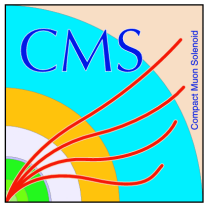
Z and W production in PbPb collisions at 2.76 TeV with CMS



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Quark Matter conference, Washington DC

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Outline

- Introduction : motivation
- CMS and muon reconstruction
- Z results (L_{int} = 150 μb^{-1})

  PAS-HIN-12-008 (new)
- W results (L_{int} = 7.3 μb^{-1})

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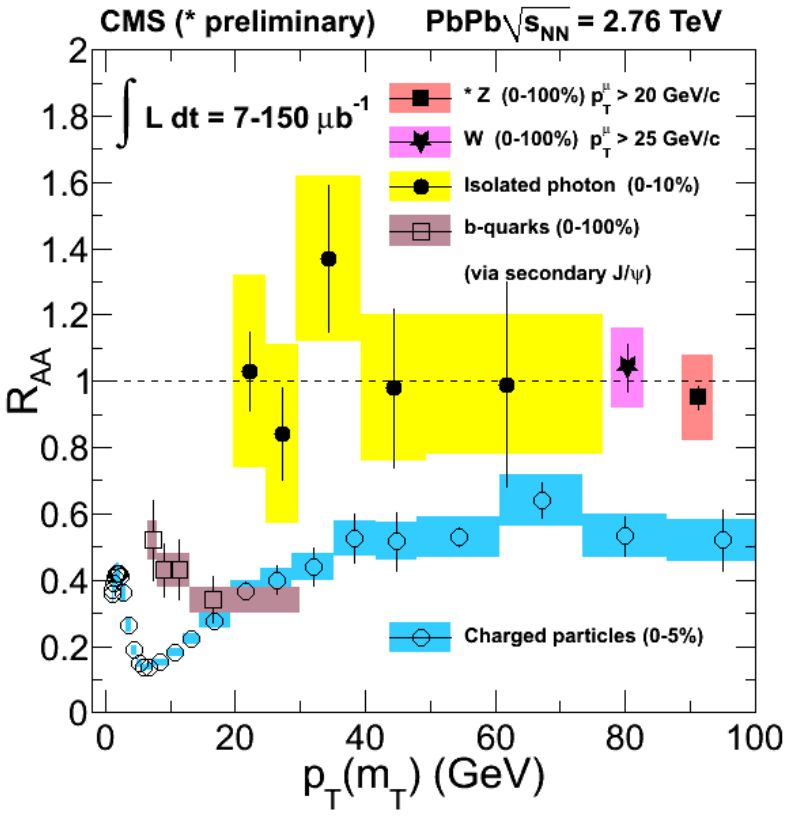
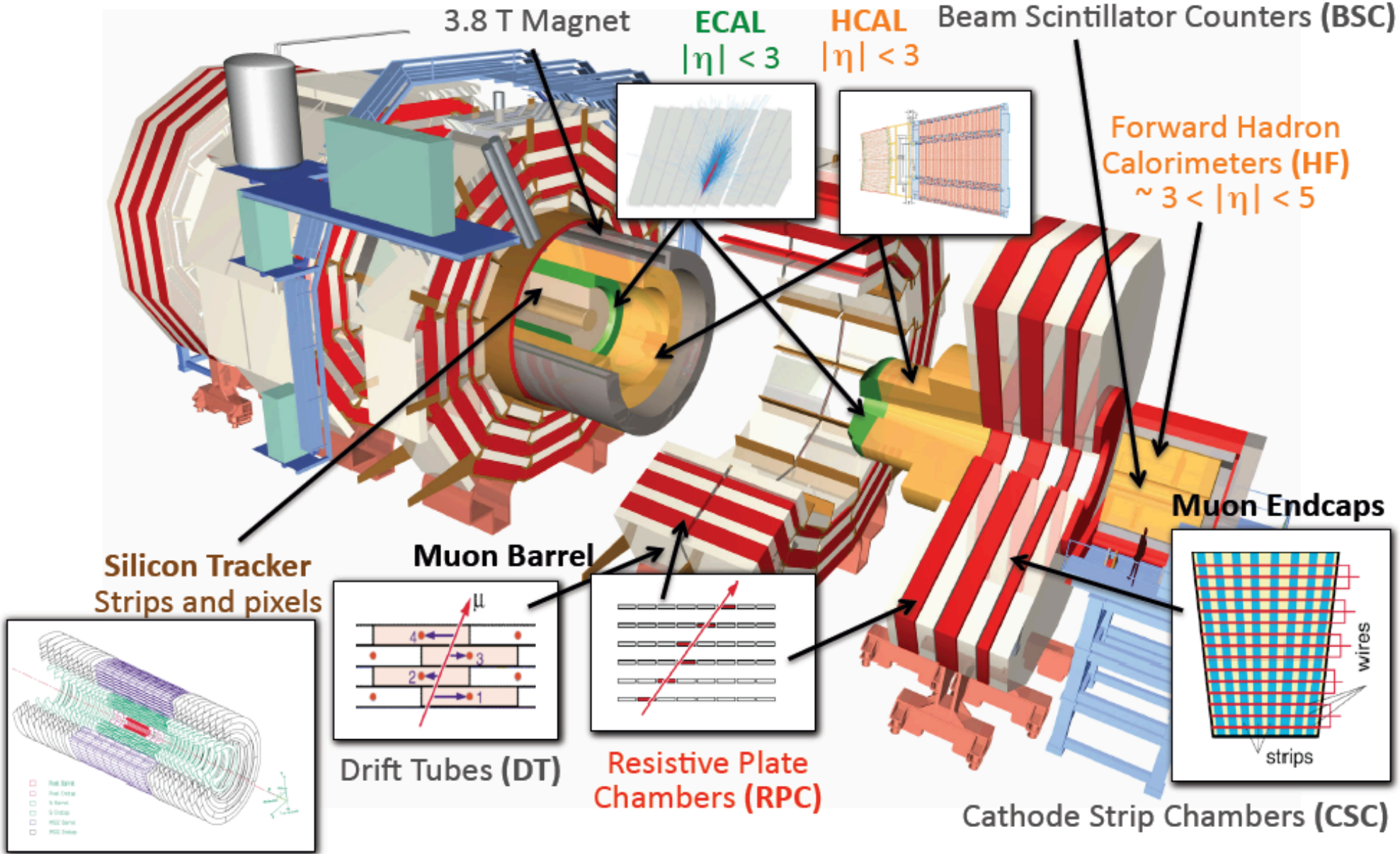
- Conclusion



