Update on Kinematic Fits

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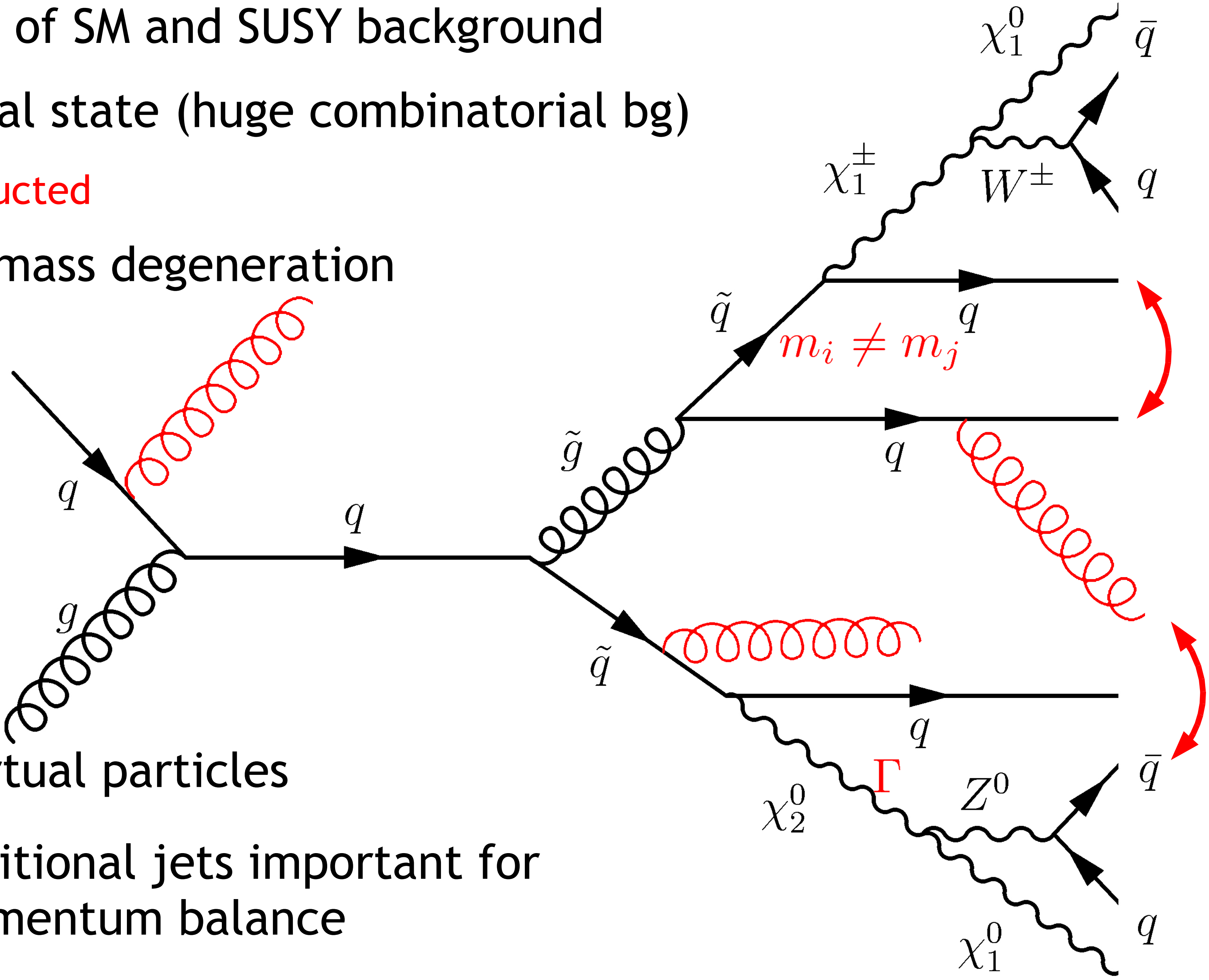
Uni HH – Susy Group Meeting - 17th February 09

Potential Problems

- Suppression of SM and SUSY background
- 7 jets in final state (huge combinatorial bg)
  - all reconstructed
- No perfect mass degeneration



- Width of virtual particles
- +FSR
- +ISR

} additional jets important for momentum balance

Commonly Used Approach

- Constrained fitting via Lagrangian Multiplier

$$\sum_{i=1}^{N_m} \left(\frac{m_i - t_i}{\sigma_i} \right)^2 + 2 \cdot \sum_{i=1}^{N_c} \lambda_i \cdot f_i$$

- Find extremum where all derivatives vanish
- If constraints are linear find perfect solution within one Gauss-Newton step
- Invariant mass constraints are (highly) non-linear → linearization and iterative approach
- **General problem:** Fit can converge at local (and not global) minimum

