Report from Gamma-Gamma group

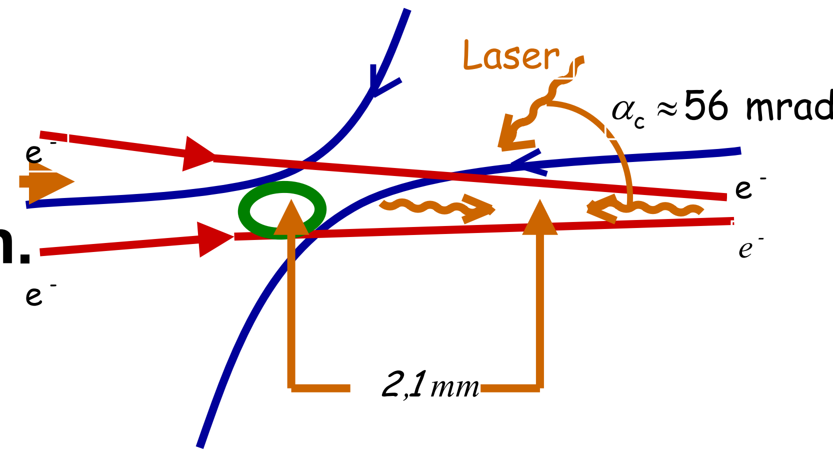
A.F.Zarnecki, Warsaw University

Photon Collider @ ILC

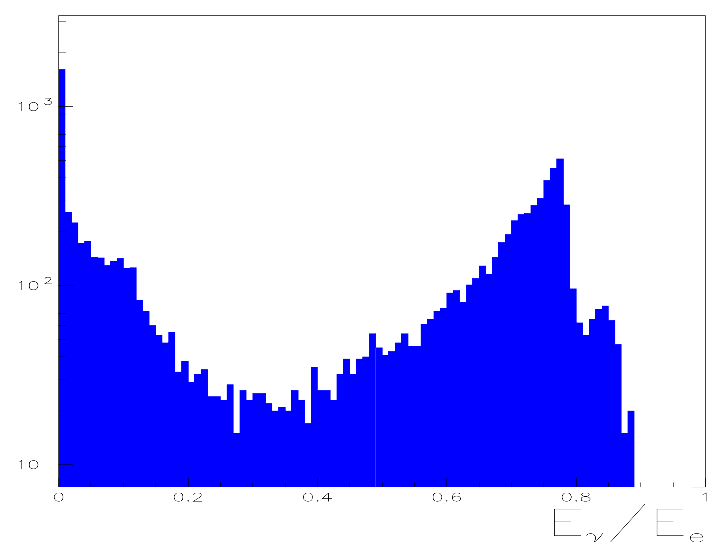
3 sessions
one joined with SUSY and Gen.

11 talks
+ 3 talks in other sessions

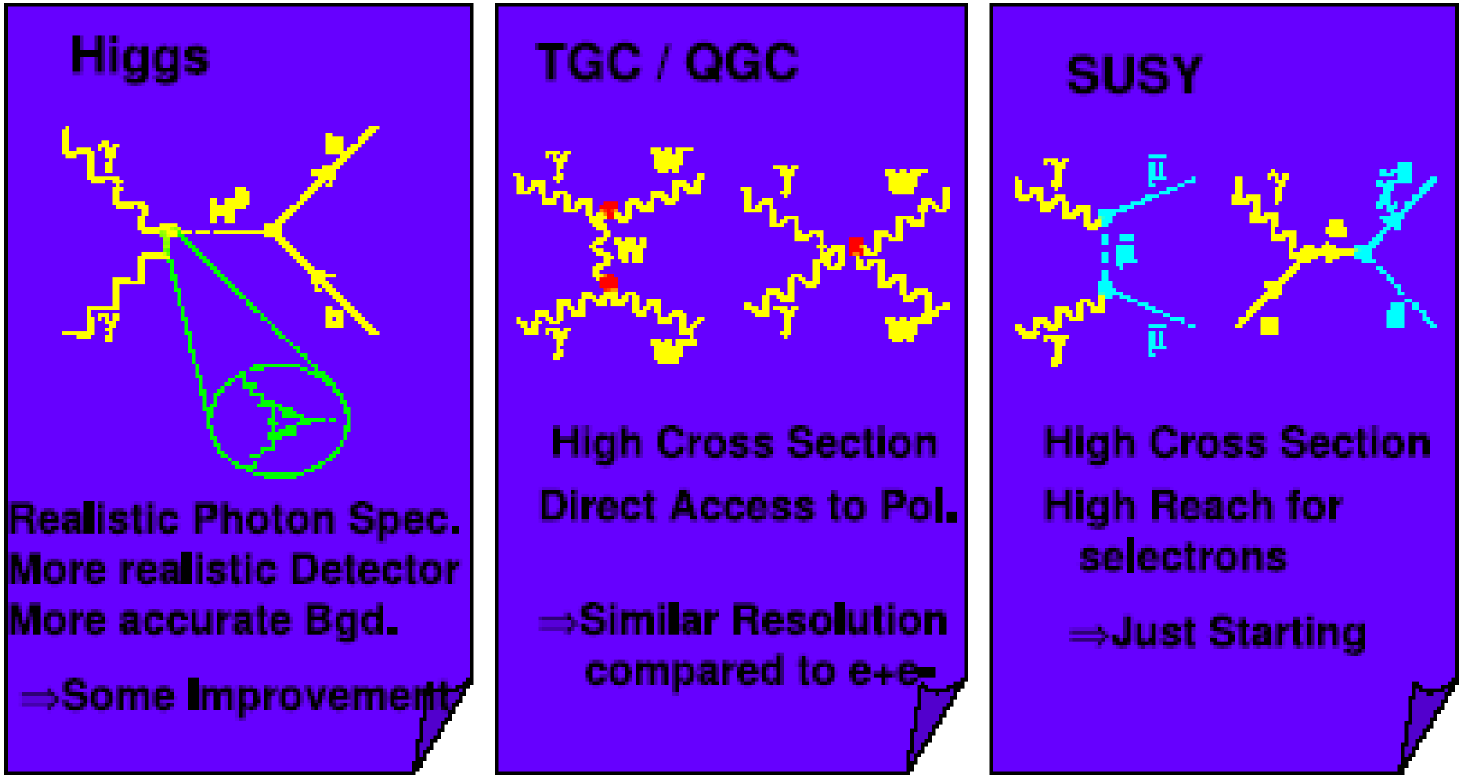
New studies and results
+ updated results of
realistic simulations



Simulation achieved by V. Telnov



Physics Highlights
of Photon Collider



A.Stahl, LCWS’2002

SM Higgs

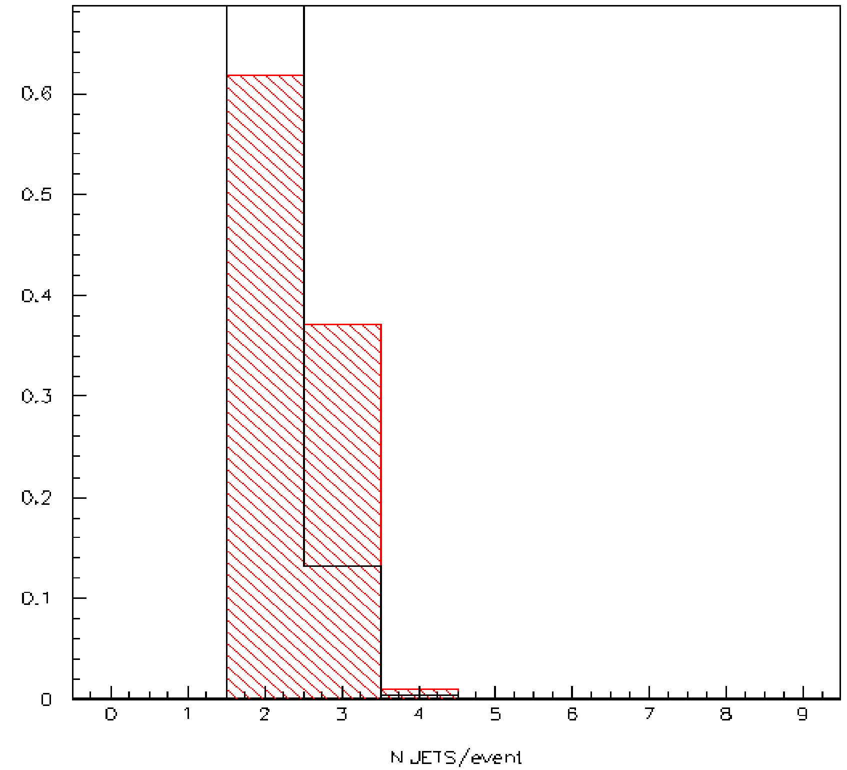
$$\Gamma(h \to \gamma\gamma) \times BR(h \to b\bar{b})$$

Aura Rosca

Improved background analysis based on SHERPA (CERN-TH/2003-284)

- Measure the two-photon partial width:
  - Contribution to the two photon decay width from any kind of massive charged particles. Deviation of the partial width from Standard Model prediction:
    - Evidence for new physics;
    - Can be directly compared to predictions of alternative models (MSSM, NMSSM, general 2HDM).

Number of reconstructed jets (J=0)



Sherpa correctly reproduces jet structure for J=0 events

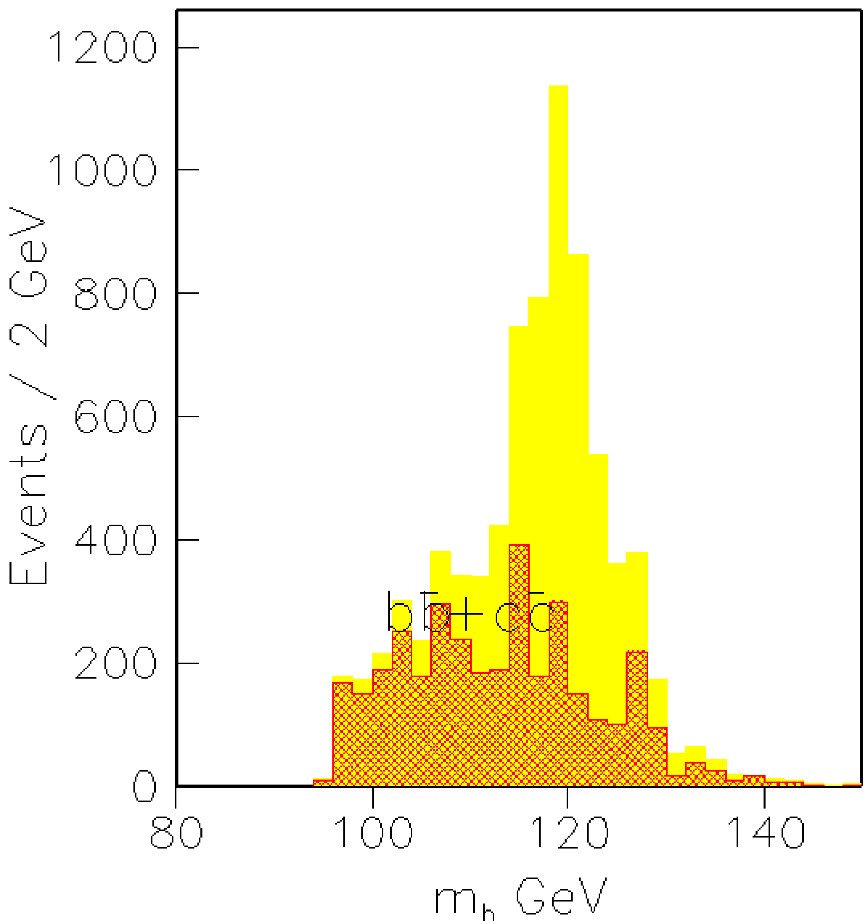
SM Higgs $\Gamma(h \to \gamma\gamma) \times BR(h \to b\bar{b})$

