Improved analysis on $\gamma\gamma \to$ *higgs* $\to b\bar{b}$

including overlaid events, vertex smearing and crab crossing for SM and MSSM

P. Nieżurawski, A. F. Żarnecki, M. Krawczyk

Faculty of Physics
Warsaw University

Overview

Our analysis of precision $\sigma(\gamma\gamma \to \textit{higgs} \to b\bar{b})$ measurement includes:

- realistic $\gamma\gamma$-spectra
- b-tagging
- overlaying events $\gamma\gamma \to \textit{hadrons}$ (OE)
- results for SM at $M_h = 120, 130, 140, 150, 160$ GeV
- results for MSSM at $M_A = 200, 250, 300, 350$ GeV
  with $\tan\beta = 7$, $M_2 = \mu = 200$ GeV (following M. Mühlleitner *et al.*)

Recent development:

- crossing angle
- primary vertex distribution

$\gamma\gamma \longrightarrow$ higgs $\longrightarrow b\bar{b}$

Photon-photon spectrum: CompAZ

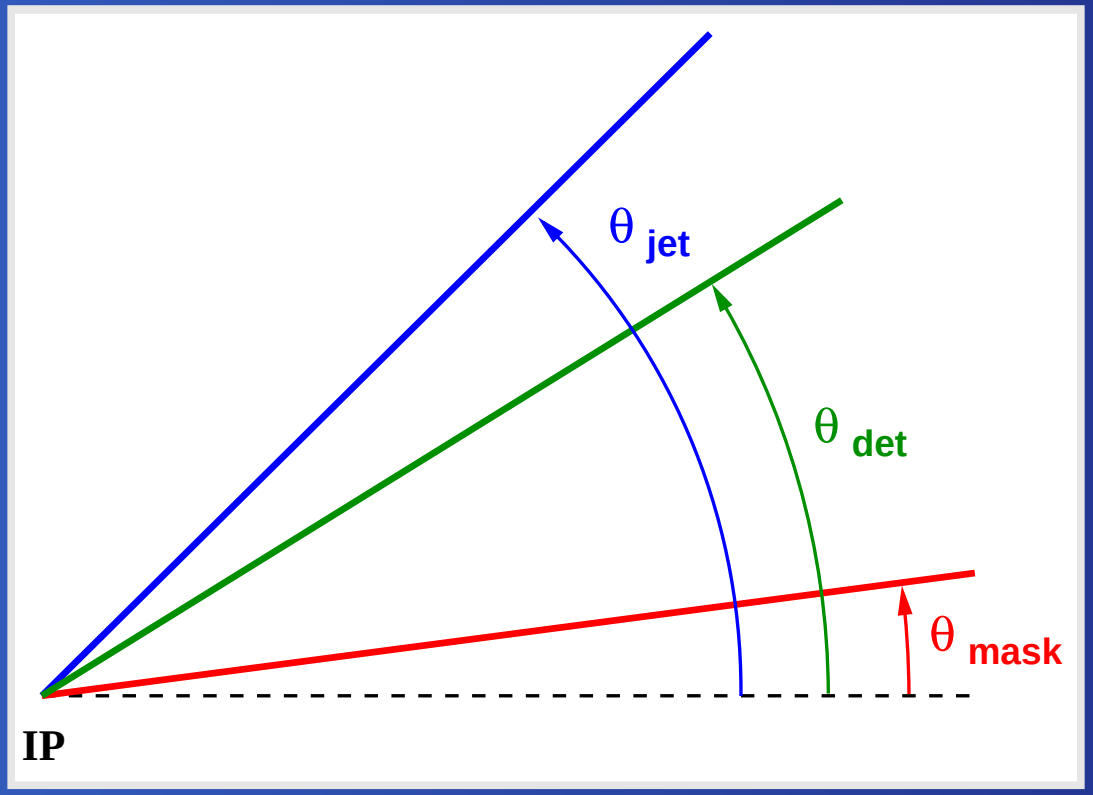
Signal: HDECAY, PYTHIA
Background: NLO $Q\bar{Q}(g)$ (G. Jikia)
Pile-up events $\gamma\gamma \longrightarrow$ *hadrons* with realistic $\gamma\gamma$-luminosity spectrum (V. Telnov)
Parton Shower (signal only) : PYTHIA
Fragmentation: PYTHIA (Lund)

