Electroweak bosons in CMS

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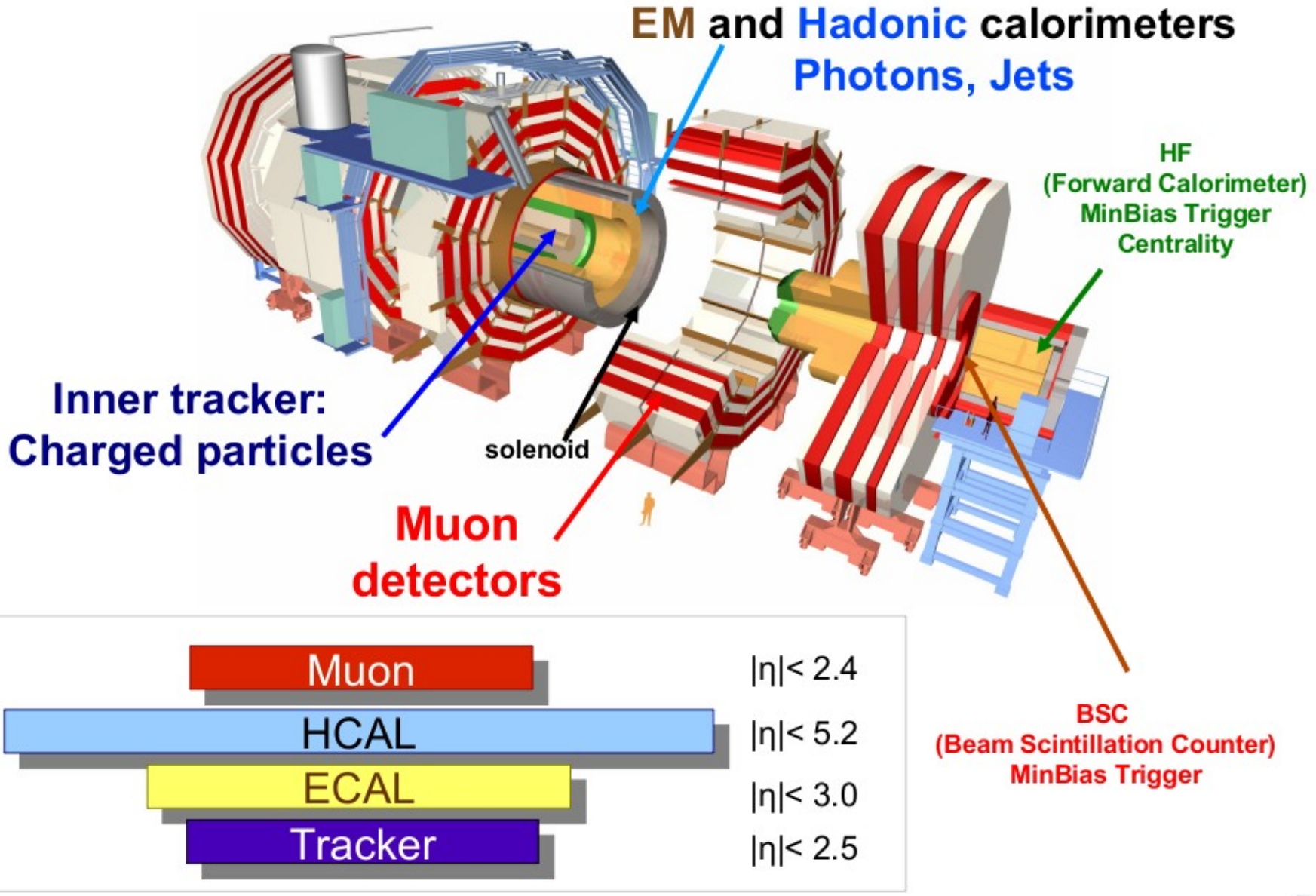
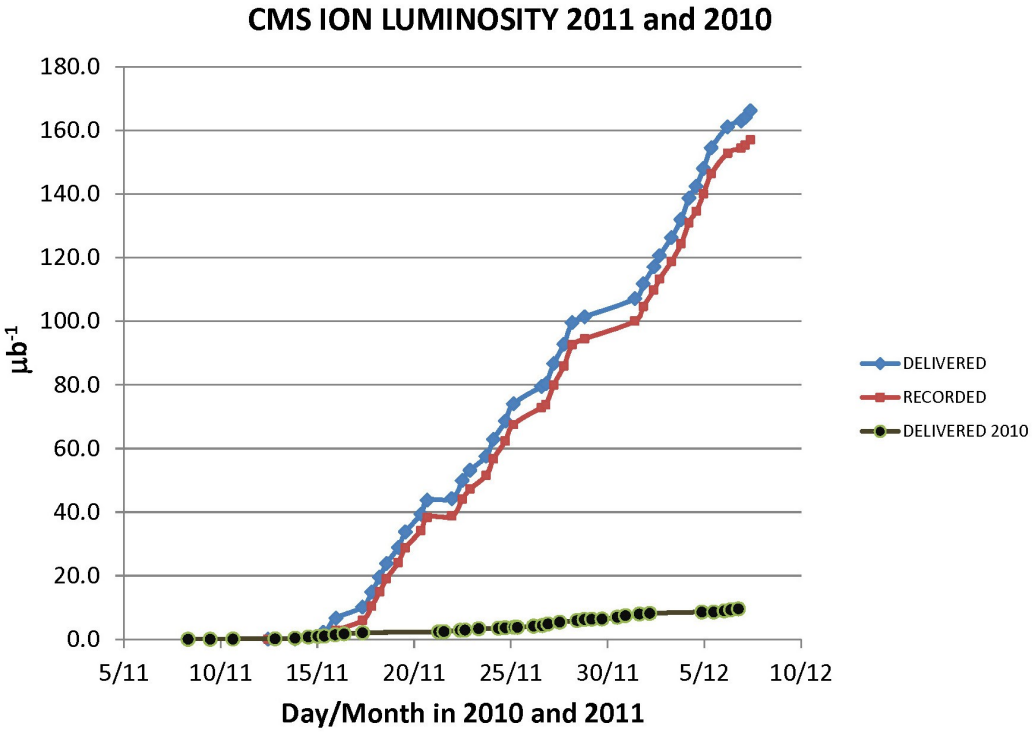
for the CMS Collaboration

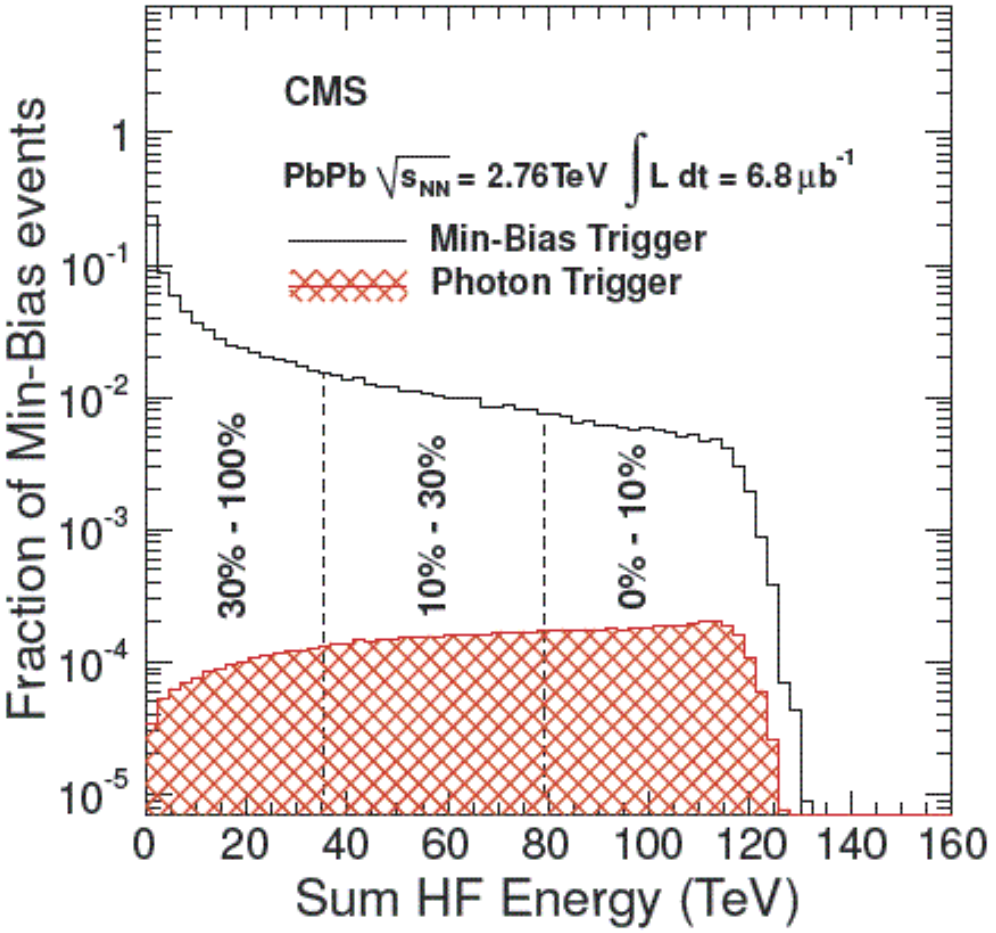
International Conference on the Initial Stages in High-Energy Nuclear Collisions, Illa da Toxa
9-14. September 2013

