

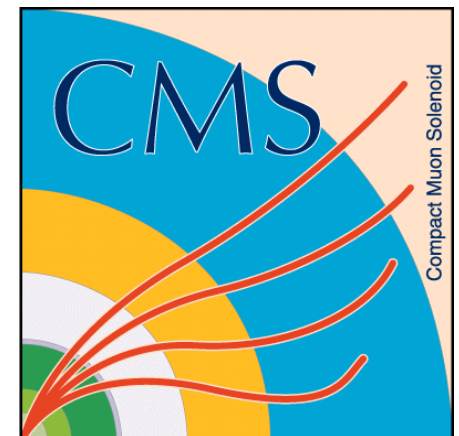
Results on photon and electroweak boson production in PbPb collisions

Anna Julia Zsigmond

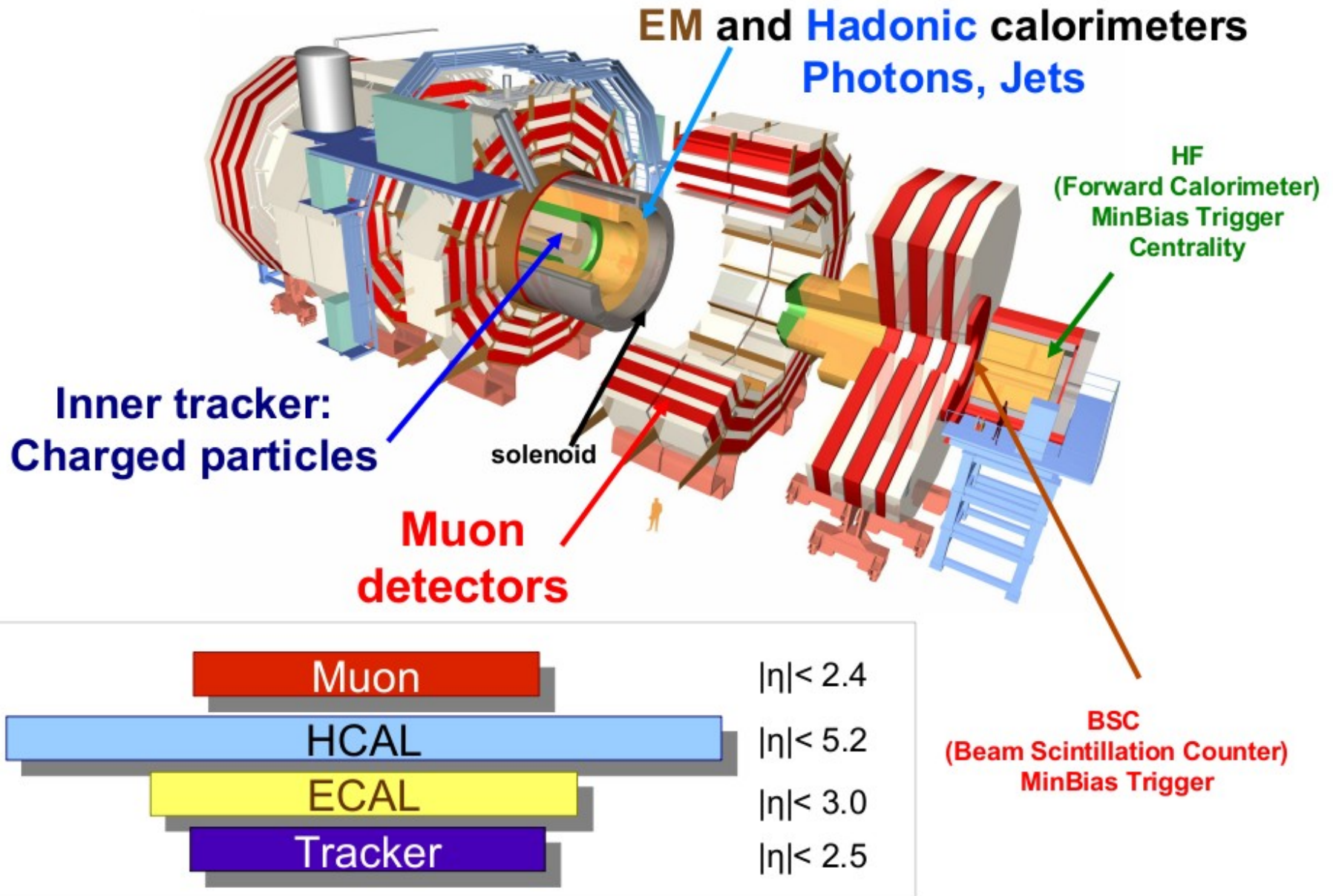
Wigner RCP and Eötvös Loránd University

for the **CMS Collaboration**

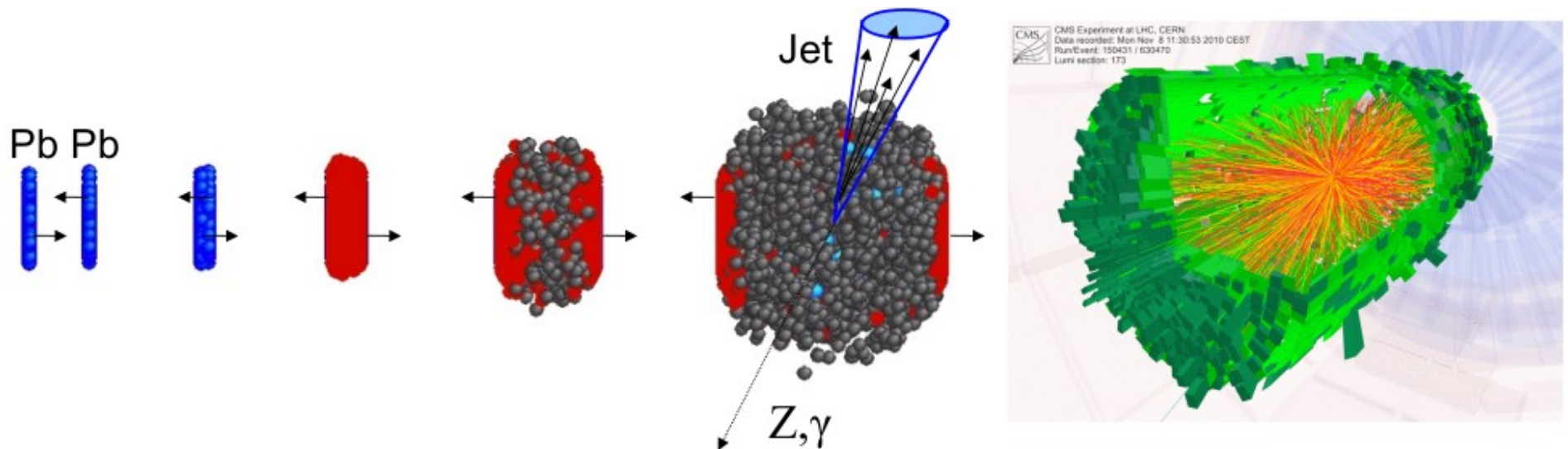
Zimányi School 2012



CMS detector



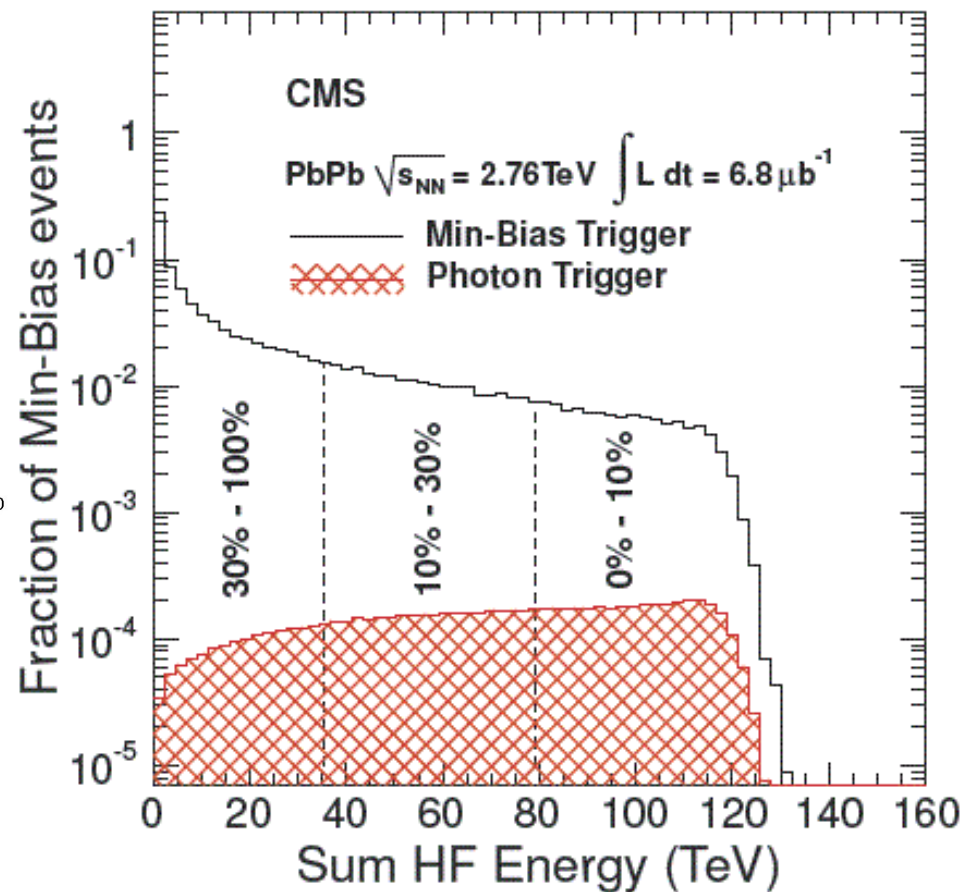
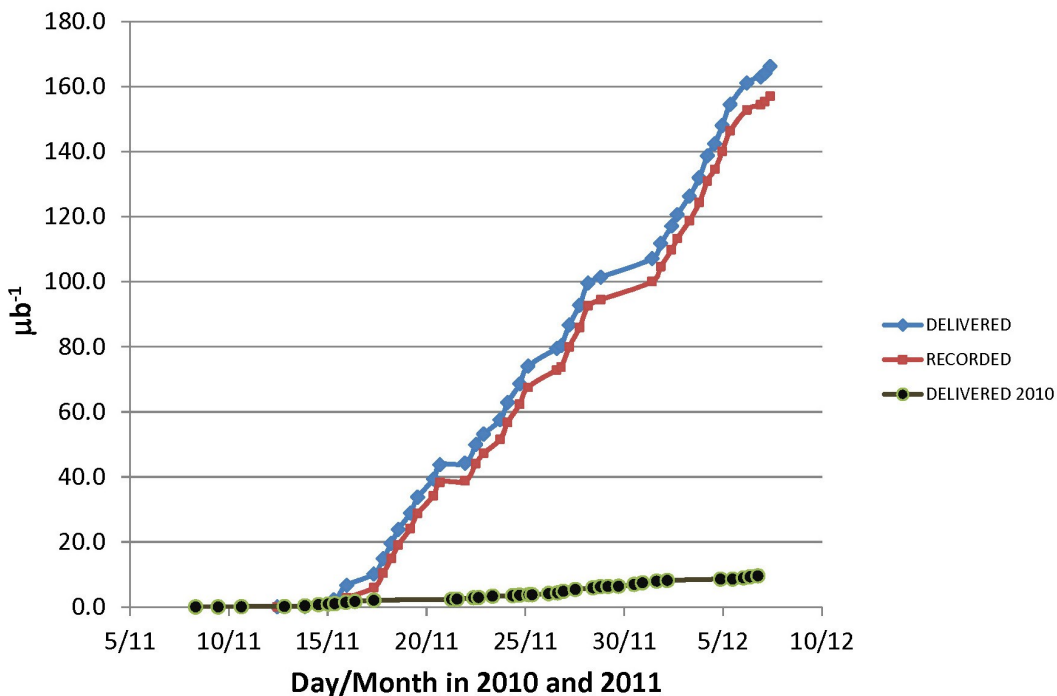
Studies of PbPb collisions



