# Comparisons of KKMC and PHOKHARA for radiative return at low energies

## *Studies of $\mu$-pair and $\pi$-pair production*

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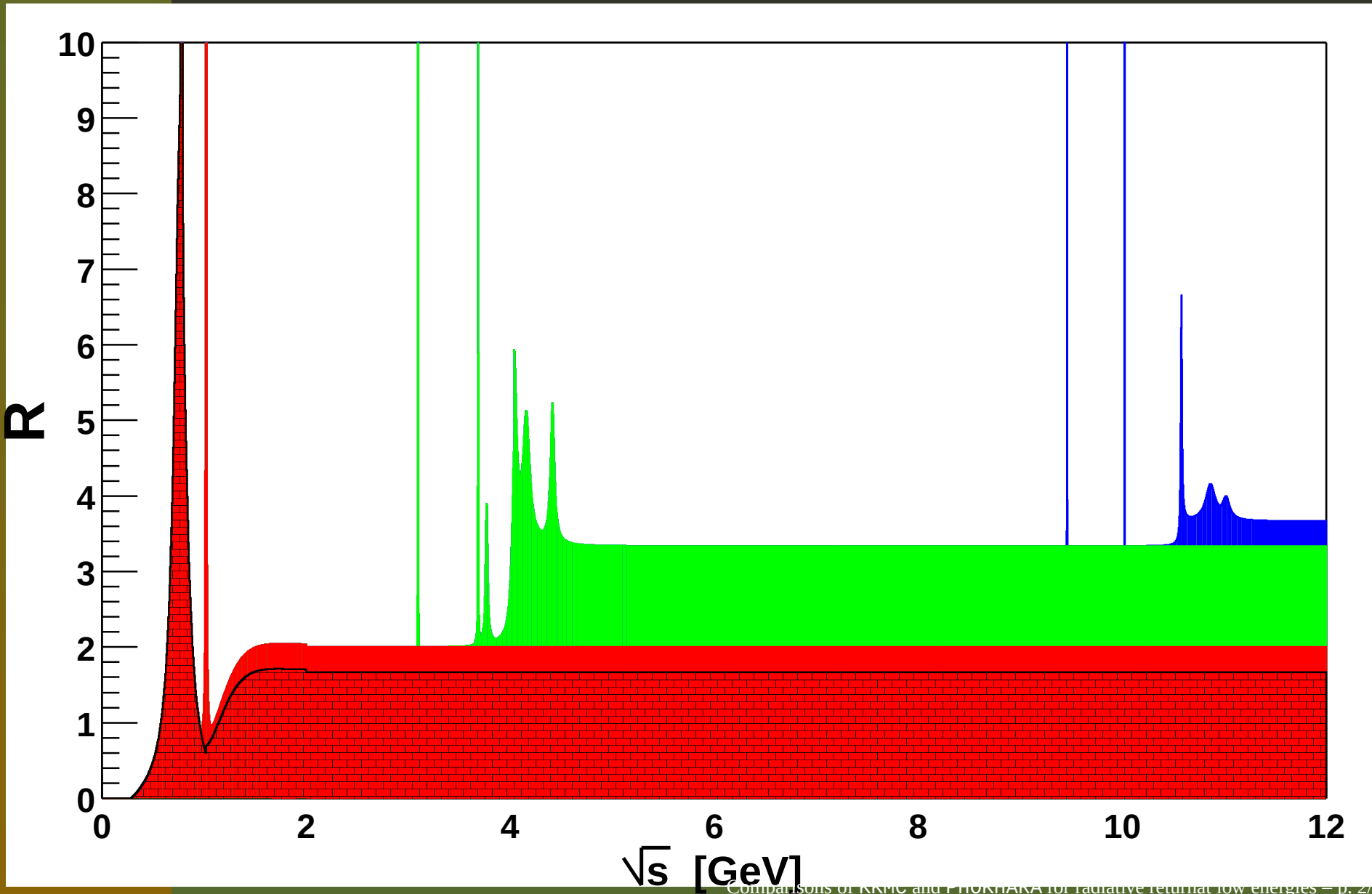
Based on study in collaboration with A. Denig and J. Kuhn

# Introduction; $R(s) = \sigma_h/\sigma_\mu$



# Introduction

- What is “radiative return” in $e^+e^-$ experiment?
- Why it is interesting or/and important?
- KKMC event generator was very instrumental for predictiong $e^+e^- \to \mu^+\mu^-, q\bar{q}$, including radiative return at LEP.
  Can KKMC also help at low energy colliders?
- Below are some test which adress this question.

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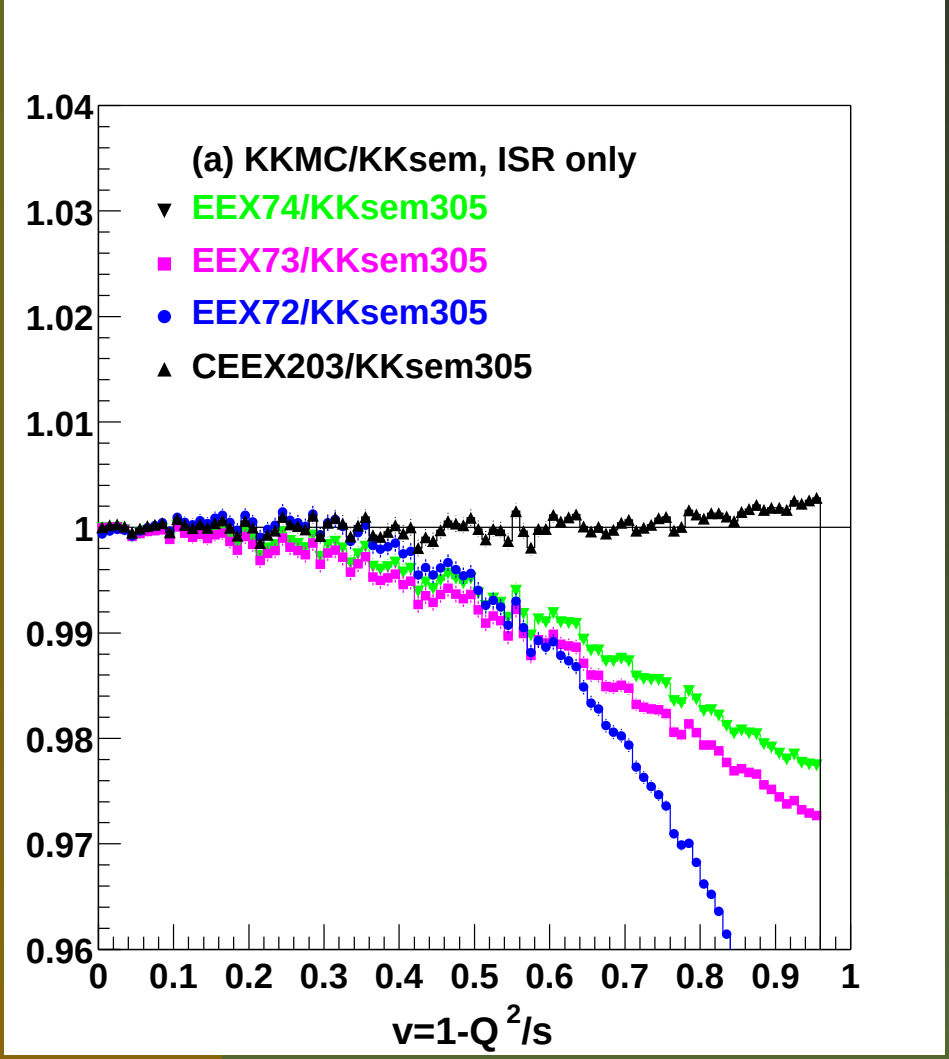
- Repeat whichever possible tests for the $e^-e^+ \to \pi^-\pi^+$ process