Aura Rosca

B-tag cut on two fastest jets allows rejection of J=0 bb background!

$$\frac{\Delta\left[\Gamma(h \to \gamma\gamma)BR(h \to b\bar{b})\right]}{\left[\Gamma(h \to \gamma\gamma)BR(h \to b\bar{b})\right]} = 1.5\%$$

was 1.9% with Pythia



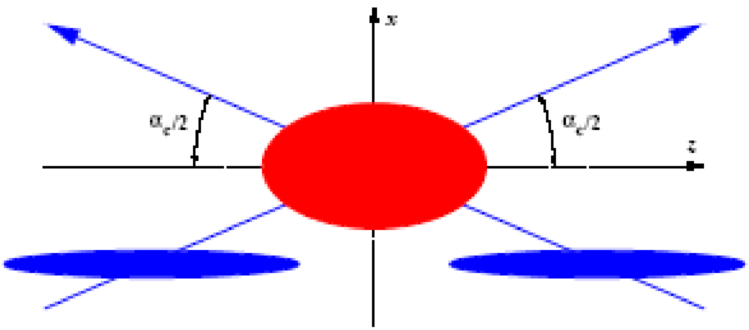
SM Higgs $\Gamma(h \to \gamma\gamma) \times BR(h \to b\bar{b})$

