W and Z events at CMS

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(*on behalf of CMS* ***Vector Boson Task Force***)

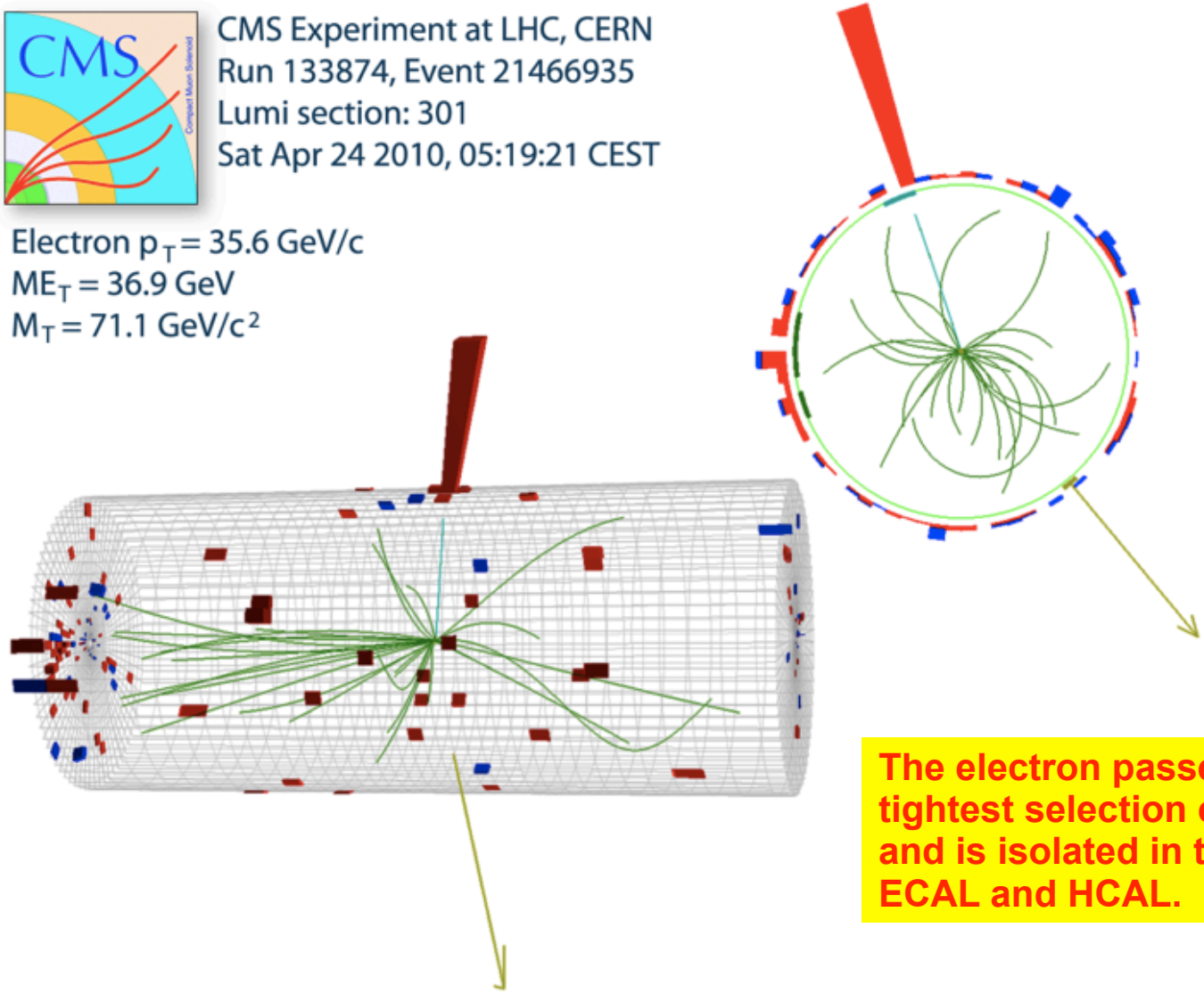
Disclaimer: The results presented in these slides are very very preliminary.
Not all results shown here are approved for presentation outside the CMS.

