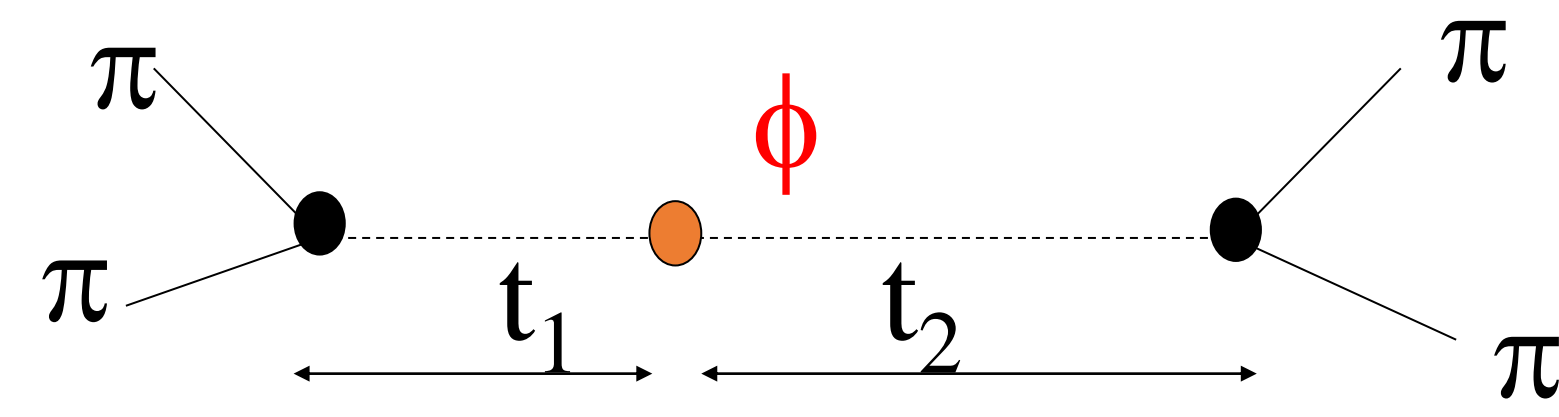


Tests of CPT symmetry and quantum coherence with entangled neutral kaons at KLOE-2

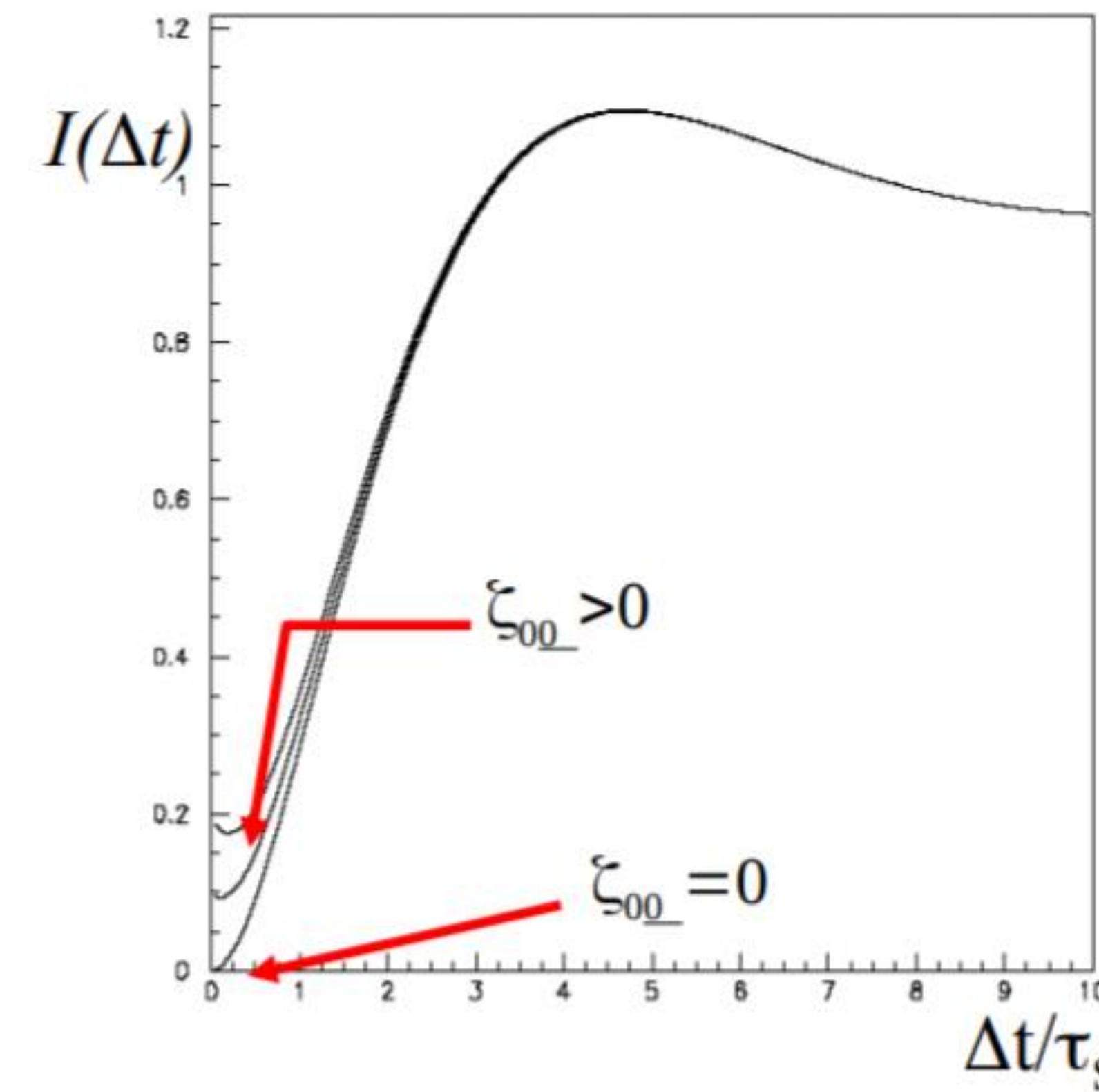
Riccardo D'Amico on behalf of the KLOE-2 Collaboration