Detector performance: SIMDET 4.01
Jets: Durham algorithm with $y_{cut} = 0.02$,
(clusters & tracks below $\theta_{\text{det}} = 555$ mrad are ignored)

Selection of $b\bar{b}$ events for $M_{\text{higgs}} = 120$ (300) GeV:

- ZVTOP-B-Hadron-Tagger by T. Kuhl
- consider only jets with $p_T^{\text{jet}}/E_T > 0.1$ (OE-jets suppression)
- $N_{\text{jets}} = 2,\ 3$
- $|P_z|/E < 0.12$ (0.07) where $P_z = \sum p_z^{\text{jet}}$ and $E = \sum E^{\text{jet}}$
- $|\cos\theta_{\text{jet}}| < 0.71$ (0.65) for each jet

Angles



2 or 3 jets above
$\theta_{\text{jet}} = 45^\circ$ $(\cos\theta_{\text{jet}} = 0.71)$

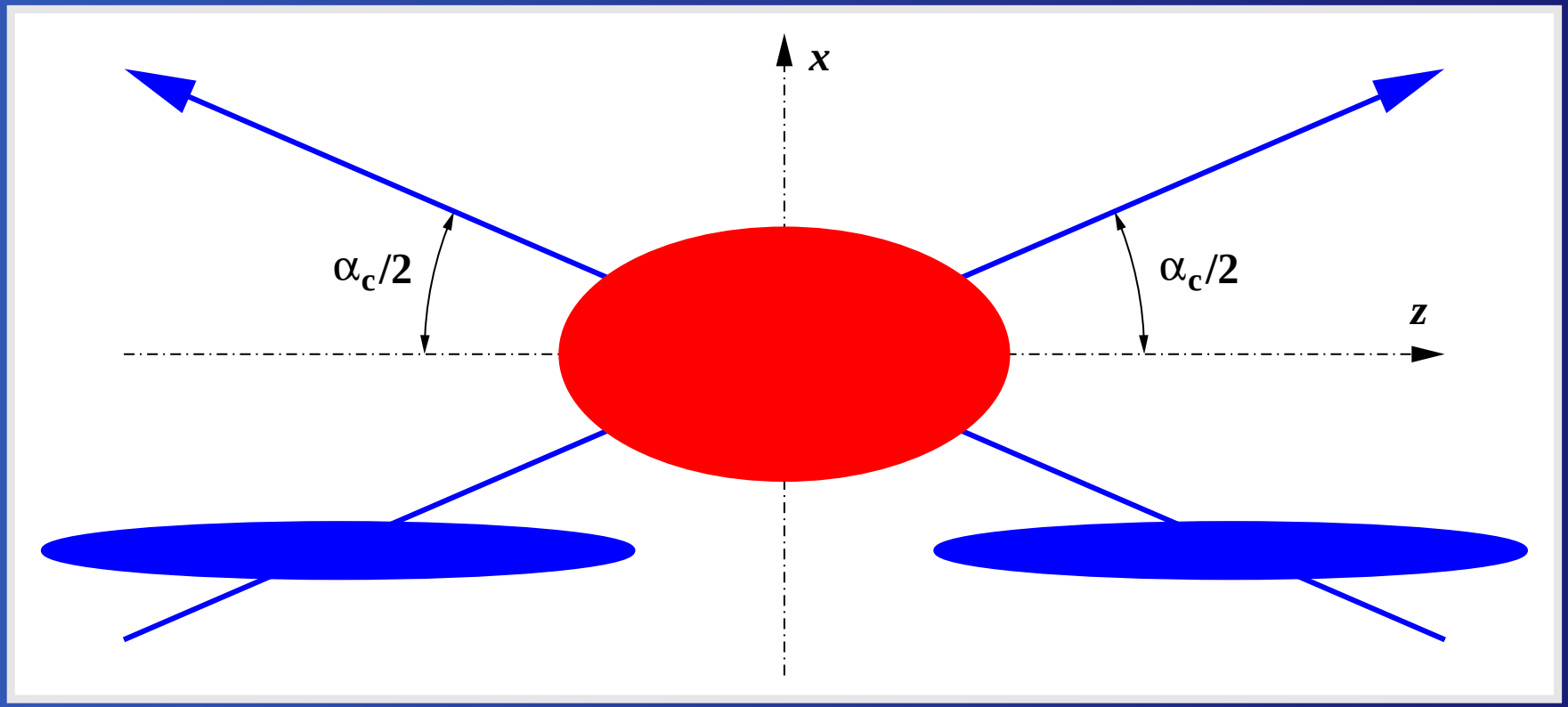
Tracks/clusters ignored below
$\theta_{\text{det}} = 32^\circ$ $(\cos\theta_{\text{det}} = 0.85)$