LPC Physics Forum
(May 27, 2010)

First "golden" W candidate event: W→eν

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/c^2

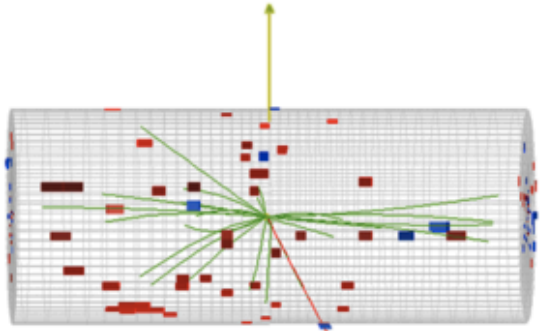


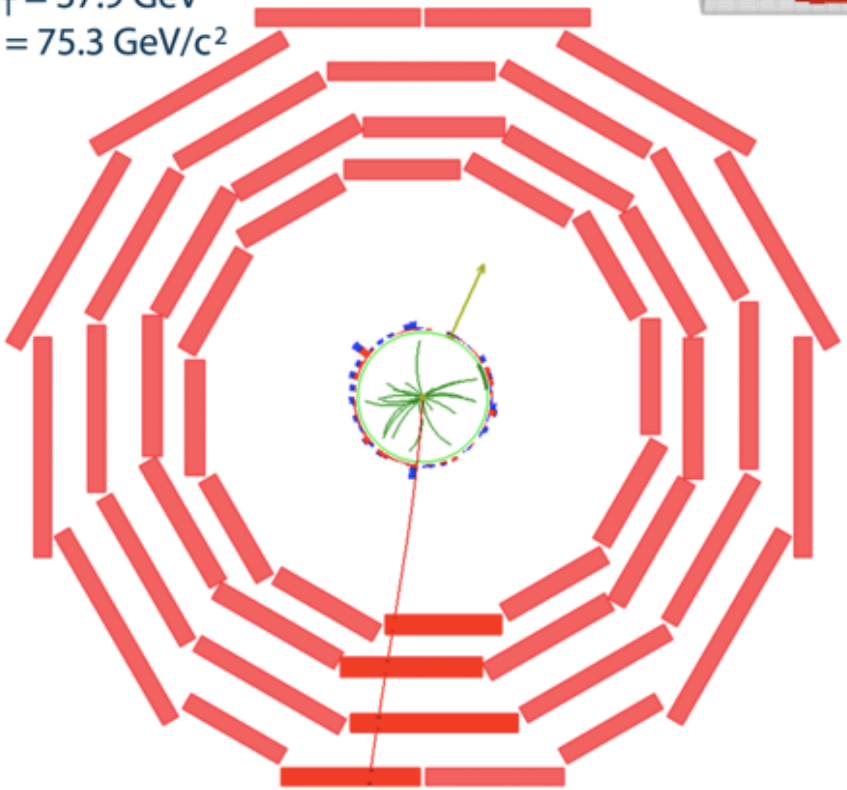
The electron passes our tightest selection criteria and is isolated in tracker, ECAL and HCAL.

First "golden" W→μν candidate followed soon

CMS Experiment at LHC, CERN
Run 133875, Event 1228182
Lumi section: 16
Sat Apr 24 2010, 09:08:46 CEST

