First CMS data on massive di-leptons resonances search

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Out-line of the talk

- **Introduction : theory motivations, LHC status**
- **CMS detector**
- **CMS apparatus performances**
- **Low pt electron selection**
  - * Data / MC comparison
  - * Di-lepton invariant mass spectrum (Z, W)
  - * Event display of Z, W from data
- **High pt electron selection**
  - * Data / MC comparison
  - * Check of ECAL calibration to high energy electrons
  - * Expected di-electron mass spectrum & bg
  - * Exclusion limit
- **Conclusions**

Theory motivations

High mass dilepton neutral resonances predicted by:

New gauge bosons, spin1: superstring, GUT, little Higgs, etc
- SSM
- Z_ψ, Z_η, Z_χ in E_6 and SO(10)
- Z_{LRM}, Z_{ALRM} in left-right models
- Z_{B-L}, 2 parameters M and c

Kaluza-Klein massive graviton, spin 2: Randall-Sundrum
2 parameters M and c
decays also into $\gamma\gamma$ or ZZ

Tevatron limits: = 963 GeV for SSM, =848 for RS for $c = 0.1$

LHC status

- CMS recorded now over ~ 43 pb^{-1}
- Data :

  * Analysis presented here: 3, 4 and 15

    pb^{-1}

  * Maximum luminosity = $2*10^{32}$ cm^{-2}s^{-1}

- MC:
  - NLO Monte Carlo (POWHEG) for EWK processes
  - PYTHIA for QCD and t t^{bar}
  - PYTHIA for hadronization
  - Detector simulation with GEANT4

Total Integrated Luminosity 2010 (Mar 30 10:00 UTC - Nov 03 01:46 UTC)

Delivered 46.36 pb^{-1}
Recorded 42.51 pb^{-1}

CMS detector

CMS

Weight	**14000t**
Diameter	**15m**
Length	**21.6m**
Magnetic field	**3.8T**

HCAL

Muon chamber : Drift Tubes, CSC and RPC's

Tracker : Si strips and pixels

ECAL
+ PbWO4 Crystals+Si/Pb Preshower

3.8T solenoid

Iron yoke

Beam pipe

Trigger
- L1: hardware w/ output 100 kHz
- HLT: farm of pc's w/ same framework offline, $O(10^2)$ Hz

# CMS apparatus performances

Calibration with π⁰
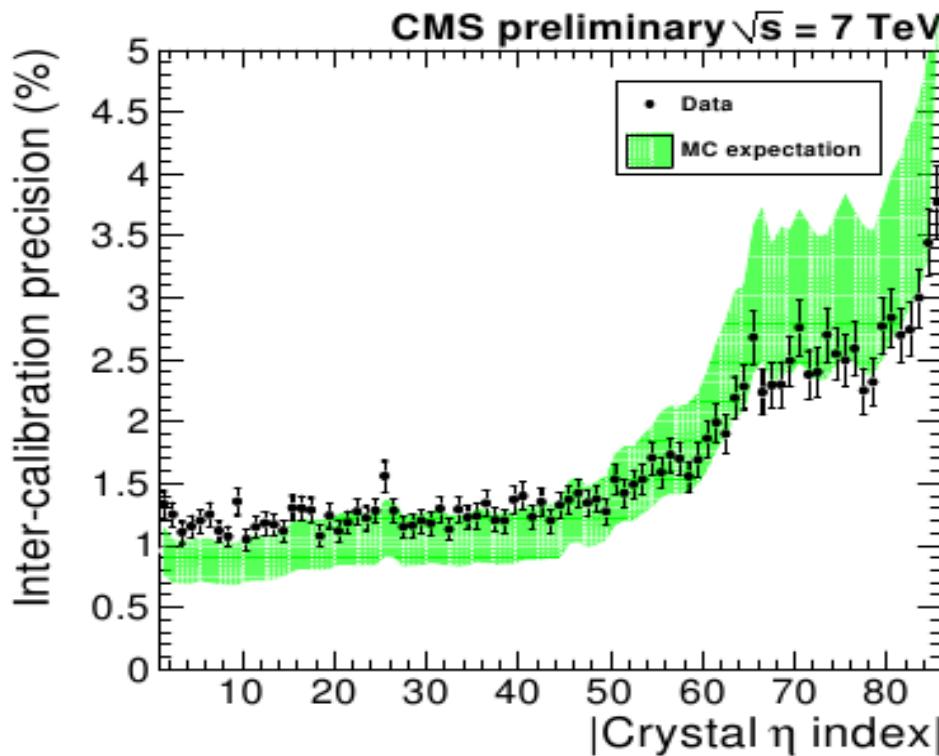
- ◆ The crystal by crystal calibration precision is found to be 1.2%

- ◆ While from MC it is 1.1(+/-)0.2%

CMS-PAS-EGM-10-003

Low pt electron selection

- **Trigger: cluster $E_T > 15$ GeV**

- **Kinematics:**
  - $E_T > 20$ GeV
  - $0. < |\eta| < 1.442$ or $1.566 < |\eta| < 2.5$

- **Clustering and tracking customized to recover bremsstrahlung losses**

- **Identification: cluster-track matching, e.m. shower shape and hadron leakage H/E**

- **Isolation:**
  - **Sum P_T within cone of $\Delta R < 0.3$, removing electron 'footprint'**
  - **Isolation from tracker, ECAL and HCAL relative to electron P_T**
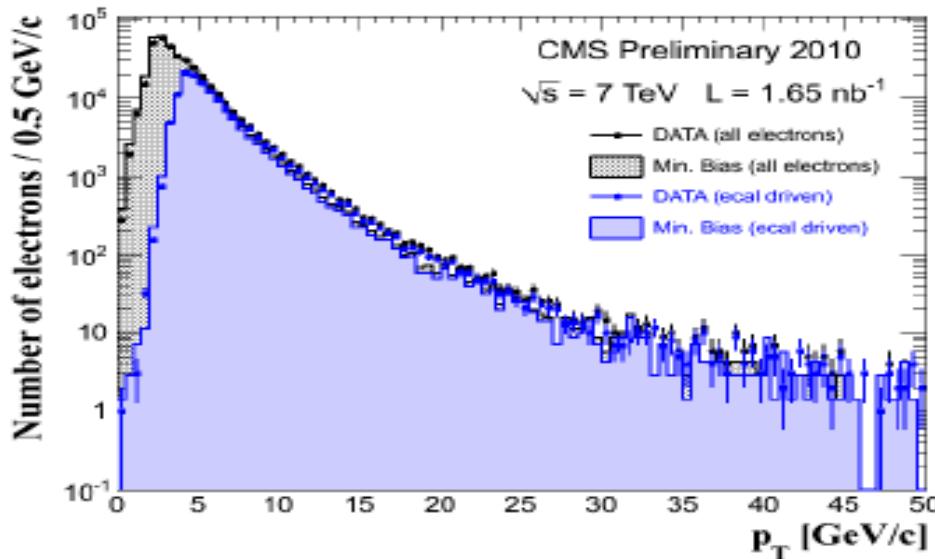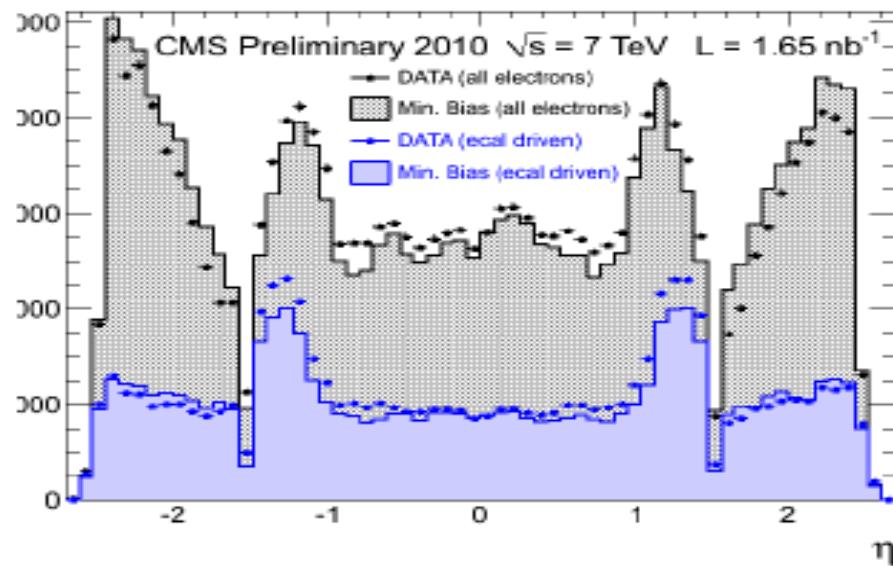
CMS-PAS-EGM-10-004