Alternative Approach

- Formulation of constraints as additional χ^2 term → "cost function"
- To interpret cost function as χ^2 all correlations have to be taken into account

$$\left(\frac{M_{\text{inv}}(j_1, j_2, j_3) - M}{\sigma}\right)^2$$

with

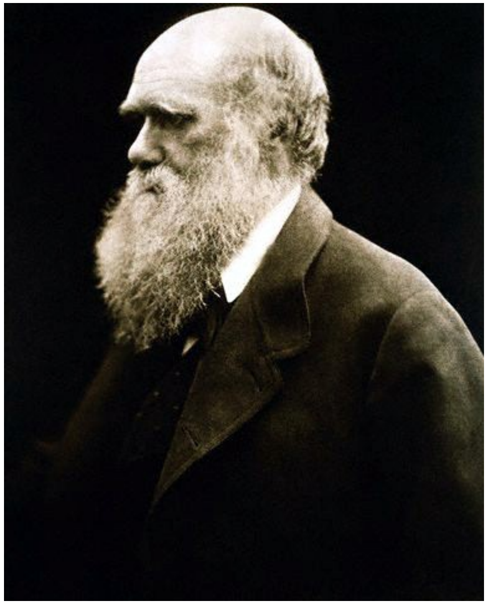
$$\sigma^2 = \sum_{i=1}^{N_m} \left(\frac{\partial M_{\text{inv}}}{\partial i}\right)^2 \cdot \sigma_i^2 + \Gamma_m^2$$

- Minimize cost function: many possible algorithms (gradient, simplex, LBFGS, simulated annealing ... genetic algorithm)

Genetic Algorithm

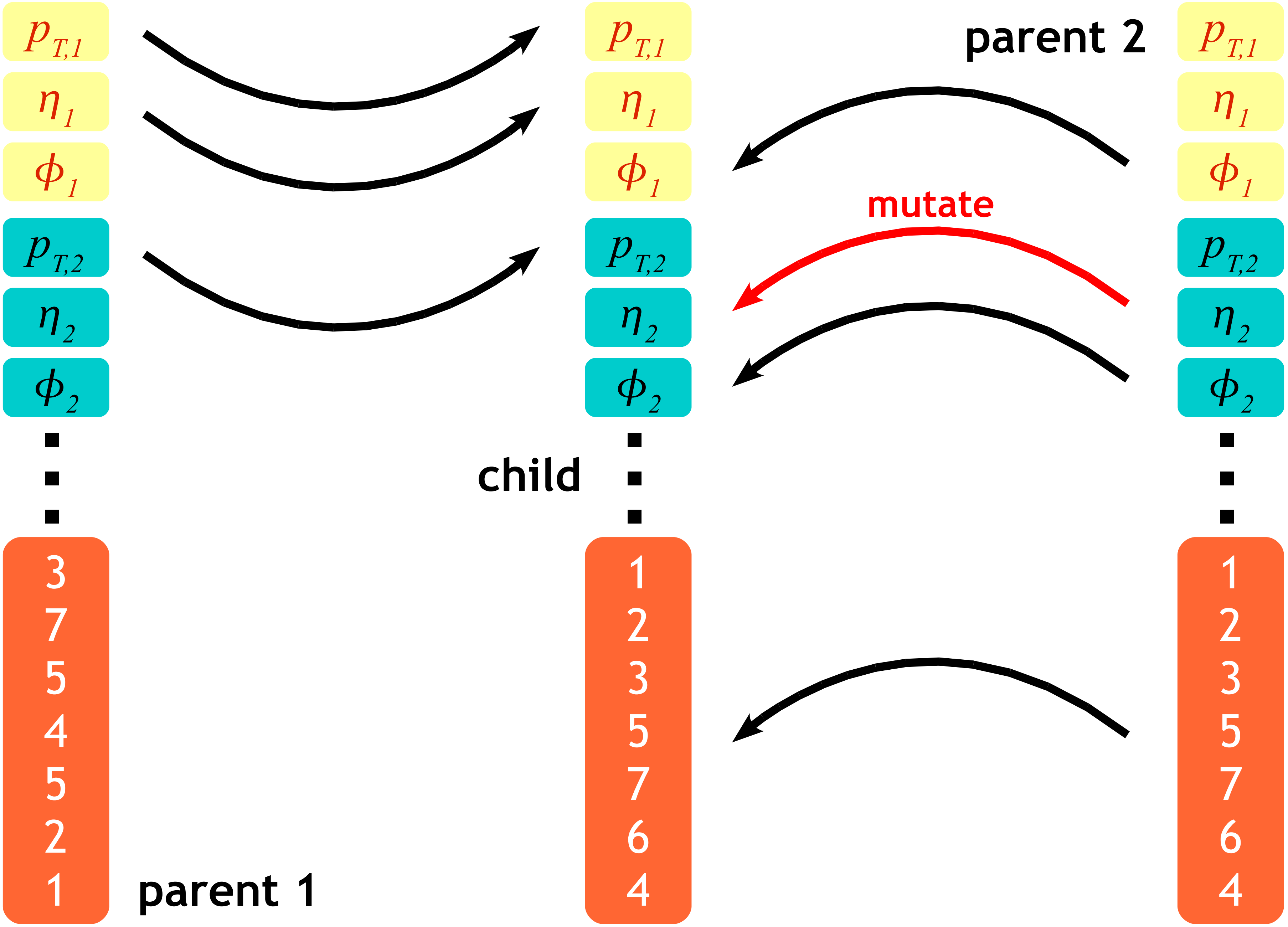
- Final state 4-momenta are properties (*genes*) of *individuum*; jet combination is one additional *gene*
- A fitness function (here χ^2) defines if a *individuum* is *fittest*