Muon $p_T = 38.7$ GeV/c
$ME_T = 37.9$ GeV
$M_T = 75.3$ GeV/c^2



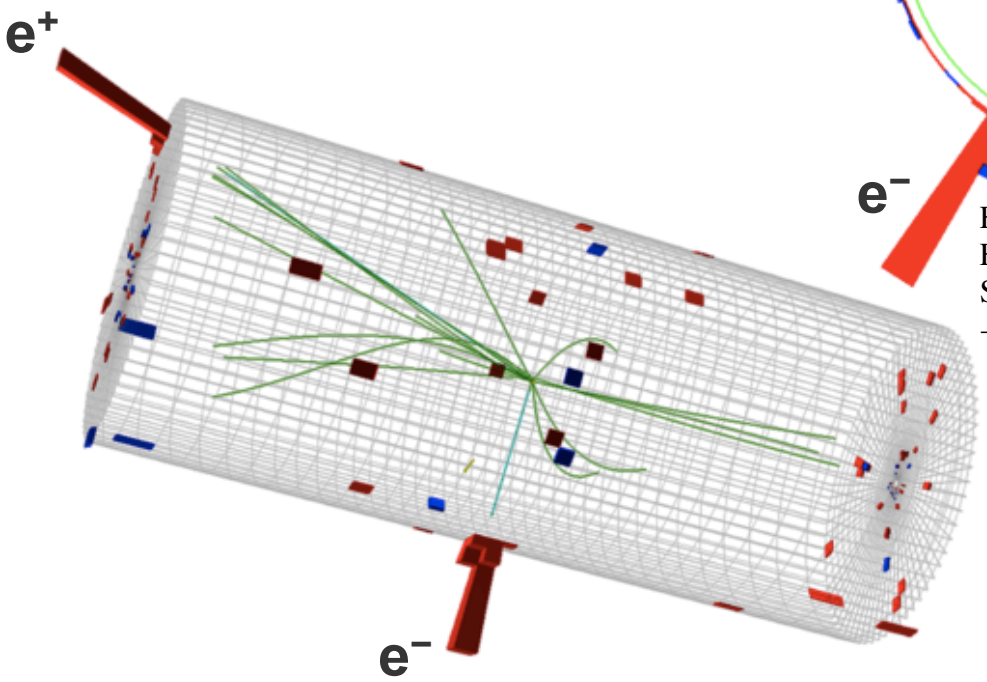


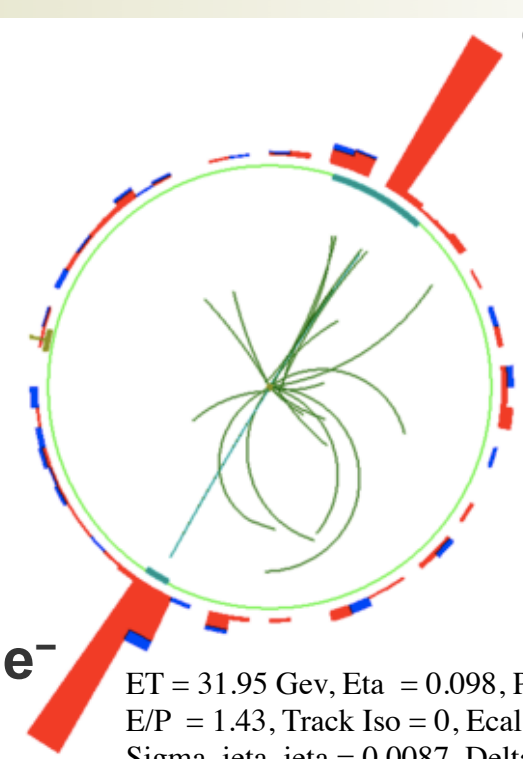
The muon passes our tightest selection criteria and is isolated.

First "golden" Z candidate event: Z→ee

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/c^2





e^+: ET = 34.01 Gev, Eta = 1.80, Phi = 1.03, fBrem = 0.611, E/P = 2.61, Track Iso = 0, Ecal Iso = 0.74, Hcal Iso = 0, Sigma_ieta_ieta = 0.0245, DeltaEta = 0.0016, DeltaPhi = 0.0135, H/E =0.

