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9/26/2008

8.13 MW2-5

Poisson statistics:

Measurement of gamma radiation from ^{137}Cs source

Topics to be discussed

1. Probability theory
 1. Independent events
 2. Poisson distribution
2. Experimental setup
3. Results
 1. Comparison to Matlab-generated Poisson data sets
4. Discussion of errors
5. Conclusions

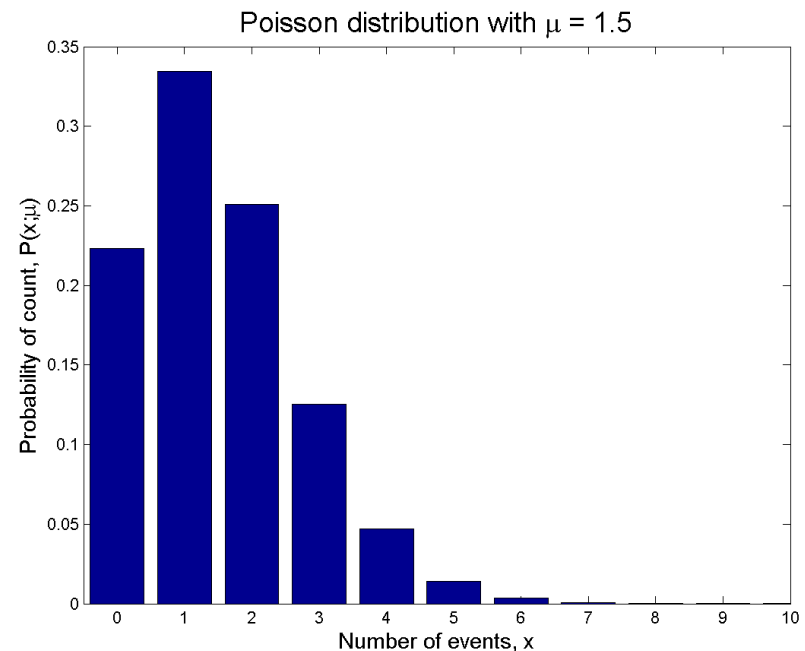
Independent events

- Occurrence of one event does not affect the likelihood of others.
- Radioactive emission of photons by sample of ^{137}Cs

Poisson distribution

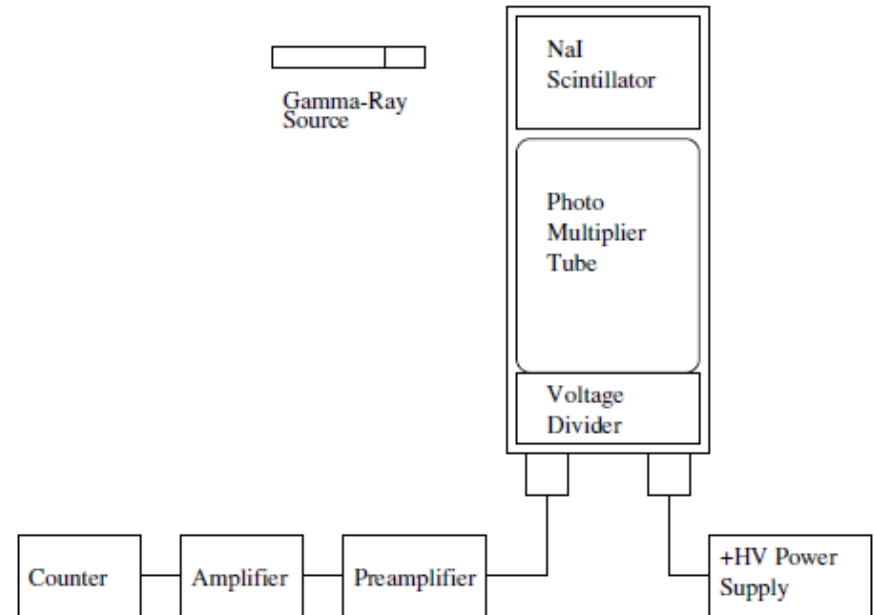
- A process involving independent events with “mean rate”: λ
- Observation period: T
- Expected number of events (“on average”): $\mu = \lambda T$