Remove particles on Pythia level below $\theta_{\text{mask}} = 7.5^\circ$
$(\cos\theta_{\text{mask}} = 0.99)$

Crab-wise crossing of beams

$$\sigma'_x = \sqrt{\tfrac{1}{2}(\sigma_x^2 + \sigma_z^2 \tan^2(\alpha_c/2))} \qquad \sigma'_y = \sigma_y/\sqrt{2} \qquad \sigma'_z = \sigma_z/\sqrt{2}$$

Bunch:	$\sigma_x = 140$ nm	$\sigma_y = 7$ nm	$\sigma_z = 0.3$ mm
Primary vertex:	$\sigma'_x = 3.6\ \mu$m	$\sigma'_y = 5$ nm	$\sigma'_z = 0.2$ mm



$\alpha_c = 34$ mrad

SM, $M_h = 120$ GeV

Corrected reconstructed mass:

$$W_{\rm corr} \equiv \sqrt{W_{rec}^2 + 2P_T(E + P_T)}$$

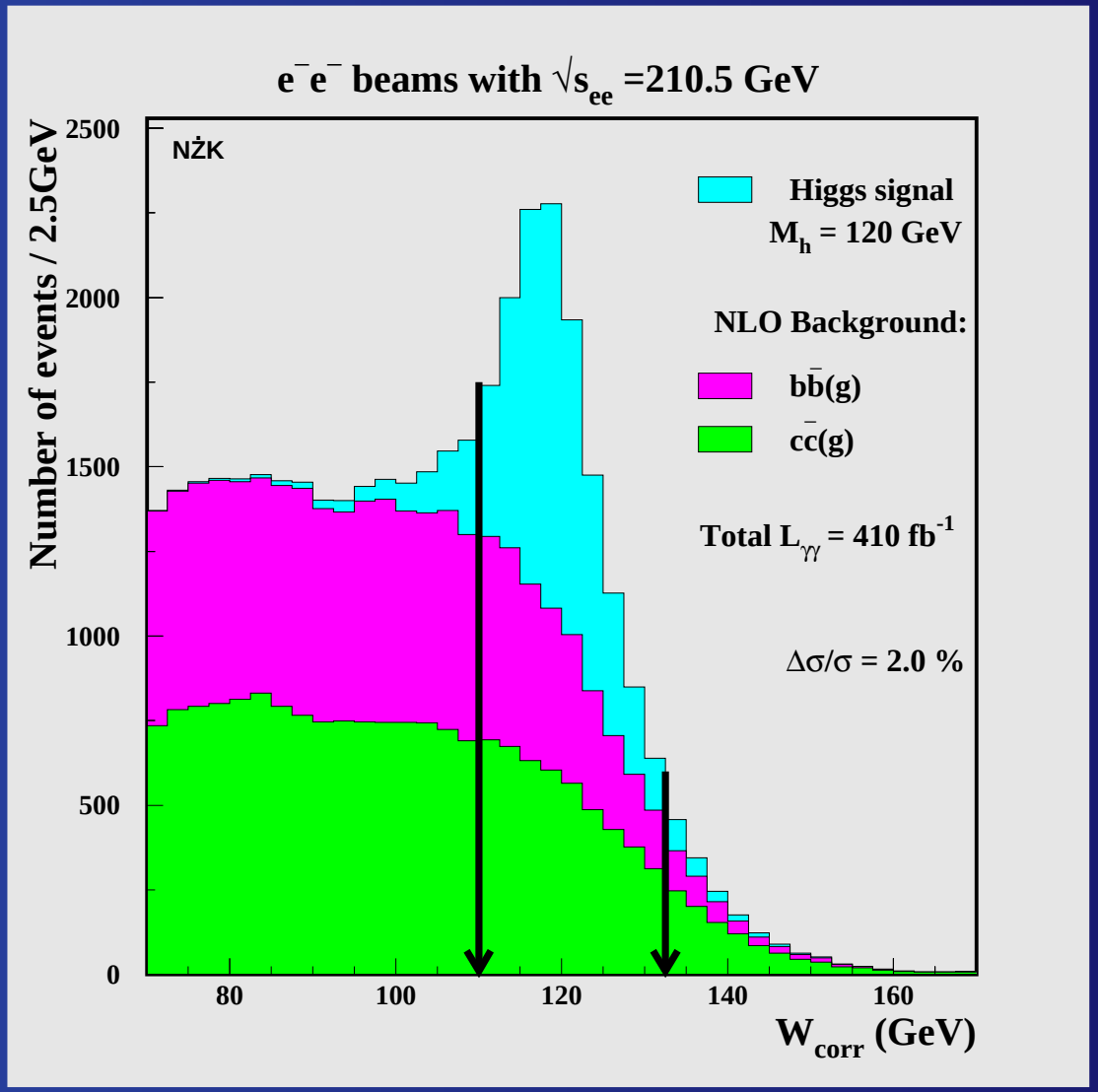
(using only accepted jets)