1) Starting from starting values create a first *generation* of *individua* (starting *population*): use all possible jet combinations (1260 for 7 jets)
2) Select N best fitting *individua* (here 25)
3) Create M (here 1000) new *individua* by selecting randomly two *parents* and take randomly the *genes* from either one or the other *parent*
4) *Mutate* (variation within the measurement errors) each *gene* (except jet combination) with a given probability (here 10 %)
5) Back to step 2) until convergence is reached (here: no change within 3 *generations*) or fixed iteration number is reached (here 300)



Charles Darwin
(**1809** – 1882)
On the origin of species (**1859)**

Genetic Algorithm (cont.)



parent 1	child	parent 2
$p_{T,1}$	$p_{T,1}$	$p_{T,1}$
η_1	η_1	η_1
ϕ_1	ϕ_1	ϕ_1
$p_{T,2}$	$p_{T,2}$	$p_{T,2}$
η_2	η_2	η_2
ϕ_2	ϕ_2	ϕ_2
⋮	⋮	⋮
3 7 5 4 5 2 1	1 2 3 5 7 6 4	1 2 3 5 7 6 4

mutate

Starting Values for Neutralinos

- In typical Susy scenarios: $m_{\chi_1^\pm} - m_{\chi_1^0} \gtrsim m_W$

$\rightarrow$ small relative momentum of W and χ^0

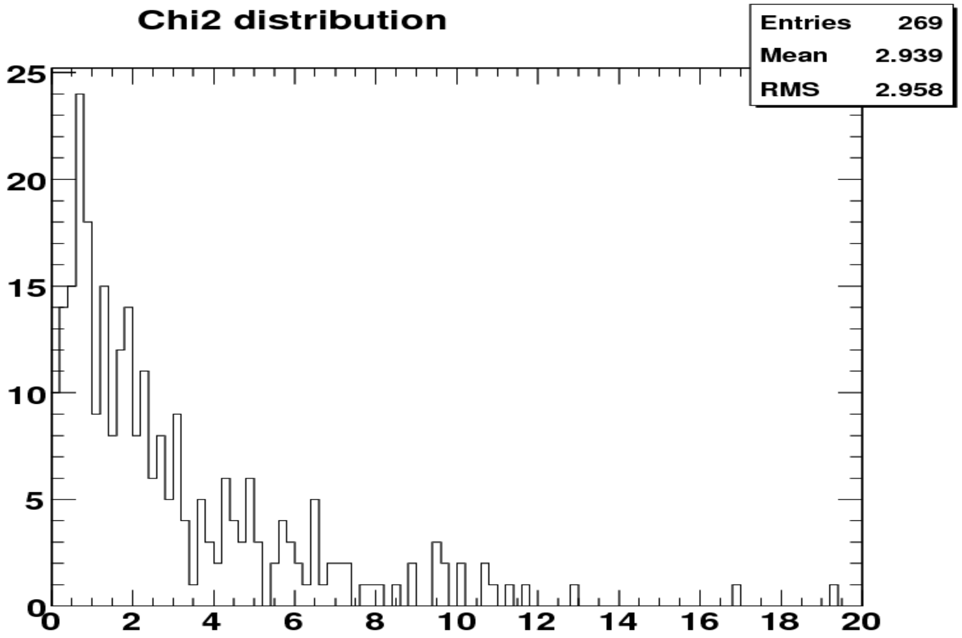
- Assume same direction of W and χ^0 and adjust χ^0 momentum to fulfill mass constraint

