Study of systematic error on acceptance for

$$\mathbf{W} \longrightarrow \mu\,\nu$$

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Systematics

Total cross section measurements are dominated by the sistematic uncertainty, even for modest integrated luminosity. The main cross section uncertainty is related to the acceptance uncertainty, which in turn comes from our limited knowledge of the underlying physics: non-perturbative mechanisms, PDFs, and so on.

My work

- Comparison of acceptances with Leading Order generators, i.e. Herwig and Pythia, and Next to Leading, i.e. MC@NLO, both in Stand Alone mode and in the Athena framework, at generation level
- Study of systematics with MC@NLO for:
  - PDF : CTEQ6.1M error sets
  - Intrinsic P_t of partons
  - ISR

Event generation

- **Stand Alone MCs:**

  HERWIG 6.5.10 (Fortran) and PYTHIA 8.1.05 (C++):

  samples of 100 k events

- **MCs + Athena release 11.0.5**

  samples of 40 k events

  - Acceptances at generation level
  - Standard DC3-job Options:

https://twiki.cern.ch/twiki/bin/view/Atlas/WaSample HERWIG

https://twiki.cern.ch/twiki/bin/view/Atlas/WZPythiaSample PYTHIA

Note: √s > 60 GeV for Z production

The work was done with CTEQ6L PDF, at leading order

Kinematics cuts

Channel	kinematics cuts (allowed region)
$W \to e\nu$	$p_T^e > 20\,\text{GeV}, \quad \not{E}_T = p_T^\nu > 20\,\text{GeV}$
	$\lvert\eta_e\rvert < 1.37 \;\cup\; 1.52 < \lvert\eta_e\rvert < 2.5$
$W \to \mu\nu$	$p_T^\mu > 20\,\text{GeV} \quad \not{E}_T = p_T^\nu > 20\,\text{GeV}$
	$\lvert\eta_\mu\rvert < 2.5$
$Z \to e^+e^-$	$p_T^{e^\pm} > 20\,\text{GeV}$
	$\lvert\eta_{e^\pm}\rvert < 1.37 \;\cup\; 1.52 < \lvert\eta_{e^\pm}\rvert < 2.5$
$Z \to \mu^+\mu^-$	$p_T^{\mu^\pm} > 20\,\text{GeV}$
	$\lvert\eta_{\mu^\pm}\rvert < 2.5$

Geometrical acceptances

Pythia in Athena
These are at reconstruction level!

	Acceptances [%]				
	Stand Alone		Athena		
Channel	Herwig	Pythia	Herwig	Pythia	CSC note
$W \rightarrow e\nu$	43.38	42.18	41.52	42.84	44.3
$W \rightarrow \mu\nu$	46.12	45.29	45.12	46.37	45.4
$Z \rightarrow e^+e^-$	36.23	34.26	33.71	35.22	42.4
$Z \rightarrow \mu^+\mu^-$	40.92	40.06	39.53	40.74	39.9

	Herwig	Pythia	
$W \rightarrow e\nu$	**34.27**	**34.51**	**Marc Goulette**
$p_T > 25$ GeV: both $\|\eta\| < 2.5$+cracks only for *e*	34.40	34.12	M. Venturi
$Z \rightarrow ee$	**45.27**	**46.20**	**Marc Goulette**
$p_T > 20$ GeV: both $\|\eta\| < 2.5$+cracks: both $\sqrt{s} > 60$ GeV	33.71	35.22	M. Venturi
	-	*35,95*	*Ellie Dobson*

Acceptance systematics for $W \longrightarrow \mu\nu$

MC@NLO 3.3

with PDF version CTEQ6.1 M

Home produced samples of 50 k events, both in Stand Alone mode, and in Athena release 11.0.5, at <u>generation level</u>

Standard cuts:
$P_t > 20$ GeV for both, $|\eta|<2,5$ for μ

PDF error sets: a brief introduction

There are formidable difficulties when standard statistical methods are applied to global QCD analysis:

1. Large body of data from many different experiments to fit (~ 1800 data points from 15 experiments for CTEQ)
2. The theoretical model has its own uncertainties
3. Correlance in uncertainties?

