W,Z analysis items and tools

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on behalf of

Pavia, Roma1, Roma2, Roma3 groups

ATLAS Analysis Italia

Frascati

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INFN

Istituto Nazionale
di Fisica Nucleare

ATLAS Experiment

Outline

First Part on Physics

- Acceptance
  - ★ studies from MC generator comparisons
- Efficiency
  - ★ measurement from data
- Momentum scale
  - ★ analysis from data with Z decay

Second Part on Tools (EWPA)

- Analysis tools
  - ★ Overview of EWPA framework

Cross section measurements

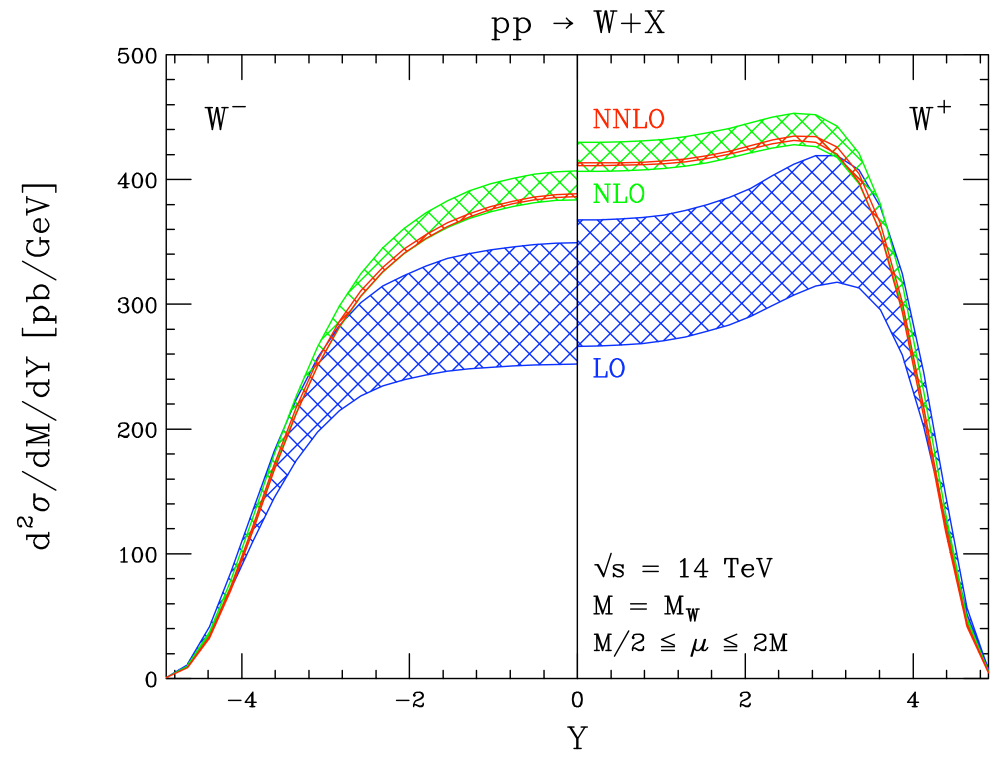
- Starting from the well-known formula

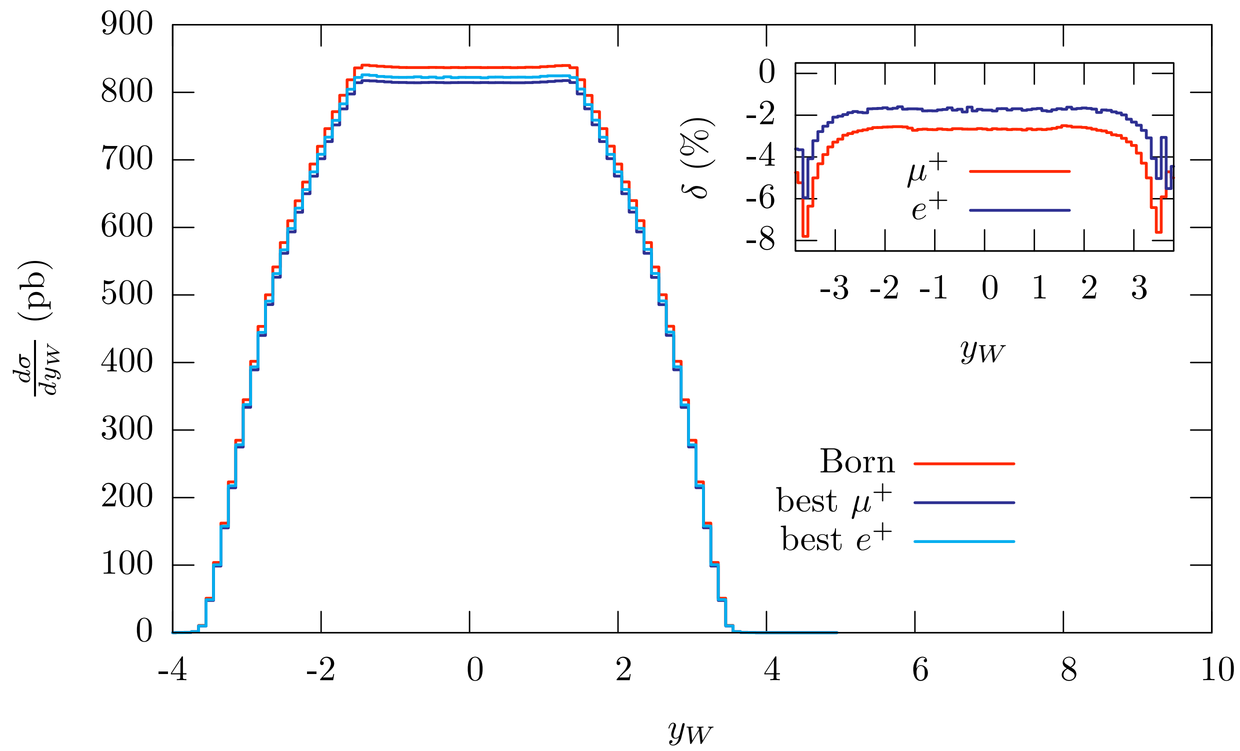
$$\sigma_{V\to ll} = \frac{(N_{obs} - N_{bgk})}{\int \mathcal{L}dt \cdot A \cdot \epsilon}$$

- In this talk focus on:
  - ★ Acceptance measured from MC and defined as (as example)
    - $W\to\mu\nu$: fraction of events with at least 1μ with $p_T > 20$ GeV & $|\eta| < 2.4$
    - $Z\to\mu\mu$: fraction of events with at least 2μ with $p_T > 20$ GeV & $|\eta| < 2.4$
  - ★ Efficiencies measured from data
    - $Z\to\mu\mu$: calculated from data using Tag&Probe method
    - $W\to\mu\nu$: use $\varepsilon(p_T,\eta,\varphi)$ calculated from Z events
  - ★ Analysis of muon momentum scale

Acceptance (PV)

- Theoretical uncertainties coming from
  - ★ NLO corrections (QCD and EW)





Acceptance

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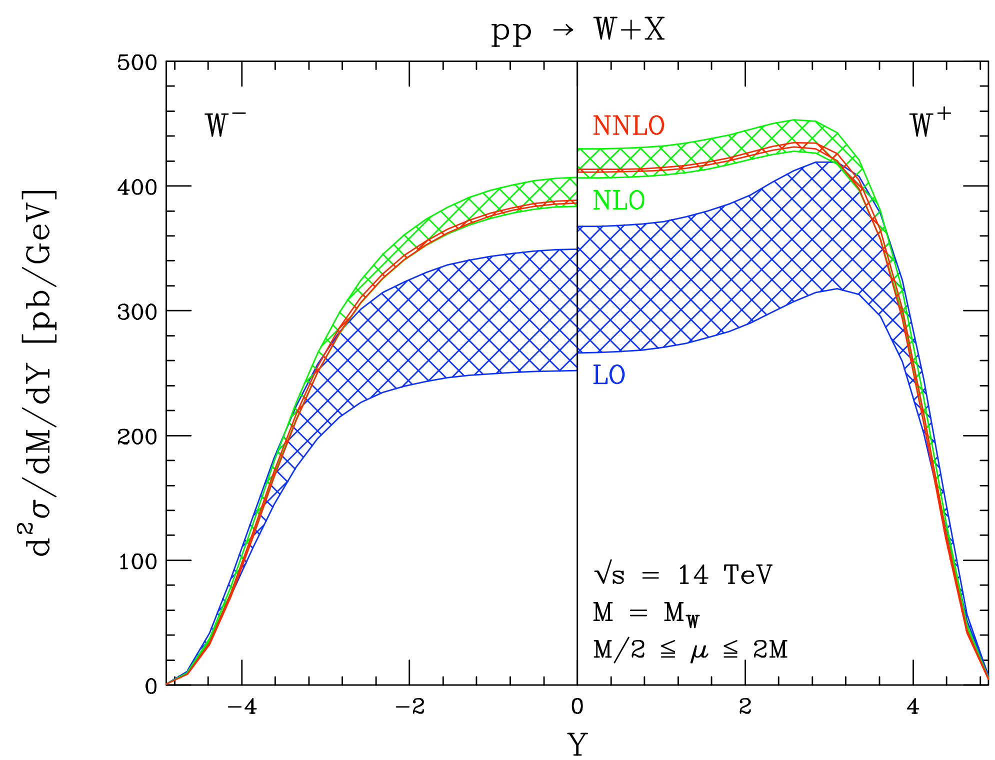
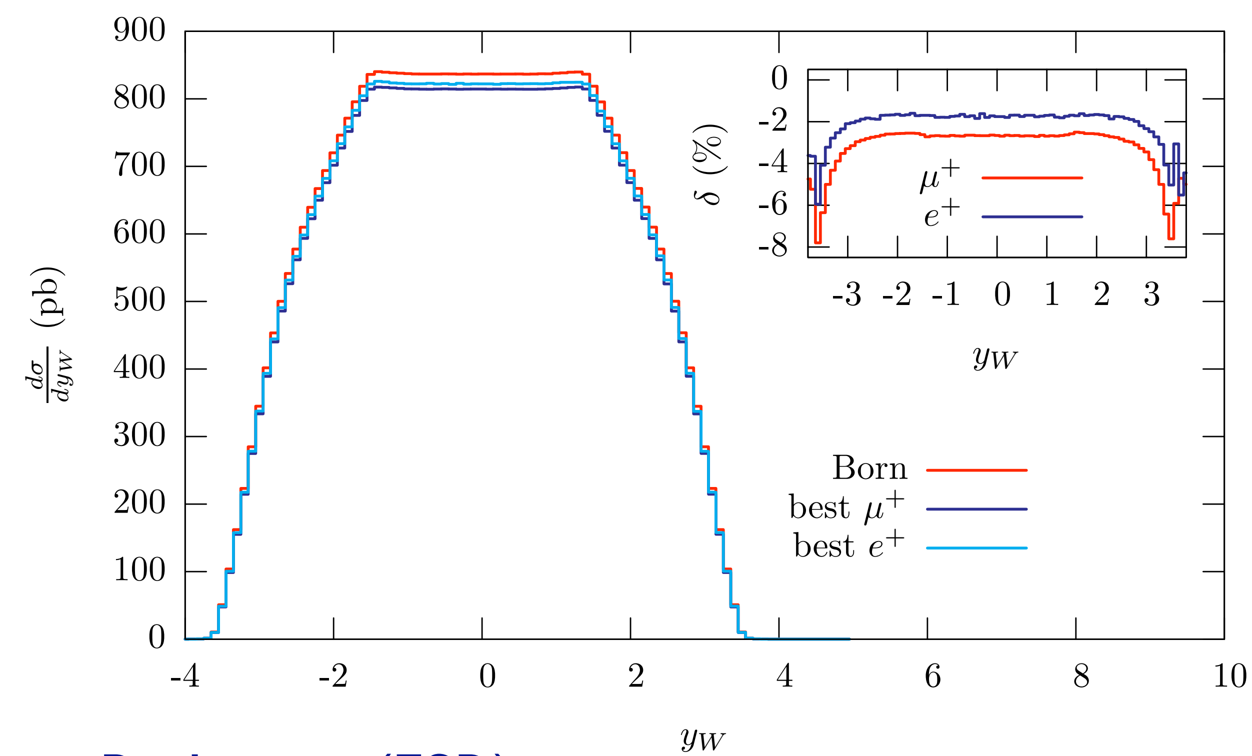




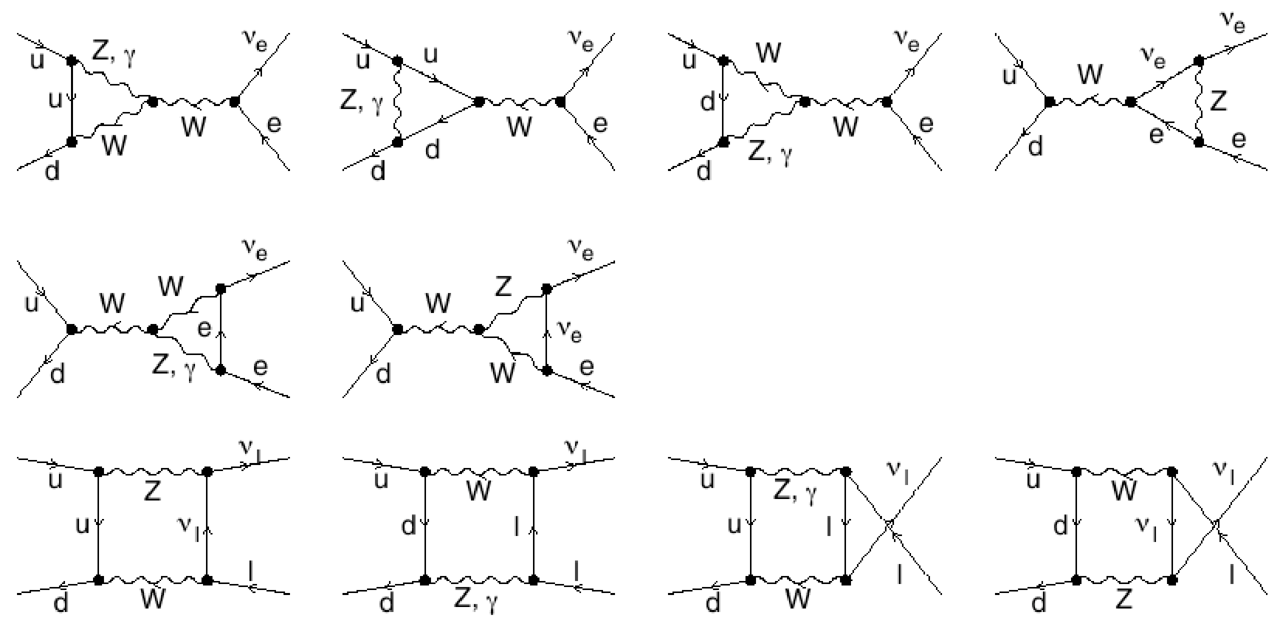
  - ★ Initial State Radiation (ISR) and Final State Radiation (FSR)
  - ★ Intrinsic k_T of the incoming partons (k_T)
  - ★ Underlying Event (UE)
  - ★ Matrix element corrections (ME)
  - ★ Parton Density Functions (PDF)

taken from CSC note
"Electroweak boson cross-section measurments with ATLAS"

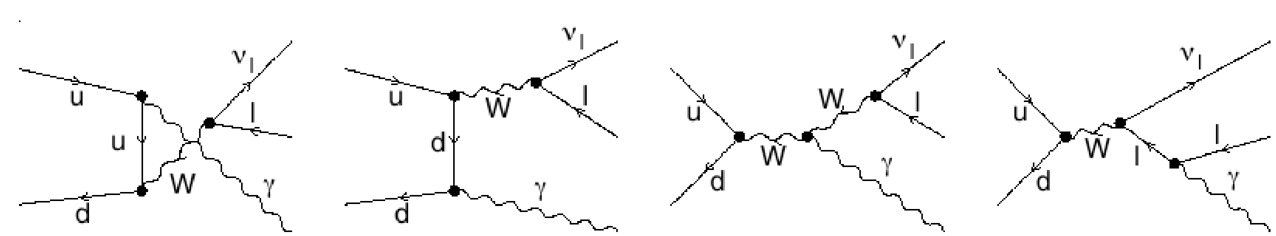
HORACE[1] generator

- HORACE (Higher Order RAdiative CorrEctions) is a Monte Carlo generator for single W/Z boson production at hadron colliders. It simulates:
  - ★ complete O(α) EW corrections and QED radiations beyond O(α) corrections

- Complete O(α) EW corrections
  - ★ vitual one-loop corrections
    ⇒ electroweak Sudakov logs



  - ★ real bremsstrahlung corrections
    ⇒ collinear singularities



[1] Carloni Calame, Montagna, Nicrosini, Treccani, Vicini - http://www.pv.infn.it/~hepcomplex/horace.html

HORACE[1] generator

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  - ★ complete O(α) EW corrections and QED radiations beyond O(α) corrections
- QED radiations beyond O(α) corrections
  - ★ to simulate the mechanism of multi-photon emission the QED Parton Shower approach is used to exactly solve the QED DGLAP equations for the lepton Structure Function $D(Q^2,x)$

$$Q^2 \frac{\partial}{\partial Q^2} D(x, Q^2) = \frac{\alpha}{2\pi} \int_x^1 \frac{dy}{y} P_+(y) D(\frac{x}{y}, Q^2)$$

$$P_+(x) = \frac{1+x^2}{1-x^2} - \delta(1-x) \int_x^1 dt P(t)$$

  - ★ the $D(Q^2,x)$ accounts for universal virtual and real photon emissions, in collinear approximation, up to all order in p_T
    - allows for exclusive photon generations , a “full” radiation event simulation can be done
  - ★ QED PS matched with NLO EW (to avoid double counting)
  - ★ See here for Horace ATLAS Interface

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NLO effects

- Effects for NLO QCD, QED and EW corrections have been evaluated comparing
  - ★ Herwig LO vs Horace LO born tuning (born tuning)
  - ★ Herwig+Photos vs Horace QED (NLO QED)
  - ★ Herwig LO vs MC@NLO (NLO QCD)
  - ★ Horace QED vs Horace EW (NLO EW)

- Athena 11.5.0 - EW corrections are evaluated in the G_μ scheme
  - ★ here are the generators main parameters

