

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

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

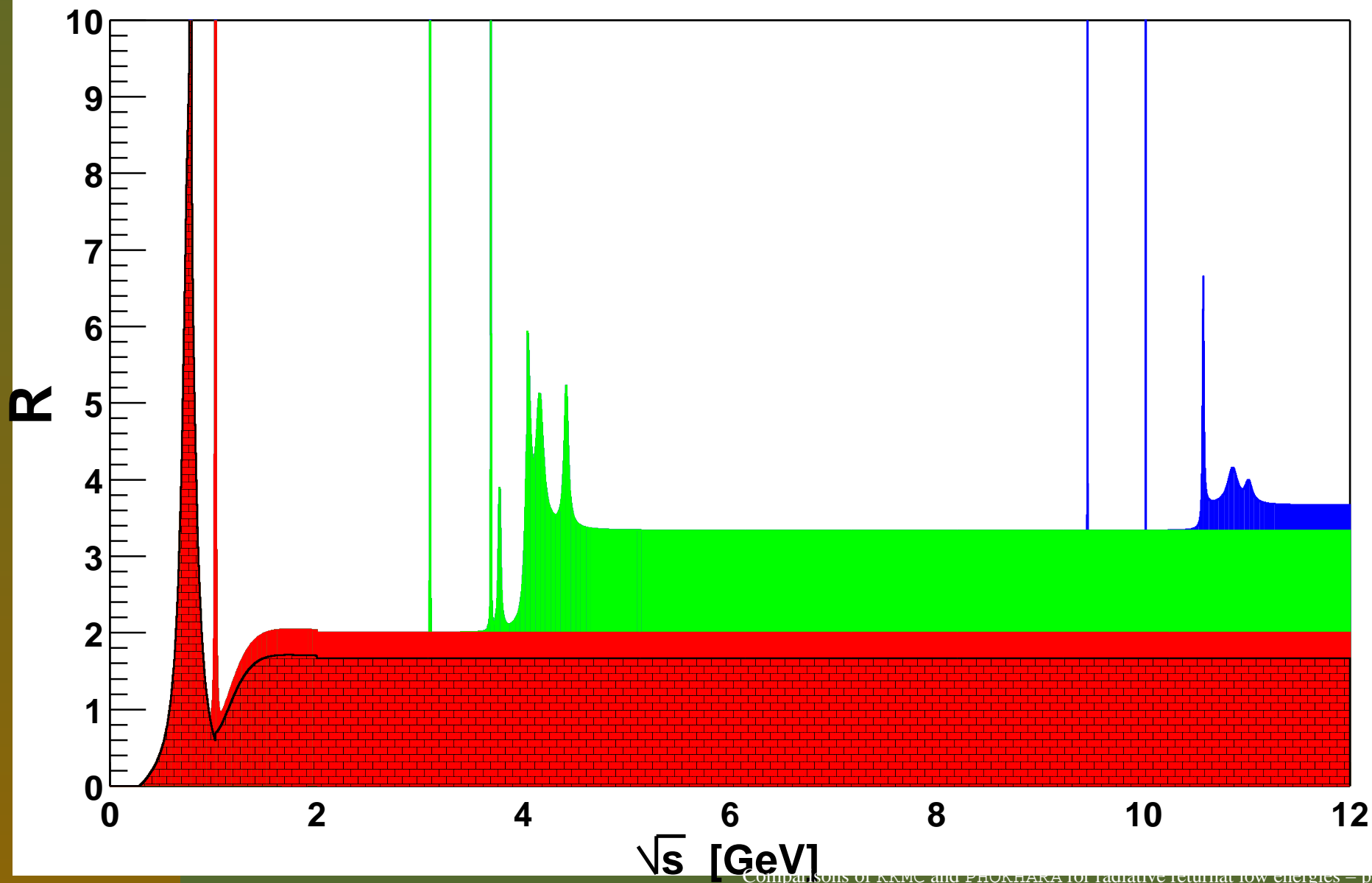
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Based on study in collaboration with A. Denig and J. Kuhn

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



# Introduction

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- What is “radiative return” in  $e^+e^-$  experiment?
- Why it is interesting or/and important?
- KKMC event generator was very instrumental for predictiong  $e^+e^- \rightarrow \mu^+\mu^-, q\bar{q}$ , 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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- For  $\mu$ -pairs KKMC features in addition two types of exponentiations, FSR and interference  $\text{ISR} \otimes \text{FSR}$

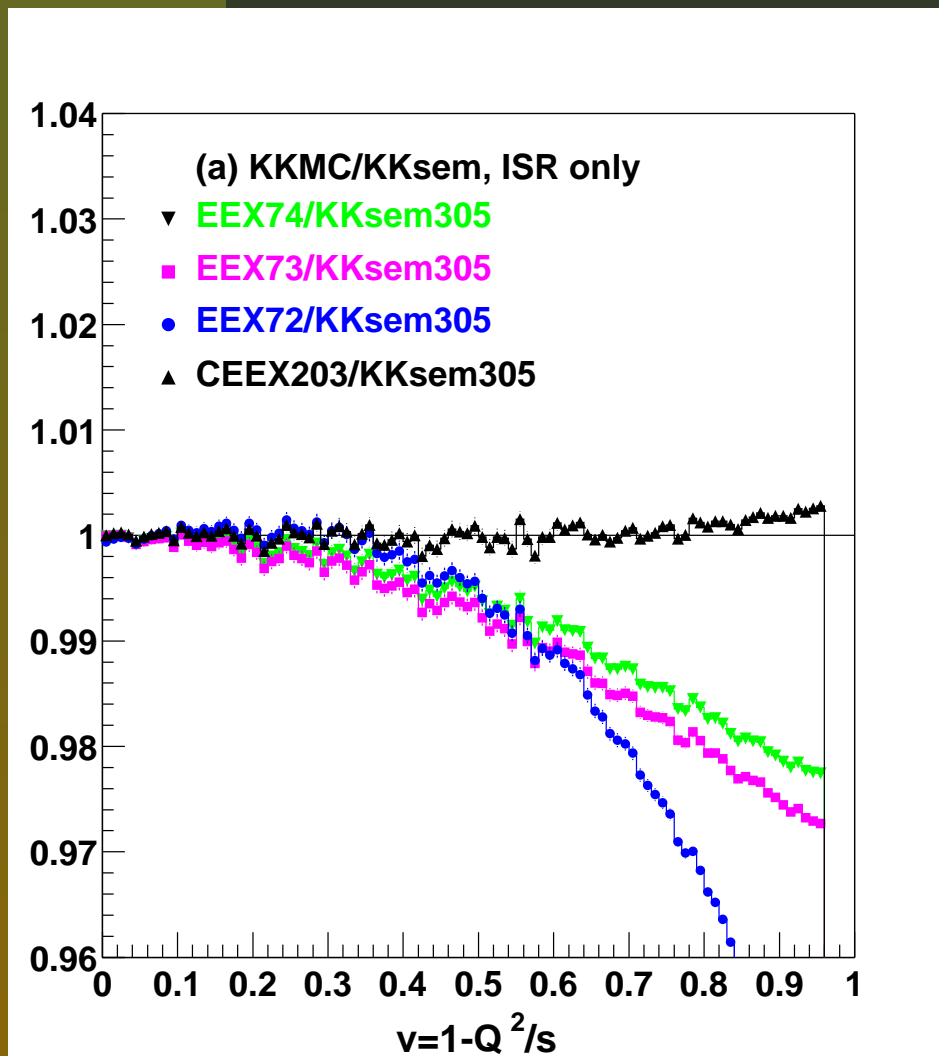
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- For  $\mu$ -pairs KKMC features in addition two types of exponentiations, FSR and interference  $\text{ISR} \otimes \text{FSR}$
- Repeat whichever possible tests for the  $e^-e^+ \rightarrow \pi^-\pi^+$  process

