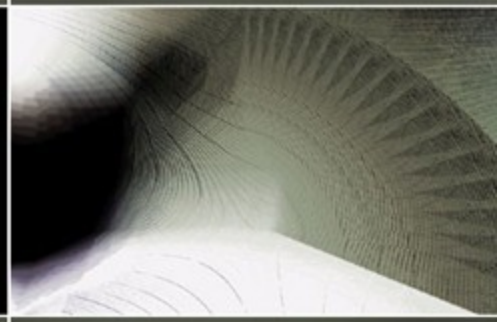
ν Beams, ν Flux Determination, and ν Cross Section (Problem 7.1)



Group 11
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Stating the Problem

- Overview:
  - Flux and cross section constraints from Near Detectors in long baseline experiments
- Given:
  - 35187 ν_μ events observed at the **Near Detector (ND)**
  - 3380 ν_μ events observed at the **Far Detector (FD)**
  - Cross section (σ) at **ND** and **FD**: 2.5e-9 cm^2
  - Flux (ϕ) at **ND** and **FD**: 1.92e13 cm^{-2} / 10e21 POT
  - Uncertainties:
    - Cross section, σ_σ: 20%
    - Flux, σ_ϕ: 10%

Stating the Problem Cont.

- Main Question:
  - What is the probability of disappearance (**P**) with 6e20 POT
  - What is the uncertainty associated with **P**
- Extra Questions:
  - Q1 – the correlation of flux and cross section
  - Q2 – the uncertainty in **P** change as a function of:
    - ϕ and σ uncertainties
    - POT
  - Q3 – **P** change with the addition of background

Approach I

- Main motivation:
  - Constraining the ϕ and σ in **ND**
- Approach:
  - Find χ^2 in **ND**
  - Determine the best set of ϕ and σ from minimized χ^2 in **ND**
  - Determine the **P** from number of events at **FD**

$$N^{ND} = \sigma\phi POT$$

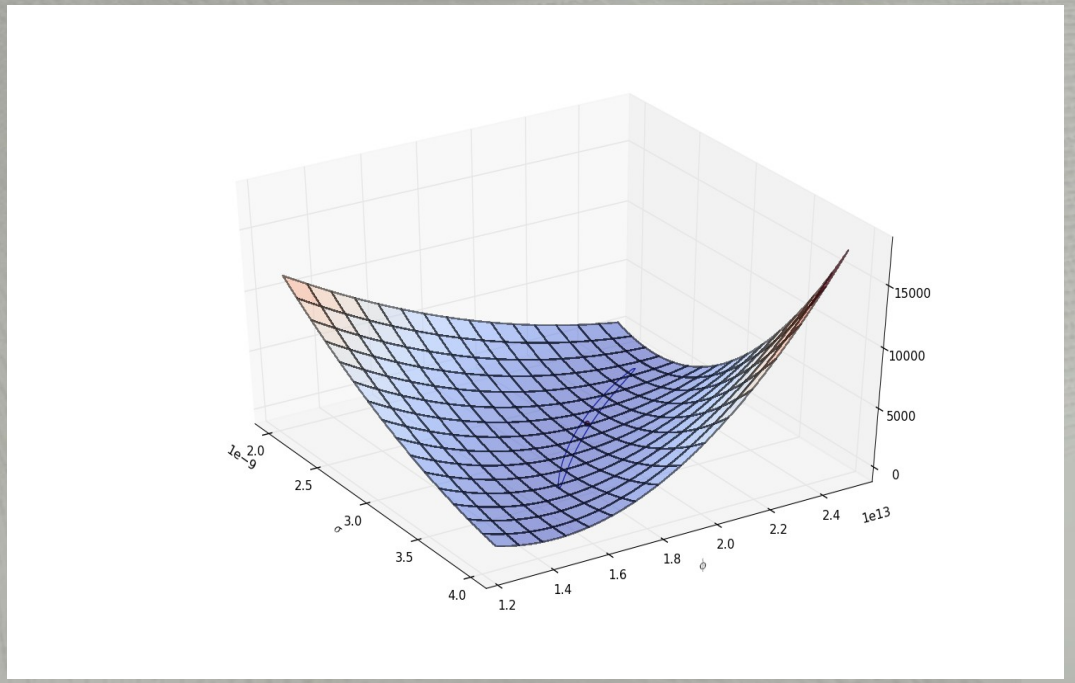
$$N^{FD} = P\sigma\phi POT$$

ϕ, σ: best fit parameters
N^{ND}: Predicted events at **ND**
N^{FD}: Predicted events at **FD**

Approach I Cont.

