V ATLAS Italia Physics Workshop, 18-19 May 2011

W/Z Results

Giacomo Artoni

INFN Roma 1 and “Sapienza” Università di Roma

W/Z Inclusive Cross Section Measurement

In a nutshell...

$$\sigma_{tot} = \sigma_{W/Z} \times BR(W/Z \to l\nu/ll) = \frac{N - B}{A_{W/Z} C_{W/Z} L_{int}}$$

- **N: number of events passing our selection criteria;**
- **B: estimated number of background events;**
- **$A_{W/Z}$: acceptance factor** $A_{W/Z} = \frac{N_{MC,gen,cut}}{N_{MC,gen,all}}$ **;**
- **$C_{W/Z}$: trigger and reconstruction efficiencies** $C_{W/Z} = \frac{N_{MC,rec}}{N_{MC,gen,cut}}$ **;**
- **L_{int}: integrated luminosity (37.6 pb^{-1} for $e^{\pm}$ and 33.8 pb^{-1} for $\mu^{\pm}$).**

Italian groups involved

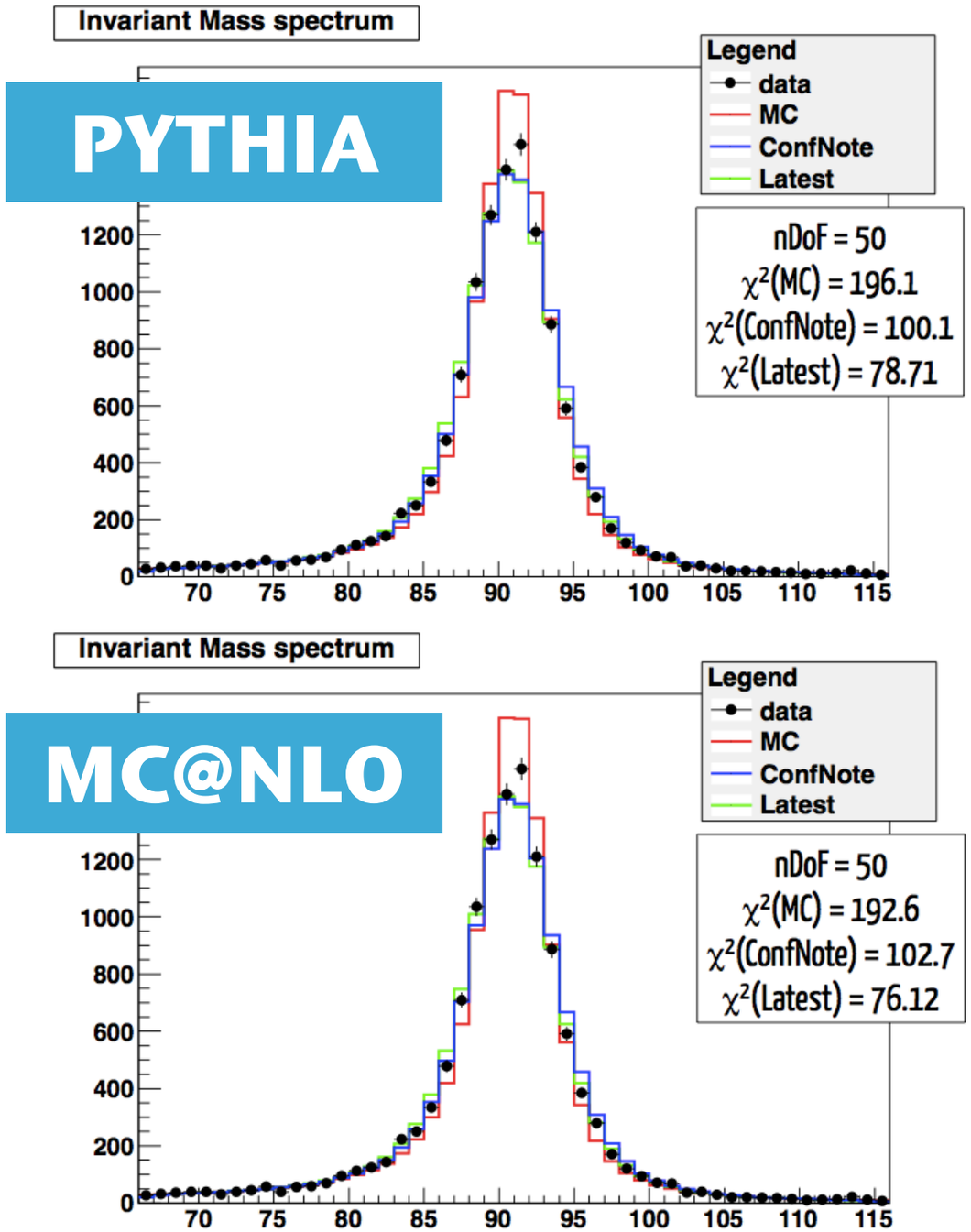
Disclaimer: I will focus on the Z→μμ cross section measurement since it has been completed only by italians!

- **Bologna**: **Benedetto Giacobbe, Alberto Mengarelli;**
- **Frascati**: **Claudio Gatti;**
- **Pavia**: **Massimiliano Bellomo*;**
- **Roma 1**: **Giacomo Artoni, Sara Borroni, Stefano Giagu, Michele Giunta, Valerio Ippolito, Francesco Lo Sterzo, Paolo Mastrandrea, Marco Rescigno, Elena Solfaroli Camillocci**
- **Roma 2**: **Antonio Salvucci.**

***W, Z Inclusive Cross Section Measurements Group co-convenor and μ primary responsible for the measurement.**

Muon p_T resolution (Frascati, Roma1 & Roma2)

- **Muon p_T resolution has to be adjusted on MC to resemble the distributions seen in data;**
- **This has been done in different ways and it is still under study;**
- **The systematic effect induced by this is about 0.4% for the W and about 0.2% for the Z.**



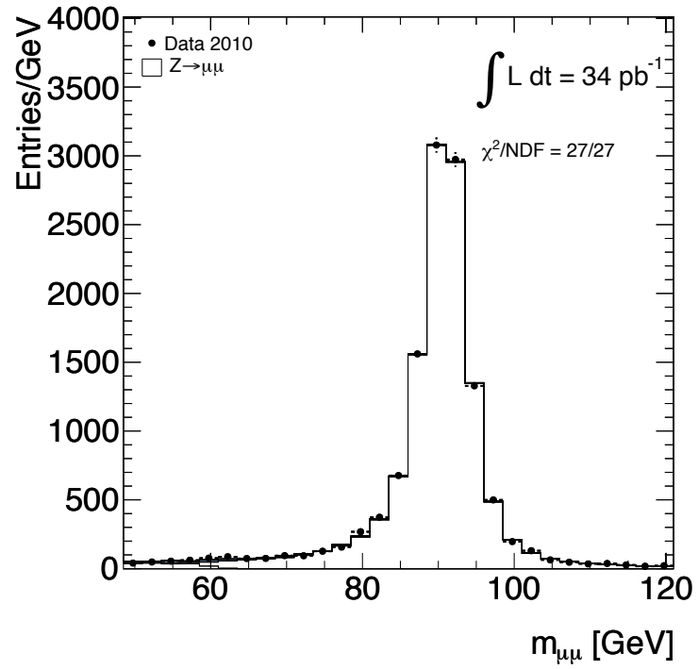
Background estimation (Frascati, Pavia & Roma1)

