PROMPT PHOTONS IN DIFFRACTIVE PHOTOPRODUCTION
(status report)

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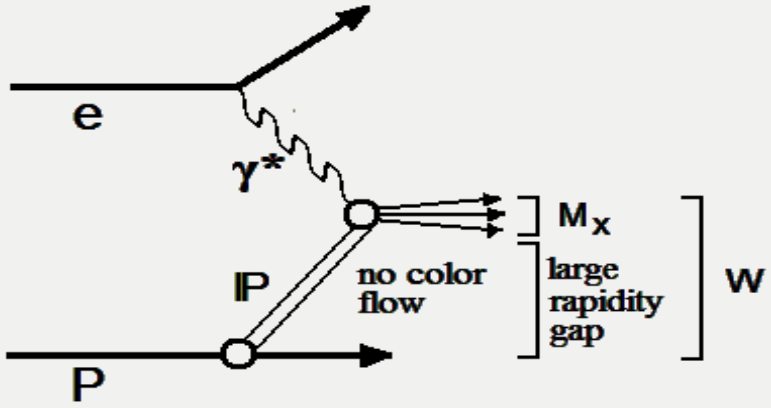
Goals

- Estimate the contribution of non-diffractive contamination to data signal by fitting the Rapgap and contribution from Pythia or Herwig to data.
- Study the differences between Pythia and Herwig MC in prediction of non-diffractive contribution.

Objectives and procedures

Our physics objective is to select diffractively produced prompt photons in photoproduction. These events can be explained if the scattered proton escapes through the beam pipe while emitting a colorless object (pomeron), which scatters with the electron. Therefore such events are characterized by low momentum transfer from proton to the pomeron and a large rapidity gap between the hadrons systems Mx and the proton. In other words we are trying to identify a subset of prompt photon events with low X_{IP} and η_{max}.



Our ***general method*** to distinguish the signal from hadronic background is based on MC fit of the dZ distribution (dZ - *energy weighted mean width of the electromagnetic cluster in Z direction*). This fit allows us statistically separate prompt photon left peak (signal) from π^0 decay right peak (background).

$$dZ = \frac{\sum_i E_i \left| Z_{cluster} - Z_i \right|}{w_{cell} \sum_i E_i}$$

Data samples and event selection

- ***Data***: 0405e, 06e, 0607p (Mini Ntuples v08b), 374 pb^{-1}
- ***MC signal***: (Rapgap 3.202 v08b, diffractive php) direct + resolved
- ***MC non-diff. background***: (Pythia, Herwig, v08b, prompt photon in php) direct + resolved
- ***MC background***: (Pythia, v08b giant dijet) direct + resolved

True level selection

Event selection

$0.2 < y < 0.7$

$Q^2 < 1\ GeV^2$

Prompt photon selection

Fmck_prt[]=29

$-0.7 < \eta < 0.9$

$5 < Et < 15$ GeV

Eparticle / Ejet > 0.9

Hadronic jet selection

$4 < Et\ jet < 35$ GeV

$-1.5 < \eta\ jet < 1.8$

Diffractive event selection

$\eta_{max} < 2.5$ for Eparticle > 0.4 GeV

$X_{IP} < 0.03$

Detector level selection

Event selection

Trigger HPP16 on

$|Zvtx| < 40$ cm

$|BCAL\ time| < 10$ ns

$Cal\_pt < 10$

$0.2 < Yjb < 0.7$

No SINISTRA electron with prob > 0.9 and $Yel < 0.7$

Hadronic jet selection

$4 < Et\ jet < 35$ GeV

$-1.5 < \eta\ jet < 1.8$

Prompt photon selection

Tufo[][0]=31

$-0.7 < \eta < 0.9$

$5 < Et < 15$ GeV

Ezufo / Ejet > 0.9

Zufoeemc / Zufoecal > 0.9

track isolation in cone 0.2

Diffractive event selection

$\eta_{max} < 2.5$ for Ezufo>0.4 GeV

$X_{IP} < 0.03$

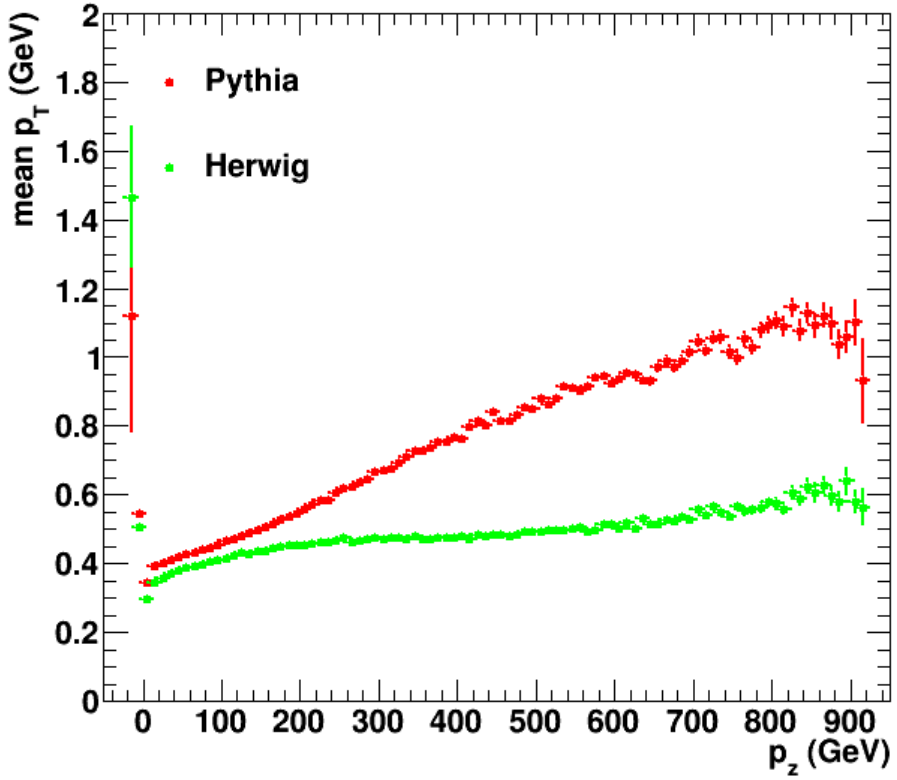
$E_{FPC} < 1$ GeV (in HERA1 case)

HERA2, mean p_T vs. p_z distributions of stable particles (profile histograms)

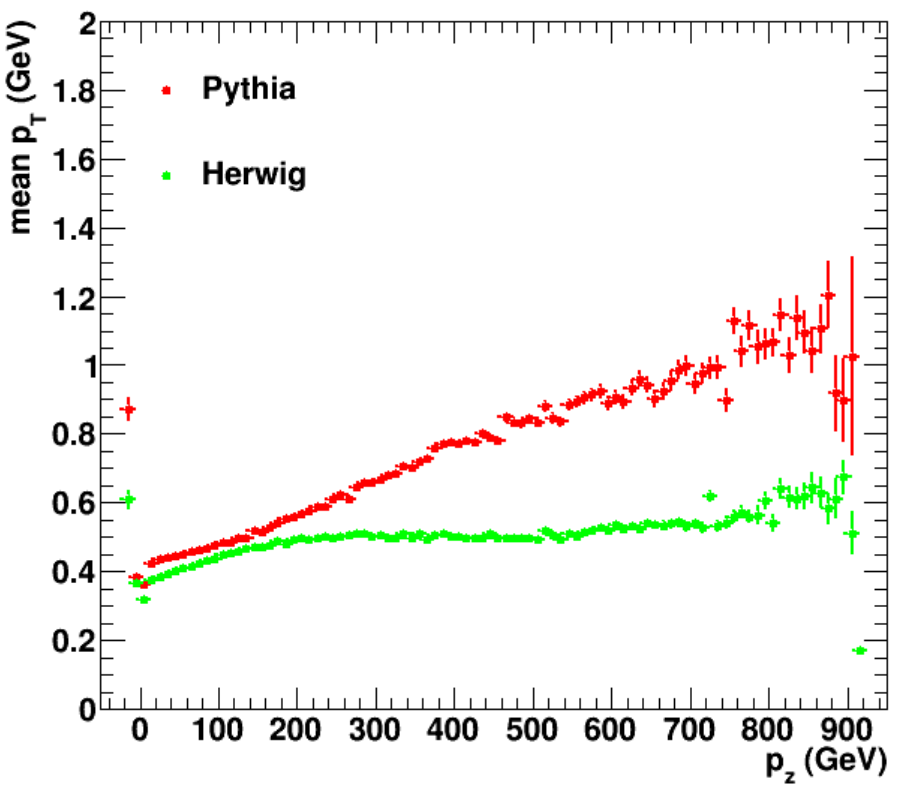
γ+jet selection, hadron level, no diff. cuts

red – **Pythia** non-diff. signal;
green – **Herwig** non-diff. signal;

resolved



direct



Pythia predicts higher p_T for particles than Herwig.
We assume this is the main reason of differences between Pythia and Herwig in estimation of non-diff. background

HERA2, fits of MCs to the η_{max} distribution

γ+jet selection

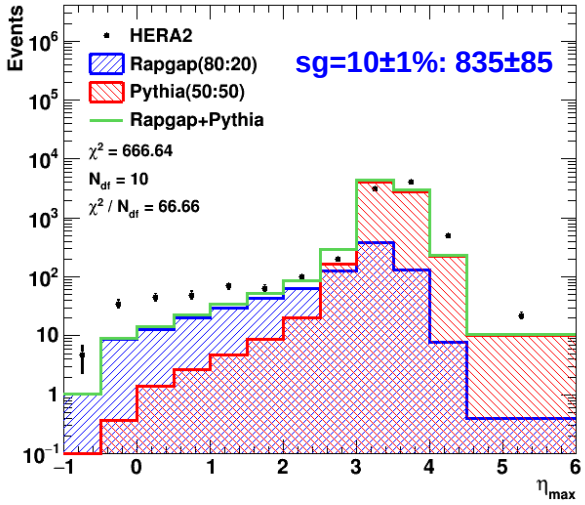
black dots – **data**, fitted photons;

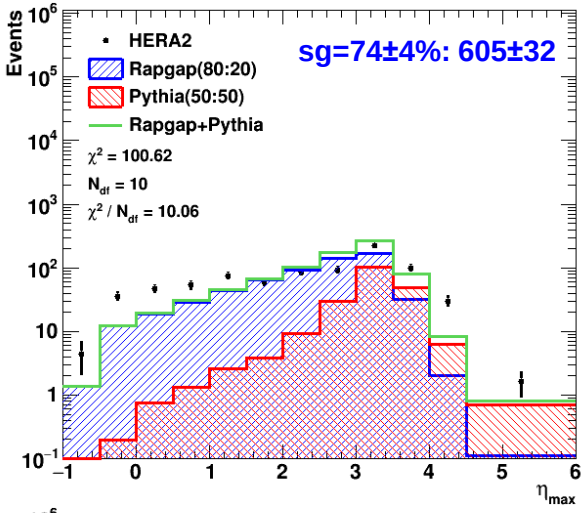
blue – **Rapgap** diff. signal, 80/20 sum, not-reweighted;

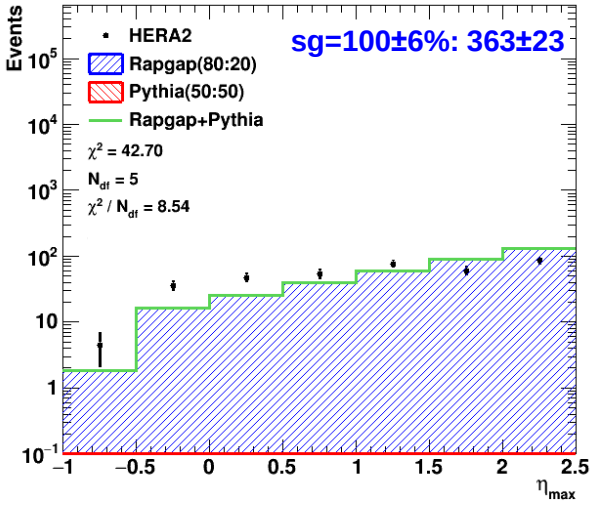
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | X_{IP} | $\eta_{max}+X_{IP}$

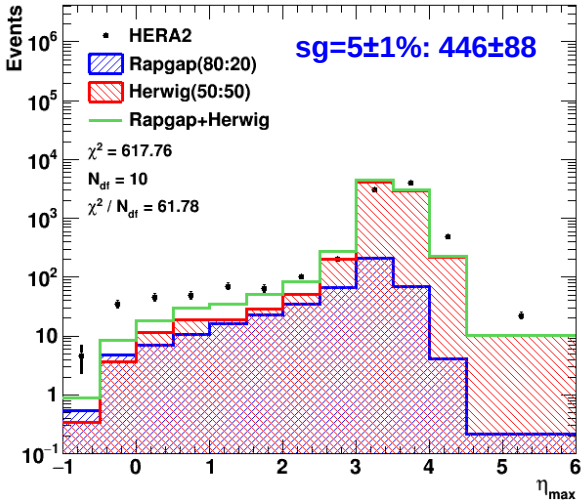
Pythia

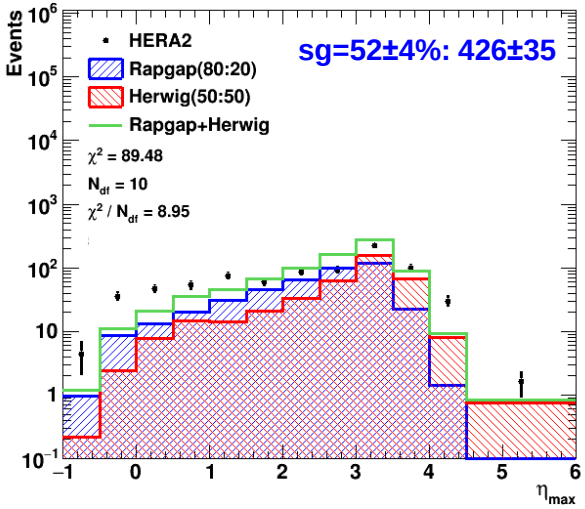


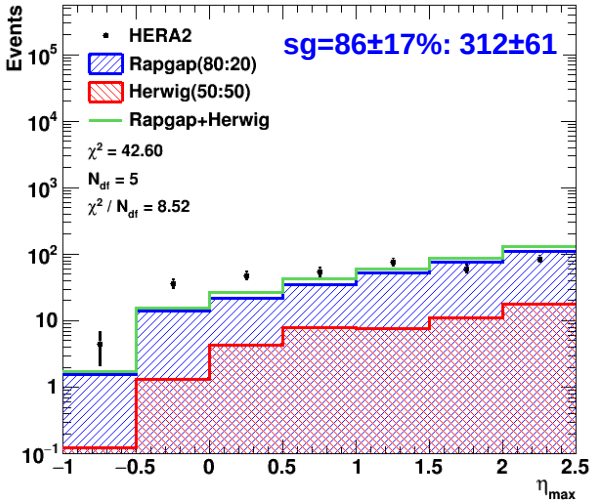




Herwig







The fits are poor and one requires the reweighting of Rapgap. The result of fit after applying the diff. cuts is compatible within error with corresponding result on next slide (reweighted case)

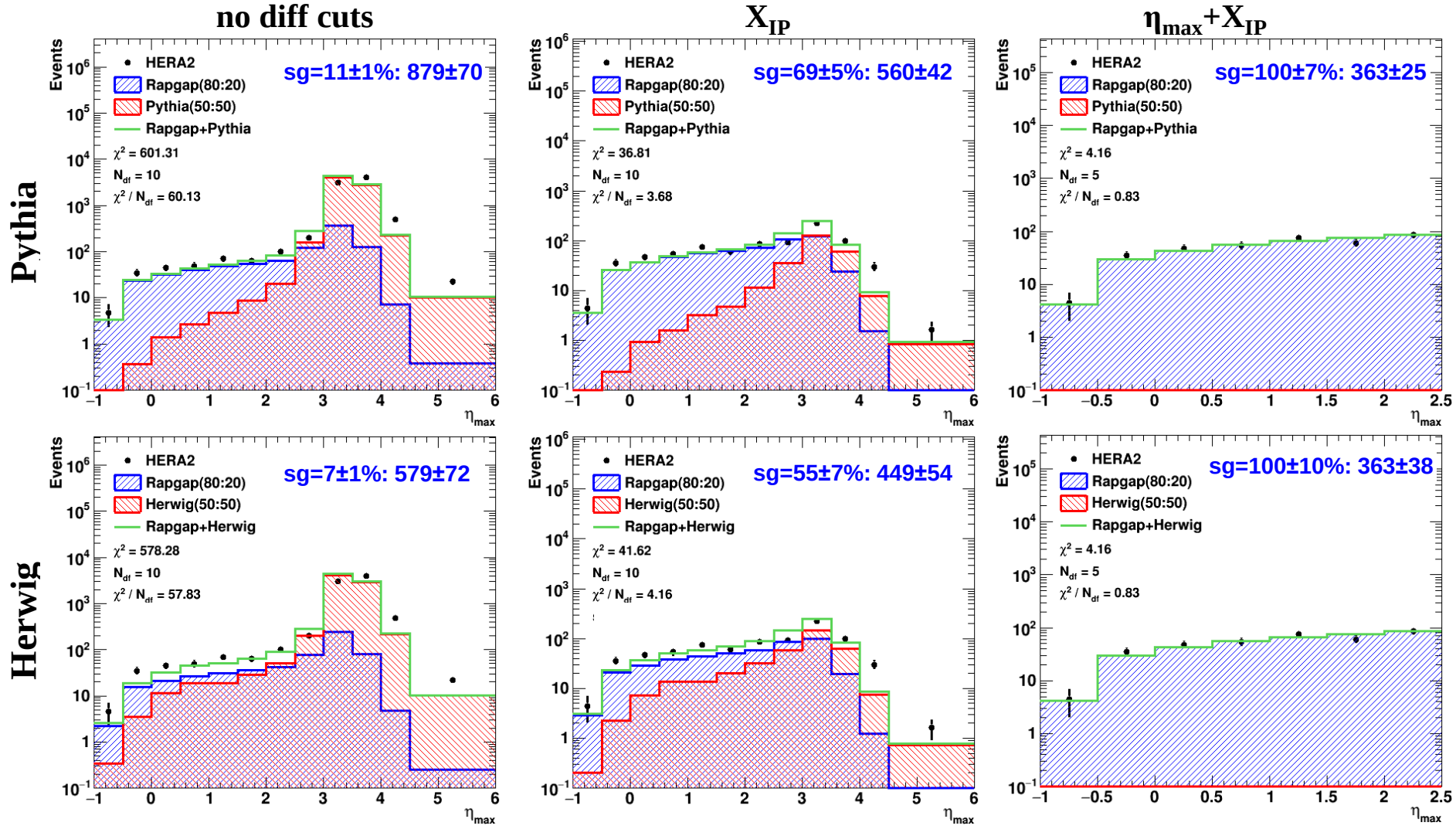
HERA2, fits of MCs to the η_{max} distribution

γ+jet selection

black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;



After applying the diffractive cuts the fit does not require any non-diffractive background, the best description of the η_{max} distribution is by Rapgap only

HERA2, fits of MCs to the X_{IP} distribution

γ+jet selection

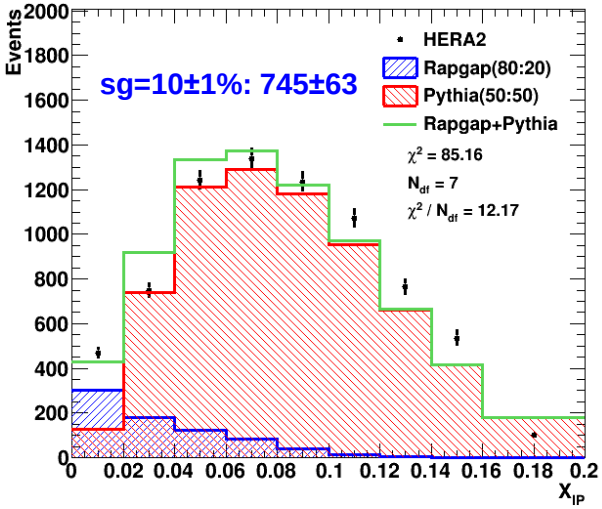
black dots – **data**, fitted photons;

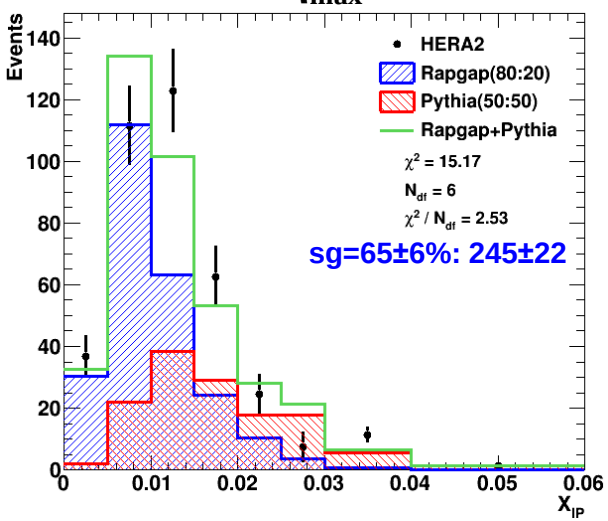
blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

