Benemérita Universidad Autónoma de Puebla

and

Dual C-P Institute of High Energy Physics, México

Production of charged Higgs at the future collider ep LHeC

Jaime Hernandez -Sanchez

in collaboration with:

O. Flores, C. Honorato, S. Rosado (BUAP, México)
S. Moretti (U. of Southampton, UK)

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Outline

- Brief introduction of 2HDM-III and how four-zero Yukawa texture is the mechanism that controls the FCNC.
- The 2HDM-III agrees with main flavor constraints from low energy processes.
- Phenomenology of neutral and charged Higgs bosons could be quiet different.
- Some interesting channels decays at tree level: $H,h,A \to bs,\tau\mu$, H+ —> cb, ts, decays are sensitive to the pattern of Yukawa texture.
- Benchmarks scenarios are found and one could have a $BR(h,H \to bs) \sim 0.1$ keeping h-decays compatible with SM.
- Brief discussion $e\,p \to q(h,H)\nu_e$ with flavor violating decays of the Higgs bosons (h,H): cross sections, some distributions and cuts.
- e p —> q nu H+, considering H—> c b, results at parton level

Yukawa textures

The Yukawa textures are consistents with the relations between quarks masses and flavor mixing parameters.

Yukawa textures could come of a theory more fundamental and it could be a flavor symmetry.

H. Fritzsch, Z. Z. Xing, Prog.Part. Nucl. Phys. 45 (2000)1.
H. Fritzsch, Z. Z. Xing, Phys. Lett. 555 (2003)63.

Yukawa sector in 2HDM type III

$$\mathcal{L}_Y = Y_1^u \bar{Q}_L \Phi_1 u_R + Y_2^u \bar{Q}_L \Phi_2 u_R + Y_1^d \bar{Q}_L \Phi_1 d_R + Y_2^d \bar{Q}_L \Phi_2 d_R \,,$$

$$M_f = \frac{1}{\sqrt{2}}(v_1 Y_1^f + v_2 Y_2^f), \qquad f = u, d, l,$$

$$M_f = \begin{pmatrix} 0 & C_f & 0 \\ C_f^* & \tilde{B}_f & B_f \\ 0 & B_f^* & A_f \end{pmatrix}.$$

$$\boxed{\bar{M}_f = V_{fL}^{\dagger} M_f V_{fR}.}$$

$$(\tilde{Y}_2^l)_{ij} = \frac{\sqrt{m_i m_j}}{v}\tilde{\chi}_{ij} = \frac{\sqrt{m_i m_j}}{v}\chi_{ij} e^{\vartheta_{ij}},$$

The off-diagonal terms are constrained by CKM

F. González, O. Félix-Beltrán, J.Hernandez-Sanchez, S. Moretti, R. Noriega, A. Rosado, Phys.Lett. B742 (2015) 347-352.
J. Hernandez-Sanchez, L. Lopez-Lozano, R. Noriega, A. Rosado, Phys.Rev. D85 (2012) 071301

Some arguments o motivations

The 2HDM-II could be transformed into 2HDM-III through the loops-effects of sfermions and gauginos

Andreas Crivellin, Phys.Rev. D83 (2011) 056001

In models with more than one Higgs doublet the MFV case is more stable in suppressing FCNCs than the hypothesis of NFC when the quantum corrections are taken into account.

A.J. Buras, M.V. Carlucci, S. Gori and G. Isidori, Higgs-mediated FCNCs: Natural Flavour Conservation vs. Minimal Flavour Violation , JHEP 10 (2010) 009 [arXiv:1005.5310].

Similar phenomenology in MHDM with flavor symmetries (Nearest-Neighbor-Interaction texture)

G. C. Branco, L. Lavoura and F. Mota, Phys. Rev. D 39, 3443 (1989)
Alfredo Aranda, Cesar Bonilla, J.Lorenzo Diaz-Cruz. Phys.Lett. B717 (2012) 248-251

2HDMs is studied in renormalization group evolution of the Yukawa couplings and the cases when the Z2-symmetry is broken, called non-diagonal models.

J. Bijnens, J. Lu and J. Rathsman, Constraining General Two Higgs Doublet Models by the Evolution of Yukawa Couplings , JHEP 05 (2012) 118

2HDM-III + Yukawa texture contain the following information:

It could come from a more fundamental theory (susy models with seesaw mechanism).

+

Yukawa texture is the flavor symmetry of the model and do not require of the discrete flavor symmetry.

+

The Higgs potential must be expressed in the most general form.

J. L. Diaz-Cruz, J. Hernandez-Sanchez, S. Moretti, R. Noriega, A. Rosado, Phys.Rev. D79 (2009) 095025
J. Hernandez-Sanchez, S. Moretti, R. Noriega-Papaqui, A. Rosado, JHEP 1307 (2013) 044

$$\mathcal{L}^{\bar{f}_i f_j \phi} = -\left\{ \frac{\sqrt{2}}{v} \overline{u}_i \left(m_{d_j} X_{ij} P_R + m_{u_i} Y_{ij} P_L \right) d_j \, H^+ + \frac{\sqrt{2} m_{l_j}}{v} Z_{ij} \overline{\nu_L} l_R H^+ + H.c. \right\}$$
$$- \frac{1}{v} \left\{ \bar{f}_i m_{f_i} h_{ij}^f f_j h^0 + \bar{f}_i m_{f_i} H_{ij}^f f_j H^0 - i \bar{f}_i m_{f_i} A_{ij}^f f_j \gamma_5 A^0 \right\},$$

where ϕ_{ij}^f ($\phi = h, H, A$), X_{ij}, Y_{ij} and Z_{ij} are defined as:

$$\phi_{ij}^f = \xi_\phi^f \delta_{ij} + G(\xi_\phi^f, X), \quad \phi = h, H, A,$$
$$X_{ij} = \sum_{l=1}^{3} (V_{\rm CKM})_{il} \left[X \frac{m_{d_l}}{m_{d_j}} \delta_{lj} - \frac{f(X)}{\sqrt{2}} \sqrt{\frac{m_{d_l}}{m_{d_j}}} \tilde{\chi}_{lj}^d \right],$$
$$Y_{ij} = \sum_{l=1}^{3} \left[Y \delta_{il} - \frac{f(Y)}{\sqrt{2}} \sqrt{\frac{m_{u_l}}{m_{u_i}}} \tilde{\chi}_{il}^u \right] (V_{\rm CKM})_{lj},$$
$$Z_{ij}^l = \left[Z \frac{m_{l_i}}{m_{l_j}} \delta_{ij} - \frac{f(Z)}{\sqrt{2}} \sqrt{\frac{m_{l_i}}{m_{l_j}}} \tilde{\chi}_{ij}^l \right].$$

With this structure in different limits one can have different 2HDM

$$\left(g_{2HDM-III}^{f_u i f_d j H^+} = g_{2HDM-any}^{f_u i f_d j H^+} + \Delta g^{f_u i f_d j H^+} \right)$$

J. Hernandez-Sanchez, S. Moretti, R. Noriega-Papaqui, A. Rosado, JHEP07 (2013) 044

2HDM-III	X	Y	Z	ξ_h^u	ξ_h^d	ξ_h^l	ξ_H^u	ξ_H^d	ξ_H^l
2HDM-I-like	$-\cot\beta$	$\cot\beta$	$-\cot\beta$	c_α/s_β	c_α/s_β	c_α/s_β	s_α/s_β	s_α/s_β	s_α/s_β
2HDM-II-like	$\tan\beta$	$\cot\beta$	$\tan\beta$	c_α/s_β	$-s_\alpha/c_\beta$	$-s_\alpha/c_\beta$	s_α/s_β	c_α/c_β	c_α/c_β
2HDM-X-like	$-\cot\beta$	$\cot\beta$	$\tan\beta$	c_α/s_β	c_α/s_β	$-s_\alpha/c_\beta$	s_α/s_β	s_α/s_β	c_α/c_β
2HDM-Y-like	$\tan\beta$	$\cot\beta$	$-\cot\beta$	c_α/s_β	$-s_\alpha/c_\beta$	c_α/s_β	s_α/s_β	c_α/c_β	s_α/s_β

- $\mu - e$ universality in τ decays
- Leptonic meson decays $B \to \tau\nu$, $D \to \mu\nu$, $D_s \to \mu\nu, \tau\nu$ and semileptonic decays $B \to D\tau\nu$
- $B \to X_s\gamma$ decays
- $B^0 - \bar{B}^0$ mixing
- Eelectro-weak precision test(including S,T,U oblique parameters)

Finally with all these above constraints one can find: $\chi_{kk}^f \sim 1$ and $|\chi_{ij}^f| \leq 0.5$, As the four-zero texture controls the FCNC, then the most general Higgs potential could be considered for the 2HDM-III

$$
\begin{aligned}
V(\Phi_1, \Phi_2) = \; & \mu_1^2(\Phi_1^\dagger \Phi_1) + \mu_2^2(\Phi_2^\dagger \Phi_2) - \left(\mu_{12}^2(\Phi_1^\dagger \Phi_2) + \mathrm{H.c.}\right) + \frac{1}{2}\lambda_1(\Phi_1^\dagger \Phi_1)^2 \\
& + \frac{1}{2}\lambda_2(\Phi_2^\dagger \Phi_2)^2 + \lambda_3(\Phi_1^\dagger \Phi_1)(\Phi_2^\dagger \Phi_2) + \lambda_4(\Phi_1^\dagger \Phi_2)(\Phi_2^\dagger \Phi_1) \\
& + \left(\frac{1}{2}\lambda_5(\Phi_1^\dagger \Phi_2)^2 + \left(\lambda_6(\Phi_1^\dagger \Phi_1) + \lambda_7(\Phi_2^\dagger \Phi_2)\right)(\Phi_1^\dagger \Phi_2) + \mathrm{H.c.}\right)
\end{aligned}
$$

The custodial symmetry, pertubativity and unitarity are imposed and we obtain the following parameters of Higgs potential:

$$\text{for } \tan\beta \le 10: \qquad |\lambda_{6,7}| \le 1, \qquad \lambda_6 = -\lambda_7,$$