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

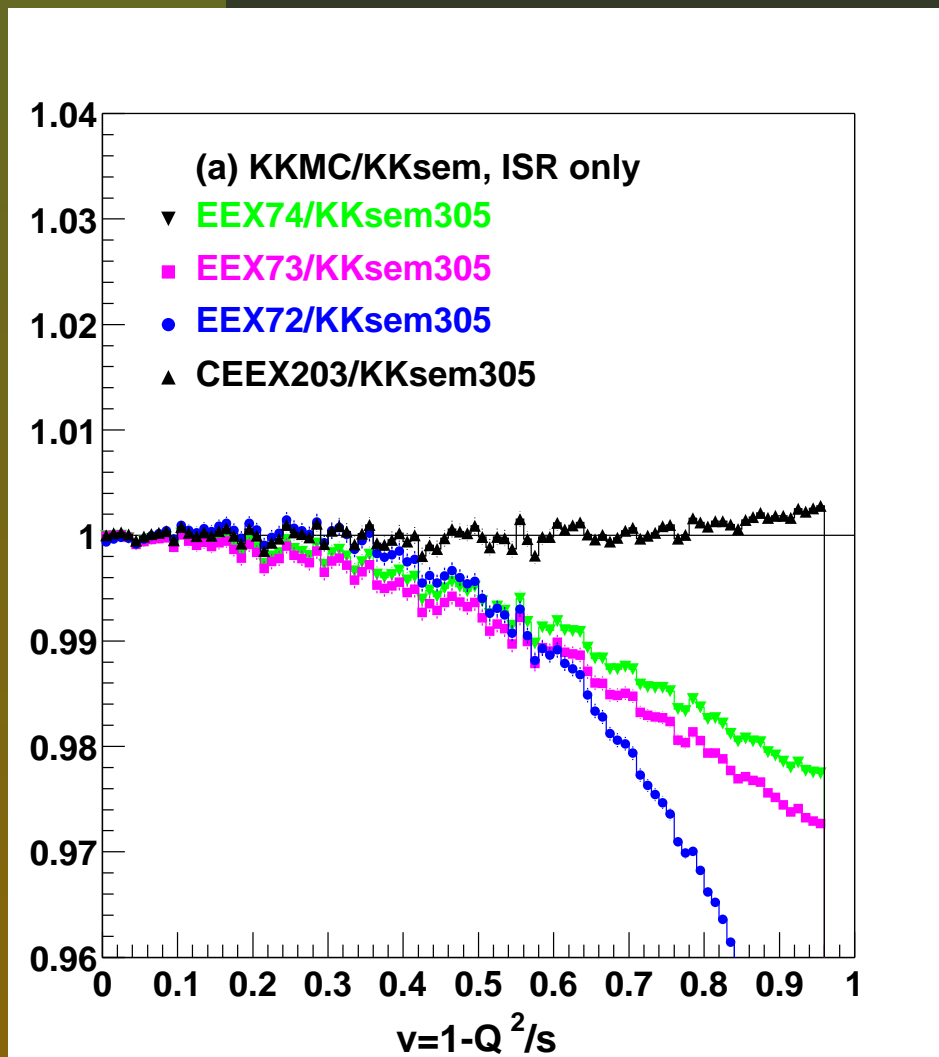
EEX=Exclusive Exponentiation  
CEEX=Coherent Exclusive Expn.

- $d\sigma/dQ^2$  from KKMC with CEEX mat. el. (CEEX203) agrees with KKsem within 0.2%, (black triangles)