Kaon Interferometry in a ϕ -factory:

$$|i\rangle = \frac{1}{\sqrt{2}} [|K^0\rangle|\bar{K}^0\rangle - |\bar{K}^0\rangle|K^0\rangle]$$



$$\Delta t = |t_1 - t_2|$$



Most precise test of quantum coherence in an entangled system.

$$I(\pi^+\pi^-, \pi^+\pi^-; \Delta t) = \frac{N}{2} [|\langle \pi^+\pi^-, \pi^+\pi^- | K^0\bar{K}^0(\Delta t) \rangle|^2 + |\langle \pi^+\pi^-, \pi^+\pi^- | \bar{K}^0K^0(\Delta t) \rangle|^2 - (1 - \zeta_{0\bar{0}}) \cdot 2\Re(\langle \pi^+\pi^-, \pi^+\pi^- | K^0\bar{K}^0(\Delta t) \rangle \langle \pi^+\pi^-, \pi^+\pi^- | \bar{K}^0K^0(\Delta t) \rangle^*)]$$

ζ_{00} decoherence parameter in the $K^0\bar{K}^0$ basis (QM predicts: $\zeta_{0\bar{0}} = 0$).
[or ζ_{SL} in the $K_S K_L$ basis].

Decoherence effects might arise in a quantum gravity picture necessarily entailing CPT violation [Ellis et. al, NP B241 (1984) 381 (*); Ellis, Mavromatos et al. PRD53 (1996) 3846 (**)]:

• In this case the relevant parameter in the modified time evolution of neutral kaons is the γ parameter (at most $\gamma = O(m_K^2 / M_{planck}) \approx 2 \times 10^{-20}$ GeV).

• the initial entangled state is modified adding a tiny symmetric part $\rightarrow \omega$ effect (at most $\omega = O(m_K^2 / M_{planck} / \Delta\Gamma) \sim 1 \times 10^{-3}$)

$$|i\rangle \propto \frac{1}{\sqrt{2}} [|K^0\rangle|\bar{K}^0\rangle - |\bar{K}^0\rangle|K^0\rangle] + \omega [|K^0\rangle|\bar{K}^0\rangle + |\bar{K}^0\rangle|K^0\rangle] \rightarrow \text{[in the } K^0\bar{K}^0 \text{ basis]}$$

