

# **RA3 Rare Processes**

## **Projects Dingfelder/Lenz**

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# CmF Funded Projects: CPV in Higgs

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- Find **new sources** of **CP violation** in the extended Higgs sector
  - benchmark: **C2HDM** - 2HDM with complex coupling parameters
- CP violating couplings expected to be small
  - constrained through indirect measurements: electron EDM, Higgs rates
- **Direct measurements:**
  - Higgs distributions e.g.  $H \rightarrow \tau\tau$   
→ see today's talk from C. Grefe et al.
  - neutral Higgs bosons  $h_1, h_2$  and  $h_3$  with CPV signatures

# Neutral Higgs with CPV signatures

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- **Simultaneous** measurement of rates

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CP-even decays                      and                      CP-odd decays

$$\sigma(h_2) \times \mathcal{B}(h_2 \rightarrow h_1 h_1) = 191 \text{ fb} \quad \sigma(h_2) \times \mathcal{B}(h_2 \rightarrow h_1 Z) = 122 \text{ fb}$$

$$\sigma(h_3) \times \mathcal{B}(h_3 \rightarrow h_1 h_1) = 235 \text{ fb} \quad \sigma(h_3) \times \mathcal{B}(h_3 \rightarrow h_1 Z) = 76 \text{ fb}$$

- Person power:

Mass of additional Higgs bosons is close to the EW scale

- 1 PhD student starting June 1 for 3 years

- Next steps:

- MC benchmarks studies to identify promising experimental signatures

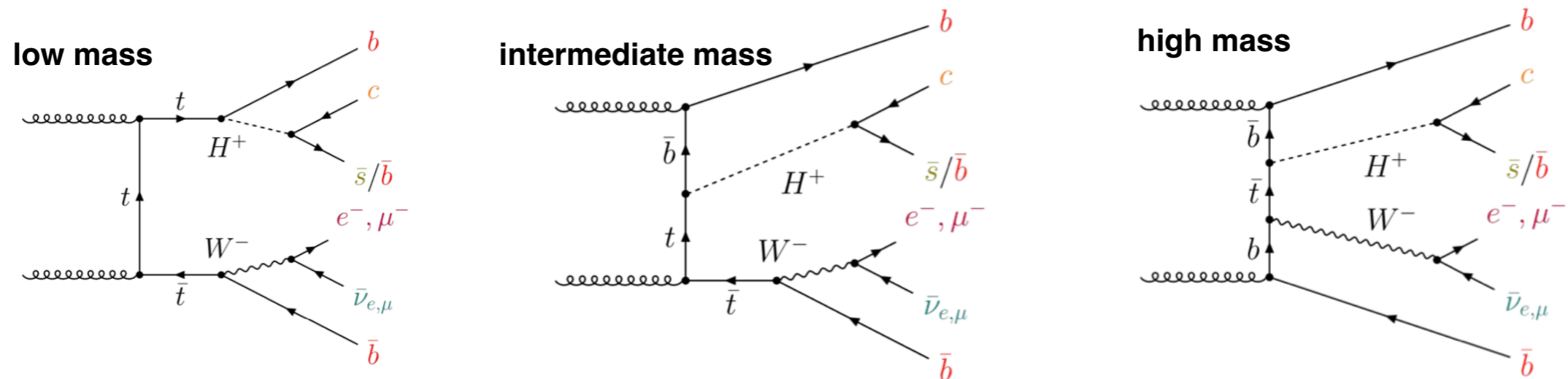
- Develop analysis strategy; Run 2 + Run 3 ATLAS data

# Other Projects: Charged Higgs Searches

- Search for  $H^\pm$  produced in association with top quarks

- e.g. **Flavourful 2HDM**: breaks flavour universality

Altmannshofer et al  
Ghosh et al



- $H^\pm$  mass dependent production mechanism: 20 to 1000 GeV
- $H^\pm \rightarrow cs$  and  $H^\pm \rightarrow cb$  final states have often high BRs at high  $\tan \beta$  values
  - probe both channels simultaneously
- Run 2 + Run 3 ATLAS data

