### COLLIDER SEARCHES AND MEASUREMENTS



**Greg Landsberg** 



10.05.2023



2



Isometry Flavor Physics: QCD Factorization and Rare Greg Landsberg - Collider Searches and Measurements - 10.05.23 **Decays** SCET • Flavor Anomalies • 750 ALPs • Conferences • Conclusions

### Flavor



### **QCD** Factorization Calculations

#### Seminal papers on charmless hadronic B meson decays

VOLUME 83, NUMBER 10

PHYSICAL REVIEW LETTERS

6 September 1999

#### QCD Factorization for $B \rightarrow \pi \pi$ Decays: Strong Phases and *CP* Violation in the Heavy Quark Limit

M. Beneke,<sup>1</sup> G. Buchalla,<sup>1</sup> M. Neubert,<sup>2</sup> and C. T. Sachrajda<sup>3</sup> <sup>1</sup>Theory Division, CERN, CH-1211 Geneva 23, Switzerland <sup>2</sup>Stanford Linear Accelerator Center, Stanford University, Stanford, California 94309 <sup>3</sup>Department of Physics and Astronomy, University of Southampton, Southampton SO17 1BJ, United Kingdom (Received 17 May 1999)



ELSEVIER

Nuclear Physics B 591 (2000) 313-418



www.elsevier.nl/locate/npe

**1363 citations** 

QCD factorization for exclusive non-leptonic *B*-meson decays: general arguments and the case of heavy–light final states

M. Beneke<sup>a,\*</sup>, G. Buchalla<sup>b</sup>, M. Neubert<sup>c</sup>, C.T. Sachrajda<sup>d</sup>

<sup>a</sup> Institut für Theoretische Physik E, RWTH Aachen, D-52056 Aachen, Germany
 <sup>b</sup> Theory Division, CERN, CH-1211 Geneva 23, Switzerland
 <sup>c</sup> Newman Laboratory of Nuclear Studies, Cornell University, Ithaca, NY 14853, USA
 <sup>d</sup> Department of Physics and Astronomy, University of Southampton, Southampton SO17 1BJ, UK

Received 19 June 2000; accepted 31 August 2000

#### 1398 citations



NUCLEAR PHYSICS

#### 1043 citations

QCD factorization for  $B \rightarrow PP$  and  $B \rightarrow PV$ decays

Martin Beneke<sup>a</sup>, Matthias Neubert<sup>b</sup>

<sup>a</sup> Institut für Theoretische Physik E, RWTH Aachen, D-52056 Aachen, Germany
<sup>b</sup> Newman Laboratory for Elementary-Particle Physics, Cornell University, Ithaca, NY 14853, USA



Nuclear Physics B 606 (2001) 245-321



www.elsevier.com/locate/npe

1144 citations

QCD factorization in  $B \rightarrow \pi K$ ,  $\pi \pi$  decays and extraction of Wolfenstein parameters

M. Beneke<sup>a</sup>, G. Buchalla<sup>b</sup>, M. Neubert<sup>c</sup>, C.T. Sachrajda<sup>d</sup> <sup>a</sup> Institut für Theoretische Physik E, RWTH Aachen, D-52056 Aachen, Germany <sup>b</sup> Theory Division, CERN, CH-1211 Geneva 23, Switzerland <sup>c</sup> Newman Laboratory of Nuclear Studies, Cornell University, Ithaca, NY 14853, USA <sup>d</sup> Department of Physics and Astronomy, University of Southampton, Southampton SO17 1BJ, UK



### **Recent LHCb Measurement**

- Search for direct CP-violation in charmless PV decays
  - **\*** Interplay of the short- and long-range contributions to produce strong-phase difference require for direct CP violation
- Studied a number of decays:  $\rho\pi$ ,  $\rho K$ ,  $K^*\pi$ ,  $K^*K$ ,  $\phi K$
- Dalitz plot projection analysis for each channel; most of the asymmetries are consistent with zero, except for pK





