

# Report on first meetings of LHC Working subGroup on $H \rightarrow bb$

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Brookhaven, 4 may 2011



# Aims of the subgroup

- ★ Joint effort to define common tools, compare calculations which will be used one day to interpret the data (theory calculations, MC generators)
- ★ Forum for interaction among ATLAS, CMS, LHCb experiments and between theory and experiments
- ★ In the end compare and combine the results, which will come from (in principle) different analysis/cuts/kinematical regions.



# Subgroup program

## Address

- ★ Production channels: HW, HZ, Htt, Hbb
- ★ Decay mode:  $H \rightarrow bb$
- ★ Background channels (dominant): tt, Wbb, Zbb, WZ, ttbb, ...
  - ➔ use NLO MC
  - ➔ which background can be determined using data ?
  - ➔ which theoretical uncertainty?

**Higgs mass region concerned : 115 - 135 GeV/c**



# Subgroup program



2 meetings until now:

**17 february** 2011

<http://indico.cern.ch/conferenceDisplay.py?confId=122483>

**17 march** 2011

<http://indico.cern.ch/conferenceDisplay.py?confId=130929>



This report will summarize briefly what was discussed and presented



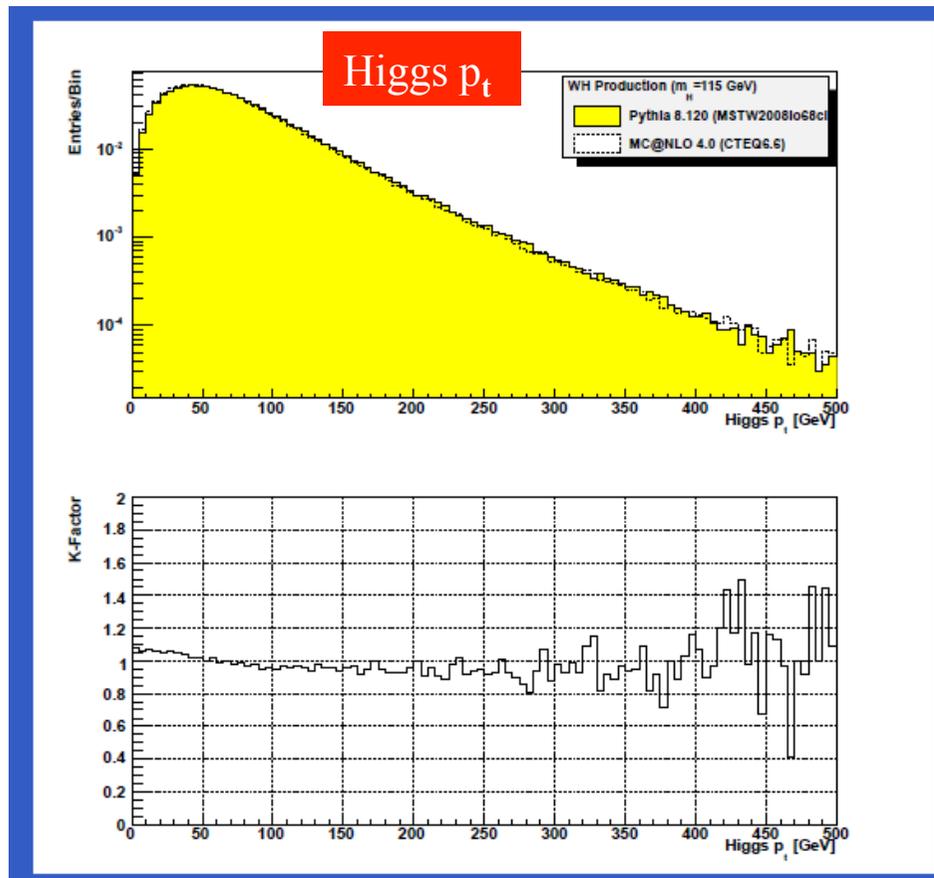
# ATLAS : WH production

(From C. Potter)

