

HOW SMALL CAN WE EXPLORE ?

Souvik Priyam Adhya

Supervisor: Prof. Marek Tasevsky

Co-supervisor : Prof. Jiří Chýla

Asymptotic Kinetics of Nuclei

Parton Exploration at



PEAKIN

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Co-funded
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**PHYSICS
FOR
FUTURE**



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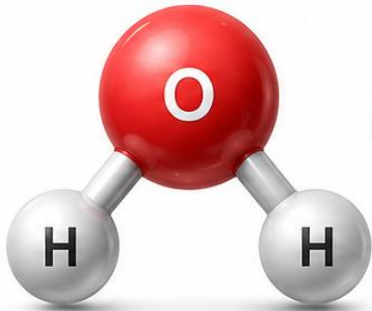
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Fundamental constituents of matter

MOLECULE

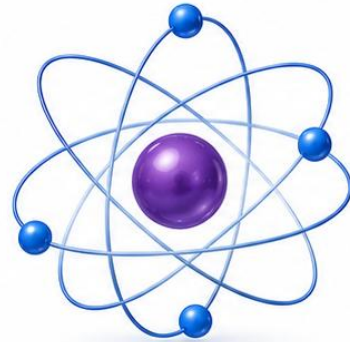
Atoms combine to form molecules.



Water (H₂O)

ATOM

Molecules are made of atoms.



Oxygen atom

ATOMIC NUCLEUS

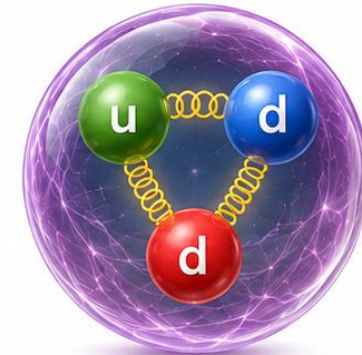
The nucleus contains protons and neutrons.



-  Proton
-  Neutron

SUBATOMIC PARTICLES

Protons and neutrons are made of quarks held together by gluons.