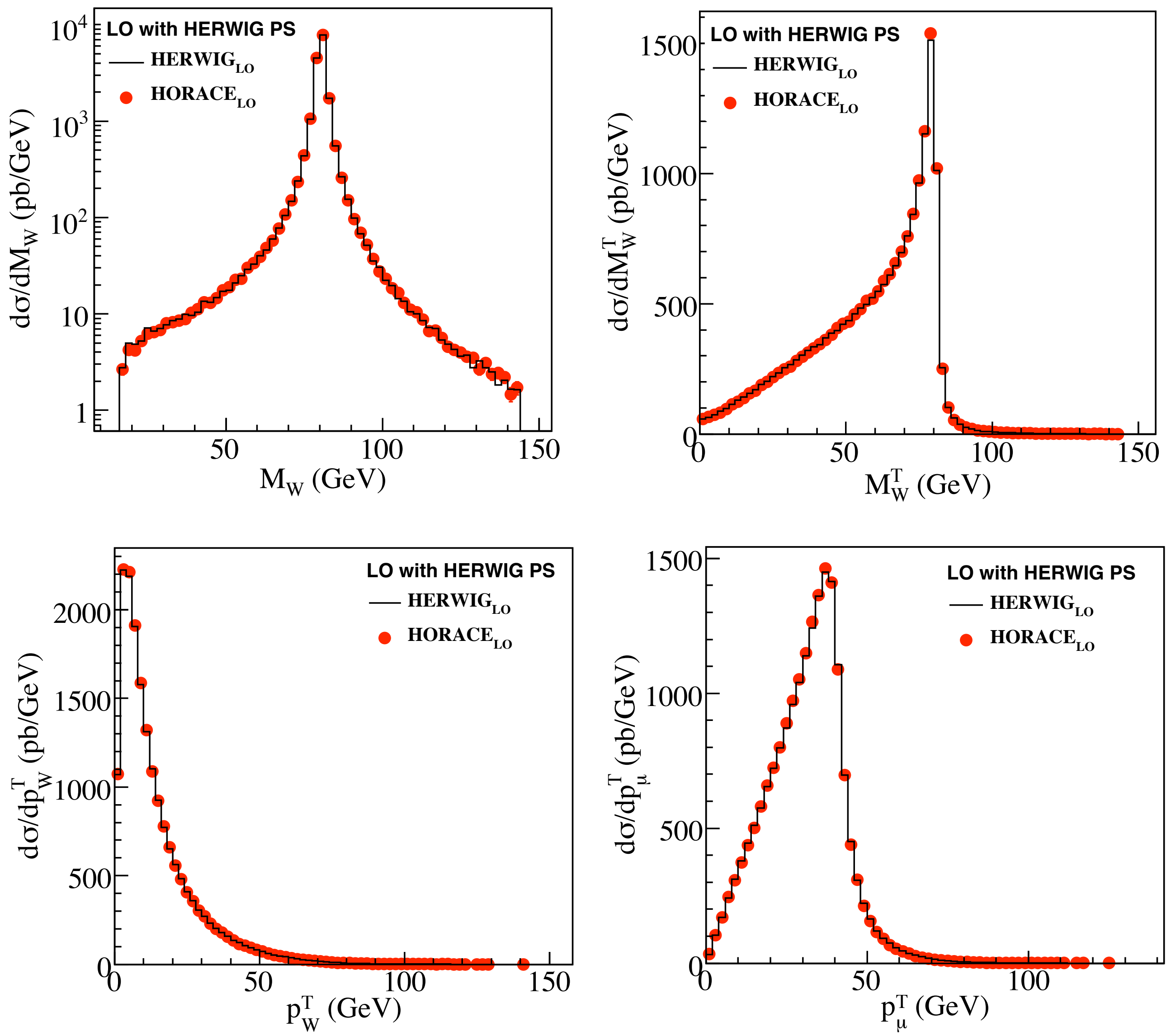
$\alpha = 0.0072993$	$\alpha_s(M_Z) = 0.118$	$sin^2\theta_W = 0.2319$
$\Lambda_{QCD} = 0.18$ GeV	$m_Z = 91.19$ GeV	$m_W = 80.425$ GeV
$\Gamma_Z = 2.495$ GeV	$\Gamma_W = 2.124$ GeV	$m_H = 115$ GeV
$m_e = 510.99892$ KeV	$m_\mu = 105.658369$ MeV	$m_\tau = 1.77699$ GeV
$m_u = 320$ MeV	$m_c = 1.55$ GeV	$m_t = 174.3$ GeV
$m_d = 320$ MeV	$m_s = 500$ MeV	$m_b = 4.95$ MeV
$V_{ud}^2 = 0.9512$	$V_{us}^2 = 0.0488$	$V_{ub}^2 = 0$
$V_{cd}^2 = 0.0488$	$V_{cs}^2 = 0.9492$	$V_{cb}^2 = 0.002$
$V_{td}^2 = 0$	$V_{ts}^2 = 0.002$	$V_{tb}^2 = 0.998$

Explanation	name	value
HERWIG - JIMMY		
Multiparton interaction	msflag	1
version	jmueo	1
p_T^{min} of secondary scatters	ptjim	3.85 GeV
Inverse proton radius squared	jmrad(73)	1.8
minimum lifetime for particle to be set stable (K_0 and Λ)	pltcut	3.33 ps
p_T^{min} in hadronic jet production	ptmin	10. GeV
PHOTOS		
Enable radiation of photons for leptons and hadrons	pmode	1
Infrared cutoff for photon radiation	xphcut	0.01
α value used (-1 $\Rightarrow \alpha = 0.00729735039$)	alpha	-1
Photon interference weight switch	interf	1
Double bremsstrahlung switch	isec	1
Higher bremsstrahlung switch	itre	1
Exponential bremsstrahlung switch	iexp	1
Switch for $gg(qq) \to t\bar{t}$ process radiation	iftop	0

NLO effects: born tuning

- Born level tuning
  - ★ before make comparisons of QED radiation effects a born tuning has been done at 0.2% level

Generator	σ_{LO}^{W} (pb)
HERWIG_{LO}	17931.86 ± 6.49
HORACE_{LO}	17935.85 ± 4.97
δ = HO-HE/HO	$(2.2 \pm 4.6)\times10^{-4}$



- Acceptances have been studied as

$$A_W(\eta_\mu(max)) = \frac{1}{\sigma_{tot}} \int_0^{\eta_\mu(max)} d|\eta_\mu| \frac{d\sigma}{d|\eta_\mu|}$$

$$A_W(p_\mu^T(min)) = \frac{1}{\sigma_{tot}} \int_{p_\mu^T(min)}^{\sqrt{s}/2} dp_\mu^T \frac{d\sigma}{dp_\mu^T}$$

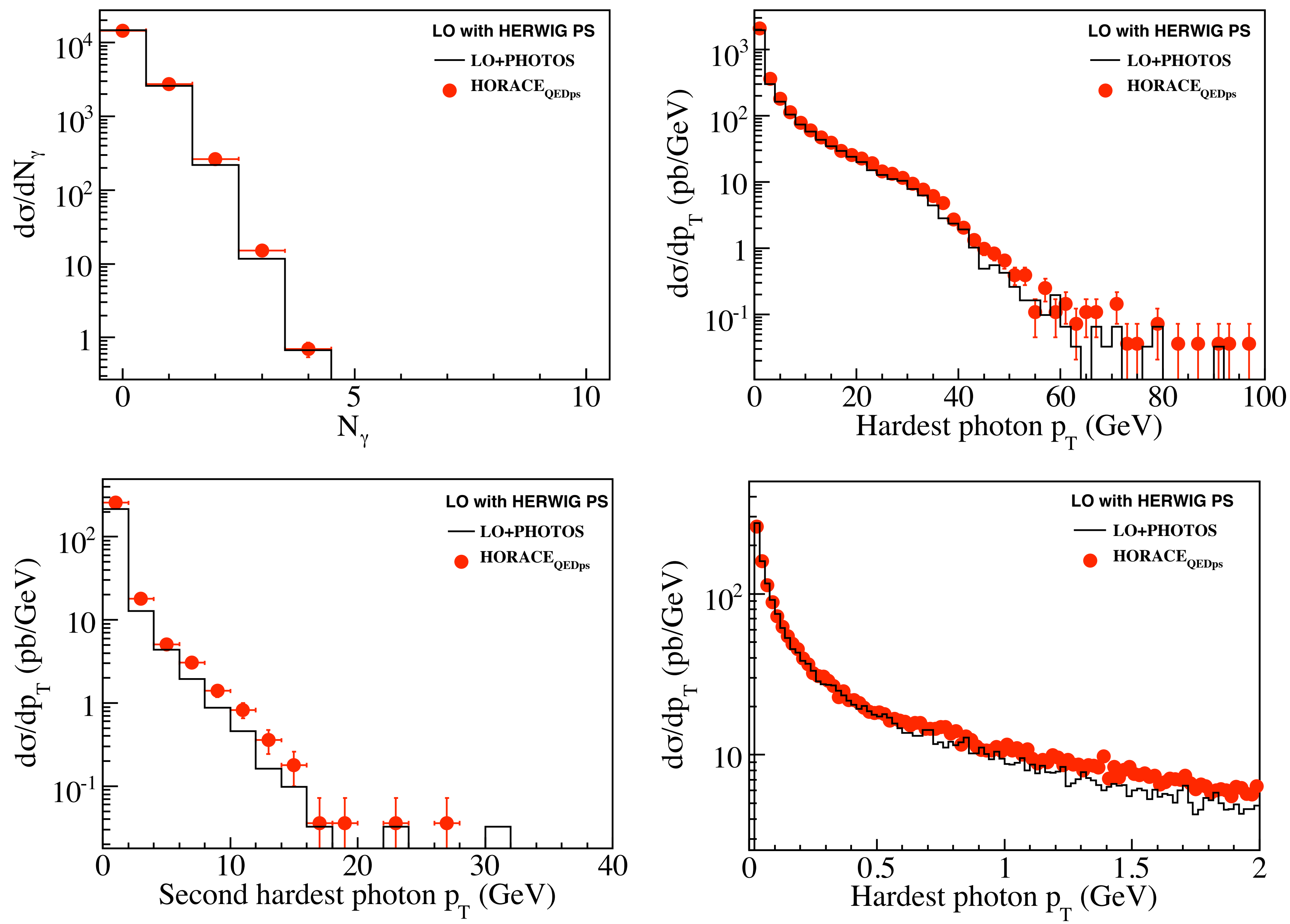
and looking at differences

$$\Delta A_W = A_W^{HORACE_{LO}} - A_W^{HERWIG_{LO}}$$

NLO effects: QED

- QED radiation as described in Herwig+Photos vs Horace_QED

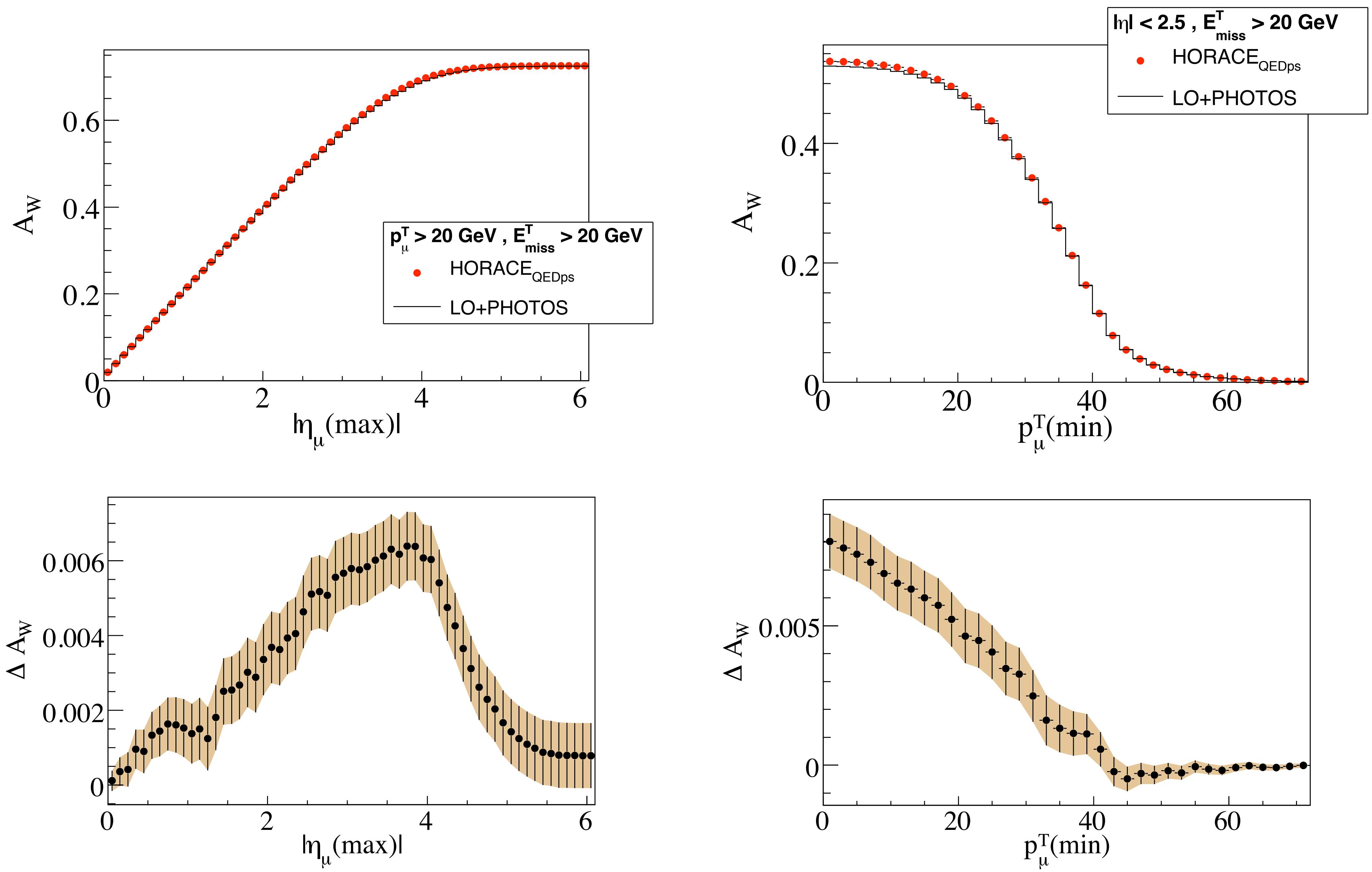
Generator	σ^{W}_{LO} (pb)
LO+PHOTOS	17927.42 ± 6.44
HORACE$_{QEDps}$	17918.66 ± 4.93
δ = HO-PHOT/HO	$(-4.9 \pm 4.5)\times 10^{-4}$



NLO effects: QED

- QED radiation as described in Herwig+Photos vs Horace_QED
  - ★ acceptances agree within 1%

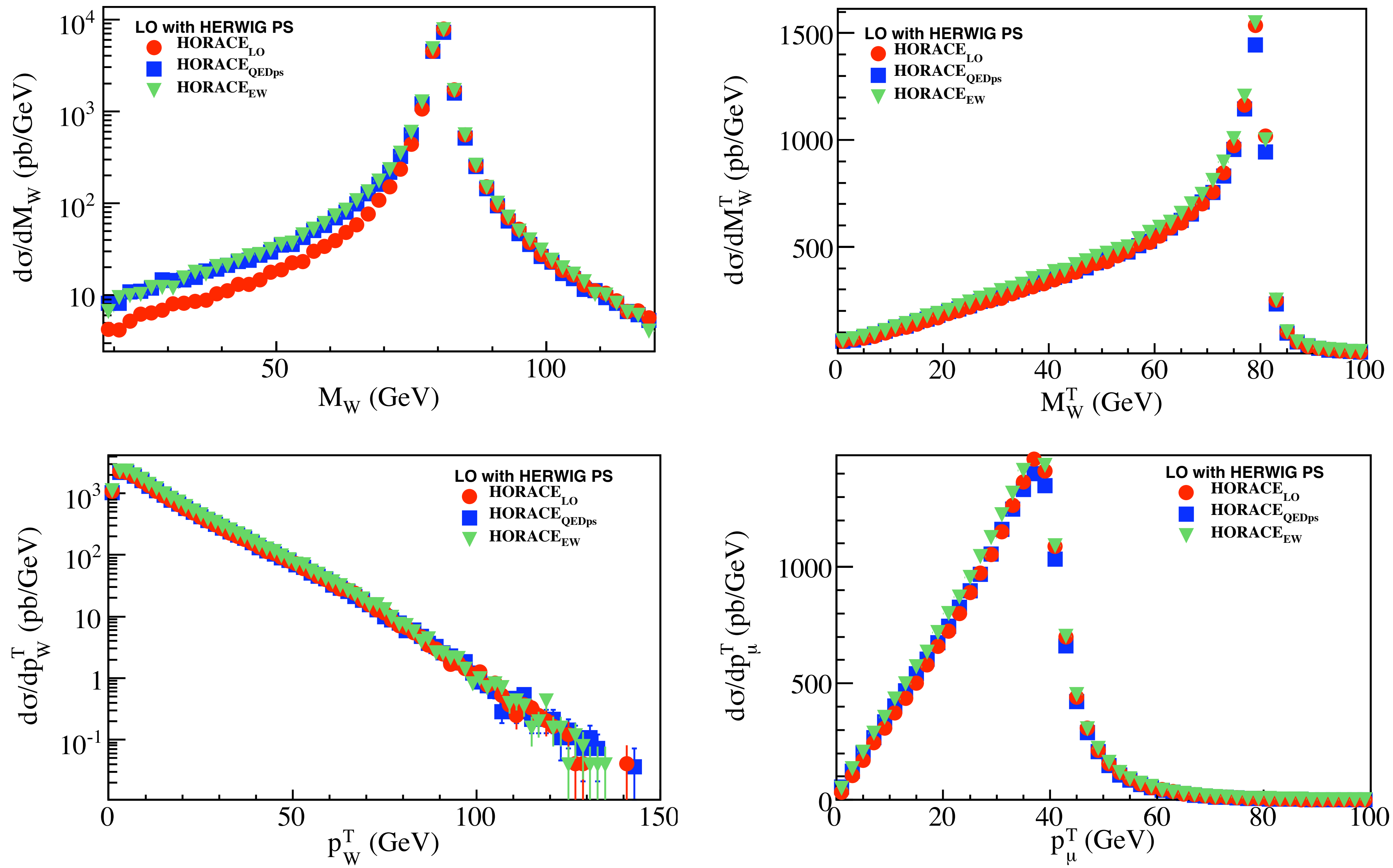
Generator	σ_{LO}^{W} (pb)
LO+PHOTOS	17927.42 ± 6.44
HORACE$_{QEDps}$	17918.66 ± 4.93
δ = HO-PHOT/HO	$(-4.9 \pm 4.5)\times 10^{-4}$



NLO effects: EW

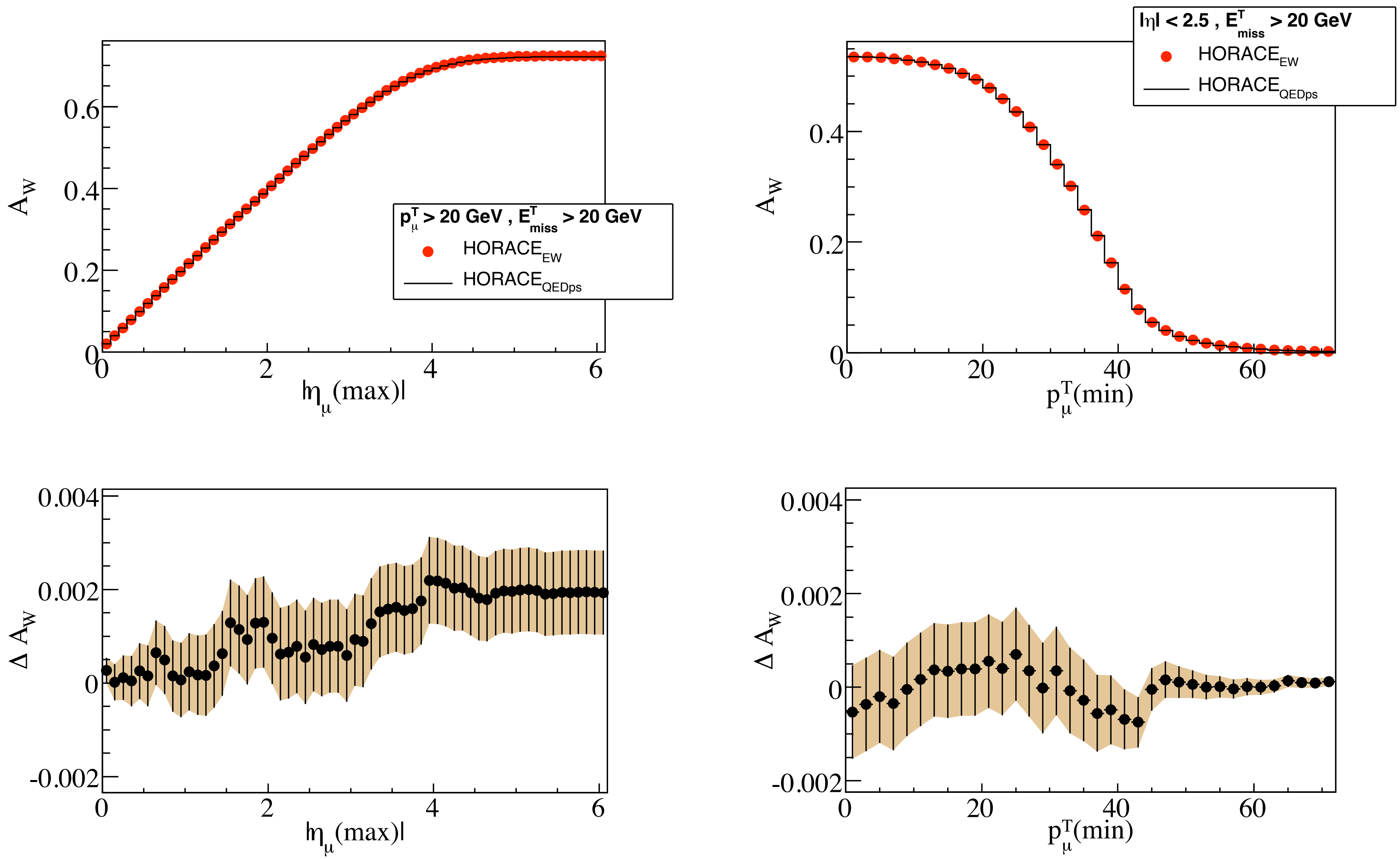
- Analysis of the EW NLO corrections
  - ★ comparisons to Horace_QED

