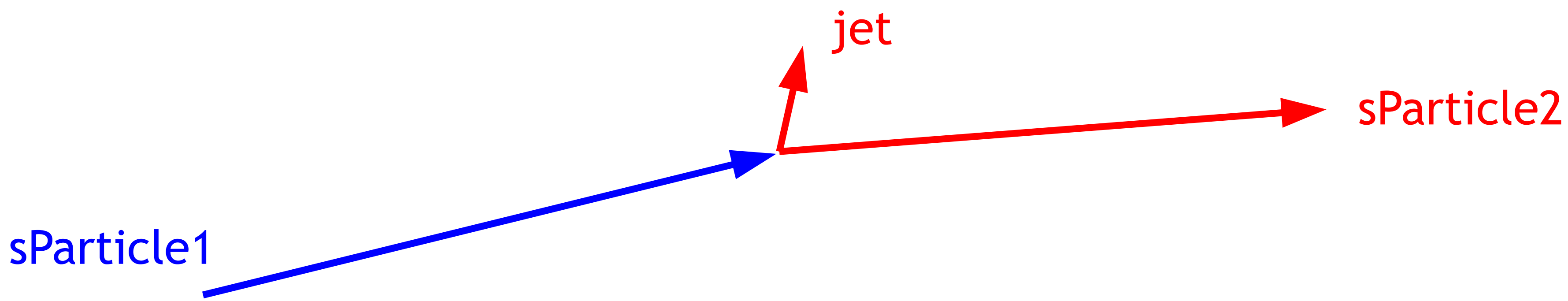
Update on Kinematic Fits

C. Sander

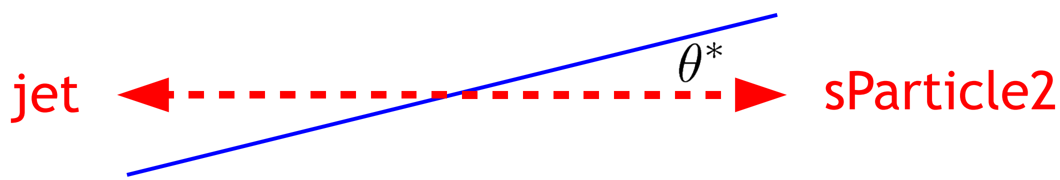
Susy Group Meeting – Hamburg – 7th July 09

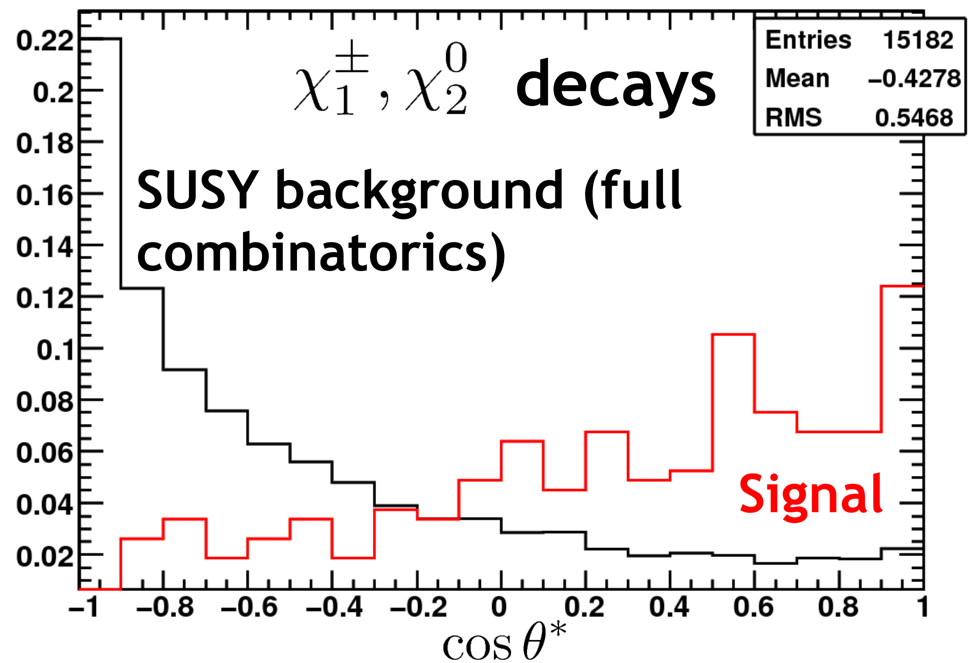
Angular Distributions

- Huge combinatorial background → Large invariant mass combinations, e.g.



