Preliminary Studies

Combinations: weighted fit, errors-on-errors

Adil Jueid

Institute for Basic Science

Pythia week (29 Apr. - 3 May 2024)

Issues in tuning efforts

- Tension between different measurements (see 2303.11363 for more details).

  For example, at LEP experiments, different methods of measuring particle spectra:

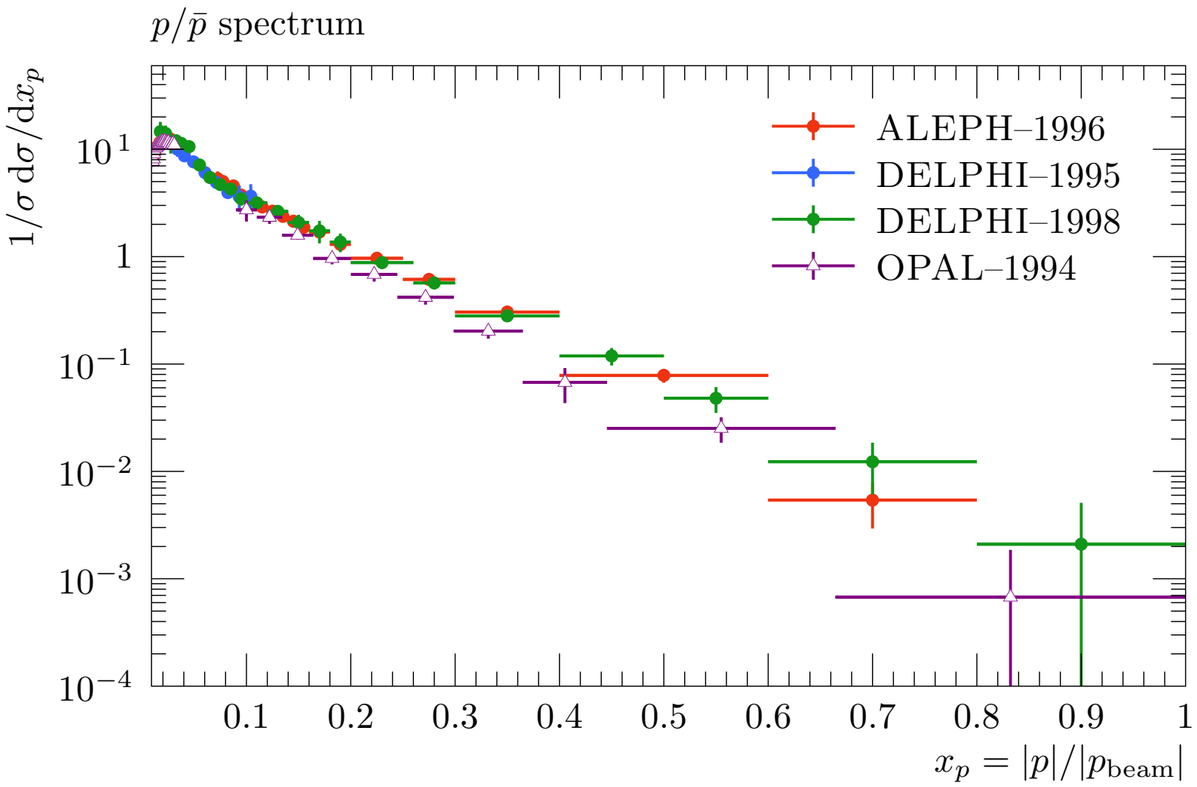
  - **ALEPH** and **OPAL** use simultaneous measurement of hadron momentum and differential energy loss in Time Projection chamber (TPC).

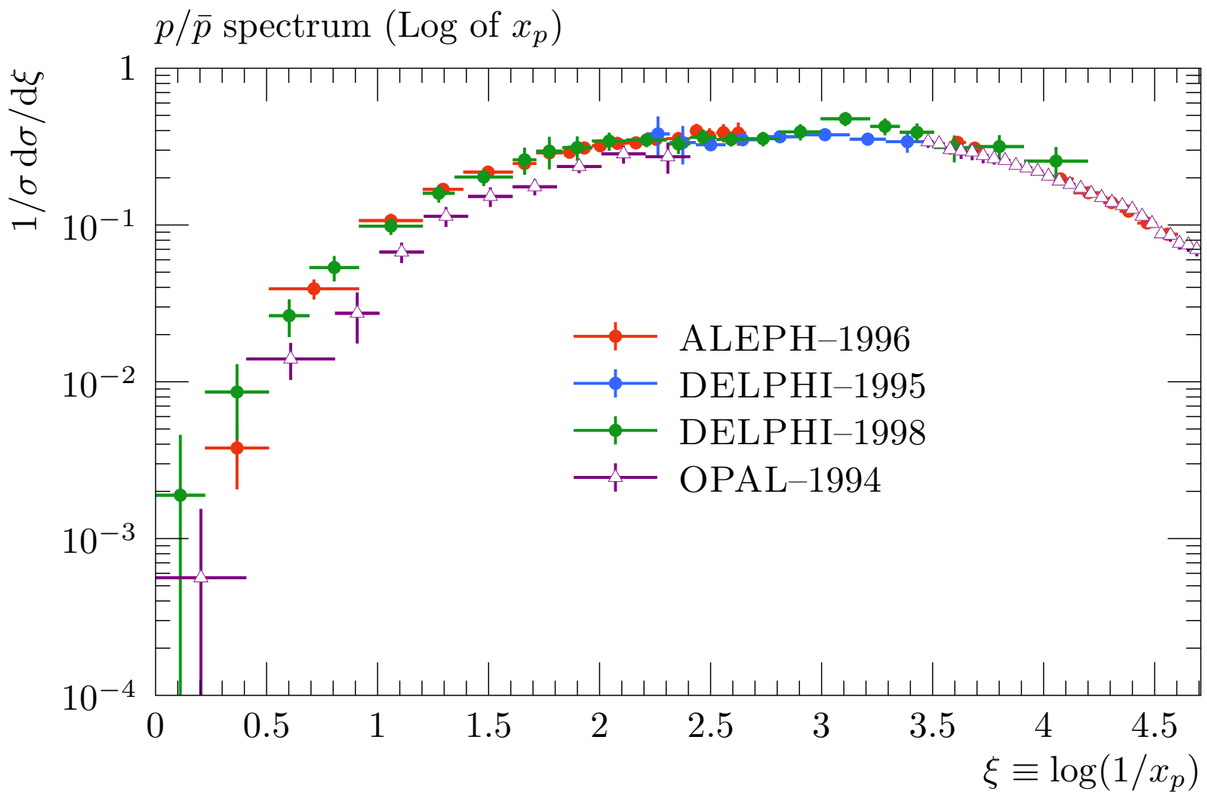
  - **DELPHI** relies on the measurement of the ionization angle in Ring Imaging CHerenkov (RICH) detector.

