1. INTRODUCTION

The discovery of a Higgs boson at the Large Hadron Collider (LHC) accomplished the long waited physics goals of getting hints on the nature of the electroweak symmetry breaking (EWSB) mechanism and understanding the generation of the fermion masses. While the discovered Higgs boson appears to be highly compatible with the Standard Model (SM) expectation [1], current data is still insufficient for revealing the true nature of the EWSB dynamics. Further pieces of information related to the shape of the Higgs potential are indeed needed, such as measurements of the Higgs cubic, quartic and even higher-order self-couplings. This would furthermore allow us to investigate whether the electroweak phase transition is of the first or second order, a fact related to the matter-antimatter asymmetry in the universe as a strong first order electroweak phase transition is of the first or second order. A process faces a rather grim prospect at the LHC, mainly because of a small signal rate of $O(0.1)$ fb [10–12], so that the study of this process is left to the experimental program of the post-LHC era that is currently under discussion at CERN and IHEP [13]. Feasibility analyses have so far shown that the $b\bar{b}\gamma\gamma$ channel can be used to constrain the size of the quartic Higgs coupling in a model-independent way, the interaction strength being allowed to deviate by a factor of at most $O(10)$ from the SM after considering an integrated luminosity of 30 ab$^{-1}$ [14–16]. The prospects of the $b\bar{b}WWW$ decay mode have also been explored, and it was shown that a new physics triple-Higgs search channel, the Standard Model Higgs quartic coupling could in principle be reached with a significance beyond the 3σ level.

Di-Higgs production via gluon fusion offers the first playground to access the Higgs cubic coupling, in particular within the high-luminosity phase of the LHC expected to collect an integrated luminosity of 3 ab$^{-1}$ of data at a center-of-mass energy of 14 TeV [2, 3]. The associated sizable (SM) production cross section of about 43 fb [4] allows one to make use of various final states to probe the Higgs cubic coupling, the two most promising signatures relying on final state systems made of four $b$-jets, or of a pair of photons and either a pair of $b$-jets or tau leptons [5–7]. At a future proton-proton collider aiming to operate at a center-of-mass energy of 100 TeV, the $b\bar{b}\gamma\gamma$ channel keeps its leading role and measurements at a precision of about 3 – 4% could be expected for a luminosity of 30 ab$^{-1}$ [8, 9]. None of these searches are, however, designed to probe the Higgs quartic coupling.

In the SM, triple-Higgs production mostly arises, at the leading-order in QCD, by gluon fusion (see Fig. 1). Such a process faces a rather grim prospect at the LHC, mainly because of a small signal rate of $O(0.1)$ fb [10–12], so that the study of this process is left to the experimental program of the post-LHC era that is currently under discussion at CERN and IHEP [13]. Feasibility analyses have so far shown that the $b\bar{b}\gamma\gamma$ channel can be used to constrain the size of the quartic Higgs coupling in a model-independent way, the interaction strength being allowed to deviate by a factor of at most $O(10)$ from the SM after considering an integrated luminosity of 30 ab$^{-1}$ [14–16]. The prospects of the $b\bar{b}WWW$ decay mode have also been explored, and it was shown that a new physics triple-Higgs search channel, the Standard Model Higgs quartic coupling could in principle be reached with a significance beyond the 3σ level.
sensitivity [14]. However, with the effort of exploiting previously overlooked advantages of the ditau system and a boosted configuration, we show in this work that the bbbbrτ channel can be promoted to a leading discovery channel for triple-Higgs production.

This paper is organized as follows. In Sec. 2, we introduce the adopted simplified model parameterizing in a model-independent way any new physics effect on the Higgs self-interactions, and we present technical details related to our simulation setup. Sec. 3 is dedicated to our event selection strategy and exhibits details on its specificity. Our results are given in Sec. 4, together with prospects for a future 100 TeV proton-proton colliders.

