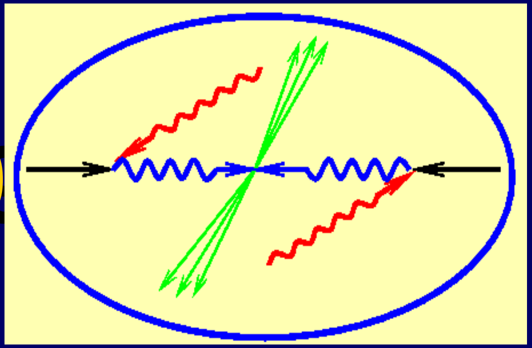
FITAL 2010

LHC2FC- CERN-17.02.2009



9 good reasons to build the Photon Linear Collider

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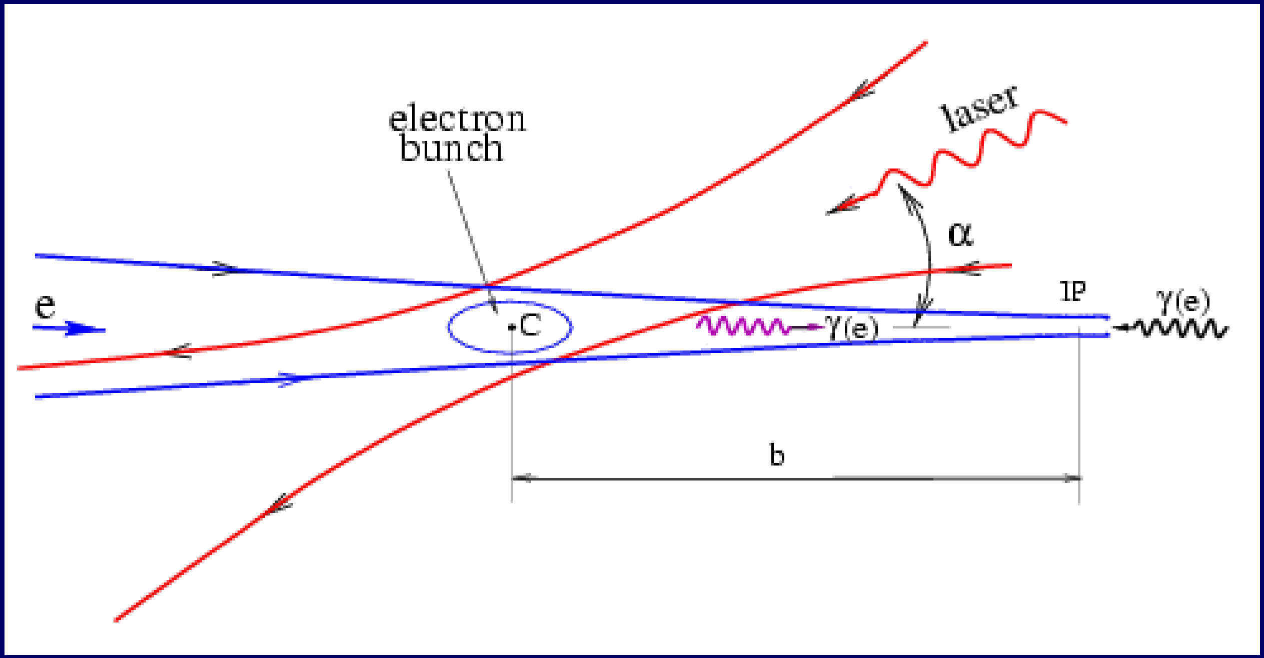
9 good reasons to build PLC

Introduction to Photon2007

1. Precision measurements of the light Higgs boson production (->bb) and distinguishing SM-like scenarios
2. Testing Higgs selfinteraction
3. Higher mass reach and covering LHC wedge
4. Establishing CP property of Higgs bosons

5. Search for SUSY particles
6. Complementarity to ILC and LHC
7. Photon structure and QCD tests
8. Anomalous W and t couplings
9. New physics in $\gamma\gamma \rightarrow \gamma\gamma$

Backward Compton scattering- basic idea of the photon collider
Ginzburg, Telnov, Serbo, Kotkin '81



- **PLC = $\gamma\gamma$ and e γ options**

PLC - main characteristics

- Variable energy and degree of polarization of the photon beams – both circular and linear polarization
- Almost monochromatic spectrum possible (a high energy peak)
- Clean or dirty collider? Hadronic interaction of photon ……

