Matrix Element Method for ILC Physics Analysis

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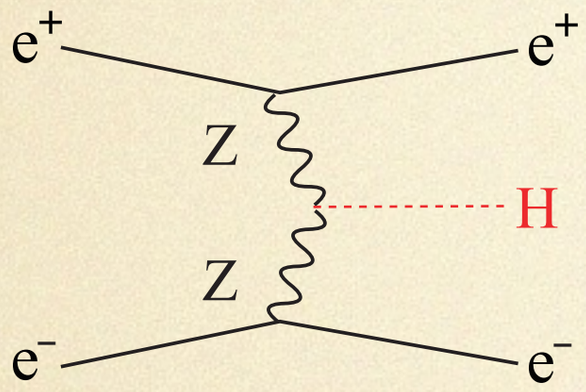
http://ilcphys.kek.jp/meeting/physics/archives/2009-05-19/GGGuide.pdf

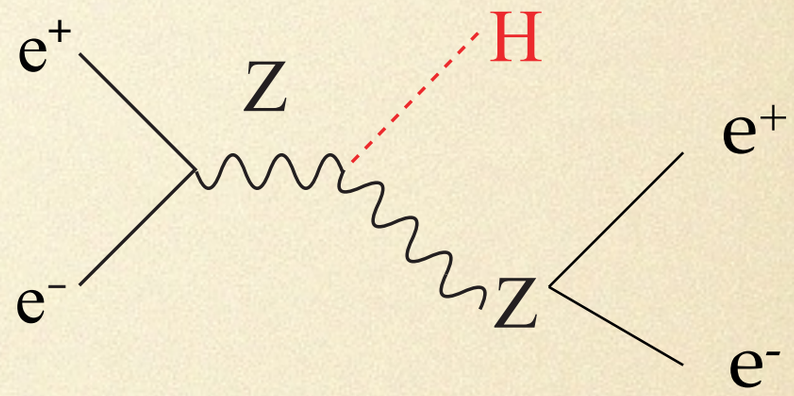
status: Physsim-1.0

- v1.0 released, available now in svn, going to be included in next ilcsoft.
- core libraries implemented: HELLib (HELAS, helicity amplitude calculation for feynman diagrams), LCME (linear collider matrix element libs, so far major Higgs production implemented: LCMEZH, LCMENNH, LCMEEEH, LCMEZHH, LCMENNHH).
- verified by using MC truth information (see previous meetings).
- typical way to use it: check out; compile; include libPhyssim.so in your $MARLIN_DLL; using namespace lcme; follow example marlin processor (included in the package).

