



U.S. DEPARTMENT OF
ENERGY

Office of Science



Nuclear fragmentation studies in UPCs

Daniel Tapia Takaki

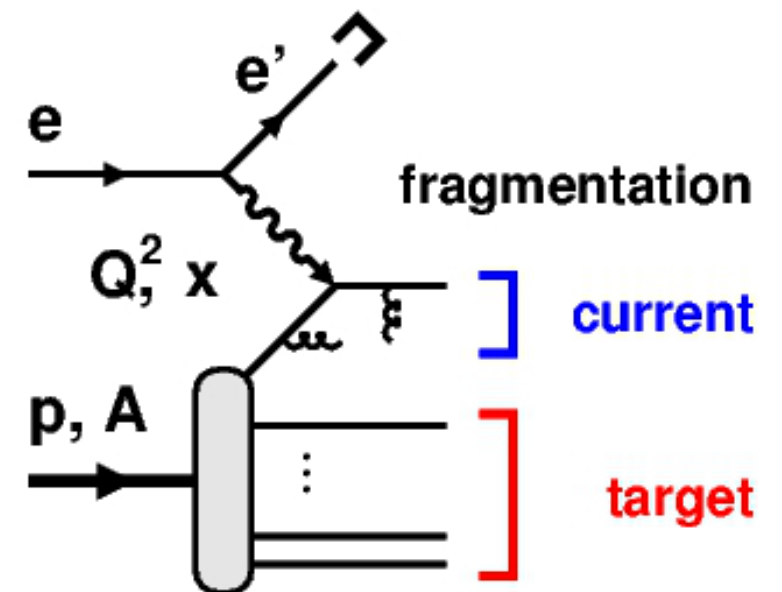
University of Kansas, UC Berkeley & LBNL

CFNS Ad hoc Workshop: Target Fragmentation physics with EIC

September 28, 2020

Plan of this talk

- **Informal discussion:** possible nuclear fragmentation studies with UPCs?



<https://indico.bnl.gov/event/9287>

- **Future opportunities at RHIC and LHC** discussed in recent Lols submitted to Snowmass 2021

New opportunities at the photon energy frontier

<https://arxiv.org/abs/2009.03838>

Ultra-Peripheral Collisions in Heavy-Ion Physics

https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF7_EF6_UPC-224.pdf

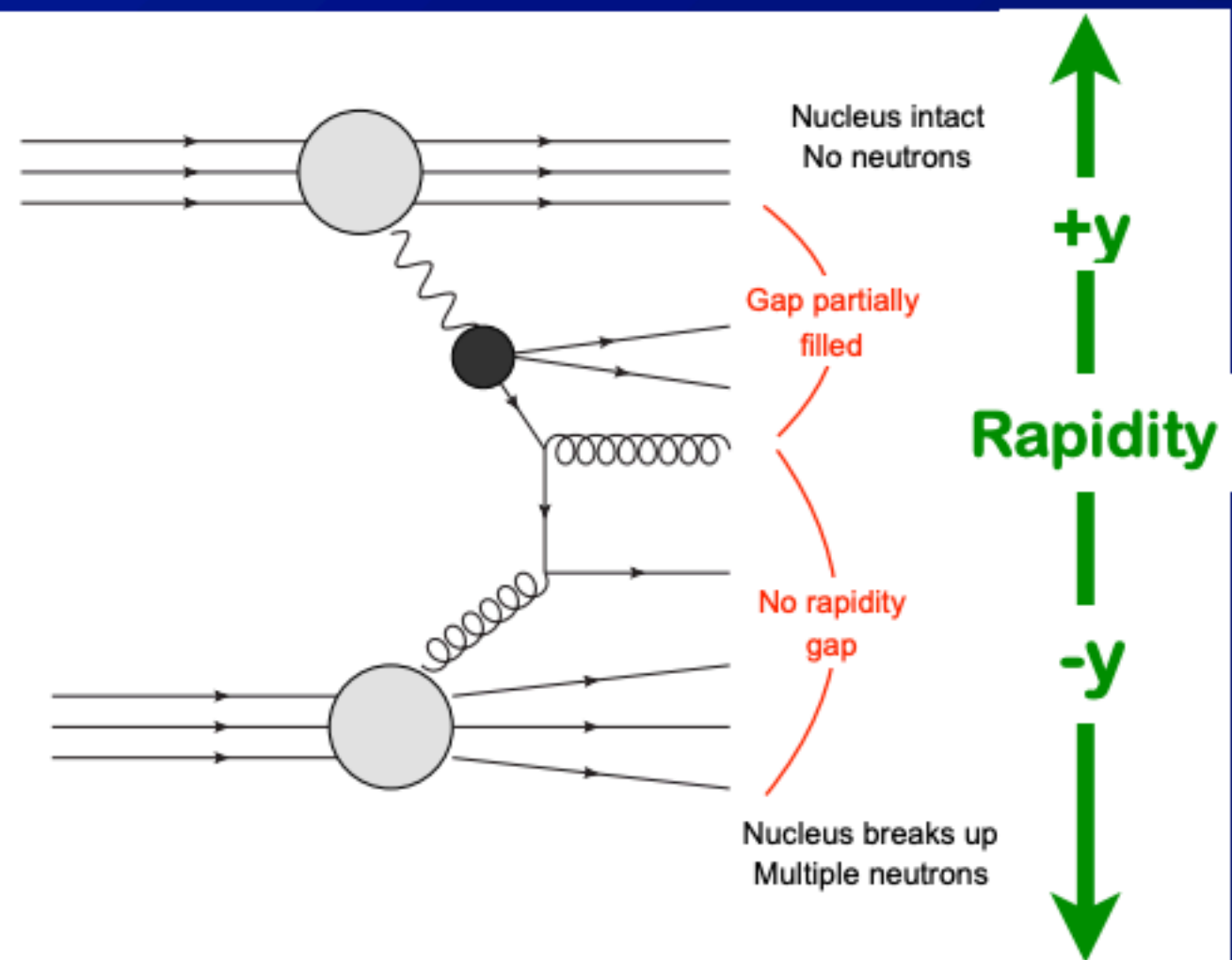
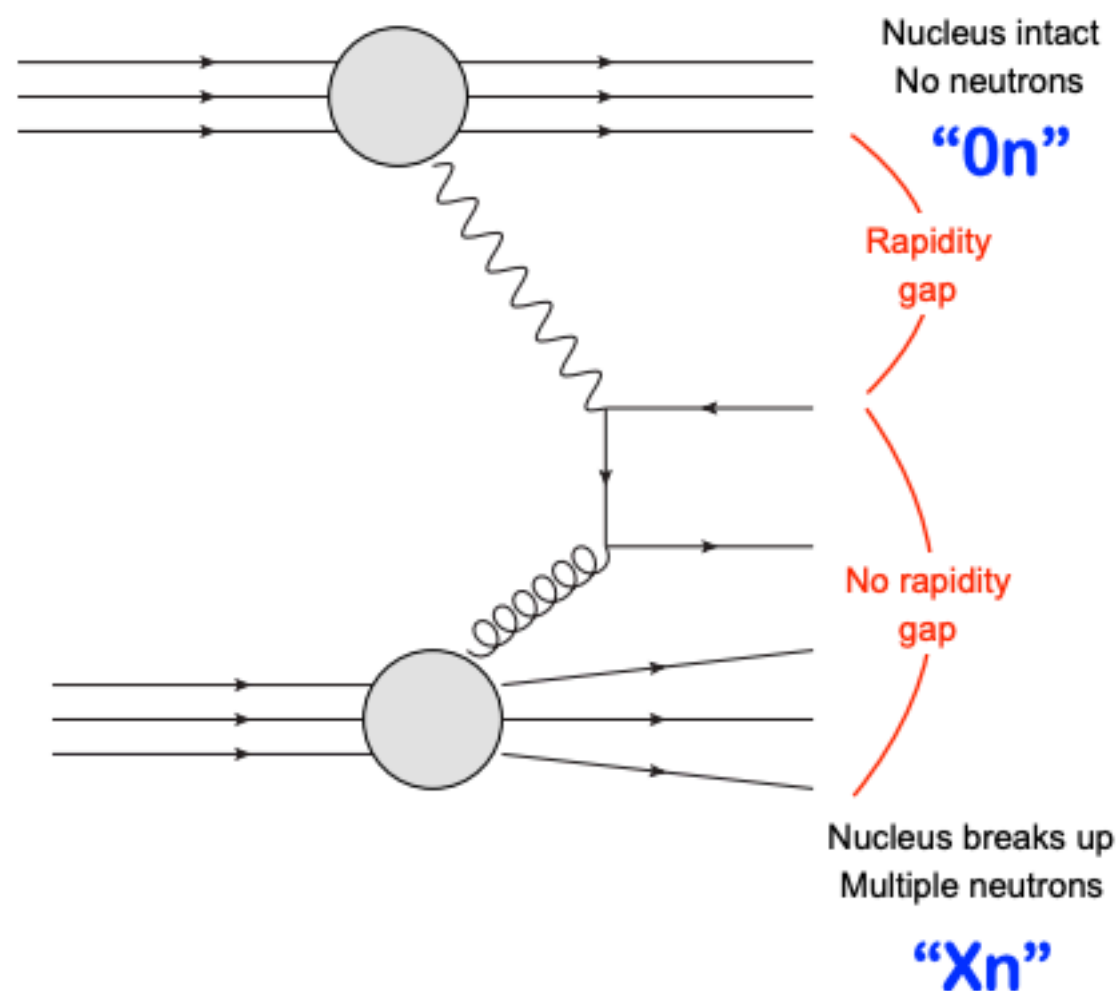
$$\gamma p(A) \rightarrow \text{Dijet} + n + X$$

