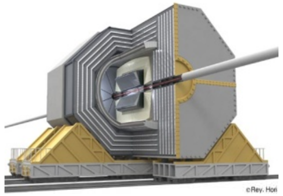

# Study with a cheated PFA

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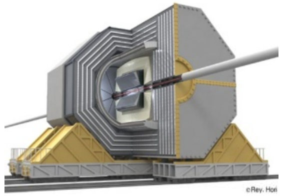
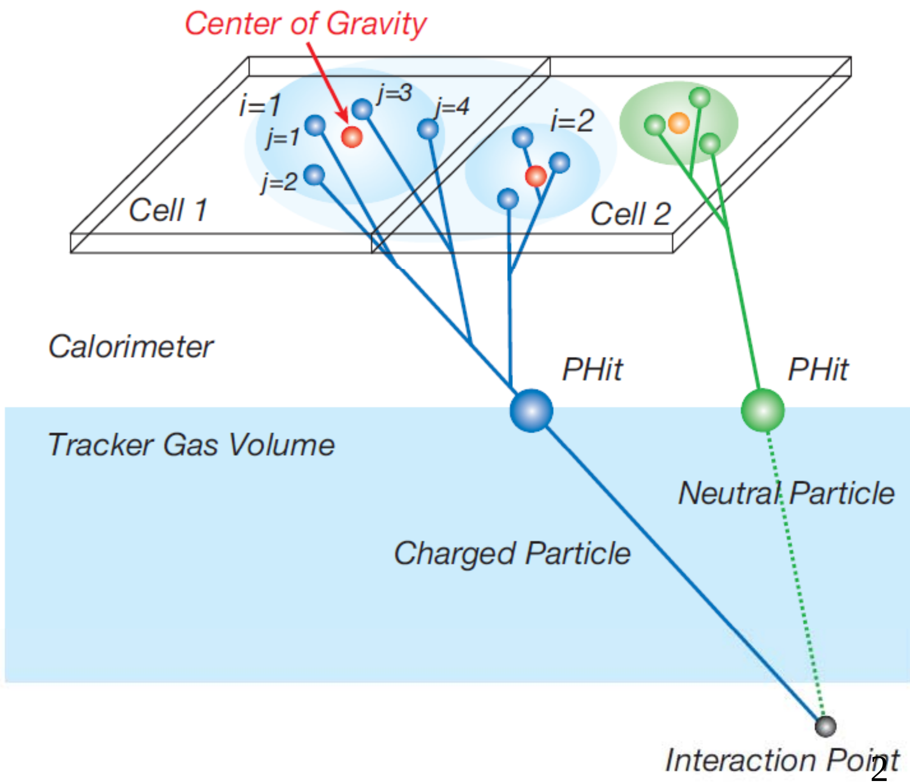
This talk is based on a paper, arXiv:0709.3147
by Sumie Yamamoto (Graduate School for Advanced Study),
Keisuke Fujii, Akiya Miyamoto (KEK)

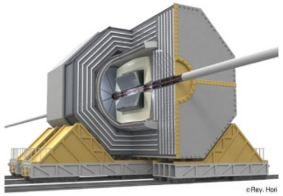


# Introduction

- Purpose of this study
  - To clarify what limits the jet energy resolution. It will help optimize PFA
  - Know the ultimate jet energy resolution attainable with an ideal PFA algorithm

- What is "Cheated PFA" ?
  - Track reconstruction:
    Cheated finder +Kalman Fitter
  - Calorimeter clustering and
    Track-Cluster matching:
    Based on MC truth information





# Detector Model

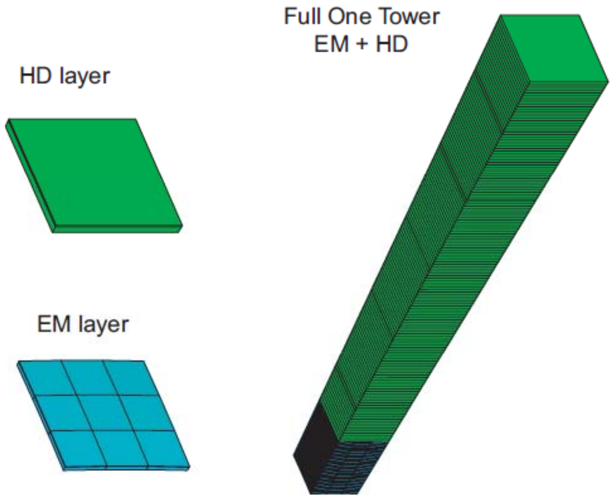
- Detector model: Similar to GLD, except Calorimeter
- Calorimeter: Tower structure