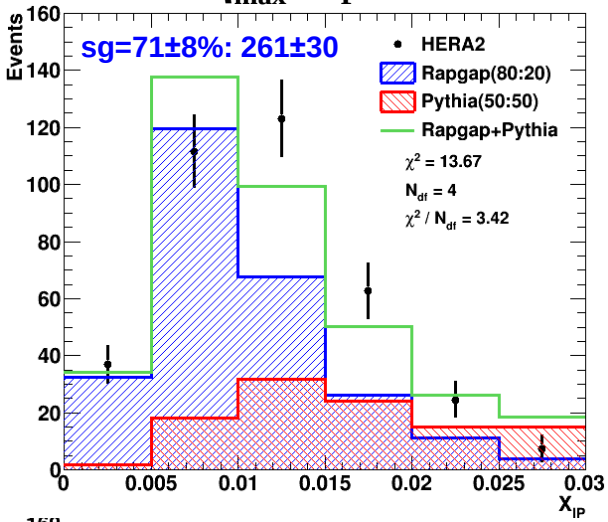
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | **η_{max}** | **$\eta_{max}+X_P$**

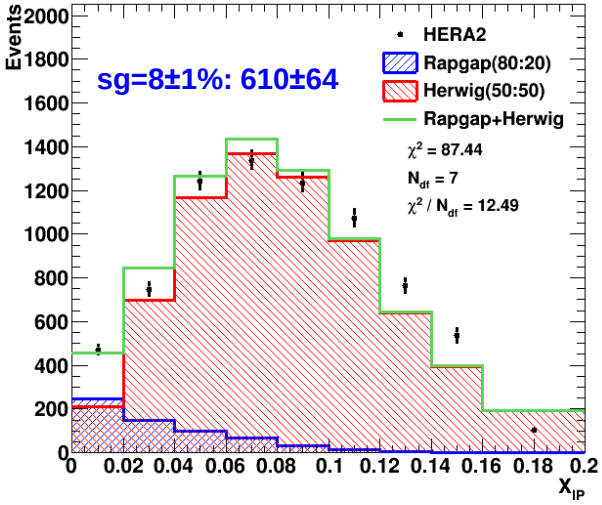
Pythia

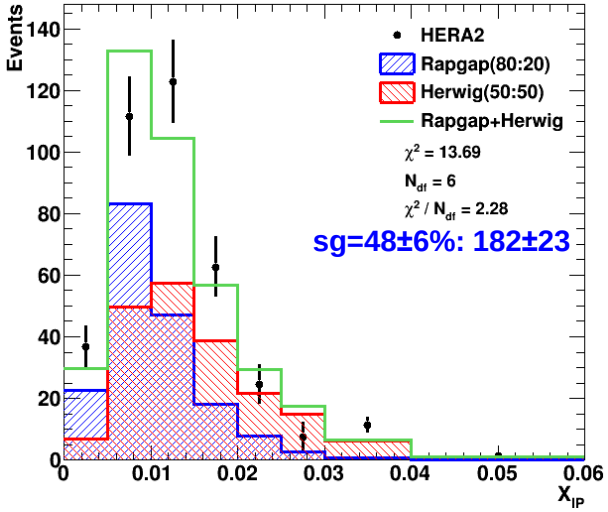


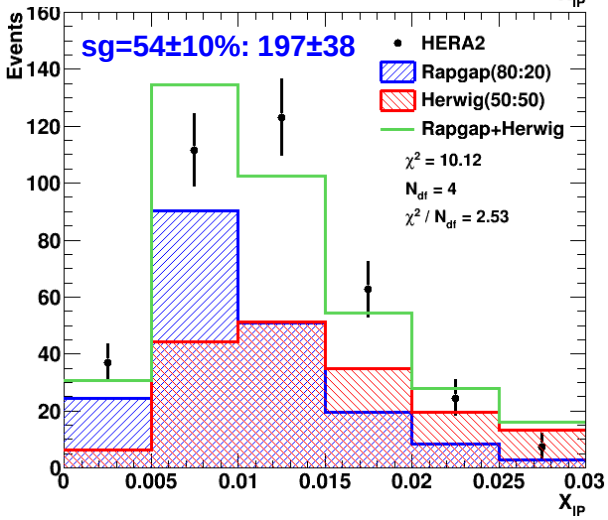




Herwig







1st column: neither Pythia nor Herwig fits the high X_{IP} region.

That is why we don't base on the non-diff background estimation using results in 3rd column

HERA2, fits of MCs to the X_{IP} distribution

γ+jet selection

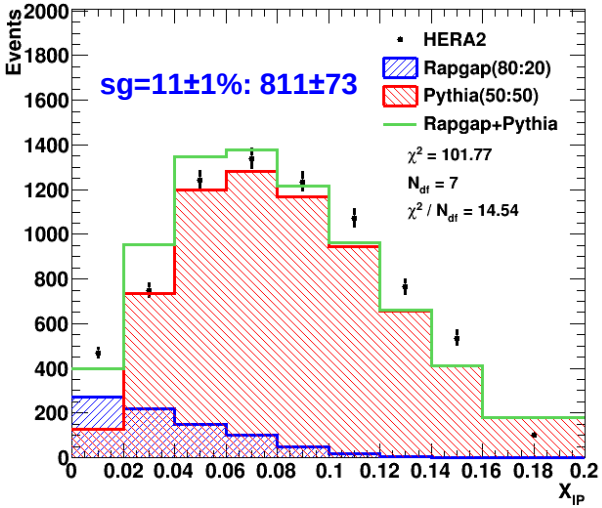
black dots – **data**, fitted photons;

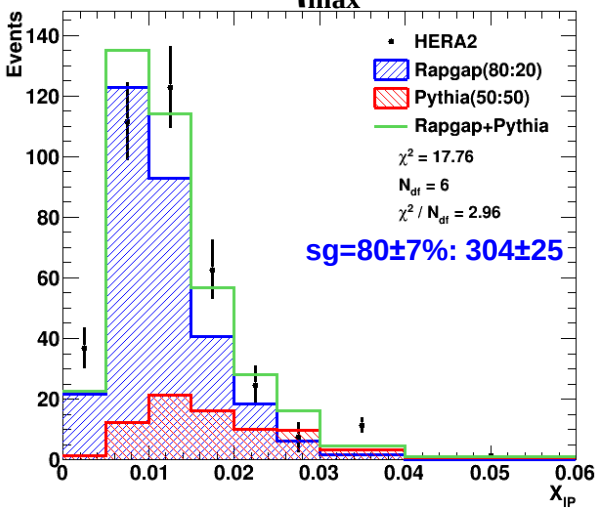
blue – **Rapgap** diff. signal, 80/20 sum, not-reweighted;

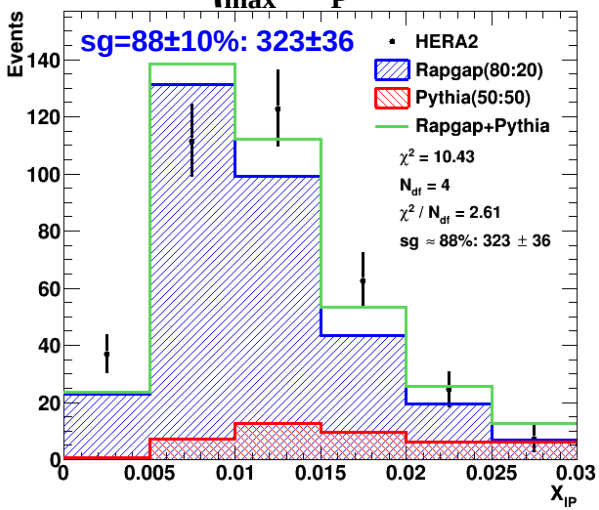
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | η_{max} | $\eta_{max}+X_P$

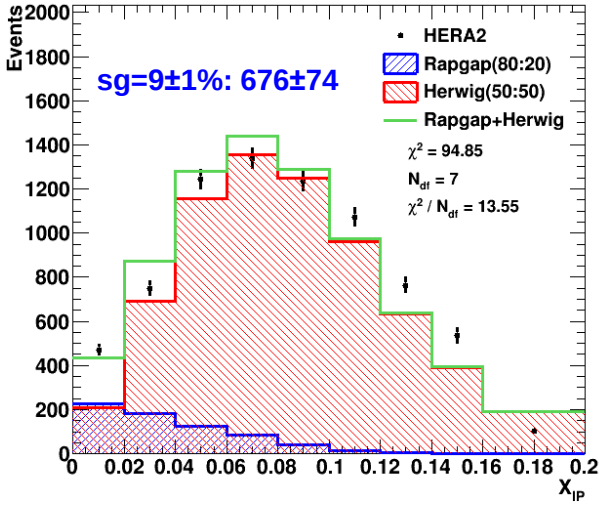
Pythia

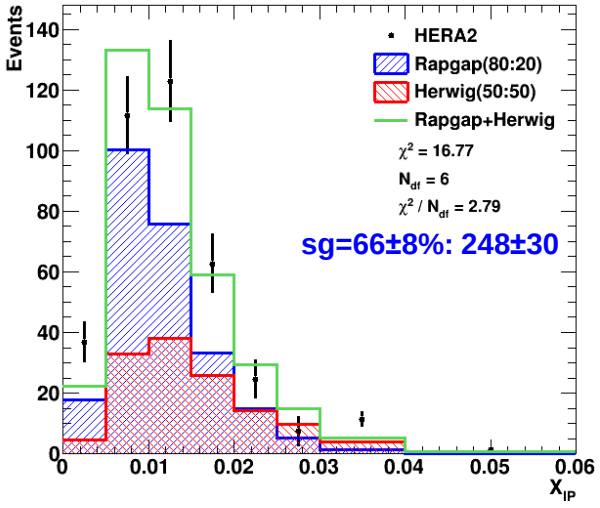


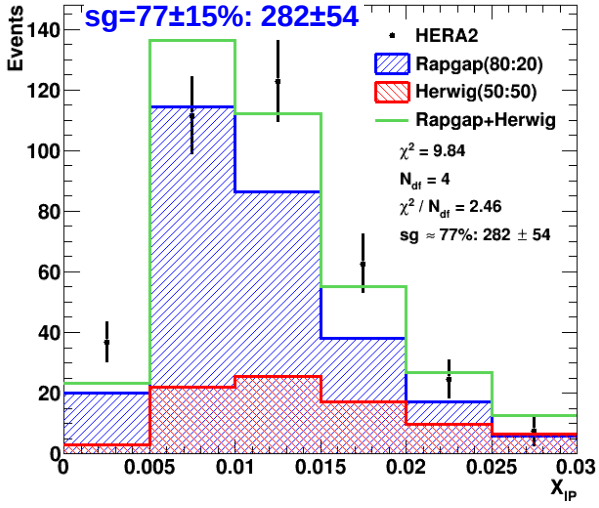




Herwig







In the case of not-reweighted Rapgap the non-diff. contamination is negligible within one and a half error, so this is more or less consistent with non-diff. background absence

HERA2, fits of MCs to the η^{γ} distribution

γ+jet selection

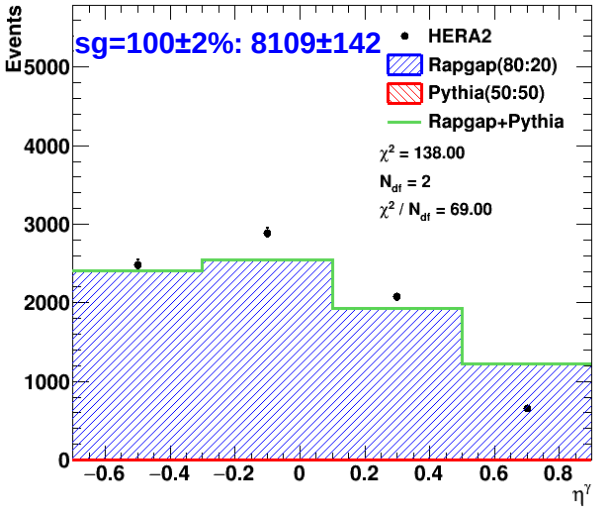
black dots – **data**, fitted photons;

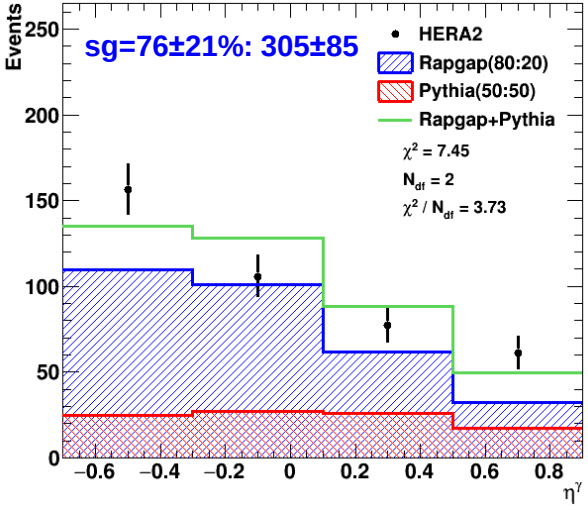
blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

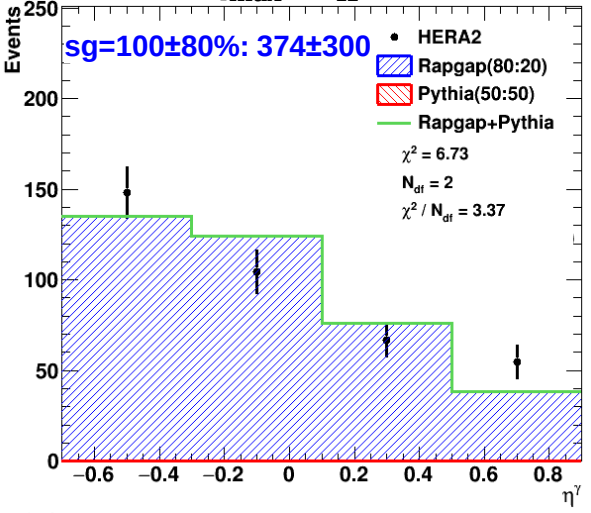
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | η_{max} | $\eta_{max}+X_{IP}$

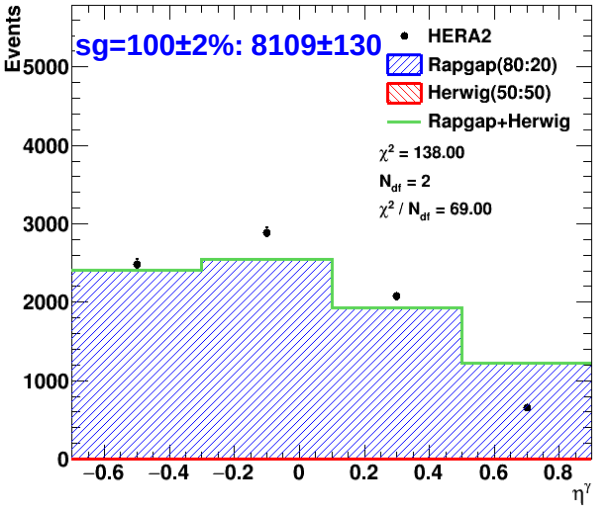
Pythia

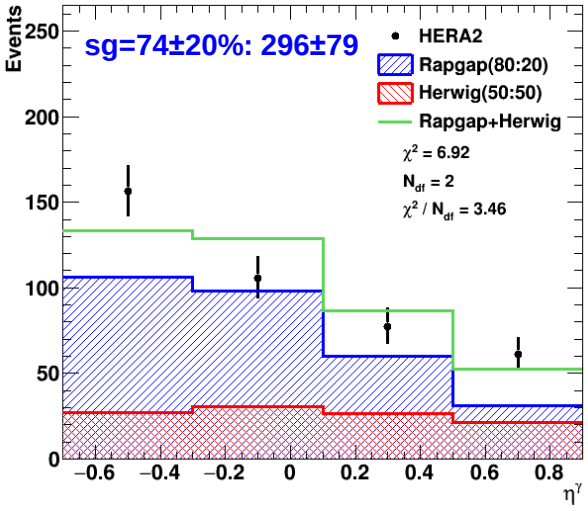


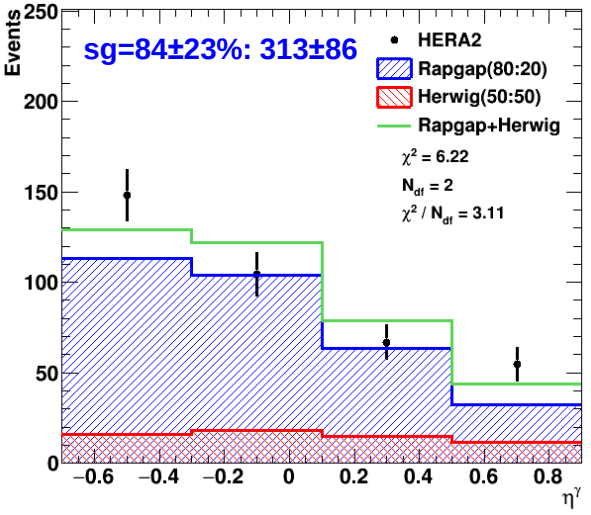




Herwig







After applying the diff. cuts for Herwig case the non-diff. contamination is negligible within error

HERA2, fits of MCs to the η^{γ} distribution

γ+jet selection

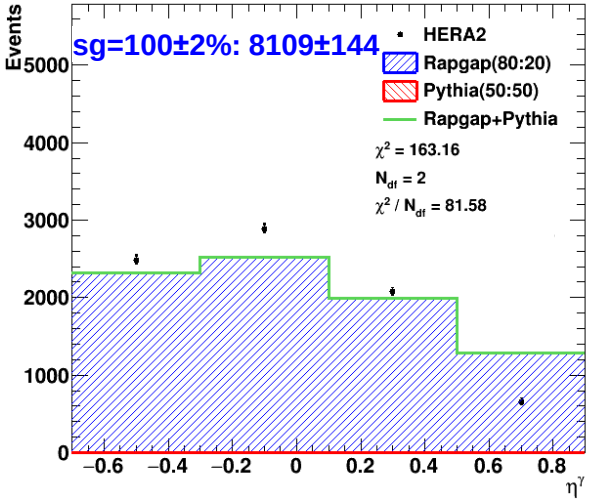
black dots – **data**, fitted photons;

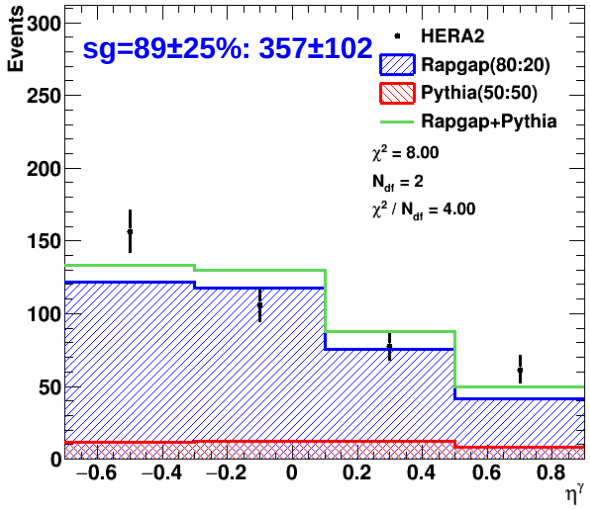
blue – **Rapgap** diff. signal, 80/20 sum, not-reweighted;

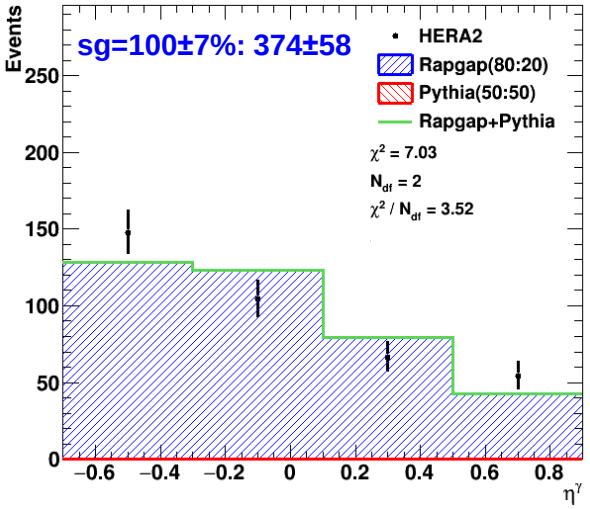
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | η_{max} | $\eta_{max}+X_{IP}$

