A preliminary study of Z+b production in ATLAS

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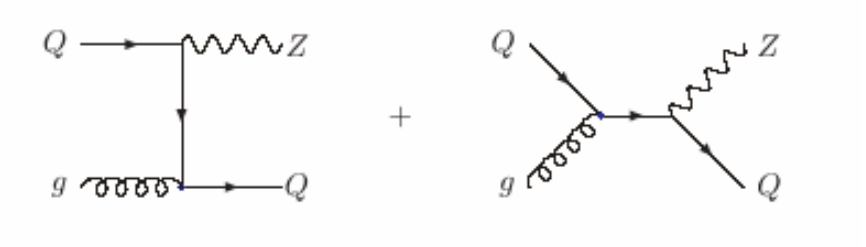
- The D0 measurement of $\sigma(Z+b)/\sigma(Z+jet)$
- Expectations at LHC
- Preliminary study in ATLAS
  - Event selection criteria
  - Expected signal and background samples
  - Outlook

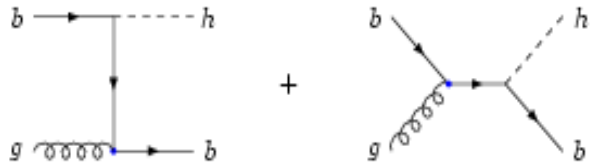
Motivations for Z+b analysis

A detailed discussion has been given in the previous talk by F.Maltoni (cfr Phys.Rev.D69:074021,2004)

- Sensitivity to b content of the proton



- Background to Higgs search



The D0 measurement of Zb/Zj

- The D0 collaboration has recently measured $\sigma(Z+b)/\sigma(Z+jet)$

  with $Z \rightarrow \mu\mu$ and $Z \rightarrow ee$

  $\rightarrow$ D0 note 4388 available on http://www-d0.fnal.gov

- The ratio is, at first order, insensitive to detector effects

  (lepton trigger efficiencies, jet energy scale, jet and lepton reconstruction efficiencies, energy resolution…)

  but it is sensitive to differences between light and b-jets

The D0 measurement of Zb/Zj

Analysis flow:

- select events with $Z \rightarrow ee$ or $Z \rightarrow \mu\mu$ + jet
- apply b-tagging
- extract content of b, c and light quarks (assuming Nc/Nb from theory)

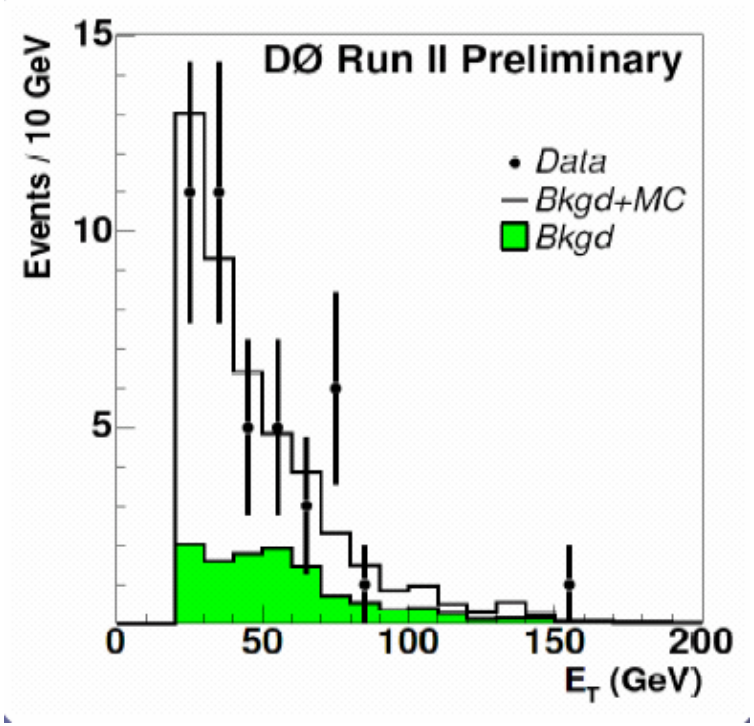
Fitted values for selected sample in 184 pb^{-1}

