

P-P PHYSICS AT LHC

W and Z production. Data and MC comparison

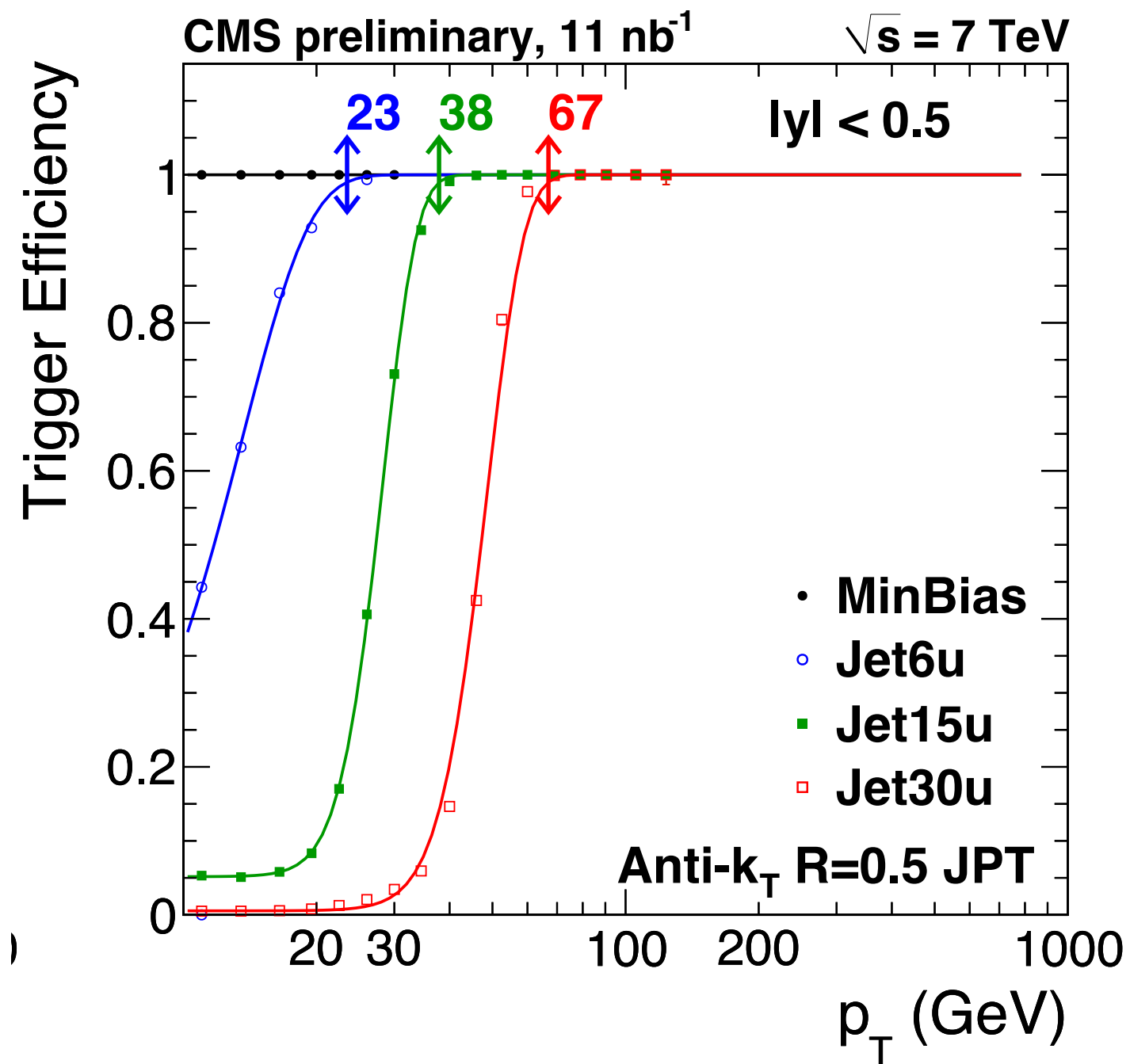
Lecture 4

DIPARTIMENTO DI FISICA

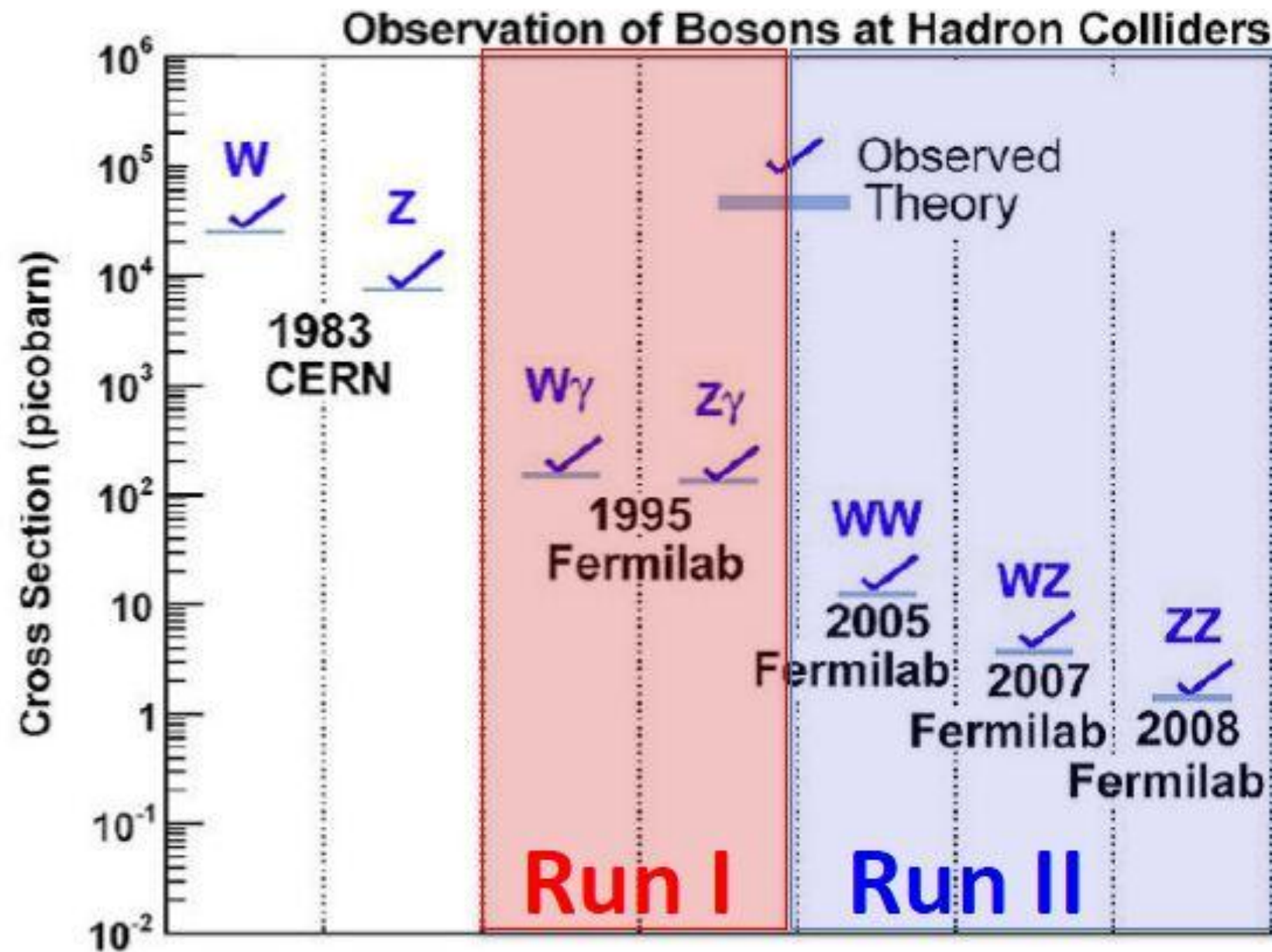


SAPIENZA
UNIVERSITÀ DI ROMA

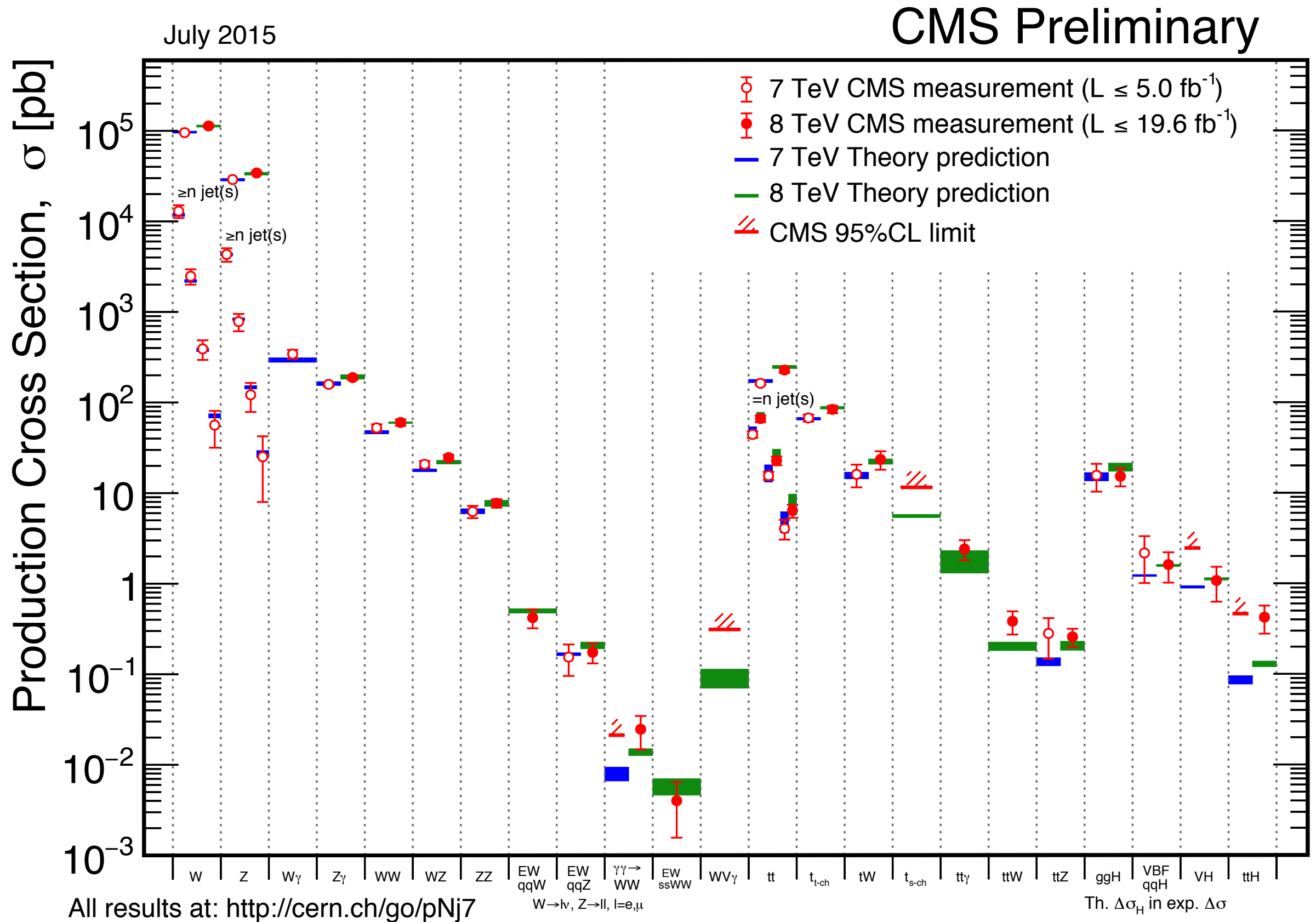
TRIGGER TURN ON



ROAD TO DISCOVERY OF EWK SYMMETRY BREAKING



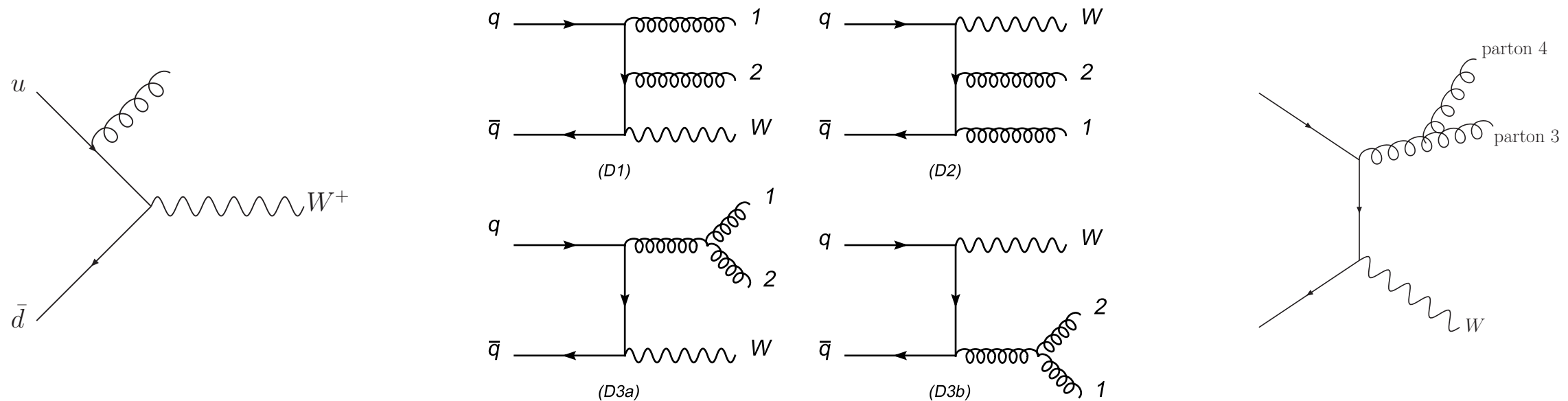
ELECTROWEAK DISCOVERY AT LHC



W/Z RELATED MEASUREMENTS

- Inclusive cross section measurements
 - status of theoretical calculations
 - impact of Parton Distribution Functions (PDF)