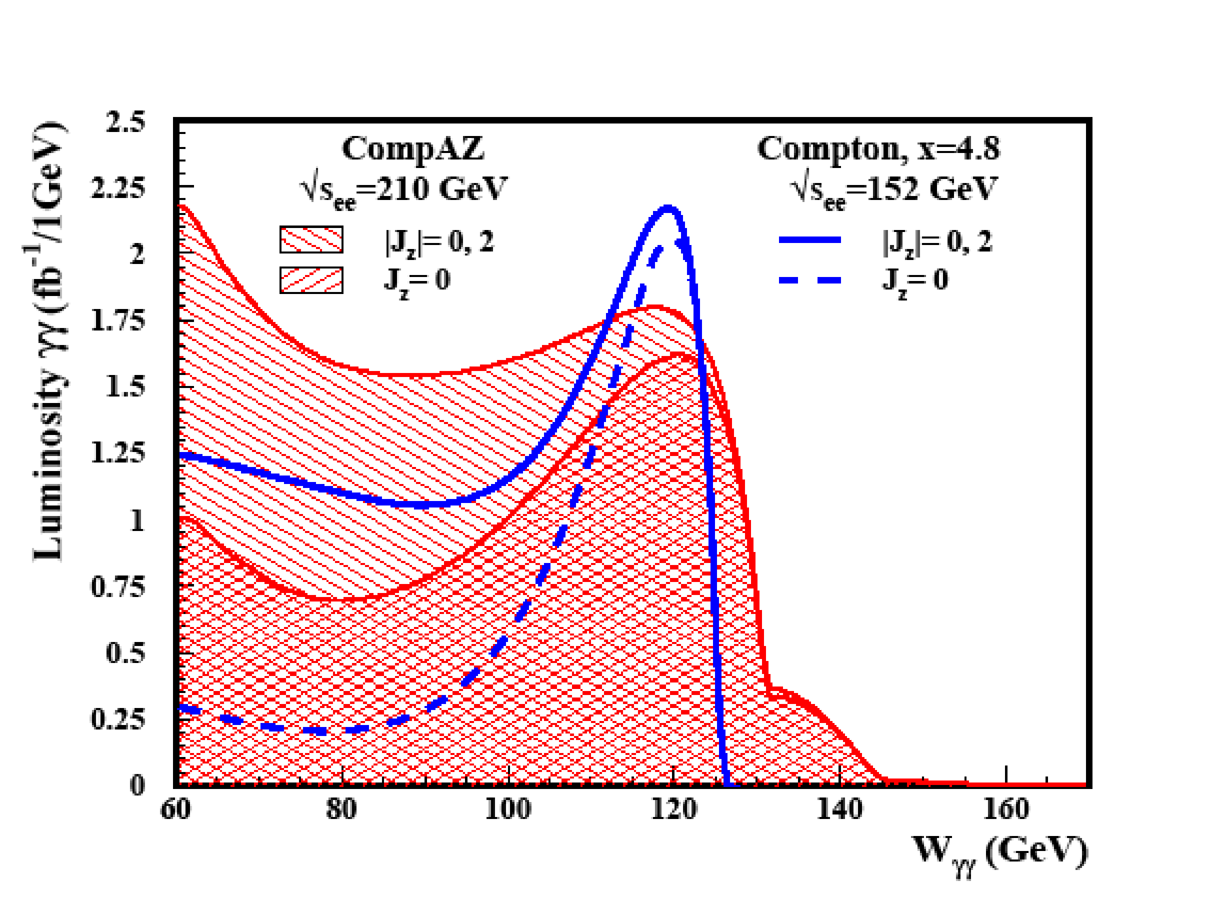
PLC at ILC

- For ILC with energy 500-1000 GeV (ILC Report 2007)
- Energy $E_{\gamma\gamma}$ up to 0.8 E_{ee} (0.9 for $e\gamma$ option)
- Luminosity $\gamma\gamma$ (peak) ~ 0.1-.2 L_{ee} (geom) peak: $E_{\gamma\gamma} > 0.65\ E_{ee}$

  → annual $\gamma\gamma$ L= 84 fb^{-1} in the peak for 120 GeV (total 410 fb^{-1})
- Mean energy spread in the $\gamma\gamma$ peak (cut): ~ 5 – 7 %
- Mean helicity at the peak: 90 - 95 %
- Important parameter x: max $E_\gamma = x/(1+x)E_e$

x=4.5 to avoid e+e- pair production

Realistic $\gamma\gamma$ spectra (Telnov)