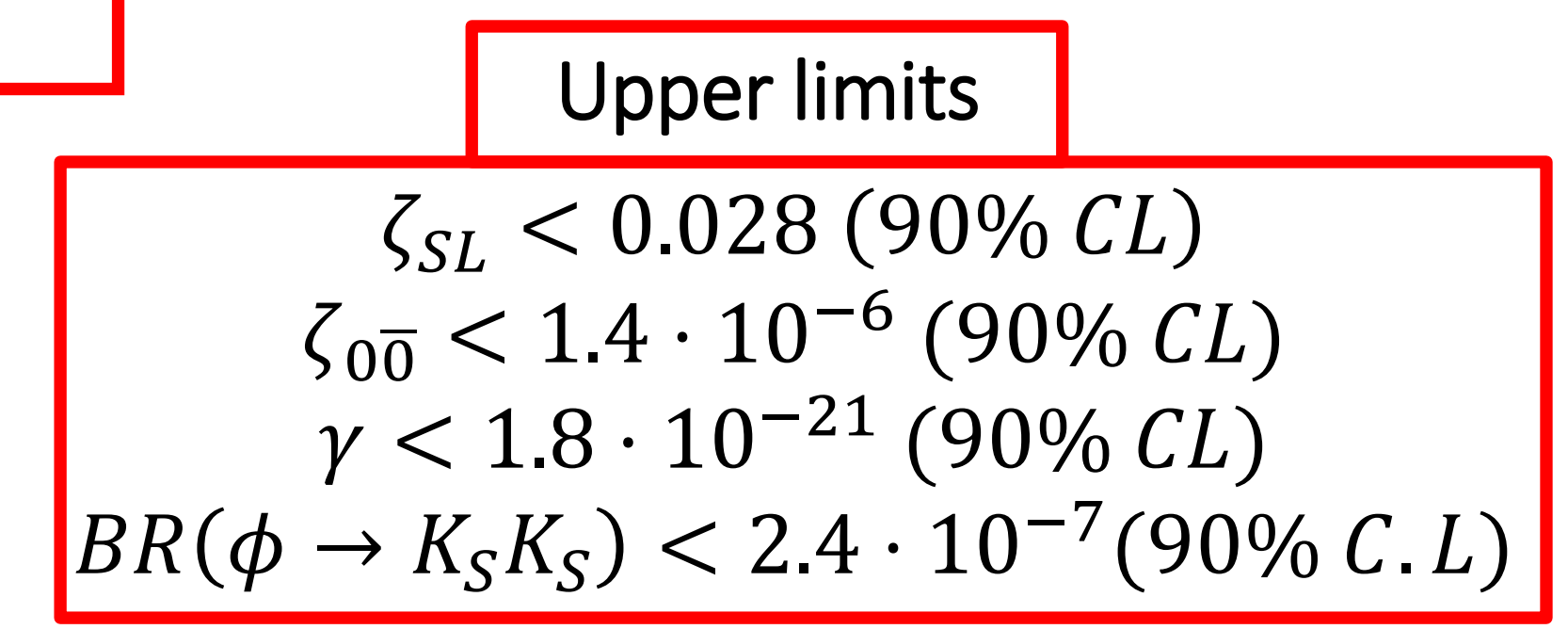
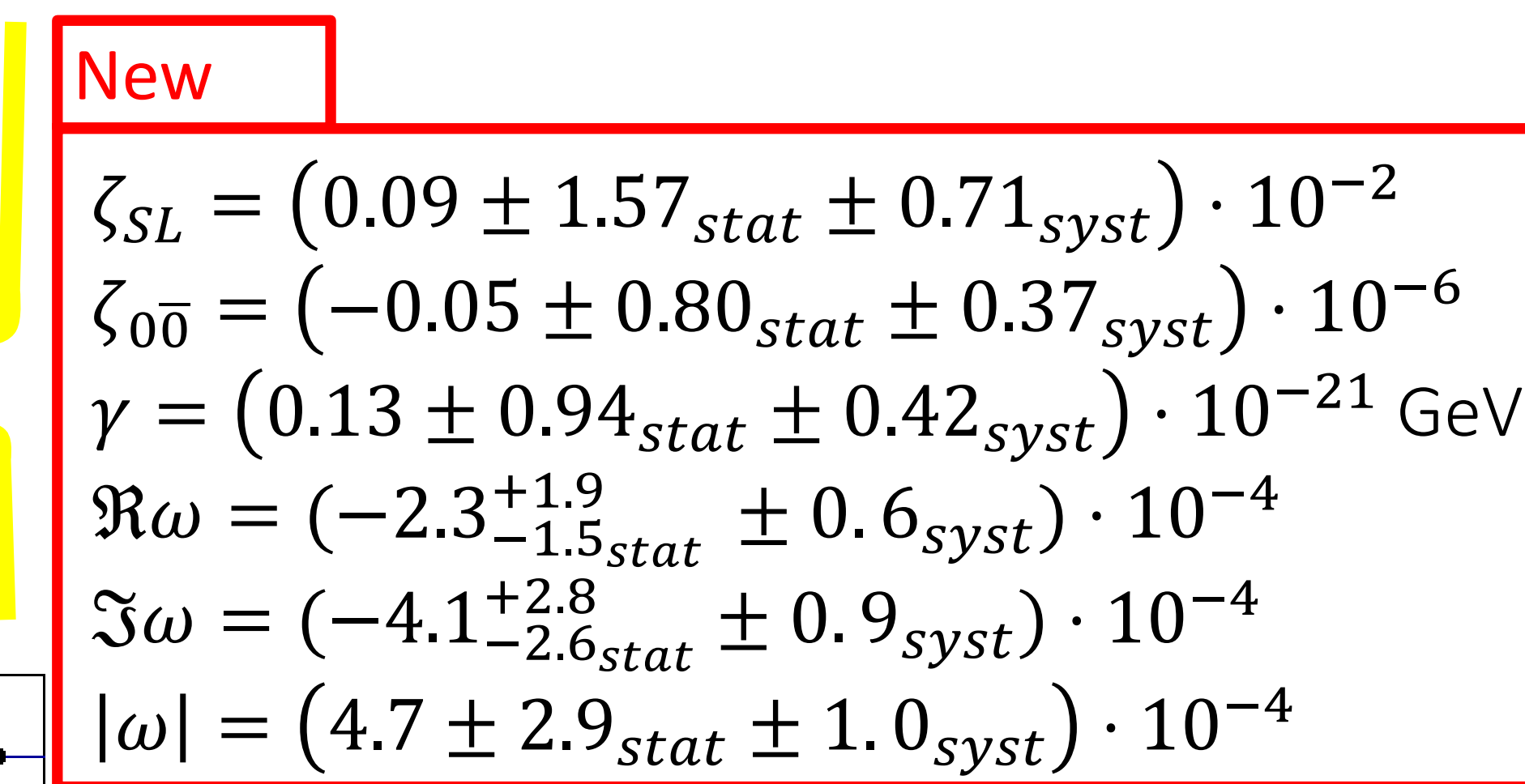
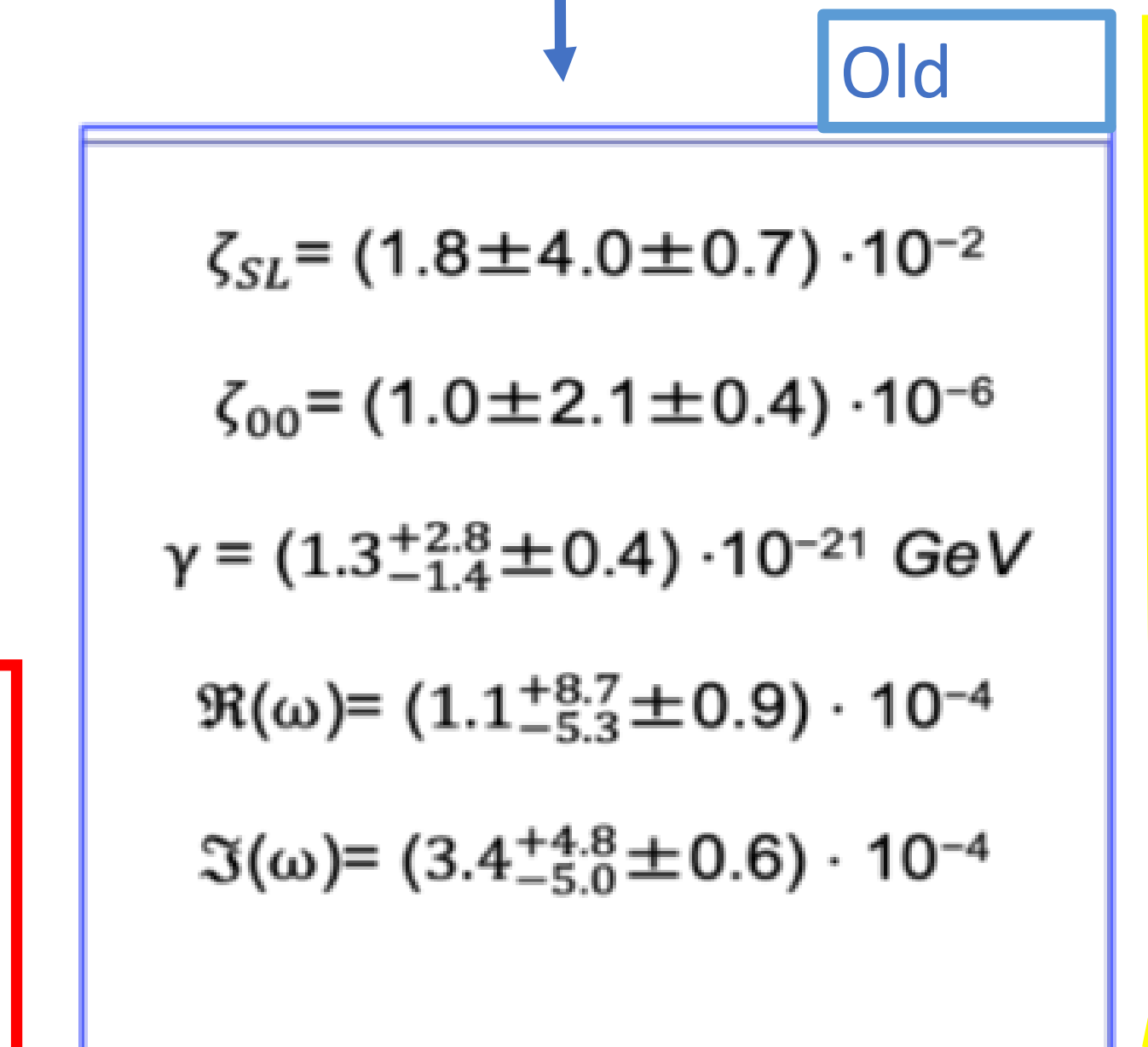
$$\text{[in the } K_S K_L \text{ basis]} \leftarrow |i\rangle \propto [|K_S\rangle|K_L\rangle - |K_L\rangle|K_S\rangle] + \omega [|K_S\rangle|K_S\rangle - |K_L\rangle|K_L\rangle]$$

