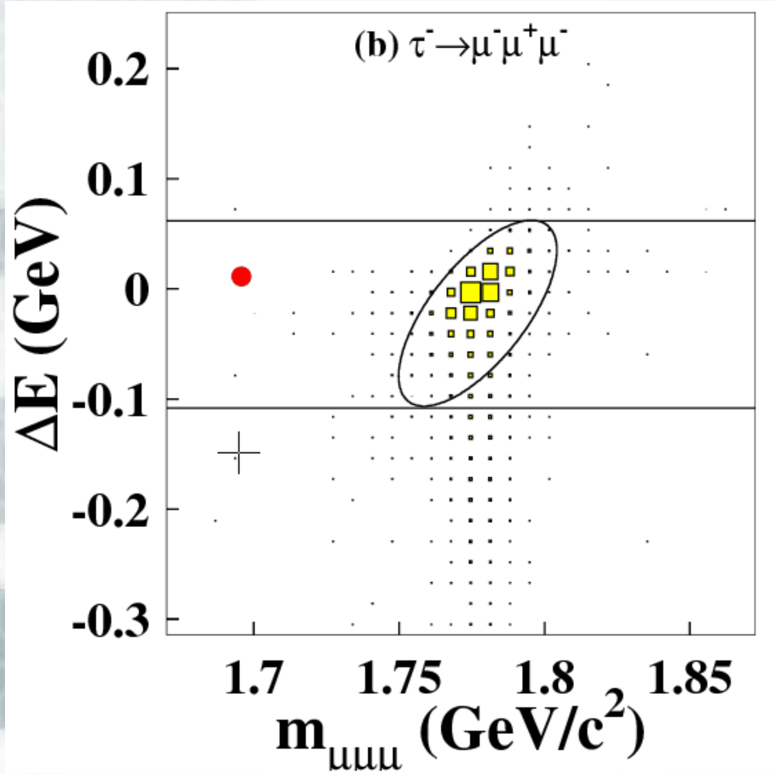
unapplied effective selection remains & μID inefficiency will decrease
→possible to reduce

upper half ellipse will be main signal-search field @ Belle II

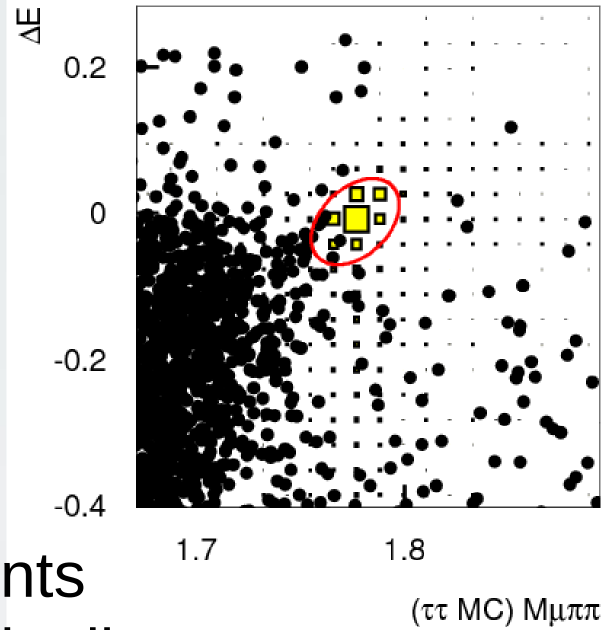
particleID works well but remains. almost all kinematical selection applied.
→hard to reject

$\tau \rightarrow \mu\mu\mu$@50ab^{-1}

- 780fb^{-1}



x70



~50ab^{-1} but 70 events does not distribute flatly because main BG comes from $\tau \rightarrow \pi\pi\pi\nu$

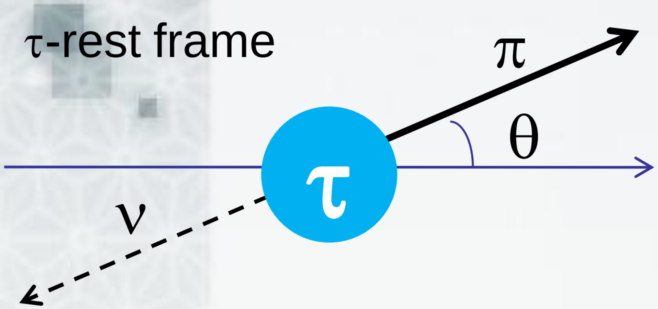
→still clean!!

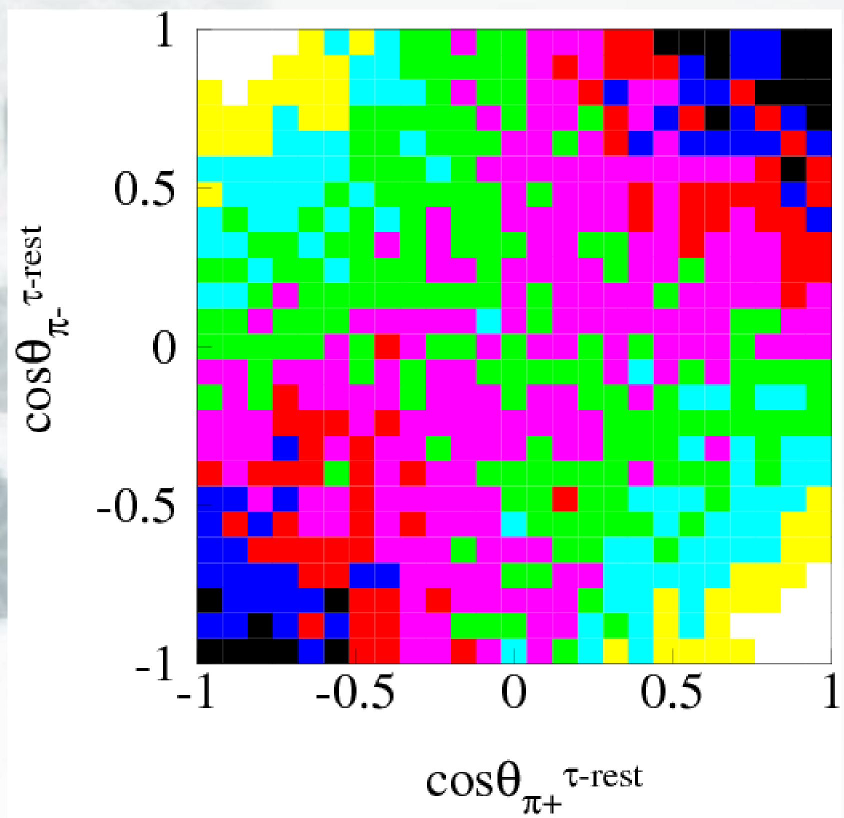
In $\tau \rightarrow \mu\pi\pi$ search, $\tau \rightarrow \pi\pi\pi\nu$ is also main BG. We have already known the effective rejection.

$\tau \rightarrow \pi\pi\pi\nu$ distribution in $\tau \rightarrow \mu\pi\pi$ selection a 5ab^{-1}. since π-fake rate in μID is 2%, this corresponds to 5x2500ab^{-1}