Correction for crossing angle:

$$p_x \to p_x - \sin(\alpha_c/2)E$$

$$E \to E - \sin(\alpha_c/2)p_x$$

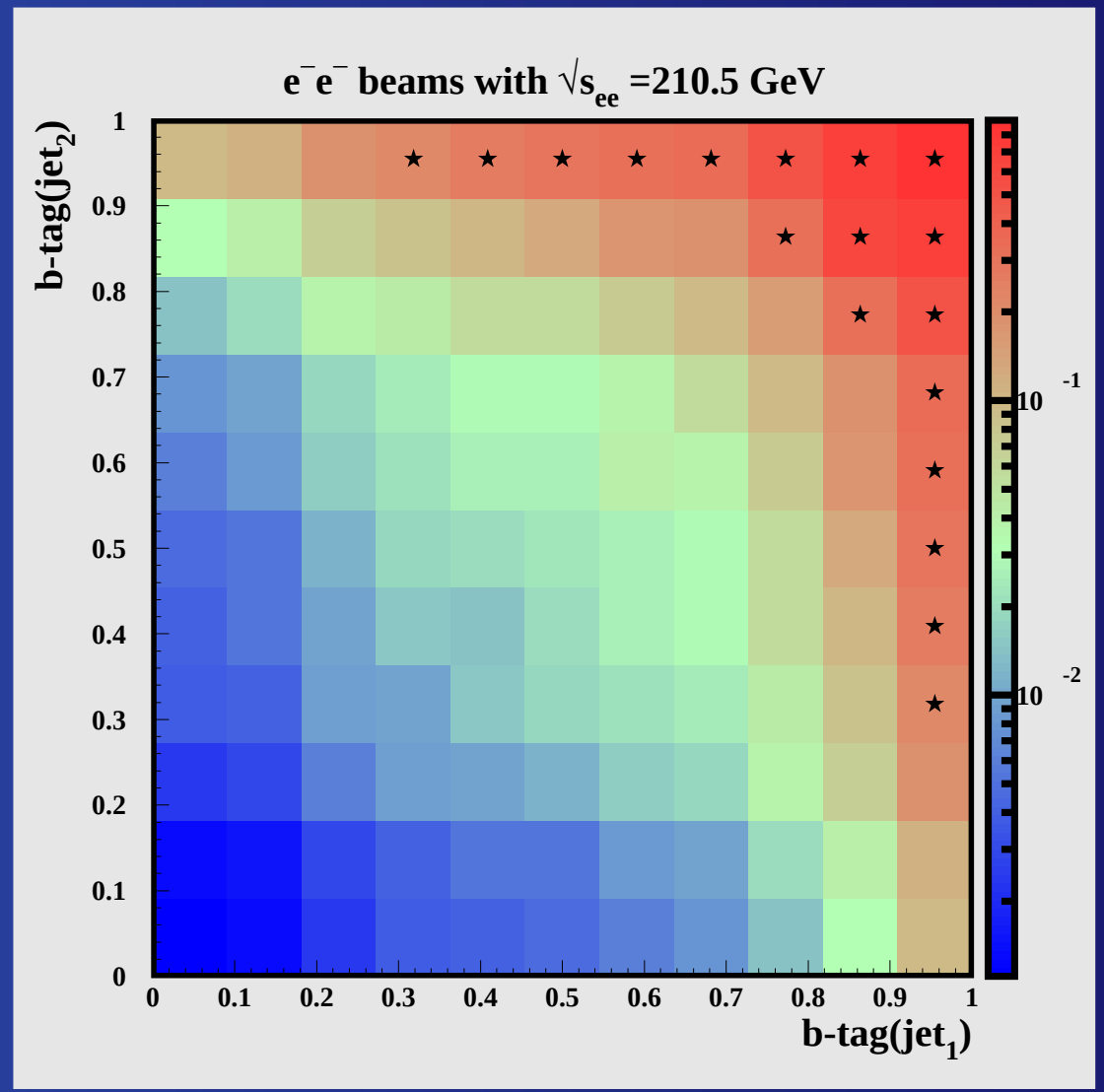
Number of overlaying events: ~ 1 per bc



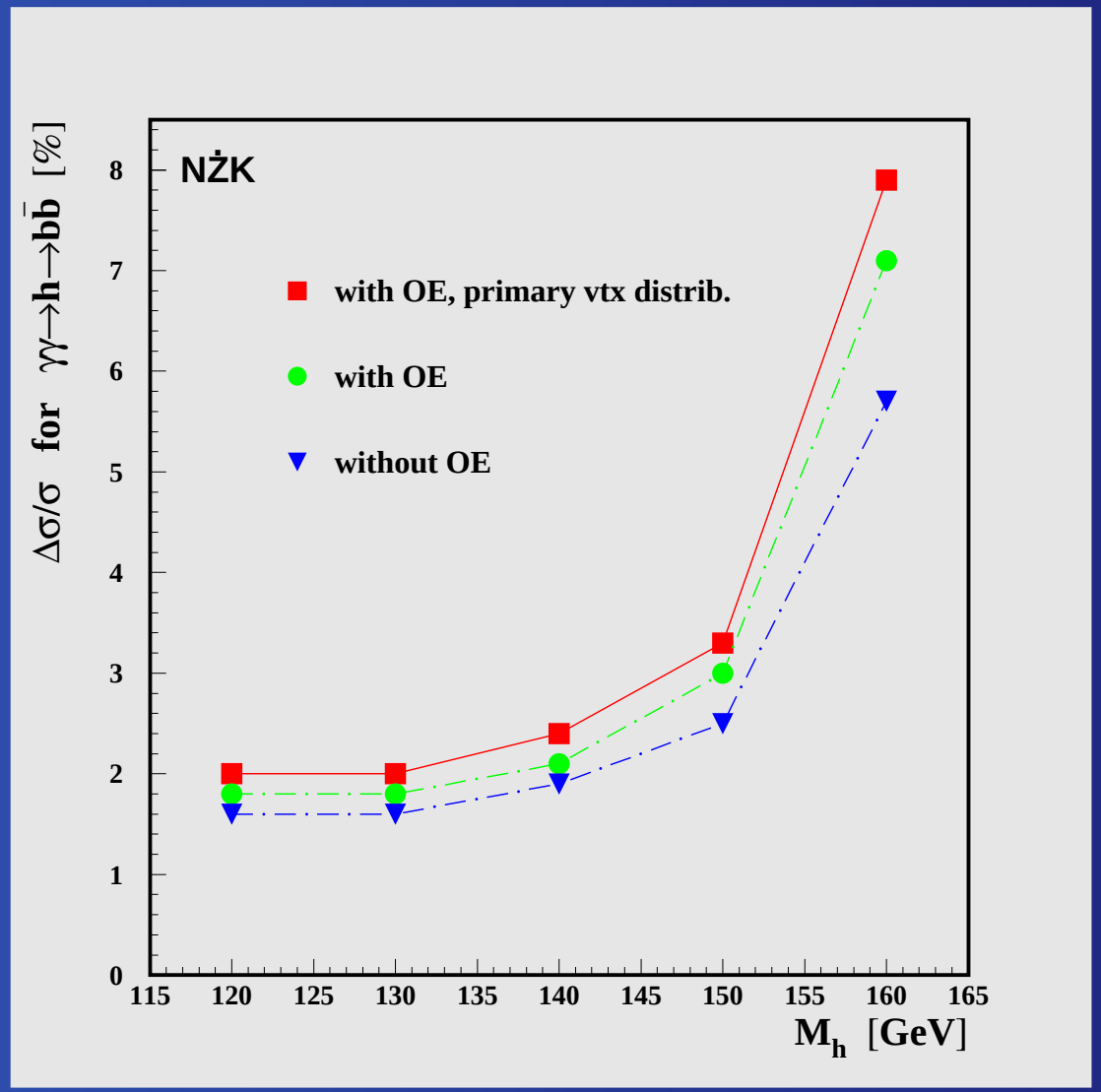
higgs-tagging at $M_h = 120$ GeV

Using *higgs*-tagging:
a cut on the ratio
of $\gamma\gamma \to h \to b\bar{b}$
to $\gamma\gamma \to b\bar{b}(g)$, $c\bar{c}(g)$ events

Earlier we used b-tagging:
a cut on the ratio
of $\gamma\gamma \to b\bar{b}(g)$
to $\gamma\gamma \to c\bar{c}(g)$ events

