Конференция Quark Matter 2019 и измерения эксклюзивных Υ и $\rho(770)^0$ мезонов в ультра-периферических p-Pb соударениях на БАК экспериментом CMS

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Petersburg Nuclear Physics Institute NRC KI, Gatchina, Russia

November 19, 2019

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Contents

Jet quenching

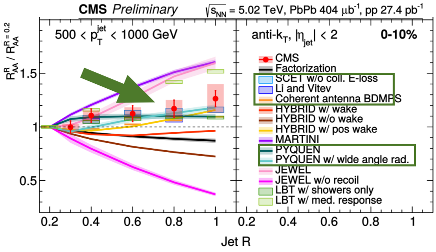
- **Hard probes: high-p_T partons, heavy quarks**
  - Produced in initial hard-scatterings
  - Tomographic probes of the medium
- **Energy loss in medium**
  - Collisional and radiative energy loss
    - Colour and mass dependence (dead-cone effect)
  - Parton interaction with medium: dependence on the coupling strength, medium dynamics, ...
  - Path-length dependence, resolution scale at which the jet probes the medium, does broader jet loose more energy ?
- **Accessed experimentally using:**
  - Spectra, nuclear modification factors
  - High-p_T v_2
  - Correlations, momentum balance, FF, ...
  - Jet substructure analysis

Next session: Yi Chen, Jet substructure and parton splitting

Thermalisation

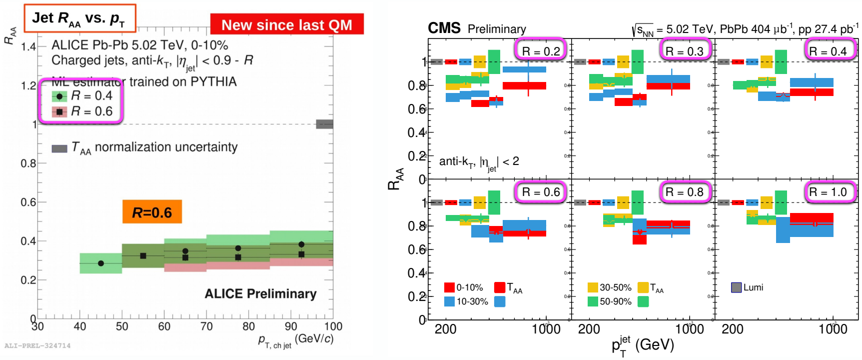
- However :
  - Large contribution of medium response leads to a large R dependence on jet R_{AA}
    - Magnitude is again model dependent
  - Features of the parton shower seem to drive behaviour of jet R_{AA} (R_{jet}) (rather then medium response)
- Jet Radial profile vs Jet R_{AA}
  - Put severe constrains on the jet-induced component

M. Taylor Jet III



(We also have: missing p_T, $\rho(r)$ with p_T bin information, 2-particle correlations,…)

Large radius R_{AA}



Suppression observed for all jet R — **very mild R-dependence**

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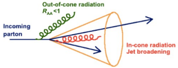
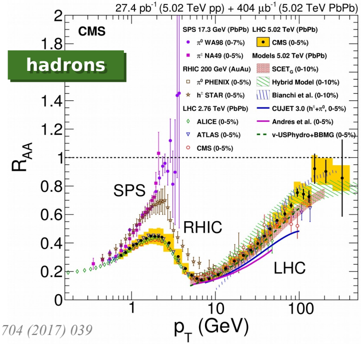
Luara Havener, Hannah Bossi, Poster, Molly Taylor, Wed.

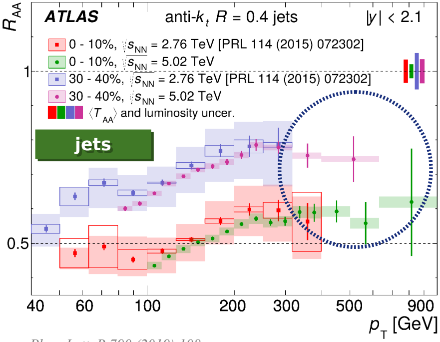
R_{AA}: evidence of jet quenching

- Evidence of jet quenching: strong suppression of high-p_T particles and jets
  - High-p_T hadron R_{AA} → 1, jets suppressed up to TeV
- Increasing with centrality
  - Weak dependence of R_{AA} on coll. energy





JHEP 1704 (2017) 039



Phys. Lett. B 790 (2019) 108

QM19 | Jet Quenching Exp | B.Trzeciak, CTU Prague

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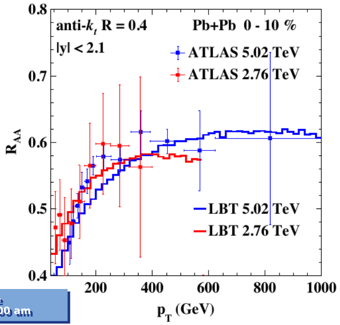
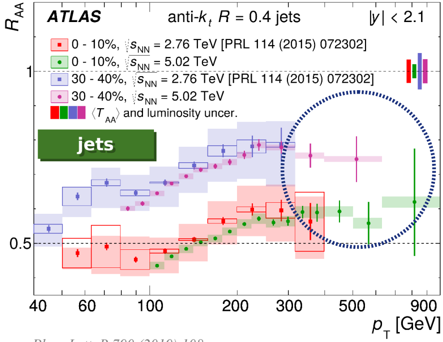
R_{AA}: evidence of jet quenching

- Strong suppression in central collisions
  - High-p_T hadron $R_{AA} \to 1$, jets suppressed up to TeV
- Weak dependence of R_{AA} on coll. energy, higher energy loss vs different slopes of initial p_T spectra
  Dependence of centrality and jet radius.



Y.He
6.11, 10:00 am



Phys. Lett. B 790 (2019) 108

QM19 | Jet Quenching Exp | B.Trzeciak, CTU Prague

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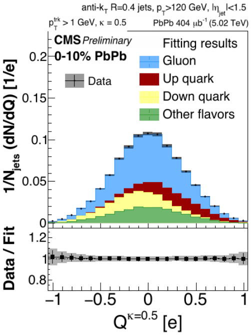
Quark-Gluon Matter as ideal gluon liquid

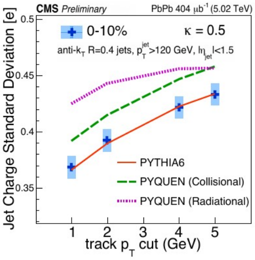
Quark/gluon fraction in HI

- **Quark / gluon fraction extracted from jet charge**
  - Study flavour dependent behaviour of energy loss mechanisms due to jet quenching
  - Jet charge is sensitive to the electric charge of the initiating parton
  - Measurement based on Pythia template fits

$$Q^{\kappa} = \frac{1}{(p_T^{\text{jet}})^{\kappa}} \sum_{i \in jet} q_i \, (p_T^i)^{\kappa}$$

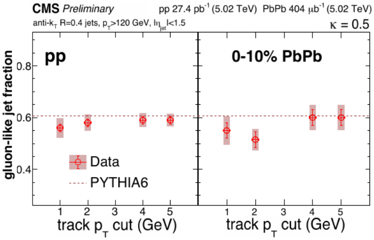


→ No increase in jet charge width observed



- Gluon-like jet fraction

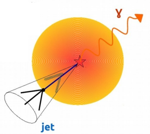
→ Consistent fractions in pp and PbPb, no significant centrality dependence



CMS, D. Hangal
6.11, 8:40 am

g-tagged jets

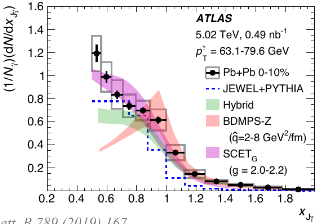
- Strong iteraction with QGP as a fluid without viscosity
- Controlled configuration of the initial hard-scattering
- Quarks vs gluon jets → flavour dependence of E_{loss}
  - LHC: dominated by quark fragmentation at higher p_T (>30 GeV)



p_T balance $x_{J\gamma} = p_T^{jet} / p_T^{\gamma}$

➔ No peak structure in central collisions

➔ Peak returns in peripheral collisions and with increasing p_T



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QM19 | Jet Quenching Exp | B.Trzeciak, CTU Prague

- Input for theory

ATLAS,D.Perpelitsa 6.11, 2:40 pm

CMS,R. Bi 6.11, 2:20 pm

CMS, Phys. Lett. B 785 (2018) 14

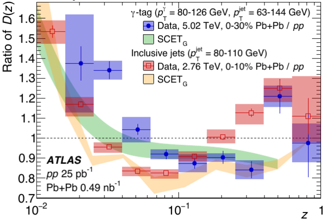
Phys, Rev. Lett 121 (2018) 242301

Fragmentation function $D(z = p_T^h / p_T^{jet})$

γ-tagged vs. inclusive jets

➔ Different modification in central collisions

➔ Flavour dependence, selection bias ?