For $J_z = 0, 2$

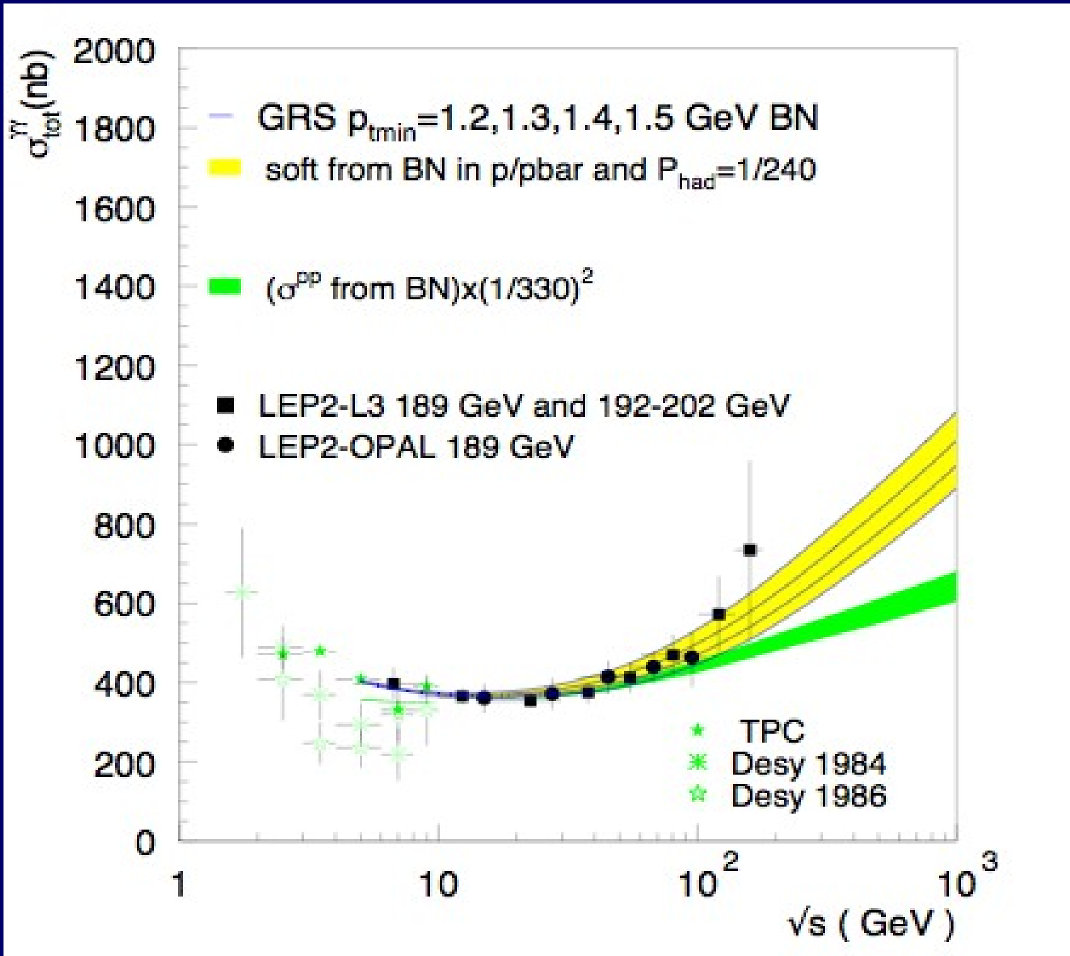
Here $J_z=0$ peak for M=120 GeV

CompAZ parametrization (A.F.Żarnecki)

