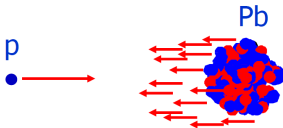


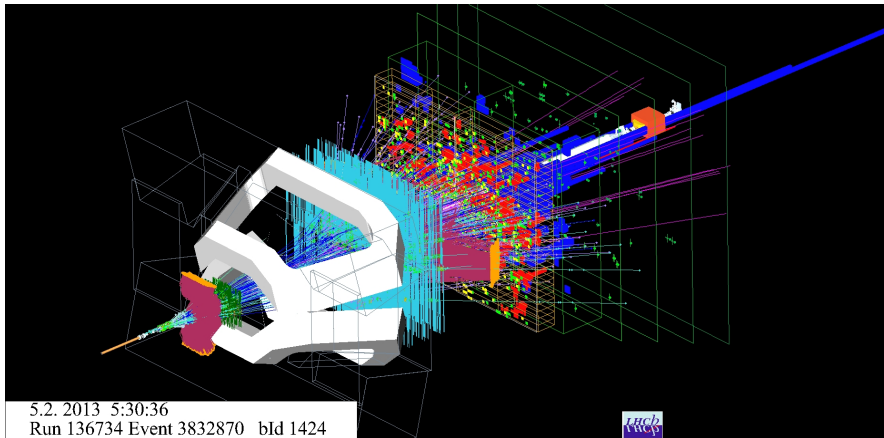
LHCb Results from pA collisions

Michael Schmelling – MPI for Nuclear Physics

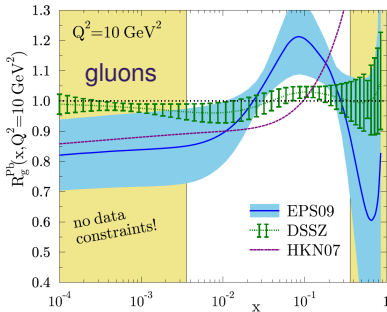
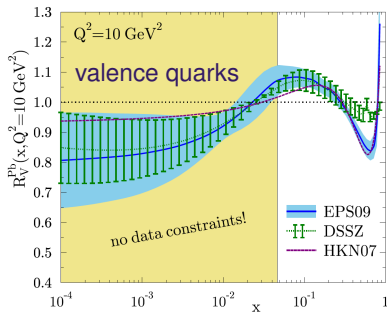


❖ physics issues

- ❑ study nuclear PDFs (parton shadowing)
- ❑ (coherent) energy loss in nuclear matter
- ❑ disentangle effects by looking at different processes
 - prompt J/ψ and J/ψ from b
 - Υ production
 - Z production
 - fixed target physics



→ ratios: (nuclear PDF)/(nucleon PDF)



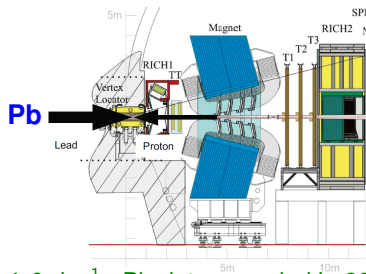
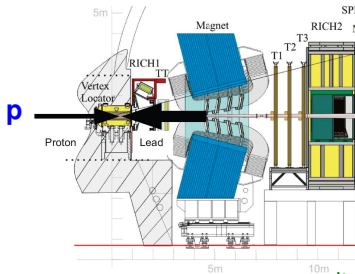
arXiv:1401.2345

- currently still large unexplored regions
- accessible regions for LHCb in J/ψ , Υ , Z production, approximately. . .
 - J/ψ : $1 \cdot 10^{-5} < x < 1 \cdot 10^{-4}$ and $7 \cdot 10^{-3} < x < 7 \cdot 10^{-2}$
 - Υ : $3 \cdot 10^{-5} < x < 3 \cdot 10^{-4}$ and $3 \cdot 10^{-2} < x < 3 \cdot 10^{-1}$
 - Z : $2 \cdot 10^{-4} < x < 3 \cdot 10^{-3}$ and $3 \cdot 10^{-1} < x$
 - fixed target: $x \sim 0.1$

nuclear modification factor:
$$R_{pA}(y) = \frac{1}{A} \cdot \frac{d\sigma_{pA}/dy}{d\sigma_{pp}/dy}$$