- Systematic uncertainties may be underestimated (?).
- Large correction factors have been applied in some LEP measurements using theory predictions.

- We usually simultaneously add a 5% flat uncertainty on the MC prediction and remove some measurements from the fits.

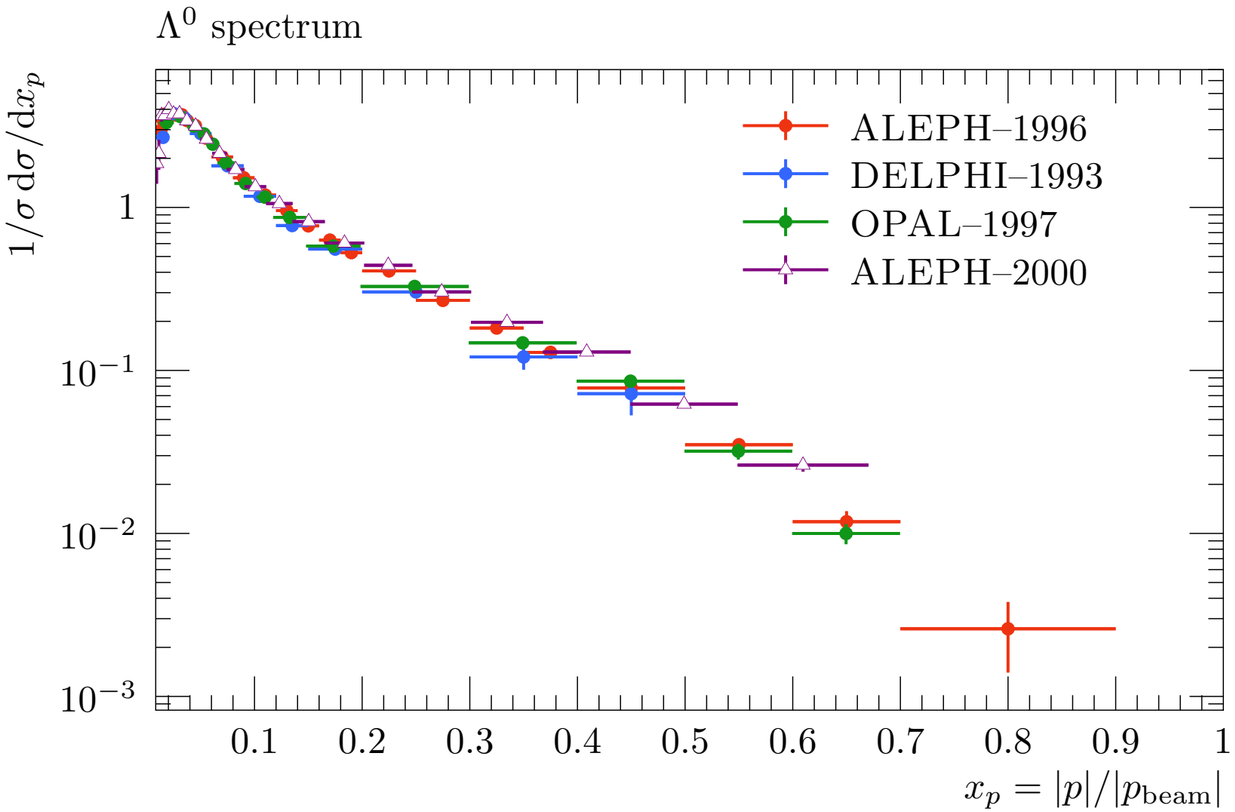
Example: Baryon spectra at LEP

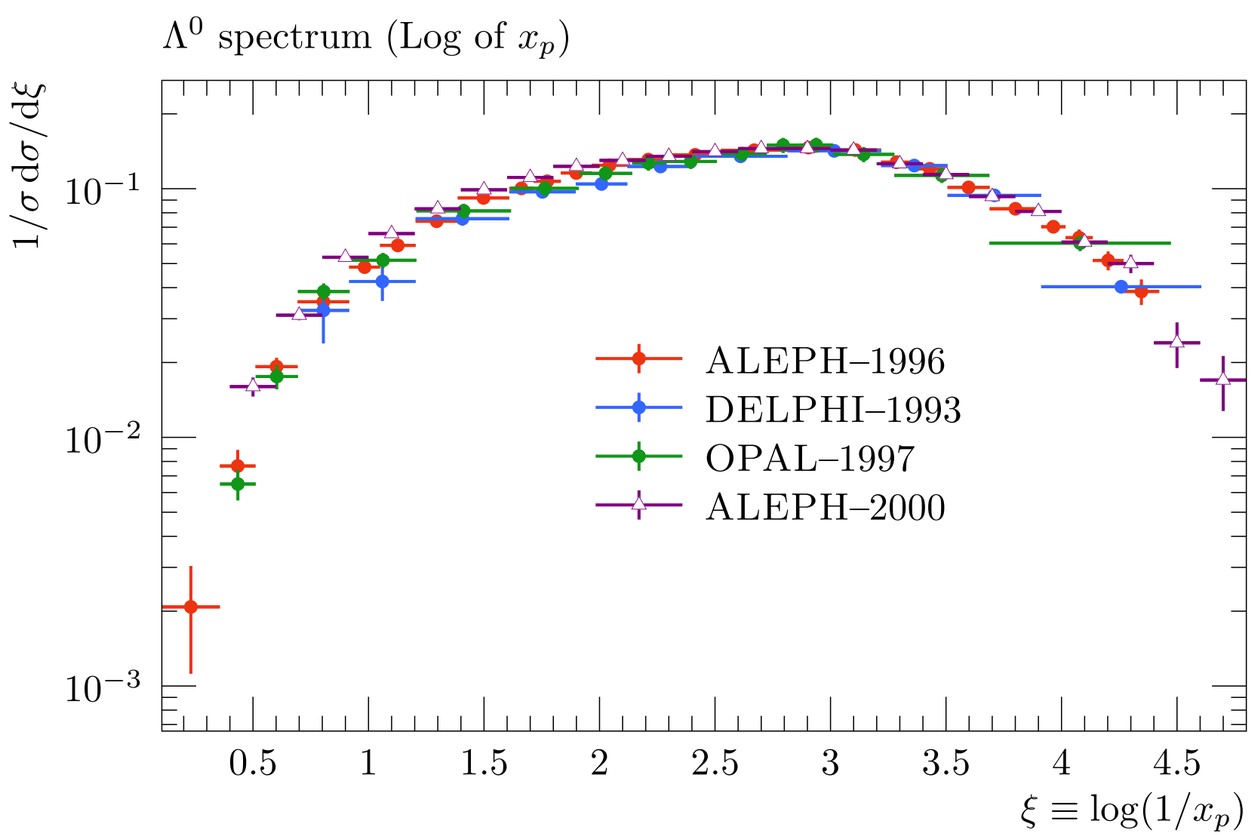




OPAL—1994 is not consistent with the other measurements for $x_p \geq 0.1$

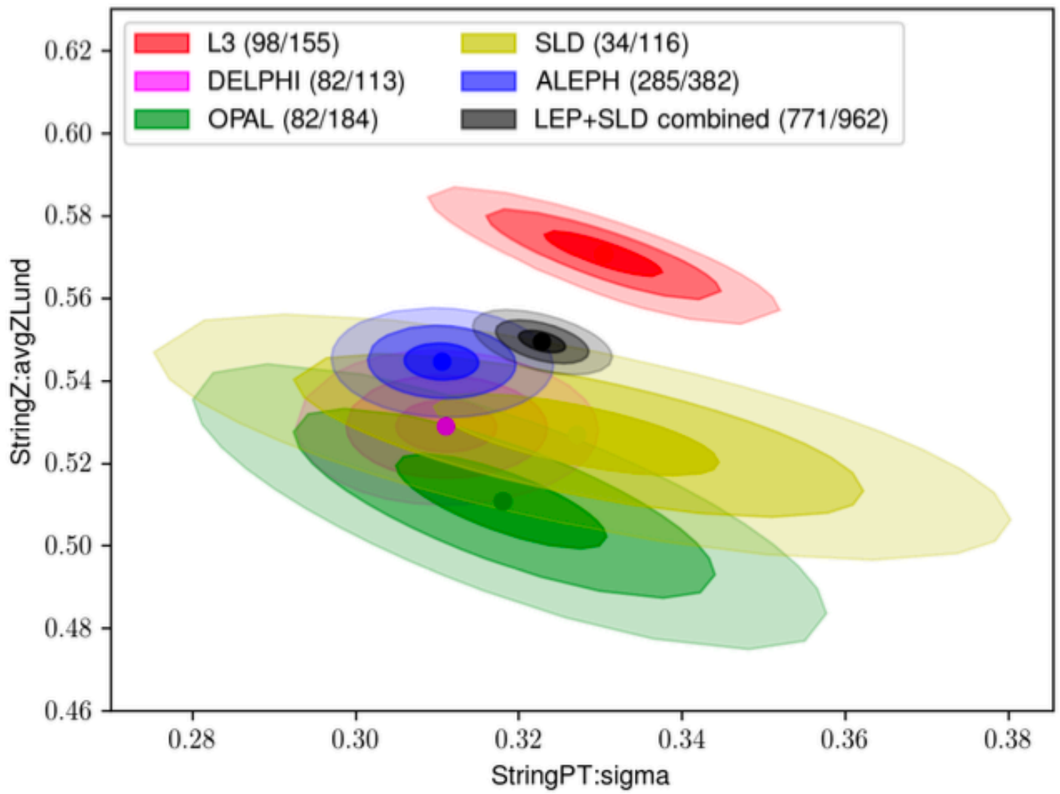