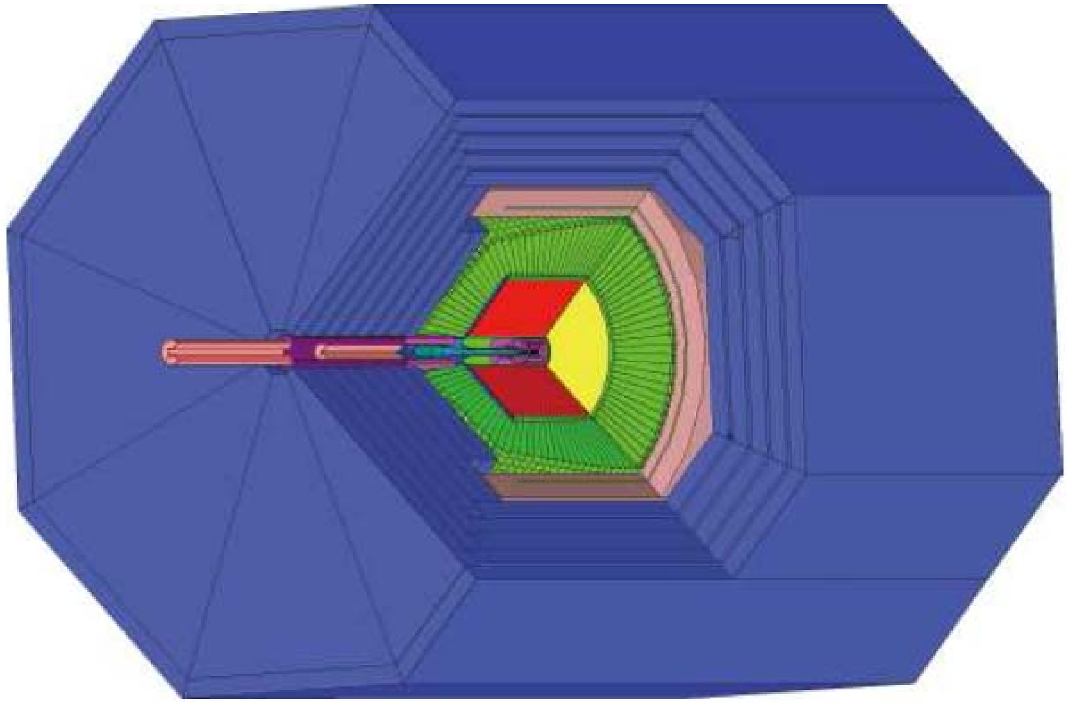
ECAL: $27.1X_0$ ( 38 layers of 4mm Pb+ 1mm Scint.), Rin = 2.1m

$$\sigma_E / E \approx 0.15/\sqrt{E(GeV)}$$ (single particle)

HCAL: $6.4\lambda$ (130 layers of 8mm Pb ; 2mm Scint.)

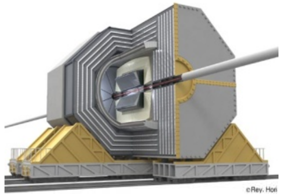
$$\sigma_E / E \approx 0.43/\sqrt{E(GeV)}$$ (single particle)



# Study of performance

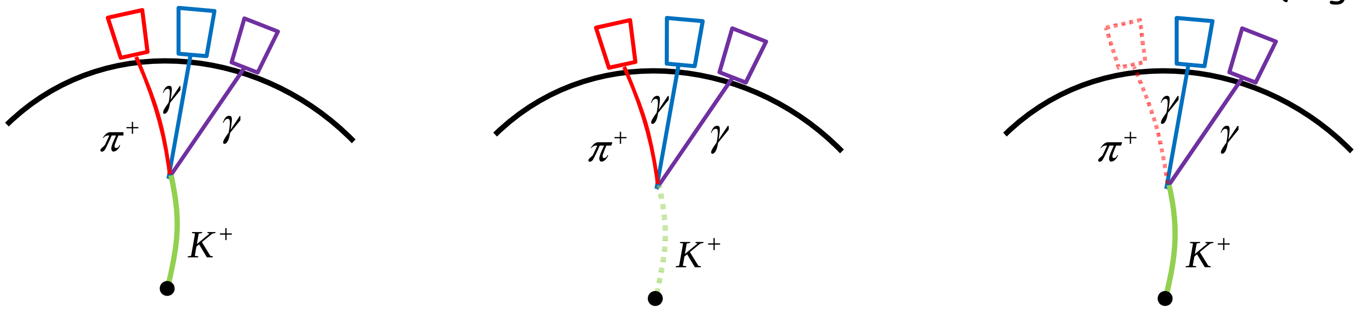
- Z0 events
  - Kink treatment
  - Detector resolution effects
- Boosted Z0: using ZZ events
- ZH events

