μBooNE Sensitivity Studies

David Caratelli

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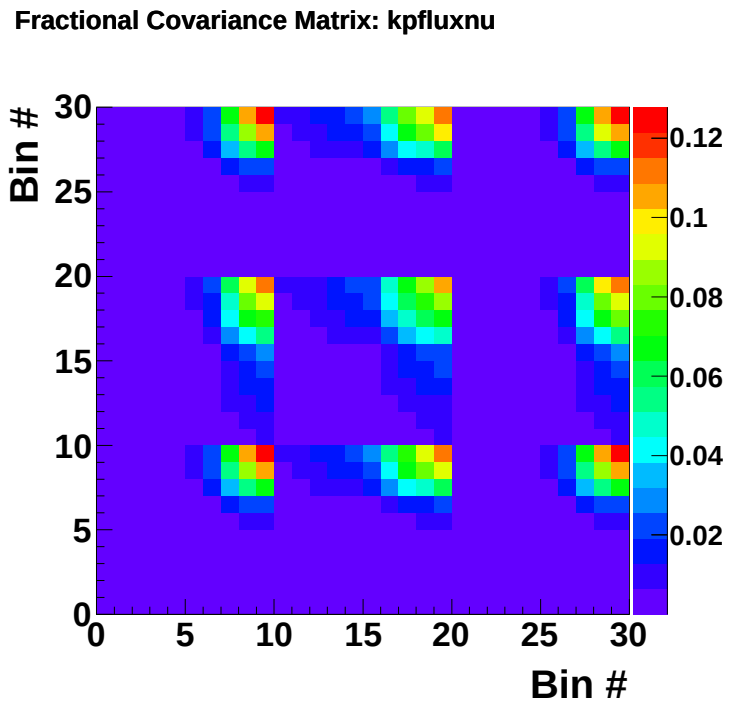
Sources for sensitivity study

Code used for sensitivity study taken from work by Georgia Karagiorgi and Corey Adams.
Source: /ubooneoffline/trunk/NewSensitivityCode
Wiki: https://cdcvs.fnal.gov/redmine/projects/ubooneoffline/wiki
These studies take into account efficiencies obtained from HandScanning. DocDB 2523

How is the νBooNE sensitivity calculated?

- N-tuples with simulated events (6.6×10^{20} POT) are used to perform a χ^2 analysis on Δm^2 - $\sin^2\theta_{\mu e}$ parameter space.
- Uncertainties for χ^2 are a combination of various systematics + statistics.
- Systematics taken into accont:
  xsec ($\pm$15% CC events, $\pm$20% NC).
  Fluxes in ν-mode: pipflux, kpfluxnu, k0flux
  Efficiencies: nueccnumuccmid, nueccncmid, nuecceff

What do the systematics look like?



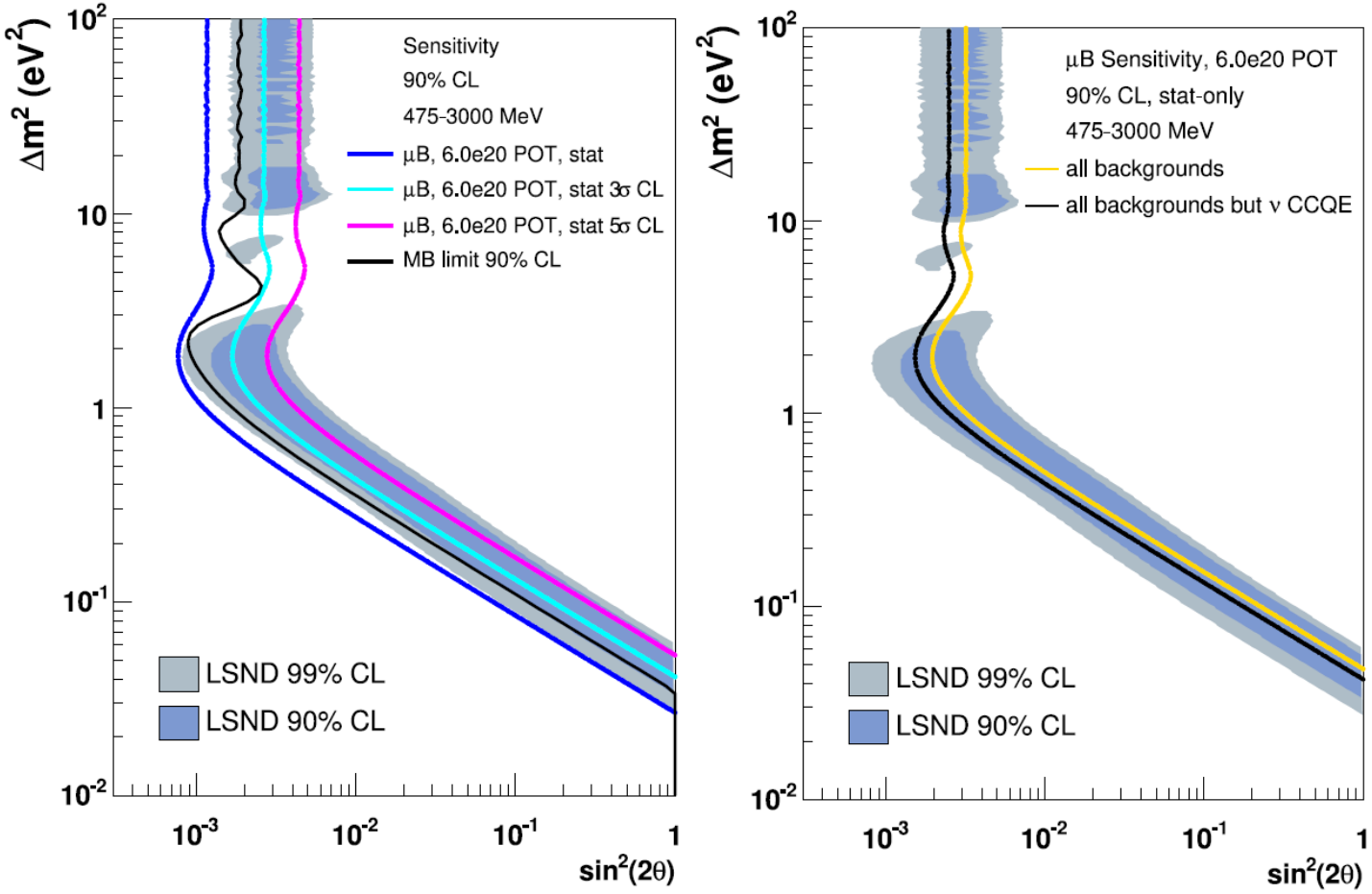
M is the covariance matrix holding uncertainty info

$$M^{ij} = M^{ij}_{\text{frac}} \times \text{events}_i \times \text{events}_j + \delta_{ij}\text{events}_i \tag{1}$$

$$\chi^2 = \sum_i^N \sum_j^N (T_i - O_i) M^{-1}_{ij} (T_j - O_j) \tag{2}$$

Sensitivities scaled miniBooNE

Taken from Georgia's thesis.



Left: ν-mode. Right: $\bar{\nu}$-mode.

Efficiency from Hand Scans - CC ν_e

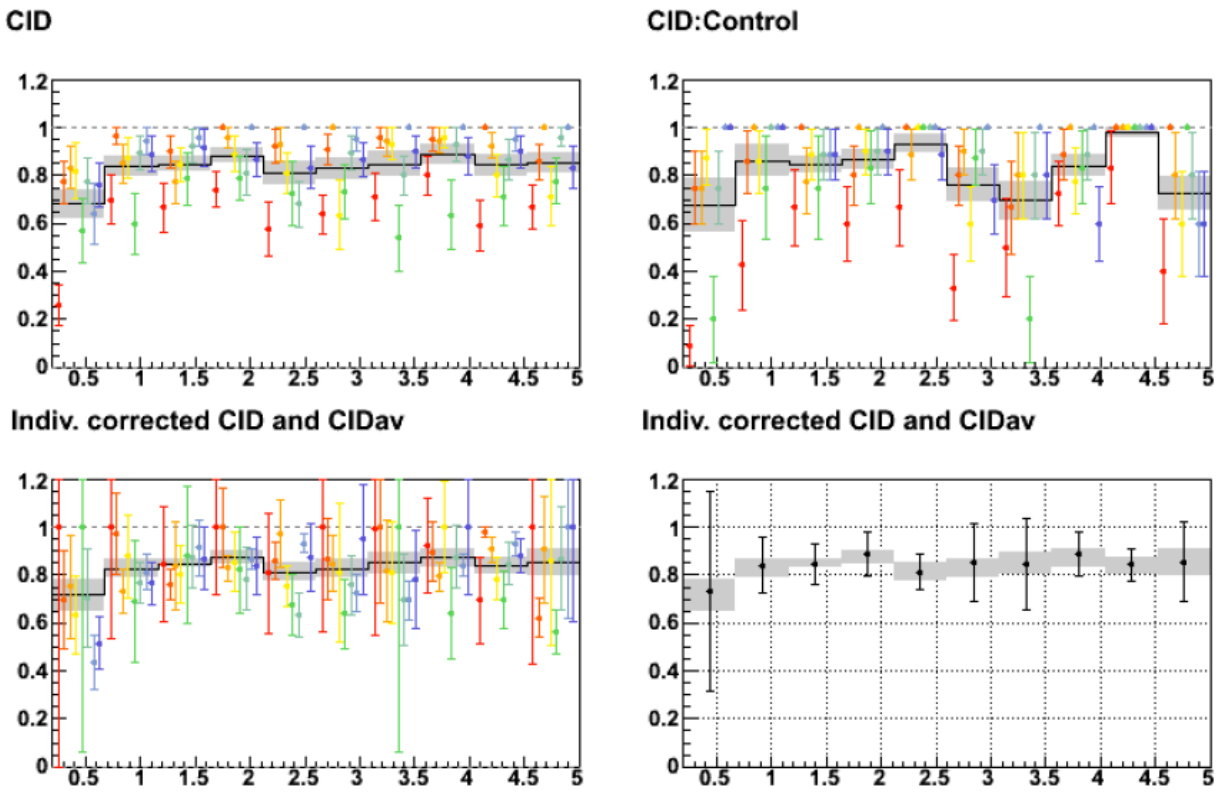


Figure 19: EFFICIENCY GROUP: Top left: $CID_i^{\nu_e\ CC}(E)$ and average over all scanners. Top right: $CID_{control\ i}^{\nu_e\ CC}(E)$ and average over all scanners. Bottom left: Individually corrected $f_i^{\nu_e\ CC}(E)CID_i^{\nu_e\ CC}(E)$, and average over all scanners. Bottom right: Average of individually-corrected $f_i^{\nu_e\ CC}(E)CID_i^{\nu_e\ CC}(E)$ over all scanners (from the bottom left panel), and combined efficiency $CID_{combined}^{\nu_e\ CC}(E)$ in black points with black line error bars. The distributions are given as functions of true neutrino energy.

