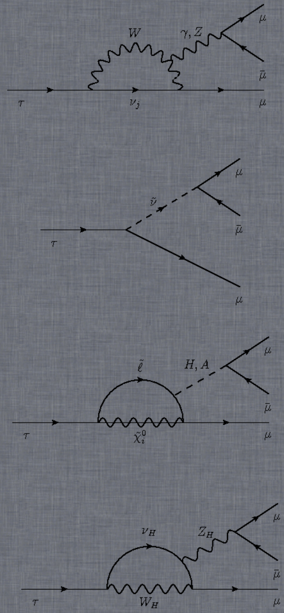
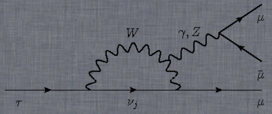
τ Physics at τ - c factory

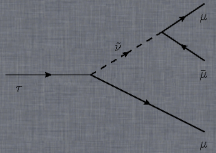
Alberto Lusiani, Marcin Chrząszcz

30th November 2012

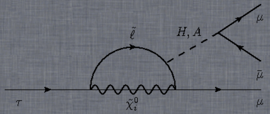




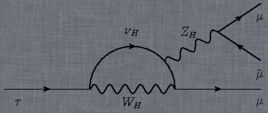
W
γ, Z
μ
$\bar{\mu}$
τ
ν_j
μ



$\tilde{\nu}$
μ
$\bar{\mu}$
τ
μ



$\tilde{\ell}$
H, A
μ
$\bar{\mu}$
τ
$\tilde{\chi}_i^0$
μ



ν_H
Z_H
μ
$\bar{\mu}$
τ
W_H
μ

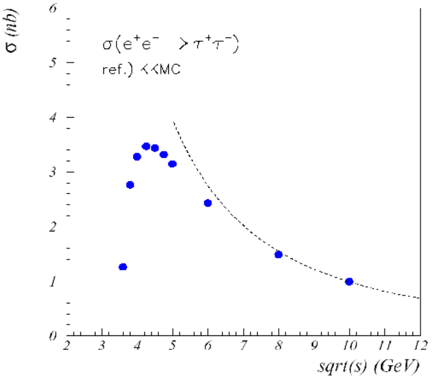
$\Upsilon(4S)$ vs $\Psi(3770)$ in τ sector

① $\tau\overline{\tau}$ cross section

- $\sigma_{\tau\overline{\tau}}(m_{\tau\overline{\tau}}) = 0.1nb$
- $\sigma_{\tau\overline{\tau}}(\Upsilon(4S)) = 0.9nb$
- $\sigma_{\tau\overline{\tau}}(\Upsilon(2S)) = 2.5nb$
- $\sigma_{\tau\overline{\tau}MAX}(4.25\text{GeV}) = 3.5nb$

$$\sigma_{\tau\overline{\tau}} = \frac{4\Pi\alpha^2}{3s}\frac{3\beta - \beta^2}{2},$$

β velocity of τ



A.Lusiani, M.Chrząszcz 2012

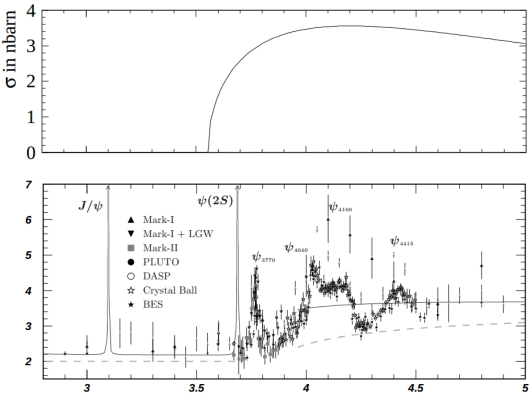
$\Upsilon(4S)$ vs $\Psi(3770)$ in τ sector

(2) SuperB $75ab^{-1}$:

- Number of $\tau\overline{\tau}$ produced: $0.9nb \times 75ab^{-1} = 6.8 \times 10^{10}$

(3) $\tau - c$ factory $7.5ab^{-1}$:

- Number of $\tau\overline{\tau}$ produced: $3 \times 7.5ab^{-1} = 2.3 \times 10^{10}$



A.Lusiani, M.Chrząszcz 2012

Current Status of LFV

1. Theoretical considerations:
   - LFV predicted in many NP models(SUSY, Majorana neutrinos).
   - In SM negligibly small $\mathcal{B} < 10^{-54}$ [1].
   - Any observation clear sign of NP.
2. Experimental status:
   - Limits for LFV channels set by BaBar, Belle and Cleo in range of $10^{-7} - 10^{-8}$ depending on the decay channel.
   - Most promising channels: $\tau \to \mu\gamma$ and $\tau \to 3\mu$.

