# Probe Higgs-gluon coupling via jet energy profile at e+e− colliders


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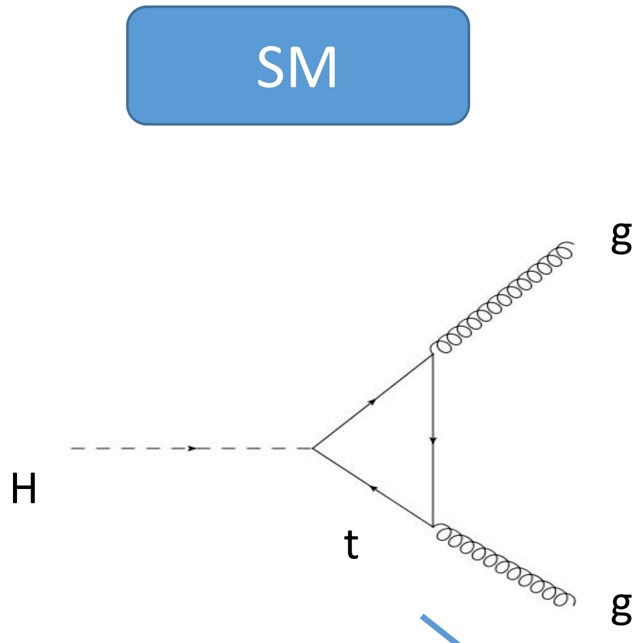
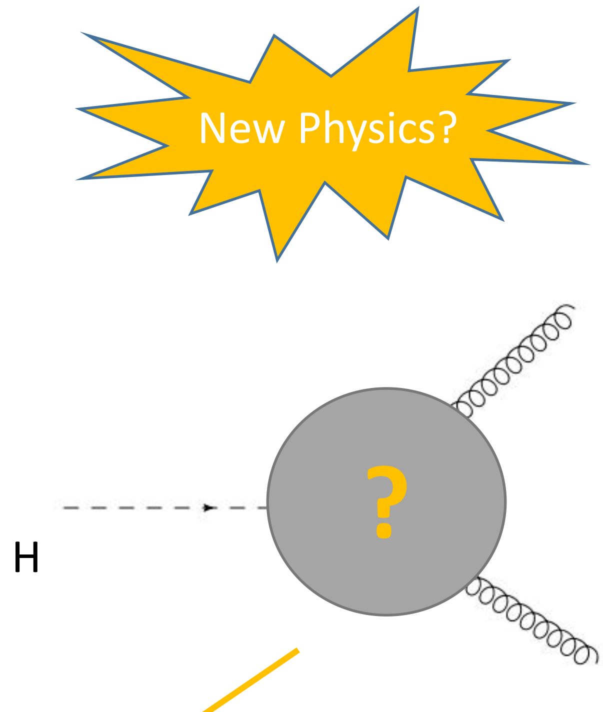
# Outline

- 1. Higgs-gluon effective coupling
- 2. Jet Energy Profile(JEP)
- 3. JEP cut and JEP weight
- 4. Estimation of statistical uncertainty
- 5. Summary