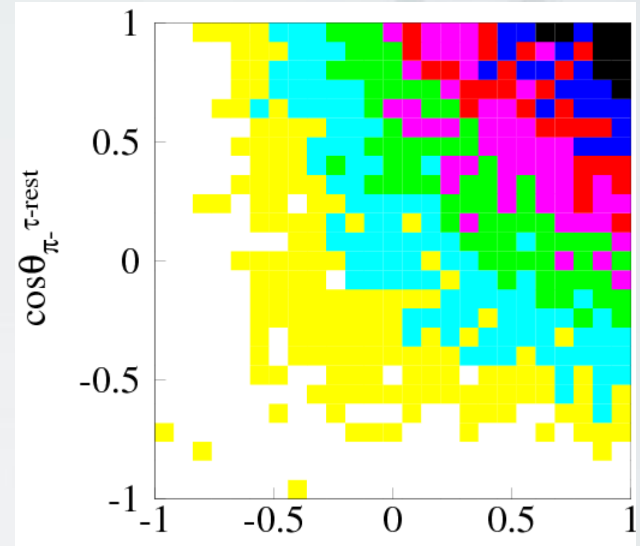
Polarized beam and τ decay

$\tau^- \rightarrow \pi^- \nu / \tau^+ \rightarrow \pi^+ \nu$

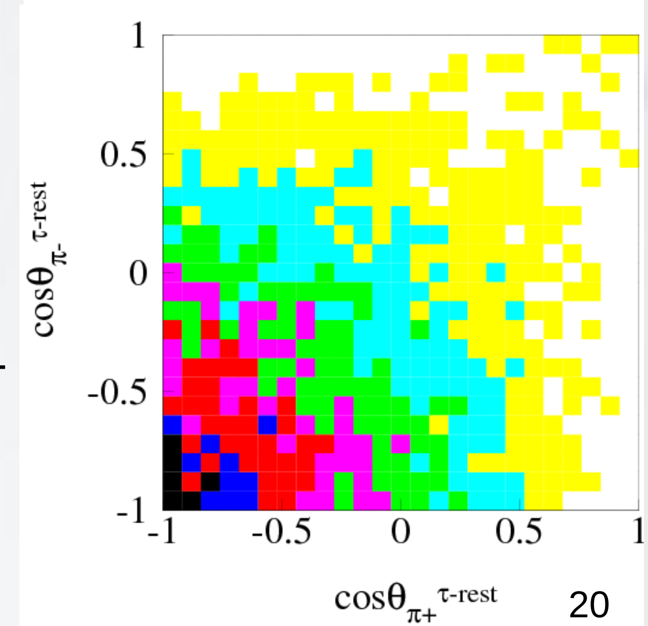




hel. of τ^- =1

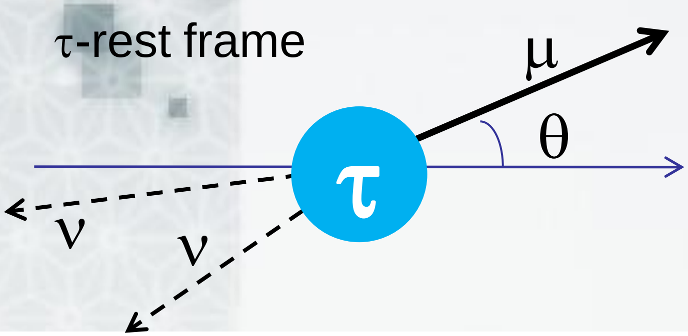


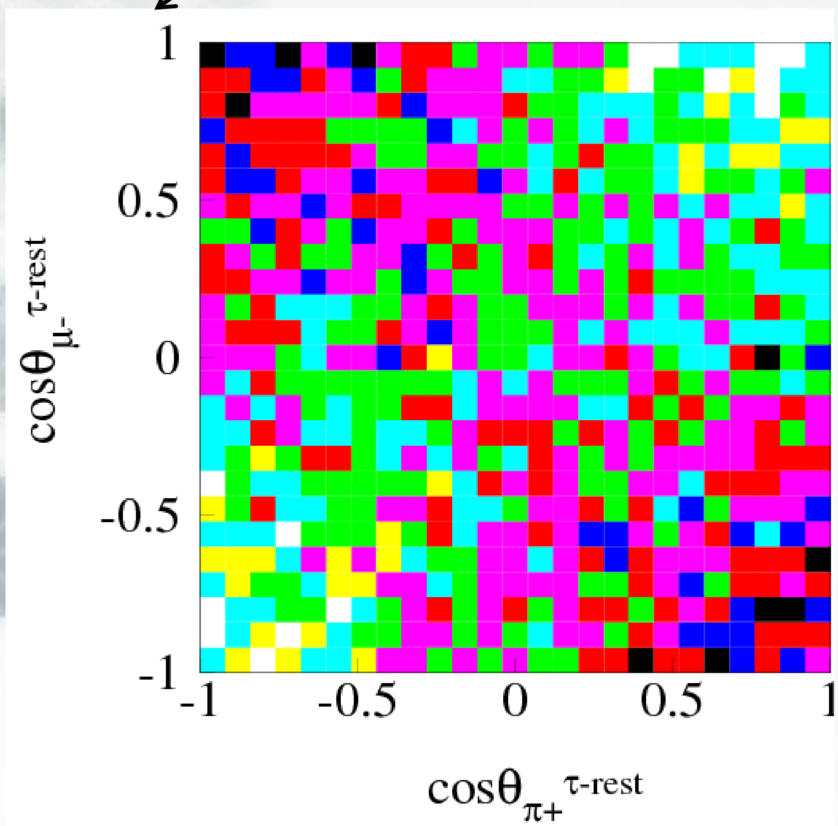
hel. of τ^- =-1



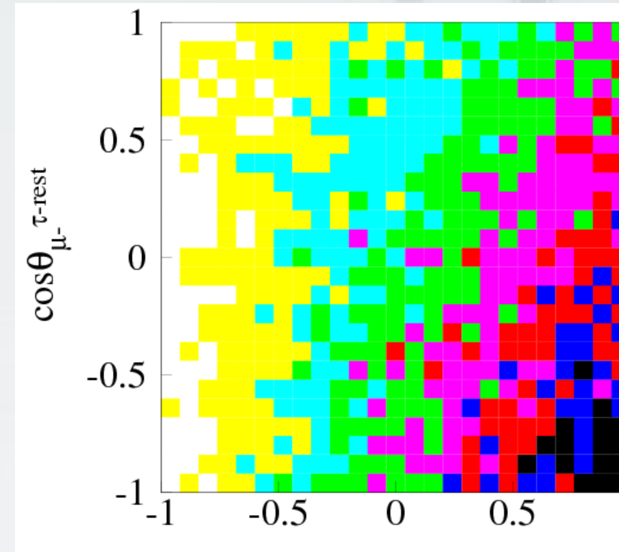
NUFACT2012

$\tau^-\to\mu^-\nu\nu/\tau^+\to\pi^+\nu$

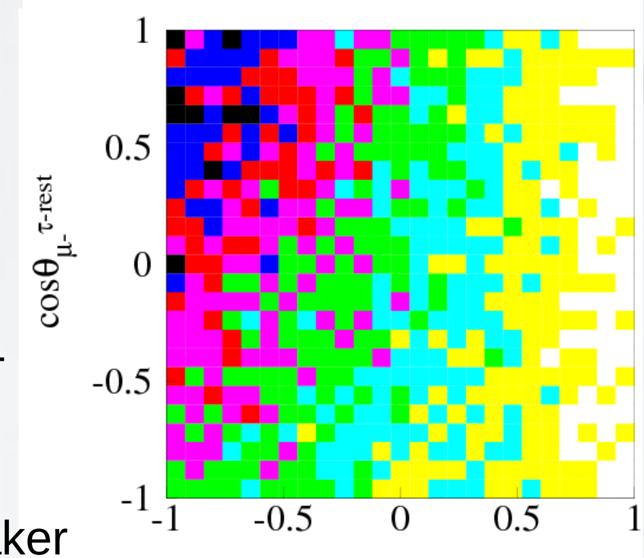




hel. of τ^- =1



hel. of τ^- =-1



Correlation is weaker than that for $\tau^-\to\pi^-\nu/\tau^+\to\pi^+\nu$.

Theoretical calc. for $\tau \rightarrow \mu\gamma$

- Most generic form for int. Lagrangian

$$\mathcal{L} = -\frac{4G_F}{\sqrt{2}}\{m_\tau A_R \overline{\tau}\sigma^{\mu\nu} P_L \mu F_{\mu\nu} + m_\tau A_L \overline{\tau}\sigma^{\mu\nu} P_R \mu F_{\mu\nu} + \mathrm{H.c.}\},$$