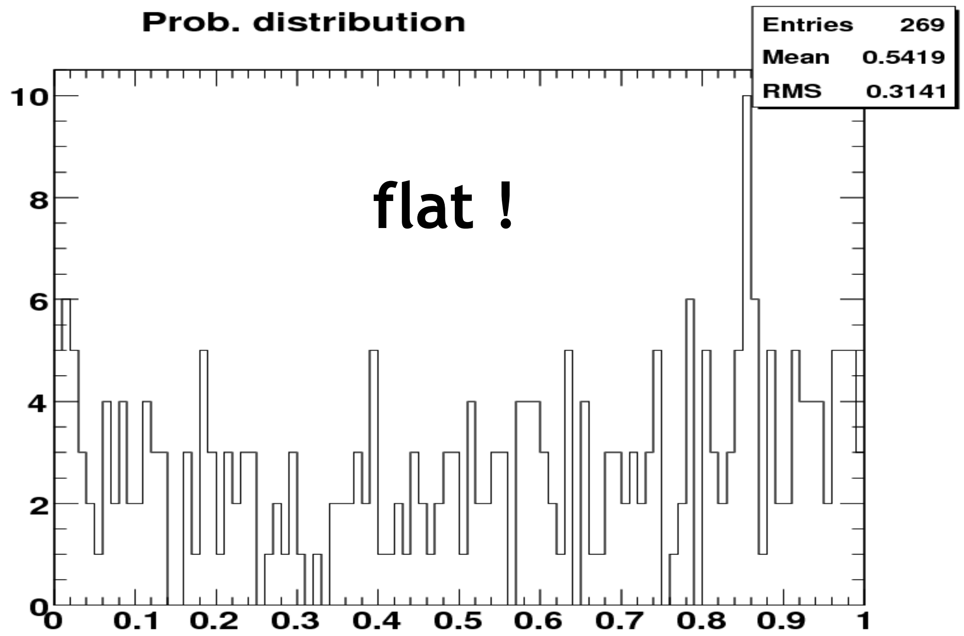
$$0 \overset{!}{=} f(x) = m^2_{\chi_1^\pm} - \left(\left(E_W + \sqrt{m^2_{\chi_0} + x \cdot p^2_W} \right)^2 - (1+x)^2 \, p^2_W \right)$$

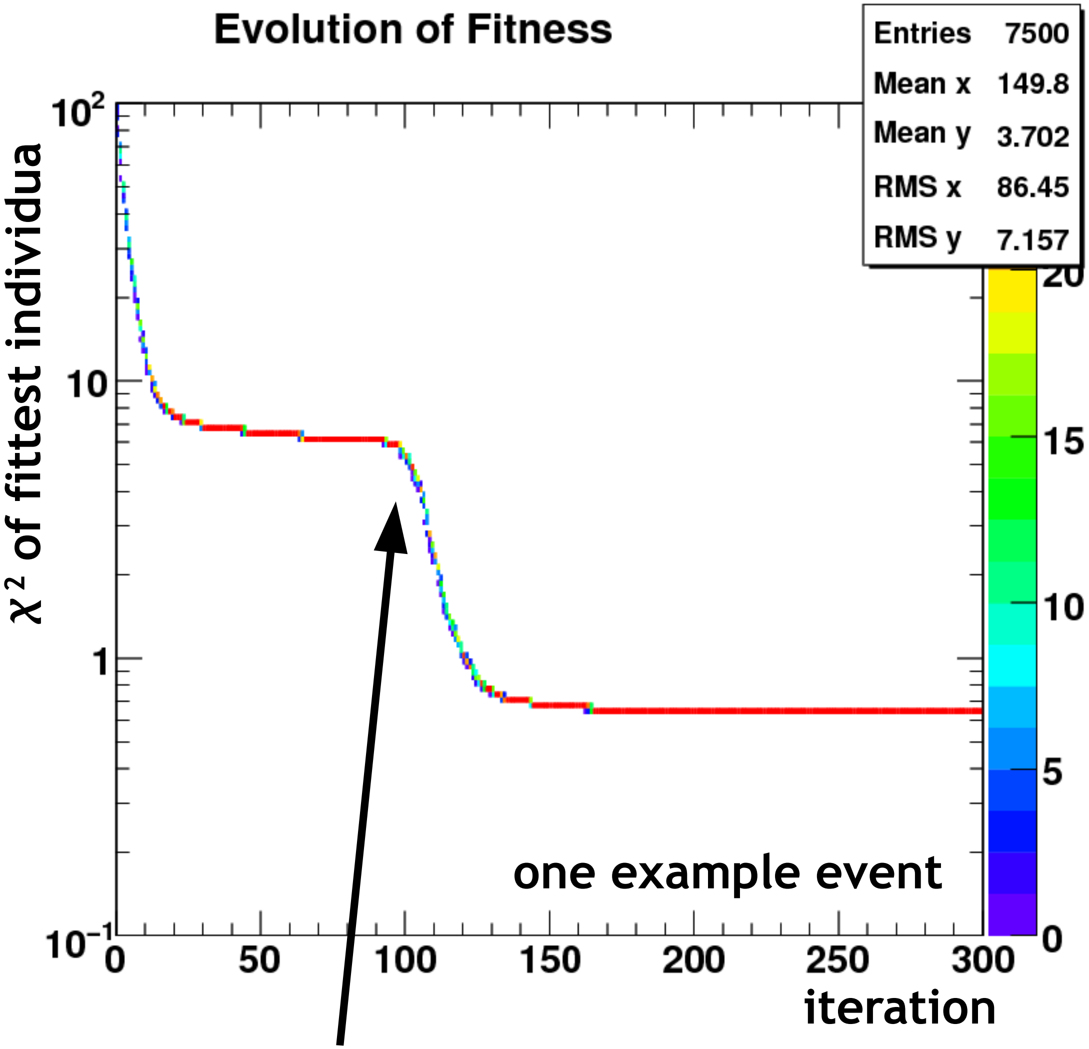
- No analytical solution → use Newton method