Solution: the **Hessian method**:

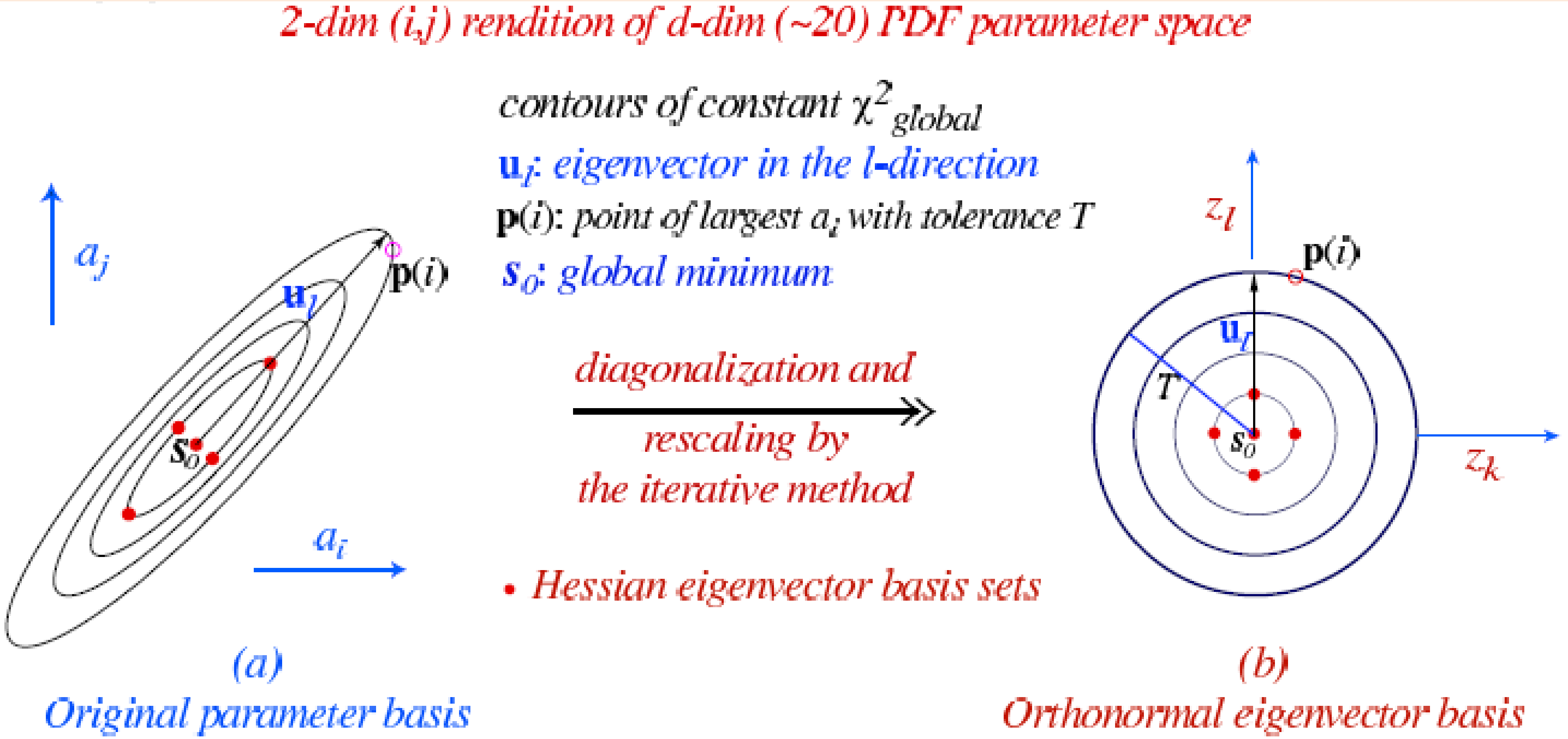
the 20x20 Hessian matrix is iteratively diagonalized, resulting in 20 eigenvalues and 20 orthonormal eigenvectors.

N_p =20 is the number of free parameters for QCD analysis, with whom we can encapsulate the behavior of the global χ^2 function in the neighborhood of the minimum