Efficiency from Hand Scans - MID ν_e CC $\rightarrow$ ν_e NC

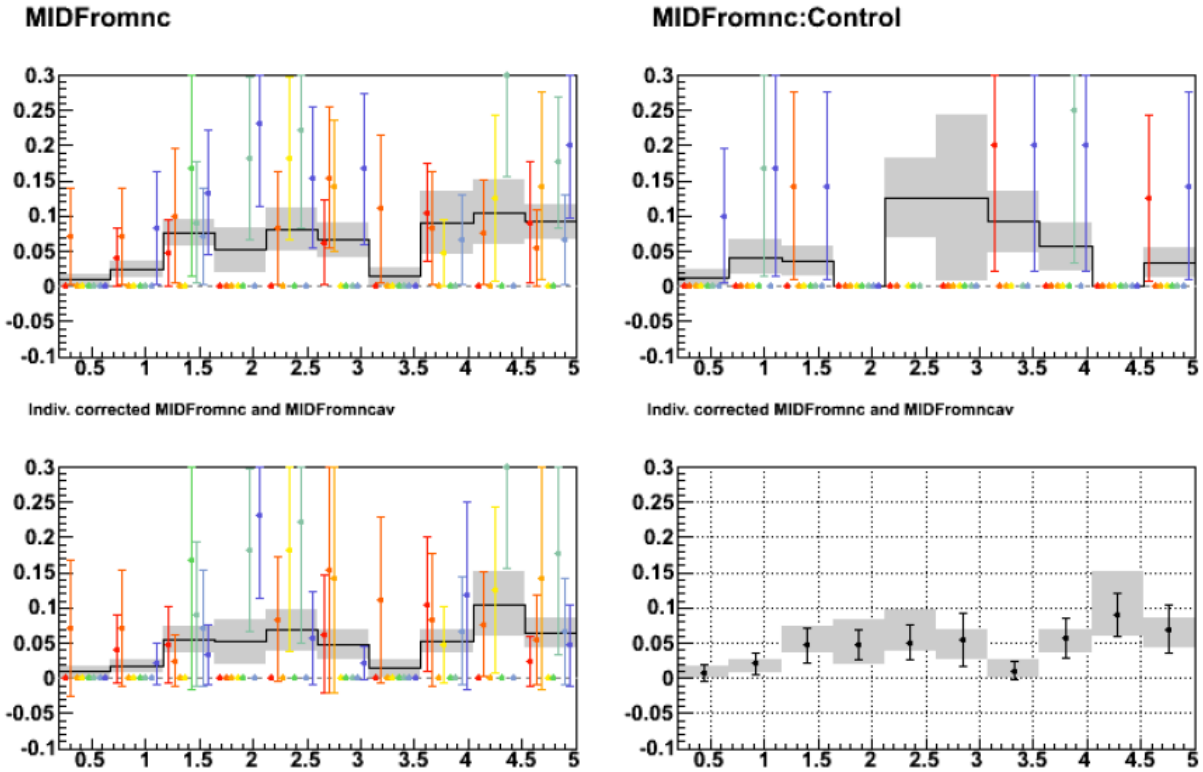


Figure 23: EFFICIENCY GROUP: Top left: $MID_i^{\nu_e\ CC,NC}(E)$ and average over all scanners. Top right: $MID_{control\ i}^{\nu_e\ CC,NC}(E)$ and average over all scanners. Bottom left: Individually corrected $f_i^{\nu_e\ CC,NC}(E)MID_i^{\nu_e\ CC,NC}(E)$, and average over all scanners. Bottom right: Average of individually-corrected $f_i^{\nu_e\ CC,NC}(E)MID_i^{\nu_e\ CC,NC}(E)$ over all scanners (from the bottom left panel), and combined efficiency $MID_{combined}^{\nu_e\ CC,NC}(E)$ in black points with black line error bars. The distributions are given as functions of true neutrino energy.

Efficiency from Hand Scans - MID ν_e CC $\rightarrow$ ν_μ CC

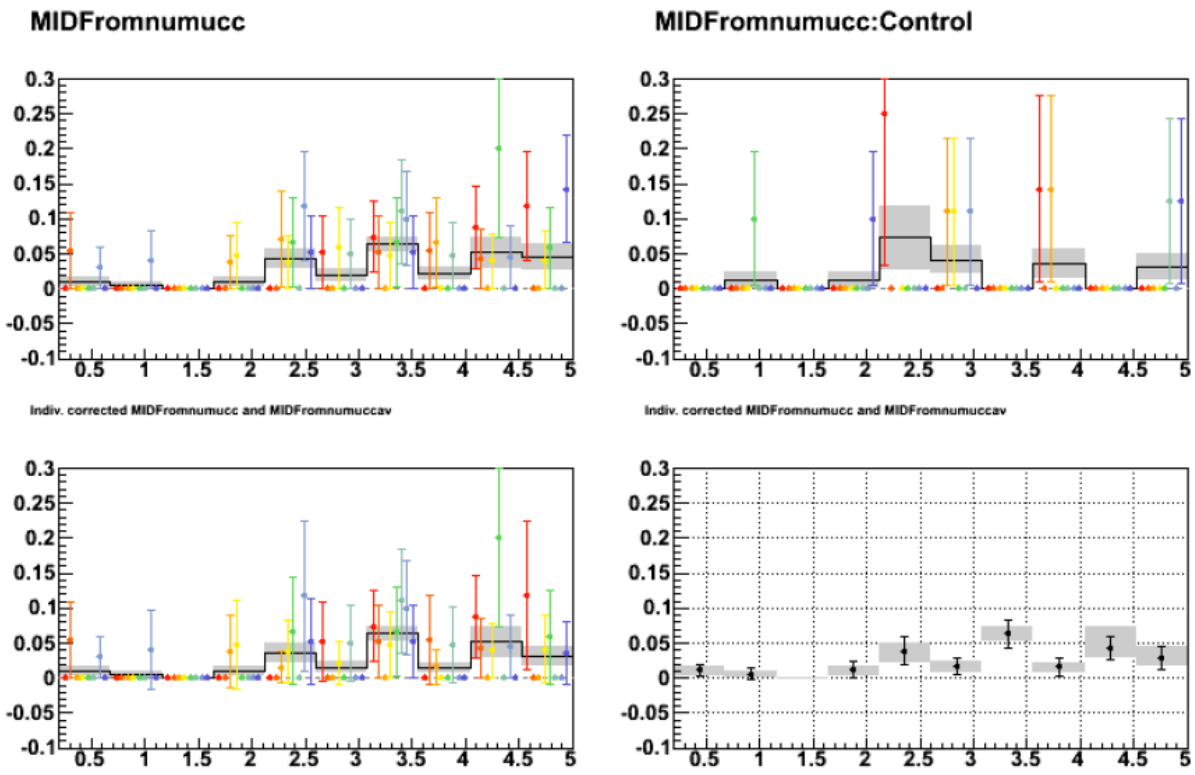


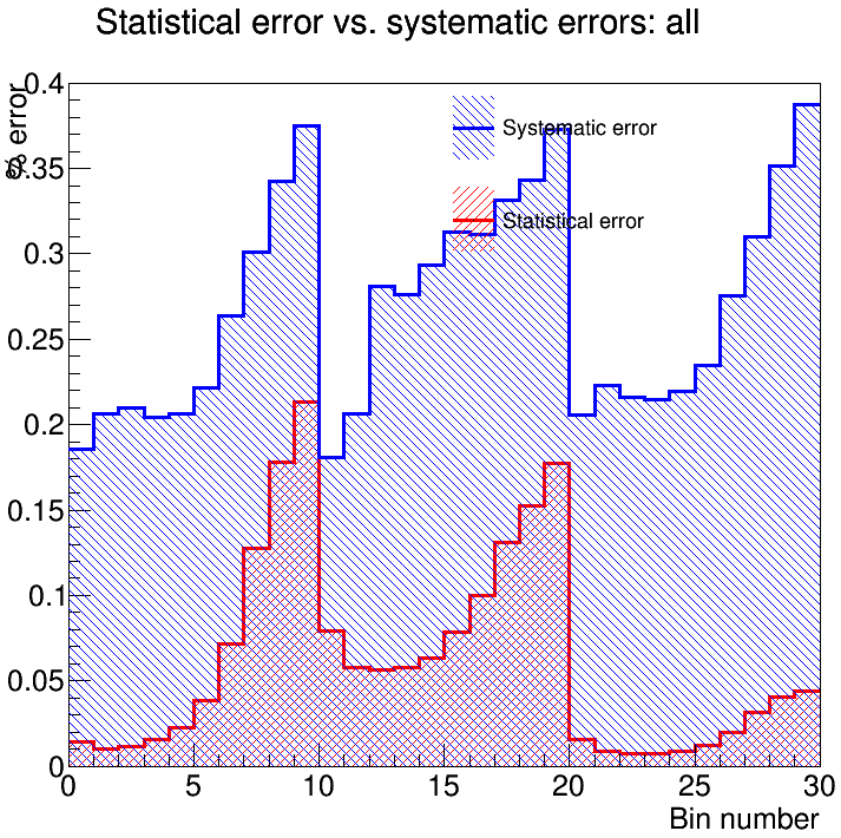
Figure 22: EFFICIENCY GROUP: Top left: $MID_i^{\nu_e\ CC,\nu_\mu\ CC}(E)$ and average over all scanners. Top right: $MID_{control\ i}^{\nu_e\ CC,\nu_\mu\ CC}(E)$ and average over all scanners. Bottom left: Individually corrected $f_i^{\nu_e\ CC,\nu_\mu\ CC}(E)MID_i^{\nu_e\ CC,\nu_\mu\ CC}(E)$, and average over all scanners. Bottom right: Average of individually-corrected $f_i^{\nu_e\ CC,\nu_\mu\ CC}(E)MID_i^{\nu_e\ CC,\nu_\mu\ CC}(E)$ over all scanners (from the bottom left panel), and combined efficiency $MID_{combined}^{\nu_e\ CC,\nu_\mu\ CC}(E)$ in black points with black line error bars. The distributions are given as functions of true neutrino energy.

