# W/Z analysis in ITALY

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- Preparation meetings in July and September
- In the last one, decided to organize:

#### 1) **a mailing list:** <u>atl wz italia@lists.infn.it</u>

# 2) a challenge with the official cut-flow

http://web.infn.it/atlas/ index.php/analisi-di-fisica/ 131-fisicaz

> Thanks to B. Giacobbe who prepared the W/Z analysis pages in the ATLAS Italia web site

# Rome 1 & Bologna already there!!

#### z -> µµ

Reference note to be used to produce cut flow: http://cdsweb.cern.ch/record/1287555/files/ATL-COM-PHYS-2010-685.pdf

#### Real data: Periods and Integrated Luminosity

Integrated Luminosity (nb-1) Run number range W-GRL Z-GRL A-C: 152844-156682 16.65 17.60 D1: 158045-158392 26.89 28.64 D2: 158443-158582 29.03 31.76 D3: 158632-158975 32.85 34.71 D4: 158041-159086 79.40 87.82 D5: 159113 28.04 28.38 D6: 159179-159224 97.05 101.85 Tot:152844-159224 310.00 330.80

#### MC sample:

https://twiki.cern.ch/twiki/bin/view/AtlasProtected/ZWD3PDProduction#MC\_D3PDs\_from\_AODs\_with\_Pileup

#### GRL to be used:

https://espace.cern.ch/atlas-perf-muon-sharepoint/Lists/WZ%20Muon%20Observation/AllItems.aspx

#### Real data ntuples:

Note: at the beginning we can use different ntuples but we have to converge soon to a common set of ntuples These are located in:

https://twiki.cern.ch/twiki/bin/view/AtlasProtected/WZObservationWithMuons#SM\_WZ\_D3PD\_production

### W/Z analysis in Bologna G. Bruni, M. Corradi, L. Bellagamba, B. Giacobbe, A. Zoccoli, A. Mengarelli, F. Lasagni, B. Giacobbe, S. Valentinetti

- Preparation of the W/Z page and of the cutflow.
- Involved in the cut flow cross check for MC and real data.



- 1) Repeat ICHEP analysis (on real data and MC)
- 2) Muon trigger eff studies
- 3) ee and  $\mu\mu$  channels combination
- 4) Luminosity, good run list and support for L determination
- 5) PDF systematics (both on the theoretical x-sec and on the measurement efficiency)
- 6) Production of a luminosity monitor

W/Z analysis in Rome I C. Bini, C. Dionisi, S. Giagu, F. Lacava, C. Luci, F. Marzano, M. Rescigno (senior), M. Giunta, P. Mastrandrea, E. Solfaroli (Post-doc), G. Artoni, S. Borroni, V. Ippolito, F. Lo Sterzo (dottorandi), F. Scutti (laureandi)

# \* Trigger requirements

ONGOING

\* Study, optimization and understanding of the trigger efficiency for  $\mu$  (L1, HLT)

\* Tag&Probe study (trigger and reco efficiency):

**ONGOING** \* implementation of the framework

- insituperformance
   \* on the (Z+iet) data
- reweighting MC

\* Study and optimization of the isolation requirements

ONGOING

**\*** Online (μIso)**\*** Offline

Background studies with datadriven method:
\* knowledge CDF

# **\*** Resolution study

ONGOING

implementation of the framework
insituperformance
reweighting MC

### W/Z analysis in Rome I Muon momentum resolution

Cesare/Elena/Federico Risultati preliminari

- Resolution spectrometer-tracker wrt to  $(\boldsymbol{p}_T, \boldsymbol{\eta}, \boldsymbol{\phi}).$
- Presently on inclusive muon samples
- Data comparison with different MC samples (Pythia):



•  $\mu$  trigger/reco efficiencies with T&P using Z- $\mu\mu$  events, cross check with incl.  $\mu$ 

#### InDet probes:

\_InDet tracks only: measure reco eff and absolute trigger eff

#### Muon probes:

Combined  $\mu$  with same id criteria as used in the analysis: measure trigger eff w.r.t. the reconstruction – relevant for physics analyses

- Tag = a selected combined muon, matching a trigger RoI (avoid biases on trigger efficiency) + other various quality and ID cuts
- Full analysis implemented in Athena (InsituMuonPerformance, within InsituPerformance)
- Results for 1.3 pb<sup>-1</sup> (period A-E) L1\_MU10 trigger (other results available)
- Method and results shown here are included in the W/Z+jets CONF notes



### W/Z analysis in Rome II G. Cattani, A. Di Ciaccio, R. Di Nardo, A. Di Simone

- Involved in the first measurement of W/Z production cross section (ATL-COM-PHYS-2010-709)
- In the last month presented in the W/Z working groups new results on:
  - Trigger studies for recent data taking periods (~3.1/pb periods A-F2)
  - Analysis of the F/B charge asymmetry of  $Z \rightarrow \mu\mu$  events
- Within the SM group:
  - involved in the physics validation task for  $Z \rightarrow \mu\mu$  channel (G. Cattani, A. Di Ciaccio)
- New manpower is coming:

**Two master students** 

R. Di Nardo (interested in the study of QCD background systematics in  $Z \rightarrow \mu\mu$  channel for T&P trigger efficiency estimation)

## W/Z analysis in Rome II Data samples and Signal extraction

- Data distributions compared with Pythia  $Z \rightarrow \mu\mu$  MC pile-up (reweighted)
- Data
  - Period A G6: run # 152844 -166198 (total integrated luminosity ~ 9.7/pb)
  - Skimmed D3PDs from Max
- All plots refer to muid tracks
  - Staco gives similar results
- Following plots only for G period
  - Better detector/reconstruction conditions

GRL + bcid**Collision event** Trigger selection • Period A-E: L1\_MU6 • Period F-G6: EF mul0 MG  $N_{VTX} >= 1, N_{tracks} >= 3, |Z_{VTY}| < 150 \text{ mm}$ •  $p_T > 15 \text{ GeV}, |\eta| < 2.4$ •  $p_T MS > 10 \text{ GeV}$  selection •  $|p|^{MS} - p_T^{DV}$  $|\mathbf{p}_{\mathrm{T}}^{\mathrm{MS}} - \mathbf{p}_{\mathrm{T}}^{\mathrm{ID}}| < 15 \mathrm{GeV}$ •  $|z_0 - z_{VTX}| < 10 \text{ mm}$ •  $p_T > 20 \text{ GeV}, |\eta| < 2.4$ •  $\sum P_{T}^{ID}/p_{T}^{I} < 0.2$  $Z \rightarrow \mu\mu$  event Opposite charge selection 60 < M < 116 GeVμμ

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### W/Z analysis in Rome II Kinematical distributions for trigger studies



- Inclusive muon distributions
  - Combined muon
  - pT>20 GeV (only for pT)
- Some discrepancies are visible
- EF\_mu10 and EF\_mu10\_MG almost identical

#### Z peaks with different triggers



Only a very small impact (if any) on the Z mass

## W/Z analysis in Rome II F/B charge asymmetry in $Z \rightarrow \mu\mu$

- Parity violation in weak current interaction give rise to an asymmetry in the polar emission of the muons
  - $d\sigma/d\cos\theta = A(1+\cos^2\theta) + B\cos\theta$
- Measurement of F/B charge asymmetry → SM test
- In pp collisions incoming quark 4-momenta in the di-muon reference frame are not known.
  - Assumed here: quark direction is the dimuon direction
- Quark transverse momentum not negligible. Quark-muon  $\theta$  angle unknown
- Use the Collins-Soper reference frame:
  - di-muon rest frame
  - θ wrt axis that bisects the angle between P1 and -P2 (incoming p momenta)



# W/Z analysis in Rome II F/B charge asymmetry in $Z \rightarrow \mu\mu$



- $\cos(\theta^*)$  distribution for data and Pythia Z  $\rightarrow \mu\mu$  MC with pile-up
- Data from last runs
  - Better reconstruction/detector conditions
- Only muon pairs of BB or BE(EB) type



• Counting method:

• 
$$A_{FB} = (F-B)/(F+B)$$

F = number of events with  $\cos(\theta^*) > 0$ B = number of events with  $\cos(\theta^*) < 0$ 

A <sub>F/B</sub> (%) MUID					
МС	Data				
1.3 +- 0.3	0.7 +- 2.7				

• Only statistical error

W/Z analysis in LNF/Pavia Background estimation to Z → µµ: template fit C. Gatti, M. Bellomo, M. Dreucci, A. Salvucci

Explicit Trigger requirement L1\_mu6 (then depends on trigger menu ...)

# Dataset up to run 166850 (periods C to H1): L ~ 20 pb-1 All ntuples from WZ group (skimmed by Max & Matthias)

GoodRunsLists

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2 combined muons (Muid) opposite sign
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Npxl>0,Nsct>5,Ntrt>5 for |\eta| < 1.9
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pT> 15 GeV

 $\Sigma pT/pT < 0.2$ 

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z0 = 10 mm (from primary vertex)
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d0 = 2 mm

#### Template-fit to reconstructed Z lineshape

 Allow for MC momentum smearing in fit
 Combined fit of events of type BB, BE and EE
 Fit separately Z lineshape obtained with ID and MS tracks (but CB-based selection)

#### + Template-fit to (q/pTID-q/pTMS)

- 1. Same procedure as above
- 2. Keep B and E regions separated

# W/Z analysis in LNF/Pavia Background estimation to $Z \rightarrow \mu\mu$ : template fit

Parameter	Value						
$\Delta b_{Bar}$	$(2.73\pm 0.10)\%$	1	0.10	0.15	-0.50	-0.58	0.50
$\Delta a^{MS}_{Bar}$	$(0.00\pm 0.09){ m TeV^{-1}}$	-	1	-0.36	0.57	-0.68	-0.45
$\Delta b_{Ecap}$	$(4.28\pm 0.39)\%$	-	-	1	-0.55	0.11	-0.08
$\Delta a^{MS}_{Ecap}$	$(0.77\pm0.22){ m TeV^{-1}}$	-	-	-	1	0.01	-0.70
$\Delta a^{ID}_{Bar}$	$(0.42\pm0.05){ m TeV^{-1}}$	-	-	-	-	1	-0.09
$\Delta a^{ID}_{Ecap}$	$(0.92\pm0.14){ m TeV^{-1}}$	-	-	-	-	-	1