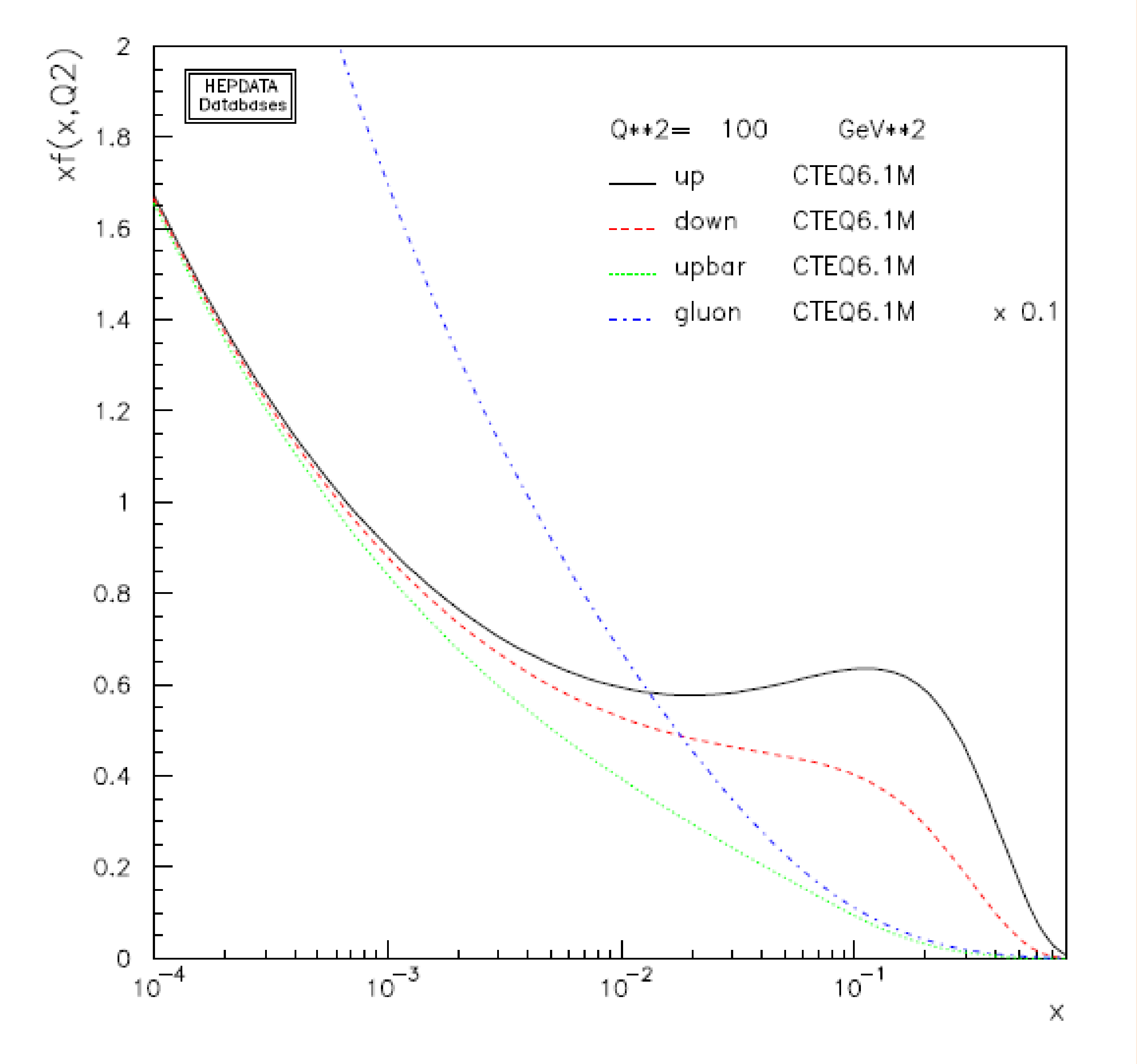
$$x\, f(Q_0,x) = A_0\, x^{A_1} (1-x)^{A_2}\, e^{A_3 x}\, (1+A_4 x)^{A_5}$$

hep-ph/0201195v3, Pumplin et al.