- In rest frame of SUSY particles: angular distribution $\cos\theta^*$ of decay products with respect to flight direction of decaying particle should be ~isotropic (for spin 0)
- $\cos\theta^*$ for typical background 4-vector configurations are not uniformly distributed (smaller angles preferred)

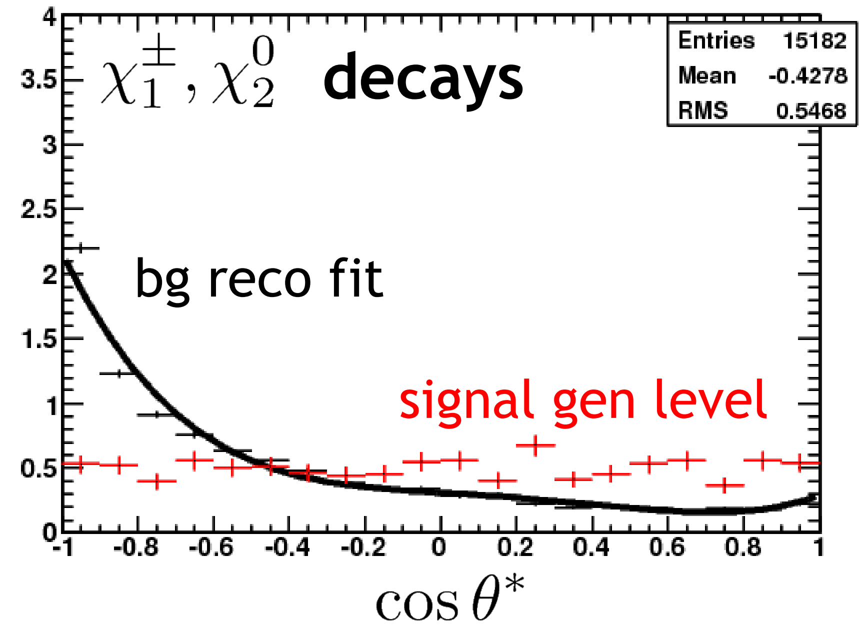




Many decay angles in SUSY cascades
→ **Use event kinematics to reduce combinatorial bg reduction**

Angular Relations in Fitness Function

Take Likelihood functions for signal (background) from generator information (fit results)

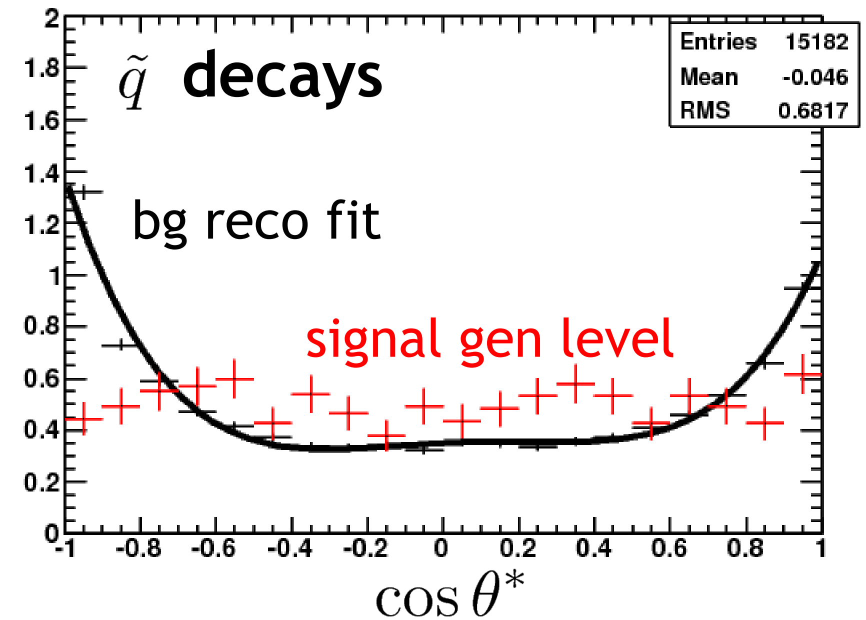


Likelihood ratio: $\mathcal{L} = \frac{L_\text{signal}}{L_\text{signal} + L_\text{bg}}$

