W/Z +jets ratio for W+jets background calculation

Maria Ilaria Besana & Federico Meloni

Introduction

- Aim of the work: estimation of W+jets background to tT semileptonic decay (electron channel) from data, using the ratio W/Z.

- Idea:

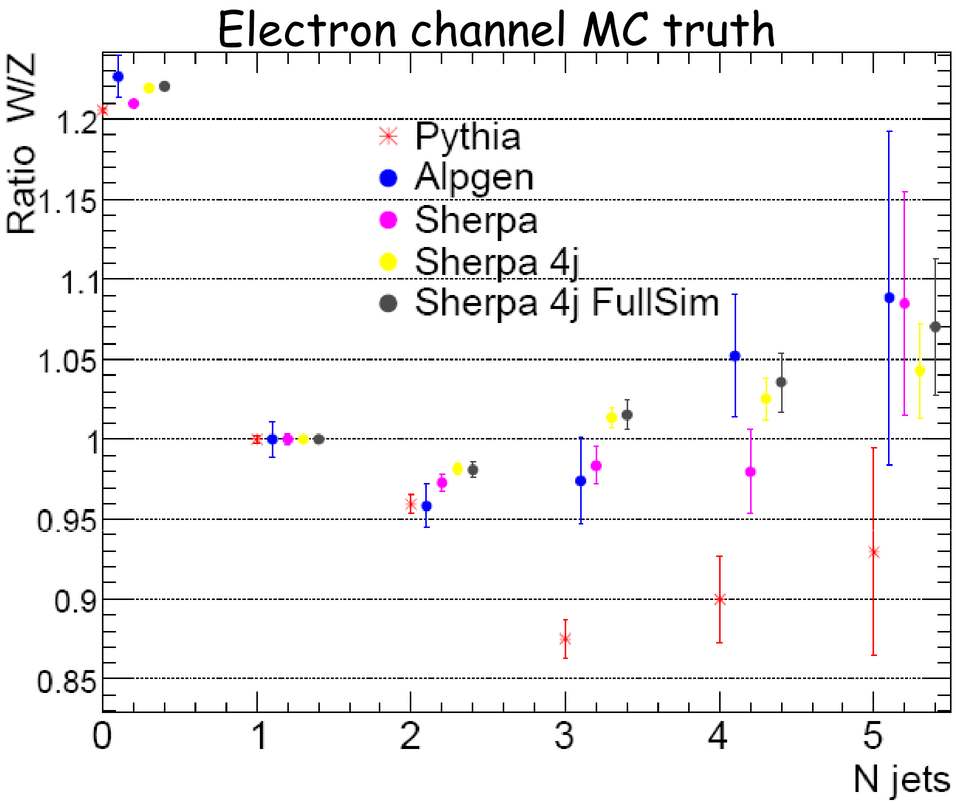
from MC from data

$$W^{SR} = C_{MC} * Z^{SR} * (W^{CR}/Z^{CR})$$

  - SR (signal region): tT selection cuts,
  - CR (control region) region at low jets multiplicity.

- Update of the analysis.

Alpgen vs Sherpa: C_{MC}



10 TeV, 200 pb[-1]

	Alpgen	Sherpa
W SR	1399	1591
W CR	159483	151432
Z CR	10303	10562
Z SR	89	101
C_{MC}	1.01	1.09
Error (%)	4	3

Difference between Alpgen and Sherpa is 8%, the difference between Alpgen and Pythia 12%.

Estimation of systematic uncertainty as the difference between Alpgen and Pythia predictions may be an overestimation.

Work in progress & next steps:

- ❑ production of Alpgen datasets with varying parameters (collaboration with Standard Model W&Z+jets sub-group),
- ❑ analyze them as soon as they are available.

