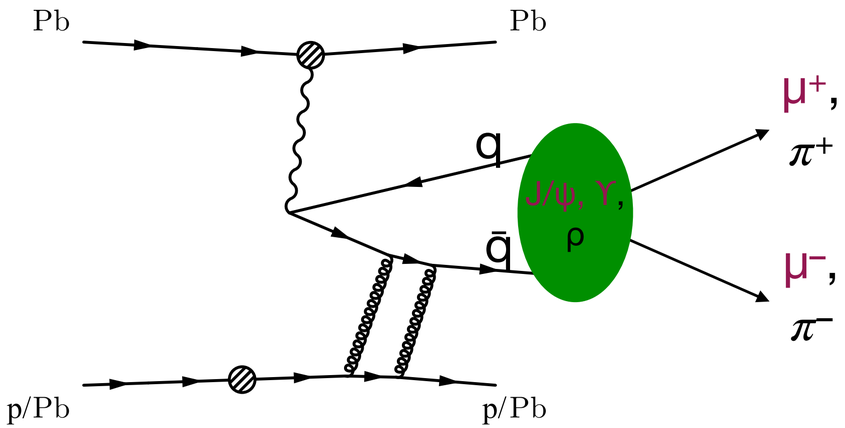
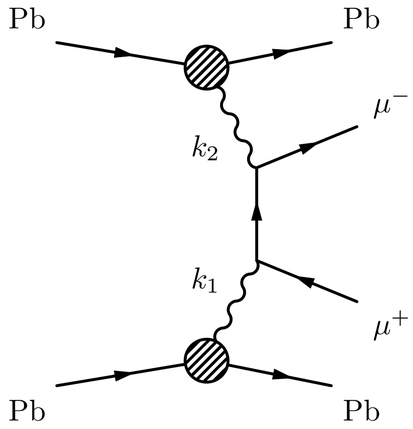
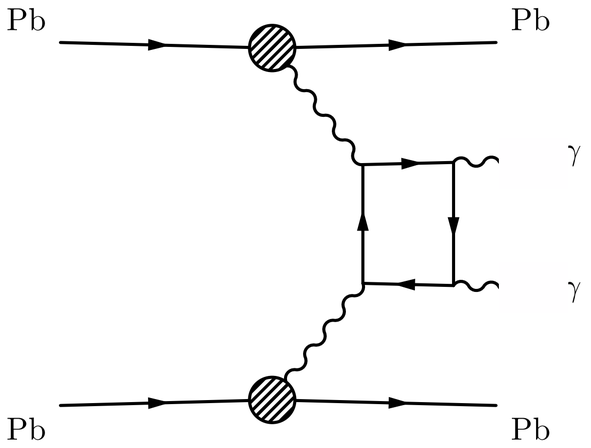
Existing exclusive UPC measurements



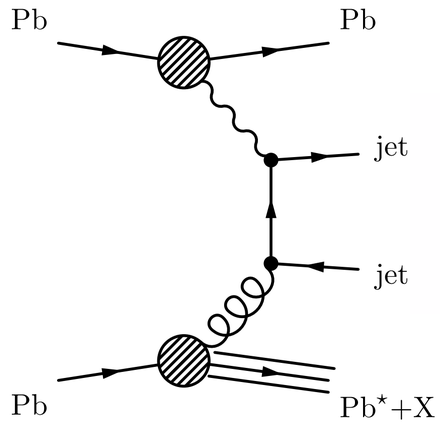
exclusive vector-meson production



exclusive continuous dilepton production



light-by-light scattering



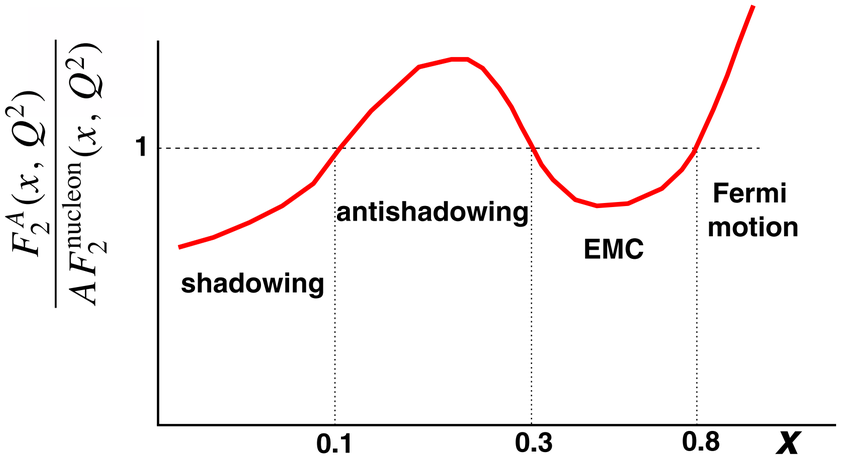
exclusive dijets

Inclusive dijets in photoproduction on Pb

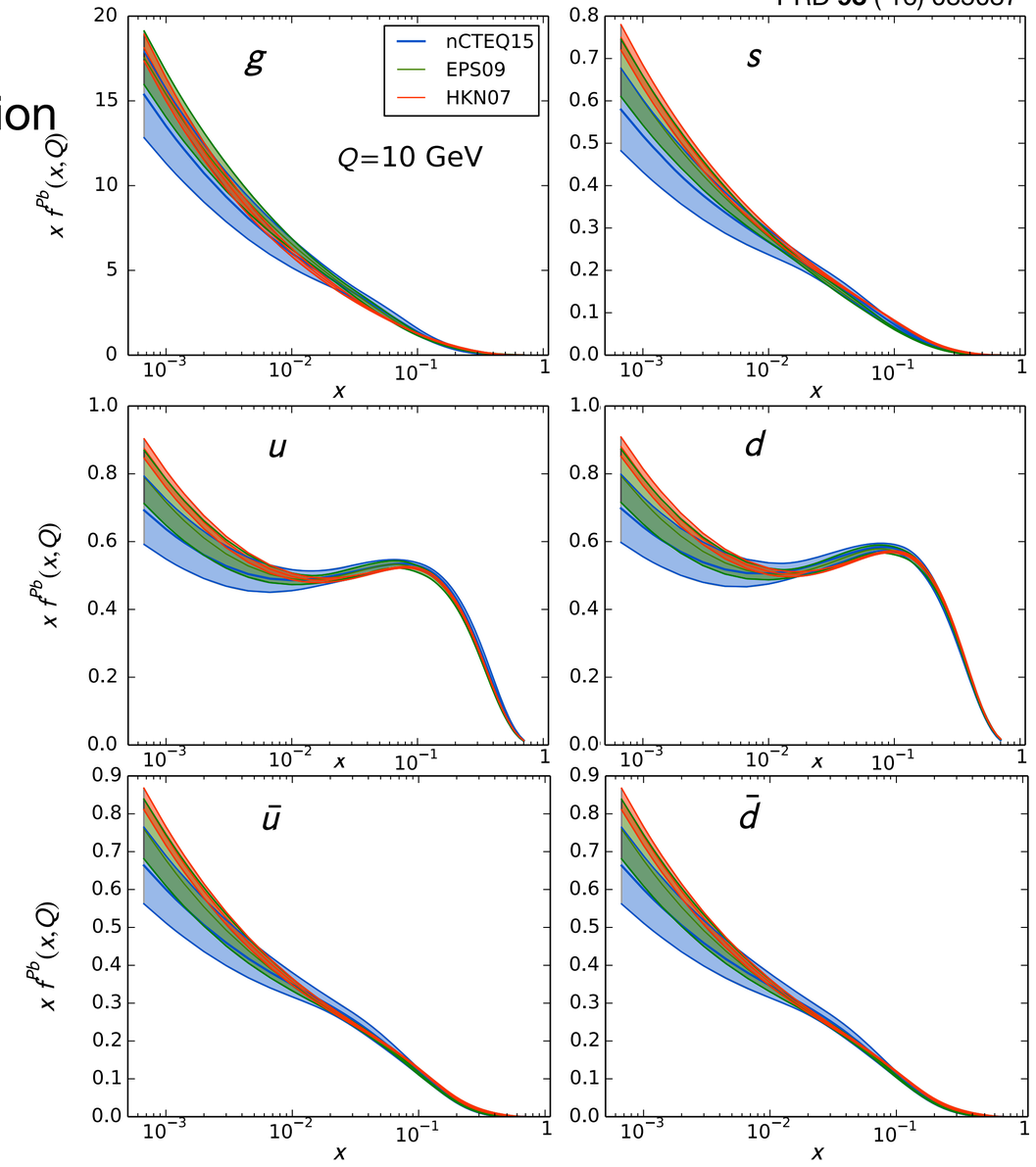
- Access to nuclear PDFs at low x_B, through photon-gluon fusion