# Effective coupling of Higgs and gluon



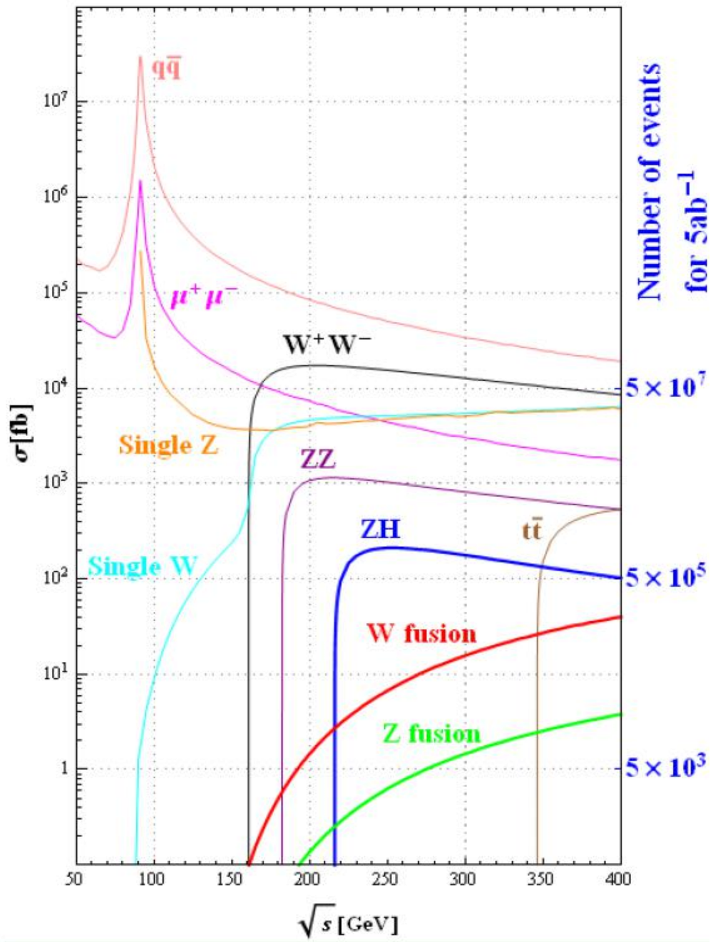

$$\kappa_g = \frac{g(hgg)}{g(hgg\,;SM)}$$

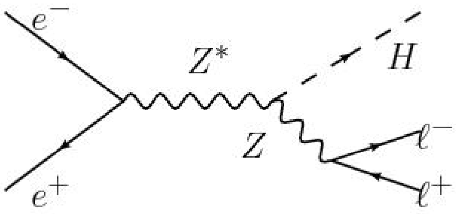
New Heavy particles ?

New Freedom ?

Or ?

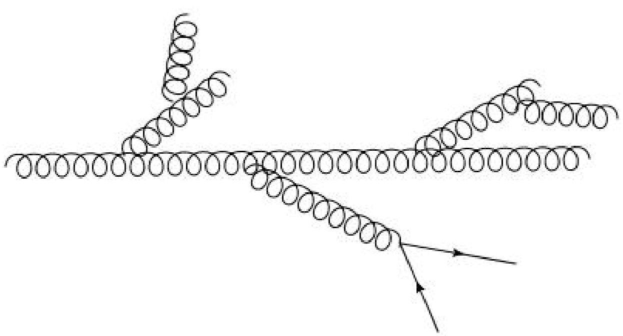
# Higgs production and decay at lepon collider

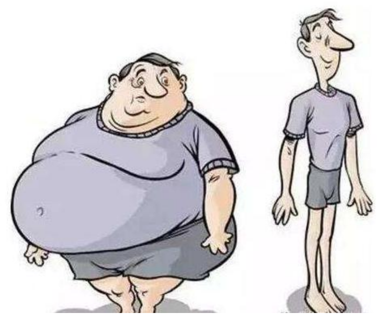


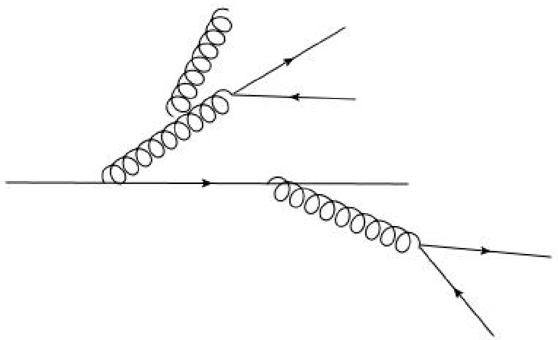




| Decay mode | Branching fraction [%] |
|---|---|
| $H \to bb$ | $57.5 \pm 1.9$ |
| $H \to WW$ | $21.6 \pm 0.9$ |
| $H \to gg$ | $8.56 \pm 0.86$ |
| $H \to \tau\tau$ | $6.30 \pm 0.36$ |
| $H \to cc$ | $2.90 \pm 0.35$ |
| $H \to ZZ$ | $2.67 \pm 0.11$ |
| $H \to \gamma\gamma$ | $0.228 \pm 0.011$ |
| $H \to Z\gamma$ | $0.155 \pm 0.014$ |
| $H \to \mu\mu$ | $0.022 \pm 0.001$ |