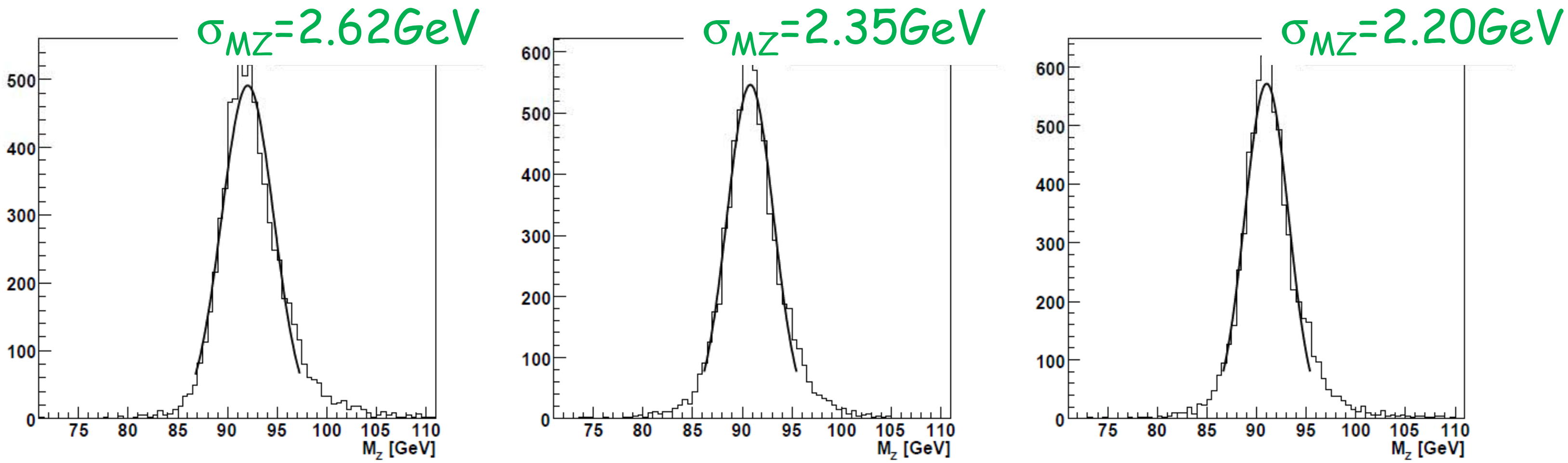


# Kink Treatment-Study using Z0

$$e^+e^- \to Z \to q\bar{q}\text{(uds only, no ISR)}$$

*No Kink Treatment* | *Kink Daughter* | *Kink Mother* (neglect charged PFOs)



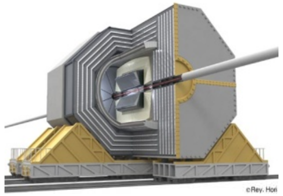




Problem: double count

Problem: ν ( K→μν )

*Kink mother scheme works better for Z0 events*

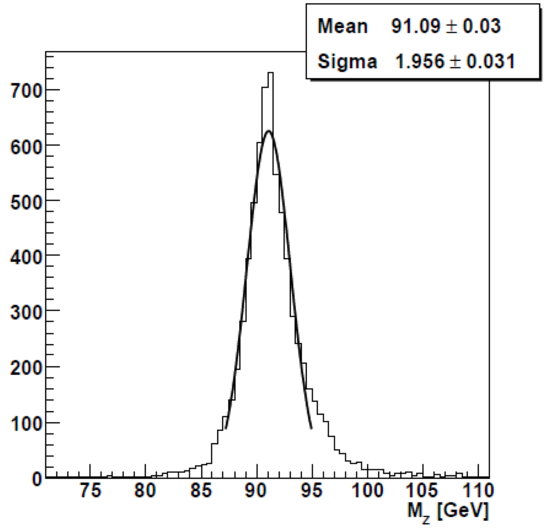
V0 treatment: no significant effect on Z0 mass resolution



