

# FACTORIZATION EFFECTS AND NEAR-THRESHOLD BOSON PRODUCTION AT LINEAR COLLIDERS

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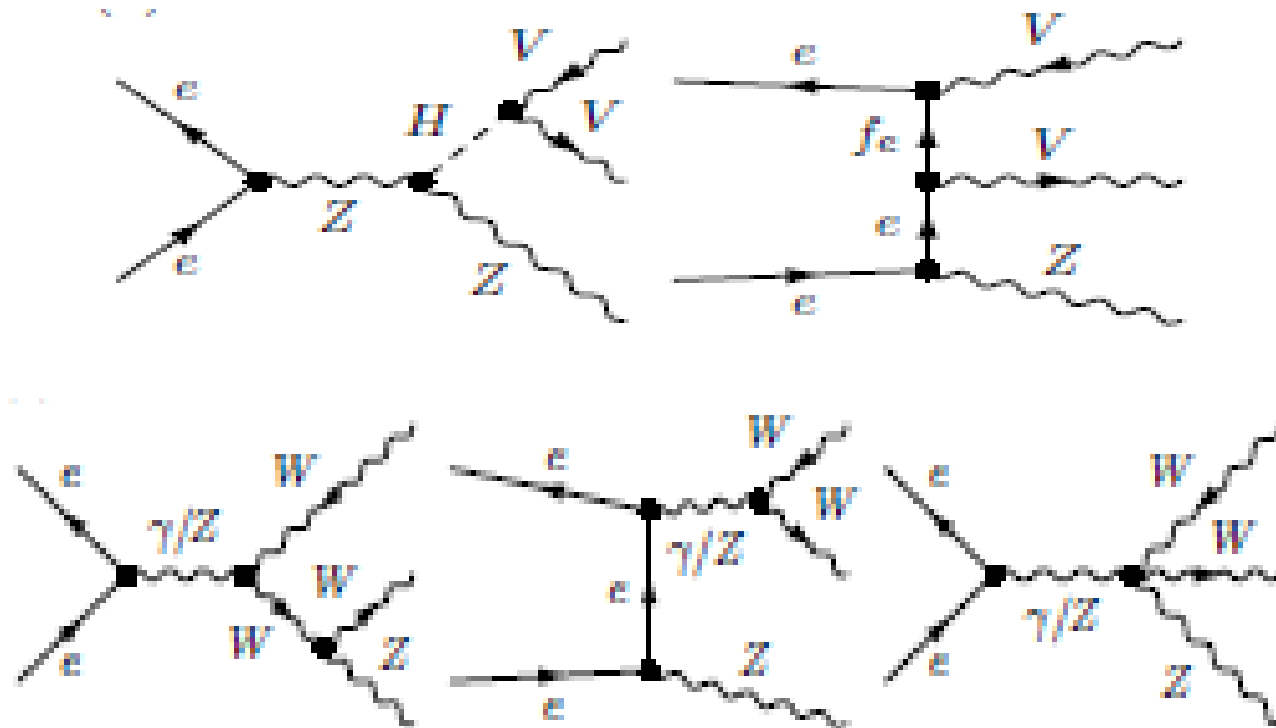
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QFTHEP 2010, Moscow, 8-15 September 2010

