

Egypt: Current status and future perspectives

Celebration of the discovery of the Higgs boson Anniversary from Africa

Ahmed Ali Abdelalim^{1,2}

¹*Zewail City of Science and Technology, Giza, Egypt.*

²*Physics Department, Faculty of Science, Helwan University, Cairo, Egypt.*

July 4th, 2022



Current ongoing Higgs analysis

1. The BLSSM Higgs sector ($\gamma\gamma$ decay of a light Higgs)-arXiv :2012.04952 [hep-ph]

Ahmed Ali Abdelalim, Biswaranjan Das, Shaaban Khalil, Stefano Moretti

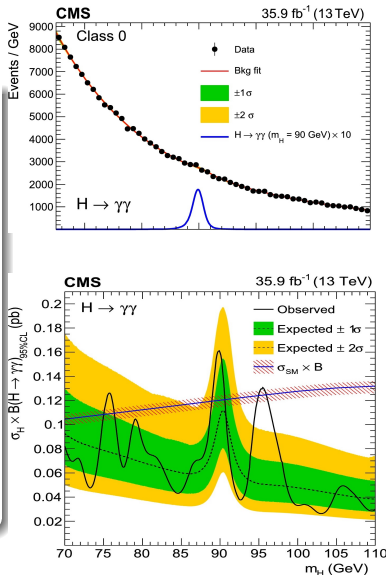
The $B - L$ Supersymmetric SM (BLSSM)

In the context of the $B - L$ Supersymmetric Standard Model (BLSSM), we investigate the consistency of a light Higgs boson, with mass around 95 – 97 GeV, with the results of a search performed by the CMS collaboration in the di-photon channel at the integrated luminosity of 35.9 fb^{-1} and $\sqrt{s} = 13 \text{ TeV}$.

CMS Collaboration, Phys. Lett. B 793, 320 (2019).

Based data-sets of size 19.7 and 35.9 fb^{-1} at $\sqrt{s} = 8$ and 13 TeV respectively, the CMS collaboration found potential signals for another neutral Higgs boson, h' , with a mass of 95 to 97 GeV, precisely in the $gg \rightarrow h' \rightarrow \gamma\gamma$ channel.

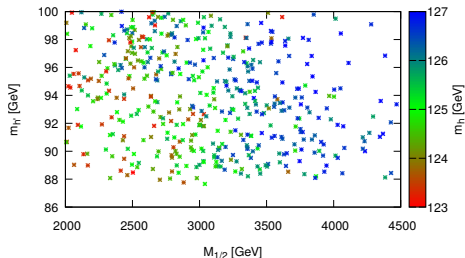
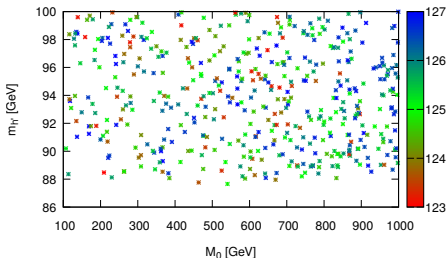
The upper limit on $(\sigma \times BR)$, normalized to that for a standard model-like Higgs boson, is in the range 0.7-0.2, with two notable exceptions : (1) in the region around the Z boson peak, where the limit rises to 1.1, which may be due to Drell–Yan dielectron production where electrons could be misidentified as isolated photons, (2) due to an observed excess with respect to the SM prediction, which is maximal for a mass hypothesis of 95.3 GeV with a local (global) significance of 2.8 (1.3) standard deviations.



Scanning the Parameters Space was done at the GUT scale by varying four input parameters :

- The universal Soft SUSY-Breaking (SSB) scalar mass term, M_0 ($= M_{Q_{1,2,3}} = M_{U_{1,2,3}} = M_{D_{1,2,3}} = M_{L_{1,2,3}} = M_{E_{1,2,3}}$), range [100-1000] GeV.
- The universal SSB gaugino mass term $M_{\frac{1}{2}}$ ($= 2M_1 = M_2 = \frac{1}{3}M_3$), range [1000-4500] GeV.
- $\tan\beta$ range [1-60] GeV.
- The universal Higgs to sfermion trilinear coupling A_0 ($= A_{\tilde{t}} = A_{\tilde{b}} = A_{\tilde{\tau}}$), range [1000-4000] GeV.
- All other model parameters are kept fixed, e.g., $m_{Z'} = 2500$ GeV, $\tan\beta' = 1.15$ and $\mu = \mu' = B_{\mu} = B_{\mu'} = 0$.
- The lightest neutral Higgs boson mass in the range $95 \text{ GeV} \geq m_{h'} \geq 97 \text{ GeV}$. the second lightest (SM-like) Higgs boson with a mass m_h which allows ± 2 GeV uncertainty in its theoretical prediction, about the experimental measurement of $m_h = 125.09 \pm 0.32$.