Example: Baryon spectra at LEP

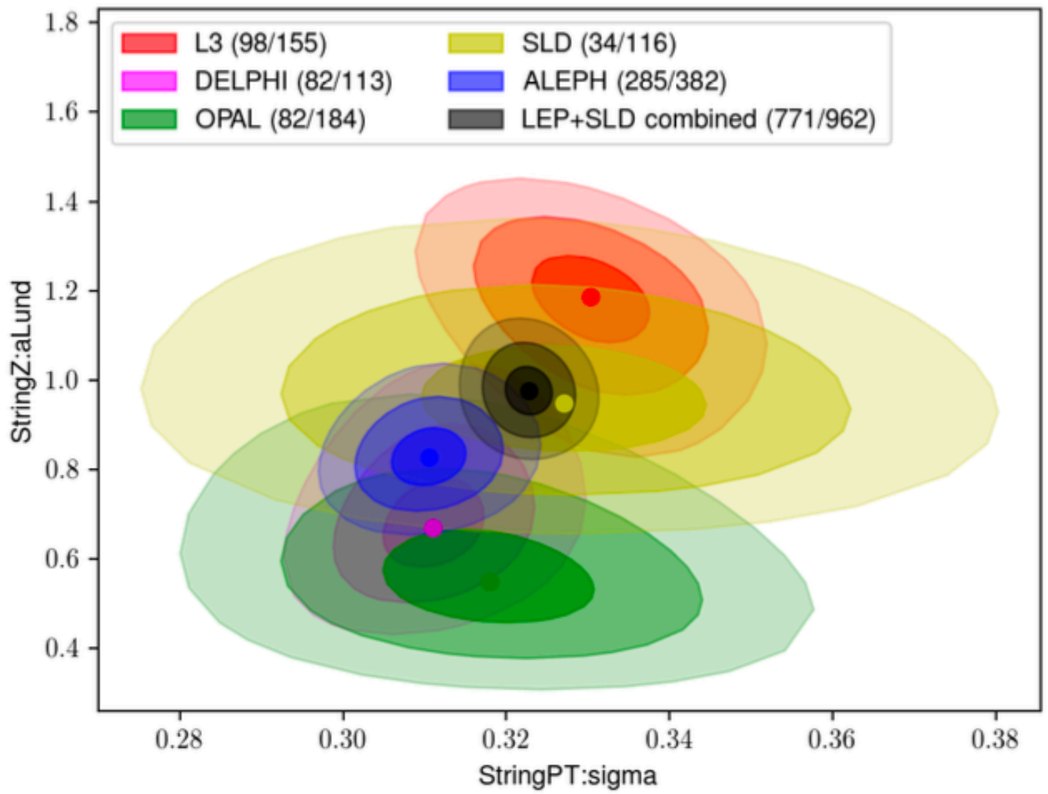




ALEPH–2000 is slightly above the other measurements for high-x

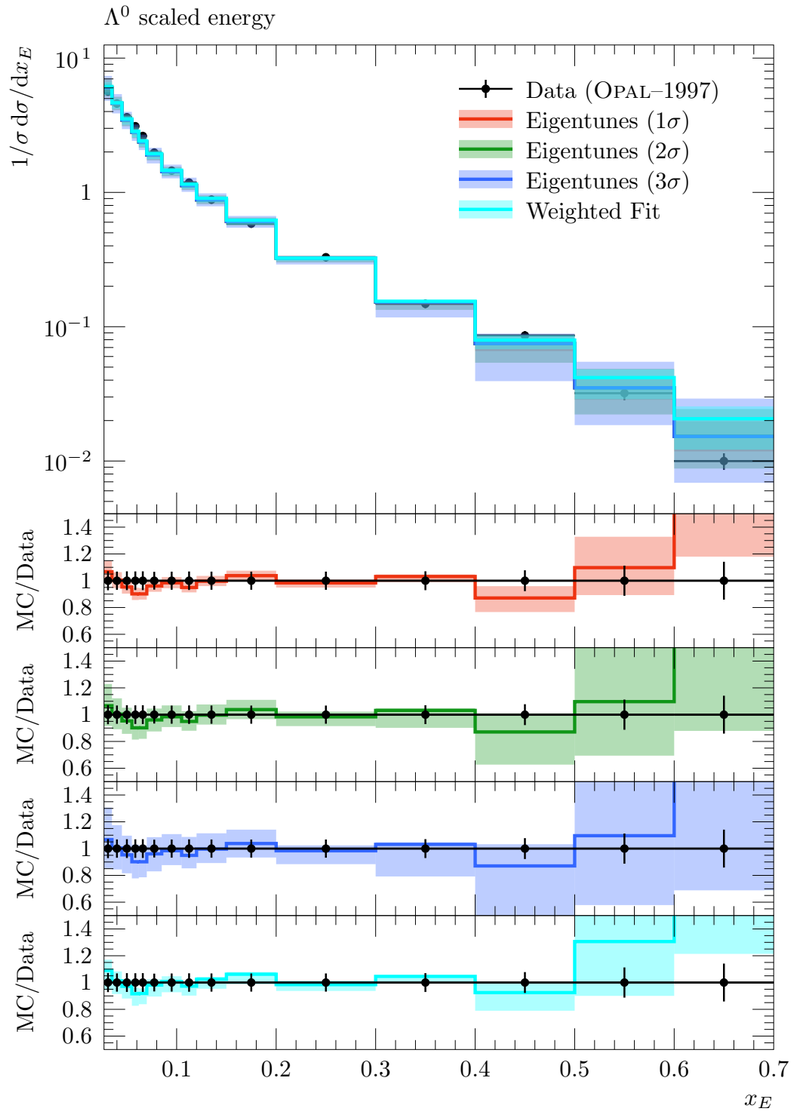
Tensions in input may lead to tensions in output

