Towards a Study of Δg_{HHH} vs. Jet Energy Resolution and Other SiD Performance Parameters

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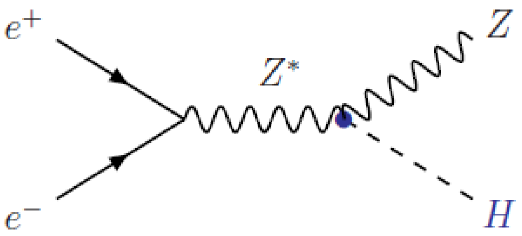
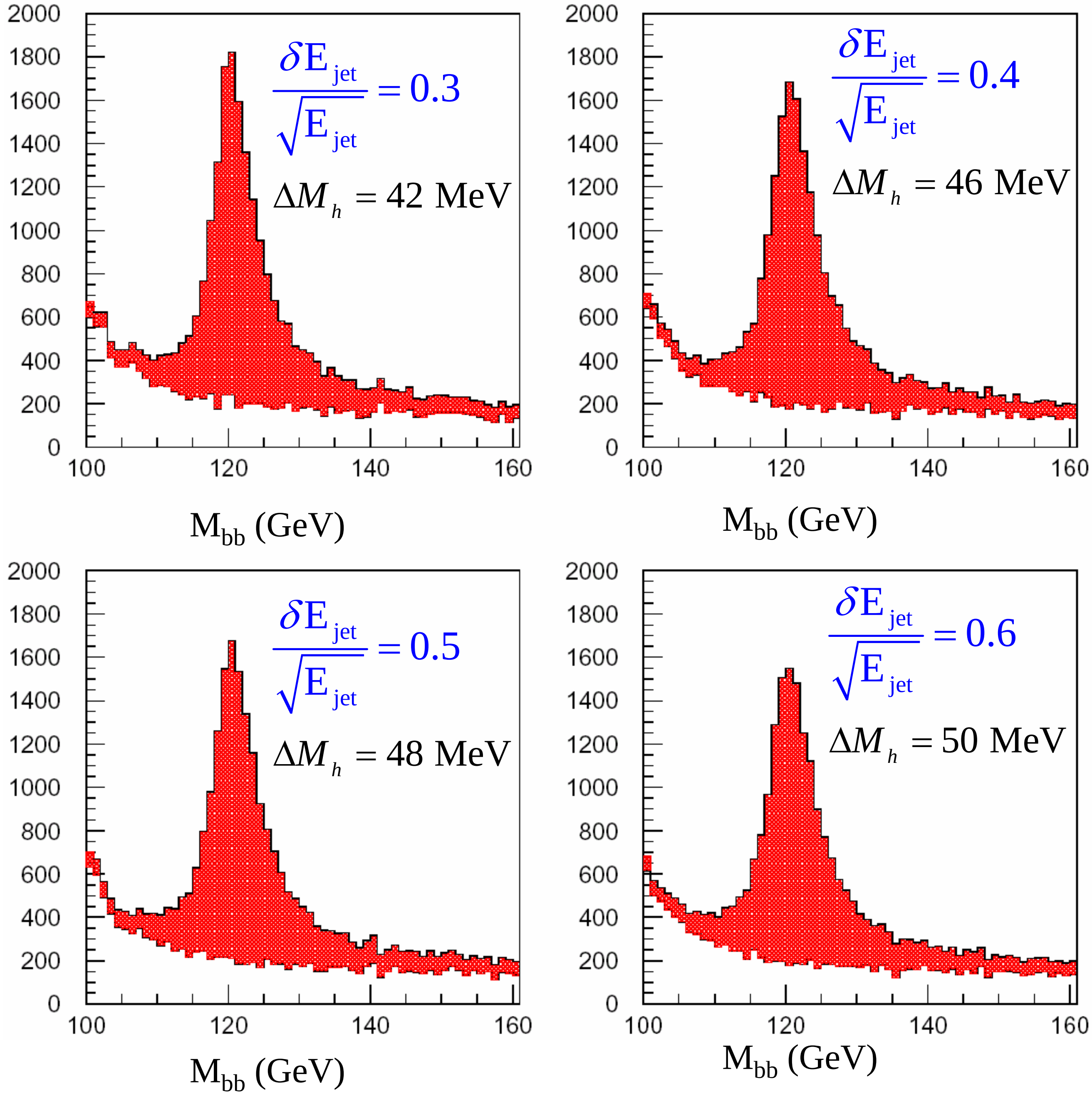


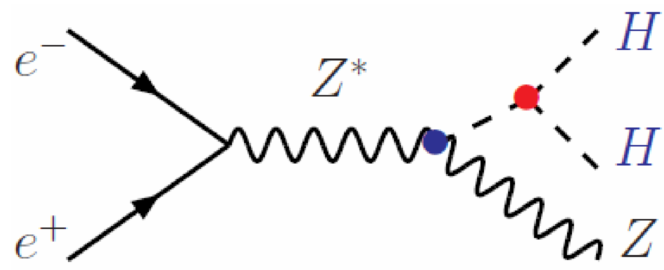
$$e^+e^- \to ZH$$
$$\to qqb\bar{b}$$



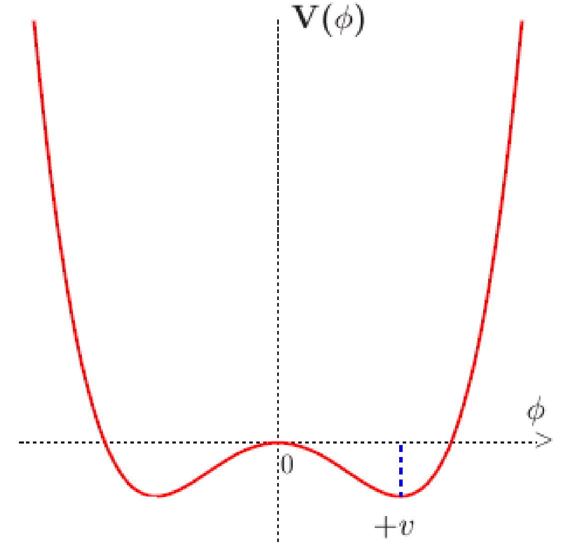
$$\sqrt{s} = 350\ GeV$$
$$L = 500\ fb^{-1}$$

$\Delta E/\sqrt{E} = 60\% \to 30\%$

equiv to $1.4\times$ Lumi



$g_{HHH} = -6\mu^2 / \mathrm{v}$



$$V(\phi) = \frac{1}{2}\mu^2\phi^2 + \frac{1}{4}\lambda\phi^4$$

Standard Model:

$$M_H^2 = 2\lambda \mathrm{v}^2 = -2\mu^2$$

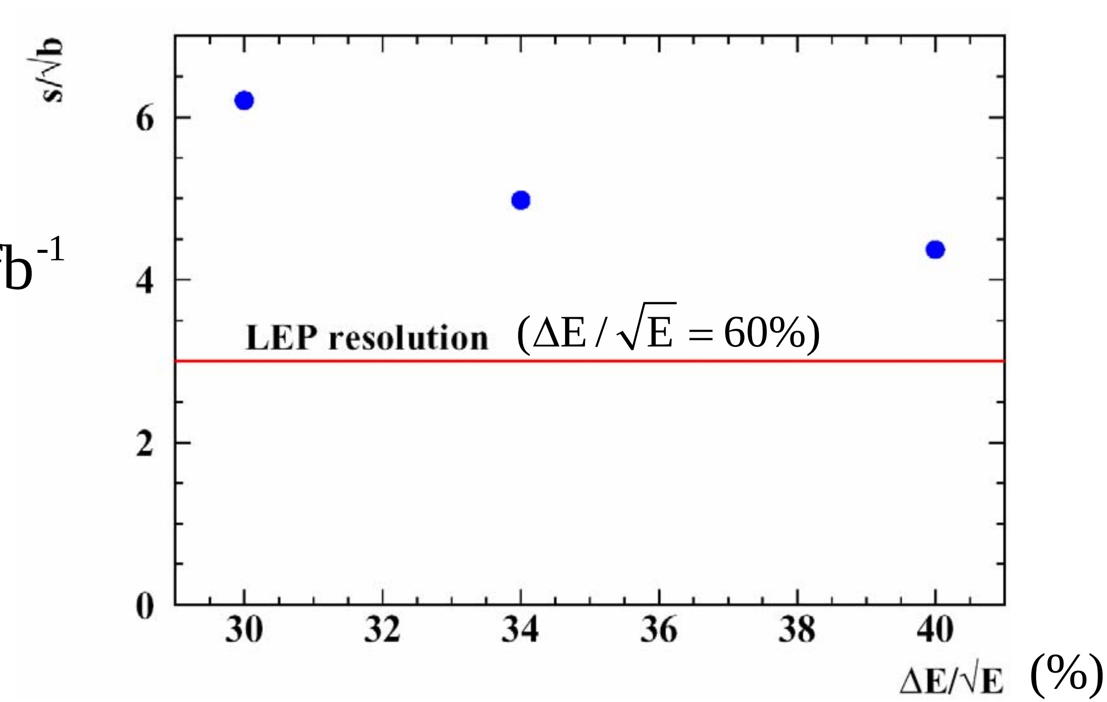
$e^+e^- \to ZHH \to q\bar{q}b\bar{b}b\bar{b}$