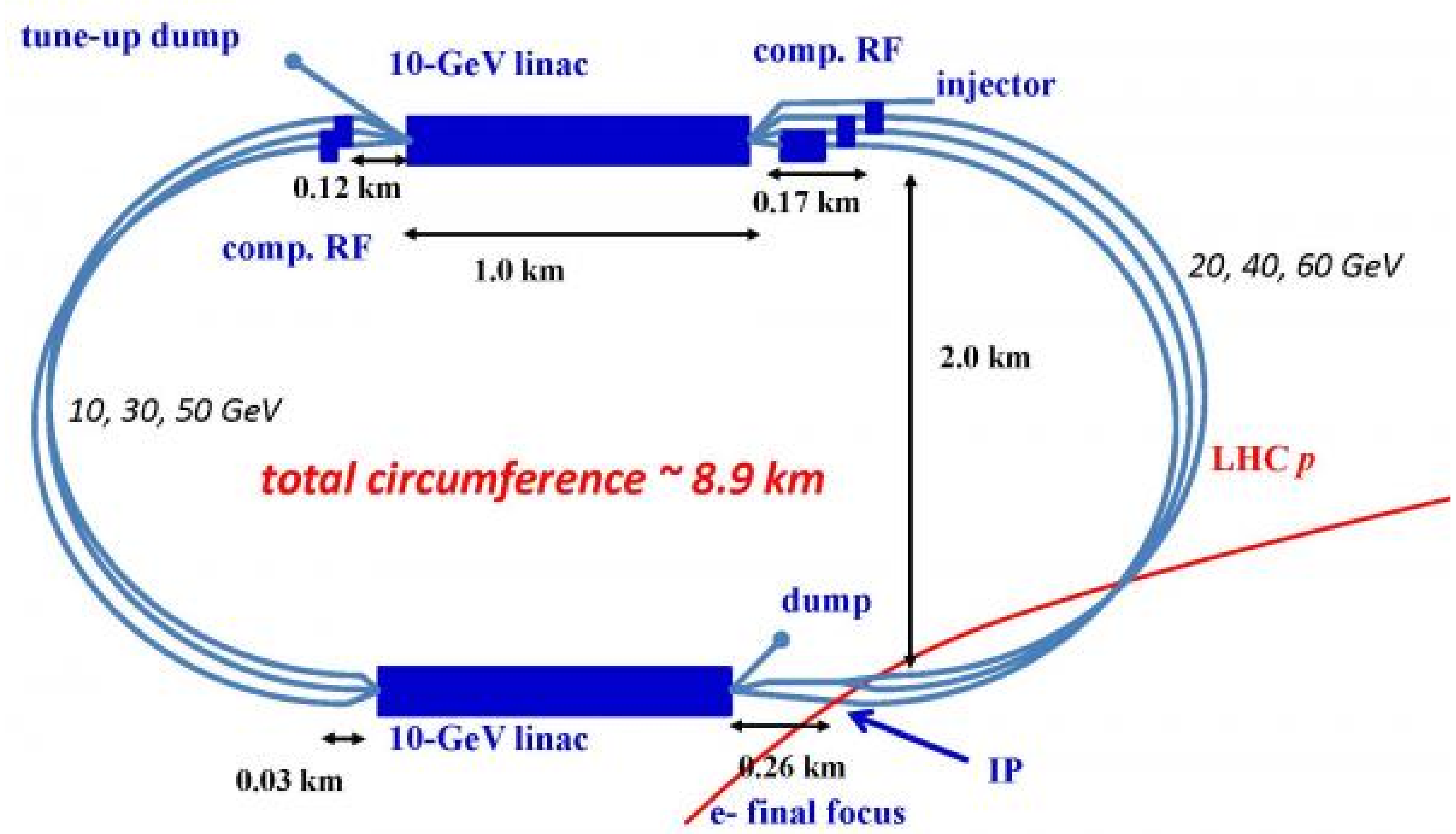
$$\sin(\beta - \alpha) \sim 1, \qquad \mu_{12} \sim v,$$

The masses of ma, mH+ and MH are chosen by STU obliques parameters

A. Cordero-Cid, J. Hernandez-Sanchez, C. Honorato, S. Moretti, A. Rosado, JHEP07 (2014) 057

LHeC Collider

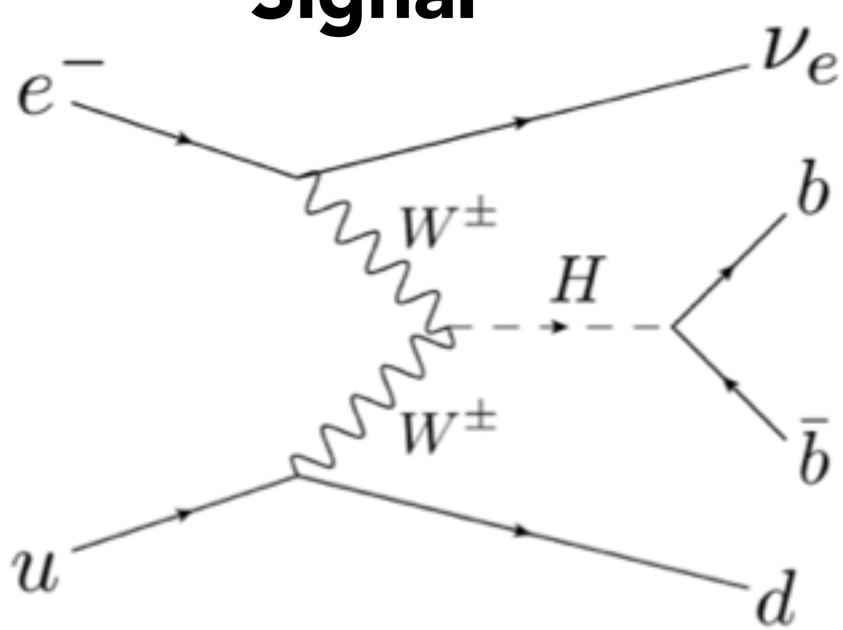
The overall kinematical range accesible at the LHeC is 20 times larger than HERA.



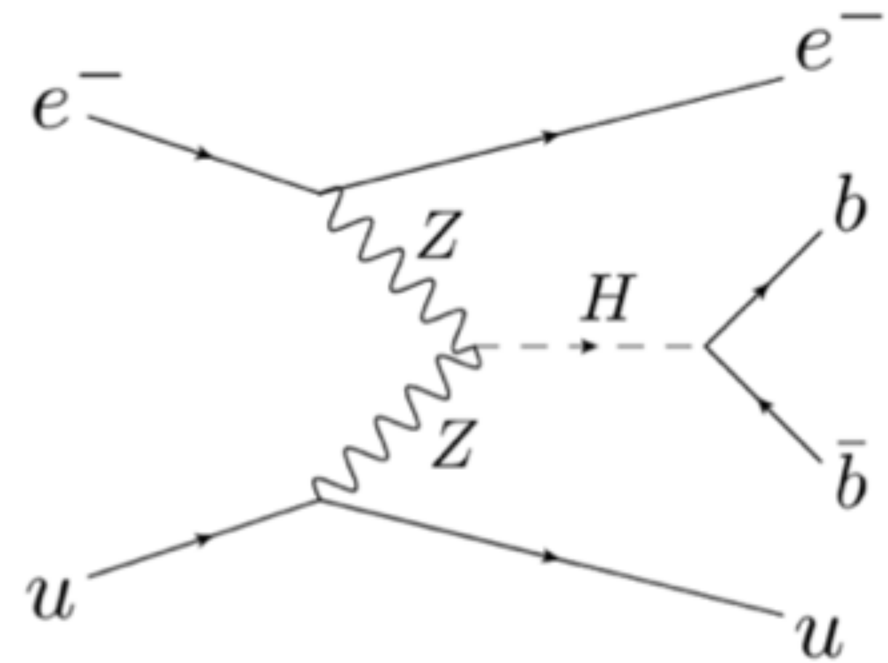
$\sqrt{s} = \sqrt{(E_e E_p)} = 1.296$ TeV (e-=60GeV p=7000 GeV) with 100/fb

J. L. Abelleira Fernandez [arXiv:1206.2913 [physics.acc-ph]]

Signal



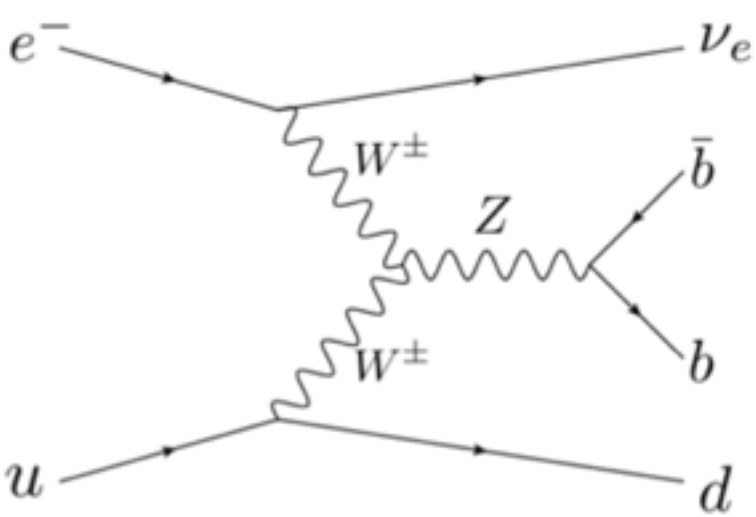
Charged current (CC) H->bb (0.063 pb)



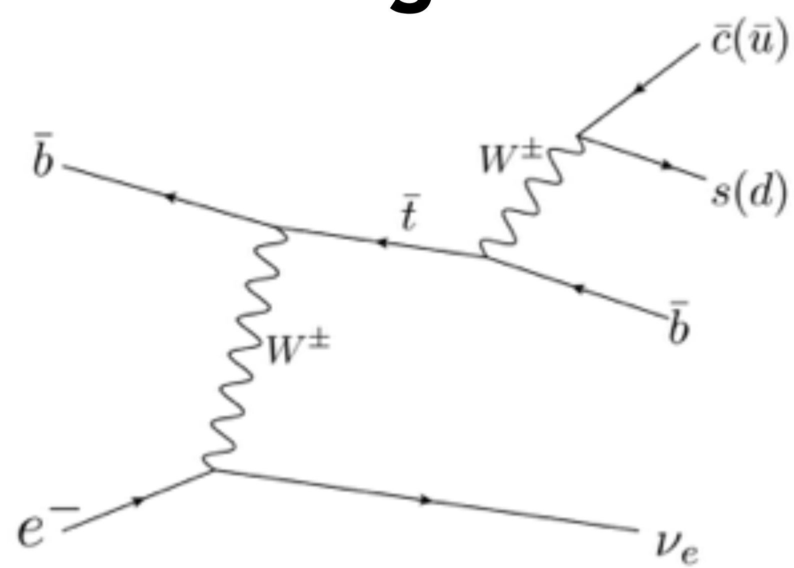
Neutral current (NC) H->bb (0.012 pb)

- CC: H->bb process is chosen as the signal because the cross section is larger than NC: H->bb process and NC rejection cut decreases large number of NC BG.

