Tau CLFV at BESIII and SCTF

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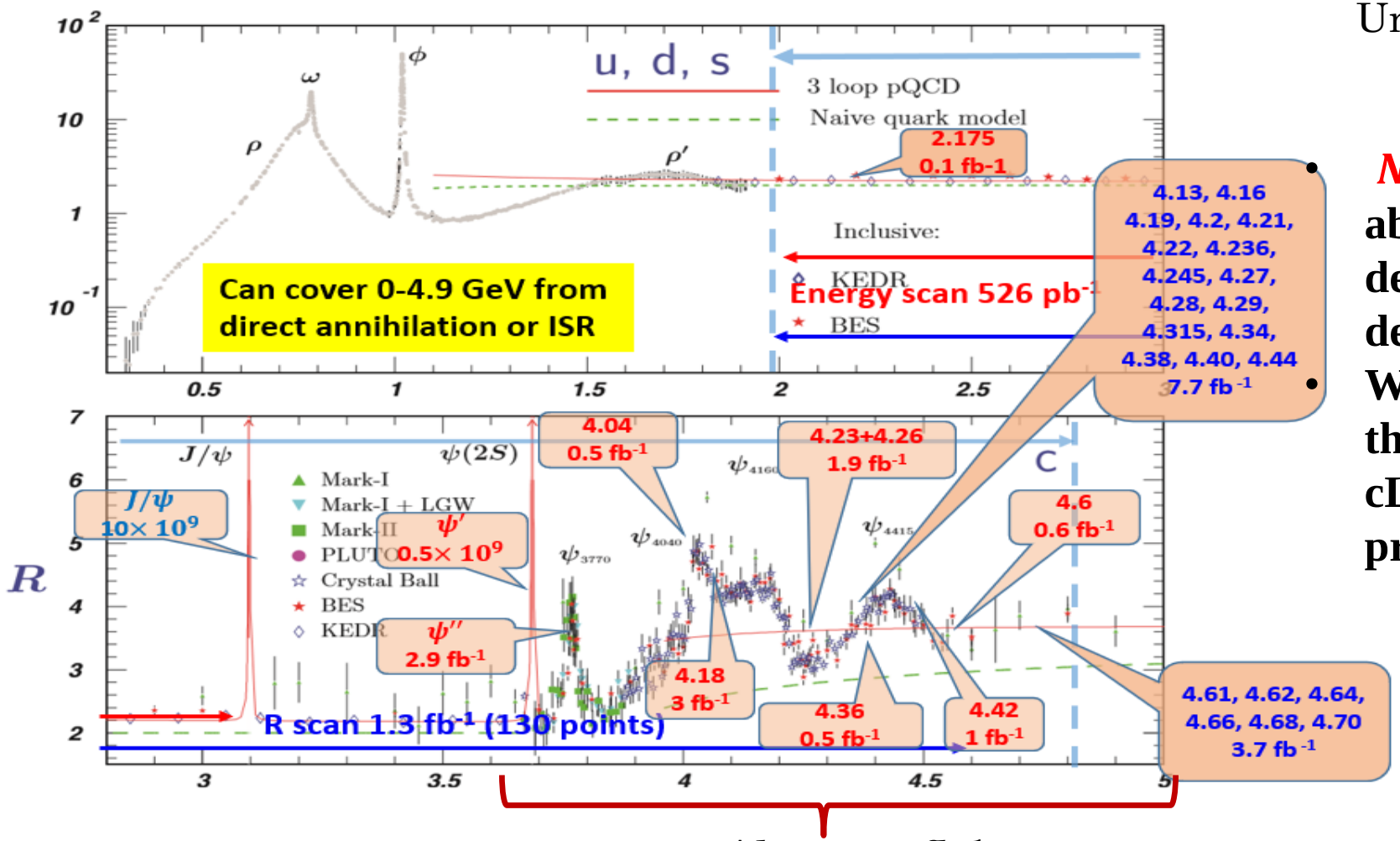
Data Samples at BESIII