## **Rare Radiative Decays**

### **Rare radiative W/Z/H boson decays**



Published for SISSA by 🖉 Springer

RECEIVED: February 9, 2015 ACCEPTED: March 9, 2015 Published: April 20, 2015

#### 67 citations

Exclusive radiative decays of W and Z bosons in **QCD** factorization

doi:10.1007/JHEP04(2015)101

#### Yuval Grossman,<sup>a</sup> Matthias König<sup>b</sup> and Matthias Neubert<sup>a,b</sup>

<sup>a</sup>Department of Physics, LEPP, Cornell University, Ithaca, NY 14853, U.S.A. <sup>b</sup>PRISMA Cluster of Excellence & Mainz Institute for Theoretical Physics, Johannes Gutenberg University. 55099 Mainz, Germany



Exclusive radiative Higgs decays as probes of light-quark Yukawa couplings

doi:10.1007/JHEP08(2015)012

Published for SISSA by D Springer

RECEIVED: May 18, 2015

ACCEPTED: July 13, 2015

PUBLISHED: August 4, 2015

108 citations

#### Matthias König<sup>a</sup> and Matthias Neubert<sup>a,b,c</sup>

<sup>a</sup> PRISMA Cluster of Excellence & Mainz Institute for Theoretical Physics, Johannes Gutenberg University, 55099 Mainz, Germany <sup>b</sup>Institut für Theoretische Physik,

Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany

<sup>c</sup>Department of Physics, LEPP, Cornell University, Ithaca, NY 14853, U.S.A.

Published for SISSA by D Springer

Received: September 29, 2016 REVISED: November 24, 2016 ACCEPTED: November 29, 2016 Published: December 12, 2016

#### Exclusive weak radiative Higgs decays in the standard

model and beyond

doi:10.1007/JHEP12(2016)037

Stefan Alte,<sup>a</sup> Matthias König<sup>a</sup> and Matthias Neubert<sup>a,b</sup>

<sup>a</sup>PRISMA Cluster of Excellence & Mainz Institute for Theoretical Physics, Johannes Gutenberg University, 55099 Mainz, Germany <sup>b</sup>Department of Physics, LEPP, Cornell University, Ithaca, NY 14853, U.S.A.







### **CMS Search for Rare Radiative Decays**

### Similar search in CMS focused on the H → Zρ and Zφ decays

	Observed	Median expected	$\pm 68\%$ expected	$\pm 95\%$ expected	Theory	$\bar{q}$ V
Isotropic decay	1.21%	0.73% Z	0.52-1.04%	0.38 – 1.41%	Z	
Z and $\rho$ longitudinally polarized	1.04%	H 0.63%	0.44 – 0.89%	0.32H1.20%		H q
Z and $\rho$ transversely polarized	1.31%	0.80%	$Z^* 0.57 - 1.14\%$	0.41–1.54%	ר- <sup>1</sup> .4 x 10	q
-		V			<i>и</i> .	Y
	Observed	Median expected	±68% <sup>q</sup> 92 ted	$\pm 95\%$ expected		Z
Isotropic decay	0.36%	0.33%	0.23 V	0.18 – 0.61%	4.2 x )-6	"U
Z and $\varphi$ longitudinally polarized	0.31%	0.27%	q = 0.20 - 0.39%	0.15 – 0.52%		
Z and $\phi$ transversely polarized	0.40%	0.36%	0.26 – 0.50%	0.19 – 0.68%		









### Gauge Bosons at Small pr

### SCET-based calculations for Λ<sub>QCD</sub> « p<sub>T</sub>(V) « M<sub>V</sub>

Eur. Phys. J. C (2011) 71:1665 DOI 10.1140/epjc/s10052-011-1665-7 The European Physical Journal C

Regular Article - Theoretical Physics

**398 citations** 

#### Drell–Yan production at small $q_T$ , transverse parton distributions and the collinear anomaly

Thomas Becher<sup>1</sup>, Matthias Neubert<sup>2,3,a</sup>

<sup>1</sup>Institut für Theoretische Physik, Universität Bern, Sidlerstrasse 5, 3012 Bern, Switzerland

<sup>2</sup>Institut für Physik (THEP), Johannes Gutenberg-Universität, 55099 Mainz, Germany