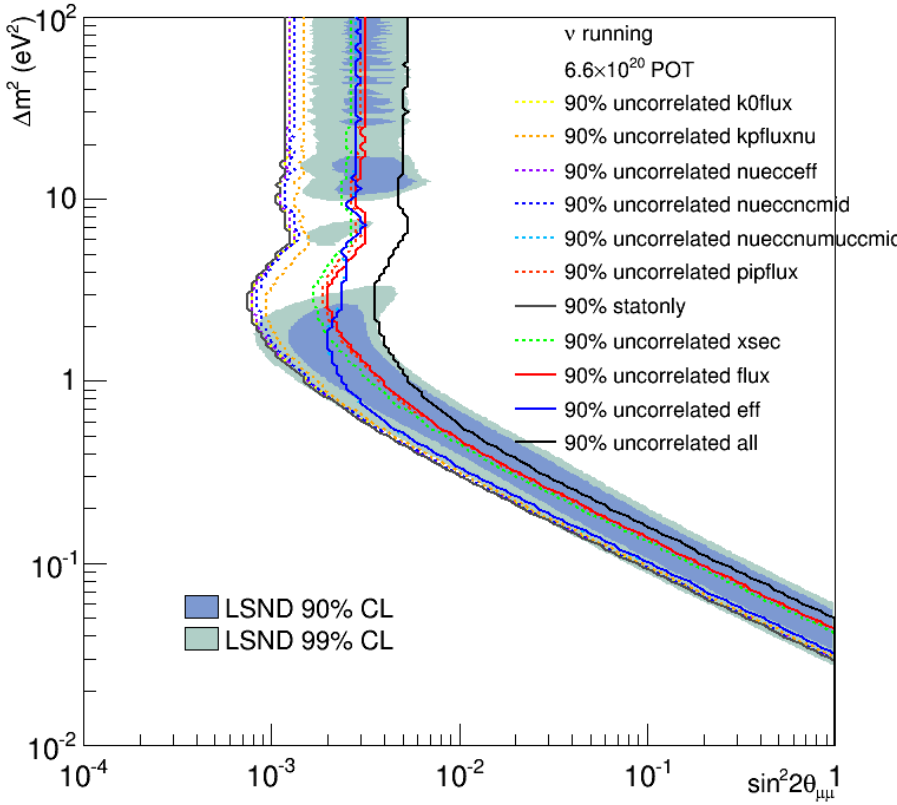
What we did

Looked at how the systematics in the covariance matrix affect μBooNE's sensitivity.

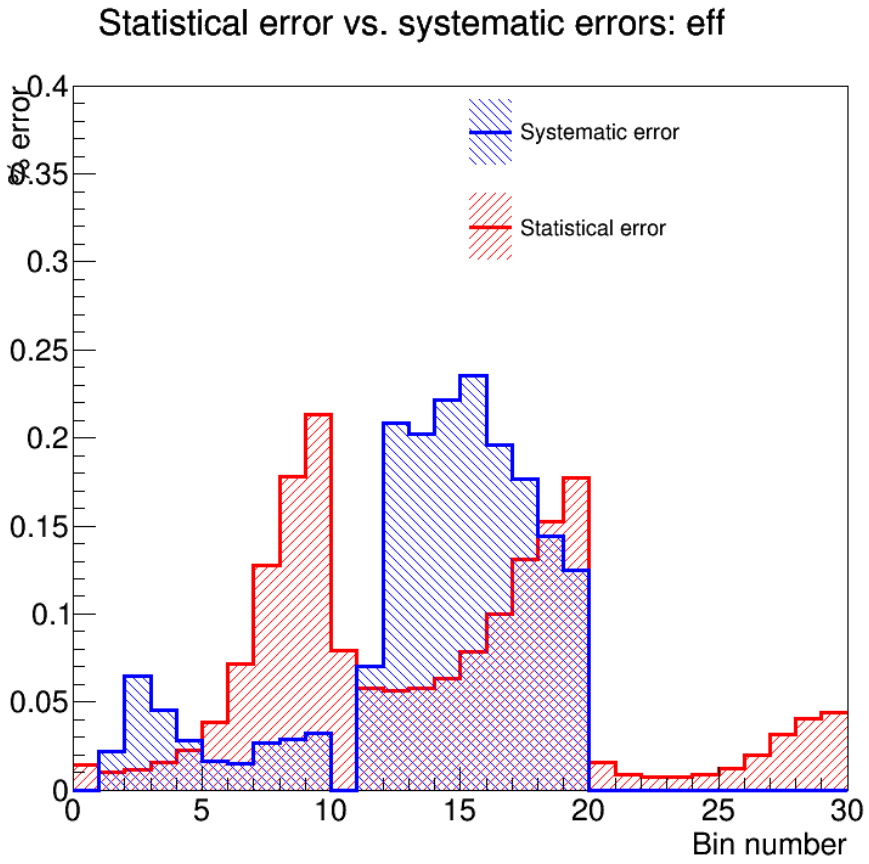
- Compare the % uncertainties coming from statistics and those coming from diagonal elements of the covariance matrix.
- For each source of systematics, use the full covariance matrix, only diagonal terms (no bin-bin correlation) and only information coming from oscillated and background ν_es, neglecting info from ν_μs.