Consequently,

$A_L \neq 0, A_R = 0$ μ in $\mu\gamma$ behaves similarly to π in $\pi\nu$

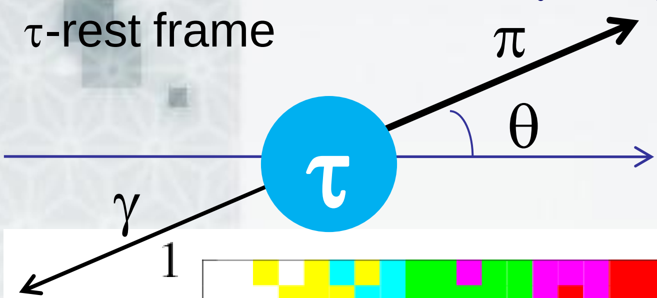
$A_L = 0, A_R \neq 0$ μ in $\mu\gamma$ behaves oppositely to π in $\pi\nu$

ex) SUSY SU(5) GUT

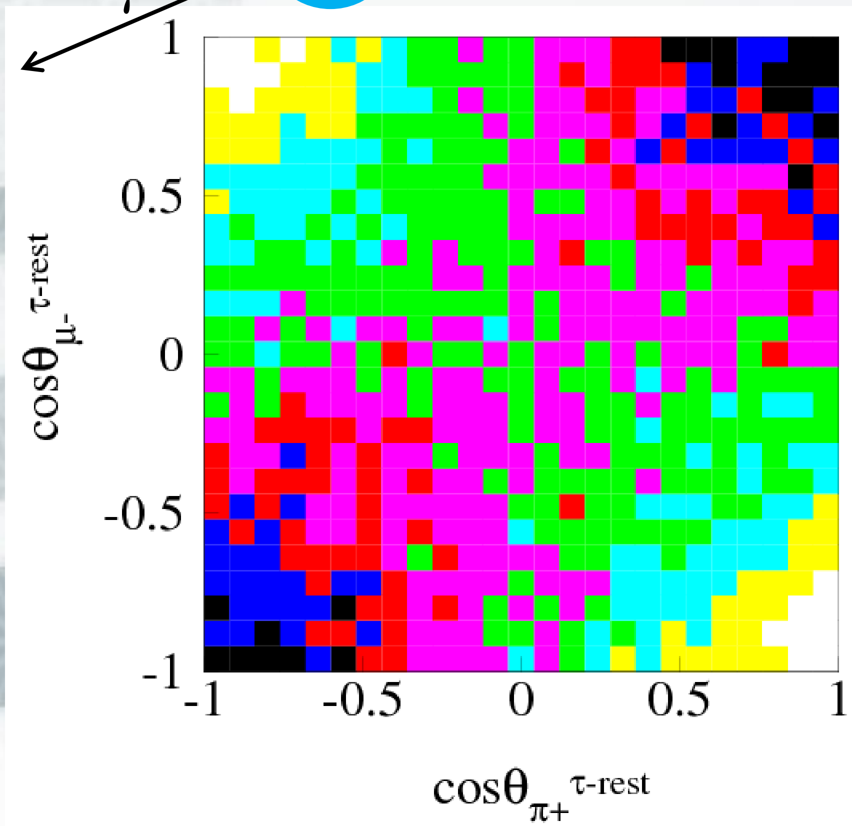
$A_L \neq 0, A_R = 0$

Phys.Rev. D63 (2001) 113003

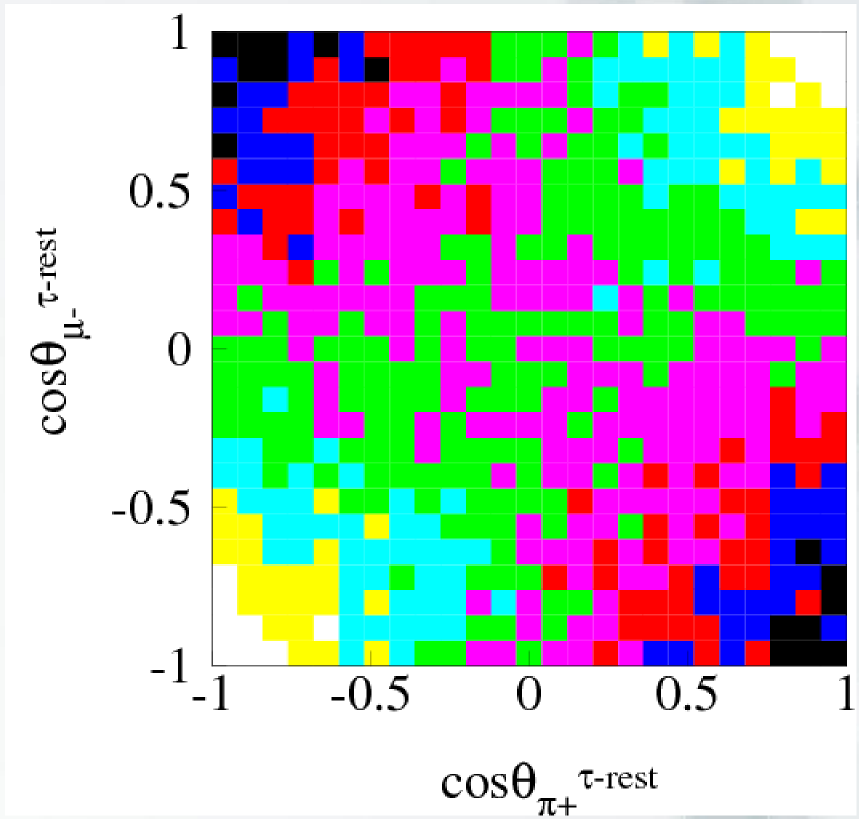
$\tau^- \to \mu^- \gamma / \tau^+ \to \pi^+ \nu$



These plots include h=±1.

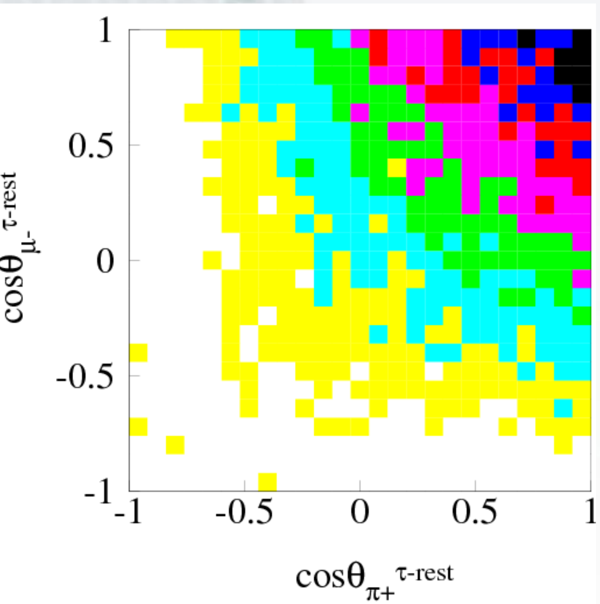


$A_L \neq 0, A_R = 0$

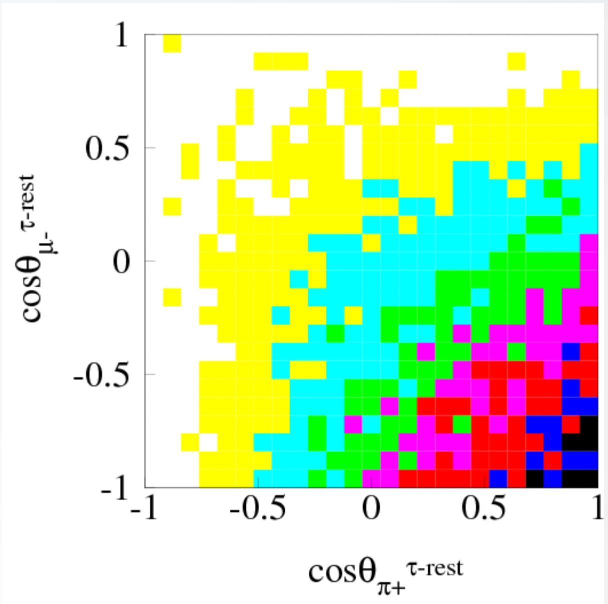


$A_L = 0, A_R \neq 0$

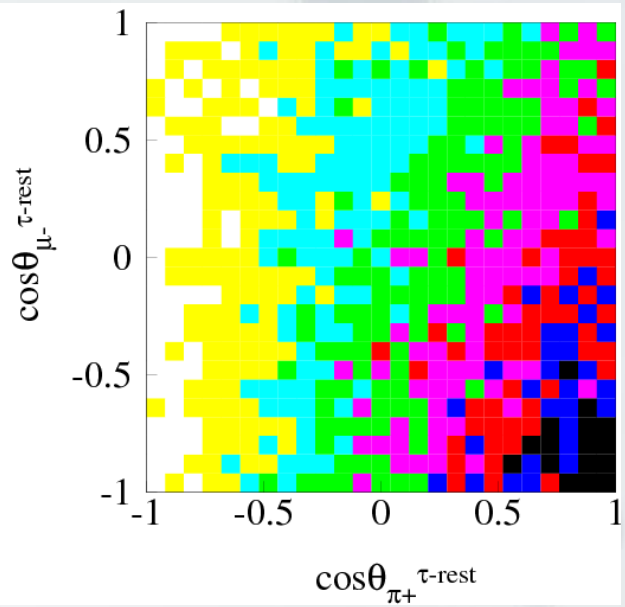
Comparison



$A_L \neq 0, A_R = 0$



$A_L = 0, A_R \neq 0$



$\tau^- \to \mu^- \nu\nu / \tau^+ \to \pi^+ \nu$

- Only h=1 case is shown.