Relation between χ^2 and likelihood

$$\mathcal{L} = \exp\left(\frac{-\chi^2}{2}\right)$$

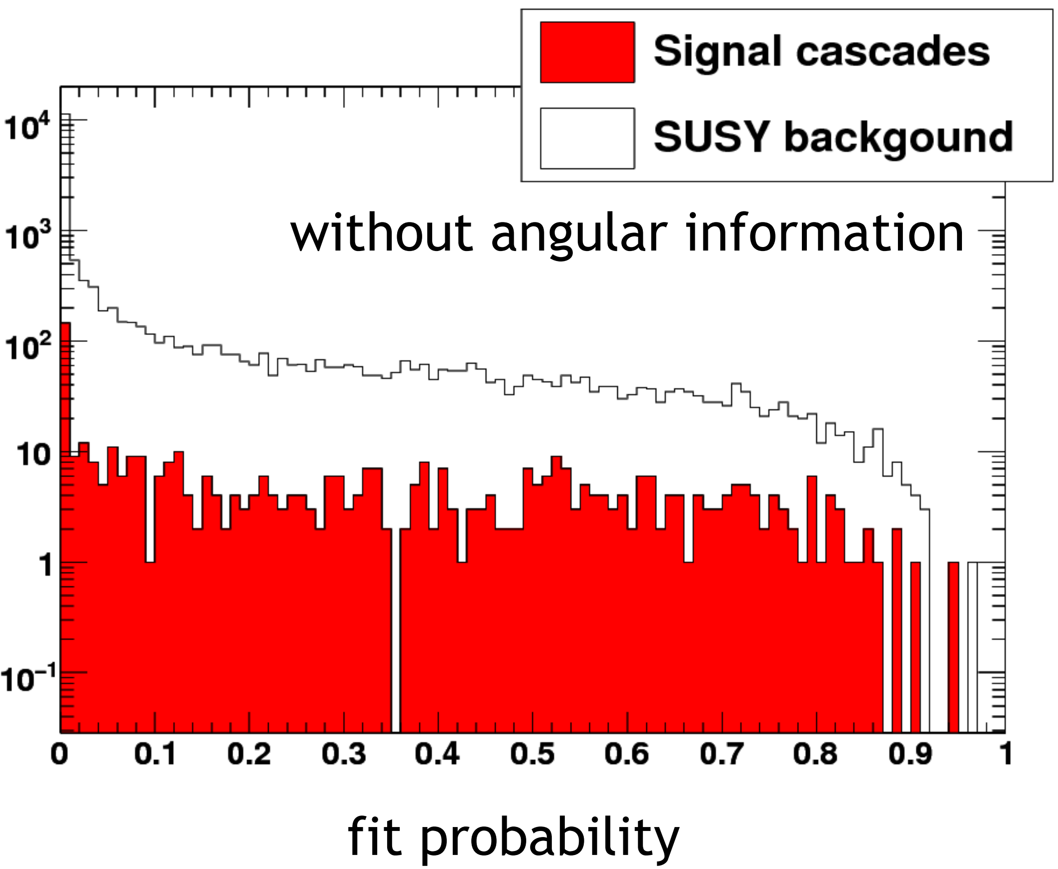
$$\rightarrow \chi^2 = -2 \cdot \log \mathcal{L}$$

