



Global Kinematic Fits

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- After discovery of SUSY the masses of the sparticles have to be determined
- If some masses are (almost) degenerated (e.g. squark masses or χ^0 and χ^\pm in mSUGRA scenarios) it might be possible to select events with a rather similar cascade topology
- In these cascades the masses of the SUSY particles at a particular position in the decay chain can be assumed equal for each event

Global unknowns: SUSY masses

Local unknowns: momenta of two LSPs

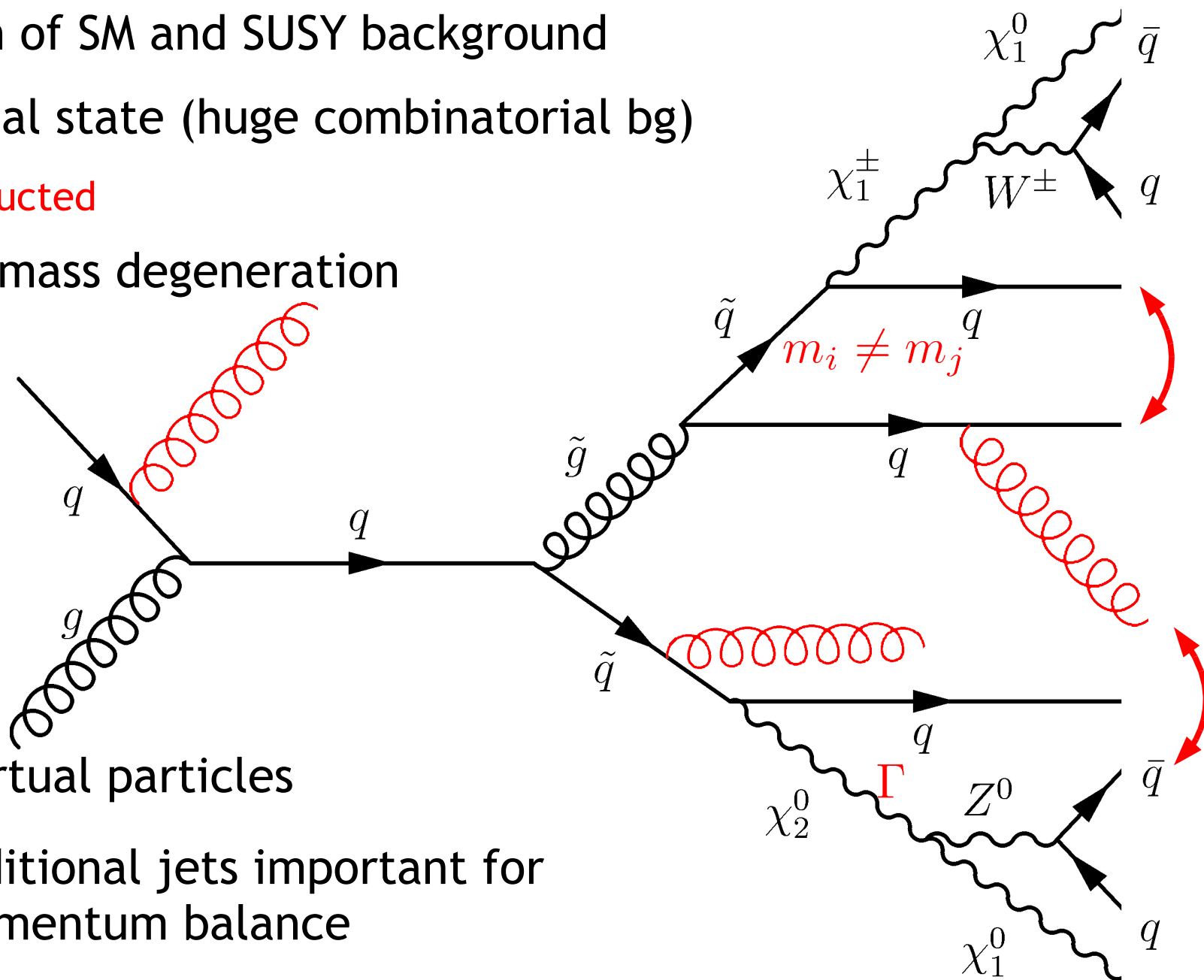
Constraints 1: right combinations of the final state particles should have invariant masses of corresponding SUSY particle

Constraints 2: Momentum balance in transverse plane

→ If there are more constraints than local unknowns, the problem is overconstrained for a large number of events

