Katharsis of Ultimate Theory Standards

Meeting 2.2 @ DESY (Hamburg)

26 – 28 June 2024

indico.desy.de/event/43627

DESY.

Emmy Noether-Programm

DFG Deutsche Forschungsgemeinschaft

Organized by:

S. Heinemeyer, P. Slavich

Local organizers:

J. Braathen, G. Weiglein

KUTS @ CERN

E. BAGNASCHI (CERN, LOC)
M. MCCULLOUGH (CERN, LOC)
S. HEINEMEYER (IFT MADRID)
H. RZEHAK (U. TÜBINGEN)
P. SLAVICH (LPTHE)

HTTPS://INDICO.CERN.CH/E/KUTS-CERN

27/02/2023 - 01/03/2023

GENERATED WITH MIDJOURNEY

English

catharsis | kə'THärsəs |

noun (plural **catharses** | -sēz |)

1 the process of releasing, and thereby providing relief from, strong or repressed emotions.

2 *Medicine, rare* purgation.

ORIGIN

early 19th century (in catharsis (sense 2)): from Greek ***katharsis***, from ***kathairein*** ‘cleanse’, from ***katharos*** ‘pure’. The notion of ‘release’ through drama (catharsis (sense 1)) derives from Aristotle's *Poetics*.

Katharsis of Ultimate Theory Standards

Precision SUSY Higgs Mass Calculation Initiative

As is well known, the experimental accuracy of the mass measurement of the observed signal is already below the GeV-level, whereas in the (N)MSSM the theory uncertainty is still at the level of several GeV. Therefore, a dedicated effort for reducing the theory uncertainty to the level of the experimental accuracy would be appropriate.

We therefore plan to start a coordinated initiative in this direction, which is meant to get the people working in this field together to contribute to a highly focused and ongoing working group.

Goals:

The main idea is to provide a platform where the relevant experts of the field can communicate with each other, exchange ideas and discuss in detail the open questions. We will (for now) concentrate *only* on (N)MSSM Higgs *mass* calculations. We do not want (at least for the moment) to dilute the effort by including other observables etc.

In particular the following issues should be addressed:

- Identification and listing of existing corrections, and how the are included in public codes.
- Identification and estimate of remaining uncertainties, taking into account the dependence of the theoretical uncertainty on the considered region of parameter space.
- Development of tools to make existing results that are complicated and numerically slow accessible for general analyses, i.e. development of "fast" codes.
- Identification of the most important future improvements.
- Seek to identify teams who tackle those improvements.

General structure:

- This will be an ongoing effort.
- We will try to meet twice a year.
- The emphasis of the meetings will be on free discussions, rather than on talks.
- We will have *very informal* and possibly web-based write-ups, so that, e.g., the "identification and listing" is not lost, but kept for further discussion.

Meetings:

- twice a year
- meeting structure:

* one afternoon (arrival in the morning)

* one full day

* one morning (departure in the afternoon)

- ample room for free discussion (Santander style)

Main organizers:

- Marcela Carena (Fermilab)
- Howard Haber (St. Cruz)
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https://sites.google.com/site/kutsmh/

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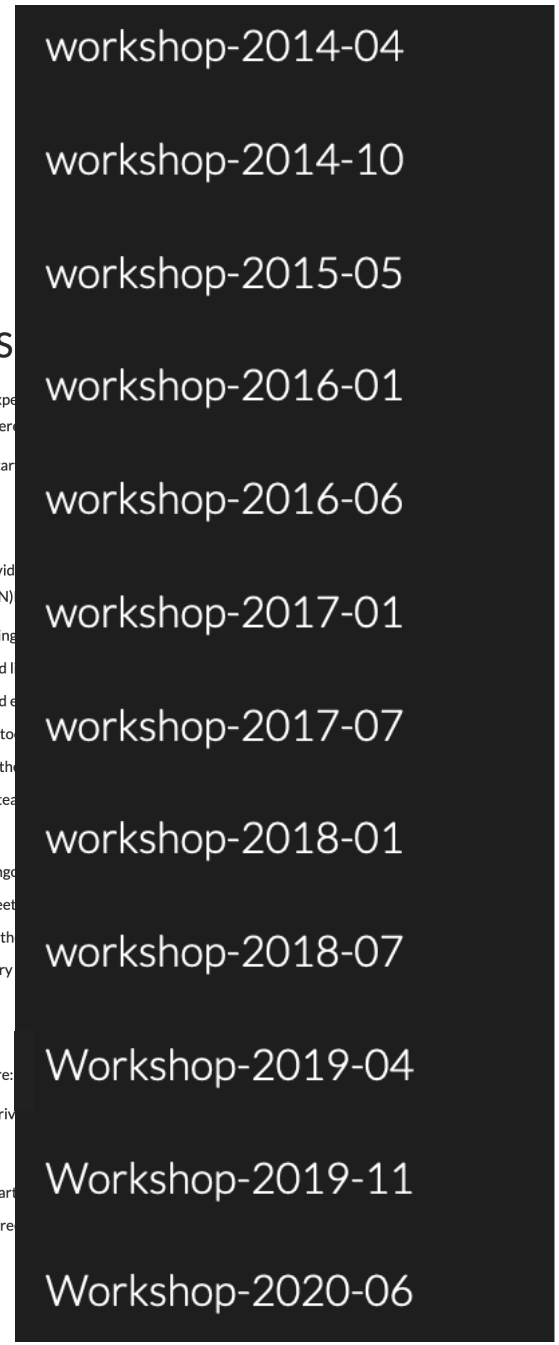

