Inclusive Antineutrino Nucleus Scattering Analysis at MINERνA

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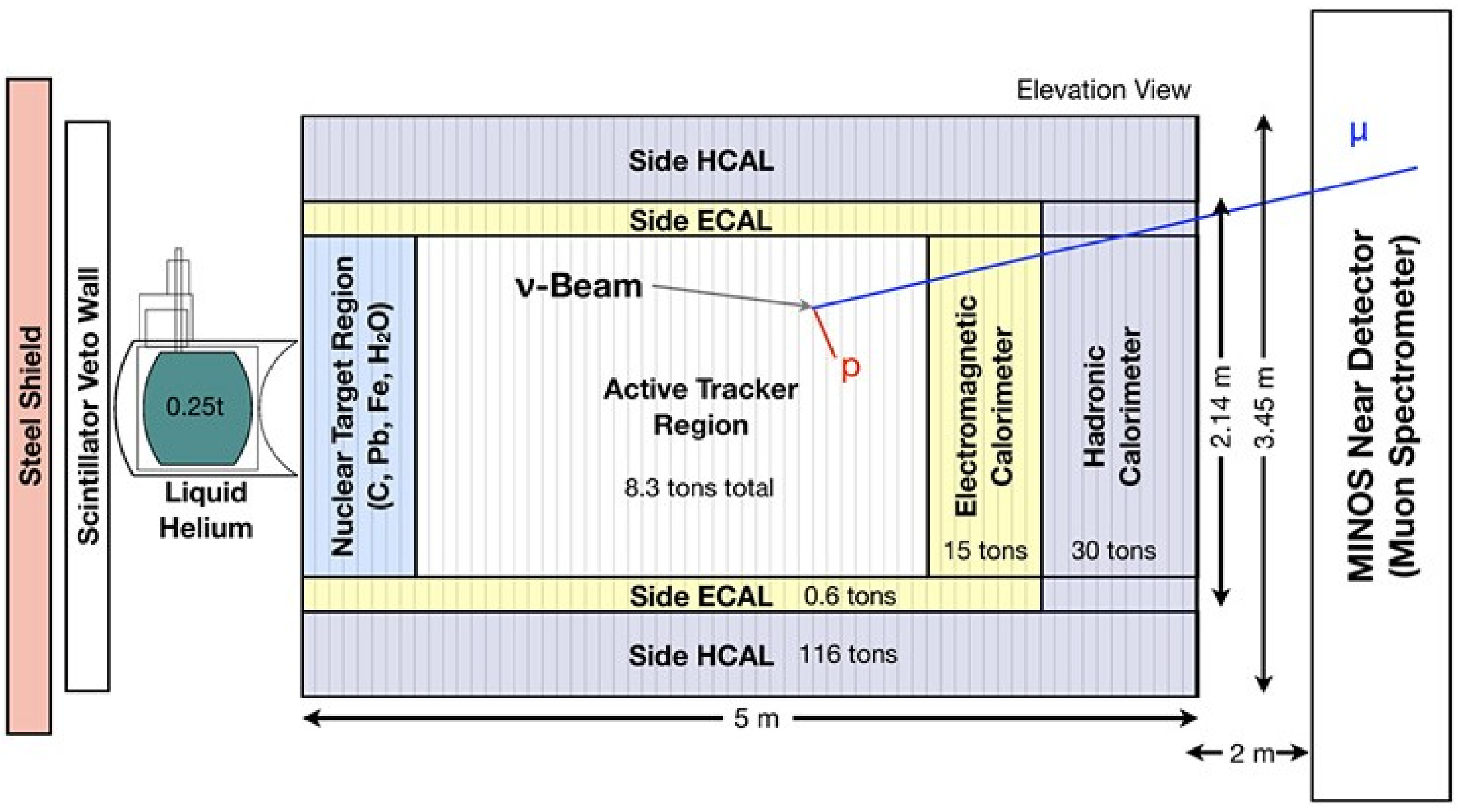
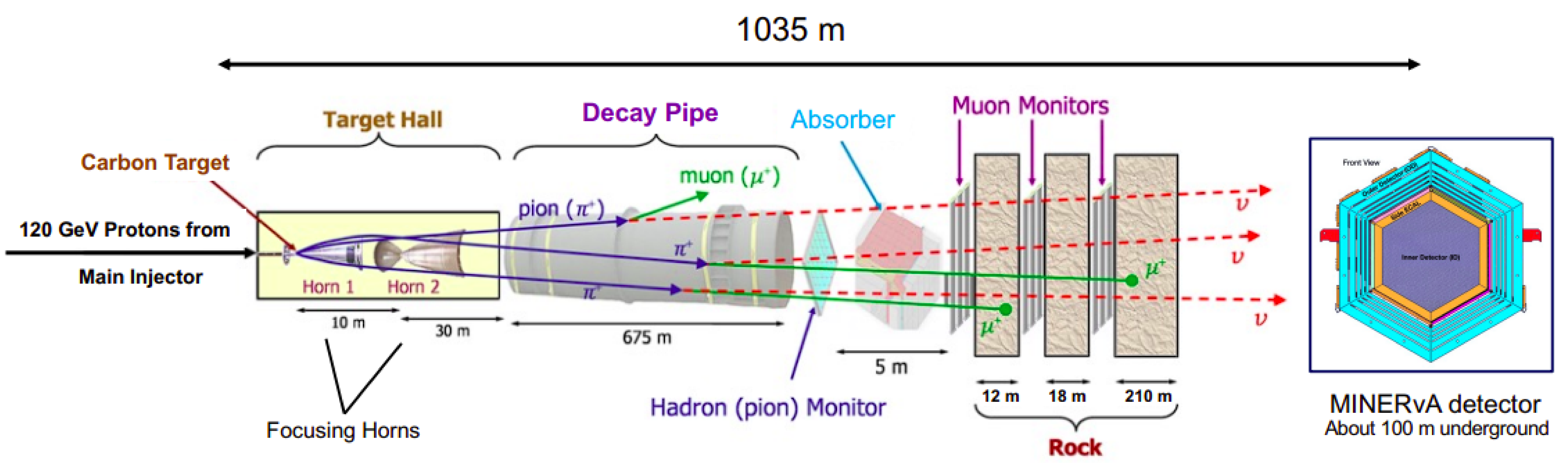
1. Why MINERνA ?



