WG4: Outlook and Plans

Conveners

ATLAS: Stefano Manzoni

CMS: Fabio Monti

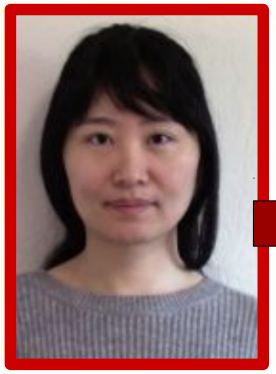
Theory: Ramona Gröber, Javier Mazzitelli, Maggie Mühlleitner

Higgs WG general meeting, November 15th 2023

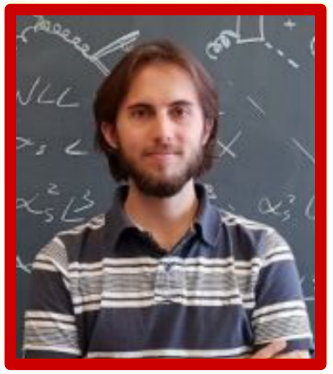
We got promoted!

LHC-HH cross group → Working Group 4: HH and multi-Higgs

The WG4 conveners:








CMS: Nan Lu → Fabio Monti

ATLAS: Stefano Manzoni

Theory: Ramona Gröber, Javier Mazzitelli, Maggie Mühlleitner

Thanks a lot Nan for your work in the last years!

Meetings this year:

20/03:	signal and background MC [link]
29/03:	EFT H+HH [link]
20/10:	MonteCarlo at NLO [link]
14-15/11:	General Meeting

Variety of topics covered in these meetings

SM predictions | EFT analyses | BMS models

SM predictions

- Main topics discussed this year:
  - Progress on EW corrections to gg→HH
  - Developments on MC generators for ggF
    - NNLO+PS HTL
    - New POWHEG NLO+PS [arbitrary mh; mt scheme uncertainties]
  - NLO+PS generator for bbH background

- Ongoing task: HH production cross section recommendations for RUN III

Good opportunity to include further theory developments!

ggF: $\mathrm{NNLO}_{\mathrm{FTapprox}} \rightarrow \mathrm{NNLO}_{\mathrm{FTapprox}} + (\mathrm{N^3LO}+\mathrm{N^3LL})_{\mathrm{HTL}}$

VBF: $\mathrm{N^3LO} \rightarrow \mathrm{N^3LO} + \mathrm{NLO\ EW}$

SM predictions

- Some areas in which new theory results are expected and/or needed
  - NNLO+PS including finite top mass effects
  - Full NLO EW corrections to gg→HH

    uncertainty estimate to be added in the meantime (10%?)
  - Reduction of top mass scheme uncertainties

- On the MC side there is now a new NLO+PS generator

Agree on which MC to be used as baseline
and how to include more accurate evaluation
of the top-quark mass scheme unc. at analysis level

Effective Field Theory

- Main topic and ongoing activities are connected to EFT H + HH combination

Physics:

- which questions are most important for a combination?
- which tools available?
- which steps to be done, which experience needed?
- how to treat the backgrounds?
- how to treat the decays (width)
- SMEFT/HEFT
- operators so far not considered: chromomagnetic, operators that enter at loop level (like trilinear)

Practical aspects:

- organisational aspects: build a task force? set up communication channels for people interested contributing?
- feasible to have a recommendation, a LHCHWG note?
- is there an overlap with activities within the EFT WG?

