

Higgs@CLIC

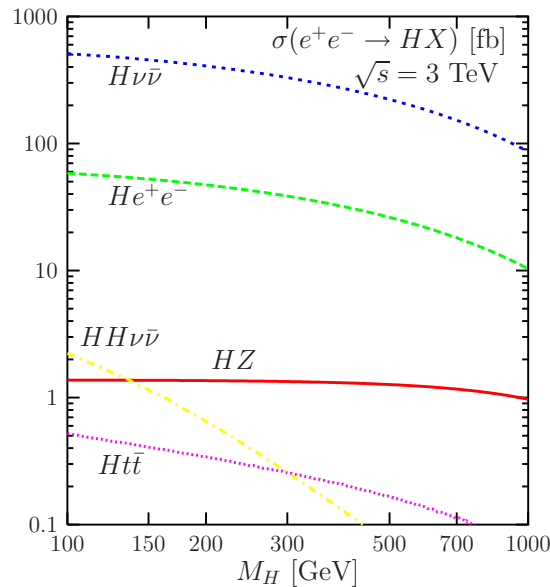
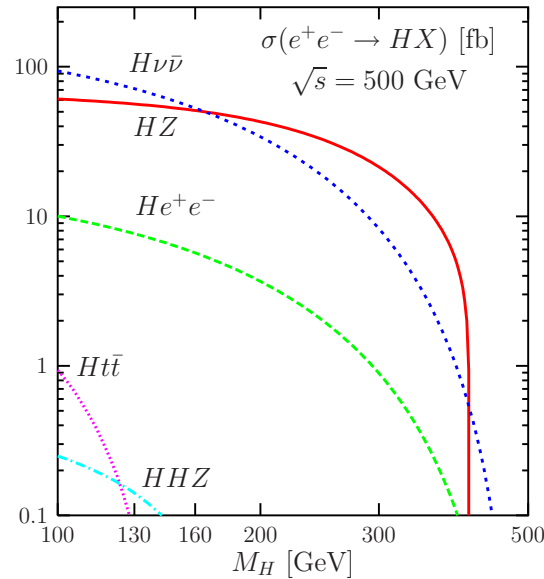
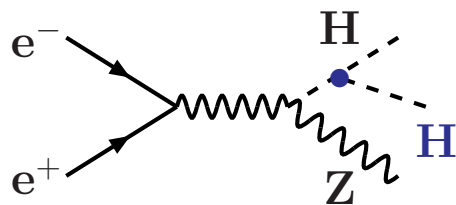
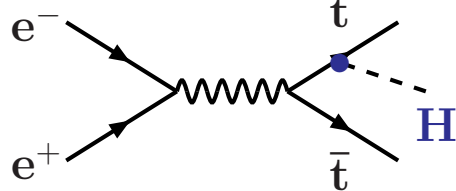
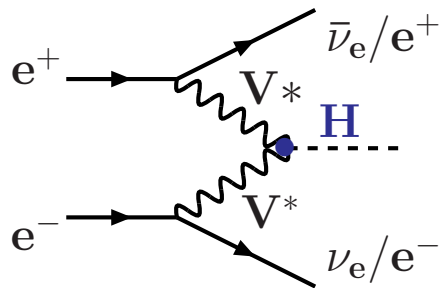
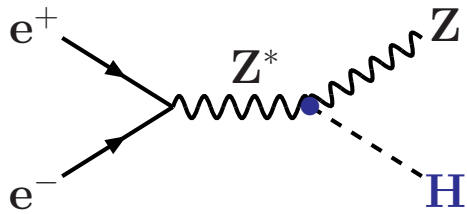
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Working Group: Marco Battaglia,

- The Higgs in the SM
- The Higgses of the MSSM
- The Higgs sector in other scenarios
- Discussions/suggestions

The Higgs in the SM



Very precise measurements mostly at $\sqrt{s} \lesssim 500$ GeV mainly in $e^+e^- \rightarrow ZH$ (which has $\sigma \propto 1/s$)

| | |
|-----------------|--------------|
| g_{HWW} | ± 0.012 |
| g_{HZZ} | ± 0.012 |
| g_{Hbb} | ± 0.022 |
| g_{Hcc} | ± 0.037 |
| $g_{H\tau\tau}$ | ± 0.033 |
| g_{Htt} | ± 0.030 |
| λ_{HHH} | ± 0.22 |
| M_H | ± 0.0004 |
| Γ_H | ± 0.061 |
| CP | ± 0.038 |

\Rightarrow difficult to beat (except for g_{HWW} ...)