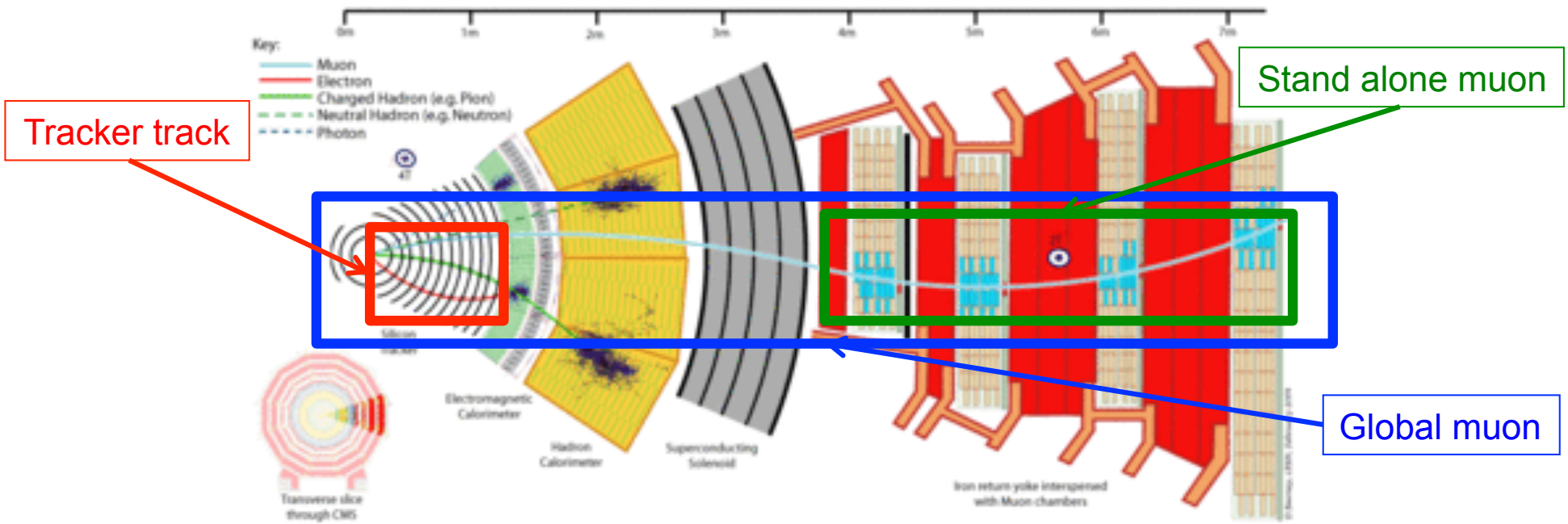
Motivation

- LHC allowed the first observation and measurement of Z and W bosons in PbPb collisions
- Z and W yields are predicted to be unaffected by the strongly interacting medium produced in PbPb collisions
- Precise measurement of Z and W production in heavy ion collisions may help to constrain nuclear PDFs
- Calibration of the detectors: validate efficiency and energy scale of lepton reconstruction
- For now, both Z and W are studied through their leptonic decay channels: $Z \rightarrow \mu^+\mu^-$, $W^\pm \rightarrow \mu^\pm\nu$

CMS detector

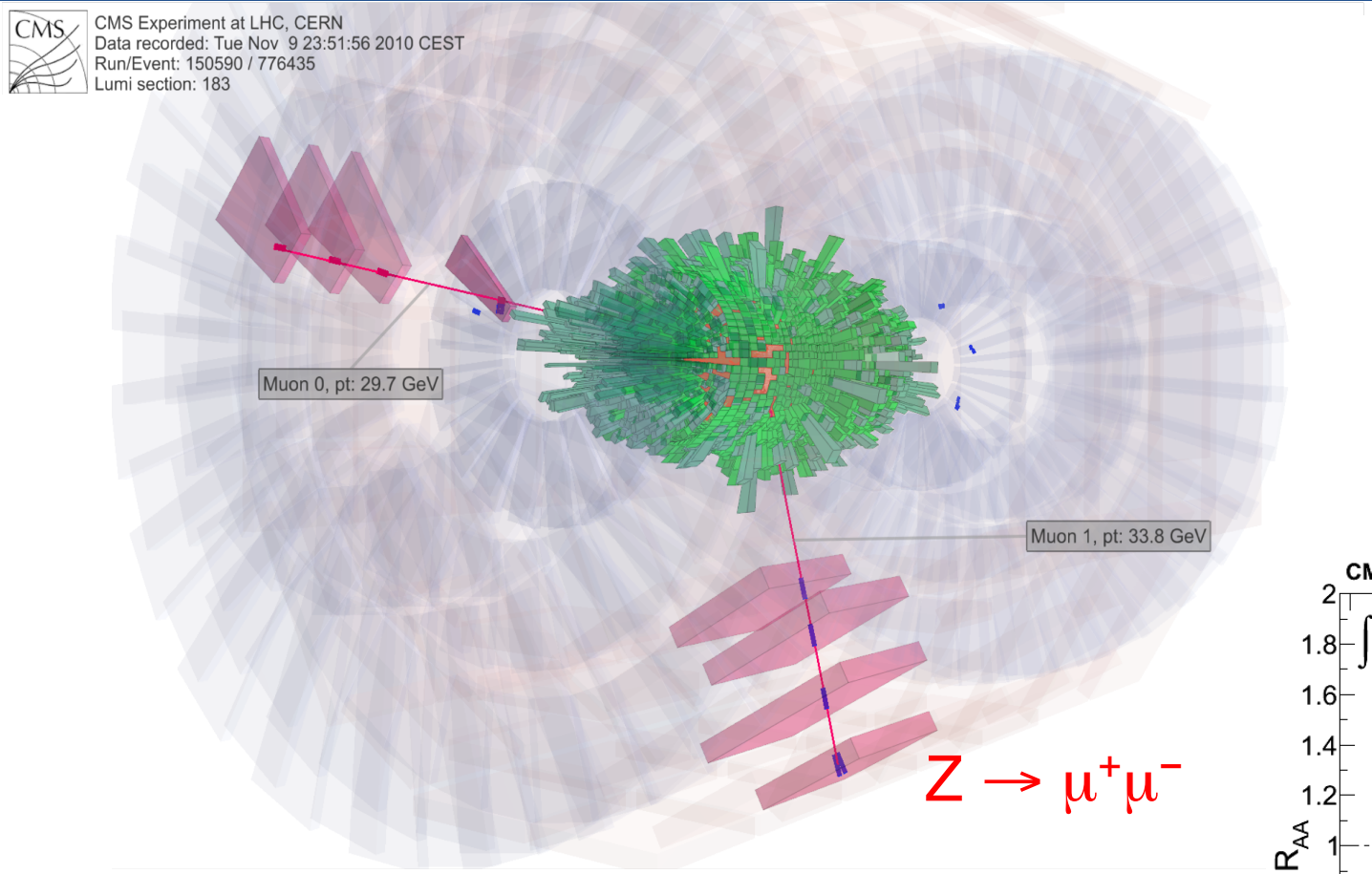


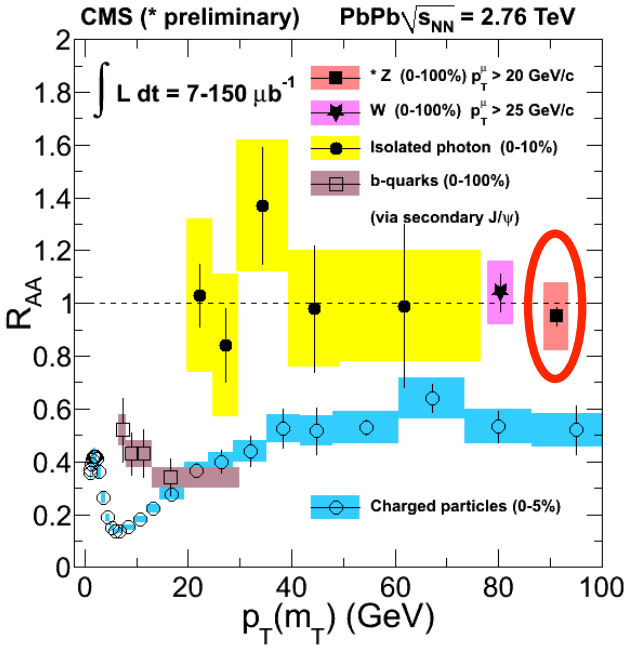
Muon reconstruction



- Muon reconstruction requires information from the tracker and muon systems, tracks reconstructed in the tracker are matched to tracks reconstructed in the muon system
- Used inner tracking modified for HI collisions
- Excellent high-p_T resolution : 1-2%
- Good muon trigger performance

$Z \rightarrow \mu^+ \mu^-$

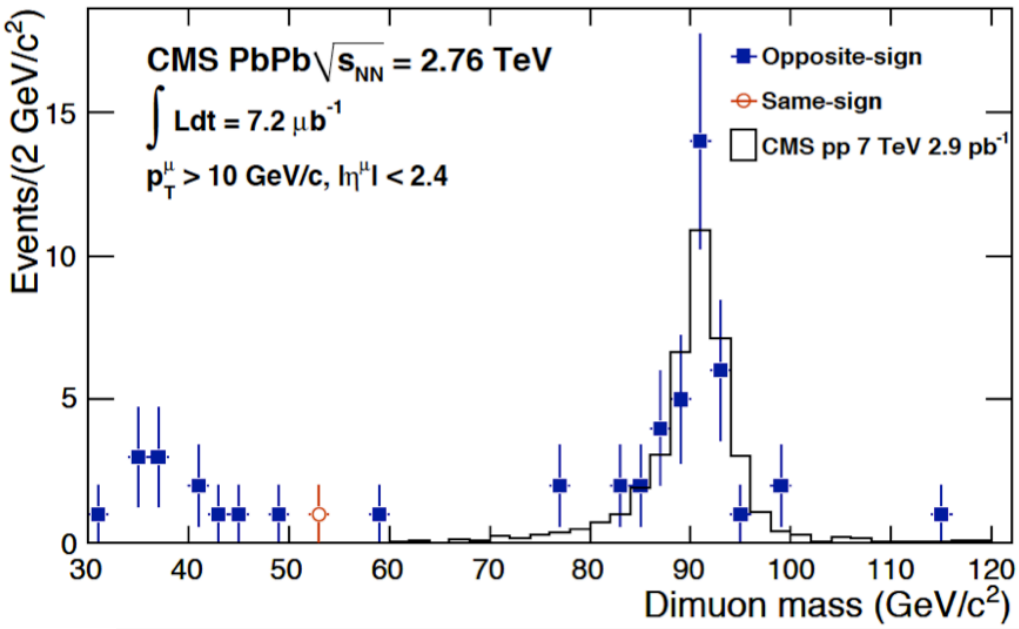




Z boson

- Data sample Pb+Pb collisions at $\sqrt{s}$ = 2.76 TeV :
  - 2010 : L_{int} = 7.2 μb^{-1}
  - 2011 : L_{int} = 150 μb^{-1}