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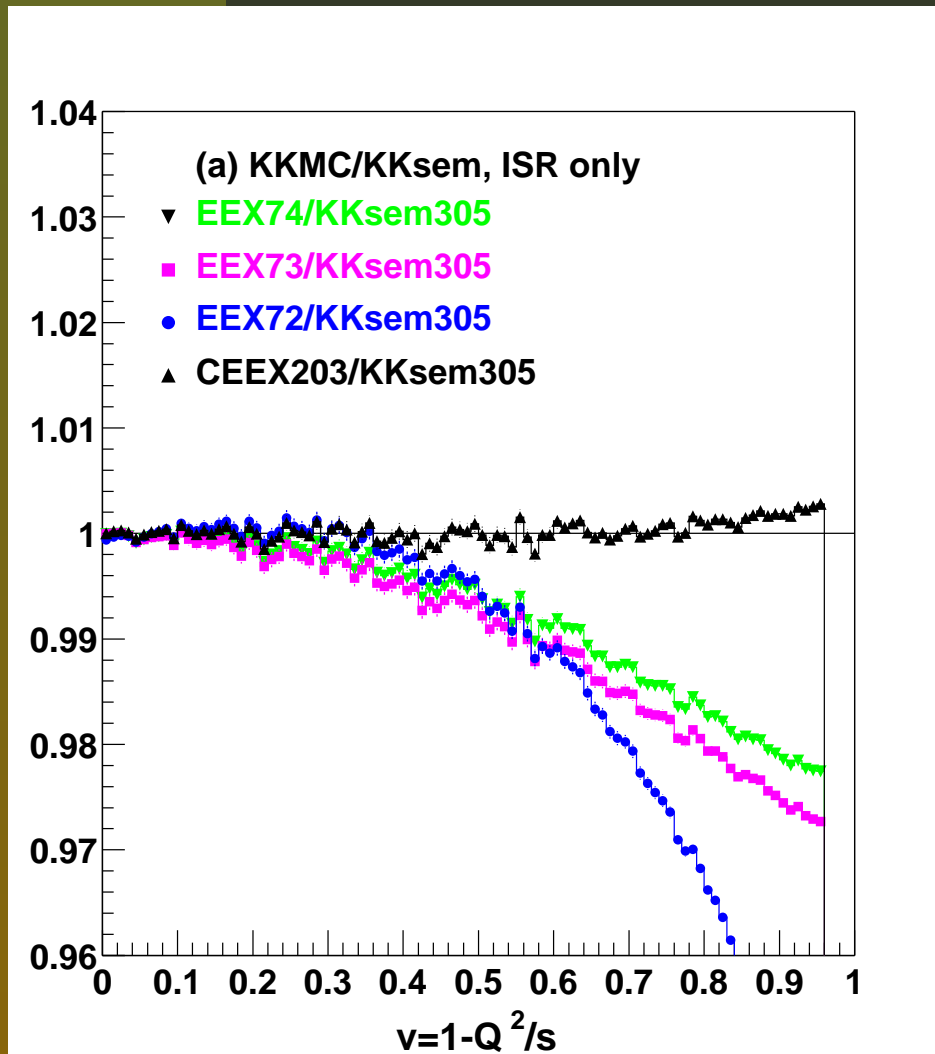
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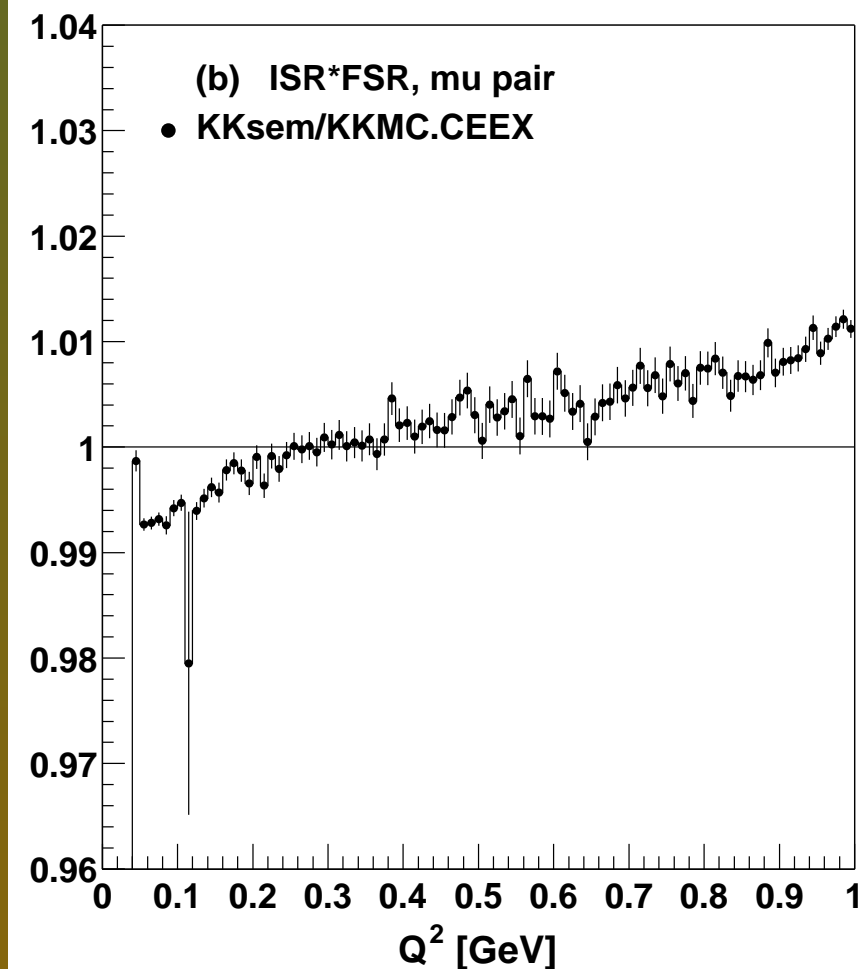
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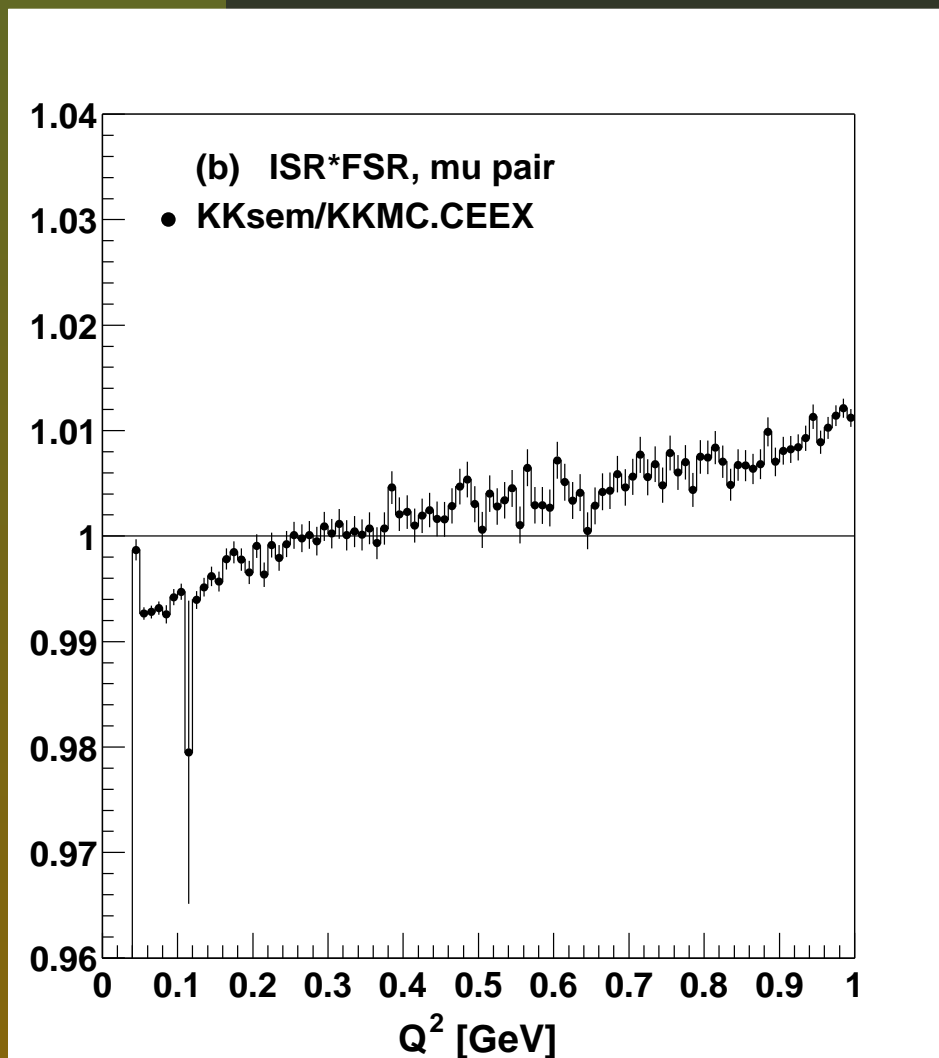
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- at low  $Q^2$  they diverge by about 0.3%, the origin unidentified
- KKMC with incomplete, EEX-type matr. elem. differs from KKsem by about 2-3% at low  $Q^2$