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

Preliminary Results





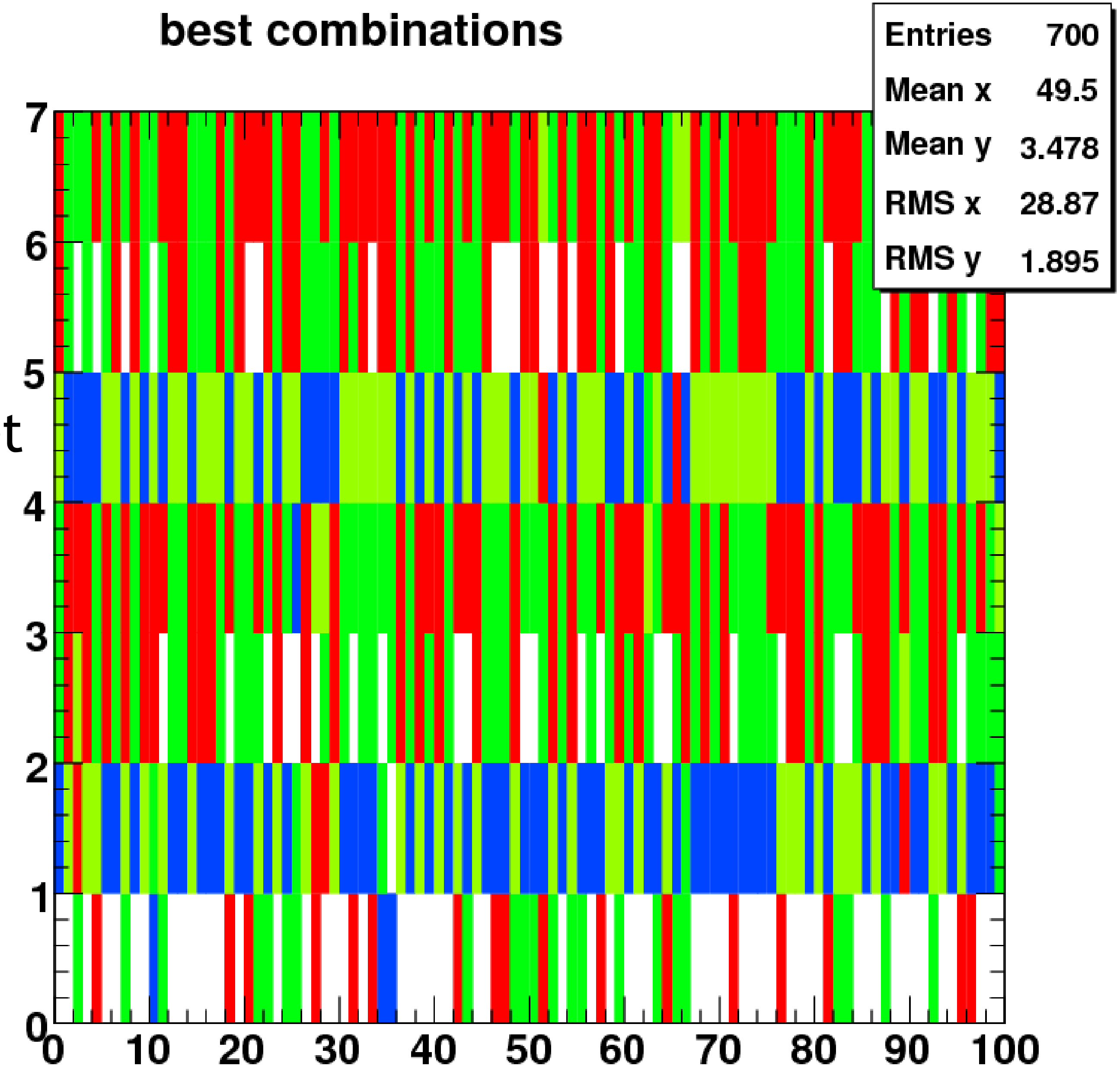


Advantage of genetic algorithm:
might overcome local minima

Visualization of Best Combinations