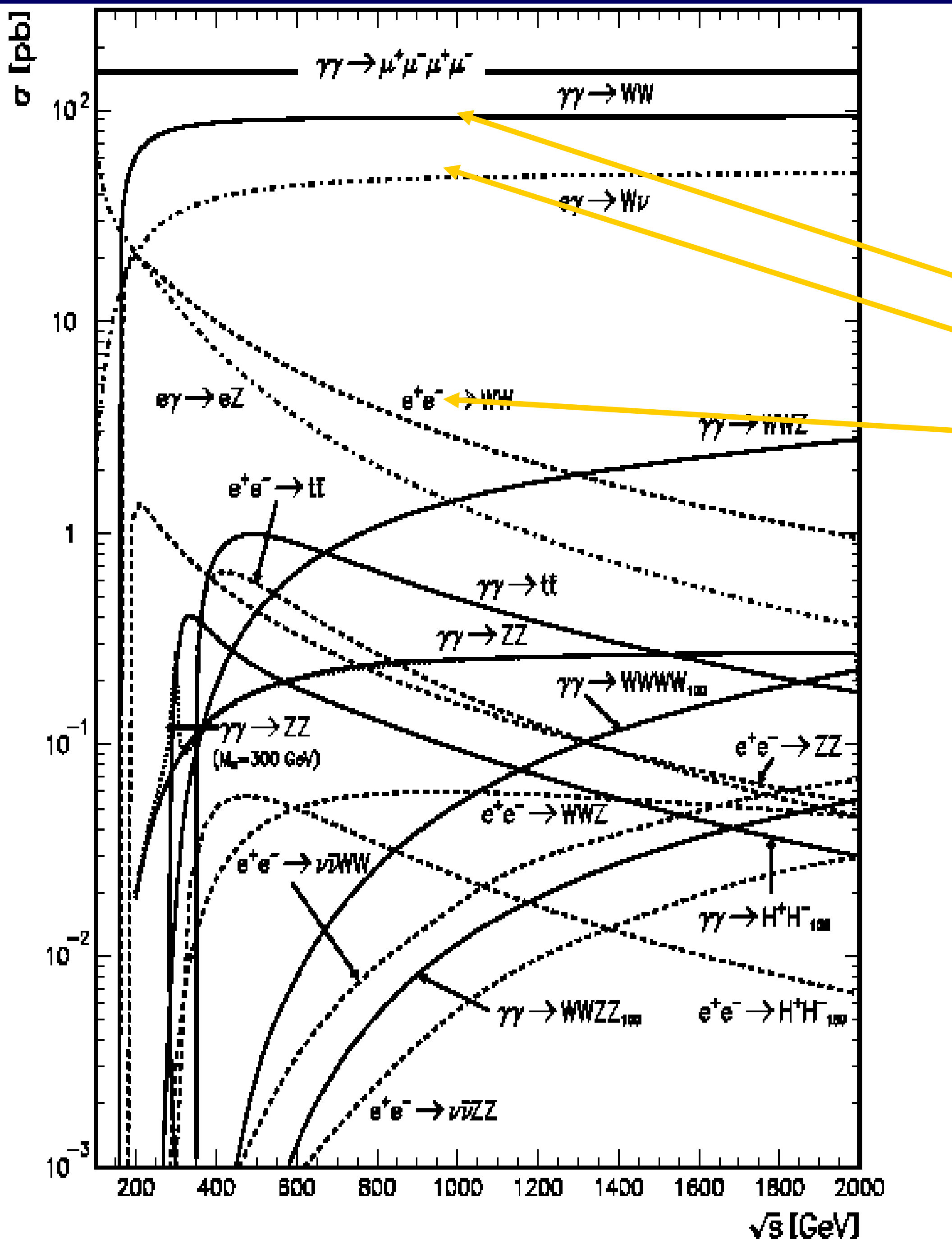
Hadronic cross section

Godbole, Pancheri, deRoeck

- Large $\gamma\gamma$ to hadrons cross section
- Various study of QCD possible, eg. comparison with γ p and pp case
- Measurements of the hadronic (partonic) structure of the photon
- In e γ option DIS on a <u>real</u> photon for the first time possible
- The structure of polarized photon



Cross sections



WW or W ν

eγ γγ

e+e-

Belanger et al

Higgs Study – CP conservation

- SM Higgs – couplings to W/Z, fermions known, mass and selfcoupling unknown. LEP limit 114 GeV

- 2HDM: 5 Higgses, H+,H-; h,H,A; sum rules of couplings

- the lightest h can be SM-like (|relative direct couplings| ~1) (decoupling or non-decoupling of heavy Higgses)

- the lightest h can be very light below say 50 GeV (with suppressed coupling to W/Z, but g-2!) → H is SM-like

- the lightest can be A not h

- Model II → mass of H+ above 350 GeV (b->s gam)