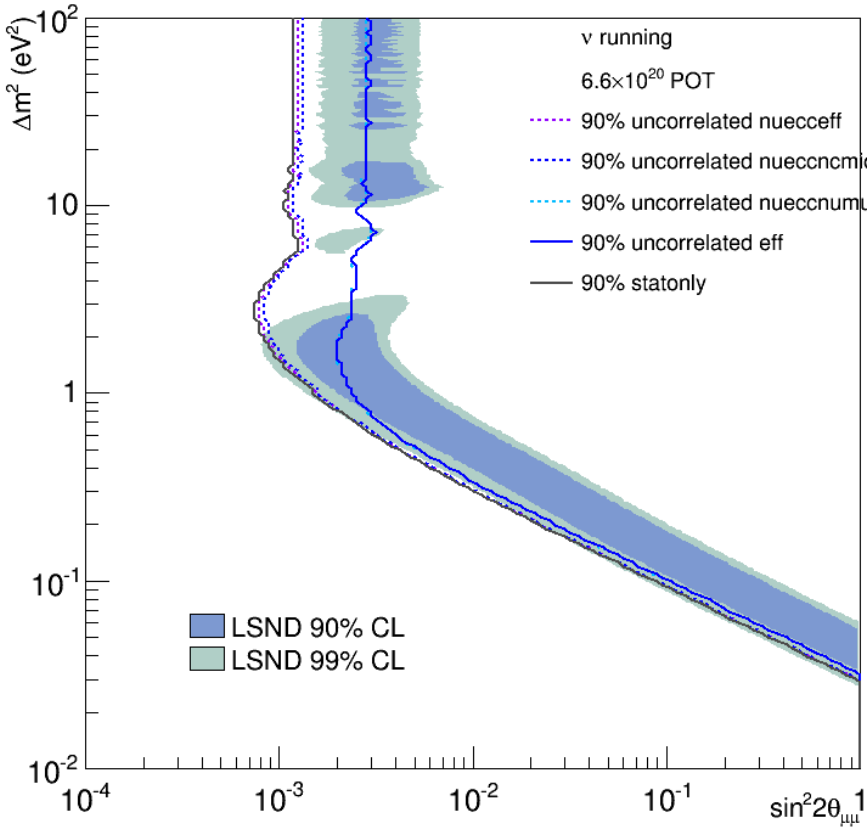
All systematics



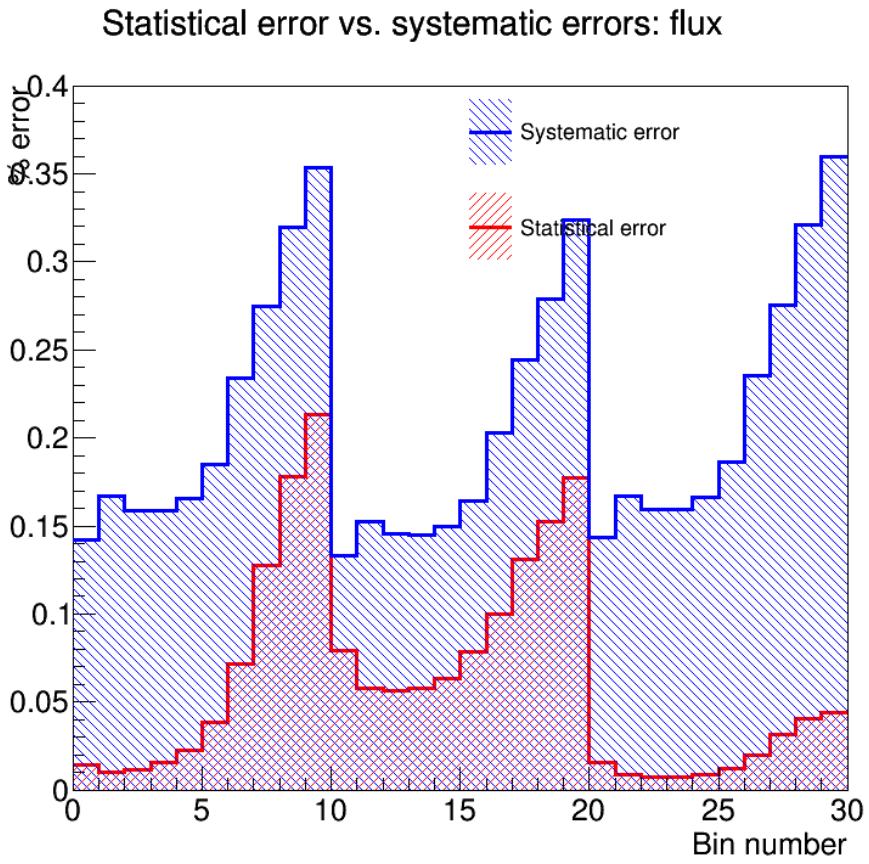


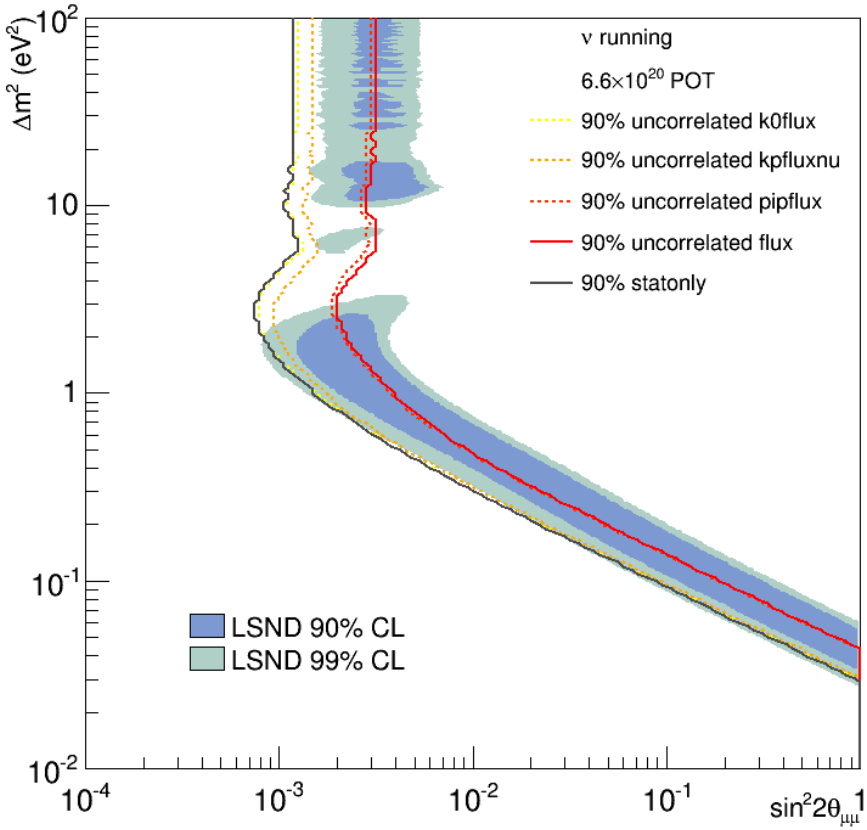
Efficiency systematics



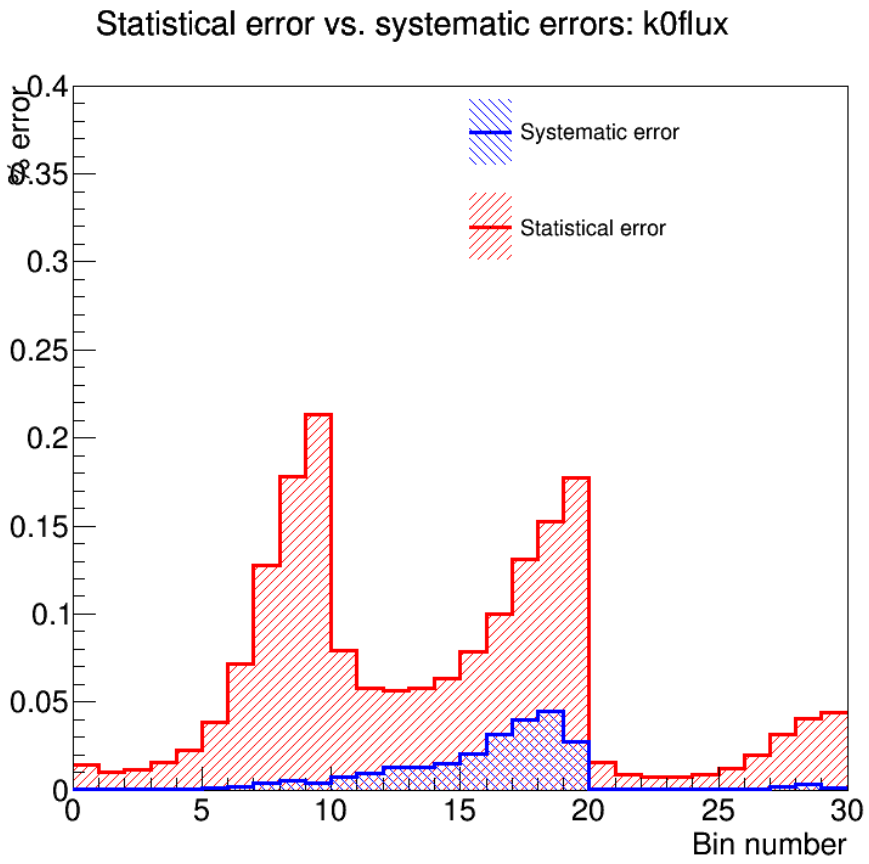


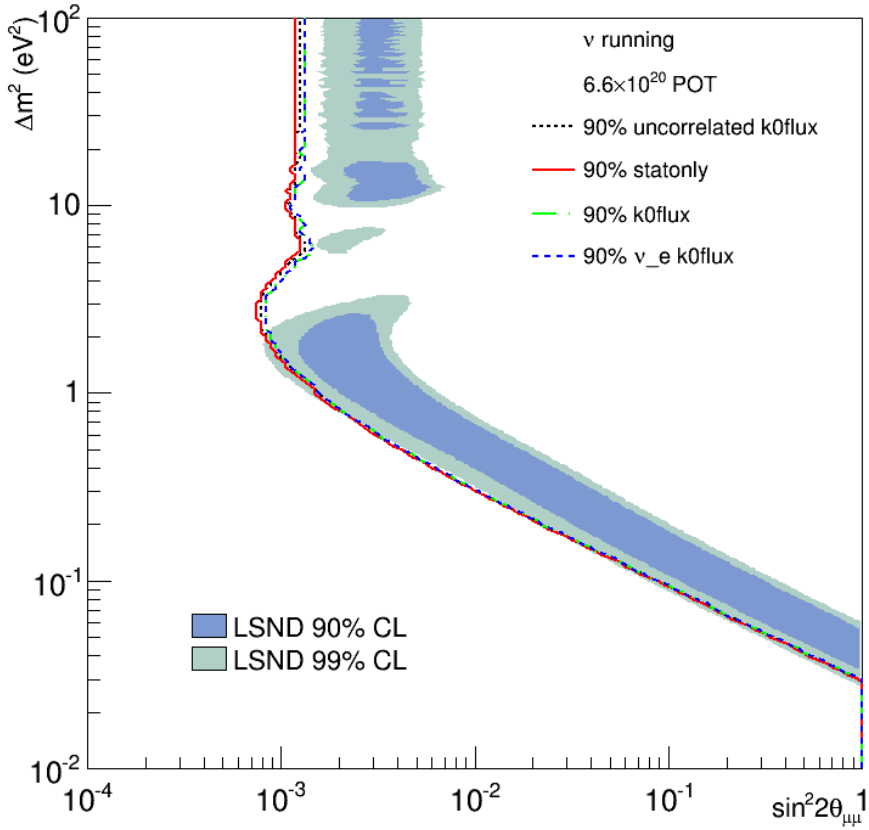
Flux systematics