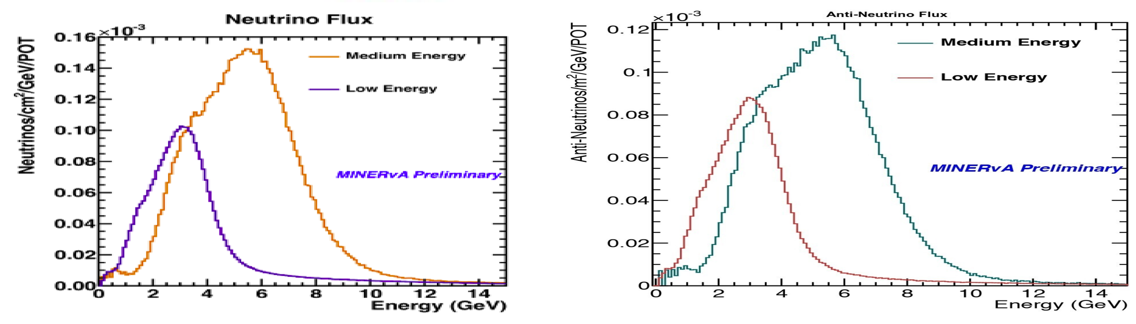
MINERνA is a dedicated high statistics $\nu(\bar{\nu})$-A scattering experiment, which is the first of its kind, using different nuclear targets viz. C, Fe and Pb in the same (anti)neutrino beam. The goal of the MINERνA experiment include :

- **Cross sections** for ν and $\bar{\nu}$ scattering off nucleons bound inside the nuclear target and deep inelastic scattering, where high energy (anti)neutrinos probe deep inside the nucleons and see individual quarks.
- **Medium effects** This is to study how Z and A or targets affect neutrino interactions. This is done by using various upstream targets like iron, lead, carbon and water. The motivation is to understand nuclear medium effects in a wide range of Bjorken x and Q^2.
- **Final state interactions** The understanding of nuclear medium effects will shed light on the hadron dynamics in the presence of axial vector response function.