  ⟶ constrain nuclear PDFs, where uncertainties are large

  ⟶ access region of nuclear shadowing



PRD **93** ('16) 085037



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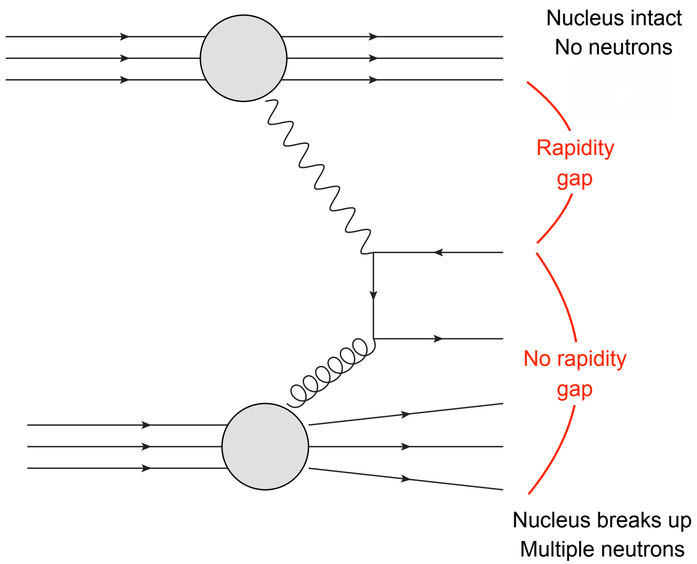

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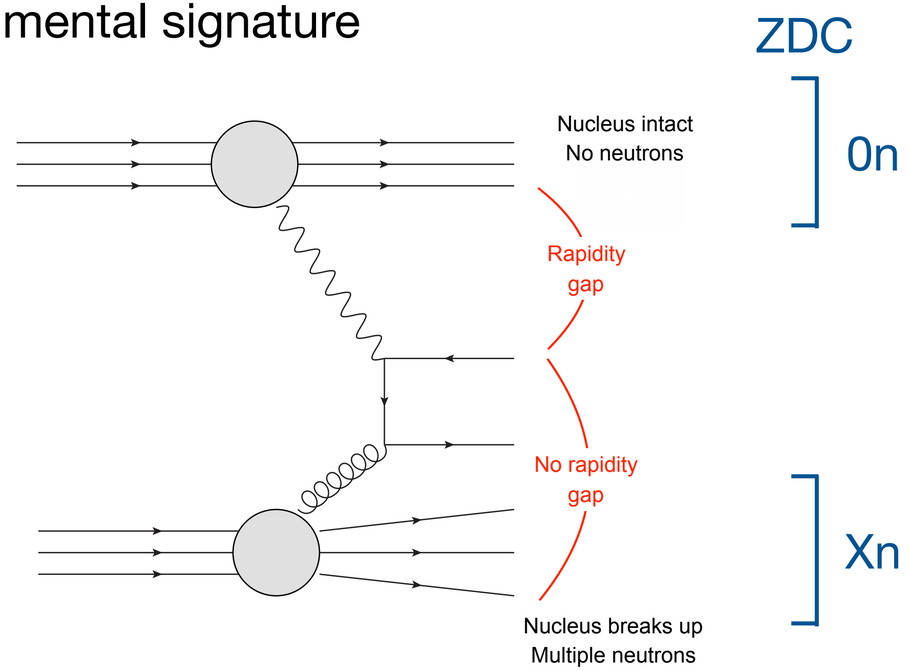

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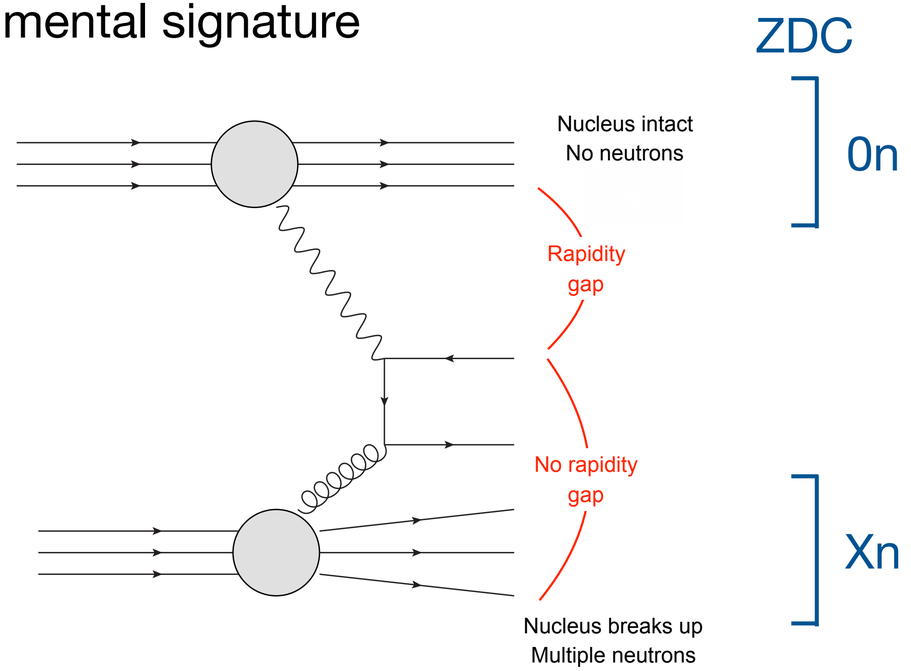
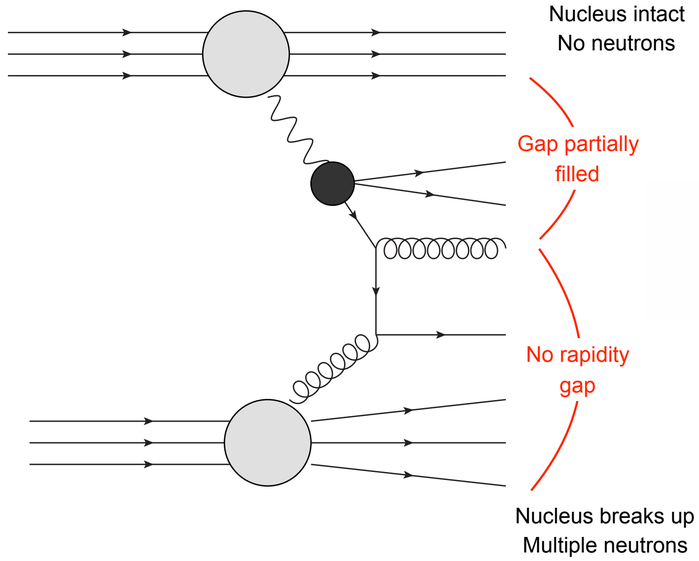


direct photon



resolved photon

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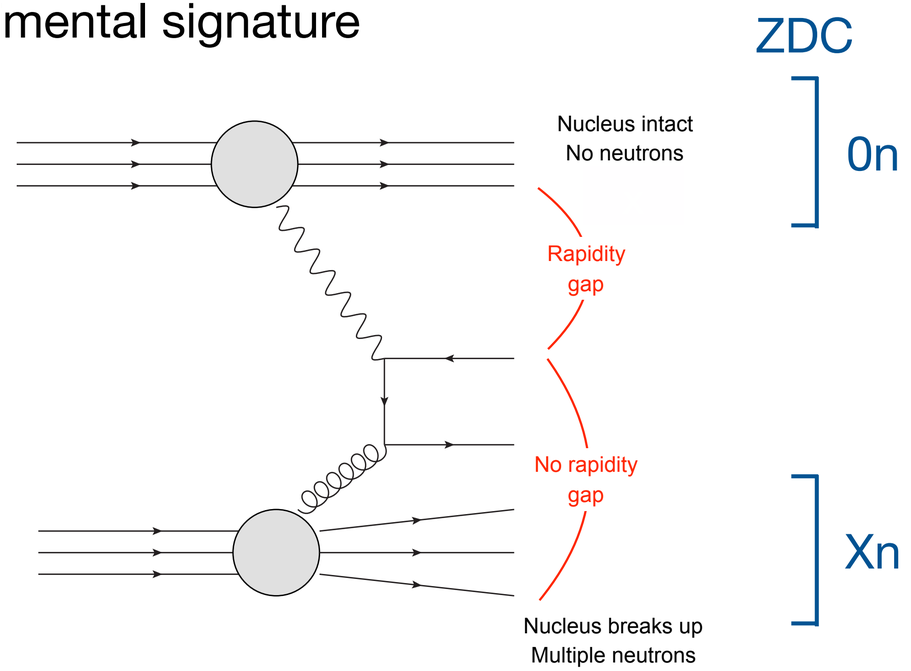

