

# Search for new physics at the LHC through the study of the electron- positron pair mass spectrum

Vincent Dero Journées des Jeunes Chercheurs

# Just me

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- ▶ Vincent
- ▶ Age : 25
- ▶ Hair : brown
- ▶ Eyes : green
- ▶ Single
- ▶ Height : 189 cm
- ▶ Weight 70 Kg

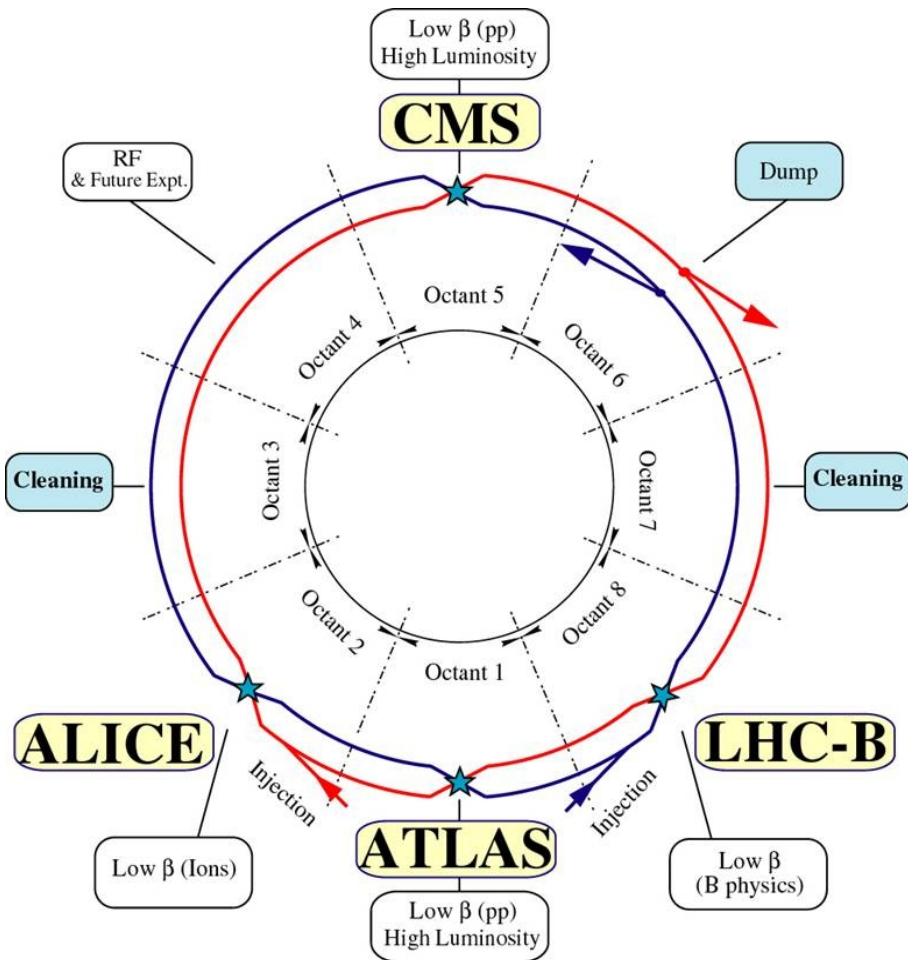


# Me

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- Brussels institute (ULB)
- ▶ Collaboration : CMS
- ▶ Group : HEEP (*High Energy Electron Pairs*)

# LHC



The LHC,  
*a discovery machine :*

- very high energy : **14 TeV**

collision @ **7 TeV** since end of march  
until end 2011 : @ **7 TeV**  
after : move to higher energies

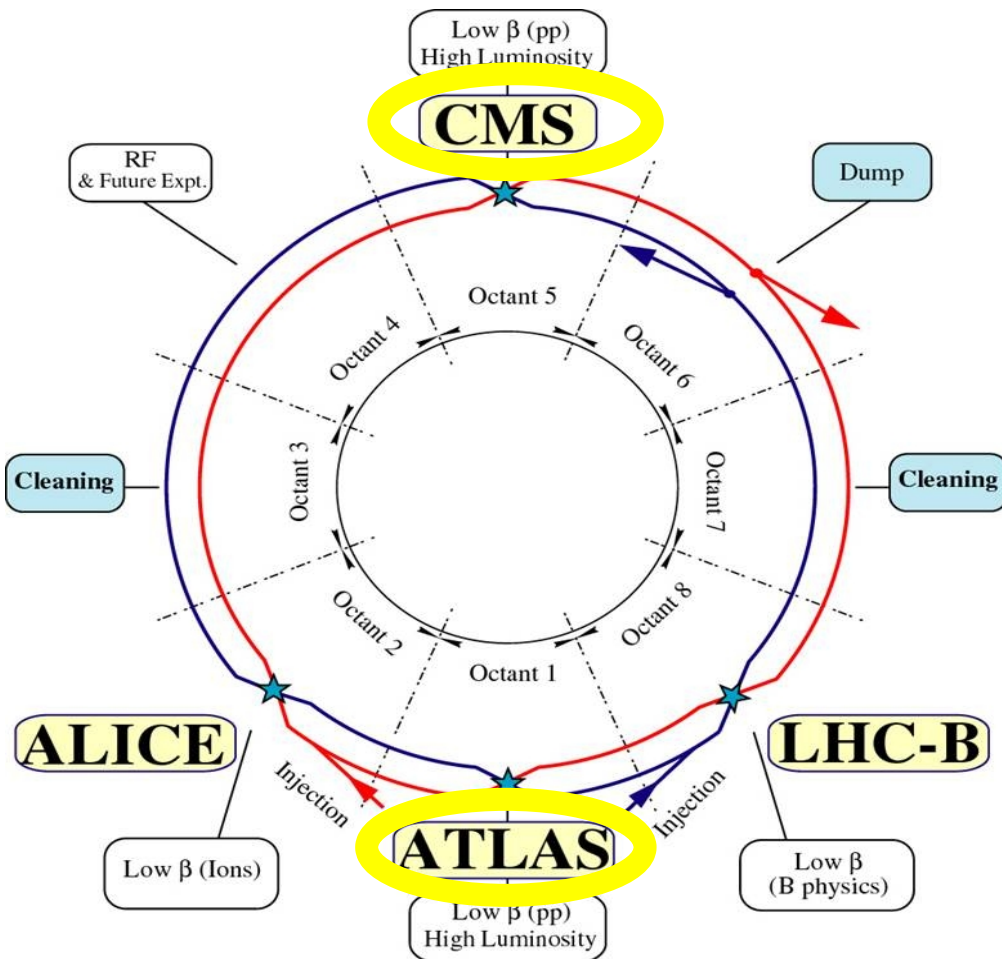
-> *a new range in energy is explored*

- very high luminosity

$\sim 10^2$  x Tevatron lumi

-> *very rare process can be measured*

# LHC



2 general purpose experiments :

**CMS** and **ATLAS**

# The goal of my work

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- ▶ Study physics, of course! And most precisely *new physics*
- ▶ *Numerous model of new physic describing process with final states into leptons and quarks*
  - Looking for quarks? *No!*
  - Looking for leptons? *Yes!*

# The goal of my work

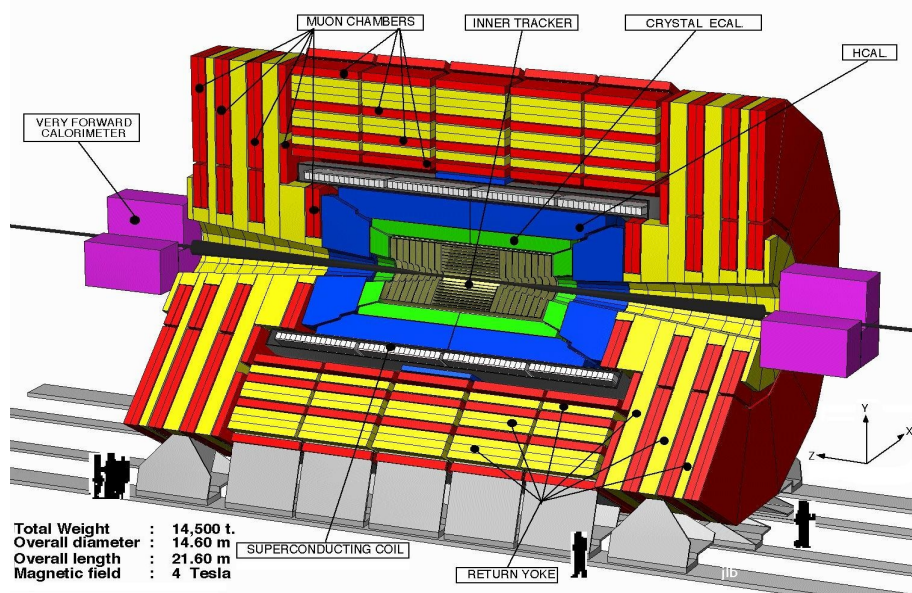
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- ▶ Study physics, of course! And most precisely *new physics*
- ▶ *Numerous model of new physic describing process with final states into leptons and quarks*
  - Looking for quarks? *No!*
  - Looking for leptons? *Yes! electrons!*

# CMS

## Compact Muon Solenoid

### *A Compact Solenoidal Detector for LHC*



How can you see an electron in CMS?