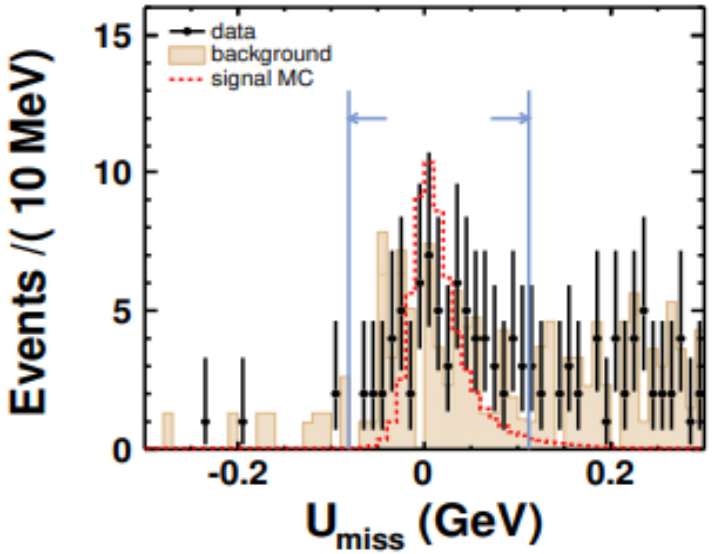
Until 2020

- $N_{\tau\tau}$ produced at BESIII is about 7×10^7 (including ψ' decay), **not enough** for cLFV decays of tau
- With **10Billion** Jpsi at BESIII, there can be anther way for cLFV searches via with high precision:

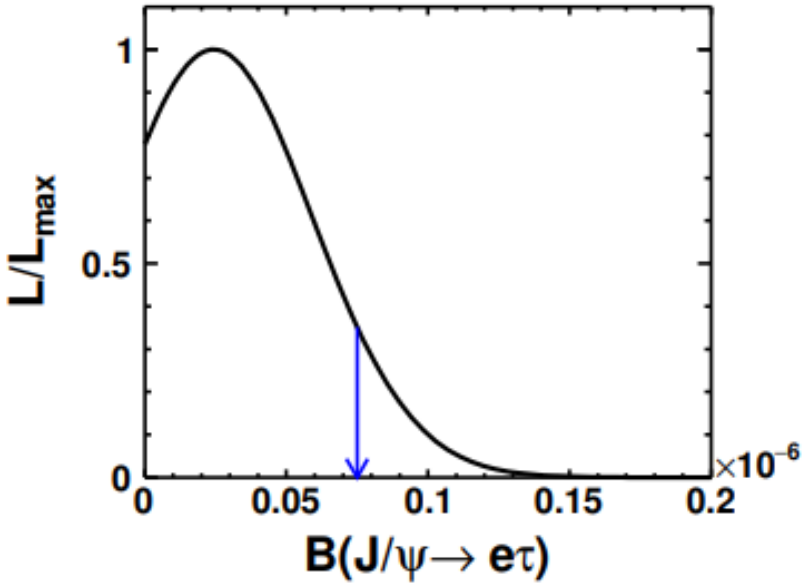
$$J/\psi \to e\tau/e\mu$$

LFV decay of $J/\psi \to e\tau$ at BESIII

- **Reconstructed channel:**
  - $J/\psi \to e^{\pm}\tau^{\mp}$ with $\tau^{\mp} \to \pi^{\mp}\pi^{0}\upsilon_{\tau}$
- **Dominant background:**
  - Radiative Bhabha; $J/\psi \to \pi^{+}\pi^{-}\pi^{0}$
- **Observable:** $U_{miss} = E_{miss} - c|\vec{p}_{miss}|$, select efficiency 20%