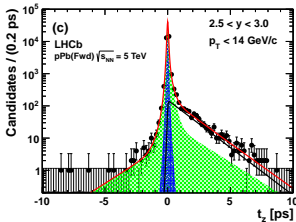
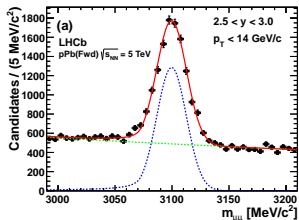
forward-backward asymmetry:
$$R_{FB}(y) = \frac{\sigma_{pA}(+|y|)}{\sigma_{pA}(-|y|)}$$

- positive rapidity in direction of the proton
- pp cross-section cancels in R_{FB}
- exploit asymmetric layout of LHCb to measure forward and backward

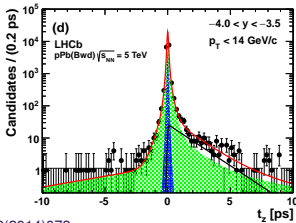
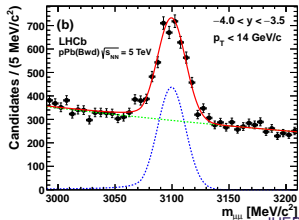


results from 1.6 nb^{-1} pPb-data recorded in 2013 →

→ separate prompt and delayed components by a simultaneous fit of mass and pseudo-proper-time $t_z = (z_{J/\psi} - z_{PV}) \cdot M_{J/\psi} / p_z^{J/\psi}$



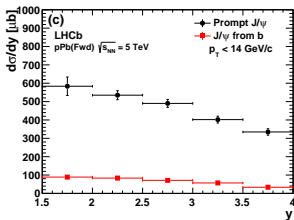
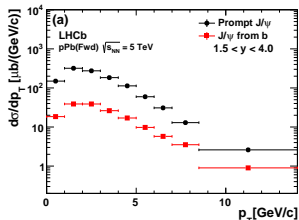
pA collisions:
forward hemisphere
 $2.5 < y < 3.0$
 $p_T < 14 \text{ GeV}/c$



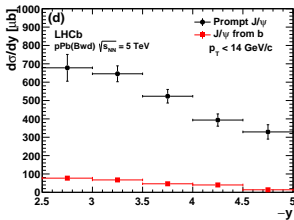
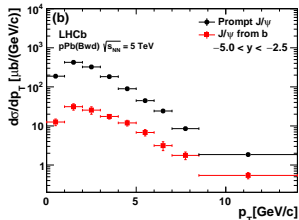
pA collisions:
backward hemisphere
 $-4.0 < y < -3.5$
 $p_T < 14 \text{ GeV}/c$

JHEP02(2014)072

❖ $\sqrt{s} = 5 \text{ TeV}$, transverse momentum $0 < p_T < 14 \text{ GeV}/c$



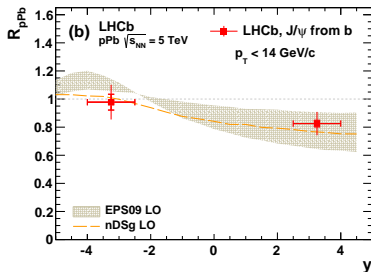
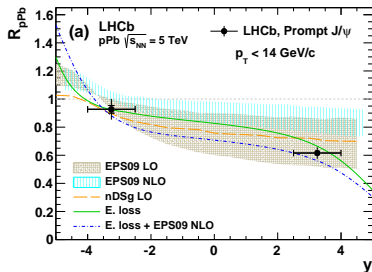
pA collisions:
 forward hemisphere
 $1.5 < y < 4.0$



pA collisions:
 backward hemisphere
 $-5.0 < y < -2.5$

JHEP02(2014)072

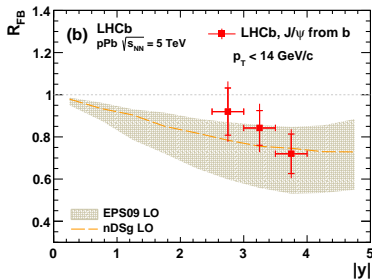
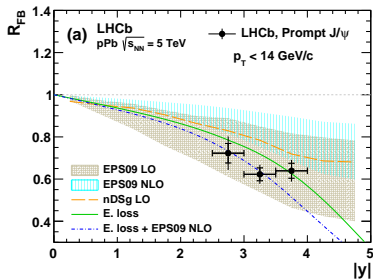
→ common range of forward and backward acceptance: $2.5 < |y| < 4.0$