→ We can expect only left-handed interaction case.

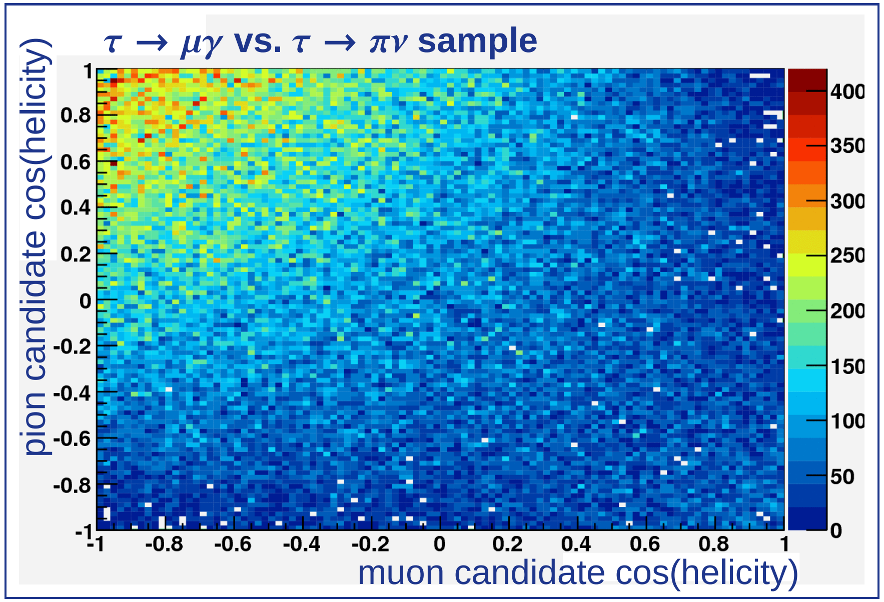
Discussion for the advantage of the polarized beam

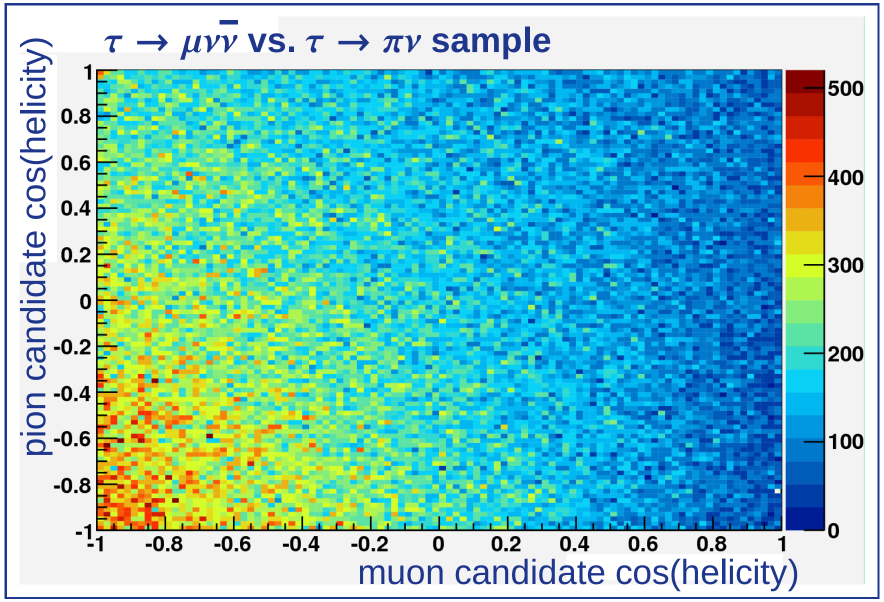
1. Anyway, for the right-handed interaction, drastic advantage is not expected.
2. How to reconstruct τ (or helicity) direction.
   - Yes, we can know the tau direction in the signal events. But, in the BG events, since γ comes from ISR, reconstructed τ is completely different from original τ.
3. Beam polarization is not equal to the tau polarization. (But, similar)
   - In the forward region, more h=1 taus will be found than h=-1 taus. (i.e., 100% tau polarization cannot be expected and beam polarization may be not 100%.)
4. Reconstruction for tag-side decay can not be expected.
   - $\tau \rightarrow \pi\nu$ is contaminated by $\tau \rightarrow \rho(\rightarrow \pi\pi^0)\nu$ with π^0 missing and $\tau \rightarrow K\nu$ with misidentification of K by π.

More real MC study is necessary.→ Taking the detector effect into account, real reconstruction of τ and evaluation of the gain from polarized beam should be considered.

SuperB $\tau \to \mu\gamma$ and $\tau \to e\gamma$ sensitivity

- extrapolate from final *BABAR* result **expected upper limit**
  - use *BABAR* efficiency and background estimates for 2σ signal box
  - assume 35% improved inv. mass resolution from more precise track-photon vertexing
  - assume 20% larger photon efficiency
  - scale from *BABAR* analysis luminosity to 75 ab^{-1} for Super*B*
- $\tau \to \mu\gamma$ expected 90% CL upper limit: $2.4{\cdot}10^{-9}$, eff 7.32%, bkg 335 ev
- $\tau \to e\gamma$ expected 90% CL upper limit: $3.0{\cdot}10^{-9}$, eff 3.90%, bkg 18 ev
- for specific LFV models, polarization can improve S/N ratio

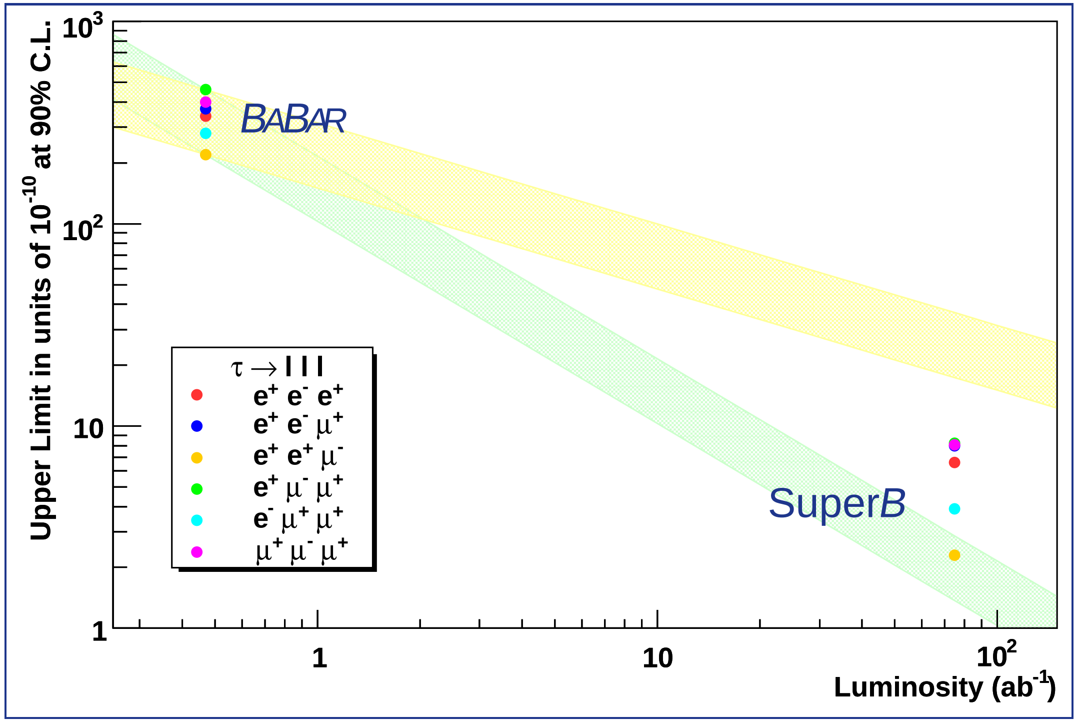




Expected 90% CL upper limits for $\tau \to 3\ell$ at SuperB@75 ab^{-1}

- re-optimizing BABAR $\tau \to 3\ell$ analysis for SuperB luminosity
- extrapolations lie between $1/\mathcal{L}$ and $1/\sqrt{\mathcal{L}}$ improvement