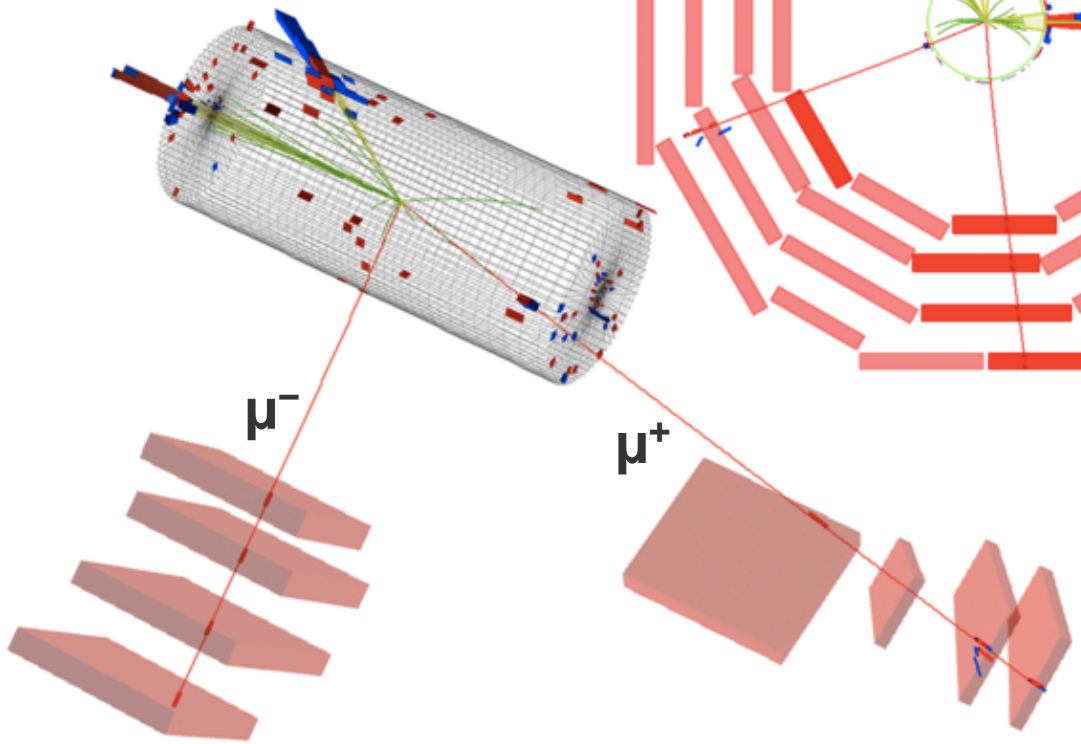
e^-: ET = 31.95 Gev, Eta = 0.098, Phi = -2.13, fBrem = 0.010, E/P = 1.43, Track Iso = 0, Ecal Iso = 0.66, Hcal Iso = 0, Sigma_ieta_ieta = 0.0087, DeltaEta = -0.0014, DeltaPhi = -0.0125, H/E =0.

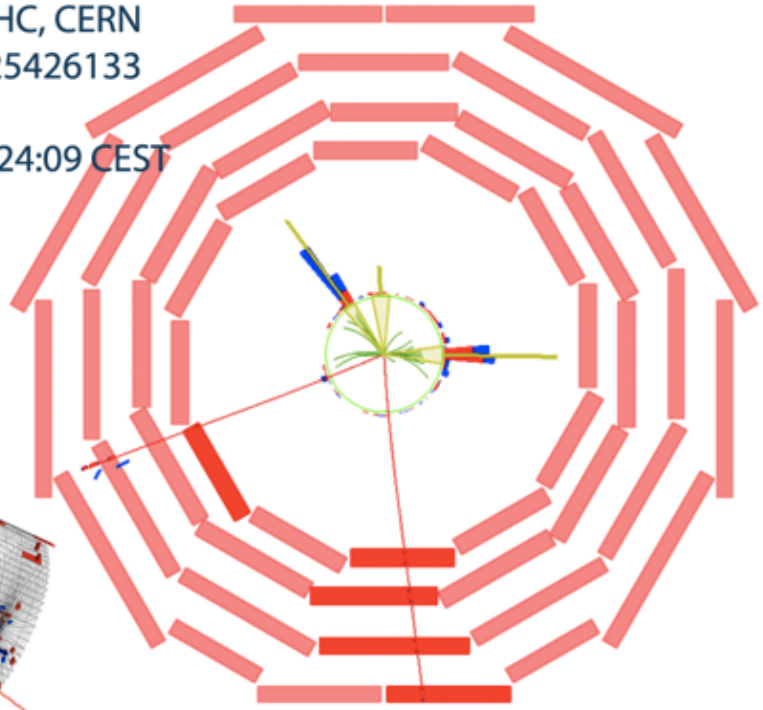
Both electrons pass our tightest selection criteria and are isolated in tracker, ECAL and HCAL. They are back-to-back in ϕ. There is no MET in the event.

First "golden" Z→μμ candidate event

CMS Experiment at LHC, CERN
Run 135149, Event 125426133
Lumi section: 1345
Sun May 09 2010, 05:24:09 CEST

Muon p_T= 67.3, 50.6 GeV/c
Inv. mass = 93.2 GeV/c^2





pfMET = 15 GeV
tcMET = 20 GeV
sumET = 350 GeV
MET Sign. = 0.8

```
ak5CaloJets:
unCor pt    eta    phi
59.14     1.906   -0.015
55.47     1.246   2.201
15.14     4.480   1.628

goodMuons:
pt    eta     phi  charge
67.3 -1.12  -2.74    1
50.6 -0.06  -1.51   -1
```

Both muons pass our tightest selection criteria and are isolated. There are three high p_T jets in the event. The jets do not pass b-rag criteria.