Charged particle :

*give a track*

Strong interacting particle :

*give an energy deposition in calorimeters*

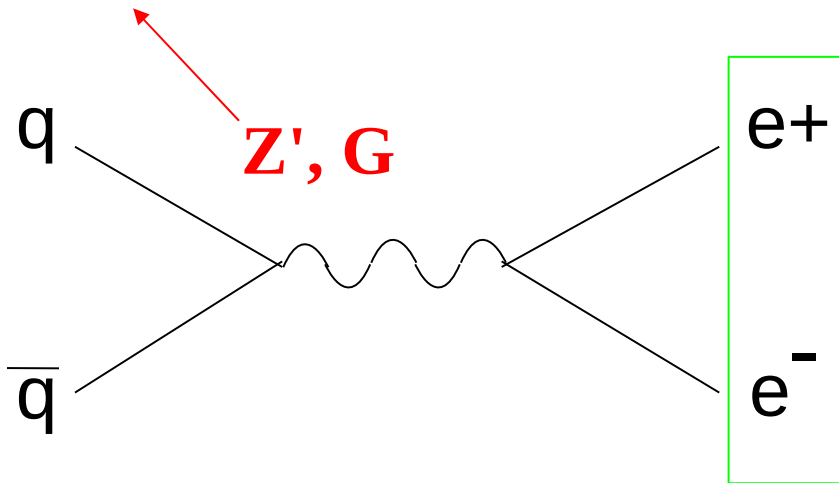


# What channel?

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- ▶ New physics: promising models
  - GUT :  $Z'$
  - Gravitons : Randall Sundrum, Kaluza-Kein

*New physics*

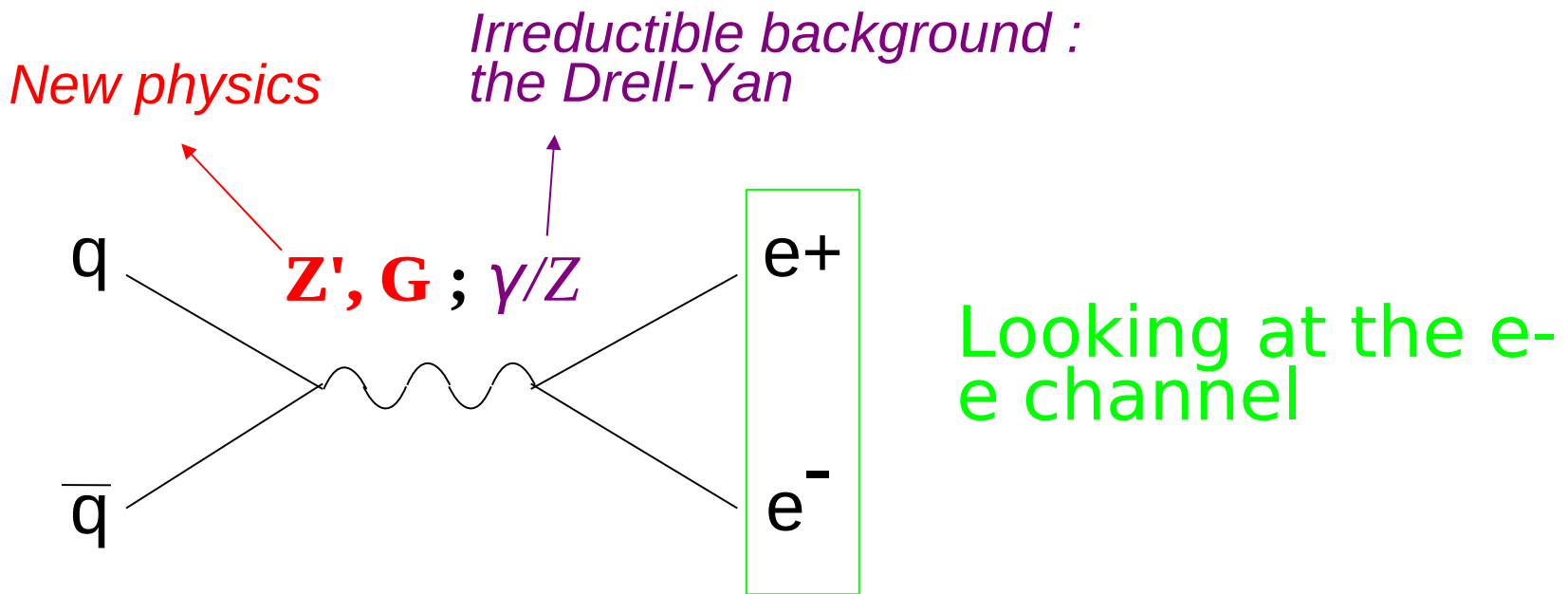


Looking at the e-e channel

# What channel?

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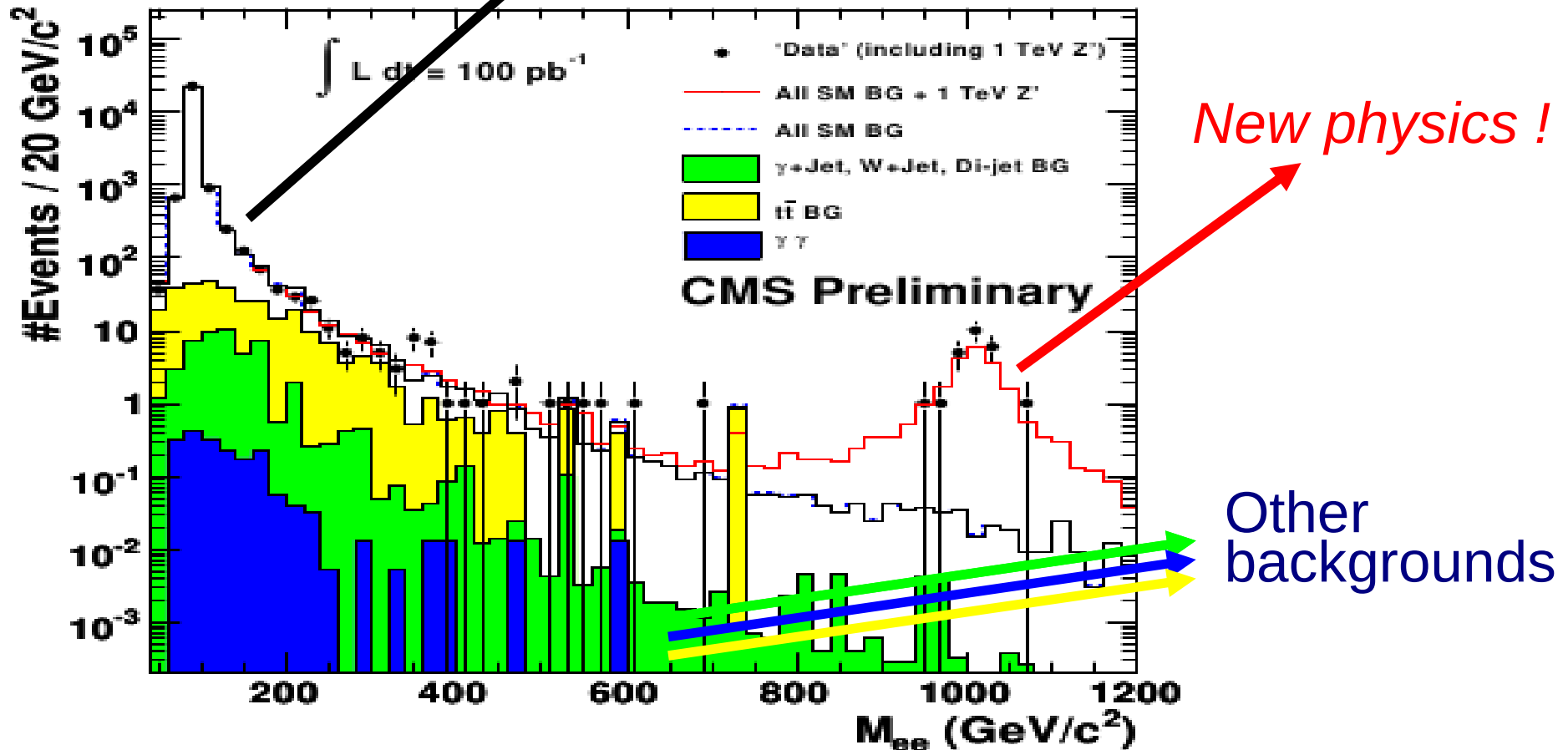
- ▶ New physics: promising models
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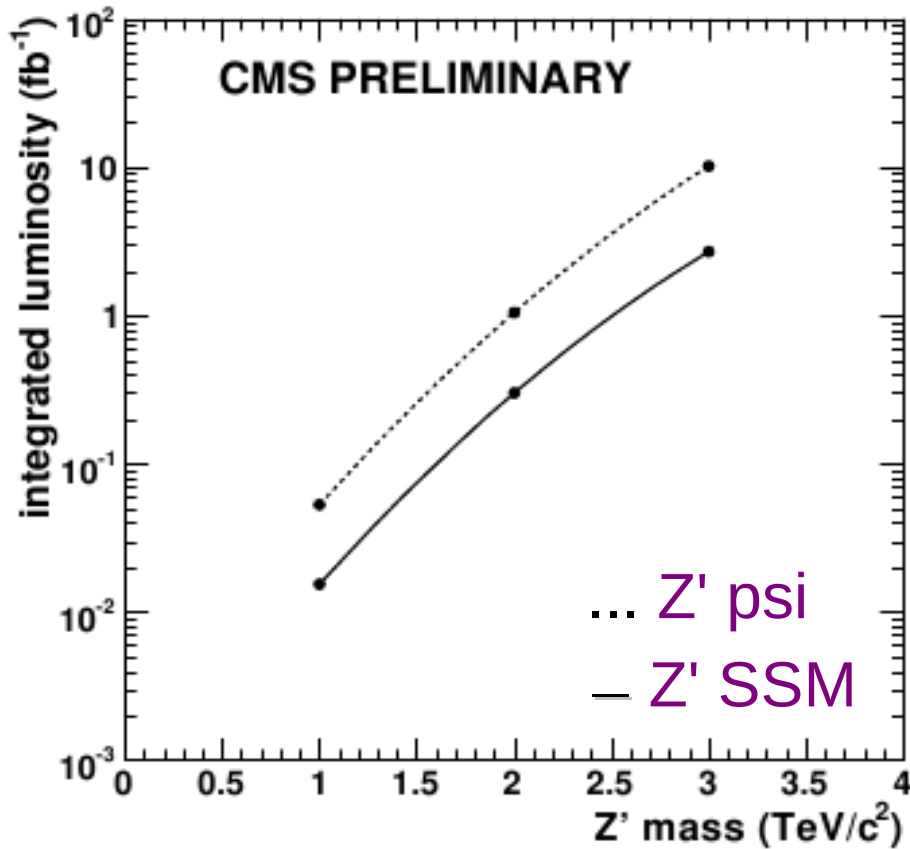
# Mass distribution