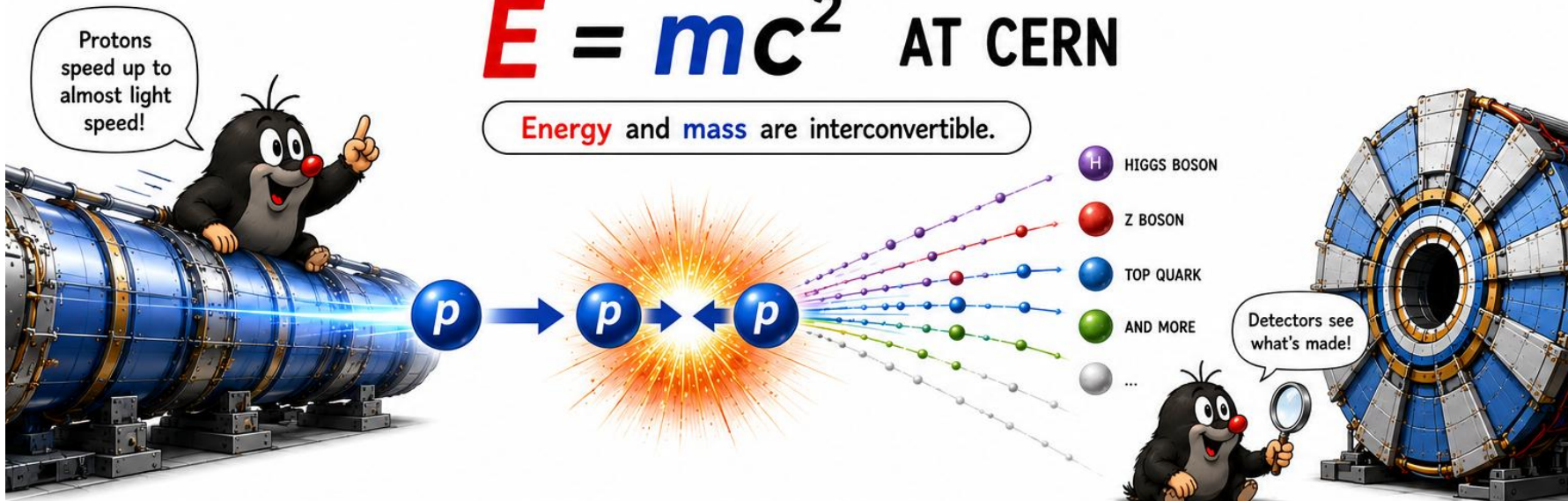


-  Up quark
-  Down quark
-  Down quark
-  Gluon

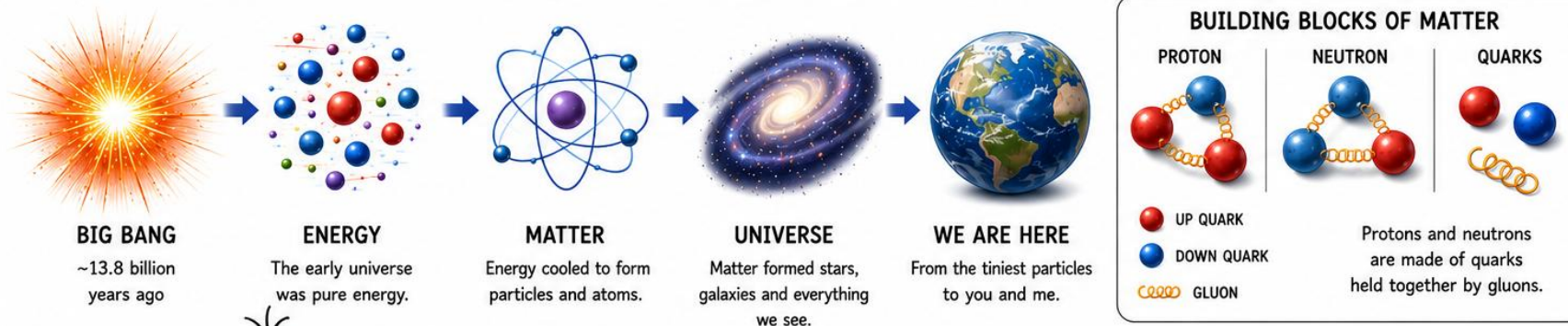
SMALLER SCALE

Zooming in: from larger structures to the most fundamental building blocks of matter.