Forward instrumentation in all the LHC experiments and at RHIC

$$\gamma p(A) \rightarrow \text{“dijet”} + n + X$$

ATLAS has preliminary results on inclusive photonuclear dijets

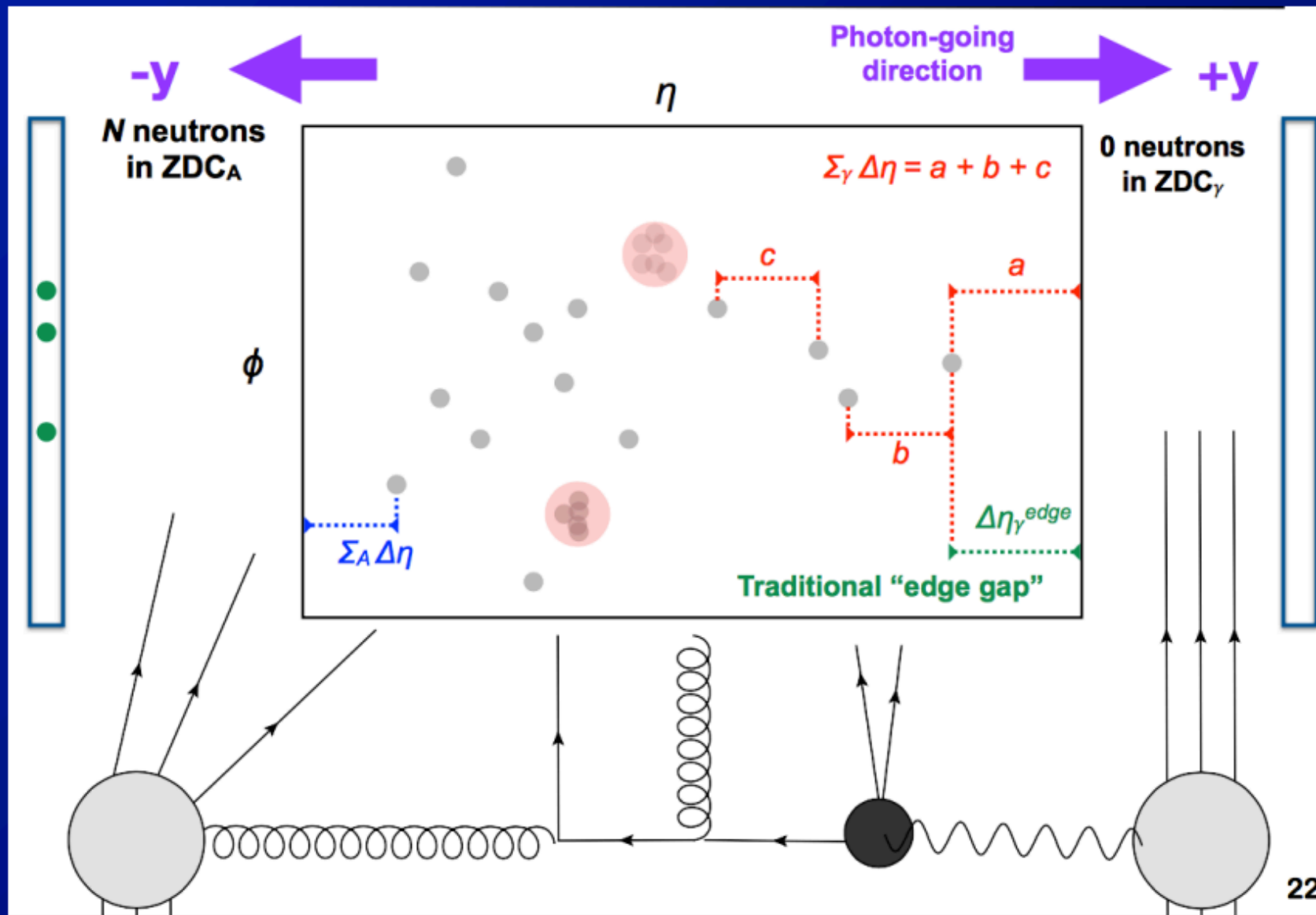
Photo-nuclear processes



B. Cole, APS Hadronic Workshop 2019

$$\gamma p(A) \rightarrow \text{Dijet} + n + X$$

Gap analysis



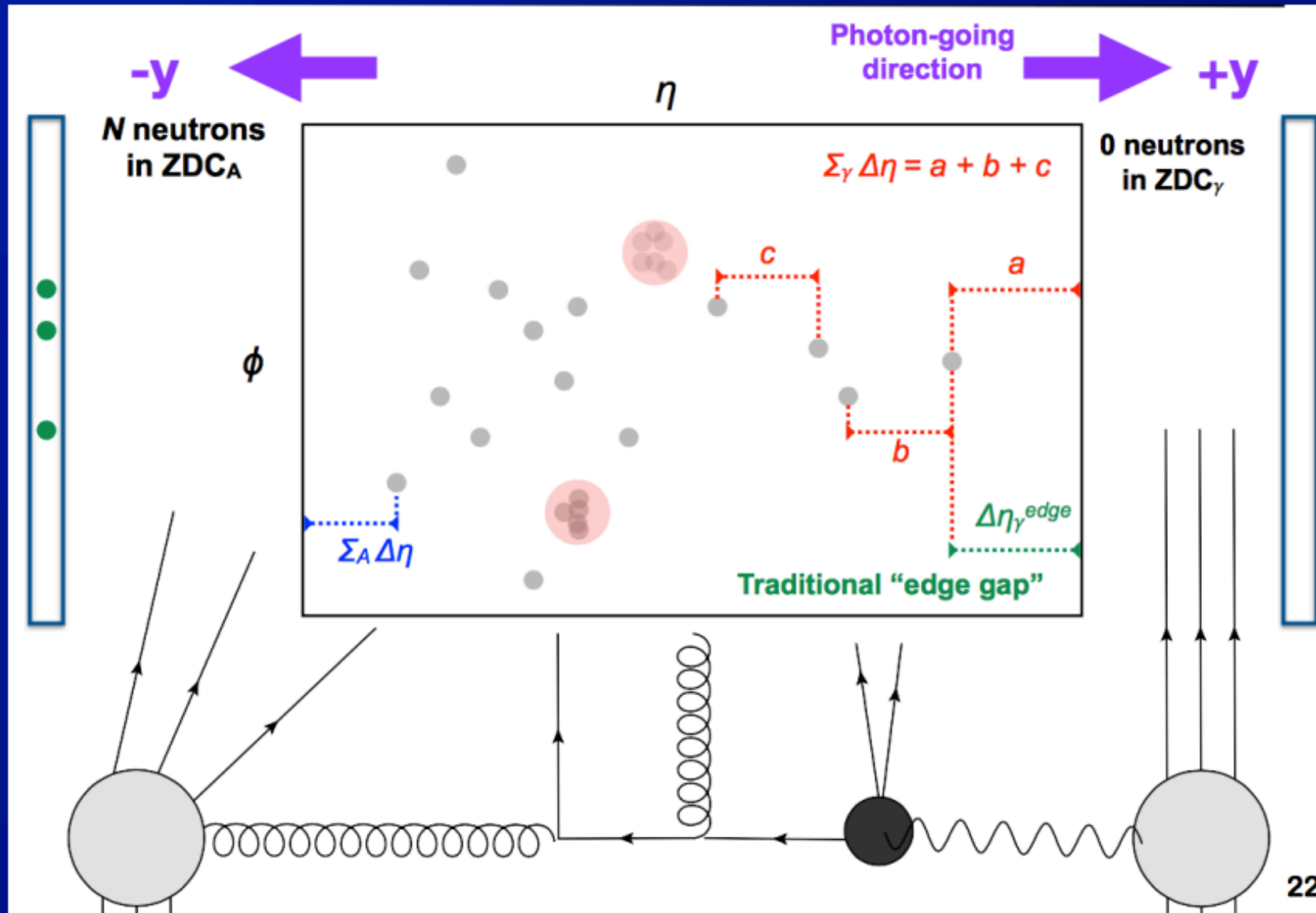
Such an analysis could in principle be extended to look at fragmentation studies

- Require gap on photon side: $\Sigma_Y \Delta\eta > 2$
- Reject large gaps on nuclear side: $\Sigma_A \Delta\eta < 3$