<sup>3</sup>Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany



10



Greg Landsberg - Collider Searches and Measurements -

11

### **Higgs Boson Cross Section**

### N<sup>3</sup>LL + EW corrections at two-loop level

ELS

Eur. Phys. J. C (2009) 62: 333–353 DOI 10.1140/epjc/s10052-009-1030-2 THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Theoretical Physics

### Renormalization-group improved prediction for Higgs production at hadron colliders

**Valentin Ahrens<sup>1</sup>, Thomas Becher**<sup>2,a</sup>, **Matthias Neubert**<sup>1</sup>, **Li Lin Yang**<sup>1</sup> <sup>1</sup>Institut für Physik (THEP), Johannes Gutenberg-Universität, 55099 Mainz, Germany <sup>2</sup>Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510, USA

#### 235 citations

Physics Letters B		Contents lists available at ScienceDirect	
		Physics Letters B	
EVIER www.elsevier.com/locate/physletb	ER	www.elsevier.com/locate/physletb	

Physics Letters B 698 (2011) 271-274

CDF+D0, arXiv:1103.3233

Tevatron Run II Preliminary,  $L \le 8.2 \text{ fb}^{-1}$ 

0 95% CL Limit/SM Expected Fevatron Observed Exclusion ±10 Expected ±20 Expected SM= March 7, 2011 190 130 140 150 160 170 180 200 $m_{\rm H} \, ({\rm GeV/c^2})$ 

Updated predictions for Higgs production at the Tevatron and the LHC

Valentin Ahrens<sup>a</sup>, Thomas Becher<sup>b</sup>, Matthias Neubert<sup>a</sup>, Li Lin Yang<sup>a,\*</sup>

<sup>a</sup> Institut für Physik (THEP), Johannes Gutenberg-Universität, D-55099 Mainz, Germany<sup>b</sup> Institute for Theoretical Physics, University of Bern, CH-3012 Bern, Switzerland

**47 citations** 

# Flavor Anomalies



PURY

AP CAL

HAMP



Ranch Ranch Dressins Bade

Y'all get yo



# **Rebirth of a Leptoquark**

### Simultaneous explanation of R(K), R(D\*), and g-2 anomalies

PRL 116, 141802 (2016)

PHYSICAL REVIEW LETTERS

week ending 8 APRIL 2016

Minimal Leptoquark Explanation for the  $R_{D^{(*)}}$ ,  $R_K$ , and  $(g-2)_{\mu}$  Anomalies

Martin Bauer<sup>1</sup> and Matthias Neubert<sup>2,3</sup>
<sup>1</sup>Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany
<sup>2</sup>PRISMA Cluster of Excellence & MITP, Johannes Gutenberg University, 55099 Mainz, Germany
<sup>3</sup>Department of Physics & LEPP, Cornell University, Ithaca, New York 14853, USA
(Received 5 November 2015; published 8 April 2016)



Published for SISSA by O Springer

**130 citations** 

RECEIVED: April 15, 2021 REVISED: July 8, 2021 ACCEPTED: July 19, 2021 PUBLISHED: August 11, 2021

### Reading the footprints of the $B\mbox{-meson}$ flavor anomalies

Claudia Cornella,<sup>a</sup> Darius A. Faroughy,<sup>a</sup> Javier Fuentes-Martín,<sup>b</sup> Gino Isidori<sup>a</sup> and Matthias Neubert<sup>a,b,c</sup>

 <sup>a</sup> Physik-Institut, Universität Zürich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland
 <sup>b</sup> PRISMA<sup>+</sup> Cluster of Excellence & MITP, Johannes Gutenberg University, Staudingerweg 9, 55128 Mainz, Germany
 <sup>c</sup> Department of Physics & LEPP, Cornell University, Ithaca, NY 14853, U.S.A.

