Radiative corrections for ORCA

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Why?

- Determination of neutrino mass ordering
  - measurement of count rates of electron and muon neutrinos as a function of energy and zenith angle
    - atmospheric neutrino flux
    - neutrino oscillations
    - neutrino detection
    - event reconstruction
    - PID (track-like versus shower-shower versus atmospheric muons)

- ORCA represents a high-precision experiment
  - envisaged precision 1–5 %

Why?

- *“Measurement of differential cross-sections and structure functions in neutrino and antineutrino scattering on lead”*,
  PhD thesis, Rolf Oldeman

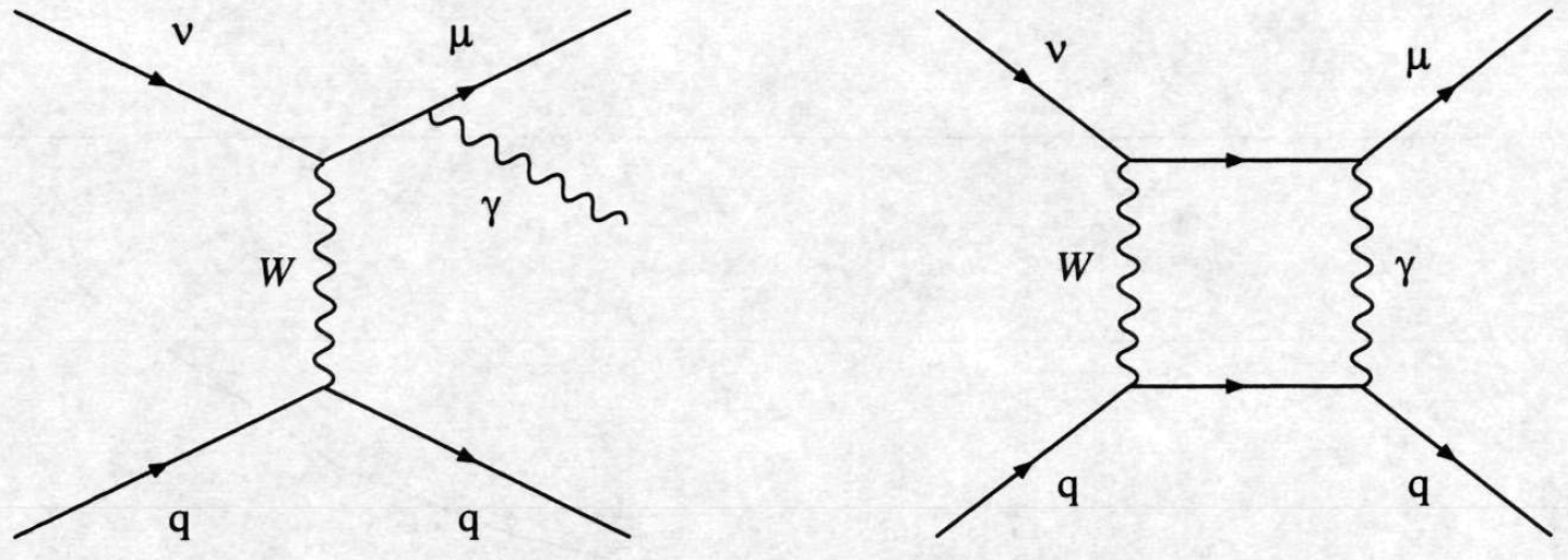


Figure 3.12: Diagrams of the radiative corrections considered in the scheme of Bardin.

