Electron and photon reconstruction in CMS
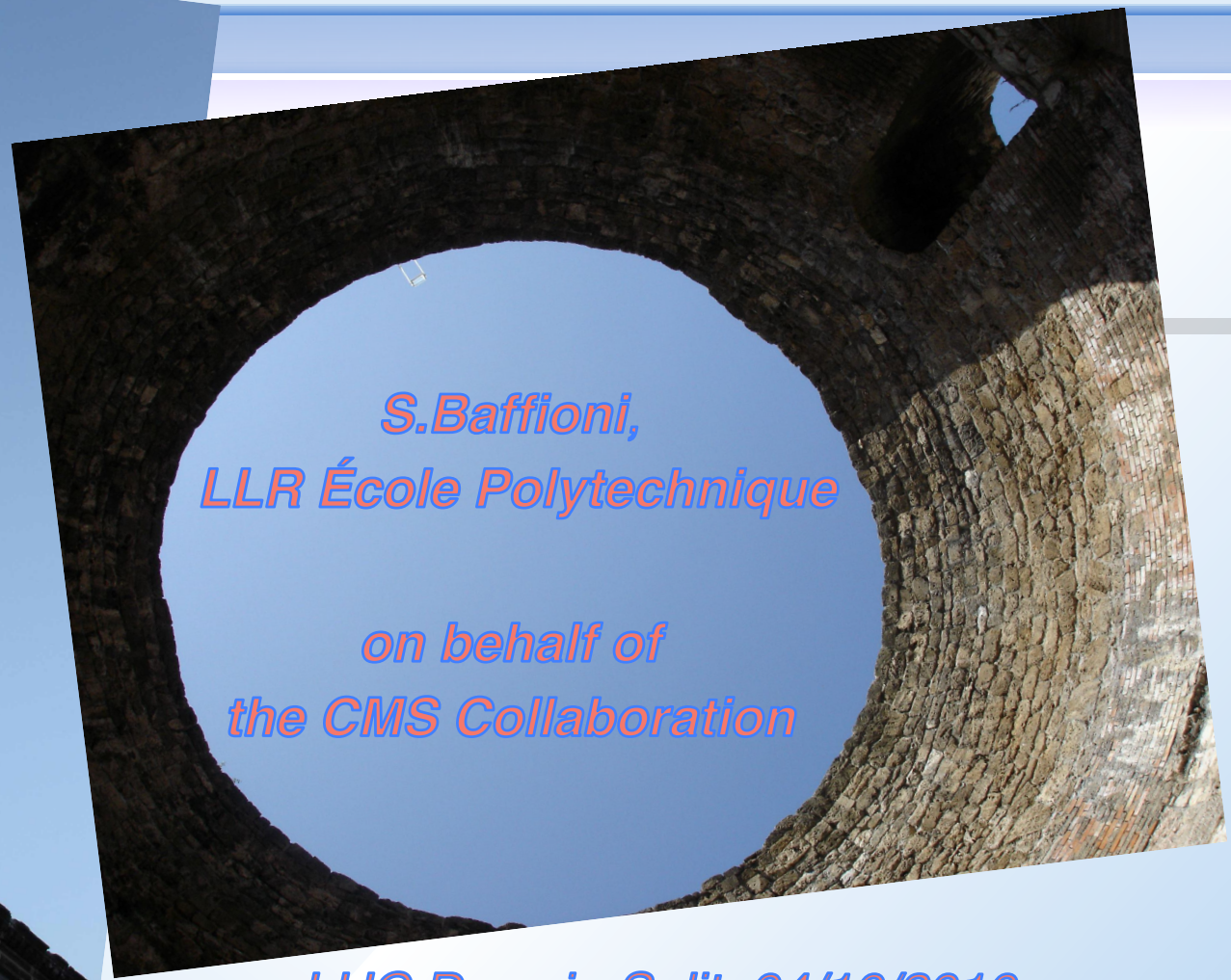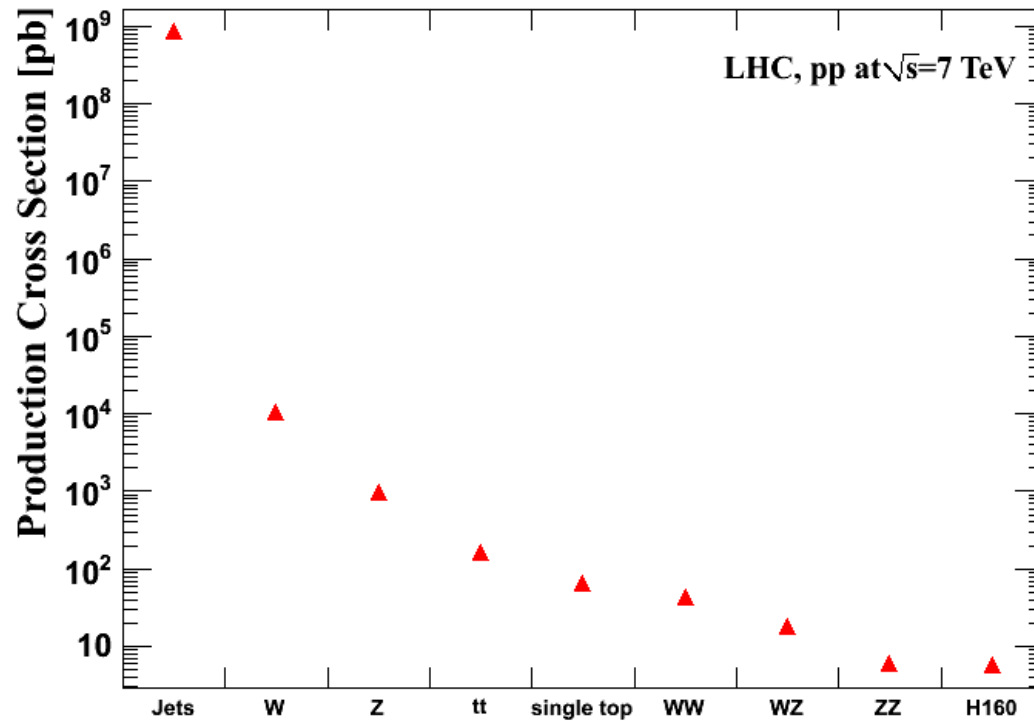
S.Baffioni,
LLR École Polytechnique

