Combined probability (Method I)

- First set of 9 variables. This set is reasonable and well motivated, however is has been selected *a posteriori*. The bias of the *a posteriori* selection is discussed later. First we investigate the effect of correlations between kinematical variables with three different methods:

- Neglect correlations between variables; define $\Pi = \Pi_i P_i$

  $$\Pi_T = \Pi \times \sum_{k=0}^{n-1} (-\ln \Pi)^k / k\,!$$

- The control sample has a probability $\Pi_T = 46\%$

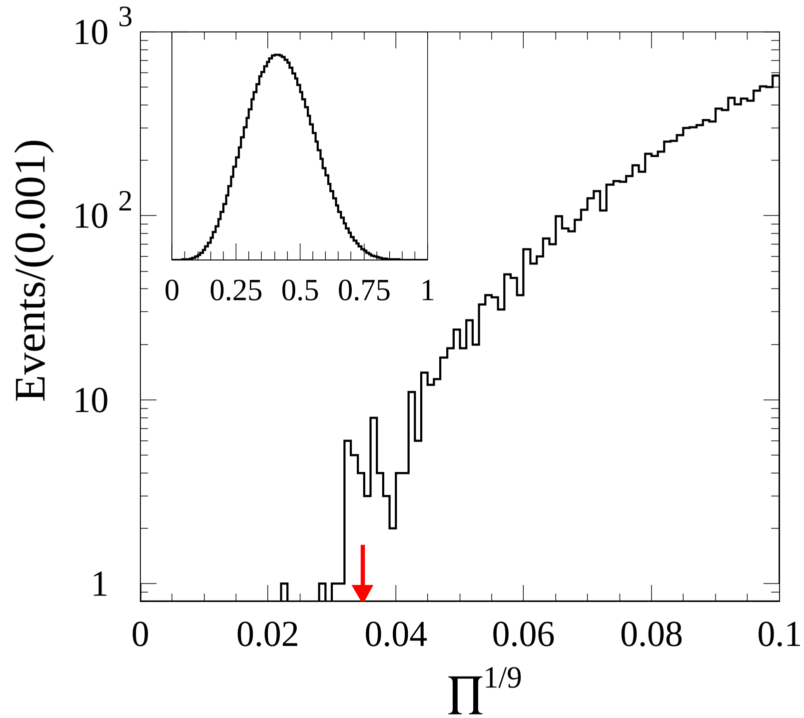
- Events with a superjet have $\Pi_T = 1.6\ 10^{-6}$ (4.8 sigma effect).

- Folding the η–distributions, $\Pi_T = 4.5\ 10^{-6}$.
  The η– asymmetries do not drive the low Π_T value.

hep-ex/0109019

Combined probability (Method II)

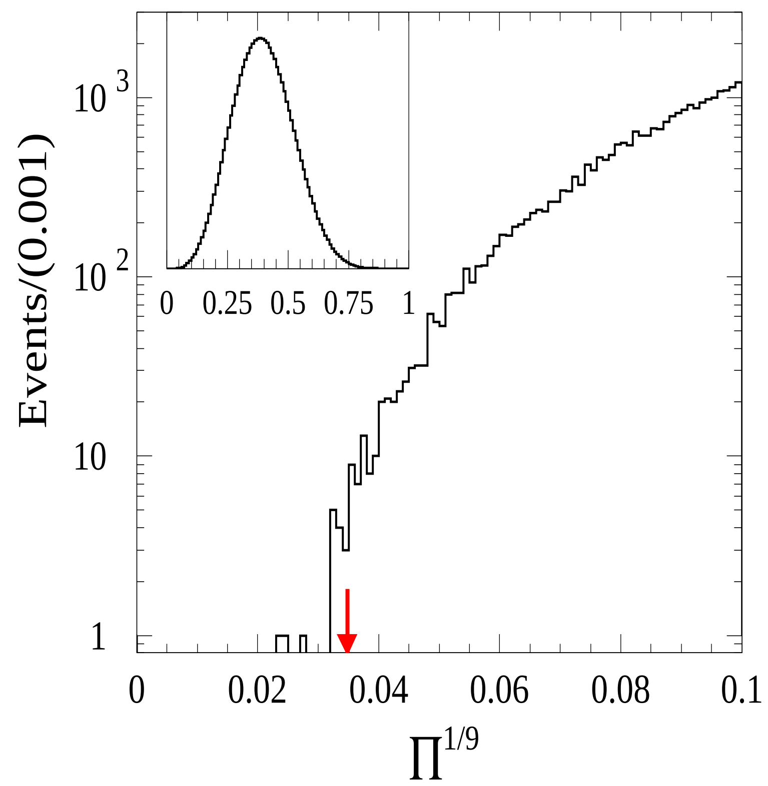
- This method accounts for correlations
- Use about 3000 simulated events +
  - Non-W: use data with a superjet, MET > 20 GeV and I > 0.2 (12 events) or data with MET>20, I> 0.2, and one jet with a SECVTX tag and SLT taggable (165 events)
- Perform 10^7 experiments each one with 8 2-jet and 5 3-jet events
- In each experiment, randomly extract each cross section σ_i using Gaussian uncertainties in the prediction of each cross section and then the corresponding number of events Ni including Poisson fluctuations.
- Then randomly extract Ni events from each simulation
- Compare the distributions of the 13 events to the templates using the usual K-S test and derive the product of probabilties Π.
- We find 16 events with a probability Π smaller than the data.



$\Pi_C = (1.6 \pm 0.4)\ \mathrm{x}10^{-6}$

Check using the data

- Use the control sample of data (42 events)
- The 13 events with a superjet have $\Pi^{1/9}$=0.0345
- The probability that 13 different events extracted randomly from the control sample have a product of probabilities Π no larger than the data is $(1.4 \pm 0.4) \times 10^{-6}$.
- Among these particular 42 events, it is hard to find a subsample of 13 events that disagrees with the SM simulation as much as the events with a superjet.
- The 42 events cannot contain more than 8 events with the same philum of superjet events.



Combined probability

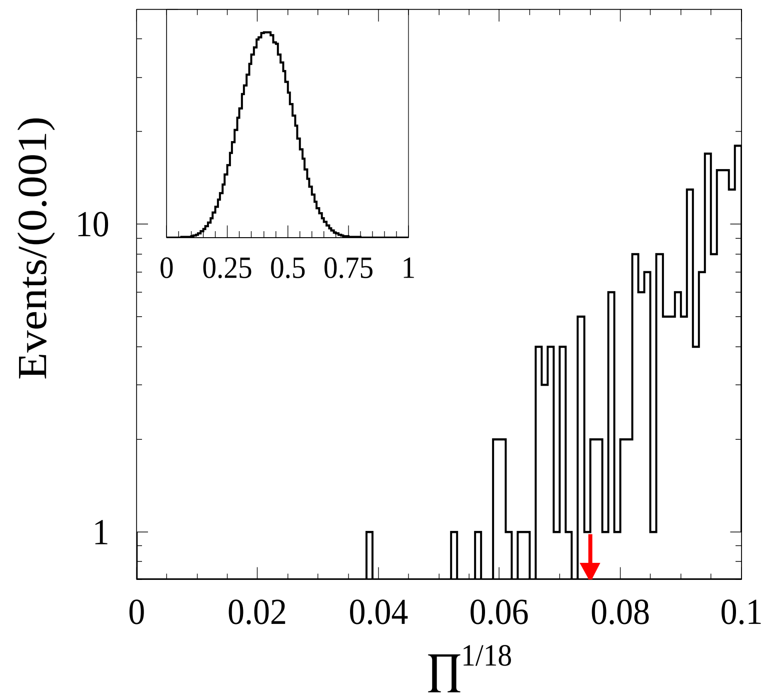
- The combined probability depends on the estimate of the sample composition and its uncertainties. If we assume that events are all due to top quark production, $\Pi_T = 1.2 \times 10^{-5}$ for events with a superjet and $\Pi_T = 0.8 \times 10^{-2}$ for the control sample