Piotr Niezurawski

Overlying (pile-up) events + vertex smearing due to beam crossing angle

Tighter b-tag cuts needed

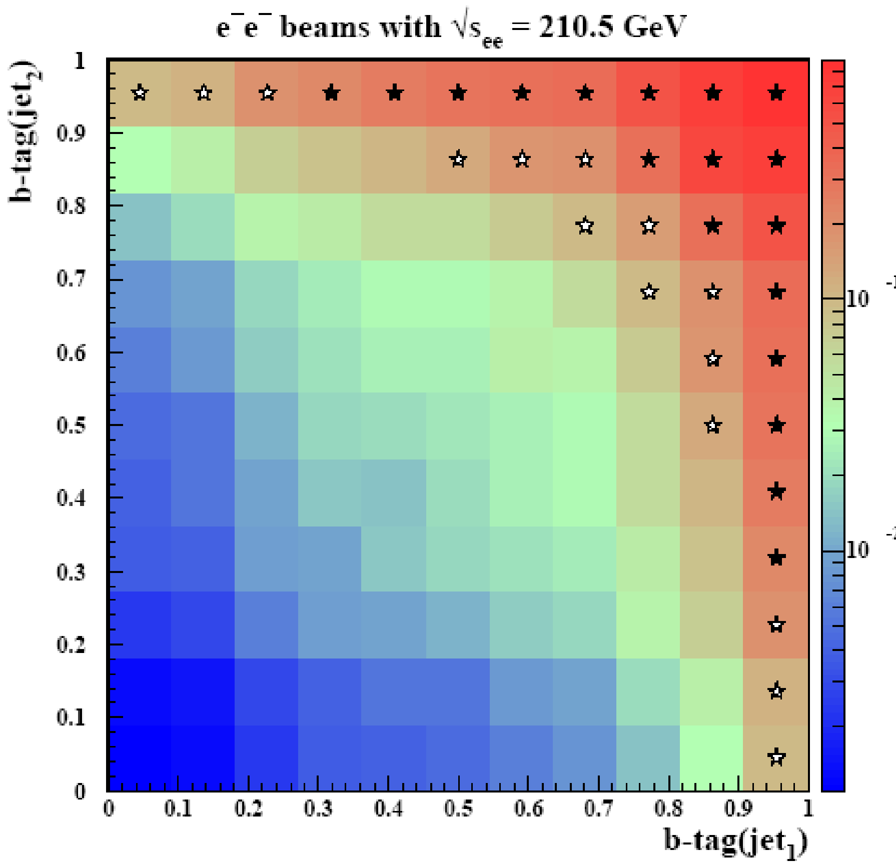
Crab Crossing



$\alpha_c = 34$ mrad

Primary vertex distribution

	Bunch	Vertex
σ_x	140 nm	3.6 μm
σ_y	15 nm	11 nm
σ_z	0.3 mm	0.2 mm

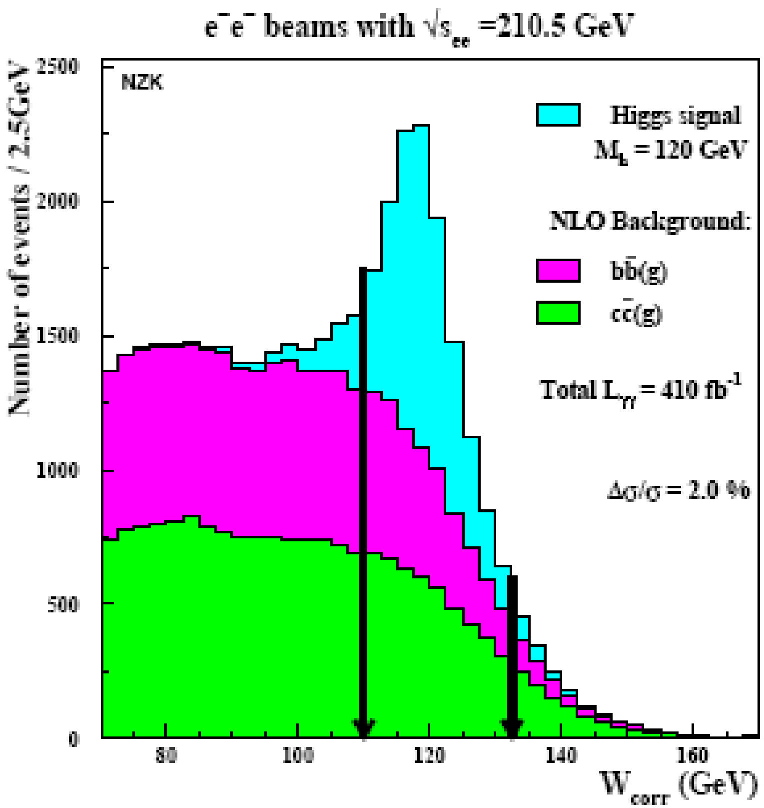


SM Higgs $\Gamma(h \to \gamma\gamma) \times BR(h \to b\bar{b})$

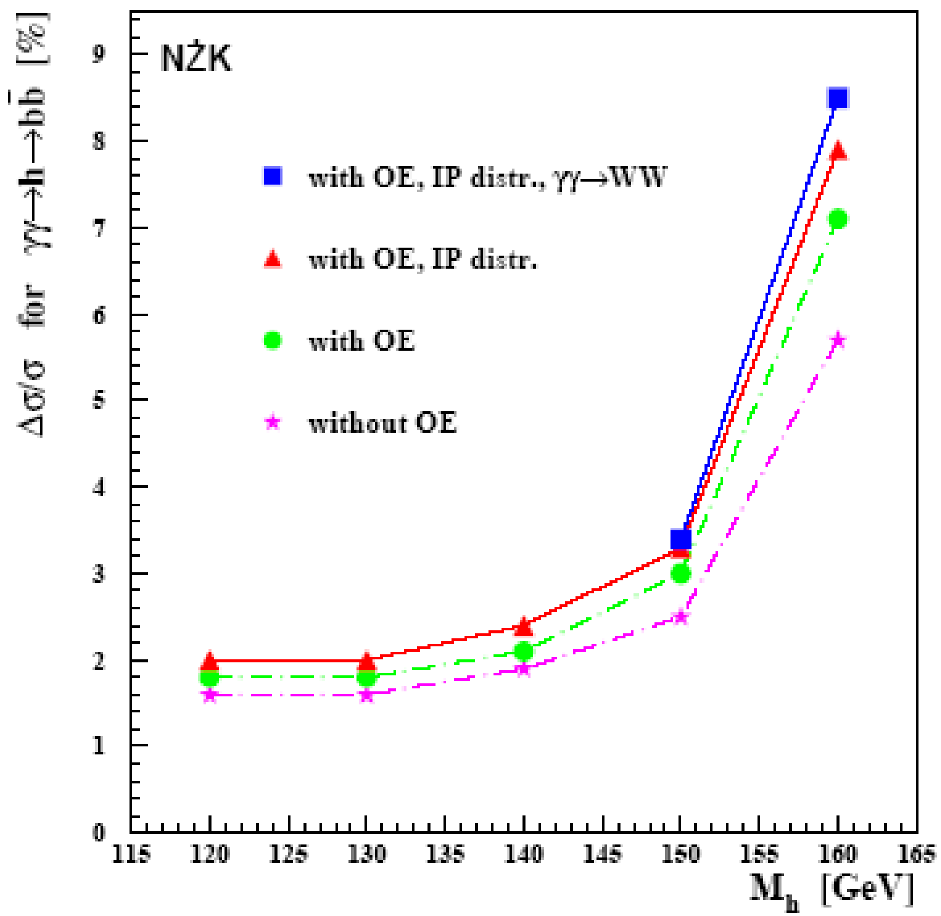
Piotr Niezurawski

Corrected mass distribution for $M_h = 120$ GeV

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



precision of $\Gamma_{\gamma\gamma} \times BR(h \to b\bar{b})$

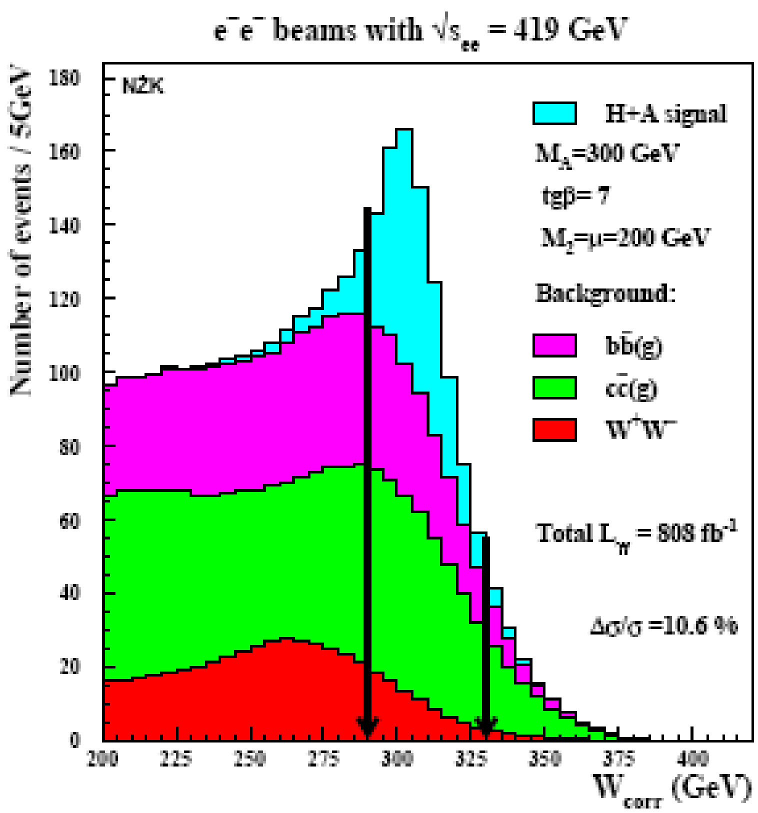


MSSM Higgs $\Gamma(H/A \to \gamma\gamma) \times BR(H/A \to b\bar{b})$

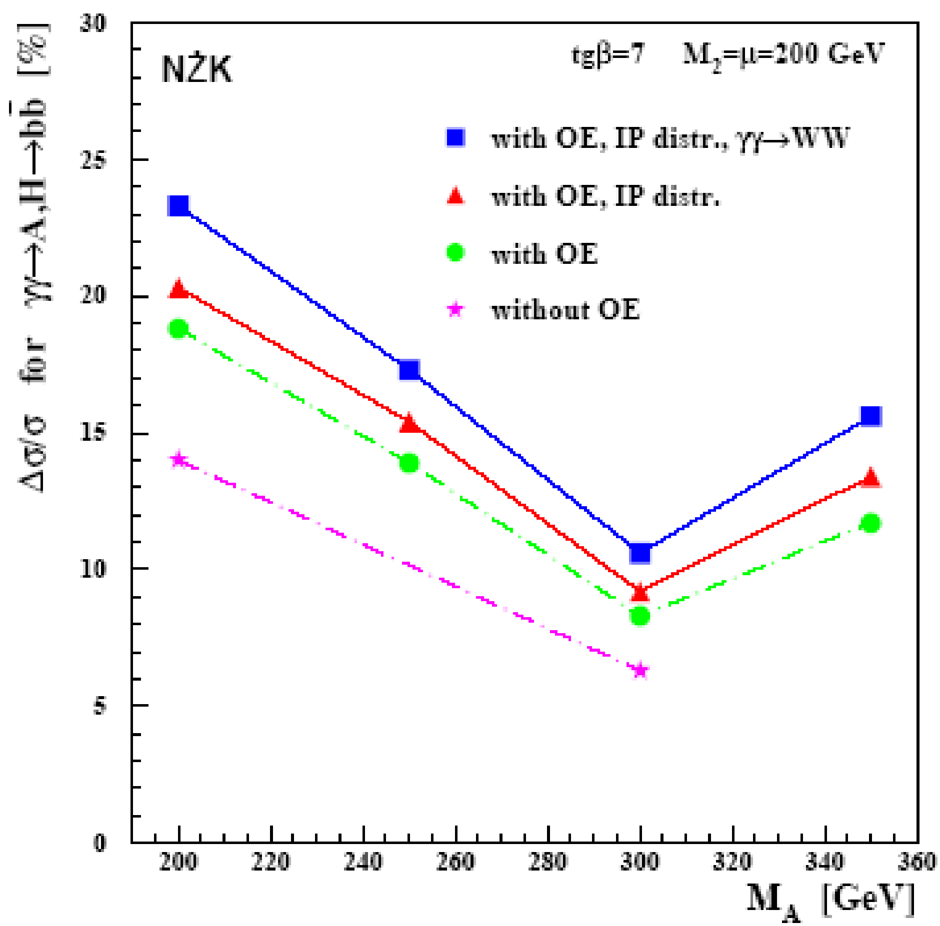
Piotr Niezurawski

Corrected mass distribution for $M_A = 300$ GeV

$\tan\beta = 7$, $M_2 = \mu = 200$ GeV



precision of $\Gamma_{\gamma\gamma} \times BR(h \to b\bar{b})$



Higgs in CP violating SUSY

Jan Kalinowski

H-A mixing

diagonalize the complex matrix given by the Weisskopf-Wigner sum

$$\mathcal{M}_c^2 = M^2 - iM\Gamma$$

[Choi, Liao, Zerwas, JK, hep-ph/0407347]

Interesting physics case the decoupling limit: $m_A^2 \gg |\lambda_i| v^2$

- H_1 must be the CP-even SM–like $\Longrightarrow$ it decouples from the H/A system
- H/A almost degenerate $\Longrightarrow$ mixing between H and A can be finite and large

$$\mathcal{M}_c^2 = \begin{bmatrix} m_H^2 - i m_H \Gamma_H & \delta m_{HA}^2 \\ \delta m_{HA}^2 & m_A^2 - i m_A \Gamma_A \end{bmatrix} \Longrightarrow \mathcal{M}^2 = C\, \mathcal{M}_c^2\, C^{-1}$$

- the C and the complex mixing angle θ are given by [Güsken, Kühn, Zerwas '85]

$$C = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}, \quad X \equiv \frac{1}{2}\tan 2\theta = \frac{\delta m_{HA}^2}{m_H^2 - m_A^2 - i(m_H\Gamma_H - m_A\Gamma_A)}$$

Higgs in CP violating SUSY

Jan Kalinowski

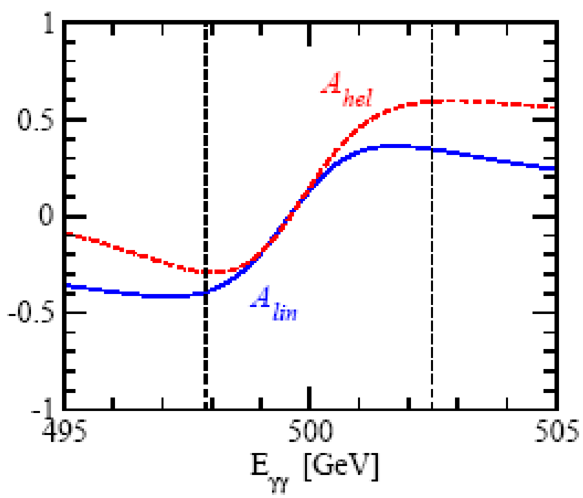
H-A mixing

Large CP asymmetries expected both in production and decay

Higgs formation in polarized $\gamma\gamma$ collisions

CP-even and CP-odd asymmetries

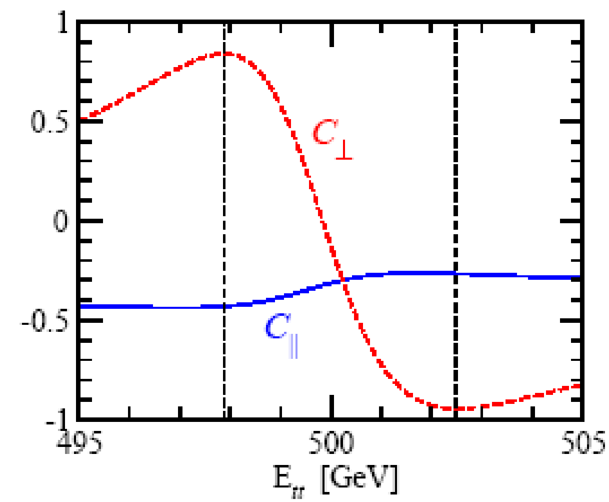
$$\mathcal{A}_{\rm lin} = \frac{\sigma_\parallel - \sigma_\perp}{\sigma_\parallel + \sigma_\perp} \quad \text{and} \quad \mathcal{A}_{\rm hel} = \frac{\sigma_{++} - \sigma_{--}}{\sigma_{++} + \sigma_{--}}$$



polarization of top quarks in $H_i \Rightarrow t\bar{t}$

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\phi^*} = \frac{1}{2\pi}\left[1 - \frac{\pi^2}{16}\frac{(m_t^2 - 2m_W^2)^2}{(m_t^2 + 2m_W^2)^2}\left(C_\parallel \cos\phi^* + C_\perp \sin\phi^*\right)\right]$$

[ϕ^* – angle between $t\bar{t}$ decay planes]



CP violation in generic model

A.F.Zarnecki

H-A mixing

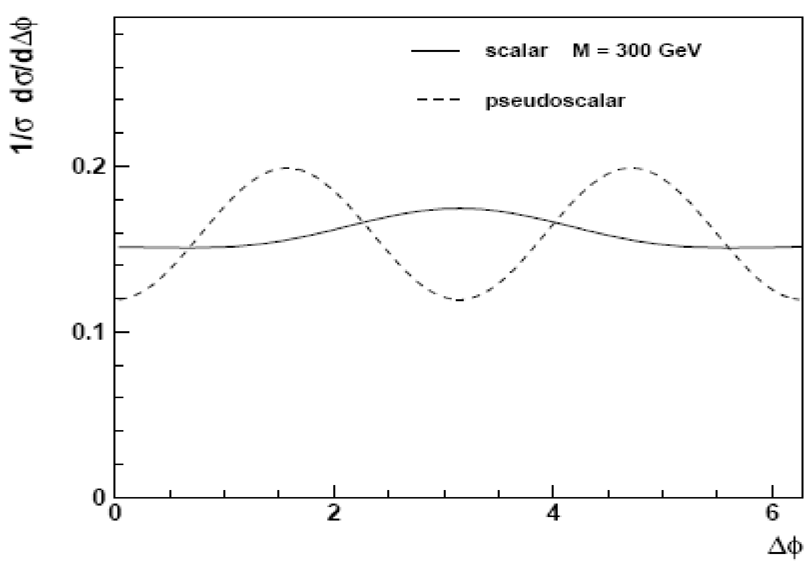
We consider generic tensor couplings of a Higgs boson $\mathcal{H}$ to ZZ and W^+W^-:

$$g_{\mathcal{H}ZZ} = ig\frac{M_Z}{\cos\theta_W}\left(\lambda_H \cdot g^{\mu\nu} + \lambda_A \cdot \varepsilon^{\mu\nu\rho\sigma}\frac{(p_1+p_2)_\rho\,(p_1-p_2)_\sigma}{M_Z^2}\right)$$