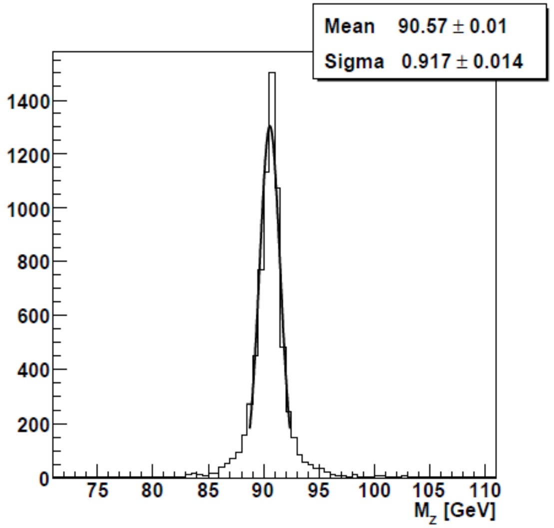
# Effect of detector resolution

- Replace 4 momenta of PFOs by MC truth. → See detector resolution effects.

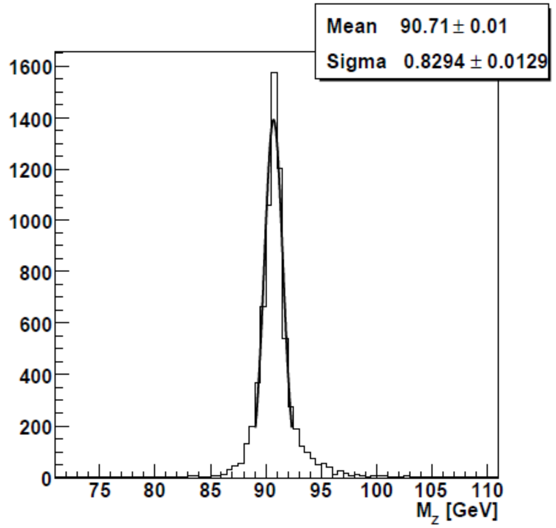
ECAL=MC Truth




E/HCAL=MC Truth




CAL&Track=MC Truth

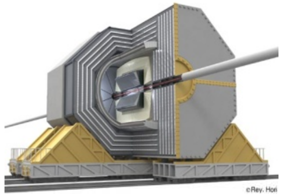



ECAL Contrib.:1.02GeV HCAL Contrib.:1.73GeV Track Contrib.:0.39GeV

Remaining contribution ( Acceptance, Neutrino, energy double counting) : 0.829 GeV

-- Undetected particle: tail on the lower mass side

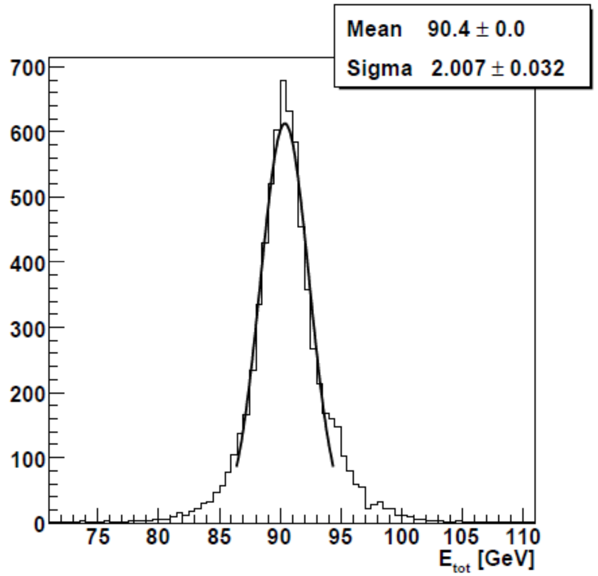
-- Double counting : tail on the higher mass side (Neutral kink daughters of particle masses kicked out from the detector materials

