Leptoquarks and excited quarks

Leptoquark de 1ère génération,

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Search for Heavy Resonances Decaying into Z+j,

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Recherche de Leptoquark de première génération:

Planning actuel

- **Données jusqu'au shutdown de mars**

  luminosité ~ 1fb^{-1} (80% de la lumi enrégistrée)
- **Format CAF trees + outils CAF-UTIL**
- **Première priorité: préparer les outils pour l'analyse du canal eejj**

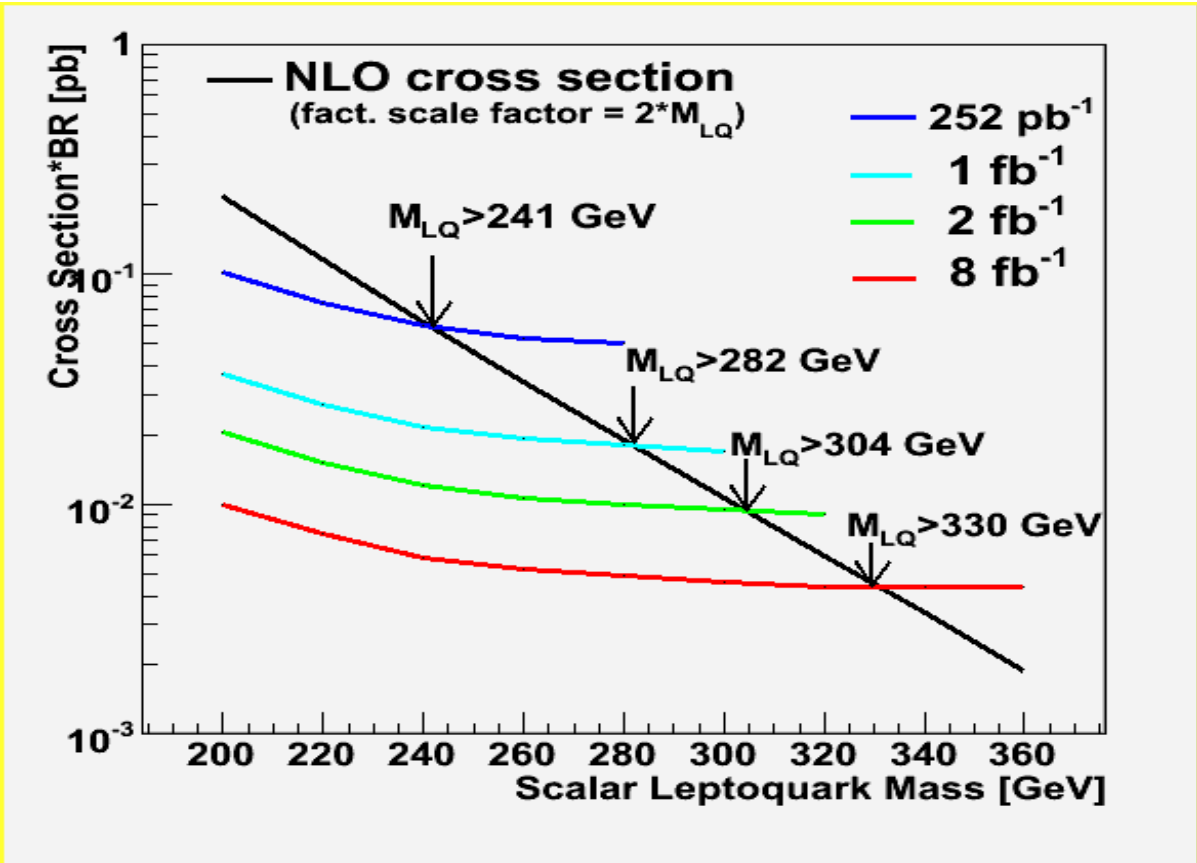
  (thèse d'Anne Fleur Barfuss)
- **Analyse du canal eνjj**

Estimation de la limite attendue à 95% C.L pour différentes luminosités

- **Publication:** data = 1 evt bck = 0.54±0.15 evt canal eejj

  ε = 18.5% à 36 % pour M_{LQ}: 200 à 300 GeV 252 pb^{-1}
- **Extrapolation:** ε = 40 ±4 % pour M_{LQ}>320 GeV

  bruit de fond rescalé en luminosité (erreur totale de 30%)