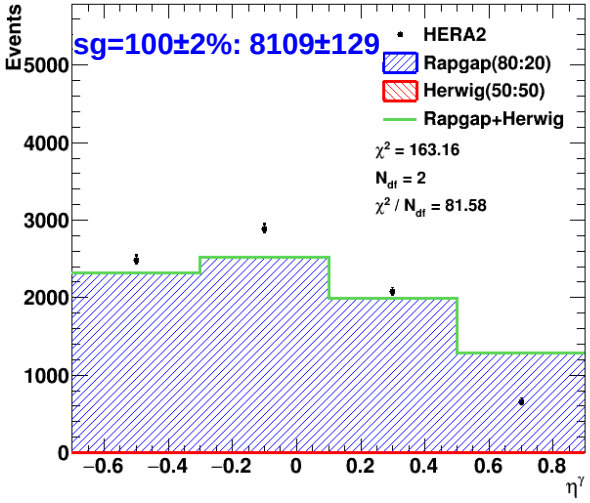
Pythia

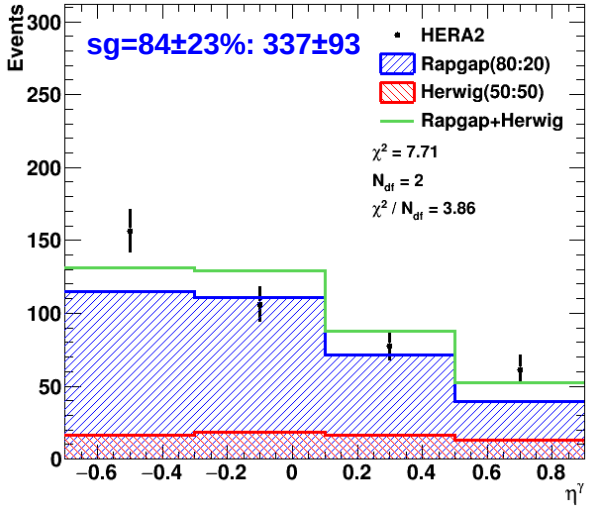


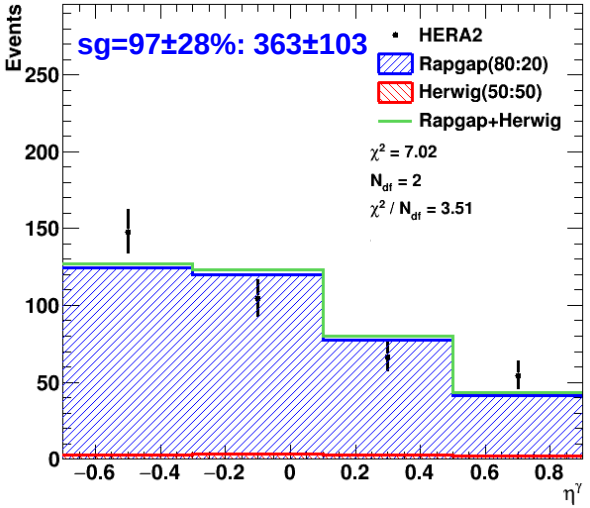




Herwig







No non-diff. background is required

HERA2, fits of MCs to the X_γ distribution

γ+jet selection

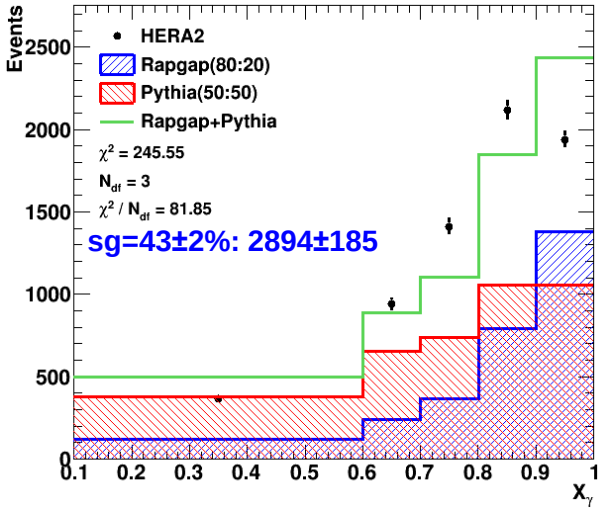
black dots – **data**, fitted photons;

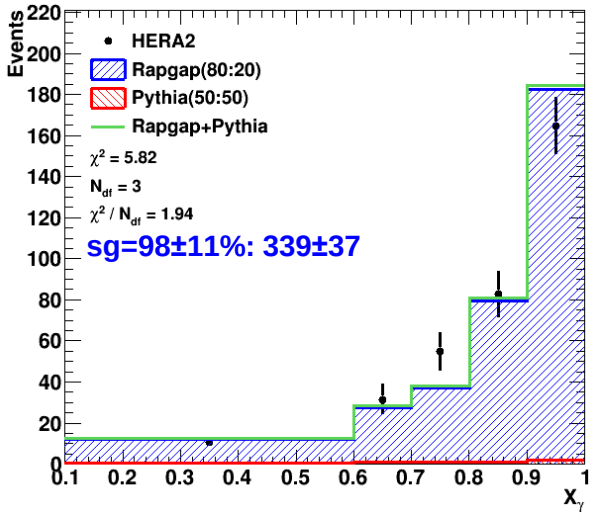
blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

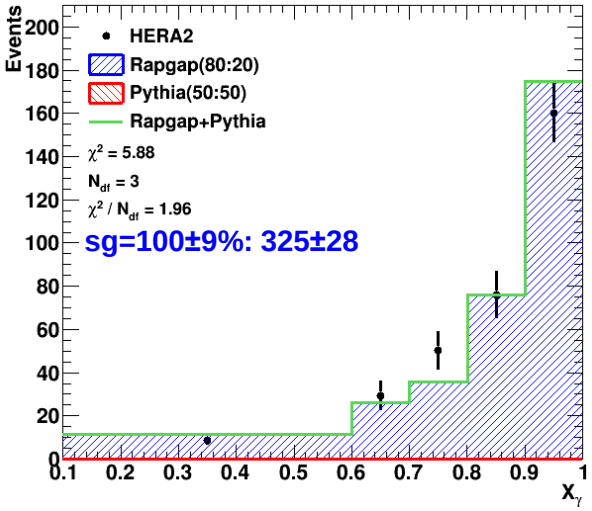
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | **η_{max}** | **η_{max}+X_{IP}**

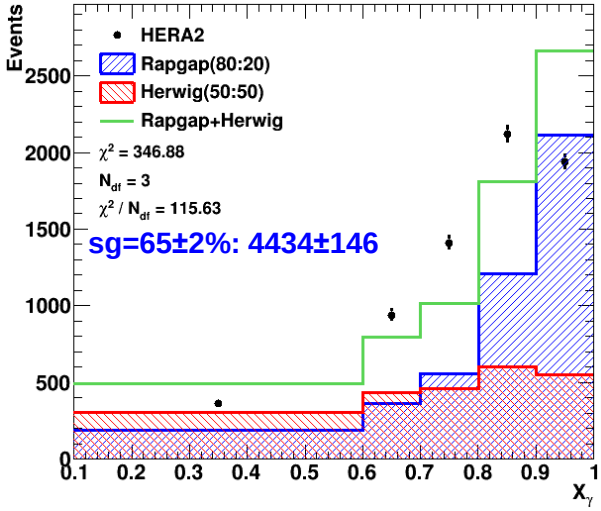
Pythia

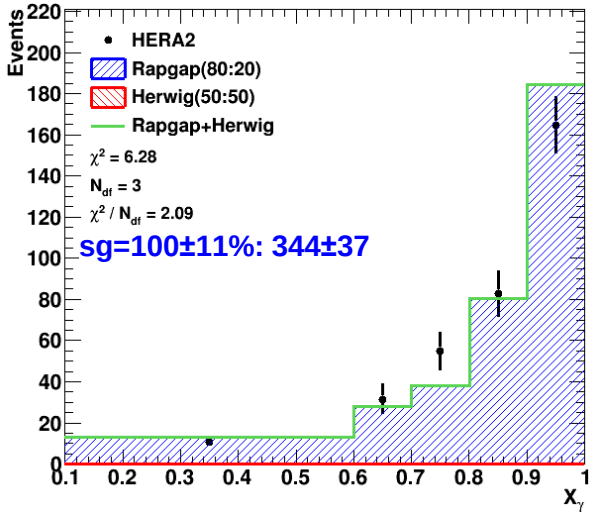


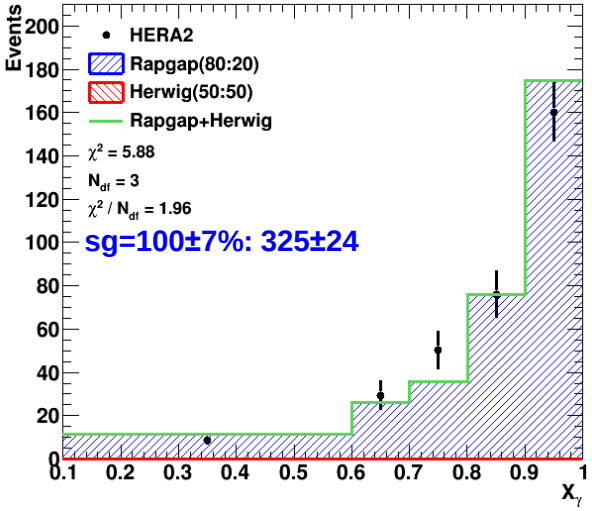




Herwig







X_γ fits give zero non-diff. background both for reweighted and non-reweighted Rapgap MC

HERA2, fits of MCs to the X_γ distribution

γ+jet selection

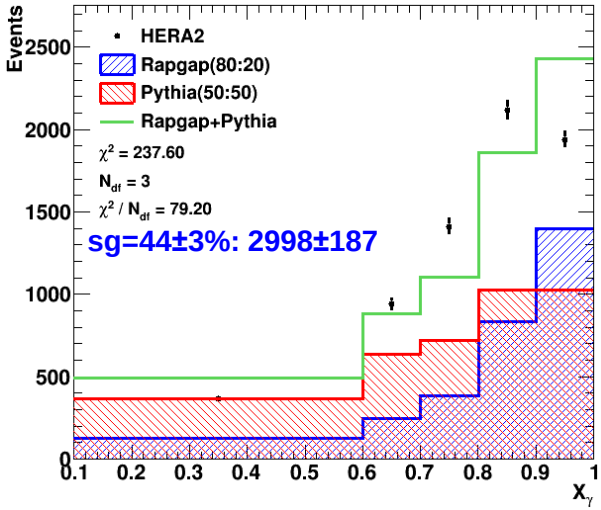
black dots – **data**, fitted photons;

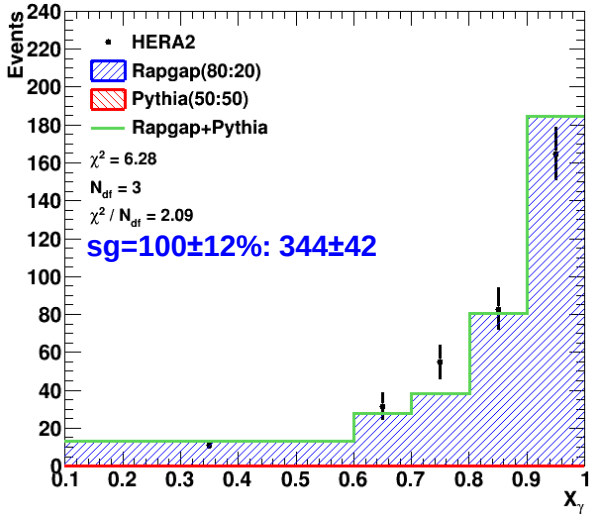
blue – **Rapgap** diff. signal, 80/20 sum, not-reweighted;

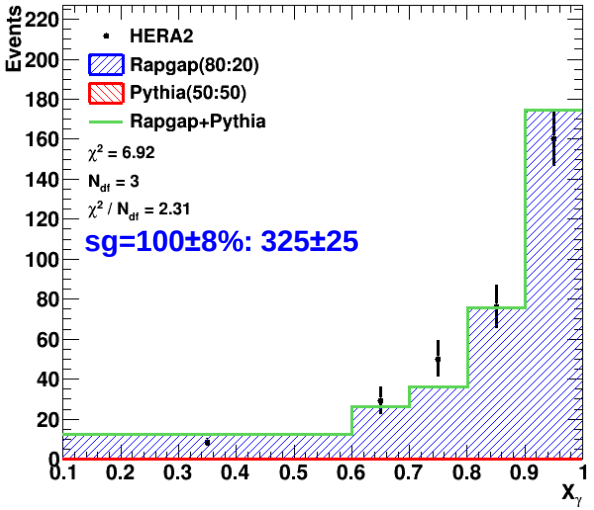
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | η_{max} | $\eta_{max}+X_{IP}$

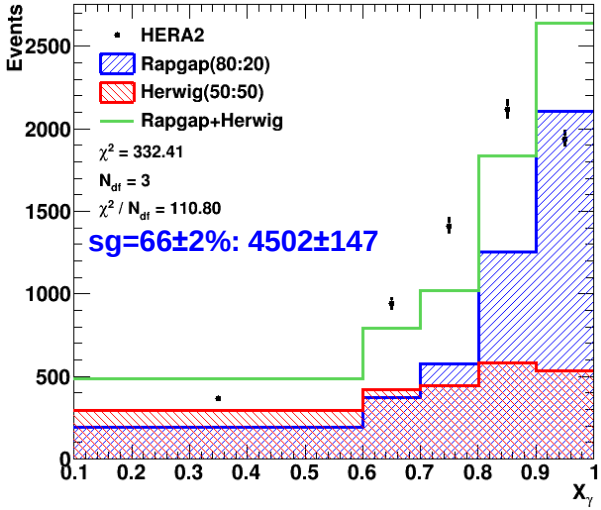
Pythia

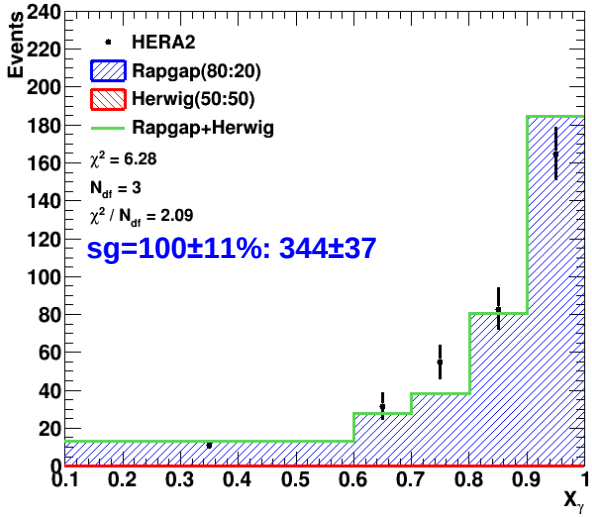


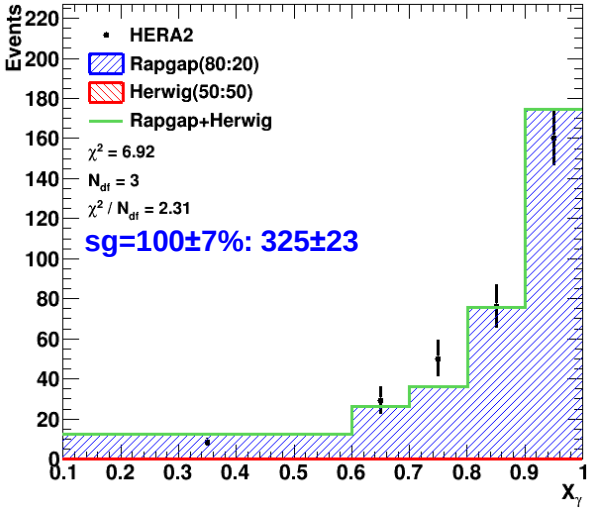




Herwig







No non-diff. background is required

HERA2, fits of MCs to the Z_{IP} distribution

γ+jet selection, fit range 0-0.9

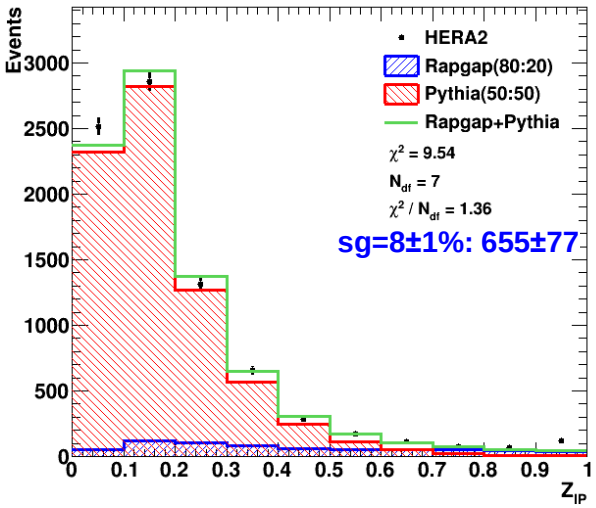
black dots – **data**, fitted photons;

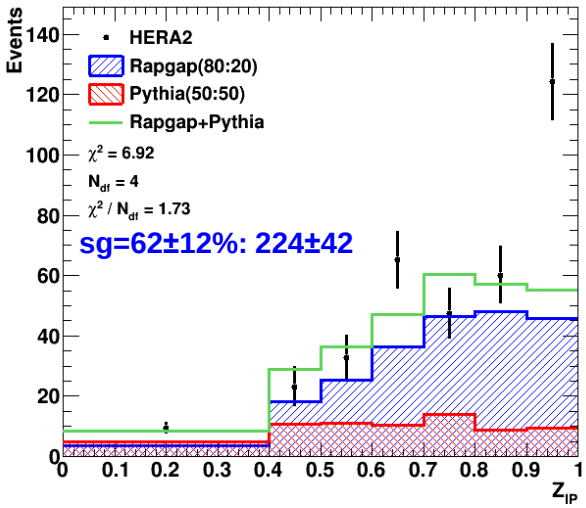
blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

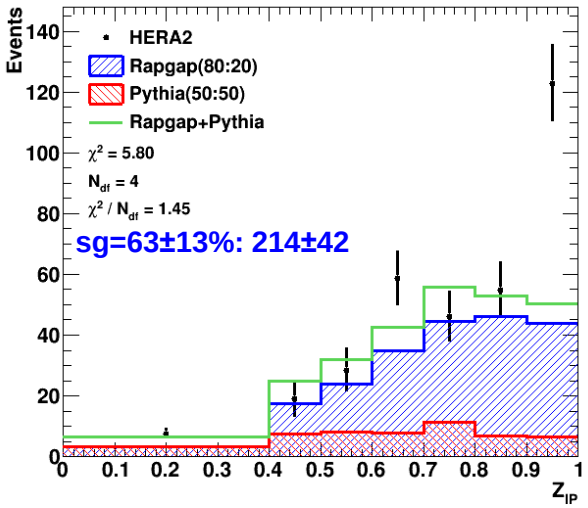
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | η_{max} | $\eta_{max}+X_{IP}$