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

- Now FSR in KKMC (CEEX m.el.) and KKsem is switched on

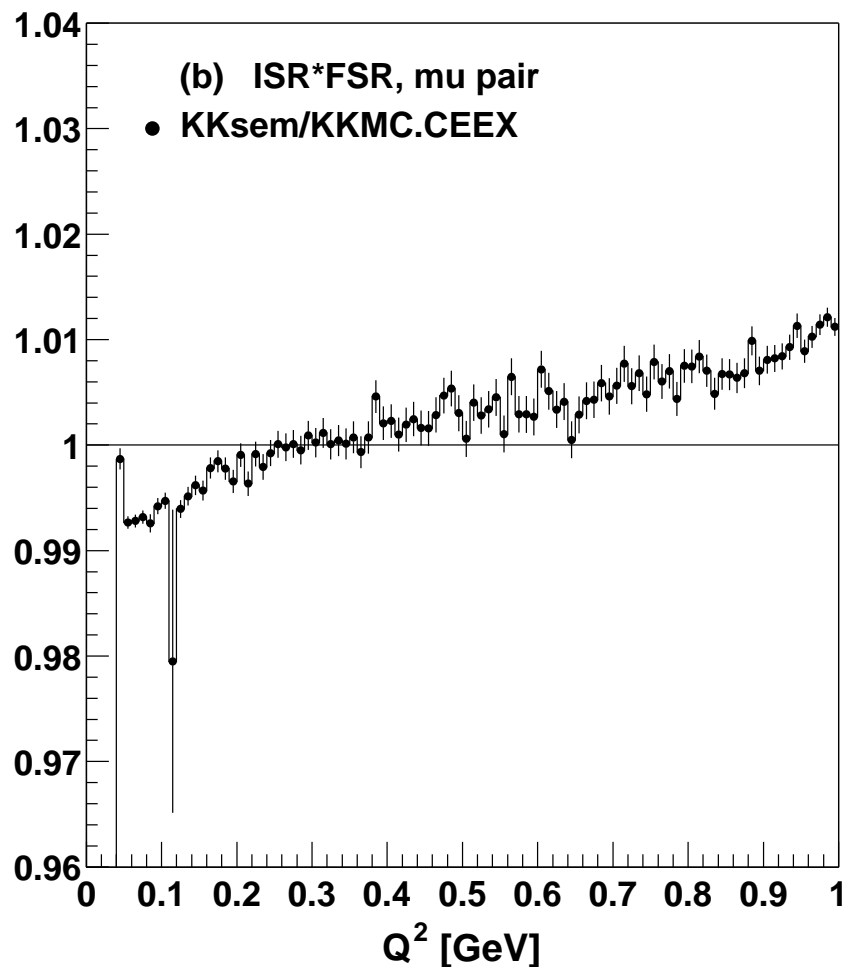


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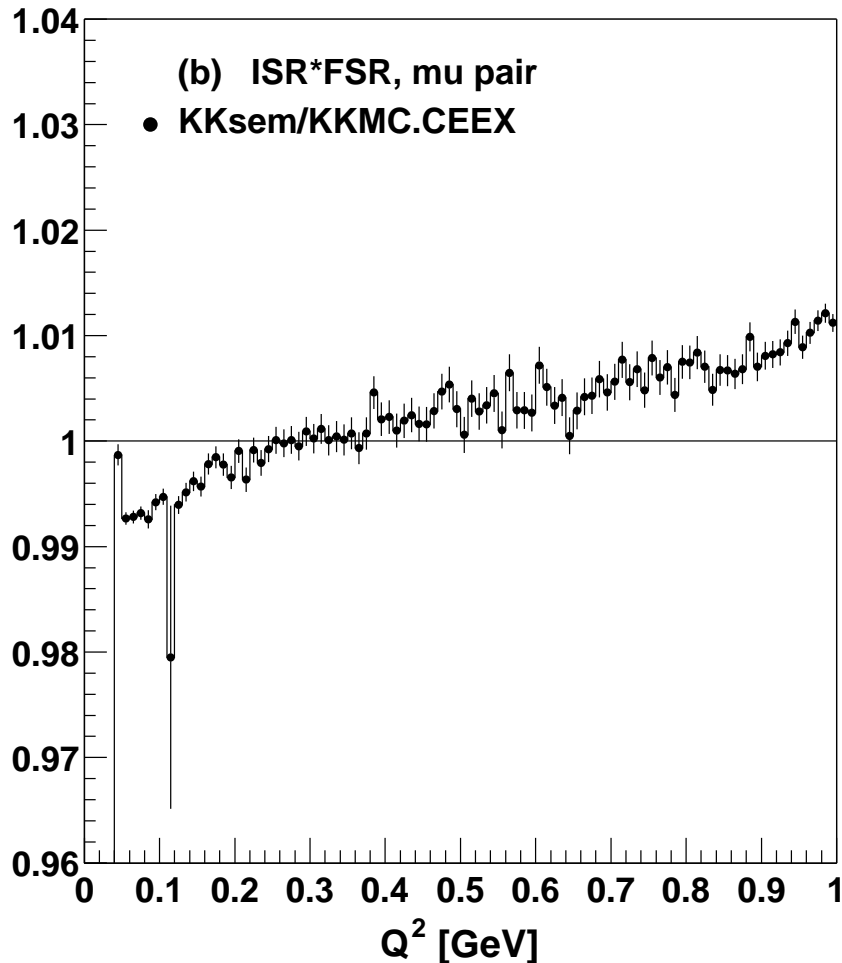
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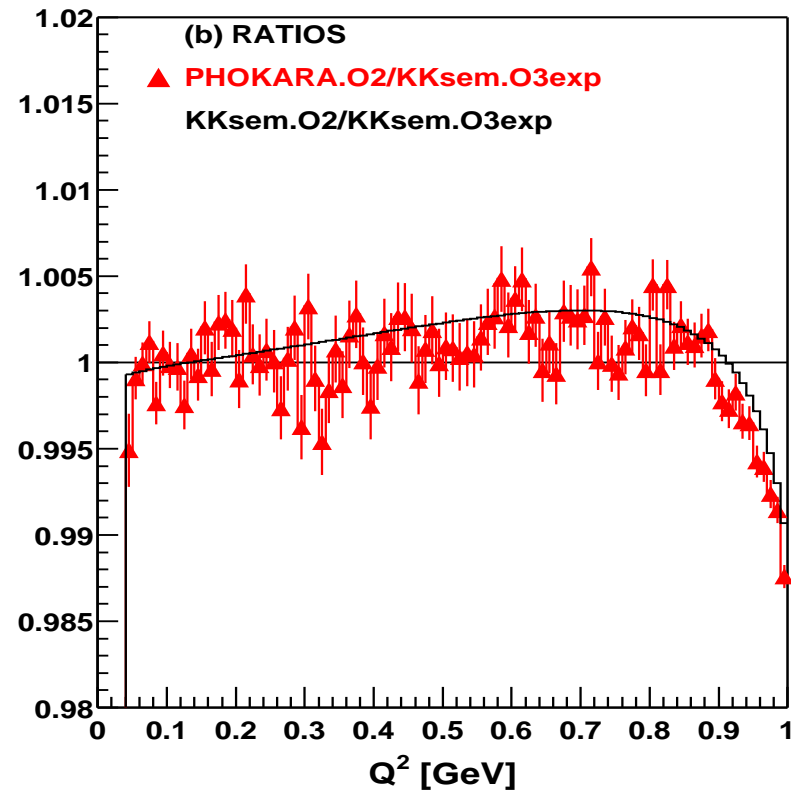
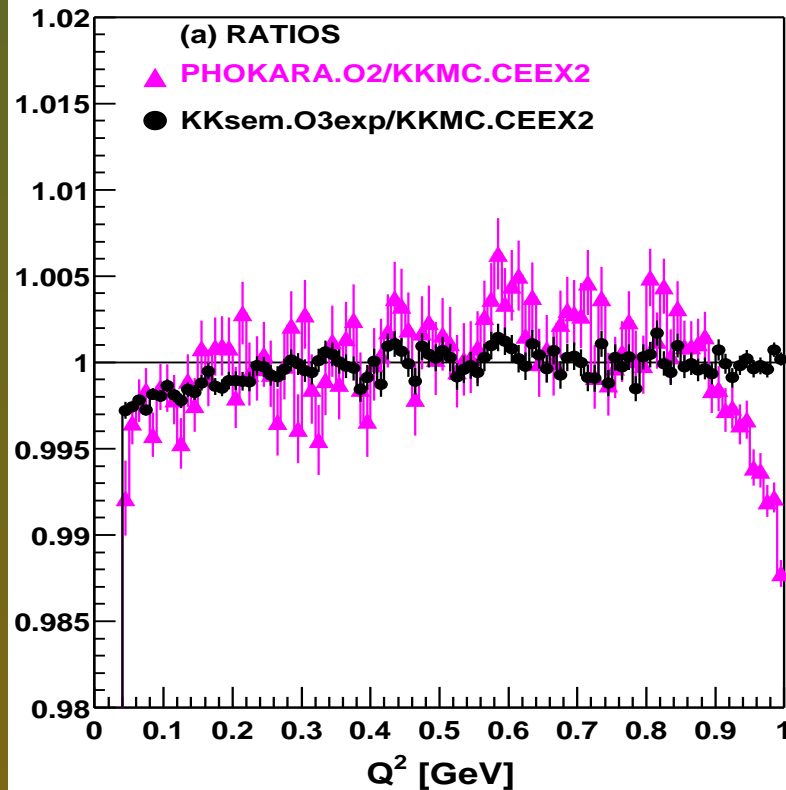