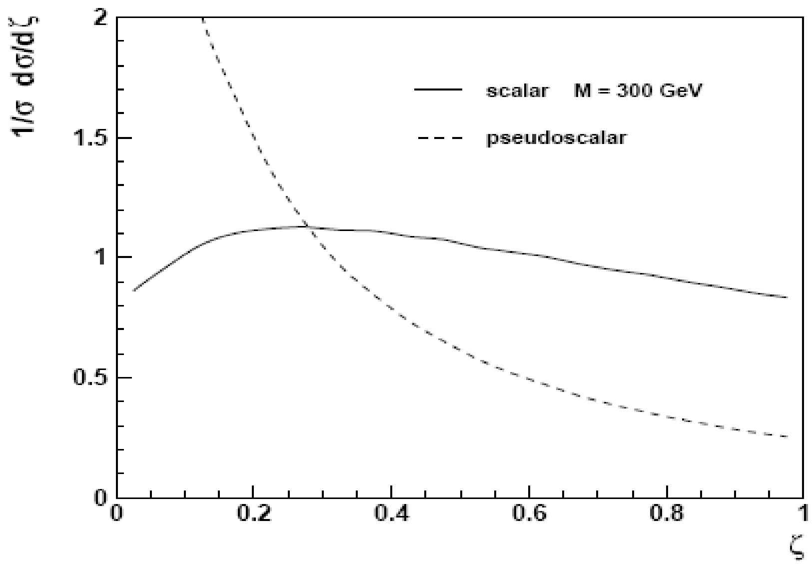
$$g_{\mathcal{H}WW} = igM_W\left(\lambda_H \cdot g^{\mu\nu} + \lambda_A \cdot \varepsilon^{\mu\nu\rho\sigma}\frac{(p_1+p_2)_\rho\,(p_1-p_2)_\sigma}{M_W^2}\right)$$

with: $\lambda_H = \lambda \cdot \cos\Phi_{CP}$ $\quad \lambda_A = \lambda \cdot \sin\Phi_{CP}$

$\Delta\phi$



ζ



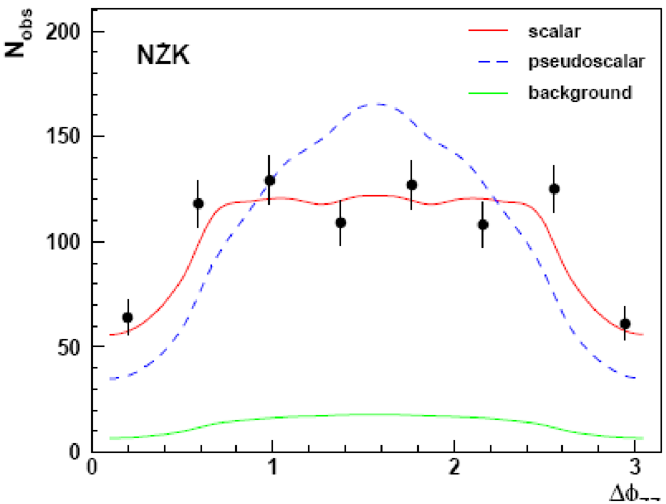
Both $\Delta\phi$ and ζ distributions clearly distinguish between scalar and pseudoscalar higgs.

CP violation in generic model

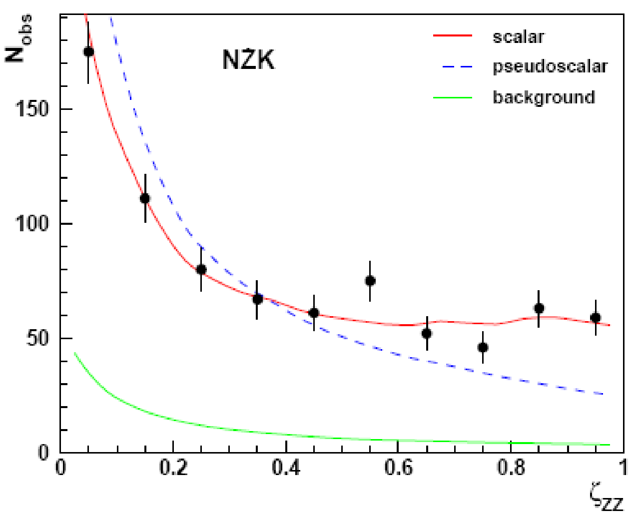
Measured $\Delta\phi_{ZZ}$ distribution:

A.F.Zarnecki

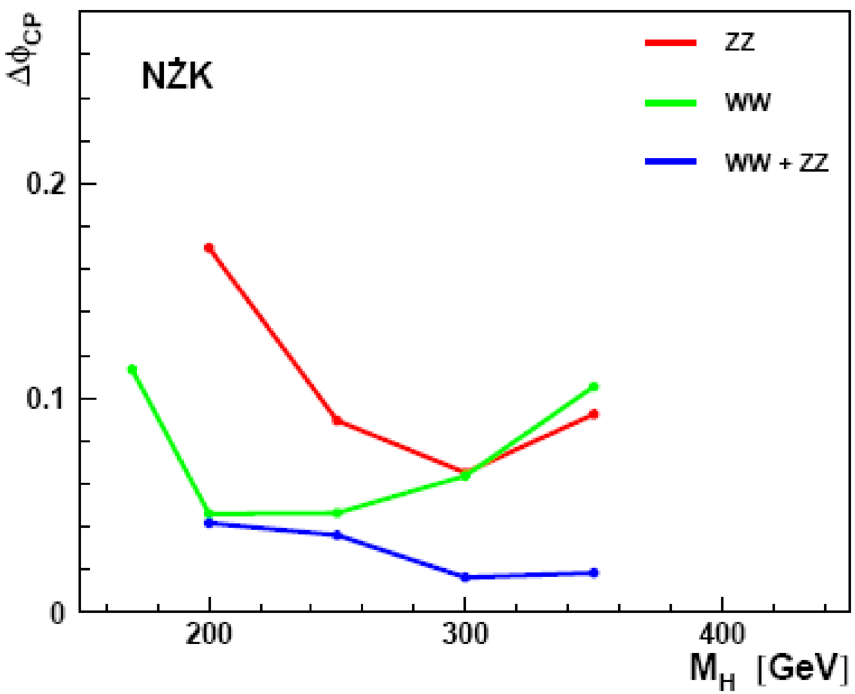
H-A mixing



Measured ζ_{ZZ} distribution:



CP phase Φ_{CP}

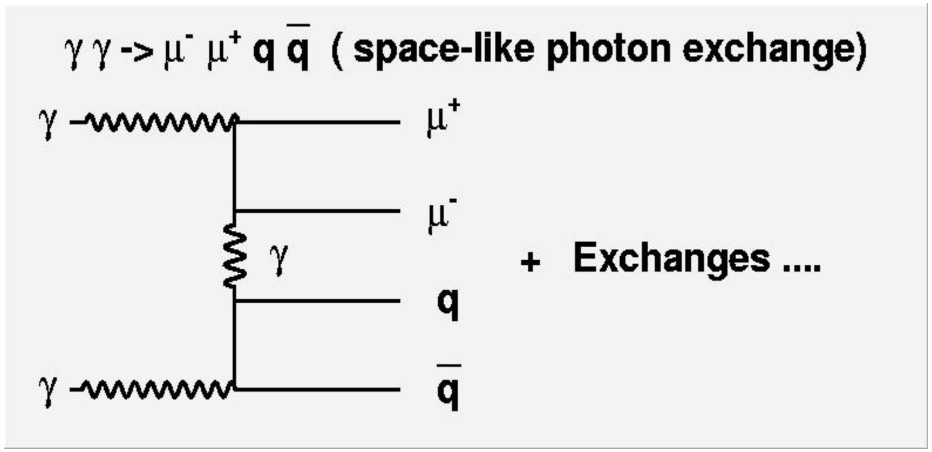


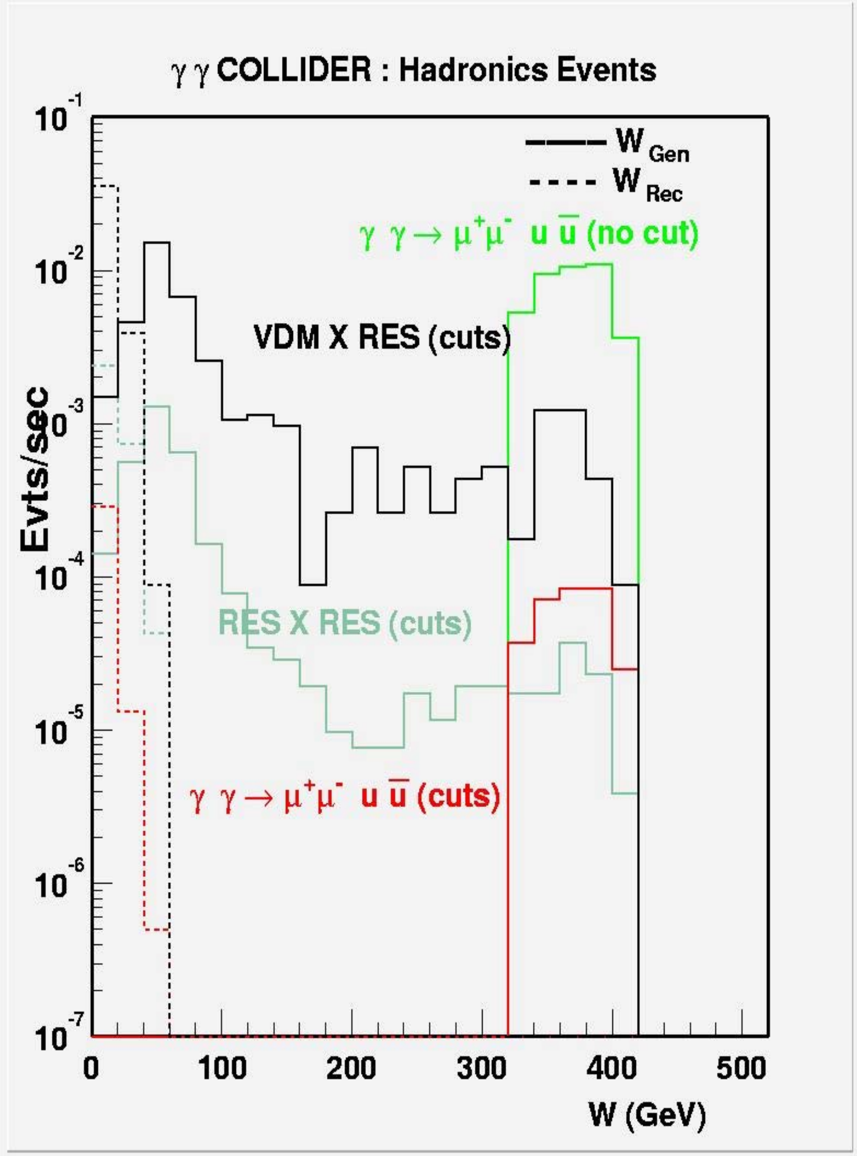
$\Delta\Phi_{CP} \leq 50$ mrad

2 Lepton 2 Quark Production in 2 Photon Collisions

Wilfred da Silva

semi-analytic computation
without approximation





study of luminosity measurement
using the 2 lepton 2 quark channel

LO predictions for $\gamma\gamma\to 4f$ and $\gamma\gamma\to 4f+\gamma$

Markus Roth, Alex Bredenstein – EW+AT

Motivation for dedicated MC code:

$\gamma\gamma \to \mathrm{WW}$

- one of the largest cross sections
- contains gauge boson couplings
  $\gamma\mathrm{WW}$ and $\gamma\gamma\mathrm{WW}$
  (limits on anomalous couplings)
- if $M_\mathrm{H} \gtrsim 160\,\mathrm{GeV} \Rightarrow \gamma\gamma \to \mathrm{H} \to \mathrm{WW}$
- sensitive on extra dimensions

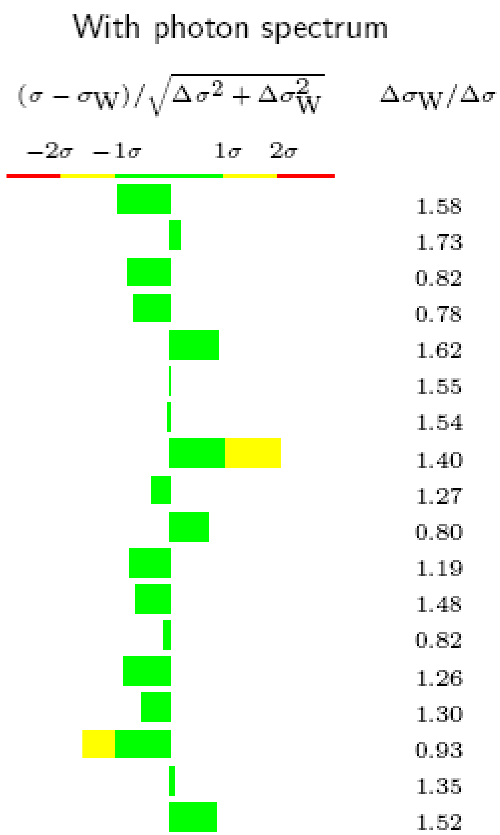
Features of the calculation:

- Lowest-order prediction for all processes $\gamma\gamma \to 4f$ and $\gamma\gamma \to 4f + \gamma$ (including gluon-exchange diagrams)
- Monte Carlo generator available upon request
- Photon beam spectrum in the parametrization of COMPAZ implemented
- Non-standard triple- and quartic-gauge-boson couplings and an effective $\gamma\gamma H$ coupling can be optional included.

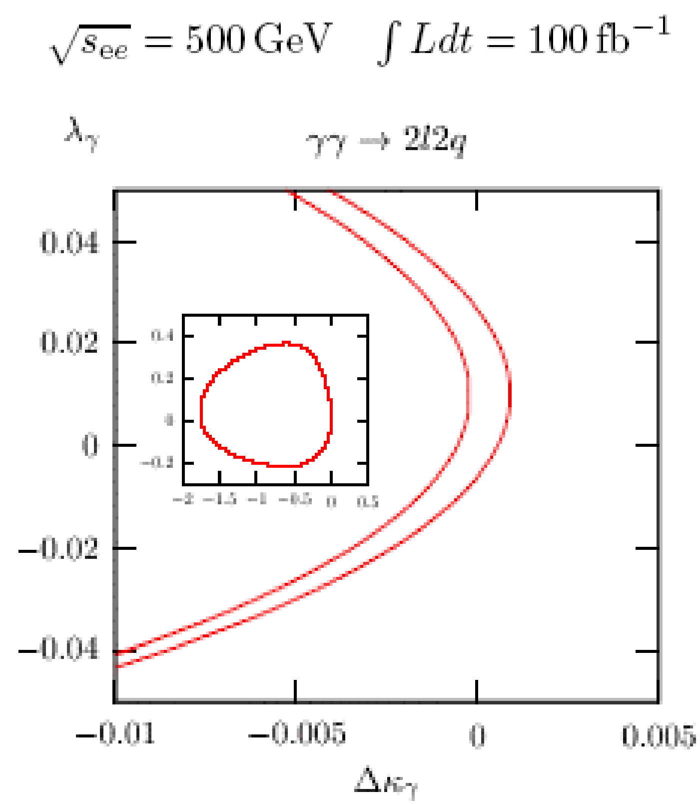
LO predictions for γγ→4f and γγ→4f+γ

Markus Roth, Alex Bredenstein – EW+AT

Good agreement with MADGRAPH & WHIZARD



Limits on anomalous triple couplings



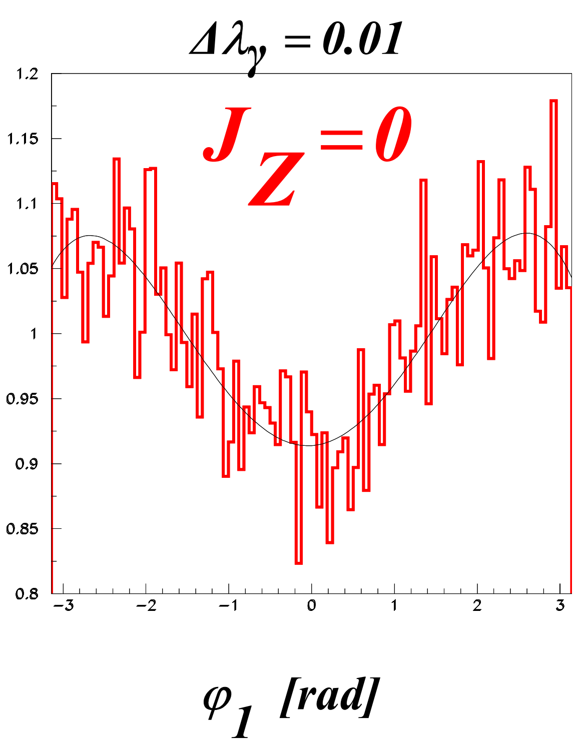
TGCs at a $\gamma\gamma$ – collider at TESLA

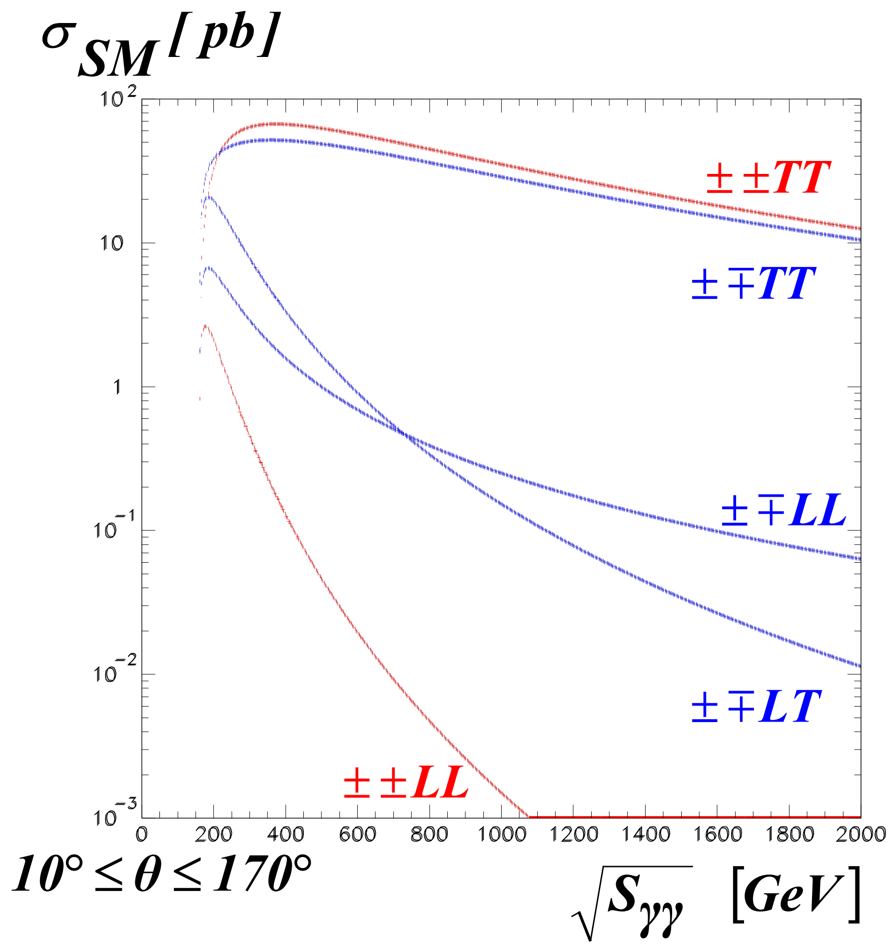
Jadranka Sekaric (EW+AT)

$$\gamma\gamma \rightarrow W^+W^- \rightarrow q\bar{q}q\bar{q}$$

Promising channel for κγ - λγ measurements: Δκγ, Δλγ ~ 10-4

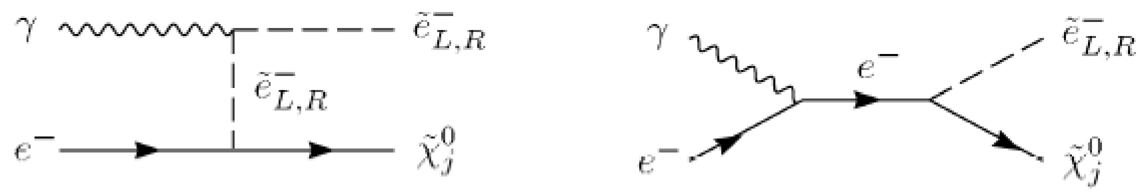
Anomalous couplings contribute to W_LW_L
→ large deviations expected!