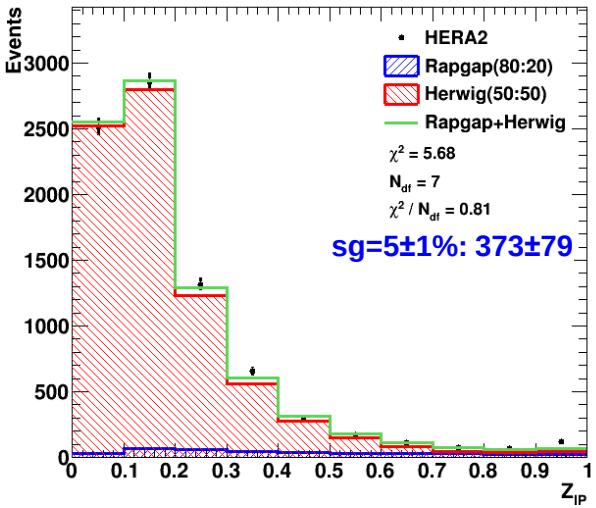
Pythia

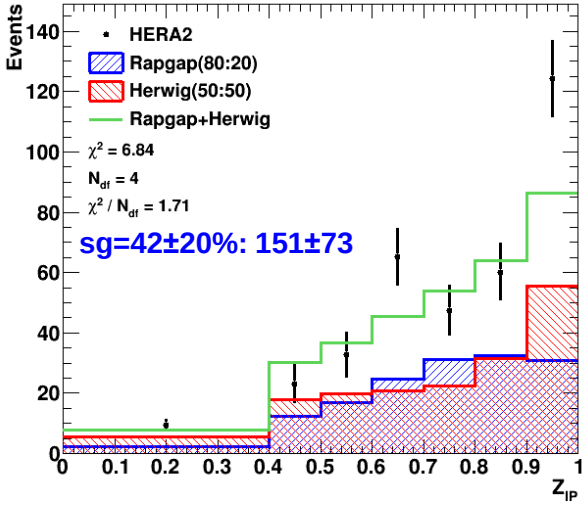


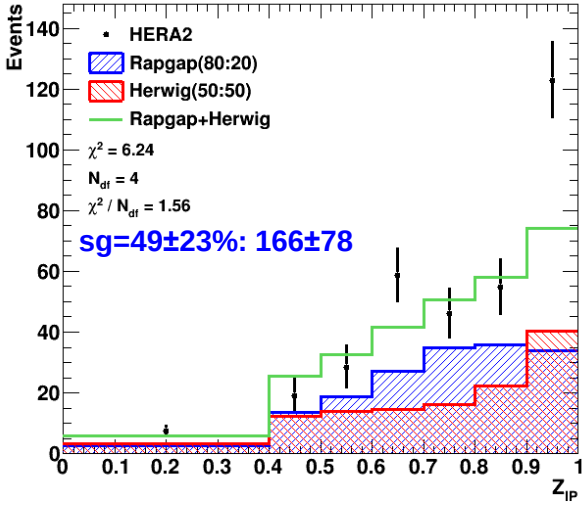




Herwig







All Z_{IP} range is plotted, but fit is done only in the range 0-0.9

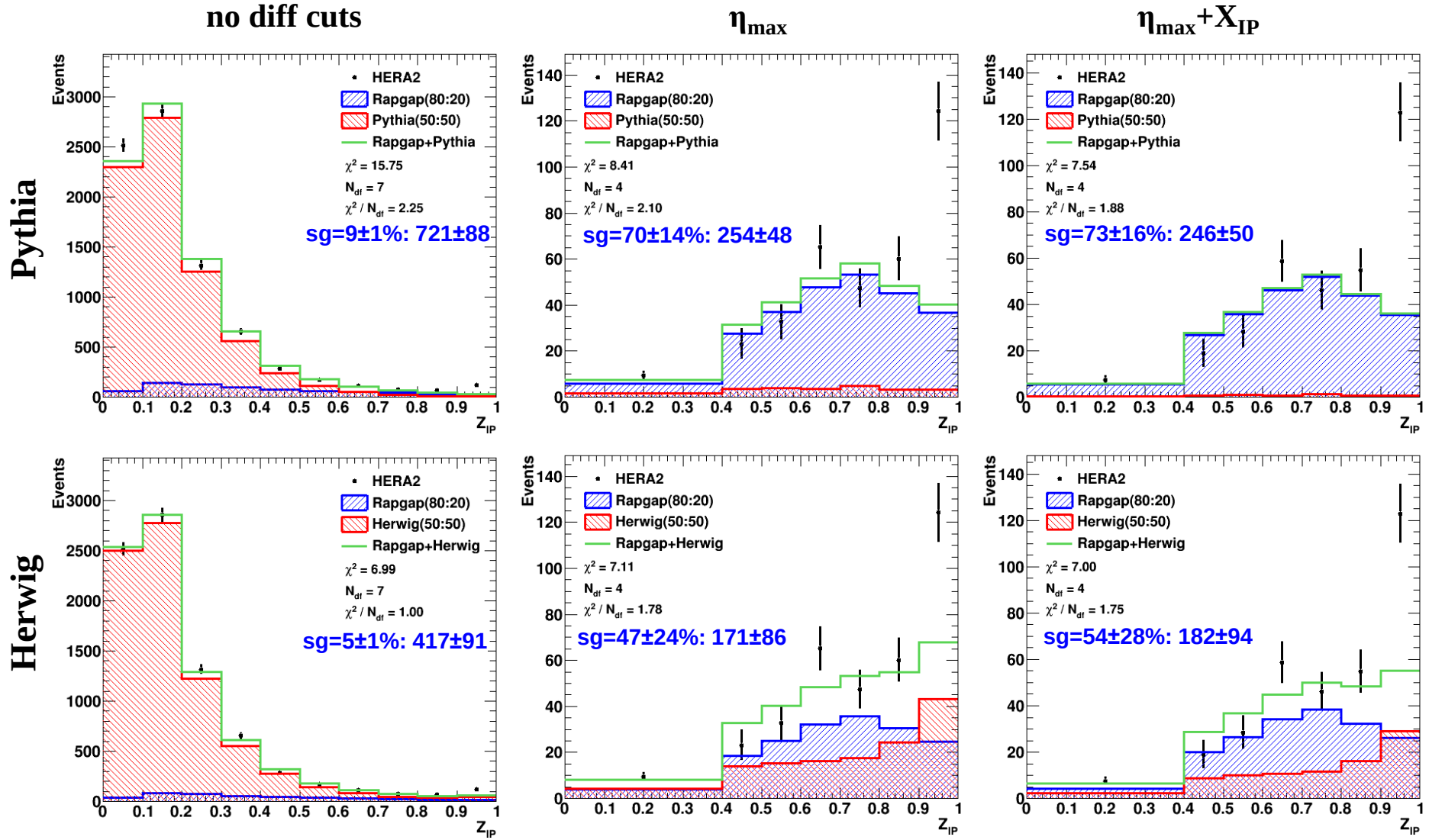
HERA2, fits of MCs to the Z_{IP} distribution

γ+jet selection, fit range 0-0.9

black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, not-reweighted;

red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;



All Z_{IP} range is plotted, but fit is done only in the range 0-0.9

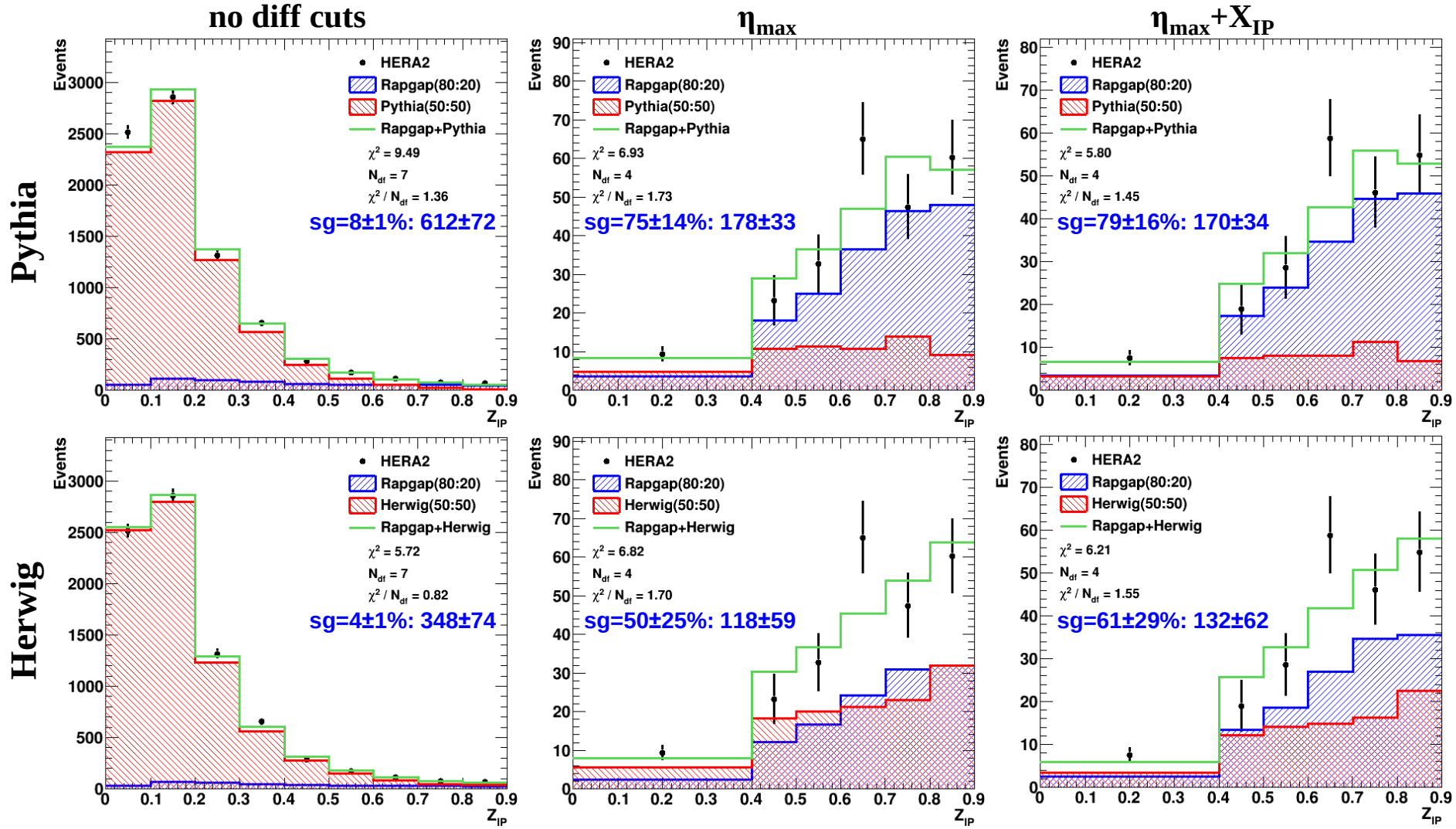
HERA2, fits of MCs to the Z_{IP} distribution

γ+jet selection, last bin 0.9-1 is excluded from fit

black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;



The non-diff. contamination is negligible within one and a half error after applying the diff. cuts

HERA2, fits of MCs to the Z_{IP} distribution

γ+jet selection, last bin 0.9-1 is excluded from fit

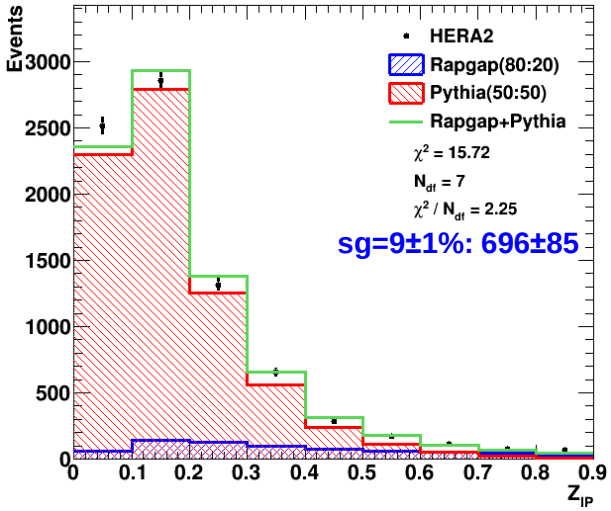
black dots – **data**, fitted photons;

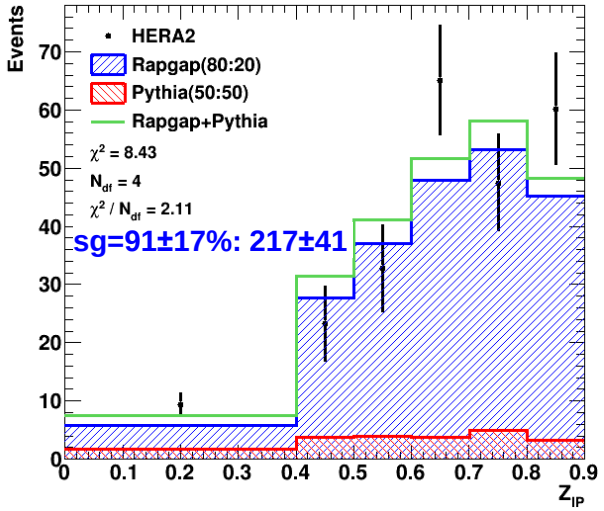
blue – **Rapgap** diff. signal, 80/20 sum, not-reweighted;

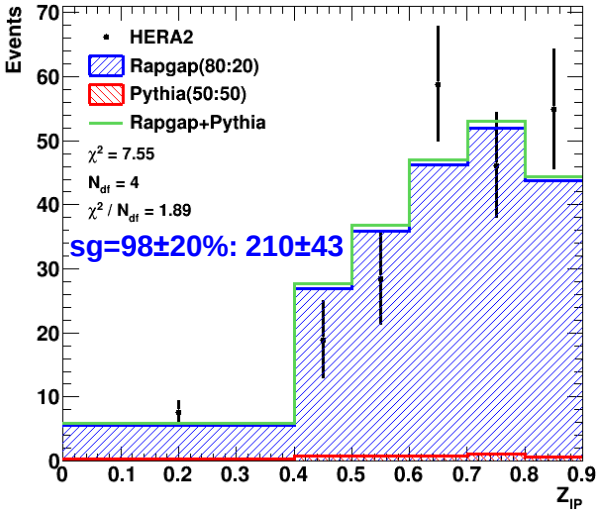
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | η_{max} | $\eta_{max}+X_{IP}$

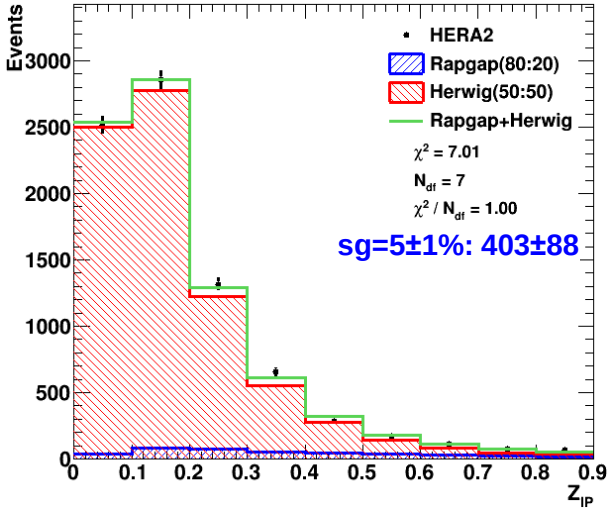
Pythia

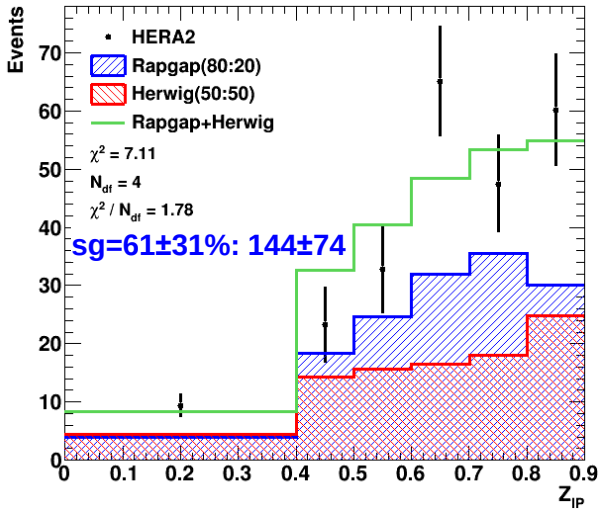


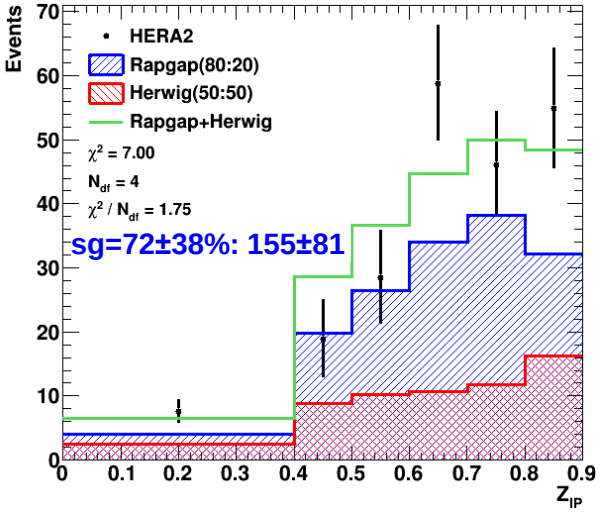




Herwig







The non-diff. contamination is negligible within error after applying the diff. cuts

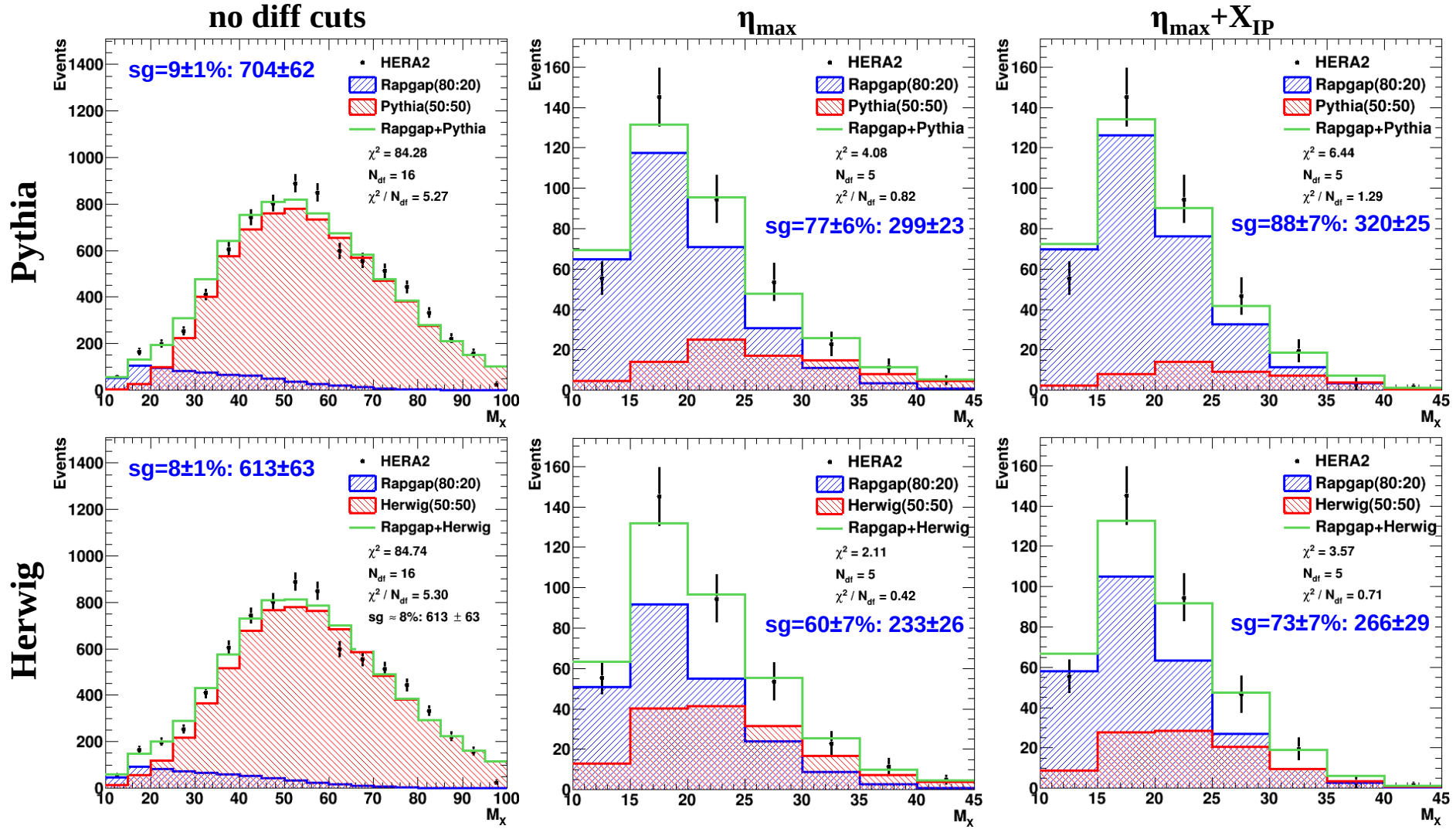
HERA2, fits of MCs to the M_X distribution

γ+jet selection

black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;



M_X fits imply the presence of non-diff. background after applying the diff. cuts

HERA2, fits of MCs to the M_X distribution

γ+jet selection

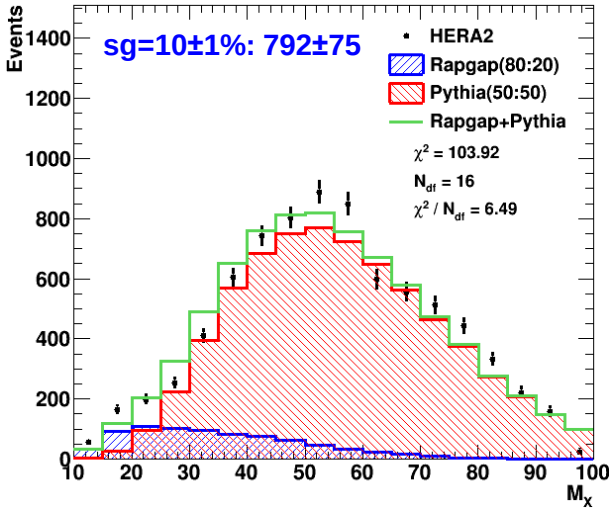
black dots – **data**, fitted photons;

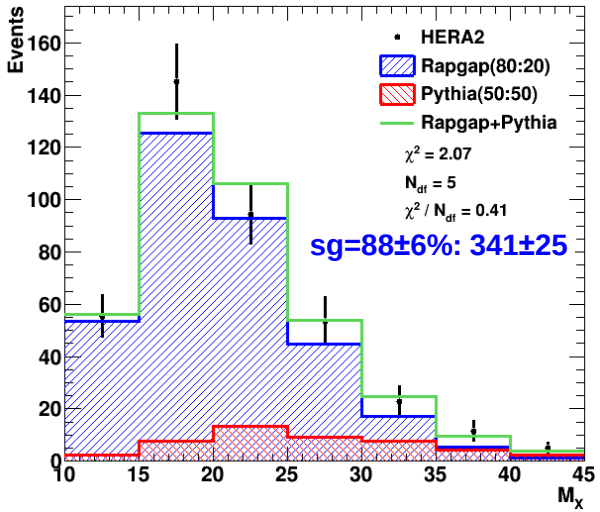
blue – **Rapgap** diff. signal, 80/20 sum, not-reweighted;