svn co https://svnsrv.desy.de/basic/physsim/Physsim/trunk

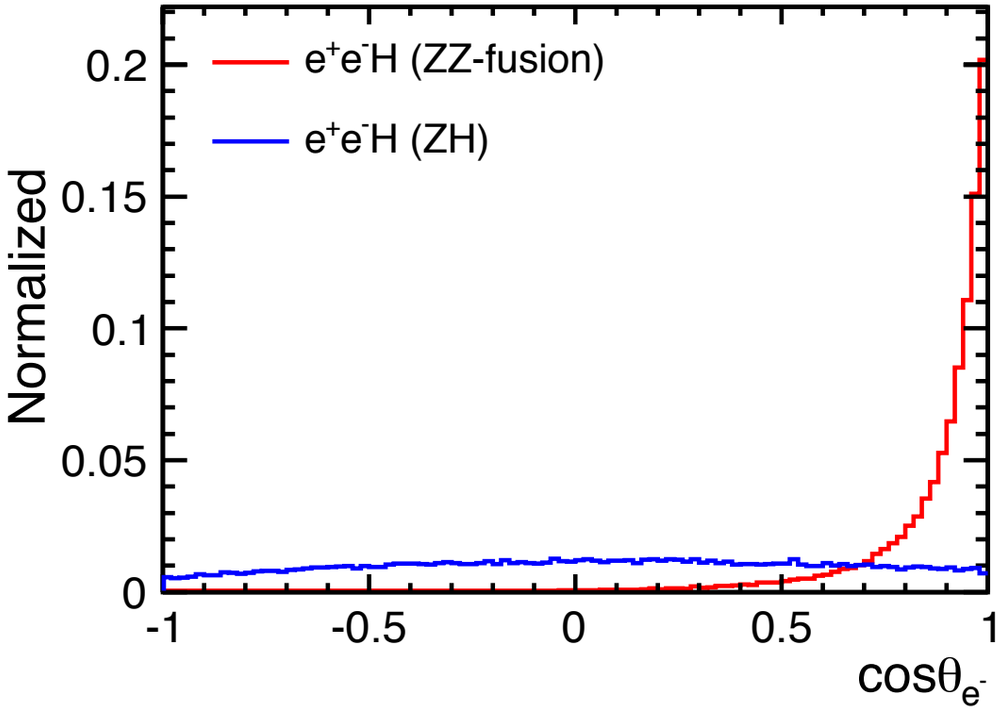
first application: e+e- —> e+e-H

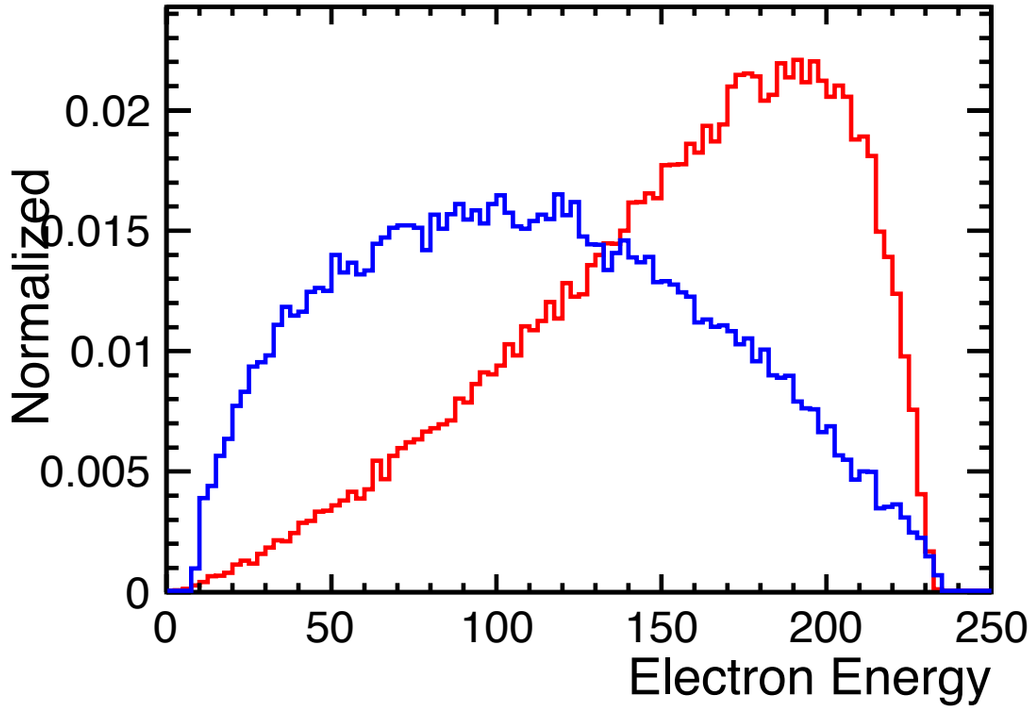


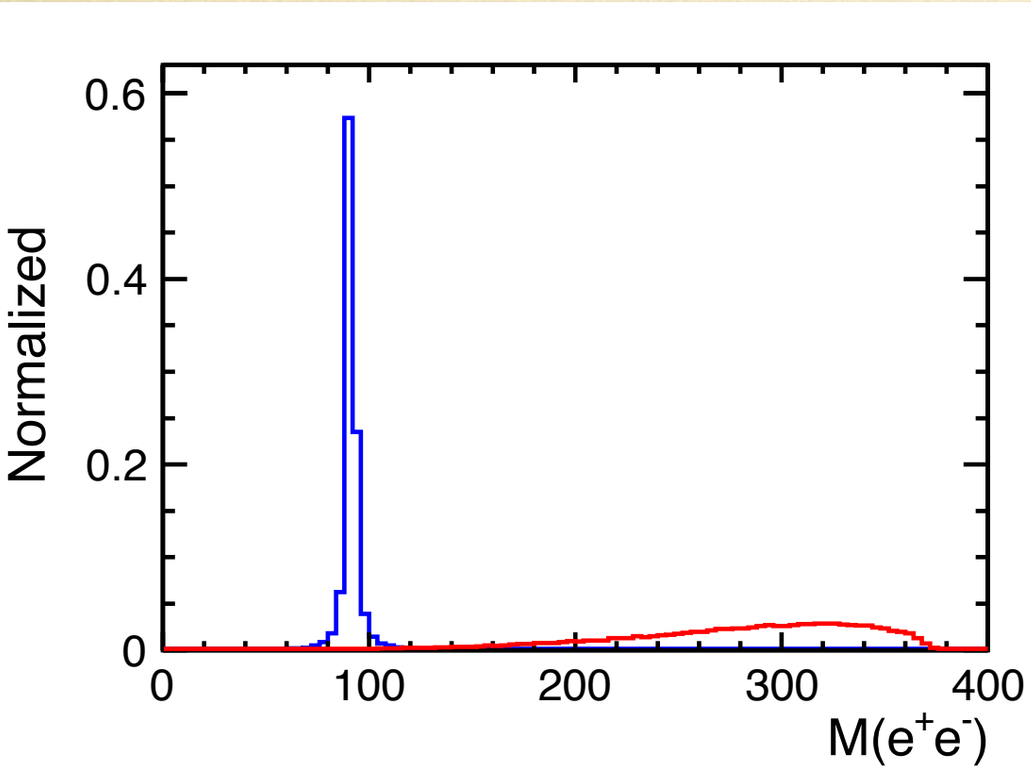


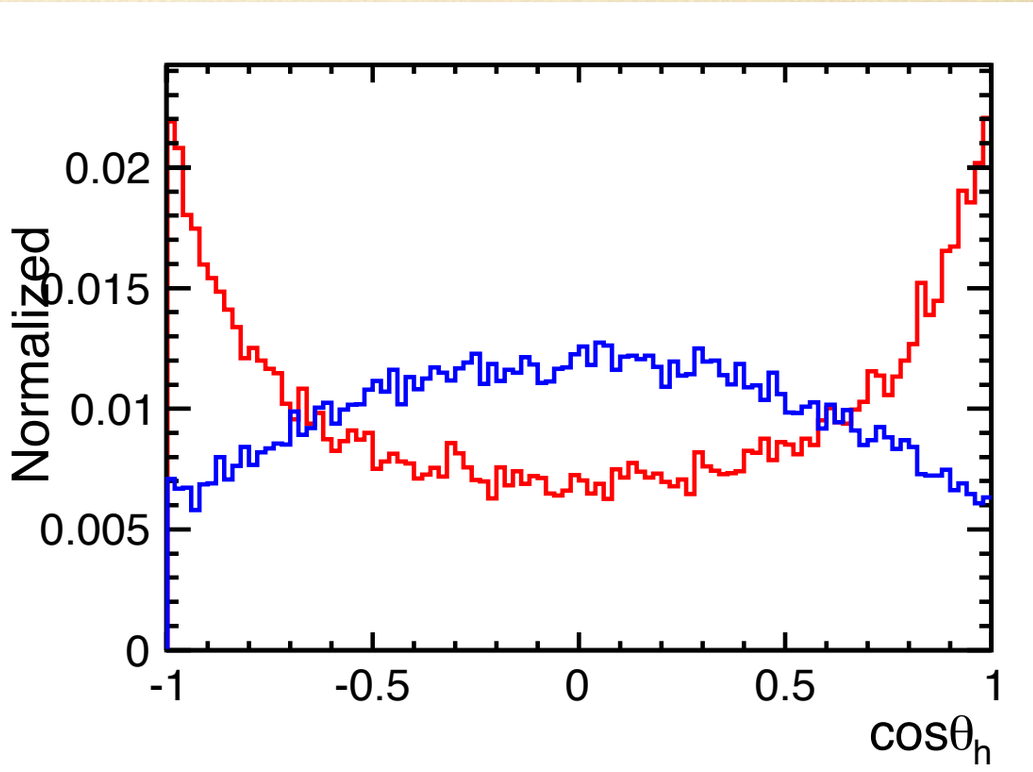
- to discover the Higgs production channel via ZZ-fusion.
- provide another HZZ coupling measurement, important at high energies (σ_S=0.7/7.5/22.8 fb @ 250/500/1000 GeV).
- crucial to discriminate events via ZH production.
- relatively straightforward to apply ME method, since kinematics can be fully reconstructed! and LCMEEEH and LCMEZH are ready.
- a new analysis @ ILC is being setup, samples are generated with DBD softwares, with restrictions in generators.

