CAFAna E_ν true binning test

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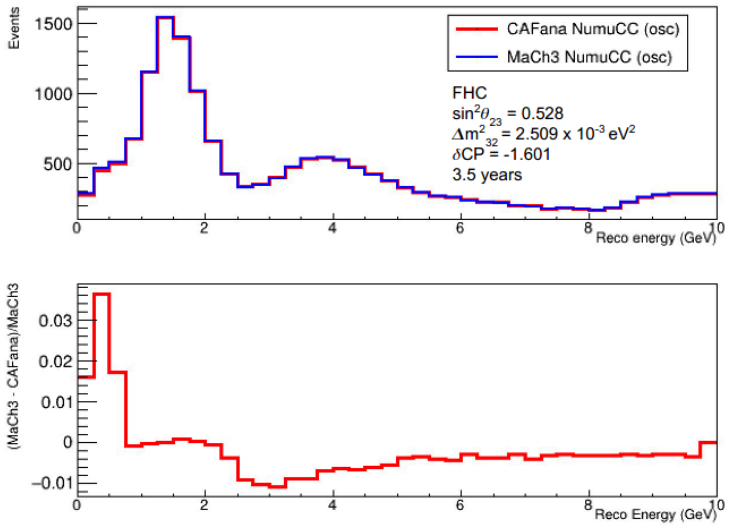
Motivation

