Phenomenology of doubly charged scalar bosons from the isospin doublet

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[arXiv:2102.12950]

1. Introduction

Doubly charged scalar

Y	2	3/2	1
Isospin	Singlet	Doublet $\Phi_{3/2}$	Triplet
Model	[A. Zee(1986)], [K.S. Babu(1988)]	[M. Aoki, et al. (2011)], [K. Enomoto, et al.(2019)]	Left-right model Type-II seesaw

. Collider phenomenology of $\Phi_{3/2}$ is not well known.

➡ Our work : Signal-background analysis for $\Phi_{3/2}$

2. Model

[M. Aoki, et.all (2011)]

- Model : Type-I 2HDM + $\Phi_{3/2}$

  ➡ Charged scalar $H_1^{\pm}$, $H_2^{\pm}$, $\Phi^{\pm\pm}$

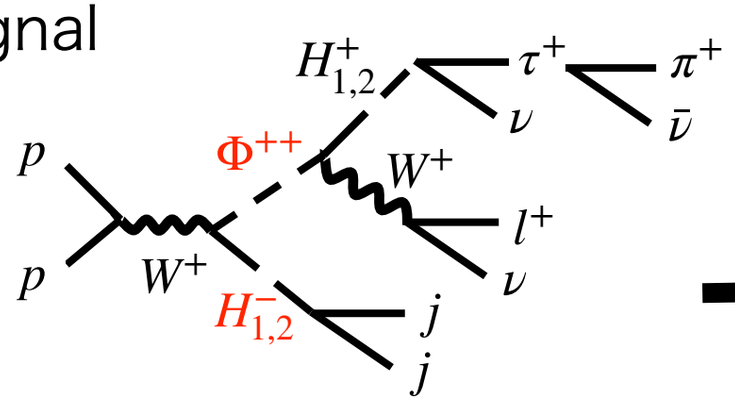
- Analyzed Scenarios

  Scenario I : $m_{H_{1,2}} < m_t + m_b$

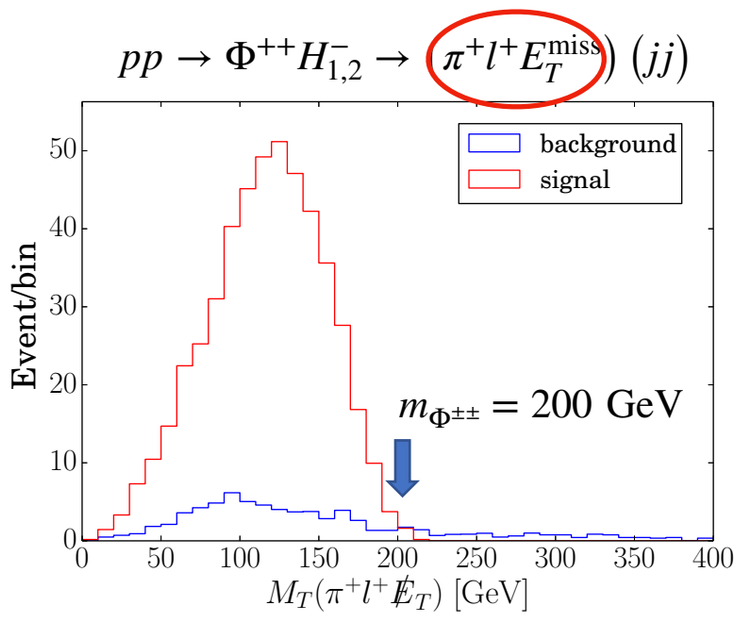
  Scenario II : $m_{H_{1,2}} > m_t + m_b$