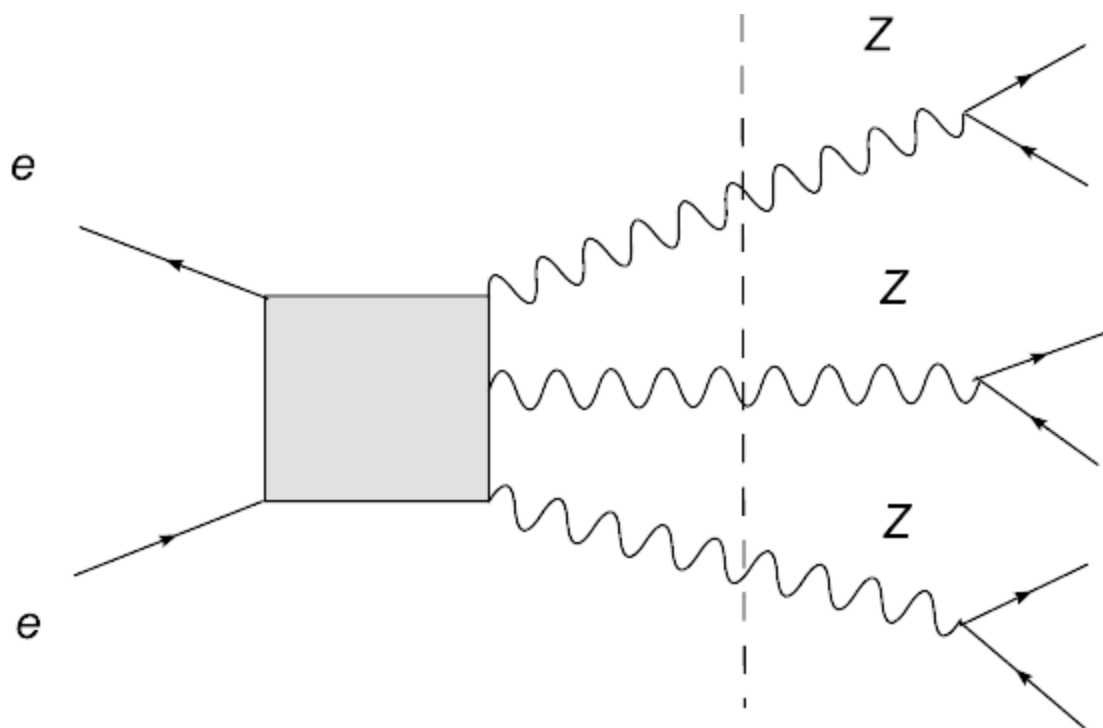
Near-threshold production of the unstable particles (UP's), as a rule, is accompanied by large finite-width effects (FWE). The boson-pair production  $e^+e^- \rightarrow ZZ; ZH; W^+W^- \rightarrow \sum_f 4f$  at threshold energy (LEP II experiments) have been considered with an account of complete one-loop EW corrections. Now, the processes of multi-boson production  $ZZZ; ZW^+W^-; ZZW^+W^-$  are intensively studied. These processes are available at Tevatron, LHC and future *ILC*. To describe FWE we have to consider full process, for instance  $e^+e^- \rightarrow ZZZ; ZW^+W^- \rightarrow \sum_f 6f$ . An account of complete NLO corrections to these processes is very complicated problem. So, the consideration was fulfilled in the SPA for the case of light Higgs ( $M_H = 120, 150$  GeV) [Su Ji-Juan et al., Phys. Rev. D78, 016007 (2008); Sun Wei et al., Phys. Lett. B680, 321 (2009); F. Boudjema et al., Phys. Rev. D 81, 073007 (2010)].

The processes  $e^+e^- \rightarrow ZZZ; ZW^+W^-$  at the tree level in SPA are described by the following diagrams ( $ZZZ$  - 9 diagrams,  $ZW^+W^-$  - 16 diagrams).



To account complete NLO corrections we have to consider thousands diagrams.

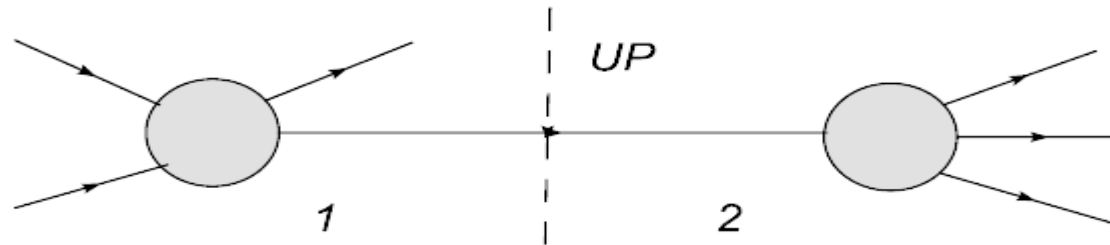
To account FWE in a standard way we have to consider full process with 6-particles final states.



The model cross-section of the inclusive processes  $e^+e^- \rightarrow ZZZ$ ;  $ZW^+W^- \rightarrow \sum_f \underline{6f}$  can be represented in three-convolution form (factorization effect):