Generator	σ_{LO}^{W} (pb)
HORACE$_{LO}$	17686.24 ± 1.51
HORACE$_{QEDps}$	17700.95 ± 1.51
HORACE$_{EW}$	17414.58 ± 1.98
δ = EW-LO/LO	-0.0156 ± 0.0001
δ = EW-QEDps/QEDps	-0.0164 ± 0.0001



NLO effects: EW

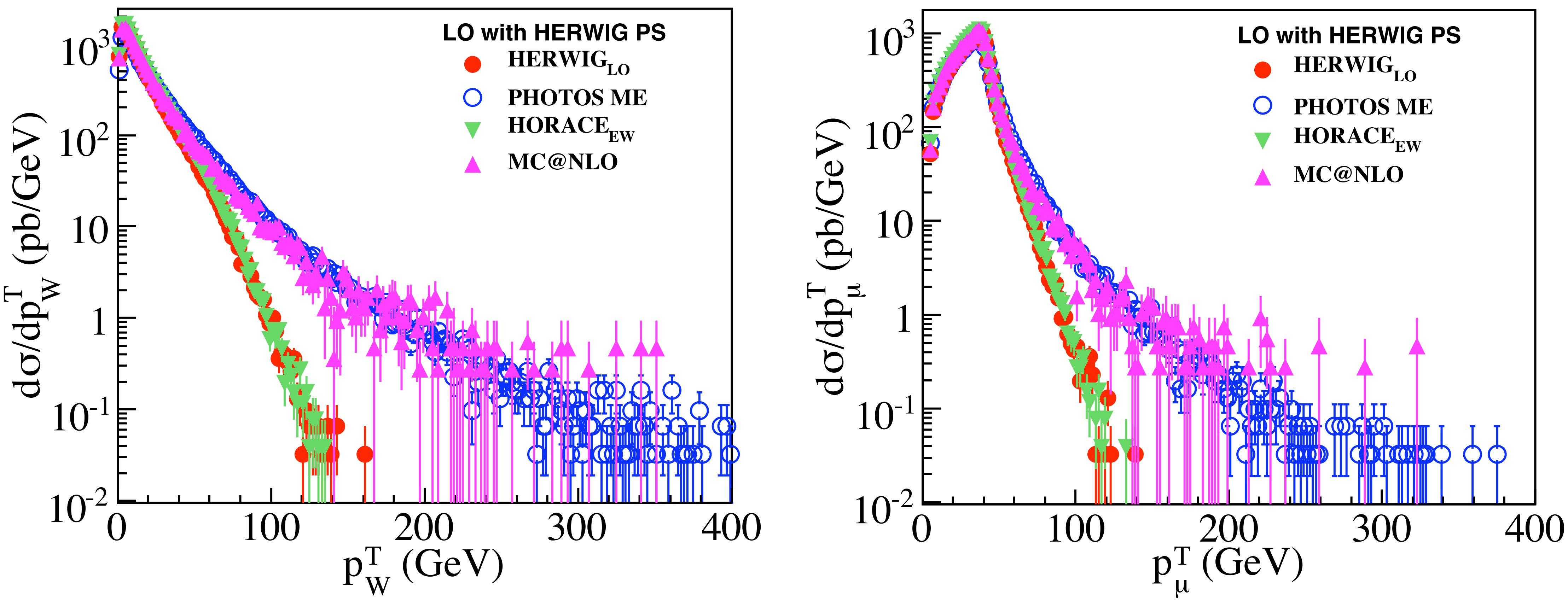
- Analysis of the EW NLO corrections
  - ★ effects < 0.2%



NLO effects: QCD

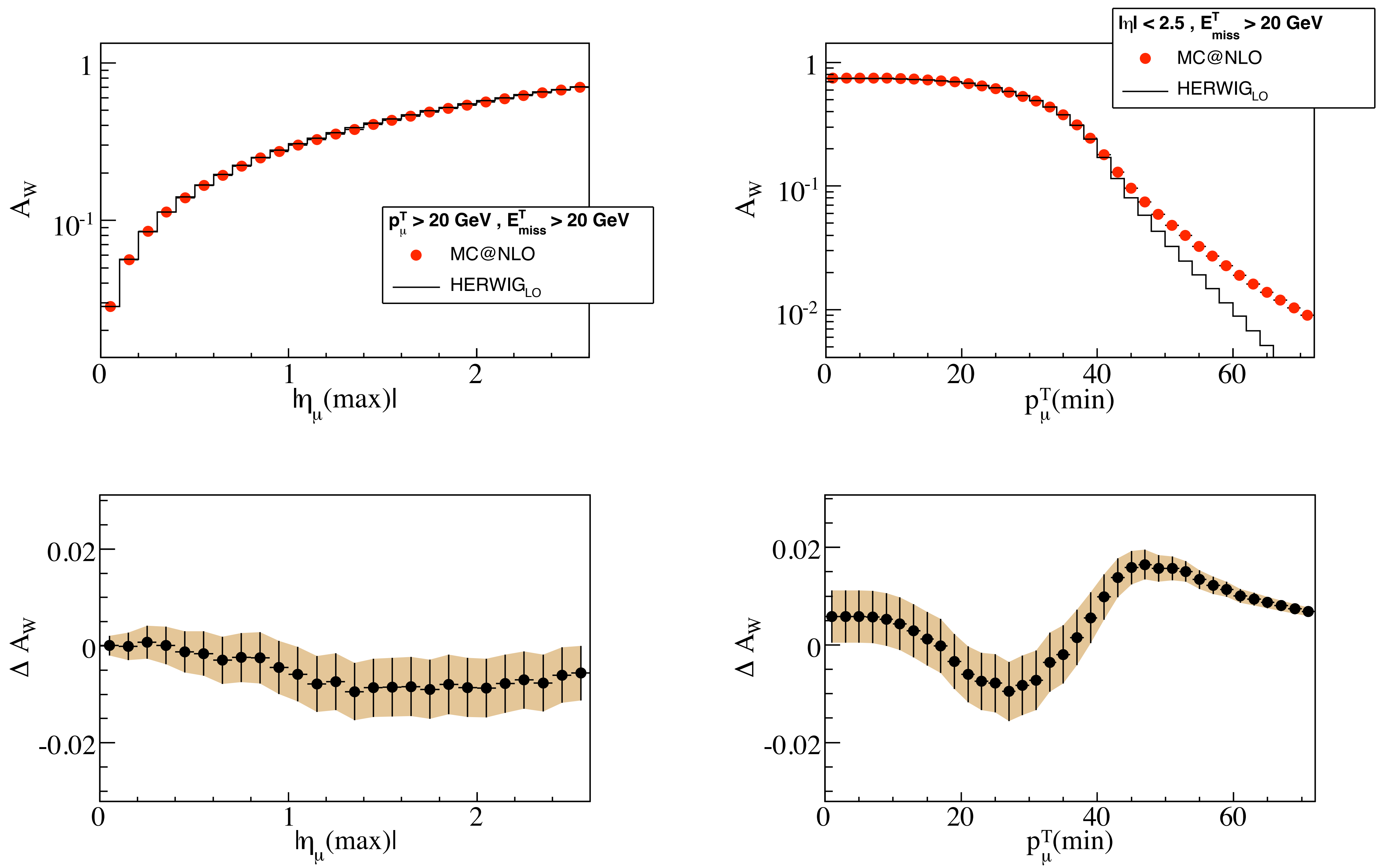
- Analysis of the QCD NLO corrections
  - ★ using MC@NLO
  - ★ enhancement of production at high-p_T

Generator	σ^W (pb)	$\epsilon_{g.f.}$ ($p^T_\mu > 5\ GeV$, $\|\eta\| < 2.8$)
HERWIG$_{LO}$	17931.86 ± 6.49	$0.712\ (\sim 6 \cdot 10^{-4})$
LO+PHOTOSME	17939.64 ± 6.42	$0.712\ (\sim 6 \cdot 10^{-4})$
MC@NLO	13861.55 ± 25.32	$0.999\ (\sim 10^{-4})$
HORACE$_{EW}$	19032.66 ± 2.33	$0.719\ (\sim 6 \cdot 10^{-4})$



NLO effects: QCD

- Analysis of the QCD NLO corrections
  - ★ effects at the level of 1% going to 2% at high p_T cuts



Acceptance (RM2)

- We studied acceptance's consistency between HERWIG and PYTHIA, both in Stand Alone mode and in the Athena framework at generation level, imposing kinematical cuts on the following Drell Yan processes:
  - ★ $W \to \mu\nu$, $e\nu$
  - ★ $Z \to \mu\mu$, ee

- Goal is to understand the kinematical cuts to be applied and ensure all the job options to be exactly the same; compare acceptance values with previous work done at CERN
  - ★ M. Goulette's study of systematics with Herwig/Pythia/MC@NLO in Athena, at generation level
  - ★ T. Petersen's study of W mass; in particular, study of prefilter efficiencies at reconstruction level
  - ★ "W mass CSC Note: Measurement of W boson mass at ATLAS with early data" ATLAS Collaboration, 3 april 2008

Comparison with T. Petersen's work

- Pythia in Athena

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

	Acceptances [%]				T.P.
	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

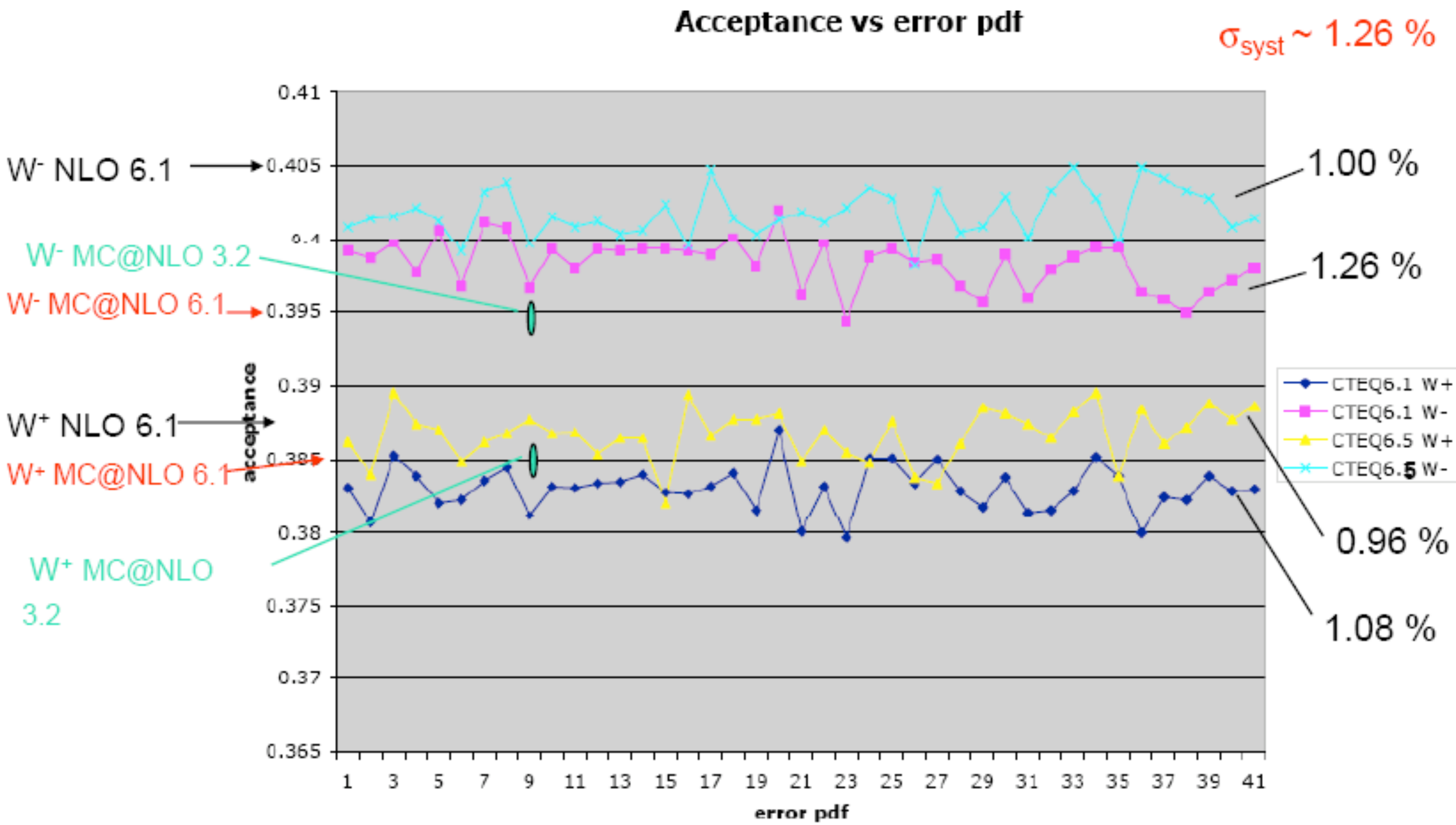
these are at reconstruction level

Comparison with M. Goulette's results

Process	Analysis	ATHENA		
		Herwig	Pythia	Mc@NLO*
$W \to e\nu$ pT > 25 GeV: both | η | < 2.5+cracks only for electron	MG	34.27	34.51	36.84
	RM2	34.4	34.12	(… to do)
$Z \to ee$ pT > 20 GeV: both | η | < 2.5+cracks: both, $\sqrt{s} > 60$ GeV	MG	45.27	46.20	51.02
	RM2	33.71	35.22	(… to do)

- Still to clarify $Z \to ee$ discrepancy: reconstructed events?
- MC@NLO comparison
- Studies with MC@NLO of systematic errors on acceptance due to:
  - ★ Different PDFs, ISR, FSR, kT of incoming partons, UE, ME, EW corrections

PDF impact on acceptance (J. Huston)



Acceptance

- Summarizing all considered effects (from CSC note and previous analysis)

channel \ effect	ISR*	k_T	UE	ME	PDF**	QED	QCD	EW
$W\to\mu\nu$	10.2%	1.9%	1.0%	neglig.	1%	1.8%	0.6%	neglig.
$Z\to\mu\mu$	2.8%	0.5%	0.9%	neglig.	1%	2.8%	tbe***	tbe***

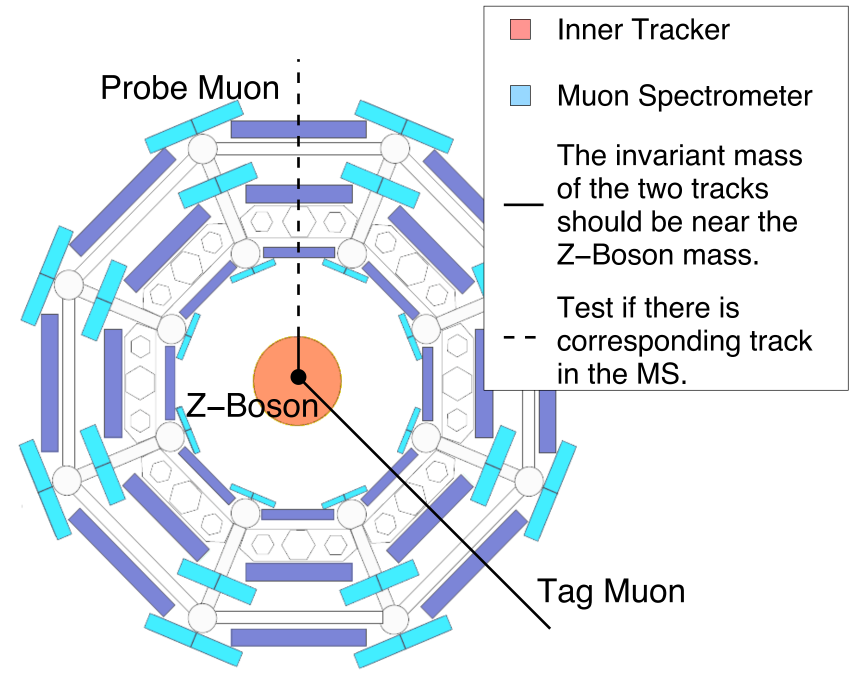
* effect only in Pythia
** measured from CTEQ 6.5 error set
*** to be evaluated in new analysis in release 14

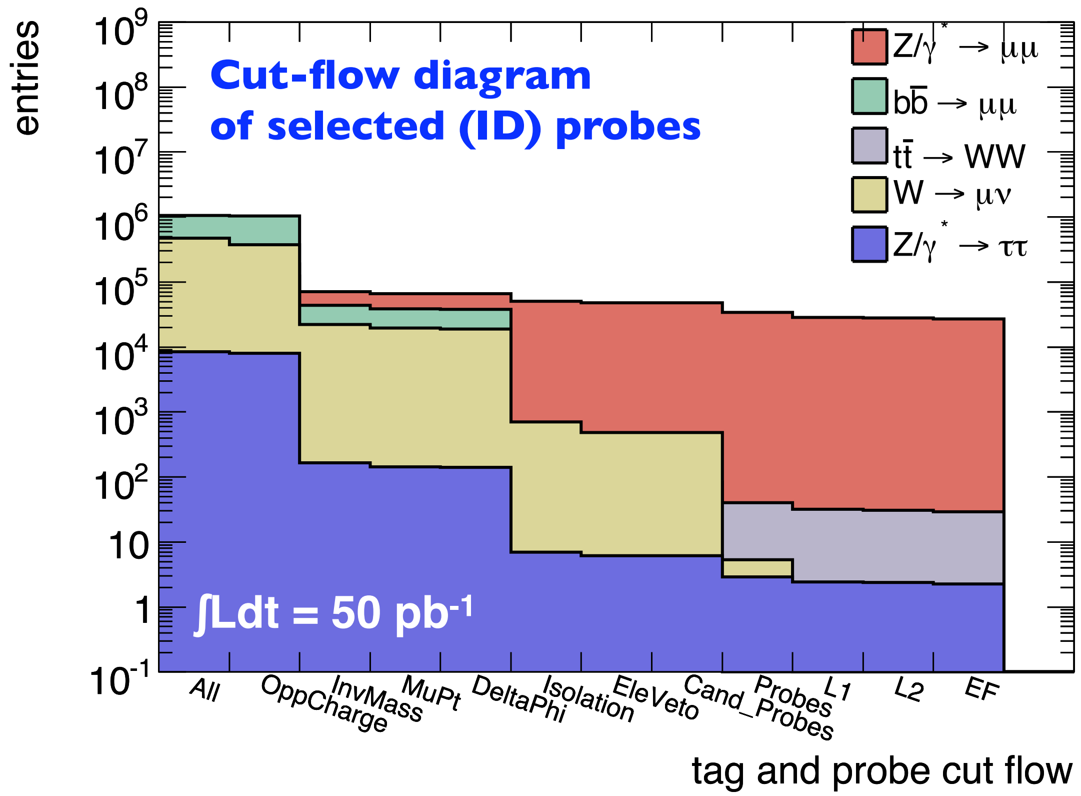
- Total relative uncertainty is calculate taking 20% (th. uncert.) of above numbers
  - ★ $\delta A/A$ = 2.3% for W events and $\delta A/A$ = 1.1% for Z events
  - ★ QCD and EW effects to be added
- Next analysis will focus on complete calculation for QCD and EW NLO effects and PDF uncertainties impact (using also different sets/effects, help is needed here!)