# $\mu$-pair mass spectrum from KKMC and KKsem

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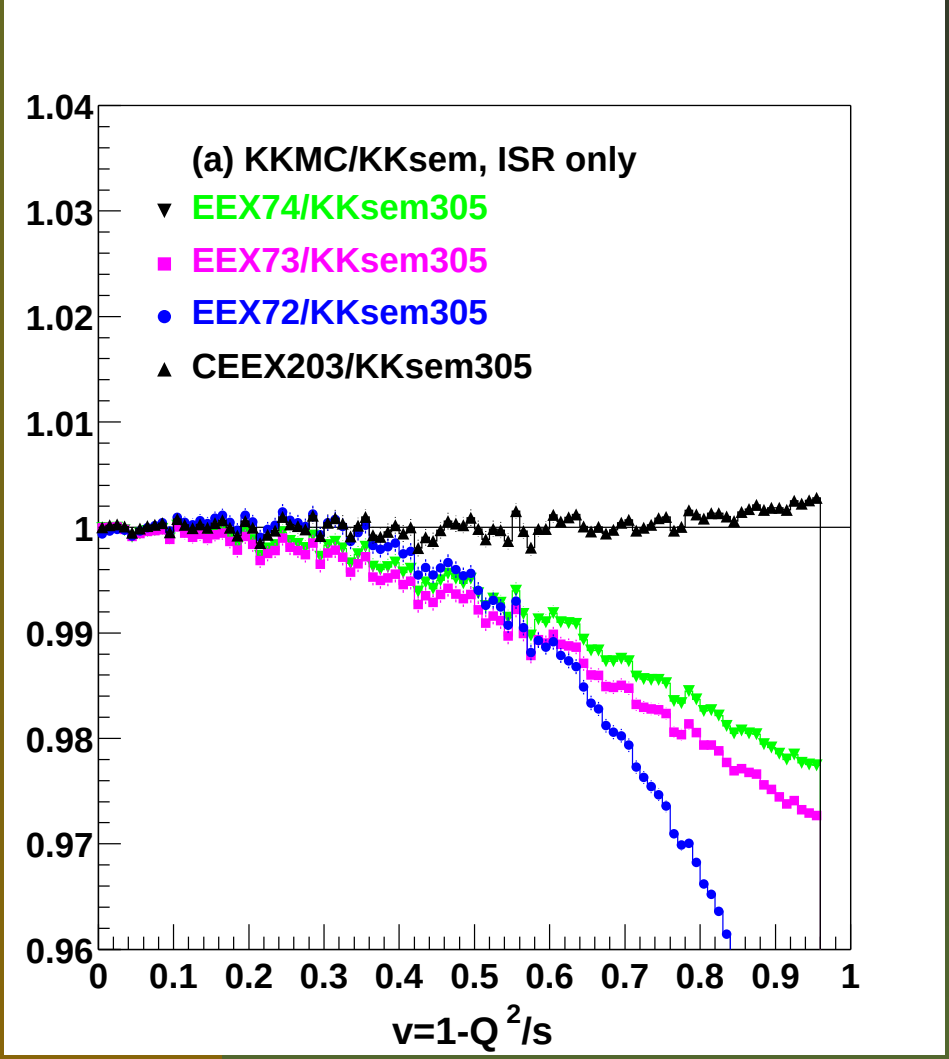


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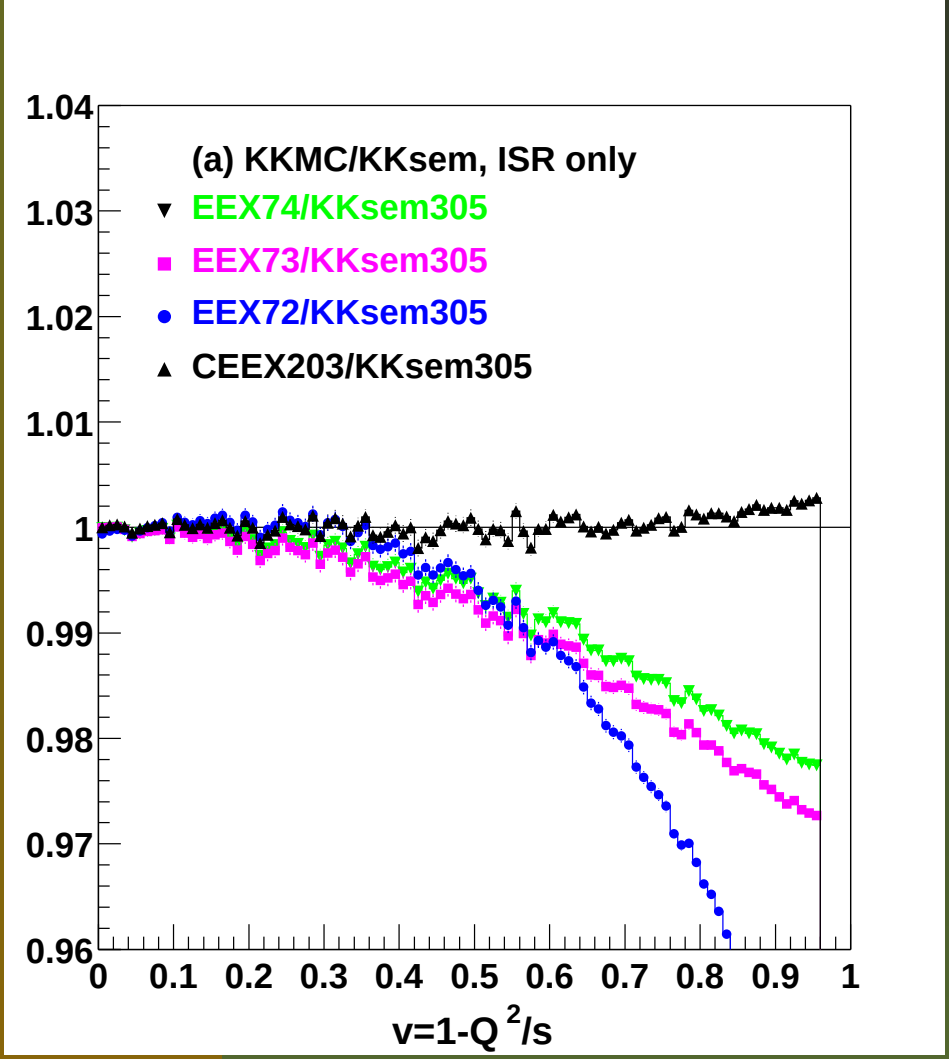