Prévisions pour LHC

- **Leptoquark Single and Pair production at LHC with CalcHEP/CompHEP in the complete model**

  hep-ph/0502067 (luminosite 300fb^{-1})

  production de LQ (M=500 GeV) + canal eejj

  (production en paire et single)

  → 16000 LQ scalaires pour un bruit de fond de 614 evts

ou une limite M_{LQ} de l'ordre de 1250 GeV

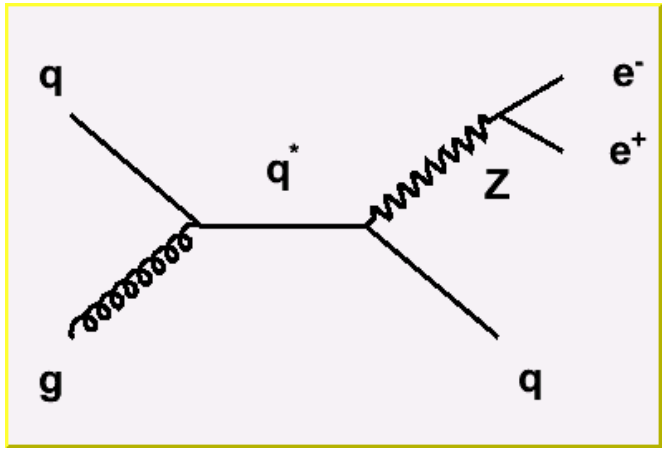
- **Rescalé à une luminosité de 10 fb^{-1} (1 an a 10^{33} ! Fin 2008 ???)**

  → 500 LQ scalaires pour un bruit de fond de 20 evts

ou une limite M_{LQ} de l'ordre de 900 GeV

Search for Heavy Resonances Decaying into Z+j

-Signal is clear – instrumental background can be neglected
-Not yet explored
-Excited quarks can produce such a signal -> quark substructure



« gauge » interaction: Z+1j
peak in M_{Zj}, $p_{TZ'}$ p_{Tj}
explored at present

Data Sample & selection

-2EMhightpt Pass2 skim: 2 EM, |id|=10,11, p_T > 15 GeV
-TMBTree produced by p16.05.01, duplicated events removed
-Bad runs and LBN's removed (from CAL, SMT, CFT and Muon groups)
-Calorimeter quality required, no: EmptyCrate, CoherentNoise, RingOfFire, NoonNoise
-Triggers: pass at least 1 of 22 selected single or di-electron triggers
-Preselection: >= 2 electrons, p_T>15 GeV pointing to Vtx, |id| = 10,11, emfrac>0.9, iso<0.15

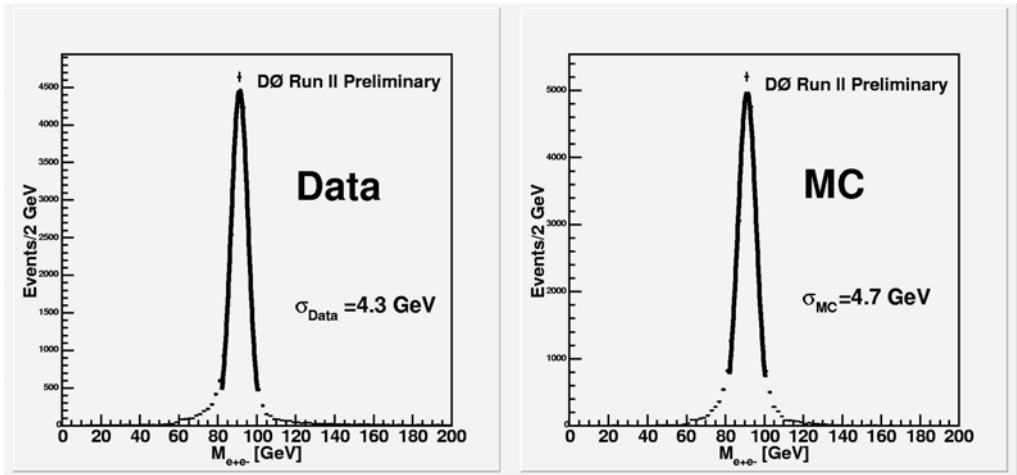
Final selection:

>1 em isolated object with at least 1 associated track: e+/-
EC:HMX8<20, CC:HMX7<10
p_T^1>30, p_T^2 > 25 GeV
$|Z_{vert}|$ < 50 cm
28033 evts

at least 1 Z: 80 < M_{ee} < 102 GeV
24722 evts

at least 1 confirmed jet
p_T>10 GeV
|η| < 2.5
4819 evts

L_{int} = 376 +/- 24 pb^{-1} used,
Data from April 2002→August 2004



Very clean Z signal, almost no background
Good agreement between Data and MC

Data, SM background and signal (M_{q^*}=500 GeV)

SM Background

Inclusive Z production generated by Pythia:

$2 \rightarrow 1$ process : $\bar{q} + q \rightarrow Z +$ QCD radiation

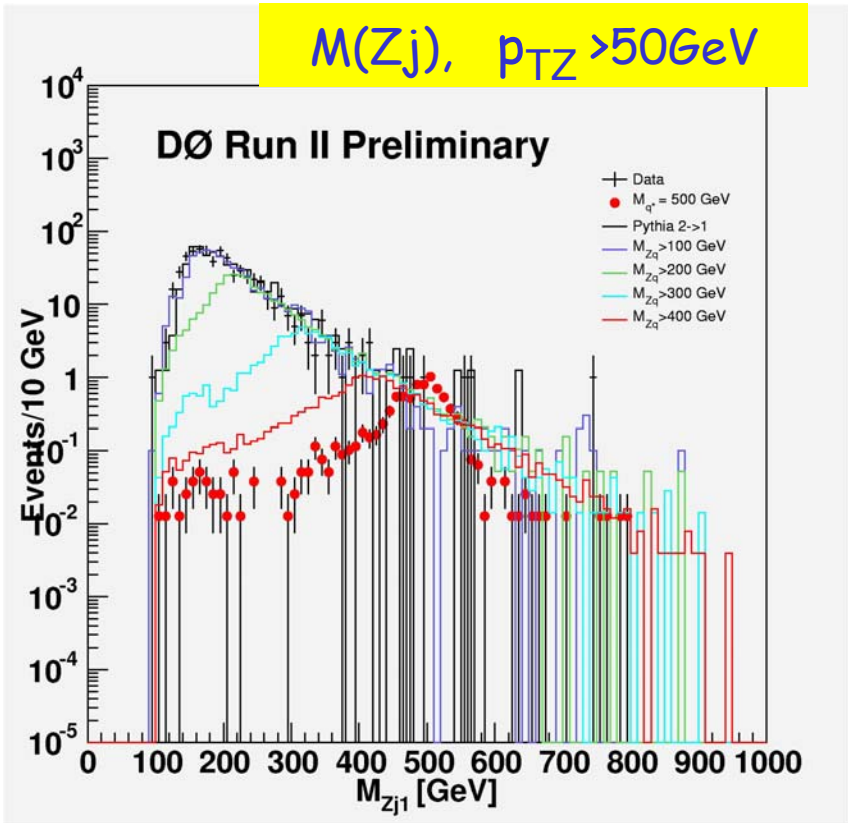
$2 \rightarrow 2$ process : $g\,(\bar{q}) + q \rightarrow Z + q\,(g) +$ QCD radiation

2→2 process with variable M_{Zq} threshold:
100, 200, 300,400 GeV
and pT_min(parton) threshold: 30 GeV

2→1 MC, normalized to total nb of data events
2→2 MC are normalized to data,
using M_{Zq}>100 GeV