# Quark and gluon jet substructure







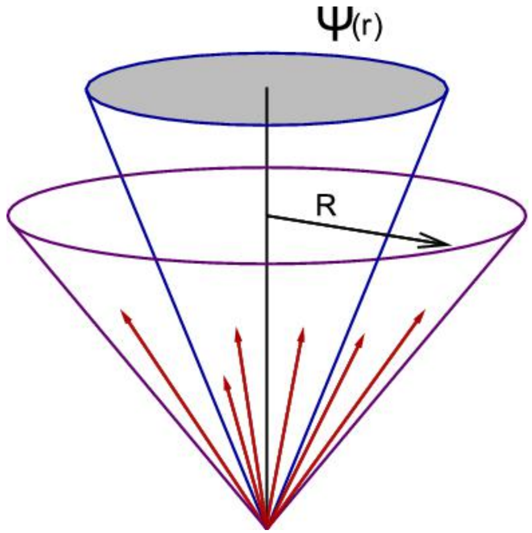
gluon jet radiate more

quark jet radiate less

They have different distribution of energy

Use Jet Energy Profile to extract the information of jet substructure

# Jet Energy Profile(JEP)



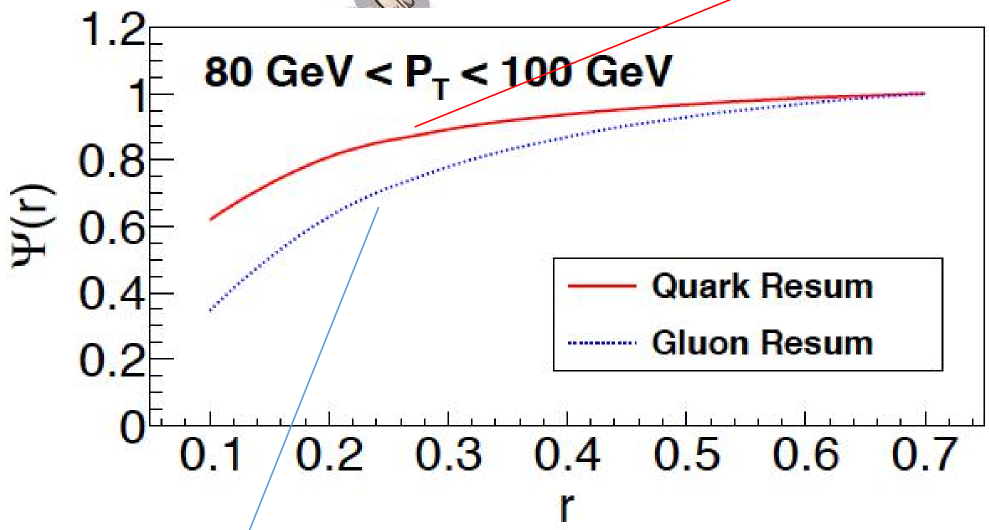

For a jet of size R, the integrated JEP is defined as the fraction of jet transverse momentum that lies inside a sub-cone of size r (< R).

$$\psi(r) = \frac{1}{N_j}\sum_j \psi_j(r) = \frac{1}{N_j}\sum_j \frac{\sum_{r_i<r} p_{\mathrm{T},i}(r_i)}{\sum_{r_i<R} p_{\mathrm{T},i}(r_i)}$$

JEP of single jet

# JEP distinguish quark and gluon jet

Quark initiated jets radiate less and are narrower with a quickly raising JEP.




Gluon initiated jets radiate more and are broader with a slowly raising JEP.

# JEP cut and JEP weight

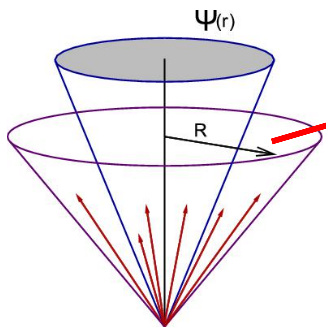
**Improvement**

**JEP cut** : choose a region for the JEP of jets (According to the distribution of gluon-jets JEP and quark-jets JEP)
1. effectively remove the background-jets by analyzing the internal structure of jets
2. decrease the JEP uncertainty

**JEP weight** : quark-jets and gluon-jets are given different weights by their average JEP value (**Accumulated JEP**)

# Accumulated JEP

$$\Lambda^N(r) = \frac{\sum_j \psi_j(r)}{\sum_j^{\rm SM} \psi_j(r)}$$




choose the part that lies outside the sub-cone of size r (< R).

$$Y^N(r) = \frac{\sum_j (1-\psi_j)}{\sum_j^{\rm SM} (1-\psi_j)}$$

generic observable

$$Z^N(r) = \frac{\sum_j (\psi_j + b)}{\sum_j^{\rm SM} (\psi_j + b)}$$

a tunable parameter

$\Lambda^{\rm N}$(b=0)

$Y^{\rm N}$(b=-1)

# Statistical Uncertainty

**Statistical Uncertainty of Kg**

$$\delta\kappa_g^Z = \frac{\sqrt{N}}{2N_g}\Big[\big(\frac{\sigma(r)}{\psi_g + b}\big)^2 + f_g + (f_b + f_c)\big(\frac{\psi_q + b}{\psi_g + b}\big)^2 + f_{\rm BG}\big(\frac{\psi_{\rm BG} + b}{\psi_g + b}\big)^2\Big]^{1/2}$$

uncertainty of JEP — uncertainty of event number

The minimal uncertainty can be met at $\frac{\partial \delta\kappa_g^Z}{\partial b} = 0$