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- KKMC with incomplete, EEX-type matr. elem. differs from KKsem by about 2-3% at low $Q^2$

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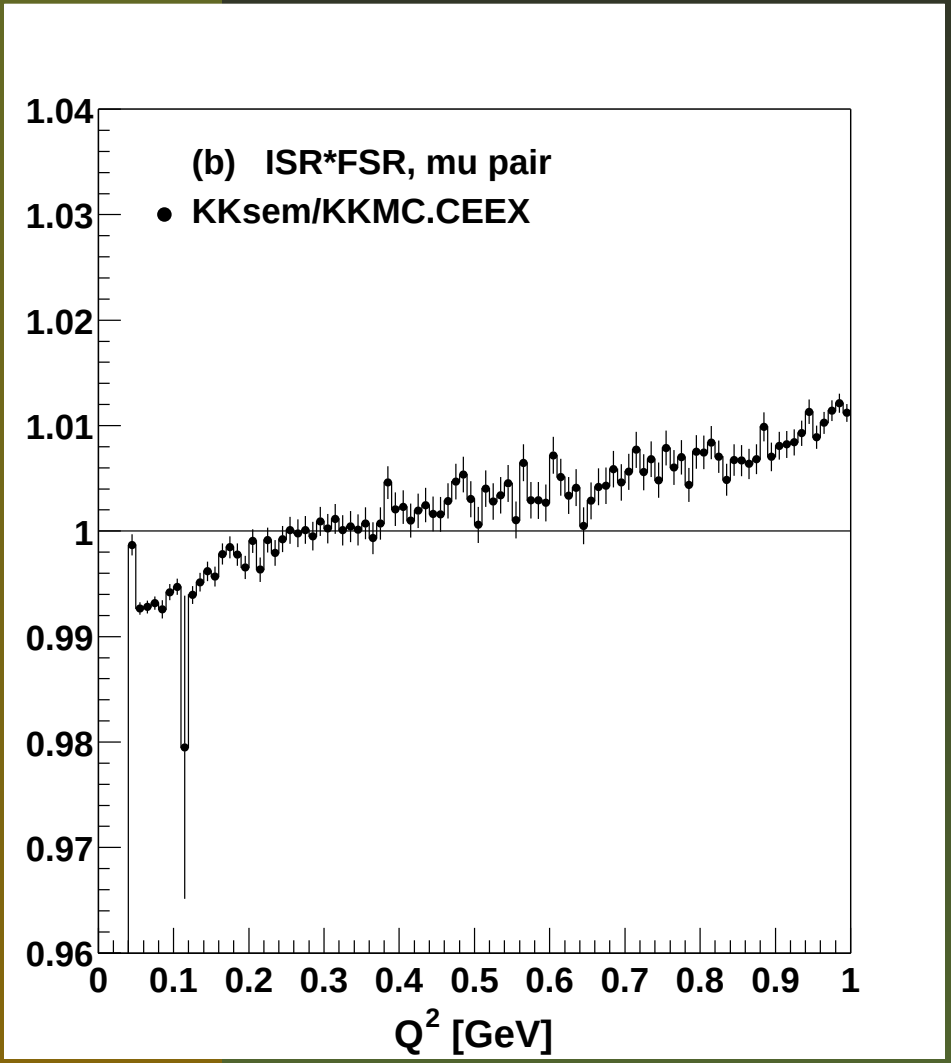


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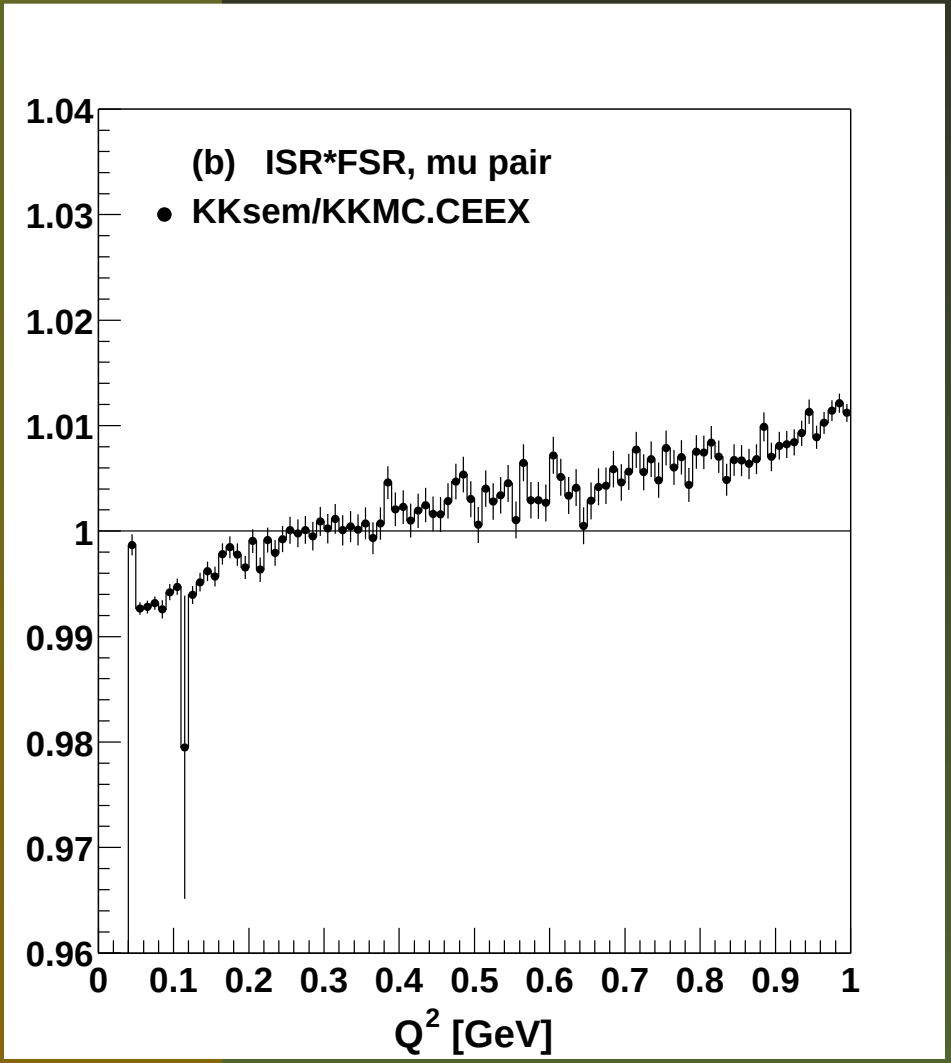