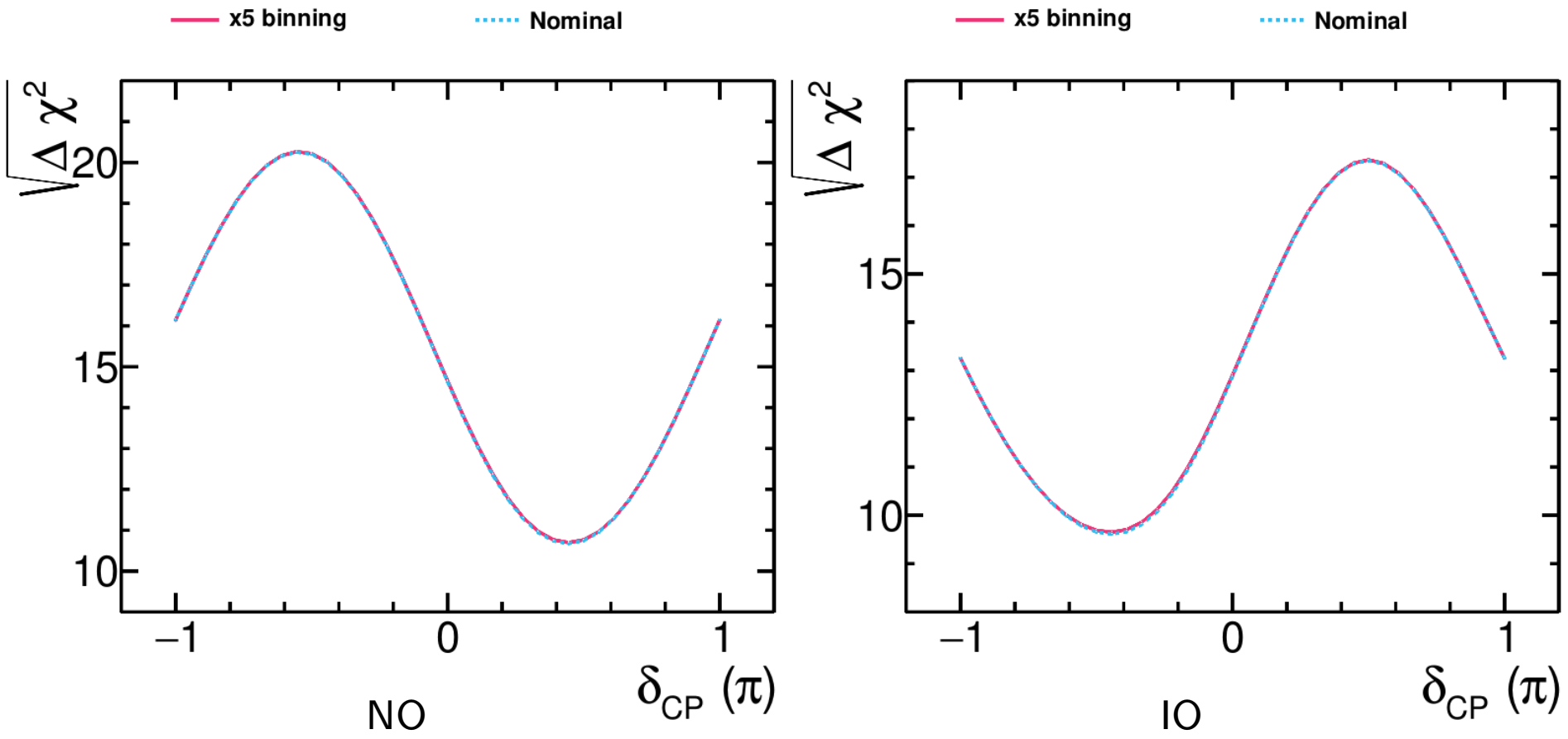


- MaCh3 found differences with CAFAna event rates, eventually narrowed down to the binned vs unbinned oscillation probability treatment
- This led to a request in the low sensitivity paper ARC review to check the impact finer binning has on the CAFAna results