- Differential cross sections ($d\sigma/d\eta$, $d\sigma/dp_T$)
- V+jets measurement
- Z boson properties
 - Couplings between Z boson and fermions
 - Asymmetries induced by couplings
 - Angular coefficients
 - Weak mixing angle
- W Boson properties
 - Charge asymmetries
 - W polarization
 - W mass
 - W width
- Diboson production: $W\gamma$, $Z\gamma$, WW , WZ , ZZ

W/Z PRODUCTION



- Cross section and spectrum of W and Z in hadron collisions is measured with small uncertainties
 - Benchmark for Standard Model physics
 - One of very first validation measurements at LHC
- data/MC comparison provides powerful validation of QCD calculations
 - Provides luminosity monitor at LHC at high luminosity
 - similar to use of Bhabha at LEP!

W/Z CROSS SECTION

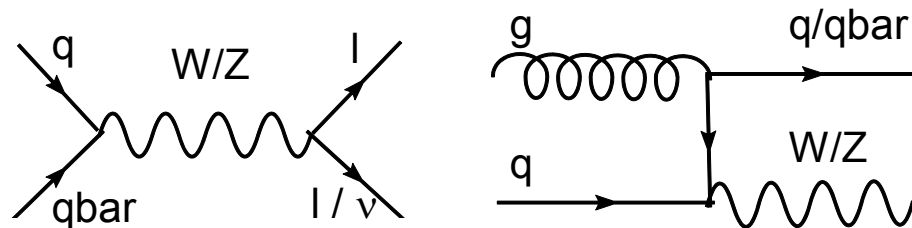
$$\frac{d\hat{\sigma}}{dM^2} = \frac{\hat{\sigma}_0}{N} Q_q^2 \delta(\hat{s} - M^2), \quad \hat{\sigma}_0 = \frac{4\pi\alpha^2}{3M^2} \quad \hat{\sigma}(q\bar{q} \rightarrow e^+e^-) = \frac{4\pi\alpha^2}{3\hat{s}} \frac{1}{N} Q_q^2$$