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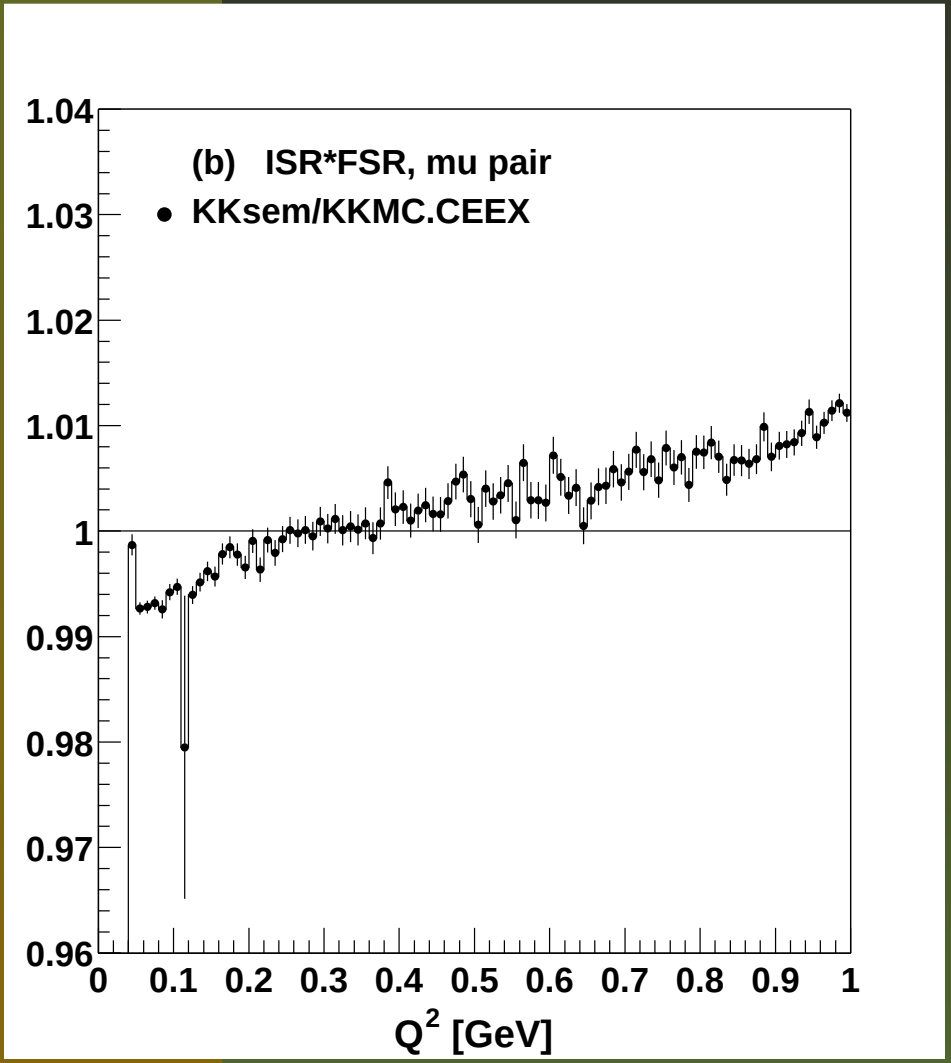