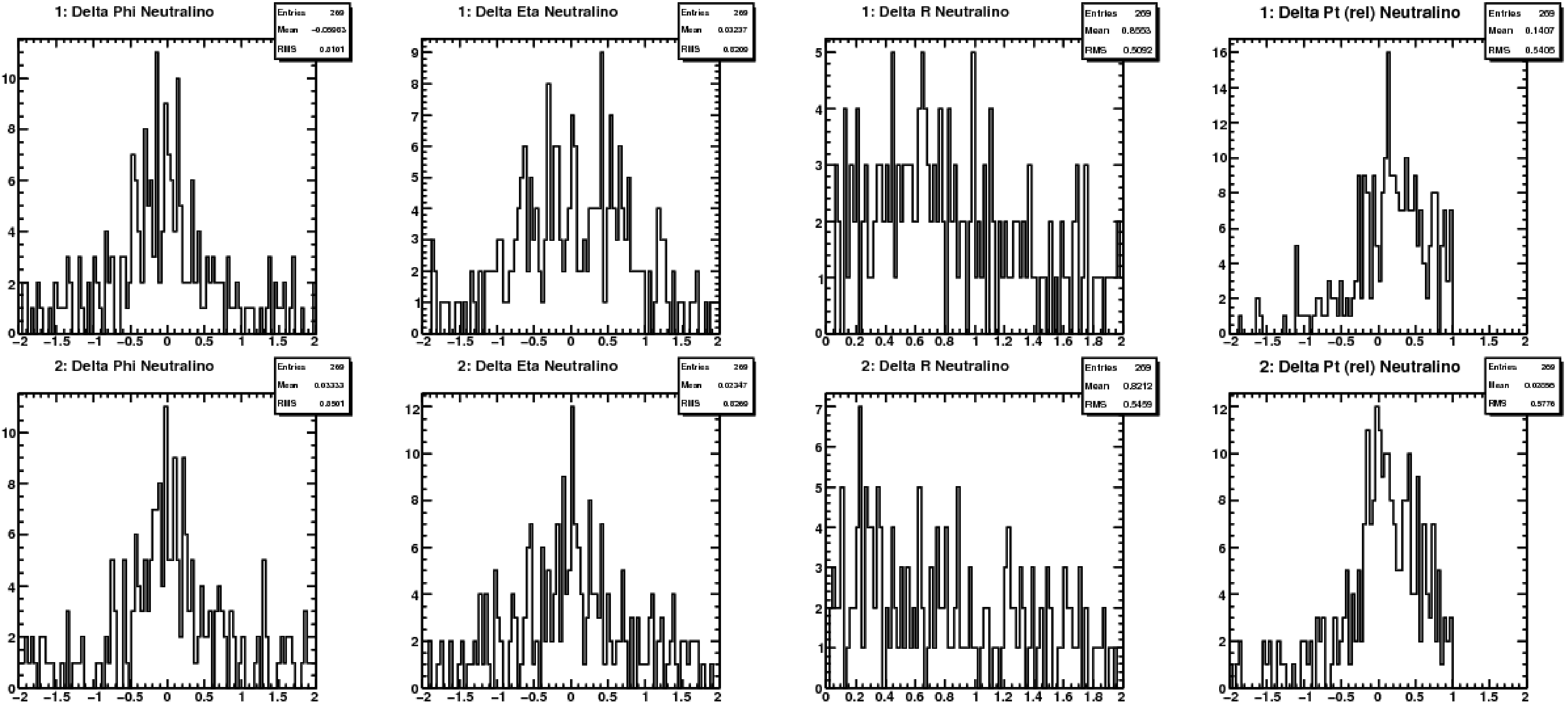
~ 20% complete right cascade
most wrong combinations are
exchange of the two branches

- 🟥 second W jet
- 🟥 second W jet
- 🟨 second squark jet
- 🟩 first W jet
- 🟩 first W jet
- 🟦 first squark jet
- ☐ first gluino jet