$E = mc^2$ AT CERN

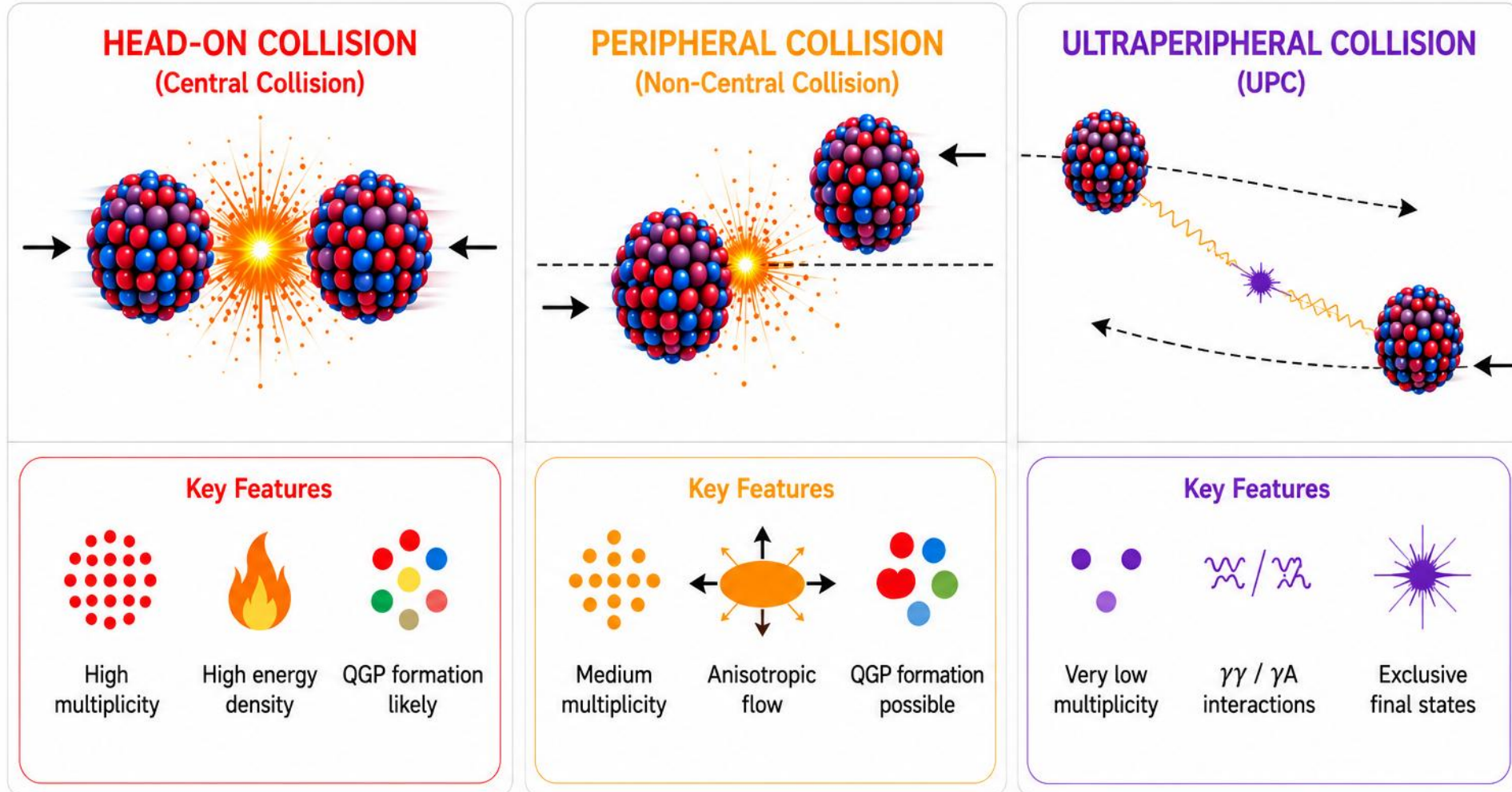


CONNECTION TO THE BIG BANG



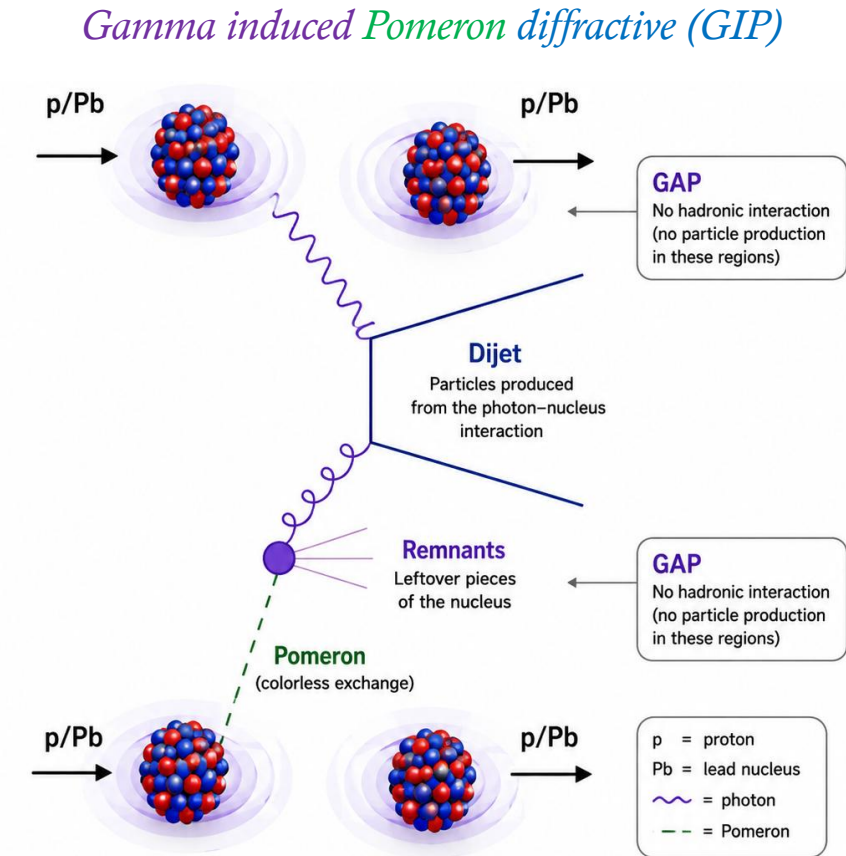
At **CERN**, we recreate tiny moments of the Big Bang to understand how our **Universe** began.