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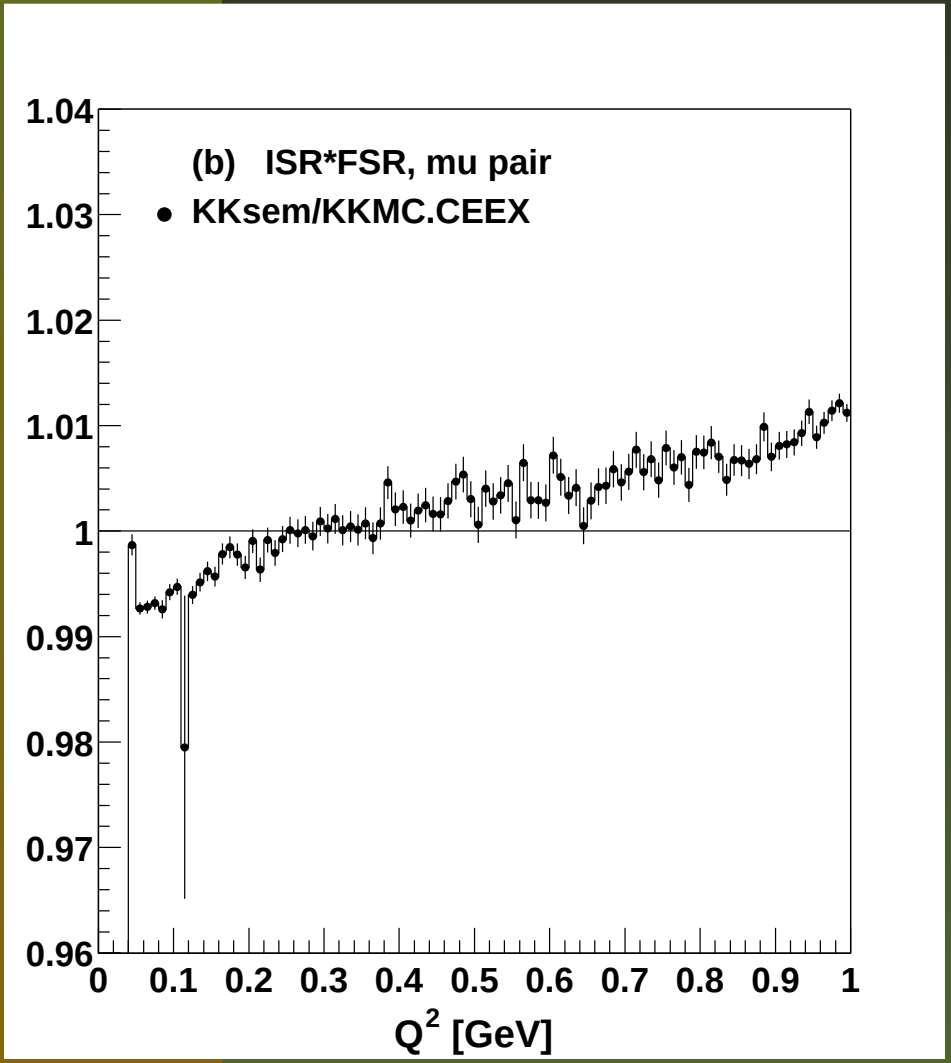
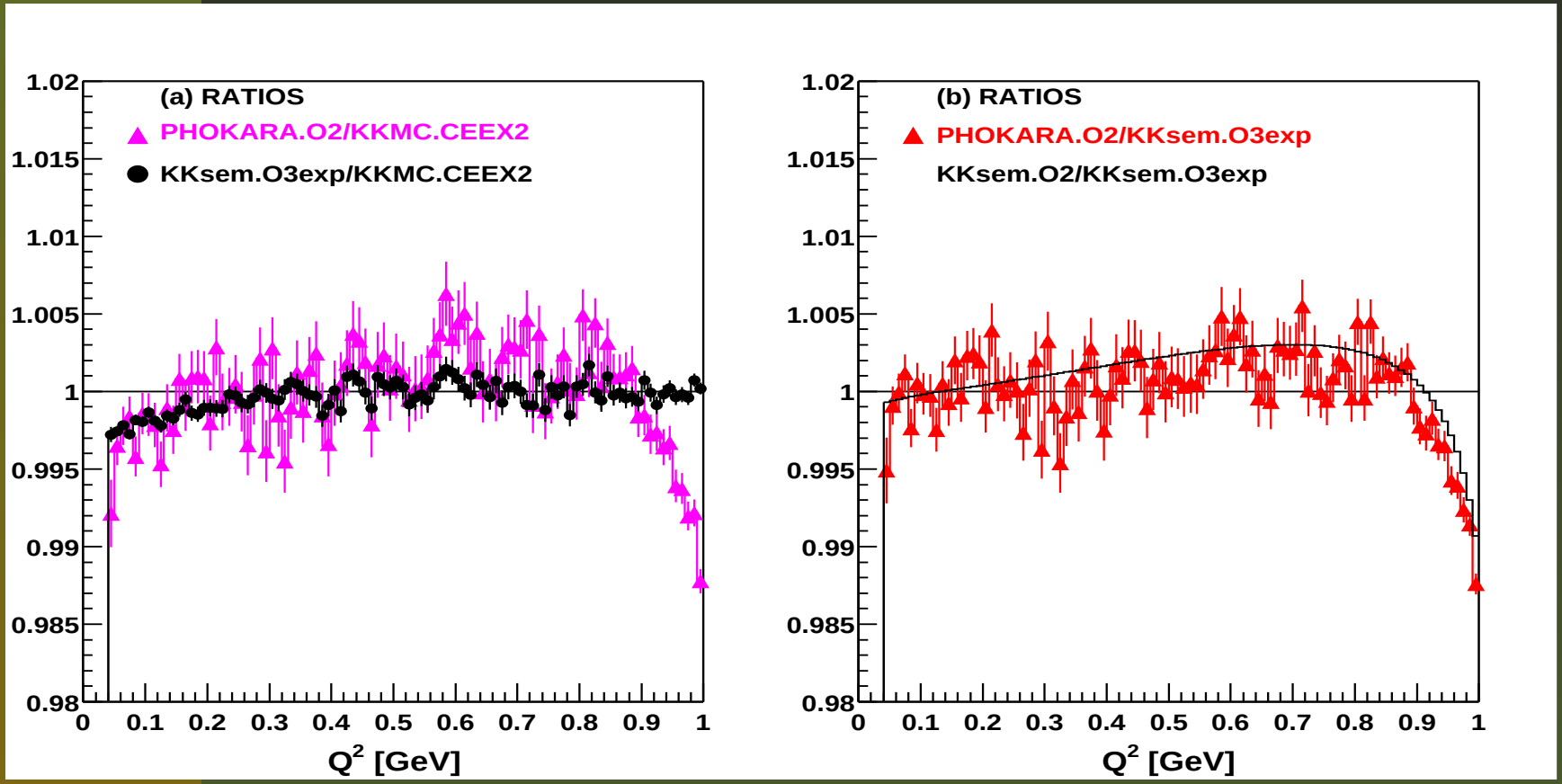



- Now FSR in KKMC (CEEX m.el.) and KKsem is switched on
- The interference ISR$\otimes$FSR is present in KKMC and absent in KKsem
- KKsem more incomplete for FSR than for ISR
- Reasonable agreement is seen...

# PHOKHARA included in the game (ISR), $\mu$-pairs again




PHOKHARA agrees to within 0.3% with KKMC and KKsem.