Fit Quality

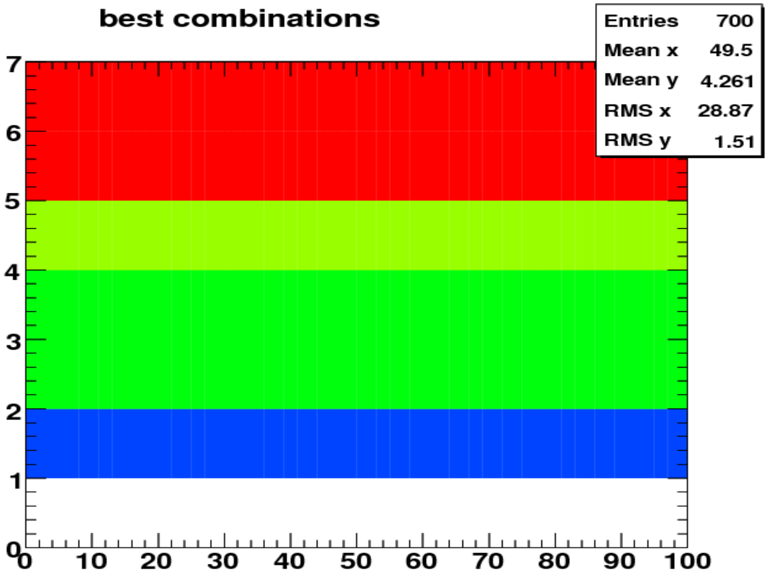
- Resolution of unmeasured particles

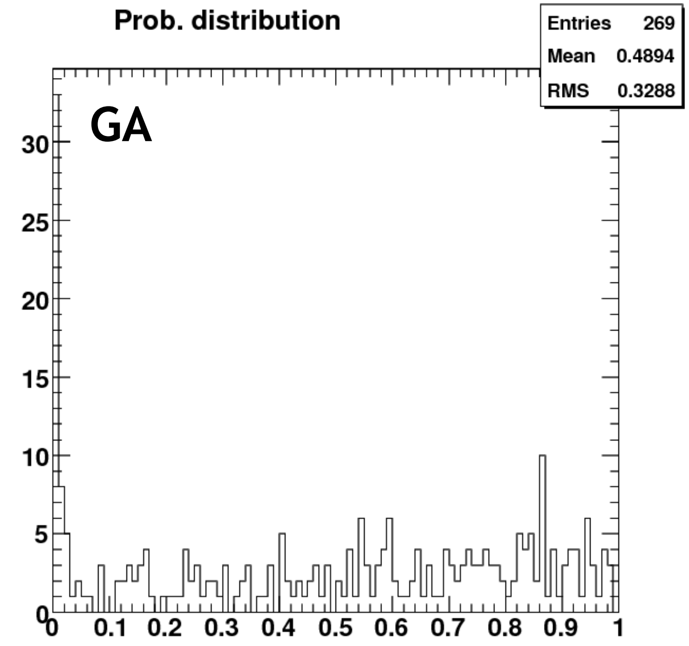


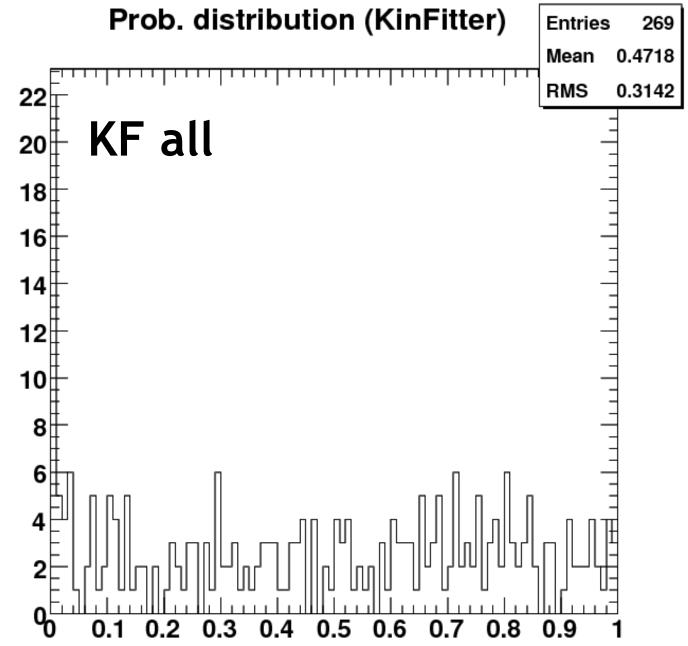
- Also wrong combinations are plotted!

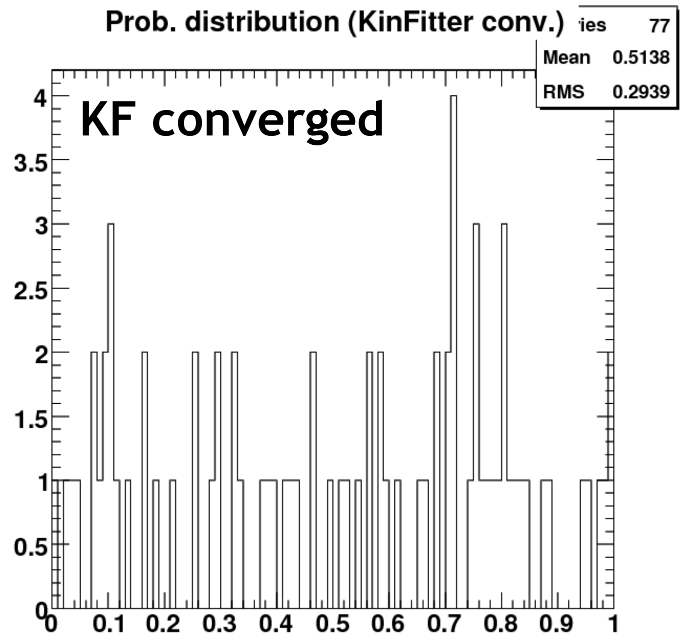
Genetic Algorithm vs. KinFitter

- No combinatorial background
- KinFitter: only 77 out of 269 events converge for right combination (constraints are not fulfilled as required)
- KinFitter: no correlation of invariant masses and jets
- KinFitter: Lagrangian multiplier for momentum balance