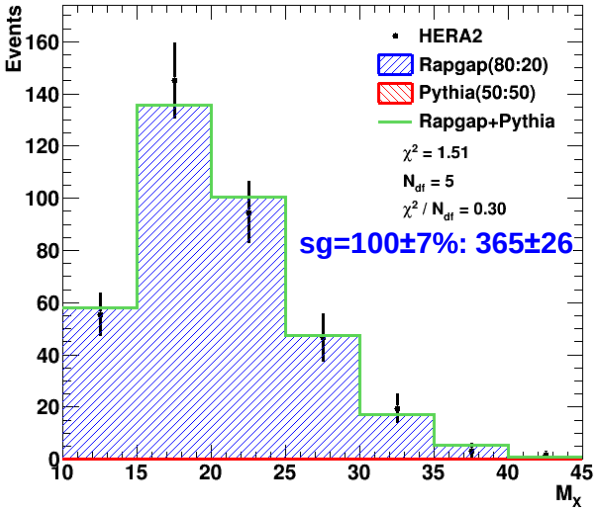
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | η_{max} | $\eta_{max}+X_{IP}$

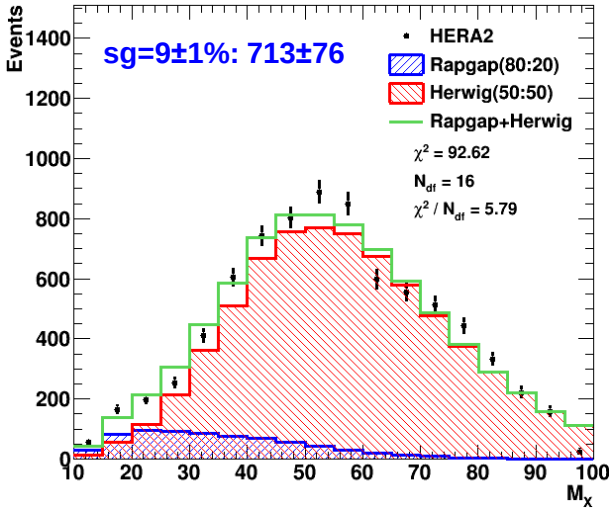
Pythia

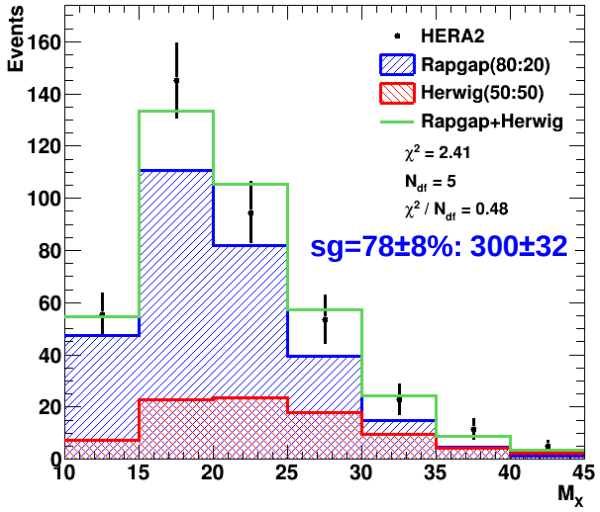


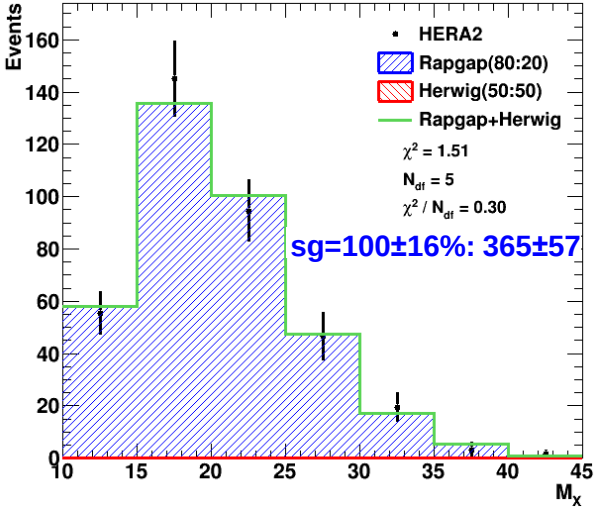




Herwig







The case of not-reweighted Rapgap gives no contamination after applying the diff. cuts

Conclusions

- The fits to only two variables X_{IP} and M_x imply the non-diffractive background presence after applying the diffractive cuts. However we don't base on these results due to the bad Pythia/Herwig description of corresponding variables.
- The fits to other four variables (η_{max}, η^{γ}, X_{γ}, Z_{IP}) yield absence or background less than 1-1.5 statistical error.
- So the most of variables are fitted satisfactory by RAPGAP after applying the diffractive cuts and therefore are consistent with no Pythia and Herwig background. It means: ***our diffractive cuts $\eta_{max} < 2.5$ and $X_{IP} < 0.03$ reject almost all the non-diffractive events.***

Future plans

- Recalculate cross sections.

Thanks for help and support to Peter Bussey, Ian Skillicorn, David Saxon

Backup slides

HERA1, fits of MCs to the X_P distribution

γ+jet selection

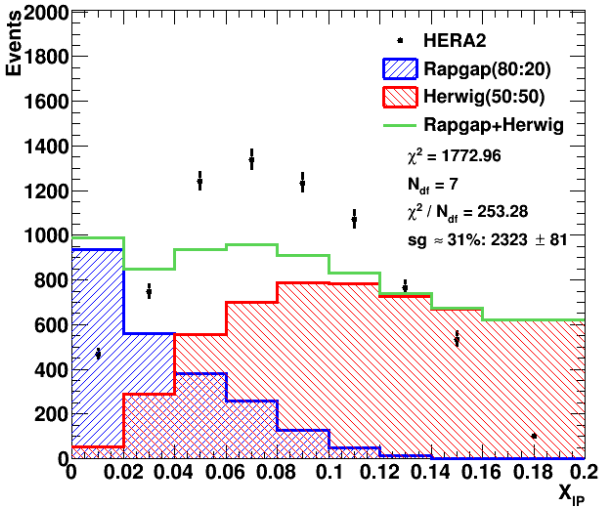
black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

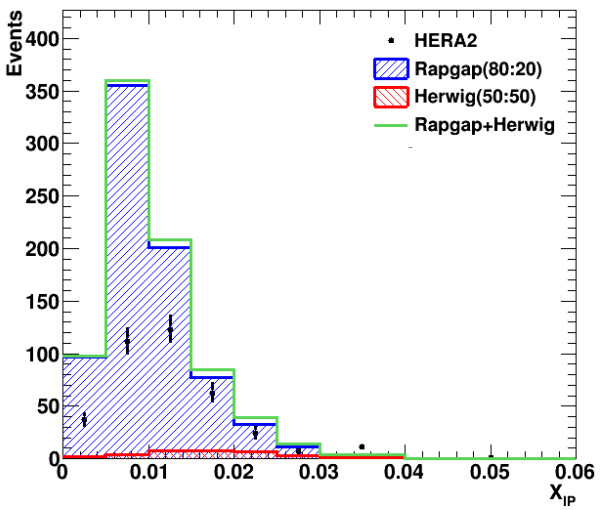
red – **Herwig** non-diff. signal with soft underlying events, 50/50 sum;

Herwig with SUE

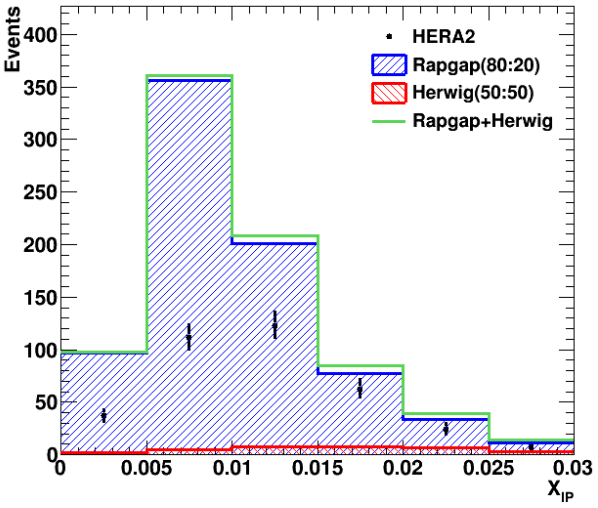
no diff cuts



η_{max}



η_{max}+X_{IP}



There are no fits in 2 and 3 column, the scale factor evaluated from column 1 is used instead.

HERA1, fits of MCs to the X_P distribution

γ+jet selection

black dots – **data**, fitted photons;

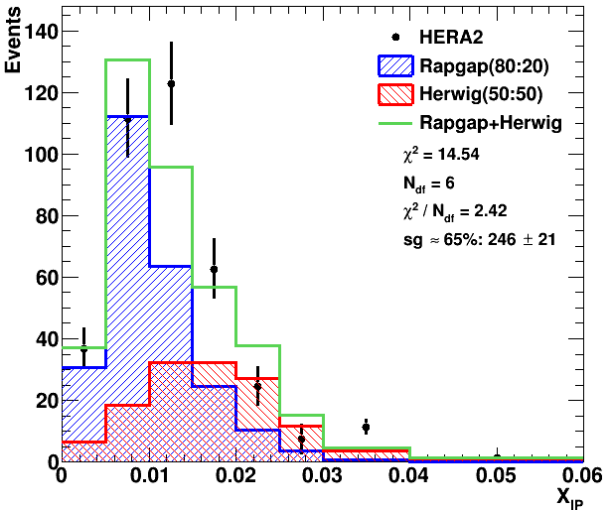
blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

red – **Herwig** non-diff. signal with soft underlying events, 50/50 sum;

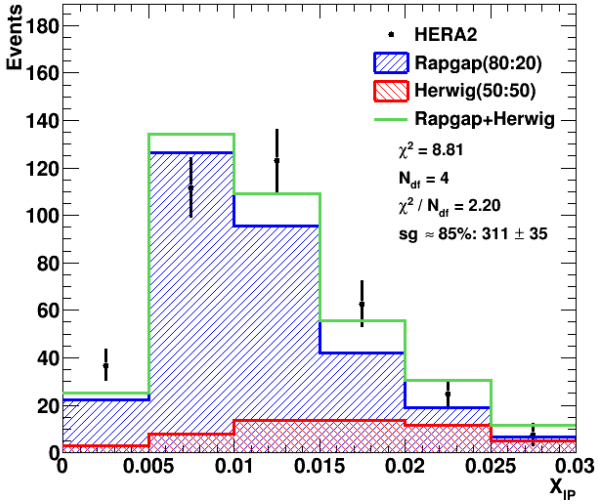
Herwig with SUE

no diff cuts

η_{max}



$\eta_{max}+X_{IP}$



HERA2, fits of MCs to the η_{max} distribution

γ+jet selection

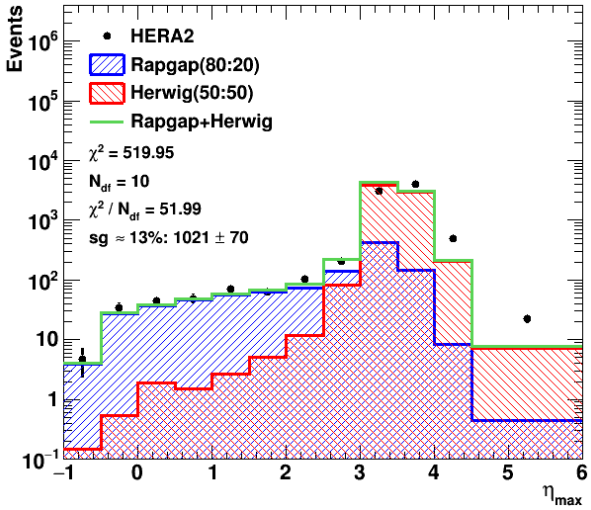
black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

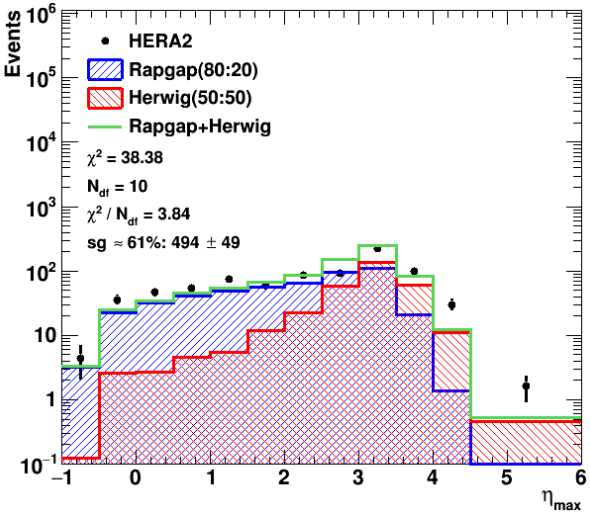
red – **Herwig** non-diff. signal with soft underlying events, 50/50 sum;

Herwig with SUE

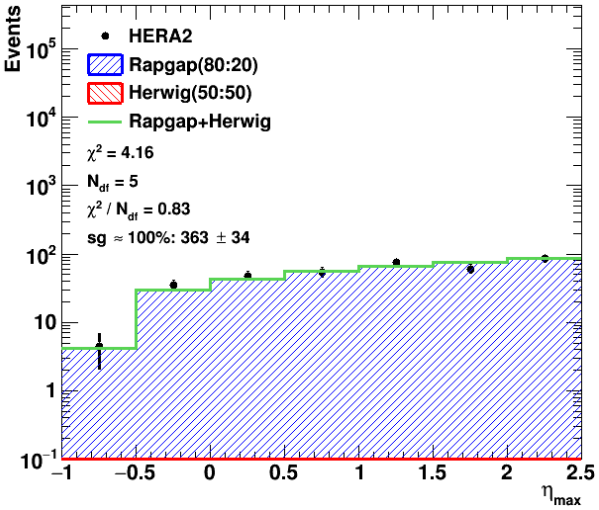
no diff cuts



X_P



η_{max}+X_{IP}



HERA2, fits of MCs to the η distribution

γ+jet selection

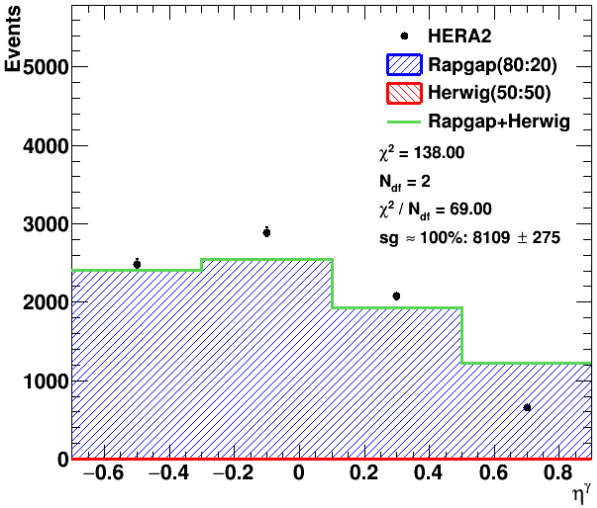
black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

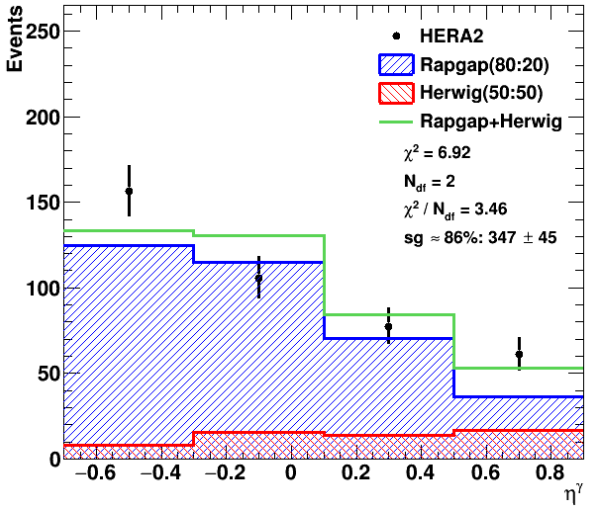
red – **Herwig** non-diff. signal with soft underlying events, 50/50 sum;

Herwig with SUE

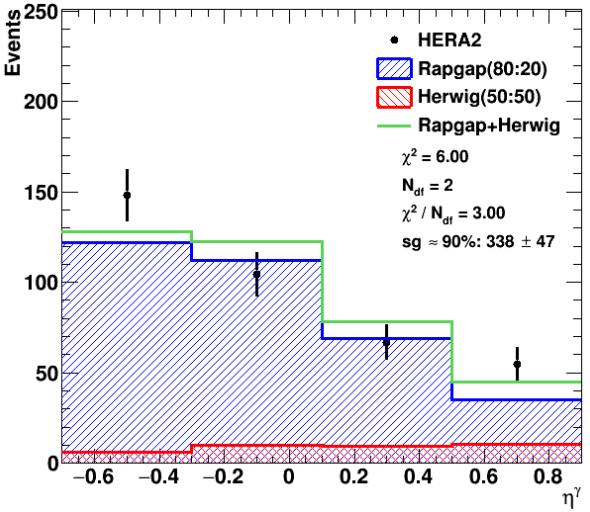
no diff cuts



η_{max}



$\eta_{max}+X_{IP}$



HERA2, fits of MCs to the X_γ distribution

γ+jet selection

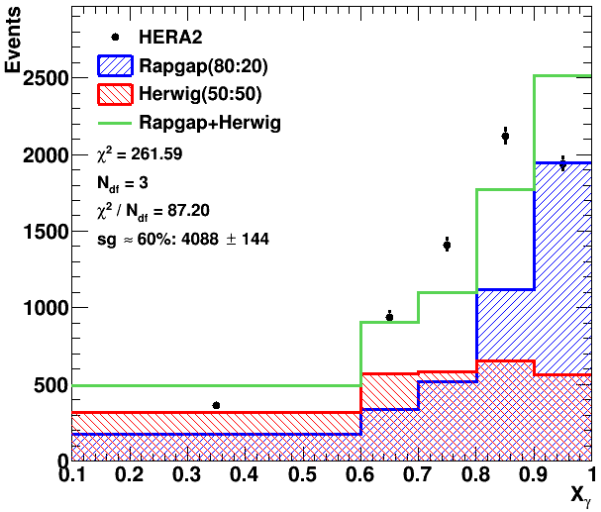
black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

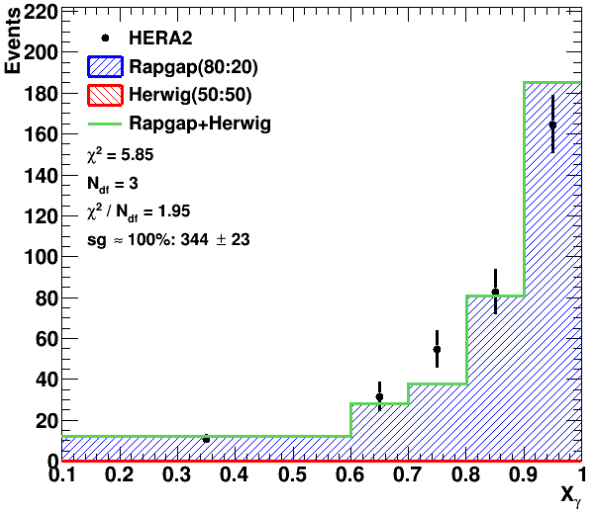
red – **Herwig** non-diff. signal with soft underlying events, 50/50 sum;

Herwig with SUE

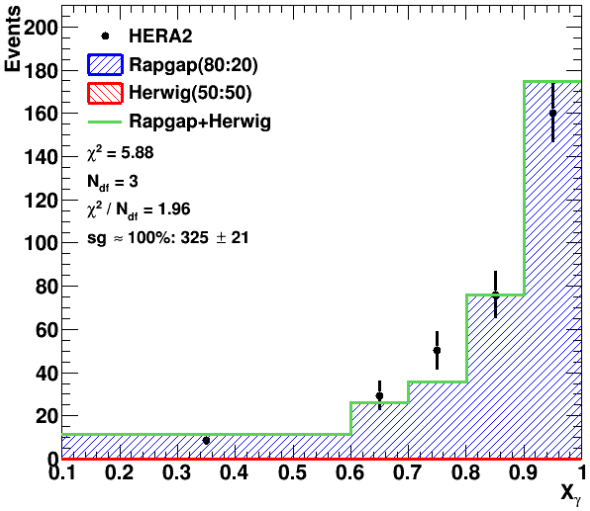
no diff cuts



η_{max}



η_{max}+X_{IP}



HERA2, fits of MCs to the Z_P distribution

γ+jet selection

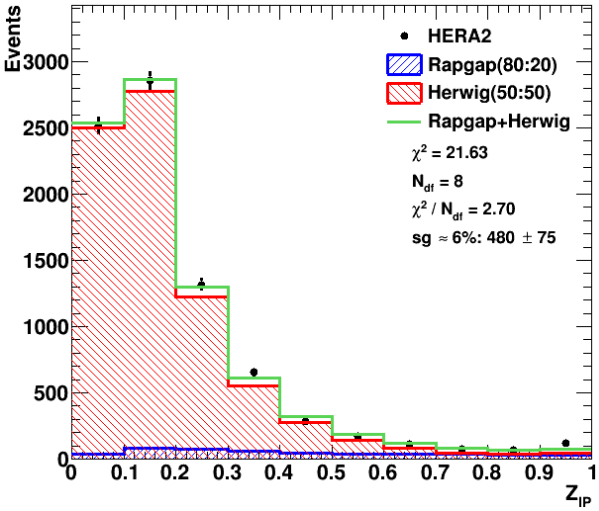
black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