$$P(x; \mu) = \frac{\mu^x e^{-\mu}}{x!}$$



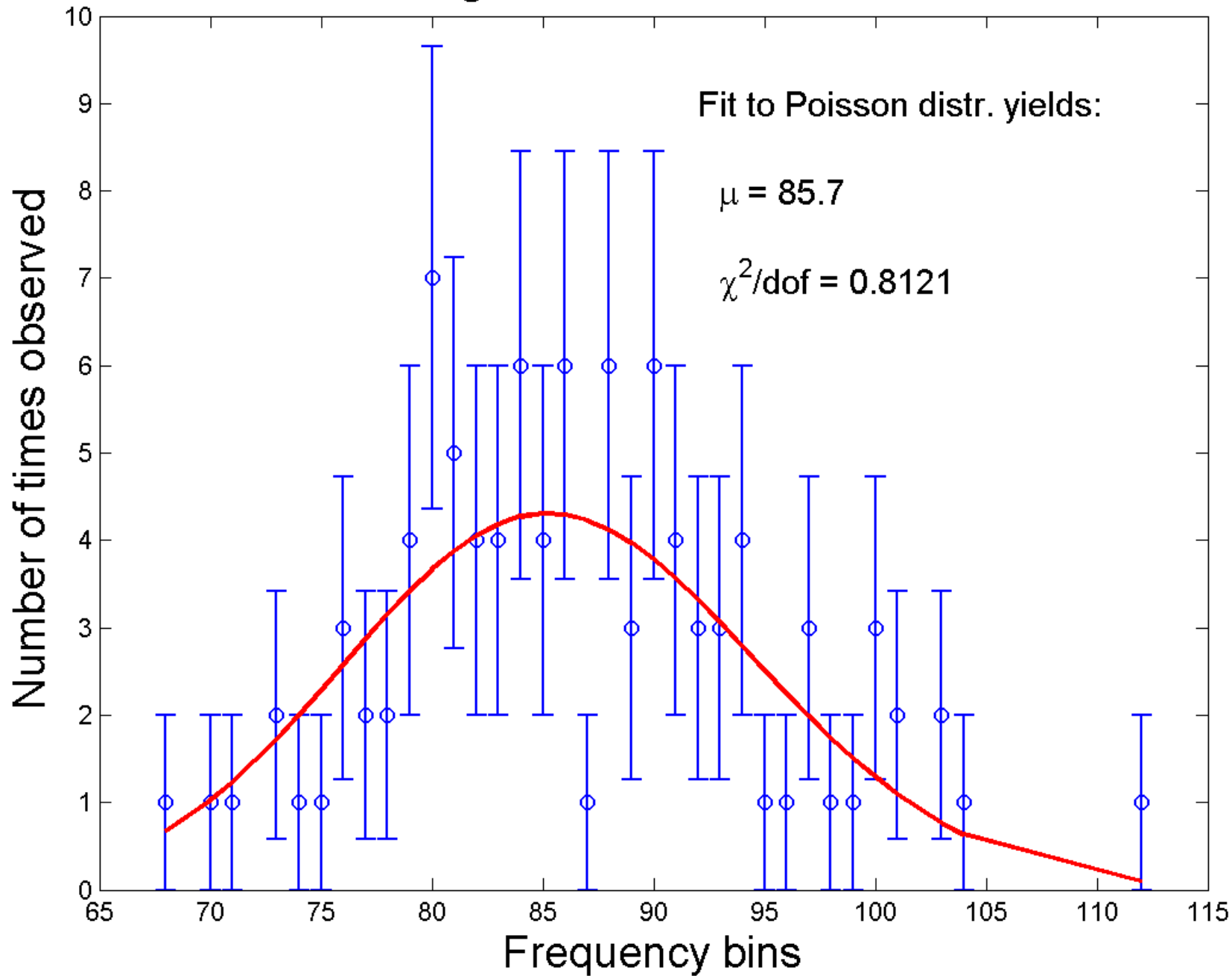
Experimental details

- Main “knobs”:
 - Source-detector distance
 - Amplifier gain



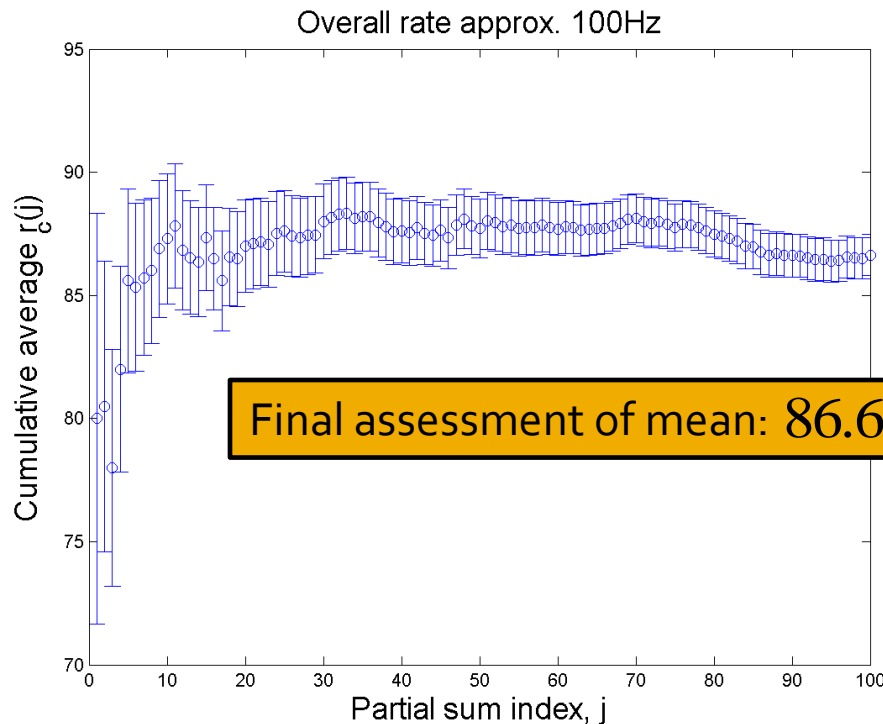
- Configured for counting rates of 1, 4, 10, 100 sec^{-1}
- Took 100 one-second measurements.