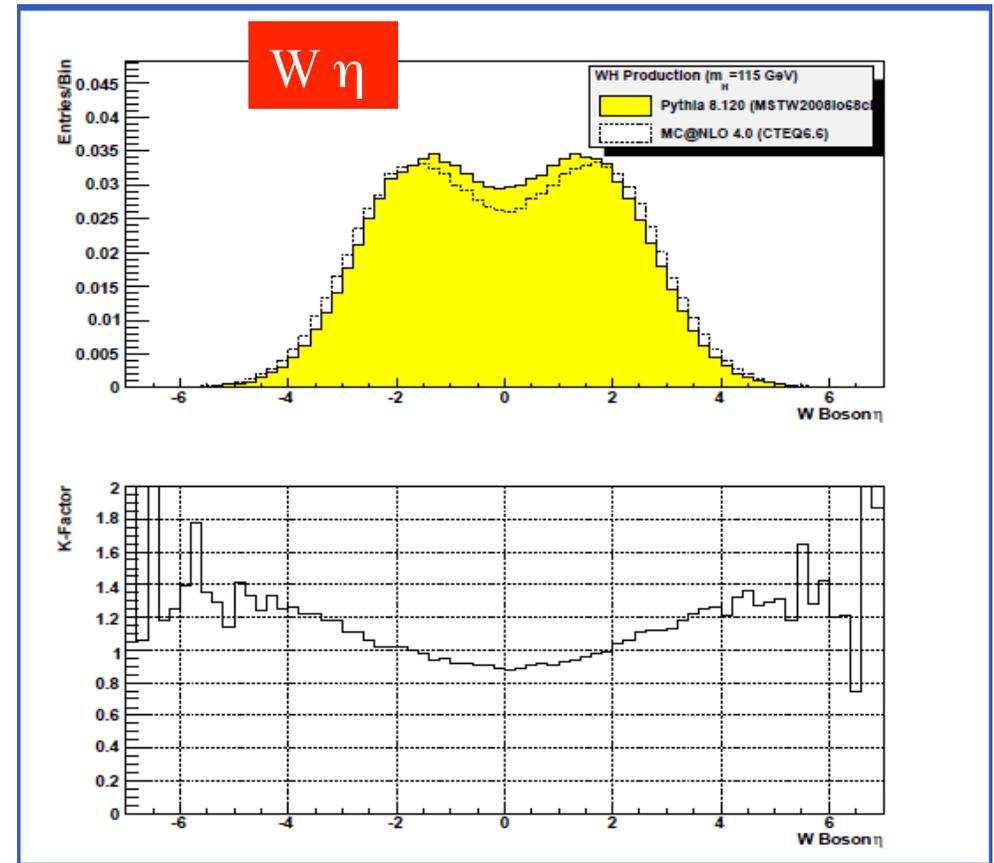
Using : PYTHIA 8.12 (LO) vs MC@NLO 4.0  
Proposed cut  $pt(H) > 200 \text{ GeV}$ ,  $pt(W) > 200 \text{ GeV}$

$m_H = 115 \text{ GeV}$

## WH Production: Higgs Differential K-Factor



## W Boson Differential K-Factor





# ATLAS : $t\bar{t}$ production

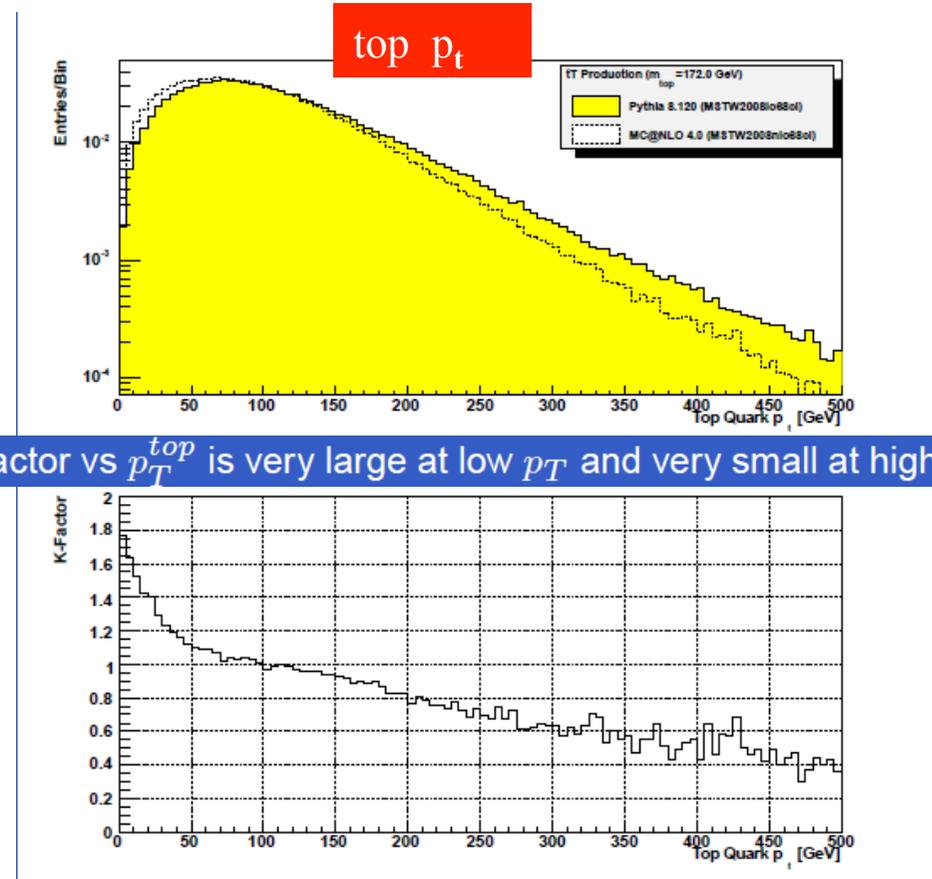
(From C. Potter)

Suggested cuts :

Exactly one isolated lepton with  $p_T > 25$  GeV

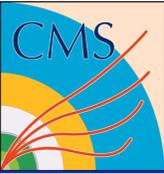
At least 6 jets with  $p_T > 20$  GeV

At least 4 b-tagged jets with  $p_T > 20$  GeV



K-Factor vs  $p_T^{top}$  is very large at low  $p_T$  and very small at high  $p_T$ .