2. The NuMI beamline

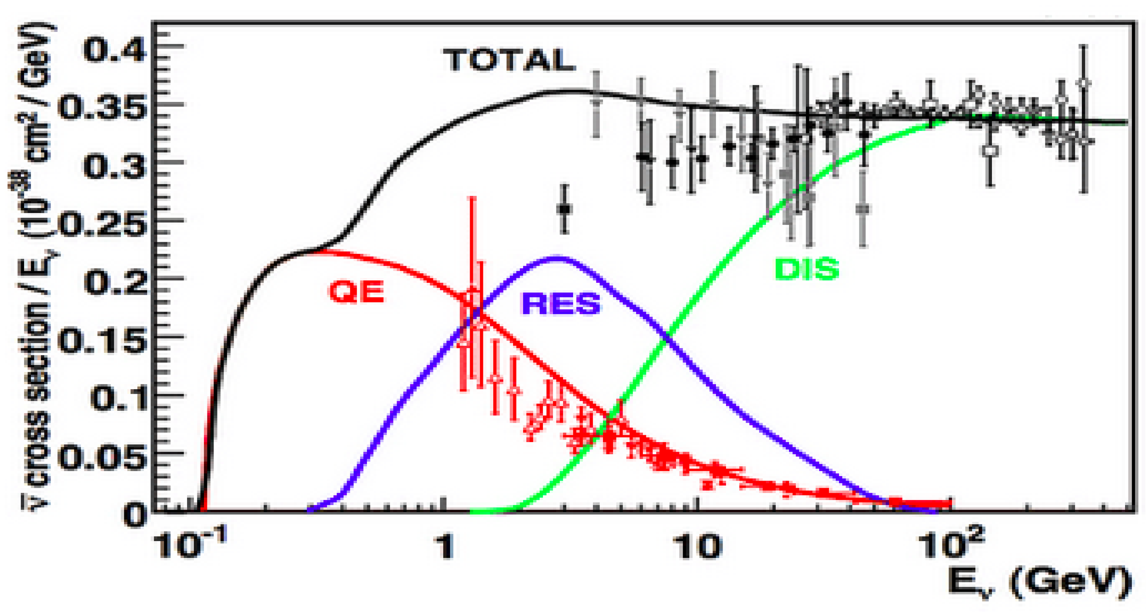


- The NuMI beamline uses 120 GeV protons on a graphite target to produce neutrino beams of 3 GeV and 6 GeV energy.
- The magnetic horn current can be reversed to select $\bar{\nu}_\mu$ or ν_μ beam.



3. Analysis Goal

The goal of my analysis is to calculate double differential **inclusive** $\bar{\nu}_\mu$ cross section

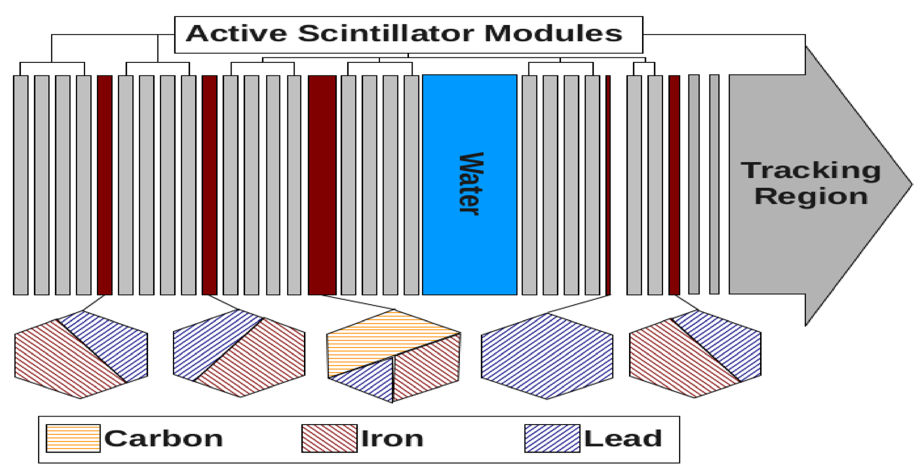


We use the following formula to extract cross sections:

$$\left(\frac{d^2\sigma}{dxdQ^2}\right)_{\alpha\beta} = \frac{\Sigma_{ij}U_{ij\alpha\beta}(N_{\text{data},ij} - N_{ij}^{\text{Bkgd}})}{A_{\alpha\beta}(\Phi T)(\Delta x)_\alpha(\Delta Q^2)_\beta}$$