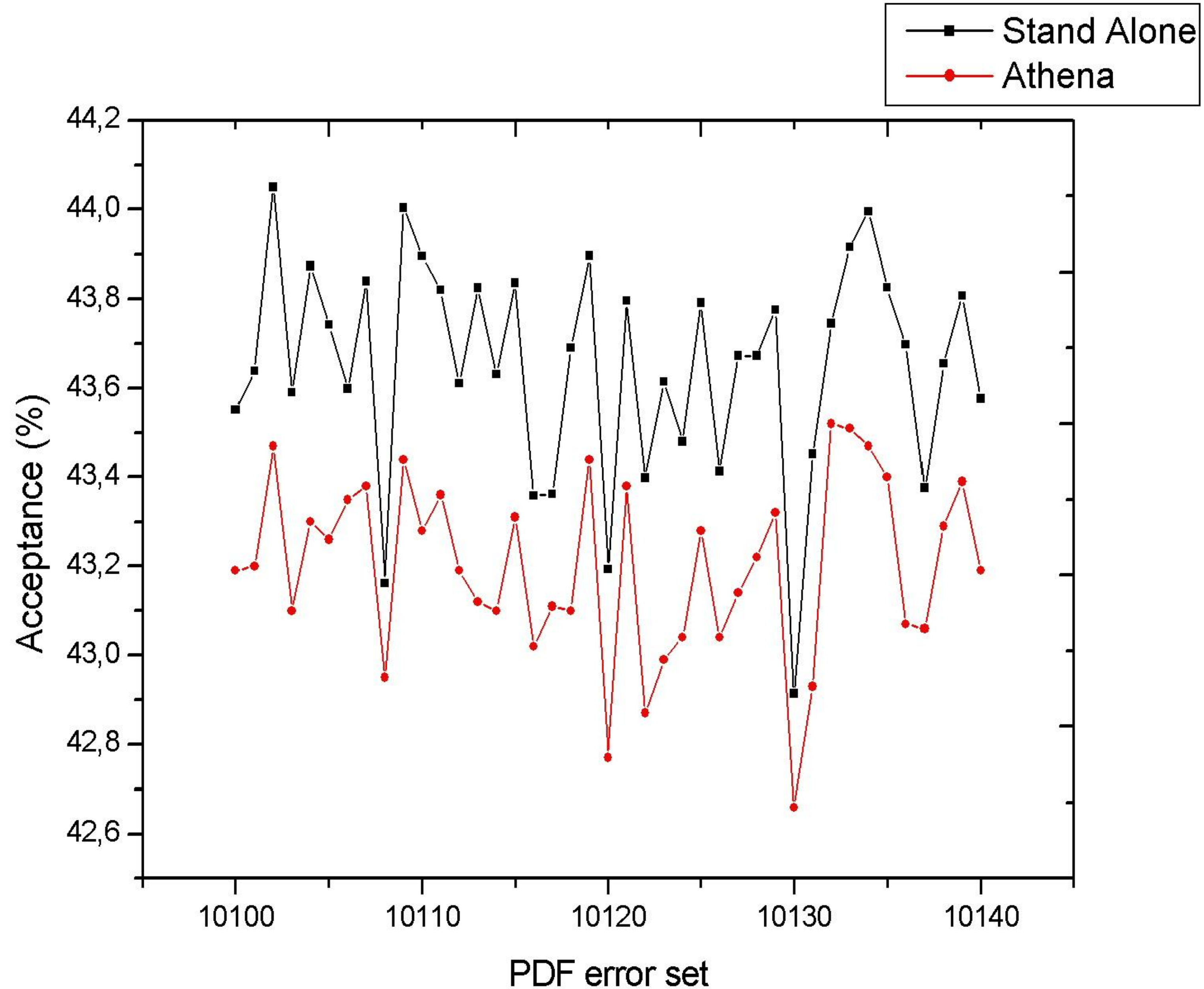
The result is <u>2Np+1 PDF sets</u>: the best fit S_0 + $2N_p$ error sets (along the plus and the minus direction)