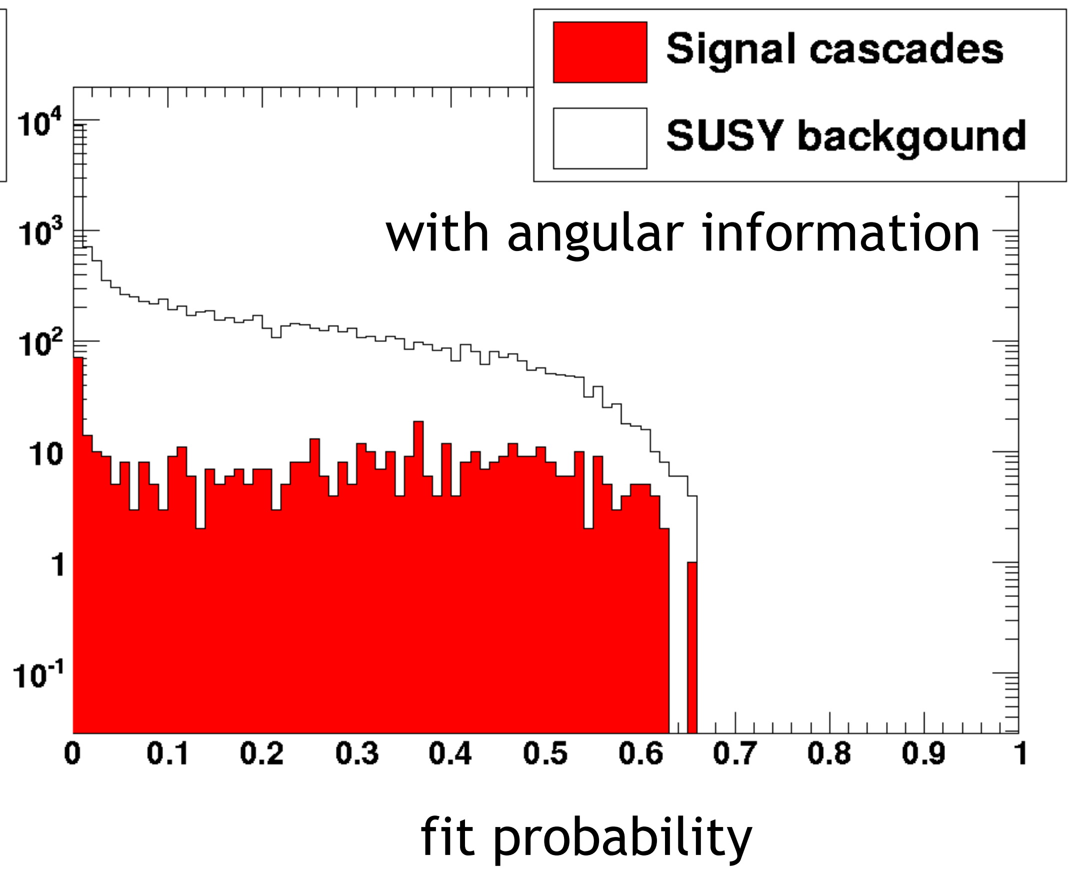


Two squark and two chargino/neutralino decays yield four new contributions to fitness function

Potential problem: signal is ~ uniformly distributed, but now particular regions are preferred → some signal events more converge with wrong combination

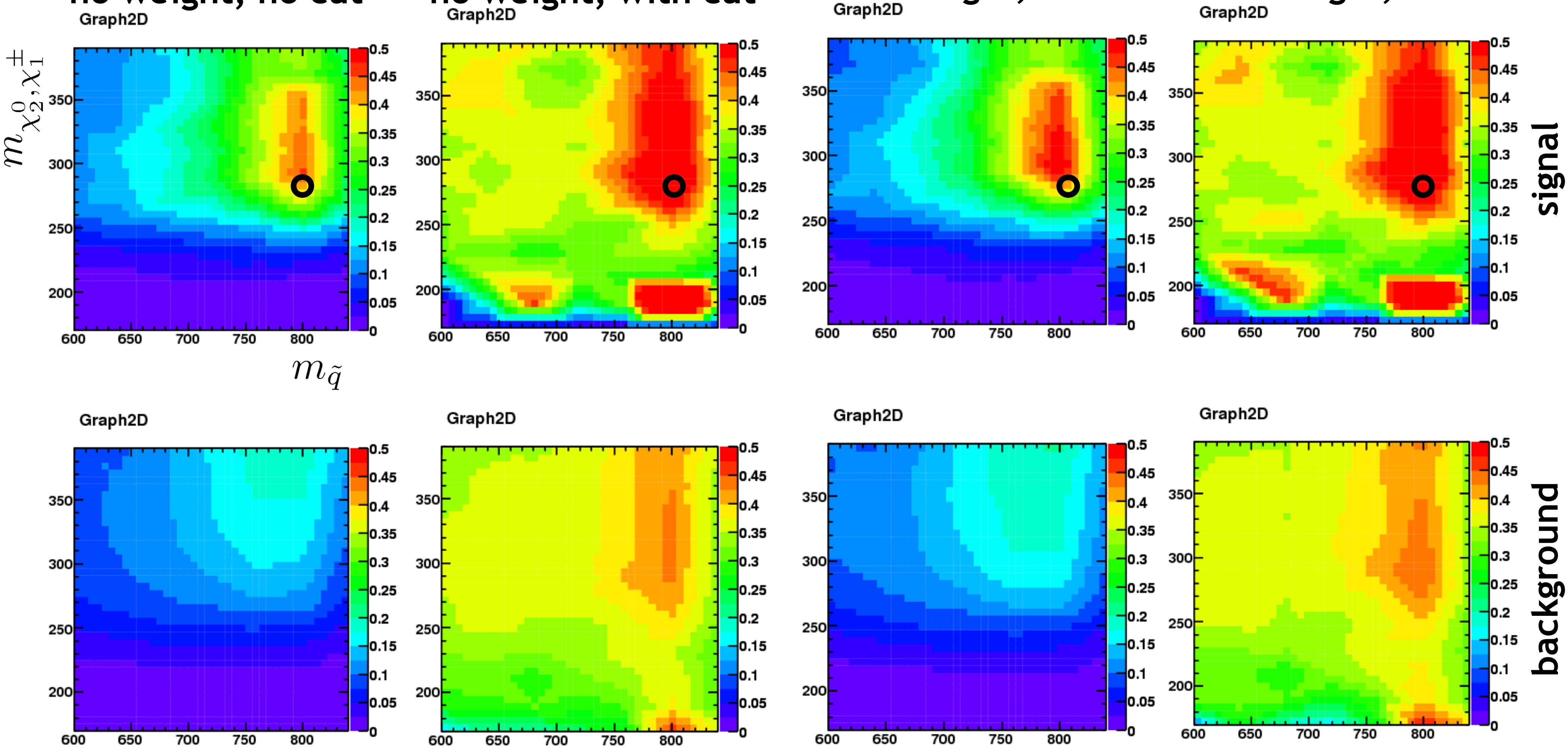
- As expected, usage of angular variables changes probability distribution of signal and background in different ways
- Additional χ^2 term correspond **NOT** to normal distributed measurement → **deviation from flat distribution**
- **Way out:** use angular information after the fit (e.g. event weighting ...)