2. THEORETICAL FRAMEWORK AND TECHNICAL DETAILS

In order to probe for possible new physics effects in multiple-Higgs interactions, we modify in a model-independent fashion the SM Higgs potential,

\[ V_h = \frac{m_h^2}{2} h^2 + (1 + \kappa_3) \lambda_{hhh}^\text{SM} v^3 + \frac{1}{4} (1 + \kappa_4) \lambda_{hhh}^\text{SM} h^4, \]

by introducing two \( \kappa_i \) parameters that vanish in the SM. In our notation, \( h \) denotes the physical Higgs-boson field, \( m_h \) its mass and \( v \) its vacuum expectation value. The SM self-interaction strengths moreover read

\[ \lambda_{hhh}^\text{SM} = \lambda_{hhh}^\text{SM} = \frac{m_h^2}{2v^2}. \]

We simulate our triple Higgs signal and the associated backgrounds by implementing the above Lagrangian in the FeynRules package [18] that we use along with the NloCT program [19] to generate a UFO library [20]. The latter allows for event generation for both tree-level and loop-induced processes within the MADGRAPH5_aMC@NLO [21, 22] framework, that we use to convolute hard scattering matrix elements with the next-to-leading (NLO) set of NNPDF 2.3 parton densities [23] for a center-of-mass energy of \( \sqrt{s} = 100 \text{ TeV} \).

The hard-scattering events are then decayed, showered and hadronized within the PYTHIA 6 environment [24] and reconstructed by using the anti-\( k_T \) algorithm [25] as implemented in FASTJET [26], with a radius of \( R = 1 \) and 0.4 for a fat jet and slim jet definition, respectively.

Hadronic taus are defined as specific slim jets for which there is no hadronic object of \( p_T > 1 \text{ GeV} \) and no photon with a \( p_T > 1.5 \text{ GeV} \) at an angular distance of the jet axis greater than \( r_{\text{in}} = 0.1 \) and smaller than \( r_{\text{out}} = 0.4 \). The resulting tau-tagging efficiency is of about 50%, for a fake rate of mistagging a light-flavor jet as a tau of roughly 5%. Those performances can be compared to what could be expected from the high-luminosity phase of the LHC, for which an efficiency of 55% can be expected for a mistagging rate of 0.5% [7].

Our analysis relies on the reconstruction of boosted Higgs bosons. To this aim, we employ the template overlap method [27, 28] as embedded in the TEMPLATETAGGER program [29], and we use a new template observable derived from the \( t\bar{t} \) quantity proposed in Ref. [30], which we here maximize over the different three-body Higgs templates. We make use of various two-body and three-body (NLO) Higgs templates featuring a sub-cone size of 0.1 to compute the discriminating overlaps \( Ov_3^2 \) and \( Ov_3^3 \), respectively, that allow for a boosted Higgs boson identification. The performance of the method yields a tagging efficiency of 40% for a mistagging rate of 2%.

As suggested by the representative Feynman diagrams of Fig. 1, triple-Higgs production depends on both \( \kappa_i \) parameters as well as on the top Yukawa coupling. While in either an effective field theory framework or an ultraviolet-complete model building approach, the \( \kappa_i \) parameters are not independent, they will be varied in-
TABLE I: Fiducial cross sections of all components of the SM background after the baseline selection described in Sec. 3. The results include an NLO K-factor of 2, and the suffixes ‘τ’ and ‘bb’ respectively indicate decays into a tau-lepton and a b b pair; ℓ_h denoting similarly a hadronically-decaying top quark.

| Class       | Backgrounds | Cross section [ab] |
|-------------|-------------|--------------------|
| t/W samples | t,ℓ_ℓh_b   | 2.3 × 10^4        |
|             | t,ℓ_ℓZ_b   | 6.6 × 10^3        |
|             | t,ℓ_bℓ_b   | 4.7 × 10^5        |
|             | W^3_b W^−_b b b b | 4.7 × 10^5 |
|             | ℓℓℓ         | 6.6 × 10^4        |
|             | X_ττb b b   | 6.9 × 10^4        |
|             | X_ττb b j j | 1.5 × 10^7        |
|             | Z_ττℓ_hb ℓ_h | 1.6 × 10^5        |
|             | X_ττZ_b b ℓ_h | 2.0 × 10^3        |
|             | Z_ττh_b ℓ_h | 300               |
|             | h_h ℓ_hb ℓ_hb | 23              |
|             | h_h h_h ℓ_hb | 15               |
|             | h_h h_h Z_ττ | 11               |
|             | h_h h_h τ τ | 1.3 × 10^3        |

FIG. 3: Distribution in the m_ττ invariant mass (as defined in the text) after the baseline selection for the three SM background categories and for a SM triple-Higgs signal.

into a pair of tau leptons. Di-Higgs production in association with jets finally forms the last class of background processes on its own. The full list of considered SM backgrounds is summarized in Table I, where we additionally present the fiducial cross sections, multiplied by a conservative NLO K-factor of 2, obtained after requiring the presence of two hadronic taus and missing transverse energy (cf. the baseline selection described in Sec. 3).