ATLAS will not use Pythia for  $t\bar{t}$  simulation, rather use AcerMC



# CMS : $VH \rightarrow Vbb$

Study of  $VH \rightarrow Vbb$

*(From D. Wright)*

- ◆ **Pythia6 (LO)** *(PDF CTEQ6L1)*
- ◆ **Herwig++ (NLO) POWHEG** *(PDF MRST2002nlo)*

$M_H = 120$  GeV

$\sqrt{s} = 7$  TeV

	pythia6 (pb)	herwig++ (pb)	K-factor
<b>H → bb W → lv</b>	0.1074	0.1327	1.235
<b>H → bb Z → ll</b>	0.0177	0.0231	1.302
<b>H → bb Z → vv</b>	0.0353	0.0458	1.299

( $l=e,\mu,\tau$ )



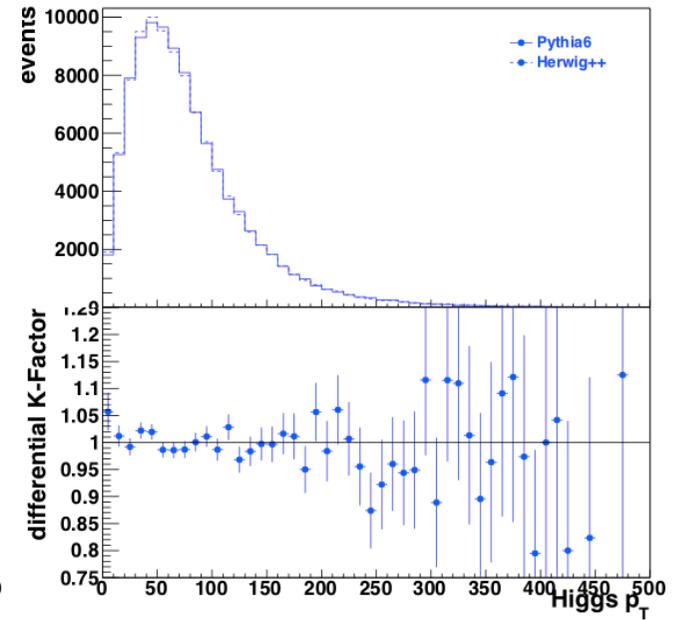
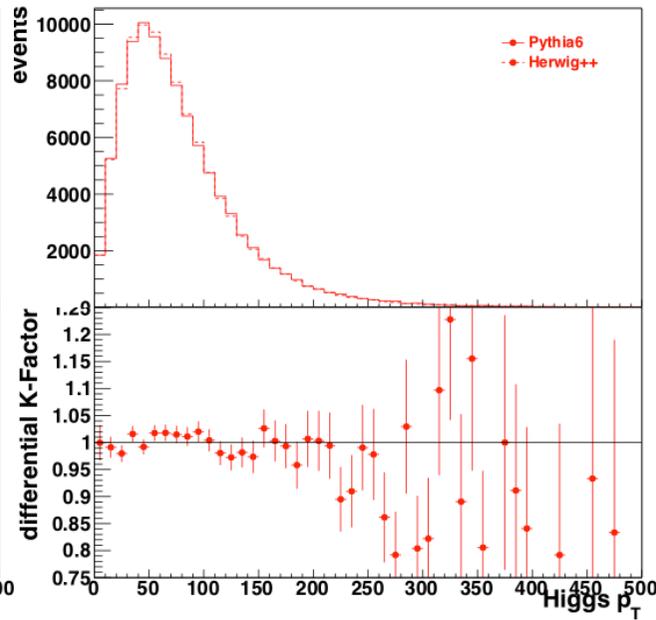
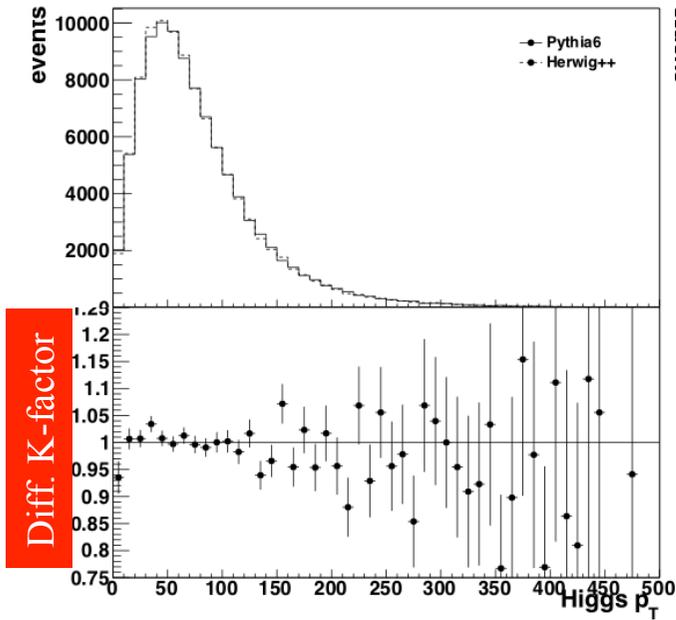
# Higgs $p_T$

*(From D. Wright)*

$W \rightarrow lv$

$Z \rightarrow l^+l^-$

$Z \rightarrow \nu\nu$



Higgs  $p_T$



# Higgs $\eta$

(From D. Wright)

