In [1]:
```
# IMPORTING REQUIRED PACKAGES AND CONSTANTS
import numpy as np
```

Problem 3.2 ---

In [52]:
```
# Determining the uncertainties considering counting events
avg_back, avg_forw = 1037, 998
sigma_back, sigma_forw = np.sqrt(avg_back), np.sqrt(avg_forw)
print("Backward: ", avg_back, " ± ", sigma_back)
print("Forward: ", avg_forw, " ± ", sigma_forw)
```

```
Backward:  1037  ±  32.202484376209235
Forward:  998  ±  31.591137997862628
```

a)

Particles ejected in the backward direction: 1040 ± 30 particles.

Particles ejected in the forward direction: 1000 ± 30 particles

b)

These results do not generate doubts about the validity of the theory, because their margin of errors intersect.

Problem 7.2 ---

In [53]:
```
# DEFINING A FUNCTION THAT RETURNS THE WEIGHTED AVERAGE AND UNCERTAINTY
def weighted_error(values, deltas):
    values, deltas = np.array(values), np.array(deltas)
    weight_matrix = []
    for delta in deltas:
        weight_matrix.append(1/delta**2)
    weight_matrix = np.array(weight_matrix)
    x_best = np.dot(values,weight_matrix)/weight_matrix.sum()
    uncertainty = 1/np.sqrt(weight_matrix.sum())
    return x_best, uncertainty
```

In [54]:
```
# Calculating the weighted average and uncertainty for the measurement of the mass of the elementary particle
m, m_uncertainty = weighted_error([1967.0,1969.0,1972.1],[1.0,1.4,2.5])
print("m = (",m, " ± ", m_uncertainty, ") MeV/c^2")
```

```
m = ( 1968.0995112414469  ±  0.7737759544994183 ) MeV/c^2
```

The weighted average with uncertainty is: $\boxed{m = 1968.1 \pm 0.8\, MeV / c^2}$

Problem 7.6 ---

In [55]:
```
# Determining the uncertainties considering counting (decays) events
obs_4, obs_6 = 412, 576
sigma_4, sigma_6 = np.sqrt(obs_4), np.sqrt(obs_6)
print("4 hour observation: ", obs_4, " ± ", sigma_4)
print("6 hour observation: ", obs_6, " ± ", sigma_6)
```

```
4 hour observation:  412  ±  20.29778313018444
6 hour observation:  576  ±  24.0
```

a)

The uncertainty in the 4-hour observation is: 20.3 decays.

The uncertainty in the 6-hour observation is: 24.0 decays.

b)

In [56]:
```
# Determining the uncertainties considering counting (decays) events
p1, p2 = obs_4/4, obs_6/6
sigma_p1, sigma_p2 = sigma_4/4, sigma_6/6
print("Physicist 1: ", p1, " ± ", sigma_p1)
print("Physicist 2: ", p2, " ± ", sigma_p2)
```

```
Physicist 1:  103.0  ±  5.07444578254611
Physicist 2:  96.0  ±  4.0
```

Physicist 1 reports: 105 ± 5 decays.

Physicist 2 reports: 100 ± 4 decays.

c)

In [57]:
```
# Calculating the weighted average and uncertainty
d, d_uncertainty = weighted_error([p1,p2],[sigma_p1,sigma_p2])
print("(",d, " ± ", d_uncertainty, ") decays")
```

```
( 98.68263473053892  ±  3.1413792310152386 ) decays
```

The weighted average for the hourly decay rate is: 100 ± 3 decays.