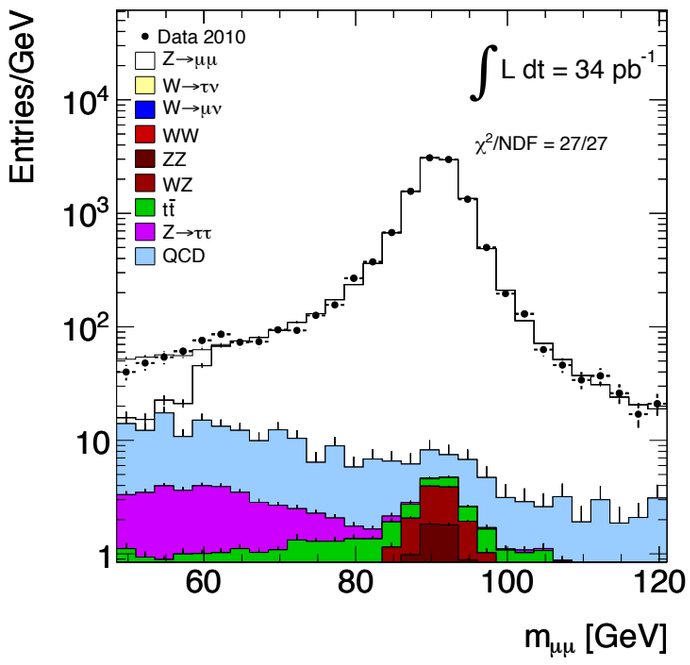
- The electroweak backgrounds (ttbar, $Z\to\tau\tau$, $W\to\tau\nu$, WW, WZ, ZZ, $W\to\mu\nu$) have been estimated using only MC (total contribution is about 0.4%).

- But can you see the background in the upper plot?

- Only on log scale background is visible and this should tell you which precision this measurement has achieved and how clean our signal is!

- The only background for which we decided not to rely on MC is the QCD (and yet its contribution will be of about 0.2 %).

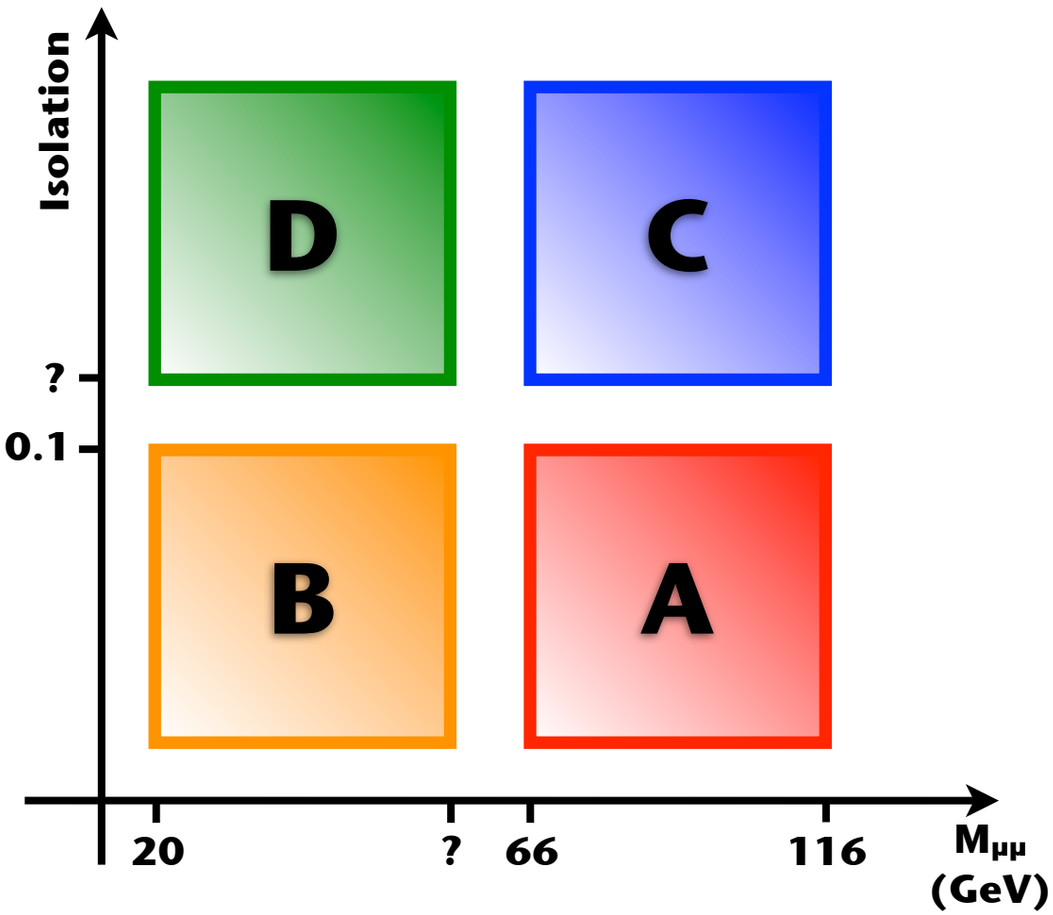




Background estimation (Frascati, Pavia & Roma1)

Nevertheless, we decided to use two different approaches:

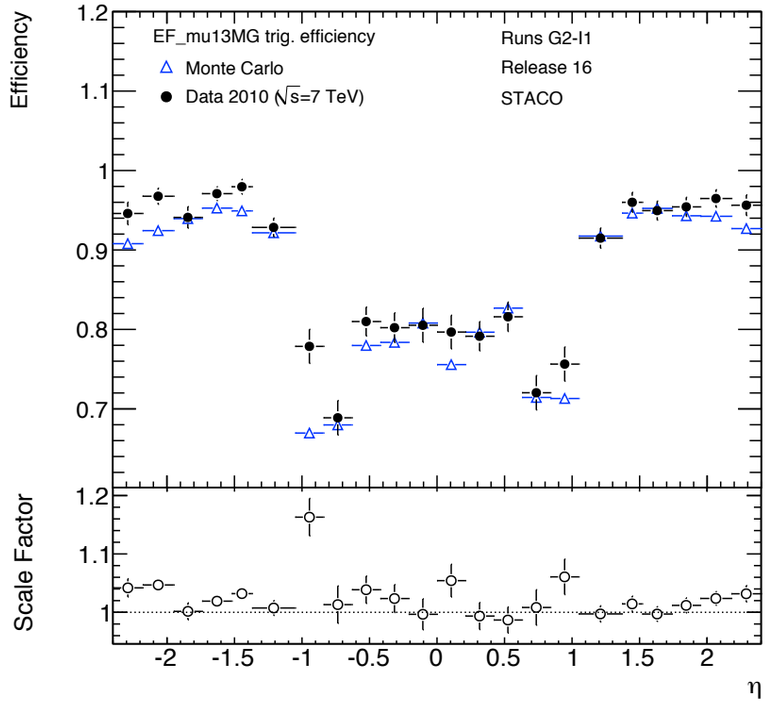
- **Template fit method:**
  - **We extract templates for the QCD and then we fit the invariant mass spectrum to measure the component of QCD.**
  - **These templates have been taken from MC and data and also tested for different selections.**
- **'ABCD' method:**
  - **We assume that the QCD background has no correlation between $M_{\mu\mu}$ and isolation;**
  - **So we can use sideband to extract the number of QCD events in the signal region! (but we need to subtract electroweak MCs first).**

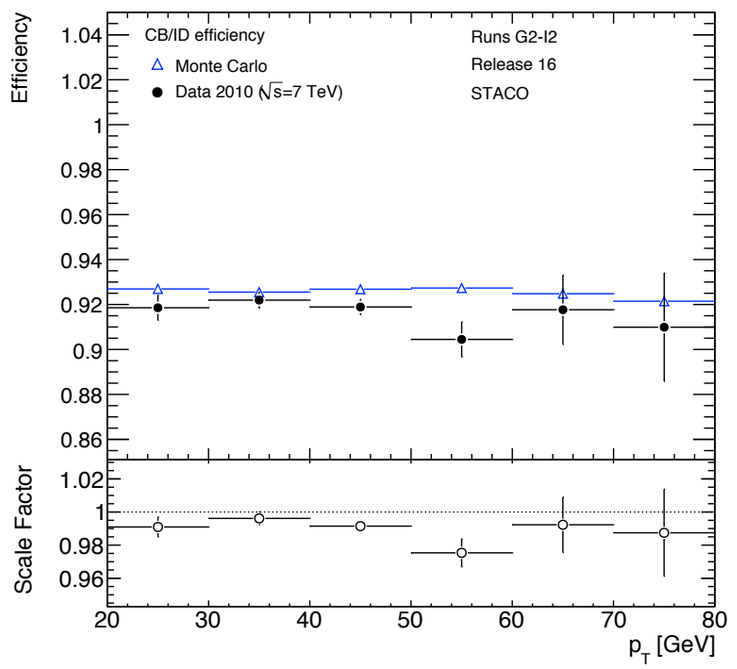


$$N_A = \frac{N_B \times N_C}{N_D}$$

$A_{W/Z}$ & $C_{W/Z}$ (Pavia & Roma1)

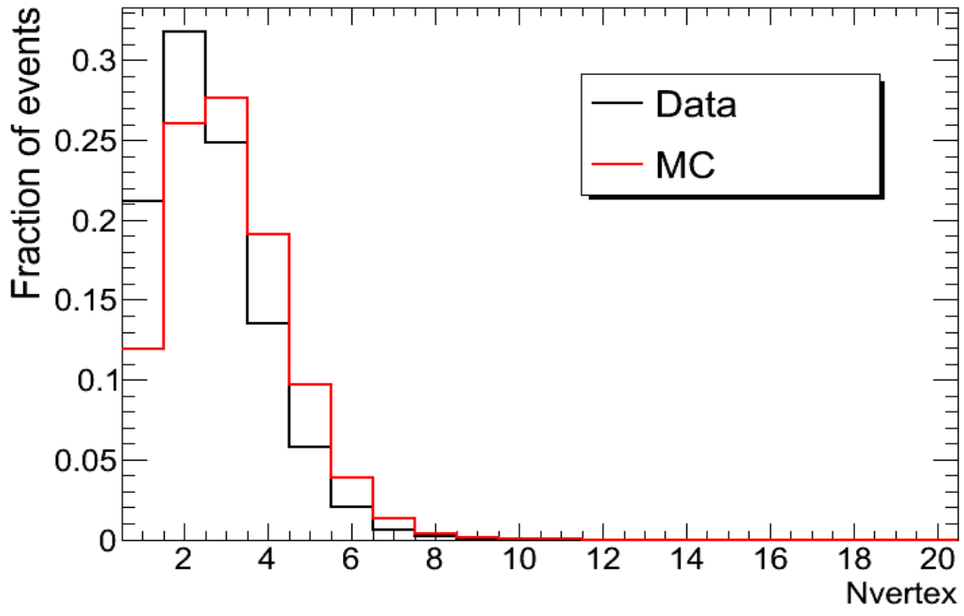
- $A_{W/Z}$ have been calculated using PYTHIA MonteCarlo;
- For the $C_{W/Z}$, we have different terms that must be combined:
  - Trigger efficiency;
  - Reconstruction efficiency (0.8% syst);
  - Isolation efficiency (0.6% syst);
- For all these cases, a Tag & Probe method has been used.

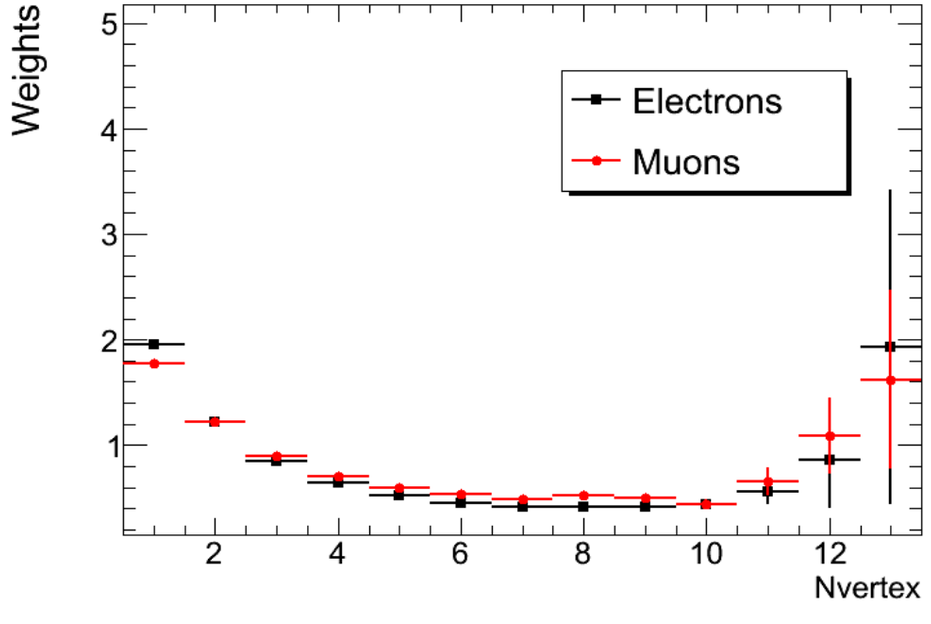




Pile-up reweighting (Bologna)

- MC has been reweighted to have the same distribution of the number of verteces as in data;
- The systematic uncertainty for this effect has been calculated generating 10000 sets of weights.
- The final systematic effect is estimated to be $^{+0.045\%}_{-0.022\%}$;
- We must keep in mind the difference in MC efficiency if we apply this reweighting or not is about 0.06%!