Unless very heavy Higgs...

The Higgs in the SM

Measurements which need the high cross section of $e^+e^- \rightarrow H\nu\bar{\nu}$:

- $\text{BR}(H \rightarrow \mu^+\mu^-) \propto 10^{-4}$

Higgs couplings to 2d generation

- $\text{BR}(H \rightarrow \gamma Z) \propto 10^{-3}$

complementary/same(?) to $H\gamma\gamma$

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- Trilinear Higgs couplings

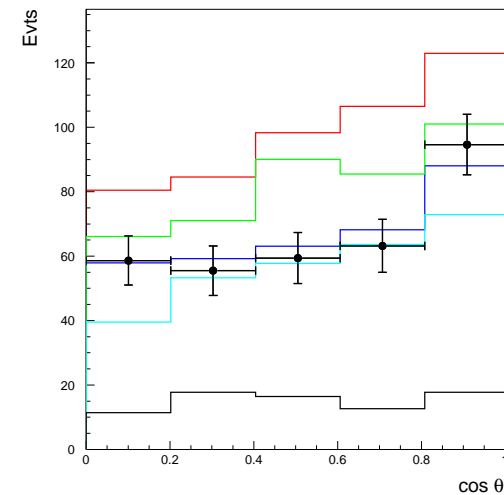
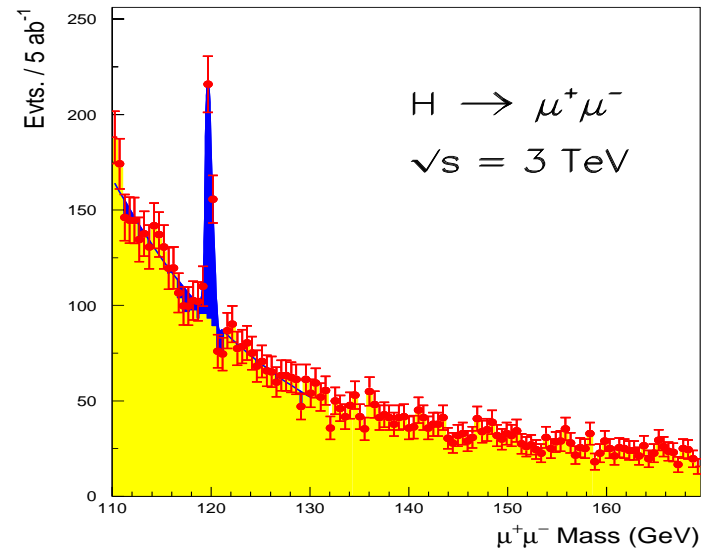
$e^+e^- \rightarrow W^*W^* \rightarrow HH\nu\nu$

– stats better than $HZ@500$ GeV

– additional info/separation (θ^*)

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with a high lumi needed, a few ab^{-1}



Borrow material from previous CLIC study, hep-ph/0412251.