	Dielectron channel	Dimuon channel
Nb	61.0	18.7
Nc	102.8	31.6
N_{light}	1797.4	1273.4

The D0 measurement of Zb/Zj

$$\frac{\sigma(Z+b)}{\sigma(Z+j)} = 0.024 \pm 0.005(stat)\,^{+0.005}_{-0.004}(syst)$$

Theory NLO (F.Maltoni et al.): 0.018 +/- 0.004



Main sources of systematic uncertainty:

- b/c tagging efficiencies
- background estimation
- theory uncertainty on σ(Z+c)/σ(Z+b)

Expectations at LHC

As suggested by Maltoni et al., the measurement of Z+b production at LHC should be even more interesting than at Tevatron for several reasons:

- The contribution of Zbb is much less significant, so most of the cross-section comes from Zb
  $\Rightarrow$ Better sensitivity to b PDF
- The total inclusive cross-section is larger by about a factor 50
- There will be a smaller background of tagged Z+c events
- The cross-section for Zj events, a source of background when the light quark jet is mis-tagged as b jet, is less significant

Expectations at LHC

Tevatron

Cross sections (pb)					
	ZQ	$Z(Q\overline{Q})$	ZQj	$ZQ\overline{Q}$	ZQ inclusive
$gb \to Zb$	(8.23) 10.4	0.169	2.19	0.631	$13.4 \pm 0.9 \pm 0.8 \pm 0.8$
$q\bar{q} \to Zb\bar{b}$	3.32	1.92	–	1.59	6.83
$gc \to Zc$	(11.3) 16.5	0.130	3.22	0.49	$20.3\,^{+1.8}_{-1.5} \pm 0.1\,^{+1.3}_{-1.2}$
$q\bar{q} \to Zc\bar{c}$	5.66	6.45	–	1.70	13.8
	Zj		Zjj		Zj inclusive
$q\bar{q} \to Zg, gq \to Zq$	(876) 870		137		$1010\,^{+44\,+9\,+7}_{-40\,-2\,-12}$

from Phys.Rev.D69:074021,2004

jets with Pt>15 GeV $|\eta|<2.5$

LHC

Cross sections (pb)					
	ZQ	$Z(Q\overline{Q})$	ZQj	$ZQ\overline{Q}$	ZQ inclusive
$gb \to Zb$	(826) 649	11.3	304	78.1	$1040\,^{+70\,+70\,+30}_{-60\,-100\,-50}$
$q\bar{q} \to Zb\bar{b}$	24.3	13.5	–	11.4	49.2
$gc \to Zc$	(989) 921	8.8	396	61.5	$1390 \pm 100^{+60\,+40}_{-70\,-80}$
$q\bar{q} \to Zc\bar{c}$	36.7	41.7	–	11.3	89.7
	Zj		Zjj		Zj inclusive
$q\bar{q} \to Zg, gq \to Zq$	(13500) 11600		4270		$15870\,^{+900\,+60\,+300}_{-600\,-300\,-500}$

Preliminary study of Z+b in ATLAS

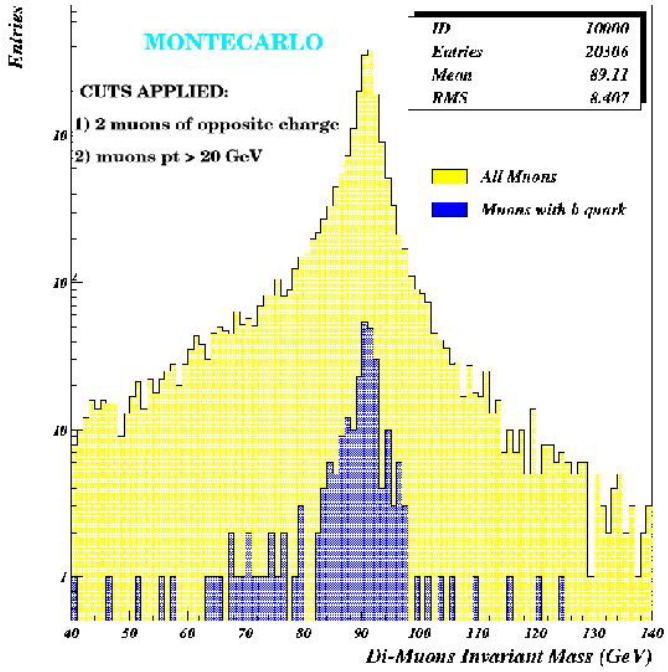
We have performed a preliminary study on the feasibility of Z+b measurement in ATLAS