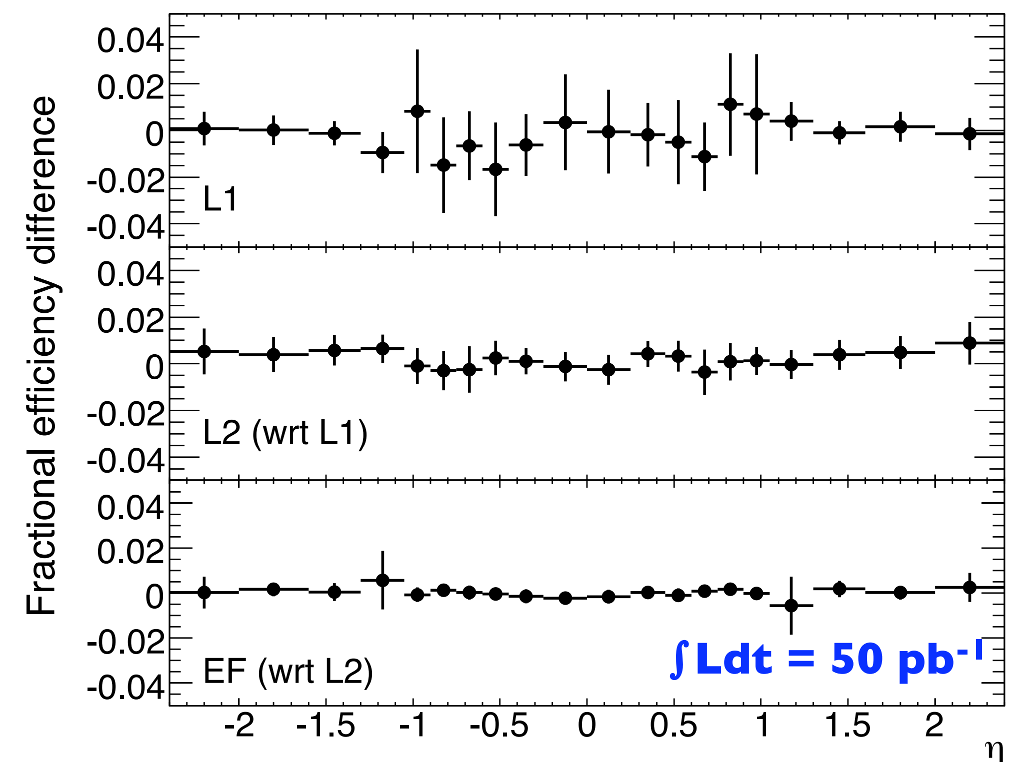
Trigger efficiency from $Z \to \mu^+\mu^-$ (PV)

- Measurements referred to Inner Detector or Muon Spectrometer offline reconstruction
  $c_1 * c_2 < 0$, $81 < M_{\mu\mu} < 101$ GeV, $p_T > 20$ GeV
- Background rejection with kinematic and tight isolation cuts
  - ★ ID $\Rightarrow \Sigma N^{ID} < 4$, $\Sigma p_T^{ID} < 8$GeV,
  - ★ Calo $\Rightarrow E_{jet} < 15$GeV, $\Sigma E_T^{EM} < 6$GeV
- Errors for 50 $pb^{-1} \approx 0.3\%$ (stat) $\pm$ 0.5% (syst.) background contribution <0.1%

Tag and Probe method







Tag and Probe analysis (RM1)

- Study trigger efficiency using Tag and Probe on $Z \to \mu^+\mu^-$ events
- ATHENA algorithm
- Analysis from AOD with ROOT output (ntuple and histograms)
- Efficiency is evaluated using only reconstructed quantities; MC truth is used only to control the fake level
- Segnale $Z \to \mu^+\mu^-$:
  - 33.000 events (about 40 pb^{-1} @ 10 TeV)
  - no pile-up and cavern background
  - generation filter: at least 1μ with $p_T > 10$ GeV in the acceptance region ($\varepsilon \approx 85\%$)
- Samples and cross cross sections [pb]
  - $Z \to \mu+\mu-$ (5145) $\sigma = 1200$
  - $Z \to \tau+\tau-$ (5146) $\sigma = 1200$
  - $W \to \mu\nu$ (5105) $\sigma = 10000$
  - $Zbb \to 4l$ (5177) $\sigma = 0.5$
  - ttbar (5205) $\sigma = 460$

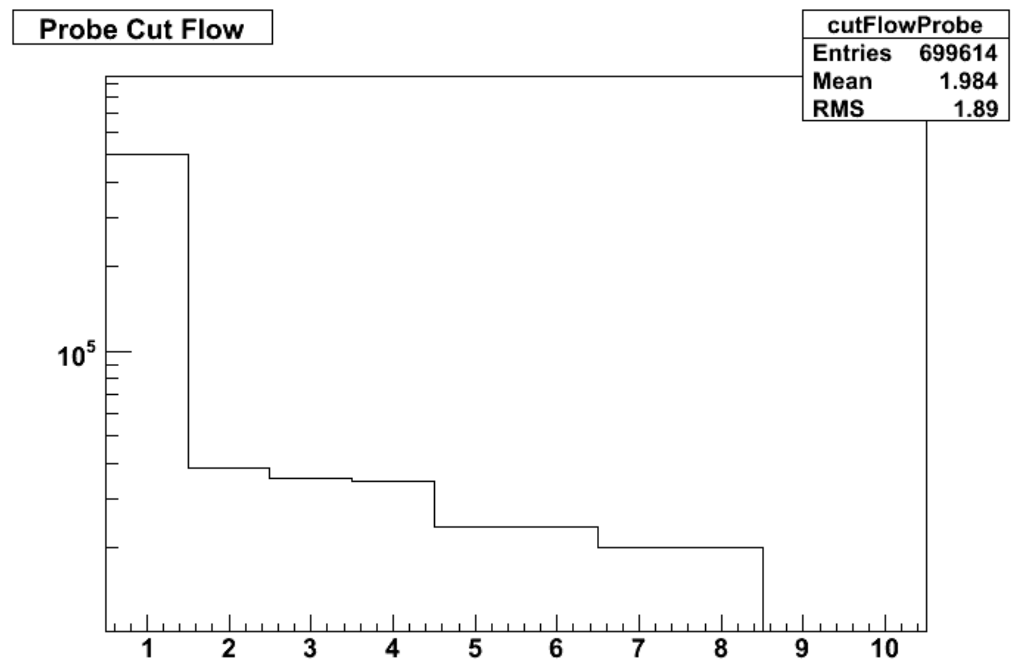
Still missing bbar
(not simulated in rel13)

Tag and Probe selection

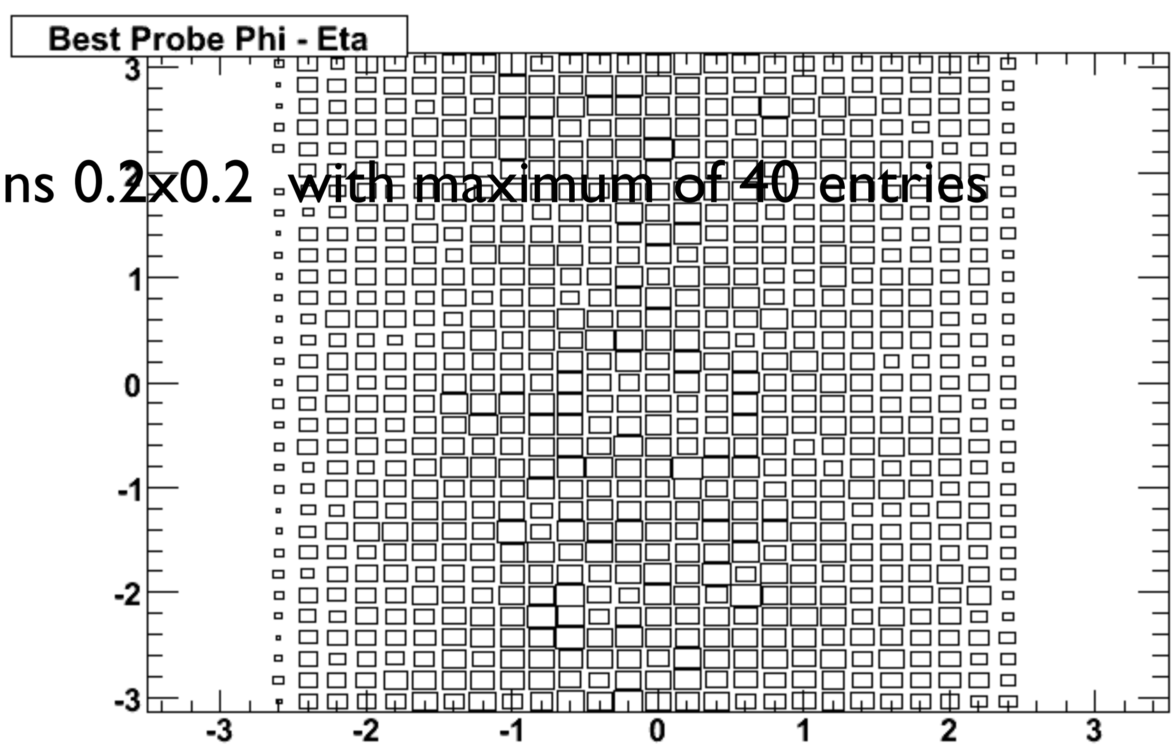
- Tag selection:
  - ★ p_T >5 GeV and $|\eta| < 2.5$
  - ★ Combined muon (or standalone for first data analysis)
  - ★ Impact parameter cut $d_0 < 0.1$ mm
  - ★ Trigger EF (EF_mu20)
  - ★ ID and Calorimeter isolation in a 0.3 cone (4.5 GeV)
  - ★ If more than 1 tag is found, then we keep them all
- Probe selection:
  - ★ ID tracks (tag subtracted) w/ opp charge
  - ★ pT >5 GeV and $|\eta| < 2.4$
  - ★ Impact parameter cut $d_0 < 0.1$ mm
  - ★ Same tag vertes $d_{z0} < 0.5$ mm (for pile-up)
  - ★ ID isolation in a 0.3 cone (1.6 GeV)
  - ★ $\Delta\varphi$ cut tag-probe ($\pi \pm 1.0$)
  - ★ Cut on the tag-probe invariant mass within 6σ from Z mass, about 12 GeV
  - ★ If more than 1 probe selected, keep the one with tag-probe invariant mass closer to Z mass

Tag and Probe selection

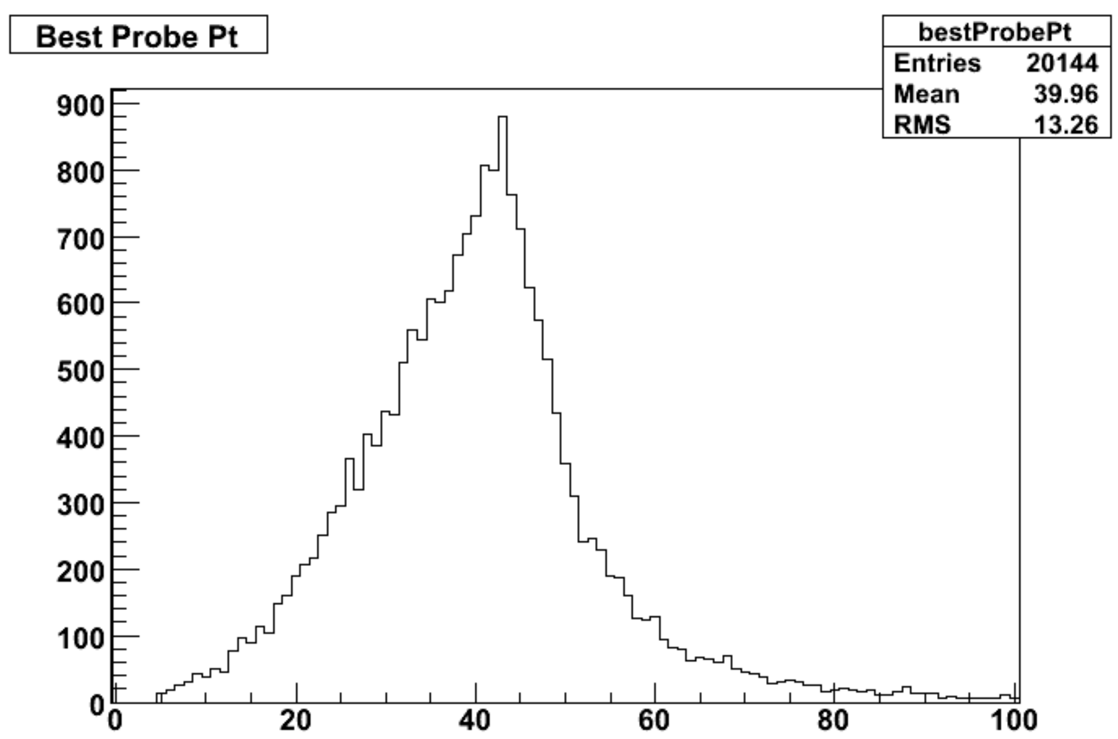
1. All with opposite charge
2. After pt and eta cut
3. After d_0 cut
4. After D_{z0} cut
5. After isolation
6. After deltaPhi cut
7. After invariant mass cut
8. Best probe