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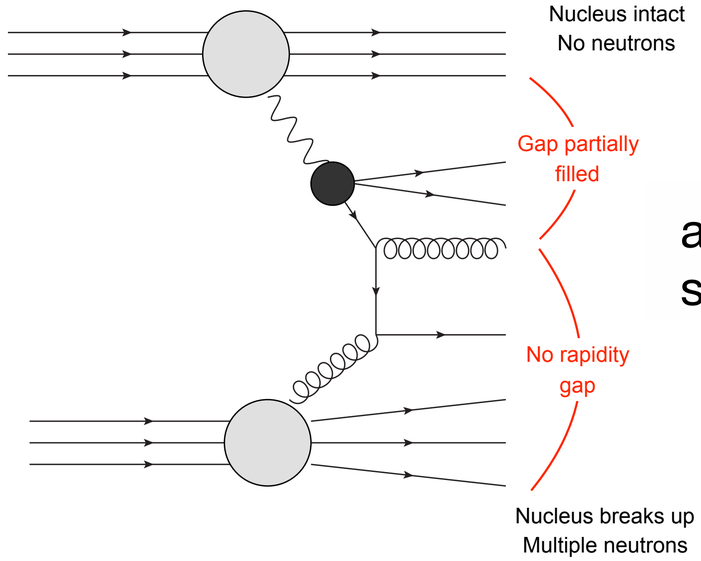

resolved photon

access to partonic structure of photon!

Inclusive dijets in photoproduction on Pb

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- Measurement:

  - ATLAS preliminary: ATLAS-CONF-2017-011

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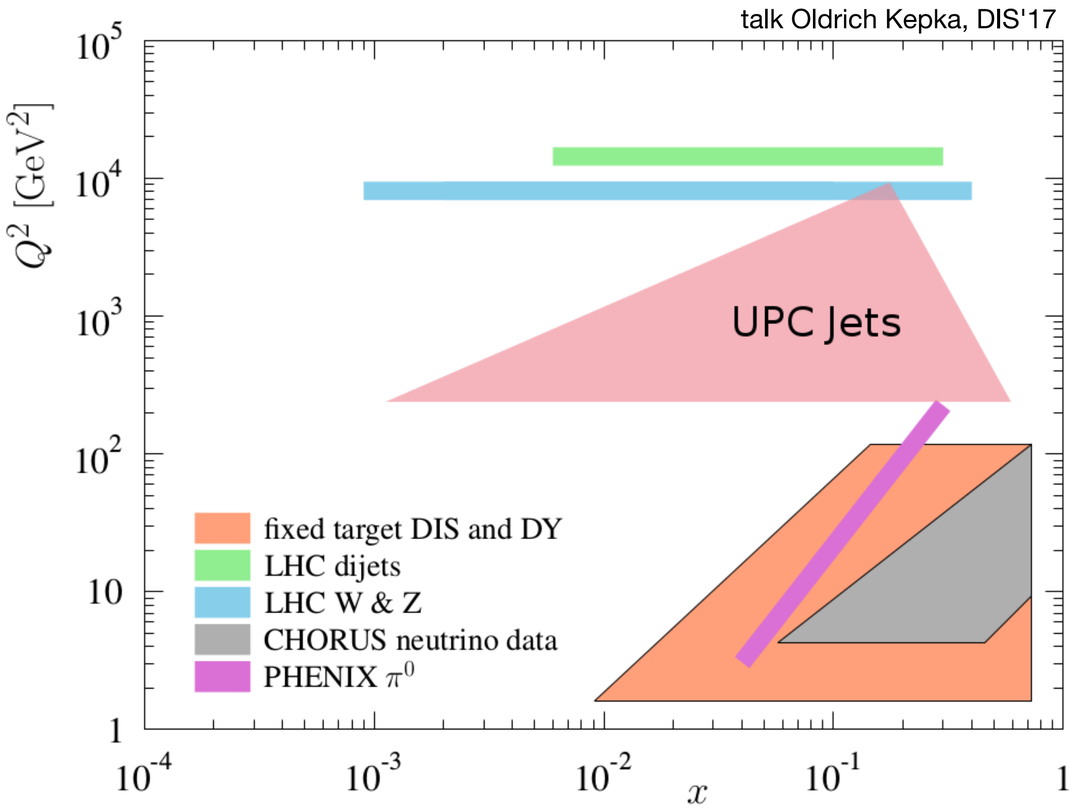

ATLAS measurement

- PbPb at $\sqrt{s_{NN}} = 5.02$ TeV; $\mathcal{L}$=0.38 nb^{-1}
- at least 2 jets
- $p_{T,\text{leading jet}} > 20$ GeV; $p_{T,\text{subleading jet}} > 15$ GeV
- $|\eta_{jet}|<4.4$
- $H_T>40$ GeV; $M_J>35$ GeV
- # neutrons in ZDCs: 0nXn
- $\sum\Delta\eta>2$ in 0n (photon) direction; $\sum\Delta\eta<3$ in Xn (break-up) direction, with $\Delta\eta>0.5$.

$$H_T = \sum_{\text{jet}} p_{T,jet} \xrightarrow{2\to2} 2Q$$

$$M_J = \sqrt{\left(\sum_{\text{jet}} E_{\text{jet}}\right)^2 - \left|\sum_{\text{jet}} \vec{p}_{\text{jet}}\right|^2}$$

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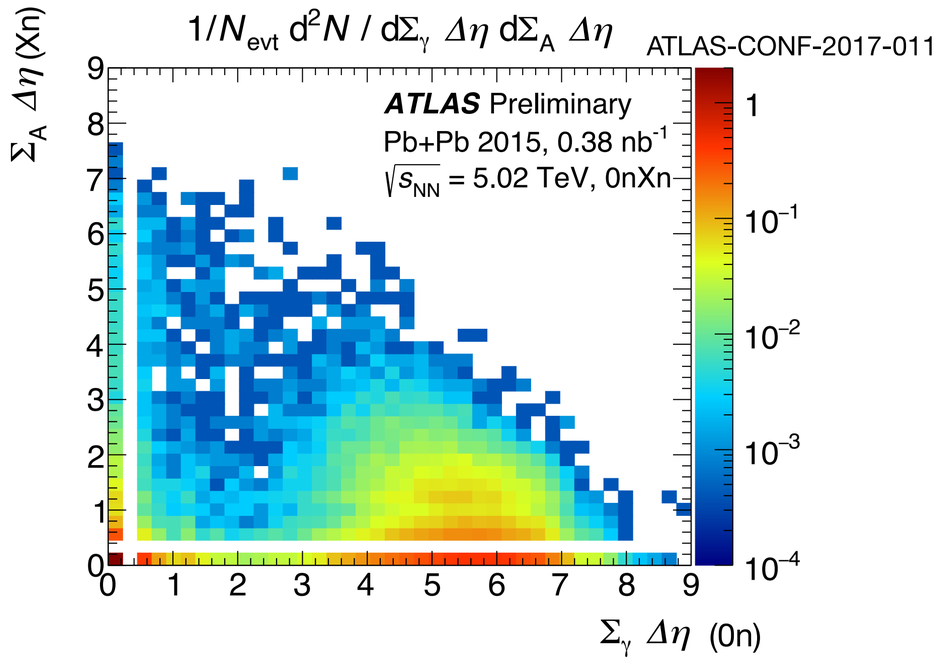