CMS detector



PbPb collisions in CMS





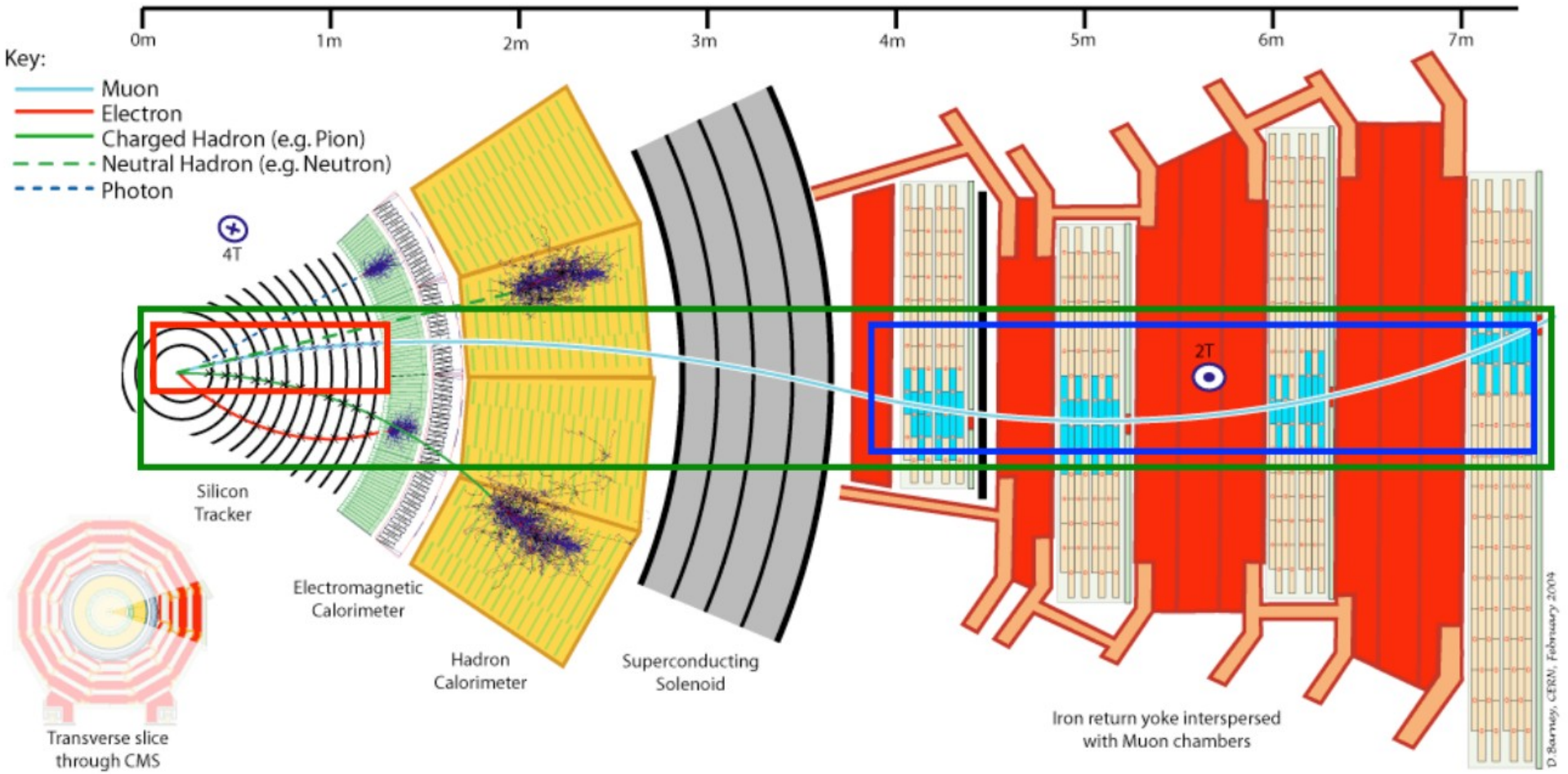
- The total hadronic cross section is divided into centrality classes
- The corresponding impact parameter and number of binary collisions comes from Glauber model calculations

Introduction to EWK bosons

- LHC energies allow for first measurements of Z and W bosons in heavy ion collisions
- Electroweak bosons are essentially not perturbed by the QCD medium
  - At first order, check the binary scaling hypothesis
  - Serve as a reference to modified processes (jets...)
  - Second order modifications ultimately constrain initial state (npdf)
- Isolated photons
  - From 2010: PLB 710 (2012) 256
  - From 2011: PLB 718 (2013) 773, photon+jet
- Z in muon and electron channel
  - From 2010: PRL 106 (2011) 212301
  - From 2011: CMS-PAS-HIN-12-008 and CMS-PAS-HIN-13-004
- W in muon channel
  - From 2010: PLB 715 (2012) 66

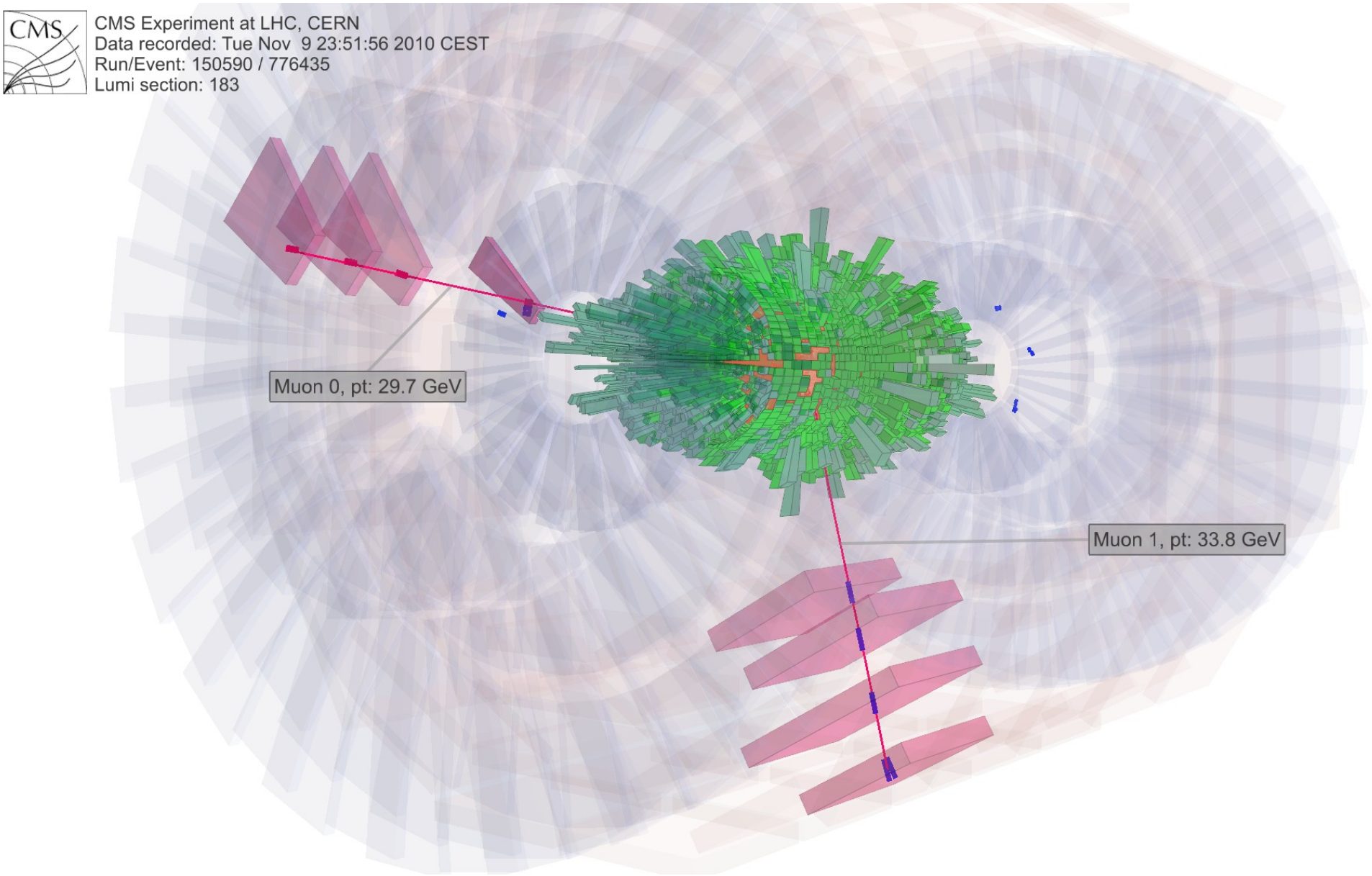
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN

Muon reconstruction



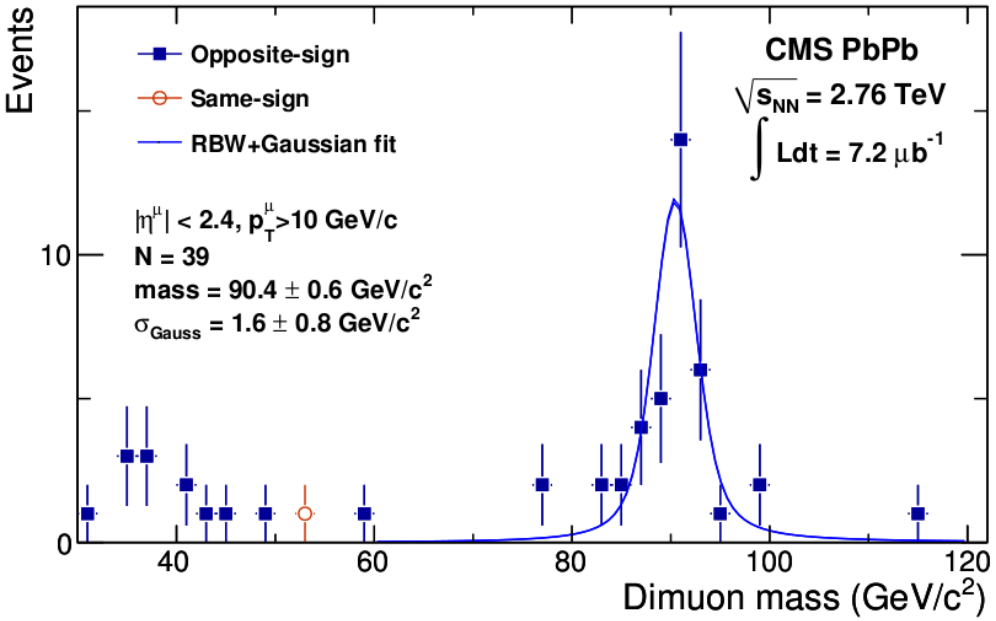
- Global muons reconstructed with information from inner tracker and muon stations
- Good resolution for high p_T muons

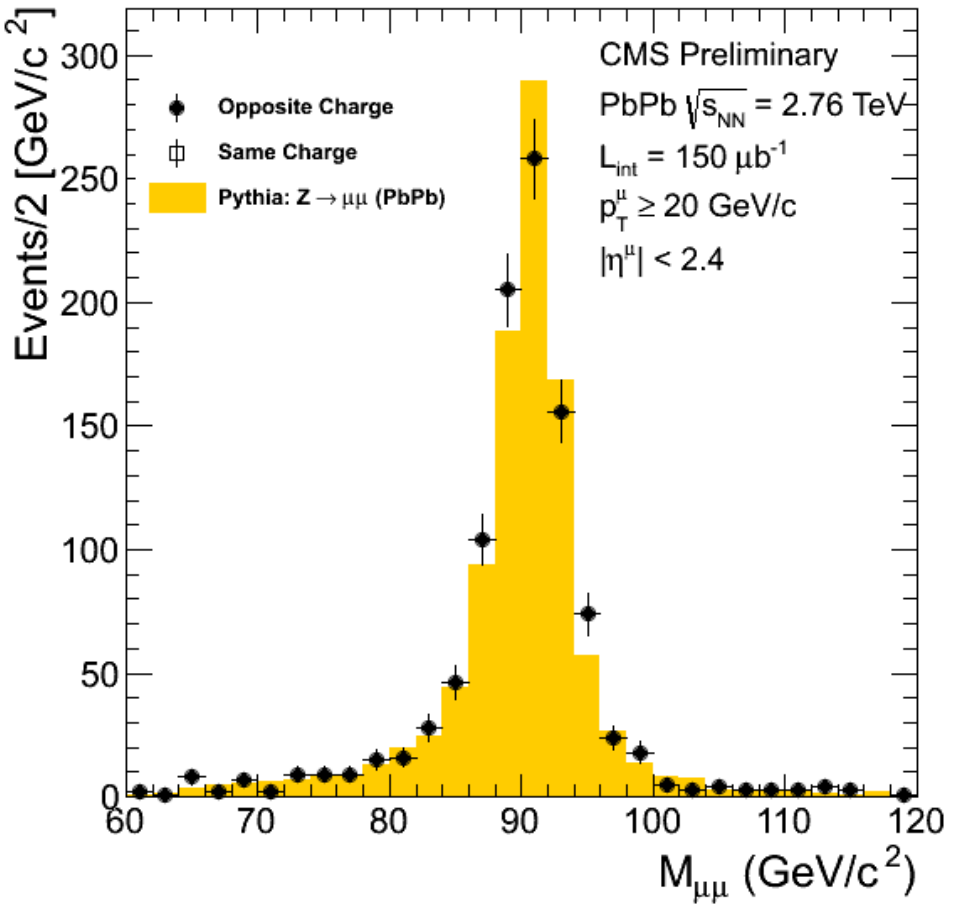
First $Z \rightarrow \mu^+\mu^-$ candidate in PbPb



Z production in muon channel

PRL 106 (2011) 212301
CMS-PAS-HIN-13-004



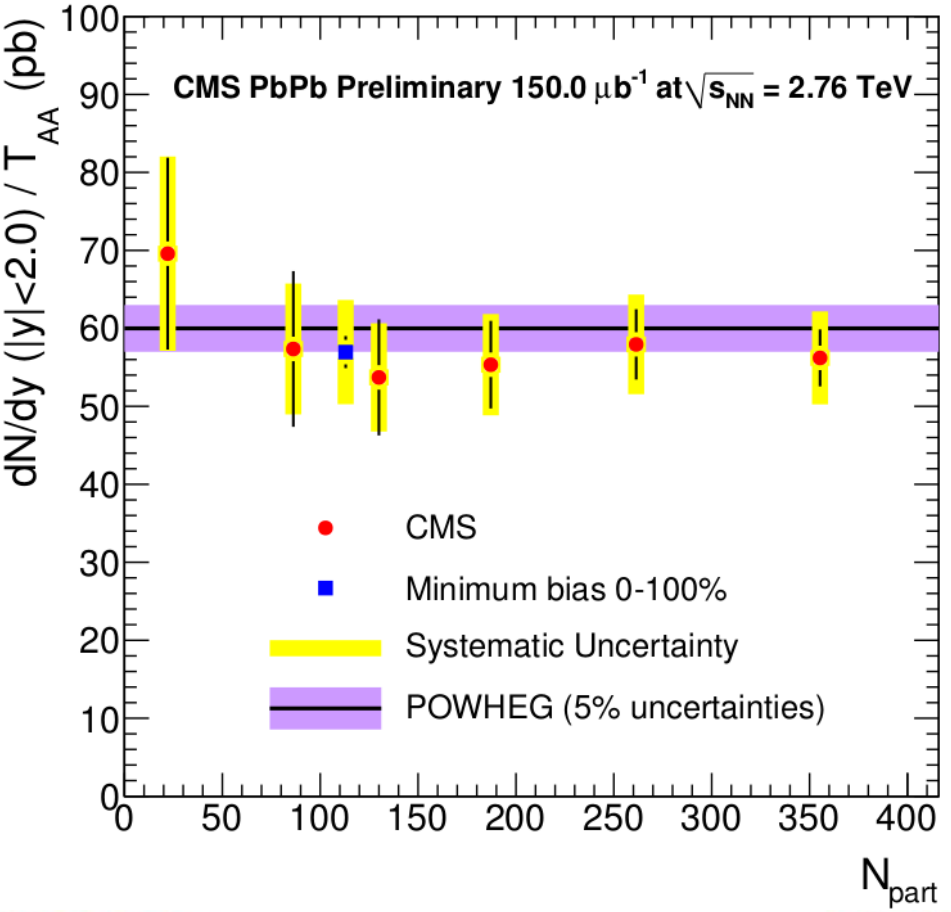


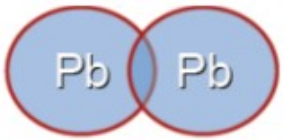
- 2010: 39 Z candidates
  - $p_T^{\mu} > 10$ GeV/c
- 2011: 1022 Z candidates
  - $p_T^{\mu} > 20$ GeV/c
  - $|\eta^{\mu}| < 2.4$

Z production in muon channel

CMS-PAS-HIN-12-008

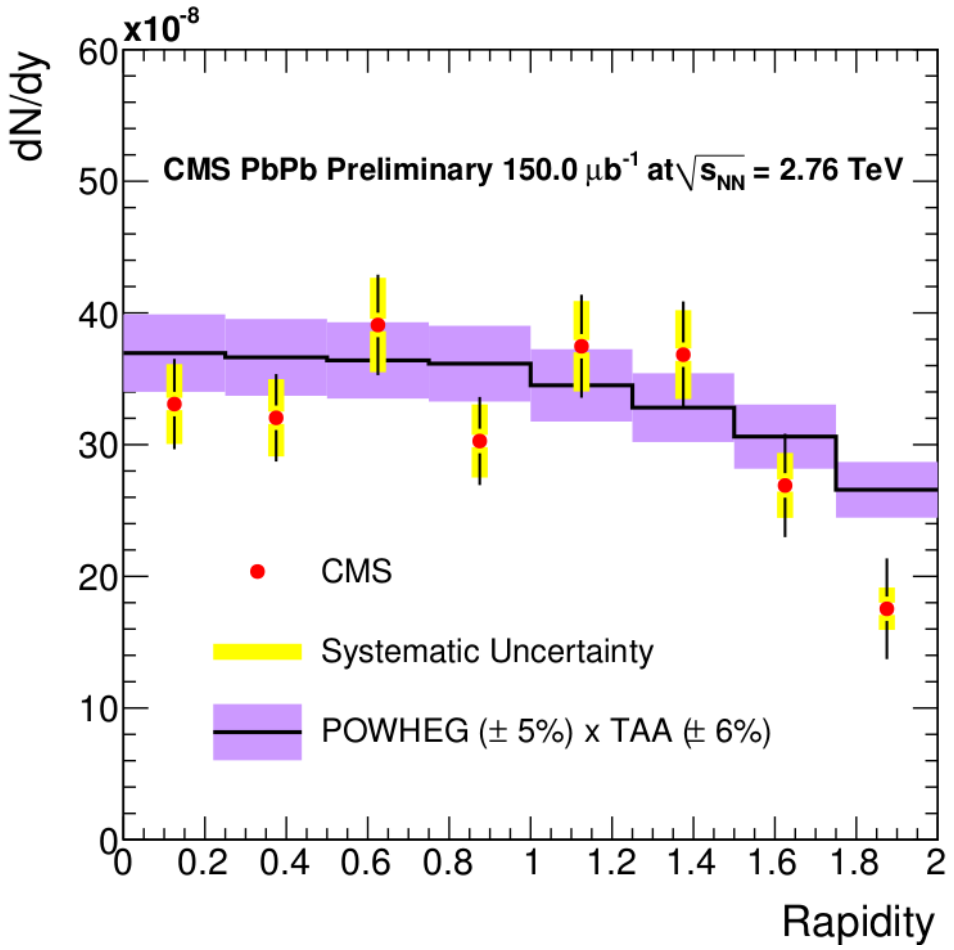
- Z production scales with number of binary nucleon-nucleon collisions
- Comparison with **POWHEG** NLO generator
  - Good description of data at LHC and Tevatron energies