JEP uncertainty

$$\delta\kappa_g^Z = \delta\kappa_g^N \left\{1 - f_{\rm B}\left[1 + \frac{\sigma^2(r)}{(\psi_g - \psi_q)^2 f_{\rm B}}\right]^{-1}\right\}^{1/2}$$

difference of quark-jets JEP and gluon-jets JEP

# MC Simulation

Whizard 1.95 → Generate events at the future e+e- collider for the center-of-mass energy 250 GeV and integrated luminosity 5 ab-1.

↓

PYTHIA → Shower and Hadronization

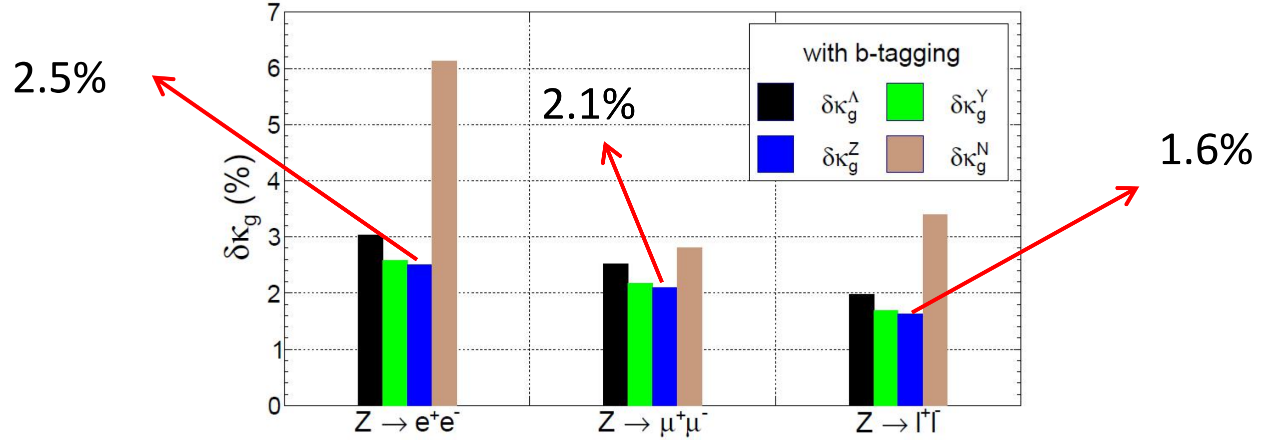
↓

FASTJET 3.3.0 → Anti-kt algorithm with cone size R = 1.5

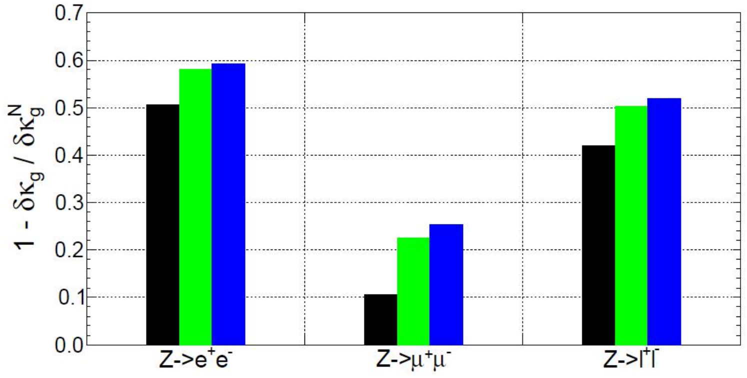
kinematic cuts-->b/c-tagging-->JEP cut-->JEP weight