Moving beyond the candidate hunt: what next ?

- By now we have gone past the phase of hunting for W's and Z's
  - have ~5 Z candidates in each lepton (e,μ) channel and ~50 W's
- Can start plotting the distribution of kinematic variables
  - *e.g.,* m_T and MET for W and m_{ll} for Z
  - estimate background contribution under the signal peak with help from Monte Carlo simulation
  - compute rough estimates of the production cross section and compare with theory predictions (NLO)
- Still not quite in *civilized* state of analysis
  - low statistics: huge statistical uncertainty in any measured quantity
  - reconstruction/ triggering efficiency not fully understood

"Analysis design evolving with the data"

W/Z analysis ingredients

Triggers and Datasets

- Event selection for W/Z requires >= 1 HLT lepton candidate matching in ΔR an offline lepton candidate passing all standard selection. Paths used are single lepton trigger with lowest unprescaled thresholds.

  - Mu SD: HLT_Mu9 (backup: HLT_L2Mu11)
  - EG SD: HLT_Photon15 (backup: HLT_Photon20)

Lepton Selection

- Muons

Global & tracker muon, PT > 20,25 GeV, |eta| < 2.1
N track hits > 10, N global muon hits > 0, chi2/ndof < 10, d0<2mm
Combined relative isolation (R=0.3) < 0.15

- Electrons

A few suggested working points tested for each signal extraction method: straw man points are 70% efficient for W, 95% for Z electrons

CMS W/Z analysis goals for ICHEP

✦The VBTF goal is to submit for publication a paper describing measurements of:

- inclusive W, W^+, and W^- production cross sections, in e, μ, and combined channels
- inclusive Z production cross section, in e, μ, and combined channels
- inclusive cross section ratio W/Z in e, μ, and combined channels
- inclusive cross section ratio W^+/W^- in e, μ, and combined channels

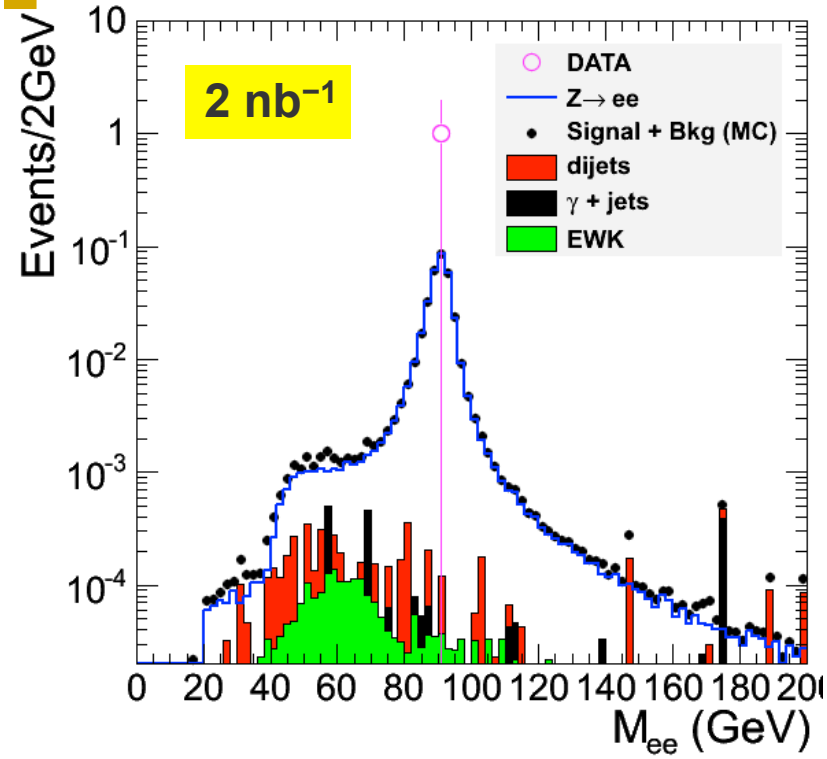
✦Target luminosity for these measurements is roughly 0.1−1 pb^{-1}.