- transverse momentum and η,φ distribution for selected probes

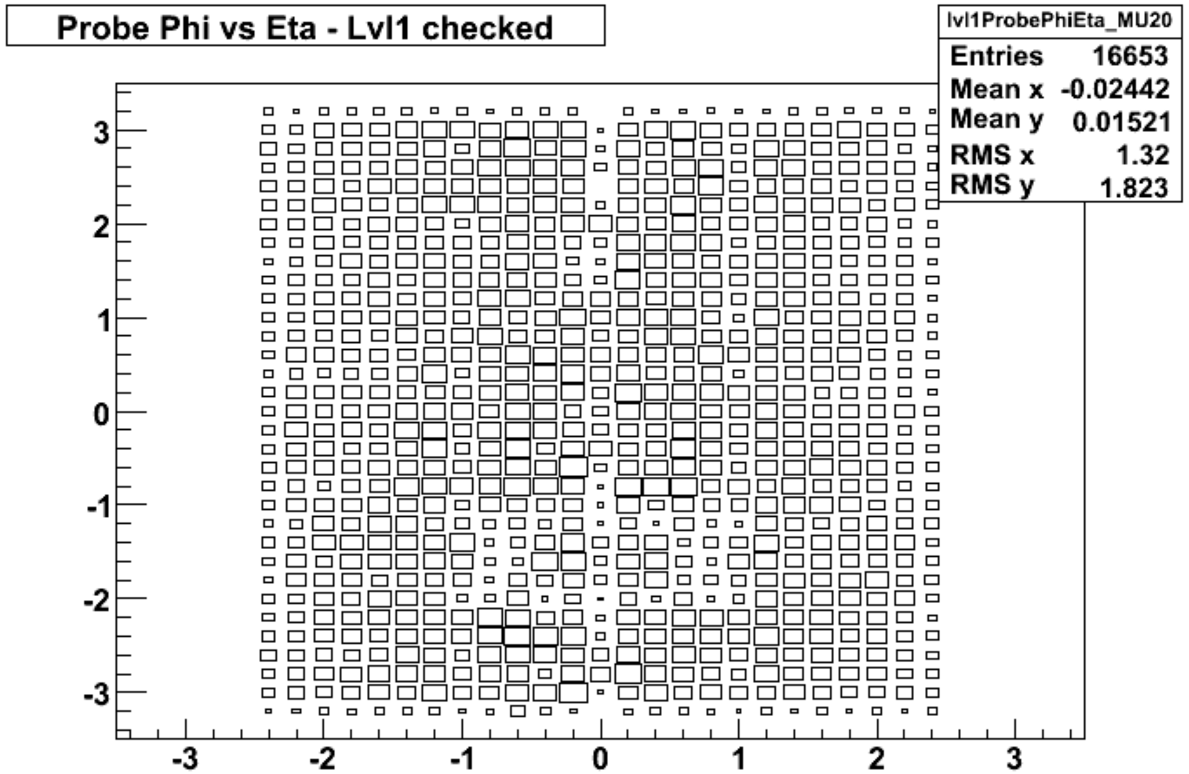


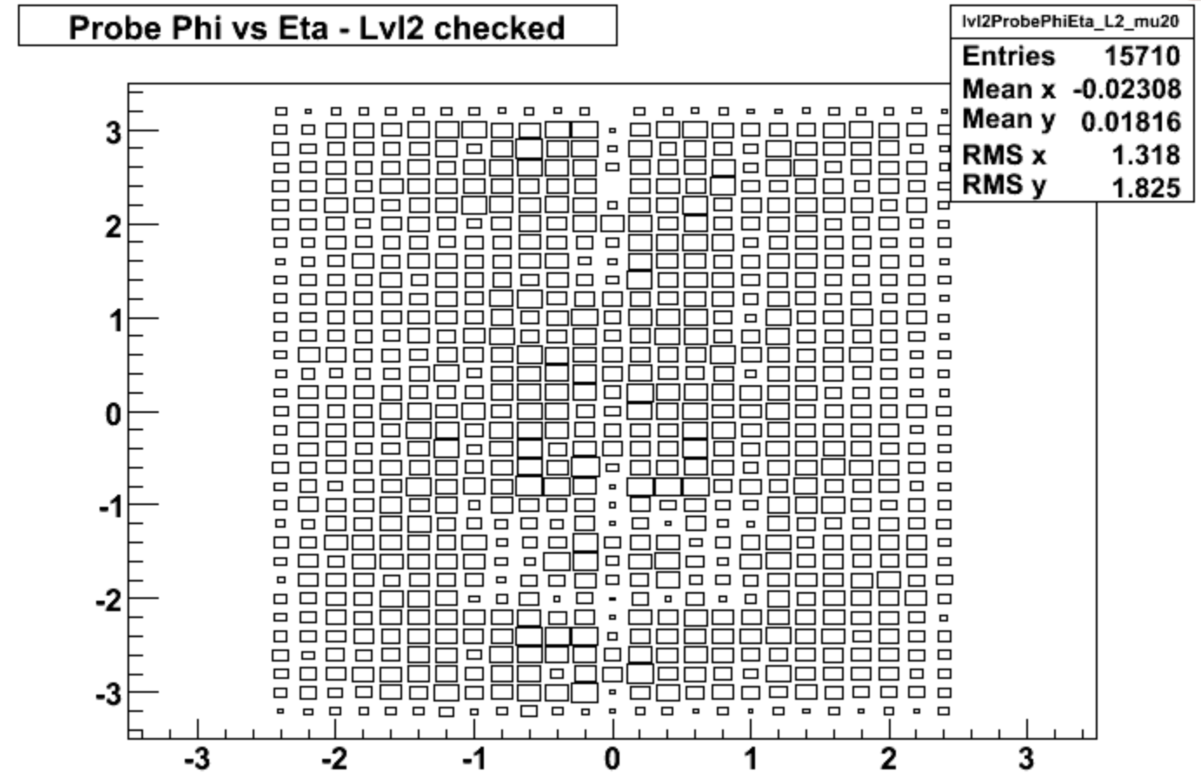
bins 0.2x0.2 with maximum of 40 entries

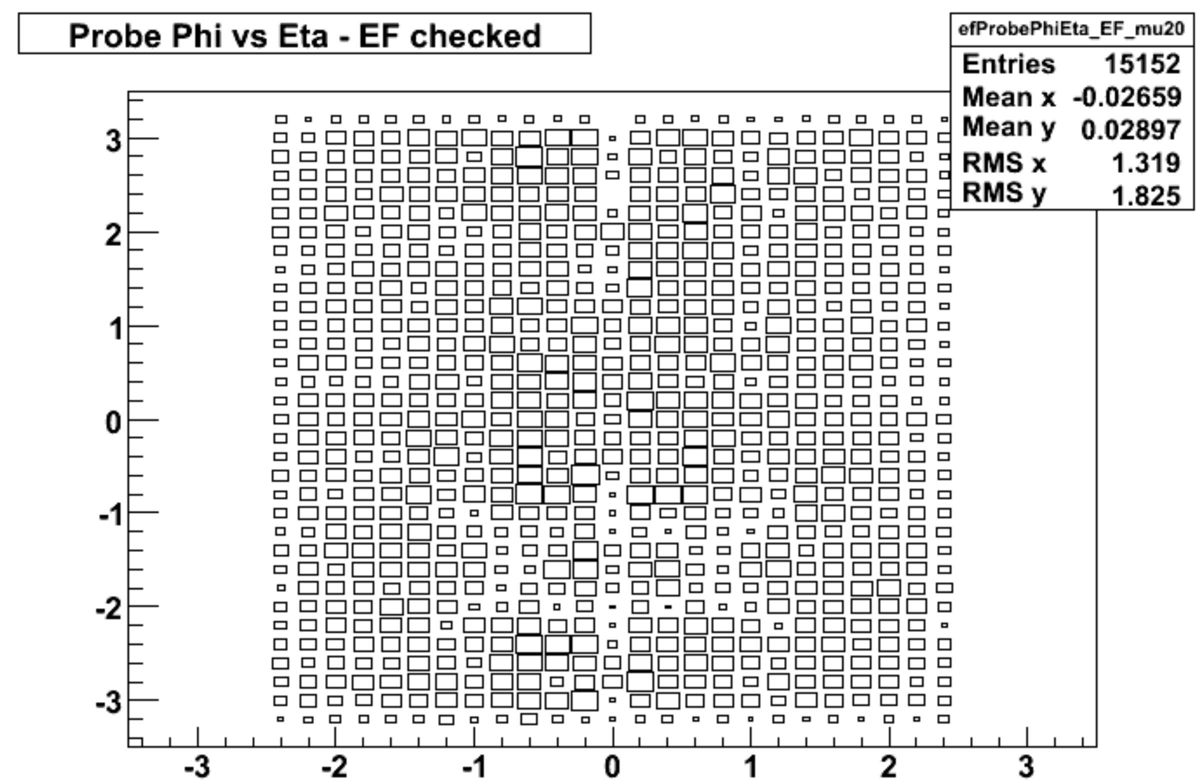


- 20144 selected probes (0.2% fakes) with spectrometer coverage in eta-phi

Results





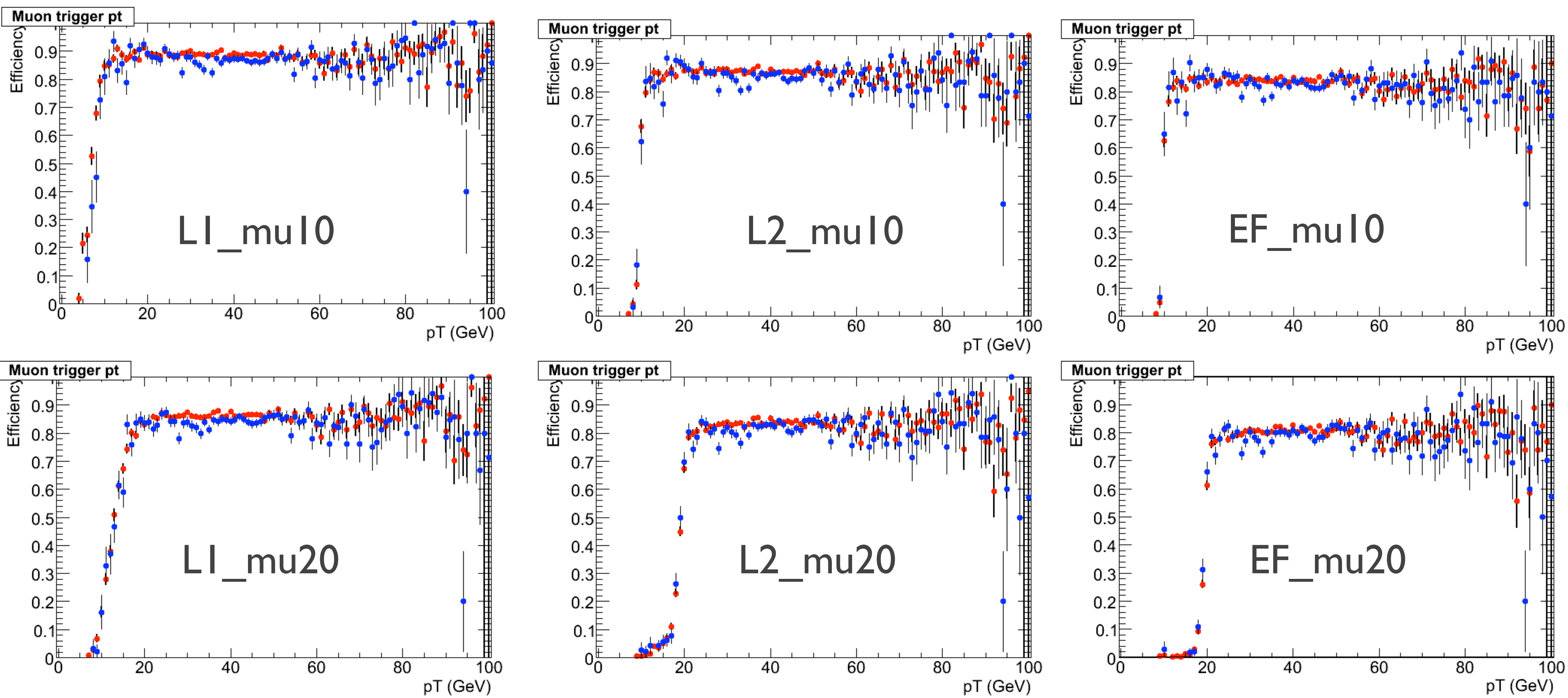


- Then check after trigger level
  - ★ Level 1 acceptance effects clearly visible

Results

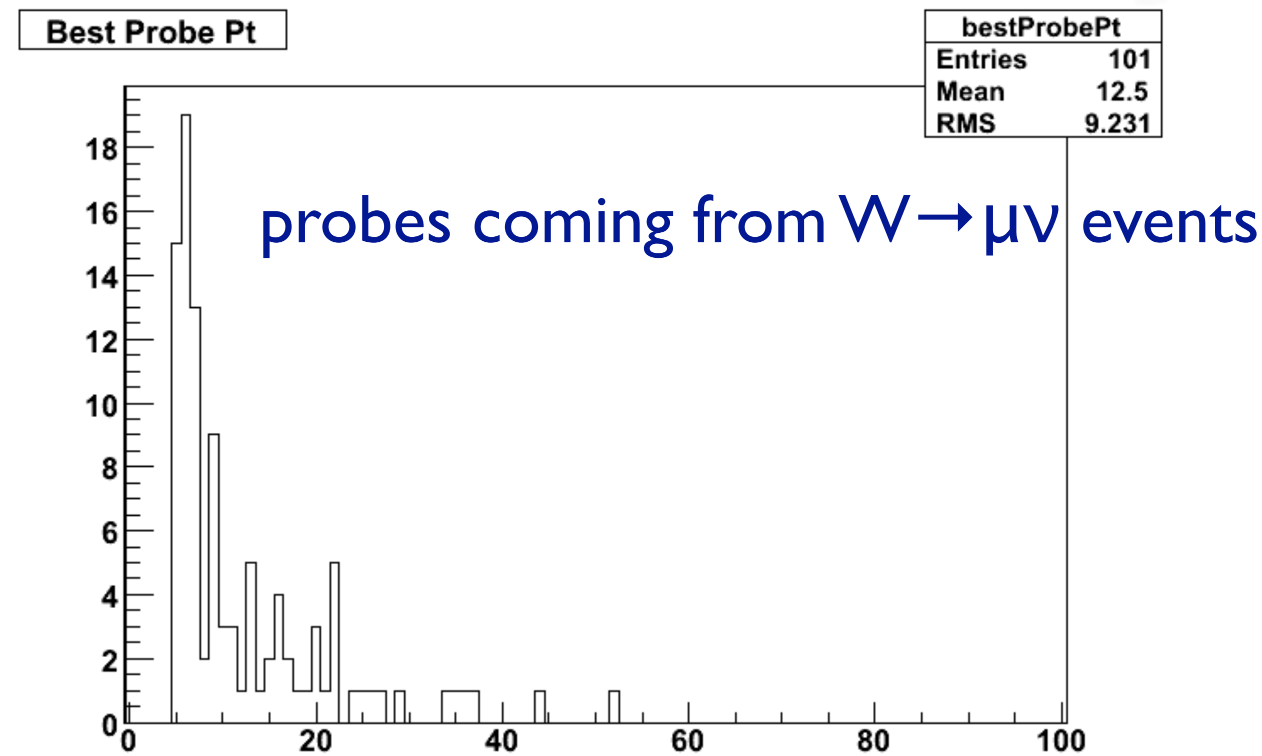
- Trigger turn-on curves for mu10 and mu20

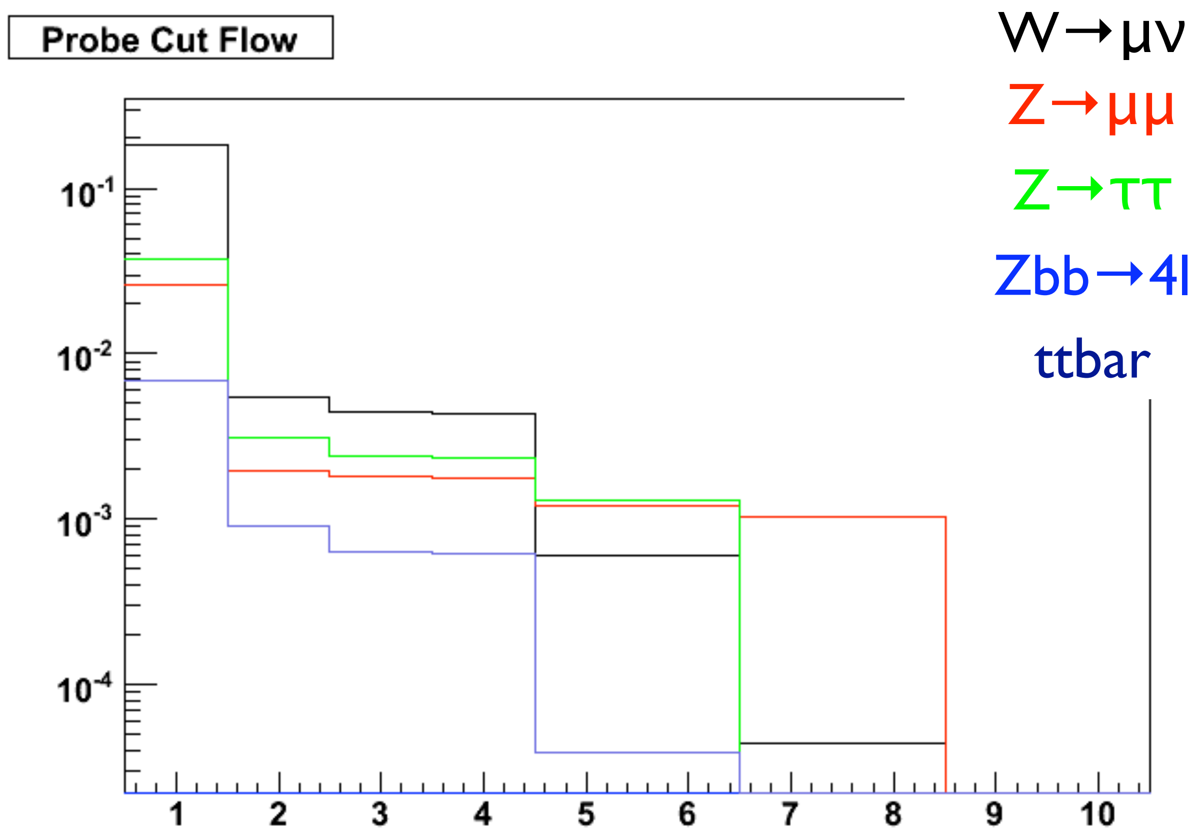
MC
TagAndProbe

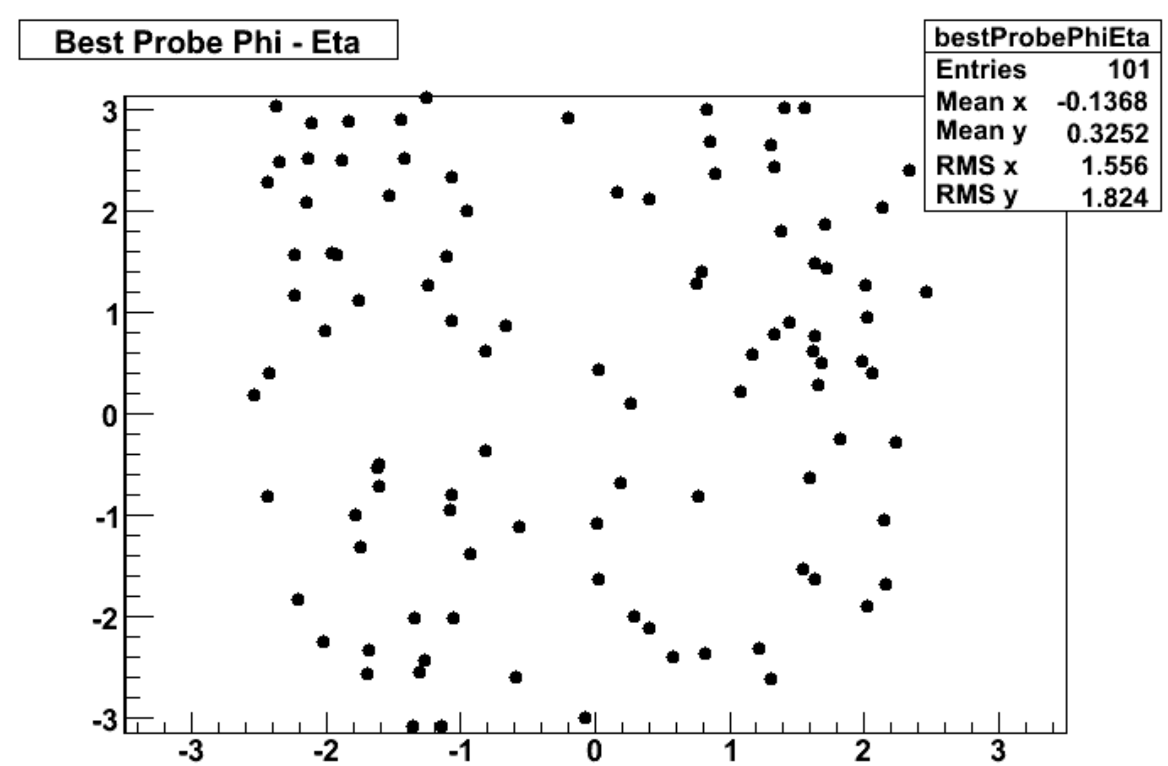


Background analysis

sample	probe/pb^{-1}	
$Z\to\mu^+\mu^-$	730.9	96.74%
$W\to\mu\nu$	20.2	2.67%
ttbar	2.9	0.38%
$Z\to\mu^+\mu^-$	1.5	0.2%
$Z\to\tau^+\tau^-$	1.3	0.17%
$Zbb\to 4l$	5 10^{-4}	<0.01%

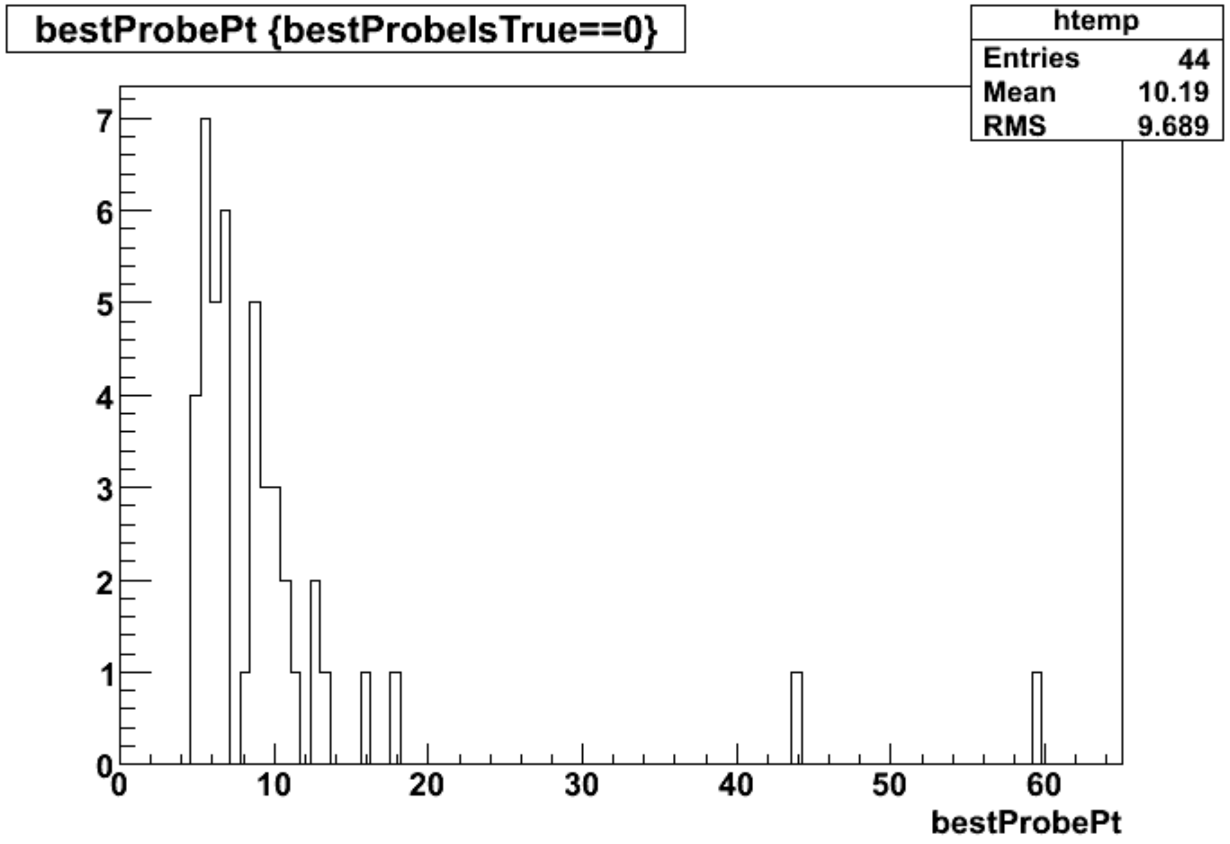


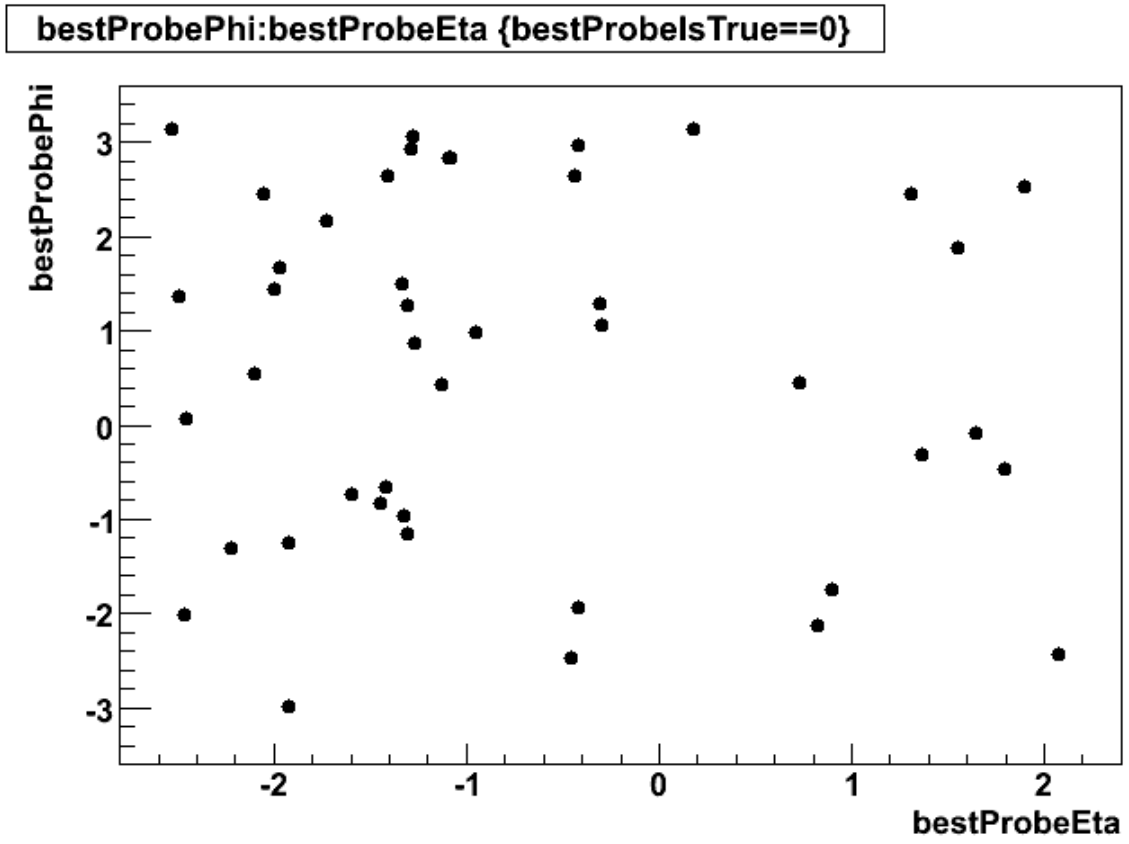




Pile-up and cavern background

- On 33000 events we select (wrt sample w/o pile-up) 27491 (32414) tag
  - ★ most are reduced by the trigger
- 15752 (20144) probe, where isolation cut has the bigger impact
  - ★ cause we are not asking that isolation tracks are coming from interaction vertex
- 0.3% (0.2%) is the probe fake level





