

# Proposed Studies for Offshell Higgs

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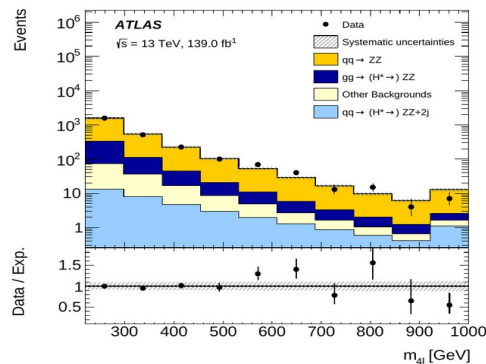
Yellow Report 5 Kick-off Meeting

11 June 2024

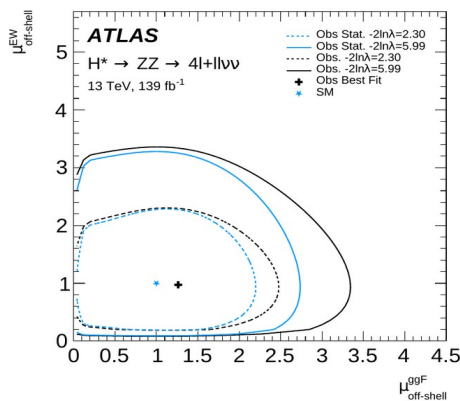
# Recent experimental results

ATLAS, *Phys.Lett.B* 846 (2023)

$$\Gamma_H = 4.5^{+3.3}_{-2.5} \text{ MeV}$$

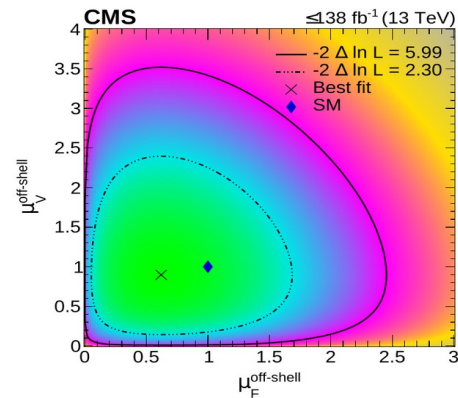
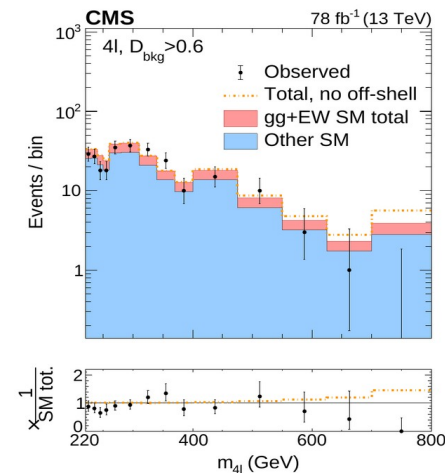


(a)



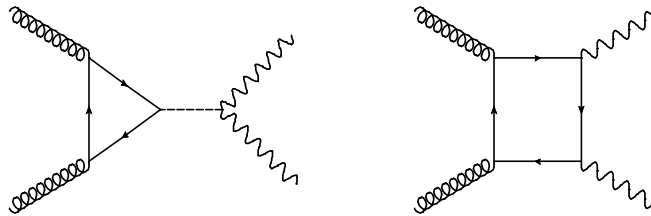
CMS, *Nature Phys.* 18 (2022)

$$\Gamma_H = 3.2^{+2.4}_{-1.7} \text{ MeV}$$



# Theory Status

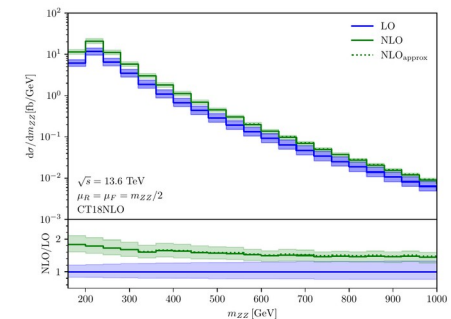
- Need signal, background and their interference



- **Full NLO QCD** corrections now known

[Agarwal, Jones, Kerner, von Manteuffel '24]

- (Approximate) **NLO QCD + PS** in POWHEG-BOX.
- Progress beyond NLO **extremely difficult**.