CAFAna E_ν binning

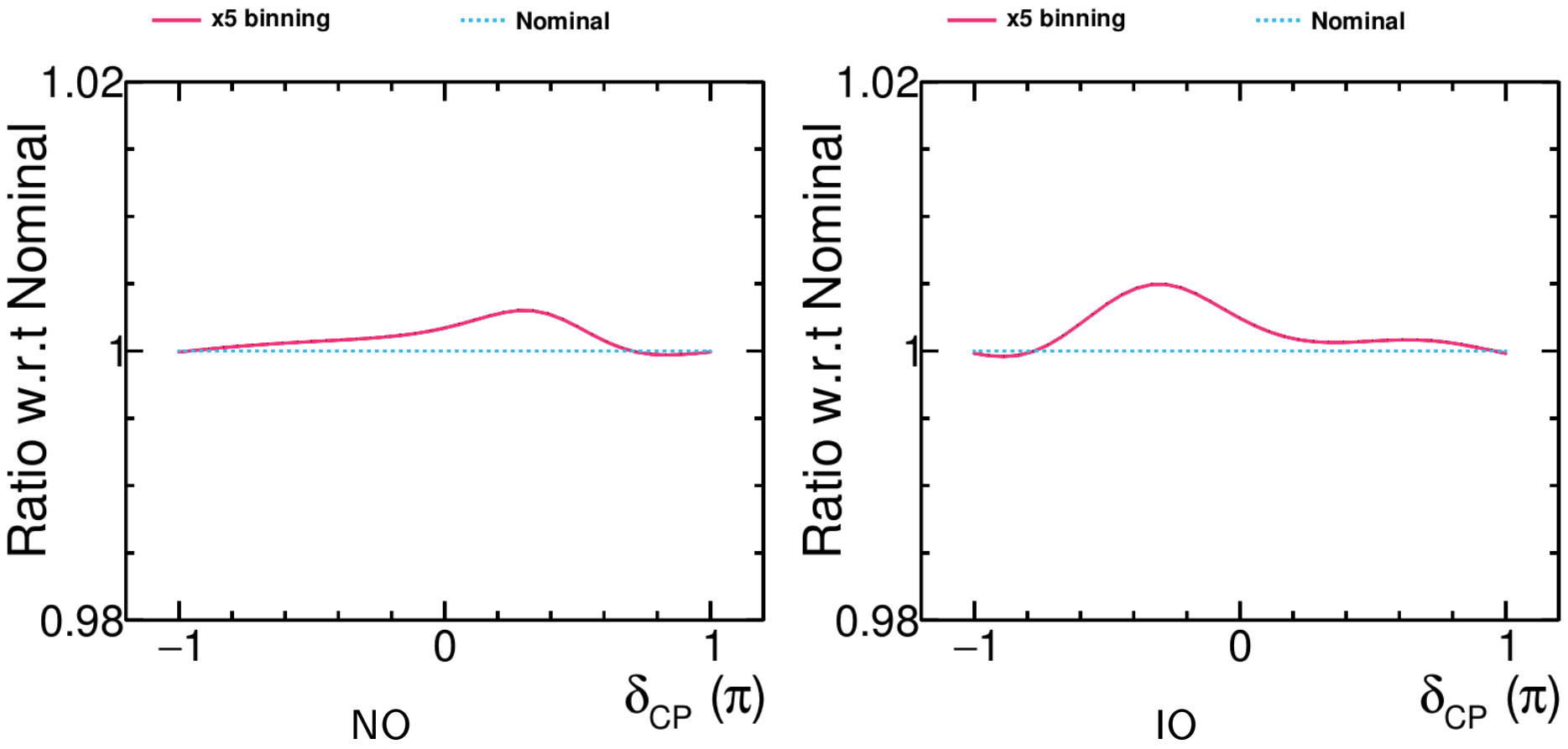
- By default uses 100 bins between 0.5 and 120 GeV, with bin edges $E_i \sim 1/i$ to produce bins with $\sim 1/E^2$ width
- For this test, I simply divided each existing bin into 5 equal width bins. Limited to 5x binning because of RAM usage (and the 16 GB limit on FermiGrid).
- Nominal binning: 0, 0.5, 0.5051, 0.5103, 0.5156, 0.5211, 0.5266, 0.5323, 0.538, 0.544, 0.55, 0.5562, 0.5625, 0.569, 0.5756, 0.5824, 0.5893, 0.5964, 0.6037, 0.6111, 0.6188, 0.6266, 0.6346, 0.6429, 0.6513, 0.66, 0.6689, 0.6781, 0.6875, 0.6972, 0.7071, 0.7174, 0.7279, 0.7388, 0.75, 0.7615, 0.7734, 0.7857, 0.7984, 0.8115, 0.825, 0.839, 0.8534, 0.8684, 0.8839, 0.9, 0.9167, 0.934, 0.9519, 0.9706, 0.99, 1.01, 1.031, 1.053, 1.076, 1.1, 1.125, 1.151, 1.179, 1.207, 1.238, 1.269, 1.303, 1.338, 1.375, 1.414, 1.456, 1.5, 1.547, 1.597, 1.65, 1.707, 1.768, 1.833, 1.904, 1.98, 2.062, 2.152, 2.25, 2.357, 2.475, 2.605, 2.75, 2.912, 3.094, 3.3, 3.536, 3.808, 4.125, 4.5, 4.95, 5.5, 6.188, 7.071, 8.25, 9.9, 12.38, 16.5, 24.75, 49.5, 120

MO sensitivities



All plots are ND+FD 334 kt-MW-yr with equal FHC and RHC; use NuFit 4.0 true parameter values; include all systematic and oscillation parameters; have a penalty term on θ_{13}.