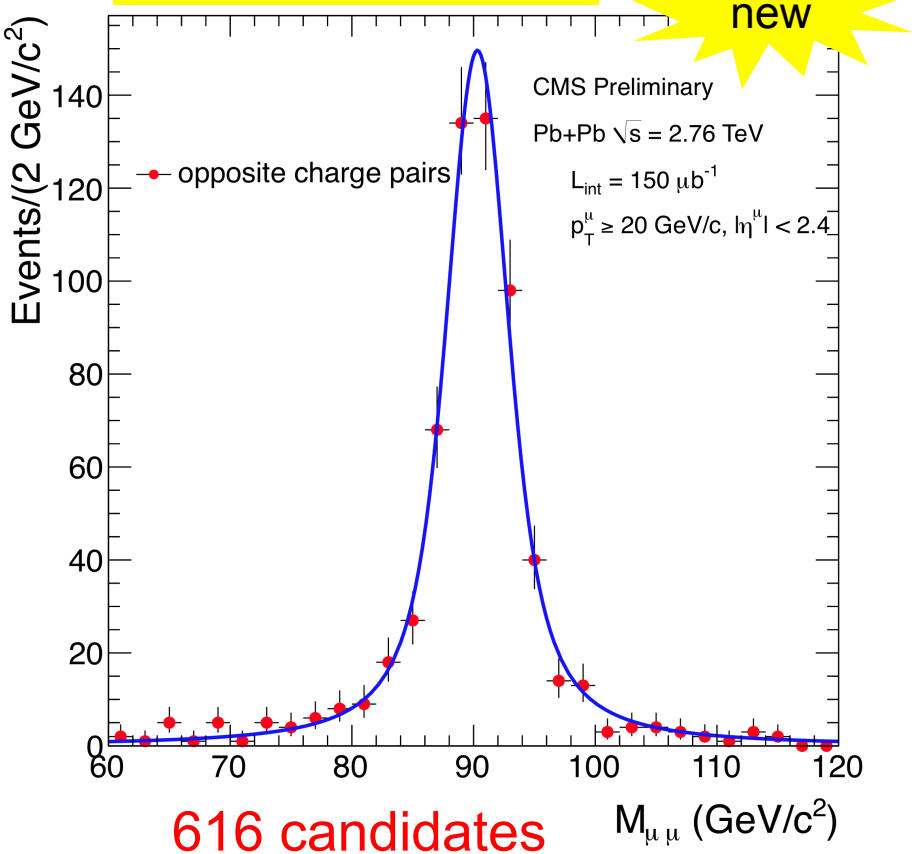
PRL 106 (2011) 212301



39 candidates

CMS-PAS-HIN-12-008

new

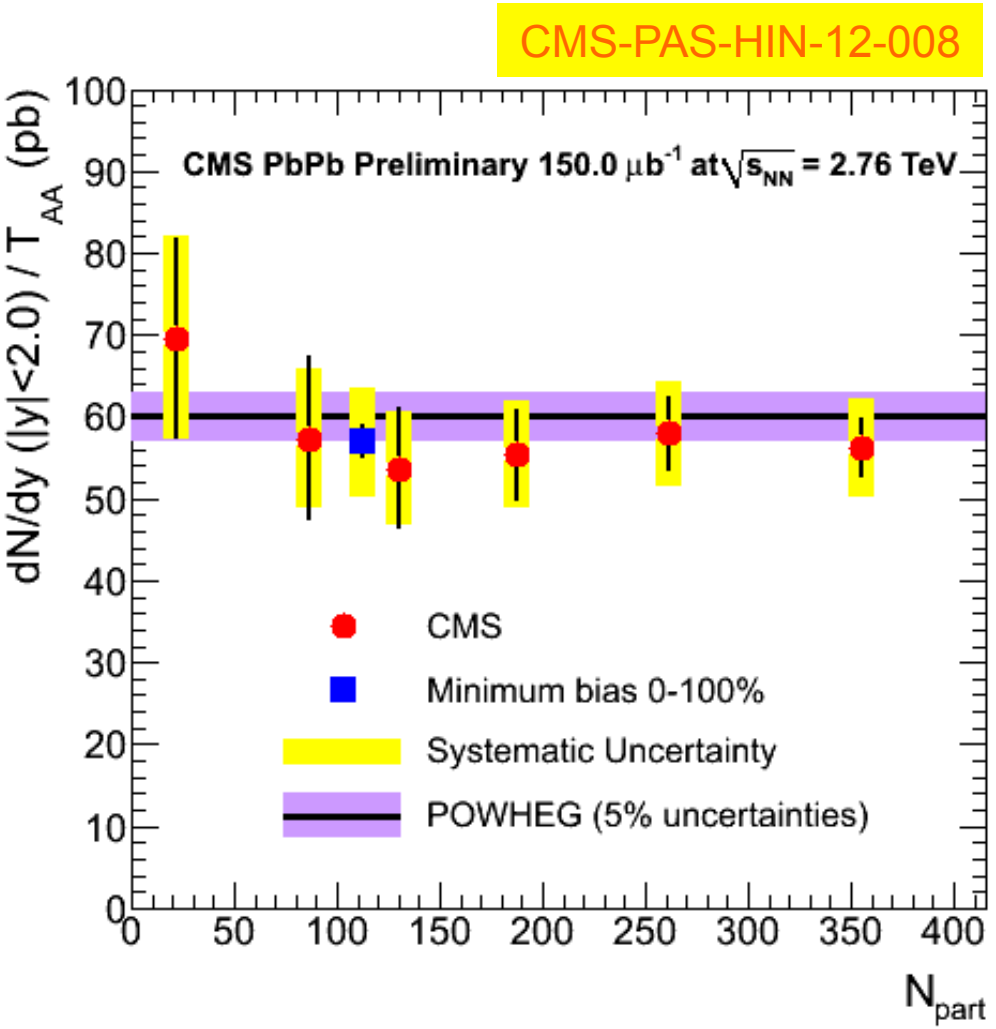


616 candidates

no same charge pairs

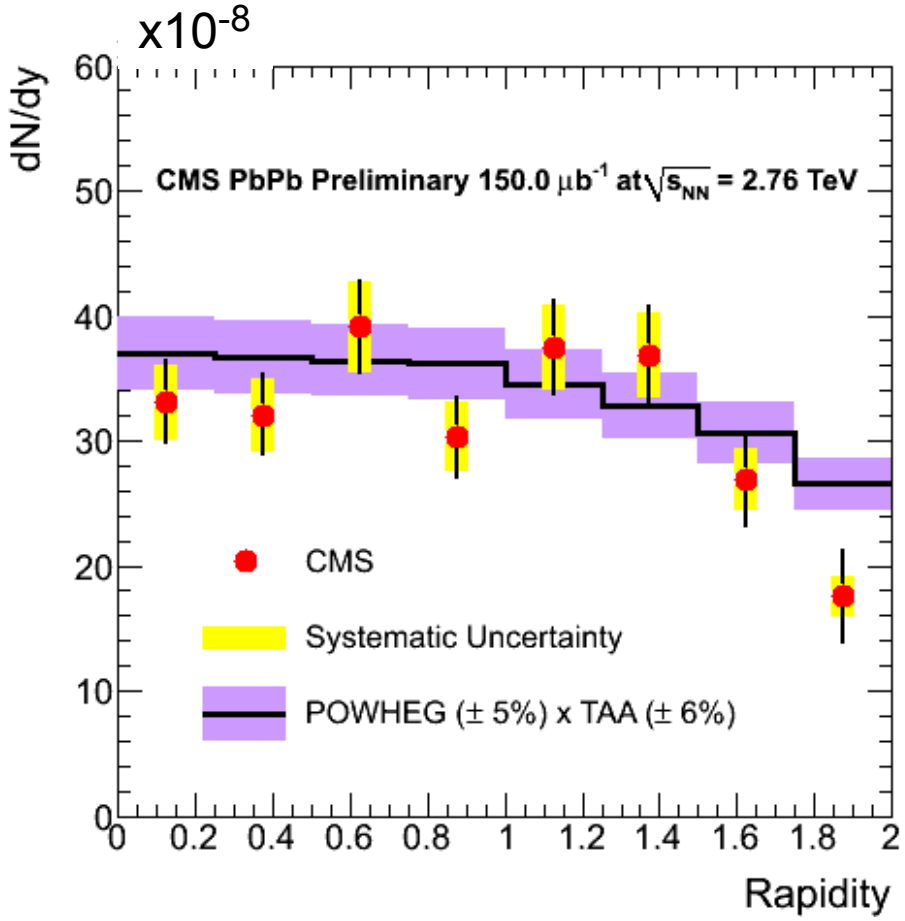
dN/dy T_{AA} vs. N_{part}

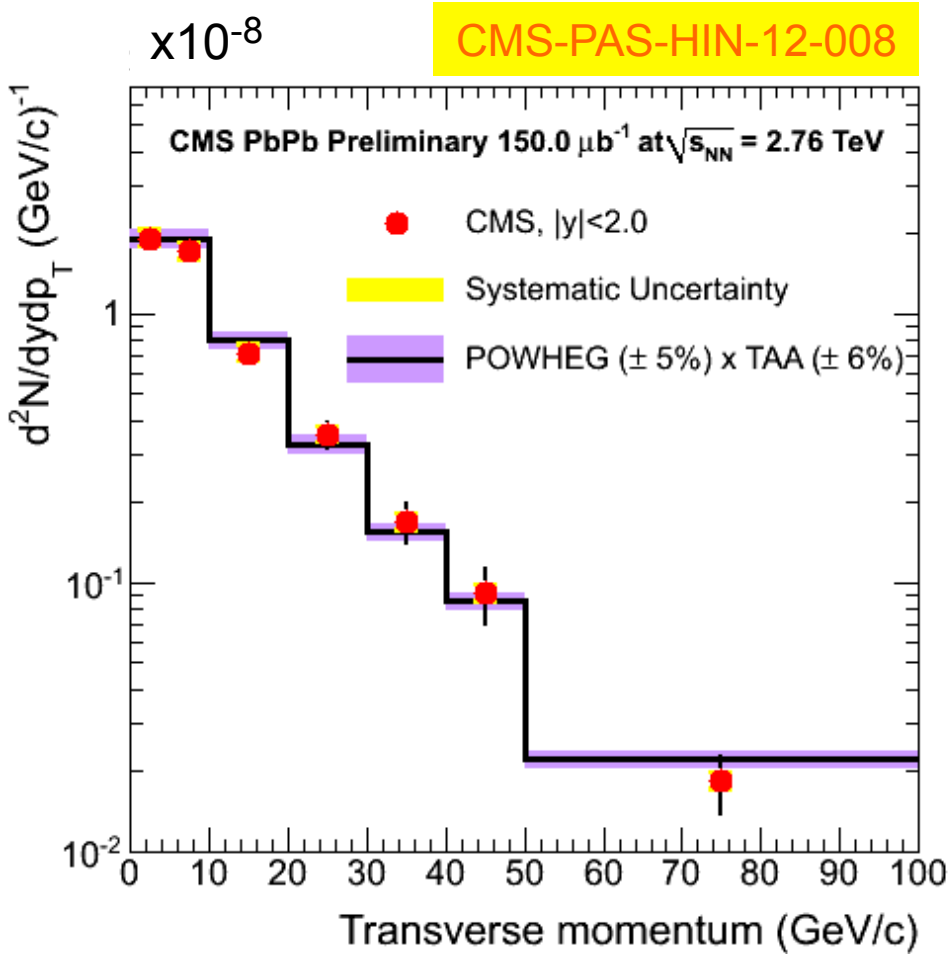
- $dN / T_{AA} = d\sigma_{pp} R_{AA}$
- T_{AA} : nuclear overlap function estimated with a Glauber model calculation