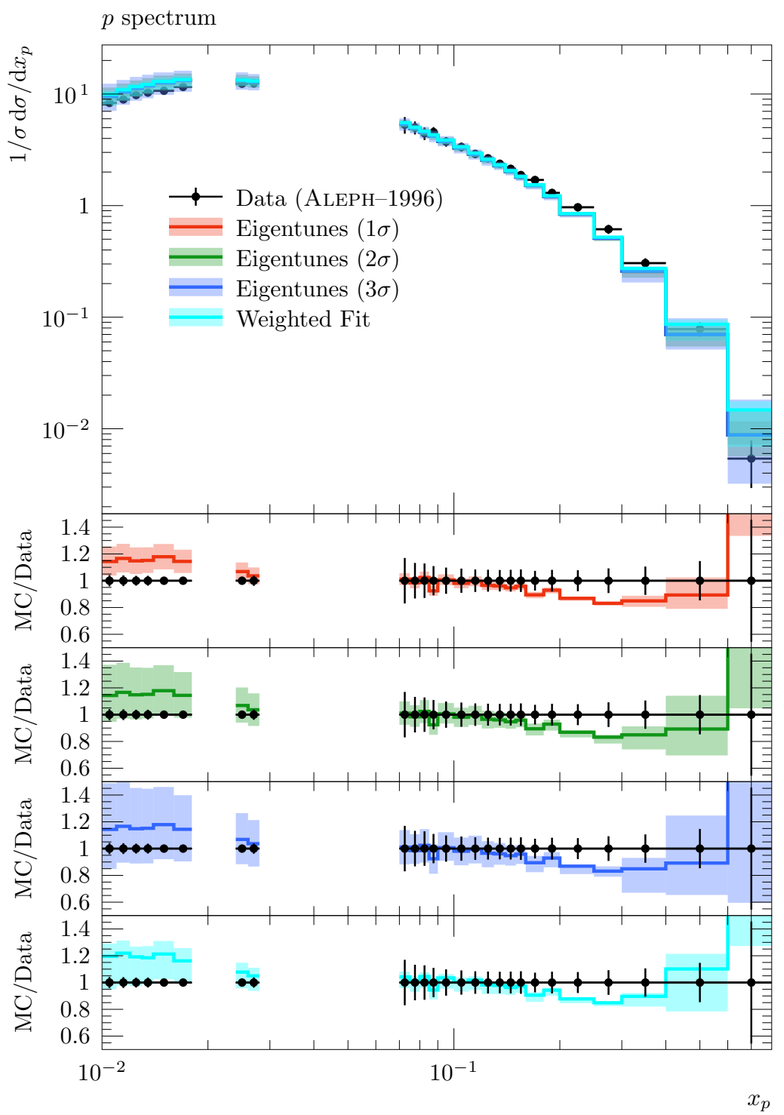




S. Amoroso, S. Caron, A.J., R. Ruiz de Austri, P. Skands, 1812.07424

Large uncertainties on the fitted parameters?





AJ, J. Kip, R. Ruiz de Austri, P. Skands, 2303.11363

Weighted fit

Consider n measurements that lead to n determinations of a parameter p ($p_i \pm \sigma_i$). The total χ^2 of the variable p is can be given as

$$\chi^2 = \sum_{i=1}^{n} \frac{(p - p_i)^2}{\sigma_i^2}$$

Differentiating χ^2 with respect to p gives $\left.\frac{\partial \chi^2}{\partial p}\right|_{p=\hat{p}} = 0 \Longrightarrow \hat{p} = \frac{\sum_i p_i \sigma_i^{-2}}{\sum_i \sigma_i^{-2}}$

The variance is obtained from double differentiation of χ^2 $\Longrightarrow \sigma_{\hat{p}} = \frac{1}{\sqrt{\sum_i \sigma_i^{-2}}}$

The value of $\sigma_{\hat{p}}$ is driven by the measurement with the smallest error on p

$\Longrightarrow$ Inflate it by some factor to ensure consistency between the different measurements.

Preliminary results with Errors-on-errors formula

The Log-likelihood is modified if we take into account some uncertainty on the systematic uncertainties (theory or experimental).

Refs:

talk of Enzo and Glen, G. Cowan, 1809.05778, E. Canonero, A. E. Brazzale, G. Cowan, 2304.10574

$$\chi^2_{5\%} = \sum_i \frac{(\mathrm{Data}_i - \mathrm{MC}_i)^2}{\sigma_i^2} \rightarrow \sum_i \left(1 + \frac{1}{2\epsilon_i^2}\right) \times \log\left(1 + 2\epsilon_i^2 \frac{(\mathrm{Data}_i - \mathrm{MC}_i)^2}{\sigma_i^2}\right)$$

$$\sigma_i^2 = \sigma_{i,\mathrm{exp.}}^2 + \sigma_{i,\mathrm{stat.}}^2 + (0.05 \times \mathrm{MC}_i)^2$$