- A sample of Z+jet events has been generated with PYTHIA and processed through a fast simulation of the ATLAS detector (ATLFAST)
- Only $Z \rightarrow \mu\mu$ has been considered
- Efficiencies on signal and background have been evaluated, with two independent b-jet identification methods
  - soft lepton tagging
  - inclusive b-tagging of jets
- Expected signal and background samples have been estimated, based on the cross-sections from F.Maltoni et al., for an integrated luminosity of 10 fb^{-1} (1 year at initial LHC luminosity, 10^{33} $cm^{-2}s^{-1}$)

Z+b in ATLAS: event selection

Event selection – first step

- Two isolated muons with
  - Pt > 20 GeV/c
  - opposite charge
  - invariant mass close to Mz
    - (80 GeV<Mμμ<105 GeV)
- The two muons also provide the trigger for this type of events



► Eff. ~ 70 % on Z+jet events

cross-checked with a detailed simulation of the muon spectrometer and full track reconstruction in the muon spectrometer

Z+b in ATLAS: soft muon tagging

Event selection 1 – Soft muon analysis

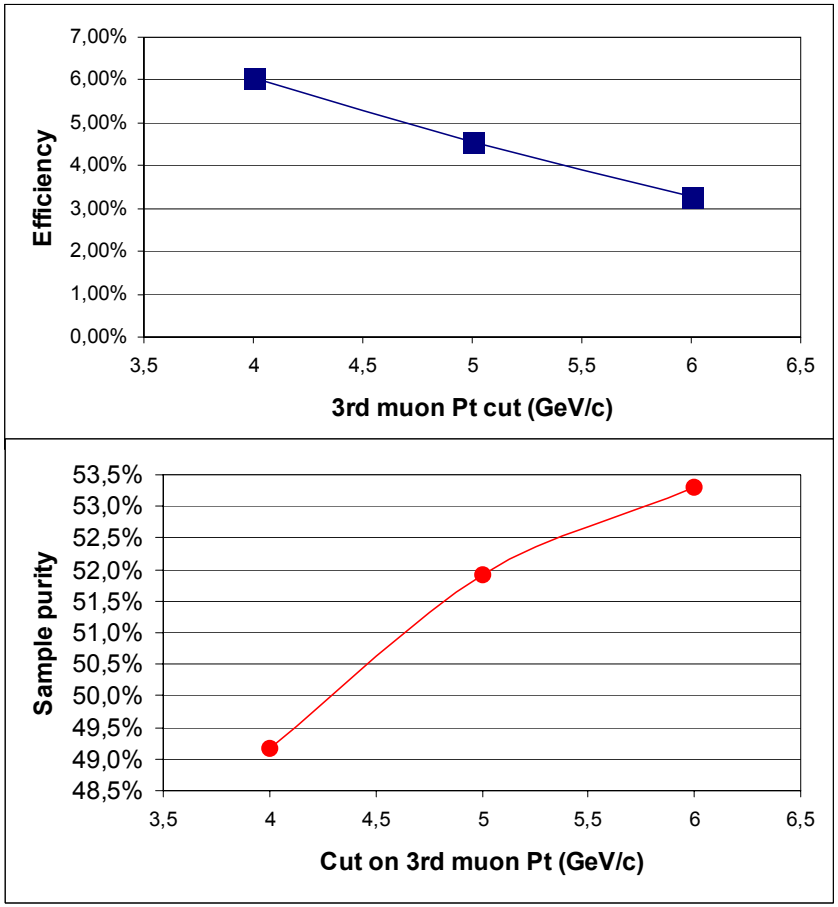
- Require a third muon (soft, non–isolated) in the barrel region with a minimum Pt

Cut on 3rd muon Pt	Efficiency on Z(μμ)+b	Nb in 10 fb-1	Nc in 10 fb-1	Ntot in 10 fb-1
Pt>4 GeV/c	6.0%	24400	9900	49700
Pt>5 GeV/c	4.4%	18300	6100	35300
Pt>6 GeV/c	3.3%	13200	3800	24800

