Letter of Interest concerning group F08

What can we expect at an e+e- TeV collider from LHC indications for new heavy scalars ?

F. Richard August 2021 (updated version)

Introduction

- The general mood in HEP is that we should expect nothing new and be content with precision measurements
- In that case an e+e- collider reaching the top threshold is sufficient
- The selling argument for a Linear Collider is its **expandability in energy** to cope with unforeseen discoveries from LHC
- If these discoveries are to occur in the present machine, there should already be **some indications** in the present data (not yet fully analysed)
- I have decided to look into the LHC searches for new scalars and had **some surprises**
- I will therefore briefly summarize these findings and give a brief evaluation of the **rates and backgrounds at an e+e- LC**

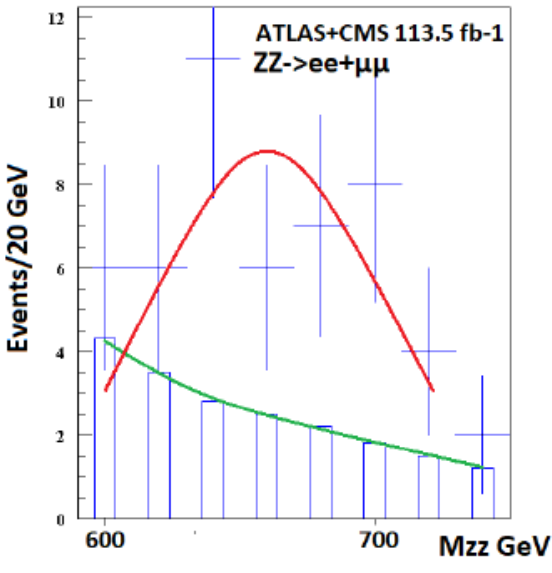
Three Arxiv papers already describe this work:

- https://arxiv.org/abs/2001.04770
- https://arxiv.org/abs/2003.07112
- https://arxiv.org/abs/2103.12639

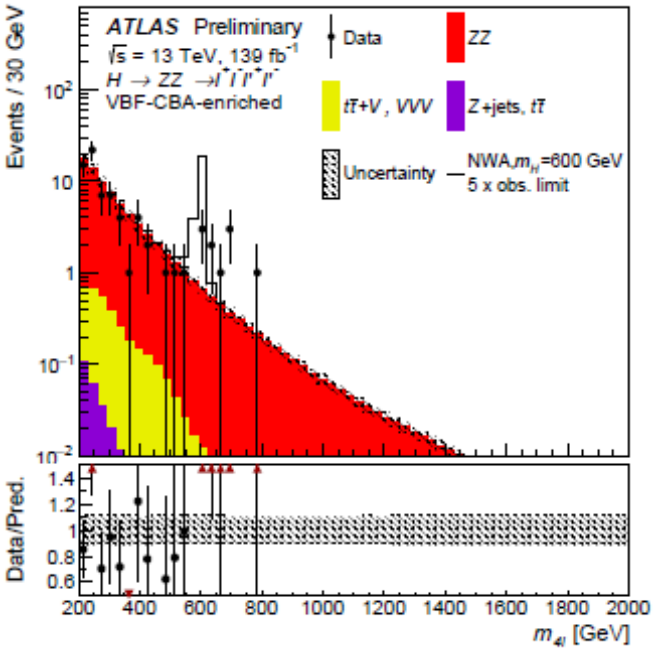
Presented at **International Workshop on Future Linear Colliders, LCWS2021**

H(660) in 4 leptons

- Paolo Cea, a physcist from Bari, had a look at the data from CMS and ATLAS and found coincidental fluctuations at ~700 GeV



- I did the same and found the following combined result which indeed suggests a bump at 660 GeV with a ~100 GeV width (see figure)
- This indication is observed by ATLAS in ZZ/WW fusion



- Not seen in tt (but ggF suggests there is coupling), nor in **WW** (2HDM !)

