Fano factor

In statistics, the **Fano factor**,[1] like the coefficient of variation, is a measure of the dispersion of a probability distribution of a Fano noise. It is named after Ugo Fano, an Italian American physicist.

The Fano factor is defined as

$$F = \frac{\sigma_W^2}{\mu_W},$$

where σ_W^2 is the variance and μ_W is the mean of a random process in some time window W. The Fano factor can be viewed as a kind of noise-to-signal ratio; it is a measure of the reliability with which the random variable could be estimated from a time window that on average contains several random events.

For a Poisson process, the variance in the count equals the mean count, so $F = 1$ (normalization).

If the time window is chosen to be infinity, the Fano factor is similar to the variance-to-mean ratio (VMR) which in statistics is also known as the index of dispersion.

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Use in particle detection

In particle detectors, the Fano factor results from the energy loss in a collision not being purely statistical. The process giving rise to each individual charge carrier is not independent as the number of ways an atom may be ionized is limited by the discrete electron shells. The net result is a better energy resolution than predicted by purely statistical considerations. For example, if w is the average energy for a particle to produce a charge carrier in a detector, then the relative FWHM resolution for measuring the particle energy E is:[2]

$$R = \frac{FWHM}{\mu} = 2.35\sqrt{\frac{Fw}{E}},$$

where the factor of 2.35 relates the standard deviation to the FWHM.

The Fano factor is material specific. Some theoretical values are:[3]

Si:	0.115
Ge:	0.13
GaAs:	0.12 [4]
Diamond:	0.08

Measuring the Fano factor is difficult because many factors contribute to the resolution, but some experimental values are:

Ar (gas): 0.20 ± 0.01/0.02[5]
Xe (gas): 0.13 to 0.29[6]
CZT: 0.089 ± 0.005[7]

Use in neuroscience

The Fano factor, along with the coefficient of variation, has been used in neuroscience to describe variability in recorded spike trains.

See also

- Fano noise
- Index of dispersion – equivalent to the Fano factor for an infinite time window
- Ugo Fano

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