2.9pb⁻¹ Z→ee & W→eν
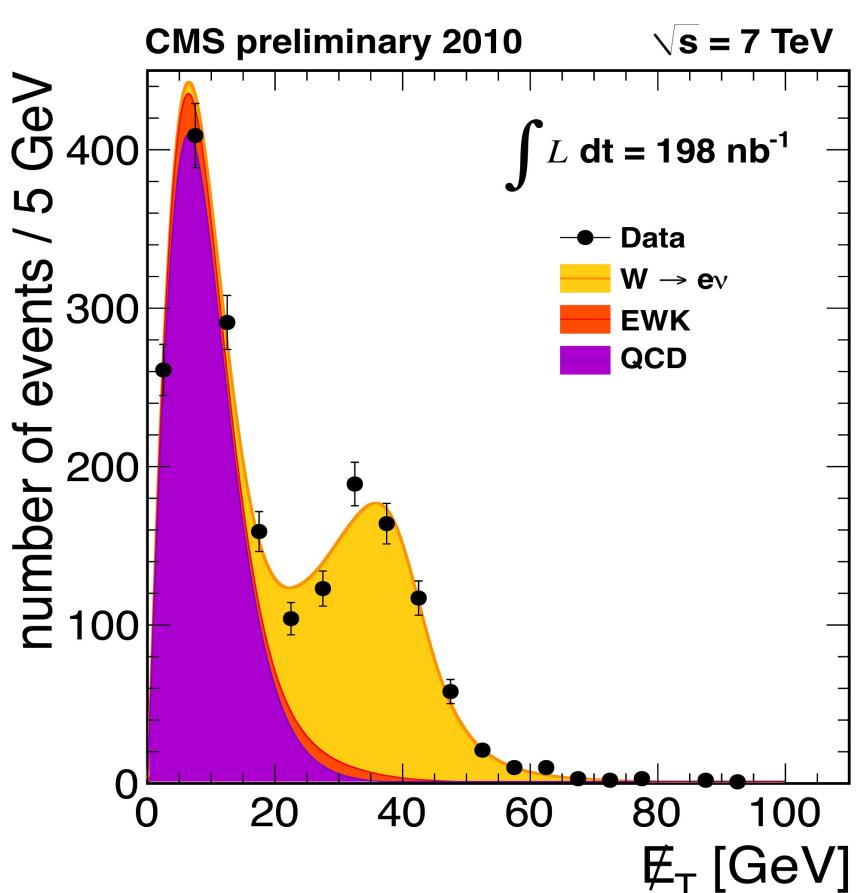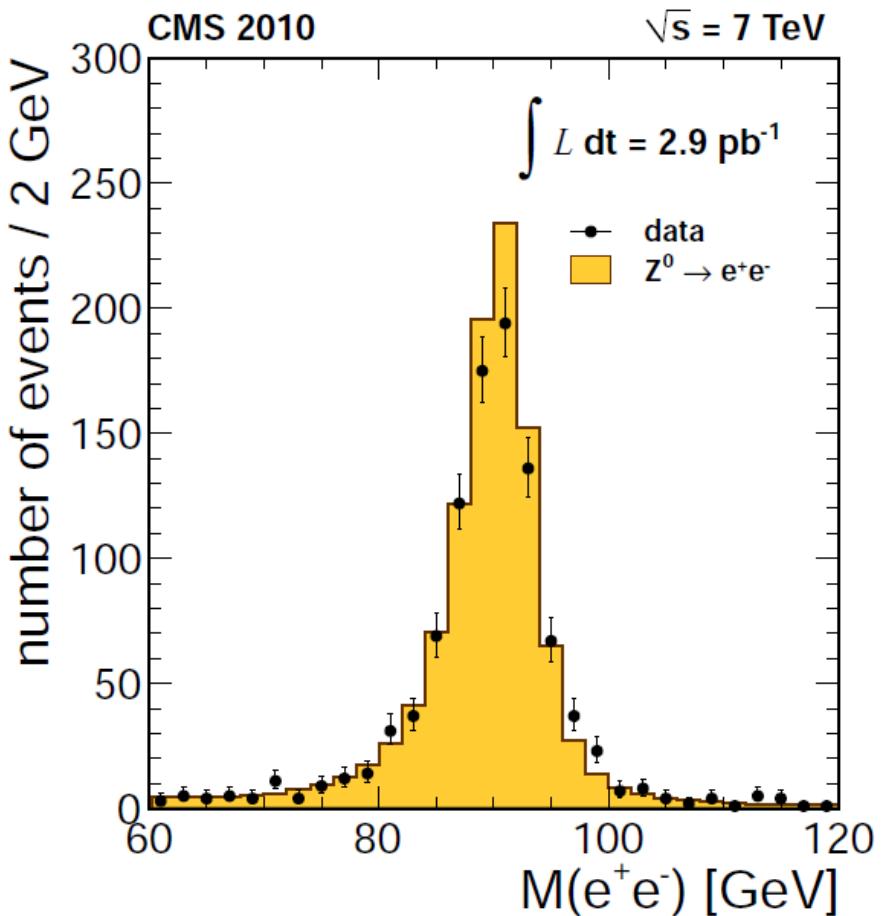
CMS-PAS-EWK-10-002

2.9pb⁻¹ Z→μμ & W→μν
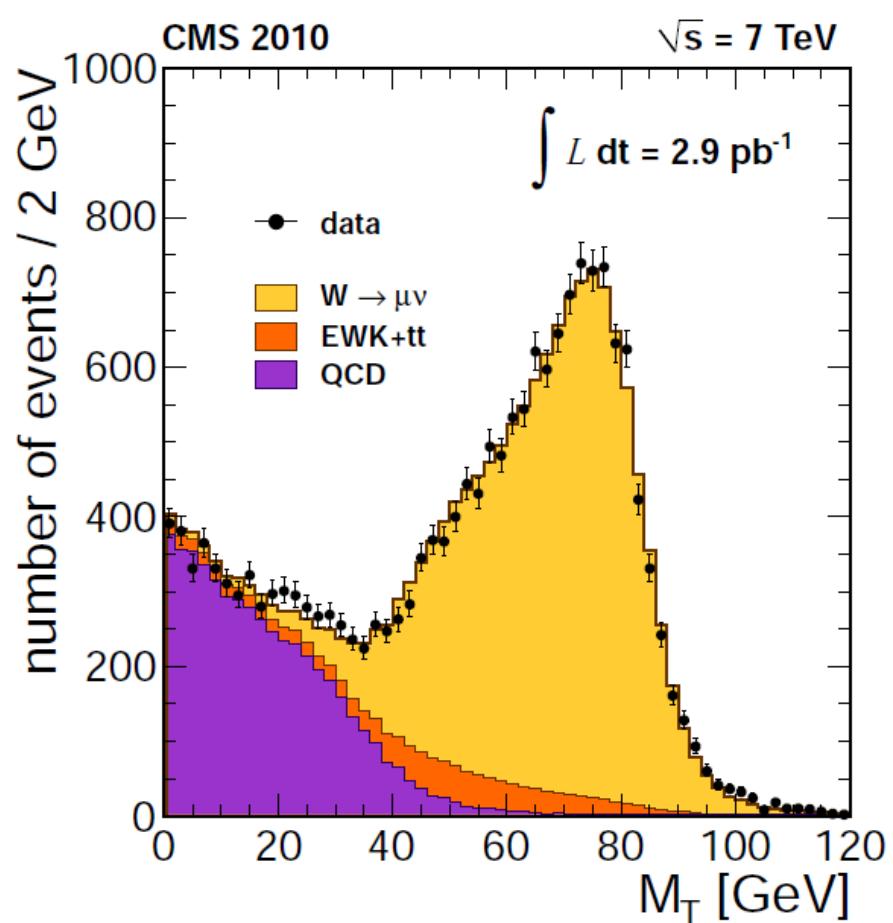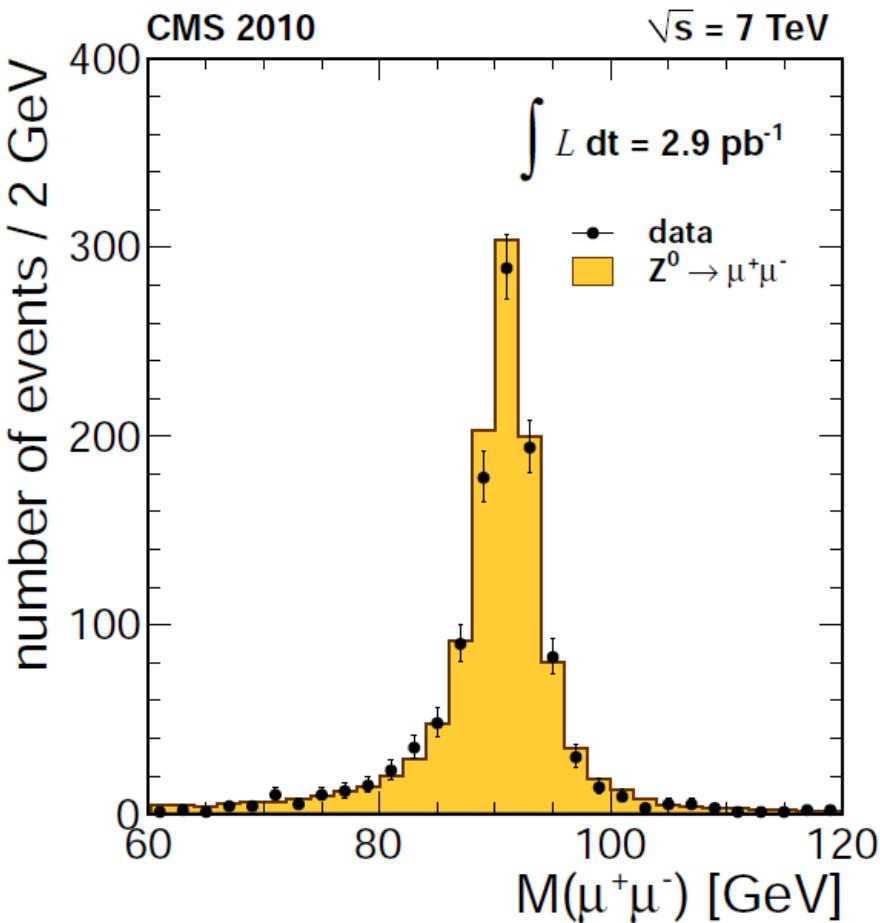
CMS-PAS-EWK-10-002

