Where's

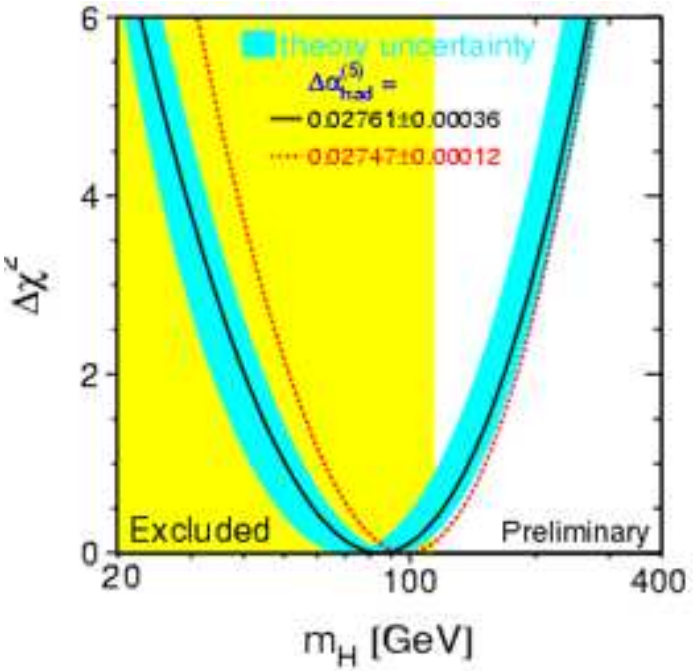


Figure 3: The $\Delta\chi^2$ curve for the fit of the Higgs mass. The dark shaded band corresponds to the theoretical uncertainty, while the dotted line corresponds to a different evaluation of $\Delta\alpha^{(5)}_{had}$ [9]. The mass range experimentally excluded by LEP searches is represented by the light shaded area.

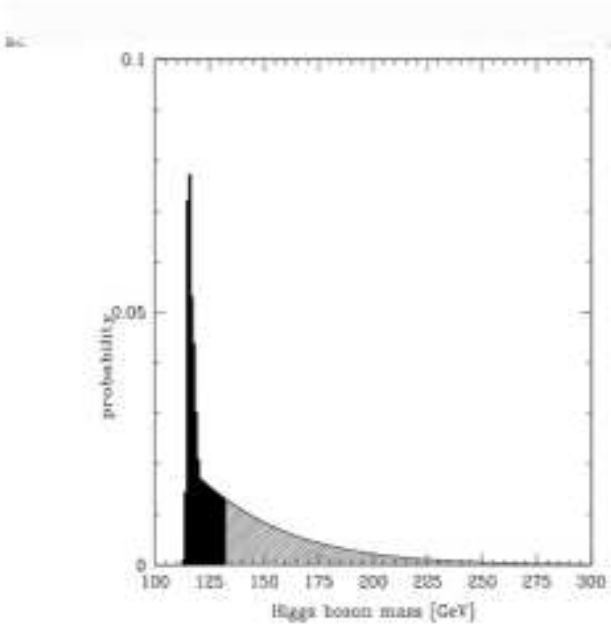


FIGURE 5. Probability density for M_H obtained by combining precision data with direct search results at LEP 2. The peak is due to the candidate Higgs events observed at LEP (updated from Ref. [9]).

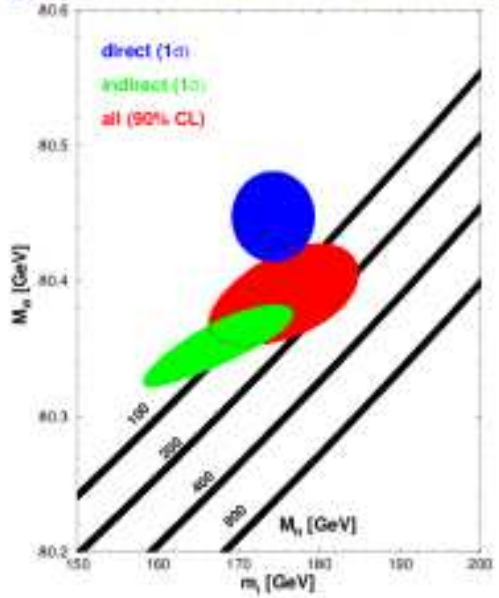


FIGURE 1. One-standard-deviation (39.35% CL) regions in the M_W–m_t plane for the direct and indirect data. The combined 90% CL contour ($\Delta\chi^2 = 4.605$) is also shown. The widths of the M_H bands represent the theoretical uncertainty in the SM prediction ($\alpha_s(M_Z) = 0.120$).