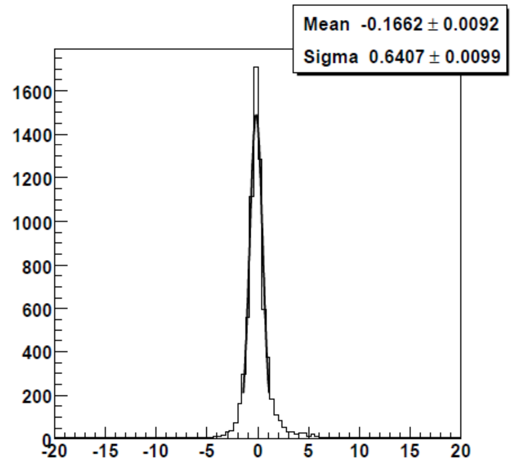


# Remaining Contributions

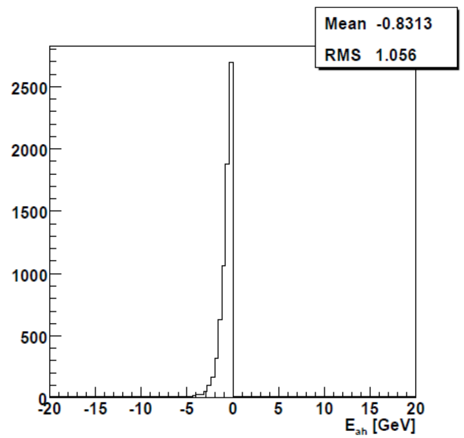
- Tracing break points of particle trajectories,

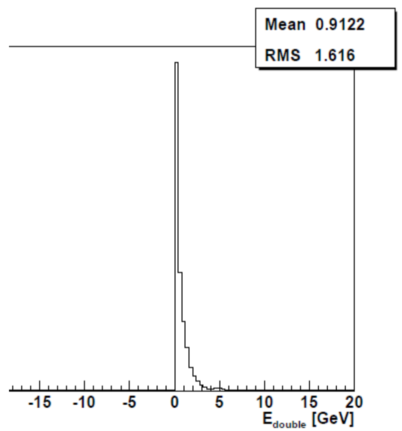
Eliminate double counted energies:




σ=2.20GeV → 2.01 GeV
Double count contribution~ 0.92 GeV
( Double count only ~ 0.45 GeV, but with detector resolution effect ~0.92 GeV )