Full di-electron mass spectrum
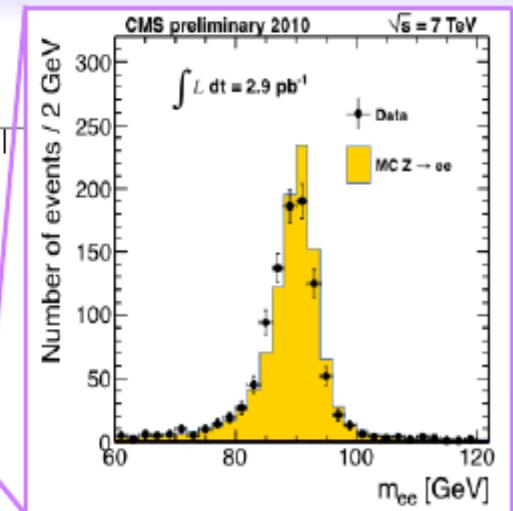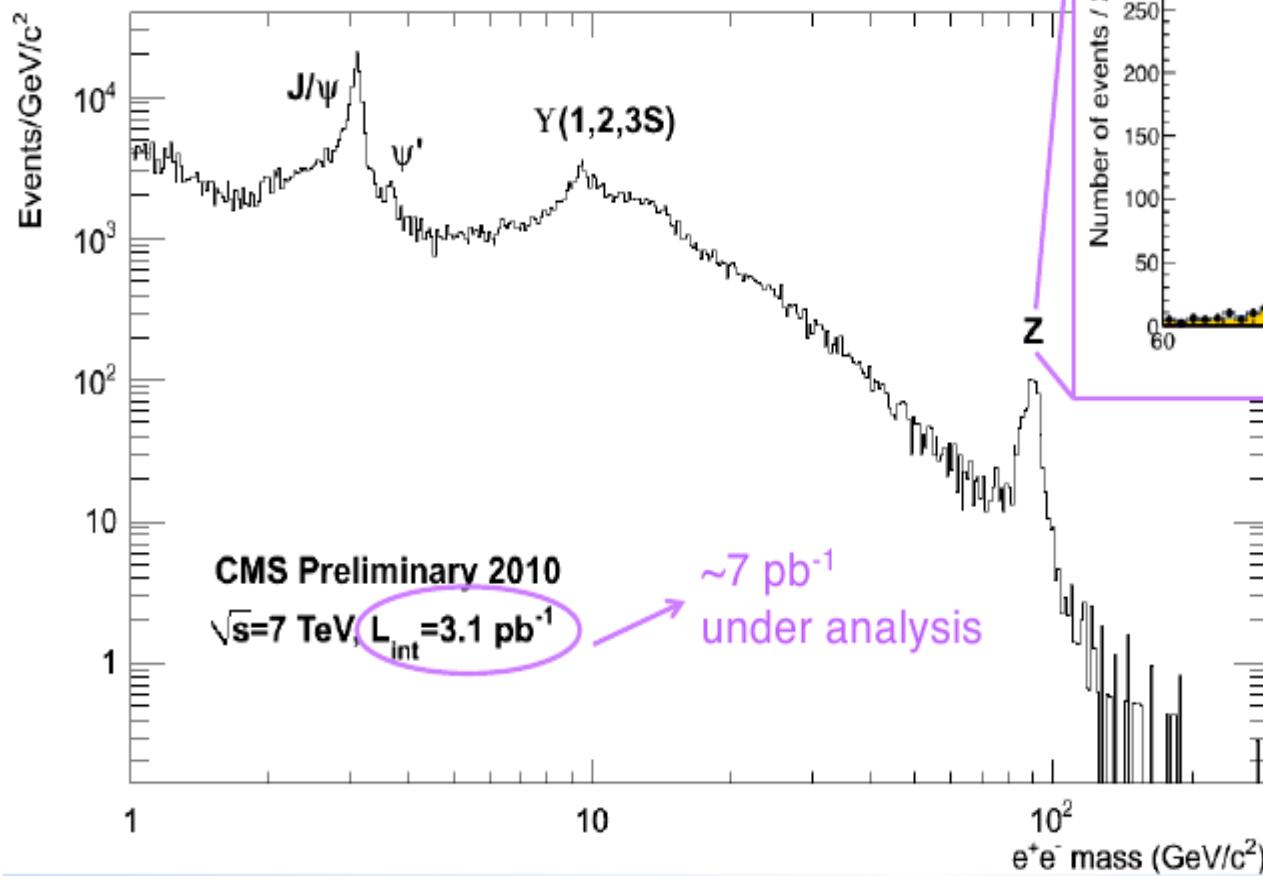
Full di-muon mass spectrum

Event display of Z to ll

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
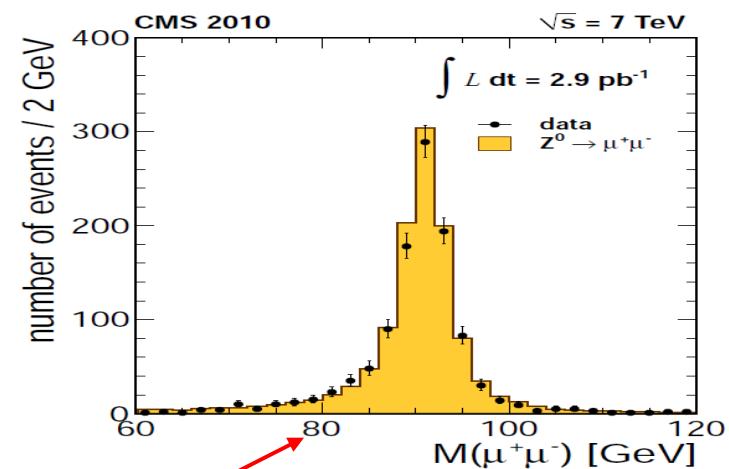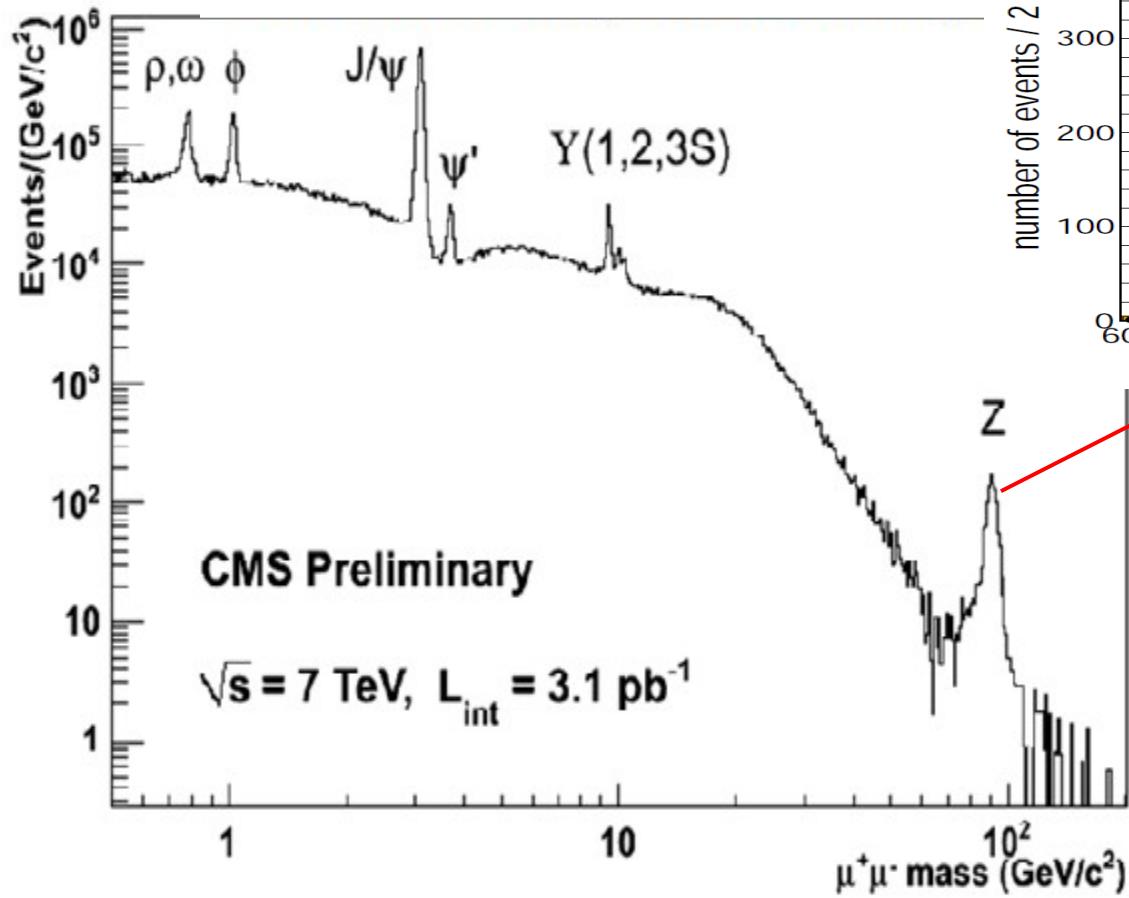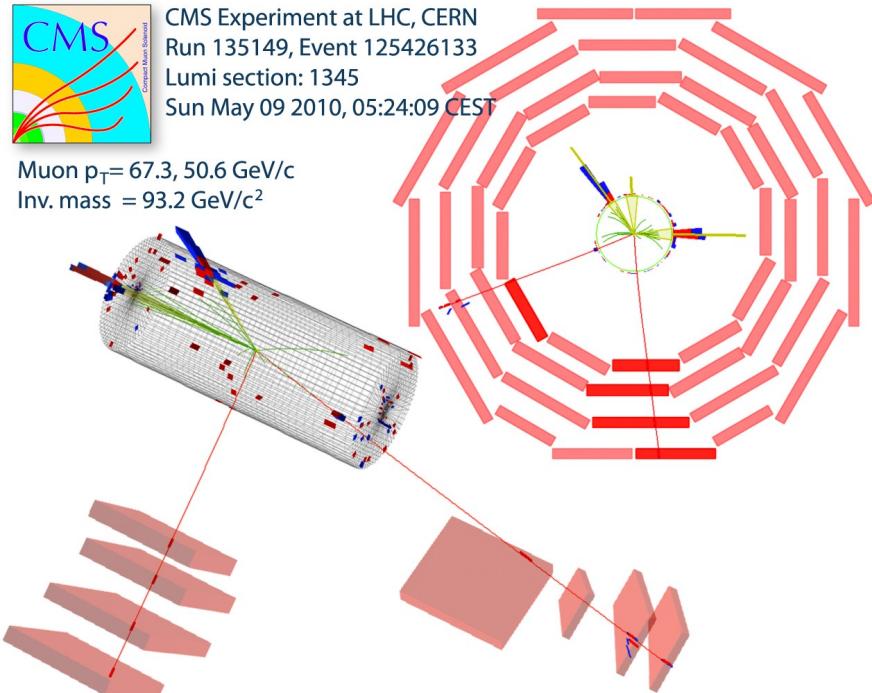
Z→μμ candidate