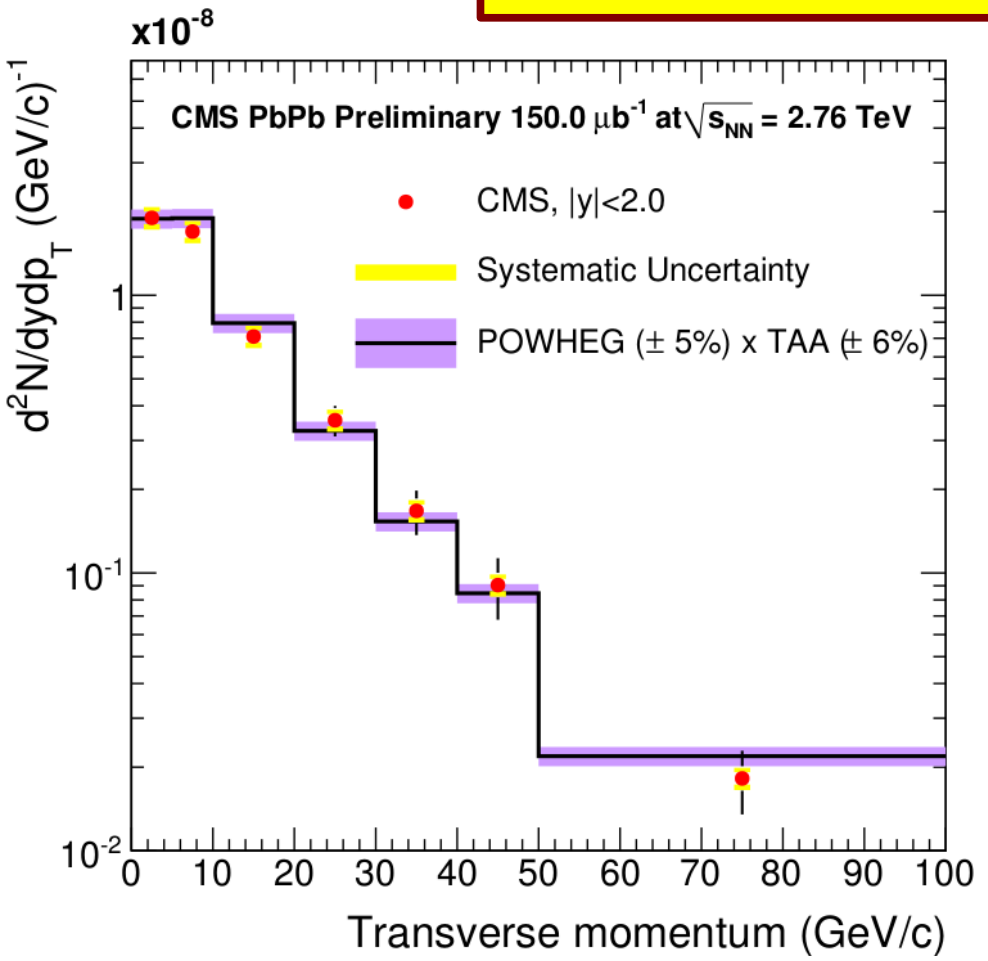




Z production in muon channel

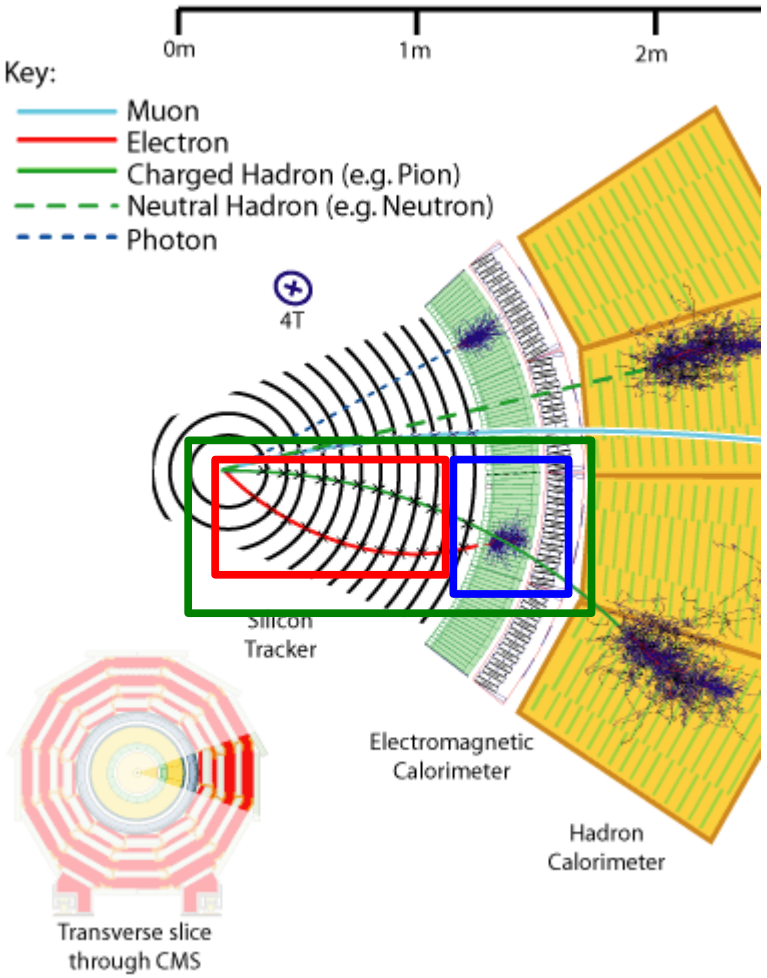
CMS-PAS-HIN-12-008





- Differential measurement with 2011 statistics
- No large deviations from the POWHEG reference

Electron reconstruction

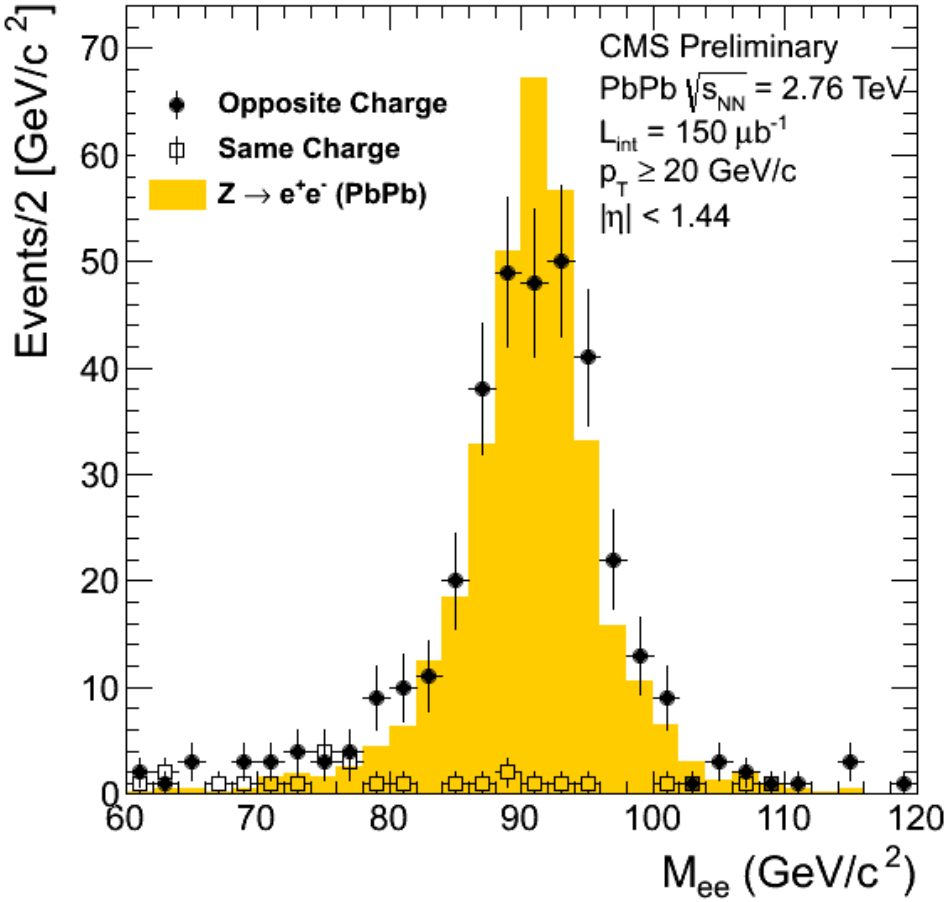


- Seeded by supercluster in ECAL
- Inner track reconstructed from the outside with radiation taken into account
- Electron candidate a supercluster matched to an inner track