- Z production scales with T_{AA}
- Assuming from POWHEG $d\sigma_{pp} / dy = 59.6$ pb in $|y| < 2$



$R_{AA} = 0.95 \pm 0.03 \pm 0.13$

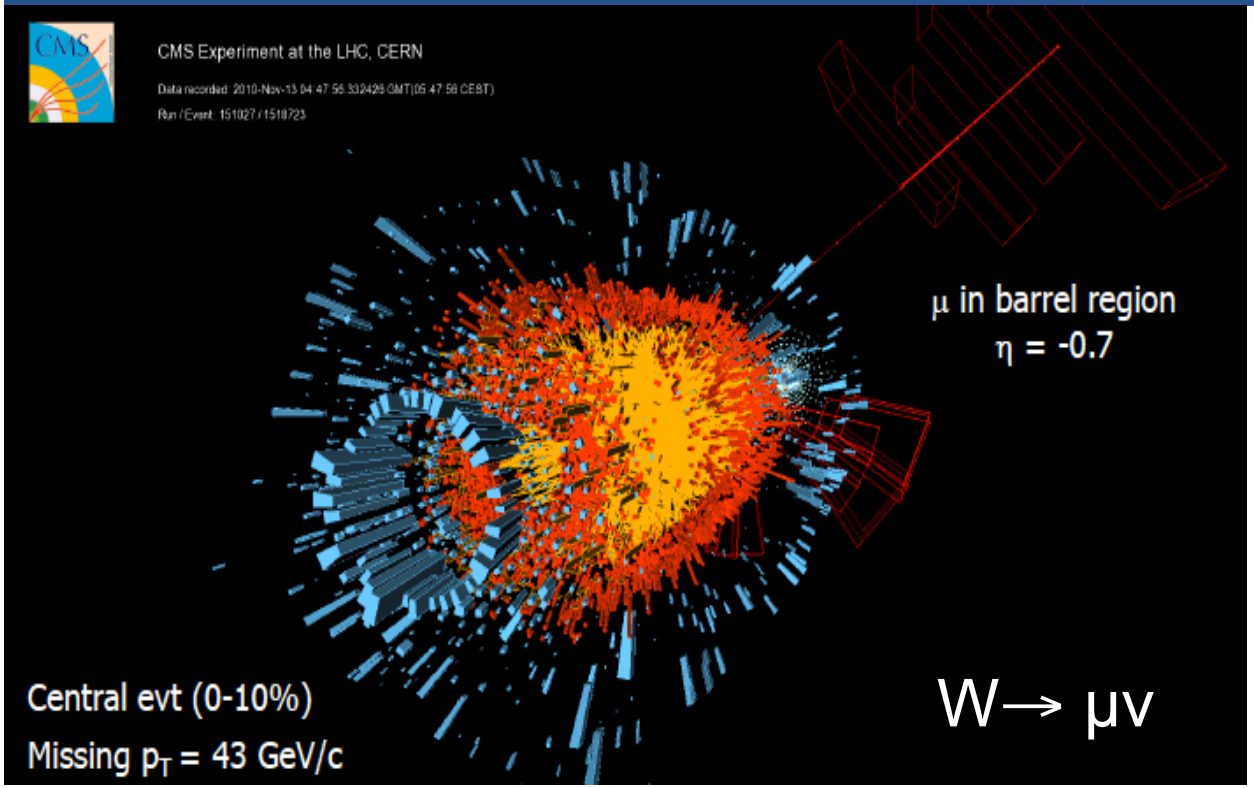
Normalized Z yield vs. p_T and rapidity



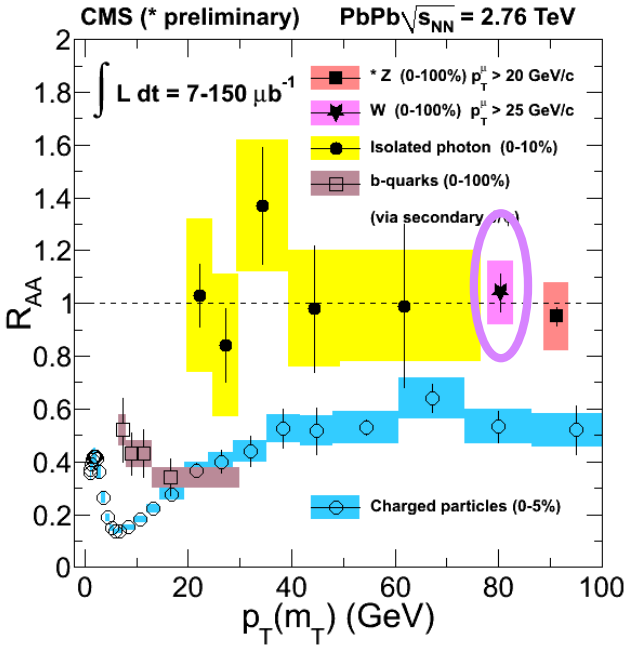


- 8 rapidity bins and 7 p_T bins (more bins than 2010 data)
- Both dN/dy and $d^2N/dydp_T$ are in good agreement with POWHEG