Combined Muon Performance (RM3)

- After last W,Z meeting we (Rome3) we have decided to use EWPA for Combined Performance (CP) studies and also for physics analysis

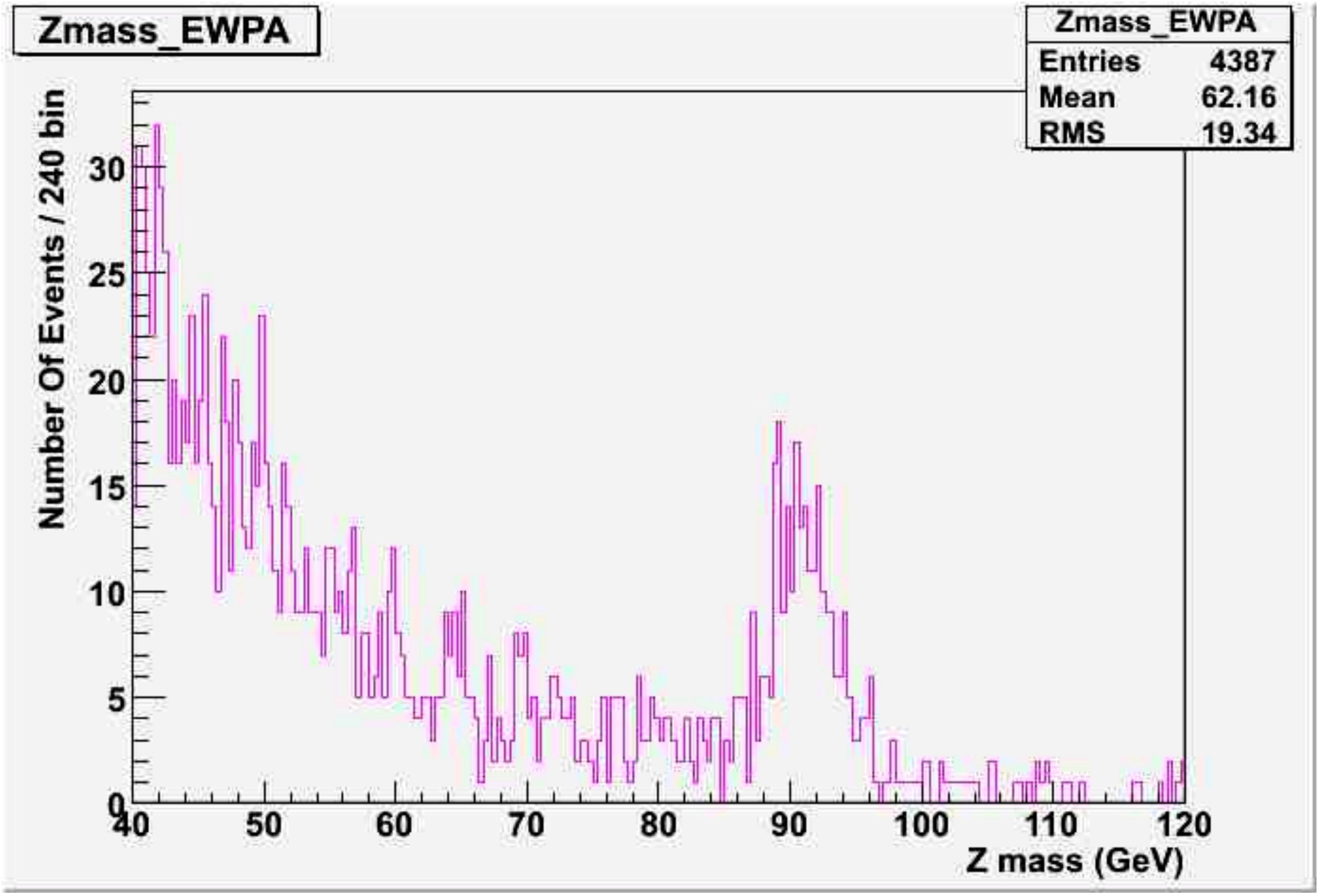
- EWPA tutorial was made in Roma Tre on May 12
  See link from twiki
  https://twiki.cern.ch/twiki/bin/view/Atlas/EWPARome3TutorialSession
  (Note this is with ATHENA 13.0.40, outdate for recent devs ...)

- However tutorial has been very useful to start first CP studies from AODs of release 13 and to make a preliminary analysis of FDR2 data

Combined Muon Performance

- FDR2: Run 52293 ~ 110000 events from the Muon Stream
- dataset fdr08_run2.0052293.physics_Muon.merge.AOD.o3_f8_m10
- DPDs have been produced on the grid from AODs (Athena 14.1.0, EWPA-00-02-03) and then analized locally in ROOT

- Di-muon invariant mass selected with only
  - ★ pt>10 GeV & |η|<2.4



Momentum scale

- EWPA modularity allows to easily create new analysis tools in Athena

- We are now developing the EWMuCP tool to study Combined Performance on the momentum scale. Developments is done also at ROOT level using the D3PD made in EWPA
  - ★ easy test of the new code before update into EWMuCP

- To study the momentum scale we use the parametrization proposed by O. Kortner

MS = measured

$$\delta p = p_{MS}\left(\delta\overline{B} + \frac{p_{MS}}{q\left|\int_{P} \vec{B}\times d\vec{l}\right|}\bullet\delta gr\right) + (1+\varepsilon)E_{loss}$$

B field

mis-alignment

Calorimeter E loss

Momentum scale

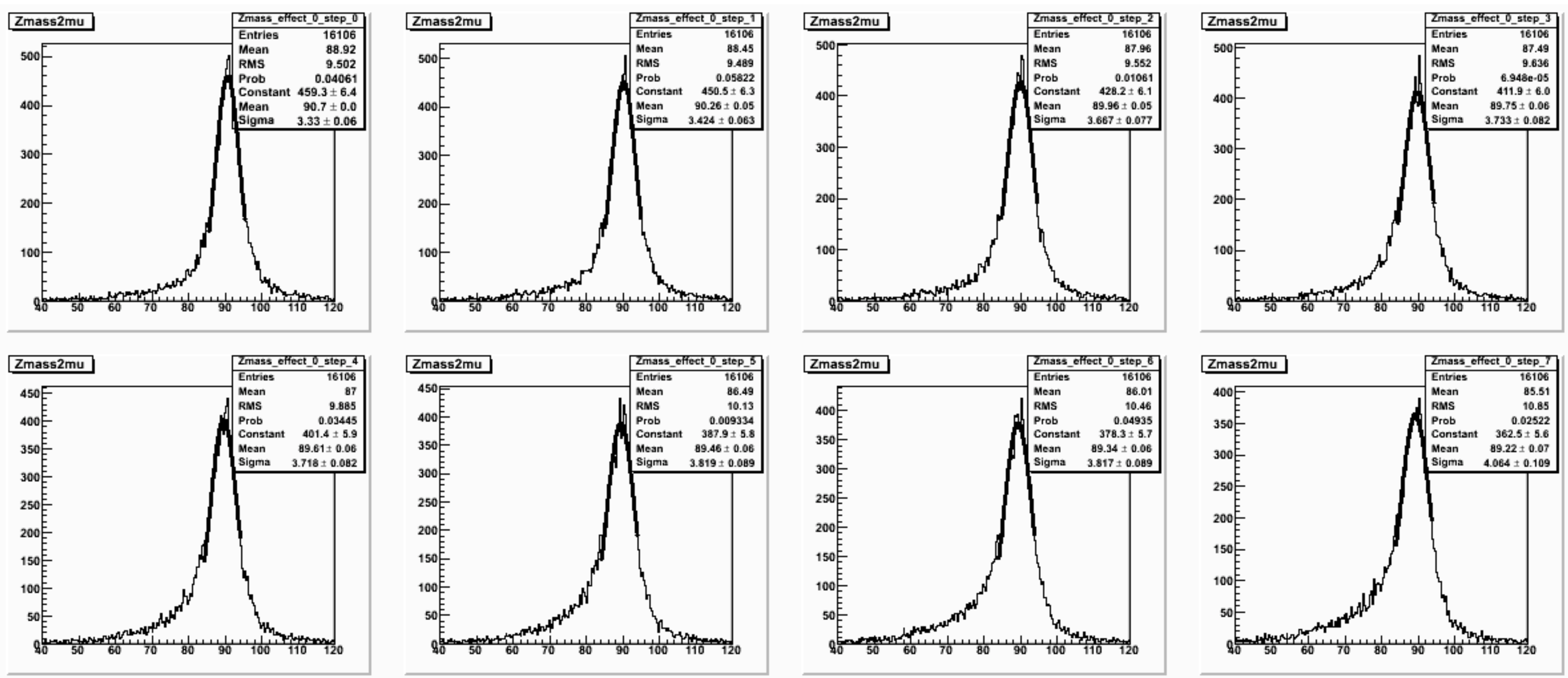
- The analysis is organized into 2 steps:
  - ★ 1) Study of effects of δB, δgr, ε parameters variations on observables (today results)
  - ★ 2) Reconstruction of variations starting from observables with a constrained-fit event-by-event minimizing the difference (M_{inv}-M_Z).
- Constrained-fit: we use a X^2 function with δB, δgr, ε as fit parameters:

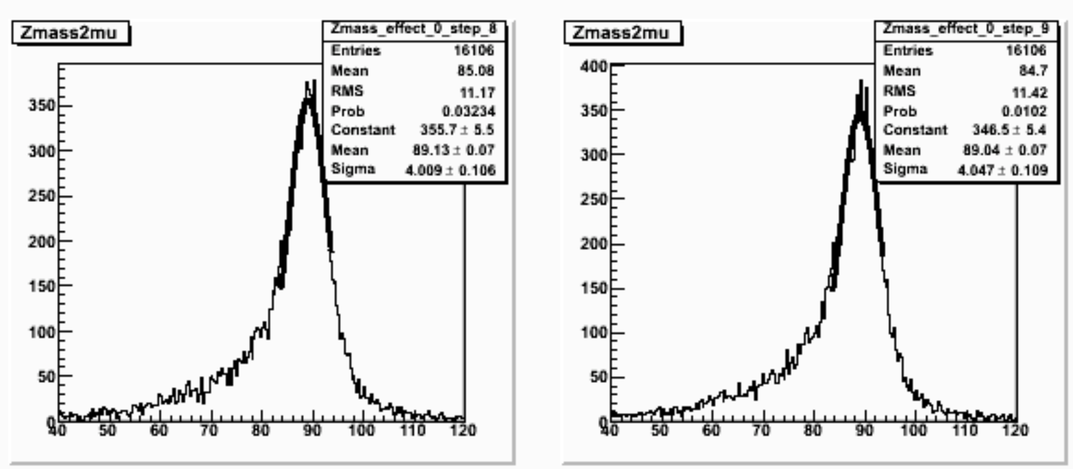
$$X^2 = \left(\frac{\delta\overline{B}}{1\%(?)}\right)^2 + \left(\frac{\delta gr}{500\,\mu m(?)}\right)^2 + \left(\frac{\varepsilon}{5\%(?)}\right)^2 + \frac{(M_{inv} - 91)^2}{\Gamma_Z^2} + ?$$

- The '?' means that the variation scales have to be optimized and that other terms could be added (e.g. asymmetry)
- The distributions of the fit parameters should give the mean corrections to be applied to the given set of data

Momentum scale

- 30 k events, variation of B from 0 to 1 %





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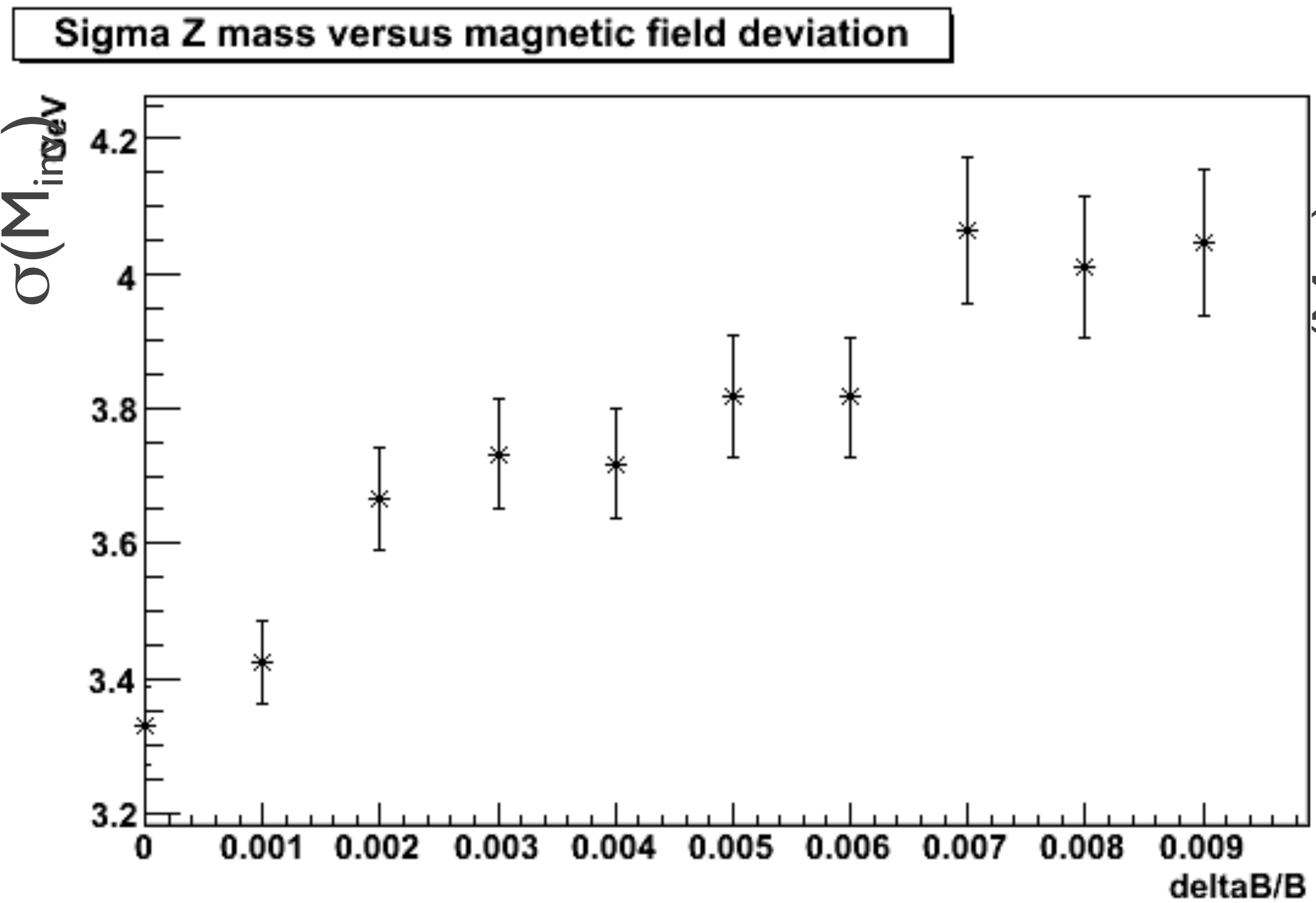

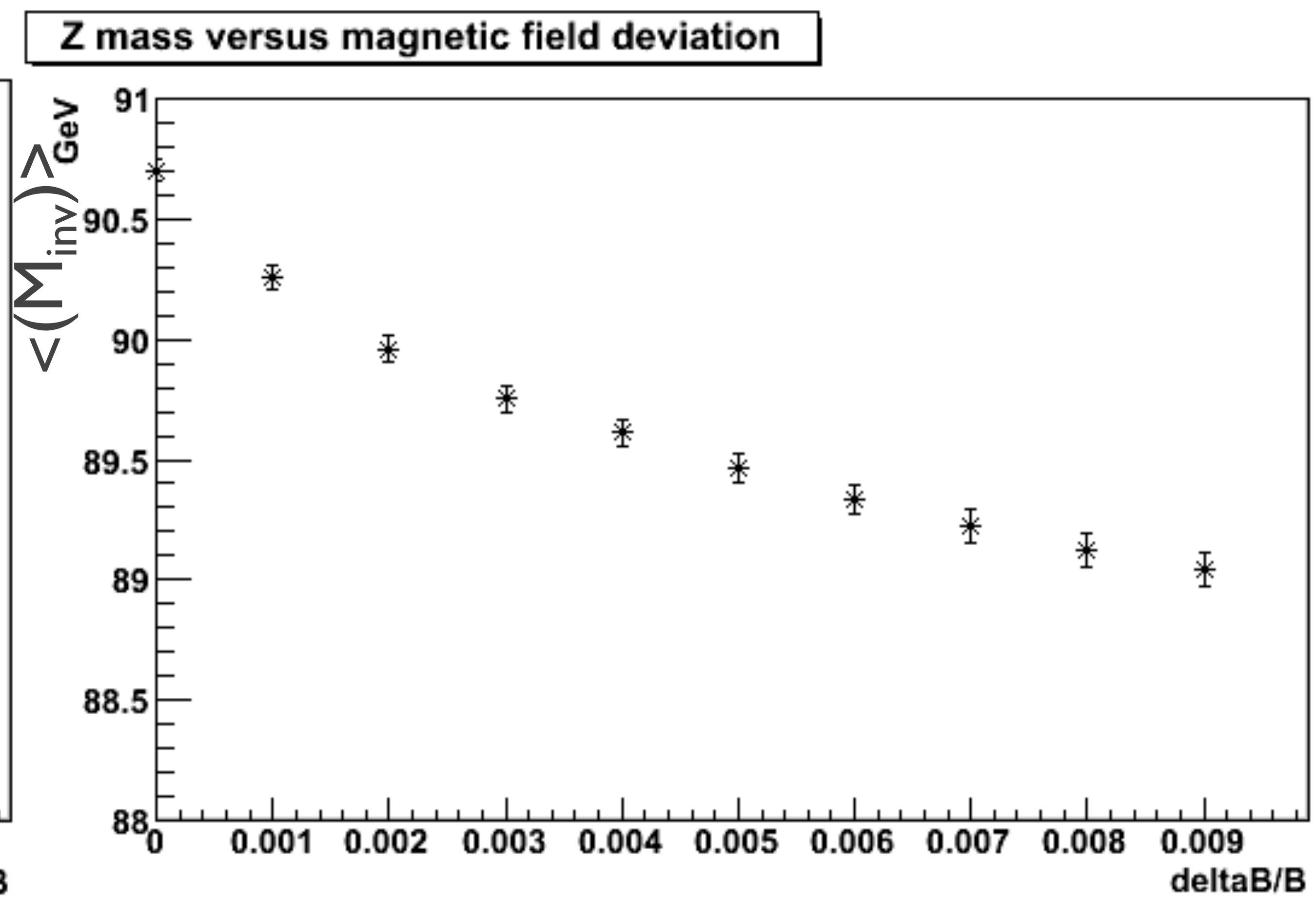

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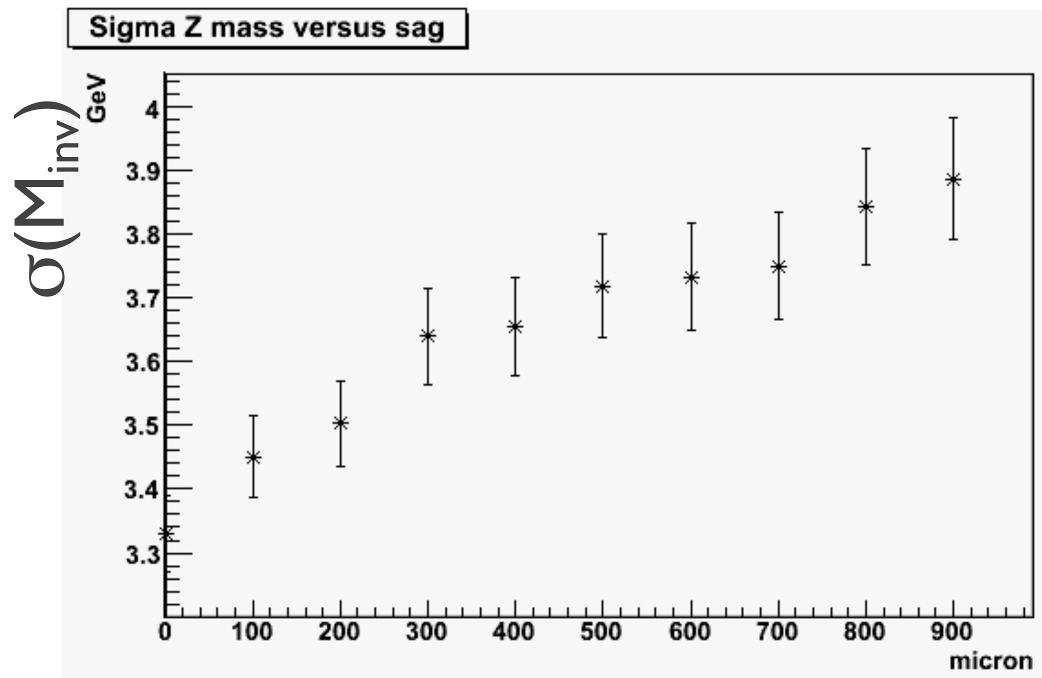

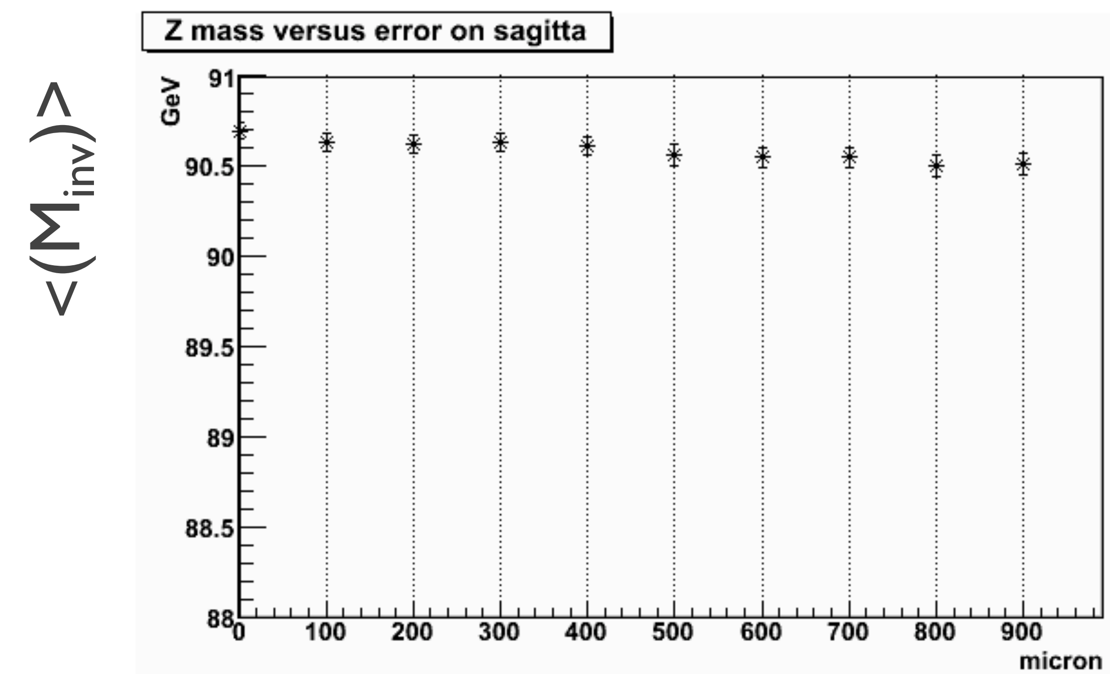

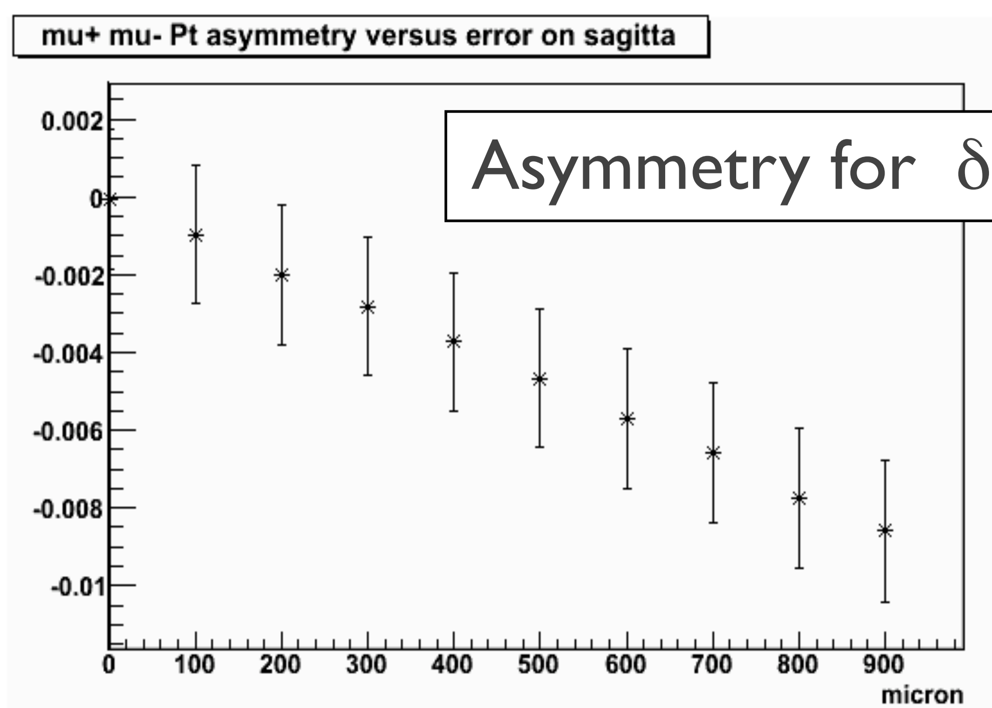

Asymmetry for $\delta B \sim 0$

$$Asymmetry = \frac{p_t^+ - p_t^-}{p_t^+ + p_t^-}$$

Momentum scale

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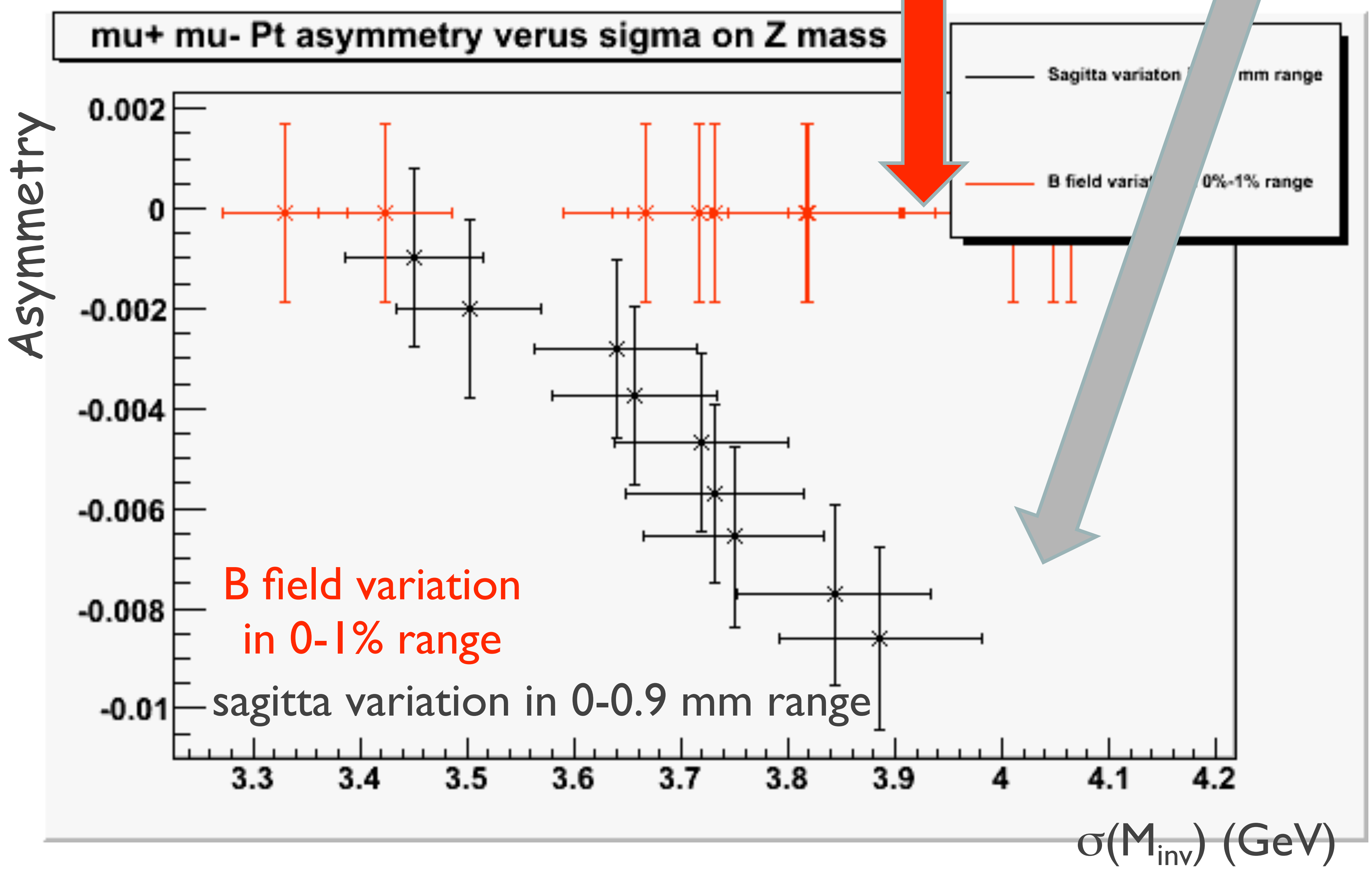

Conclusion and outlook

- Acceptances: different effects have to be considered
  - ★ Focalize to NLO effects to fill the table with updated numbers (PV)
  - ★ Help is needed for the analysis of the impact of PDFs (?)
  - ★ Still to clarify $Z \rightarrow ee$ discrepancy: reconstructed events? (RM2)
  - ★ MC@NLO comparison (RM2)
  - ★ Studies with MC@NLO of systematic errors on acceptance (RM2)
- Efficiencies from data:
  - ★ Analysis and method are quite stable since CSC analysis, going to be ported to common tools for the collaboration (PV in collab. with M.Schott, see next slides ...)
  - ★ If enough statistic they will be tested also in FDR2 data (PV)
  - ★ Detailed tests with new pile-up (first results show robustness of method) (PV-RM1)
  - ★ Analysis of bbar background (RM1)
  - ★ Efficiency without combined muons (RM1)
- Momentum scale
  - ★ Continue the development of the constrained fit (RM3)
  - ★ The first results show a good sensibility in studied variables and it should be possible to determine single contributions (RM3)
- I've prepared a item-table to discuss with you at the end of the talk ...

Tag and Probe tools (PV)

- EWPA has its own Tag and Probe Athena/ARA tool that allow to loop on pairs of selected TP tracks flagged with a selection bit-set
  - ★ see more details at https://twiki.cern.ch/twiki/bin/view/Atlas/EWPATagAndProbeMethod

Objectives

- Not every user should run own performance evaluation in data
- Performance groups should provide central processed information
  - Common definition of efficiency and resolution
  - Common basis for calculating systematic uncertainties
- Common database access
- Provide Interface to ATLFast I

Probe Collection Tool

- Athena Tool
- Creating a collection of Probe-tracks in Store-Gate
- Example for muons: Collection of ID tracks which fulfill the Z Boson selection requirements

Efficiency determination

- Athena Algorithm (should be independent from probe selection)
- Testing if reconstructed muon can be matched to Truth/Probe/…

Storage of efficiency information

- Common way of representation efficiencies
  - Tag & Probe efficiencies
  - Based on Monto Carlo Truth
  - For various reconstruction algorithms

Condition database

- Common access of performance information for the whole collaboration

Tag and Probe tools

- The direction is for common tools for the collaboration developed together with Performance Groups
  - ★ i'm collaborating with M. Schott to merge our tools as a standard tool (also for egamma)
  - ★ working also on representation of efficiency with DB connection

APEfficiencyMatrix

- Represents a 1 to 4 dimensional matrix
- Full userdefined, variable binning
- Projection methods, i.e. can project efficiency distribution on chosen dimension
- Additive, i.e.
  - can add efficiency information of two Athena jobs, luminosity blocks, …
- Interface to conditions database
- Member variables for identification in database: NameID, Software Version, Interval of validity
- Further user-methods:
  - Create Root histograms
  - ...

APEfficiencyEntry

- Number of trials
- Number of successes
- Methods for efficiency/uncertainty calculation

Derived classes: Muon Example

- Predefined binning with respect of the muon spectrometer
- Predefined dimensions: φ, η, p_T, (isolation)
- Special functions for Muon-Object support

EWPA analysis package

M. Bellomo, INFN

ATLAS Analysis Italia

Frascati

June 19, 2008

Motivations

- Every AOD based analysis requires a set of common actions
  - ★ accessing information from AOD through StoreGate service
  - ★ pre-filter particles when reading
  - ★ remove overlap between objects
  - ★ make track-matching
  - ★ calculate general User Data information and attach it to the relevant objects
  - ★ save all of that on disk to iterate analysis over more steps

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- So why not take these actions to a common abstract level ? This will
  - ★ prevent to "re-invent the wheel" every time :-)
  - ★ easy the development of new analysis tools since many services are already in place
  - ★ allow for validation of common part by a larger community of people with all the derived benefits
  - ★ easy the comparisons of different analysis results
  - ★ easy the collaboration among different groups

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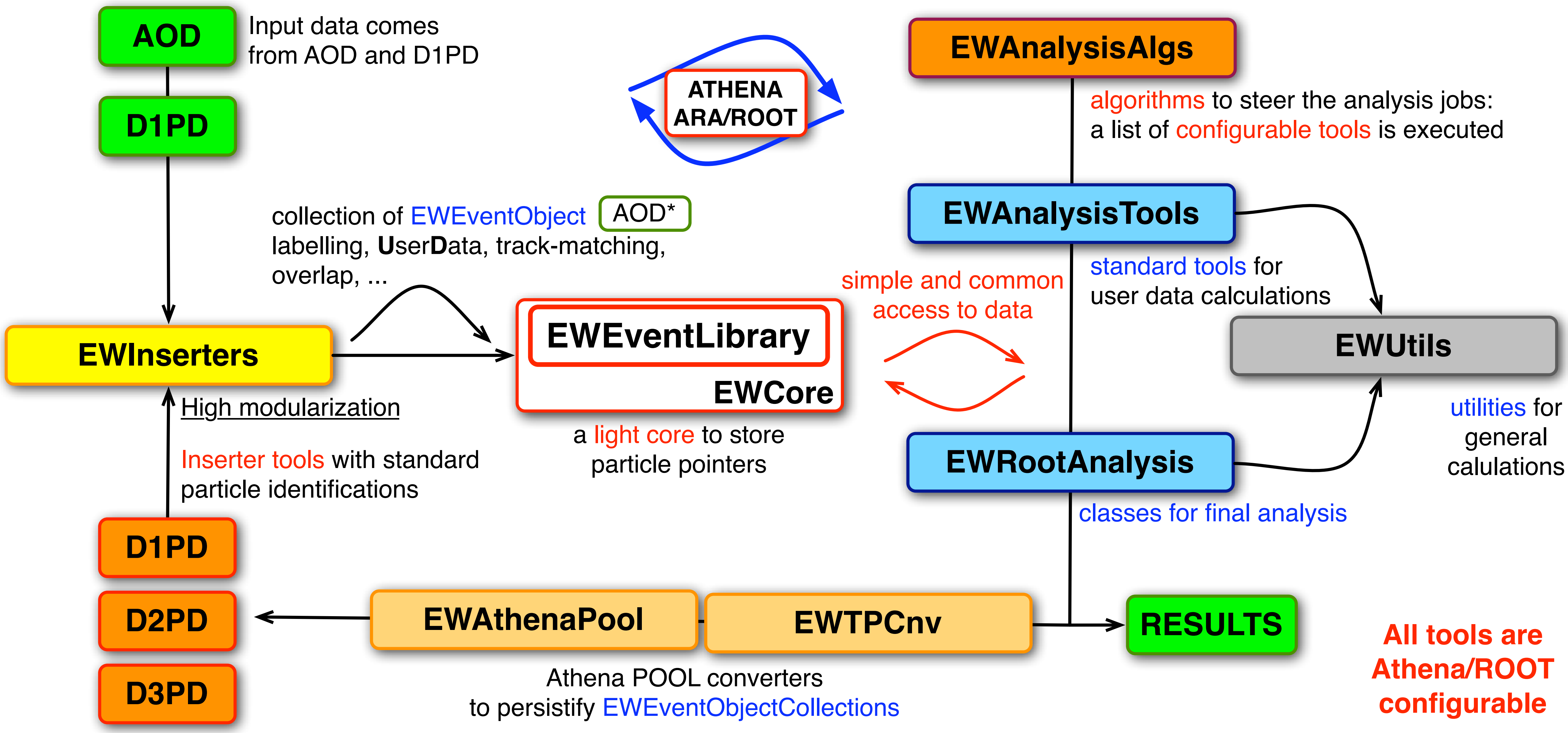
  - ★ easy the comparisons of different analysis results
  - ★ easy the collaboration among different groups
  - ★ ... i guess that the list of pro's is clearly longer that the cons's one ...

