Matrix Element Method for ILC Physics Analysis

Junping Tian, Keisuke Fujii (KEK)

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

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status: alpha version

$$L(\mathbf{p}_i^{\rm vis}|\mathbf{a}) = \frac{1}{\sigma_{\mathbf{a}}}[\prod_{j\in{\rm inv.}}\int\frac{d^3p_j}{(2\pi)^3 2E_j}][\prod_{k\in{\rm vis.}}\int\frac{d^3p_k}{(2\pi)^3 2E_k}W_i(\mathbf{p}_i^{\rm vis}|p_k,\mathbf{a})]|M(p_j,p_k;\mathbf{a})|^2$$

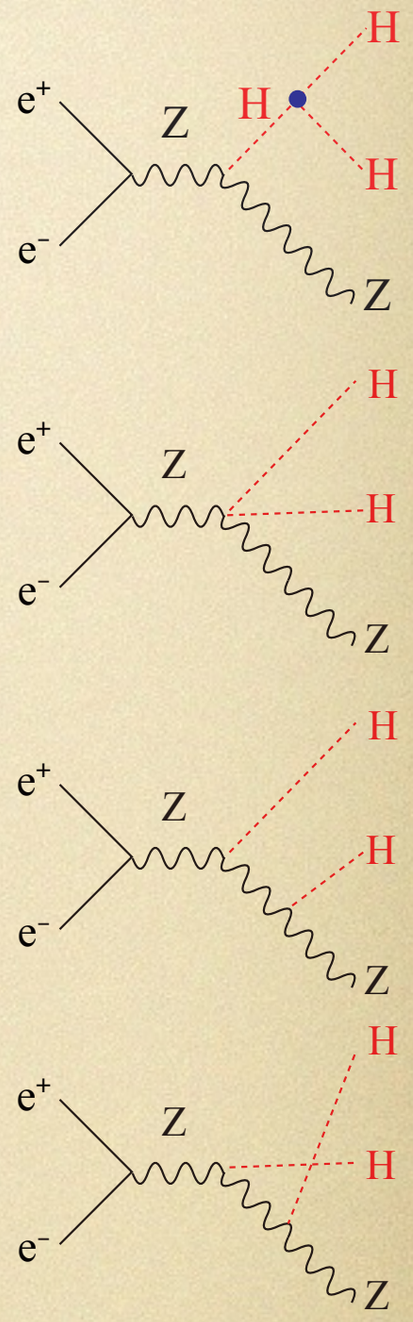
- test samples are generated without any ISR and BS.
- detector transfer function ($W(p_i \mid p_k,a)$) used a delta function, and no invisible variables. (test with MC information)
- ME calculated for each event in this way should be exactly as same as the ME used in event generation (as event weights).
- to verify the calculated ME, if each event is weighted by ($1./|ME|^2$), all variables should be uniformly distributed.

`login.cc.kek.jp:/home/ilc/tianjp/analysis/PostDBD/MEM/src/higgs/ZHH/LCMEZHH.cxx`

`/home/ilc/tianjp/analysis/PostDBD/MEM/example_stdhep/src/MEMExampleProcessor.cc`

example core code to calculate matrix element

```
   //-----------------------------
   // Higgs Production Amplitude
   //-----------------------------
   HELVector zs(em, ep, glze, grze, kM_z, gamz);

   Double_t v      = 2.*kM_w/kGw;
   Double_t ghhh   = -TMath::Power(fMass,2)/v*3.;
   Double_t gzzh   = kGz*kM_z;
   Double_t gzzhh = kGz*kGz/2.;

   HELScalar hh(h1, h2, ghhh, fMass, 0.);
   HELVertex amp1(zs, zf, hh, gzzh);          // HHH self-coupling

   HELVertex amp2(zs, zf, h1, h2, gzzhh);     // ZZHH 4-point

   HELVector vz1(zf, h1, gzzh, kM_z, gamz);
   HELVertex amp3(zs, vz1, h2, gzzh);         // double H-strahlung

   HELVector vz2(zf, h2, gzzh, kM_z, gamz);
   HELVertex amp4(zs, vz2, h1, gzzh);         // double H-strahlung

   Complex_t amp   = amp1 + amp2 + amp3 + amp4;
```