$W^{\pm} \rightarrow \mu^{\pm}\nu$



Experimental signature: a high p_T muon recoiling against an (undetected) neutrino in transverse plane



Muon p_T spectrum

- Good quality muons reconstructed offline in $|\eta| < 2.1$
- Veto on Z candidates

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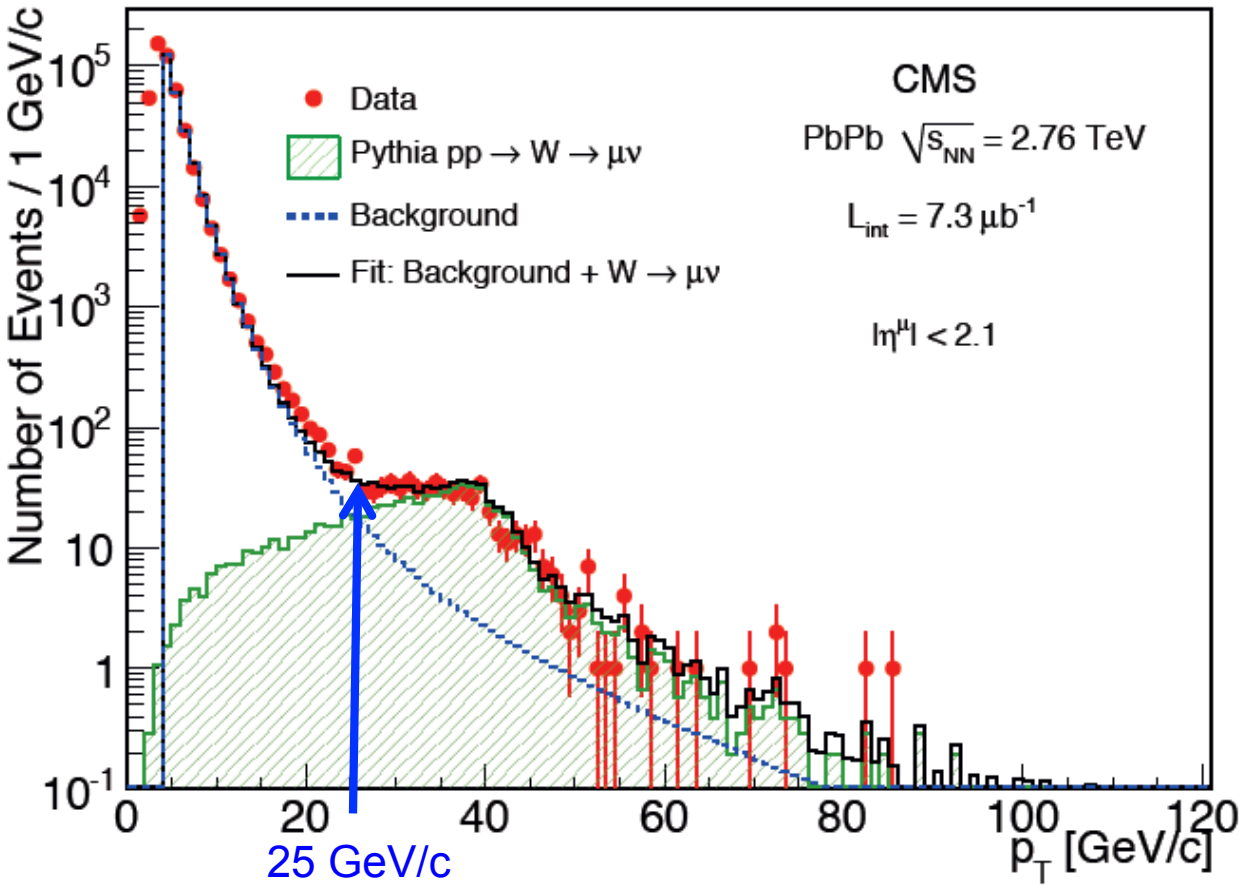

- Bump in the region $p_T > 25$ GeV/c where W decay products are expected
- For the analysis we require $p_T > 25$ GeV/c

Missing p_T

$\not{p}_T = -\sum \vec{p}_T$ of all charged tracks with p_T > 3 GeV/c

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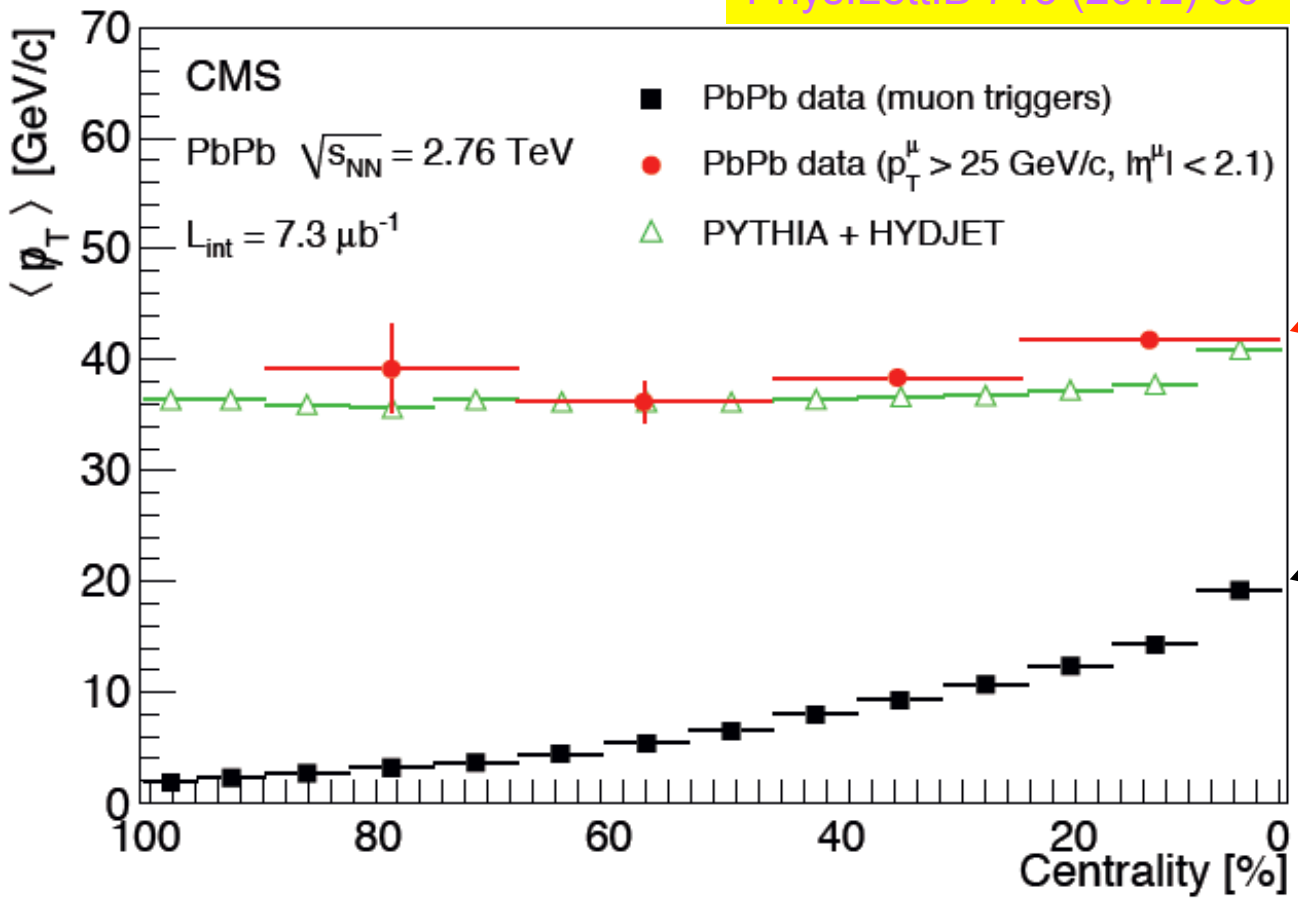

After high p_T muon selection, almost no dependence vs. centrality

Before selection

$\not{p}_T > 20\ GeV/c$ used in the analysis

W transverse mass m_T

- Transverse mass $m_T = \sqrt{2 p_T^{\mu} \not{p}_T (1 - cos\phi)}$ $\phi = \phi(\mu) - \phi(\not{p}_T)$
- Sharp Jacobian peak at $m_T = m_W$
- pp data at 2.76 TeV analyzed with the same procedure

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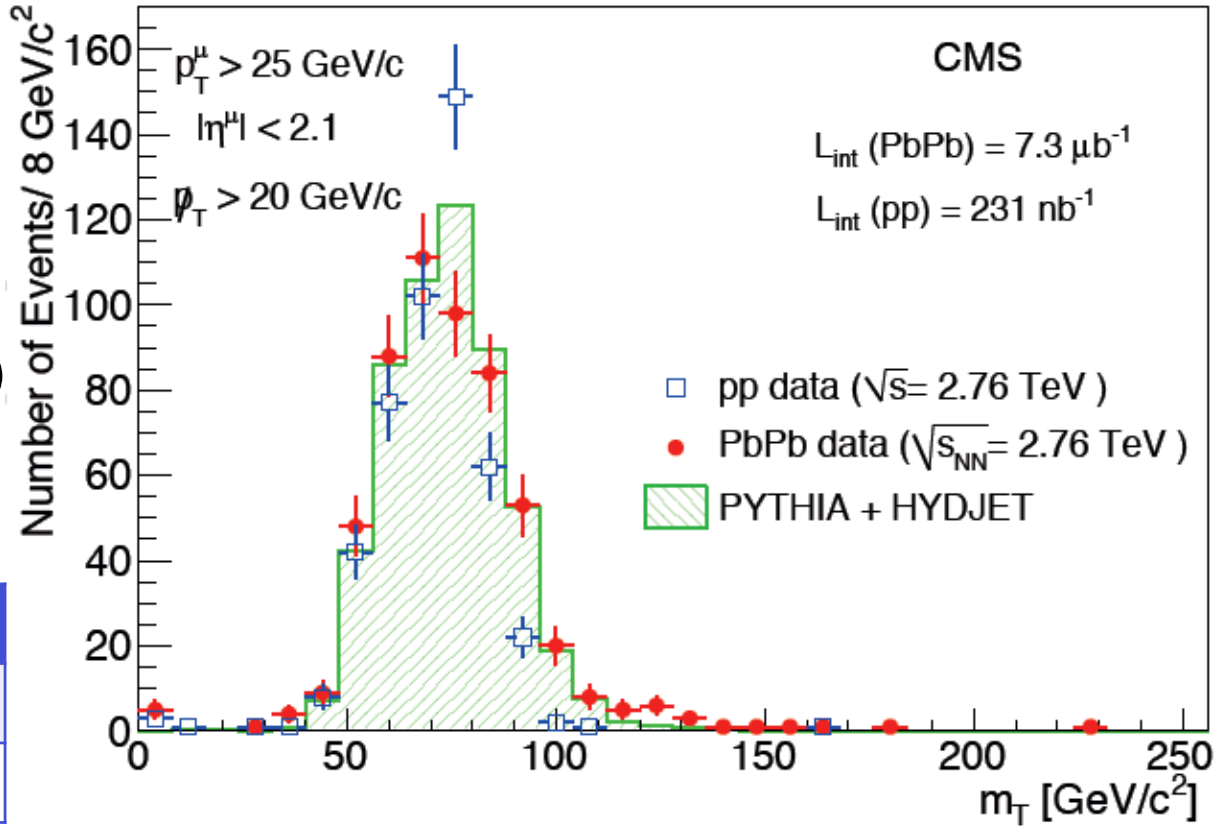
- Compatible W signals in PbPb and pp
- Residual contamination from $Z \rightarrow \mu^+\mu^-$ and $W \rightarrow \tau\, \nu$ subtracted (2%); QCD (<1%)



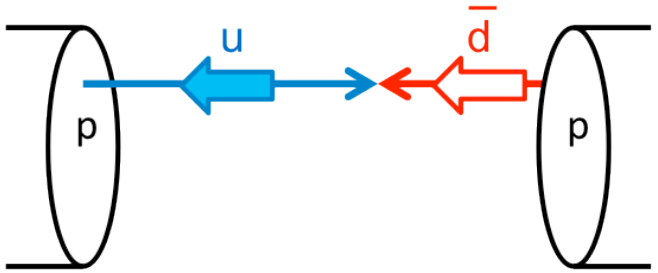
Selected events :

	PbPb	pp
W^+	275	301
W^-	264	165

$W^{\pm} \rightarrow \mu^{\pm}\nu$

- Different yields expected for
  - $W^{+} \rightarrow \mu^{+}\nu$
  - $W^{-} \rightarrow \mu^{-}\nu$

- W are mostly produced via the fusion of a valence quark and a sea antiquark ($u\bar{d} \rightarrow W^{+}$ and $d\bar{u} \rightarrow W^{-}$)



- More W^{-} (less W^{+}) in PbPb than in pp:

$\rightarrow$ strong isospin effect expected

(small when considering $W^{+} + W^{-}$)

$W^{\pm} \rightarrow \mu^{\pm}\nu$ in pp

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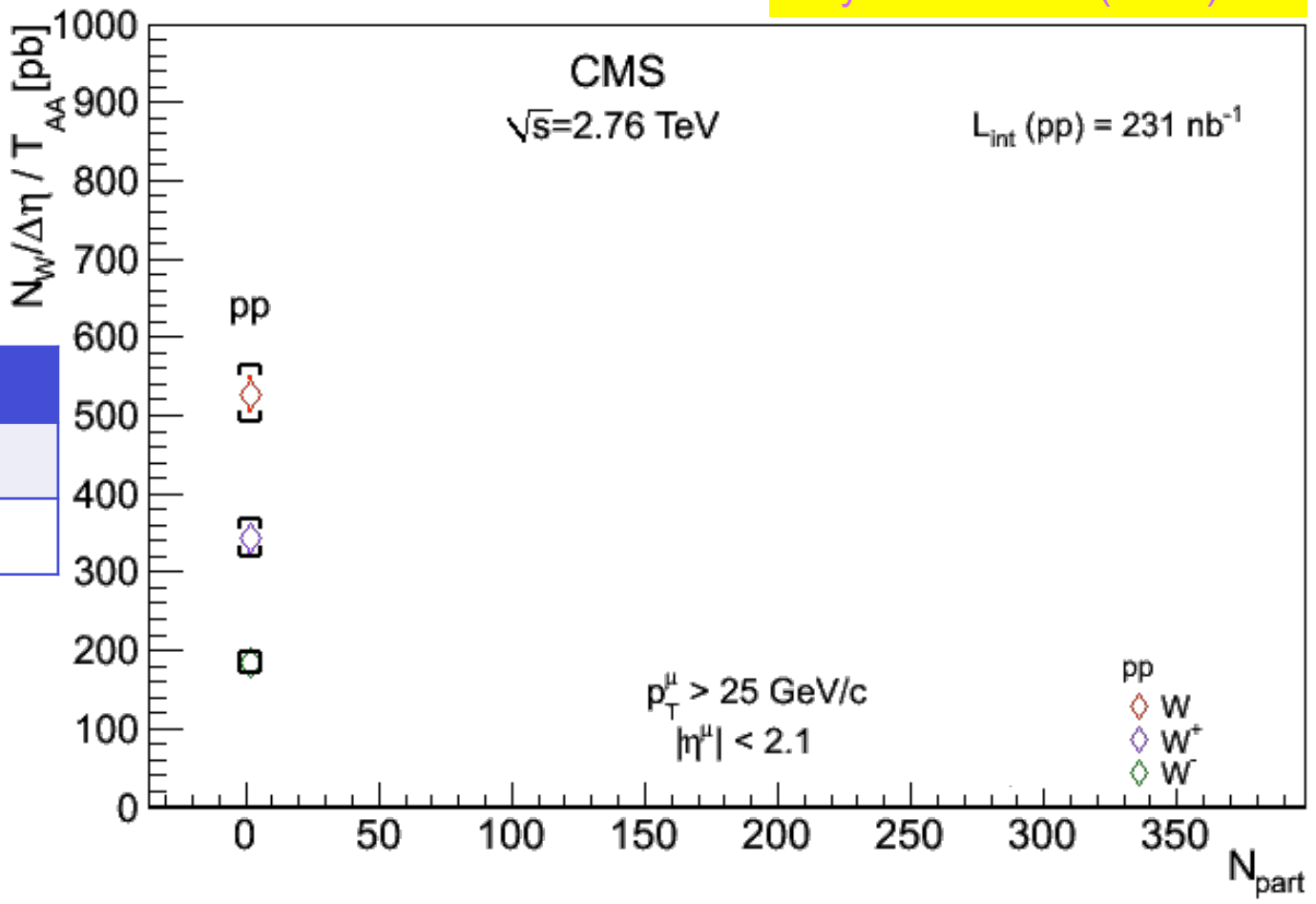
	pp
W^+	301
W^-	165



