

Blind analysis in *TWIST*

2003 Fall Meeting of the DNP of the APS

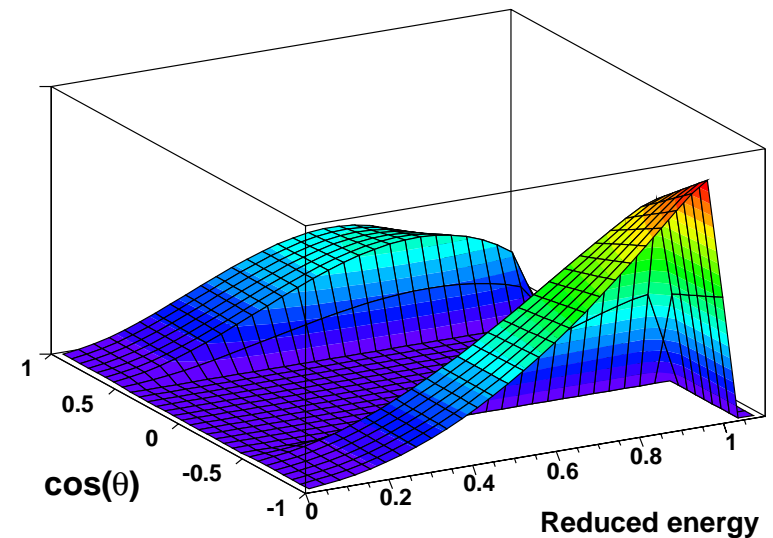
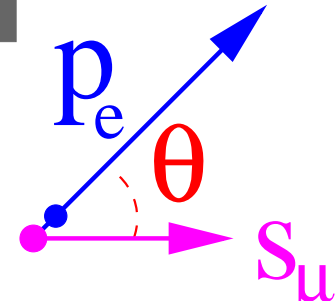
Andrei Gaponenko

- What *TWIST* measures
- Blind analysis motivation
- Existing methods
- The *TWIST* implementation
- Conclusion

What *TWIST* measures

Muon decay parameters define the **shape** of the spectrum

$$\begin{aligned} \frac{d^2\Gamma}{x^2 dx d\cos(\theta)} &\propto 1-x + \frac{2}{9}\rho(4x-3) \\ &+ \frac{1}{3}P_\mu \cos(\theta) \xi(1-x) \\ &+ \frac{2}{9}P_\mu \cos(\theta) \xi\delta(4x-3) \end{aligned}$$



Fitting the shape

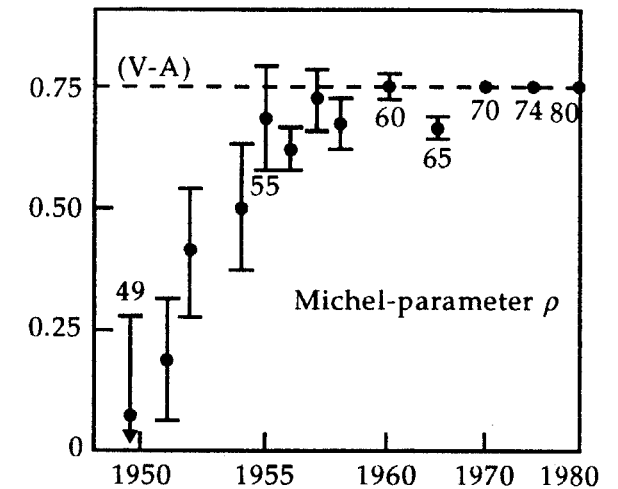
Need to take into account detector response. The technique:

$$\underbrace{n_i(\rho_{\text{Data}})}_{\substack{\uparrow \\ \text{Data}}} = \underbrace{n_i(\rho_{\text{MC}})}_{\substack{\uparrow \\ \text{MC}}} + \frac{\partial n_i}{\partial \rho} \underbrace{(\rho_{\text{Data}} - \rho_{\text{MC}})}_{\substack{\uparrow \\ \text{Fit parameter}}}$$

- Many effects of **reconstruction** cancel.
- **Monte-Carlo** must reproduce effects of the detector.
 - ▷ But spectrum distortions by the thin detector are **small**.