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The KUTS report: 2012.15629

Eur. Phys. J. C (2021) 81:450
https://doi.org/10.1140/epjc/s10052-021-09198-2

THE EUROPEAN PHYSICAL JOURNAL C

Review

Higgs-mass predictions in the MSSM and beyond

P. Slavich[1,a], S. Heinemeyer[2,3,4], E. Bagnaschi[5], H. Bahl[6], M. Goodsell[1], H. E. Haber[7], T. Hahn[8], R. Harlander[9], W. Hollik[8], G. Lee[10,11,12], M. Mühlleitner[13], S. Paßehr[9], H. Rzehak[14], D. Stöckinger[15], A. Voigt[16], C. E. M. Wagner[17,18,19], G. Weiglein[6], B. C. Allanach[20], T. Biekötter[6], S. Borowka[21], J. Braathen[6], M. Carena[18,19,22], T. N. Dao[23], G. Degrassi[24], F. Domingo[25], P. Drechsel[6], U. Ellwanger[26], M. Gabelmann[13], R. Gröber[27], J. Klappert[9], T. Kwasnitza[15], D. Meuser[6], L. Mihaila[28], N. Murphy[29], K. Nickel[25], W. Porod[30], E. A. Reyes Rojas[31], I. Sobolev[6], F. Staub[13]

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Abstract Predictions for the Higgs masses are a distinctive feature of supersymmetric extensions of the Standard Model, where they play a crucial role in constraining the parameter space. The discovery of a Higgs boson and the remarkably precise measurement of its mass at the LHC have spurred new efforts aimed at improving the accuracy of the theoretical predictions for the Higgs masses in supersymmetric models. The "*Precision SUSY Higgs Mass Calculation Initiative*" (KUTS) was launched in 2014 to provide a forum for discussions between the different groups involved in these efforts. This report aims to present a comprehensive overview of the current status of Higgs-mass calculations in supersymmetric models, to document the many advances that were achieved in recent years and were discussed during the KUTS meet-

Editors: P. Slavich and S. Heinemeyer.

