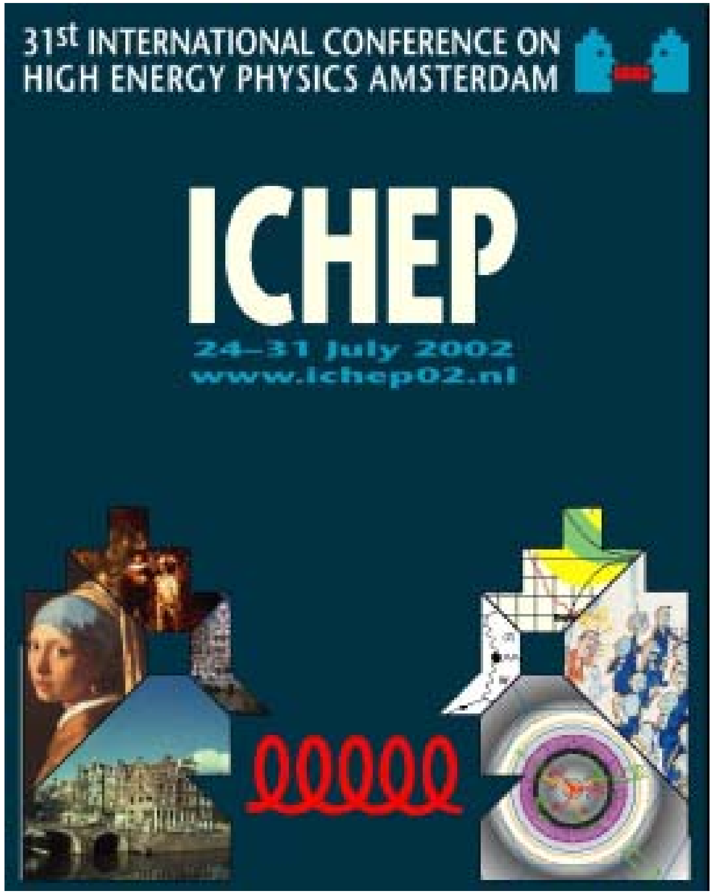
Physics at a Gamma- Gamma Collider

Stefan Söldner - Rembold

Fermilab

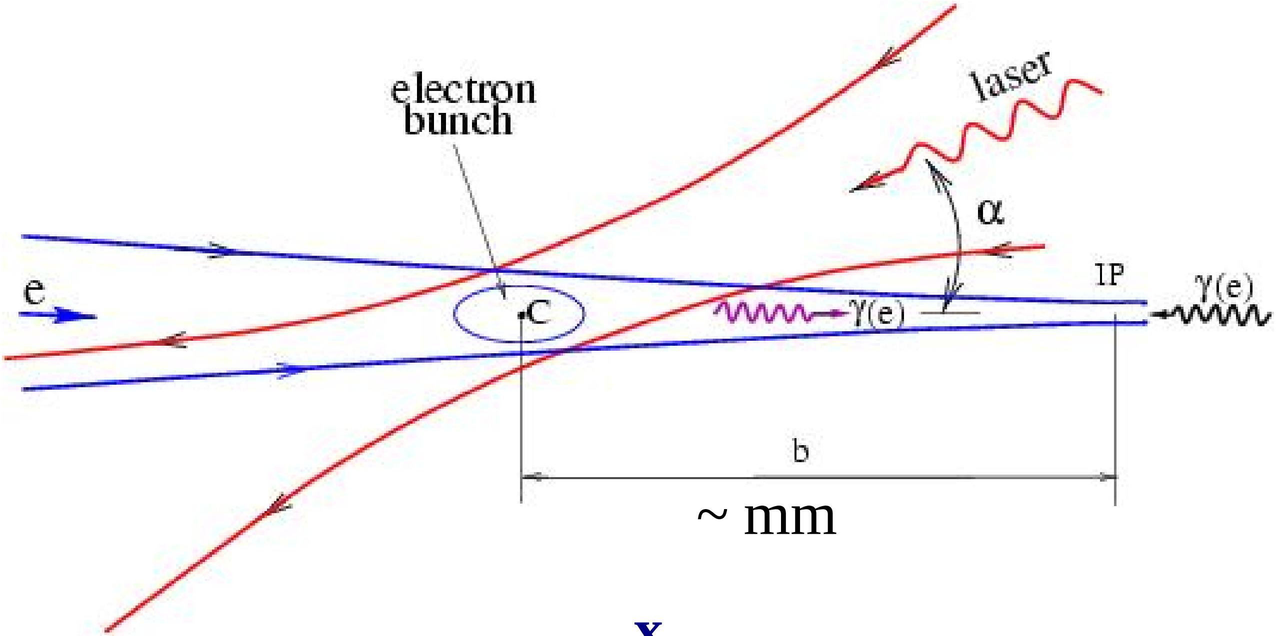


Abstracts:
155/655: P.Niezurawski,A.F.Zarnecki, M.Krawczyk (NZK)
624/625: M.Doncheski, S.Godfrey
770: ECFA/DESY (A.De Roeck,M.Krämer, M.Krawczyk,S.Maxfield, SSR)
812: G.Jikia, SSR