$$\frac{d\sigma}{dM^2 dy} = \frac{\hat{\sigma}_0}{N_S} \left[\sum_k Q_k^2 (q_k(x_1, M^2) \bar{q}_k(x_2, M^2) + [1 \leftrightarrow 2]) \right]$$

$$\begin{aligned} \hat{\sigma}^{q\bar{q}' \rightarrow W} &= \frac{\pi}{3} \sqrt{2} G_F M_W^2 |V_{qq'}|^2 \delta(\hat{s} - M_W^2), \\ \hat{\sigma}^{q\bar{q} \rightarrow Z} &= \frac{\pi}{3} \sqrt{2} G_F M_Z^2 (v_q^2 + a_q^2) \delta(\hat{s} - M_Z^2) \end{aligned}$$

W/Z RATE

□ Production:



- rate Tevatron: $3\text{M } W \rightarrow l\nu \text{ per fb}^{-1}$
- rate LHC: $10\text{M } W \rightarrow l\nu \text{ per fb}^{-1}$
(Z rate $\sim 1/10$ W rate)

DY production at LO + NLO

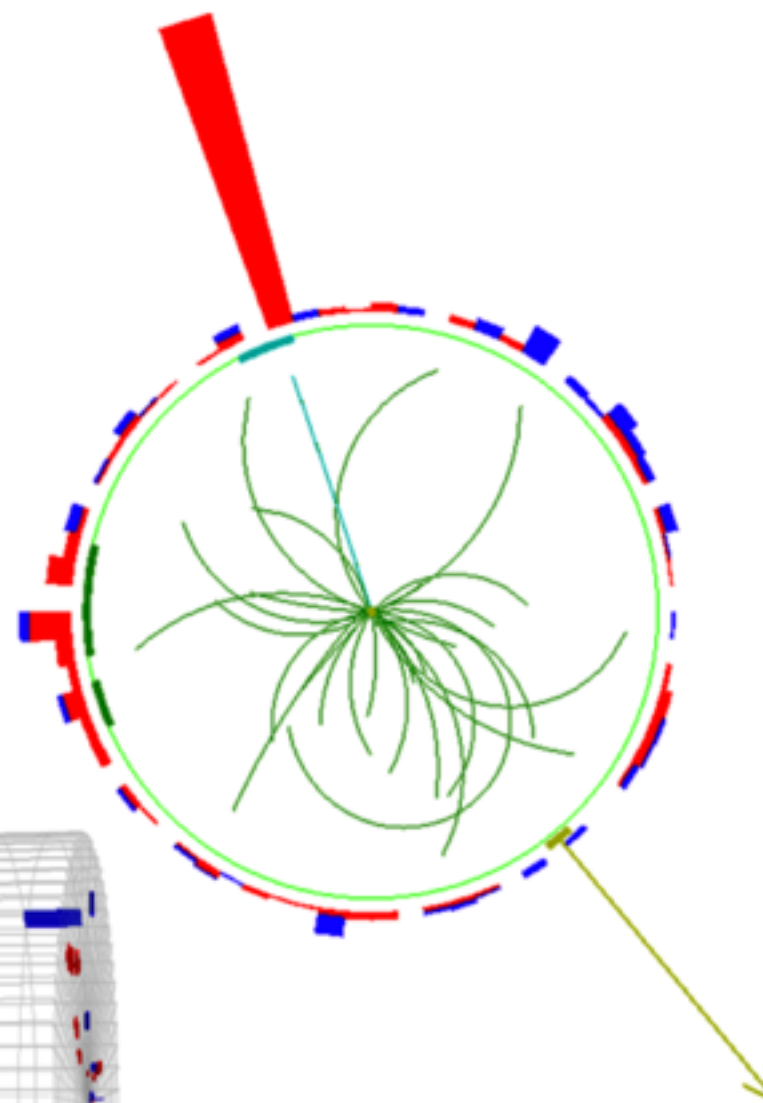
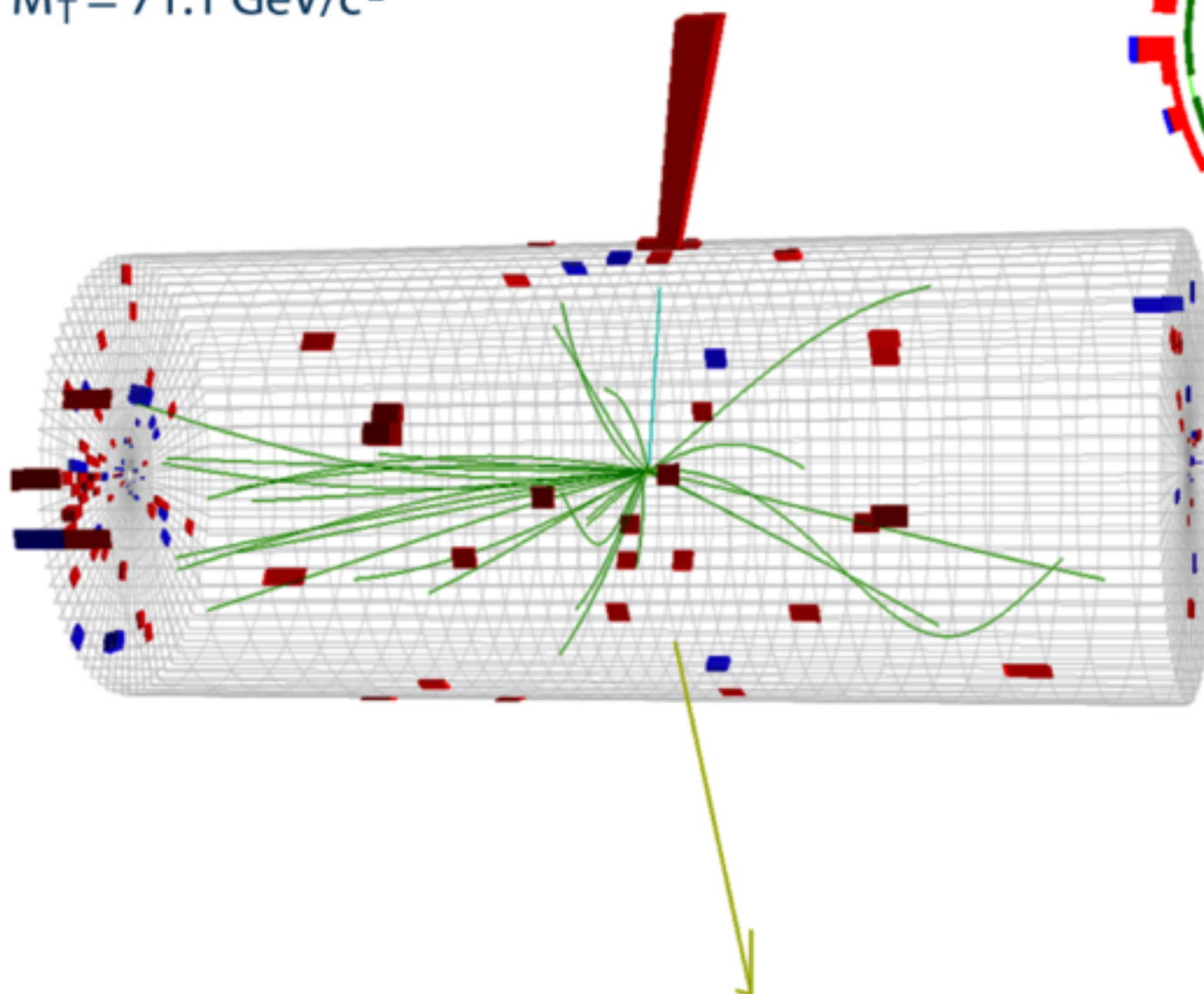
□ Signature: relatively high p_T , isolated **leptons** (trigger)
missing E_T due to neutrino in W decay
pileup / Underlying Event / jets at NLO