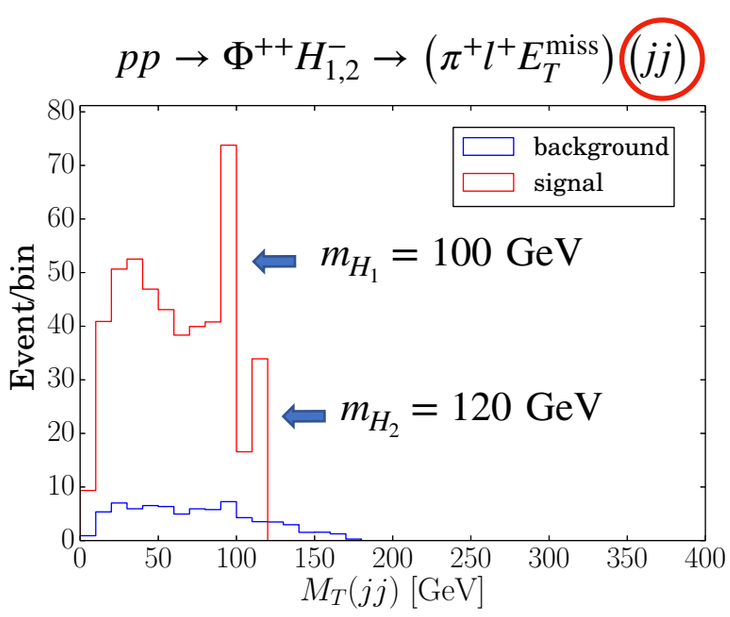
3.Signal vs. Background @ HL-LHC (Scenario I)

Signal



With
- transverse mass
- kinematical cut





4. Summary

. $\Phi_{3/2}$ is introduced in some models. But, its collider phenomenology is not well known.

. $H_1^{\pm}$, $H_2^{\pm}$, $\Phi^{\pm\pm}$ are expected to be detectable at HL-LHC.

Scenario I

1. Input

$$m_{H_1^\pm} = 100\ \text{GeV},\ \ m_{H_2^\pm} = 120\ \text{GeV},\ \ m_{\Phi^{\pm\pm}_{3/2}} = 200\ \text{GeV}$$

$$\sin(\alpha-\beta) = 1,\ \ \tan\beta = 10,\ \ \chi = \pi/4$$

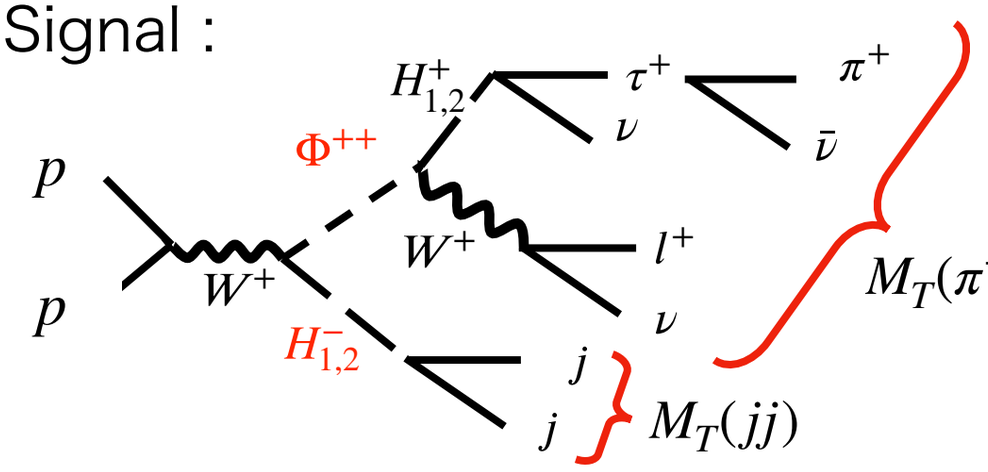
2. Main decay

$$\Phi^{\pm\pm} \to H^\pm_{1,2} W^\pm$$

$$H^\pm_{1,2} \to \tau\nu,\ cs$$

3.Signal vs. Background @ HL-LHC

Signal :



- Transverse mass $M_T^2 = \left(\sum_i E_{iT}\right)^2 - \left(\sum_i \vec{p}_{iT}\right)^2$