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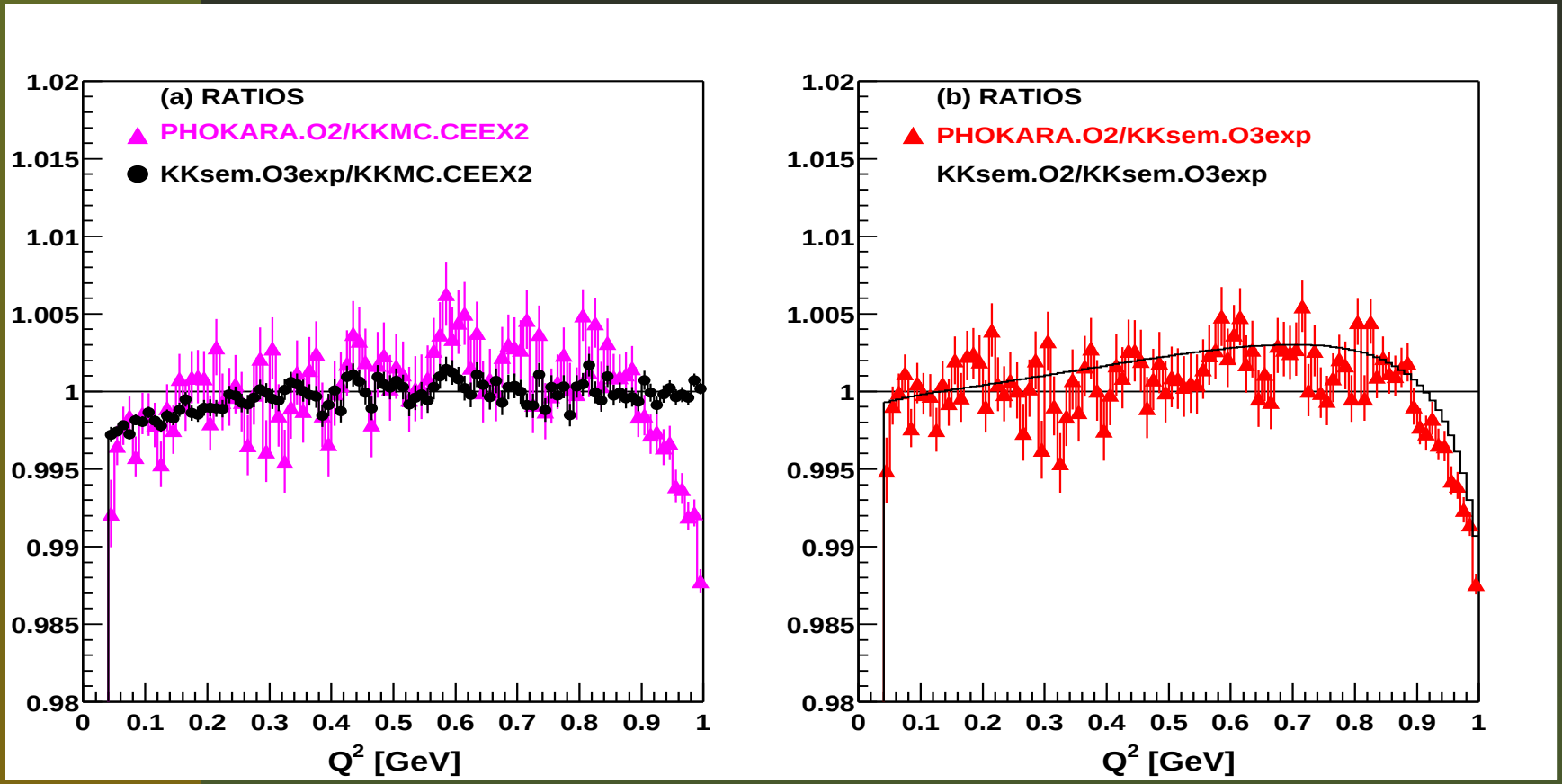
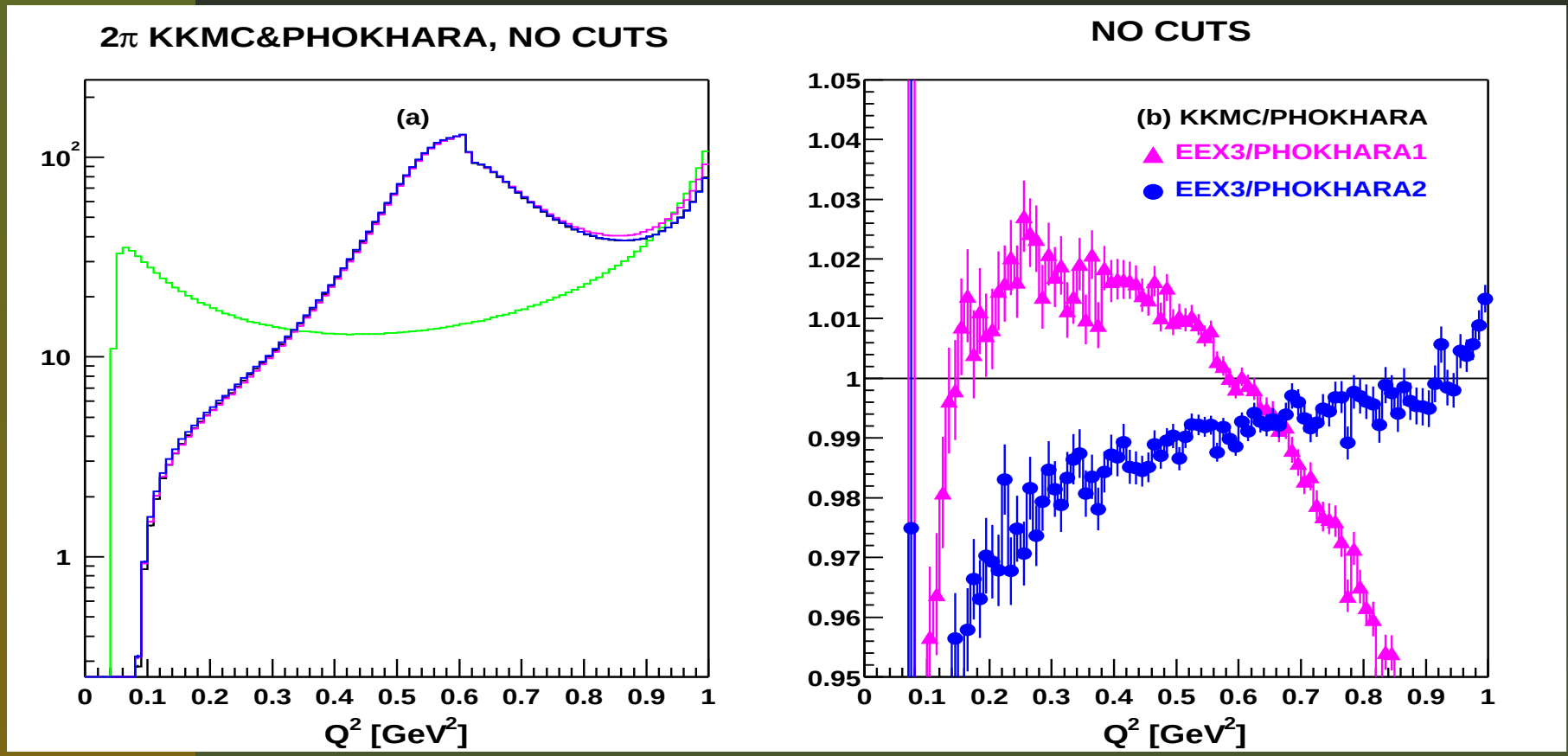



Discrepancy at high $Q^2$ reflects lack of exponentiation in PHOKHARA

This is clearly demonstrated in right plot where we switch OFF exponentiation in KKsem (black curve) and get agreement of with PHOKHARA.