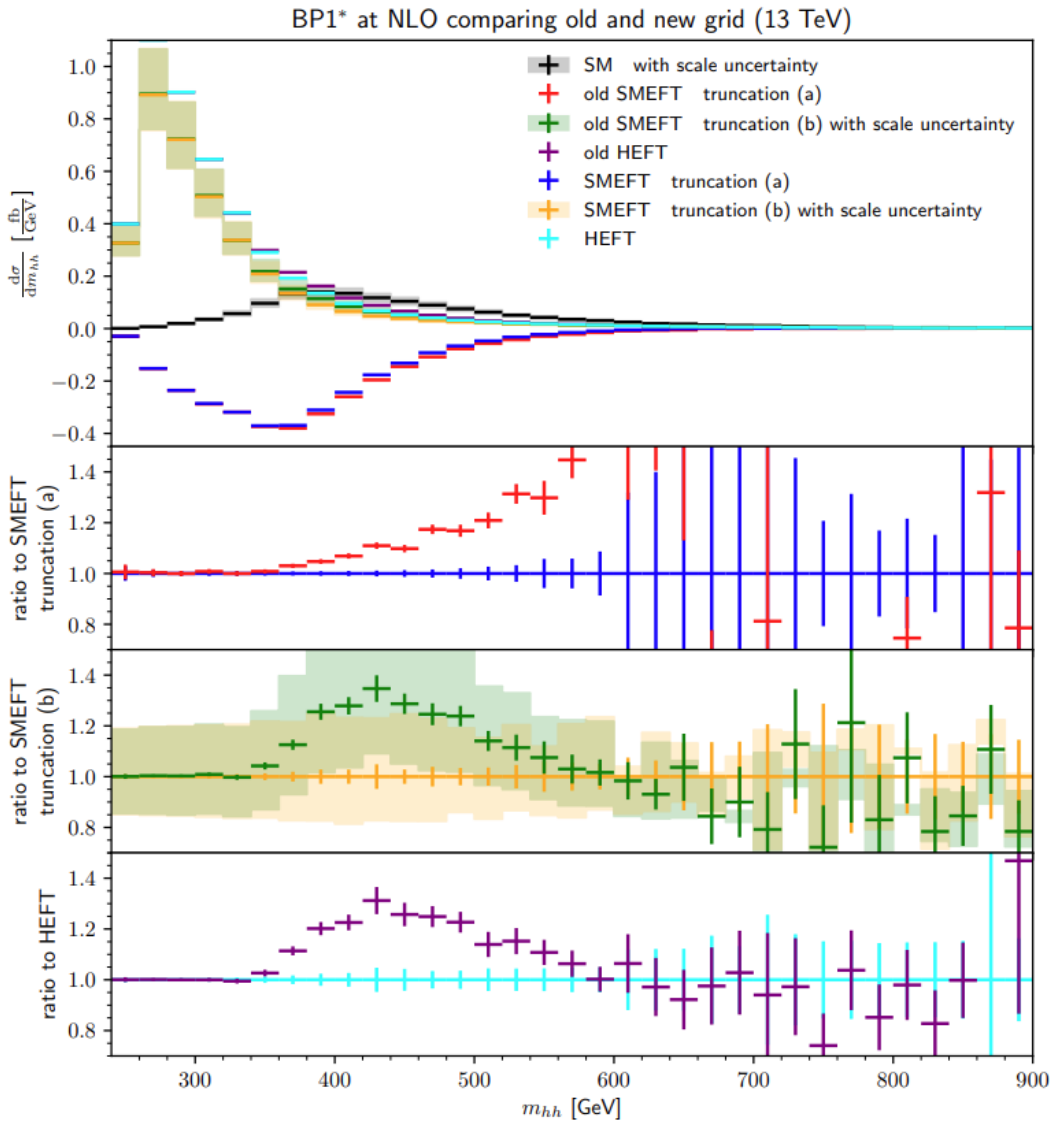
[slide from Ramona]

Mattermost channel created, to discuss both physics and the organizational steps to arrive to a recommendation

If you want to participate in the EFT H and HH combination task force please join here

Effective Field Theory

- Issue in c_{hhh} variation found in POWHEG generators ggHH and ggHH_SMEFT



- Ongoing activities: update of EFT note LHCHWG-2022-004
  update of cross section recommendations vs c_{hhh}

Resonant BSM

- Recent new results were presented earlier today in parallel session

Full NLO QCD corrections for HH production in the 2HDM

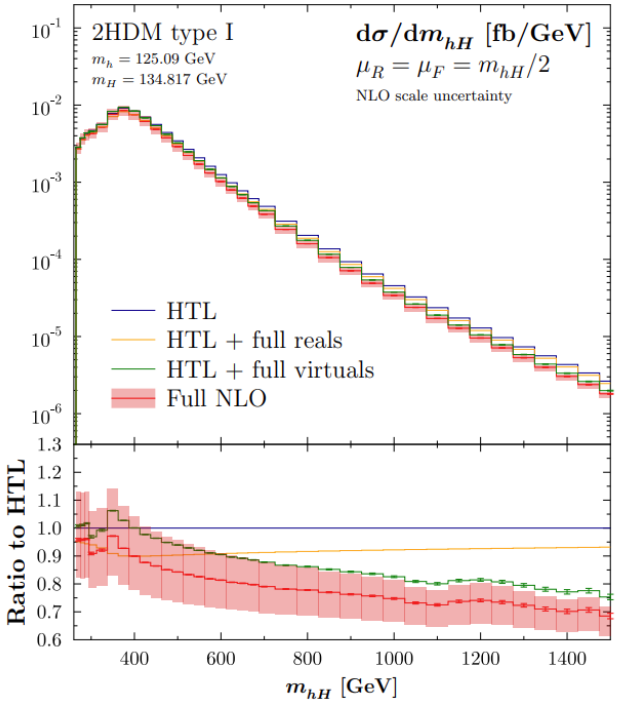
[Michael Spira]