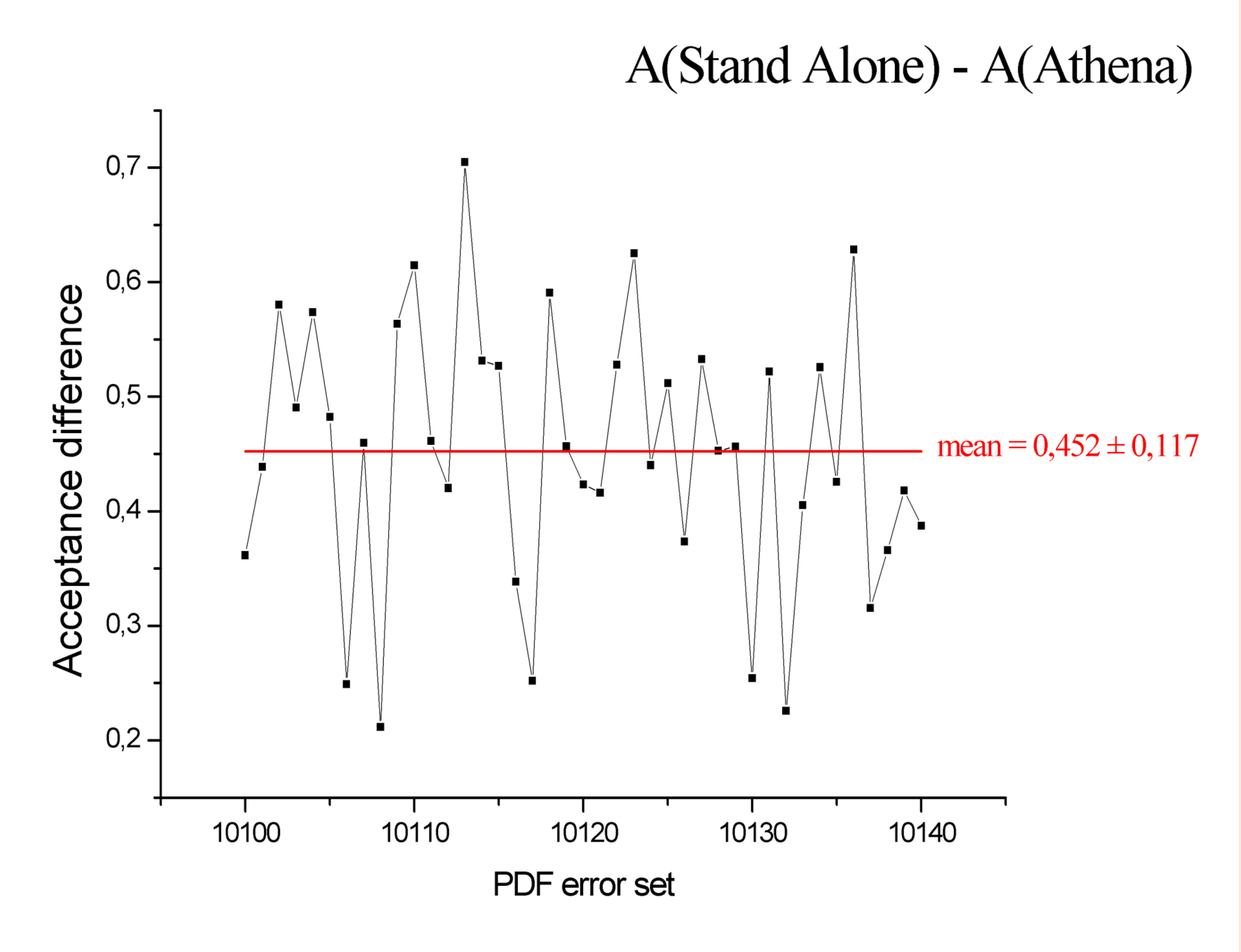
CTEQ 6.1 distributions



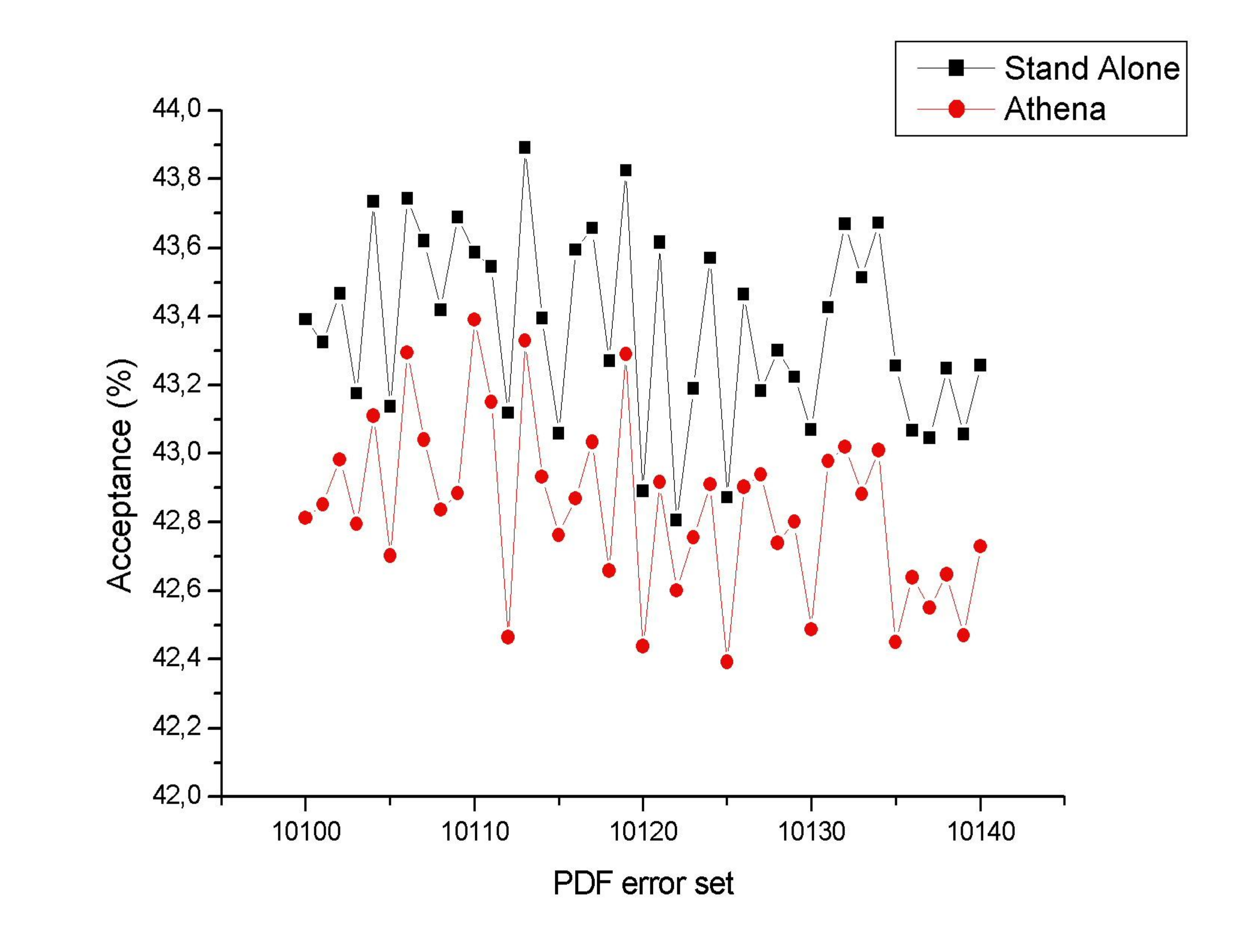
$W^+ \longrightarrow \mu^+\nu$



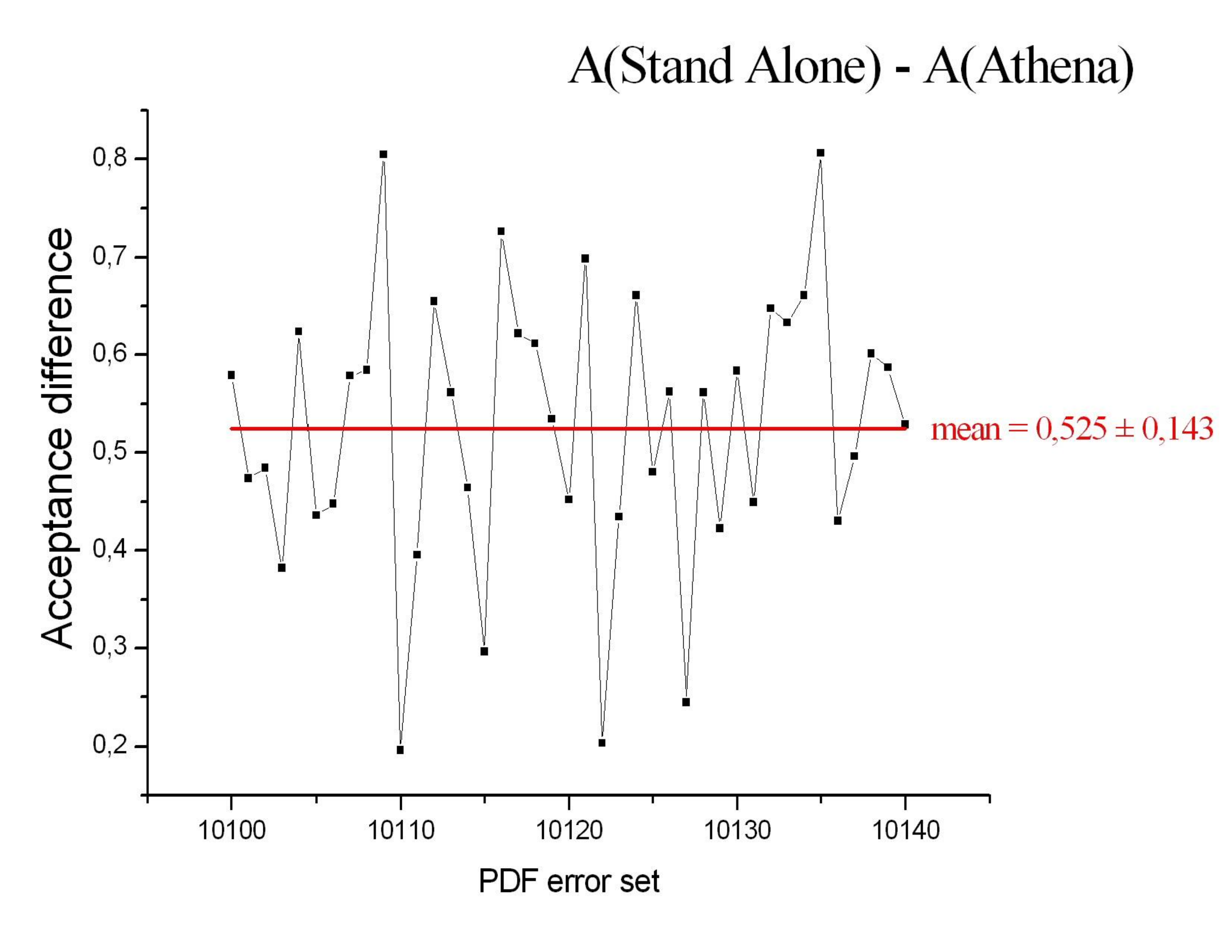
$W^+ \longrightarrow \mu^+\nu$



$W^- \longrightarrow \mu^- \nu$



$W^- \longrightarrow \mu^- \nu$



$$\Delta X^{+}_{max} = \sqrt{\sum_{i=1}^{N}[max(X_i^{+} - X_0, X_i^{-} - X_0, 0)]^2}$$

$$\Delta X^{-}_{max} = \sqrt{\sum_{i=1}^{N}[max(X_0 - X_i^{+}, X_0 - X_i^{-}, 0)]^2}$$