Muon Quality ID cuts (Bologna)

- In our selection, we require a combined muon (following MCP prescriptions) whose inner detector track should pass specific requirements;

- The systematic uncertainty for each of these cuts has been calculated varying each cut and looking at the effect on the final measurement.

Cut	δσ/σ (%)
B Layer	0.216
Pixel	0.030
SCT	0.053
Pixel/SCT holes	0.017
TRT	0.034
Total	0.23

Results for σ_{tot} (nb)

	$\sigma \cdot BR$	stat	syst	lumi	acc
W^+	6.257	0.017	0.152	0.213	0.188
W^-	4.149	0.014	0.102	0.141	0.124
W	10.391	0.022	0.238	0.353	0.312
Z	0.945	0.006	0.011	0.032	0.038

- Unlike the first measurement with 0.3 pb^{-1}, our statistical error is much smaller than the systematic uncertainty;
- This proves that our effort in studying all the systematics was necessary;
- Especially in the Z case, our total uncertainty is mostly due to acceptance and luminosity uncertainties…

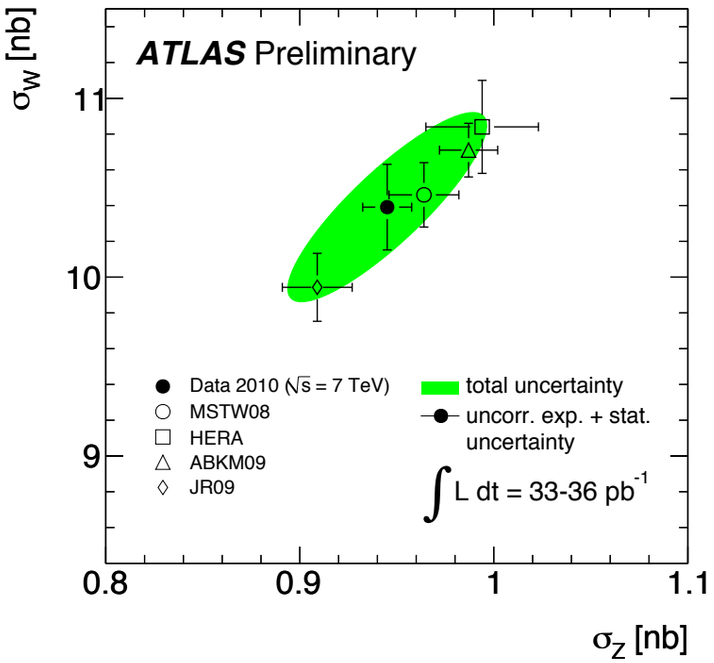
Comparison with CMS

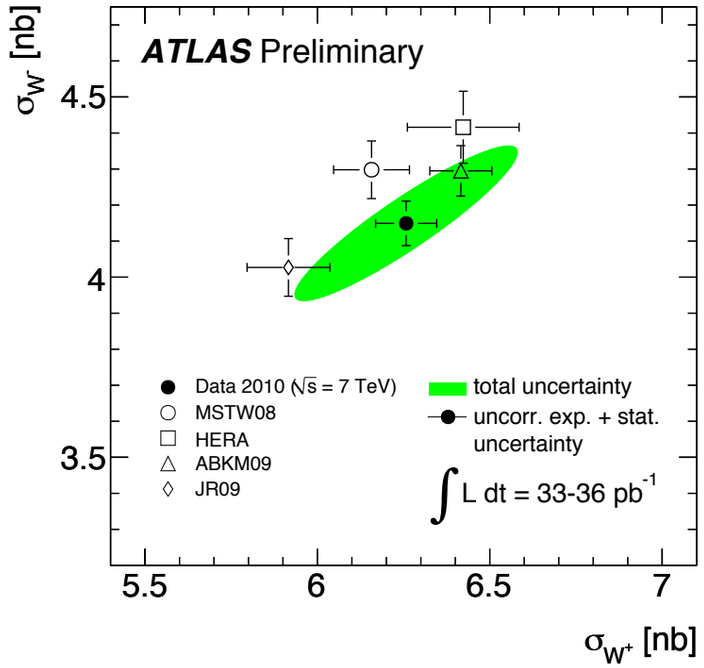
ATLAS		statistical	systematic	acceptance
σ(W)/σ(Z)	10.906	0.079	0.215	0.164

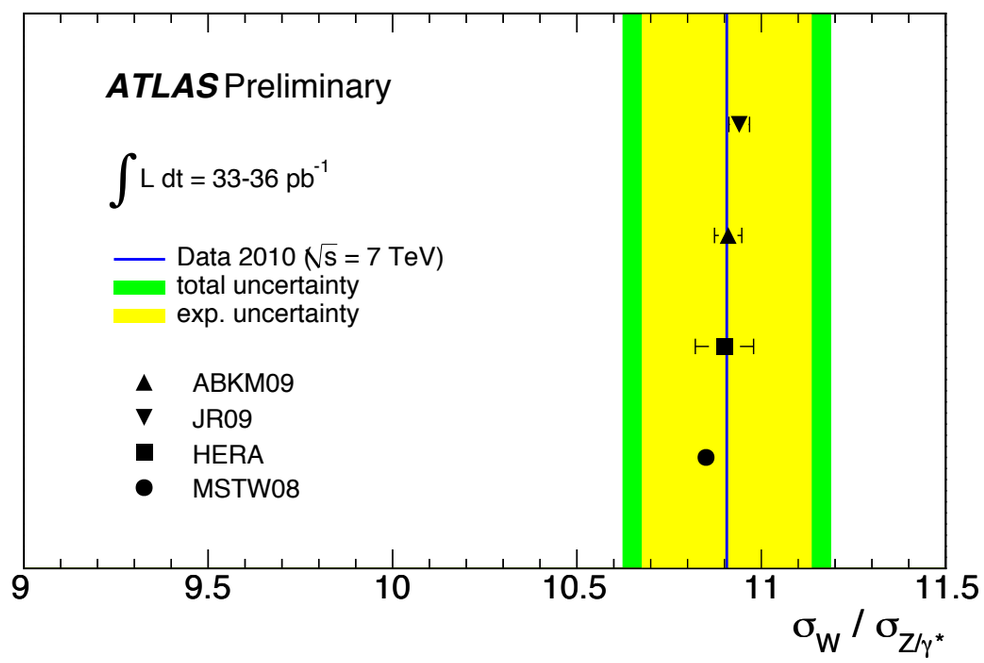
CMS		statistical	systematic	theory
σ(W)/σ(Z)	10.54	0.07	0.08	0.16

With the current studies, see following slides, we expect to reach a systematic uncertainty similar to that of CMS, so do not be scared!!