Another reasonable choice

- E_T^l η^l E_T^{suj} η^{suj} E_T^b η^b M_T^W $\not{E}$
- This set of variables is less complete but more intuitive than our first choice
- We find $\Pi_T = 7.4 \times 10^{-5}$ and $\Pi_C = 2.5 \times 10^{-5}$

Combined probability (18 variables)

- we studied 18 variables before choosing 9 to characterize the difference between the data and the simulation.
- Events with a superjet appear less anomalous when using the remaining variables: $\Pi_T = 1.9 \times 10^{-2}$ and $\Pi_C = 2.3 \times 10^{-2}$ for events with a superjet ($\Pi_T = 0.75$ for the complementary sample).
- remove the *a posteriori* bias using all 18 variables
- $\Pi_c = (3.4 \pm 0.6) \times 10^{-5}$ (4.1 σ)
- $\Pi_T = 6 \times 10^{-7}$



Estimate of the production cross section

- Pending an obscure detector effect that is not visible in any other data samples……or a very low probability statistical fluctuation
- The interpretation of the superjets in terms of new physics would require a low-mass, strongly interacting object, decaying semileptonically with a branching ratio of 1 and a lifetime of the order of a picosecond
- a light scalar bottom is a candidate (no limits)
- we assume $b_s \rightarrow c\, l\, \nu_s$ (pretending)
- plus the production of a massive state which decays to $b\, b_s$ (pretending) in order to fit the tagging rates
- Patchwork, in absence of a suitable model

hep-ex/0109020

Matrix element

$$\frac{d\Gamma}{dz_c dz_l} = K[(1-z_c)(1-z_l) - R_{\tilde{\nu}} + R_c(z_c - z_l + R_{\tilde{\nu}} - R_c)]$$

Decay mediated by the higgsino right-handed coupling

$$z_c = \frac{2p_{\tilde{b}} \cdot p_c}{m_{\tilde{b}}^2} \quad \text{and} \quad z_l = \frac{2p_{\tilde{b}} \cdot p_l}{m_{\tilde{b}}^2}$$

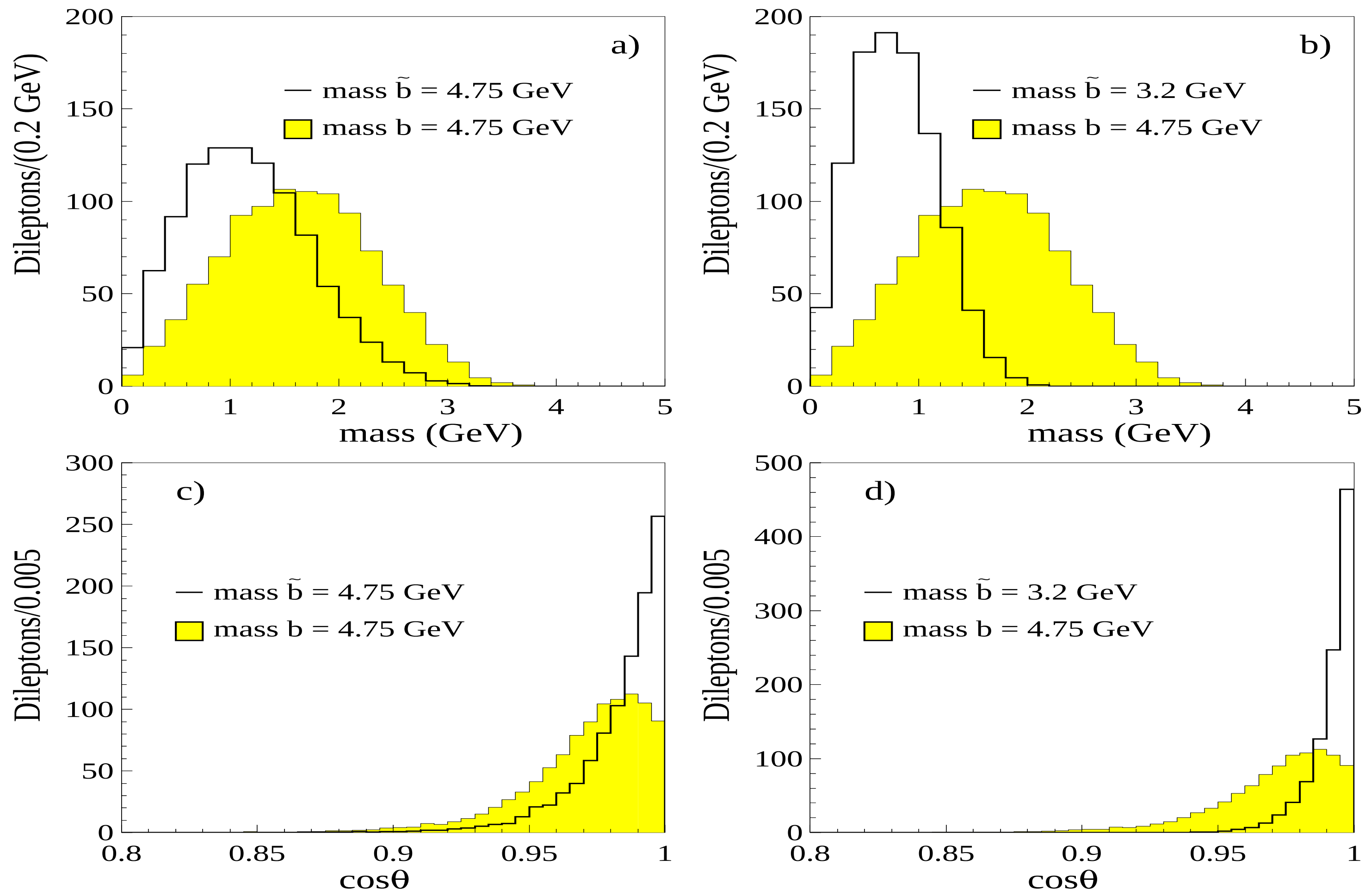
$$2\sqrt{R_c} < z_c < 1 + R_c - R_{\tilde{\nu}}$$

$$\frac{1 + R_c - R_{\tilde{\nu}} - z_c}{1 - [z_c - \sqrt{z_c^2 - 4R_c}]/2} < z_l < \frac{1 + R_c - R_{\tilde{\nu}} - z_c}{1 - [z_c + \sqrt{z_c^2 - 4R_c}]/2}$$