Discrepancy $\sim 2\%$ at low $Q^2$ is more interesting.

# $\pi$-pair mass distribution, no cuts




In case of $\pi$-pairs KKMC is restricted to inferior EEX matr. elm.

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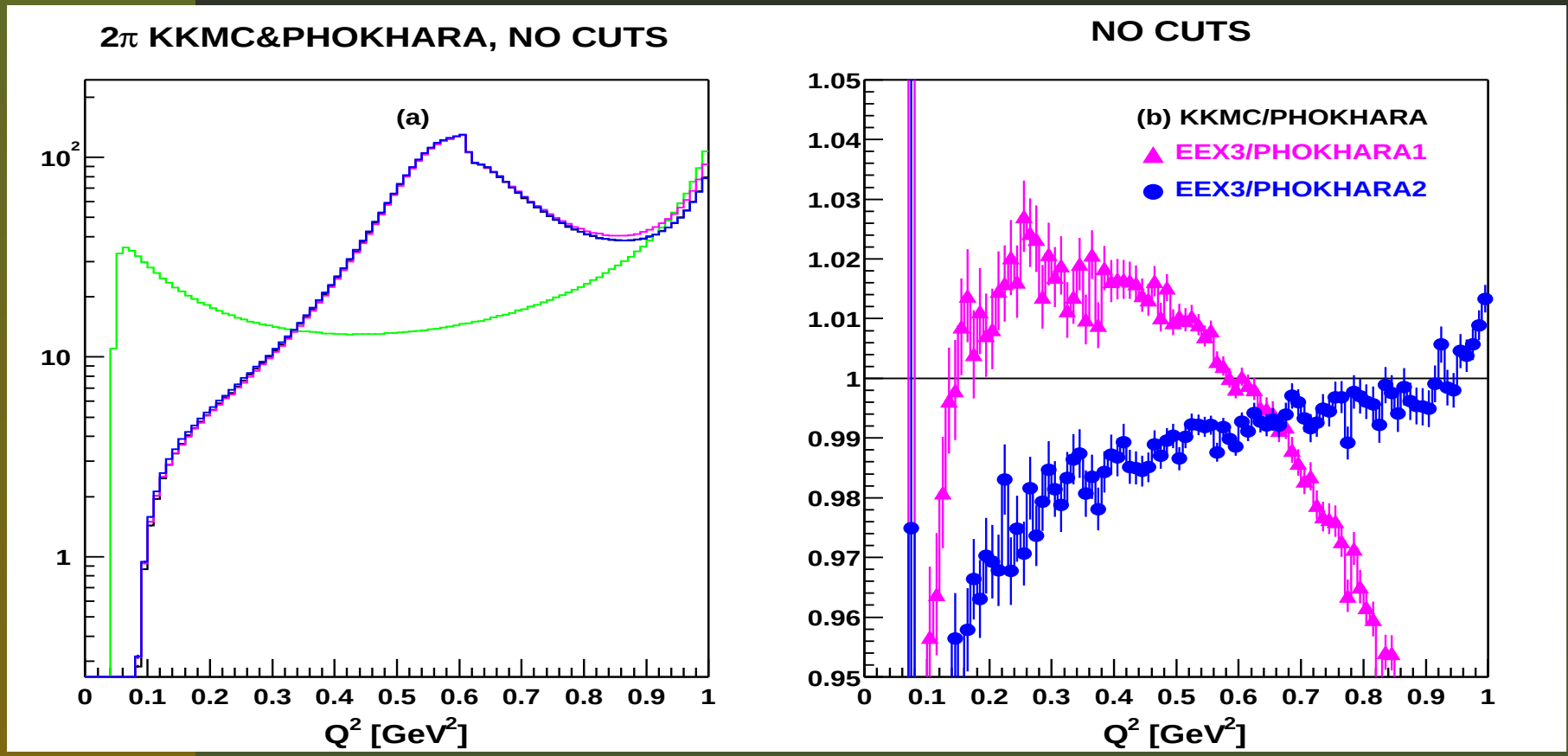