Channel	Eff (%)	BKG	UL(10^{-10})
$e^+e^-e^+$	5.2 ± 0.5	1.7 ± 0.6	5.1
$e^+e^-\mu^+$	2.3 ± 0.2	0.16 ± 0.05	7.5
$e^+e^+\mu^-$	8.6 ± 0.9	0.3 ± 0.1	2.4
$\mu^+\mu^-e^+$	4.2 ± 0.4	3.8 ± 1.3	8.3
$\mu^+\mu^+e^-$	6.5 ± 0.6	0.8 ± 0.3	3.4
$\mu^+\mu^-\mu^+$	4.1 ± 0.4	3.3 ± 1.0	8.1



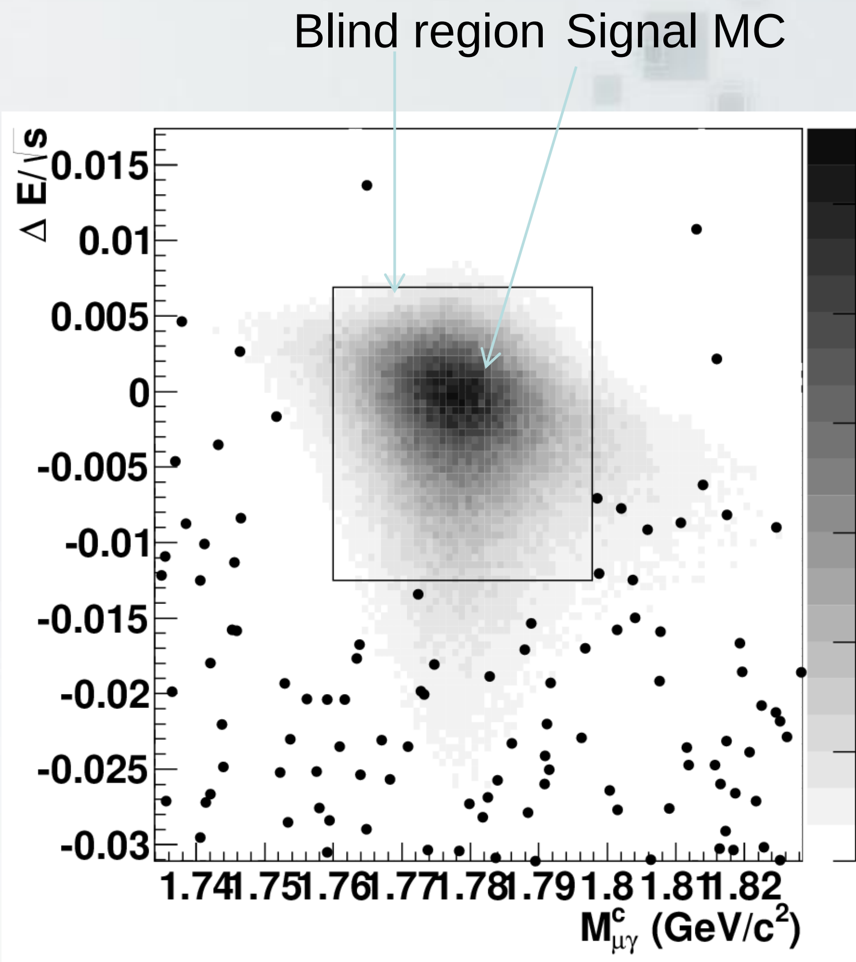
$\tau \to \mu\gamma$ search with Belle's full data sample

New search for $\tau \rightarrow \mu\gamma$

- data: $980 fb^{-1}$
  - not only Υ(4S) but also Υ(1S), Υ(2S), Υ(3S), Υ(5S)
- strategy is changed as discussed
  - Selection criteria is quit different from the previous.
- Blind analysis is performed.
- # of signal is evaluated by UEML.

Remaining events and eff.

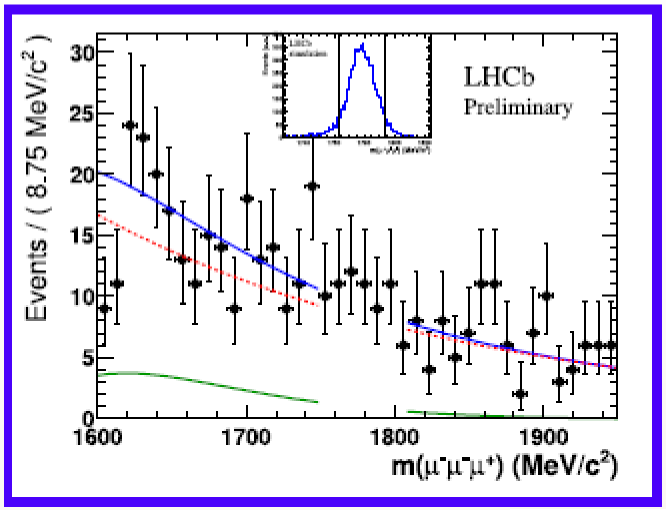
- After applying all selections,
105 events are found and the detection efficiency is 6.5%.
For the blinded region, 10.2±2.2 BG events are expected.
In total, 115.2±11.4 events are expected. →BG level reduced by 33% while efficiency is similar to the previous analysis. → The expected upper limit is $\mathcal{B}(\tau\rightarrow\mu\gamma)<5.3\times10^{-8}$ @90%CL.



The blind region has not been opend yet.

$\tau \to \mu\mu\mu$ from LHCb

Paul Seyfert's talk at FPCP2012



21 % of the signal
0.14 % of the background

- 7.9×10^{10} τ produced

(mainly comes from $D_s \to \tau\nu$)

- τ-tag is impossible.

- $\mathcal{B}(\tau \to \mu\mu\mu) < 6.3 \times 10^{-8}$ @90%CL

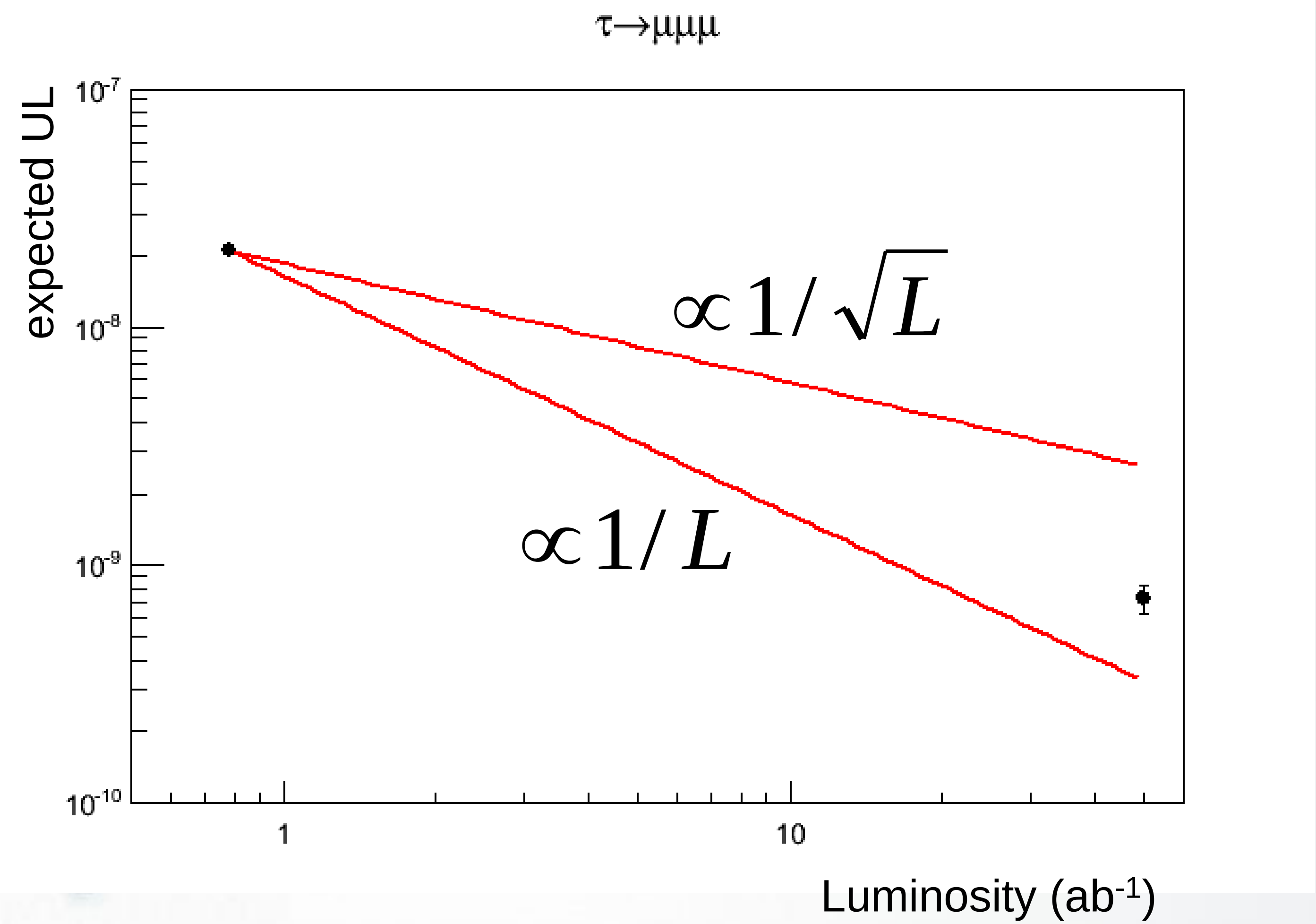
→Next year, another $1.5 fb^{-1}$ data will be accumulated.