3. SIGNAL SELECTION

Our triple-Higgs analysis relies for its baseline selection on the properties of the b b b b τ + τ − final state. We preselect events featuring exactly two hadronic taus with a p_T > 25 GeV and a pseudorapidity |η| < 2.5, as well as a missing transverse energy E_T > 25 GeV.

After this preselection, the two taus are enforced to be compatible with the decay of a Higgs boson by means of the m_T^Higgs-bound and m_T^True variables [32–34]. The former quantity is defined by minimizing, over all possible assignments for the neutrino four-momenta, the invariant mass of the system made of the two tau jets and the two invisible neutrinos. This minimization procedure however requires that each tau jet is matched with a neutrino and that the resulting two-body invariant mass is compatible with the tau mass. For cases for which there is no such a solution, the m_T^True variable is constructed instead in the same way, but without this last constraint. We present the resulting m_ττ distribution in Fig. 3, m_ττ generically denoting m_T^Higgs-bound when it can be constructed and m_T^True otherwise. Most signal events exhibit an m_ττ value lying between the Z and the Higgs boson masses, whereas background events from the X_ττ + jets category mainly feature smaller m_ττ values. We therefore impose that m_ττ ∈ [105, 135] GeV to ensure compatibility with a Higgs ditau decay and a very good
discrimination from the $X_{\tau\tau} + \text{jets}$ background category.

We move on with the reconstruction of the two other Higgs bosons for which we rely on a configuration where one of them is boosted and the other one is resolved. We select events featuring at least one fat jet whose basic properties satisfy $p_T > 300$ GeV and $|\eta| < 2.5$. The fat jet invariant mass is moreover required to lie in the [105, 135] GeV window and the template overlaps are constrained to $O_{h3} > 0.7$ and $O_{h2} > 0.2$. We additionally require the presence of at least two slim jets and tag two of them as candidates for a non-boosted Higgs decay. This tagging is such that the dijet invariant mass $m_{jj} \in [105, 135]$ GeV minimizes $|m_{jj} - m_h|$. Furthermore, one of the two tagged slim jets must be b-tagged and the fat jet must contain a doubly-b-tagged substructure when we assume a b-tagging efficiency of 70% when a $B$-hadron is present in a cone of radius $R = 0.4$ around the jet direction, for a corresponding mistagging rate of 1%.

At this stage, the background is dominated by its $t/W$ component (see Table II). In contrast to the triple-Higgs signal in which the missing energy originates from the two neutrinos associated with the tau decays, most background events feature either more than two neutrinos, or a missing energy originating from a $W$-boson pair. This suggests to take advantage of the $m_{T2}$ variable [35, 36] to ensure an efficient background rejection. The $m_{T2}$ spectrum is bounded from above and its shape depends both on a test mass and on the mass of the semi-invisibly decaying particle. Moreover, the upper bound sharply rises for increasing test masses above the true mass of the invisible particle [37]. As the true invisible mass is zero for the triple Higgs signal, the associated $m_{T2}$ distribution is naturally broader than for the background, provided the test mass is taken large enough. This feature is illustrated in Fig. 4 for which we have chosen an optimized test mass of 190 GeV, which allows for a maximal background and signal separation.

![FIG. 4: $m_{T2}$ spectra for the signal (in the case of a SM Higgs potential) and the various components of the background.](image)

After having reconstructed all three Higgs bosons, we derive the invariant mass of the triple-Higgs system $m_{hhh}$ and constrain it to be smaller than 1.6 TeV.

### 4. RESULTS AND DISCUSSION

We present in Table II the fiducial cross sections resulting from the application of the various selections introduced in Sec. 3, both for the signal (assuming the SM case with $\kappa_3 = \kappa_4 = 0$) and the background. We can observe the complementarity of the various steps, the $m_{T2}$ and boosted Higgs requirements reducing the background by a factor of more than 2000, while the reconstruction of the resolved Higgs boson and the $b$-tagging conditions bring the signal over background ($S/B$) ratio down to the percent level. The background is at this stage dominated by $t/W$ events and is further reduced to a manageable level by means of the $m_{T2}$ selection. The selection on the triple-Higgs invariant mass finally brings the background rate to half the signal one for the considered benchmark.