Histogram for $\sim 100 \text{ sec}^{-1}$ data



What is the characteristic of the parent distribution?

- The long 100-s measurement yields: $\lambda = 87.5 \text{ sec}^{-1}$
- Confirmed by cumulative averages of 1-second data



Matlab generated Poisson sets

- Measured data set is characterized by: $(\mu, \sigma) = (86.6, 8.34)$
- Reasonable? Given parent Poisson distr: $\bar{\mu} = 87.5$
- Generated 100-element Poisson data sets, to find statistical fluctuations on (μ, σ)

Set #	Mean	Std. dev.	Set #	Mean	Std. dev.
1	87.03	8.09	6	87.87	8.49
2	87.58	8.30	7	88.28	9.95
3	87.89	9.97	8	88.15	8.96
4	86.15	9.87	9	88.32	9.27
5	85.37	7.93	10	88.85	8.81

Does Poisson fit?

- Is (μ, σ) of the measured set typical?

- Measured set:

$$(\mu, \sigma) = (86.6, 8.34)$$

- Simulated set:

$$(\mu, \sigma) = (87.5 \pm 1.0, 9.0 \pm 0.8)$$

- Does $\sigma = \sqrt{\mu}$?

- Measured set:

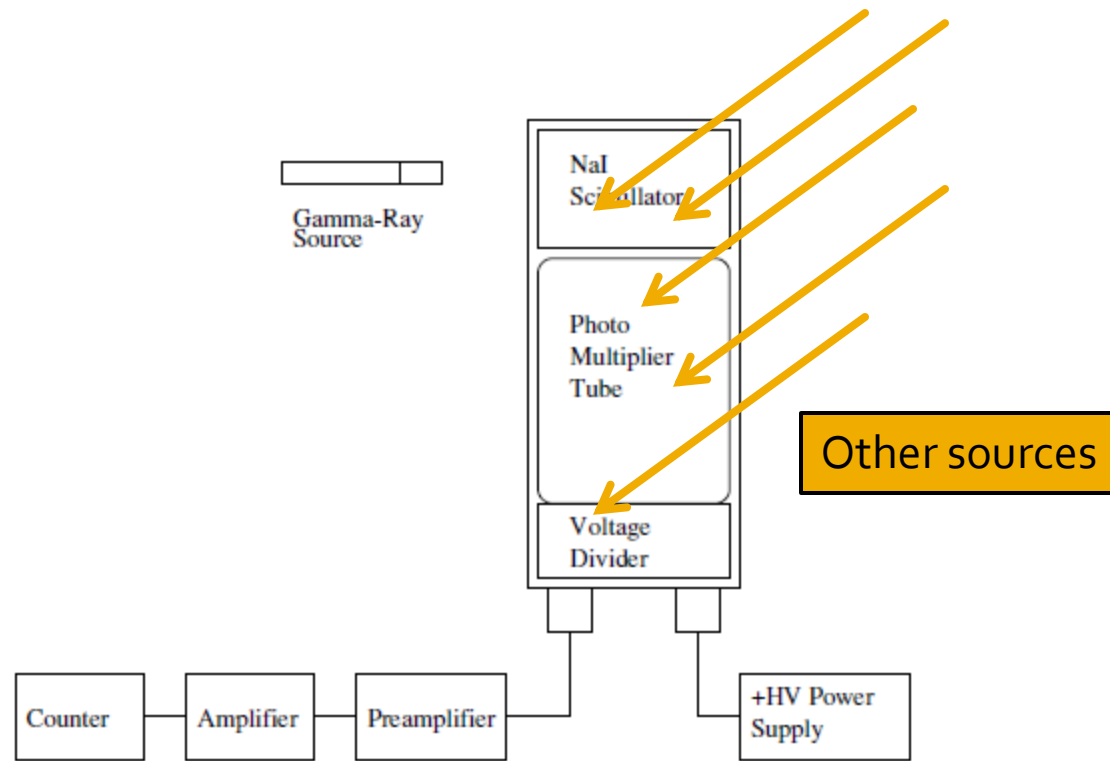
$$\sigma / \sqrt{\mu} = 0.90$$

- Simulated set:

$$\sigma / \sqrt{\mu} = 0.95 \pm 0.08$$

Brief error analysis

- Our expt. and analysis are robust against “hidden sources”



Conclusions

- Counting experiments of emission from Cs.
- Direct fit shows that Poisson distr. describes data well.
- Comparison with Matlab-generated sets show:
 - Data set parameters within statistical fluctuations
 - The relation $\sigma = \sqrt{\mu}$ holds for data