JHEP02(2014)072

- results require interpolation of pp cross-section to $\sqrt{s} = 5$ TeV
- $R_{pPb} \neq 1$: the nucleus is not a loose collection of independent nucleons
- tighter bound B -mesons less affected than prompt J/ψ
- energy loss and shadowing are about equally important
- J/ψ data agree with “energy loss + NLO shadowing”

→ interpolated pp cross-section not required

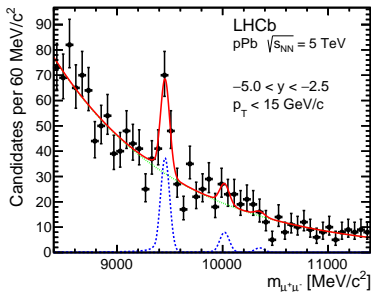
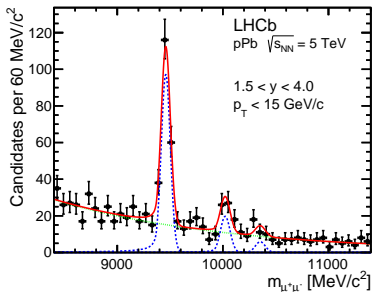


JHEP02(2014)072

- differential measurement in $|y|$
- same observations/conclusions as for R_{pPb}

→ study heavier systems

→ *statistics limited measurement*

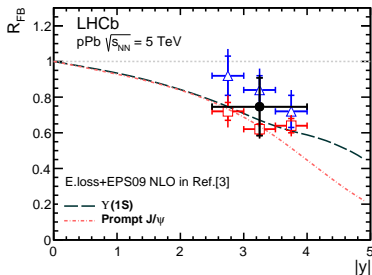
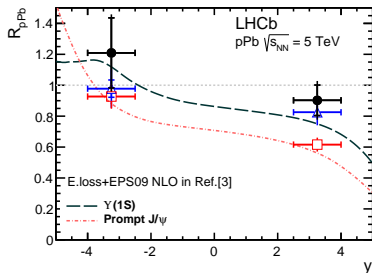


JHEP07(2014)094

- no differential measurements possible
- kinematic range: $p_T < 15$ GeV/c, $1.5 < y < 4.0$ and $-5.0 < y < -2.5$
- study nuclear effects in common rapidity range $2.5 < |y| < 4.0$
- evidence for strong suppression of $\Upsilon(2S)$ and $\Upsilon(3S)$

→ focus on $\Upsilon(1S)$

→ $\Upsilon(1S)$ nuclear modification factor and forward-backward asymmetry

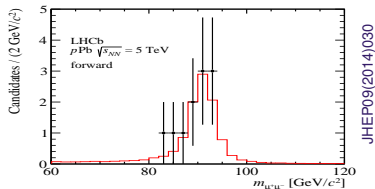
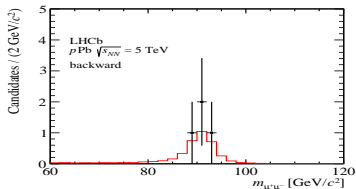


JHEP07(2014)094

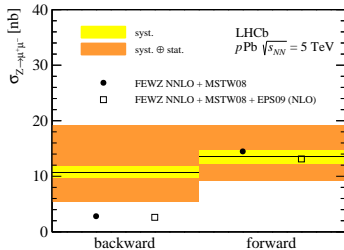
- large uncertainties
- less suppression for Upsilon than for prompt J/ψ production (red symbols)
- backward data consistent with expectations of anti-shadowing
- Upsilon consistent with J/ψ from b (blue symbols)

❖ more data needed for firm conclusions

→ clean signals: 4 backward-candidates, 11 forward-candidates



JHEP09(2014)030



→ muon selection

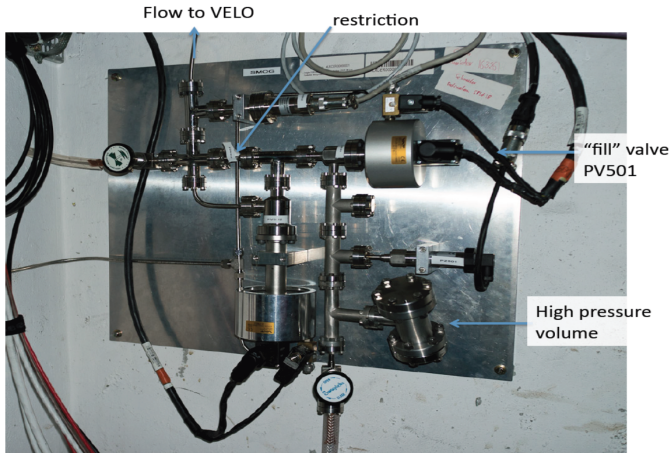
- $p_T > 20$ GeV/c, $2.0 < \eta < 4.5$
- $60 < M(\mu^+\mu^-) < 120$ GeV/c²

→ cross-section results

$$\sigma_{\text{fwd}} = 13.5 \pm_{4.0}^{5.4} (\text{stat}) \pm 1.2(\text{syst}) \text{ nb}$$

$$\sigma_{\text{bwd}} = 10.7 \pm_{5.1}^{8.4} (\text{stat}) \pm 1.0(\text{syst}) \text{ nb}$$

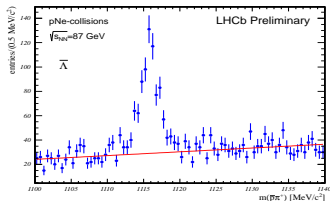
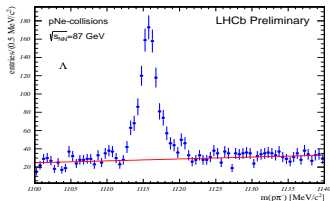
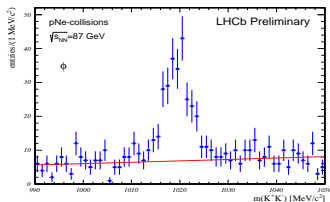
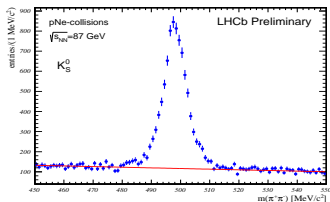
SMOG: System for Measuring Overlap with Gas



→ injection of Ne-gas into VELO

→ proton-Neon collisions recorded during the pA pilot run

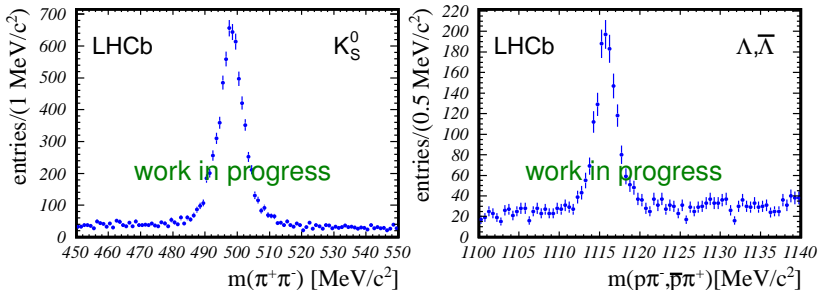
- $\sqrt{s_{NN}} = 87 \text{ GeV}$, boost to center-of-mass $\Delta y \approx 4.5$
- LHCb: backward direction in the nucleon-nucleon center-of-mass



LHCb-CONF-2012-034

→ a first look at PbNe collisions

PbNe-interactions - $\sqrt{s_{NN}}=54.4$ GeV



- O(1/2h) very low luminosity data taking with PbNe interactions
- plots based on 1/4 of available statistics

❖ possibility to study nuclear PDFs at large x !



→ rich harvest already from $1.6 \text{ nb}^{-1} \text{ pA}$ running

■ initial measurements

- production of prompt J/ψ and J/ψ from b
- Upsilon production
- Z production
- first sets of event with fixed target pNe and PbNe collisions

■ current limitations

- not enough statistics for heavy particles to allow definite conclusions
- no pp reference data at $\sqrt{s} = 5 \text{ TeV}$

■ more data in pA and pp at the same $\sqrt{s_{NN}}$ would be useful

■ in the meantime focus on further analyses of existing data

- energy flow, multiplicities, strangeness production, . . .
- charm and beauty production cross-section, excited charmonium states
- correlations (ridge effect)
- central-exclusive-production