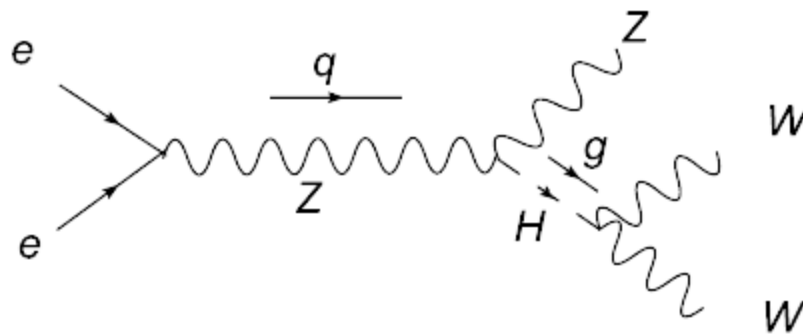
$$\sigma(s) = \int \int \int \sigma(s; m_1^2, m_2^2, m_3^2) \rho(m_1^2) \rho(m_2^2) \rho(m_3^2) dm_1^2 dm_2^2 dm_3^2 \quad (1.1)$$

## FACTORIZATION EFFECT



$$S = 0; \frac{1}{2} \quad |M|^2 = k |M_1|^2 \cdot |M_2|^2$$

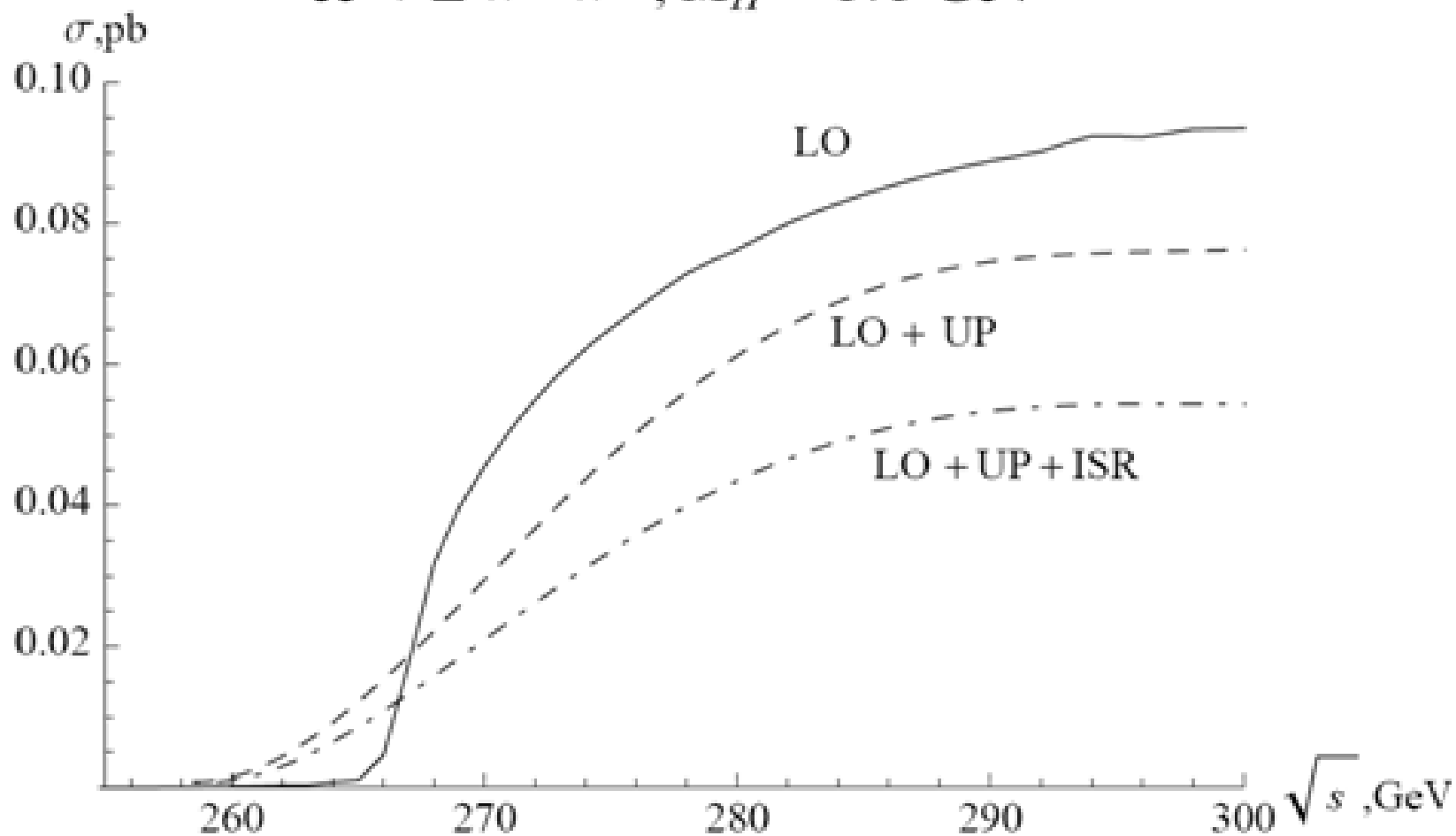
$$S = 1; \frac{3}{2}; 2; \dots \quad J(|M|^2) = k |M_1|^2 \cdot J(|M_2|^2)$$