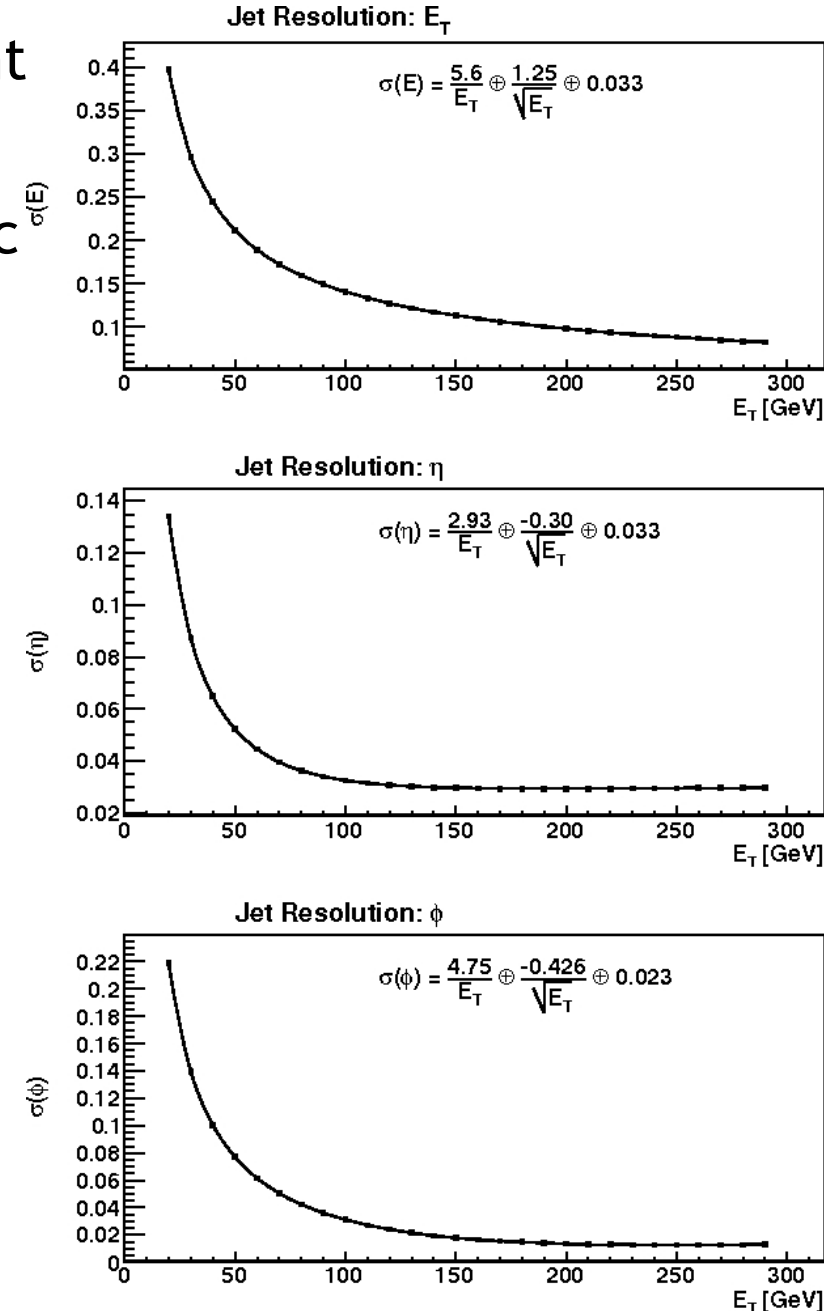
- Analogy: Tracker alignment (global unknowns: alignment parameters, local unknowns: track parameters, constraints: vertex ...)

- 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

- **No combinatorial background:** only use right combinations
- **Avoid non-degenerated masses:** use specific cascade only
- **Perfect momentum balance:** use MC information of ISR
- **Use Toy-MC:** Take parton kinematics from generator process and smear them in E_T , η , ϕ according to expected resolutions
- Start values for global mass parameters from invariant multi-jet masses
- Start values for unmeasured LSP momenta: Truth ? Zero ? Arbitrary ? W/Z ? ...
- **Non-linearity:** iterative solution



Original Code KinFitter adapted to global fit by Torben and Benedikt

- Normalization of constraints:

$$\sum_i f_i(m, l, u) = 0$$

non-degenerated mass spectrum or width $\rightarrow \Delta m$

$$\Delta f_i = \frac{\partial f_i}{\partial m} \cdot \Delta m$$

$$\rightarrow \sum_i \frac{f_i(m, l, u)}{\Delta f_i} = 0$$

- Function of Merit: how to define if a step is accepted or not

so far:

$$\Delta \sum_i \left| \frac{f_i(m, l, u)}{\Delta f_i} \right| < 0$$

now: $\Delta M < 0$ with

$$M = \chi^2 + \mu \cdot \Delta \sum_i \left| \frac{f_i(m, l, u)}{\Delta f_i} \right| \quad \text{with } \mu = \max \lambda_i$$

Nocedal & Wright §15.4

- Second order correction:

If constraints are non-linear one could suffer from Maratos effect, i.e. a step in the steepest direction can increase objective function (χ^2) as well as increase violation of constraints Nocedal & Wright §15.5

The following correction will reduce the merit function at least near the solution: Nocedal & Wright §15.6

$$p'_k = A_k^T (A_k A_k^T)^{-1} c(x_k + p_k)$$

where p_k is the step, $c(x)$ the constraints and A the Jacobian of c

This step is only tried once, since back tracking make no sense (p_k is not steepest descent at $x_k + p'_k$)

- For each “Newton-step” the sum of all constraints has to be reduced
- Very preliminary** results for 412 events:

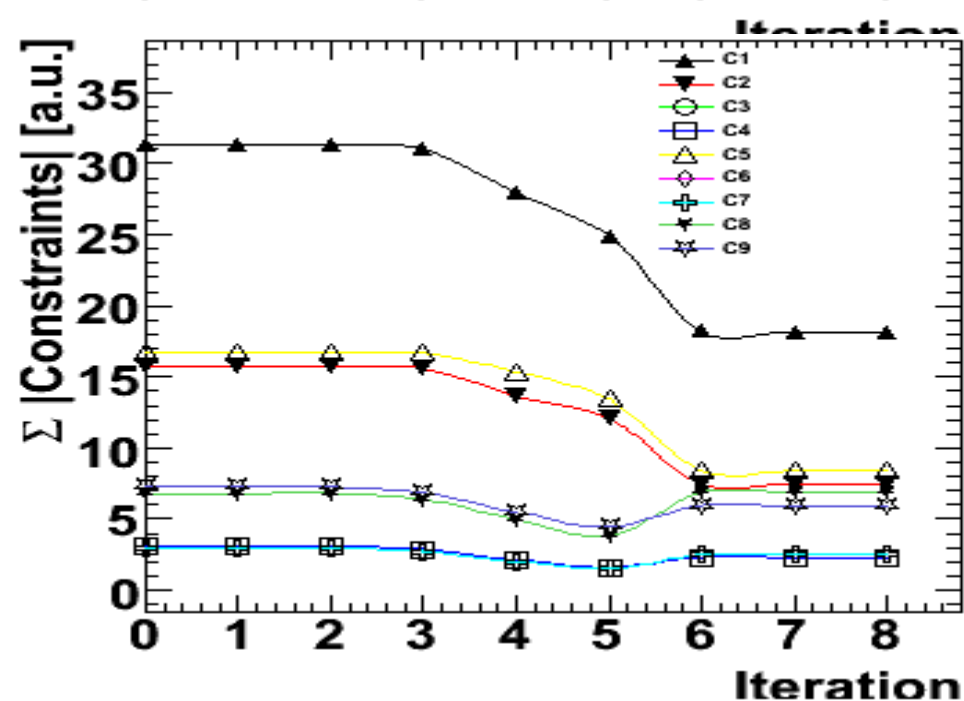
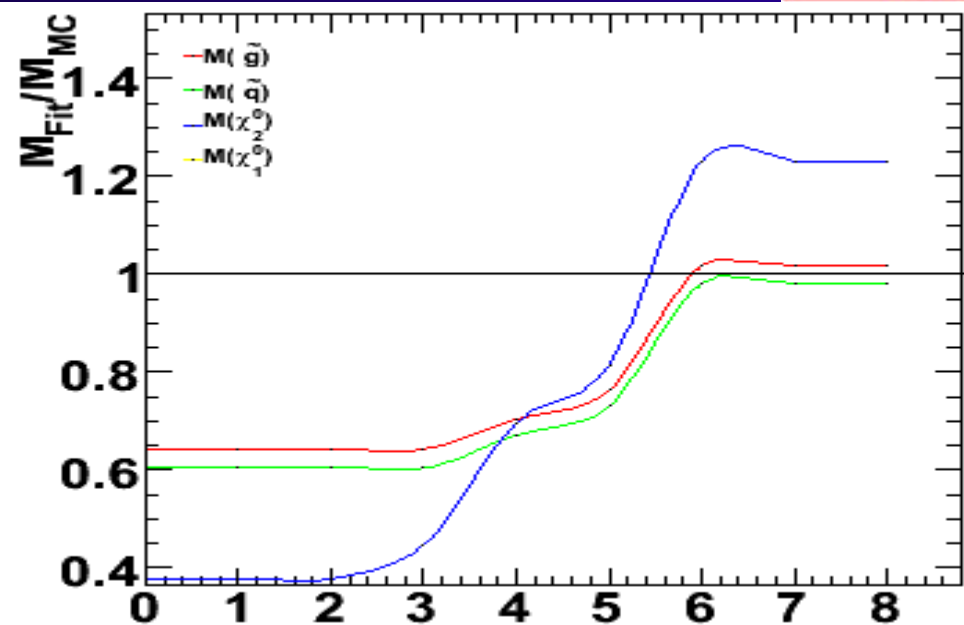
	Fit result	True Mass
$m_{\tilde{g}}$	696 GeV	~685 GeV
$m_{\tilde{q}}$	647 GeV	~660 GeV
$m_{\chi_1^\pm}$	259 GeV	~210 GeV