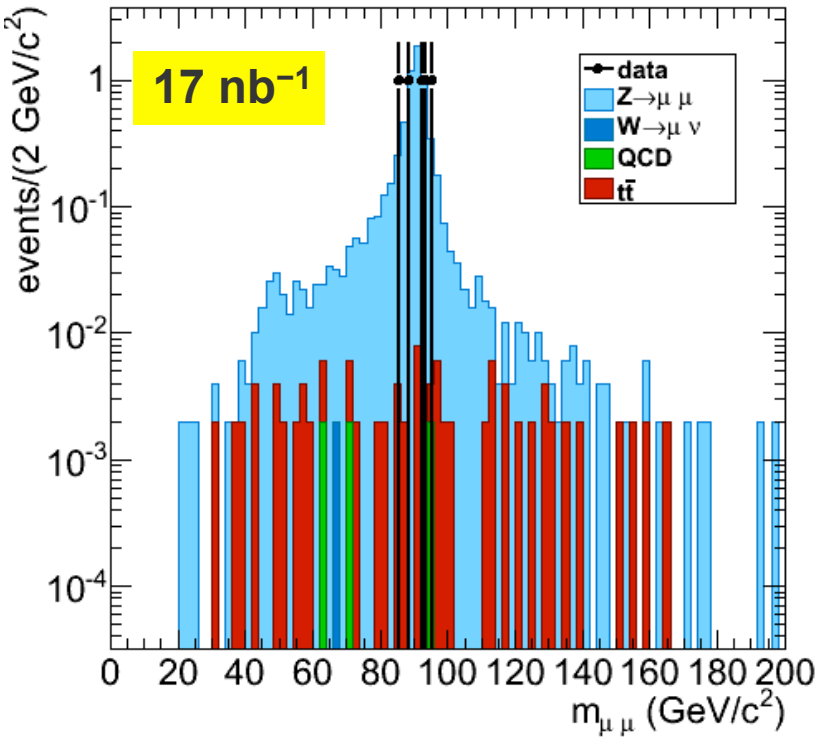
- At 0.1 pb^{-1}, the Z samples are inadequate to estimate lepton efficiencies and MET modeling, and the measurement strategy must rely on simulations, W samples, and other control samples to interpret the observed W and Z signals as cross section measurements.
- In the event that 1 pb^{-1} is quickly achieved, the lower luminosity techniques can serve as cross checks and early indicators of analysis performance.

✦Successful achievement of VBTF publication goals depends largely on successful commissioning of lepton, missing ET, and luminosity measurements.

- The task force therefore shares a number of tasks with the commissioning efforts of the corresponding DPGs and POGs.

Z→ee, μμ snapshots in data





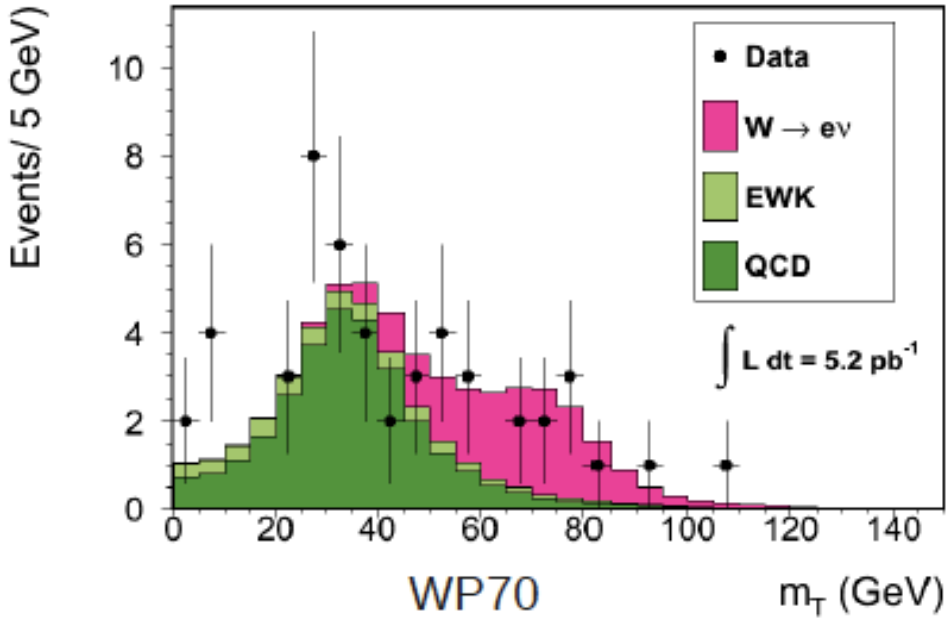
With full 17 nb^{-1} data we have 5 Z→ee and 5 Z→μμ candidates.