Phys. Rev. Lett. 123, 042001 (2019)

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Jet quenching

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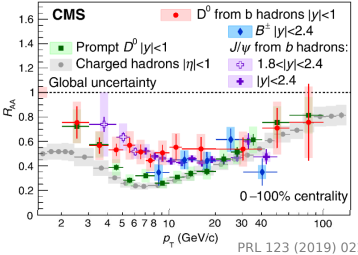
Next session: Yi Chen, Jet substructure and parton splitting

In-medium energy loss → medium properties



PRL 123 (2019) 022001

In-medium shower modification and nature of the energy loss.

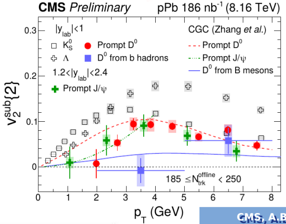
Flavour dependence ?

How the fragmentation is modified ?

Heavy-flavour jets in pPb

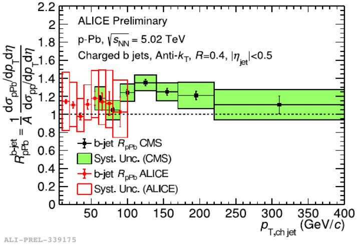
$$\frac{dN}{d\Delta\phi} \propto 1 + \sum_n 2 v_{n,n} \cos(n\Delta\phi) \quad v_{n,n} = \langle \cos(n\Delta\phi) \rangle$$

- v_2 of heavy-flavour particles in pPb collisions
  - v_2 of beauty consistent with 0
- → R_{pPb}: No modification of c,b,D-tagged jets in pPb collisions observed
- → R=0.3/R=0.6 consistent with pp

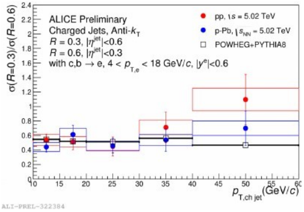


CMS, A.Baty, 5.11., 8:40 am

b-jets



HFE-jets



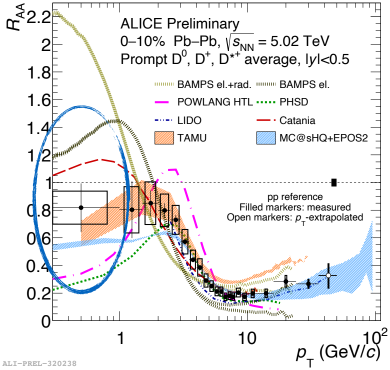
ALICE, J.Kvapil, 6.11., 2:00 pm

ALICE, S. Sakai, poster

Contents

Energy loss in medium: Open *charm* R_{AA}

New

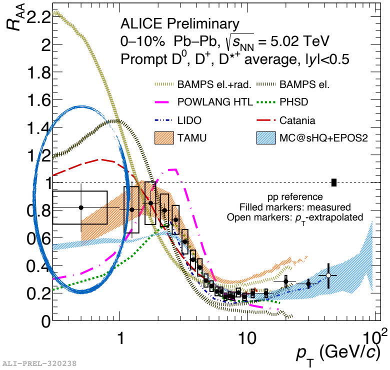


- Down to p_T=0 at LHC!
- Strong constraints to theories
  ➡Interplay of radial flow, recombination, shadowing etc.

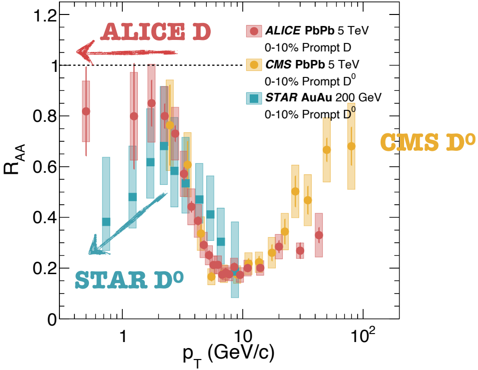
G.M. Innocenti, 5 Nov, 11:00

Energy loss in medium: Open *charm* R_{AA}

New



World open charm R_{AA} (0-10%)



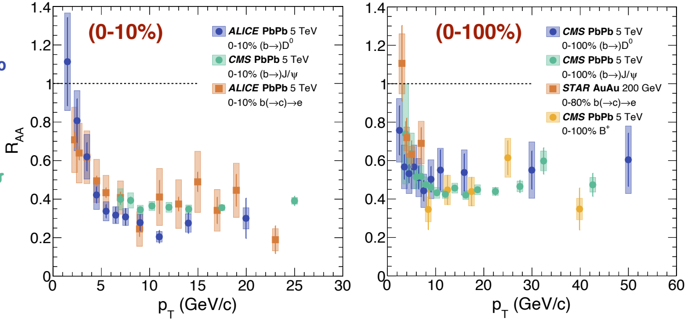
- Difference trend between LHC and RHIC?

G.M. Innocenti, 5 Nov, 11:00

Energy loss in medium: Open *beauty* R_{AA}

World open beauty R_{AA}

New!
ALICE b→D⁰
New!
ALICE b→e
CMS b→J/ψ



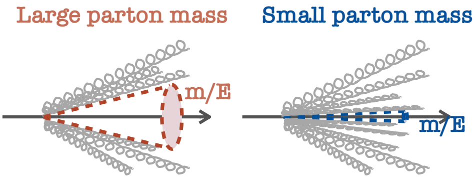
CMS b→D⁰
New!
STAR b→e
CMS b→J/ψ
CMS B⁺

- New players in the game!

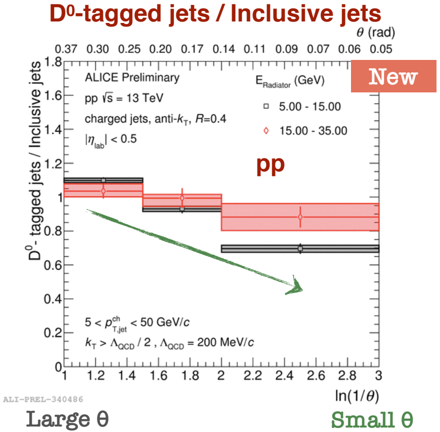
M. Kelsey, 5 Nov, 17:40
D. Thomas, 5 Nov, 12:00

One source of flavor hierarchy: Dead cone effect

- **Dead cone effect**
  ➡ Radiation (for both vacuum and medium induced) is suppressed inside θ < m/E

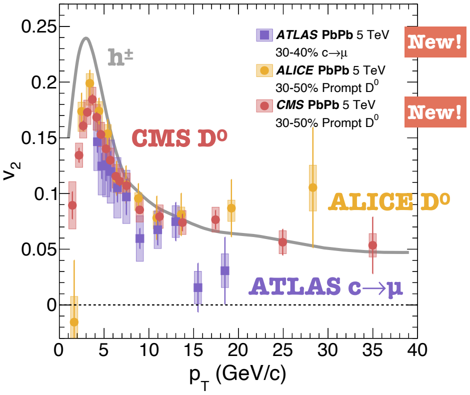


- **D-tagged jets have lower splitting at small angle**
- First direct observation of dead cone effect!
- Lower-energy radiator has stronger effect



Open *charm* collective flow in AA

ATLAS-CONF-2019-053
CMS-PAS-HIN-19-008



- High-precision
- Prominent flow structure
- Good agreement among measurements
  ➡ $c \to \mu$ shift a bit to low-p_T: daughter μ
- $v_2(h^\pm) > v_2$(open charm)