EWPA architecture

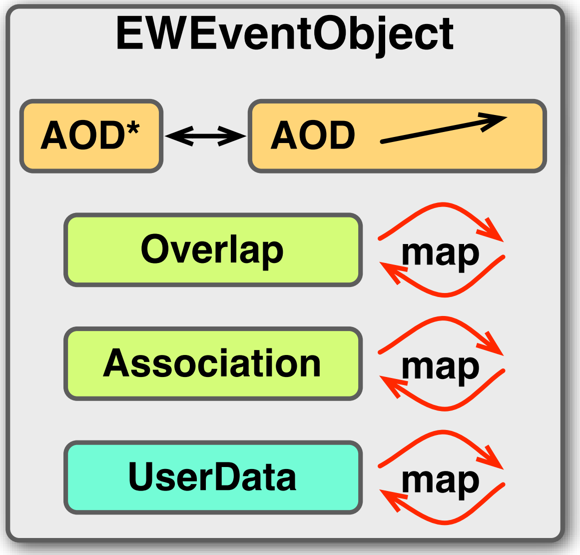
- EWPA is a modular framework trying to address previous points



- EWPA can run transparently in Athena or in ARA with the same configuration files

Information handling

- There are inserter tools to read/pre-select objects from StoreGate and put them inside EWEventLibrary
  - ★ interact with SG retrieving the AOD container
  - ★ apply the pre-selection (fully configurable and with by-pass mode)
  - ★ build the EWEventObject passing to it the AOD particle pointer



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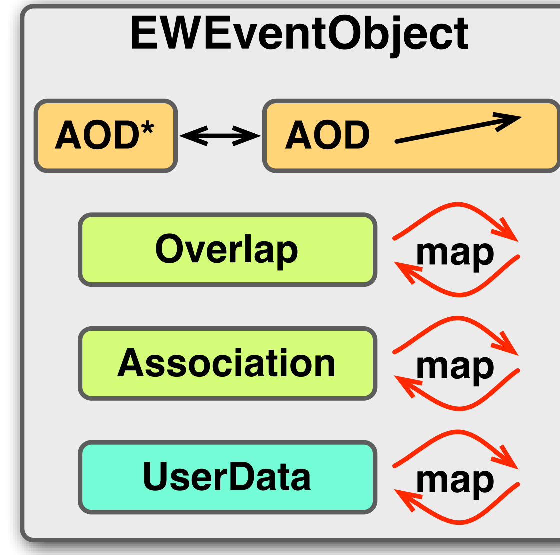
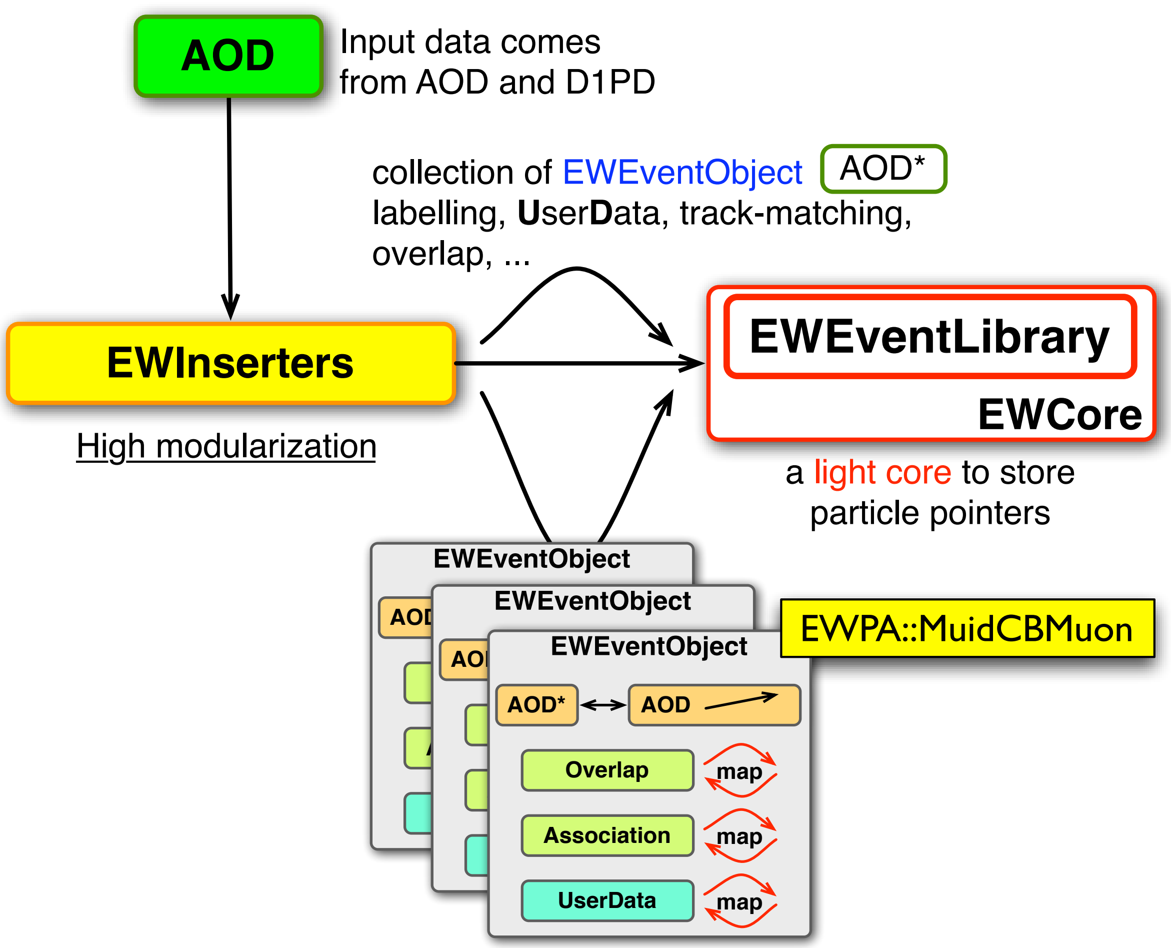
  - ★ filling EWEventLibrary attaching a Label (C++ enumeration)



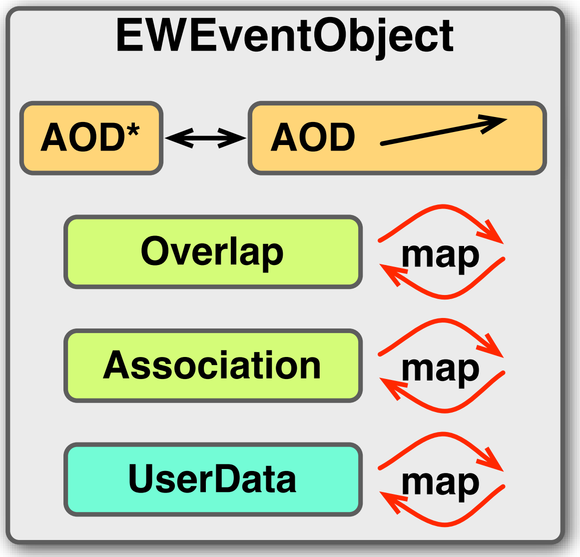


- ★ EWEventLibrary holds the vectors of inserted objects labelled in a simple way
- ★ Provides methods to get them, single and combinatorial loops
- ★ This greatly simplify the data access
- ★ AOD pre-selection will be made standard for ATLAS with common tools

Information access

- EWEventObject store the pointer to the AOD particle (m_part)
  - ★ you can access directly all the 4-vector properties with pt(), eta(), ... methods

```
float EWEventObject::pt() {
  return m_part->pt();
}
```



  - ★ you can access ALL the AOD object properties

```
EWEventObject* track;
EWEventLybrary::get(EWPA::MuidCBMuon, track, 0);

if(track->muon()) {
   float chi2 = track->muon()->matchChi2();
}
```

  - ★ you can easily get loops on particles

single loops

```
EWEventObject* track;
EWEventLibrary::resetCounter(EWPA::MuidCBMuon);
while(EWEventLybrary::getNext(EWPA::MuidCBMuon, track))
{
   if(track->muon())
      float chi2 = track->muon()->matchChi2();
}
```

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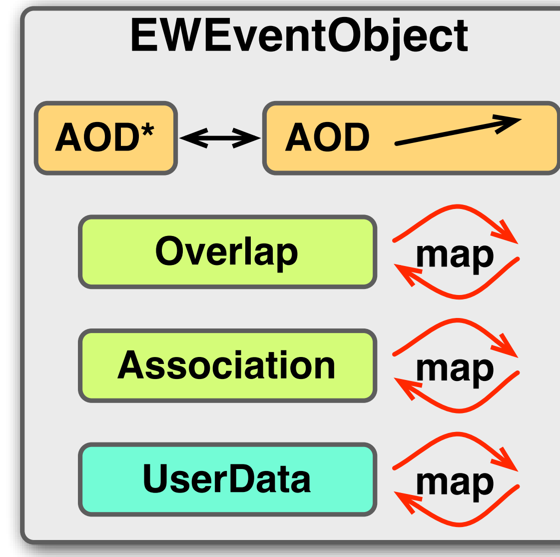

  - ★ you can access ALL the AOD object properties

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EWEventObject* track;
EWEventLybrary::get(EWPA::MuidCBMuon, track, 0);

if(track->muon()) {
   float chi2 = track->muon()->matchChi2();
}
```

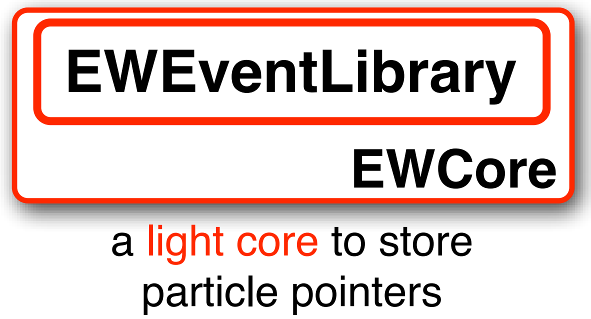
  - ★ you can easily get loops on particles

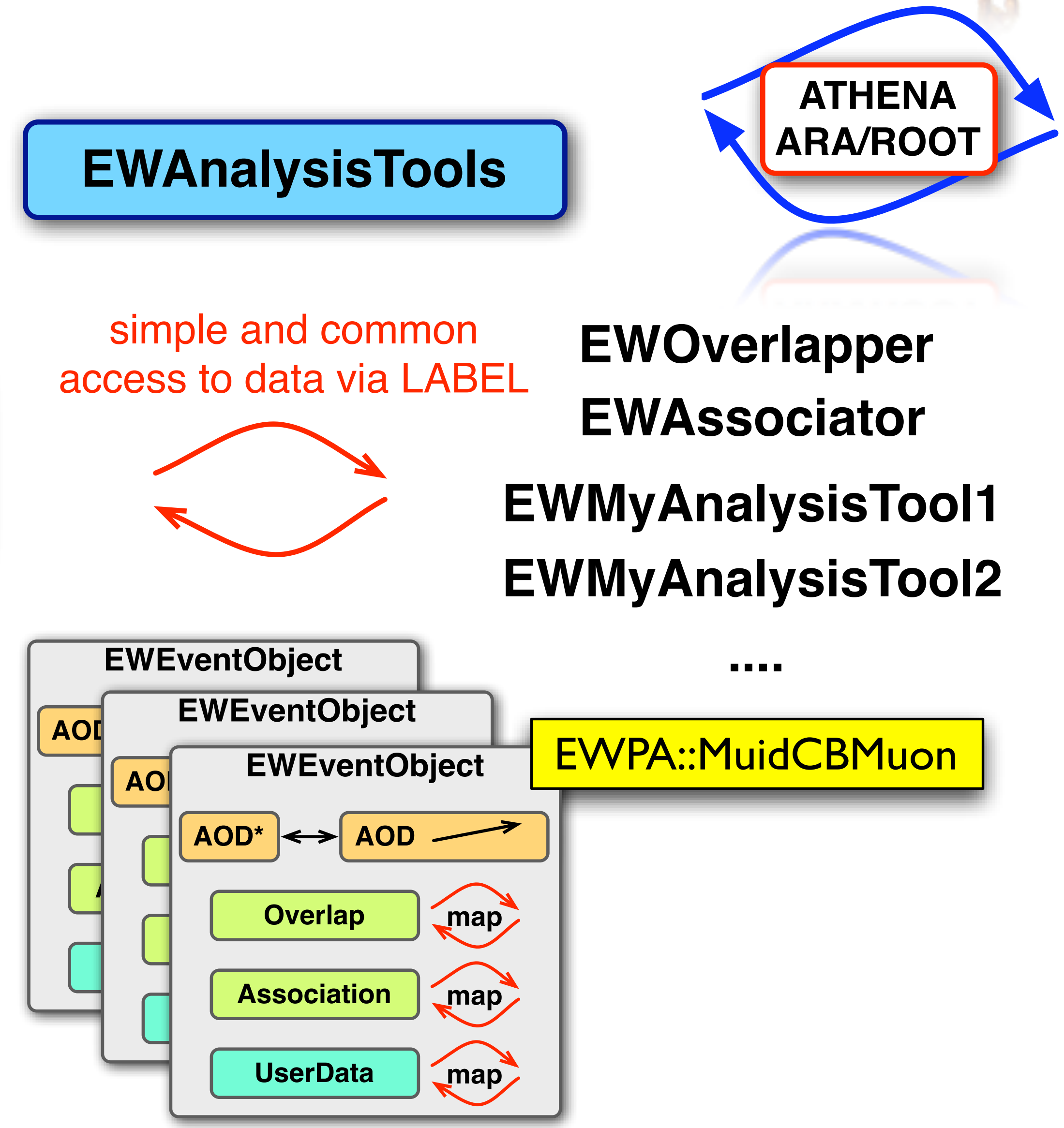
combinatorial loops

```
EWEventObject* track;
EWEventLibrary::resetCombCounter(EWPA::MuidCBMuon);
while(EWEventLybrary::getNextComb(EWPA::MuidCBMuon, track1, track2))
{
   float invMass = track1->invMass(track2);
}
```

Dual tools

- Every tool in EWPA is a "dual" tool
  - ★ "dual" means that you can run it in ATHENA and ARA without changing 1 line of code
  - ★ of course some things cannot be done in ARA (e.g. track extrapolation)
  - ★ the configuration is done via python file in ATHENA and ARA again without changing 1 line of code





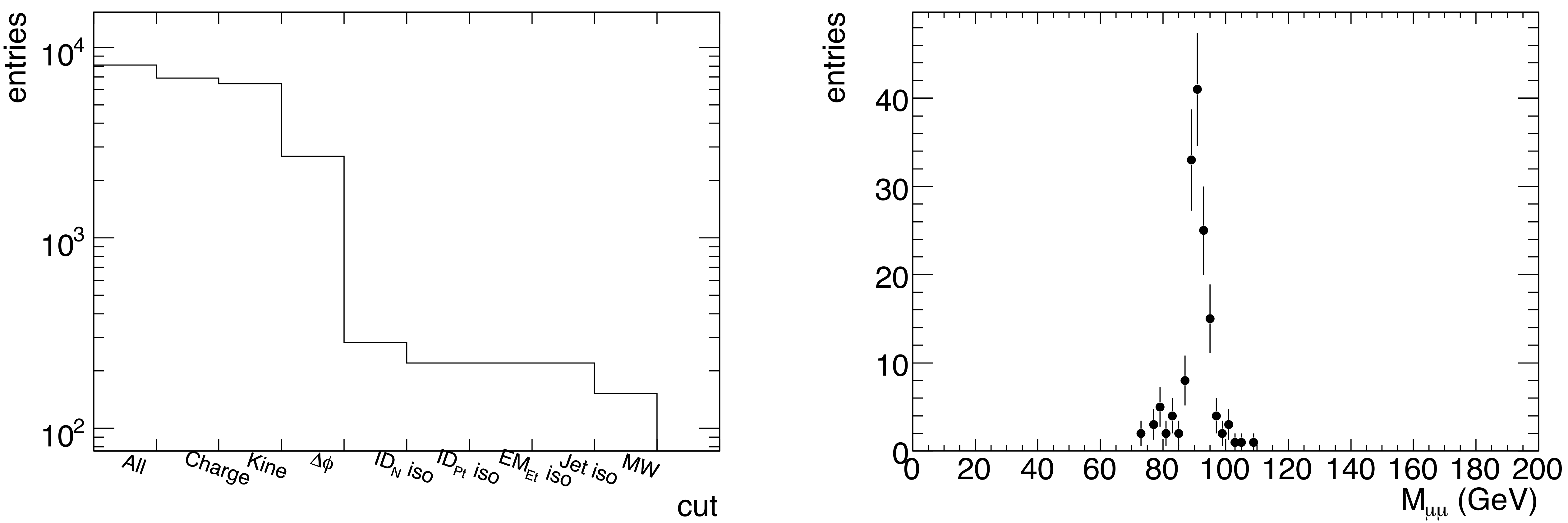
- Already available tools:
  - ★ EWAssociator: makes 1-1 track-matching based on dR cone searches
  - ★ EWOverlapper: to remove object-overlap based on dR cone searches (preliminary)
  - ★ EWTagAndProbe: to select probe tracks for performance from data <THIS WILL BE PORTED OUTSIDE EWPA AS COMMON TOOL>
  - ★ Each of them asks particles to EWEventLibrary and add information to EWEventObject

D^NPD making

- EWPA can be configured as DPD maker
  - Primary DPD (D1PD): nothing but a small AOD (or ESD for that matter), e.g. a typical AOD may be ~200 KB/event, whereas the D1PD will be ~ 10KB/event
  - Secondary DPD (D2PD): POOL-based DPD with more analysis-specific information. Typically, this is produced from Primary DPD and may be created using standard Athena or by using a framework like EventView or EWPA
  - Tertiary DPD (D3PD): Does not need to be POOL-based, it includes flat ntuples. Typically the output of an analysis
- DPD making is done via
  - Skimming : Removing uninteresting events (filtering) ex: check if the event has objects fulfilling some conditions on and pt and η
  - Thinning :Removing unused objects ex: electrons, tracks, jets not satisfying particular requirements
  - Slimming : Removing properties of objects ex: track summary
- EWPA-00-02-03 supports for thinning of objects, also other features will be added in next update

Running on the grid

- Twiki page for run in Ganga https://twiki.cern.ch/twiki/bin/view/Atlas/EWPAFdr2
  - ★ Just an example of Z to muon selection on 0.36 pb^{-1} of data



- Different exercises to make D2PD, D3PD stored on the grid

Documentation

- Documentation
  - TWiki page https://twiki.cern.ch/twiki/bin/view/Sandbox/EWPAMainPage
  - CVS repository /offline/PhysicsAnalysis/AnalysisCommon/EWPA
  - mailing list https://lists.infn.it/sympa/info/ewpa-news
- HowTo tutorials listed from the main twiki
  - How to read the D3PD EWTree
  - How to develop dual tools in EWPA
  - How to run EWPA with FDR2 data
- Doxygen code is quite in place: need only to generate pages and do some checks
  - i expect they will be ready soon :-)
- A EWPA session with PAT tutorial will be done at Cern in July (in 14-18 week)

W,Z analysis: trying to fill a table ...

Acceptance	NLO EW PV	NLO QCD R2	NLO QED PV R2	PDF ?
	ISR R2	k_T R2	ME R2	UE R2
Efficiency from data	trigger/offline R1 PV	backgrounds R1 PV	probe system R1	pile-up - caver R1 PV
	fakes R1 PV	efficiency storage X PV		
Momentum scale	Z spectrum analysis R3	constrained fits R3		
Signal selection and Background estimation*	W/Z signals X	EW backgrouns X	QCD background X	
EWPA code	PV, RM3 users R3 PV	more devs ? X		

*probably all of us want to have a look here

X = others, basically CERN and Lisbona group