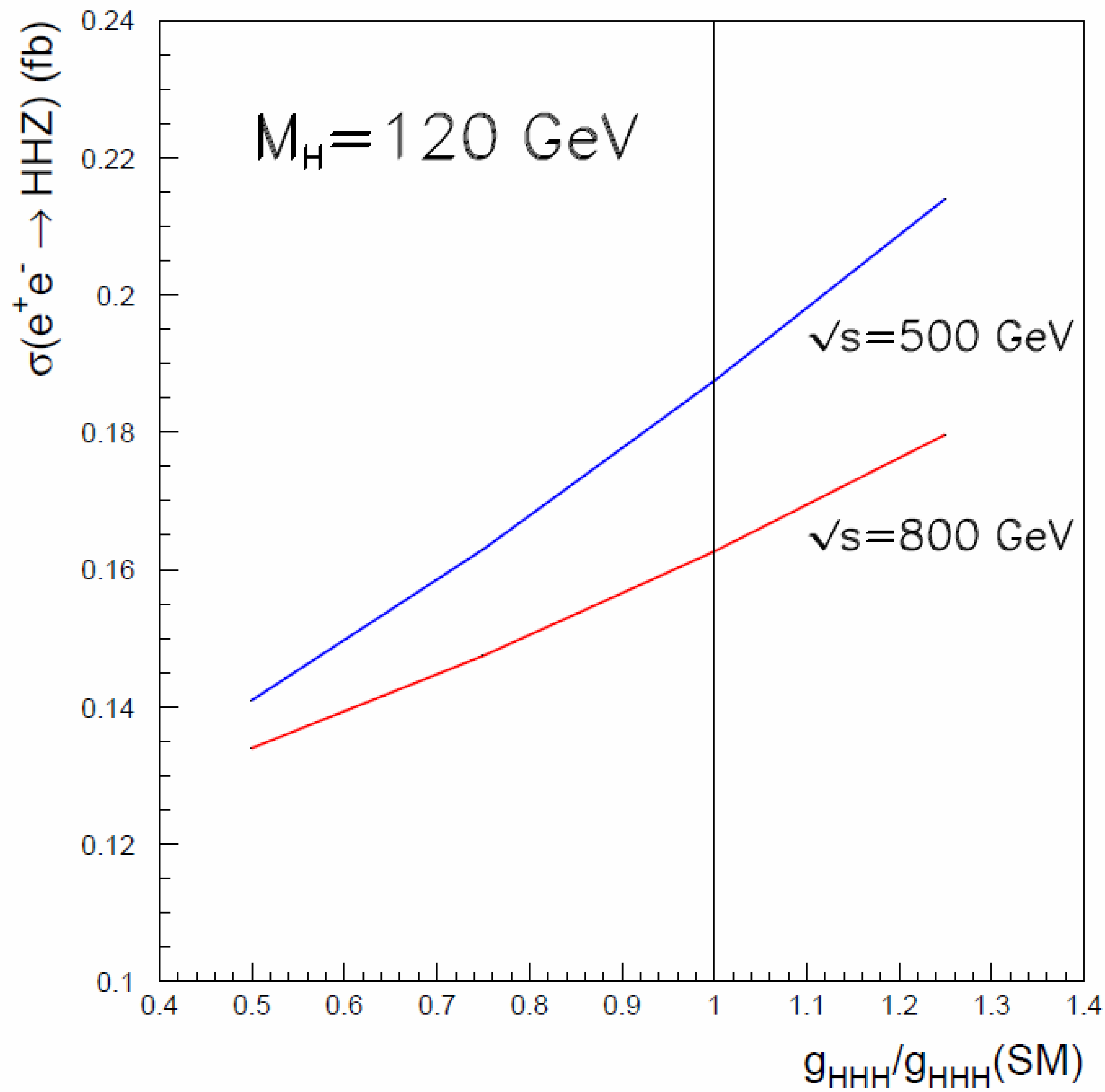
$\sqrt{s}$ = 500 GeV, L=1000 fb^{-1}

$\Delta E/\sqrt{E} = 60\% \to 30\%$

equiv to $4\times$ Lumi

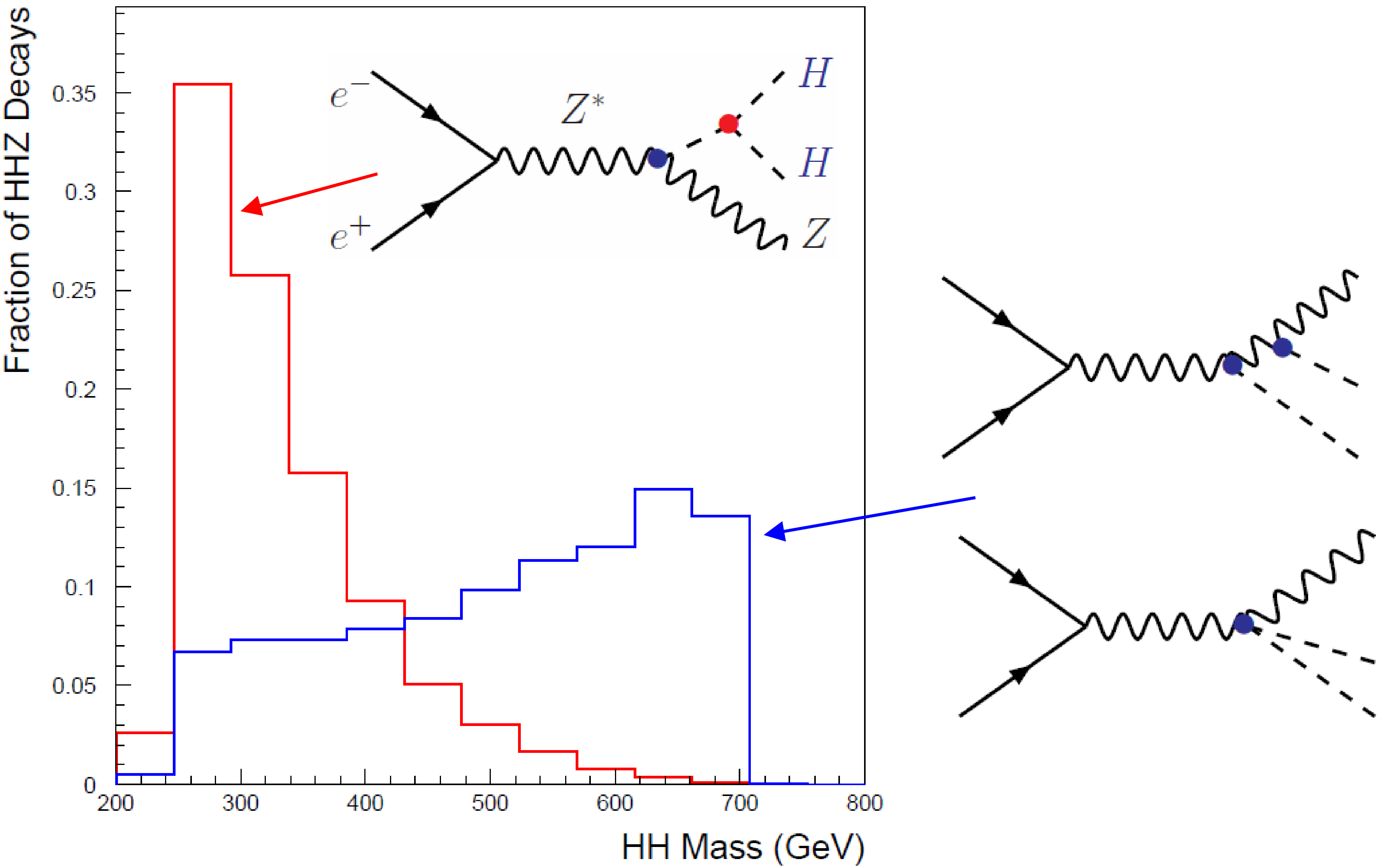
C. Castanier et al. hep-ex/0101028





M_H=120 GeV
√s=500 GeV
√s=800 GeV
σ(e+e- → HHZ) (fb)
g_{HHH}/g_{HHH}(SM)
0.1
0.12
0.14
0.16
0.18
0.2
0.22
0.24
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4