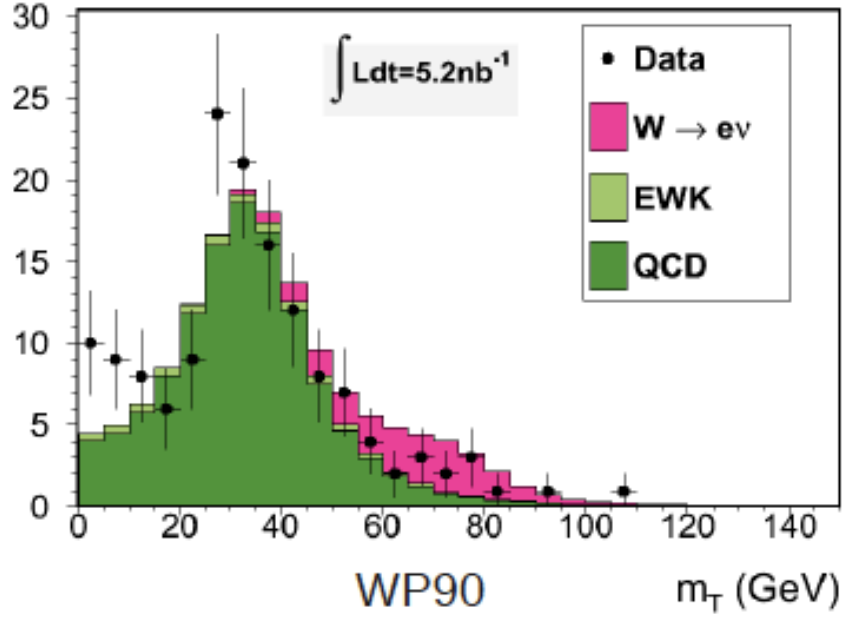
Expect 8.5 Z→ee candidates from MC assuming σ=1300 pb (Pythia), acceptance = 0.4358, ε_{ele} = 0.95, trigger efficiency = 1.

Observed Z→ee cross section in data = 748 ± 334 pb

Reasonable data/MC agreement given statistics

W→eν snapshot in data (5.2 nb^{-1})





Using …

- Powheg acceptance, 58.9%
- Some efficiencies from MC
  - Trigger = 100%, Reco = 98%
  - MT cut = 83% / 84%
  - Recalculated WPs in MC for 30→20 GeV (65% / 85%)
- Background estimates from the EWK & QCD MC's