	W^+	W^-
Stand Alone	$43,55^{+1,27}_{-0,92}$	$43,39^{+1,10}_{-1,31}$
Athena	$43,19^{+0,80}_{-0,91}$	$42,81^{+1,23}_{-0,98}$

Marc Goulette's result with ResBos MonteCarlo:

W^+: +0,68, - 0,84

W^-: +0,89, - 0,90

Intrinsic P_t of partons

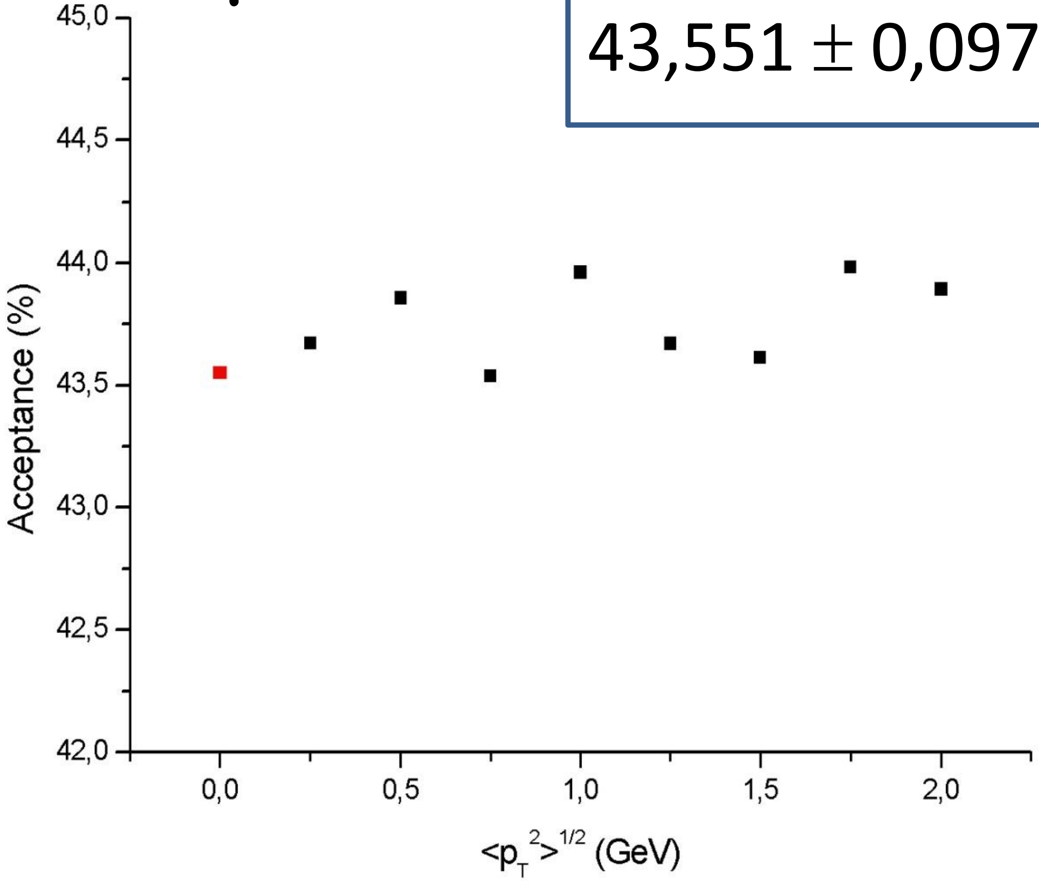
At LO, we expect the colliding partons to be exactly collinear with the colliding beams : W produced with $P_t=0$

But:

1. Partonic intrinsic (non-perturbative) P_t due to Fermi motion, $\langle P_t \rangle \sim \Lambda_{QCD}$
2. Perturbative emission of hard partons : hard, power-law tail in vector boson P_t distribution

So, what about correlations between ISR and intrinsic P_t ?