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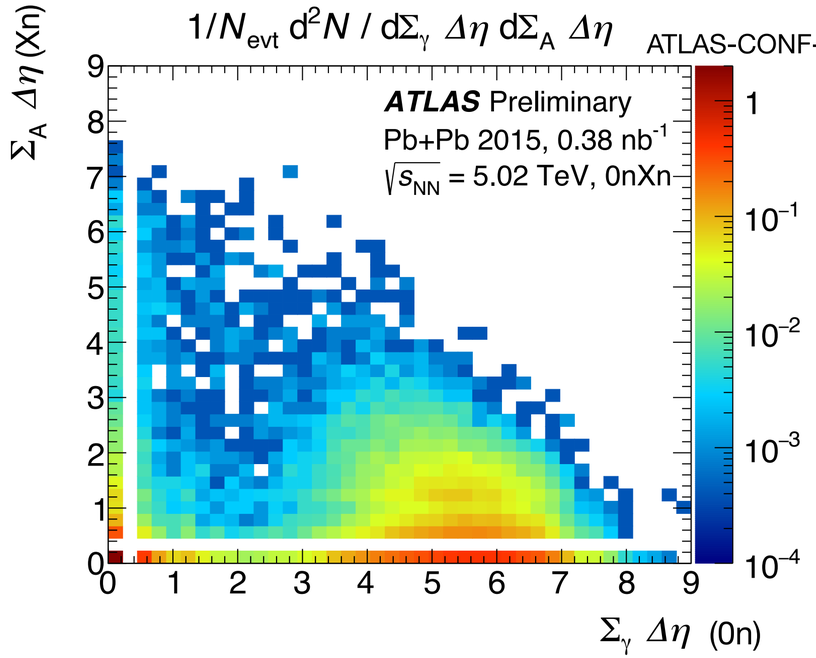
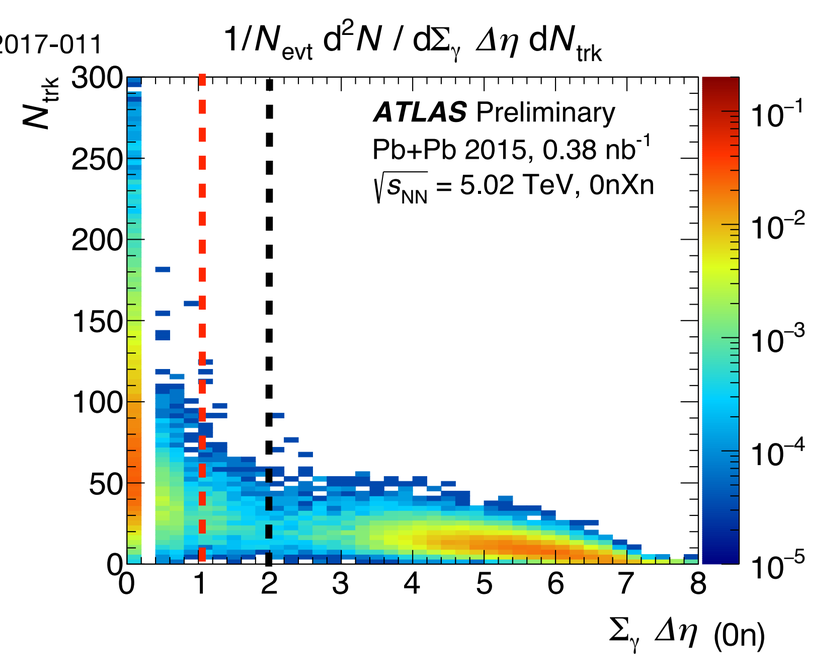
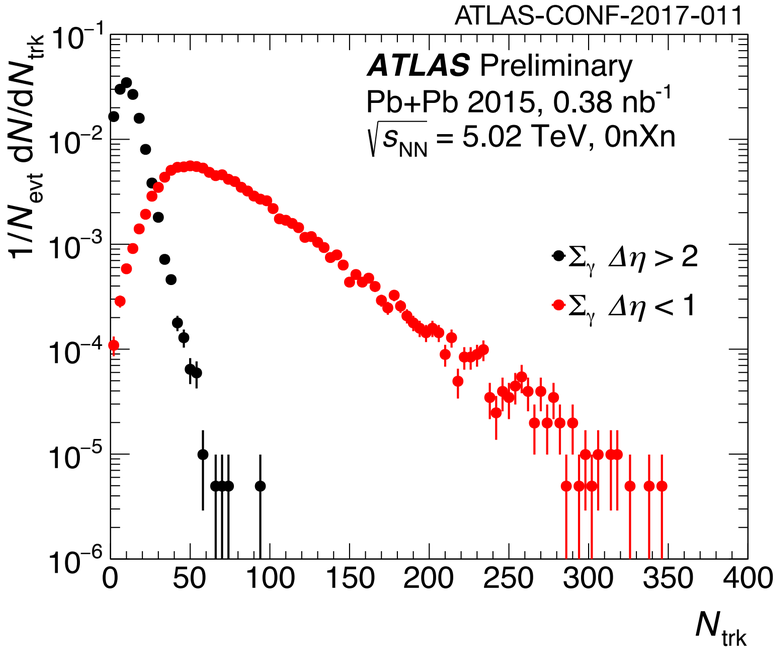


