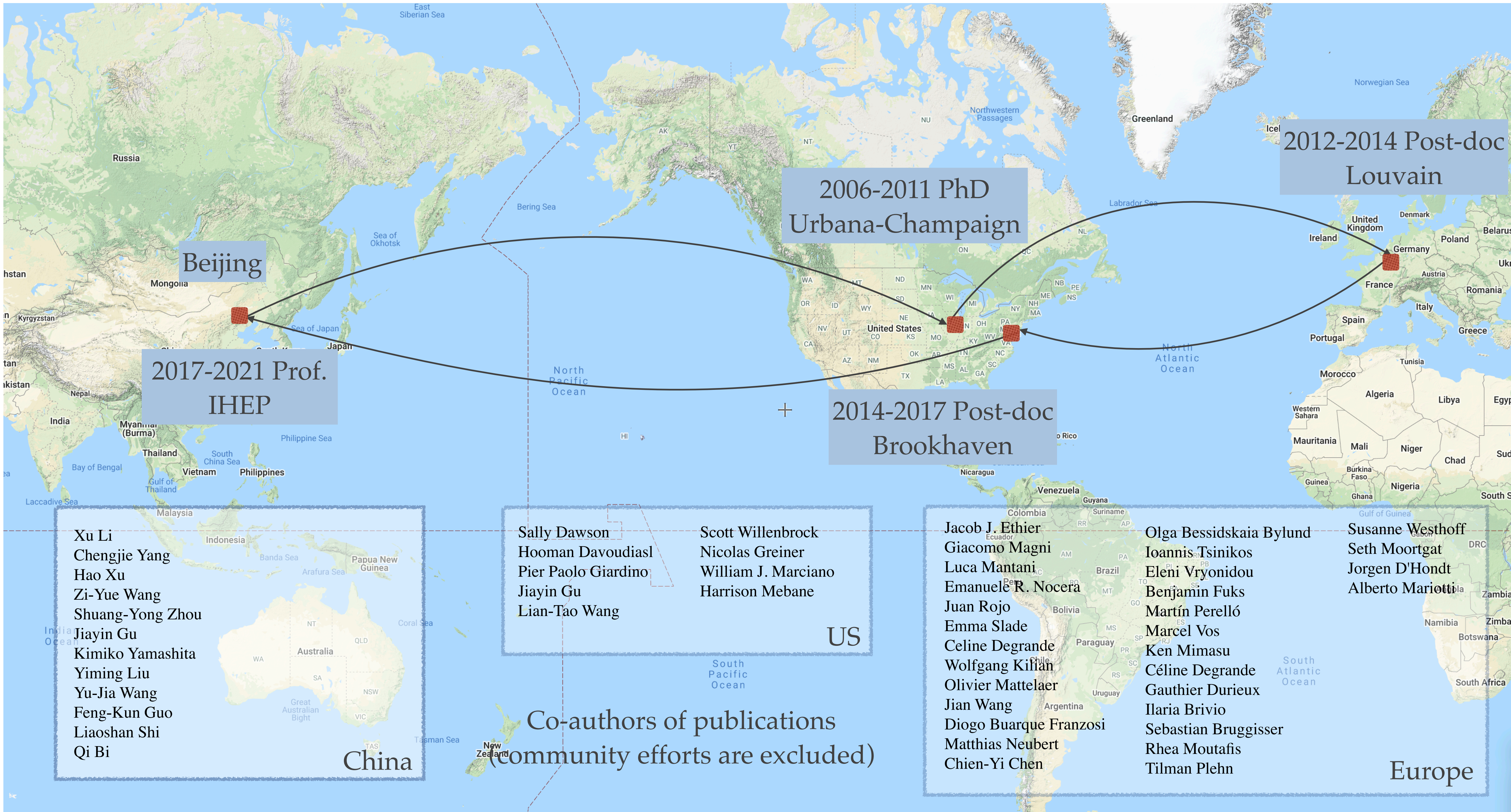


Cen Zhang Memorial@MBI2022

Eleni Vryonidou



**MBI Workshop 2022
Shanghai and Online
22-25/8/2022**



Beijing

2006-2011 PhD
Urbana-Champaign

2012-2014 Post-doc
Louvain

2017-2021 Prof.
IHEP

2014-2017 Post-doc
Brookhaven

+

- China**
- Xu Li
 - Chengjie Yang
 - Hao Xu
 - Zi-Yue Wang
 - Shuang-Yong Zhou
 - Jiayin Gu
 - Kimiko Yamashita
 - Yiming Liu
 - Yu-Jia Wang
 - Feng-Kun Guo
 - Liaoshan Shi
 - Qi Bi

- US**
- Sally Dawson
 - Hooman Davoudiasl
 - Pier Paolo Giardino
 - Jiayin Gu
 - Lian-Tao Wang
 - Scott Willenbrock
 - Nicolas Greiner
 - William J. Marciano
 - Harrison Mebane

Co-authors of publications
(community efforts are excluded)

- Europe**
- Jacob J. Ethier
 - Giacomo Magni
 - Luca Mantani
 - Emanuele R. Nocera
 - Juan Rojo
 - Emma Slade
 - Celine Degrande
 - Wolfgang Kilian
 - Olivier Mattelaer
 - Jian Wang
 - Diogo Buarque Franzosi
 - Matthias Neubert
 - Chien-Yi Chen
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 - Ioannis Tsinikos
 - Eleni Vryonidou
 - Benjamin Fuks
 - Martin Perelló
 - Marcel Vos
 - Ken Mimasu
 - Céline Degrande
 - Gauthier Durieux
 - Ilaria Brivio
 - Sebastian Bruggisser
 - Rhea Moutafis
 - Tilman Plehn
 - Susanne Westhoff
 - Seth Moortgat
 - Jorgen D'Hondt
 - Alberto Mariotti

Cen Zhang (张岑) (Beijing, Inst. High Energy Phys.) 

hep-ph

Author Identifier: [Cen.Zhang.1](#)Advisor: [Scott S. Willenbrock](#)

- 2017-present
JUNIOR, Beijing, Inst. High Energy Phys.
- 2014-2017
POSTDOC, Brookhaven
- 2012-2014
POSTDOC, Louvain U., CP3

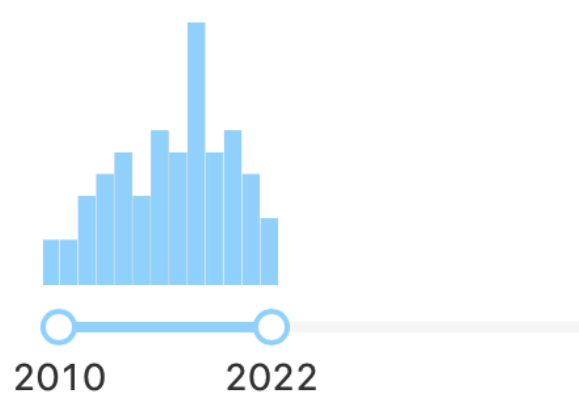
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 [edit](#)**Research works (69)**

Cited By

Date of paper



Number of authors

- Single author 11
- 10 authors or less 59

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- Exclude Review of Particle Physics 69