## **CMS Searches for LQ3**

m





# **CMS Searches for LQ3**

- A new search for Pati-Salam U<sub>1</sub> vector LQ in the  $\tau\tau$  channel, a spin-off of the MSSM Higgs search
- Significant interference with the SM DY ττ continuum taken into account
- Started probing interesting parameter space from the point of view of flavor anomalies





# **ATLAS Searches for LQ3**

- Analogous ATLAS analysis focuses on the final states with τ leptons and b jets and sets limits on Yang-Mills vector LQs decaying to bτ or tv<sub>τ</sub>
- Require either a pair of τ<sub>h</sub> leptons or a single τ<sub>h</sub> lepton and at least 2 b jets
- Limits also reach 1.8 TeV in this analysis







### **Cross-Generational Couplings**

- ATLAS has recently done a search for scalar LQs that have cross-generational couplings, e.g., ce, bµ
- Only pair production is considered and the final states with a pair of OSSF leptons and b- or ctagged jets are analyzed
- Limits are set as functions of the LQ mass and B(LQ  $\rightarrow$  q $\ell$ ) for q = b, c and  $\ell$  = e,  $\mu$
- More recent search for LQ  $\rightarrow$  (t,b)+(e, $\mu$ , $\nu$ ) considers both scalar and vector LQs





## **ATLAS Sear**

- A new search for LQ3 coupled cro e.g. to a  $\tau$  and a c quark, using a  $\tau$
- Can also be interpreted as an excited  $\tau^*$  search
- **Employs S**<sub>T</sub> as the sensitive variable
- Typically dominant background from misidentified  $\tau_h$  is determined from control samples is data and verified in the DY control region





**Composite model** 



10-

 $10^{-2}$ 

10



### **CMS Excess in LQ3 Search**

- Another preliminary result from CMS, inspired by the flavor anomalies  $oldsymbol{O}$
- Looks for single, pair, and t-channel production of LQ3 in the  $\tau\tau$ +X final states



- **★** Uses  $S_T = \Sigma p_T(\tau) + p_T(j_1) + ME_T$  as a discriminating variable for resonant and  $\chi =$  $e^{-2y^*}$ , where  $y^* = |y_1 - y_2|/2$  the rapidity separation between two leading (tau) jets for non-resonant production
- Global fit to multiple search regions for different LQ3 mass and couplings
  - **\star** See ~3.5 $\sigma$  excess peaking in non-resonant production at large VLQ masses and couplings; no excess is seen for resonant production; global  $\sigma$  is hard to quantify





## What About ATLAS?

- A related search, just made public, actually sees a deficit at high masses .Q<sup>u</sup>LQ<sup>u</sup>) [pb]
  - Unlike CMS, ATLAS search is focused on pair p
- Uses NN parameterized w.r.t. m(LQ)
- Not exactly comparable with the CMS analysis channel LQ3 exchange considered), but likely that the CMS excess is due to a statistical flu







## **More From ATLAS**

- Fresh off the press: a new search from ATLAS considers single LQ3 production, as well as t-channel diagram with the LQ3 mediator directly comparable with the CMS search
- Requires a  $\tau$  lepton pair and a high-p<sub>T</sub> (> 200 GeV) b jet
- No significant excess seen in the S<sub>T</sub> distribution in both the τ<sub>l</sub>τ<sub>h</sub> and τ<sub>h</sub>τ<sub>h</sub> channels, with the sensitivity high enough to start ruling out the CMS excess (N.B. ATLAS assumes Br(LQ3 → bτ) = 0.5, while CMS assumes 1)
- Additional limits are also set in the low-p<sub>T</sub> b jet signal region



21



### CMS H(eµ) Excess - LFV Search

- New CMS search for LFV Higgs boson decay H(eµ)  $\bigcirc$
- Apart from setting a stringent limit on the H(125) LFV decay, it also scans the eµ mass
- An excess with a local (global) significance of 3.8 (2.8) $\sigma$  is seen at a mass of 146 GeV
- Probably already ruled out by an earlier ATLAS analysis, judging by the mass plot **\*** Would be nice if ATLAS could produce a limit at 146 GeV based on that analysis





### CMS H(eµ) Excess - LFV Search

- New CMS search for LFV Higgs boson decay H(eµ)  $\bigcirc$
- Apart from setting a stringent limit on the H(125) LFV decay, it also scans the eµ mass
- An excess with a local (global) significance of 3.8 (2.8) $\sigma$  is seen at a mass of 146 GeV
- Probably already ruled out by an earlier ATLAS analysis, judging by the mass plot **\*** Would be nice if ATLAS could produce a limit at 146 GeV based on that analysis





