First WWdiff results from full simulation studies of WW and single-W production

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Disclaimer

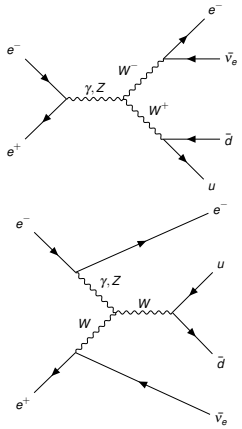
- This is not the complete talk as it will be shown in Paris, but mostly just a collection of ILD results that may or may not make it into the final slides
- Very much WIP

WWdiff?

- One of the ECFA Higgs/Top/EW focus topics
- “[...] [T]he main objective of this focus topic is to understand the full potential of e^+e^- colliders with respect to gauge boson interactions, using the full differential information from W-pair and single-W events to extract CP-even and CP-odd couplings, based on detailed detector simulation with assessments of systematic uncertainties, at all centre-of-mass energies”
- This work: produce (nD-)differential cross-sections
- Later: use them in SMEFT fits and to extract couplings

WWdiff

- Look at all 4-fermion final states that look like a W-pair
- hadronic, semi-leptonic (e, μ, τ), leptonic
- Nicely named in ILD mc-2020, `4f_ww_h`, `4f_ww_sl` etc.
- Special case: semi-leptonic $qq\nu$ final state: ‘single-W’ `4f_sw_sl` (also contains W-pairs)
- This work: focus on $qq\nu$



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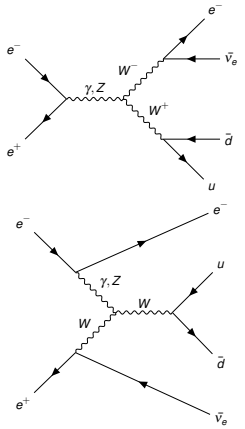


WW kinematics

- 8 degrees of freedom
- W^- production angles:
  - $\cos\theta_{W^-}$
  - ϕ_{W^-} (isotropic, irrelevant)
- $W^\pm$ decay angles:
  - In $W^\pm$ rest frames
  - $\cos\theta_{f/\bar{f}}$
  - $\phi_{f/\bar{f}}$
- $\left(M_{W^-} = M_{W^+} = M_{W,\mathrm{SM}}\right)$
- Hadronic decay angles need jet-charge, not further investigated here
- Focus on production and leptonic decay angles

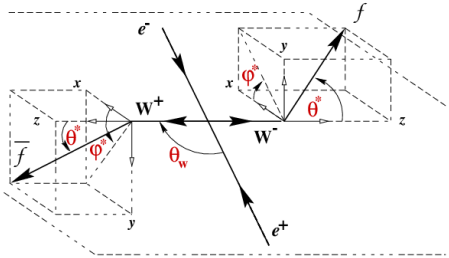


Figure 3.9: *Production and decay angles of W bosons.*

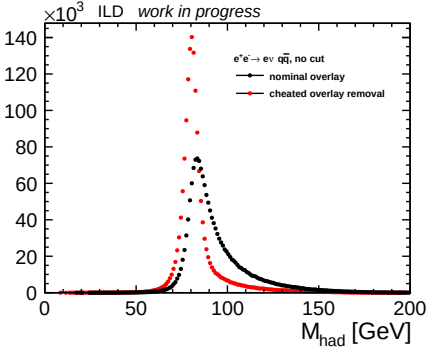
Used data

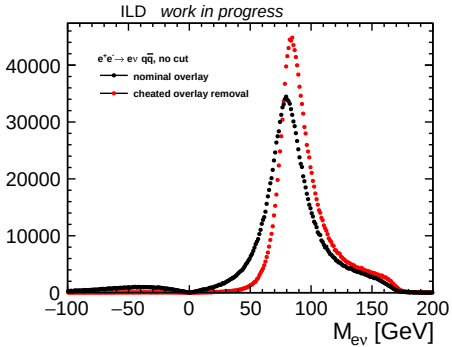
- A small subset of ILD mc-2020 `4f_sw_sl` DST files
- Converted to edm4hep format and processed with ‘bleeding-edge’ Key4hep tools, to also use this for other detectors later
- Only looking at unpolarized data for easier comparison to LEP and FCC-ee for now, but output of polarized differential cross-sections can be added easily
- Current focus: detector resolution, beam background effects
- Signal-only, cheated isolated electron id, cheated FSR+brems recovery, red plots: cheated overlay removal
- Two sets of results, one arbitrarily restricts M_{ev} to be compatible with M_W within 15 GeV