Z production in electron channel

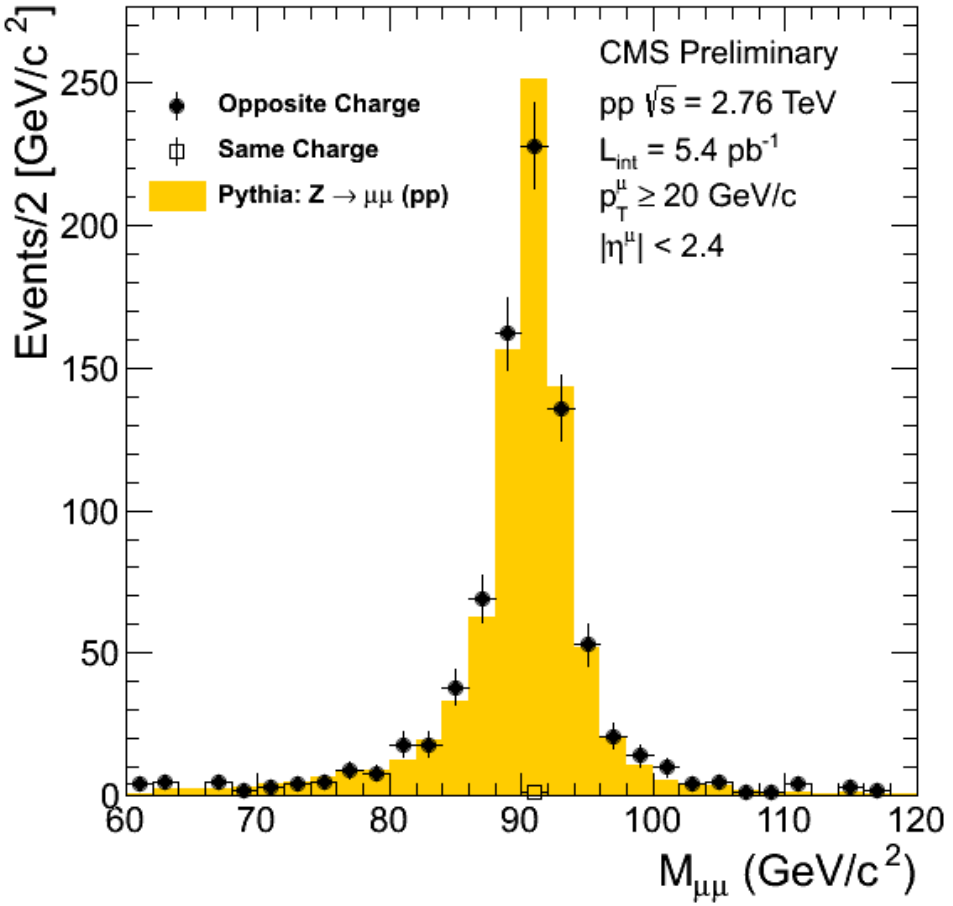
CMS-PAS-HIN-13-004

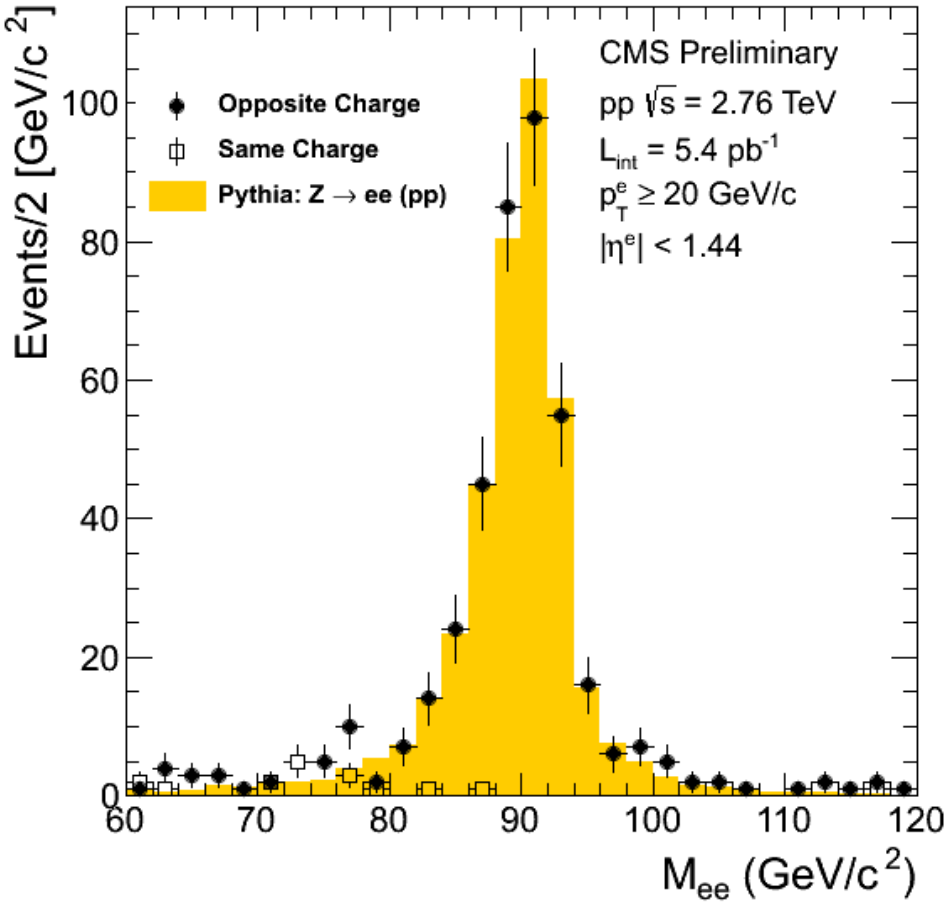
- Electron selection:
  - p_T^e > 20 GeV/c
  - $|\eta^e|$ < 1.44 only ECAL Barrel
  - Shower shape used to reject photons
  - HCAL used to reject QCD jet background
- Background well described by same sign pairs
- 328 Z candidates



Z production in pp collisions

CMS-PAS-HIN-13-004



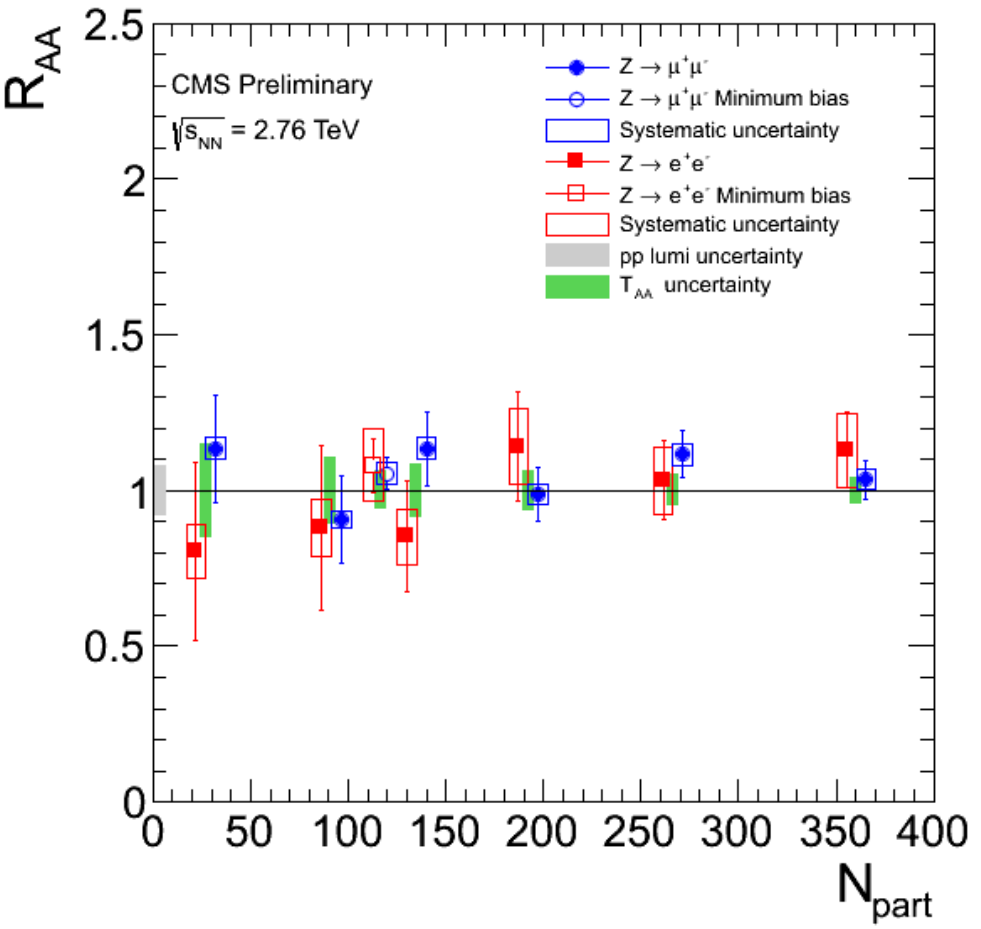


- Reference data from 2013 February L_{int} = 5.35 pb^{-1}
- Direct measurement of nuclear modification factor (R_{AA}) possible