- MSSM (CP conserv, Model II): h- SM like (decoupling, degenerate H,A,H+; H with suppressed coupling to W/Z !!); h mass 90(LEP) -135GeV(theory)

Higgs Study – CP violation

- 2HDM – neutral Higgses have no definite CP properties h1,h2,h3; all couple to W/Z

- However – S scenario possible in 2HDM:
  h,H,A states with normal couplings to W/Z.
  CP violation <u>only</u> in selfcouplings (eg. AAA, AH+H-..) - for 2HDM potential with hard violation of Z_2 symmetry

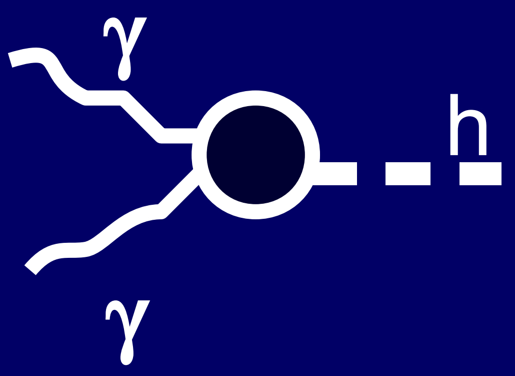
  (Lavoura,Botella94,Sokolowska,Kanishev,MK 2008)

- CP-MSSM – very light h1 is allowed by LEP

SM Higgs-resonance decaying in bb -> extracting $\Gamma_{\gamma\gamma}$

Studies (simulations) for Mh=120 GeV:

- Ohgaki, Takahashi, Watanabe 1997
- Jikia, Soldner-Rembold 1999
- Asner, Gronberg, Gunion 2001
- Niezurawski, Zarnecki, MK 2002
- Moenig, Rosca 2003



Cross section x Br ~ 2 %

(+Br to bb from e+e-) → **3 % accuracy for $\Gamma_{\gamma\gamma}$**

In BSM $\Gamma_{\gamma\gamma}$ sensitive to SUSY particles, charged Higgs bosons charged new particles (new generations..). Large deviation from the SM arises for strongly interacting models

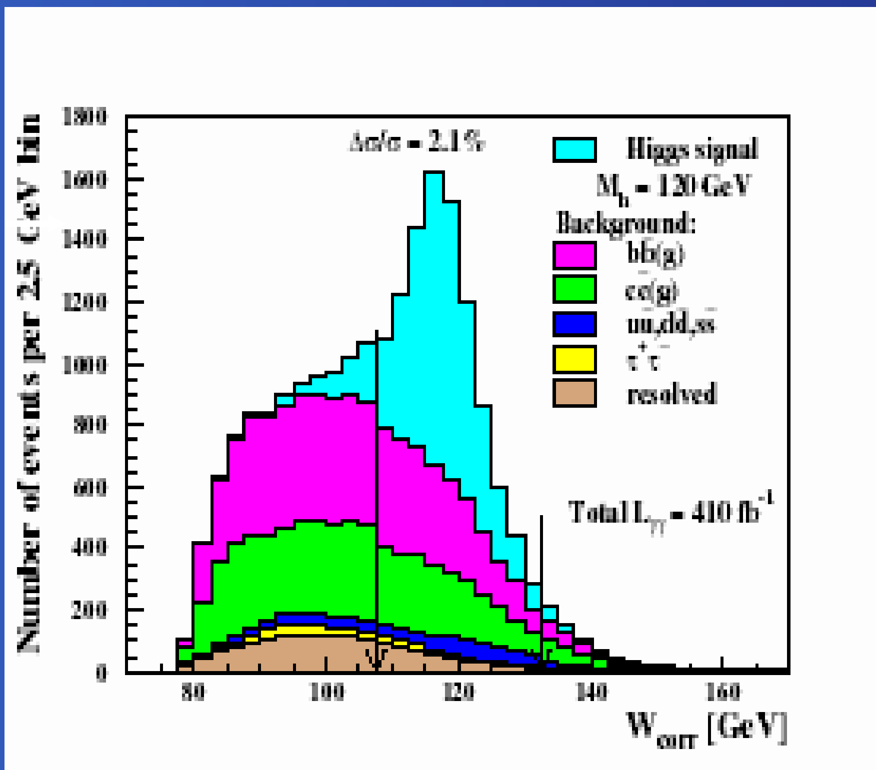
Distinguishing SM-like scenarios possible

Note that $h\gamma\gamma$ vertex has a phase !!

