

Search of BSM physics in Higgs sector with CMS detector

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The CMS detector:



Data collected:

CMS Integrated Luminosity, pp, 2012, $\sqrt{s}=$ 8 TeV



CMS Integrated Luminosity, pp, 2015, $\sqrt{s}=$ 13 TeV



• Run 1

- LHC: 6.13 fb⁻¹ in 2011 and 23.30 fb⁻¹
 in 2012
- CMS recorded: 5.5 fb⁻¹ recorded in 2011 and 21.79 fb⁻¹ in 2012
- Run 2
 - LHC delivered: 4.22 fb⁻¹
 - CMS recorded @ 3.8 T : 2.8 fb⁻¹

<u>13TeV vs 8TeV:</u>

Gluon fusion and VBF production get 2.6x boost relative to 8 TeV ⇒Discovery channels visible with ~5fb⁻¹

data analyzed in the following slides = run I data: 5.1 fb⁻¹ in 2011 and 19.7 fb⁻¹ in 2012

BSM physics in Higgs sector:

• Test the discovered Higgs at 125 GeV:

- Is Higgs deviating from SM ?
 ⇒ measure Higgs properties
- Exotic decays of the Higgs
- Search for Higgs as decay product of new particles



• Search for more Higgs

- ⇒ Various BSM models are predicting more than 1 Higgs:
- Additional EW singlet: h, H
- 2HDM (as MSSM): H, A, h, H⁺, H⁻
- NMSSM (2HD+singlet):
- Higgs triplet models (SM doublet + triplet):
 H⁺, H⁻, H⁺⁺, H⁻

organized here in 3 parts: -high mass (greater that 125 GeV boson) -low mass (lighter) -charged

Outline:

- Searches for exotic decay of the Higgs:
 - Higgs to Invisible
 - Lepton Flavour Violating decay
 - Higgs to light Higgs
- High mass searches:
 - high mass scalar resonance
 - MSSM neutral Higgs in ττ
 - production/decay in association with a Z
- Low mass searches:
 - h(125) in lighter neutral Higgs
 - 2 HDM low mass a in ττ
 - NMSSM low mass h in bb
- Charged Higgs searches:
 - H⁺⁻→τυ
 - H⁺→cs



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Searches for exotic decay of the Higgs:



Higgs to Invisible + y

Z



- the neutralino decays then in a gravitino + a photon
- 2 cases:
 - if $m_h/2 < m_{\chi_1} < m_h$: 1 photon produced
 - if $m_{\chi_1} < m_h/2$: 2 photons produced
- both ZH and ggH production are considered



- more that 1 γ with $E_T > 45 \text{ GeV}/c^2 + \text{MET}$





100

 $\widetilde{\chi}_{1}^{0}$ mass [GeV]

120

60

80





Η



Lepton flavour violating dec: VBF 1.878 · 10³ (exp.) 3.470 · 10³ (obs.)

• constraints on Yukawa couplings:



•

all

0.480 · 10⁻³ (exp.)

0.358 · 10⁻³ (obs.)





Search of a high mass scalar decaying in VV





Search of X—hh

- Tiny h→hh SM cross-section but can be signature for radion, KK or RS graviton
- 3 channels are used:
 - hh \rightarrow bbbb, hh \rightarrow bbtt (large branching fraction of h \rightarrow bb and h \rightarrow tt)
 - hh \rightarrow bbyy (h \rightarrow yy small but benefits of the clear m_{yy} resonance)





Pseudo-Scalar Decay in Z + h

Phys. Lett. B 748 (2015) 221 arXiv:1510.01181

- 2HDM at low tan β
- A \rightarrow Z+h (Z \rightarrow ee, µµ, vv), (h \rightarrow bb, $\tau\tau$)
- dominant for 220 GeV < m_A < $2m_t$ (ttbar decay not possible)
- search for a resonance in $m_{llbb}/m_{ll\tau\tau}$
- dominant production is $gg \rightarrow A$, narrow width approximation ($\Gamma_A/m_A < O(1\%)$)







Pseudo-Scalare Decay in Z + h



B(A

10





limite also produced for type-I 2HDM







CMS PAS HIG-15-001

limit on tanß vs cos(\beta-\alpha) for m_H =350GeV,m_A =150GeV



Low mass searches:

H(125) Decays in Ligher Neutral Bosons

- the H(125) can decay in lighter scalar bosons: $H\rightarrow a/h$
 - search for lighter scalar boson with low mass (~10 GeV)
 - \Rightarrow expected to be boosted



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Light Pseudo-Scalar in Association With a bbar Pair

- production of a light pseudo-scalar A associated with a bbar pair in a Type II 2 HDM context
- A $\rightarrow \tau\tau$:3 finals states considered
 - $e\tau_h$, $\mu\tau_h$ and μe

arXiv:1511.03610

19.7 fb⁻¹ (8 TeV)

CMS

10³



Light Neutral Higgs in SUSY Cascades:

- in NMSSM context
- search of a light neutral Higgs boson (h1) produced in SUSY cascades \overline{b}_{q}

- consider h1 decay in bbar
 - fit on m_{bb}
- NMSSM "P4" benchmark
 - h2 =h(125 GeV), h1 is mostly singlet i.e.
 suppressed couplings to V

q

- Interpretations:
 - Model independent limits on resonant production
 - MMSSM interpretation in 2 scenarios:
 - $M_3 = Mq = 1 \text{ TeV} \rightarrow \text{fully excluded}$
 - decoupled-squarks: vary M1, M2, M3



Charged Higgs searches:

$H^{+-} \rightarrow \tau v, H^{+-} \rightarrow tb$

• Two productions modes depending of $m_{\rm H}^{+-}$:



H⁺-→Tv, H⁺-→tb

Interpretation of the result in various benchmark scenarios: updated m_h^{max} , m_h^{mod+} , m_h^{mod-} , light stop, light stau, tau-phobic, and low-M_H







<u>Final state:</u> isolated lepton +>= 4 jets +large MET

- assumption of BR(cs)=100%
- tt fully reconstructed thanks to kinematic fits
 - relaxed constraint on mjj to match both
 W (background) and H⁺ mass



Conclusion:

- Large number of models tested → no sign of new physics yet:
 - Some models starting to be excluded
 - Many model starting to be tested (NMSSM)
 - Invisible decays of neutral Higgs probing O(30%) BR
- Run I data reaching O(fb) sensitivity on model independent limits on σxBR in many channels
- A lot of CMS run I results not presented in this talk
 - full list of results available <u>here</u>
- Starting to analyze run II data
 - Expand coverage of Run I with more low mass searches
 - Increase combined approach between exotica/SUSY/diboson searches and Higgs interpretations

Stay Tuned !

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