*Spectrum from Monte Carlo!*

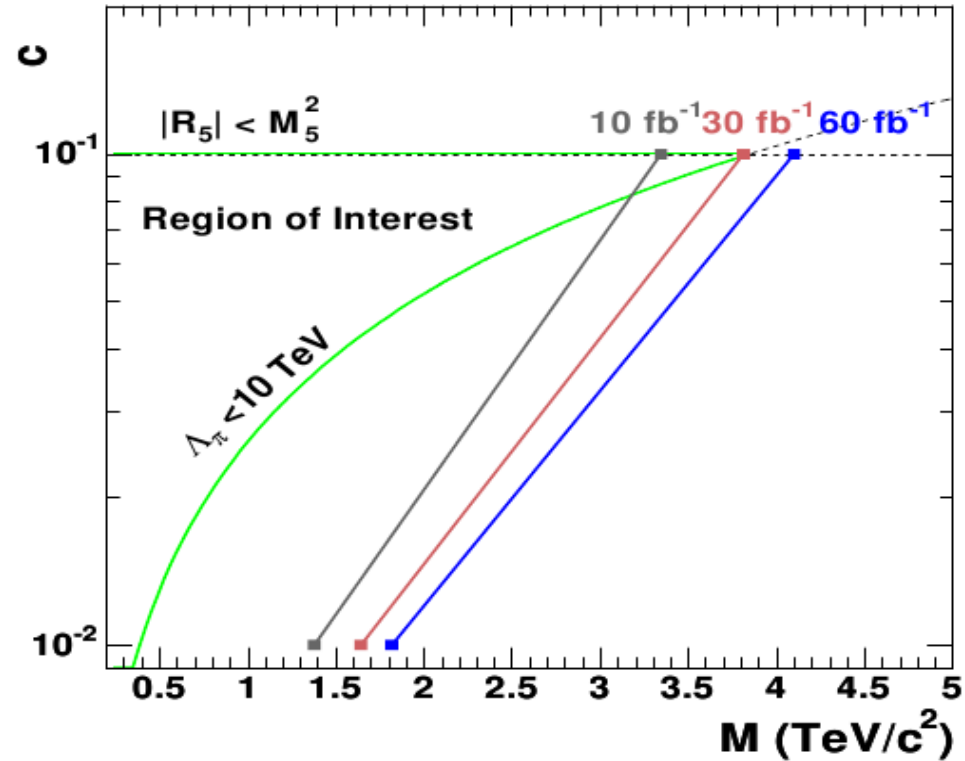
*The Drell-Yan process*



# Discovery potential for 10 TeV collisions



Lumi needed for  $5\sigma$  significance



Discovery potential for KK graviton in fonction of the coupling constant

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# HEEP strategie

# Can we believe our result if we see a pic at 1 TeV ?

---

- ▶ *Idea* : measure the Drell-Yan X-section and compare with the expected value
- ▶ Things to study carefully :
  - *Efficiencies* of electrons reconstruction and selection
  - *Backgrounds* rejection and estimation
  - *Calibration* and *energy resolution*
  - *Systematics*

# Can we believe our result if we see a pic at 1 TeV ?

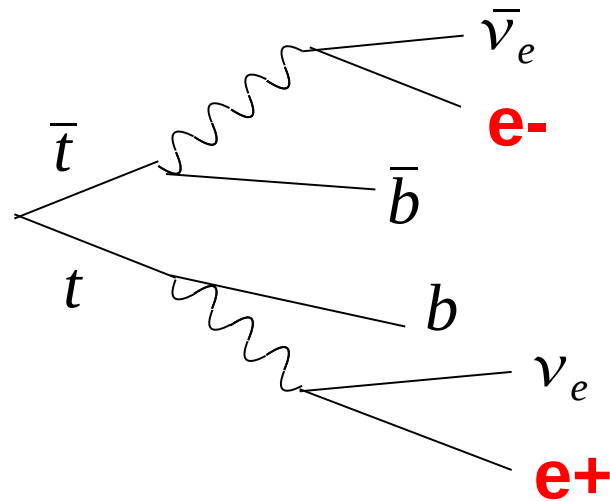
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# Backgrounds : e-mu method

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- ▶ Main background : the  $t\bar{t}$  background :



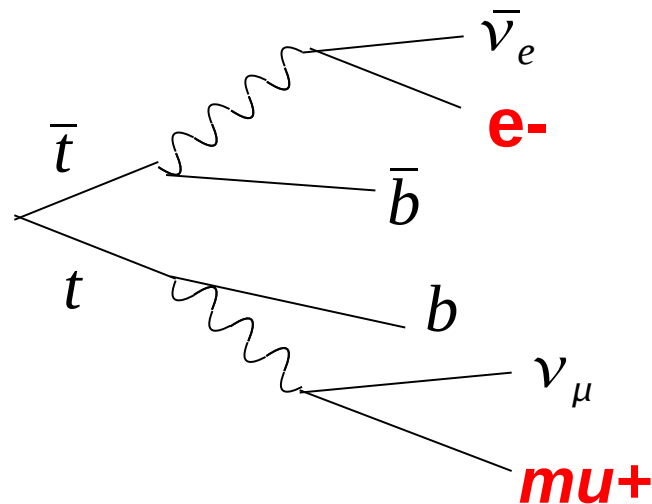
- ▶ In a few case, the final state is roughly the same (2 electrons)!



# Backgrounds : e-mu method

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- ▶ Main background : the ttbar background :



- ▶ Idea : estimate *on the data* the number of ttbar using *the e-mu channel!*
  - The number of ttbar- $\rightarrow$  e mu is 2x ttbar- $\rightarrow$  ee !

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Now we have DATA !

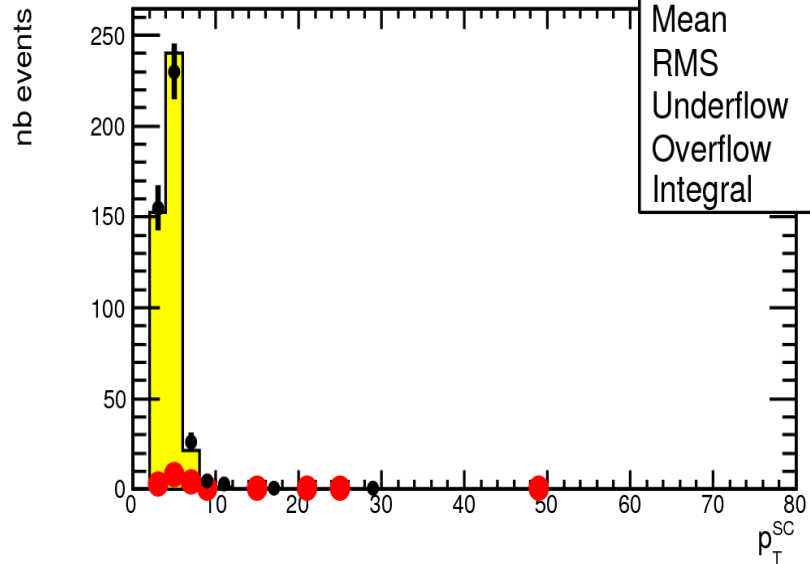
# Now we have data!!!

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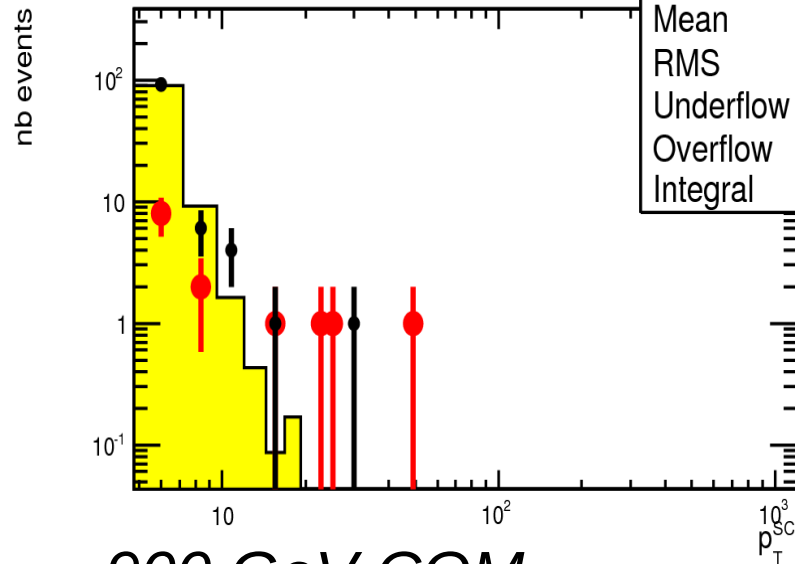
- End 2009 :
  - **First collisions @ 900 TeV (SPS COM)**