MO sensitivities



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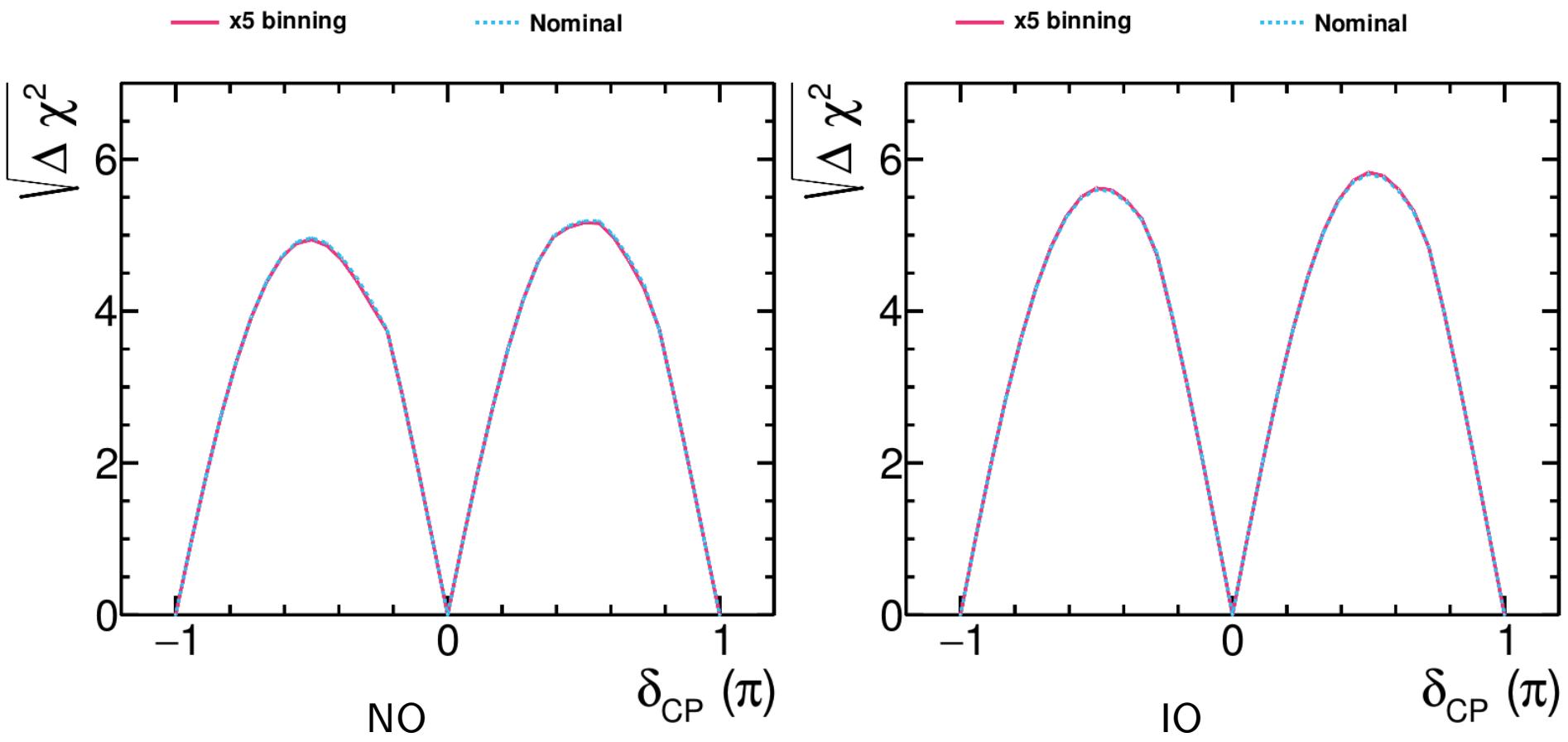
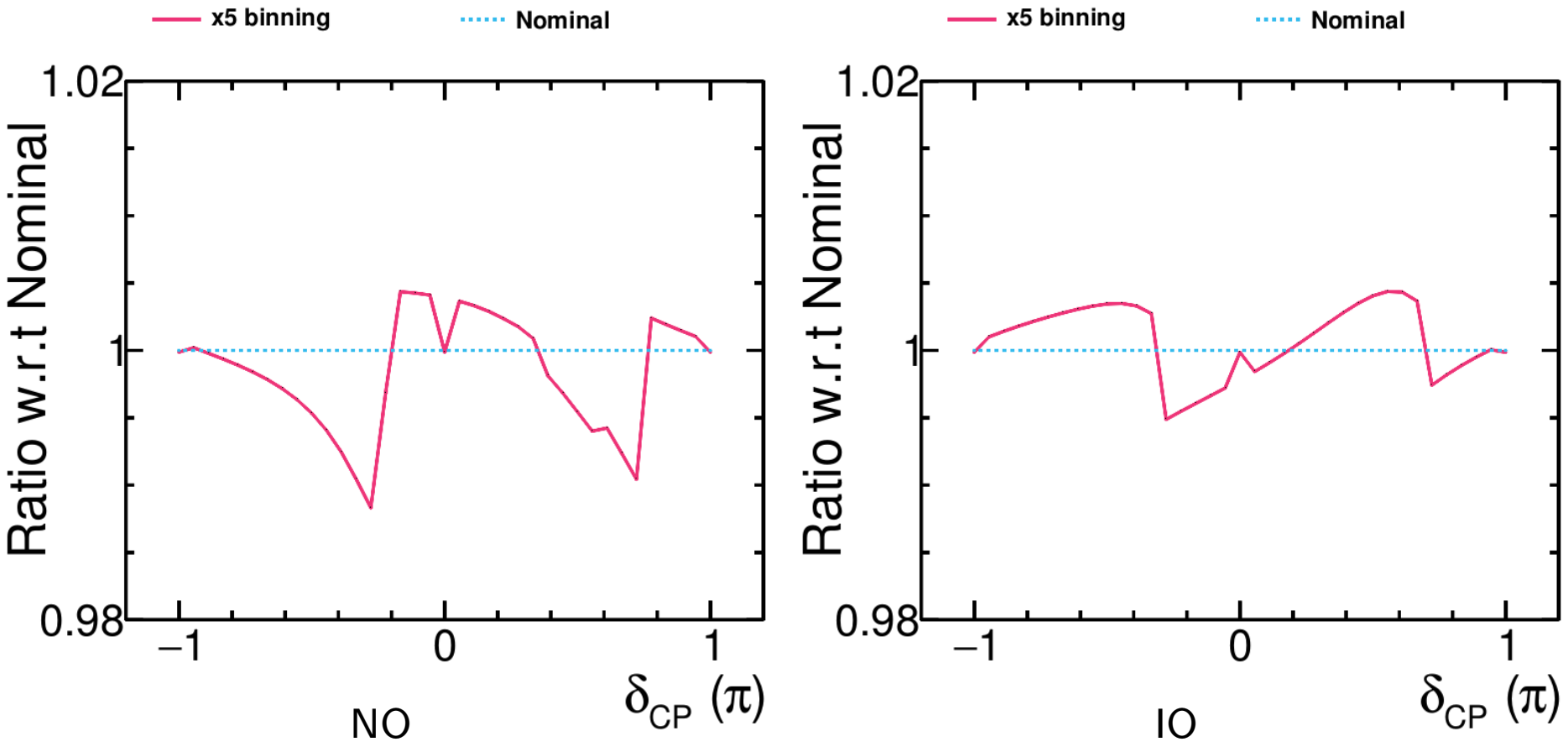
