First measurement of the forward rapidity gap distribution in pPb collisions at $\sqrt{s_{NN}} = 8.16$ TeV with the CMS experiment

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Physics relevance

Diffraction

Diffractive collisions : special inelastic collisions in which no quantum numbers are exchanged between colliding particles; characterized by a Rapidity Gap, caused by t-channel **pomeron**(s) ($\mathbb{P}$) exchange.

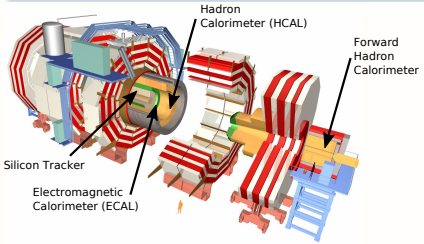
Rapidity Gap ($\Delta\eta$) : the rapidity regions free of final-state particles

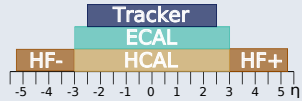
Latest pA diffraction : were done by HELIOS with $\sqrt{s} = 27$ GeV
Z. Phys. C 49 (1991) 355

Problems studied with diffraction

- Nature of the pomeron in QCD
- Small-x problem and "saturation" of parton densities
- Cross sections of inelastic diffractive processes are very sensitive to nonlinear saturation effects, which get more important for scattering off nuclei.
- Diffraction of hadrons on nuclear targets at very high energies is also relevant for cosmic-ray physics.

CMS Detector

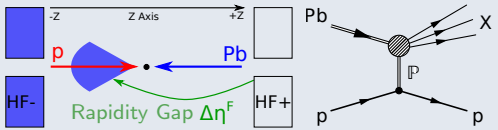




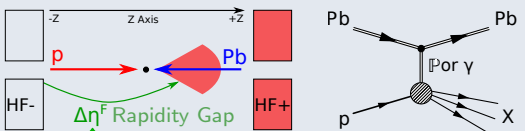
- Silicon tracker: $|\eta| < 2.5$
- ECAL and HCAL: $|\eta| < 3.0$
- Forward Hadron Calorimeter (HF): $3.0 < |\eta| < 5.2$

Data and event topologies

Event topologies of interest



Lead dissociation ($\mathbb{P}$Pb)



Proton dissociation ($\mathbb{P}$p+γp)

Data, MC event generators

Data : CMS, pPb $\sqrt{s_{NN}} = 8.16$ TeV, 6.4 μb^{-1} (2016)

HIJING :

- hard parton scatterings: perturbative QCD
- soft interactions: string excitations

EPOS-LHC : Gribov-Regge theory for the parton interactions; Gluon saturation — phenomenological implementation

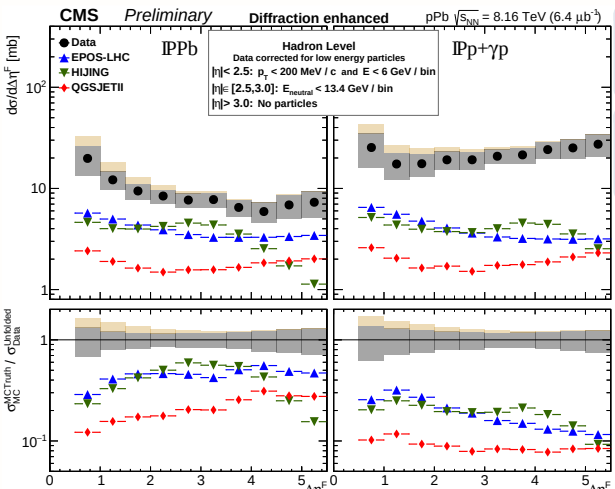
QGSJET II-04 : Gribov-Regge theory for the parton interactions; Gluon saturation via higher order pomeron-pomeron interactions

The generators do not include photon (γ) exchange processes

Rapidity Gap ($\Delta\eta^F$)

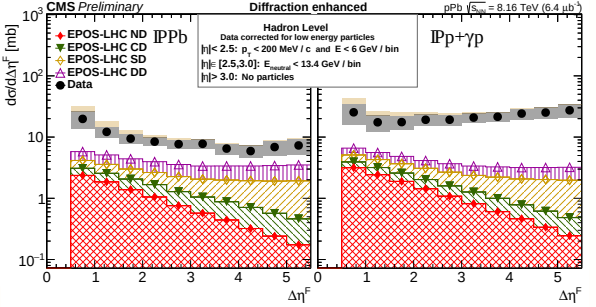
- Central region (bins of 0.5 in η):
  - For $|\eta| < 2.5$:
    - No charged particles with $p_T > 0.2$ GeV
    - The total energy of all particles less than 6 GeV
  - For $2.5 \leq |\eta| < 3.0$:
    - The total energy of neutral hadrons less than 13.4 GeV
- No detectable activity at the HF acceptance on the side of $\Delta\eta^F$

Hadron-level FRG cross section at diffractive enhanced subsample for $|\eta| < 3.0$



- IPPb topology: predictions of EPOS-LHC and QGSJET II is 2 and 4 times below the data.
- The EPOS-LHC and QGSJET II shapes are similar to the data
- The HIJING prediction falls at large $\Delta\eta^F$

- IPp+γp topology: all the generators are more than a factor of 5 below the data
- This suggests a very strong contribution from γp events which is not yet implemented in the considered event generators



Summary

- Forward rapidity gap distribution $\frac{d\sigma}{d\Delta\eta^F}$ from pPb collisions at $\sqrt{s_{NN}} = 8.16$ TeV have been measured for the first time for both **pomeron-lead** ($\mathbb{P}$Pb) and **pomeron-/γ-proton** ($\mathbb{P}$p+γp) topologies
- For the $\mathbb{P}$Pb topology case, where the γ-**exchange** contribution should be negligible:
  - Predictions of EPOS-LHC is about a factor of 2 and QGSJET II a factor of 4 are below the data
  - However for both of those generators the shape of the $\frac{d\sigma}{d\Delta\eta^F}$ spectrum is similar to that of the data
  - The rapidity spectrum from the HIJING generator falls at large $\Delta\eta^F$ in contrast to the data
- For the $\mathbb{P}$p+γp case:
  - The cross section of EPOS-LHC and QGSJET II are lower than data by more than a factor of 5
  - This suggests a very strong contribution from γp events which is not yet implemented in the considered event generators
- These data may be of significant help in the modeling of ultrahigh-energy cosmic ray air showers

Thank you for attention!