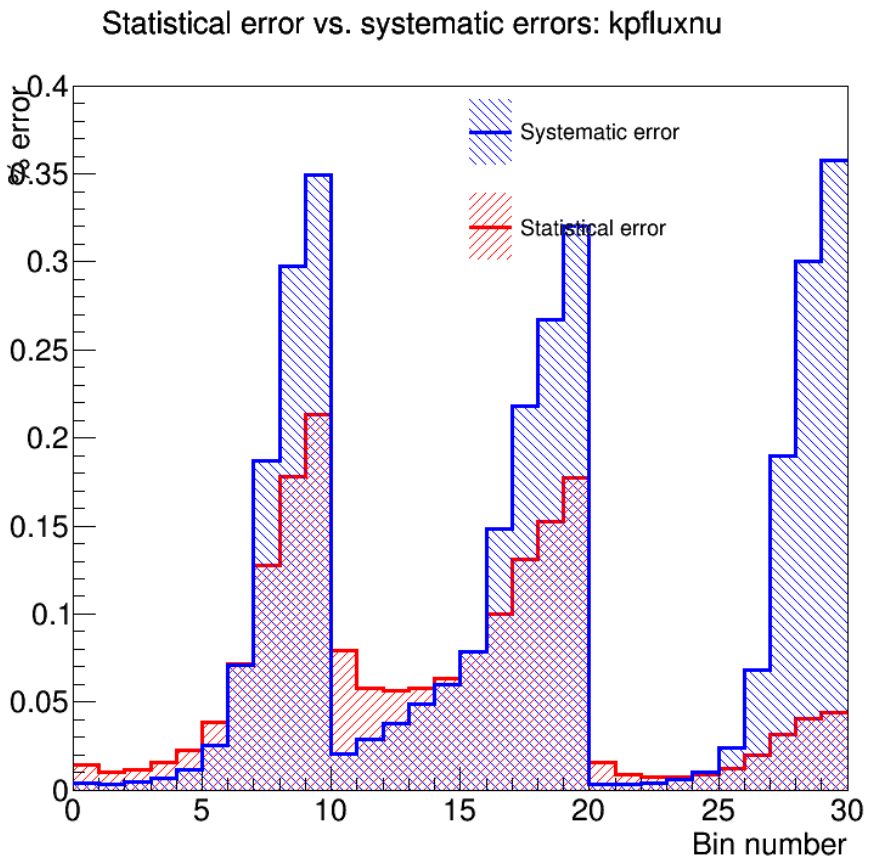


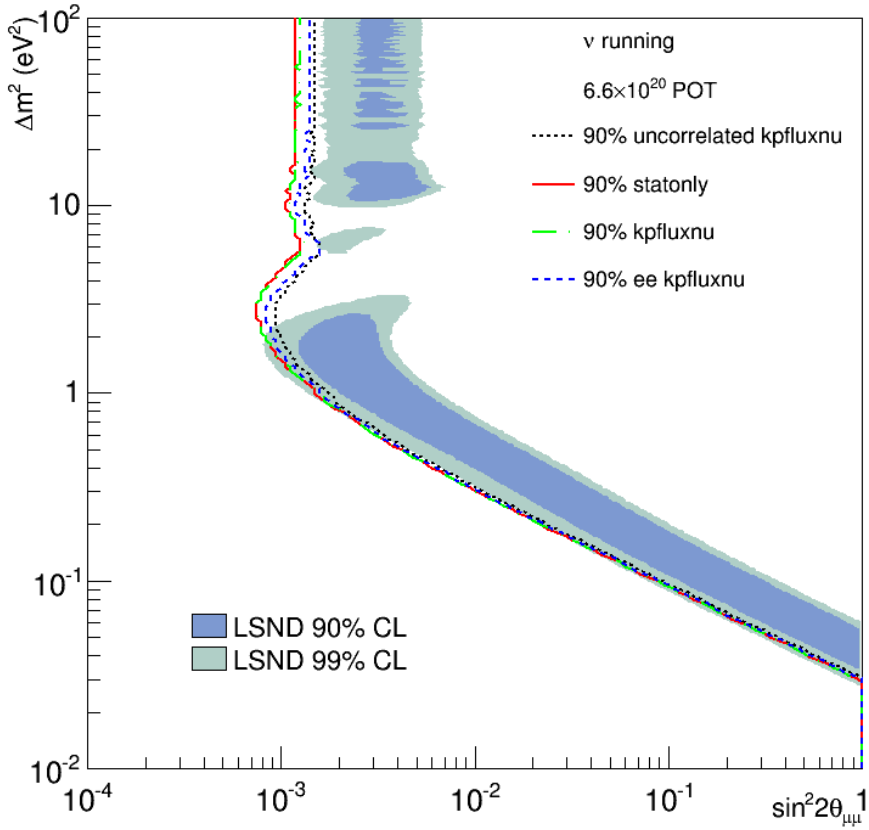
K^0 flux systematics



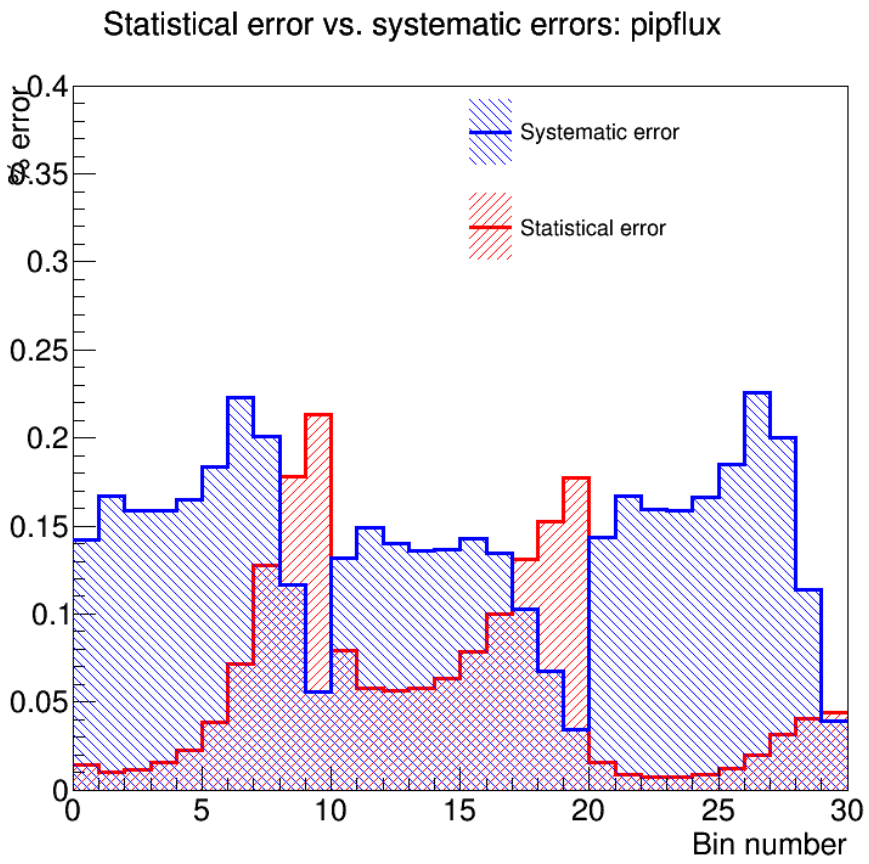


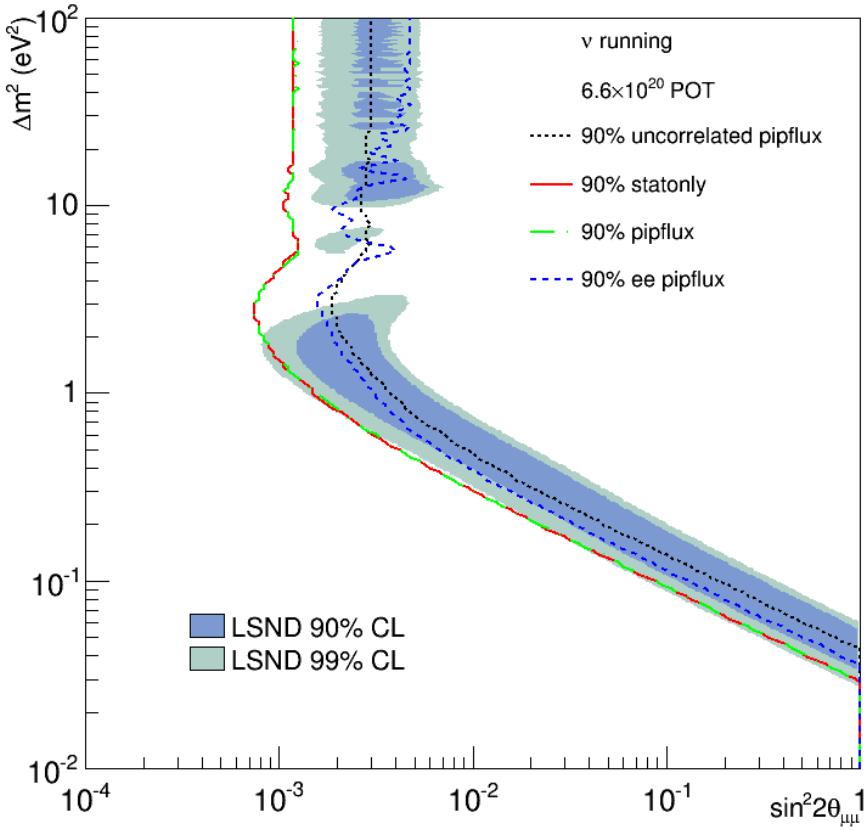
K^+ flux ν systematics



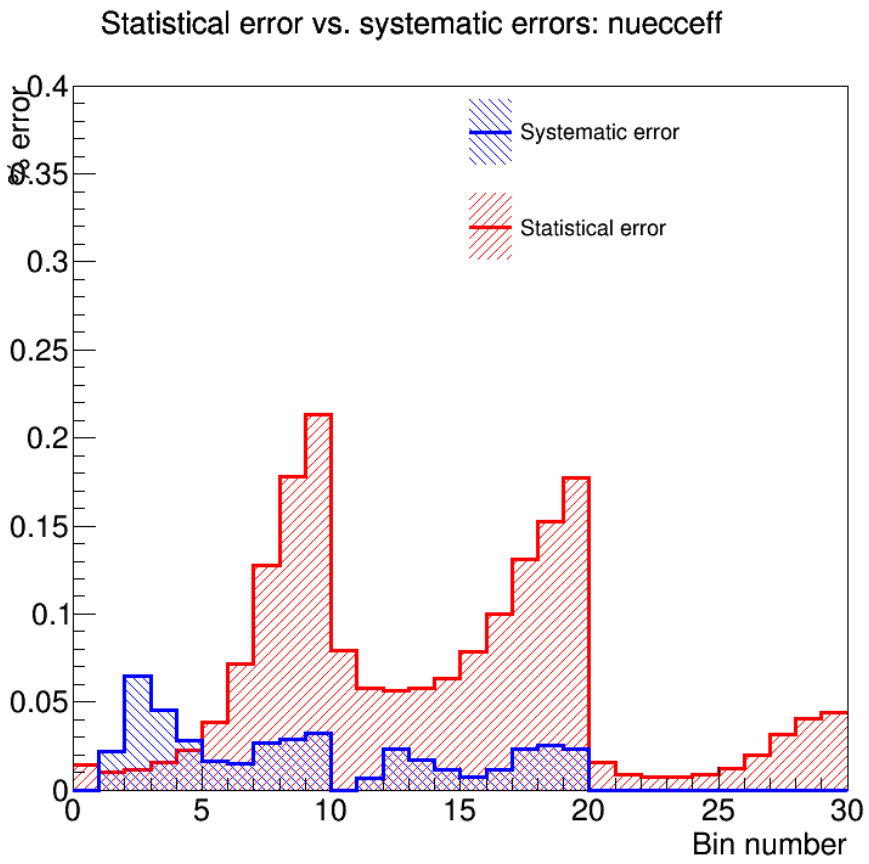


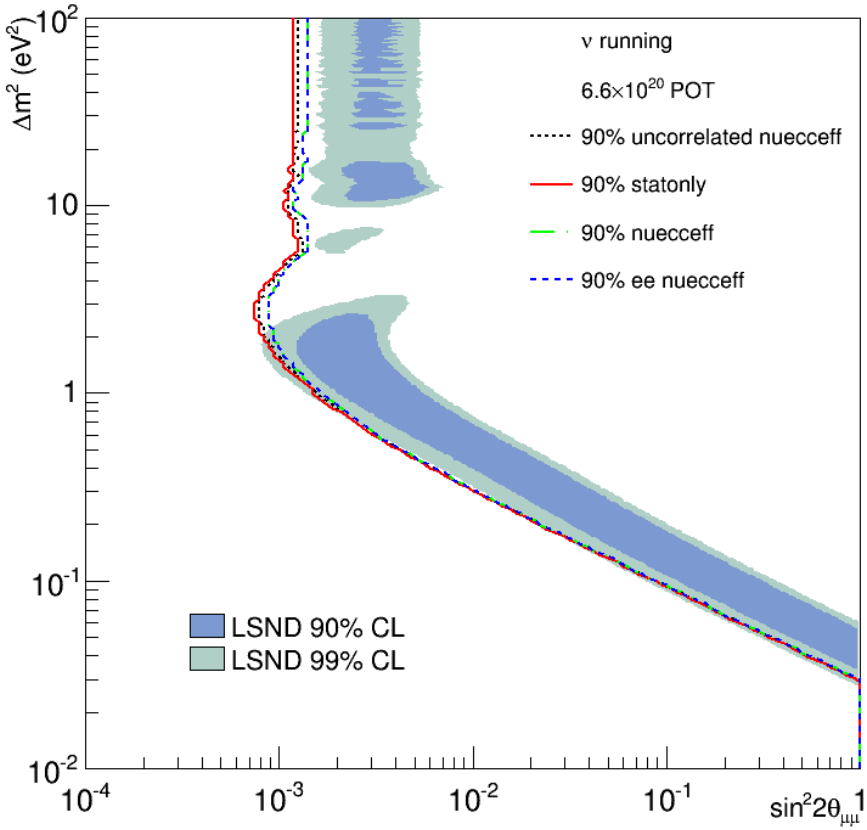
π^+ flux systematics systematics



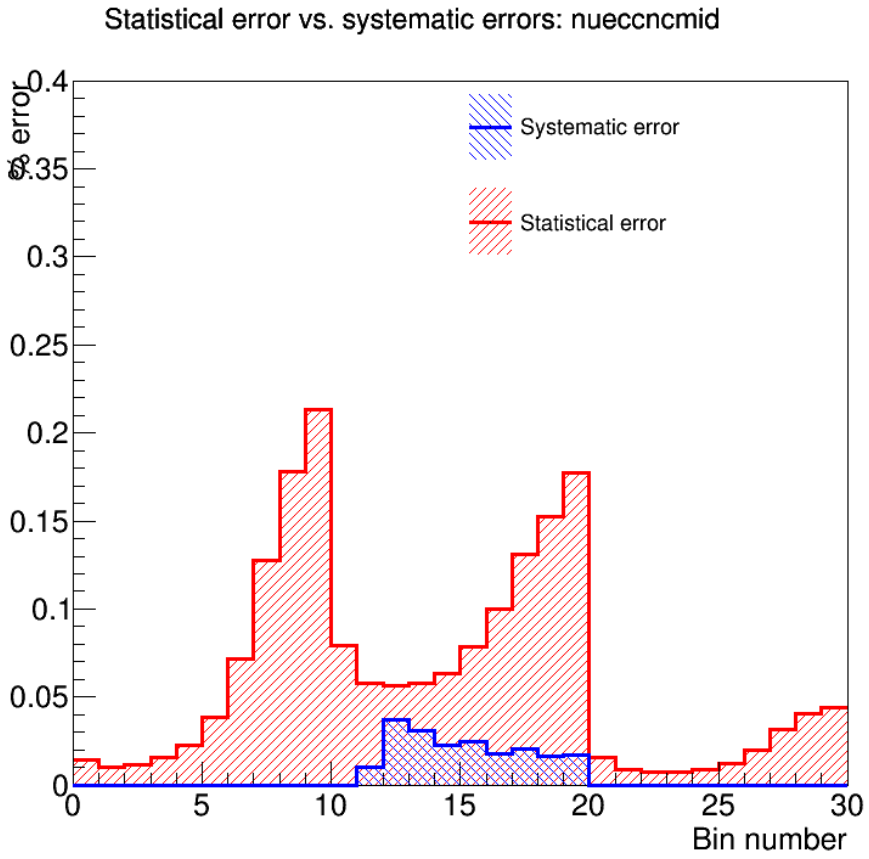


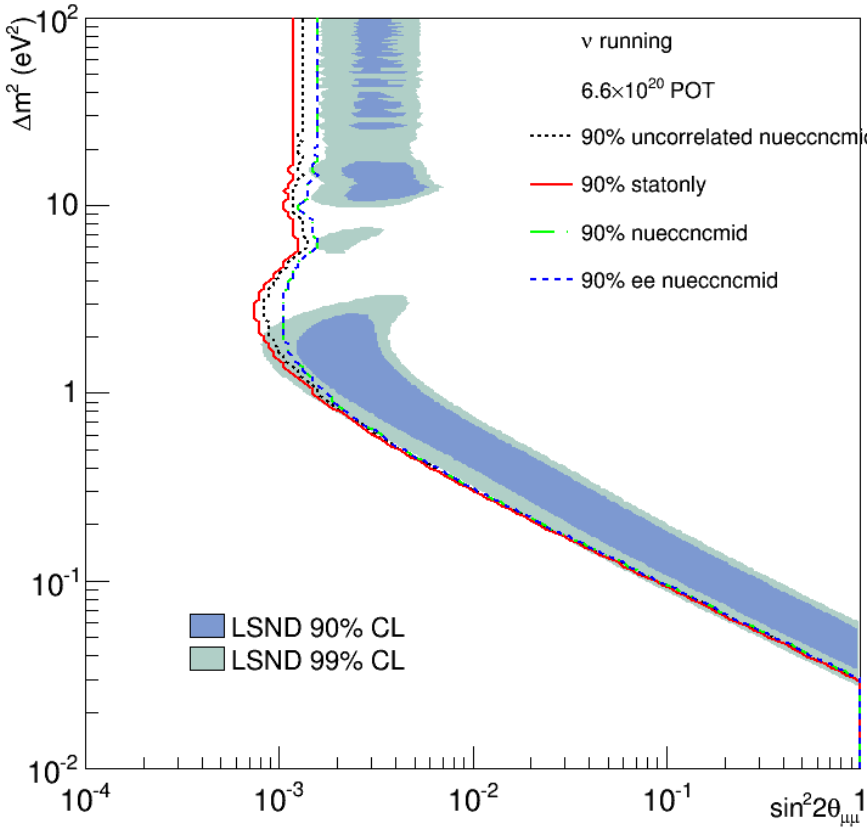
CID ν_e CC efficiency systematics



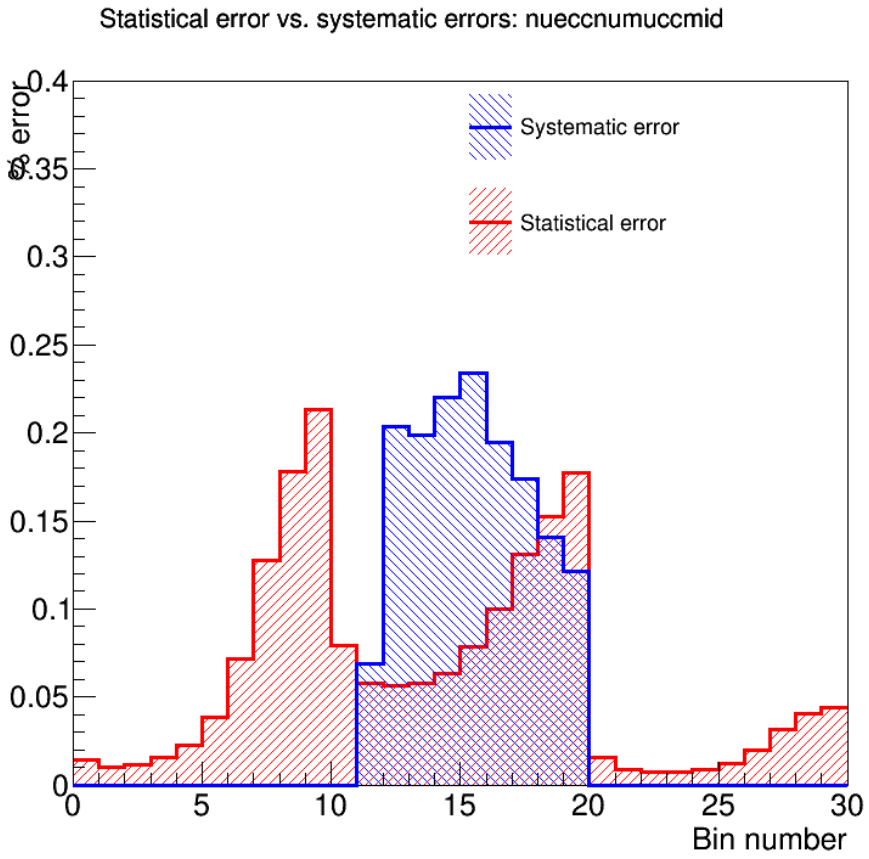


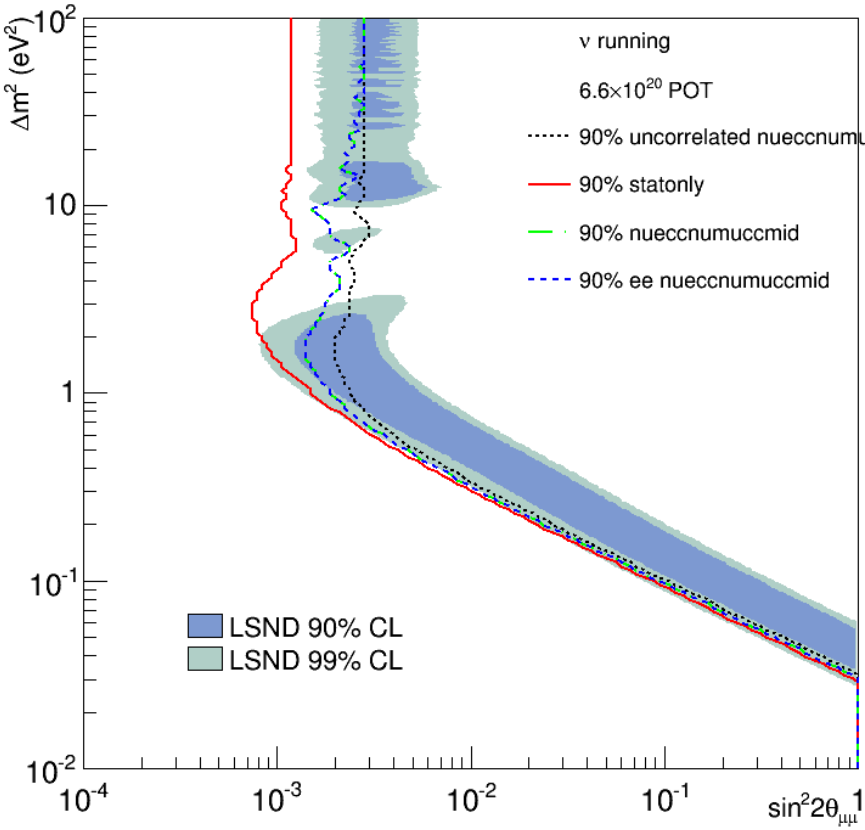
MID ν_e CC $\rightarrow$ ν_e NC efficiency systematics