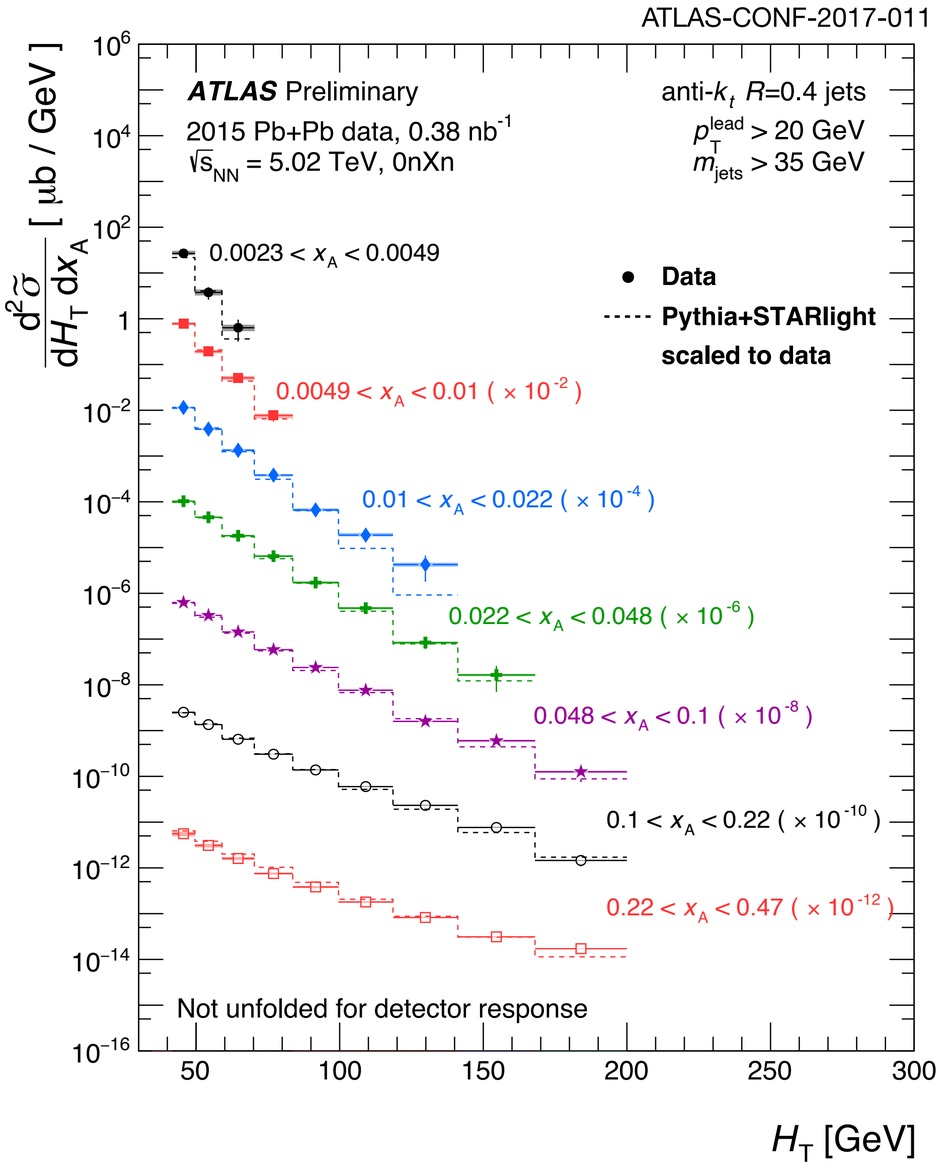


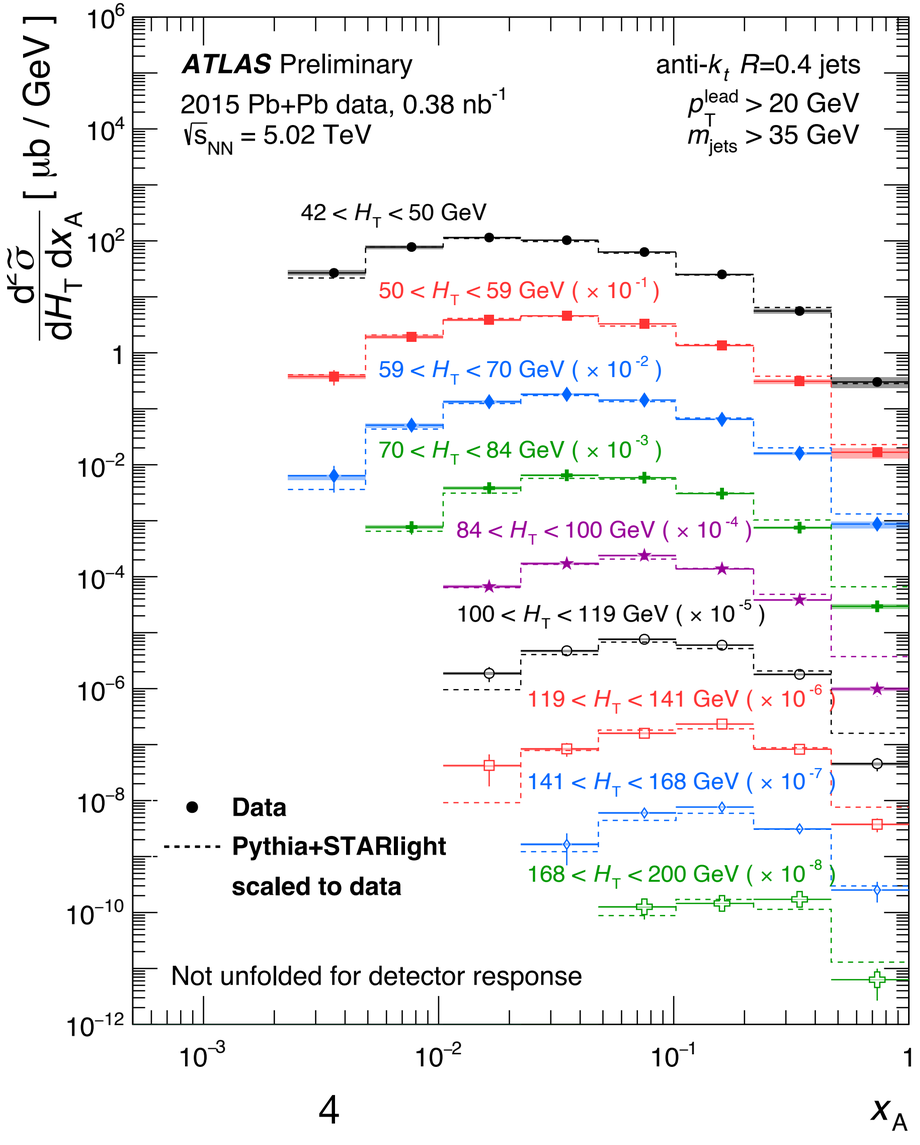


ATLAS measurement: results

$$y_J = \frac{1}{2}\ln\left(\frac{\sum_{\text{jet}} E_{\text{jet}} + \sum_{\text{jet}} p_{z,\text{jet}}}{\sum_{\text{jet}} E_{\text{jet}} - \sum_{\text{jet}} p_{z,\text{jet}}}\right)$$

$$x_A = \frac{M_J}{\sqrt{s}} e^{-y_J} \xrightarrow{2\to 2}$$ parton energy fraction





- STARlight: photon flux
- PYTHIA: γ^*+p
  - CTEQ6L1 proton PDF
  - SaS 1D photon PDFs
  - no nuclear modifications

- General good agreement of data and MC
- Proof of principle that photoproduction of jets can be studied in UPCs at LHC!

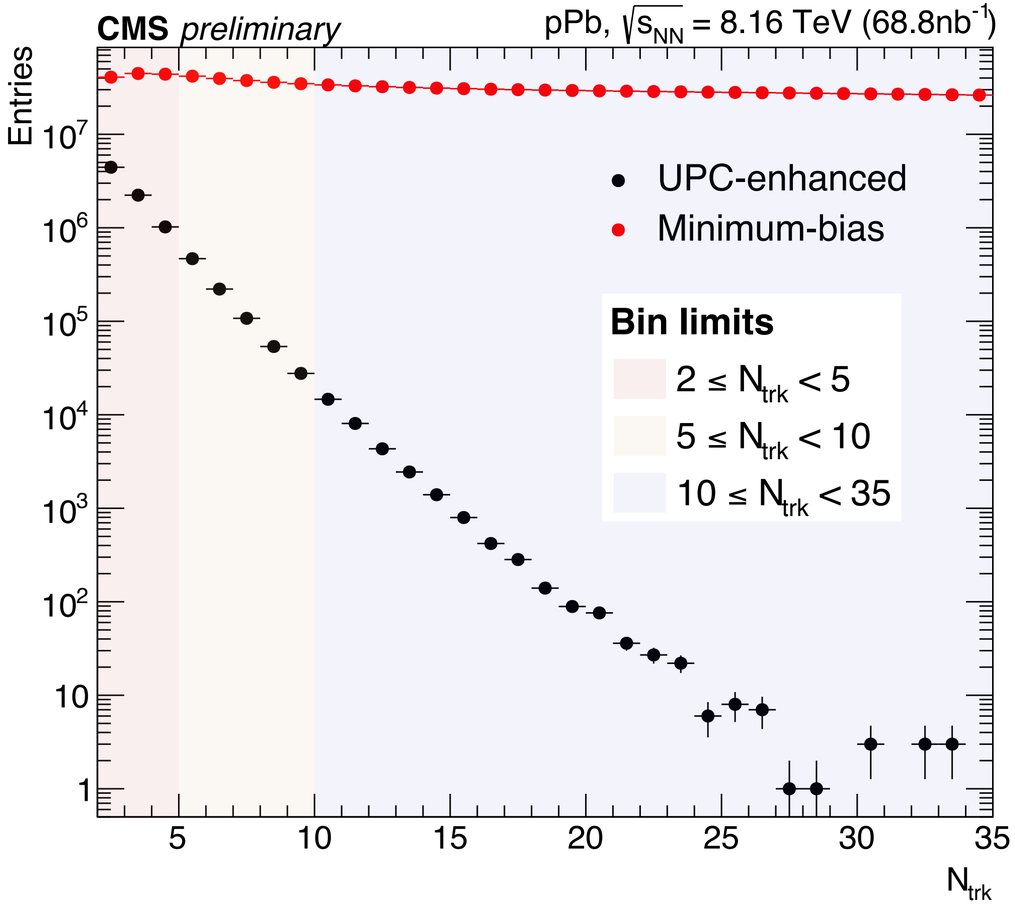
Two-particle angular correlations in γp interactions at CMS

- pPb at $\sqrt{s_{NN}} = 8.2\ \mathrm{TeV}$; $\mathcal{L}$=68.8 nb^{-1}

- Forward region – γp selection:
  - 0 neutrons in ZDC of Pb-going side
  - >10 GeV in hadron forward calorimeter in p-going side
- Large rapidity gap on Pb-going side

- Tracks: 0.3<p_T< 3.0 GeV; |η|<2.4

CMS PAS HIN-18-008



track: p_T>0.4 GeV<p_T; |η|<2.4

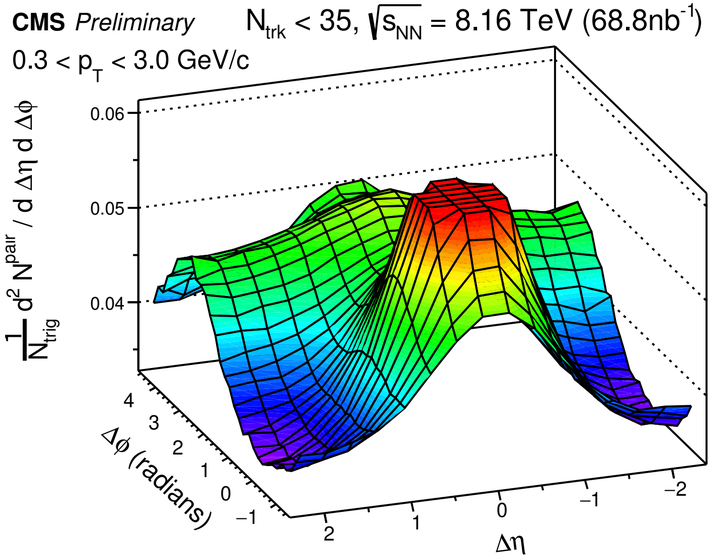
Correlation function

Correlation function:

$$\frac{1}{N_{\text{trig}}}\frac{\mathrm{d}^2N^{\text{pair}}}{\mathrm{d}\Delta\eta\mathrm{d}\Delta\phi} = B(0,0)\frac{S(\Delta\eta,\Delta\phi)}{B(\Delta\eta,\Delta\phi)}$$