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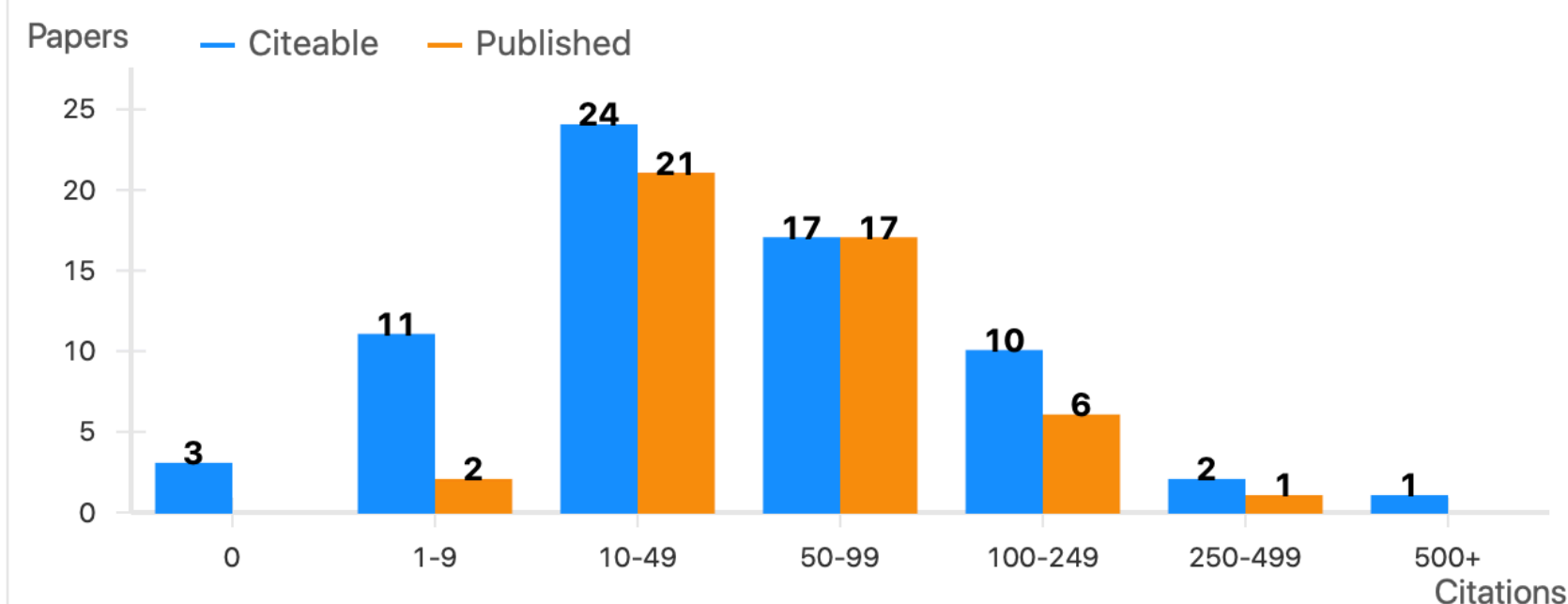
- article 56

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Citation Summary

 Exclude self-citations 

	Citeable 	Published 
Papers	68	47
Citations	5,862	2,970
h-index 	37	31
Citations/paper (avg)	86.2	63.2



- A huge range of important contributions to particle phenomenology
- His work ranges from very phenomenological to rather formal
- Cen was a major player in driving the EFT programme for collider physics

My collaboration with Cen

Cen and I overlapped as postdocs in Belgium, we first met in 2013

Started collaborating around 2015 and worked together continuously since then

Visited Cen in BNL 2015 and Beijing 2018 and Cen visited me at CERN in 2019

Wrote 10 papers together, several projects were initiated and driven by Cen

I have learnt a huge amount from Cen, proud to be his most frequent collaborator

I have enjoyed Cen's **hospitality and kindness** on multiple occasions

Collaborators

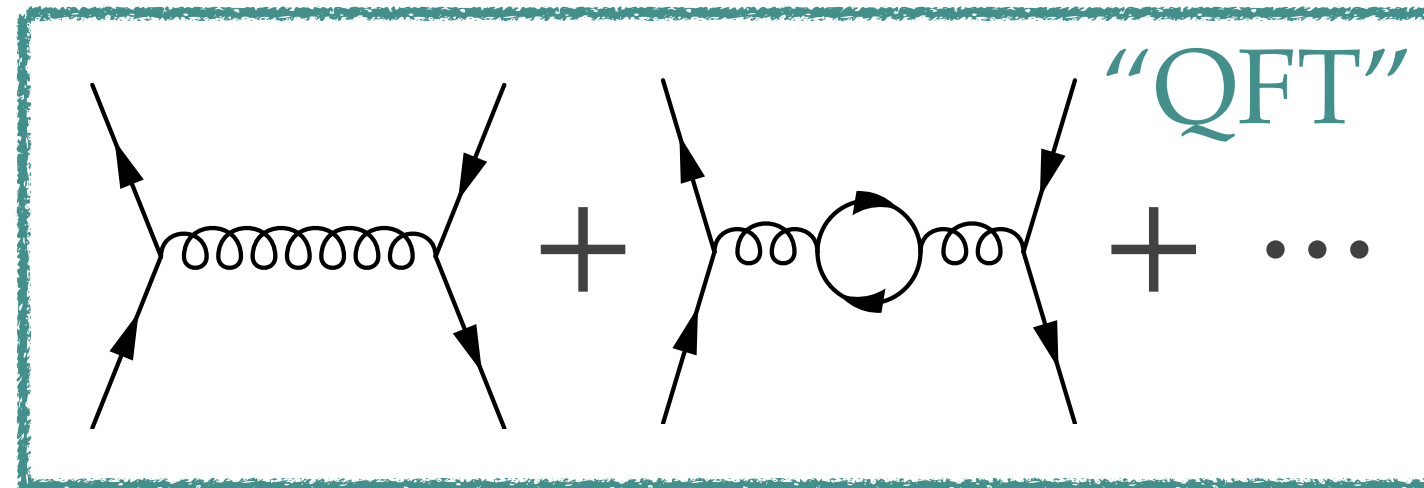
<input type="checkbox"/> Eleni Vryonidou	15
<input type="checkbox"/> Fabio Maltoni	14
<input type="checkbox"/> Shuang-Yong Zhou	10
<input type="checkbox"/> Gauthier Durieux	10
<input type="checkbox"/> Ken Mimasu	7

<https://inspirehep.net/authors/1333165?ui-citation-summary=true>

Precision computations in SMEFT

- * EFT is a QFT: we can **systematically improve** SMEFT predictions

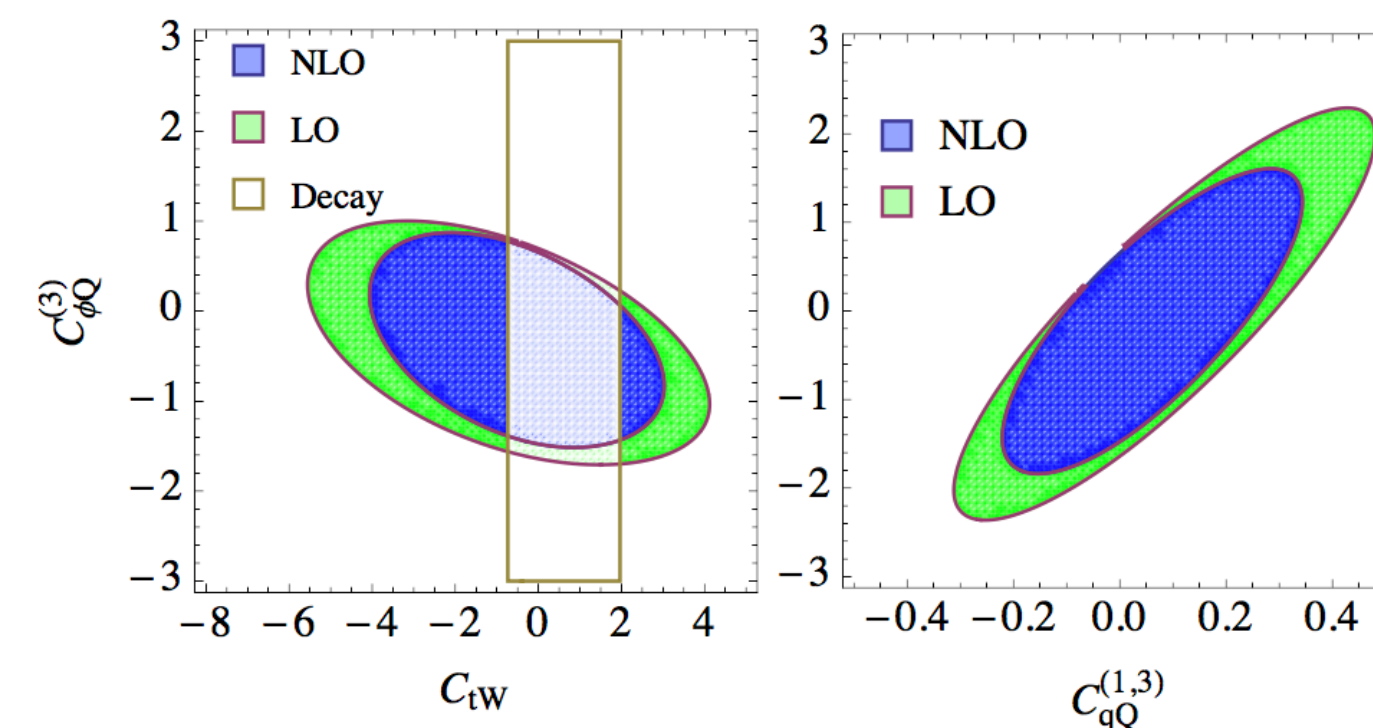
First approximation: LO
Improved calculation: NLO



- * Cen initiated the programme of **calculating** precision (NLO) SMEFT predictions for collider processes - top quark, Higgs,...