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- KKsem more incomplete for FSR than for ISR

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- KKsem more incomplete for FSR than for ISR
- Reasonable agreement is seen...

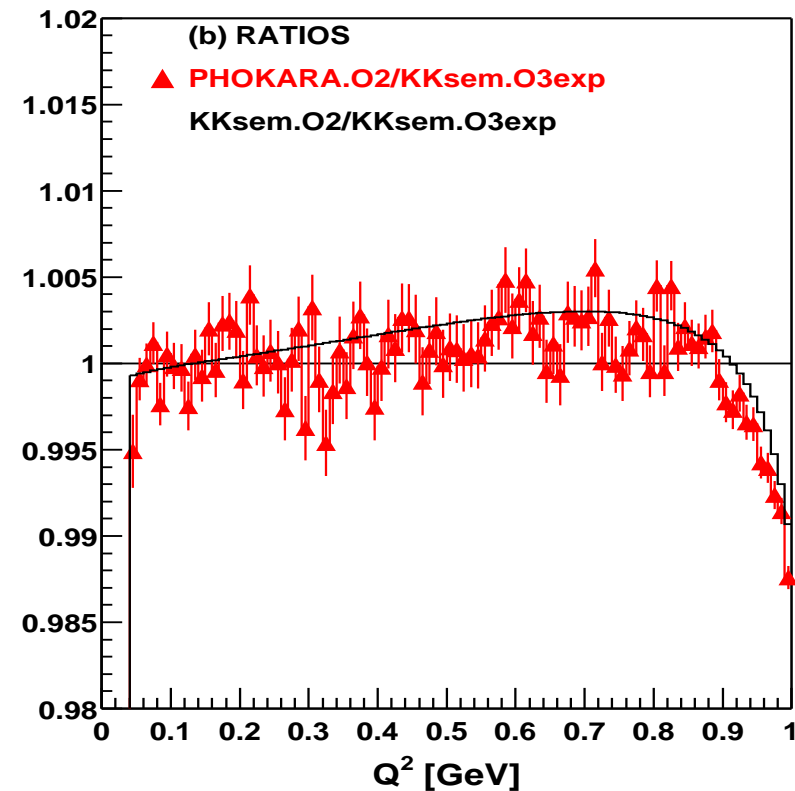
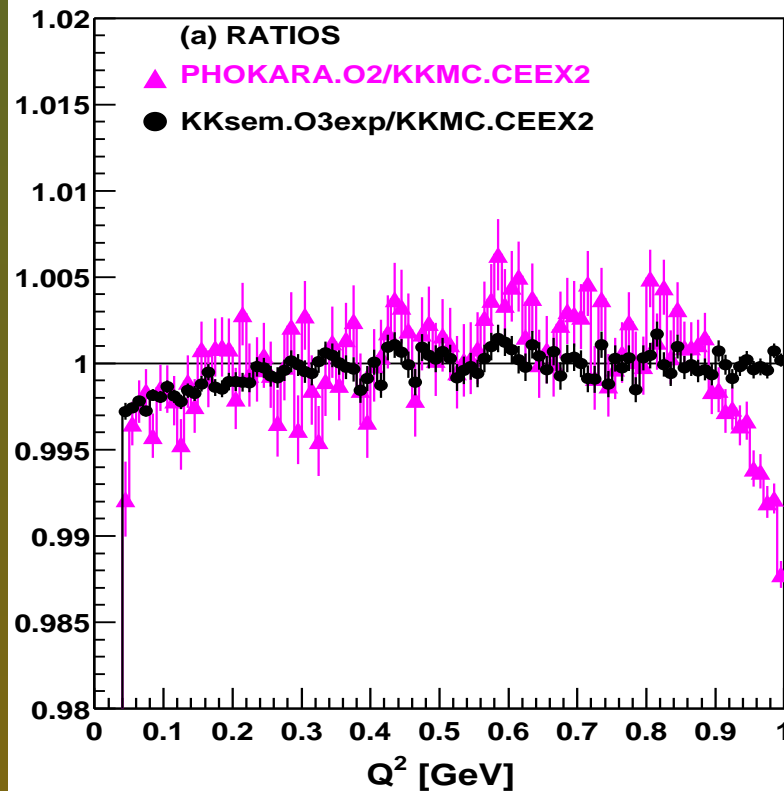
# PHOKHARA included in the game (ISR), $\mu$ -pairs again