- N_{trig}=number of tracks with $0.3<p_T<3.0$ GeV
- S: particle pairs from same event
- B: particle pairs from mixed events

γp enhanced



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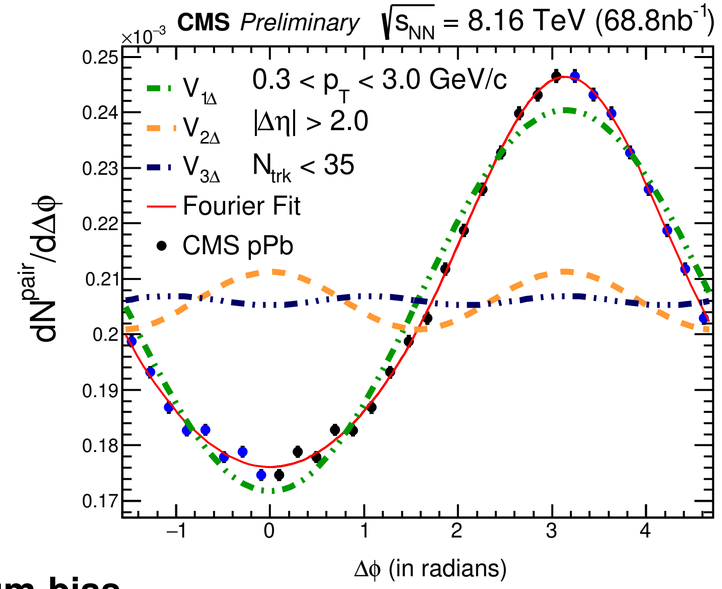
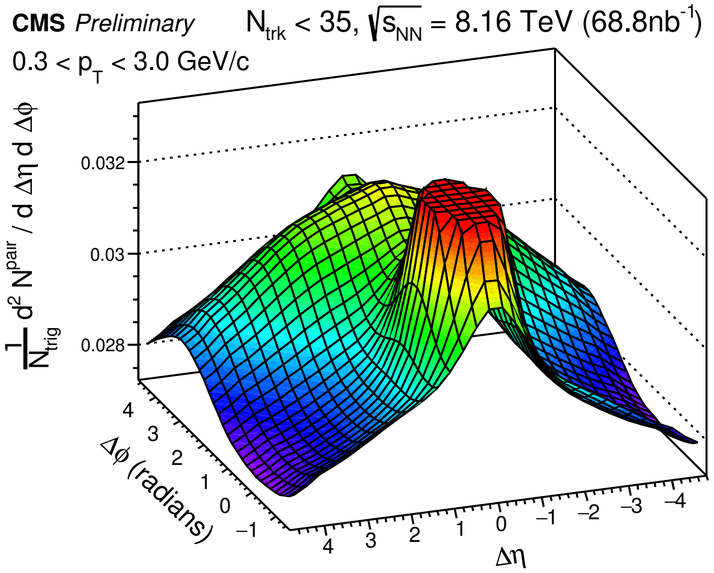
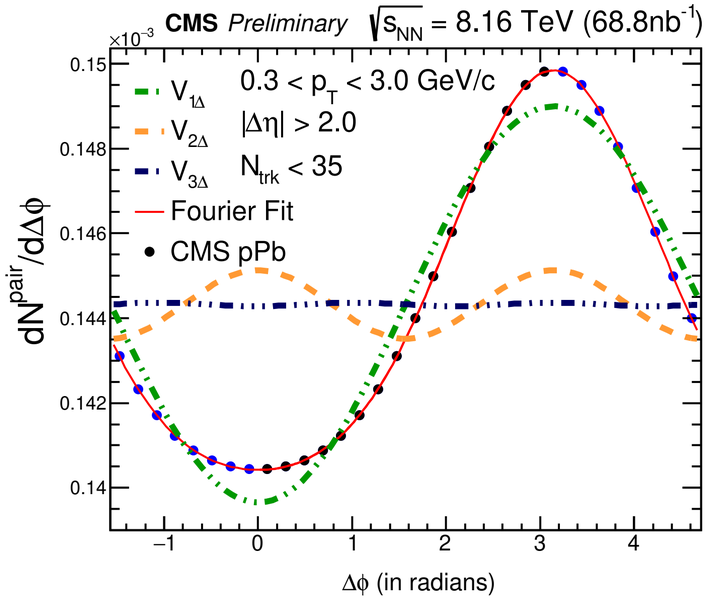
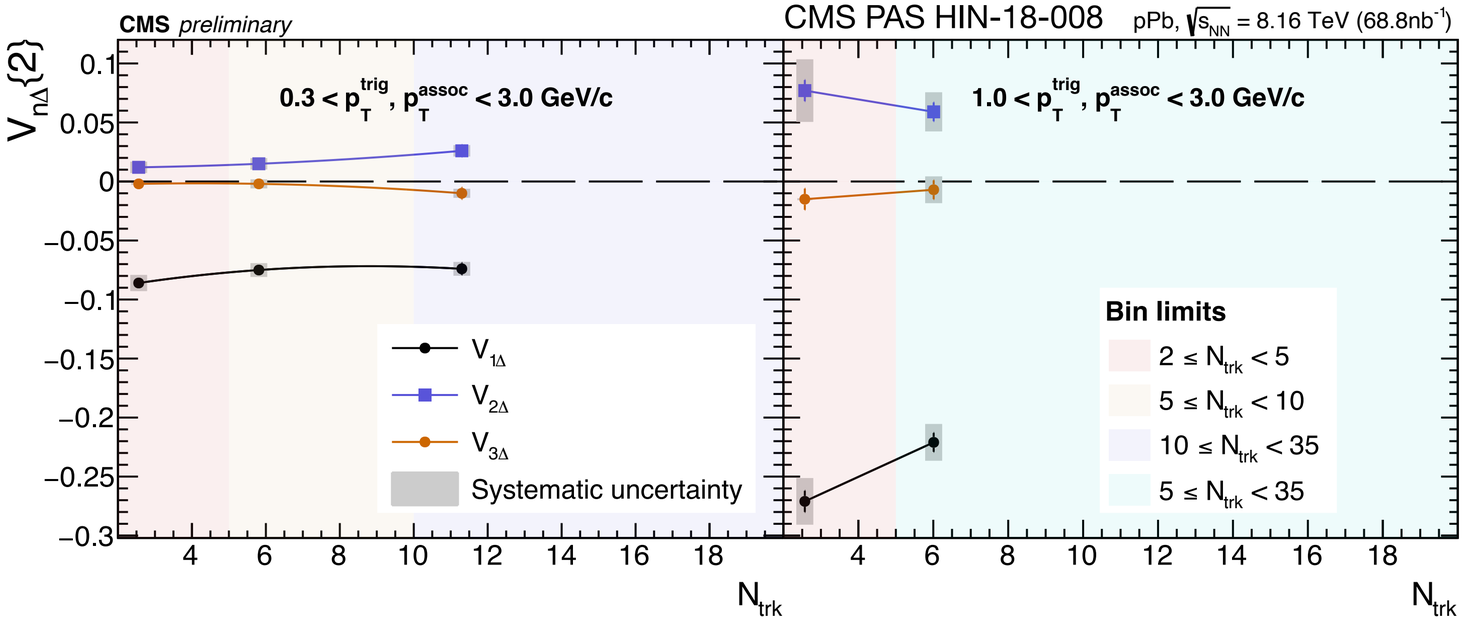