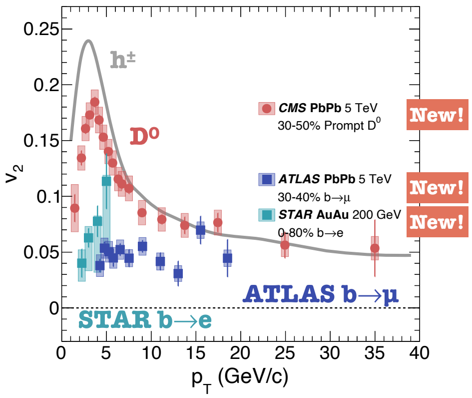
S. Lim, 5 Nov, 9:00
C. Bernardes, 5 Nov, 15:20

Jing Wang (MIT), Open HF: Experiments, QM 2019 (Wuhan) 17

Open *beauty* collective flow in AA

ATLAS-CONF-2019-053
CMS-PAS-HIN-19-008

Open charm v_2 compilation

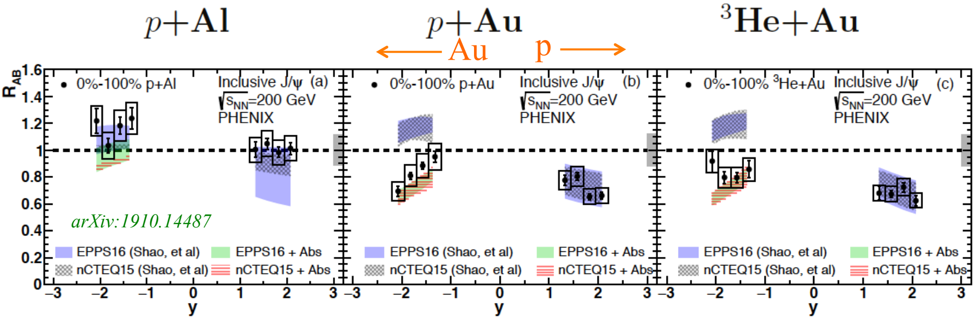


- Non-zero open beauty v_2 in AA collisions at RHIC (~3.4σ) and LHC!

S. Lim, 5 Nov, 9:00
M. Kelsey, 5 Nov, 17:40
C. Bernardes, 5 Nov, 15:20

J/ψ Suppression at RHIC

K. Smith, HF-II



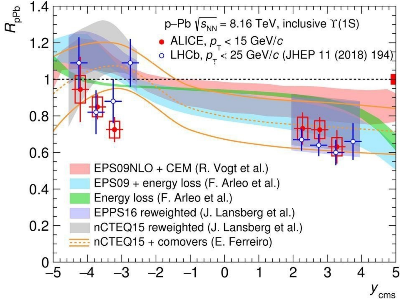
Suppression in both forward and backward rapidity with Au beam

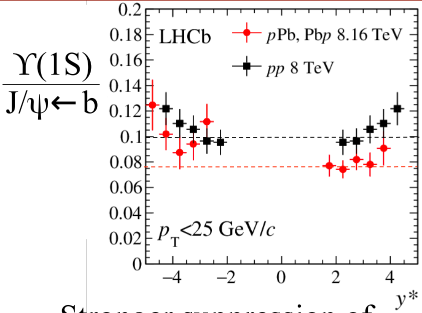
Forward rapidity: nPDFs alone describe data reasonably well

Backward rapidity: Nuclear absorption in addition is needed

Υ(1S) Suppression in pPb

J. Ghosh, SS-I
S. Chen, HF-IV





Strong suppression at forward

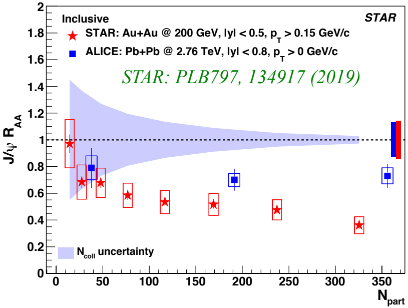
Calculations describe at forward
but slightly overestimate at backward

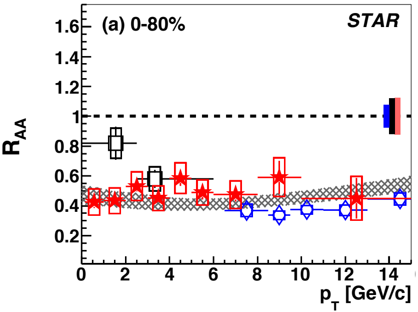
Stronger suppression of Υ(1S) than J/ψ←B at forward

Final-state effect of Υ(1S)?
Shadowing + J/ψ←b y smearing?

J/ψ Suppression at RHIC

Y. Liu, HF-II





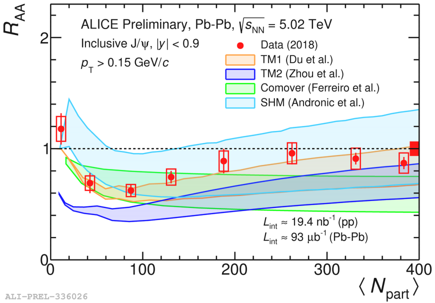
R_{AA} decreases towards central collisions

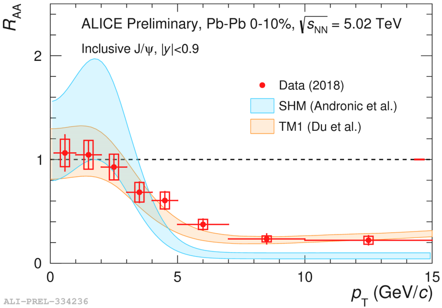
No strong p_T dependence

Strong suppression at high-p_T → color screening

J/ψ Suppression at LHC (mid-y)

X. Bai, HF-II





R_{AA} increases from semi-peripheral to central collisions

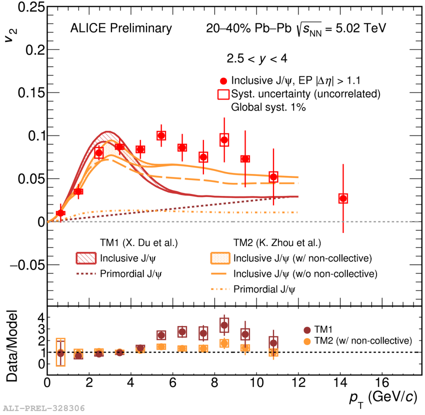
Clear decreasing trend with increasing p_T

Regeneration wins at low-p_T

Zebo Tang (USTC) QM2019, Nov. 3-9, Wuhan, China 18

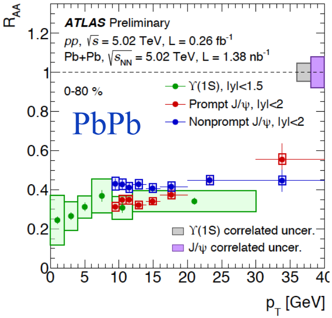
J/ψ v_2 in PbPb@5 TeV

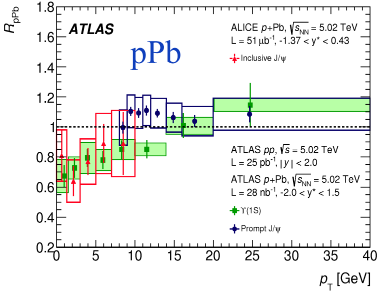
X. Bai, HF-II

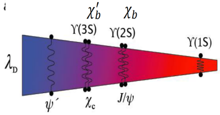


- Positive v_2 in PbPb @ 5.02 TeV
- v_2 at p_T>4 GeV/c can not be described by transport models!!
- Contribution from jet fragmentation?