thanks for helping me to prepare this talk

We concentrate on Higgs physics in this presentation

Luminosity Spectrum of a Photon Collider



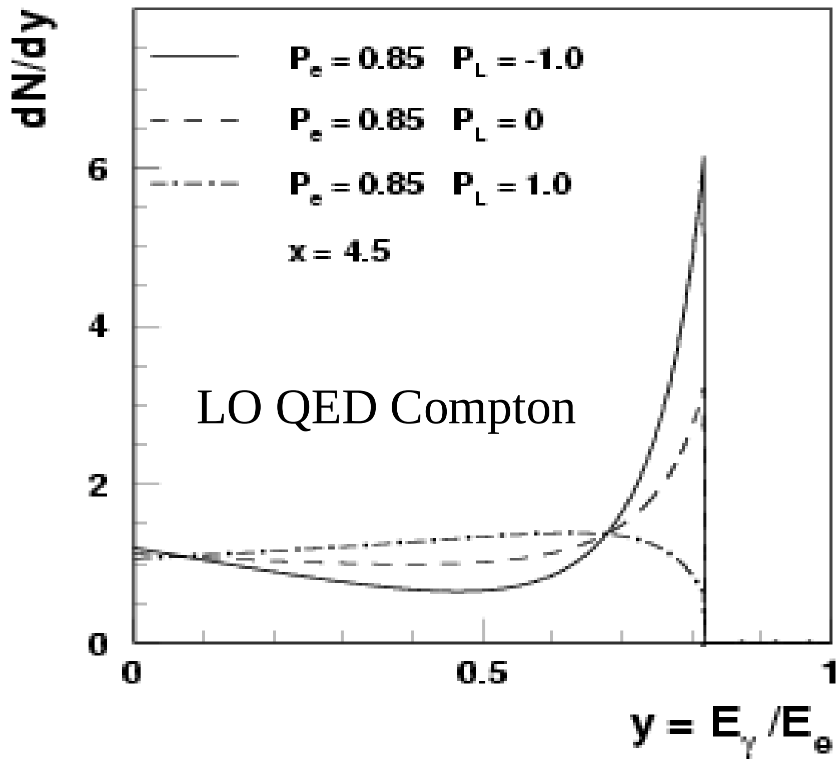
$$E_\gamma^{max} = \frac{x}{x+1} E_e$$

$$x = \frac{4 E_\gamma^0 E_e}{m_e}$$

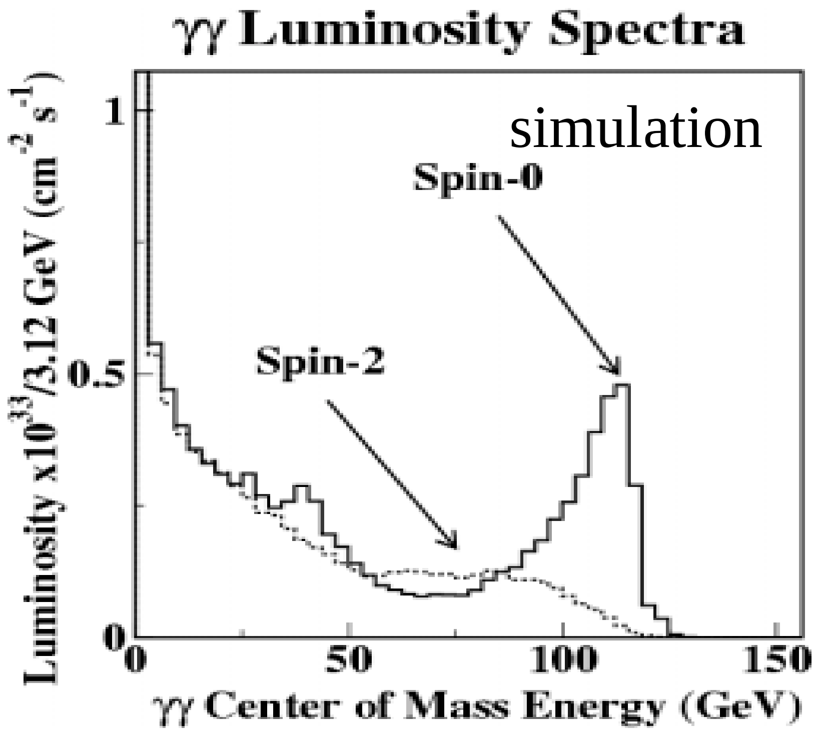
$$E_e = 250\,GeV;\, E_\gamma^0 = 1.17\,eV\,(\lambda = 1.06\,\mu m) \Rightarrow$$

$$x = 4.5 \wedge E_\gamma^{max} = 0.82\, E_e$$

V.Telnov et al.



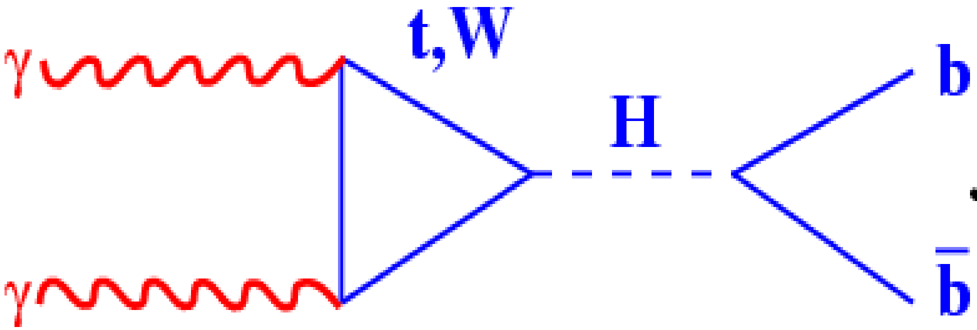
Polarisation is crucial for obtaining peaked energy spectrum



two - photon system can be in spin 0 or spin 2 state

for more details see
Jeff Gronberg, session RD4

Production Mechanism for Neutral Higgs Bosons



- s - channel production gives access to $\mathbf{m < \sqrt{s}}$

- Landau -Yang theorem selects spin states

- all charged and massive particles contribute => Cross-section (two - photon) width is sensitive to physics at higher scales

- Model independent measurement of total width Γ_H

Background: photon - photon -> bb(g) and cc(g)

$$\frac{d\sigma^{Born}(J_z=0)}{dt} = \frac{12\pi\alpha^2 Q_q^4}{s^2}\frac{m_q^2 s^2 (s-2m_q^2)}{t_1^2 u_1^2} \propto \frac{m_q^2}{s}$$

$$\frac{d\sigma^{Born}(J_z=\pm 2)}{dt} = \frac{12\pi\alpha^2 Q_q^4}{s^2}\frac{(t_1 u_1 - m_q^2 s)(u_1^2+t_2^2+2m_q^2)}{t_1^2 u_1^2}$$

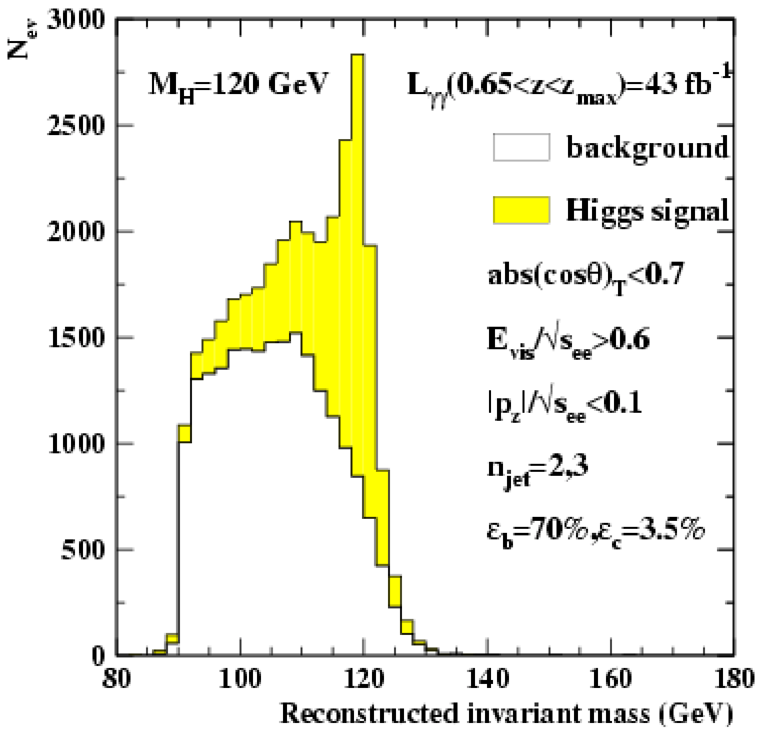
J_z=0 suppression is only valid in LO

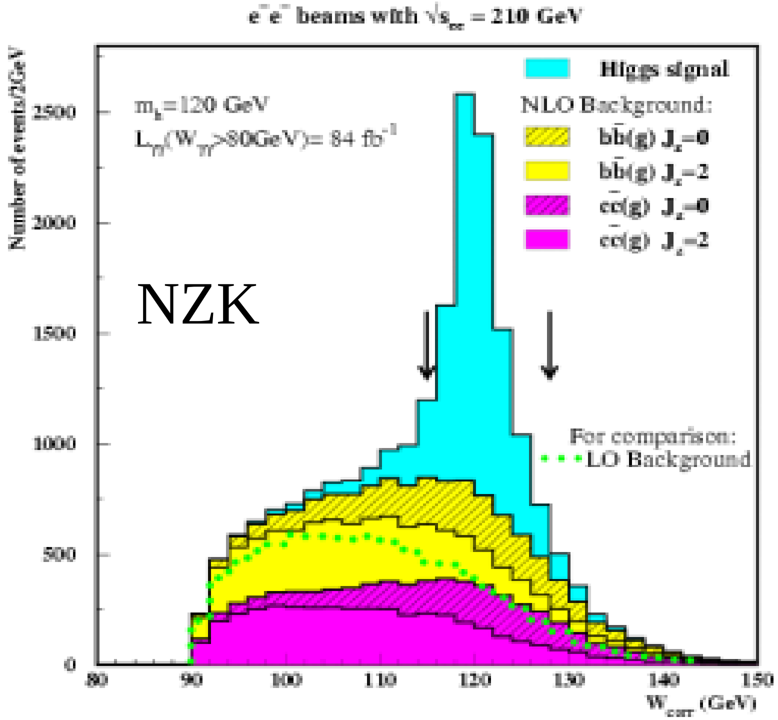
The background cross - sections have to be evaluated in NLO.