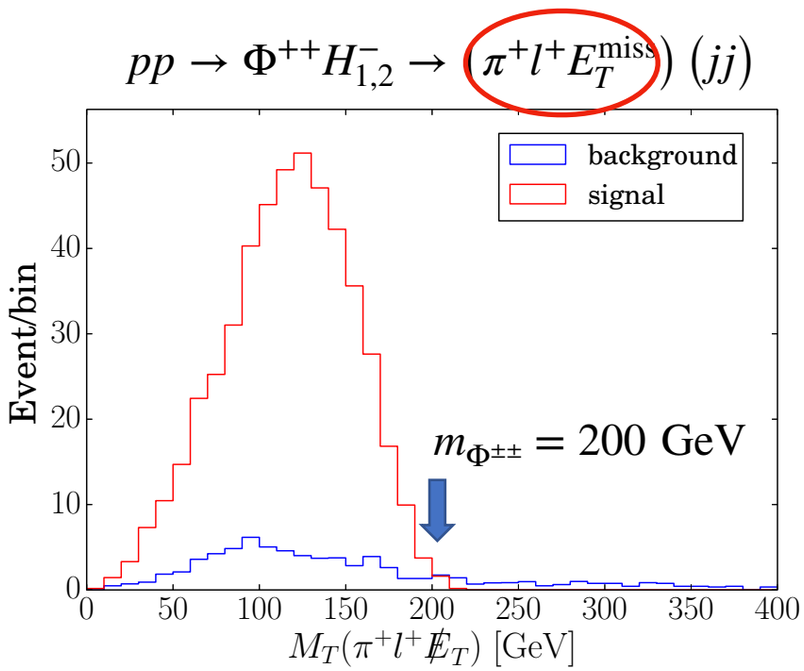
→ "Jacobian peak" @ $M_T \approx M$

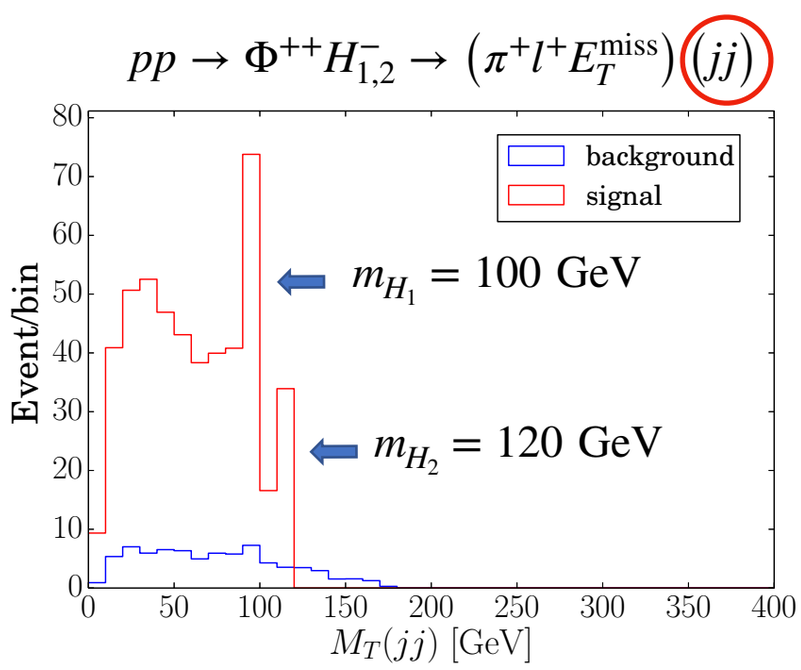
$M_T \le M$: end-point is M

- Kinematical cut : $90\ \text{GeV} < M_{jj} < 180\ \text{GeV}$,

$\Delta\eta_{jj} < 2.5,\ \Delta R_{jj} < 2$

→ Signal：82%　Background：2%





Event #

S	B	Significance
487	75	20

Three Jacobian peaks from this signal

Scenario II

1. Input

$$m_{H_1} = 200\,\text{GeV},\ \ m_{H_2} = 250\,\text{GeV},\ \ m_{\Phi} = 300\,\text{GeV}$$

