Comments on systematics of corrected MB distributions

Karel Safarik
(presented by A. Morsch)

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For discussion (1)

- The event sample to normalize to
  - Sample defined by physics process
    - INEL (ALICE)
    - NSD (less well defined) (ALICE, CMS)
  - Sample defined by detector acceptance
    - INEL with at least one particle in some acceptance window
      - Published up to now:
        - ALICE in $\eta$ window
        - ATLAS in both $\eta$ and $p_T$ window
For discussion (2)

- The track sample to be normalized
  - Correct down to $p_T = 0$ (used by ALICE and CMS)
  - Use a $p_T$ cut-off defined by tracking efficiency (used by everybody)
Sample defined by physics process

- **Advantage**
  - Comparison with theoretical models, not necessarily a MC
  - Comparison with other experiment

- **Disadvantage**
  - Model dependent
    - One has to correct for the non-observed (triggered - selected) events. However, this extrapolation is not done just using the models: usually one uses constraint from ones own data and/or previous measurements.
Sample defined by detector acceptance

- Advantage
  - less model dependent, but not completely
  - for finite tracking inefficiency $\varepsilon$

\[
\begin{align*}
N_{\text{event}} &= \sum_{M} P_{M} \left(1 - \varepsilon^{M}\right) \\
N_{\text{track}} &= \sum_{M} P_{M} M \left(1 - \varepsilon\right)
\end{align*}
\]

- $\langle N \rangle$ depends on true multiplicity distribution at low multiplicity ($M$)
Sample defined by detector acceptance

- Disadvantage
  - This is suitable only for models formulated as Monte Carlo generators, but there are models which are not. Example: QGSM
Correction down to $p_T=0$

- Advantage
  - Again comparison with non-MC models and with other experiments.
  - This correction can only be used when an experiment reaches low tracking efficiency for very low $p_T$
    - The correction is small and very well-constrained (one measures the value on a already falling spectrum and it is constrained to zero at $p_T=0$
    - in ALICE conservative error of $\sim 0.5\%$ on mean multiplicity
Correction down to $p_T = 0$

- Disadvantage
  - One assumes that $p_T$ dependence is falling down monotonically with $p_T$ from 50MeV/c (ALICE) to 0
  - However, that seems reasonable and the model dependence is very small.
Use a $p_T$ cut-off defined by tracking efficiency

- Advantage: well suited for MC model comparison,
  
  - However, there are still model dependent corrections (unless one goes to very large $p_T \sim 1.5$ GeV).
  
  - At 500 MeV p and anti-p will have substantial energy loss (see Bethe-Bloch), one has to correct for this to get the momentum at primary vertex to do the $p_T$ cut!

  - This correction is purely model dependent (relative amount of protons (even worse antiprotons)) their momentum spectra, and ultimately uncorrectable are $dE/dx$ fluctuations).

  - Usually this uncertainty is much larger than the correction towards 0 (from a much lower cut-off).
Use a $p_T$ cut-off defined by tracking efficiency

- Disadvantage
  - Comparison with non-MC models and other experiments practically impossible
  - Tuning of MC models in restricted range (1/3 of charged particles in $p_T$ in the case of ATLAS)
Conclusions

- Event selection
  - we have to do both, events samples defined by physics processes and detector acceptance

- Track selection
  - Correction or cut-off, depends on what is more suitable for a given detector and particular reconstruction method, i.e. which gives less systematic uncertainty and larger coverage.