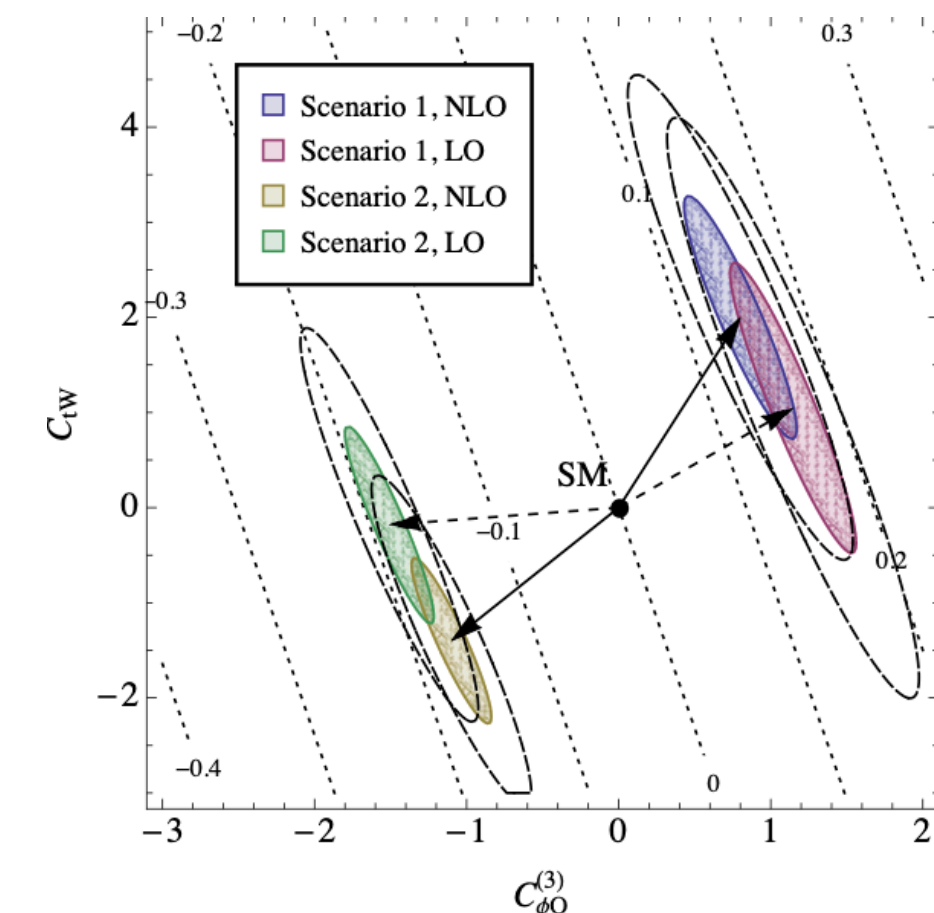
- * NLO affects our accuracy in **determining** the SMEFT couplings and in **pinpointing** the origin of observed deviations from the SM

Single-top production Determination



Zhang; *Phys. Rev. Lett.* 116 (2016) 16, 162002

Pinpointing



SMEFT@NLO

* Cen's work provided invaluable predictions and analyses for many key LHC (and future collider) processes

* Several papers written on NLO (mainly QCD and sometimes EW) corrections:

- Top FCNC: Degrande, Maltoni, Wang, Zhang *Phys.Rev.D* 91 (2015) 034024
- Single top: Zhang; *Phys. Rev. Lett.* 116 (2016) 16, 162002
- Pair production: Franozi & Zhang; *Phys.Rev.D* 91 (2015) 11, 114010
- ttV: Bylund, Maltoni, Tsirikos, Vryonidou, Zhang; *JHEP* 05 (2016) 052
- EW top loops in e^+e^- : Durieux, Gu, Vryonidou, Zhang; *Chin.Phys.C* 42 (2018) 12, 123107
- tZ/H: Degrande, Maltoni, Mimasu, Vryonidou, Zhang; *JHEP* 10 (2018) 005
- ttH: Maltoni, Vryonidou & Zhang; *JHEP* 10 (2016) 123
- EW top loops in Higgs: Vryonidou & Zhang; *JHEP* 08 (2018) 036
- $t\bar{t}$ in e^+e^- : Durieux, Perello, Vos, Zhang; *JHEP* 10 (2018) 168