Combinations







- As you can see from these plots (left to right, σ_W vs σ_Z, σ_{W^+} vs σ_{W^-} and σ_W/σ_Z), we now have enough precision to test different sets of parton distributions;
- What should we do to have a better test of the PDFs? We should go to a $d\sigma/dy$ measurement…

Differential Measurement

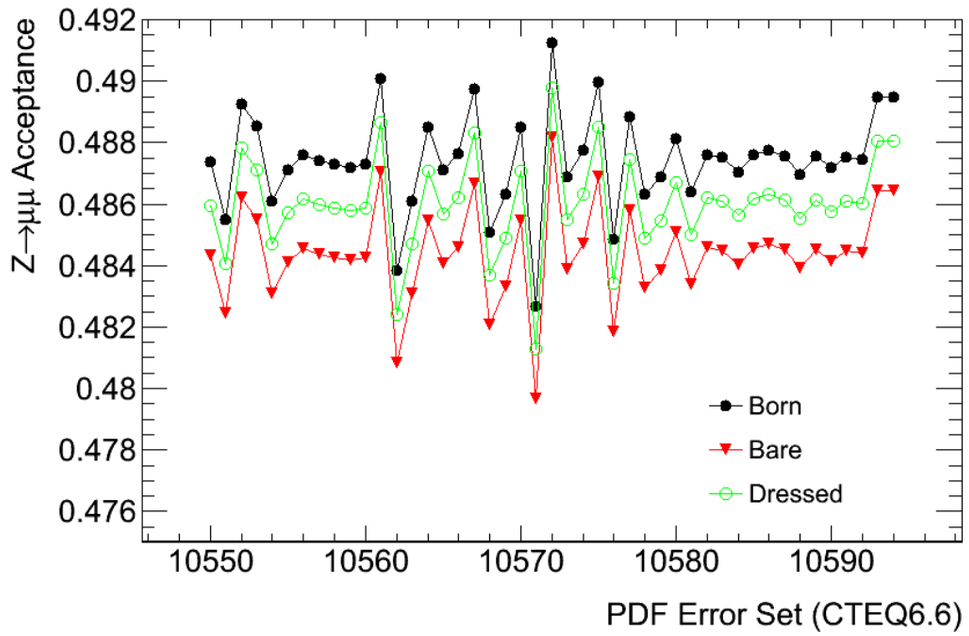
People involved: all of the Conf Note except that for Roma2
Roberto Di Nardo and Francesco Guescini joined while Antonio left.

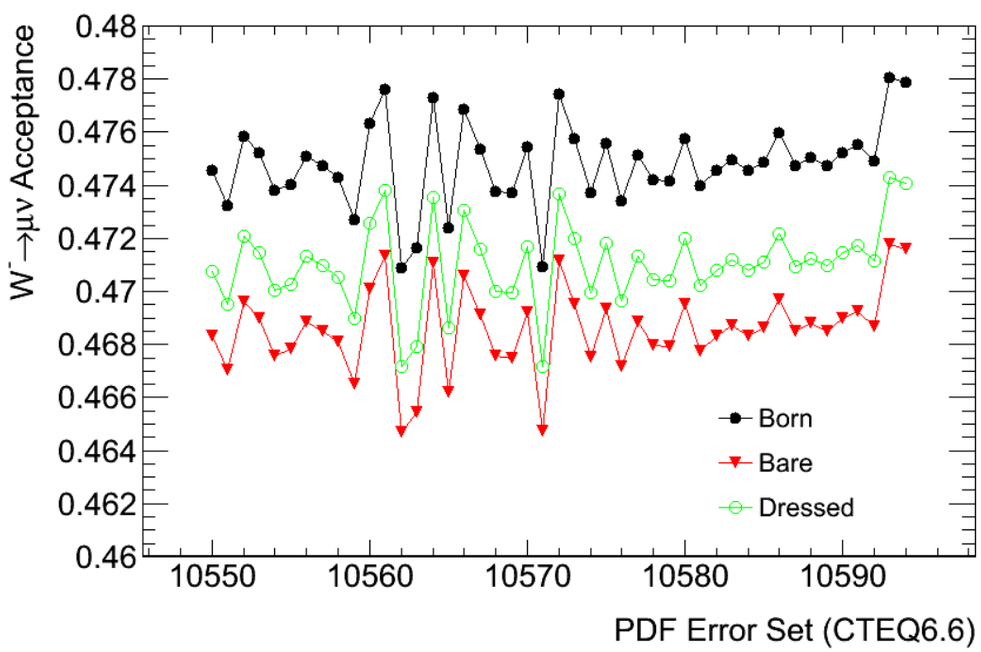
What's different from the inclusive measurement?

- The core of the measurement is exactly the same, except that we want everything calculated in bins of y_Z;
  - This includes a lot of work because we need to evaluate systematic effects as a function of the lepton η;
- We also need to define a strategy on the fiducial volume for electrons and muons to enable a better combination (and also exploit the Z cross section measurement from forward electrons);
- Change MC: passing from PYTHIA to MC@NLO to POWHEG;
- Test different PDFs to see what is the impact on the final measurement;
- As I already said, we need to review our systematic uncertainties calculation and check that we have not been too conservative!

Towards a 2011 paper (Roma2)

- **Acceptances have been calculated for different lepton definitions:**
  - **Born which means lepton before FSR (and this is actually where we are correcting at the moment);**
  - **Bare (leptons after FSR), which should be what we really see;**
  - **Dressed (leptons after FSR + FSR γs), which, of course we do not see, but have been studied as a cross-check.**