In order to set limits and derive the future collider sensitivity in the $(\kappa_3, \kappa_4)$ plane, we compute a significance $\sigma$ defined as the likelihood ratio [38]

\[
\sigma = \sqrt{2 \ln \frac{L(B|S+B)}{L(S+B|S+B)}}
\]

where $S$ and $B$ are the expected number of signal and background events respectively. The signal sensitivity turns out to be of about $2\sigma$ in the SM case for a luminosity of 30 ab$^{-1}$, with a number of signal events $S \sim 3$ and background events $B \sim 1.4$. The number of signal events could however be increased by considering the strategic approach of including the contributions of a semi-leptonic $\tau_\tau t\bar{t}b\bar{b}b\bar{b}$ final state, as it has been recently proposed for di-Higgs searches at the LHC [7].

Scanning over the $\kappa_i$ parameters, we show in Fig. 5 the luminosity goals of a 100 TeV proton-proton collider necessary for achieving a $2\sigma$ exclusion (left panel). Despite

| Selection          | Signal | $t/W$ | $X_{\tau\tau}$ | $hh$ |
|--------------------|--------|-------|----------------|------|
| Baseline           | 27     | $1.0 \times 10^6$ | $1.6 \times 10^5$ | $1.3 \times 10^3$ |
| $m_{T2}$           | 12     | $1.4 \times 10^5$ | $2.6 \times 10^6$ | 670   |
| Boosted Higgs      | 0.92   | 640   | $6.5 \times 10^3$ | 35    |
| $m_{jj}$           | 0.47   | 180   | 81             | 4.1   |
| $b$-tagging        | 0.15   | 15    | 0.20           | 0.034 |
| $m_{T2}$           | 0.11   | 0.37  | 0.093          | 0.029 |
| $m_{hhh}$          | 0.10   | $8.5 \times 10^{-3}$ | 0.012 | 0.026 |

TABLE II: Signal and background cross sections, in ab, at different stage of the analysis strategy depicted in Sec. 3. The signal to background ratio $S/B$ and the significance $\sigma$ for a luminosity of 30 ab$^{-1}$ are also indicated.
the dominance of destructive interferences on the upper-
right-corner of the $(\kappa_3, \kappa_4)$ plane, our analysis
demonstrates that the SM expectation can in principle be
excluded with $30 \text{ ab}^{-1}$. Conversely, we present in the right
panel of the figure the significance contours obtained
when considering a luminosity of $30 \text{ ab}^{-1}$. In order to
access the sensitivity gap in the parameter space region
limited by $\kappa_3 \in [0, 2]$ and $\kappa_4 \in [0, 14]$, one could combine
our results with other channels, like the $\tau \gamma b b b b$ mode
that could enhance the sensitivity of the present analysis,
and the $\gamma \gamma b b b b$ channel investigated in Refs. [14–16]. Our
findings could moreover be merged with the more precise
prospects on the $\kappa_3$ parameters that stem from di-Higgs
probes expected to be produced at a large rate [8, 9].

In this work, we have continued our investigation of the
possibilities of a future proton-proton collider expected
to run at $\sqrt{s} = 100$ TeV to unravel the true nature of the
EWSB mechanism. We have shown that in addition to the $\gamma \gamma b b b b$ golden channel, the $b b b b \tau \tau$ mode is a comple-
mentary probe to the quartic Higgs self-interaction. Our
results are comparable to those derived in other triple-
Higgs channels, so that combinations of several searches
could offer handles to parameter space regions featuring
low cross sections and not accessible with a single triple-
Higgs analysis. Such a combination also gives hope to

access the SM couplings beyond the $3\sigma$ level.

Acknowledgements: We are very grateful to Minho Son
for valuable help and discussions, in particular on tau
reconstruction, as well as to K.C. Kong, Ian M. Lewis
and Graham Wilson for useful comments and suggestions
during the course of this project. We also thank the HT-
CaaS group of the Korea Institute of Science and Tech-
nology Information (KISTI) for providing the necessary
computing resources and acknowledge the Korea Future
Collider Study Group (KFCSG) for motivating us to pro-
ceed with this work. JHK is supported in part by US-
DOE (DE-FG02-12ER41809) and by the University of
Kansas General Research Fund allocation 2302091. SL is
supported by the National Research Foundation of Korea
(NRF) grant funded by the Korea government (MEST)
(No. NRF-2015R1A2A1A15052408), and by the Korean
Research Foundation (KRF) through the Korea-CERN
collaboration program (NRF-2016R1D1A3B01010529).
The work of BF is partly supported by French state
funds managed by the Agence Nationale de la Recherche
(ANR), in the context of the LABEX ILP (ANR-11-
IDEX-0004-02, ANR-10-LABX-63), and by the FKPPL
initiative of the CNRS.