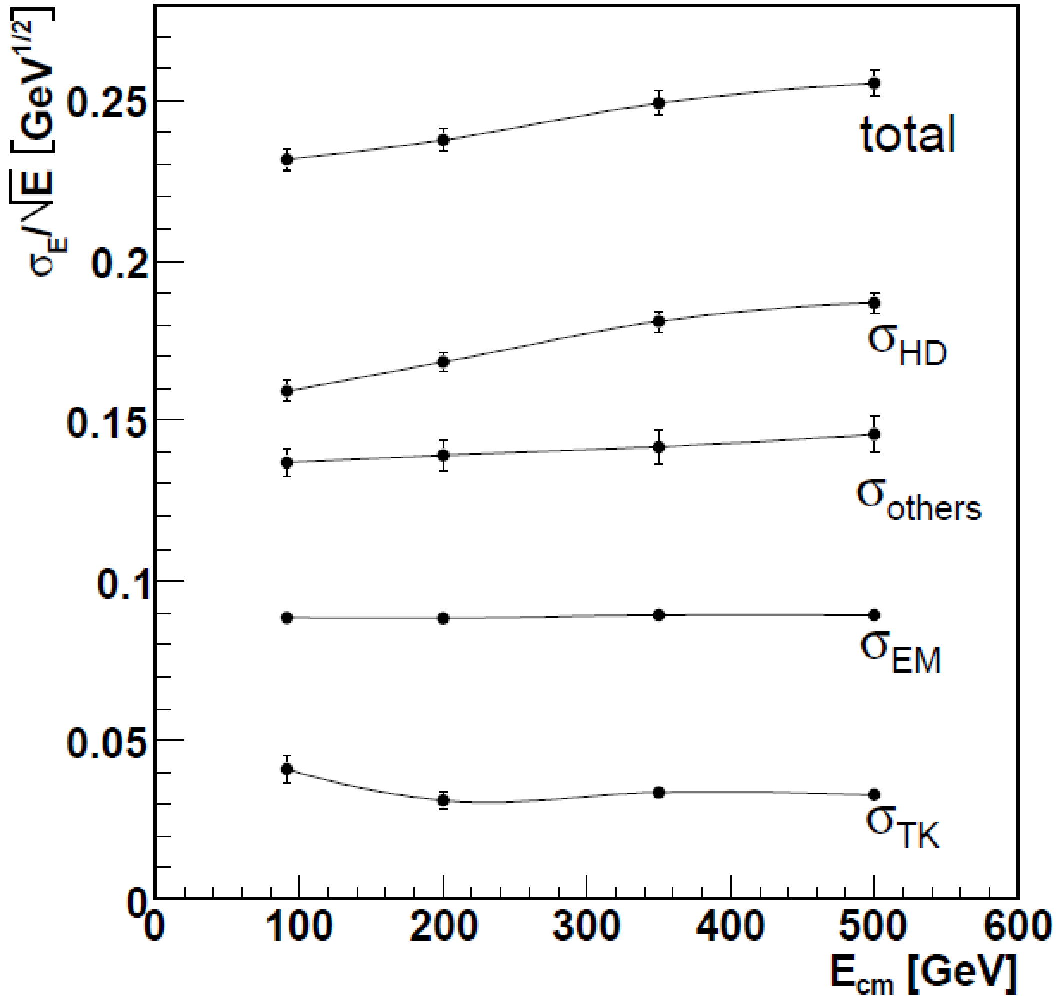



Un-detected only Double count only

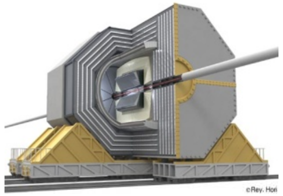
# Energy Resolution of Jet energy

$e^+e^- \to Z \to q\bar{q}$ at higher energies




$$\sigma_{Ejet} \approx 0.23 \times \sqrt{E_{jet}(GeV)}$$

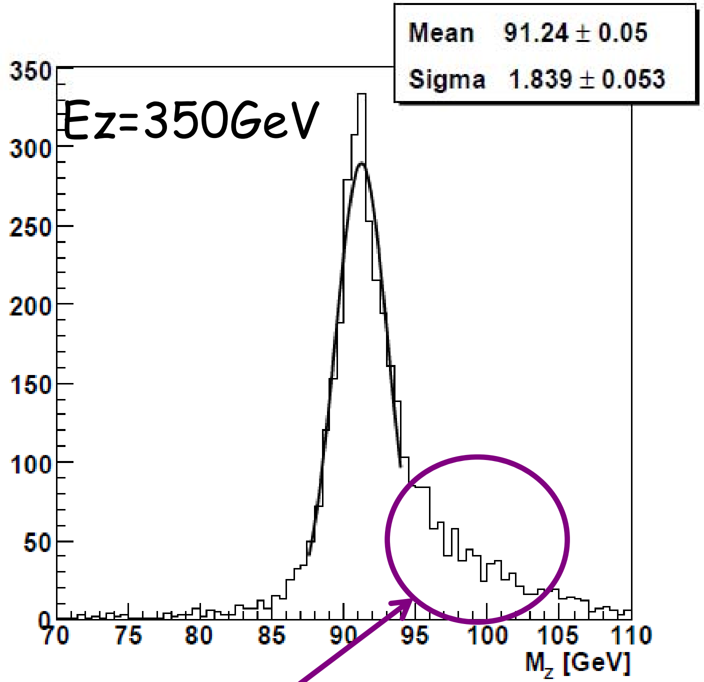
Slight increase in $\sigma_{HD}$ is
Mainly un-corrected energy dependence of calibration constant of hadron calorimeter