W CANDIDATES



CMS Experiment at LHC, CERN
Run 133874, Event 21466935
Lumi section: 301
Sat Apr 24 2010, 05:19:21 CEST

Electron $p_T = 35.6$ GeV/c
 $ME_T = 36.9$ GeV
 $M_T = 71.1$ GeV/c²

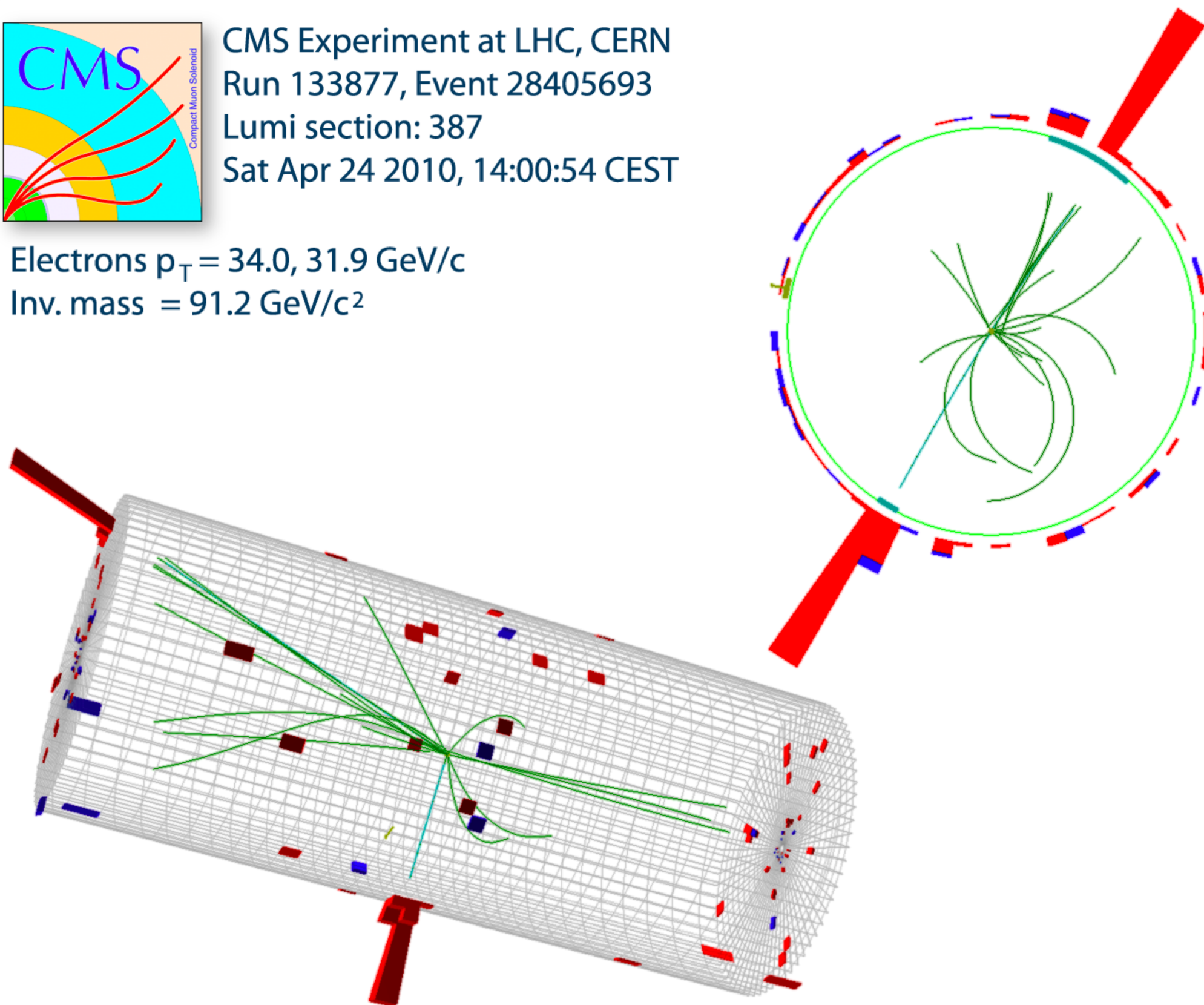


$Z \rightarrow e^+e^-$ CANDIDATE



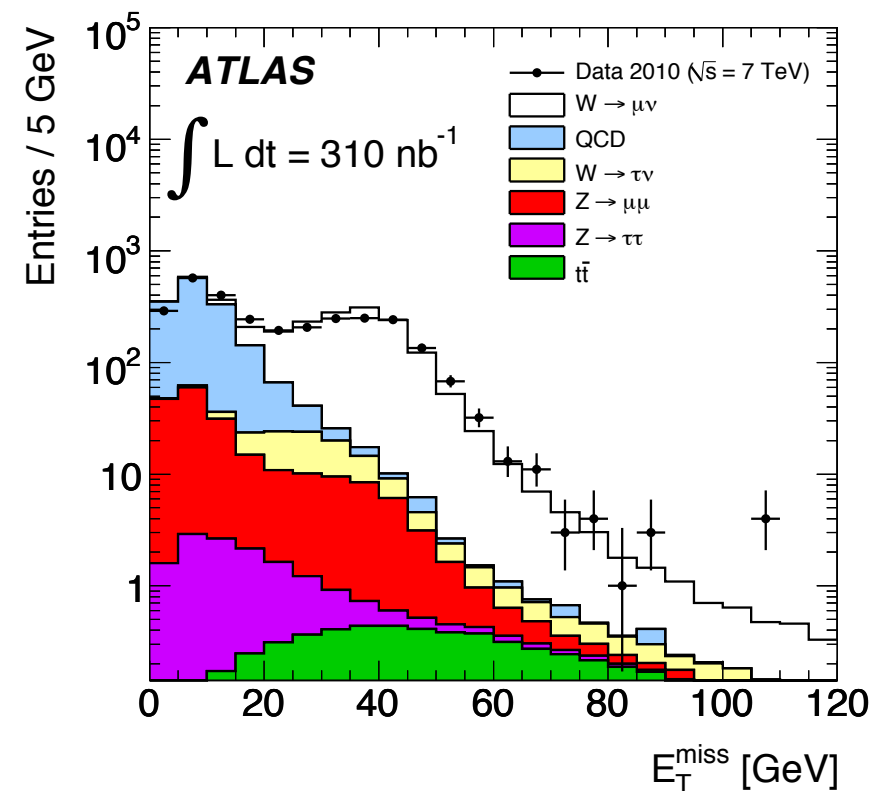
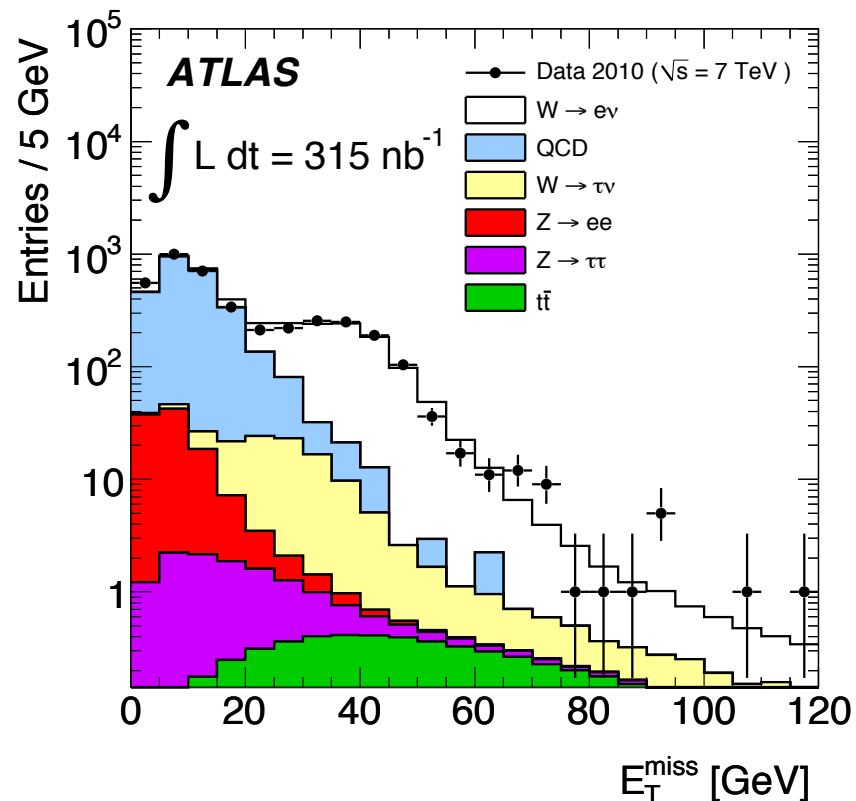