B. Cole
APS Hadronic Workshop 2019

$$\gamma p(A) \rightarrow \text{Dijet} + n + X$$

Gap analysis

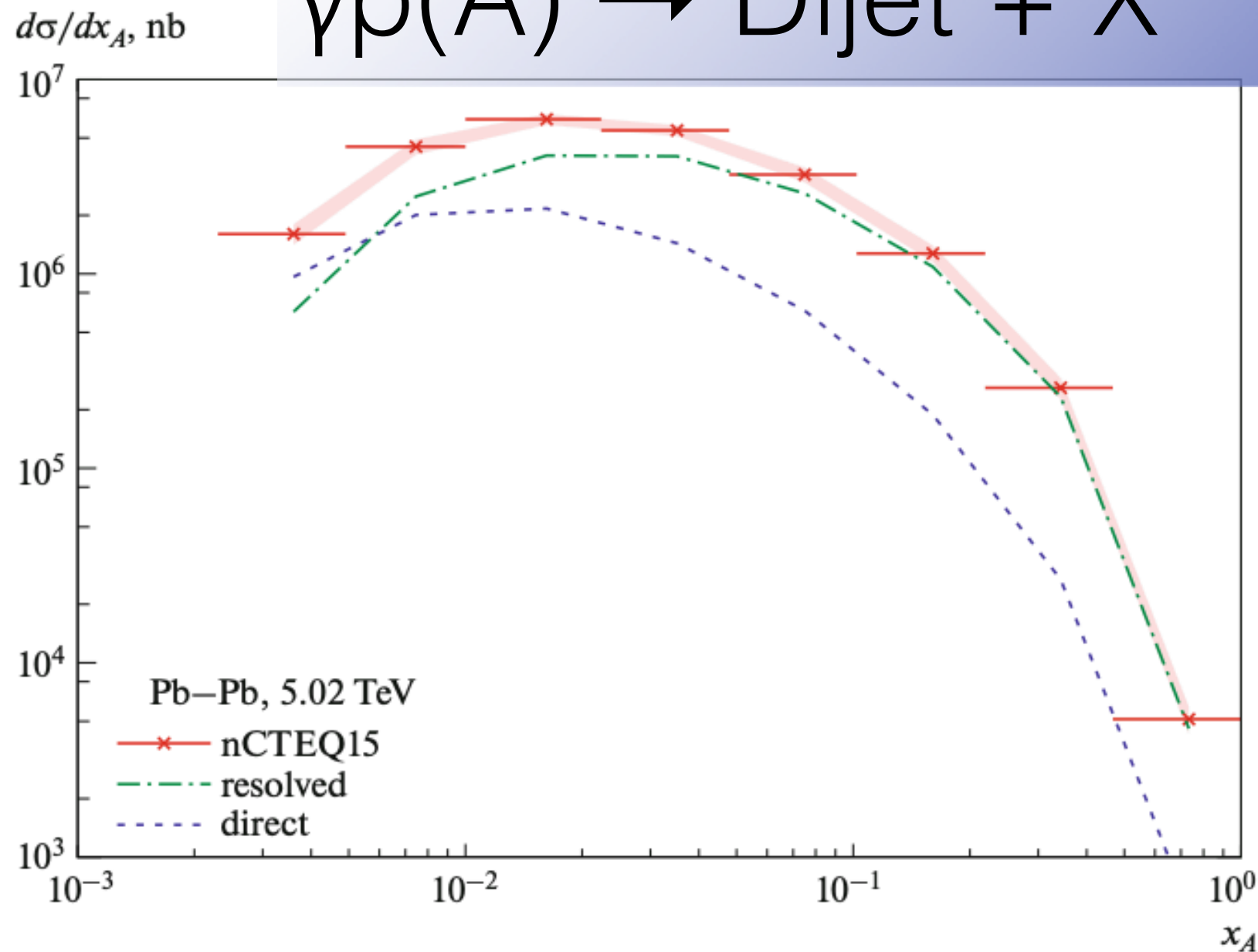


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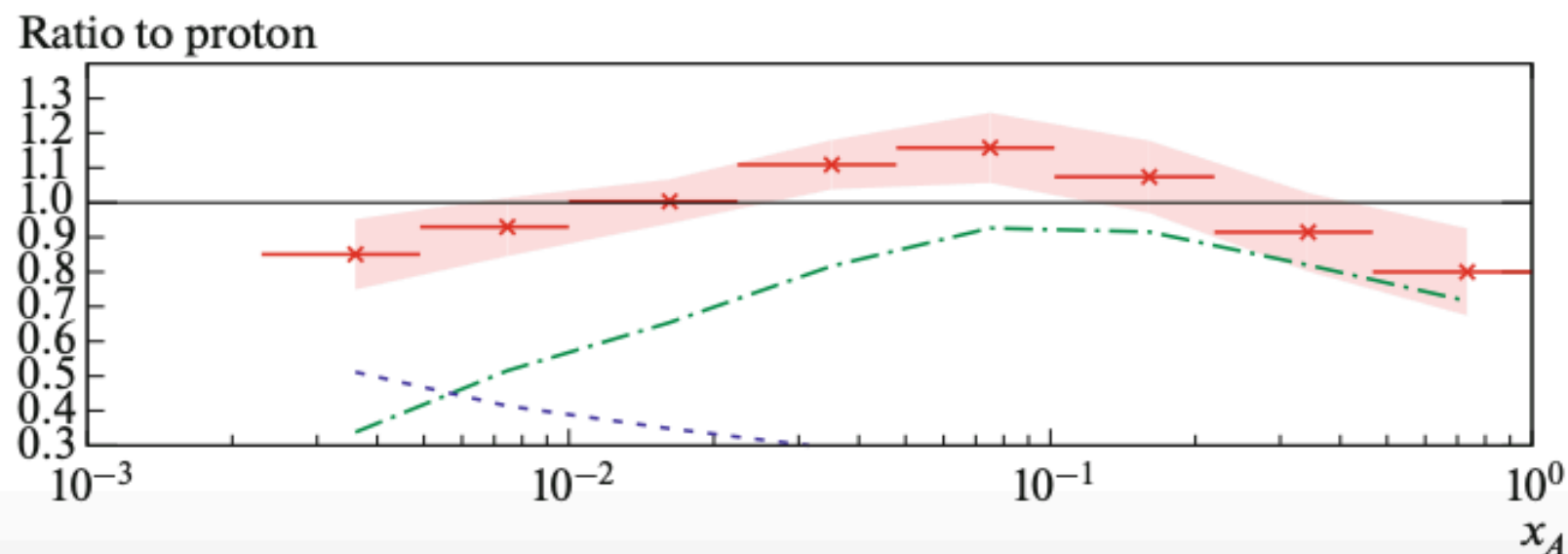
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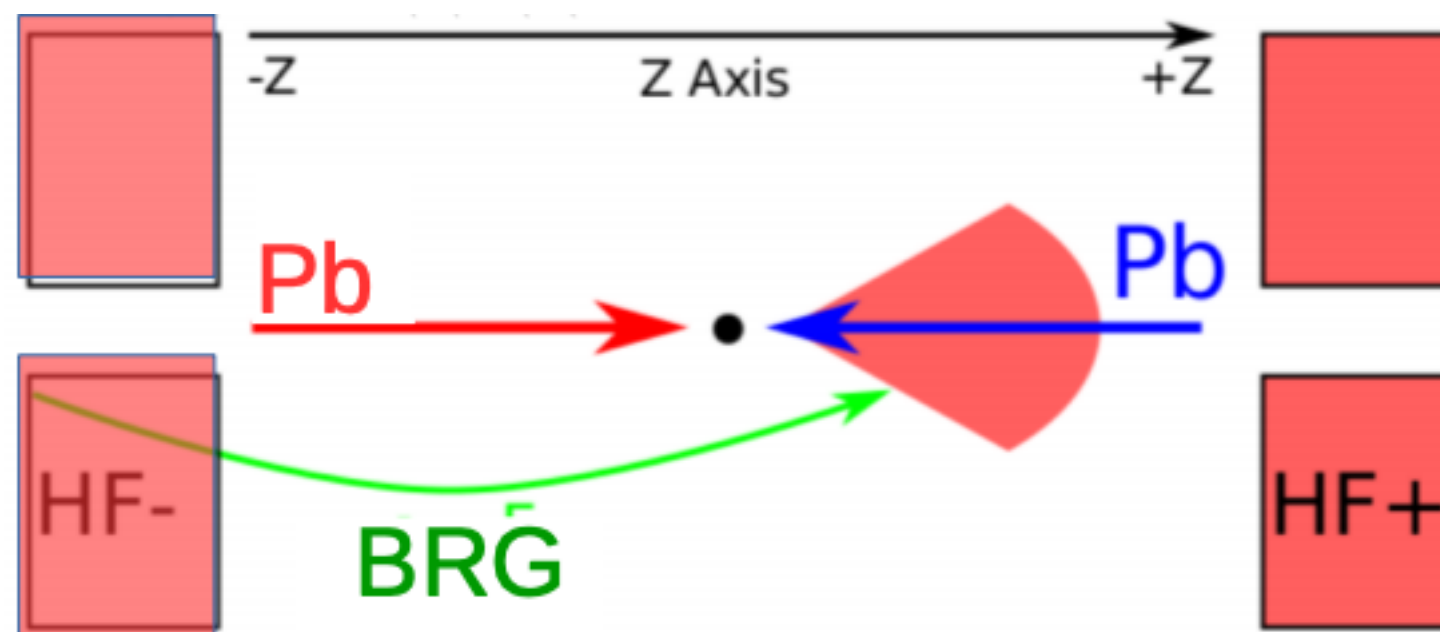
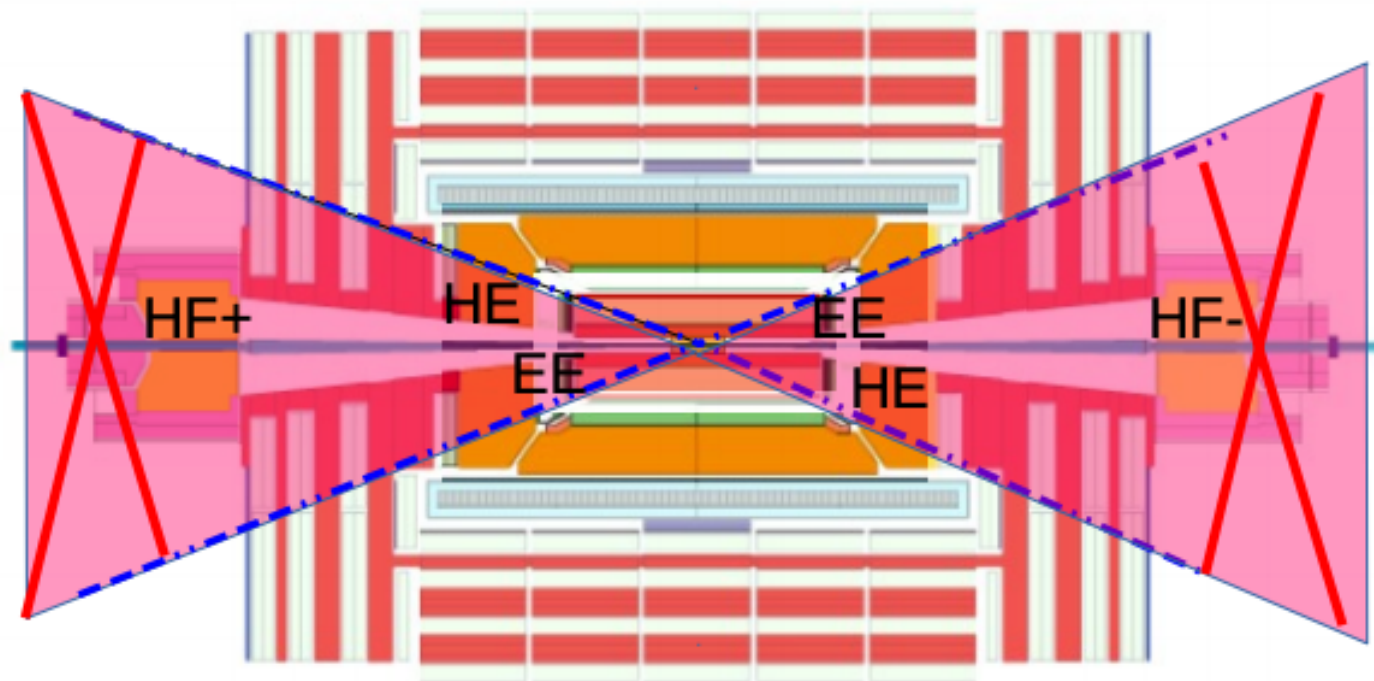