some distributions



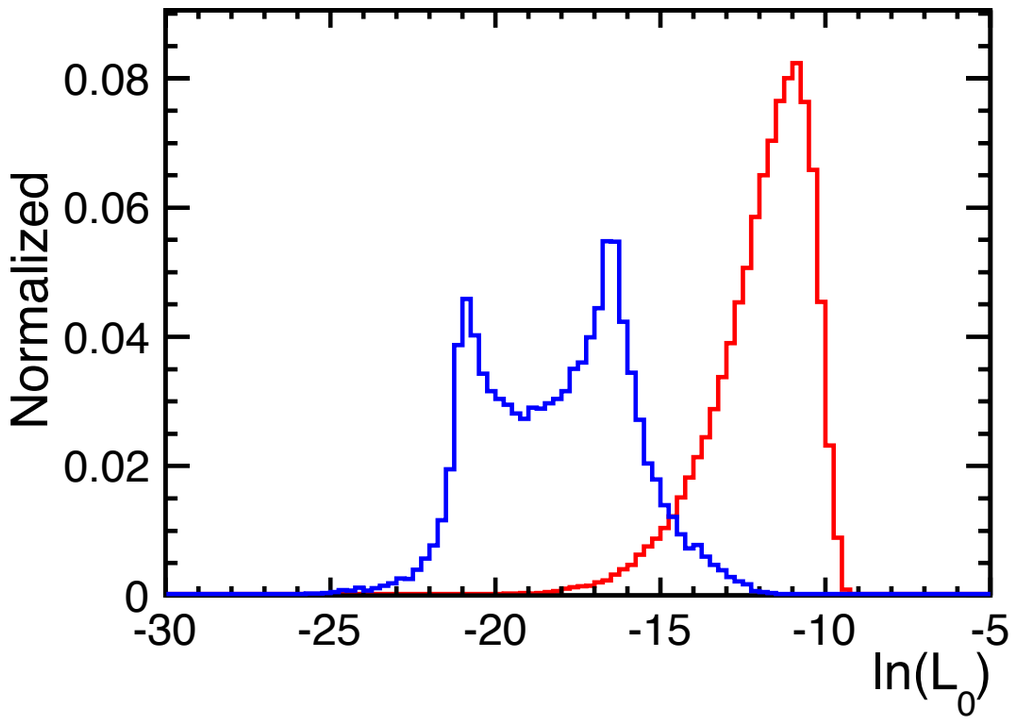




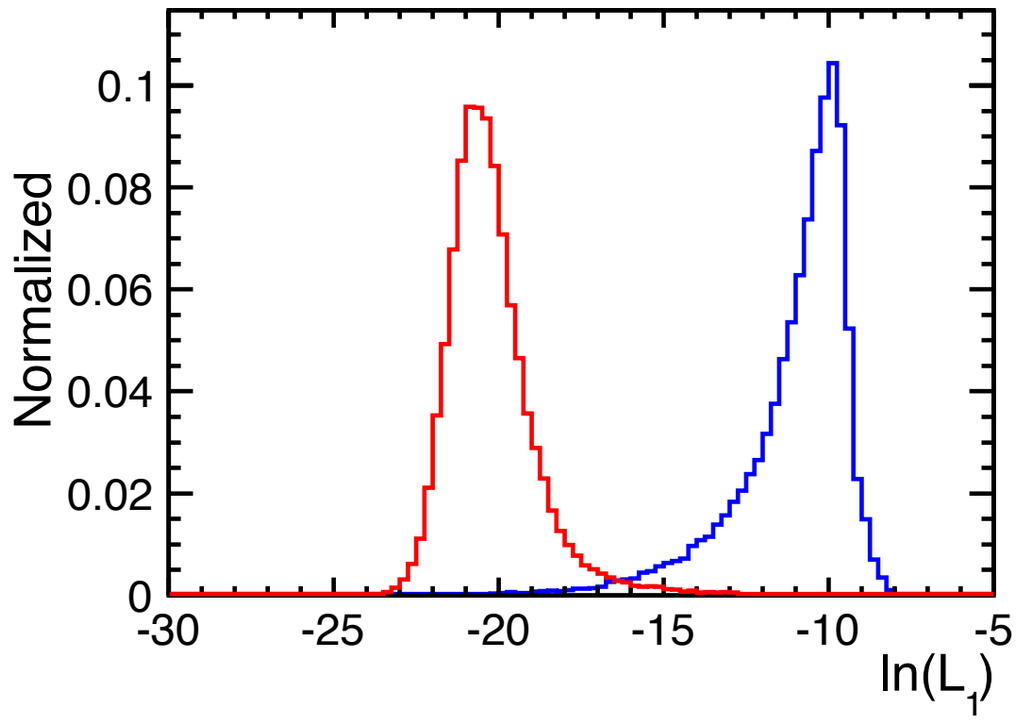


matrix elements (generator level)