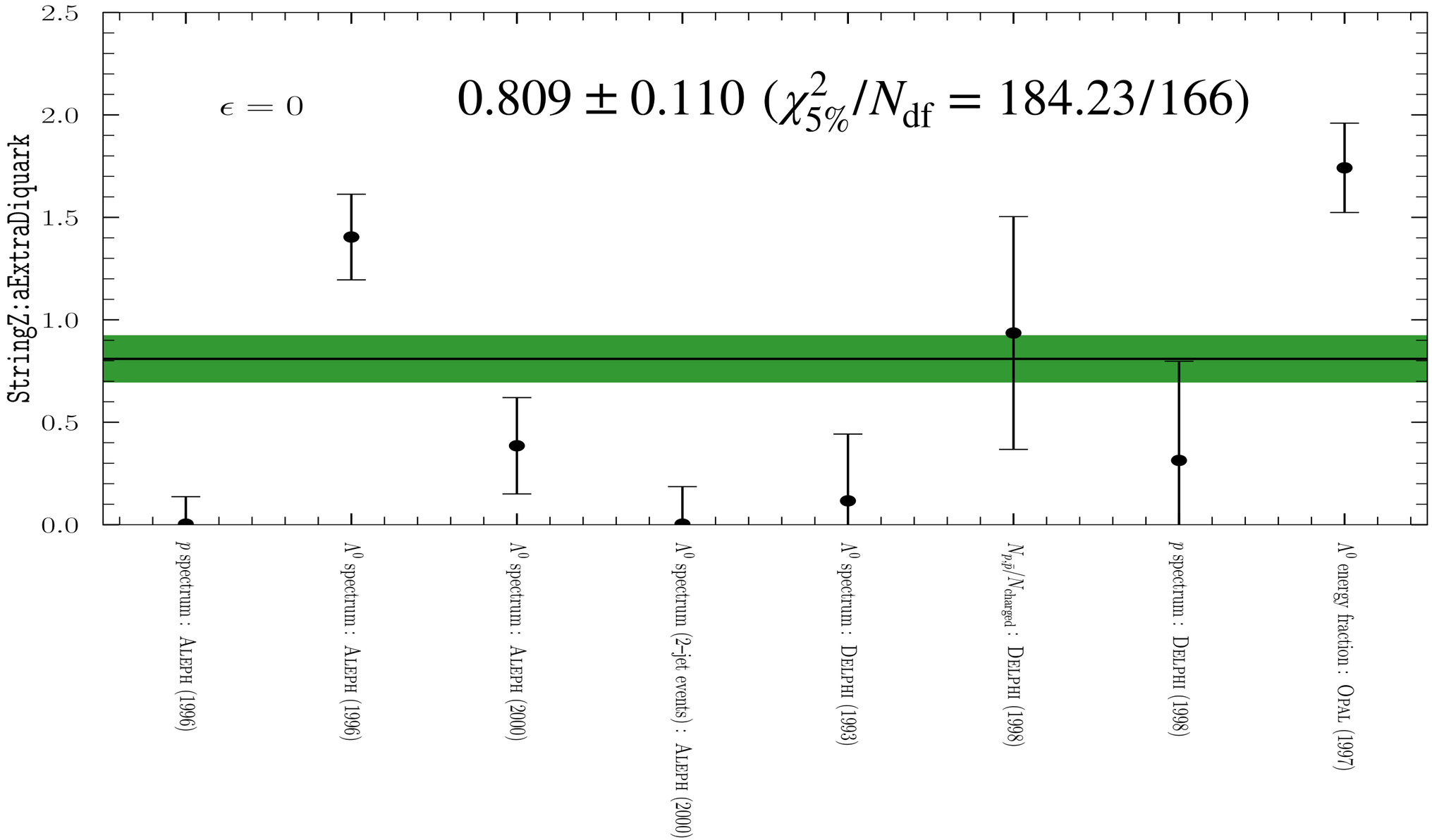
ϵ_i quantifies the degree of uncertainty on σ_i^2