Types of collision in colliders



Diffractional photoproduction

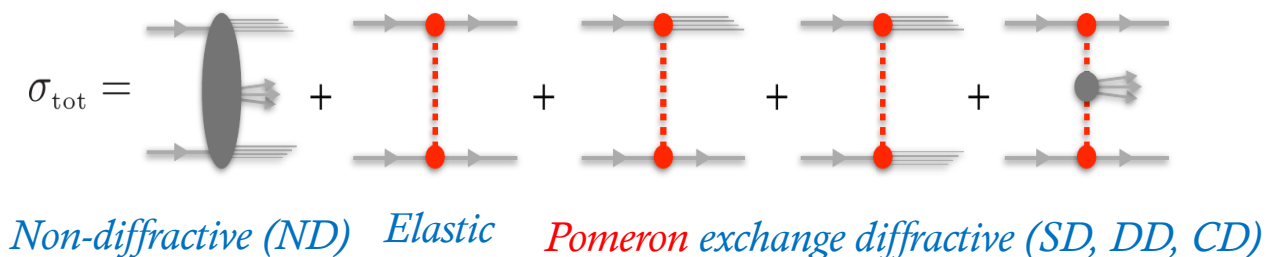
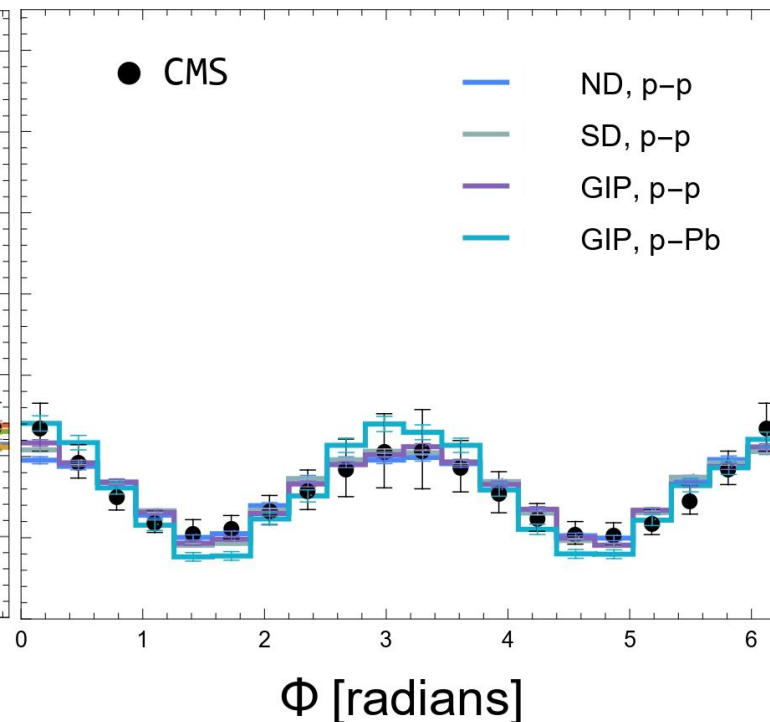
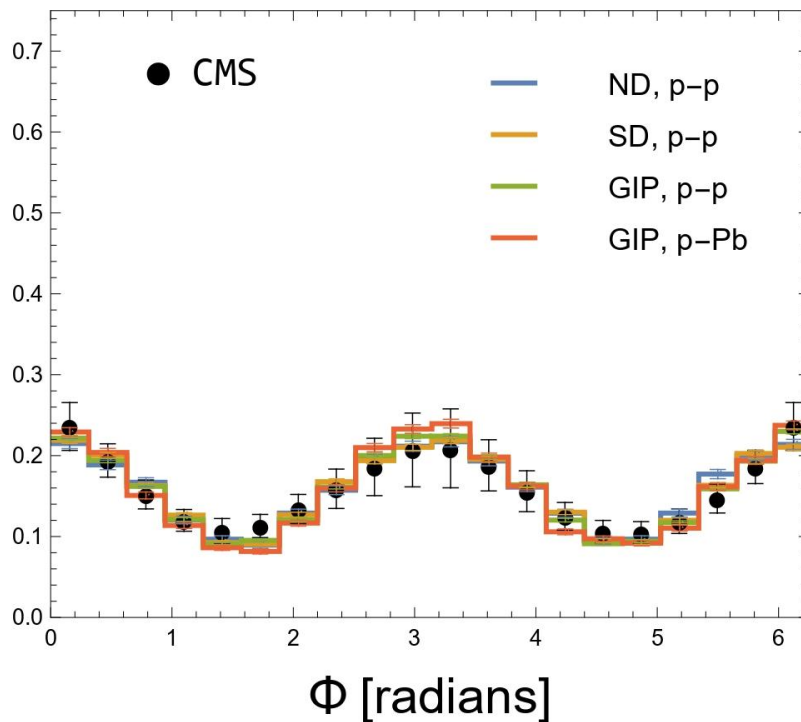
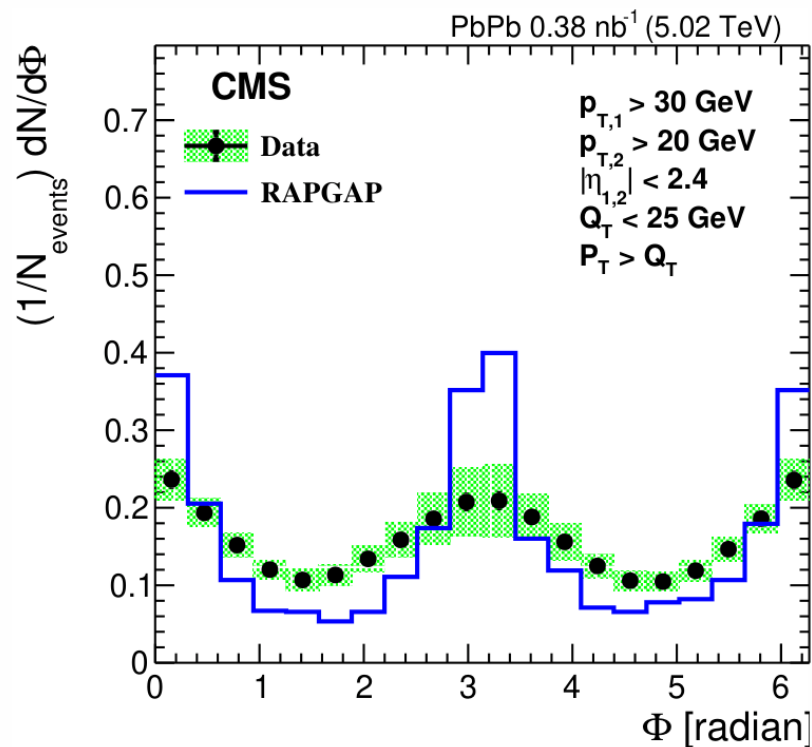
- Dijets as unique probe for *novel tomography imaging of the nucleon and nucleus*:
 - Ideally, 2 final state jets produced in back-to-back in transverse plane with nearly balanced transverse momenta.
 - **Deviations** → *nonperturbative structure of the nucleon and nucleus*.
- **Processes**:
 - One nucleus/proton → provides photon (γ)
 - Other nucleus/proton → provides pomeron (P)
- **Diffractional** refers to :
 - process in which there is a **large rapidity gap** between the produced jets and the nuclear target.
 - **Photoproduction**: $Q^2 < 1 \text{ GeV}^2$ (other limit is DIS)
- *Diffractional photoproduction (as background) helps to understand Exclusive processes (only dijets as final state, Pomeron ladder with dijet) which gives direct access to QCD Wigner functions (parton tomography).*