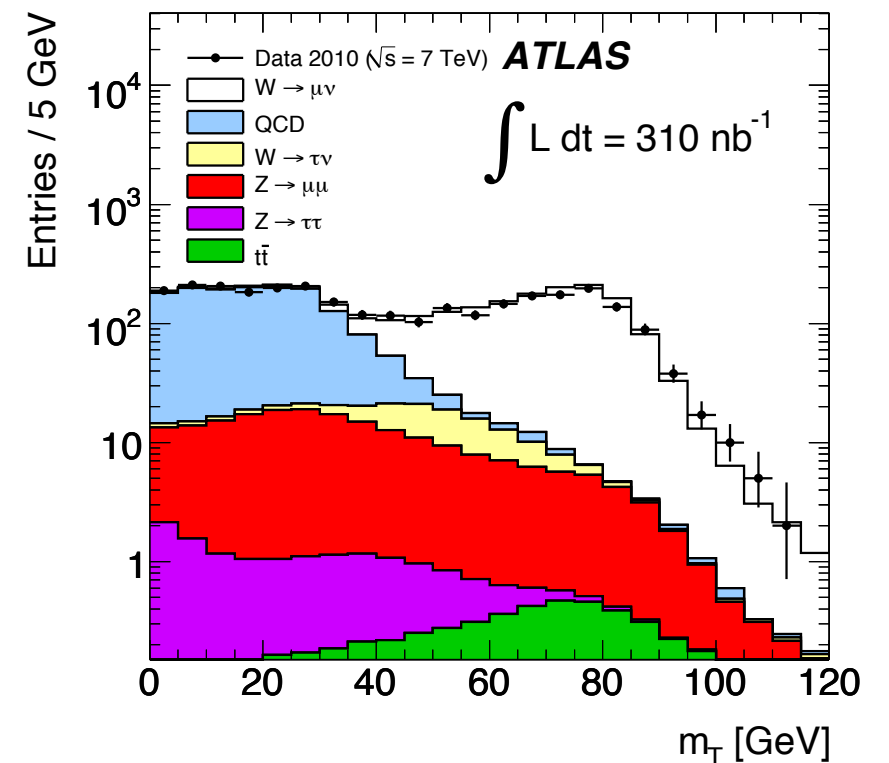
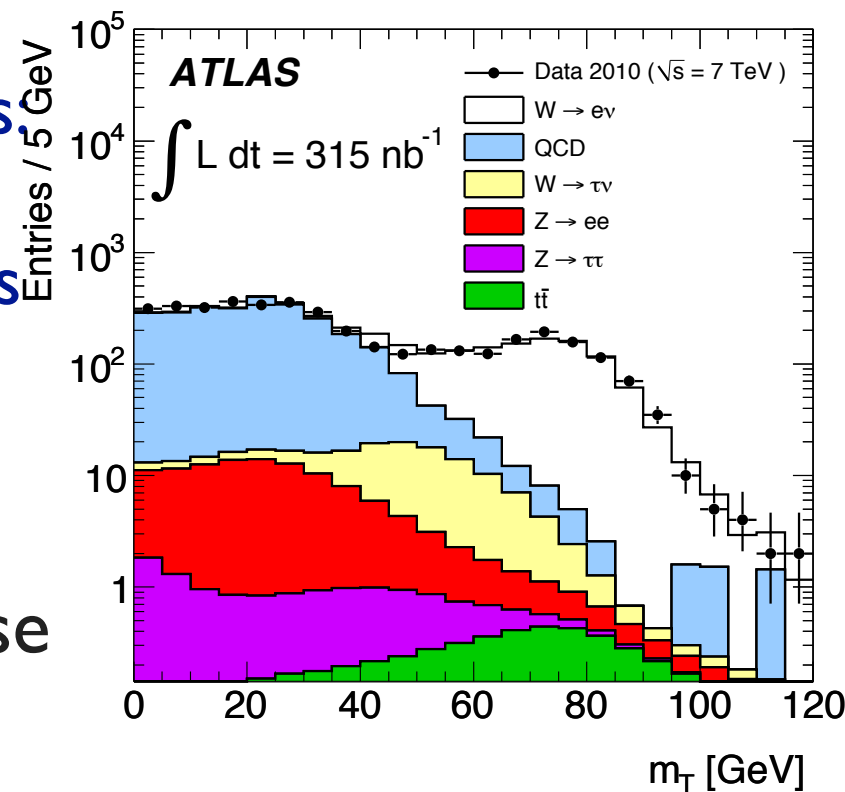
CMS Experiment at LHC, CERN
Run 133877, Event 28405693
Lumi section: 387
Sat Apr 24 2010, 14:00:54 CEST