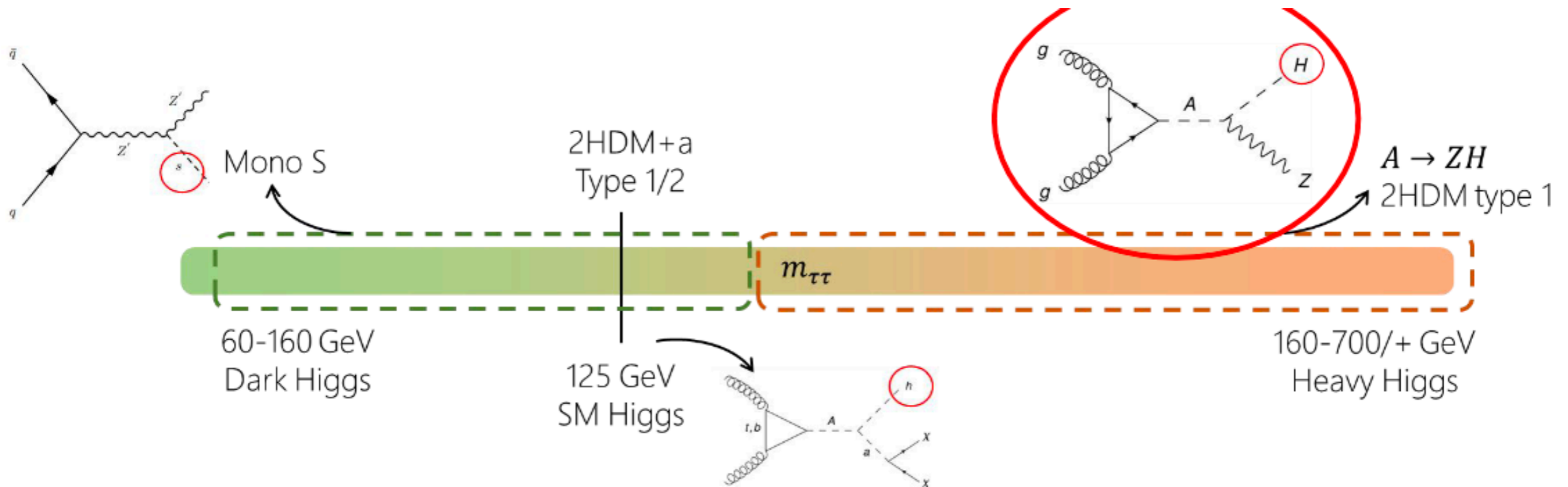
# $H^\pm \rightarrow cs, cb$ : Status

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- All MC signal samples are produced
- **SPANet** to reconstruct the  $t\bar{t}$  system and for signal/bkg classification
  - use charm and **strange tagging** for jet assignment
    - plan to establish a **collaboration** with **Siegen**
  - working on the final training setup
- Ongoing work on signal and control region definitions
- Timescale: end 2027

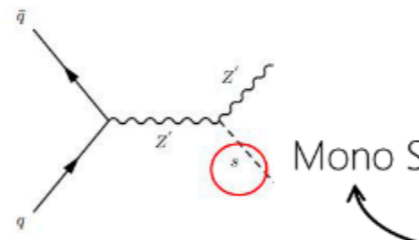
# Other Projects: Mono-Higgs $H \rightarrow \tau\tau + \text{MET}$

- Search for a resonance  $S$  decaying into di-taus + MET
- Benchmark models depend on the  $S$  mass
  - **Dark Higgs** for low  $S$  masses
  - $A \rightarrow ZH(S) \rightarrow \tau\tau\nu\nu$  above 160 GeV
  - 2HDM+a for 125 GeV Higgs



# $H \rightarrow \tau\tau + \text{MET}$ : Status

- **2HDM+a high mass samples ready**
  - developing ML-based classifier
  - finalising signal and control region definitions
    - first data/MC studies look promising
- Working on **low-mass models**: find uncovered phase-space which can be probed by  $H \rightarrow \tau\tau + \text{MET}$
- Run 2 + Run 3 ATLAS data
- Timescale: end 2027



2HDM+a benchmarks