$W^+ \longrightarrow \mu^+\nu$



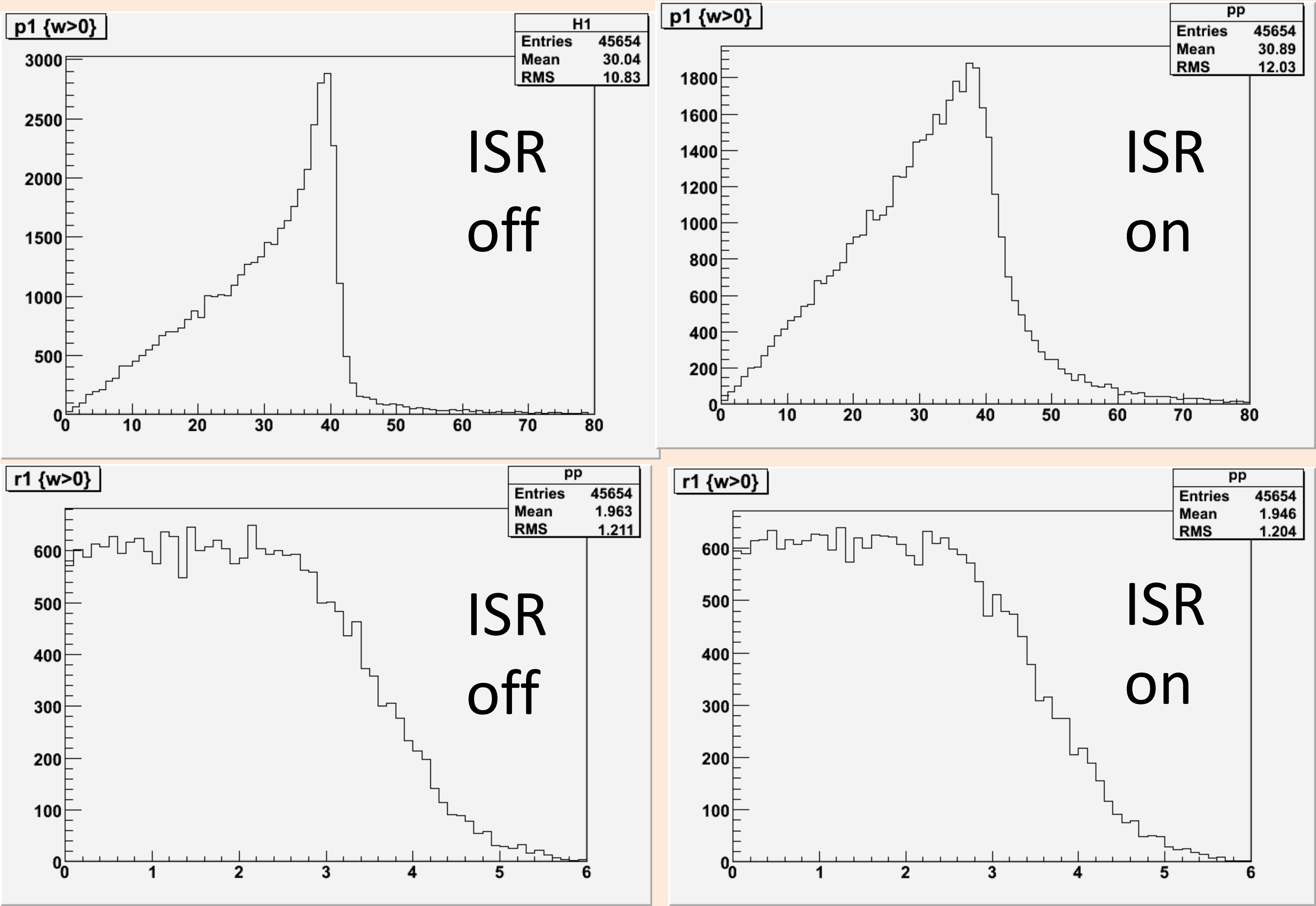
$43{,}551 \pm 0{,}097$

$\sqrt{\langle P_t^2 \rangle}$ GeV	Acceptance Stand Alone (%)
0	43,551
0,25	43,672
0,5	43,858
0,75	43,538
1	43,963
1,25	43,672
1,5	43,613
1,75	43,893
2	43,839

Just fluctuactions! Indeed our physical value (acceptance) should not depend on such a non-perturbative quantity!

Marc Goulette's result: 0,41 % (P_t on)

Muon P_t and pseudorapidity in Stand Alone mode



$W^+ \longrightarrow \mu^+\nu$

	ISR on	ISR off	off-on
Stand Alone	43,551	46,559	3,008
Athena	43,190	43,195	0,005

Marc Goulette's result: 0,11 %

Work to be done next

- EW corrections (Photos), UE on/off, ME on/off
- Tony Weidberg (Oxford): what about merging muons and photons in Athena, for $\Delta R<\Delta R_{MAX}$?
  - Study the sensitivity to ΔR_{MAX}
  - Study the sensitivity in imposing a cut on photon P_t
- Osamu Jinnouchi (Cern): validation of MRST2007lomod.LHgrid, modified Leading Order, with Herwig and Pythia, for W and Z acceptances