Not All $e^+e^- \rightarrow ZHH$ Diagrams Contain the HHH Coupling



SIMDET Analysis for $\sqrt{s} = 800$ GeV, 1 ab^{-1} by Battaglia, Boos, Yao

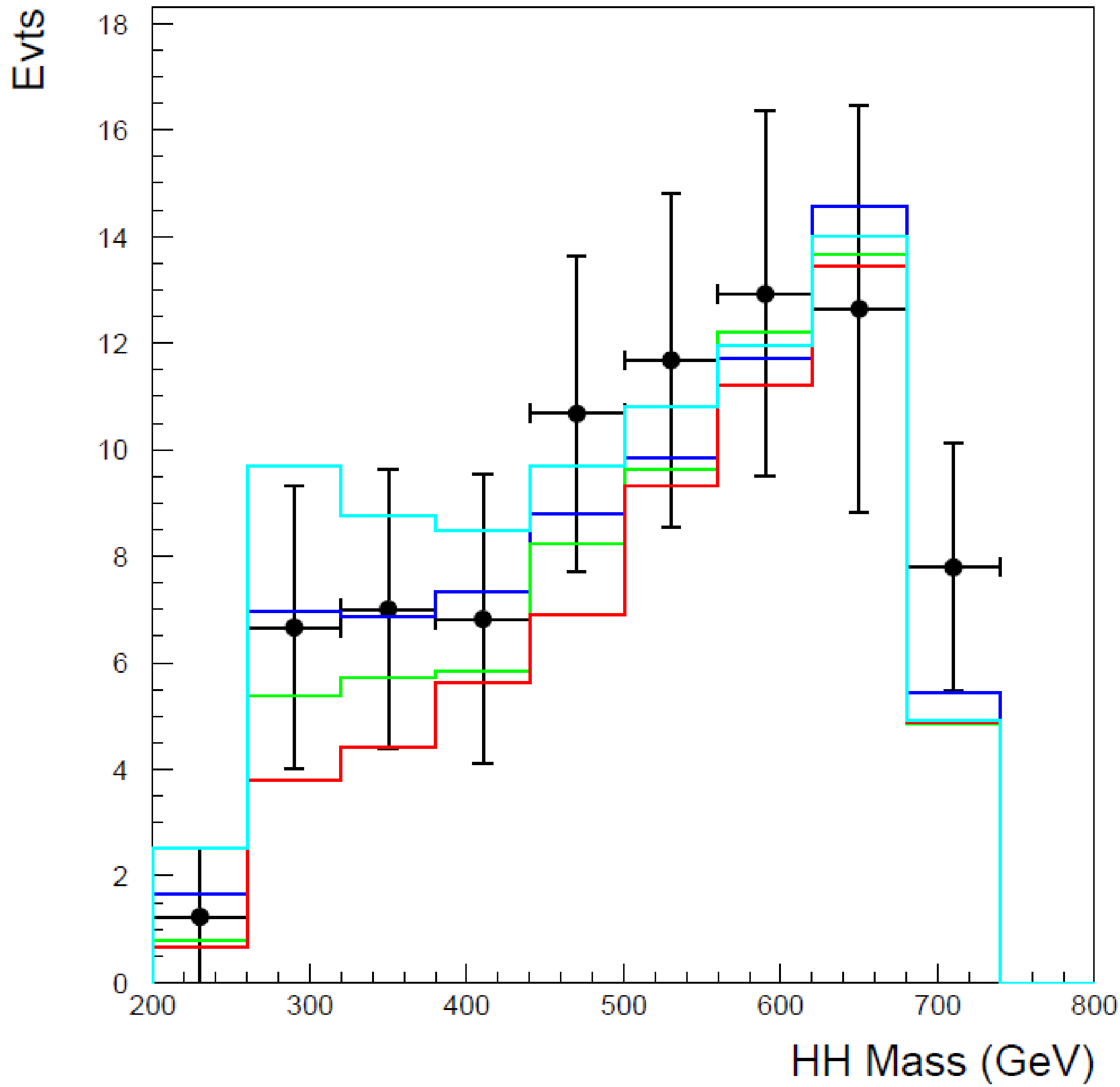
hep-ph/0111276

$\frac{g_{HHH}}{g_{HHH}^{SM}} = 1.25$

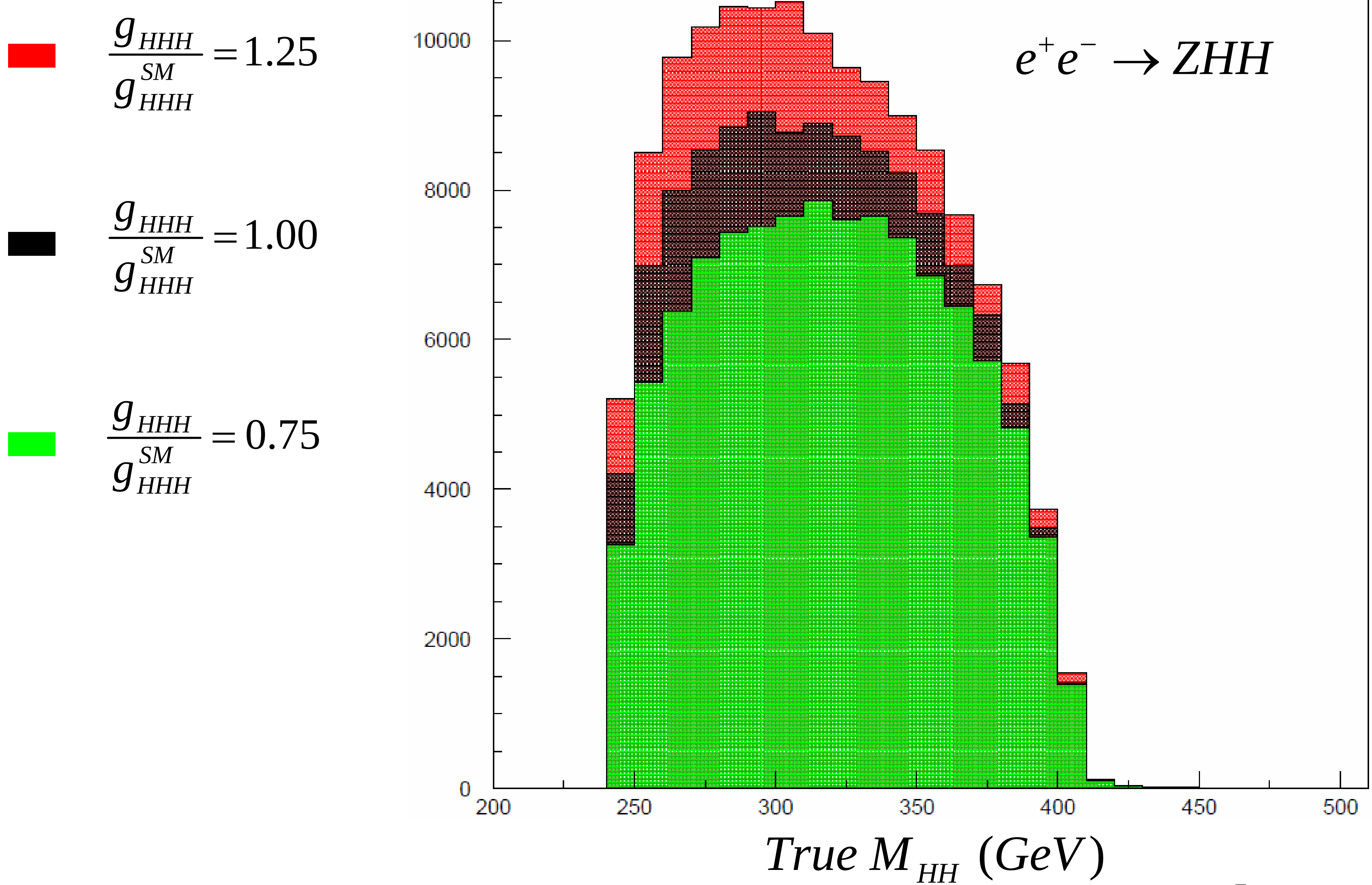
$\frac{g_{HHH}}{g_{HHH}^{SM}} = 1.00$

$\frac{g_{HHH}}{g_{HHH}^{SM}} = 0.75$

$\frac{g_{HHH}}{g_{HHH}^{SM}} = 0.50$



$\sqrt{s} = 500$ GeV



Plan for Analyis

- We need to assign jets to parent bosons as best we can to suppress background to ZHH and to optimize M_{HH} resolution. Use ZVTOP for b-tagging and for a vertex charge analysis to distinguish b from bbar. Try to use H mass constraints (ΔM_H=60 MeV).
- At MH=120 GeV the bb BR is 70% so that only 50% of ZHH events are Zbbbb. We should therefore try to include other Higgs decays in analysis. Also include ZHH→l^+l^-HH, $\nu\nu$HH .
- Perform analysis with baseline SiD. Then vary ΔE_{jet}, vtx detector parameters, tracker parameters.

Progress with Tools

- LCIO Reconstructed Particles can be successfully read out in JAVA, C++ and FORTRAN.
- There is an interface from LCIO reconstructed particles to SIMDET common block so that SIMDET-based analysis code can be run on LCIO files with reconstructed particles (see http://www-sid.slac.stanford.edu/BenchMarking/ for details)
- The org.lcsim Fast MC is working, and the relationship between single particle energy resolution and jet energy resolution is now understood; features have been added to allow users to easily vary the jet energy resolution.

Perfect PFA : What theory predicts

- Jet energy resolution
  $\sigma^2(E_{jet}) = \sigma^2(ch.) + \sigma^2(\gamma) + \sigma^2(h^0) + \sigma^2(conf.)$
- Excellent tracker :
  $\sigma^2(ch.) << \sigma^2(\gamma) + \sigma^2(h^0) + \sigma^2(conf.)$
- Perfect PFA : $\sigma^2(conf.) = 0$
- $\sigma^2(E_{jet}) = A_\gamma^2 E_\gamma + A_h^2 E_{h0} = w_\gamma A_\gamma^2 E_{jet} + w_{h0} A_h^2 E_{jet}$
  $\sigma(E_{\gamma,h})/E_{\gamma,h} = A_{\gamma,h}/\sqrt{E_{\gamma,h}}$

Typically $w_\gamma = 25\%$; $w_{h0} = 13\%$

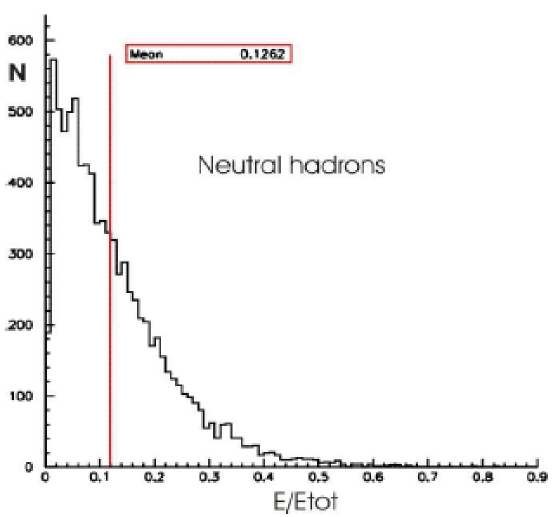
I find $w_\gamma=28\%$; $w_{h0}=10\%$

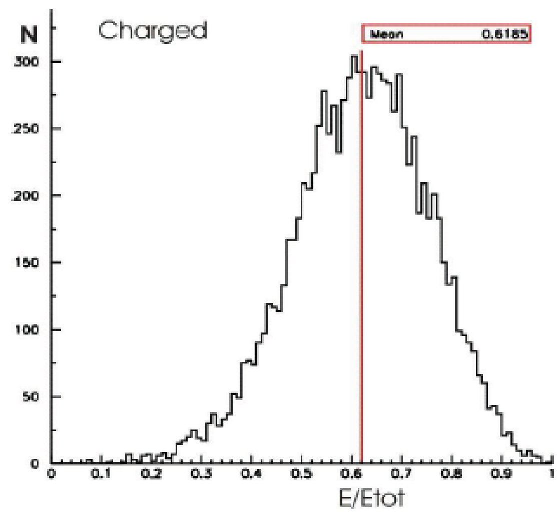
$A_\gamma = 11\%$; $A_{h0} = 34\%$

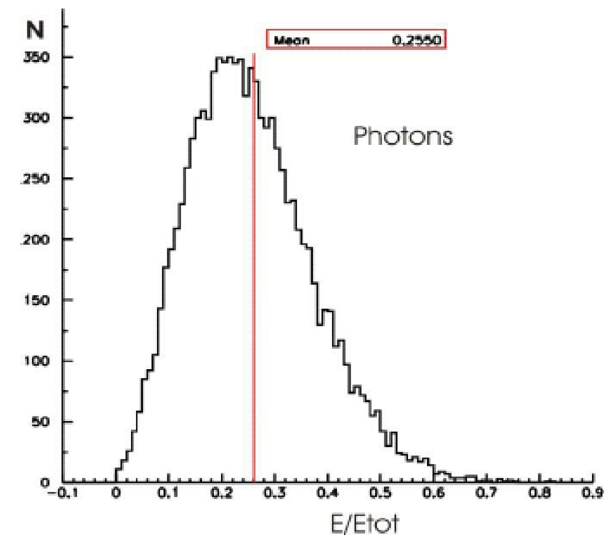
$\Rightarrow \sigma(E_{jet})/E_{jet} = 12\%/\sqrt{E_{jet}}$