S. Borowka, P. Drechsel, L. Mihaila, N. Murphy, K. Nickel, F. Staub: Former academic affiliation.

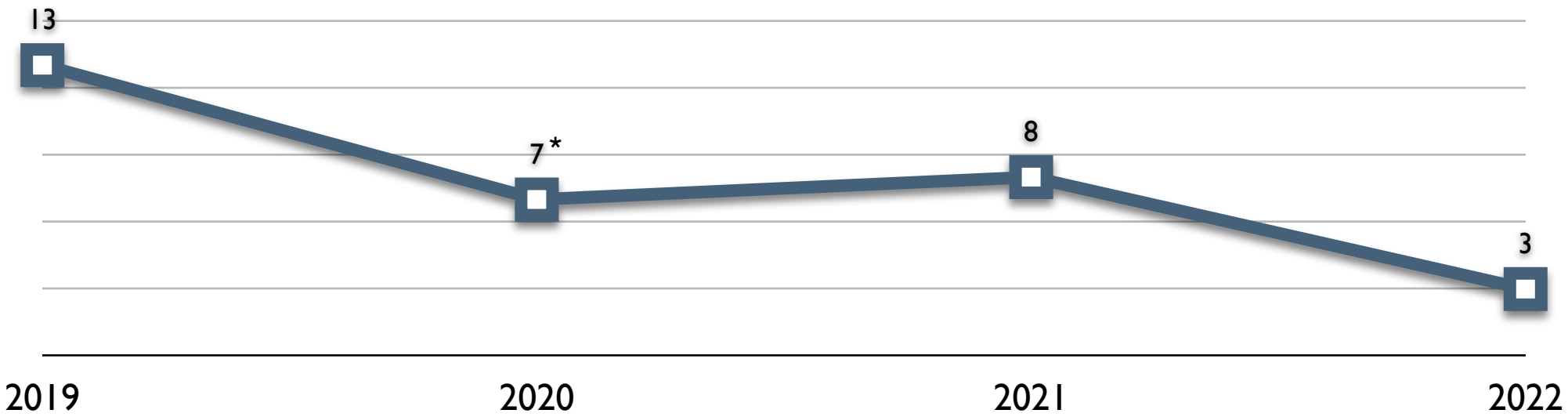
[a] e-mail: slavich@lpthe.jussieu.fr (corresponding author)

Published online: 25 May 2021

A 2-year slumber follows…

…until KUTS reawakens!!!

KUTS-related papers, 2019-2022



* including KUTS report

KUTS 2: time to widen our focus

- From *"Higgs-mass calculations in SUSY"* to *"Precision calculations in BSM"* (including non-SUSY models, other Higgs properties, non-Higgs observables…)

- No phenomenology, lest we become "Higgs Days without experimentalists"

- Which future directions for KUTS? Please contribute to the discussion!

KUTS 12 (or 2.1) @ CERN, 27/02-01/03 2023

Monday Afternoon:
Old-style KUTS:
The NMSSM

- Martin Gabelmann: *Recent developments in NMSSMCALC*
- Pietro Slavich: *Higgs mass in the NMSSM with heavy BSM particles*

Tuesday Morning:
New observables:
M_W prediction

- Dominik Stöckinger: *M_W in FlexibleSUSY*
- Mark Goodsell: *M_W in SARAH*

Tuesday Afternoon I:
New observables:
Trilinear Higgs couplings

- Martin Gabelmann: *Automated Higgs trilinear calculation*
- Johannes Braathen: *Higgs trilinear calculations @ 2-loop*