Summary

- @Belle I
  - Around $1000 fb^{-1}$ data sample accumulated
    ~ 10^9 τ sample
  - 48 τ LFV decays have been searched for.
  - ULs for almost all modes reach $O(10^{-8})$.
    - This corresponds to 100x sensitive result than CLEO's.
    - $\tau \to \mu\gamma / e\gamma$ search with Belle's full data sample is on-going.
- @Belle II
  - x50 larger data sample is expected ~ 10^{11} τ sample
  - $\mathcal{B}_{90}(\tau \to \mu\gamma) \sim O(10^{-9})$, $\mathcal{B}_{90}(\tau \to \mu\mu\mu) \sim O(10^{-10})$
  - $\tau \to \mu\gamma$ (most BG-rich) $\tau \to \mu\mu\mu$ (most BG-clean)

    τBG:diffcult to reject, lower in ΔE
    μBG:possible to reject, higher in ΔE
    in higher ΔE region, BG-clean region will be found.
    we do not expect BG rejection by polarized beam so much.

Estimation for τ→μμμ



Expected UL is obtained by taking average of Poisson weight, i.e.,

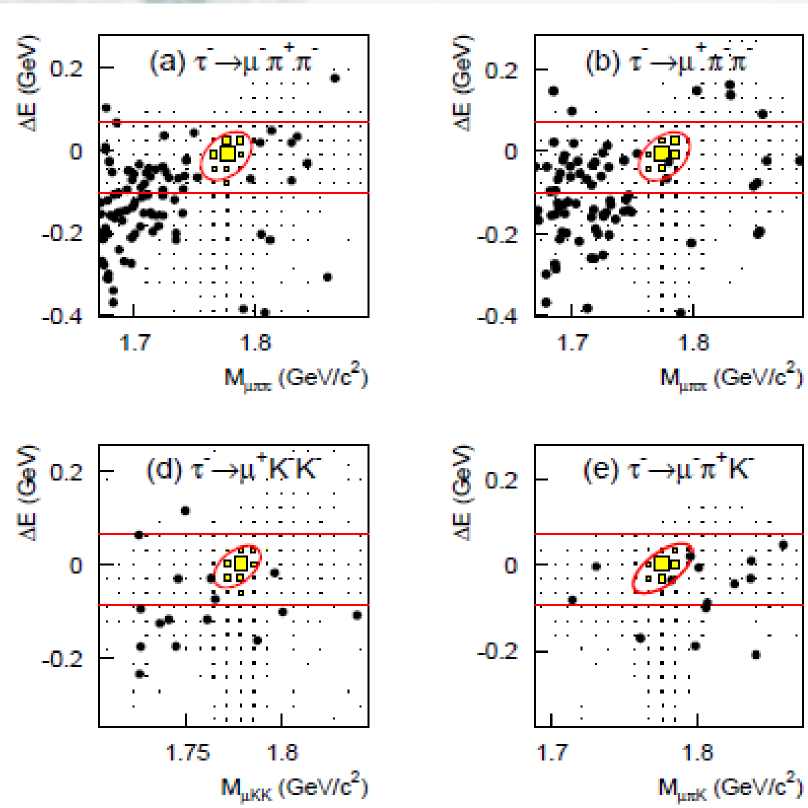
$$\bar{s}_{90} = \sum_{n=0}^{\infty} s_{90}(N^{obs} = n) \times P(n, N_{BG}^{\exp})$$

where

$$P(n,\nu) = \frac{e^{-\nu}}{n!}\nu^n$$

The error comes from varying N_{BG}^{exp} with $\pm 1\sigma$.

Result for τ→ℓhh'



In the signal region

- 1event : in $\mu^+\pi^-\pi^-$ and $\mu^-\pi^+K^-$
- no events: in other modes
- ⇒ no significant excess/Expected # of BG: 0.06-0.72

Mode	ε (%)	N_{BG}	σ_{syst} (%)	N_{obs}	s_{90}	$\mathcal{B}$ (10^{-8})
$\tau^- \to \mu^-\pi^+\pi^-$	5.83	0.63 ± 0.23	5.3	0	1.87	2.1
$\tau^- \to \mu^+\pi^-\pi^-$	6.55	0.33 ± 0.16	5.3	1	4.02	3.9
$\tau^- \to e^-\pi^+\pi^-$	5.45	0.55 ± 0.23	5.4	0	1.94	2.3
$\tau^- \to e^+\pi^-\pi^-$	6.56	0.37 ± 0.18	5.4	0	2.10	2.0
$\tau^- \to \mu^-K^+K^-$	2.85	0.51 ± 0.18	5.9	0	1.97	4.4
$\tau^- \to \mu^+K^-K^-$	2.98	0.25 ± 0.13	5.9	0	2.21	4.7
$\tau^- \to e^-K^+K^-$	4.29	0.17 ± 0.10	6.0	0	2.28	3.4
$\tau^- \to e^+K^-K^-$	4.64	0.06 ± 0.06	6.0	0	2.38	3.3
$\tau^- \to \mu^-\pi^+K^-$	2.72	0.72 ± 0.27	5.6	1	3.65	8.6
$\tau^- \to e^-\pi^+K^-$	3.97	0.18 ± 0.13	5.7	0	2.27	3.7
$\tau^- \to \mu^-K^+\pi^-$	2.62	0.64 ± 0.23	5.6	0	1.86	4.5
$\tau^- \to e^-K^+\pi^-$	4.07	0.55 ± 0.31	5.7	0	1.97	3.1
$\tau^- \to \mu^+K^-\pi^-$	2.55	0.56 ± 0.21	5.6	0	1.93	4.8
$\tau^- \to e^+K^-\pi^-$	4.00	0.46 ± 0.21	5.7	0	2.02	3.2

Set upper limits at 90%CL:

Br(τ→ℓhh')< (2.0-8.6)x10^{-8}

→most sensitive results

(preliminary)

τ→ℓℓℓ@BaBar

Update analysis from 376fb^{-1} → 477fb^{-1}

(PR D81,111101(2010))

Improve lepton ID eff.