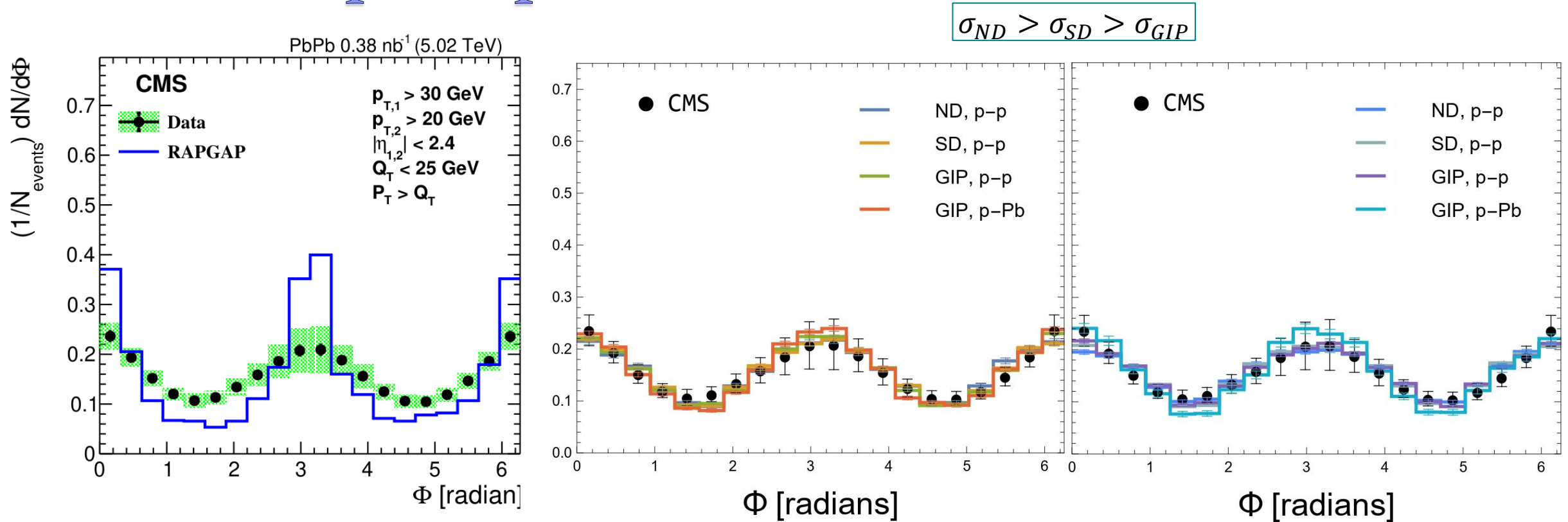
 In UPC, the ions stay intact and pass by each other, but their **electromagnetic fields** interact to produce interesting physics!