# Results (with only b-tagging)

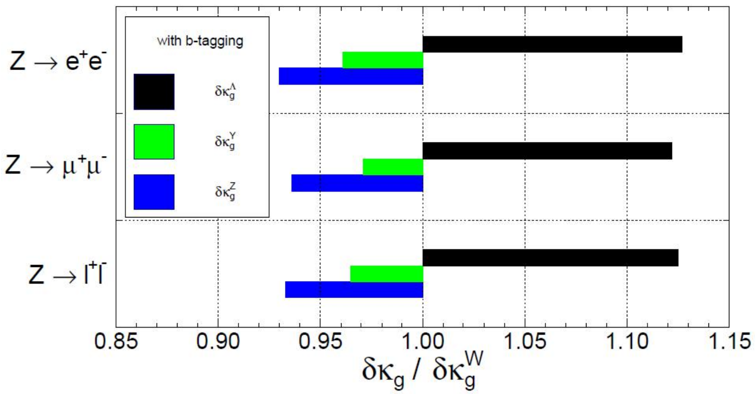
Uncertainty of Kg




Total Improvement

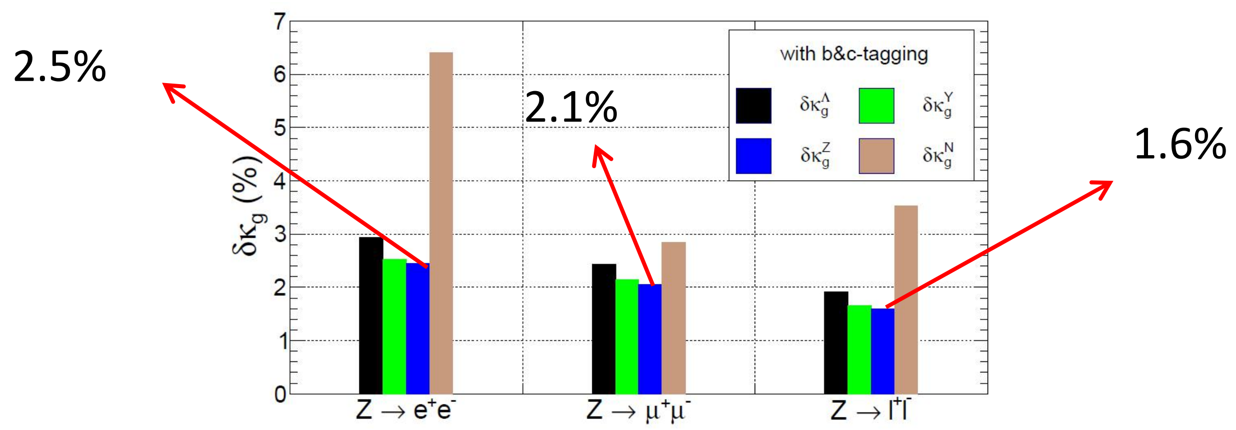



Improvement from JEP weight

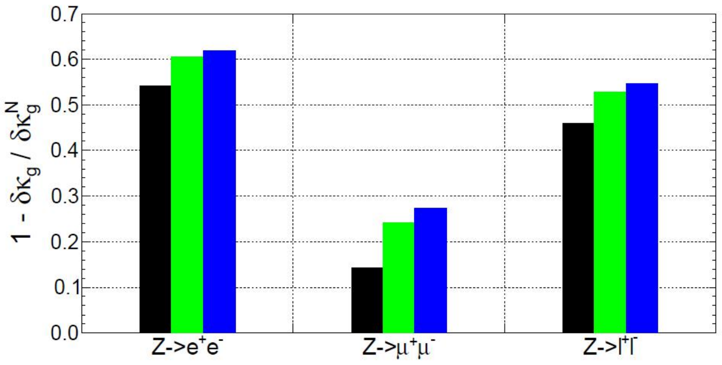


# Results (with b&c-tagging)

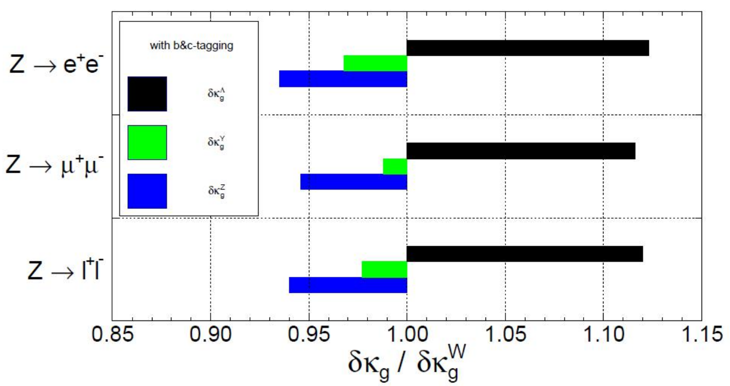
Uncertainty of Kg




Total Improvement




Improvement from JEP weight



# Summary

Using accumulated JEP for the measurement of the Higgs-gluon effective coupling.

MC simulation at e+e- colliders for the center-of-mass energy 250 GeV and integrated luminosity 5 ab-1.

The statistical uncertainties of Kg can reach about 1.6% in the channels of Z boson decaying to lepton pairs.

Totally reduced by about 52% (45% from the JEP cut contribution and 7% from the JEP weight contribution) compared to that without using JEP.