Minimum-bias





Results


CMS preliminary
CMS PAS HIN-18-008
pPb, $\sqrt{s_{NN}}$ = 8.16 TeV (68.8nb^{-1})
$V_{n\Delta}\{2\}$
$0.3 < p_T^{trig}, p_T^{assoc} < 3.0$ GeV/c
$1.0 < p_T^{trig}, p_T^{assoc} < 3.0$ GeV/c
$V_{1\Delta}$
$V_{2\Delta}$
$V_{3\Delta}$
Systematic uncertainty
Bin limits
$2 \le N_{trk} < 5$
$5 \le N_{trk} < 10$
$10 \le N_{trk} < 35$
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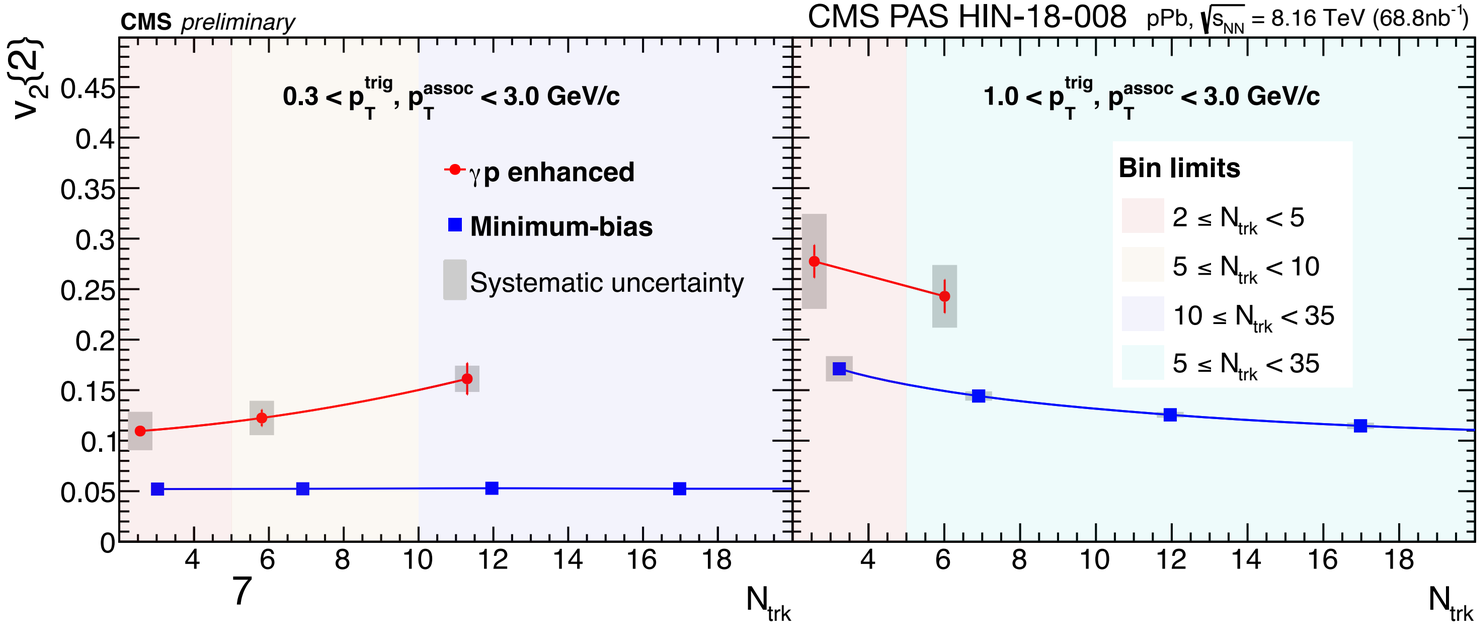
N_{trk}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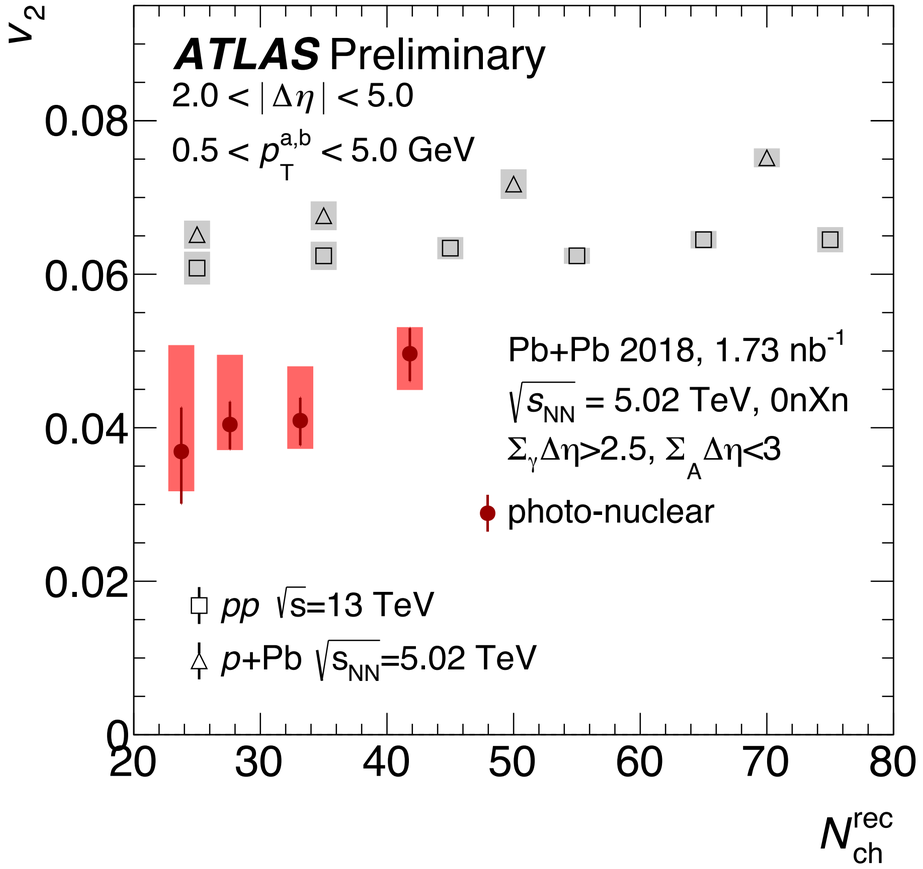
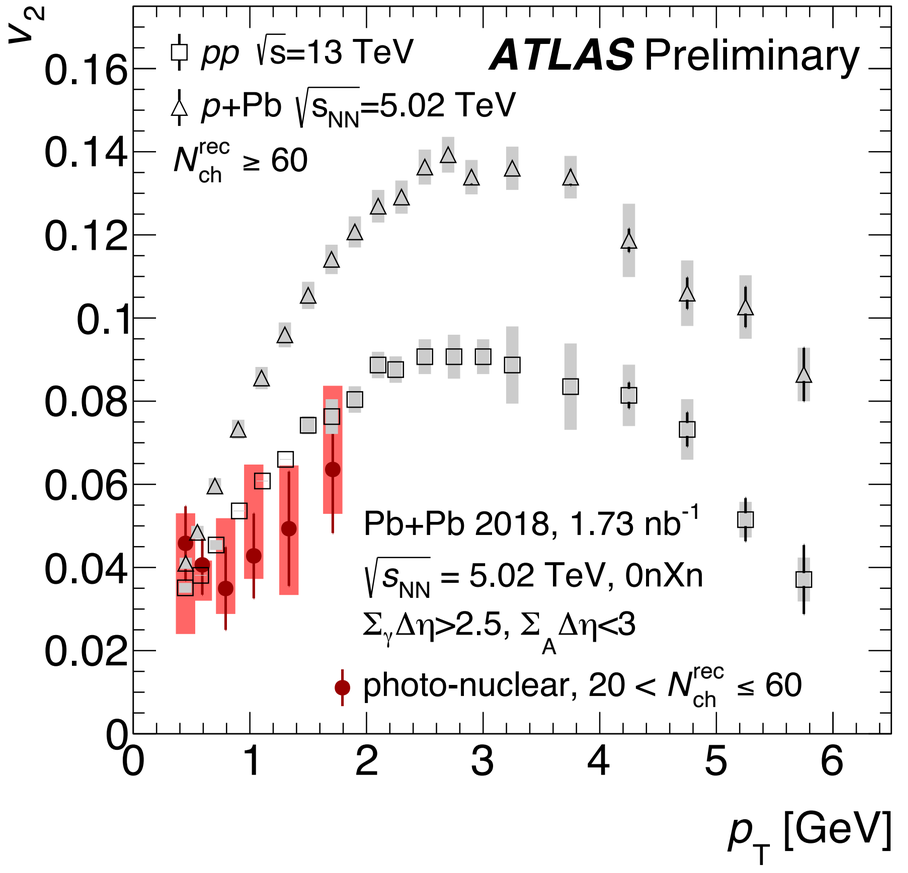
Two-particle angular correlations in γPb interactions at ATLAS

- PbPb at $\sqrt{s_{NN}} = 5.02$ TeV; $\mathcal{L}$=1.73 nb^{-1}
- # neutrons in ZDCs: 0nXn
- $\Sigma\Delta\eta$>2.5 in 0n (photon) direction; $\Sigma\Delta\eta$<3 in Xn (break-up) direction.