Signal Simulation

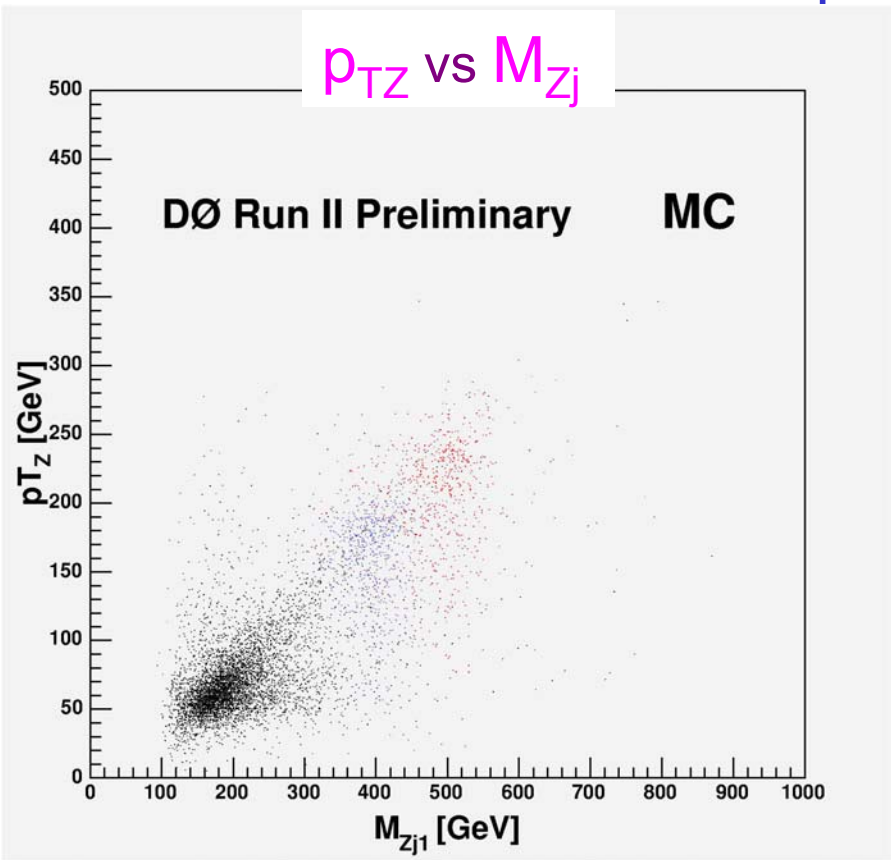
Spin ½ resonance with narrow width simulated
for M = 300, 400, 500, 600, 700 GeV
using the q+g→q*→Z+q model of Pythia



-Data: black error bars
-Signal (M_{q^*}=500 GeV): red dots
-SM bg: colored histograms:
M_{Zq}>100,200,300,400 GeV

95% CL cross section upper limits

Topological cut around M_{Zj} and p_{TZ}



SM bkg: black,
resonances: M=400, M=500

Good separation between background and signal:

$$\left(\frac{M_{Zj} - M_{Zj}^{c}}{M_{ZJ}^{RMS}}\right)^2 + \left(\frac{p_{TZ} - p_{TZ}^{c}}{p_{TZ}^{RMS}}\right)^2 = k^2$$

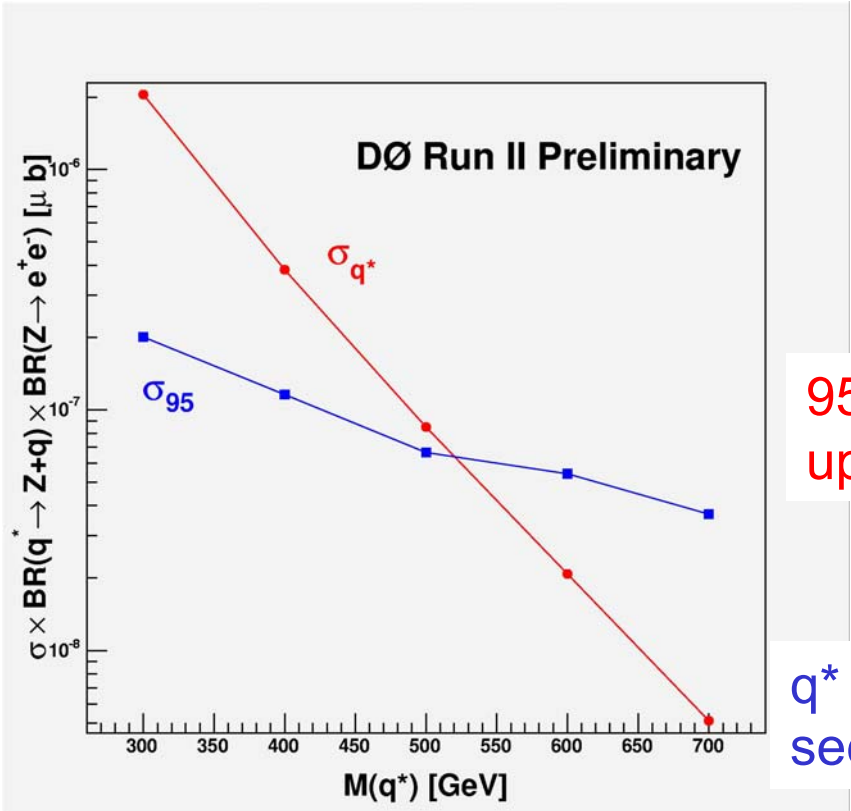
$M_{Zj}^{c} \sim M_{q^*}$ $p_{TZ}^{c} \sim M_{q^*}/2$