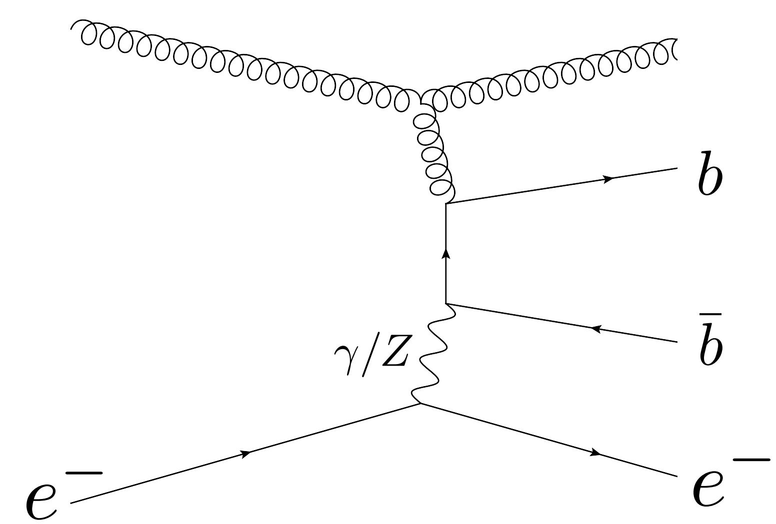
Background



CC Z production (0.29 pb)



Single top production (0.43 pb)

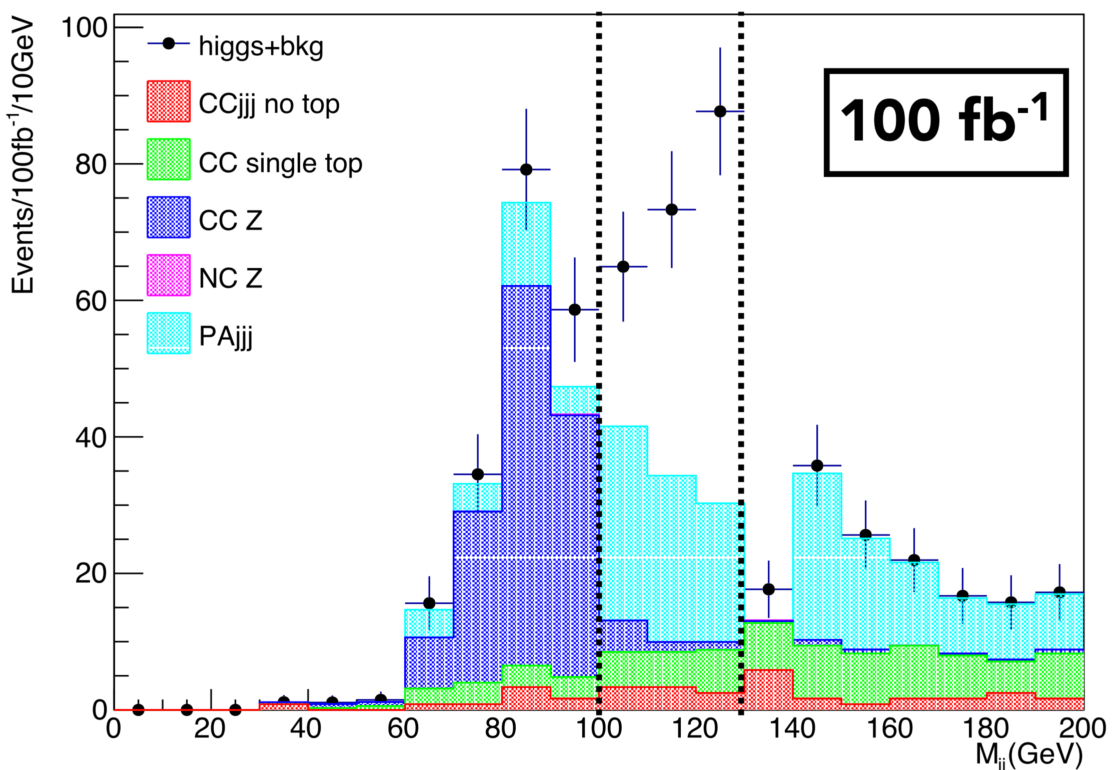


NC multi jets

https://indico.cern.ch/event/356714/contributions/844945/attachments/709283/973691/Updates_on_Hbb_studies.pdf

Masahiro Tanaka, Masahiro Kuze, Masaki Ishitsuka (Tokyo Institute of Technology)
Uta Klein (Liverpool University)
25 June 2015, LHeC Workshop 2015 @CERN and Chavannes-de-Bogis

- Mass reconstructed with 1st and 2nd minimum η b-jets.
- Signal region is defined as [100,130] GeV.