Diffractive photoproduction

$$\sigma_{ND} > \sigma_{SD} > \sigma_{GIP}$$

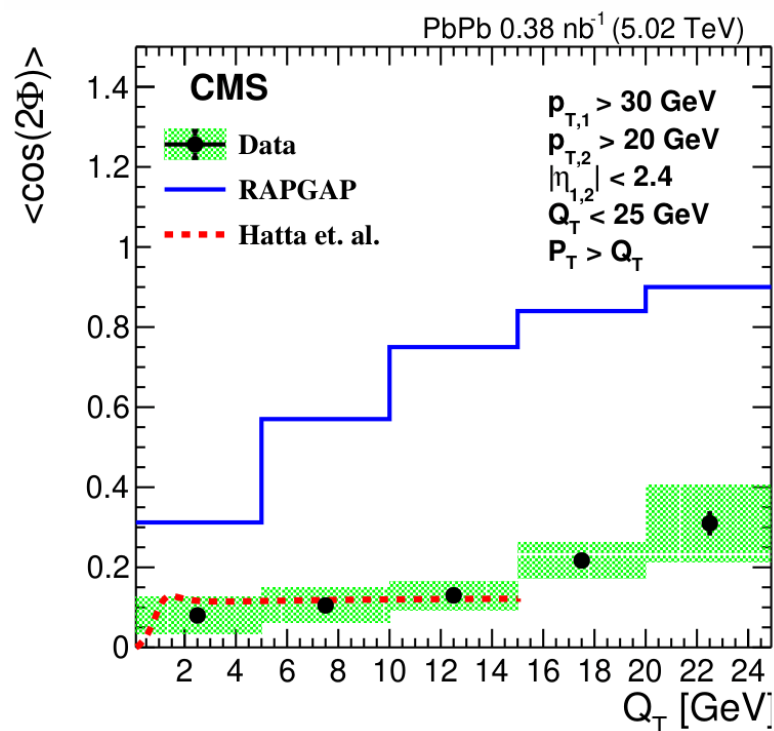


Diffractive photoproduction

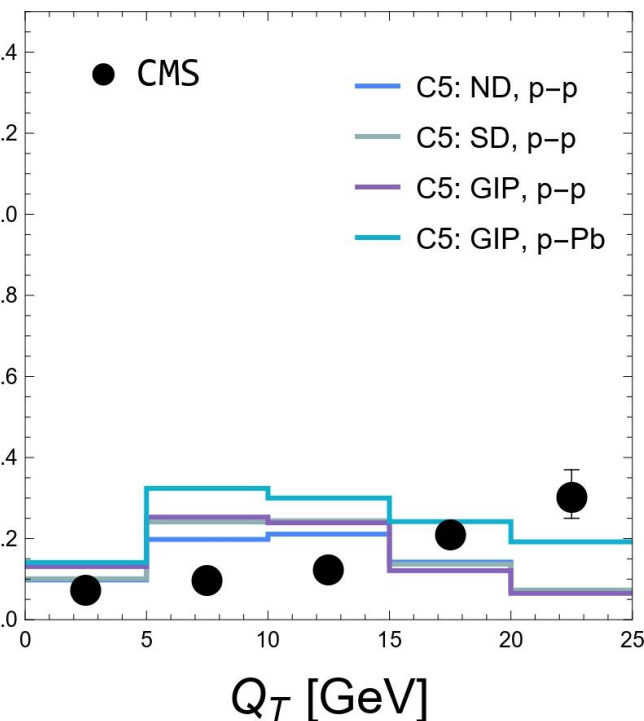
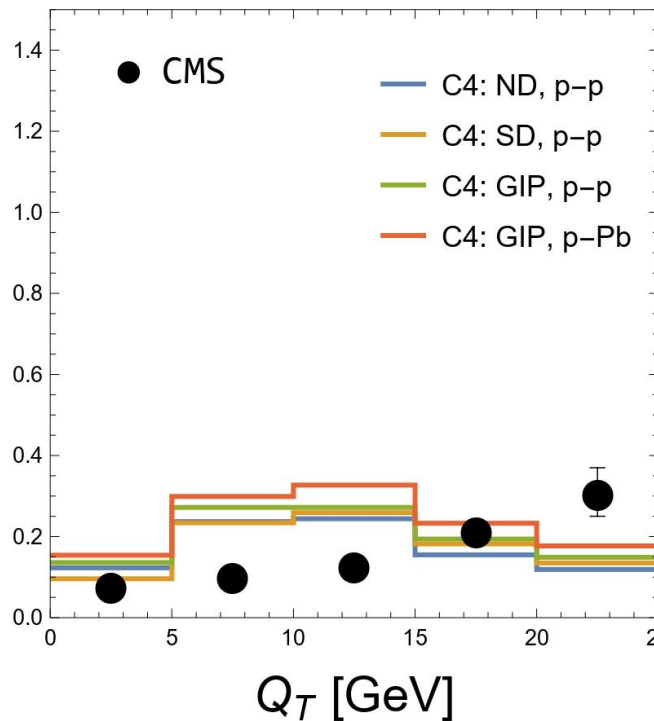


- Pythia (8.3) studies of azimuthal correlations of dijets, *but only in events selected to have a rapidity gap*:
 - Implement **CMS rapidity gap cuts** (further tightened exclusivity condition) to select diffractive events.
- **Impact** :
 - Rapidity gaps isolate diffractive γ -IP (GIP) interactions, enabling access to gluon dynamics through anisotropic distribution (nontrivial correlations in TMD associated with incoming hadrons).

Diffractive photoproduction



$$\sigma_{ND} > \sigma_{SD} > \sigma_{GIP}$$



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Diffraction photoproduction

These distributions are not directly calculable in perturbative QCD, making them challenging to measure.

However, they can be accessed through exclusive diffractive dijet production in ultraperipheral collisions (UPCs) at the LHC and the future Electron-Ion Collider (EIC).

Thank you !