Summary and conclusions of HI session

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Experimental results
HI and fixed target with LHCb

LHCb has unique forward kinematics as heavy-ion collider and in fixed target mode → System for Measuring Overlap with Gas (SMOG) served as a “pseudo-target”

First direct determination of the antiproton production cross-section in pHe collisions
HI and fixed target with LHCb

LHCb has unique forward kinematics as heavy-ion collider and in fixed target mode → System for Measuring Overlap with Gas (SMOG) served as a “pseudo-target”

No strong differences are observed between pHe data and the theoretical predictions that do not include any intrinsic charm contribution

→ No evidence for a substantial intrinsic charm content of the nucleon is found.
Multiplicty fluctuations at fixed number of ancestors/MPI influence pA and AA distributions as a function of centrality: uptick effect.
HF measurements with ALICE

Heavy-flavor quarks (charm and beauty) mainly produced in hard scattering → can probe the entire evolution of the QGP

- $R_{p\text{-Pb}}$, Pb-Pb 0-20% (p-Pb data reference)
- $R_{\text{p-Pb}}$ (pp data reference)

$D^0$-tagged jets, $p_{T,D^0} > 3$ GeV/c
charged jets, anti-$k_T$, $R = 0.3$, $|\eta_{\text{jet}}| < 0.6$

p-Pb initial cold nuclear matter state effects on D jets are small
→ charm jet quenching in lead-lead collisions should not be influenced by such effects
HF measurements with ALICE

Heavy-flavor quarks (charm and beauty) mainly produced in hard scattering → can probe the entire evolution of the QGP

Flow-like effects in the HF sector studied in high-multiplicity p-Pb collisions → Collective effects? Initial or final state cold nuclear matter effects? Color reconnections?
$v_2^c(c\rightarrow e)$

- Increases smoothly with $p_T$
- $v_2^c(c\rightarrow e)$ from charm decay
- $v_2^c(c\rightarrow e)$ from PHENIX PRC92.034913

$v_2^b(b\rightarrow e)$

- Is consistent with zero within stat and sys
- $v_2^b(b\rightarrow e)$ from bottom decay
- $v_2^b(b\rightarrow e)$ from PHENIX PRC92.034913

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Rachid Nouicer
HF and quarkonia with PHENIX and STAR

More suppression of Υ(1S) in central collisions
More suppression of Υ(2S+3S) compared to Υ(1S)
→ consistent with “sequential melting” expectation
The $\gamma$ yields differ by a factor 10 at low $p_T$ from pp to AA

→ gap partially filled by p-Au
→ pp high multiplicity points can help
Theory models
Soft QCD from $ee$ to AA with **PYTHIA**

Developments:

- String-string interactions $\rightarrow$ vortex lines (can reproduce pp ridge structure and strangeness enhancement)
- Angantyr extension for pA and AA: currently no QGP effects (ropes, shoving) in AA but can reproduce global features
Empirical model derived from particle data:

- no radial flow in p-Pb
- no jet modification in p-Pb
- no color reconnection

→ can reproduce particles spectra
Flow harmonic coefficients

Experimental data cannot bring to a conclusion on whether it is an initial state or a final state effect.

Proton structure definition is crucial.

Fluctuating internal d.o.f


Alba Soto Ontoso
Future projects
ElectronIonCollider

Addresses open questions on structure of nucleons and nuclei:

- **spin of nucleons and nuclei**: quarks contribute to a fraction of proton spin
- **tomography in momentum and spatial space**
- **saturation**: gluon occupancy amplified for nucleus

**EU-US collaboration: more news in 2019!**

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Physics of Heavy Ions is active, rich and still to develop!

- small systems like pp and p-Pb (d-Au) were planned as control systems but show instead interesting features to be studied/understood more (initial/final state effects? cold/hot nuclear matter effects?)

- MPI effects are visible in global observables in AA and pA

What are the HI measurements which are more influenced by MPI?

Look forward to new (more precise) experimental results, to new small collision systems... in general to more interaction among experimental and theoretical community!