Motivation for blind analysis

- Tool to eliminate **human systematics**: avoid (even subconscious) biases.
- The method: Keep the final result hidden till the measurement is done.
- The value of a measurement does not contain any information about its correctness!



W. Greiner, B. Müller,
Gauge theory of weak interactions,
Springer (1996)

Blind analysis methods

- The hidden signal box method (rare decays): blind the dataset.
- The hidden offset method (precision measurements—BaBar, KTeV): secret bias in fitter code. Need also to bias plotted distributions.

TWIST requirements

- Hard to break
- Can look at (all) data
- Do not exclude *TWIST* members from doing any part of analysis.
- Convenient.
- Minimum modifications to the existing software.

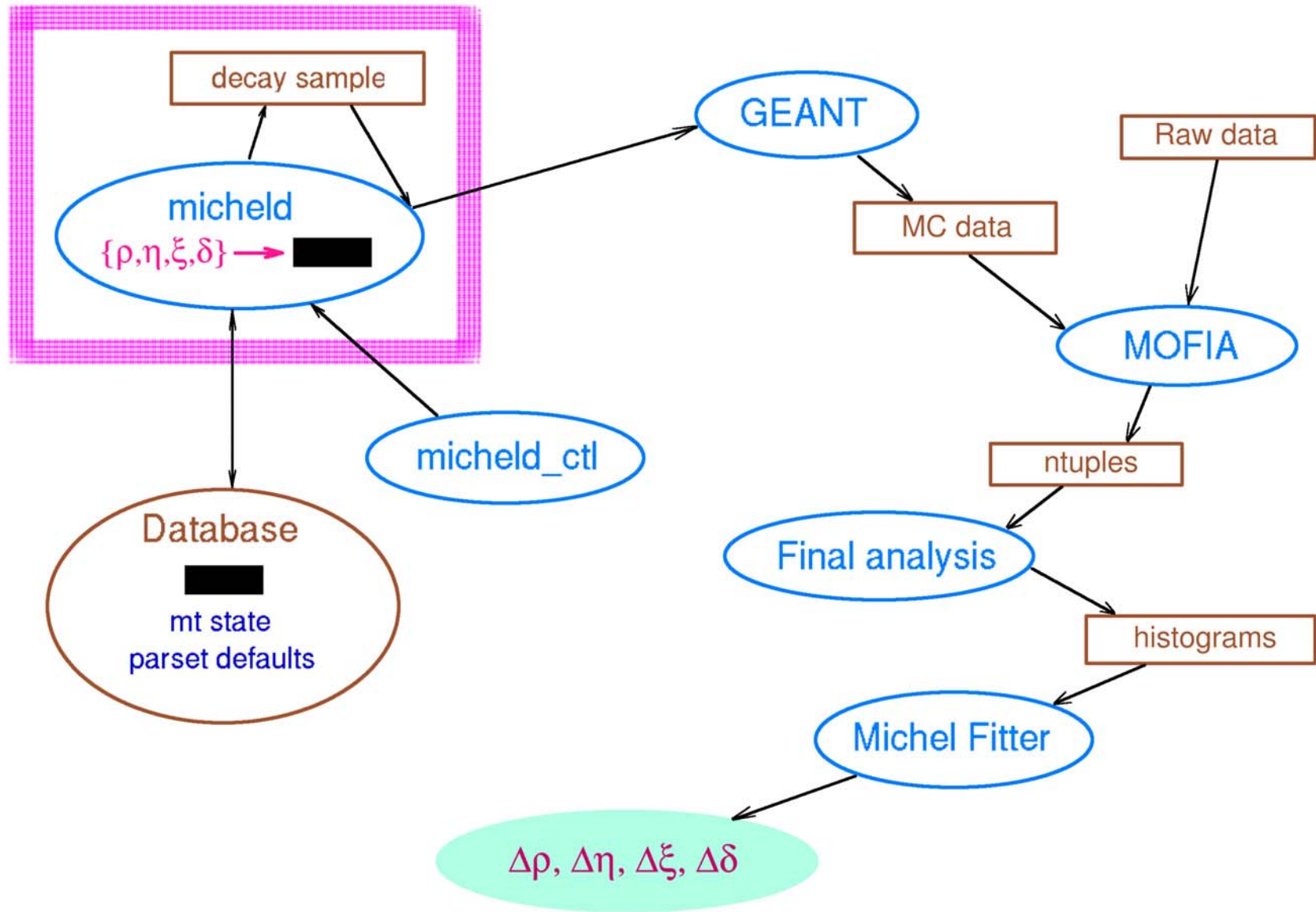
TWIST implementation

The idea:

$$n_i(\rho_{\text{Data}}) = n_i(\rho_{\text{MC}}) + \frac{\partial n_i}{\partial \rho} \Delta \rho$$

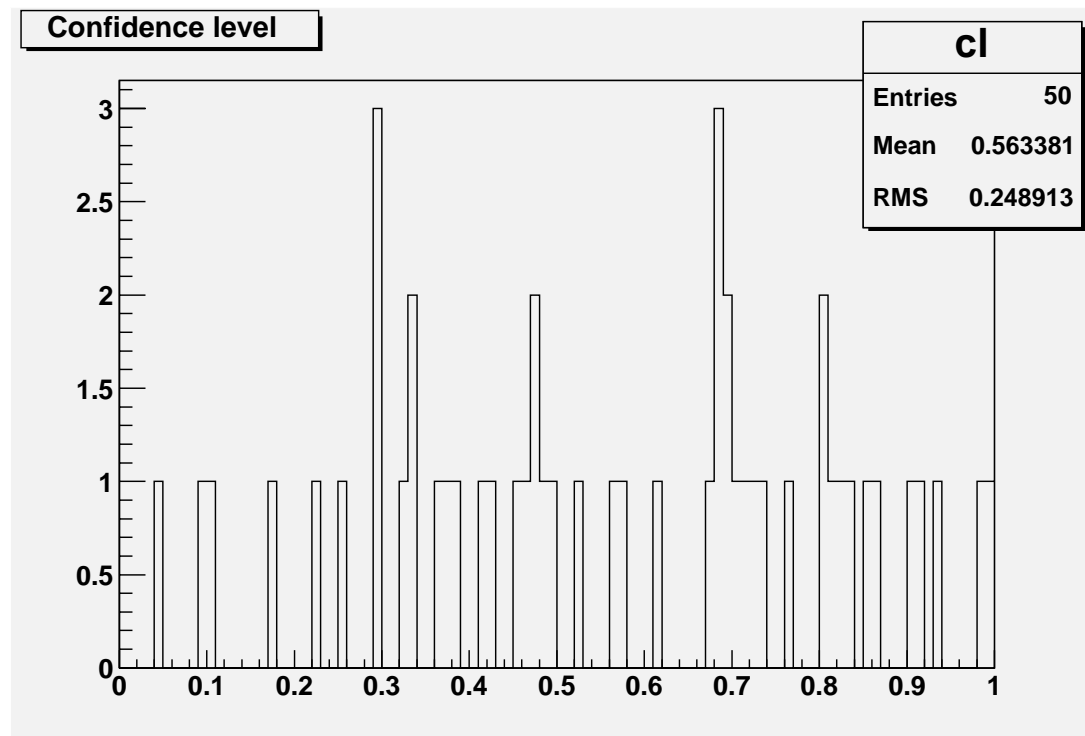
- **Blind MC samples**, not the fitter.
- Use public key cryptography to encrypt the “secret” values.
- Clear text values are known only to a process running on a server which is not accessible by *TWIST* people.
- Keep and re-use generated decay samples. We do not know the secret parameters, but know that they do not change between MC productions.