Previous KLOE measurement $L = 380 \text{ pb}^{-1}$ KLOE PLB 642 (2006) 315 (***)

* [https://doi.org/10.1016/0550-3213\(84\)90053-1](https://doi.org/10.1016/0550-3213(84)90053-1)

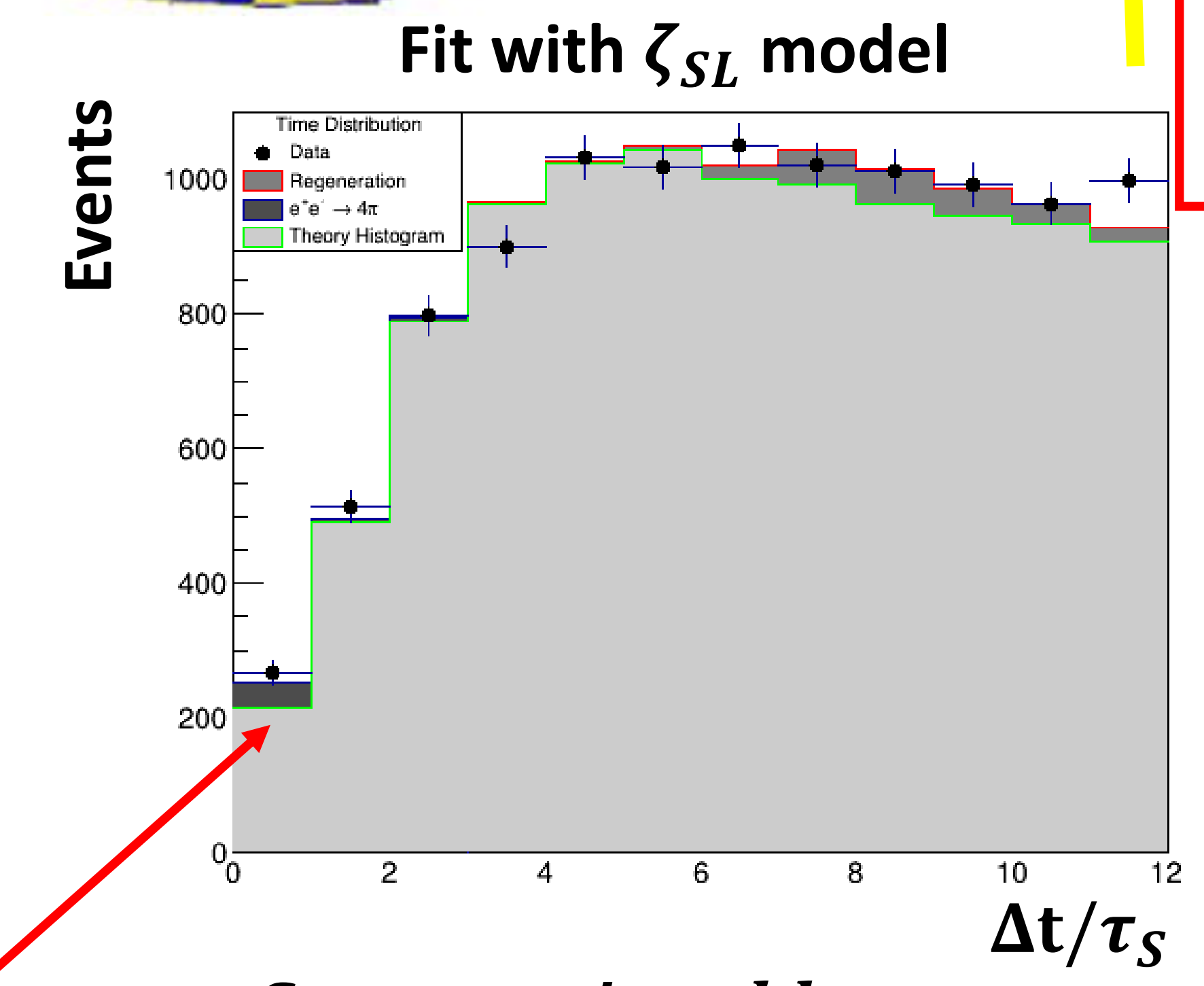
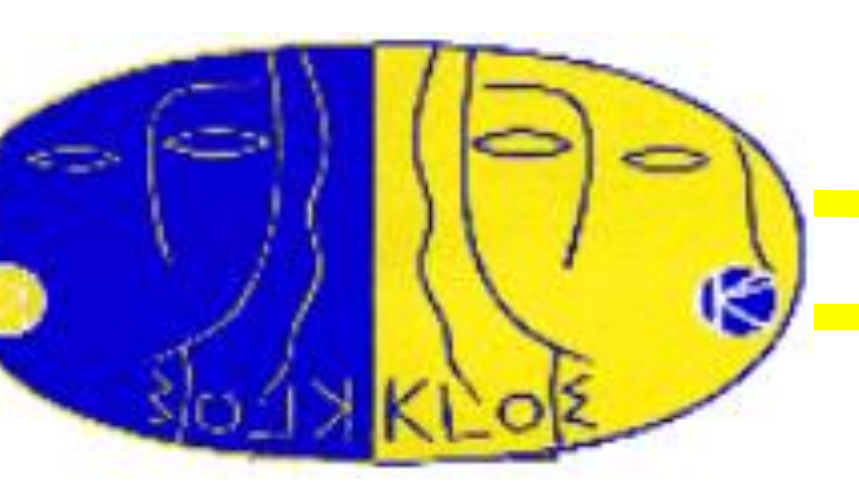
** <https://doi.org/10.1103/PhysRevD.53.3846>