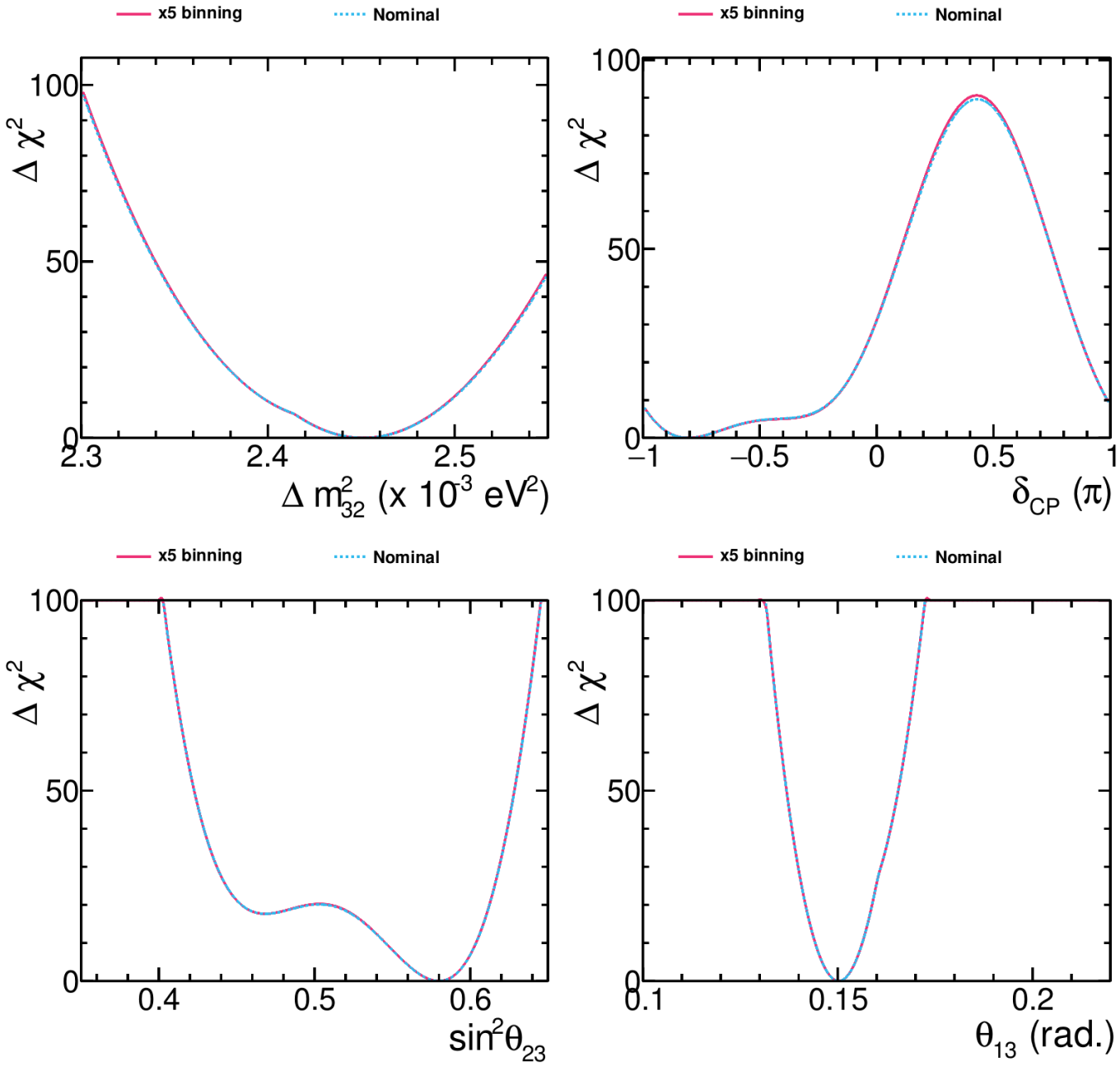
CPV sensitivities