[1] ATLAS, CMS Collaboration, G. Aad et al.,
"Measurements of the Higgs boson production and decay
rates and constraints on its couplings from a combined
ATLAS and CMS analysis of the LHC pp collision data
at $\sqrt{s} = 7$ and 8 TeV, JHEP 08 (2016) 045,
[arXiv:1606.02268].

[2] M. J. Dolan, C. Englert, and M. Spannowsky, "Higgs
self-coupling measurements at the LHC, JHEP 10
(2012) 112, [arXiv:1206.5001].

[3] J. Baglio, A. Djuadi, R. Gröber, M. Mühleitner,
J. Quevillon, and M. Spira, "The measurement of the
Higgs self-coupling at the LHC: theoretical status, JHEP
04 (2013) 151, [arXiv:1212.5581].

[4] D. de Florian and J. Mazzitelli, Higgs pair production at next-to-next-to-leading logarithmic accuracy at the LHC, JHEP 09 (2015) 053, [arXiv:1505.07122].

[5] ATLAS Collaboration, Projected sensitivity to non-resonant Higgs boson pair production in the \(bb\bar{b}b) final state using proton–proton collisions at \(\text{HL-LHC}\) with the ATLAS detector, ATL-PHYS-PUB-2016-024.

[6] ATLAS Collaboration, Study of the double Higgs production channel \(H(\rightarrow \bbbar)H(\rightarrow \gamma\gamma)\) with the ATLAS experiment at \(\text{HL-LHC}\), ATL-PHYS-PUB-2017-001.

[7] CMS Collaboration, Higgs pair production at the High Luminosity LHC, CMS-PAS-FTR-15-002.

[8] R. Contino et al., Physics at a 100 TeV \(pp\) collider: Higgs and EW symmetry breaking studies, arXiv:1606.09408.

[9] A. Azatov, R. Contino, G. Panico, and M. Son, Effective field theory analysis of double Higgs boson production via gluon fusion, Phys. Rev. D92 (2015), no. 3 035001, [arXiv:1502.00539].

[10] T. Plehn and M. Rauch, The quartic higgs coupling at hadron colliders, Phys. Rev. D72 (2005) 053008, [hep-ph/0507321].

[11] T. Binoth, S. Karg, N. Kauer, and R. Ruckl, Multi-Higgs boson production in the Standard Model and beyond, Phys. Rev. D74 (2006) 113008, [hep-ph/0609207].

[12] F. Maltoni, E. Vryonidou, and M. Zaro, Top-quark mass effects in double and triple Higgs production in gluon-gluon fusion at NLO, JHEP 11 (2014) 079, [arXiv:1408.6542].

[13] N. Arkani-Hamed, T. Han, M. Mangano, and L.-T. Wang, Physics opportunities of a 100 TeV proton–proton collider, Phys. Rept. 652 (2016) 1–49, [arXiv:1511.06495].

[14] B. Fuks, J. H. Kim, and S. J. Lee, Probing Higgs self-interactions in proton-proton collisions at a center-of-mass energy of 100 TeV, Phys. Rev. D93 (2016), no. 3 035026, [arXiv:1510.07697].

[15] C.-Y. Chen, Q.-S. Yan, X. Zhao, Y.-M. Zhong, and Z. Zhao, Probing triple-Higgs productions via 462\# decay channel at a 100 TeV hadron collider, Phys. Rev. D93 (2016), no. 1 013007, [arXiv:1510.04013].

[16] A. Papavassiliou and K. Sakurai, Triple Higgs boson production at a 100 TeV proton–proton collider, JHEP 02 (2016) 006, [arXiv:1508.06524].

[17] W. Kilian, S. Sun, Q.-S. Yan, X. Zhao, and Z. Zhao, New Physics in multi-Higgs boson final states, arXiv:1702.03554.

[18] A. Alloul, N. D. Christensen, C. Degrande, C. Duhr, and B. Fuks, FeynRules 2.0 - A complete toolbox for tree-level phenomenology, Comput. Phys. Commun. 185 (2014) 2250–2300, [arXiv:1310.1921].