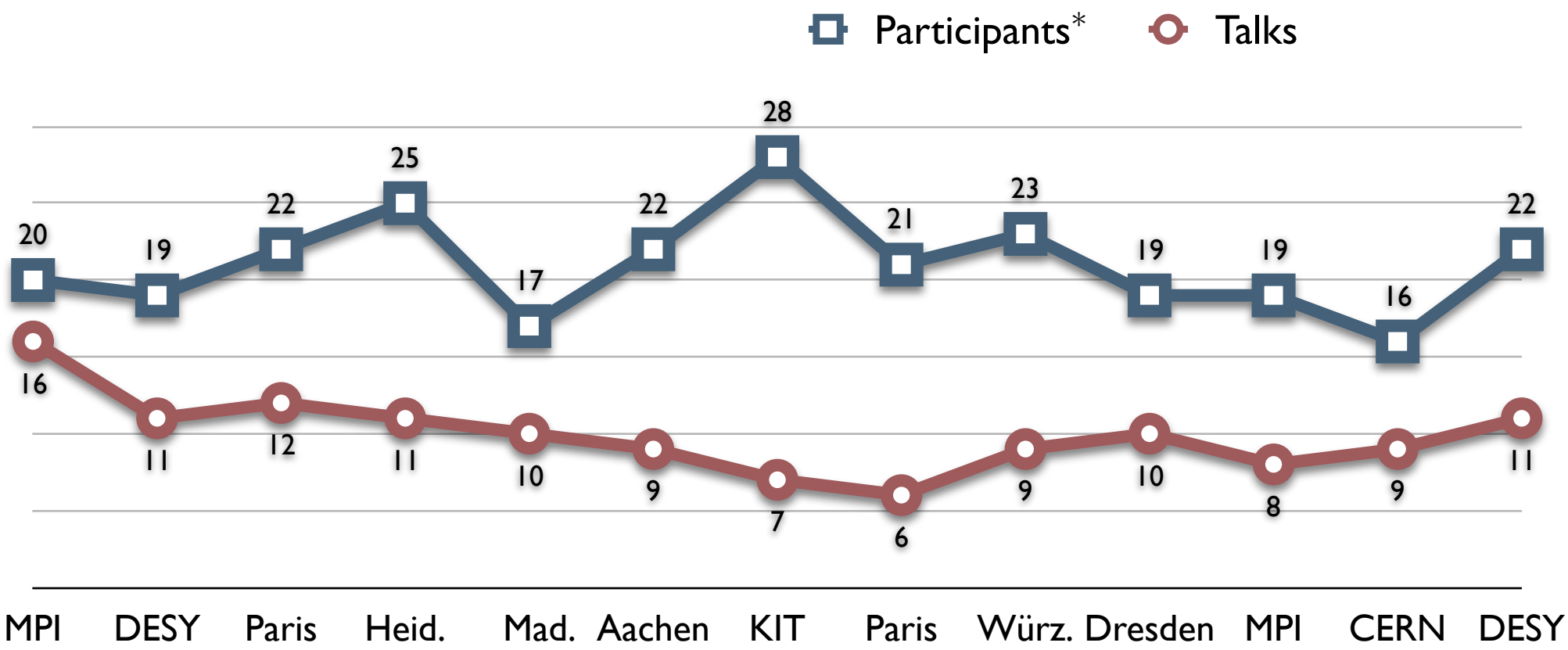
Tuesday Afternoon II:
General issues

- Johannes Braathen: *External-leg corrections as origin of large logs*
- Wojciech Kotlarski: *FlexibleDecay*

Friday Morning:
Sven + Wrap-up

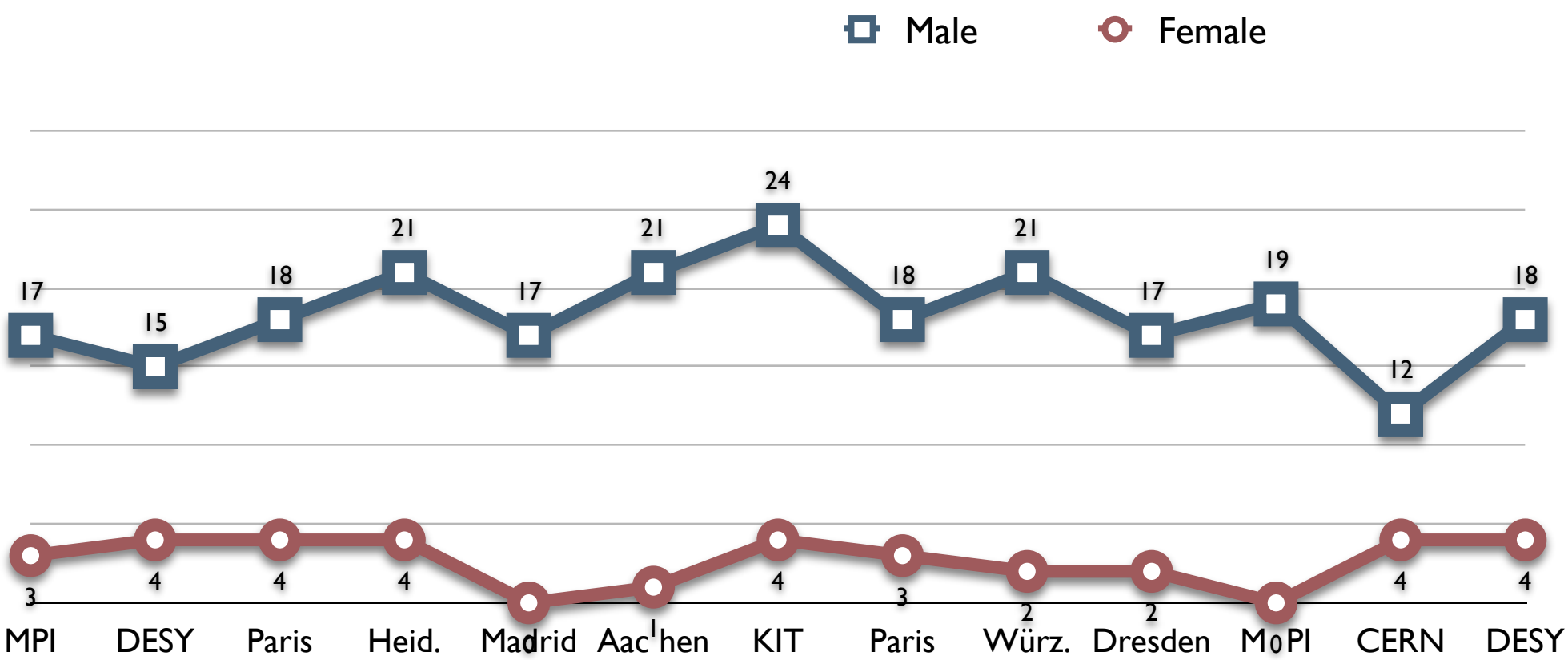
- Sven Heinemeyer: *Automated renormalization-scheme choice*
- All participants: *Discussion on the future of KUTS*