*** <https://doi.org/10.1016/j.physletb.2006.09.046>



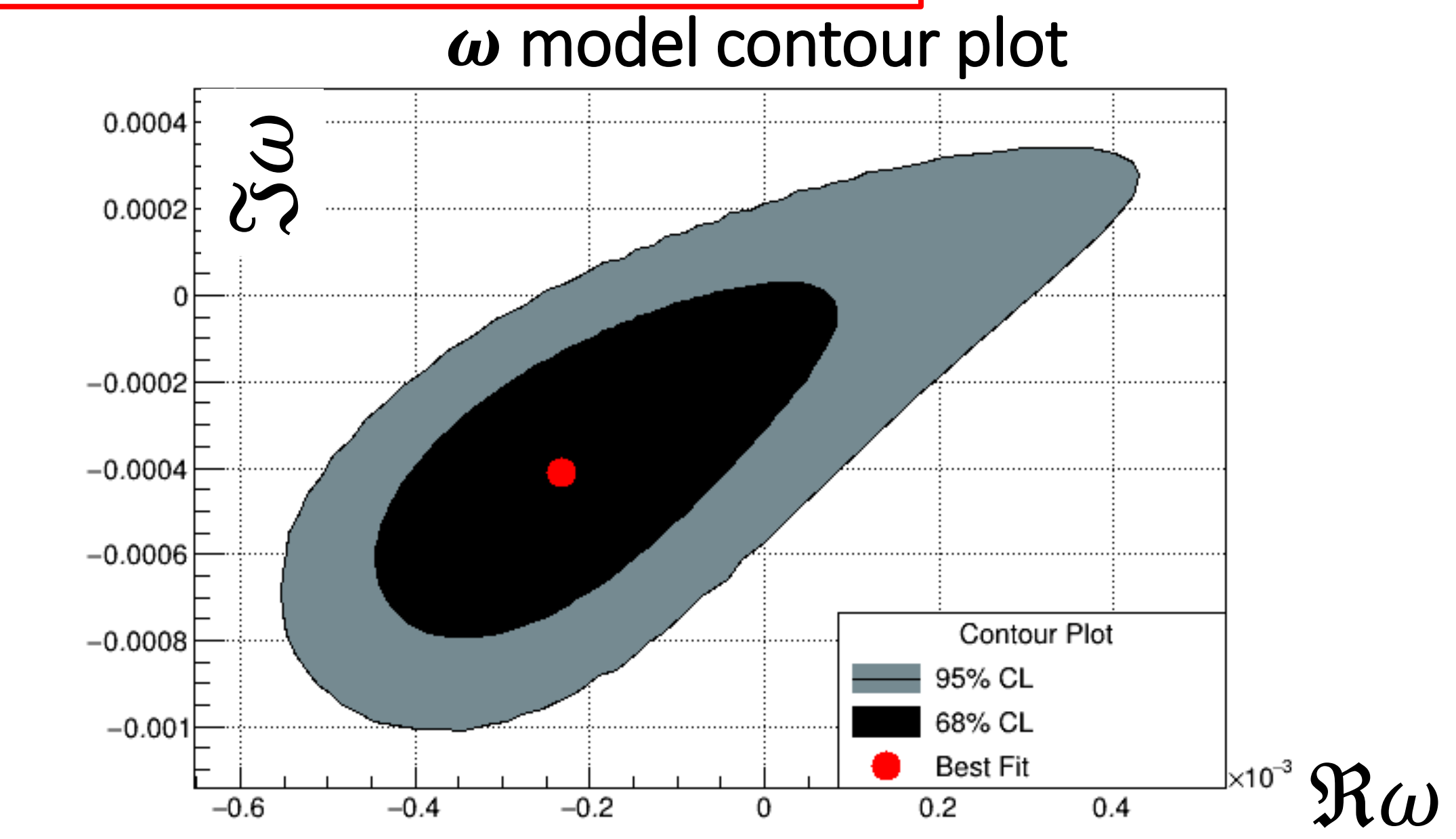
Fit including Δt resolution and efficiency effects + regeneration;
Statistical uncertainty reduced by half
Central values consistent with zero
Preparation of publication in progress