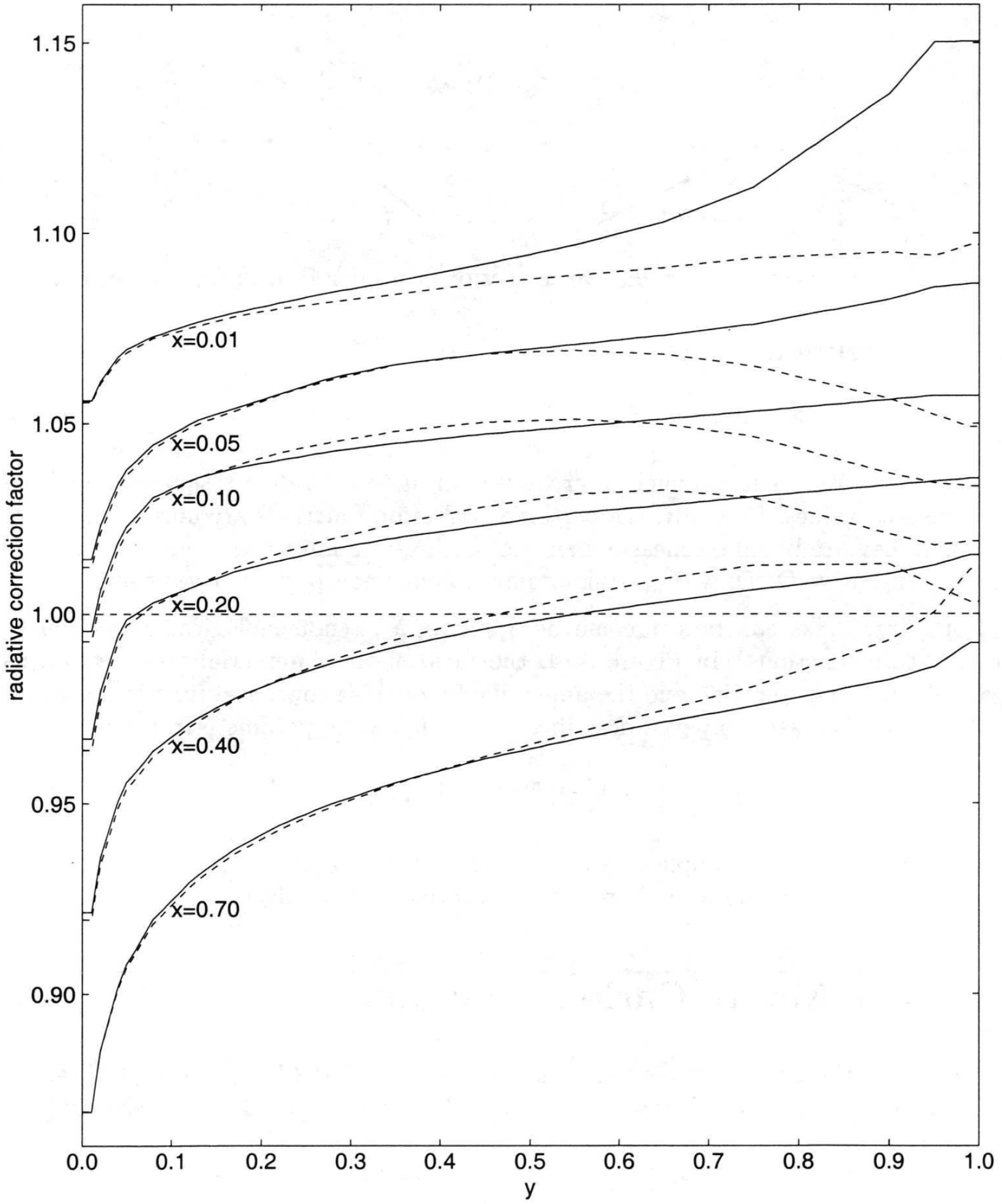


Figure 3.13: Ratio of the cross-section including radiative processes and the bare cross-section at $E_\nu = 50\,\text{GeV}$, as a function of x and y. The solid line refers to neutrinos, the dashed line to anti-neutrinos.