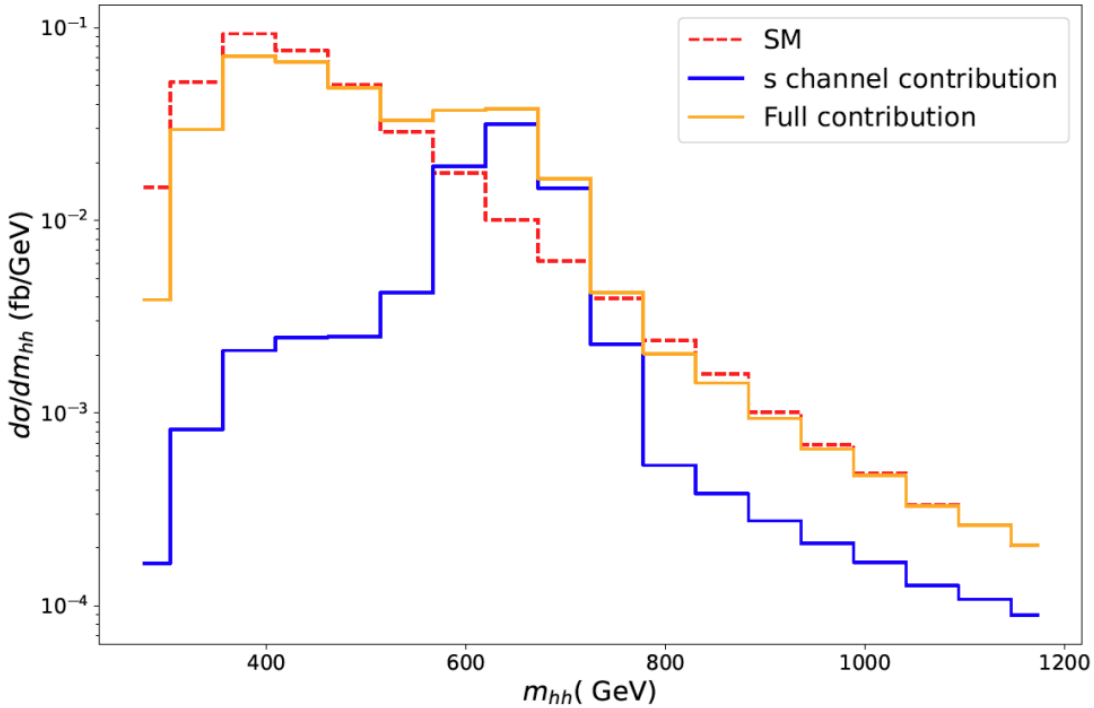
Pure resonant vs full cross section in real singlet extension

[Alain Verduras]

Studying effects of NLO corrections to triple Higgs couplings in the 2HDM at HL-LHC

[Kateryna Radchenko]





Some topics that are worth looking into in the future:

- Signal-background interference in BSM models

Expected developments in NLO MC generators (inclusion of HH resonance) instrumental to this goal

- BSM HH production in the transition between resonant and non-resonant

Multi-Higgs

- Future group activities not restricted to di-Higgs
- WG4 parallel earlier today: review of HHH workshop
- Activities of WG4 in connection to multi-Higgs production still to be defined!
    - HHH XS recommendations for the SM?
    - Recommendations/MC for λ_3 and λ_4 variations?
    - EFT for HH+HHH?
    - BSM resonant benchmarks?
    - ...
- Some open questions:
    - m_t scheme uncertainties for HHH cross section
    - models that allow large λ_4 variations and are not excluded by other searches
    - resonant models that could be first observed in triple Higgs

Higgs Pairs Workshop

- Call for expressions of interest to host HH Workshop in 2024/2025 sent earlier this year
- We received four bids:

University of Maryland, College Park, Washington DC, USA

Fermilab, Batavia, USA

University of Science and Technology of China (USTC), Hefei, China

Hotel Hermitage, Elba Island, Italy by University of Pisa & INFN Pisa

Thanks to everyone involved in preparing these great proposals!

After gathering feedback from the HH community through an online survey and evaluating the various proposals received, the organizing committee has decided...

Higgs Pairs 2025:

Hotel Hermitage, Elba Island, Italy, 11-17 May 2025

Higgs Pairs organizing committee:

Alessandra Betti
Valentina Cairo
Ramona Gröber
Nan Lu
Stefano Manzoni
Javier Mazzitelli
Fabio Monti
Margarete Mühlleitner
Marco Valente

Local organising committee:

Alberto Annovi
Paolo Azzurri
Giuseppe Bagliesi
Edoardo Bossini
Dario Buttazzo
Giorgio Chiarelli
Maria Agnese Ciocci
Silvio Donato
Paolo Francavilla
Sandra Leone
Chiara Roda
Andrea Rizzi
Angelo Scribano
Monica Verducci