Z→ee 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/c^2
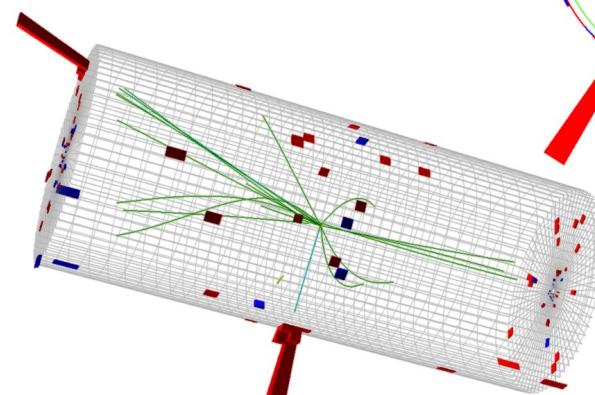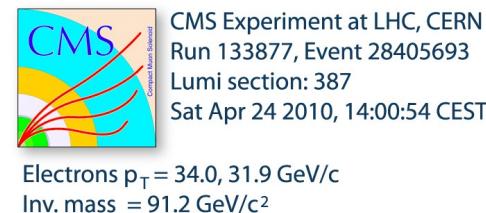
# Event display of W

W→eν candidate

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
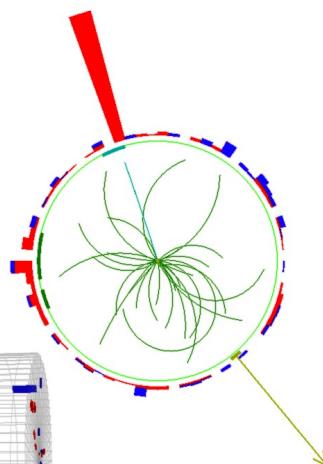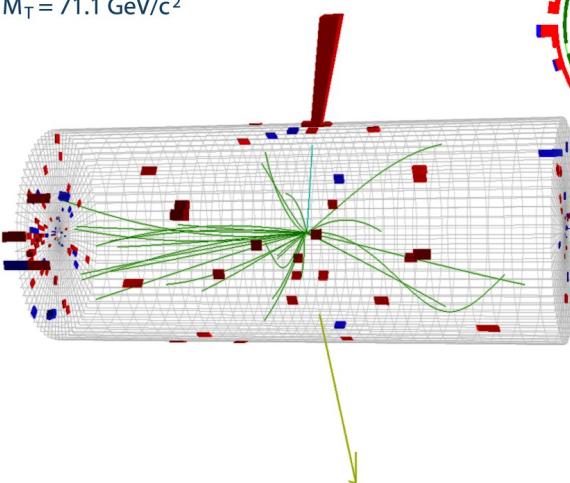
W→μ ν candidate

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
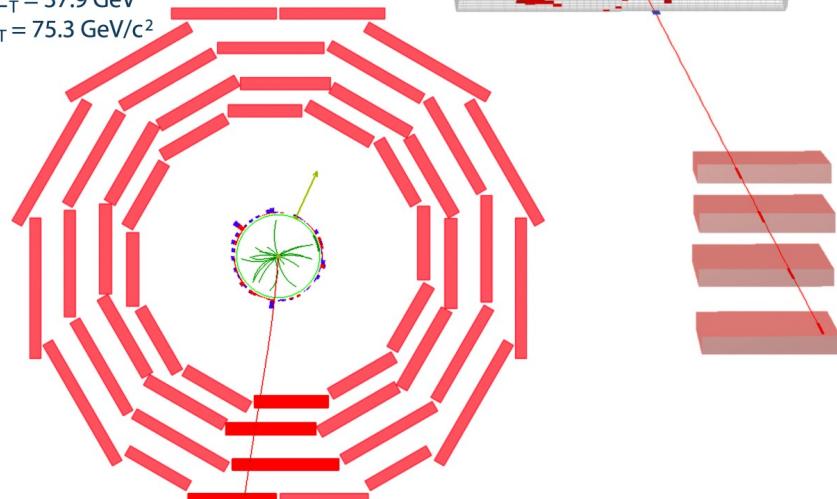
W and Z cross sections

$$\sigma(pp \to W + X \to \ell\nu + X) = 9.22 \pm 0.24(\text{stat.}) \pm 0.47(\text{syst.}) \pm 1.01(\text{lumi.}) \text{ nb}$$