The Higgs in the SM

Other topics to be covered

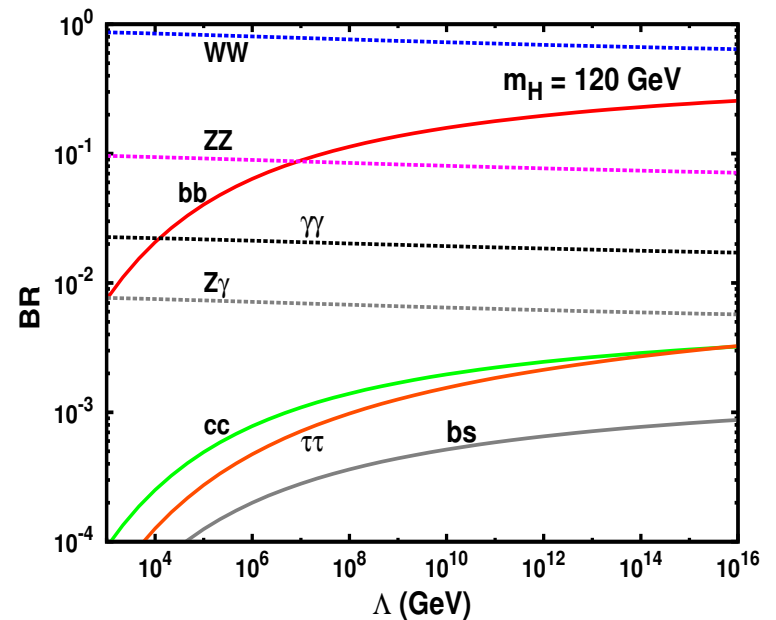
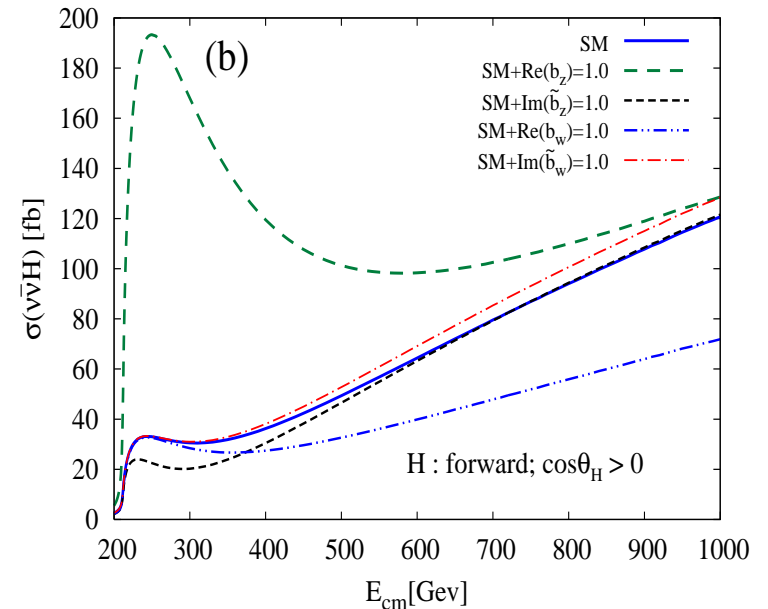
- Anomalous Higgs couplings
some (eg. CPV) need high \sqrt{s}
⇒ **Godbole et al.**

- $e^+e^- \rightarrow ttH$:
Determination of Higgs CP from:
 - total cross section,
 - top polarization and FB asymmetry
 ⇒ **Muhlleitner et al.**

- Trilinear Higgs couplings
 - with anomalous couplings
 - composite Higgs models
 ⇒ **Groeber+Muhlleitner**

- Effective Yukawa couplings:
 - Hbb couplings vs NP scale
 - FCNC Higgs decays
 ⇒ **Gabrielli+Mele**

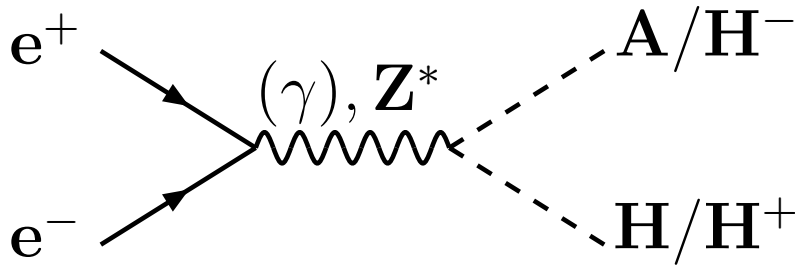
Report/with the Alternative group...



The Higgses of the MSSM

5 Higgs states: h, H, A, H^\pm

- For h , same as SM Higgs
- H, A, H^\pm : additional channels:



Decoupling: $M_H \approx M_A \approx M_{H^\pm} \gg M_Z$
 Kinematical reach: $M_\Phi \approx \frac{1}{2}\sqrt{s}$
 At CLIC: $M_\Phi \approx 1.5$ TeV (beyond LHC).

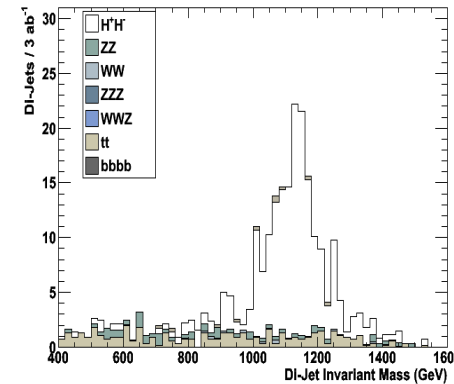
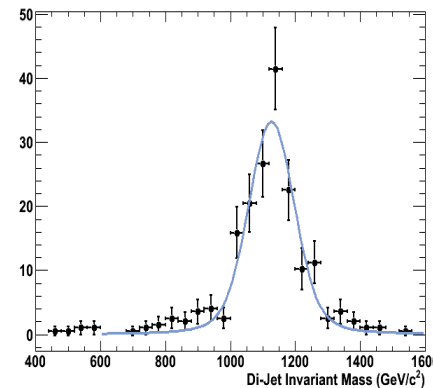
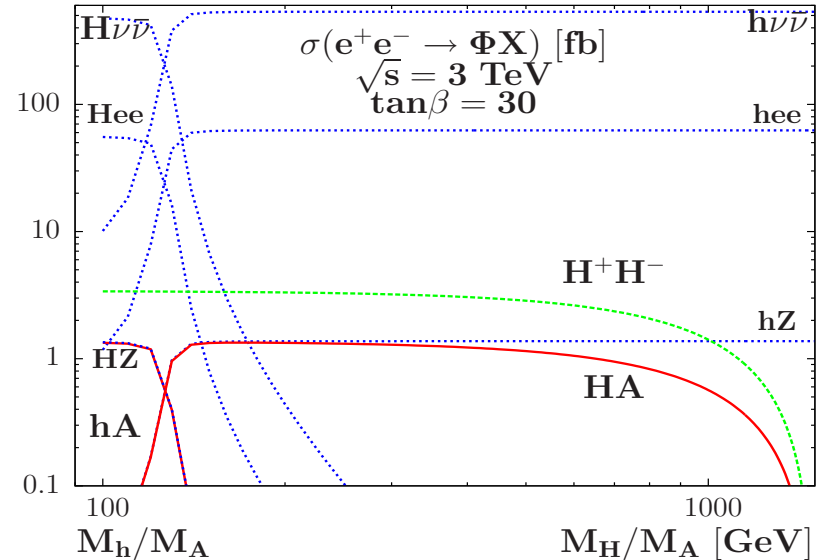
Full simulation for H^+H^- (MB)

