


# Report from Physics & Performance WG

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# Introduction and news

- P&P working group activity since last meeting:
  - Summary report at the FCC Physics Workshop (+ additional meeting for rehearsal)  
<https://indico.cern.ch/event/1439509/timetable/>
  - Meeting last week (brief summary in this talk)- <https://indico.cern.ch/event/1506570/>
- Fully ramped up sample production and finalising plans + timelines for analyses to go into the ESPP input documents (list + discussion in this talk)
  - Following up with contributors, if we haven't been in touch please inform us of your plans a.s.a.p.
- Next meetings scheduled for:
  - 20th of February, 4PM CERN Time- <https://indico.cern.ch/event/1506571/>
  - 6th of March, 4PM CERN Time- <https://indico.cern.ch/event/1506572/>
  - Please save the dates and plan your contributions!

# 5th meeting agenda



**FUTURE  
CIRCULAR  
COLLIDER**

## FCC-hh Physics & Performance meeting

Thursday 6 Feb 2025, 16:00 → 18:00 Europe/Zurich

Description <https://cern.zoom.us/j/61598274766?pwd=F2EgtDJUOGD5tbAsBEQA0TP8T0aoTb.1>

**zoom** FCC-hh Physics & Performance meeting Join ▼


**16:00** → 16:20 **Roundtable discussion** ⌚ 20m ✎

Sample production status & requests ⌚ 10m ✎

 Sample production ...  Sample production ...

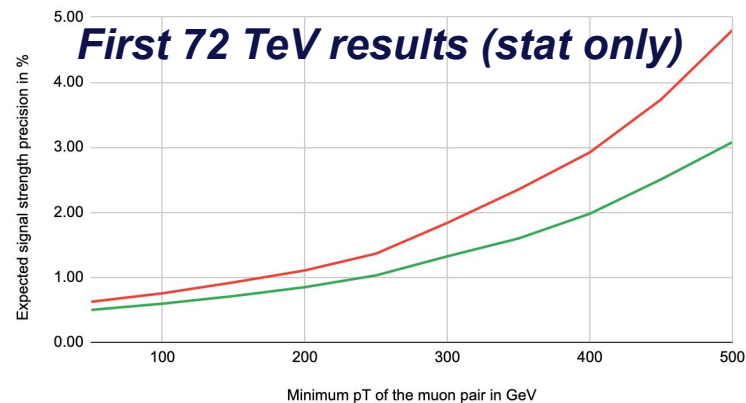
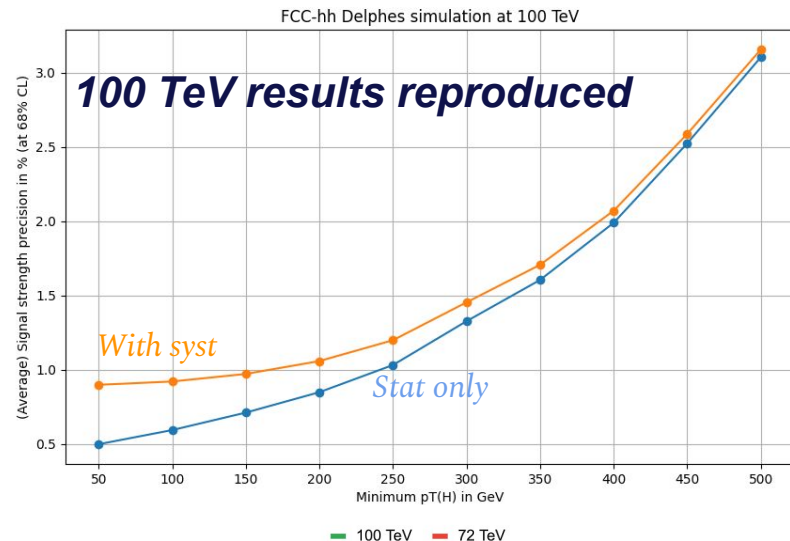
**16:20** → 16:40 **Higgs to muons analysis** ⌚ 20m ✎

**Speaker:** Birgit Stapf (CERN)

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# $H \rightarrow \mu\mu$ analysis

- Status of redoing the 2019 Higgs rare decay analyses at alternative energies
  - Focus on  $H \rightarrow \mu\mu$  channel: Exploit high pT and ratio w.r.t  $H \rightarrow 4\mu$  to limit impact of systematic uncertainties (cf. [CERN-ACC-2018-0045](#))
- Reproduced 100 TeV results of  $H \rightarrow \mu\mu$  signal strength measurement in simple analysis setup
- First 72 TeV results available w. same setup
  - 84 TeV samples under high prio production
- Next steps:
  - Move to ratio with  $H \rightarrow 4\mu$
  - Improved & more realistic analysis strategy





# Roundtable: Sample production

- Started new production tag (fcc\_v07) for official Delphes samples for 2025 results
  - Using latest key4hep release including finally a fix for previously persistent memory/crash issues, as well as fix for the jet matching (amongst others)
  - Highest priority samples are the ones for  $b\bar{b}yy$  and  $H \rightarrow \mu\mu$  analysis, they are completed at 100 TeV, and in progress at other energies
- LHE generation of the highest priority key analysis samples (single Higgs) at alternative energies nearly completed, expanding to broader scope
- [Link to spreadsheet tracking production status](#)
- In case of further requests please get in touch a.s.a.p.