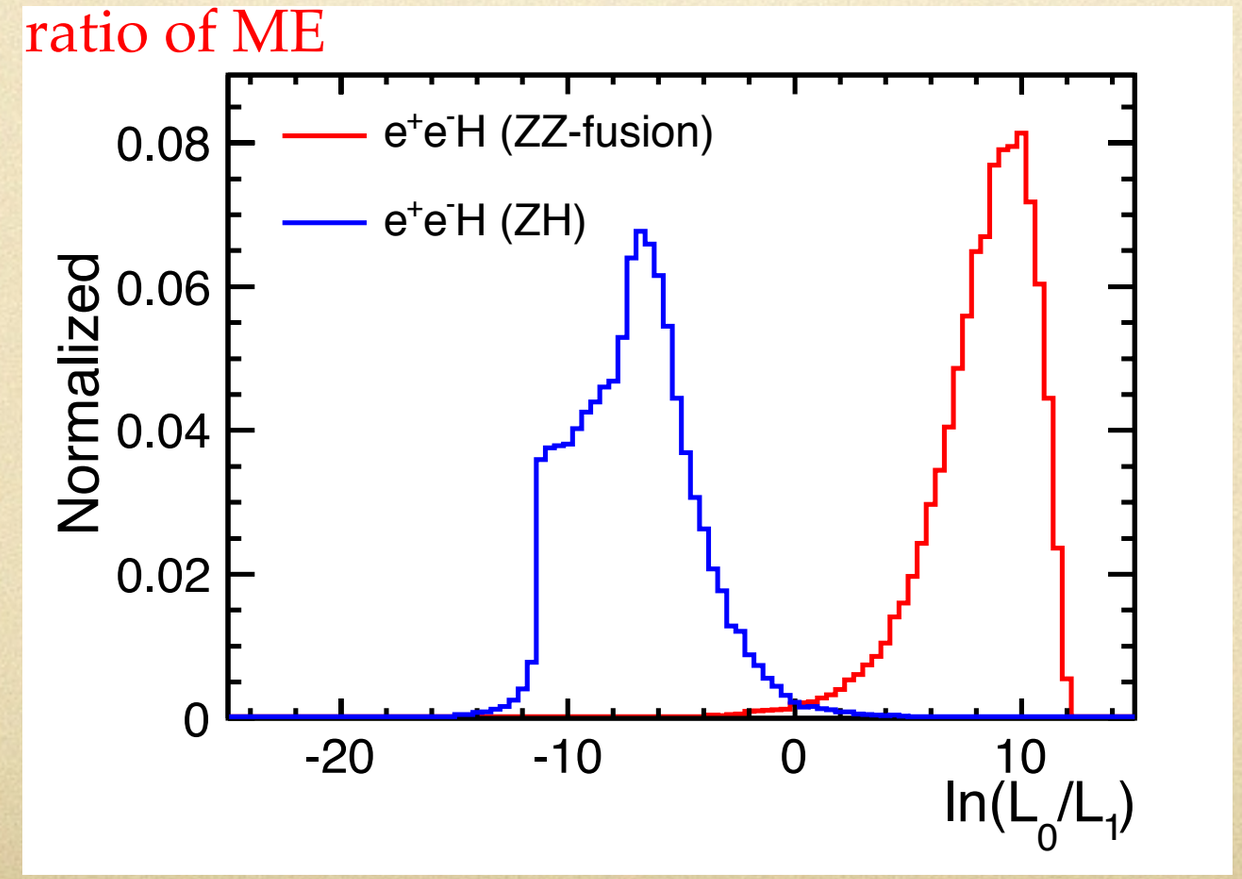
ME as from ZZ-fusion



ME as from ZH



ratio of ME



L_0: ME from ZZ-fusion

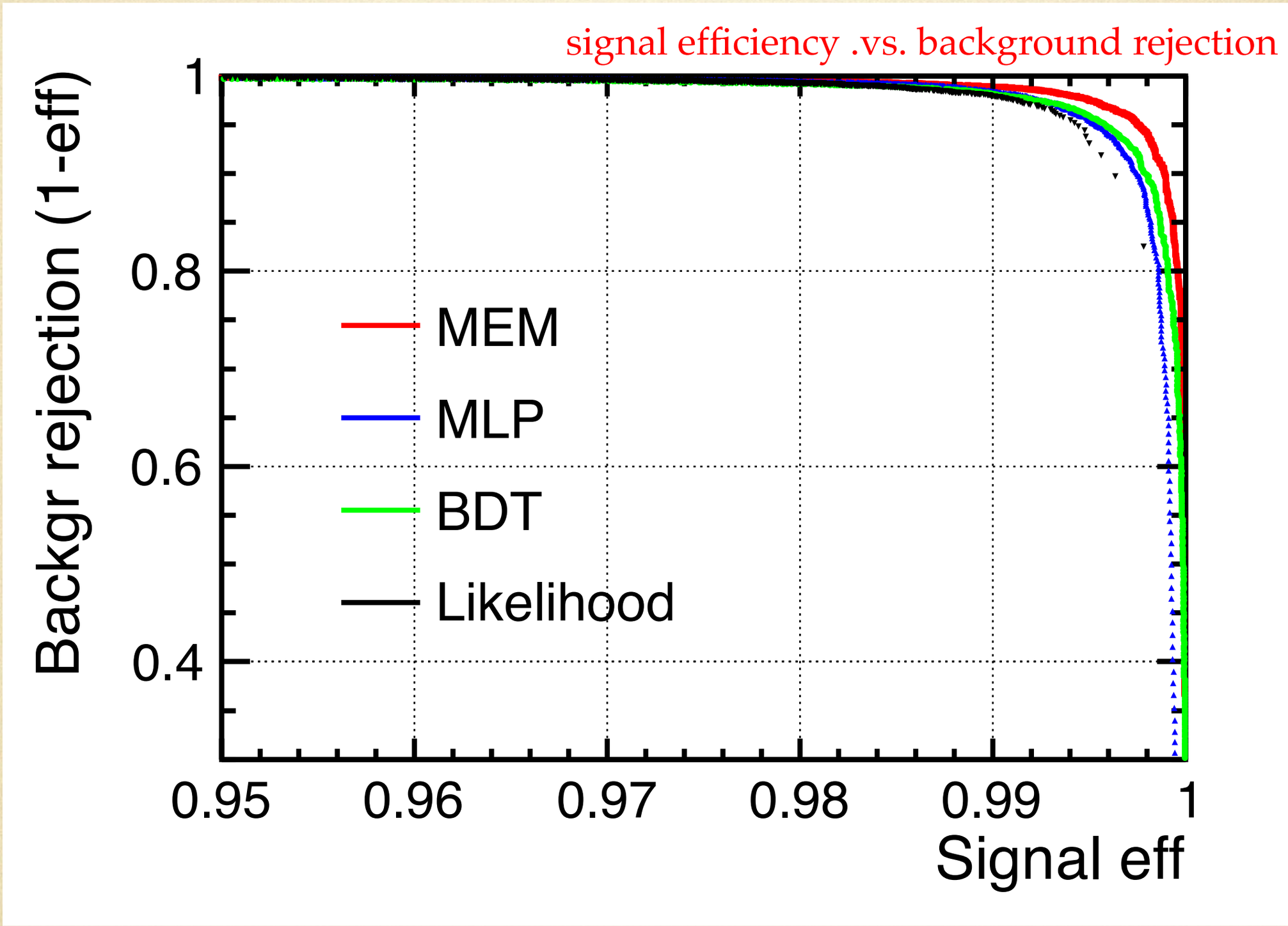
L_1: ME from ZH

(Neyman-Pearson lemma)

one question: would MEM be better than other MVA methods such as MLP, BDT, Likelihood?

- principle experiment: we can do this test based on generator information.
- degree of freedom: ECM rest-frame (ecm,cosθ_H,ϕ_H); Z rest-frame (mZ,cosθ_F,ϕ_F); or (energy electron, cosθ_e,ϕ_e);
- input all possible kinematics, but, not to confuse usual MVA training too much, remove some variables which have almost same distributions, such as some phi distributions.