What if ...

... the lightest Higgs boson is, indeed, quite light ($m_h \sim 90$-150 GeV), but it's production rate at LEP (Tevatron) is suppressed by new physics

— Suppression of Higgs production/decay rates are typical in XD models

- $e^+ e^- \to Z^{0*} \to Z^0 h$ in TeV^{-1} size XDs:

  KK excitations of Z^0 interefere destructively with SM amplitude for $s < M_n^2$ ...

$$F_{KK} = 2 \sum_{n=1}^{\infty} \frac{s - M_Z^2}{s - M_n^2} = \pi R A(s) \left[\cot(\pi R A(s)) - 1 \right] ,$$

  ... leading to (substantially) suppressed production rates for $s < M_1^2$

Model

- assume one TeV-size XD Dienes,Dudas,Ghergetta('99), Masip,Pomarol (`00)

visible brane	bulk
SM matter	SM gauge
Higgs doublet: Φ_u	Higgs doublet: Φ_d

$$\mathcal{L}^5 = -\frac{1}{4}\left(F^a_{MN}\right)^2 - \frac{1}{4}\left(B_{MN}\right)^2 + \left|D_M\Phi_d\right|^2 + \left|D_\mu\Phi_u\right|^2\delta(x^5)\,,$$

$$\Phi_u = \frac{1}{\sqrt{2}}\begin{pmatrix}\Phi_u^{0*}\\ \Phi_u^-\end{pmatrix} = \frac{1}{\sqrt{2}}\begin{pmatrix}v_u + h\cos\alpha + H\sin\alpha + i\cos\beta A\\ \cos\beta H^-\end{pmatrix},$$

$$\Phi_d^{(0)} = \frac{1}{\sqrt{2}}\begin{pmatrix}\Phi_d^+\\ \Phi_d^0\end{pmatrix} = \frac{1}{\sqrt{2}}\begin{pmatrix}\sin\beta H^+\\ v_d - h\sin\alpha + H\cos\alpha + i\sin\beta A\end{pmatrix},$$

— Calculate $Z^0 h$ (Wh) production at LEP (Tevatron)

$$\sigma(e^+e^- \to Zh) = \sigma_{SM}\left[\sin(\beta-\alpha) + 2\cos\alpha\sin\beta F_{KK}\right]^2\,,$$

$$F_{KK} = 2\sum_{n=1}^{\infty}\frac{s - M_Z^2}{s - M_n^2} = \pi R A(s)\left[\cot(\pi R A(s)) - 1\right]\,,$$

- observe threefold suppression: α, β, F_{KK}

Surprise!