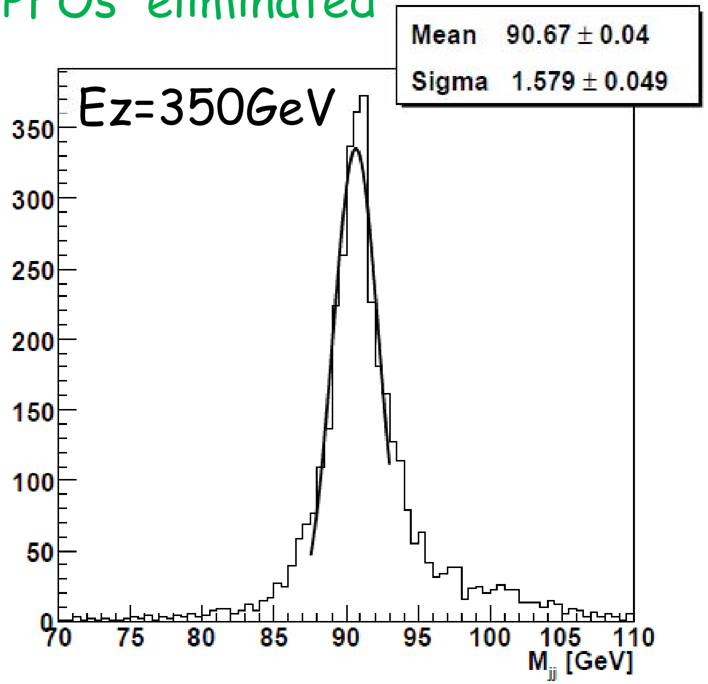
# Resolution of boosted Z0

- Jet mass resolution as a function of Z momentum
- Using the process, $e^+e^- \to Z^0Z^0 \to \nu\bar{\nu} + q\bar{q}(q = d,u,s)$
  To see pure detector effects, ISR off, $\Gamma_{Z0}$=0

Standard Treatment



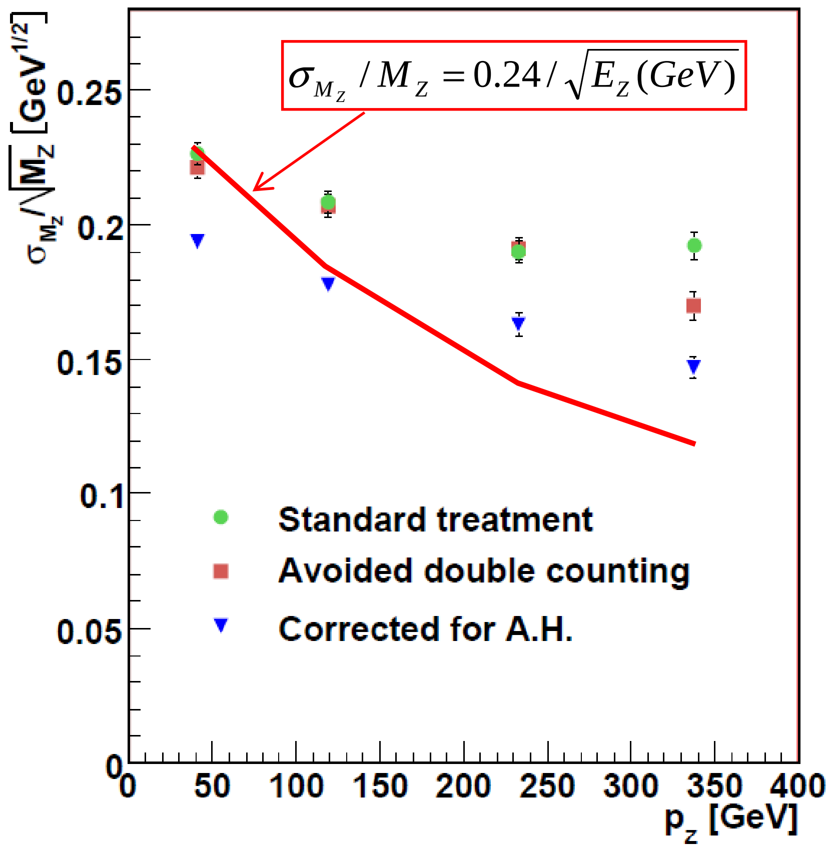

Double counted daughter PFOs eliminated




Due to secondaries produced by interactions with detector materials

# σ(Mz) vs Ez

Jet mass resolution as a function of the momentum of Z

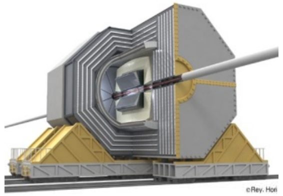



$$\frac{\sigma_M}{M} \approx \frac{1}{2}\sqrt{\left(\frac{\sigma_{E_1}}{E_1}\right)^2 + \left(\frac{\sigma_{E_2}}{E_2}\right)^2}$$