- More W^+ than W^- in pp due to the isospin effect

Centrality dependence

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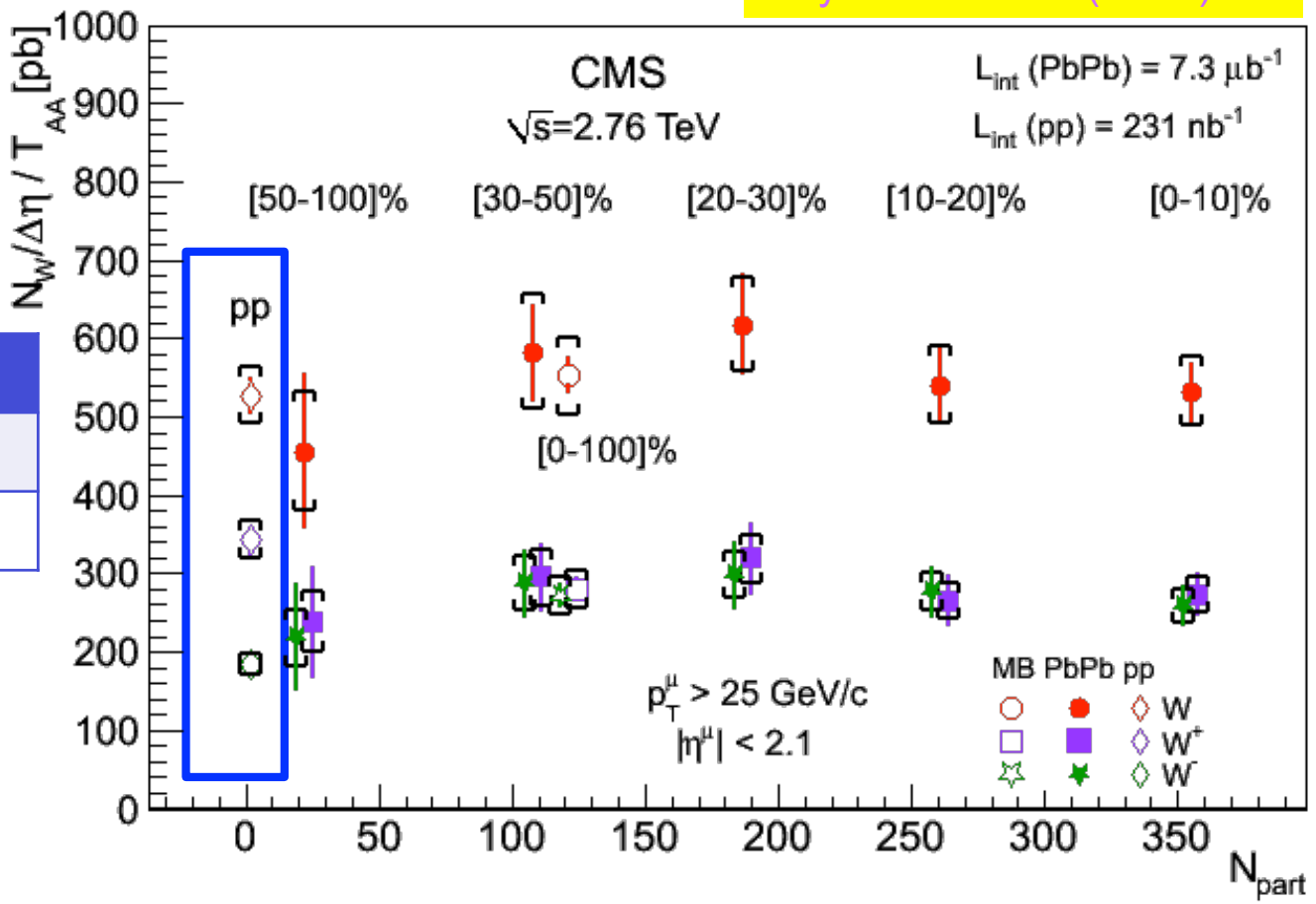
	PbPb	pp
W^+	275	301
W^-	264	165



- Within uncertainties, no dependence of W production vs. centrality observed in PbPb collisions

Centrality dependence

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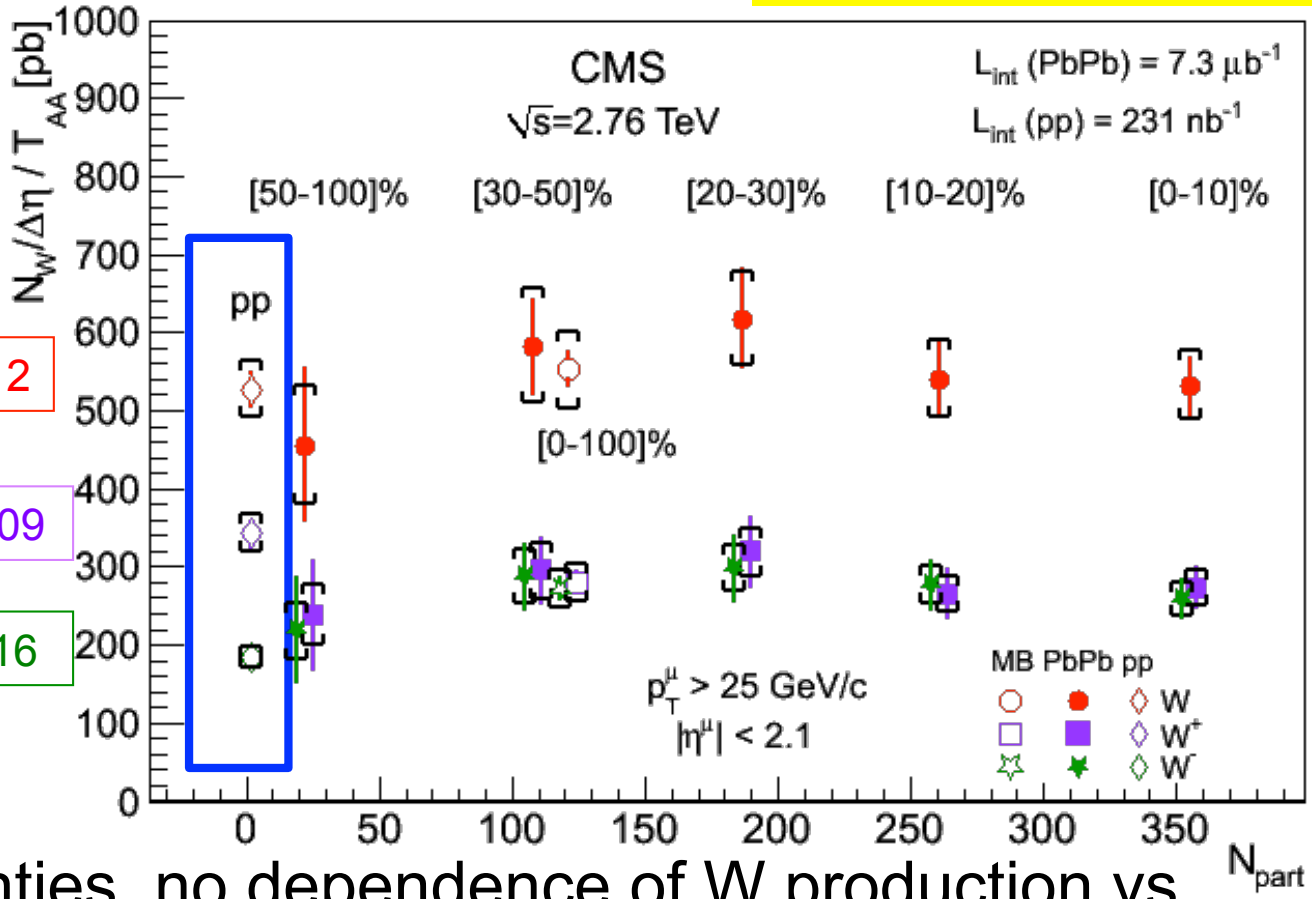
$R_{AA}(W) = 1.04 \pm 0.07 \pm 0.12$