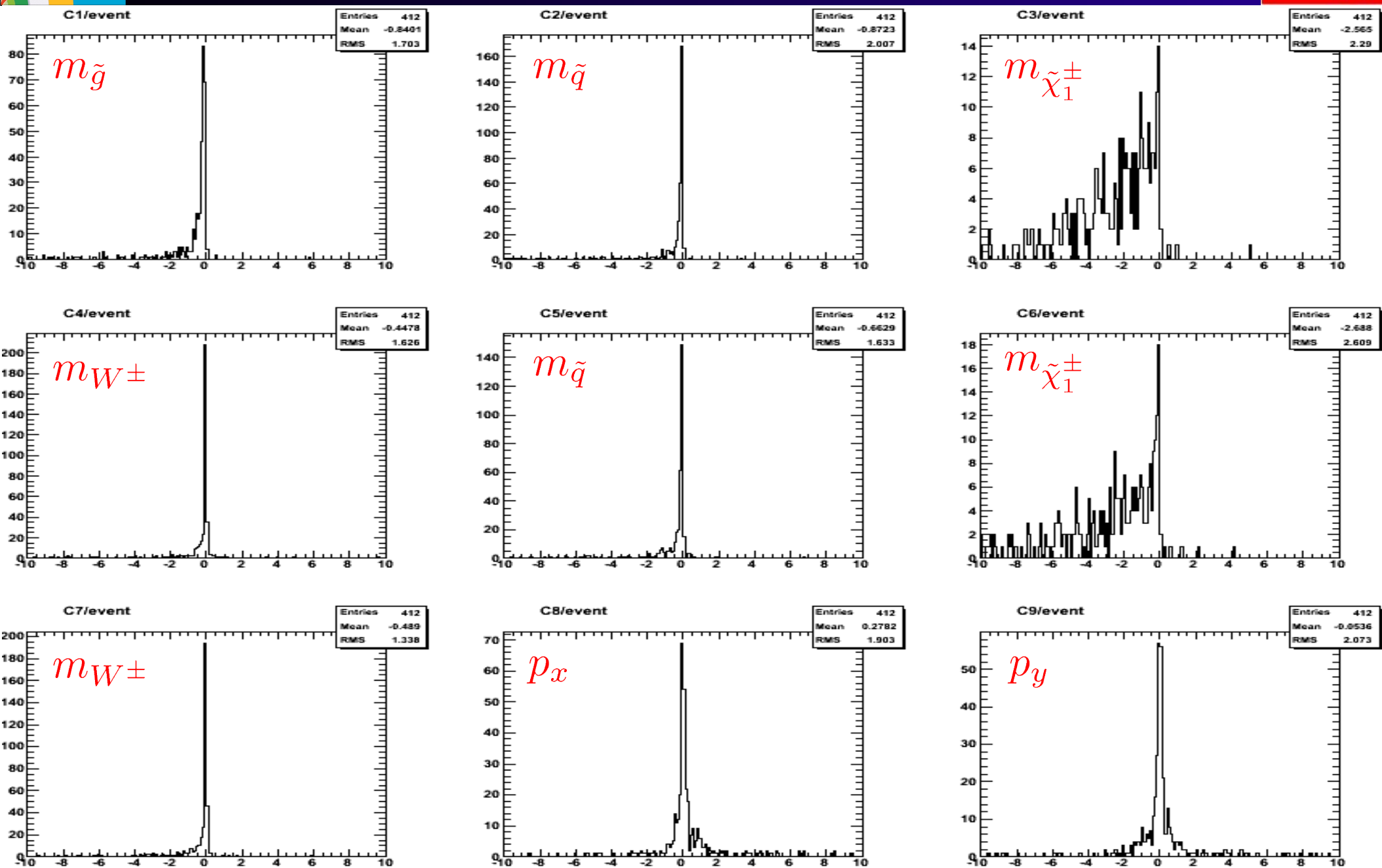
- Fitted masses agree on 2-20% level with true mass values

Used mSUGRA parameters: LM4

$m_0 = 210$ GeV, $m_{1/2} = 285$ GeV

$A_0 = 0$, $\tan \beta = 10$, $\text{sign } \mu = +$







- Check once more if second order correction is implemented correctly
- Improve starting values of neutralino momenta
- Improvement of line search algorithm
- Do some preselection cuts and study SUSY background
- Apply improvements also on event-by-event KinFitter (suffers from same effects)