### CMS H(eµ) Excess - LFV Search

- New CMS search for LFV Higgs boson decay H(eµ)  $\bigcirc$
- Apart from setting a stringent limit on the H(125) LFV decay, it also scans the eµ mass
- An excess with a local (global) significance of 3.8 (2.8) $\sigma$  is seen at a mass of 146 GeV
- Probably already ruled out by an earlier ATLAS analysis, judging by the mass plot **\*** Would be nice if ATLAS could produce a limit at 146 GeV based on that analysis







### One of the first papers on the 750 GeV excess

PHYSICAL REVIEW D 93, 115030 (2016)

#### Flavor anomalies, the 750 GeV diphoton excess, and a dark matter candidate 140 citations

**F**hed

Martin Bauer<sup>1</sup> and Matthias Neubert<sup>2,3</sup>

 Lut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany
 <sup>2</sup>PRISMA Cluster of Excellence & MITP, Johannes Gutenberg University, 55099 Mainz, Germany
 <sup>3</sup>Department of Physics & LEPP, Cornell University, Ithaca, New York 14853, USA (Received 21 January 2016; published 22 June 2016)

#### Diphoton resonance from a warped extra dimension

#### Martin Bauer,<sup>a</sup> Clara Hörner<sup>b</sup> and Matthias Neubert<sup>b,c</sup>

<sup>a</sup> Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany
<sup>b</sup> PRISMA Cluster of Excellence & Mainz Institute for Theoretical Physics, Johannes Gutenberg University, 55099 Mainz, Germany
<sup>c</sup> Department of Physics & LEPP, Cornell University, Ithaca, NY 14853, U.S.A.

#### doi:10.1007/JHEP07(2016)094

### 21 December, 2015 140 citations





10



Background-only fit

#### **35 citations**

#### The "forgotten" decay S -> Z+h as a CP analyzer

Martin Bauer (U. Heidelberg), Matthias Neubert, Andrea Thamm (U. Mainz)

Scalar particles *S* which are gauge singlets under the Standard Model are generic features of many models of fundamental physics, in particular as possible mediators to a hidden or dark sector. We show that the decay  $S \rightarrow Zh$  provides a powerful probe of the CP nature of the scalar, because it is allowed only if *S* has CP-odd interactions. We perform a model-independent analysis of this decay in the context of an effective Lagrangian and compute the relevant Wilson coefficients arising from integrating out heavy fermions to one-loop order. We illustrate our findings with the example of the 750 GeV diphoton resonance seen by ATLAS and CMS and show that the  $S \rightarrow Zh$  decay rate could naturally be of similar magnitude or larger than the diphoton rate.

Comments: 6 pages, 2 figures Subjects: High Energy Physics - Phenomenology (hep-ph) Report number: MTTP/16-067 Cite as: arXiv:1607.01016 [hep-ph] (or arXiv:1607.01016v1 [hep-ph] for this version) https://doi.org/10.48550/arXiv.1607.01016 **20 citations** 



## Practical 95% CL

 In April 2016 I've offered Matthias a bet against X(750): 20 bottles of wine from me if it's real against 1 bottle from him if it's not

**★** The catch: >€100/bottle

- Fortunately for Matthias, after some hesitation, he decided not to take the bet
  - ★ Now, €100 richer and 750 papers wiser he probably appreciates what 95% confidence implies!







Greg Landsberg - Collider Searches and Measurements - 10.05.23



## Sic Transit Gloria Mundi





## Sic Transit Gloria Mundi

From: "Kenneth Lane" <lane@bu.edu> Subject: New model for the 750 GeV diphoton resonance Date: January 11, 2016 at 4:42:13 PM GMT+1 To: "Kenneth Lane" <lane@bu.edu>

> The Sexion -- A New Model for the 750 GeV Diphoton Resonance Kan D. Kane, Department of Physics, Commonwealth University

> > Abstract

It is proposed that the apparent diphoton resonance at 750 GeV recently reported by ATLAS and CMS in their early Run 2 data is the "sexion", a loosely-bound state of six 125-GeV Higgs bosons. This model neatly explains the sexion's mass and its large two-photon branching ratio. The latter is understood as the square of an amplitude of a cooperative phenomenon in which any of the six constituent Higgs bosons decay to two photons, times phase space, thus implying a two-photon decay rate  $6^{5} = 7760$  times as large as that of the H(125).

