Measurement of angular distributions for

$$\gamma\gamma \to h \to ZZ \to ll\ jj$$

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NŻK

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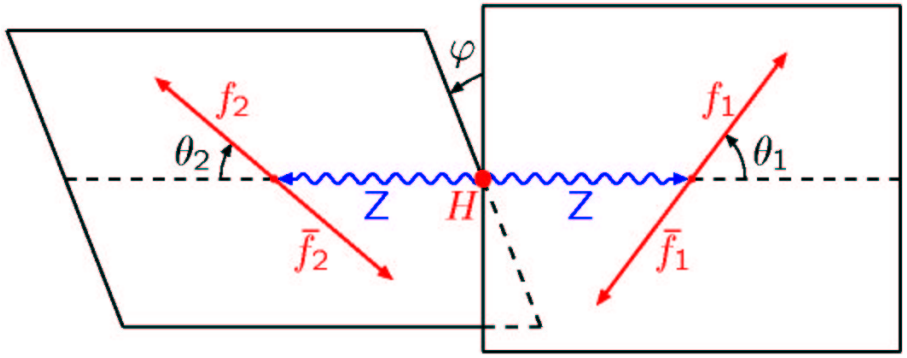
Outline

- Introduction
- Resolution
- Acceptance
- Quark/anti-quark ambiguity
- Results

Introduction

Angular distributions



5 angles:

- polar angle θ_Z for $h \to ZZ$ decay
- polar angle θ_l for $Z \to l^- l^+$ decay
- polar angle θ_j for $Z \to q\bar{q}$ decay
- azimuthal angles between Higgs and Z decay planes: ϕ_l and ϕ_j

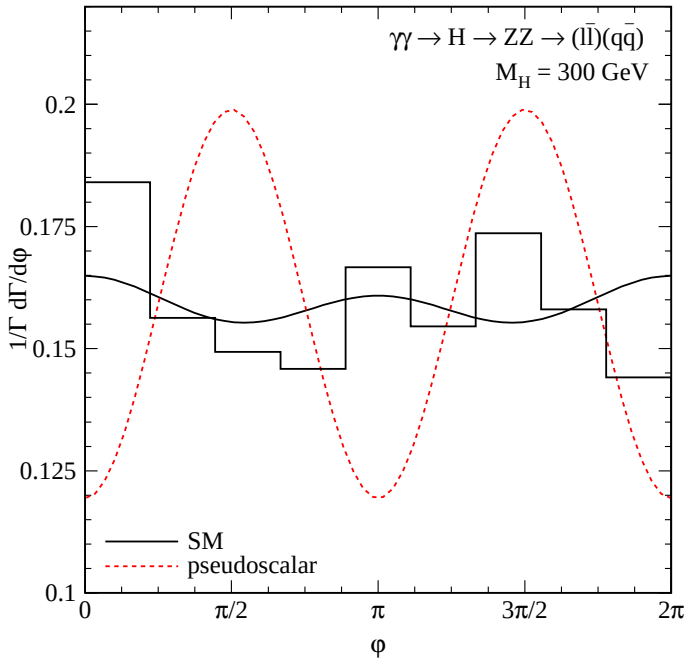
angle between two planes: $\Delta\phi = \phi_j - \phi_l$

S.Y.Choi, D.J.Miller, M.M.Muhlleitner, P.M. Zerwas, Phys.Lett.B553(2003)61, hep-ph/0210077

D.J.Miller, Prague, November 2002:

Measurement of angular distributions

$\Rightarrow$ Higgs spin and parity



$\Rightarrow$ **detector effects ?!**

Introduction

Simulation

$\gamma\gamma$ spectra from **CompAZ**,
$\sqrt{s_{ee}} = 500$ GeV

Higgs events generated with PYTHIA 6.152
$\gamma\gamma \to h \to ZZ \to e^+e^-q\bar{q},\ /\ \mu^+\mu^-q\bar{q}$
m_h = 300 GeV

PYTHIA properly simulates all angular distributions for SM Higgs

pseudoscalar Higgs $\Rightarrow$ reweighting events

detector simulation with SIMDET v. 3.01

$h \to ZZ \to llqq$ event selection

- balanced transverse momentum:
  $P_T/E_T < 0.1$
- 2 leptons ($e^\pm$ or $\mu^\pm$) + 2 hadronic jets
- cut on lepton and jet angle
  $\cos\theta_{l,jet} < 0.95$
- leptons and jets reconstruct into two Z° with probability $P_Z > 0.001$
  based on reconstructed invariant mass