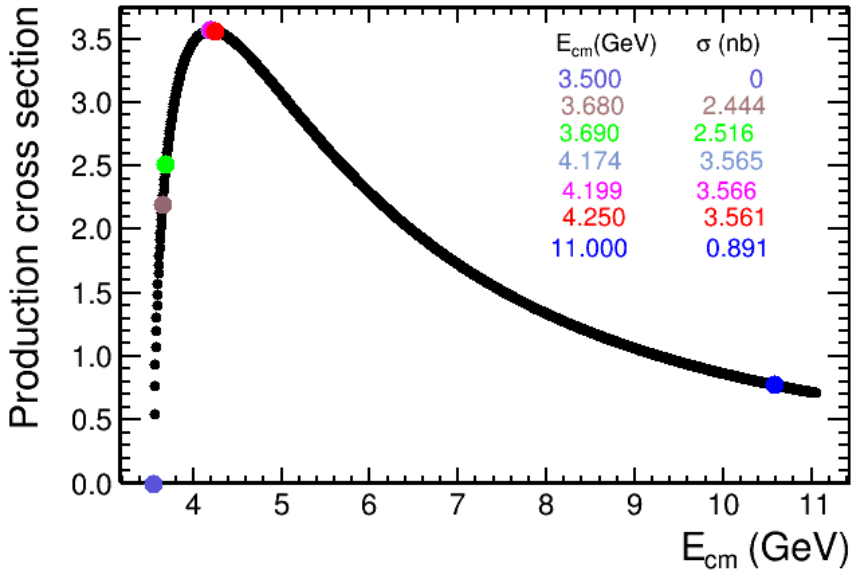
arXiv:2103.11540



$\mathcal{B}_{UL}^{90}(J/\psi \to e\tau)) < 7.5 \times 10^{-8}$

Studies of τ at STCF

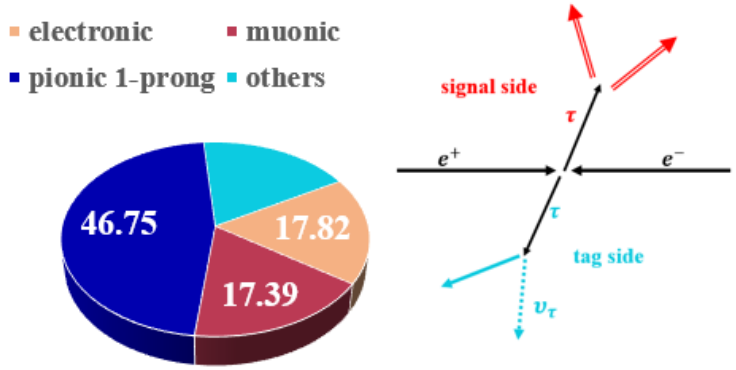
- **Proposed STCF in China**
  - **Peaking luminosity (0.5-1)×10^{35} $cm^{-2}s^{-1}$ at 4 GeV**
  - **Energy range E_{cm} = 2-7 GeV**
  - **Potential to increase luminosity and realize beam polarization**



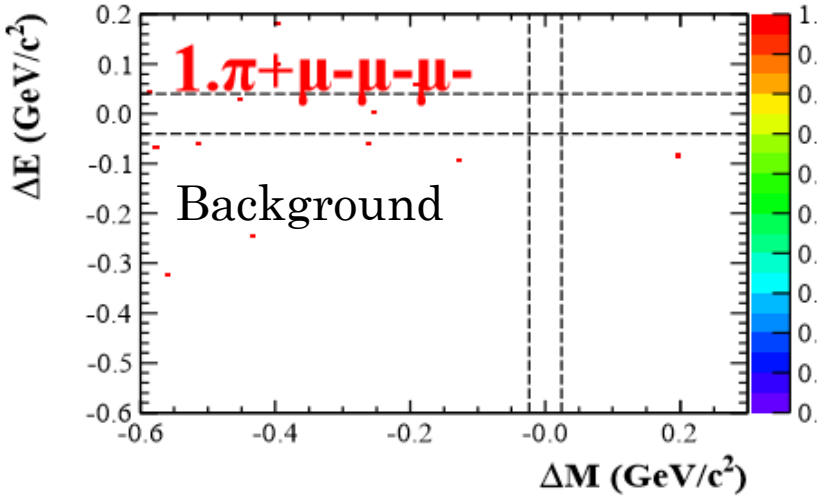
- Peaking cross section locates in 4-5 GeV
- At 4.26 GeV, number of tau pairs per year:

  $N_{\tau\tau}$ ~ **1.0 ab^{-1} ×3.5 nb = 3.5× 10^9**
- $e^+e^- \to \gamma\tau^+\tau^-$ is not the main background
- Improved π/μ misid rate at STCF

LFV decay of $\tau \to lll$ at STCF



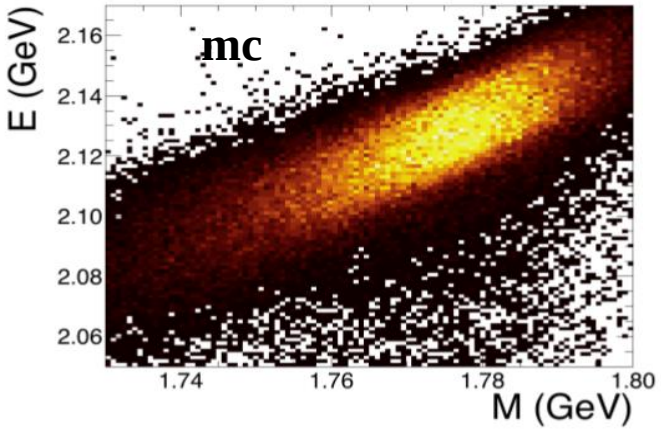
- Signal side: $\tau \to 3leptons$
- Tag side: $\tau \to e\nu\bar{\nu}$, $\mu\nu\bar{\nu}$, $\pi\upsilon + n\pi^0$ ($\mathcal{B}r = 82\%$)
- Almost background free, **the sensitivity : $\mathcal{B}_{UL}^{90}(\tau \to \mu\mu\mu) \sim 1/\mathcal{L}$**
- Best efficiency ($\tau \to \mu\mu\mu$): 22.5% **(including tag branching fraction)**