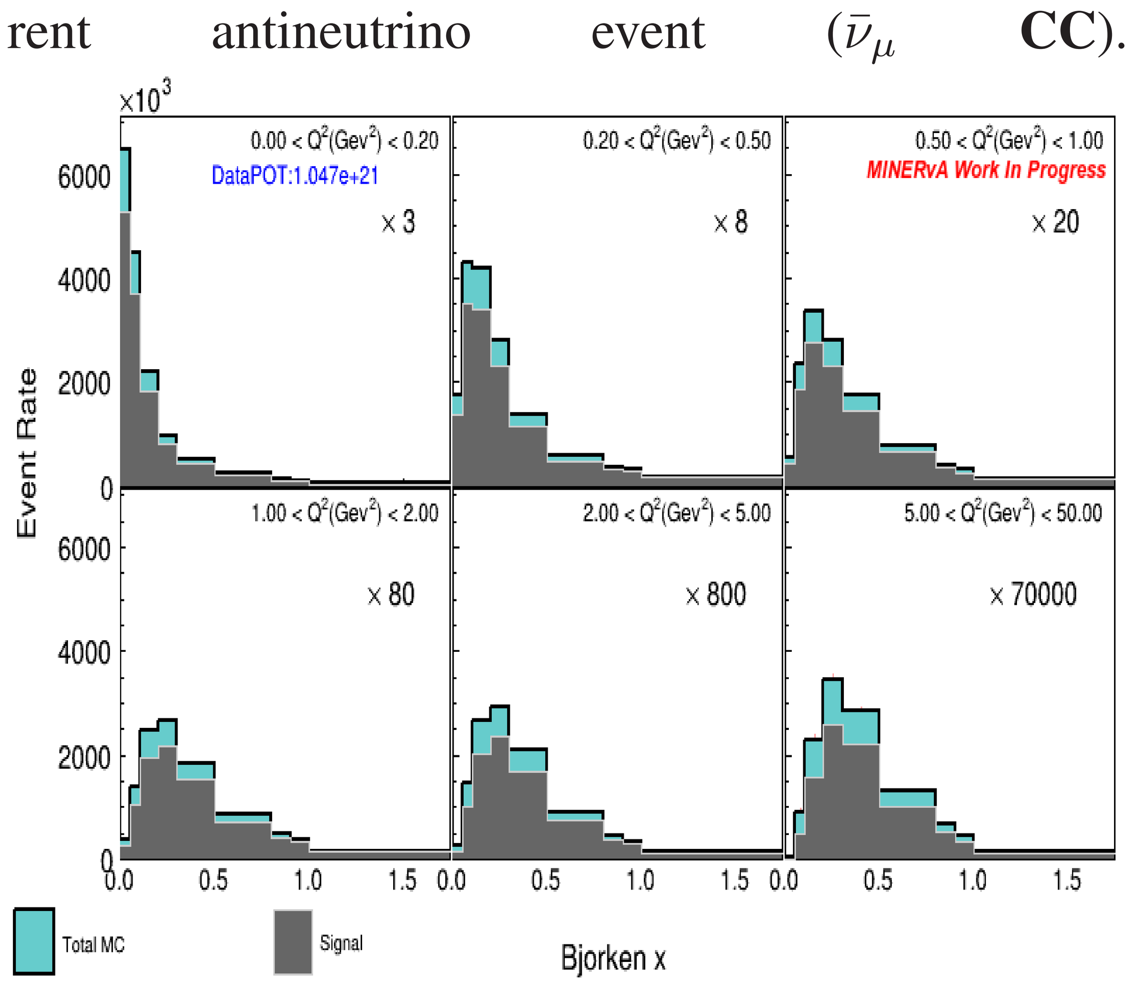
which involves **event selection**(N_{data}), **background subtraction**(N^{Bkgd}), **unfolding**(U), **efficiency correction**(A) and **bin width normalisation**(Δx,ΔQ^2).