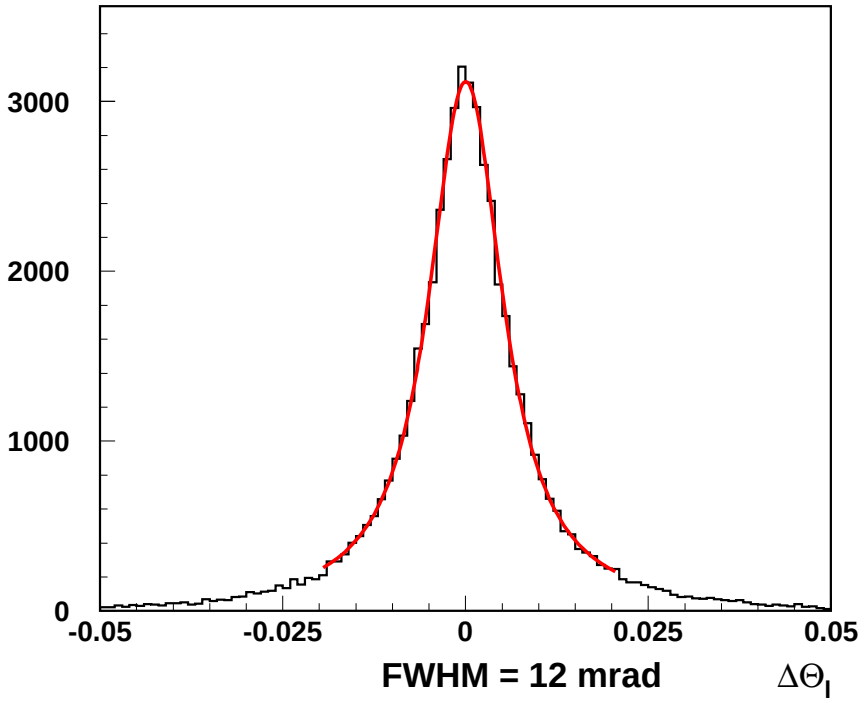
SM Higgs selection efficiency ~54%
(for $ZZ \to q\bar{q}\,l^+l^-$ events)
$BR(ZZ \to q\bar{q}\,l^+l^-) \approx 9.4\%\ \ (l = \mu, e)$