# DQM on data

gsf_pt	
Entries	421
Mean	4.152
RMS	2.015
Underflow	0
Overflow	0
Integral	421

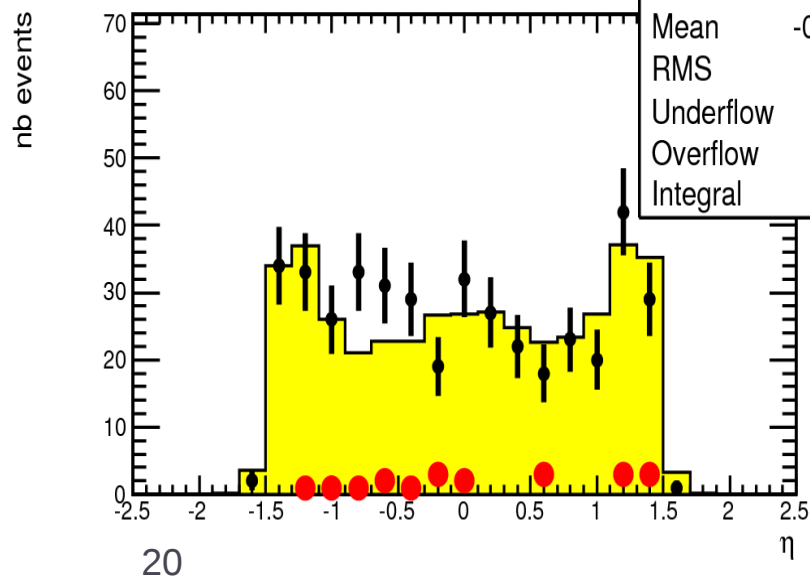


gsf_ptLog	
Entries	421
Mean	6.646
RMS	2.688
Underflow	0
Overflow	0
Integral	104

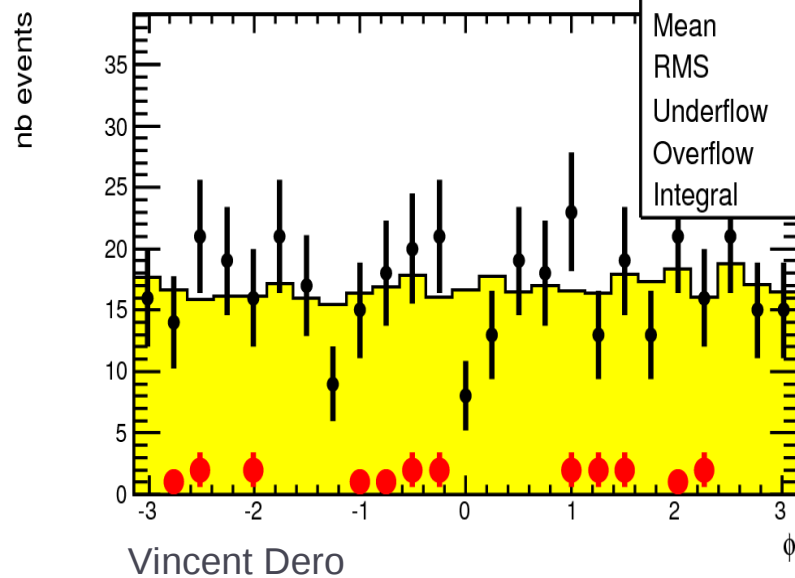


900 GeV COM

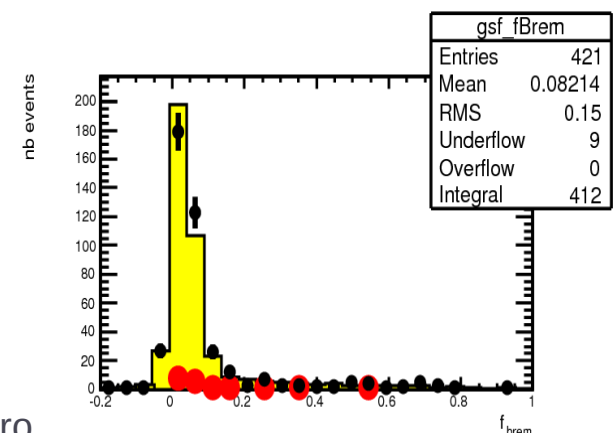
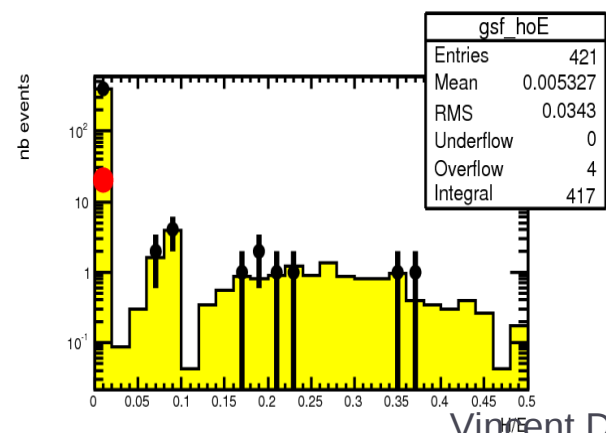
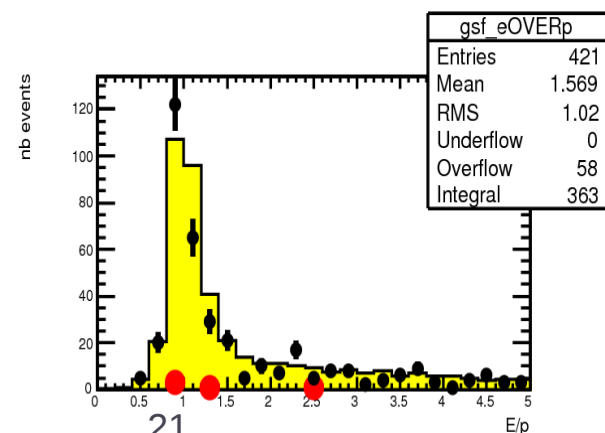
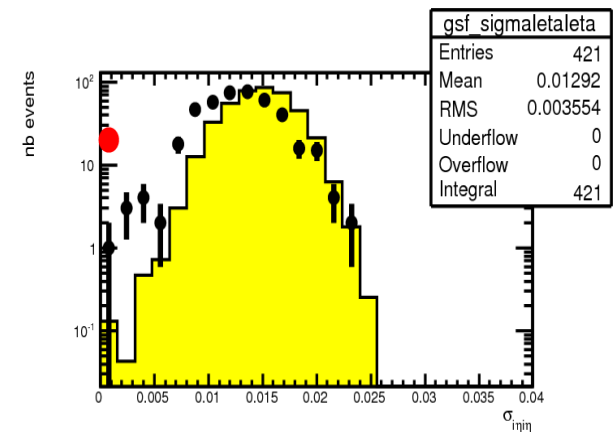
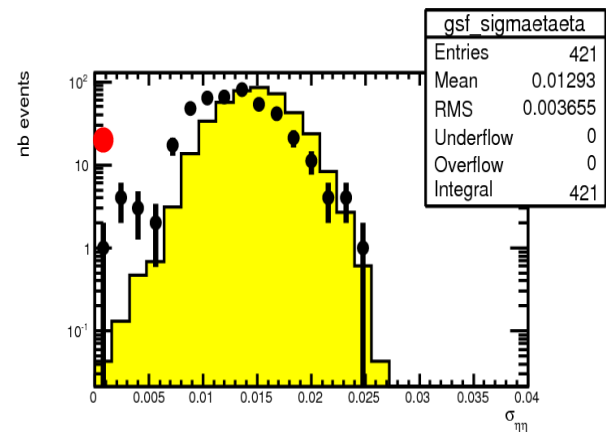
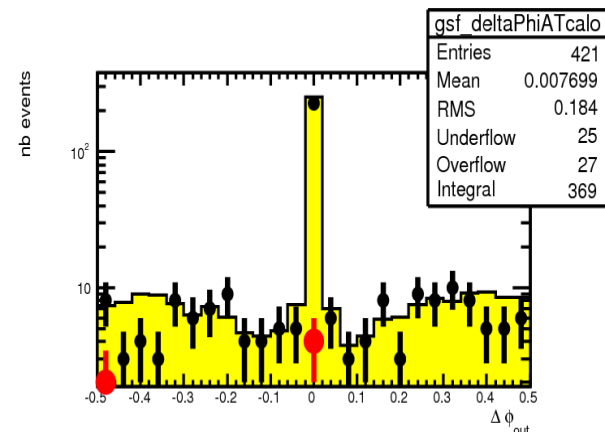
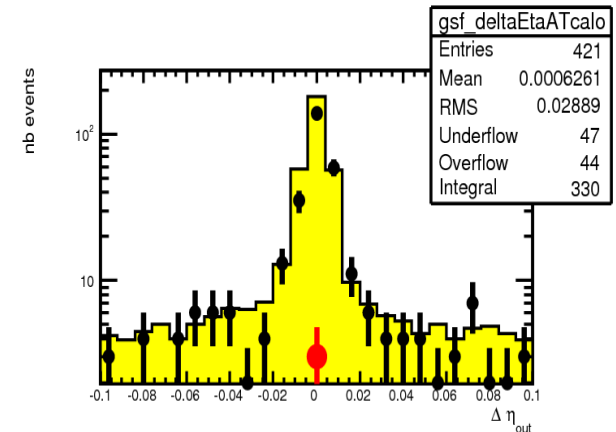
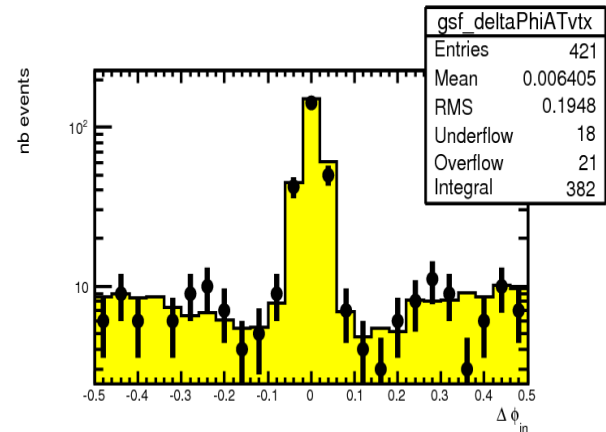
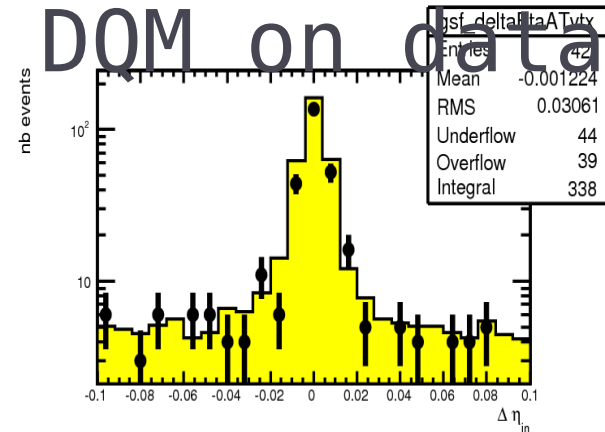
gsf_eta	
Entries	421
Mean	-0.04887
RMS	0.9057
Underflow	0
Overflow	0
Integral	421



gsf_phi	
Entries	421
Mean	0.003201
RMS	1.811
Underflow	0
Overflow	0
Integral	421



# DQM on data



# Now we have data!!!

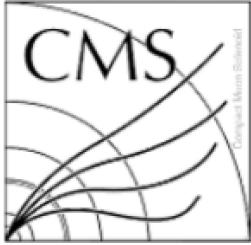
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- End 2009 :
  - First collisions @ 900 GeV (SPS COM)
  - **First collisions @ 2.350 TeV**