High-p_T J/ψ vs. ϒ(1S)





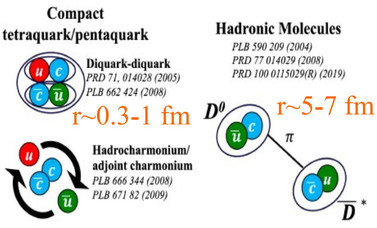


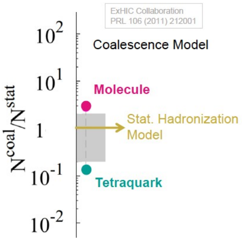
Similar suppression between prompt J/ψ and ϒ(1S) in PbPb at high-p_T

Similar suppression in pPb also (precision need be improved)

X(3872)

M. Durham, HF-IV
Y. Lee, HF-IV

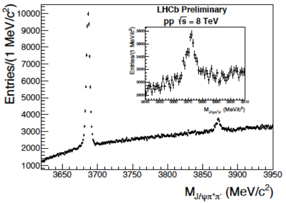




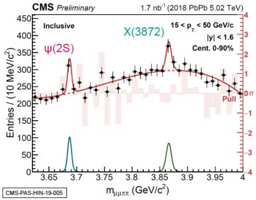
Measuring the yield in high-multiplicity/ density environment may shed light on the internal structure

LHCb pp

LHCb pPb available



CMS PbPb



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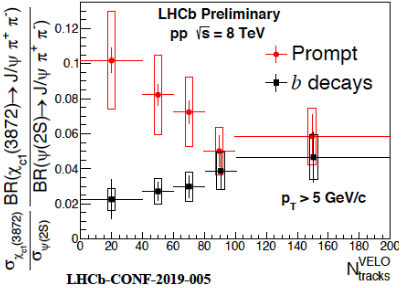
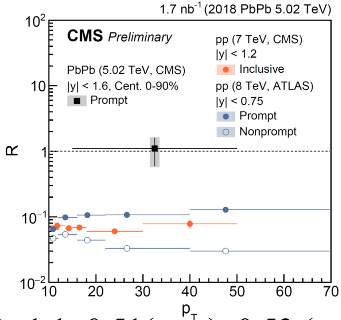
X(3872) over ψ(2S) Ratio

M. Durham, HF-IV
Y. Lee, HF-IV





Syst. uncertainty fully correlated

R=1.1±0.51(stat.)±0.53 (syst.)

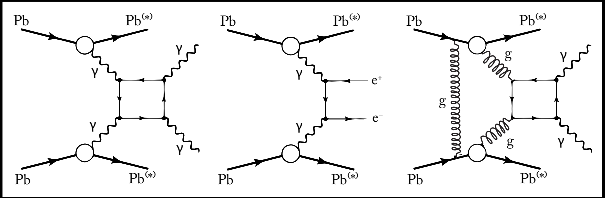
Increasing suppression relative to ψ(2S) as event activity increases

Indication of enhancement in PbPb relative to ψ(2S)

Contents

LbyL: Signal & backgrounds

CMS: 1810.04602



"LbyL": including loops for leptons, quarks and W bosons	"QED": dielectrons reconstructed as photons	"CEP": gluon exchange with photons produced through quark loops
SIGNAL	BACKGROUND	

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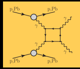
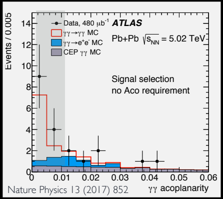
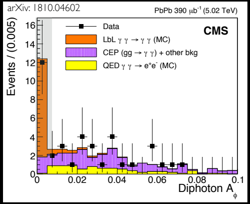


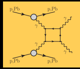
ATLAS & CMS data (2015)

2015 data set provided evidence (< 5σ significance) of light-by-light scattering





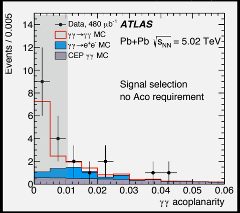
	ATLAS	CMS
Luminosity	0.48 nb^{-1}	0.39 nb^{-1}
Fiducial acceptance	$E_{T\gamma}$ > 3 GeV, $\|\eta\|$<2.37 $M_{\gamma\gamma}$ > 6 GeV, $p_{T\gamma\gamma}$ < 2 GeV, Aco < 0.01	$E_{T\gamma}$ > 2 GeV, $\|\eta\|$<2.4 $M_{\gamma\gamma}$ > 5 GeV, $p_{T\gamma\gamma}$ < 1 GeV, Aco < 0.01
Candidates / expected background	13 / 2.6±0.7	14 / 4.0±1.2
Signficance	4.4σ	4.1σ



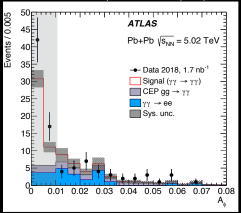
ATLAS: 2015 vs. 2018

P. Palni,
Tues morning

Nature Physics 13 (2017) 852



Phys. Rev. Lett. 123 (2019) 052001



	ATLAS 2015	ATLAS 2018
Luminosity	**0.48 nb^{-1}**	**1.7 nb^{-1}**
Fiducial acceptance	$E_{T\gamma} > 3$ GeV, $\lvert\eta\rvert<2.37$ $M_{\gamma\gamma} > 6$ GeV, $p_{T\gamma\gamma} < 2$ GeV, Aco < 0.01	$E_{T\gamma} > 3$ GeV, $\lvert\eta\rvert<2.37$ $M_{\gamma\gamma} > 6$ GeV, $p_{T\gamma\gamma} <$ 1-2 GeV, Aco < 0.01
Candidates / expected background	13 / 2.6±0.7	59 / 12±3
Signficance	4.4σ evidence	**8.2σ** observation!

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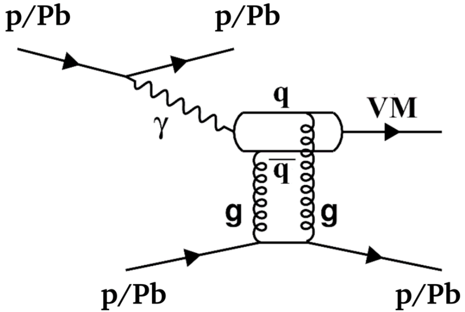
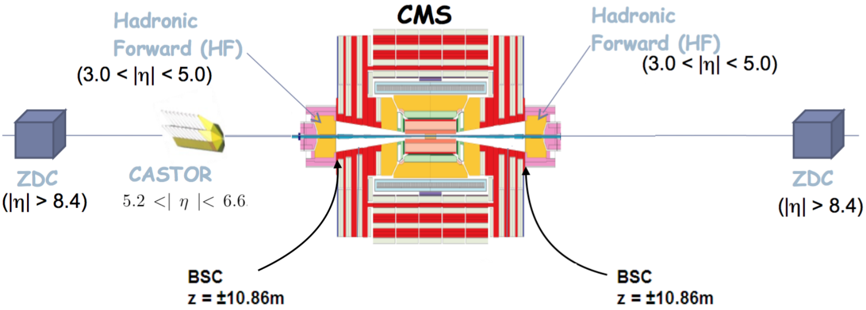
Contents

Ultra-Peripheral Collisions (UPC)



- The study of exclusive photoproduction offers a probe of target hadron structure, its generalized parton distributions

CMS Detector



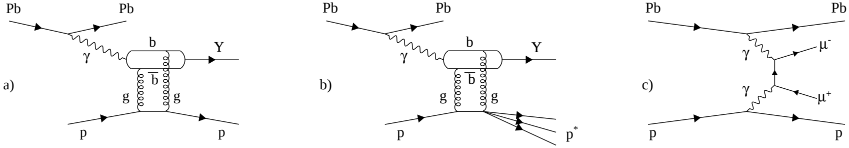
Exclusive Υ photoproduction in pPb

CMS collaboration,

Measurement of exclusive Υ photoproduction from protons in pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

Eur. Phys. J. C 79 (2019) 277

Data and event topology



Exclusive production

Semi-exclusive production

Background

Data

- Data: CMS, pPb $\sqrt{s_{NN}} = 5.02$ TeV (2013)
- $\mathcal{L} = 32.6\text{nb}^{-1}$
- Υ meson rapidity range: $|y| < 2.2$
- Photon-proton centre-of-mass energy:
  $91 < W_{\gamma p} < 826$ GeV
  $W^2_{\gamma p} = 2E_p m_\Upsilon e^{\pm y}$

MC generator

STARLIGHT:

- Exclusive Υ(nS) photoproduction events
- Exclusive QED background

Event selections

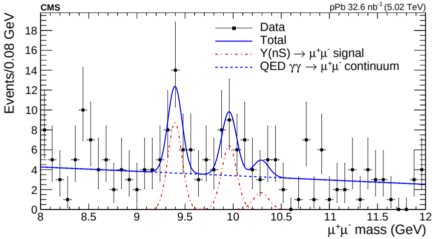
Event selection

Online selection:

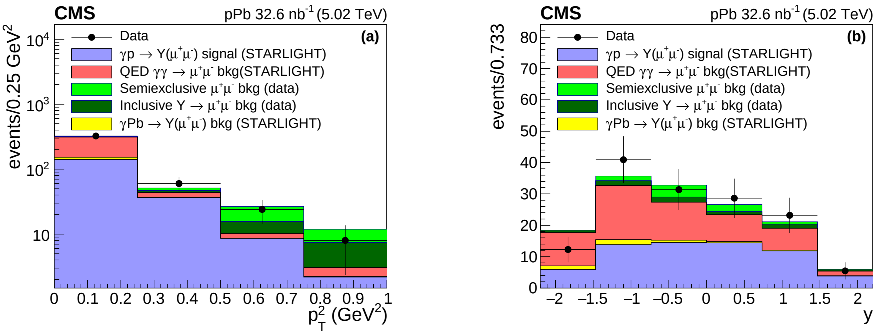
- At least one muon
- Number of tracks: [1, 6]

Offline selection:

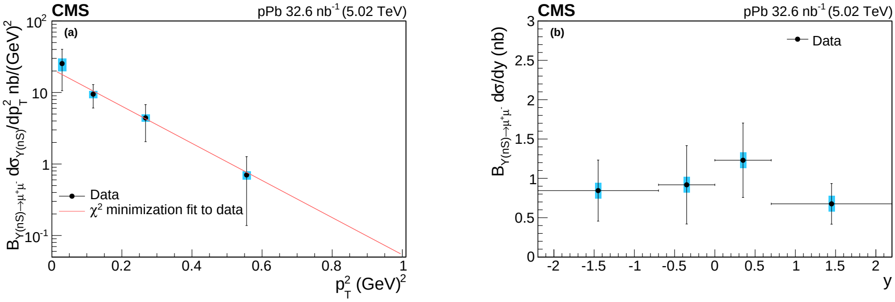
- Two opposite-charge muons with: $p_T > 3.3$ GeV, $|\eta_\mu| < 2.2$
- Single vertex with no extra charged particles with $p_T > 0.1$ GeV
- HF tower energy deposit < 5 GeV
- For dimuon selection: 0.1 GeV $< p_T <$ 1 GeV



Comparison to background

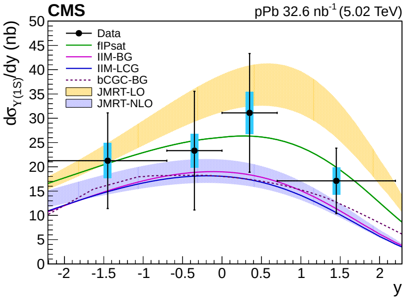


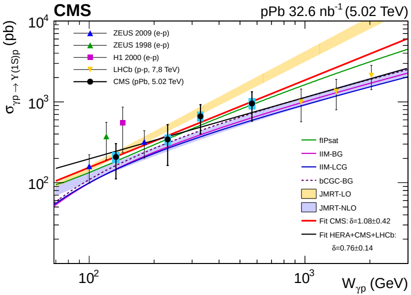
Result



- Fitted as $\sigma \sim e^{-bp_T^2}$
- $b = 6.0 \pm 2.1$ (stat) $\pm\, 0.3$ (syst) GeV^{-2}
- Consistent with ZEUS results: $b = 4.3^{+2.0}_{-1.3}$ (stat)$^{+0.5}_{-0.6}$ (syst) GeV^{-2}

Result: comparison with predictions and other data





- CMS results between previous ZEUS and LHCb data.
- δ (CMS only) $= 1.08 \pm 0.42$
- δ (ZEUS) $= 1.2 \pm 0.8$
- $\sigma \sim W_{\gamma p}^{\delta}$
- δ (CMS + ZEUS + H1) $= 0.99 \pm 0.27$
- δ (CMS + ZEUS + H1 + LHCb) $= 0.77 \pm 0.14$

Exclusive $\rho(770)^0$ photoproduction in pPb

CMS collaboration,
Measurement of exclusive $\rho(770)^0$ photoproduction in ultraperipheral pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV
Eur. Phys. J. C 79 (2019) 702

$\rho(770)^0$ photoproduction

Data

- Decay mode: $\rho(770)^0 \to \pi^+\pi^-$
- Data: CMS, pPb $\sqrt{s_{NN}} = 5.02$ TeV (2013)
- $\mathcal{L} = 16.9\mu b^{-1}$
- Photon-proton centre-of-mass energy: $29 < W_{\gamma p} < 213$ GeV
- $0.025 < |t| < 1.000$ GeV^2

MC generator

STARLIGHT:

- Exclusive $\rho(770)^0$ (resonant and non-resonant)
- Exclusive $\rho(1700)^0$

Event selections

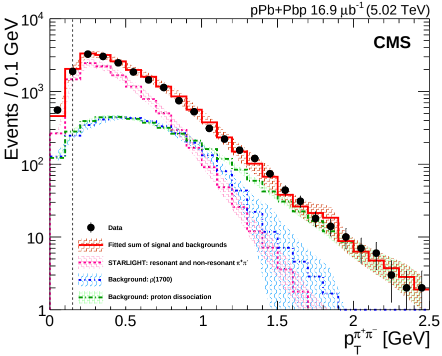
Event selection

Online selection:

- At least one track

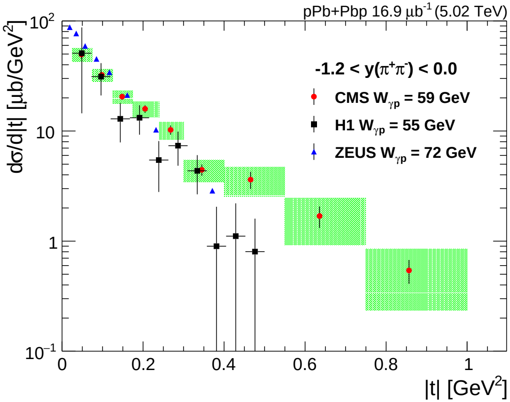
Offline selection:

- Leading HF tower < 3 GeV
- Exactly two tracks from the same PV with $|\eta_{track}| < 2.0$, $p_T^{lead} > 0.4$ GeV, $p_T^{sublead} > 0.2$ GeV
- $|y_{\pi^+\pi^-}| < 2.0$
- Leading HE tower < 1.95 GeV
- CASTOR energy < 9 GeV
- ZDC^+ energy < 500 GeV
- ZDC^- energy < 2000 GeV



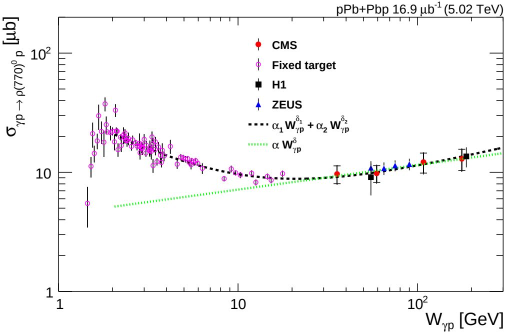
Results for $d\sigma/d|t|$

- Fitted as: Ae^{-bt+ct^2}
- $b = 9.2 \pm 0.7$ (stat) GeV^{-2}, $c = 4.6 \pm 1.6$ (stat) GeV^{-4}
- Regge formula: $b = b_0 + 2\alpha' ln(W_{\gamma p}/W_0)^2$
- $W_0 = 92.6$ GeV
- $\alpha' = 0.28 \pm 0.11$ (stat) ± 0.12 (syst) GeV^{-2}, consistent with ZEUS data and Regge expectations



Results for σ

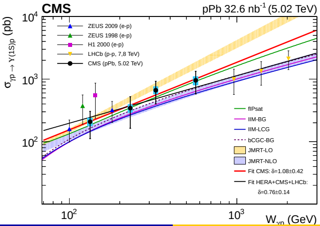
- Fitted with: $\alpha_1 W_{\gamma p}^{\delta_1} + \alpha_2 W_{\gamma p}^{\delta_2}$ (full range)
- Fitted with: $\alpha W_{\gamma p}^{\delta}$ (CMS and HERA combined)
- $\delta_1 = -0.81 \pm 0.04$ (stat) ± 0.09 (syst)
- $\delta_2 = 0.36 \pm 0.07$ (stat) ± 0.05 (syst)
- $\delta = 0.24 \pm 0.13$ (stat) ± 0.04 (syst)