$A_\gamma = 11\%$; $A_{h0} = 50\%$

$\Rightarrow \sigma(E_{jet})/E_{jet} = 17\%/\sqrt{E_{jet}}$





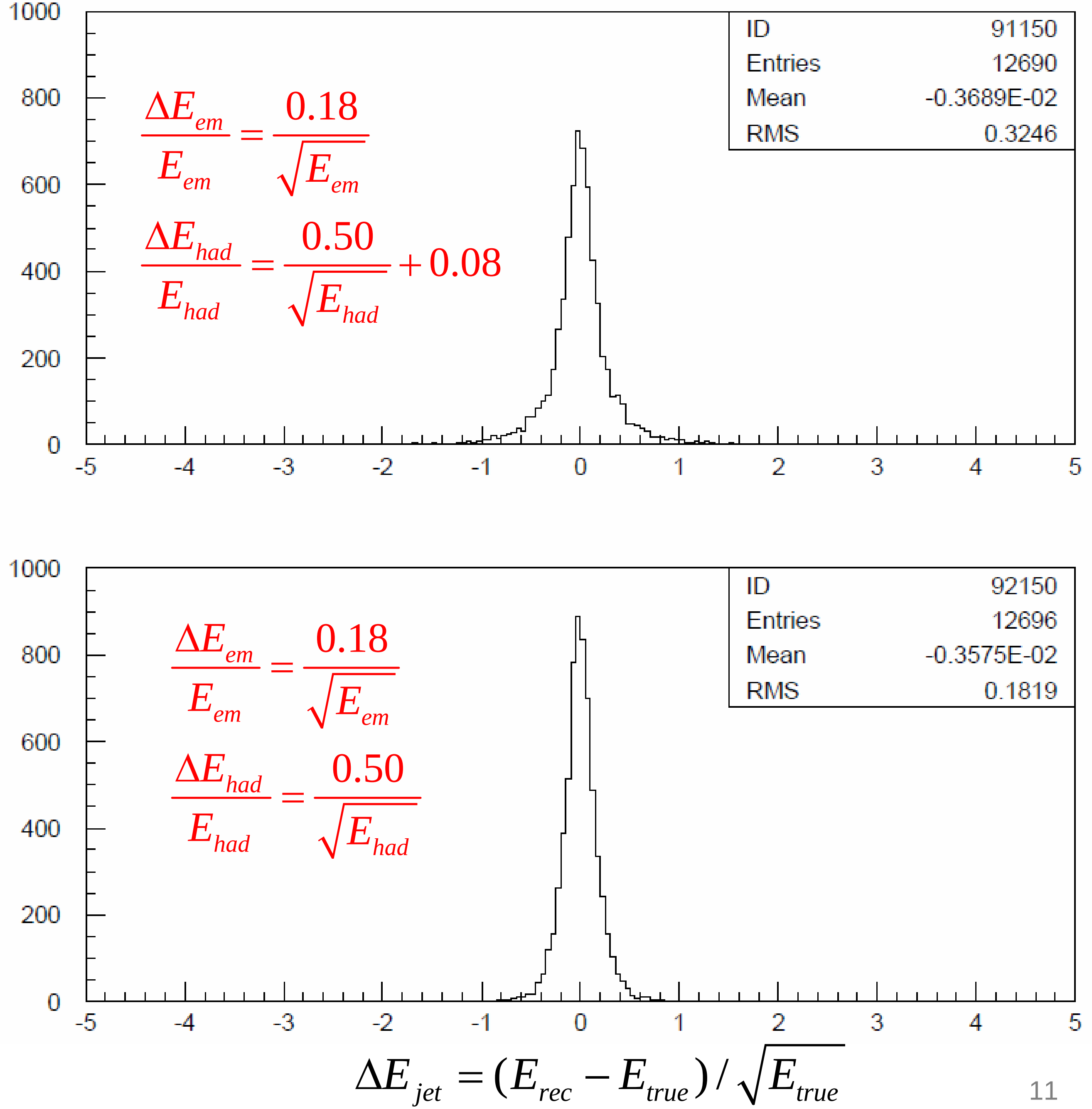


Alexei Raspereza, DESY, ILC Workshop, Snowmass, August 26, 2005

$\sqrt{s} = 500$ GeV

$e^+e^- \to u\bar{u}$

E_{true} is adjusted for neutrinos and particles outside detector acceptance



Drop constant term in single particle resolution for now. Assume negligible contribution from charged particles to jet energy resolution and write

$$\sigma^2 = (1+\lambda(1-r))^2 A_\gamma^2 w_\gamma E_{jet} + (1+\lambda r)^2 A_h^2 w_h E_{jet} = c^2 E_{jet}$$

where $c = 0.3, 0.4, 0.5, 0.6$

$r =$ hadronic resolution degradation fraction

($r = 1$ to only degrade hadronic resolution

$r = 0$ to only degrade em resolution)