Selectron production in eγ

Alexander Oh



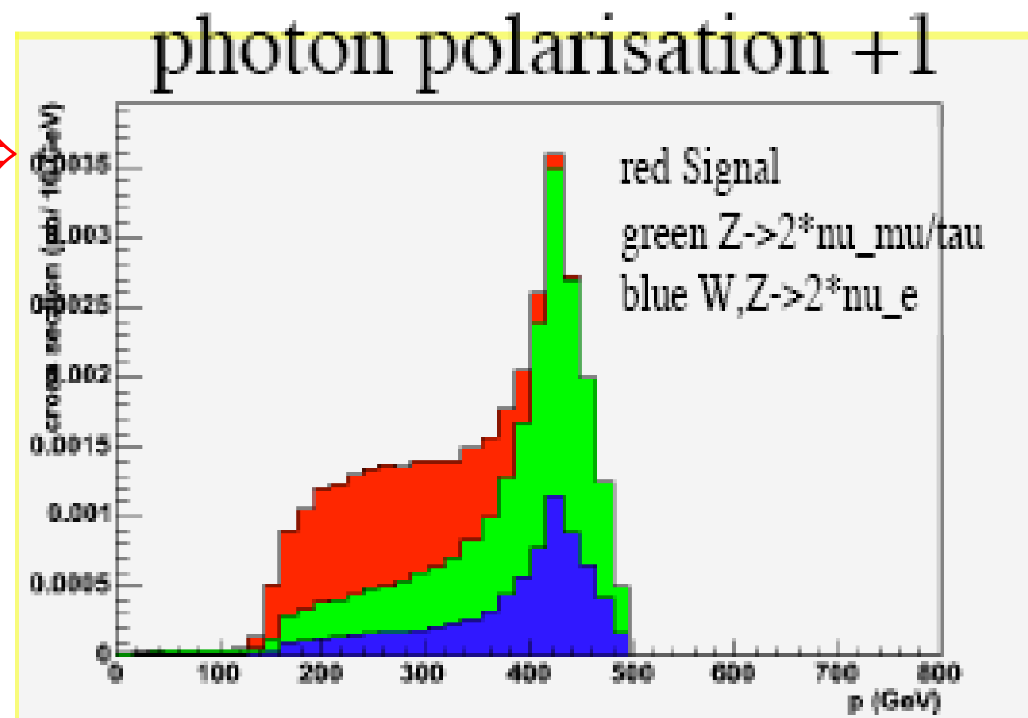
eγ collider is discovery machine if

selectron mass lies inbetween

$0.5 \sqrt{s_{ee}} < m < 0.8 \sqrt{s_{ee}}$

Measured electron momentum:

Selectron mass of 513 GeV ⇒



$\sqrt{s_{ee}} = 1$ TeV

SIMDET Version 4

"Selection criterium":

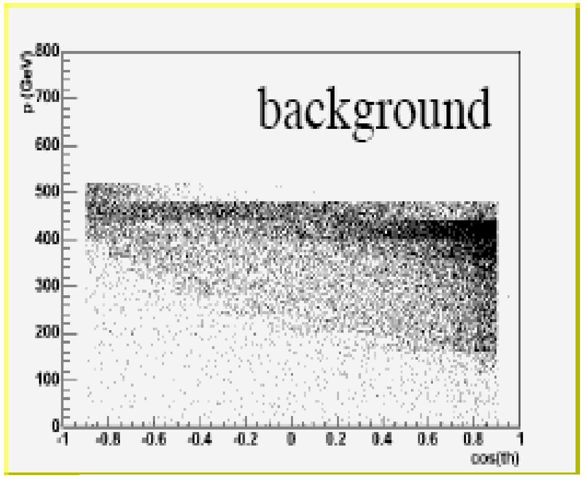
– one identified electron track

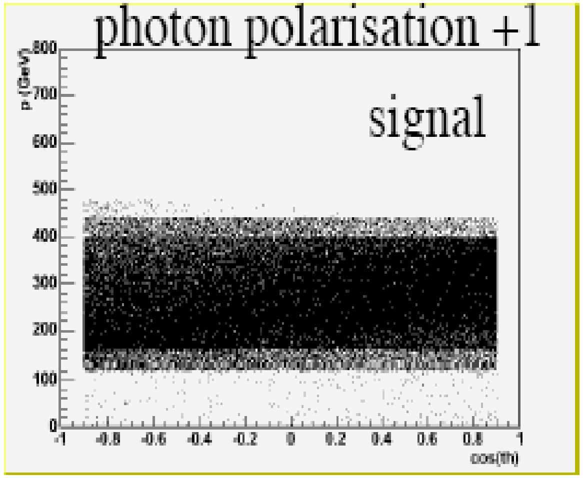
Selectron production in eγ

Alexander Oh

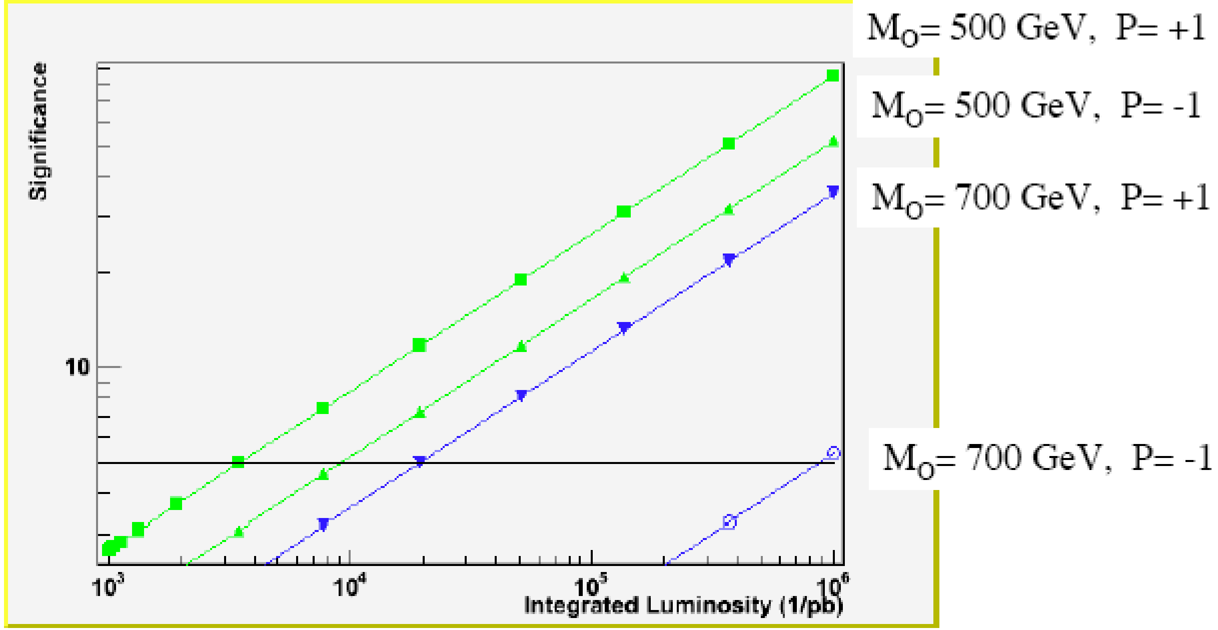
2-D analysis
cos(θ) vs p

S/B ~ 50 can be obtained





Luminosity needed for discovery:



Determination of SUSY BRs

Huber Nieto-Chaupis

SHERPA + PYTHIA + SIMDET

Pile-up events included

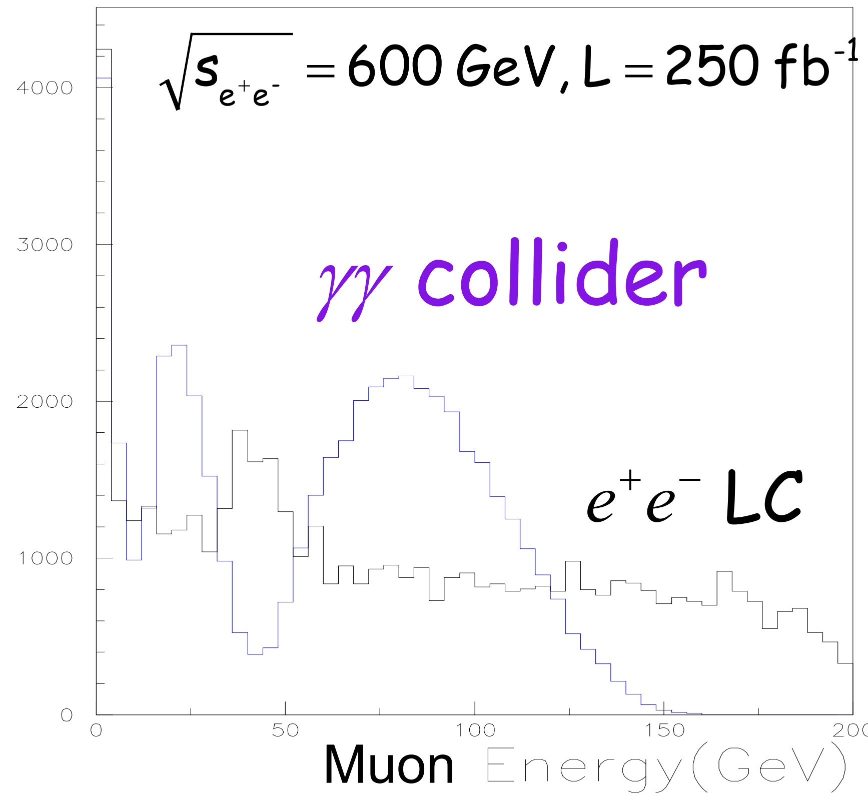
Much richer structure helps us to constrain process kinematics $\Rightarrow$

$$\tilde{\mu}_L^{\pm} \rightarrow \mu^{\pm} \tilde{\chi}_1^0$$

Statistical precision ~2%

For slepton $\tilde{\tau}_1$ analysis: ~7%

- Sleptons : $\tilde{\mu}_L$ analysis

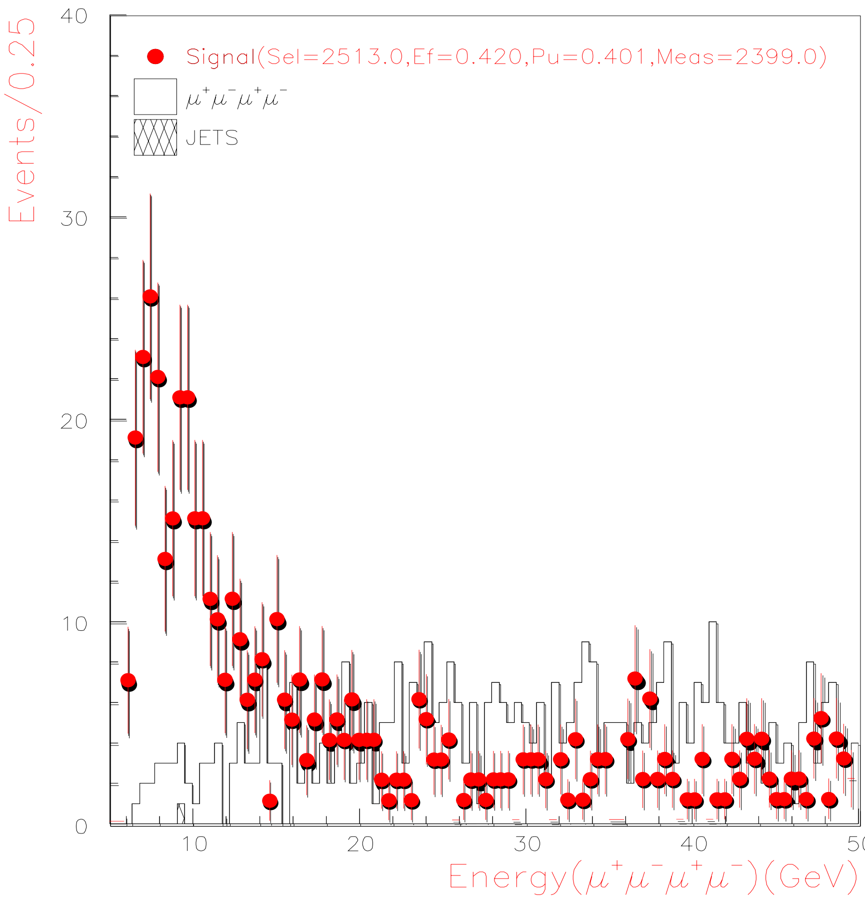


Determination of SUSY BRs

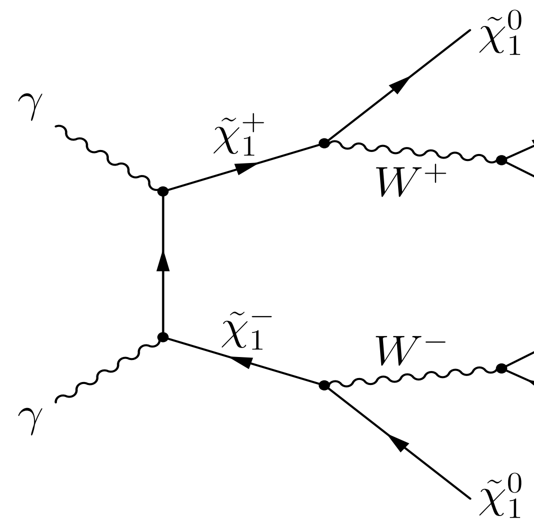
Huber Nieto-Chaupis

4 muon final state

Low energy muons from cascade decays



Chargino decays



$$\Delta BR(\tilde{\chi}_1^\pm \rightarrow W^\pm \tilde{\chi}_1^0) = 8.2\% \, (250 \text{ GeV})$$