- μ: 66%→77%
- e: 89%→91%

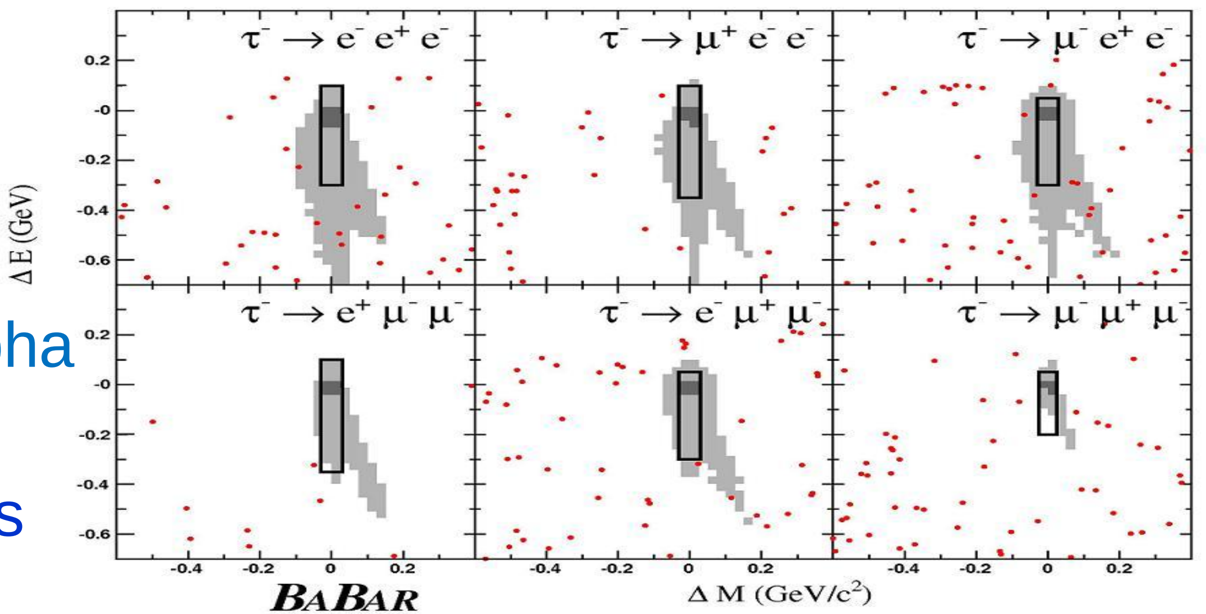
→Better BG rejection

BG : two-photon Bhabha

no events in signal region for all modes

Br<(1.8-3.3)x10^{-8}

Improved by a factor of 2-3 from previous results



Channel	Efficiency (%)	N_{bgd}	Exp. UL	N_{obs}	UL
$e^+e^-e^+$	8.6 ± 0.2	0.12 ± 0.02	3.4×10^{-8}	0	2.9×10^{-8}
$e^+e^-\mu^+$	8.8 ± 0.5	0.64 ± 0.19	3.7×10^{-8}	0	2.2×10^{-8}
$e^+e^+\mu^-$	12.6 ± 0.7	0.34 ± 0.12	2.2×10^{-8}	0	1.8×10^{-8}
$e^+\mu^-\mu^+$	6.4 ± 0.4	0.54 ± 0.14	4.6×10^{-8}	0	3.2×10^{-8}
$e^-\mu^+\mu^+$	10.2 ± 0.6	0.03 ± 0.02	2.8×10^{-8}	0	2.6×10^{-8}
$\mu^+\mu^-\mu^+$	6.6 ± 0.6	0.44 ± 0.17	4.0×10^{-8}	0	3.3×10^{-8}

Frequently asked question

- Why $\tau \to e\gamma$ UL's are different between Belle and BaBar?

→Expected upper limits are same while observed upper limits are different.

TABLE I. Means and resolutions of m_{EC} and ΔE distributions for the signal MC events, the numbers of observed (obs) and expected (exp) events inside the 2σ signal ellipse, the signal efficiencies (ε), and the 90% C.L. upper limits (UL).

Decay modes	$\langle m_{EC} \rangle$ (MeV/c^2)	$\sigma(m_{EC})$ (MeV/c^2)	$\langle \Delta E \rangle$ (MeV)	$\sigma(\Delta E)$ (MeV)	2σ signal ellipse obs	2σ signal ellipse exp	ε (%)	UL ($\times 10^{-8}$) obs	UL ($\times 10^{-8}$) exp
$\tau^\pm \to e^\pm \gamma$	1777.3	8.6	−21.4	42.1	0	1.6 ± 0.4	3.9 ± 0.3	3.3	9.8
$\tau^\pm \to \mu^\pm \gamma$	1777.4	8.3	−18.3	42.2	2	3.6 ± 0.7	6.1 ± 0.5	4.4	8.2

BaBar's paper: PRL 104, 021802 (2010)

BaBar observes smaller number of the event than expected.
expected: 1.6 +- 0.4
observed: 0
} this makes observed UL smaller.

Predicted BF for $\tau \to \mu\gamma$ in various models

- Various models predict BF for $\tau \to \mu\gamma$.

	reference	$\tau \to \mu\gamma$	$\tau \to \mu\mu\mu$
SM + heavy Maj ν_R	PRD 66(2002)034008	10^{-9}	10^{-10}
Non-universal Z'	PLB 547(2002)252	10^{-9}	10^{-8}
SUSY SO(10)	PRD 68(2003)033012	10^{-8}	10^{-10}
mSUGRA+seesaw	PRD 66(2002)115013	10^{-7}	10^{-9}
SUSY Higgs	PLB 566(2003)217	10^{-10}	10^{-7}

These numbers are the most optimistic case.

Predicted BF in various models

Ratios of LFV decay BFs make us distinguish between NP models.

	SUSY+GUT (SUSY+Seesaw)	Higgs mediated	Little Higgs	non-universal Z' boson
$\left(\dfrac{\tau \to \mu\mu\mu}{\tau \to \mu\gamma}\right)$	$\sim 2 \times 10^{-3}$	0.06~0.1	0.4~2.3	~16
$\left(\dfrac{\tau \to \mu ee}{\tau \to \mu\gamma}\right)$	$\sim 1 \times 10^{-2}$	$\sim 1 \times 10^{-2}$	0.3~1.6	~16
$Br(\tau \to \mu\gamma)$ @Max	$<10^{-7}$	$<10^{-10}$	$<10^{-10}$	$<10^{-9}$

Favourite modes $\tau \to \mu\gamma$ ⟷ $\tau \to \mu\mu\mu$

Thus, it is important to search for various kinds of τ LFV.

→ We have performed 48 analyses for τ LFV with the Belle data sample.

Conclusions

- SuperKEKB fully funded
  - Approved by Japanese government in December 2010 and by Japanese Diet (parliament) in March 2011
- Belle II detector 50% funded by Japanese government
- Funding in other countries requested or already approved
- MoU signed with German and Slovenian funding agencies

- Exciting and Rich program of Physics for Belle II
- Complementary approach to High Energy Colliders, LHCb
- Look forward to friendly competition from LHCb and SuperB
- Construction well underway.
- First collisions in 2015
- Not too late to join!

Next Open Collaboration meeting – July 22-25 Bad Aibling, Germany

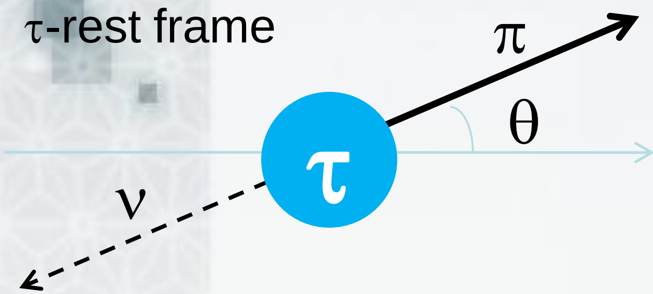
http://indico.mppmu.mpg.de/indico/conferenceDisplay.py?confId=1636

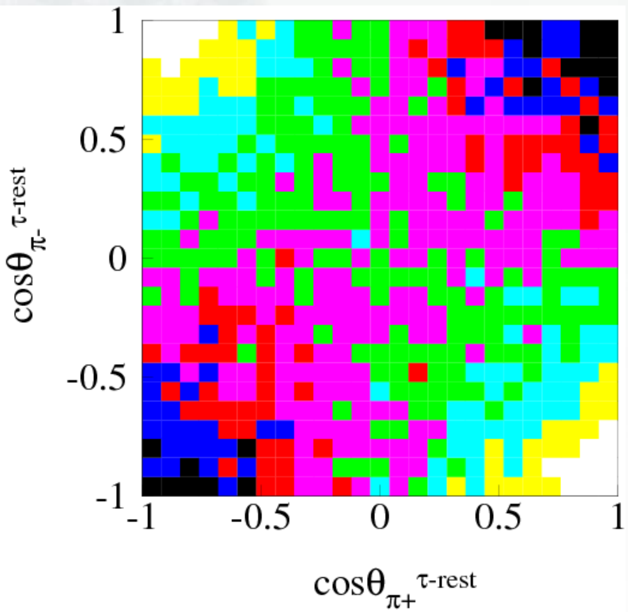
http://belle2.kek.jp/

To obtain helicity angle distribution.