Example: StringZ:aExtraDiquark

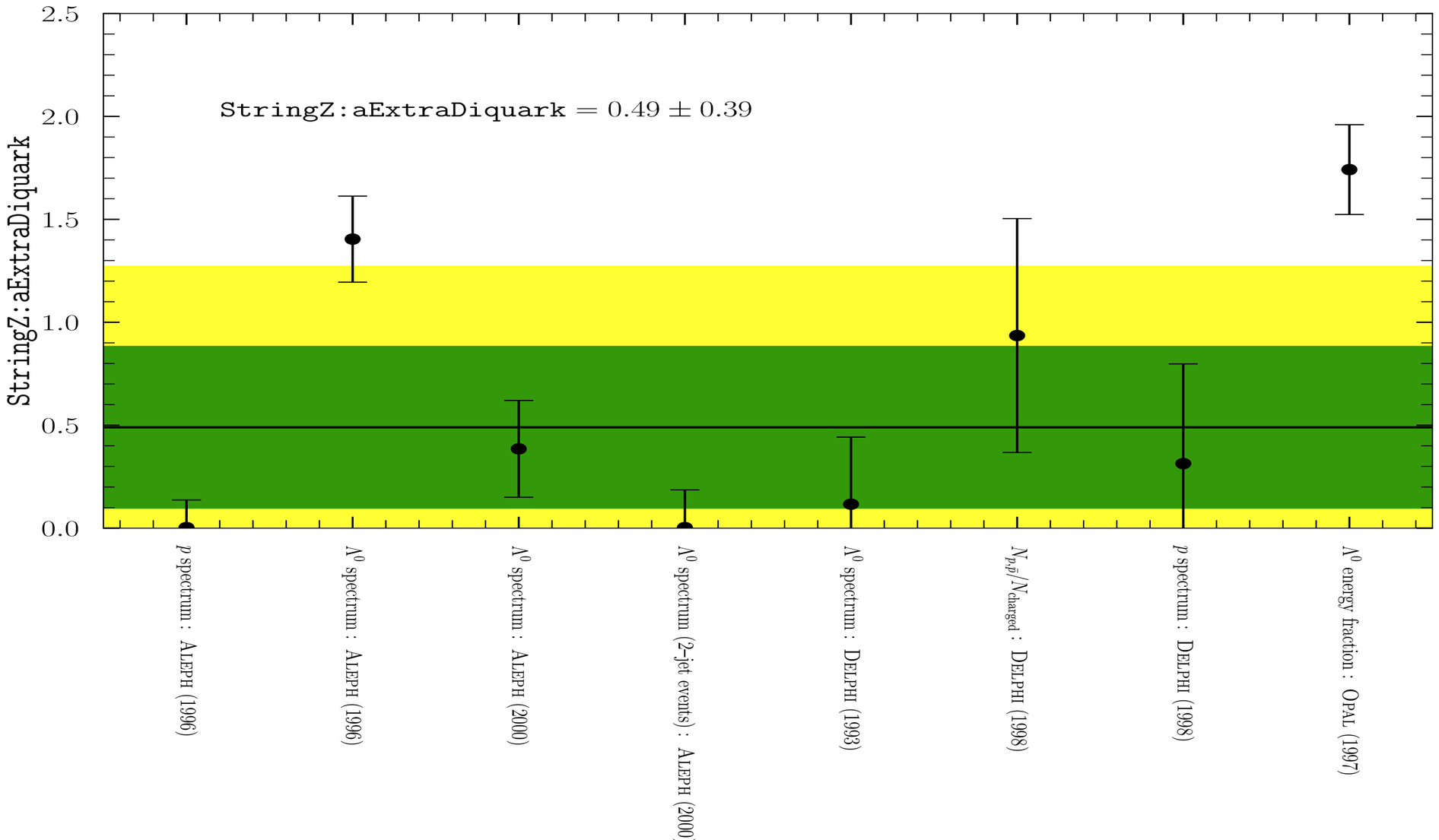
We consider a simple example of the determination of StringZ:aExtraDiquark (with the VINCIA shower algorithm instead of the simple Pythia shower)
We include 8 measurements of baryon spectra at LEP-I.

Measurement	`StringZ:aExtraDiquark` $\chi^2_{5\%}/N_{\mathrm{df}}$	
p spectrum (ALEPH_1996_S3486095)	0.003 ± 0.134	38.51/25
Λ^0 spectrum (ALEPH_1996_S3486095)	1.404 ± 0.209	11.30/24
Log of Λ^0 scaled momentum (ALEPH_2000_I507531)	0.385 ± 0.235	23.04/21
Log of Λ^0 scaled momentum in 2-jet events (ALEPH_2000_I507531)	0.003 ± 0.183	22.30/21
Λ^0 spectrum (DELPHI_1993_I360638)	0.116 ± 0.326	12.40/10
$N_{p/\bar{p}}/N_{\mathrm{charged}}$ vs momentum (DELPHI_1998_I473409)	0.936 ± 0.568	6.09/22
p spectrum (DELPHI_1998_I473409)	0.314 ± 0.484	8.31/22
x_E of Λ^0 (OPAL_1997_S3396100)	1.742 ± 0.218	11.20/14