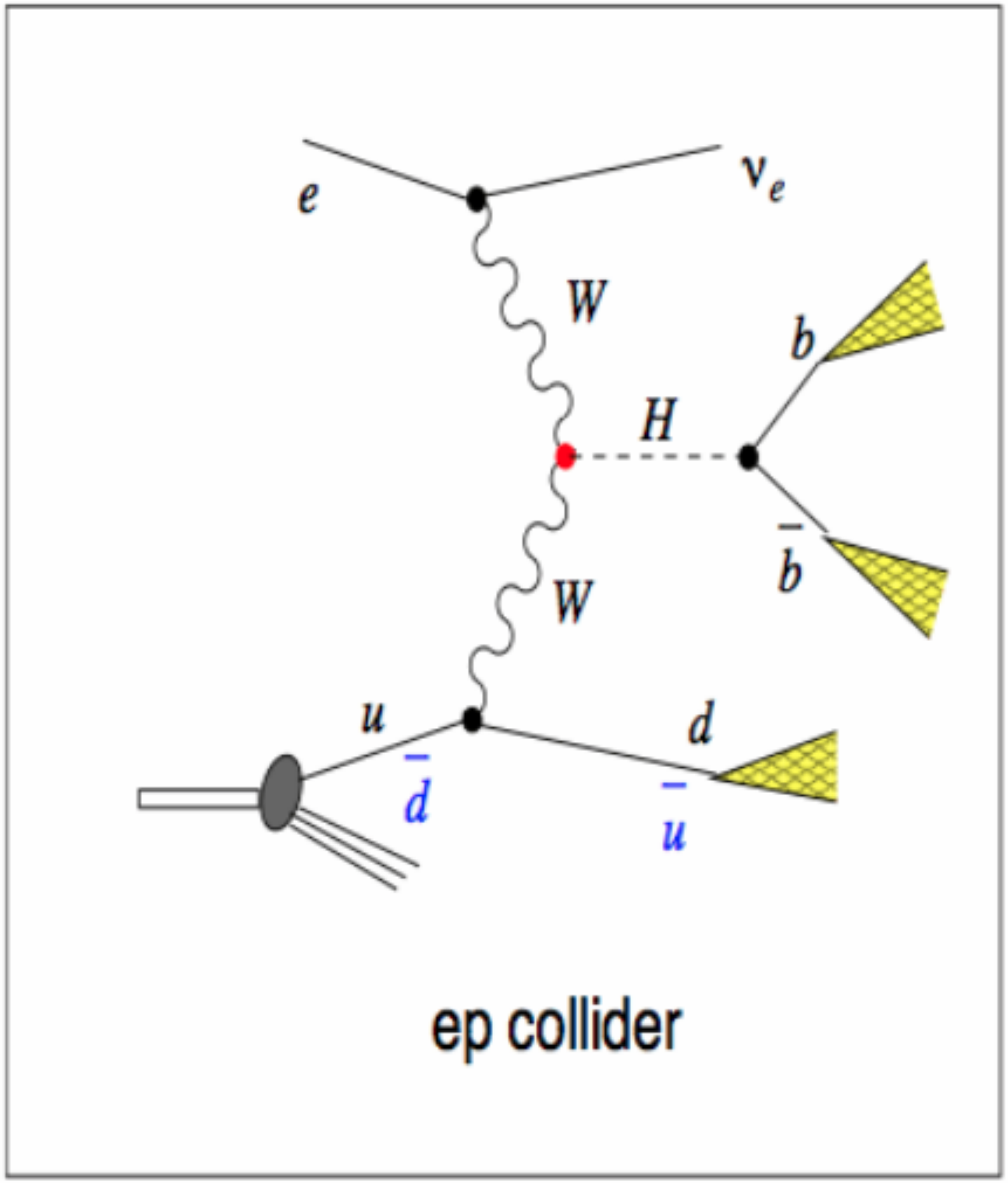
Events in signal region

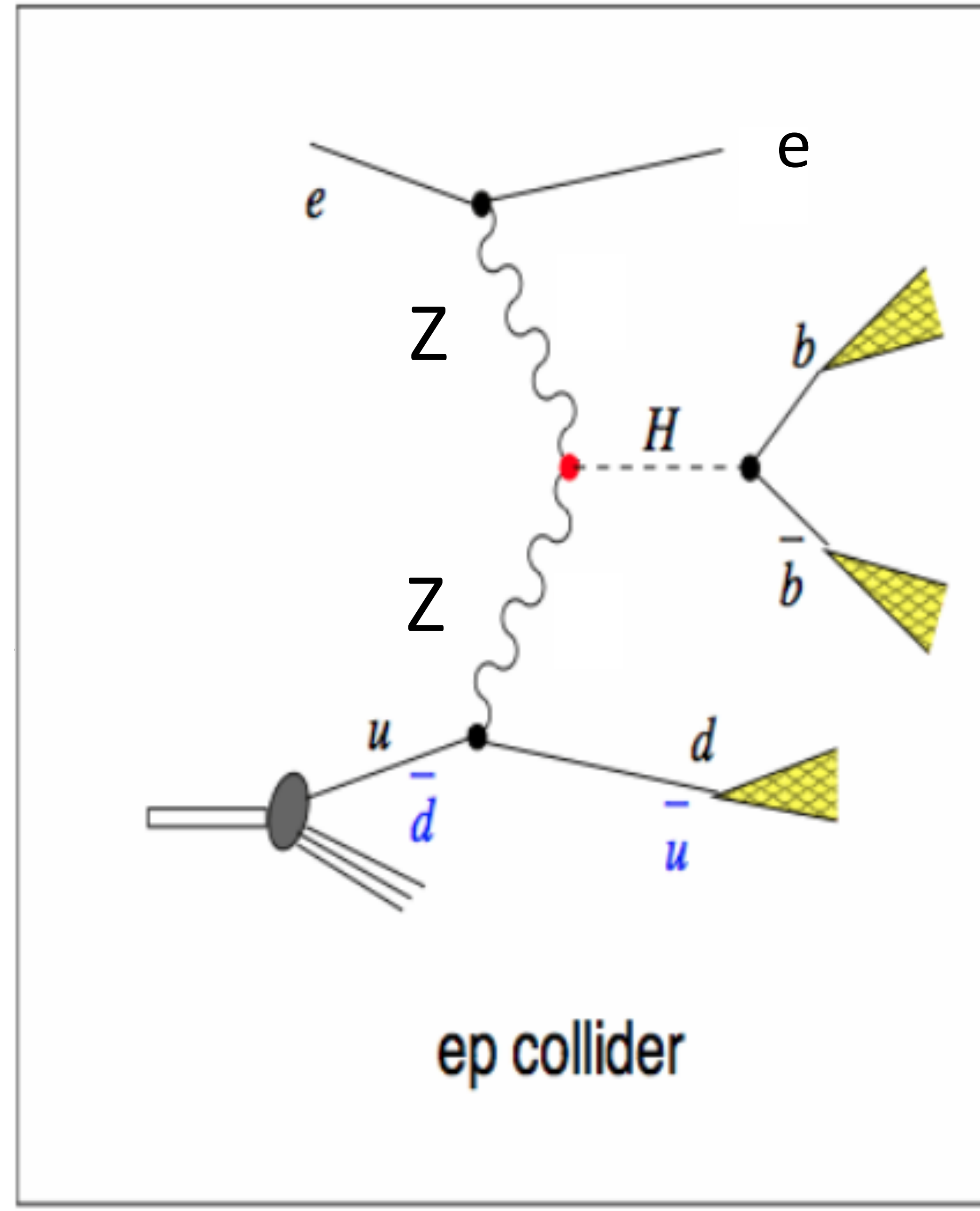
Signal H->bb	119±2
CCjjj no top	9±3
CC single top	17±2
CC Z	7±1
NC Z	0
PAjjj	73±17
CCbkg total	33±4
NCbkg total	73±17

- Errors are weighted

$S/\sqrt{B}$ = 11.5

- We can detect H->bb signal in good efficiency.
- Peak around 80 GeV is Z boson from CC background.
- PAjjj background has large statistical error due to small statistics.
- Electron tagging of Photo-production events could further suppress BG under peak.





The background is reduced a lot

In the 2HDM; H= h0, H0

For H0 the coupling VVH0 is proportional to Cos(β-α) and VVh0 to Sin(β-α)

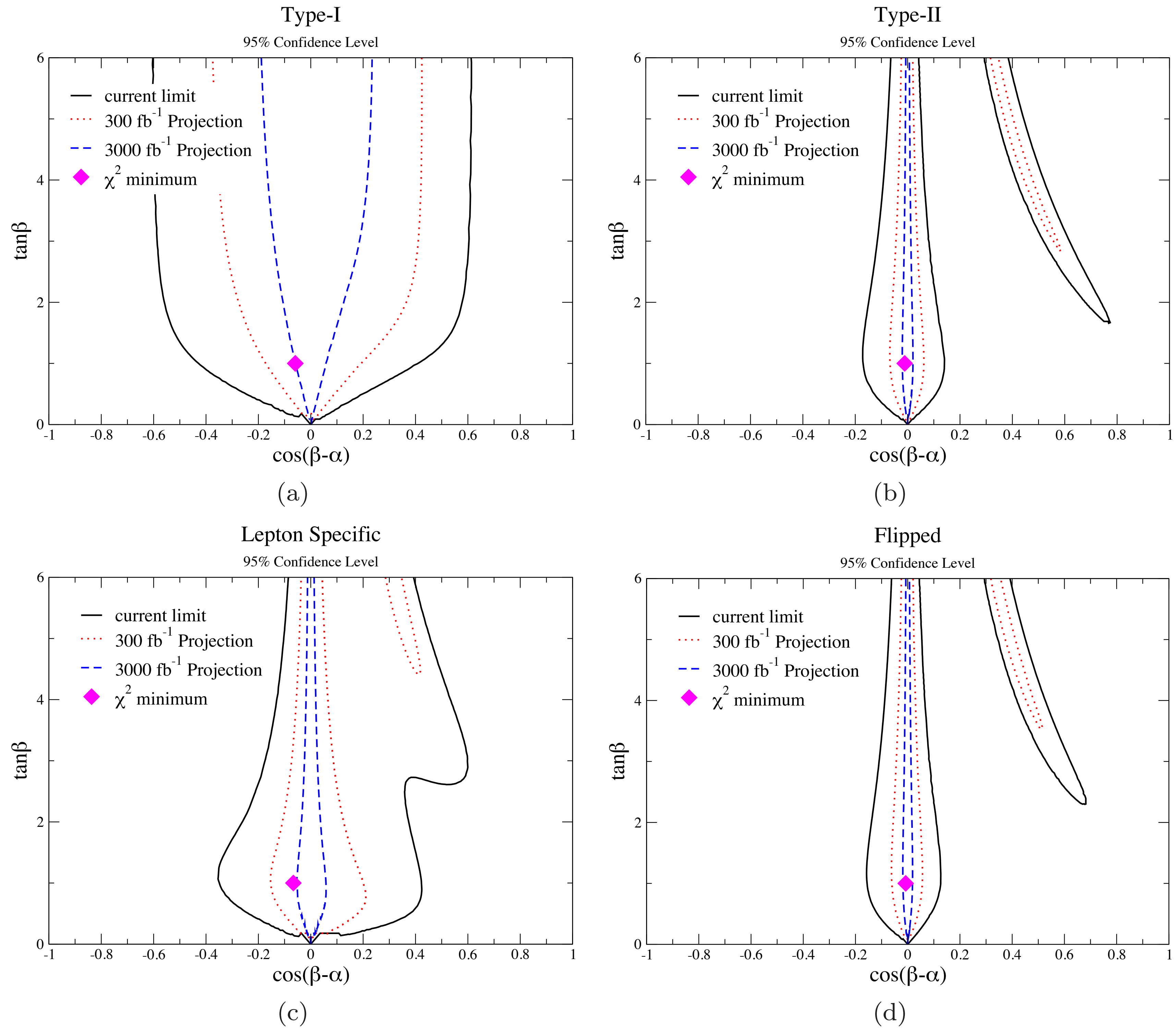


FIG. 1: Allowed regions in the $(\cos(\beta-\alpha), \tan\beta)$ plane in Type I (a), Type II (b), Lepton Specific (c), and Flipped (d) 2HDMs obtained by performing a χ^2 analysis. The region between the black (solid), red (dotted), and blue (dashed) lines is allowed at 95% confidence level corresponding to the current limits and the projected limits for integrated luminosities of 300 fb^{-1} and 3000 fb^{-1}, respectively.

Chien-Yi Chen, S. Dawson, Marc Sher. Phys.Rev. D88 (2013) 015018, Phys.Rev. D88 (2013) 039901

- **Scenario Ia**: 2HDM-III as 2HDM-I, with the couplings $\phi f f$ given by $g^{\phi f f}_{2HDM-III} = g^{\phi f f}_{2HDM-I} + \Delta g$ and $\cos(\beta - \alpha) = 0.1$, $\chi^u_{kk} = 1.5$ (k=2,3), $\chi^d_{22} = 1.8$, $\chi^d_{33} = 1.2$, $\chi^{u,d}_{23} = 0.2$, $\chi^\ell_{22} = 0.5$, $\chi^\ell_{33} = 1.2$, $\chi^\ell_{23} = 0.1$, $m_A = 100$ GeV and $m_{H^\pm} = 110$ GeV, taking $Y = -X = -Z = \cot\beta = 2, 15, 30$.

- **Scenario Ib**: the same as scenario Ia but with $\cos(\beta - \alpha) = 0.5$.

- **Scenario IIa**: 2HDM-III as 2HDM-II, namely, the couplings $\phi f f$ given by $g^{\phi f f}_{2HDM-III} = g^{\phi f f}_{2HDM-II} + \Delta g$ and $\cos(\beta - \alpha) = 0.1$, $\chi^u_{22} = 0.5$, $\chi^u_{33} = 1.4$, $\chi^d_{22} = 2$, $\chi^d_{33} = 1.3$, $\chi^u_{23} = -0.53$, $\chi^d_{23} = 0.2$, $\chi^\ell_{22} = 0.4$, $\chi^\ell_{33} = 1.2$, $\chi^\ell_{23} = 0.1$, $m_A = 100$ GeV and $m_{H^\pm} = 110$ GeV, taking $X = Z = 1/Y = \tan\beta = 2, 15, 30$.

- **Scenario Y**: 2HDM-III as 2HDM-Y, namely, the couplings $\phi f f$ given by $g^{\phi f f}_{2HDM-III} = g^{\phi f f}_{2HDM-Y} + \Delta g$ and $\cos(\beta - \alpha) = 0.1$, $\chi^u_{22} = 0.5$, $\chi^u_{33} = 1.4$, $\chi^d_{22} = 2$, $\chi^d_{33} = 1.3$, $\chi^u_{23} = -0.53$, $\chi^d_{23} = 0.2$, $\chi^\ell_{22} = 0.4$, $\chi^\ell_{33} = 1.1$, $\chi^\ell_{23} = 0.1$, $m_A = 100$ GeV and $m_{H^\pm} = 110$ GeV, taking $X = 1/Y = -1/Z = \tan\beta = 2, 15, 30$.

