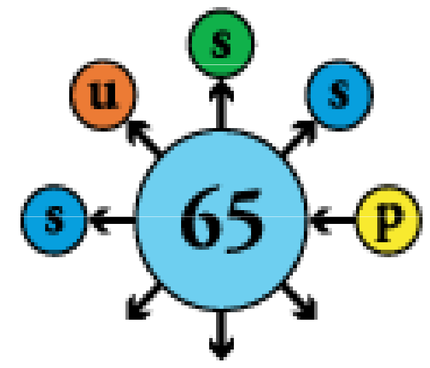
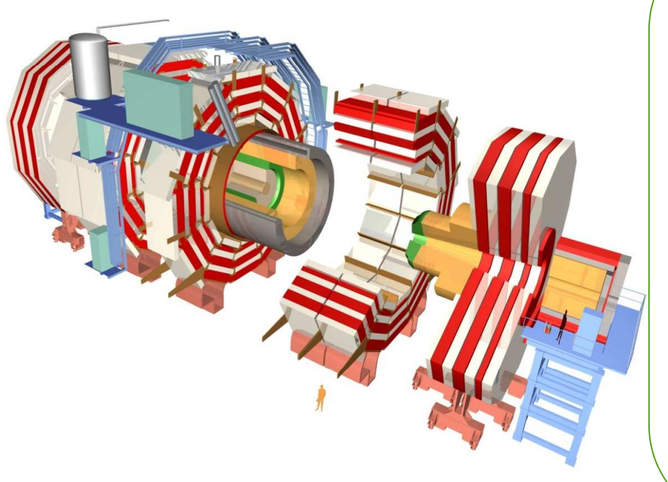
$W \rightarrow \mu\nu$ @ CMS

Measurement of the inclusive $W \rightarrow \mu\nu$ cross-section with early CMS data

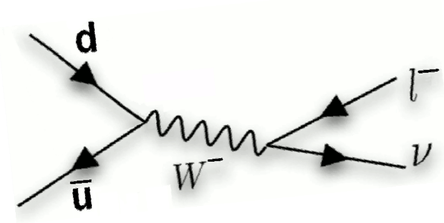
María Cepeda, CIEMAT

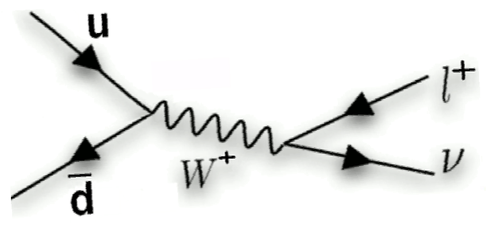




The inclusive production of W bosons with their subsequent muonic decay will be among the first physical signals to be measured in CMS with the first data from the LHC. It will be an invaluable tool to test the Standard Model in the new energy regime.

This study represents one of the first steps in the detailed understanding of reference physics processes at the LHC: transverse momentum spectra, associated jet activity, beyond-leading-order effects and parton density functions.



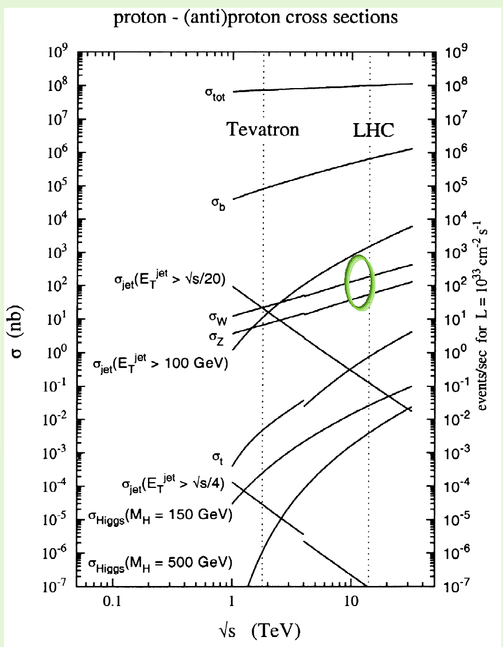


ElectroWeak Physics at the LHC

Vector Boson production → benchmark process for the LHC

- Large production cross-section
- Well understood theoretically
- Clean and simple experimental signatures
- Standard Candles for detector calibration
- Background for many BSM searches

σ(pb)	√s	
LO	10 TeV	14 TeV
Z→ll	1200	1800
W→lν	11800	17200

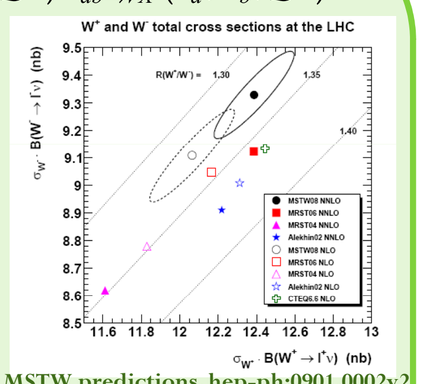


Vector Boson Production

$$\sigma_{pp\rightarrow VX} = \sum_{a,b=q,\bar{q},g} \int_0^1 dx_1 dx_2 f_a(x_1, Q^2) f_b(x_2, Q^2) \sigma_{ab\rightarrow VX}(x_a, x_b, Q^2)$$

PDFs $f_a(x, Q^2)$: parametrization of the partonic content of the proton, obtained from global fits to the existing data.

Vector Boson measurements will help to discriminate between PDF predictions. Relative measurements and distribution shapes will be key as most of the systematics cancel out in their computation.



Latest Predictions for W&Z cross-sections:

MSTW predictions, hep-ph:0901.0002v2

PDF set (10 TeV)	$\sigma_{W+} Br_{W\rightarrow l\nu}$ (nb)	$\sigma_{W-} Br_{W\rightarrow l\nu}$ (nb)	$\sigma_z Br_{Z\rightarrow ll}$ (nb)
MSTW08	8.62 ± 0.16	6.30 ± 0.12	1.39 ± 0.025
CTEQ66	8.77 ± 0.18	6.22 ± 0.14	1.40 ± 0.027
HERAPDF	8.64 ± 0.10	6.27 ± 0.11	1.38 ± 0.02

W Selection

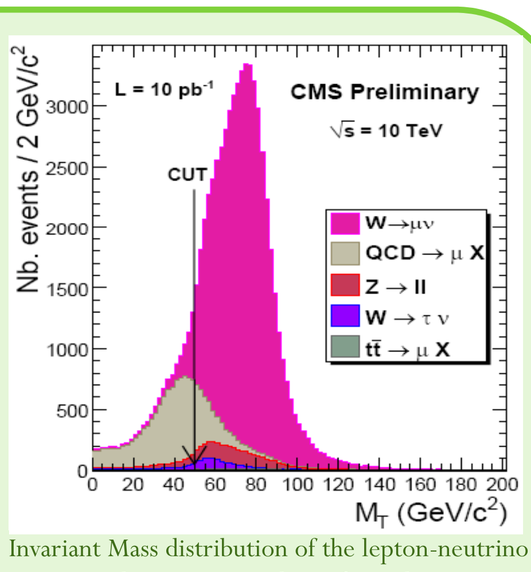
Experimental signature:

W events are characterized by a single isolated, high pt lepton in the detector, accompanied by an imbalance in the energy of the event caused by the presence of a neutrino in the decay chain (high missing Transverse Energy or MET).