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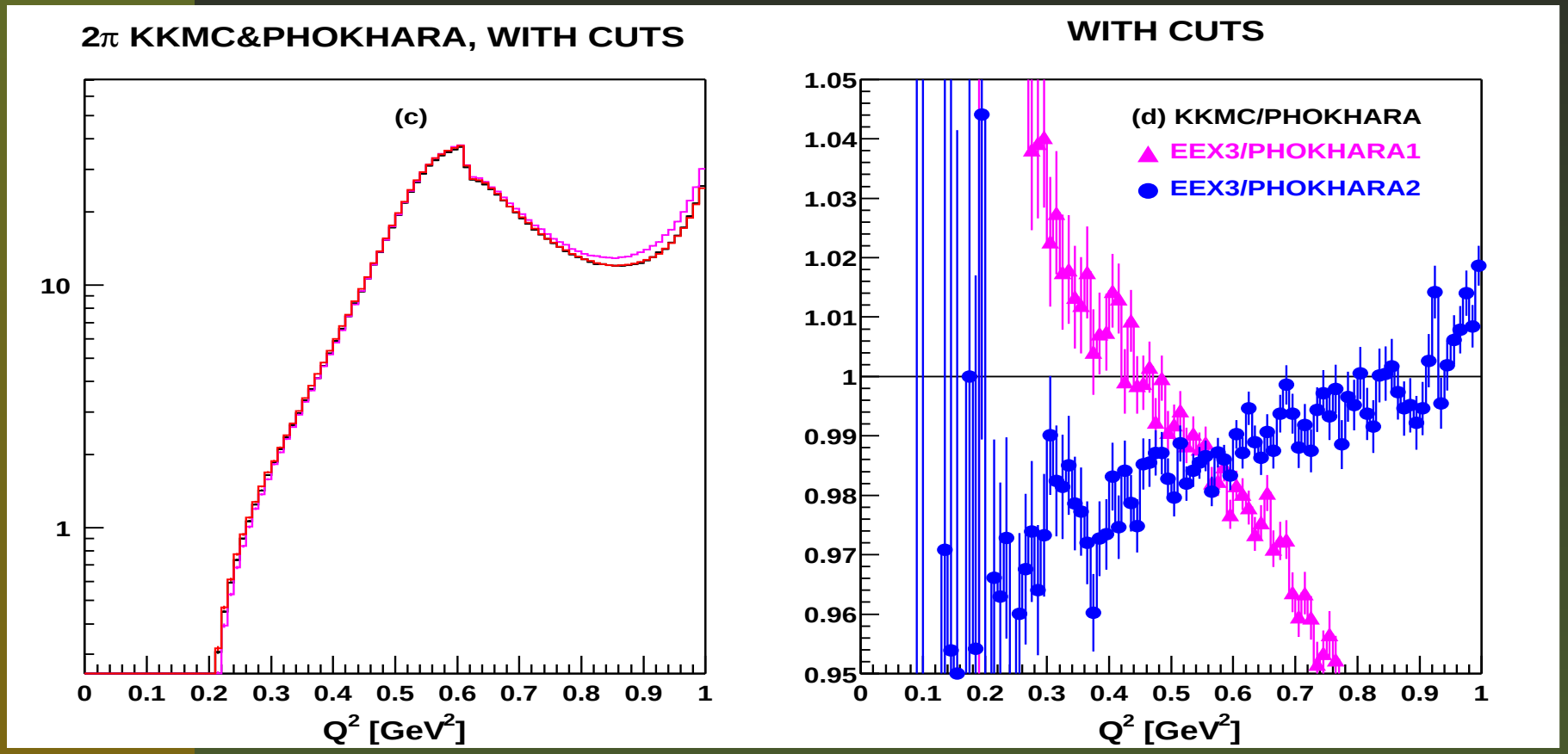
This clearly shows that for higher precision applications ISR in KKMC must be upgraded to CEEX level with complete second order.

# $\pi$-pair mass distribution, with cuts

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Even bigger discrepancy $\sim$2% reflects incomplete second order m.elm. in KKMC

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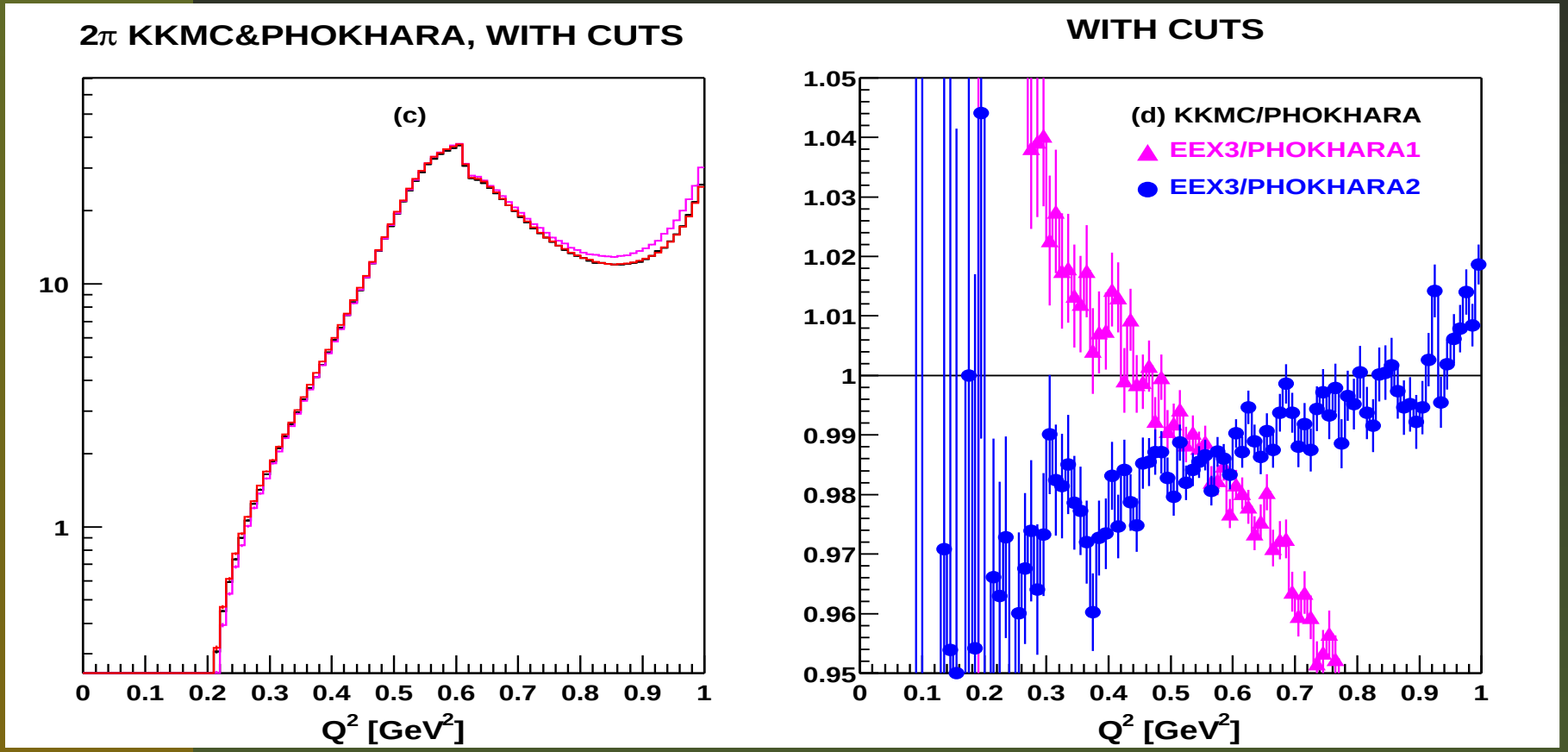


Discrepancy $\sim$3% reflects incomplete second order m.elm. in KKMC

It is mainly due to approximate treatment of double real emission in EEX.

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