PHOKHARA agrees to within 0.3% with KKMC and KKsem.

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

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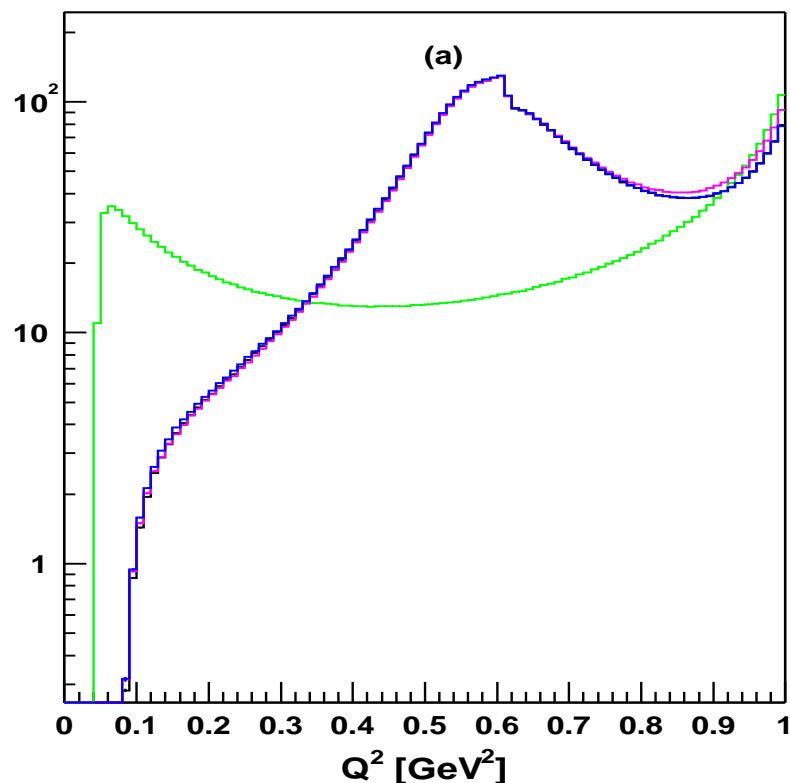
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This is clearly demonstrated in right plot where we switch OFF exponentiation in KKsem (black curve) and get agreement of with PHOKHARA.

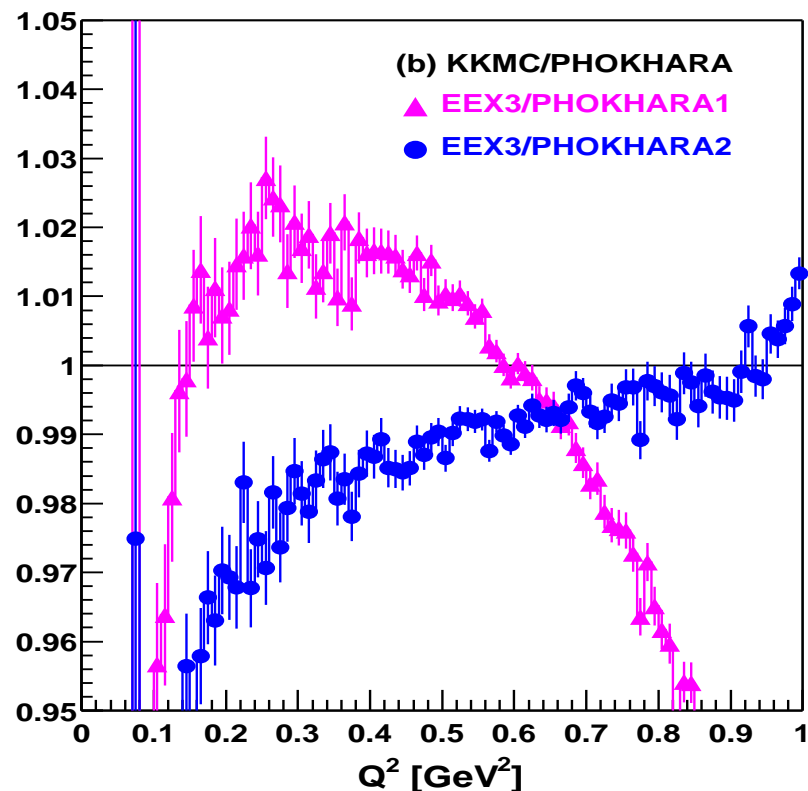
Discrepancy  $\sim 2\%$  at low  $Q^2$  is more interesting.