The NLO simulation of non - resonant background includes:

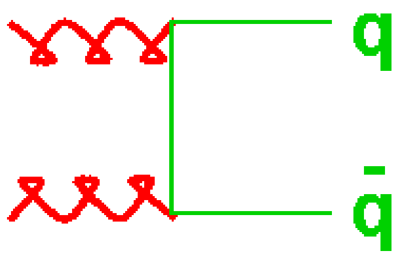
- exact one - loop QCD corrections (Jikia, Tkablazde)
- non - Sudakov form factor (Melles, Stirling, Khoze)

JSR (NIMA472 (2001) 133)





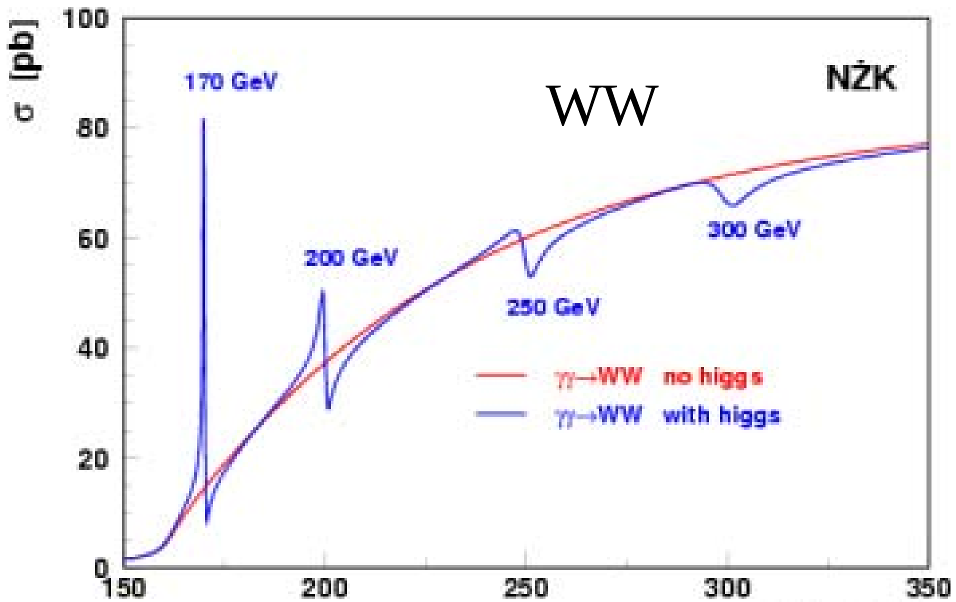
(LO) Background:

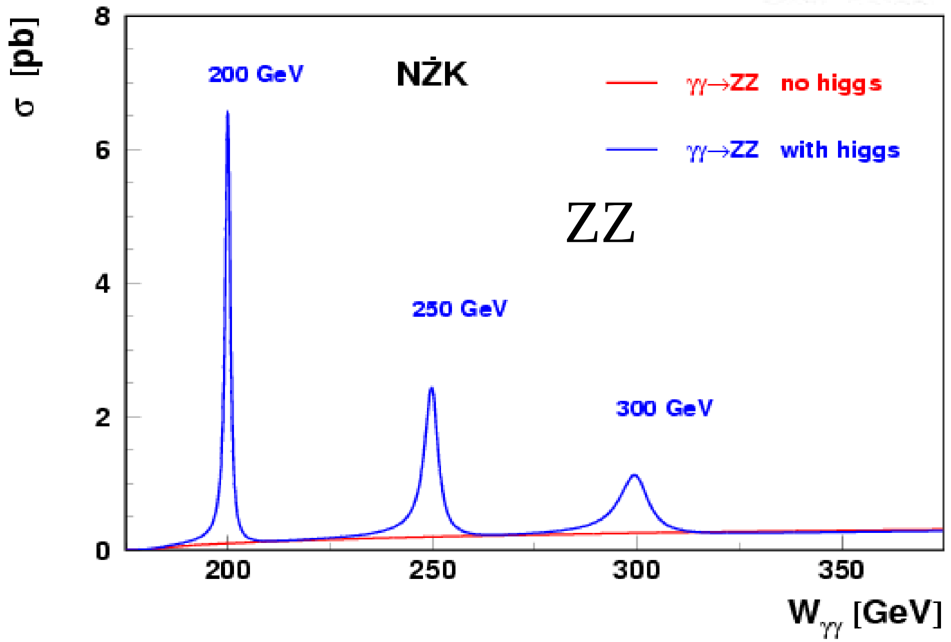


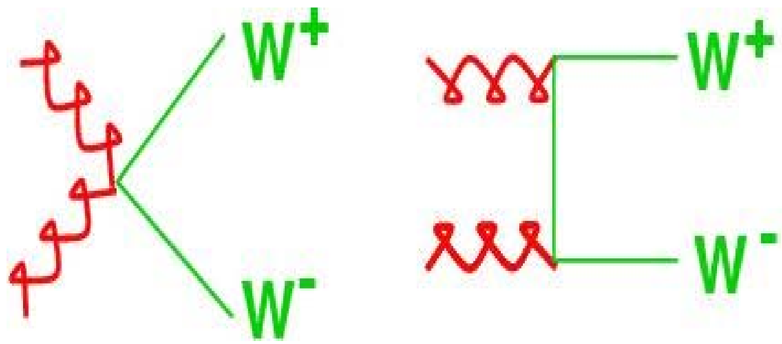
$$\frac{\sigma(\gamma\gamma\to c\bar{c})}{\sigma(\gamma\gamma\to b\bar{b})} \approx \frac{e_c^4}{e_b^4} = 16$$

t-channel->use angular and E_{vis} cuts

Higgs Decaying into WW or ZZ





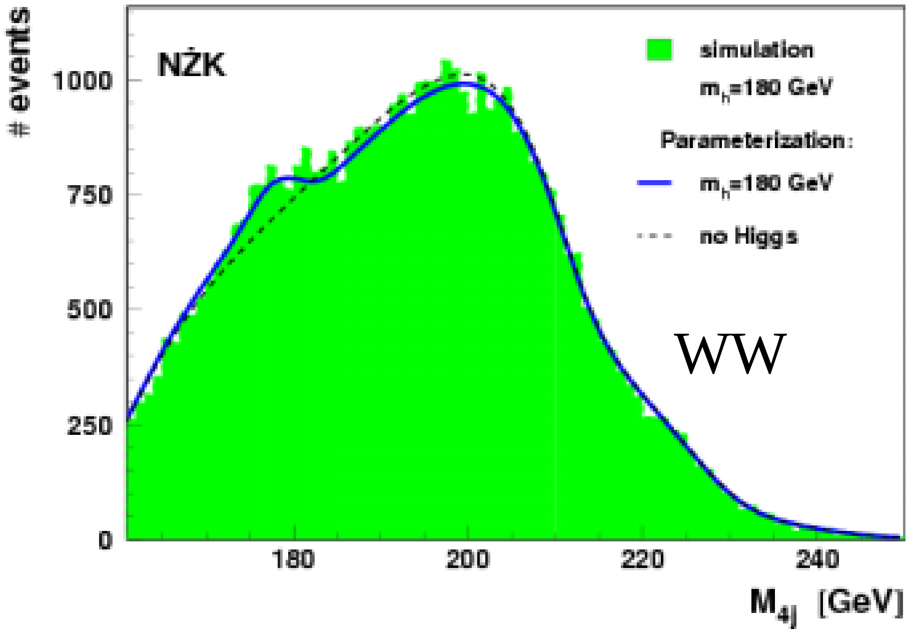


Large background from WW production:

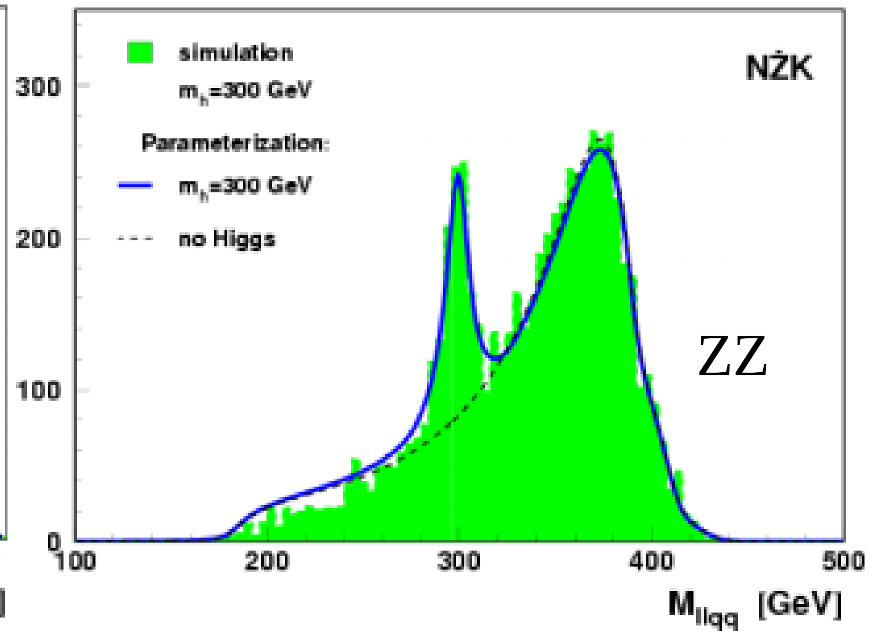
interference must be taken into account

<u>additional observable:</u>

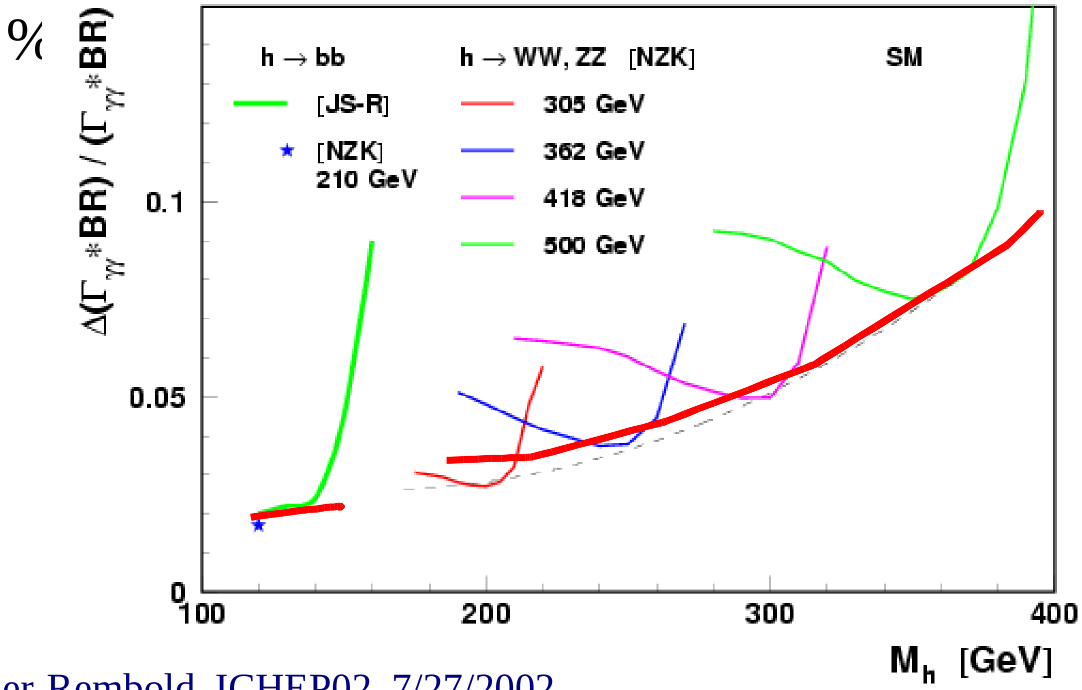
phase $\phi_{\gamma\gamma}$ of $\gamma\gamma\rightarrow$Higgs amplitude



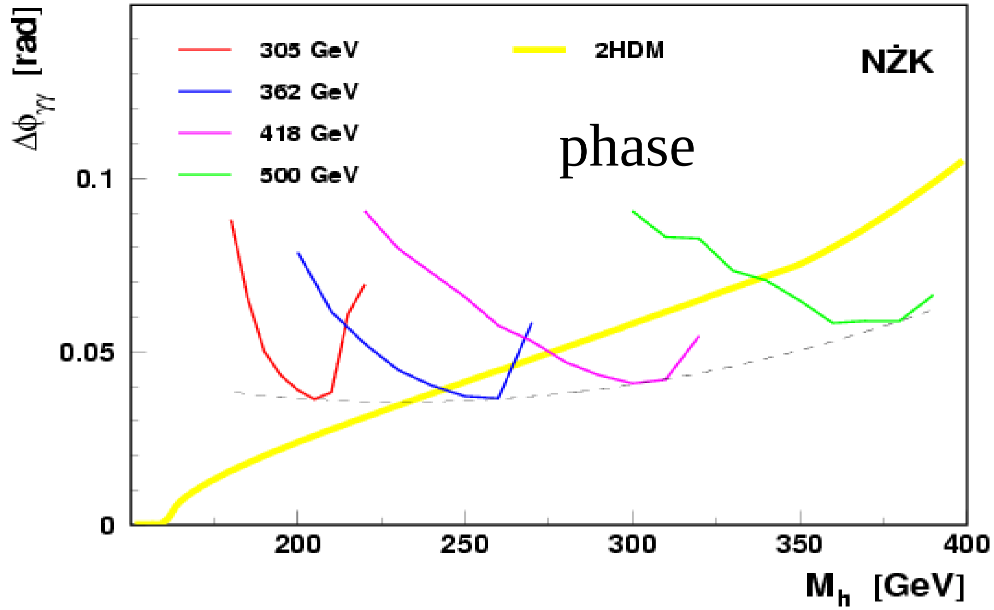
events
NŻK
simulation
m_h=180 GeV
Parameterization:
m_h=180 GeV
no Higgs
WW
0
250
500
750
1000
180
200
220
240
M_4j [GeV]

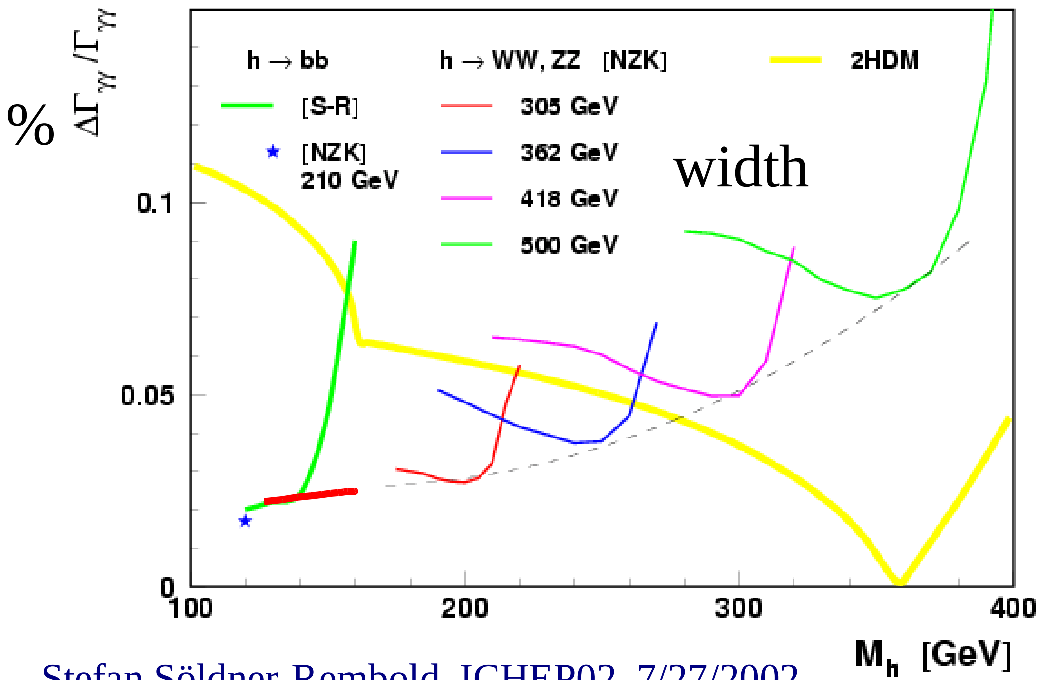


simulation
m_h=300 GeV
Parameterization:
m_h=300 GeV
no Higgs
NŻK
ZZ
0
100
200
300
100
200
300
400
500
M_llqq [GeV]



%
Δ(Γ_γγ*BR) / (Γ_γγ*BR)
h → bb
[JS-R]
[NZK]
210 GeV
h → WW, ZZ [NZK]
305 GeV
362 GeV
418 GeV
500 GeV
SM
0
0.05
0.1
100
200
300
400
M_h [GeV]