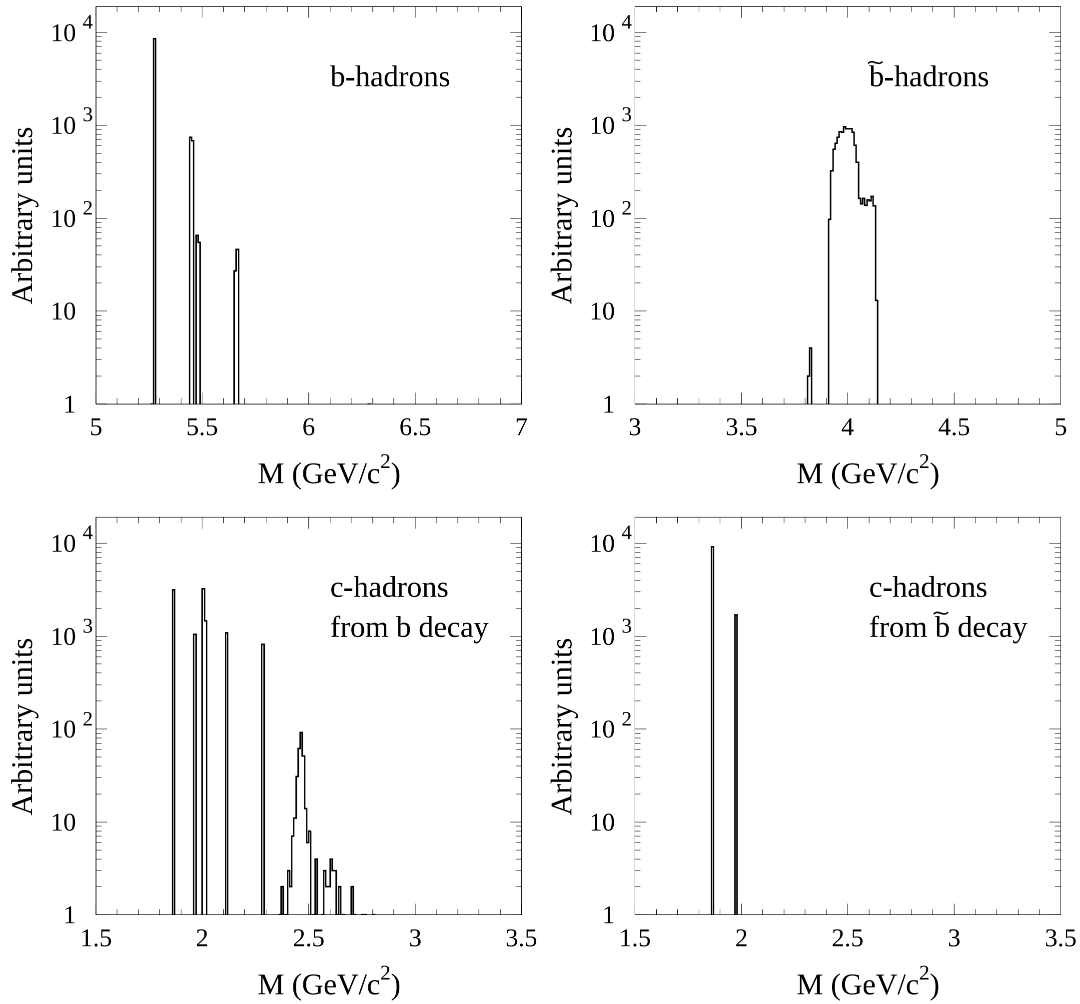
Decay mediated by the wino left-handed coupling

$$\frac{d\Gamma}{dz_c dz_l} = K(z_c + z_l - 1 + R_{\tilde{\nu}} - R_c).$$

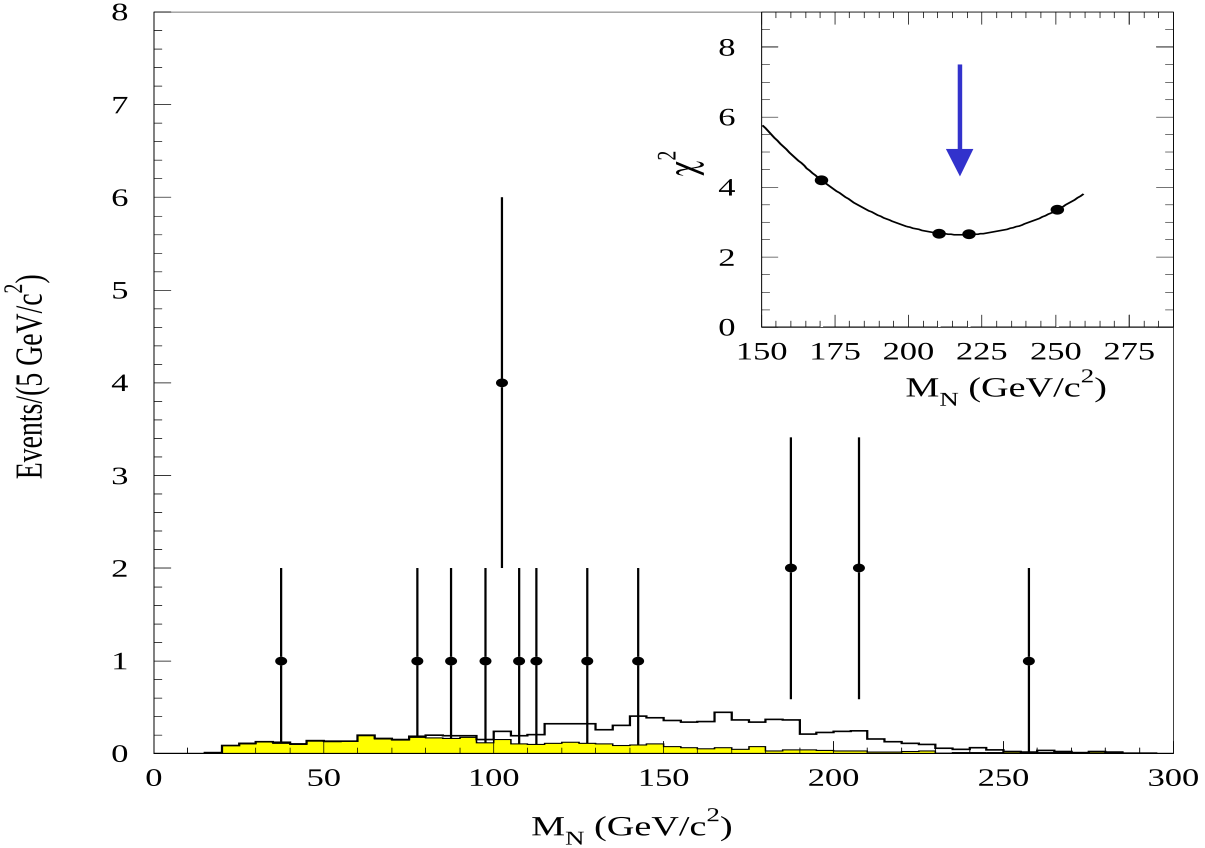
Difference with V-A decays



Use Herwig (spectator model)