Implementation-3



Tests

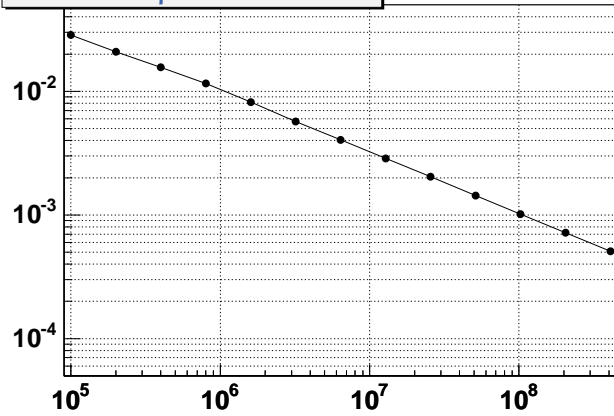
2×50 samples of 10^8 decays, plus
 4×50 derivative spectra of 10^7 decays



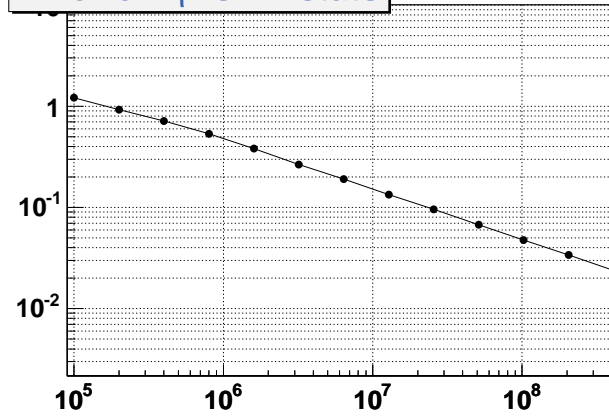
Confidence level of the fits

Tests-2

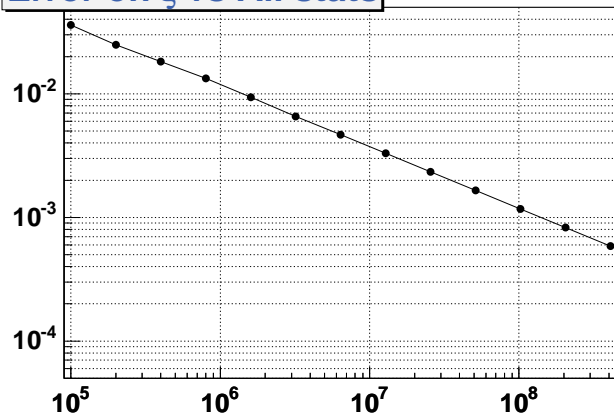
Error on ρ vs All stats



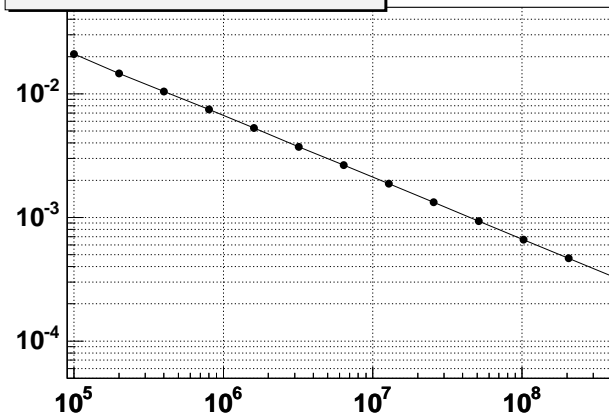
Error on η vs All stats



Error on ξ vs All stats