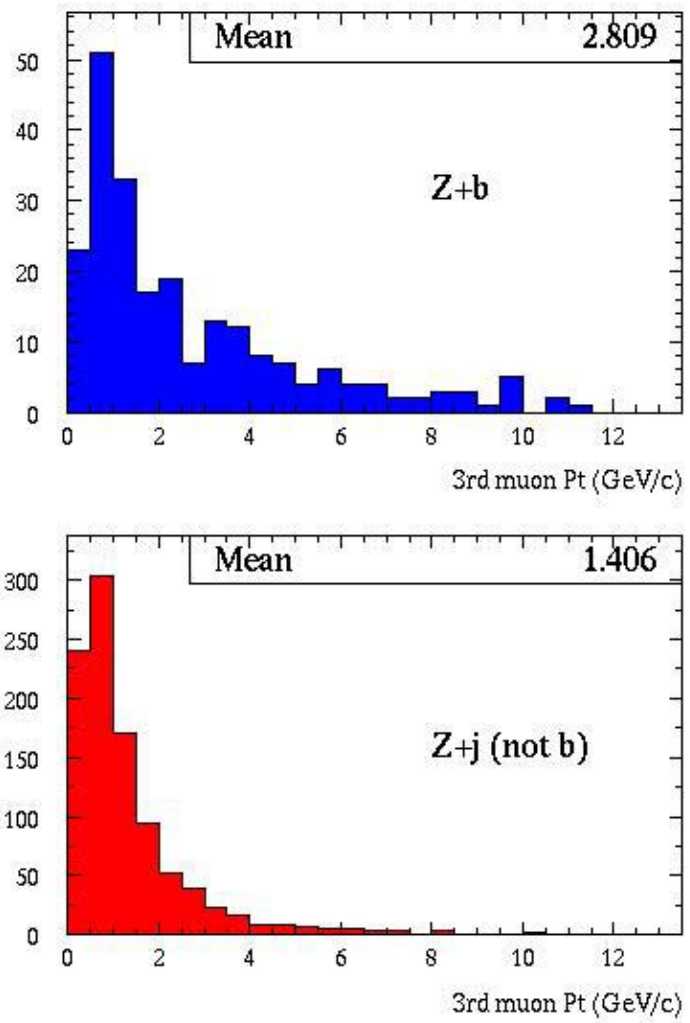
The efficiency is small (BR(b→μ)~10%),
but the selected sample has high purity (~50%)