Resolution

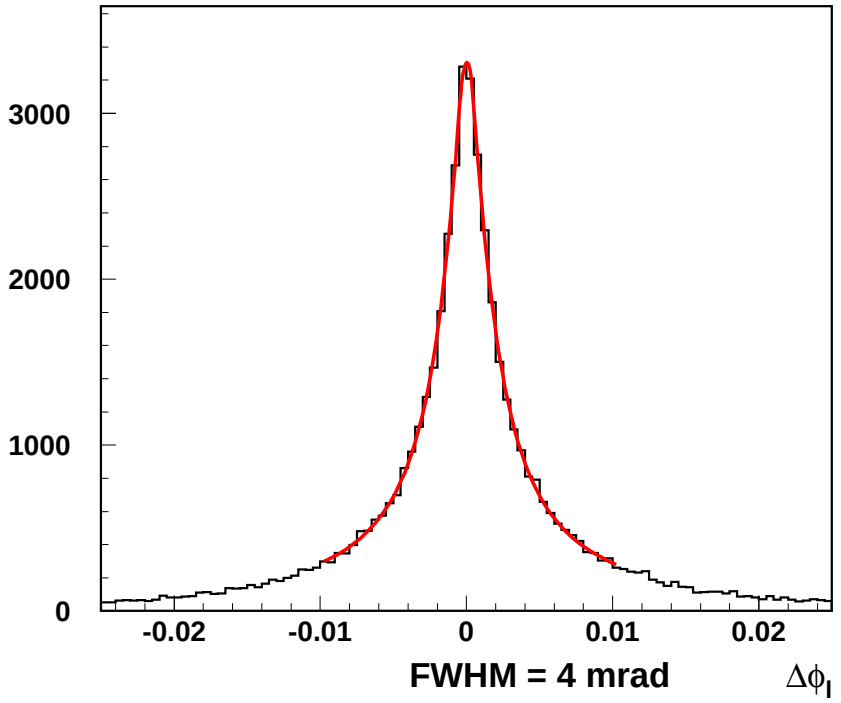
$Z \to l^+ l^-$

Expected accuracy of decay angles measurement

polar angle θ_l



azimuthal angle ϕ_l



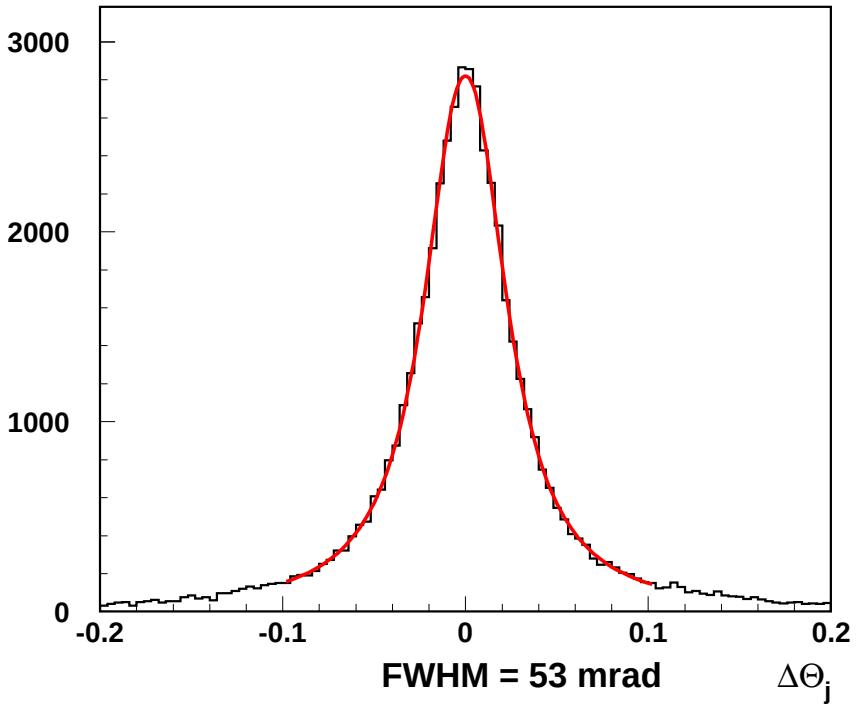
Shape described by Breit-Wigner distribution

Resolution

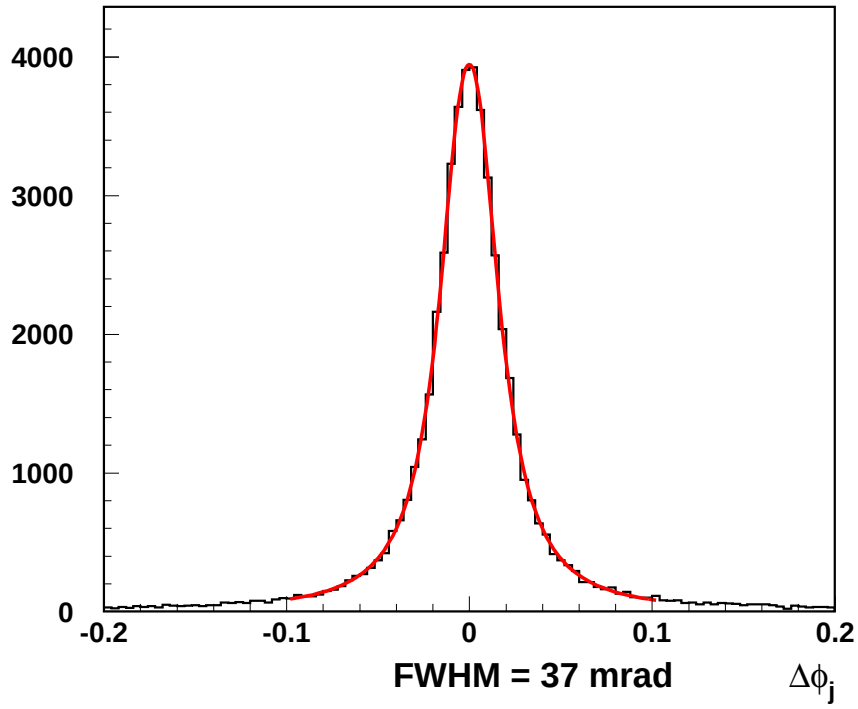
$Z \to q\bar{q}$

Expected accuracy of decay angles measurement

polar angle θ_q



azimuthal angle ϕ_q ($\sim$ same for $\Delta\phi$)