* Major milestone in our programme: development and release of SMEFT@NLO

Automated one-loop computations in the standard model effective field theory

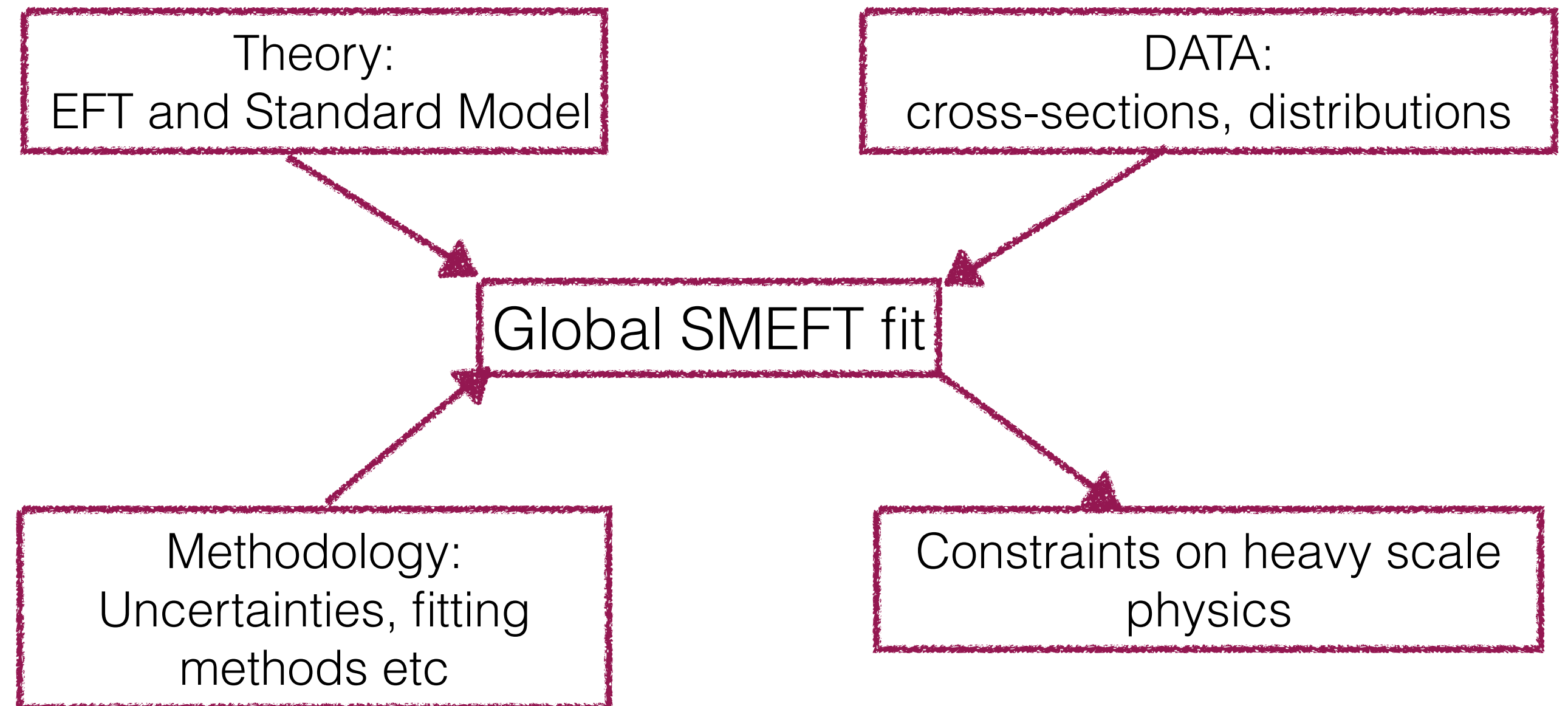
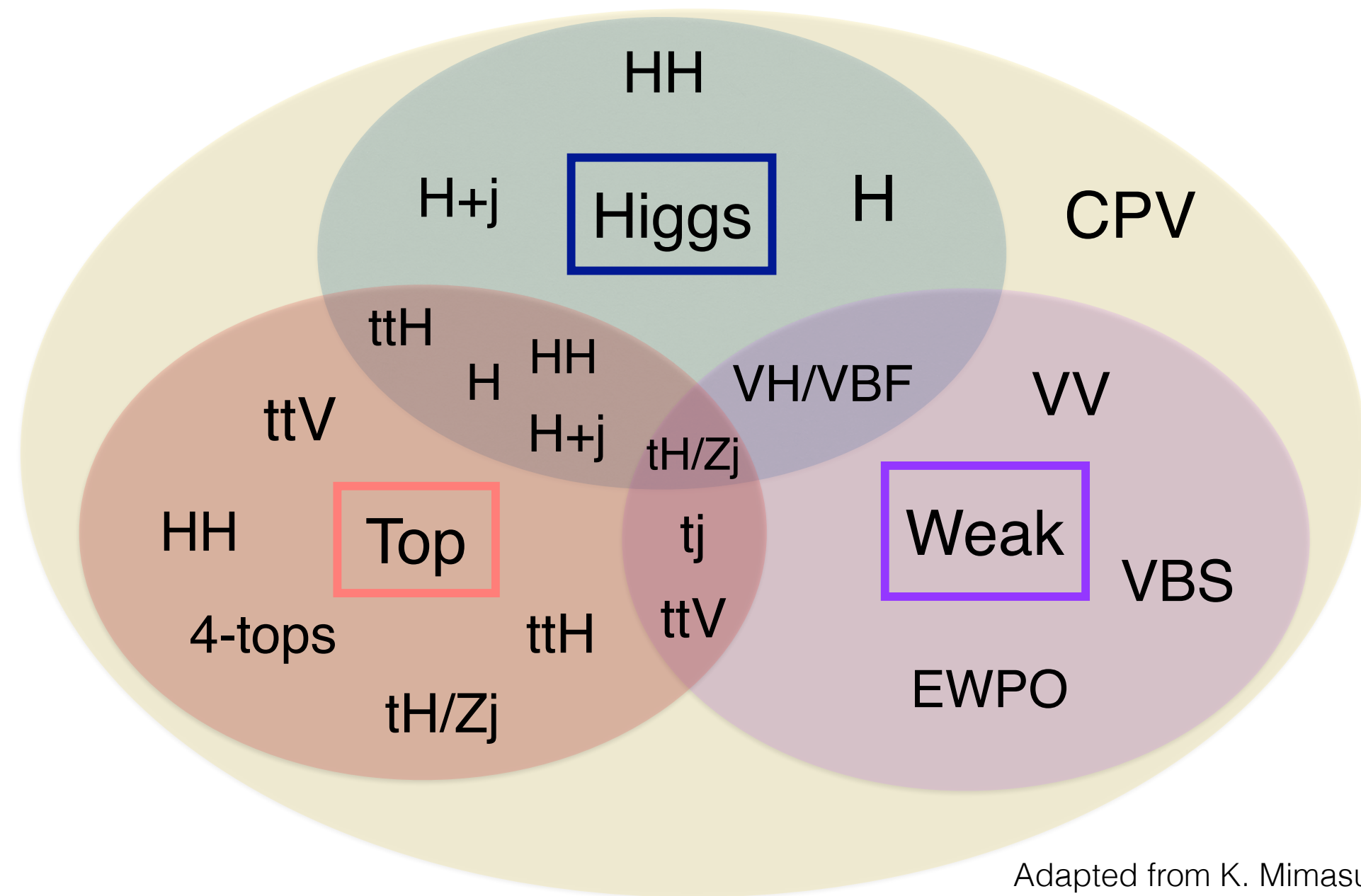
Céline Degrande^{1,*}, Gauthier Durieux^{2,†}, Fabio Maltoni^{1,3,‡}, Ken Mimasu¹,
Eleni Vryonidou^{4,||} and Cen Zhang^{5,6,¶}

Phys. Rev. D 103, 096024 (2021)

* **Generic** NLO SMEFT predictions for collider simulations

* **Industry-standard** tool for experimental & theory communities

Global fits of LHC data

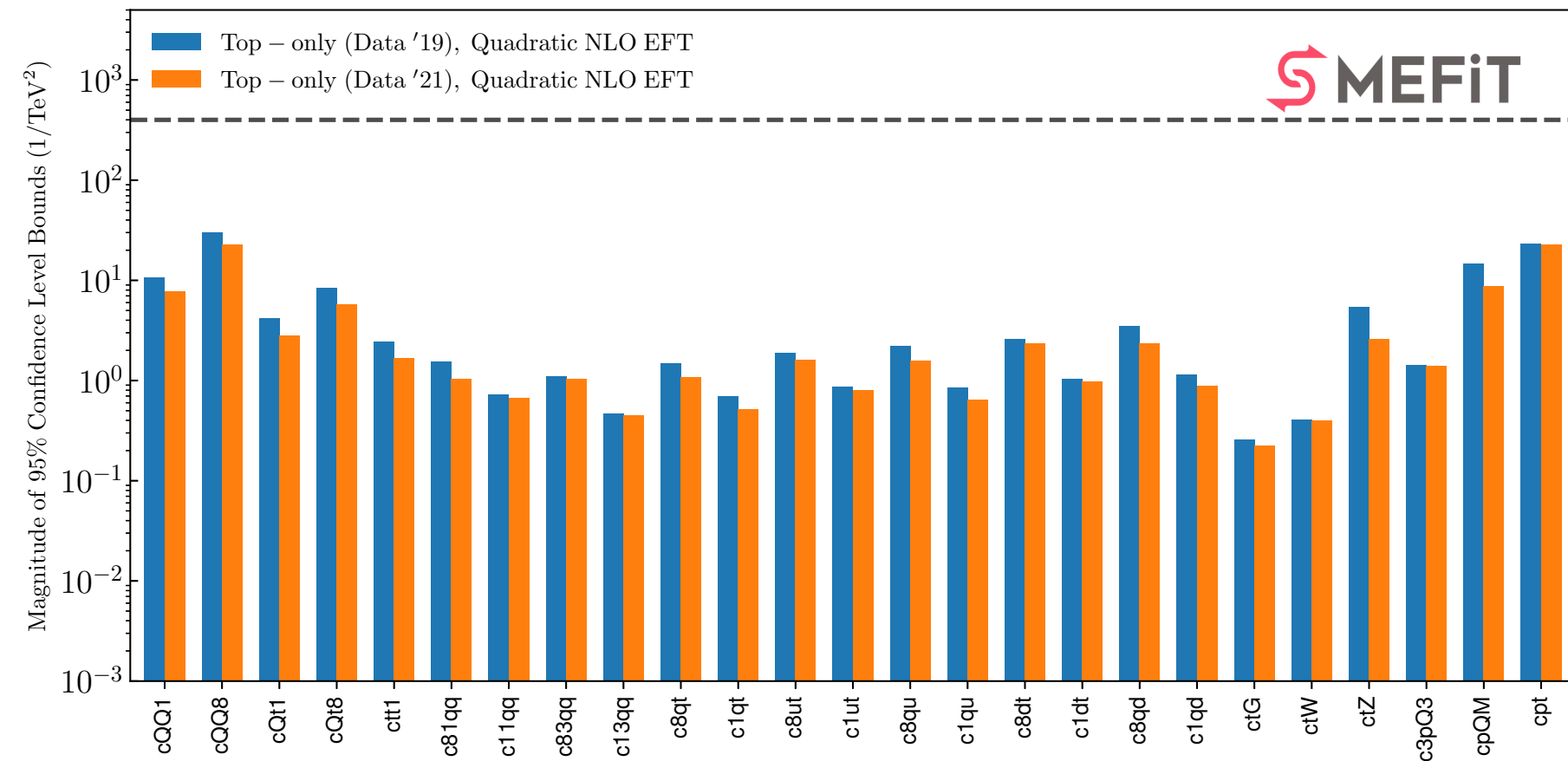


A complicated and difficult procedure but absolutely necessary to identify any deviations from the SM