# Status & plans: Definite deliverables

- New baseline: [running scenario at 84 TeV](#), [Delphes card II for detector performance](#)
    - Common note describing the Delphes detector parameterization configurations (“cards”) planned for all analyses documents to reference, updated w.r.t. 2019 studies (Michele, Birgit)
    - Additional points: energies of 72, ~100 and 120 TeV | Idealistic Delphes card I
    - Luminosity scenarios to be agreed on? Full scan, few key points? For now: 30 ab<sup>-1</sup>
  - Analyses in advanced stage, definitely planned for **31st of March deadline**:
    - Higgs self-coupling in  $b\bar{b}yy$  (Angela, Paola, Birgit) - all energies, both Delphes cards
    - Single Higgs ratios - minimum  $H \rightarrow \mu\mu / H \rightarrow 4\mu$  - (Birgit, Michele) - all energies, both Delphes cards
    - Higgs self-coupling in  $b\bar{b}ll + E_T^{miss}$  (Birgit, Kerstin, Elisabetta) - @ 100 TeV, Delphes card II only
    - VBS  $WW$  (Chilufya, Marc-Andre et al) - @ 100, 27 and 50 TeV, older Delphes card
- All (planned) as stand-alone notes that can be referenced by the FCC-hh summary note

# Status & plans: Probable deliverables

- New baseline: [running scenario at 84 TeV](#), [Delphes card II for detector performance](#)
  - Common detector performance/Delphes configuration note (Michele, Birgit)
  - Additional points: energies of 72, ~100 and 120 TeV | Idealistic Delphes card I
  - Luminosity scenarios to be agreed on? Full scan, few key points? For now: 30 ab<sup>-1</sup>
- Analyses in earlier stage, but committed to first results for **31st of March deadline**:
  - First result of Top-Yukawa coupling in  $\bar{t}tH(\gamma\gamma)$  standalone (Elena, Stefano, Birgit) - likely only at 84 TeV, with card II for first iteration, ratio analysis potentially on a longer timeline
  - VBF  $HWW$  lineshape analysis (Elliot) - currently working on 100 TeV, switch to 84 TeV possible?, card II for first iteration
  - Differential distributions of  $\bar{t}t$ ,  $\bar{t}tV$ ,  $VV$  processes as input to global fits (Michele, Birgit, Elliot?) - important results, timeline a bit critical, ideally @ all energies, as first iteration only 100 TeV?

# Status & plans: Longer timeline

- Further analyses + updates/expansions of results possible on the longer timeline, for the symposium in Venice **end of June** :
  - Adding missing channels, energy scenarios and/or detector performance benchmarks to the key analyses where needed
  - Ratio analysis of  $\bar{t}tH(\gamma\gamma)$  /  $\bar{t}tZ(ee)$ , combination of  $\bar{t}tH(\gamma\gamma)$  and  $\bar{b}b\gamma\gamma$  for 2D  $\kappa_t$  vs  $\kappa_\lambda$  scans
  - Higgs width from off-shell VBF  $H \rightarrow WW$  (Robin, Birgit) - first round of tester samples @ 100 TeV in production, Delphes card II, detailed analysis strategy (incl. energy points) to be defined
  - Re-interpretation of  $\bar{b}b\gamma\gamma$  di-Higgs results as resonant narrow resonance scan (Angela, Birgit) - at least 84 TeV, ideally all energies + both Delphes cards



# Status & plans: Timeline unclear

- Ongoing analyses / important results with timelines that are still (somewhat) unclear:
  - $\bar{b}b\tau\tau$  (Monica, Jordy, et al): Advanced re-analysis of the channel involving new ML techniques, main bottleneck background sample statistics under discussion, currently @ 100 TeV, old Delphes card - ideally update at least to new production, include 84 TeV - probable to have at least an initial result for March deadline, full-scale results and combination with  $\bar{b}b\gamma\gamma$  on June timeline possible?
  - $\bar{t}tH(bb) / \bar{t}tZ(bb)$  2019 ratio analyses that would be valuable to redo at alternative energies, but currently uncovered - shares a lot of base samples with other analyses, possible on June timeline, perhaps earlier if started soon?
  - Triple Higgs/quartic coupling (James, Holly, Tom): Just started on sample production
  - CPV HVV couplings (Sarah, Andy, Sinead, Aidan, Christophe, Julia + masters students): investigating sensitivity to CPV couplings through measurements of CP-odd observables- using private samples- update in P+P meeting planned soon.
- Is there anything missing we'd like to study further by the open symposium (e.g. BSM analyses)?

# Summary

- Many ideas and ongoing analyses, still lots of work to do!
  - Need to really streamline & focus efforts for the key deliverables by end of March
    - Make sure the analyses in advanced state are documented in time!
    - Converge on baseline lumi scenario soon,  $30\text{ab}^{-1}$  still applicable now that new baseline is the 84 TeV running scenario?
  - Help very welcome!