$$\sigma(pp \to Z(\gamma^*) + X \to \ell^+\ell^- + X) = 0.882^{+0.077}_{-0.073}(\text{stat.})^{+0.042}_{-0.036}(\text{syst.}) \pm 0.097(\text{lumi.}) \text{ nb}$$
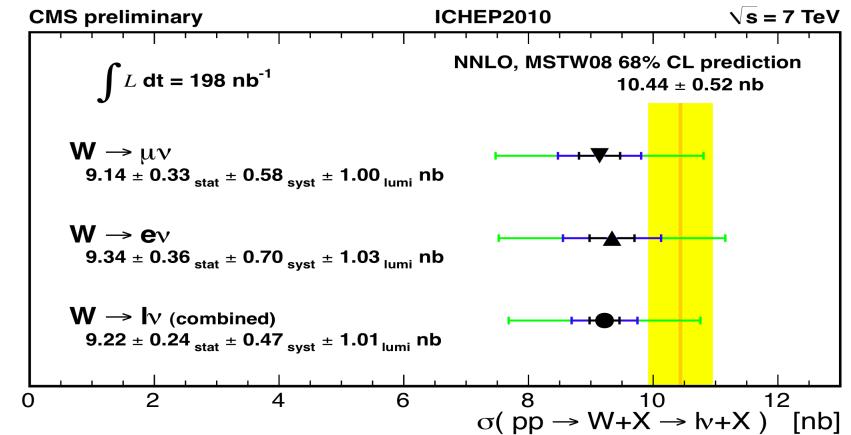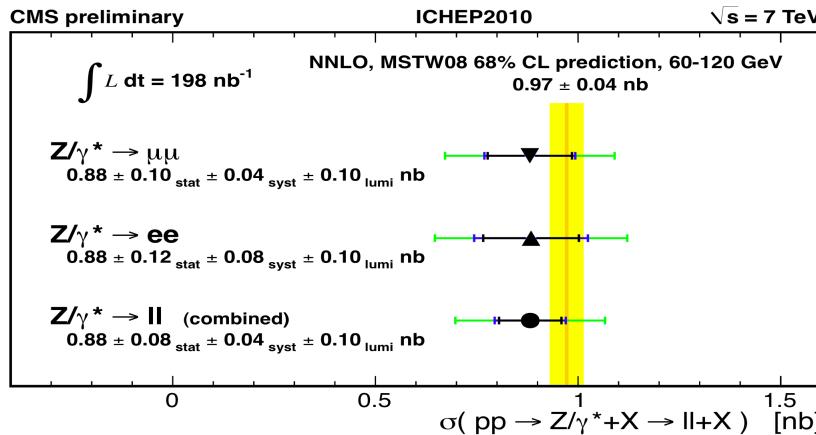
- Lepton channels combined w likelihood accounting errors and their correlations
- Cross sections compatible with Standard Model
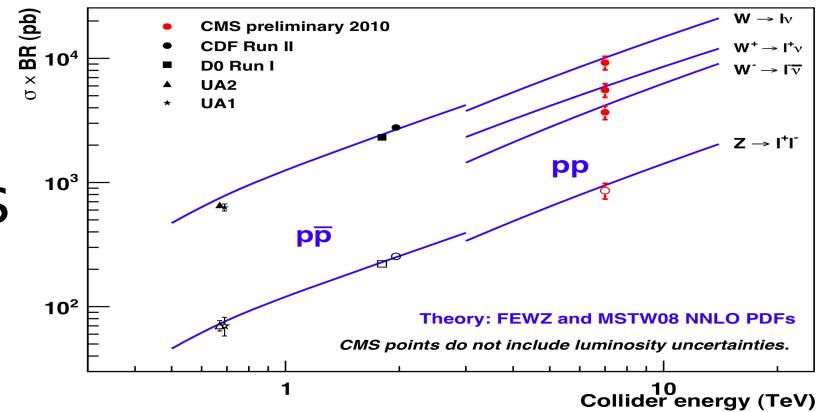
High pt electron selection

- HEEP ID   (High energy electron pair)

Official HEEP Selection v3.0 (Current Version)		
Variable	**Barrel**	**Endcap**
E_T	> 25 GeV	> 25 GeV
$|\eta_{sc}|$	< 1.442	$1.560 < |\eta_{sc}| < 2.5$
isEcalDriven		
$|\Delta\eta_{in}|$	< 0.005	< 0.007
$|\Delta\varphi_{in}|$	< 0.09	< 0.09
H/E	<0.05	<0.05
$\sigma_{i\eta i\eta}$	n/a	<0.03
E^{2x5}/E^{5x5}	>0.94 OR $E^{1x5}/E^{5x5} > 0.83$	n/a
EM + Had Depth 1 Isolation	<2+0.03*Et	<2.5 for Et<50 else
		<2.5+0.03*(Et-50)
Had Depth 2 Isolation	n/a	<0.5
Track Isol: Trk Pt	<7.5	<15

Kinematics cuts

Shower shape cuts

Isolation cuts

HEEP selection efficiency (MC study)

Process	Drell-Yan				SSM Z′
mass (GeV/c^2)	> 40	> 120	> 200	> 500	1000
global acceptance, reconstruction and selection efficiency	0.27	0.40	0.49	0.61	0.67
final number of selected events	33,700	487	76	3.4	15.7

For 2 selected electrons (LO calculated cross sections)

Data driven methods "tag and probe" for efficiency and background evaluation

|	Barrel		Endcap	
	$Z \rightarrow ee$	jet bg.	$Z \rightarrow ee$	jet bg.
efficiencies	$93.9 \pm 0.1\%$	–	$94.3 \pm 0.2\%$	–
rejection power	–	$99.8 \pm 0.1\%$	–	$98.4 \pm 0.4\%$

and at high mass by selected DY events

CMS-EXO-09-006

Data & MC comparison

Pseudo-rapidity distribution
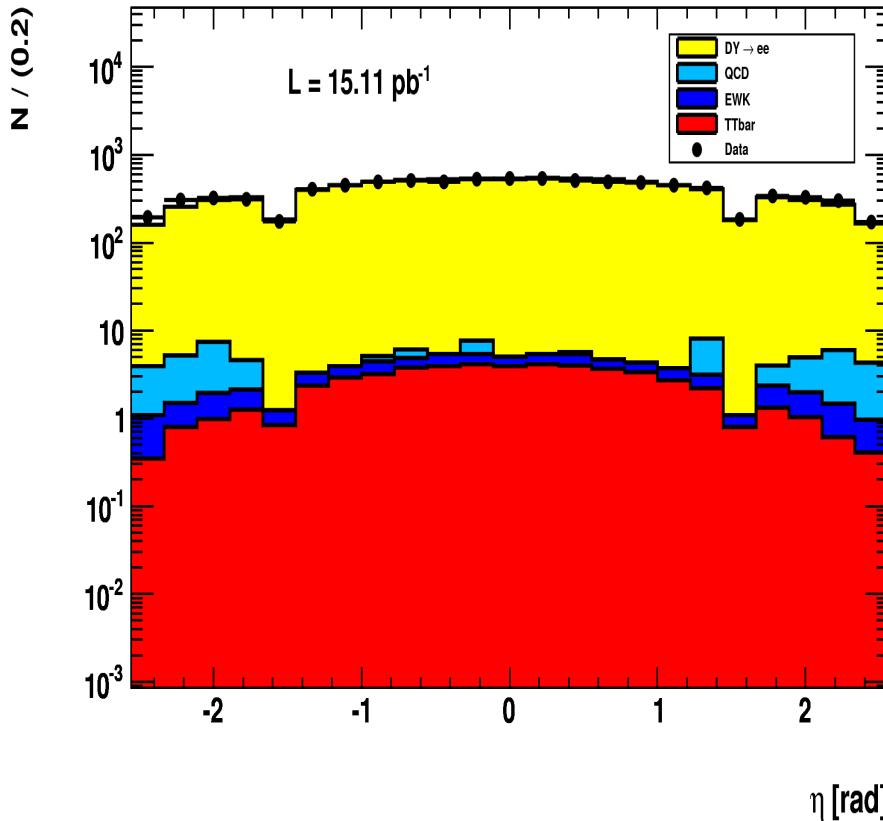
**Azimuth angle distribution**
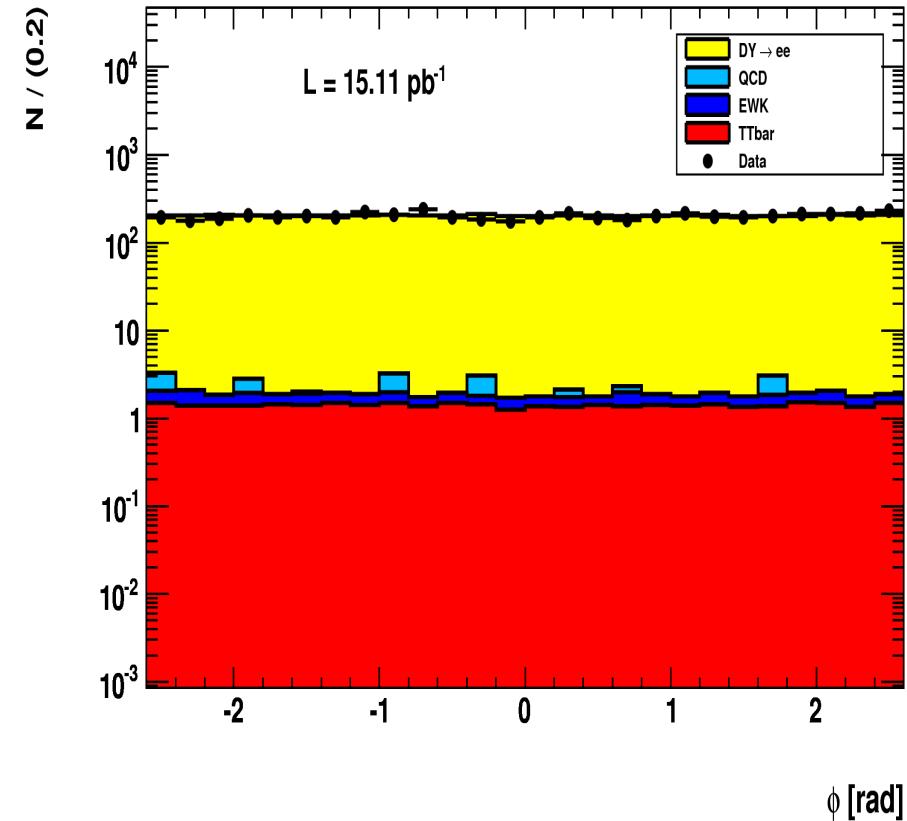
Work in progress in the framework of search for new physics BSM