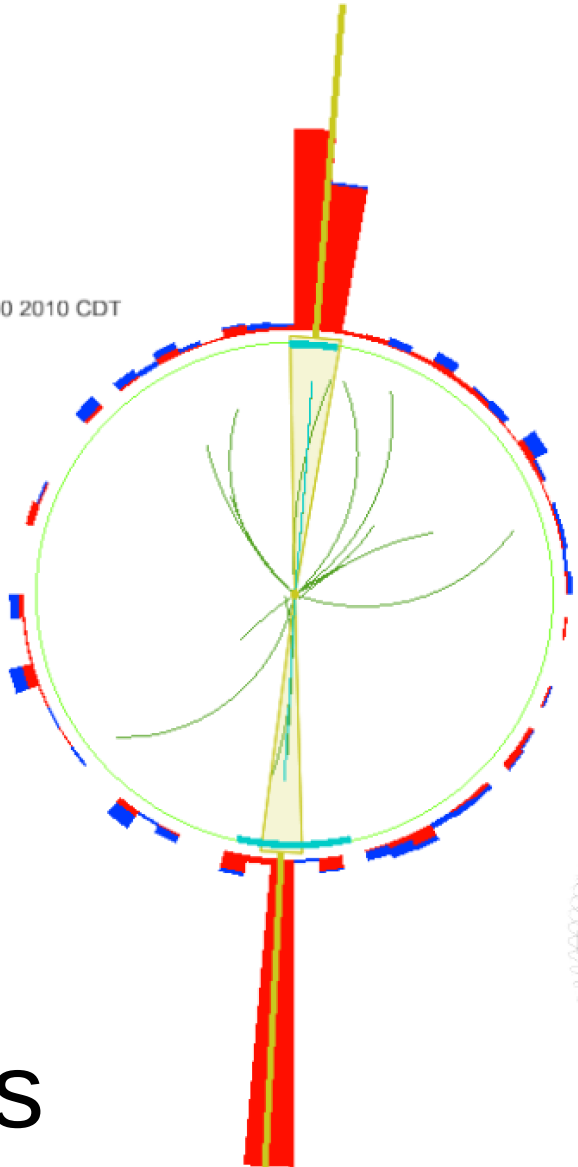
# Now we have data!!!

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- End 2009 :
  - First collisions @ 900 GeV (SPS COM)
  - First collisions @ 2.350 TeV
- March 2010 -> November 2010 :
  - **First collisions @ 7 TeV !**
  - **~ 35 pb-1 of (good) data recorded**
  - **~ 10 000 Z's observed !**



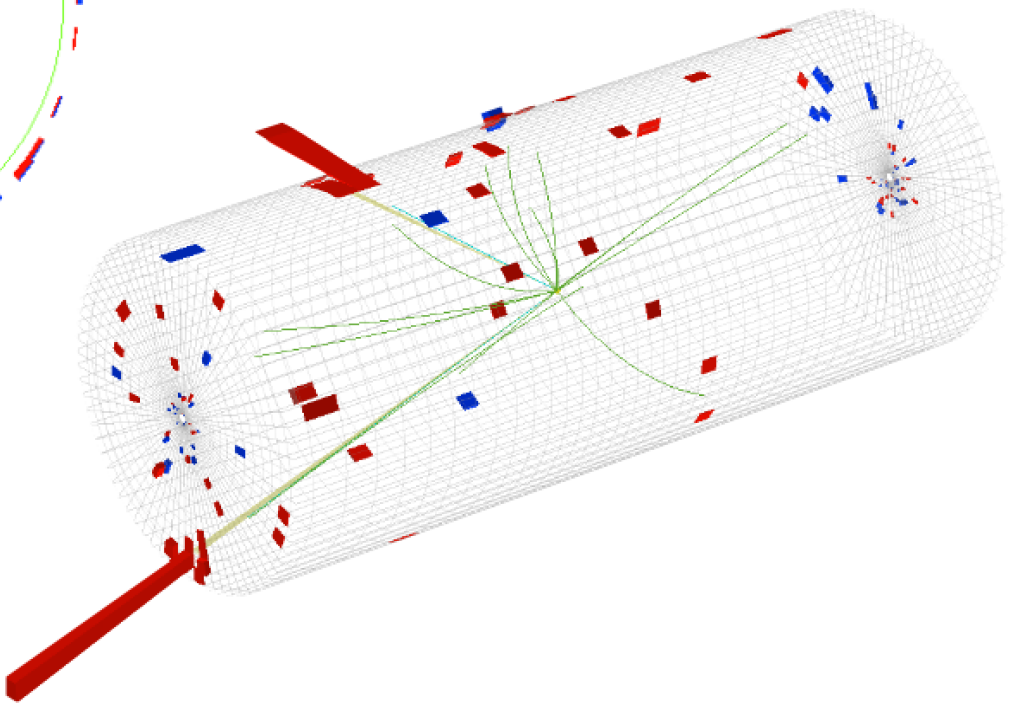
CMS Experiment at LHC, CERN  
Data recorded: Sat May 22 00:54:30 2010 CDT  
Run/Event: 136033 / 99386647  
Lumi section: 785