NLO pQCD cross section of dijet photoproduction in PbPb UPCs & preliminary ATLAS data



V. Guzey
Phys.Part.Nucl.Lett. 16 (2019) 5, 498-502

$$\gamma A \rightarrow \text{Dijet} + X$$

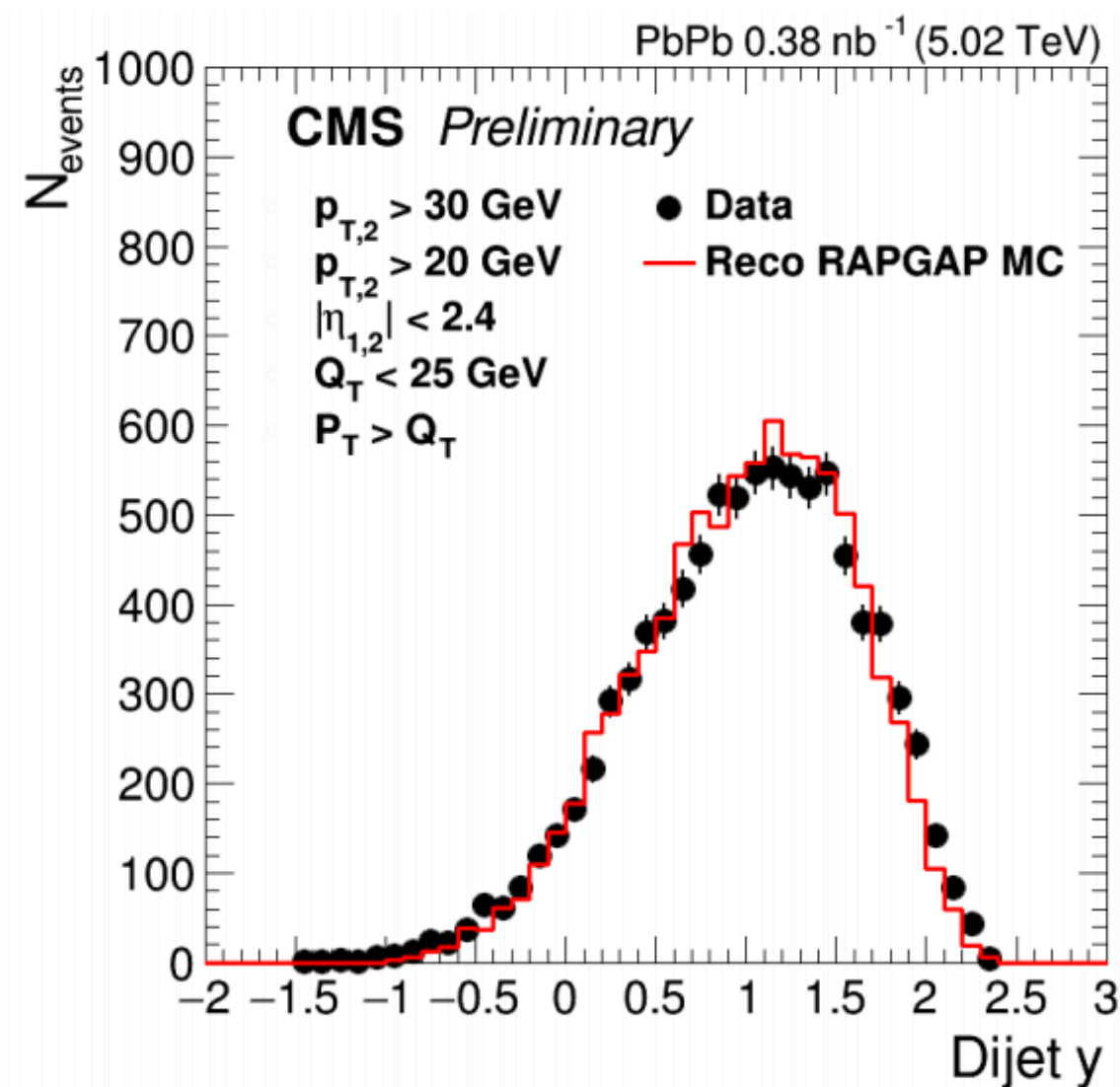
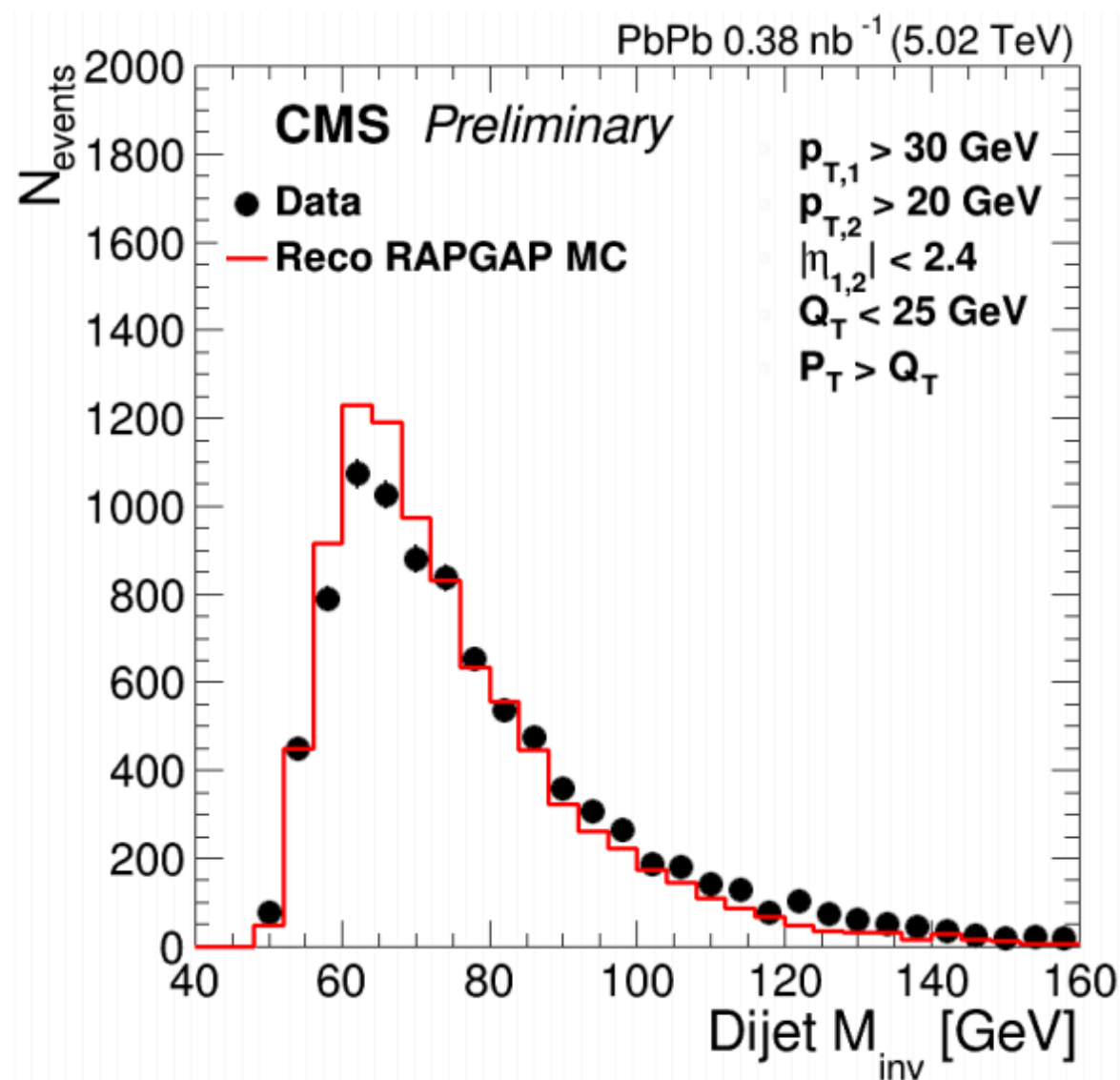