When we see the helicity of tau-, the figure can be divided into 2 fugures.

τ-rest frame

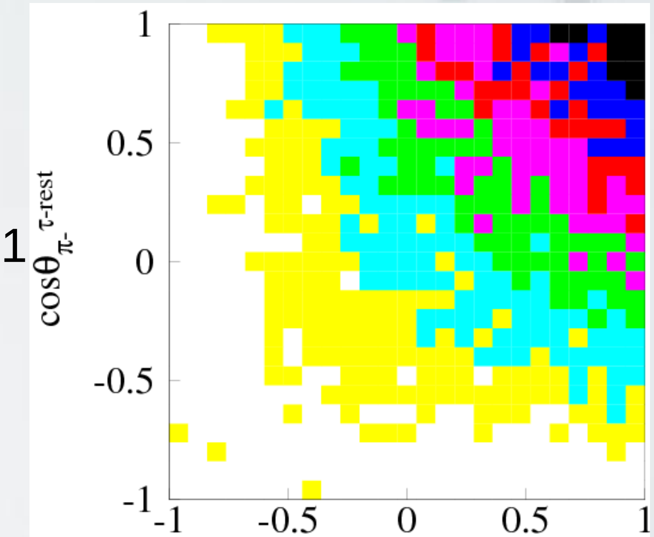




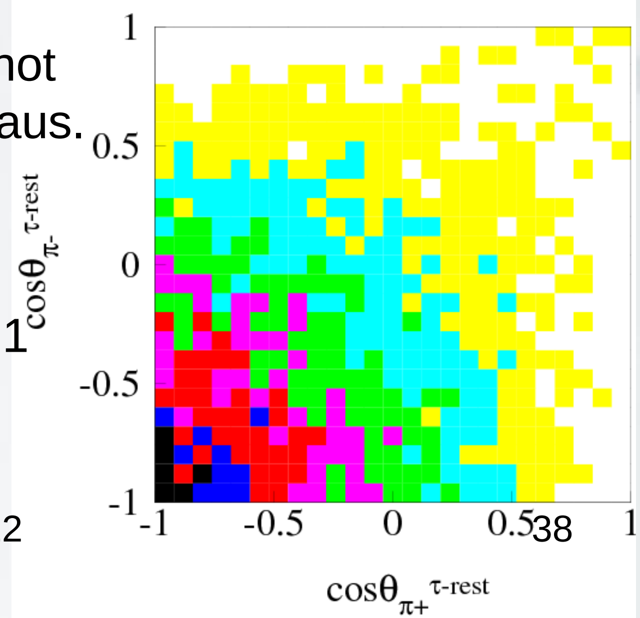
This angle is between tau direction and pi direction.
And at this figure, we donot care the helicity of both taus.

angle distribution of pi to tau direction for $\tau^-\to\pi^-\nu/\tau^+\to\pi^+\nu$

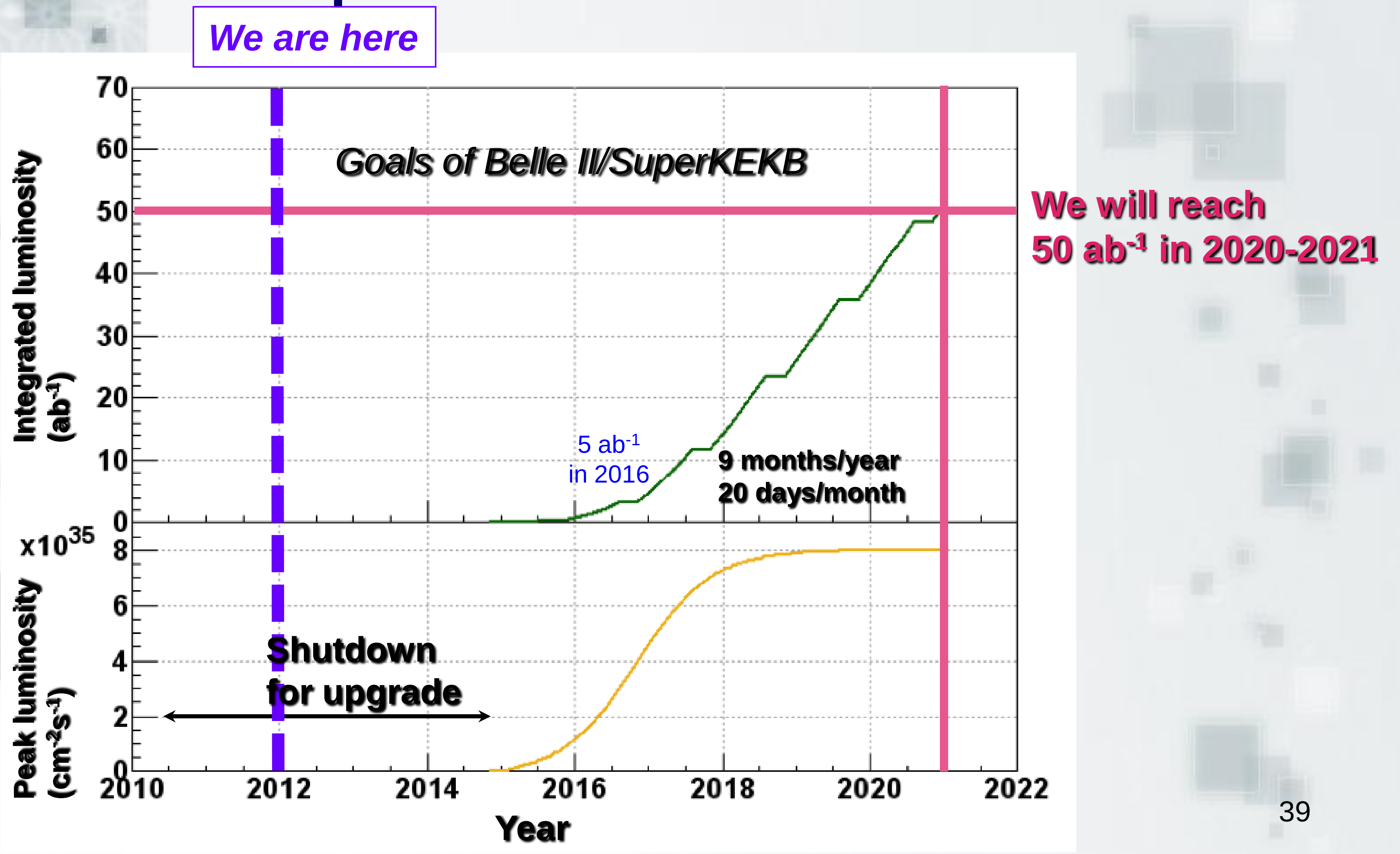
hel. of τ^- =1

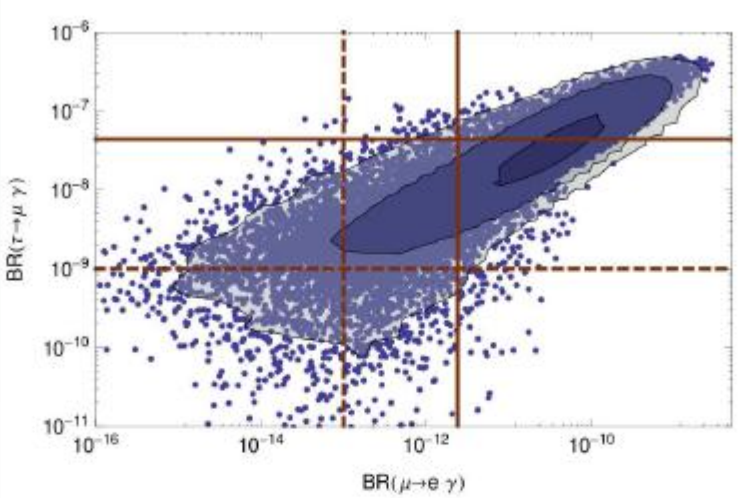


hel. of τ^- =-1



Expected luminosity on SuperKEB




10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
BR($\tau \to \mu\ \gamma$)
10^{-16}
10^{-14}
10^{-12}
10^{-10}
BR($\mu \to e\ \gamma$)