Cen's physics intuition and computational skills were crucial in this effort

Global Fits efforts

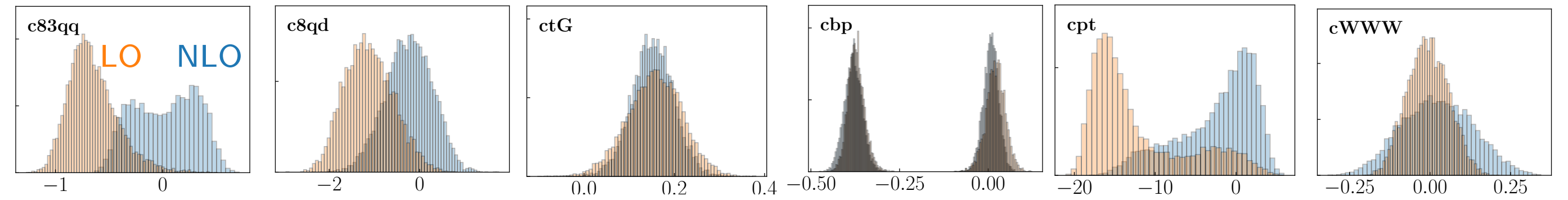
Top sector



Hartland, Maltoni, Nocera, Rojo, Slade, Vryonidou and Zhang *JHEP* 04 (2019) 100

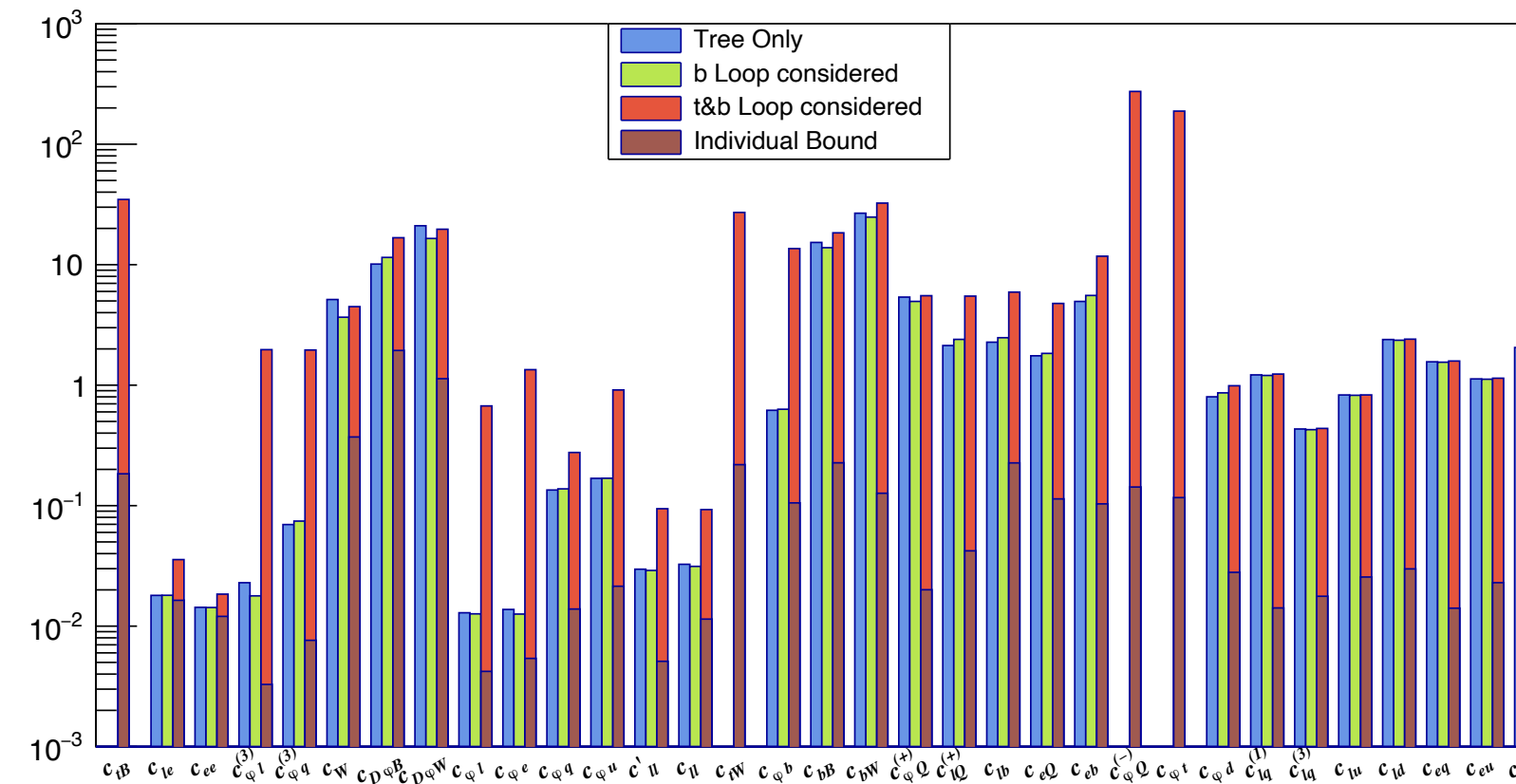
Brivio, Bruggisser, Maltoni, Moutafis, Plehn, Vryonidou, Westhoff, Zhang *JHEP* 02 (2020) 131

Top+Higgs+EW



Ethier, Maltoni, Mantani, Nocera, Rojo, Slade, Vryonidou and Zhang *JHEP* 11 (2021) 089