A. Bylinkin
ICHEP 2020

$$\gamma A \rightarrow \text{Dijet} + X$$

(CMS-PAS-HIN-18-011)

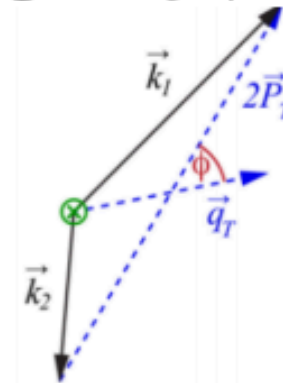
Dijet kinematics



A. Bylinkin
ICHEP 2020

$\gamma A \rightarrow \text{Dijet} + X$

Exclusive dijets in UPC PbPb @5 TeV (CMS-PAS-HIN-18-011)



Vector sum of 2 jets:

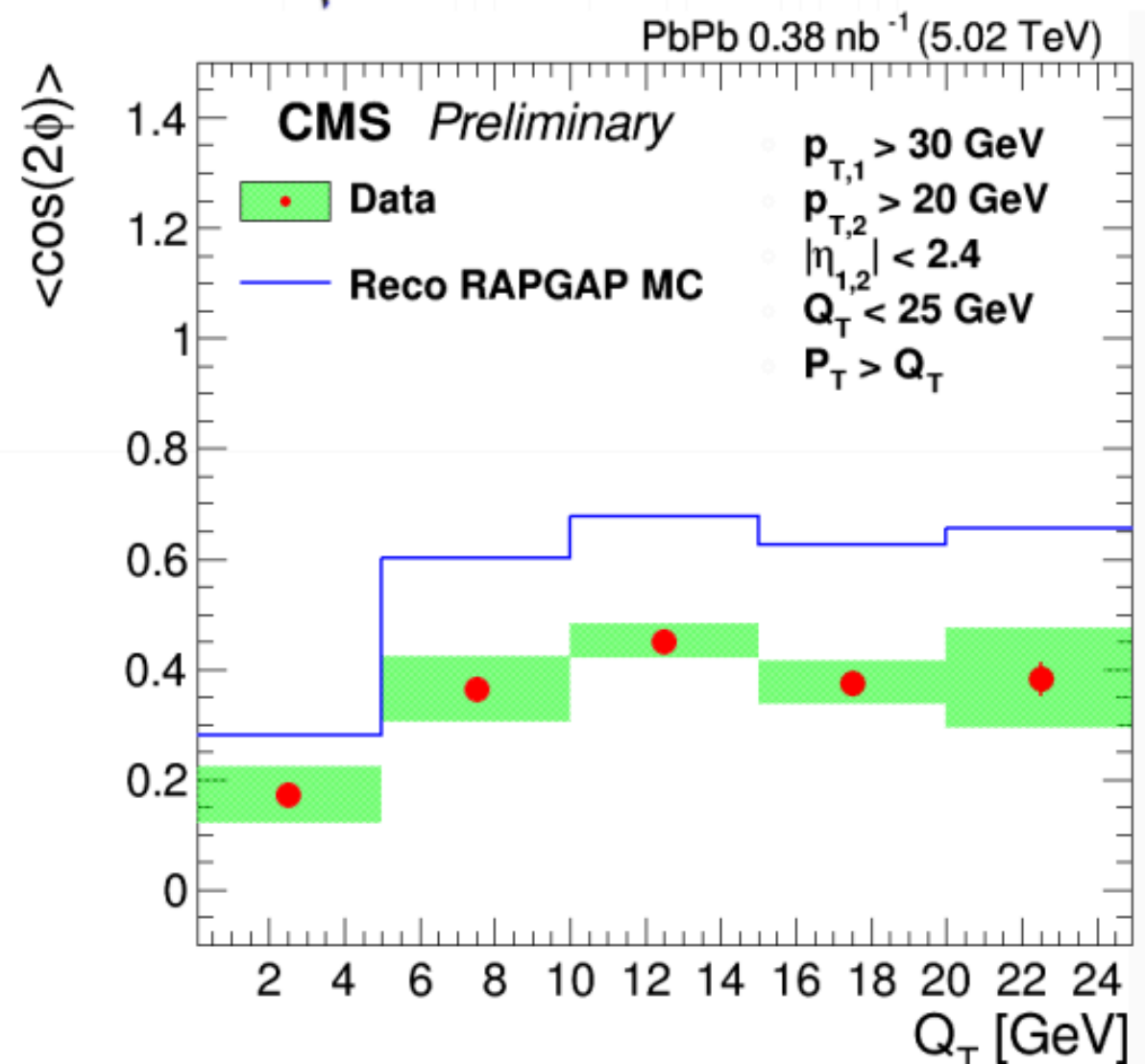
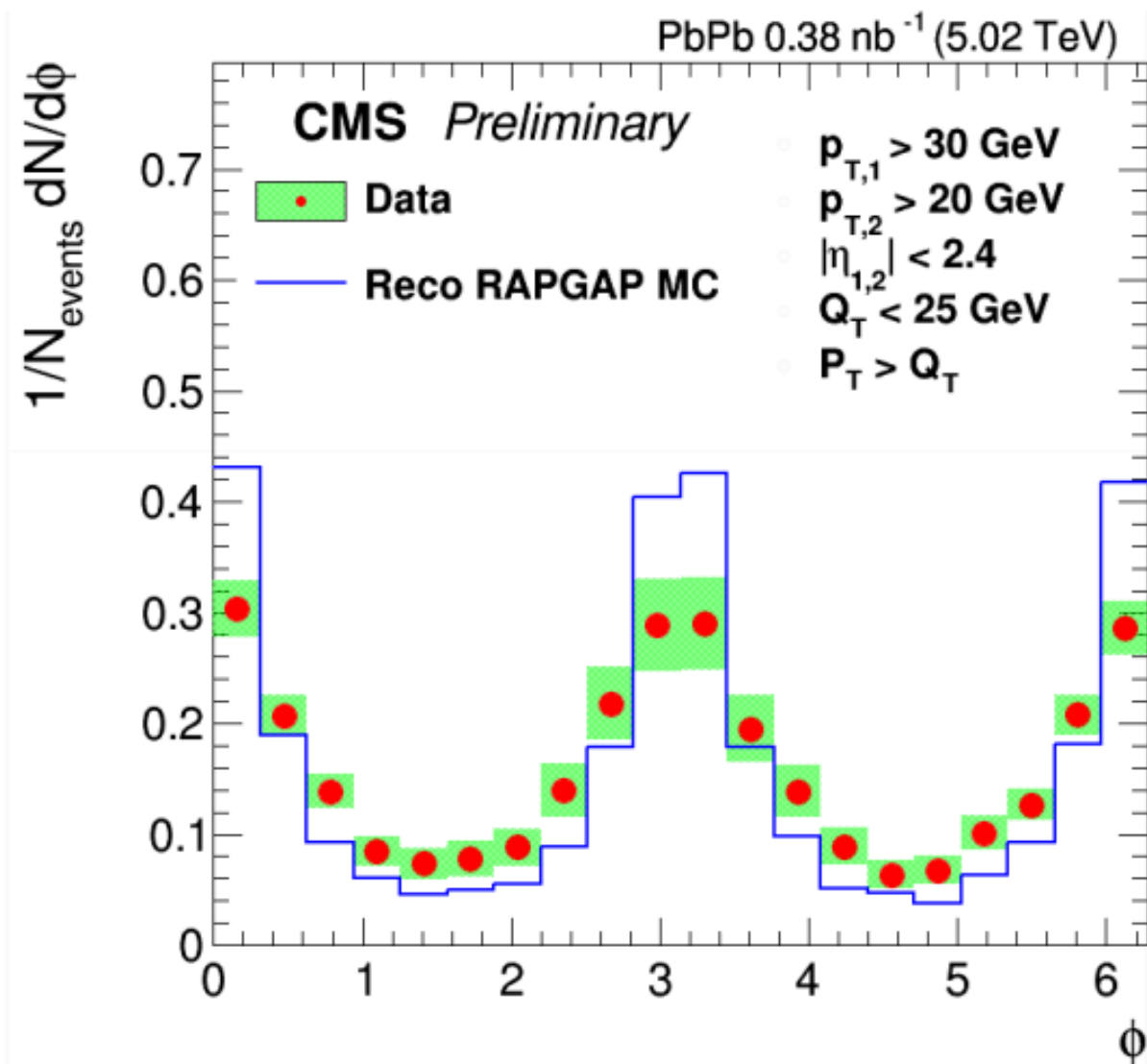
$$\vec{Q}_T = \vec{k}_1 + \vec{k}_2$$