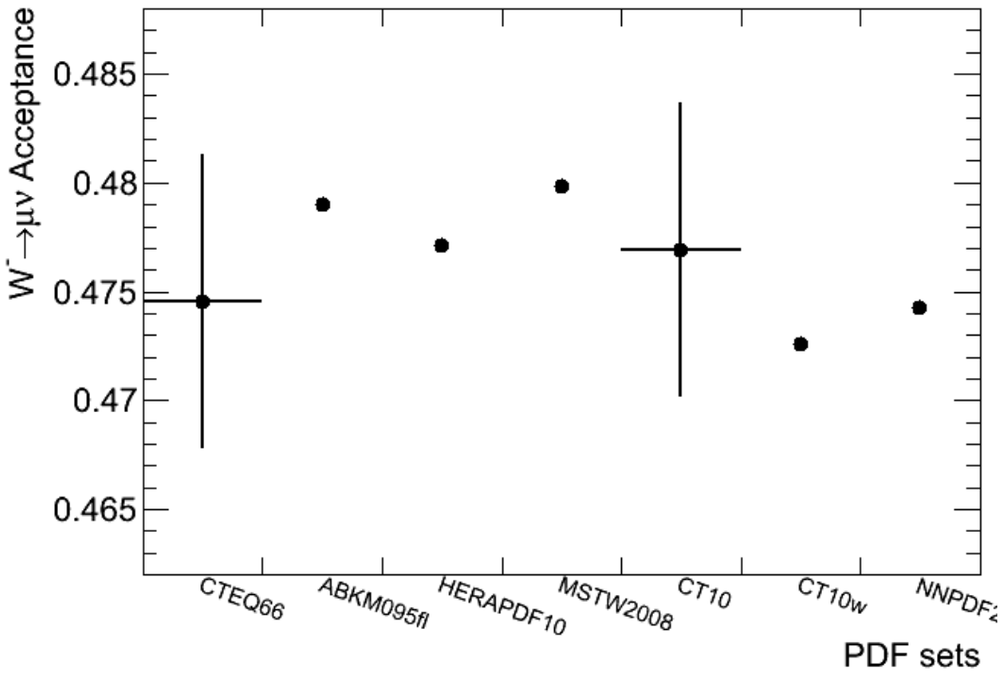


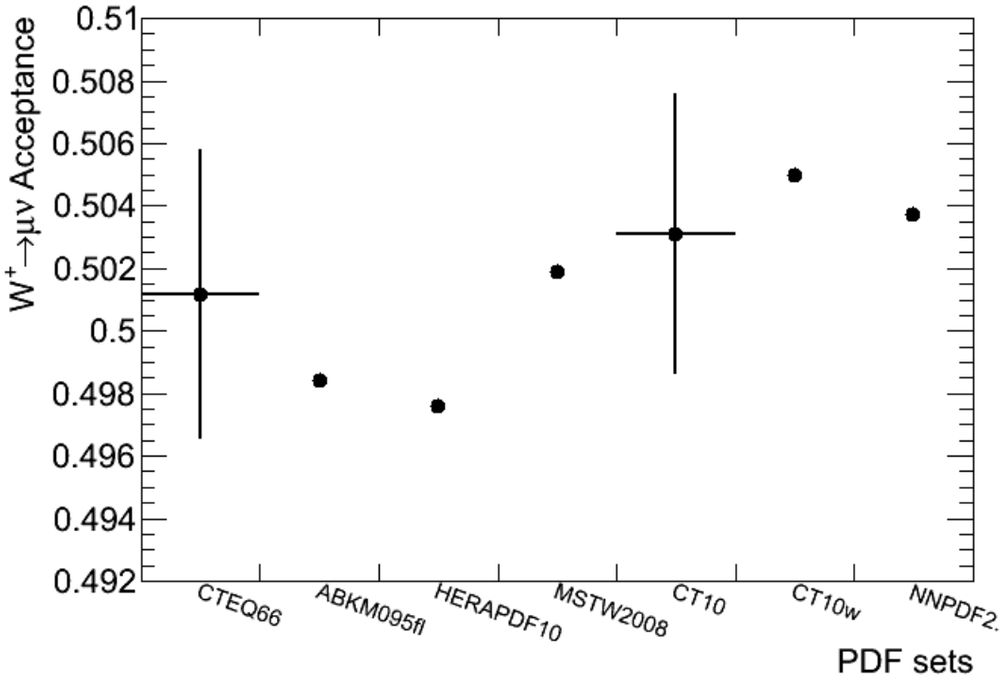
Acceptances (Roma2)

- **PDF reweighting:**

$$w_{PDF} = \frac{f_{PDF_{new}}(x_{flav_1}, Q) f_{PDF_{new}}(x_{flav_2}, Q)}{f_{PDF_{old}}(x_{flav_1}, Q) f_{PDF_{old}}(x_{flav_2}, Q)}$$

- **Work in progress:**
  - **Waiting for W and Z POWHEG samples for more comparisons;**
  - **Include correlation factors between W^+, W^- and Z for the ratio measurements.**

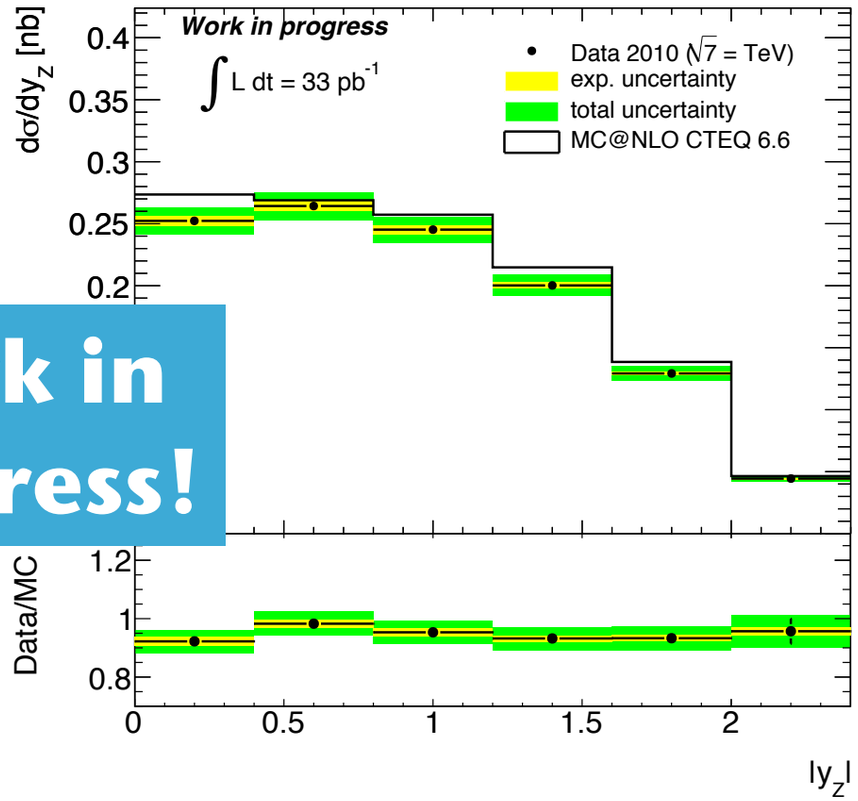




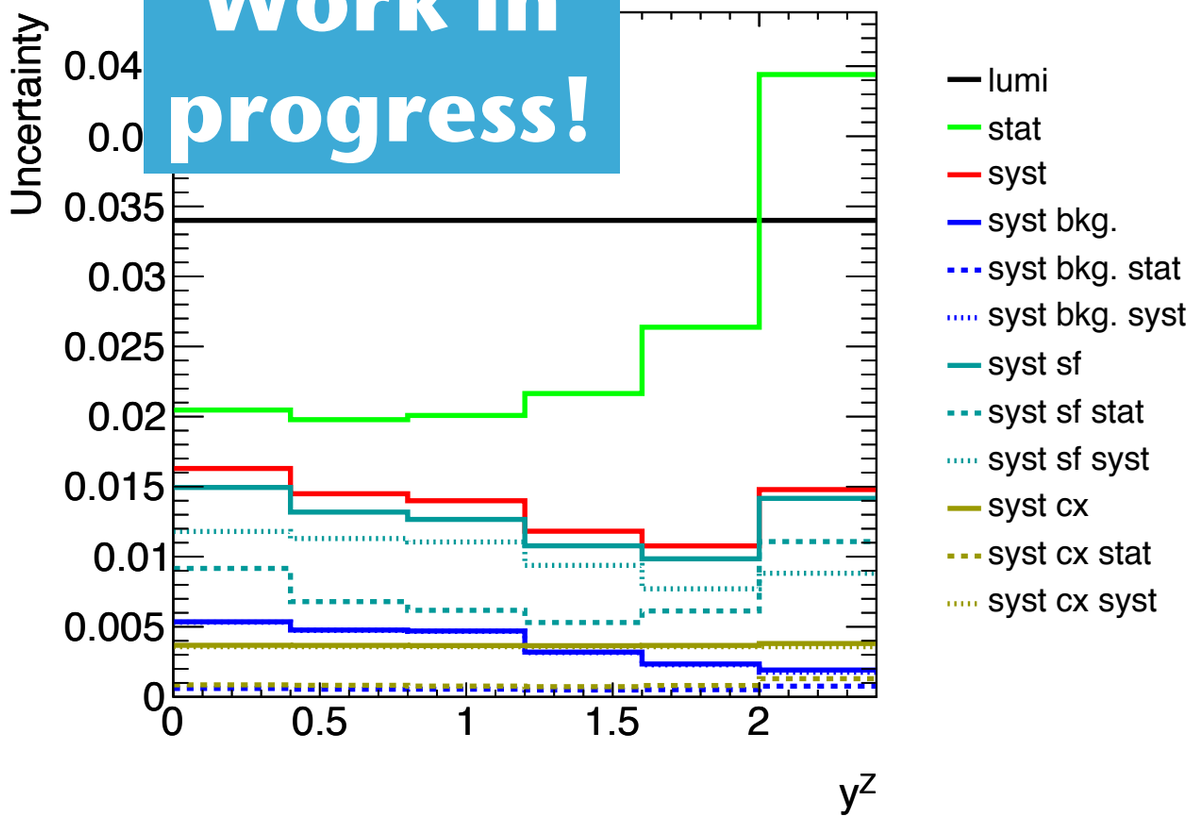
Status of the analysis

- **The measurement is almost completed. Unfortunately all the numbers are not final because we expect to change some inputs and we will have to re-calculate most of them.**
- **The framework for the measurement is complete, though!**
- **We would like to end all these studies as soon as possible and make a paper out of them!**

Work in progress!



Work in progress!



Measurement of the b-jet cross section in Z events

People involved → Lecce group: Gabriele Chiodini,

Nicola Orlando,Stefania Spagnolo

The measurement

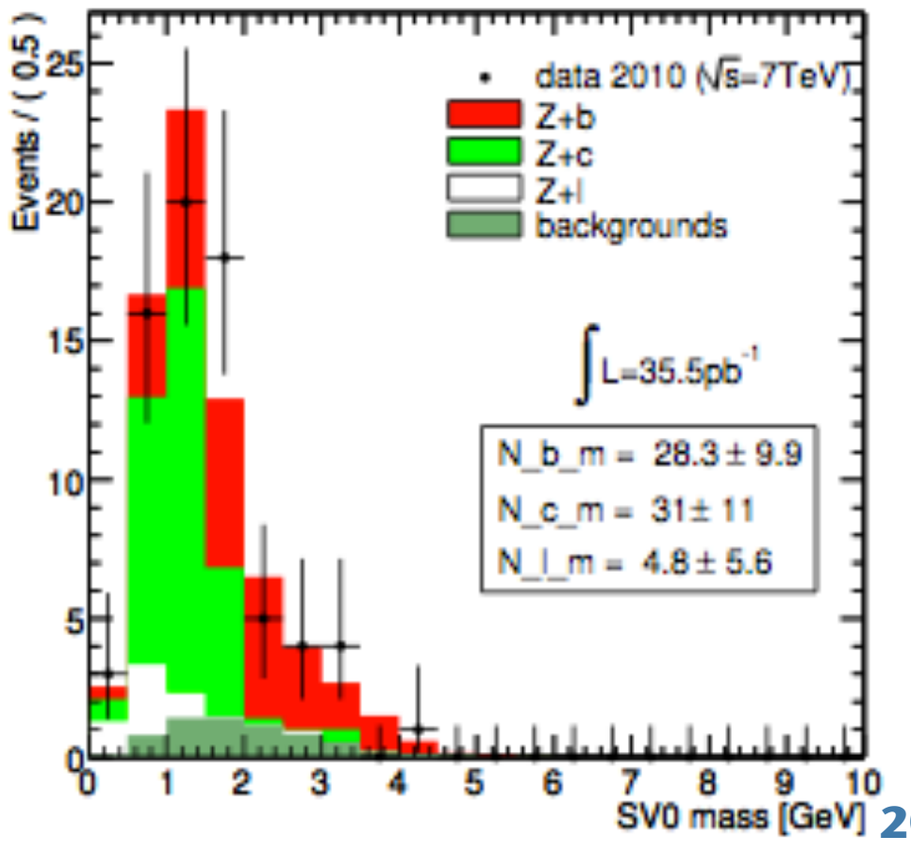
- **The goal is to measure the b-jet cross section in Z/γ^* events;**

$$\sigma_b = \frac{N_b}{A \times L}$$

- **N_b is the number of b-jets in Z events, determined from a background-subtracted fit to the secondary vertex mass distribution;**

- **A is the acceptance, derived from MC, and defined as the probability for a particle level b jet in a Z event to be fully reconstructed and tagged with a secondary vertex;**

- **L is the integrated luminosity used.**



NB: Lecce is working on both channels, electrons and muons!

