

Miniworkshop on tau lepton physics

Cinvestav, 22-23 may 2017, México City

Mexican Group at Belle II
Organizers: Pablo, Eduard, Ivan, Gabriel
“Frontera de la Ciencia”, project 296



τ _____



μ _____
 e _____

The only lepton that can decay into hadrons...and in a large diversity of other channels

Experiment	Number of τ pairs
LEP	$\sim 3 \times 10^5$
CLEO	$\sim 1 \times 10^7$
BaBar	$\sim 5 \times 10^8$
Belle	$\sim 9 \times 10^8$
Belle II	$\sim 10^{12}$

4.5 billion $\tau^+\tau^-$ pairs in full dataset from
 $\sigma(\tau^+\tau^-)_{E=\Upsilon(4S)} = 0.9 \text{ nb}$

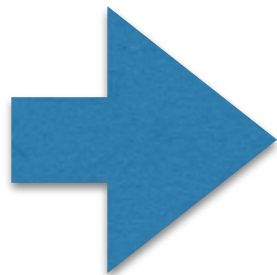
What we have learnt so far from tau?

- Despite its heavyness, the tau lepton is very much SM-like; \Rightarrow useful tool for precision SM tests and New Physics searches/constraints
- Tau decays: No anomalies observed (too low $|V_{us}|$?).
- Tau in B meson and Higgs boson decays: possible excess

Many interesting issues remain worth to be studied after 40 years!

Tau physics is a very interesting and clean Lab:

- ▶ Fundamental parameters: m_τ , $\alpha_s(m_\tau)$, V_{us} , m_s **Golterman, Passemar, Banerjee**
- ▶ Tests of SM properties: LFU, structure of weak currents, **Epifanov, Passemar, Banerjee**
- ▶ Potential for NP: LFU, LFV, LNV, EDM, MDM, ... **González-Sprinberg, Passemar, Banerjee**
- ▶ Meson spectroscopy in a clean environment (ρ , K^* , a_1 , T, S, ...) **Shekhovtsova**
- ▶ Anomalies in production: $R(D^{(*)})$, $H \rightarrow \mu\tau$ **Banerjee**
- ▶ Novel weak currents in Michel parameters: **Epifanov, Sasaki**
- ▶ Analysis tools and generator events: **Was, Was, Shekhovtsova, Zarembo**



BR's, spectral functions, good control of hadronic uncertainties, radiative corrections, polarization measurements, ...

Summary of discussions in a few words

- Better determinations of $|V_{us}|$ required to test unitarity. Many channels in strange tau decays. Br's, Strange spectral functions.
- Five-body leptonic decays: further information on Michel parameters to constrain New currents
- Precision leptonic and semileptonic decays can further constrain models (h, H^\pm , LQ, SUSY, heavy ν 's...)
- Spin-spin correlations among dominant decays of tau leptons, useful to further constrain NP through MP
- LFV decays: if observed, disentanglement of NP through correlations of different channels. LFV different in τ than in μ
- Imagine ways for a first measurement of τ MDM .

Golden studies: CP and LF violation in tau decays

Estimated sensitivities

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multiplicity
Physics”

	Current sensitivity/	Belle II sensitivity/
$\text{Br}(\tau \rightarrow \mu \gamma)$	$\text{Br} < 10^{-8}$	$\text{Br} \sim 10^{-9} \sim 10^{-10}$
$A_{\text{CP}}(\tau \rightarrow K_S \pi \nu_\tau)$	$(-0.36 \pm 0.23 \pm 0.11)\%$	$\times 70$ more sensitive
$ \text{Re}, \text{Im}(d_\tau) $	$\leq 10^{-17}$	$\leq 10^{-18} \sim 10^{-19}$
$\text{Br}(\tau \rightarrow \pi \eta \nu)$	$\leq 10^{-4}$	under study
$\rho, \eta, \xi_\rho \xi, \xi_\rho \xi \delta$	Stat Uncert $\sim 10^{-3}$	Stat Uncert $\sim 10^{-4}$
$\text{Br}(\tau \rightarrow \mu \pi^0, \mu \eta)$	$\text{Br} < (2.7, 2.3) \times 10^{-8}$	$\text{Br} < 10^{-10}$
$\text{Br}(\tau \rightarrow \mu \mu \mu)$	$\text{Br} < 2.1 \times 10^{-8}$	$\text{Br} < 10^{-9}$
$R(D), R(D^*)$	$\pm 0.047, \pm 0.017$	$\pm 0.010, \pm 0.005$

Further improvements are expected in (allowed, rare and forbidden) exclusive hadronic channels

Wish list of our group in Belle II:

Podesta

- $\tau^- \rightarrow K_S \pi^0 \pi^- \nu_\tau$: BR and spectrum measurements interesting for CP violation studies and isospin breaking in $K^*(892)$
- Inclusion of backgrounds relevant for SCC in tauola
- Better measurements of spectral functions of interest for m_s , V_{us} and $\alpha_s(m_\tau)$ and of new exclusive channels
- Interest in collaboration on studies of five-body leptonic channels at Belle II
- Generation of tau data from MC campaigns.
- Interest of Mexican Group in study of $\tau^- \rightarrow \ell^- (\pi^0 \pi^0, \pi^0 \eta, \eta \eta)$ channels
- LNV, heavy sterile neutrinos in tau decays

Proceedings: J. Phys. Conf. Ser (Pablo, Gabriel)

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Thank you to all the speakers!!!!

**Thank you very much for attending this meeting
and for very interesting discussions**

We are eager for further collaboration in the future

**We invite theorist of the mexican community with
interest in tau lepton physics to contribute with ideas.**

Nice trip back home!

Golden studies: CP and LF violation in tau decays

Estimated sensitivities

	Current sensitivity/	Belle II sensitivity/
$\text{Br}(\tau \rightarrow \mu \gamma)$	$\text{Br} < 10$	$\text{Br} \sim 10$
A	$(-0.36 \pm 0.23 \pm 0.11)\%$	$\times 70$ more sensitive
$ \text{Re}, \text{Im}(d)$	\approx	\approx
$\text{Br}(\tau \rightarrow \pi \eta \nu)$	\approx	under study
ρ	Stat Uncert	Stat Uncert ~ 10
Br	$\text{Br} < (2.7, 2.3) \times 10$	$\text{Br} < 10$
$\text{Br}(\tau \rightarrow \mu \mu \mu)$	$\text{Br} < 2.1 \times 10$	$\text{Br} < 10$
$R(D), R(D^*)$	$\pm 0.047, \pm 0.017$	$\pm 0.010, \pm 0.005$

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