CPV sensitivities



1D Asimovs (NO only)



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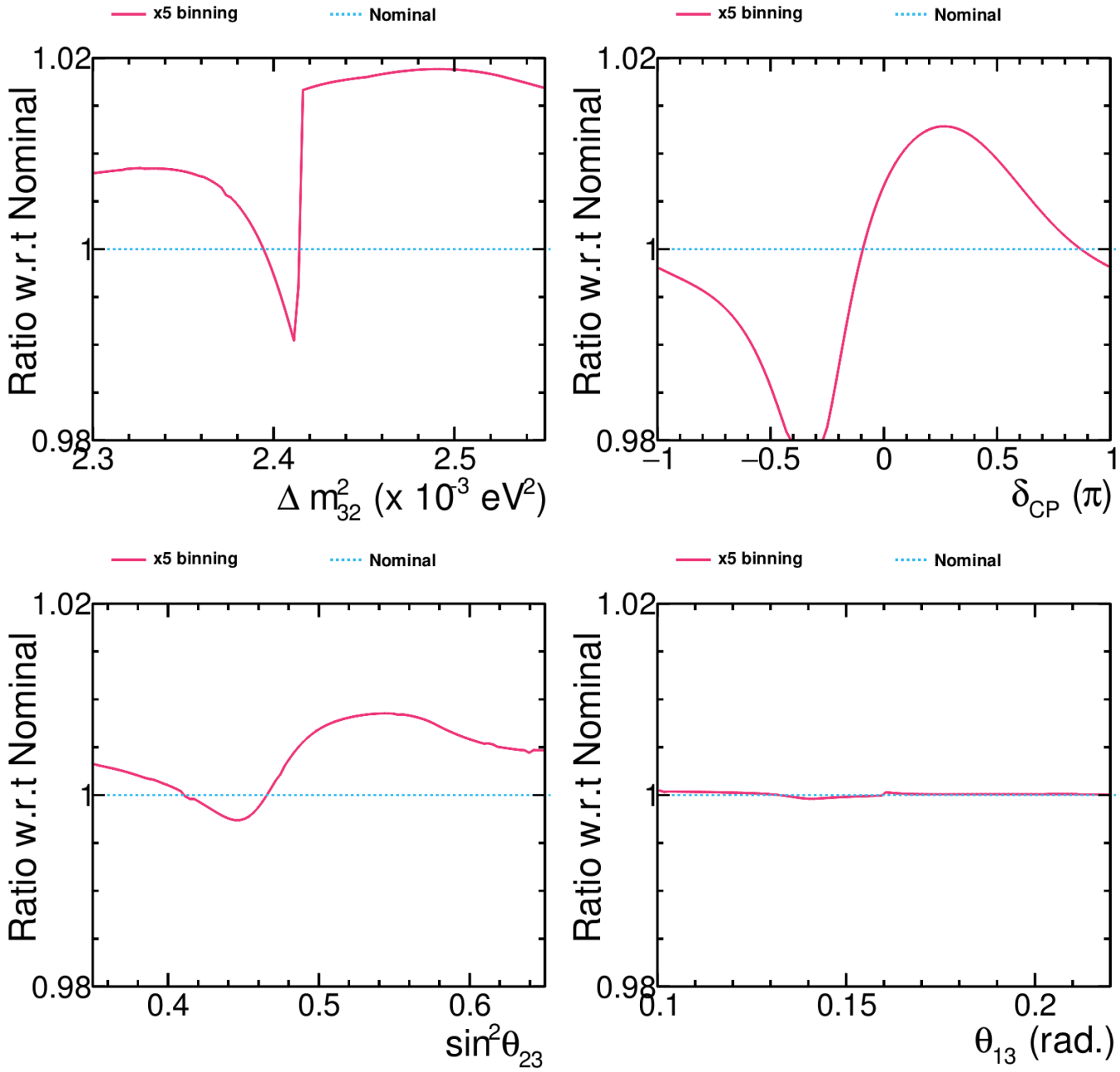

Conclusions

- Few percent discrepancies at 334 kt-MW-yr. Largest of interest for the low exposure paper, so reviewer is satisfied
- But this is something we might need to bear in mind for the future. For higher exposures the discrepancies will increase.
- Might also be an issue for other studies, so probably needs validation for every application
- Finer binning possible in CAFAna, but RAM usage is very large. Maybe needs more careful optimization in future