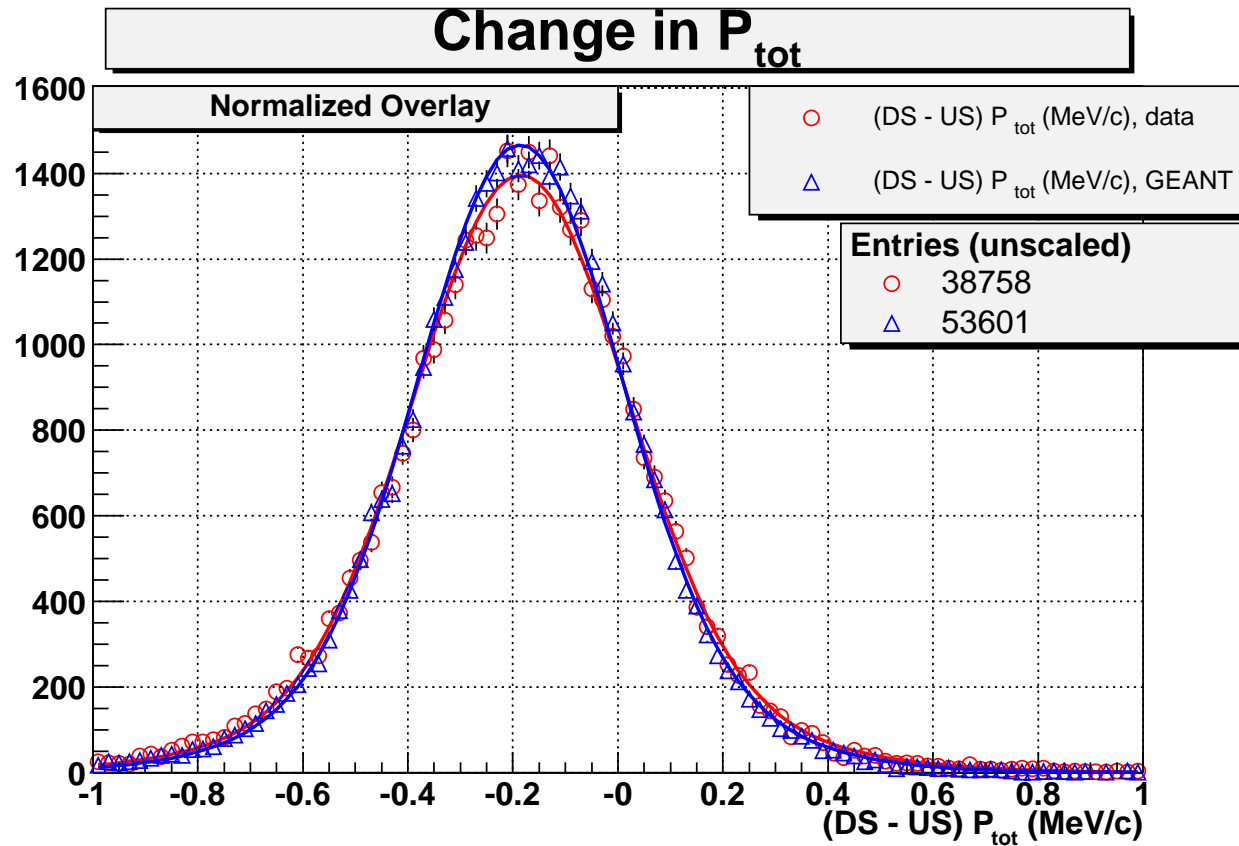
Error on δ vs All stats



Conclusion

- Blind analysis makes the result more valuable.
- Can be done naturally in *TWIST*.
- A new blind analysis scheme is implemented and being used in *TWIST*.

Example of MC validation



Overlay of Δp distributions from DATA and GEANT for the “half stack” technique. (By Rob MacDonald.)