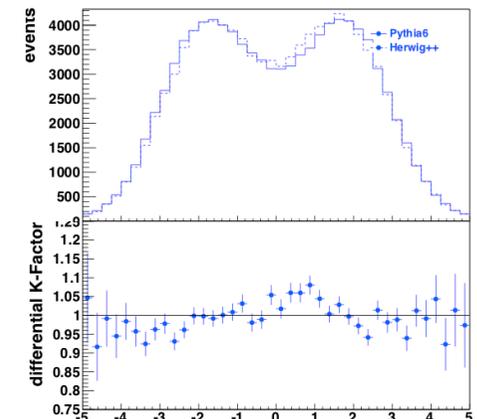
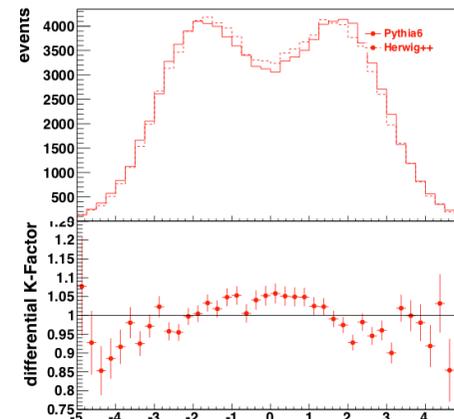
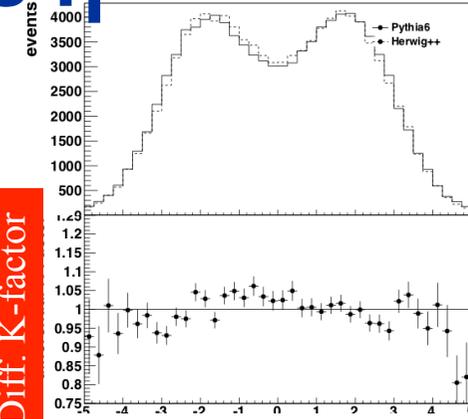
$V_{pT} > 0$

$W \rightarrow l\nu$

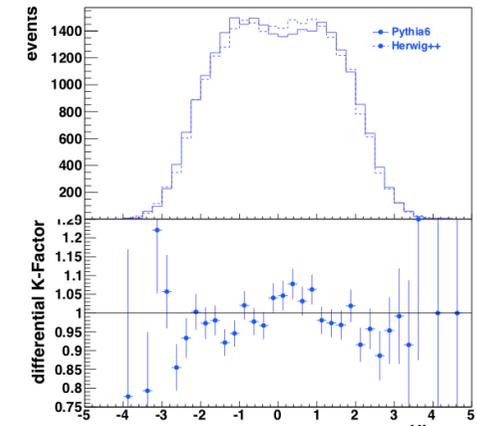
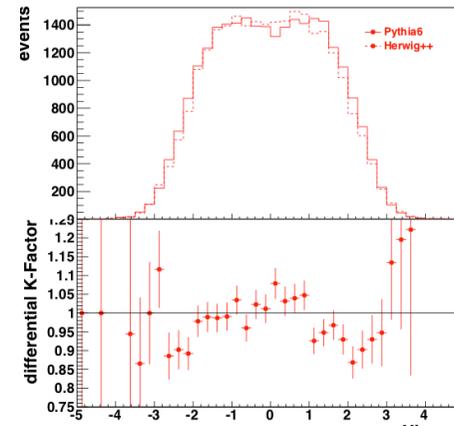
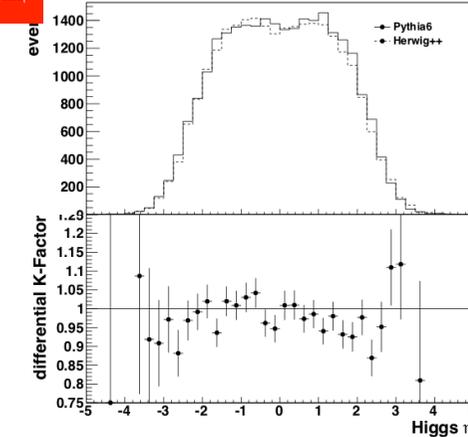
$Z \rightarrow l^+l^-$

$Z \rightarrow \nu\nu$

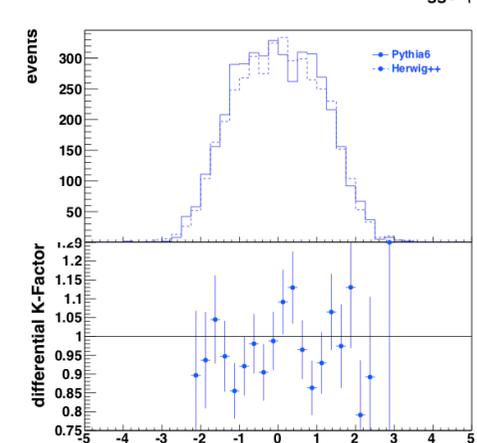
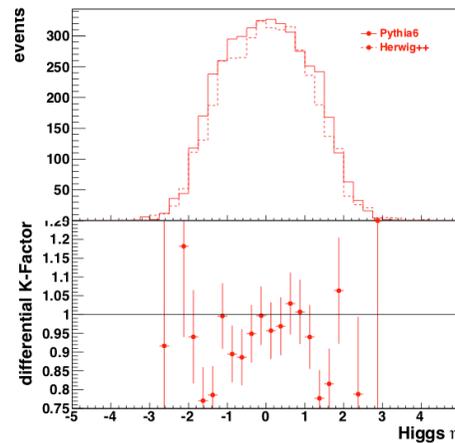
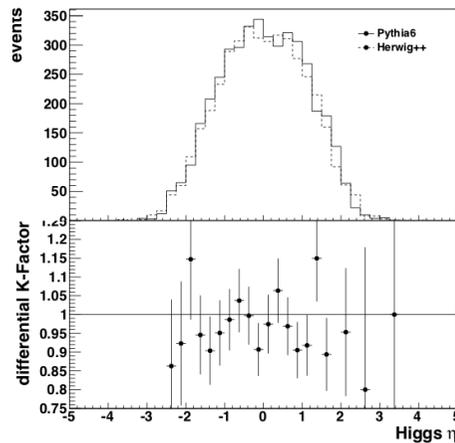
Diff. K-factor