$A_\gamma = 0.18 \quad A_h = 0.50 \quad w_\gamma = 0.28 \quad w_h = 0.10$

Given a desired jet energy resolution c the parameter λ is given by

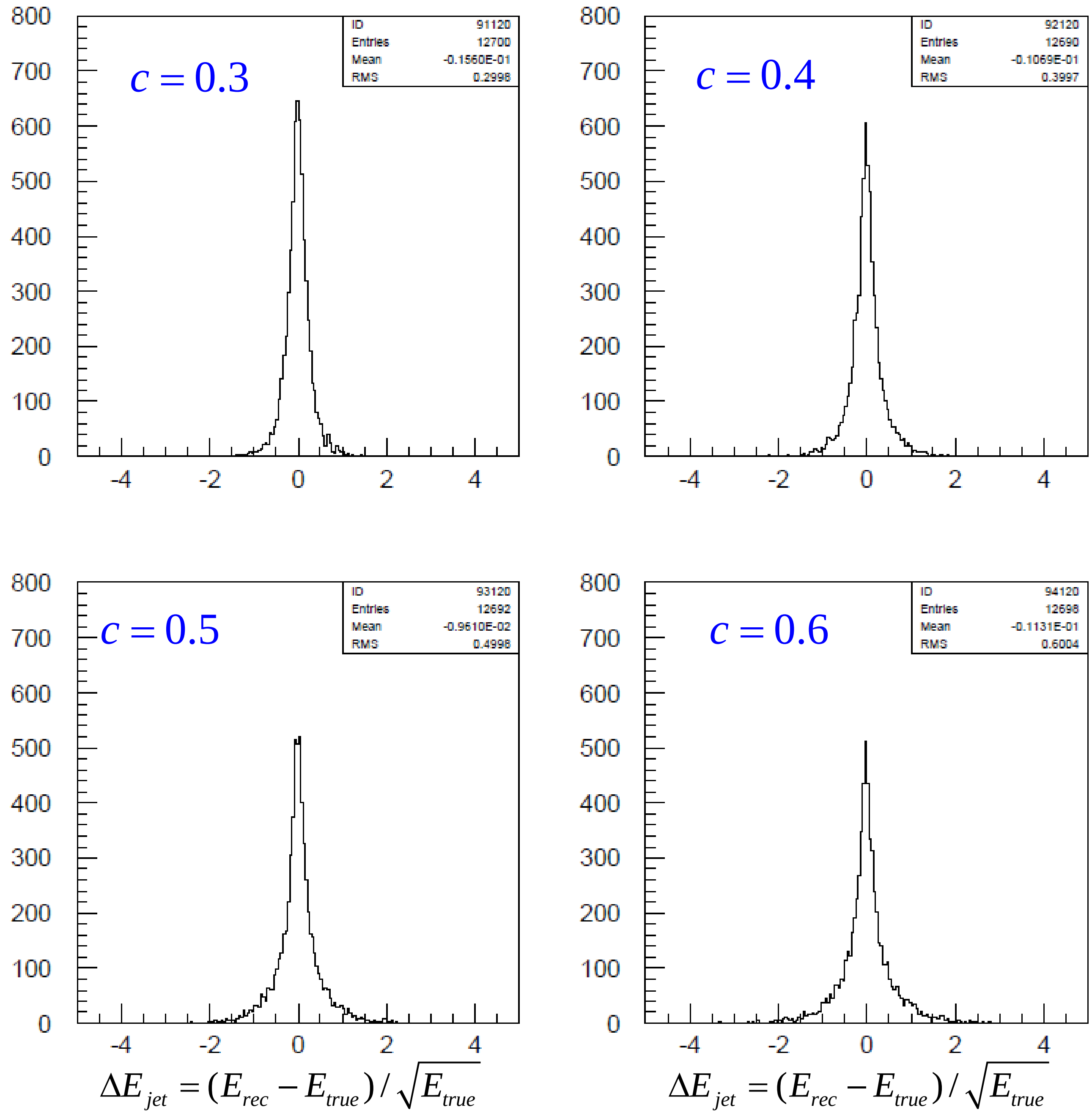
$$\lambda = \frac{c^2 - A_\gamma^2 w_\gamma - A_h^2 w_h}{(1-r)A_\gamma^2 w_\gamma + r A_h^2 w_h}$$

$e^+e^- \rightarrow u\bar{u}$

$\sqrt{s} = 500$ GeV

$r = 1.0$

(only degrade had resolution)

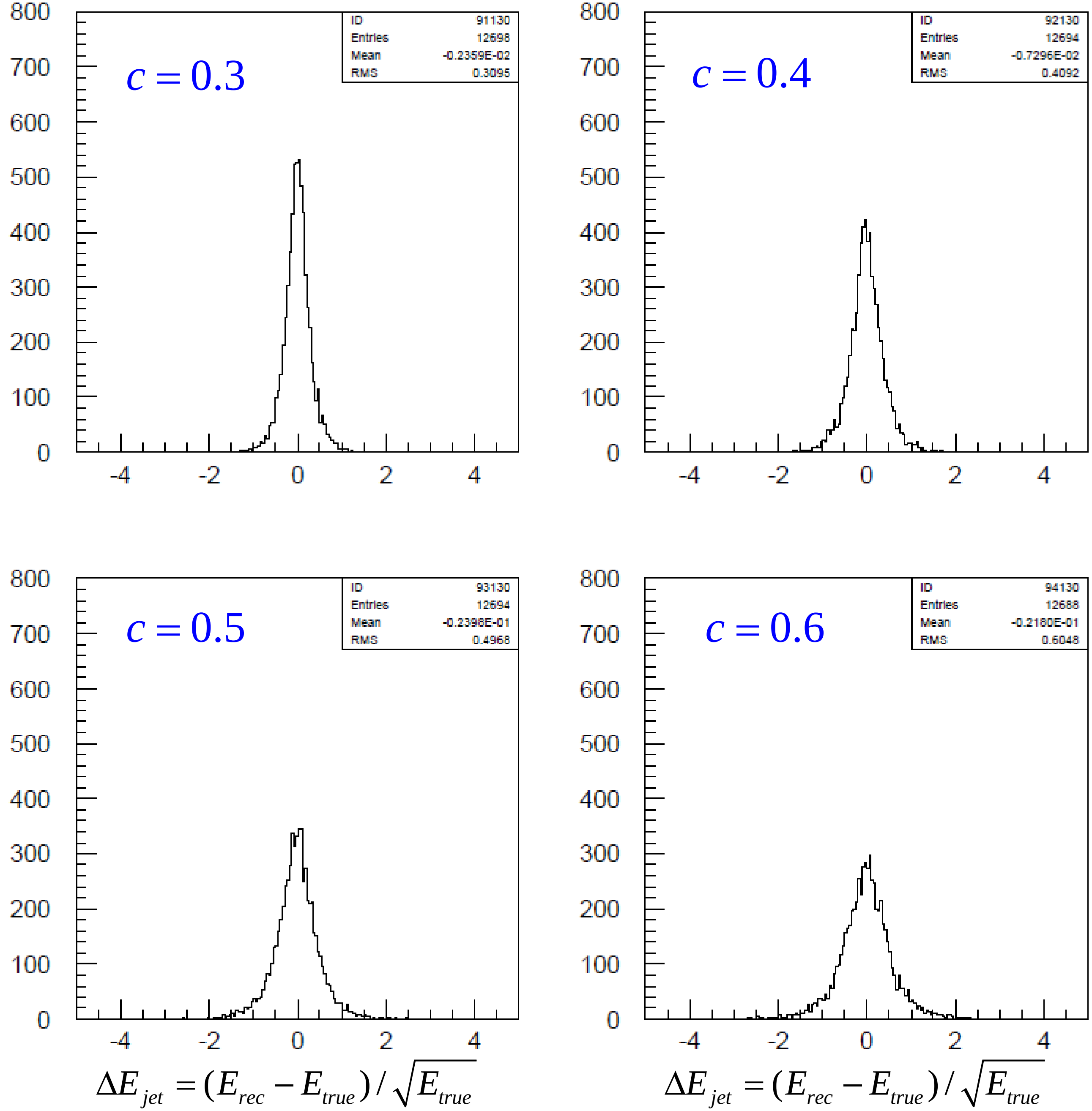


$$e^+e^- \rightarrow u\bar{u}$$

$\sqrt{s} = 500$ GeV

$r = 0.5$

(degrade em & had resolutions with equal wgt)