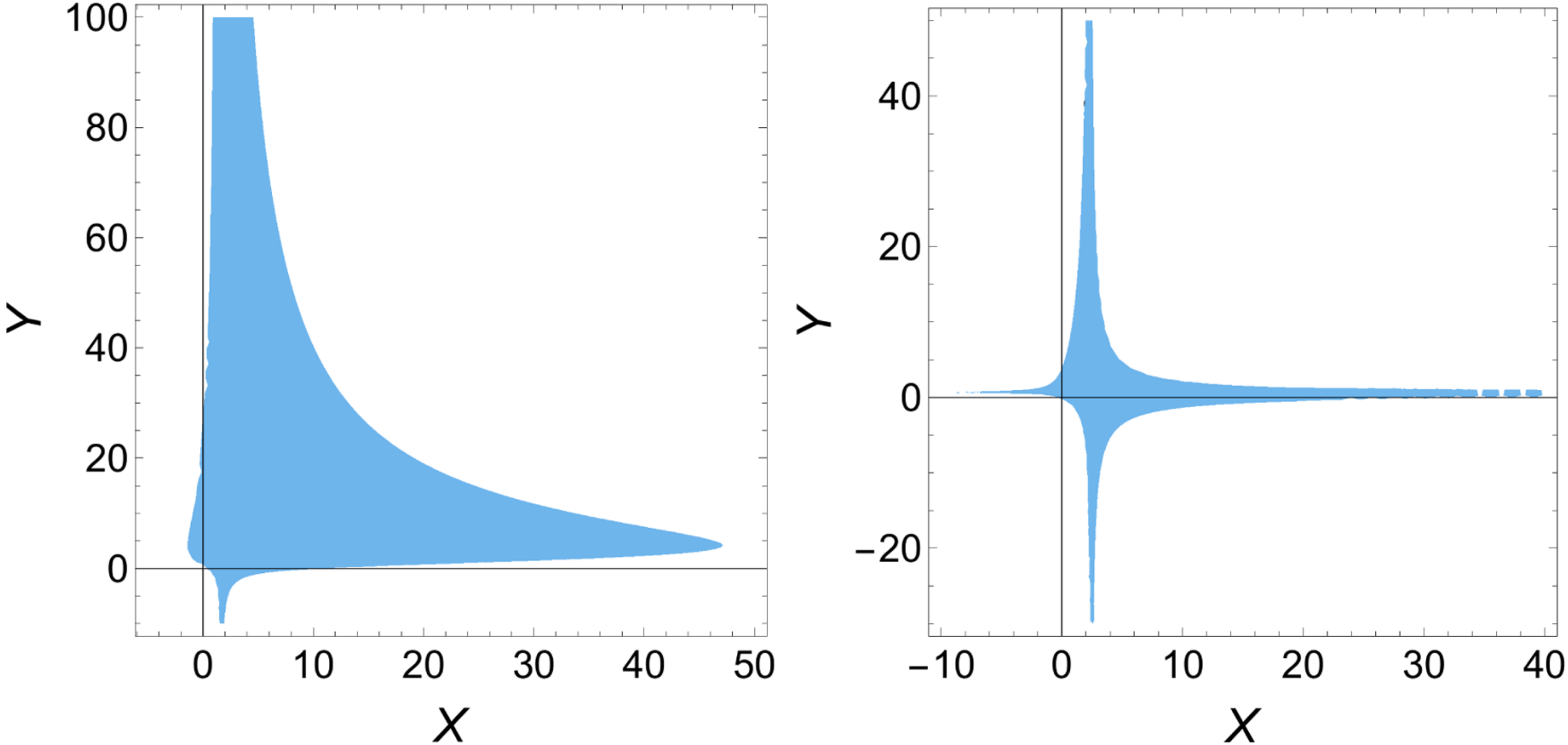


FIG. 1. The allowed region in the plane X vs Y, using the constraint Eq. (13), which is obtained from the radiative inclusive decay $B \to X_s\gamma$. We obtain the Scenario Ib, which is shown in the left panel, with $0.1 \le \cos(\beta - \alpha) \le 0.5$, $\chi^u_{kk} = 1.5$ ($k = 2, 3$), $\chi^d_{22} = 1.8$, $\chi^d_{33} = 1.2$, $\chi^{u,d}_{23} = 0.2$, $\chi^\ell_{22} = 0.5$, $\chi^\ell_{33} = 1.2$, $\chi^\ell_{23} = 0.1$. For Scenario IIa and Y, the allowed region is given in the right panel with $\cos(\beta - \alpha) = 0.1$, $\chi^u_{22} = 0.5$, $\chi^u_{33} = 1.4$, $\chi^d_{22} = 2$, $\chi^d_{33} = 1.3$, $\chi^u_{23} = -0.53$, $\chi^d_{23} = 0.2$, $\chi^\ell_{22} = 0.4$, $\chi^\ell_{33} = 1.2$, $\chi^\ell_{23} = 0.1$. For both cases $m_h = 125$ GeV, 130 GeV $\le m_H \le$ 300 GeV, 100 GeV $\le m_A \le$ 250 GeV, 110 GeV $\le m_{H^\pm} \le$ 200 GeV.

Process: $e^- p \to \nu_e \phi q_f$; $\phi \to b\bar{s}$ +h.c.

These processes lead to 3-jets+ $\not{E}_T$

We demanded two jets in the central rapidity region: one tagged b-jet and one low flavor jet.

The remaining jet (q_f) has been tagged in the forwards region and the central jet veto (no more than one low flavor jet): are criterions to enhance the signal to the SM backgrounds.

TABLE I. Parameters for few optimistic benchmark points in the 2HDM-III as a 2HDM-I, -II and -Y configuration. Here bs stands for BR($\phi \to b\bar{s} + \bar{b}s$), in units of 10^{-2}, where $\phi = h, H$, while $\sigma.bs$ stands for the cross section multiplied by the above BR as obtained at the LHeC in units of fb. We have analyzed only the benchmarks where the $\sigma.bs$ is greater than 0.15 fb, so that at least 15 events are produced for 100 fb^{-1}.

				$m_h = 125$ GeV		$m_H = 130$ GeV		$m_H = 150$ GeV		$m_H = 170$ GeV	
2HDM	X	Y	Z	bs	$\sigma.bs$	bs	$\sigma.bs$	bs	$\sigma.bs$	bs	$\sigma.bs$
Ib35	28	10	28	15.66	6.392	51.8	1.209	51.6	0.30	1.58	0.117
Ib47	30	5	30	16.14	3.086	48.2	10.983	48.0	0.127	1.80	0.839
Ib57	44	5	44	17.58	11.861	38.6	5.14	38.4	2.303	3.68	0.137
IIa11	20	2	20	1.42	1.055	25.2	0.097	25.0	0.091	24.8	0.085
IIa14	26	2	26	1.44	1.651	26.0	0.059	25.8	0.054	25.6	0.049
IIa26	36	1	36	1.46	1.621	26.4	0.045	26.2	0.042	26.0	0.038
Ya11	20	2	−2	1.42	1.084	25.2	0.062	25.0	0.059	24.8	0.054
Ya12	22	2	−2	1.44	1.078	25.6	0.057	25.4	0.053	25.2	0.048
Ya14	26	2	−2	1.46	1.441	26.0	0.057	25.8	0.053	25.6	0.049

We consider only σ.bs > 0.15 fb; at least 15 events for 100 fb^(-1)

We applied the following basic preselections:

$$p_T^q > 15.0 \quad \text{GeV}, \Delta R(q,q) > 0.4$$

$\Delta R = \Delta\eta^2 + \Delta\phi^2$, where η and ϕ are the pseudo-rapidity and azimuthal angle respectively.

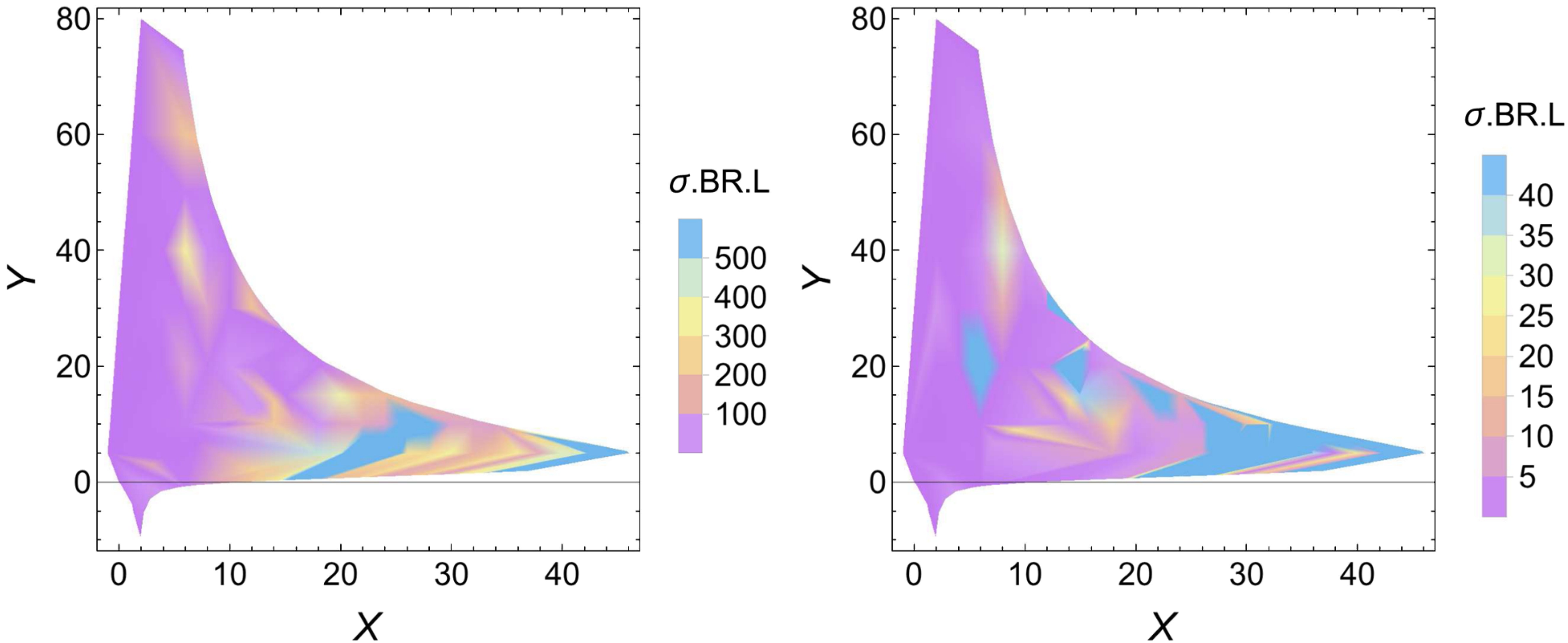


FIG. 2. Event rates (σ.BR.L) at parton level for the neutral Higgs boson h (left panel) and $m_H = 130$ GeV (right panel), where L is the integrated luminosity. We show Scenario Ib for 100 fb^{-1}. We consider $m_h = 125$ GeV.