Top + Top loops in EWPD



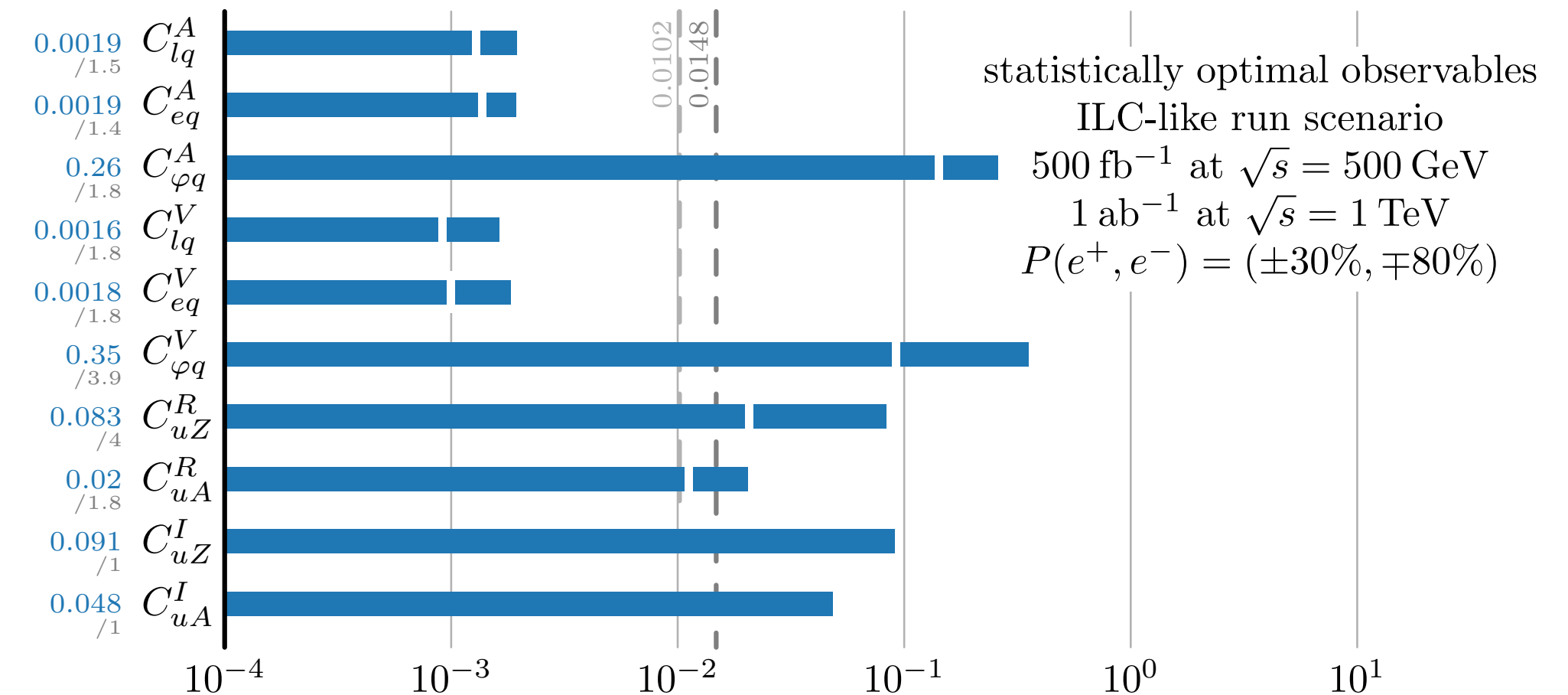
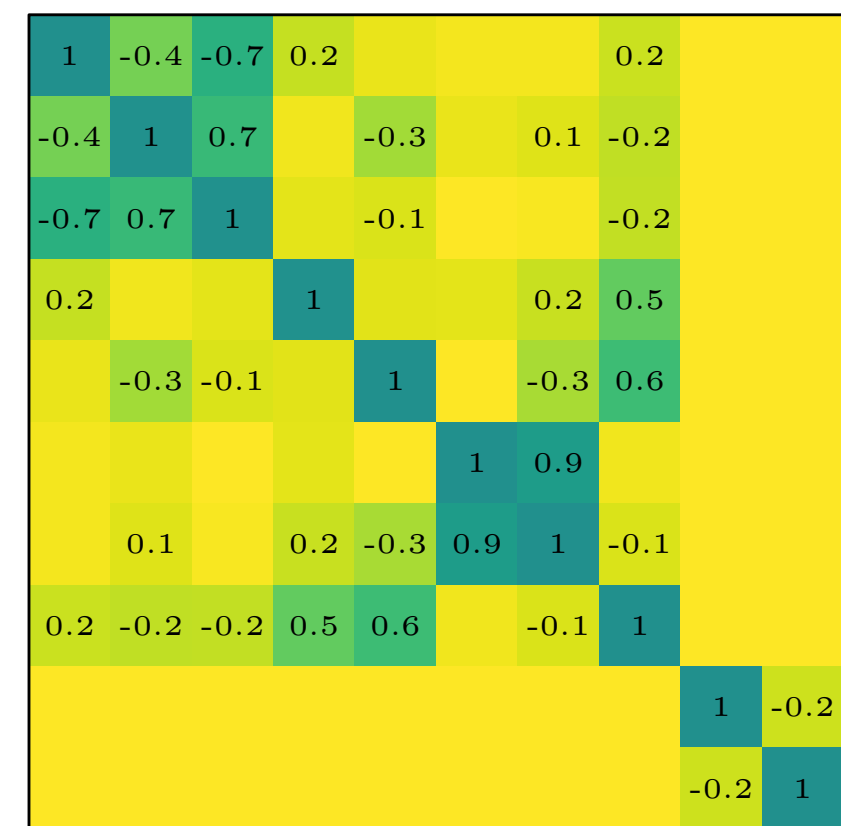
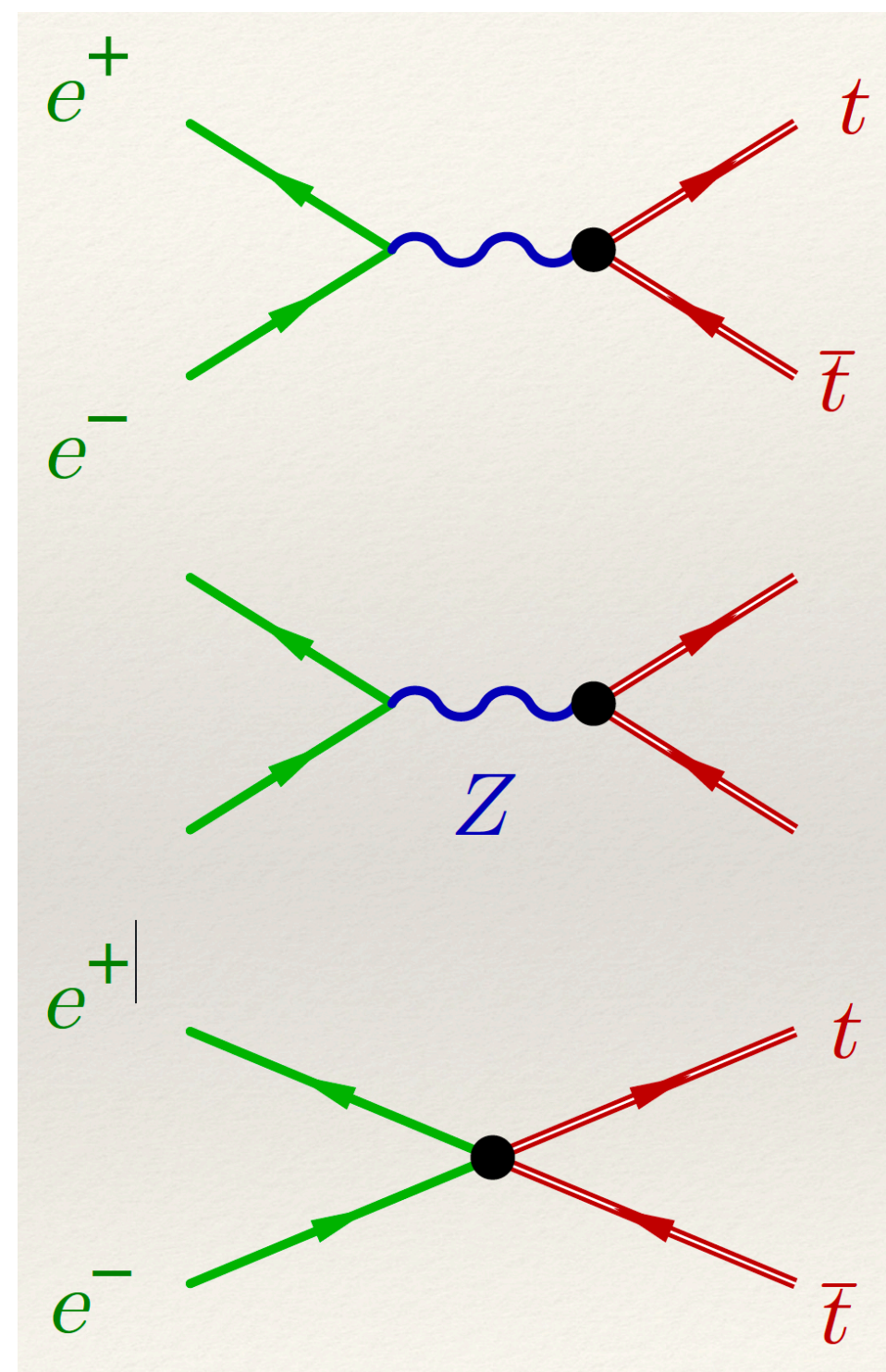
Liu, Wang, Zhang, Zhang, Gu [arXiv:2205.05655](https://arxiv.org/abs/2205.05655)

Long projects requiring a lot of calculations but also a lot of effort to understand the results

Crucial contributions from Cen

Future collider studies

- Top pair production in e^+e^- and top coupling determination
- Future Collider scenarios: ILC, CLIC, CEPC (1-loop) etc



Durieux, Perello, Vos, Zhang; *JHEP* 10 (2018) 168

Gen was involved in several community studies for future collider studies:
 CLIC *JHEP* 11 (2019) 003, CERN Yellow Rep.Monogr. 3 (2018), CEPC: [arXiv:1811.10545](https://arxiv.org/abs/1811.10545)
 HL-LHC: *CERN Yellow Rep.Monogr.* 7 (2019) 867-1158, *CERN Yellow Rep.Monogr.* 7 (2019) 1-220

New Directions: Positivity

Not all EFTs are equal!