\*Assuming no correction for multiple scattering in ID

**Resolution Parametrization:** 

 $rac{\sigma(p_T)}{p_T} = rac{p_{Calo}}{p_T} \oplus p_{ms} \oplus p_{meas} imes p_T$ 

\*\* Only Statistical Errors Correction Terms:

 $p_T \rightarrow p_T \times (1+g \Delta b + g \Delta a^{MS} p_T)$ 

 $p_T \rightarrow p_T \times (1+g \Delta a^{ID} p_T)$ 

In MS barrel <0.1 TeV<sup>-1</sup> $\rightarrow$  <40  $\mu$ m misalignment In ID barrel 0.4 TeV<sup>-1</sup> $\rightarrow$  30  $\mu$ m misalignment

# W/Z analysis in LNF/Pavia Background estimation to $Z \rightarrow \mu\mu$ : template fit



W/Z analysis in LNF/Pavia Background estimation to  $Z \rightarrow \mu\mu$ : QCD shape from non-isolated events

#### Check Data/MC agreement Data Non-Isolated vs MC Non-Isolated





Very similar invariant mass shape for non-isolated events in data and MC

Similar results using same-sign events. The three methods give results in agreement.

W/Z analysis in LNF/Pavia Background estimation to  $W \rightarrow \mu v$ : QCD shape from non-isolated events

After cleaning and ETMiss cut, with QCD shapes extracted data/MC disagreement recovered

To reduce MT vs isolation correlation, reject events where ETMiss is along a Jet or the muon direction



#### W/Z analysis at Udine/ICTP W + Jets Production Measurement with Charge Asym. B. Acharya, K. Shaw

Work Presented in Top Cross-section meeting, to be presented at WZ Physics Group.

W-boson production at LHC **charge asymmetric** due to different PDF's of quarks and antiquarks in protons.

$$r \equiv \frac{\sigma(pp \to W^+)}{\sigma(pp \to W^-)}$$

$$N_{W^+} + N_{W^-} = \left(\frac{r_{MC} + 1}{r_{MC} - 1}\right) (N_{W^+} - N_{W^-})_{DATA}$$

$$Total W + Jets$$

$$Relatively well understood We measure this difference from theory$$

As other relevant SM processes are charge symmetric, can measure the number of selected events with positive  $(D^+)$  and negative  $(D^-)$  leptons

$$D^+ - D^- \approx \mathcal{N}_W^+ - \mathcal{N}_W^-.$$

Event Selection - Exactly one lepton with  $p_T > 25$  GeV and Missing  $E_T > 20$  GeV

		$W \rightarrow \mu \nu + jets$	$W \rightarrow \tau \nu + jets$	$Z \rightarrow \mu \mu + jets$	QCD	Data			
Muon channel results with data from A to F2 (2.9 pb <sup>-1</sup> ) $(N_W^+ - N_W)_{DATA} = 2298$	$W^+$	7357	131	236	430	7051			
	$W^-$	4734	96	203	358	4753			
	$W_{TOT}$	12091	227	439	788	11804			
	A	0.22	0.16	0.07	0.091	0.19			
	ε	0.392	0.007	0.147	0.0002	0.034			

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W/Z analysis in Lecce 1 fb-1 analysis @ 7 TeV G. Chiodini, S. Spagnolo, N. Orlando

Z+b-jet (PhD project if available)

-Background for associate H production

-Prediction tests for pQCD

-Sensitivity to New Physics

Di-Boson production (longer term interest) -Anomalous gauge-boson couplings -Vector-boson scattering

#### W/Z analysis in Rome III

T. Baroncelli, B. di Micco, A. Farilla, M. Iodice, D. Orestano, F. Petrucci + 2 nuovi acquisti + S. Franchino

#### Situazione attuale

-Finalising inclusive μ's analysis (few pb-1 sample)
-First version of CONF note by end of the year. Paper?

#### Future interests

-Ratio of W/Z x-sections using the inclusive muon spectrum

-Trigger eff, reco, momentum scale for Z-> μμ

-Performance studies <sup>18</sup>

## W/Z analysis in ITALY Conclusions and Next steps

- Clear view of the ongoing activities
  - Several groups already active and presenting in official meetings. Very good starting point-
  - Some other groups started: finding their way (W/Z list seems useful)
  - Few groups have longer scale to start (next year probably)
- To be done:
  - Complete the cut flow challenge and understand differences
  - Converge on some common items
    - Groups/people which still have to start, better join existing efforts
- Reconvene 15 (16) December in Rome II for a small W/Z workshop with presentations from individuals (Thanks to A. di Ciaccio for taking care!)
  - Tasks which require helps should be presented