h_{SM}=125 GeV:3-jet+$\not{E}_T$ with 100 fb^{-1}

Details in arXiv: 1503.01464
PRD 94, 055003 (2016)

- a: $N_j \gtrsim 3$
- b: $N_{b-tag} \gtrsim 1$ (with ϵ_b=0.50, ϵ_c=0.10 and ϵ_j=0.01, where j=u,d,s,g)
- cd : at least two central jets (within $\eta < 2.5$) with $\not{E}_T > 20 GeV$ → 3j not survive and photo production is reduced
- e: lepton (e or μ) veto with $p_T > 20$ GeV and $\eta < 3.0$
- f: in the central region: $|M_{bj} - M_{h(H)}|$ is minimum and with 15 GeV mass windows.
- g: remaining leading jet with $p_T > 25$ GeV and $-5.5 < \eta < -0.5$
- h: $m_{\phi j_f} > 190$ GeV

i:We required only one low flavored jet in the central regions (this has severe impact on the processes)

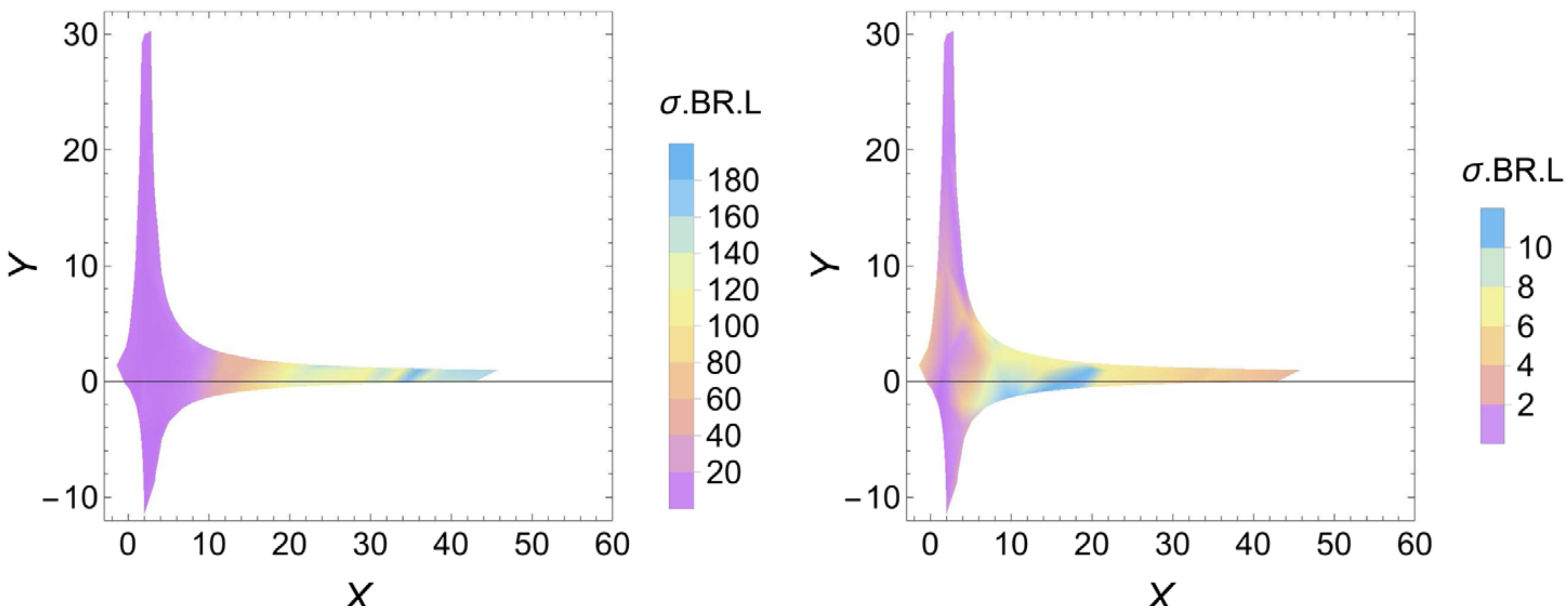


FIG. 3. The same as Fig. 2, but now for the Scenario IIa. Similar results for Scenario Y are obtained.

TABLE II. Expected number of events after different combinations of cuts for signal and backgrounds at the LHeC with an integrated luminosity of 100 fb^{-1} for $m_h = 125$ GeV. SimEvt stands for the actual number of events analyzed in the Monte Carlo simulations. RawEvt stands for the number of events with only the generator–level cuts (14) imposed; for the signal as well as for background, these are calculated from the total cross section times branching ratio. In the final column we mention the significances($\mathcal{S}$) defined as $\mathcal{S} = S/\sqrt{B}$, where S stands for signal events, background events B for 100 fb^{-1} of data after all cuts mentioned in the "i" column. The number in the parenthesis in the final column represent the significances for 1000 fb^{-1}.

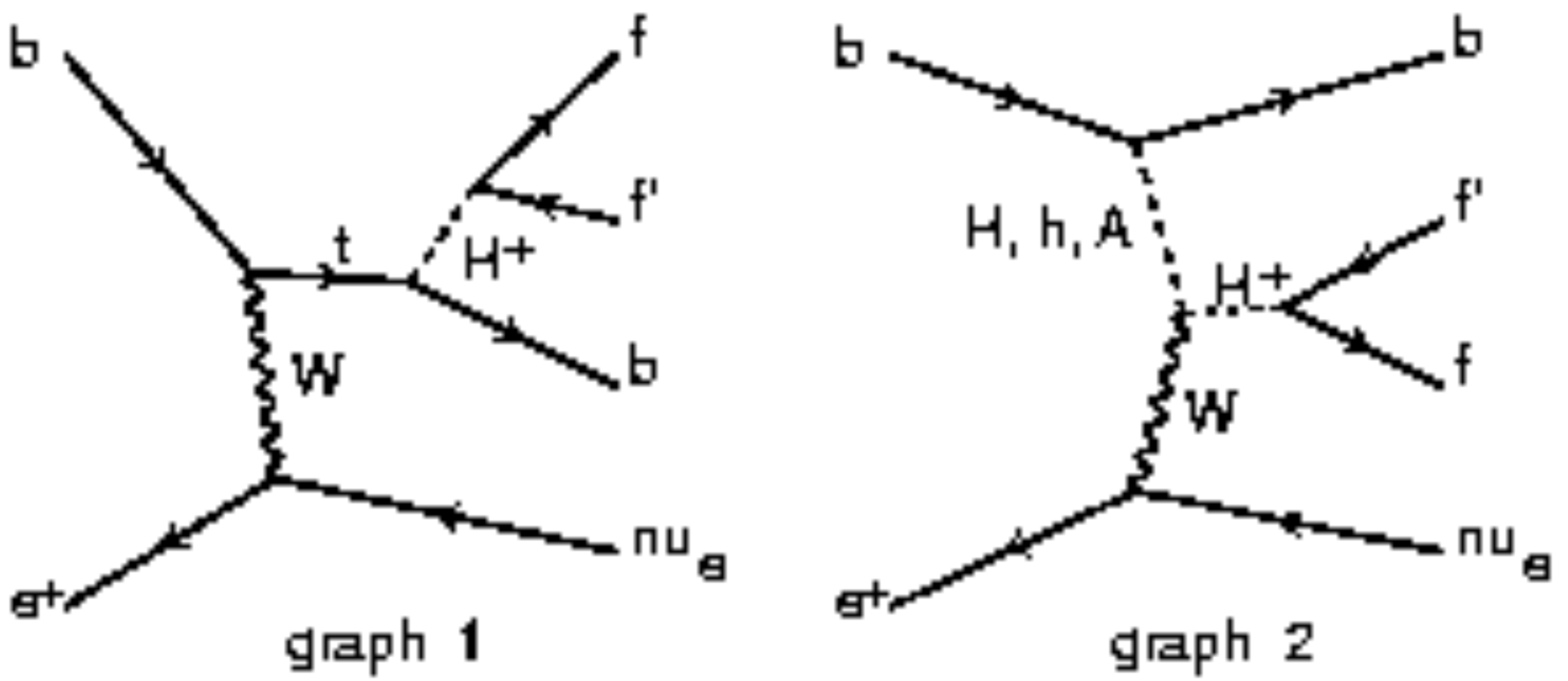
Proc	SimEvt	RawEvt	a	b	c	d	e	f	g	h	i	$\mathcal{S}$
Ib35	100 K	639.2	447.6	177.3	117.1	97.4	93.8	37.8	31.7	25.4	15.8	1.2(3.8)
Ib47	100 K	308.6	216.8	85.1	56.2	47.1	45.5	18.4	15.6	13.0	8.1	0.62(2.0)
Ib57	100 K	1186.1	833.7	325.7	215.5	180.6	173.9	70.3	59.1	49.3	31.1	2.4(7.5)
IIa11	100 K	105.5	74.3	29.1	19.2	16.0	15.4	6.3	5.3	4.4	2.8	0.21(0.70)
IIa14	100 K	165.1	116.1	45.2	30.0	25.4	24.4	9.7	8.3	6.9	4.4	0.33(1.05)
IIa26	100 K	162.1	114.4	44.7	29.5	24.5	23.6	9.5	8.1	6.8	4.3	0.33(1.03)
Ya11	100 K	108.4	76.3	29.8	19.6	16.4	15.8	6.4	5.4	4.6	2.9	0.22(0.70)
Ya12	100 K	107.8	76.2	29.6	19.5	16.3	15.7	6.3	5.4	4.5	2.8	0.21(0.67)
Ya14	100 K	144.1	101.7	39.8	26.0	21.7	20.8	8.2	7.0	5.9	3.8	0.29(0.92)
$\nu t\bar{b}$	100 K	50712.1	28338.4	15293.7	9845.0	8144.2	7532.7	2982.1	2058.0	652.2	139.6	
$\nu b\bar{b}j$	560 K	14104.6	6122.8	3656.7	1858.5	1787.1	1650.1	257.5	152.5	85.2	15.1	
$\nu b2j$	90 K	18043.1	8389.2	3013.0	1691.5	1445.5	1373.7	389.5	206.1	77.2	11.3	$B = 170.8$
$\nu 3j$	300 K	948064.2	410393.4	15560.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$\sqrt{B} = 13.1$
$eb\bar{b}j$	115 K	256730.1	55099.8	36353.6	12659.8	1432.0	200.7	54.1	24.8	18.0	4.5	
$et\bar{t}$	130 K	783.3	685.0	384.5	265.9	179.3	26.2	11.6	10.5	3.9	0.3	

Results in () is for 1000 fb^(-1)

TABLE IV. Same as Table III but for $m_H = 150$ GeV.

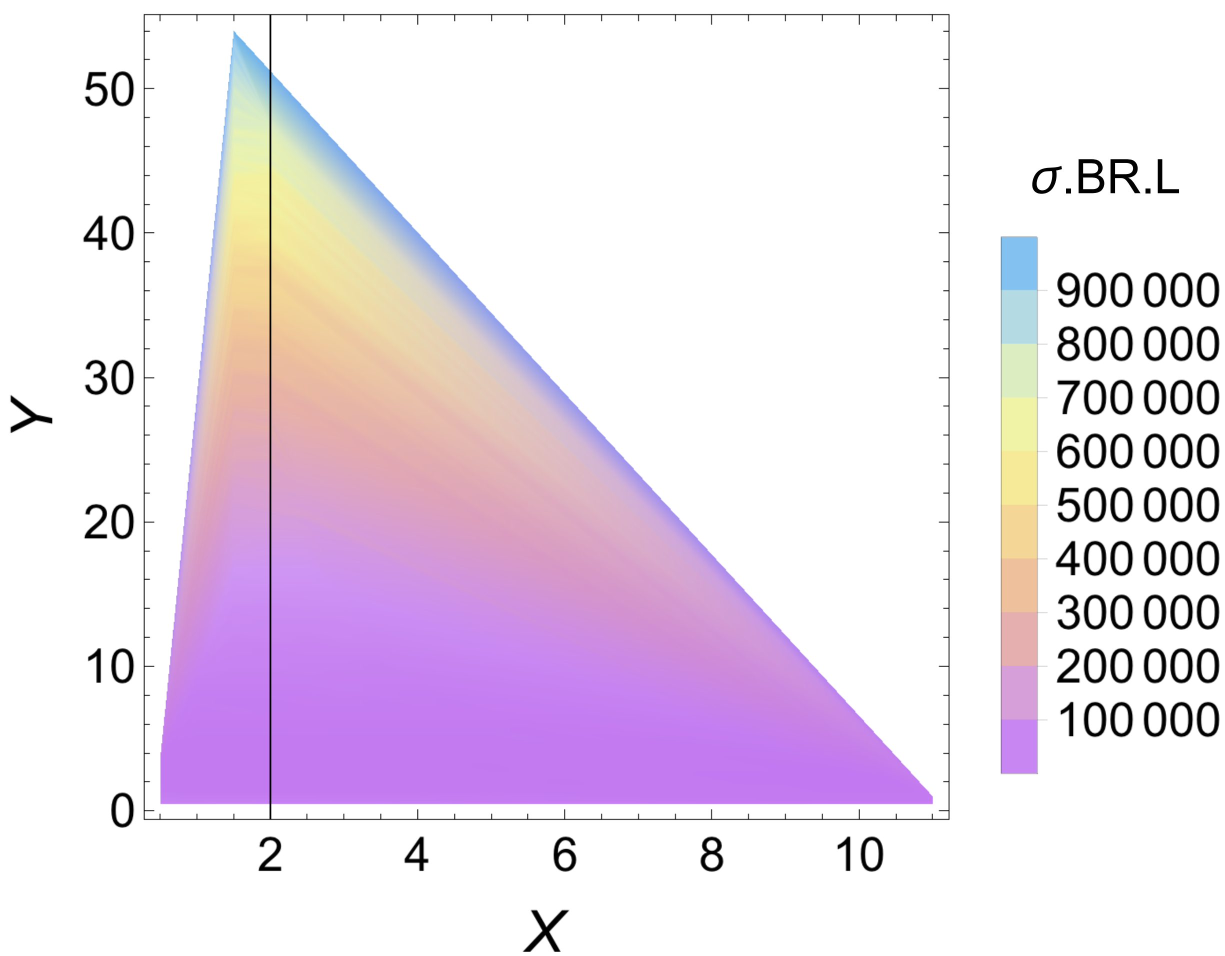
Proc	SimEvt	RawEvt	A	B	C	D	E	F	G	H	I	$\mathcal{S}$
Ib35	100 K	30.0	23.3	9.1	8.2	6.9	6.5	1.5	1.3	1.2	0.8	0.10(0.33)
Ib47	100 K	12.7	9.9	3.8	3.4	2.9	2.7	0.6	0.5	0.5	0.3	0.04(0.12)
Ib57	100 K	230.3	179.6	69.3	62.6	52.6	49.9	11.7	10.1	9.1	6.4	0.83(2.62)
IIa11	100 K	9.1	6.9	2.7	2.4	2.0	1.9	0.4	0.4	0.3	0.2	0.026(0.08)
IIa14	100 K	5.4	4.1	1.6	1.4	1.2	1.1	0.3	0.2	0.2	0.1	0.013(0.04)
IIa26	100 K	4.2	3.2	1.3	1.1	0.9	0.9	0.2	0.1	0.1	0.1	0.013(0.04)
Ya11	100 K	5.9	4.5	1.8	1.6	1.3	1.2	0.3	0.2	0.2	0.1	0.013(0.04)
Ya12	100 K	5.3	4.0	1.6	1.4	1.2	1.1	0.3	0.2	0.2	0.1	0.013(0.04)
Ya14	100 K	5.3	4.0	1.6	1.4	1.2	1.1	0.3	0.2	0.2	0.1	0.013(0.04)
$\nu t\bar{b}$	100 K	50712.1	28338.4	15293.7	11810.9	9808.7	9039.0	751.7	476.8	194.5	32.3	
$\nu b\bar{b}j$	560 K	14104.6	6122.8	3656.7	2395.6	2300.1	2120.8	199.3	112.4	70.8	12.4	
$\nu b2j$	90 K	18043.1	8389.2	3013.0	2427.2	2030.3	1933.1	234.2	83.7	41.0	6.3	$B = 60.1$
$\nu 3j$	300 K	948064.2	410393.4	15560.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$\sqrt{B} = 7.7$
$eb\bar{b}j$	115 K	256730.1	55099.8	36353.6	21280.9	2270.8	385.6	36.1	24.8	20.3	9.0	
$et\bar{t}$	130 K	783.3	685.0	384.5	291.5	199.0	29.1	3.5	3.0	1.2	0.1	