Results on Decoherence parameters

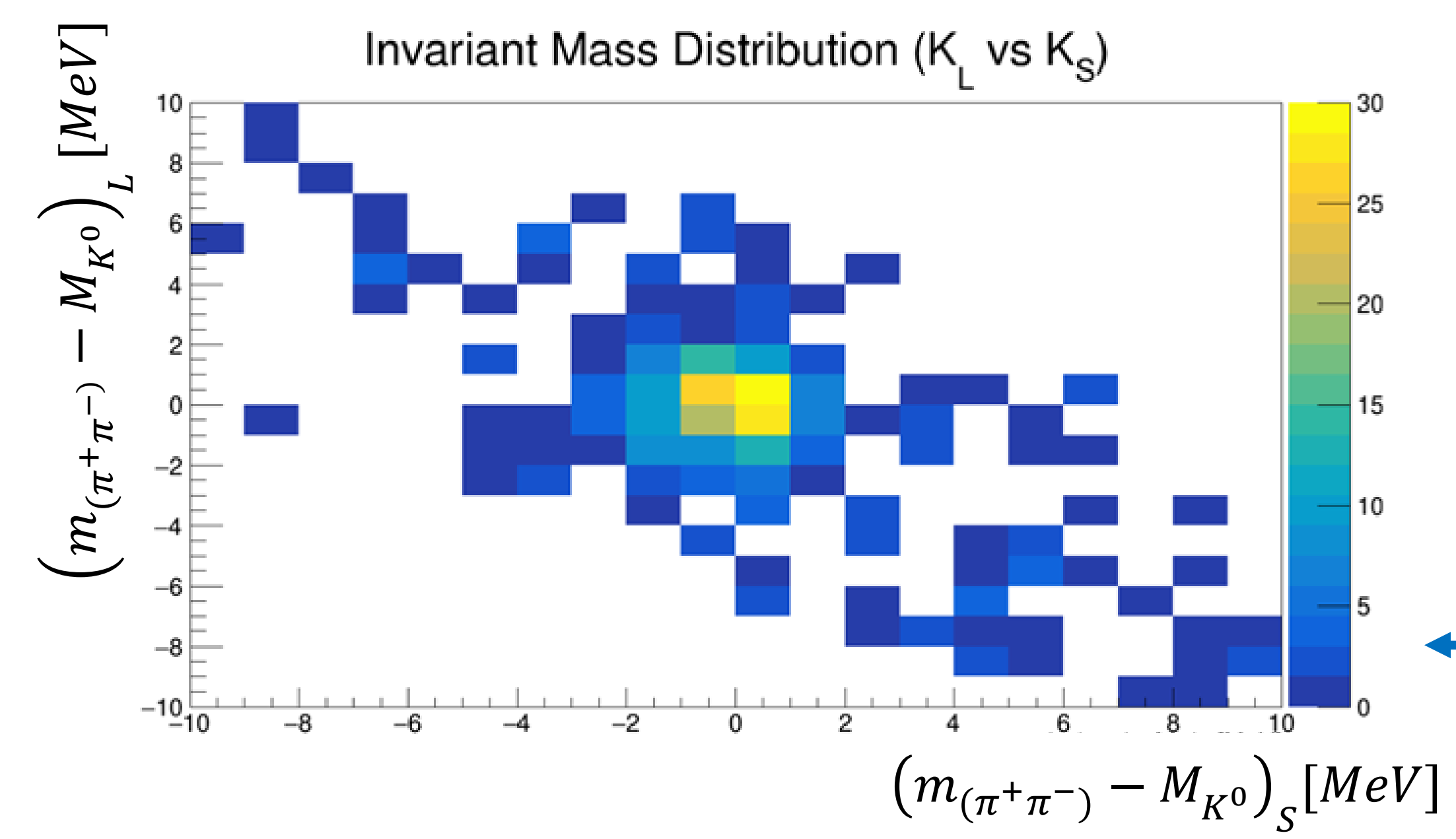


Systematic table

	$\delta\zeta_{SL} \cdot 10^2$	$\delta\zeta_{00} \cdot 10^7$	$\delta\gamma \cdot 10^{21} \text{ GeV}$	$\delta\text{Re}\omega \cdot 10^4$	$\delta\text{Im}\omega \cdot 10^4$	$\delta \omega \cdot 10^4$
Cut stability	± 0.56	± 2.9	± 0.33	± 0.53	± 0.65	± 0.78
4 π Background	± 0.37	± 1.9	± 0.22	± 0.32	± 0.19	± 0.32
Regeneration	± 0.17	± 0.9	± 0.10	± 0.06	± 0.63	± 0.58
Resolution	± 0.18	± 0.9	± 0.10	± 0.15	± 0.09	± 0.15
Phys. Const.	± 0.04	± 0.2	± 0.02	± 0.03	± 0.09	± 0.07
Total	± 0.71	± 3.7	± 0.42	± 0.64	± 0.93	± 1.04