Search for optimum k:
- highest q* acceptance
- smallest SM bg

→least σ_{95}^{ave}

SM bg is normalized to data
- M_{Zj}> 150 GeV and p_{TZ} > 50 GeV
- Using M_{Zq} > 100 GeV p_{Tp} > 30 GeV

Preliminary results: **CONFnote 4893, D0note4895**



95% CL cross section upper limit

q* production cross section x BR

M_{q^*} < 520 GeV excluded

Plans and update since conf.note

Aim to publish the results of the pass2 data set
Plan to finnish new Analysis note, for December 2005

We Have:
-taken into account EBs requests: result did not change
use jets with pT>20 GeV, select EM objects by detector eta
-cross checked pTZ vs MZj1 cut with NN output
-cross checked CL95/CLA method with TLimit/MCLimit
-Estimated W->enu bkg: neglible

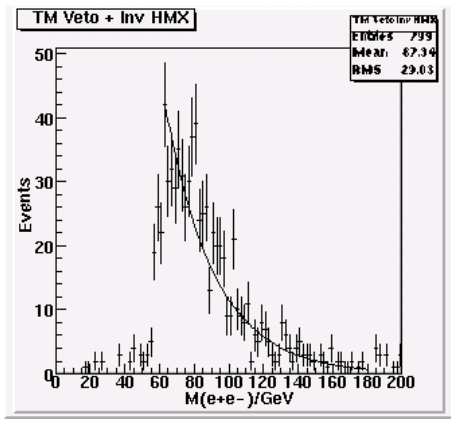
We are:
-Generating more MC: resonances with large widths,
-> to do model independent search and present results as function of mass and width of resonance.
-verifing EM-efficiencies
-writing Analysis note

Backup

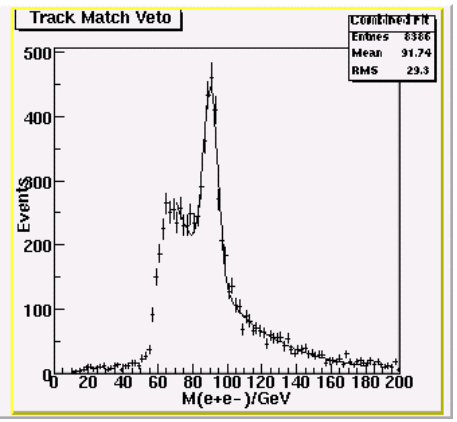
Instrumental Background (QCD)

mix-up between electromagnetic and hadron jets

TM veto & inverse HMX



Only TM veto



determine slope:

$f_{QCD}=e^{-dMee}$

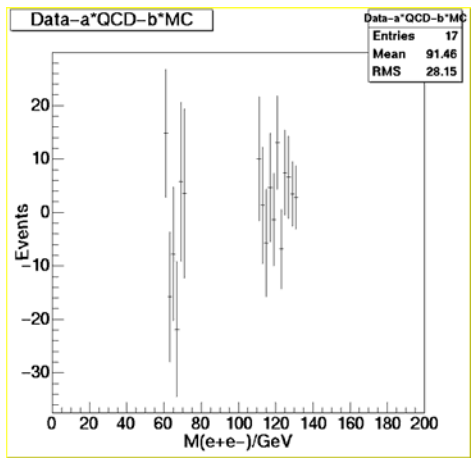
$d=0.0286\ GeV^{-1}$

Fit a and b in sideband:

$60<M_{ee}<70$ and $110<M_{ee}<130$ GeV

$$\sum_i \frac{(n_i^D - a f_{QCD}(M_i) - b n_i^{MC})^2}{n_i^D + b^2 n_i^{MC}}$$

X^2/NDF = 13.4/17



$$N_{QCD} = \frac{a}{d\Delta}(e^{-dM_1} - e^{dM_2})$$

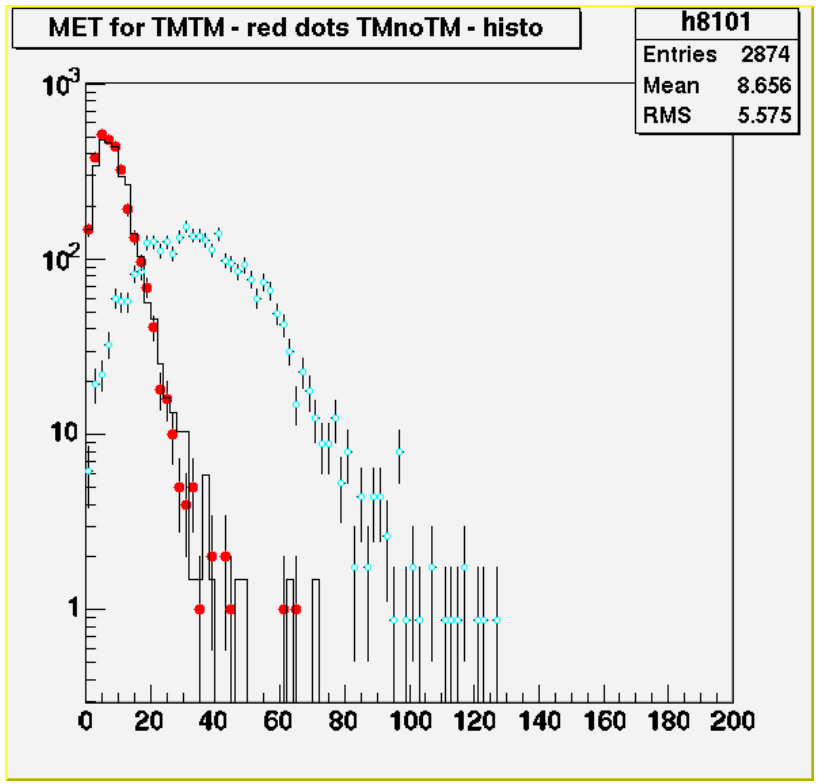
$$= 183.6 \pm 6.3 = 0.74 \pm 0.02\%$$

$M_1=80$, $M_2=102$ GeV

QCD background is negligible

Instrumental Background (W→ev+j)

- Hadron jet simulates em object
- Expected in the TM-noTM sample
- Since TM-TM and TM-noTM sample show similar MET distribution this kind of background should be small.



- Quantitative estimation done with W→ev+j MC sample.

SM Background

Inclusive production of Z has been generated by Pythia

$2 \rightarrow 1$ process : $\bar{q} + q \rightarrow Z +$ QCD radiation

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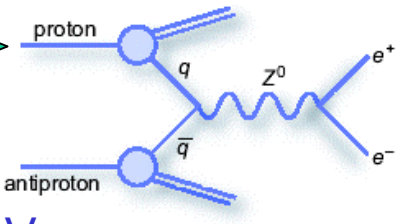
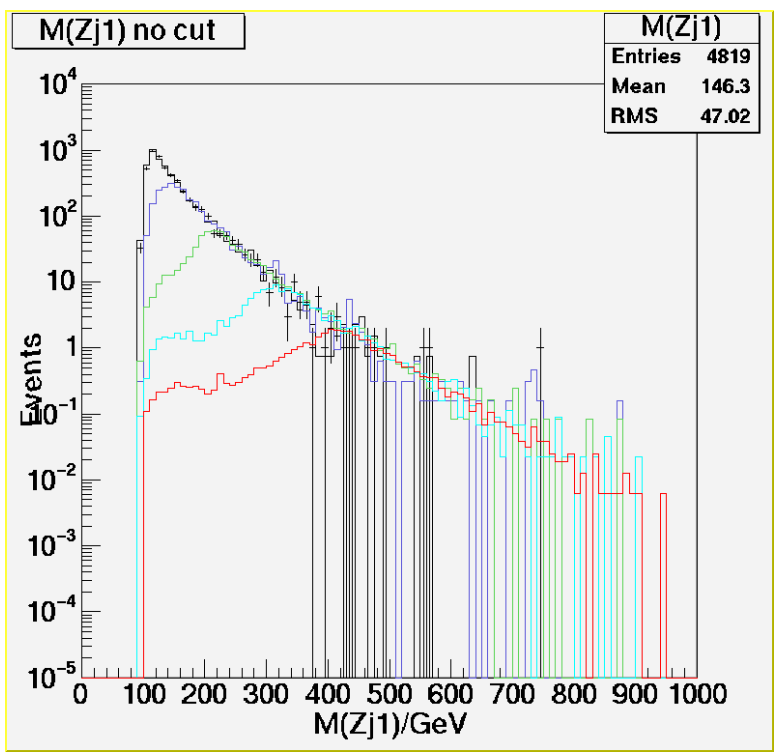


2→2 process with variable M_{Zq} threshold: 100, 200, 300,400 GeV
and pT_min(parton) threshold: 30 GeV



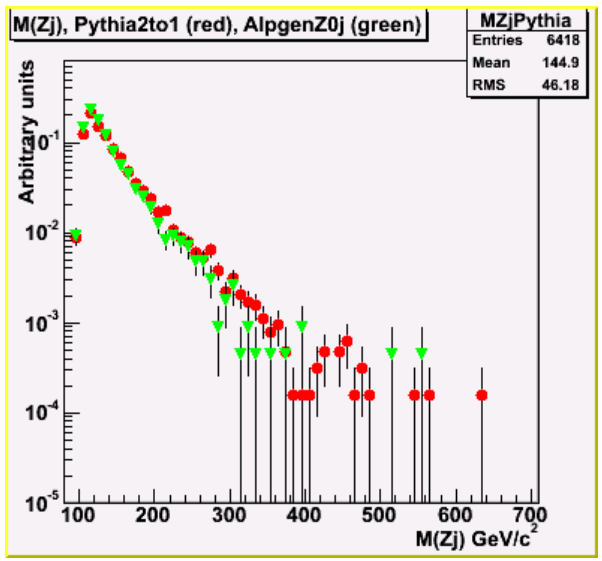
- Data (with error bars) and
- MC (histogram)
  w/o topological cut

- 2→1 events are normalized to the total number of data events, good description of the data in M(Zj1) < 300 GeV
- 2→2 events are normalized to data, using M_{Zq}>100 GeV, good description of the data in M(Zj1) > 150 GeV (region of interest)

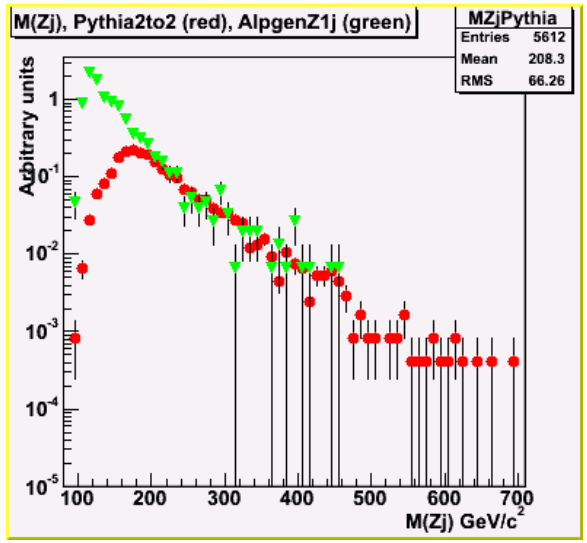
Use separate M_{Zq} thresholds in different M(Zj1) regions

ALPGEN Z+nj generator

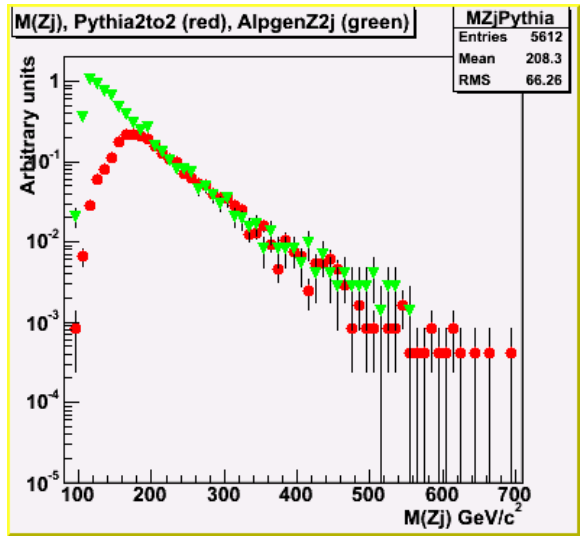
Z+0j agrees well with Pythia 2→1 for all M_{Zj} and p_{TZ}
Z+1j and Z+2j results in similar M_{Zj} slope for M_{Zj}>200 GeV
and agrees with Pythia 2→2 M_{Zq}>100 GeV, p_{Tp}>50 GeV



Pythia2to1, Z+0j



Pythia2to2, Z+1j



Pythia2to2, Z+2j