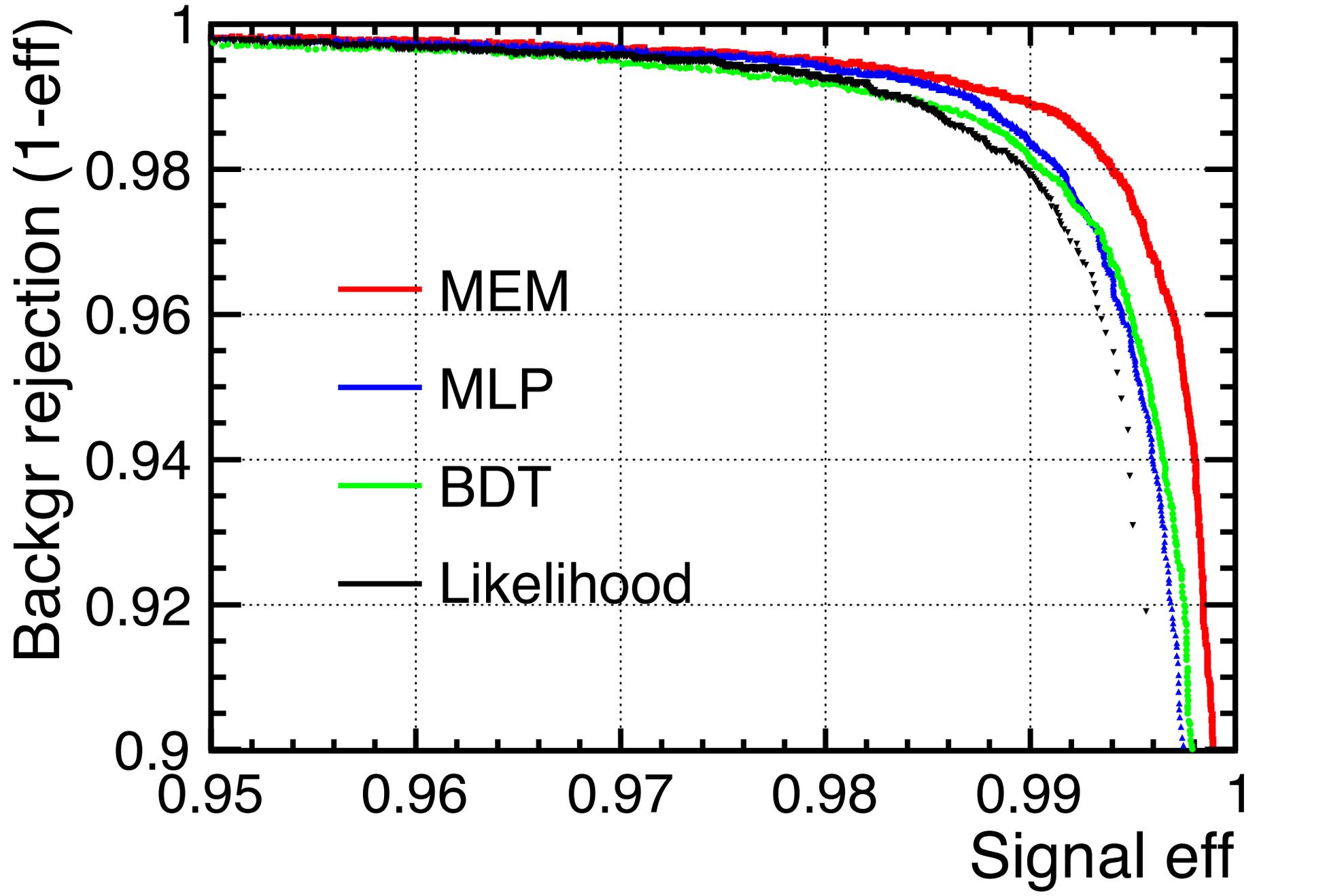
physicist .vs. statistician



all methods look impressive, excellent background rejection!

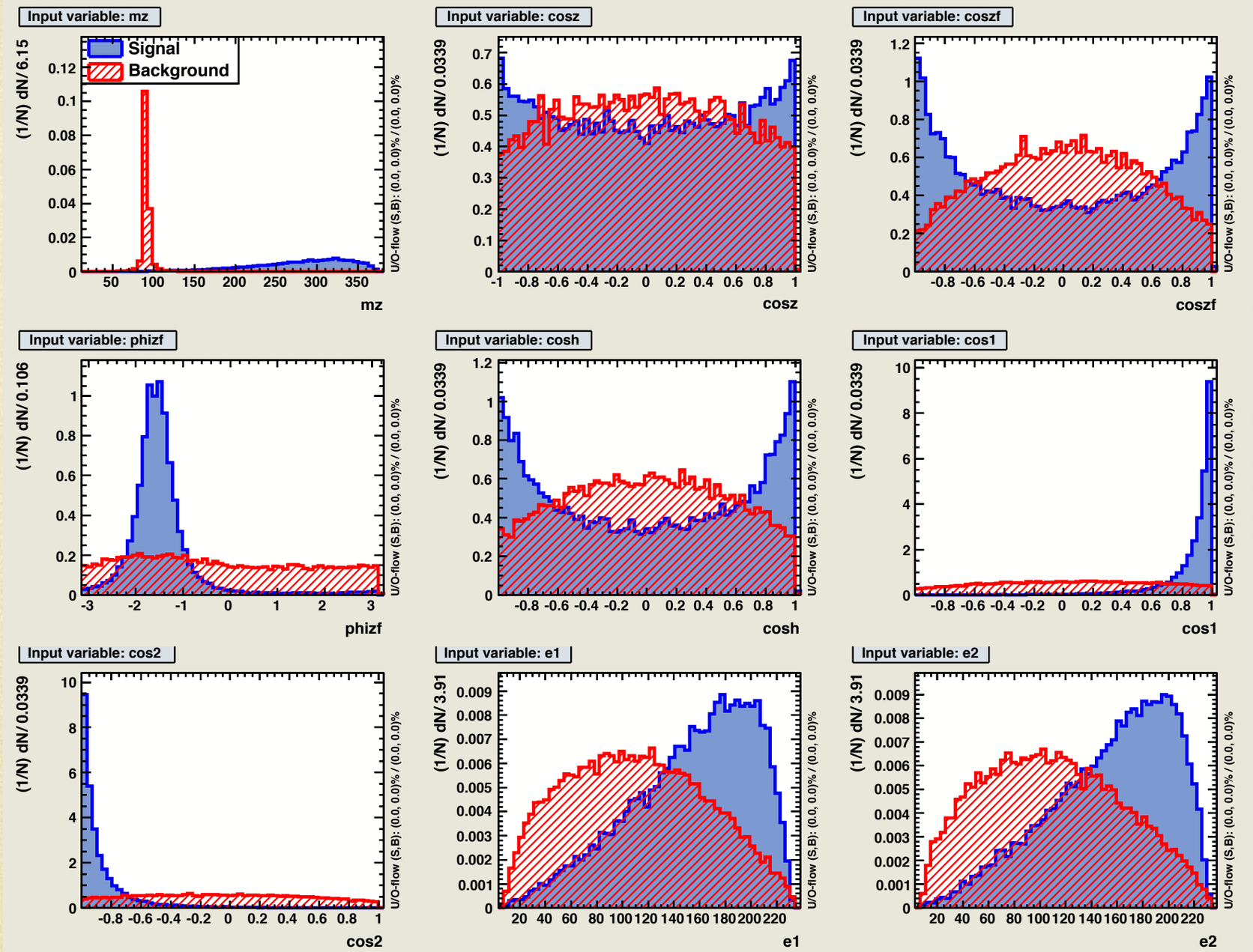
physicist .vs. statistician

signal efficiency .vs. background rejection



it's not actually a surprise since true likelihood is only known by physicist; but it's still impressive that usual MVA work so perfectly without any knowledge of physics!