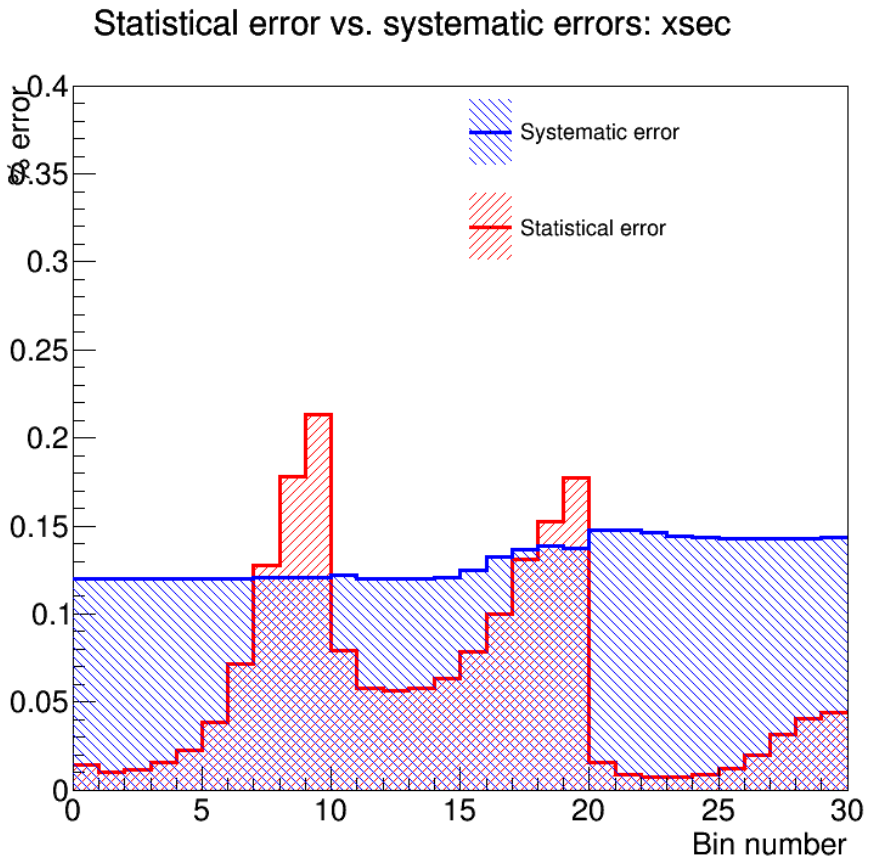


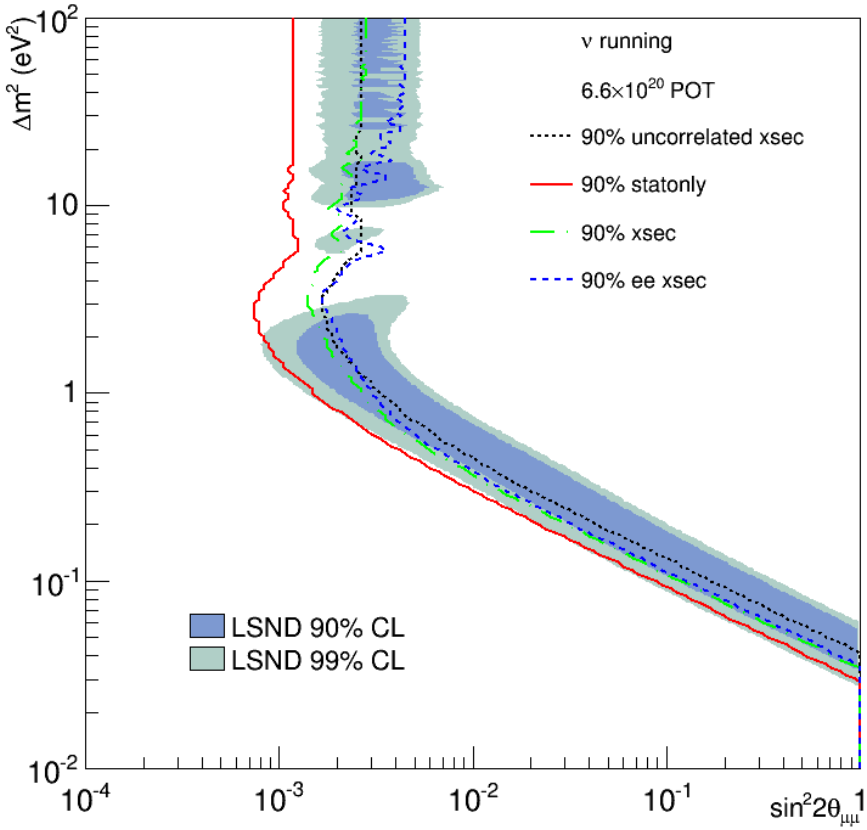
MID ν_e CC $\rightarrow$ ν_μ CC efficiency systematics