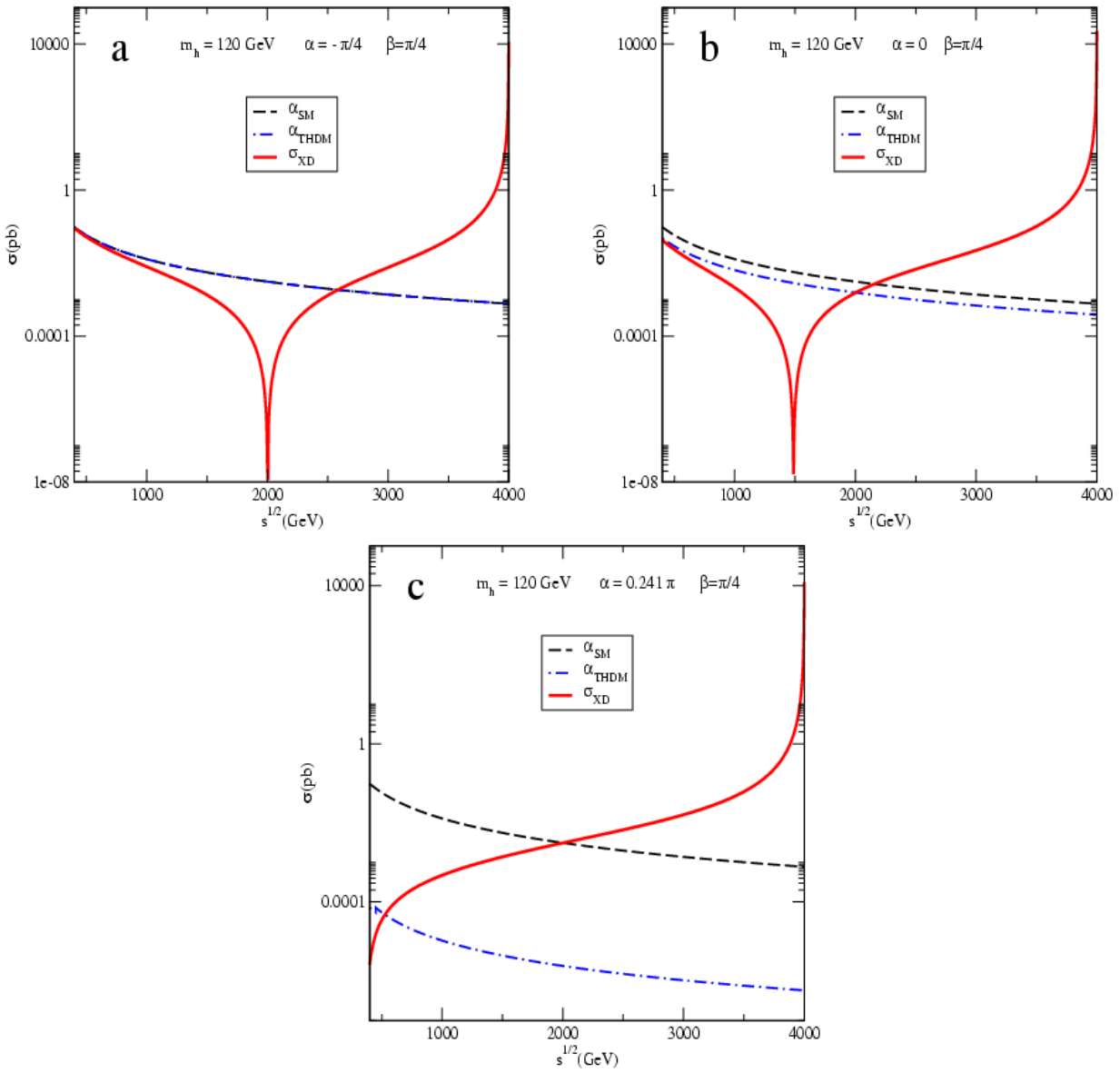


FIG. 1: SM, THDM and XD cross sections for $e^+e^- \to Zh$. Each plot corresponds to a different set of values for α and β all with $m_h = 120$ GeV and with a compactification scale $M_c = 4$ TeV.