The cross-section in SPA:

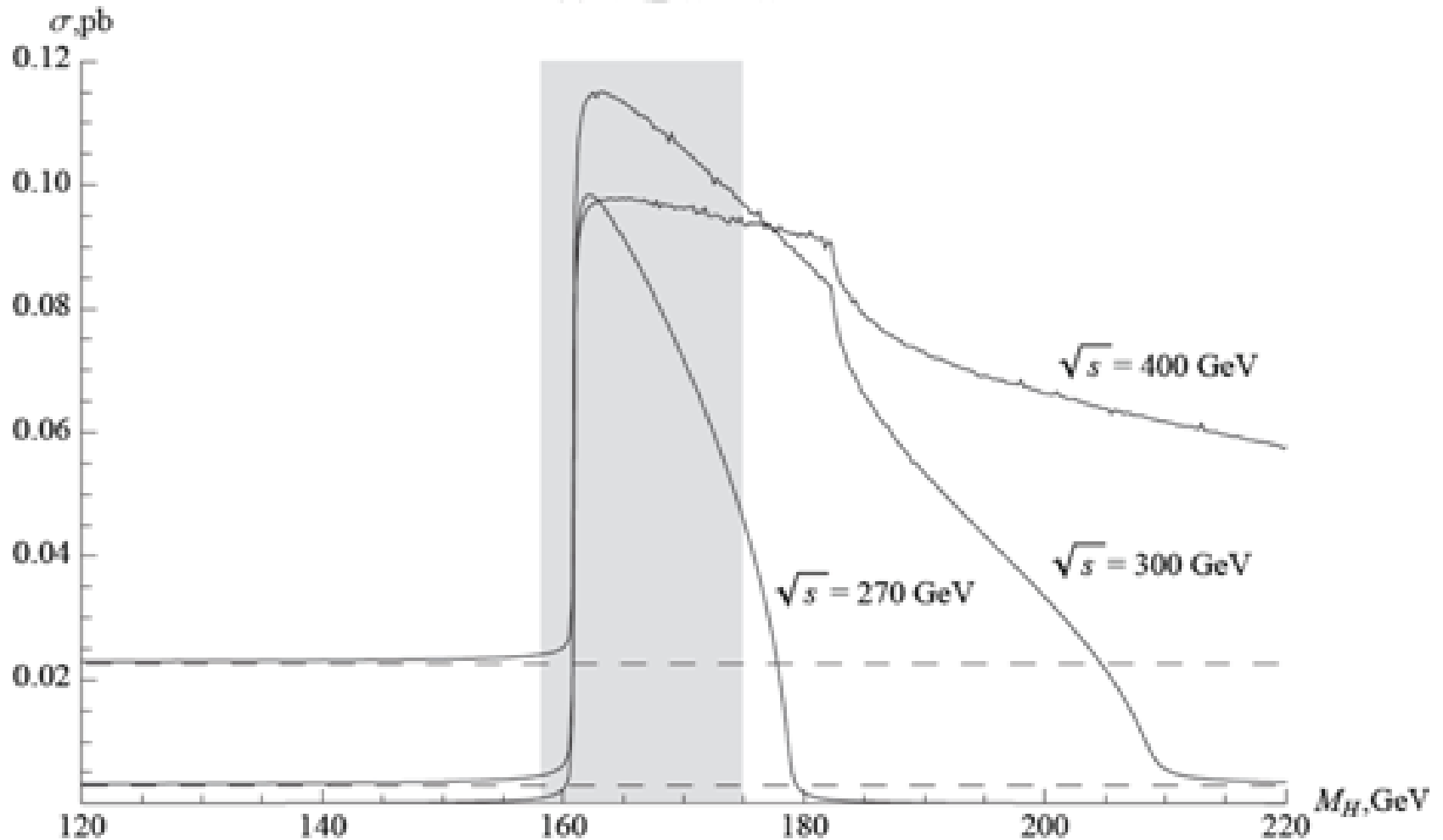
$$\sigma(S) = 12 \frac{\Gamma_Z^{ee}(S)}{|P_Z(S)|^2} \int \Gamma(Z(S) \rightarrow ZH(g)) \frac{g \Gamma_H^{WW}(g)}{|P_H(g)|^2}$$