- Bulk properties: charged particle production, elliptic flow, two-particle correlations
- Study of the initial state: **Z, W and photons**
- Study of the medium properties:
 - Medium modification to hard probes (Yen-Jie's talk)
 - Quarkonium suppression

PbPb collisions in CMS

CMS ION LUMINOSITY 2011 and 2010



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



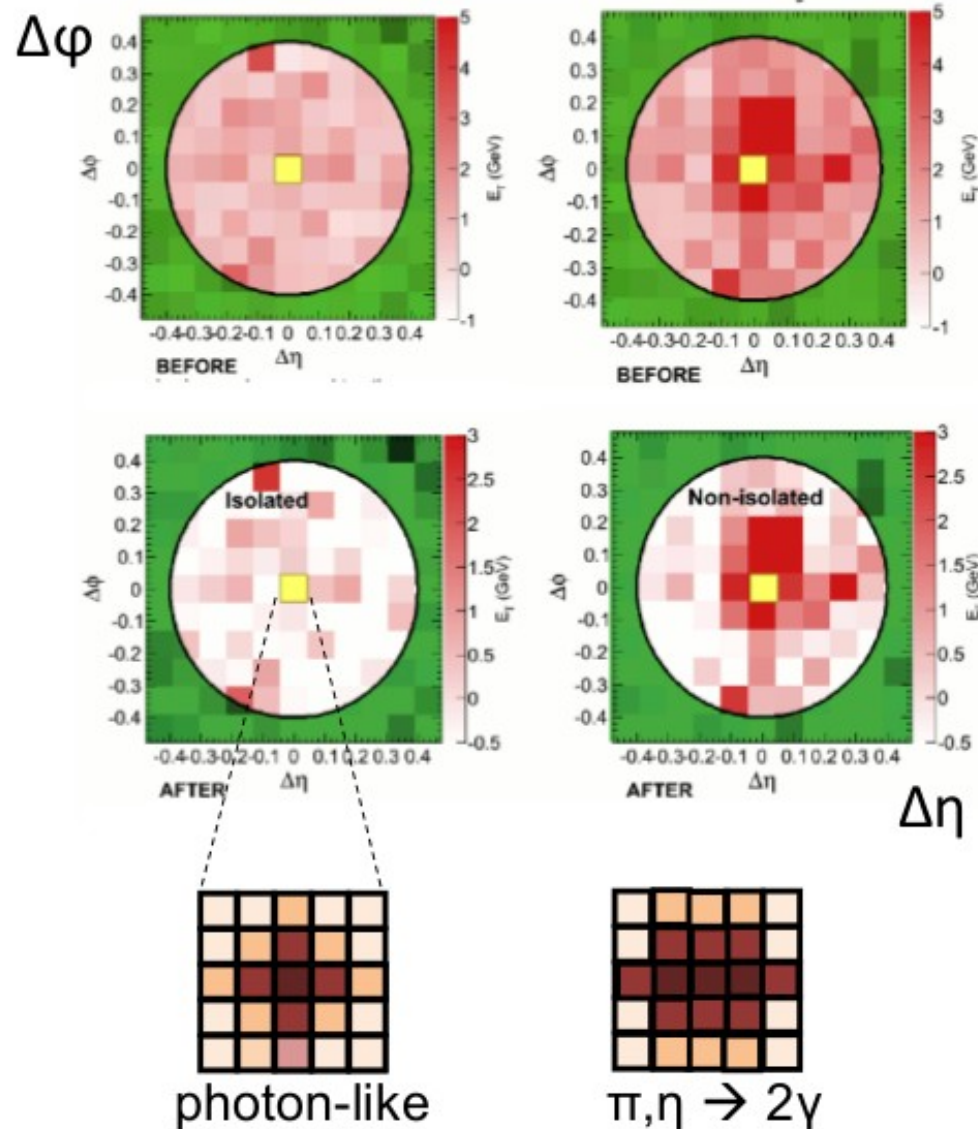
Introduction to EWK bosons

- Electroweak bosons (photon, Z, W) 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: accepted (in press) by PLB, photon+jet (Yen-Jie's talk)
- $Z \rightarrow \mu\mu$
 - From 2010: PRL 106 (2011) 212301
 - From 2011: PAS-HIN-12-008
- $W \rightarrow \mu\nu$
 - From 2010: PLB 715 (2012) 66

Isolated photons

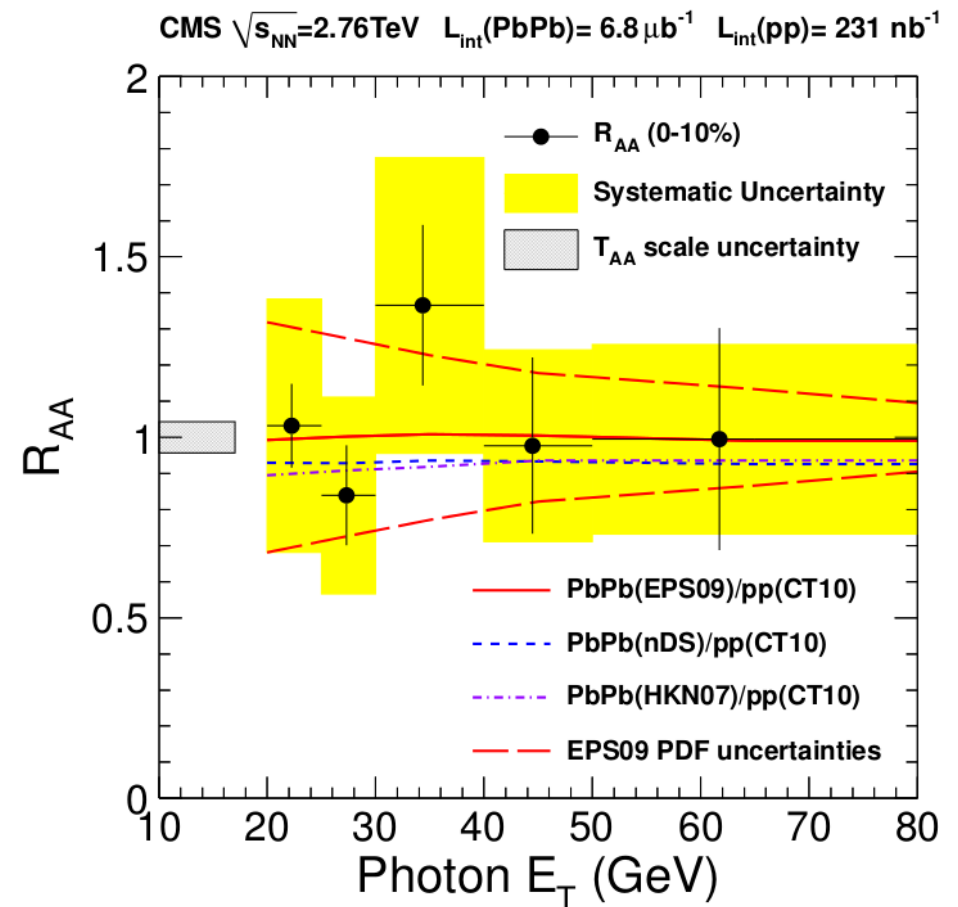
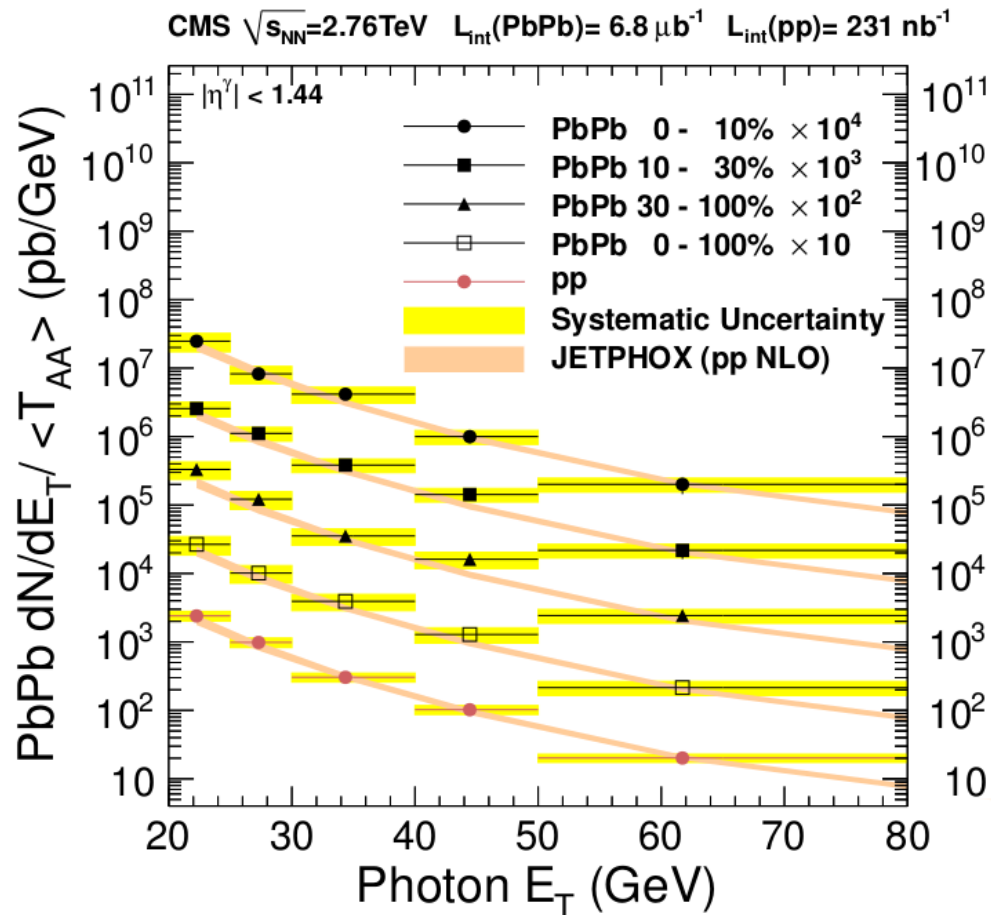
PLB 710 (2012) 256

- Trigger on ECAL clusters
 - Uncorrected $E_T > 15$ GeV, fully efficient for $E_T > 20$ GeV
- Subtract underlying event
 - From same pseudorapidity strip, event by event
- Look for isolated cluster
 - Remove photons from bremsstrahlung and jet fragmentation...
- Look at shower shape in the highly segmented ECAL
 - Further remove isolated π^0, η



Isolated photon spectra and R_{AA}

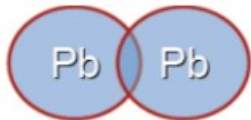
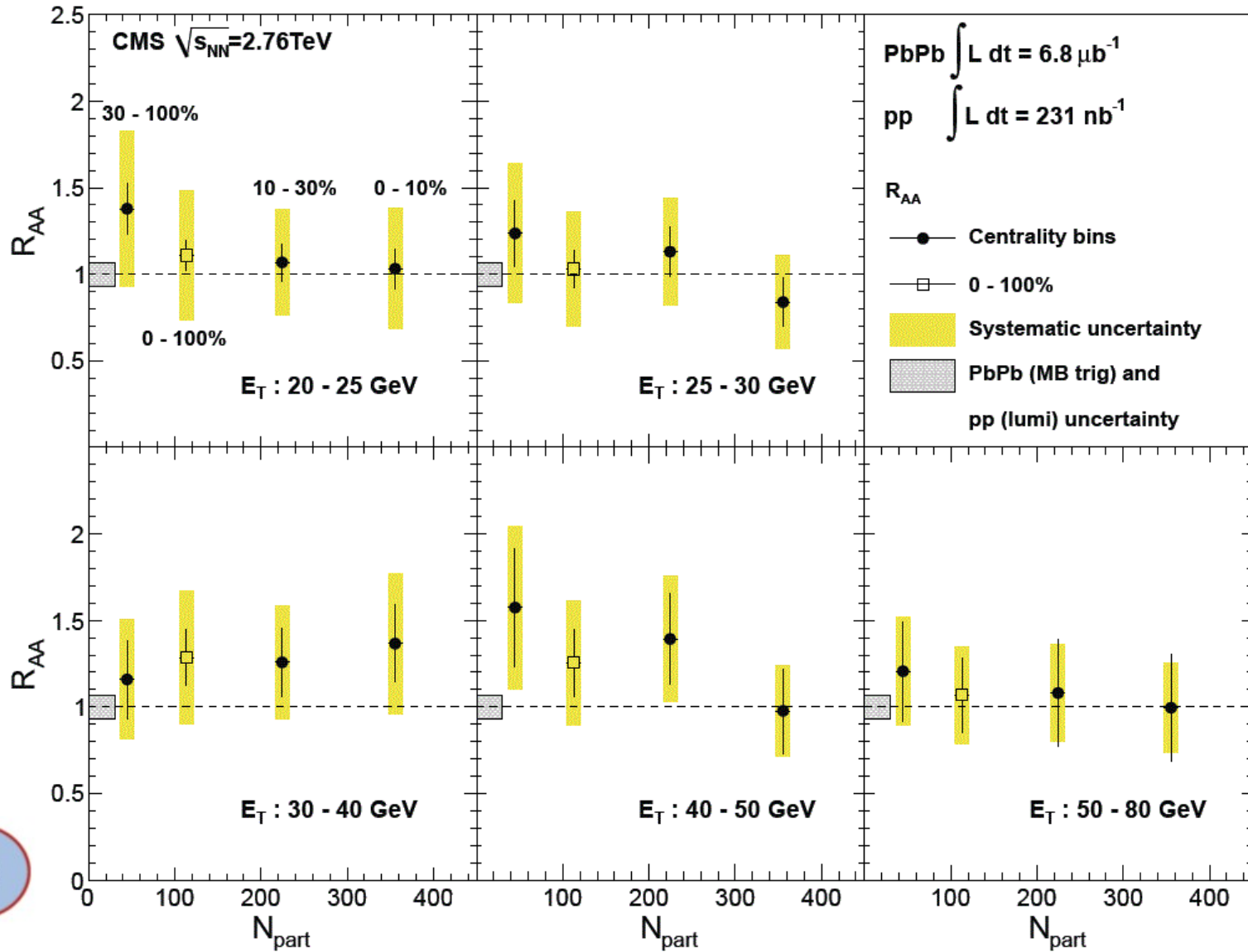
PLB 710 (2012) 256



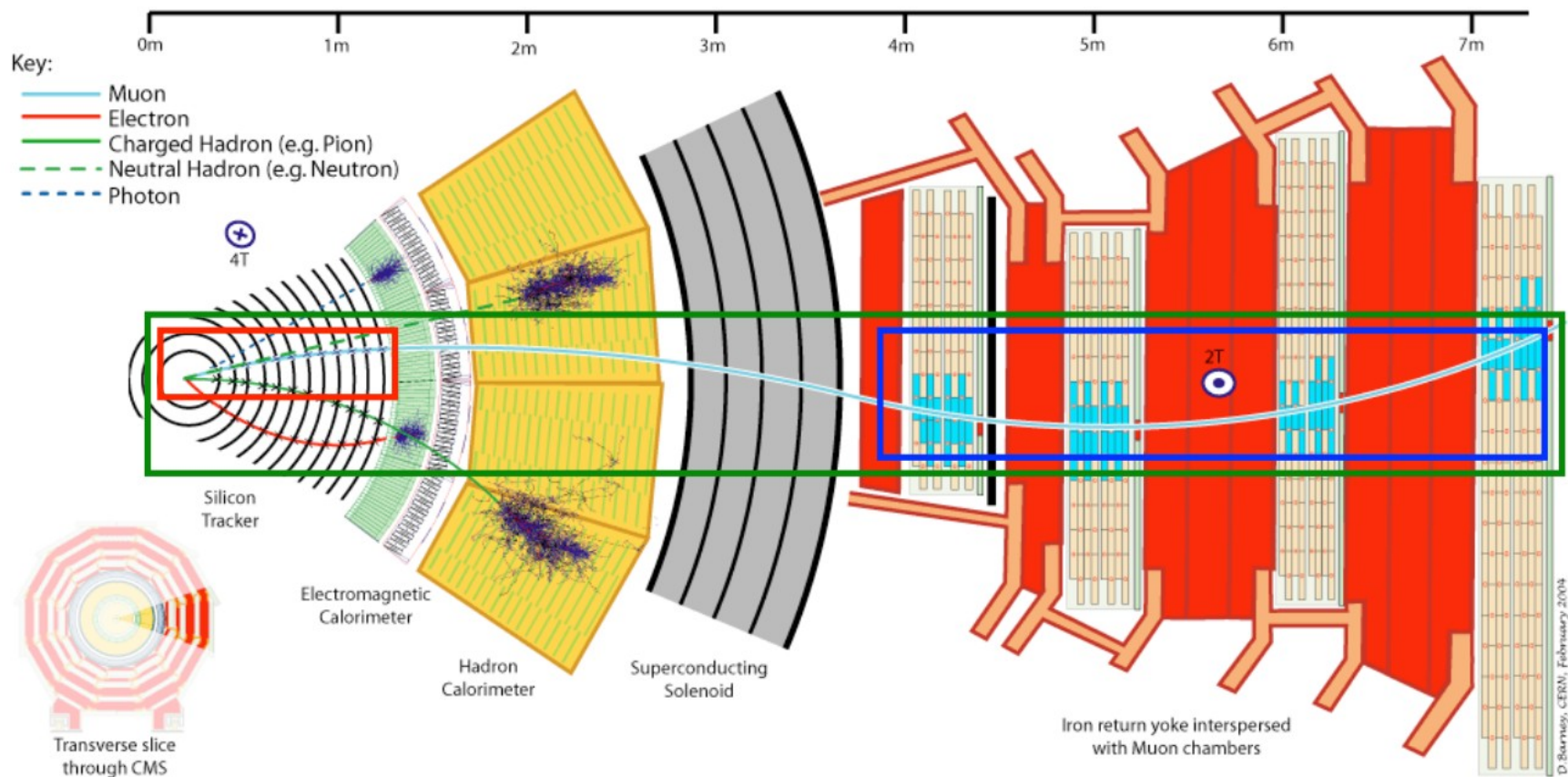
- Photons are not influenced by the strongly interacting matter
- Spectrum is consistent with NLO calculations

Centrality (in)dependence

PLB 710 (2012) 256



Muon reconstruction



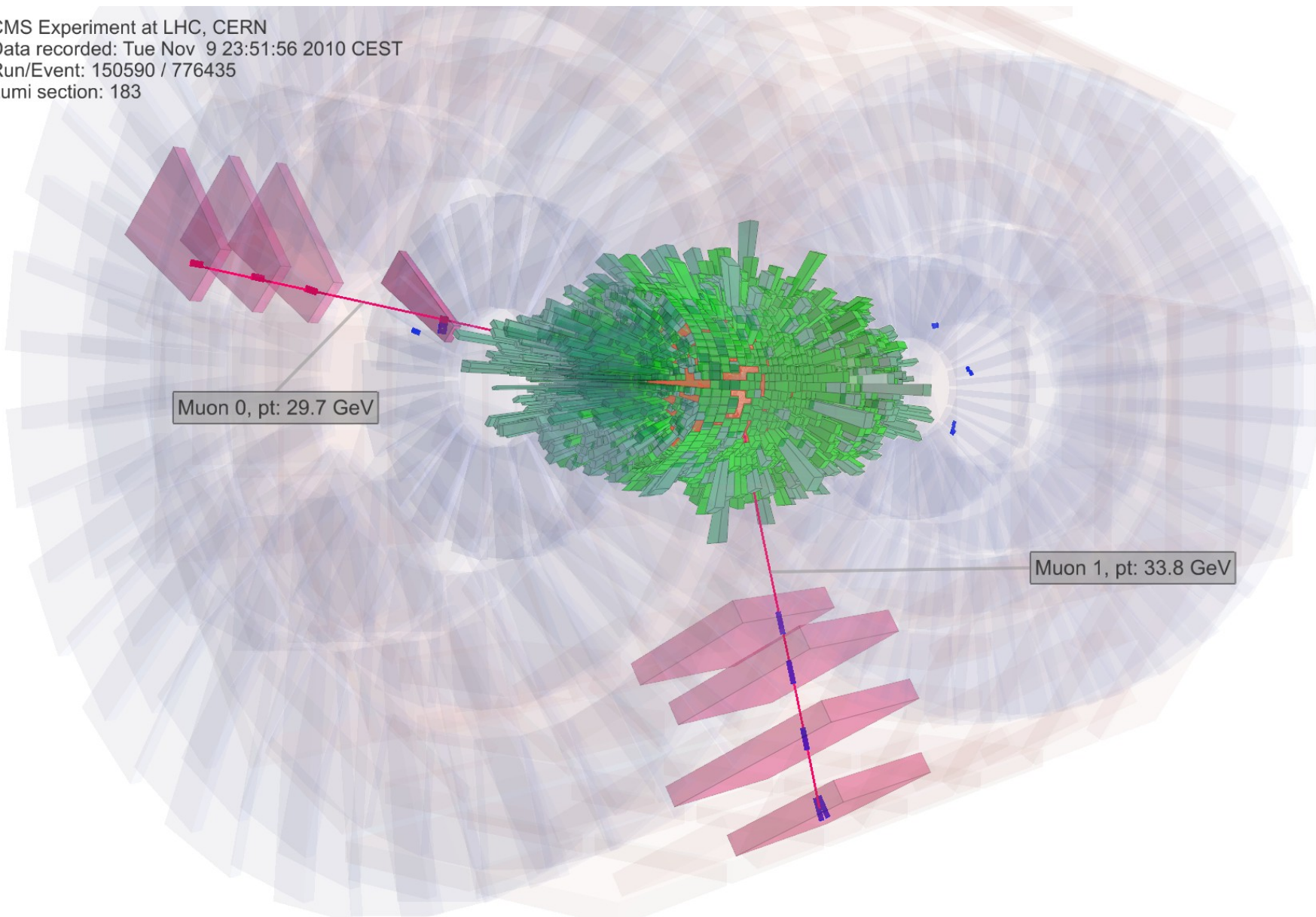
- Z and W bosons are identified through their muon decay channels
- **Global muons** reconstructed with information from **inner tracker** and **muon stations**



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

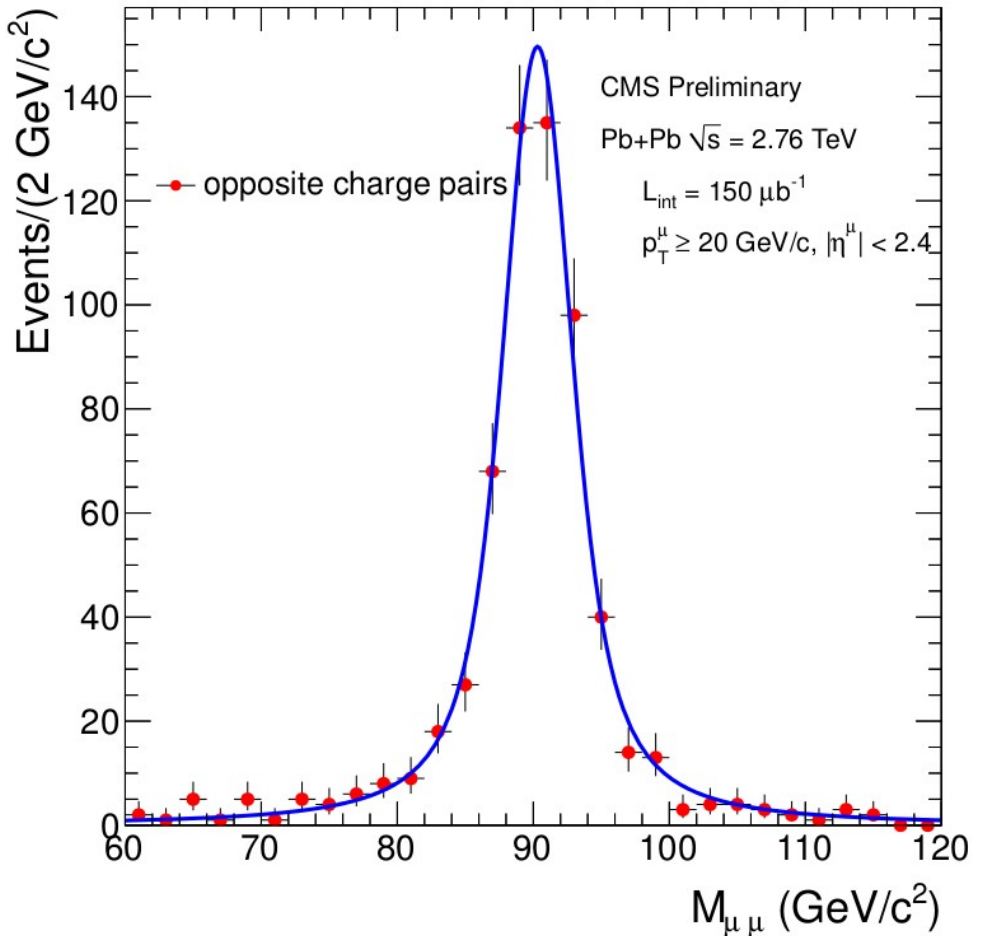
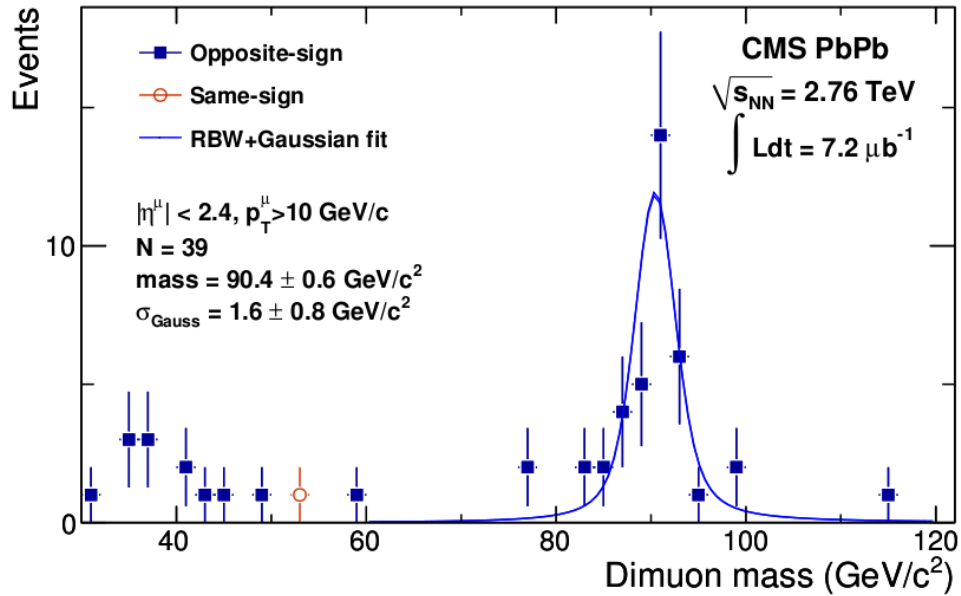


CMS Experiment at LHC, CERN
Data recorded: Tue Nov 9 23:51:56 2010 CEST
Run/Event: 150590 / 776435
Lumi section: 183



Z boson production

PRL 106 (2011) 212301
CMS-PAS-HIN-12-008

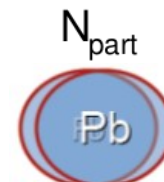
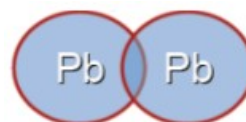
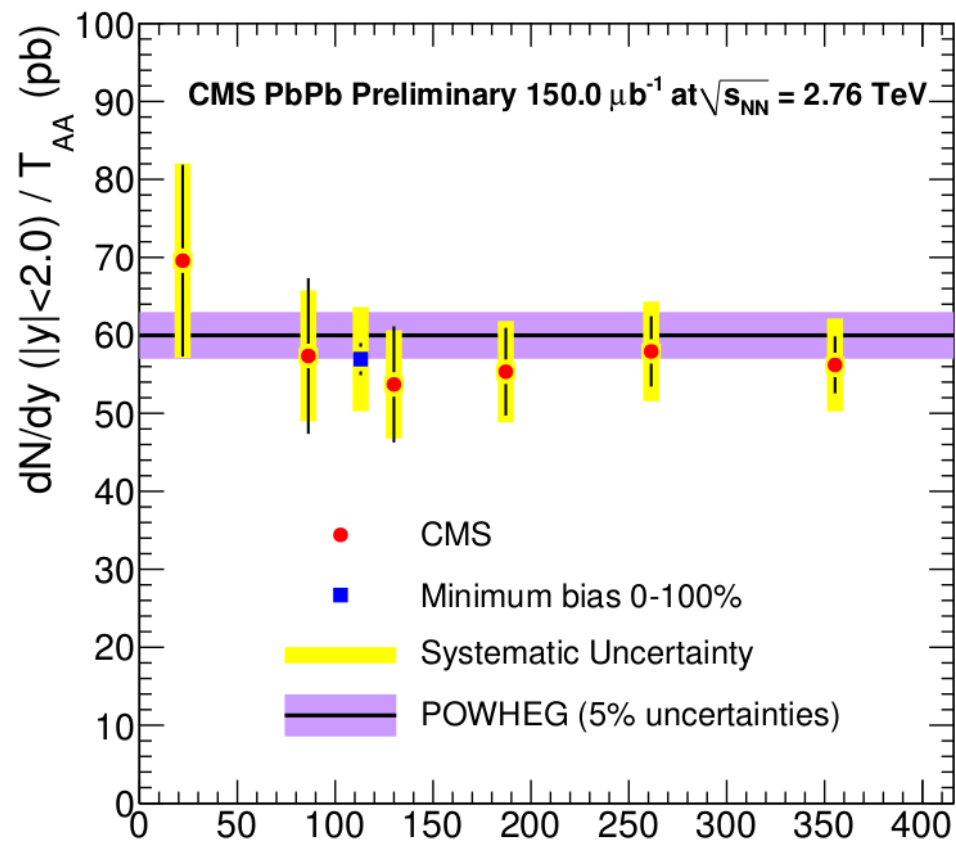


- 2010: 39 Z candidates
 - $p_T^\mu > 10 \text{ GeV}/c$
- 2011: 616 Z candidates
 - $p_T^\mu > 20 \text{ GeV}/c$

Z boson production

CMS-PAS-HIN-12-008

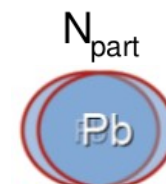
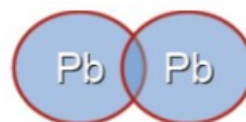
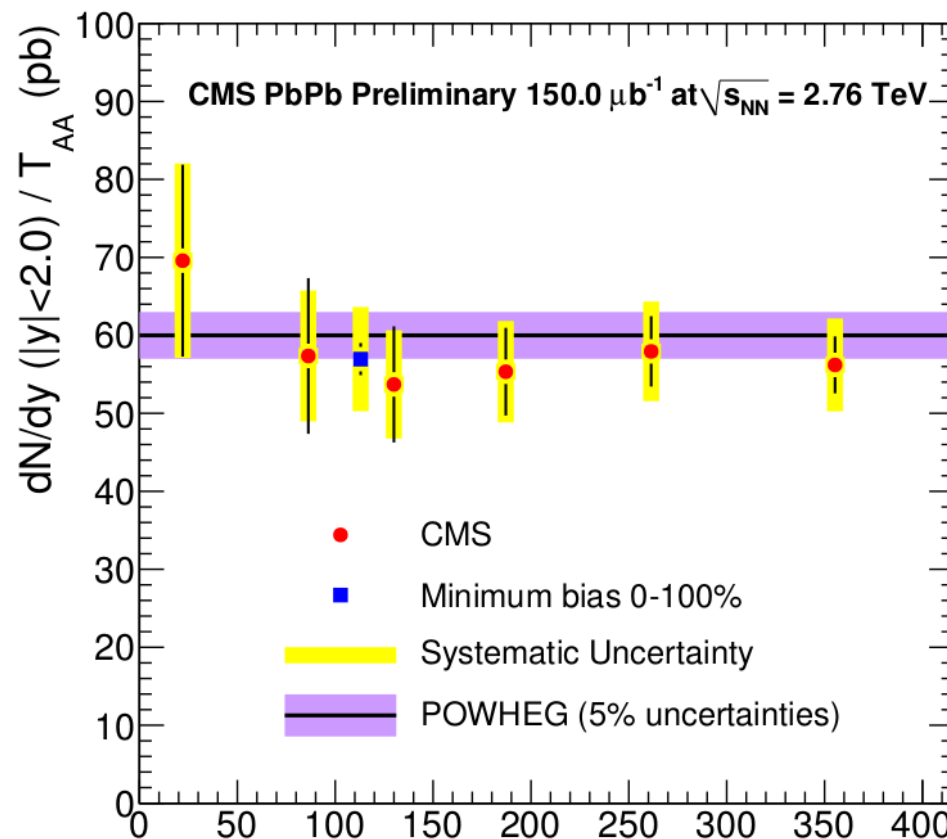
- 20 times less proton-proton reference data to PbPb at 2.76 TeV c.m. energy
- Comparison with POWHEG NLO generator
 - Good description of data at LHC and Tevatron energies



Z boson production

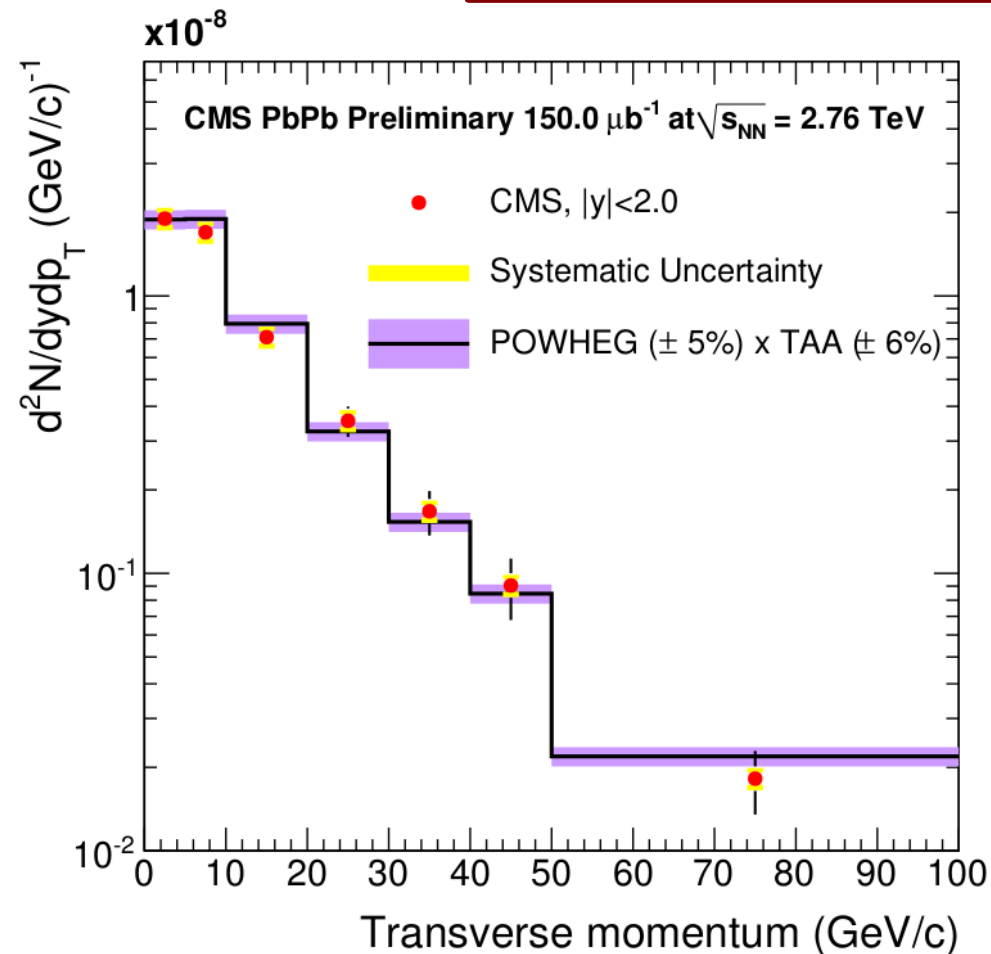
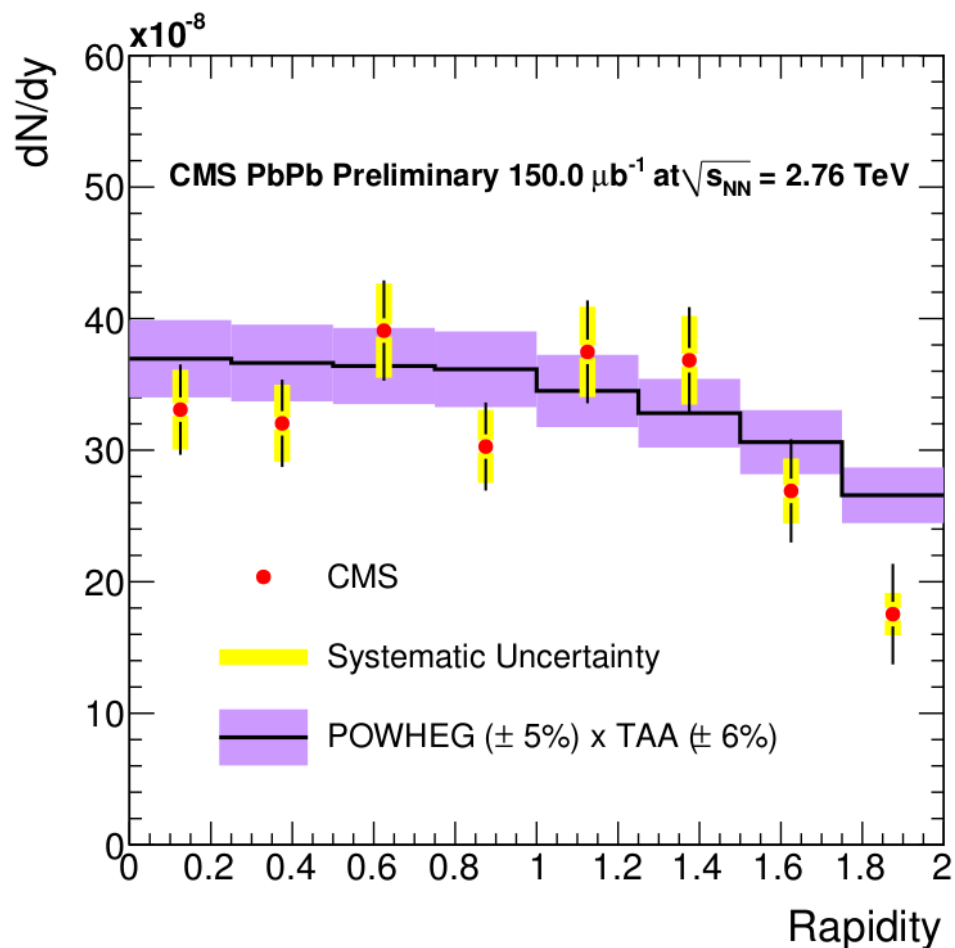
CMS-PAS-HIN-12-008

- $\frac{dN_{AA}}{T_{AA}} = d\sigma^{pp} \times R_{AA}$
- T_{AA} : nuclear overlap function from Glauber-model calculations
- Z production scales with T_{AA}
- $\frac{dN_{AA}}{T_{AA}} = 56.9 \pm 2.0 \pm 6.7 \text{ pb}$
- According to POWHEG $\frac{d\sigma^{pp}}{dy} = 59.6 \pm 3.0 \text{ pb}$, if $|y| < 2$
- $R_{AA} = 0.95 \pm 0.03 \pm 0.13$

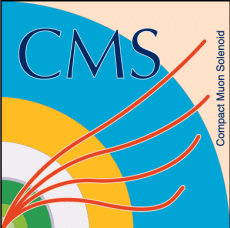


Z boson production

CMS-PAS-HIN-12-008



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



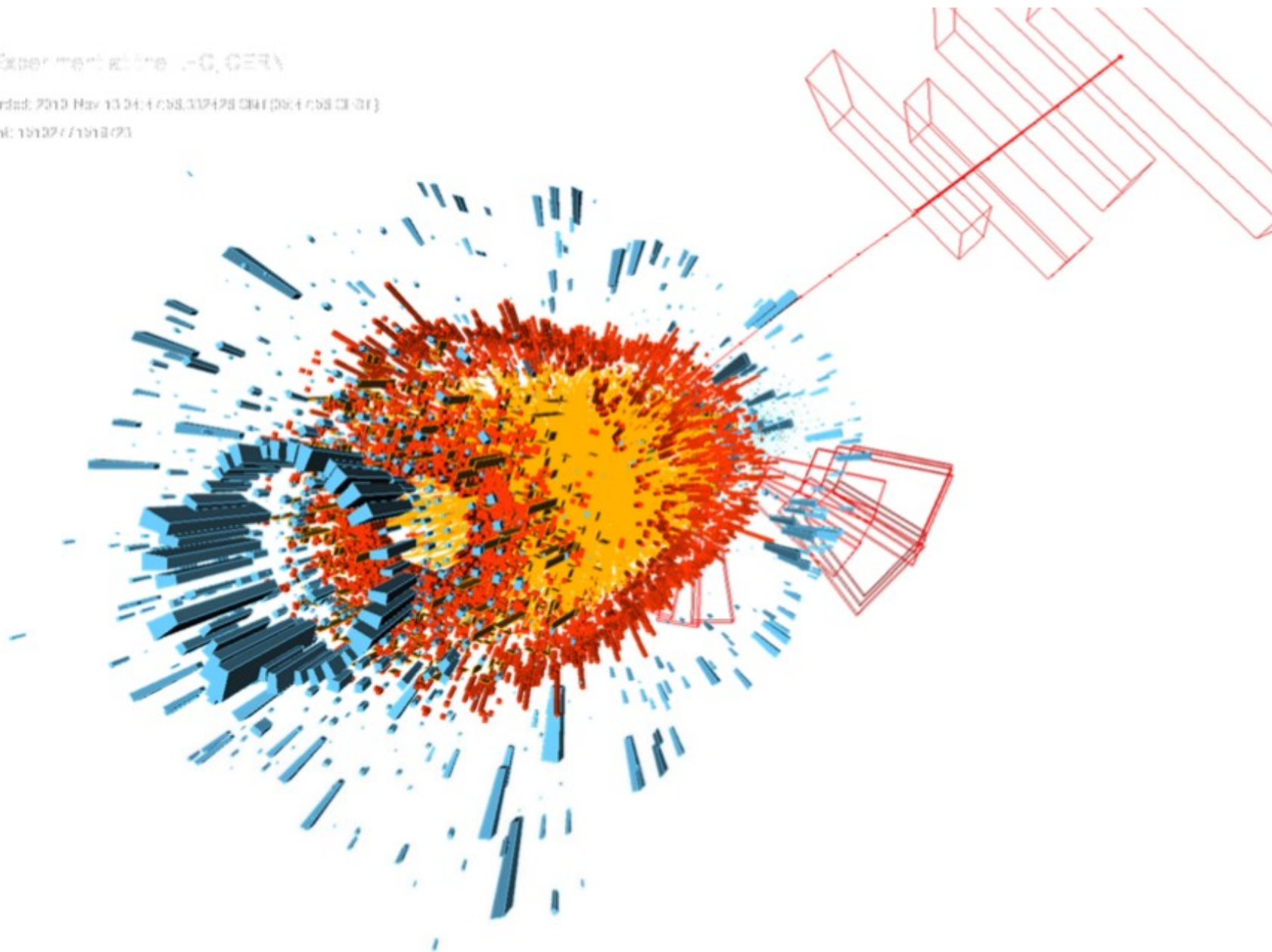
$W \rightarrow \mu\nu$ boson candidate



CMS Experiment (hep-ex/0305025)

Data recorded: 2010 May 13 04:46:58.32478081 (29:46:58.030)

Run/Evt: 15127/151373

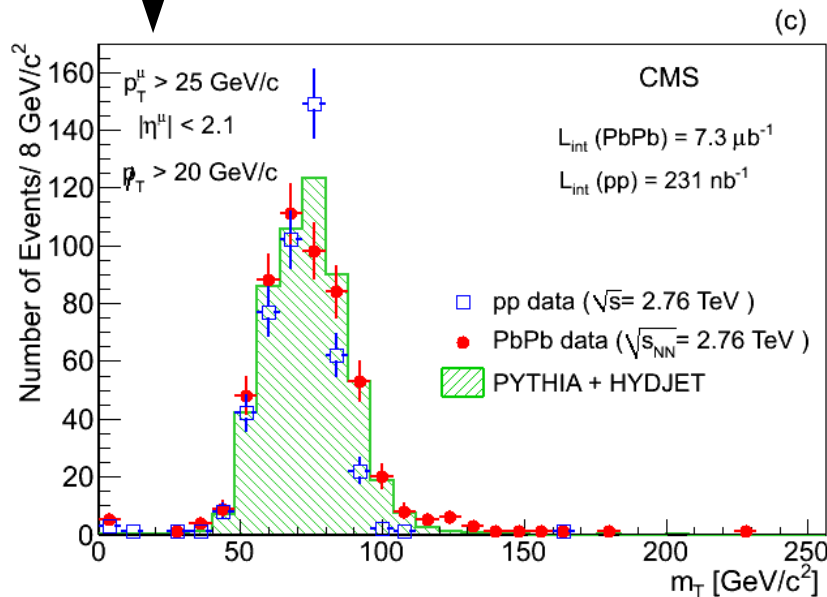
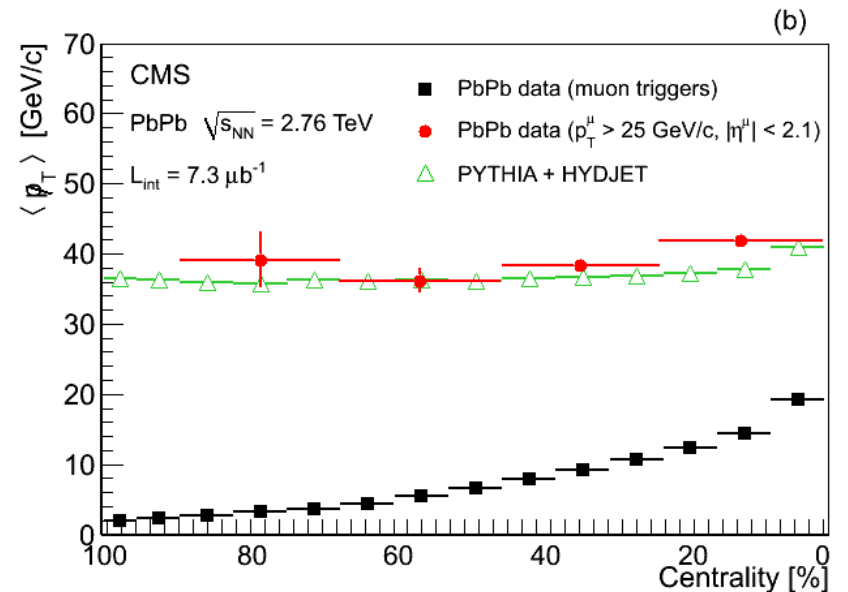
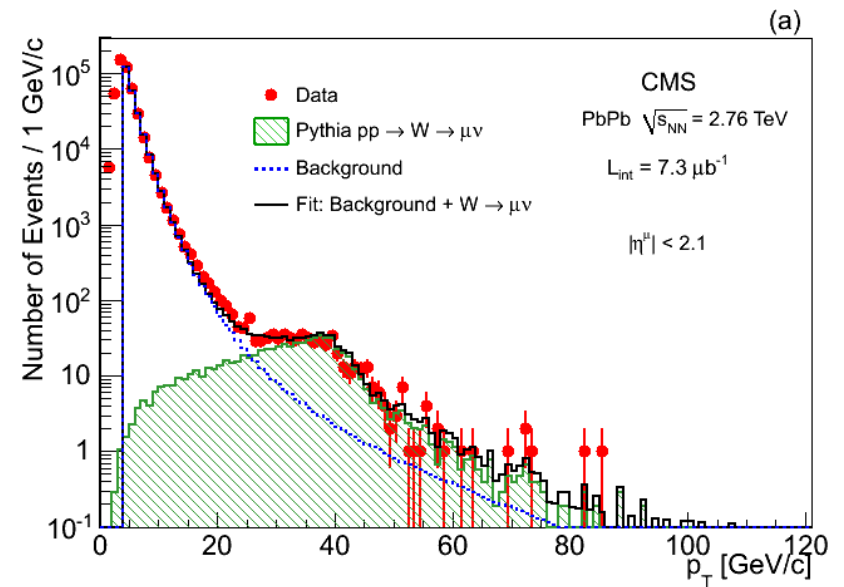


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W boson production

- Signal already visible in muon p_T spectrum
- Simple missing p_T tracks ($p_T^{\text{track}} > 3 \text{ GeV}/c$)
- Then transverse mass

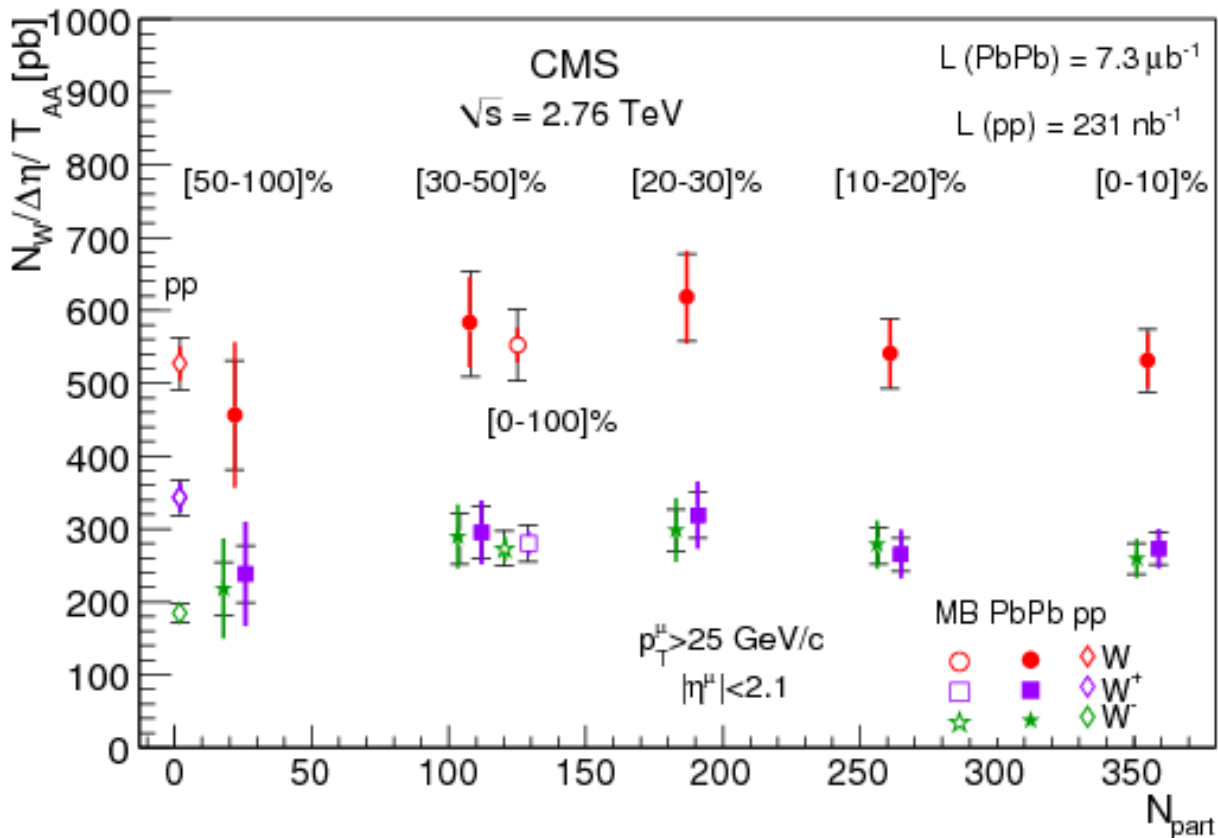
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W boson production results

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- Less W^+ and more W^- produced in PbPb, then in pp \rightarrow isospin effect
- 2010 PbPb statistics \approx 2011 pp statistics at 2.76 TeV c.m. energy



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

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

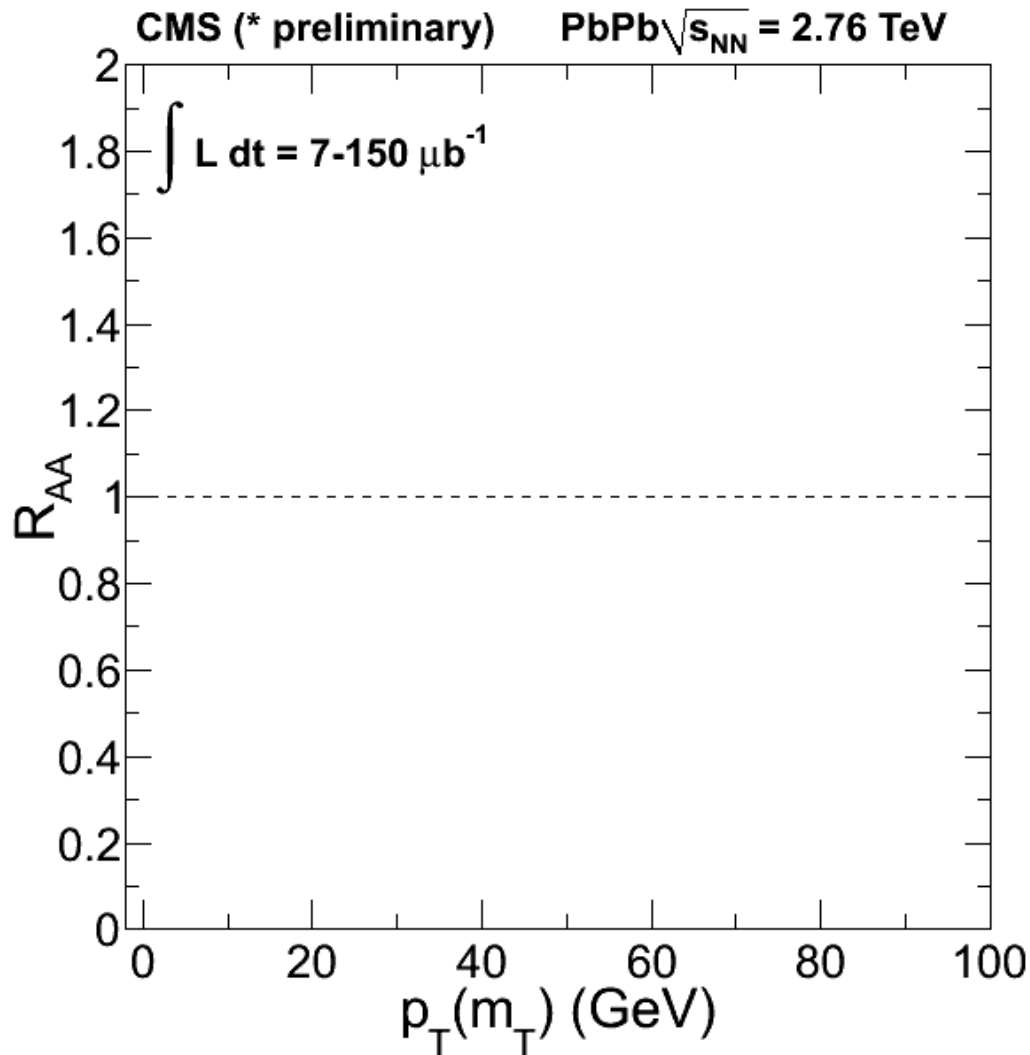
$$R_{AA}(W^+) = 0.82 \pm 0.07 \pm 0.09$$

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

Consistent with isospin effect

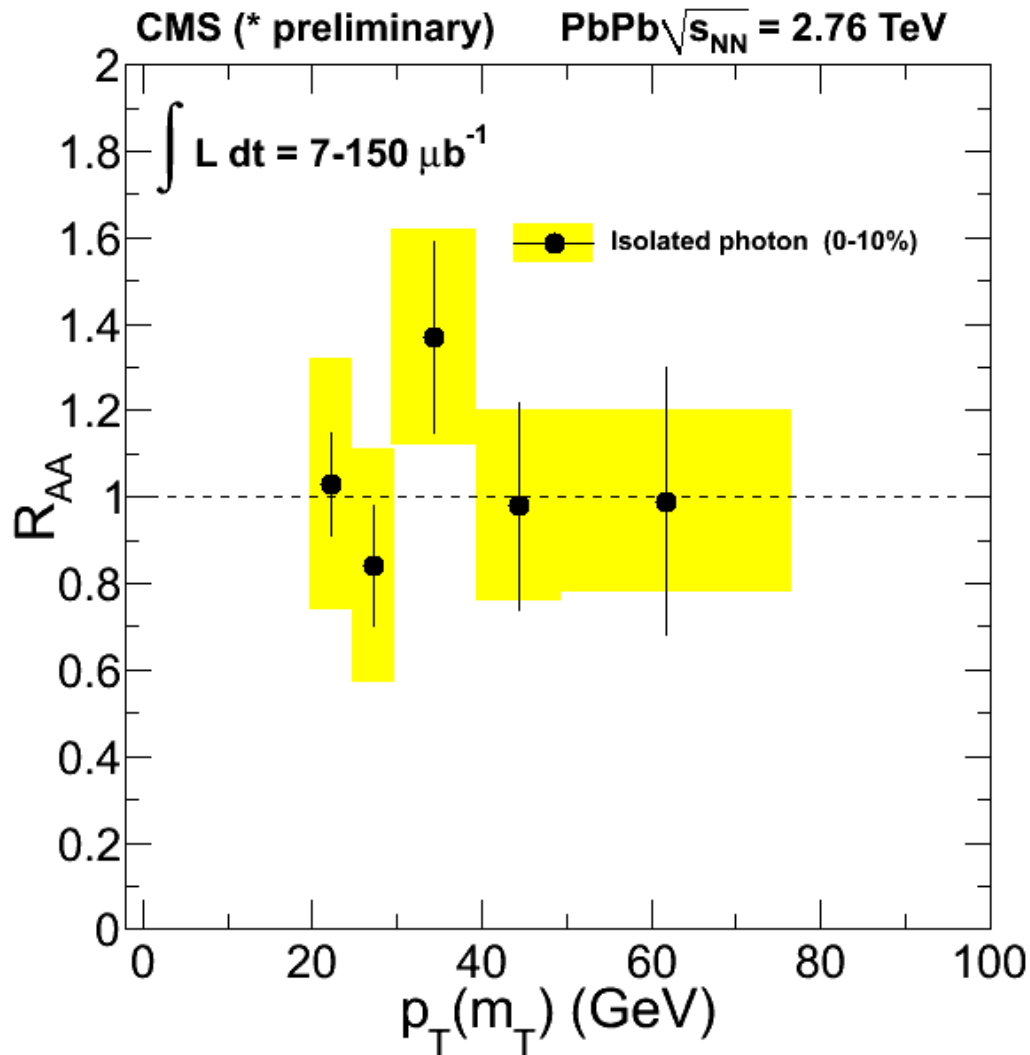


Summary



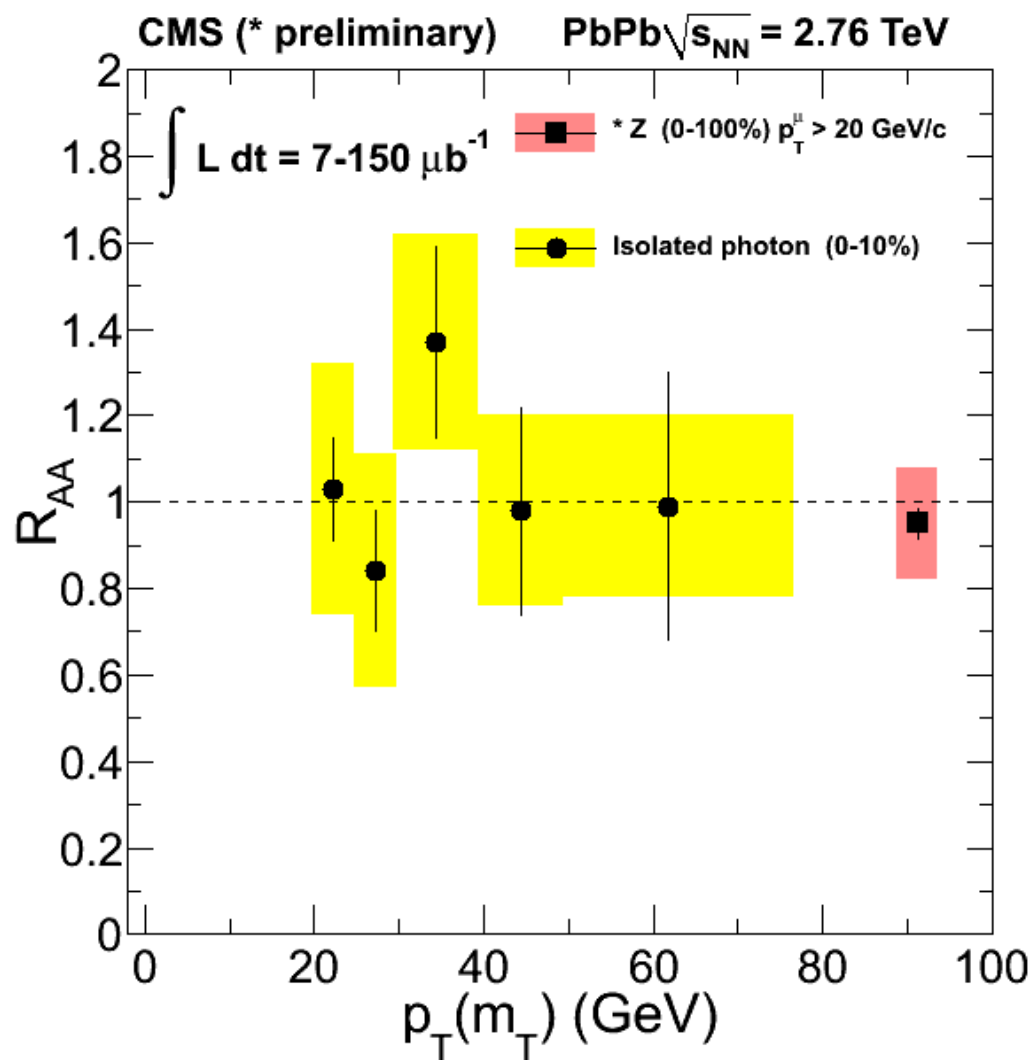
- $R_{AA} = \text{PbPb yield} / \text{pp yield}$
(normalized by the number of binary collisions)
- $R_{AA} < 1$ suppression
- $R_{AA} = 1$ no modification
- $R_{AA} > 1$ enhancement