Production of H+ in ep collider

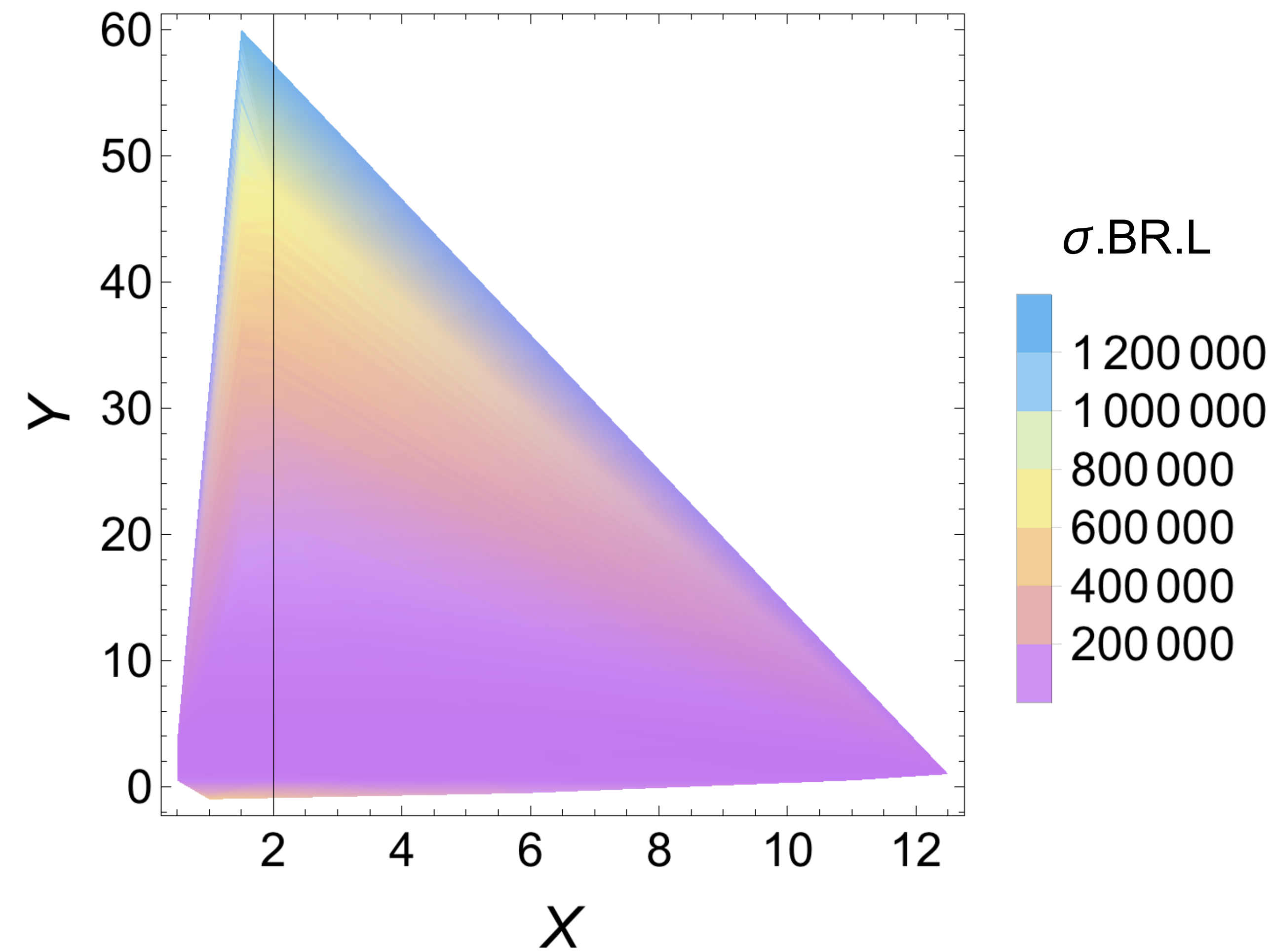


We focus in H+ —> cb, in 2HDM-III (also in MHDM) could be relevant

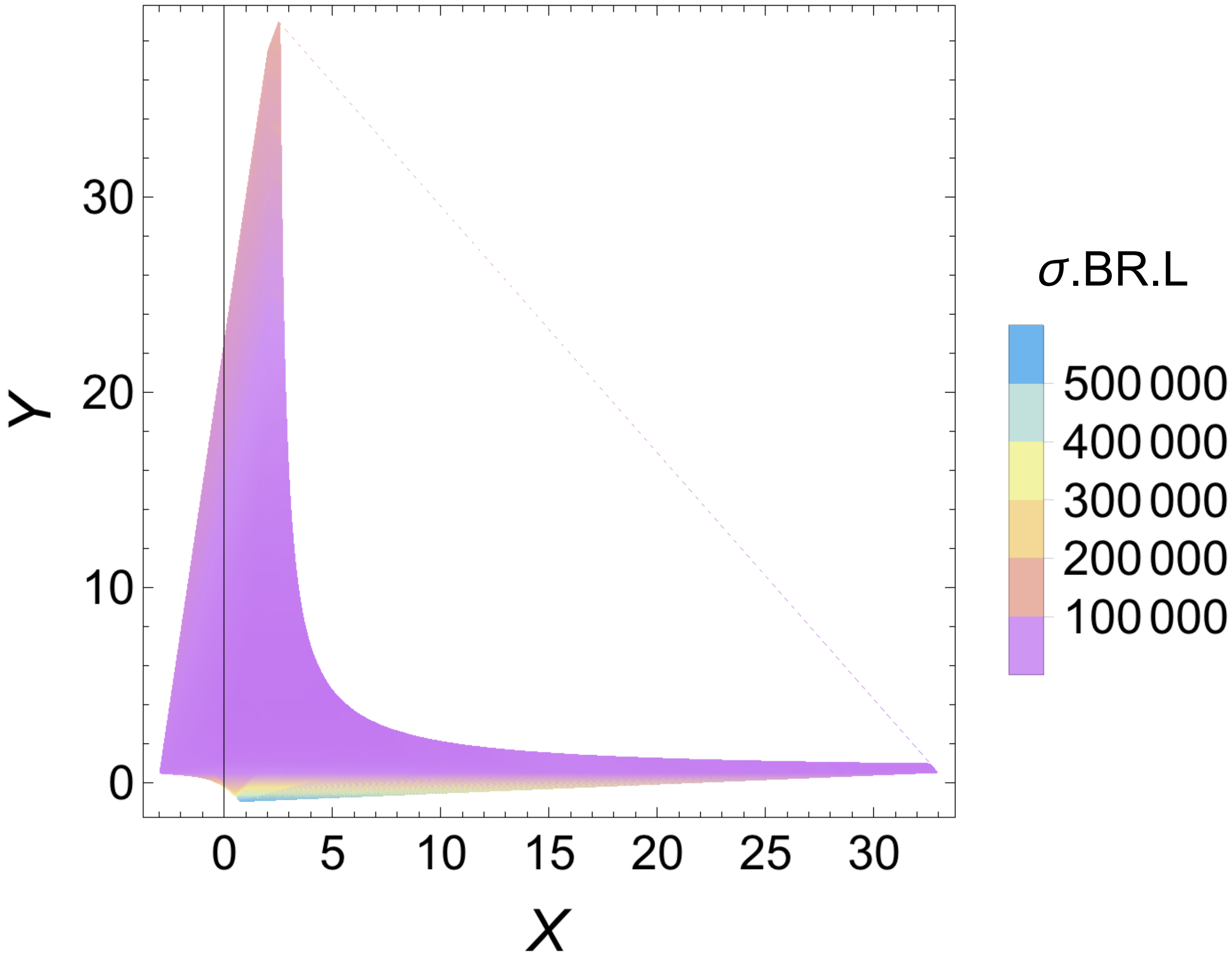
BR (H+ —> cb) ~ 0.9 in 2HDM-III
~0.8 in MHDM PRD 85, 115002 (2012)
(See Kei Yagyu's talk)



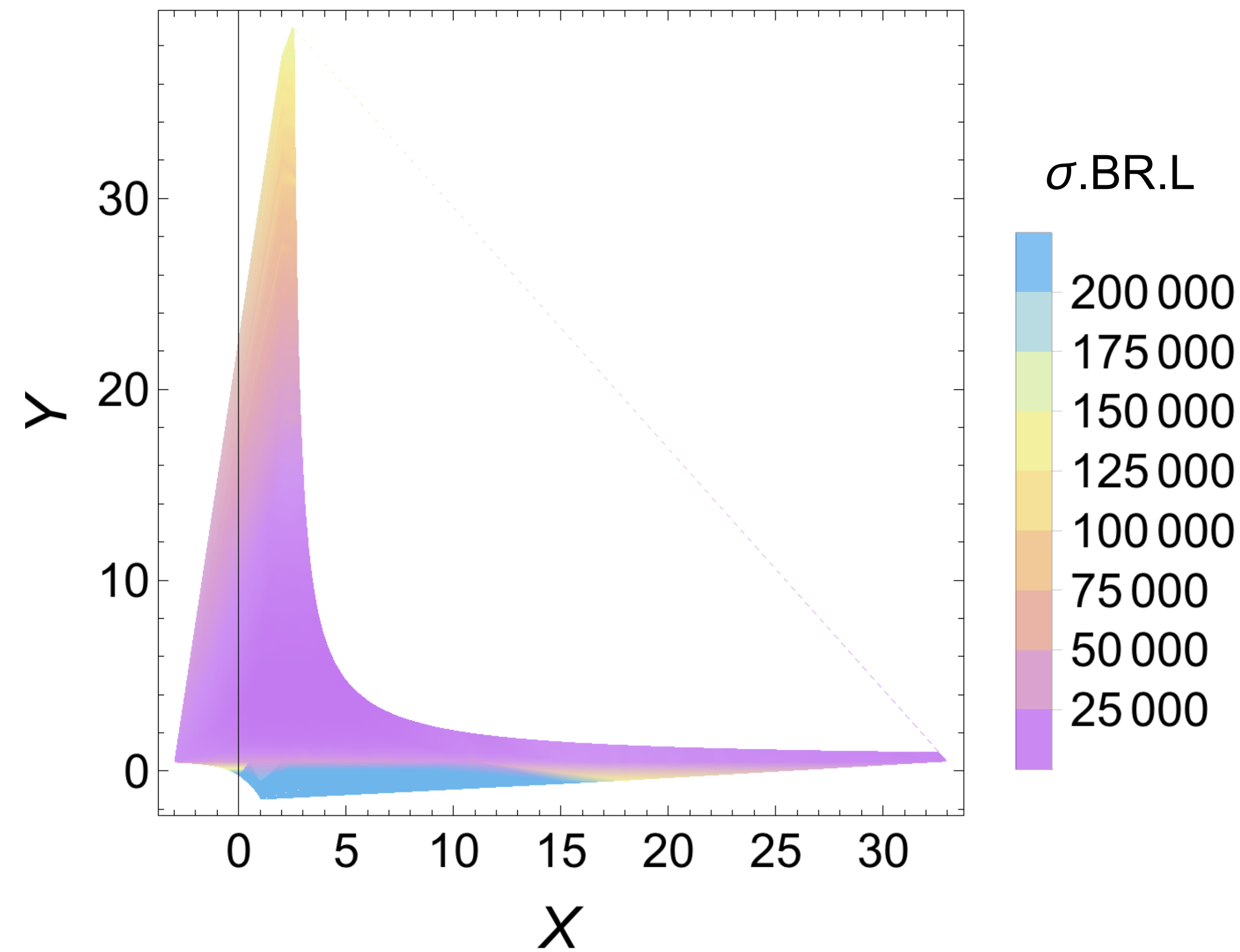
Scenario Ia
Cos (beta-alpha)~0.1



Scenario Ib
Cos(beta-alpha)~0.5



Scenario II



Scenario Y

(with ϵ_b=0.50, ϵ_c=0.10 and ϵ_j=0.01, where j=u,d,s,g)

	S	B	S/B^1/2
Ia (X=5,Y=5)	372.5	3724.03	6.1
Ib (X=5,Y=5)	376.67		6.1
II (X=32,Y=0.5)	286.31		4.69
Y (X=32, Y=0.5)	298.58		4.89

These results are at parton level, but we have optimist prospects, taking only the background of e b.
We are analyzing exhaustively the background (work in progress).

Summary

We show the 2HDM-III and the interesting signals.

We study the signal h—> sb in the future ep collider LHeC: e p —> q nu h (consistent with the study of h—>bb of the other simulation group).

Our study is consistent with flavor physics, Higgs physics and EWPO.

Following the same strategies for the neutral Higgs boson, we study the production of H+ in the future ep collider LHeC.

We show some results at parton level, however the study is in progress. We have spectacular event rates.