$R_{AA}(W^+) = 0.82 \pm 0.07 \pm 0.09$

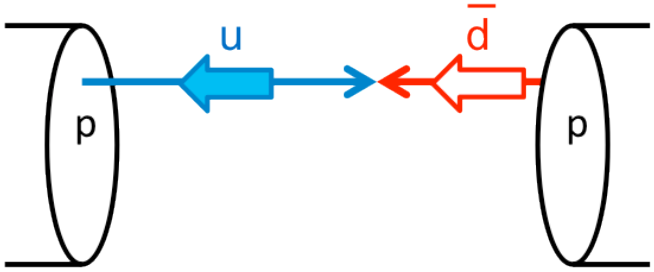
$R_{AA}(W^-) = 1.46 \pm 0.14 \pm 0.16$



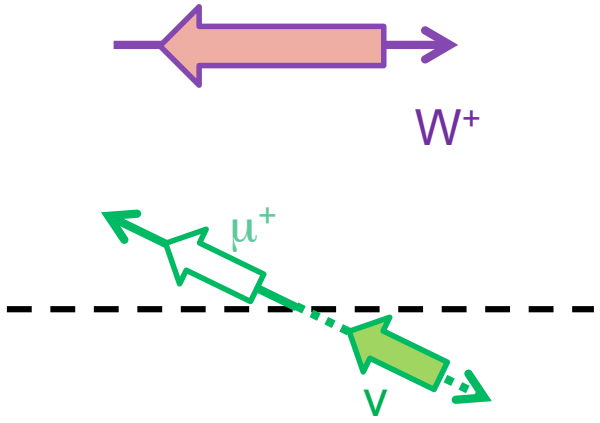
- Within uncertainties, no dependence of W production vs. centrality observed in PbPb collisions
- Individual R_{AA} for W^+ and W^- reflect the different u & d quark content in Pb and proton → isospin effect

Different $\mu^{\pm}$ distributions vs. η

- W are boosted in the valence quark direction (away from midrapidity)



- Spin conservation
  - μ^+ (μ^-) are boosted back to (away from) midrapidity
  - Asymmetric μ^+ and μ^- distributions varying with pseudorapidity



→ Different acceptances for W^+ and W^-

Muon charge asymmetry

- Muon charge asymmetry :

$$\frac{N(W^+) - N(W^-)}{N(W^+) + N(W^-)}$$

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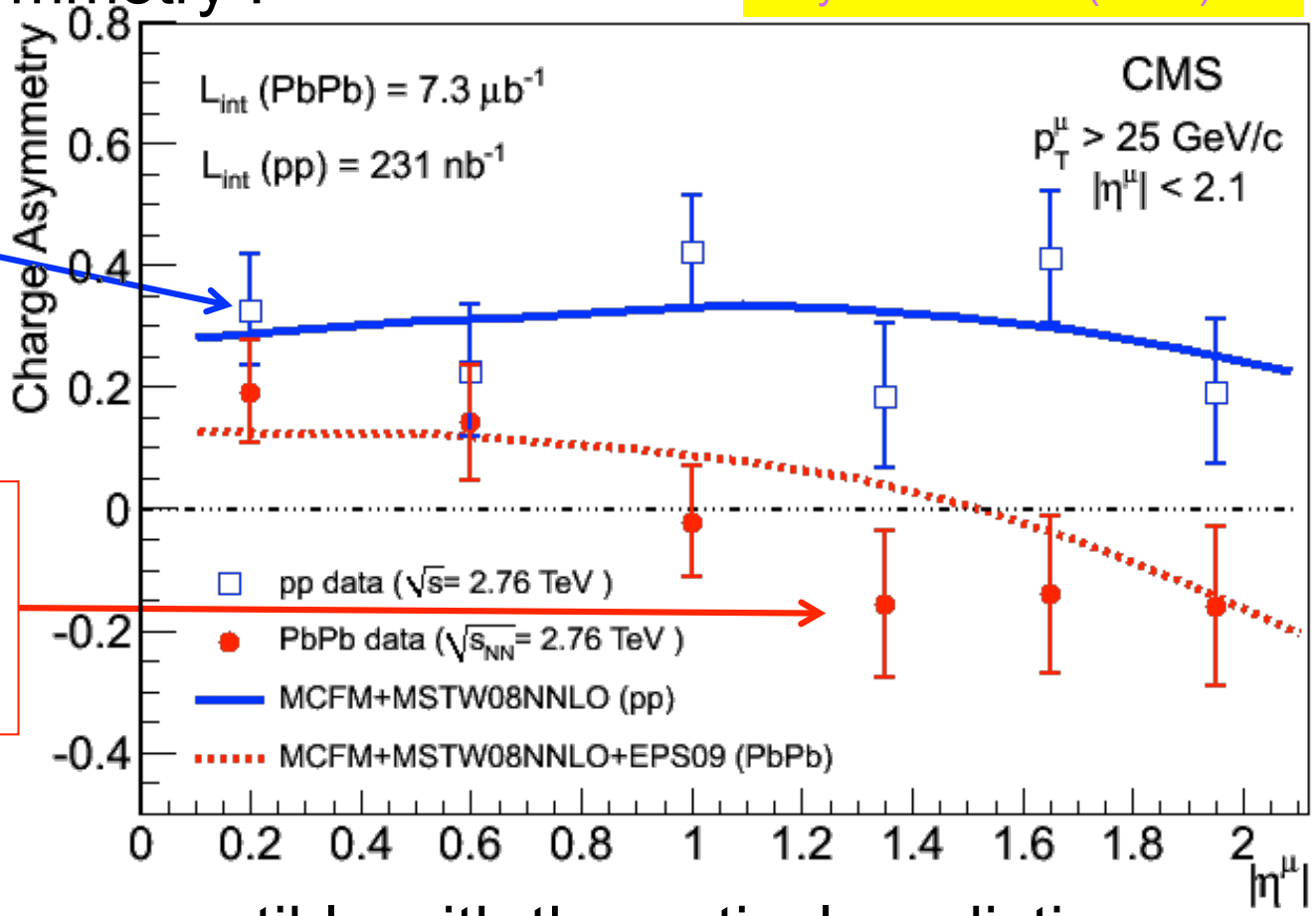
pp : W^+ production higher than W^-

PbPb : Predominance of W^- production for large muon rapidities



Experimental values compatible with theoretical predictions :

- MCFM calculation (@NLO) + nucleon PDF (MSTW08) (pp data)
- + [nuclear PDF (EPS09)] (PbPb data)

Conclusion

- Within uncertainties, no modification of W and Z production is observed with respect to theoretical NLO pQCD p-p cross sections scaled by elementary nucleon-nucleon collisions
- Confirm Glauber model validity in nucleus-nucleus collisions
- W^+ and W^- yields in PbPb collisions exhibit an isospin effect as expected, enhancement for W^- production and reduction of W^+ with respect to that measured in pp collisions at same $\sqrt{s}$
- Muon charge asymmetry evaluated in PbPb and pp collisions. In agreement with NLO pQCD calculation