[19] C. Degrande, Automatic evaluation of UV and R2 terms for beyond the Standard Model Lagrangians: a proof-of-principle, Comput. Phys. Commun. 197 (2015) 239–262, [arXiv:1406.3030].

[20] C. Degrande, C. Duhr, B. Fuks, D. Grellscheid, O. Mattelaer, and T. Reiter, UFO - The Universal FeynRules Output, Comput. Phys. Commun. 183 (2012) 1201–1214, [arXiv:1108.2040].

[21] J. Alwall, R. Frederix, S. Frixione, V. Hirschi, F. Maltoni, O. Mattelaer, H. S. Shao, T. Stelzer, P. Torrielli, and M. Zaro, The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations, JHEP 07 (2014) 079, [arXiv:1405.0301].

[22] V. Hirschi and O. Mattelaer, Automated event generation for loop-induced processes, JHEP 10 (2015) 146, [arXiv:1507.00020].

[23] R. D. Ball et al., Parton distributions with LHC data, Nucl. Phys. B867 (2013) 244–289, [arXiv:1207.1303].

[24] T. Sjostrand, S. Mrenna, and P. Z. Skands, PYTHIA 6.4 Physics and Manual, JHEP 0605 (2006) 026, [hep-ph/0603175].

[25] M. Cacciari, G. P. Salam, and G. Soyez, The Anti-k(t) jet clustering algorithm, JHEP 0804 (2008) 063, [arXiv:0802.1189].

[26] M. Cacciari, G. P. Salam, and G. Soyez, FastJet User Manual, Eur. Phys. J. C72 (2012) 1896, [arXiv:1111.6097].

[27] L. G. Almeida, S. J. Lee, G. Perez, G. Sterman, and I. Sung, Template Overlap Method for Massive Jets, Phys.Rev. D82 (2010) 054034, [arXiv:1006.2035].

[28] L. G. Almeida, O. Erdogan, J. Juknevich, S. J. Lee, G. Perez, et al., Three-particle templates for a boosted Higgs boson, Phys.Rev. D85 (2012) 114046, [arXiv:1112.1957].

[29] M. Backovic and J. Juknevich, TemplateTagger v1.0.0: A Template Matching Tool for Jet Substructure, Comput. Phys. Commun. 185 (2014) 1322–1338, [arXiv:1212.2976].

[30] J. H. Kim, K. Kong, S. J. Lee, and G. Mohlabeng, Probing TeV scale Top-Philic Resonances with Boosted Top-Tagging at the High Luminosity LHC, Phys. Rev. D94 (2016), no. 3 035023, [arXiv:1604.07421].

[31] D. de Florian and J. Mazzitelli, Two-loop corrections to the triple Higgs boson production cross section, JHEP 02 (2017) 107, [arXiv:1610.05012].

[32] A. J. Barr, S. T. French, J. A. Frost, and C. G. Lester, Speedy Higgs boson discovery in decays to tau lepton pairs : \(h\rightarrow\tau\tau\), JHEP 10 (2011) 080, [arXiv:1106.2322].

[33] A. J. Barr, B. Gripaios, and C. G. Lester, Measuring the Higgs boson mass in dileptonic W-boson decays at hadron colliders, JHEP 07 (2009) 072, [arXiv:0902.4864].

[34] A. J. Barr, M. J. Dolan, C. Englert, and M. Spannowsky, Di-Higgs final states augMT2ed – selecting hh events at the high luminosity LHC, Phys. Lett. B728 (2014) 308–313, [arXiv:1309.6318].

[35] C. G. Lester and D. J. Summers, Measuring masses of semi-invisibly decaying particles pair produced at hadron colliders, Phys. Lett. B463 (1999) 99–103, [hep-ph/9906349].

[36] A. Barr, C. Lester, and P. Stephens, \(m(T2)\): The Truth behind the glamour, J. Phys. G29 (2003) 2343–2363, [hep-ph/0304226].

[37] A. J. Barr, B. Gripaios, and C. G. Lester, Weighing Wimps with Kinks at Colliders: Invisible Particle Mass Measurements from Endpoints, JHEP 02 (2008) 014, [arXiv:0711.4008].

[38] C. Cowan, K. Cranmer, E. Gross, and O. Vitells, Asymptotic formulae for likelihood-based tests of new physics, Eur. Phys. J. C71 (2011) 1554, [arXiv:1007.1727]. [Erratum: Eur. Phys. J.C73,2501(2013)].