on behalf of
the CMS Collaboration

LHC Days in Split, 04/10/2010
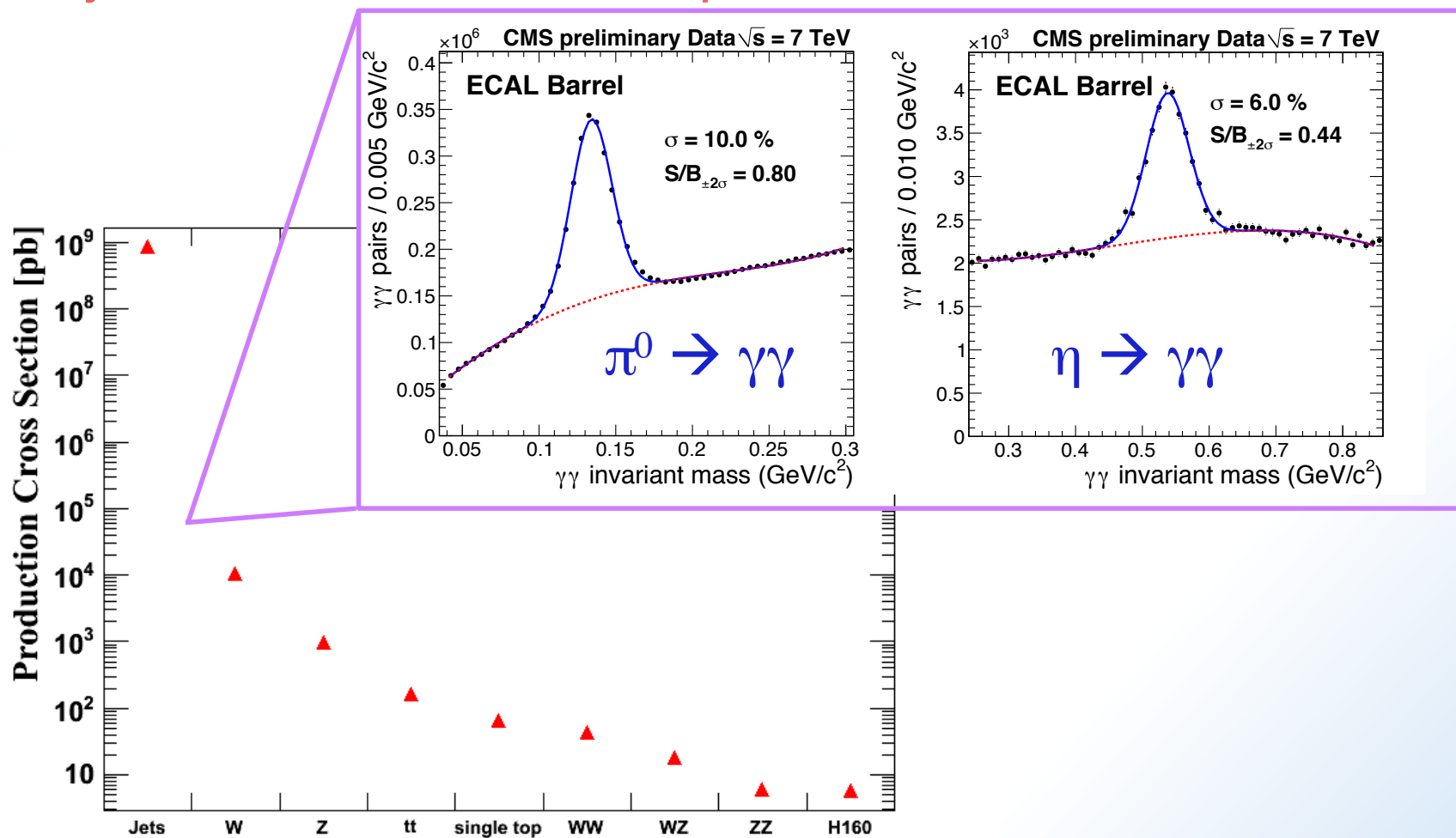
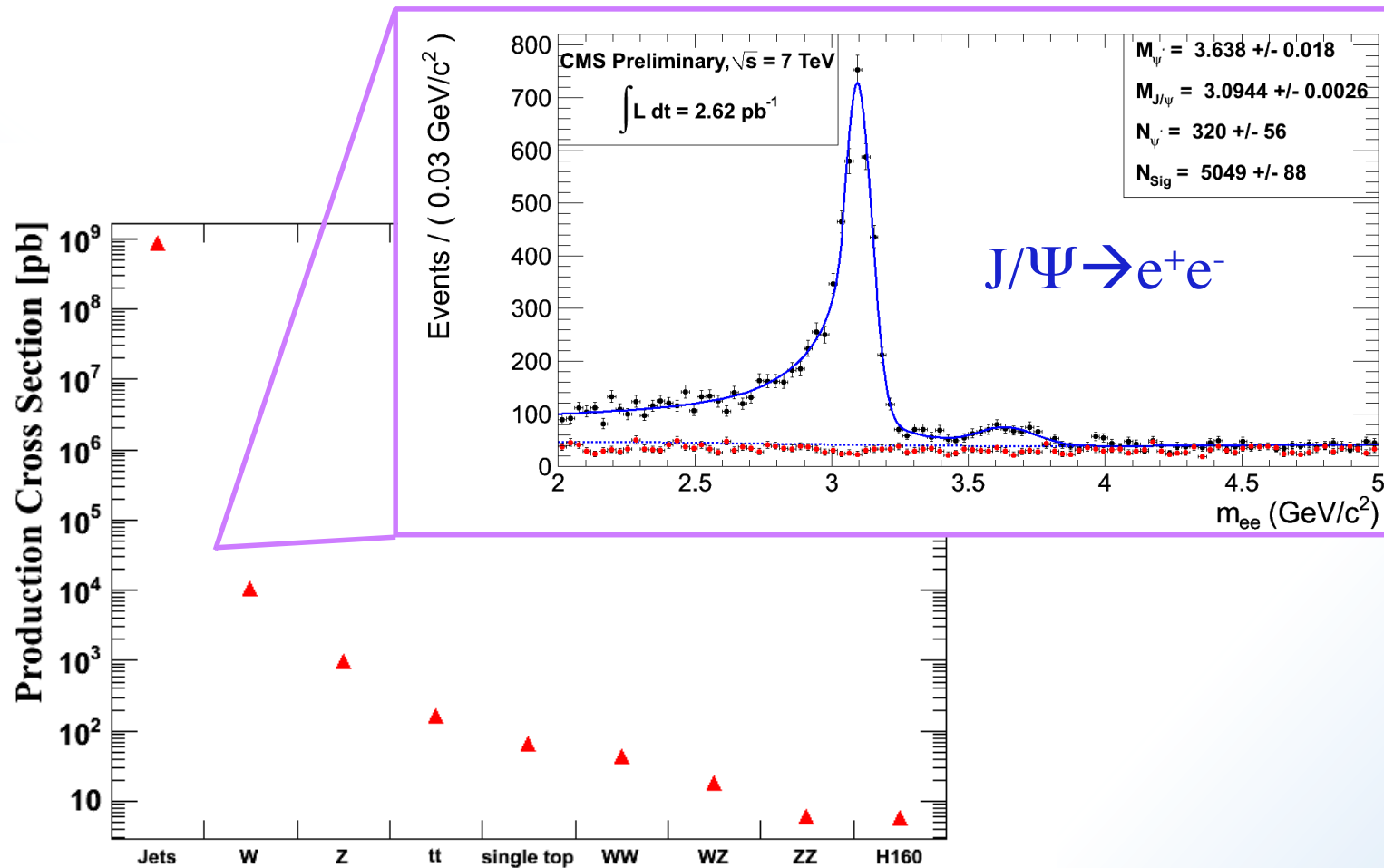# Introduction / Outline

⚓ Physics with electrons and photons:

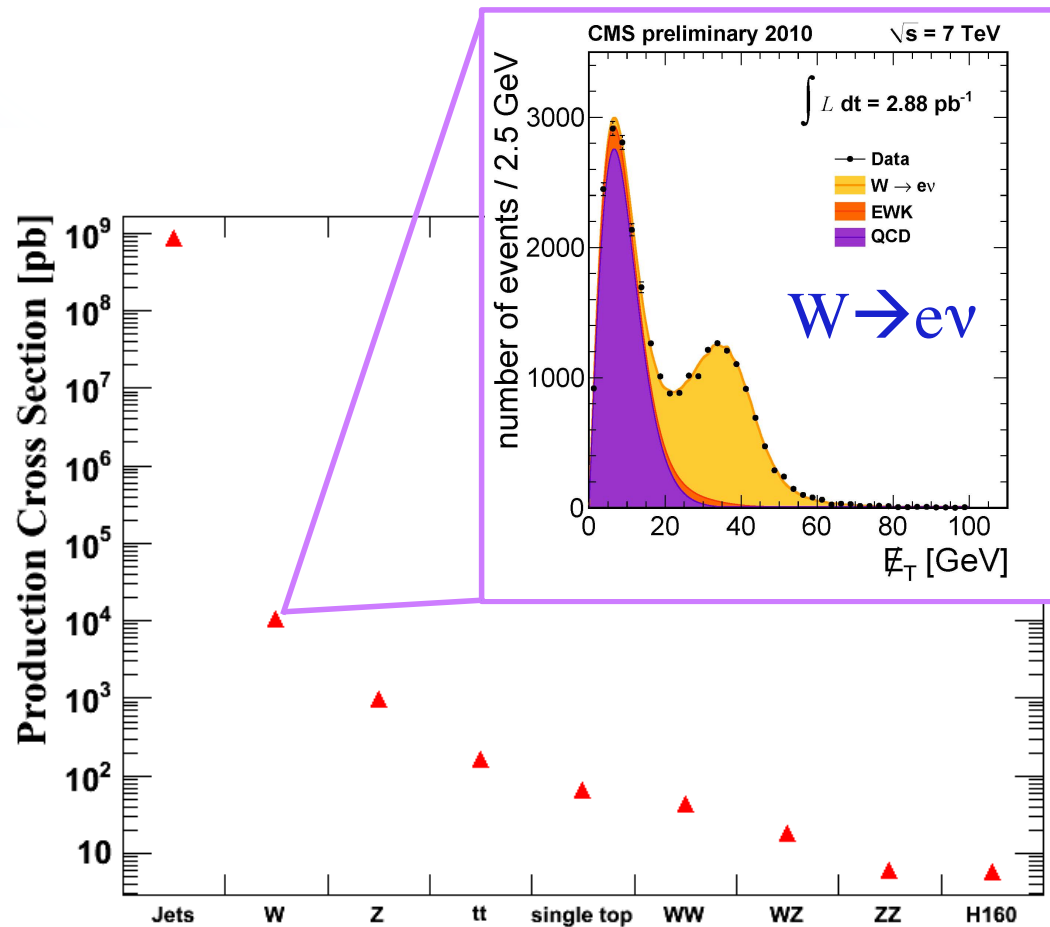# *Introduction / Outline*

⚓ Physics with electrons and photons:

Introduction / Outline

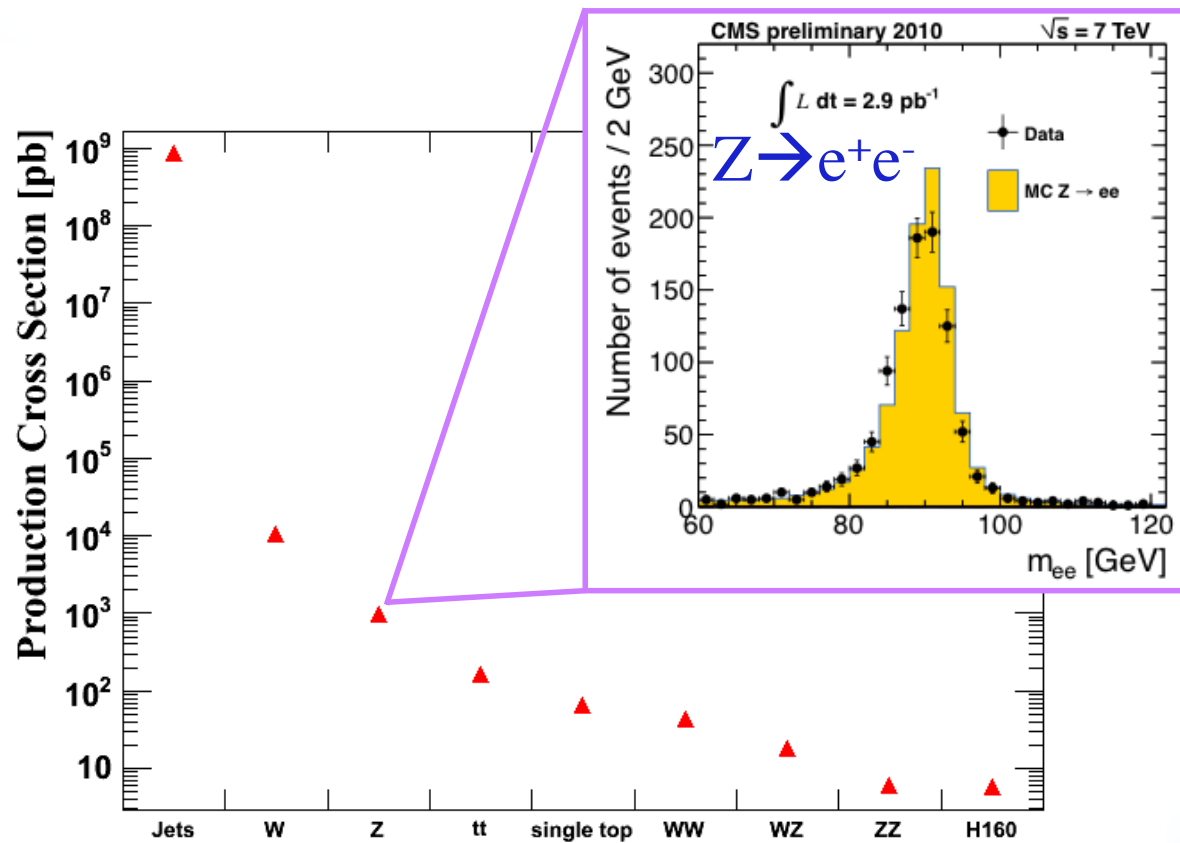⚓ Physics with electrons and photons:

Introduction / Outline

⚓ Physics with electrons and photons:

Introduction / Outline

⚓ Physics with electrons and photons:

Introduction / Outline

⚓ Physics with electrons and photons:
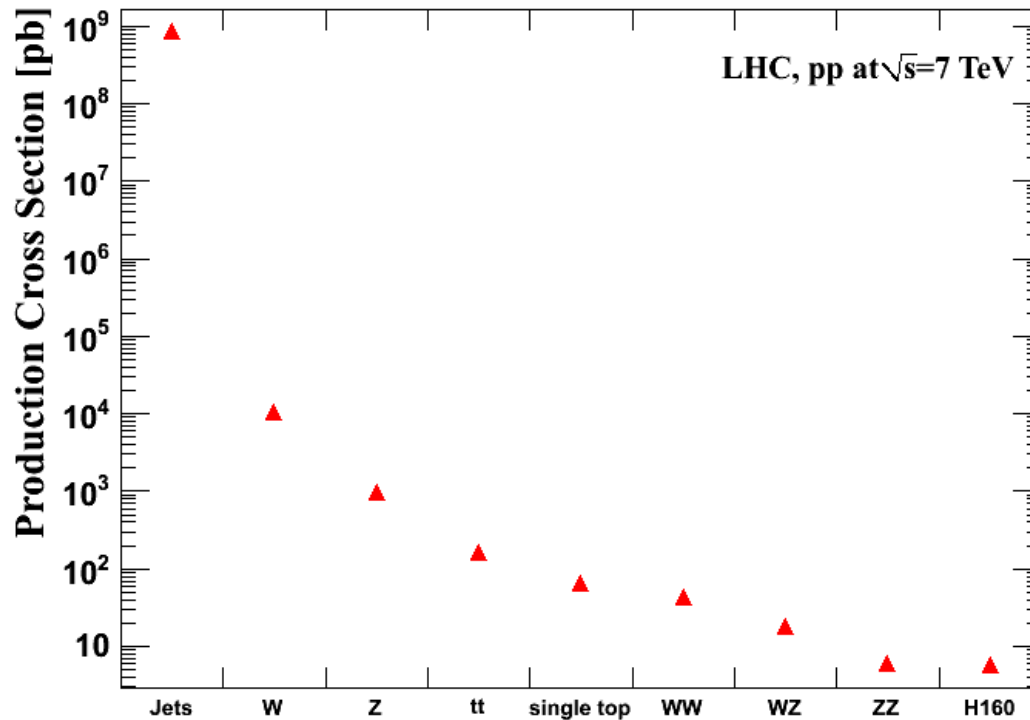
⚓ Outline:

💬 Photons:
- reconstruction
- selection
- conversion

💬 Electrons:
- reconstruction
- minimum bias events
- W and Z events:
  - seeding
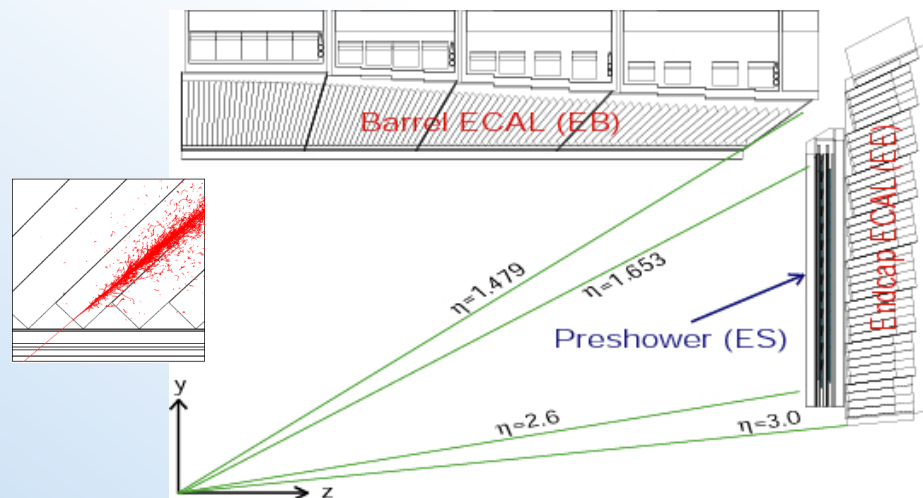 - reconstruction efficiency
  - selection
- fake rate

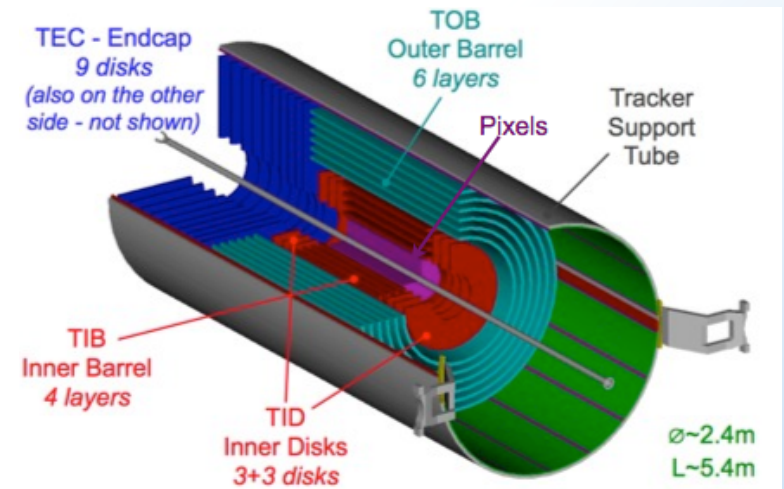💬 Perspectives

Detecting electrons and photons

⚓ Electromagnetic Calorimeter

- 🗫 Scintillating crystals
  ($\eta \times \phi = 0.017 \times 0.017°$ in the barrel)
- 🗫 Barrel: $|\eta| < 1.479$ $r = 1.29$ m
- 🗫 Endcaps: $1.479 < |\eta| < 3$ + preshower

⚓ Tracker

- 🗫 Silicon $|\eta| < 2.5$
- 🗫 Pixels: 3 barrel layers
                2 endcap disks
- 🗫 Strips: 10 barrel layers
                12 endcap disks

Barrel ECAL (EB)

Endcap ECAL (EE)

$\eta=1.479$ $\eta=1.653$

Preshower (ES)

$\eta=2.6$ $\eta=3.0$

y

z

TEC - Endcap
9 disks
(also on the other
side - not shown)

TOB
Outer Barrel
6 layers

Pixels

Tracker
Support
Tube

TIB
Inner Barrel
4 layers

TID
Inner Disks
3+3 disks
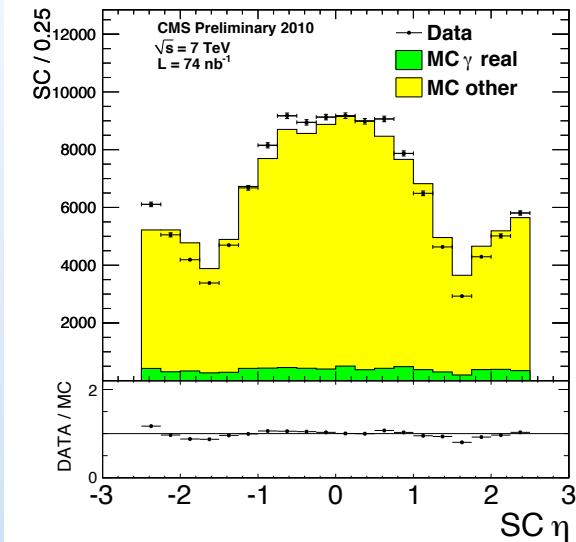
ø~2.4m
L~5.4m

⚓ Tracker and ECAL inside a 3.8 T solenoid
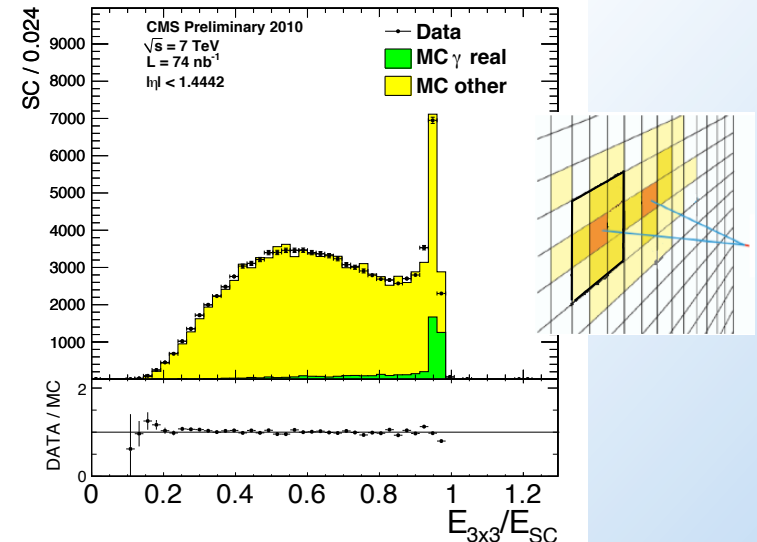
Photon reconstruction