input to MVA



some experience (adjusting input variables):

a.) remove unnecessary input variables (no difference or highly correlated)

b.) BDT is very robust, usually can handle correlations well

c.) Likelihood is very sensitive to very sharp distributions

d.) MLP is sensitive to correlated variables, moderate to sharp distribution.

next step

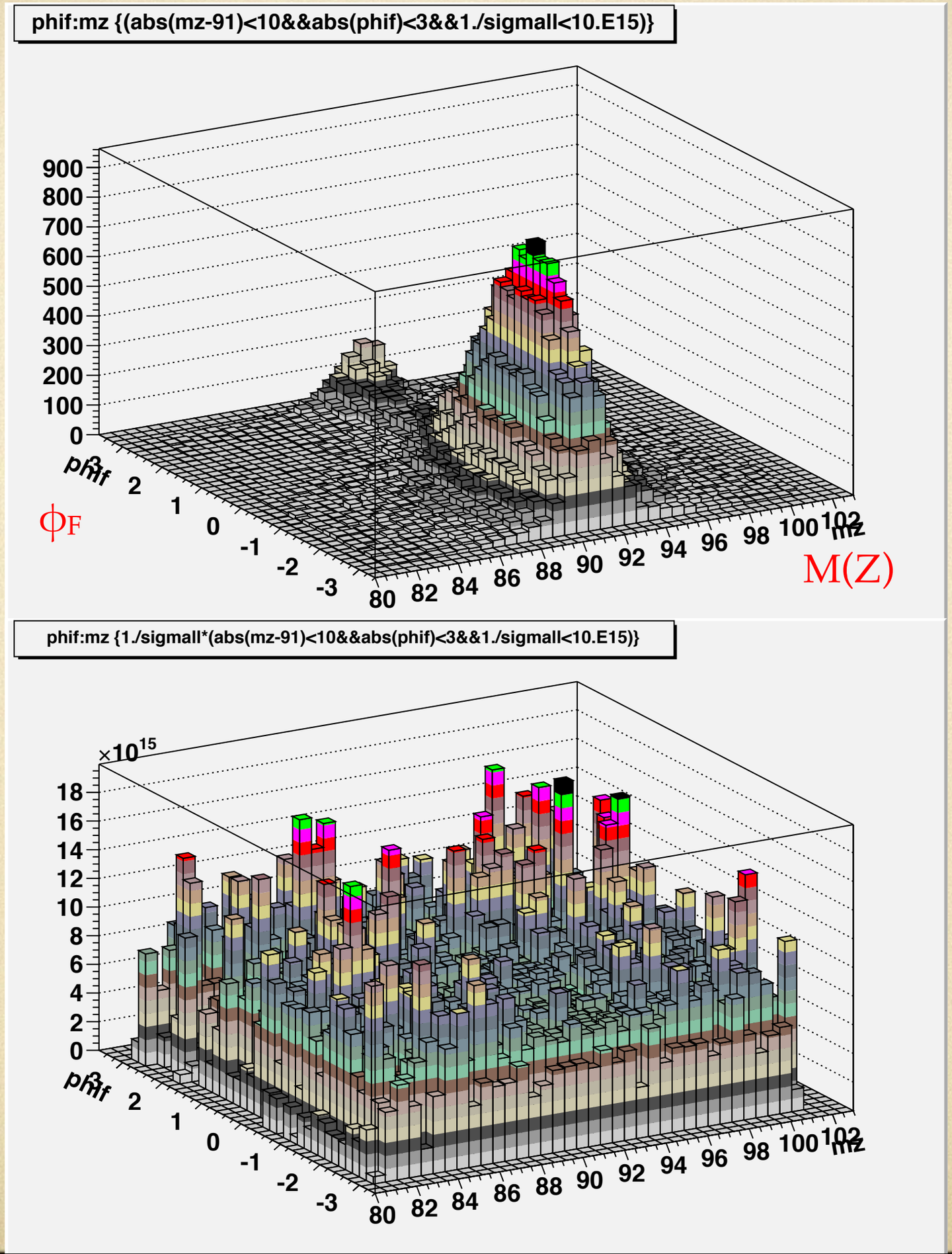
- so far new ME tools seem working well, challenging technics next is how to integrate ME efficiently in analysis with detector transfer function.

- try to complete eeH analysis based on both usual method and ME method (need implement ME for dominant background eeqq also via ZZ-fusion).

- ultimate goal is to apply ME method for Higgs self-coupling analysis.

back up

verification: ZHH



original events

weighted by $\frac{1}{|\mathrm{ME}|^2}$

verification: $\nu\nu$HH

original events

weighted by $\frac{1}{|\mathrm{ME}|^2}$