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

2 $\pi$  KKMC&PHOKHARA, NO CUTS



NO CUTS

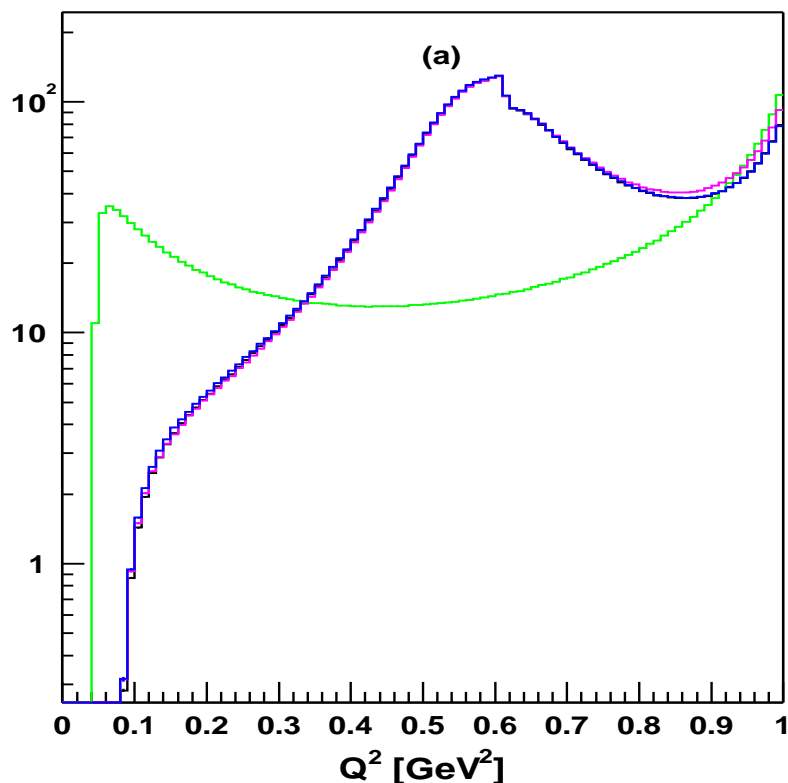


In case of  $\pi$ -pairs KKMC is restricted to inferior EEX matr. elm.

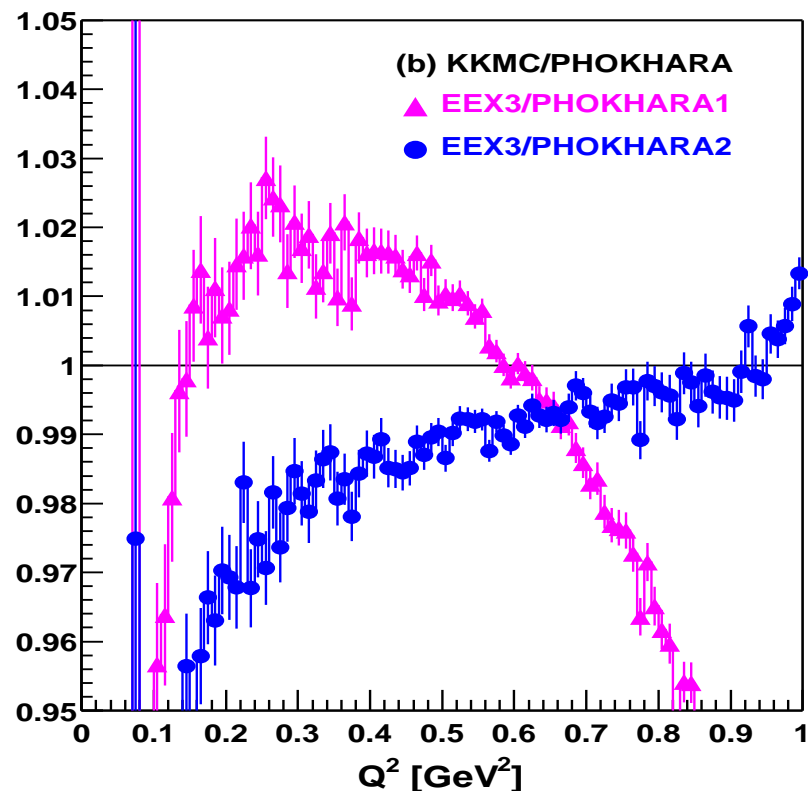
Discrepancy  $\sim 1\%$  reflects incomplete second order m.elm. in KKMC

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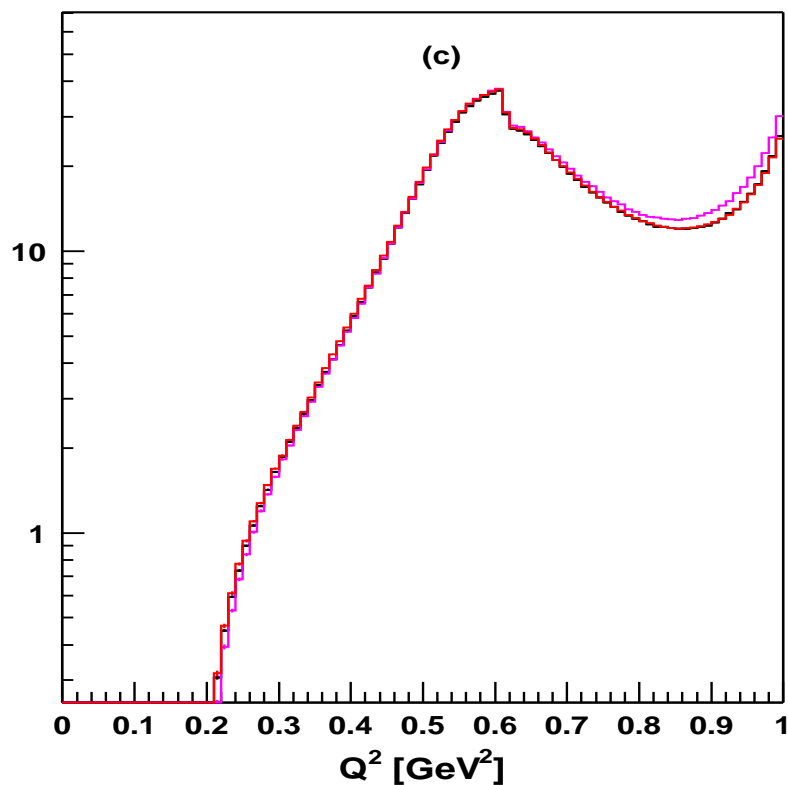