⚓ Photon and electron reconstruction:

- 💬 Large material budget (~1 X/X_0, up to 1.8)
- 💬 High magnetic field (3.8 T)
- 💬 → Conversions and Bremsstrahlung
- 💬 → **SuperCluster (SC)**: aggregate of ECAL clusters spread in φ
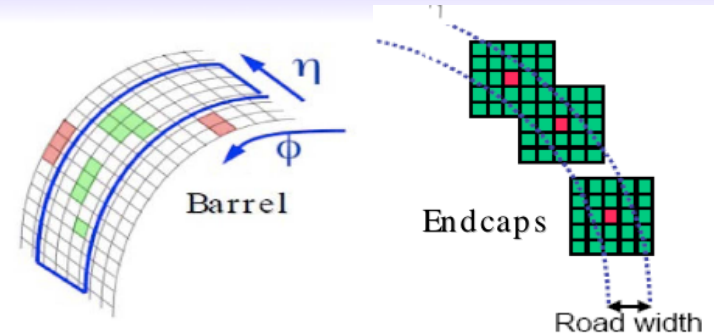
⚓ DATA vs MC (QCD and γ+jet)

$p_T > 20$ GeV/c
in barrel or endcaps
$E_{had}/E_{ECAL} < 0.05$

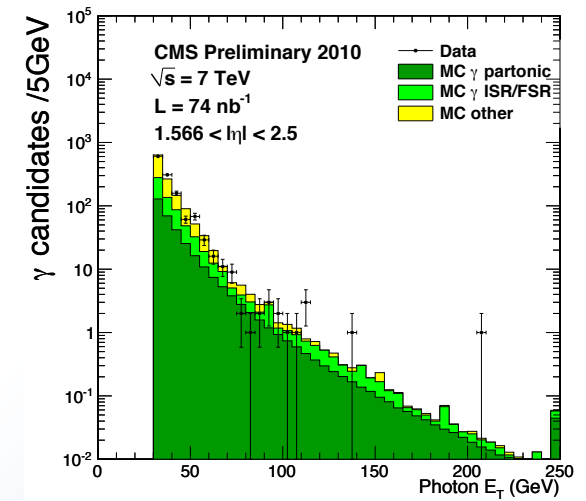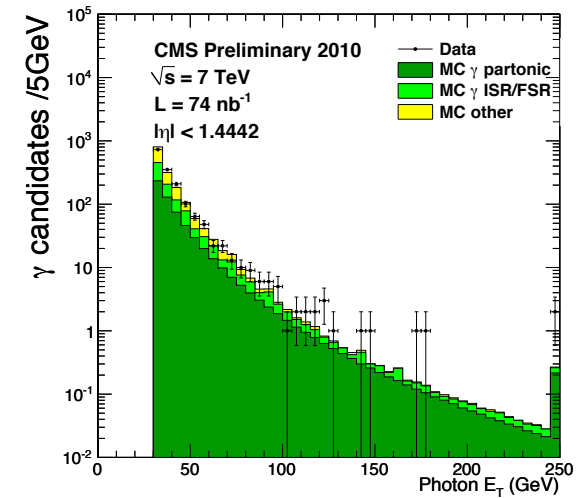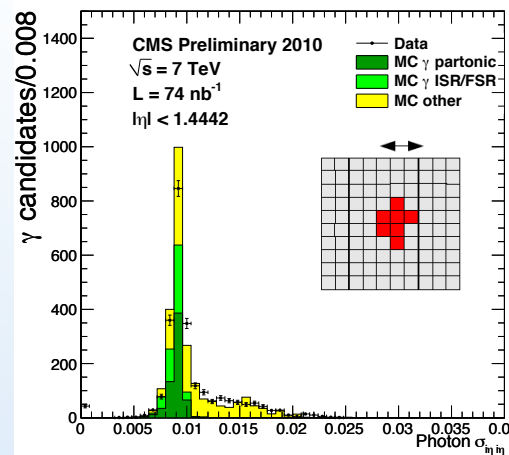# Photon selection

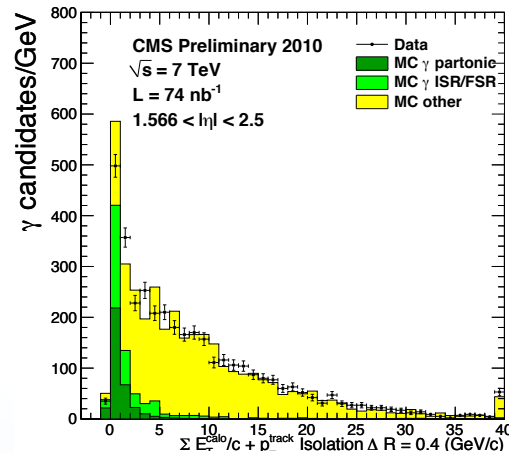⚓ Photon selection:

💬 No track associated to the SC

💬 Isolation:
  • tracker
  • ECAL
  • HCAL

💬 Shower shape

💬 → Signal enriched sample

Photon conversion

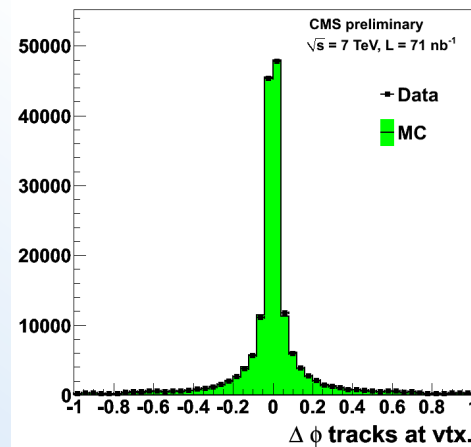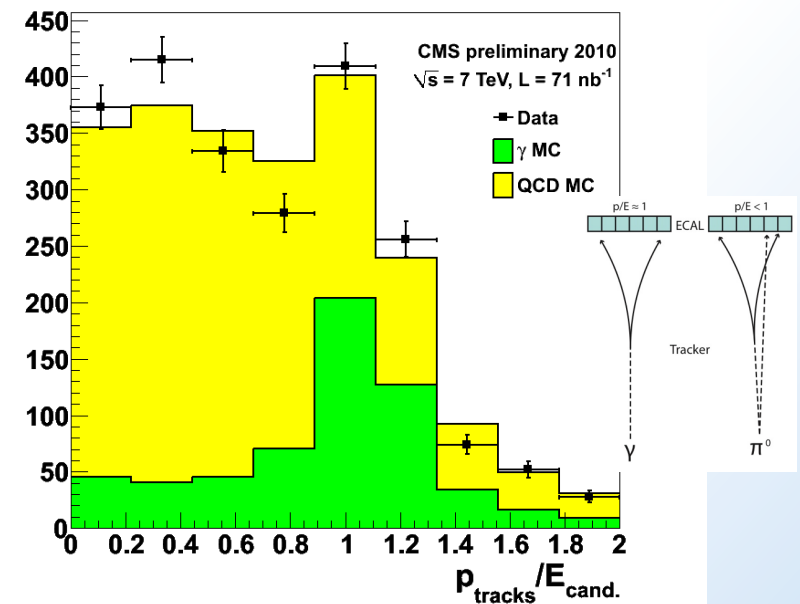⚓ **Conversion identification:**

💬 **After identification**

💬 **Combination:**
- ECAL
- Tracker

ECAL SC

[2]

[1]
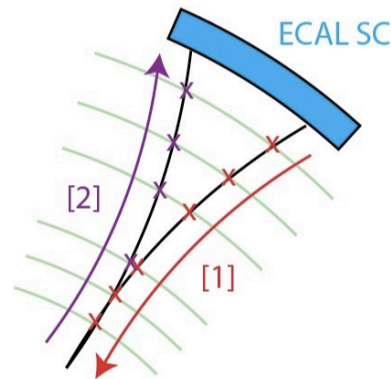
💬 **Selection:**
- low angular separation
- good vertex

CMS preliminary
$\sqrt{s}$ = 7 TeV, L = 71 nb^{-1}

- Data
- MC

$\Delta \phi$ tracks at vtx.

CMS preliminary 2010
$\sqrt{s}$ = 7 TeV, L = 71 nb^{-1}

- Data
- γ MC
- QCD MC

$p_{tracks}/E_{cand.}$

p/E ≈ 1   ECAL   p/E < 1

Tracker

γ π^0

Electron reconstruction

⚓ Electron candidate = Track + ECAL SuperCluster:

- 💬 Track seeding driven by
  - ECAL (isolated electrons in W/Z p_T range)
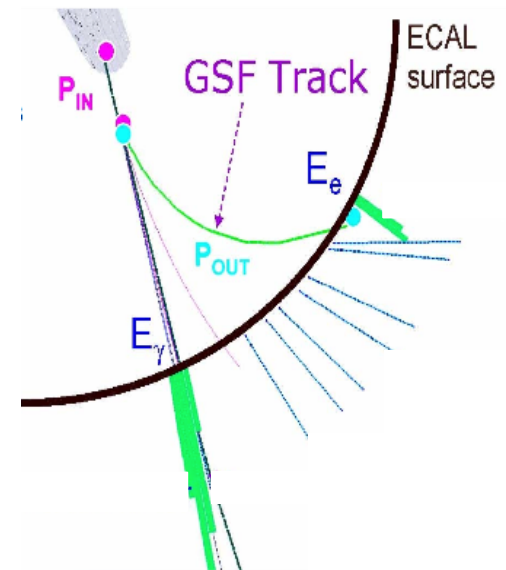 - or Tracker (non isolated or low p_T electrons)
- 💬 Gaussian Sum Filter tracking
  - fraction of brem energy loss *(fbrem)*
  - track reconstructed right out to ECAL surface
- 💬 Association Track/SC
- 💬 Classification of electrons
  - with respect to their brem fraction
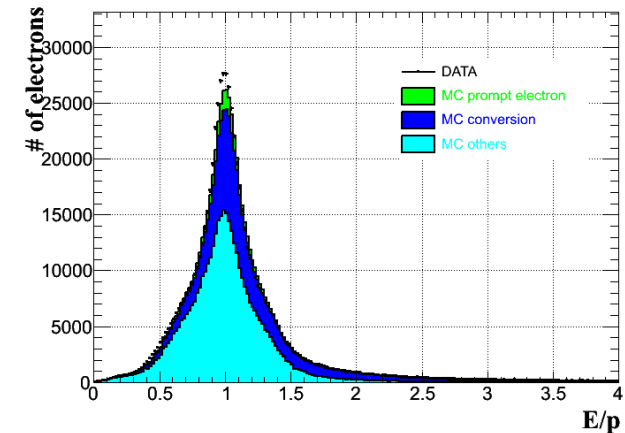 - E & p combination for better momentum estimation
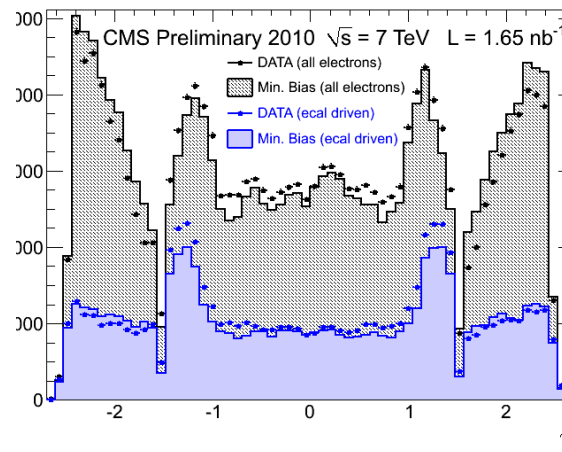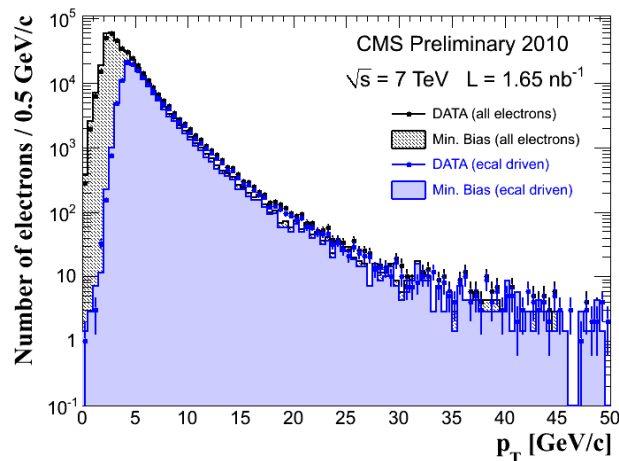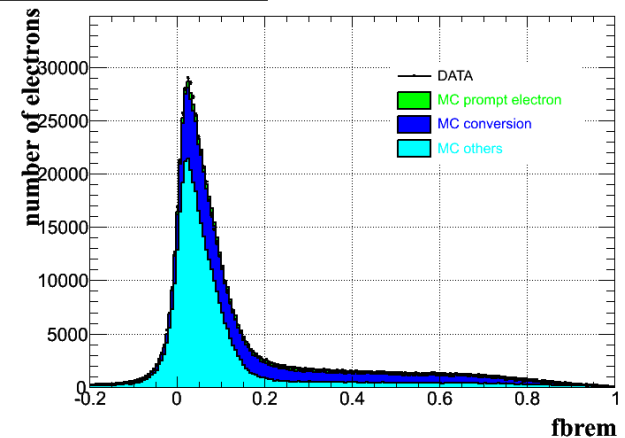
Electrons in Minimum Bias events

⚓ Electron candidates in Minimum Bias:

💬 Mainly **hadrons (61.5%)**
photon conversions (33.9%),
very few **real electrons (4.6%)**

💬 Useful to commission electron variables
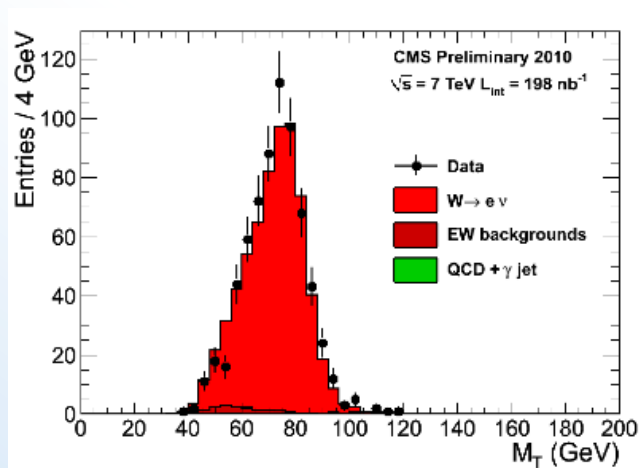and early detect features

W and Z events

⚓ With increasing lumi: commissioning of $p_T > 20$ GeV electrons
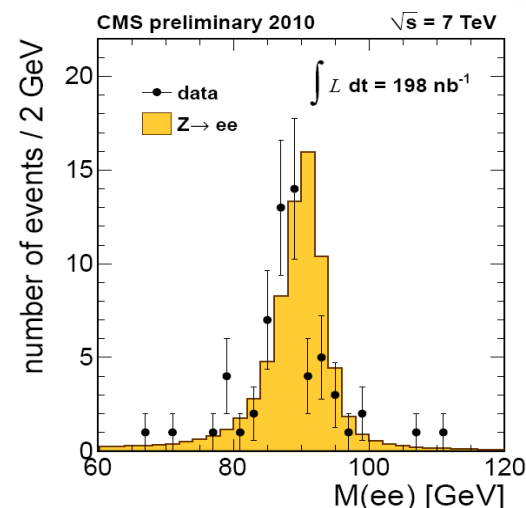
💬 W events

- high $\not{E}_T$
- no hadronic activity
- electromagnetic trigger

💬 Z Tag and Probe

- **tag**: well defined electron (triggered, identified and isolated)
- **probe**: high E_T isolated SuperCluster, Z mass cut, ID
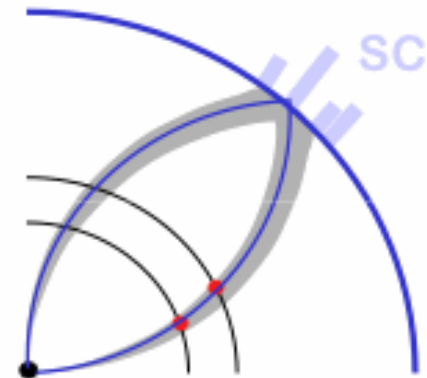

⚓ → electron key variables

⚓ → reconstruction, isolation and ID efficiencies
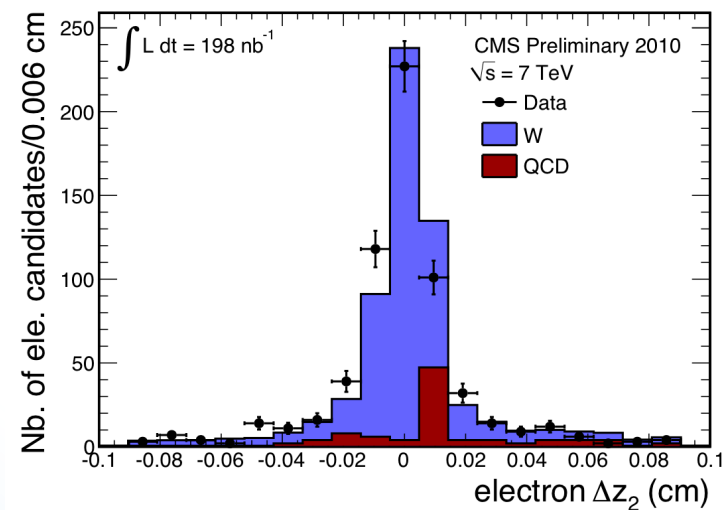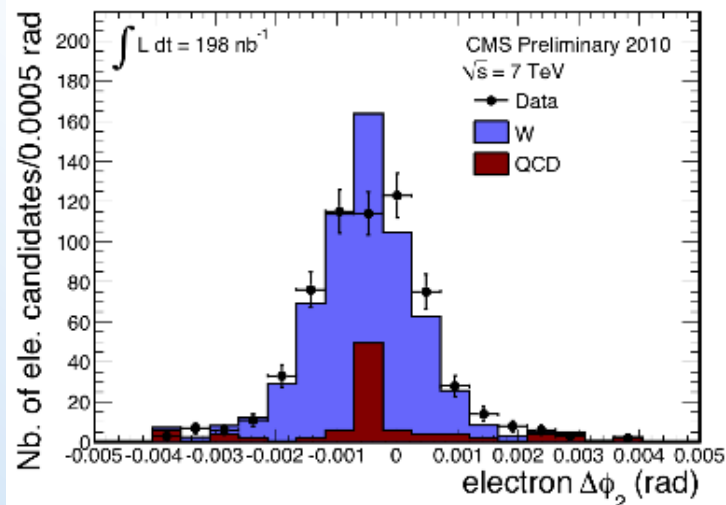
Electron seeding

