μS+B Fit

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Process:

1. Determine the distribution of the signal and background.

2. Use these distribution to generate Asimov data.

3. Fit Asimov data.

$$\mu S+B: \ \mu = \frac{N_{obs}}{N_{exp}}$$

Likelihood Fit Principle:

How to calculate?

Use likelihood model to quantify.

- Signal strength $\mu \equiv \frac{\sigma_{obs}}{\sigma_{exp}}$
- For each bin, $\mathrm{E}(n) = \mu * s_i + b_i$ Poisson
- Basic form:

$$L(\mu) = \frac{(\mu s + b)^n}{n!} e^{-(\mu s + b)}$$

- Add nuisance parameters (NP) to model.
  - besides POI(parameter of interest, here is μ)
  - describe uncertainty, bkg parameterization, …… anything we need.

ATLAS EXPERIMENT Likelihood function: an example ATLAS EXPERIMENT

$$\mathcal{L} = \prod_i \left\{ \frac{e^{-\nu_i}}{n_{i!}} \prod_j^{n_i} [\nu_i^{sig} \mathcal{F}_i^{sig}(m^j, \theta; m_H) + \nu_i^{bkg} \mathcal{F}_i^{bkg}(m^j\ )] \right\} \times \prod_l G_l(\theta)$$

- Function form: $$f = N \cdot \begin{cases} e^{-\frac{1}{2}\alpha_L^2} \cdot \left[\left(\frac{\alpha_L}{n_L}\right)\left(\frac{n_L}{\alpha_L} - [\alpha_L + x]\right)\right]^{-n_L}, x < -\alpha_L \\ e^{-\frac{1}{2}x^2}, \quad -\alpha_L \le x \le \alpha_H \\ e^{-\frac{1}{2}\alpha_H^2} \cdot \left[\left(\frac{\alpha_H}{n_H}\right)\left(\frac{n_H}{\alpha_H} - [\alpha_H - x]\right)\right]^{-n_H}, x > \alpha_H \end{cases}$$
- $\mathcal{F}^{sig}$: pdf(probability distribution function) of signal, describe the signal shape.
- $\mathcal{F}^{bkg}$: pdf of background
- Function minimizes the bias observed in the extracted signal yield
- The bkg model with the least parameters is chosen
- G_l: Uncertainties.

Likelihood Fit Principle:

- Easy to do combination each channels/categories.

Times the subpart directly!

$$L(\mu, \theta) = \prod_i L_i(\mu, \theta_i)$$

- uniformed, simultaneous statistical procedure and framework
- can easily include necessary correlations   Share the same name
- Final model can be very complicated to consider all info from the analysis.

Profile likelihood ratio

ATLAS EXPERIMENT

$$\lambda(\mu) \equiv \frac{L(\mu, \hat{\hat{\theta}})}{L(\hat{\mu}, \hat{\theta})}$$

Maximize L for specified μ

Under NPs with θ

Maximize L

$$0 \leq \lambda \leq 1$$

Larger λ, better agreement data & hypothesis

- Test statistics

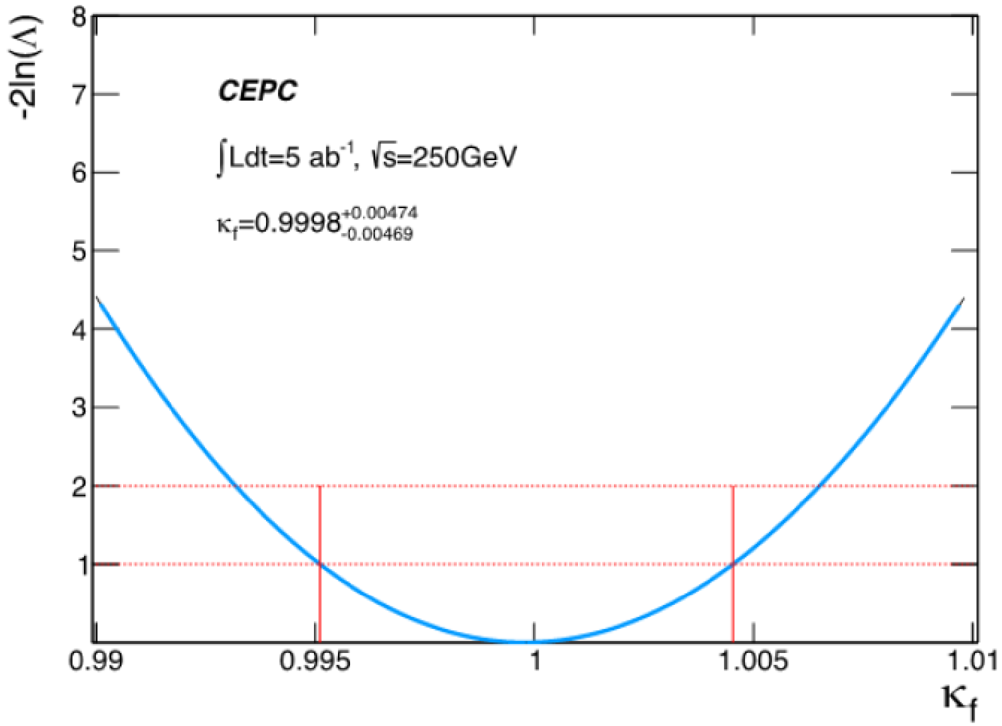
$$q(\mu) \equiv -2 \ln \lambda(\mu)$$

Higher q, less incompatible.

To reject background-only (μ = 0) hypothesis using

- $$q_0 = \begin{cases} -2 \ln \lambda(0) & \hat{\mu} \geq 0 \\ 0 & \hat{\mu} < 0 \end{cases}$$

Fit method: likelihood scan



Deviation at 1σ : precision Δμ

Deviation at (1.95) σ : upper limit at 95% C.L.

Fit result:

```
All fits done in 0.01 min (cpu), 0.02 min (real)

  Fit Summary of POIs ( STATUS OK )
-----------------------------------------------
RooRealVar::qz4v = 1.00003 +/- (-0.995064,0.997171)  L(-5 - 5)
```

μ σ

At 95% Confidence level, the upper limit of Br is $(\mu + 2\sigma)$Br.
Here, the value is 0.32%.

σ is statistical error.