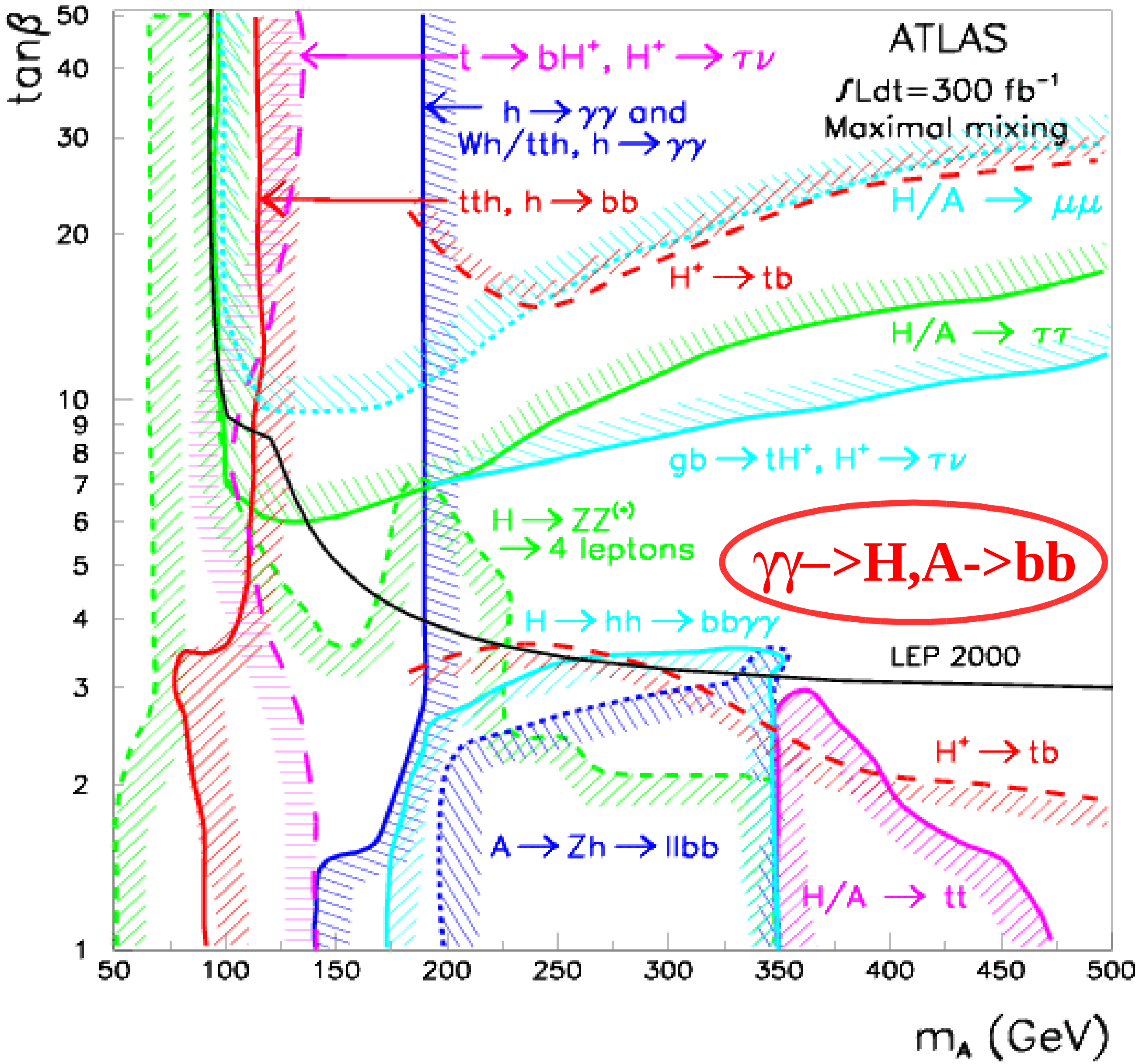




combined precision
of phase and two-photon
width determination

gives sufficient precision
to distinguish
SM from 2HDM models

Testing Higgs Sector at the LHC

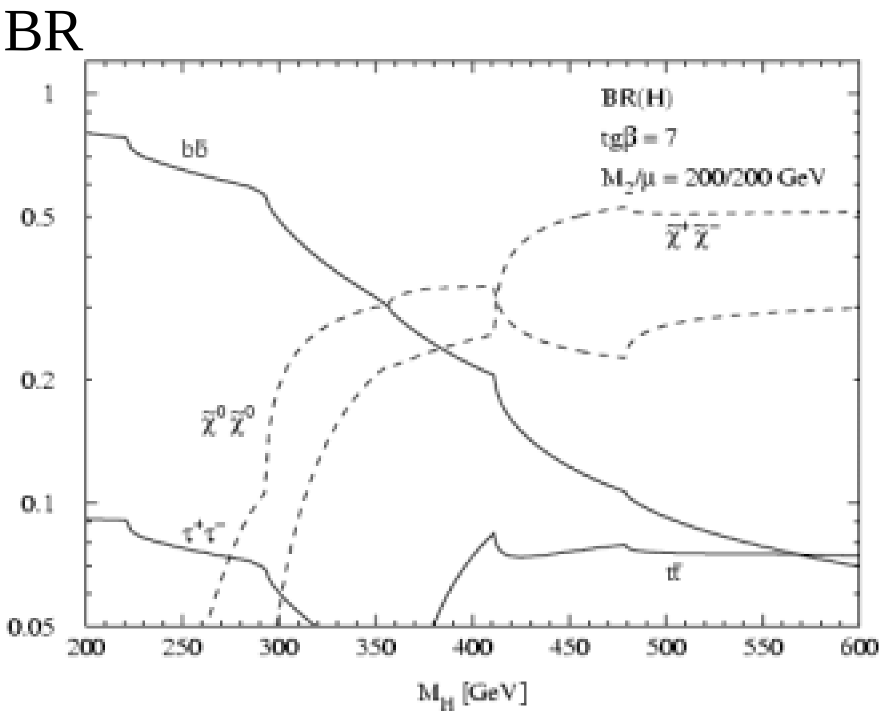


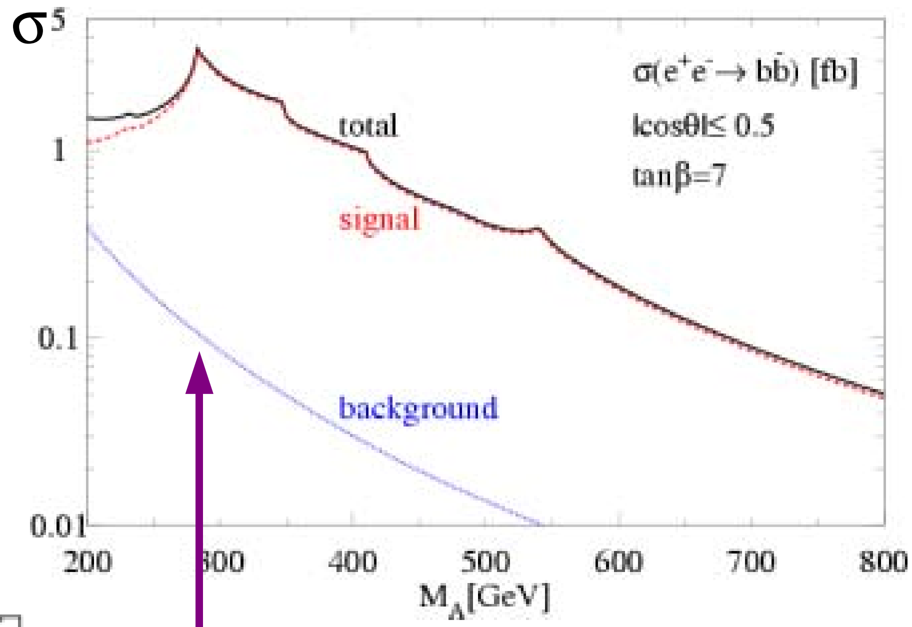
Stefan Söldner-Rembold, ICHEP02, 7/27/2002

MSSM Higgs Bosons H,A:

M.Mühlleitner et al.
(PLB508 (2001) 311)

