- Binomial distribution

For p – probability of success, getting n successes in N trials is described by discrete probability distribution

$$P_p(n \mid N) = \frac{N!}{n!(n-N)!} p^n (1-p)^{N-n}$$

- Poisson distribution

It is an approximation to the binomial distribution for small sample sizes n<<N (for a limited detector size, the number of hits n is much smaller than the total number of quanta emitted by the source). Introducing a parameter $\bar{n} = Np$ – expected (average) number of successes (detected particles)

$$P_n = \lim_{N \to \infty} P_p(n \mid N) = \frac{\bar{n}^n e^{-\bar{n}}}{n!}$$

- Gaussian distribution

For a large number of counts (n, $\bar{n}$ >>1, but still <<N) using Stirling's formula, the definition of $n = \bar{n} + \delta n$ and neglecting terms ~δn^2 we obtain

$$P(N) = \frac{1}{\sqrt{2\pi\bar{n}}} e^{-(n-\bar{n})^2 / 2(\bar{n})} = \frac{1}{\sigma\sqrt{2\pi}} e^{-(n-\bar{n})^2 / (2\sigma^2)}$$

You can consult http://mathworld.wolfram.com/BinomialDistribution.html and related pages for the derivations