Nuclear modification factor

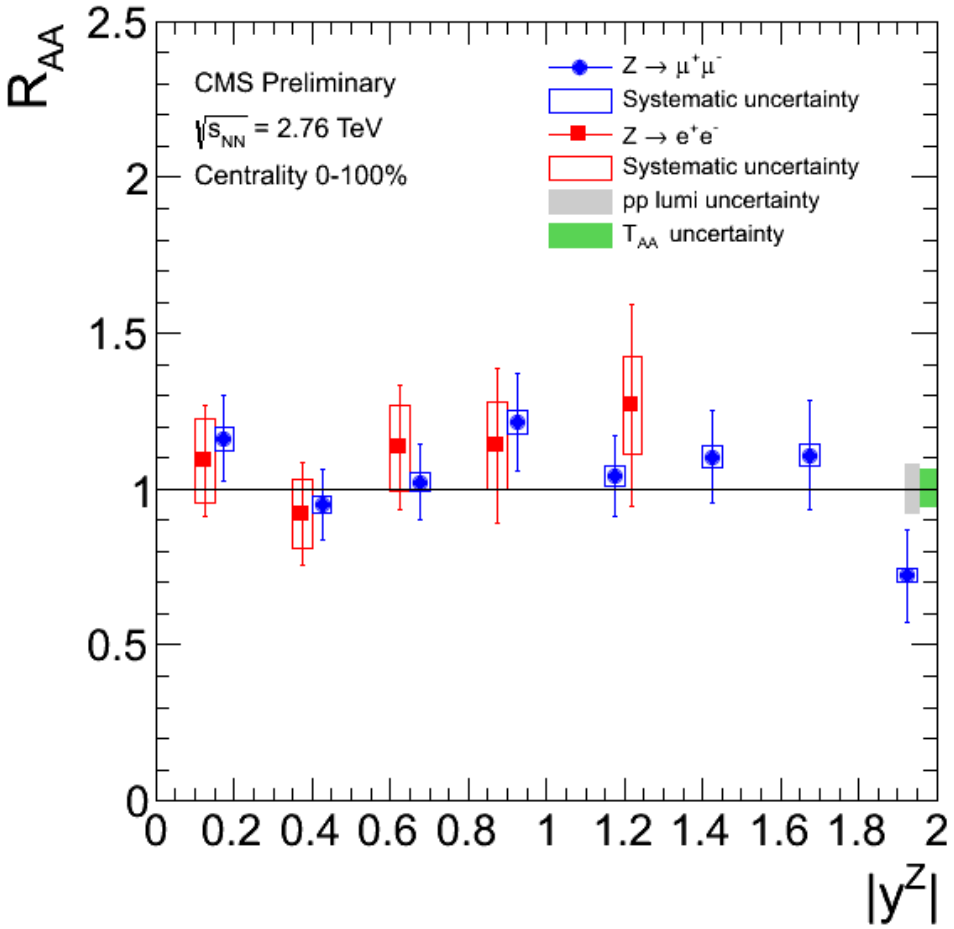
CMS-PAS-HIN-13-004

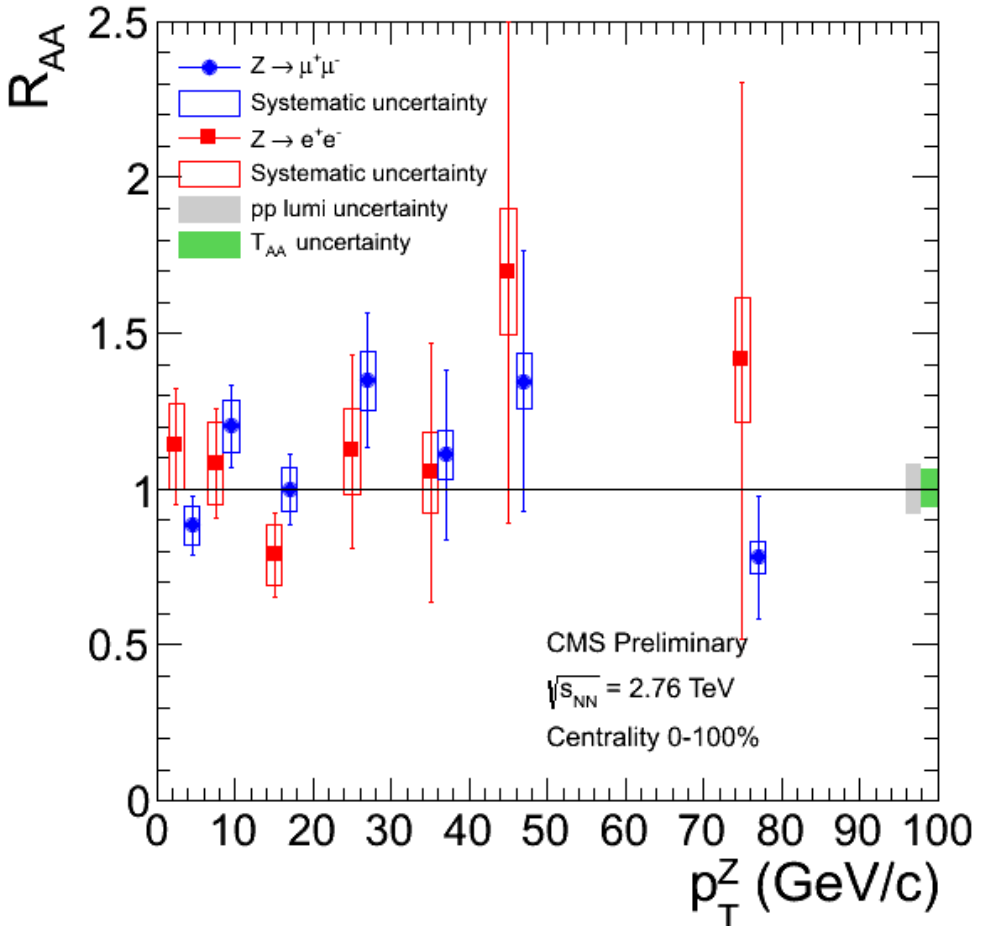
- $dN_{AA} / T_{AA} = d\sigma^{pp} \times R_{AA}$
- T_{AA}: nuclear overlap function from Glauber-model calculations
- R_{AA} (muon) = 1.06 ± 0.05 ± 0.11
- R_{AA} (electron) = 1.08 ± 0.09 ± 0.14
- The two leptonic decay channels are in agreement
- Z production (as expected) scales with T_{AA}