– Mass fit to $H^+H^- \rightarrow t\bar{t}b\bar{b}$ signal

$$M_{H^\pm} = 1136 \pm 5.5 \text{ GeV}$$

– Di-jet mass for H^+H^- and signal events after kinematic fitting

Same simulation for $e^+e^- \rightarrow HA$



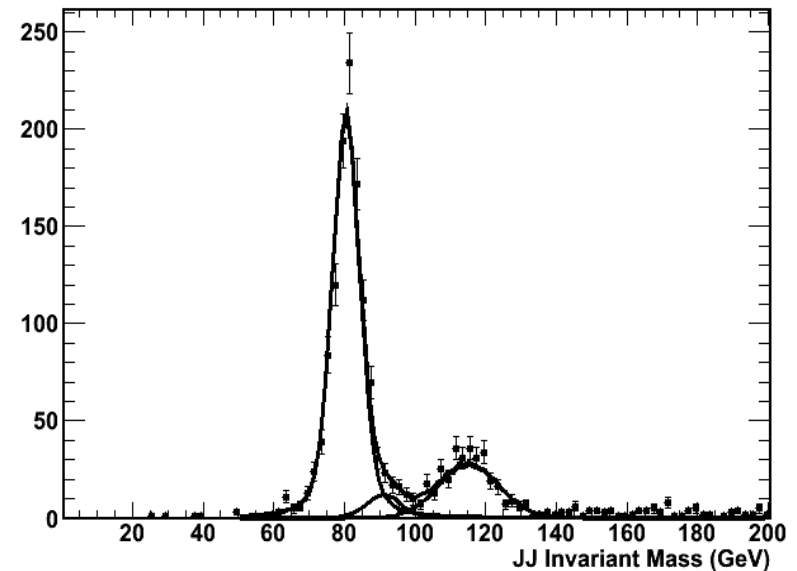
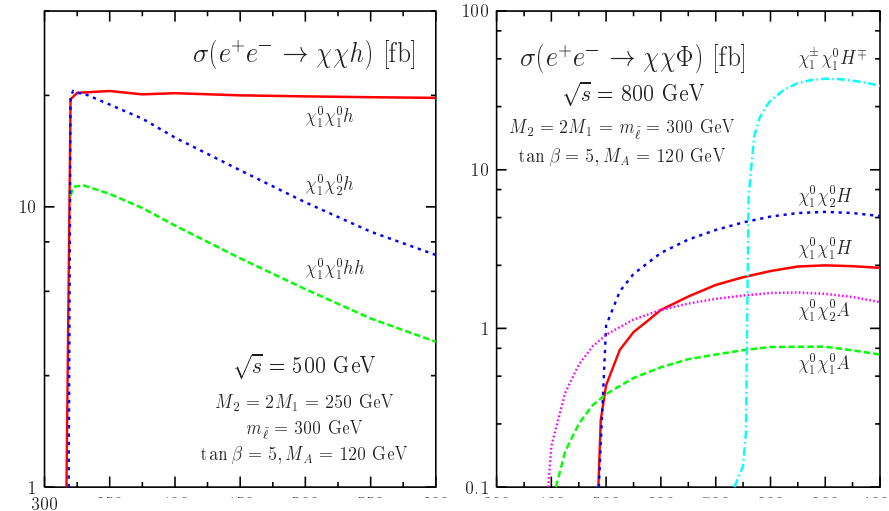
The Higgses of the MSSM

- Cascade decays of SUSY particles
 - charginos/neutralinos to Higgs (probes H couplings to sparticles)
 - stop2 to stop1 and a Higgs (good measurement of trilinear A_t)

Again full simulation:

- $$e^+e^- \rightarrow \chi_2^0\chi_2^0 \rightarrow \chi_1^0 h \chi_1^0 h$$
- $$\Rightarrow 4b + \mathbf{E}_T^{\text{miss}} \text{ final states}$$
- (in full inclusive SUSY events)
- di-jet invariant mass distr. (with ISR and beamstrahlung)
 - Higgs energy distribution

M. Battaglia



The Higgses in other scenarios

Dream scenario: new Z' at 3 TeV

CLIC@ $M_{Z'}$ \Rightarrow a Higgs factory!