Idea: Use axiomatic principles of QFT

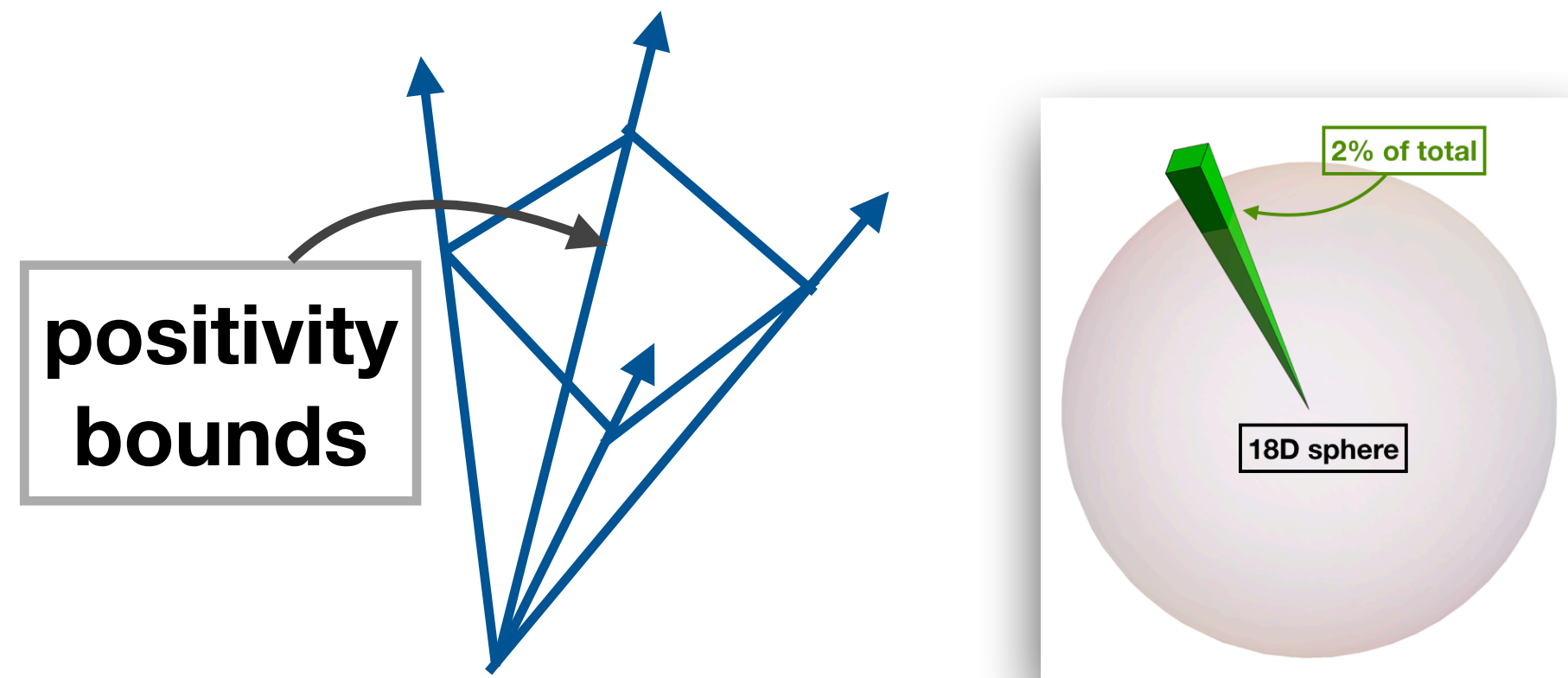
- lorentz invariance, unitarity, causality, locality, analyticity

Use these to **set constraints on EFT coefficients**

A new research direction initiated by Cen in China with his collaborator Shuang-Yong Zhou from Hefei

More formal than previous research directions, with potentially important phenomenological consequences

Positivity work and legacy paper



Cen's legacy single author paper:

SMEFTs living on the edge: [arXiv: 2112.11665](https://arxiv.org/abs/2112.11665)
(recomposition from PDF file and final editing by Jiayin Gu, Xu Li, Jiang-Hao Yu, Hao Zhang and Shuang-Yong Zhou)

Main idea: At dim=8 one could determine the UV theory completely by pairing the information with positivity.

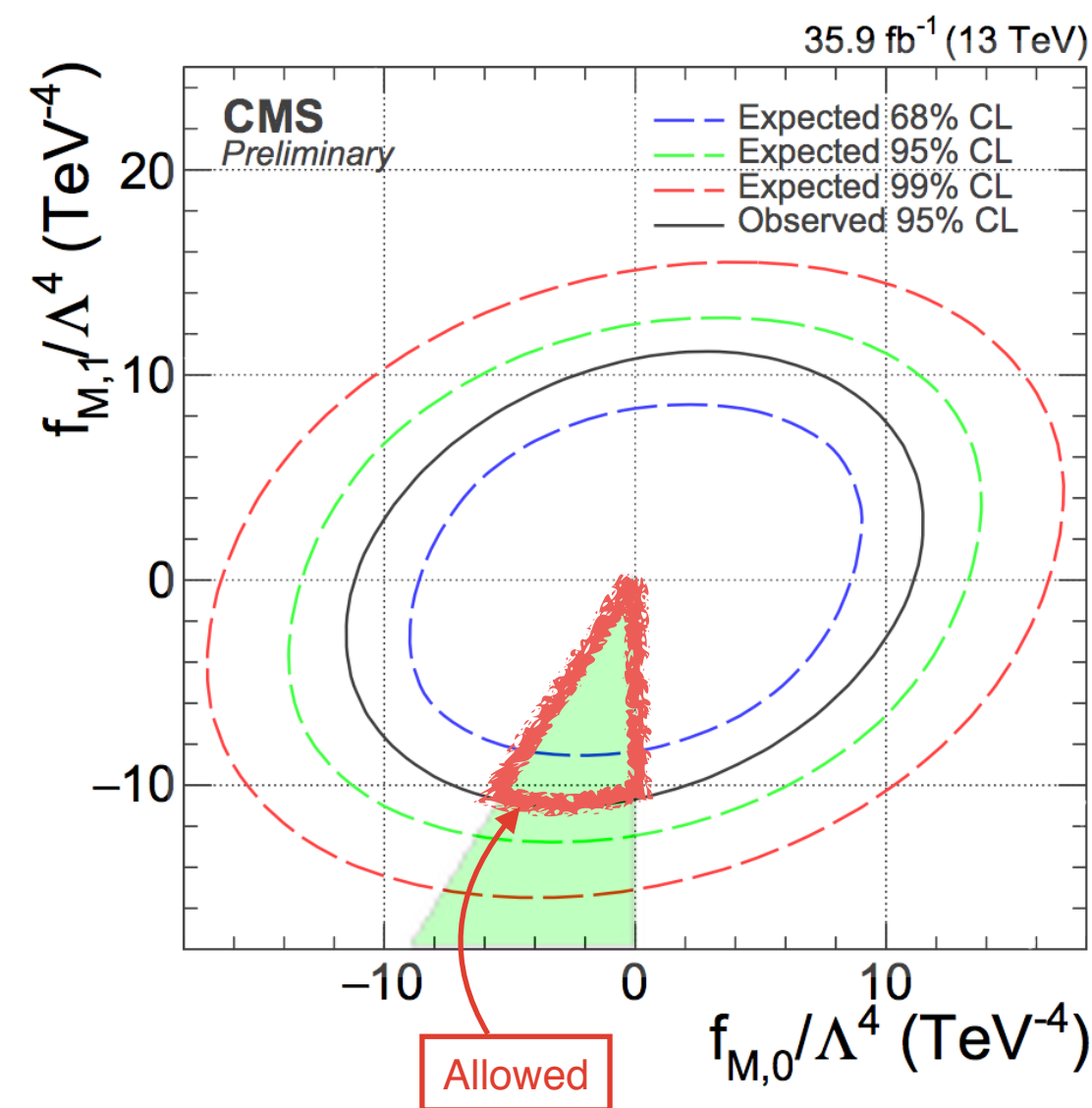
Highly active and productive area of research:

- VBS *Phys.Rev.D* 100 (2019) 9, 095003
- aQGC *JHEP* 06 (2019) 137
- Chiral perturbation theory: *JHEP* 07 (2020) 214
- Convex geometry: *Phys.Rev.Lett.* 125 (2020) 20, 201601
- e+e- scattering: *Chin.Phys.C* 45 (2021) 2, 023108
- Transverse VBS: *JHEP* 01 (2021) 095
- Positivity in lepton colliders: *Phys.Rev.Lett.* 129 (2022) 1
- Generalised elastic positivity for spin-2: *JHEP* 04 (2021) 217
- Multifield positivity: *Phys.Rev.Lett.* 127 (2021) 12
- Triple crossing: *JHEP* 12 (2021) 115
- Drell-Yan moments: [2204.13121](https://arxiv.org/abs/2204.13121)