[1] T.P Cheng, L.Li, Phys. Rev. Lett. 45 (1980) 1908

$\tau \to \mu\gamma$ at $\tau - c$ factory

SM background for $\tau \to \mu\gamma$:

- $\tau \to \mu\gamma\nu_\mu\nu_\tau$
- $\tau \to \pi\pi^0\nu_\tau$
- $\tau\tau \to \mu\nu_\mu\nu_\tau + \pi\pi^0\nu_\tau \to \mu\gamma\pi^+\gamma\mu_\nu\nu_\tau\nu_{\overline{\tau}}$
- Initial state radiation: $e^+e^- \to \tau\overline{\tau}\gamma$
- Initial state radiation: $e^+e^- \to \mu\overline{\mu}\gamma$

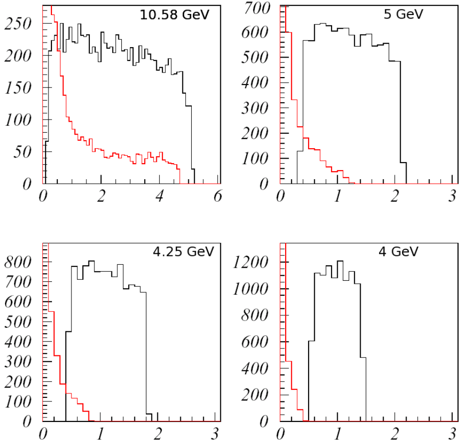
ISR strongly suppress the the sensitivity in $\mathcal{B}$ factories.

A.Lusiani, M.Chrząszcz 2012

Suppression ISR at charm threshold

E_γ FSR

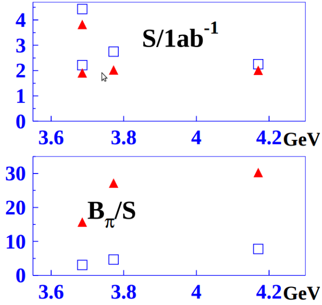
$E_\gamma \tau \to \mu\gamma$ ISR vanishes for $E \approx 4 GeV$



A.Lusiani, M.Chrząszcz 2012

Expected sensitivity for $\tau \to \mu\gamma$

From MC studies [2] one can estimate the background in the $\rfloor - \tau$ factory using KK2F with TAUOLA generator.



A full data set of $7.5ab^{-1}$ is sufficient to put an exclusion limit on $\tau \to \mu\gamma$ of order of 10^{-9}.

[2] A.V. Bobrov, A.E Boundar, arxiv: 1206.1909

Probe QCD

- Using analytical constraints and the Operator Product Expansion one can compute ration between harmonic and leptonic decays:
$R_\tau \equiv \frac{\Gamma(\tau \to \nu hadrons(\gamma))}{\Gamma(\tau \to e\nu_\tau\nu_e)} = R_{\tau,V} + R_{\tau,A} + R_{\tau,S}$
- Which can be further devided to contributions coming form different quarks and currents:
$R_\tau \equiv \frac{\Gamma(\tau \to \nu hadrons(\gamma))}{\Gamma(\tau \to e\nu_\tau\nu_e)} = R_{\tau,V} + R_{\tau,A} + R_{\tau,S}$
- Theoretical prediction can be wrote in a form:
$R_{\tau,V+A} = N_c|V_{ud}|^2 S_{EW}(1 + \delta_P + \delta_{NP})$ [3]
- Biggest correction comes from δ_P.

[3] W.A. Rolke and A.M. Lopez, Nucl. Instr. Meth. in Phys. Res. A458, 745 (2001).

CP Violation

- CP violation in τ sector is becoming a popular subject in light that the CKM matrix cannot explain matter-antimatter asymmetry.
- Much more decay modes than in μ sector.
- Possible contributions from charge Higgs at loop level.

The most promising channel is: $\tau \rightarrow K_s \pi \nu$

1. SM in 3rd loops generates asymmetry.
2. Numerical studies showed that NP can contribute in 1%
3. Expected sensitivity with full data set is expected to be of the order of 0.01%

A.Lusiani, M.Chrząszcz 2012