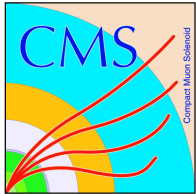


# Charged Particle Production in pPb Collisions Measured by CMS



Eric Appelt  
(Vanderbilt University)

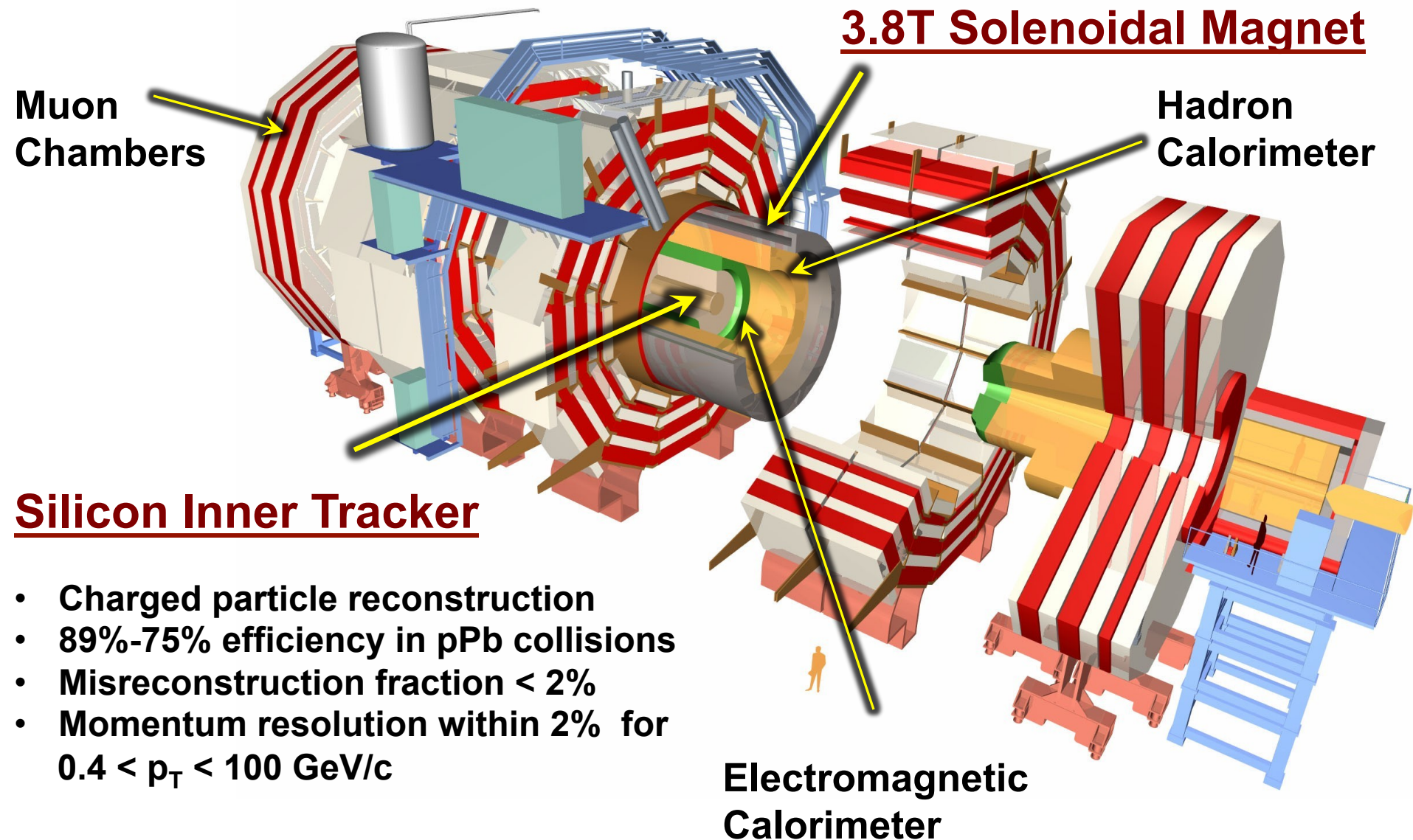


*for the CMS Collaboration*

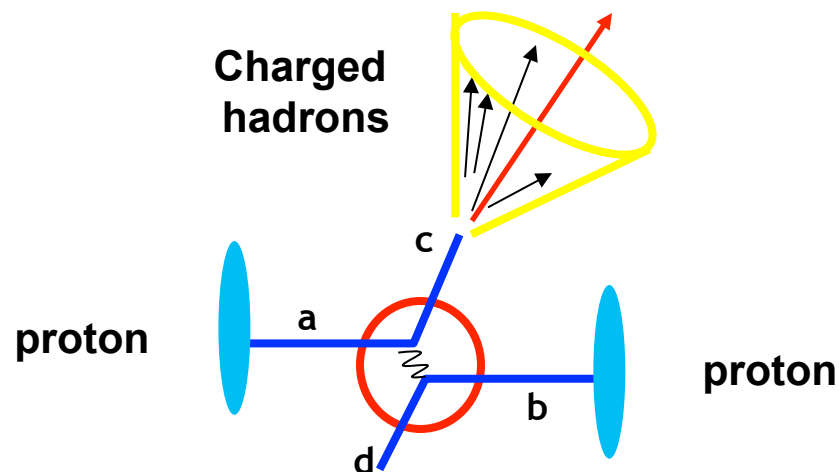
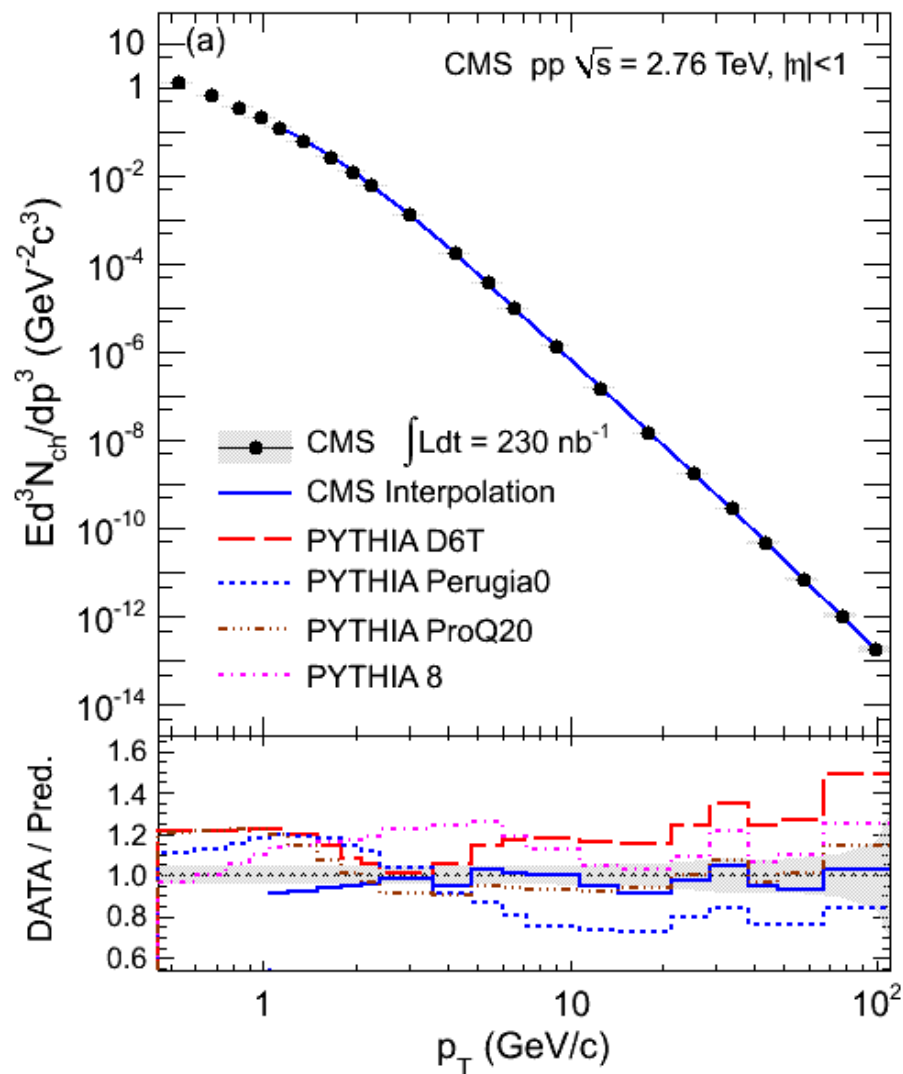
LHC UO Meeting, Madison WI  
November 7<sup>th</sup>, 2013



# The CMS Detector



# Charged Particle Production (pp 2.76 TeV)



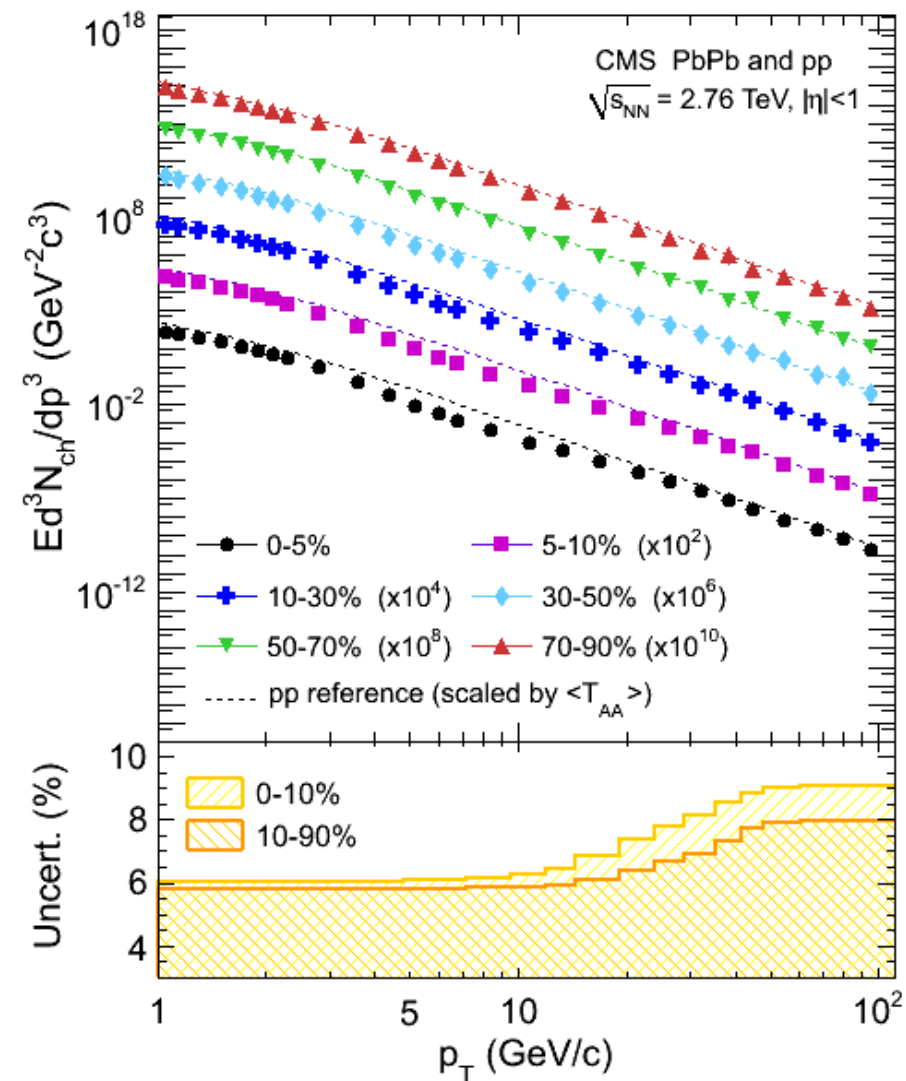
Parton Distribution Function

Hard-scattering cross-section

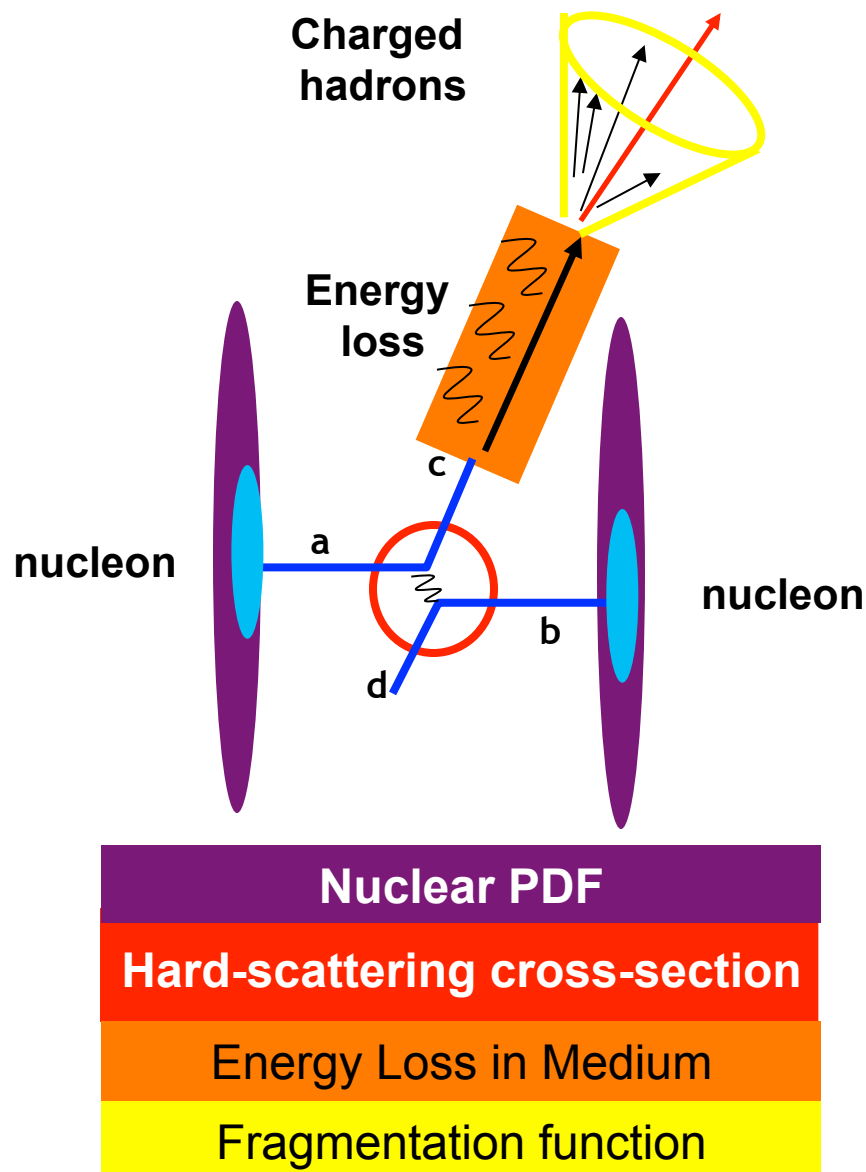
Fragmentation function

CMS Collaboration, EPJC 72 (2012) 1945

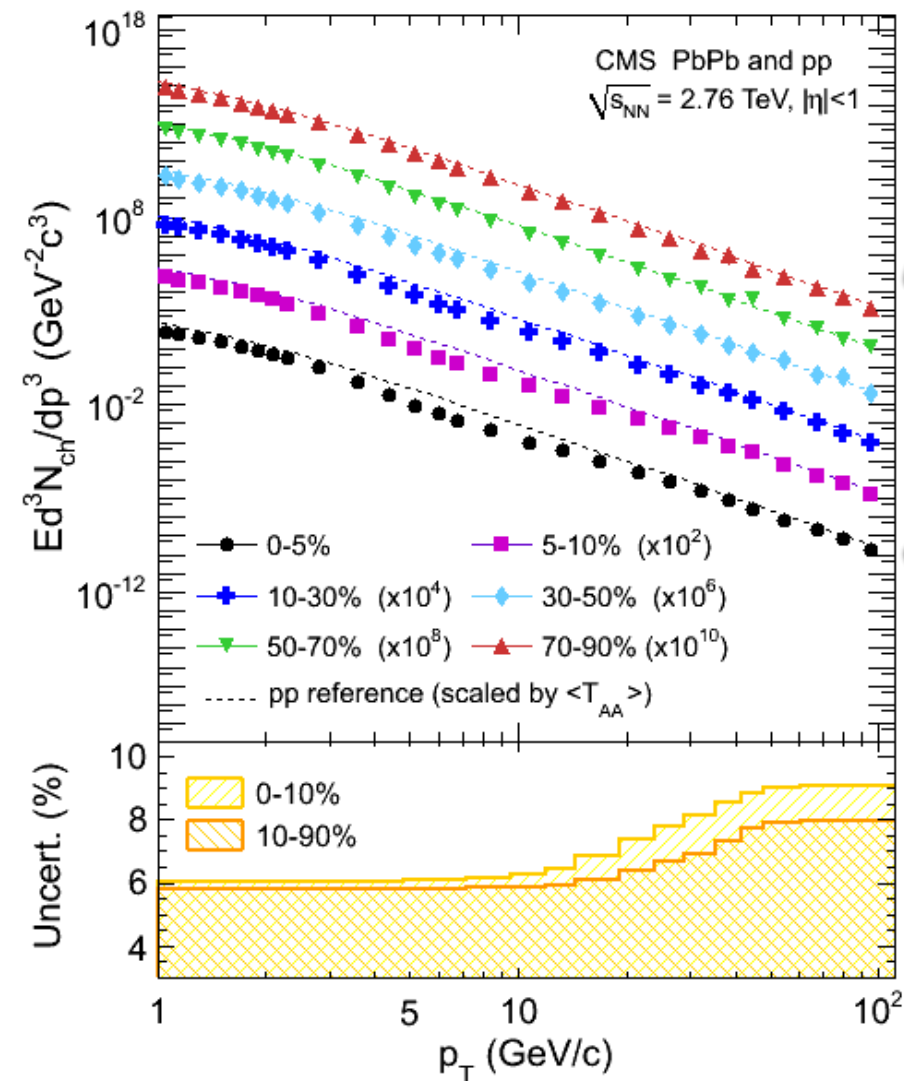
# Charged Particle Production (PbPb 2.76 TeV)



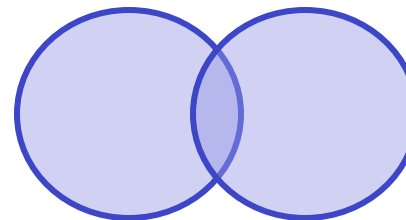
CMS Collaboration, EPJC 72 (2012) 1945



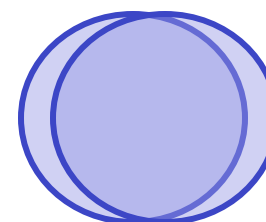
# Charged Particle Production (PbPb 2.76 TeV)



“Peripheral” Collisions



“Central” Collisions

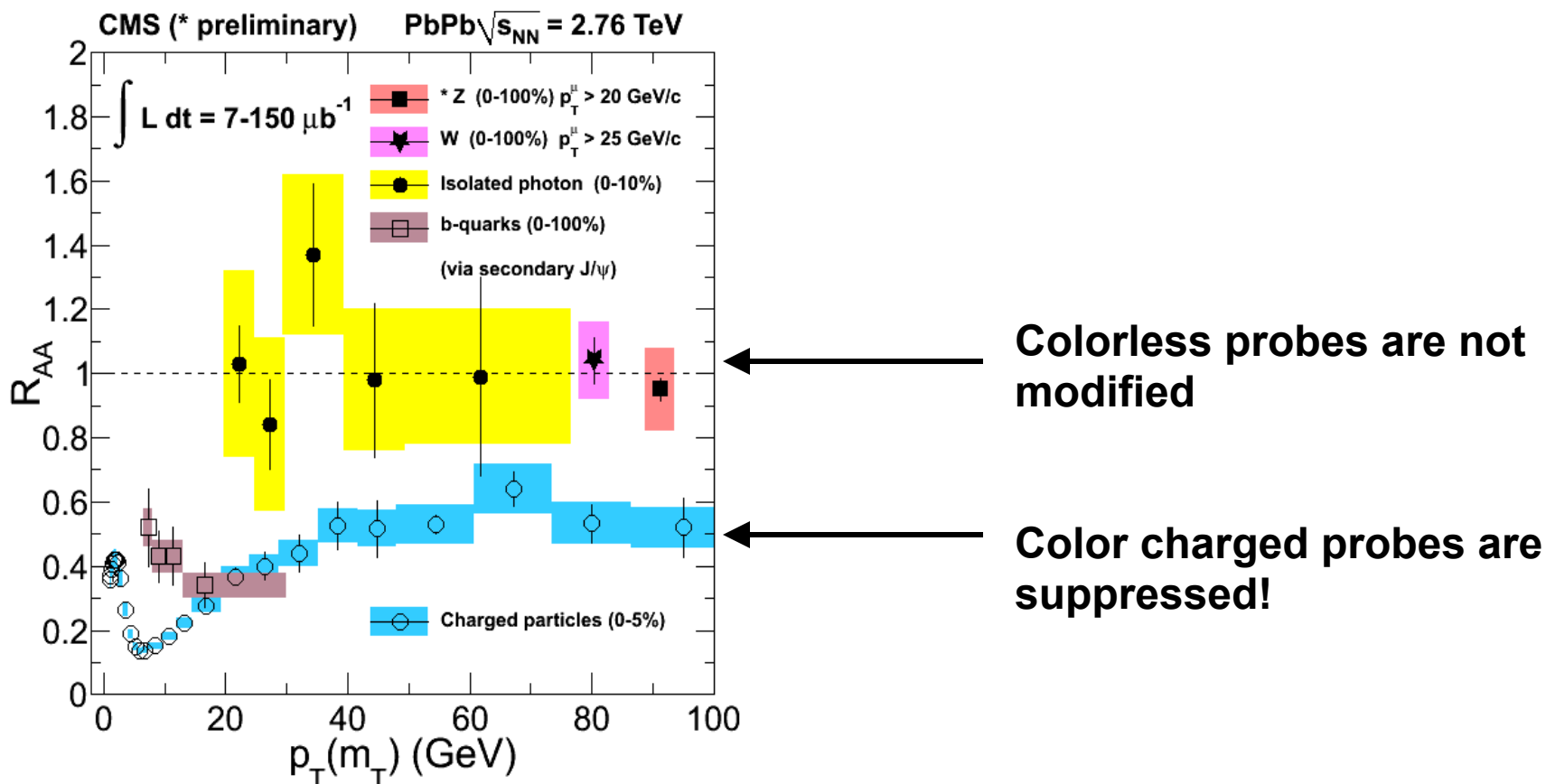


CMS Collaboration, EPJC 72 (2012) 1945

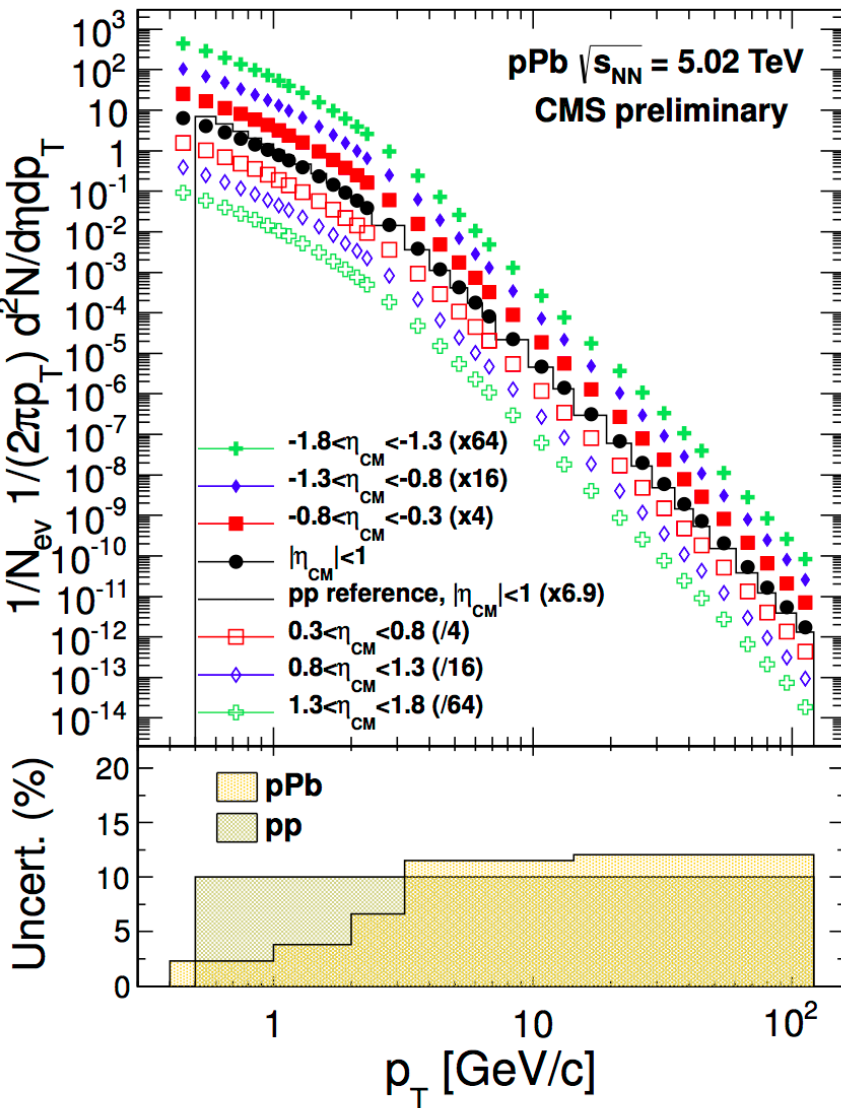
# Nuclear Modification Factor ( $R_{AA}$ )

$$R_{AA} = \frac{\sigma_{pp}^{inel}}{\langle N_{coll} \rangle} \frac{d^2 N_{AA} / dp_T d\eta}{d^2 \sigma_{pp} / dp_T d\eta} \sim \frac{\text{“QCD Medium”}}{\text{“QCD Vacuum”}}$$

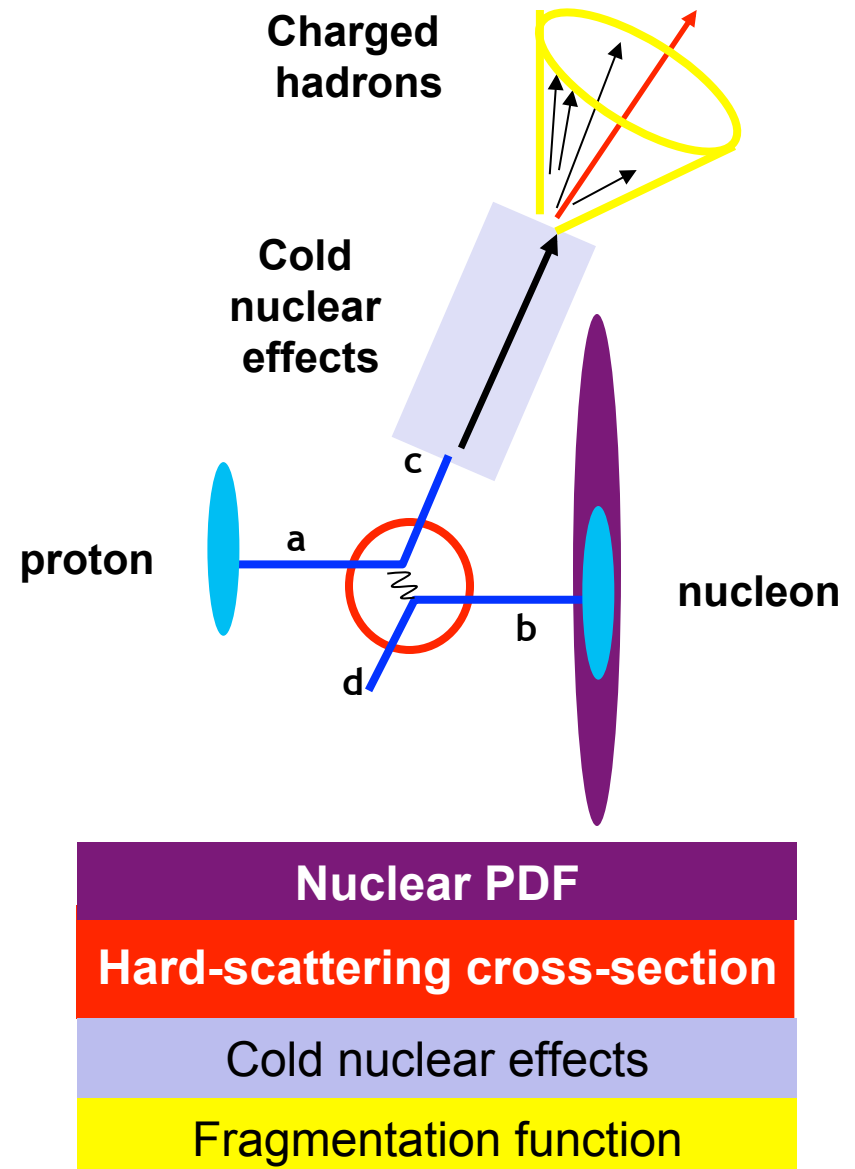
$R_{AA} > 1$ : enhancement  
 $R_{AA} = 1$ : no medium effect  
 $R_{AA} < 1$ : suppression



# Charged Particle Production (pPb 5.02 TeV)

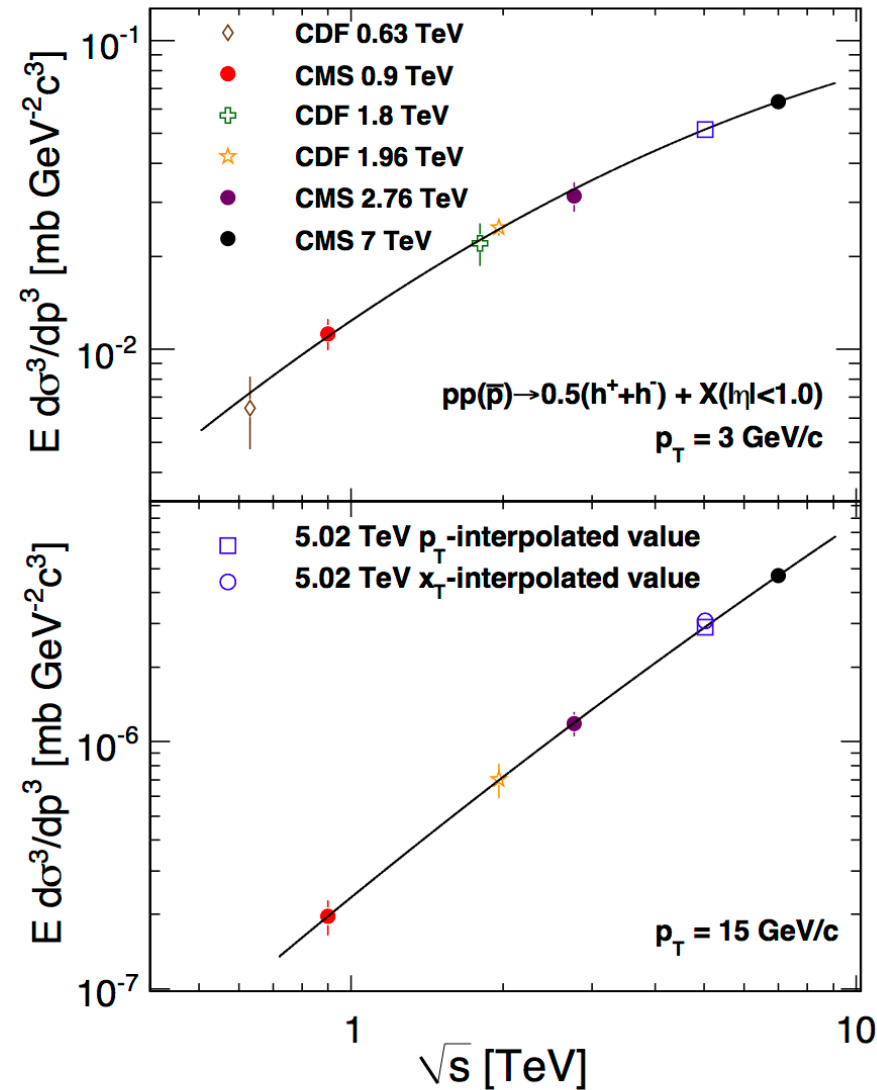


**CMS-PAS-HIN-12-017**





# pp Reference Interpolation

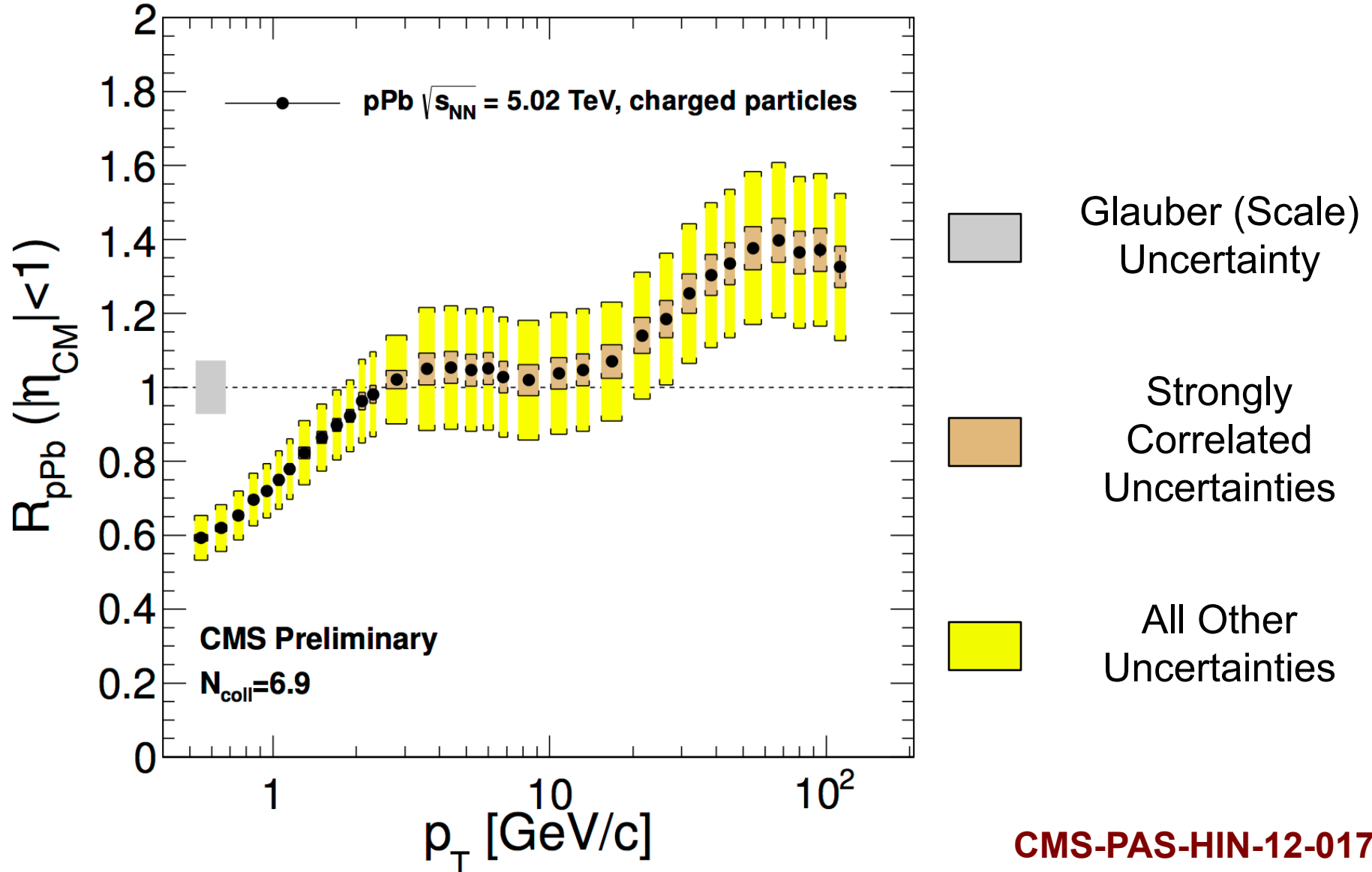


- **No pp reference spectrum at 5.02 TeV has been measured!**
- **A reference spectrum must be interpolated from existing CMS and CDF data.**
- **Results in one of the dominant systematic uncertainties of 10% on  $R_{pPb}$**

CDF Collaboration, Phys. Rev. Lett. 61 (1988)  
 CDF Collaboration, Phys. Rev. D82 (2010) 119903  
 CMS Collaboration, JHEP 08 (2011) 086  
 CMS Collaboration, EPJC 72 (2012) 1945



# Nuclear Modification Factor ( $R_{pPb}$ )

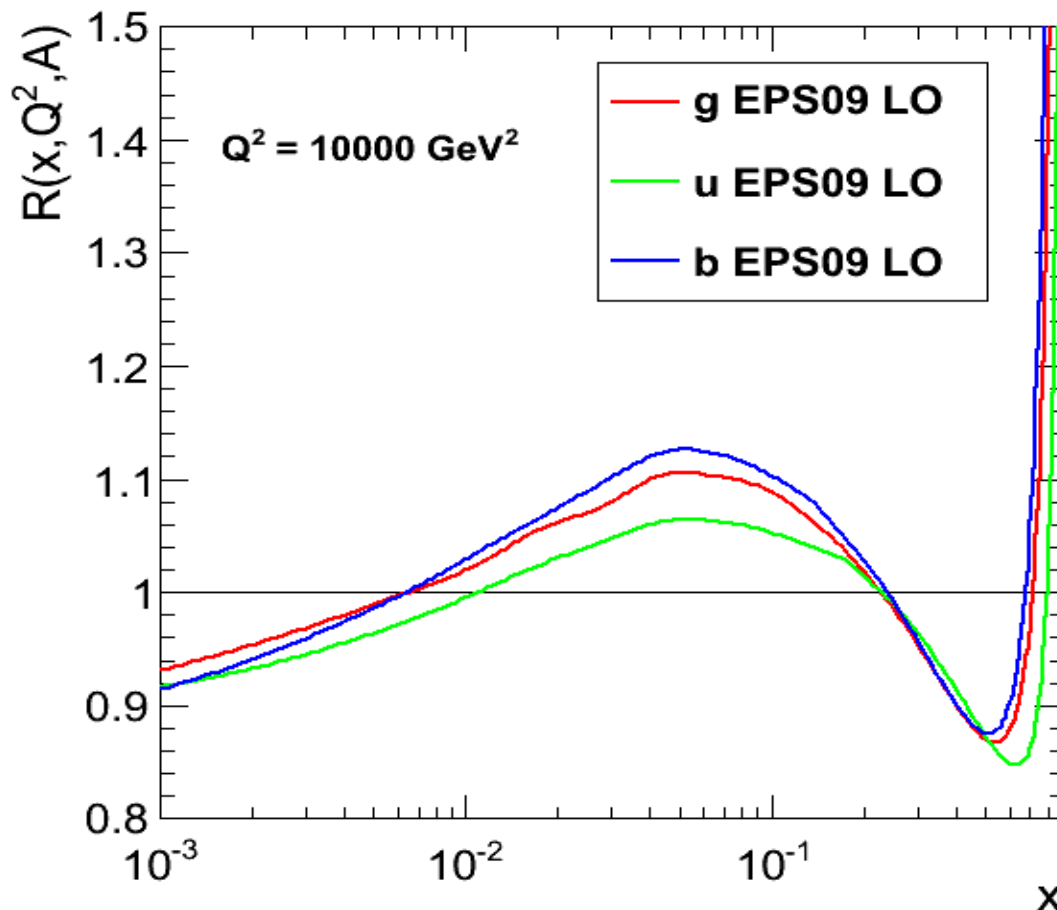


**CMS-PAS-HIN-12-017**

# Example Nuclear PDF Parameterization

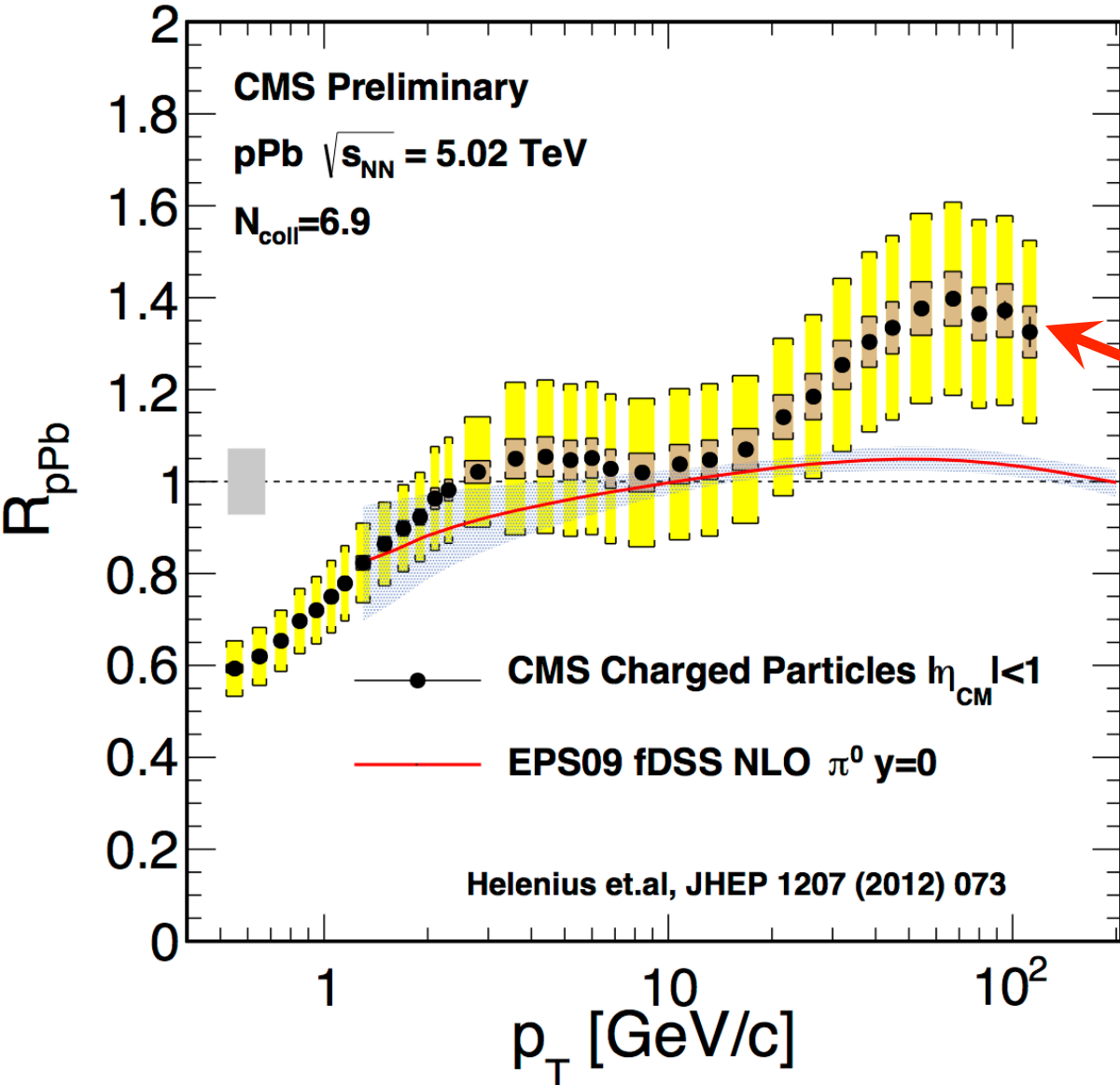
François Arleo and Jean-Philippe Guillet <http://lapth.cnrs.fr/npdfgenerator/>

$$R = \frac{\text{nPDF}}{\text{PDF}}$$



**EPS09**, K. J. Eskola, H. Paukkunen and C. A. Salgado, JHEP 04 (2009) 065

# $R_{pPb}$ Theory Comparison



Enhancement in the  $p_T$  region predicted by theory.

More enhancement than expected!

**CMS-PAS-HIN-12-017**

# Conclusions

- **Charged particle pPb  $\sqrt{s_{NN}} = 5.02$  TeV spectrum measured to  $p_T = 100$  GeV/c**
- **Reference spectrum determined by interpolating existing pp measurements from  $\sqrt{s_{NN}} = 0.63$  to 7 TeV**
- **$R_{pPb}$  reaches 1 at  $p_T = 2-3$  GeV/c and rises to 1.3-1.4 at 100 GeV/c**
- **Analysis Summary: CMS-PAS-HIN-12-017**  
<http://cds.cern.ch/record/1625865>
- **Supplementary Plots:**  
<https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN12017>

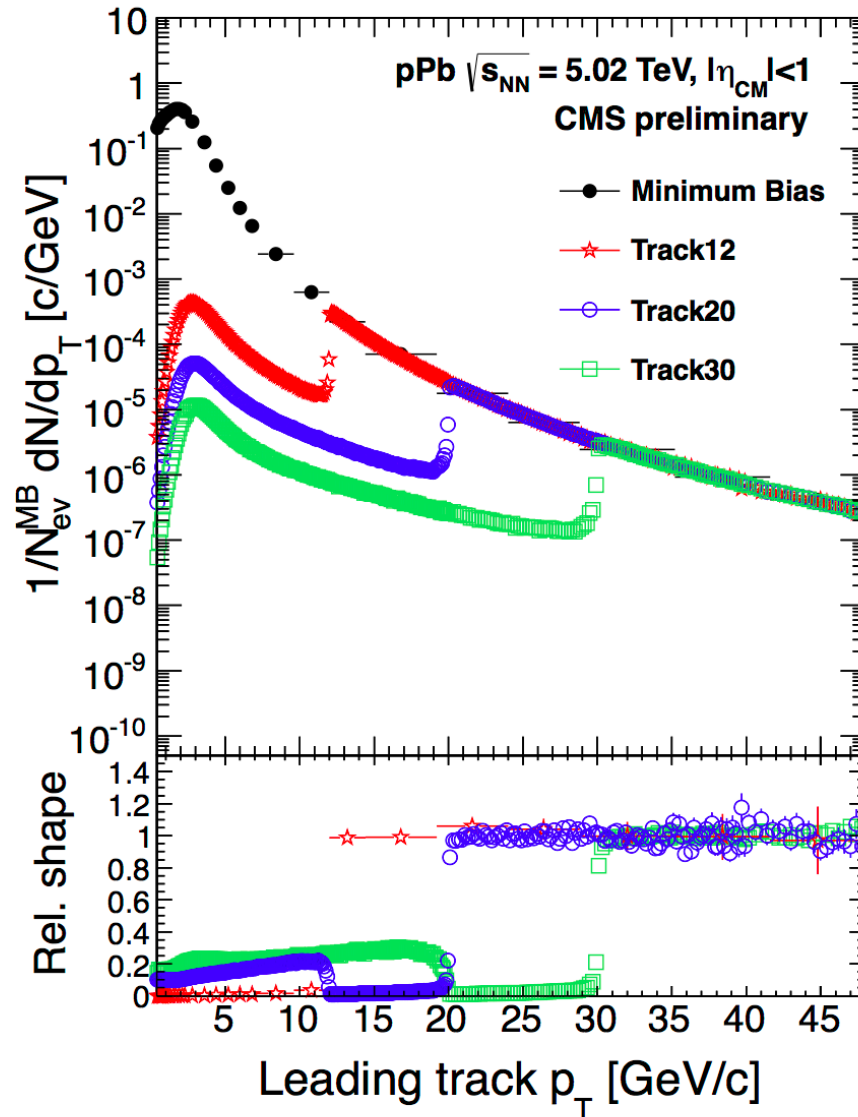
# References

- **PbPb and pp Spectra at 2.76 TeV:** CMS Collaboration, EPJC 72 (2012) 1945
- **pp spectra at 0.63 and 1.8 TeV:** CDF Collaboration, Phys. Rev. Lett. 61 (1988) 1819
- **pp spectrum at 1.96 TeV:** CDF Collaboration, Phys. Rev. D82 (2010) 119903
- **pp spectra at 0.9 and 7 TeV:** CMS Collaboration, JHEP 08 (2011) 086
- **nPDF generator:** François Arleo and Jean-Philippe Guillet  
<http://laph.cnrs.fr/npdfgenerator/>
- **EPS09 parameterization:** K. J. Eskola, H. Paukkunen and C. A. Salgado, JHEP 04 (2009) 065
- **Pion  $R_{pPb}$  prediction:** Helenius et. al., JHEP 1207 (2012) 073

# Backup



# Trigger Combination





# Tracking Performance