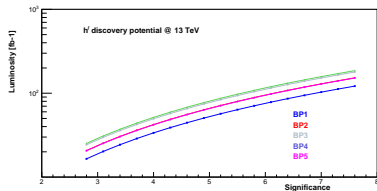
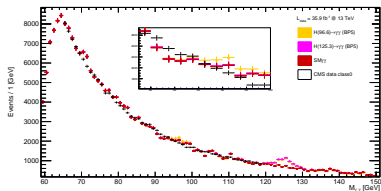
Moreover, the scanned points are tested to be consistent with the Higgs boson experimental measurements performed by the LEP, TeVatron and the LHC. They also need to satisfy the experimental constraints on the Branching Ratios (BRs) of the most stringent B -meson decay channels within a 2σ error, which are given by $\text{BR}(B \rightarrow X_s \gamma) = (3.32 \pm 0.15) \times 10^{-4}$, $\text{BR}(B_s \rightarrow \mu^+ \mu^-) = (3.1 \pm 0.6) \times 10^{-9}$ and $\text{BR}(B_u \rightarrow \tau^\pm \nu_\tau) = (1.06 \pm 0.19) \times 10^{-4}$.



BP	$m_{h'}$	m_h	$\sigma(pp \rightarrow h' \rightarrow \gamma\gamma)$	$\sigma(pp \rightarrow h \rightarrow \gamma\gamma)$	$\tilde{\mu}$
1	95.3	125.9	13.1	43.5	0.43
2	96.1	125.9	13.2	43.8	0.44
3	96.2	126.1	13.5	43.4	0.45
4	96.3	125.4	10.0	49.0	0.33
5	96.6	125.3	13.0	44.7	0.43

Table – The masses (in GeV) of the two lightest neutral Higgs bosons and the cross sections (in fb) at 13 TeV for the processes $pp \rightarrow h' \rightarrow \gamma\gamma$ and $pp \rightarrow h \rightarrow \gamma\gamma$ for the selected BPs. The last column shows the corresponding $\tilde{\mu}$ values, the ratios $\sigma(pp \rightarrow h' \rightarrow \gamma\gamma) / \sigma(pp \rightarrow h'_{\text{SM}} \rightarrow \gamma\gamma)$, where h'_{SM} is a SM-like state with mass equal to $m_{h'}$, illustrating that our h' state is always significantly weakly coupled to gluons and photons.

- Event Reconstruction : all events have to have :
 - di-photon with $|\eta^\gamma| \leq 2.5$ and out of the crack region between the barrel and end-cap parts of the CMS EM-calorimeters.
 - p_T leading photon in the pair has to have $p_T^{\gamma 1} / M_{\gamma\gamma} > 30.6/65.0 = 0.47$.
 - p_T next-leading photon in the pair has to have $p_T^{\gamma 2} / M_{\gamma\gamma} > 18.2/65.0 = 0.28$.
- Results :



- Conclusions : Integrated luminosity needed for a 5σ discovery of such h' state in the above channel, which turned out to be less than the total Run 2 data sample.

2. Higgs self-coupling and Dark Matter Searches

(Reham Aly, Walaa Elmetnawy, Aya Beshr, Ahmed Ali Abdelalim, Shaaban Khalil)

- Search for dark matter produced in association with a Higgs boson for CMS Run II data.
- Search for dark matter produced in association with a Higgs boson for FCC. - Studing the Higgs self-coupling.

Current ongoing Higgs analysis

3. Rare Exotic Higgs Decay - (preprint)

Abdulrahman Mohamed, Ahmed Ali Abdelalim

- Aim : The aim of this research is to extend the studies of Higgs-boson decays into a single vector meson and a photon ($h \rightarrow V\gamma$) under the FCC-ee conditions and investigate the possibility of using these processes to probe the light-quark Yukawa couplings.

Conclusions

- ENHEP : contains 7 physicists (2 theoretical and 5 experimental) and 10 (PhD and MSc) active students.
- Fayoum University : contains 4 physicists and 10 (PhD and MSc) active students.

Thank you