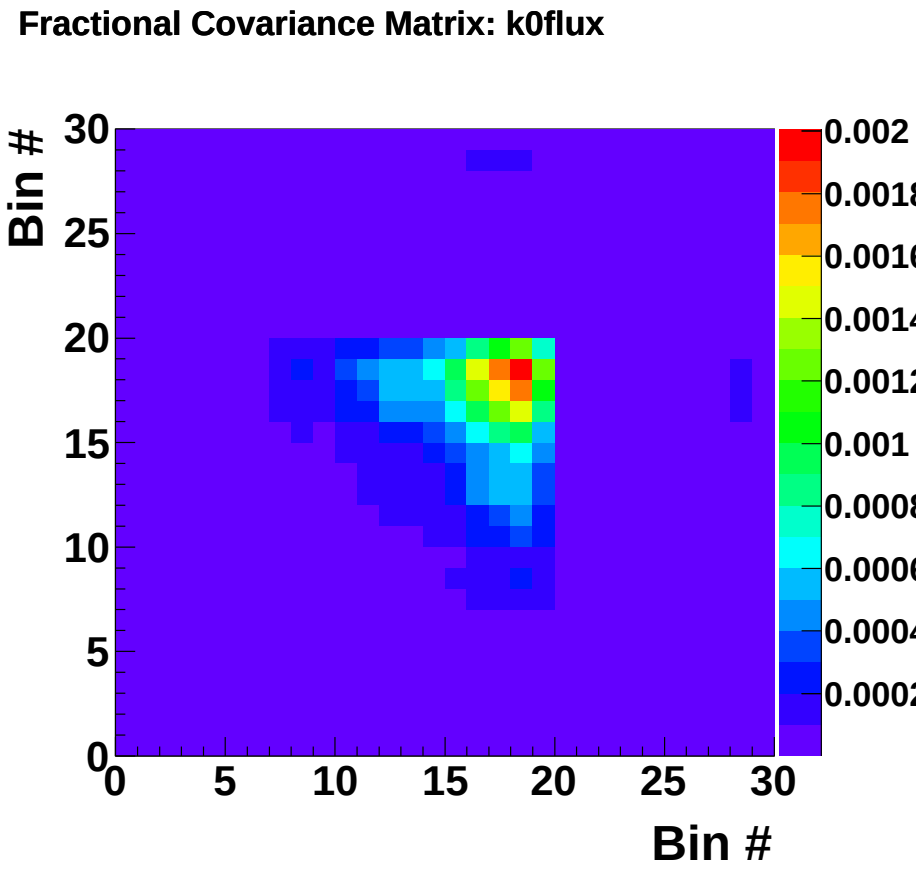
xsec systematics



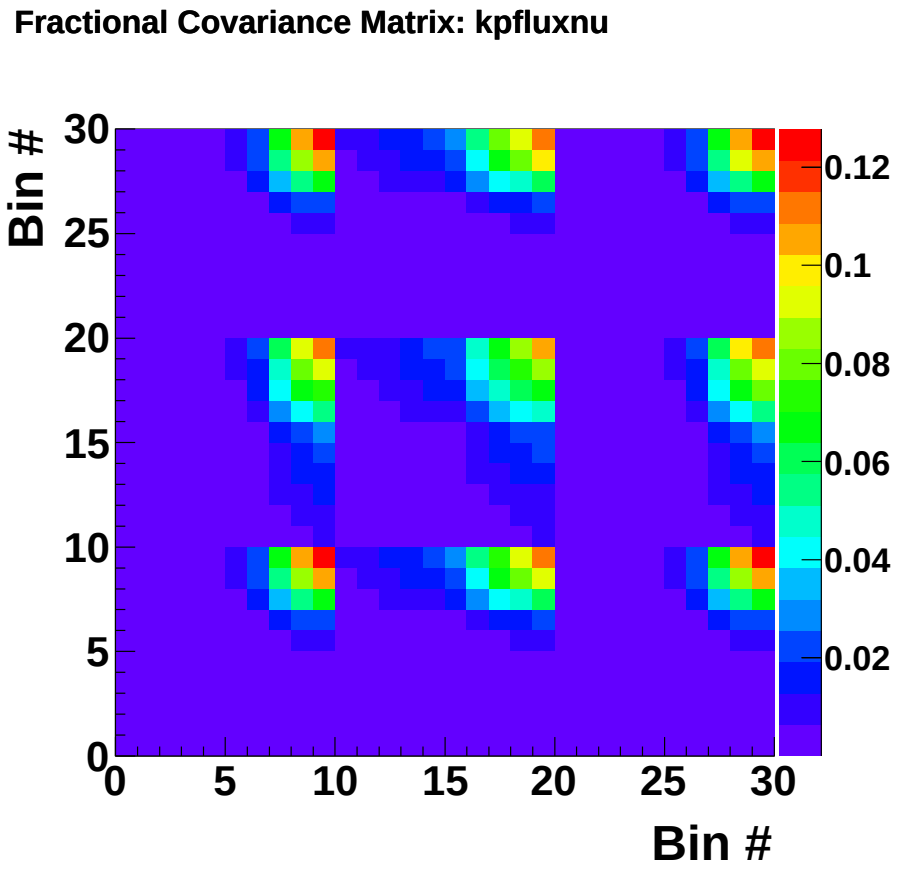


Backup

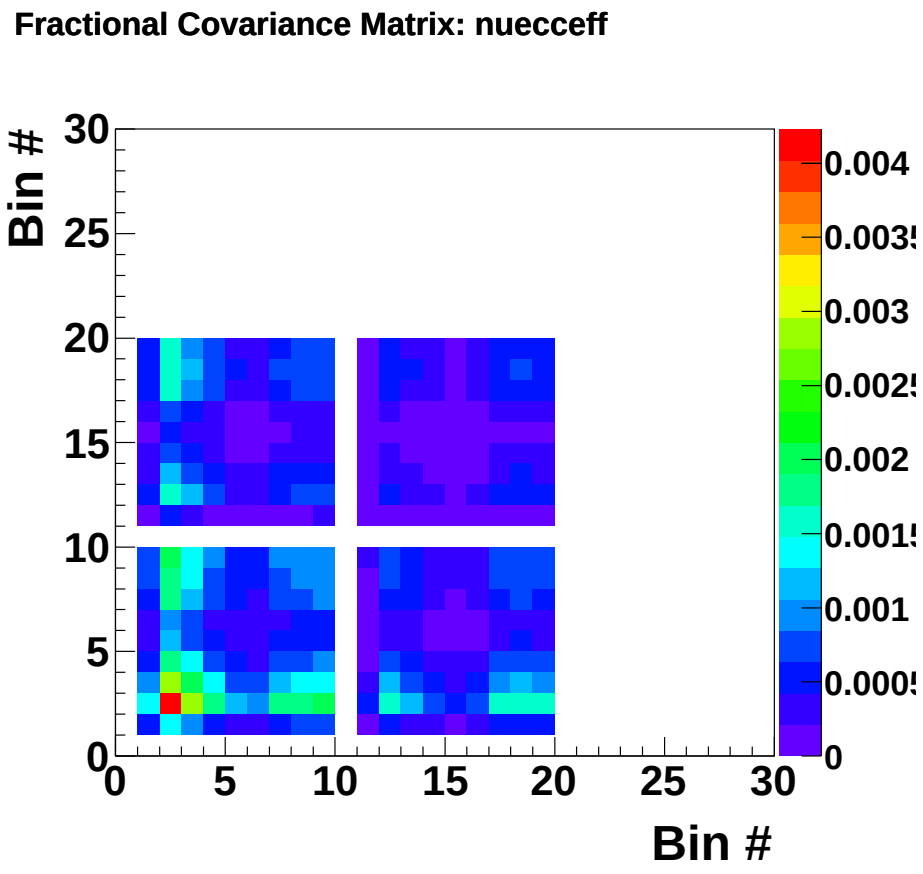
Covariance Matrix: k0flux



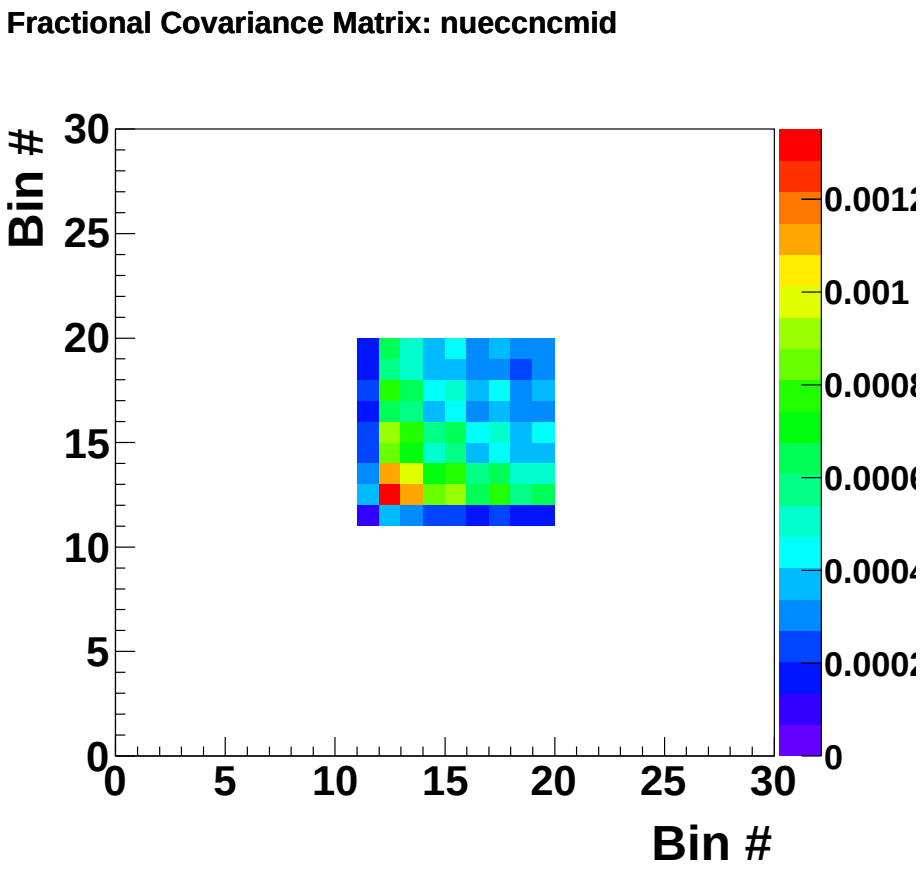
Covariance Matrix: kpfluxnu



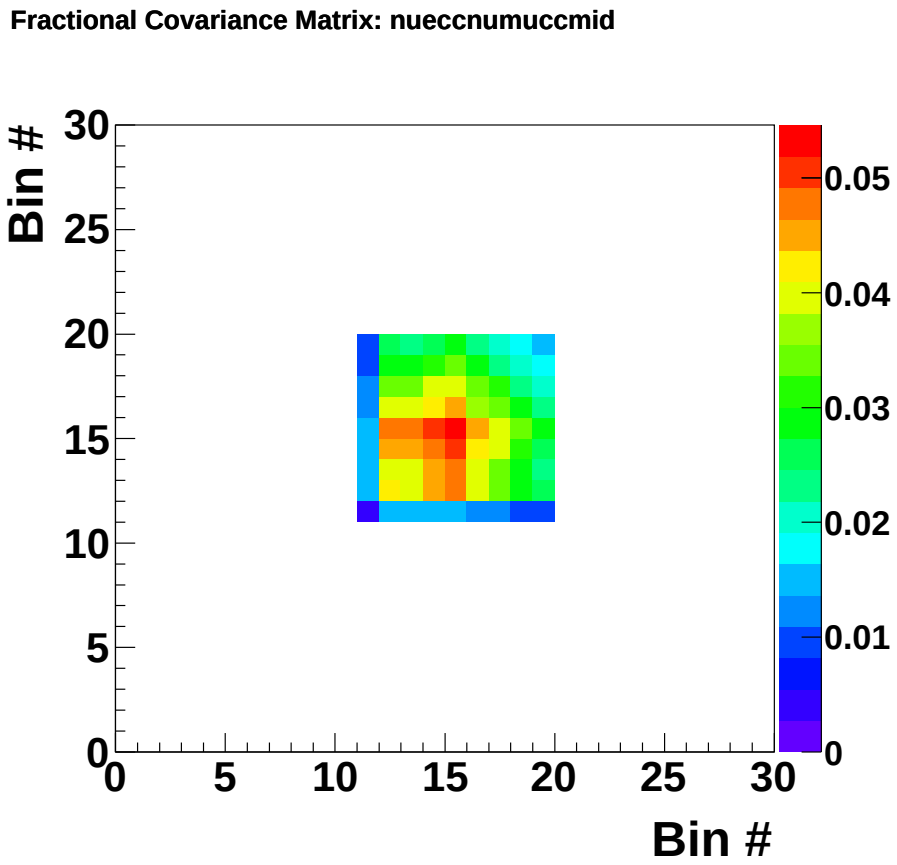
Covariance Matrix: nuecceff



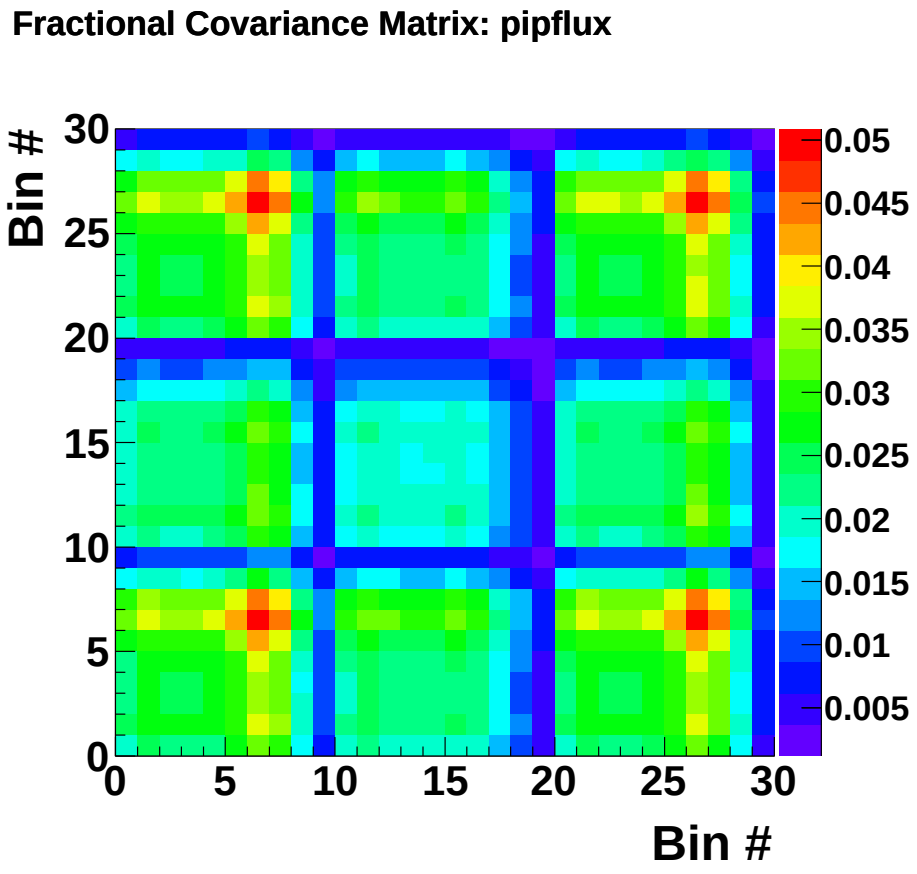
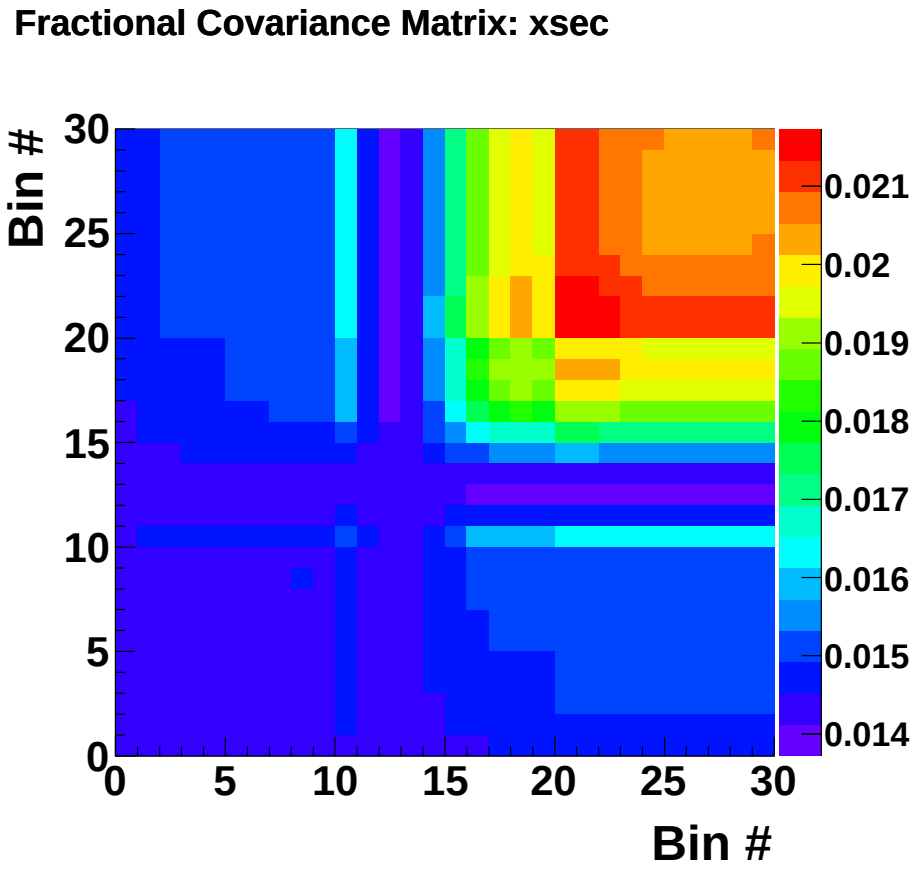
Covariance Matrix: nueccncmid



Covariance Matrix: nueccnumuccmid



Covariance Matrix: pipflux



Covariance Matrix: xsec