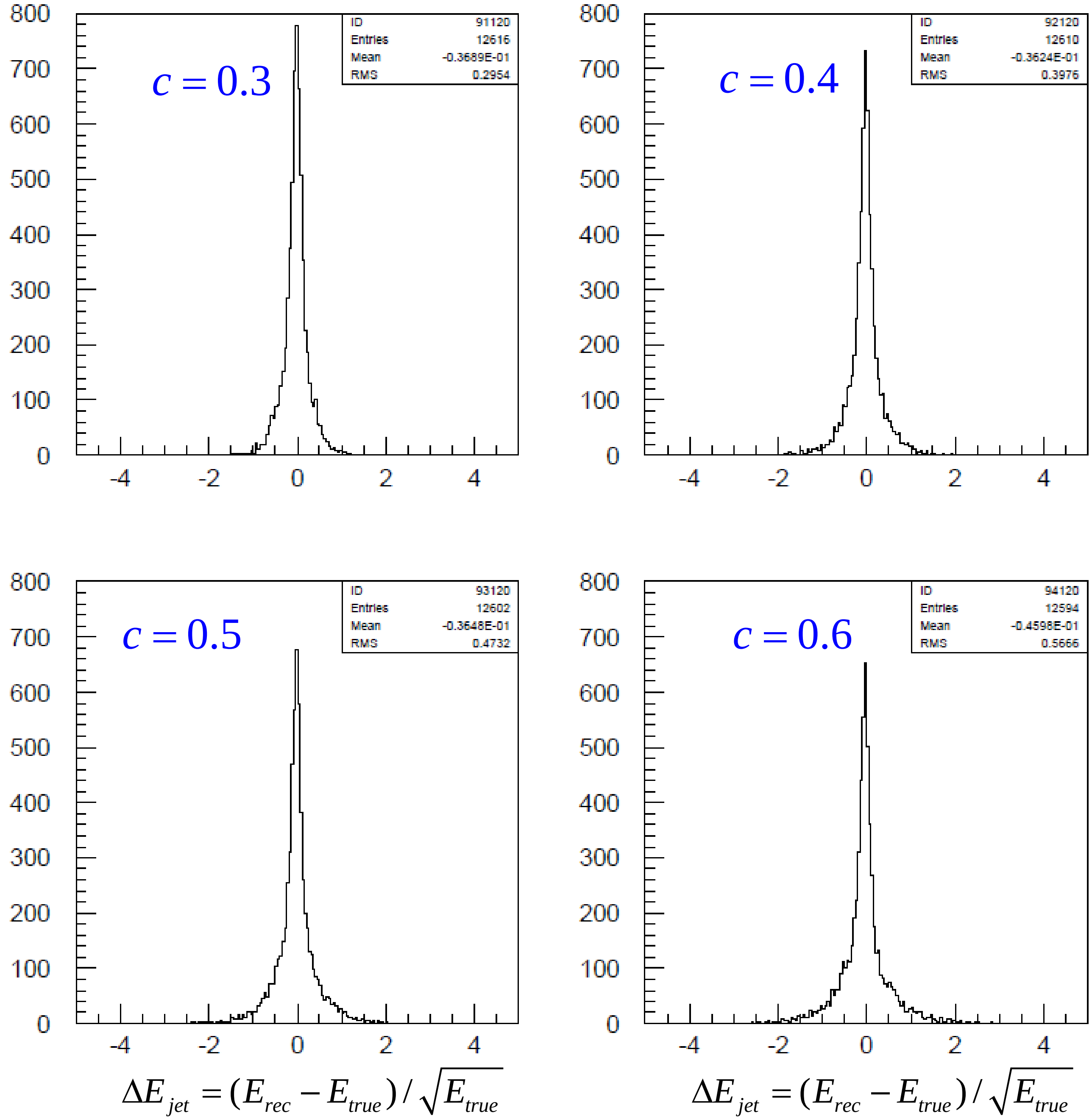


$e^+e^- \to u\bar{u}$

$\sqrt{s} = 100$ GeV

$r = 1.0$

(only degrade had resolution)

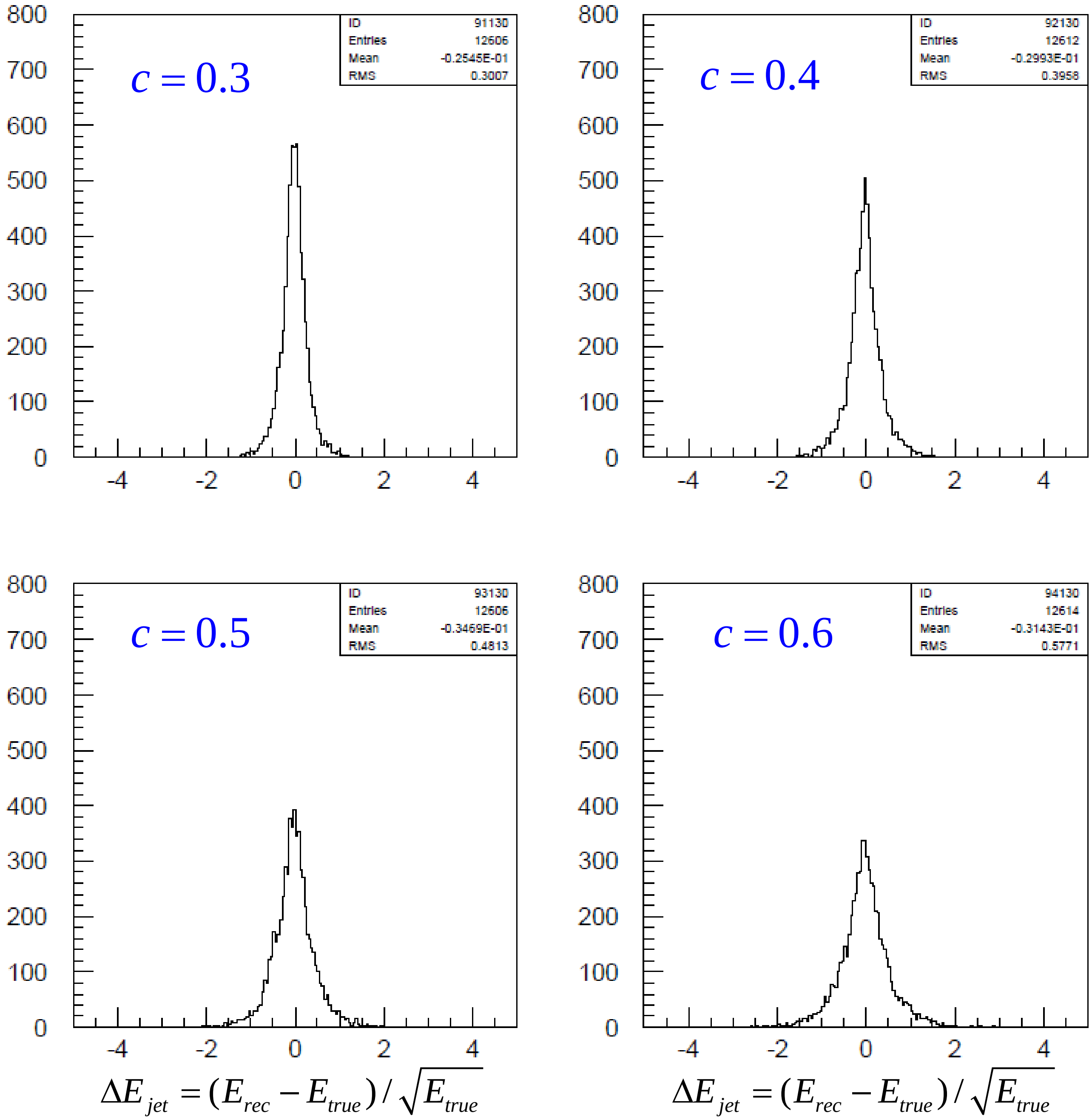


$e^+e^- \to u\bar{u}$

$\sqrt{s} =$ 100 GeV

$r = 0.5$

(degrade em & had resolutions with equal wgt)