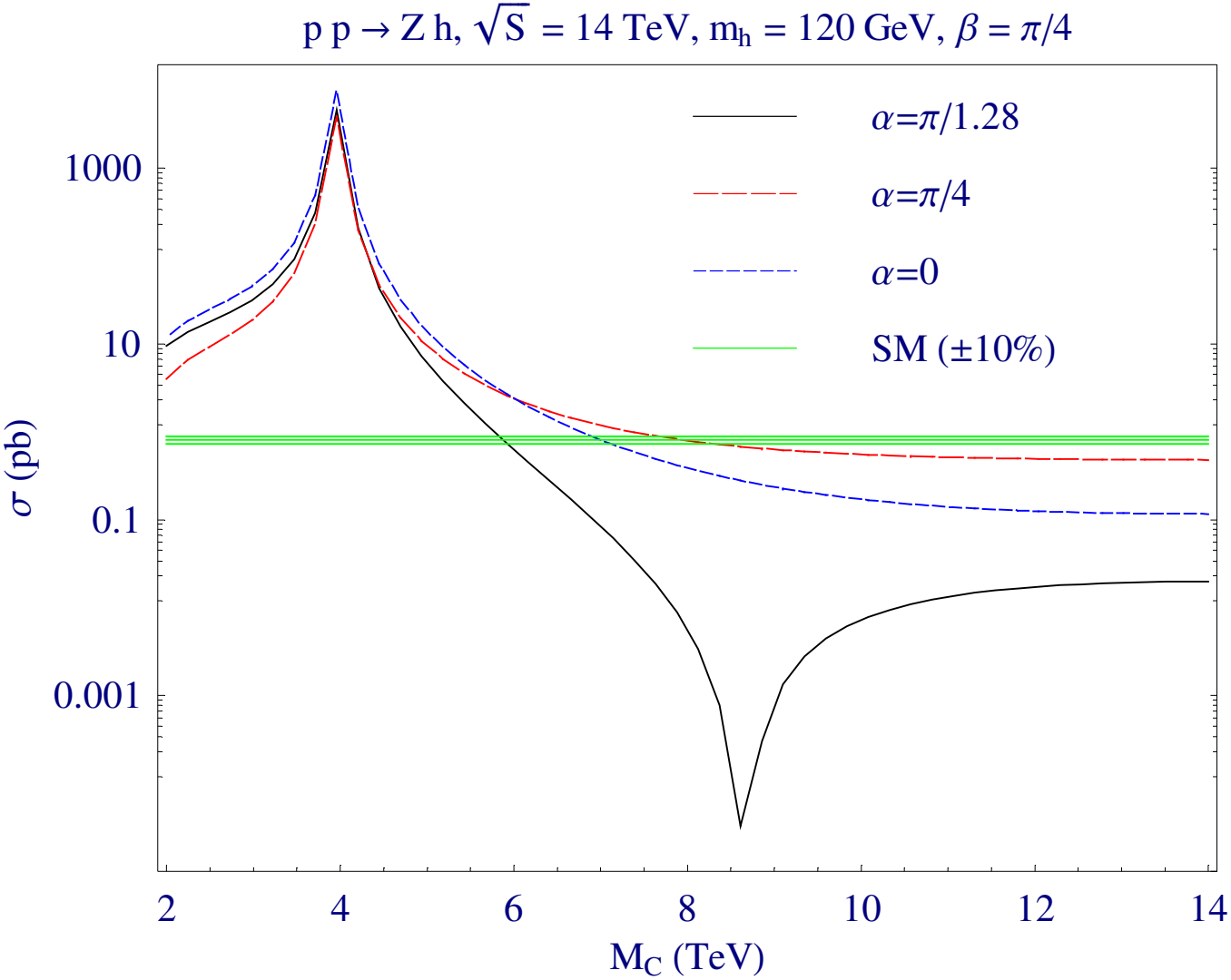


FIG. 2: Higgs production cross section in association with a Z boson as a function of the compactification scale for selected values of the mixing parameters. For reference the SM cross section is shown with a 10% uncertainty band around it.

Higgs Quiz

— Where's the Higgs?

- in the bulk-mail
- on the brain
- on some skating wheels
- at www.higgsboson.com
- at Edinborough
- all the above
- none of the above

Summary & outlook

— Key observations:

- if Z^0 in bulk ⇒ $\sigma(Z^0h)$ suppressed @ LEP/Tev/LC, enhanced @ LHC/CLIC
- if h in bulk ⇒ enhanced $\sigma(Z^0h)$ @ LHC/CLIC measures its location

— Model and analysis can be extended

- theory: include brane-kinetic terms and/or warp

  Are brane kinetic terms (BKTs) describe the same physics as the "mixing"?

  Is it straightforward to warp this?

- phenomenology:

  Special cases? (2HDM, 5DSM, ...); Other processes? ($gg \to h$, ...)

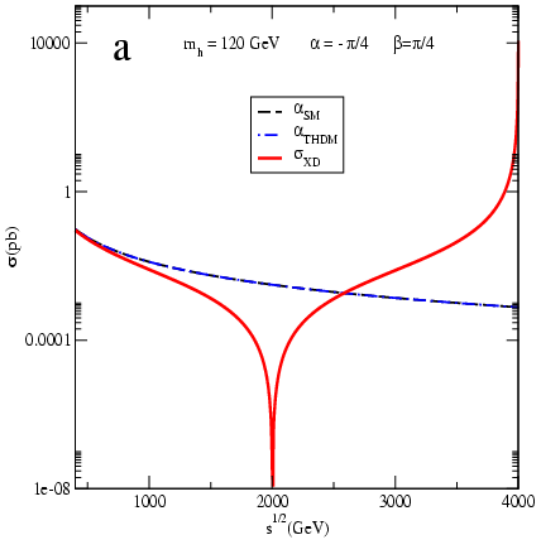
  What's the new (if any) phenomenology induced by BKTs?

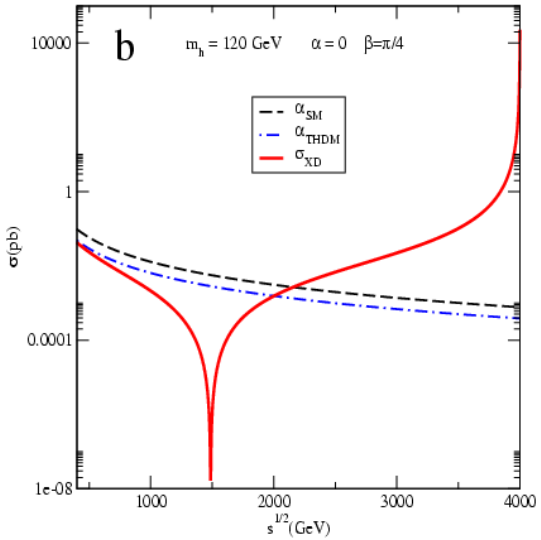
- experiment:

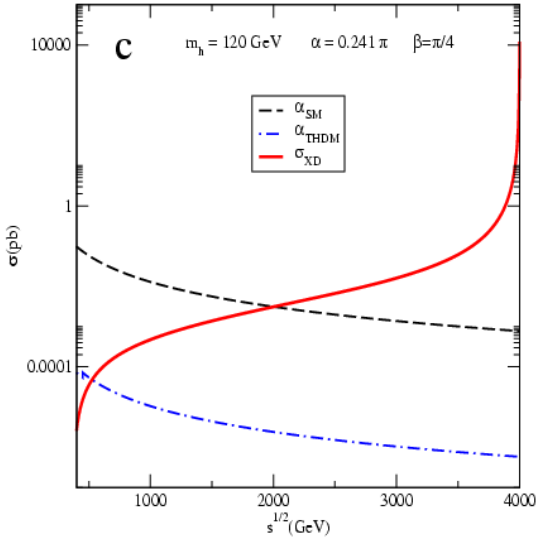
  In what para-region can the peak be observed at LHC/CLIC?

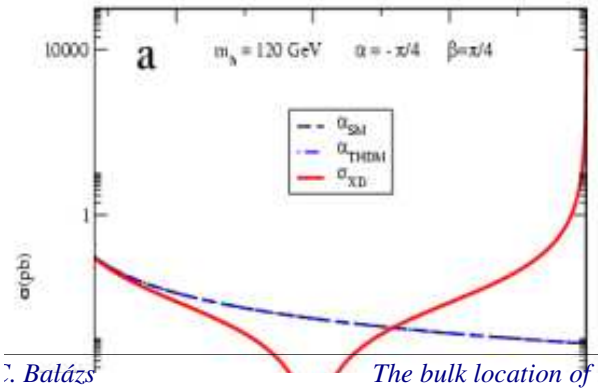
  Backgrounds?

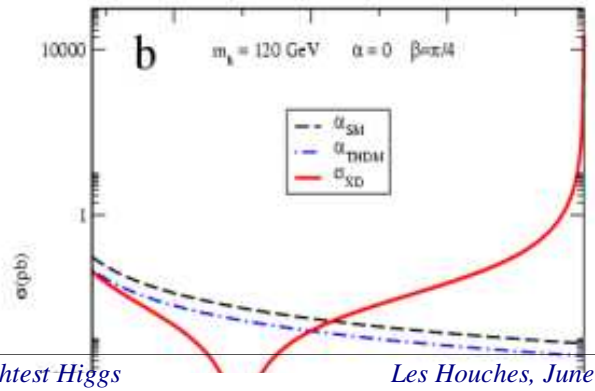
Appendix


a
m_h = 120 GeV α = - π/4 β=π/4
α_{SM}
α_{THDM}
σ_{XD}
10000
1
0.0001
1e-08
1000
2000
3000
4000
σ(pb)
$s^{1/2}$(GeV)


b
m_h = 120 GeV α = 0 β=π/4
α_{SM}
α_{THDM}
σ_{XD}
10000
1
0.0001
1e-08
1000
2000
3000
4000
σ(pb)
$s^{1/2}$(GeV)


c
m_h = 120 GeV α = 0.241 π β=π/4
α_{SM}
α_{THDM}
σ_{XD}
10000
1
0.0001
1000
2000
3000
4000
σ(pb)
$s^{1/2}$(GeV)


a
m_h = 120 GeV α = - π/4 β=π/4
α_{SM}
α_{THDM}
σ_{XD}
10000
1
σ(pb)


b
m_h = 120 GeV α = 0 β=π/4
α_{SM}
α_{THDM}
σ_{XD}
10000
1
σ(pb)

Summary & outlook

— Key observations:

- if Z^0 in bulk ⇒ $\sigma(Z^0h)$ suppressed @ LEP/Tev/LC, enhanced @ LHC/CLIC
- if h in bulk ⇒ enhanced $\sigma(Z^0h)$ @ LHC/CLIC measures its location

— Model is simple, but general enough to flexibly parametrize Higgs location

- (extremely) easily calculable

— Model and analysis can be extended

- theory: include brane-kinetic terms and/or warp

  Are brane kinetic terms (BKTs) describe the same physics as the "mixing"?

  Is this setup a specific case with vanishing brane kinetics?

  Are BKTs the specific case of this?

  Is it straightforward to warp this?

- phenomenology:

  What's the new (if any) phenomenology induced by BKTs?

- experiment: