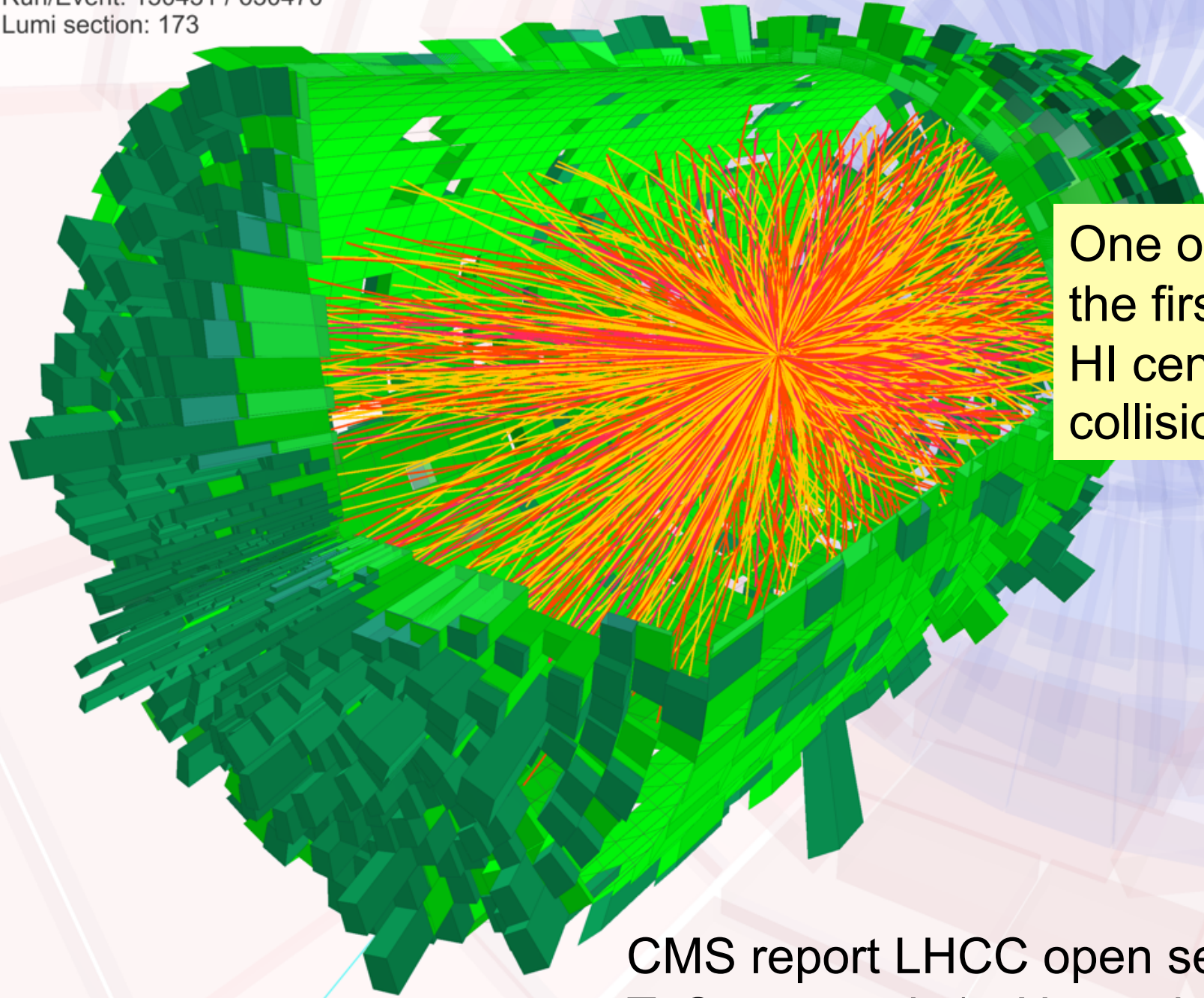




CMS Experiment at LHC, CERN
Data recorded: Mon Nov 8 11:30:53 2010 CEST
Run/Event: 150431 / 630470
Lumi section: 173



One of
the first
HI central
collisions

CMS report LHCC open session,
T. Camporesi, 17 November, 2010



Acknowledgement

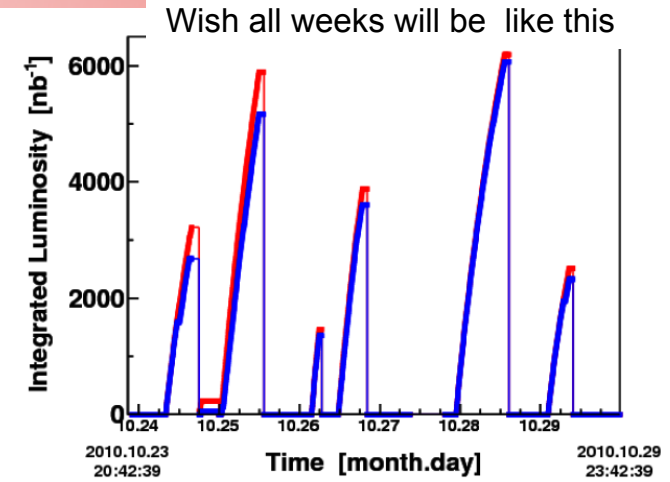
- The performance of the accelerator complex has been outstanding. The accelerator teams have been amazing us and to them goes our deepest thanks
- The WLCG and IT have delivered
- The content of these slides is the product of the tireless effort of thousands of CMS colleagues over many years.

To them goes the credit

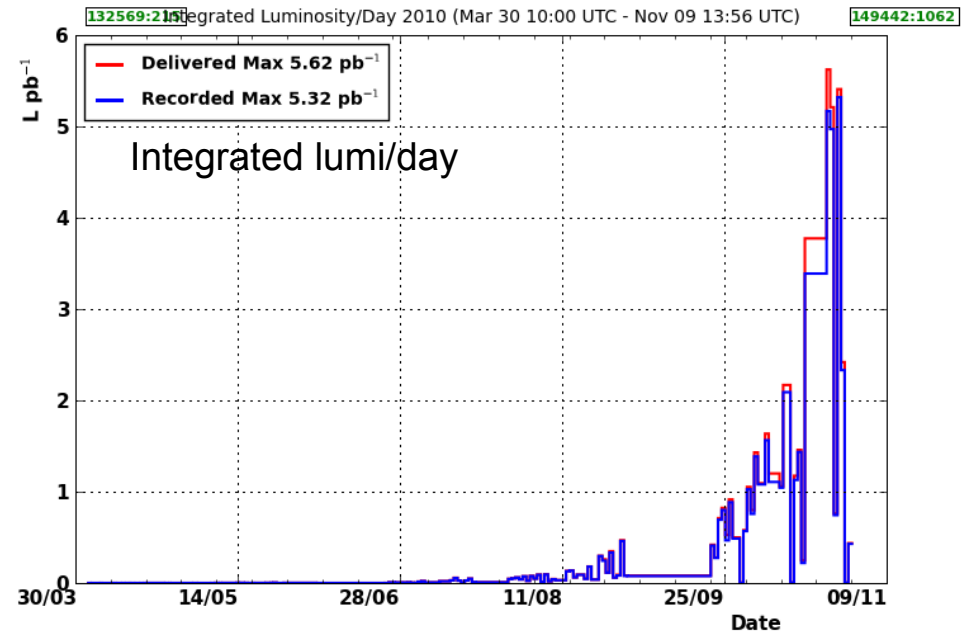
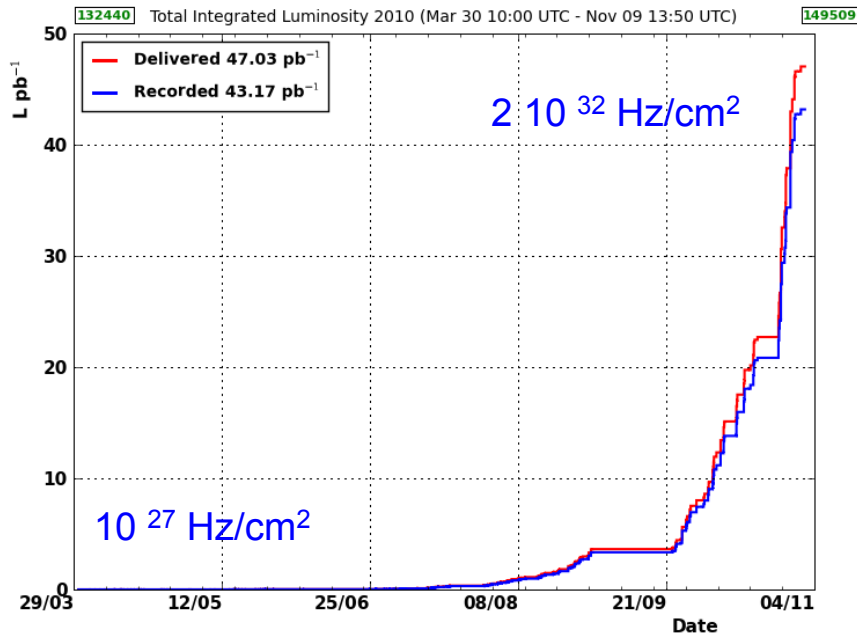


CMS PP campaign

LHC Delivered 47 pb⁻¹, CMS recorded 43 pb⁻¹
 Overall data taking efficiency 92%
 ~85% with all subdetectors in perfect conditions



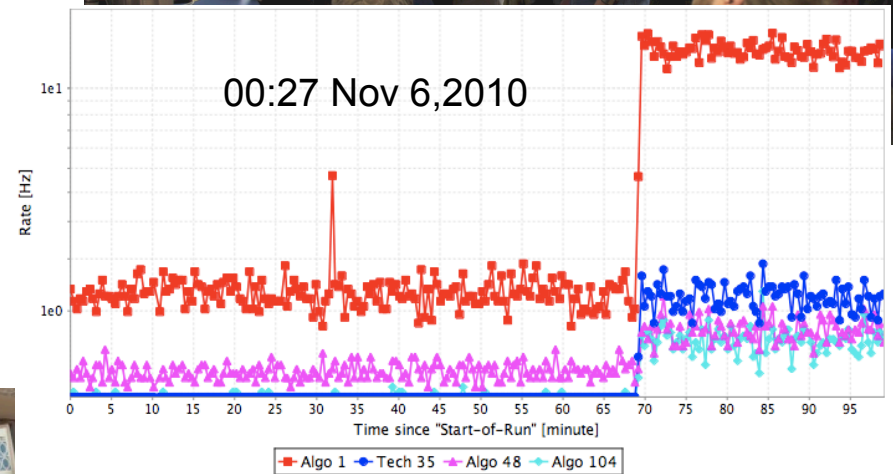
Heavy Ions: delivered ~ 1.96 μb⁻¹, efficiency > 95%



Thanks to the LHC Team !

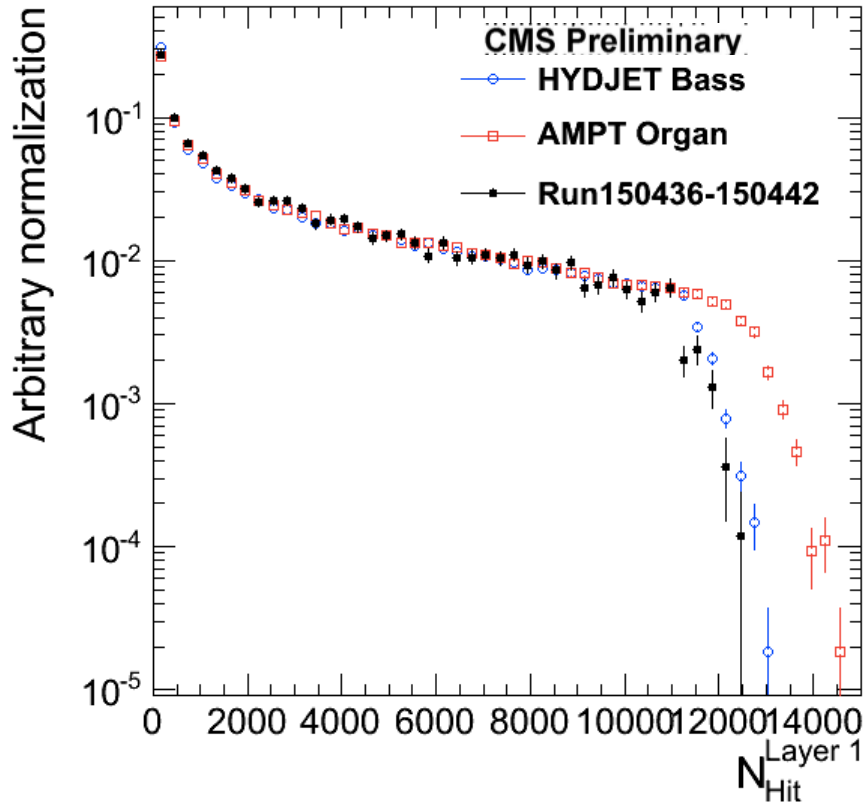


Heavy ion startup

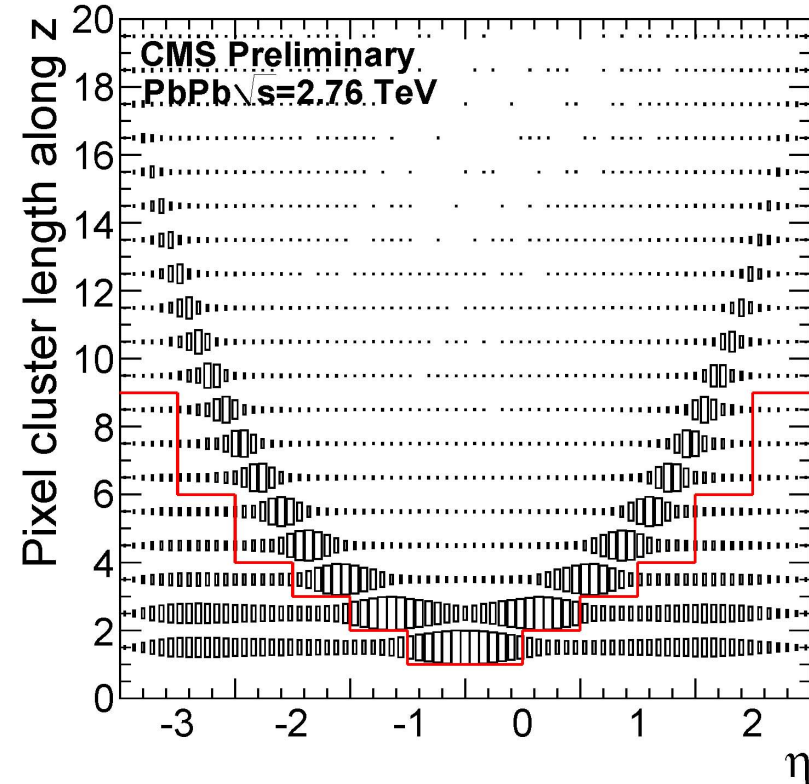




Heavy ion tracking: pixel



Pixel Hit multiplicity agrees well with MC tuned with RHIC AuAu and LHC pp collisions

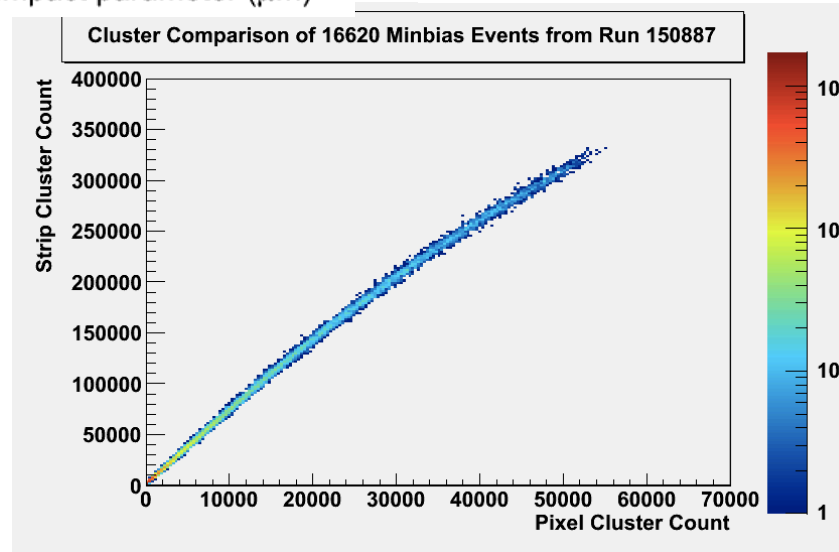
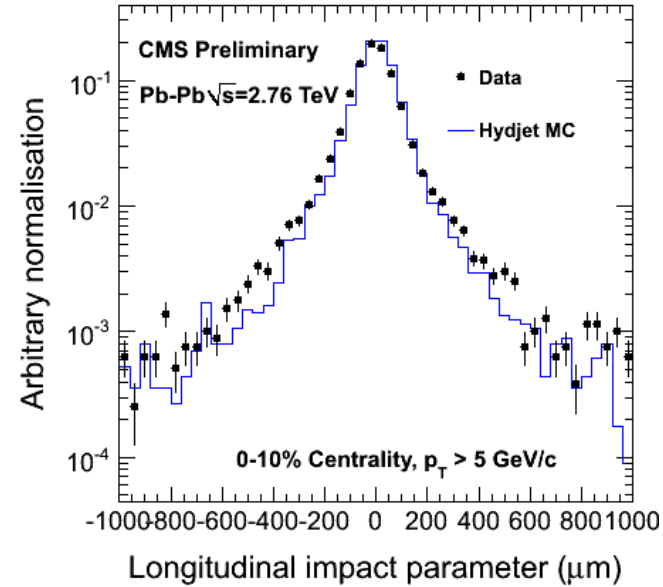
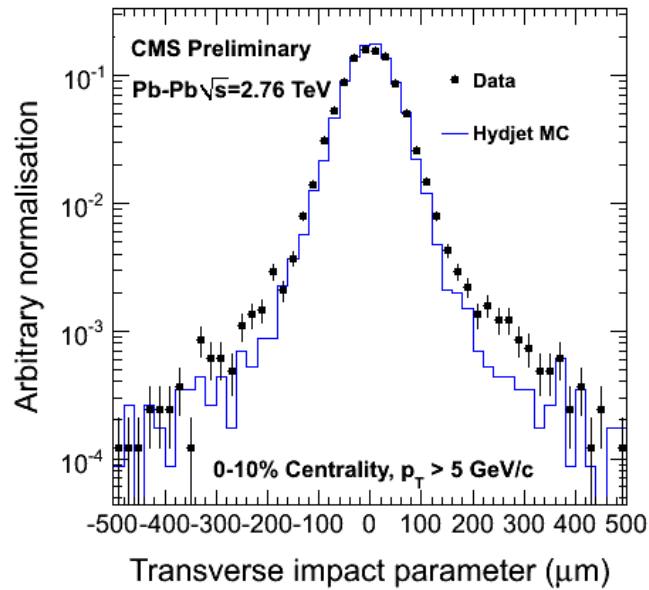


Smiley plot (red line separates background from hits coming from IP originated tracks) similar to pp running



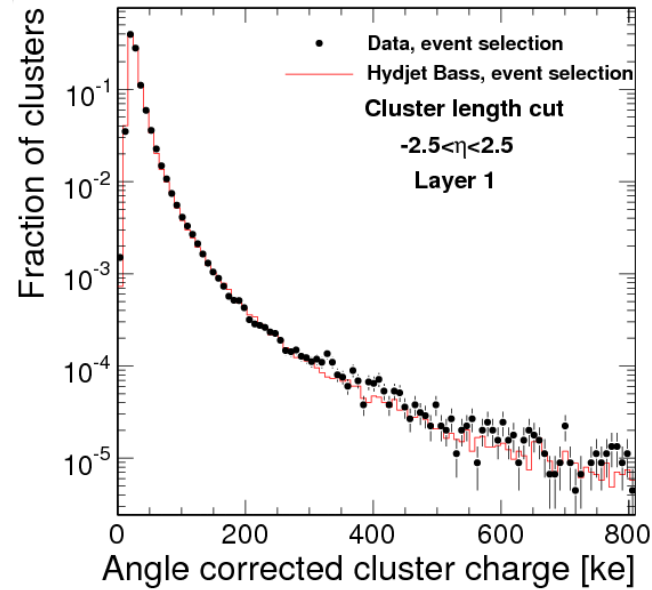
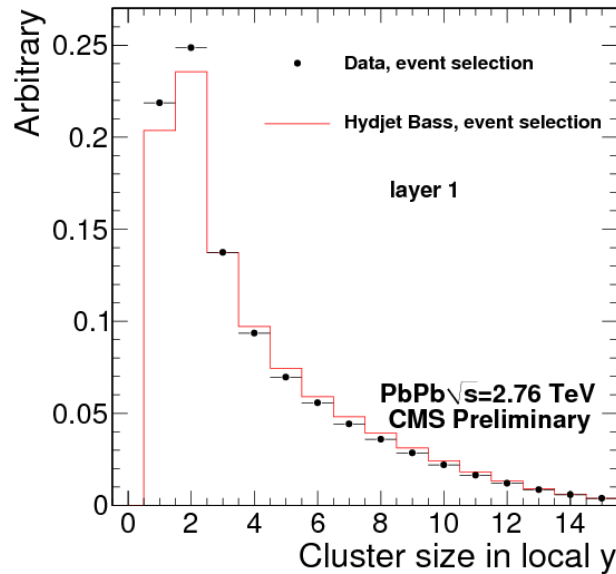
Heavy ion full tracking

0-10% Centrality, p_T (track) > 5 GeV/c

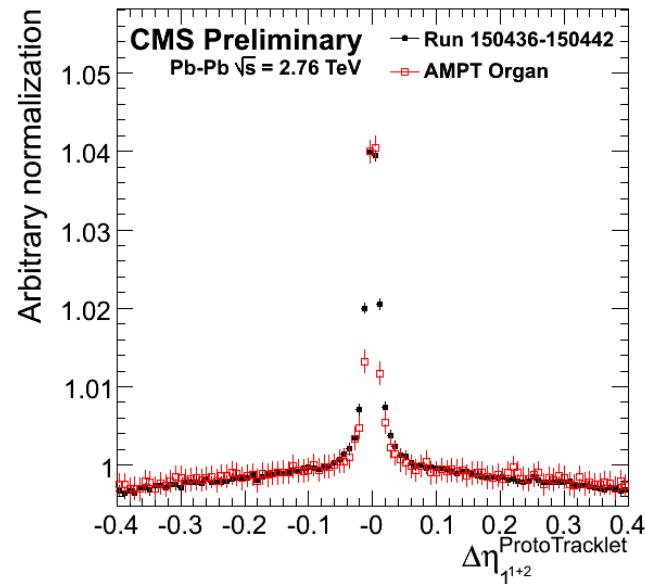
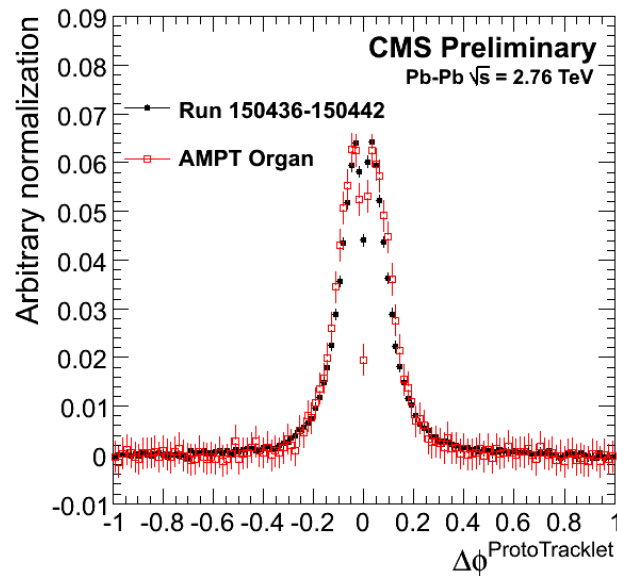




More HI pixel performance



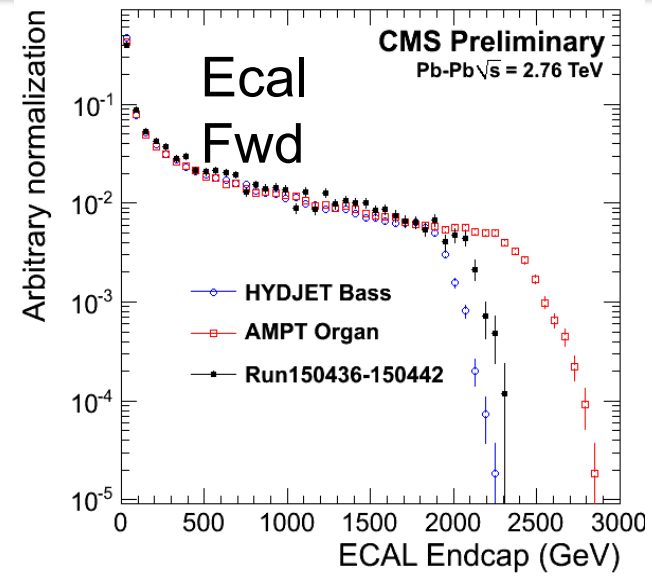
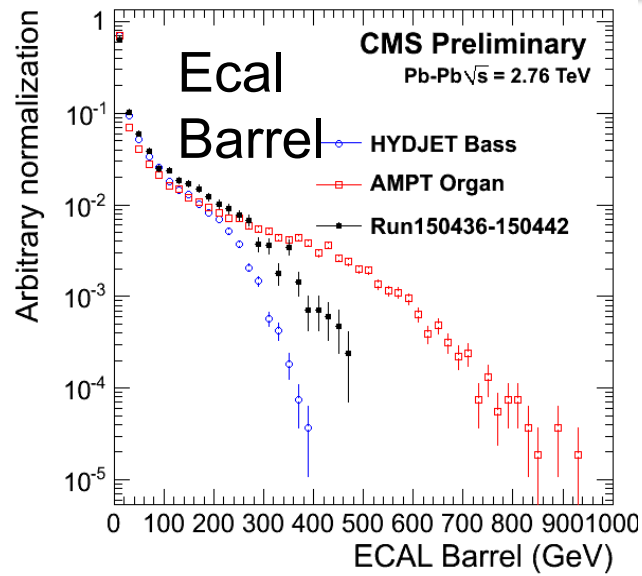
Pixel cluster length and charge similar to one seen in pp running



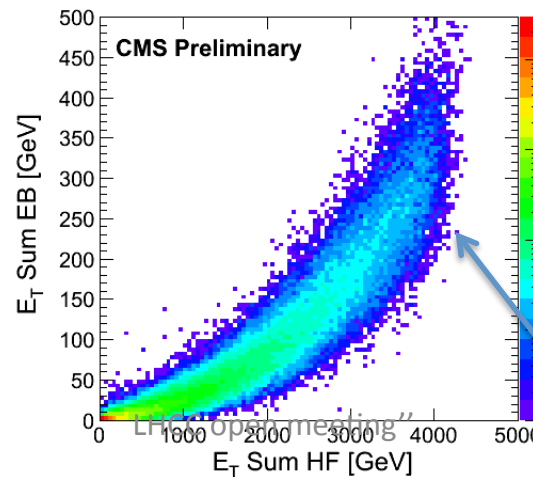
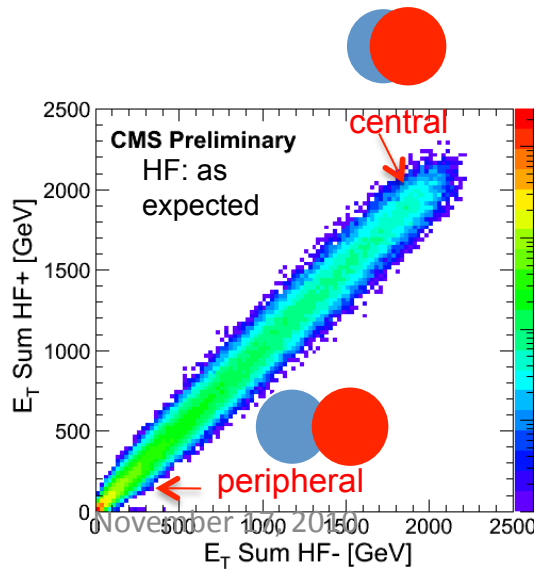
Pixel tracklets $\Delta\eta$ and $\Delta\phi$ distributions well reproduced by MC and similar to one seen in pp running



Heavy Ion : calorimeters



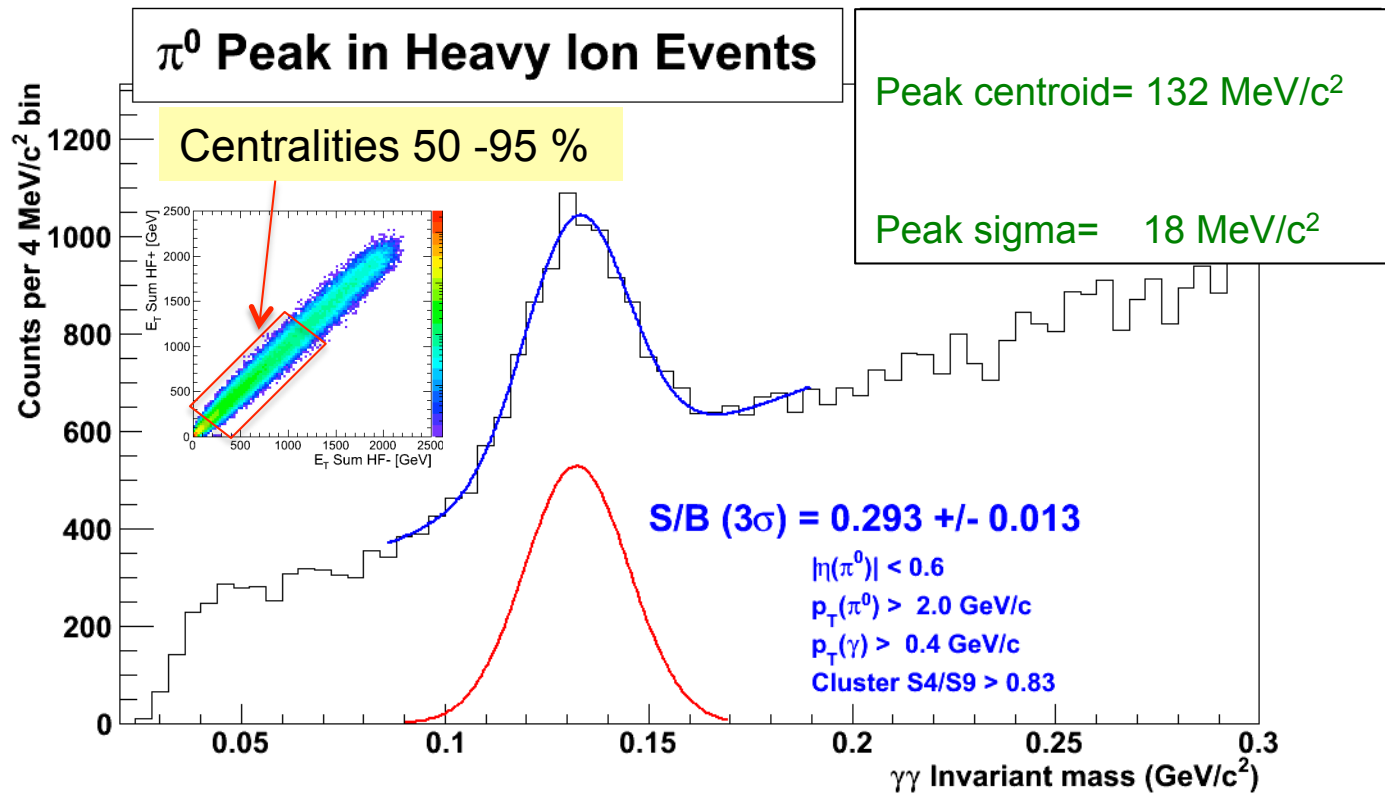
Energy distribution in Barrell and endcap well reproduced by tuned MC



'Growth' of energy flow for central event is more important in barrel than in forward



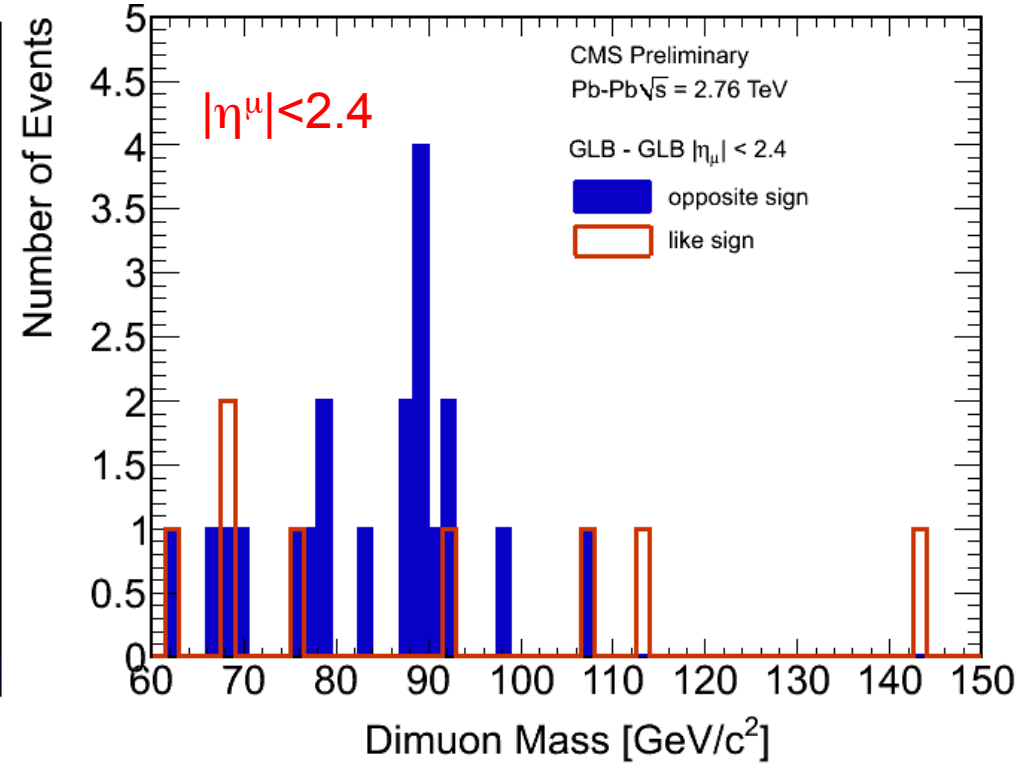
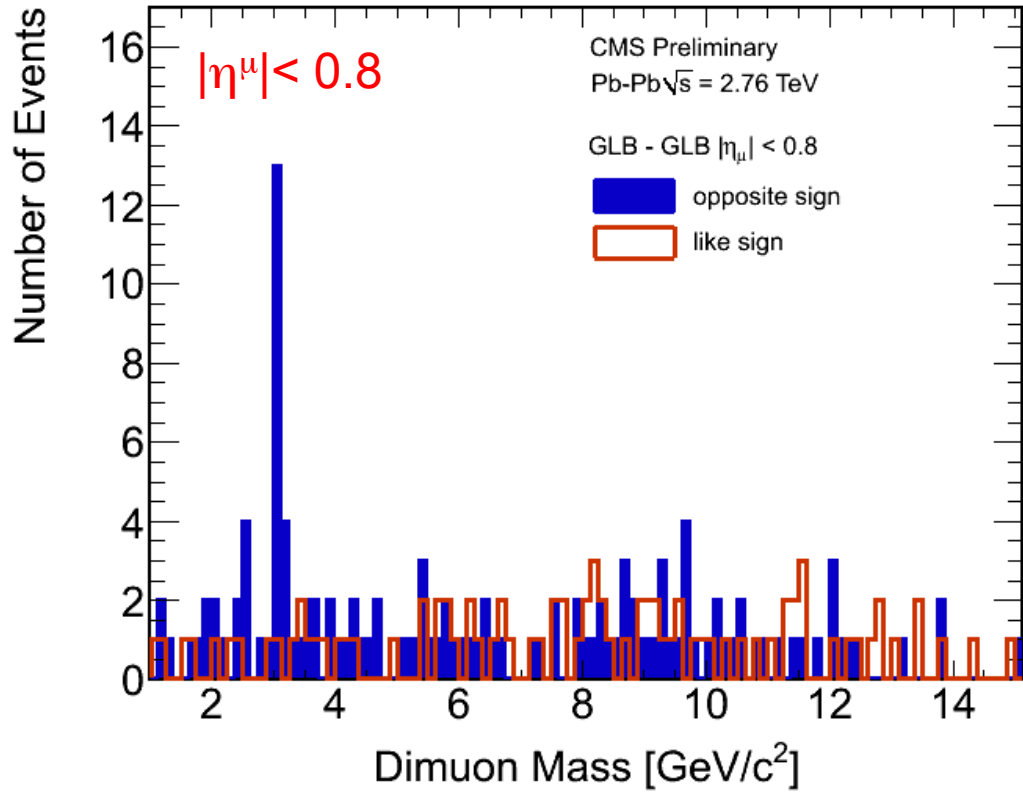
Heavy Ion π^0



Despite a busier environment the π^0 looks good(small mass shift due to non-corrected selection bias)



HI: Di- μ mass distrib ($1.6 \mu\text{b}^{-1}$)

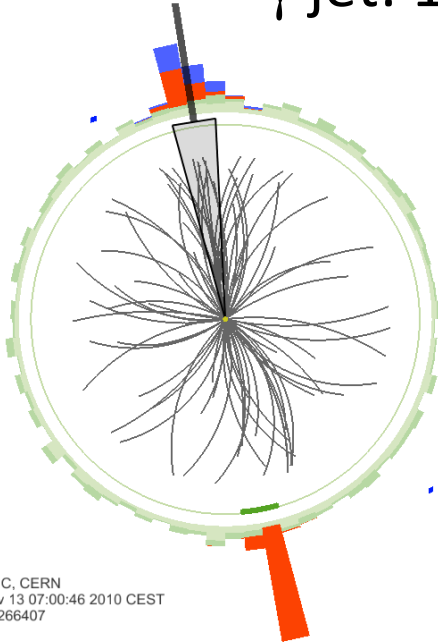


blue= opposite sign
red= like-sign

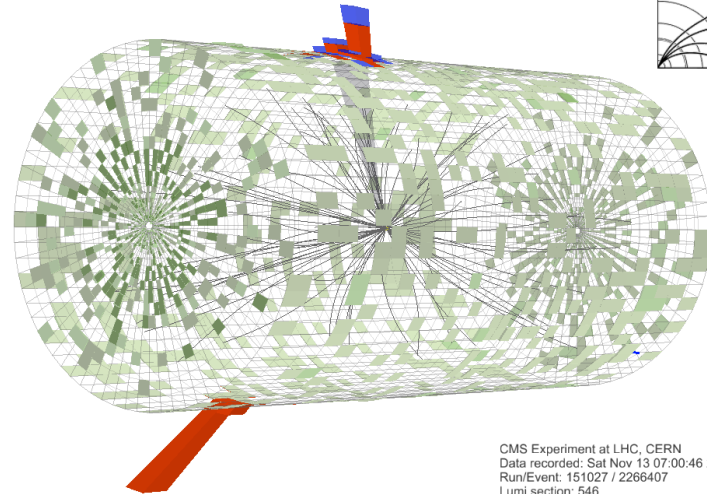
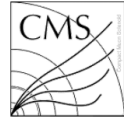


Heavy Ions, events: γ -Jet

γ jet: 100 GeV photon against 100 GeV E_t jet



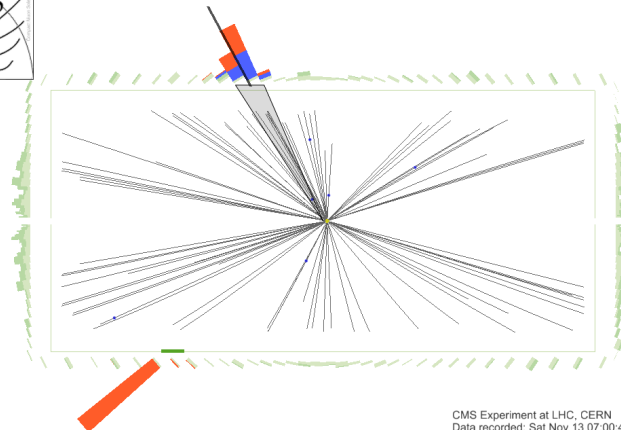
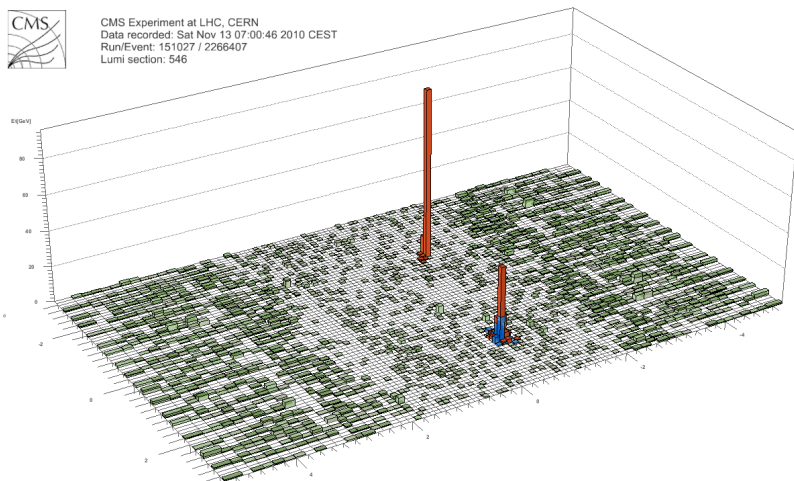
CMS Experiment at LHC, CERN
Data recorded: Sat Nov 13 07:00:46 2010 CEST
Run/Event: 151027 / 2266407
Lumi section: 546



CMS Experiment at LHC, CERN
Data recorded: Sat Nov 13 07:00:46 2010 CEST
Run/Event: 151027 / 2266407
Lumi section: 546



CMS Experiment at LHC, CERN
Data recorded: Sat Nov 13 07:00:46 2010 CEST
Run/Event: 151027 / 2266407
Lumi section: 546

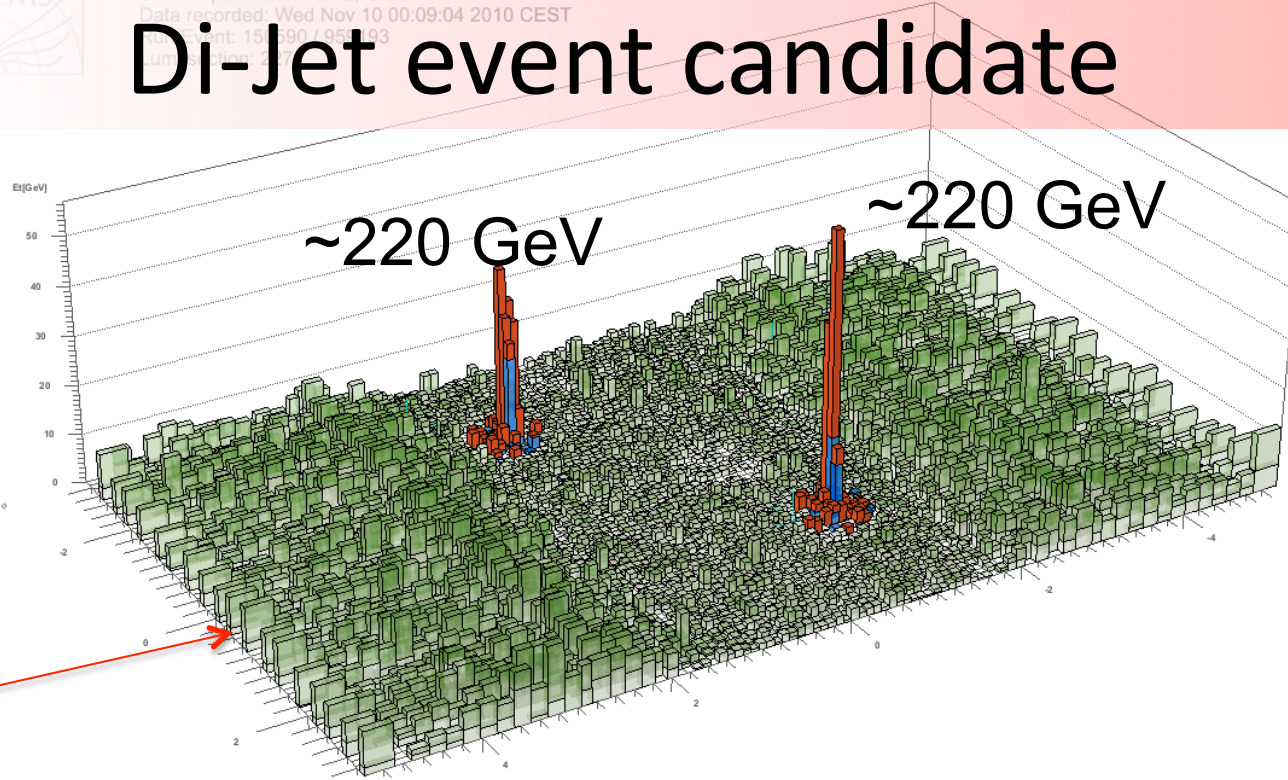


CMS Experiment at LHC, CERN
Data recorded: Sat Nov 13 07:00:46 2010 CEST
Run/Event: 151027 / 2266407
Lumi section: 546

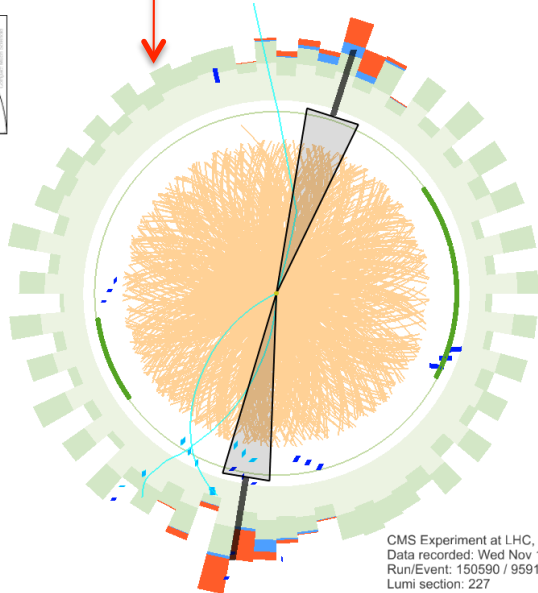


CMS Experiment at LHC, CERN
Data recorded: Wed Nov 10 00:09:04 2010 CEST
Run/Event: 150590 / 959193
Lumi section: 227

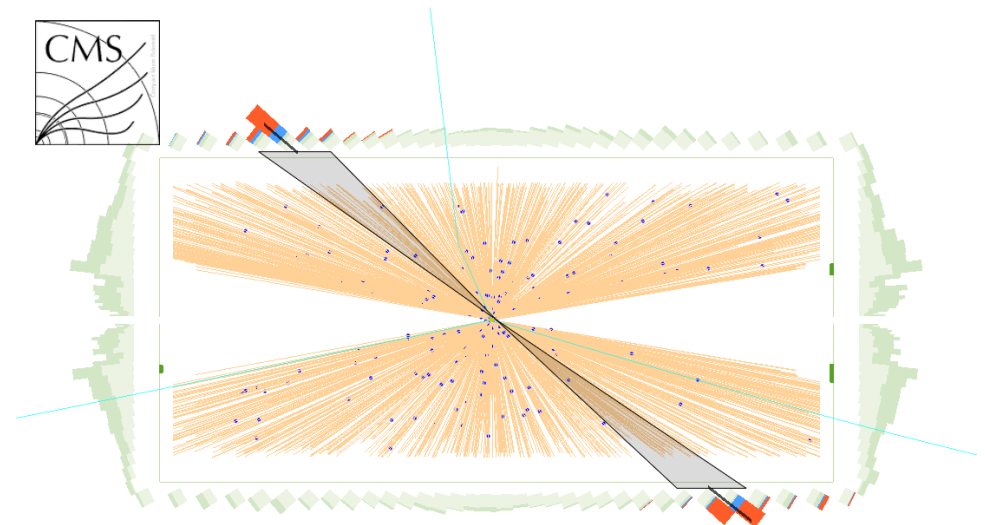
Di-Jet event candidate



Cog-wheel effect due to projection of ϕ structure of fwd calo



CMS Experiment at LHC, CERN
Data recorded: Wed Nov 10 00:09:04 2010 CEST
Run/Event: 150590 / 959193
Lumi section: 227



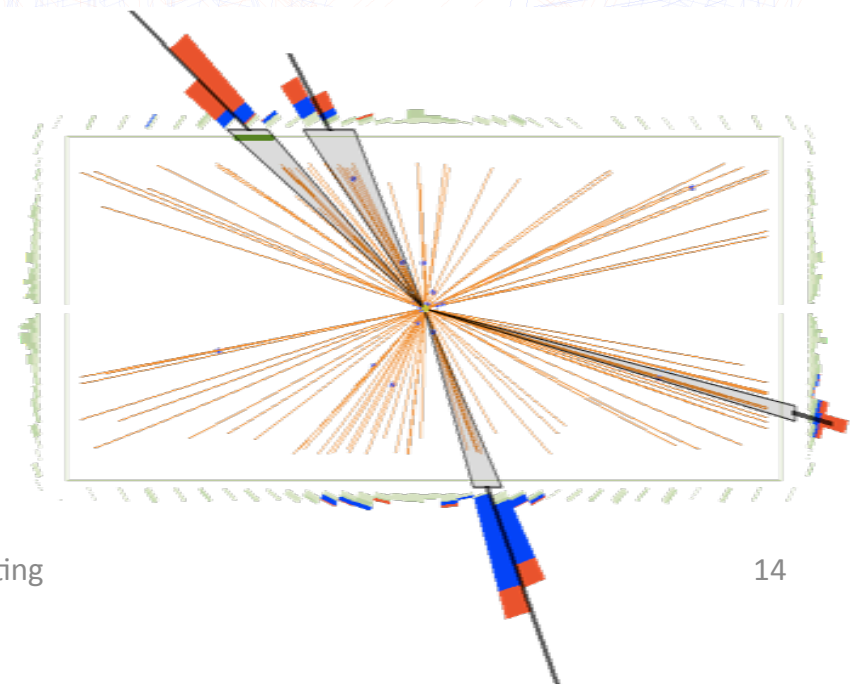
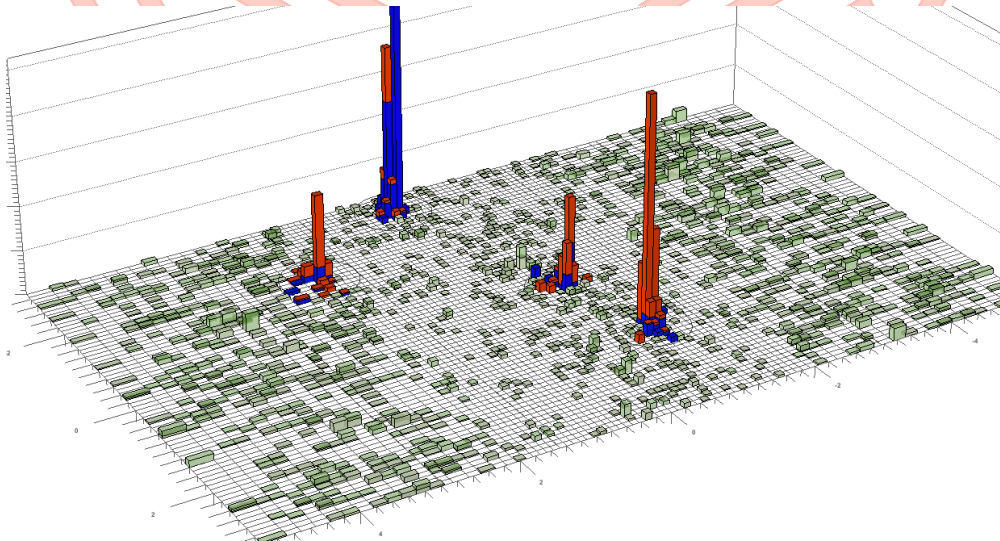
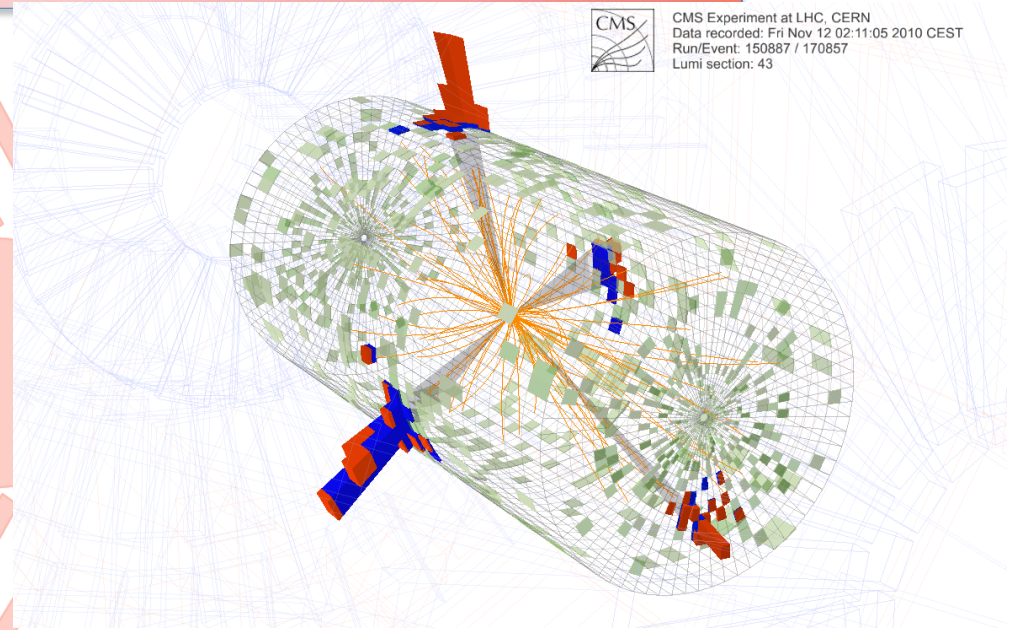
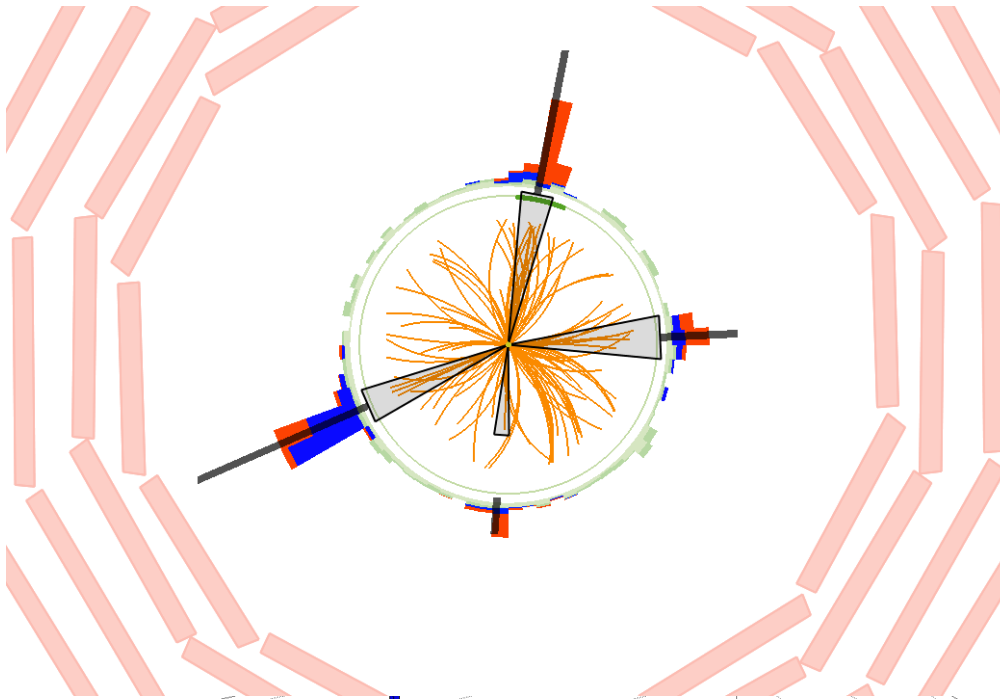
CMS Experiment at LHC, CERN
Data recorded: Wed Nov 10 00:09:04 2010 CEST
Run/Event: 150590 / 959193
Lumi section: 227



Heavy Ions: 4 jet



CMS Experiment at LHC, CERN
Data recorded: Fri Nov 12 02:11:05 2010 CEST
Run/Event: 150887 / 170857
Lumi section: 43

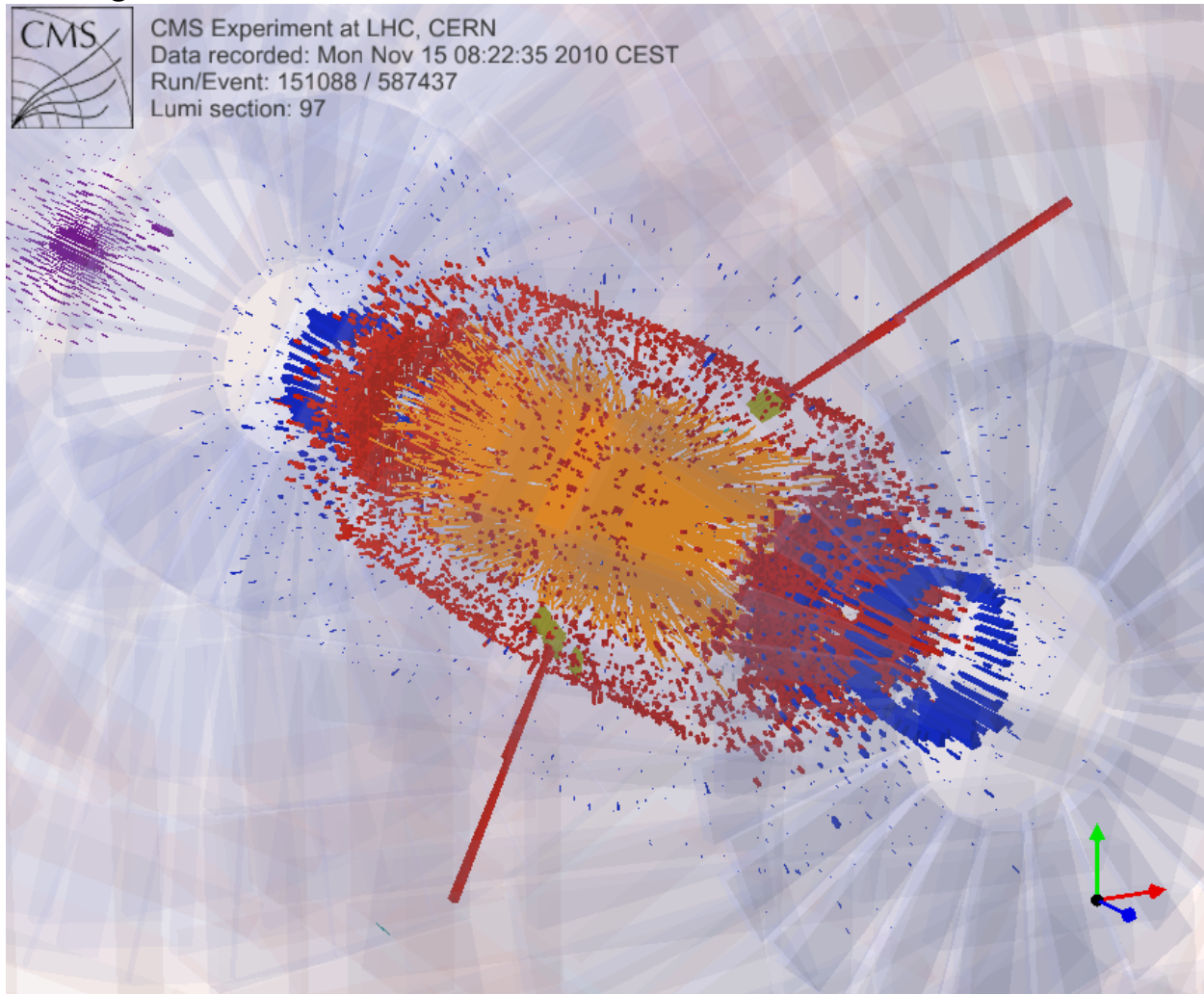




Heavy Ions: $e^+e^- Z$ candidate

$M_{e^+e^-} = 96 \text{ GeV}$

(E_e not corrected for underlying event)



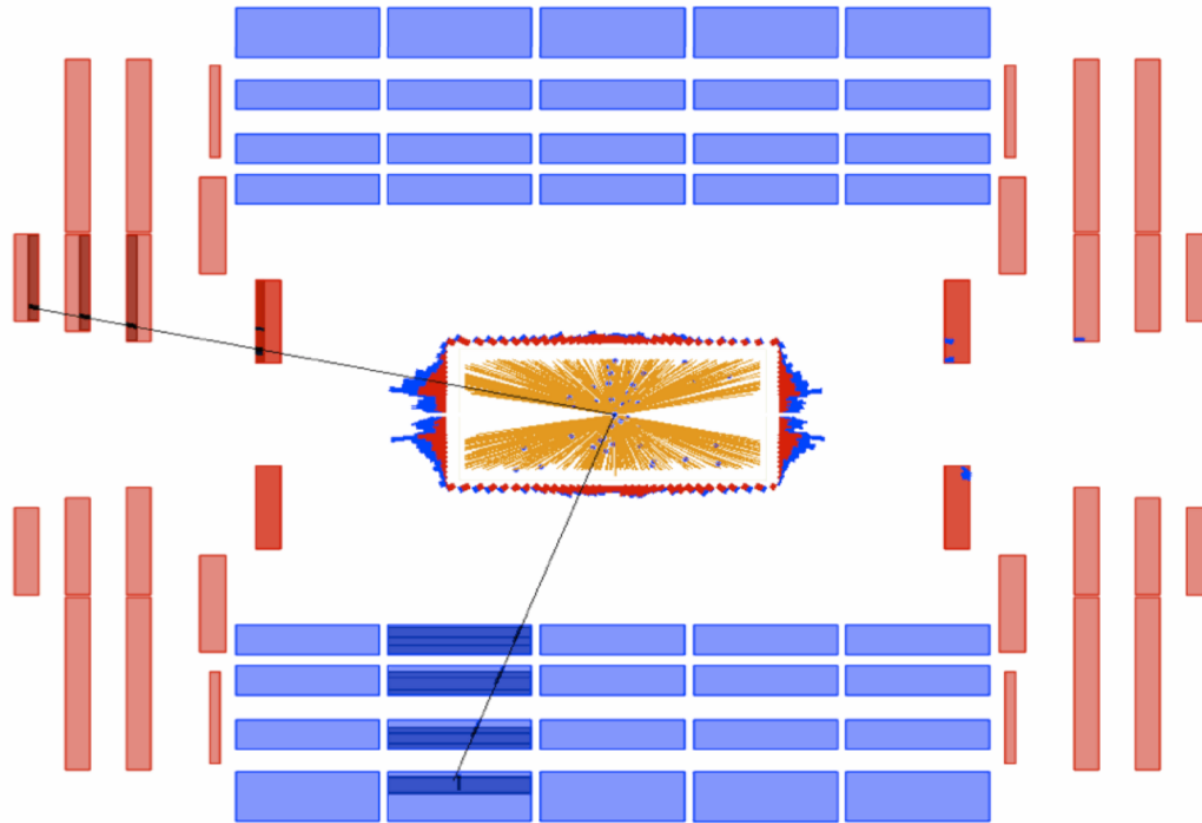


Our first $\mu^+\mu^-$ Z candidate

$M_{\mu^+\mu^-} = 93 \text{ GeV}$: possibly the first Z ever seen in HI



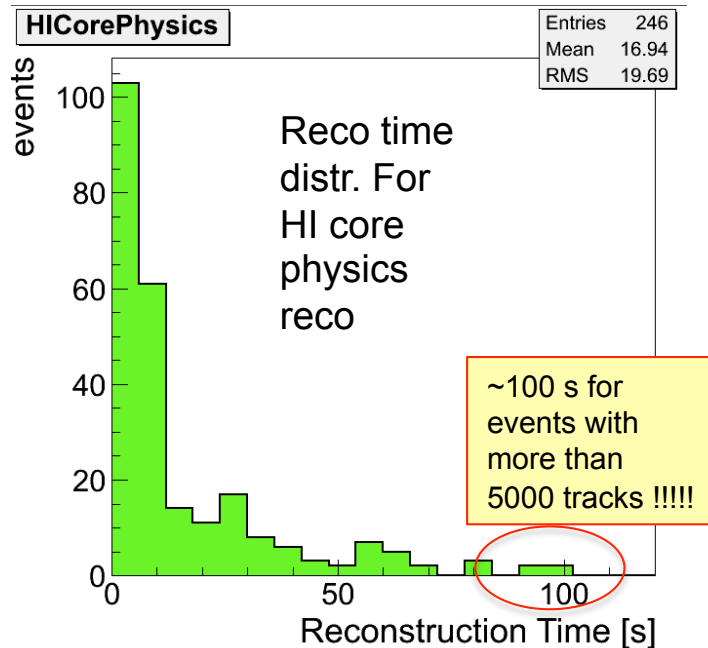
CMS Experiment at LHC, CERN
Data recorded: Tue Nov 9 23:51:56 2010 CEST
Run/Event: 150590 / 776435
Lumi section: 183



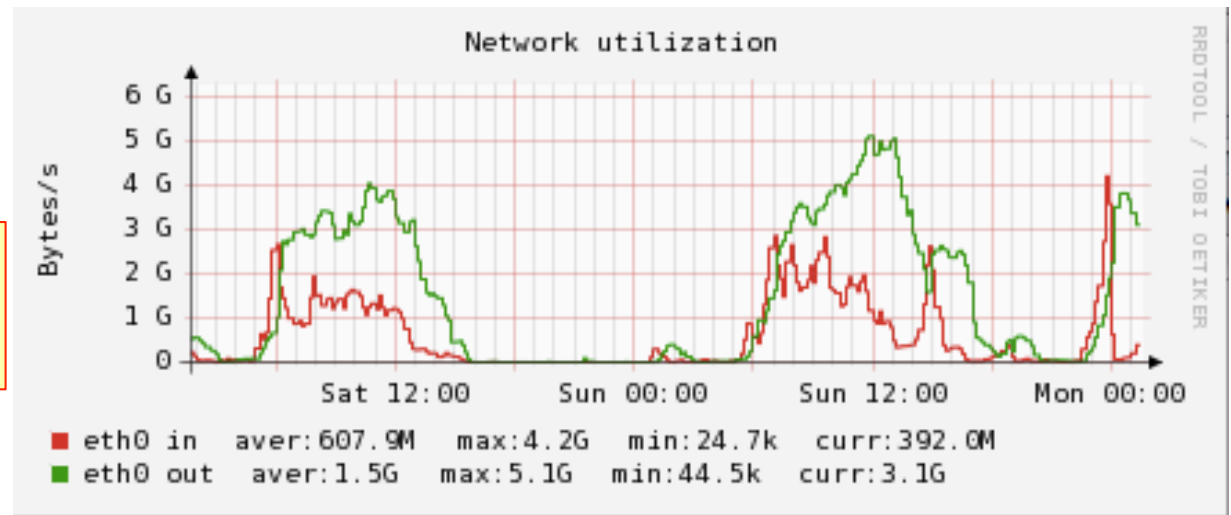


software/computing performance

- Average time to Reco pp event ($2 \cdot 10^{32}$ Lumi triggers)= 2s
- Average time to Reco Heavy Ion event: 11 s
- Average time to process a L1 trigger at HLT: $40 \cdot 10^{-3}$ s
- L1 Trigger rates pp: 70 KHz (limited by HLT CPU time)
- HLT output (logging) rates: 300-600 Hz (pp), ~ 200 Hz(HI)
- Prompt calibration loop commissioned: last period PP reco delayed by 48 hours to allow calibration constants to be used
- Full certification of reco within a week



Castor I/O





Shutdown activities

Beam stop:

06 Dec

Upgrade cooling
power for Filter farm

Magnet ramp down:

07 Dec

Services stop:

09 Dec

Cooling maintenance

Partial services restored:

07 Jan

Install TOTEM T1 -Z

Full services restored:

21 Jan

Install TOTEM T1 +Z

BP pump-down start

28 Jan

Magnetic field tests:

07 Feb

Magnetic field on:

08 Feb

End of shutdown

18 Feb



Outlook on early 2011

- Restart operation: last week of January with mid-week global runs (2 days exercises)
- Before beam restarts: collect 10 days of Cosmics (> 2 millions tracks for tracker alignment purposes)
- Release CMSSW 4.1 (new ROOT) and deploy in filter farm and Tier0 well before LHC re-start
- 64 bit version of CMSSW being actively commissioned: will deploy when validated online
- ...continue where we left off in 2010



Leptons invariant masses

QCD

Heavy flavours

Electroweak

Top

Searches

PHYSICS RESULTS

NOTE: The results shown are approved, but, for most, the accompanying paper is being circulated in the collaboration and not yet ready for public distribution.

They should appear shortly in

<http://cdsweb.cern.ch/collection/CMS%20Papers?ln=en>

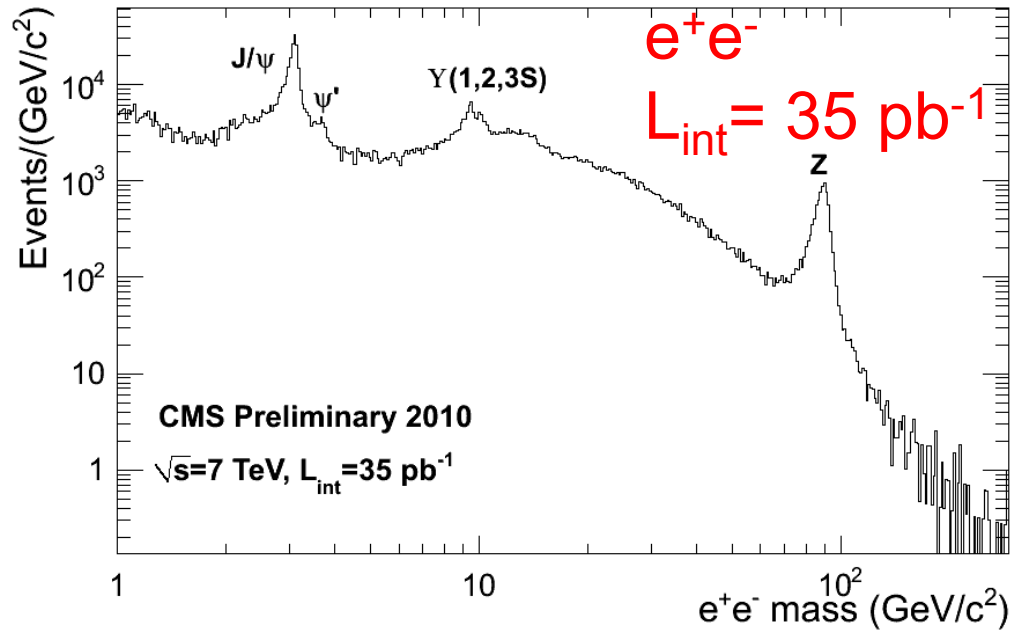


Physics publications

- First Measurement of the Cross Section for Top-Quark Pair Production in Proton-Proton Collisions at $\sqrt{s} = 7$ TeV, [arXiv:1010.5994](#), Submitted to PLB.
- Search for Quark Compositeness with the Dijet Centrality Ratio in pp Collisions at $\sqrt{s} = 7$ TeV, [arXiv:1010.4439](#), accepted by PRL
- Search for Dijet Resonances in 7 TeV pp Collisions at CMS, [arXiv:1010.0203](#), accepted by PRL
- Observation of Long-Range, Near-Side Angular Correlations in Proton-Proton Collisions at the LHC, [JHEP 09 \(2010\) 091](#)
- First Measurement of the Underlying Event Activity at the LHC with $\sqrt{s} = 0.9$ TeV, [EPJC Online first 6th Nov, DOI 10.1140/epjc/s10052-010-1453-9](#)
- Measurement of the charge ratio of atmospheric muons with the CMS detector, [PLB 62 \(2010\) 83](#)
- Transverse-momentum and pseudorapidity distributions of charged hadrons in pp collisions at $s = 7$ TeV, [PRL 105 \(2010\) , 022002](#)
- First Measurement of Bose-Einstein Correlations in proton-proton Collisions at $s = 0.9$ and 2.36 TeV at the LHC, [PRL 105 \(2010\) , 032002](#)
- Transverse momentum and pseudorapidity distributions of charged hadrons in pp collisions at $s = 0.9$ and 2.36 TeV, [JHEP 02 \(2010\) 041](#)



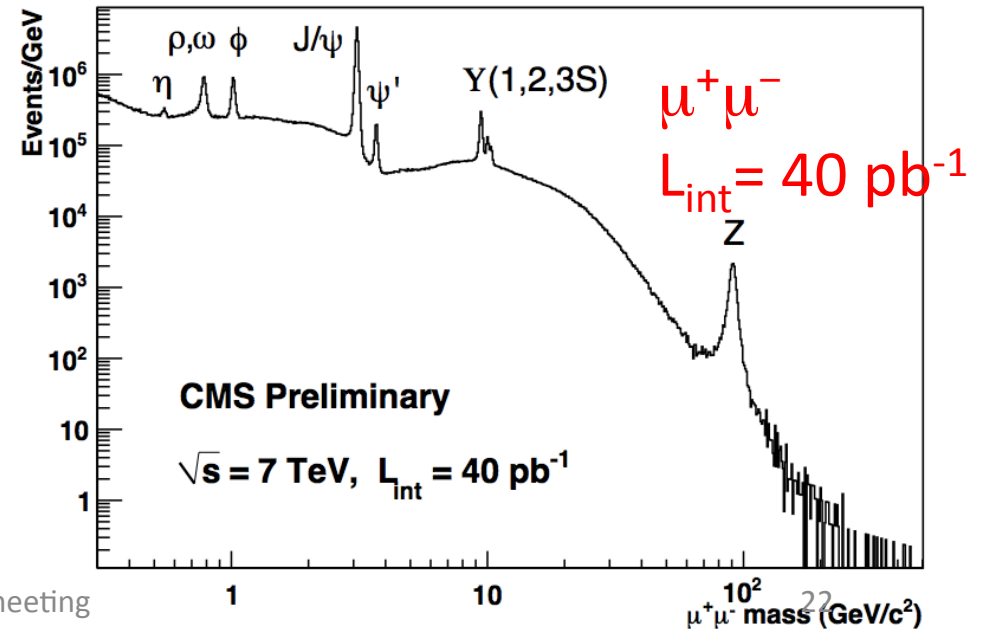
Invariant mass distributions



$\mu^+\mu^-$ widths:
J/ψ 30 MeV
Y 67 MeV

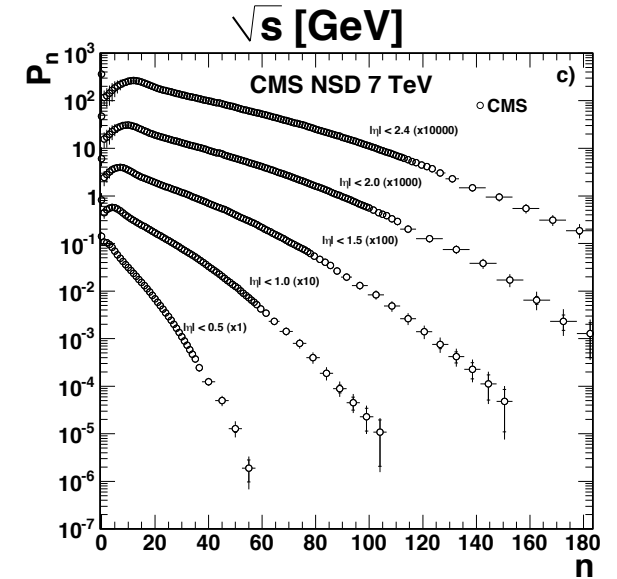
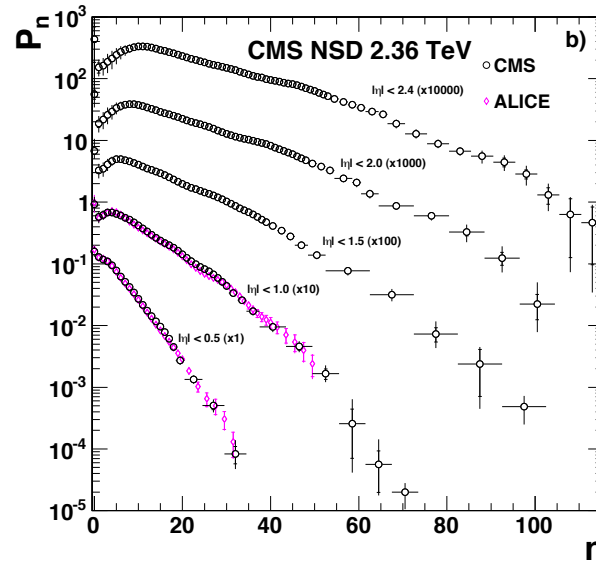
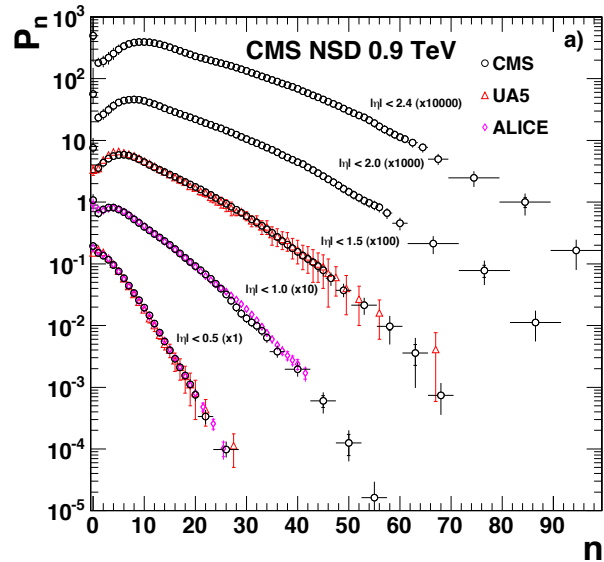
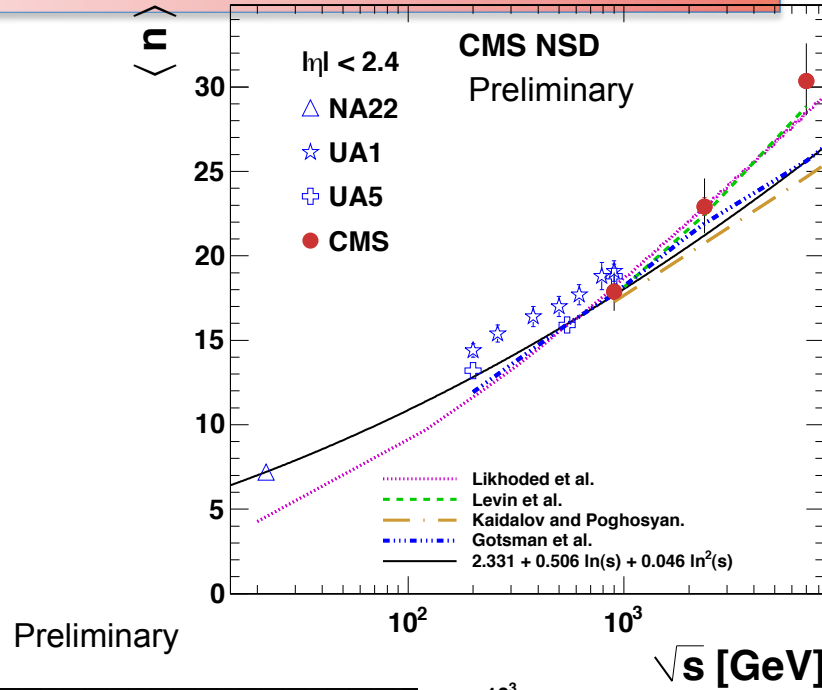
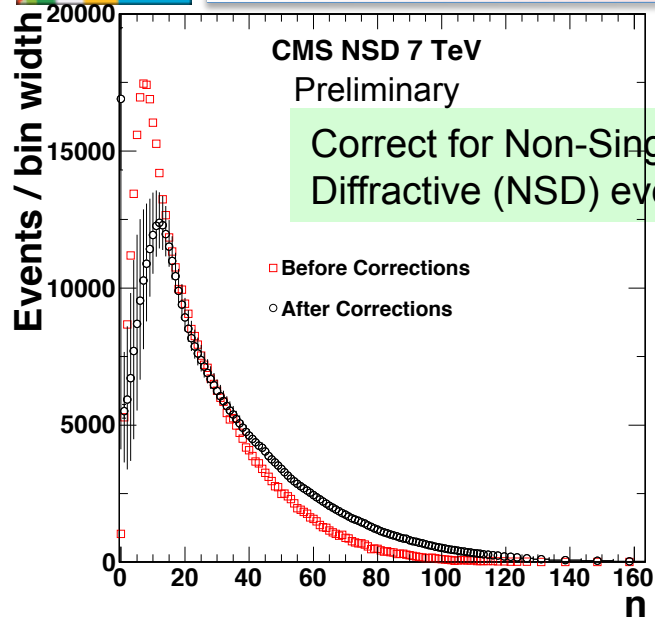
A tribute to Level1 and HLT trigger capability and flexibility

e^+e^- widths:
J/ψ 52 MeV
Y 149 MeV



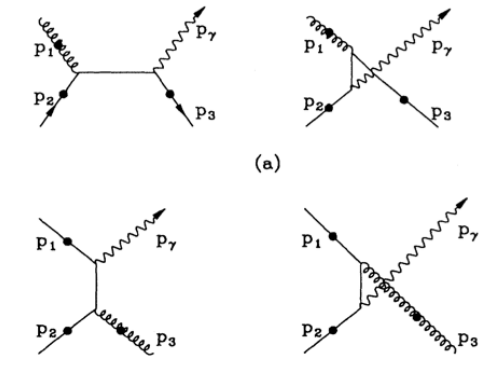


Soft QCD: multiplicities





QCD: prompt γ production

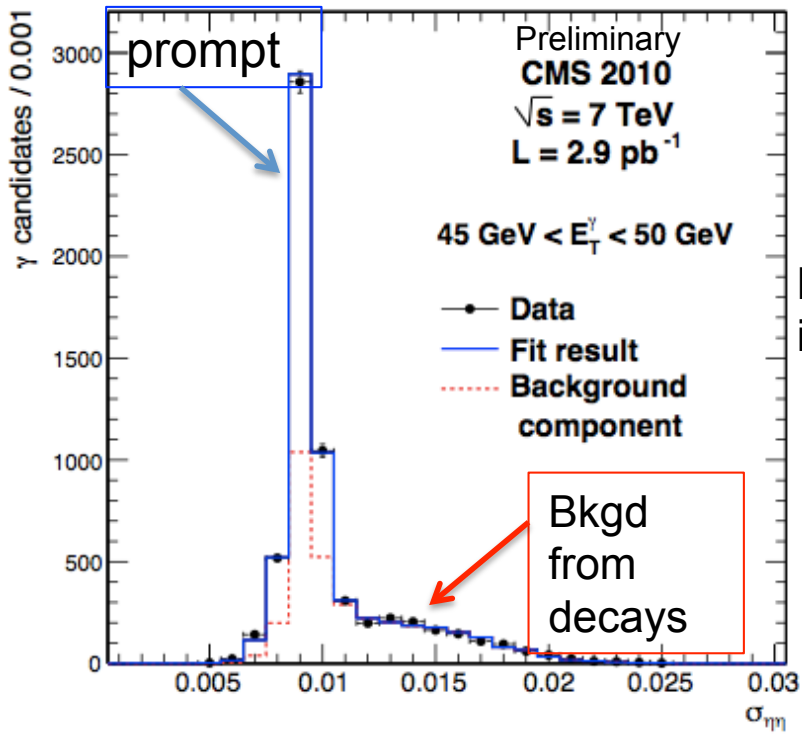


$$\sigma_{\eta\eta}^2 = \frac{\sum_{\text{crystal-i}} \omega_i (\eta_i - \bar{\eta})^2}{\sum_{\text{crystal-i}} \omega_i}$$

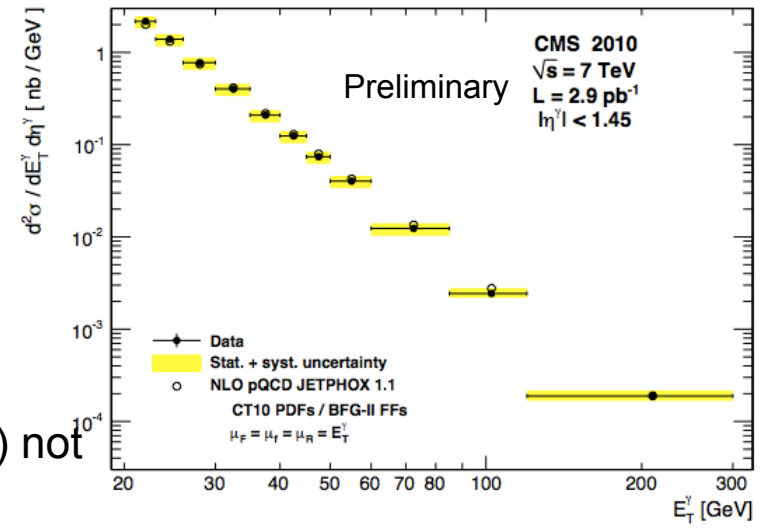
crystal-i
in 5x5
aroundmx

$$\omega_i = \max\left(0, 4.7 + \ln\left(\frac{E_i}{E_{5x5}}\right)\right)$$

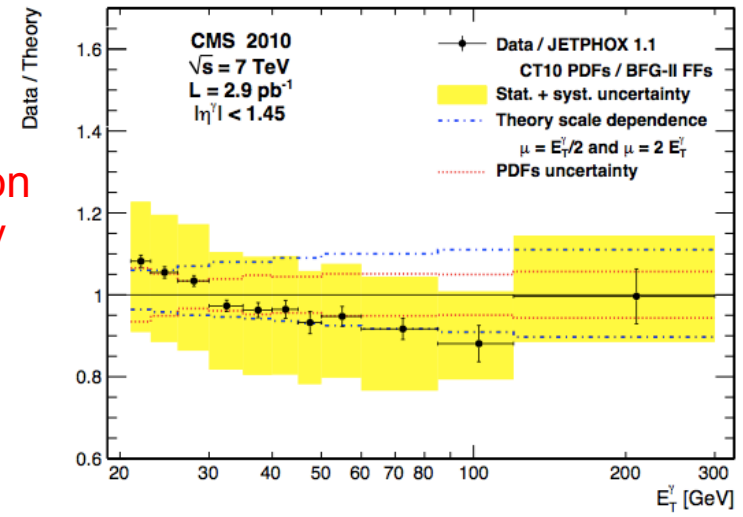
Discr variable: $\sigma_{\eta\eta}$



Lumi error (11%) not included



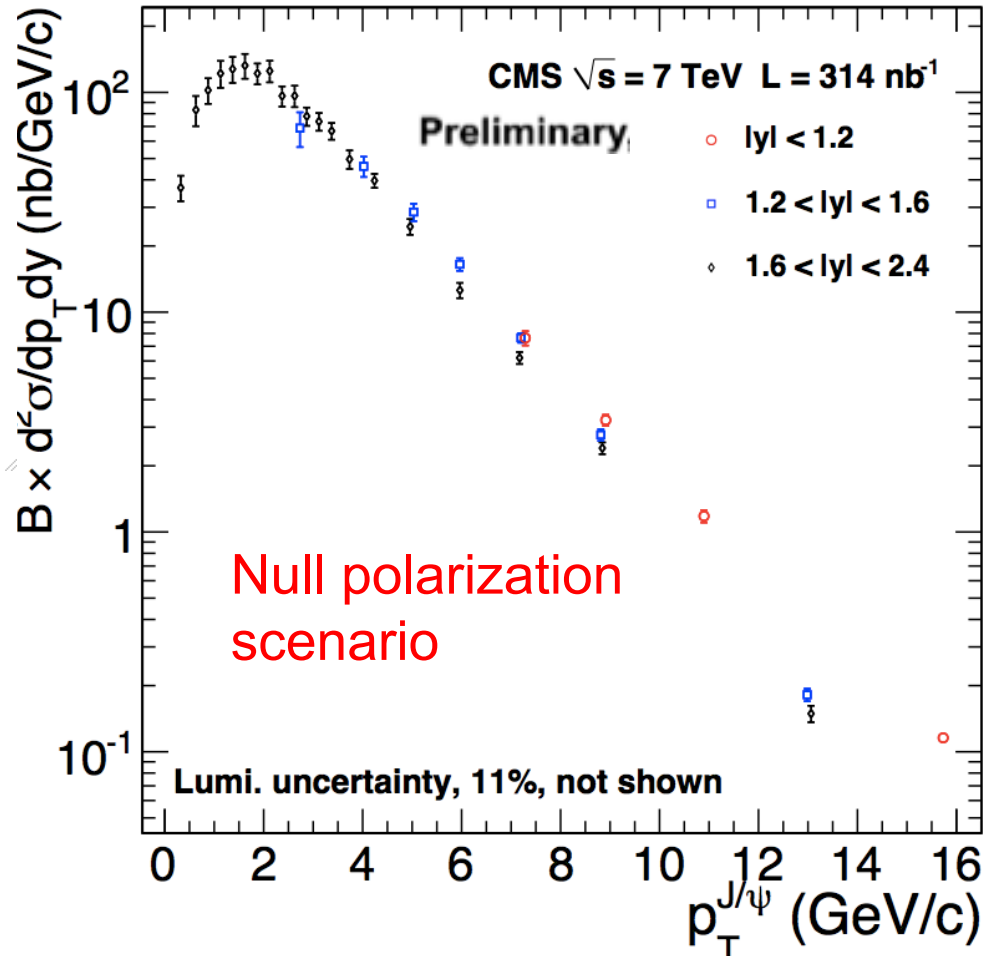
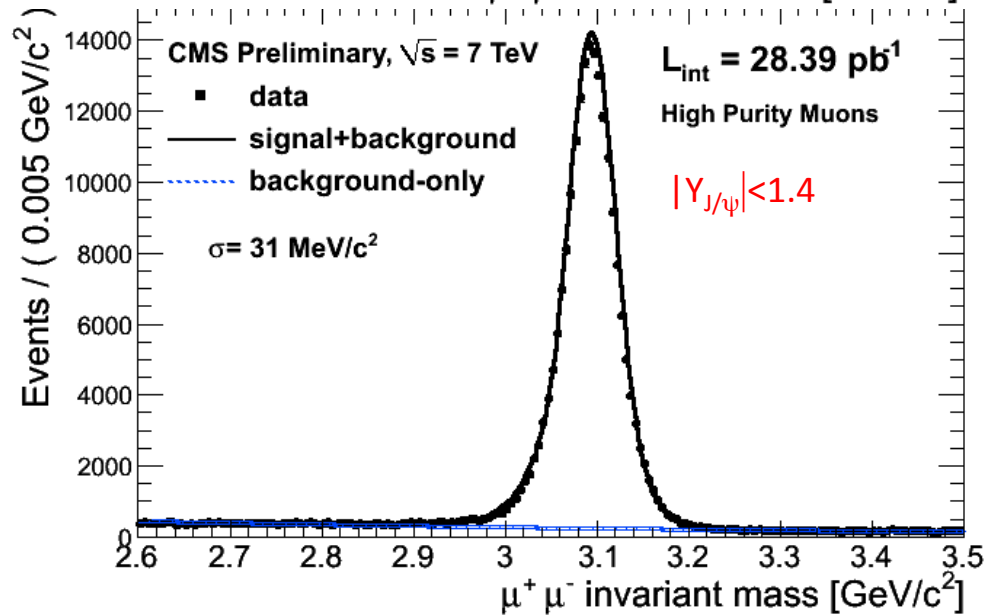
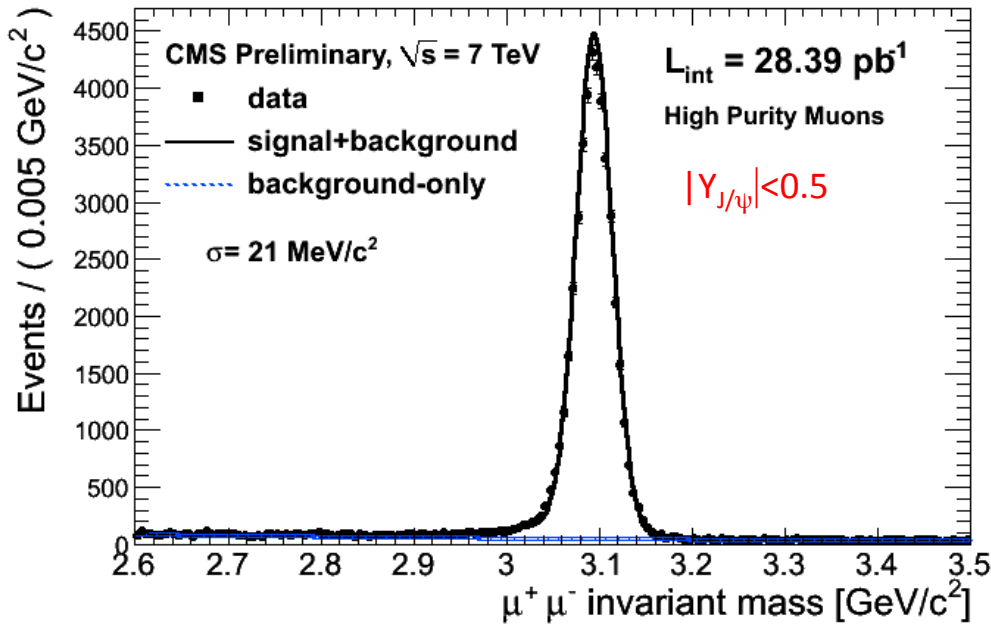
Comparison with theory



Measurement at higher Q^2 and lower $x_t = 2E_t/\sqrt{s}$ than Tevatron



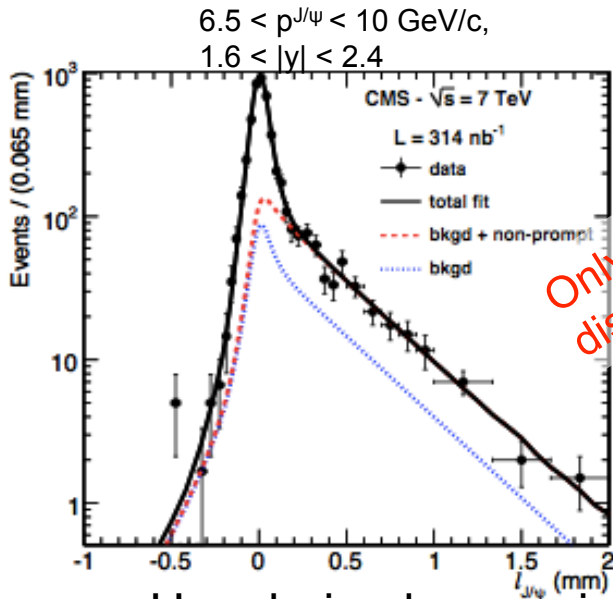
J/ψ production cross sections





... and separating prompt/b decay

Transverse J/ψ flight distance in bins of p_T and η

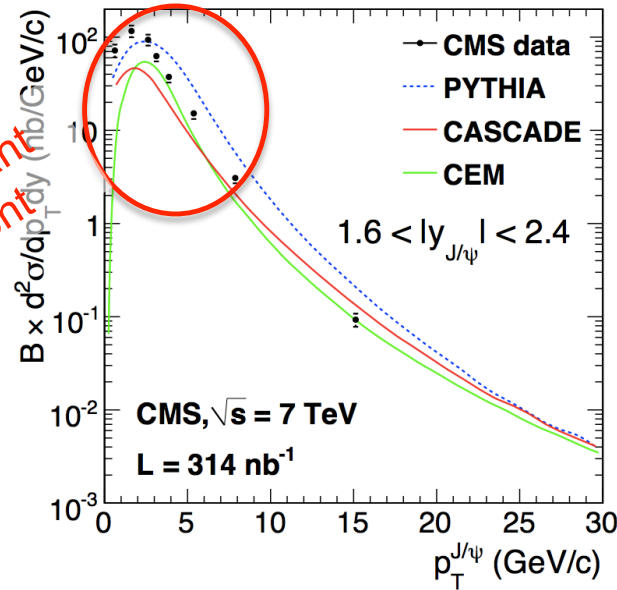


Unpolarized scenario :

$$BR(J/\psi \rightarrow \mu^+ \mu^-) \cdot \sigma(pp \rightarrow \text{prompt } J/\psi) = 196.7 \pm 3.8 \pm 10.7 \pm 21.6 \text{ nb}$$

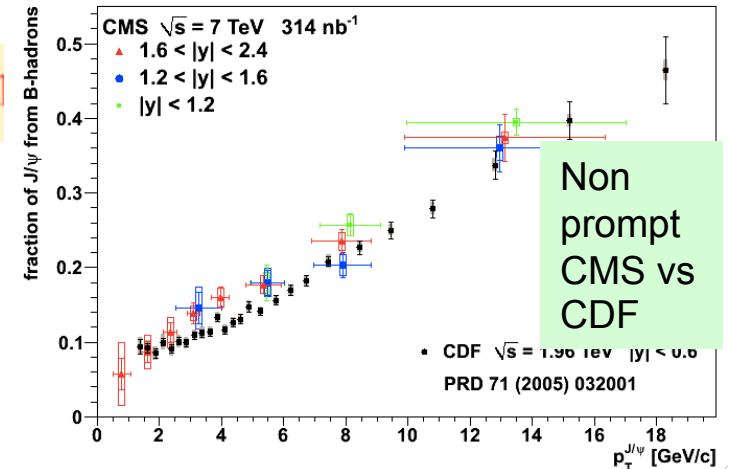
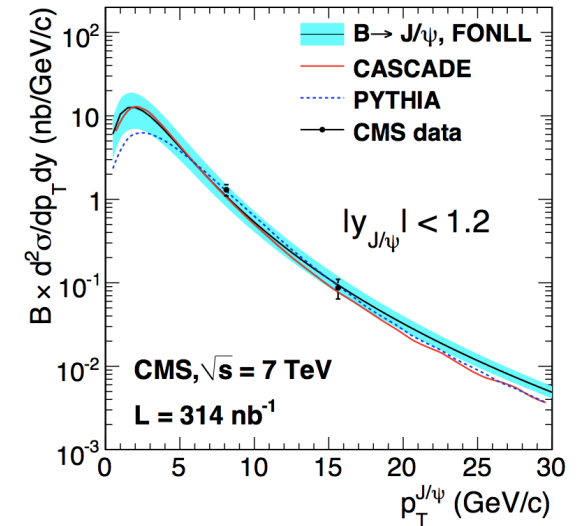
$$BR(J/\psi \rightarrow \mu^+ \mu^-) \cdot \sigma(pp \rightarrow bX \rightarrow J/\psi X) = 53.3 \pm 2.2 \pm 4.6 \pm 5.9 \text{ nb}$$

Prompt diff. x-section



Only significant disagreement

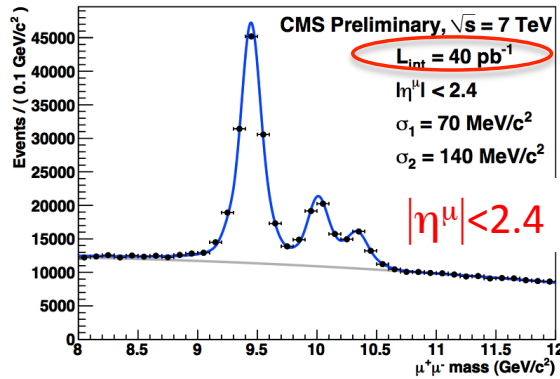
Non-Prompt diff. x-section



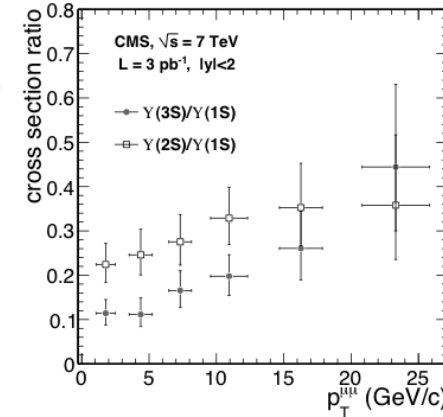
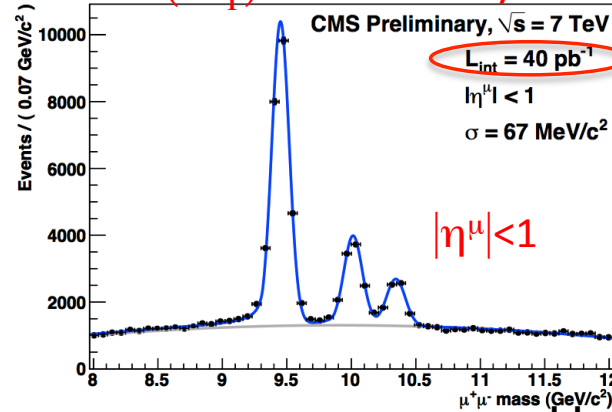


Y production

$\sigma(m_Y) = 70 \pm 2 \text{ MeV}/c^2$



$\sigma(m_Y) = 67 \pm 2 \text{ MeV}/c^2$

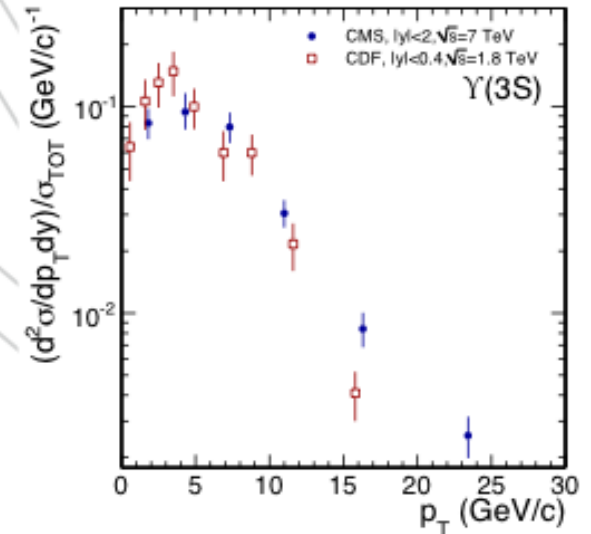
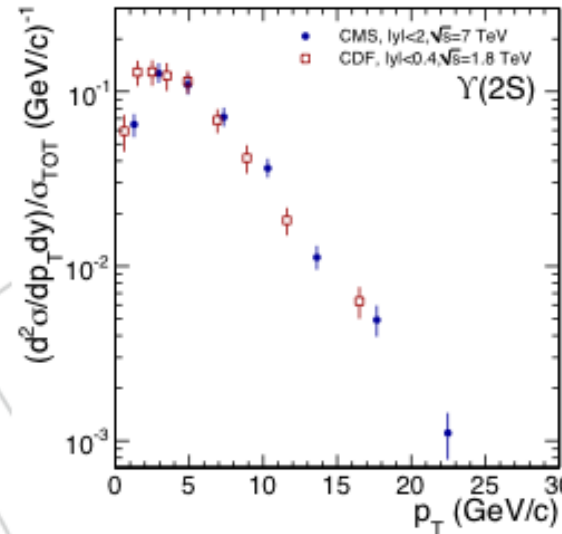
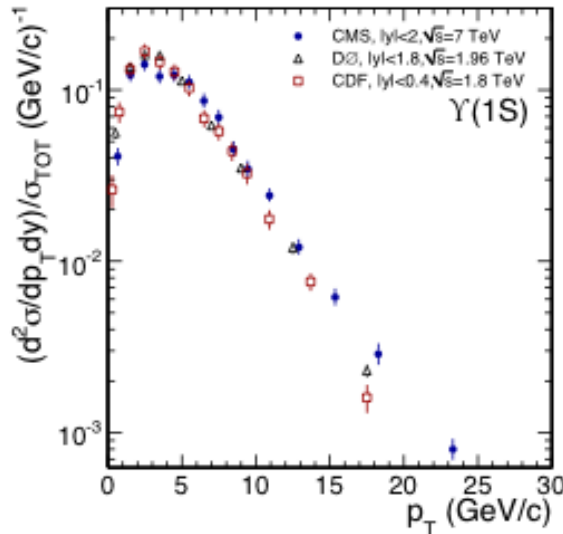


σ Ratios
 $|\gamma^Y| < 2$

Unpolarized production assumption

$$\begin{aligned} \sigma(pp \rightarrow Y(1S)X) \cdot B(Y(1S) \rightarrow \mu^+\mu^-) &= (7.49 \pm 0.13(\text{stat.})_{-0.49}^{+0.67}(\text{syst.}) \pm 0.82(\text{lumi.})) \text{ nb}, \\ \sigma(pp \rightarrow Y(2S)X) \cdot B(Y(2S) \rightarrow \mu^+\mu^-) &= (1.93 \pm 0.08(\text{stat.})_{-0.14}^{+0.19}(\text{syst.}) \pm 0.21(\text{lumi.})) \text{ nb}, \\ \sigma(pp \rightarrow Y(3S)X) \cdot B(Y(3S) \rightarrow \mu^+\mu^-) &= (1.04 \pm 0.07(\text{stat.})_{-0.09}^{+0.12}(\text{syst.}) \pm 0.11(\text{lumi.})) \text{ nb}. \end{aligned}$$

CMS
vs
CDF &
D0

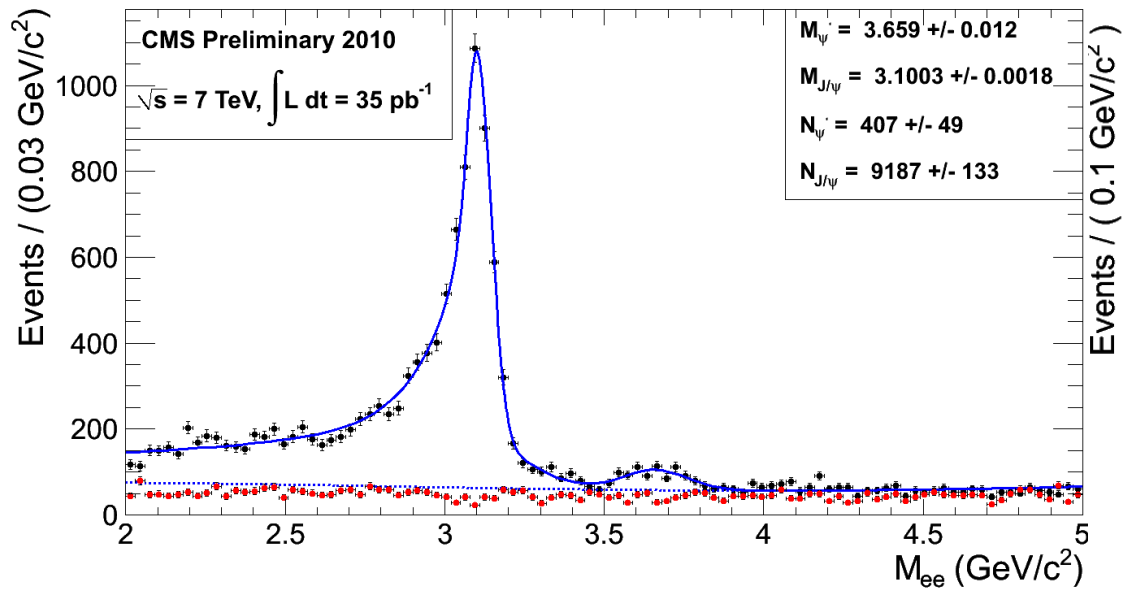


Novi

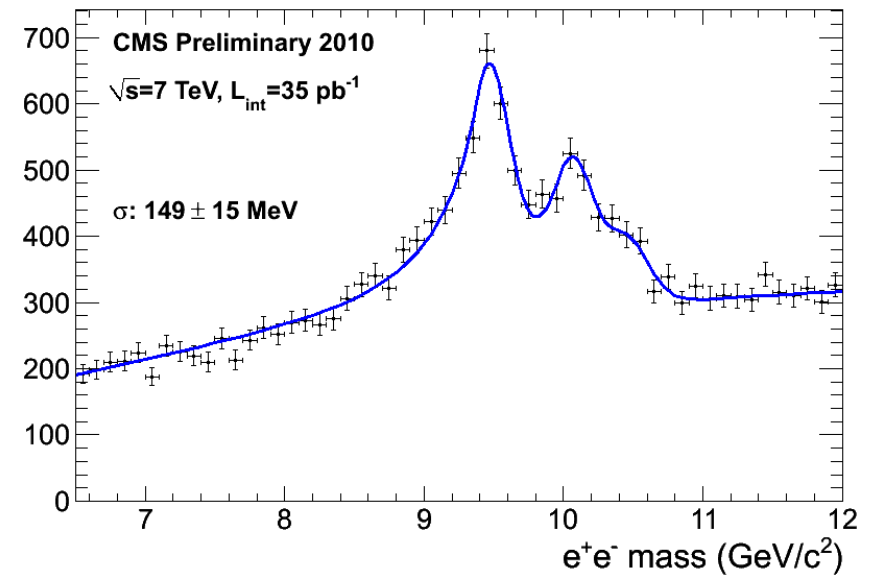


Quarkonia: e^+e^- decays

J/ ψ full statistics



Y full statistics





$B_s \rightarrow J/\psi \phi$

Fit results:

$$\mu_{\text{gauss}} = 5.3670 \pm 0.0012 \text{ GeV}/c^2$$

$$\sigma_{\text{gauss}} = 16.4 \pm 1.2 \text{ MeV}/c^2$$

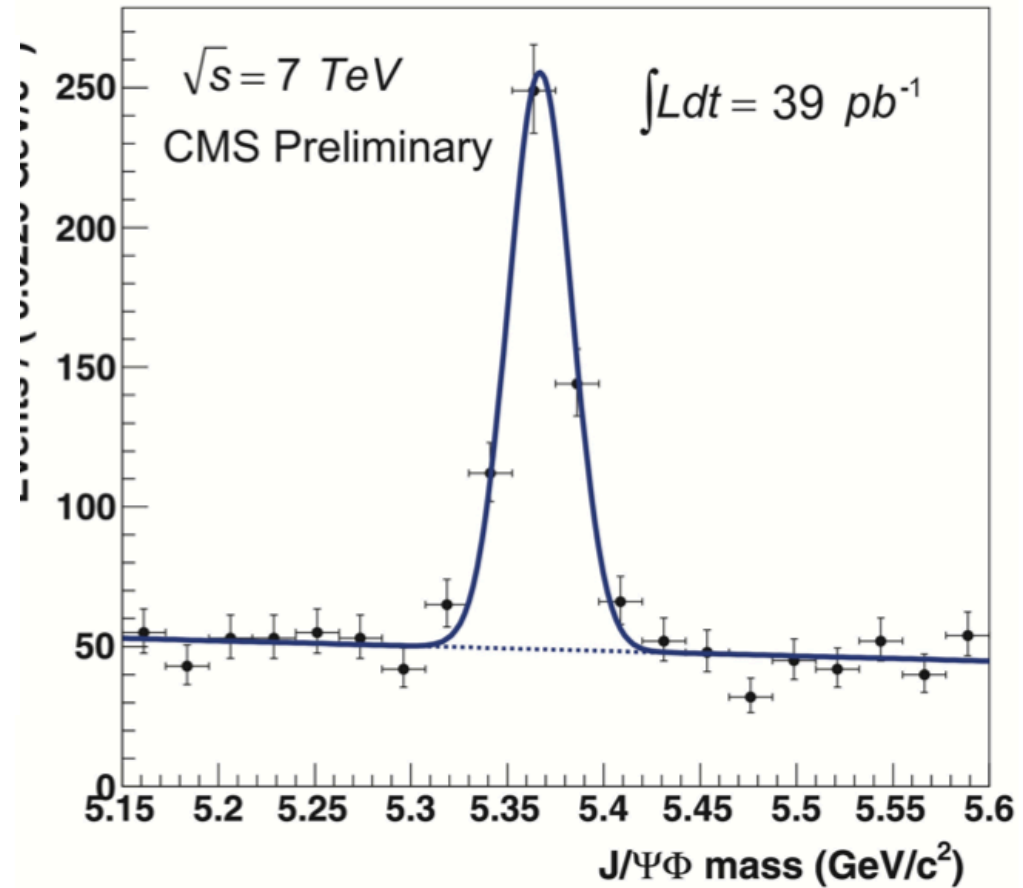
$$N_{\text{signal}} = 377 \pm 26$$

$$N_{\text{BG}} = 978 \pm 36$$

$$\chi^2/\text{ndof} = 0.91$$

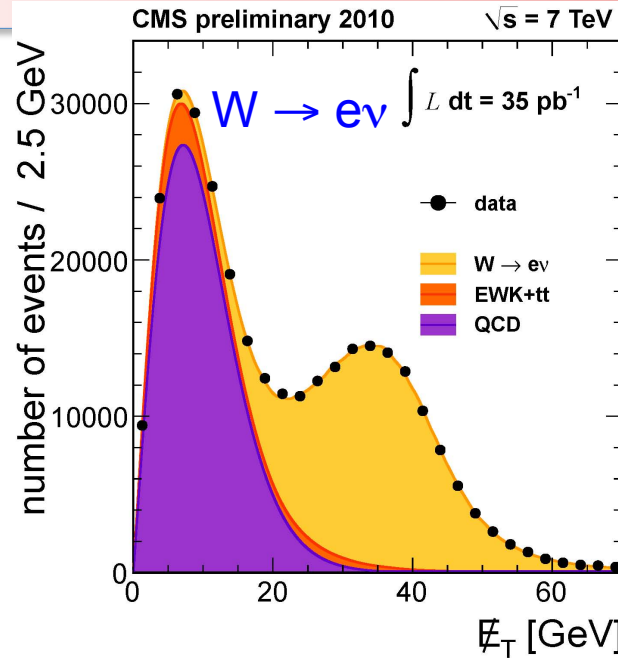
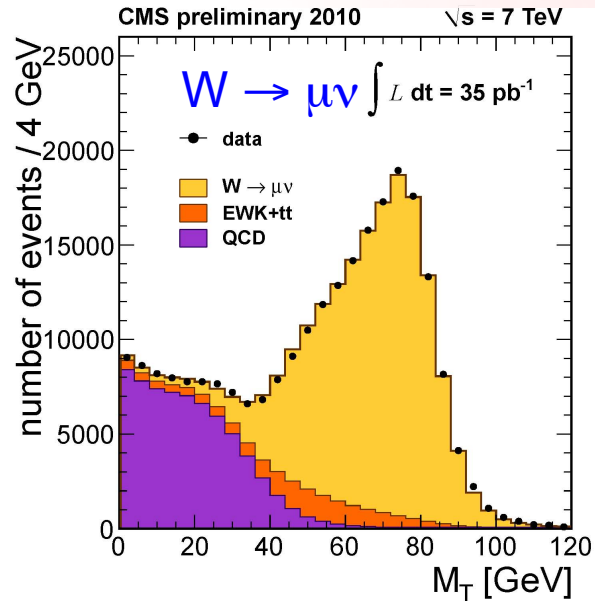
$$S/\sqrt{S+B} \approx 10$$

$$S/B \approx 0.4$$



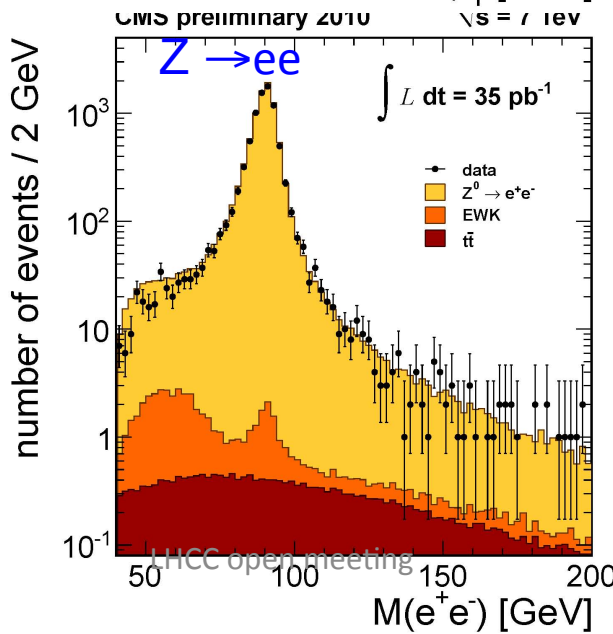
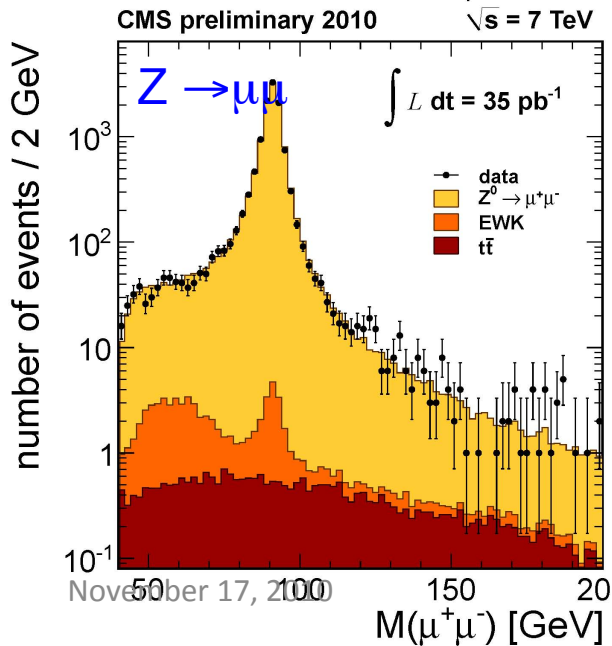
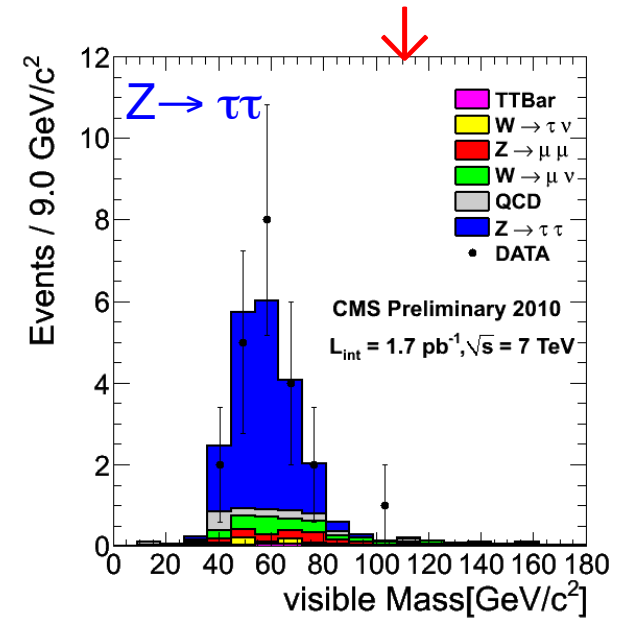


W and Z



← W (35 pb⁻¹)

Z → ττ

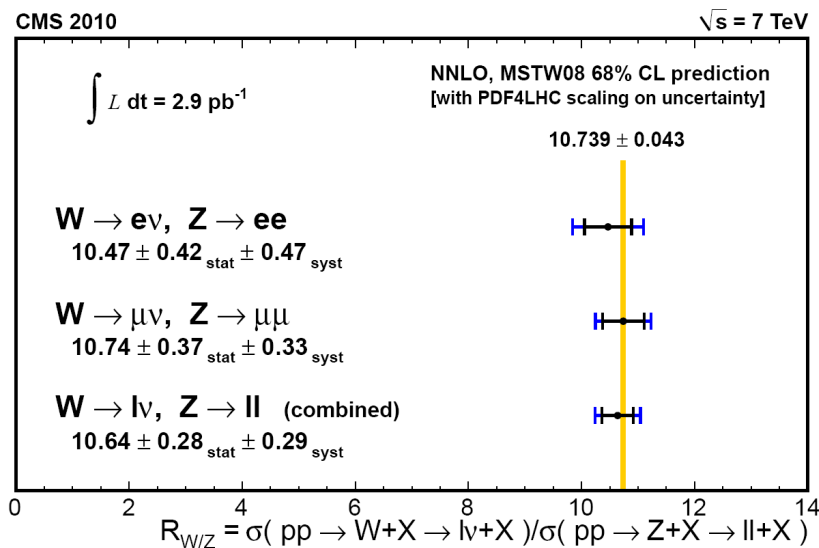
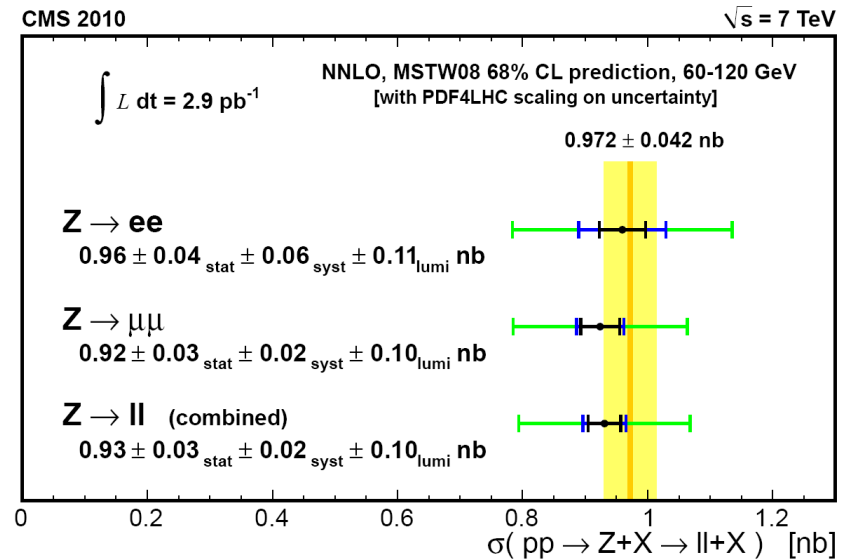
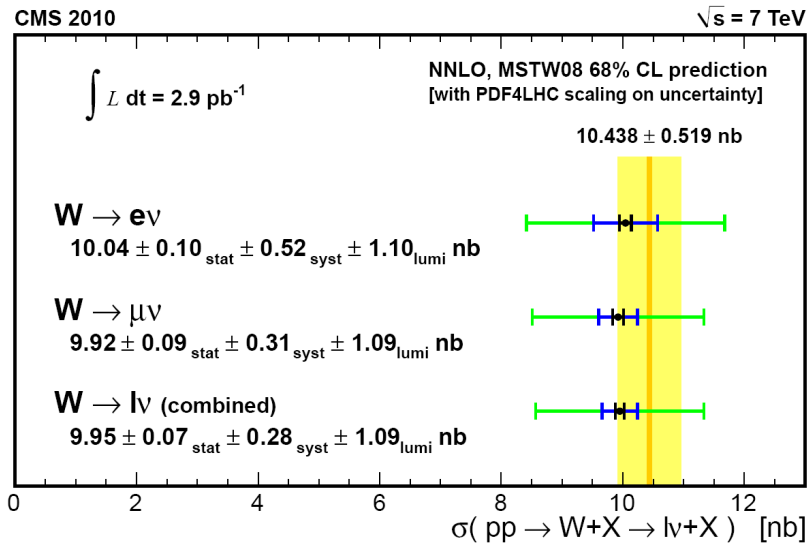


← Z (35 pb⁻¹)



Electroweak: Z & W cross sections

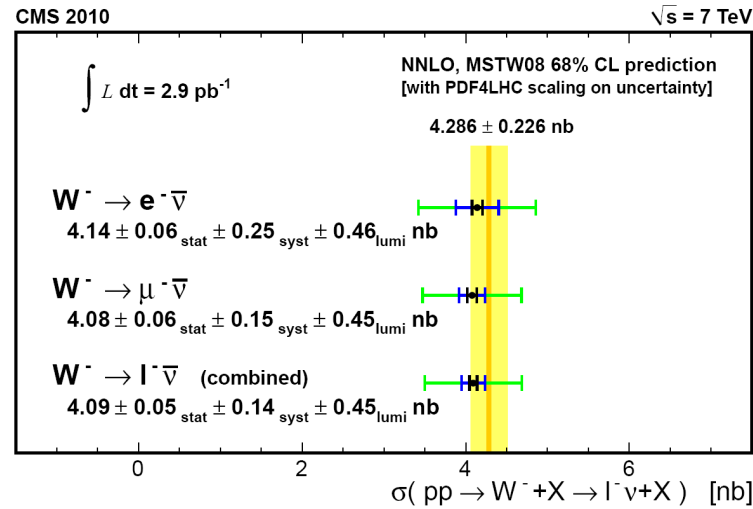
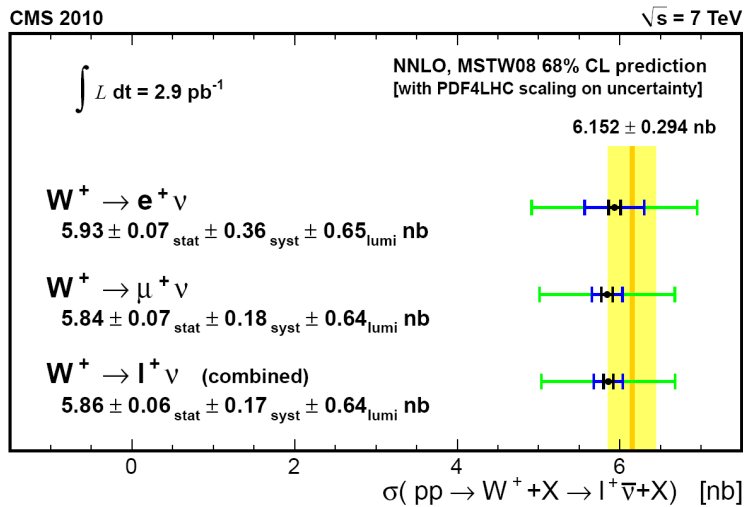
Z and W cross sections and ratios



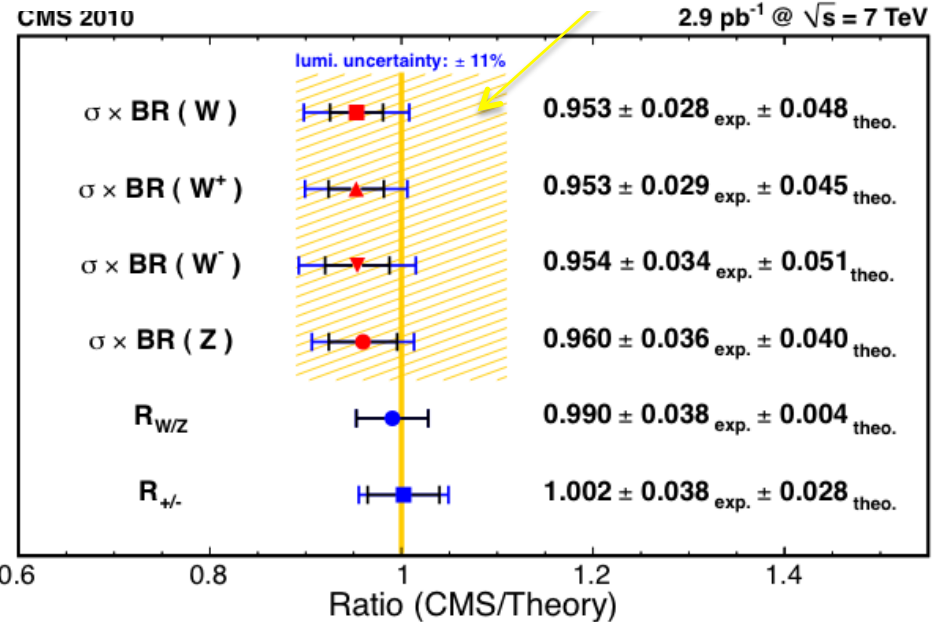
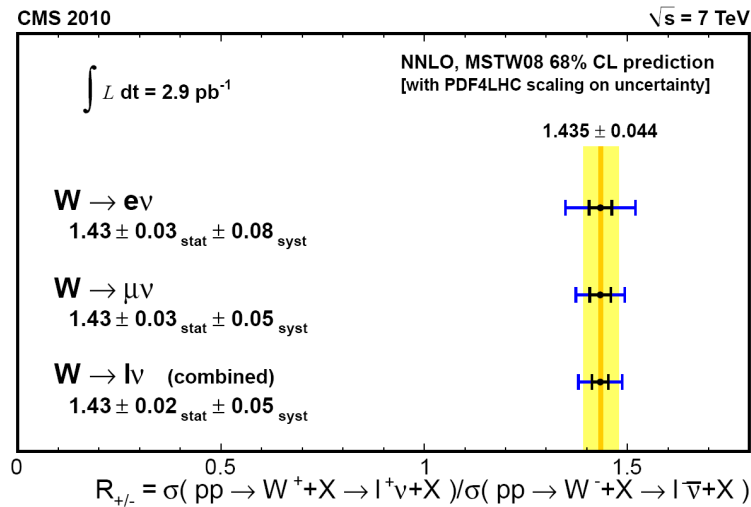


W⁺ and W⁻ and theory

Clearly Lumi the area with largest potential of improvement



Lumi error



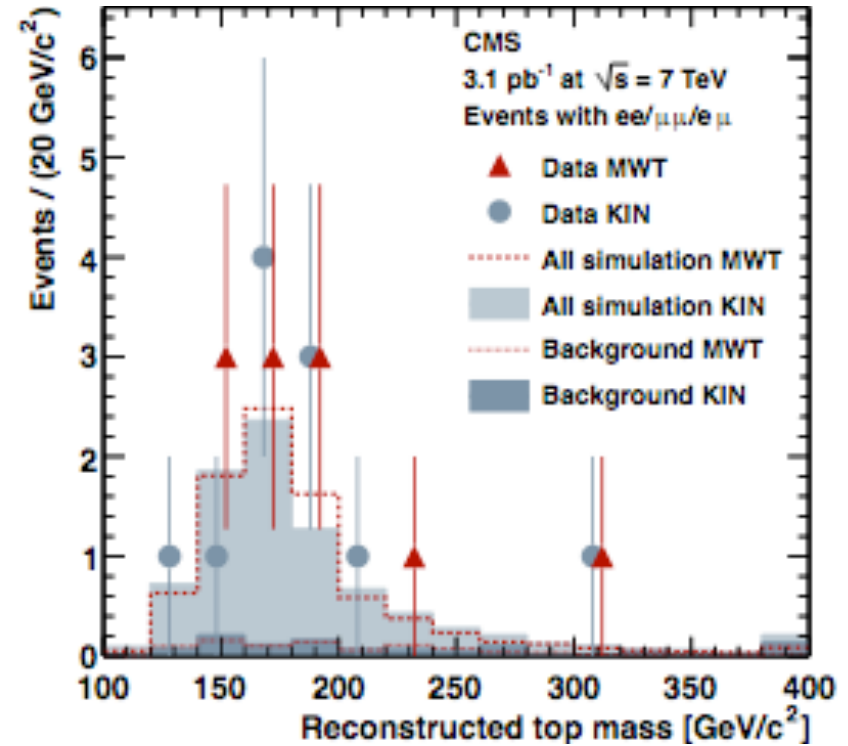
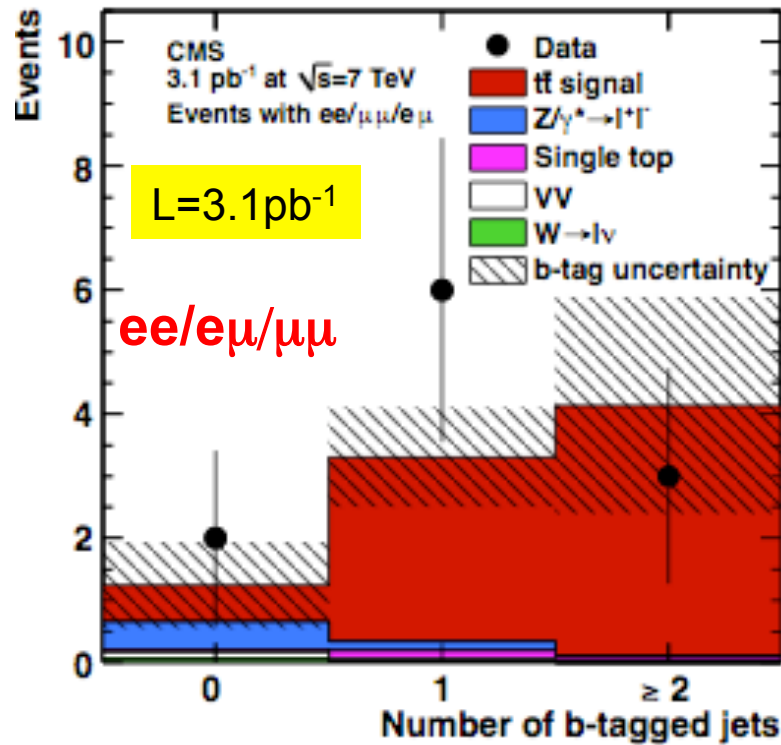
November 17, 2010



Top

Full selection applied: Z-Veto, $|M(\text{ll})-M(\text{Z})| > 15 \text{ GeV}$
MET > 30 (20) GeV in $ee, \mu\mu, (e\mu)$; $N(\text{jets}) \geq 2$

$$\sigma(\text{pp} \rightarrow \text{t} \bar{\text{t}}) = 194 \pm 72(\text{stat.}) \pm 24(\text{syst.}) \pm 21(\text{lumi.}) \text{ pb}$$



Submitted to PL-B arXiv:1010.5994

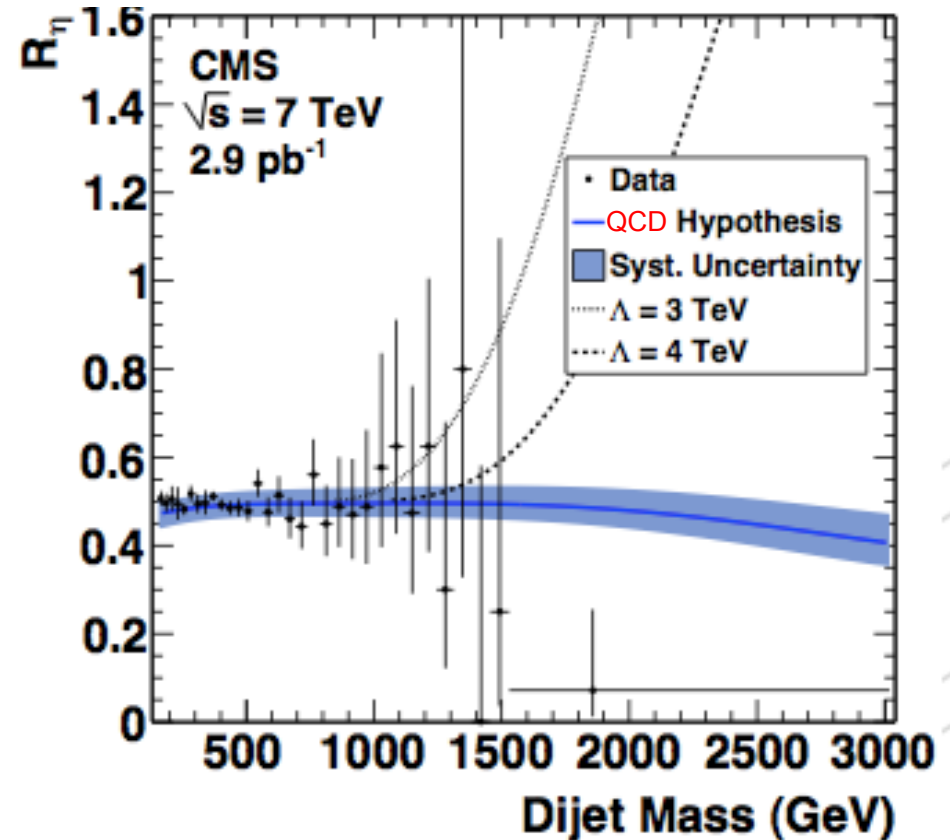
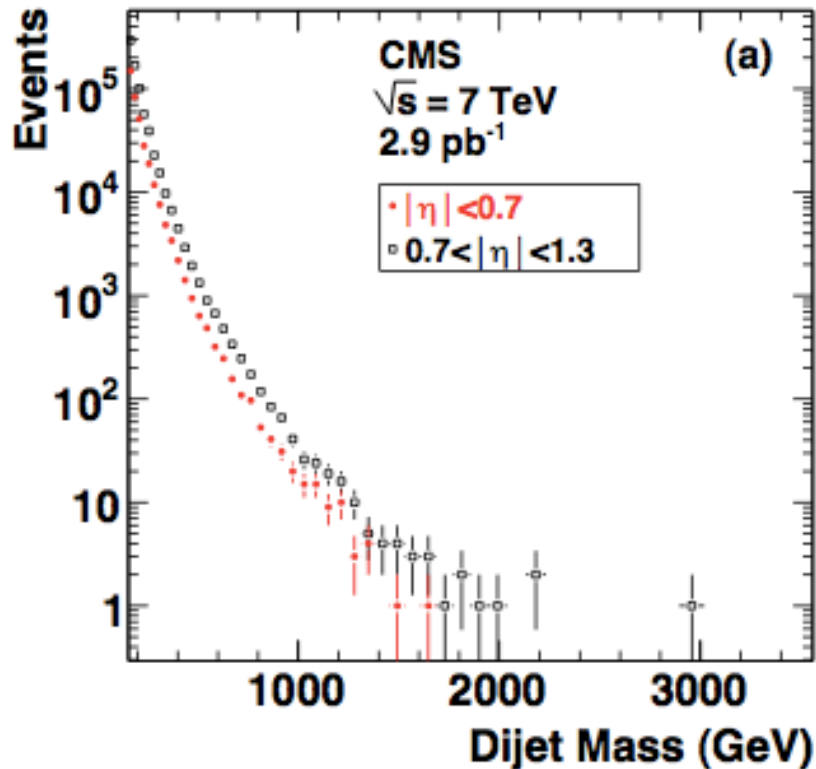


Quark compositeness/QCD

Centrality
ratio

$$R_{\eta} = \frac{\sum_{|\eta| < 0.7} Dijets}{\sum_{0.7 < |\eta| < 1.3} Dijets}$$

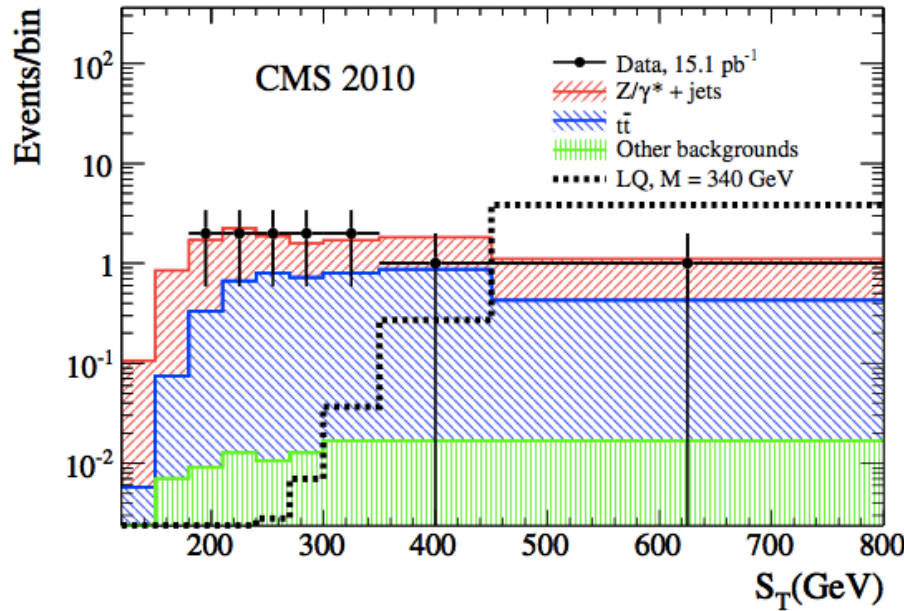
Contact interaction: excluded for $\Lambda < 4$ TeV
(higher than expected ~ 2.9 TeV- due to fewer-than-expected events at high Dijet mass)



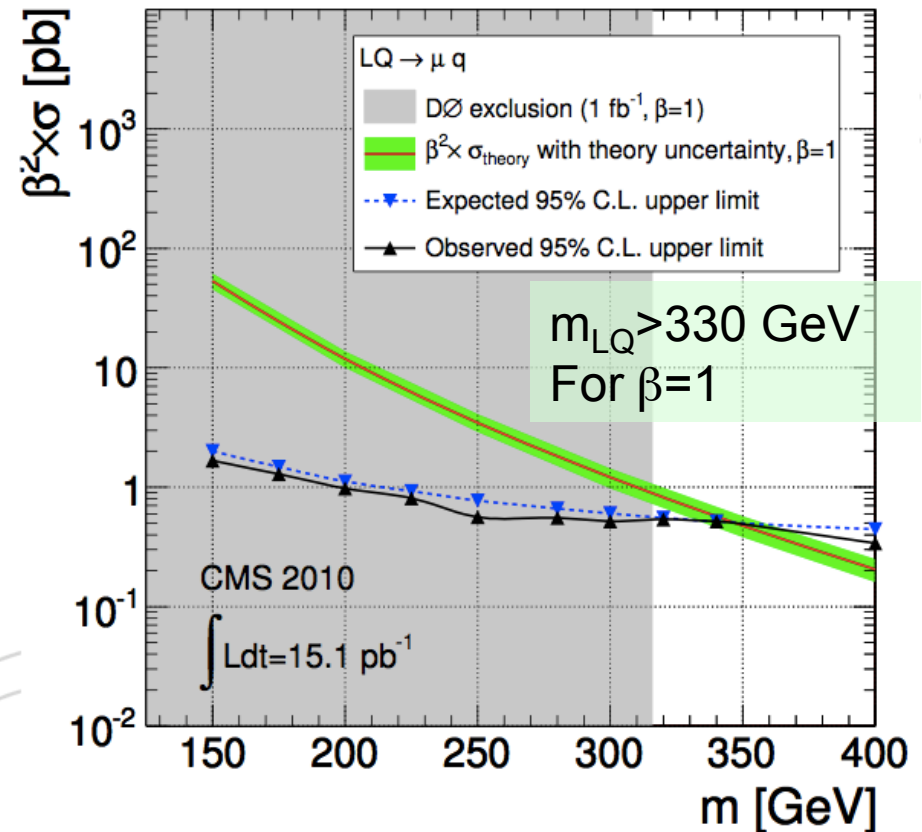


Leptoquark search

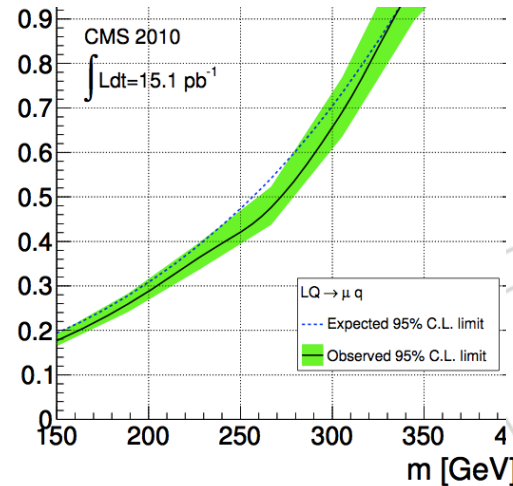
- Search for pair produced LQ decaying β % in μ +jet



Final disci variable $S_T = \sum_{\mu_{1,2}} p_t^\mu + \sum_{Jet_{1,2}} p_t^{jet}$



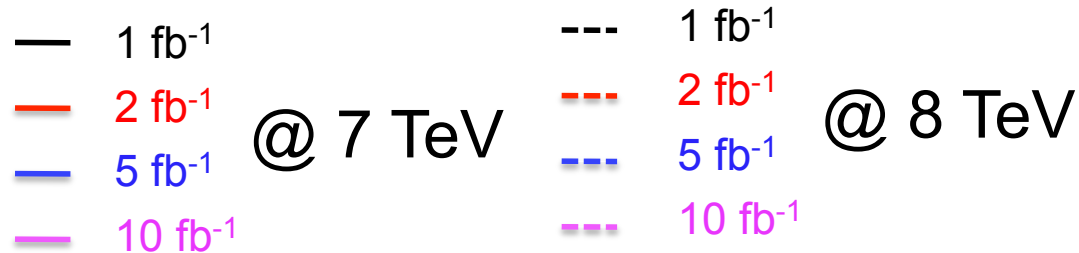
As a function of β



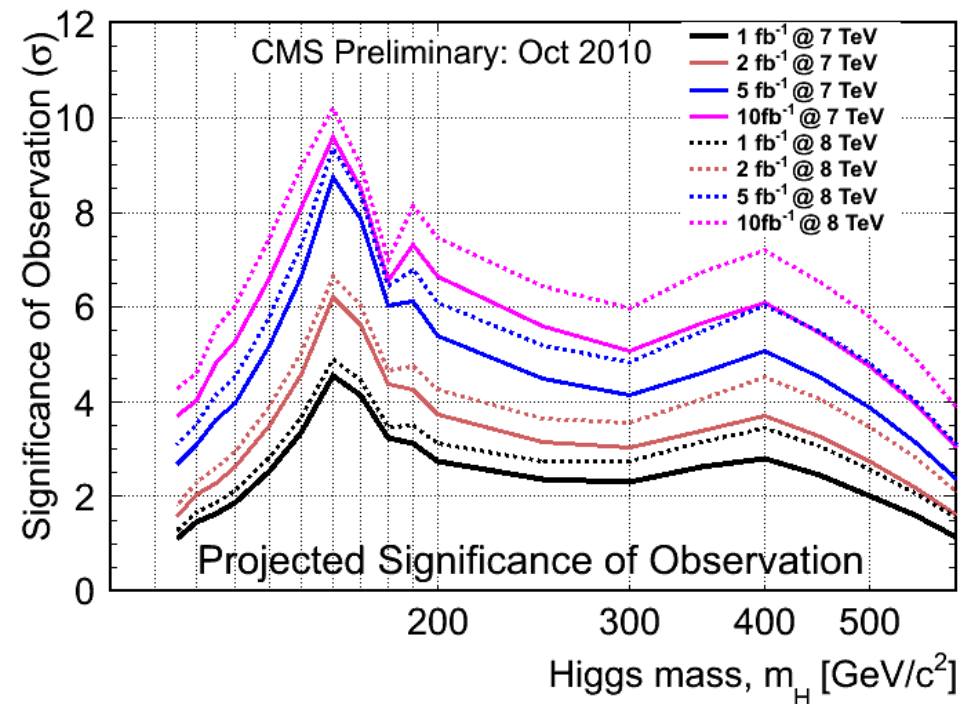
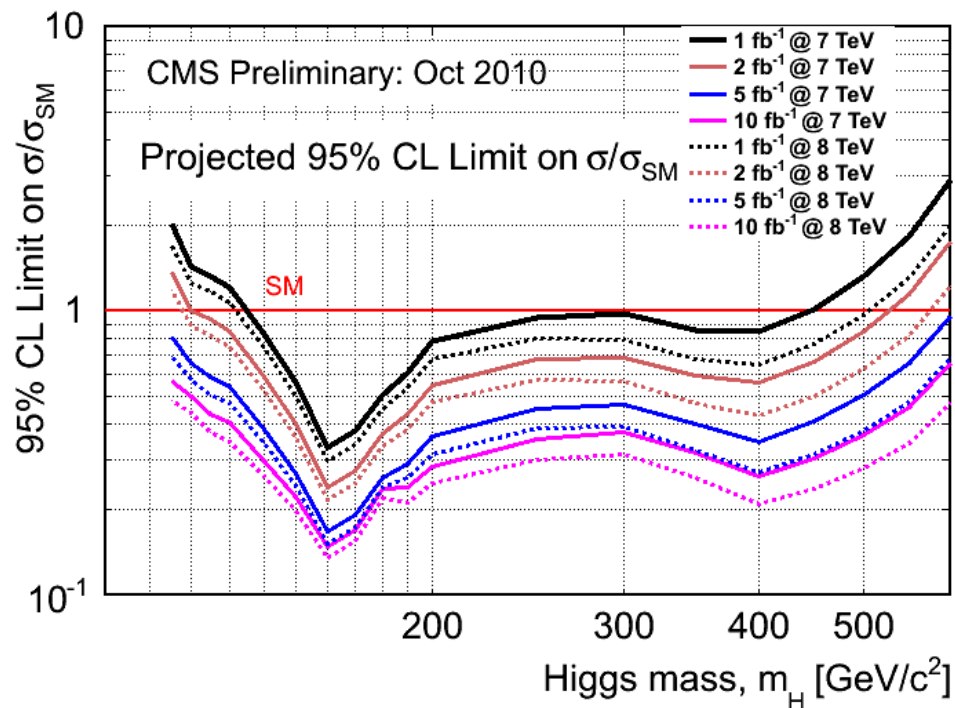


Higgs search perspectives

5 to 10 fb⁻¹ of accumulated lumi become very interesting

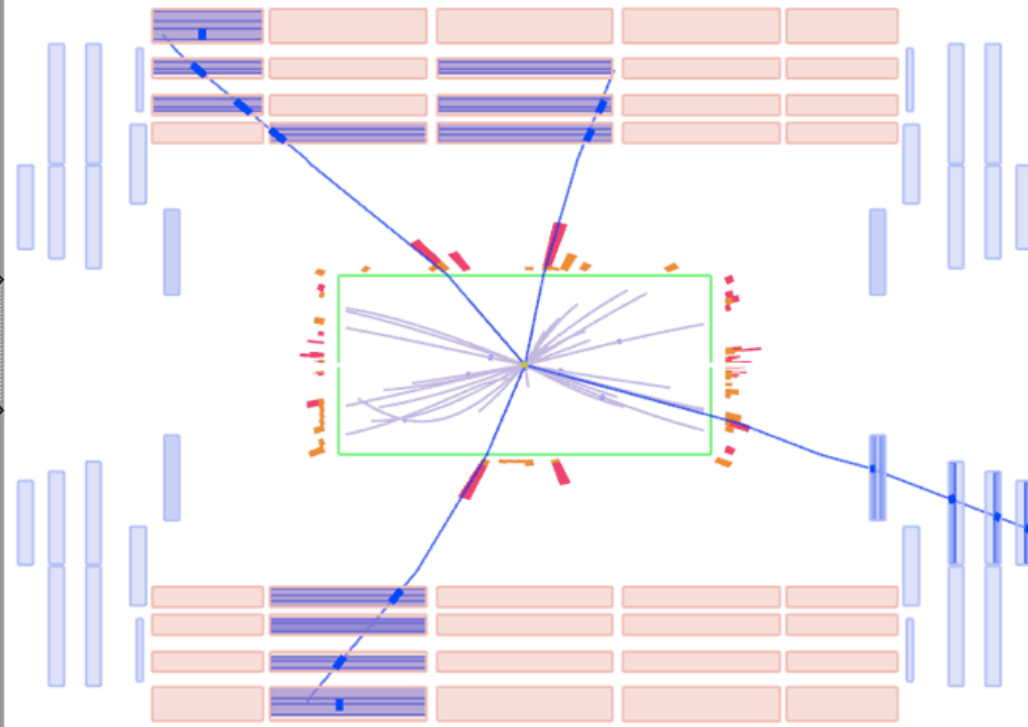
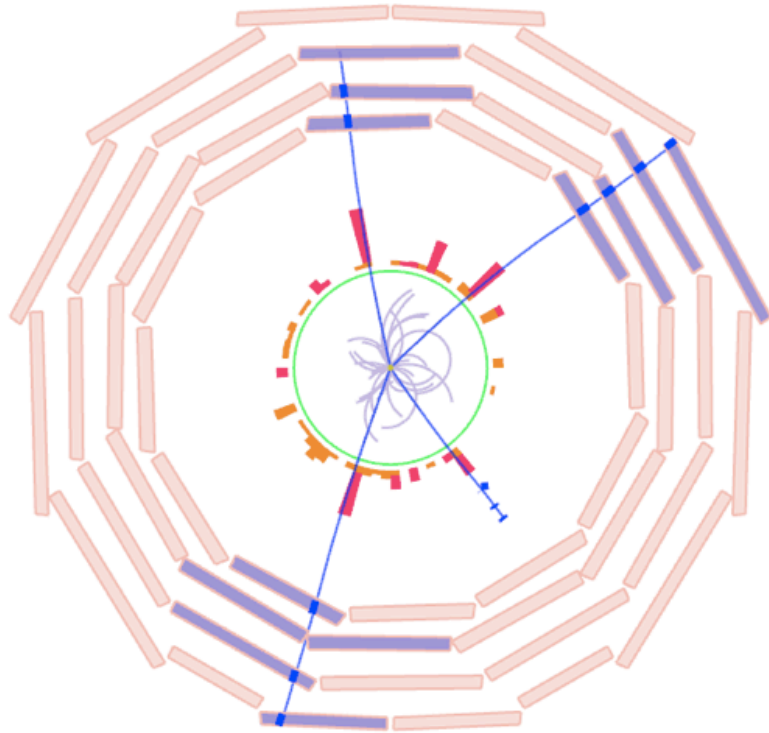


With 5 fb⁻¹ can exclude or have 3 σ evidence from 114 to 600 GeV





A beautiful ZZ event



Invariant Masses

$\mu_0 + \mu_1$: 92.15 GeV (total(Z) p_T 26.5 GeV, ϕ -3.03),
 $\mu_2 + \mu_3$: 92.24 GeV (total(Z) p_T 29.4 GeV, ϕ +.06),
 $\mu_0 + \mu_2$: 70.12 GeV (total p_T 27 GeV),
 $\mu_3 + \mu_1$: 83.1 GeV (total p_T 26.1 GeV).



Summary

- 2010 has been a great year for LHC (Thanks !!!) and for CMS
- The physics results which are being produced show that the understanding of the detector is quite advanced
- We are eager to take the challenge of ~ 100 times more luminosity in the next year(s)...and we are 'tired' of settings limits and look forward to a discovery era

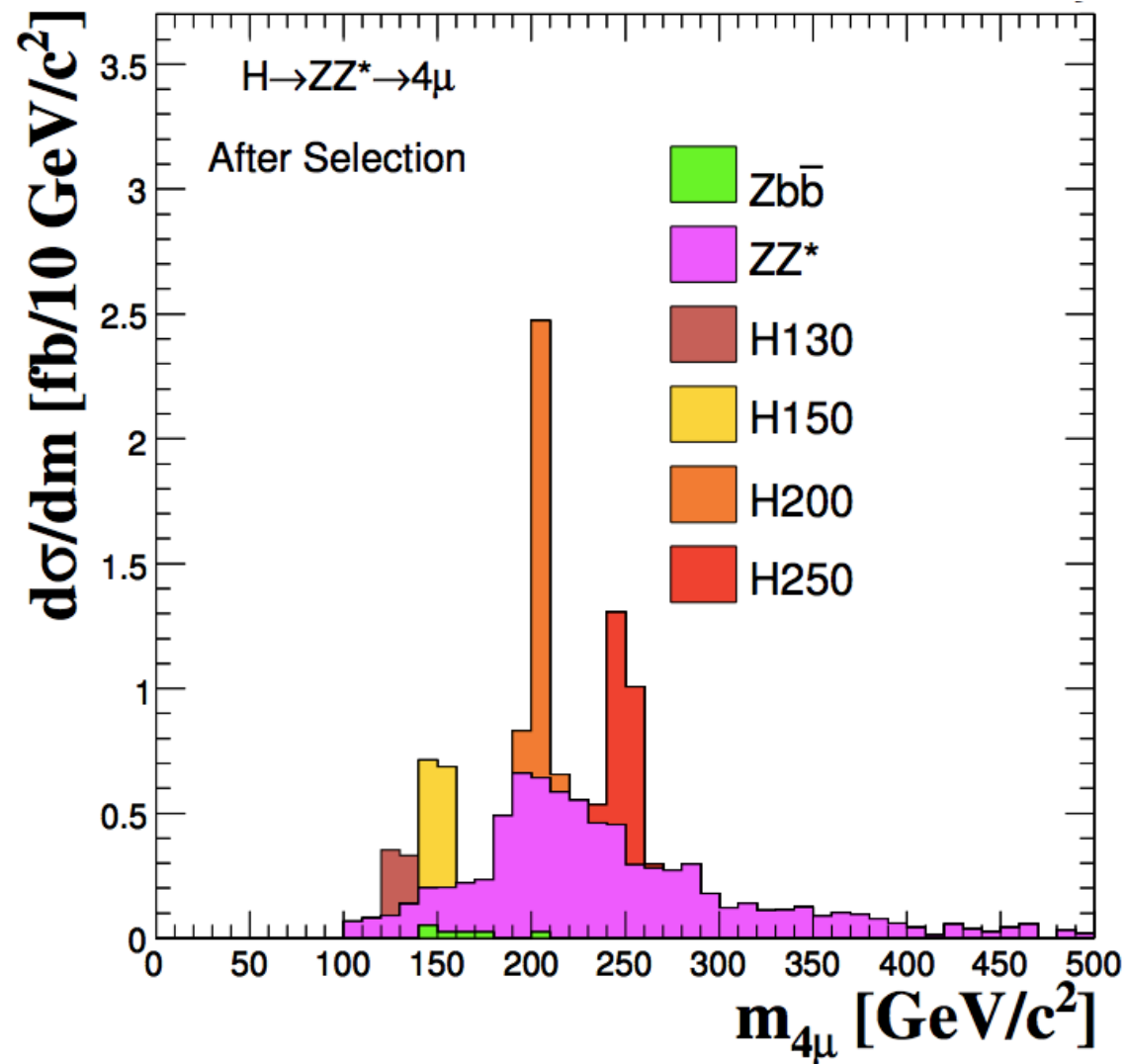


Backup



4 μ mass

PAS HIG 008-3





Soft QCD: strange particle prod