Selections

- Z selection in e^+e^- and $\mu^+\mu^-$ channel (close to the one for the Z cross section inclusive measurement);

- Jet selection: good quality, $p_T > 25$ GeV, $|\eta|$ within "certified b-tagging acceptance", isolation with respect to leptons;

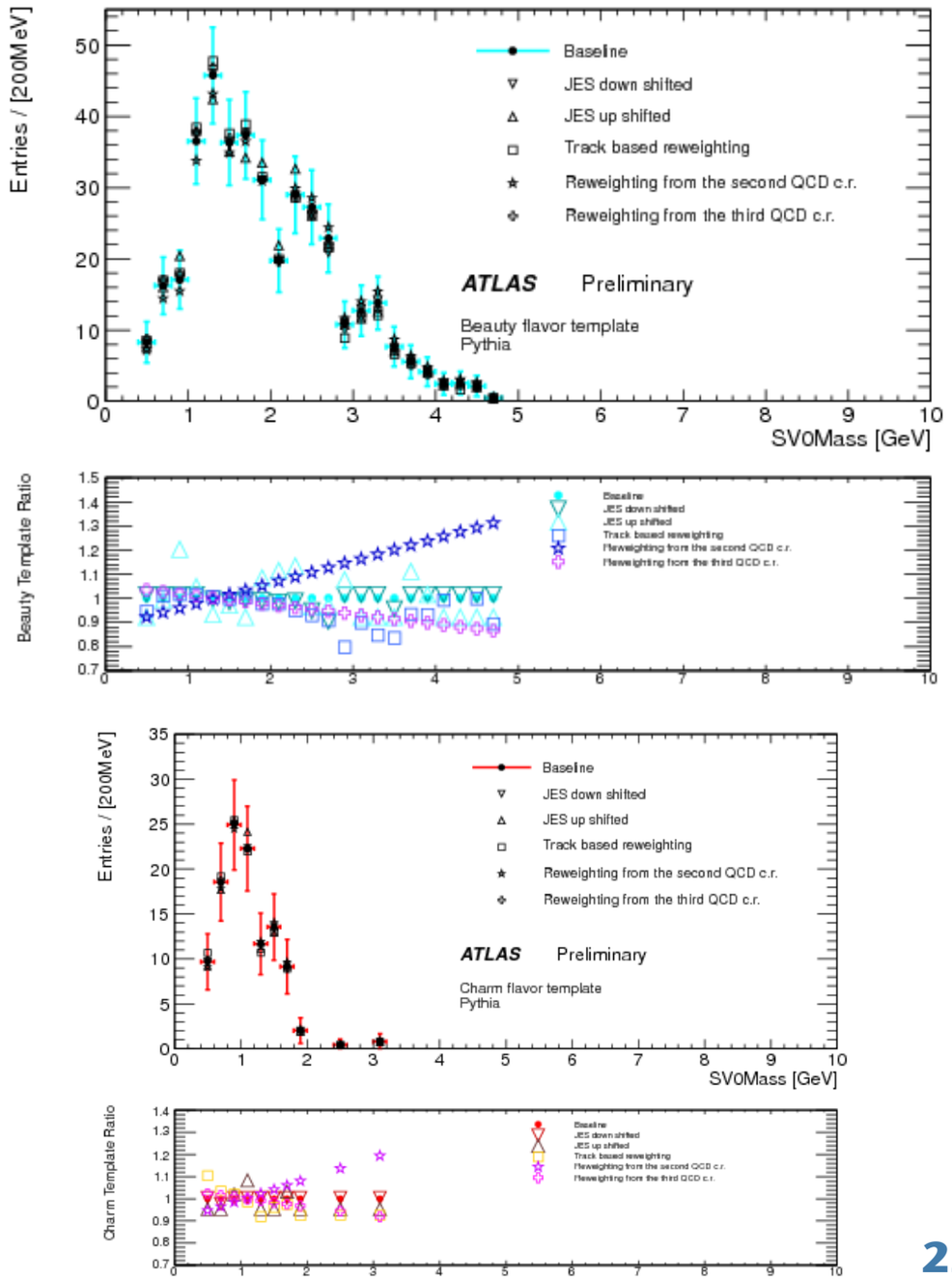
- B-tagging with secondary vertex identification techniques: *SV0*weight greater than cut optimized by b-tagging performance group;

  - very low background, mainly from ttbar;

  - purity of b-tagging is limited; b-discriminating variable used for final counting of b jets is *SV0*Mass, which is the invariant mass from tracks emerging from the b-tagging secondary vertex in the jet.

Acceptances and template systematics

- SV0Mass distributions from light, c and b quarks are extracted from MC processed with the data selection;
- SV0Mass distribution in data is fit to the sum of the template MC SV0 distributions with free normalization for each of them;
- Systematics in template shapes considered:
  - track multiplicity at secondary vertex (from data/MC comparison);
  - Data/MC shape from light or c/b enriched jet selections;
  - JES uncertainty;
  - b-tagging uncertainty;
  - different MC generators.



Measurement of the cross section for jets produced in association with Z bosons

People involved → Roma1 group: Giacomo Artoni (exploiting Roma1 work for the Z cross section measurement)

Brief introduction to the measurement

$$\frac{d\sigma}{d\alpha} = \frac{N - B}{L} \times U(\alpha)$$

- **The goal is to measure the differential cross section with respect to 4 observables (α):**
  - **Inclusive jet multiplicity;**
  - **p_T of all jets in events with at least one jet;**
  - **p_T of the leading jet in events with at least one jet;**
  - **p_T of the sub-leading jet in events with at least two jets;**
- **The U(α) factors are the unfolding corrections needed to pass from detector to particle level (because we want to compare with theoretical predictions at particle level)!**

QCD background estimation

- As done for the Z inclusive analysis, I have been asked to give an estimate of the number of expected QCD events for this analysis (in the muon channel only);

- I am currently working to match new requirements in the muon and jet selections;

- So currently we do not have final numbers in hand, but we should be able to converge soon (after merging some of the selections with the W+jets group);

- An internal note is being prepared at the moment and the goal is to have a paper with this measurement.

Conf Notes w.r.t. CMS

- Here I must give you some bad news :(
- I will talk about only those measurements I have already discussed in the previous slides;

Subject	ATLAS	CMS
W/Z Inclusive Cross Section	Conf Note, 35 pb^{-1} March 18, 2011	Conf Note, 36 pb^{-1} March 18, 2011
W/Z Differential Cross Section	work in progress	Conf Note, 36 pb^{-1} March 22, 2011
Z + b Cross Section	work in progress	Conf Note, 36 pb^{-1} March 22, 2011
Z + Jets Cross Section	Conf Note, 33 pb^{-1} March 19, 2011	Conf Note, 36 pb^{-1} March 18, 2011

- We are practically at the same stage but probably some inches behind!

Plans for the future

- And here I must give you more bad news :'(
- Not many of the groups that have been working on these analyses will continue with 2011 data;
- Bologna will continue working on the subject to use W and Z as luminosity monitors; they will focus on di-boson production to investigate physics beyond the SM;
- Lecce will continue to work within the Z + b group with 2011 data;
- All other people will not work anymore on these signatures;
- It will be necessary to find another primary responsible for the measurement since Max will change analysis too.