Participants & Talks



(*) including remote and part-timers

KUTS participants by gender



Relevant* papers since KUTS-12:

- 2303.05409 Baglio, Campanario, Glaus, Mühlleitner, Ronca, Spira
  Full NLO QCD predictions for Higgs-pair production in the 2HDM

- 2305.03015 Bahl, Braathen, Gabelmann, Weiglein ✓ KUTS 13
  anyH3: precise predictions for the trilinear Higgs coupling in the SM and beyond

- 2306.04127 Egle, Mühlleitner, Santos, Viana
  Electroweak Corrections to Higgs Boson Decays in a Complex Singlet Extension of the SM and their Phenomenological Impact

- 2307.02476 Degrassi, Slavich
  On the two-loop BSM corrections to $h \longrightarrow \gamma\gamma$ in the aligned THDM

- 2307.14976 Aiko, Braathen, Kanemura
  Leading two-loop corrections to the Higgs di-photon decay in the IDM

- 2307.14983 Banik, Hinrichsen, Porod
  Renormalized e.o.m for scalars and fermions in the 2PI formalism

- 2308.04059 Dao, Gabelmann, Mühlleitner ✓ KUTS 13
  The $O(\alpha t+\alpha\lambda+\alpha\kappa)^2$ Correction to the ρ Parameter and its Effect on the W Boson Mass Calculation in the Complex NMSSM

Relevant papers since KUTS-12 (cont'd):

- 2308.07845 Dittmaier, Rehberg, Rzehak
  Renormalization of a Standard Model Extension with a Dark Abelian Sector and Predictions for the W-Boson Mass
- 2310.15622 Kanemura, Mura
  On the criterion of perturbativity with the mass-dependent beta function in extended Higgs models
- 2311.01889 Bahl, Meuser, Weiglein ✓ KUTS 13
  Complete electroweak O(Nc^2) two-loop contributions to the Higgs boson masses in the MSSM and aspects of two-loop renormalisation
- 2311.15892 Aiko, Kanemura, Kikuchi, Sakurai, Yagyu ✓ KUTS 13
  H-COUP Version 3: A program for one-loop corrected decays of any Higgs bosons in non-minimal Higgs models
- 2402.14630 Khasianevich, Kotlarski, Stöckinger, Voigt ✓ KUTS 13
  FlexibleSUSY extended to automatically compute physical quantities in any BSM theory: Charged LFV processes, Higgs decays, and user-defined observables
- 2404.12439 Bahl, Carena, Ireland, Wagner
  Improved Thermal Resummation for Multi-Field Potentials

Relevant papers since KUTS-12 (cont'd):

- 2406.17635 Borschensky, Dao, Gabelmann, Mühlleitner, Rzehak ✓ KUTS 13

  Higgs Mass Predictions in the CP-Violating High-Scale NMSSM

The Program

Wednesday Afternoon: — Higgs masses

- D. Meuser: *$O(N_c^2)$ Higgs-mass corrections in the MSSM*
- C. Borschensky: *MhEFT in NMSSMCalc*

Thursday Morning: — Higgs decays

- J. Wünsche: *Updates on FlexibleEFTHiggs*
- K. Yagyu: *H-COUP*
- W. Kotlarski: *FlexibleDecay*

Tuesday Afternoon: — Triple Higgs couplings

- A. Dashko: *Effective potential and thermal phase transitions*
- K. Radchenko: *AnyH3 and di-Higgs production in the THDM*
- A. Verduras: *Di-Higgs production in the RxSM*
- J. Braathen: *2-loop trilinears in general theories*

Friday Morning: — Beyond Higgs

- U. Khasianevich: *NPointFunctions*
- M. Gabelmann: *M_W in NMSSMCalc*
- All Participants: *The future of KUTS*

Let the KUTS-13 begin!!!

Let the KUTS2-2 begin!!!