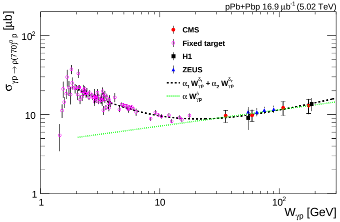


Summary:

- The first measurement of the exclusive photoproduction of Υ in UPC pPb at $\sqrt{s_{NN}} = 5.02$ TeV is performed by CMS
- The data are consistent with available pQCD approaches of the low-x gluon proton density
- The new insights on the gluon proton distribution in this poorly explored region between ZEUS and LHCb data

- The first measurement of the exclusive photoproduction of $\rho(770)^0$ in pPb at $\sqrt{s_{NN}} = 5.02$ TeV is performed by CMS
- The results are consistent with electron-proton DIS at HERA, i.e. lead ions can act as a source of quasi-real photons
- Measured $d\sigma/d|t|$ systematically lower than STARLIGHT generator predictions in the high-$|t|$ region





backup

JETSCAPE instrument: a unified framework for heavy-ion collisions

Initial design by:

- **Modular, extensible and task-based event generator**
- **Framework is agnostic to “multi-stage”, “energy-loss”**
- **JETSCAPE framework manual (arXiv:1903.07706)**
  JETSCAPE pp19 tune (arXiv:1910.05481)

GitHub JETSCAPE 2.0 is available: github.com/JETSCAPE

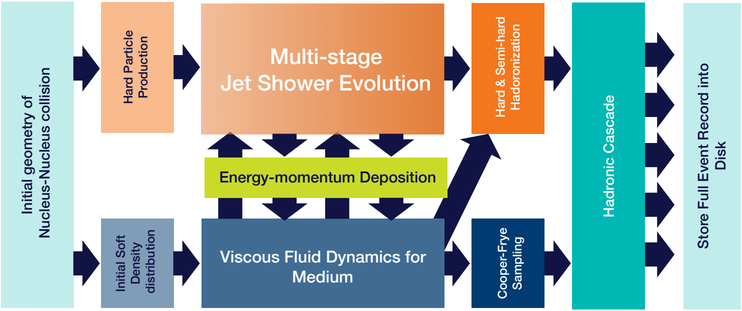


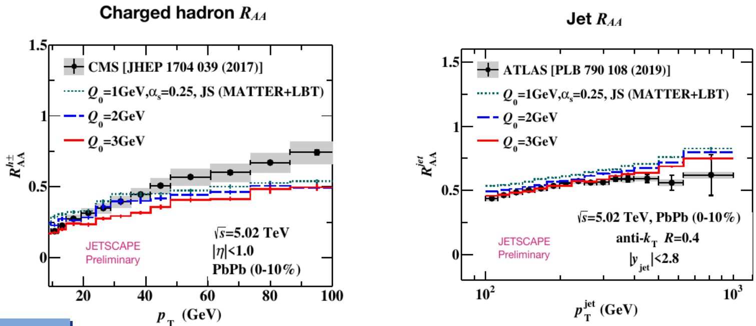
Diagram by:
Y. Tachibana

A. Kumar (for the JETSCAPE collaboration), Quark Matter 2019, Wuhan, November 6th, 2019

3

Jet quenching vs models

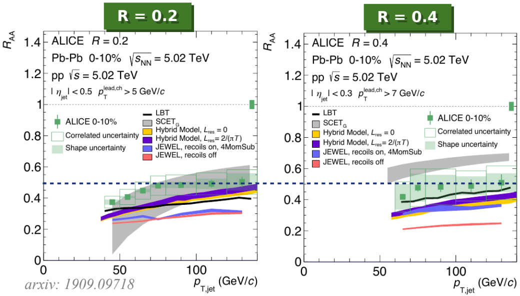
- Strong suppression in central collisions
  - High-p_T hadron R_{AA} → 1, jets suppressed up to TeV
- JETSCAPE prediction: reasonable agreement with data, but bit different slopes

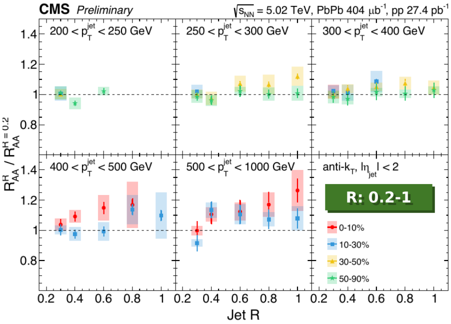


A. Kumar
6.11, 9:40 am

Soft dynamics: TRENTO (2+1D) initial condition + free streaming + (2+1D) VISHNew hydro
Energy loss: MATTER+LBT with recoil

Jet R_{AA}, R scan





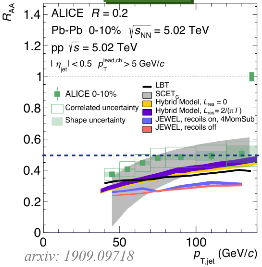
- Large R: suppression vs recovery of quenched energy
- → No strong R_{AA} dependence on R
- → High p_T jets: hint of en. recovery in central collisions

CMS M.Taylor, 6.11, 11:20 am

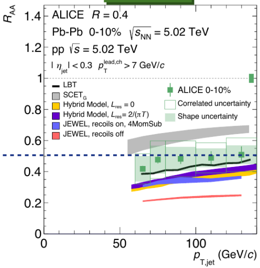
Jet R_{AA}, R scan vs models

- Strong R dependence in some of the models
- Opposites trends vs increasing R

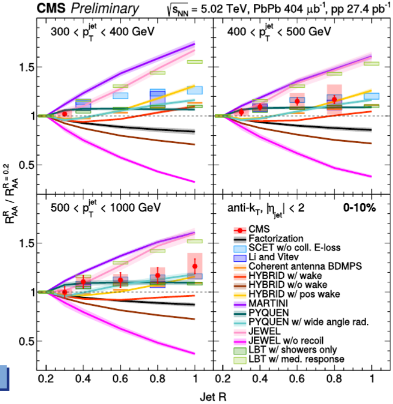
R = 0.2



R = 0.4



R: 0.2-1



- **R-scan: Strong constraints on jet quenching models**

→ Konrad Tywoniuk

- Complementary to jet substructure studies

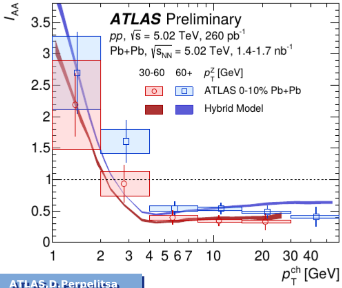
→ Yi Chen

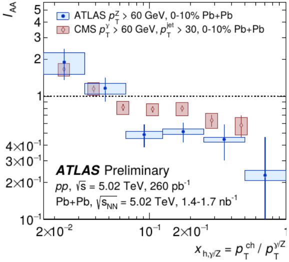
CMS M.Taylor, 6.11, 11:20 am

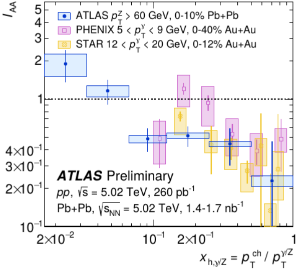
Z-tagged charged particle yields

- **Low p_T**: well-calibrated probe down to 30 GeV/c, no jet requirement, less bkg. w.r.t. γ
  - ➔ Enhancement at p_T < 2-3 GeV/c, x <0.05
  - ➔ Suppression at large ch. particle p_T, x_{hZ}

I_{AA} = Pb+Pb / *pp* ratio of per-Z yields







ATLAS,D.Perpelitsa
6.11, 2:40 pm

- Models can quantitatively reproduce the degree of suppression, Hybrid model can catch $p_{T,z}$ dependence
- CMS systematically higher (jet p_T > 30 GeV/c)
- Similar suppression at RHIC
- Good prospects for Run3/4 !