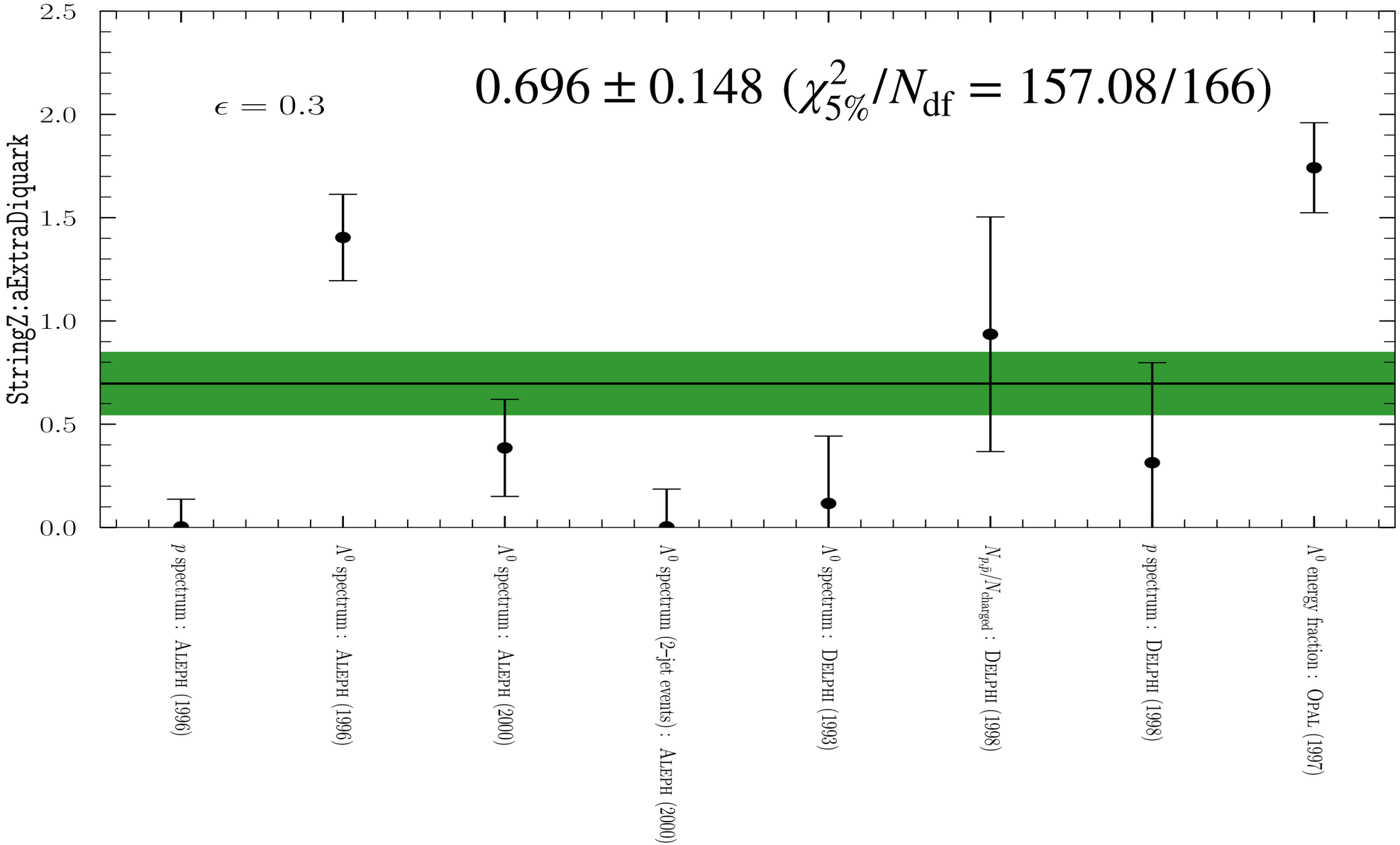
Results: Simple combination



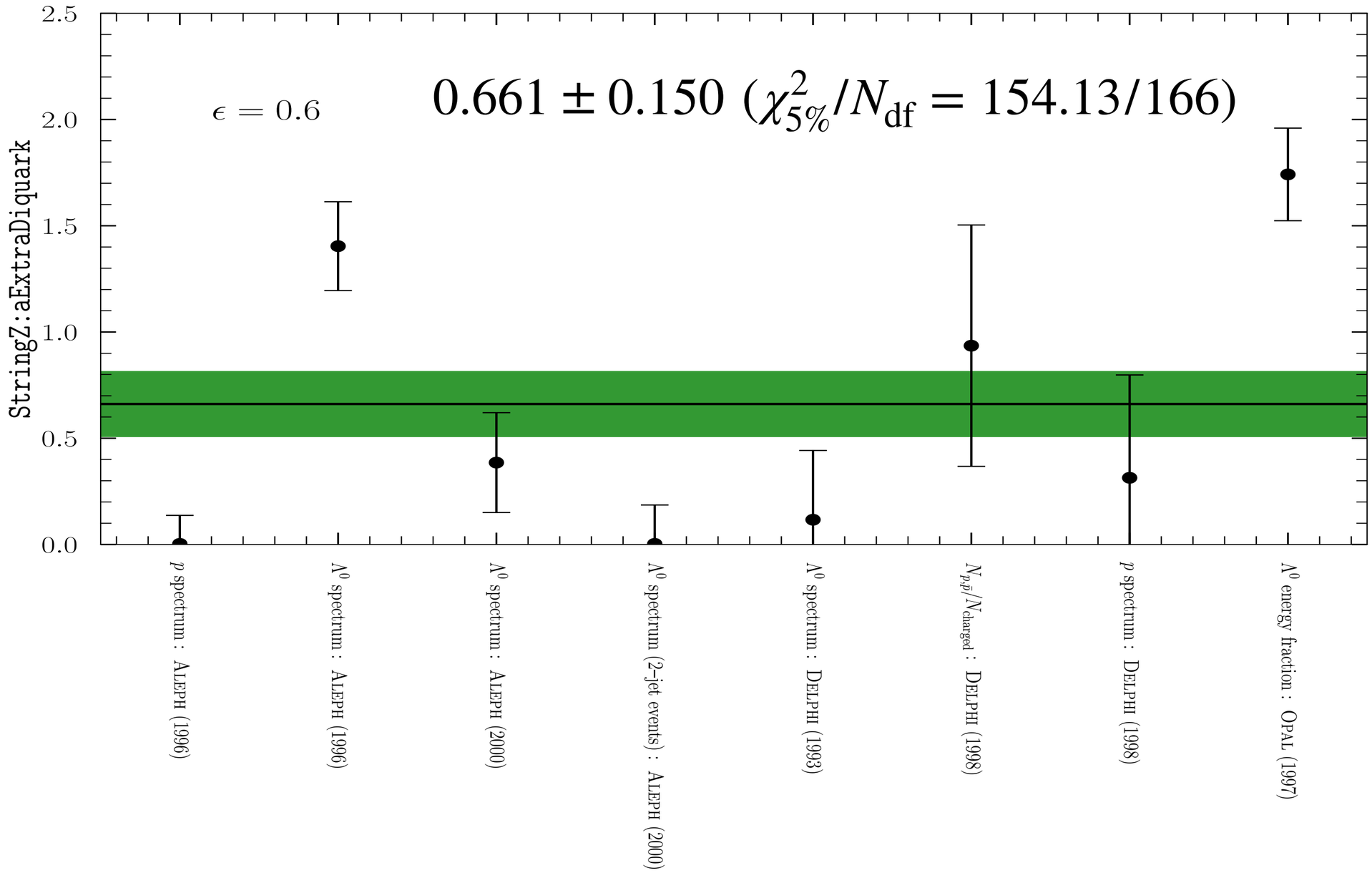
Results: weighted fit



Results: Errors on errors



Results: Errors on errors



Thank you for your attention