Vector difference of 2 jets

$$\vec{P}_T = \frac{1}{2}(\vec{k}_1 - \vec{k}_2)$$



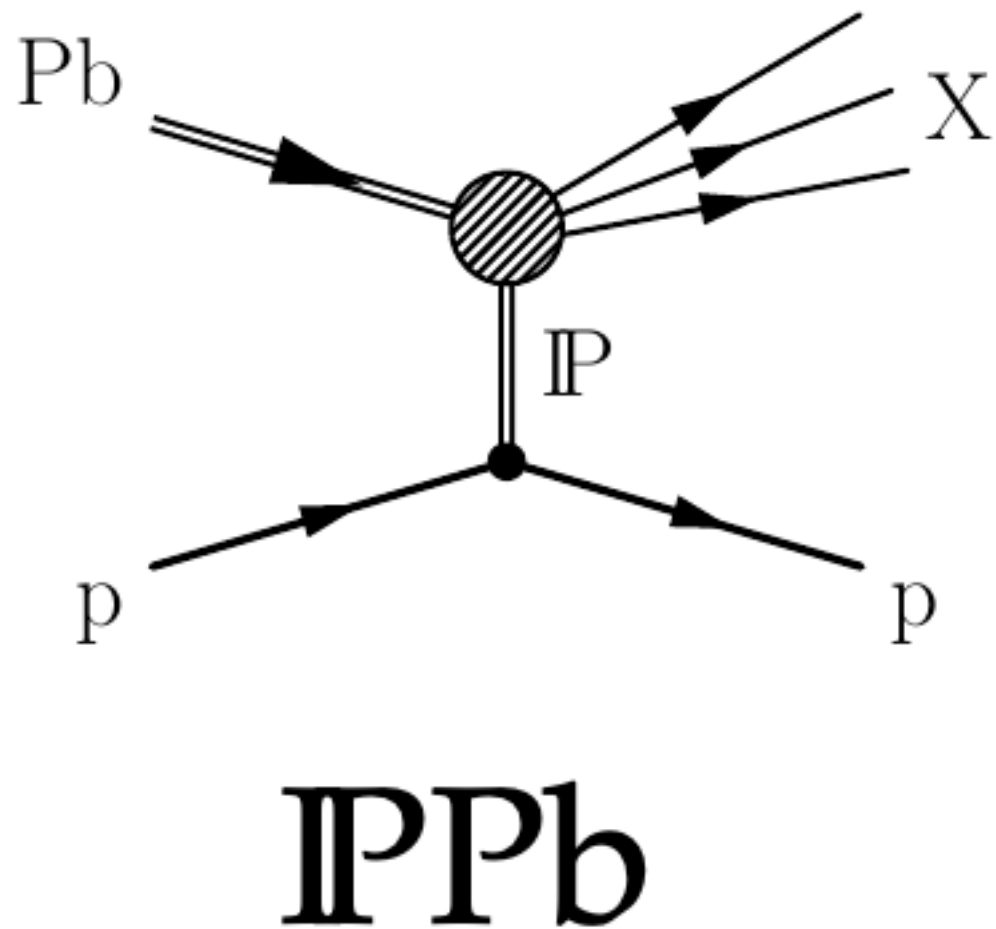
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ICHEP 2020



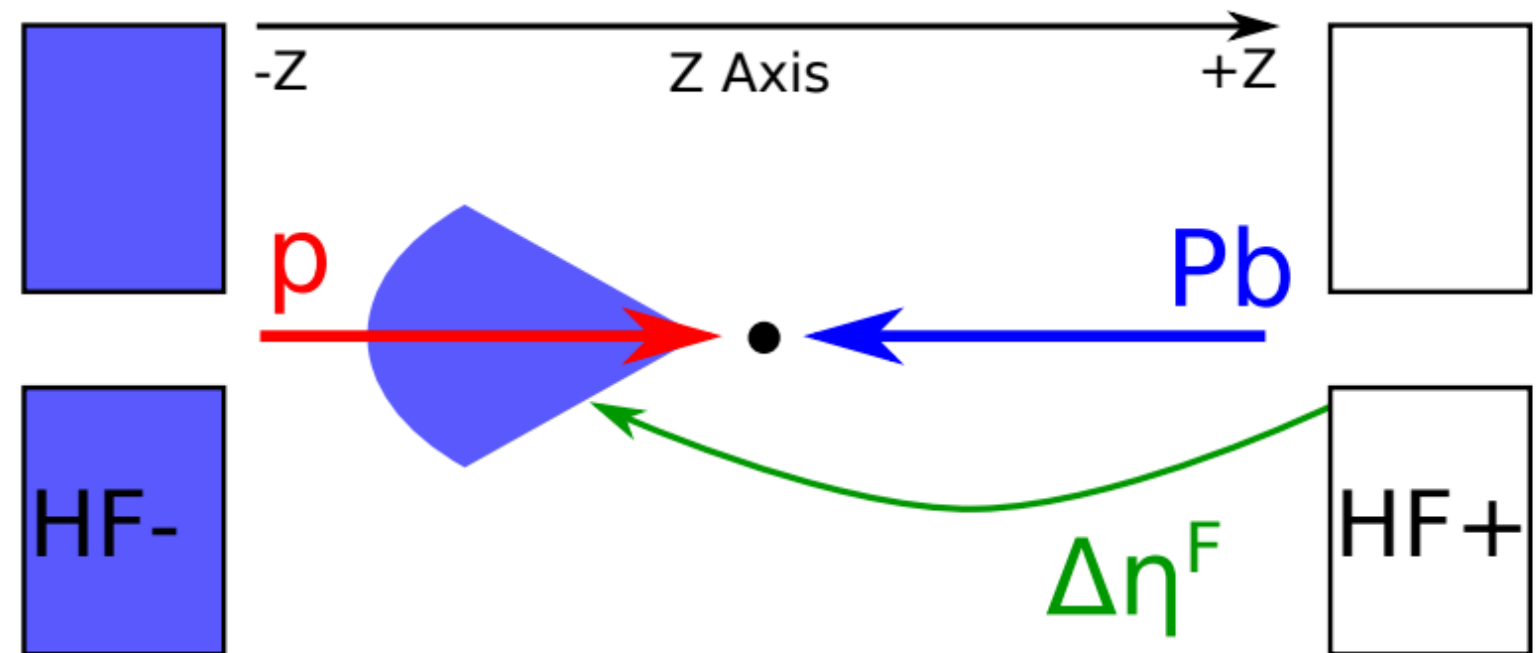
Diffraction

See V. Guzey's talk on diffraction as a special case of target fragmentation

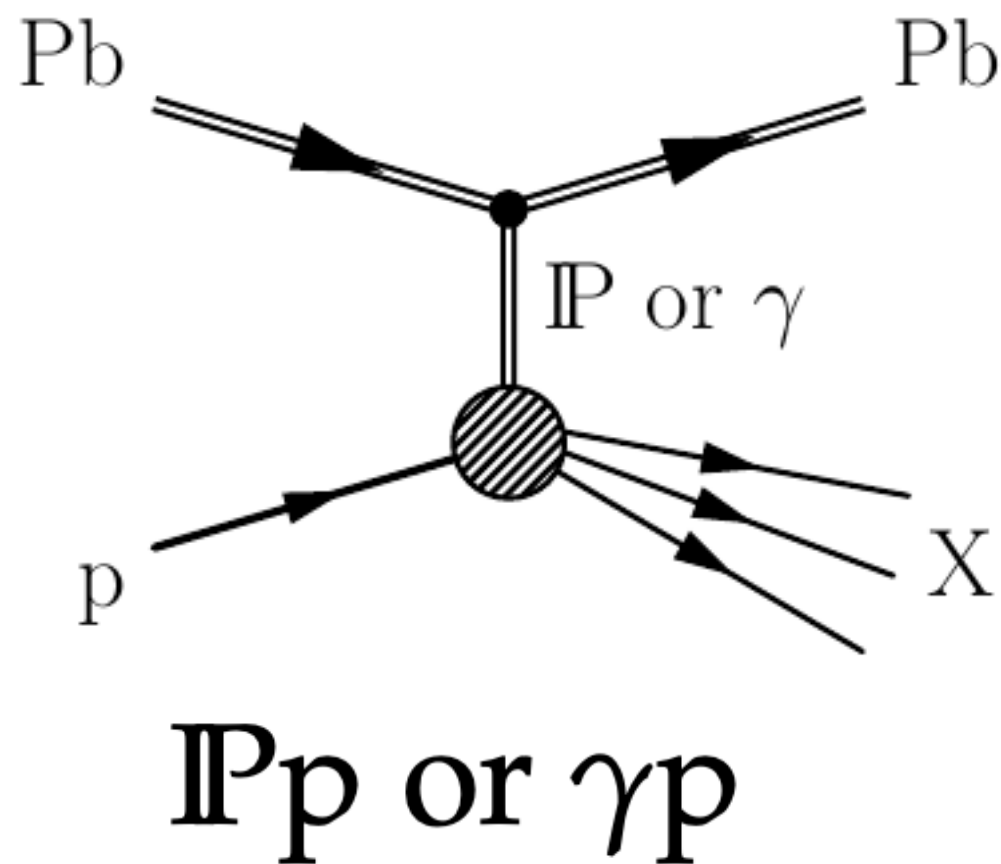
First diffraction measurement in heavy-ions & prospects for inclusive UPCs