Data & MC comparison

Di-electron transverse energy distribution

Di-electron energy distribution
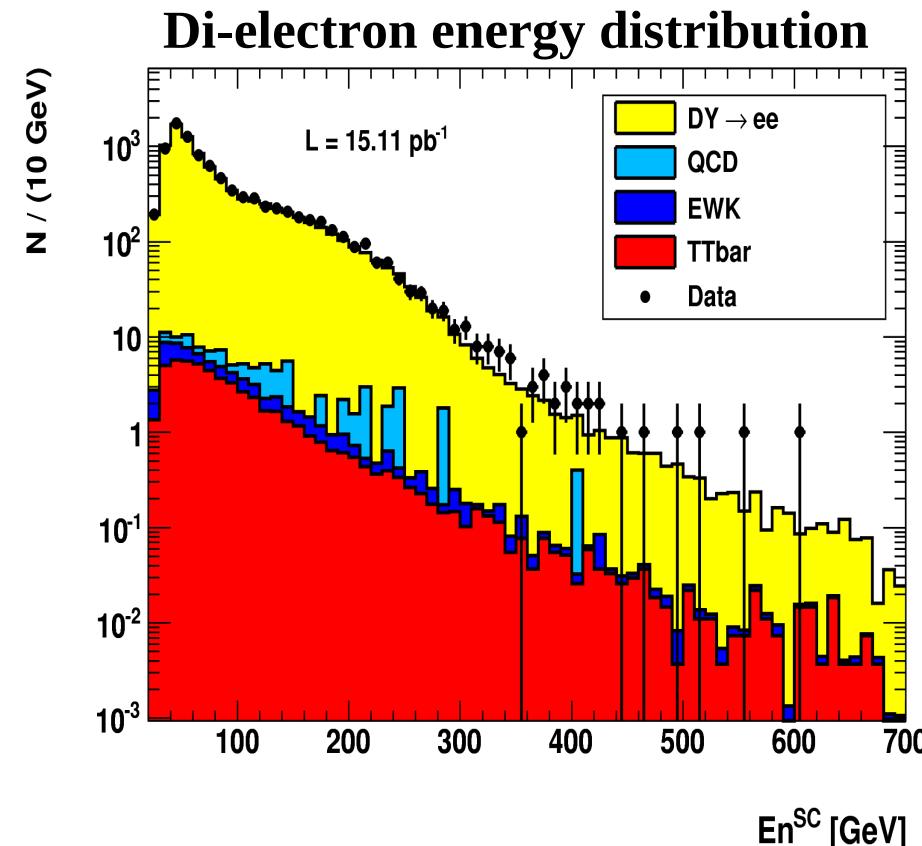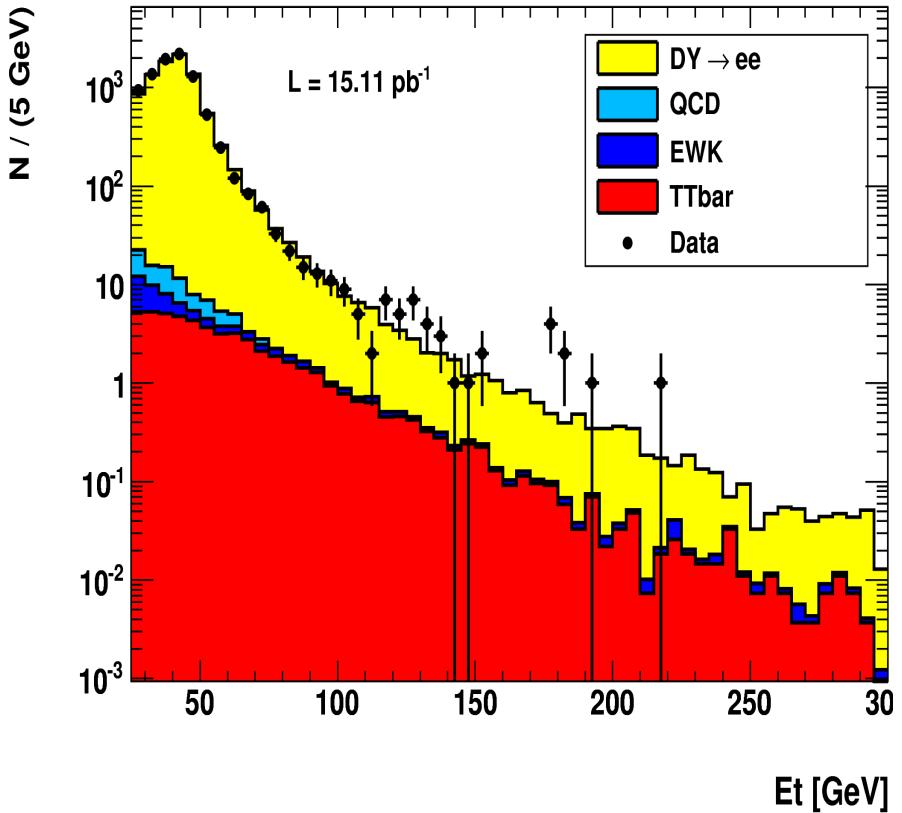
Work in progress in the framework of search for new physics BSM

Check of ECAL calibration to high energy electrons
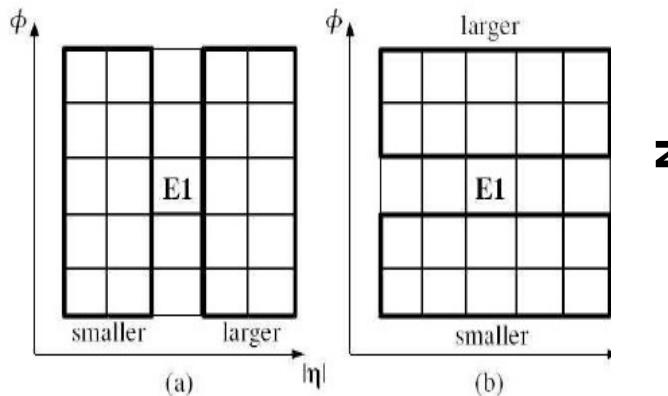
* **For integrated luminosity of 4.1 pb^{-1}**

▪ **Mean of dist. (+/-) Error on Mean**

▪ **Error on Mean = RMS / (N)$^{0.5}$**

$|\eta|$	Mean	RMS	N	Error
MC: 1.80-2.50	0.02	0.46	478	0.02
Data: 1.80-2.50	**0.00**	0.46	499	**0.02**
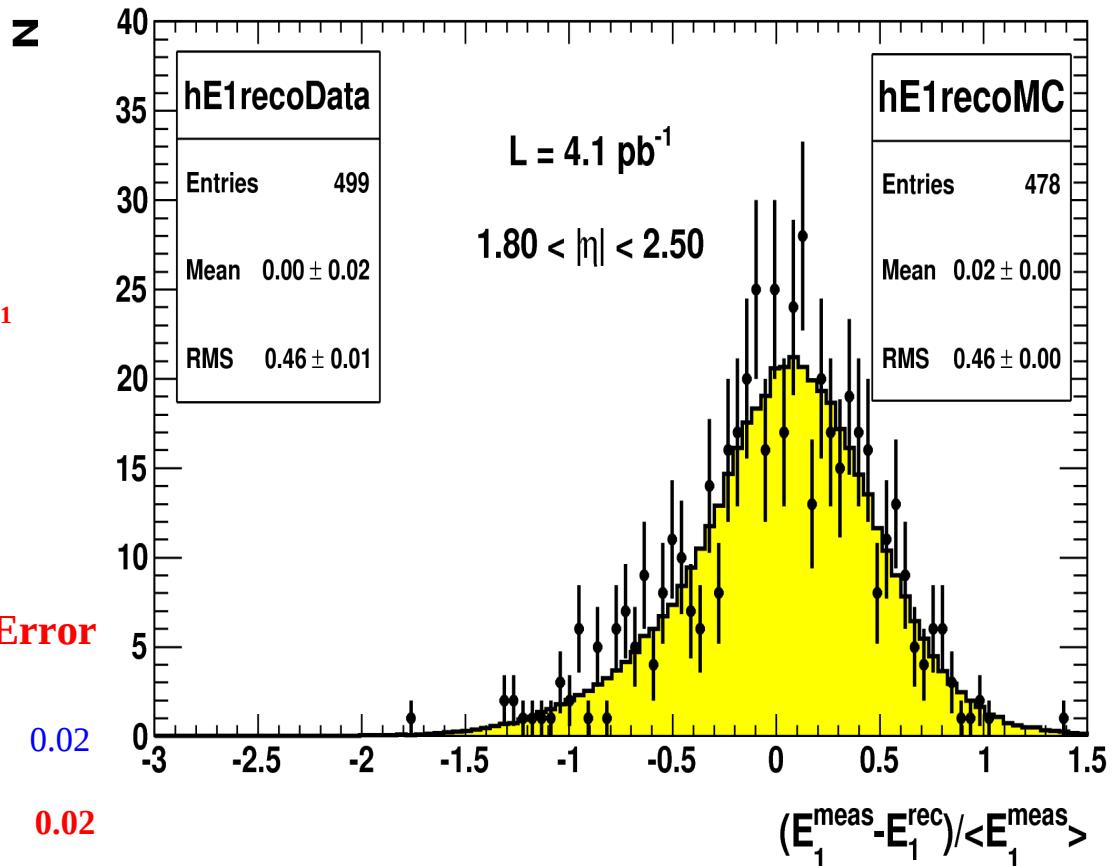
Work in progress in the framework of search for new physics BSM