Reconstruction definitions

- Every event is treated like a W-pair event
- Reco electron is selected from truth and FSR+brems photons are added back to it
- Hadronic W is defined as the sum of all visible PFOs minus the electron and identified overlay
- Neutrino is defined as initial state minus the electron and minus the hadronic W
- Leptonic W is electron + neutrino
- N.B.: neither W needs to be an actual W

Results (no cut)





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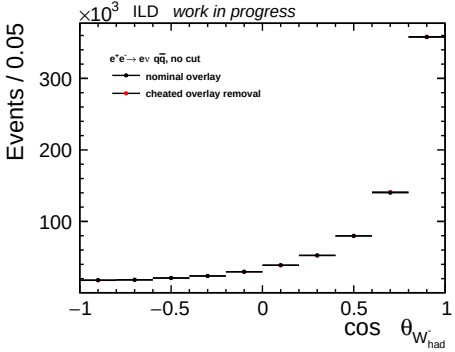

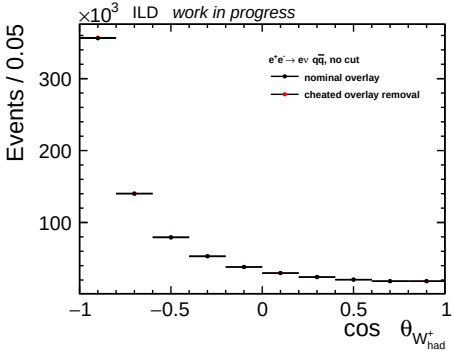

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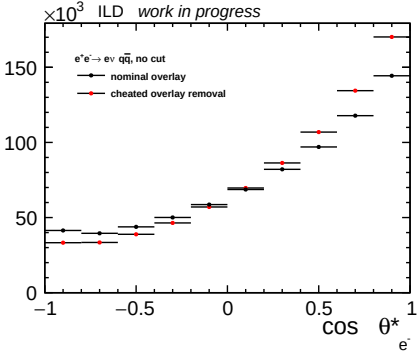

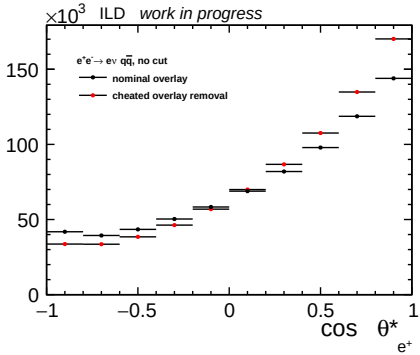

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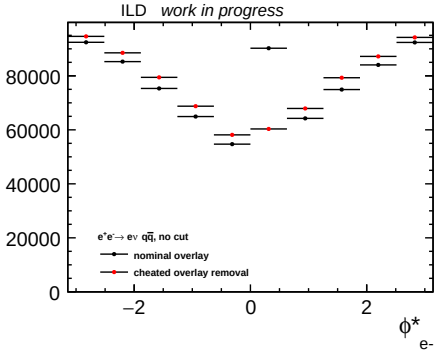
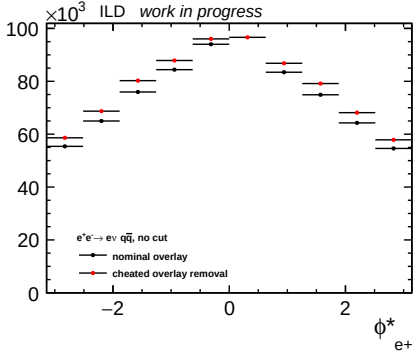
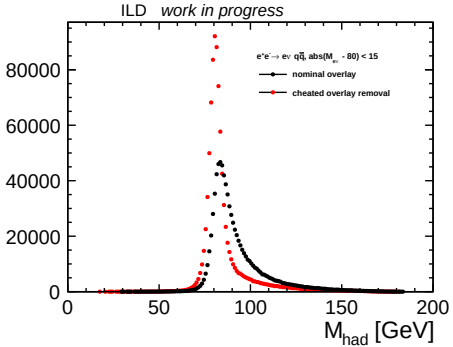
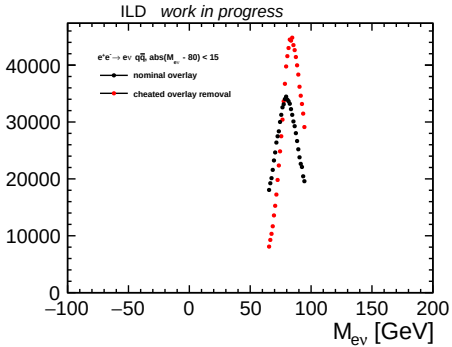