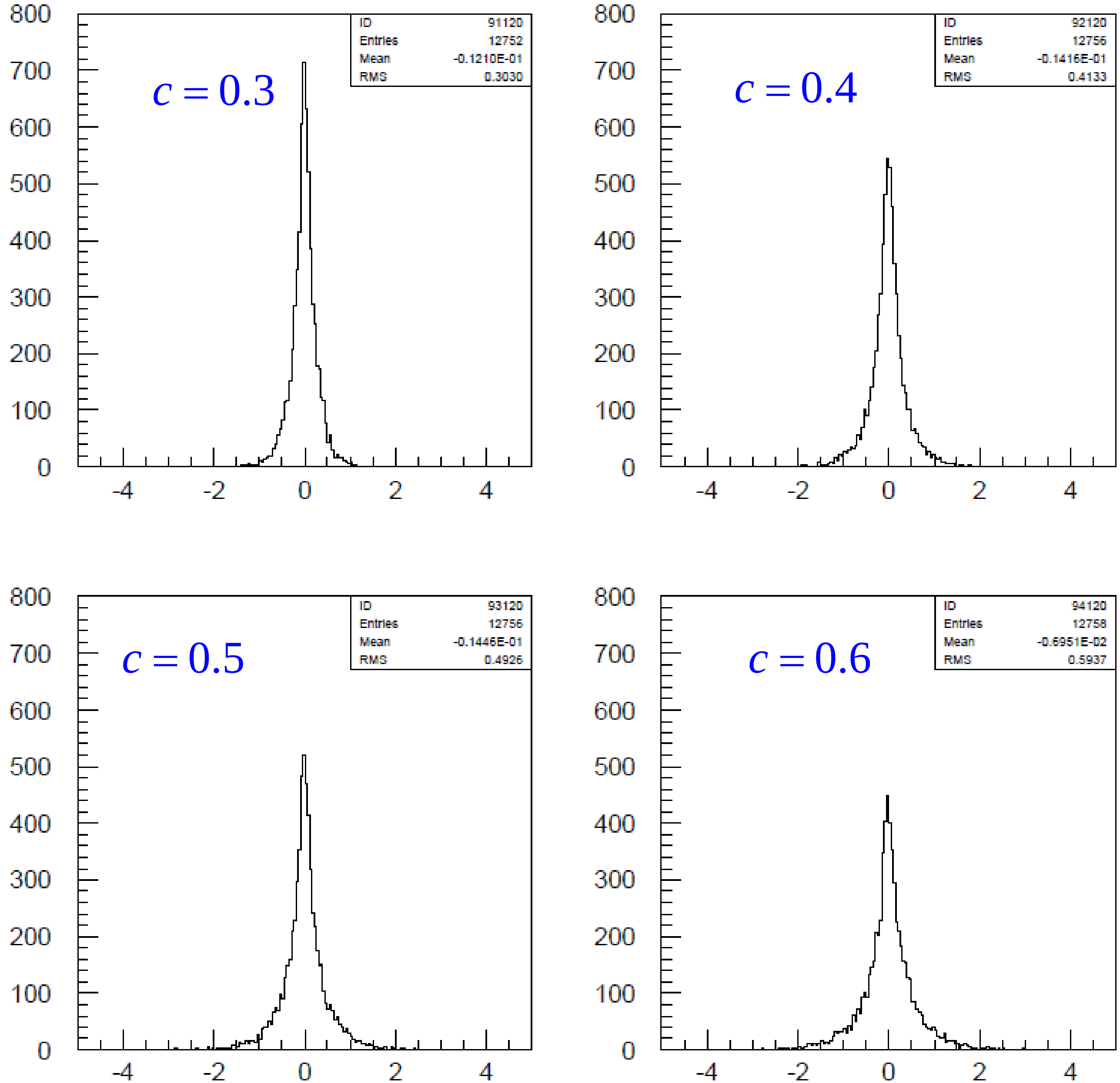


$$e^+e^- \to u\bar{u}$$

$$\sqrt{s} = 1000 \text{ GeV}$$

$r = 1.0$

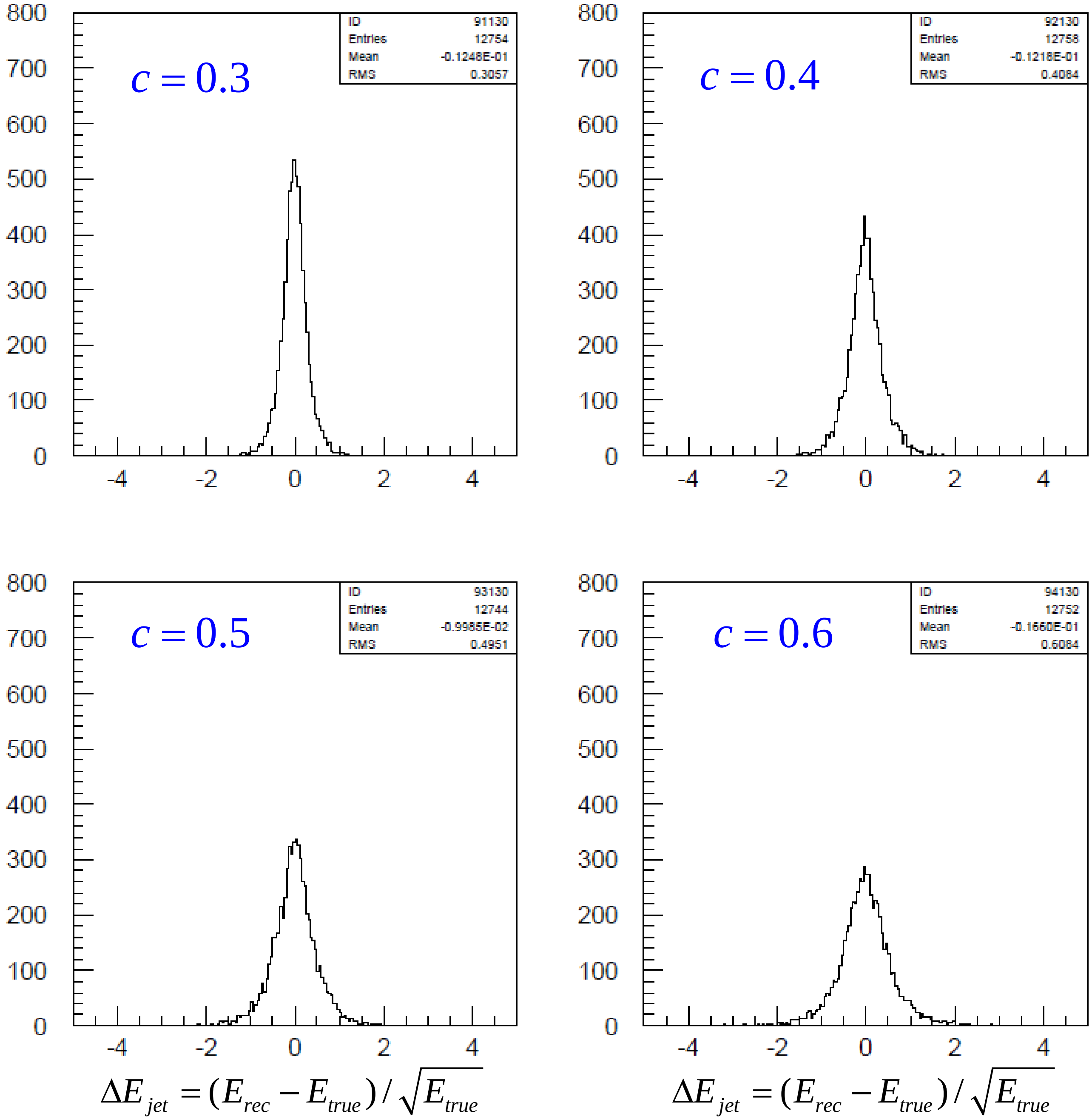
(only degrade had resolution)



$\Delta E_{jet} = (E_{rec} - E_{true}) / \sqrt{E_{true}}$ $\Delta E_{jet} = (E_{rec} - E_{true}) / \sqrt{E_{true}}$

$$e^+e^- \to u\bar{u}$$

$\sqrt{s} = 1000$ GeV



$r = 0.5$

(degrade em & had resolutions with equal wgt)

Next Steps

- Finish FORTRAN/C to JAVA interface so that hep.lcd ZVTOP can be called from FORTRAN90 analysis code.
- Incorporate Higgs Mass Constraints into Jet Energy Fitting Algorithm for 6 Jets (Currently it only has Beam Energy-Momentum Constraints)
- Start Optimizing Neural Network Analyses