Detail of χ^2_{ND}:

$$\chi^2_{ND} = \frac{(N - \phi\sigma POT)^2}{N} + \frac{(\sigma - \sigma_i)^2}{\sigma_\sigma} + \frac{(\phi - \phi_i)^2}{\sigma_\phi}$$



N:observed number of events

ϕ_i: 1.92e13 cm^{-2} / 10e21 POT

σ_i:2.5e-9 cm^2

σ_σ:uncertainty in cross section

σ_ϕ:uncertainty in flux

Detail of χ^2_{ND} with background:

$$\chi^2_{ND} = \frac{(N - \phi\sigma POT - background)^2}{\sqrt{N^2 + background^2}} + \frac{(\sigma - \sigma_i)^2}{\sigma_\sigma} + \frac{(\phi - \phi_i)^2}{\sigma_\phi}$$

Results of Approach I

- Uncertainty:
  - W/o background: 0.903 +/- 0.017
  - With background: 0.904 +/- 0.020
- Correlation trend:
  - Anti-correlation between σ and ϕ as expected

	σ	ϕ	**P**
Background	2.7e-9	1.9e13	0.904
w/o Background	3e-9	2e13	0.903

Correlation Matrix:

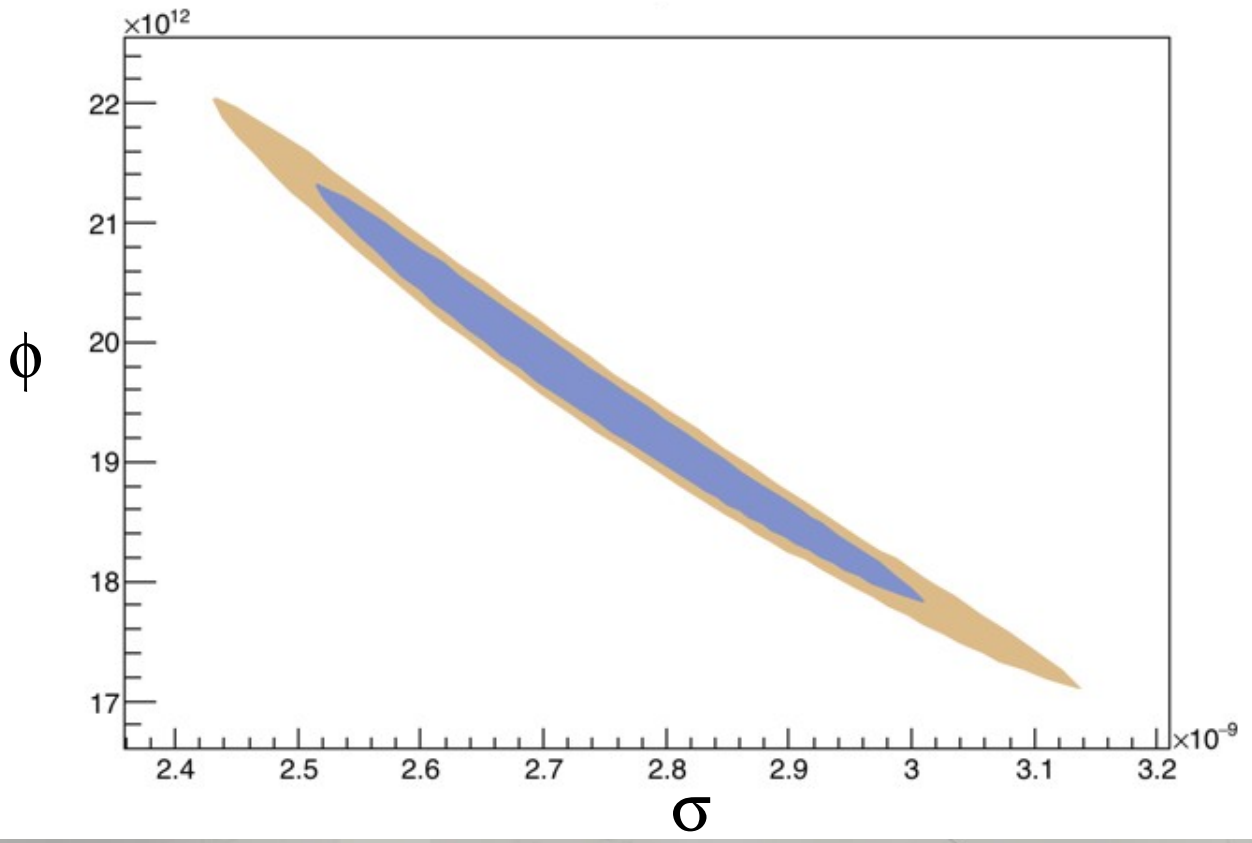
1.0	-0.998
-0.998	1.0

Covariance Matrix:

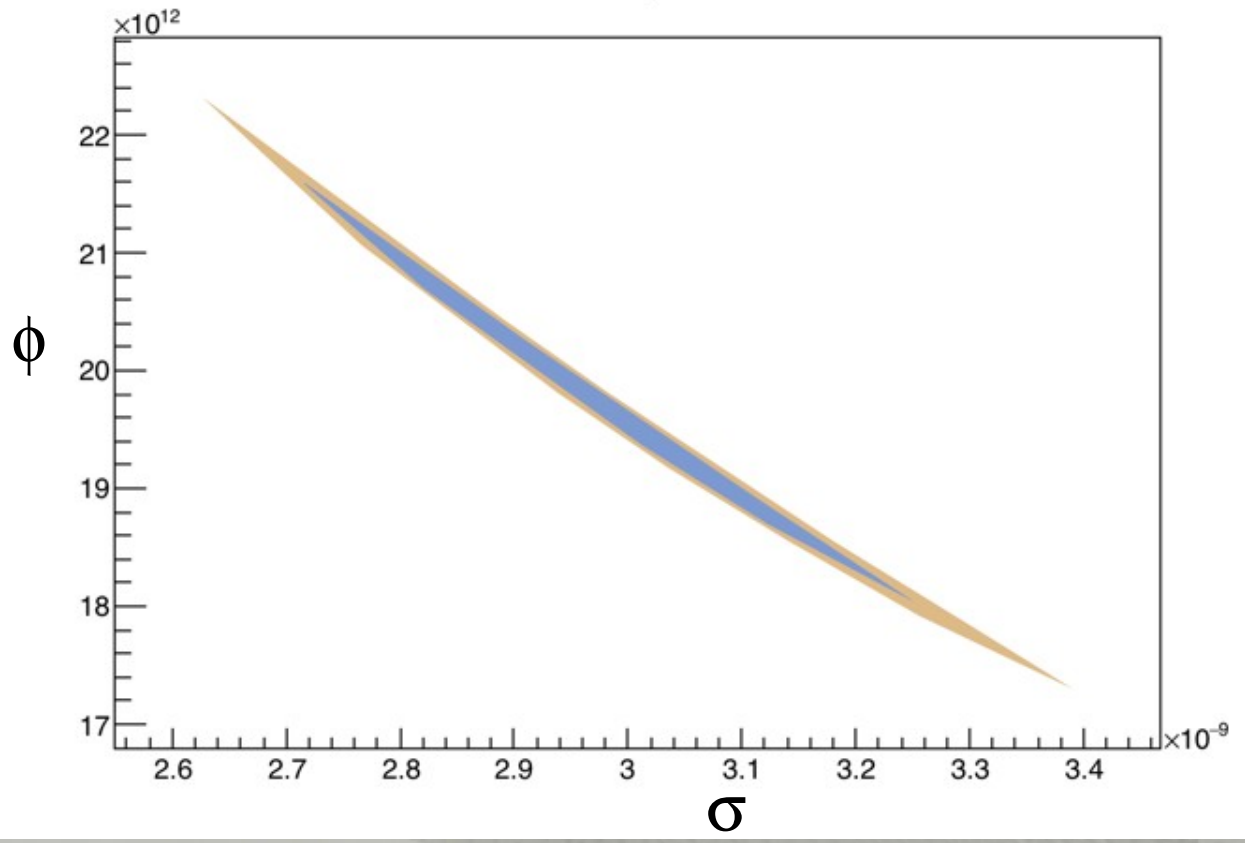
7.1e-20	-4.7e2
-4.7e2	3.2e24

Results of Approach I Cont.

χ^2 Minimization: Background



χ^2 Minimization: w/o Background



Approach II Results – ND-FD Combined χ^2

- Treated **ND** and **FD** equally:
  - The same **ND** and **FD** χ^2

$$\chi^2_{ND} = \frac{(N - \phi\sigma POT)^2}{N} + \frac{(\sigma - \sigma_i)^2}{\sigma_\sigma} + \frac{(\phi - \phi_i)^2}{\sigma_\phi} + \frac{(N_{FD} - P\sigma\phi POT)^2}{N_{FD}}$$

	σ	ϕ	Appearance **P**	Disappearance **P**	Error
W/o background	2.9e-9	2e+13	0.096	0.904	0.0017

7.0e-20	-4.7e2	-7.1e-15
-4.7e2	3.1e24	-6.4e6
-7.1e-15	6.3e6	3e-6

Covariance Matrix

Conclusion

- Uncertainty in **P** increases when background is added
- **P** slightly decreases as background is added
- σ and ϕ are correlated
- Our two approaches agree

The End

Thank you for listening!