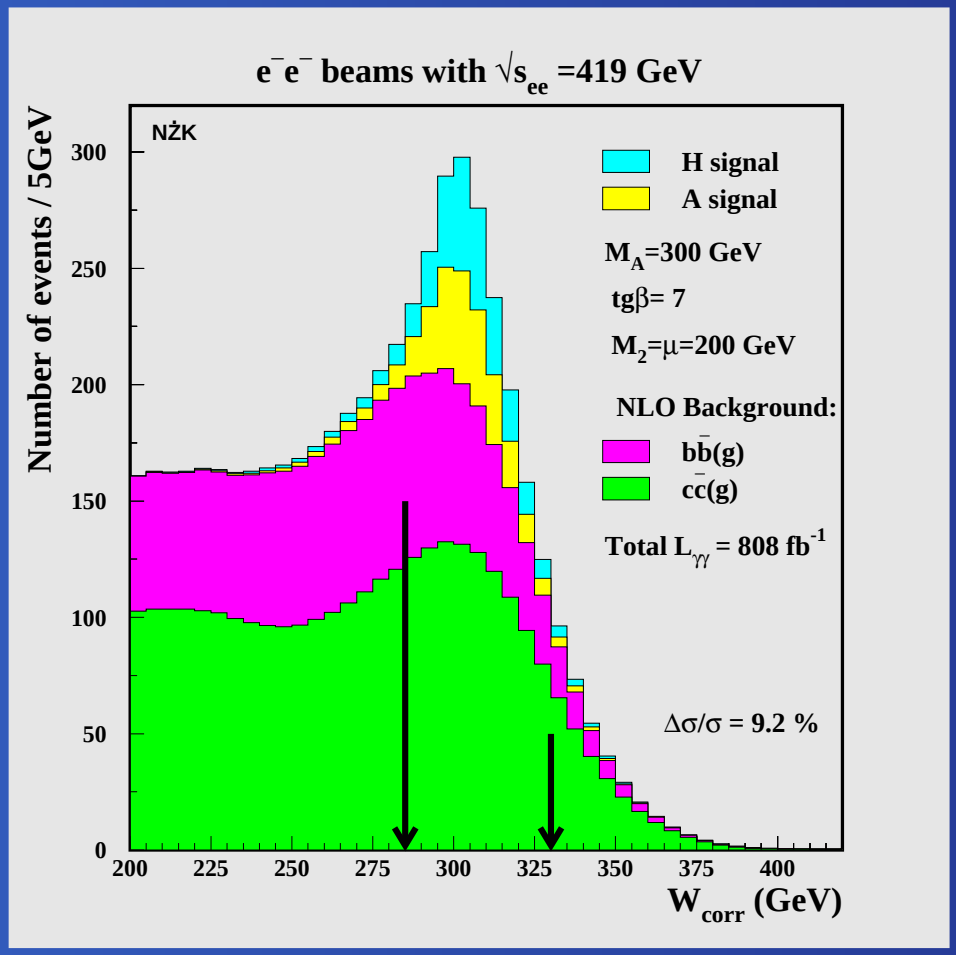


SM summary, $M_h = 120$-160 GeV

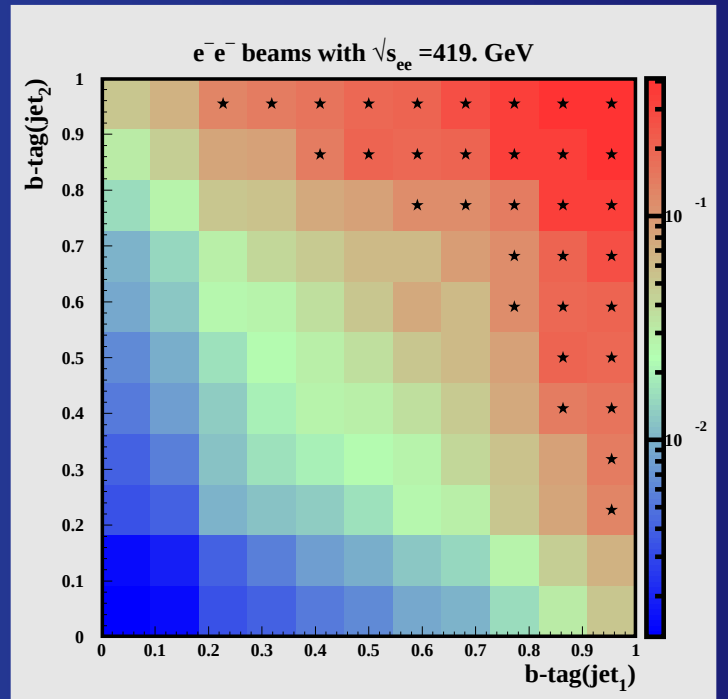


MSSM, $M_A = 300$ GeV

Number of overlaying events: ~ 2 per bc

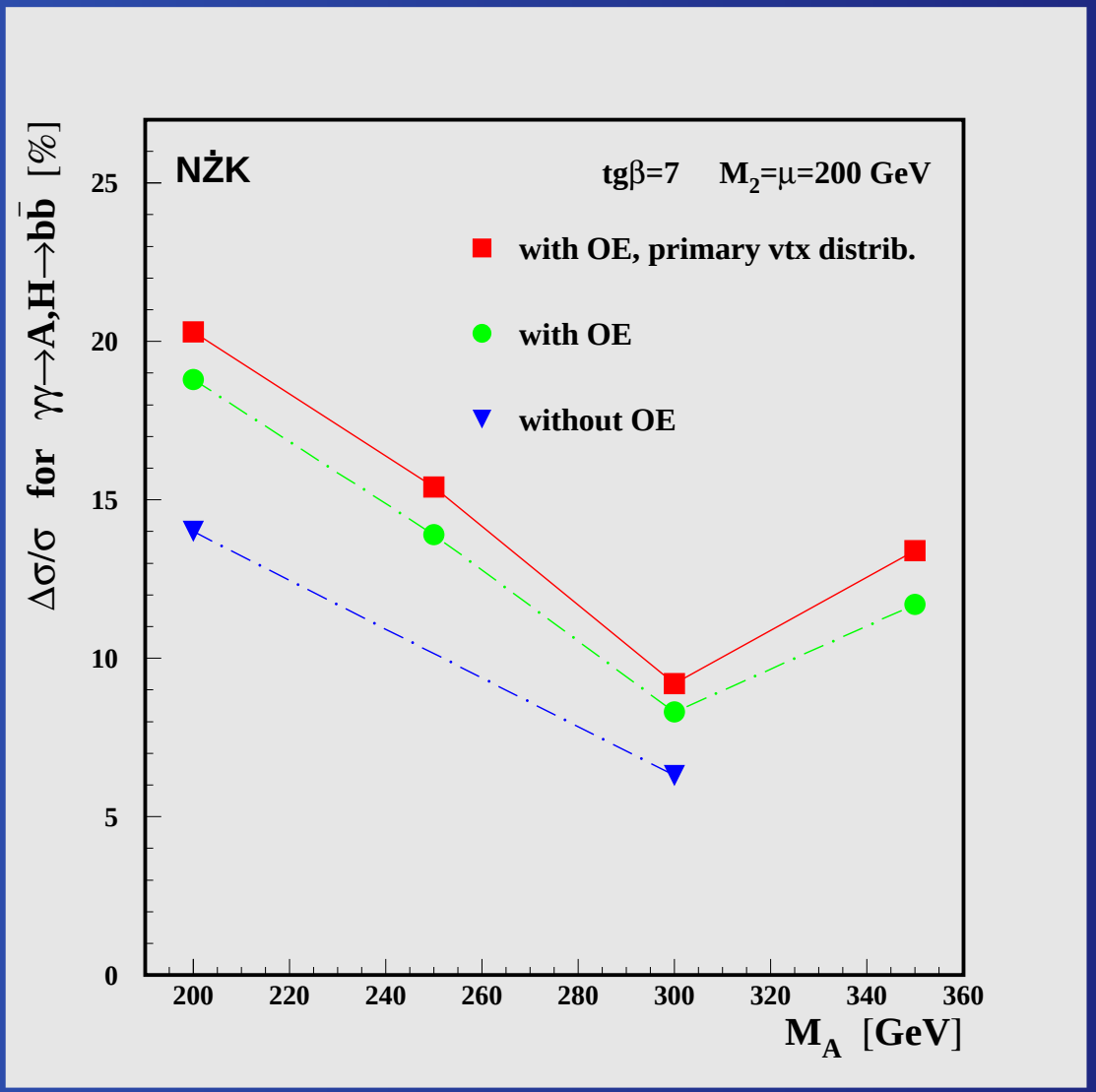


Optimal *higgs*-tagging



$$\frac{\#\gamma\gamma \to h \to b\bar{b}}{\#\gamma\gamma \to b\bar{b}(g),\ c\bar{c}(g)}$$

MSSM, $M_A = 200$-350 GeV



Conclusions

- High precision for SM & MSSM higgses can be achieved despite $\gamma\gamma \to$ *hadrons* pile-up events and primary vertex distribution.
- Cut on $p_T^{\rm jet}/E_T$ discriminates OE jets, remaining after $\theta_{\rm det}$ cut.
- Optimal cuts per mass point: $|P_z|/E$, $\cos\theta_{\rm jet}$.
- *higgs*-tagging: cut on the ratio of $\gamma\gamma \to h \to b\bar{b}$ to $\gamma\gamma \to b\bar{b}(g)$, $c\bar{c}(g)$ events (region in the plane btag$_1 \otimes$btag$_2$)
- Precision of 2% for $\Gamma(h \to \gamma\gamma){\rm Br}(h \to b\bar{b})$ at $M_h = 120$ GeV.

Plans:

- Background $\gamma\gamma \to WW$
- MSSM: parameters space scan