Main backgrounds after selection:

Electroweak: Z→ll (~6%), W→τν (~2%), ttbar (<1%)

QCD : mainly bbar (<10%)



Invariant Mass distribution of the lepton-neutrino system in the transverse plane after selection cuts

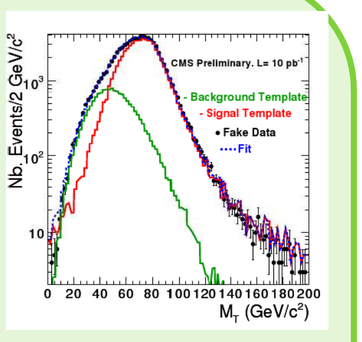
Data-Driven QCD Background Estimation

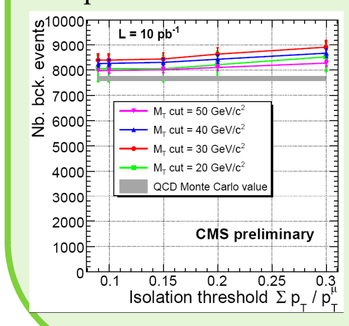
Template method:

❖Clean samples of Z→ μμ events can be used to model the missing energy distribution (MET) of the W.

❖The shape of the QCD background MET distribution can be obtained through the inversion of the isolation cut.

➔The number of signal events is obtained from a two component fit to the data, using these two templates.





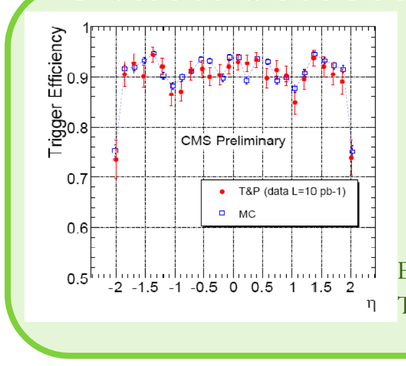
Matrix method:

❖A 2×2 bin method using two non-correlated variables.

❖The phase space of these two variables is divided into a signal region and three background enriched control regions.

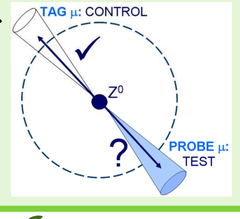
➔The QCD background contamination in the selected signal region can be inferred from a simple proportional rule.

Muon Selection Efficiencies: Tag&Probe



Example: Trigger Efficiency

All the online (trigger) and offline (reconstruction, identification, isolation) efficiencies for leptons are computed from a clean ZMuMu sample with tag&probe method.



Clean Zμμ

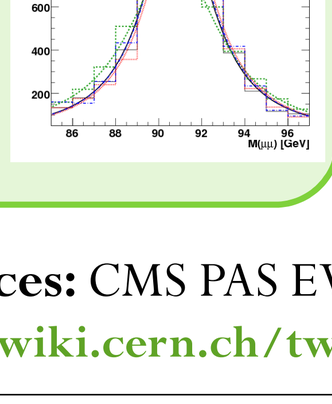
1st Muon: TAG ✓

2nd Muon: Probe: ?

X ✓

Muon Momentum Resolution

Di-muon resonances will be used to measure momentum scale and resolution. The reconstructed Z→μμ invariant mass distribution is fitted to the expected one including correction parameters to the muon transverse momentum.



W Cross-Section Measurement

$$\sigma_W \times Br(W \rightarrow \mu\nu) = \frac{N_W^{obs} - N_W^{bckg}}{A_W \cdot \varepsilon_W \cdot \int Ldt}$$

Uncertainty at Start-Up:

❖Statistical: ~1% at $\mathcal{L}$=10 pb^{-1}→ Measurement dominated by systematics!

❖A_W: Detector Acceptance, from Monte Carlo (QED and QCD corrections, PDF uncertainties)→ ~2%

❖ε_W : Selection efficiency (trigger,reconstruction, identification) evaluated from data→ <3%

❖N^{obs}- N^{bckg}: Background Estimation (from MC or from data) → <2%

❖**Luminosity:** ~10% (later on expected to be ~ 3-7%)

➔*Robust CMS Strategy to measure the W cross-section is ready!*

➔*Looking forward to the first LHC data!*

References: CMS PAS EWK-07-002, EWK-09-001

https://twiki.cern.ch/twiki/bin/view/CMS/PhysicsResults#EWK_physics