LHC blind in this region
LC only sensitive to sqrt(s)/2





σ(bb)~0.09 fb at 300 GeV

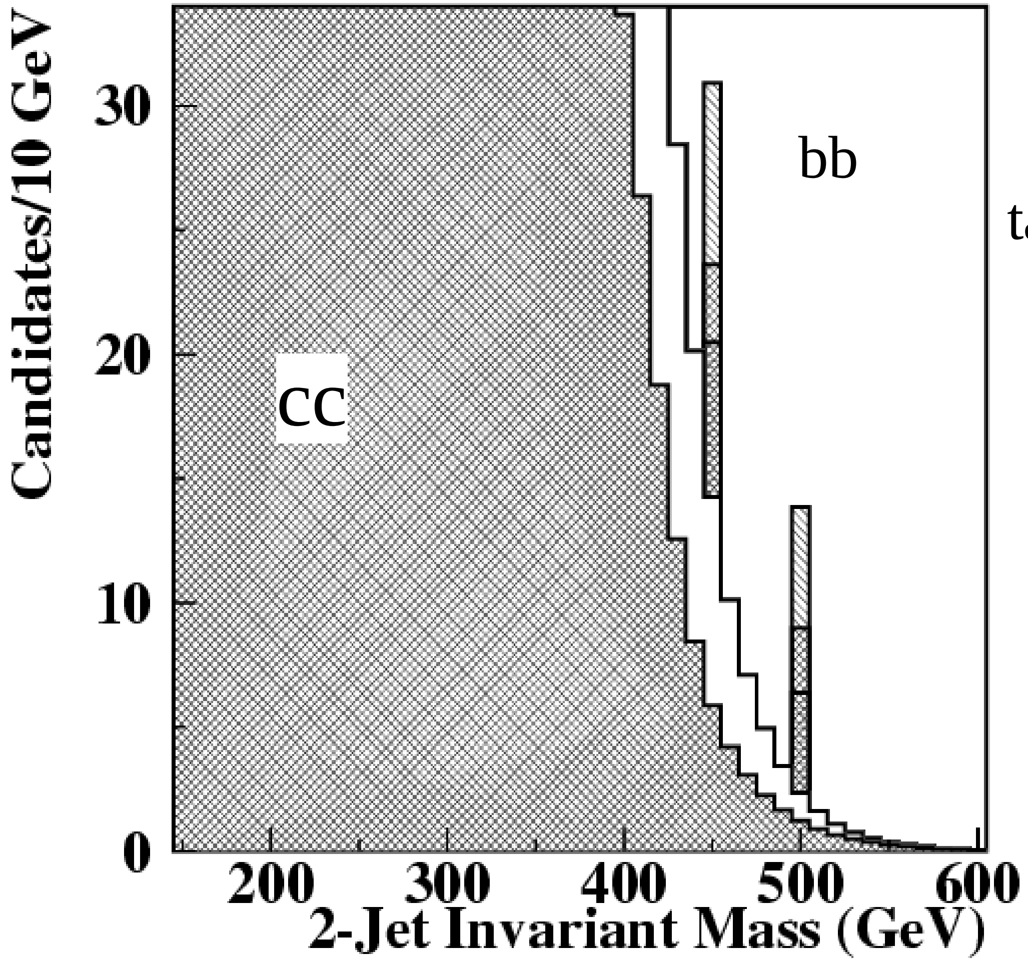
mass window of +-3 GeV
(1 % resolution) yields S/B ~ 30

