New measurements in fixed-target collisions at LHCb

Sara Sellam* for the LHCb collaboration

*sara.sellam@cern.ch
SMOG: fixed-target program

SMOG: System for Measuring Overlap with Gas.

Noble gases at a pressure of $O(10^{-7})$ mbar are injected into the VELO.

$\sqrt{s_{NN}} = 110 \text{ GeV}$

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$y = y^* + ln(\frac{\sqrt{s_{NN}}}{m_p})$

$x_F \approx \frac{2}{\sqrt{s_{NN}}} \sqrt{M^2 + p_T^2} \sinh(y^*)$

$y = \frac{y^* + \ln(\frac{\sqrt{s_{NN}}}{m_p})}{\sqrt{s_{NN}}}$

$y^* = y - \frac{\ln(\frac{\sqrt{s_{NN}}}{m_p})}{\sqrt{s_{NN}}}$

- $-3.0 < y^* < 0$
- Probe intrinsic charm content in the nucleon.
- Access nPDF anti-shadowing region.
Charmonia production in pNe collisions at $\sqrt{s_{NN}} = 68.5$ GeV

- Charmonium production is suppressed by Cold Nuclear Matter effects in proton-nucleus collisions.
- Production cross-section of $J/\psi$ is well produced by Vogt’s predictions with both 1% and no Intrinsic Charm contribution.

- First measurement of the $\psi(2S)$ over $J/\psi$ production in fixed target mode.
- $\psi(2S)$ to $J/\psi$ production ratio is in agreement with other measurements at small values of target atomic mass number $A$. 
The measurement of $J/\psi$ yield with the $D^0$ production can improve the interpretation of the charmonium $c\bar{c}$ suppression due to the presence of the hot and dense medium.

Assuming that $\sigma_{J/\psi} \propto <N_{coll}>^{\alpha'}$ and $\sigma_{D^0} \propto <N_{coll}>$

$=>$ $\sigma_{J/\psi}/\sigma_{D^0} \propto <N_{coll}>^{\alpha'-1}$

$J/\psi$ and $D^0$ production ratio strongly depends on $p_T$.

$J/\psi$ production is affected by additional nuclear effects with respect to $D^0$.

No anomalous $J/\psi$ suppression is observed in the largest $N_{coll}$ that could indicate the formation of QGP.
• Models of antiproton production in cosmic rays (CRs) collisions with the interstellar medium limit the interpretation of the \( \bar{p} \) flux in CRs measurements.

• The measurement of prompt \( \bar{p} \) in pHe collisions at \( \sqrt{s_{NN}} = 110 \) is extended to include \( \bar{p} \) from anti-hyperon decays.

\[
R_{\Lambda} \equiv \frac{\sigma(pHe \rightarrow \Lambda X \rightarrow \bar{p}X)}{\sigma(pHe \rightarrow \bar{p}_{prompt}X)}
\]

\[
R_{\bar{H}} \equiv \frac{\sigma(pHe \rightarrow \bar{H}X \rightarrow \bar{p}X)}{\sigma(pHe \rightarrow \bar{p}_{prompt}X)}
\]

• The ratio of \( \bar{\Lambda} \) over \( \bar{H} \) is well reproduced by EPOS-LHC.

• Models largely underestimate the anti-hyperon contributions to the \( \bar{p} \) production.
SMOG2: extension of the fixed-target programme

- **SMOG2**: confinement cell for the gas to be installed upstream of the nominal IP (z in [-500,-300]mm).
- More gas target: \(H_2, D_2, He, N_2, O_2, Ne, Ar, Kr, Xe\).
- Gas density increased by up to two orders of magnitude for the same gas.

- pp and SMOG2 luminous regions separated. Simultaneous data-taking is possible. Large statistics.
- Unique opportunities to extend heavy-ion, QCD and astrophysics studies.

LHCb-FIGURE-2022-002

LHCb Upgrade simulation

Candidates

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<th>beam-beam collisions</th>
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