A(400) in 4 independent channels

- A ttbar paper from CMS has claimed a 3.5 sd at ~400 GeV
- CMS took into account interference with the QCD background (major handicap of LHC)
- Signals were observed by ATLAS in tt, tt+b and in hZ + b
- **4 signals at ~3 sd, result in >5 sd when combined**

Reaction	Mass GeV	Nb of s.d.	Ref ArXiv
X(400)->tt	400	3.5	*1908.01115*
X(400) ->ττ	400	2.2	*2002.12223*
X(400)->ττ+b	400	2.7	*2002.12223*
A(400)->h(125)Z+b	440	3.6	*1712.06518*
X(400) + high pt e/μ	400	3	*2002.11325*

Global interpretation

- The Georgi Machacek model rightly describes these observations (see 2103.12639)
- It predicts cascades which should reflect into excesses in the ttW, ttZ and tttt
- It qualitatively explains the various excesses observed in *1901.05300*

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Selection	Best-fit β_g^2	Significance
ATLAS Run 1 SS $\ell\ell$ and $\ell\ell\ell$ + b-jets	6.51 ± 2.99	2.37σ
ATLAS Run 1 OS $e\mu$ + b-jets	4.09 ± 1.37	2.99σ
CMS Run 2 SS $e\mu$, $\mu\mu$ and $\ell\ell\ell$ + b-jets	1.41 ± 0.80	1.75σ
CMS Run 2 OS $e\mu$	2.79 ± 0.52	5.45σ
CMS Run 2 $\ell\ell\ell + E_{\mathrm{T}}^{\mathrm{miss}}$ (WZ)	9.70 ± 3.88	2.36σ
ATLAS Run 2 SS $\ell\ell$ and $\ell\ell\ell$ + b-jets	2.22 ± 1.19	2.01σ
ATLAS Run 2 OS $e\mu$ + b-jets	5.42 ± 1.28	4.06σ
ATLAS Run 2 $\ell\ell\ell + E_{\mathrm{T}}^{\mathrm{miss}}$ (WZ)	9.05 ± 3.35	2.52σ
Combination	2.92 ± 0.35	8.04σ

The simplidied model seems to describe the discrepancies in different corners of the phase-space with large differences in cross-sections, eg, OS and SS di-leptons

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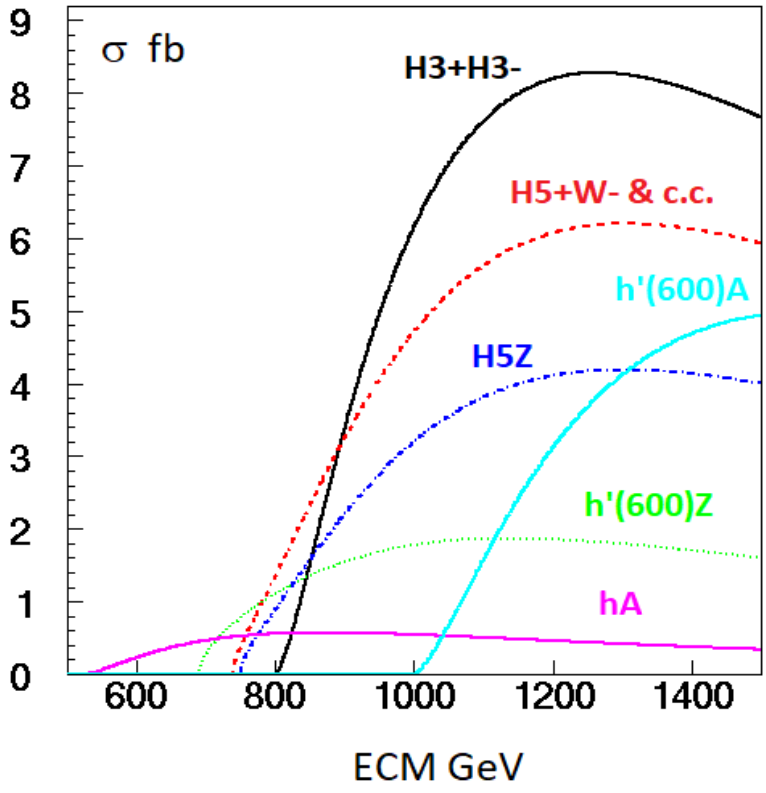
Prospects for e+e- discoveries



- Most masses are predicted
- At least 1 TeV needed, preferably 1.5 TeV to observe H++

Conclusions

- There is hope for LHC discoveries in a near future and one is eagerly awaiting for full analysis and professional data combinations
- Eager to see missing analyses and HL-LHC
- Possible interpretation of these signals within the Georgi Machacek model