only two - jet events used

100% polarisation

D.Asner et al, hep-ph/0110320 $\sqrt{s_{ee}} = 630\,\mathrm{GeV}$

US study



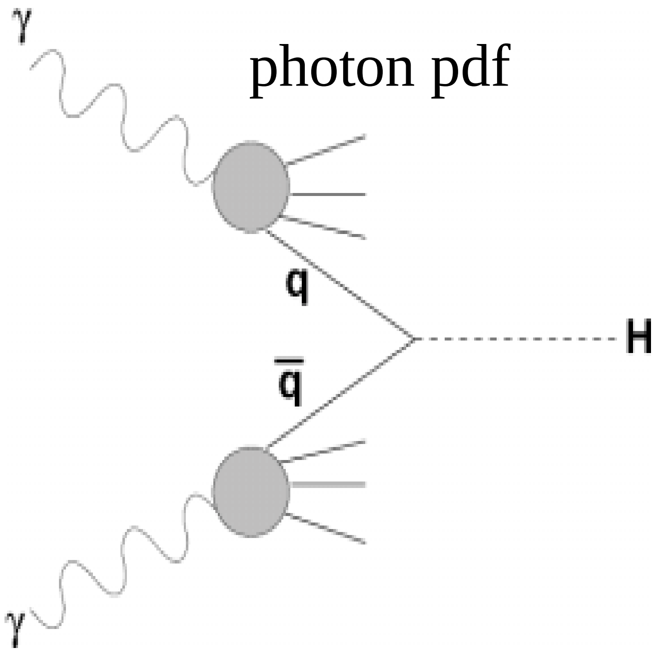
tan β = 3-15

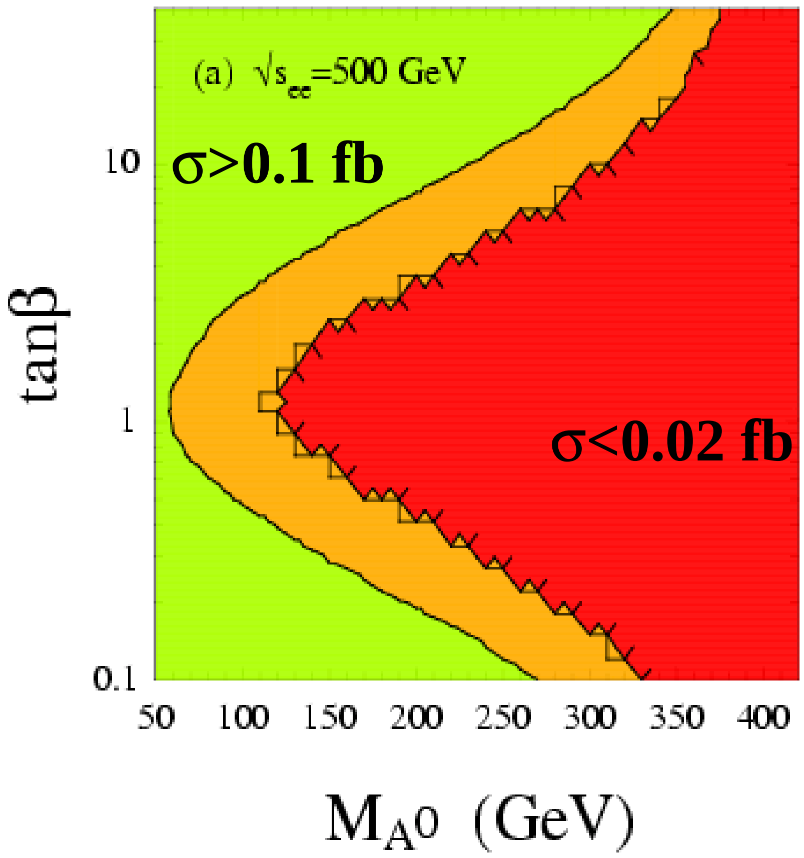
no experimental smearing

Photon Collider has unique discovery potential in medium tan β region

Resolved Photon Contribution to Higgs Production

M.Doncheski, S.Godfrey,hep-ph0105070





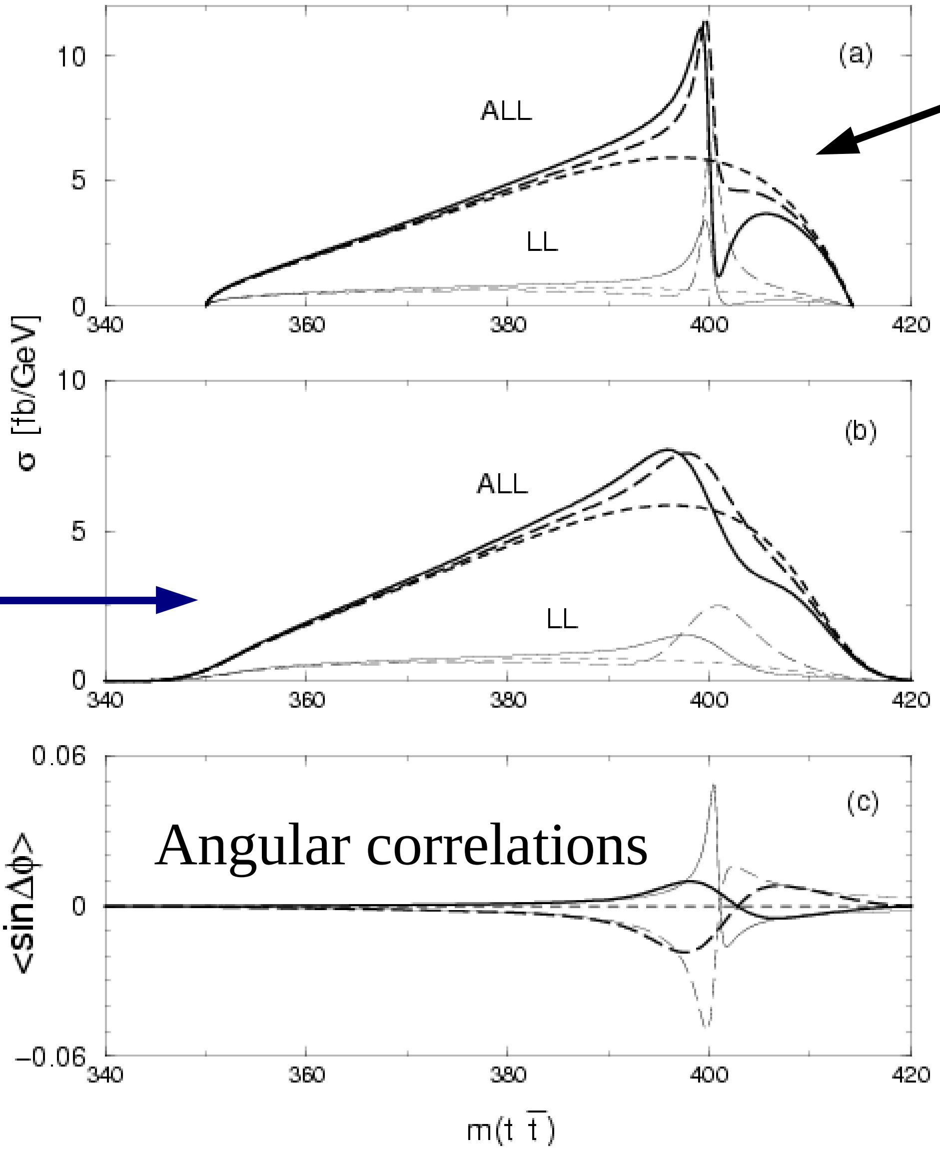
CP not invariant -> Higgs Bosons A and H mix

E.Asakawa
hep-ph/0101234

x=4.83
$P_e P_L$=-1
$M_{A,H}$=400 GeV

smeared with
$\Delta m(tt)$=3 GeV

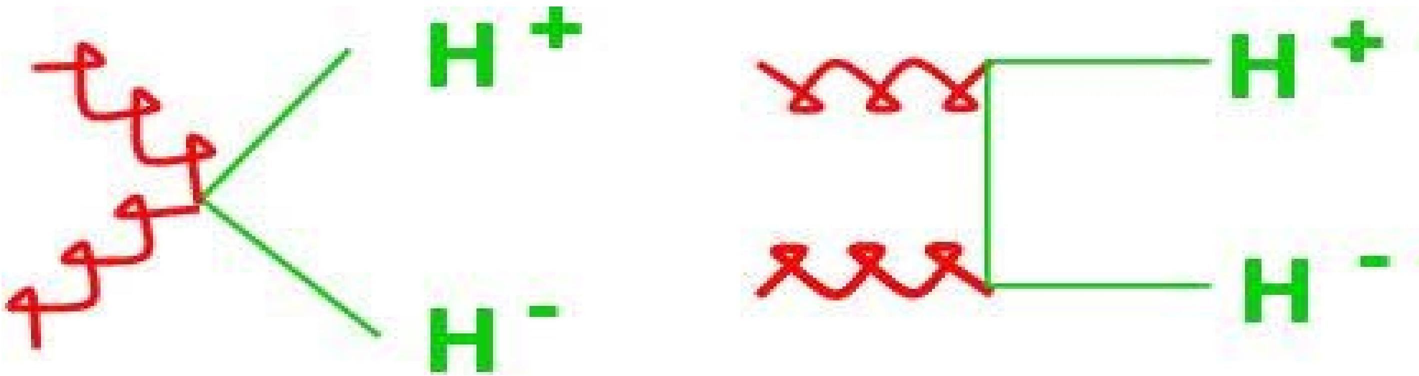
ϕ : azimuthal
angle of b
in t rest frame



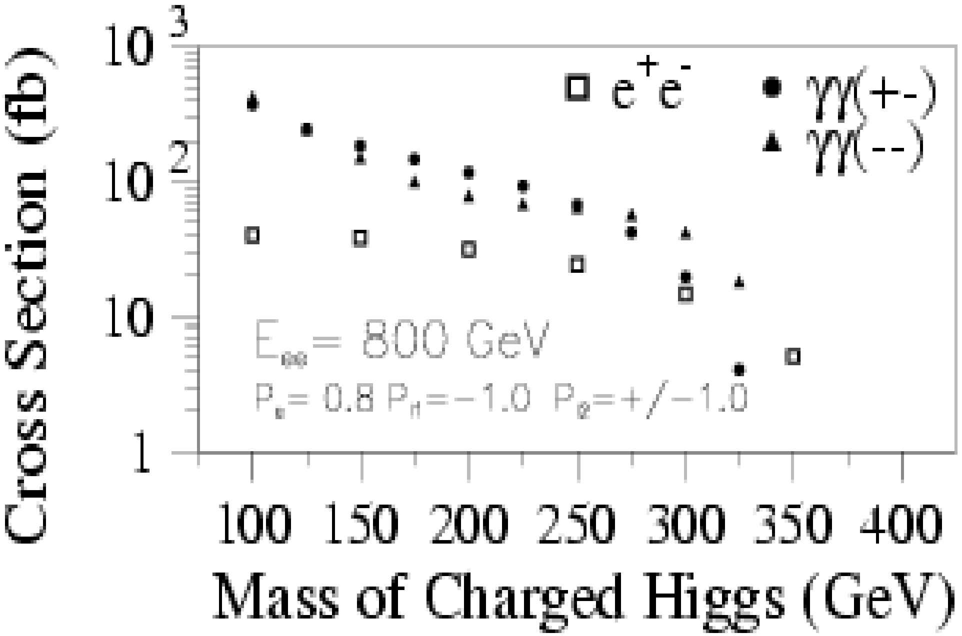
'QED'
$\gamma\gamma$->tt

$\sqrt{s_{ee}} = 500\,\mathrm{GeV}$

Charged Higgs Production



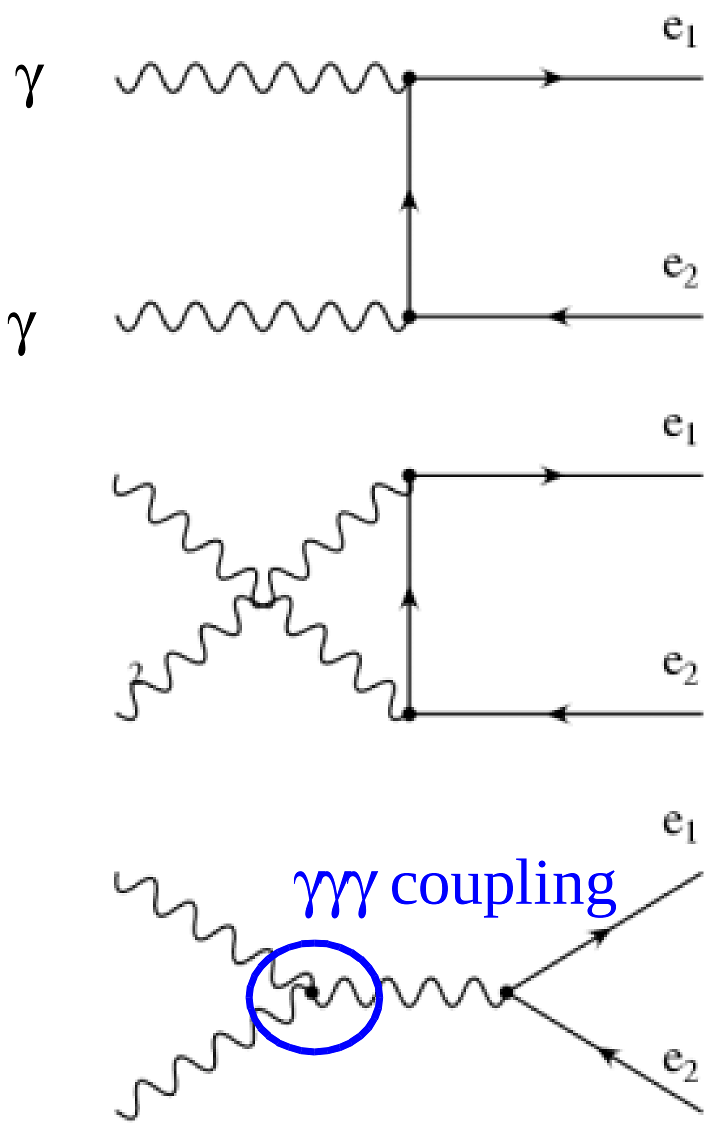
H.Logan, M.Velasco



- large cross -section in γγ
- possible mass measurement using threshold behaviour (difficult for τν decays)
- background/detector studies underway