Di-electron mass spectrum & bg

(a) 10 TeV, MC scaled to ∫ L dt = 100 pb⁻¹

(b) 10 TeV, pseudo-experiment ∫ L dt = 100 pb⁻¹
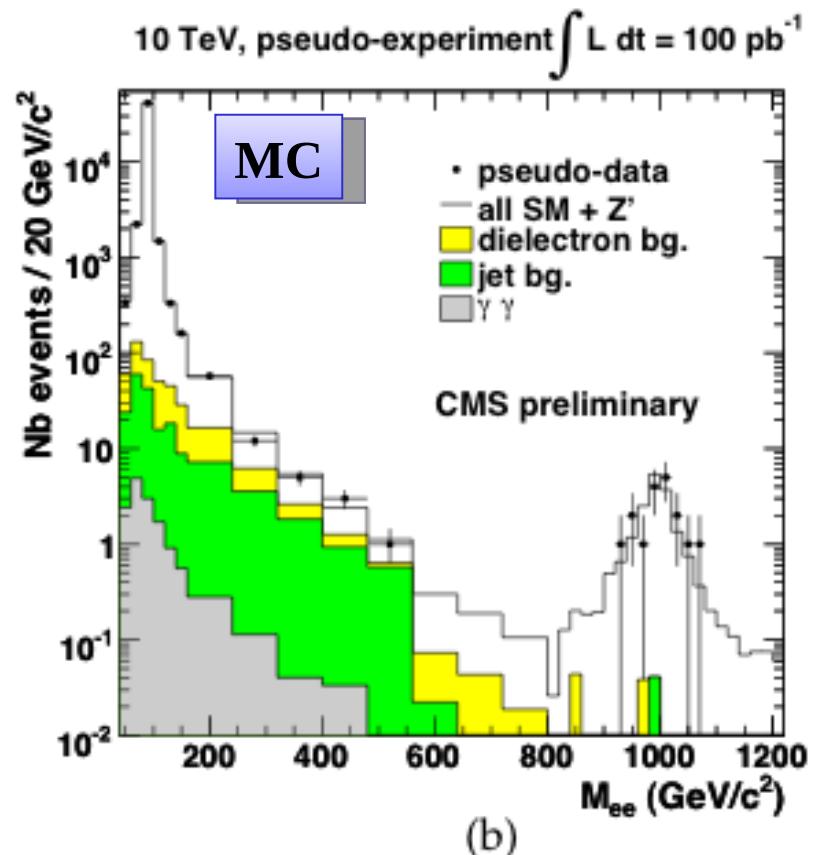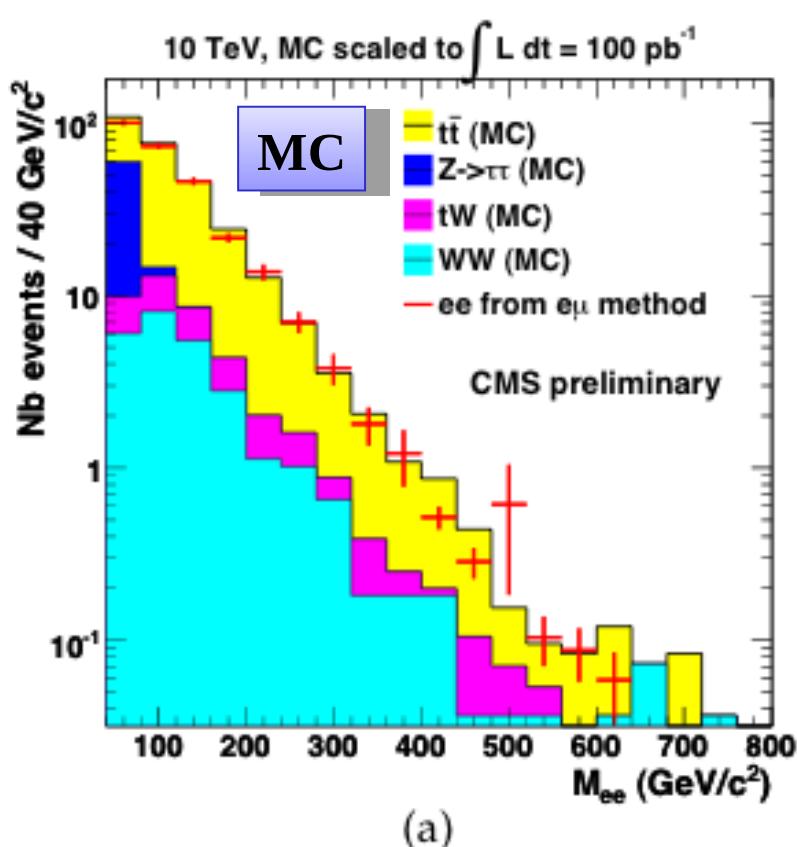
main background is tt,
also measured by b tagging

normalisation by Z peak

CMS-EXO-09-006

Discovery potential at 5 σ significance in ee channel

CMS-Note-2010/008
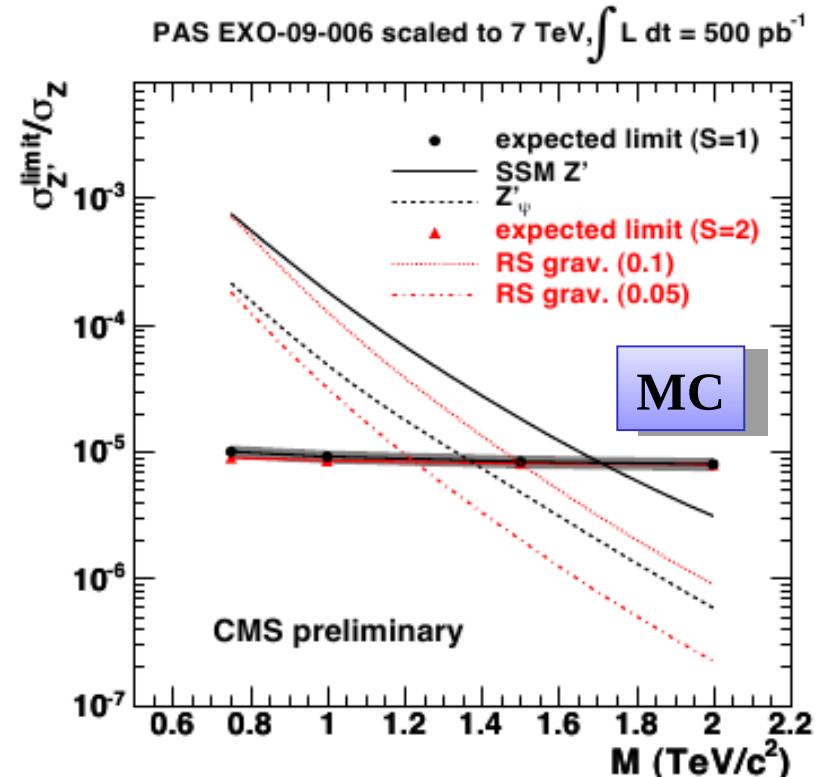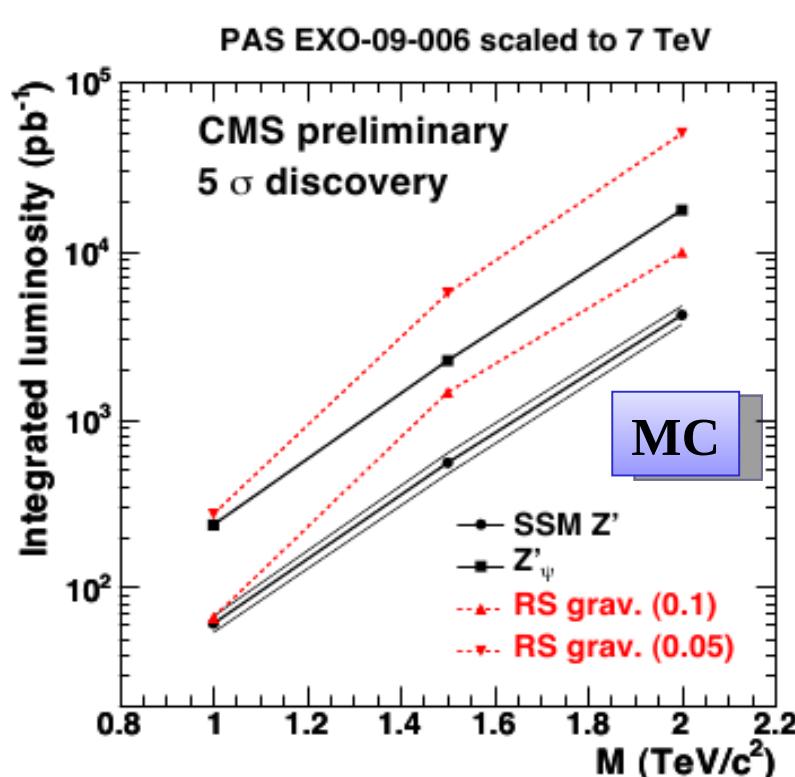
Three lines, gray band: systematic uncertainties