- **STCF with 1ab^{-1}:**

$$\mathcal{B}_{UL}^{90}(\tau \to \mu\mu\mu) < \frac{N_{UL}^{90}}{2\varepsilon N_{\tau\tau}} \sim 1.5 \times 10^{-9}$$

LFV decay of $\tau \to \gamma\mu$ at STCF



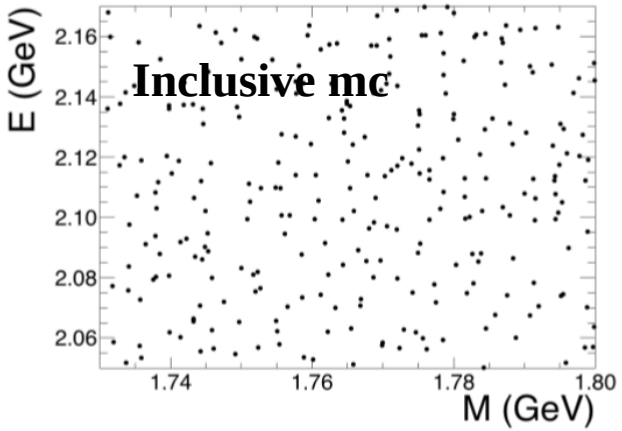
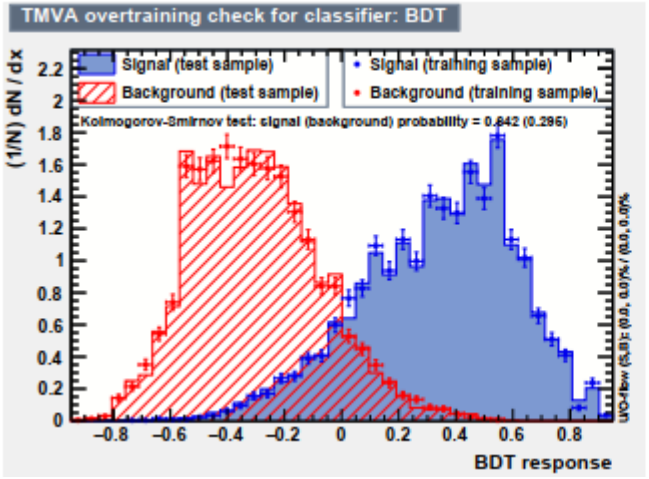
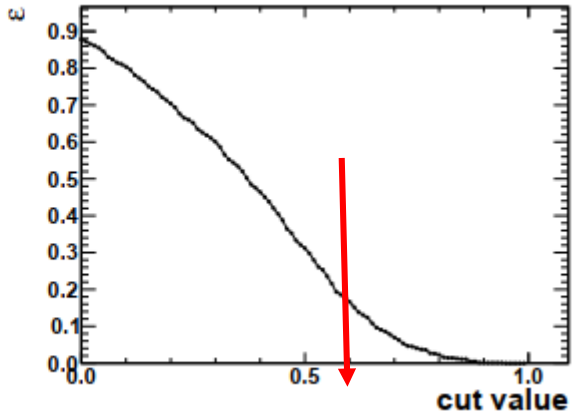


TABLE II. Optimization for pion/muon separation.

	μ eff. at 1 GeV	$UL(\mathcal{B}(\tau \to \gamma\mu))/10^{-8}$
3 %	96.7 %	1.2
1.7 %	92.6 %	1.5
1 %	87.3 %	1.8





- **STCF with 1ab^{-1}:**

$$\mathcal{B}_{UL}^{90}(\tau \to \gamma\mu) < \frac{N_{UL}^{90}}{2\varepsilon N_{\tau\tau}} \sim 1.2 \times 10^{-8}$$

LFV decay of $J/\psi \to e\tau$ at STCF

- The cLFV decays of vector mesons $V \to l_i l_j$ are also predicted **in various of extension models** of SM:

$$\mathcal{B}_{UL}^{90}(J/\psi \to e\mu) < 10^{-13}$$
$$\mathcal{B}_{UL}^{90}(J/\psi \to e(\mu)\tau)\,) < 10^{-9}$$

- At **STCF**, **1 trillion J/ψ** can be obtained per year, taken efficiency from BESIII, the upper limit can be predicted to be:

$$\mathcal{B}_{UL}^{90}(J/\psi \to e\mu) < 3.6 \times 10^{-11}$$
$$\mathcal{B}_{UL}^{90}(J/\psi \to e\tau)\,) < 7.1 \times 10^{-10}$$

- The $\mathcal{B}_{UL}^{90}(J/\psi \to e\tau)\,)$ can be further **optimized** with better PID.