Non - Commutative (NC) Field Theories

S.Godfrey,M.Doncheski

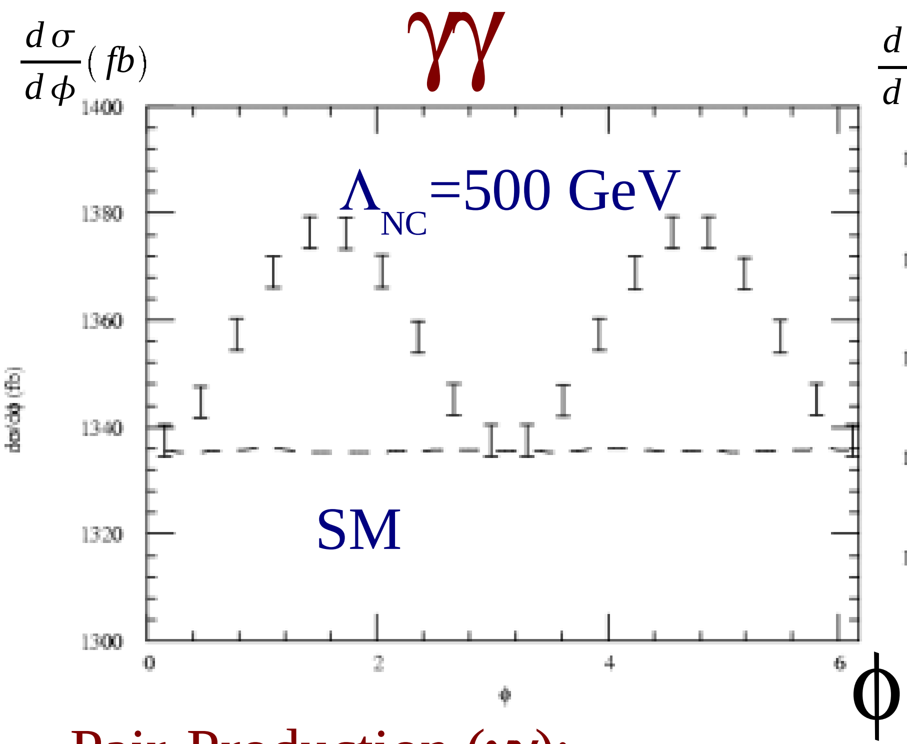


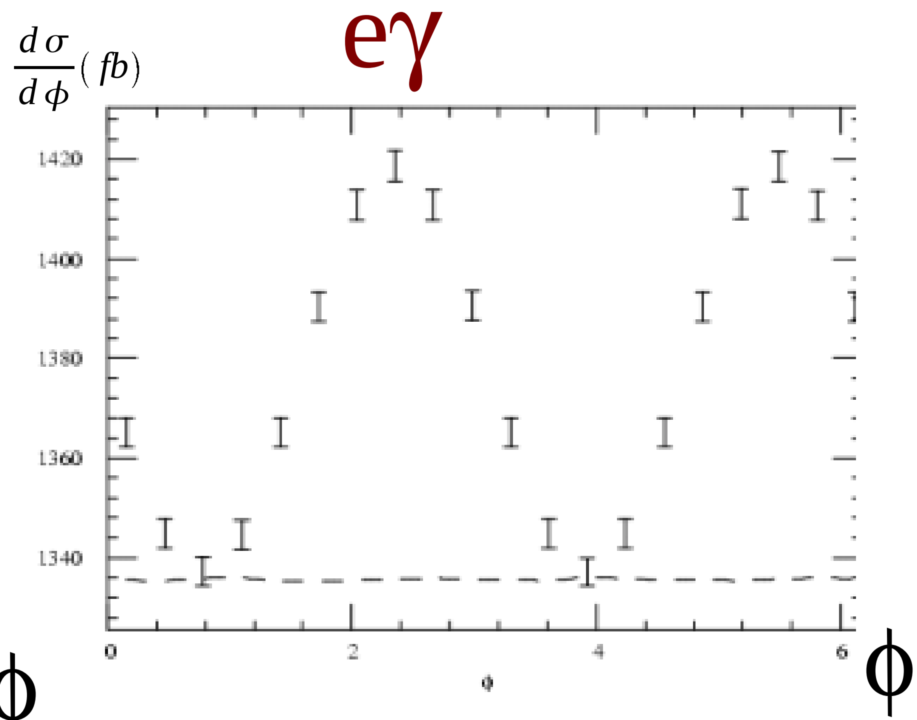
related to non- commuting space- time in string theories

Λ_{NC}: scale where NC effects become significant

OPAL: Λ_{NC}>142 GeV @ 95 % CL

this study:
p_T>10 GeV,$10^0<\theta<170^0$, L_{ee}=500 fb^{-1}





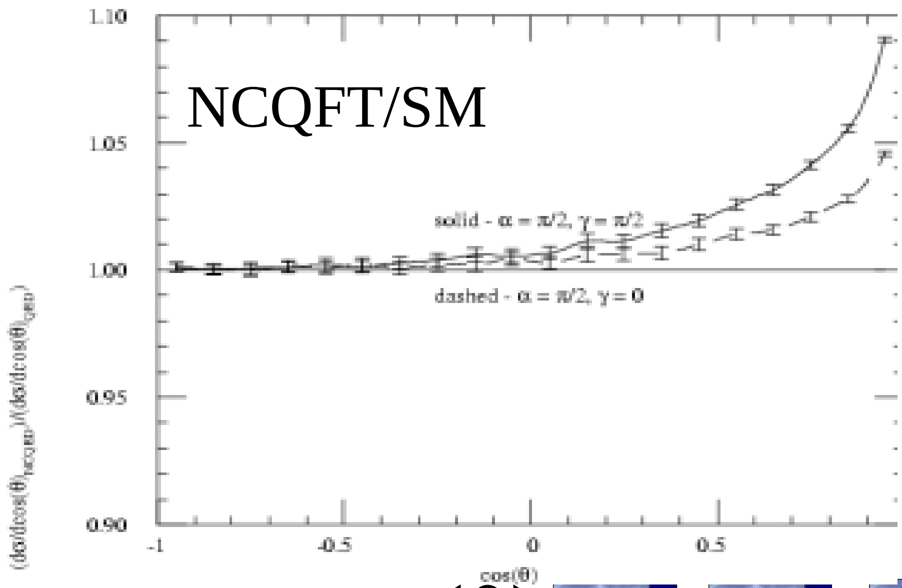
Pair-Production (γγ):

-space-time non-commutivity

Compton-Proces (eγ):

-space-space and space-time non-commutivity

Λ_{NC} sensitivity similar to Bhabha process but different combination of NC matrix elements tested



SUMMARY

- Several promising scenarios for Higgs production at a Photon Collider have been studied :

  120 - 160 GeV (SM H->bb)
  160 - 400 GeV (SM H->WW,ZZ)
  200 - 500 GeV (MSSM H,A->bb)
  charged Higgs production

- Non-commutative field theories: $e\gamma$ complementary to e^+e^-

- Many other topics omitted (SUSY, LQs, QCD..)

- Very important for Photon-Collider:

  a) excellent b -tagging to suppress charm background
  b) excellent energy resolution (no beam energy constraint)

The Photon Collider provides many unique physics opportunities