$$\sin(\alpha-\beta) = 1,\ \ \tan\beta = 3,\ \ \chi = \pi/4$$

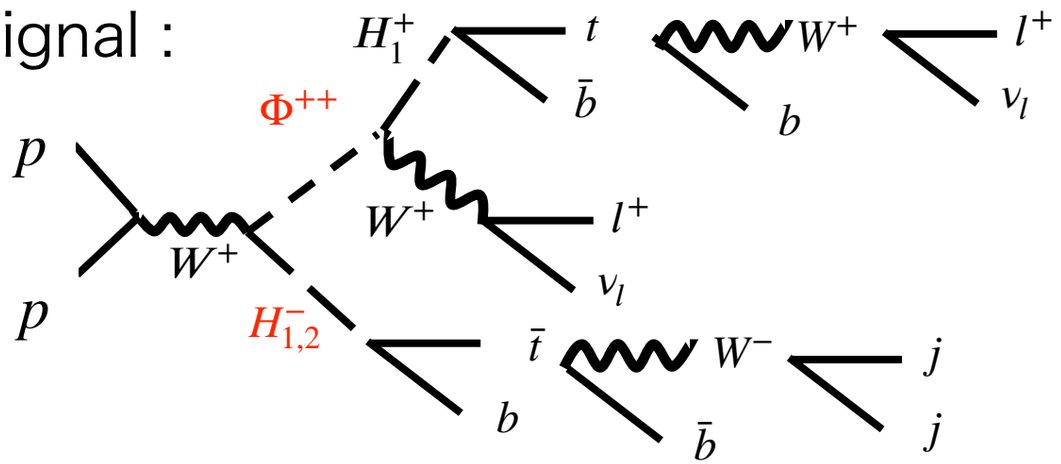
2. Main decay

$$\Phi^{\pm\pm} \to H^{\pm}_{1,2} W^{\pm}$$

$$H^{\pm}_{1,2} \to tb \to (Wb)b$$

3.Signal vs. Background @ HL-LHC

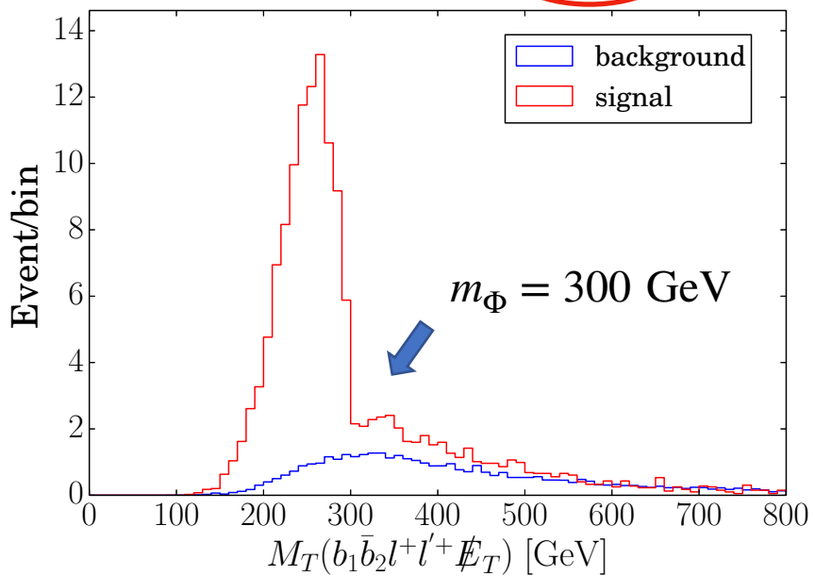
Signal :



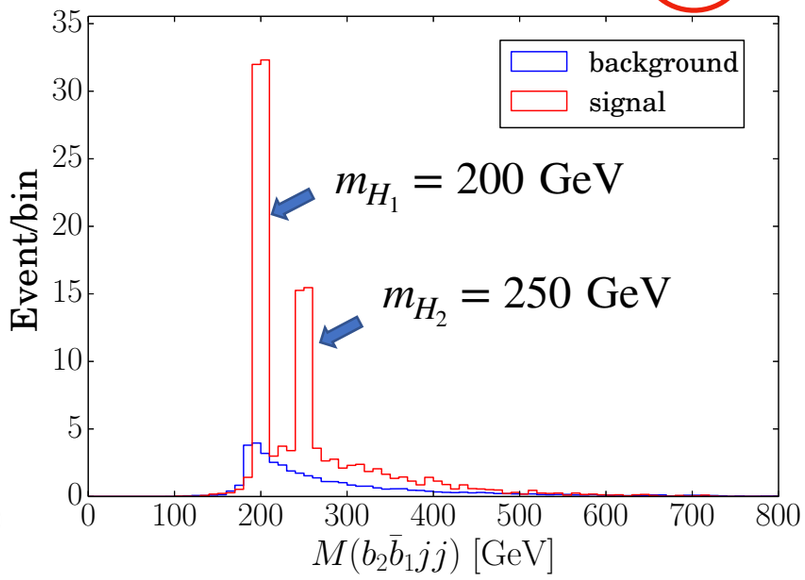
- Significance : 11
- Distinction of b : comparison of p_T

$$m_{H_{1,2}} - m_t - m_b \gtrless m_t - m_W - m_b$$

$pp \to \Phi^{++}H_1^- \to (l^+l'^+\nu\nu b\bar{b})(jjb\bar{b})$



$pp \to \Phi^{++}H^-_{1,2} \to (l^+l'^+\nu\nu b\bar{b})(jjb\bar{b})$



Event #

S	B	Significance
145	40	11

Three peaks
from this signal