Radiative corrections Pb at 50 GeV

- radiative correction factor larger than envisaged precision of ORCA
- radiative correction factor for electron neutrinos should be even larger

N.B. (1/2)

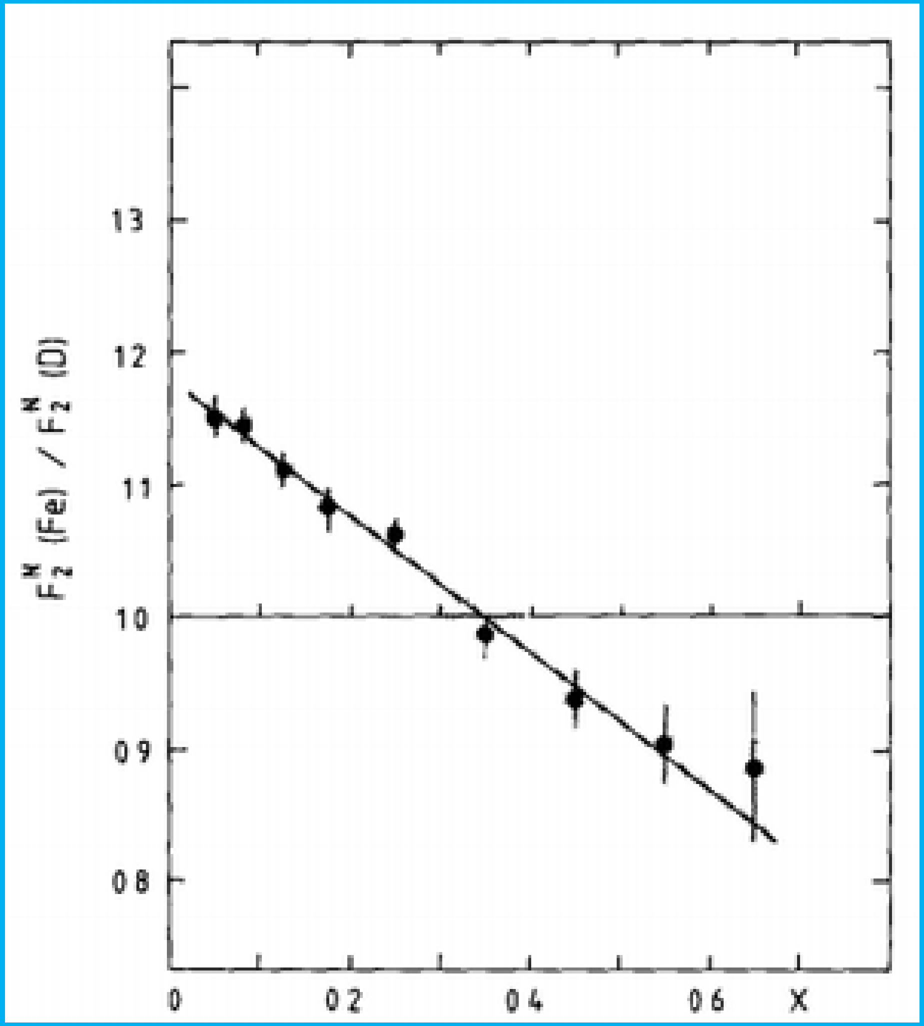
The resulting model for the differential cross-section has two problems. When the differential cross-section is integrated over the kinematically allowed range of x and y, the resulting total neutrino-nucleon cross-section at low E_ν differs significantly from the measured values. Secondly, the parton distribution functions are unreliable at low Q^2, since they are based on measurements at high Q^2 and are extrapolated to low Q^2 using perturbative QCD, without taking into account non-perturbative effects.

Both drawbacks can be overcome by applying a phenomenological correction to the structure functions. In Figure 3.14, the ratio of the differential cross-section as measured in a first iteration and the unmodified model is shown as a function of x and Q^2. The ratio is reasonably well described by the following parameterization:

$$\rho(x, Q^2) = 1 - 0.5\left(1 - \frac{x}{0.7}\right) \cdot \frac{1}{1 + \frac{Q^2}{20x}}. \tag{3.27}$$

This parameterization is applied as a multiplicative factor to the structure functions of the model, used in the second and final iteration of the analysis.

N.B. (2/2)



EMC effect

- DIS
  - $F_2^A \neq \ (A - Z)\, F_2^n + Z\, F_2^p$

Summary & Outlook

- It is important to consider radiative corrections
  - radiative correction factors can be larger than envisaged precision

- It is important to consider other corrections
  - (historical) discrepancy between data and model
  - non-perturbative effects
  - EMC effect (ARCA?)