QM19 | Jet Quenching Exp | B.Trzeciak, CTU Prague

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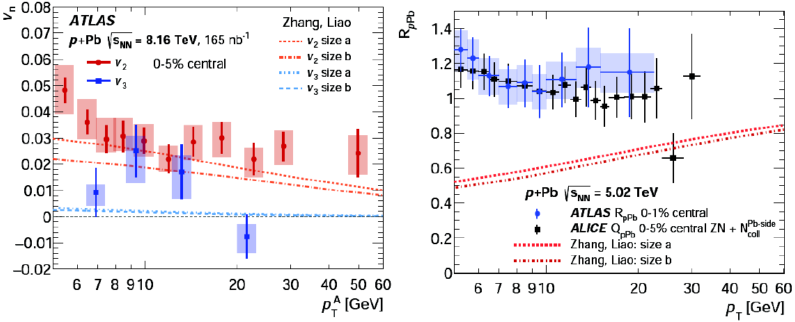
Small systems: v_2 vs R_{pA}

- High-p_T particle v_2
  - ➔ v_2 in pPb up to high p_T
  - ➔ Can be reproduced by model, however R_{pPb} underpredicted



ATLAS, K.Keys, 5.11, 11:20 am

QM19 | Jet Quenching Exp | B.Trzeciak, CTU Prague

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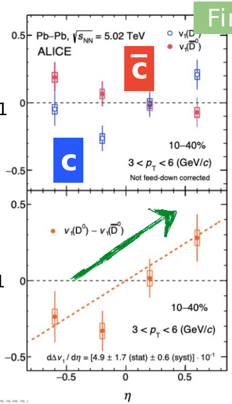
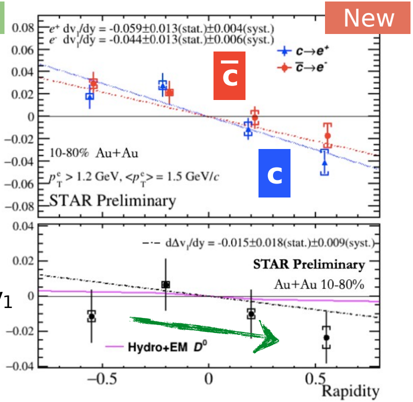
Probing the strong initial EM-field

ALICE
D^0 v_1
in PbPb



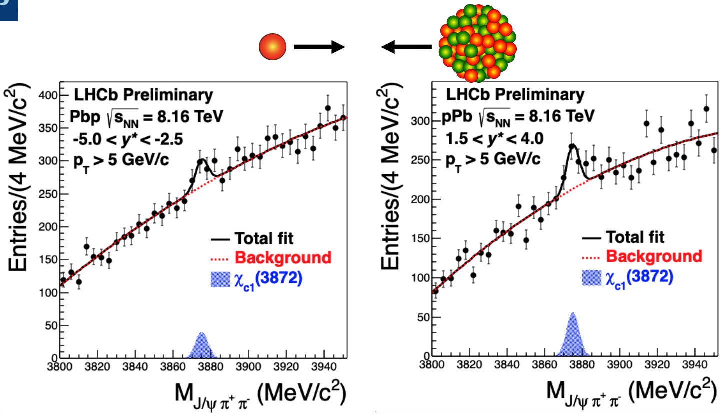


STAR
$c \to e$ v_1
in AuAu

arXiv:1910.14406
S. Tang 5 Nov, 16:40
M. Kelsey, 5 Nov, 17:40

- Δv_1 slope ($d\Delta v_1/d\eta$): slope(D^0) ~ 10^{-1} ≫slope ($h^{\pm}$) ~ 10^{-4}
- $d\Delta v_1/d\eta$ slope: negative (RHIC) vs. positive(LHC)?

X(3872) in pPb collisions



Theorists: predictions welcome

QUARK MATTER 2019 Wuhan, China 4-9 November

Matt Durham - LANL

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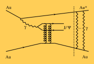
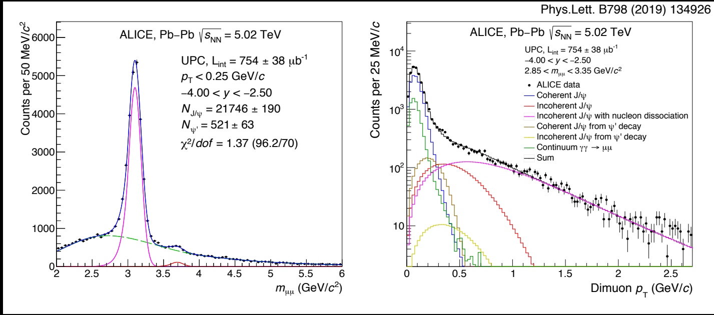
Nuclear PDFs using J/ψ in Pb+Pb



Full Run 2 dataset from ALICE!



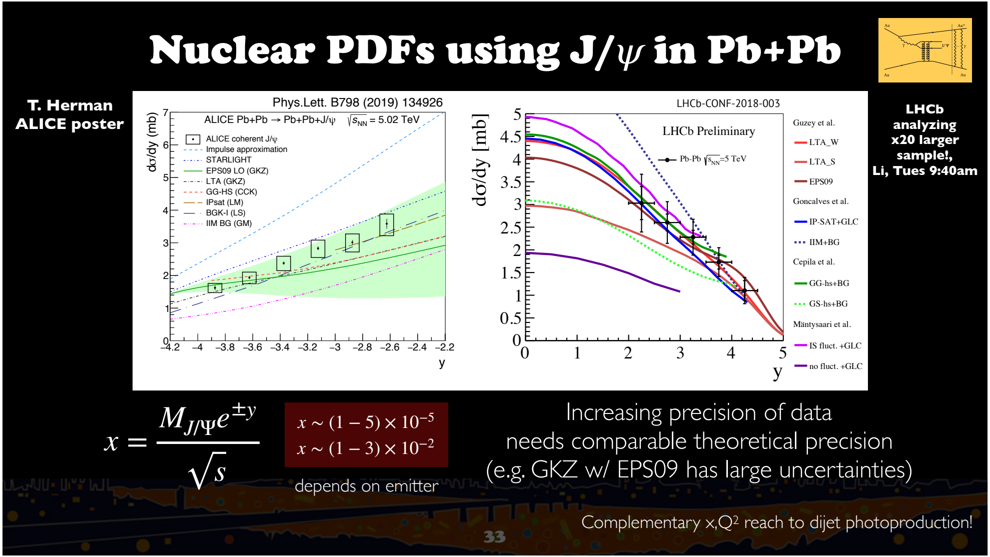
cf. HERA data!

$m_{\mu\mu}$ sensitive to contributions from:

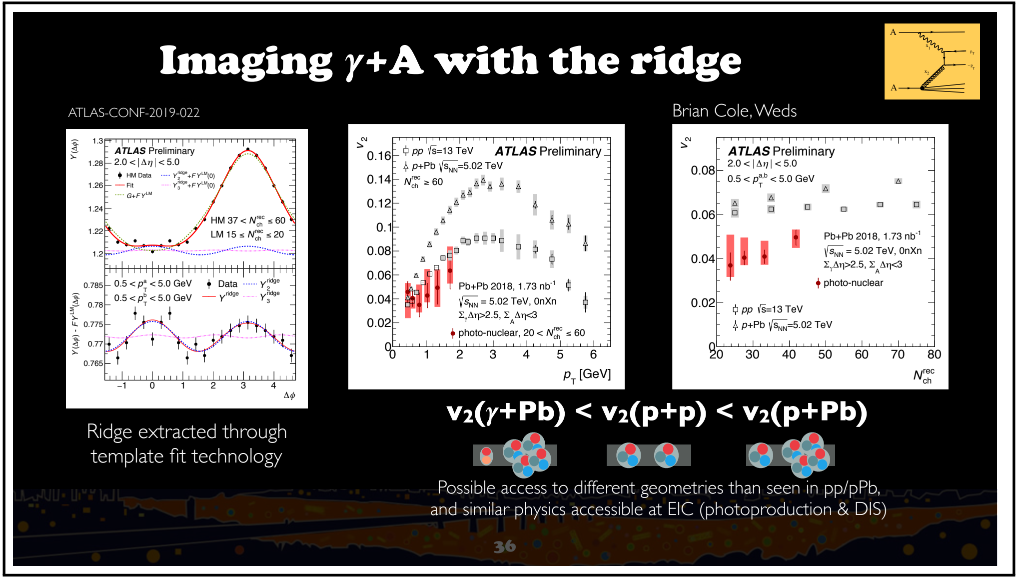
J/Ψ
Ψ'
$\gamma\gamma \to \mu\mu$

J/Ψ p_T distribution sees three scales:

nucleus (10s MeV)
nucleon (100's MeV)
dissociated nucleon (GeV)