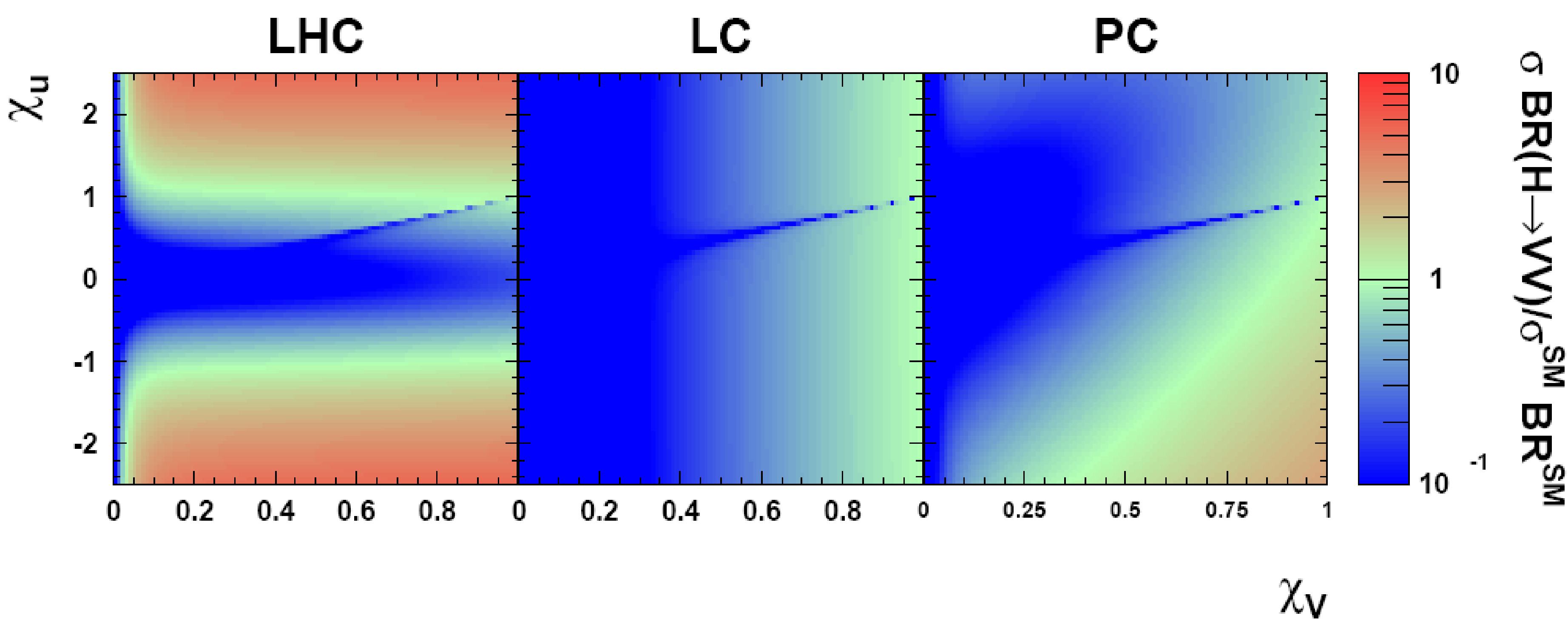
$$5.7\% \, (300 \text{ GeV})$$

Synergy with LHC and LC

A.F.Zarnecki (Higgs+Loopverein session tomorrow)

Measurements at LHC, LC and Photon Collider are complementary, being sensitive to different combinations of Higgs-boson couplings

Cross sections × BR relative to SM $M_H = 250 GeV$

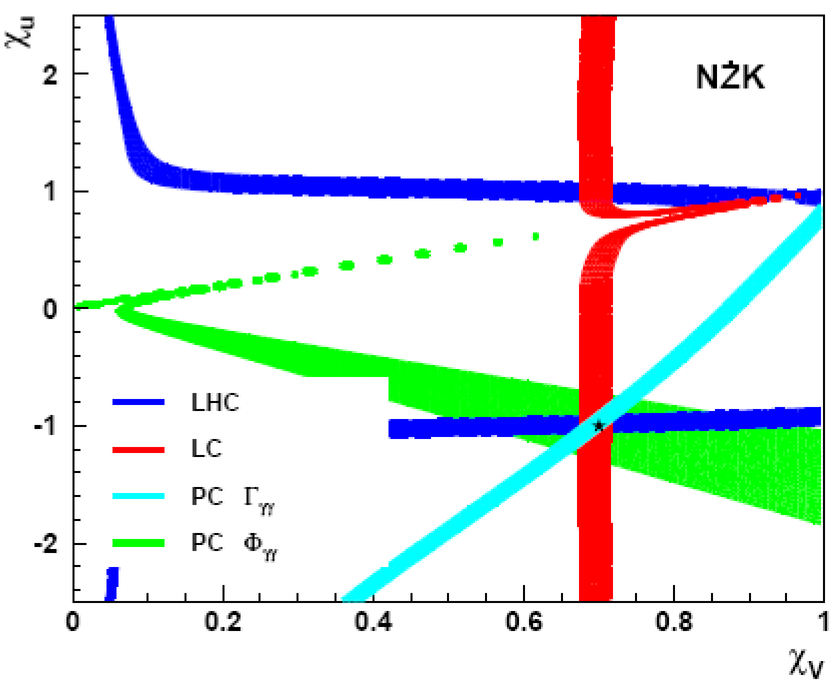


Synergy with LHC and LC

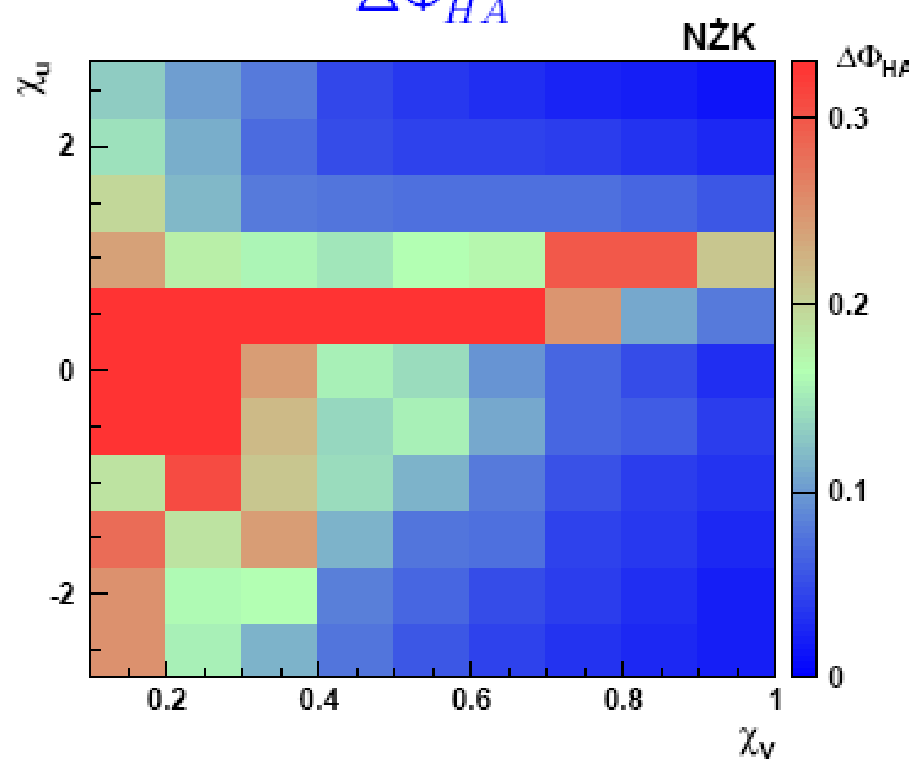
A.F.Zarnecki (Higgs+Loopverein session tomorrow)

2HDM(II) with CP violation ⇒ determination of H-A mixing angle:

$\chi_V = 0.7 \quad \chi_u = -1 \quad M_H = 250$ GeV



$\Delta\Phi_{HA}$



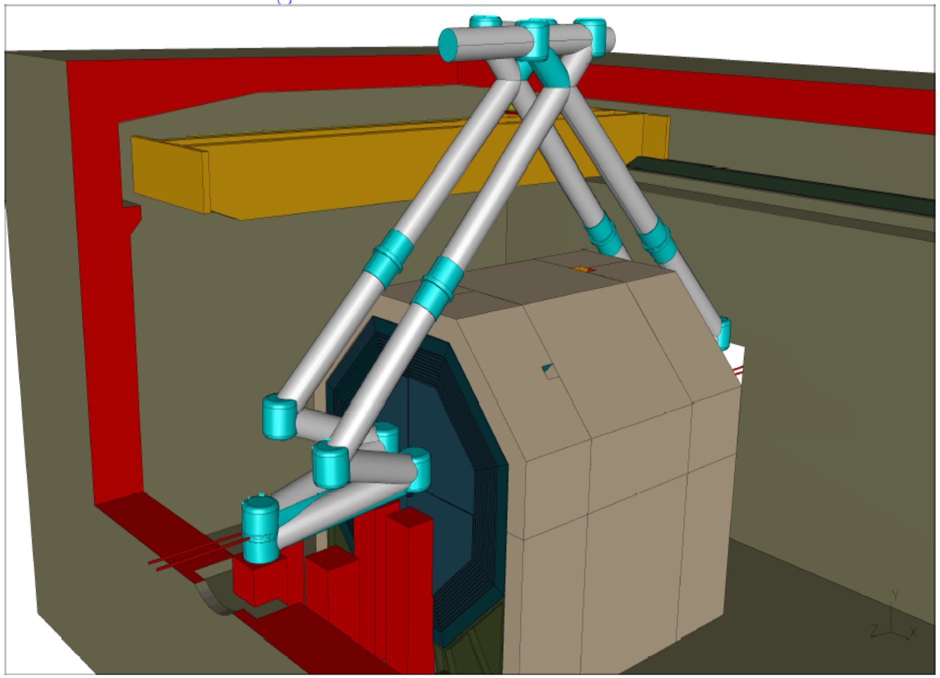
$\langle \Delta\Phi_{HA} \rangle$ = 150 mrad