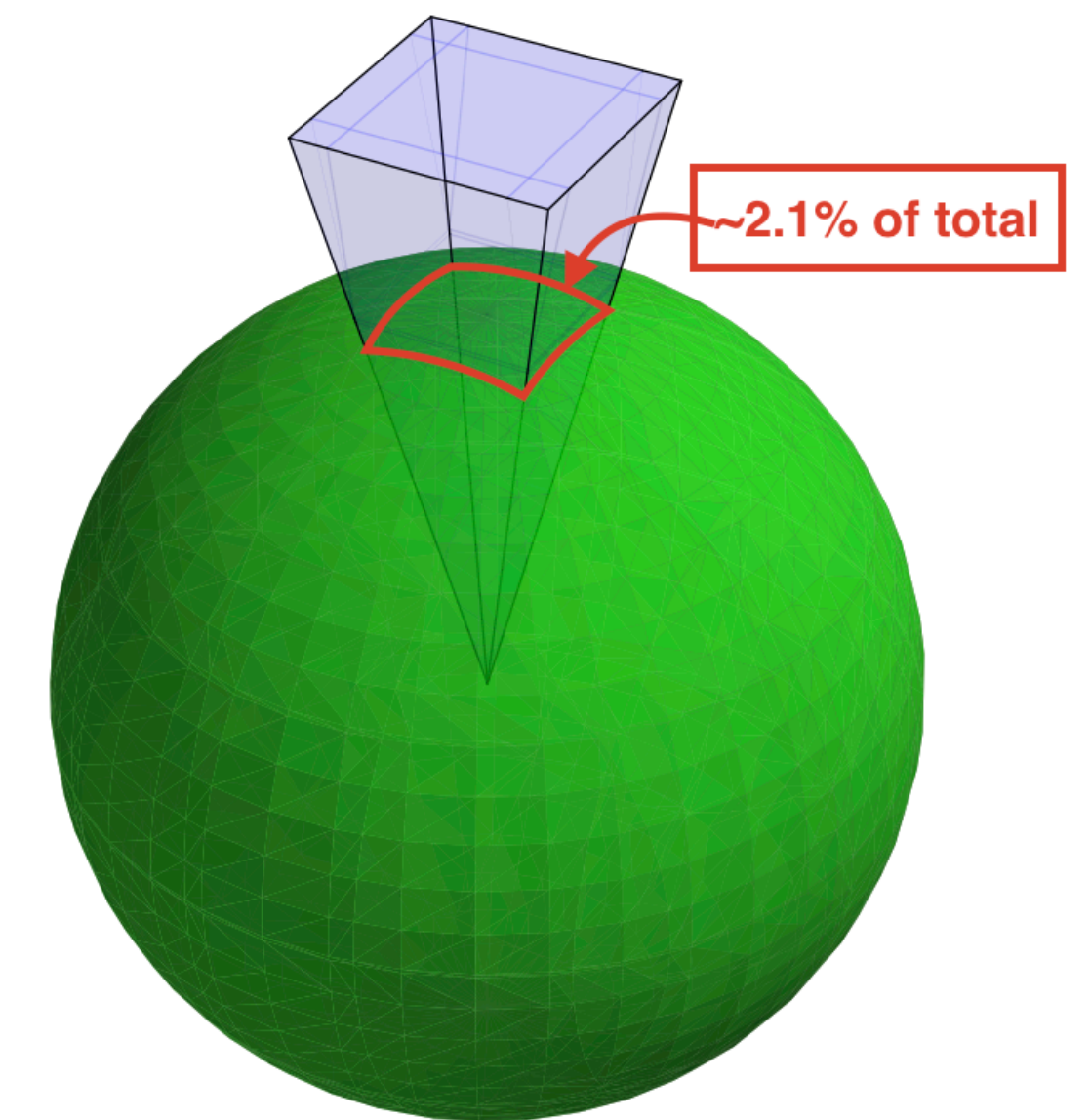
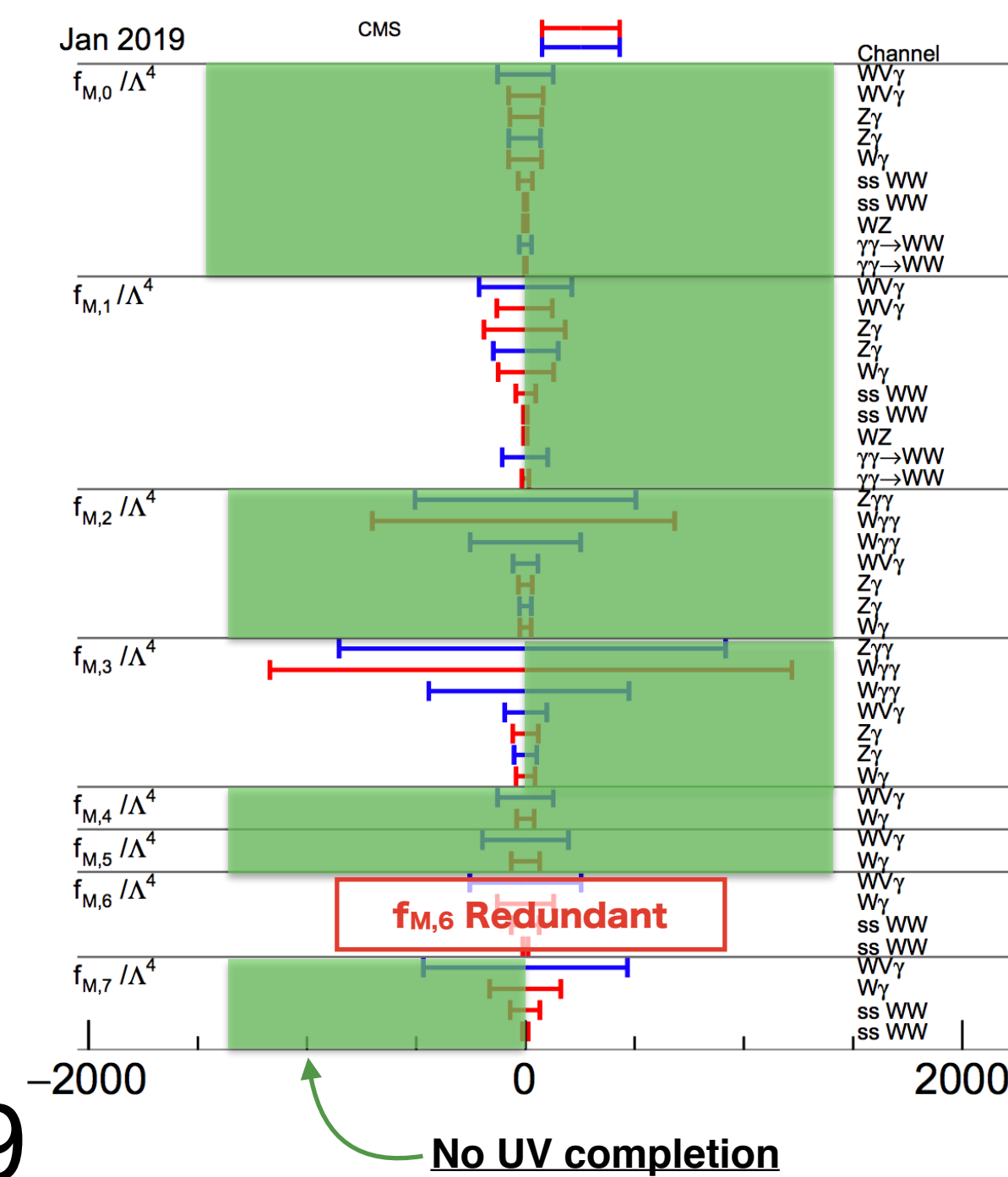
Cen and MBI

MBI2019 in Thessaloniki, Greece

Cen attended the conference and gave two talks: one on EFT@NLO and one on Positivity Bounds on VBS and aQGC



aQGC, Cen's talk@MBI2019



Very important effects on allowed parameter space!

Cen has made many and important contributions to phenomenology
His physics abilities and intuition were invaluable
He was also a humble and kind colleague
He is sorely missed by his collaborators



Higgs Hunting, Paris, 2019