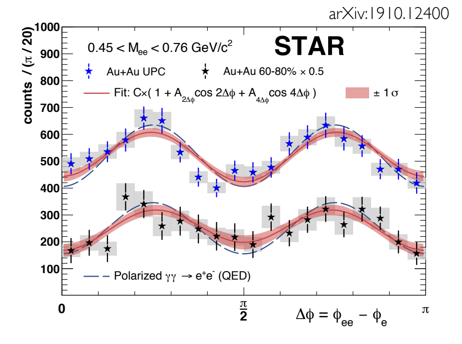
$$x = \frac{M_{J/\Psi} e^{\pm y}}{\sqrt{s}}$$

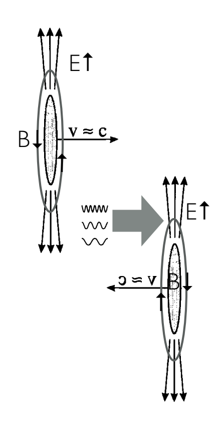

Imaging γ+A with the ridge
ATLAS-CONF-2019-022
Brian Cole, Weds
ATLAS Preliminary
Ridge extracted through
template fit technology
v2(γ+Pb) < v2(p+p) < v2(p+Pb)
Possible access to different geometries than seen in pp/pPb,
and similar physics accessible at EIC (photoproduction & DIS)
36

Impact of polarization

NEW FOR QM2019

Brandenburg Tues 9am





STAR has also performed first measurement sensitive to the linear polarization of the photons, calculated by Li et al (2019): interpreted by STAR as analogous to **vacuum birefringence**, only seen until now in astrophysical measurements

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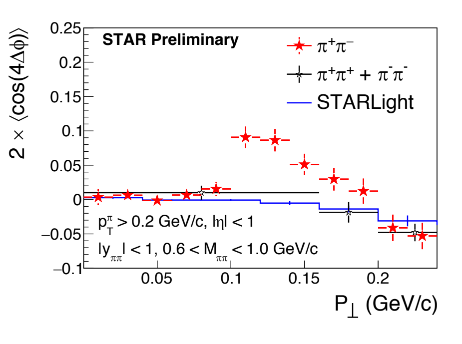
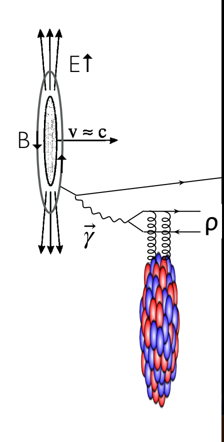
Impact of polarization

NEW FOR QM2019

Brandenburg Tues 9am





Similar polarization-drive effects are seen in coherent ρ production: possibly sensitive to generalized TMD distribution

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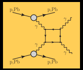
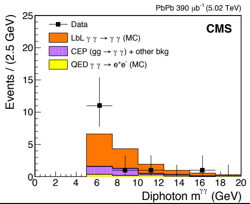
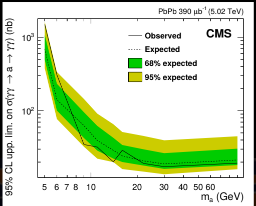
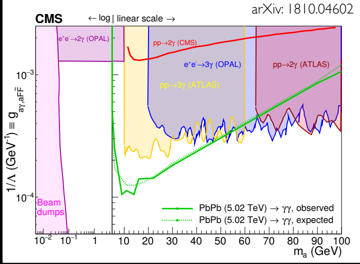
Searches for axion-like particles









similar limits from ATLAS, and expectations for Run3/4 in 1812.06772

$$\gamma + \gamma \to a \to \gamma + \gamma$$

Limits on coupling of ALPs to photons: using LbyL in future searches is an active goal for LHC Runs 3 & 4 (10x luminosity over Run 2)

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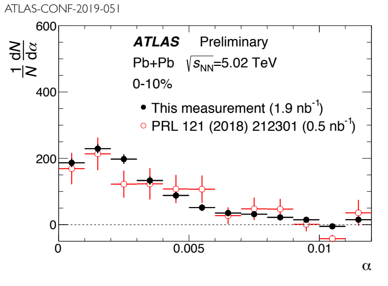
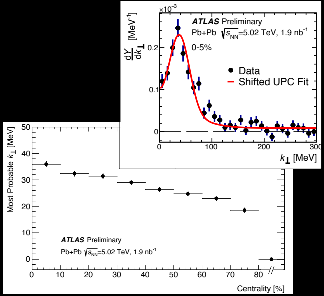
ATLAS nonUPC μμ at QM19

NEW FOR QM2019

P. Palni, Tues morning





ATLAS has repeated this measurement with 4x the 2015 luminosity: significant observation of a dip structure near α=0…

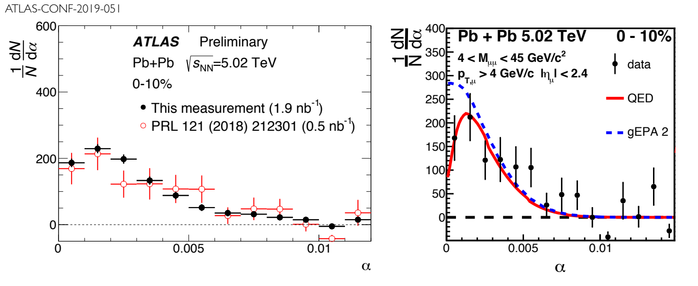
Peak evolution most robustly represented using $k_\perp = \pi\alpha\overline{p_T}$

60

QCD or QED?

NEW FOR QM2019

P. Palni, Tues morning



JUST BEFORE QM2019

ATLAS has repeated this measurement with 4x the 2015 luminosity: significant observation of a dip structure near α=0…

A structure reproduced by the full QED calculation of Zha, et al (1812.02820v3)

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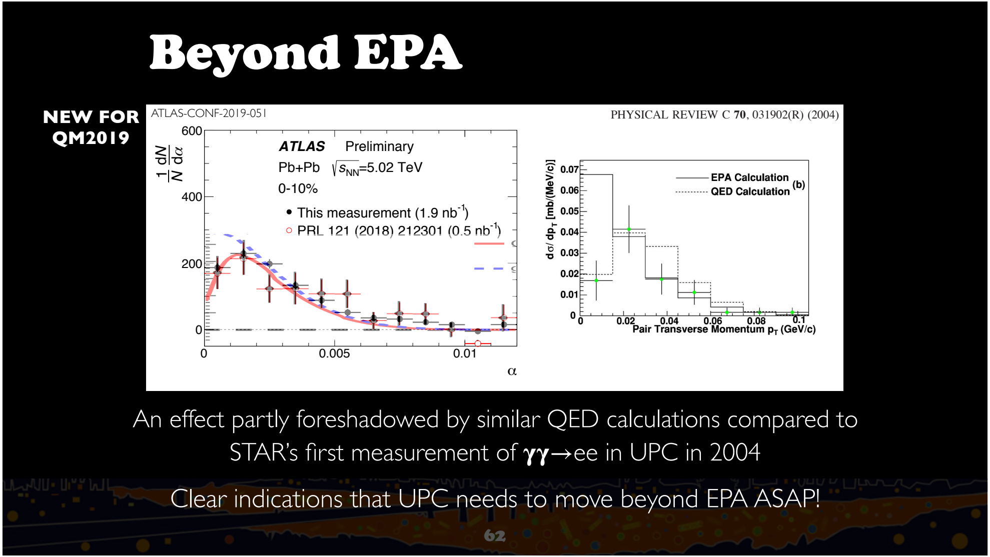
Beyond EPA
NEW FOR QM2019
ATLAS-CONF-2019-051
ATLAS Preliminary
Pb+Pb √sNN=5.02 TeV
0-10%
This measurement (1.9 nb-1)
PRL 121 (2018) 212301 (0.5 nb-1)
1/N dN/dα
α
PHYSICAL REVIEW C 70, 031902(R) (2004)
EPA Calculation
QED Calculation
(b)
dσ/dpT [mb/(MeV/c)]
Pair Transverse Momentum pT (GeV/c)
An effect partly foreshadowed by similar QED calculations compared to STAR's first measurement of γγ→ee in UPC in 2004
Clear indications that UPC needs to move beyond EPA ASAP!
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