Combined likelihood analysis of (dwarf galaxy) dark matter searches

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Overview

Preliminaries

- Poissonian probability mass function:

$$P_p(x|\mu) = \frac{\mu^x}{x!} e^{-\mu} \tag{1}$$

— probability to observe x events, when the expectation value is μ.

- **Likelihood function** $\mathcal{L}$ of a model, given some data:

$$\mathcal{L}(\mu|x) = P(x|\mu), \tag{2}$$

The *likelihood* of a model expectation μ, given the data point x, is equal to the *probability* of the data point x, given the expectation value μ.

Profile likelihood analyses

- Simple (1D) case: Assuming

$$\mathcal{L}\left(\vec{\pi} = (p, \vec{n})|\vec{d}\right) \tag{3}$$

with the parameter of interest p and nuisance parameters $\vec{n}$, the *profile likelihood* is defined as:

$$\mathcal{PL}(p_0|\vec{d}) = \frac{\max(\mathcal{L}(p = p_0, \vec{n}))}{\max(\mathcal{L}(p, \vec{n}))}, \tag{4}$$

where the maximization is performed over the *complete* parameter range ($\forall\pi$) for the denominator, but only for the subrange with $p = p_0$ for the numerator.
($\longrightarrow$ "likelihood ratio test statistic")

- Wilks & Co.: $-2\ln(\mathcal{PL})$ approaches $\chi^2(1)$ $\longrightarrow$ possibility to infer parameter ranges / limits.

$\mathcal{L}$ for ACT observations

Two Poisson processes:

- signal
- background

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