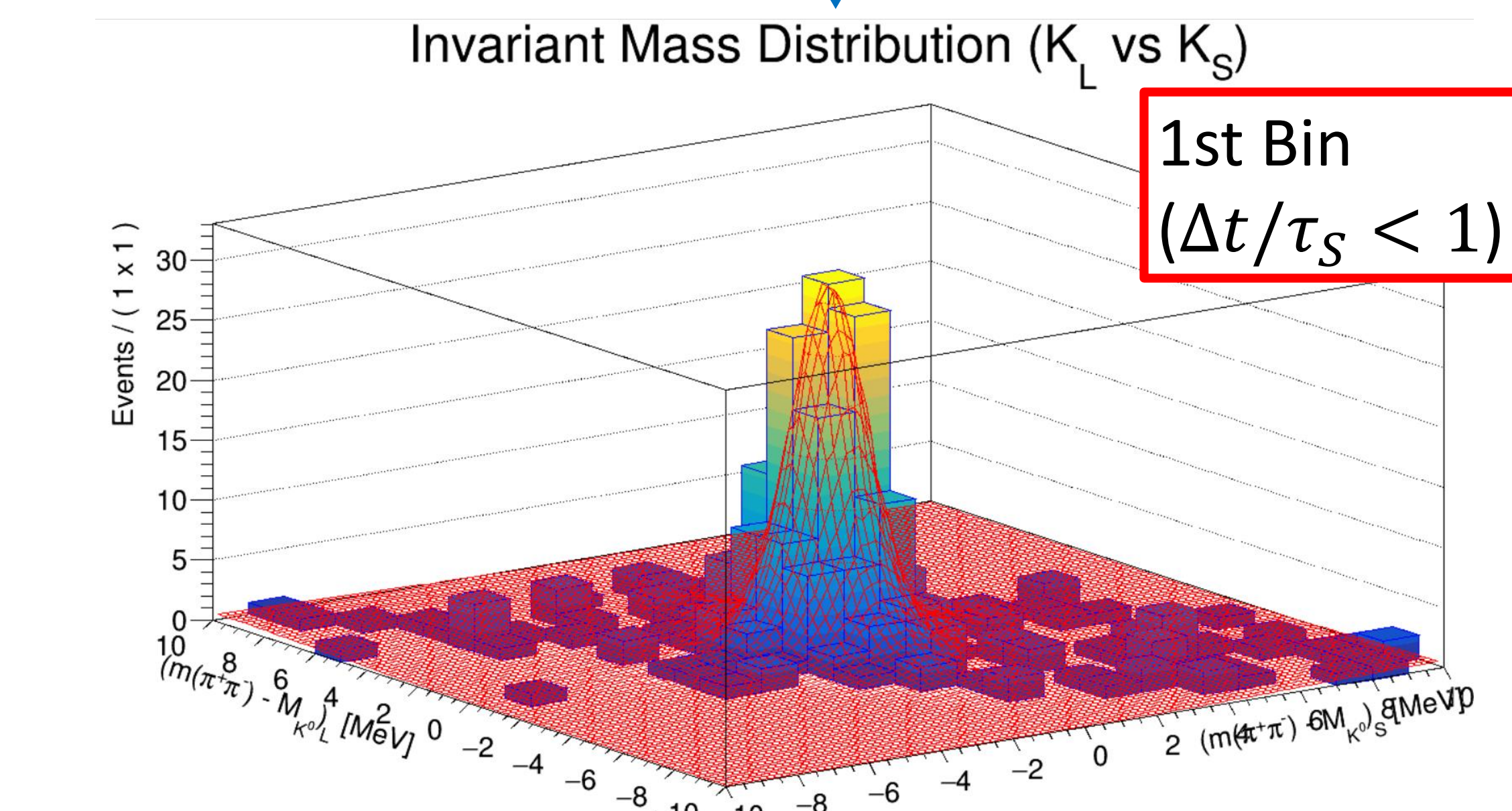


Improved Analysis:



KLOE data: $L = 1.7 \text{ fb}^{-1}$ Improvements wrt past analysis:

- $\cos(\theta_{\pi^+\pi^-}) > -0.975$ cut to improve Δt resolution
- improved $e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-$ background evaluation from 2D fit of the invariant mass.



$$N_{bkg, Bin1} = 39 \pm 5$$

$$N_{bkg, Bin2} = 6 \pm 2$$

$$N_{bkg, Bin3} = 6 \pm 2$$