Choice of the b b_s mass

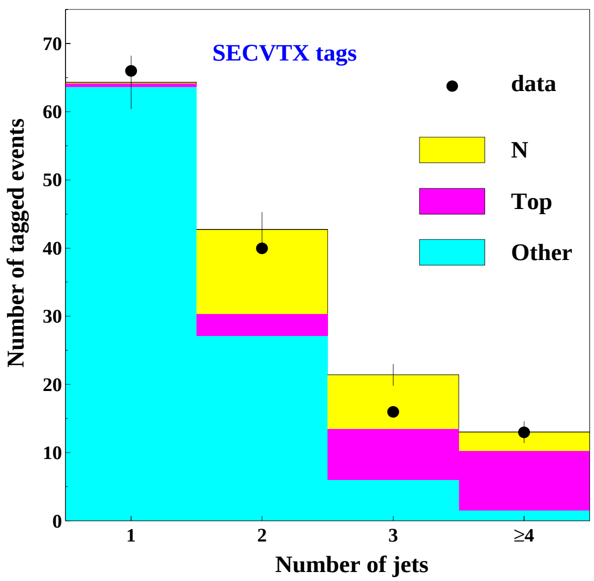


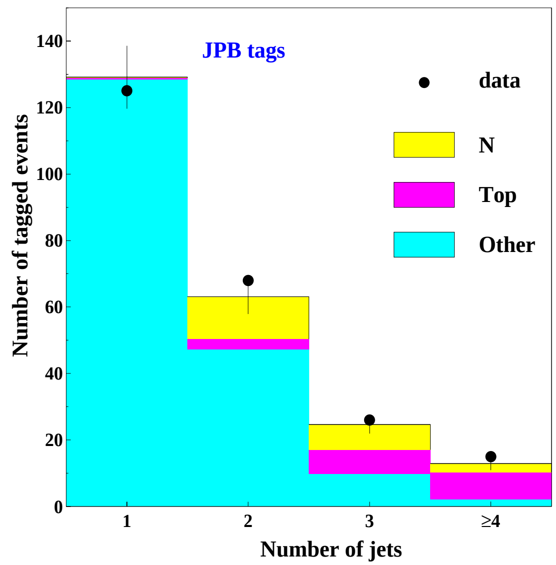
P=10.3%

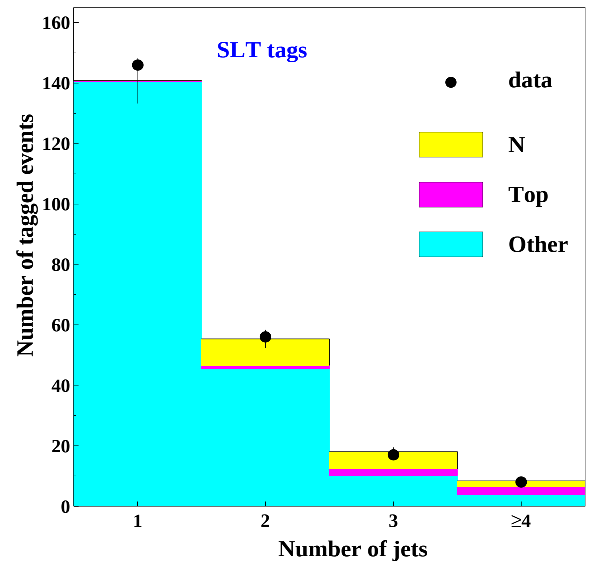
Fit of the tagging rates

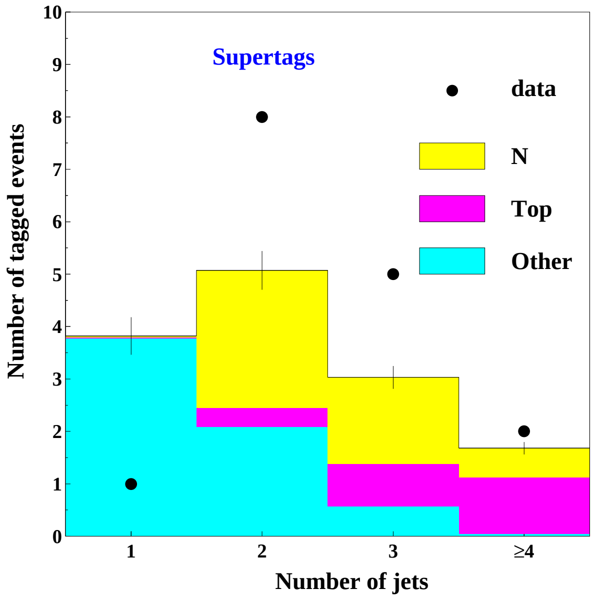
- with all SM process + b b_s production
- the top cross section and the rate of b b_s are unconstrained parameter of the fit
- the best fit yields χ^2=28 for 29 d.o.f.
- it returns σ_{tt}=4.0 ± 1.5 pb (42 events)
- 52 ± 22.1 b b_s events