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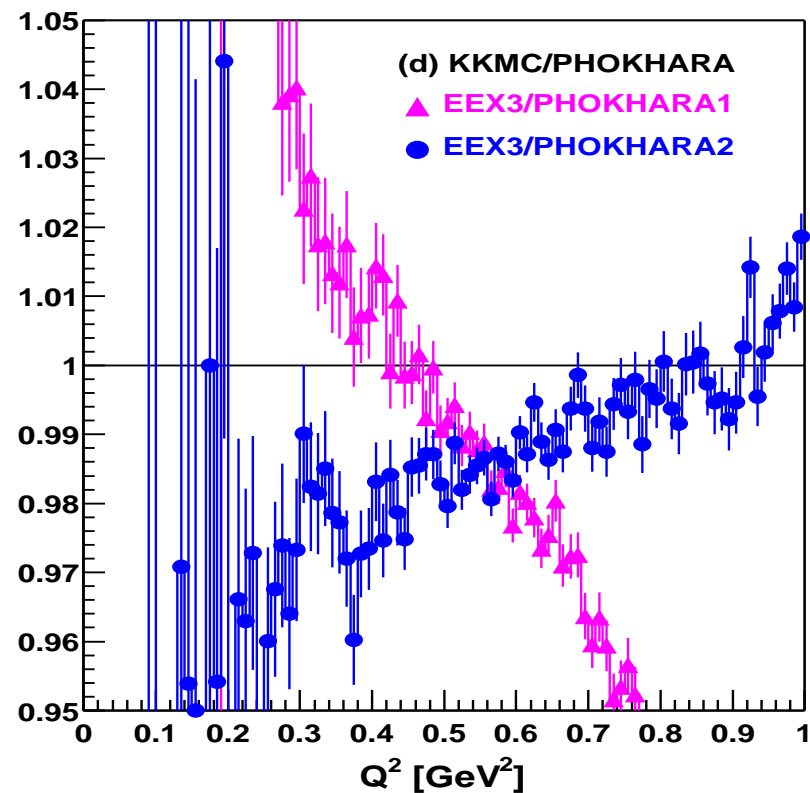
This clearly shows that for higher precision applications ISR in KKMC must be upgraded to CEEEX level with complete second order.

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

2 $\pi$  KKMC&PHOKHARA, WITH CUTS



WITH CUTS

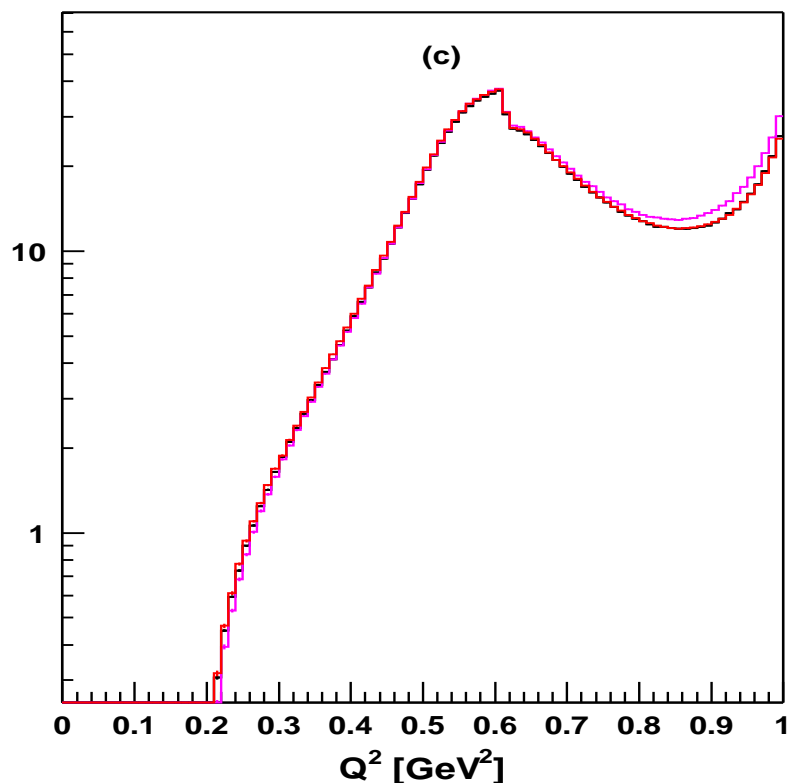


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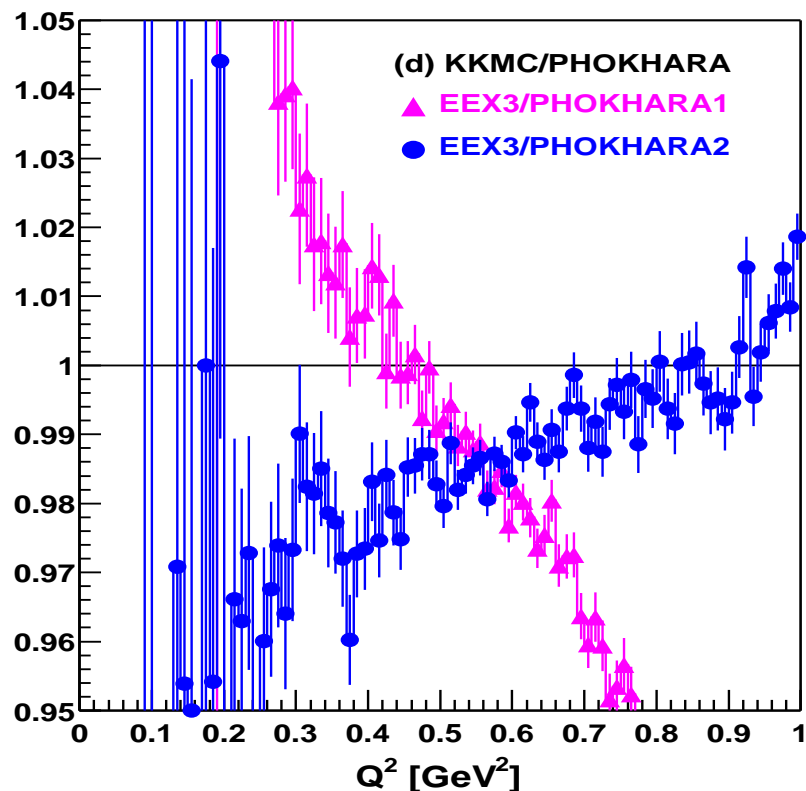
Even bigger discrepancy  $\sim 2\%$  reflects incomplete second order m.elm. in KKMC

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

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WITH CUTS



Discrepancy  $\sim 3\%$  reflects incomplete second order m.elm. in KKMC  
It is mainly due to approximate treatment of double real emission in EEX.  
ISR in KKMC must be upgraded to CEEX level with complete second order.

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