Electrons $p_T = 34.0, 31.9$ GeV/c
Inv. mass = 91.2 GeV/c²



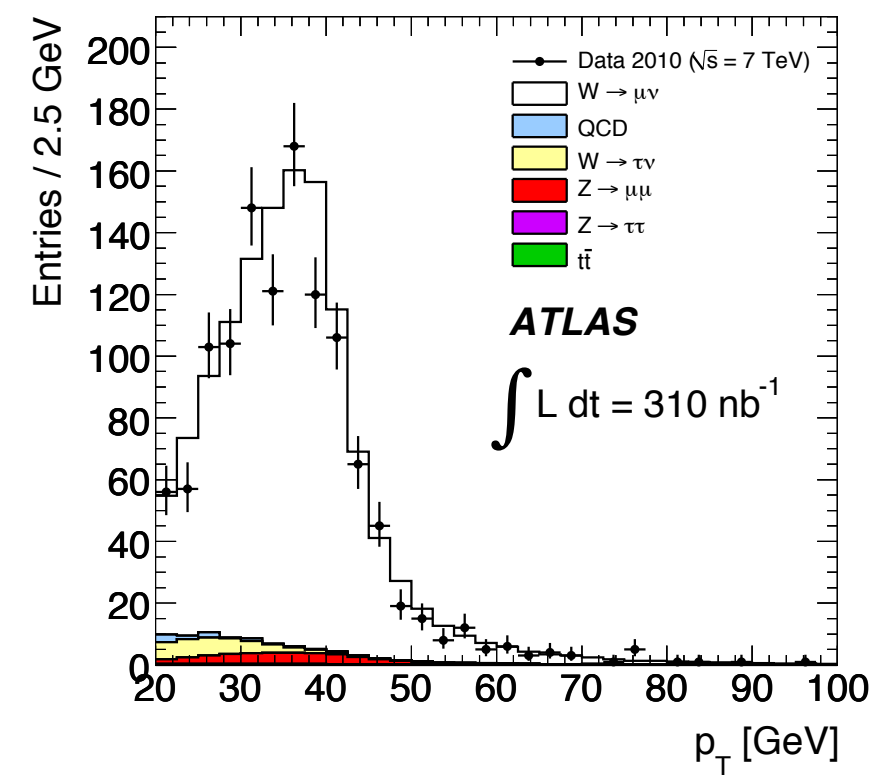
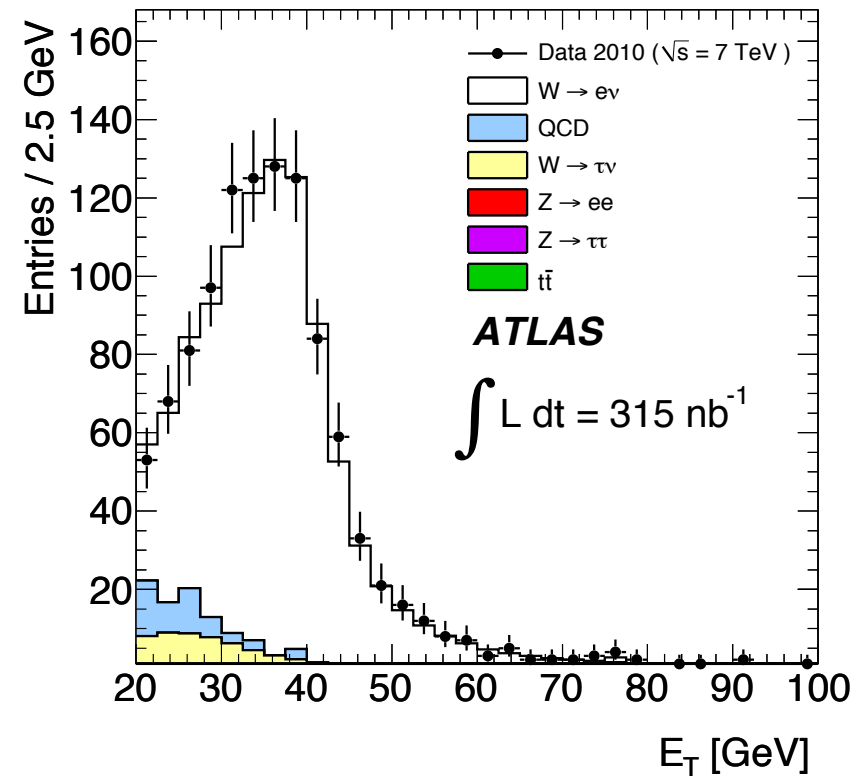
INCLUSIVE W ANALYSIS

- High p_T leptons
 - select isolated leptons
 - reduce probability of hadrons faking leptons
- Large missing transverse energy
 - leptons with correct charge in final state
 - missing energy from neutrinos
- Main W backgrounds from tau decays
 - leptons with correct charge in final state
 - missing energy from neutrinos



INCLUSIVE W/Z ANALYSIS

- W sample: p_T spectrum of leptons after requirements on missing energy and transverse mass



- Z sample almost background free
 - Recall: no other sources of high energy leptons in Standard Model
 - Only background due to New Particles which typically are expected to have small cross section! :-)