# Proposed Studies for YR5

1. Parton shower and jet merging benchmarking

(Rafael, Li, Raoul)

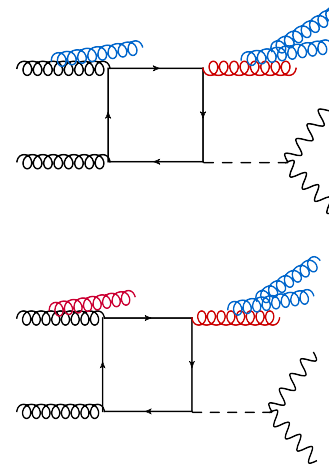
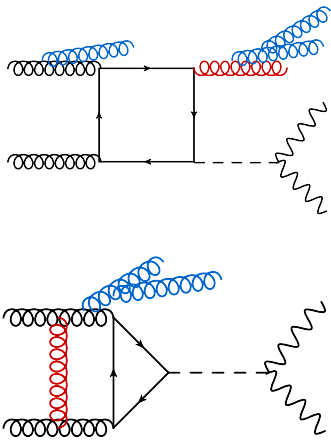
2. Polarized vector bosons (Rafael)

3. EFT interpretations (Eleni)

# PS/Jet merging benchmarking

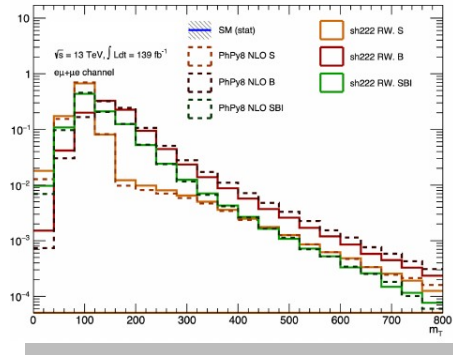
## How to include additional radiation in theory predictions?

- Parton showers (NLO+PS in POWHEG-BOX)
- Jet merging (SHERPA/MADGRAPH)
- NLO+PS:
  - Matrix elements @ NLO QCD
  - 0- and 1-jet generated @ **matrix element level**
  - Additional jets from **PS**
- Jet merging
  - Matrix elements @ LO QCD
  - 0- and 1-jet (2-jet ??) generated @ **matrix element level**
  - Additional jets from **PS**

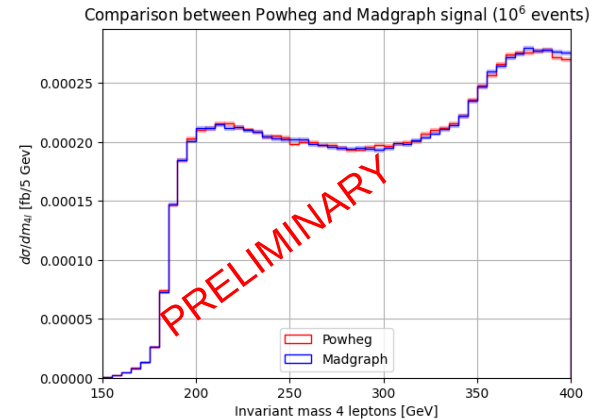


# PS/Jet merging benchmarking

- Different ways of including jets
  - Different behavior according to jet bin
  - Different uncertainties
  - ...
- Systematic benchmarking exercise:
  - (Building on earlier work.)
  - Compare publically-available tools (POWHEG, SHERPA, MADGRAPH).
  - Understand different treatment of QCD radiation.
  - E.g. look at **invariant mass distribution** for different jet bins using different tools.
  - Study **signal**, **background**, **interference** separately (where possible).
  - Allow more direct comparison/combination of results, e.g. ATLAS and CMS.