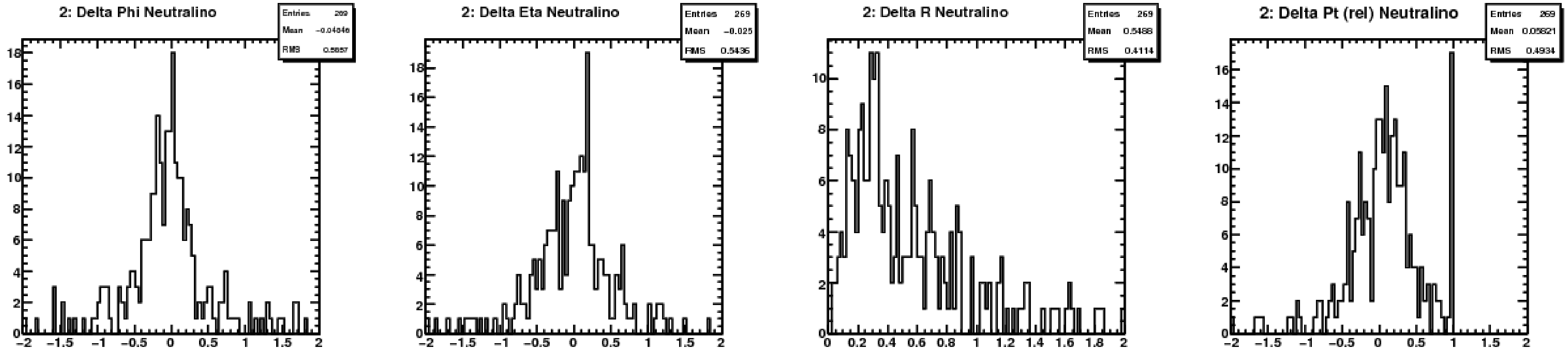




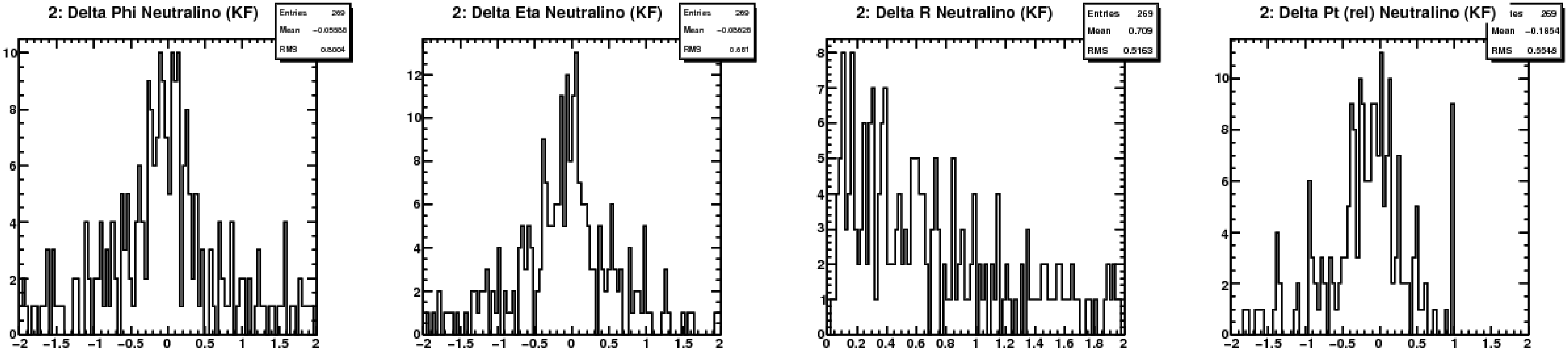


Genetic Algorithm vs. KinFitter (cont.)

- Genetic Algorithm: RMS (ΔR) = 0.41



- KinFitter: RMS (ΔR) = 0.52



Plans and Ideas

- Study event selections (jet p_T and η) ... same as Hannes
- *Mutation* of jet combination
- Add Susy background
- Scan over mass hypothesis od mSUGRA parameters
- Think about “dynamic hypothesis selection “