⚓ **Ecal driven seeding**

💬 $\Delta\phi_2, \Delta z_2$

- between hit position
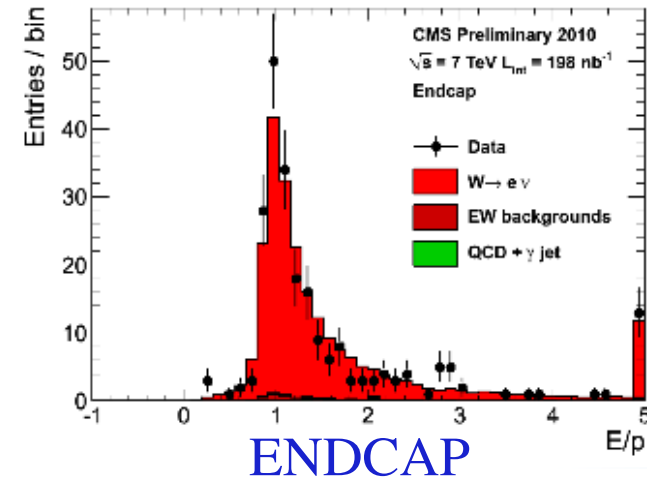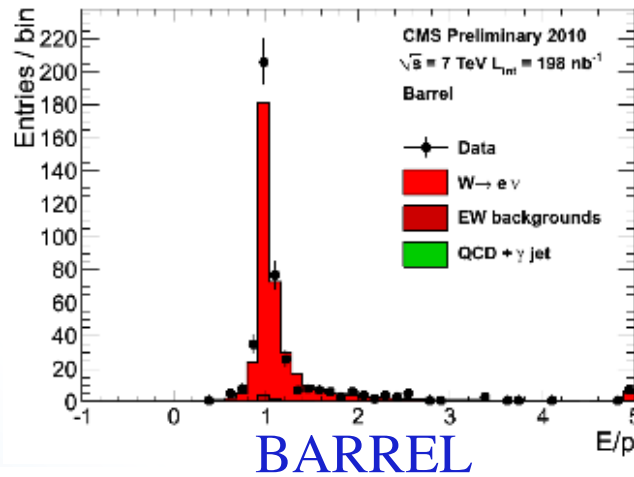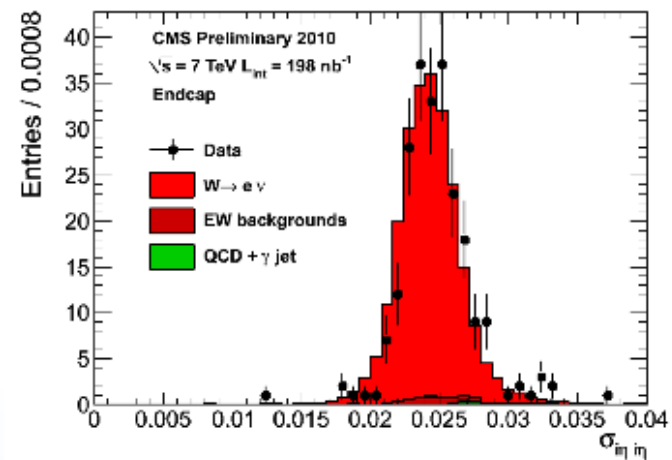- and expected one in the second pixel layer
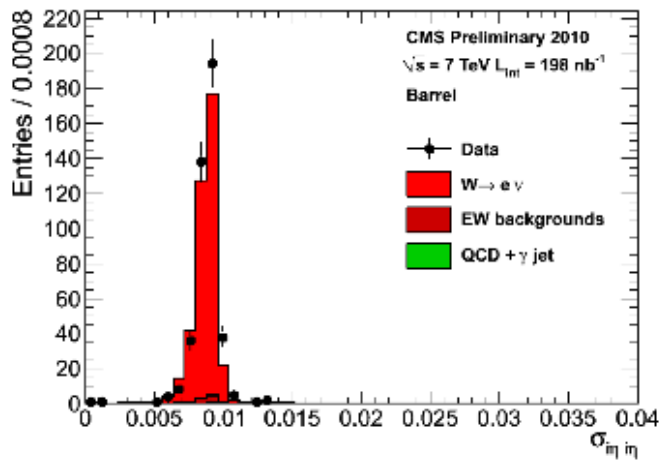- in the barrel pixels

W events

Electron key variables

⚓ Key variables for electrons in W events

E/p

BARREL

ENDCAP

shower
shape

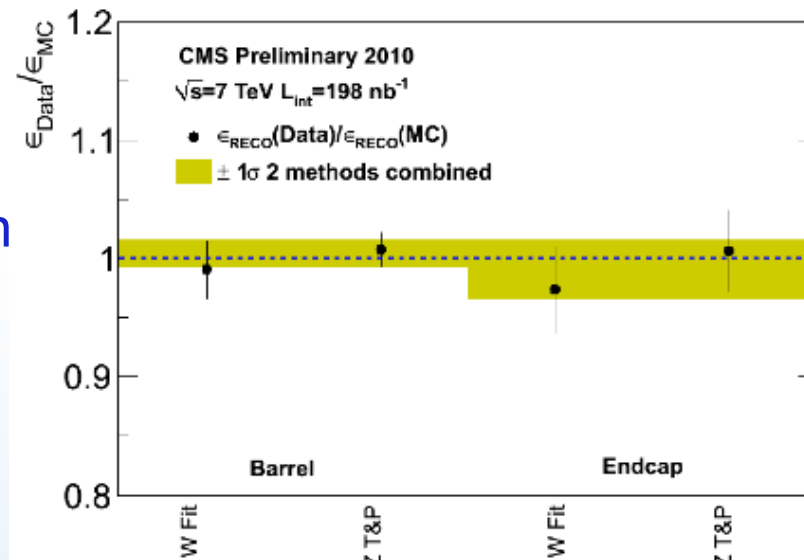⚓ Good agreement in all distributions

Electron reconstruction efficiency

⚓ Efficiency with respect to SuperCluster:

💬 Measured with Z Tag&Probe method (~70 Zee)

Z Tag & Probe	Measured efficiency	Error (stat. + syst)	MC efficiency
Reco Eff Barrel	99.3%	1.4%	98.5%
Reco Eff Endcap	96.8%	3.4%	96.1%

💬 Comparison between different methods

Electron selection

⚓ Simple Cuts for early analyses:

🗨 Defined to select W events at 95% (WP95) and 80% (WP80)

🗨 Separation barrel/endcaps

🗨 Based on ID (shower shape, track-SC matching), isolation (track, ECAL, HCAL), conversion rejection

🗨 Efficiency measured with Z Tag&Probe

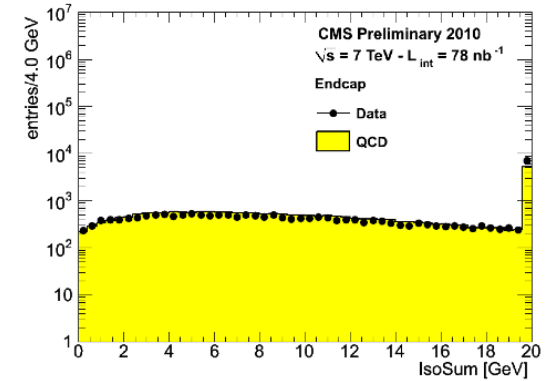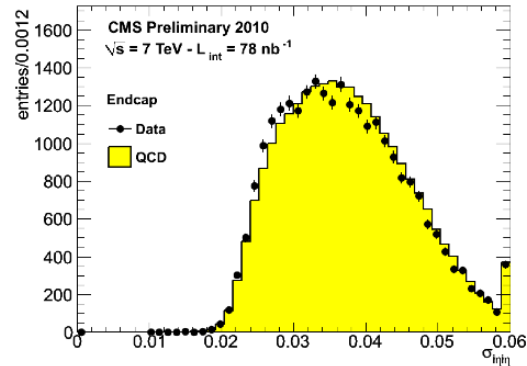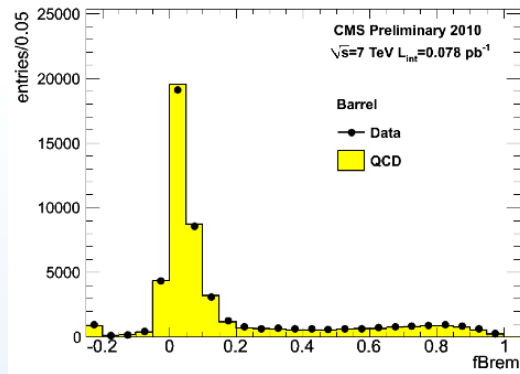| Z Tag & Probe	Measured efficiency	Error (stat. + syst)	MC efficiency
WP95 Barrel	92.5%	3.2%	95.4%
WP95 Endcap	86.4%	6.7%	92.9%
WP80 Barrel	77.5%	4.7%	85.1%
WP80 Endcap	75.1%	8.6%	76.2%
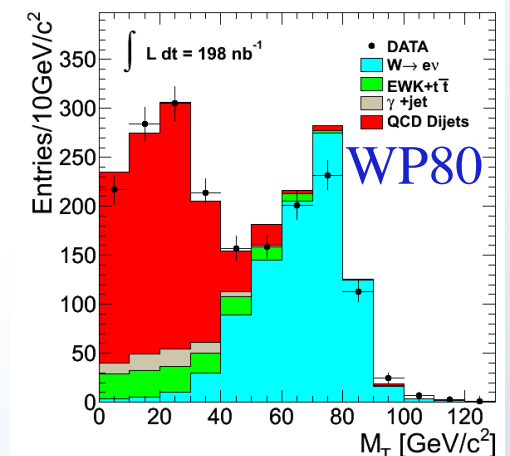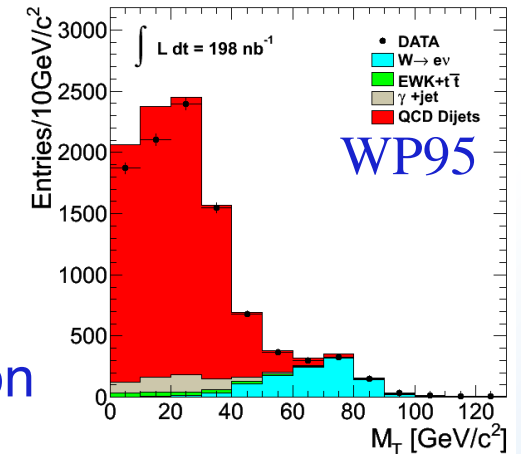
⚓ With increasing luminosity: cuts in categories

🗨 Categories as function of fbrem, E/p, p_T and barrel/endcaps
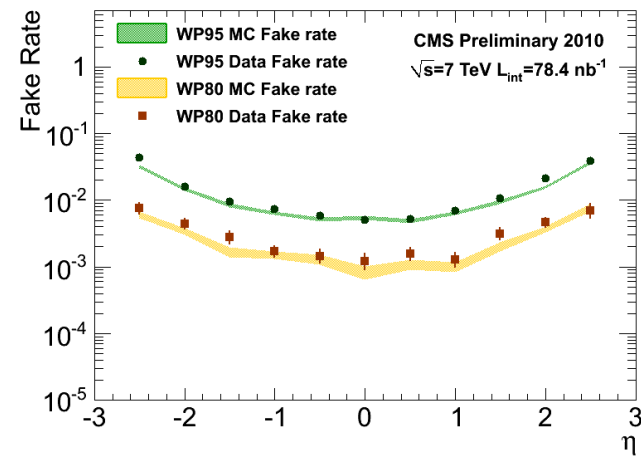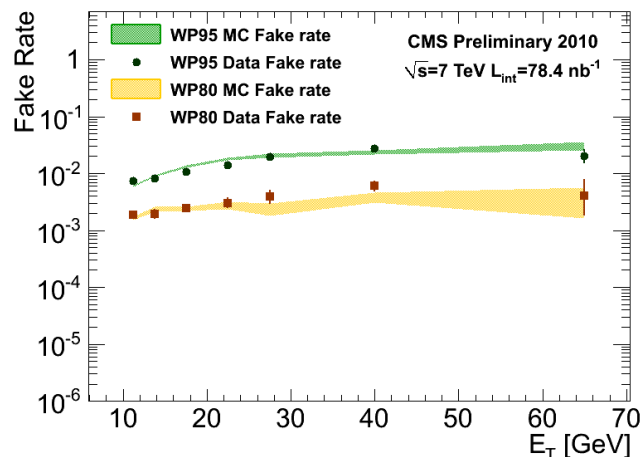
Electron fake rate

⚓ Measured using jet events:

💬 Jet trigger $E_T > 15$ GeV + 1 jet $E_T > 20$ GeV + $\not{E}_T < 30$ GeV

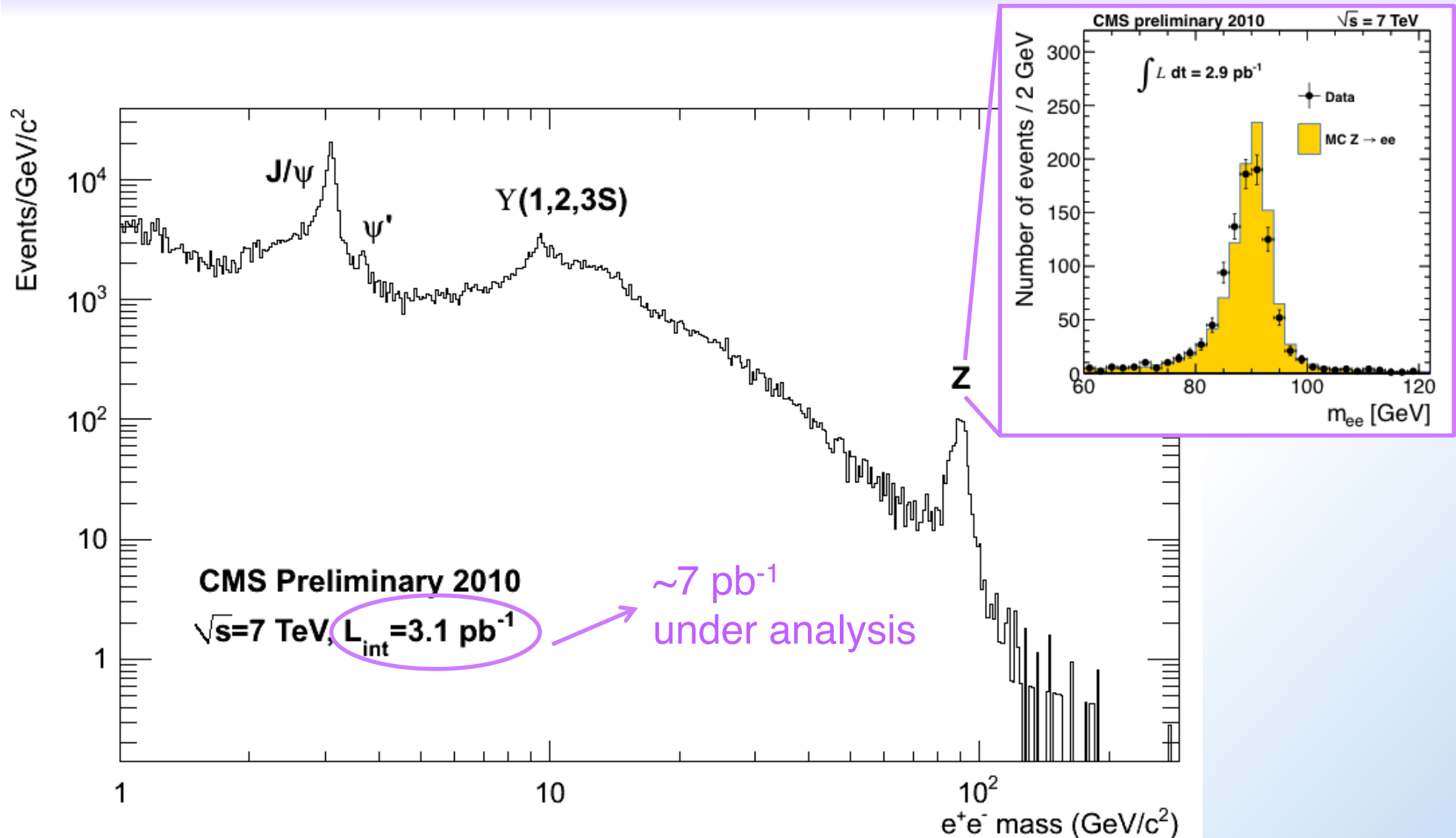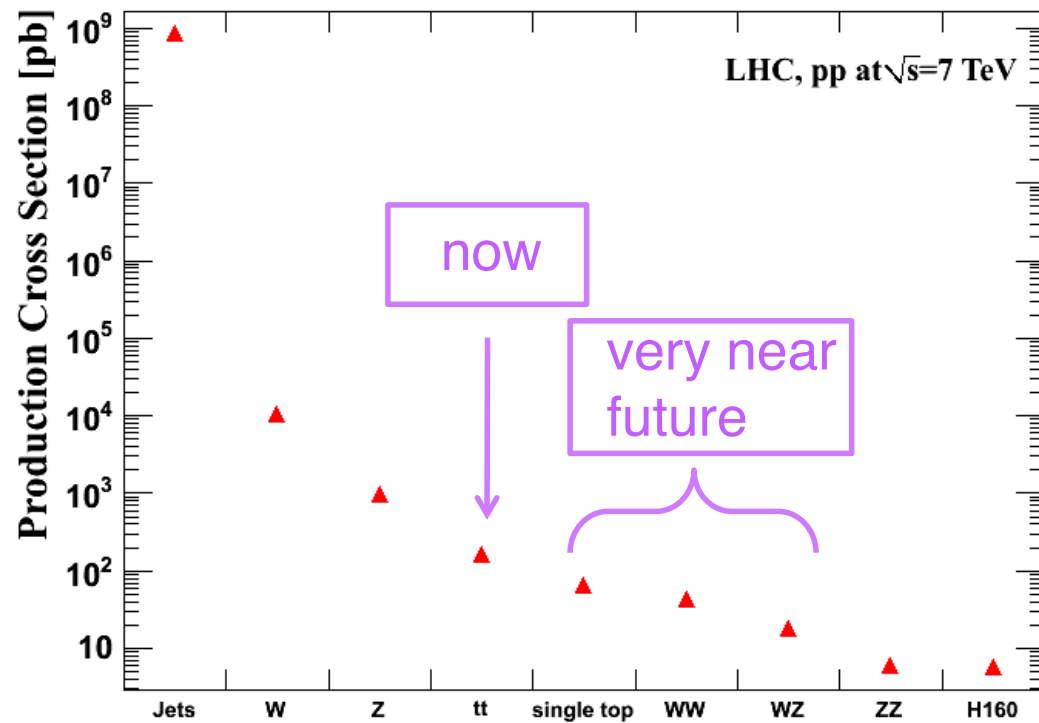

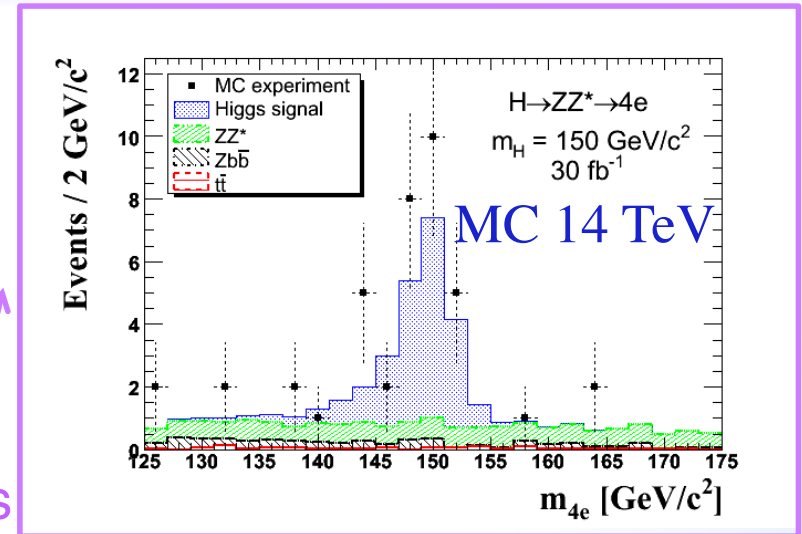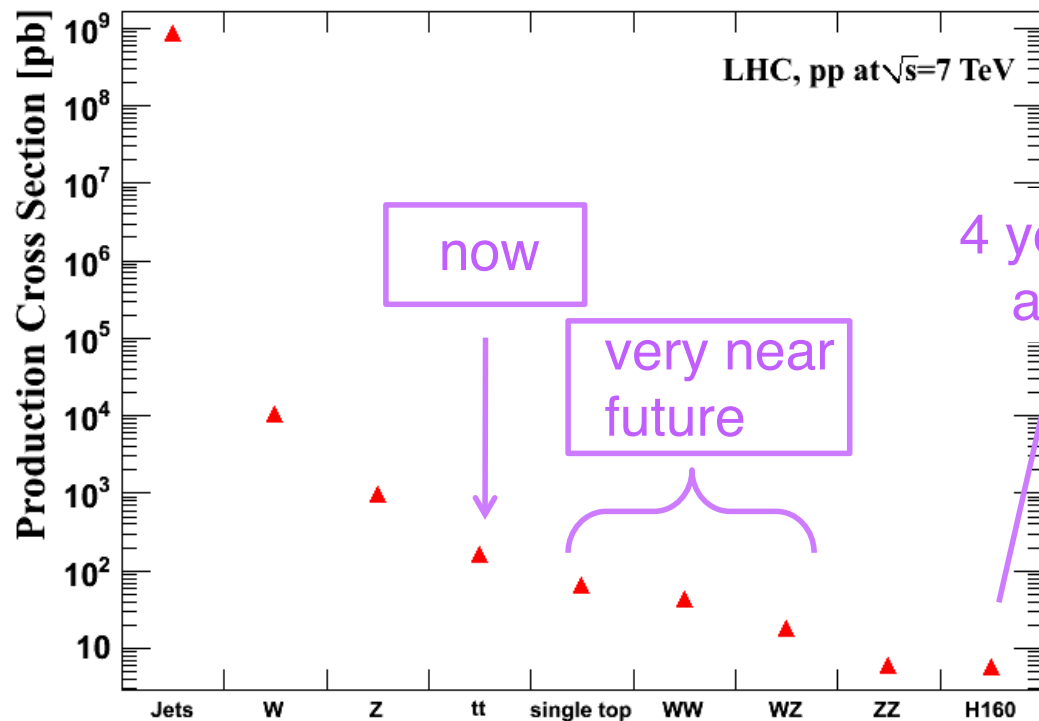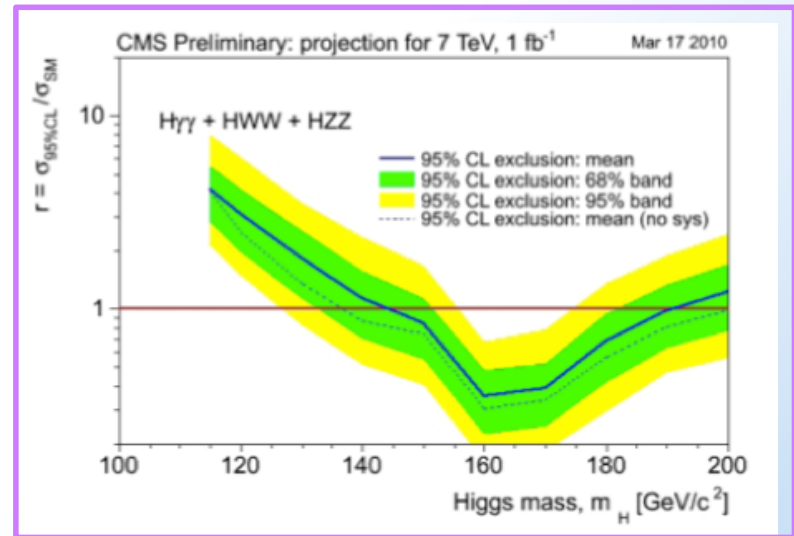💬 Fake rate = number of electrons with ID / number of electrons

WP95
WP80

New data analyzed

Perspectives

Perspectives

Perspectives

now

very near
future

4 years
ago
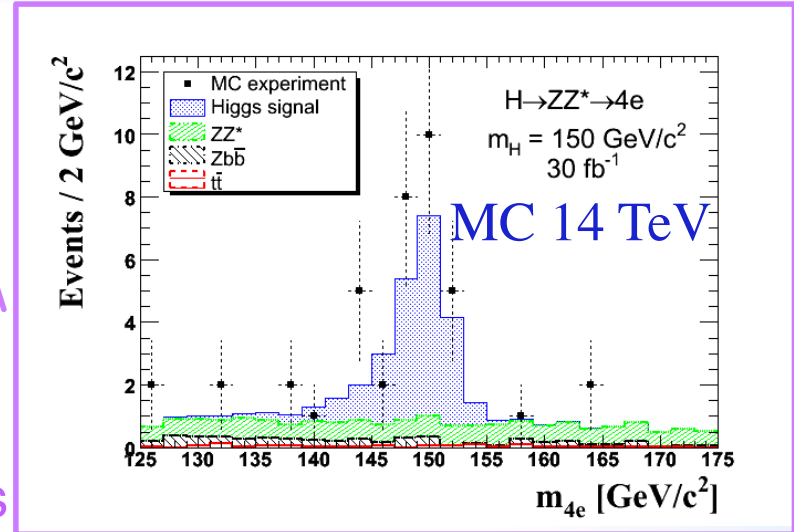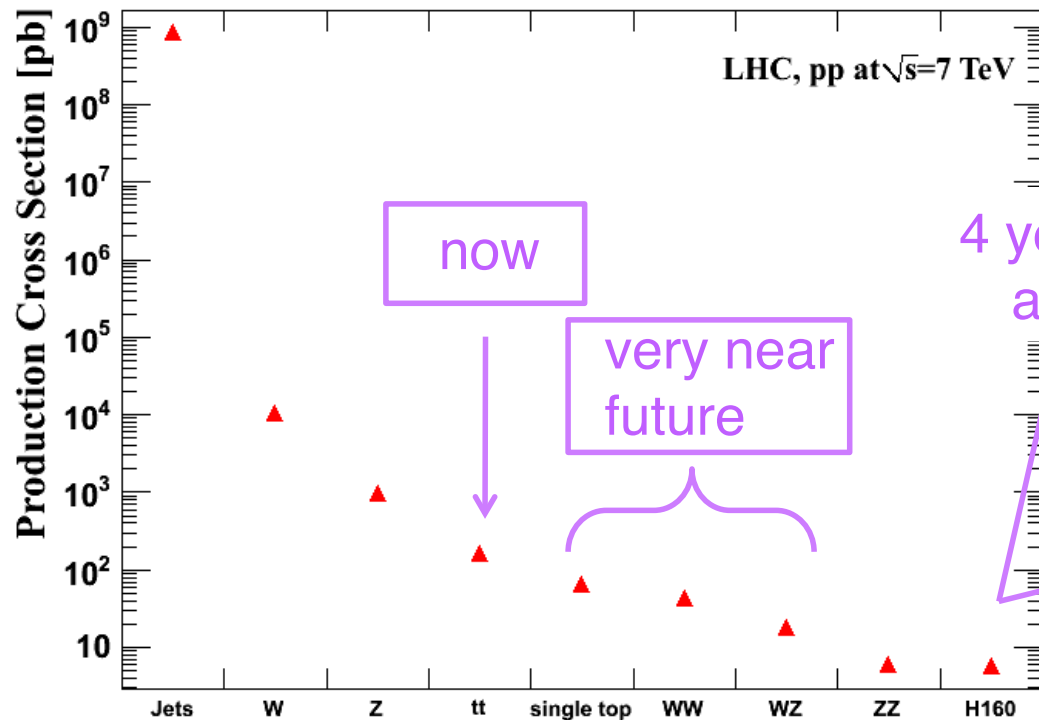
Conclusion

⚓ With 74 nb^{-1} and 198 nb^{-1} at √s = 7 TeV

- 💬 CMS has commissioned the **key observables** for the reconstruction, identification and isolation of primary electrons and photons
- 💬 **Photons :**
  - key observables have been compared between data and MC simulation for background and photon enriched samples and found in very good agreement
- 💬 **Electrons**:
  - Reconstruction and selection **efficiencies** have been measured and found to be very close to MC simulation
  - **Fake** rate has been measured and found in good agreement with expectation

⚓ ~ 7 pb^{-1} under analysis

⚓ ~ > 30 pb^{-1} at the end of 2010 ?

References

⚓ CMS-DPS-2010-032 -- *Electron Reconstruction and Identification at √s = 7 TeV*

⚓ CMS-PAS-EGM-10-005 -- *Photon reconstruction and identification at sqrt(s) = 7 TeV*

⚓ CMS-PAS-EWK-10-002 -- *Measurements of Inclusive W and Z Cross Sections in pp Collisions at √s = 7 TeV*

⚓ CMS-PAS-PFT-10-003 -- *Commissioning of the Particle-Flow Reconstruction in Minimum-Bias and Jet Events from pp Collisions at 7 TeV*

⚓ Eur. Phys. J. C 49 -- *Electron reconstruction in CMS*

⚓ CMS NOTE-2006/115 -- *Discovery potential for the SM Higgs boson in the $H \rightarrow ZZ^{(*)} \rightarrow 4e$ decay channel*