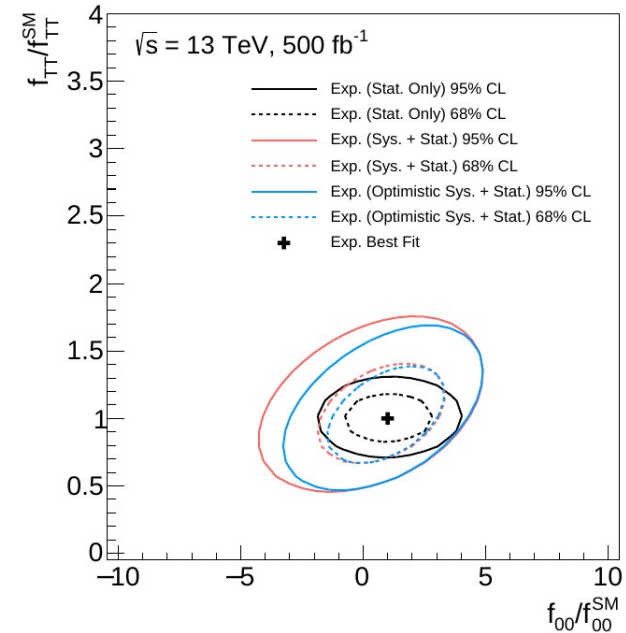
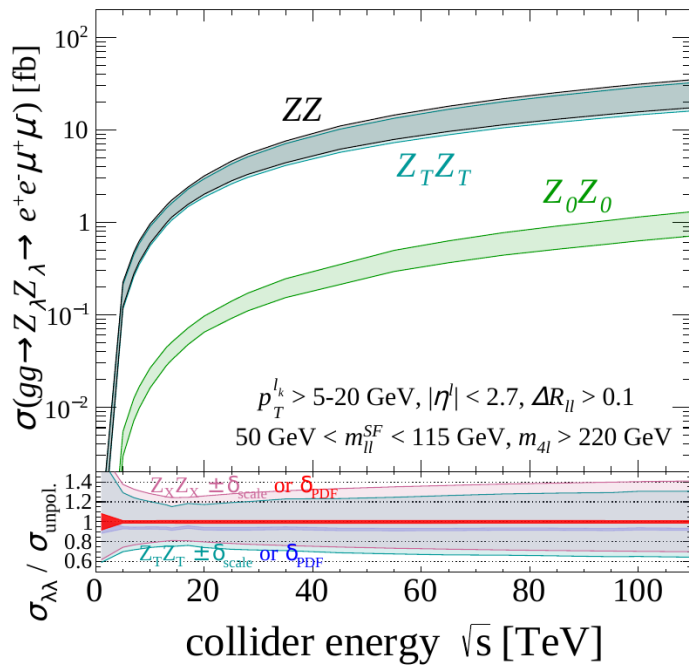


Talk by B. Kortman



# Offshell Studies with Polarized Bosons

- Study EWSB through polarized vector bosons in offshell regime.
  - Longitudinally polarized vector bosons grow with energy.
  - Tool for exploring impact of new physics (through e.g. SMEFT)
- Complementary to onshell coupling studies.
- Initial study: [Javurkova, Ruiz, Coelho Lopes de Sá, Sandesara '24]



# EFT Interpretations

- Plans to continue EFT activities in the spirit of:

**Off-shell Higgs Interpretations Task Force: Models and Effective Field Theories**  
**Subgroup Report**

[Aleksandr Azatov](#) (SISSA, Trieste and INFN, Trieste), [Jorge de Blas](#) (Granada U., Theor. Phys. Astrophys. and CAFPE, Granada), [Adam Falkowski](#) (IJCLab, Orsay), [Andrei V. Gritsan](#) (Johns Hopkins U.), [Christophe Grojean](#) (DESY and Humboldt U., Berlin)

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- Possibility of extensions:
  - **Validation** and **comparisons** of available EFT codes (SMEFT@NLO vs JHUGen)
  - More detailed phenomenological studies, including relevant analysis cuts (need input from experiments)
  - **Subset of EFT directions** with most promising sensitivity from off-shell Higgs measurements
  - **Can off-shell Higgs be useful once other constraints from other processes are taken into account?**
  - CP-violation in off-shell Higgs



# EFT Interpretations

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- This will require a co-ordinated effort from a large number of contributors.
- **Not clear if this is feasible on the time-scale of YR5.**
- Should we include this as an initial goal and see how it goes?

THANK YOU FOR YOUR ATTENTION