Reasonable data/MC agreement given statistics

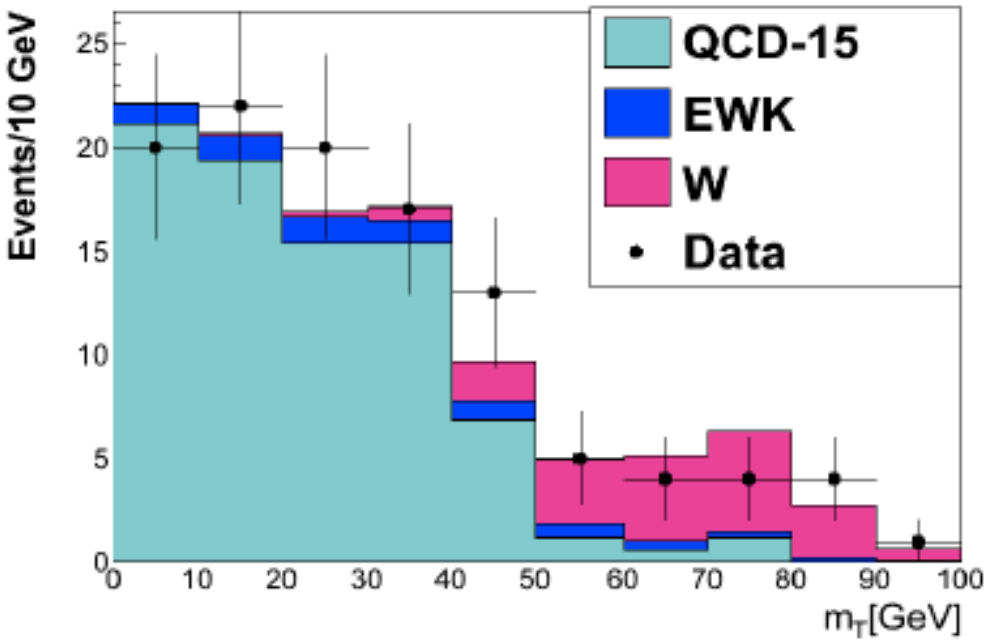
Yields for MT > 50 GeV

	Data	W	Total MC BG	QCD 15/em	EWK
WP90	24	19.8	11.8 / 18.0	10.4 / 13.6	1.4
WP70	17	15	2.7 / 5	1.7 / 4	1

crude cross section (cf. ~9.7 nb @ NLO)

	with QCD15 (nb)	with QCDem (nb)
WP90	5.7 ± 2.8 ± ?	4.2 ± 2.9 ± ?
WP70	8.8 ± 2.7 ± ?	7.4 ± 2.9 ± ?

W→μν snapshot in data (5.2 nb^{-1})



Muon ID + Isolation

crude cross section (cf. ~9.7 nb @ NLO)

w/ QCD15 (nb)	w/ IncMu (nb)
11.0 ± 3.3 ± ?	10.8 ± 3.3 ± ?

Using …

- Powheg acceptance, 59%
- Selection efficiencies from MC : 98.3%, 97.8%
- Background estimates from the MC

Yields for MT > 50 GeV

Data	W	Total MC BG	QCD15/ IncMu	EWK
22	15.2	4.6 / 5	2.8 / 3.2	1.8

Reasonable data/MC agreement given statistics

Outlook for ICHEP: $\int L\,dt = 0.1–0.3\ pb^{-1}$

- **For ICHEP/EWK-10-002 we plan for the ~0.1 pb^{-1} scenario:**
  - Z observation, ~60 golden candidates, 13% stat. precision
  - W analysis, ~600 candidates, 4% stat. precision
  - W/Z cross section ratio to 14% stat.
  - W+/W- ratio to 8% stat.
  - One-bin tag-and-probe lepton efficiency known to 4% (9%) for 90% (70%) operating point

- **Wouldn't be able to apply Z-driven techniques to W.**
  - Some (if not all) efficiency and W signal-modeling to be estimated from simulation, from W data themselves, or from other non-Z sources.
  - Hope for large late update.
  - 100 nb^{-1} result can only crudely be Z data-driven and have some inelegant ingredients.
  - Less lumi will imply more and more MC-based ingredients/ extrapolations.

References for additional information

1. Analysis Note & PAS:

   Drafts in progress in SVN !

Measurements of Inclusive W and Z Cross Sections in pp Collisions at $\sqrt{s} = 7$ TeV

CMS PAPER EWK-10-002 **CMS PAPER AN-10-116**

The CMS Collaboration

2. Vector Boson Task Force main twiki:
   https://twiki.cern.ch/twiki/bin/view/CMS/EWKVBTF

3. W/Z candidates in early 7 TeV data:
   https://twiki.cern.ch/twiki/bin/viewauth/CMS/WandZCandidates

4. VBTF summary (J Berryhill) in CMS Physics Week plenary on May 18
   http://indico.cern.ch/getFile.py/access?contribId=33&sessionId=15&resId=1&materialId=slides&confId=93670

Summary

✦Observed W and Z candidate events at CMS
- in both lepton channels
- with 17 nb^{-1} data find ~5 Z and ~50 W in each channel
  → consistent with theory/NLO predictions given the statistics
- Making progress on signal extraction techniques, S/B optimization, ...
  → efforts ongoing to understand detector effects and systematics, signal and background modeling, MET resolution, ...

✦Analysis strategy for ICHEP
- prepare for 0.1−0.3 pb^{-1} integrated luminosity
- some efficiency and W signal-modeling to be estimated from simulation, from W data themselves, or from other non-Z sources.
- not enough # of Z's for calibration → crude cross check from data

✦Analysis strategy for publication
- prepare for 1−10 pb^{-1} integrated luminosity
- mostly data driven, use full ingredients developed during last year !