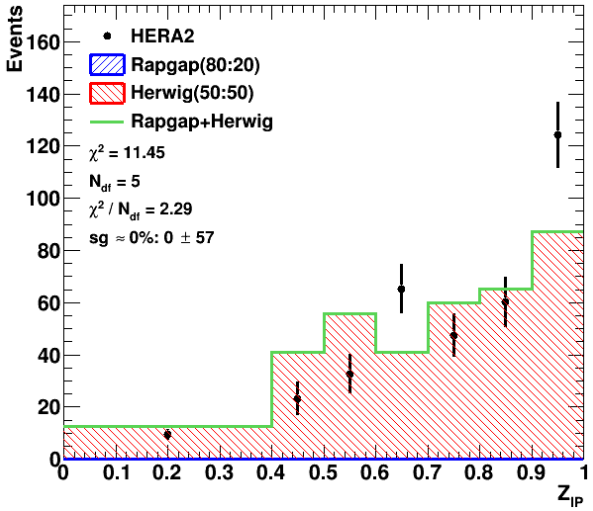
red – **Herwig** non-diff. signal with soft underlying events, 50/50 sum;

Herwig with SUE

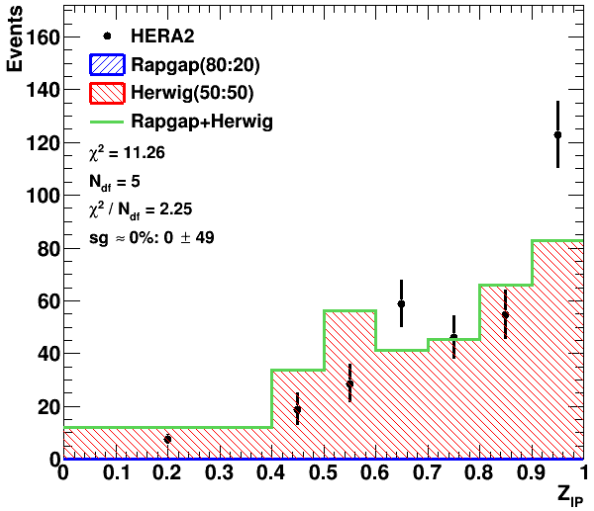
no diff cuts



η_{max}



η_{max}+X_{IP}



HERA2, fits of MCs to the Z_P distribution

γ+jet selection, last bin 0.9-1 is excluded

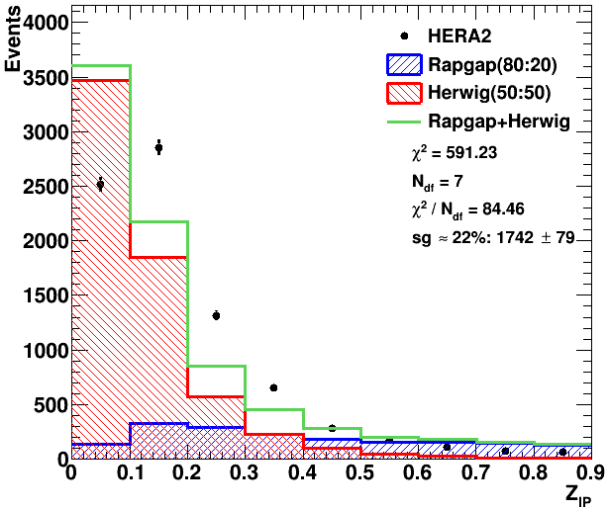
black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

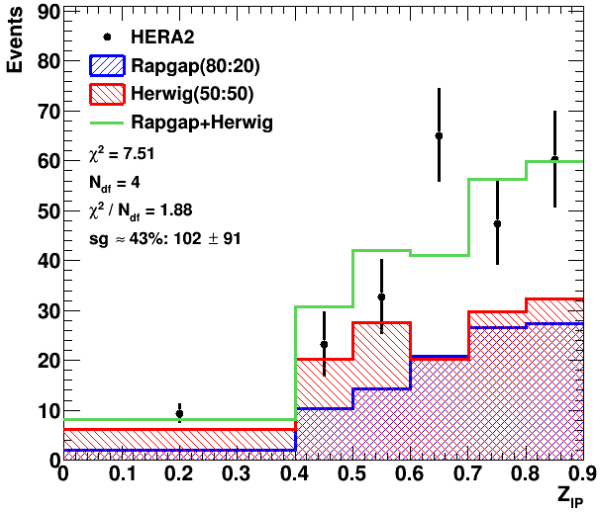
red – **Herwig** non-diff. signal with soft underlying events, 50/50 sum;

Herwig with SUE

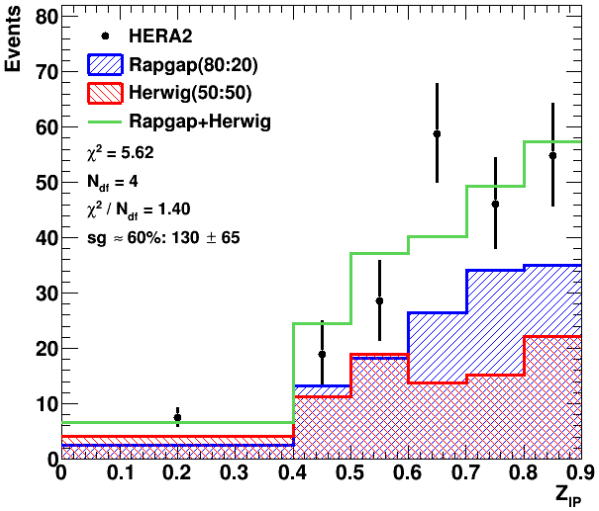
no diff cuts



η_{max}



η_{max}+X_{IP}



HERA2, fits of MCs to the M_X distribution

γ+jet selection

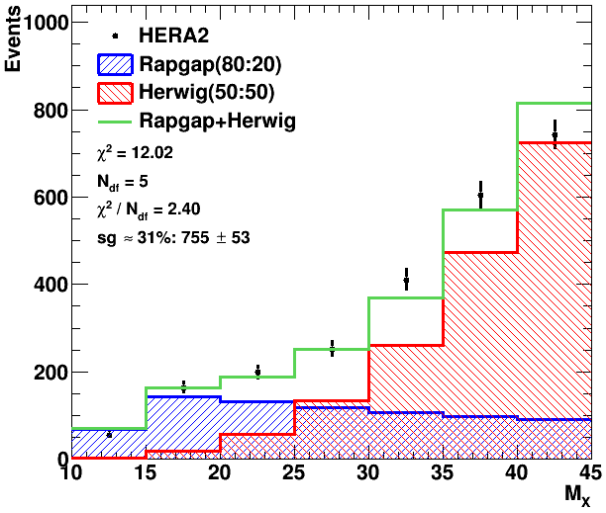
black dots – **data**, fitted photons;

blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

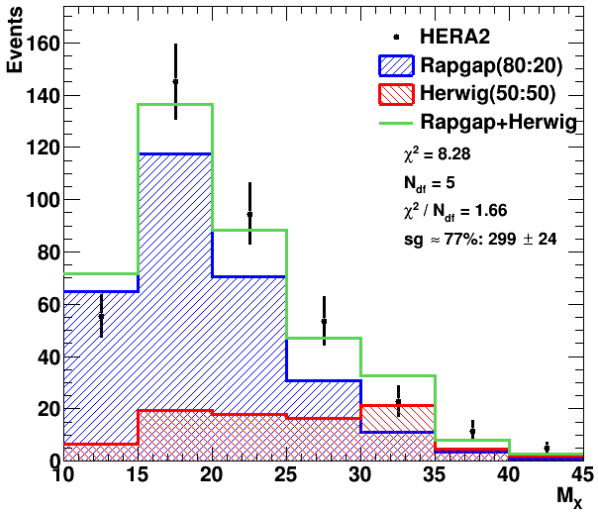
red – **Herwig** non-diff. signal with soft underlying events, 50/50 sum;

Herwig with SUE

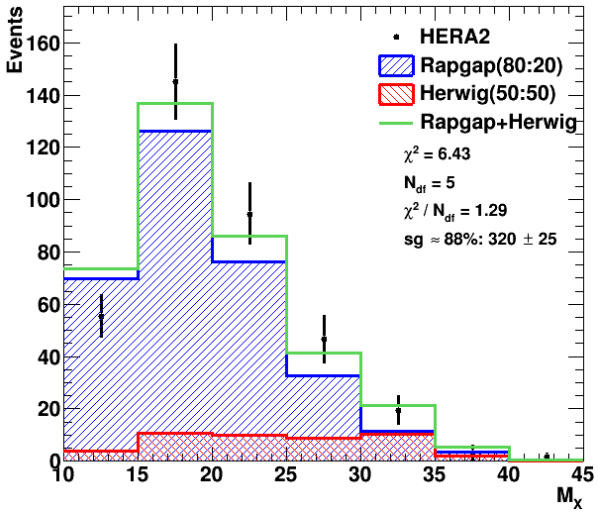
no diff cuts



η_{max}



η_{max}+X_{IP}



HERA2, mean p_T vs. p_z distributions of stable particles

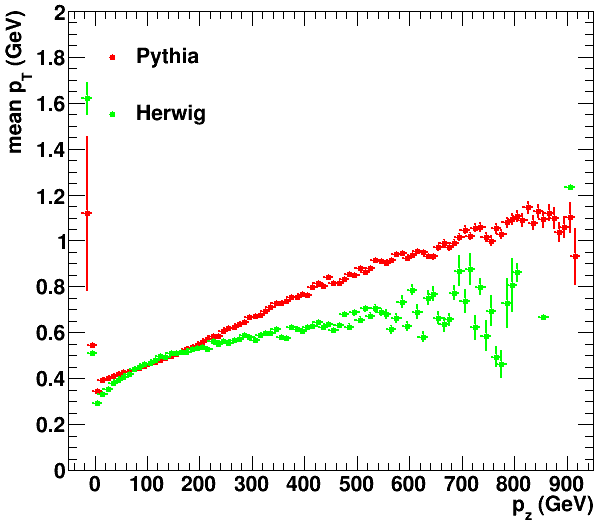
γ+jet selection, hadron level

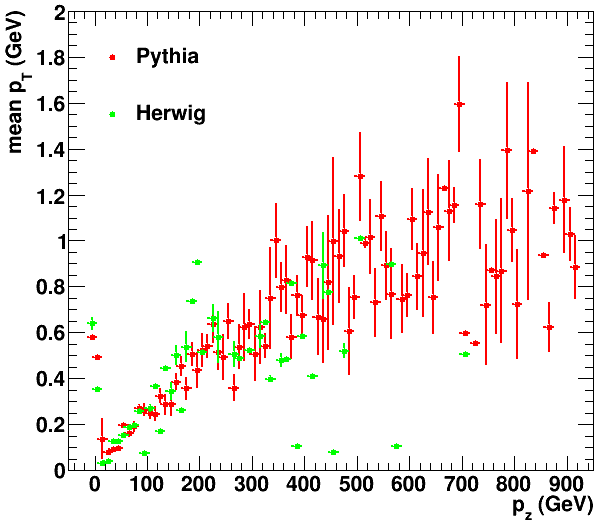
red – **Pythia** non-diff. signal;

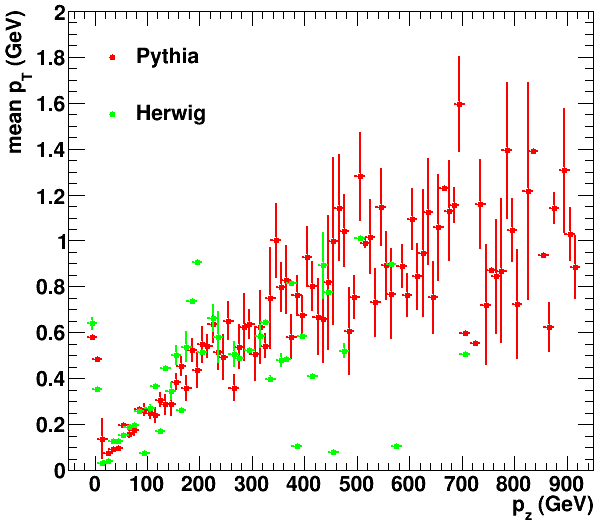
green – **Herwig** non-diff. signal with soft underlying events;

no diff cuts | **η_{max}** | **$\eta_{max}+X_{IP}$**

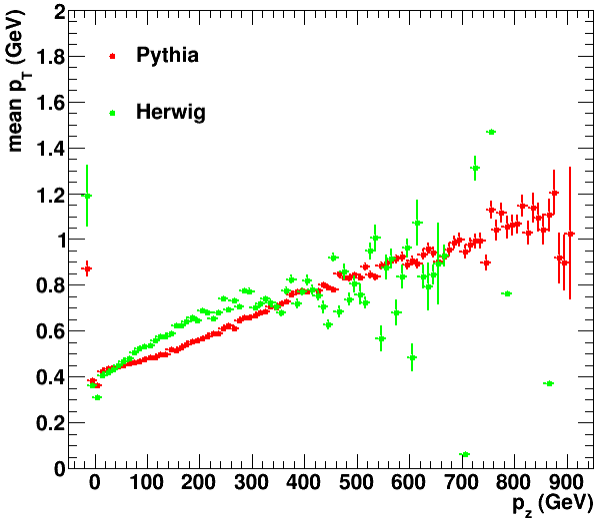
direct

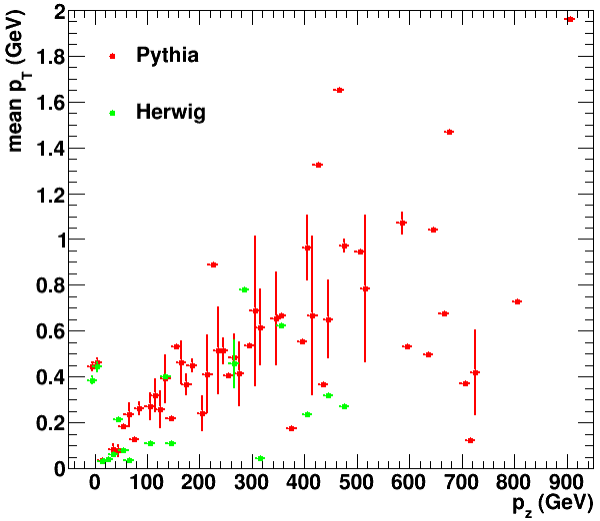


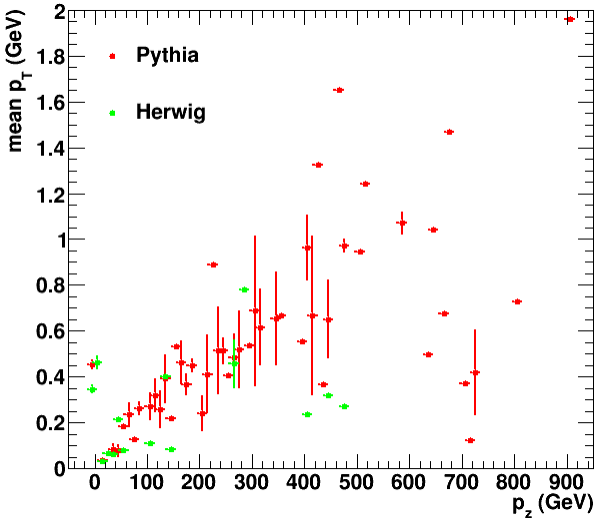




resolved







HERA2, mean p_T vs. η distributions of stable particles

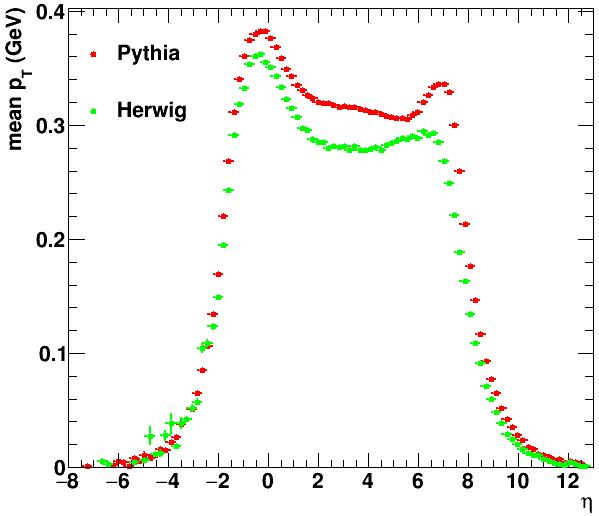
γ+jet selection, hadron level

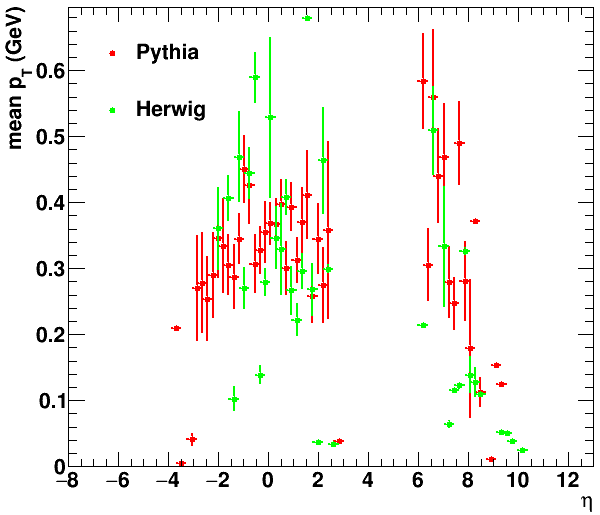
red – **Pythia** non-diff. signal;

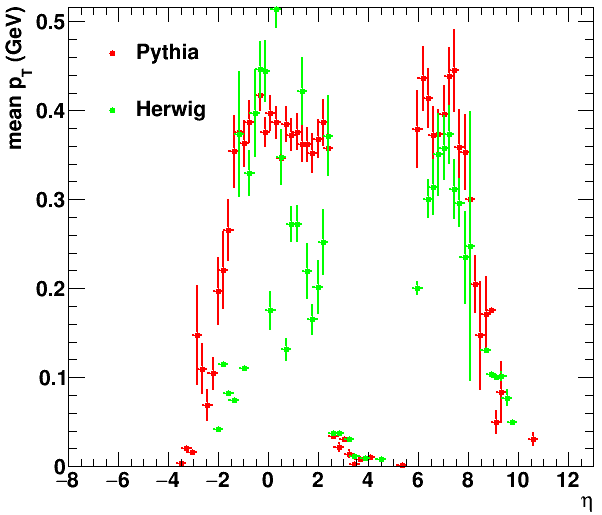
green – **Herwig** non-diff. signal with soft underlying events;

no diff cuts | **η_{max}** | **$\eta_{max}+X_{IP}$**

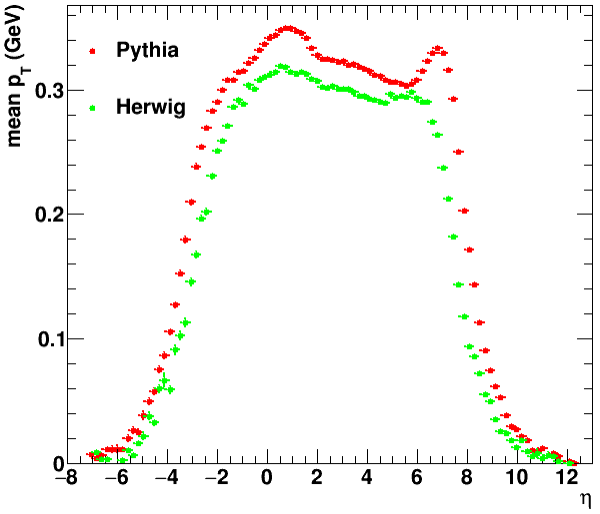
direct

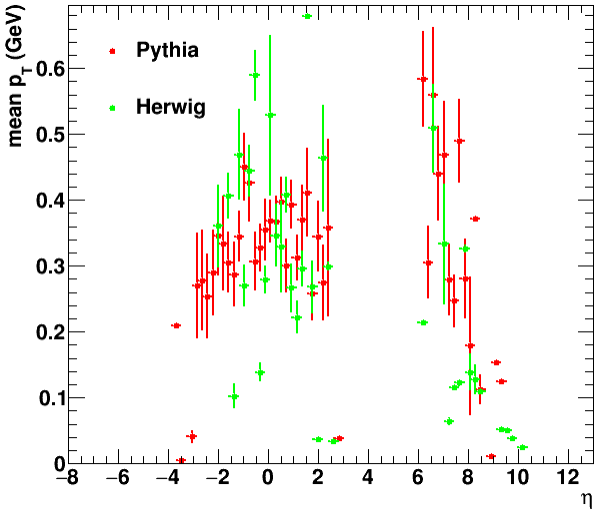


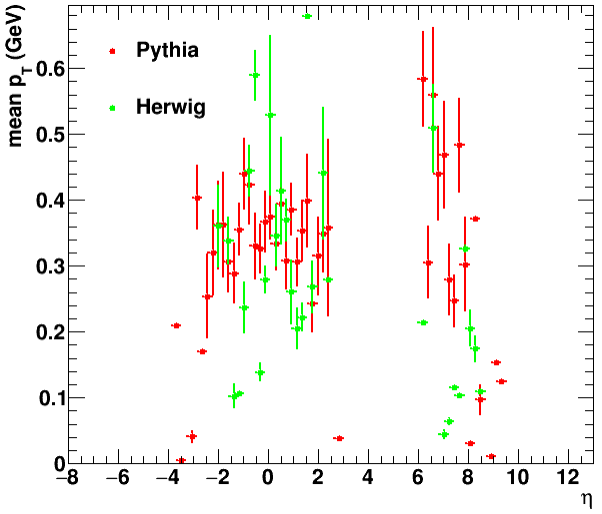




resolved







HERA2, mean p_T vs. η distributions of stable particles

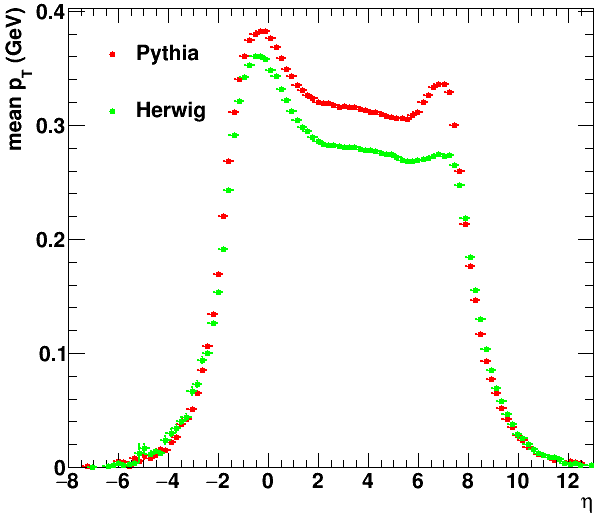
γ+jet selection, hadron level

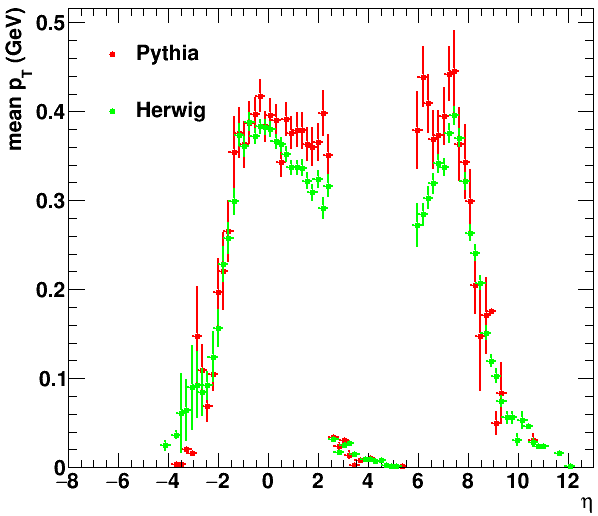
red – **Pythia** non-diff. signal;