$$\approx \frac{a}{2}\sqrt{\frac{1}{E_1} + \frac{1}{E_2}}$$

$$\approx 1/\sqrt{E_Z} \text{ if } E_1 = E_2$$

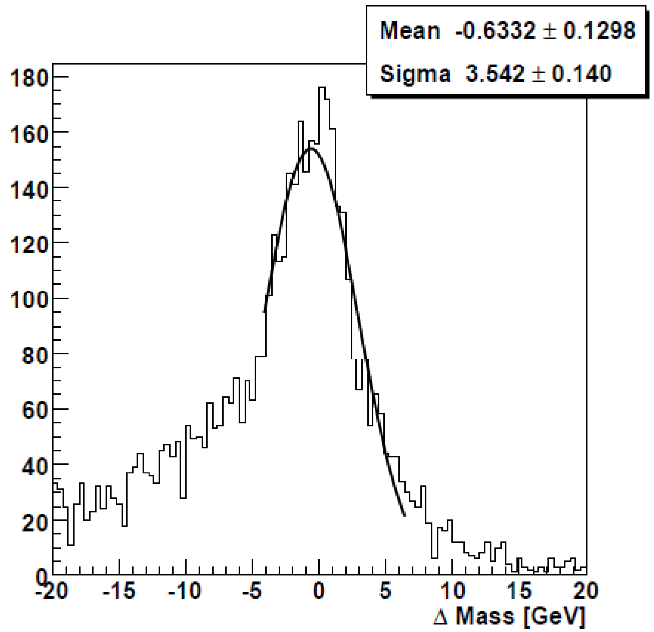
σ(Mz) improves with Pz, but not as quickly as 1/√Ez

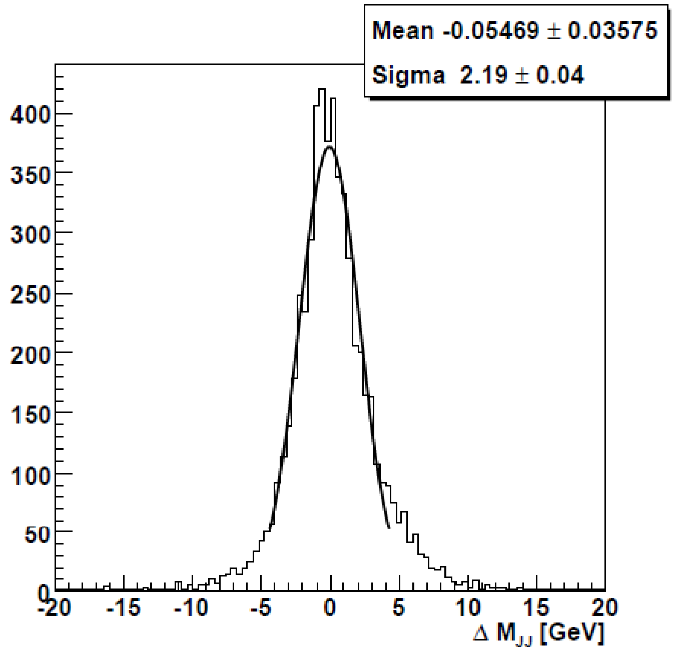


# $e^+e^- \to$ ZH process

- Ecm=350GeV, Mh=120GeV, $Z \to \nu\bar{\nu}$; including BS& ISR
- Mh is calculated as the invariant mass of all visible particles.

Without any treatment

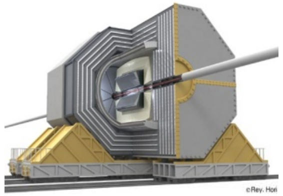



After all treatments
→ Consistent with Z0 studies

# Factors which affect σ(Mh)

| | $\sigma_{Mh}$ (GeV) | σ improvement (GeV) |
|---|---|---|
| No treatment | 3.54 | |
| Eliminate double count daughters | 3.12 | 1.67 |
| Eliminate ISR γs | 2.90 | 1.15 |
| Add energy of ν in Higgs decay | 2.40 | 1.67 |
| (tail in the distribution is removed) | | |
| Add undetected particles | 2.19 | 0.98 |



# Summary

- PFA performance was studied using a cheated PFA
- For a model detector ( similar size as GLD ),
  - $\sigma(Mz)$~2.2 GeV. ( ~ 0.23/ $\sqrt{E}$ )
  - Contributions to the resolutions are
    - Tracker: 3%, ECAL:21%, HCAL 62%, Double-Count: 4%, Acceptance 10%
- From studies of high energy $q\bar{q}$ events, $\sigma(Ejet) \propto \sqrt{Ejet}$
- From studies of Boosted Z, $\sigma(Mz)$ improves with Ez, but not as quickly as $1/\sqrt{Ez}$
- In the case of Mh study in e+e- → ZH process, ISR $\gamma$s, $\nu$ and double counted daughters make contributions similar to HCAL.