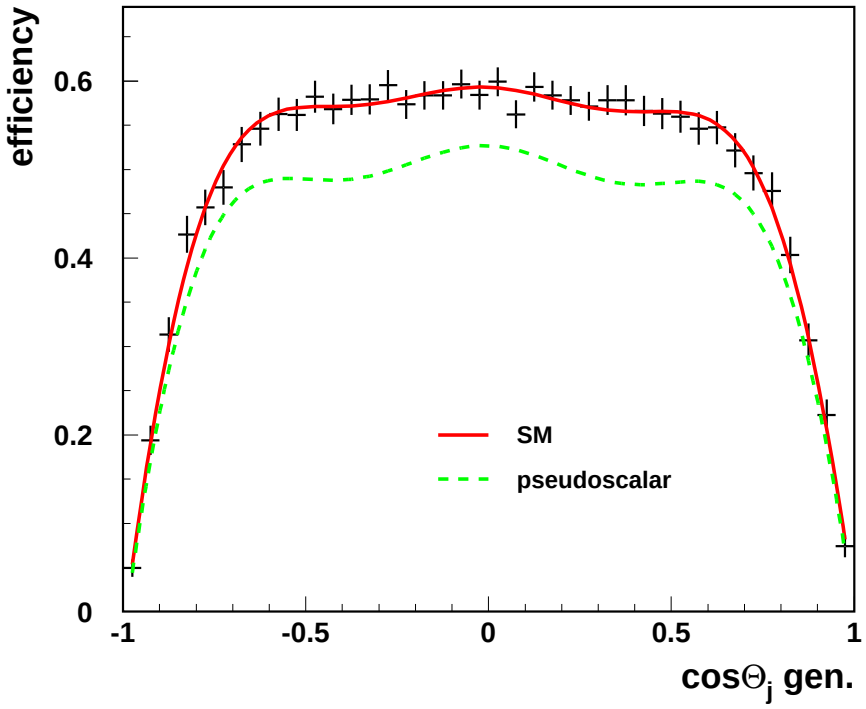


All angles can be measured with high accuracy

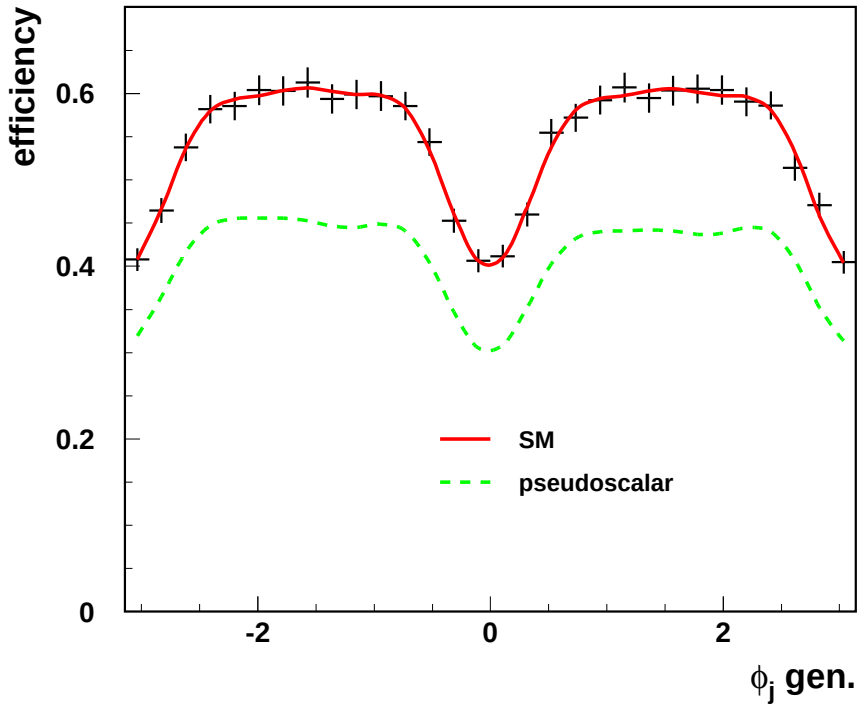
Acceptance

Selection efficiency as a function of decay angles for $Z \to q\bar{q}$

polar angle θ_q



azimuthal angle ϕ_q



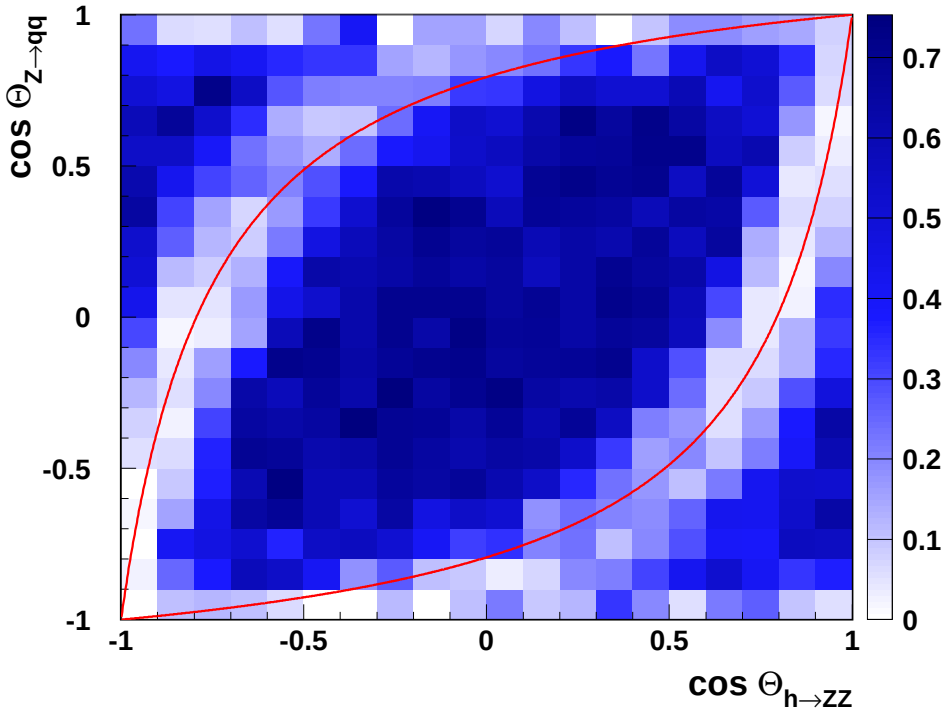
similar pattern observed for $Z \to l^- l^+$ decay angles

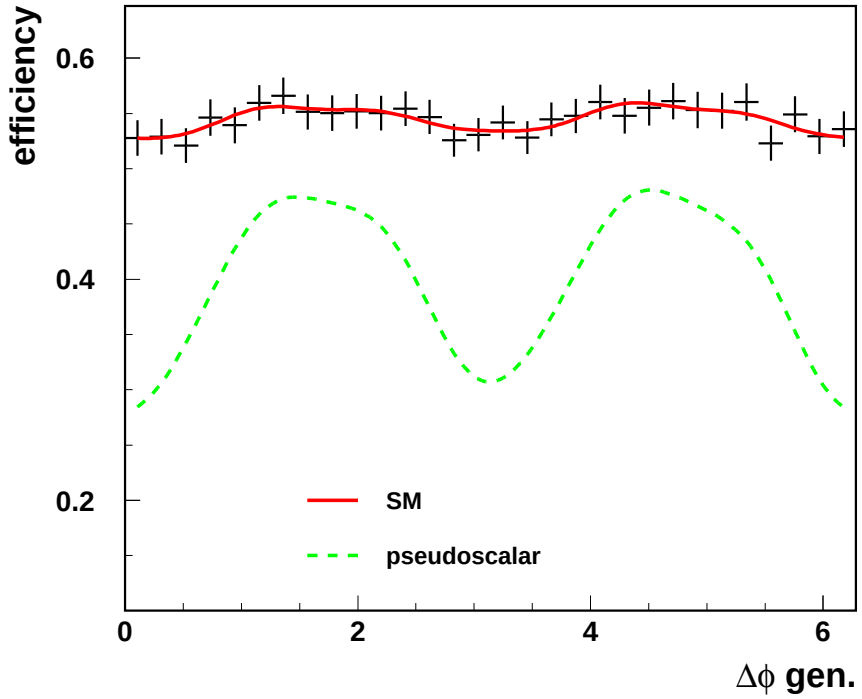
Acceptance

Acceptance losses for $\phi = 0, \pi, \ldots$ are due to the jet/lepton going in the beam direction

$\Rightarrow$ nonuniform acceptance in $\Delta\phi$:

Selection efficiency for $\phi_j \approx 0$





Effect much stronger for pseudoscalar Higgs (different $\cos\theta_{j,l}$ distribution)

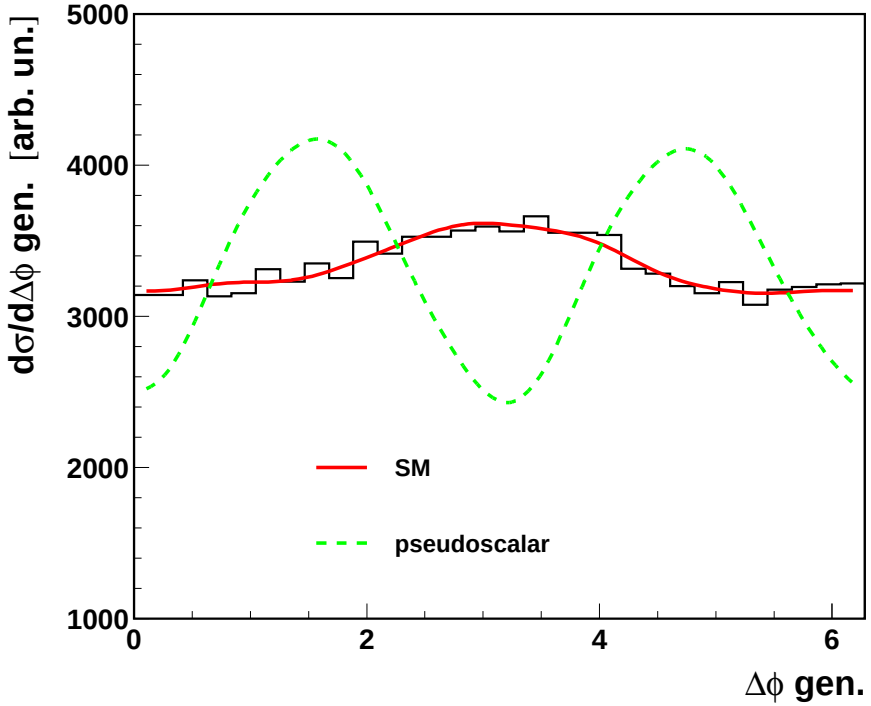
red lines: $\cos\theta_j^{LAB} = \pm\cos\theta_Z^{LAB}$

$q\bar{q}$ ambiguity

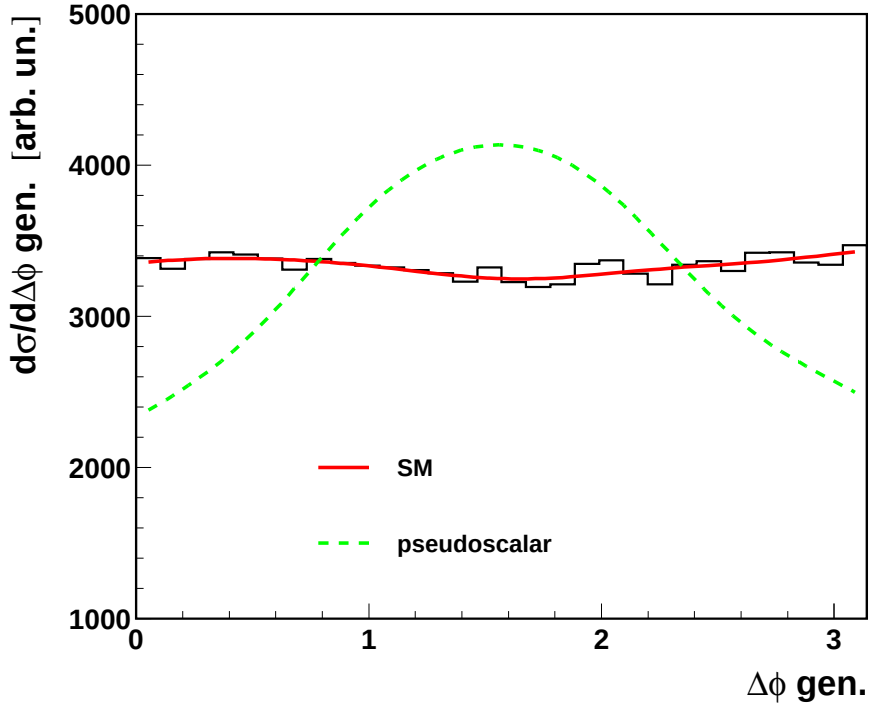
For $Z \to q\bar{q}$ one can not distinguish between quark and anti-quark jets

$\Rightarrow 0 < \Delta\phi < \pi$ (measured from l^- to the "nearest" jet)

with $q/\bar{q}$ tagging



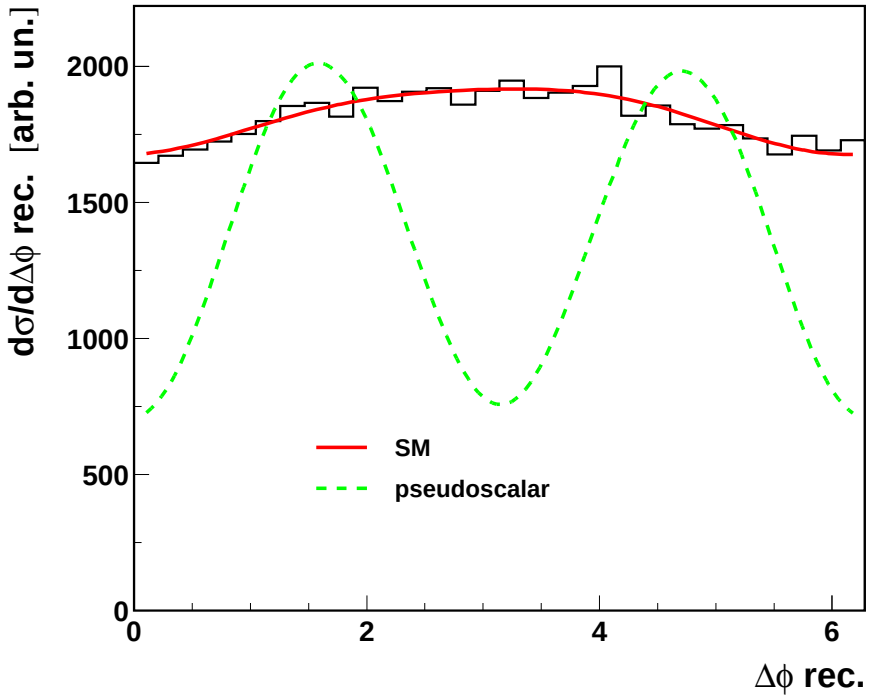
without $q/\bar{q}$ tagging



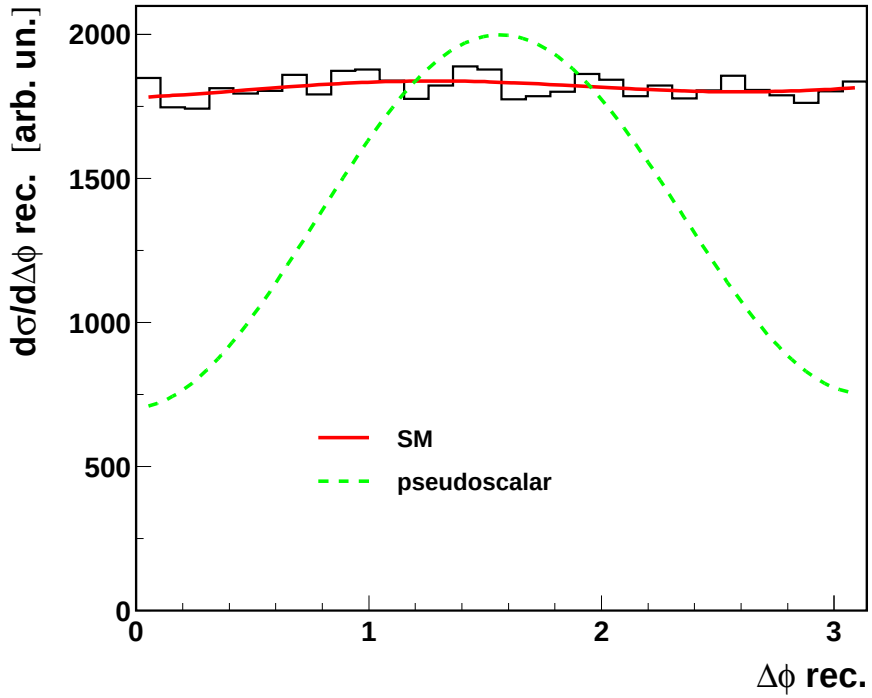
Results

Expected $\Delta\phi$ distribution after detector simulation

with $q/\bar{q}$ tagging (just for comparison)



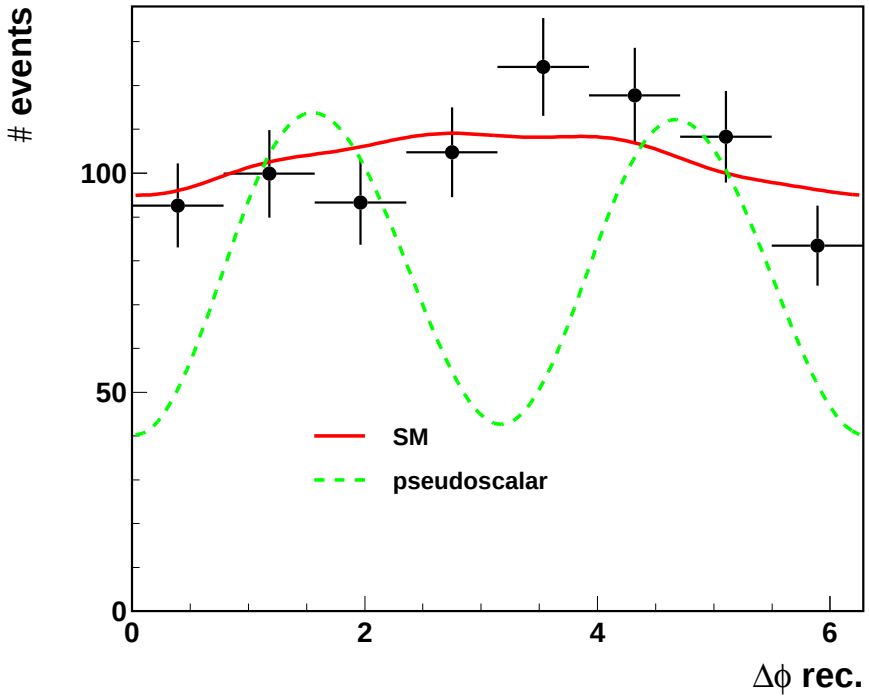
without $q/\bar{q}$ tagging (realistic)



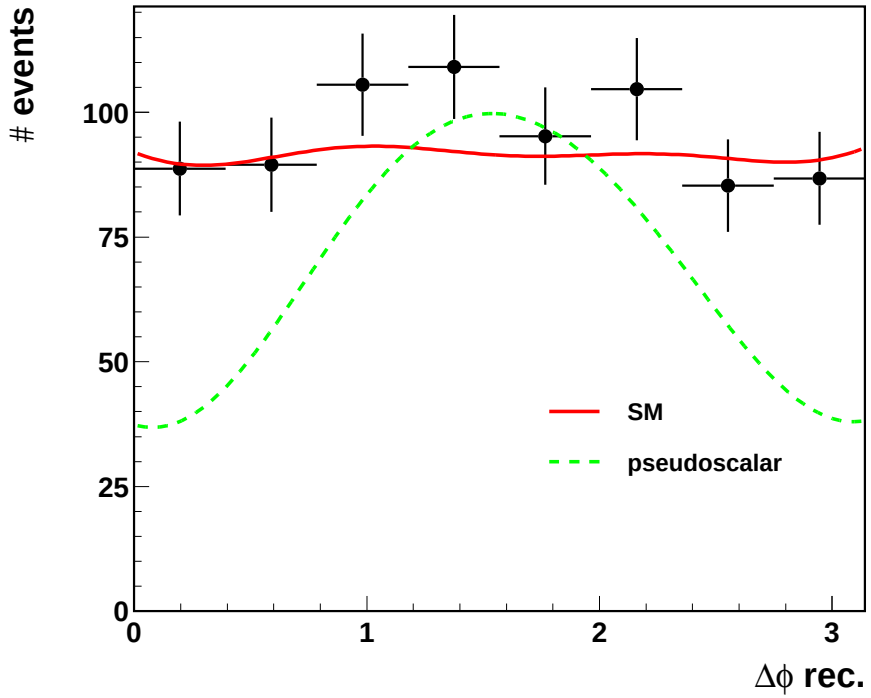
Results

Measured $\Delta\phi$ distribution
after 1 year of PC running (m_h = 300 GeV, $\sqrt{s_{ee}}$=418 GeV, $\mathcal{L} = 830\ fb^{-1}$)
$\Rightarrow$ 825 reconstructed Higgs events expected

with $q/\bar{q}$ tagging (just for comparison)



without $q/\bar{q}$ tagging (realistic)



Summary

Detector effects are very important

$\Rightarrow$ significantly modify angular distributions...

Measurement of Higgs parity possible,

even with limited statistics expected for $h \to ZZ \to ll\ jj$

No background included in the study, yet !!!

difficult, but has to be taken into account...