- Averaged probability:
  - with/without weight from angular Lilelihood ratio
  - with/without cut on fit probability (>0.1)

no weight, no cut | no weight, with cut | with weight, no cut | with weight, with cut

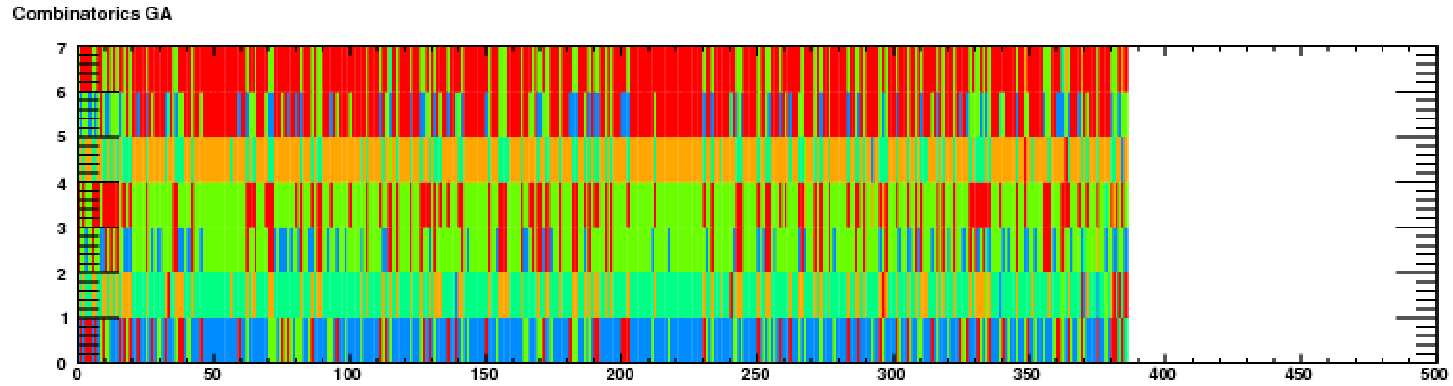


Validation of Genetic Algorithm

- **Questions:**
  - *Why does a wrong combination provide a better fit than the true combination?*
  - *What is going wrong with the true combination?*
- So far it was shown that the converged solution provides a reasonable probability distribution and the constraints are fulfilled
- Now we want to check if the fit converges at the **global** and not a **local** minimum
  - **Cha llenge:** How do we know which is the global minimum?
  - **But what we can do:** Compare the GA results including full combinatorics with GA results using the true jet combination!

Validation of GA - New implementation

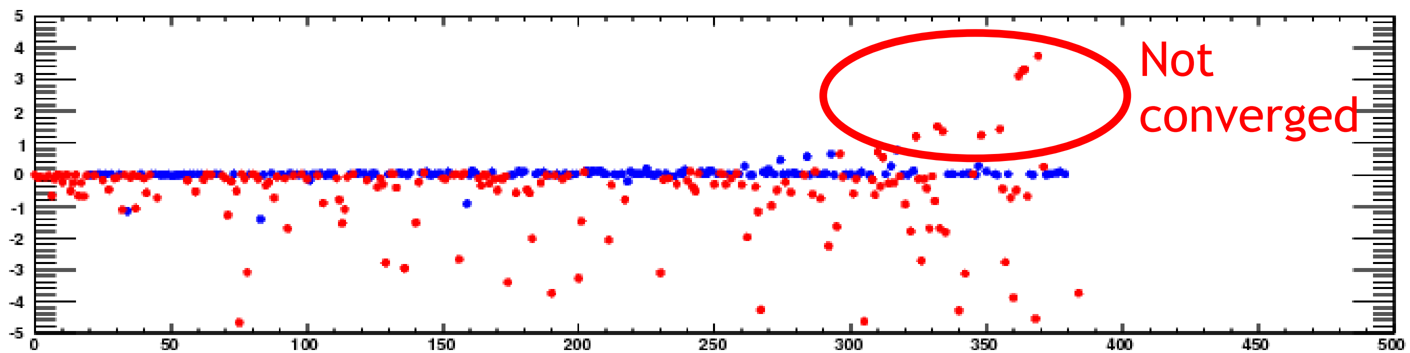
New implementation: up to N_{best} individuals survive of up to N_{same} jet combination (breeding in sub populations) + more children per coupling



$$\Delta\chi^2 = \chi^2_{\mathrm{fit\ including\ combinatorics}} - \chi^2_{\mathrm{fit\ with\ true\ jet\ combination}}$$

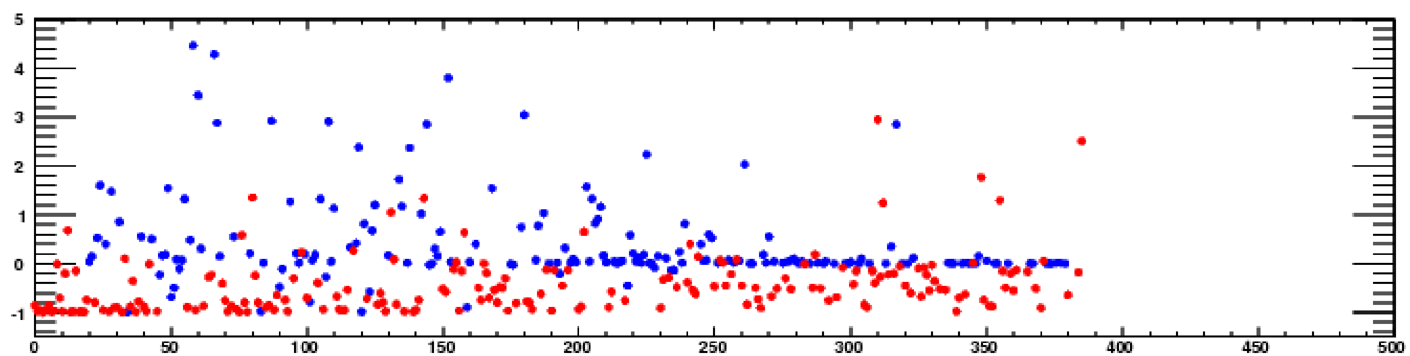
- `best == right` (blue)
- `best != right` (red)

Best is right for 181 of 386 events



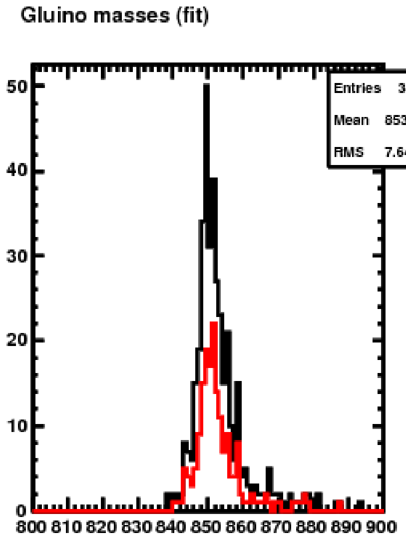
$$\Delta\chi^2 / \chi^2_{\mathrm{fit\ with\ true\ jet\ combination}}$$

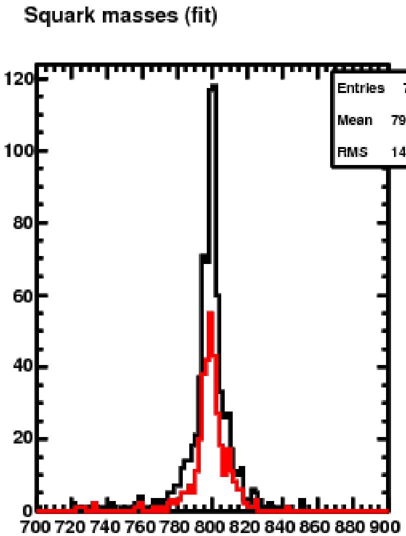
Positive values indicate that combi-fit has larger χ^2 than true-fit

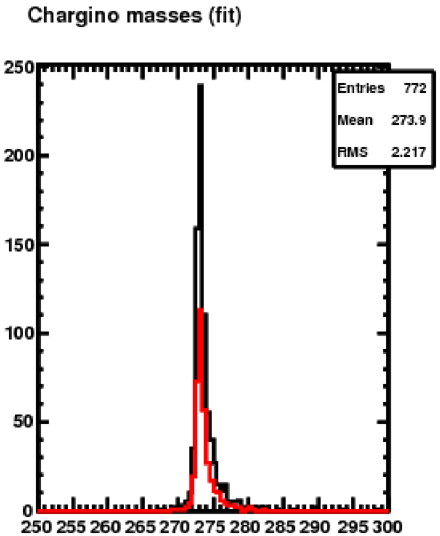


Something Special About Wrong Combs?

- No significant systematic shift of constraints visible for wrong combinations in comparison with true combinations







- Pulls show small systematic effect (similar for best == true and best != true)

$$\text{pulls} = \frac{\text{fit} - \text{constraint}}{\sigma}$$

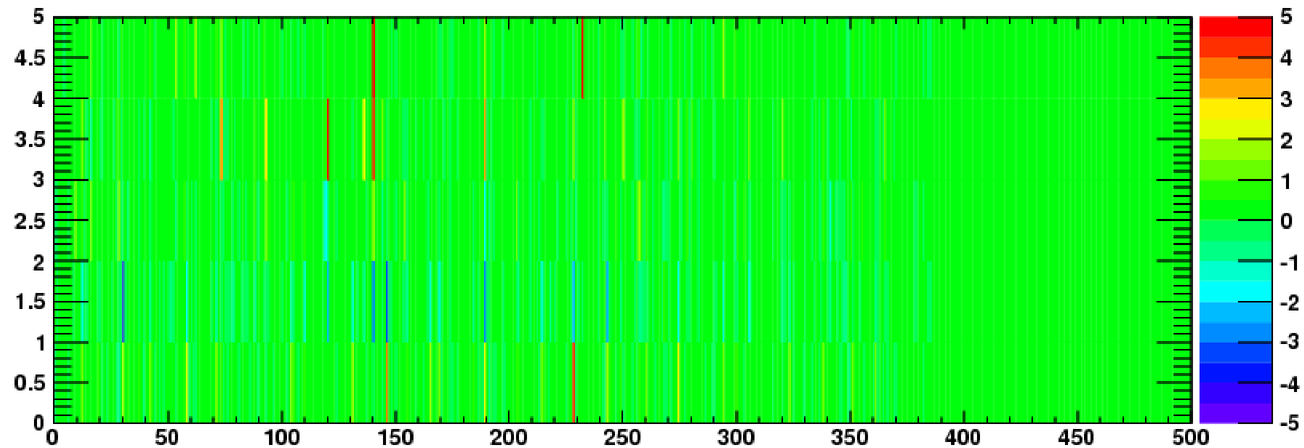
Chargino 2

Chargino 1

Squark 2

Squark 1

Gluino 1



best != true