SM summary $\gamma\gamma \rightarrow h \rightarrow bb$

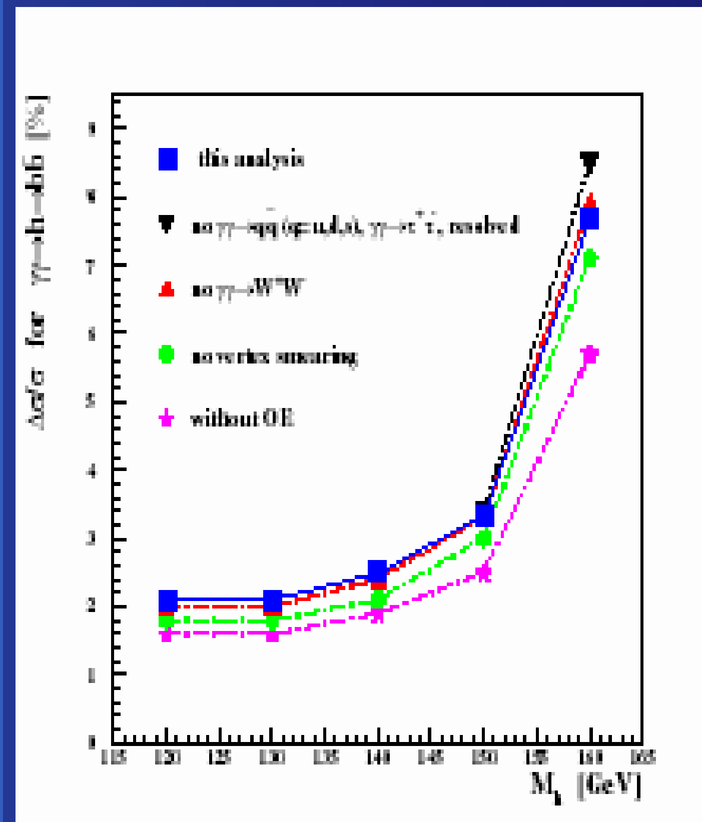
Niezurawski et al.,

Results for $M_h = 120$ GeV



Corrected invariant mass distributions for signal and background events

Results for $M_h = 120$-160 GeV



For $M_h = 150, 160$ GeV additional cuts to reduce $\gamma\gamma \rightarrow W^+W^-$

SM-like scenarios

- In many Standard Models
  SM-like scenarios are realized
  (Higgs mass >114 GeV, SM tree-level couplings
  or SM tree-level decay width)
- In models with two doublets:

- MSSM with decoupling of heavy Higgses

$\rightarrow$ *LHC-wedge*

- 2HDM with and without CP violation

both h or H can be SM-like

- Dark 2HDM (Intert Model)