Discovery potential at 5 σ significance in μμ channel

CMS-Note-2010/008

MC

Z prime

MC
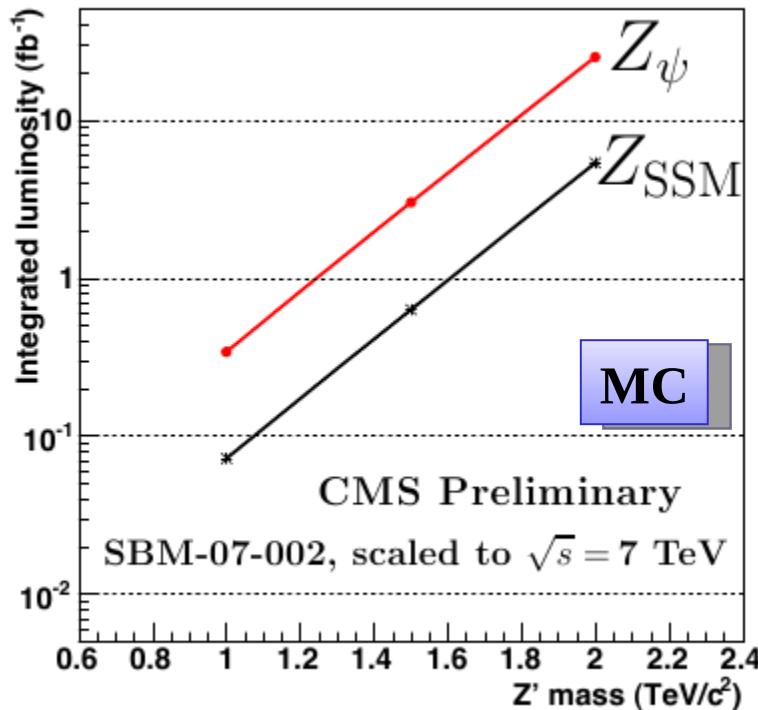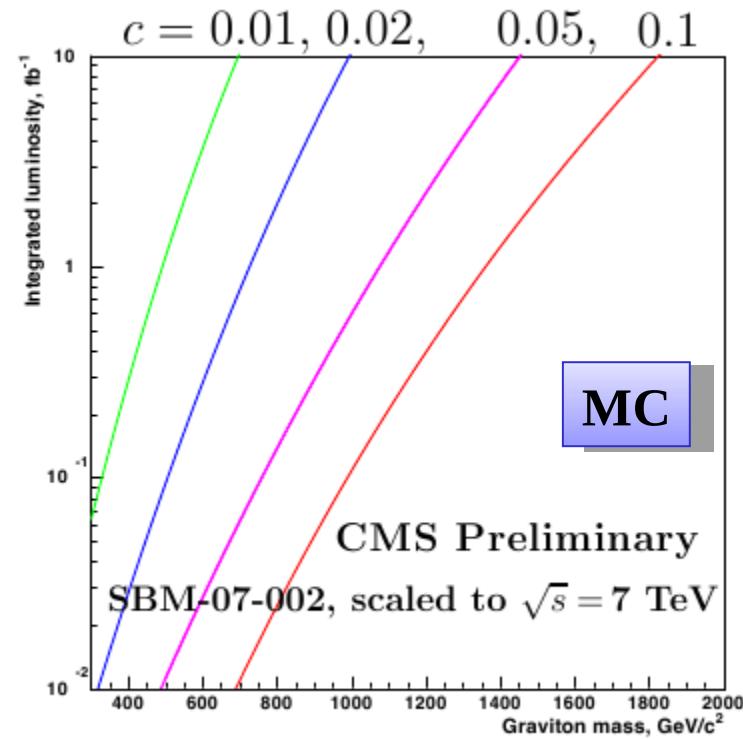
RS Graviton

Conclusions

- CMS recorded now over ~ 43 pb^{-1}
 Data: Maximum luminosity = $2*10^{32}$ cm^{-2}s^{-1}

- Good matching between data and MC is observed for low and high pt electrons

- Electromagnetic calorimeter (ECAL) is in good shape with energy calibration of precision of 1.2%, which is in good agreement with MC precision 1.1(+/-)0.2%

- Energy calibration has been checked, from data for int. lumi. 4.1 pb^{-1}, for high pt electrons (E>100 GeV) with precision of 2% in the ECAL endcap

- Z and W cross section:

$$\sigma(\text{pp} \rightarrow W + X \rightarrow \ell\nu + X) = 9.22 \pm 0.24(\text{stat.}) \pm 0.47(\text{syst.}) \pm 1.01(\text{lumi.}) \text{ nb}$$

$$\sigma(\text{pp} \rightarrow Z(\gamma^*) + X \rightarrow \ell^+\ell^- + X) = 0.882^{+0.077}_{-0.073}(\text{stat.})^{+0.042}_{-0.036}(\text{syst.}) \pm 0.097(\text{lumi.}) \text{ nb}$$

- **Search for Drell-Yan and new physics beyond standard model, with current 43 pb^{-1}, is in progress.**

BACKUP

Muon reconstructions and selection

- Trigger: $p_T > 9$ GeV/c

- Kinematics:
  - $p_T >$ 20 GeV/c
  - $\mu_1 : |\eta| < 2.1$ $\quad$ μ_2 for Z: $|\eta| < 2.4$

- Track quality:
  - Matching hits in tracker (10) pixel (1) and at least 2 muon stations
  - $\chi^2/\text{ndf} < 10$; d_0 cut reject cosmics

$$I_{\text{comb}}^{\text{rel}} = \left\{ \sum (p_T(tracks) + E_T(em) + E_T(had)) \right\} / p_T(\mu)$$

$$I_{\text{trk}} = \sum p_T(tracks)$$

CMS preliminary 2010 $\quad$ $\sqrt{s} = 7$ TeV

$\int L \, dt = 198 \text{ nb}^{-1}$

data
$W \to \mu\nu$
EWK
QCD

number of events / 0.02

Isolation Variable
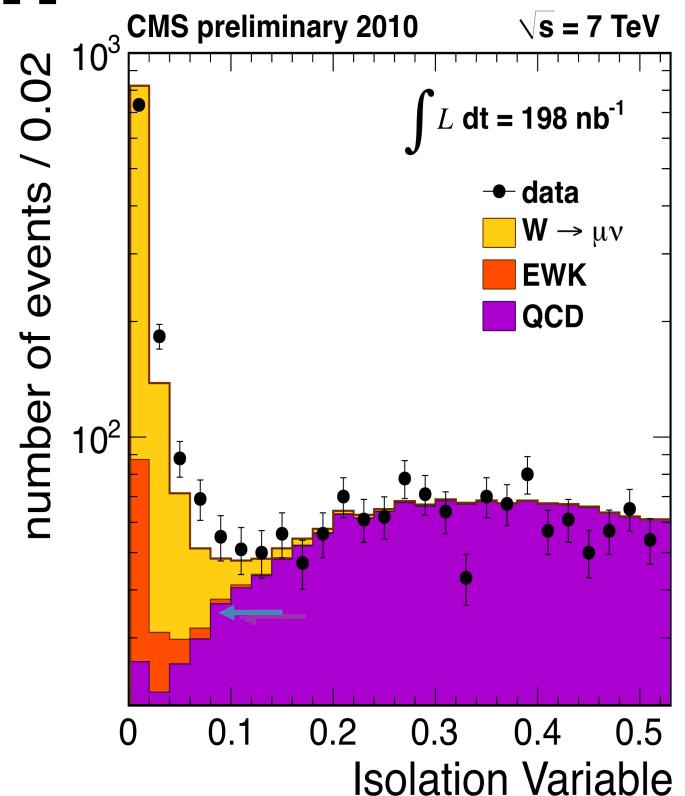
Systematic uncertainties on W→*lν*

Source	W→*μν* (%)	W→*eν* (%)
Reconstruction/Id	3.0	6.1
Trigger efficiency	3.2	0.6
Isolation efficiency	0.5	1.1
Momentum scale/resolution	1.0	2.7
mE$_T$ scale/resolution	1.0	1.4
Background subtraction	3.5	2.2
PDF on acceptance	2.0	2.0
Other theoretical uncertainty	1.4	1.3
Total (w/o luminosity)	**6.3**	**7.7**
Luminosity	11.0	11

systematic uncertainties on Z→ll

Source	Z→μμ (%)	Z→ee (%)
Reconstruction/Id	2.5	7.2
Trigger efficiency	0.7	-
Isolation efficiency	1.0	1.2
Momentum scale/resolution	0.5	-
PDF on acceptance	2.0	2.0
Other theoretical uncertainty	1.6	1.3
Total (w/o luminosity)	3.8	7.7
Luminosity	11.0	11