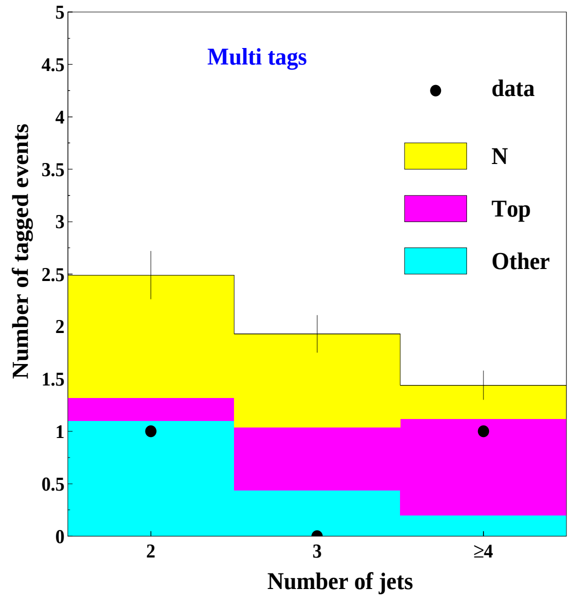
Observed and fitted tagging rates



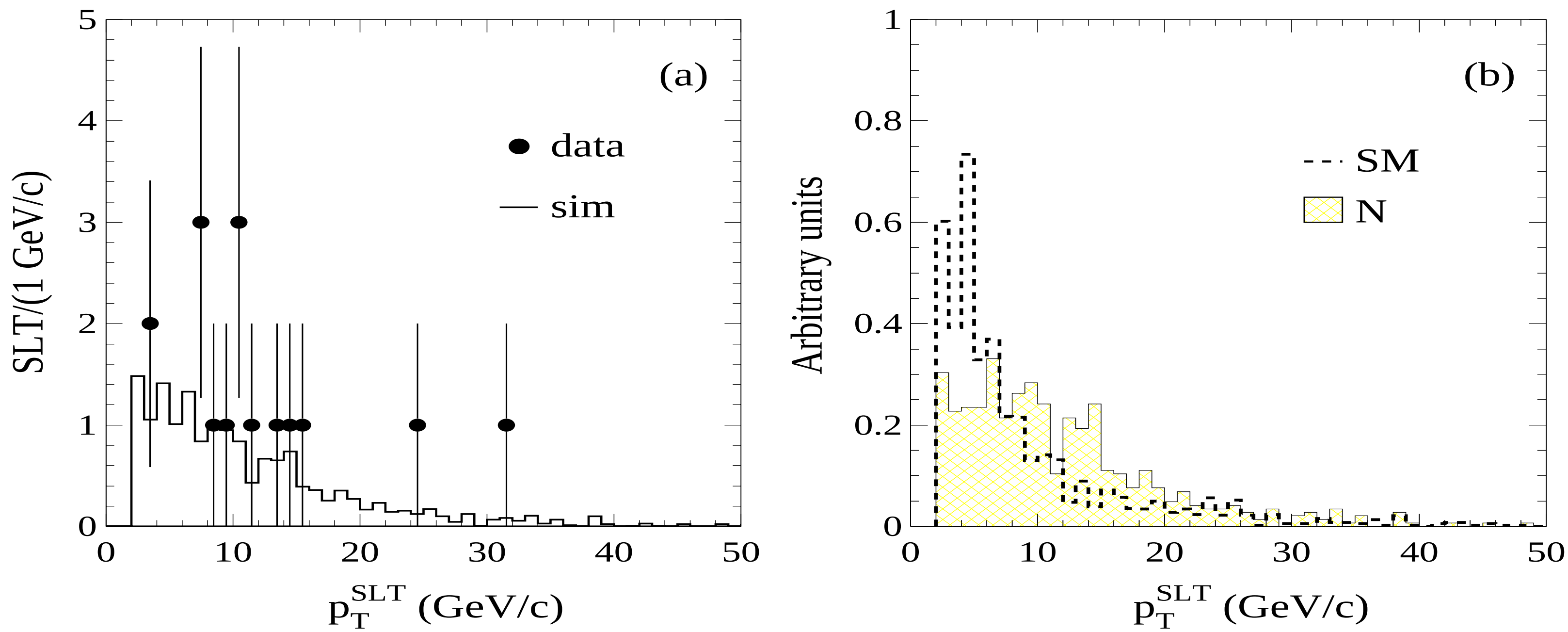








SLT transverse momentum

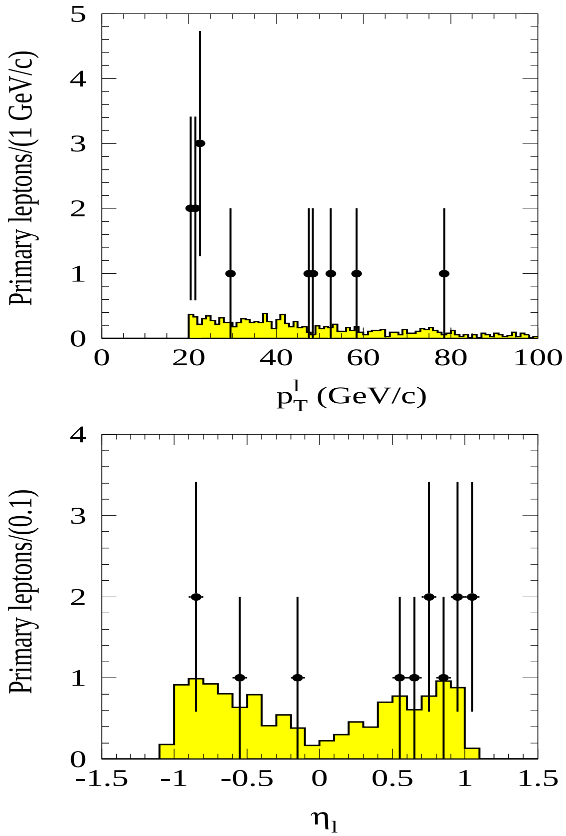


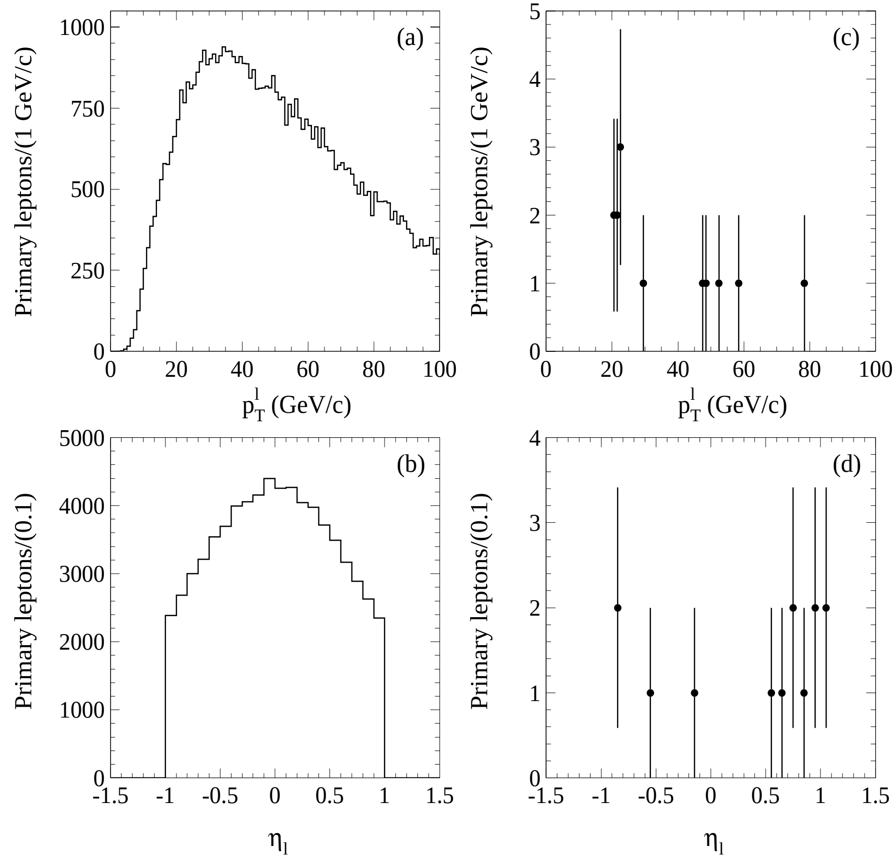
- the probability increases from 1% to 11.8%

Evaluation of the acceptance

- Use two method of increasing complexity:
- 1) *W*+Higgs simulation; the H is identified with the b b_s system; treat the *W* H production as a $2 \rightarrow 3$ hard scattering
- 2) an effective Lagrangian approach to model the data

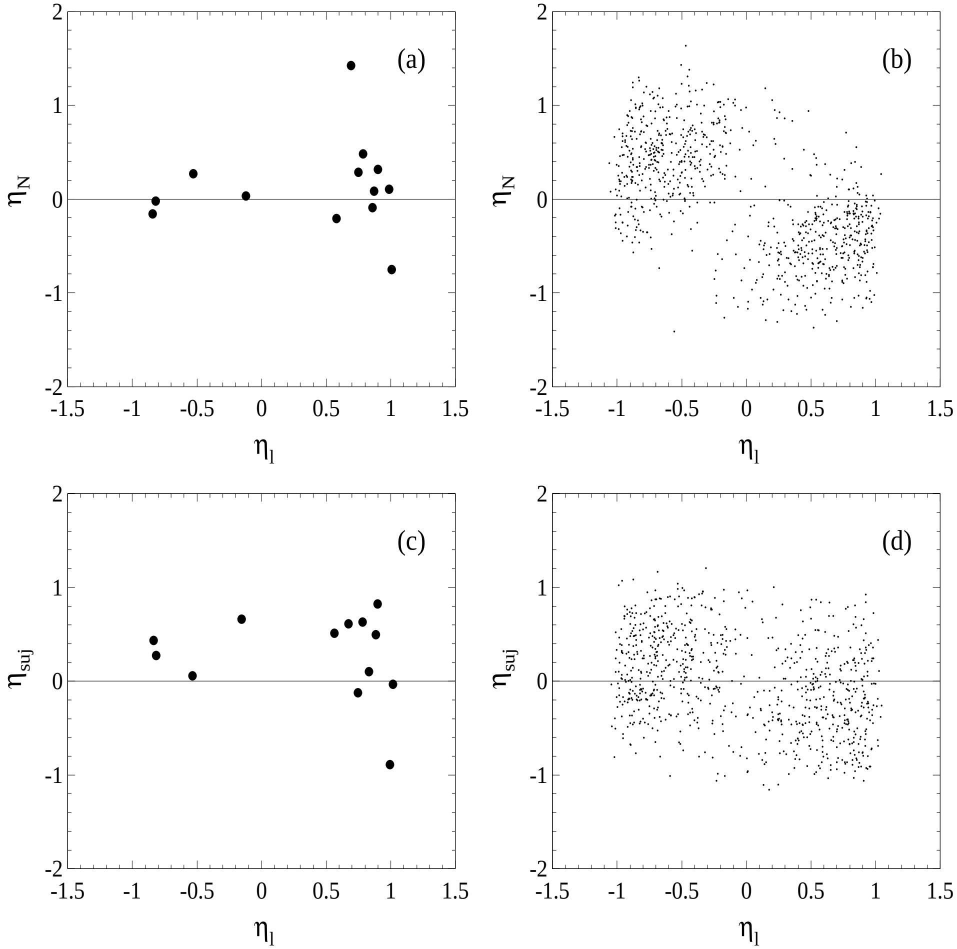
W H simulation

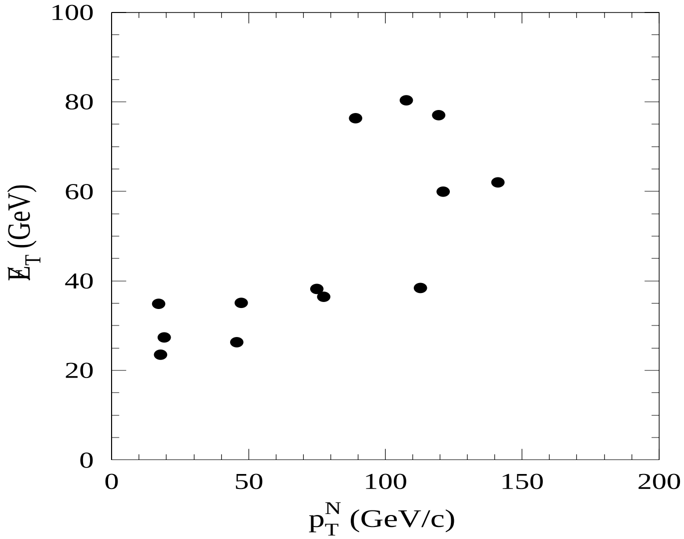


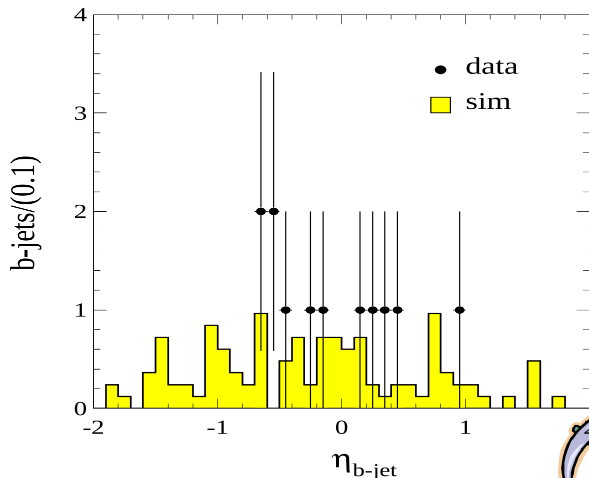


- weight the lepton polar angle distribution as $z^4 = \cos^4\theta$ in the rest frame of the initial partons

Other distributions







Effective Lagrangian

$$u(p_1) + \overline{d}(p_2) \longrightarrow e^+(p_l) + \nu_s(k) + \bar{b}(p_b) + b_s(p_s)$$

$$\phi_{\mu\nu}(x) = (1/\Lambda)^2 \partial_\mu \partial_\nu \phi(x) \text{ and } \tilde{\phi}_{\mu\nu} = (1/\Lambda)^2 \partial_\mu \partial_\nu \tilde{\phi}(x)$$

scalar fields

$$\psi_l^{\mu\nu}(x) = (1/\Lambda)^2 \partial^\mu \partial^\nu \psi_l(x) \text{ and } \psi_b^{\mu\nu}(x) = (1/\Lambda)^2 \partial^\mu \partial^\nu \psi_b(x)$$

b-quark and lepton fields

$$\chi_q^{\mu\nu}(x) = (1/\Lambda)^2 \partial^\mu \partial^\nu [\frac{1+s_q}{2} \psi_u(x) + \frac{1-s_q}{2} \psi_d(x)]$$
$$\xi_q^{\mu\nu}(x) = (1/\Lambda)^2 \partial^\mu \partial^\nu [\frac{1-s_q}{2} \psi_u(x) + \frac{1+s_q}{2} \psi_d(x)]$$

initial state quark fields

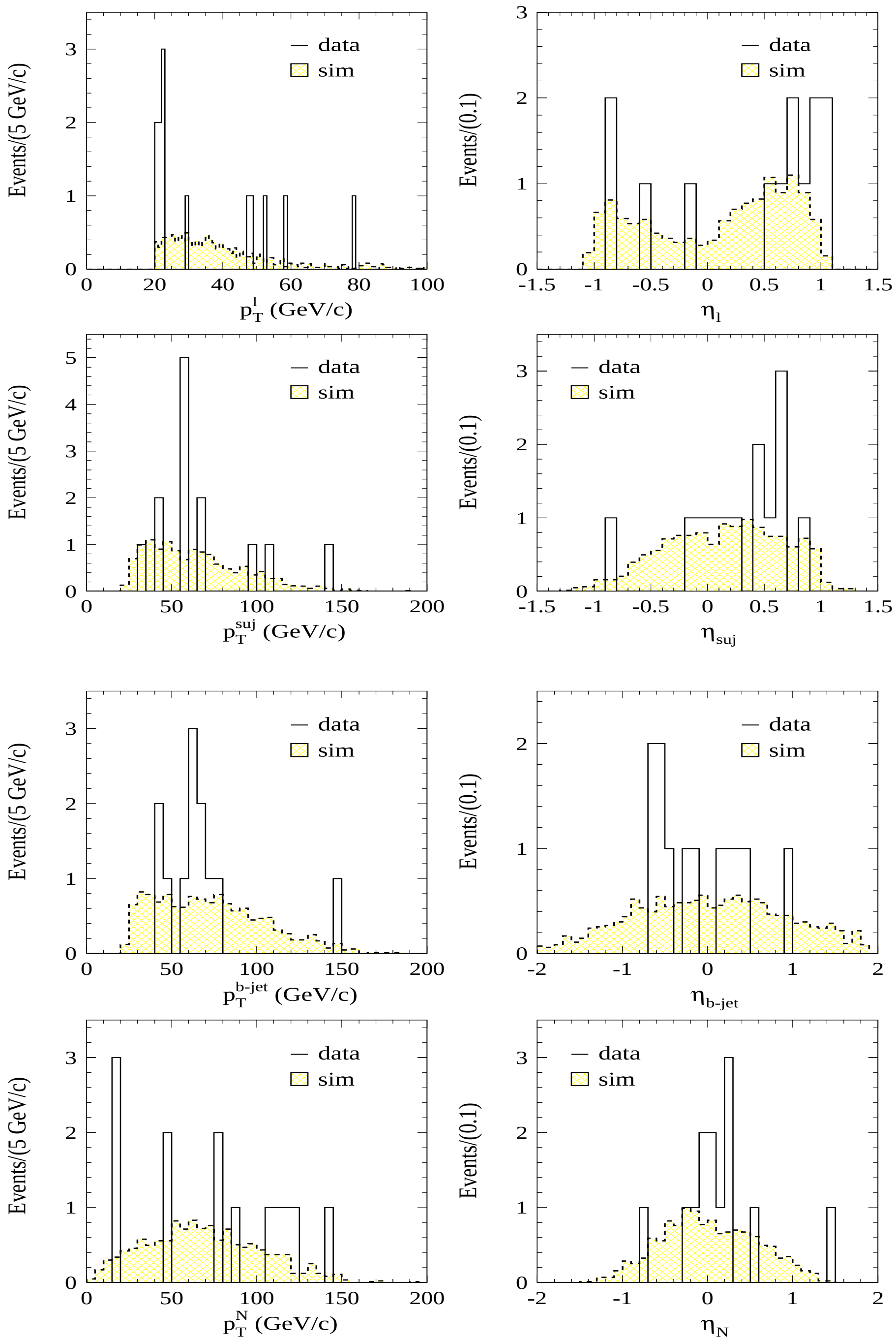
$$\mathcal{L}(x) = (\frac{f}{\Lambda^{10}}) \partial_\lambda \{ \phi^\dagger_{\alpha\beta}(x) \tilde{\phi}'_{\delta\phi}(x) \psi"^{\tau\sigma}_b(x) \} \gamma^\rho \partial^\lambda \{ \overleftrightarrow{\partial}^\omega \ \psi_l^{\mu\nu}(x) \ \overleftrightarrow{\partial}_\omega \ [(\partial_\tau \bar{\xi}_q^{\delta\phi}(x)) \gamma_\rho \ \overleftrightarrow{\partial}_\mu \overleftrightarrow{\partial}_\nu \ (\partial_\sigma \chi_q^{\alpha\beta}(x))] \}$$

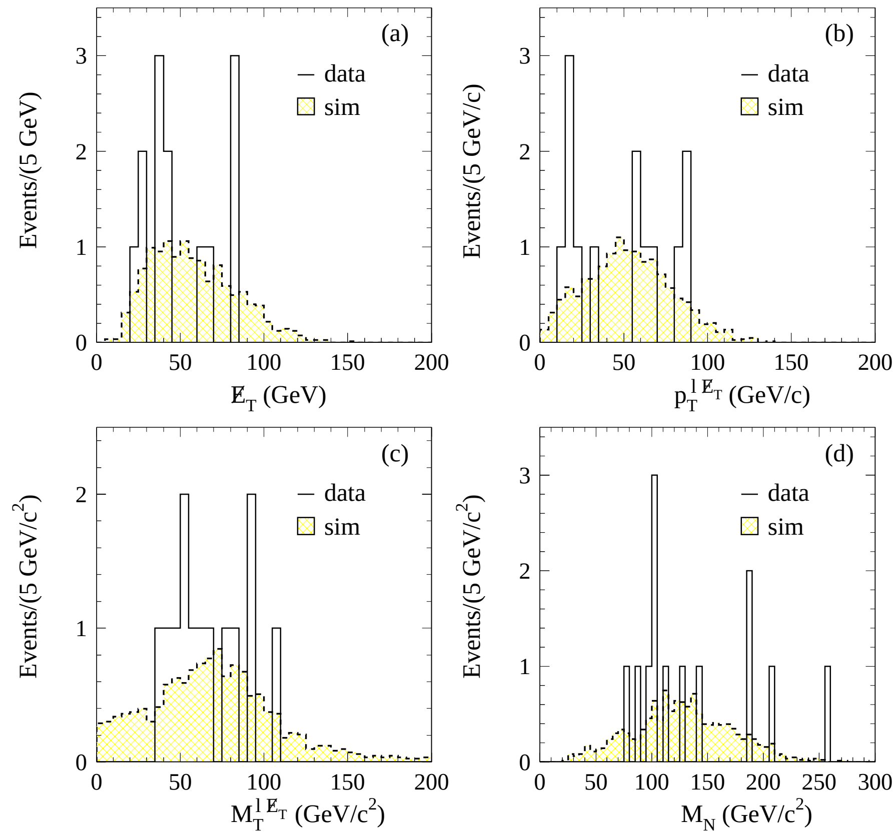
$(p_1 - p_2) \cdot p_l = s^{1/2} p_l^* \cos \theta$

$$|\mathcal{M}|^2 = \left(\frac{f}{\Lambda^2}\right)^2 \frac{\hat{s}^{13}}{(\hat{s} + \Lambda_1^2)^{20}} \frac{(E_b \ E_l)^5 (k \ E_s)^4}{(\hat{s} - M^2)^2 + M^2 \Gamma^2} [1 - \cos\vartheta_l \ \cos\vartheta_b] \times$$
$$(1 - \frac{2E_l}{\sqrt{\hat{s}}})^2 (1 - \frac{4E_l}{\sqrt{\hat{s}}})^2 \left[\cos\vartheta_l \ sin\vartheta_b \ (\frac{1-\cos\vartheta_k}{2})(\frac{1+\cos\vartheta_s}{2})\right]^4$$

Effective Lagrangian

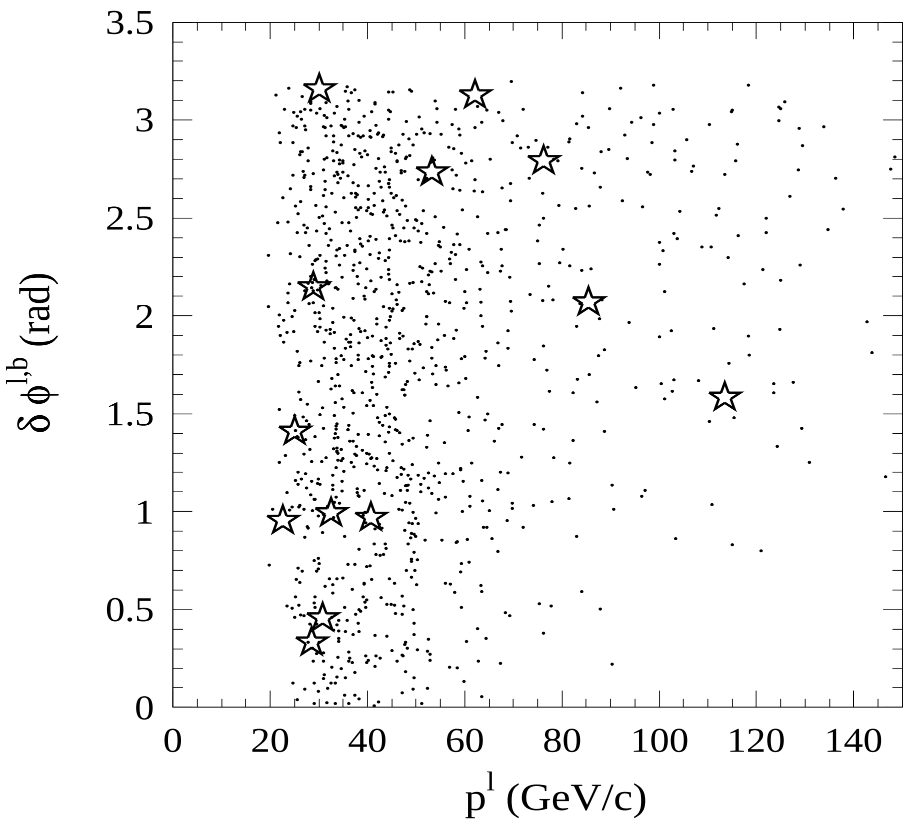
- Beside being a patchwork, it can be seen as the Taylor expansion of an unknown interaction Lagrangian. We pick arbitrarily those terms which appear to be useful to model the events
- we need a lot of derivative couplings : composite structure, high spin
- we stabilize the *s*-behaviour with a form factor for each of the 20 derivatives
- plus a propagator (M= 350 and Γ = 5 GeV)

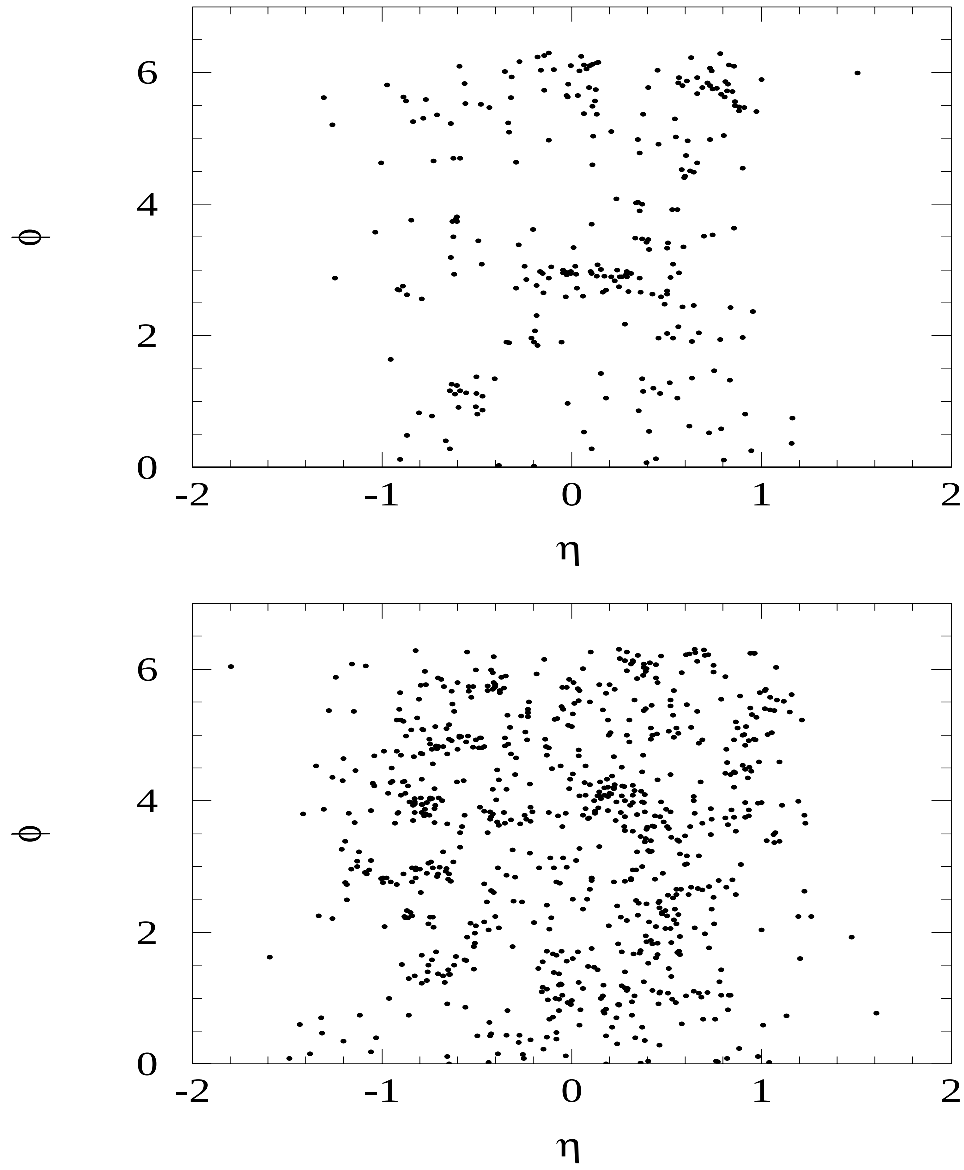

data
sim
Events/(5 GeV/c)
Events/(0.1)
p_T^l (GeV/c)
η_l
p_T^{suj} (GeV/c)
η_{suj}
$p_T^{b\text{-}jet}$ (GeV/c)
$\eta_{b\text{-}jet}$
p_T^N (GeV/c)
η_N


(a)
(b)
(c)
(d)
data
sim
Events/(5 GeV)
Events/(5 GeV/c)
Events/(5 GeV/c^2)
$\not{E}_T$ (GeV)
$p_T^{l\not{E}_T}$ (GeV/c)
$M_T^{l\not{E}_T}$ (GeV/c^2)
M_N (GeV/c^2)

Acceptance and cross section

- The W H simulation yields a 9.1 % acceptance and the simulation using the effective Lagrangian yields a 10.8 % acceptance
- Averaging the two results, the corresponding cross section for producing events with a superjet is $\sigma = 5 \pm 2$ pb
- the size of the cross section for producing a final state with an invariant mass of about 350 GeV is typical of strong interactions, but it corresponds to $\Lambda = 10$ MeV in the effective Lagrangian
- hot line: 1 800 black hole


3.5
3
2.5
2
1.5
1
0.5
0
0
20
40
60
80
100
120
140
$\delta\phi^{l,b}$ (rad)
p^l (GeV/c)



X

Complementary sample