Representative Near detector performance plots for measuring neutrino-electron scattering

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1 Definitions

- *IMD events/sample* - events with a muon in the final state in μ^- decay mode;
- *ES^- events/sample* - events with an electron in the final state in μ^- decay mode;
- *ES^+ events/sample* - events with an electron in the final state in μ^+ decay mode;
- *Coordinate system* - z-axis coincides with the straight section axis and points downstream;
- *Lepton polar angle θ_l* - angle between the lepton momentum and the z-axis;
- *Lepton azimuth angle φ_l* - angle of the lepton momentum projection in a plane perpendicular to the z-axis;
- $\xi_l \equiv E_l \theta_l^2$, $\zeta_l = p_l(1 - \cos\theta_l) \approx \frac{1}{2} E_l \theta_l^2 = \frac{1}{2}\xi_l$;
- x^{gen} - MC truth value of variable x;
- x^{rec} - reconstructed value of variable x (like p_l^{rec}, θ_l^{rec}, etc.);
- x^{est} - estimated (calculated) value of variable x (like E_ν^{est});

2 Measurement resolutions for pure leptonic interactions

Resolution plots should be produced for neutrino-electron events only. These plots are to show what is the capability of the detector to measure the neutrino flux using neutrino-electron scattering. Separate plots for events with a muon in the final state and an electron in the final state should be produced. All figures contain mean and RMS value. Fitting is optional.

2.1 Vertex transverse coordinates, *i.e.* perpendicular to the z-axis

Absolute difference $\Delta x = x^{rec} - x^{gen}$ should be plotted. If resolution on the y coordinate differs, it should also be plotted.

2.2 Lepton momentum

Relative difference $\delta p_l = (p_l^{rec} - p_l^{gen})/p_l^{gen}$ should be plotted. In addition to the resolution integrated over the whole momentum spectrum, the momentum dependence of the resolution $\delta p_l(p_l)$ should be shown.

2.3 Lepton polar angle

Absolute difference $\Delta\theta_l = \theta_l^{rec} - \theta_l^{gen}$ should be plotted.

2.4 Lepton azimuth angle

Absolute difference $\Delta\varphi_l = \varphi_l^{rec} - \varphi_l^{gen}$ should be plotted. The lepton azimuth angle gives additional information when the neutrino angle w.r.t. z-axis is not zero.

2.5 Neutrino energy

The measurement uncertainties of the above quantities translate nontrivially to the uncertainty of the estimated neutrino flux as a function of the incoming neutrino energy. It is not simple to define this uncertainty and the neutrino flux estimation can be done in numerous ways. Therefore, we suggest the neutrino energy is estimated on event-by-event basis and the performance of this estimation is shown. Relative difference $\delta E_\nu = (E_\nu^{est} - E_\nu^{gen})/E_\nu^{gen}$ integrated over the whole momentum spectrum should be plotted. In addition to this the energy dependence of the resolution $\delta E_\nu(E_\nu)$ should be shown.

3 Background rejection

3.1 Signal and background efficiencies

One table per decay mode should be produced. Tables should have the structure as of the table below.

Table 1: Signal and background efficiencies for μ^- decay mode.

	Signal		Background				
	IMD	ES$^-$	Total	ν_μ-CC	ν_μ-NC	$\bar{\nu}_e$-CC	$\bar{\nu}_e$-NC
# simulated events							
# after reconstruction							
# after cut1 (description)							
# after cut2 (description)							
...							

3.2 ξ_l resolution

Resolution should be plotted in terms of relative difference $\delta\xi_l = (\xi_l^{rec} - \xi_l^{gen})/\xi_l^{gen}$.

3.3 ξ_l distribution after cuts

Distributions of ξ_l separately for for the three samples - IMD, ES$^-$ and ES$^+$ should be plotted after all cuts have been applied (except the ones on ξ_l itself, if any). These plots are to illustrate signal-to-background separation capability of the detector. For IMD it would be beneficial to plot also $\xi_l' = E_l\theta_l'^2$, where θ_l' is the estimated scattering angle of the muon with respect to the neutrino direction. If one chooses to use this variable, the method of estimation should be briefly discussed.