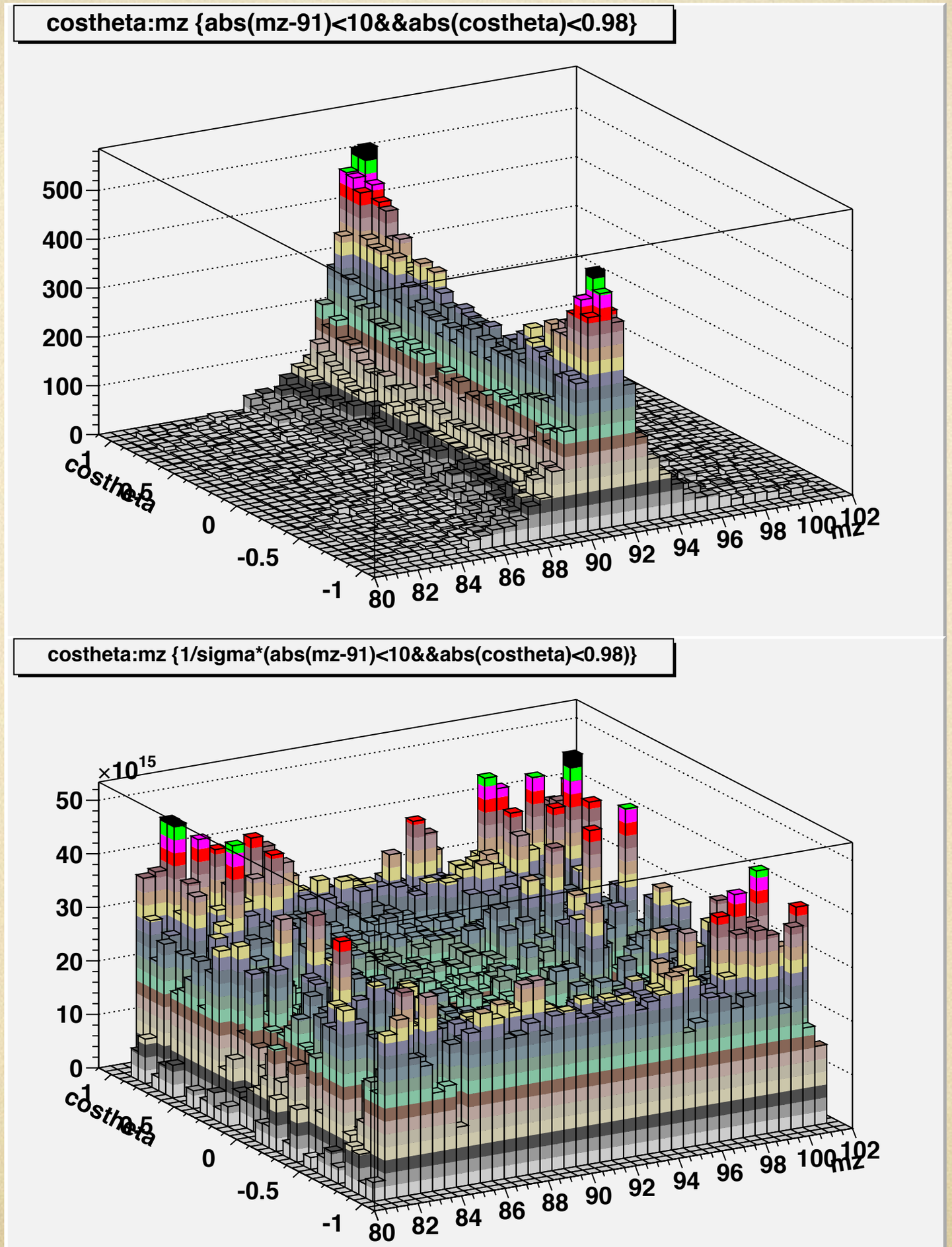


example core code to include beam polarisations

```
//_____________________________________________________________________
// --------------------------
//  Get Matrix Element Squared
// --------------------------
Double_t LCMEZHH::GetMatrixElement2()
{

  Double_t sigmaLL = GetMatrixElement2(-1,-1);
  Double_t sigmaLR = GetMatrixElement2(-1,1);
  Double_t sigmaRL = GetMatrixElement2(1,-1);
  Double_t sigmaRR = GetMatrixElement2(1,1);

  Double_t weightElectron = (1.-fPolElectron)/2.;
  Double_t weightPositron = (1.+fPolPositron)/2.;

  Double_t sigma = 0.;
  sigma += (sigmaLL+sigmaLR)*weightElectron*weightPositron;
  sigma += (sigmaRL+sigmaRR)*(1.-weightElectron)*(1.-weightPositron);
  //  cerr << "Debug:  sigma = " << sigma << endl;
  return (sigma);
}
```

verification:

$\cos\theta_Z - M(Z)$



original events

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