electrons

pt	eta	phi	charge	E/p
46.5	-1.80	-1.61	1	0.99
43.1	-1.07	1.47	-1	1.5

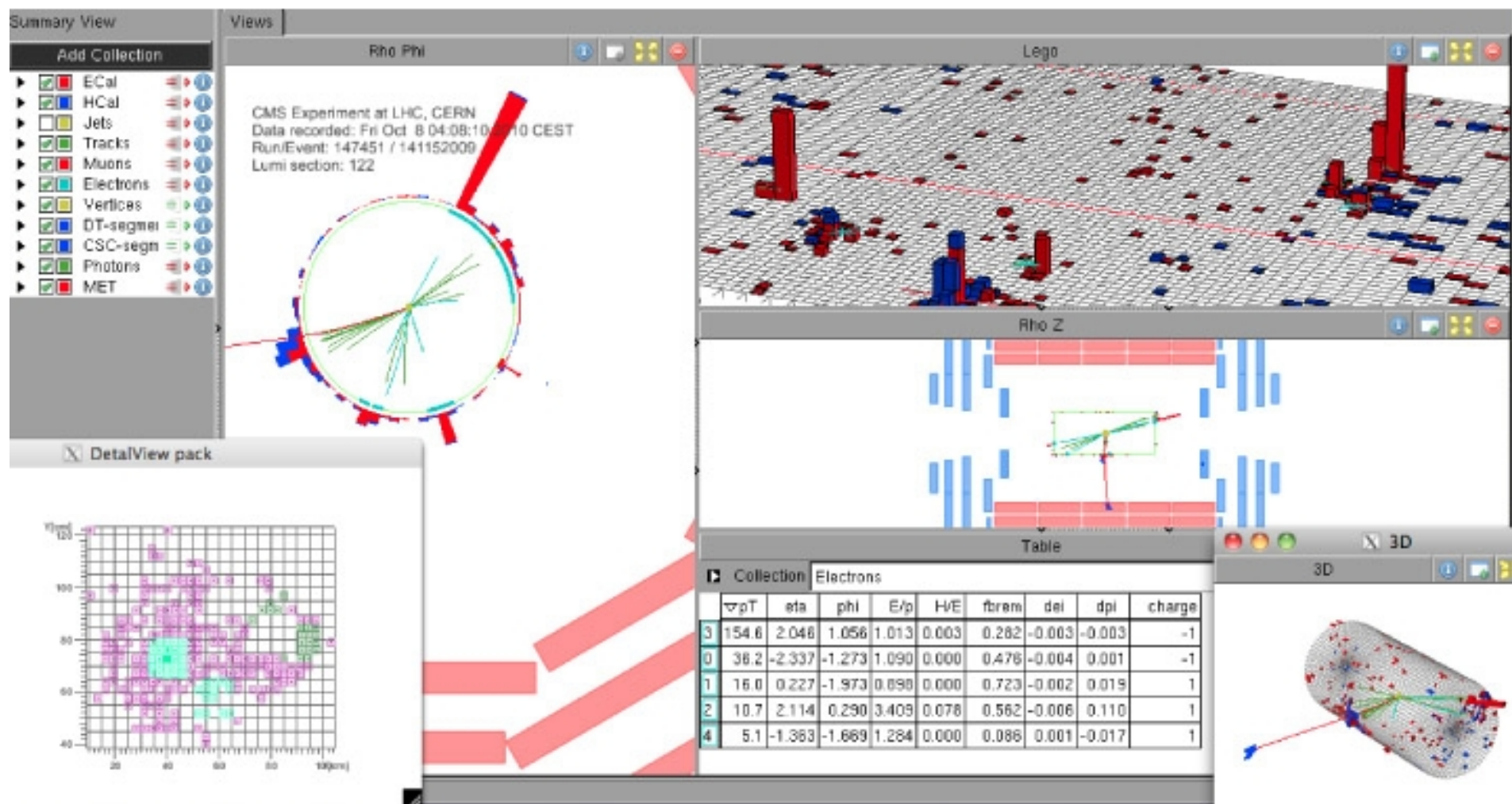
inv. mass = 95.5 GeV/c<sup>2</sup>

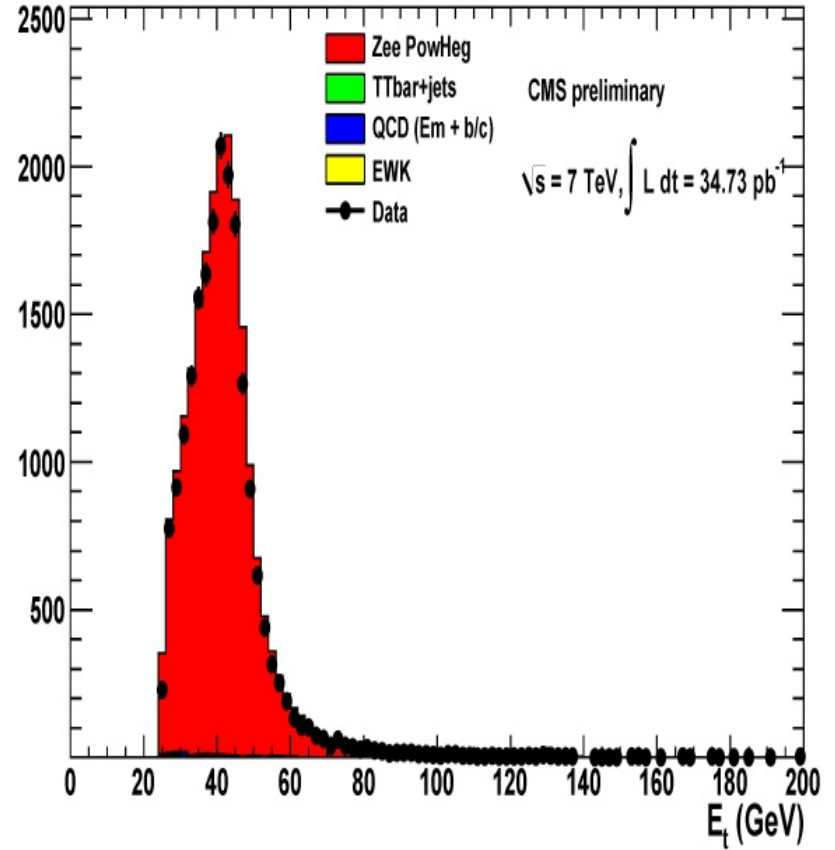
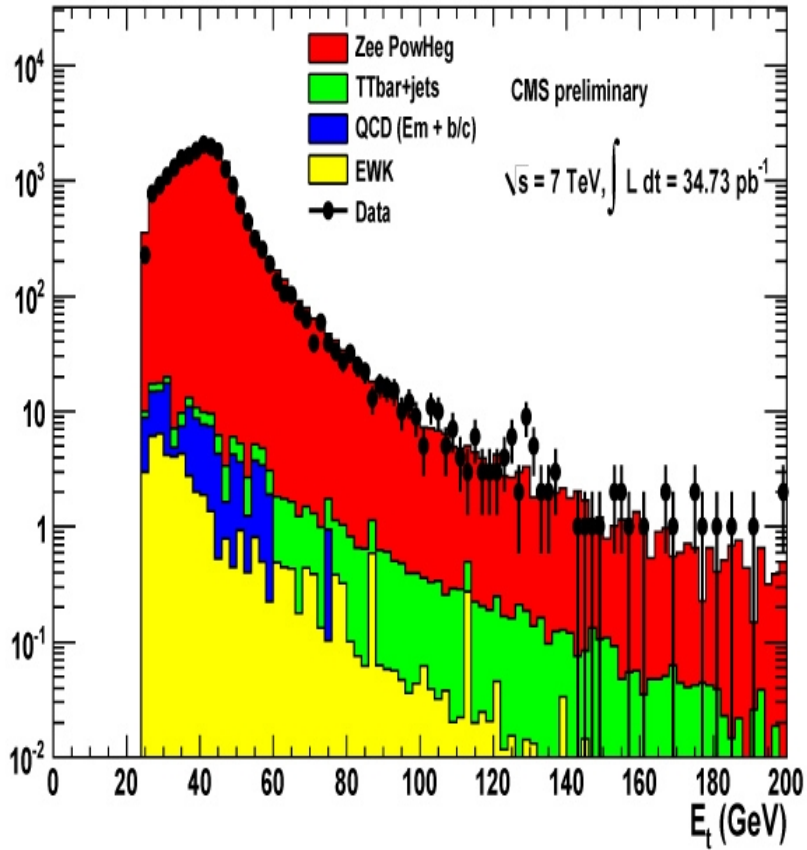


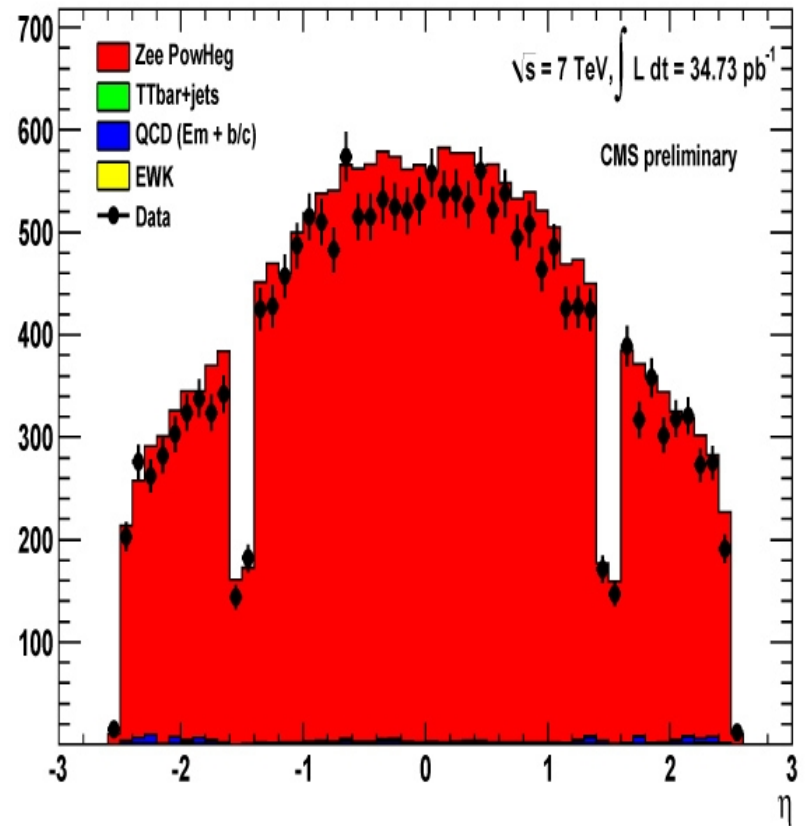
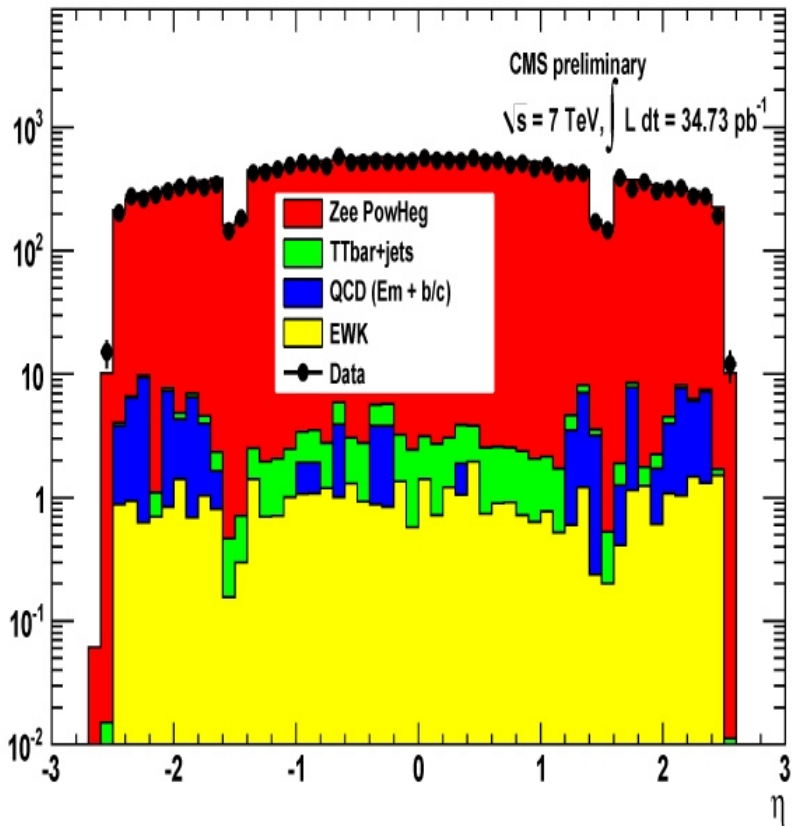
First Z's



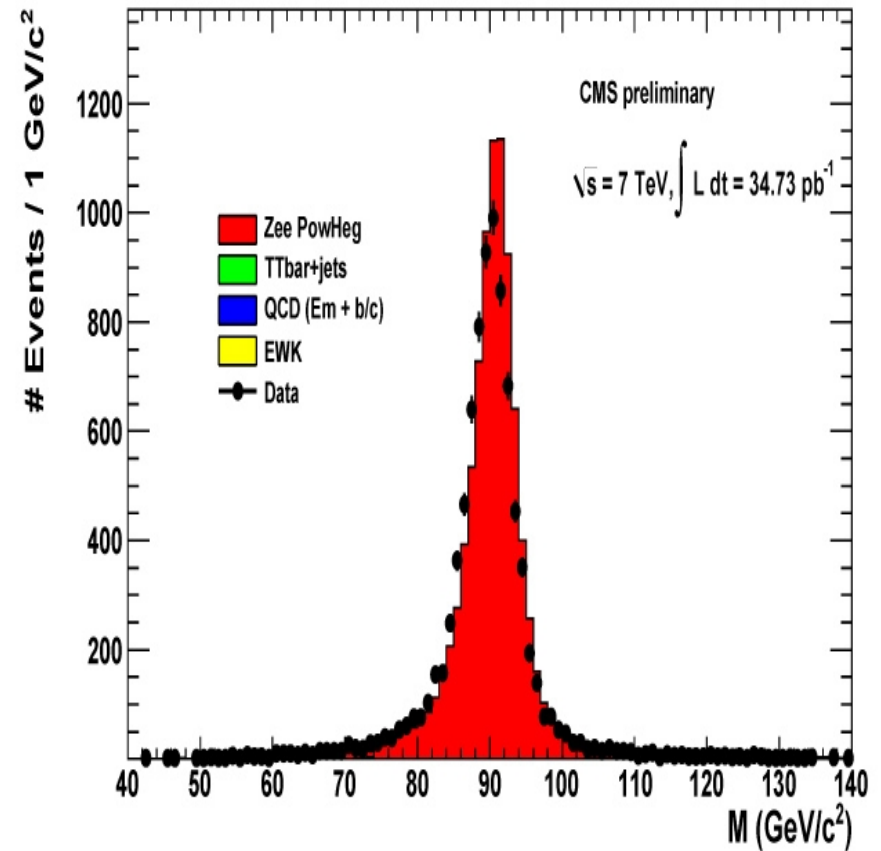
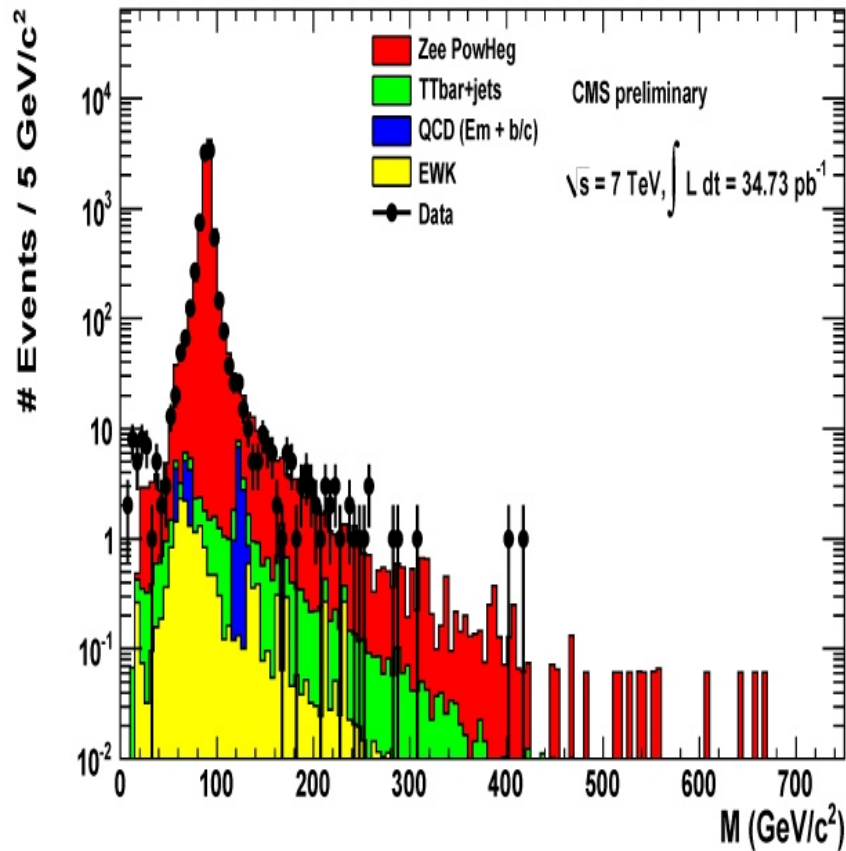
Mass = 703 GeV







# E-e spectrum



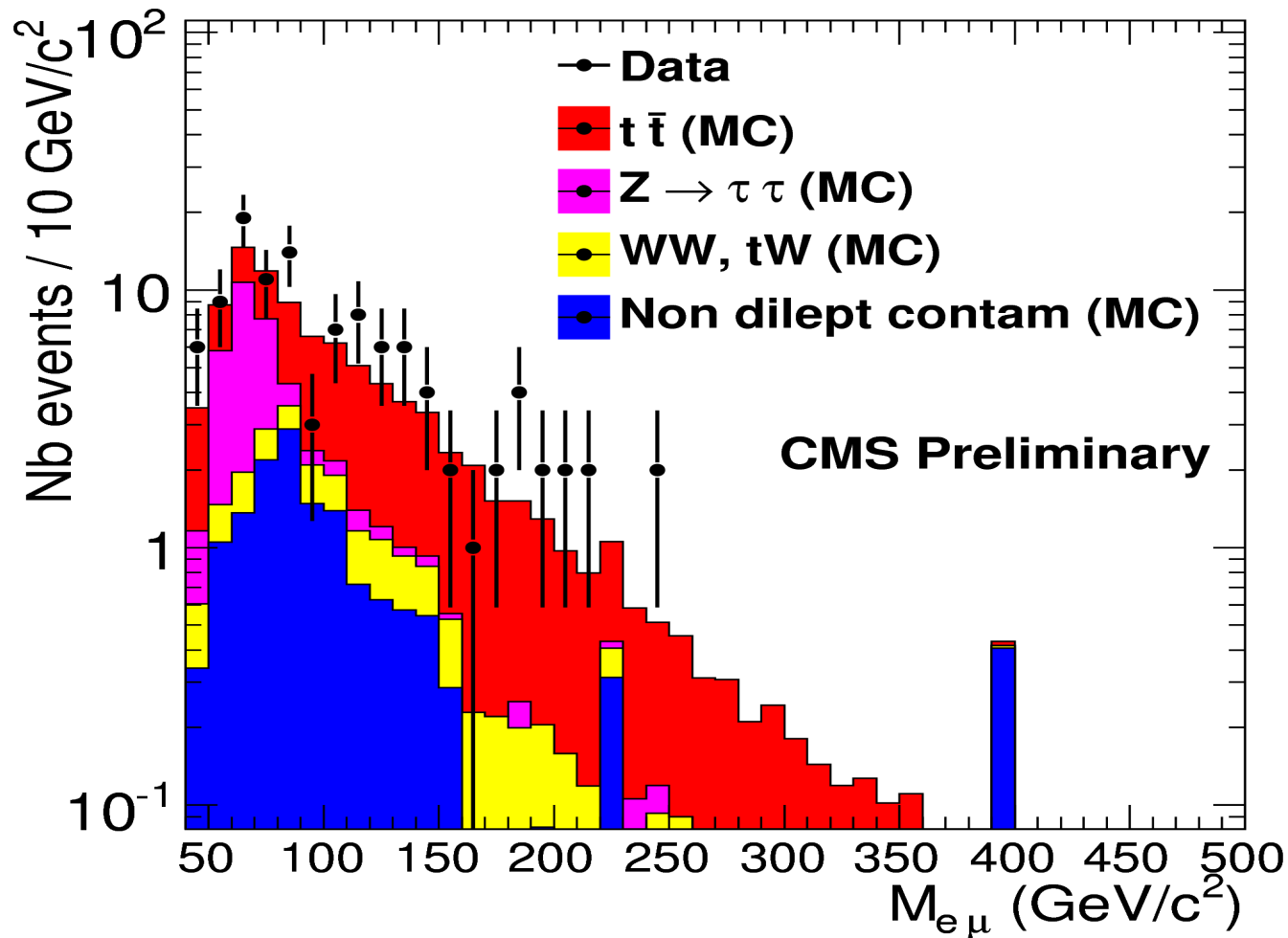
# E-e spectrum

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Sample	$N (M > 40)$	$N (60 < M < 120)$	$N (M > 200)$
Data	10001	9794	31
Drell-Yan MC	10571.1	10356.9	23.4
Total background	86.5	48.7	3.9

# E-mu method : results

$$7 \text{ TeV}, \int L dt = 35.0 \text{ pb}^{-1}$$



# E mu spectrum

**M>60**

**nb data = 95 +- 10 (stat)**

**nb MC = 80.4 +- 2.4 (syst)**

**M>120**

**nb data = 33 +- 6 (stat)**

**nb MC = 27.1 +- 0.8 (syst)**

**M>200**

**nb data = 6 +- 2 (stat)**

**nb MC = 7.0 +- 0.2 (syst)**

*-> agree with MC*

# Plans

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End 2010 :

- keep on looking at 2010 data :
  - look at simple distributions to control data
  - finalise Z' ee paper
  - finalise e-mu
  
- writing thesis



# Plans

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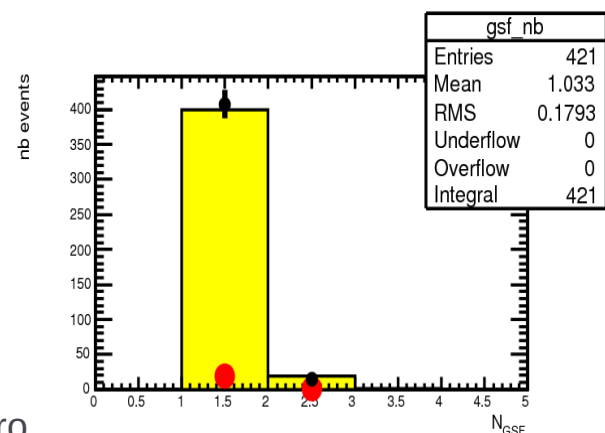
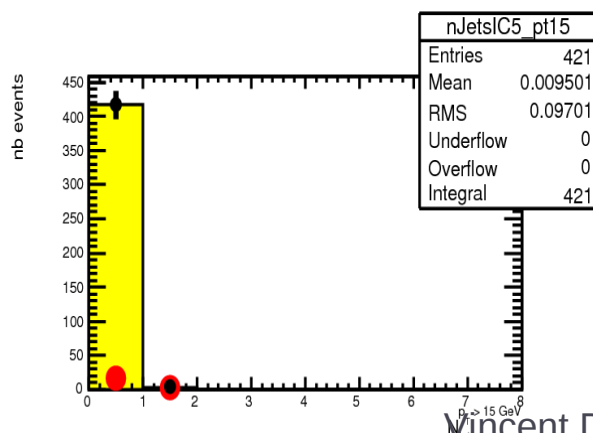
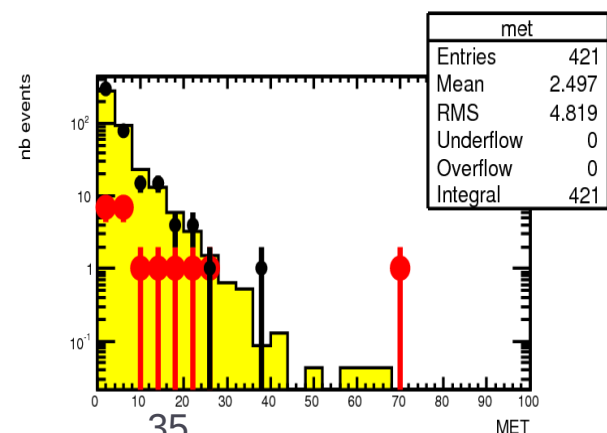
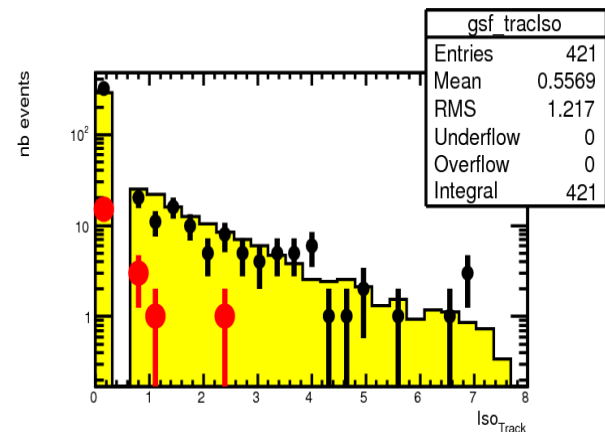
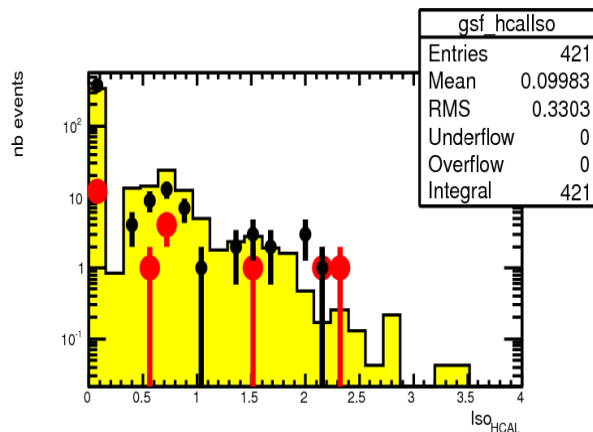
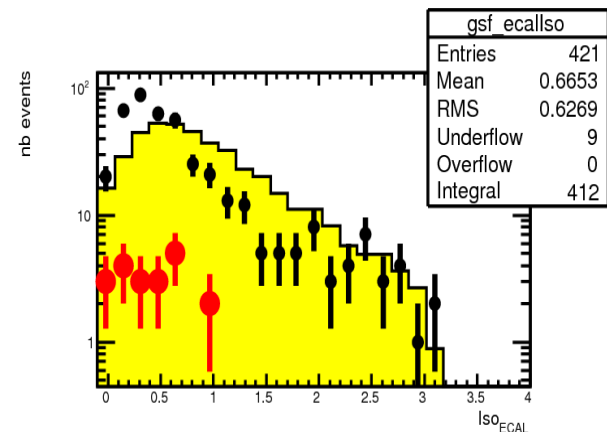
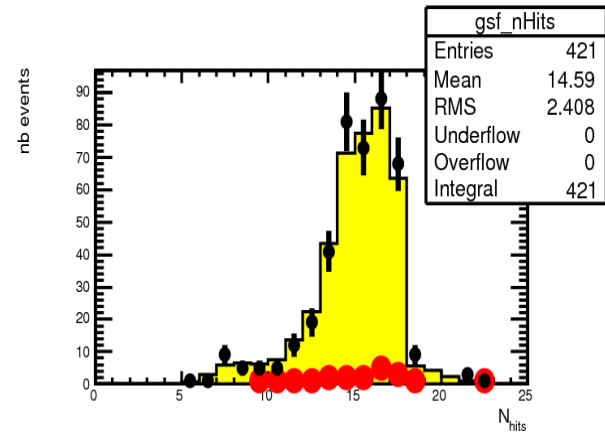
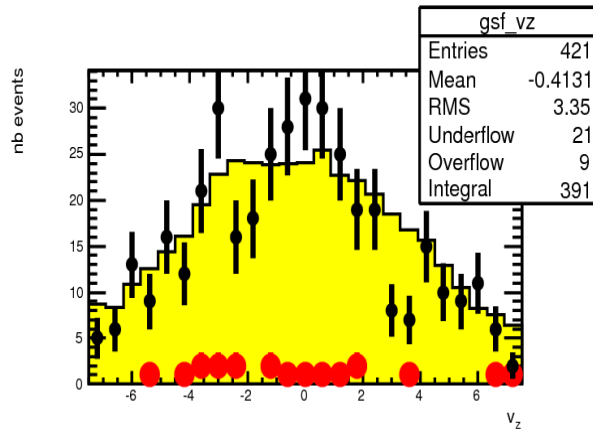
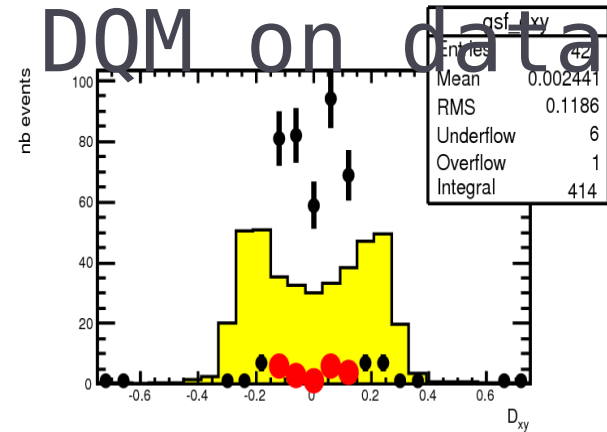
2011 :

- look at new data : 7 TeV, 8 TeV ?
  - gives results with e-mu
  - look at others di-leptonic signatures :
    - excess in  $e^+ \mu^-$  (wrt  $e^- \mu^+$ ) due to extra-dimensional model
- finalize thesis!

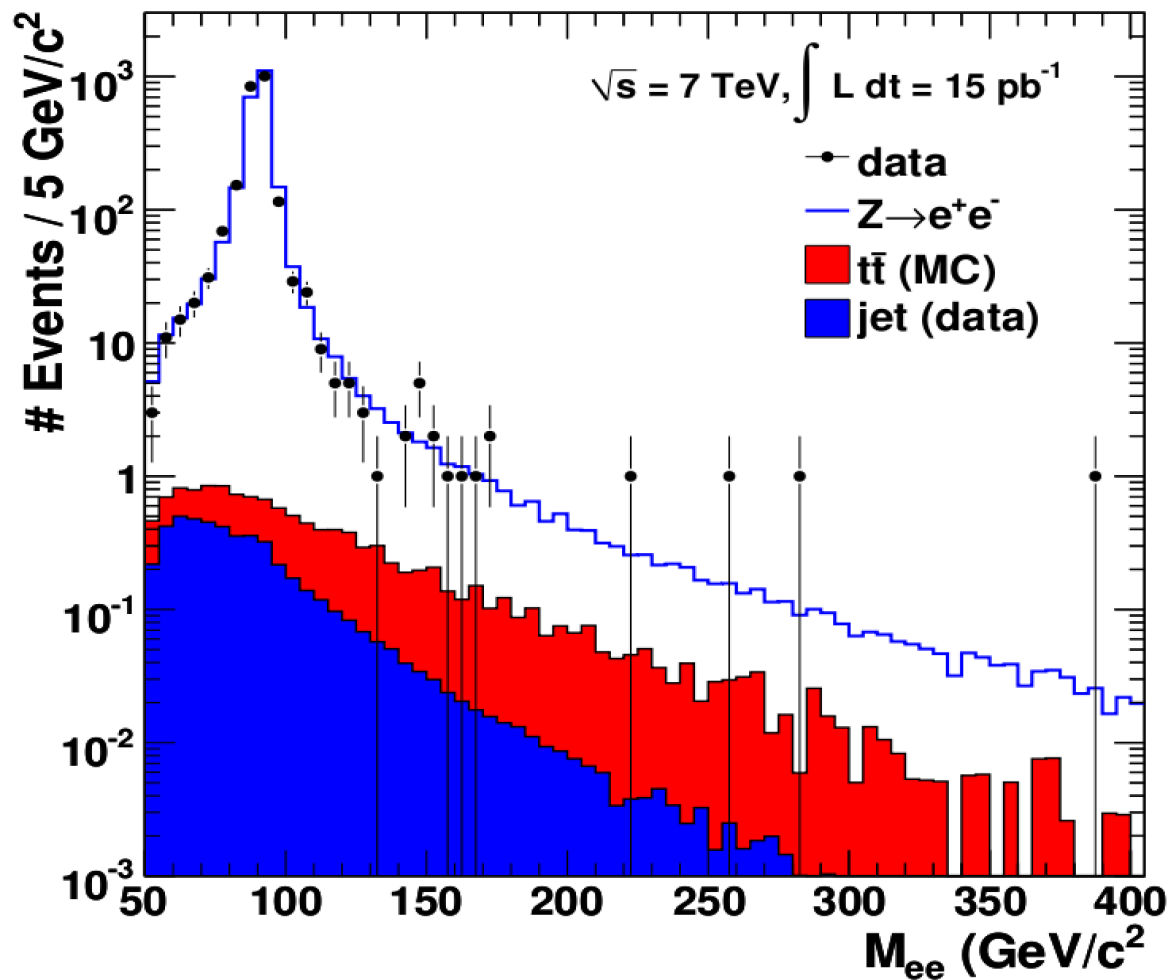
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# BACKUP

# DQM on data



# E-e spectrum



# Like Sign