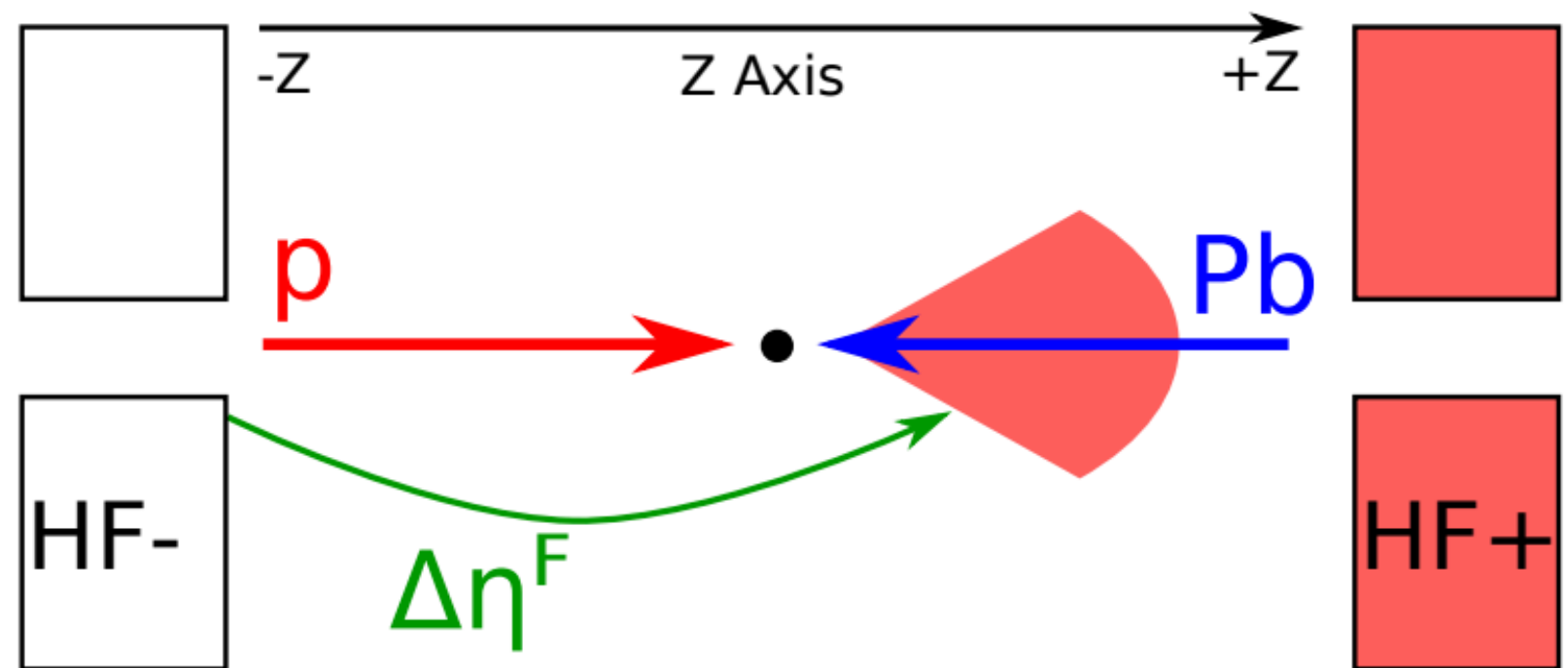
Large rapidity gaps



First diffraction measurement in heavy-ions & prospects for inclusive UPCs



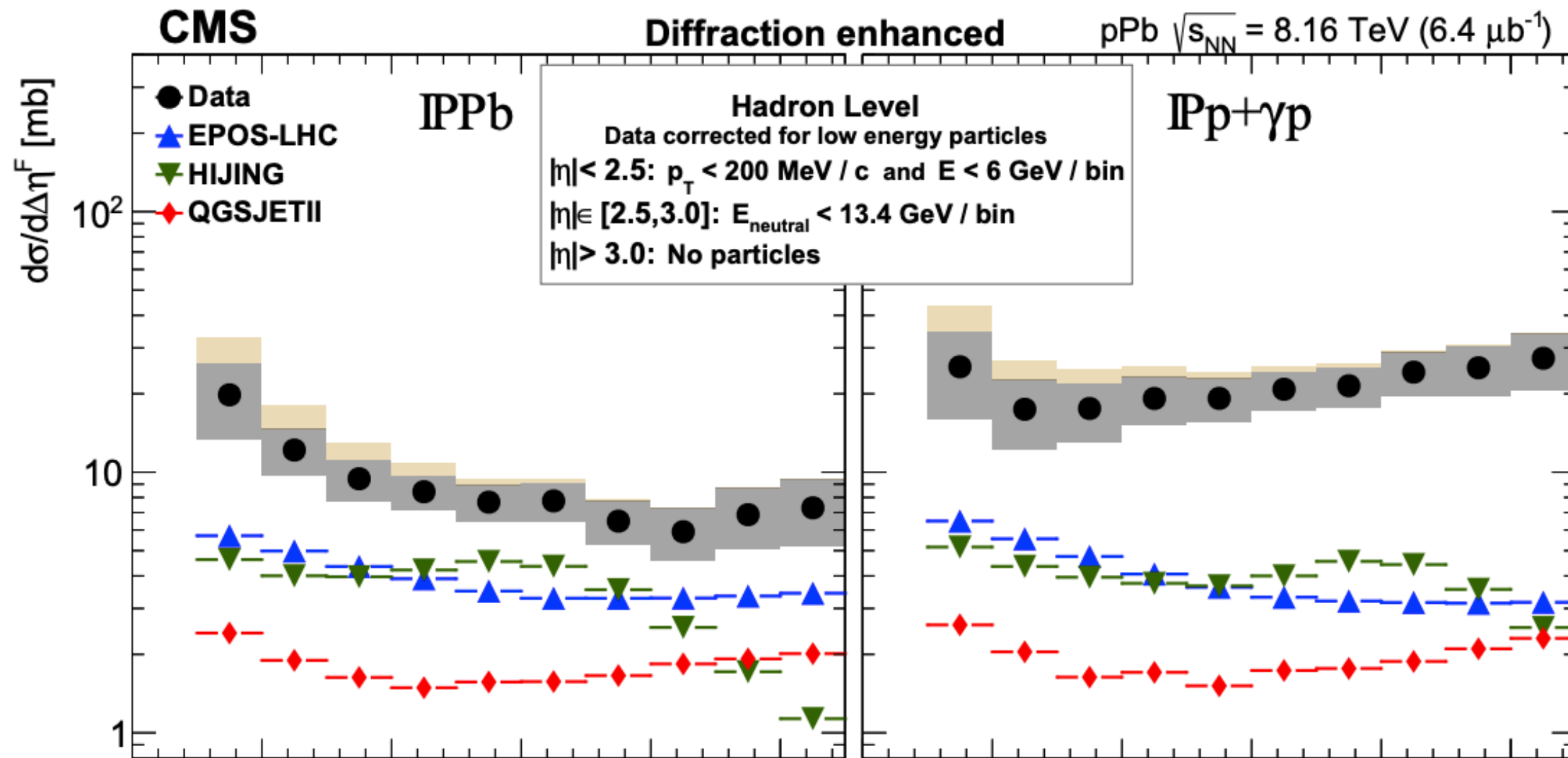
Large rapidity gaps



First diffraction study in pPb

CMS HIN-18-019

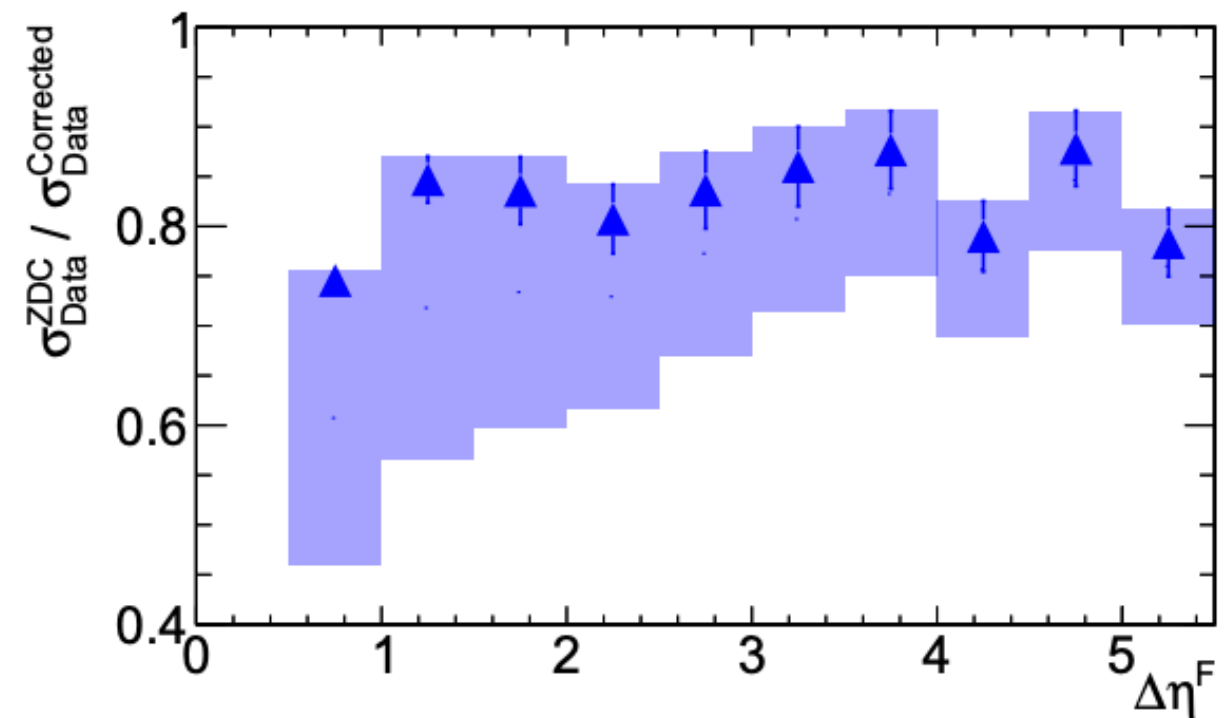
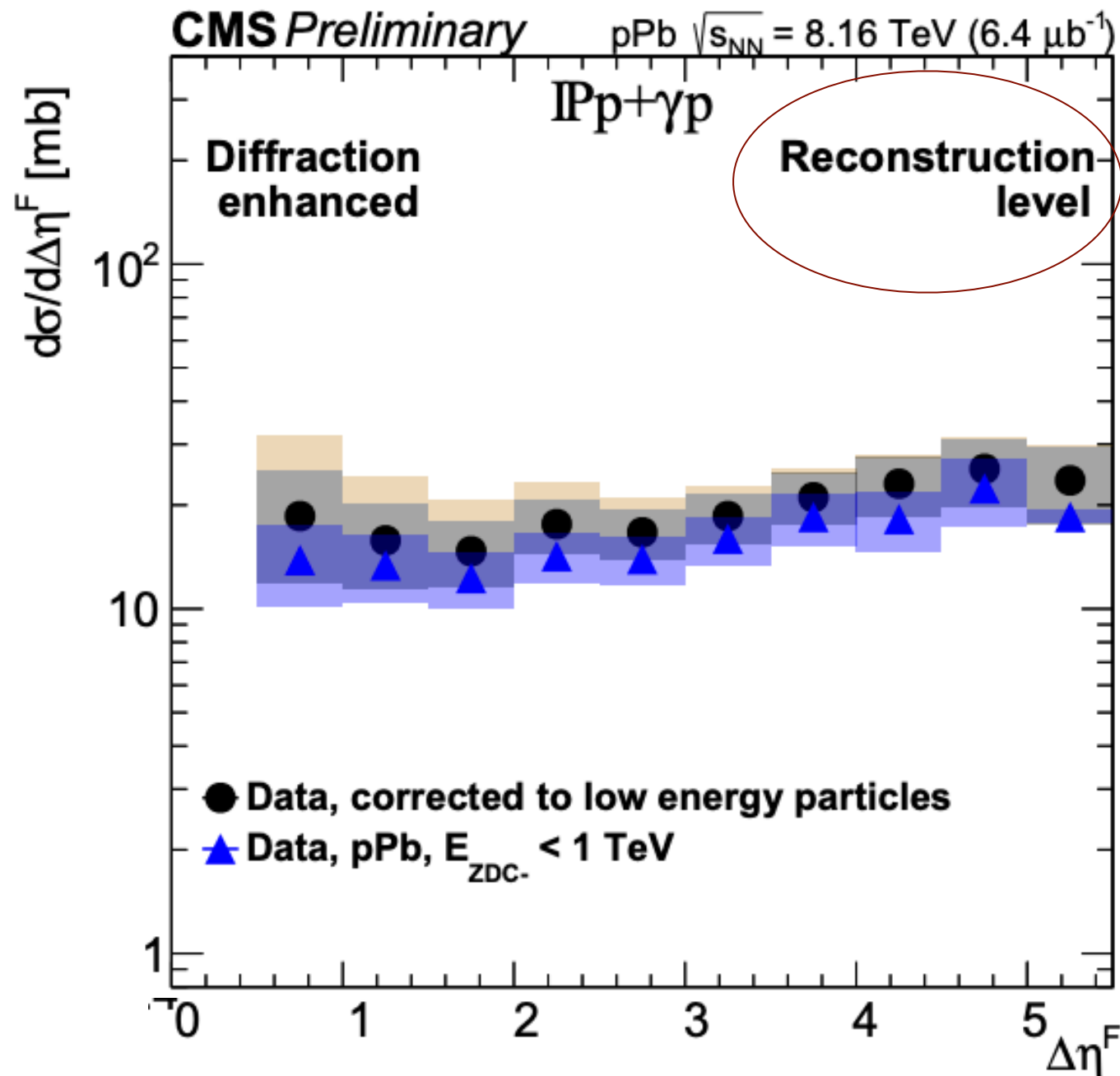
Large rapidity gap technique



First Diffraction measurement in pPb
Observation of enhancement of photon-induced component
vs. rapidity gap size

First diffraction study in pPb

CMS HIN-18-019



Fraction of events selected with the ZDC veto requirement

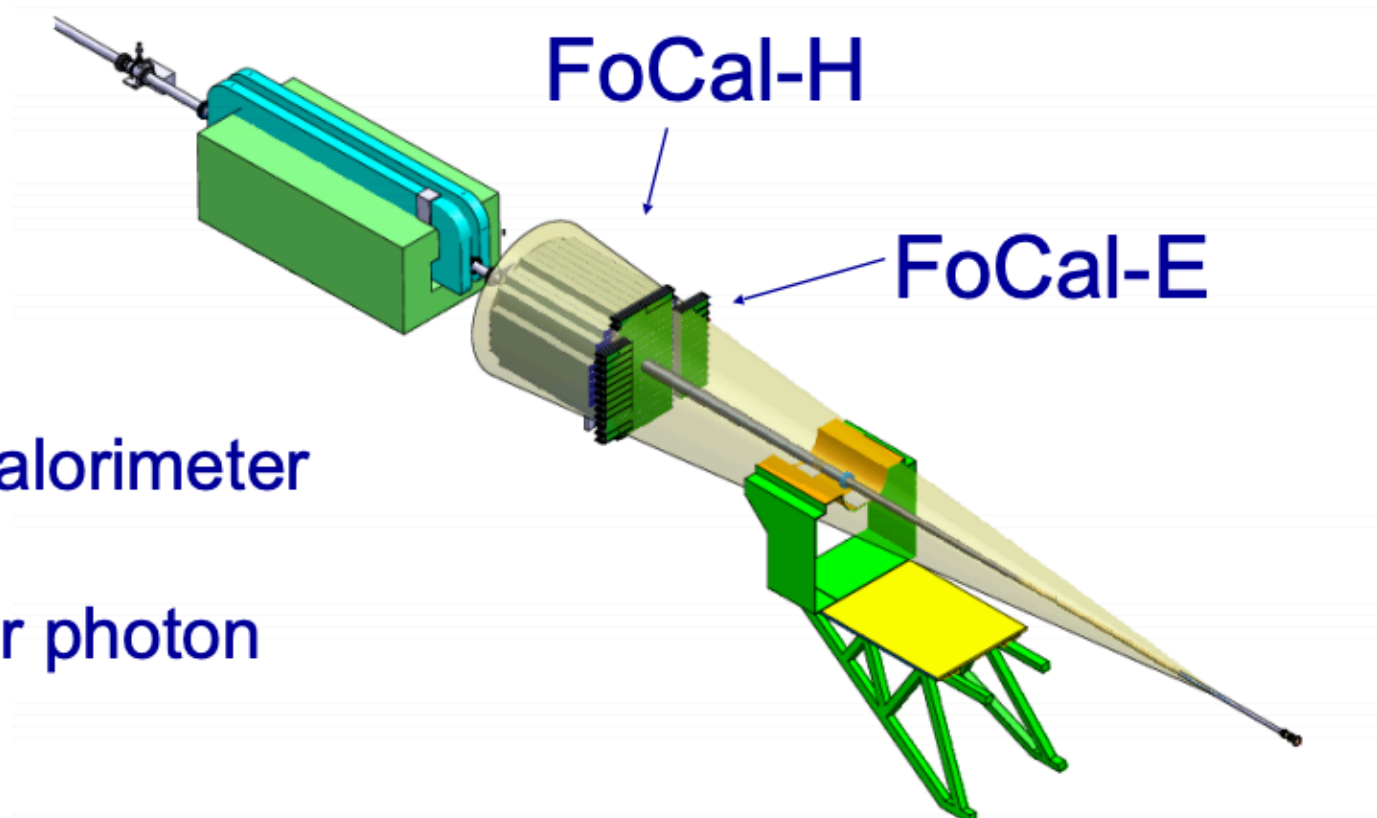
Future opportunities at LHC

ALICE FoCal for Run 4 (2026)

$$3.2 < \eta < 5.8$$

FoCal-E: high-granularity Si-W calorimeter for photons and π^0

FoCal-H: hadronic calorimeter for photon isolation and jets



Observables:

- π^0
- Direct (isolated) photons
- Jets

Advantage in ALICE:
forward region not instrumented;
'unobstructed' view of interaction point

FoCal Letter of Intent got LHCC approval this summer

<https://cds.cern.ch/record/2696471>

Discussion points

- Results on dijet in PbPb UPC and diffraction in pA at LHC exist, and analyses can be “adjusted” to study target fragmentation region
- New detector proposed in the forward region, namely, FoCaL at ALICE can make an impact on these studies
- We will have a ‘contributed paper’ for Snowmass 2021. Your contributions are welcome