- Note the degradation in the 0th bin

Results (with cut)





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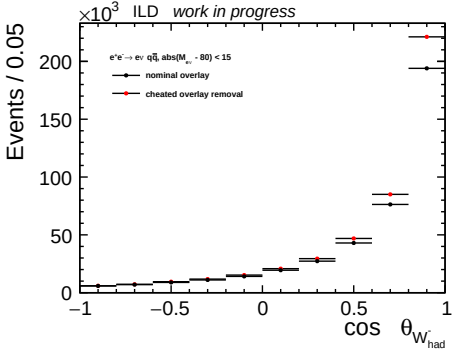

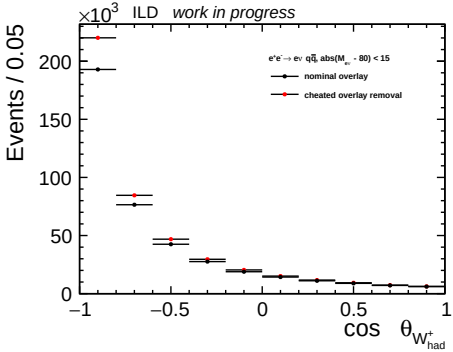

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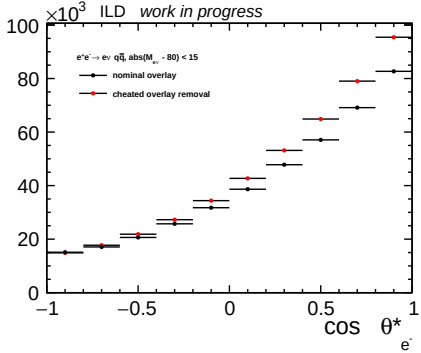

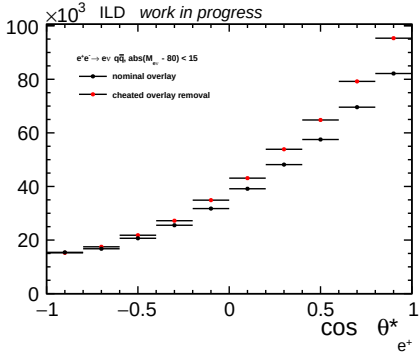

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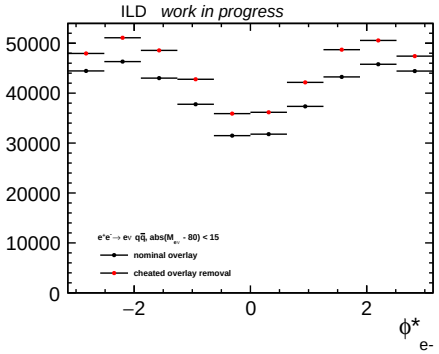
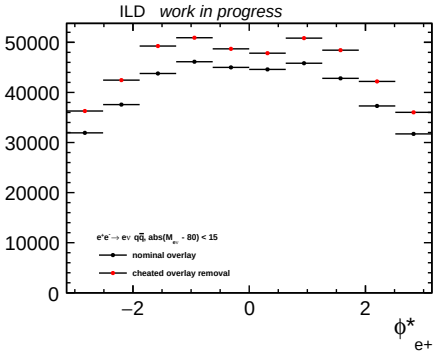
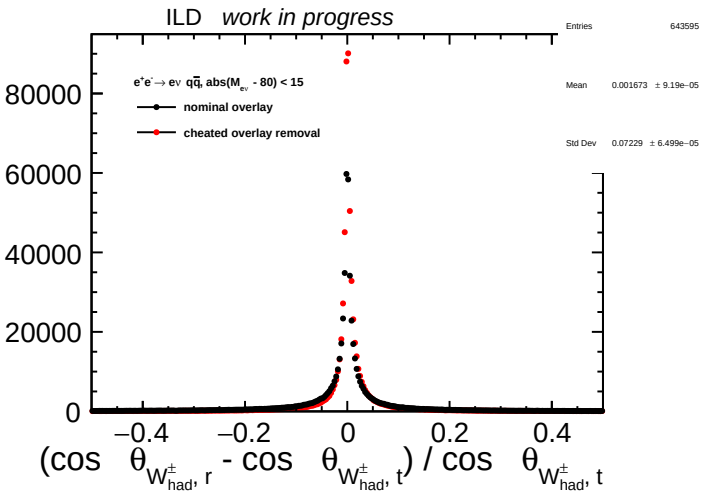




- Degradation in 0th bin mostly disappears

Results (with cut)

- Attempt to plot resolutions for the angles



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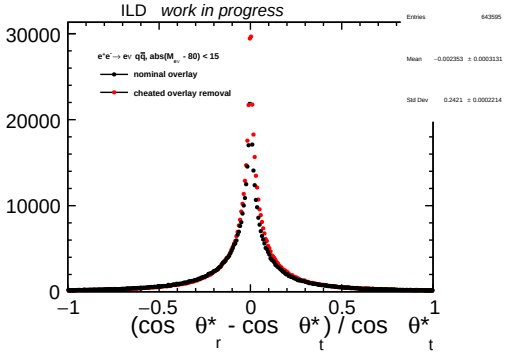

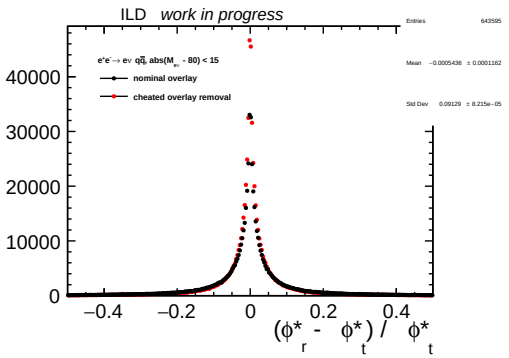

Outlook and summary

- In preparation: overlay removal and electron selection/reconstruction without cheating, investigation of neutrino reconstruction improvements, kinematic fit (also of ISR)
- Planned: full statistics and event selection from full SM background (pending mini-DST production)
- Comparisons with other detector concepts (if they have working reconstruction)

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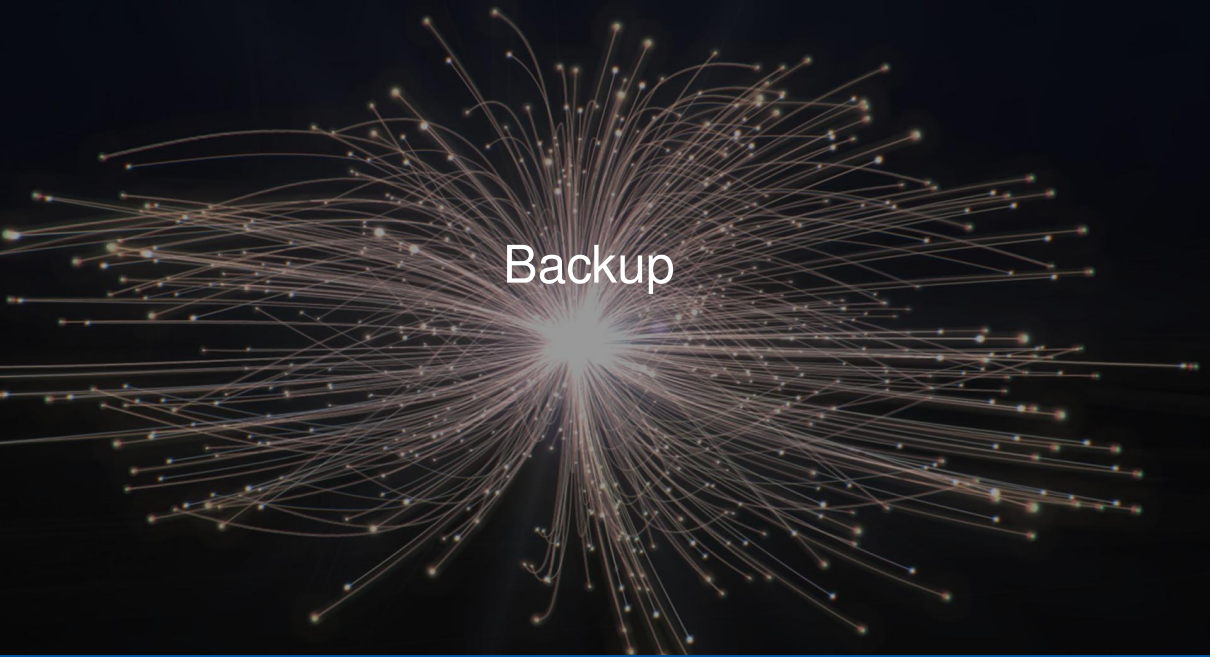
Backup