$\gamma\gamma$ technical work at Zeuthen

Design study for a laser cavity

- a laser cavity with a power enhancement around 100 can decrease the needed laser power by the same amount
- with the TESLA bunch structure the length of the cavity is 100 m and can be mounted around the detector
- to increase the conversion rate and to minimise the dead region the laser-beam crossing angle should be as small as possible
- if the mirrors cut into the laser beam the diffraction losses stay small, however the broadening of the focus is serious

Design of the laser resonator in the hall

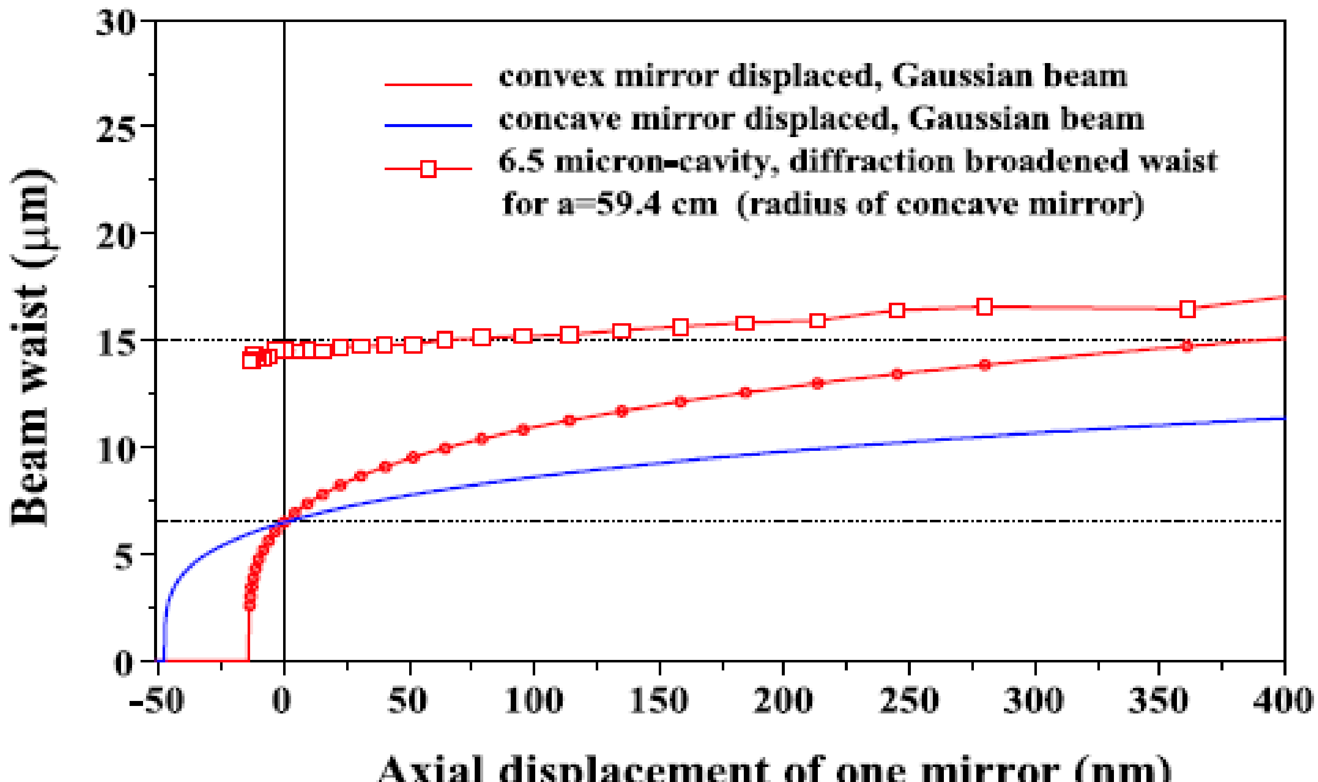


$\gamma\gamma$ technical work at Zeuthen

With a laser-beam crossing angle of 55 mrad and a laser power of 9 J the TDR parameters can be recovered

However the alignment tolarances are tight

Misalignment of focusing telescope:



Need precision of $\sim$ 100nm

γγ technical work at Zeuthen

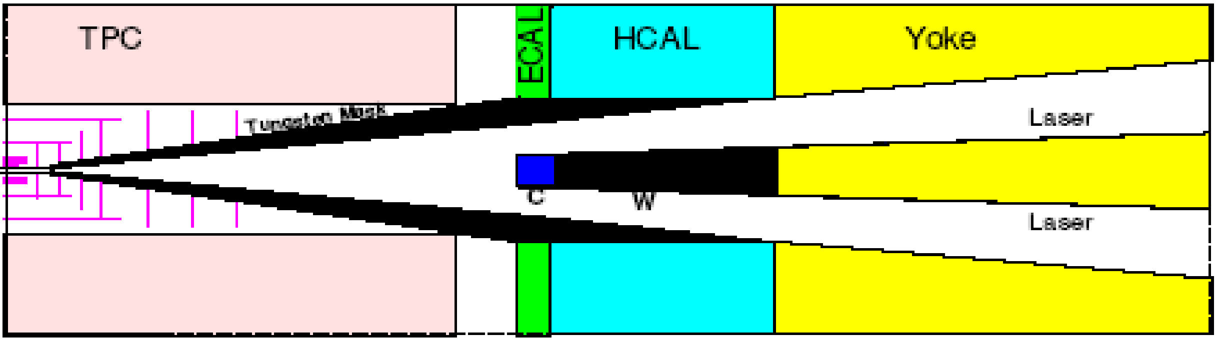
Detector and backgrounds

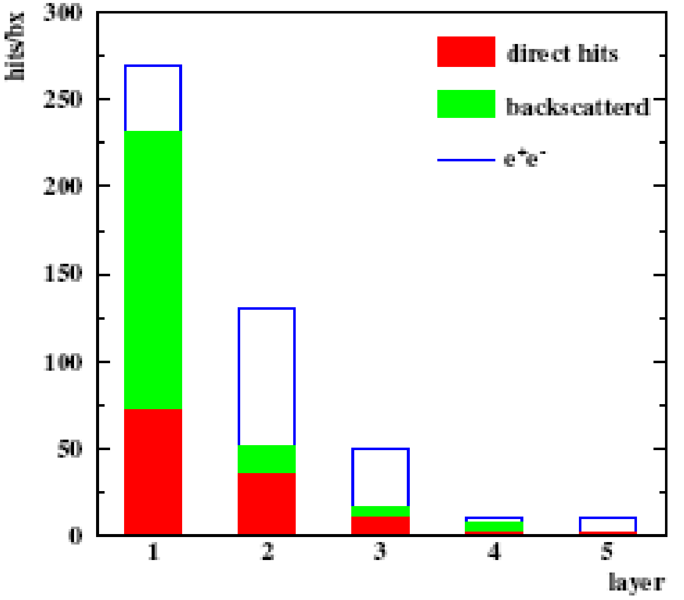
Background in the detector driven by

- large disruption angle of electron beam
- angle between outgoing beam and B-field

Background can be supresses with tungsten masks

However then on the level as in e^+e^-

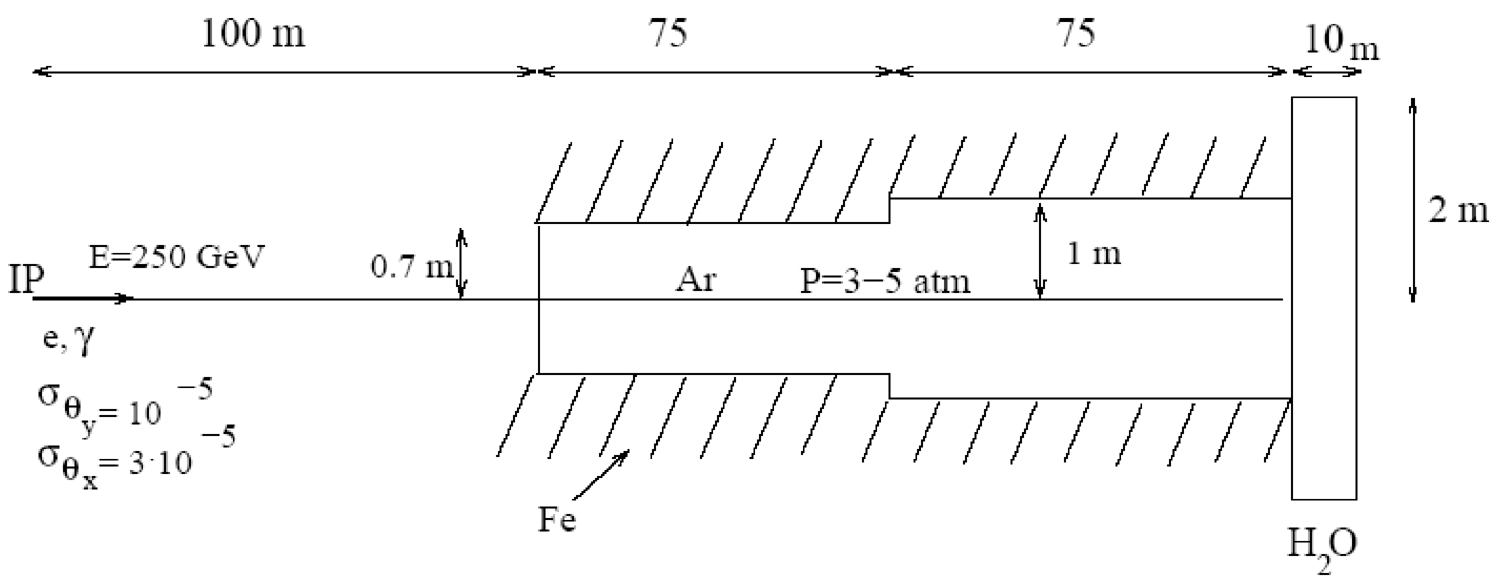




Beam dump for the Photon Collider

Valery Telnov

The scheme used in the simulation



The proposed scheme of the beam dump looks very attractive and can be used for all LC modes of operation.

The Photon Collider in the LC project

Valery Telnov

Letter submitted to:

- **International Steering Committee on Linear Colliders**
- **Worldwide Study Organizing Committee**

Special requirements for photon collider:

- **Crossing angle > 30 mrad**
- **Horizontal and vertical emittances as small as possible**
- **Spot size at IP as small as possible**
- **Beam dump**
- **Detector design allowing replacement of elements in the forward region**
- **Space for laser lines and housing**

Signed by: J.Gronberg, V.Telnov, T.Takahashi, K.Cheung, A.De Roeck, M.Krawczyk, K.Mönig, M.Velasco