Z - Z' -Higgs coupling via mixing

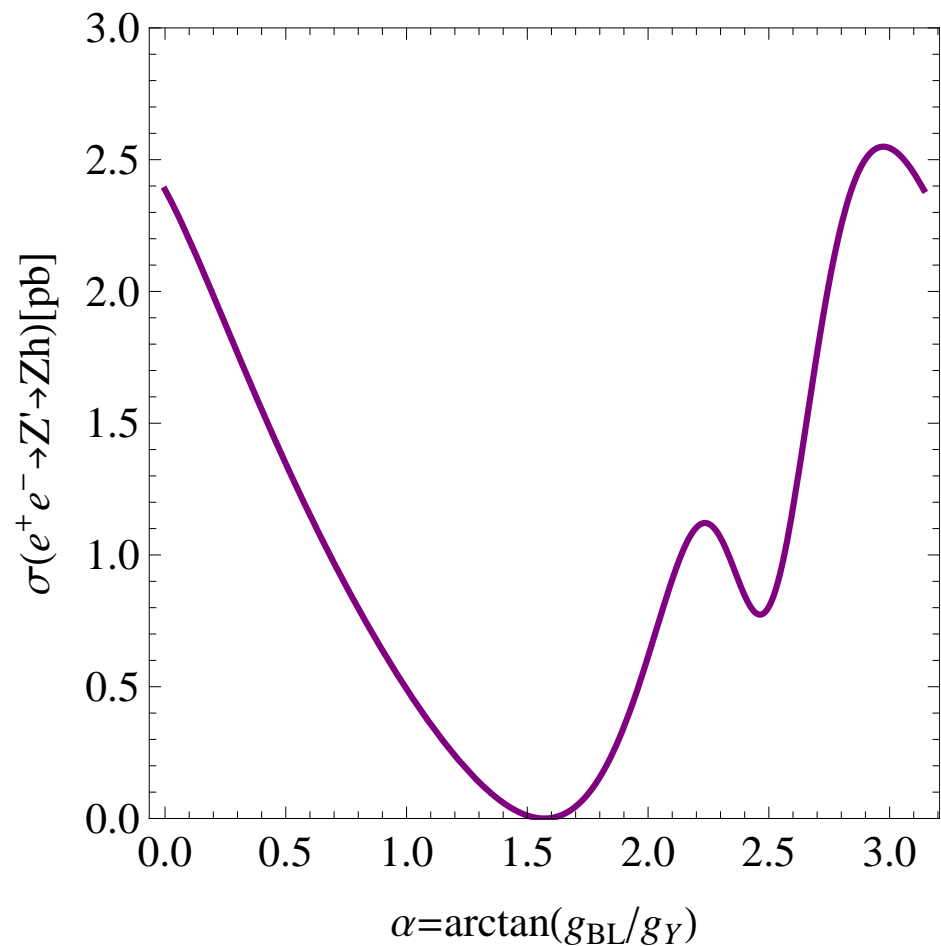
but $\Gamma(Z' \rightarrow Z_L h) \propto M_{Z'}^2 / M_Z^2$

$$\sigma \propto \frac{\text{BR}(Z' \rightarrow ee)\text{BR}(Z' \rightarrow Zh)}{M_{Z'}^2}$$

- **Example: minimal Z' model**
- 1 U(1), 1 SM-like h , no new f ,
- 2 cplgs: $g_Y, g_{B-L} = g_{Z'}$, $\tan\alpha$
- weak depend. on $g_{Z'}$, M_h
- dependence on α shown \longrightarrow
- up to $\mathcal{O}(1)$ pb cross section!**
- largest source of Higgses,
- probes Z - Z' mixing angle,
- discriminates between models.
- **To come: $Z' \rightarrow H\gamma, HZ$**
- **Same for Z_{KK}, Z_H, \dots**

$$\sqrt{s} = M_{Z'} = 3 \text{ TeV}$$

$$M_{h_{\text{SM}}} = 120 \text{ GeV}$$



Ennio Salvioni

Discussion/Suggestions

Comments on the previous items:

- There are full simulations for the main new physics points: the SUSY processes $e^+e^- \rightarrow HA, H^+H^-$ and SUSY \rightarrow Higgs.
- There are previous detailed studies for some relevant points: measurement of $\lambda_{HHH}, BR(H \rightarrow \mu^+\mu^-, Z\gamma)$
- Missing study (benchmark group?): critical study of $e^+e^- \rightarrow \nu\bar{\nu}H$
- Overlap with Alternative group for (anomalous) coupling issue..

Any other items to be studied?

- Heavy singlet Higgs boson discovery (any volunteer?).
- SUSY Higgs sector beyond MSSM.
- stop2 (stau2) decay into stop1 (stau1) and a Higgs.
- Strongly interacting Higgs sector (together/for Alternative group?).
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