$V_{pT} > 100$  GeV



$V_{pT} > 200$  GeV





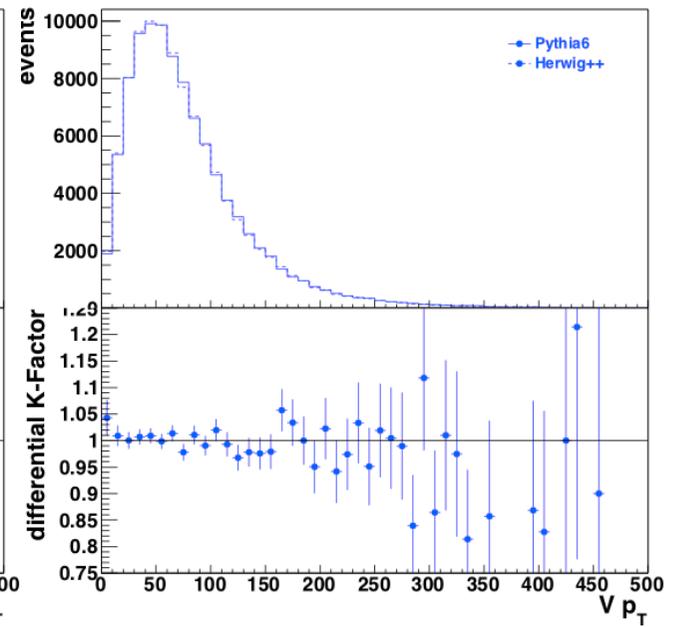
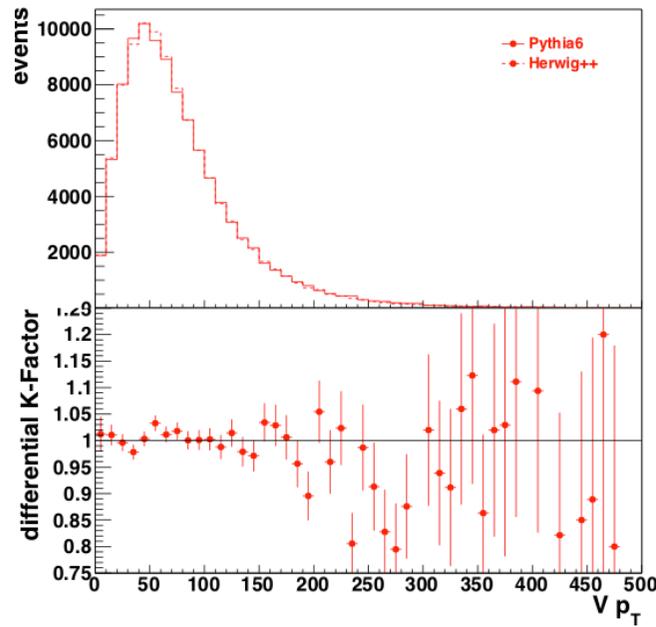
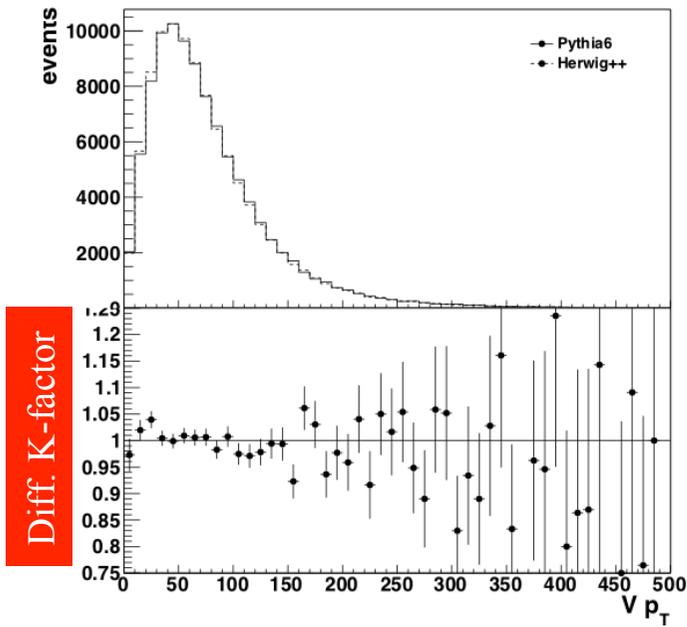
# $V p_T$

*(From D. Wright)*

$W \rightarrow l\nu$

$Z \rightarrow l^+l^-$

$Z \rightarrow \nu\nu$





$V \eta$

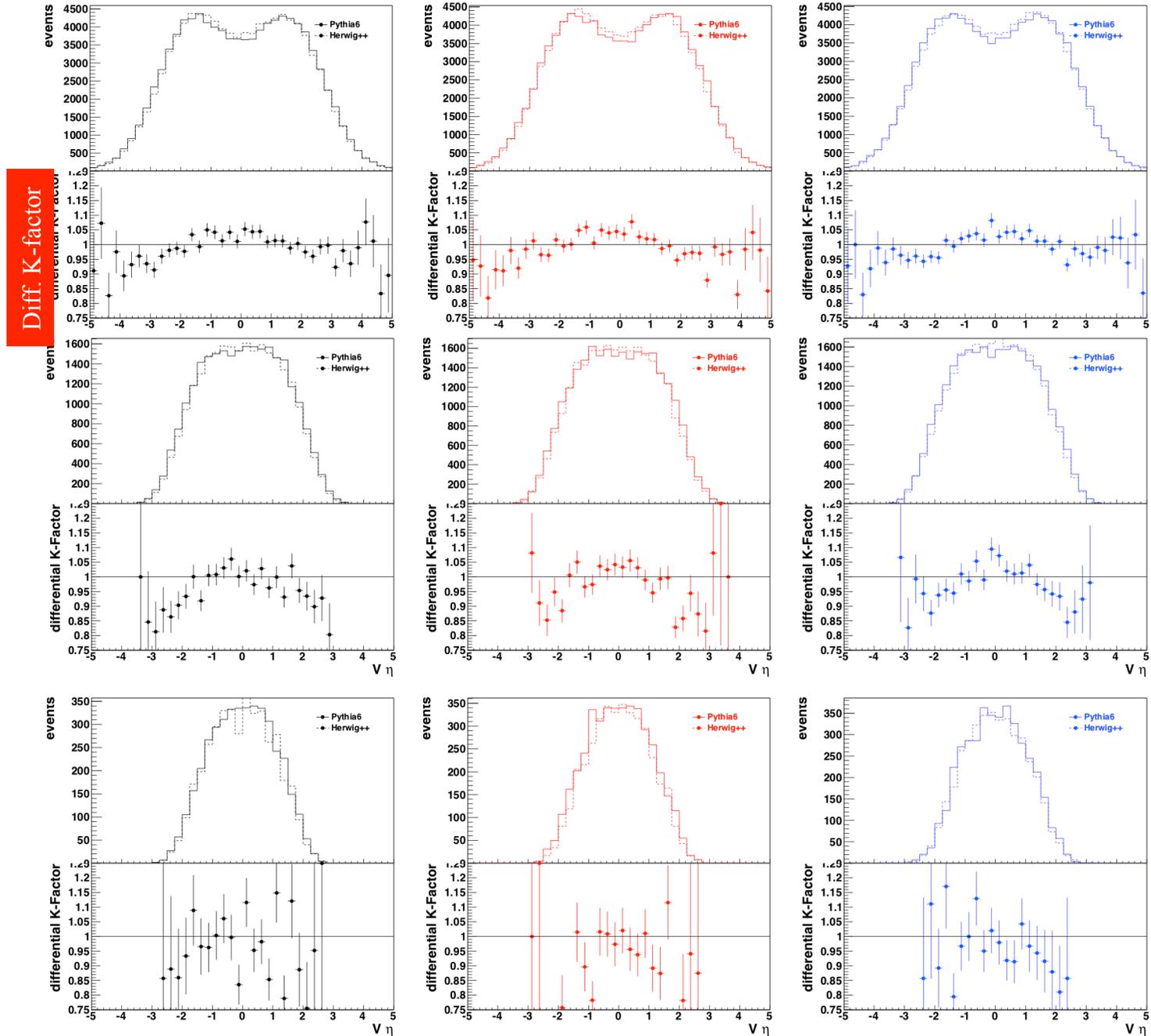
(From D. Wright)

$Z \rightarrow \nu\nu$

$V_{pT} > 0$

$W \rightarrow l\nu$

$Z \rightarrow l^+l^-$



$V_{pT} > 100 \text{ GeV}$

$V_{pT} > 200 \text{ GeV}$

*(From C. Matteuzzi)*

## Study of VH with PYTHIA vs HERWIG :

$M_H=125$  GeV

Comparison made at different steps of event generation:

1. Higgs and W production
2. W decay
3. final hadronization ( within the LHCb acceptance)  
from H decay

Jet reconstruction has been made with KT algorithm

Cross sections (in mb):

process	COMPHEP	Pythia 6.220	Pythia 6.319	HERWIG
$HW$	$3.220E - 10$	$2.559E - 10$	$2.535E - 10$	$2.610E - 10$
$HZ^0$	$1.531E - 10$	$1.319E - 10$	$1.329E - 10$	$1.413E - 10$

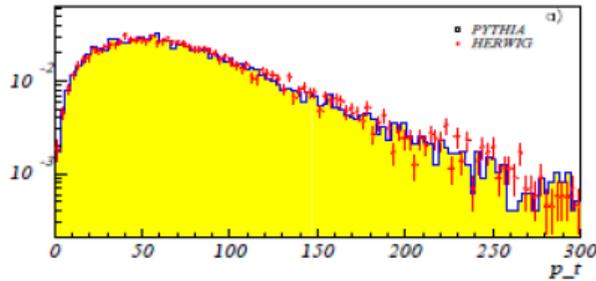
*(From C. Matteuzzi)*

★ Study of WH with PYTHIA vs HERWIG :

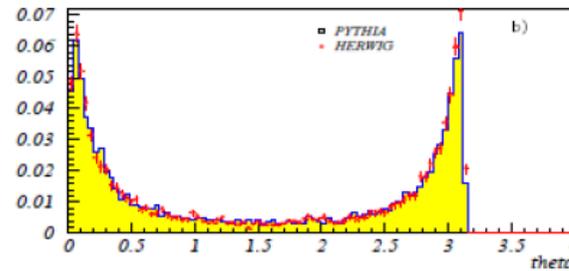
■ PYTHIA

+ HERWIG

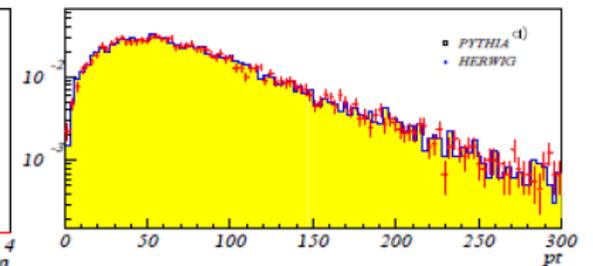
**$p_T$  of Higgs**



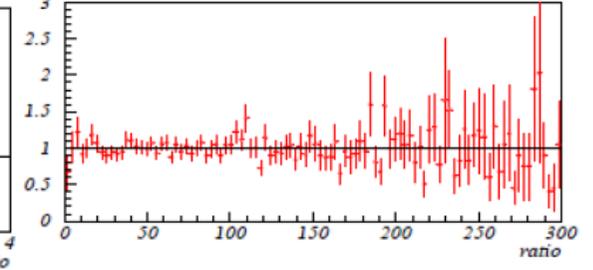
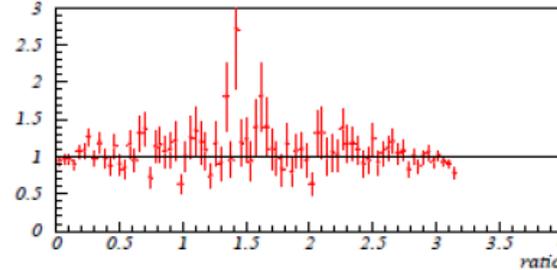
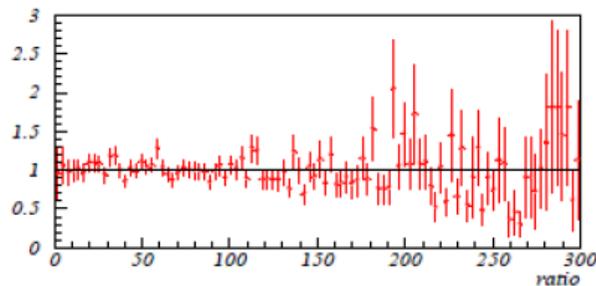
**Higgs polar angle  $\theta$**



**$p_T$  of W**



( PYTHIA )  
— HERWIG



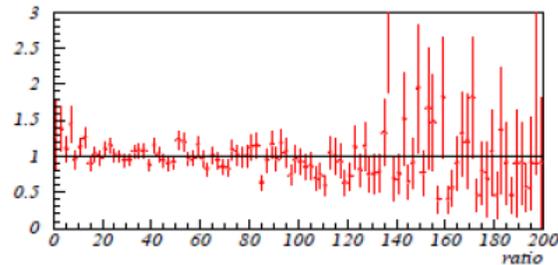
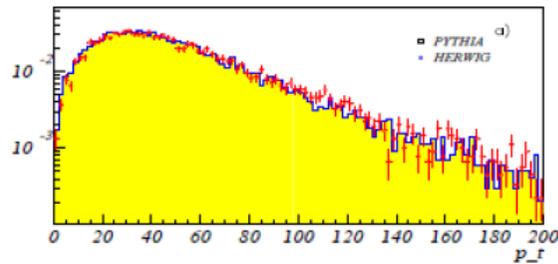
*(From C. Matteuzzi)*

Study of the event WH inside LHCb :

PYTHIA

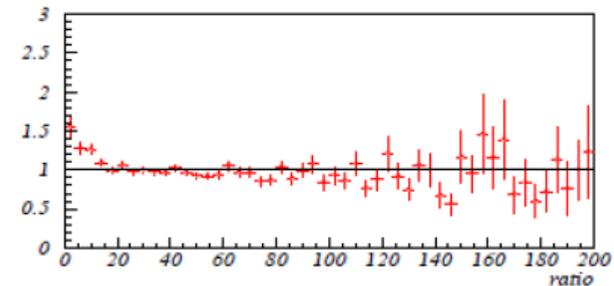
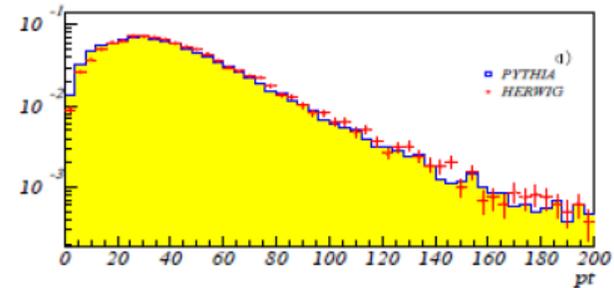
+ HERWIG

**$p_T$  of the charged lepton**



( PYTHIA )  
— HERWIG

**$p_T$  of the B**



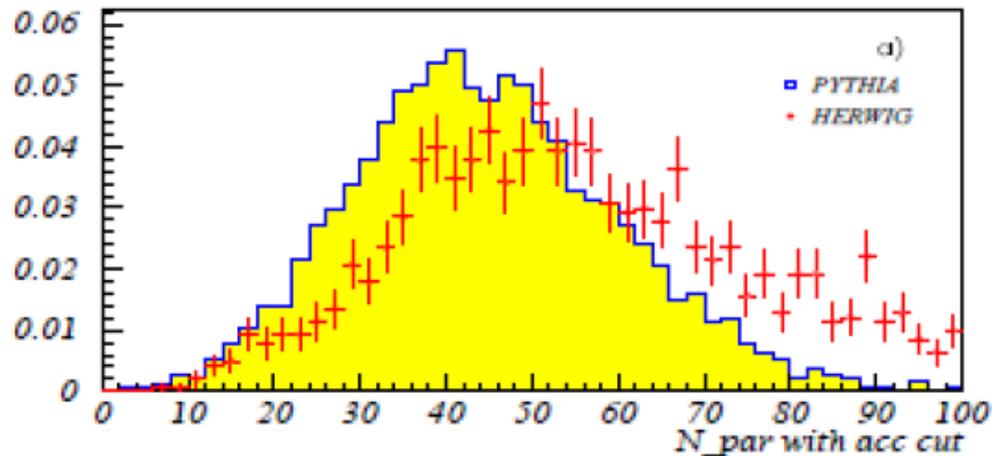
*(From C. Matteuzzi)*

Study of the event WH inside LHCb :

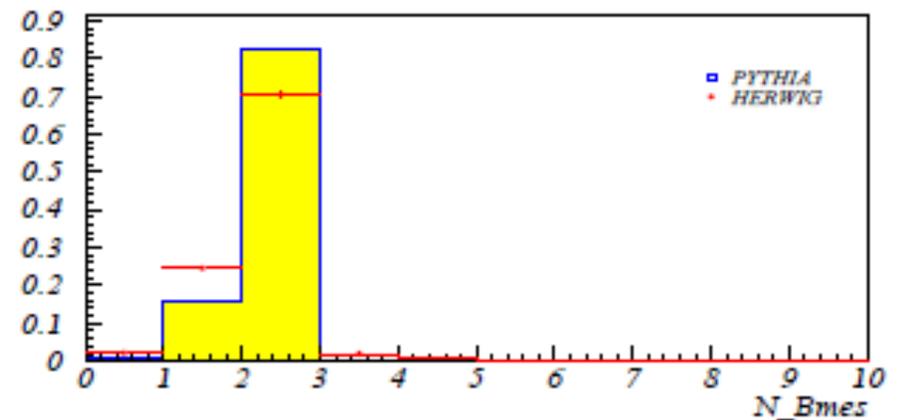
■ PYTHIA

+ HERWIG

**Charged particles multiplicity in LHCb acceptance**



**B hadron multiplicity in LHCb acceptance \***



\* LHCb acceptance = 15-400 mrad  
and  $p_t^{\text{lept}} > 10$  GeV inside acc.



# Work on going

(From L. Reina)

★  $t\bar{t}H, H \rightarrow b\bar{b}$  vs  $t\bar{t}b\bar{b}$ , from LO to NLO studies

- Study distributions used in experimental studies (see Freiburg's talk) using LO tools to investigate general properties.
- Study NLO inclusive distributions ( $t\bar{t}H$  on-shell).
- NLO  $pp \rightarrow t\bar{t}H, H \rightarrow b\bar{b}$  in NWA (Bevilacqua et al.).
- NLO  $t\bar{t}b\bar{b}$  (Bevilacqua et al., Bredenstein et al.).
- Include  $t\bar{t}H$  in POWHEG and MC@NLO  (R.Frederix et al., arXiv:1104.5613)



Study of differential distributions

- ▷  $\frac{d\sigma}{dm(bb)}, \frac{d\sigma}{dp_T(bb)}$  ( $b\bar{b}$  from  $H \rightarrow b\bar{b}$ );
- ▷  $\frac{d\sigma}{dm(b_1 b_2)}, \frac{d\sigma}{dp_T(b_1 b_2)}$  ( $b_1 b_2$  two leading  $b$ -jets);
- ▷  $\frac{d\sigma}{d\eta(b_1 b_2)}, \frac{d\sigma}{d\phi(b_1 b_2)}$ ;
- ▷  $\frac{d\sigma}{dH_T}$ ; etc.....



# What next?

- ★ What cross section inside acceptance and after cuts
- ★ What are the effect of the cuts on K-factor
- ★ Study the effect of jet definition, jet veto and b-jet tagging
- ★ Use of MC@NLO (ATLAS) for VH, ttH
- ★ Use of POWHEG (ATLAS, CMS, LHCb) for Wbb background
  - ↳ *first results for the next subgroup meeting*  
(also Wbb @ NLO events available from S. Frixione)
- ★ Determine relative importance of the background channels, which persumably are different for ATLAS/CMS and LHCb
- ★ Will NNLO calculations/generators available in the future ??