Nuclear modification factor

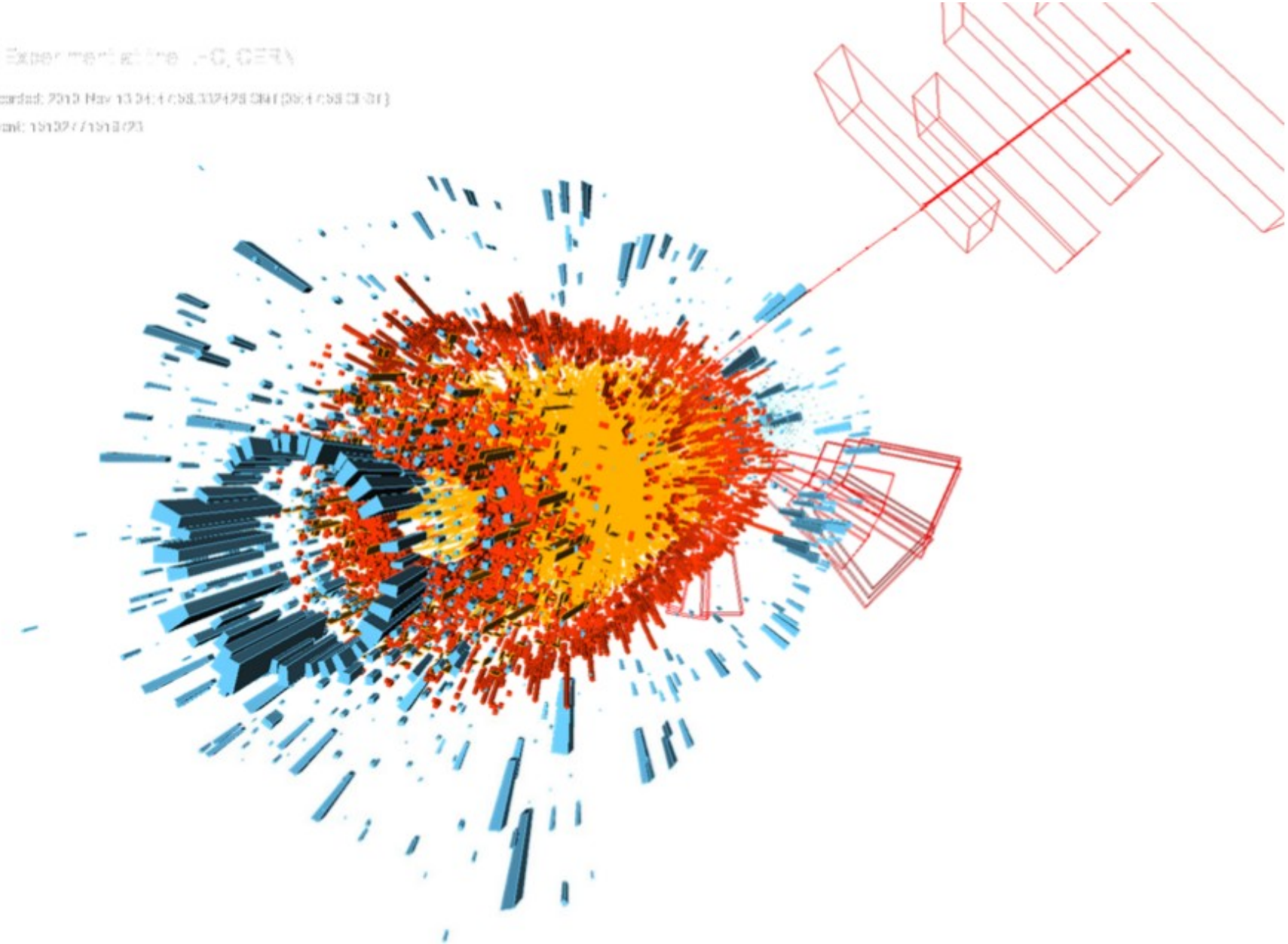
CMS-PAS-HIN-13-004





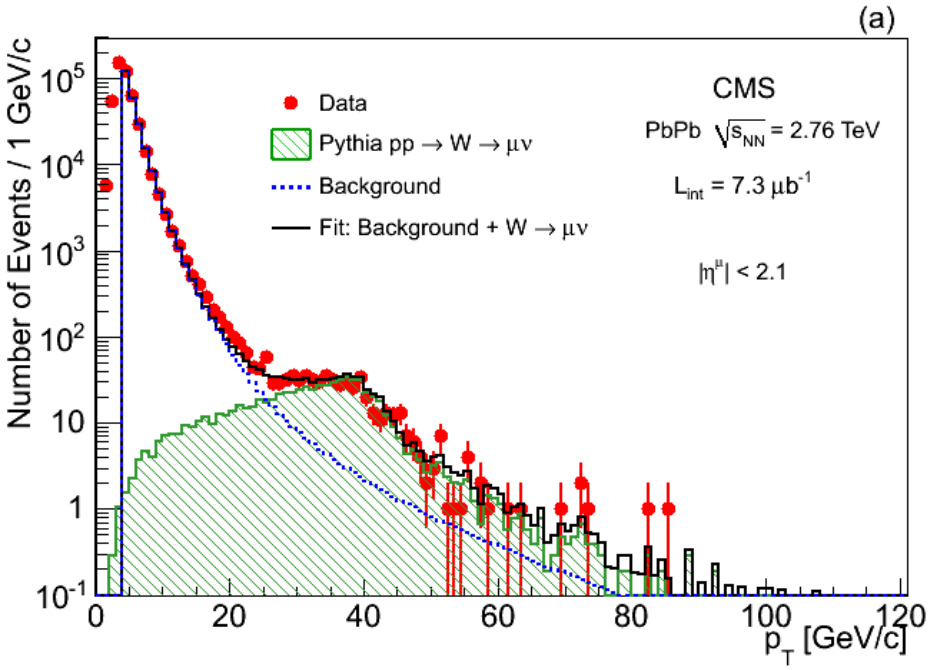
- Split in rapidity and p_T
- Possible nuclear effects are within the uncertainties of the measurements

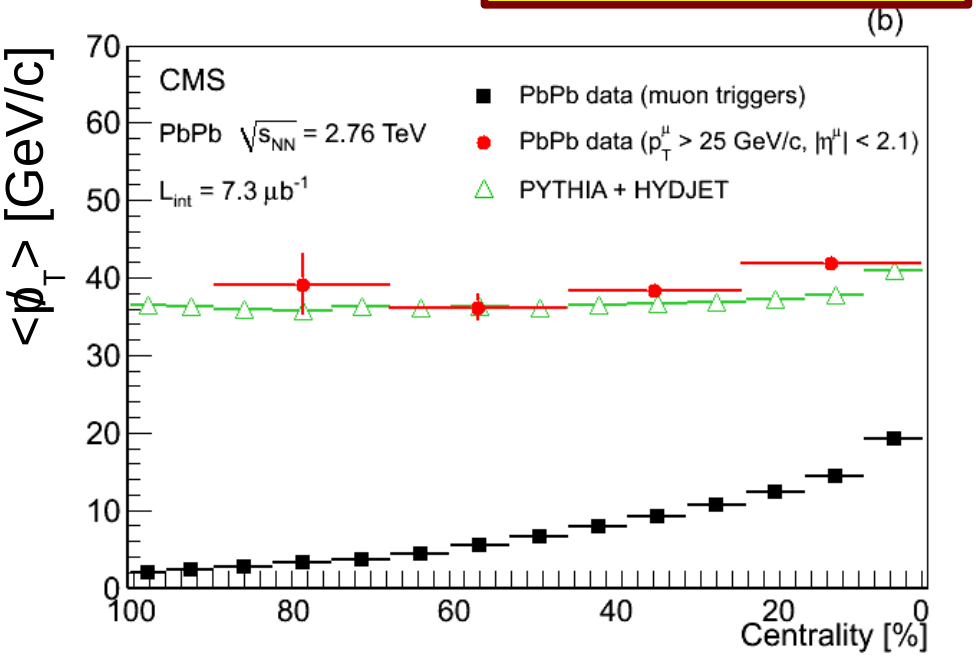
W → μν boson candidate



W boson production

PLB 715 (2012) 66

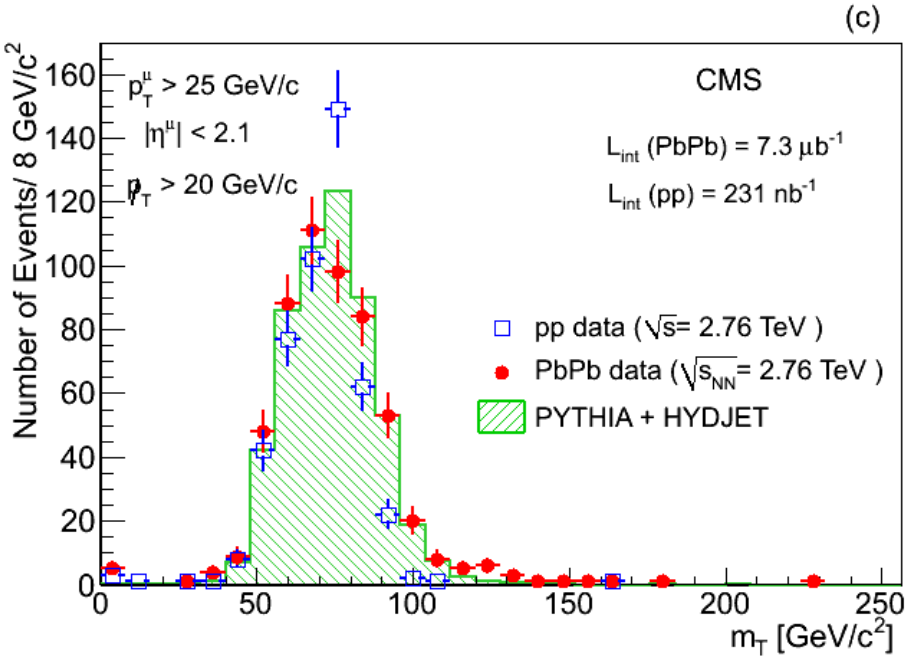




- W signal visible in single muon p_T spectrum
- Simple missing p_T calculated from p_T > 3 GeV tracks in the event
- W candidate selection with one muon p_T > 25 GeV, $|\eta|$ < 2.1, missing p_T > 20 GeV and veto on Z candidates

W boson production

PLB 715 (2012) 66



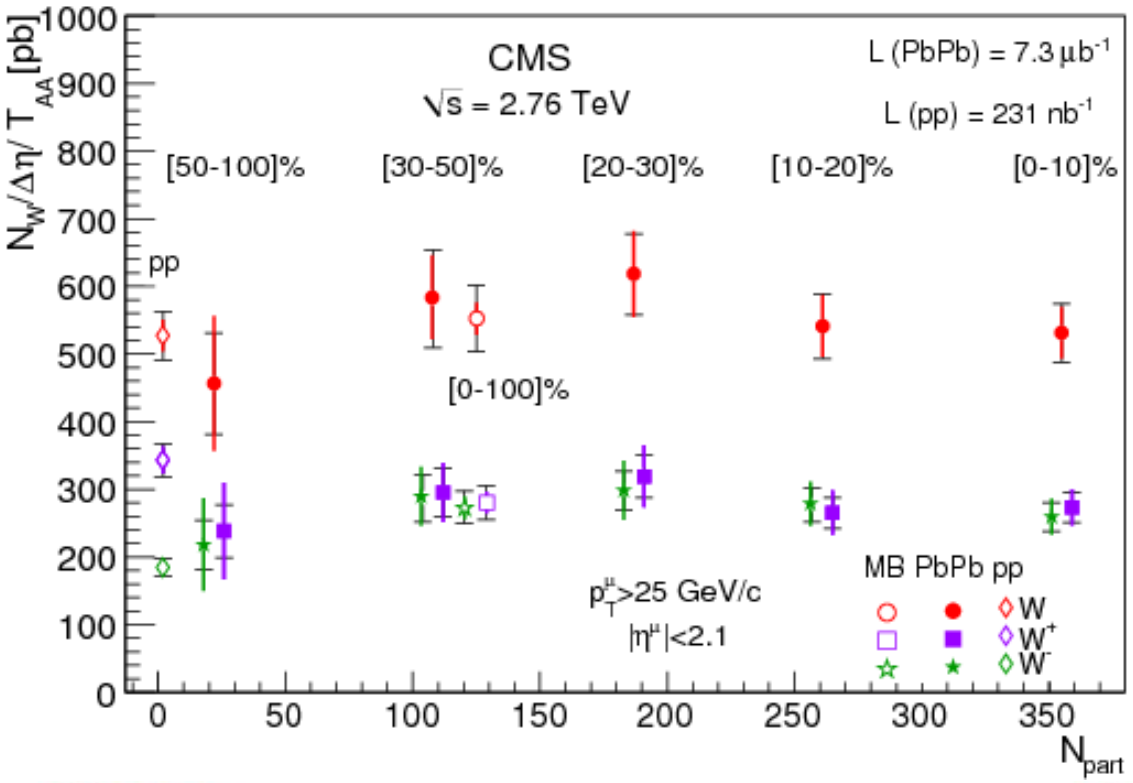
- Transverse mass reconstructed from the muon and missing p_T measurements
- W candidates at 2.76 TeV