4. Nuclear Targets



5. Event Distribution

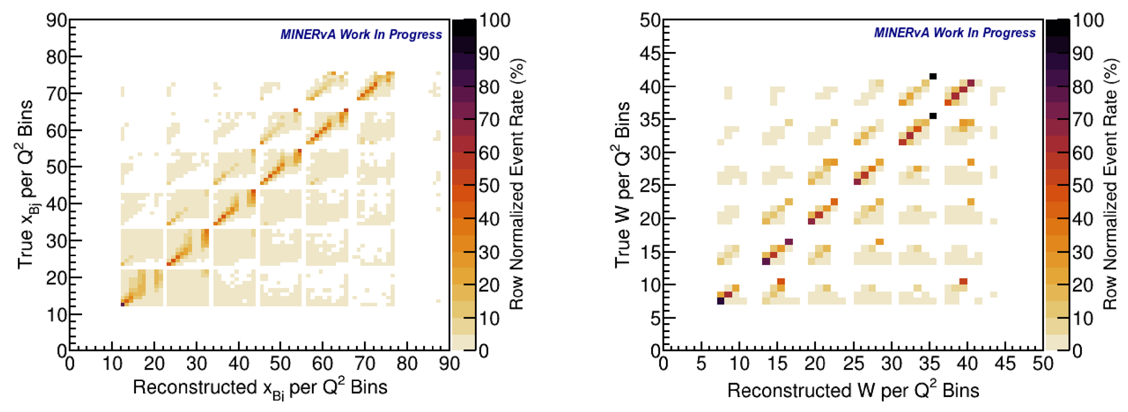
The **signal** is defined as charged current antineutrino event ($\bar{\nu}_\mu$ **CC**).



For iron of all targets using full statistics

6. Migration Matrix

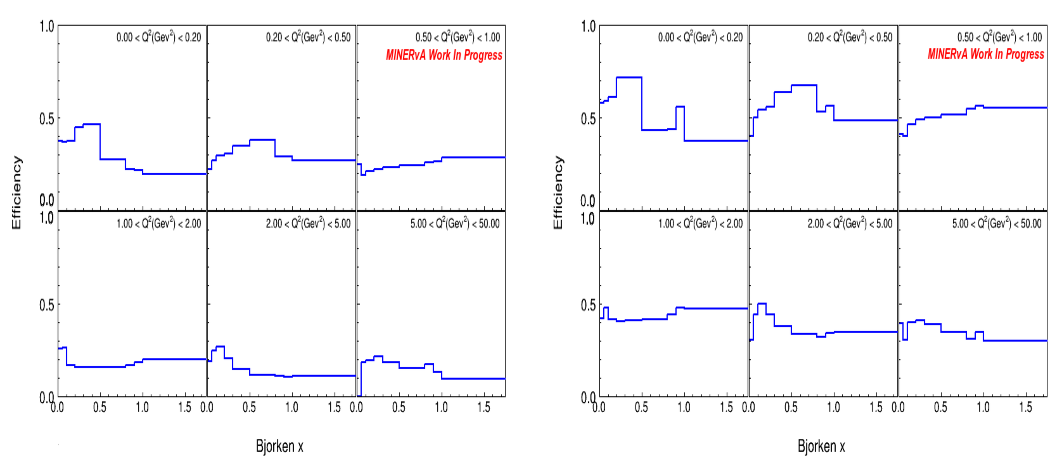
- The unfolding matrix makes sure that we remove the smearing in the measurement of a variable due to detector effects.
- The unfolding matrix U_{ij} maps a reconstructed variable from the j bin to true variable in the i bin.
- This makes sure, that we use the most suitable binning for unfolding procedure.



Binning for x (Left)
:[0, 0.05, 0.1, 0.2, 0.3, 0.5, 0.8, 0.9, 1, 1.75]
Binning for W (Right) : [0,2,5,8,10]

7. Efficiency Correction

$$\text{Efficiency} = \frac{\text{Reconstructed events}}{\text{True events (true cuts only)}}$$



- The set of event selection cuts used to isolate the signal are unable to reconstruct some fraction of the signal events, which we can by the above equation.
- Therefore, an efficiency correction is applied to the cross-section calculation to recover the true signal distribution.

8. Conclusions

- 2 dimensional plots for event distribution with contribution from various channels, efficiency distribution plots, and migration matrices have been successfully obtained.
- Background subtraction has been successfully performed.
- Suitable binning has been chosen for unfolding procedure using the migration matrices obtained.
- After performing the unfolding study, the double differential cross section in bins of x and Q^2 or W and Q^2 will be ready to be extracted.