Inert Model or Dark 2HDM

Ma..' 78, Barbieri.. ' 2006

- exact Z_2 in L and in vacuum →
  Z_2 parity – odd are only dark scalars

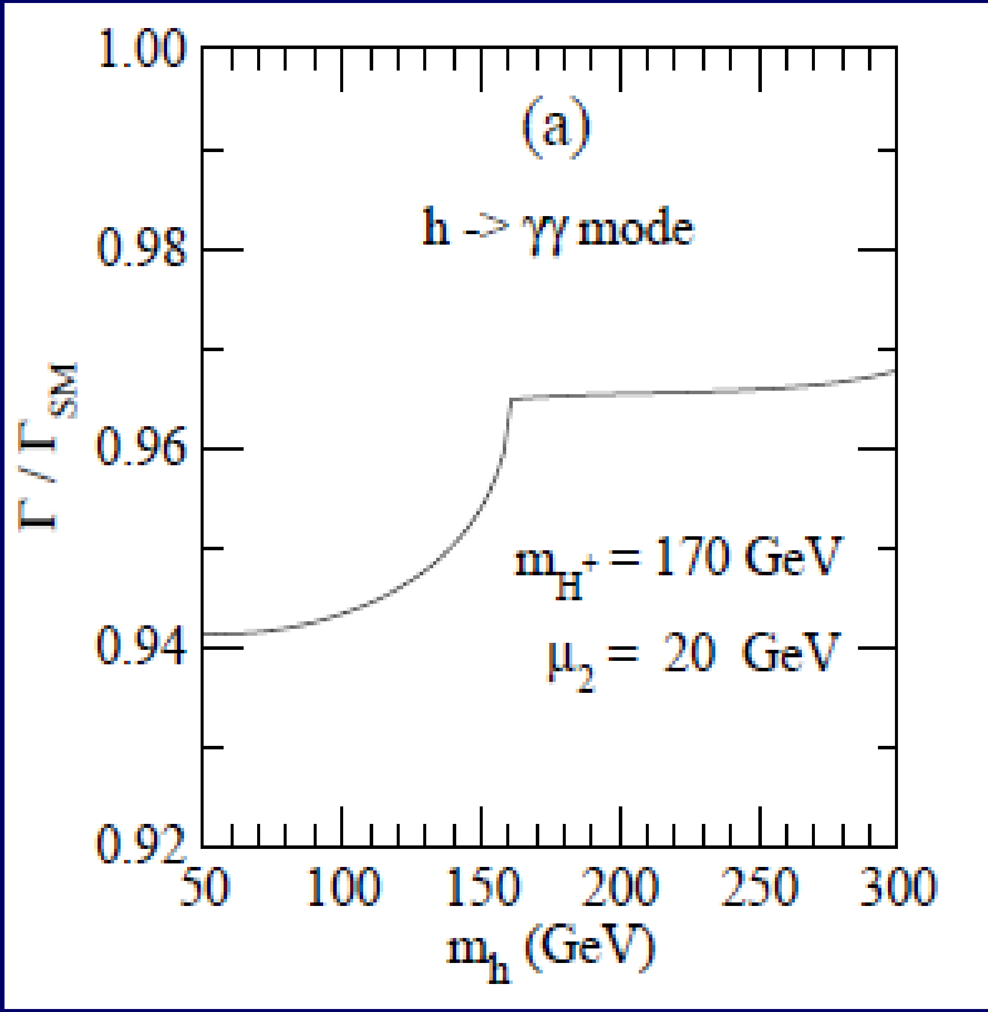
- nonzero vev only doublet Φ_1 → only it couples to fermions (Model I) → Higgs boson h SM-like

$$M^2_h = m_{11}{}^2 = \lambda_1 v^2$$

- four scalars from Φ_2 with Z_2-odd parity (dark scalars D) (no Yukawa interaction (so „inert"))

- the lightest dark scalar candidate for a dark matter
  here we consider H

Dark 2HDM: γγh

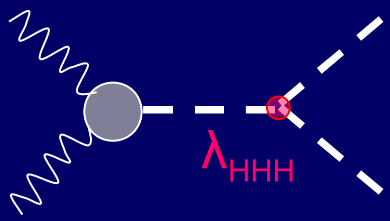


Measurement of Higgs self-coupling

E. Asakawa D. Harada S. Kanemura, Y. Okada , K. Tsumura

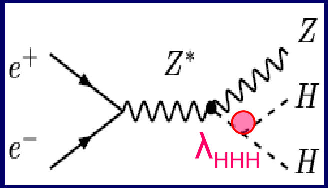
LEI 2007 Dec2007, Hiroshima

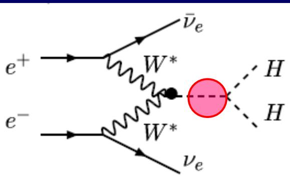
γγ→HH at PLC.



And we try to answer a question:

Comparing with ILC,





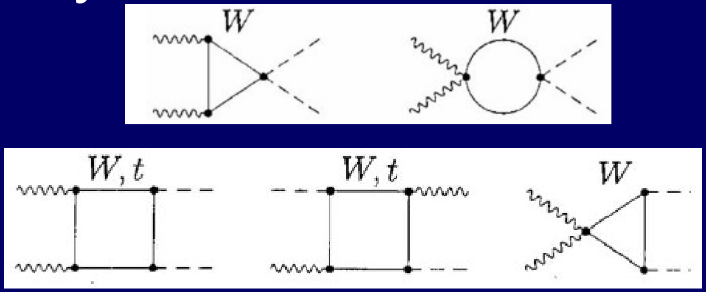
Superior?
Comparable?
Complement?

seem-to-be advantage

- 2 body final state
- Polarization (J_Z=0)

seem-to-be disadvantage

- Large contribution from box diagrams
- Luminosity



For 2HDM -

Cornet, Hollik 0808.0719[hep-ph]

Asakawa at al. 0809.0094[hep-ph]