Z+b in ATLAS: soft muon tagging

Efficiency and purity
vs 3rd muon Pt cut



3rd muon Pt distributions



Z+b in ATLAS: inclusive b-tagging

Event selection 2 – Inclusive b-tagging of jets

- Require a b-tagged jet with Pt>15 GeV

  b-tagging efficiency: on b jets ~ 31%

  on c jets ~ 6%

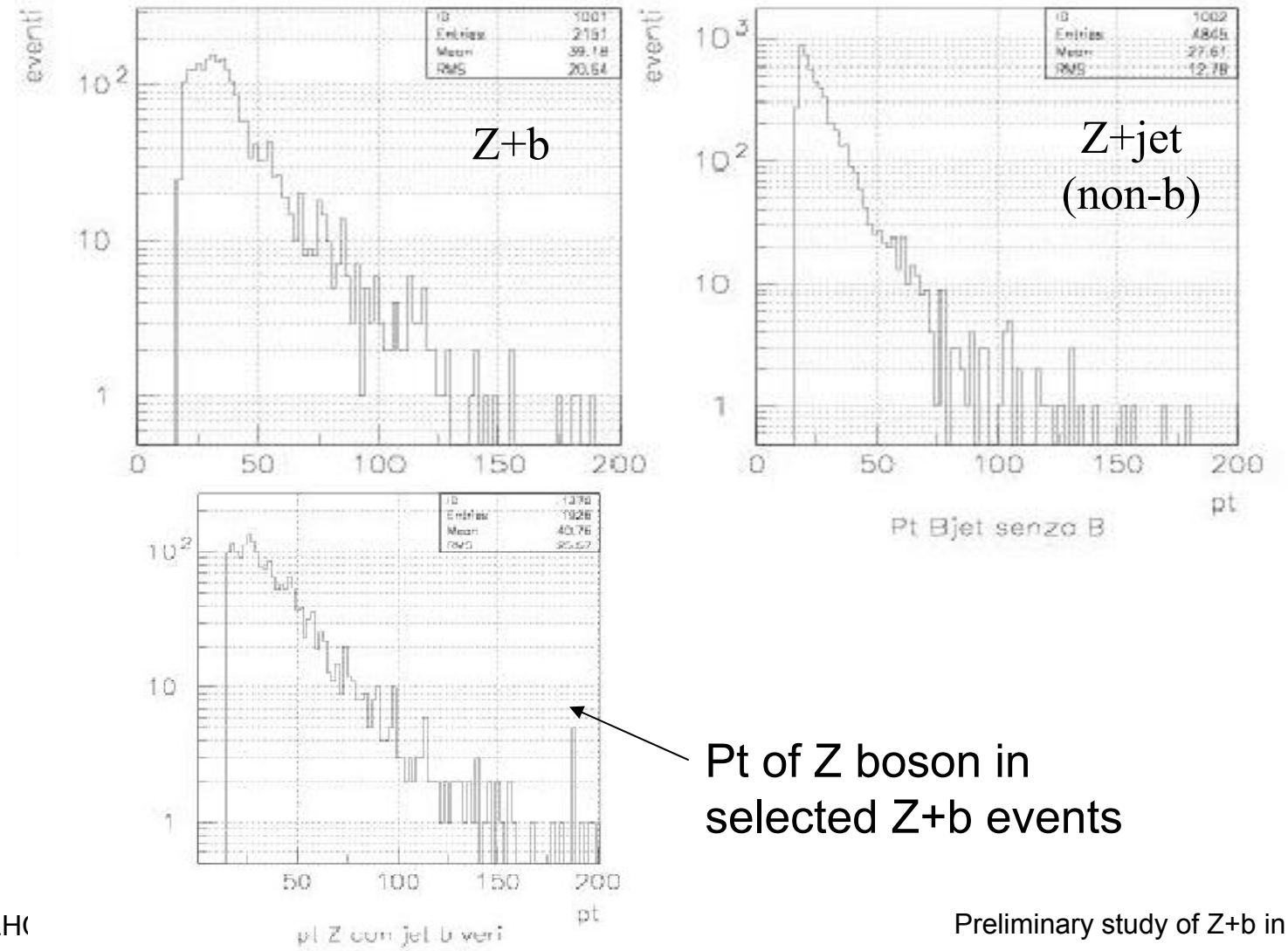
  on light q and gluon jets ~ 1.5%

Efficiency on Z(μμ)+b	Nb in 10 fb-1	Nc in 10 fb-1	Ntot in 10 fb-1
21 %	87000	25000	~250000

Very high statistics, good purity (~35%)

Z+b in ATLAS: inclusive b-tagging

Pt distributions of b-tagged jets



Pt of Z boson in
selected Z+b events

Z+b in ATLAS: summary

- A very preliminary study of Z+b production in ATLAS has been done, using a fast detector simulation
- Two different b-tagging algorithms have been considered:
  - Soft muon
  - Inclusive b-tagging of jets

- The selected samples have high efficiency and very good purity
- The expected statistics is very high

➔ The study is worth being carried on…..

Z+b in ATLAS: outlook

The expected statistics is very high, so

- The measurement error will be dominated by systematic effects

  Not evaluated yet, but

  – Theory uncertainty on $\sigma(Z+c)$ is smaller than at Tevatron
  – Experimental uncertainties evaluated from data will have small statistical errors
- Possibility to explore differential distributions
  – η of the Z and the b $\leftrightarrow$ x_1 x_2 of the initial partons

Work will continue on

– more appropriate MC generators
– detailed detector simulation
– proper inclusion of all the backgrounds
– other/new/(better?) b-tagging algorithms
– estimate of systematic uncertainties, to infer the expected sensitivity to b PDF
– potential of differential distribution analysis