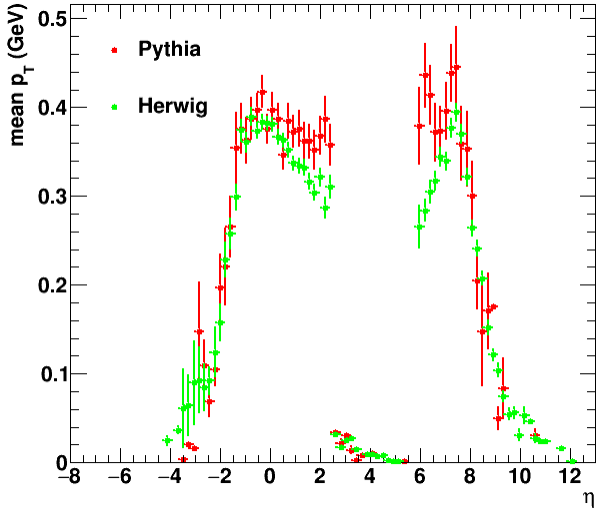
green – **Herwig** non-diff. signal;

no diff cuts | **η_{max}** | **$\eta_{max}+X_{IP}$**

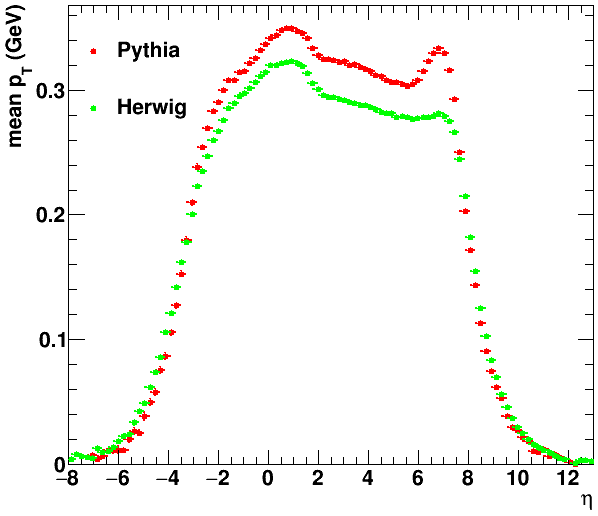
direct

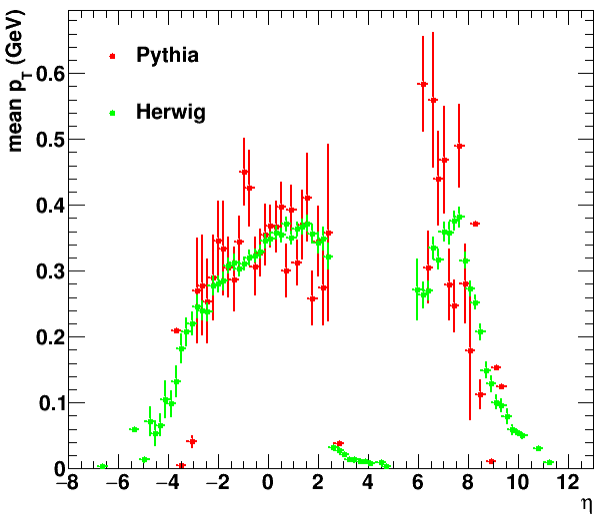


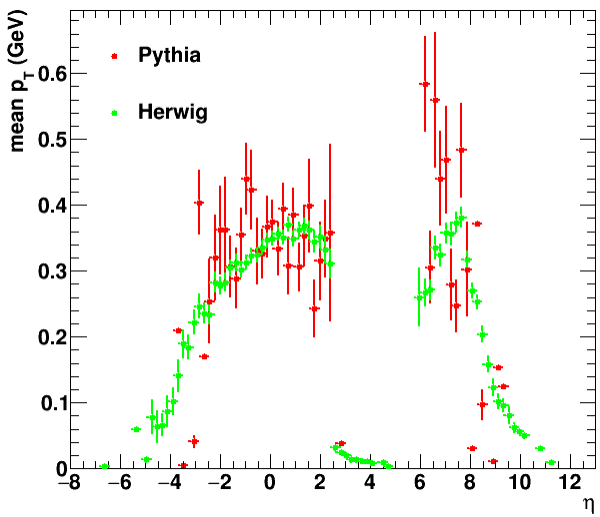




resolved







HERA2, mean p_T vs. p_z distributions of stable particles

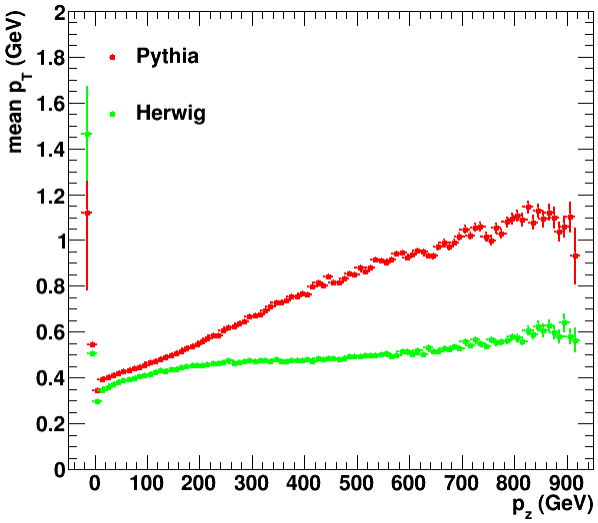
γ+jet selection, hadron level

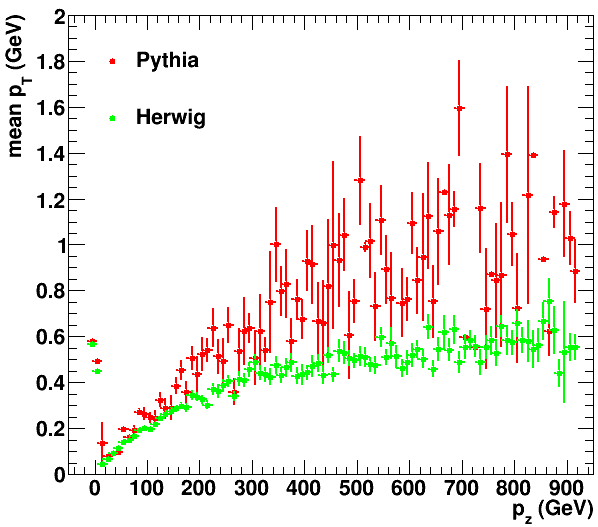
red – **Pythia** non-diff. signal;

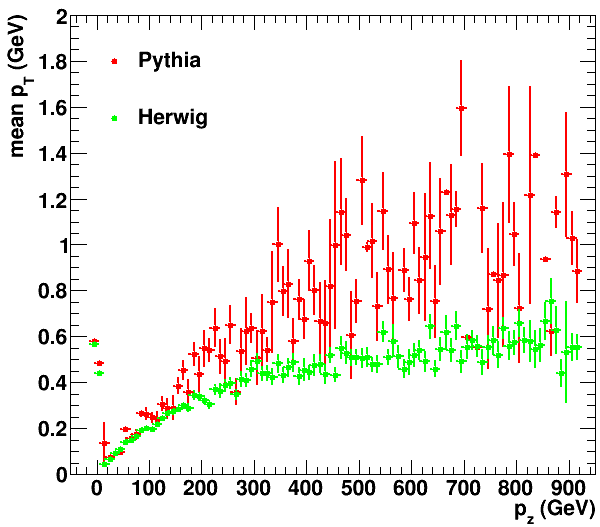
green – **Herwig** non-diff. signal;

no diff cuts | η_{max} | $\eta_{max}+X_{IP}$

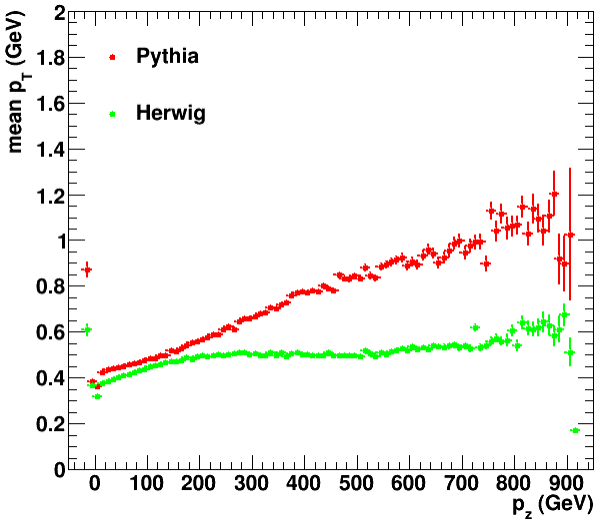
direct

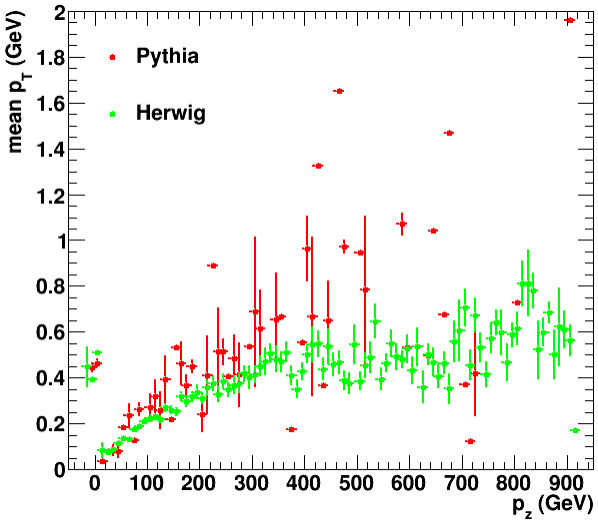


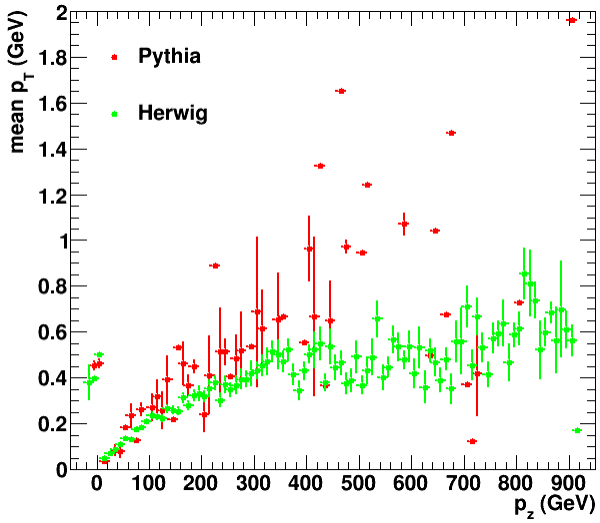




resolved





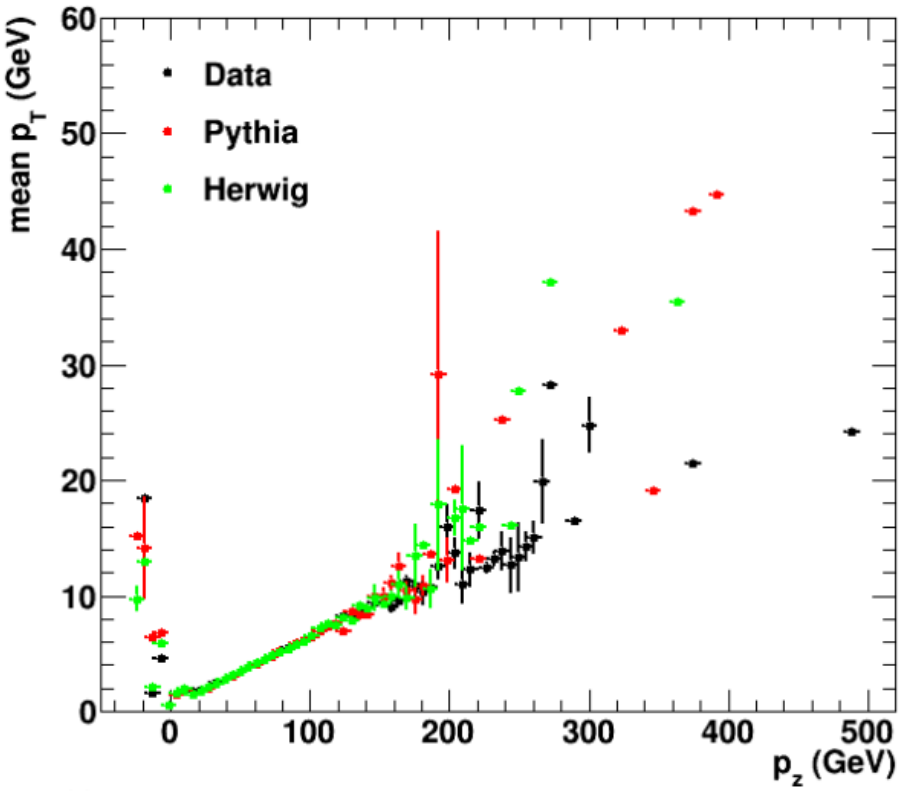


HERA2, mean p_T vs. p_z distributions of stable particles

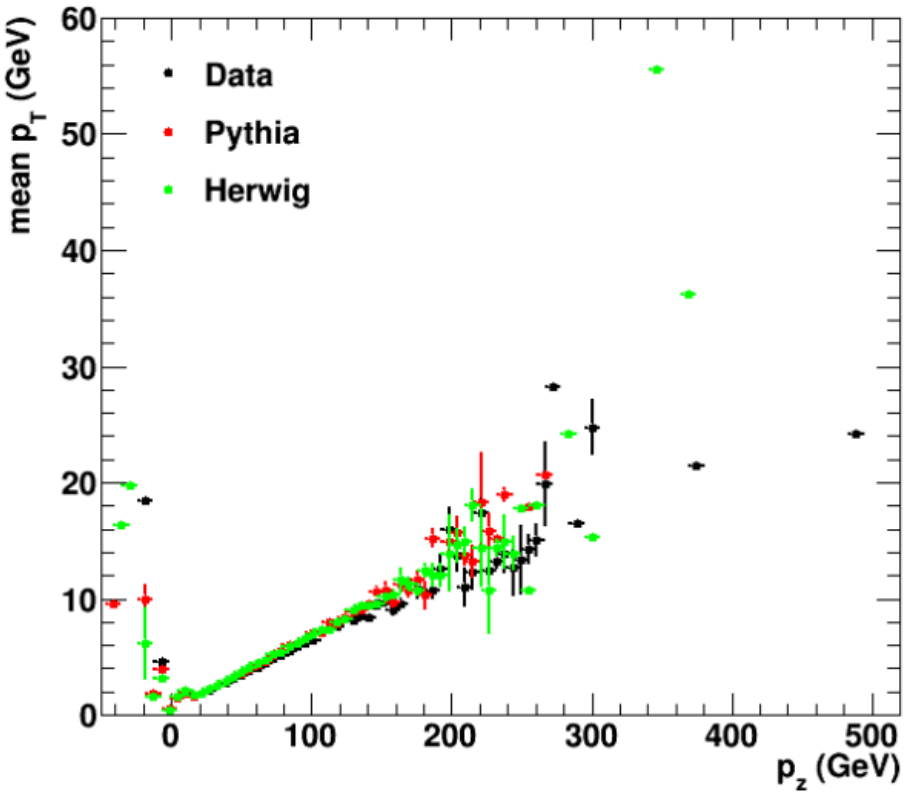
γ+jet selection, detector level, no diff. cuts

red – **Pythia** non-diff. signal;
green – **Herwig** non-diff. signal;

resolved



direct



HERA2, fit of MCs to the X_P distribution

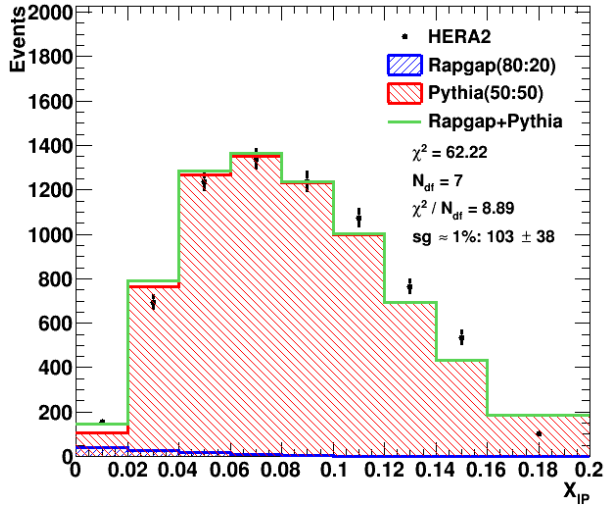
γ+jet selection

black dots – **data**, fitted photons, with η_{max} >2.5 cut;

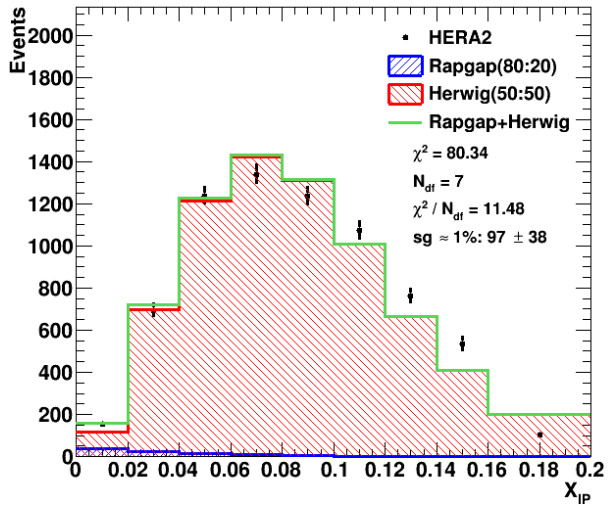
blue – **Rapgap** diff. signal, 80/20 sum, reweighted, no diff. cuts;

red – **Pythia** (top), **Herwig** (bottom) non-diff. signal, 50/50 sum, with η_{max} >2.5 cut;

Pythia



Herwig



HERA2, fit of MCs to the X_{IP} distribution (1st column)

γ+jet selection

black dots – **data**, fitted photons;