Z^{SR}: effect of combination of electron and muon channel

- Main contribution to statistical error comes from Z^{SR}.
- We can reduce it combining electron and muon channel for Z samples.
  - default:

    $W_{e,\mu}^{SR} = C_{MC} * (Z_{e,\mu}^{SR} * (W_{e,\mu}^{CR}/(Z_{e,\mu}^{CR}))$
  - combination:

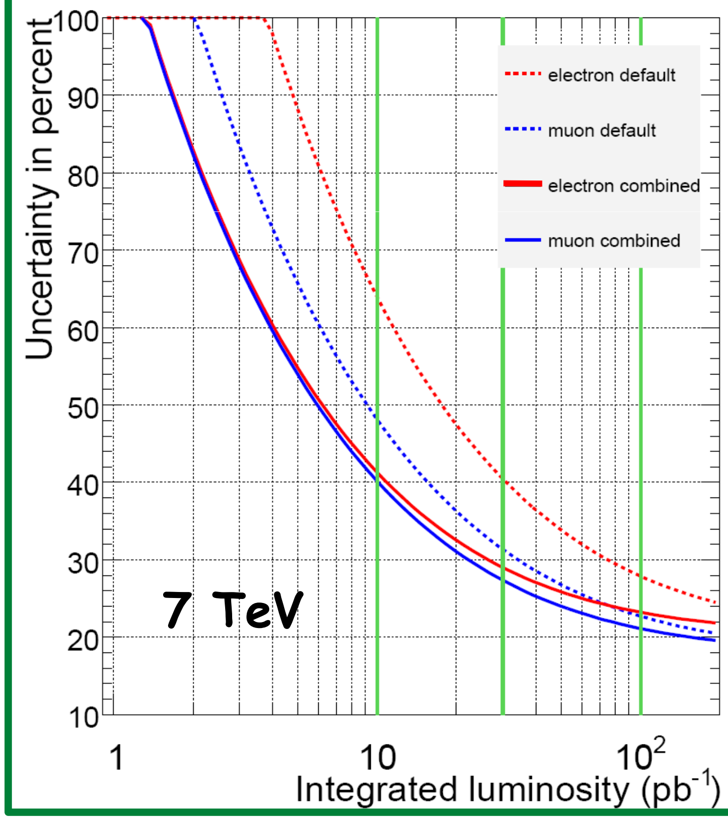
    $W_{e,\mu}^{SR} = C_{MC} * (Z_e+Z_\mu)^{SR} * (W_{e,\mu}^{CR}/(Z_e+Z_\mu)^{CR})$

$$\frac{(Z_e)^{SR}}{(Z_e)^{CR}} = \frac{(Z_\mu)^{SR}}{(Z_\mu)^{CR}} = \frac{(Z_e+Z_\mu)^{SR}}{(Z_\mu+Z_\mu)^{CR}}$$

Reduction of uncertainty especially in the electron channel!

NB: all done with numbers and errors reported in the summer note (ATL-PHYS-PUB-2009-087) rescaled to 7 TeV.

Uncertainty on W+jets background estimation as a function of luminosity:

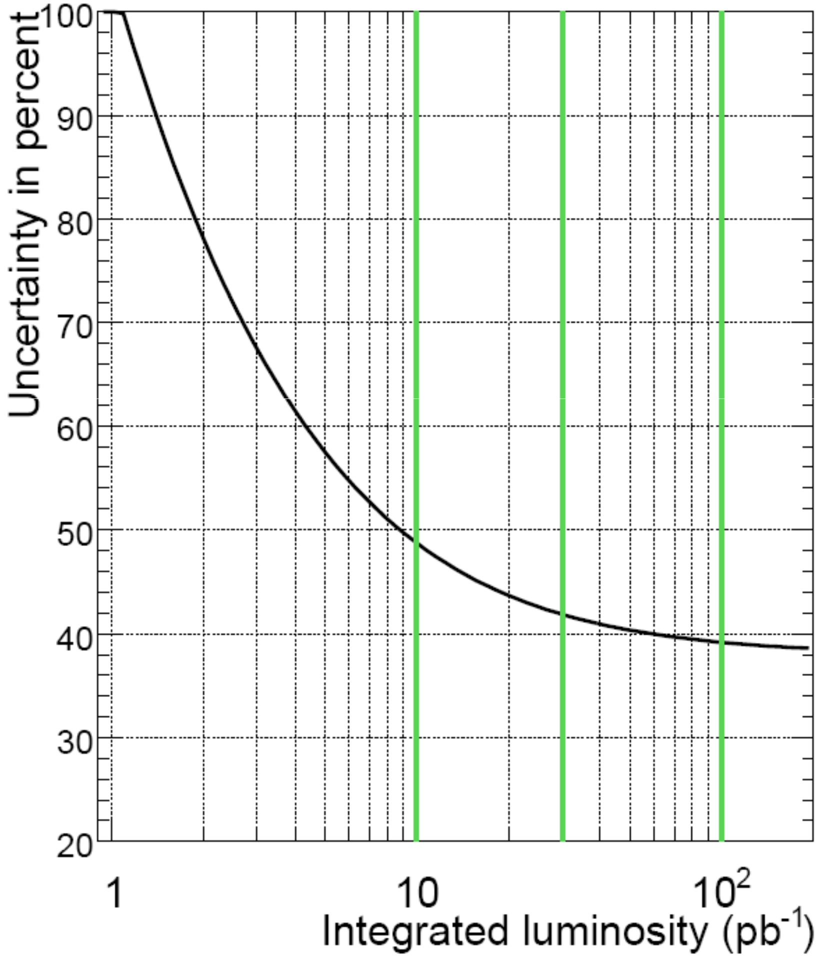


Uncertainty on tT cross section

Uncertainty on tT cross section as a function of luminosity, 7 TeV, electron channel.

- uncertainty on W+jets background obtained from ratio method,
- uncertainty on luminosity: 23%,
- JES uncertainty: 20%,
- efficiency & acceptance: 9%,

Next step: redo these plots with 7 TeV samples.



New samples r808 & new isolation cut

Isolation cut for electrons:

- default = ETcone20 < 6 GeV
- new = ETcone20 < 4 GeV + 0.023*(p_T)

(http://indico.cern.ch/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=72117)

Effect on tT signal and W background (10 TeV, 200 pb^{-1})			
	Default isolation cut	**New isolation cut**	**Rel 14 results**
tT	3800	3800	2600
W+jets	2090	2120	1305

Effect on background estimation:			
	Default isolation cut	**New isolation cut**	**Rel 14 results**
Z SR	140	144	82
W CR	212500	210800	148700
Z CR	14200	14000	10210
C_{MC}	1.00 (error 2%)	0.98 (error 2%)	1.00(error 4%)

W control region contamination

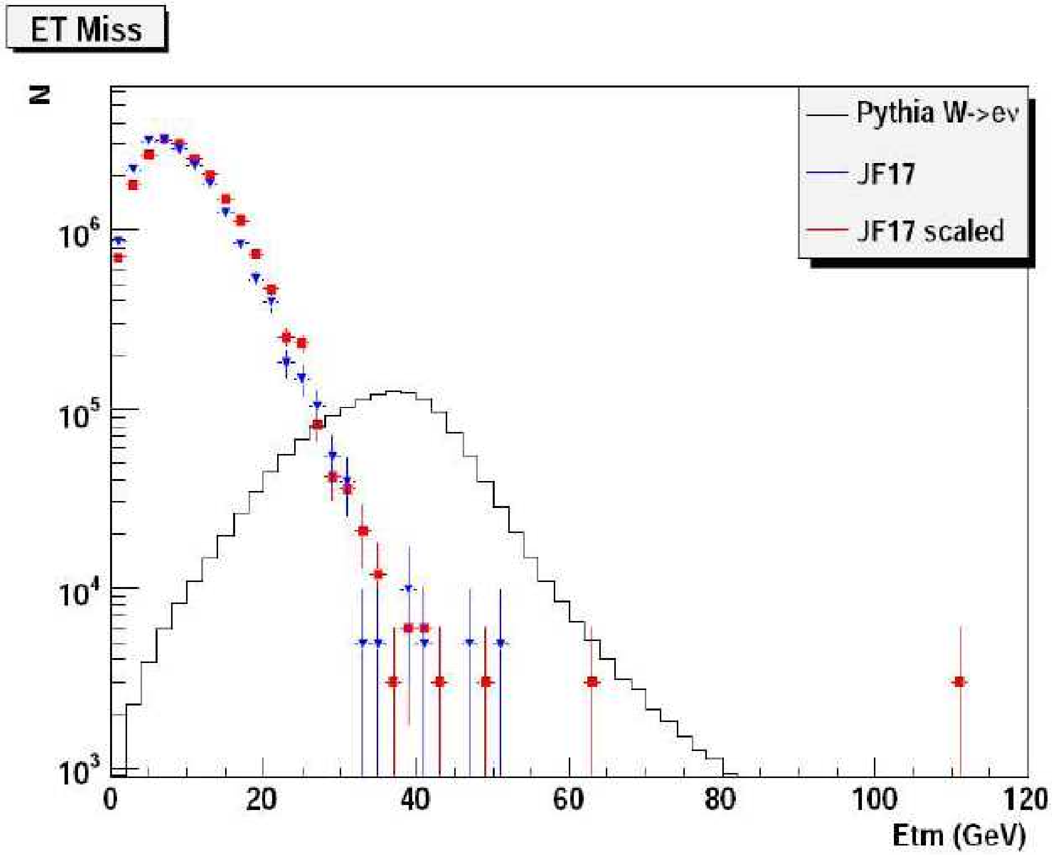
Expected number of events 10 TeV, 200 pb^{-1}			
	Default isolation cut	New isolation cut	Rel 14 results
W(eυ)	212500	210800	148700
W(τυ)	7800	7670	5570
Z(ee)	214	213	1197
Z(ττ)	1630	1640	879
tT	1170	1150	203
Single top	380	380	272
B/S	0.053	0.052	0.055

Next step:
develop a strategy for backgrounds (especially for W^{CR}), data-driven as much as we can.

Estimation of QCD contamination: see next 2 slides.

QCD background to W(eu):the method

- The shape of ETmiss is not much modified by electron ID cuts (see figure).
- We can thus estimate QCD to W (or tT) selection by:
  - using loose electrons (with medium veto) to estimate the shape of ETmiss in QCD events;
  - measure the medium/loose ratio for QCD at low ETmiss;
  - rescale at high ETmiss



QCD background to W(eν):results

Expected number of events, 0.041 pb^{-1} 10 TeV		
W	QCD	QCD estimation
274.6 ±0.2	189.0 ±13.0	227 ±5.3

Work in progress & next steps:

- Actually some residual correlations between electron ID and ETmiss, under investigation.
- Medium/loose ratio to be measured as a function of p_T,η.
- Removing contamination of signal in background estimate (about 4% of W pass the loose, not medium selection, but this can be measured with Z).
- QCD background in release 15 much higher than in 14 (conversion to be removed), effect of looser (more robust) cuts of r15 to be checked, possibly move to tight electrons.

Back-up

Sherpa datasets

- Matrix element up to 3 jets:
  - mc08.108857.SherpaW3jetstoenuQCD.merge.AOD.e418_a84_t53
  - mc08.108854.SherpaZ3jetstoeeQCD.merge.AOD.e418_a84_t53_tid068619
- Matrix element up to 4 jets:
  - mc08.104990.Sherpa010103W4jetstoenu.merge.AOD.e427_a84_t53
  - mc08.104993.Sherpa010103Z4jetstoee.merge.AOD.e435_a84_t53
- Matrix element up to 4 jets full simulation:
  - mc08.104990.Sherpa010103W4jetstoenu.merge.AOD.e427_s462_r635_t53
  - mc08.104993.Sherpa010103Z4jetstoee.recon.log.e435_s462_r635_t53

Summer note results: Z samples

Electron channel

Process	Control region (200 pb^{-1})	Signal region (200 pb^{-1})
Z (ee)	10210	82
Z ($\mu\mu$)	0.0	0.0
Z($\tau\tau$)	0.1	0.1
W	6.0	0.0
$t\bar{t}$	8.4	2.8
Single top	2.9	0.0
Wbb	0.0	0.0
WW+WZ+ZZ	24.9	0.5
QCD	110	0.4

Muon channel

Pocess	Control region (200 pb^{-1})	Signal region (200 pb^{-1})
Z ($\mu\mu$)	15750	150
Z (ee)	0.0	0.0
Z($\tau\tau$)	0.9	0.0
W	0.0	0.0
$t\bar{t}$	10.5	5.0
Single top	2.3	0.0
Wbb	0.0	0.0
WW+WZ+ZZ	40.0	1.0
QCD	$\leq$50.0	$\leq$0.5

- low background contamination,
- statistical error negligible for CR, but not for SR:
  - 8% muon channel,
  - 11% electron channel

Summer note results: W CR

Process	Electron Analysis (200 pb^{-1})	Muon Analysis (200 pb^{-1})
W(eν)	**148700**	0.0
W(μν)	43	**190300**
W(τν)	5570	6820
Z(ee)	1197	0.0
Z (μμ)	1.0	8066
Z(ττ)	879	1130
tt	203	241
Single top	272	308
Wbb	97	119
WW+WZ+ZZ	427	557
QCD	42000	31000

- statistical error is negligible both in electron and muon channel (< 1%)
- not negligible QCD contamination both in electron and muon channel.

↓ 50% uncertainty on QCD

Error from background:

- **~17%** electron ch.
- **~11%** muon ch.

Summer note results: C_{MC} uncertainty & summary

	Electron Analysis	Muon analysis	Combined
Alpgen	1.00±0.04	0.92±0.04	0.96±0.03
Pythia	0.80±0.06	0.89±0.05	0.85±0.04

Systematic uncertainty of 12%.

Summary:

Source of uncertainty	Electron Analysis	Muon analysis
Statistical for 200 pb^{-1}	11.3 %	8.3%
Purity of control region W sample	17.0%	12.7%
Monte Carlo correction factor	12.1%	12.1%
JES*	3.6%	2.3
Total uncertainty	**23.9%**	**19.6%**

*: uncertainty of 10% for central jets ($|\eta|<3.2$), 20% otherwise.

Some details…

- W+jets:
  - Trigger e20_loose*
  - 1 lepton p_T>20 GeV
  - ETmiss > 20 GeV

  Signal region
  - at least 4 jets p_T>20 GeV (3 of them p_T >40 GeV)

  Control region
  - only 1 jets pT>20 GeV
- Z+ jets (control sample):
  - Trigger e20_loose
  - 2 leptons p_T>20 GeV, opposite charge
  - 80 GeV< Mee < 100 GeV

  Signal region:
  - 2 electrons: p_T>20 GeV, opposite charge
  - 80 GeV <Mee <100GeV
  - at least 4 jets p_T>20 GeV (3 of them p_T >40 GeV)

  Control region:
  - only 1 jet with p_T>20 GeV

*e15_medium used only for comparison between Alpgen and Sherpa, because in r808 samples is prescaled by a factor 1000!

New samples: r635 & new isolation cut

Isolation cut for electrons: default = ETcone20 < 6 GeV

new = ETcone20 < 4 GeV + 0.023*(p_T)

Effect on ttbar signal and W background (10 TeV, 200 pb-1)		
	Default isolation cut	**New isolation cut**
$t\bar{t}$	2919	2907
W+jets	1397	1420

Effect on background estimation:		
	Default isolation cut	**New isolation cut**
Z SR	89	90
Z CR	10303	10197
W CR	159483	158658

New samples: r635 vs r808

Expected number of events 10 TeV, 200 pb-1		
	r635	**r808**
tT	3000	3800
W SR	1430	2090
Z SR	89	140
W CR	164900	212500
Z CR	10300	14200
C_{MC}	1.01 (error 2%)	1.00 (error 2%)

The difference between the 2 samples is a combination of effects:

- Electron identification is 12% more efficient, because of a change in egamma electron definition moving from rel.14 to rel.15;
- Using AntiKT instead of the cone we find more jets: higher probability that events pass the 2 cuts on jets;
- ETmiss cut is 1-2% more efficient.

(Z+4jets)/(Z+1jet): comparison between electron and muon channel

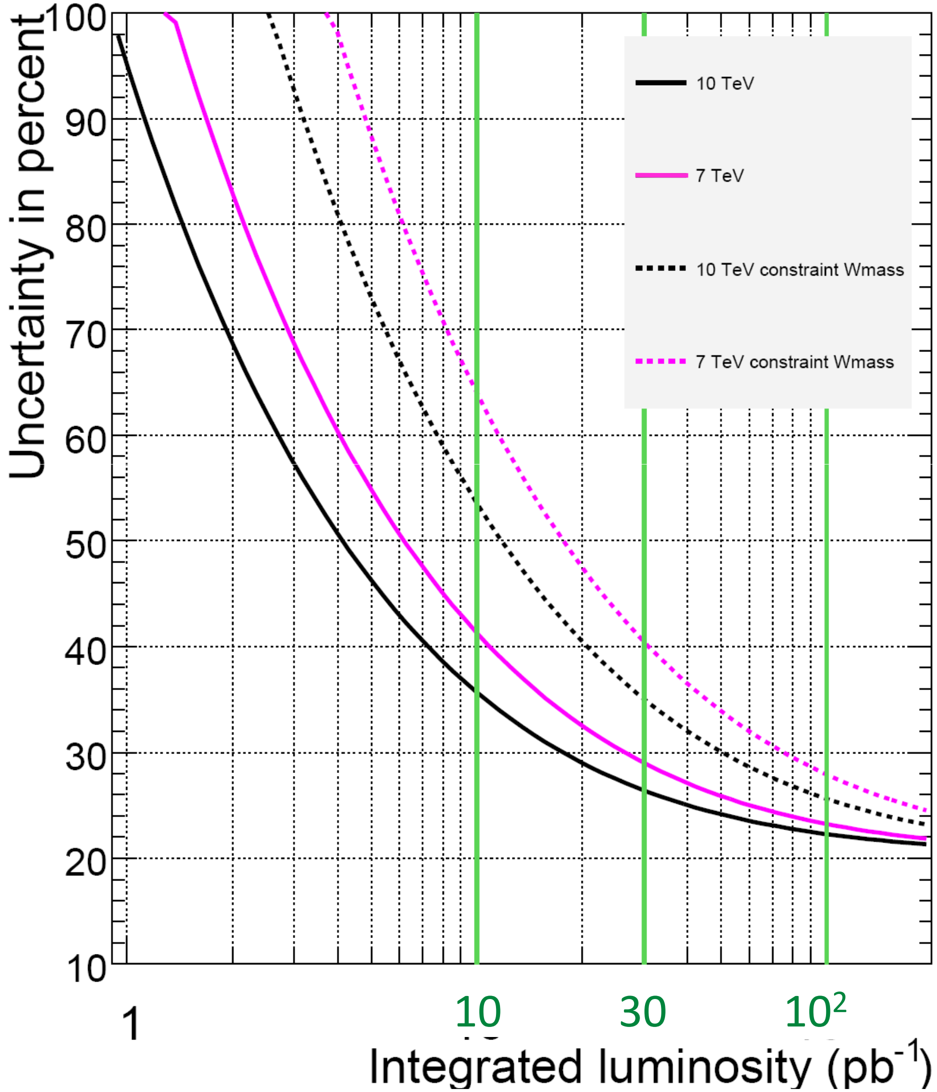
	Electron	**Muon**
4 jets	82*	150*
1 jet	10210	15750
ratio	0.0080	0.0095
error	0.0009	0.0008

Electron and muon channel are equivalent, taking into account uncertainty coming from MC available statistics!

* Expected number of events at 10 TeV, 200 pb^{-1} integrate luminosity.

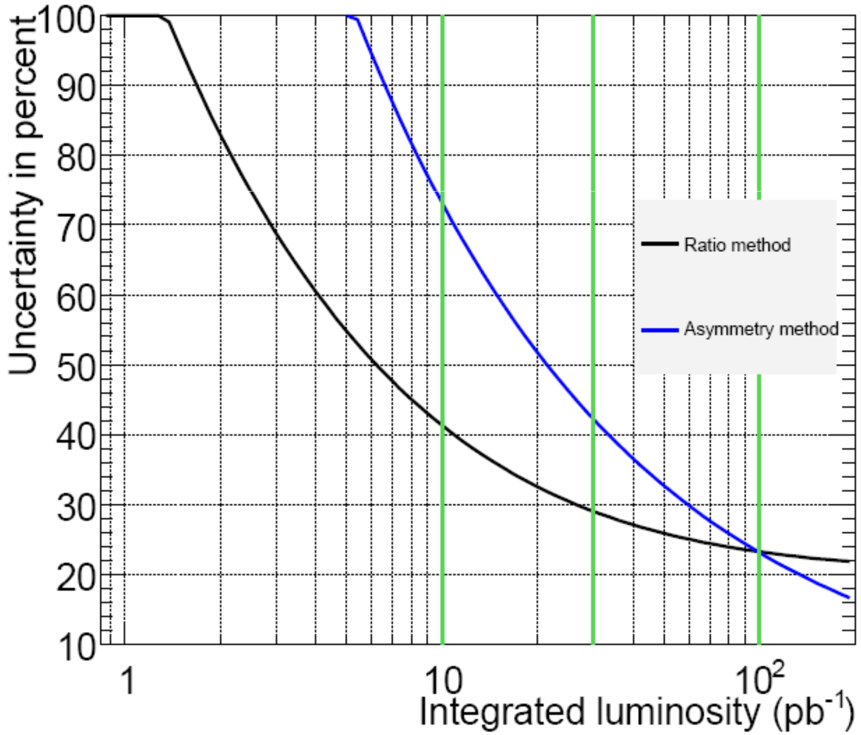
Uncertainty on W+jets estimation I

Uncertainty on W+jets background estimation as a function of luminosity, combined method, electron channel.



Uncertainty on W+jets estimation II

W+jets uncertainty as a function of luminosity at 7 TeV: comparison between ratio method and asymmetry method



- Ratio method: electron channel; this is the ultimate precision both in electron channel and in electron+muon channel.
- Asymmetry method: combination of electron+muon channel;

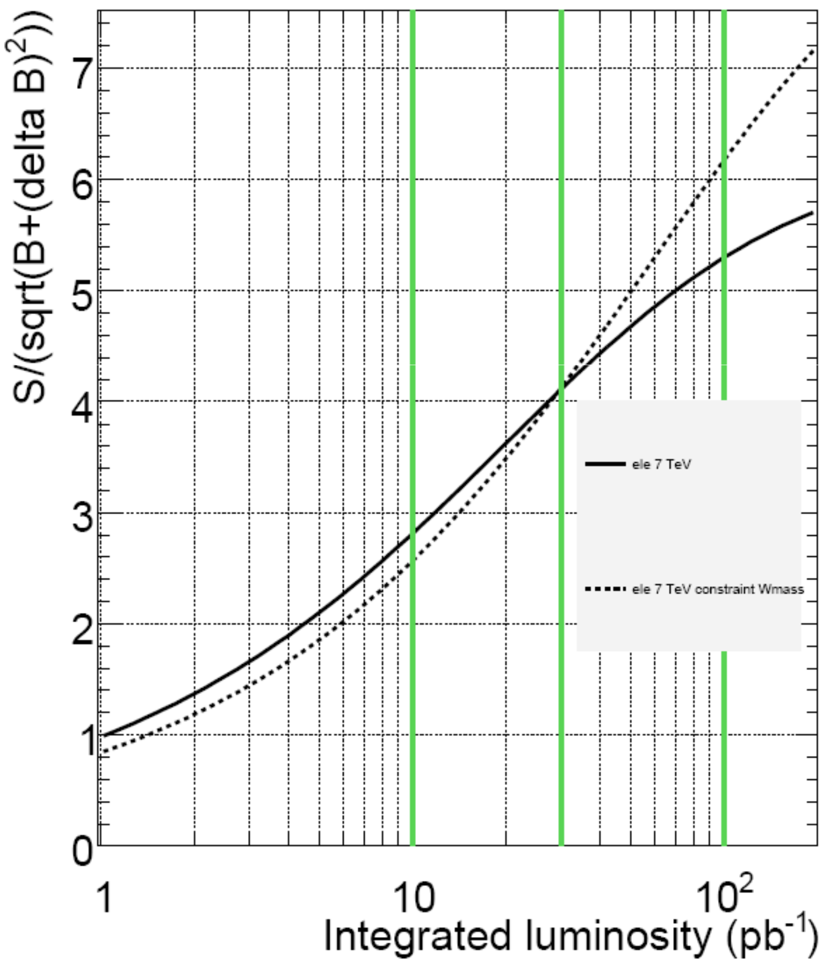
  reference numbers presented by by Bobby Acharya: (http://indicobeta.cern.ch/getFile.py/access?contribId=5&resId=0&materialId=slides&confId=71588).

Expected number of events electron+muon channel, 10 TeV, 60 pb^{-1}			
tT	W^+	W^-	other back.
690	350	226	188

Ratio W^+/W^-=1.57

Effect of W mass constraint cut on $S/(B+\Delta B^2)^{1/2}$

$S/(B+\Delta B^2)^{1/2}$ as a function of luminosity, 7 TeV, electron channel



$\Delta B = \Delta_{(W+jets)} + \Delta_{(other\ backgrounds)}$

- error on W+jets obtained with ratio method combining electron and muon channel for the Z,
- error on other backgrounds: 5%.

$S/(B+\Delta B^2)^{1/2}$ vs significance

How significance is calculated?

Aim: calculate probability of having a number of background events higher or equal with respect to observed number of events.
Probability is calculated as a convolution of a Gaussian and a Poisson distribution:

- Gaussian distribution reflects our knowledge of expected number of background events, its width is the uncertainty,
- Poisson distribution reflects statistical nature of the process.

Probability is represented in terms of σ of an equivalent Gaussian distribution.