$ee \rightarrow Z W^+ W^-$ ,  $M_H = 175$  GeV



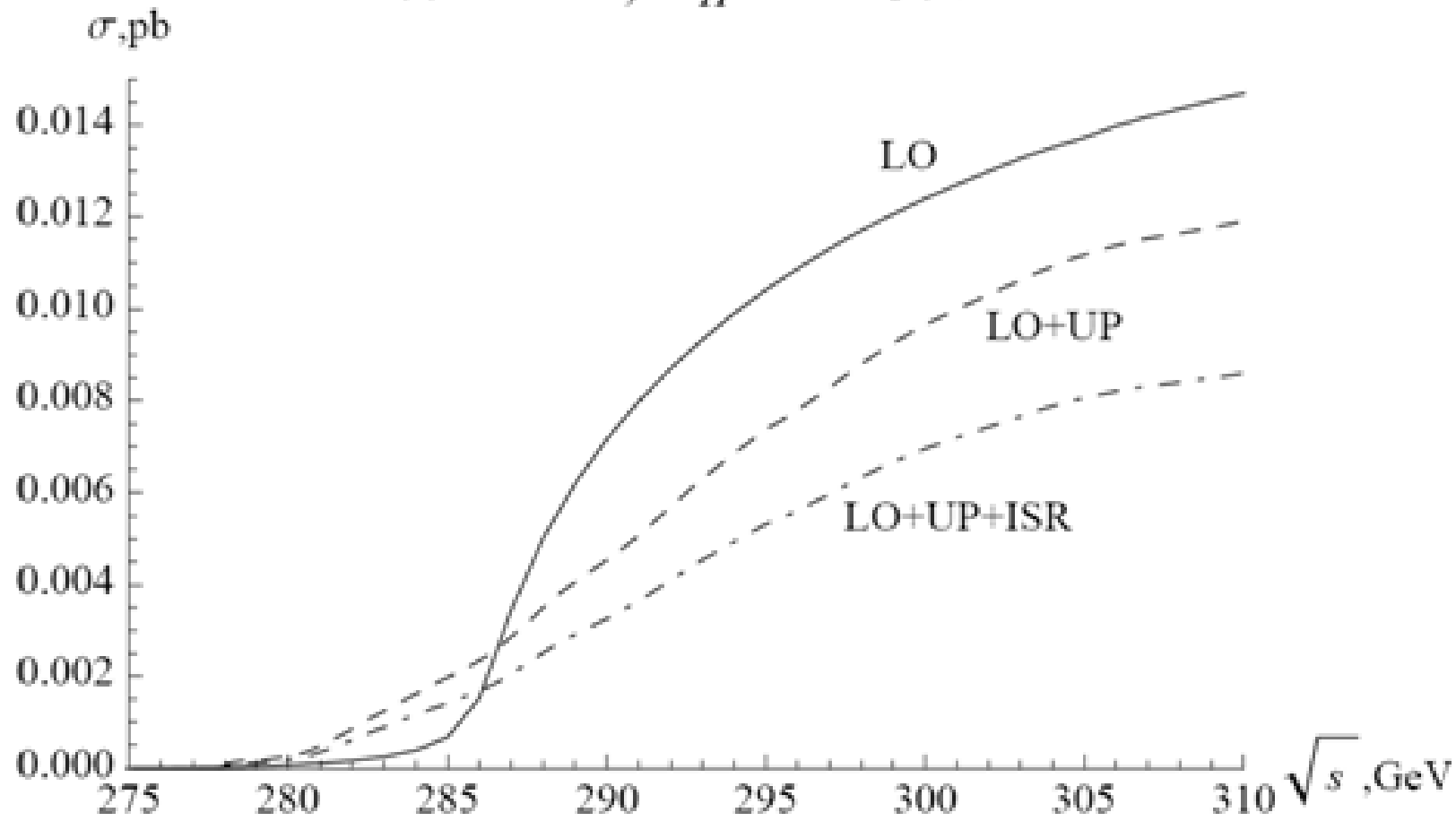
$ee \rightarrow Z W^+ W^-$

LO



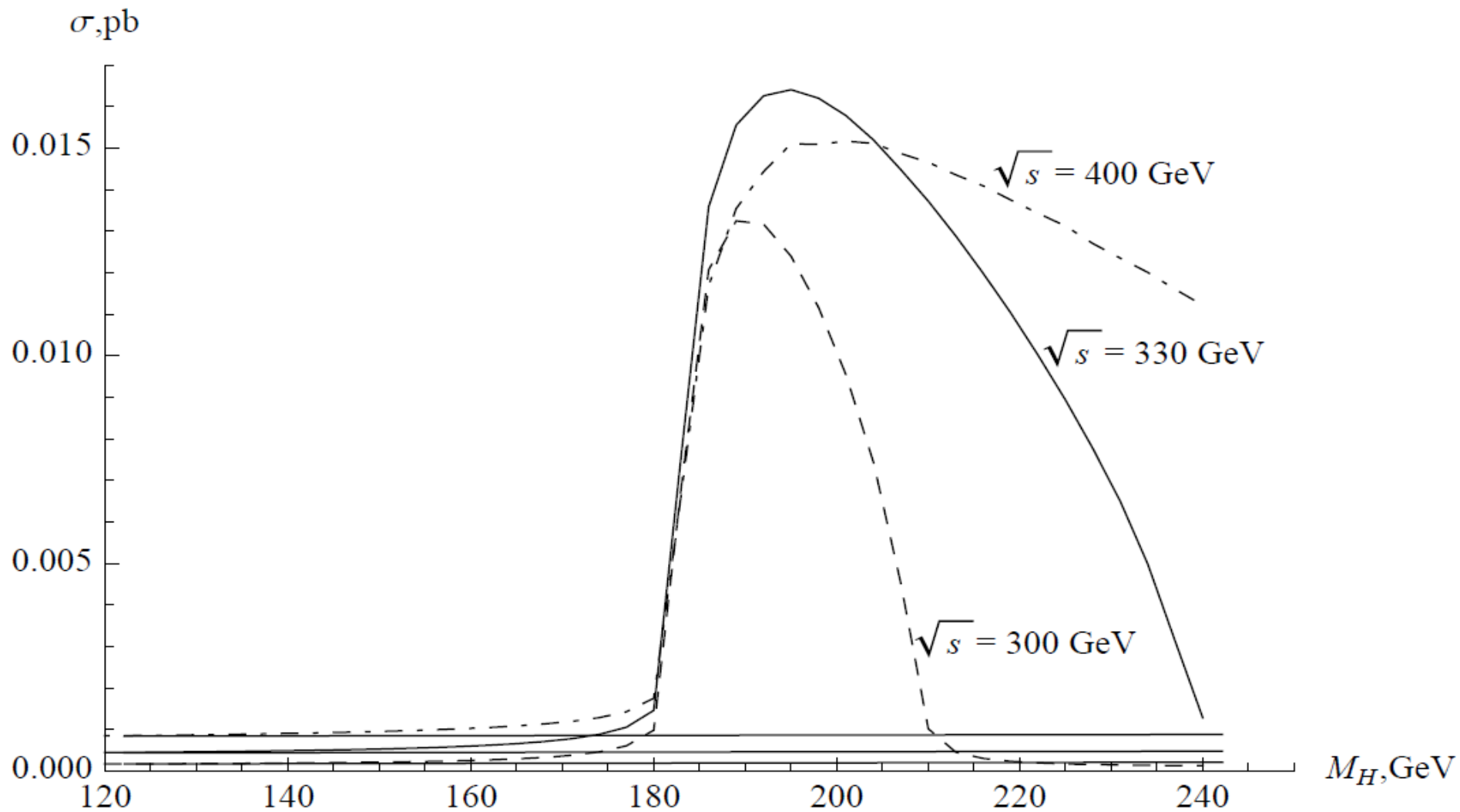
Tevatron 95% CL exclusion:  $158 \leq M_H \leq 175 \text{ GeV}$  [B. Kilminster, ICHEP 2010, July 26]

$ee \rightarrow ZZZ, M_H = 195 \text{ GeV}$





$ee \rightarrow ZZZ$  LO



## CONCLUSIONS

1. FWE's strongly depend on Higgs diagram contribution. It can be comparable with ISR and one-loop corrections.
2. FWE's are large at wide energy region when Higgs-resonant contribution is large. FWE's are small when Higgs contribution is small.
3. Higgs contribution into cross-section at resonance energy region is dominant.
4. Model approach and factorization method significantly simplify the calculations in a comparison with the traditional one.