Our new model is described in the abstract. No further explanation is needed.

Note added in proof: The other five go "poof".

Acknowledgments: The author thanks many colleagues who have inspired and inquired about his <u>diphoton</u> resonance model. Those colleagues, those who have participated in valuable discussions, and my funding sources wish to remain anonymous.



Atonement



Greg Landsberg - Collider Searches and Measurements - 10.05.23 27

# ALPS



## **Axion-Like Particles**

### • Axion-like particles at the LHC and beyond

#### Collider probes of axion-like particles

https://doi.org/10.1007/JHEP12(2017)044

327 citations

#### Martin Bauer,<sup>a</sup> Matthias Neubert<sup>b,c</sup> and Andrea Thamm<sup>b</sup>

<sup>a</sup>Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany <sup>b</sup>PRISMA Cluster of Excellence & Mainz Institute for Theoretical Physics, Johannes Gutenberg University, 55099 Mainz, Germany <sup>c</sup>Department of Physics & LEPP, Cornell University, Ithaca, NY 14853, U.S.A.

PRL 119, 031802 (2017)

PHYSICAL REVIEW LETTERS

week ending 21 JULY 2017

#### LHC as an Axion Factory: Probing an Axion Explanation for $(g-2)_{\mu}$ with Exotic Higgs Decays

68 citations

Martin Bauer,<sup>1</sup> Matthias Neubert,<sup>2,3</sup> and Andrea Thamm<sup>2</sup>

<sup>1</sup>Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany <sup>2</sup>PRISMA Cluster of Excellence & MITP, Johannes Gutenberg University, 55099 Mainz, Germany <sup>3</sup>Department of Physics & LEPP, Cornell University, Ithaca, New York 14853, USA (Received 27 April 2017; published 21 July 2017)

Eur. Phys. J. C (2019) 79:74 https://doi.org/10.1140/epjc/s10052-019-6587-9

THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Theoretical Physics

#### 149 citations

#### Axion-like particles at future colliders

#### Martin Bauer<sup>1</sup>, Mathias Heiles<sup>2</sup>, Matthias Neubert<sup>2,3</sup>, Andrea Thamm<sup>4,a</sup>

<sup>1</sup> Institute for Particle Physics Phenomenology, Ogden Centre for Fundamental Physics, Durham University, South Road, Durham DH1 3LE, United Kingdom

<sup>2</sup> PRISMA Cluster of Excellence, Mainz Institute for Theoretical Physics, Johannes Gutenberg University, 55099 Mainz, Germany

<sup>3</sup> Department of Physics, LEPP, Cornell University, Ithaca, NY 14853, USA

4 Theoretical Physics Department, CERN, 1211 Geneva, Switzerland

29



# TLAS Sea





### decaying hadronically



#### Limits on $\sigma(pp \rightarrow H)Br(H \rightarrow Za)$ [pb]

 $a \rightarrow s\bar{s}$  $a \rightarrow gg$ a mass [GeV] Exp Obs Exp Obs 16+6 0.5 17 0.75  $19^{+7}$ 20  $17^{+7}$ 18 1.0  $20^{+8}$  $19^{+7}$ 1.5 22 20  $26^{+10}_{-7}$  $23^{+9}$ 2.0 27 24  $32^{+12}_{-9}$  $38^{+15}_{-11}$ 2.5 40 33  $65^{+25}_{-18}$  $75^{+29}_{-21}$ 3.0 78 68  $110^{+40}_{-30}$ 3.5 120 320+130 4.0 340

f<sub>a</sub> [GeV]