Summary



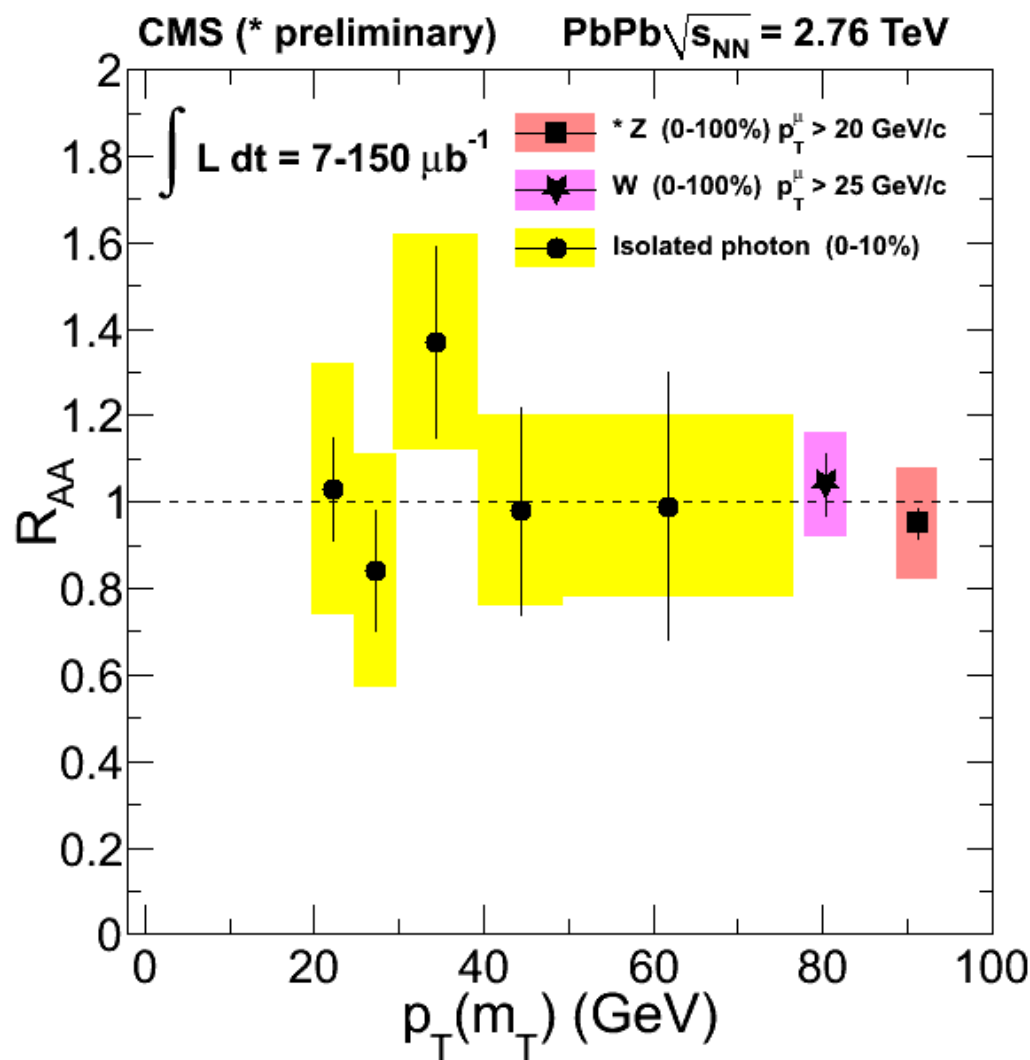
- Photons are not modified by the strongly interacting matter

Summary



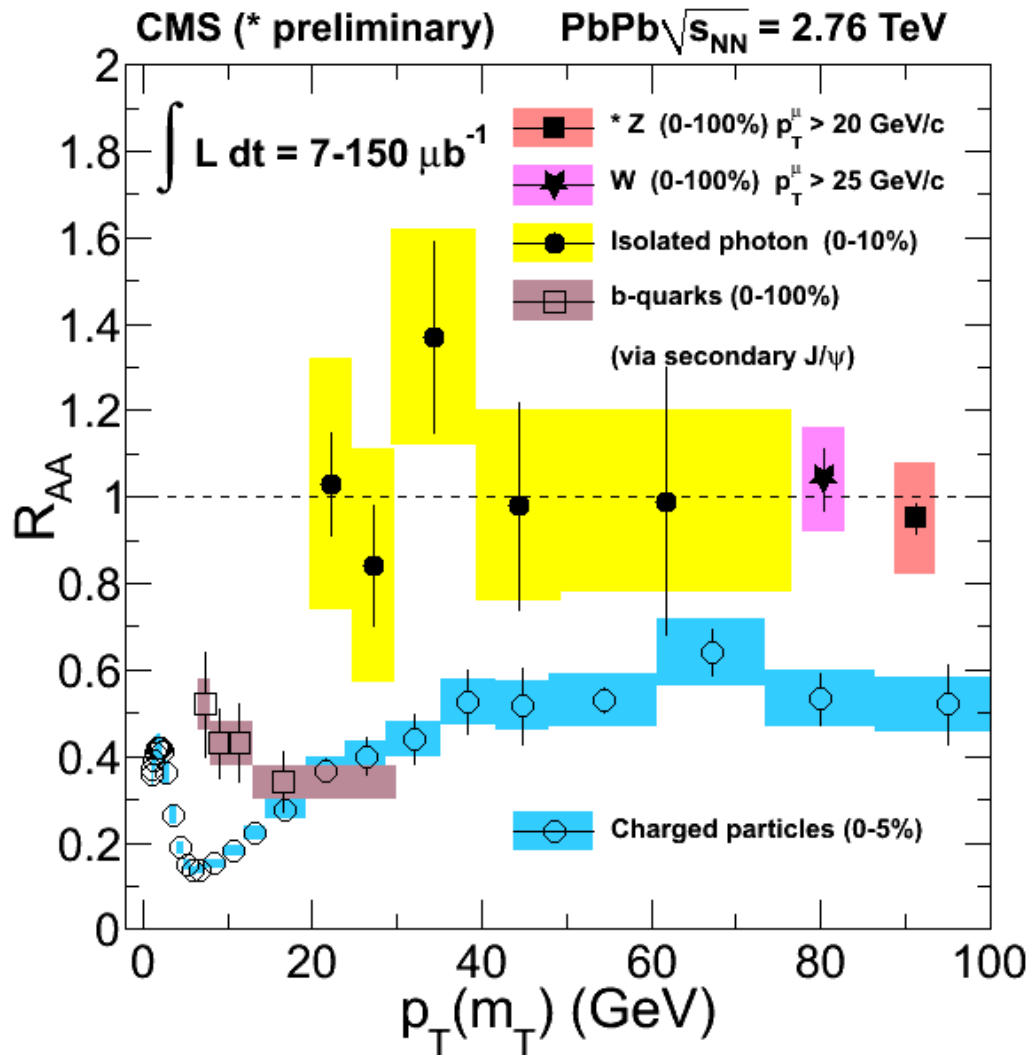
- Photons are not modified by the strongly interacting matter
- Z boson production also scales with number of binary collisions
- Nuclear effects (isospin, shadowing, ...) small with respect to uncertainties

Summary



- Photons are not modified by the strongly interacting matter
- Z boson production also scales with number of binary collisions
- Nuclear effects (isospin, shadowing, ...) small with respect to uncertainties
- W boson production also scales with number of binary collisions
- Strong isospin effect when separating W^- and W^+

Summary



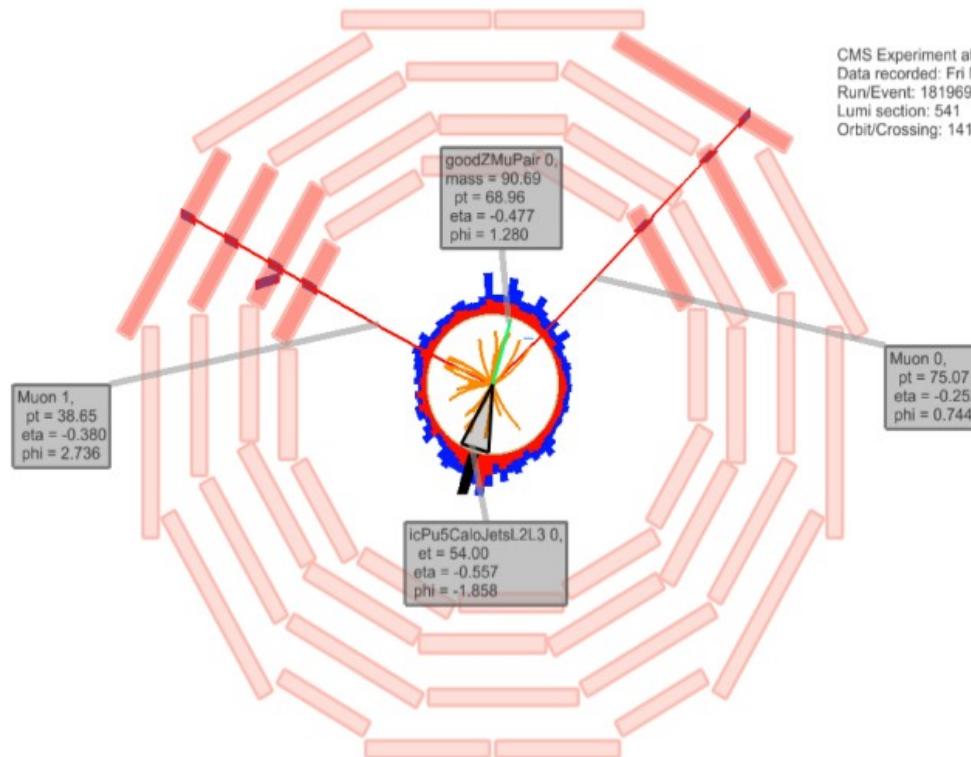
- Photon, Z and W boson production scales with number of binary collisions
- BUT other strongly interacting particle yields are modified
 - Inclusive charged particle production
 - b quarks identified from secondary J/ ψ

Outlook

- Analyses of 2011 PbPb data are still ongoing

$$Z \rightarrow e^+e^-, W \rightarrow \mu\nu$$

- High statistics pPb and pp data in 2013
- Longer term: high statistics from γ +jet, Z+jet, ...



CMS Experiment at LHC, CERN
Data recorded: Fri Nov 18 03:32:48 2011 CEST
Run/Event: 181969 / 19790244
Lumi section: 541
Orbit/Crossing: 141750167 / 2762

Backup



CMS Heavy-ion results

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