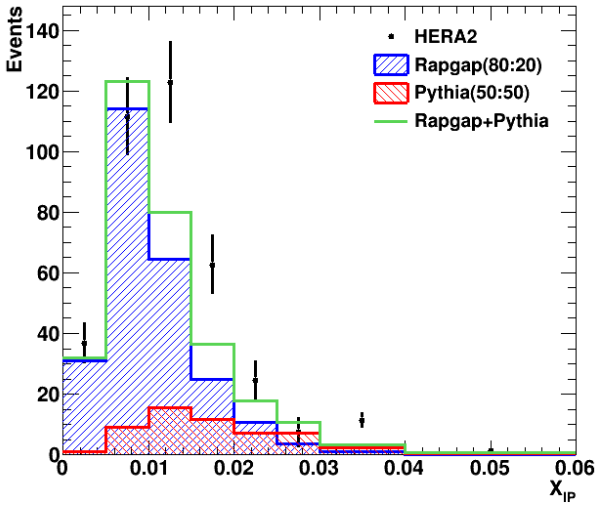
blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

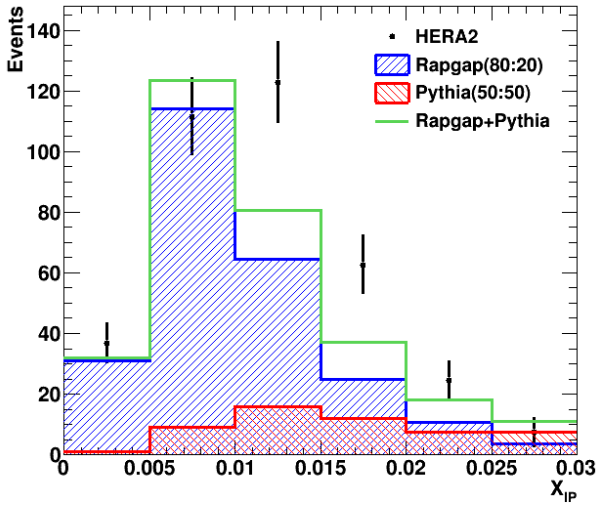
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

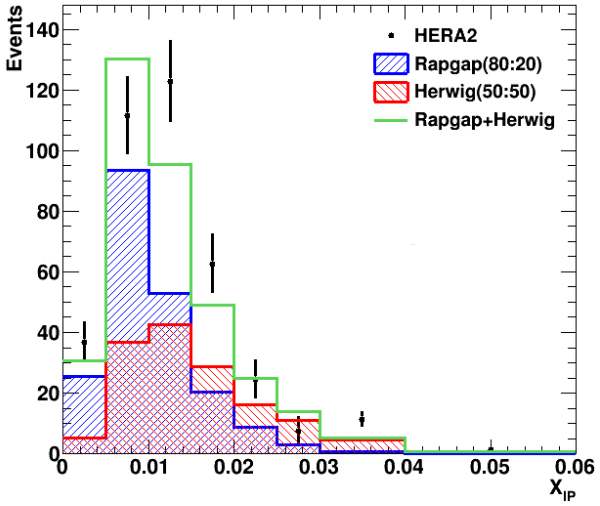
no diff cuts

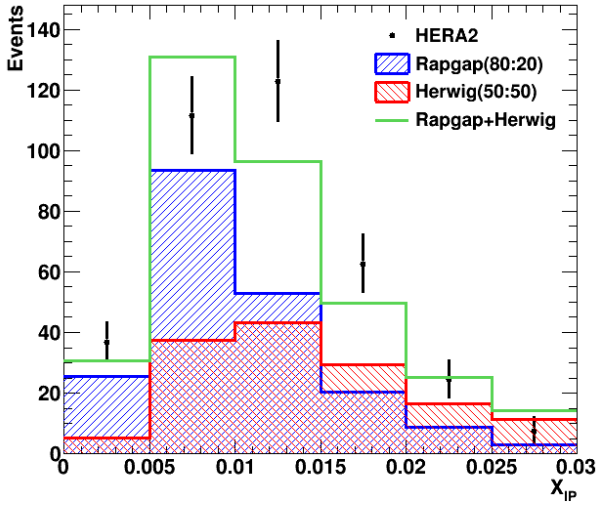
Pythia

Herwig









There are no fits in 2 and 3 column, the scale factor evaluated from column 1 is used instead

HERA2, fits of MCs to the X_{IP} distribution (1st column)

γ+jet selection

black dots – **data**, fitted photons;

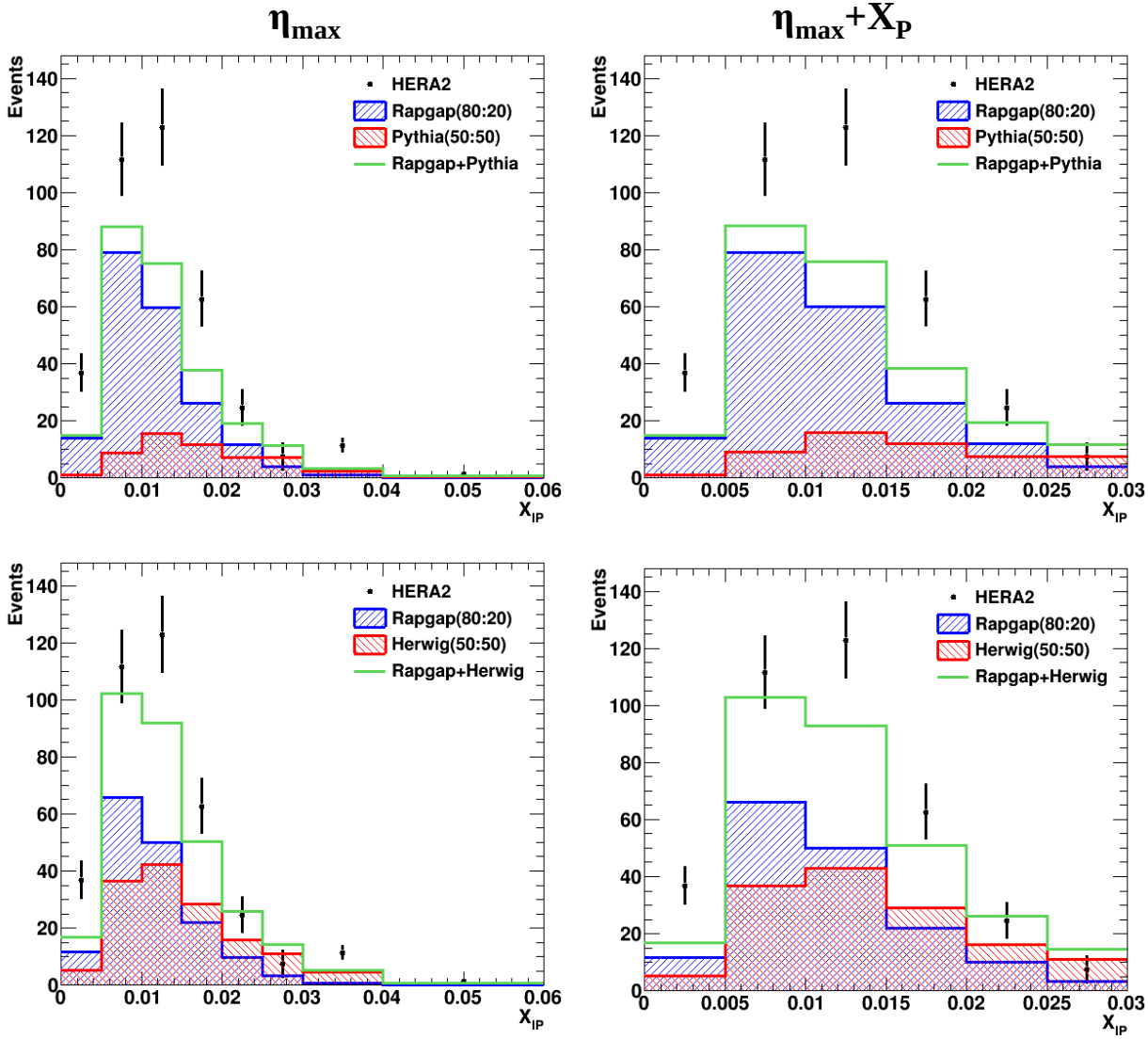
blue – **Rapgap** diff. signal, 80/20 sum, not-reweighted;

red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts

Pythia

Herwig



There are no fits in 2 and 3 column, the scale factor evaluated from column 1 is used instead

HERA2, fits of MCs to the Z_{IP} distribution

γ+jet selection

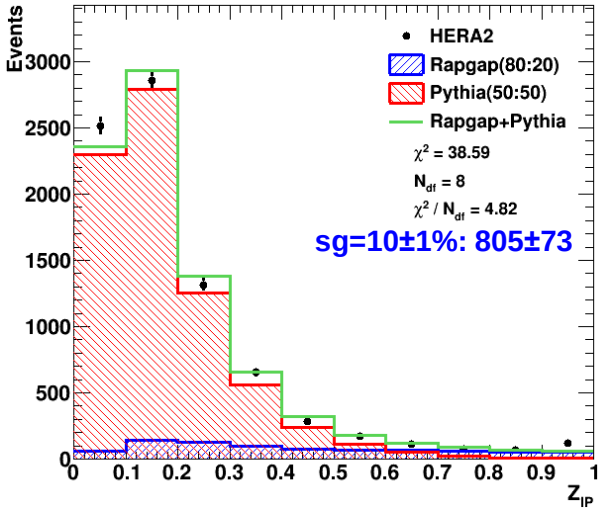
black dots – **data**, fitted photons;

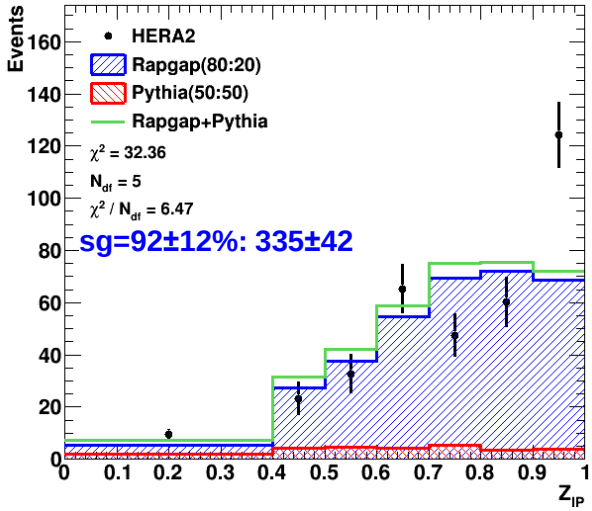
blue – **Rapgap** diff. signal, 80/20 sum, reweighted;

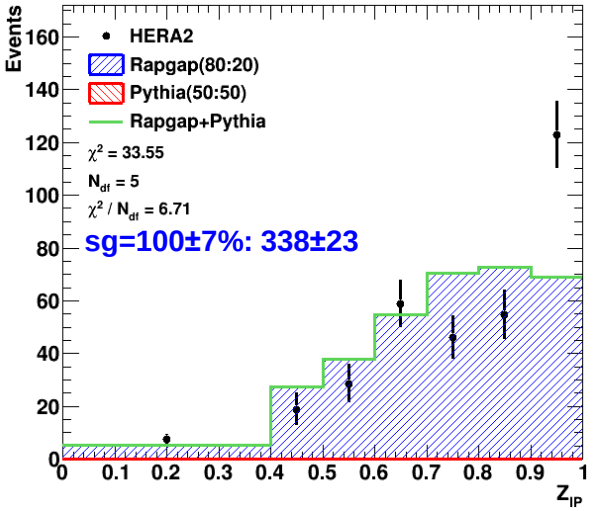
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | η_{max} | $\eta_{max}+X_{IP}$

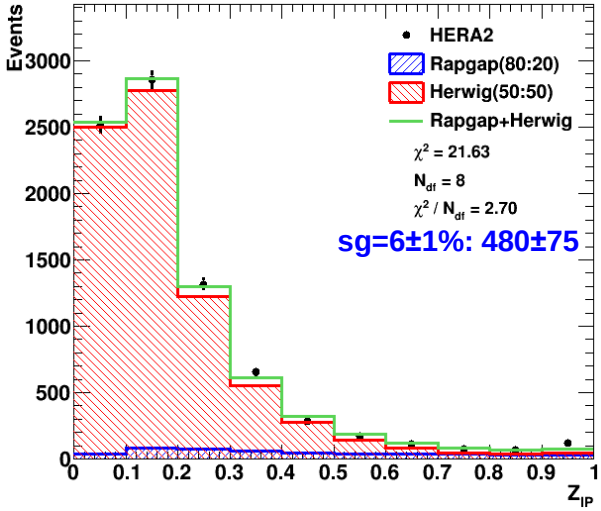
Pythia

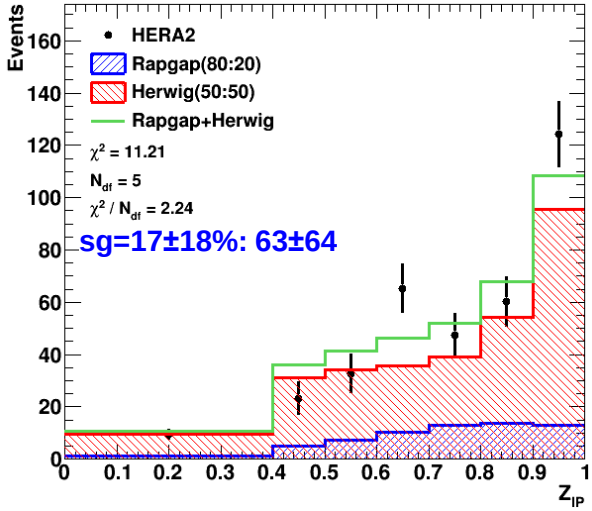


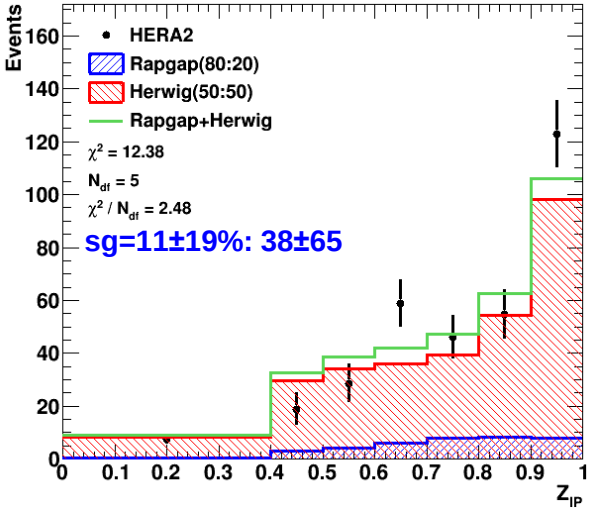




Herwig







Herwig describes the right peak better than Pythia

HERA2, fits of MCs to the Z_{IP} distribution

γ+jet selection

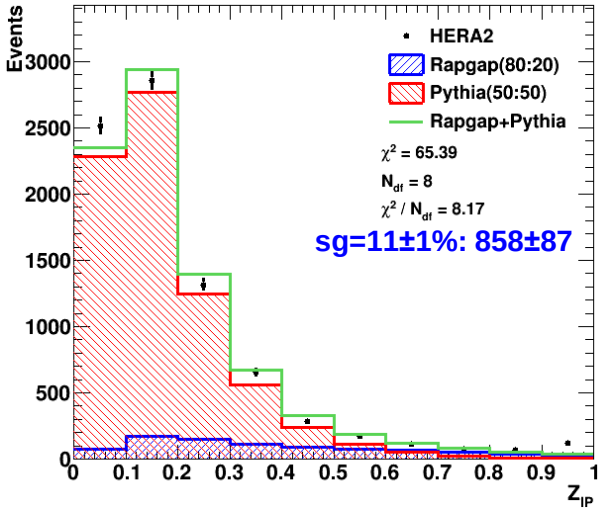
black dots – **data**, fitted photons;

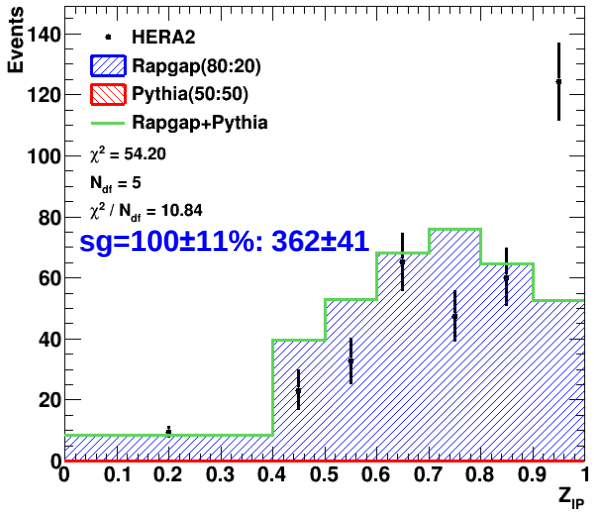
blue – **Rapgap** diff. signal, 80/20 sum, not-reweighted;

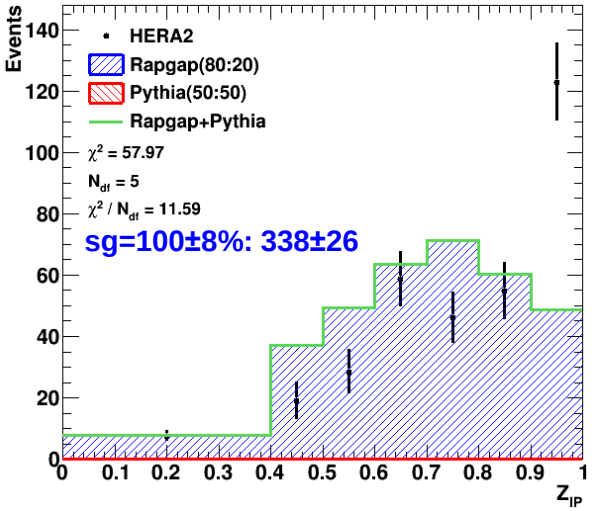
red – **Pythia** (top row), **Herwig** (bottom row) non-diff. signal, 50/50 sum;

no diff cuts | η_{max} | $\eta_{max}+X_{IP}$

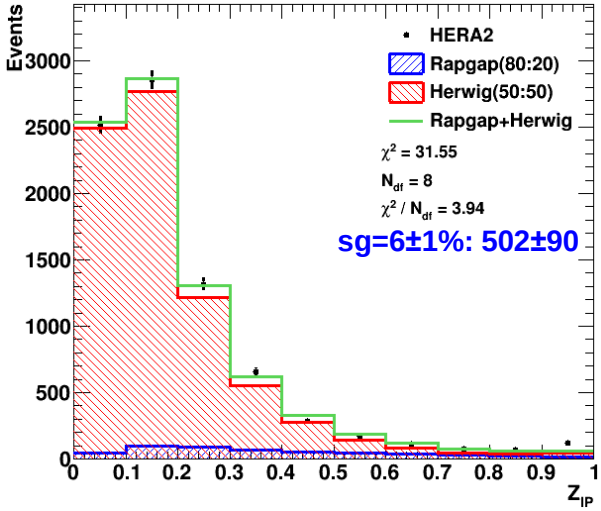
Pythia

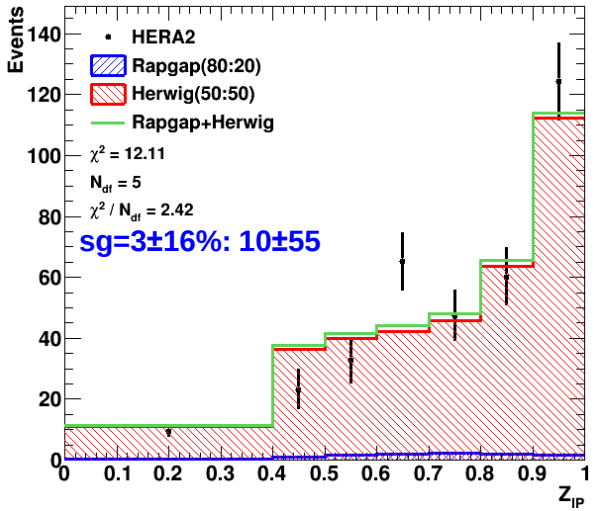


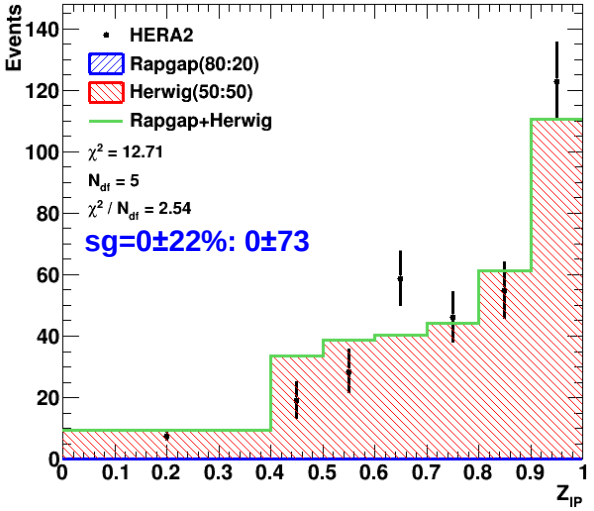




Herwig







RAPGAP does not fit the η_{max} distribution very well, apply reweighting when evaluating the acceptances:

$$w = \begin{cases} 1 - 0.5(\eta_{max} - 1), & w \geq 0.45 \\ 0.45, & w < 0.45 \end{cases}$$