 $oldsymbol{O}$ 



### **CMS: Machine Learning for ALPs**

**Recent example from CMS: end-to-end deep ML reconstruction of the** ECAL to resolve overlapping photon showers





# and its Application

10.05.23 **Greg Landsberg - Collider Searches and Measurements -** Based on this regression technique, a dedicated analysis for a very light pseudoscalar a in a 0.1-1.2 GeV mass range has been conducted

 Look for an excess in the plane of two reconstructed yy masses, for the overall mass in the H boson window



 Sensitivity exceeds that from the generic limits based on H→yy decays, demonstrating the power of the technique

CL upper limit on B(H

95%



 $m_a$  [GeV]

m<sub>ALP</sub> (GeV)



### H $\rightarrow$ a(bb)a(µµ) in highresolution dimuon mass distribution

Local (global) significance of
 3.3 (1.7)σ at M(a) = 52 GeV





10<sup>-3</sup>

20

30

40

50

60

m<sub>a</sub> [GeV]

AS

AT



### H $\rightarrow$ a(bb)a(µµ) in highresolution dimuon mass distribution

Local (global) significance of
 3.3 (1.7)σ at M(a) = 52 GeV





Greg Landsberg - Collider Searches and Measurements -

34





# What Does ATLAS See?

Observed

Expected for signal plus background

Expected for backgroun

LEP

85 90 95 100

ATLAS



- No full Run 2 ATLAS result in the ਰੁੱ low-mass diphoton channel yet **\*** The 2016 ATLAS result is not 10 inconsistent with the CMS one The full Run 2 ATLAS MSSM H( $\tau\tau$ ) 10<sup>-</sup> result contradicts the 1.2 TeV excess seen in CMS 10
- The 95-96 GeV light Higgs boson has long been a subject of theoretical interest since an old LEP hint in the H(bb) channel







Looking forward to ATLAS 139 fb<sup>-1</sup> updates in the yy channel!



## In the Meantime...

- CMS has just released a new low-mass h(γγ) analysis based on full Run 2 data
- The overall excess is still there, with about the same significance (2.9σ local; 1.3σ global) albeit with twice as low cross section
- Still need more data (ATLAS Run 2?) to understand whether the excess is real





## In the Meantime...

- CMS has just released a new low-mass h(γγ) analysis based on full Run 2 data
- The overall excess is still there, with about the same significance (2.9σ local; 1.3σ global) albeit with twice as low cross section
- Still need more data (ATLAS Run 2?) to understand whether the excess is real



## Conferences



## Aspen Conferences

- In 2005, Matthias and I decided to organize the Aspen 2006 Winter Conference on Particle Physics
  - ★ We invited Marcela Carena and Gudrid Moortgat-Pick to join us
  - **★** Each Aspen conference has a motto; ours was

2006 Aspen Winter Conference "Particle Physics at the Verge of Discovery"

- It was a fun conference, with a skiing race filmed on a professional video, live tango performance, etc.
- And our motto worked out just six years later!



## **2006 Aspen Conference**









### **Aspen Conferences (cont'd)**

- Ten years later, we decided to do it again, this time with Marcela and Giulia Zanderighi
- Surely enough we didn't have to think twice about the motto (the year of 750!):

2016 Aspen Winter Conference on Particle Physics



# Tango was replaced with a jazz quartet, but skiing competition stayed!



# **2016 Aspen Conference**





## **Breaking News**

- Greg Landsberg Collider Searches and Measurements 10.05.23 43
- We decided to do it yet again, ten years later!
- We invite you to the 2026 Aspen Winter Conference on Particle Physics
- Guess what the motto will be?



# **Breaking News**

- We decided to do it yet again, ten years later!
   We invite you to the 2026 Aspen Winter Conference on Particle Physics
  - Guess what the motto will be?

**2026 Aspen Winter Conference on Particle Physics** 



European Research Council Isott and syte Europee Commence

BROWN

PRISMA

Particle Physics on the Verge



Greg Landsberg - Collider Searches and Measurements -

44

### Happy Birthday, Matthias ...

### • ...and happy anniversary, MITP!



Let's keep an eye on the few anomalies I showed, but don't run to the printing press yet!

Mainz Institute for Theoretical <sup>Physics</sup>