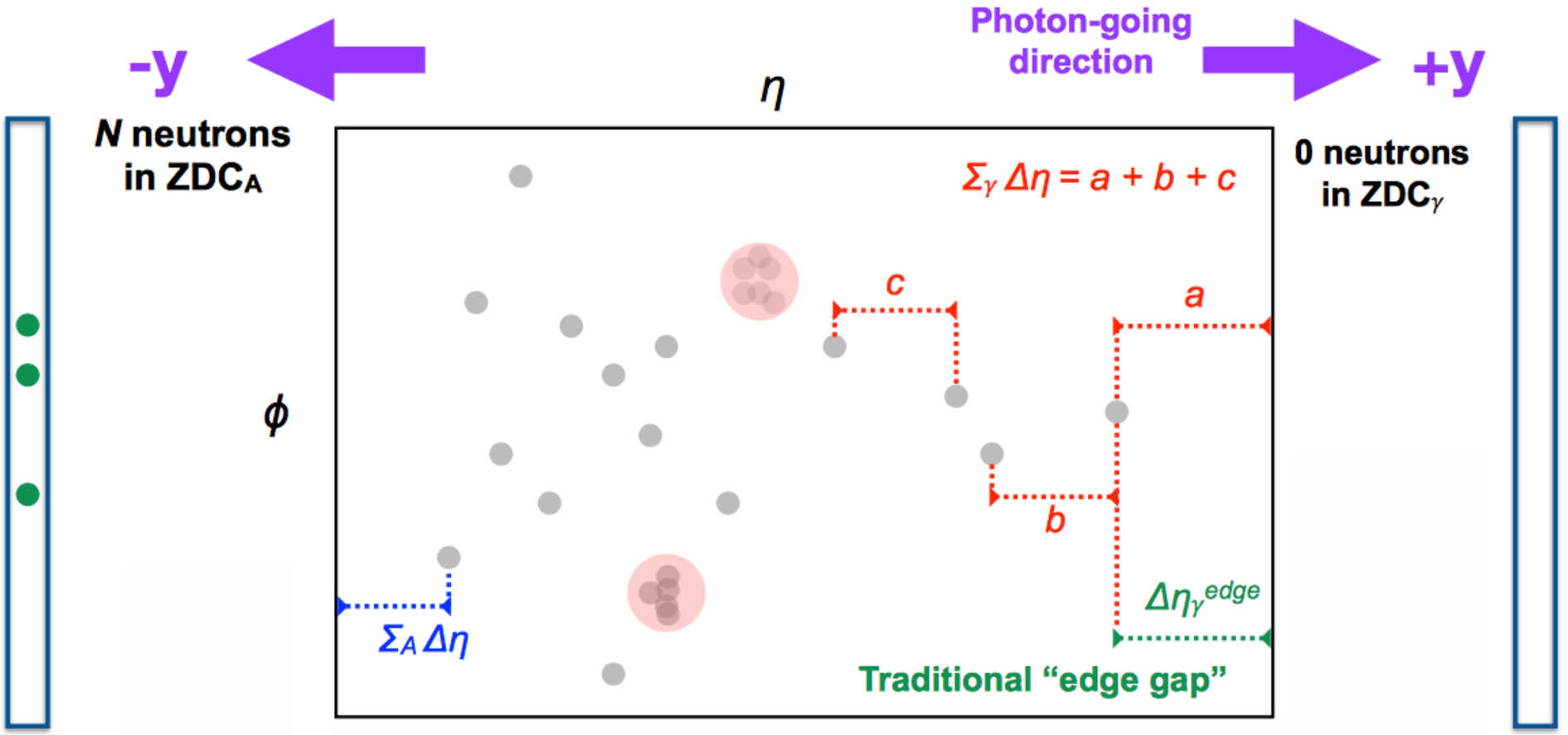
ATLAS-CONF-2019-022





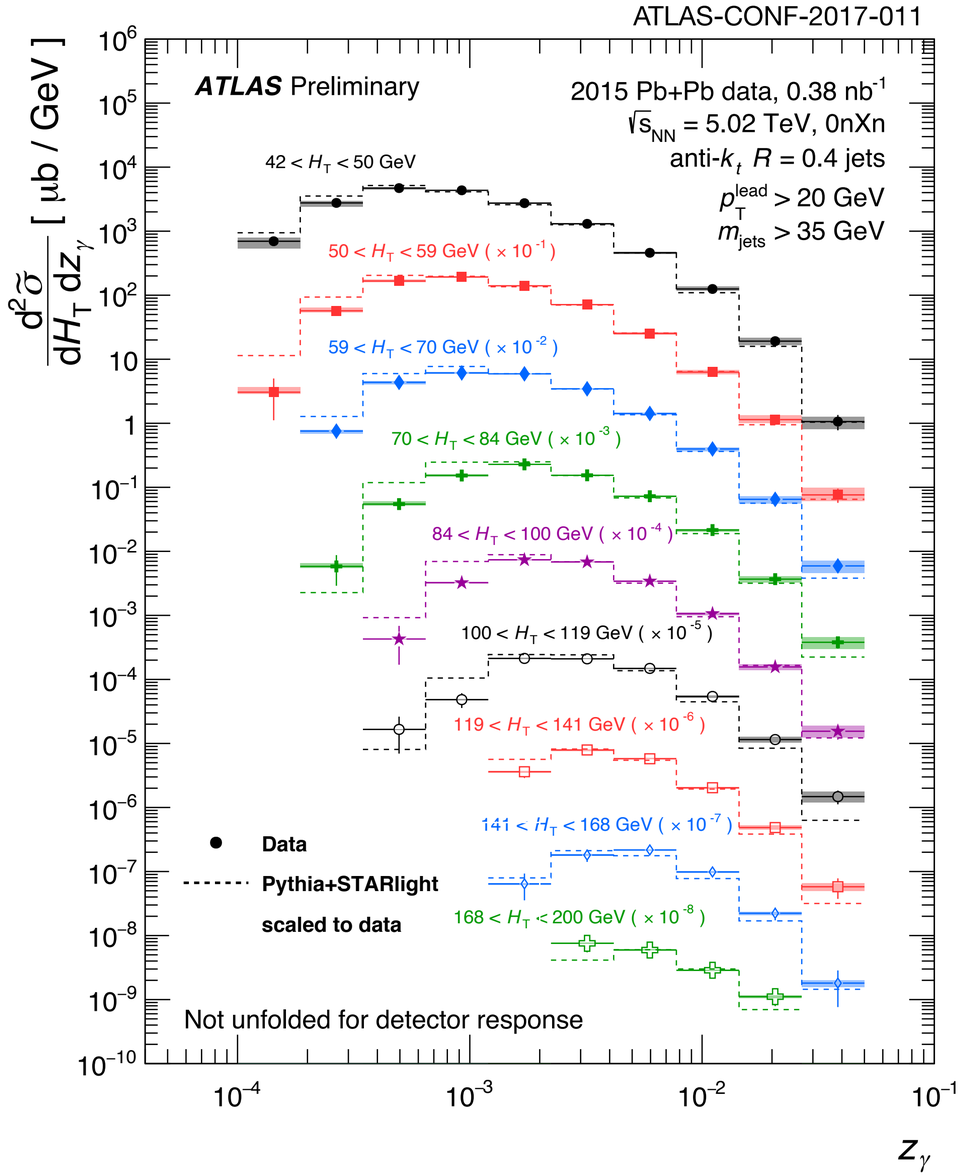
Back up

Gap analysis



The resulting clusters and the charged particle tracks are ordered in η and intervals between adjacent tracks or clusters with separation $\Delta\eta > 0.5$ are recorded

ATLAS measurement: results



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$$x_A = \frac{M_J}{\sqrt{s}} e^{-y_J}$$

$$z_\gamma = \frac{M_J}{\sqrt{s}} e^{+y_J}$$

$$= x_\gamma\, y$$