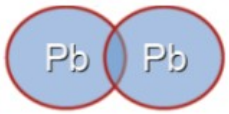
	PbPb 2010	pp 2011
W^+	275	301
W^-	264	165

W boson production

PLB 715 (2012) 66

- Less W^+ and more W^- produced in PbPb, then in pp → isospin effect
- 2010 PbPb statistics ≈ 2011 pp statistics at 2.76 TeV center-of-mass energy / nucleon pair





$$dN_{AA} / T_{AA} = d\sigma^{pp} \times R_{AA}$$

R_{AA} (W) = 1.04 ± 0.07 ± 0.12

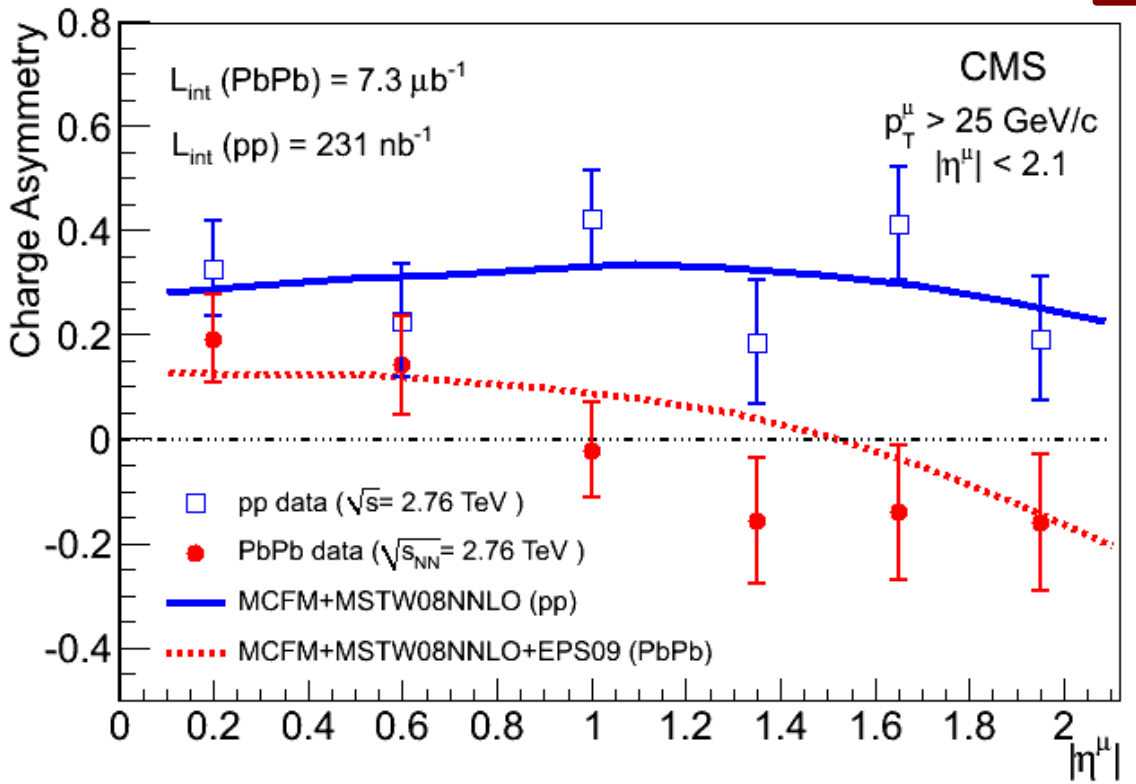
R_{AA} (W^+) = 0.82 ± 0.07 ± 0.09

R_{AA} (W^-) = 1.46 ± 0.14 ± 0.16

Consistent with isospin effect

W boson production

PLB 715 (2012) 66



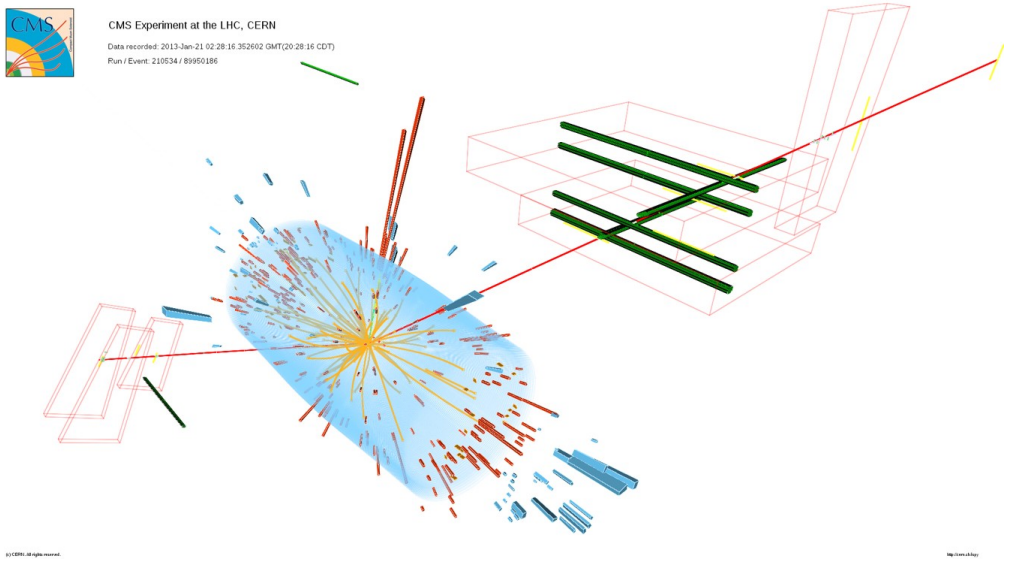
- Charge asymmetry = (N(W^+) - N(W^-)) / (N(W^+) + N(W^-))
- pp: W^+ higher than W^-
- PbPb: W^- dominates for large $|\eta^\mu|$
- Experimental values compatible with NLO pQCD predictions

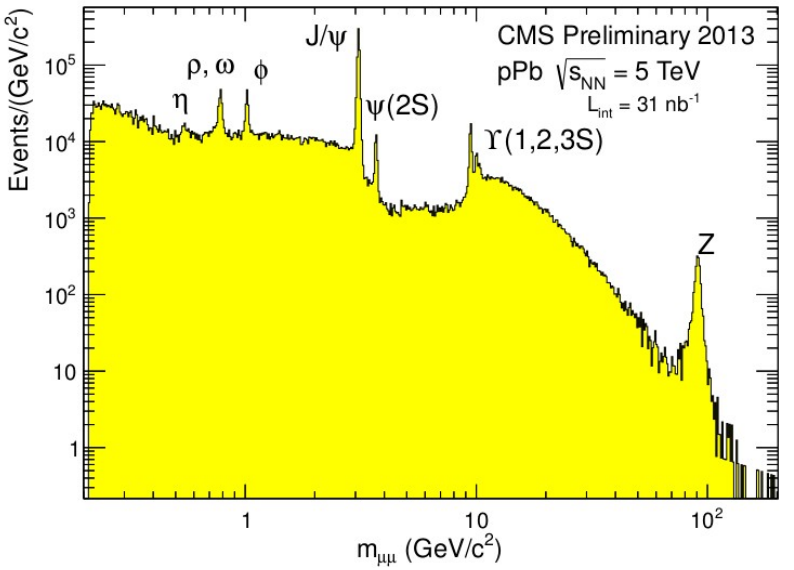
Summary

- Z and W boson production is **unmodified** by the hot QCD medium produced in heavy ion collisions
- Electroweak boson production yield **scales** with the number of binary nucleon-nucleon collisions
- Measurement of **nuclear modification factor** of Z and W bosons in **muon** channel and Z bosons in **electron** channel does not show large deviations from 1
- Nuclear effects (isospin, shadowing, etc.) on Z production are small with respect to uncertainties
- Strong **isospin effect** as expected when separating W^+ and W^-

Outlook

- **pPb collision data** taken in 2013
- Analysis of electroweak boson production ongoing
- Important input for **nuclear PDFs**
- **Z+jet** measurements in future PbPb and pPb data will give further insights to jet quenching and nuclear effects





Thank you for your attention!

CMS Heavy-ion results

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN